



Wyoming State Geological Survey  
Thomas A. Drean, Director and State Geologist



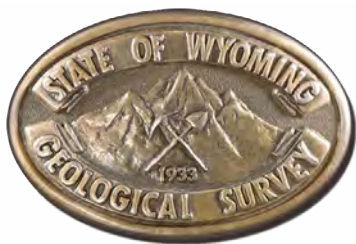
# **2012 Coalbed Natural Gas Regional Groundwater Monitoring Update: Powder River Basin, Wyoming**

*Open File Report 2013-01*

by  
**James E. Stafford and Seth J. Wittke**

**Prepared for the U.S. Bureau of Land Management  
Buffalo Field Office  
Buffalo, Wyoming**

**Laramie, Wyoming  
2013**



**Director and State Geologist Thomas A. Drean**



**Design and layout by:**

Chamois L. Andersen

James R. Rodgers

**Editing by:**

James R. Rodgers

Karl G. Taboga

2012 Coalbed Natural Gas Regional Groundwater Monitoring Update:  
Powder River Basin, Wyoming

Prepared for the Bureau of Land Management

This publication is also available online at:

<http://www.wsgs.uwyo.edu/Public-Info/OnlinePubs/OFR-2013-01.aspx>

---

Wyoming State Geological Survey

Copyright © 2013 by the Wyoming State Geological Survey. All rights reserved.

---

The WSGS encourages the fair use of its material. We request that credit be expressly given to the "Wyoming State Geological Survey" when citing information from this publication. Please contact the WSGS at 307-766-2286, ext. 224, or by email at [wsgs.sales@wyo.gov](mailto:wsgs.sales@wyo.gov) if you have questions about citing materials, preparing acknowledgments, or extensive use of this material. We appreciate your cooperation.

Individuals with disabilities who require an alternative form of this publication should contact the WSGS. For the TTY relay operator call 1-800-877-9975.

Funding for this project was made possible through a grant provided by the U.S. Bureau of Land Management.

Cover: Active CBNG drilling operation . Photo courtesy of Bureau of Land Management, Buffalo Field Office.

# **2012 Coalbed Natural Gas Regional Groundwater Monitoring Update: Powder River Basin, Wyoming**

*December 2013*

*James E. Stafford and Seth J. Wittke*

*Open File Report 2013-01*

This report was prepared under contract for the Bureau of Land Management by the Wyoming State Geological Survey

---

Wyoming State Geological Survey, P.O. Box 1347, Laramie, Wyoming 82073-1347



## Table of Contents

Introduction . . . . .	1
Methods . . . . .	1
Monitoring Data Collection, Transfer, and Storage . . . . .	1
CBNG Production Data . . . . .	6
Monitored Zones and Coal Zone Designations . . . . .	6
Wasatch Sandstone Aquifers. . . . .	7
Fort Union Coal Zones . . . . .	7
Summary Results . . . . .	8
Regional Production Information. . . . .	8
Monitoring Zone Water Level Changes and Production Data. . . . .	10
Wasatch Sandstones . . . . .	10
Wyodak Rider (Big George). . . . .	13
Upper Wyodak. . . . .	15
Lower Wyodak. . . . .	17
Cook. . . . .	18
Cook/Wall. . . . .	20
Wall. . . . .	21
Underburden Sandstones. . . . .	23
Conclusions . . . . .	24
References . . . . .	25

## Appendix

20 Mile Butte Monitoring Well Site. . . . .	32
21 Mile Monitoring Well Site. . . . .	38
All Night Creek Monitoring Well Site. . . . .	43
Amoco Sec 36 Monitoring Well Site. . . . .	49
Bar 76 Monitoring Well Site. . . . .	54
Barrett Persson Monitoring Well Site. . . . .	59
Barton Monitoring Well Site. . . . .	64
Bear Draw Monitoring Well Site. . . . .	69
Beaver Fed Monitoring Well Site. . . . .	74
Betop Monitoring Well Site. . . . .	79
Big Cat Monitoring Well Site. . . . .	83
Blackbird BG Monitoring Well Site. . . . .	88
Blackbird Coleman Monitoring Well Site. . . . .	93
Boondoggle Monitoring Well Site. . . . .	98
Bowers Monitoring Well Site. . . . .	103
Buffalo SE Monitoring Well Site. . . . .	109
Bull Creek Monitoring Well Site. . . . .	115
Bullwhacker Monitoring Well Site. . . . .	120
Carr Draw Monitoring Well Site. . . . .	125
Cedar Draw Monitoring Well Site. . . . .	131



Coal Gulch Monitoring Well Site. . . . .	136
Dilts Monitoring Well Site. . . . .	141
Double Tank Monitoring Well Site. . . . .	146
Dry Willow Monitoring Well Site. . . . .	151
Duck Creek Monitoring Well Site. . . . .	156
Durham Ranch Sec 6 Monitoring Well Site. . . . .	161
Durham Ranch Sec 14 Monitoring Well Site. . . . .	166
Echeta Monitoring Well Site. . . . .	171
Fourmile Monitoring Well Site. . . . .	176
Gilmore Monitoring Well Site. . . . .	181
Hoe Creek Monitoring Well Site. . . . .	186
Juniper Monitoring Well Site. . . . .	191
Kennedy Monitoring Well Site. . . . .	196
Kingsbury Monitoring Well Site. . . . .	201
L Quarter Circle Hills Monitoring Well Site. . . . .	206
Leiter Monitoring Well Site. . . . .	211
Lone Tree Monitoring Well Site. . . . .	216
Lower Prairie Dog Monitoring Well Site. . . . .	221
MP 2 Monitoring Well Site. . . . .	226
MP 22 Monitoring Well Site. . . . .	231
Napier Monitoring Well Site. . . . .	236
North Cordero Monitoring Well Site. . . . .	241
North Gillette Monitoring Well Site. . . . .	246
Oops Monitoring Well Site. . . . .	251
Palo Monitoring Well Site. . . . .	255
Pistol Point Monitoring Well Site. . . . .	260
Redstone Monitoring Well Site. . . . .	265
Remington Creek Monitoring Well Site. . . . .	270
Rose Draw Monitoring Well Site. . . . .	276
Sasquatch Monitoring Well Site. . . . .	281
Sec 25 Monitoring Well Site. . . . .	286
South Coal Monitoring Well Site. . . . .	291
South Cordero Monitoring Well Site. . . . .	296
South Prong Monitoring Well Site. . . . .	301
Squaw Butte Monitoring Well Site. . . . .	307
Streeter Monitoring Well Site. . . . .	312
Stuart Sec 31 Monitoring Well Site. . . . .	317
Throne Monitoring Well Site. . . . .	322
West Pine Tree Monitoring Well Site. . . . .	327
Wild Turkey Monitoring Well Site. . . . .	332
Williams Cedar Draw Monitoring Well Site. . . . .	337
Wormwood Monitoring Well Site. . . . .	343

## INTRODUCTION

The Bureau of Land Management (BLM) maintains a network of 62 groundwater monitoring well sites in the Powder River Basin (PRB), Wyoming (Figure 1; Table 1). The monitoring well data collected at these sites is used to investigate changes in groundwater levels over time that may be related to local production of coalbed natural gas (CBNG). Water level monitoring has been ongoing in some portions of the PRB since 1995 (BLM monitoring well database, 2013). For the purpose of this report, the acronym PRB (Powder River Basin) will signify only the portion of the Powder River Structural Basin that falls within Wyoming.

The BLM monitors groundwater in five “coal zones.” Listed in stratigraphic order (youngest to oldest) these are: 1) Wyodak Rider (Big George), 2) Upper Wyodak, 3) Lower Wyodak, 4) Cook, and 5) Wall. Additional groundwater monitoring is conducted in two “sand zones,” the stratigraphically higher zone of coals and sands referred to as the Wasatch coal zones and in the sandstones that underlie any Fort Union coal zone; referred to in this report as the Underburden sandstones.

Presented in this report are the results of a regional groundwater drawdown study that is being conducted by the BLM within its monitoring well network. This report will add and focus on data from January 2010 through October 2012 (hereafter referred to as the period of record or POR). Additionally, water level changes observed during this study are compared to water volumes co-produced at CBNG extraction wells located in proximity to specific groundwater monitoring well sites. This report also provides descriptions of the monitored coal zones and PRB coal nomenclature. Finally, groundwater and associated CBNG production data are listed in Appendix A for each monitoring well site for the entire duration of monitoring periods, special emphasis is placed on the 2010-2012 POR.

For the purposes of this report, CBNG production data, including water and gas production are assigned to monitoring zones. Data from the

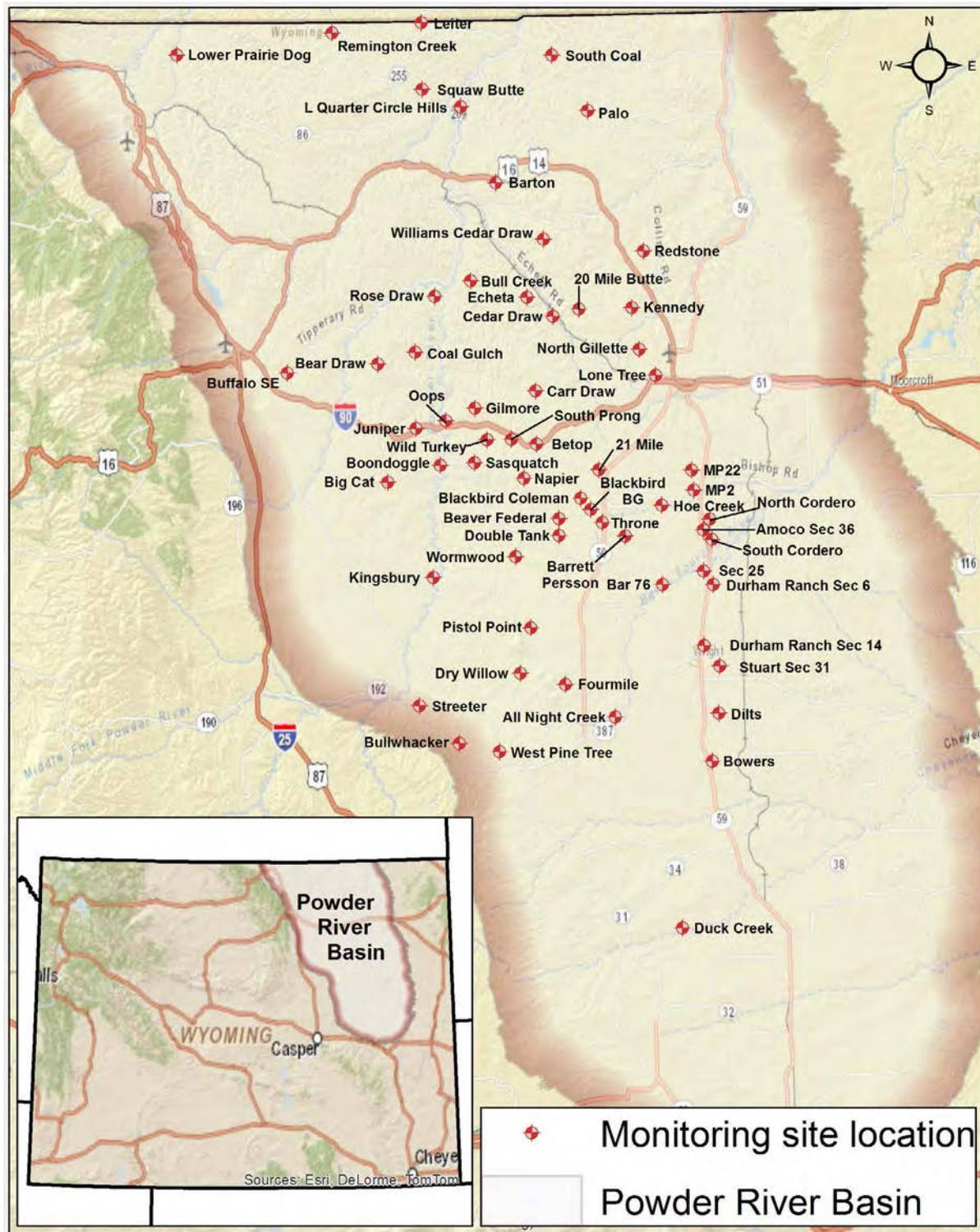
Wyoming Oil and Gas Conservation Commission (WOGCC) and the BLM Buffalo Field office were compiled, and best efforts were made to correlate CBNG production data to groundwater data by monitoring zone. However, not all CBNG production data could be matched to a specific monitoring zone due to database and reporting discrepancies.

## METHODS

### Monitoring Data Collection, Transfer, and Storage

Monitoring well locations typically consist of three main structures: a small fiberglass structure or “hut” which contains the instrument panel; a large galvanized steel culvert that encloses the wellhead; and a fence surrounding the hut to prevent livestock or game from interfering with the monitoring equipment (Figure 2-A).

Groundwater levels and wellhead gas pressures are recorded both electronically and manually. Electronic measurements are collected once per day by a data logger and stored to a memory card. Typically, the date and time, water level in feet, and gas pressure in pounds per square inch (psi), using the American Standard Code of Information Interchange (ASCII) format are collected and stored electronically. Manual measurements, on the other hand, are collected during quarterly visits by field technicians and are used to confirm electronic measurements. Manual groundwater level measurements are made using one of two types of recording instruments depending on well depth. The first type is an electronic-measuring tape (Figure 2-B) with a sensor that indicates when water level has been reached. The second type is a counter balance tape (Figure 2-C) which utilizes a system similar to a surveyor’s measuring wheel, with a counter balance that holds the tape in position. Deep wells require the use of the electronic tape measurement, and shallower wells use the counter balance measuring tape. As with any field data research program, occasionally some measurements may be inaccurate or may not be collected as scheduled. Equipment failure or transponder error may result in missed electronic measurements. High gas pressure, inability to



**Figure 1.** Bureau of Land Management (BLM) groundwater monitoring site locations in the Powder River Basin (PRB), Wyoming.

**Table 1.** List of BLM groundwater monitoring site locations in the PRB. Well sites listed in alphabetical order by county.

County	Well site name	Location				Associated wells	Completed intervals	Approximate elevation (ft.)	Start date
		Qtr/Qtr	Section	Township	Range				
<i>Campbell</i>	20 Mile Butte	SE SE	32	52 N	74 W	4	4	4557	01/28/04
	21 Mile	NE NE	22	48 N	74 W	3	3	5037	08/23/01
	All Night Creek	NW SW	36	43 N	74 W	5	5	5220	03/21/01
	Amoco Sec 36	NW SE	36	47 N	72 W	1	1	4682	04/25/95
	Bar 76	NE SE	1	45 N	73 W	1	2	4768	09/16/97
	Barrett Persson	SW SW	32	47 N	73 W	2	2	4945	12/06/00
	Barton	SE SW	3	54 N	76 W	2	2	3960	01/23/02
	Beaver Fed	SE NW	23	47 N	75 W	2	2	4783	04/18/03
	Betop	NE SE	32	49	75 W	1	1	-----	-----
	Blackbird BG	SW NE	16	47 N	74 W	1	1	4780	07/17/02
	Blackbird Coleman	SW SE	5	47 N	74 W	2	2	4778	07/12/00
	Bowers	SE SW	36	42 N	72 W	5	5	5018	01/21/98
	Carr Draw	NE NE	29	50 N	75 W	2	4	4653	09/26/07
	Cedar Draw	NE SW	2	51 N	75 W	2	2	4268	01/29/04
	Dilts	SE NW	31	43 N	71 W	2	2	4929	03/24/99
	Double Tank	NE SW	35	47 N	75 W	2	1	4783	12/19/02
	Dry Willow	SE NW	35	44 N	76 W	1	1	4944	09/29/99
	Durham Ranch Sec 6	SW NE	6	45 N	71 W	2	2	4697	11/10/97
	Durham Ranch Sec 14	SE NE	14	44 N	72 W	2	2	4861	01/13/98
	Echeta	NE NE	30	52 N	75 W	1	1	4625	09/21/99
	Fourmile	NW NE	11	43 N	75 W	3	3	5358	11/30/07
	Hoe Creek	SW SW	7	47 N	72 W	2	2	4734	01/05/98
	Kennedy	SE SE	33	52 N	73 W	2	2	4489	05/24/00
	Lone Tree	SW SE	13	50 N	73 W	2	2	4760	02/24/00
	MP 2	NW NW	2	47 N	72 W	2	2	4554	05/26/93
	MP 22	SE NE	22	48 N	72 W	4	4	4561	02/18/93
	Napier	SE SE	24	48 N	76 W	2	2	4803	05/02/01
	North Cordero	SW SW	19	47 N	71 W	1	1	4650	05/17/95
	North Gillette	SW NE	34	51 N	73 W	3	3	4380	09/25/01
	Palo	SE NE	22	56 N	74 W	2	2	4141	02/07/01
	Pistol Point	SW NE	31	45 N	75 W	1	1	5106	02/26/97
	Redstone	SE NW	26	53 N	73 W	2	2	4155	10/09/98
	Sec 25	SW SW	25	46 N	72 W	2	2	4659	11/09/96
	South Coal	NW SW	13	57 N	75 W	2	2	4103	09/18/01
	South Cordero	NE SW	6	46 N	71 W	1	1	4634	05/18/95
	South Prong	NW SE	26	49 N	76 W	2	4	4313	01/01/08
	Stuart Sec 31	NE SE	31	44 N	71 W	3	3	4933	08/18/97
	Throne	NW NW	26	47 N	74 W	2	2	5029	05/24/01
	West Pine Tree	SE SE	20	42 N	76 W	1	2	5181	09/20/07
	Williams Cedar Draw	NE SW	15	53 N	75 W	3	6	4130	04/12/07
	Wormwood	NE NW	14	46 N	76 W	2	3	4574	12/13/06



**Table 1.** cont.

County	Well site name	Location				Associated wells	Completed intervals	Approximate elevation (ft.)	Start date
		Qtr/Qtr	Section	Township	Range				
<i>Converse</i>	Duck Creek	SW SW	20	38 N	72 W	2	2	4923	03/28/05
<i>Johnson</i>	Bear Draw	SW NW	1	50 N	79 W	1	2	4624	03/11/06
	Big Cat	SE SE	24	48 N	79 W	2	2	4480	07/10/03
	Boondoggle	SE SE	7	48 N	77 W	1	1	4095	02/18/03
	Buffalo SE <sup>(1)</sup>	NW NW	12	50 N	81 W	5	5	4542	08/22/01
	Bull Creek	NW SE	12	52 N	77 W	3	3	3909	11/22/05
	Bullwhacker	NW SE	16	42 N	77 W	2	2	5050	04/11/02
	Coal Gulch	SW SW	26	51 N	78 W	1	2	4483	09/08/05
	Gilmore	SE NE	1	49 N	77 W	1	1	4536	04/04/02
	Juniper	SW SW	14	49 N	78 W	3	3	4428	03/21/01
	Kingsbury	NW SE	25	46 N	78 W	1	2	4330	10/23/07
	Oops	SW SW	16	49 N	77 W	2	3	4023	03/19/09
	Rose Draw	NE SE	19	52 N	77 W	2	3	3914	05/23/09
	Sasquatch	NE SW	12	48 N	77 W	2	2	4472	01/15/98
	Streeter	SE NW	22	43 N	78 W	2	2	4761	08/04/04
	Wild Turkey	NE SW	29	49 N	76 W	2	2	4344	11/16/04
<i>Sheridan</i>	Remington Creek	SW NE	30	58 N	79 W	4	4	3688	05/23/05
	L Quarter Circle Hills	NE SE	14	56 N	77 W	3	3	3618	04/05/05
	Leiter	NW SE	19	58 N	77 W	1	1	5181	05/16/02
	Lower Prairie Dog	SE NE	10	57 N	83 W	3	3	3715	08/24/00
	Squaw Butte	SE NE	1	56 N	78 W	1	1	----	10/17/01

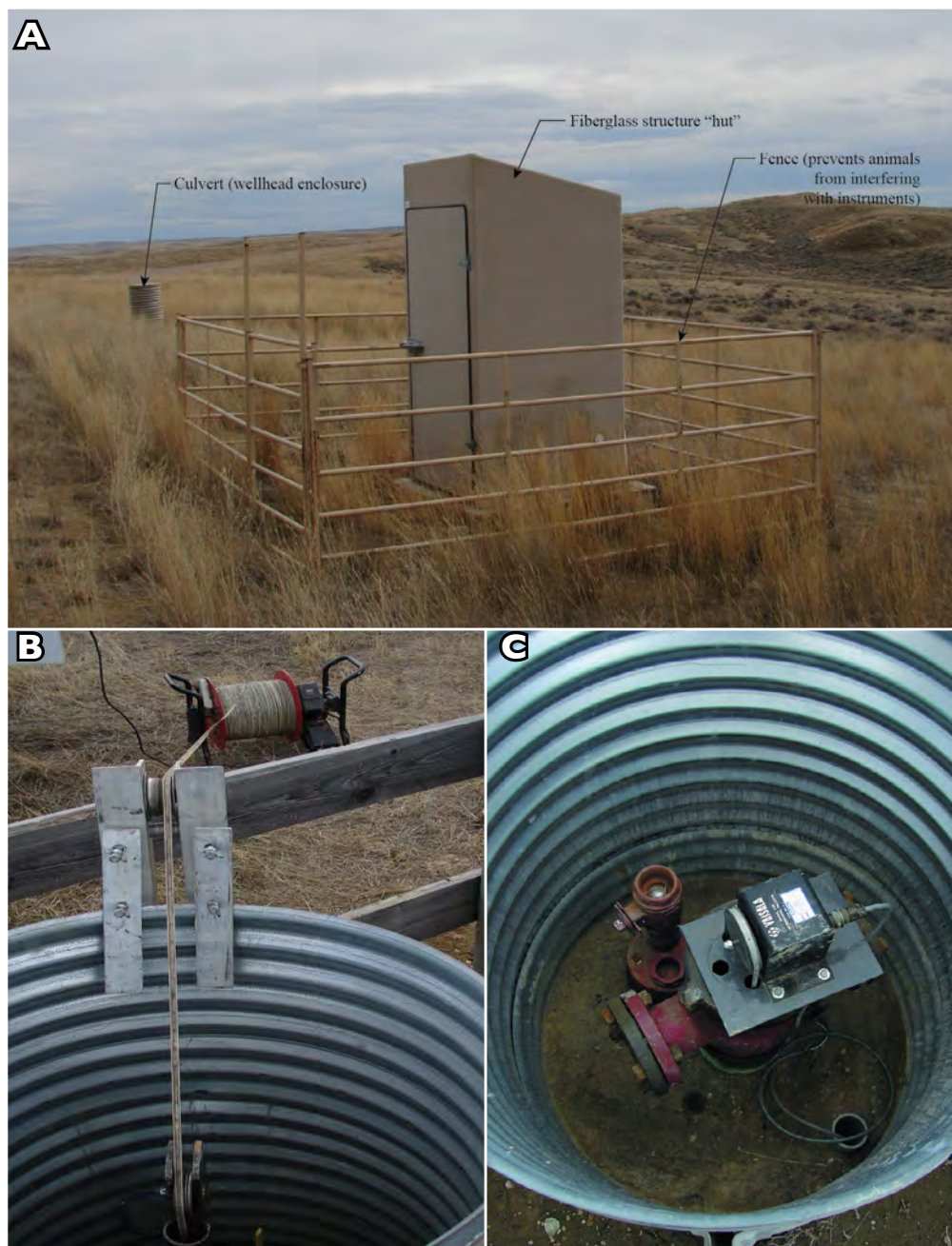
(1) The very very shallow sand monitoring well was returned to the landowner on 5/10/2007 to be used as a cattle watering well and will no longer be used as a monitoring well at this site. Therefore, both the number of wells and monitoring intervals was reduced by one as of May, 2007.

access the well site or equipment failure can affect manual data collection efforts.

During an onsite field inspection, a BLM hydrologic technician will first use a pressure gauge to determine wellhead pressure. If pressure exceeds 10 psi, the well is deemed unsafe and manual groundwater-level measurements are not obtained. If the wellhead pressure is less than 10 psi, the wellhead is opened and pressure is released. Once the pressure has dropped, a manual measurement is taken. The measurement is logged and then compared to the electronic measurement at the instrument panel. If the electronic measurement does not correspond to the manual measurement, an adjustment is made to the data logger and a note is made in both the technician's log book and

the well site log book. While at the instrument panel, the technician also changes the desiccant used to control moisture within the panel, replaces the memory card, reloads the electronic data logger software, calibrates the data logger, and checks the system for any needed maintenance.

Methane (CH<sub>4</sub>) analysis is done using a Gascope Utility Model 60 combustible gas indicator. BLM technicians lower a 6-foot hose into the well bore and then draw well atmosphere into the collector. An electronic detection cell reads the percentage of methane in a given volume of air. The device allows for sensitivity levels of either 0 to 5 percent, or 0 to 100 percent CH<sub>4</sub>. The higher sensitivity setting is employed on monitored sandstone wells and the lower sensitivity setting is employed for coal wells.



**Figure 2.** A) Wellhead culvert cover and equipment storage facility for the Napier groundwater monitoring well site, Campbell County, Wyoming. B) Electronic tape measuring system in use at the Juniper groundwater monitoring well site, Johnson County, Wyoming. C) Counterbalance tape used for shallow well measurements. Photos by Richard Hays, 2010.

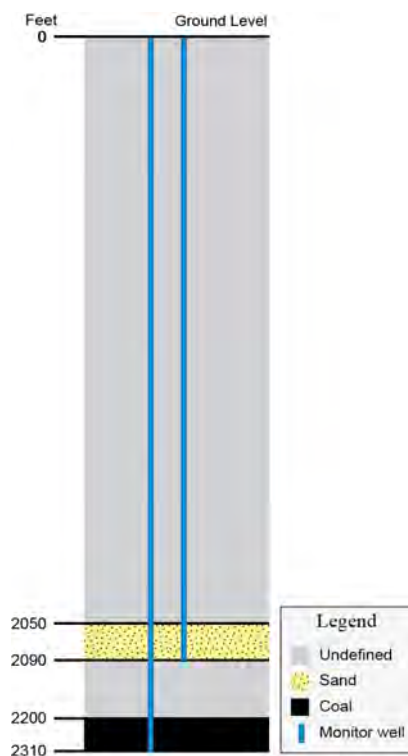
At the BLM office, data is downloaded from the memory card to a computer and imported into a Microsoft Excel spreadsheet. The data is checked for quality and consistency; notes are added to the dataset regarding data inconsistency, mechanical problems encountered at the site, or any repairs performed at the well site.

In the preparation of this report, all monitoring well data were sent from the Bureau of Land Management (BLM) to the Wyoming State Geological Survey (WSGS) on compact disc, no further modifications were made to the data by the WSGS. The BLM data can also be downloaded from the Wyoming Geographic Information

Science Center (WyGISC) at <http://www.uwyo.edu/wygisc/index.html>.

WSGS created the drawdown graphs and tables contained in this report. Values for monitor zone characteristics, such as depth of completion, were determined from the data provided by the BLM and inserted into the tables where available. Groundwater levels were calculated by subtracting the final water level for the period from the initial water level.

Schematic stratigraphic columns were created using depths provided by the BLM. The displayed distances between coals and sands were approximated from relative depths of each monitored zone. These figures are not meant to be accurate representations of particular stratigraphic sections but are presented, instead, as pictorial representations for the reader's convenience and ease of understanding (Figure 3).



**Figure 3.** Example of stratigraphic column showing relationship between monitored strata. Not to scale.

## CBNG Production Data

Water and gas production data for CBNG wells within the PRB were downloaded from the WOGCC website (<http://wogcc.state.wy.us>). WSGS identified 3,177 production wells likely to impact groundwater levels by using GIS software to extract well locations within a 1.5-mile buffer around each of the BLM monitoring well sites (Meredith and others, 2009). These production wells were then sorted according to the completed interval data obtained from the WOGCC. Of the initial 3,177 wells identified, 2,039 had sufficient completion data to be assigned to the five primary coal zones: Wyodak Rider (Big George), Upper Wyodak, Lower Wyodak, Cook, and Wall. Some monitoring well locations are not associated with production wells because well production levels are missing or incomplete, or the reported intervals of completion are ambiguous. Monitoring wells that do not have associated production data are noted in Appendix A.

Once CBNG production wells were correlated to monitoring zones, time series of CBNG production and related monitored groundwater levels were plotted in Microsoft Excel. Cumulative CBNG water and gas production data for each buffer area are displayed in map and graph form in Appendix A, respectively.

## MONITORED ZONES AND COAL ZONE DESIGNATIONS

This report presents all available data from the BLM deep groundwater monitoring well site network through October 2012. As this data set is exceedingly large, all monitoring well data have been assigned to coal designated zones for ease of use. The location of each monitoring well site is listed by county with the related monitored coal zones and sandstones in Table A.1, in Appendix A. Coal zones and sandstones are adapted from Jones 2008 (Table 2). Monitoring wells that record groundwater levels in overlying Wasatch sandstone aquifers are associated to adjacent coal zones.

**Table 2.** Coal nomenclature table for the PRB, Wyoming (modified from Jones, 2008).

Formation	Coal Zone	Coal Bed	
<i>Wasatch</i>	Upper Wasatch	Ulm Lake De Smet	Buffalo Cameron Murray Ucross
	Felix	Felix Rider Upper Felix Felix	
	Lower Wasatch	Arvada Unnamed	
	Roland	Upper Roland Roland of Baker Roland of Taff	
<i>Fort Union Tongue River Member</i>	Wyodak Rider (Big George)	Smith Rider Smith / Big George Lower Smith	
		<i>East</i>	<i>West</i>
	Upper Wyodak	Anderson Rider (Anderson) Anderson (Wyodak) Lower Anderson	Dietz #1 Dietz #2
		<i>East</i>	<i>West</i>
	Lower Wyodak	Canyon Rider Canyon	Dietz #3
	Cook	Cook (Werner) Lower Cook (Gates)	
	Wall	Wall Lower Wall Pawnee	
	Basal Tongue River	Moyer	

### Wasatch Sandstone Aquifers

The BLM deep groundwater monitoring well site network records groundwater data for multiple sandstone aquifers in the Wasatch Formation that overlie Fort Union coal beds. Wasatch sandstones consist of coarse to fine grained beds that are often lenticular or interbedded with clays, shales, and siltstones (Clarey and Stafford, 2008). They are often permeable and porous and can hold significant amounts of groundwater (Jones, 2008; Clarey and others, 2010; Flores and others, 2010). Due to the complexity of the stratigraphy and structural geology in the PRB, it is unlikely that the monitored sandstone units comprise continuous, hydrologically connected aquifers even at a local scale (Flores and others, 2010). In the PRB, Wasatch sandstones are categorized as overburden sands and may include Fort Union sandstones that lie above the Wyodak Rider coal zone (Figure 4; Table 2).

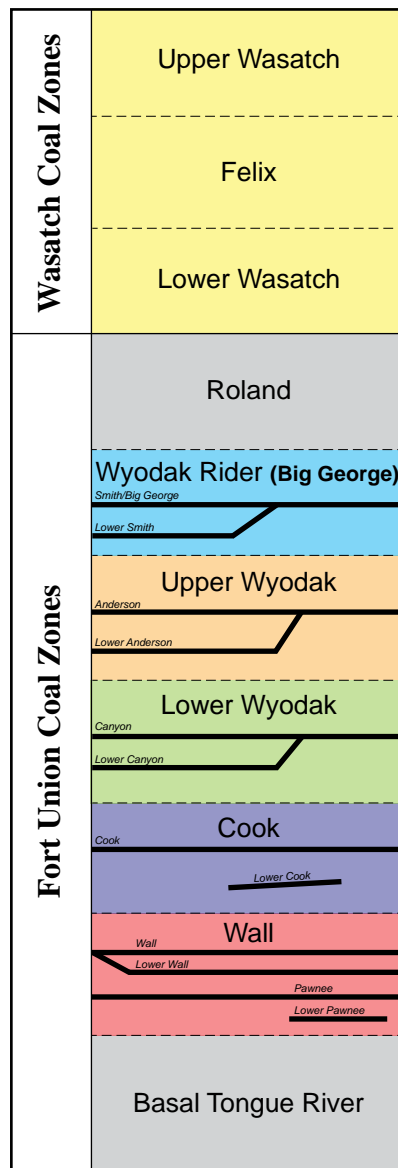
The Eocene Wasatch Formation also includes three defined coal zones (Figure 4; Table 2). Currently, Wasatch Formation coal zones are not monitored for groundwater drawdown. However, they are included in referenced material, and as a means to bracket the coal stratigraphy of the PRB.

### Fort Union Coal Zones

The primary CBNG producing coals in the PRB are found in the Paleocene Fort Union Formation (WOGCC, 2011). The coals in the Fort Union Formation are divided into coal zones based on age relative stratigraphic sequences (Jones, 2008; Flores and others, 2010). Jones 2008 defines a coal zone as a lithostratigraphic section that contains a recognizable sequence of coal beds across a series of well logs.

The BLM monitors five producing coal zones in the Fort Union Formation (Jones, 2008; Flores and others, 2010; WOGCC, 2011): the Wyodak Rider (Big George), Upper Wyodak, Lower Wyodak,





**Figure 4.** Stratigraphic chart of the geologic formations and associated coal zones in the PRB, Wyoming.

Cook, and the Wall (Figure 4; Table 2). These coal zones are ordered stratigraphically from highest to lowest, in effect, from the youngest coal zone to the oldest. The Wyodak Rider, also known as the Big George coal zone includes the Smith and Big George coal beds. The Upper Wyodak coal zone contains the Anderson and Wyodak coal beds which are also referred to as the Anderson Rider and Anderson, respectively. The Lower Wyodak coal zone comprises the Canyon coal bed. The Cook, also referred to as the Werner and Lower

Cook (or Gates) coal beds are located in the Cook coal zone (Jones, 2008). The Wall coal zone includes the Wall (Jones, 2008) and Pawnee coal beds. Individual coal beds are monitored by the BLM within the five coal zones (WOGCC, 2011).

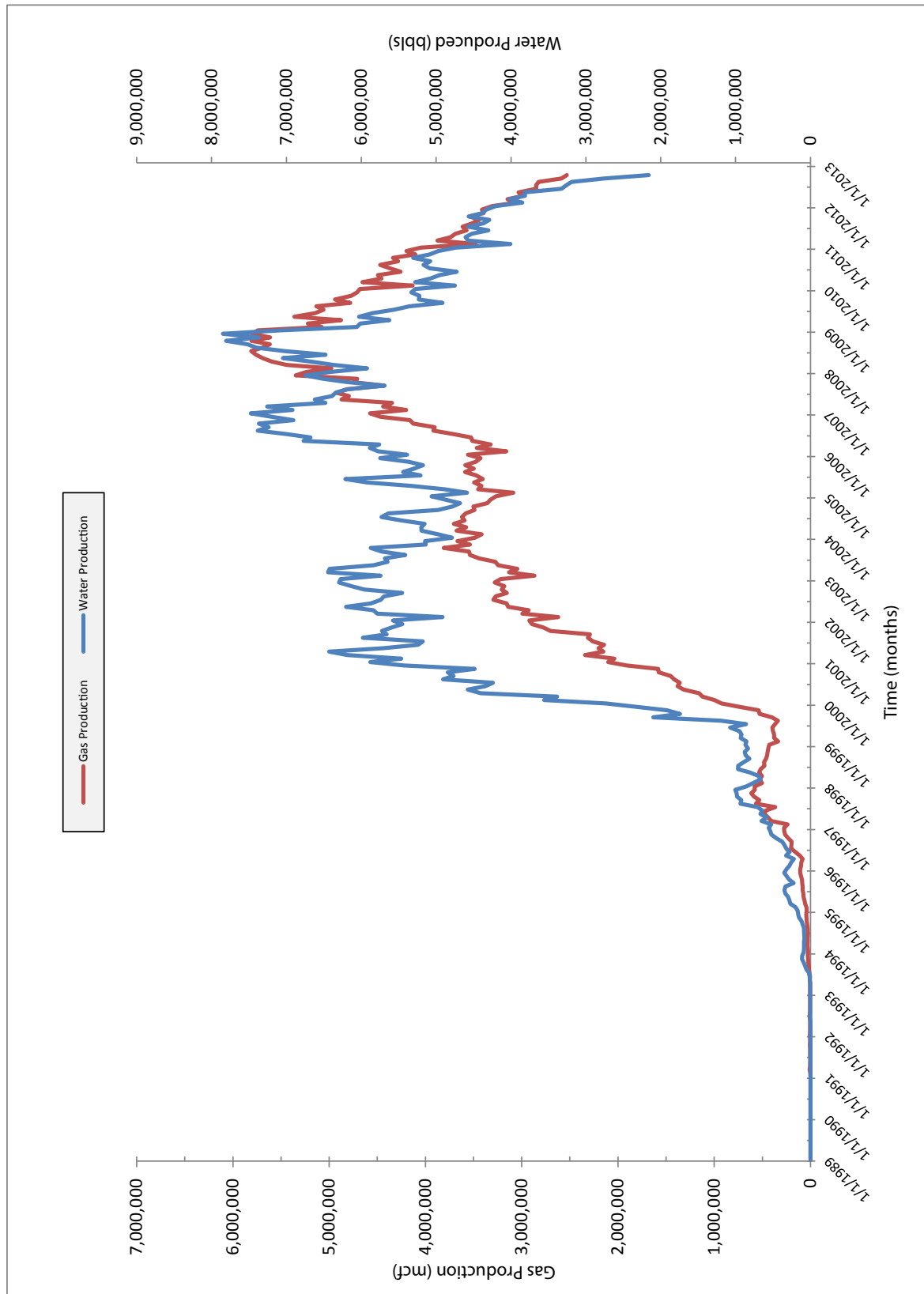
Three of the BLM monitoring sites (South Prong, Carr Draw, and Williams Cedar Draw) have completions in what is referred to as the “Gates/Wall coal.” The coal cannot be definitively assigned to either the Cook or Wall coal zone. For the sake of clarity, the summary results and appendix in this report include a sixth category, referred to as the “Cook/Wall coal zone.” The groundwater level of eight individual underburden sandstones in the Fort Union Formation are also monitored by the BLM and are classified as “Underburden sandstones” in this report.

## SUMMARY RESULTS

### Regional Production Information

Natural gas production in the PRB has been declining since reaching a peak production of 49,483,988 thousand cubic feet (Mcf) for the month of January 2009 (Figure 5). The most recent available data show that 31,750,703 Mcf of CBNG was produced in October 2012, a decrease of 17,733,285 Mcf. During the period from 1989 to October 2012 the PRB produced a total of 5,224,708,026 Mcf of CBNG; production for the 2010-2012 POR accounts for 26 percent of this total.

Water production associated with CBNG development in the basin has also decreased since reaching peak production of 68,071,235 bbls in the month of October, 2006 (Figure 5). Water production in October 2012 was 28,215,232 bbls. During the period from January 1987 to October 2012, 7,391,990,614 bbls of water were co-produced as a result of CBNG extraction in the PRB, water production from 2010-2012 POR accounted for 18 percent of this total.



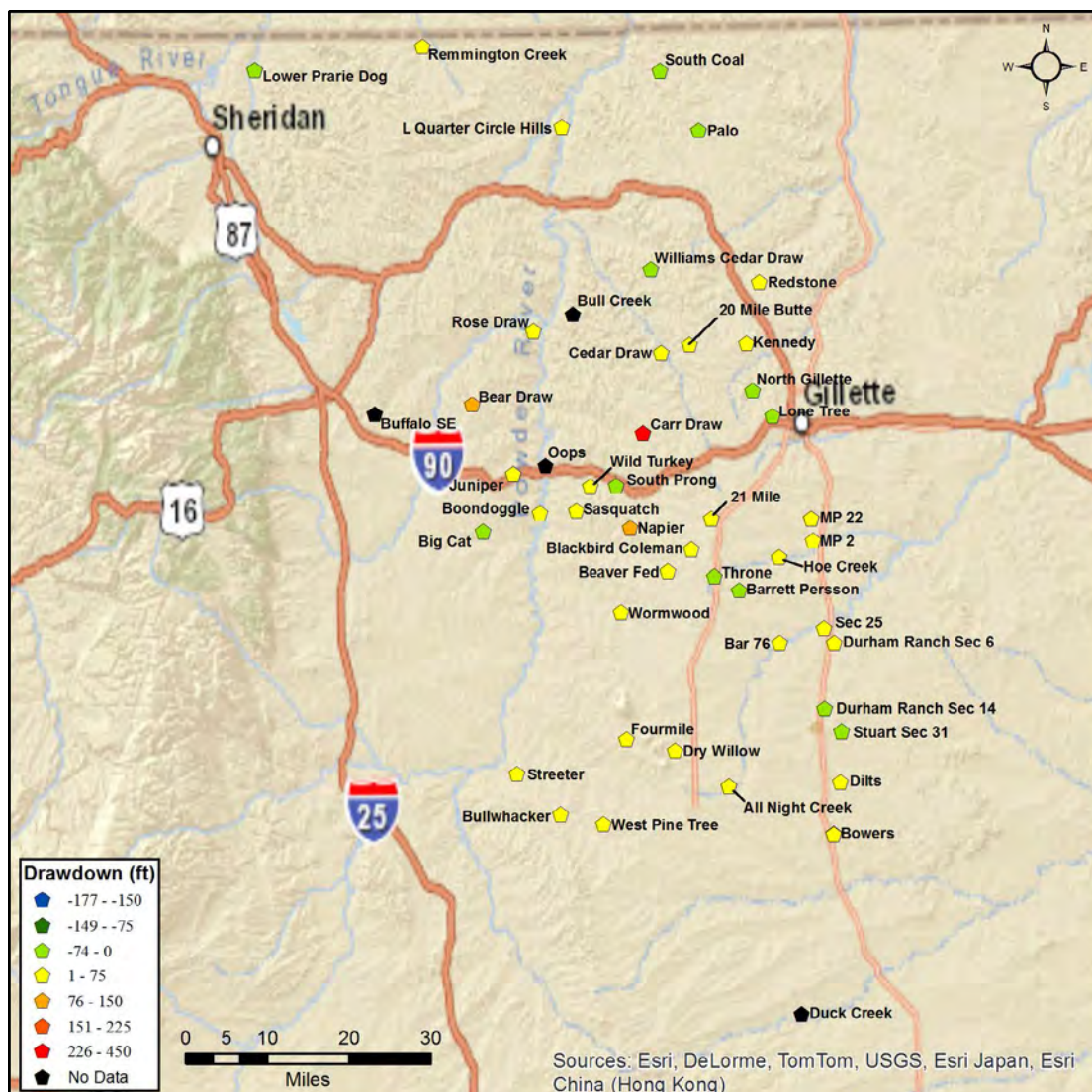
**Figure 5.** Total water and coalbed natural gas (CBNG) production for all CBNG wells in the PRB, Wyoming.

## Monitoring Zone Water Level Changes and Production Data

### *Wasatch Sandstones*

During the 2010-2012 POR, aggregate drawdown in monitored Wasatch sandstones varied greatly. The monitoring well sites at Carr Draw (279.35 ft) and Bear Draw (146.29 ft) showed the greatest amount of drawdown (Table 3 ). On the other hand, water levels recovered at a number of

monitoring well sites; the greatest recovery was observed at the Throne monitoring site which showed a 37.3 ft increase in groundwater level (Table 3). The observed water level variations appear to be scattered throughout the basin, and do not exhibit wider regional patterns (Figure 6). It should be noted that CBNG extraction does not occur in the Overburden sandstones within the 1.5 mile radii of the BLM monitoring well sites.



**Figure 6.** Measured groundwater variation in the Wasatch sandstones during the 2010-2012 POR. Negative numbers represent an increase in water levels.

**Table 3.** Change in water levels by monitoring well site during the 2010-2012 POR in the Wasatch sandstones. Negative numbers represent an increase in water levels.

Monitoring Site	Location	Drawdown (ft)	Monitored Wasatch Sandstones
Carr Draw	NE NE, 29, 50 N, 75 W	279.35	<i>Wasatch</i>
Bear Draw	SW NW, 1, 50 N, 79 W	146.29	<i>Wasatch</i>
Napier	SE SE, 24, 48 N, 76 W	95.91	<i>Wasatch</i>
Sasquatch	NE SW, 12, 48 N, 77 W	66.83	<i>Wasatch</i>
Wild Turkey	NE SW, 29, 49 N, 76 W	37.45	<i>Wasatch</i>
Bullwhacker	NW SE, 16, 42 N, 77 W	36.52	<i>Wasatch</i>
Cedar Draw	NE SW, 2, 51 N, 75 W	36.34	<i>Wasatch</i>
Juniper	SW SW, 14, 49 N, 78 W	25.77	<i>Wasatch</i>
Bull Creek	NW SE, 12, 52 N, 77 W	20.56	<i>Wasatch</i>
Bowers	SE SW, 36, 42 N, 72 W	18.43	<i>Wasatch</i>
Bowers	SE SW, 36, 42 N, 72 W	16.36	<i>Shallow</i>
Rose Draw	NE SE, 19, 52 N, 77 W	12.50	<i>Wasatch</i>
Boondoggle	SE SE, 7, 48 N, 77 W	10.74	<i>Wasatch</i>
Bar 76	NE SE, 1, 45 N, 73 W	9.56	<i>Wasatch</i>
20 Mile Butte	SE SE, 32, 52 N, 74 W	8.63	<i>Wasatch</i>
L Quarter Circle Hills	NE SE, 14, 56 N, 77 W	7.75	<i>Wasatch</i>
21 Mile	NE NE, 22, 48 N, 74 W	6.05	<i>Wasatch</i>
Durham Ranch Sec 6	SW NE, 6, 45 N, 71 W	5.31	<i>Wasatch</i>
All Night Creek	NW SW, 36, 43 N, 74 W	4.65	<i>Wasatch</i>
Sec 25	SW SW, 25, 46 N, 72 W	3.02	<i>Wasatch</i>
MP 22	SE NE, 22, 48 N, 72 W	2.80	<i>Wasatch</i>
Beaver Fed	SE NW, 23, 47 N, 75 W	2.55	<i>Wasatch</i>
Dry Willow	SE NW, 35, 44 N, 76 W	2.51	<i>Wasatch</i>
MP 2	NW NW, 2, 47 N, 72 W	2.34	<i>Wasatch</i>
Blackbird Coleman	SW SE, 5, 47 N, 74 W	2.07	<i>Wasatch</i>
Lower Prairie Dog	SE NE, 10, 57 N, 83 W	1.84	<i>Wasatch</i>
West Pine Tree	SE SE, 20, 42 N, 76 W	1.57	<i>Wasatch</i>
Hoe Creek	SW SW, 7, 47 N, 72 W	1.35	<i>Wasatch</i>
Remington Creek	SW NE, 30, 58 N, 79 W	1.33	<i>Wasatch</i>
Bowers	SE SW, 36, 42 N, 72 W	1.21	<i>Very very shallow</i>
All Night Creek	NW SW, 36, 43 N, 74 W	1.00	<i>Shallow</i>
Wormwood	NE NW, 14, 46 N, 76 W	0.70	<i>Wasatch</i>
Buffalo SE	NW NW, 12, 50 N, 81 W	0.61	<i>Wasatch</i>
All Night Creek	NW SW, 36, 43 N, 74 W	0.56	<i>Very very shallow</i>
Redstone	SE NW, 26, 53 N, 73 W	0.49	<i>Wasatch</i>
Juniper	SW SW, 14, 49 N, 78 W	0.47	<i>Shallow</i>
All Night Creek	NW SW, 36, 43 N, 74 W	0.38	<i>Very shallow</i>
Streeter	SE NW, 22, 43 N, 78 W	0.22	<i>Wasatch</i>



**Table 3.** cont.

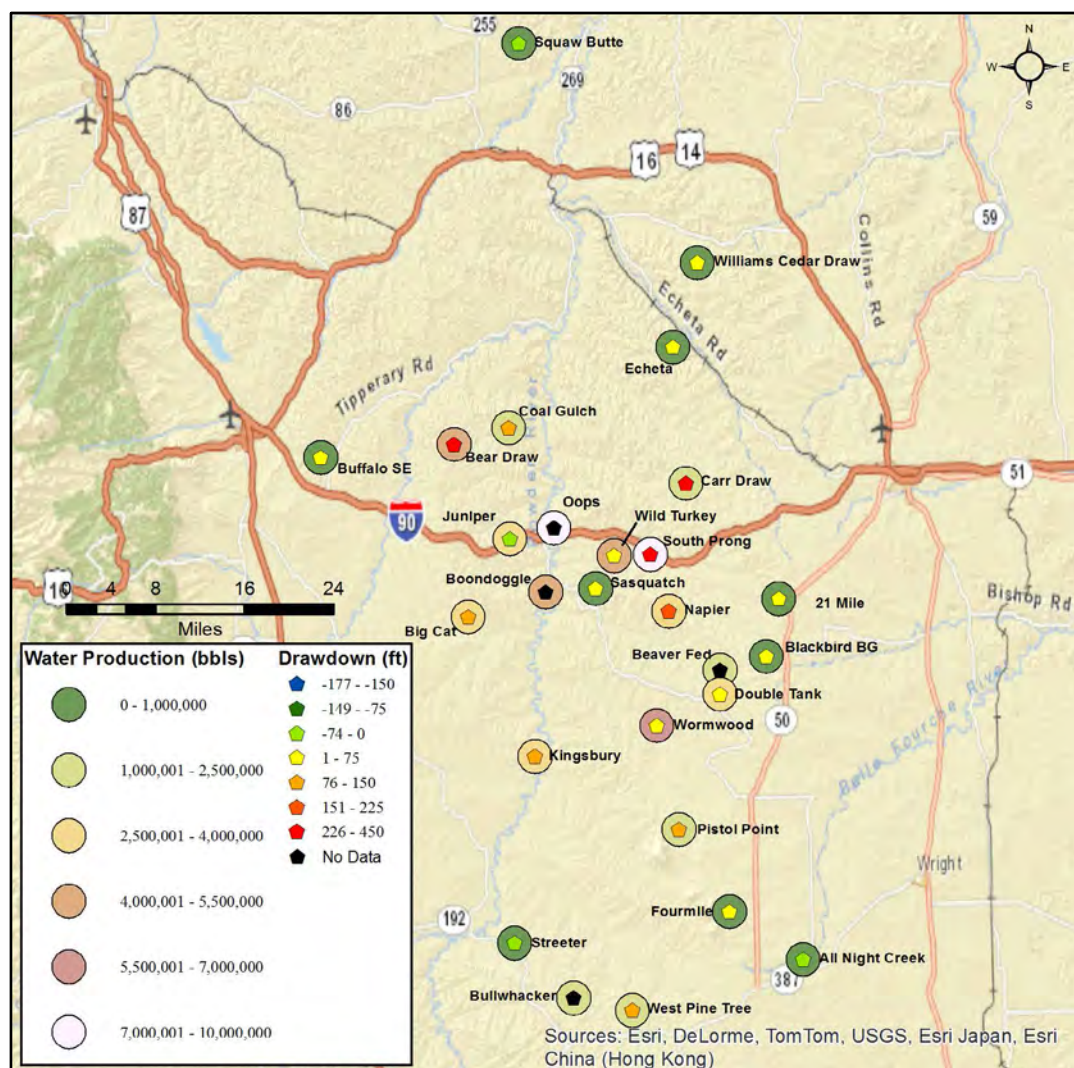
Monitoring Site	Location	Drawdown (ft)	Monitored Wasatch Sandstones
Kennedy	SE SE, 33, 52 N, 73 W	0.19	<i>Wasatch</i>
MP 22	SE NE, 22, 48 N, 72 W	0.19	<i>Shallow</i>
Dilts	SE NW, 31, 43 N, 71 W	0.11	<i>Wasatch</i>
Fourmile	NW NE, 11, 43 N, 75 W	0.06	<i>Wasatch</i>
MP 22	SE NE, 22, 48 N, 72 W	0.02	<i>Very shallow</i>
Buffalo SE	NW NW, 12, 50 N, 81 W	n/a	<i>Very very shallow</i>
Bull Creek	NW SE, 12, 52 N, 77 W	n/a	<i>Shallow</i>
Duck Creek	SW SW, 20, 38 N, 72 W	n/a	<i>Wasatch</i>
Oops	SW SW, 16, 49 N, 77 W	n/a	<i>Wasatch</i>
Bowers	SE SW, 36, 42 N, 72 W	-0.18	<i>Very shallow</i>
South Coal	NW SW, 13, 57 N, 75 W	-0.22	<i>Wasatch</i>
North Gillette	SW NE, 34, 51 N, 73 W	-0.29	<i>Wasatch</i>
Buffalo SE	NW NW, 12, 50 N, 81 W	-0.30	<i>Shallow</i>
Lone Tree	SW SE, 13, 50 N, 73 W	-0.59	<i>Wasatch</i>
Lower Prairie Dog	SE NE, 10, 57 N, 83 W	-0.71	<i>Shallow</i>
Big Cat	SE SE, 24, 48 N, 79 W	-0.86	<i>Wasatch</i>
Williams Cedar Draw	NE SW, 15, 53 N, 75 W	-1.15	<i>Wasatch</i>
Buffalo SE	NW NW, 12, 50 N, 81 W	-1.45	<i>Very shallow</i>
Durham Ranch Sec 14	SE NE, 14, 44 N, 72 W	-2.58	<i>Wasatch</i>
Barrett Persson	SW SW, 32, 47 N, 73 W	-2.96	<i>Wasatch</i>
South Prong	NW SE, 26, 49 N, 76 W	-3.06	<i>Wasatch</i>
Stuart Sec 31	NE SE, 31, 44 N, 71 W	-15.72	<i>Wasatch</i>
Palo	SE NE, 22, 56 N, 74 W	-23.20	<i>Wasatch</i>
Throne	NW NW, 26, 47 N, 74 W	-37.30	<i>Wasatch</i>

### Wyodak Rider (Big George)

Although water levels decreased at most of the monitoring well sites in the Wyodak Rider during the POR, the extent of the decreases varied greatly. The South Prong and Carr Draw monitoring well sites recorded decreases of about 400 ft, while the Buffalo SE site underwent less than 1 ft of aggregate drawdown (Table 4).

Only the Streeter (15.45 ft) and Squaw Butte (7.51 ft) monitoring wells showed water level recoveries. There seems to be a slight regional correlation to the drawdown logged in the Wyodak Rider coal zone. Greater totals of drawdown can be found in the interior of the monitoring area, with lesser amounts observed to the west, east, and north (Figure 7).

The amounts of water co-produced with CBNG from the Wyodak Rider coal zone are fairly consistent across the monitoring well sites (Table 4). CBNG water production was highest around the Oops (9,013,594 bbls) and South Prong (7,332,037 bbls) monitoring well sites during the 2010-2012 POR. The South Prong site also showed the highest drawdown (392.64 ft) in the Wyodak Rider coal zone. The Wormwood monitoring well site showed the third highest water production (6,278,740 bbls) but had the 11th highest drawdown (68.01 ft). The Streeter monitoring site had the lowest recorded water production (15,502 bbls) and the second highest recovery (7.51 ft).



**Figure 7.** Measured groundwater variation in the Wyodak Rider coal zone during the 2010-2012 POR. Negative numbers represent an increase in water levels.

**Table 4.** Change in water levels by monitoring well site during the 2010-2012 POR in the Wyodak Rider coal zone. Negative numbers represent an increase in water levels.

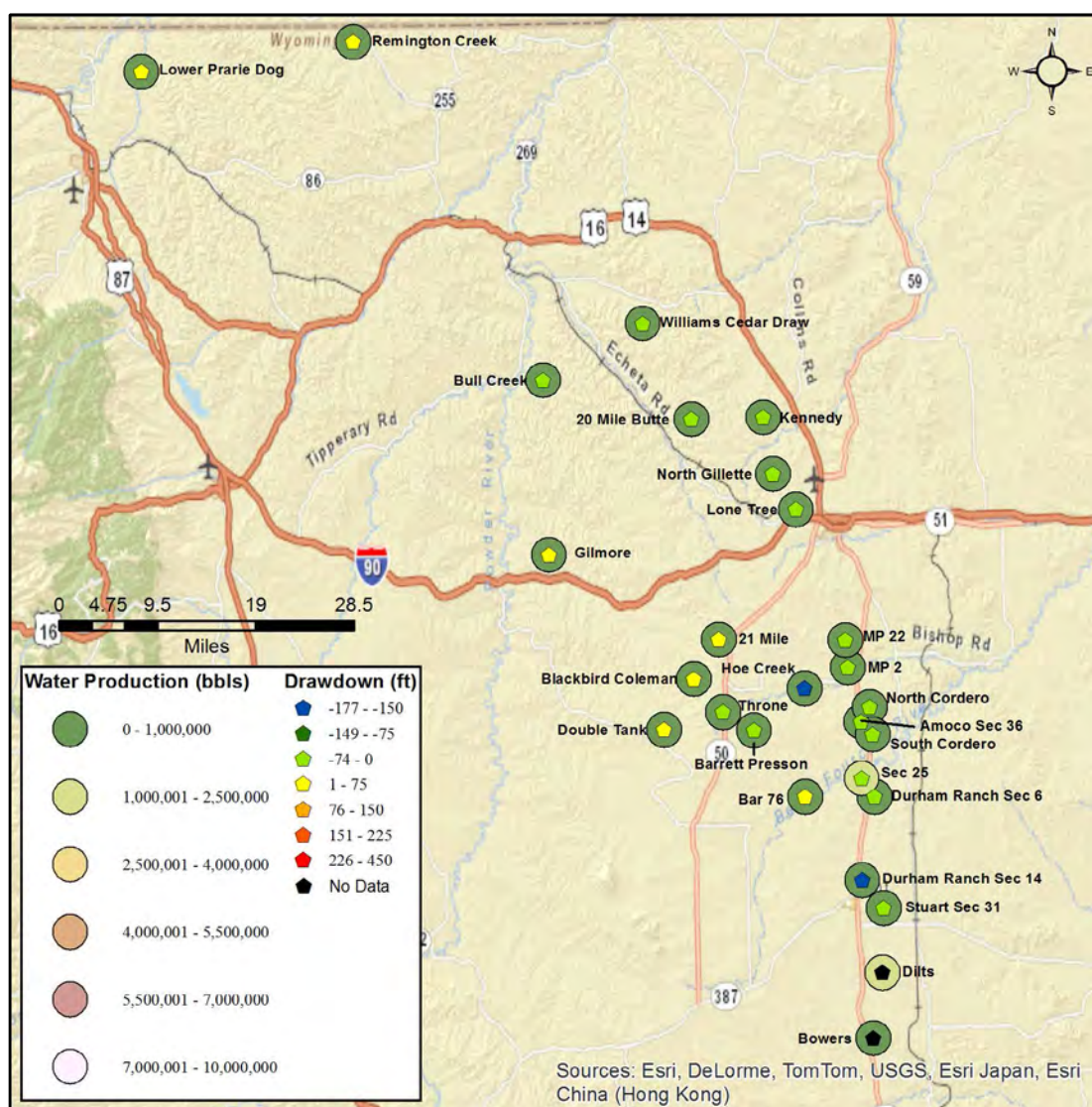
Monitoring Site	Location	Drawdown (ft)	Water Production (bbls)
South Prong	NW SE, 26, 49 N, 76 W	392.64	7,332,037
Carr Draw	NE NE, 29, 50 N, 75 W	363.15	2,001,436
Bear Draw	SW NW, 1, 50 N, 79 W	243.68	4,531,043
Napier	SE SE, 24, 48 N, 76 W	210.16	2,915,267
Big Cat	SE SE, 24, 48 N, 79 W	145.04	2,971,253
Kingsbury	NW SE, 25, 46 N, 78 W	144.61	3,776,311
West Pine Tree	SE SE, 20, 42 N, 76 W	132.17	1,653,597
Coal Gulch (Big George)	SW SW, 26, 51 N, 78 W	93.11	2,041,263
Coal Gulch (Smith)	SW SW, 26, 51 N, 78 W	88.91	2,041,263
Pistol Point	SW NE, 31, 45 N, 75 W	75.56	2,306,401
Wormwood	NE NW, 14, 46 N, 76 W	68.01	6,278,740
Wild Turkey	NE SW, 29, 49 N, 76 W	64.36	4,140,205
Double Tank	NE SW, 35, 47 N, 75 W	58.50	2,513,244
Sasquatch	NE SW, 12, 48 N, 77 W	50.91	696,008
Echeta	NE NE, 30, 52 N, 75 W	31.46	<i>No Data</i>
Fourmile	NW NE, 11, 43 N, 75 W	27.77	411,766
Blackbird BG	SW NE, 16, 47 N, 74 W	21.45	<i>No Data</i>
21 Mile	NE NE, 22, 48 N, 74 W	16.01	<i>No Data</i>
Williams Cedar Draw	NE SW, 15, 53 N, 75 W	1.39	<i>No Data</i>
Buffalo SE	NW NW, 12, 50 N, 81 W	0.61	<i>No Data</i>
All Night Creek	NW SW, 36, 43 N, 74 W	0.00	344,747
Beaver Fed	SE NW, 23, 47 N, 75 W	n/a	1,751,169
Boondoggle	SE SE, 7, 48 N, 77 W	n/a	4,279,211
Bullwhacker	NW SE, 16, 42 N, 77 W	n/a	2,217,889
Juniper	SW SW, 14, 49 N, 78 W	0.00	3,243,135
Oops	SW SW, 16, 49 N, 77 W	n/a	9,013,594
Streeter	SE NW, 22, 43 N, 78 W	-7.51	15,502
Squaw Butte	SE NE, 1, 56 N, 78 W	-15.45	<i>No Data</i>

## Upper Wyodak

Water levels increased (recovered) at over half of the monitoring well sites in the Upper Wyodak coal zone during the 2010-2012 POR. Water levels rose in excess of 160 ft at Hoe Creek (176.55 ft) and at Durham Ranch Sec 14 (164.37 ft) (Table 5). Water levels increased at other sites ranging from 68.41 ft to 0.42 ft. Seven sites indicated drawdowns ranging from 51.3 ft to 0.8 ft during the same period. Generally, water levels at monitoring sites in the eastern portion of the PRB showed some recovery. However, BLM data shows the monitoring well sites of Dilts, Durham Ranch Sec 6, Lone Tree, North Cordero, and Sturt Sec 31 as being dry. Drawdowns were observed at sites

located in the central/western portion of the basin (Figure 8).

Water production from the Upper Wydoak coal zone varied greatly across the PRB. CBNG extraction around the Sec 25 monitoring well site produced 2,172,583 bbls of water during the 2010-2012 POR, the highest in the Upper Wyodak monitoring well system (Figure 8; Table 5). The lowest recorded water production was around the Kennedy site (14,369 bbls). Water production volumes around the Hoe Creek and Durham Ranch Sec 14 monitoring well sites, which recorded the highest recovery, were 48,467 and 39,319 bbls, respectively.



**Figure 8.** Measured groundwater variation in the Upper Wyodak coal zone during the 2010-2012 POR. Negative numbers represent an increase in water levels.



**Table 5.** Change in water levels by monitoring well site during the 2010-2012 POR in the Upper Wyodak coal zone. Negative numbers represent an increase in water levels.

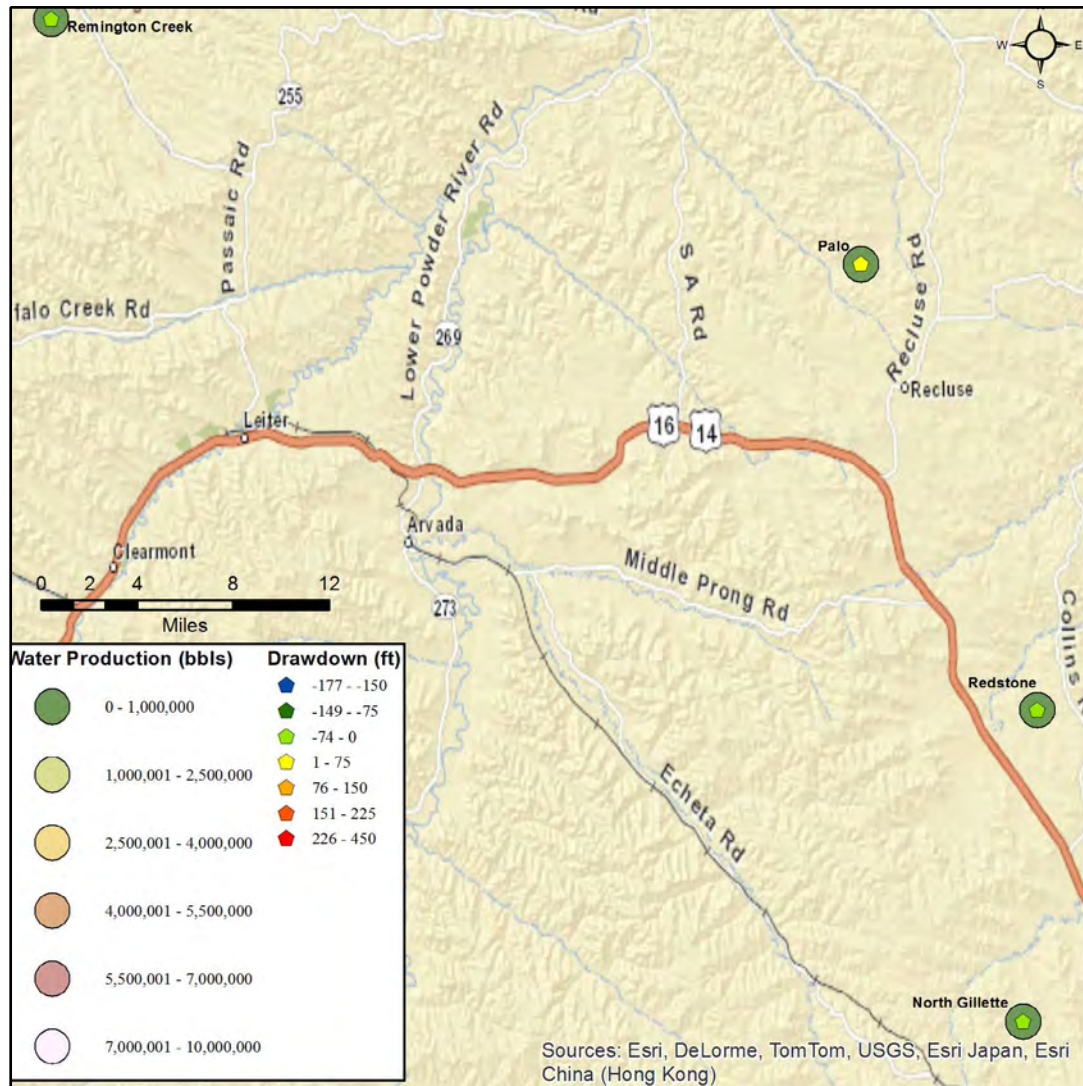
Monitoring Site	Location	Drawdown (ft)	Water Production (bbls)
Double Tank	NE SW, 35, 47 N, 75 W	51.30	<i>No Data</i>
Blackbird Coleman	SW SE, 5, 47 N, 74 W	29.22	38,759
Remington Creek	SW NE, 30, 58 N, 79 W	12.23	784,500
Lower Prairie Dog	SE NE, 10, 57 N, 83 W	4.67	436,662
Gilmore	SE NE, 1, 49 N, 77 W	2.46	<i>No Data</i>
21 Mile	NE NE, 22, 48 N, 74 W	1.21	79,052
Bar 76	NE SE, 1, 45 N, 73 W	0.80	204,623
Dilts	SE NW, 31, 43 N, 71 W	n/a	1,556,832
Bowers	SE SW, 36, 42 N, 72 W	n/a	615,366
Durham Ranch Sec 6	SW NE, 6, 45 N, 71 W	0.00	594,197
Stuart Sec 31	NE SE, 31, 44 N, 71 W	0.00	287,700
Lone Tree	SW SE, 13, 50 N, 73 W	0.00	69,525
North Cordero	SW SW, 19, 47 N, 71 W	0.00	<i>No Data</i>
South Cordero	NE SW, 6, 46 N, 71 W	-0.42	<i>No Data</i>
Williams Cedar Draw	NE SW, 15, 53 N, 75 W	-0.86	801,079
Amoco Sec 36	NW SE, 36, 47 N, 72 W	-4.62	<i>No Data</i>
20 Mile Butte	SE SE, 32, 52 N, 74 W	-5.31	380,122
MP 2	NW NW, 2, 47 N, 72 W	-14.06	<i>No Data</i>
Sec 25	SW SW, 25, 46 N, 72 W	-16.57	2,172,583
Barrett Persson	SW SW, 32, 47 N, 73 W	-20.43	478,019
Bull Creek	NW SE, 12, 52 N, 77 W	-34.00	210,341
MP 22	SE NE, 22, 48 N, 72 W	-42.22	<i>No Data</i>
Throne	NW NW, 26, 47 N, 74 W	-57.38	21,938
North Gillette	SW NE, 34, 51 N, 73 W	-64.92	<i>No Data</i>
Kennedy	SE SE, 33, 52 N, 73 W	-68.41	14,369
Durham Ranch Sec 14	SE NE, 14, 44 N, 72 W	-164.37	39,319
Hoe Creek	SW SW, 7, 47 N, 72 W	-176.55	48,467

### Lower Wyodak

There are four sites that monitor drawdown in the Lower Wyodak coal zone; of those only the Palo site recorded drawdown (1.03 ft). The remaining Lower Wyodak sites either recorded no change (Remington Creek) or recovery (Figure 9; Table 6) in water level. The largest change observed in the

Lower Wyodak sites was the 57.09 ft of recovery recorded at Redstone.

Associated water production was highest at the Redstone and Palo monitoring sites where CBNG extraction produced 490,877 and 328,821 bbls, respectively.



**Figure 9.** Measured groundwater variation in the Lower Wyodak coal zone during the 2010-2012 POR. Negative numbers represent an increase in water levels.

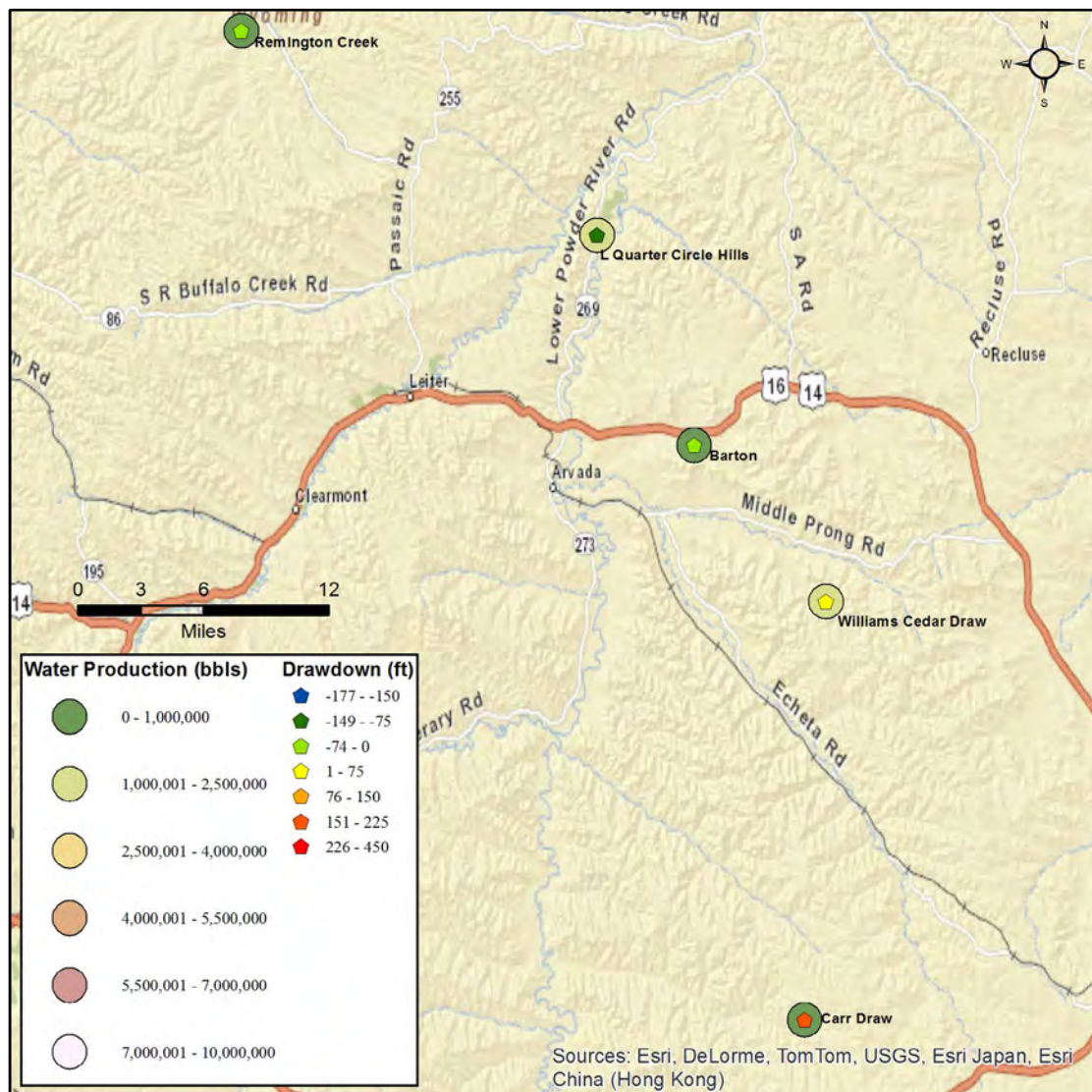
**Table 6.** Change in water levels by monitoring well site during the 2010-2012 POR in the Lower Wyodak coal zone. Negative numbers represent an increase in water levels.

Monitoring Site	Location	Drawdown (ft)	Water Production (bbls)
Palo	SE NE, 22, 56 N, 74 W	1.03	328,821
Remington Creek	SW NE, 30, 58 N, 79 W	0.00	No Data
North Gillette	SW NE, 34, 51 N, 73 W	-19.13	1,780
Redstone	SE NW, 26, 53 N, 73 W	-57.09	490,788

## Cook

Water levels varied widely in the Cook coal zone (Table 7). The Carr Draw monitoring well site recorded a total drawdown of 180.24 ft, while the water level at the L Quarter Circle Hills site registered 79.29 feet of recovery during the 2010-2012 POR. The Barton and Remington Creek sites each showed approximately 45 feet of recovery and the water level at the William Cedar Draw monitoring well site decreased by 1.44 feet. Overall, monitoring well water levels rose in the northern areas of the PRB and fell at sites located farther to the south (Figure 10).

Produced water volumes varied by a factor of ten in the monitored areas. CBNG extraction in the Carr Draw monitoring well site (highest drawdown) produced 133,950 bbls; conversely, 1,350,966 bbls of water were produced in the area around the L Quarter Circle Hills monitoring well site, which showed the highest amount of recovery in the Cook coal zone (Table 7).



**Figure 10.** Measured groundwater variation in the Cook coal zone during the 2010-2012 POR. Negative numbers represent an increase in water levels.

**Table 7.** Change in water levels by monitoring well site during the 2010-2012 POR in the Cook coal zone. Negative numbers represent an increase in water levels.

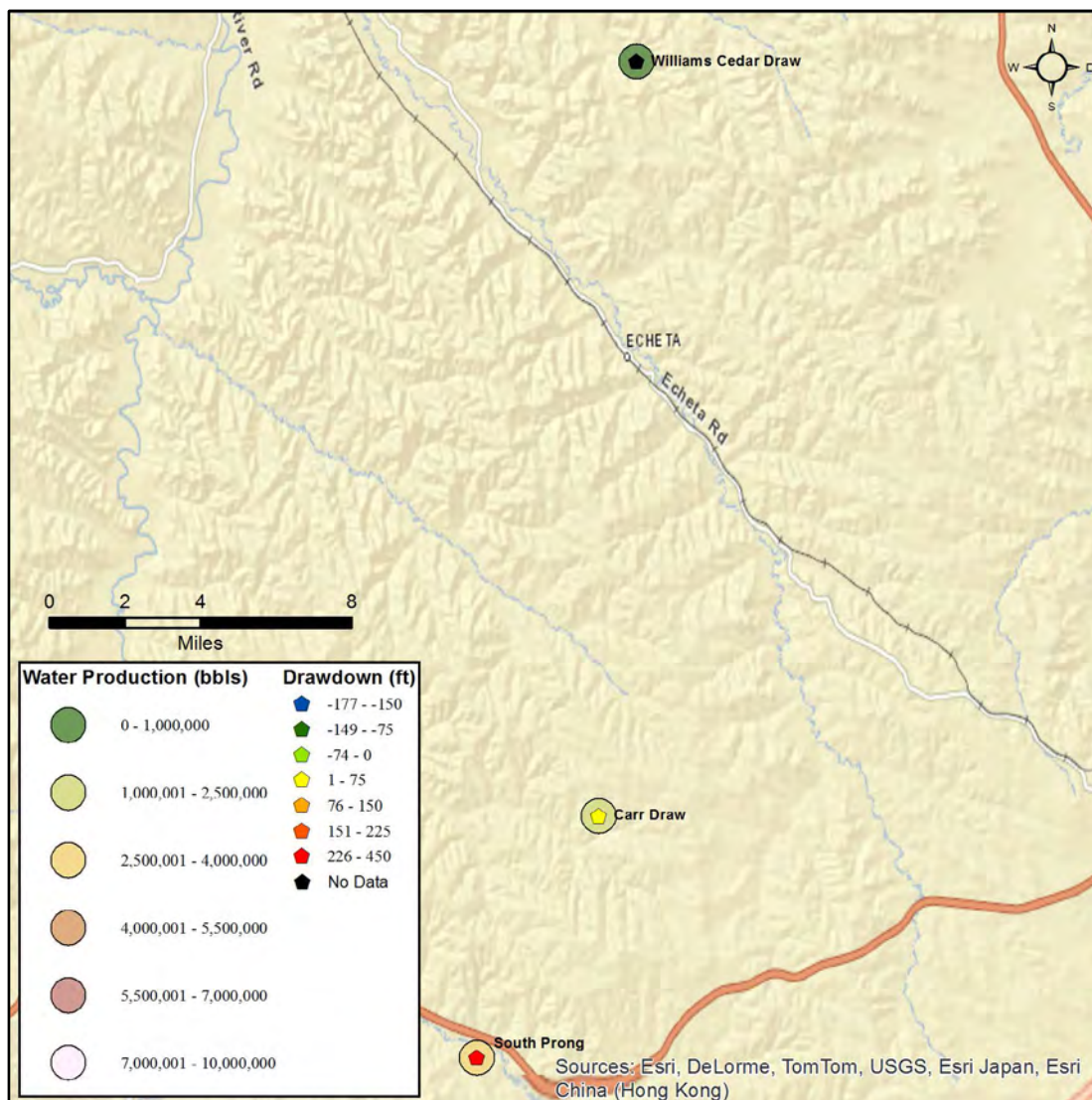
Monitoring Site	Location	Drawdown (ft)	Water Production (bbls)
Carr Draw	NE NE, Sec. 29, T. 50 N, R. 75 W	180.24	133,950
Williams Cedar Draw	NE SW, Sec. 15, T. 53 N, R. 75 W	1.44	1,384,039
Barton	SE SW, Sec. 3, T. 54 N, R. 76 W	-45.92	221,237
Remington Creek	SW NE, Sec. 30, T. 58 N, R. 79 W	-46.42	<i>No Data</i>
L Quarter Circle Hills	NE SE, Sec. 14, T. 56 N, R. 77 W	-79.29	1,350,966



### ***Cook/Wall***

Two of the three monitoring sites in the Cook/Wall coal zone show water level decreases during the 2010-2012 POR (Figure 11; Table 8). Water levels at the South Prong monitoring well site dropped 447.4 ft, while the Carr Draw site exhibited a 9.14 ft drawdown. Rates of drawdown increase

to the south within this coal zone and appear to correspond to the amounts of water produced during the POR; the area around South Prong produced 3,778,806 bbls of water in comparison to the 1,007,029 bbls produced near the Carr Draw monitoring site.



**Figure 11.** Measured groundwater variation in the Cook/Wall coal zone during the 2010-2012 POR. Negative numbers represent an increase in water levels.

**Table 8.** Change in water levels by monitoring site during the 2010-2012 POR in the Cook/Wall coal zone. Negative numbers represent an increase in water levels.

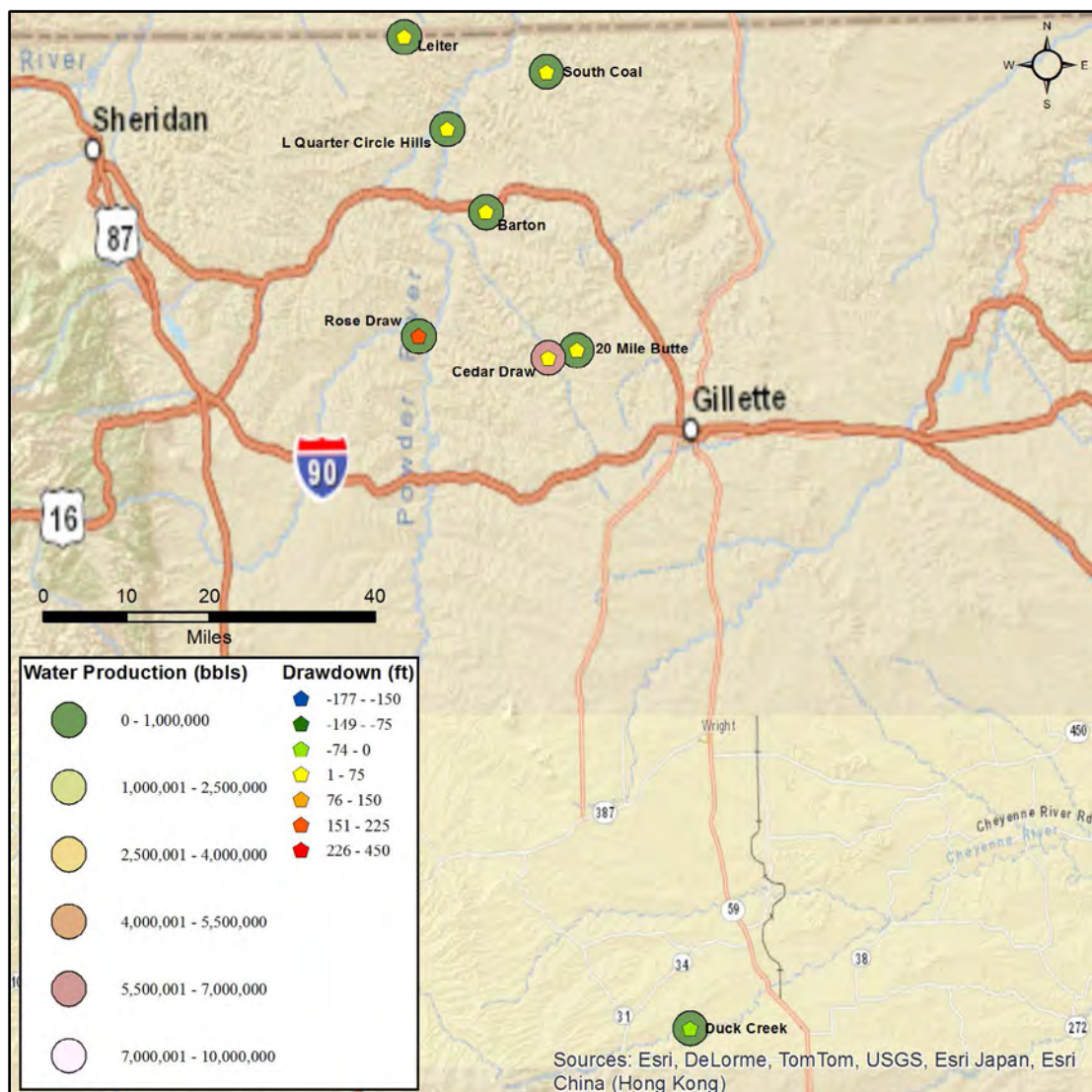
Monitoring Site	Location	Drawdown (ft)	Water Production (bbls)
South Prong	NW SE, 26, 49 N, 76 W	447.40	3,778,806
Carr Draw	NE NE, 29, 50 N, 75 W	9.14	1,007,029
Williams Cedar Draw	NE SW, 15, 53 N, 75 W	n/a	No Data



## Wall

Drawdowns were observed in eight of the nine monitoring sites in the Wall coal zone (Figure 12; Table 9). Only the Duck Creek monitoring site showed a water level recovery (25.55 ft.). The Rose Draw monitoring site recorded the highest drawdown at 170.95 ft. The remaining monitoring sites in the Wall coal zone showed drawdowns ranging from 0.08 ft at South Coal to 44.50 ft at Cedar Draw. Figure 12 shows little regional correlation to drawdown totals.

Water production volumes varied widely across the monitoring sites (Table 9). Water production around the Rose Draw monitoring site totaled 96,159 bbls. CBNG extraction near the Duck Creek site produced 224,929 bbls from January 2010 to October 2012. The highest volume of water (6,353,837 bbls) was produced in the vicinity of the Cedar Draw monitoring site.



**Figure 12.** Measured groundwater variation in the Wall coal zone during the 2010-2012 POR. Negative numbers represent an increase in water levels.

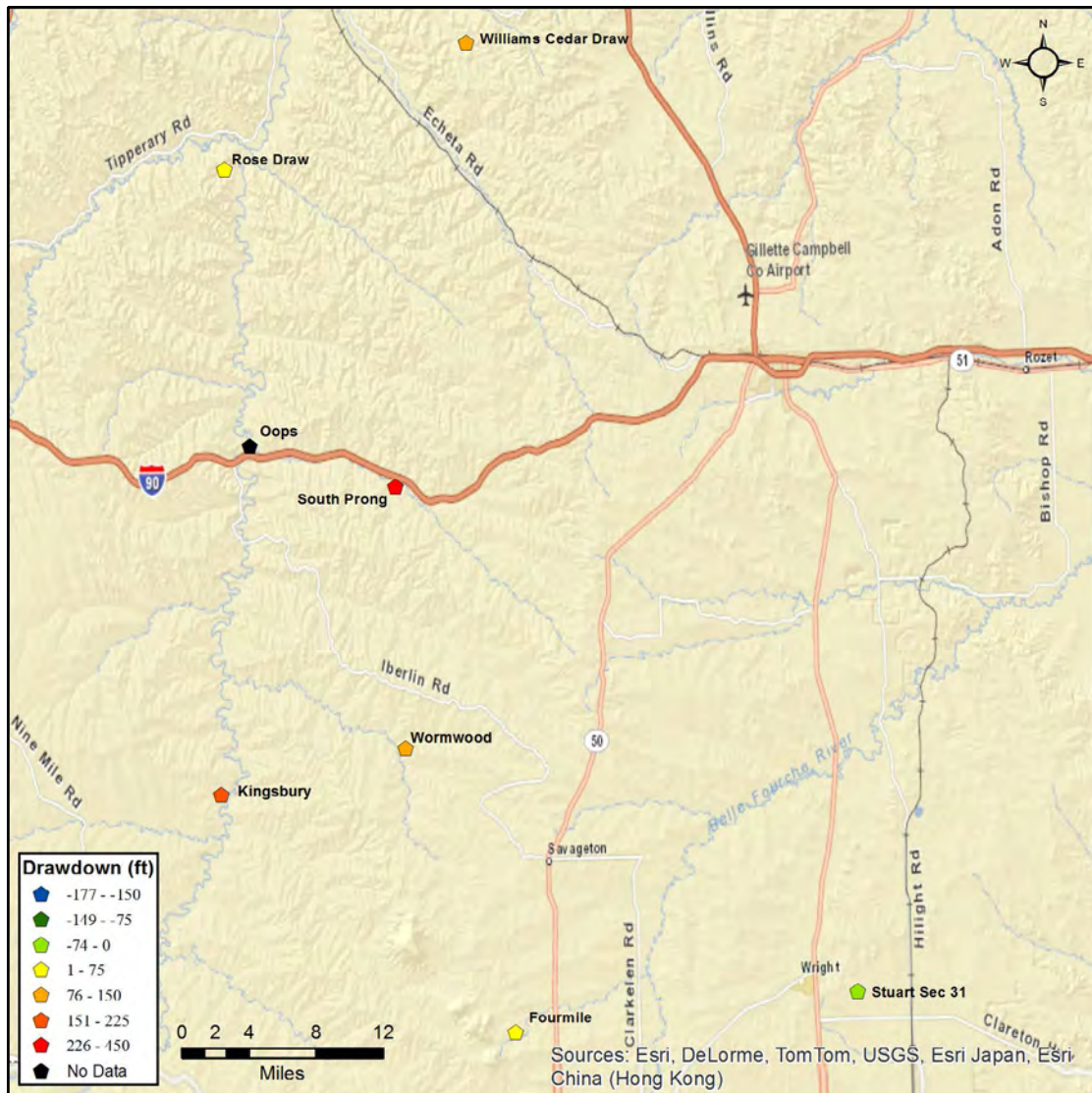
**Table 9.** Change in water levels by monitoring site during the 2010-2012 POR in the Wall coal zone. Negative numbers represent an increase in water levels.

Monitoring Site	Location	Drawdown (ft)	Water Production (bbls)
Rose Draw	NE SE, 19, 52 N, 77 W	170.95	96,159
Cedar Draw	NE SW, 2, 51 N, 75 W	44.50	6,353,837
L Quarter Circle Hills	NE SE, 14, 56 N, 77 W	36.12	37,772
20 Mile Butte (Wall)	SE SE, 32, 52 N, 74 W	32.81	<i>No Data</i>
20 Mile Butte (Pawnee)	SE SE, 32, 52 N, 74 W	26.92	<i>No Data</i>
Barton	SE SW, 3, 54 N, 76 W	2.07	21,609
Leiter	NW SE, 19, 58 N, 77 W	0.25	<i>No Data</i>
South Coal	NW SW, 13, 57 N, 75 W	0.08	<i>No Data</i>
Duck Creek	SW SW, 20, 38 N, 72 W	-25.55	224,929

### ***Underburden Sandstones***

Eight monitoring well sites recorded water levels in underburden sands across the PRB (Figure 13; Table 10). Drawdown varied significantly across the basin, the South Prong monitoring site recorded the largest drawdown of 419.52 ft, while Stuart Sec 31 site showed a recovery of 8.99 ft. Figure 13 shows no regional correlation to observed

drawdown data between monitoring wells. CBNG extraction does not occur in the Overburden sandstones within the 1.5 mile radii of the BLM monitoring well sites.



**Figure 13.** Measured groundwater variation in the Underburden sandstones during the 2010-2012 POR. Negative numbers represent an increase in water levels.

**Table 10.** Change in water levels by monitoring site during the 2010-2012 POR in the Underburden sandstones. Negative numbers represent an increase in water levels.

Monitoring Site	Location	Drawdown (ft)	Monitored Underburden Sandstones
South Prong	NW SE, 26, 49 N, 76 W	419.52	<i>Fort Union</i>
Kingsbury	NW SE, 25, 46 N, 78 W	185.02	<i>Fort Union</i>
Wormwood	NE NW, 14, 46 N, 76 W	137.77	<i>Fort Union</i>
Williams Cedar Draw	NE SW, 15, 53 N, 75 W	113.27	<i>Fort Union</i>
Rose Draw	NE SE, 19, 52 N, 77 W	49.69	<i>Fort Union</i>
Fourmile	NW NE, 11, 43 N, 75 W	22.99	<i>Fort Union</i>
Oops	SW SW, 16, 49 N, 77 W	n/a	<i>Fort Union</i>
Stuart Sec 31	NE SE, 31, 44 N, 71 W	-8.99	<i>Fort Union</i>

## CONCLUSIONS

Drawdown totals in monitored coal zones and sandstones in the PRB vary widely among the monitored sites during the 2010-2012 POR. High drawdown totals were observed at the South Prong monitoring well site (392.64 – 447.4 ft in the coal zones) in contrast to the significant recovery levels seen at Durham Ranch Sec 14 (164.37 ft) and Hoe Creek (176.55 ft). Drawdown values are roughly correlative to CBNG water production, however, there are exceptions. The Rose Draw monitoring well site recorded a drawdown of 170.95 ft in the Wall coal zone, but reported a comparatively low water production level of 96,159 bbls. Also, the L Quarter Circle Hills monitoring well site recorded a recovery of 79.29 ft in the Cook coal zone with a reported water production of 1,350,966 bbls.

Monitoring wells in the Wyodak Rider (Big George) coal zone showed the most overall drawdown in the PRB during the 2010-2012 POR, while also showing the highest amounts of water production. The Upper Wyodak coal zones show the smallest overall drawdown, with most of the monitoring sites showing negligible drawdowns or, in some cases, actual recoveries. Reported water production in the Upper Wyodak is also lower than most of the monitored coal zones.

With continued decreases in CBNG production and water co-production, future updates to the regional groundwater monitoring program are expected to show decreasing drawdown rates in many of the coal zones. Rates of drawdown have decreased in most of the monitored coal zones over the past three years with the Upper and Lower Wyodak coal zones, generally, showing overall recovery.

## REFERENCES

- Clarey, K.E., Gribb, N.W., Hays, R.J., and McLaughlin, J.F., 2010, 1993–2006 coalbed natural gas regional groundwater monitoring report: PRB, Wyoming (updated version): Wyoming State Geological Survey, Open File Report 2010-02, 101 p.
- Clarey, K.E., and Stafford, J.E., 2008, Water production and water quality, *in* Copeland, D.A., and Ewald, M.L., eds., Water associated with coal beds in Wyoming's PRB – Geology, hydrology, and water quality: Wyoming State Geological Survey Exploration Memoir No. 2, p. 111–161.
- Davis, J.C., 1986, Statistics and data analysis in geology: New York, John Wiley and Sons, Inc., 635 p.
- Flores, R.M., Spear, B.D., Kinney, S.A., Purchase, P.A., and Gallagher, C.M., 2010, After a century – revised Paleogene coal stratigraphy, correlation, and deposition, PRB, Wyoming and Montana: U.S. Geological Survey Professional Paper 1777, 97 p.
- Jones, N.R., 2008, Coal bed nomenclature and distribution, *in* Copeland, D.A., and Ewald, M.L., eds., Water associated with coal beds in Wyoming's PRB – Geology, hydrology, and water quality: Wyoming State Geological Survey Exploration Memoir No. 2, p. 45-108.
- Meredith, E., Wheaton, J., Kuzara, S., Donato, T., Bierbach, S., and Schwartz, C., 2009, 2009 Annual coalbed methane regional groundwater monitoring report: PRB, Montana, Montana Bureau of Mines and Geology, Open File Report 591, 69 p., 7 sheets.
- Wyoming Geographic Information Science Center (WyGISC), 2013, *at* <http://www.uwyo.edu/wygisc/index.html>.
- Wyoming Oil and Gas Conservation Commission, 2011, *at* <http://wogcc.state.wy.us/>.
- Wyoming State Engineer's Office, 2013, *at* <http://seo.state.wy.us/>.



## Appendix

20 Mile Butte Monitoring Well Site. . . . .	32	Juniper Monitoring Well Site. . . . .	191
21 Mile Monitoring Well Site. . . . .	38	Kennedy Monitoring Well Site. . . . .	196
All Night Creek Monitoring Well Site. . . . .	43	Kingsbury Monitoring Well Site. . . . .	201
Amoco Sec 36 Monitoring Well Site. . . . .	49	L Quarter Circle Hills Monitoring. . . . .	206
Bar 76 Monitoring Well Site. . . . .	54	Leiter Monitoring Well Site. . . . .	211
Barrett Persson Monitoring Well Site. . . . .	59	Lone Tree Monitoring Well Site. . . . .	216
Barton Monitoring Well Site. . . . .	64	Lower Prairie Dog Monitoring Well. . . . .	221
Bear Draw Monitoring Well Site. . . . .	69	MP 2 Monitoring Well Site. . . . .	226
Beaver Fed Monitoring Well Site. . . . .	74	MP 22 Monitoring Well Site. . . . .	231
Betop Monitoring Well Site. . . . .	79	Napier Monitoring Well Site. . . . .	236
Big Cat Monitoring Well Site. . . . .	83	North Cordero Monitoring Well Site. . . . .	241
Blackbird BG Monitoring Well Site. . . . .	88	North Gillette Monitoring Well Site. . . . .	246
Blackbird Coleman Monitoring Well Site. . . . .	93	Oops Monitoring Well Site. . . . .	251
Boondoggle Monitoring Well Site. . . . .	98	Palo Monitoring Well Site. . . . .	255
Bowers Monitoring Well Site. . . . .	103	Pistol Point Monitoring Well Site. . . . .	260
Buffalo SE Monitoring Well Site. . . . .	109	Redstone Monitoring Well Site. . . . .	265
Bull Creek Monitoring Well Site. . . . .	115	Remington Creek Monitoring Well. . . . .	270
Bullwhacker Monitoring Well Site. . . . .	120	Rose Draw Monitoring Well Site. . . . .	276
Carr Draw Monitoring Well Site. . . . .	125	Sasquatch Monitoring Well Site. . . . .	281
Cedar Draw Monitoring Well Site. . . . .	131	Sec 25 Monitoring Well Site. . . . .	286
Coal Gulch Monitoring Well Site. . . . .	136	South Coal Monitoring Well Site. . . . .	291
Dilts Monitoring Well Site. . . . .	141	South Cordero Monitoring Well Site. . . . .	296
Double Tank Monitoring Well Site. . . . .	146	South Prong Monitoring Well Site. . . . .	301
Dry Willow Monitoring Well Site. . . . .	151	Squaw Butte Monitoring Well Site. . . . .	307
Duck Creek Monitoring Well Site. . . . .	156	Streeter Monitoring Well Site. . . . .	312
Durham Ranch Sec 6 Monitoring Well. . . . .	161	Stuart Sec 31 Monitoring Well Site. . . . .	317
Durham Ranch Sec 14 Monitoring Well. . . . .	166	Throne Monitoring Well Site. . . . .	322
Echeta Monitoring Well Site. . . . .	171	West Pine Tree Monitoring Well Site. . . . .	327
Fourmile Monitoring Well Site. . . . .	176	Wild Turkey Monitoring Well Site. . . . .	332
Gilmore Monitoring Well Site. . . . .	181	Williams Cedar Draw. . . . .	337
Hoe Creek Monitoring Well Site. . . . .	186	Wormwood Monitoring Well Site. . . . .	343

## APPENDIX A

The following monitoring well site descriptions include graphs that have abbreviated terms, including:

- MR – Manual Recording
- TR – Transducer Recording

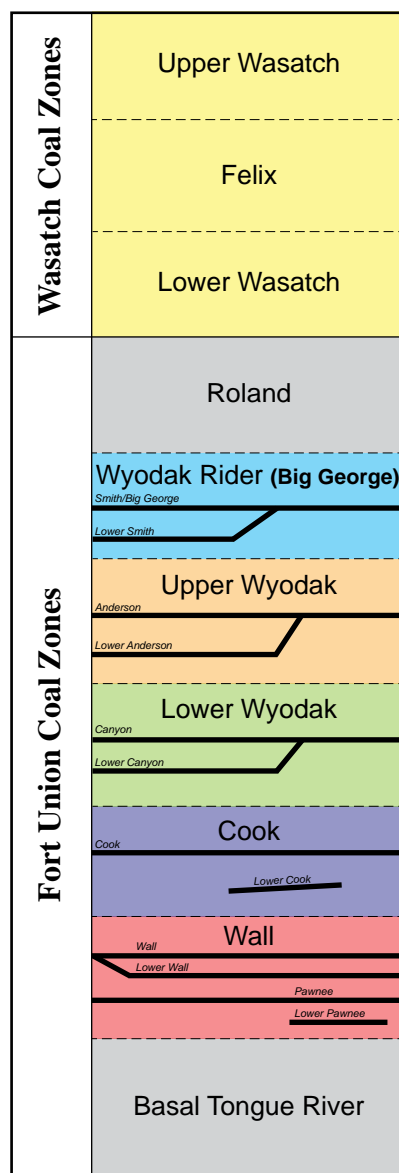
Production graphs include the following abbreviations:

- (bbls) for barrels
- (Mcf) for thousand cubic feet

For the purpose of clarification, the following notes apply to the Appendices:

- Negative numbers in the drawdown tables signify a rise in water levels, while a positive number signifies a drop in the water level.
- All monitoring well data in the Appendix for the 2010-2012 report are classified by the five associated coal zones and the aforementioned “Cook\Wall” coal zone (see Monitored Zones and Coal Zone Designations, Figure A.1).
- Monitoring wells were assigned to coal zones based on the completion interval and monitored strata (Table A.1). All monitored Wasatch sandstones have also been classified according to the associated monitored coal zones, with the exception of the Boondoggle and Dry Willow wells, which are only completed into Wasatch sandstones (Table A.1).
- Appendix A is sorted by monitoring well site not monitored zone. Please refer to Table A.1 to find monitoring well sites within desired coal zones. Regional information by coal zone can be found in “Summary Results.”
- Production data is reported from the five associated coal zones as well as unknown, unmonitored, and multiple. Unknown coal zones have no information about what coal production is occurring from. Unmonitored coal zones are experiencing production but none is occurring in identified zones. Multiple zone production

indicates that production is occurring in multiple coal zones from a single well and that at least one of the multiple zones are being monitored. Unknown and unmonitored wells are not shown on the figures showing production occurring within the monitoring buffer area.



**Figure A.1.** Stratigraphic chart of the geologic formations and associated coal zones in the PRB, Wyoming.

**Table A.1** Groundwater monitoring sites in the PRB, listed by monitored coal zone; refer to Figure A.1 for associated coal deposit.

Monitoring well site	Well identifier	Lithology zone	Description	County	Year First Monitored	Monitored interval bottom depth (ft.)	Completion interval thickness (ft.)
20 Mile Butte	49-005-50983 (1)	Wasatch sandstone	n/a	Campbell	2004	550	40
20 Mile Butte	49-005-50948 (1)	Upper Wyodak coal	Anderson	Campbell	2004	933	37
20 Mile Butte	49-005-50985 (1)	Wall coal	Wall	Campbell	2004	1,518	22
20 Mile Butte	49-005-50986 (1)	Wall coal	Pawnee	Campbell	2004	1,705	13
21 Mile	49-005-07200 (1)	Wasatch sandstone	n/a	Campbell	2001	1,020	221
21 Mile	49-005-07198 (1)	Wyodak Rider coal	Big George	Campbell	2001	1,325	47
21 Mile	49-005-07199 (1)	Upper Wyodak coal	Anderson (Wyodak)	Campbell	2001	1,560	22
All Night Creek		Wasatch sandstone	very very shallow sand	Campbell	2002	240	40
All Night Creek		Wasatch sandstone	very shallow sand	Campbell	2002	420	70
All Night Creek		Wasatch sandstone	shallow sand	Campbell	2002	640	60
All Night Creek	P128989W (2)	Wasatch sandstone	sand	Campbell	2001	860	20
All Night Creek	P128990W (2)	Wyodak Rider coal	Big George	Campbell	2001	1,051	67
Amoco Sec 36	P72107W (2)	Upper Wyodak coal	Anderson (Wyodak)	Campbell	1995		
Bar 76	49-005-31560 (1)	Wasatch sandstone	overburden sand	Campbell	1997	679	20
Bar 76	49-005-31560 (1)	Upper Wyodak coal	Anderson (Wyodak)	Campbell	1997	777	51
Barrett Persson	P127246W (2)	Wasatch sandstone	overburden sand	Campbell	2001	1,230	50
Barrett Persson	P127245W (2)	Upper Wyodak coal	Anderson (Wyodak)	Campbell	2001	1,334	68
Barton	49-005-43038 (1)	Cook coal	Cook	Campbell	2002	1,055	31
Barton	49-005-47264 (1)	Wall coal	Wall	Campbell	2002	1,245	45
Bear Draw	P166862W (2)	Wasatch sandstone	overburden sand	Johnson	2006	2,094	42
Bear Draw	49-019-25144 (1)	Wyodak Rider coal	Big George	Johnson	2006	2,310	105
Beaver Fed	49-005-50085 (1)	Wasatch sandstone	overburden sand	Campbell	2003	625	73
Beaver Fed	49-005-50085 (1)	Wyodak Rider coal	Big George	Campbell	2003	1,256	70
Betop	49-005-29688 (1)	Fort Union coal	unknown coal	Campbell	1991	1,795	67
Big Cat	49-019-06358 (1)	Wasatch sandstone	overburden sand	Johnson	2003	888	26
Big Cat	49-019-06357 (1)	Wyodak Rider coal	Big George	Johnson	2003	2,047	77
Blackbird BG	49-005-33383 (1)	Wyodak Rider coal	Big George	Campbell	2002	1,150	42
Blackbird Coleman	P125798W (2)	Wasatch sandstone	overburden sand	Campbell	2002	690	20
Blackbird Coleman	49-005-36025 (1)	Upper Wyodak coal	Anderson (Wyodak)	Campbell	2000	1,500	74
Boondoggle	P64166W (2)	Wasatch sandstone	overburden sand	Johnson	2003	921	53
Boondoggle	P133197W (2)	Wyodak Rider coal	Big George	Johnson	2003	1,253	202
Bowers	P145551W (2)	Wasatch sandstone	very very shallow sand	Campbell	1998	80	15
Bowers	P145550W (2)	Wasatch sandstone	very shallow sand	Campbell	1998	350	85
Bowers	P145549W (2)	Wasatch sandstone	shallow sand	Campbell	1998	440	88
Bowers	P145548W (2)	Wasatch sandstone	sand	Campbell	1998	595	75
Bowers	49-005-31713 (1)	Upper Wyodak coal	Anderson (Wyodak)	Campbell	2002	752	30
Buffalo SE		Wasatch sandstone	very very shallow sand	Johnson	2002	130	75
Buffalo SE	P144311W (2)	Wasatch sandstone	very shallow sand	Johnson	2002	230	75
Buffalo SE	P144312W (2)	Wasatch sandstone	shallow sand	Johnson	2002	595	75
Buffalo SE	49-019-06351 (1)	Wasatch sandstone	sand	Johnson	2001	1,498	16

Table A.1 cont.

Monitoring well site	Well identifier	Lithology zone	Description	County	Year First Monitored	Monitored interval bottom depth (ft.)	Completion interval thickness (ft.)
Buffalo SE	49-019-06350 (1)	Wyodak Rider coal	Smith	Johnson	2001	1,596	8
Bull Creek	P153817W (2)	Wasatch sandstone	shallow sand	Johnson	2005	520	40
Bull Creek	P153819W (2)		overburden sand	Johnson	2005	927	51
Bull Creek	49-019-06402 (1)	Upper Wyodak coal	Anderson	Johnson	2005	1,018	44
Bullwhacker		Wasatch sandstone	overburden sand	Johnson	2002	1,238	36
Bullwhacker	P142614W (2)	Wyodak Rider coal	Big George	Johnson	2002	1,430	92
Carr Draw	49-005-07634 (1)	Wasatch sandstone	overburden sand	Campbell	2007	800	66
Carr Draw	49-005-07635 (1)	Wyodak Rider coal	Big George	Campbell	2007	1,463	61
Carr Draw	49-005-07634(1)	Cook coal	Cook (Werner)	Campbell	2007	1,832	45
Carr Draw	49-005-07636(1)	Cook/Wall coal	Lower Cook (Gates/Wall)	Campbell	2007	2,096	166
Cedar Draw	49-005-42272 (1)	Wasatch sandstone	overburden sand	Campbell	2004	1,470	80
Cedar Draw	49-005-37156 (1)	Wall coal	Wall	Campbell	2004	1,674	97
Coal Gulch	49-019-24209 (1)	Wyodak Rider coal	Smith	Johnson	2005	1,495	13
Coal Gulch	49-019-24209 (1)	Wyodak Rider coal	Big George	Johnson	2005	1,852	214
Dilts	P112454W (2)	Wasatch sandstone	overburden sand	Campbell	1999	300	40
Dilts		Upper Wyodak coal	Anderson (Wyodak)	Campbell	1999	658	78
Double Tank	49-005-50083(1)	Wyodak Rider coal	Big George	Campbell	2002	1,230	78
Double Tank	49-005-50084(1)	Upper Wyodak coal	Anderson (Wyodak)	Campbell	2002	1,500	48
Dry Willow		Wasatch sandstone	sand	Campbell	1999	202	54
Duck Creek		Wasatch sandstone	overburden sand	Converse	2005	890	12
Duck Creek		Wall coal	Pawnee	Converse	2005	1,238	20
Durham Ranch Sec 6	P106974W (2)	Wasatch sandstone	overburden sand	Campbell	1997	285	30
Durham Ranch Sec 6	P106975W (2)	Upper Wyodak coal	Anderson (Wyodak)	Campbell	1997	363	35
Durham Ranch Sec 14	P106972W (2)	Wasatch sandstone	overburden sand	Campbell	1998	690	24
Durham Ranch Sec 14	P106973W (2)	Upper Wyodak coal	Anderson (Wyodak)	Campbell	1998	816	100
Echeta		Wyodak Rider coal	Big George	Campbell	1999	867	6
Fourmile	49-005-07517 (1)	Wasatch sandstone	overburden sand	Campbell	2007	825	47
Fourmile	49-005-07645(1)	Wyodak Rider coal	Big George	Campbell	2007	1,446	87
Fourmile	49-005-07645 (1)		underburden sand	Campbell	2007	1,646	100
Gilmore		Upper Wyodak coal	Anderson (Wyodak)	Johnson	1998	1,375	55
Hoe Creek		Wasatch sandstone	overburden sand	Campbell	1998	210	60
Hoe Creek		Upper Wyodak coal	Anderson (Wyodak)	Campbell	1998	910	80
Juniper		Wasatch sandstone	shallow sand	Johnson	2002	640	90
Juniper	49-019-06352 (1)	Wasatch sandstone	sand	Johnson	2001	1,130	44
Juniper	49-019-06457 (1)	Wyodak Rider coal	Big George	Johnson	2001	1,614	66
Kennedy	P145907W (2)	Wasatch sandstone	overburden sand	Campbell	2000	578	58
Kennedy	P145908W (2)	Upper Wyodak coal	Anderson	Campbell	2000	743	36
Kingsbury	49-019-06437 (1)	Wyodak Rider coal	Big George	Johnson	2006	1,425	13
Kingsbury		Fort Union sand	underburden sand	Johnson	2007	1,567	36
L Quarter Circle Hills	49-033-25634 (1)	Wasatch sandstone	overburden sand	Sheridan	2005	517	24
L Quarter Circle Hills	49-033-25633 (1)	Cook coal	Cook	Sheridan	2005	711	27

**Table A.1** cont.

Monitoring well site	Well identifier	Lithology zone	Description	County	Year First Monitored	Monitored interval bottom depth (ft.)	Completion interval thickness (ft.)
L Quarter Circle Hills	49-033-25631 (1)	Wall coal	Wall/Pawnee	Sheridan	2005	876	14
Leiter	P62919W (2)	Wall coal	Pawnee	Sheridan	2002	568	393
Lone Tree	P121683W (2)	Wasatch sandstone	overburden sand	Campbell	2000	530	40
Lone Tree	P121682W (2)	Upper Wyodak coal	Wyodak/Anderson	Campbell	2000	723	76
Lower Prairie Dog		Wasatch sandstone	shallow sand	Sheridan	2002	280	45
Lower Prairie Dog		Wasatch sandstone	sand	Sheridan	2000	400	48
Lower Prairie Dog		Upper Wyodak coal	Anderson	Sheridan	2000	653	15
MP 2	P90657W (2)	Wasatch sandstone	overburden sand	Campbell	1993	310	50
MP2		Upper Wyodak coal	Anderson (Wyodak)	Campbell	1993	410	74
MP 22	P110021W (2)	Wasatch sandstone	very shallow sand	Campbell	1998	80	65
MP 22	P110020W (2)	Wasatch sandstone	shallow sand	Campbell	1998	185	78
MP 22	P90659W (2)	Wasatch sandstone	sand	Campbell	1993	400	60
MP22	P90658W (2)	Upper Wyodak coal	Anderson (Wyodak)	Campbell	1993	515	77
Napier	P133776W (2)	Wasatch sandstone	overburden sand	Campbell	2001	1,522	60
Napier	P133775W (2)	Wyodak Rider coal	Big George	Campbell	2001	1,674	89
North Cordero	P82851W (2)	Upper Wyodak coal	Anderson (Wyodak)	Campbell	1995	392	58
North Gillette		Wasatch sandstone	overburden sand	Campbell	2001	320	105
North Gillette	49-005-46837 (1)	Upper Wyodak coal	Anderson	Campbell	2001	582	48
North Gillette	49-005-46836 (1)	Lower Wyodak coal	Canyon	Campbell	2001	620	32
Oops		Wasatch sandstone	shallow sand	Johnson	2009	28.5	10
Oops		Wyodak Rider coal	Big Geprge	Johnson	2009	---	---
Oops		Fort Union sand	underburden sand	Johnson	2009	---	---
Palo	P129846W (2)	Wasatch sandstone	overburden sand	Campbell	2001	380	90
Palo	P129847W (2)	Lower Wyodak coal	Canyon	Campbell	2001	464	38
Pistol Point	P10894W (2)	Wyodak Rider coal	Big George	Campbell	1997	1,559	100
Redstone		Wasatch sandstone	overburden sand	Campbell	1998	185	25
Redstone		Lower Wyodak coal	Canyon	Campbell	1988	310	69
Remington Creek		Wasatch sandstone	overburden sand	Sheridan	2005	26	6
Remington Creek	49-033-23127 (1)	Upper Wyodak coal	Anderson	Sheridan	2005	336	22
Remington Creek	49-033-23126 (1)	Lower Wyodak coal	Canyon	Sheridan	2005	639	14
Remington Creek	49-033-23107 (1)	Cook coal	Cook	Sheridan	2005	802	15
Rose Draw	49-019-06453 (1)	Wasatch sandstone	sand	Johnson	2009	1,080	91
Rose Draw	49-019-25153 (1)	Wall coal	Wall	Johnson	2008	1,819	45
Rose Draw		Fort Union sand	underburden sand	Johnson	2009	1,870	30
Sasquatch	P133198W (2)	Wasatch sandstone	overburden sand	Johnson	2001	1,360	64
Sasquatch	P63417W (2)	Wyodak Rider coal	Big George	Johnson	1998	1,640	205
Sec 25	P103547W (2)	Wasatch sandstone	overburden sand	Campbell	1996	170	36
Sec 25	49-005-07139 (1)	Upper Wyodak coal	Anderson (Wyodak)	Campbell	1996	525	105
South Coal		Wasatch sandstone	sand	Campbell	2001	575	51
South Coal		Cook/Wall coal	Cook/Lower Wall/ Pawnee	Campbell	2001	818	36
South Cordero	P82852W (2)	Upper Wyodak coal	Anderson (Wyodak)	Campbell	1995	358	48



**Table A.1** cont.

Monitoring well site	Well identifier	Lithology zone	Description	County	Year First Monitored	Monitored interval bottom depth (ft.)	Completion interval thickness (ft.)
South Prong		Wasatch sandstone	shallow sand	Campbell	2008	484	32
South Prong	49-005-07641 (1)	Wyodak Rider coal	Big George	Campbell	2007	1,216	46
South Prong	49-005-07642 (1)	Cook/Wall coal	Lower Cook (Gates/Wall)	Campbell	2009	1,702	8
South Prong	49-005-07644 (1)	Fort Union sand	underburden sand	Campbell	2008	1,842	52
Squaw Butte	P63739W (2)	Wyodak Rider coal	Big George	Sheridan	2005	590	20
Streeter	P159898W (2)	Wasatch sandstone	overburden sand	Johnson	2004	730	208
Streeter	P159897W (2)	Wyodak Rider coal	Big George	Johnson	2004	1,378	27
Stuart Sec 31	P106970W (2)	Wasatch sandstone	sand	Campbell	1997	575	20
Stuart Sec 31	P106969W (2)	Upper Wyodak coal	Anderson (Wyodak)	Campbell	1998	780	116
Stuart Sec 31		Fort Union sand	underburden sand	Campbell	1998	830	36
Throne	P127244W (2)	Wasatch sandstone	overburden sand	Campbell	2001	1,450	50
Throne	P127243W (2)	Upper Wyodak coal	Anderson (Wyodak)	Campbell	2001	1,511	5
West Pine Tree	49-005-56980 (1)	Wasatch sandstone	overburden sand	Campbell	2007	565	27
West Pine Tree	49-005-56980 (1)	Wyodak Rider coal	Big George	Campbell	2007	1,434	87
Wild Turkey	49-019-06406 (1)	Wasatch sandstone	overburden sand	Johnson	2004	1,018	20
Wild Turkey	49-019-21363 (1)	Wyodak Rider coal	Big George	Johnson	2004	1,285	80
Williams Cedar Draw		Wasatch sandstone	shallow sand	Campbell	2007	198	32
Williams Cedar Draw	49-005-07507 (1)	Wyodak Rider coal	Smith	Campbell	2007	440	30
Williams Cedar Draw	P171911W (2)		underburden sand	Campbell	2007	634	70
Williams Cedar Draw	49-005-07508 (1)	Upper Wyodak coal	Anderson	Campbell	2007	790	55
Williams Cedar Draw	49-005-07506 (1)	Cook coal	Cook (Werner)	Campbell	2008	864	20
Williams Cedar Draw	49-005-07506 (1)	Cook/Wall coal	Wall (Gates/Wall)	Campbell	2008	1,248	32
Wormwood		Wasatch sandstone	shallow sand	Campbell	2006	520	42
Wormwood	49-005-07518 (1)	Wyodak Rider coal	Big George	Campbell	2006	1,162	88
Wormwood		Fort Union sand	underburden sand	Campbell	2006	1,350	63

(1) API numbers from the Wyoming Oil and Gas Conservation Commission

(2) Permit numbers from the Wyoming State Engineer's Office

## 20 Mile Butte Monitoring Well Site

### Location: S32 T52N R74W

### Date First Monitored: January 28, 2004

#### Drawdown Information

The 20 Mile Butte monitoring well site includes four wells. One well each is completed in the Wasatch sand, the Anderson coal of the Upper Wyodak zone, the Wall coal of the Wall zone, and the Pawnee coal of the Wall zone (Figure A.2; Table A.2). Water levels and wellhead gas pressures were measured during the POR using both manual and automatic transducer and data logger equipment. Transducer data that is missing, randomly fluctuating (noisy) or that substantially differs from concurrent manual measurements may indicate on-site equipment failure, malfunction or requirement for calibration.

#### Wasatch Sandstone

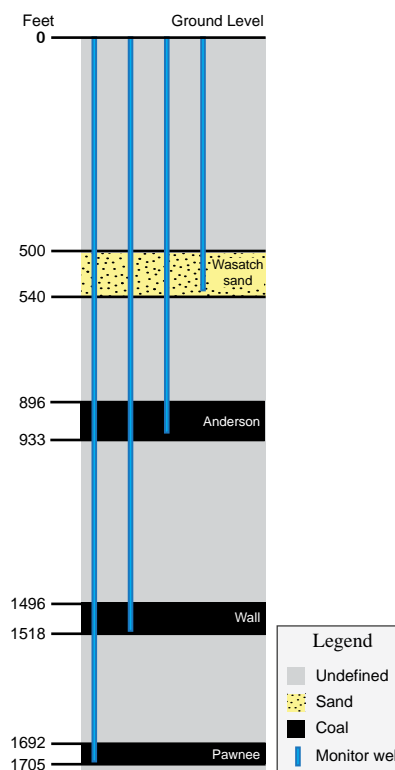
During the 2010-2012 POR, groundwater levels declined 8.63 feet, in the Wasatch sandstone; in contrast, groundwater levels declined 29.00 feet from initial static water levels over the monitoring period of 2004 - 2009 (Figure A.3; Table A.3). Gas pressure was not recorded in the Wasatch sandstone.

#### Anderson Coal

Groundwater levels rose 5.31 feet during the 2010-2012 POR. During the monitoring period of 2004-2009, groundwater levels dropped 162.91 feet (Figure A.3; Table A.3). Gas pressure in the Anderson coal has remained below 10 psi over the monitoring period of 2004-2012, peaking in 2008 at 9.65 psi and ending 2012 at 1.52 psi.

#### Wall Coal

Groundwater levels declined 32.81 feet during the 2010-2012 POR. Over the monitoring period of 2004 -2009 water levels declined a total of 273.46 feet (Figure A.4; Table A.3). Gas pressure has remained below 1 psi during the monitoring period of 2004-2012, peaking at 0.86 psi in 2004.



**Figure A.2.** Section showing relative positions of coals and sands in feet. Not to scale.

#### Pawnee Coal

Groundwater levels dropped 26.92 feet in the Pawnee coal during the 2010-2012 POR. Water levels declined 175.50 feet from 2004 to 2009 (Figure A.4; Table A.3). Gas pressure has generally been low over the entire monitoring period but spiked several times, peaking at 10.4 psi in 2009.

**Table A.2.** Table showing the depth to and thickness of monitored zones at the 20 Mile Butte monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Wasatch sand	500	540	40	356
Anderson coal	896	933	37	n/a
Wall coal	1,496	1,518	22	n/a
Pawnee coal	1,692	1,705	13	n/a

**Table A.3.** Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2010	Drawdown 2010-2012	Total drawdown (ft.)	Depth to Final water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	362.77	29.00	8.63	37.63	400.40	n/a	n/a
Anderson coal	545.00	162.91	-5.31	157.60	702.60	9.65	6/4/2008
Wall coal	521.00	273.46	32.81	306.27	827.27	0.86	9/19/2004
Pawnee coal	540.00	175.50	26.92	202.42	742.42	10.04	4/14/2009

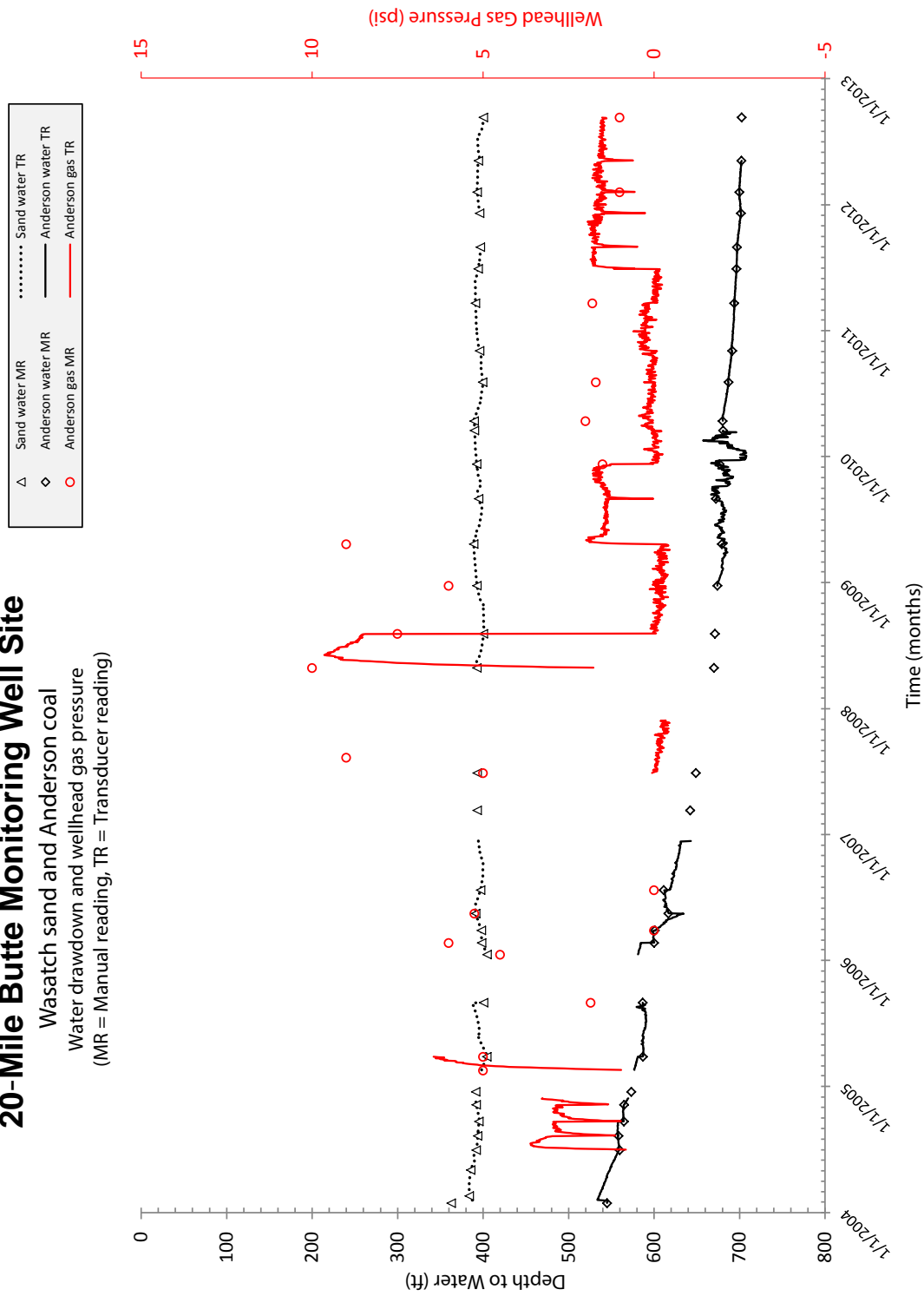
### Production Statistics

Production data were analyzed for CBNG wells within the buffer of the 20 Mile Butte monitoring well site from 2006 to 2012. Cumulative production for individual CBNG wells is displayed by location on Figure A.5. CBNG production is monitored in the Upper Wyodak and Wall coal zones and some production in this area occurs in unmonitored or multiple well zones.

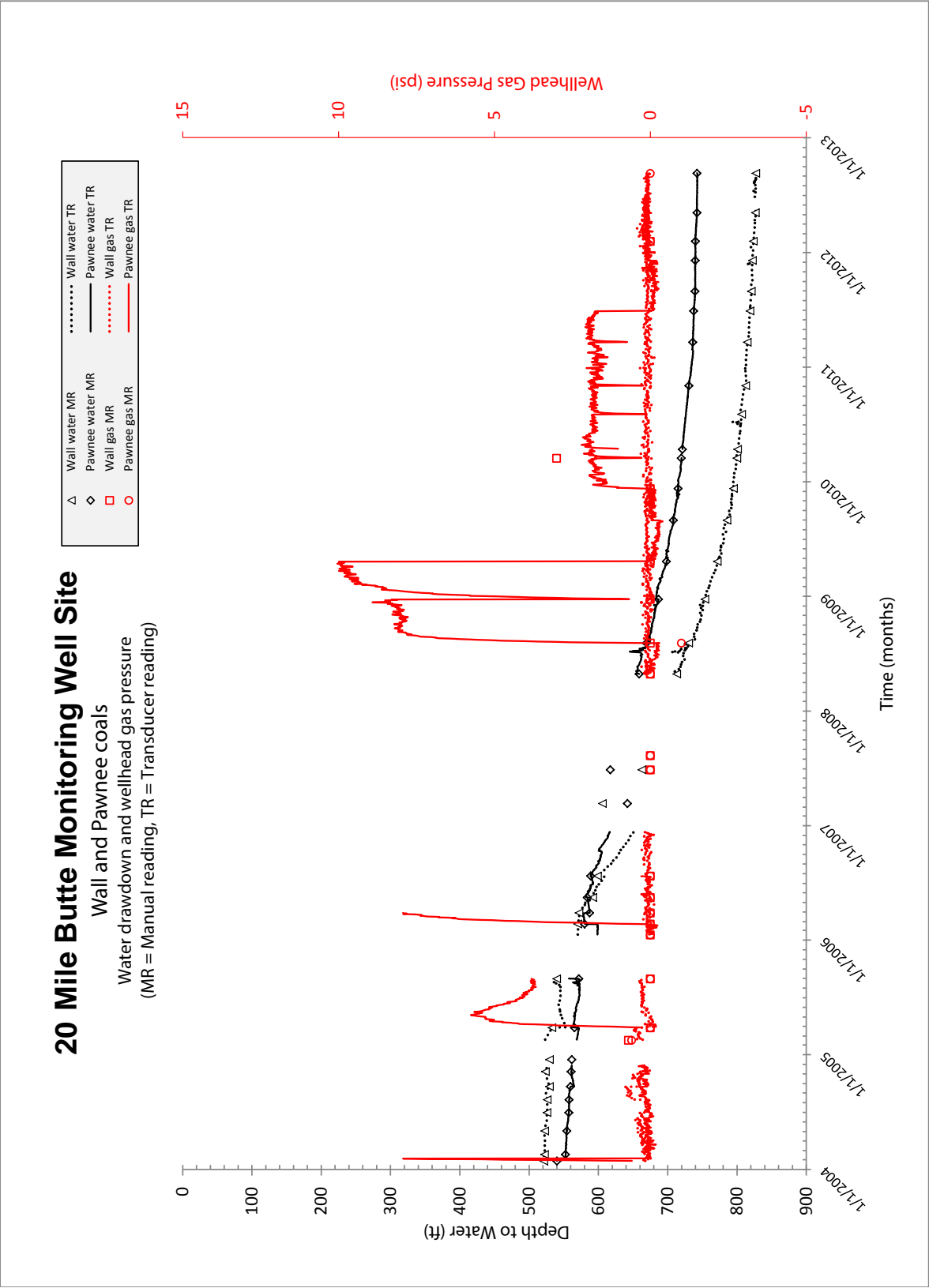
Water production surged during 2001-2002 in the Upper Wyodak zone to a peak production level of almost 58,000 bbls/month and then decreased during 2003-2012 when it ranged from 0-41,000 bbls/month (Figure A.6). During 2001-2003, gas production increased to over 50,000 Mcf/month and then declined to 36,704 Mcf/month by the end of the 2010-2012 POR.

## 20-Mile Butte Monitoring Well Site

Wasatch sand and Anderson coal  
 Water drawdown and wellhead gas pressure  
 (MR = Manual reading, TR = Transducer reading)

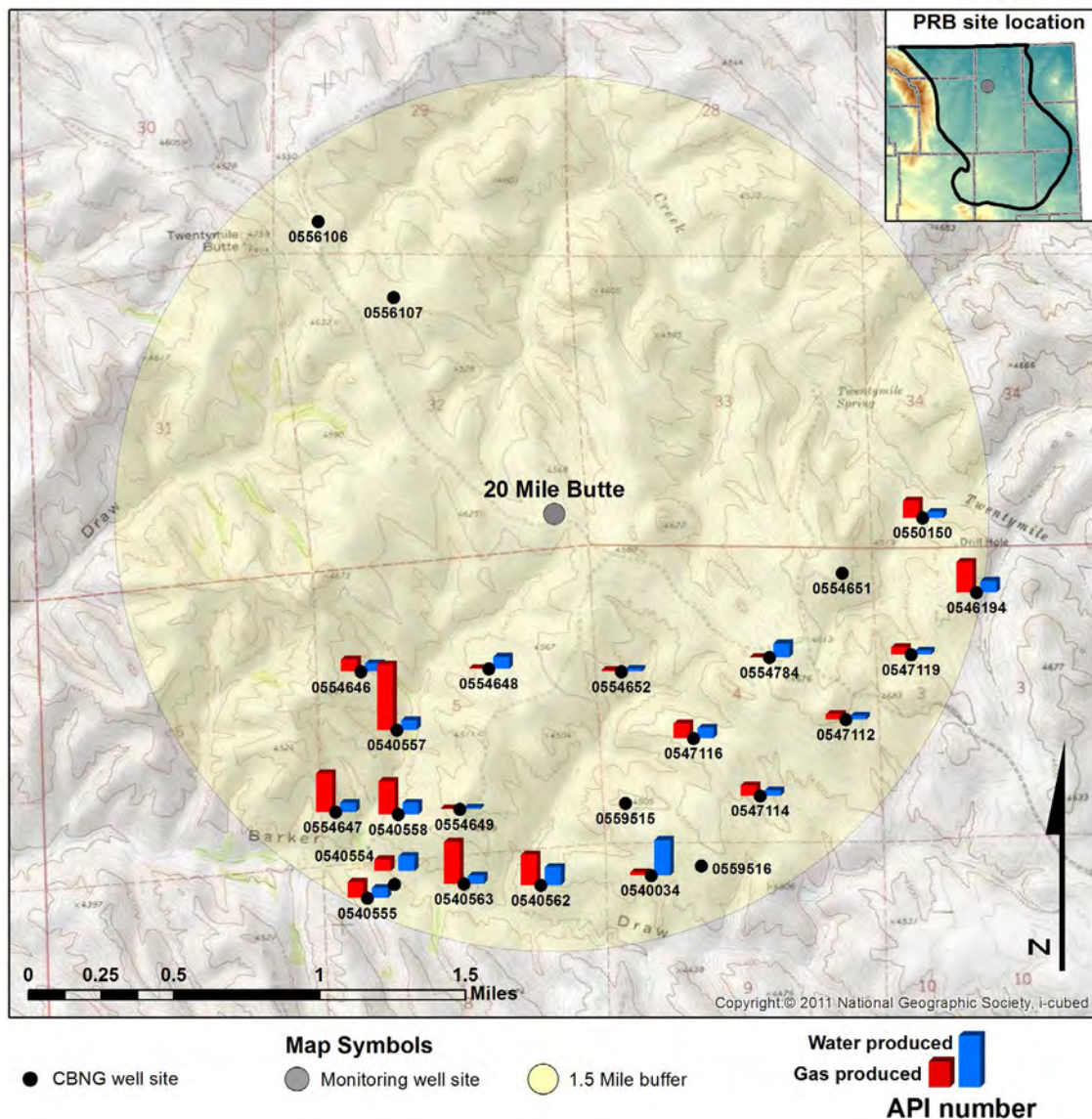


**Figure A.3.** Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the 20 Mile Butte monitoring wellsite location.



**Figure A.4.** Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the 20 Mile Butte monitoring wellsite location.



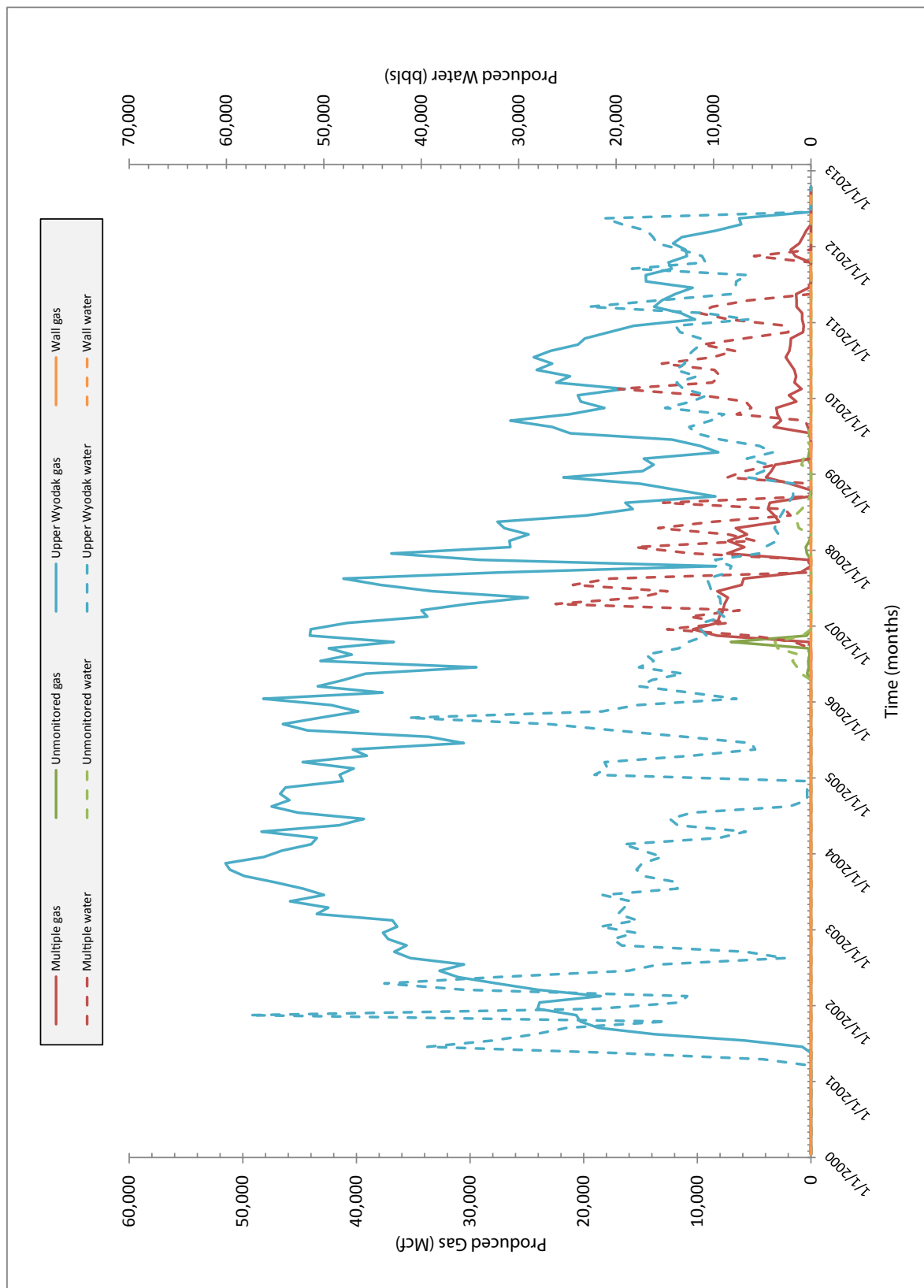


**Figure A.5.** 20 Mile Butte monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

The Wall coal zone did not produce water or gas during 2009-2012.

Water produced from multiple coal zone wells rose to over 20,000 bbls/month in 2007 and then generally declined (Figure A.6). Locally, gas production in multiple zone wells peaked in 2007 then slowly declined to 0.0 Mcf/month in 2012. Unmonitored coal zone wells had two periods of low water production in 2006 and 2008-2009

(Figure A.6). Gas production in the unmonitored coal zones peaked at 7,055 Mcf/month in 2006 and has not exceeded 1,000 Mcf/month since that period.



**Figure A.6.** Water and gas production from CBNG wells associated with the 20 Mile Butte monitoring well site

**21 Mile Monitoring Well Site**  
**Location: S22 T48N R74W**  
**Date First Monitored: August 19, 2001**

**Drawdown Information**

The 21 Mile monitoring well site includes three monitoring wells. One well each is completed in the Wasatch sand, the Big George coal of the Wyodak Rider zone, and the Wyodak coal of the upper Wyodak zone (Figure A.7; Table A.4). Water levels and wellhead gas pressures were measured during the POR using both manual and automatic transducer and data logger equipment. Transducer data that is missing, randomly fluctuating (noisy) or that substantially differs from concurrent manual measurements may indicate on-site equipment failure, malfunction or requirement for calibration.

**Wasatch Sandstone**

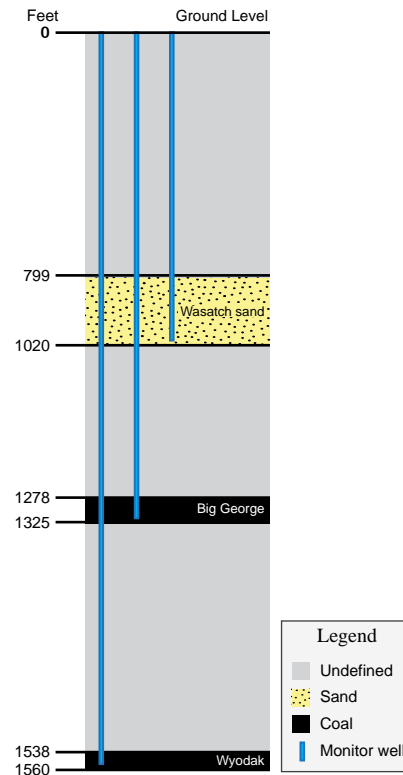
During the 2010-2012 POR, groundwater levels declined 6.05 feet in the Wasatch sandstone. Groundwater levels have declined only 6.62 feet overall from the initial static water levels measured in 2001. (Figure A.8; Table A.5). Gas pressure was not recorded in the Wasatch sandstone.

**Big George Coal**

Groundwater levels dropped 16.01 feet during the 2010-2012 POR in the Big George coal and have declined a total of 256.00 feet over the monitoring period of 2001-2012 (Figure A.8; Table A.5). Gas pressure in the Big George coal has remained relatively low (<1.00 psi) and stable over the monitoring period of 2001-2012, peaking in 2001 at 0.71 psi.

**Wyodak Coal**

Groundwater levels declined only 1.21 feet during the 2010-2012 POR. Overall, the rapid decline of 306.79 feet observed from 2001 to 2009 appears to have leveled off over the 2010-2012 POR (Figure A.8; Table A.5). Gas pressure has remained below 2.0 psi during the monitoring period of 2001-2012, peaking at 1.91 psi in 2008.



**Figure A.7.** Section showing relative positions of coals and sands in feet. Not to scale.

**Table A.4.** Table showing the depth to and thickness of monitored zones at the 21 Mile monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Wasatch sand	799	1,020	221	258
Big George coal	1,278	1,325	47	n/a
Wyodak coal	1,538	1,560	22	n/a

**Table A.5.** Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2010	Drawdown 2010-2012	Total drawdown (ft.)	Depth to Final water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	533.33	0.57	6.05	6.62	539.95	n/a	n/a
Big George coal	626.68	239.99	16.01	256.00	882.68	0.71	8/24/2001
Wyodak coal	629.86	306.79	1.21	308.00	937.86	1.91	12/13/2008

### Production Statistics

Production data were analyzed for CBNG wells within the buffer of the 21 Mile monitoring well site from 2002 to 2012. Cumulative production for individual CBNG wells is displayed by location on Figure A.9. CBNG production is monitored in the Wyodak Rider, Upper Wyodak, unmonitored and multiple coal production well zones.

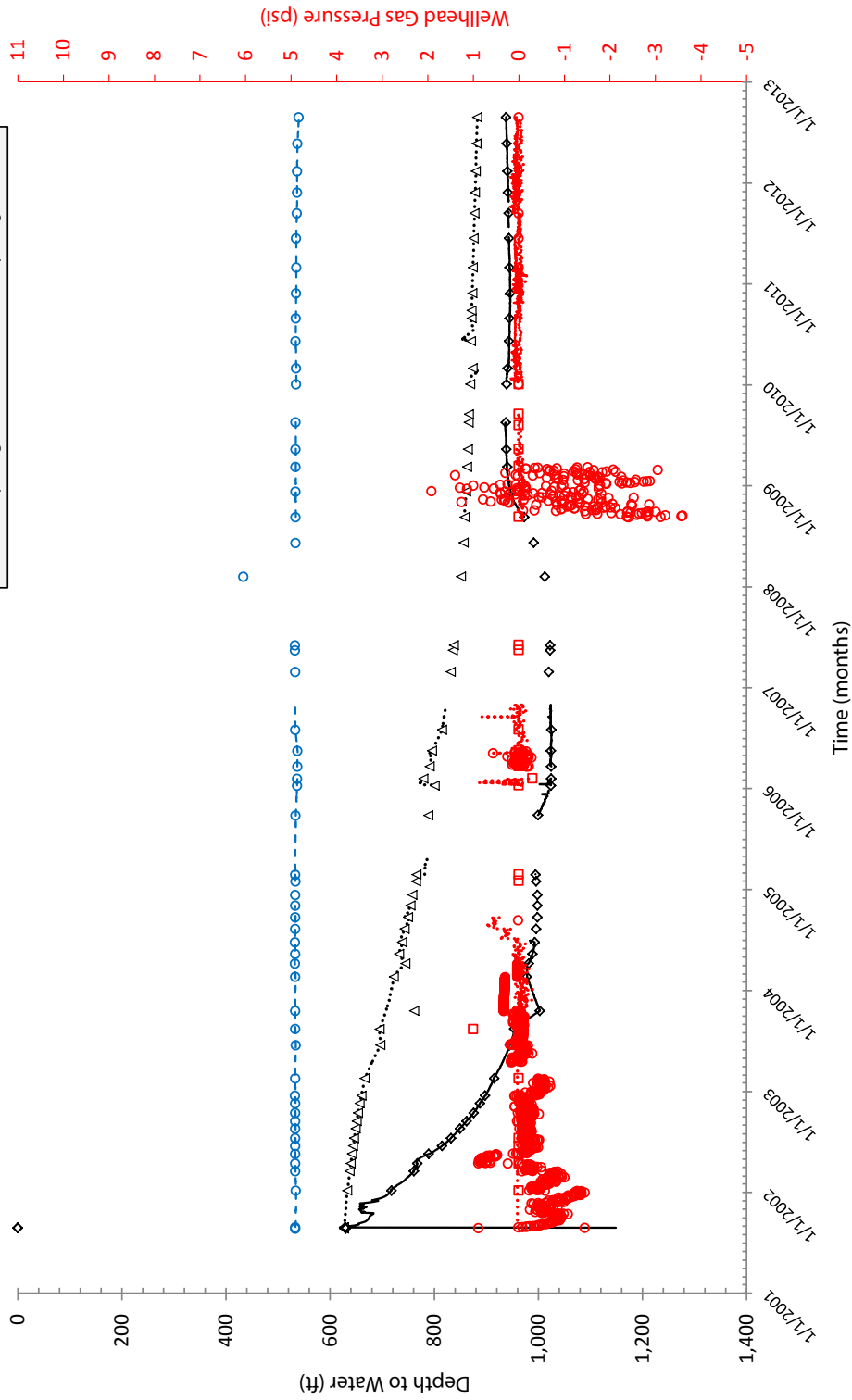
A peak water production level of almost 24,000 bbls was reached in the Wyodak Rider zone in July 2004. Water production has dropped to zero since September 2011. (Figure A.10). Gas production has always been low; peak production was 1,082 Mcf in July 2007. There has been no gas production since July 2008.

## 21 Mile Monitoring Well Site

Wasatch sand, Big George coal, and Wyodak coal

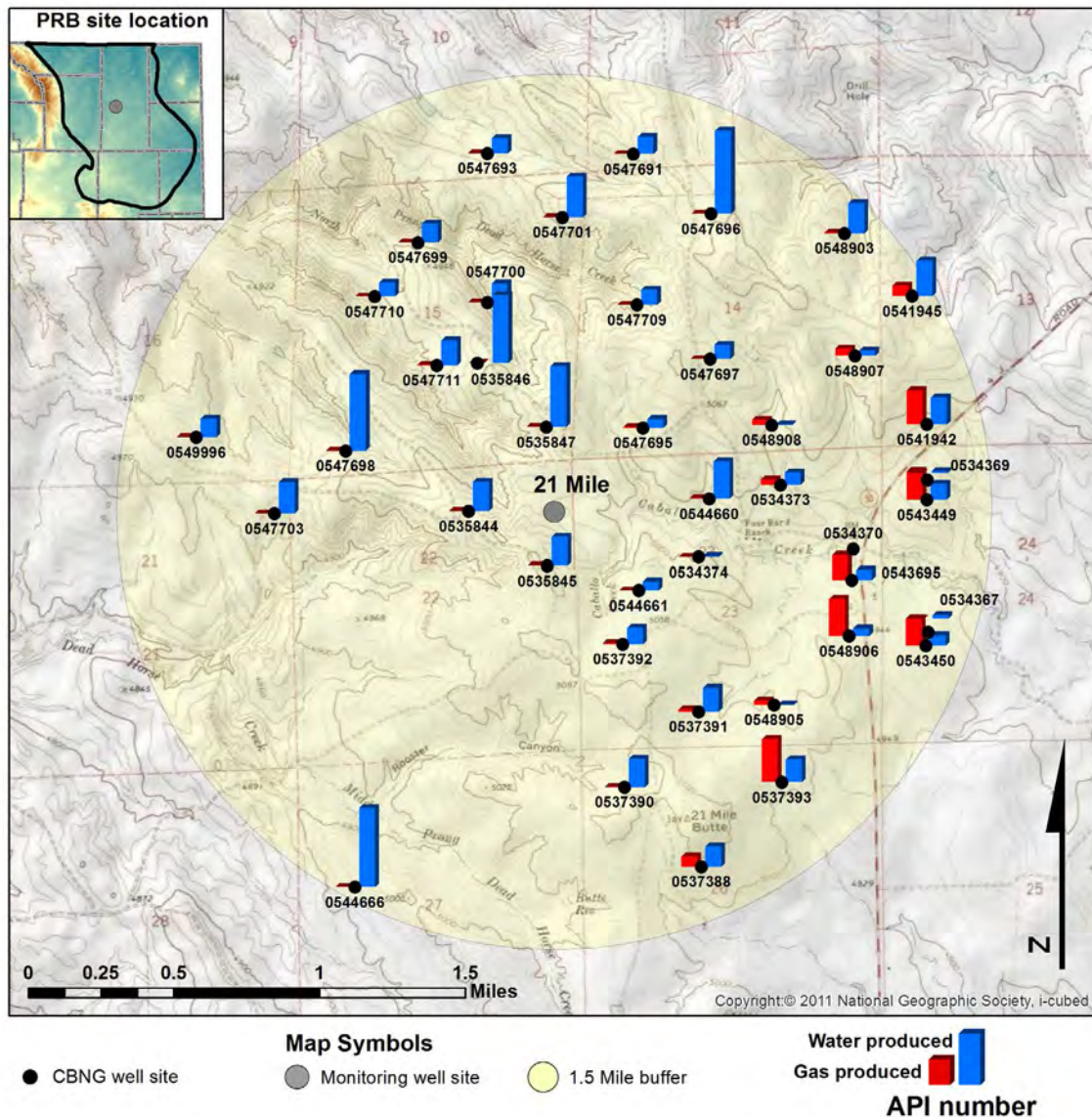
Water drawdown and wellhead gas pressure

(MR = Manual reading, TR = Transducer reading)



**Figure A.8.** Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the 21 Mile monitoring wellsite location.



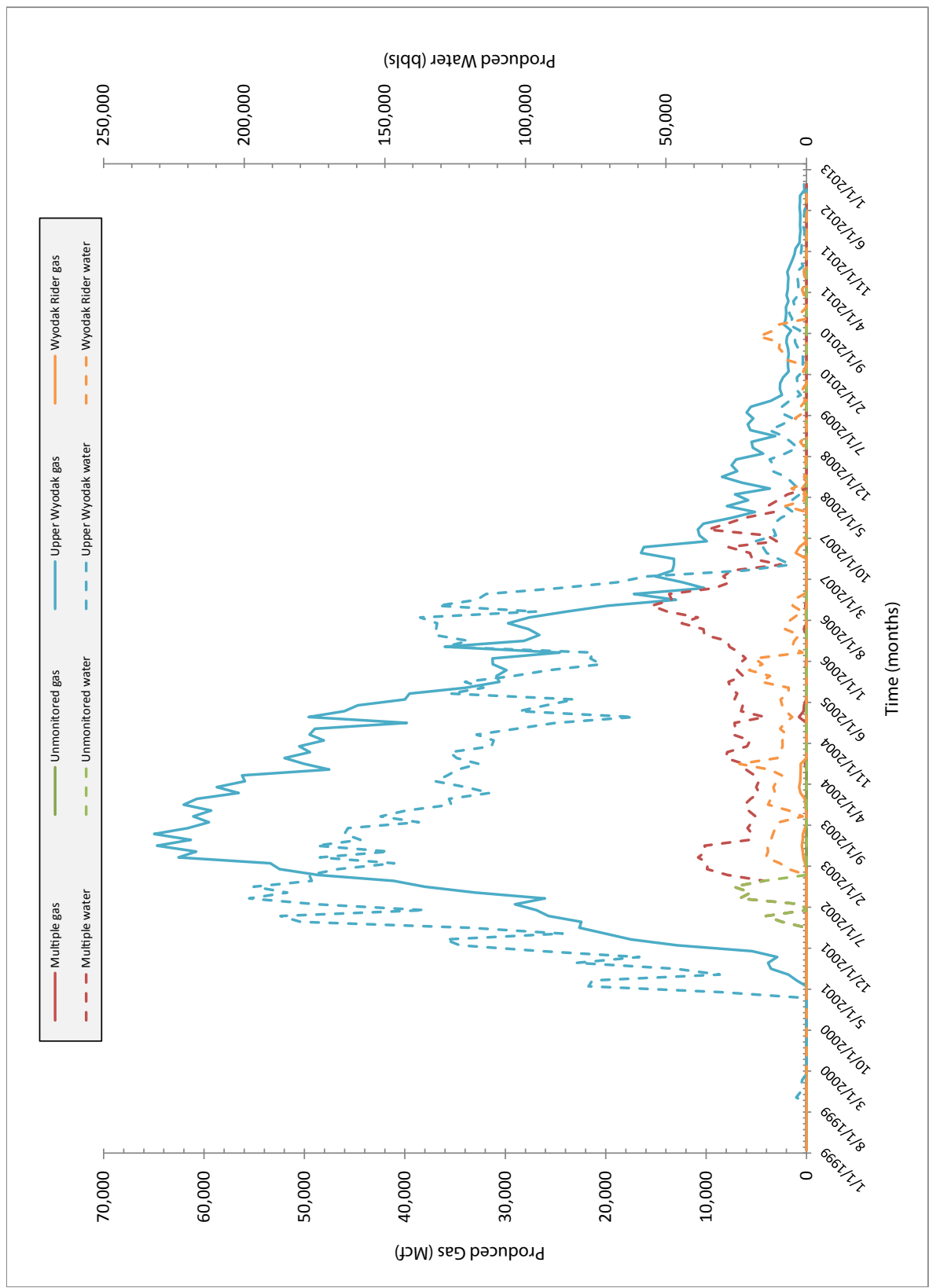


**Figure A.9.** 21 Mile monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

The Upper Wyodak produced substantial amounts of water and gas during the monitoring period of 2001-2012. Water production levels which peaked in August 2002 at 198,250 bbls, have declined significantly since 2009 (Figure A.10). Gas production, which peaked in July 2003 at almost 65,000 Mcf, has since declined and has not exceeded 10,000 Mcf/month during the monitoring period of 2008-2012.

The unmonitored coal zones only produced water during 2002, after which well use ceased (Figure A.10). Gas production in the unmonitored coal zones totaled 8 Mcf in 2002, after which no gas was produced.

Multiple zone wells initially produced modest amounts of water (<51,000 bbls/month) and small amounts of gas (<773 Mcf/month) from 2002-2008; water and gas production declined to zero from June 2008 through 2012 (Figure A.10).



**Figure A.10.** Water and gas production from CBNG wells associated with the 21 Mile monitoring well site location.

**All Night Creek Monitoring Well Site**  
**Location: S36 T43N R74W**  
**Date First Monitored: March 21, 2001**

**Drawdown Information**

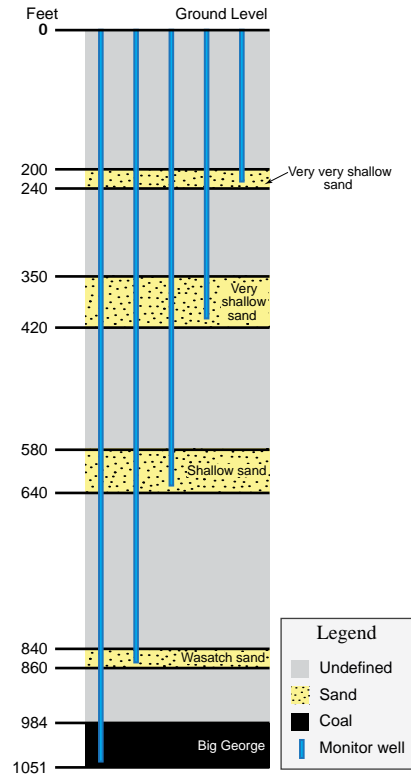
The All Night Creek monitoring well site includes five wells. Four wells are completed in Wasatch sandstones of varying depths, and one well is completed in the Big George coal of the Wyodak Rider zone (Figure A.11; Table A.6). Water levels and wellhead gas pressures were measured during the POR using both manual and automatic transducer and data logger equipment. Transducer data that is missing, randomly fluctuating (noisy) or that substantially differs from concurrent manual measurements may indicate on-site equipment failure, malfunction or requirement for calibration.

**Wasatch Sandstones**

During the 2010-2012 POR, groundwater levels in the monitored sandstone layers exhibited declines that ranged from 0.38 to 4.65 feet. In contrast, over the monitoring period of 2001-2009, groundwater level changes ranged from a rise of 21.96 feet to a decline of 3.90 feet from initial static water levels (Figure A.12; Figure A.13; Table A.7). Gas pressure was not recorded in the Wasatch sandstones.

**Big George Coal**

The well was first reported dry in May of 2007 and remained unchanged over the 2010-2012 POR; during the monitoring period of 2001-2009, groundwater levels dropped 624.08 feet (Figure A.13; Table A.7). Wellhead gas pressure in the Big George coal has varied widely over the monitoring period of 2004 -2012, ending 2012 at approximately 4 psi.



**Figure A.11.** Section showing relative positions of coals and sands in feet. Not to scale.

**Table A.6.** Table showing the depth to and thickness of monitored zones at the All Night Creek monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Very very shallow sand	200	240	40	744
Very shallow sand	350	420	70	564
Shallow sand	580	640	60	344
Wasatch sand	840	860	20	124
Big George coal	984	1,051	67	n/a

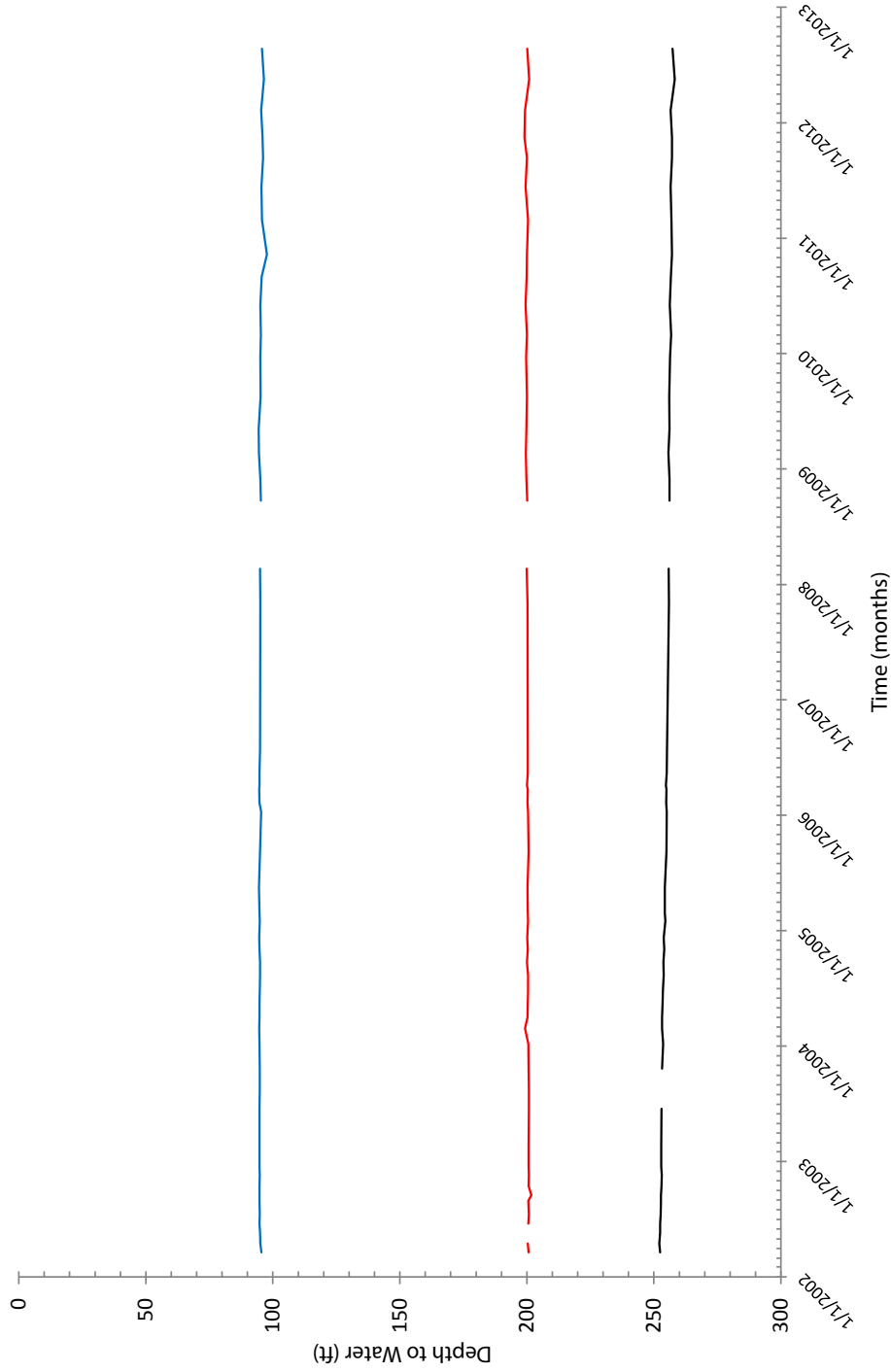
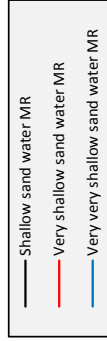
**Table A.7.** Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2010	Drawdown 2010-2012	Total drawdown (ft.)	Depth to Final water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Very very shallow sand	95.47	-0.36	0.56	0.20	95.67	n/a	n/a
Very shallow sand	200.71	-0.99	0.38	-0.61	200.10	n/a	n/a
Shallow sand	252.45	3.90	1.00	4.90	257.35	n/a	n/a
Wasatch sand	320.59	-21.96	4.65	-17.31	303.28	n/a	n/a
Big George coal	439.92	624.08	0.00	624.08	1064.00	48.53	10/29/2003

## All Night Creek Monitoring Well Site

Wasatch sands

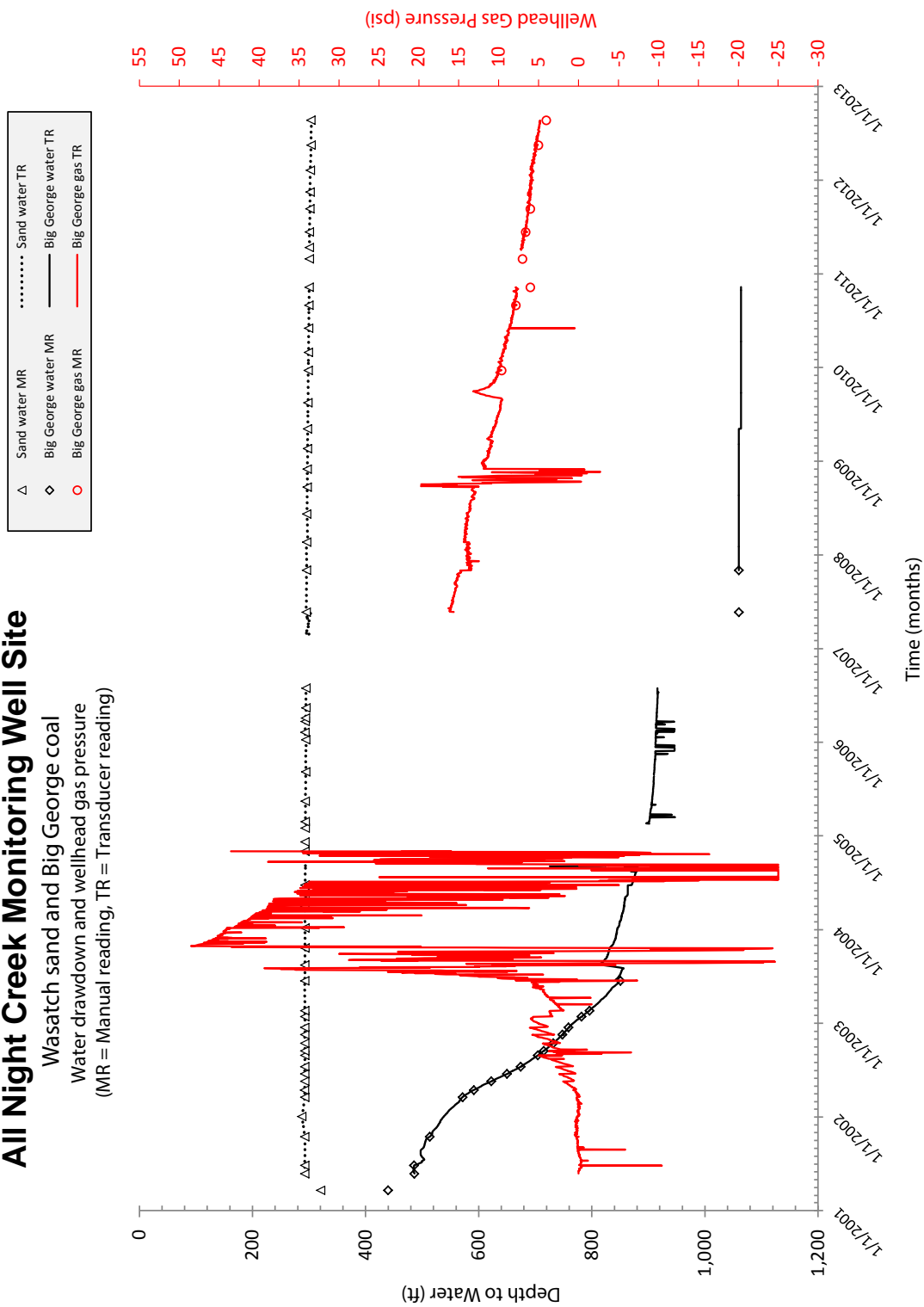
Water drawdown and wellhead gas pressure  
(MR = Manual reading, TR = Transducer reading)



**Figure A.12.** Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the All Night Creek monitoring wellsite location.

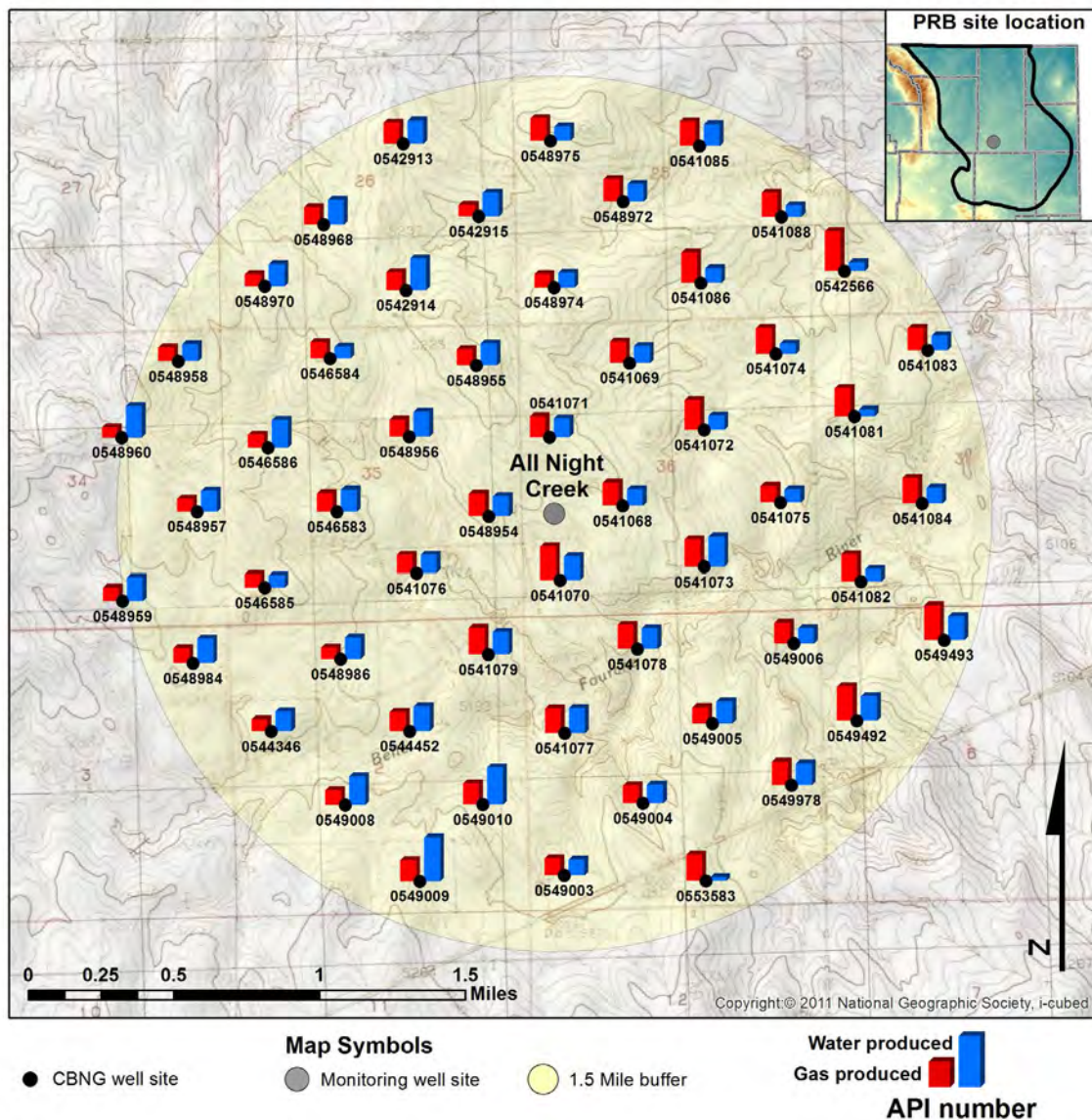
## All Night Creek Monitoring Well Site

Wasatch sand and Big George coal  
Water drawdown and wellhead gas pressure  
(MR = Manual reading, TR = Transducer reading)



**Figure A.13.** Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the All Night Creek monitoring wellsite location.





**Figure A.14.** All Night Creek monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

### Production Statistics

Production data were analyzed for CBNG wells within the buffer of the All Night Creek monitoring well site from 2000-2012. Cumulative production for individual CBNG wells is displayed by location on Figure A.14. CBNG production is monitored in the Wyodak Rider coal zone; there is no production in other coal zones within 1.5 miles of this monitoring well.

Water production in the Wyodak Rider peaked at 489,989 bbls in December 2002 and has dropped off rapidly since then (Figure A.15). Gas production began in 2001, rapidly increased, and peaked at 238,000 Mcf in October 2003. Gas production has gradually decreased from its peak to 26,000 Mcf/month at the end of the 2010-2012 POR.

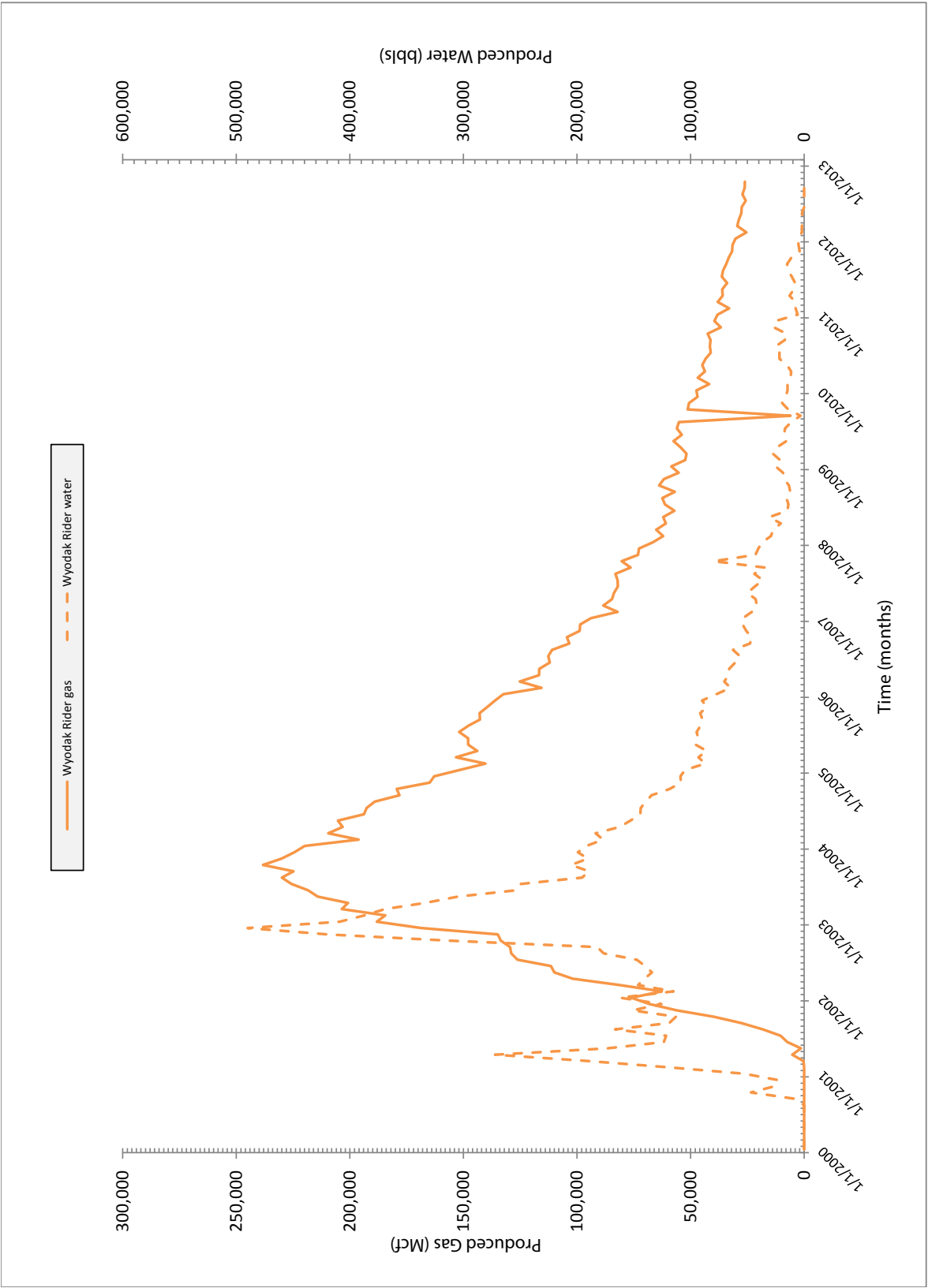


Figure A.15. Water and gas production from CBNG wells associated with the All Night Creek monitoring well site location.

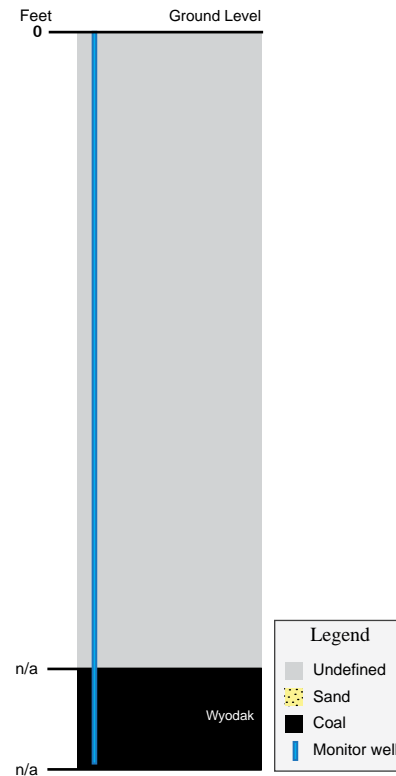
**Amoco Sec 36 Monitoring Well Site**  
**Location: S36 T47N R72W**  
**Date First Monitored: April 25, 1995**

**Drawdown Information**

The Amoco Sec 36 monitoring well site includes 1 well that is completed in the Wyodak coal of the Upper Wyodak coal zone, (Figure A.16; Table A.8). Water levels and wellhead gas pressures were measured during the POR using only manual procedures.

**Wyodak Coal**

Groundwater levels rose 4.62 feet during the 2010-2012 POR. Overall, water levels declined 248.33 feet during the monitoring period of 1995-2009 (Figure A.17; Table A.9). Gas pressure in the Wyodak coal has varied considerably during the monitoring period of 1995-2012. Gas pressure data is discontinuous and exhibits several lapses in measurement. Gas pressure peaked in 1997 at 34.11 psi and ranged from -0.8 to 6 psi over the 2010-2012 POR.



**Figure A.16.** Section showing relative positions of coals and sands in feet. Not to scale.

**Table A.8.** Table showing the depth to and thickness of monitored zones at the Amoco Sec 36 monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Wyodak coal	n/a	n/a	n/a	n/a

**Table A.9.** Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2010	Drawdown 2010-2012	Total drawdown (ft.)	Depth to Final water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wyodak coal	244.00	248.33	-4.62	243.71	487.71	34.11	10/12/97

### Production Statistics

Production data were analyzed for CBNG wells within the buffer of the Amoco Sec 36 monitoring well site from 1994-2012. Cumulative production for individual CBNG wells is displayed by location on Figure A.18. CBNG production is monitored

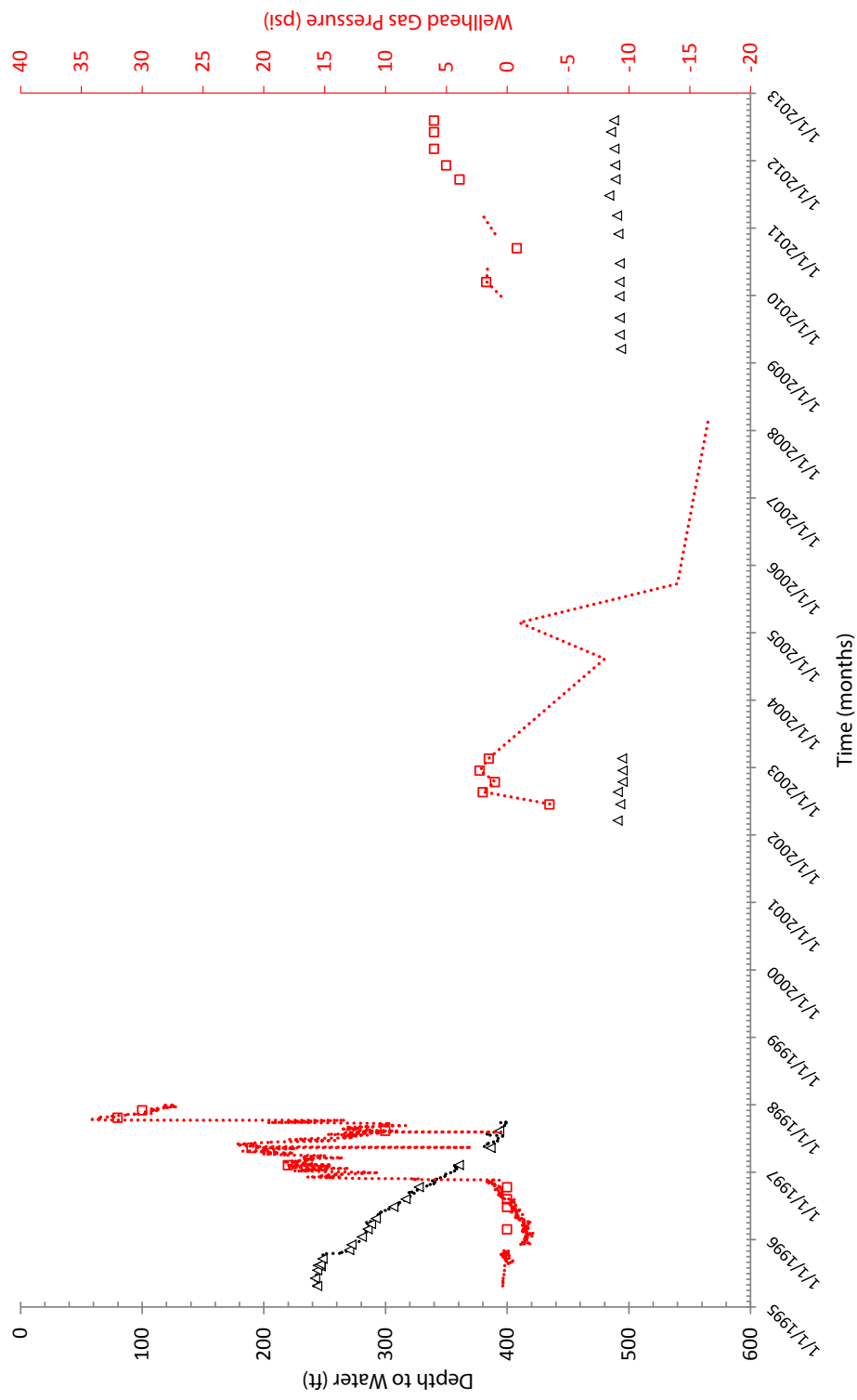
in the Upper Wyodak and unmonitored coal production zones.

Water production in the Upper Wyodak zone began in 1995 and rapidly increased, peaking in 1997 at 386,000 bbls/month; water production then

## Amoco Sec 36 Monitoring Well Site

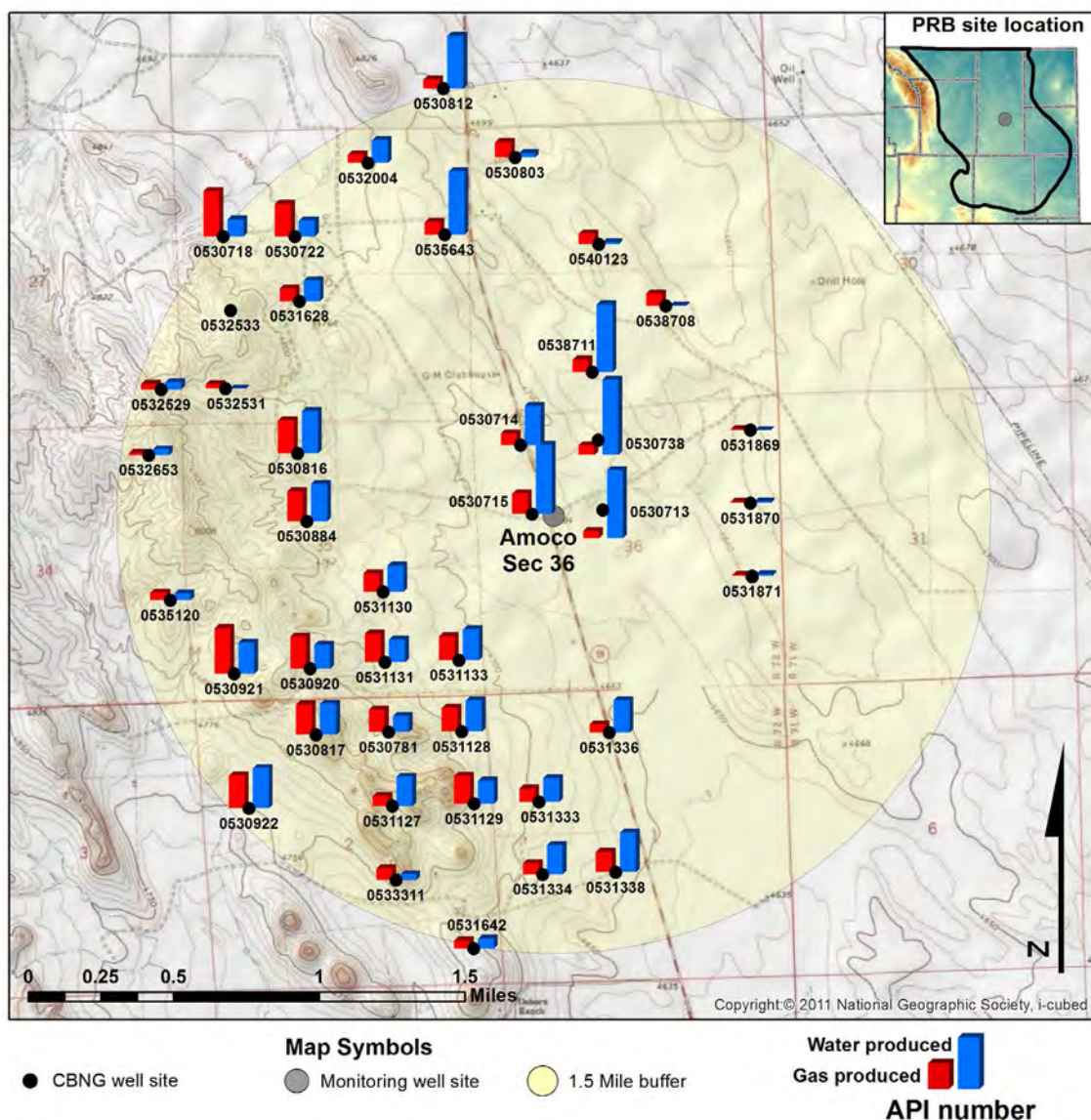
Wyodak coal

Water drawdown and wellhead gas pressure  
(MR = Manual reading, TR = Transducer reading)



**Figure A.17.** Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Amoco Sec 36 monitoring wellsite location.





**Figure A.18.** Amoco Sec 36 monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

sharply declined to zero bbls/month in 2012 (Figure A.19). Gas production in the Upper Wyodak followed a similar trend peaking at 201,000 Mcf/month in 1997 and declining to zero at the end of the 2010-2012 POR.

never produced any gas over the monitoring period of 1994-2012.

Intermittent water production in unmonitored coal zones was limited to a short period from September 1999 to December 2002 and ceased thereafter (Figure A.19). The unmonitored coal zone wells



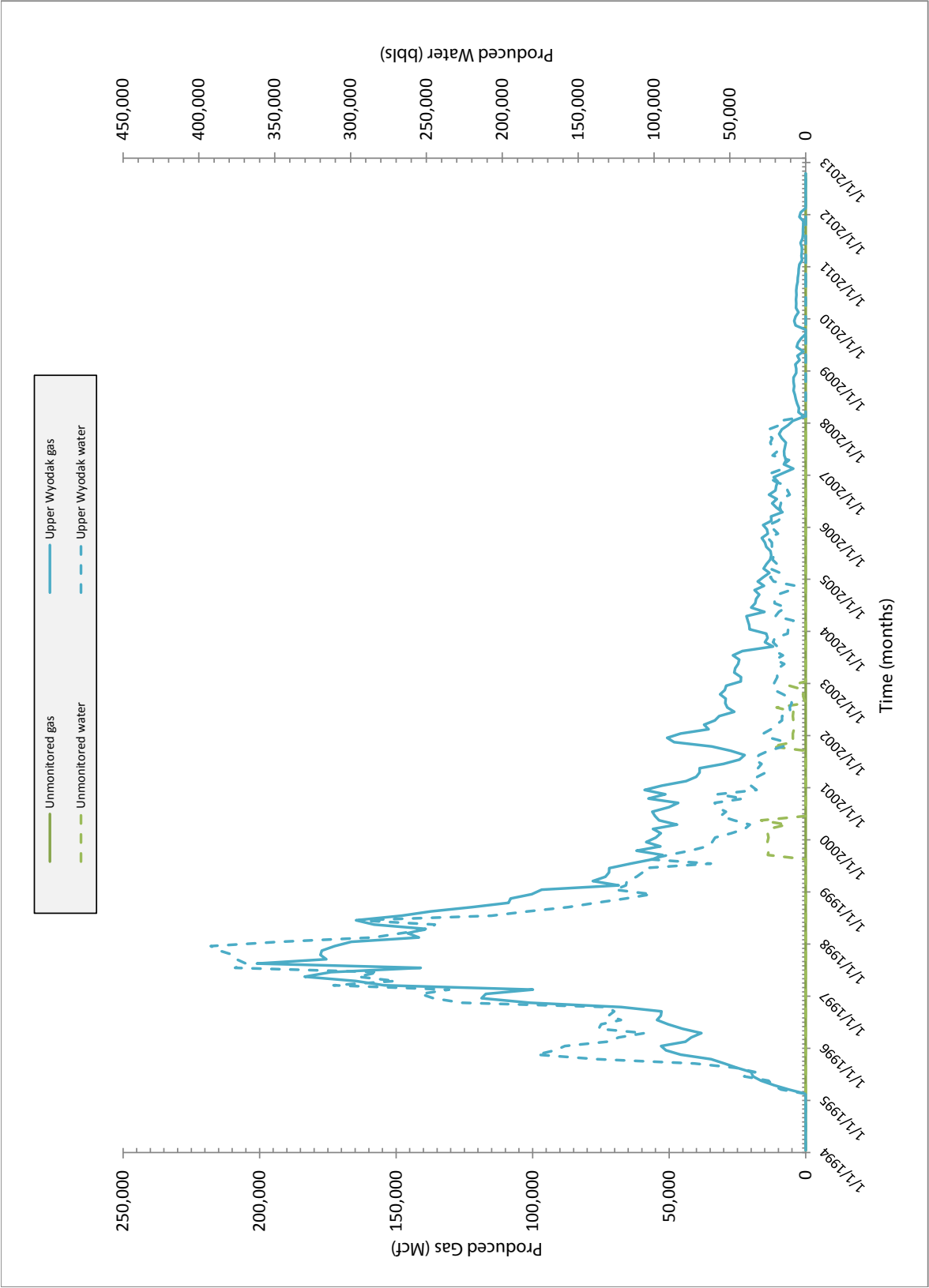


Figure A.19. Water and gas production from CBNG wells associated with the Amoco Sec 36 monitoring well site location.

# **Bar 76 Monitoring Well Site** **Location: S1 T45N R73W** **Date First Monitored: September 16, 1997**

## **Drawdown Information**

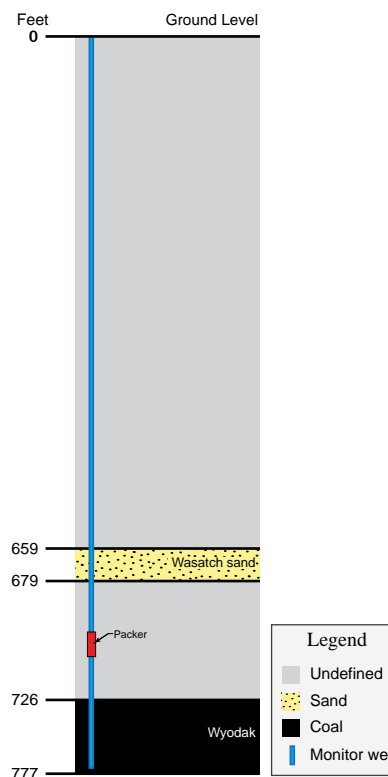
The Bar 76 monitoring well site includes one dual completion well, separated by a packer. The well is completed in a Wasatch sandstone and the Wyodak coal of the Upper Wyodak coal zone (Figure A.20; Table A.10). Water levels and wellhead gas pressures were measured during the POR using both manual and automatic transducer and data logger equipment. Transducer data that is missing, randomly fluctuating (noisy) or that substantially differs from concurrent manual measurements may indicate on-site equipment failure, malfunction or requirement for calibration.

## **Wasatch Sandstone**

During the 2010-2012 POR, groundwater levels declined 9.56 feet in the Wasatch sandstone; groundwater levels have declined 250.33 feet over the monitoring period of 1997-2009. (Figure A.21; Table A.11). Gas pressure was not recorded in the Wasatch sandstone.

## **Wyodak Coal**

Groundwater levels declined 0.80 feet during the 2010-2012 POR. During the monitoring period of 1997-2009, water levels declined 607.59 feet (Figure A.21; Table A.11). Measured gas pressure, which was relatively stable (-1.0 to 1.0 psi) from 1997-2003, exhibited a spike of 62 psi in 2003, then steadily decreased to 0.0 psi in 2007 and have remained negative since.



**Figure A.20.** Section showing relative positions of coals and sands in feet. Not to scale.

**Table A.10.** Table showing the depth to and thickness of monitored zones at the Bar 76 monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Wasatch sand	659	679	20	47
Wyodak coal	726	777	51	n/a

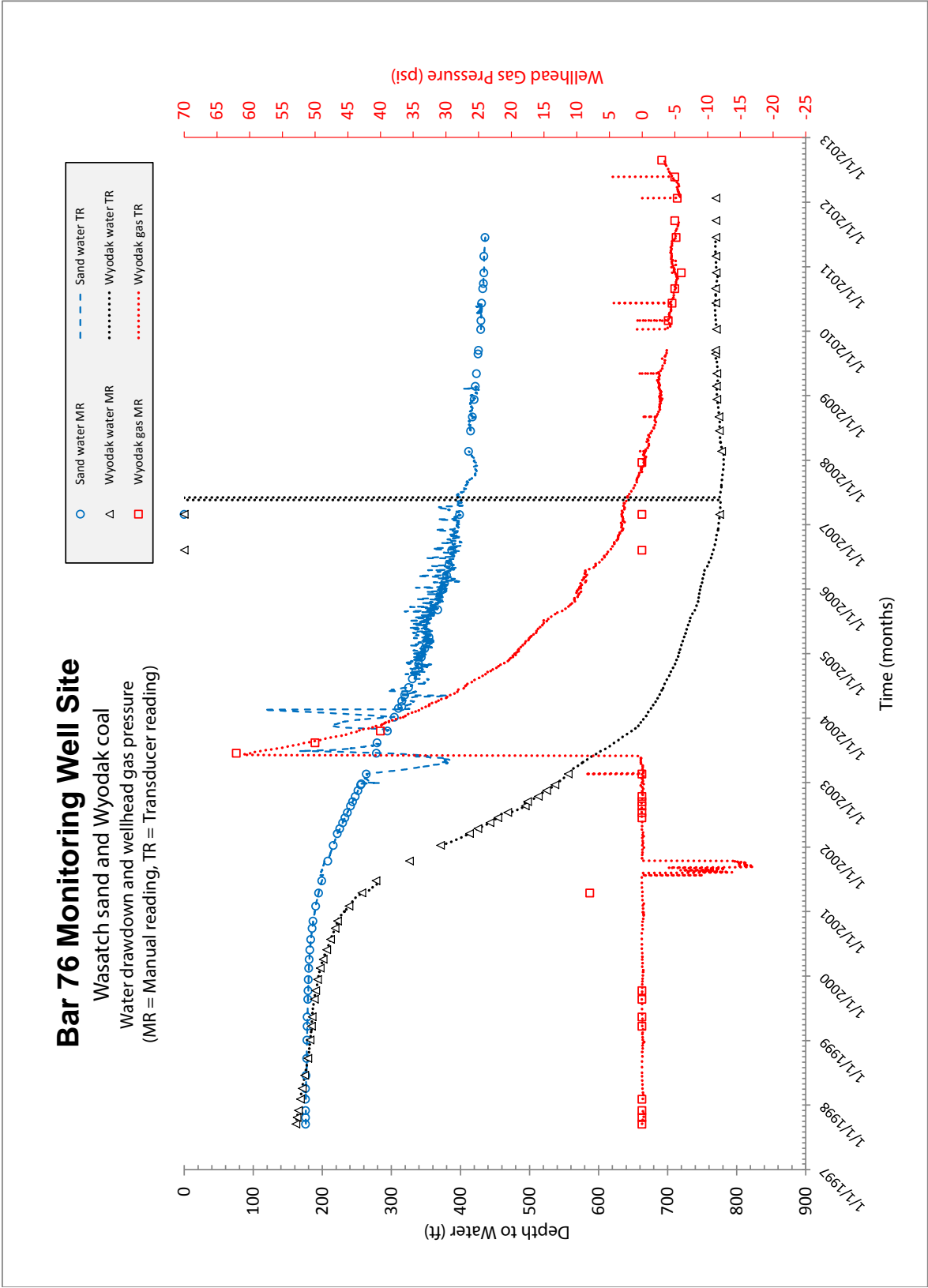
**Table A.11.** Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2010	Drawdown 2010-2012	Total drawdown (ft.)	Depth to Final water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	175.97	250.33	9.56	259.89	435.86	n/a	n/a
Wyodak coal	161.81	607.59	0.80	608.39	770.20	61.01	6/7/2003

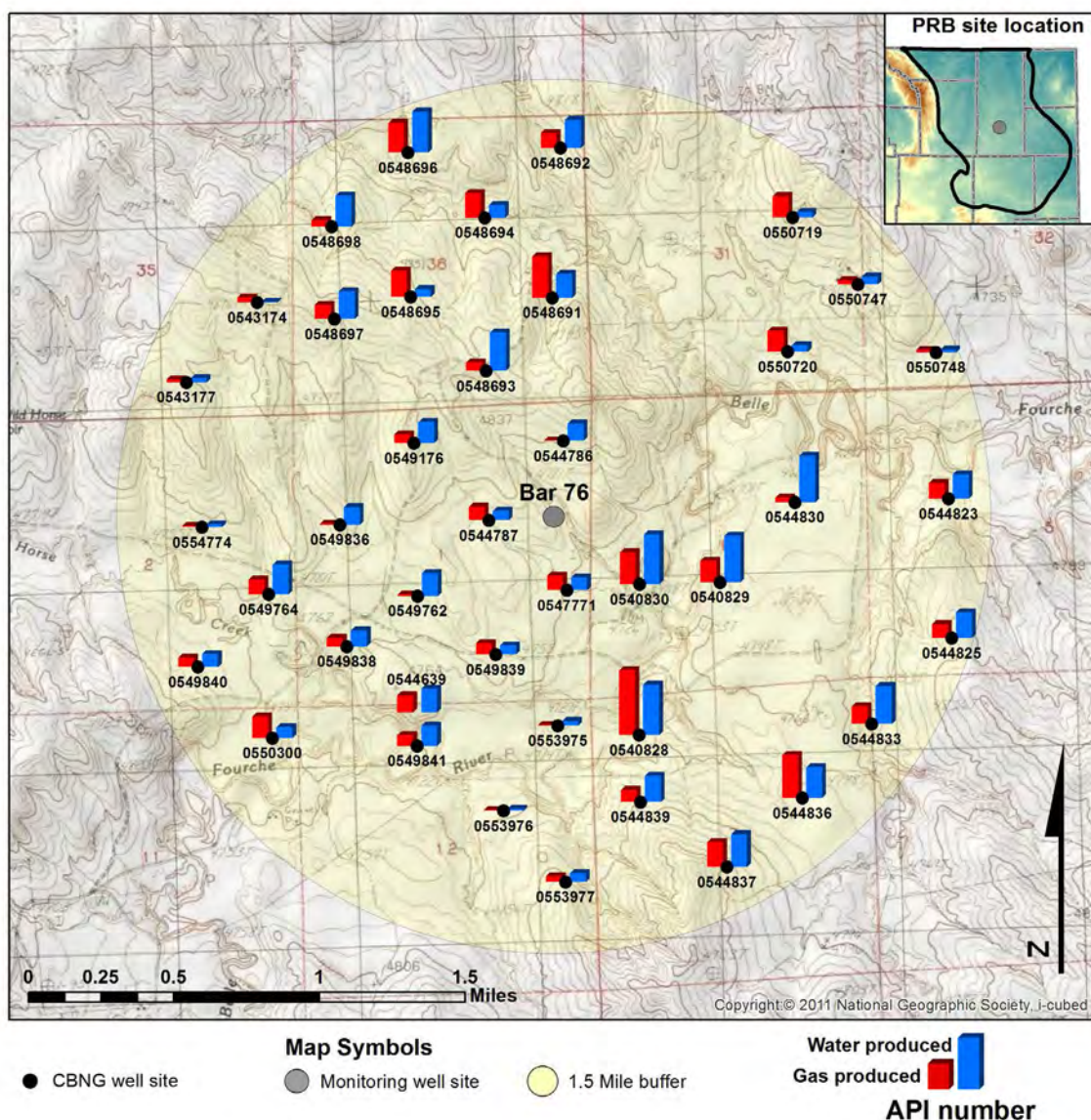
### Production Statistics

Production data were analyzed for CBNG wells within the buffer of the Bar 76 monitoring well site from 2000-2012. Cumulative production for individual CBNG wells is displayed by location

on Figure A.22. CBNG and water production is monitored in the Upper Wyodak coal and unmonitored coal zones.



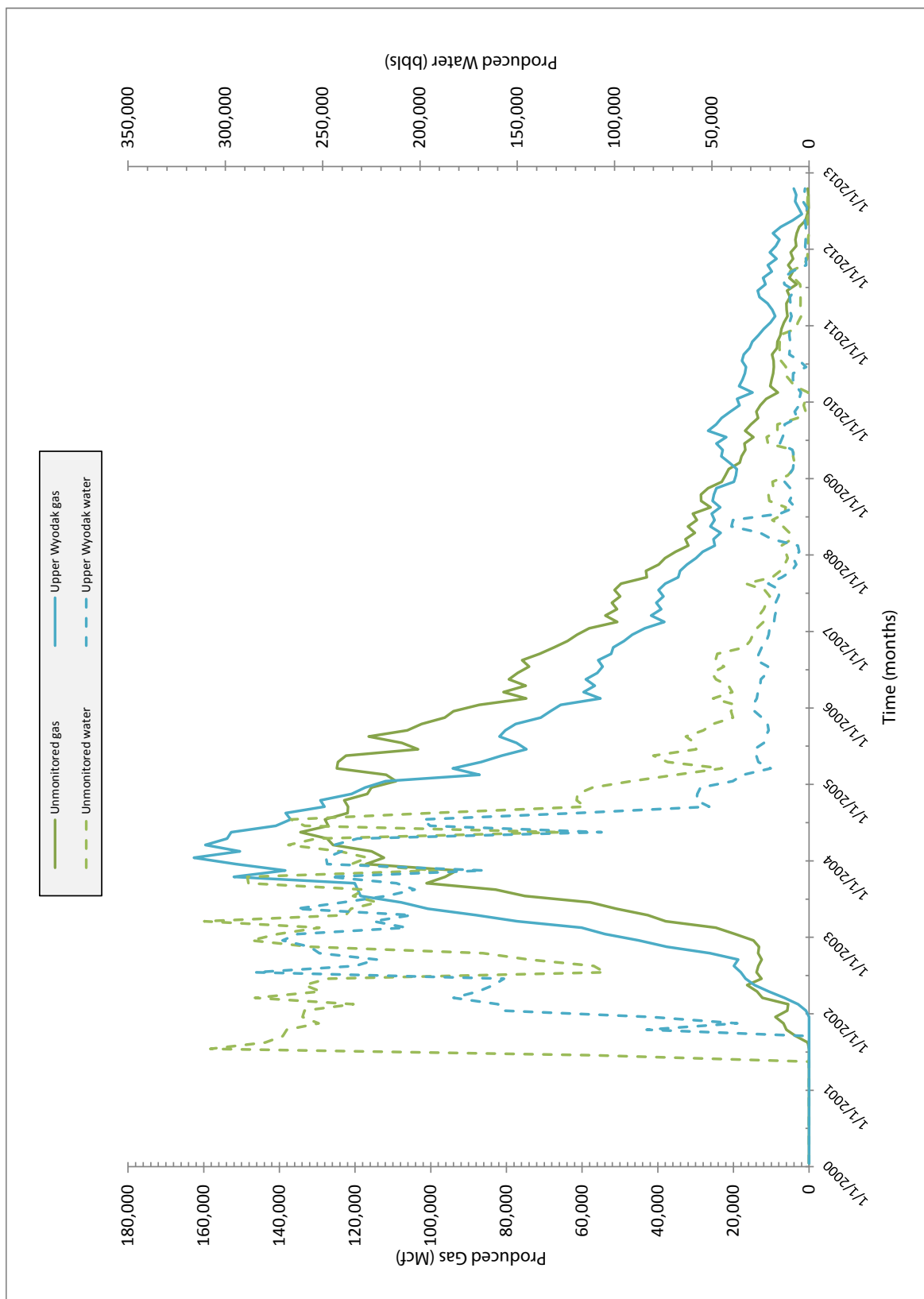
**Figure A21.** Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Bar 76 monitoring wellsite location.



**Figure A.22.** Bar 76 monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

Peak water production of 285,000 bbls/month was reached in 2002 in the Upper Wyodak coal zone (Figure A.23). Monthly water production exceeded 200,000 bbls during most months from 2002-2004 and then rapidly declined in 2005; maximum water production for the 2010-2012 POR was only 13,000 bbls/month. Gas production in the Upper Wyodak increased rapidly in early 2002, peaked at 163,000 Mcf/month in 2004, and declined to 3,400 Mcf/month by the end of the 2010-2012 POR..

Water production in unmonitored coal zones increased from 0 to 308,000 bbls/month in 2001, and remained high until early 2005, after which it decreased substantially and did not exceed 50,000 bbls/month from 2006-2012 (Figure A.23). Gas production in unmonitored coal zones peaked at 135,000 Mcf in May of 2004 and gradually declined to less than 1,000 Mcf/month by the end of the 2010-2012 POR.



**Figure A.23.** Water and gas production from CBNB wells associated with the Bar 76 monitoring well site location.



**Barrett Persson Monitoring Well Site**  
**Location: S32 T47N R73W**  
**Date First Monitored: December 6, 2000**

**Drawdown Information**

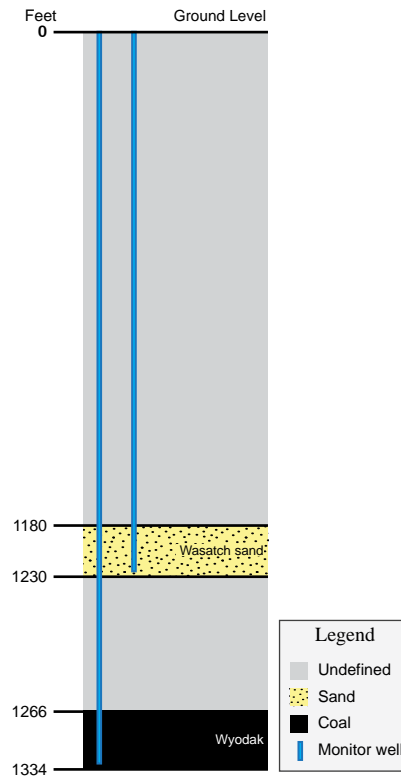
The Barrett Person monitoring well site includes two wells. One is completed in the Wasatch sandstone and the other in the Wyodak coal of the Upper Wyodak coal zone (Figure A.24; Table A.12). Water levels and wellhead gas pressures were measured during the POR using both manual and automatic transducer and data logger equipment. Transducer data that is missing, randomly fluctuating (noisy) or that substantially differs from concurrent manual measurements may indicate on-site equipment failure, malfunction or requirement for calibration.

**Wasatch Sandstone**

During the 2010-2012 POR, groundwater levels rose 2.96 feet in the Wasatch sandstone; groundwater levels declined 305.30 feet over the monitoring period of 2000-2009. (Figure A.25; Table A.13). Gas pressure was not recorded in the Wasatch sandstone.

**Wyodak Coal**

Groundwater levels rose 20.43 feet during the 2010-2012 POR. During the monitoring period of 2000-2009, water levels declined 207.03 feet (Figure A.25; Table A.13). The gas pressure data record exhibits apparent frequent random fluctuations, and gaps where transducer measurements were not obtained. The available data, however, indicate that gas pressure in the Wyodak coal did peak at 18 psi in 2008 and has been zero during the 2010-2012 POR.



**Figure A.24.** Section showing relative positions of coals and sands in feet. Not to scale.

**Table A.12.** Table showing the depth to and thickness of monitored zones at the Barrett Persson monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Wasatch sand	1,180	1,230	50	36
Wyodak Coal	1,266	1,334	68	n/a

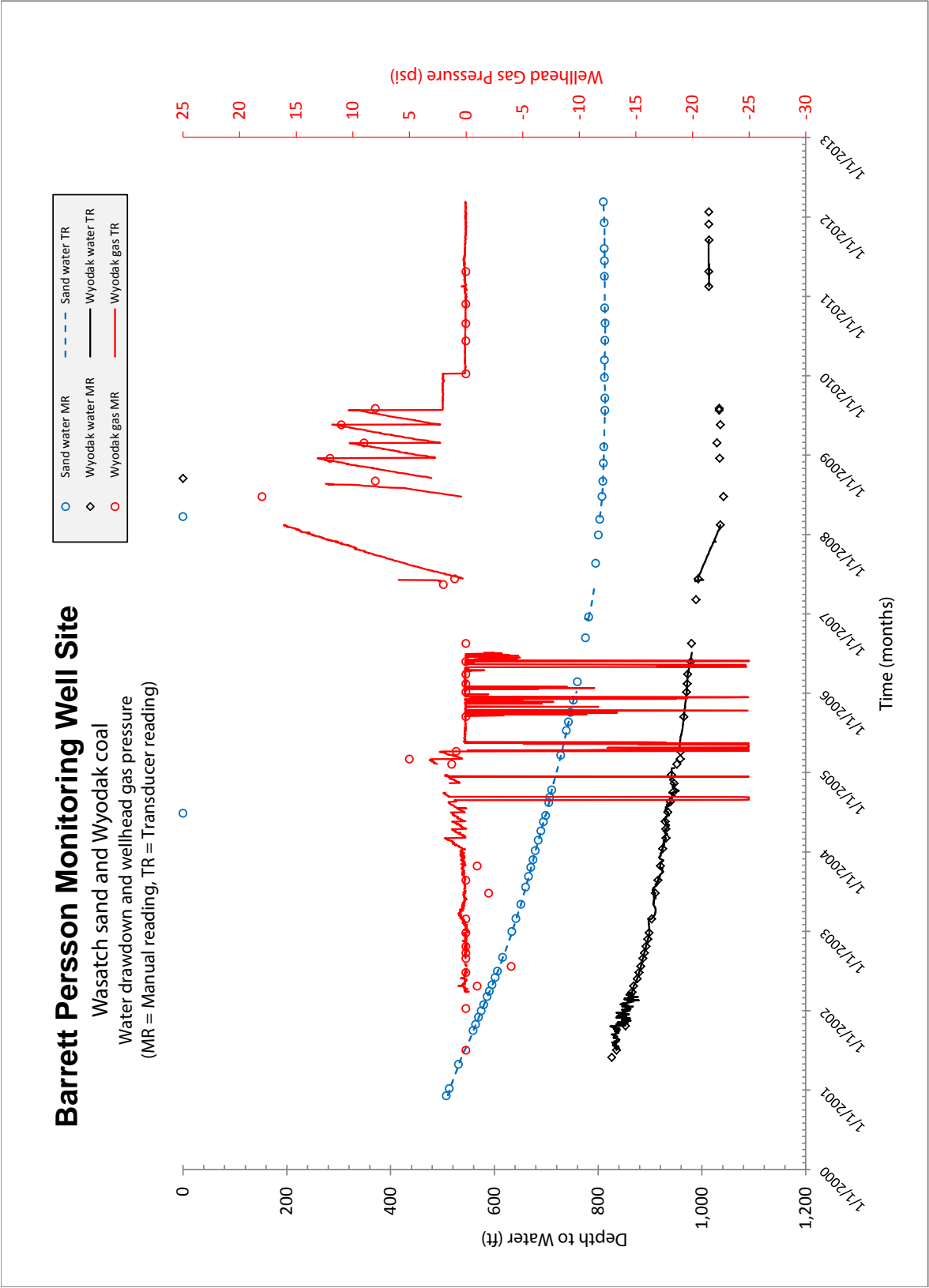
**Table A.13.** Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2010	Drawdown 2010-2012	Total drawdown (ft.)	Depth to Final water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	507.76	305.30	-2.96	302.34	810.10	n/a	n/a
Wyodak Coal	826.27	207.03	-20.43	186.60	1012.87	16.09	2/14/2008

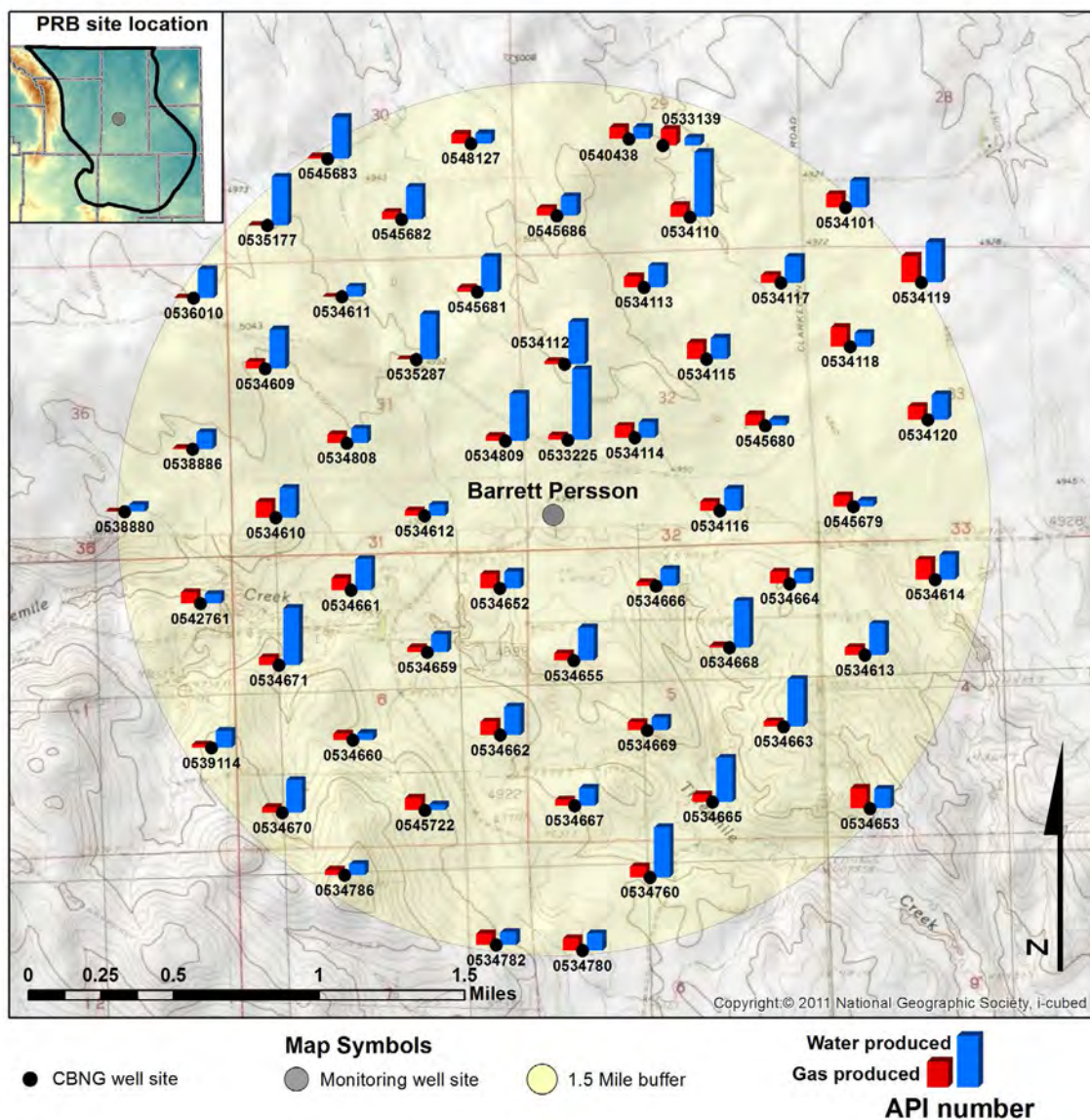
### Production Statistics

Production data were analyzed for CBNG wells within the buffer of the Barrett Persson monitoring well site from 1998-2012. Cumulative production for individual CBNG wells is displayed by location on Figure A.26. CBNG production is monitored in the Upper Wyodak and unmonitored coal zones. A peak water production level of almost 1.2 million bbls was reached in February 2000 in the Upper Wyodak coal zone (Figure A.27). Monthly

water production levels then rapidly declined the following month and remained around 100,000 bbls/month until 2009. Water production levels declined again to approximately 3,000 bbls/month for 2012. Monthly gas production levels in the Upper Wyodak rose rapidly in 2000, remained high, peaking at 82,000 Mcf/month in 2005, and then declined from 2006-2012, ending 2012 at 1,700 Mcf.

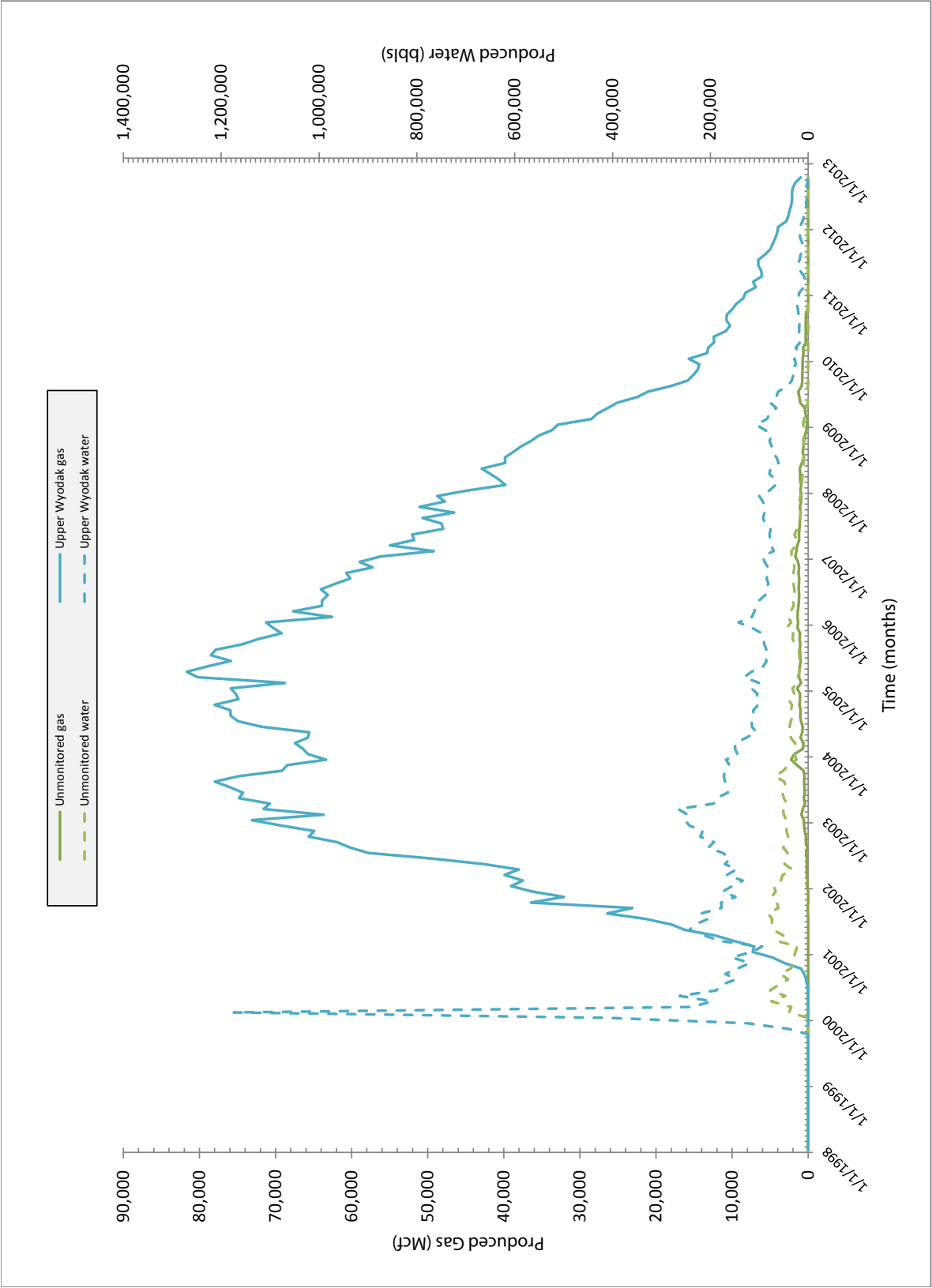


**Figure A.25.** Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Barrett Persson monitoring wellsite location.



**Figure A.26.** Barrett Persson monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

The unmonitored coal zones have seen low but consistent water production from 1999-2009 peaking at 82,000 bbls. Water production declined to zero in late 2009 and has not changed since then (Figure A.27). Gas production in the unmonitored coal zones began in 2001 and remained under 2,000 Mcf/month until production ceased in late 2010.



**Figure A.27.** Water and gas production from CBNG wells associated with the Barrett Persson monitoring well site location.

**Barton Monitoring Well Site**  
**Location: S3 T54N R76W**  
**Date First Monitored: January 23, 2002**

**Drawdown Information**

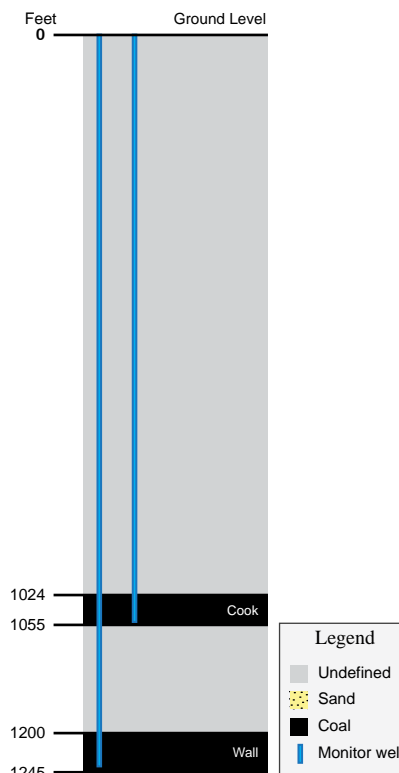
The Barton monitoring well site includes two wells. One is completed in the Cook coal of the Cook coal zone and the other in the Wall coal of the Wall coal zone (Figure A.28; Table A.14). Water levels and wellhead gas pressures were measured during the POR using both manual and automatic transducer and data logger equipment. Transducer data that is missing, randomly fluctuating (noisy) or that substantially differs from concurrent manual measurements may indicate on-site equipment failure, malfunction or requirement for calibration.

**Cook Coal**

During the 2010-2012 POR, groundwater levels rose 45.92 feet in the Cook coal; groundwater levels declined 163.85 feet over the monitoring period of 2002-2009 (Figure A.29; Table A.15). Gas pressure in the Cook coal remained relatively stable over the monitoring period of 2002-2012 peaking at 0.29 psi in 2012.

**Wall Coal**

Groundwater levels declined 2.07 feet during the 2010-2012 POR. During the monitoring period of 2002-2009, water levels declined 14.89 feet (Figure A.29; Table A.15). Gas pressure fluctuated considerably over a very small interval, never surpassing 1.22 psi over the life of the well.



**Figure A.28.** Section showing relative positions of coals and sands in feet. Not to scale.



**Table A.14.** Table showing the depth to and thickness of monitored zones at the Barton monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Cook coal	1,024	1,055	31	n/a
Wall coal	1,200	1,245	45	n/a

**Table A.15.** Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

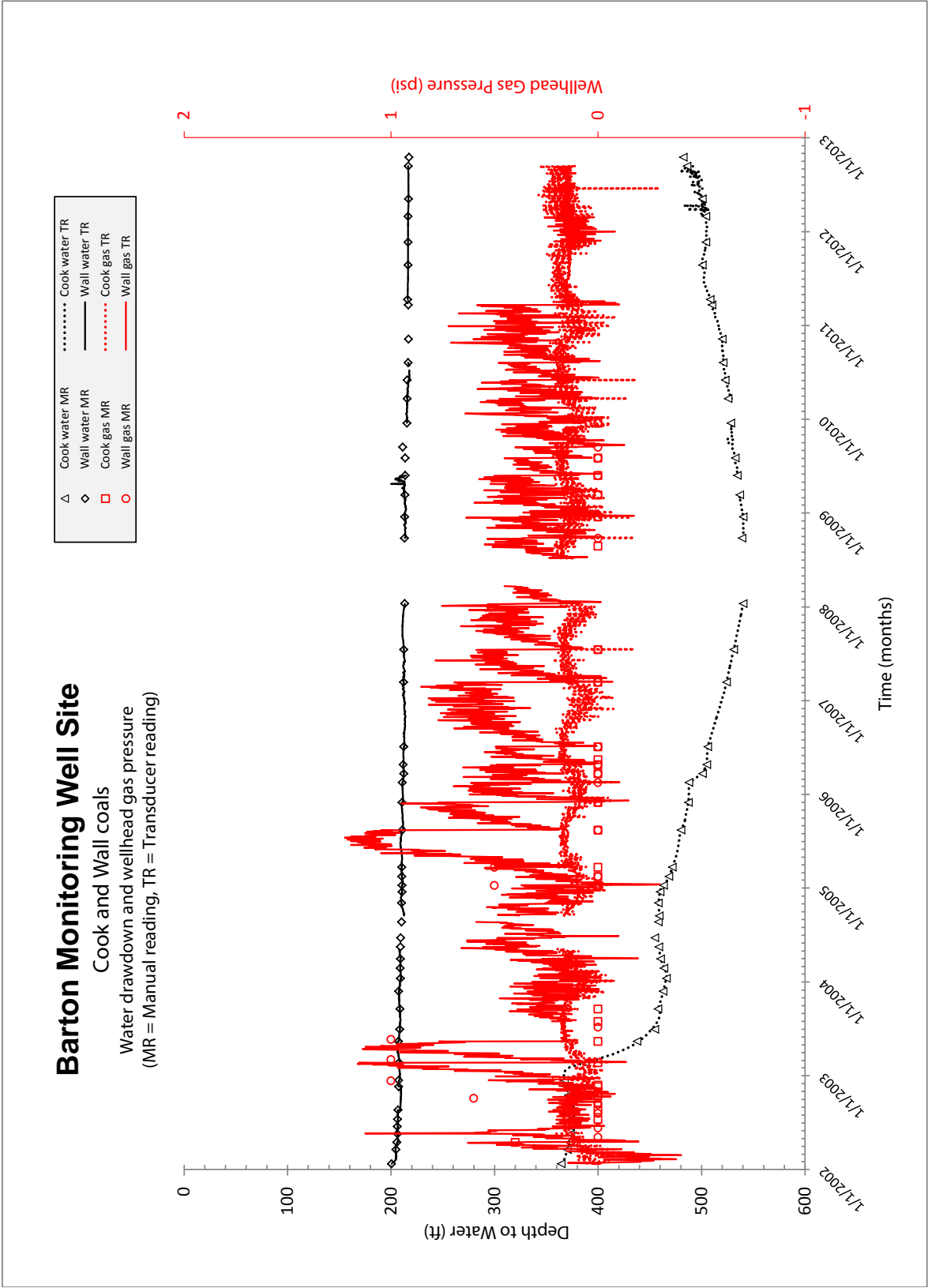
Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2010	Drawdown 2010-2012	Total drawdown (ft.)	Depth to Final water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Cook coal	364.56	163.85	-45.92	117.93	482.49	0.29	5/22/2012
Wall coal	200.48	14.89	2.07	16.96	217.44	1.22	7/16/2005

### Production Statistics

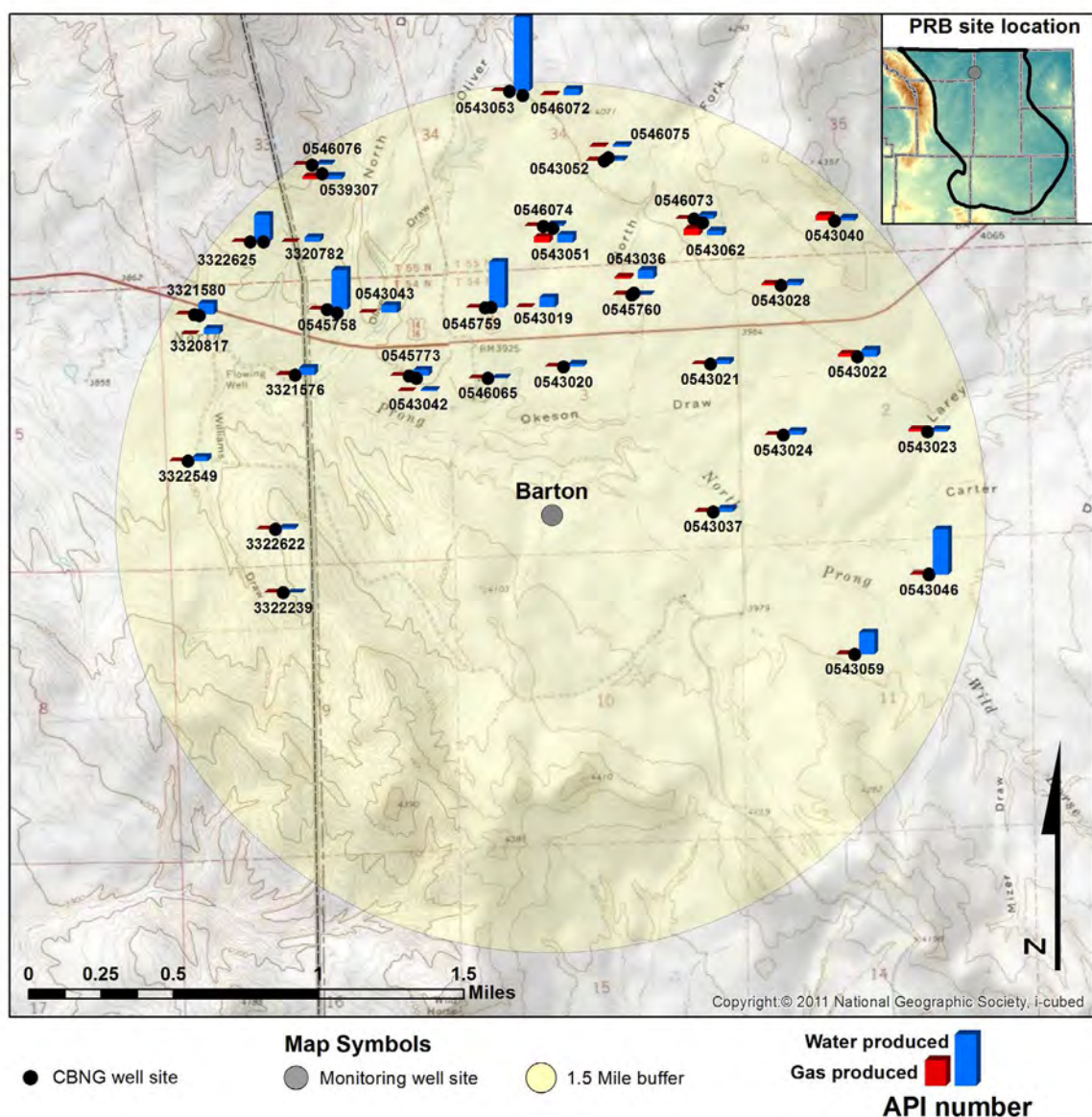
Production data were analyzed for CBNG wells within the buffer of the Barton monitoring well site from 2000-2012. Cumulative production for individual CBNG wells is displayed by location on Figure A.30. CBNG and water production is

monitored in the Cook, Wall and unmonitored coal zones.

Water production levels peaked in the Cook coal zone in May 2000 at 110,178 bbls, then declined afterwards, reaching 0.00 bbls/month by 2012



**Figure A.29.** Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Barton monitoring wellsite location.



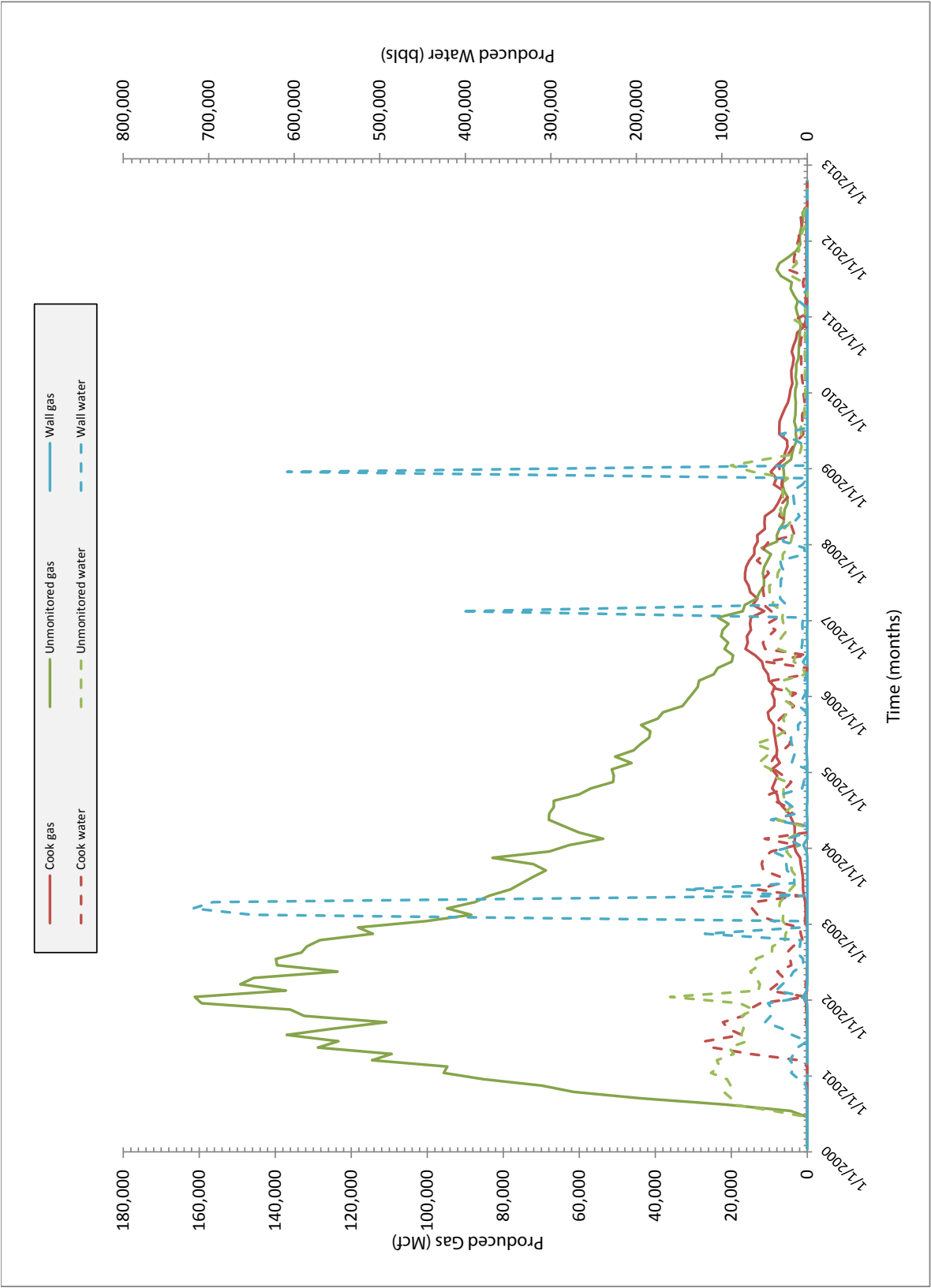
**Figure A.30.** Barton monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

(Figure A.31). Gas production in the Cook increased gradually from 2002-2007, peaking at nearly 60,000 Mcf/month, then slowly declined to zero by the end of the 2010-2012 POR..

Water production in the Wall coal reached several sharp peaks in 2003, 2007, and late 2008; there was no water production during the last five months of 2012 (Figure A.31). Gas production in

the Wall has always been low and sporadic and has never exceeded 1,100 Mcf/month.

Water production in the unmonitored coal zone production rose during 2000-2002, peaked at 160,289 bbls in January 2002 and declined to zero in 2012 (Figure A.31). Gas production in unmonitored coal zones peaked in December 2001 at about 160,000 Mcf and declined to zero by the end of the 2010-2012 POR.



**Figure A.31.** Water and gas production from CBNG wells associated with the Barton monitoring well site location.

**Bear Draw Monitoring Well Site**  
**Location: S1 T50N R79W**  
**Date First Monitored: March 11, 2006**

**Drawdown Information**

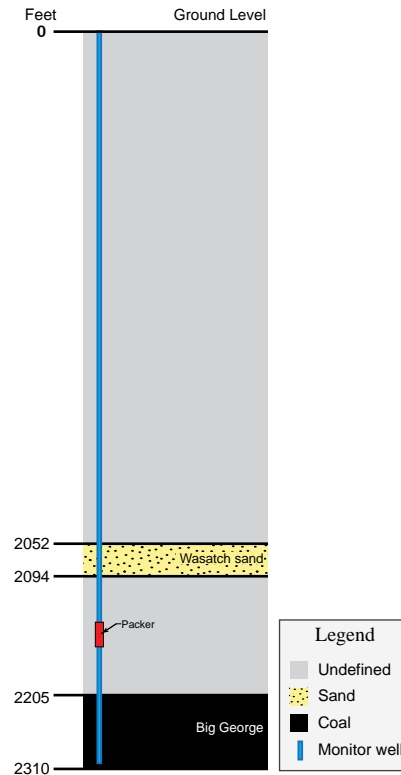
The Bear Draw monitoring well site includes one dual completion well, separated by a packer. The well is completed in a Wasatch sandstone and the Big George coal of the Wyodak Rider coal zone (Figure A.32; Table A.16). Water levels and wellhead gas pressures were measured during the POR using both manual and automatic transducer and data logger equipment. Transducer data that is missing, randomly fluctuating (noisy) or that substantially differs from concurrent manual measurements may indicate on-site equipment failure, malfunction or requirement for calibration.

**Wasatch Sandstone**

During the 2010-2012 POR, groundwater levels fell 146.29 feet in the Wasatch sandstone; groundwater levels declined 26.74 feet over the monitoring period of 2006-2009. (Figure A.33; Table A.17). Gas pressure was not recorded in the Wasatch sandstone.

**Big George Coal**

Groundwater levels declined 243.68 feet during the 2010-2012 POR. During the monitoring period of 2006-2009, water levels declined 484.02 feet (Figure A.33; Table A.17). Gas pressures in the Big George, which remained relatively stable over the monitoring period of 2006-2012, peaked at 0.23 psi in June 2007.



**Figure A.32.** Section showing relative positions of coals and sands in feet. Not to scale.

**Table A.16.** Table showing the depth to and thickness of monitored zones at the Bear Draw monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Wasatch sand	2,052	2,094	42	111
Big George coal	2,205	2,310	105	n/a

**Table A.17.** Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

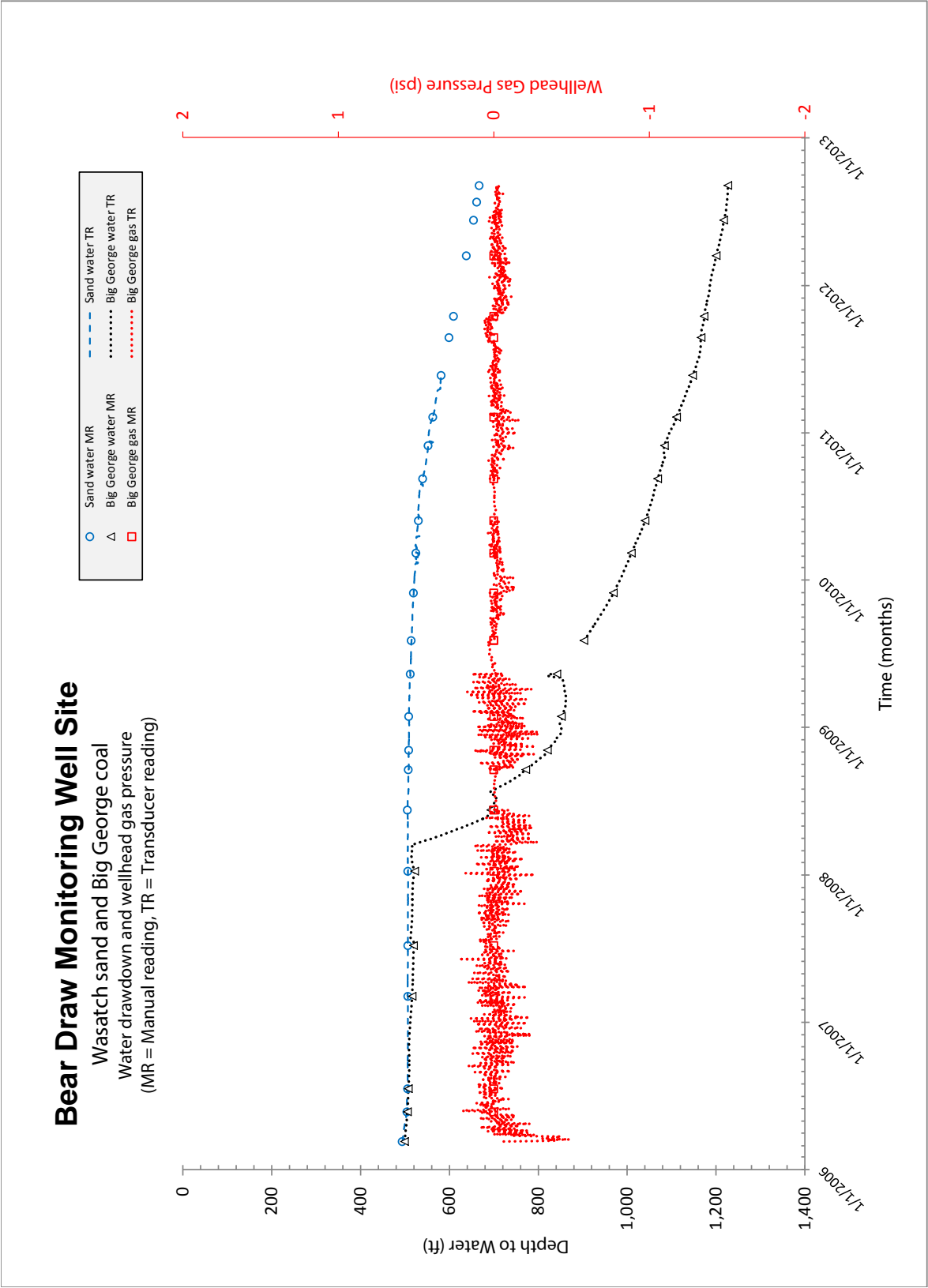
Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2010	Drawdown 2010-2012	Total drawdown (ft.)	Depth to Final water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	494.20	26.74	146.29	173.03	667.23	n/a	n/a
Big George coal	499.30	484.02	243.68	727.70	1227.00	0.23	6/6/07

### Production Statistics

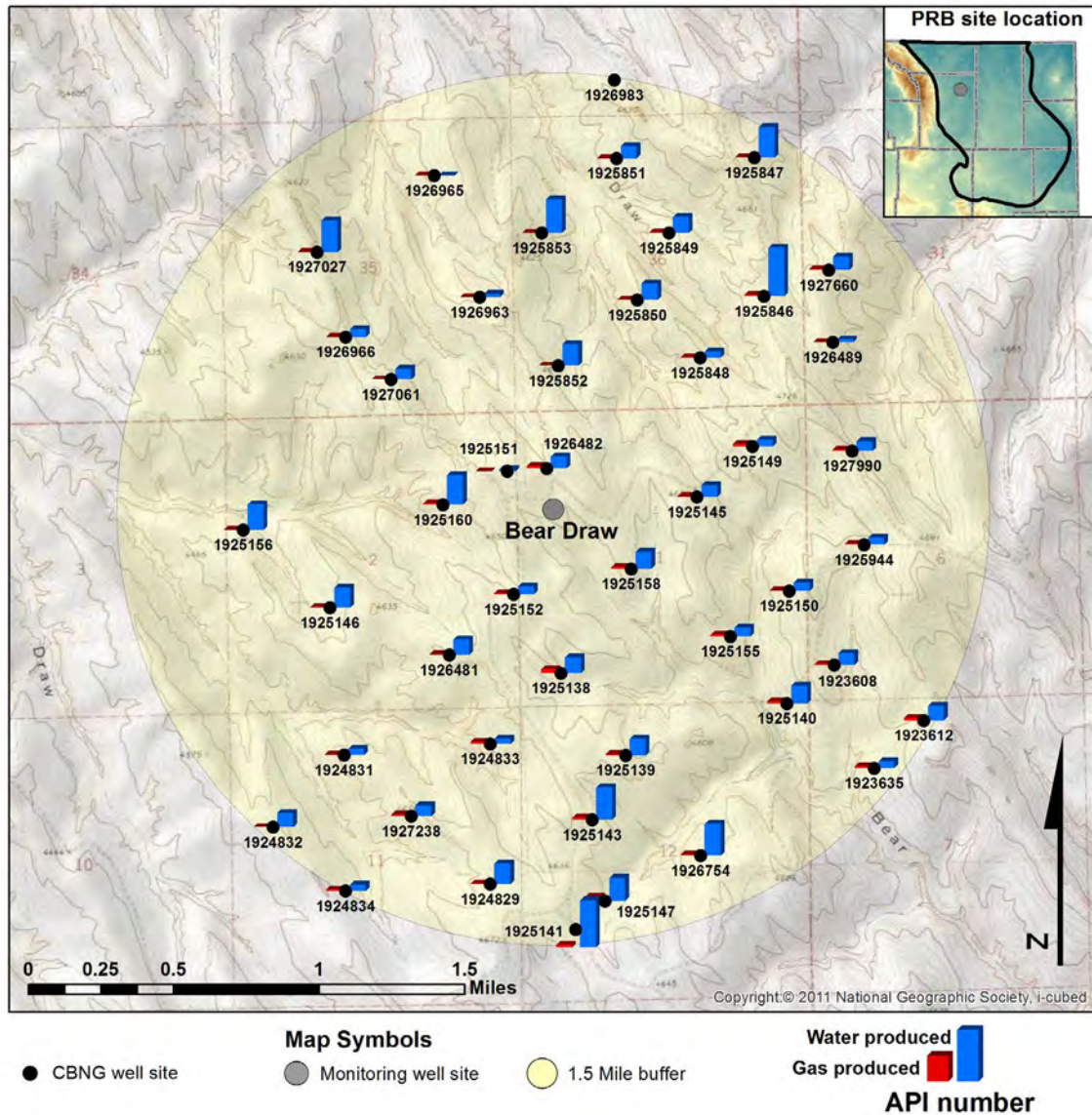
Production data were analyzed for CBNG wells within the buffer of the Bear Draw monitoring well site from 2005-2012. Cumulative production for individual CBNG wells is displayed by location on Figure A.34. CBNG production is monitored in the Wyodak Rider, multiple coal and unmonitored coal zones.

Water production in the Wyodak Rider declined to 43,000 bbls/month at the end of the 2010-2012 POR from the peak reached in May 2011 of 195,000 bbls (Figure A.35). Gas production in the Wyodak Rider peaked at nearly 30,000 Mcf in January of 2012, and then declined by about half by the end of the 2010-2012 POR.





**Figure A.33.** Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Bear Draw monitoring wellsite location.

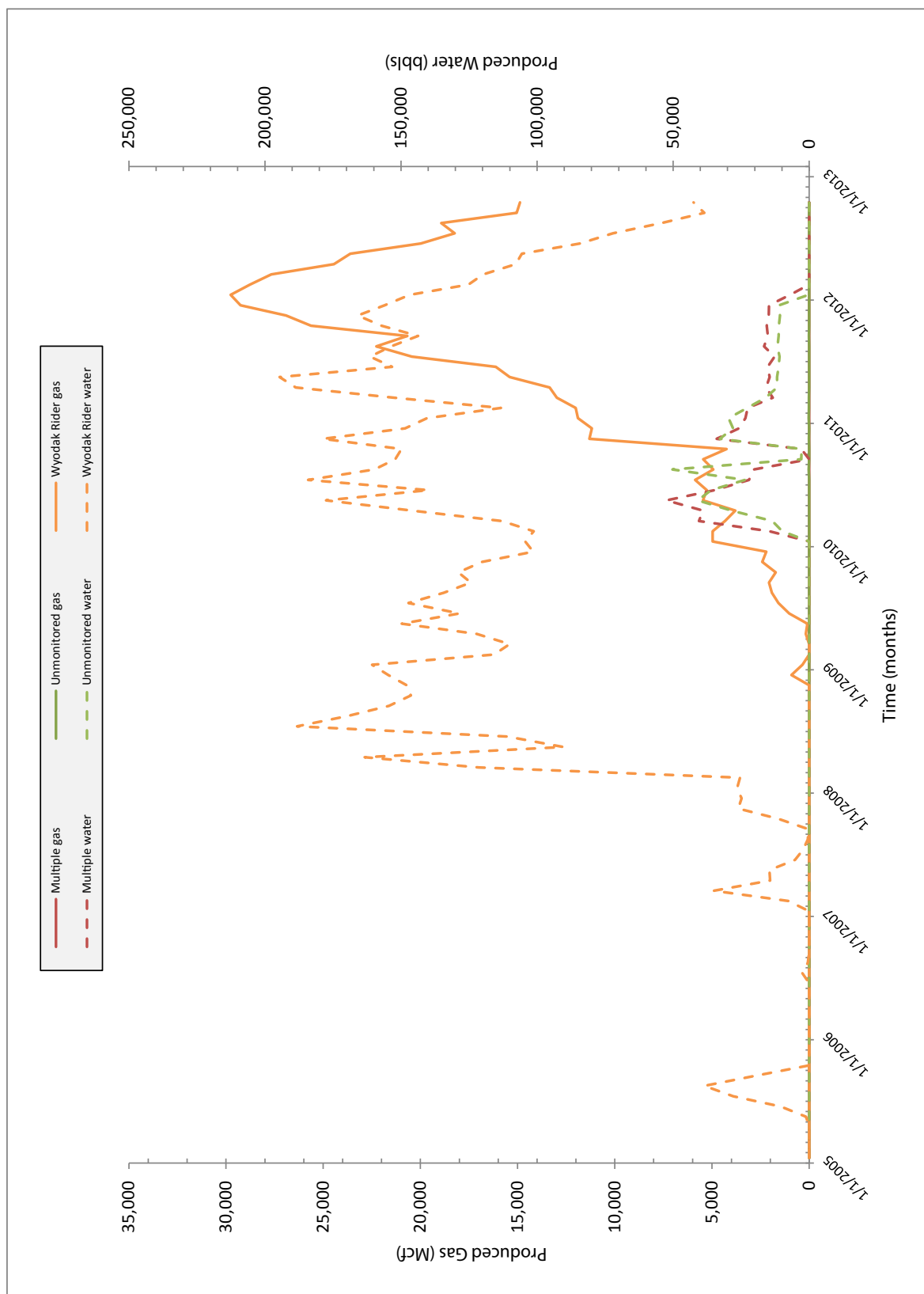


**Figure A.34.** Bear Draw monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

Water production levels in the multiple coal zone wells peaked at 52,472 bbls in May 2010 and then declined to zero by February 2012 (Figure A.35). No gas was produced from the multiple zone wells over the monitoring period.

Water production in the unmonitored coal zone production peaked at 50,228 bbls in August 2010, then declined to zero by the end of 2010 (Figure A.35). Gas production in the unmonitored coal

zones never exceeded 21 Mcf/ month, and no gas was produced in 2012.



**Figure A.35.** Water and gas production from CBNNG wells associated with the Bear Draw monitoring well site location.

**Beaver Fed Monitoring Well Site**  
**Location: S23 T47N R75W**  
**Date First Monitored: April 23, 2003**

**Drawdown Information**

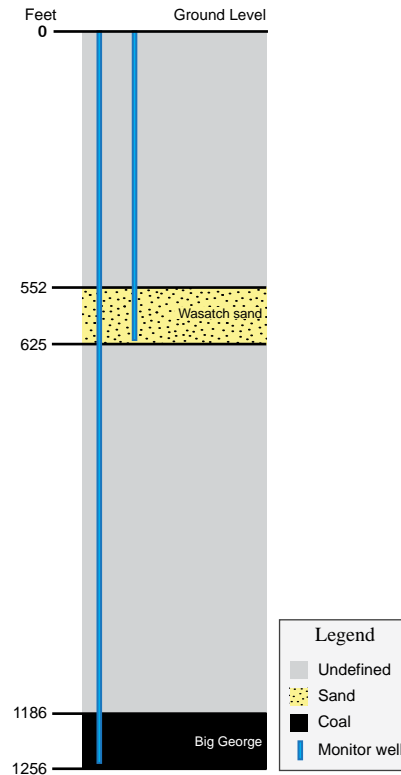
The Beaver Fed monitoring well site includes two wells. One is completed in the Wasatch sandstone and the other in the Big George coal of the Wyodak Rider coal zone (Figure A.36; Table A.18). Water levels and wellhead gas pressures were measured during the POR using both manual and automatic transducer and data logger equipment. Transducer data that is missing, randomly fluctuating (noisy) or that substantially differs from concurrent manual measurements may indicate on-site equipment failure, malfunction or requirement for calibration.

**Wasatch Sandstone**

During the 2010-2012 POR, groundwater levels fell 2.55 feet in the Wasatch sandstone; groundwater levels declined 0.59 feet over the monitoring period of 2003-2009. (Figure A.37; Table A.19). Gas pressure was not recorded in the Wasatch sandstone.

**Big George Coal**

Groundwater levels declined 504.25 feet during the 2003-2009 monitoring period. Due to high gas pressure during the 2010-2012 POR water level measurements could not be taken. Gas pressure peaked in September 2005 at 141.3 psi (Figure A.37; Table A.19).



**Figure A.36.** Section showing relative positions of coals and sands in feet. Not to scale.

**Table A.18.** Table showing the depth to and thickness of monitored zones at the Beaver Fed monitoring well site location. (measured in feet)

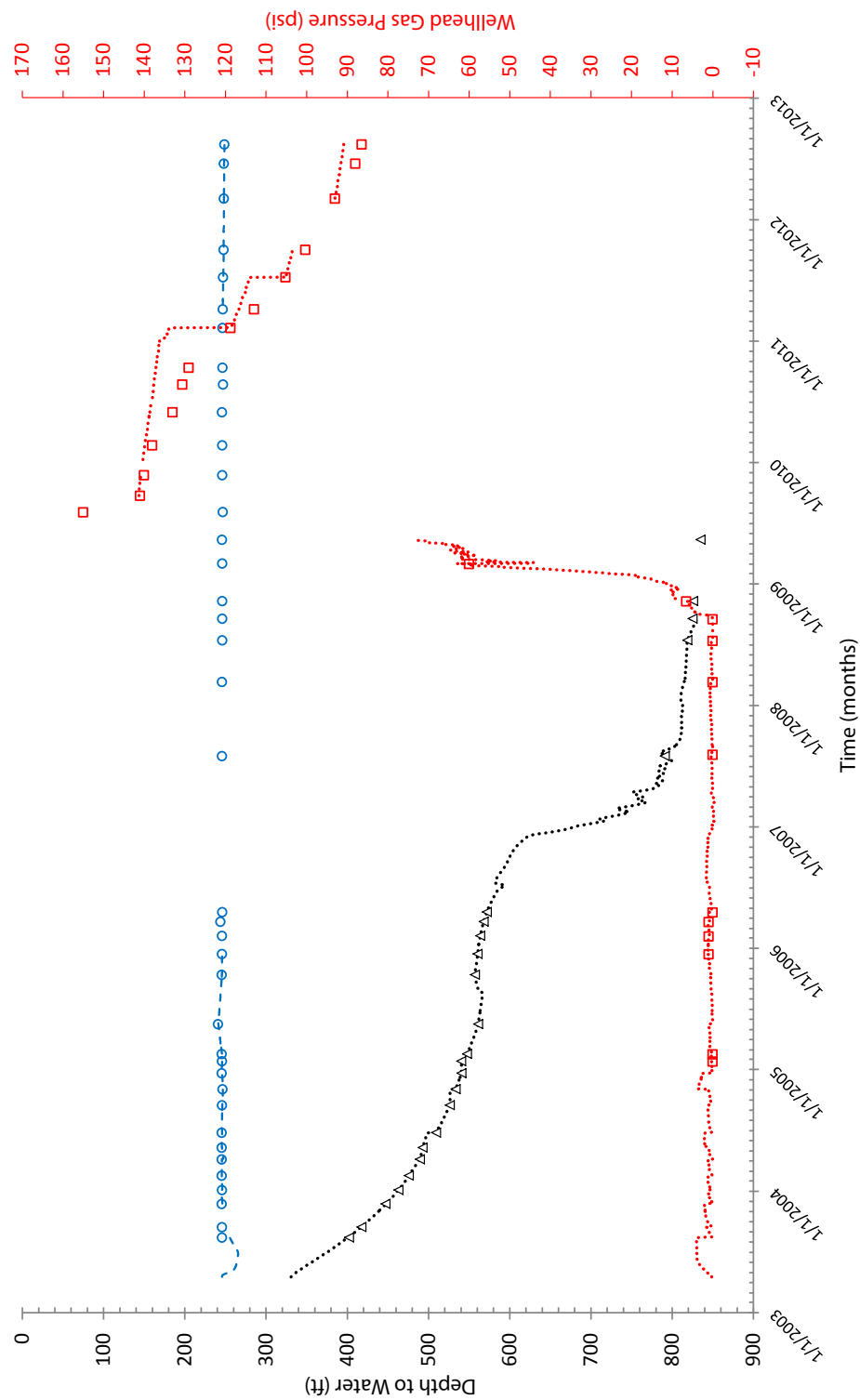
Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Wasatch sand	552	625	73	561
Big George coal	1,186	1,256	70	n/a

**Table A.19.** Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2010	Drawdown 2010-2012	Total drawdown (ft.)	Depth to Final water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	245.66	0.59	2.55	3.14	248.80	n/a	n/a
Big George coal	330.80	504.25	n/a	n/a	n/a	141.30	9/23/2009

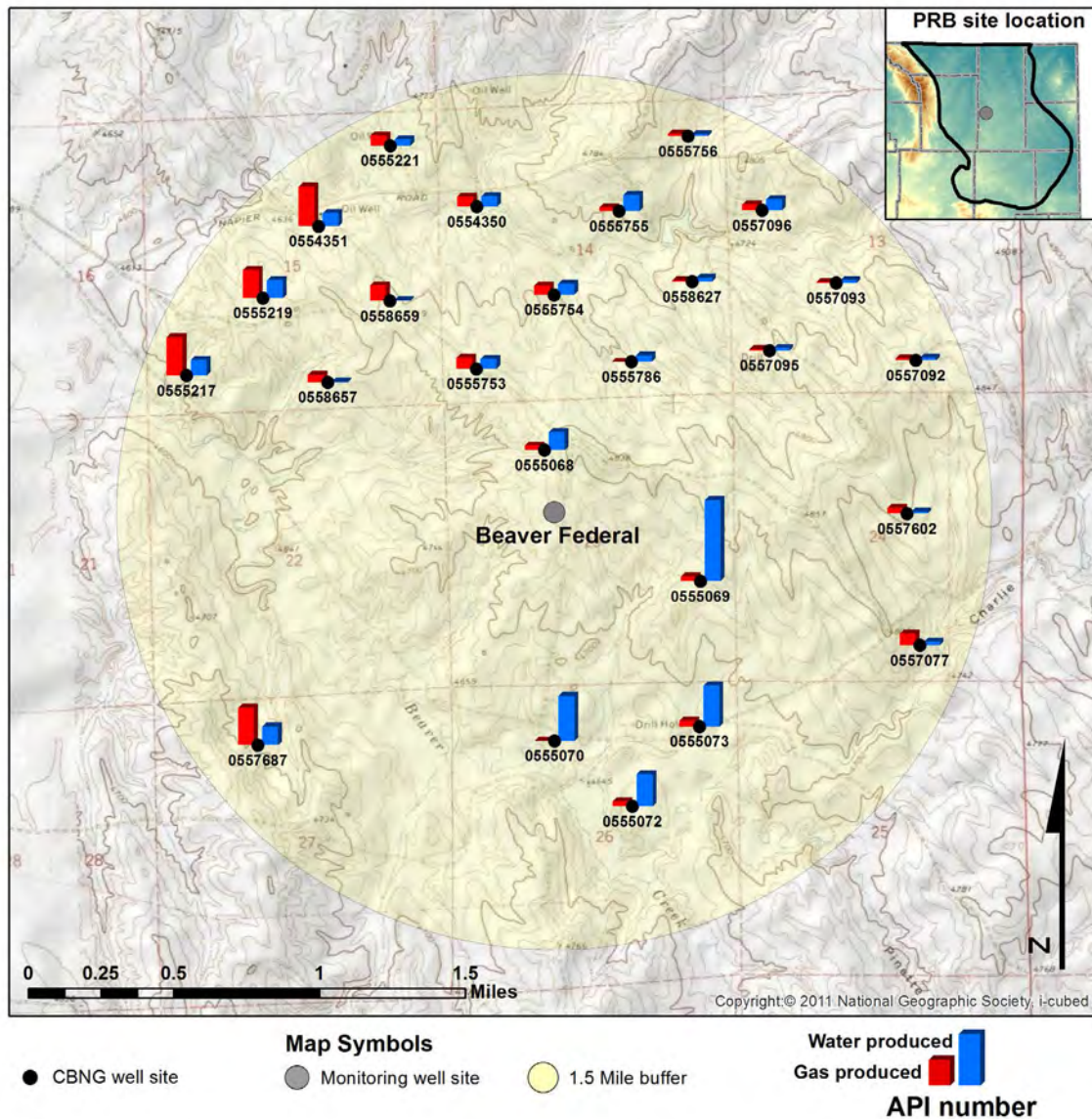
## Beaver Fed Monitoring Well Site

Wasatch sand and Big George coal  
Water drawdown and wellhead gas pressure  
(MR = Manual reading, TR = Transducer reading)



**Figure A.37.** Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Beaver Fed monitoring wellsite location.





**Figure A.38.** Beaver Fed monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

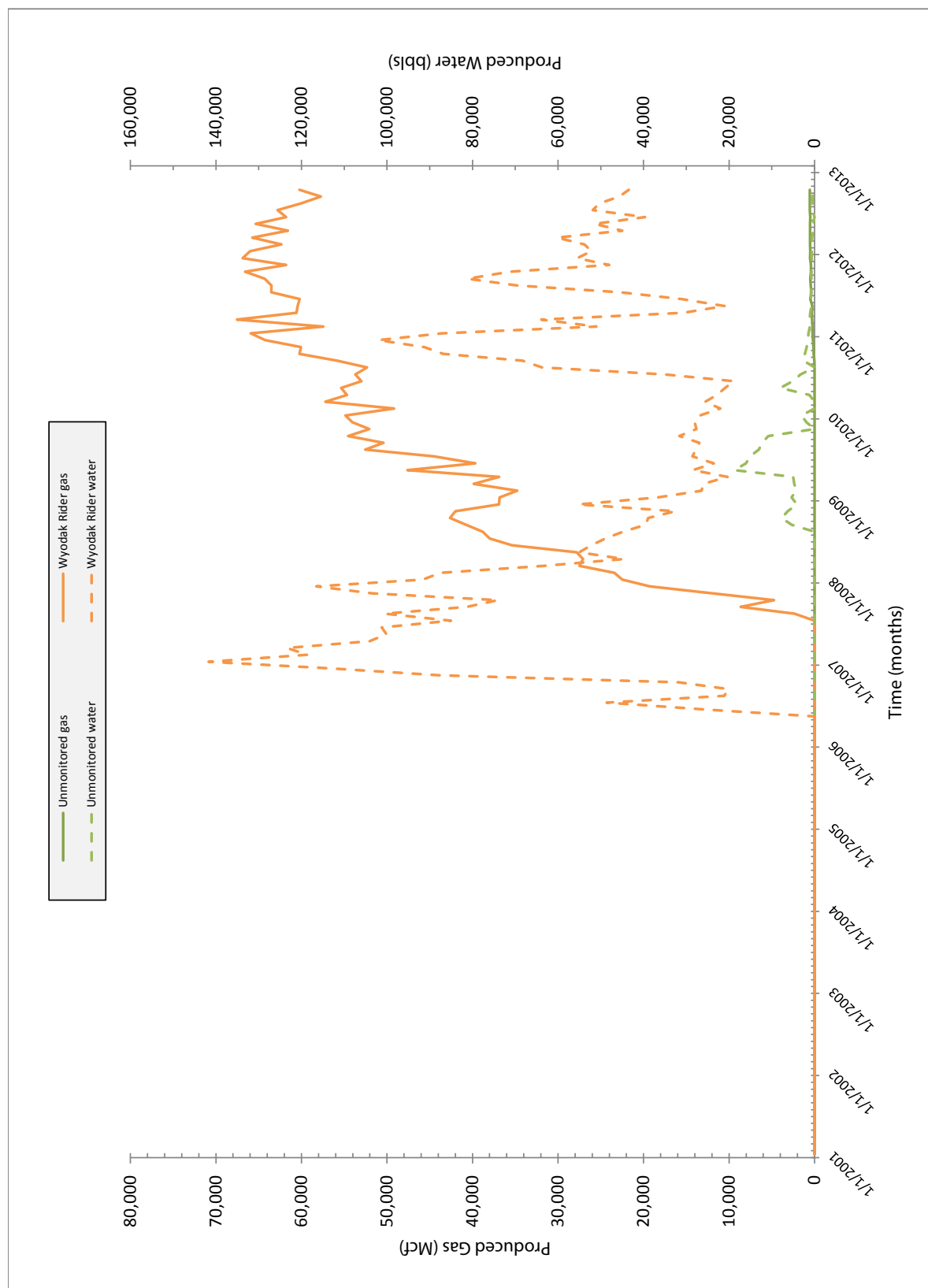
### Production Statistics

Production data were analyzed for CBNG wells within the buffer of the Beaver Fed monitoring well site from 2005-2012. Cumulative production for individual CBNG wells is displayed by location on Figure A.38. CBNG production is monitored in the Wyodak Rider and unmonitored coal zones.

Water production in the Wyodak Rider peaked at 141,699 bbls in January 2007 (Figure A.39). Gas

production levels peaked at nearly 67,000 Mcf/month in 2011 and finished 2012 at 60,000 Mcf/month.

Water production in the unmonitored coal zone wells peaked at nearly 19,000 bbls in May 2009 and declined by the end of the 2010-2012 POR to 409 bbls/month (Figure A.39). Gas production has been low but is increasing, reaching its maximum in October 2012 at 566 Mcf.



**Figure A.39.** Water and gas production from CBNNG wells associated with the Beaver Fed monitoring well site location.

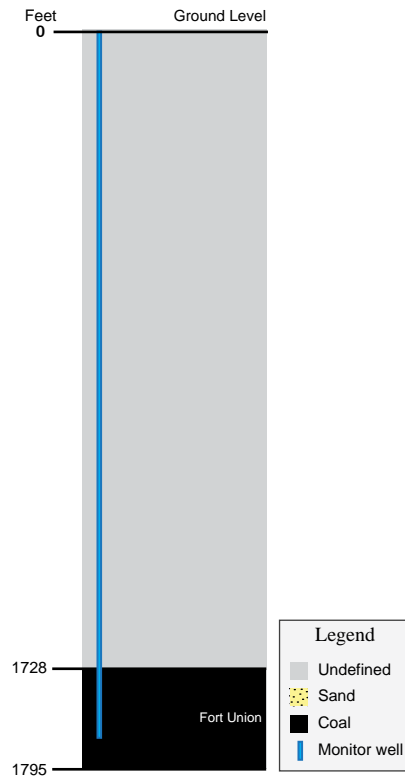
**Betop Monitoring Well Site**  
**Location: S32 T49N R75W**  
**Date First Monitored: December 1, 1991**

**Drawdown Information**

The Betop monitoring well site includes one well completed in the Fort Union coal; the coal zone is unknown (Figure A.40; Table A.20). Data for this well, during the 1991-2009 monitoring period, was recorded by the Wyoming State Engineer's Office (WSEO) with a shaft encoder reader. During the 2010-2112 POR an electronic tape was used to take measurements. The well has been reported to have a petroleum product in the water. BLM is awaiting word from the Wyoming Department of Environmental Quality (WDEQ) on what actions need to be taken to remediate the well.

**Fort Union Coal**

During the 2010-2012 POR, groundwater levels fell 105.02 feet in the Fort Union coal; water levels were stable from 1994-2007 then declined from 2008-2012 (Figure A.41; Table A.21). Gas pressure in the Fort Union coal was not recorded.



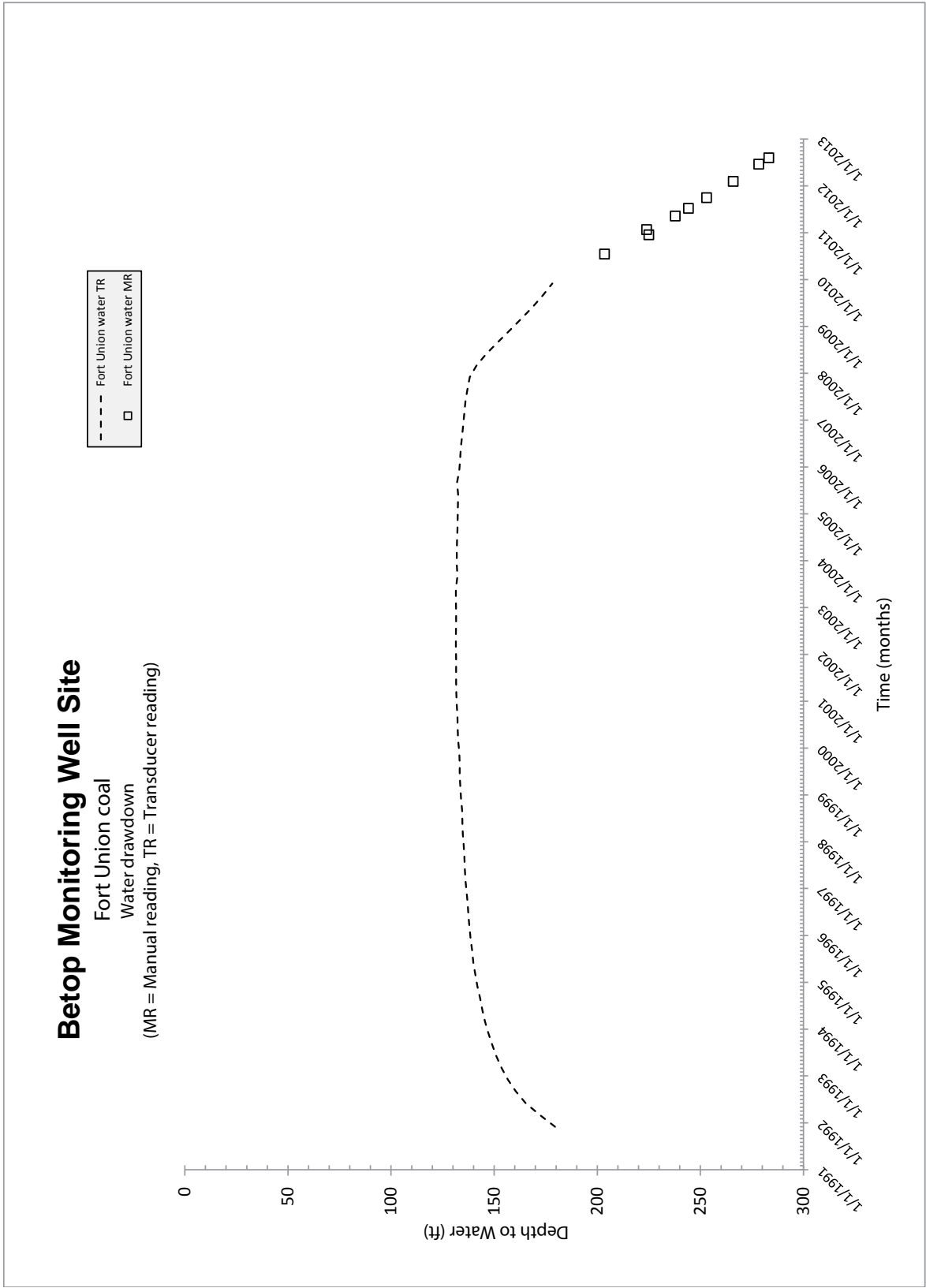
**Figure A.40.** Section showing relative positions of coals and sands in feet. Not to scale.

**Table A.20.** Table showing the depth to and thickness of monitored zones at the Betop monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Fort Union coal	1,728	1,795	67	n/a

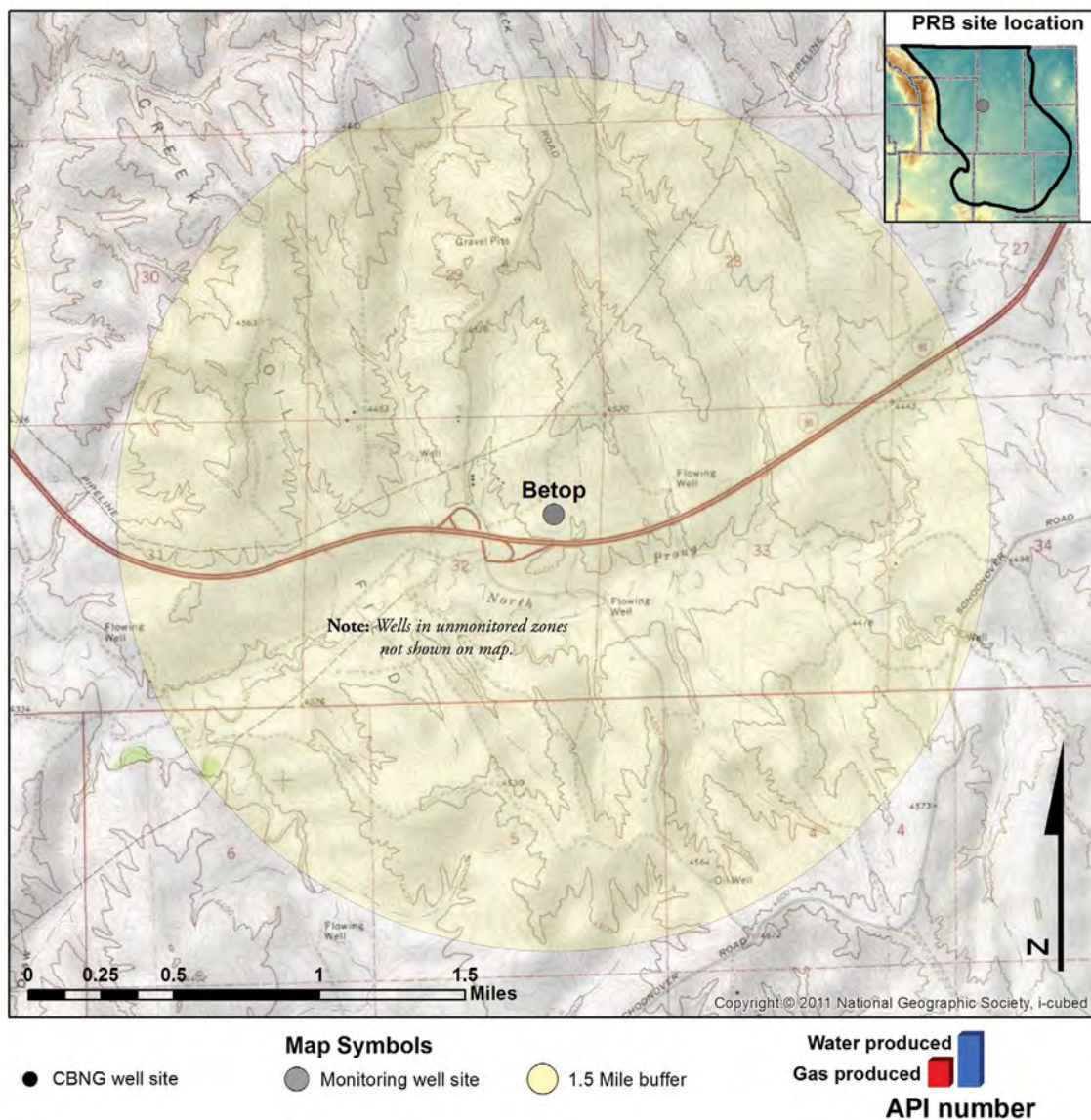
**Table A.21.** Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2010	Drawdown 2010-2012	Total drawdown (ft.)	Depth to Final water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Fort Union coal	179.49	-1.26	105.02	103.76	283.25	n/a	n/a



**Figure A.41.** Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Betop monitoring wellsite location.





**Figure A.42.** Betop monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

### Production Statistics

Production data were analyzed for CBNG wells within the buffer of the Betop monitoring well site. There has not been any gas or water production within the buffer area for the Betop monitoring well site (Figure A.42).



**Big Cat Monitoring Well Site**  
**Location: S24 T48N R79W**  
**Date First Monitored: July 10, 2003**

**Drawdown Information**

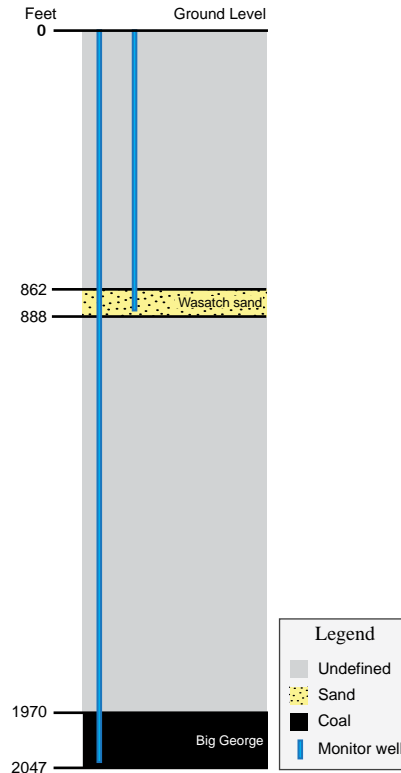
The Big Cat monitoring well site includes two wells; one is completed in the Wasatch sandstone and the other in the Big George coal of the Wyodak Rider coal zone (Figure A.43; Table A.22). Water levels and wellhead gas pressures were measured during the POR using both manual and automatic transducer and data logger equipment. Transducer data that is missing, randomly fluctuating (noisy) or that substantially differs from concurrent manual measurements may indicate on-site equipment failure, malfunction or requirement for calibration.

**Wasatch Sandstone**

During the 2010-2012 POR, groundwater levels rose 0.86 feet in the Wasatch sandstone; groundwater levels declined 2.24 feet over the monitoring period of 2003-2009 (Figure A.44; Table A.23). Gas pressure was not recorded in the Wasatch sandstone.

**Big George Coal**

During the 2010-2012 POR, groundwater levels declined 145.04 feet in the Big George coal; groundwater levels declined 986.02 feet over the monitoring period of 2003-2009 (Figure A.44; Table A.23). Gas pressure in the Big George coal peaked at 42.06 psi in 2012.



**Figure A.43.** Section showing relative positions of coals and sands in feet. Not to scale.

**Table A.22.** Table showing the depth to and thickness of monitored zones at the Big Cat monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Wasatch sand	862	888	26	1,082
Big George coal	1,970	2,047	77	n/a

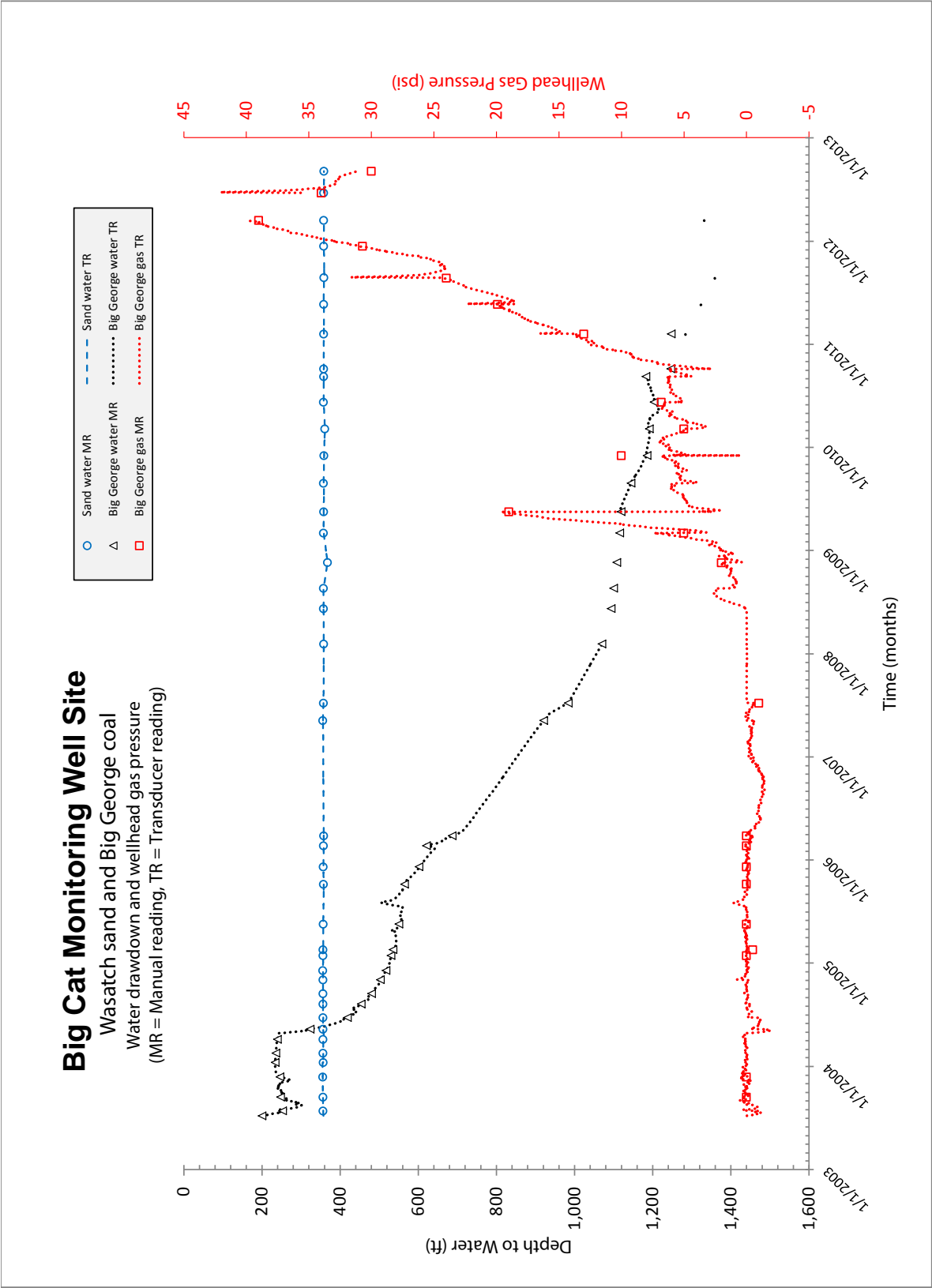
**Table A.23.** Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2010	Drawdown 2010-2012	Total drawdown (ft.)	Depth to Final water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	357.30	2.24	-0.86	1.38	358.68	n/a	n/a
Big George coal	200.24	986.02	145.04	1131.06	1331.30	42.08	6/22/12

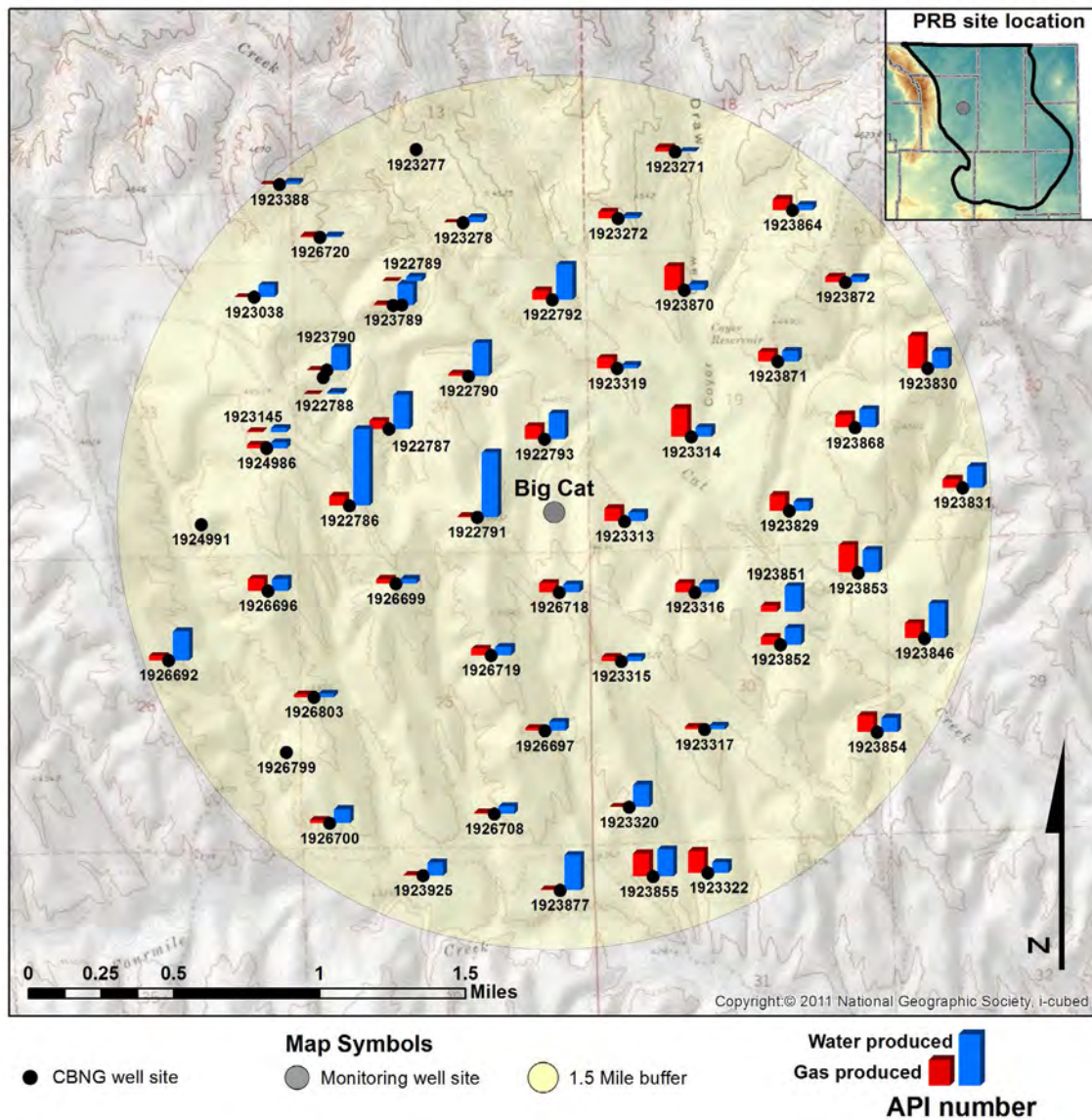
### Production Statistics

Production data were analyzed for CBNG wells within the buffer of the Big Cat monitoring well site from 2003-2012. Cumulative production for individual CBNG wells is displayed by location on Figure A.45. CBNG and water production are

monitored in Wyodak Rider, unmonitored zone and multiple zone wells.



**Figure A.44.** Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Big Cat monitoring wellsite location.

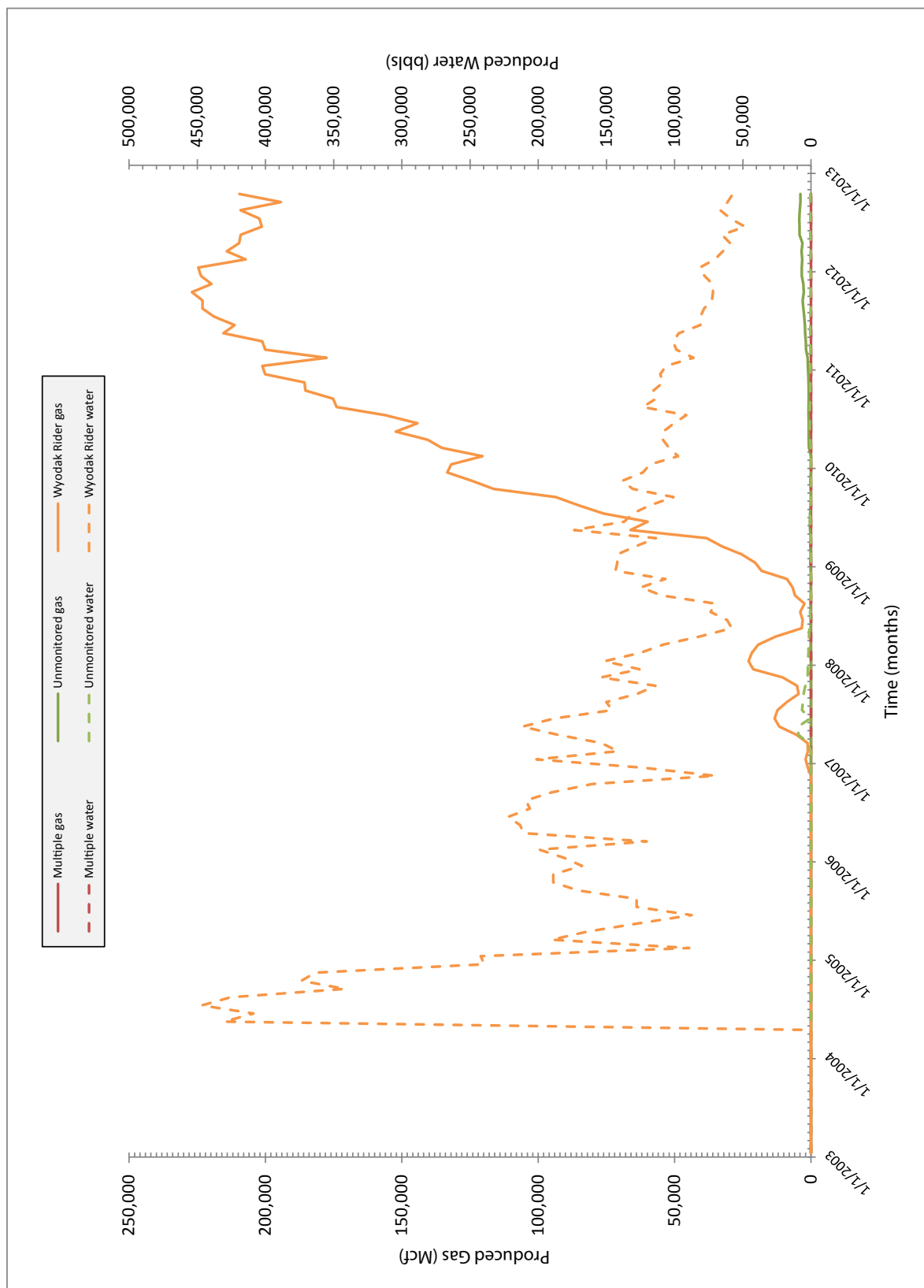


**Figure A.45.** Big Cat monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

Initial water production rates in the Wyodak Rider were quite high and peaked in July 2004 at 446,647 bbls. Water production leveled off somewhat after February 2005 and declined to 57,363 bbls/month by the end of the 2010-2012 POR (Figure A.46). Gas production in the Wyodak Rider began in 2006 and rapidly increased during 2008-2011 to a peak production rate of 226,946 Mcf in October 2011. Gas production in October 2012 was 209,592 Mcf.

There was no water or gas production recorded in the multiple zone wells for the monitoring period of 2003-2012 (Figure A.46).

Water production rates in unmonitored coal zone wells has been low and peaked in May 2007 at 9,467 bbls (Figure A.46). Gas production in the unmonitored coal zones began in March 2008 and gradually increased to a peak rate of 4,261 Mcf in July 2012.



**Figure A.46.** Water and gas production from CBNB wells associated with the Big Cat monitoring well site location.

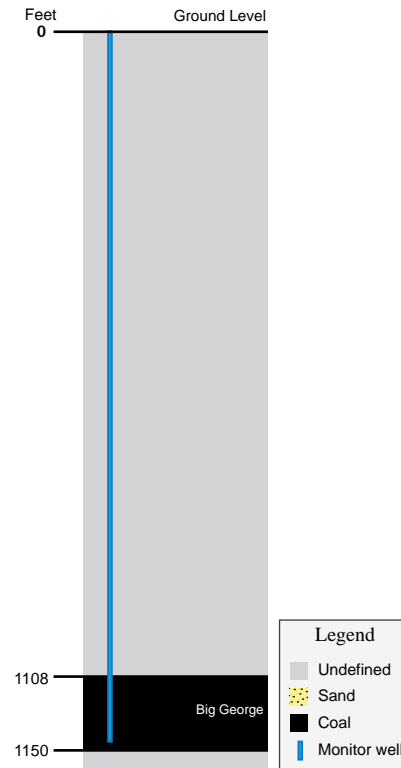
**Blackbird BG Monitoring Well Site**  
**Location: S16 T47N R74W**  
**Date First Monitored: July 17, 2002**

**Drawdown Information**

The Blackbird BG monitoring well site consists of one well completed in the Big George coal of the Wyodak Rider coal zone (Figure A.47; Table A.24). Water levels and wellhead gas pressures were measured during the POR using both manual and automatic transducer and data logger equipment. Transducer data that is missing, randomly fluctuating (noisy) or that substantially differs from concurrent manual measurements may indicate on-site equipment failure, malfunction or requirement for calibration.

**Big George Coal**

During the 2010-2012 POR, groundwater levels declined 21.45 feet in the Big George coal; groundwater levels declined 84.93 feet over the monitoring period of 2002-2009 (Figure A.48; Table A.25). Gas pressure in the Big George coal peaked at 0.50 psi in 2010.



**Figure A.47.** Section showing relative positions of coals and sands in feet. Not to scale.



**Table A.24.** Table showing the depth to and thickness of monitored zones at the Blackbird BG monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Big George coal	1,108	1,150	42	n/a

**Table A.25.** Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2010	Drawdown 2010-2012	Total drawdown (ft.)	Depth to Final water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Big George coal	489.07	84.93	21.45	106.38	595.45	0.50	10/25/10

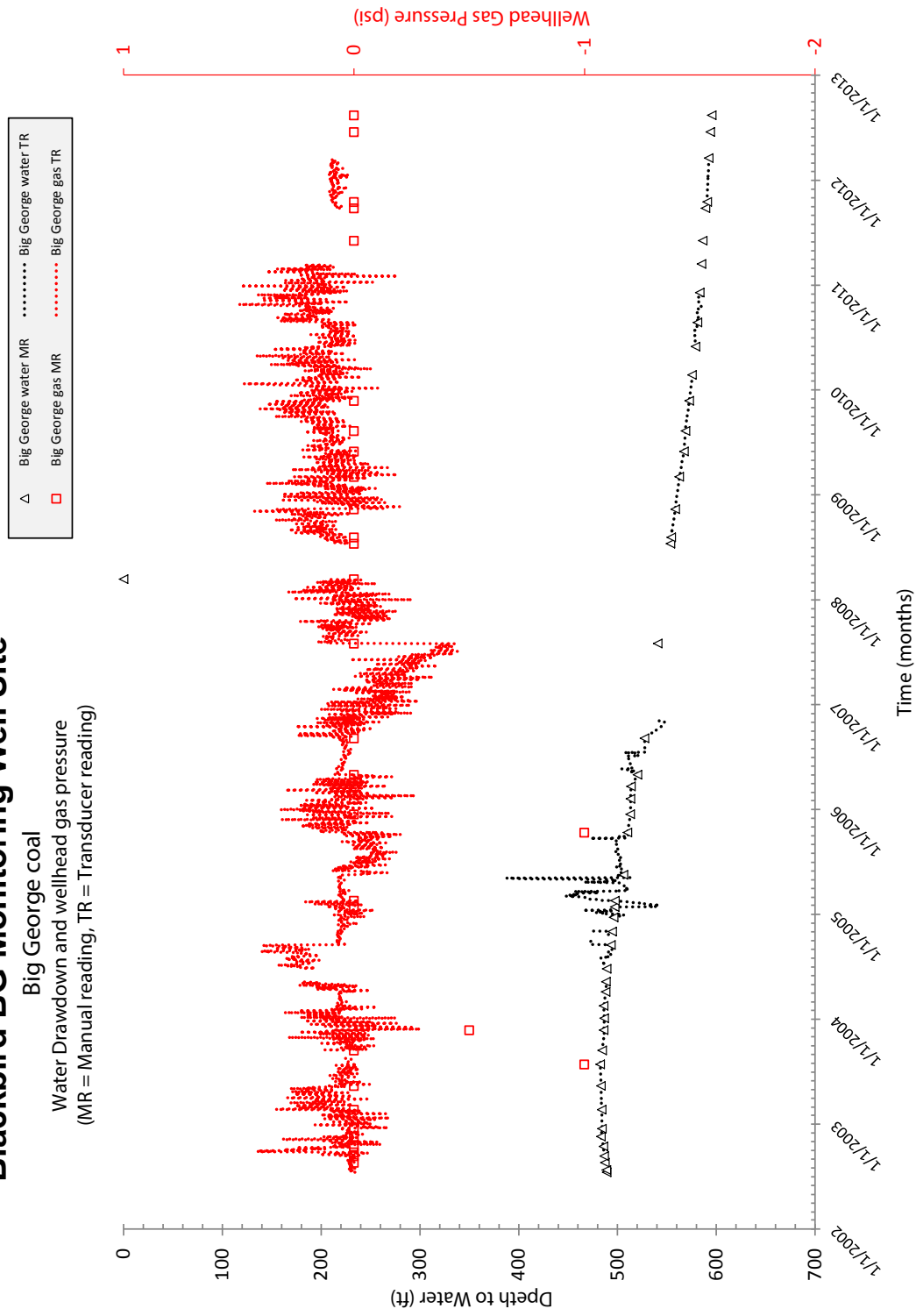
### Production Statistics

Production data were analyzed for CBNG wells within the buffer of the Blackbird BG monitoring well site from 2000-2012. Cumulative production for individual CBNG wells is displayed by location

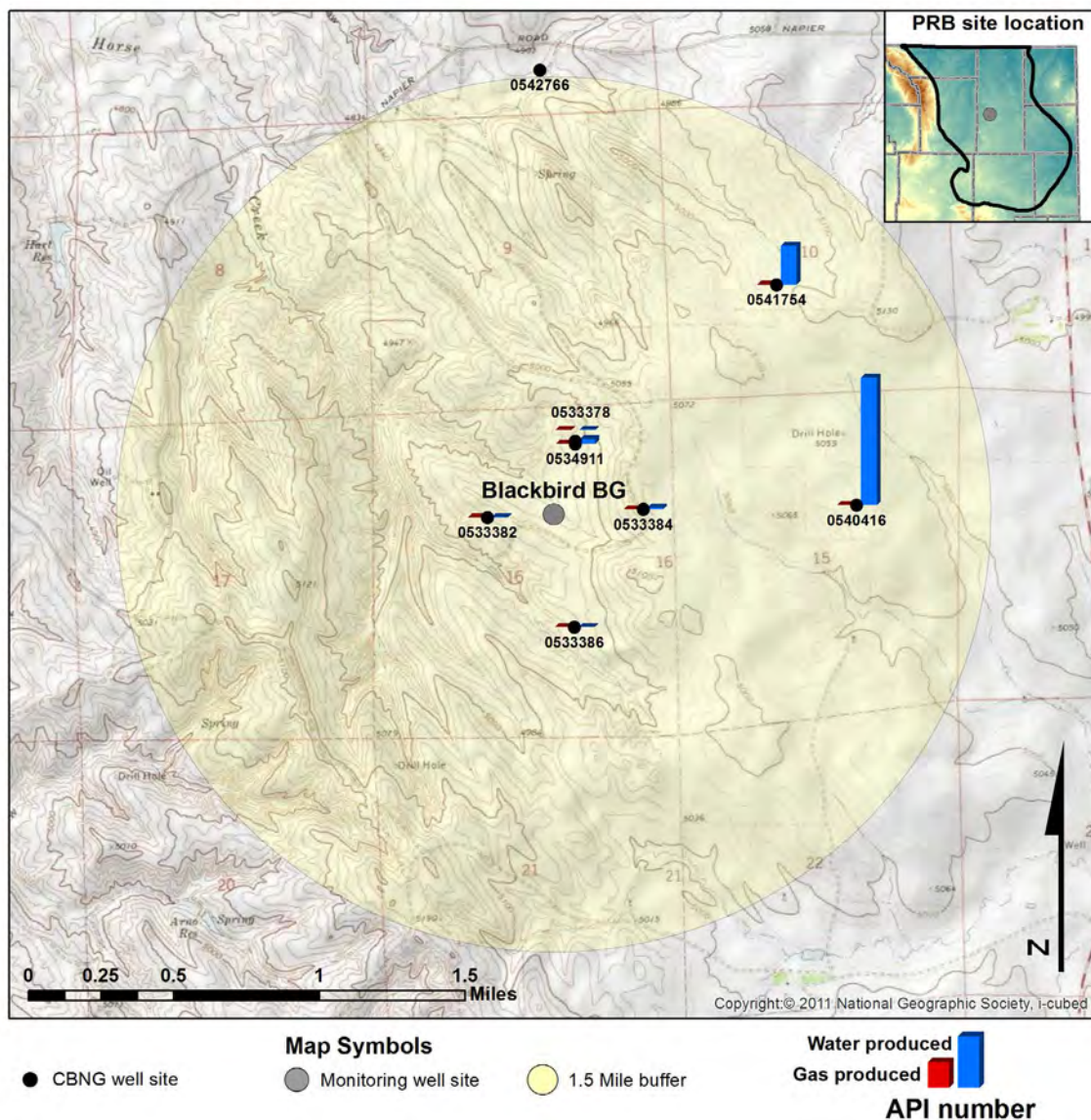
on Figure A.49. CBNG and water production are monitored in Wyodak Rider, unmonitored zone and unknown coal zone wells.

## Blackbird BG Monitoring Well Site

Big George coal  
Water Drawdown and wellhead gas pressure  
(MR = Manual reading, TR = Transducer reading)



**Figure A.48.** Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Blackbird BG monitoring wellsite location.



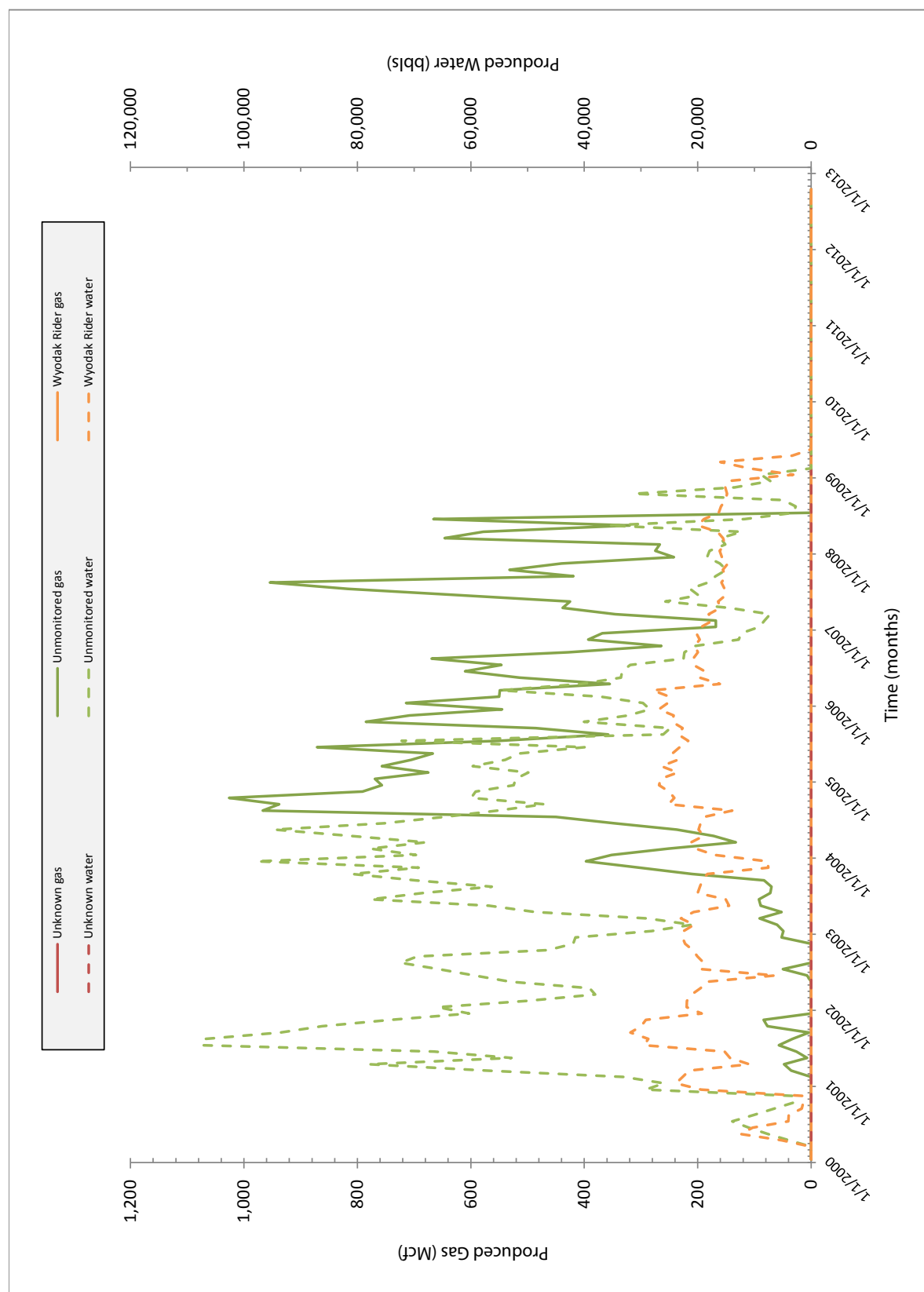
**Figure A.49.** Blackbird BG monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

Water production rates in the Wyodak Rider have generally been low and peaked in September 2001 at 31,859 bbls. No gas was produced from the Wyodak Rider during the monitoring period of 2000-2012 (Figure A.50).

Water production rates in unmonitored coal zone wells peaked in July 2001 at 107,536 bbls (Figure A.50). Gas production in the unmonitored coal

zones peaked at 1,026 Mcf in October 2004 and has declined to zero since July 2008.

Unknown coal zone wells have not produced any water or gas over the monitoring period of 2002 - 2012 (Figure A.50).



**Figure A.50.** Water and gas production from CBNG wells associated with the Blackbird BG monitoring well site location.

## Blackbird Coleman Monitoring Well Site

Location: S5 T47N R74W

Date First Monitored: July 12, 2002

### Drawdown Information

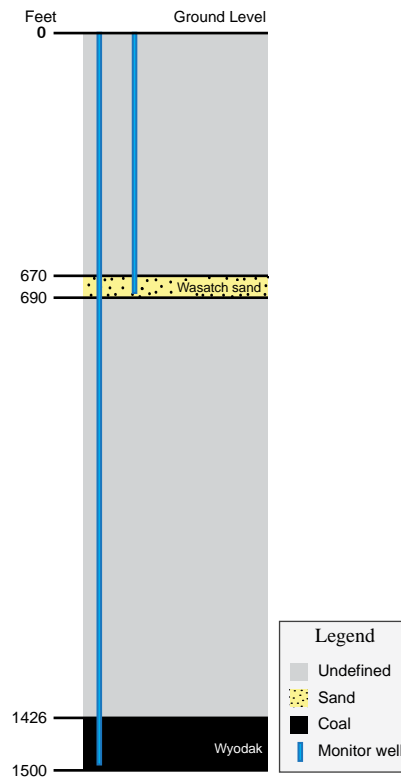
The Blackbird Coleman monitoring well site includes two wells; one is completed in a Wasatch sandstone and the other in the Wyodak coal of the Upper Wyodak coal zone (Figure A.51; Table A.26). Water levels and wellhead gas pressures were measured during the POR using both manual and automatic transducer and data logger equipment. Transducer data that is missing, randomly fluctuating (noisy) or that substantially differs from concurrent manual measurements may indicate on-site equipment failure, malfunction or requirement for calibration.

### Wasatch Sandstone

During the 2010-2012 POR, groundwater levels declined 2.07 feet in the Wasatch sandstone; groundwater levels declined 0.85 feet over the monitoring period of 2002-2009 (Figure A.52; Table A.27). Gas pressure was not recorded in the Wasatch sandstone.

### Wyodak Coal

During the 2010-2012 POR, groundwater levels declined 29.22 feet in the Wyodak coal; groundwater levels declined 123.30 feet over the monitoring period of 2002-2009 (Figure A.52; Table A.27). Gas pressure in the Wyodak coal peaked at 0.56 psi in 2010.



**Figure A.51.** Section showing relative positions of coals and sands in feet. Not to scale.

**Table A.26.** Table showing the depth to and thickness of monitored zones at the Blackbird Coleman monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Wasatch sand	670	690	20	736
Wyodak coal	1,426	1,500	74	n/a

**Table A.27.** Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

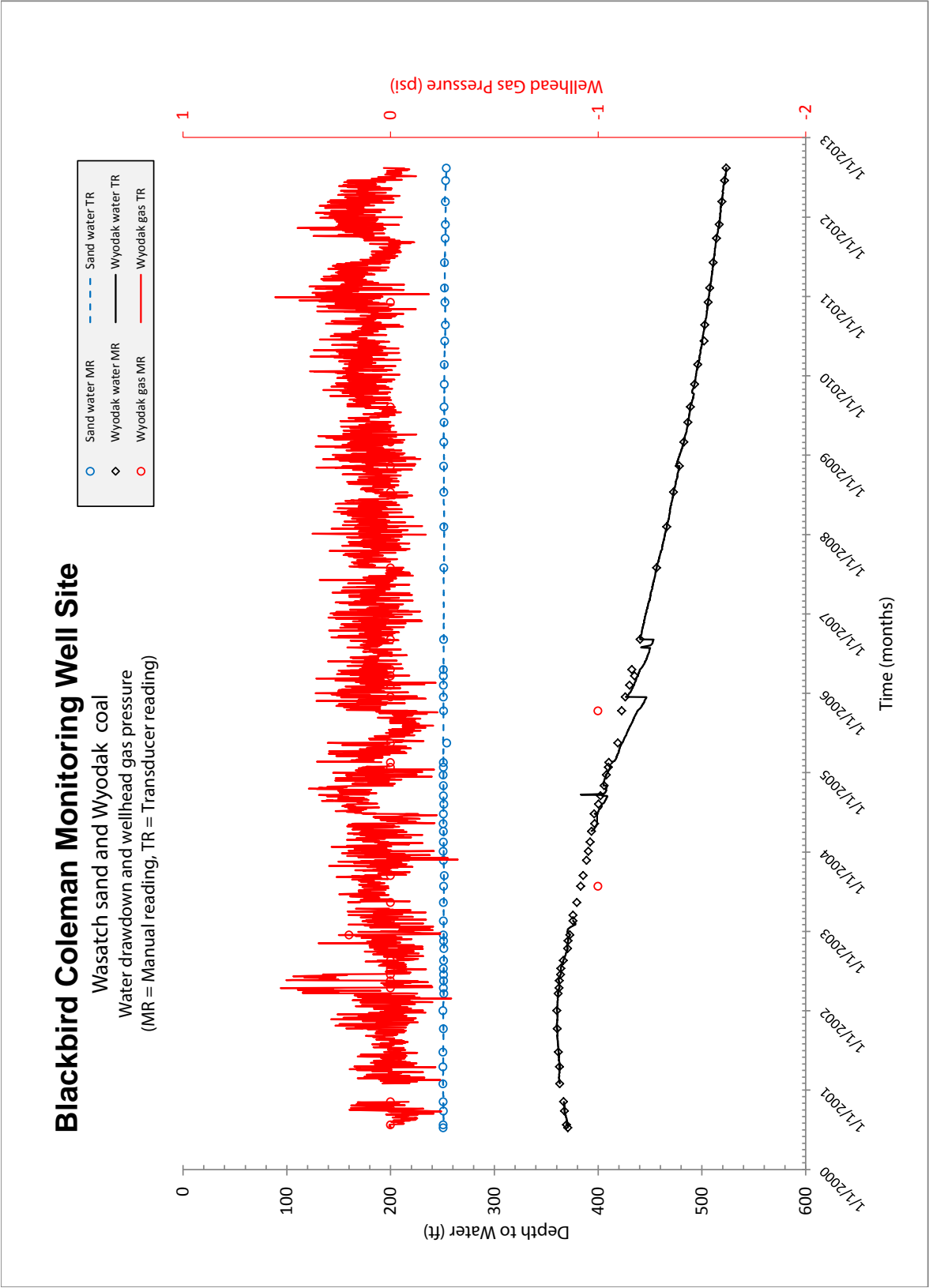
Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2010	Drawdown 2010-2012	Total drawdown (ft.)	Depth to Final water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	250.88	0.85	2.07	2.92	253.80	n/a	n/a
Wyodak coal	370.88	123.30	29.22	152.52	523.40	0.56	12/29/2010

### Production Statistics

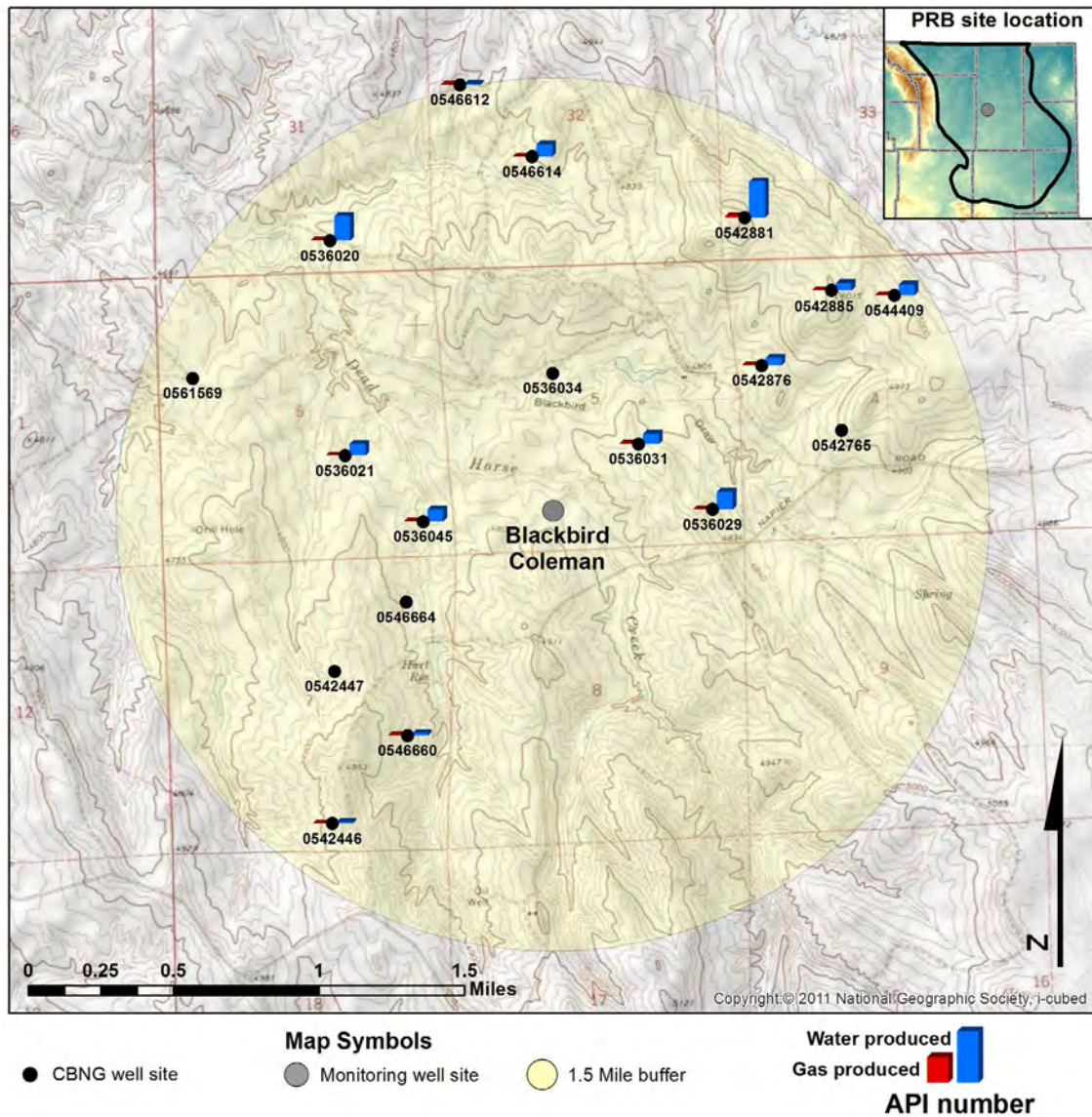
Production data were analyzed for CBNG wells within the buffer of the Blackbird Coleman monitoring well site from 2000-2012. Cumulative production for individual CBNG wells is displayed by location on Figure A.53. CBNG and water production are monitored in Upper Wyodak,

unmonitored and multiple production coal zone wells.





**Figure A-52.** Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Blackbird Coleman monitoring wellsite location.

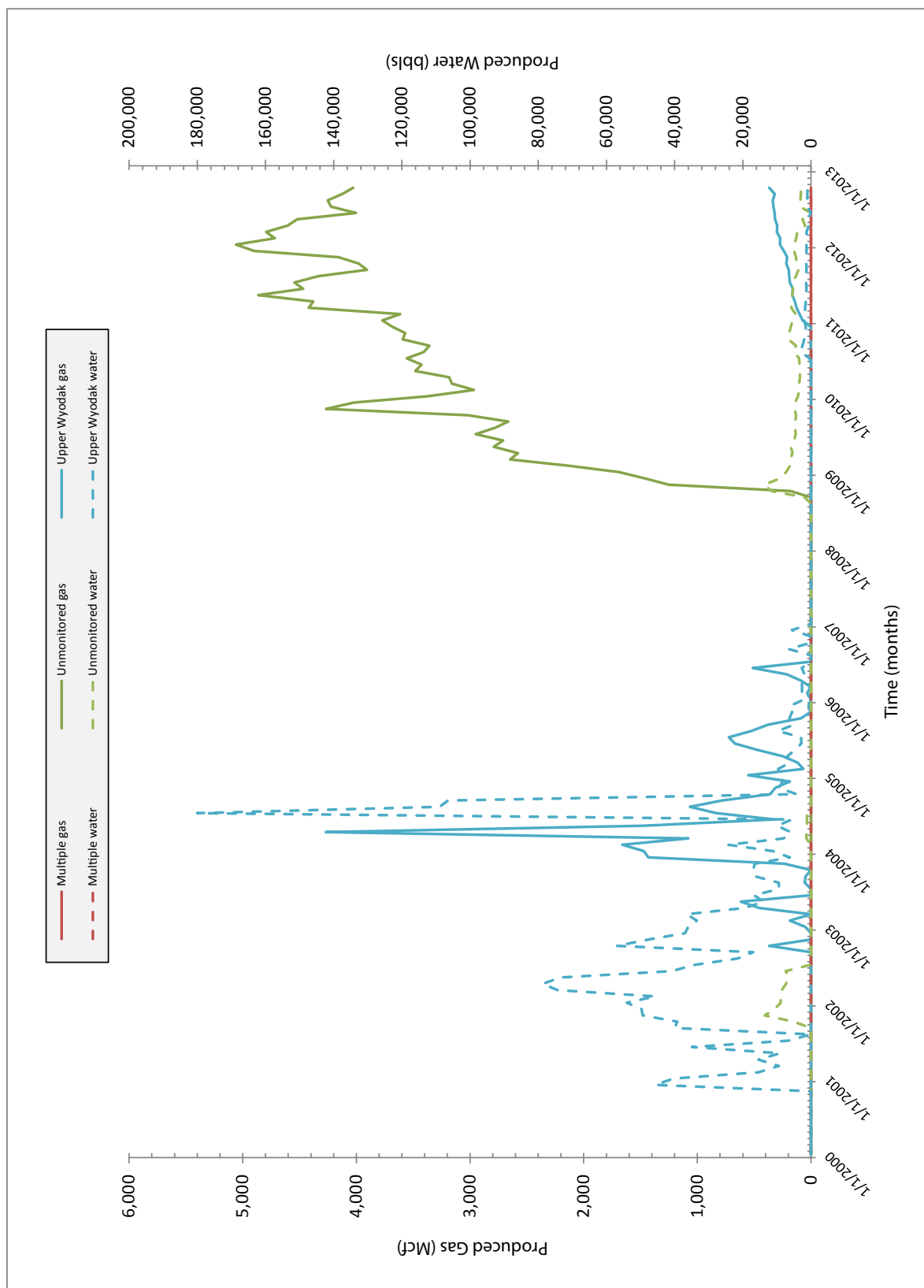


**Figure A.53.** Blackbird Coleman monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

Water production in the Upper Wyodak peaked in July 2004 at 180,049 bbls. Since 2004, water production has not exceeded 10,000 bbls/month. Gas production in the Upper Wyodak peaked at 4,269 Mcf in April 2004. Only low amounts (< 340 Mcf/month) of gas were produced from the Upper Wyodak during the 2010-2012 POR (Figure A.54).

Water production rates in unmonitored coal zone wells peaked in November 2008 at 13,699 bbls (Figure A.54). Gas production peaked at 5,060 Mcf in January 2012.

Multiple coal zone production wells have not produced any water or gas over the monitoring period of 2000-2012 (Figure A.54).



**Figure A.54.** Water and gas production from CBNG wells associated with the Blackbird Coleman monitoring well site location.

**Boondoggle Monitoring Well Site**  
**Location: S7 T48N R77W**  
**Date First Monitored: May 18, 2003**

**Drawdown Information**

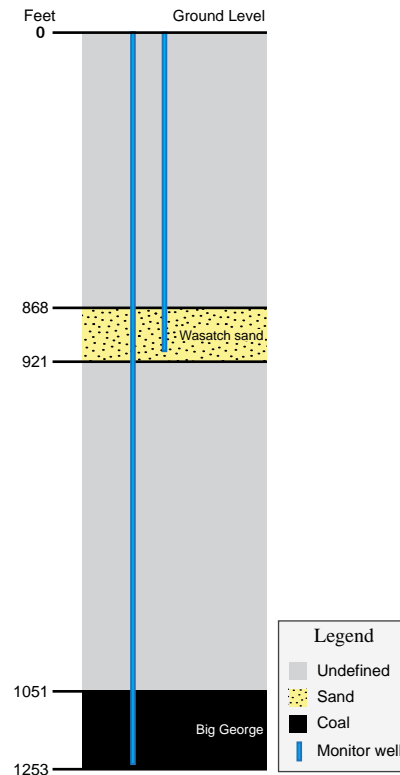
The Boondoggle monitoring well site includes two wells; one is completed in the Wasatch sandstone and the other in the Big George coal of the Wyodak Rider coal zone (Figure A.55; Table A.28). Water levels and wellhead gas pressures were intermittently measured during the POR using manual equipment only.

**Wasatch Sandstone**

During the 2010-2012 POR, groundwater levels declined 10.74 feet in the Wasatch sandstone; groundwater levels declined 23.85 feet over the monitoring period of 2003-2009 (Figure A.56; Table A.29). Four manual measurements, made in the Wasatch sand over the monitoring period of 2008-2012, indicate that gas pressure remained relatively stable over this period peaking at 1.5 psi in 2009.

**Big George Coal**

No water level or gas pressure data were reported for the monitoring well completed in the Big George coal during the entire life of the well (Figure A.56; Table A.29).



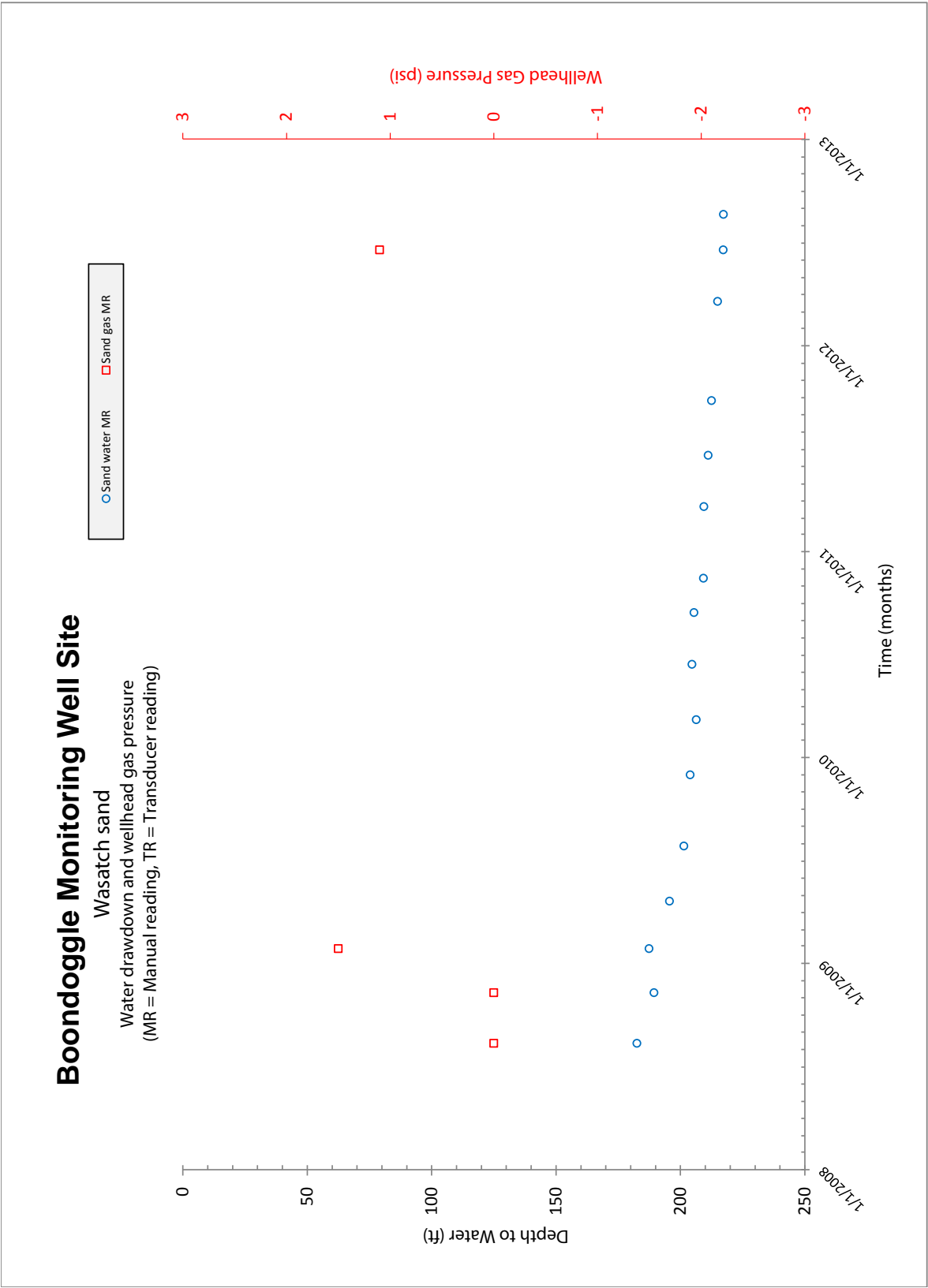
**Figure A.55.** Section showing relative positions of coals and sands in feet. Not to scale.

**Table A.28.** Table showing the depth to and thickness of monitored zones at the Boondoggle monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Wasatch sand	868	921	53	130
Big George coal	1,051	1,253	202	n/a

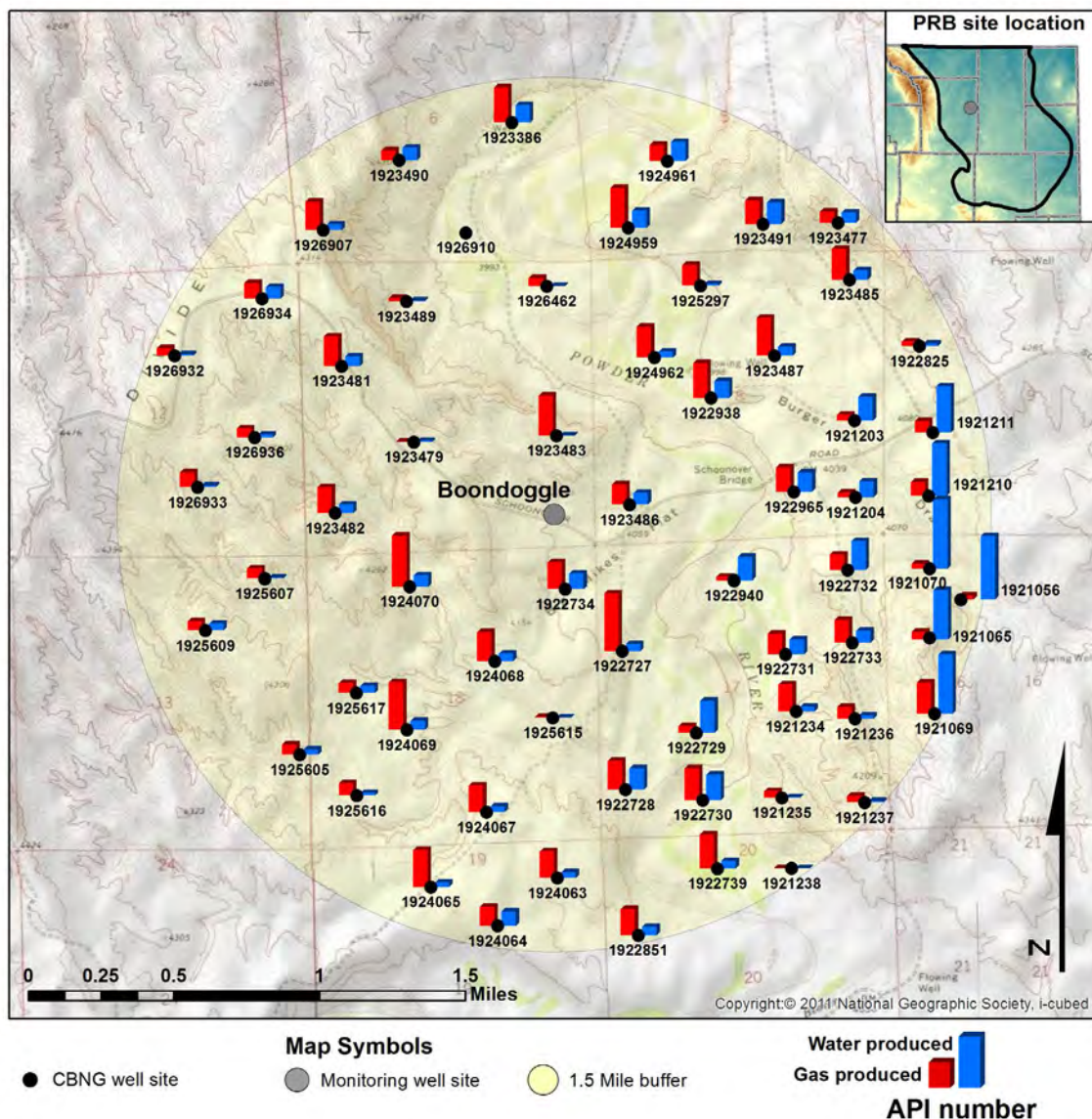
**Table A.29.** Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2010	Drawdown 2010-2012	Total drawdown (ft.)	Depth to Final water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	182.55	23.85	10.74	34.59	217.14	1.5	1/27/2009
Big George coal	n/a	n/a	n/a	n/a	n/a	n/a	n/a



**Figure A.56.** Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Boondoggle monitoring wellsite location.





**Figure A.57.** Boondoggle monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

### Production Statistics

Production data were analyzed for CBNG wells within the buffer of the Boondoggle monitoring well site from 1999-2012. Cumulative production for individual CBNG wells is displayed by location on Figure A.57. CBNG and water production are monitored in the Wyodak Rider zone wells only.

Water production in the Wyodak Rider peaked in August 2005 at 805,799 bbls then gradually declined to 30,836 bbls in October 2012 (Figure A.58). Gas production peaked at over 1.1 million Mcf in May 2007 and has declined to less than 200,000 Mcf/month since then.

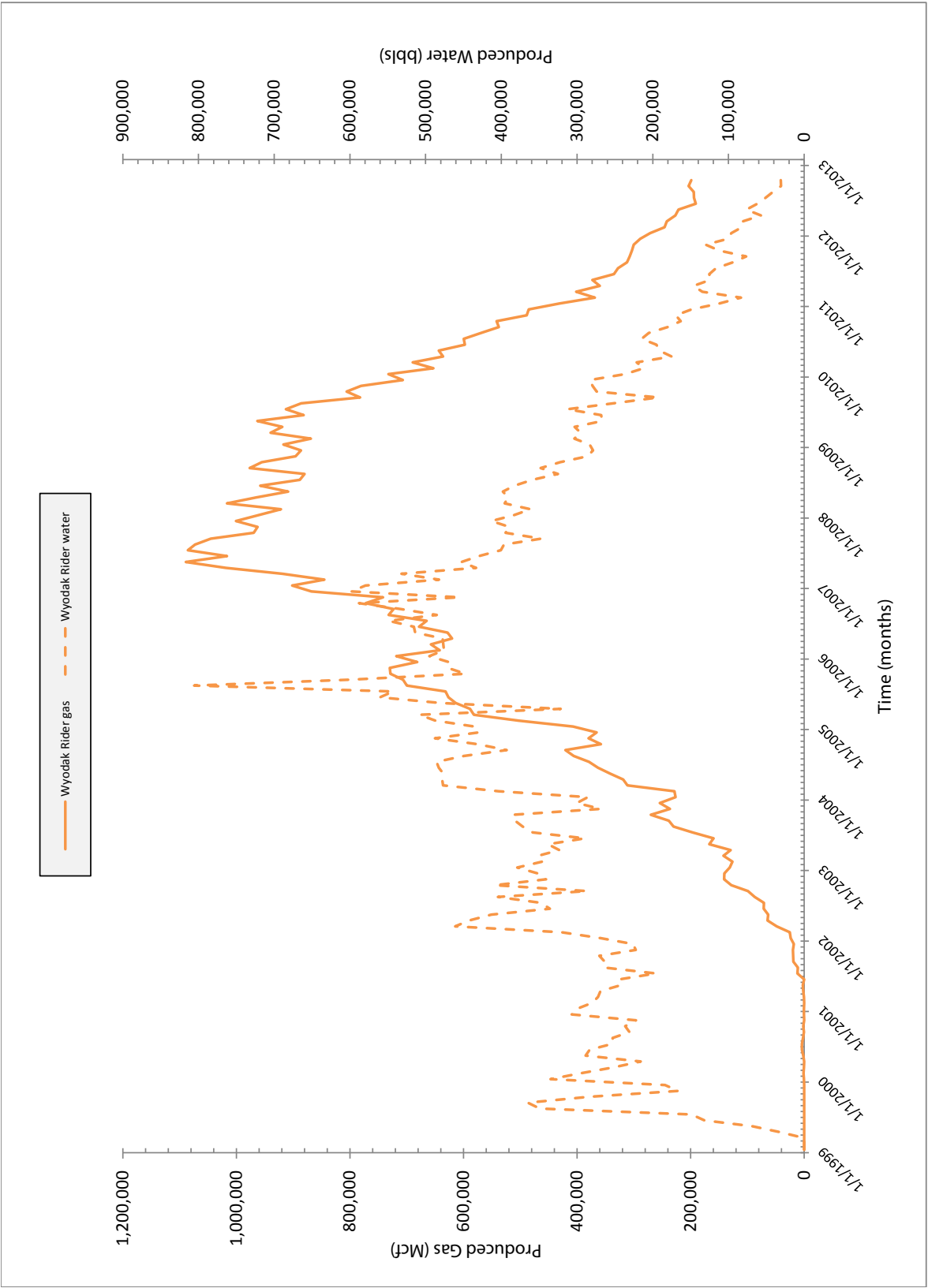


Figure A.58. Water and gas production from CBNG wells associated with the Boondoggle monitoring well site location.

# Bowers Monitoring Well Site

## Location: S36 T42N R72W

### Date First Monitored: January 21, 1998

#### Drawdown Information

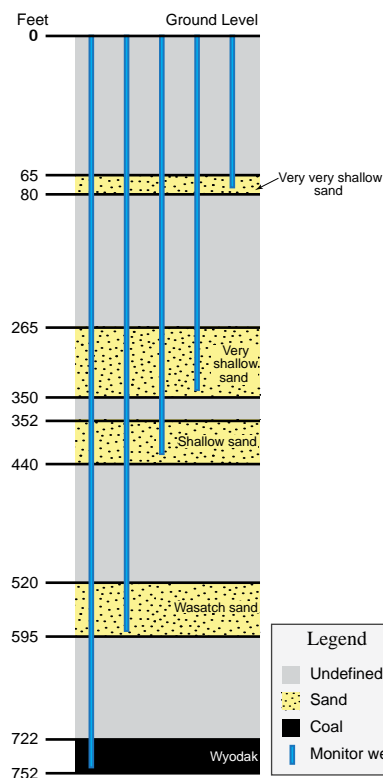
The Bowers monitoring well site includes five wells. Four wells are completed into Wasatch sandstones and the other one is completed in the Wyodak coal of the Upper Wyodak coal zone (Figure A.59; Table A.30). Water levels and wellhead gas pressures were measured in the Wyodak coal zone well during the POR using both manual and automatic transducer and data logger equipment. Transducer data that is missing, randomly fluctuating (noisy) or that substantially differs from concurrent manual measurements may indicate on-site equipment failure, malfunction or requirement for calibration.

#### Wasatch Sandstones

During the 2010-2012 POR, the four monitored sandstone layers exhibited groundwater level changes that ranged from a rise of 0.18 feet to a decline of 18.43 feet. In contrast, over the monitoring period of 1998-2009, groundwater level changes ranged from a rise of 0.76 feet to a decline of 3.30 feet from initial static water levels (Figure A.60; Table A.31). Gas pressure was not recorded in the Wasatch sandstones.

#### Wyodak Coal

The well was turned over to the operator on January 30, 2005 and converted to a producing gas well, so no data exist for the 2010-2012 POR. However, during the 1998 -2005 monitoring period, groundwater levels declined 288.65 feet in the Wyodak coal. (Figure A.61; Table A.31). Gas pressure in the Wyodak coal remained relatively stable over the monitoring period of 1998-2005 peaking at 1.73 psi in September 2000.



**Figure A.59.** Section showing relative positions of coals and sands in feet. Not to scale.

**Table A.30.** Table showing the depth to and thickness of monitored zones at the Bowers monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Very very shallow sand	65	80	15	642
Very shallow sand	265	350	85	372
Shallow sand	352	440	88	282
Wasatch sand	520	595	75	127
Wyodak coal	722	752	30	n/a

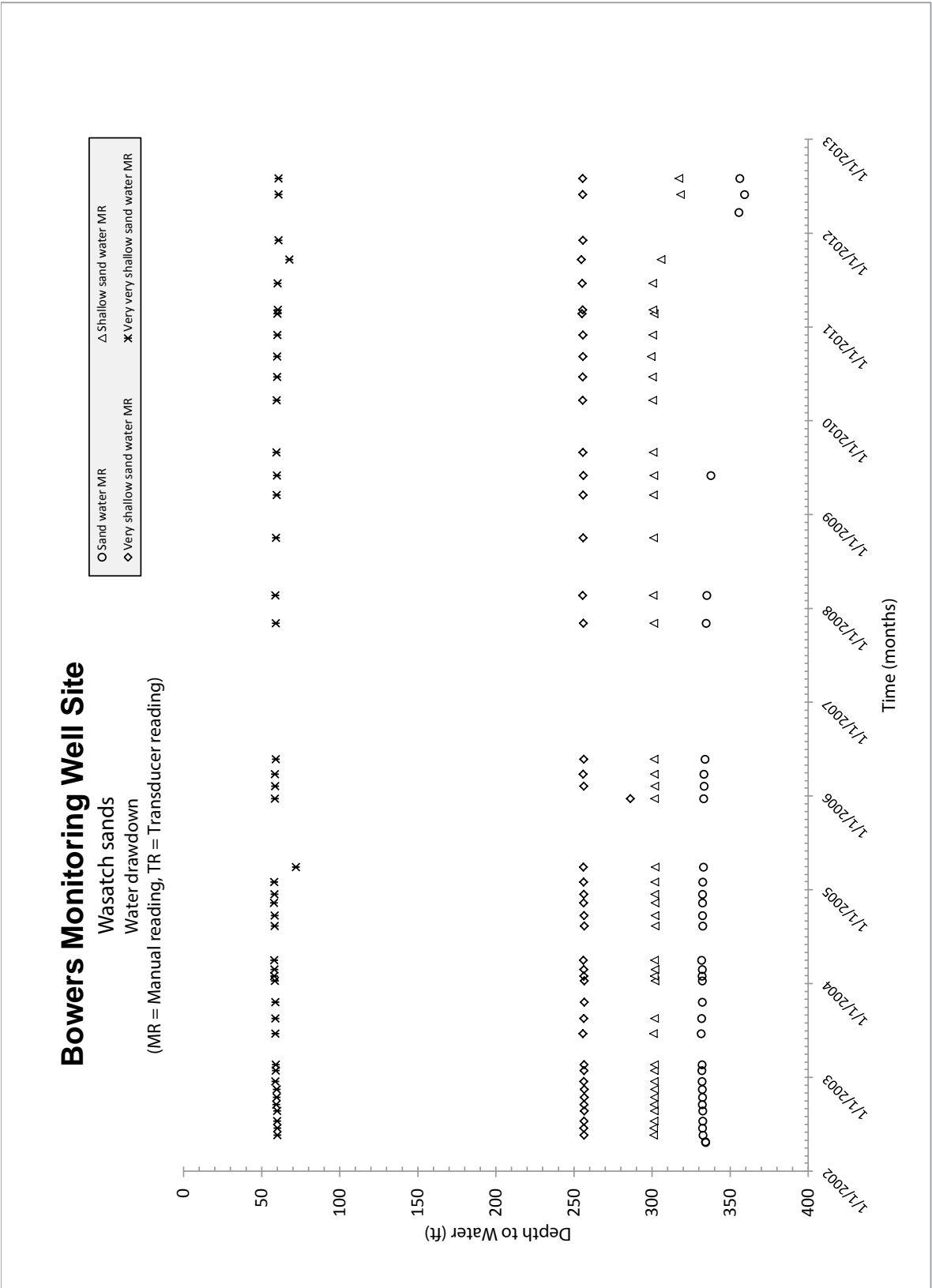
**Table A.31.** Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2010	Drawdown 2010-2012	Total drawdown (ft.)	Depth to Final water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Very very shallow sand	60.17	-0.59	1.21	0.62	60.79	n/a	n/a
Very shallow sand	256.54	-0.76	-0.18	-0.94	255.60	n/a	n/a
Shallow sand	301.01	-0.16	16.36	16.20	317.21	n/a	n/a
Wasatch sand	334.57	3.30	18.43	21.73	356.30	n/a	n/a
Wyodak coal	419.85	288.65	n/a	n/a	n/a	1.73	9/23/2000

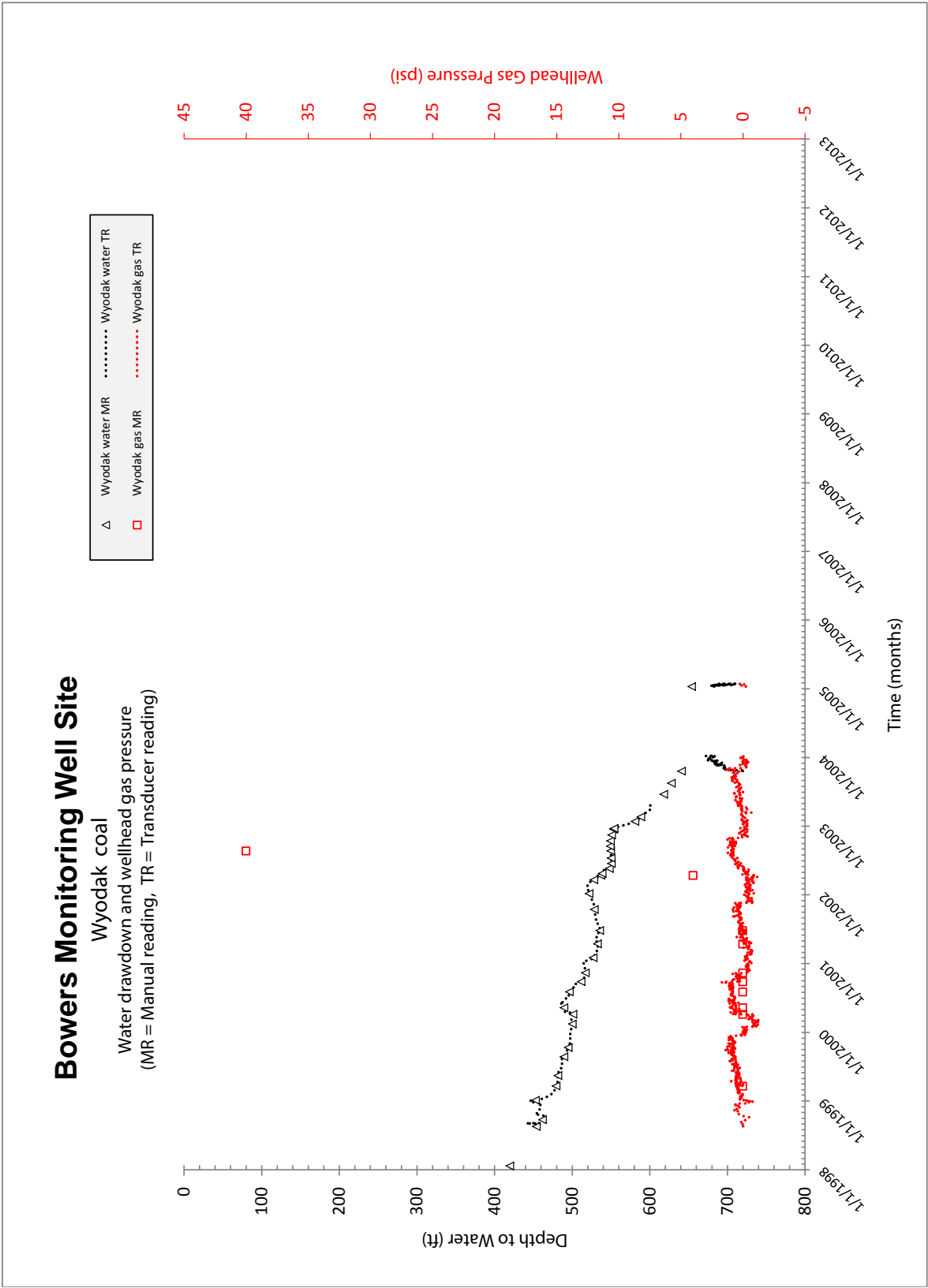
### Production Statistics

Production data were analyzed for CBNG wells within the buffer of the Bowers monitoring well site from 1997-2012. Cumulative production for individual CBNG wells is displayed by location on Figure A.62. CBNG and water production are monitored in Upper Wyodak, unmonitored, unknown and multiple production coal zone wells.

Water production rates in the Upper Wyodak peaked in October 2003 at 420,200 bbls. Gas production in the Upper Wyodak peaked at 193,032 Mcf in January 2004. Lower amounts (< 21,000 Mcf/month) of gas were produced from the Upper Wyodak during the 2010-2012 POR.

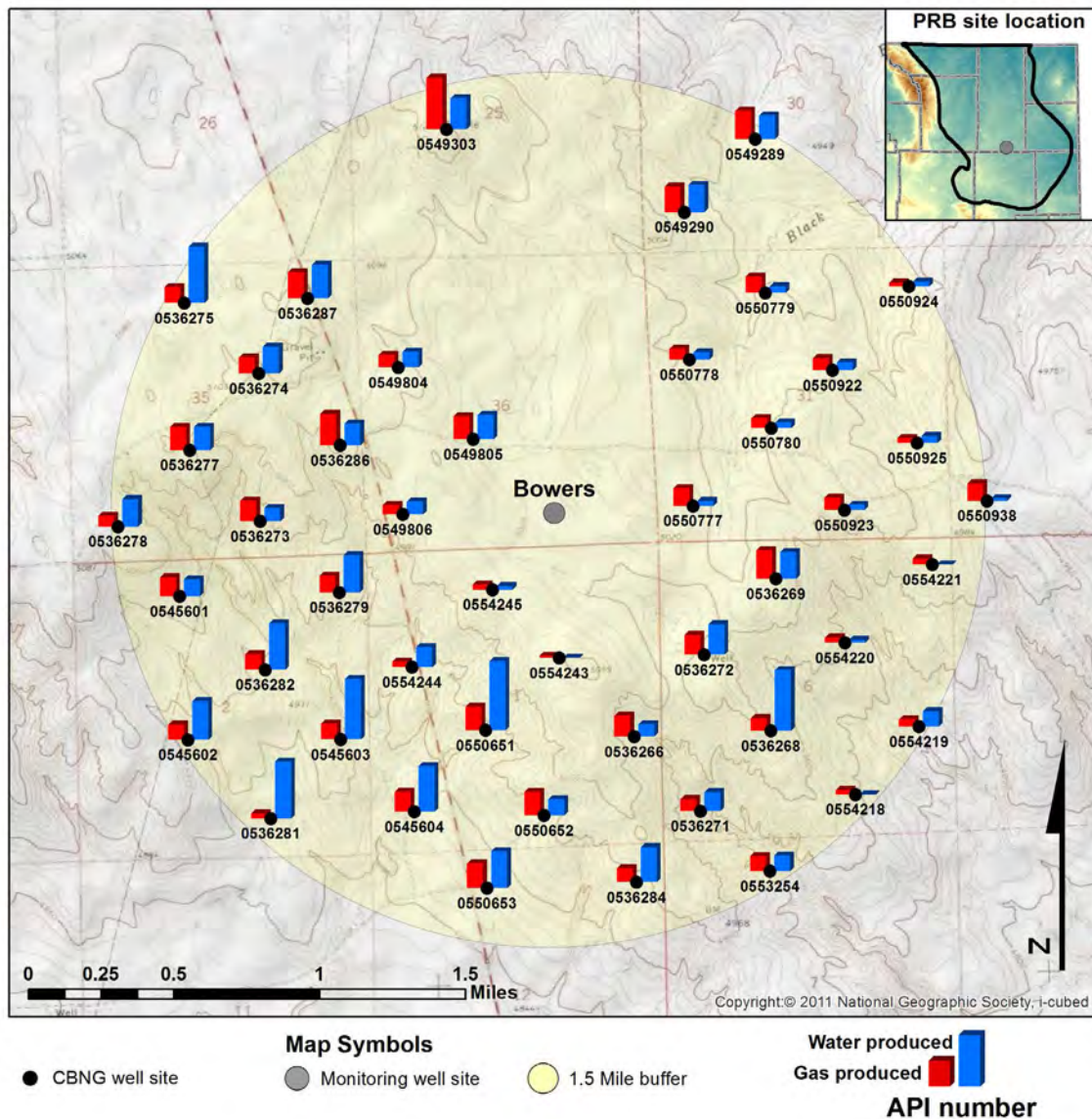


**Figure A.60.** Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Bowers monitoring wellsite location.



**Figure A.61.** Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Bowers monitoring wellsite location.





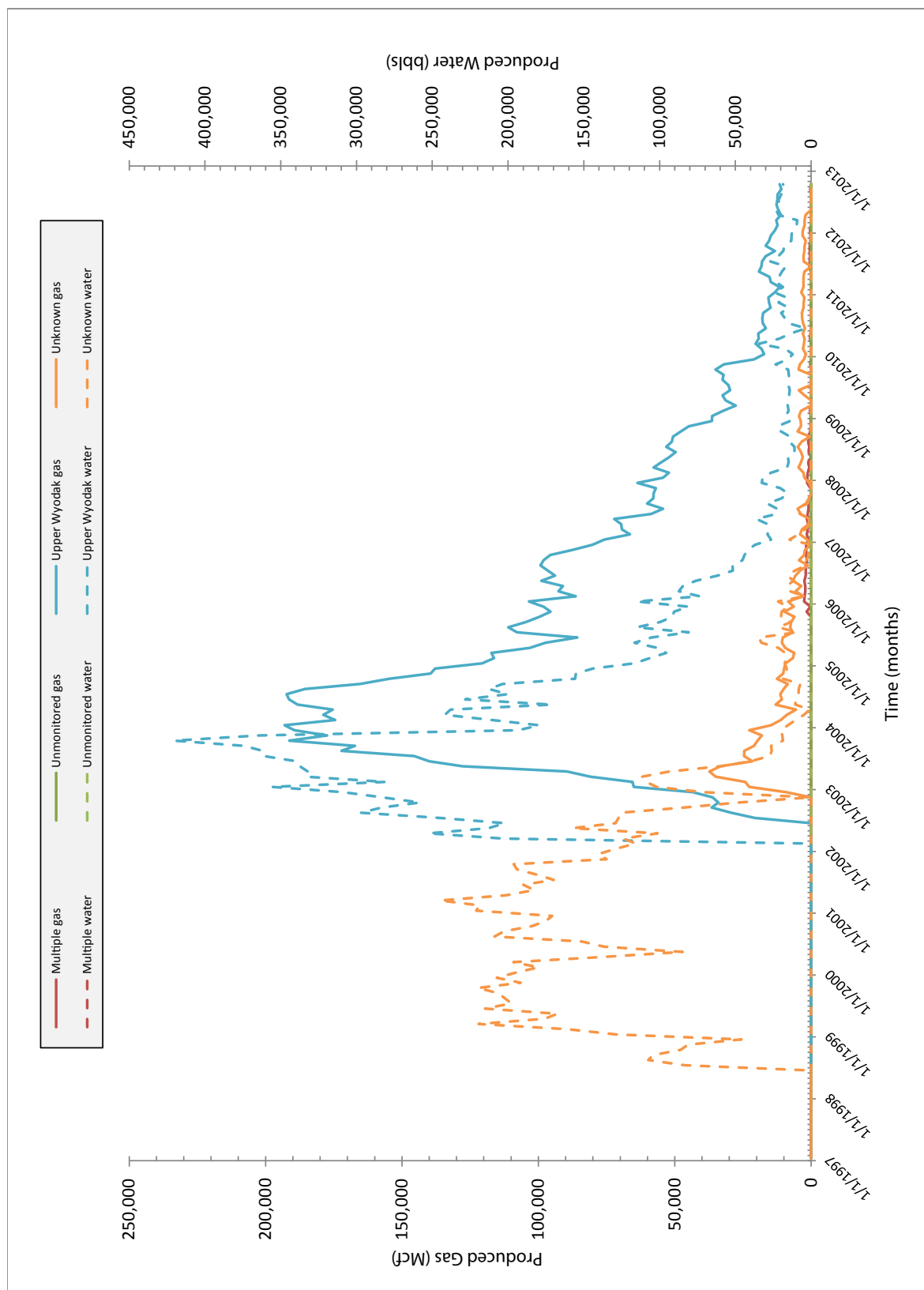
**Figure A.62.** Bowers monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

Water production rates in multiple coal zone production wells peaked in January 2006 at 2,597 bbls (Figure A.63). These wells have not produced any gas over the monitoring period of 1997-2012.

Water production in unknown coal zones peaked at 244,670 bbls in March 2001 then declined to 0 bbls/month since October 2007 (Figure A.63). Gas production in the unknown coal zones peaked

in April 2003 at 37,274 Mcf; less than 5,000 Mcf/month were produced over the 2010-2012 POR.

Unmonitored coal zone production wells have not produced any water or gas over the monitoring period of 1997-2012 (Figure A.63).



**Figure A.63.** Water and gas production from CBNG wells associated with the Bowers monitoring well site location.

**Buffalo SE Monitoring Well Site**  
**Location: S12 T50N R81W**  
**Date First Monitored: May 3, 2001**

**Drawdown Information**

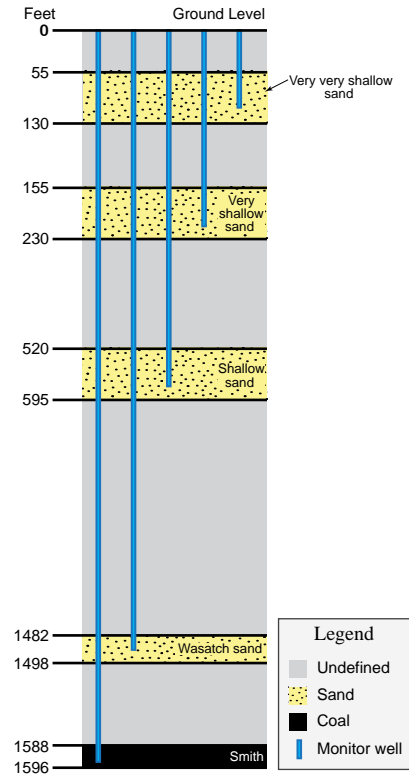
The Buffalo SE monitoring well site includes five wells. Four wells are completed into Wasatch sandstones and the other one is completed into the Smith coal of the Wyodak Rider coal zone (Figure A.64; Table A.32). Water levels and wellhead gas pressures were measured during the POR using both manual and automatic transducer and data logger equipment. Transducer data that is missing, randomly fluctuating (noisy) or that substantially differs from concurrent manual measurements may indicate on-site equipment failure, malfunction or requirement for calibration.

**Wasatch Sandstones**

During the 2010-2012 POR, the four monitored sandstone strata exhibited groundwater level changes that ranged from a rise of 1.45 feet to a decline of 0.61 feet (Figure A.65; Figure A.66; Table A.33). In contrast, over the monitoring period of 2001-2009, groundwater level changes ranged from a rise of 19.42 feet to a decline of 3.99 feet from initial static water levels. Gas pressure was not recorded in the Wasatch sandstones.

**Smith Coal**

During the 2010-2012 POR, groundwater levels declined 0.61 feet in the Smith coal; water levels declined 25.35 feet during the monitoring period of 2001-2009 (Figure A.66; Table A.33). Gas pressure in the Smith remained relatively stable over the monitoring period of 2001 -2012 peaking at 1.01 psi in May 2005.



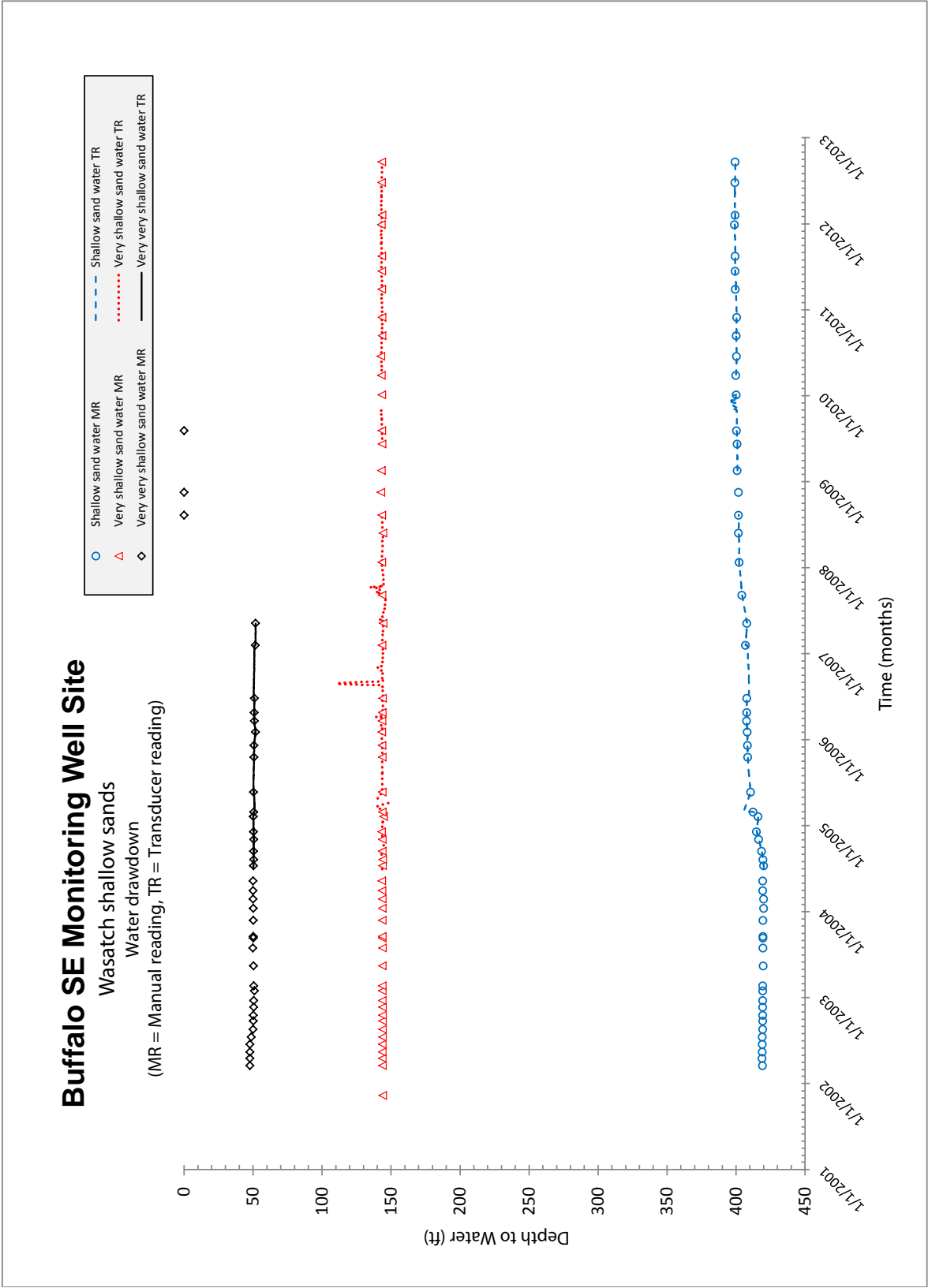
**Figure A.64.** Section showing relative positions of coals and sands in feet. Not to scale.

**Table A.32.** Table showing the depth to and thickness of monitored zones at the Buffalo SE monitoring well site location. (measured in feet)

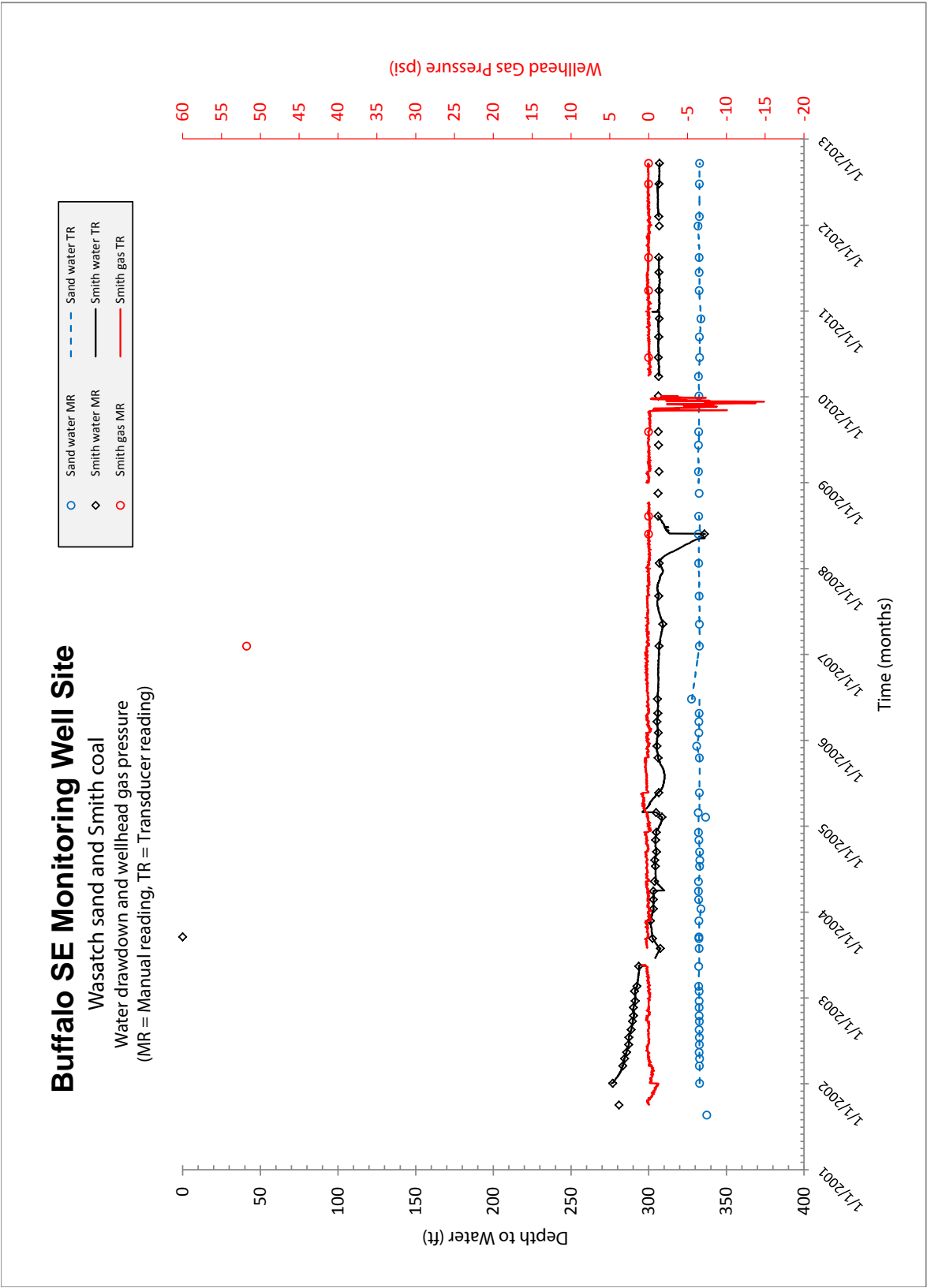
Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Very very shallow sand	55	130	75	1,458
Very shallow sand	155	230	75	1,358
Shallow sand	520	595	75	993
Wasatch sand	1,482	1,498	16	90
Smith coal	1,588	1,596	8	n/a

**Table A.33.** Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2010	Drawdown 2010-2012	Total drawdown (ft.)	Depth to Final water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Very very shallow sand	47.81	3.99	n/a	n/a	n/a	n/a	n/a
Very shallow sand	143.80	1.02	-1.45	-0.43	143.37	n/a	n/a
Shallow sand	419.23	-19.42	-0.30	-19.72	399.51	n/a	n/a
Wasatch sand	337.51	-5.21	0.61	-4.60	332.91	n/a	n/a
Smith coal	280.97	25.35	0.61	25.96	306.93	1.01	5/17/2005

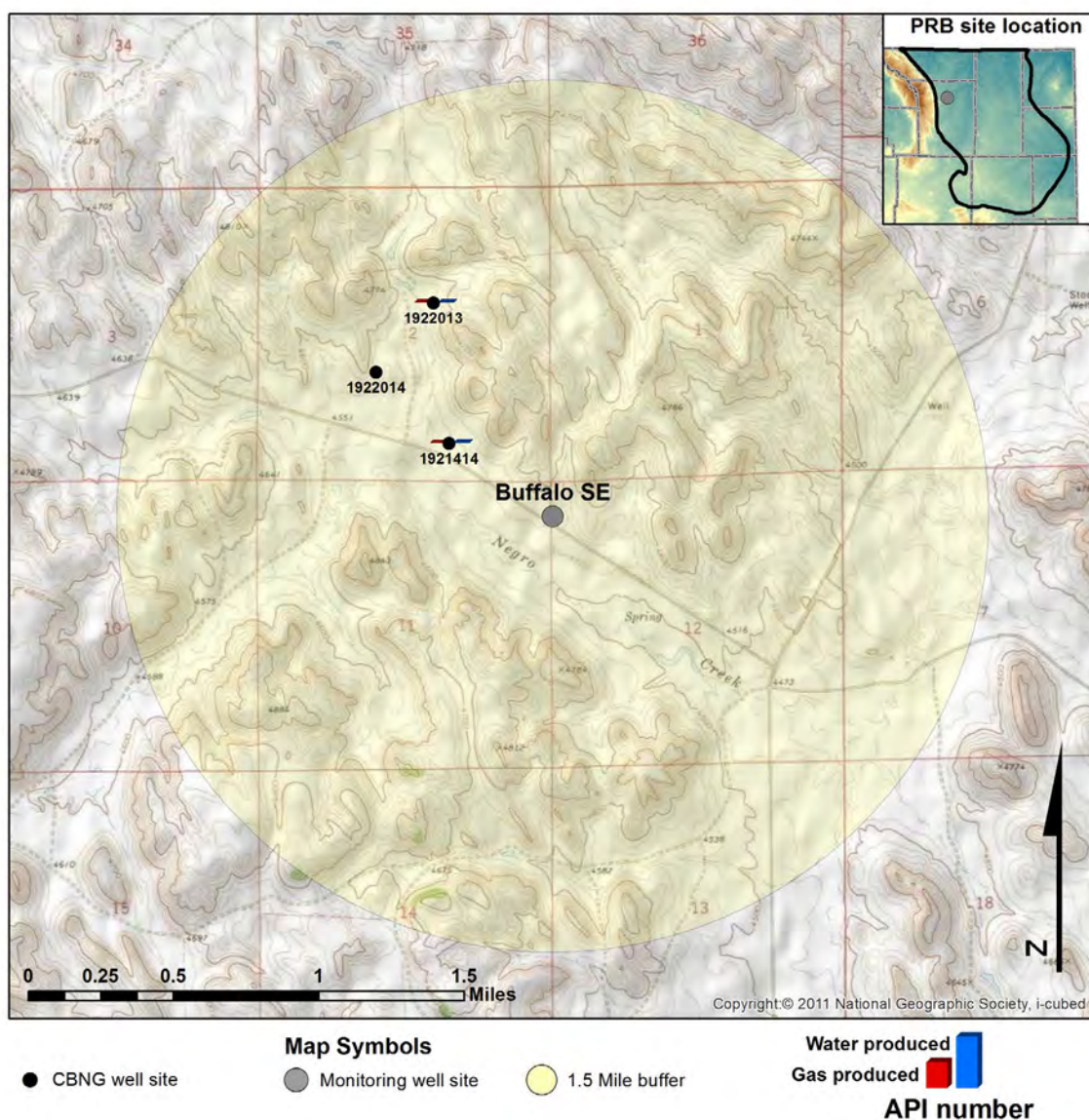


**Figure A.65.** Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Buffalo SE monitoring wellsite location.



**Figure A.66.** Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Buffalo SE monitoring wellsite location.





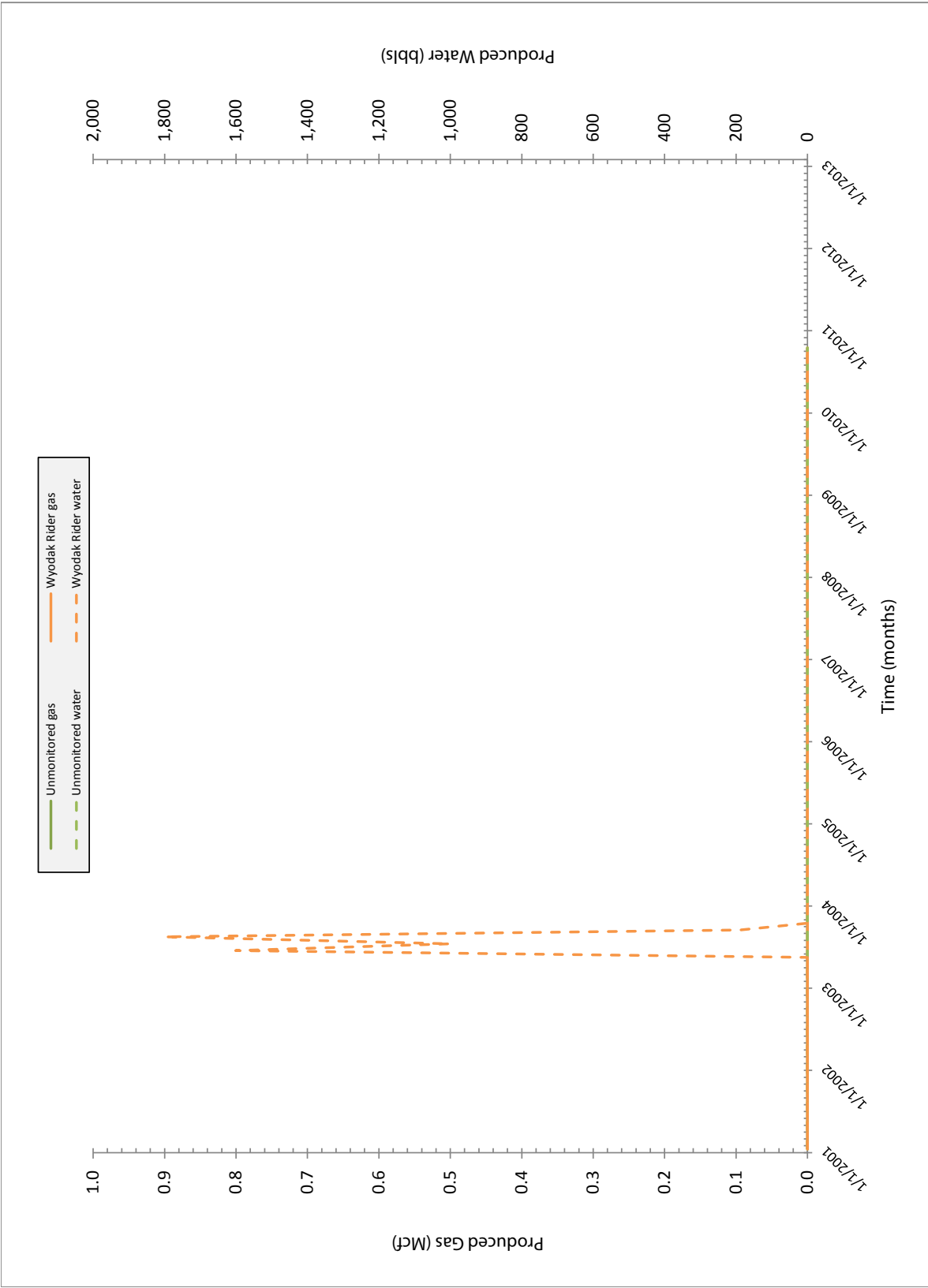
**Figure A.67.** Buffalo SE monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

### Production Statistics

Production data were analyzed for CBNG wells within the buffer of the Buffalo SE monitoring well site from 2001-2012. Cumulative production for individual CBNG wells is displayed by location on Figure A.67. CBNG and water production are monitored in Wyodak Rider and unmonitored production coal zone wells.

Water production rates in the Wyodak Rider peaked in August 2003 at 1,800 bbls. There has been no gas production in the Wyodak Rider during the monitoring period of 2001-2010 (Figure A.68).

Unmonitored coal zone production wells have not produced any water or gas over the monitoring period of 2001-2010 (Figure A.68).



**Figure A.68.** Water and gas production from CBNB wells associated with the Buffalo SE monitoring well site location.

**Bull Creek Monitoring Well Site**  
**Location: S12 T52N R77W**  
**Date First Monitored: November 22, 2005**

**Drawdown Information**

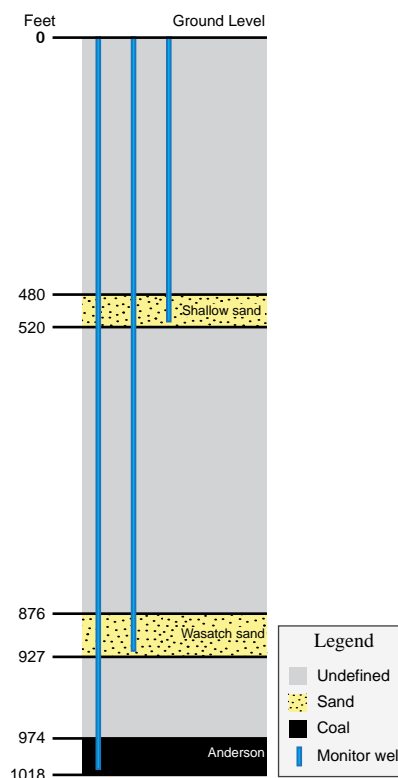
The Bull Creek monitoring well site includes three wells. Two wells are completed into Wasatch sandstones, and one is completed in the Anderson coal of the Upper Wyodak coal zone (Figure A.69; Table A.34). Water levels and wellhead gas pressures were measured during the POR using both manual and automatic transducer and data logger equipment. Transducer data that is missing, randomly fluctuating (noisy) or that substantially differs from concurrent manual measurements may indicate on-site equipment failure, malfunction or requirement for calibration.

**Wasatch Sandstones**

Sufficient groundwater data were collected on only one of the sandstone strata, listed as the Wasatch sand in Table A.35. During the 2010-2012 POR, groundwater levels in this monitored sandstone, declined 20.56 feet. In contrast, over the monitoring period of 2005-2009, groundwater levels declined 39.52 feet from initial static water levels (Figure A.70). Gas pressure was not recorded in the Wasatch sandstones.

**Anderson Coal**

During the 2010-2012 POR, groundwater levels rose 34.00 feet in the Anderson coal; water levels declined 23.49 feet during the monitoring period of 2005-2009 (Figure A.70; Table A.35). Gas pressure in the Anderson coal varied over the monitoring period of 2005-2012 peaking at 3.07 psi in October 2007.



**Figure A.69.** Section showing relative positions of coals and sands in feet. Not to scale.

**Table A.34.** Table showing the depth to and thickness of monitored zones at the Bull Creek monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Shallow sand	480	520	40	454
Wasatch sand	876	927	51	47
Anderson coal	974	1,018	44	n/a

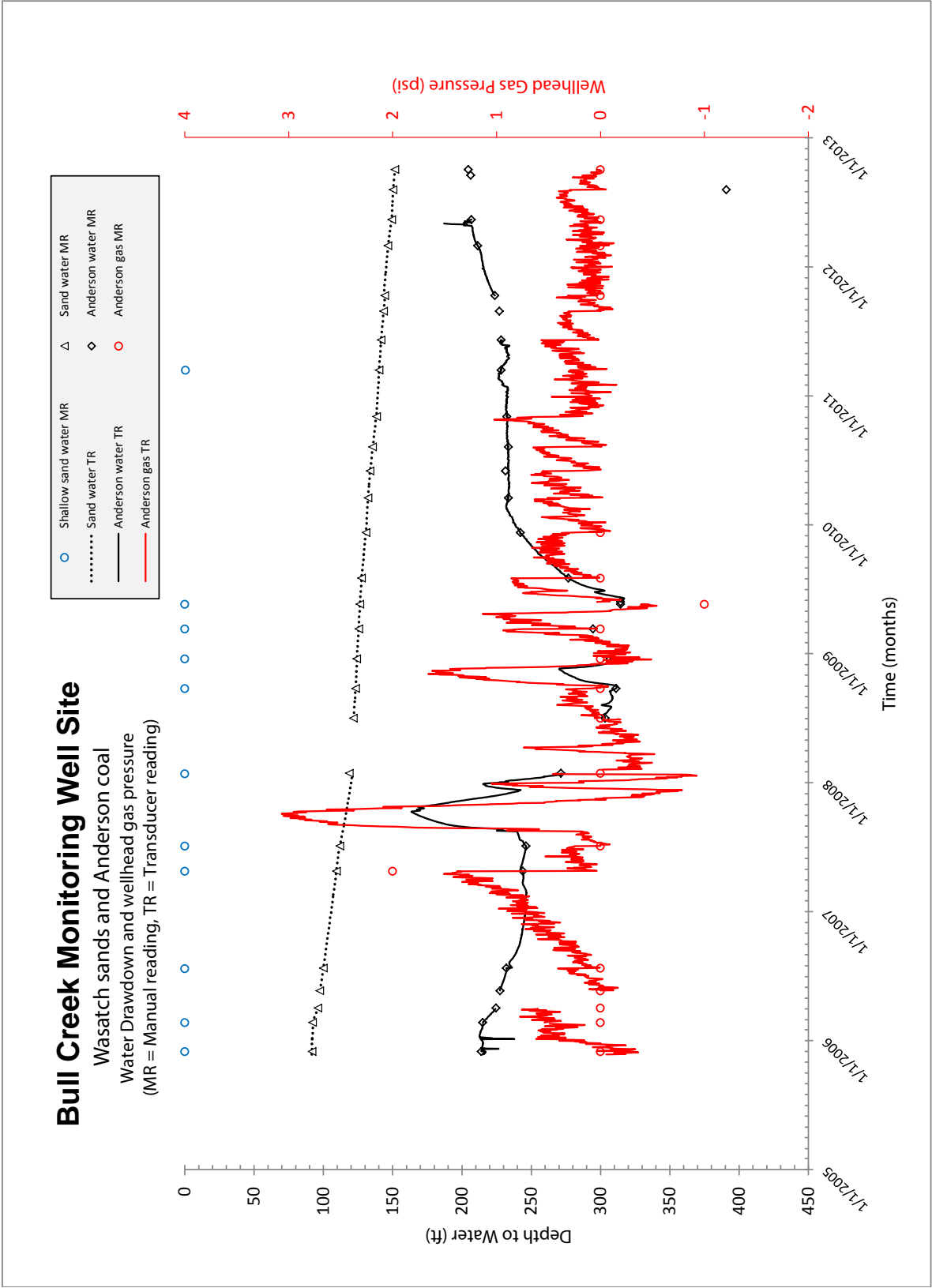
**Table A.35.** Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2010	Drawdown 2010-2012	Total drawdown (ft.)	Depth to Final water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Shallow sand	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Wasatch sand	91.57	39.52	20.56	60.08	151.65	n/a	n/a
Anderson coal	215.00	23.49	-34.00	-10.51	204.49	3.07	10/5/2007

### Production Statistics

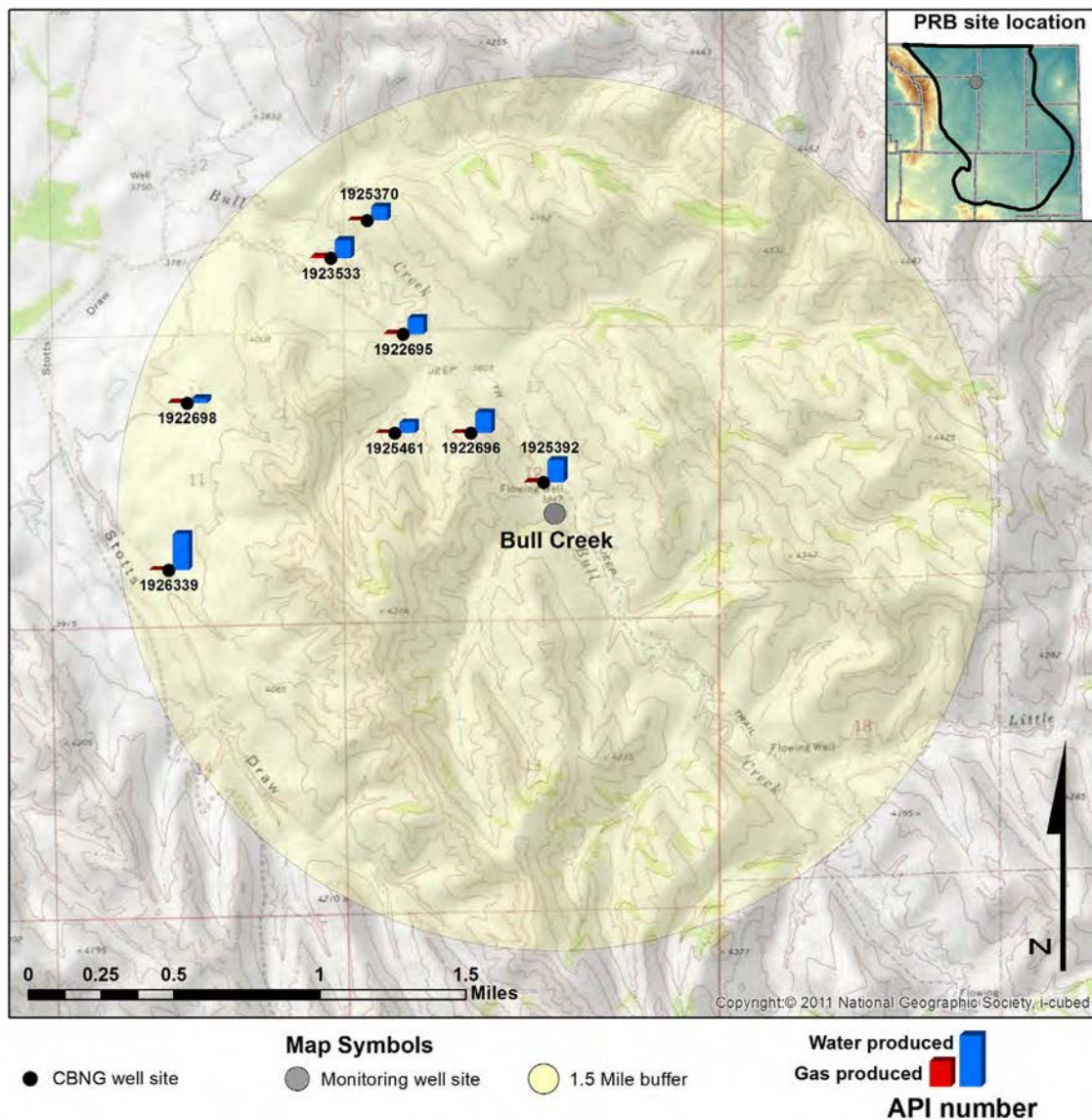
Production data were analyzed for CBNG wells within the buffer of the Bull Creek monitoring well site from 2003-2012. Cumulative production for individual CBNG wells is displayed by location on Figure A.71. CBNG and water production are monitored in the Upper Wyodak and multiple production coal zone wells.

Water production rates in the Upper Wyodak peaked in September 2006 at nearly 28,000 bbls. Gas production in the Upper Wyodak began in 2004 and peaked in March 2008 at 1429 Mcf (Figure A.72).



**Figure A.70.** Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Bull Creek monitoring wellsite location.

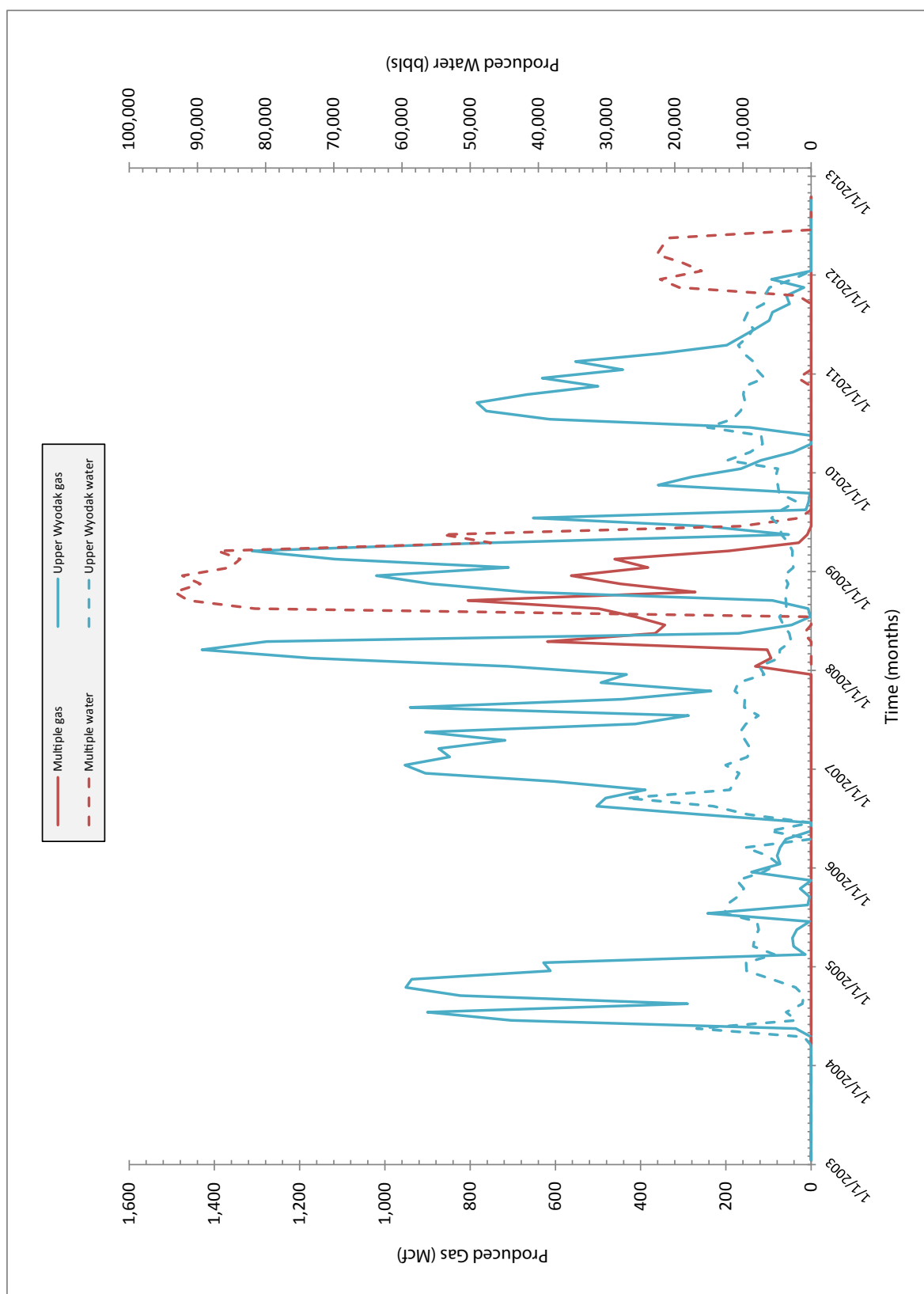




**Figure A.71.** Bull Creek monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute

Water production rates in the multiple coal zone production wells peaked at 93,337 bbls in October 2008; water production had ceased in these wells by the end of the 2010-2012 POR (Figure A.72). Gas production in the unmonitored coal zones began in 2008 and peaked at 805 Mcf in September of the same year. Gas production was zero at the end of the 2010-2012 POR.





**Figure A.72.** Water and gas production from CBNNG wells associated with the Bull Creek monitoring well site location.

**Bullwhacker Monitoring Well Site**  
**Location: S16 T42N R77W**  
**Date First Monitored: April 11, 2002**

**Drawdown Information**

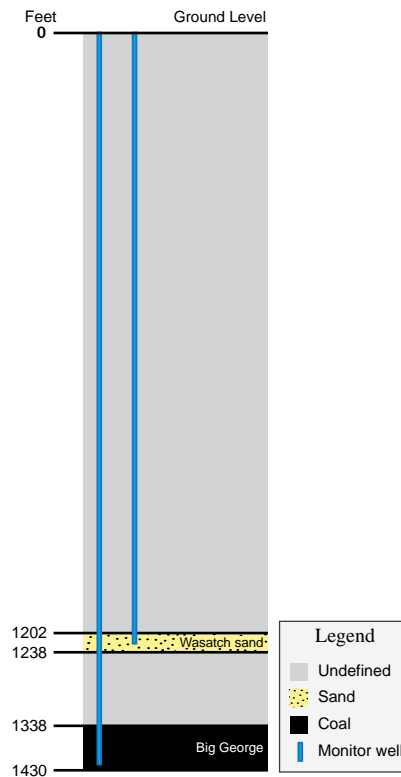
The Bullwhacker monitoring well site includes two wells; one is completed in the Wasatch sandstone and the other in the Big George coal in the Wyodak Rider coal zone (Figure A.73; Table A.36). Water levels and wellhead gas pressures were measured during the POR using both manual and automatic transducer and data logger equipment. Transducer data that is missing, randomly fluctuating (noisy) or that substantially differs from concurrent manual measurements may indicate on-site equipment failure, malfunction or requirement for calibration.

**Wasatch Sandstone**

During the 2010-2012 POR, groundwater levels in the monitored sandstone declined 36.52 feet. In contrast, over the monitoring period of 2002-2009, groundwater levels declined 209.37 feet from initial static water levels (Figure A.74; Table A.37). Gas pressure was not recorded in the Wasatch sandstone.

**Big George Coal**

Sufficient water level data were not recorded during the 2010-2012 POR. In contrast, water levels declined 1,070.73 feet during the monitoring period of 2002-2009 (Figure A.74; Table A.37). Over the monitoring period of 2002-2012, gas pressure in the Big George decreased steadily from a peak value of 311.10 psi in October 2003 to 72 psi in August 2012.



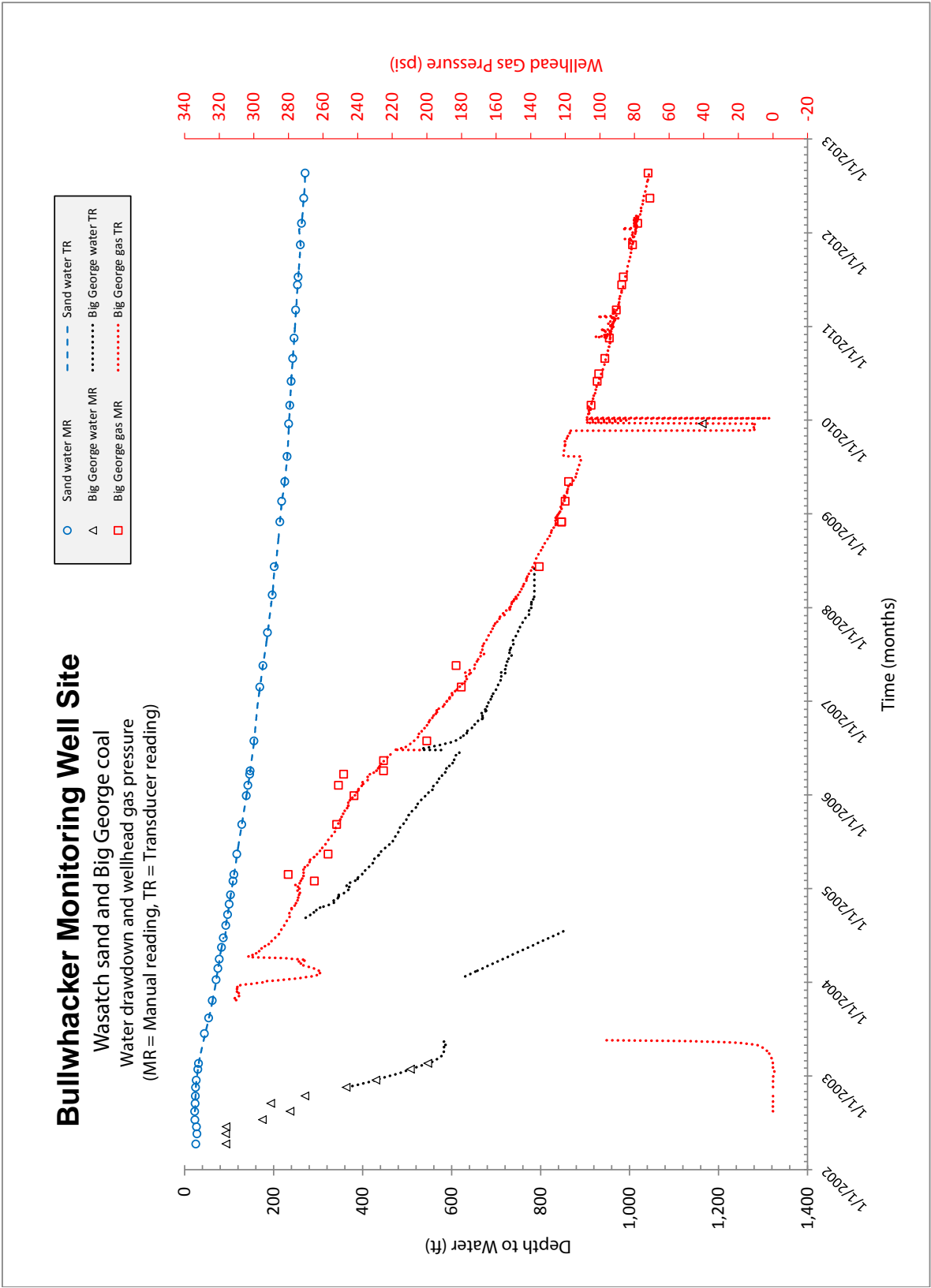
**Figure A.73.** Section showing relative positions of coals and sands in feet. Not to scale.

**Table A.36.** Table showing the depth to and thickness of monitored zones at the Bullwhacker monitoring well site location. (measured in feet)

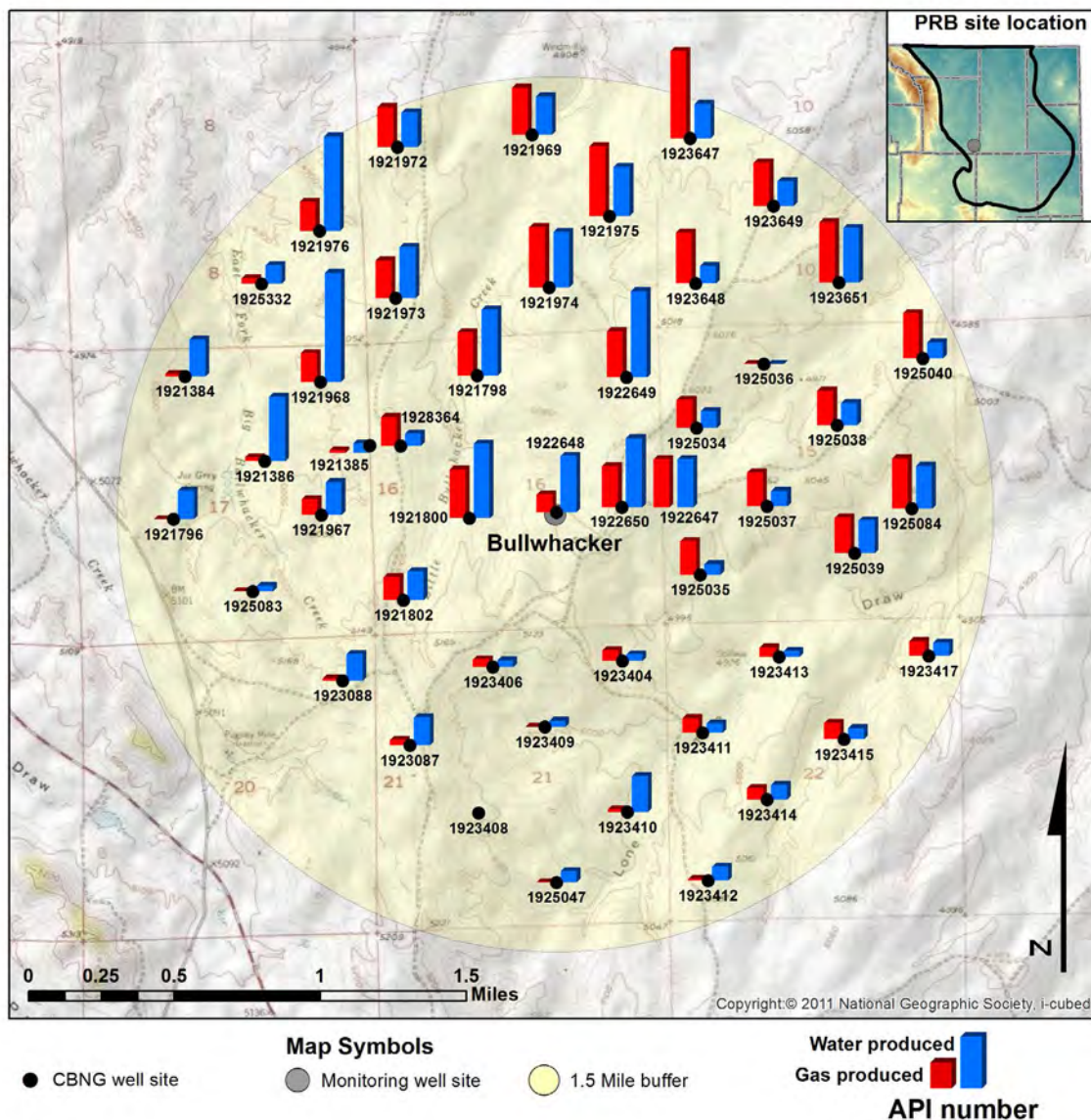
Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Wasatch sand	1,202	1,238	36	100
Big George coal	1,338	1,430	92	n/a

**Table A.37.** Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2010	Drawdown 2010-2012	Total drawdown (ft.)	Depth to Final water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	25.41	209.37	36.52	245.89	271.30	n/a	n/a
Big George coal	92.77	1,070.73	n/a	1,070.73	1,163.50	311.10	10/30/03



**Figure A.74.** Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Bullwhacker monitoring wellsite location.

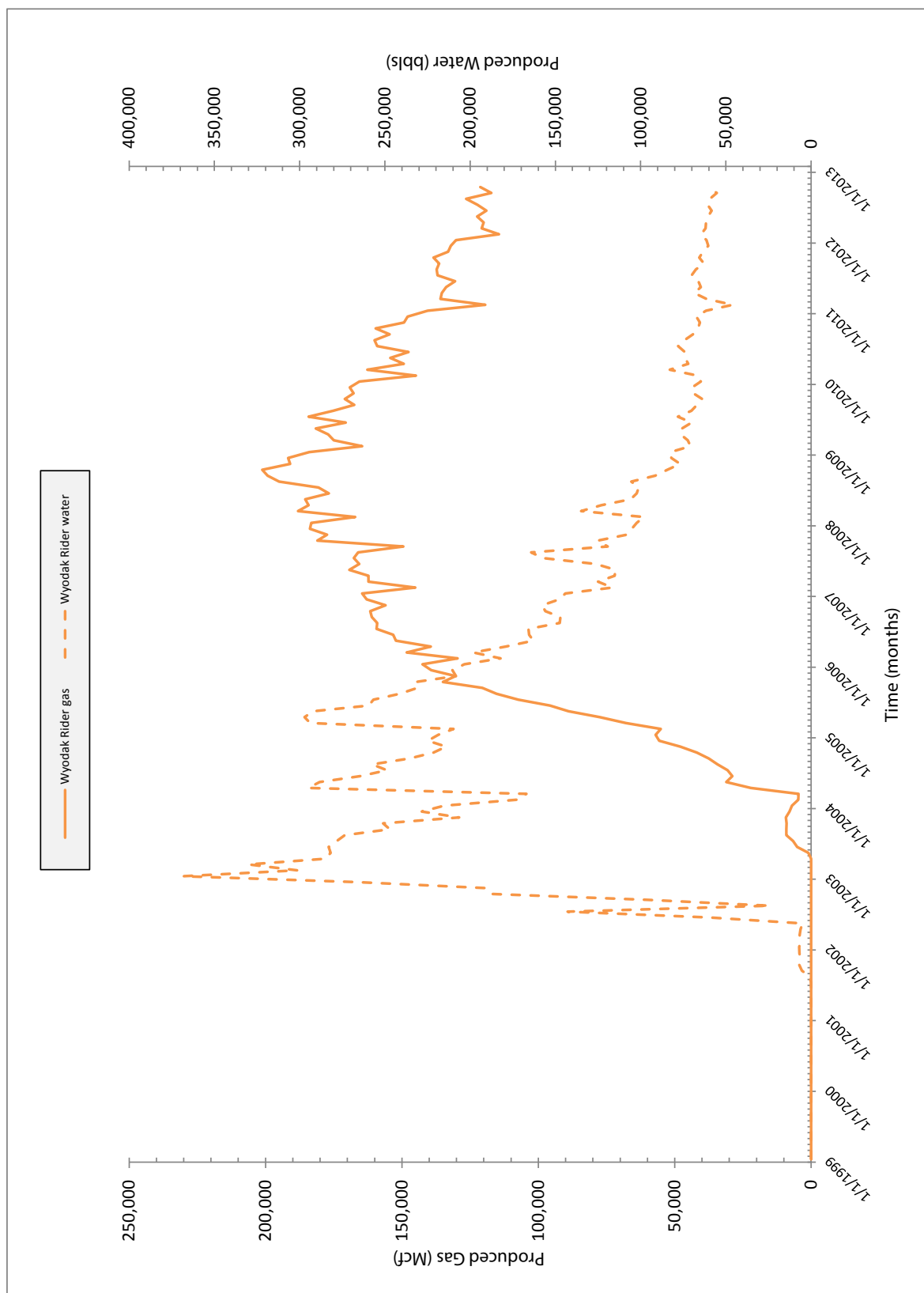


**Figure A.75.** Bullwhacker monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

### Production Statistics

Production data were analyzed for CBNG wells within the buffer of the Bullwhacker monitoring well site from 1999-2012. Cumulative production for individual CBNG wells is displayed by location on Figure A.75. CBNG and water production are monitored in the Wyodak Rider coal zone production wells.

Water production rates in the Wyodak Rider peaked in January 2003 at 368,412 bbls; production has declined steadily since then and finished 2012 at 60,666 bbls/month. Gas production in the Wyodak Rider coal zone began in 2003, peaked in October 2008 at 201,205 Mcf (Figure A.76). Gas production levels have declined to about 130,000 Mcf/month for 2011 and 2012.



**Figure A.76.** Water and gas production from CBNB wells associated with the Bullwhacker monitoring well site location.



**Carr Draw Monitoring Well Site**  
**Location: S29 T50N R75W**  
**Date First Monitored: September 26, 2007**

**Drawdown Information**

The Carr Draw monitoring well site includes two wells, separated by packers. One is completed in the Wasatch sandstone and the Big George coal of the Wyodak Rider coal zone. The second well is completed in the Werner coal and the Gates/Wall coal both of which are in the Cook coal zone, (Figure A.77; Table A.38). Water levels and wellhead gas pressures were measured during the POR using both manual and automatic transducer and data logger equipment. Transducer data that is missing, randomly fluctuating (noisy) or that substantially differs from concurrent manual measurements may indicate on-site equipment failure, malfunction or requirement for calibration.

**Wasatch Sandstone**

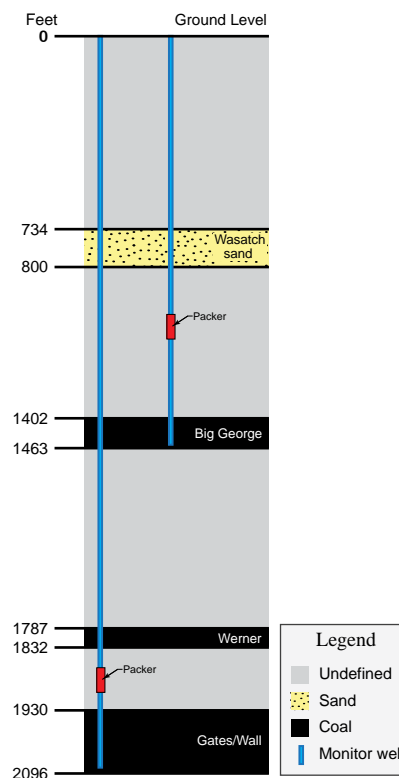
During the 2010-2012 POR, groundwater levels in the monitored sandstone declined 279.35 feet. In contrast, over the monitoring period of 2007-2009, groundwater levels declined 355.39 feet from initial static water levels (Figure A78; Table A.39). Gas pressure was not recorded in the Wasatch sandstone.

**Big George Coal**

During the 2010-2012 POR, groundwater levels declined 363.15 feet. Water levels declined 546.15 feet during the monitoring period of 2007-2009 (Figure A78; Table A.39). Gas pressure in the Big George remained fairly stable during the monitoring period of 2009 - 2012 reaching a peak value of 1.32 psi in August 2009.

**Werner Coal**

Groundwater levels declined 180.24 feet during the 2010-2012 POR. During the monitoring period of 2007-2009, groundwater levels dropped 320.26 feet (Figure A79; Table A.39). Gas pressure in the Werner coal has remained below 1.0 psi over the monitoring period of 2007-2012, peaking in August 2009 at 0.79 psi and ending 2012 at 0.16 psi.



**Figure A.77.** Section showing relative positions of coals and sands in feet. Not to scale.

**Gates/Wall Coal**

Groundwater levels declined 9.14 feet during the 2010-2012 POR. Over the monitoring period of 2007-2009 water levels rose a total of 143.52 feet (Figure A79; Table A.39). Gas pressure has remained below 1 psi during the monitoring period of 2004-2012, peaking at 0.30 psi in 2010.

**Table A.38.** Table showing the depth to and thickness of monitored zones at the Carr Draw monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Wasatch sand	734	800	66	602
Big George coal	1,402	1,463	61	n/a
Werner coal	1,787	1,832	45	n/a
Gates/Wall coal	1,930	2,096	166	n/a

**Table A.39.** Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

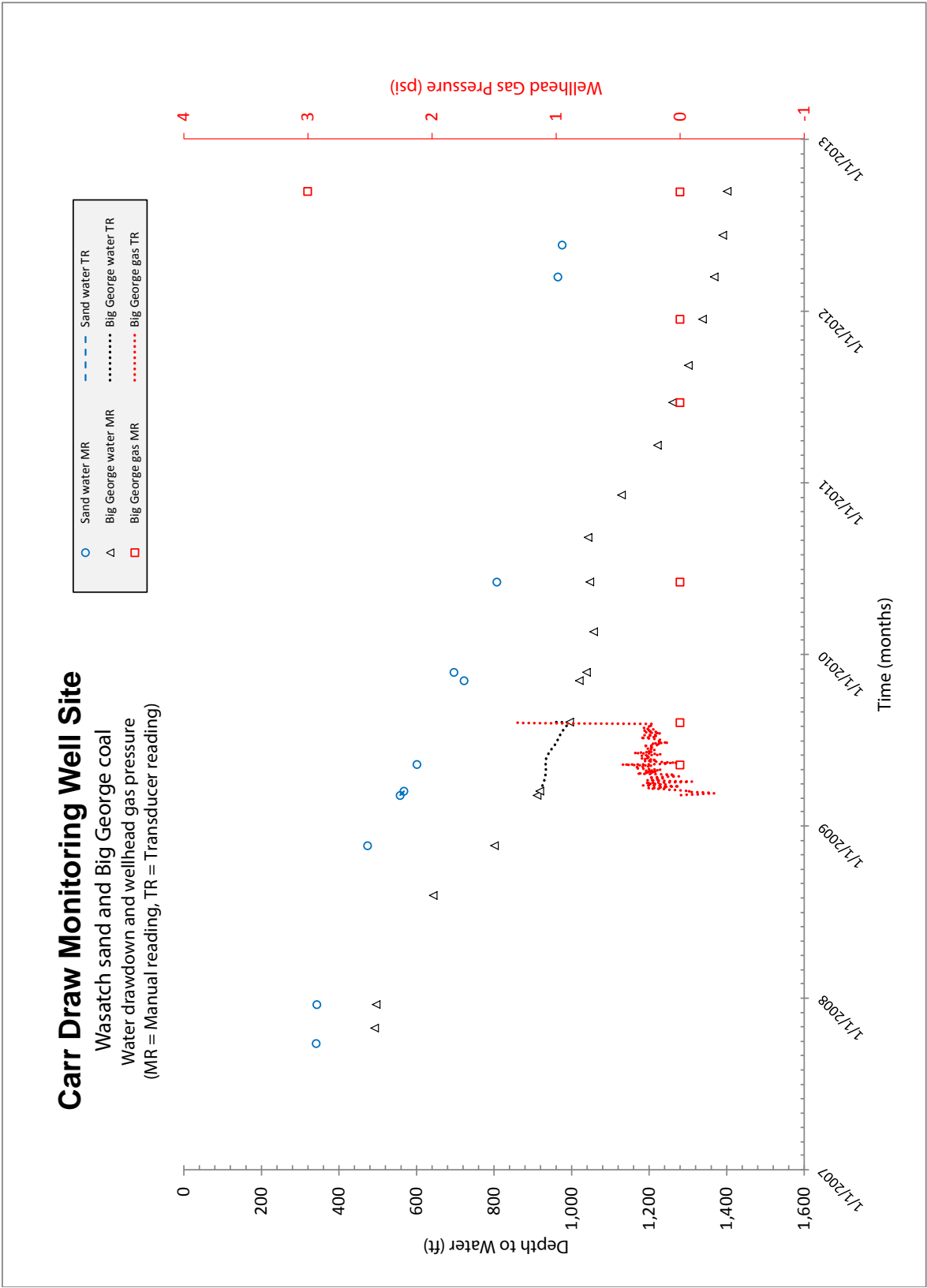
Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2010	Drawdown 2010-2012	Total drawdown (ft.)	Depth to Final water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	341.66	355.39	279.35	634.74	976.40	n/a	n/a
Big George coal	492.30	546.15	363.15	909.30	1401.60	1.32	8/9/2009
Werner coal	344.00	320.26	180.24	500.50	844.50	0.79	8/11/2009
Gates/Wall coal	490.50	-143.52	9.14	-134.38	356.12	0.30	4/27/2010

### Production Statistics

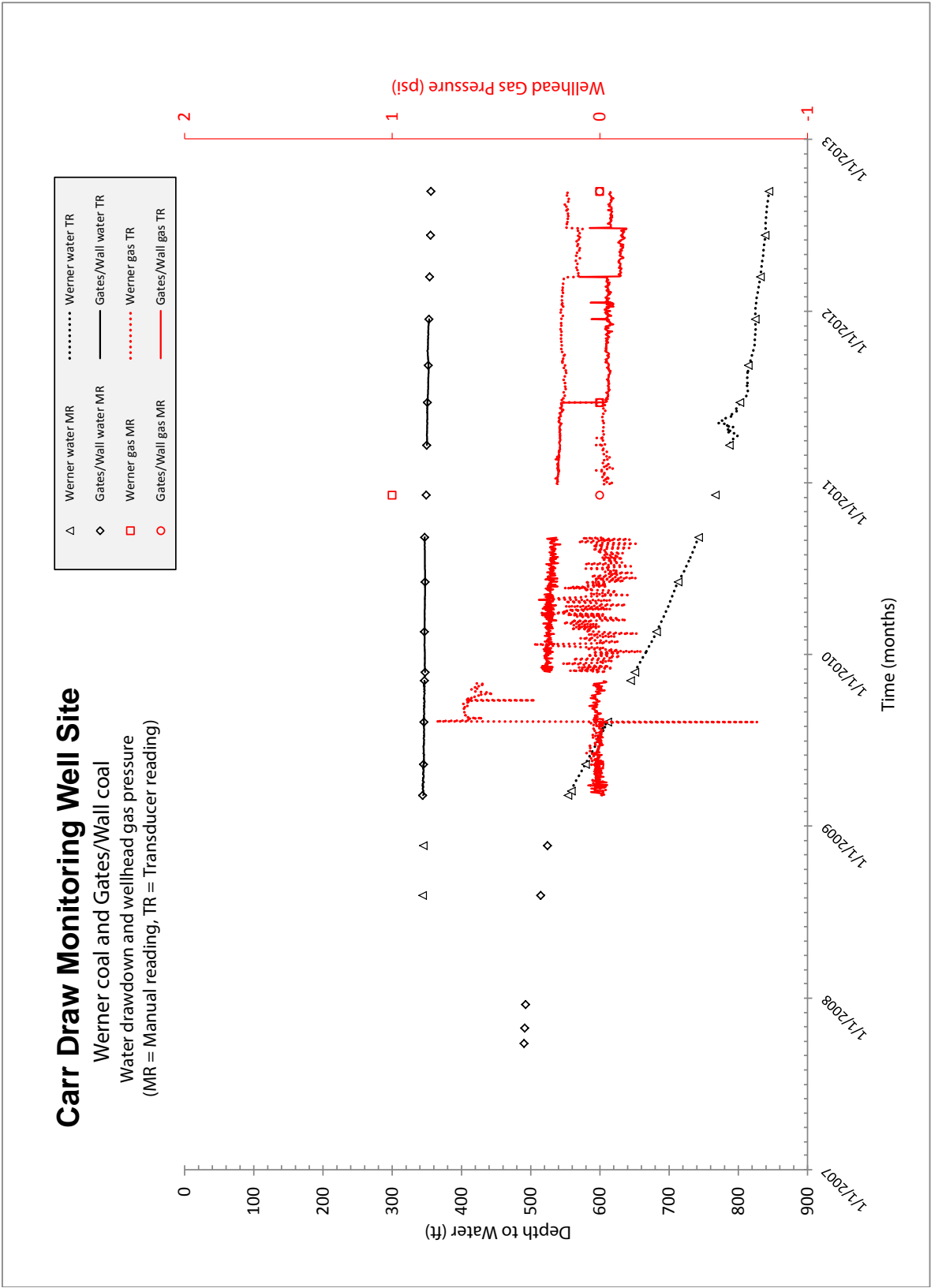
Production data were analyzed for CBNG wells within the buffer of the Carr Draw monitoring well site from 2002-2012. Cumulative production for individual CBNG wells is displayed by location on Figure A.80. CBNG and water production are monitored in the Wyodak Rider, Cook, unmonitored and in multiple coal zone production wells. Water production in the Wyodak Rider began in 2002, peaked in December 2009 at 109,507 bbls

and finished 2012 at 53,354 bbls/month. Gas production in the Wyodak Rider began in March 2009 and peaked in October 2012 at 2,081 Mcf (Figure A.81).

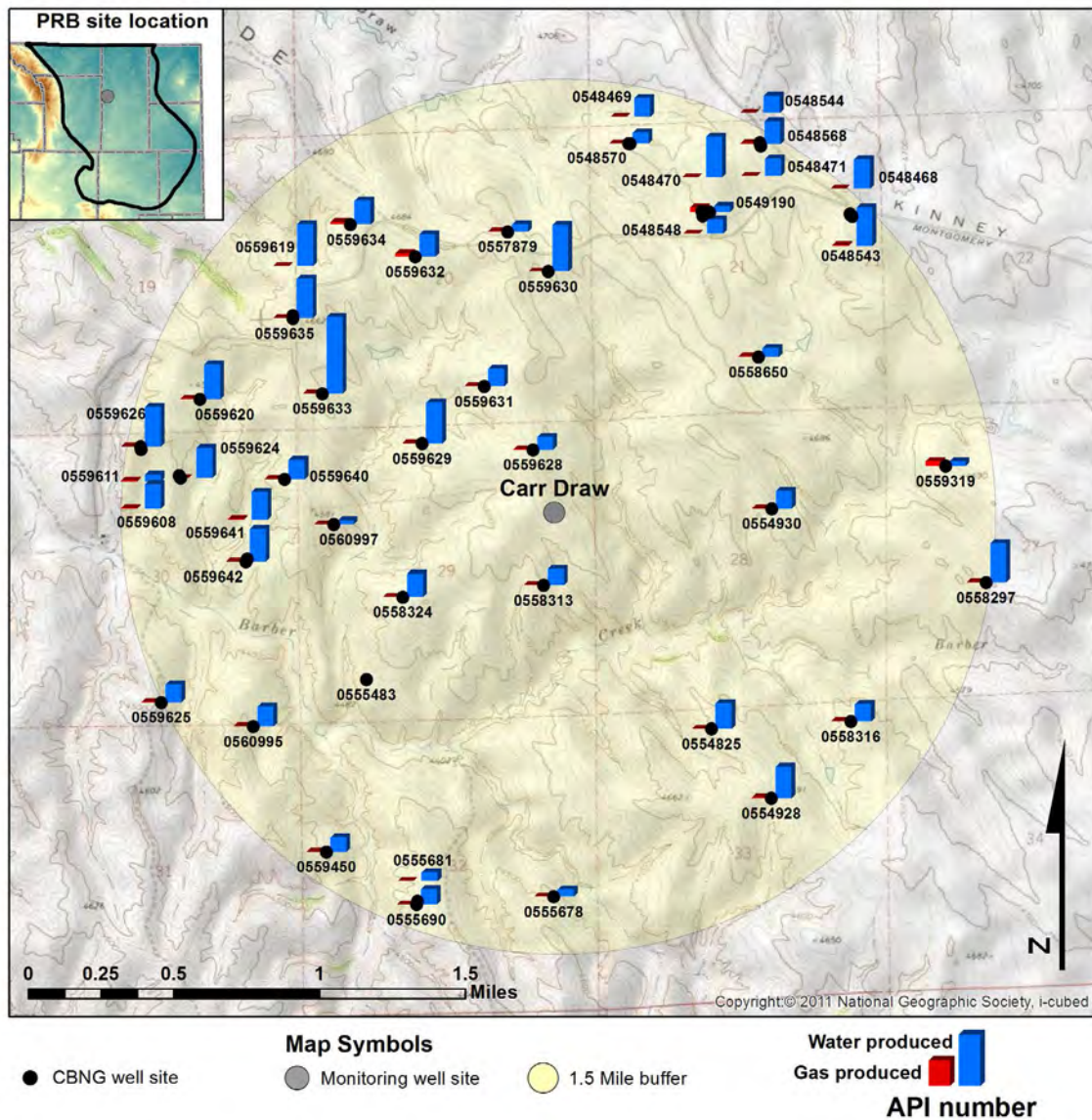
Water produced from multiple coal zone wells reached a peak value of 271,352 bbls in January 2010 and then generally declined to about 13,500 bbls/month by October 2012 (Figure A.81). Locally, gas production in multiple zone wells reached



**Figure A-78.** Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Carr Draw monitoring wellsite location.



**Figure A.79.** Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Carr Draw monitoring wellsite location.

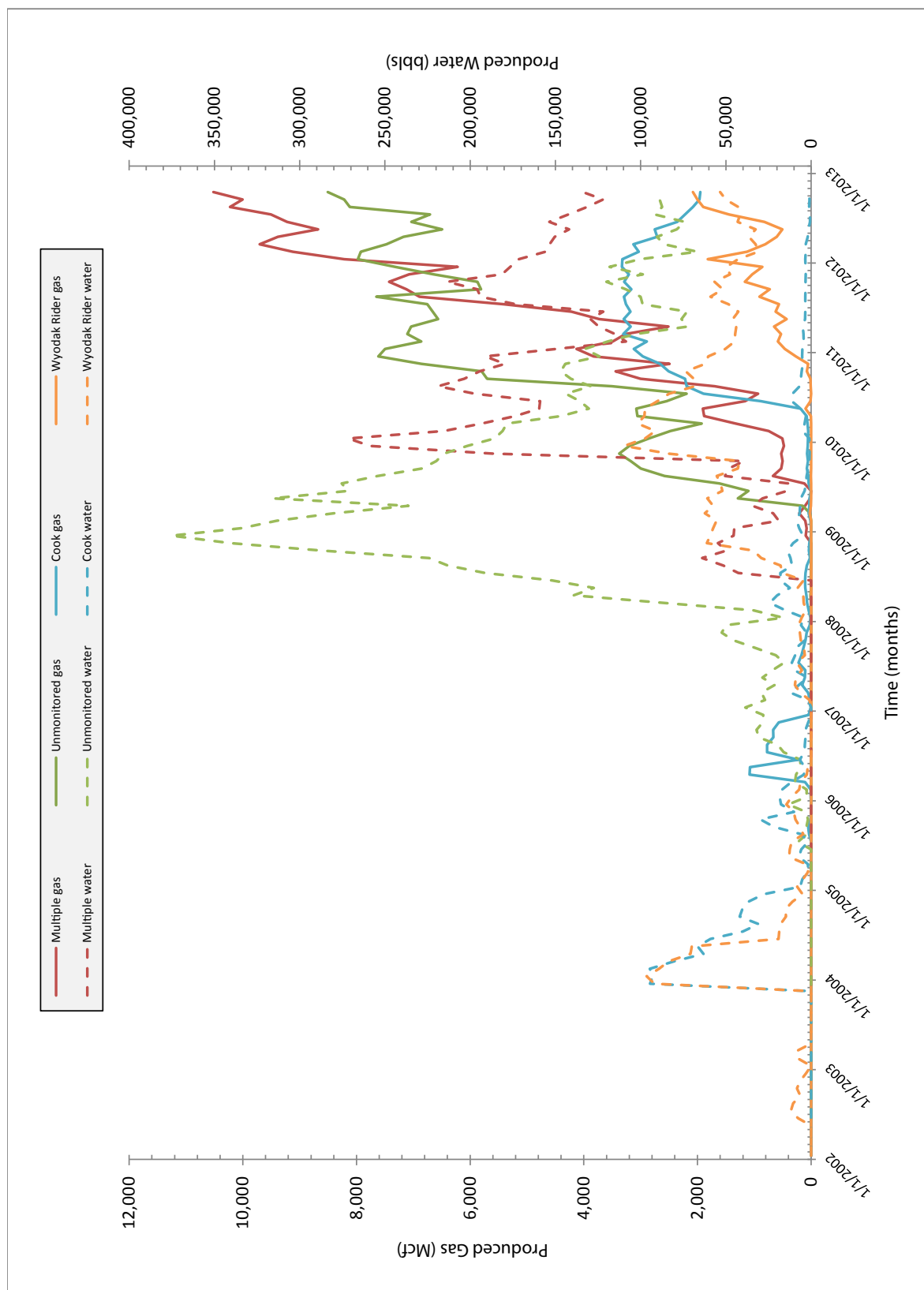


**Figure A.80.** Carr Draw monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

a peak in October 2012 at 10,520 bbls and it appears that gas production will continue to increase into 2013.

Cook coal zone wells reached peak water production of 94,597 bbls in February 2004 and peak gas production rate of 3,328 Mcf in December 2011. Gas production rates show a gradual decline during 2012.

Water production in the unmonitored coal zones peaked at 375,167 bbls in December 2008 (Figure A.81). Gas production in the unmonitored coal zones began in 2009, lagging about a year behind the major increase in water production. Gas production has been steadily increasing since 2009, and ended 2012 at 8,506 Mcf/month and should continue to grow into 2013.



**Figure A.81.** Water and gas production from CBNG wells associated with the Carr Draw monitoring well site location.



**Cedar Draw Monitoring Well Site**  
**Location: S2 T51N R75W**  
**Date First Monitored: January 29, 2004**

**Drawdown Information**

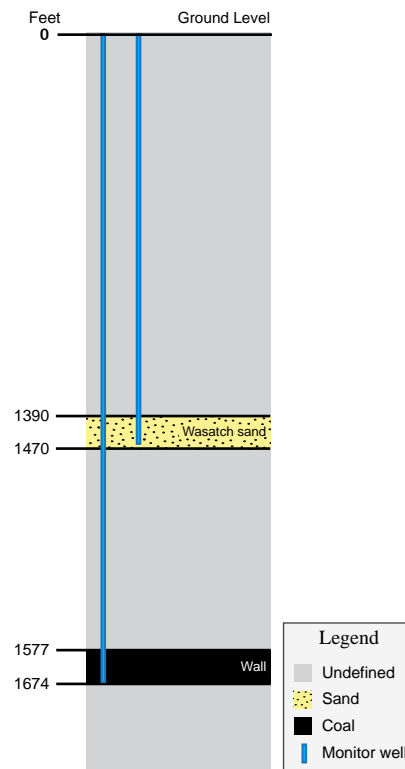
The Cedar Draw monitoring well site includes two wells. One is completed in the Wasatch sandstone and the other in Wall coal of the Wall coal zone (Figure A.82; Table A.40). Water levels and wellhead gas pressures were measured during the POR using both manual and automatic transducer and data logger equipment. Transducer data that is missing, randomly fluctuating (noisy) or that substantially differs from concurrent manual measurements may indicate on-site equipment failure, malfunction or requirement for calibration.

**Wasatch Sandstone**

During the 2010-2012 POR, groundwater levels in the monitored sandstone declined 36.34 feet. In contrast, over the monitoring period of 2004-2009, groundwater levels declined 499.51 feet from initial static water levels (Figure A.83; Table A.41). Gas pressure was not recorded in the Wasatch sandstone.

**Wall Coal**

Groundwater levels declined 44.50 feet during the 2010-2012 POR. Over the monitoring period of 2004-2009 water levels declined a total of 582.52 feet (Figure A.83; Table A.41). Gas pressure has remained below 1.5 psi during the monitoring period of 2004-2012, peaking at 1.24 psi in 2009.



**Figure A.82.** Section showing relative positions of coals and sands in feet. Not to scale.

**Table A.40.** Table showing the depth to and thickness of monitored zones at the Cedar Draw monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Wasatch sand	1,390	1,470	80	107
Wall coal	1,577	1,674	97	n/a

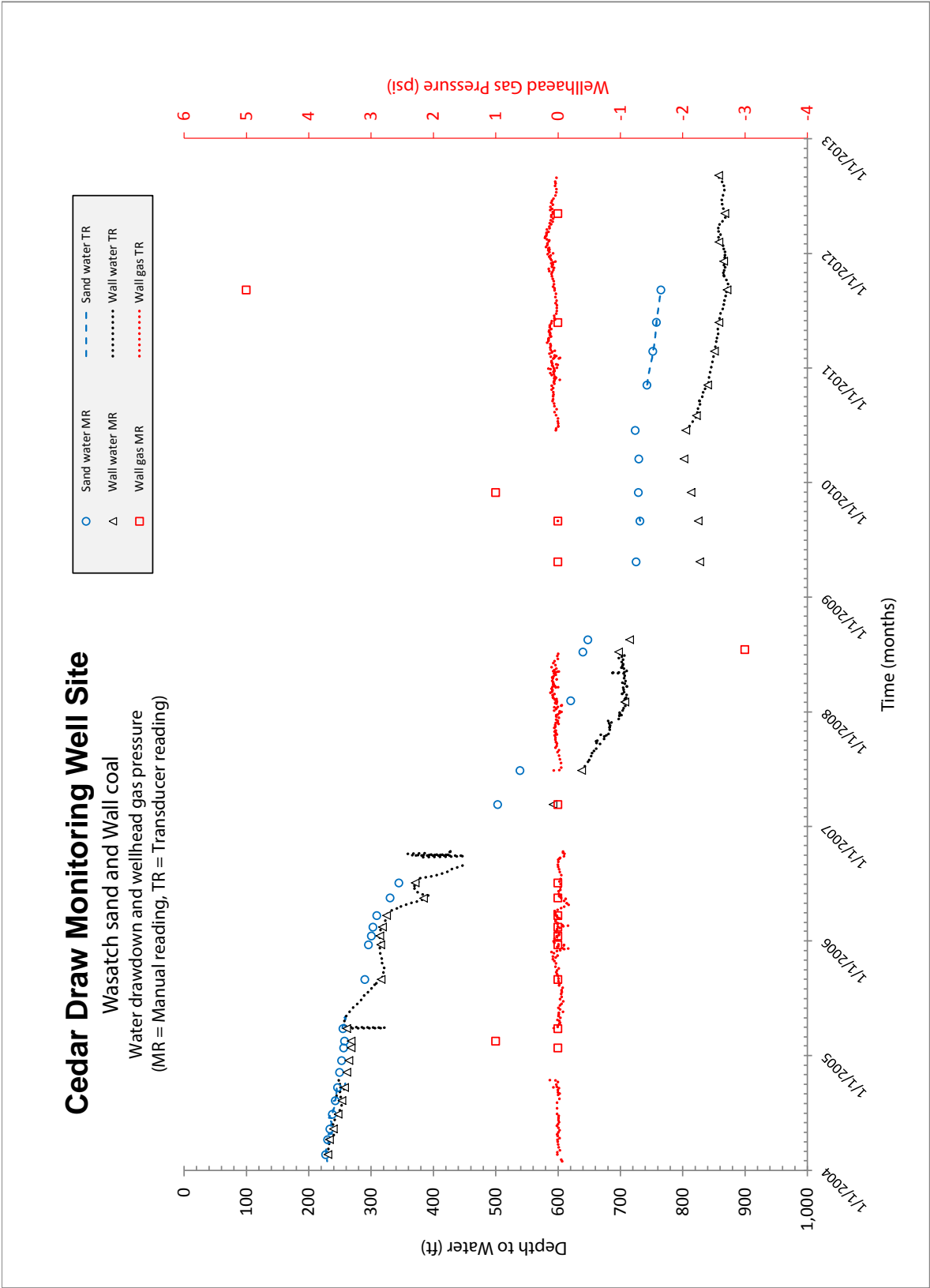
**Table A.41.** Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2010	Drawdown 2010-2012	Total drawdown (ft.)	Depth to Final water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	229.50	499.51	36.34	535.85	765.35	n/a	n/a
Wall coal	230.78	582.52	44.50	627.02	857.80	1.24	11/30/2009

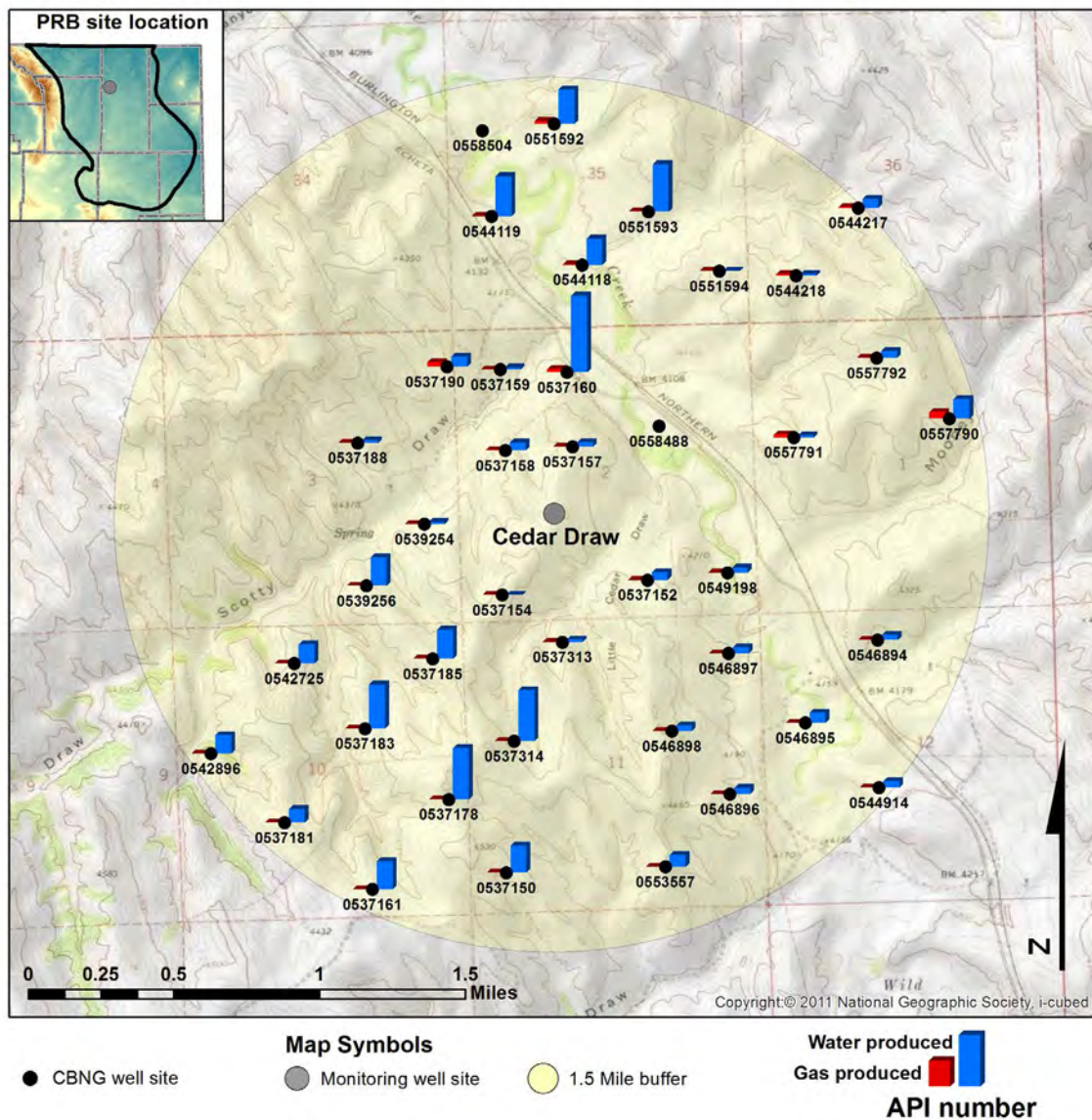
### Production Statistics

Production data were analyzed for CBNG wells within the buffer of the Cedar Draw monitoring well site from 1999-2012. Cumulative production for individual CBNG wells is displayed by location on Figure A.84. CBNG and water production are monitored in the Wall, unmonitored and in multiple coal zone production wells.

Consistent water production in the Wall coal zone began in January 2004, peaked in November 2006 at 542,823 bbls; 137,044 bbls were produced in August 2012. Gas production in the Wall coal zone began in November 2004 and peaked in July 2009 at 17,100 Mcf (Figure A.85).



**Figure A.83.** Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Cedar Draw monitoring wellsite location.

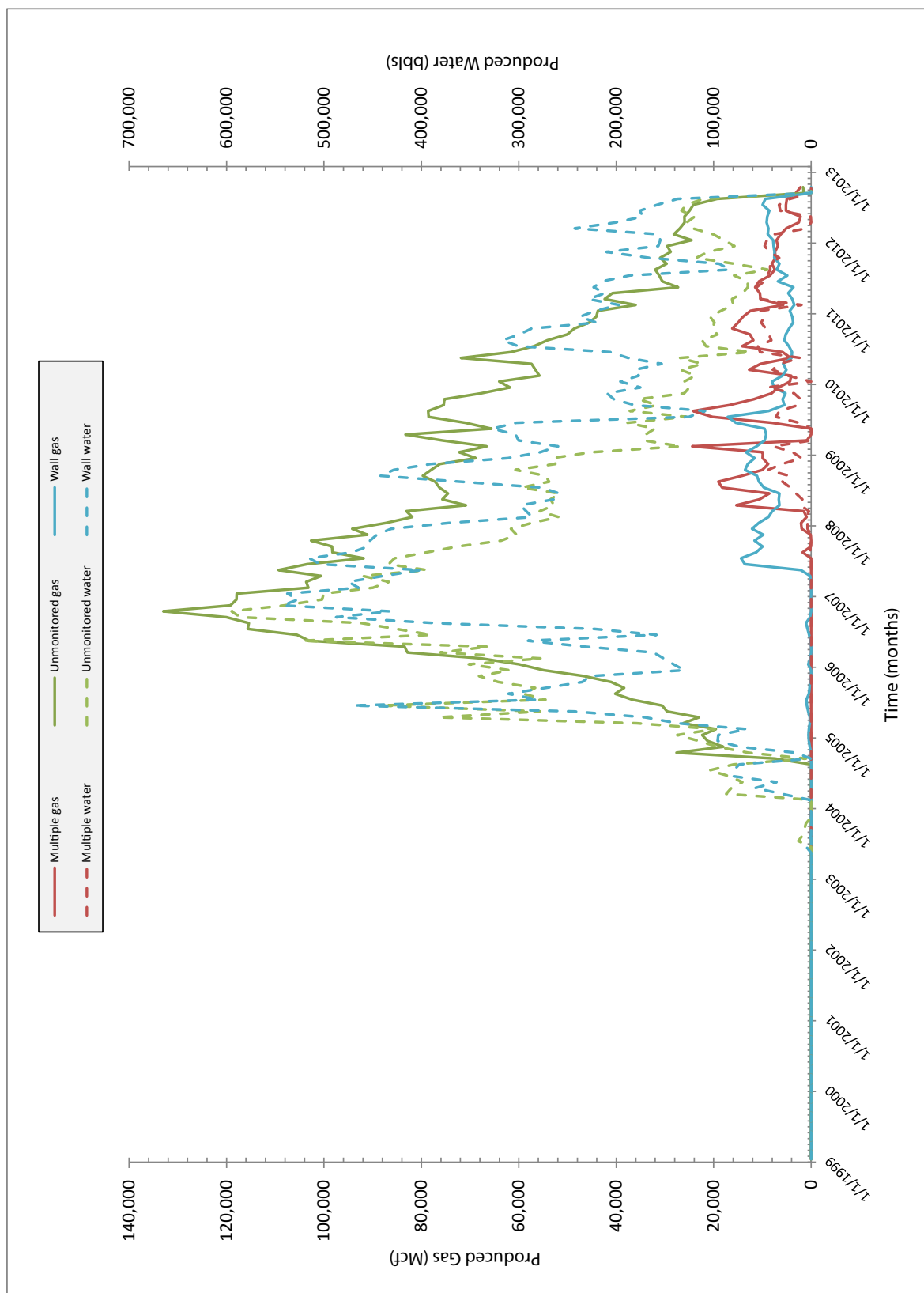


**Figure A.84.** Cedar Draw monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

Water produced from multiple coal zone wells reached a peak value of 55,941 bbls in May 2011 and declined to 21,776 bbls by August 2012 (Figure A.85). Locally, gas production in multiple zone wells peaked in February 2009 at 24,411 Mcf, and was only 2,186 Mcf in October 2012.

Water production in the unmonitored coal zones peaked at 594,951 bbls in October 2006 and declined to 110,477 bbls by August 2012 (Figure

A.85). Gas production in the unmonitored coal zones began in September 2004, peaked at 133,005 Mcf in October 2006, and was 19,343 Mcf in August 2012.



**Figure A.85.** Water and gas production from CBNNG wells associated with the Cedar Draw monitoring well site location.

**Coal Gulch Monitoring Well Site**  
**Location: S26 T51N R78W**  
**Date First Monitored: September 8, 2005**

**Drawdown Information**

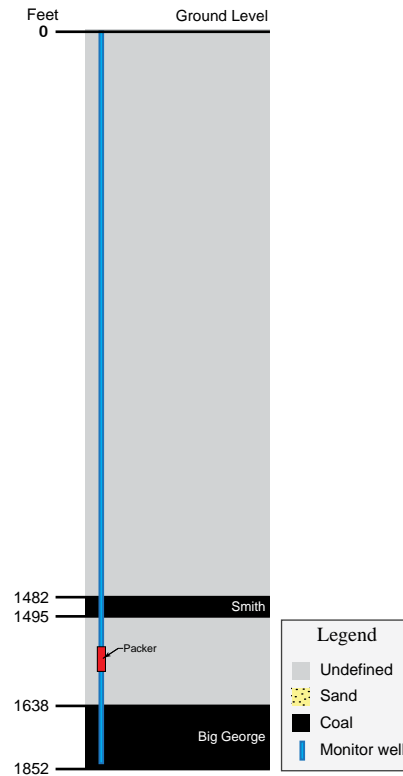
The Coal Gulch monitoring well site includes one well, separated by a packer. The well is completed in the Smith coal and the in the Big George coal both of the Wyodak Rider coal zone (Figure A.86; Table A.42). Water levels and wellhead gas pressures were measured during the POR using both manual and automatic transducer and data logger equipment. Transducer data that is missing, randomly fluctuating (noisy) or that substantially differs from concurrent manual measurements may indicate on-site equipment failure, malfunction or requirement for calibration. Similar water level measurements may indicate communication between wells, maybe due to a faulty packer.

**Smith Coal**

During the 2010-2012 POR, groundwater levels in the Smith coal declined 88.91 feet. In contrast, over the monitoring period of 2005 -2009, groundwater levels declined 219.29 feet from initial static water levels (Figure A.87; Table A.43). Maximum gas pressure was 21.93 psi in September 2012.

**Big George Coal**

Groundwater levels declined 93.11 feet during the 2010-2012 POR. Over the monitoring period of 2005-2009 water levels declined a total of 269.89 feet (Figure A.87; Table A.43). A peak gas pressure of 338.20 psi was recorded in July 2012.



**Figure A.86.** Section showing relative positions of coals and sands in feet. Not to scale.



**Table A.42.** Table showing the depth to and thickness of monitored zones at the Coal Gulch monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Smith coal	1,482	1,495	13	n/a
Big George coal	1,638	1,852	214	n/a

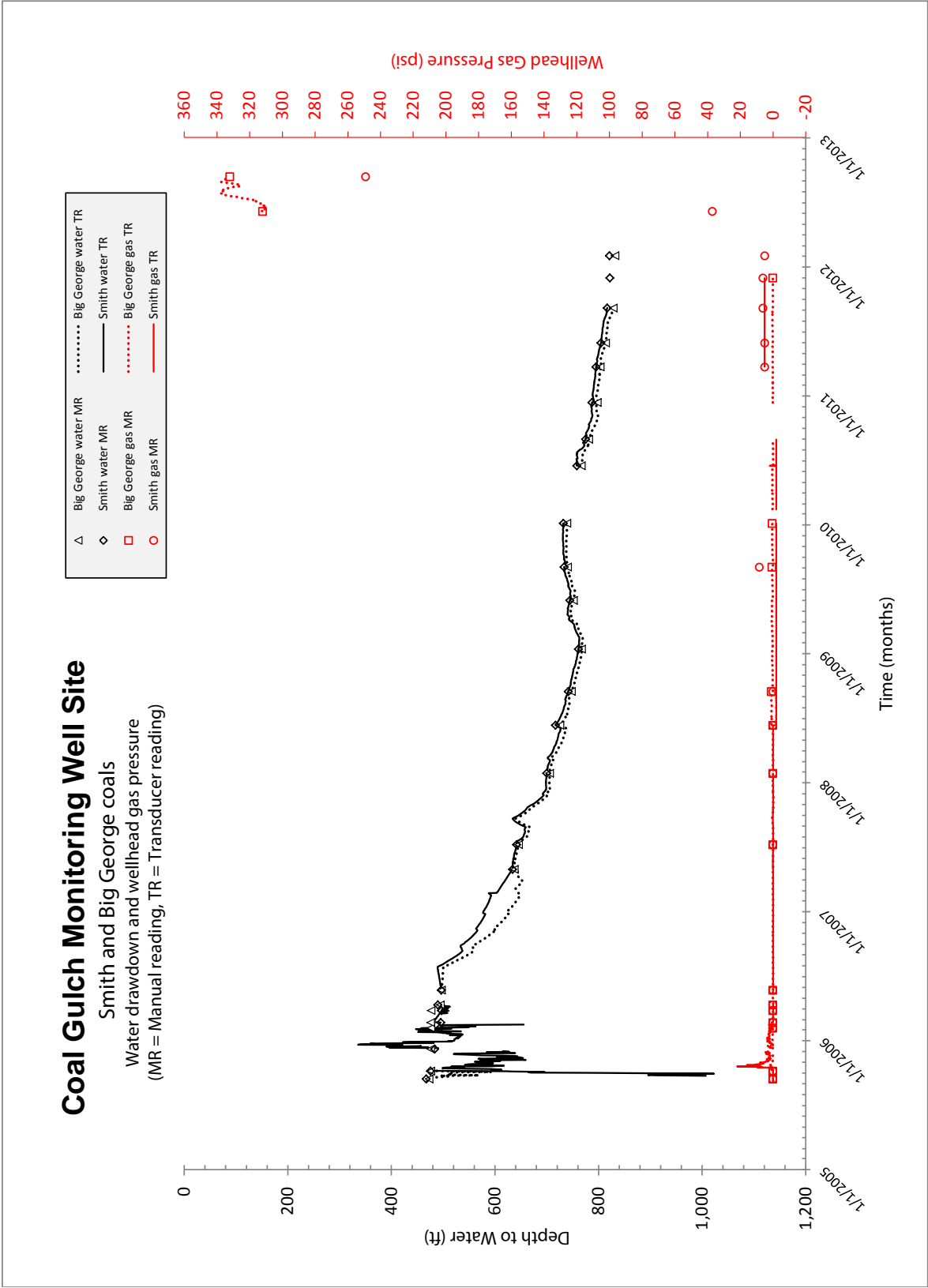
**Table A.43.** Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2010	Drawdown 2010-2012	Total drawdown (ft.)	Depth to Final water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Smith coal	513.00	219.29	88.91	308.20	821.20	21.93	9/27/2012
Big George coal	469.20	269.89	93.11	363.00	832.20	338.20	7/31/2012

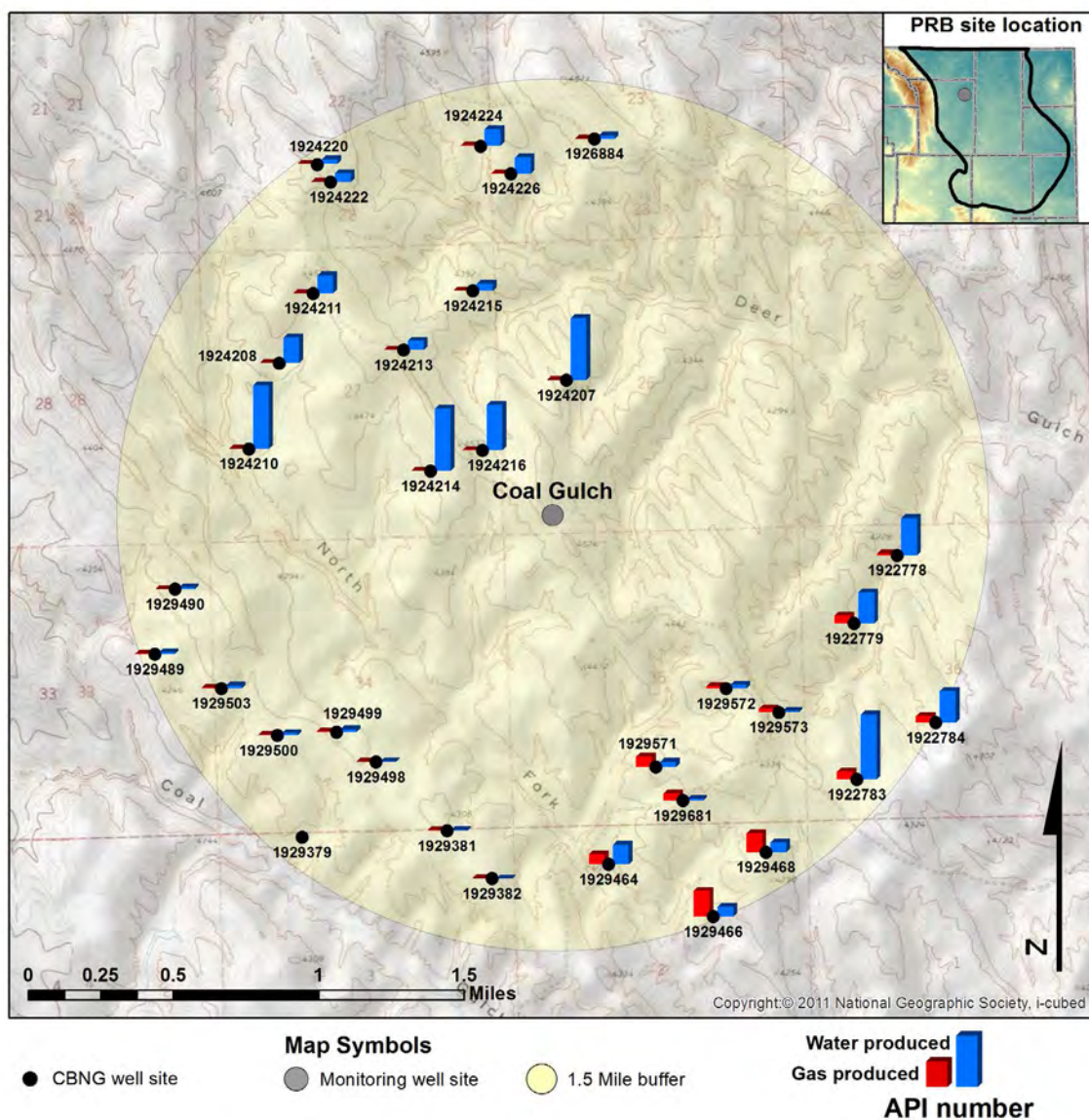
### Production Statistics

Production data were analyzed for CBNG wells within the buffer of the Coal Gulch monitoring well site from 2002-2012. Cumulative production for individual CBNG wells is displayed by location on Figure A.88. CBNG and water production are monitored in the Wyodak Rider, unmonitored and in multiple coal zone production wells.

Water production in the Wyodak Rider coal zone began in August 2003, peaked in October 2006 at 128,873 bbls; 58,650 bbls were produced in October 2012. Gas production in the Wyodak Rider began in February 2008 and peaked in September 2012 at 117,675 Mcf (Figure A.88).



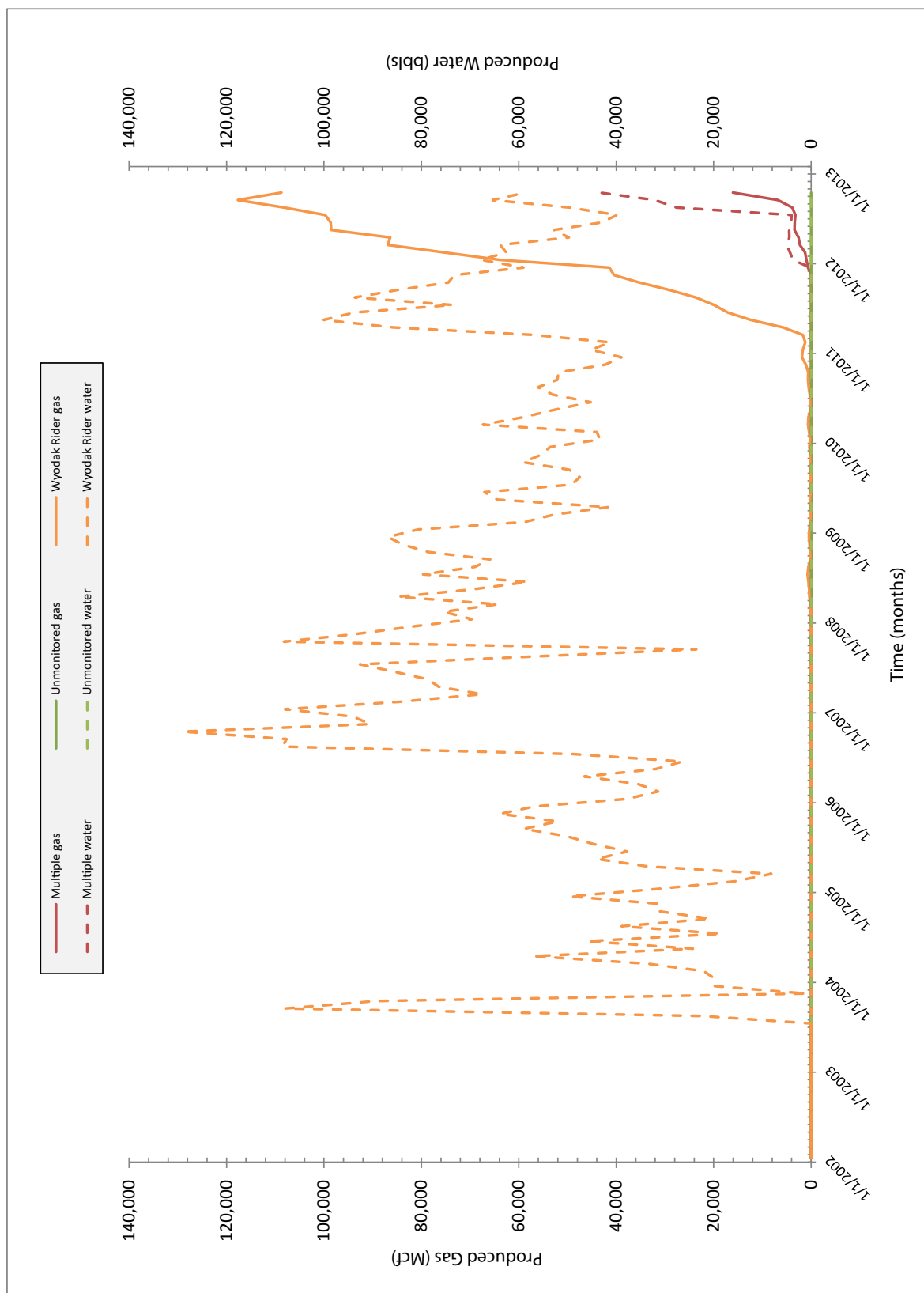
**Figure A.87.** Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Coal Gulch monitoring wellsite location.



**Figure A.88.** Coal Gulch monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

Water production from multiple coal zone wells began in December 2011 and reached a peak value of 43,451 bbls in October 2012 (Figure A.89). Locally, gas production in multiple zone wells began in December 2011 and peaked in October 2012 at 16,049 Mcf. Water and gas production rates will probably continue to increase into 2013.

Unmonitored coal zone wells have not produced recorded levels of water or gas during the 2010-2012 POR (Figure A.89).



**Figure A.89.** Water and gas production from CBNB wells associated with the Coal Gulch monitoring well site location.

# Dilts Monitoring Well Site

## Location: S31 T43N R71W

### Date First Monitored: March 24, 1999

#### Drawdown Information

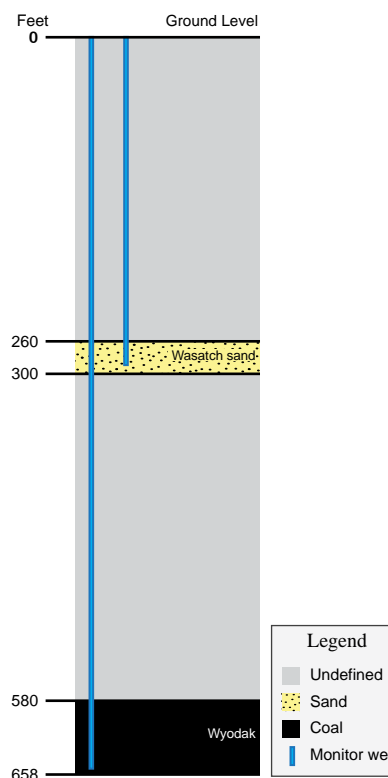
The Dilts monitoring well site includes two wells. One is completed into a Wasatch sandstone and the other into the Wyodak coal of the Upper Wyodak coal zone (Figure A.90; Table A.44). Water levels and wellhead gas pressures were measured during the POR using both manual and automatic transducer and data logger equipment. Transducer data that is missing, randomly fluctuating (noisy) or that substantially differs from concurrent manual measurements may indicate on-site equipment failure, malfunction or requirement for calibration.

#### Wasatch Sandstone

During the 2010-2012 POR, groundwater levels in the Wasatch sandstone declined 0.11 feet. In contrast, over the monitoring period of 1999-2009, groundwater levels declined 5.30 feet from initial static water levels (Figure A.91; Table A.45). Gas pressure was not recorded in the Wasatch sandstone.

#### Wyodak Coal

Groundwater levels declined 0.00 feet during the 2010-2012 POR. Over the monitoring period of 1999-2009 water levels declined a total of 317.40 feet (Figure A.91; Table A.45). A peak gas pressure of 92.56 psi was recorded in February 2000.



**Figure A.90.** Section showing relative positions of coals and sands in feet. Not to scale.

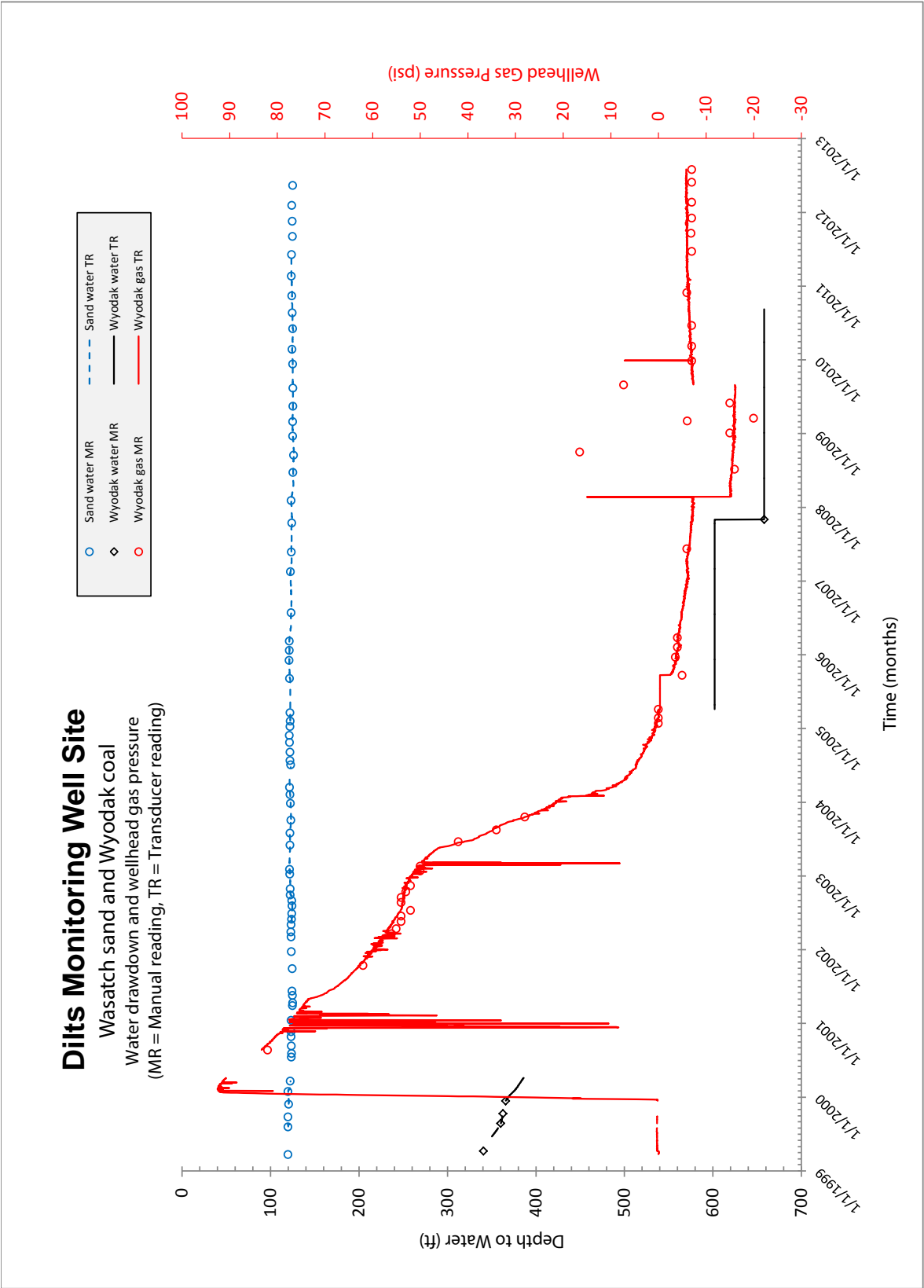
**Table A.44.** Table showing the depth to and thickness of monitored zones at the Diltz monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Wasatch sand	260	300	40	280
Wyodak coal	580	658	78	n/a

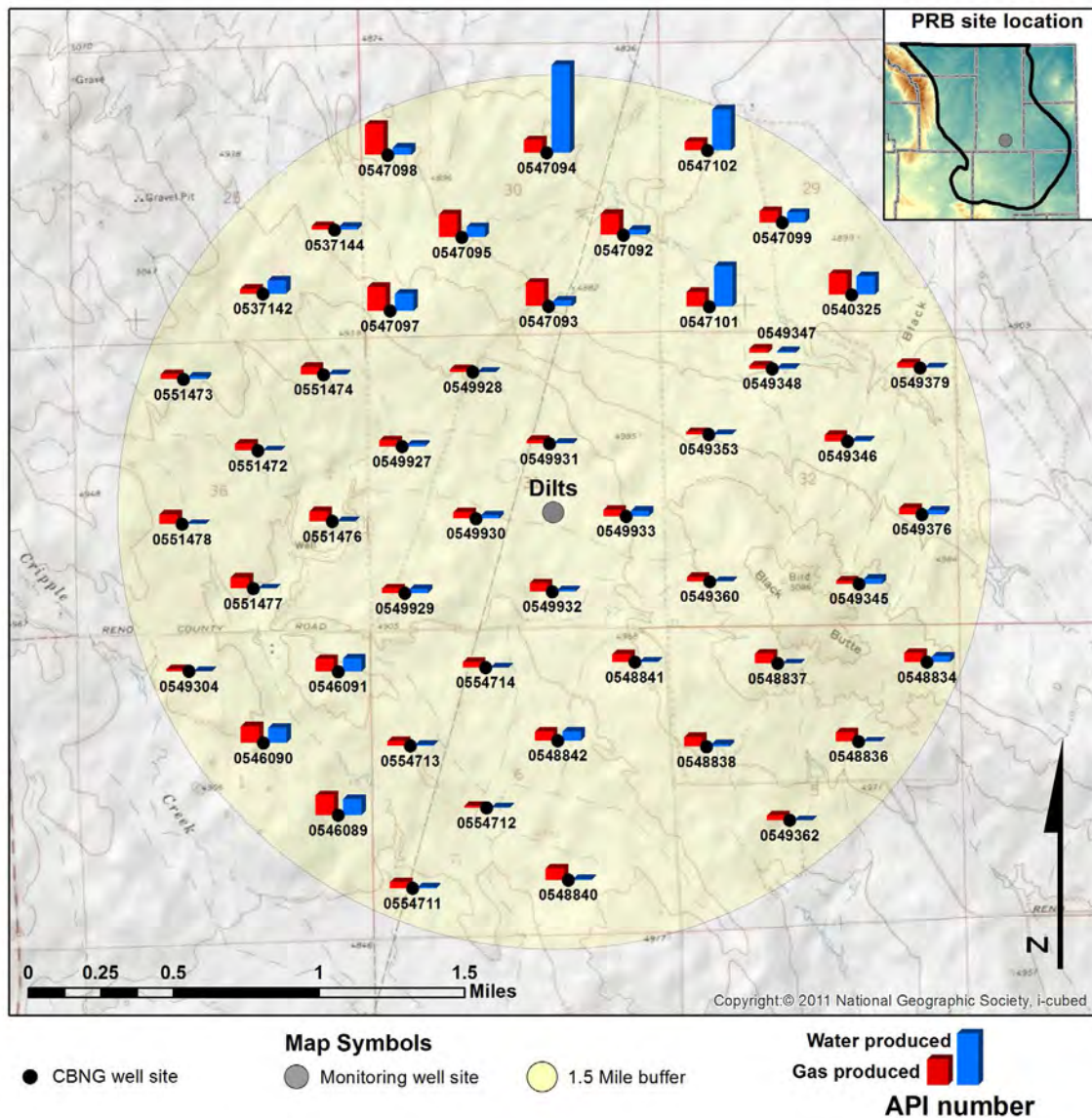
**Table A.45.** Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2010	Drawdown 2010-2012	Total drawdown (ft.)	Depth to Final water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	119.80	5.30	0.11	5.41	125.21	n/a	n/a
Wyodak coal	340.60	317.40	0.00	317.40	658.00	92.56	2/9/2000





**Figure A.91.** Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Dilts monitoring wellsite location.

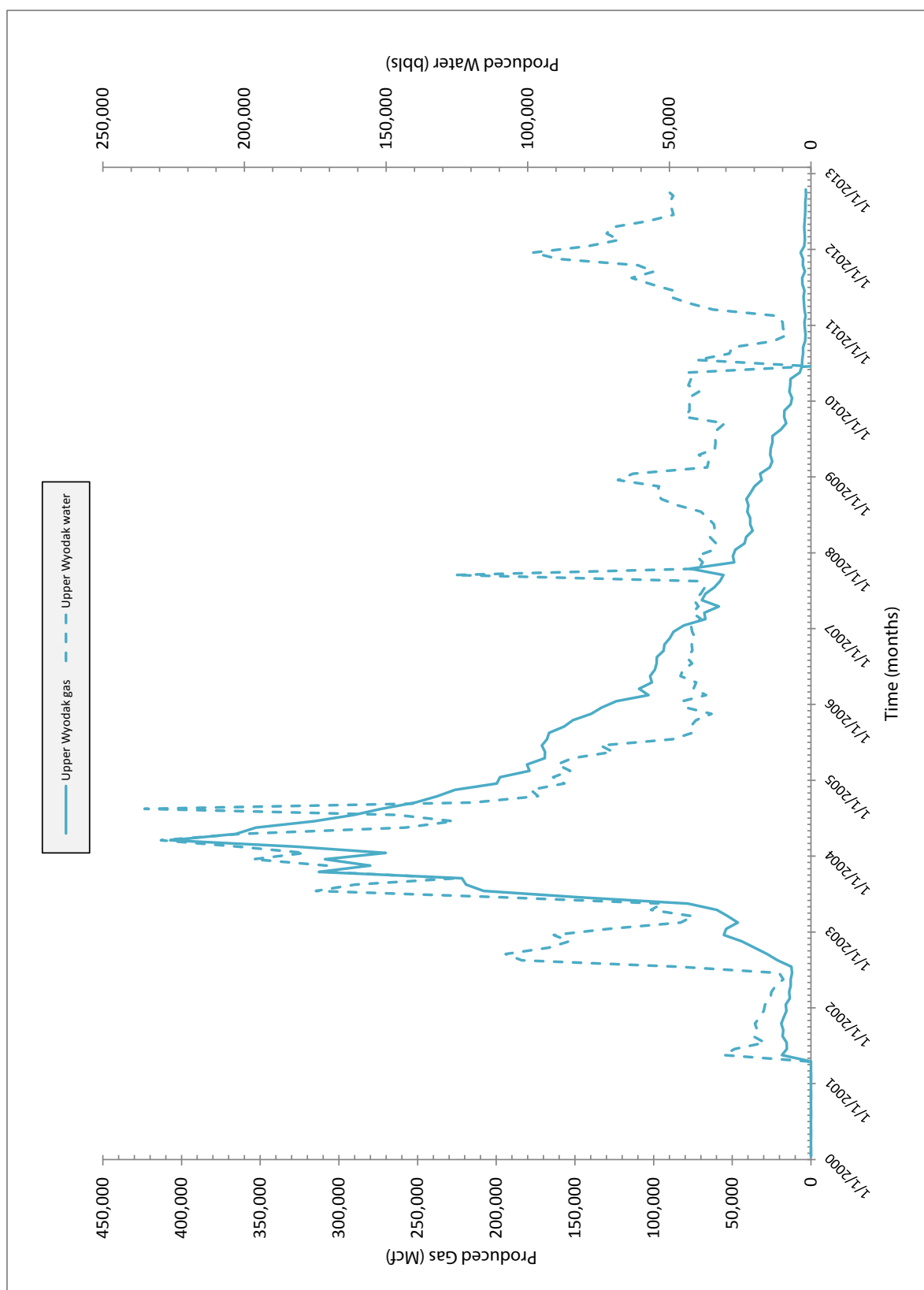


**Figure A.92.** Dilts monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

### Production Statistics

Production data were analyzed for CBNG wells within the buffer of the Dilts monitoring well site from 2000-2012. Cumulative production for individual CBNG wells is displayed by location on Figure A.92. CBNG and water production are monitored in Upper Wyodak coal zone production wells.

Water production in the Upper Wyodak coal zone began in April 2001, peaked in August 2004 at 235,302 bbls; 51,200 bbls were produced in October 2012. Gas production in the Wyodak Rider began in May 2001 and peaked in March 2004 at 407,188 Mcf (Figure A.93).



**Figure A.93.** Water and gas production from CBNB wells associated with the Dilts monitoring well site location.

**Double Tank Monitoring Well Site**  
**Location: S35 T47N R75W**  
**Date First Monitored: December 19, 2002**

**Drawdown Information**

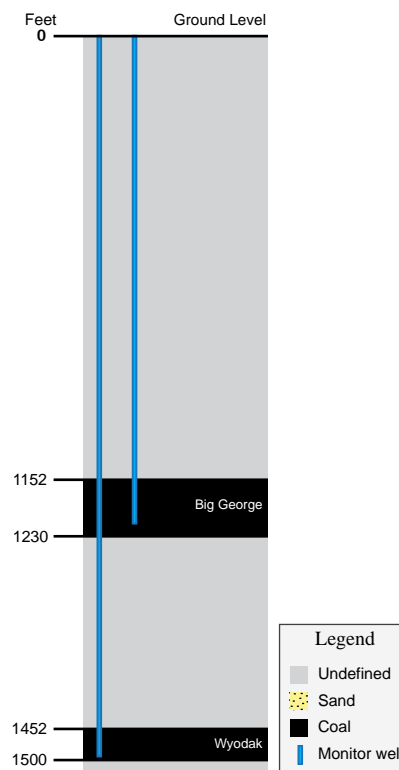
The Double Tank monitoring well site includes two wells. One is completed in Big George coal of the Wyodak Rider coal zone and the other in the deeper Wyodak coal of the Upper Wyodak coal zone (Figure A.94; Table A.46). Water levels and wellhead gas pressures were measured during the POR using both manual and automatic transducer and data logger equipment. Transducer data that is missing, randomly fluctuating (noisy) or that substantially differs from concurrent manual measurements may indicate on-site equipment failure, malfunction or requirement for calibration.

**Big George Coal**

During the 2010-2012 POR, groundwater levels in the Big George coal declined 58.50 feet. In contrast, over the monitoring period of 2002-2009, groundwater levels declined 514.89 feet from initial static water levels (Figure A.95; Table A.47). A peak gas pressure of 1.21 psi was recorded in February 2003.

**Wyodak Coal**

Groundwater levels declined 51.30 feet during the 2010-2012 POR. Over the monitoring period of 2002-2009 water levels declined a total of 296.14 feet (Figure A.95; Table A.47). A peak gas pressure of 0.54 psi was recorded in June 2003.



**Figure A.94.** Section showing relative positions of coals and sands in feet. Not to scale.

**Table A.46.** Table showing the depth to and thickness of monitored zones at the Double Tank monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Big George coal	1,152	1,230	78	n/a
Wyodak coal	1,452	1,500	48	n/a

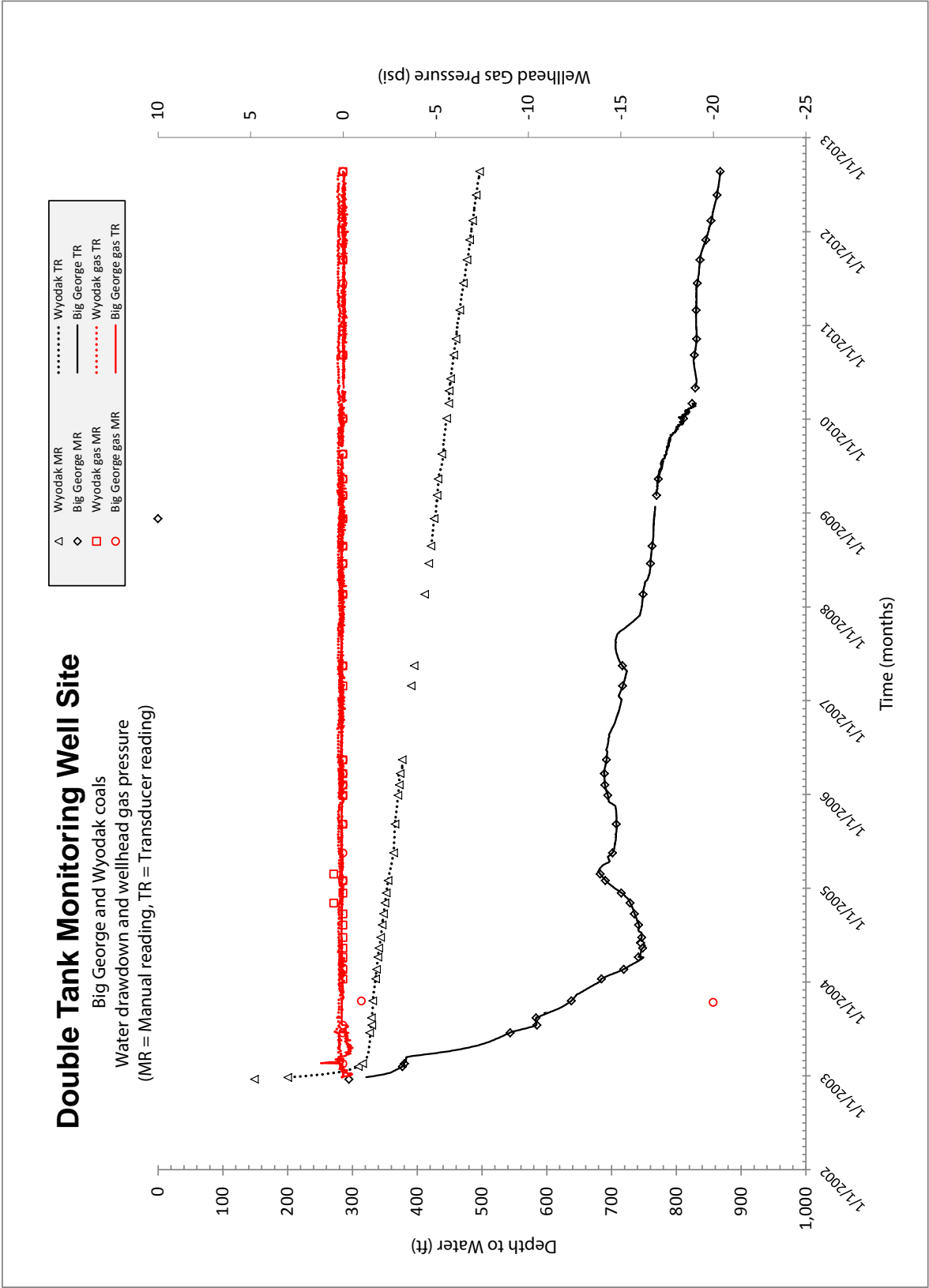
**Table A.47.** Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2010	Drawdown 2010-2012	Total drawdown (ft.)	Depth to Final water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Big George coal	294.61	514.89	58.50	573.39	868.00	1.21	2/19/2003
Wyodak coal	148.86	296.14	51.30	347.44	496.30	0.54	6/20/2003

### Production Statistics

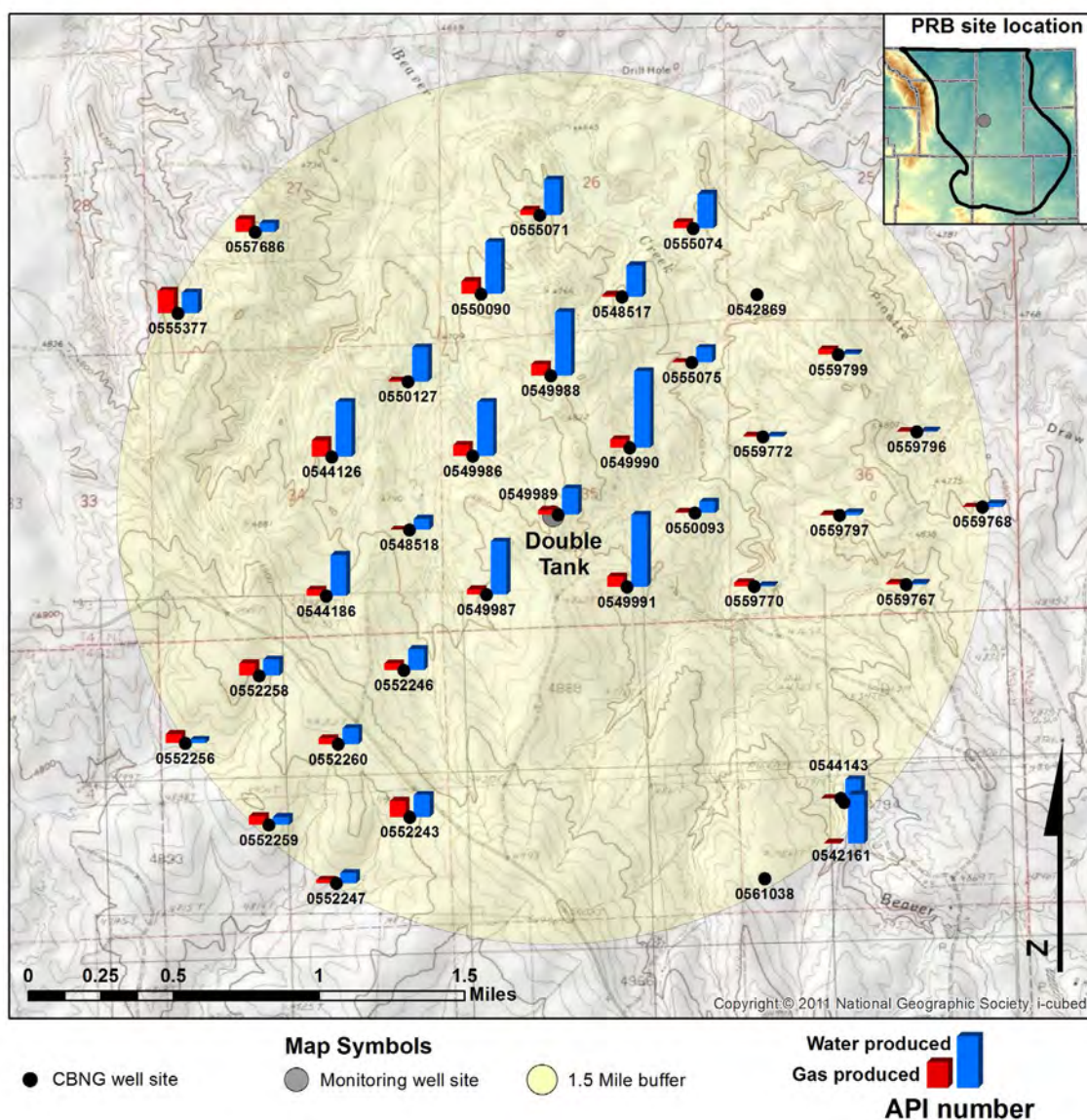
Production data were analyzed for CBNG wells within the buffer of the Double Tank monitoring well site from 2002 to 2012. Cumulative production for individual CBNG wells is displayed by location on Figure A.96. CBNG and water production are monitored in Wyodak Rider, Upper Wyodak and unmonitored Lower Wyodak coal zone wells.

Water production in the Upper Wyodak coal zone began in October 2002, peaked in November 2002 at 22,849 bbls; there has been no water production since September 2006. This coal zone has produced little gas over the monitoring period of 2002-2012. Gas production has been recorded in only three months over the 2010-2012 POR and peak production, reached in January 2005, was only 42 Mcf. (Figure A.97).



**Figure A.95.** Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Double Tank monitoring wellsite location.



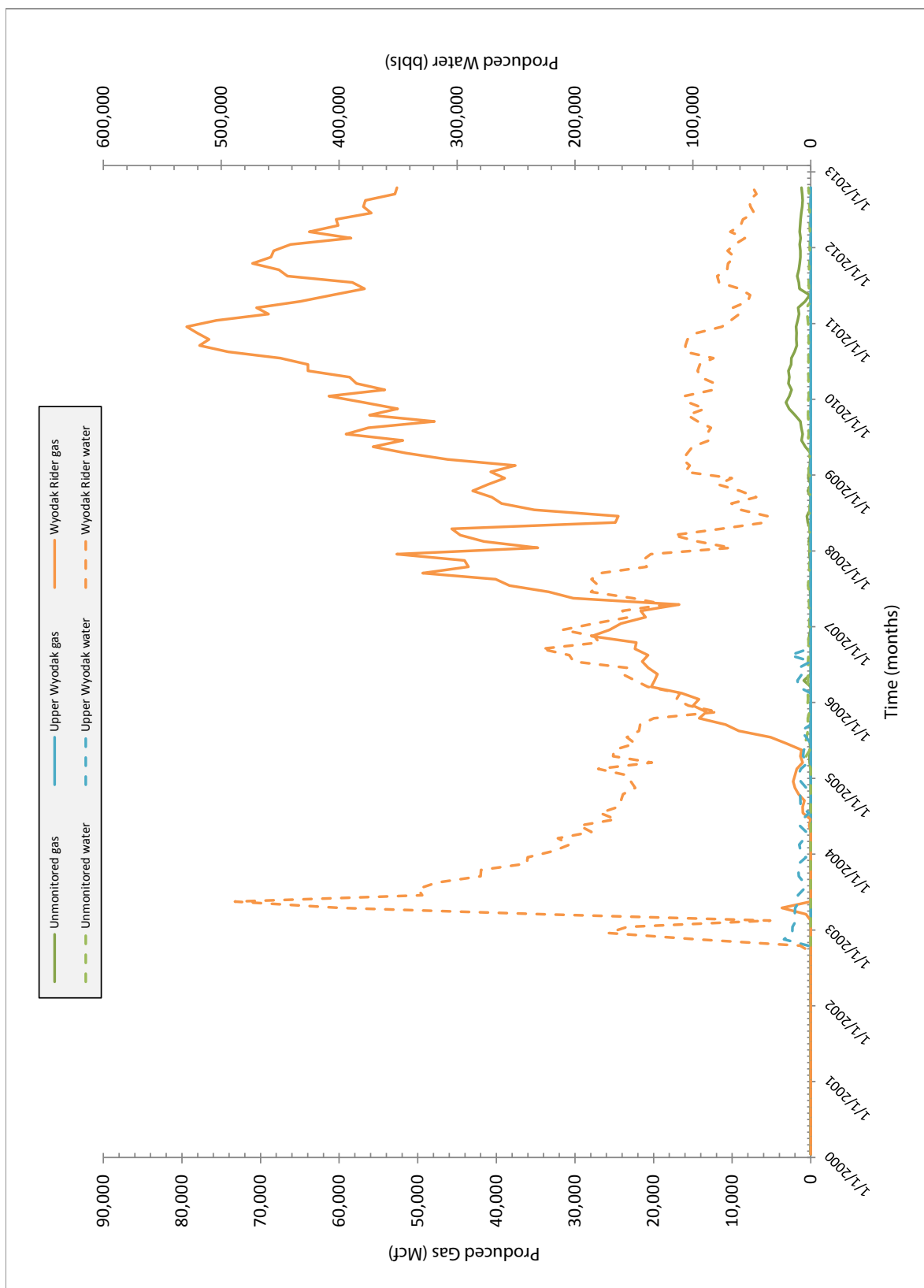


**Figure A.96.** Double Tank monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

Water production rates in the Wyodak Rider peaked in May 2003 at 488,410 bbls; production has declined steadily since then and finished 2012 at 48,874 bbls/month. Consistent gas production in the Wyodak Rider began in 2004, peaked in December 2010 at 79,402 Mcf (Figure A.97). Gas production levels have declined to 52,654 Mcf/month by October 2012.

Consistent water production in unmonitored Lower Wyodak coal zone wells began in 2005 and peaked at 4,805 bbls in June 2005. Gas production reached a peak level of 3,152 Mcf in December 2009 and continues in 2013 at low levels (<2000 Mcf/month) (Figure A.97).





**Figure A.97.** Water and gas production from CBNG wells associated with the Double Tank monitoring well site location.

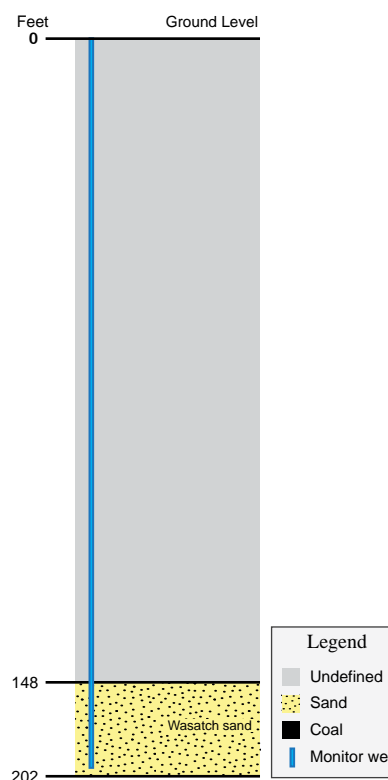
**Dry Willow Monitoring Well Site**  
**Location: S35 T44N R76W**  
**Date First Monitored: September 29, 1999**

**Drawdown Information**

The Dry Willow monitoring well site includes one well completed in the Wasatch sandstone (Figure A.98; Table A.48). Water levels were measured during the POR using both manual and automatic transducer and data logger equipment. Transducer data that is missing, randomly fluctuating (noisy) or that substantially differs from concurrent manual measurements may indicate on-site equipment failure, malfunction or requirement for calibration.

**Wasatch sandstone**

During the 2010-2012 POR, groundwater levels in the Wasatch sandstone declined 2.51 feet. In contrast, over the monitoring period of 1999-2009, groundwater levels rose 0.95 feet from initial static water levels (Figure A.99; Table A.49). Gas pressure was not recorded in the Wasatch sandstone.



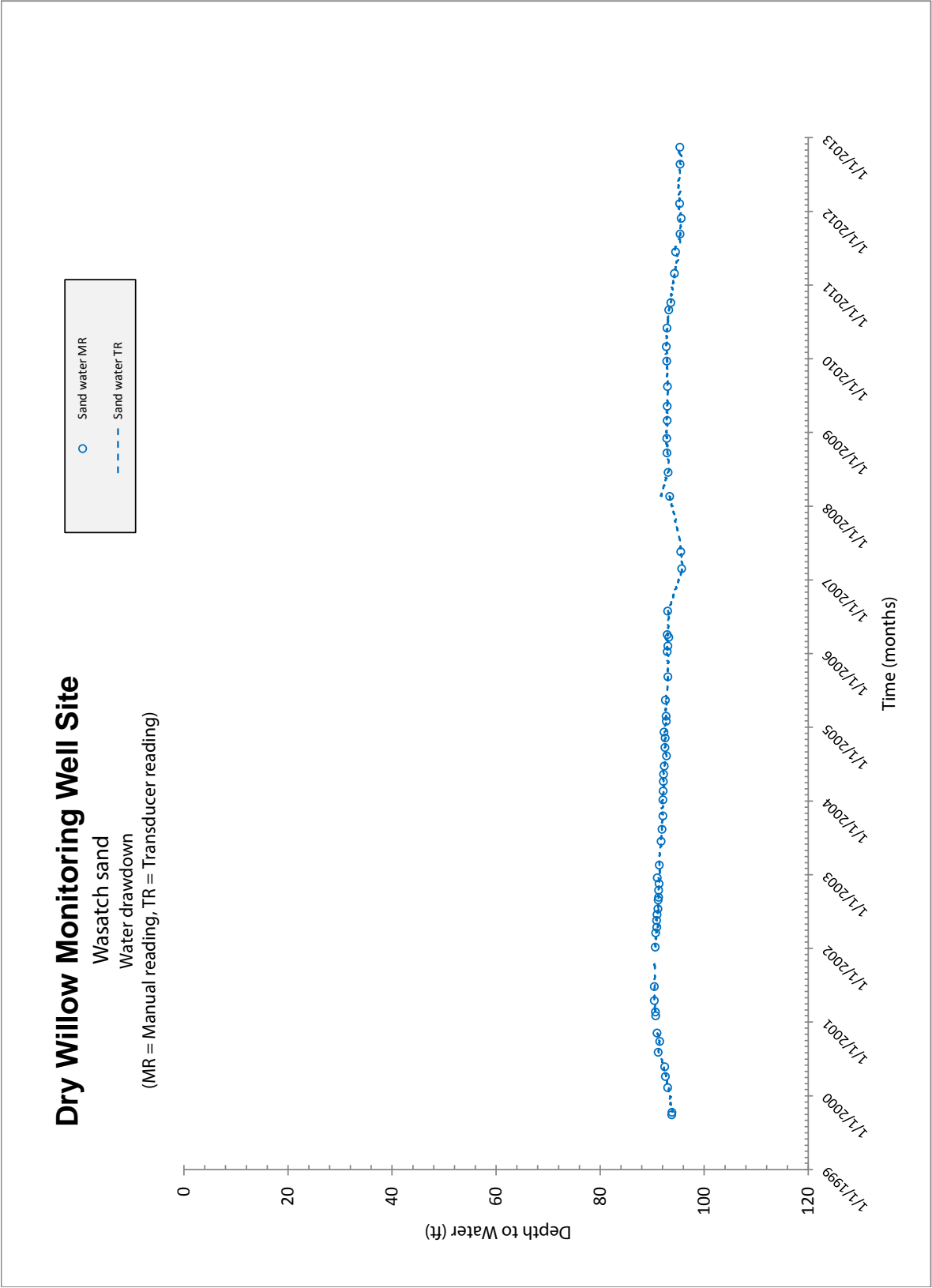
**Figure A.98.** Section showing relative positions of coals and sands in feet. Not to scale.

**Table A.48.** Table showing the depth to and thickness of monitored zones at the Dry Willow monitoring well site location. (measured in feet)

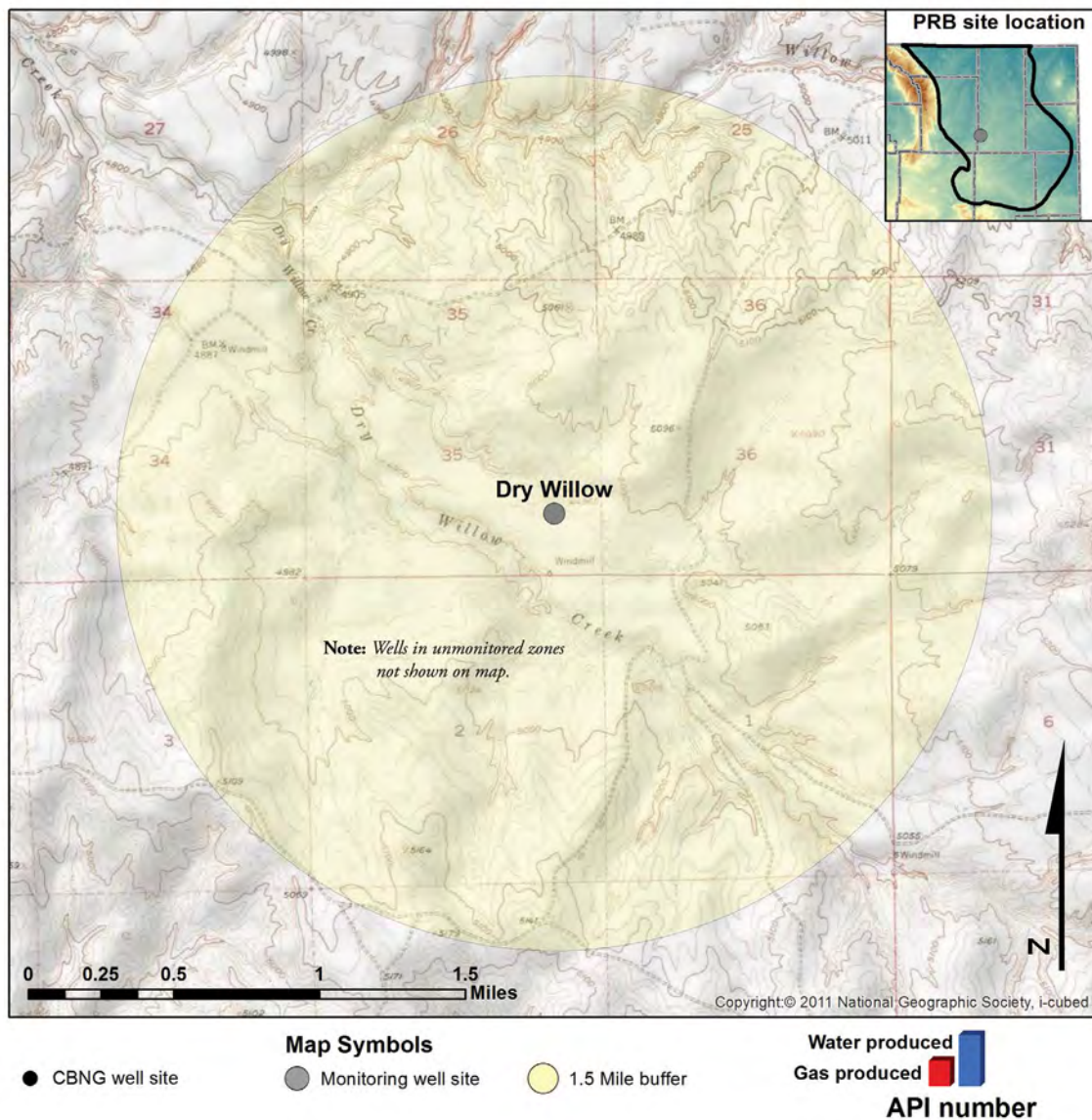
Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Wasatch sand	148	202	54	n/a

**Table A.49.** Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2010	Drawdown 2010-2012	Total drawdown (ft.)	Depth to Final water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	93.80	-0.95	2.51	1.56	95.36	n/a	n/a



**Figure A.99.** Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Dry Willow monitoring wellsite location.



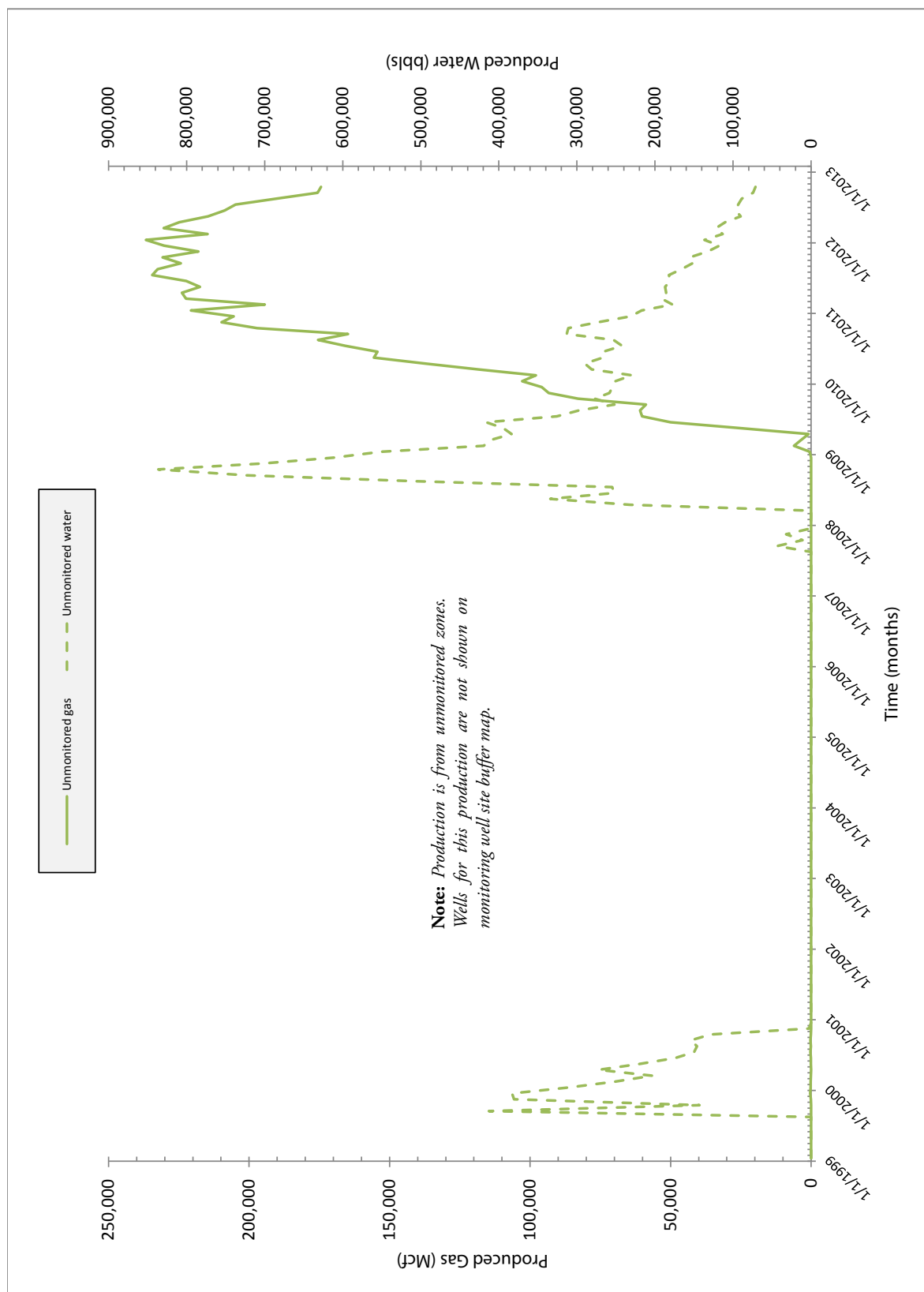
**Figure A.100.** Dry Willow monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

### Production Statistics

Production data were analyzed for CBNG wells within the buffer of the Dry Willow monitoring well site from 1999-2012. Cumulative production for individual CBNG wells is displayed by location on Figure A.100. CBNG and water production are monitored in unmonitored coal zone wells.

Consistent water production in unmonitored coal zone wells began in September 1999 and ended in

November 2000 (Figure A.101). Water production resumed in September 2007 and peaked at 836,123 bbls in October 2008. Significant gas production (>25,000 Mcf/month) began in May 2009 and reached a peak level of 236,689 Mcf in January 2012.



**Figure A.101.** Water and gas production from CBNG wells associated with the Dry Willow monitoring well site location.

**Duck Creek Monitoring Well Site**  
**Location: S20 T38N R72W**  
**Date First Monitored: March 28, 2005**

**Drawdown Information**

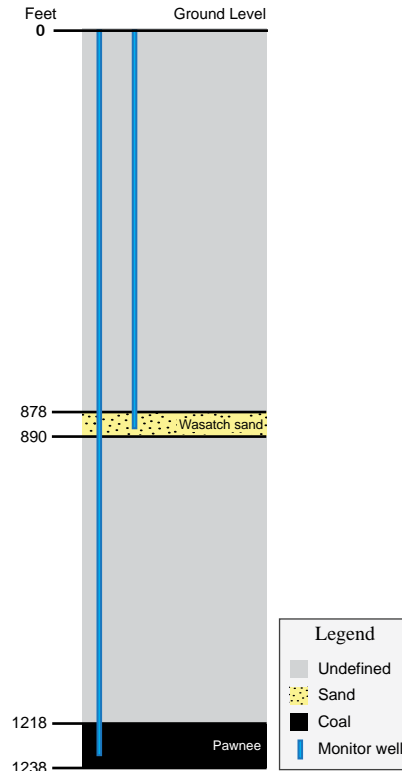
The Duck Creek monitoring well site includes two wells. One well is completed in a Wasatch sandstone and the other in the Pawnee coal of the Wall coal zone (Figure A.102; Table A.50). Water levels and wellhead gas pressures were measured during the POR using both manual and automatic transducer and data logger equipment. Transducer data that is missing, randomly fluctuating (noisy) or that substantially differs from concurrent manual measurements may indicate on-site equipment failure, malfunction or requirement for calibration.

**Wasatch Sandstone**

The data recorded for the Wasatch sand is incomplete; transducer water levels were obtained only in 2005-2006, and ranged from a high water level of 17.98 feet and a low of 19.72 feet (Figure A.103; Table A.51). The BLM has noted that these values may not be valid, due to the fact the well has been flowing artesian over the entire life of the well. Wellhead pressure has been reading between 6-7 psi. The well was turned over to the landowner on November 28, 2012 to be used for stock water.

**Pawnee Coal**

Groundwater levels rose 25.55 feet during the 2010-2012 POR. Over the monitoring period of 2005-2009 water levels declined a total of 21.77 feet (Figure A.104; Table A.51). A peak gas pressure of 48.53 psi was recorded in October 2003. The well was plugged and abandoned on November 28, 2012 and will no longer be used as a monitoring site.



**Figure A.102.** Section showing relative positions of coals and sands in feet. Not to scale.



**Table A.50.** Table showing the depth to and thickness of monitored zones at the Duck Creek monitoring well site location. (measured in feet)

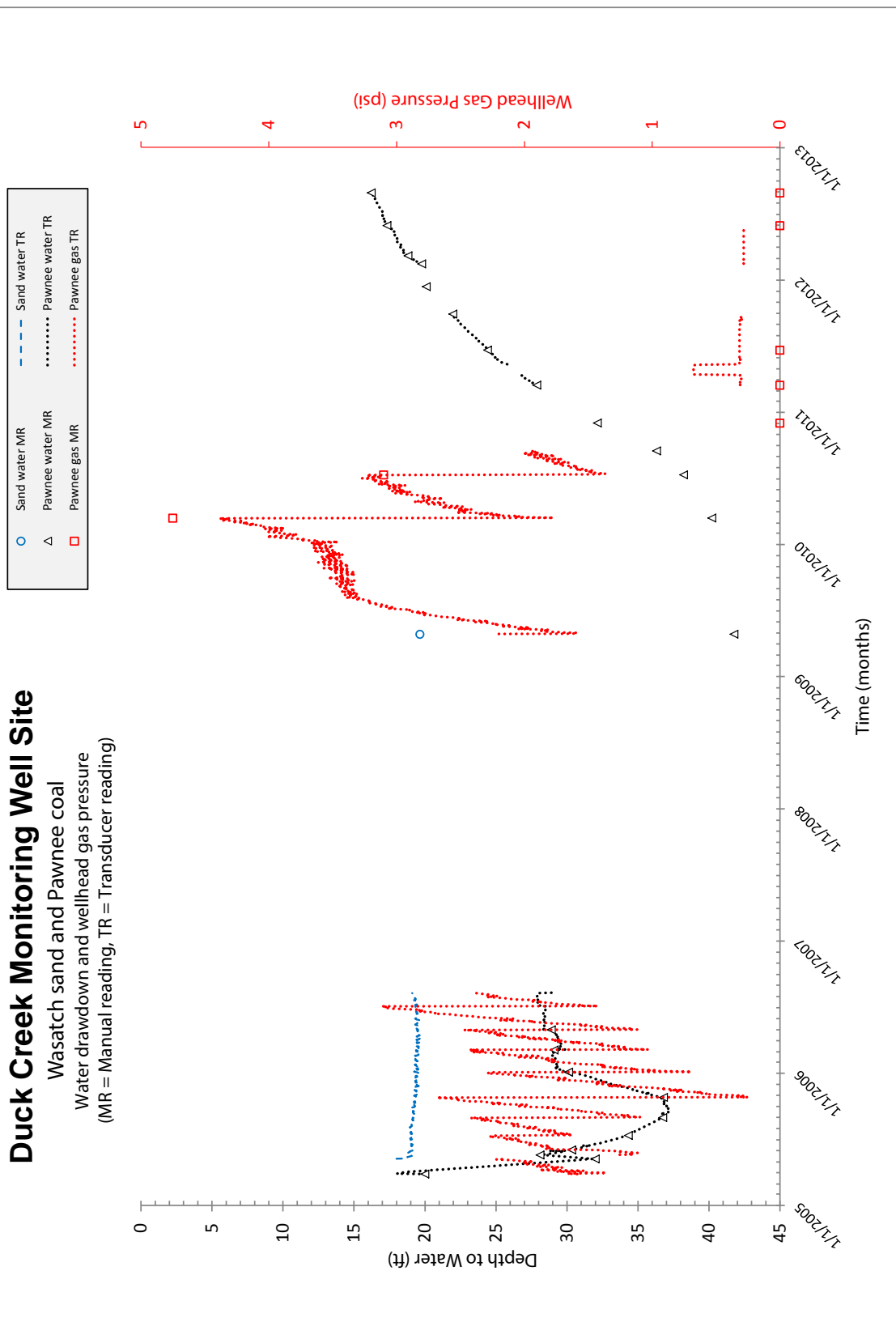
Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Wasatch sand	878	890	12	328
Pawnee coal	1218	1238	20	n/a

**Table A.51.** Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

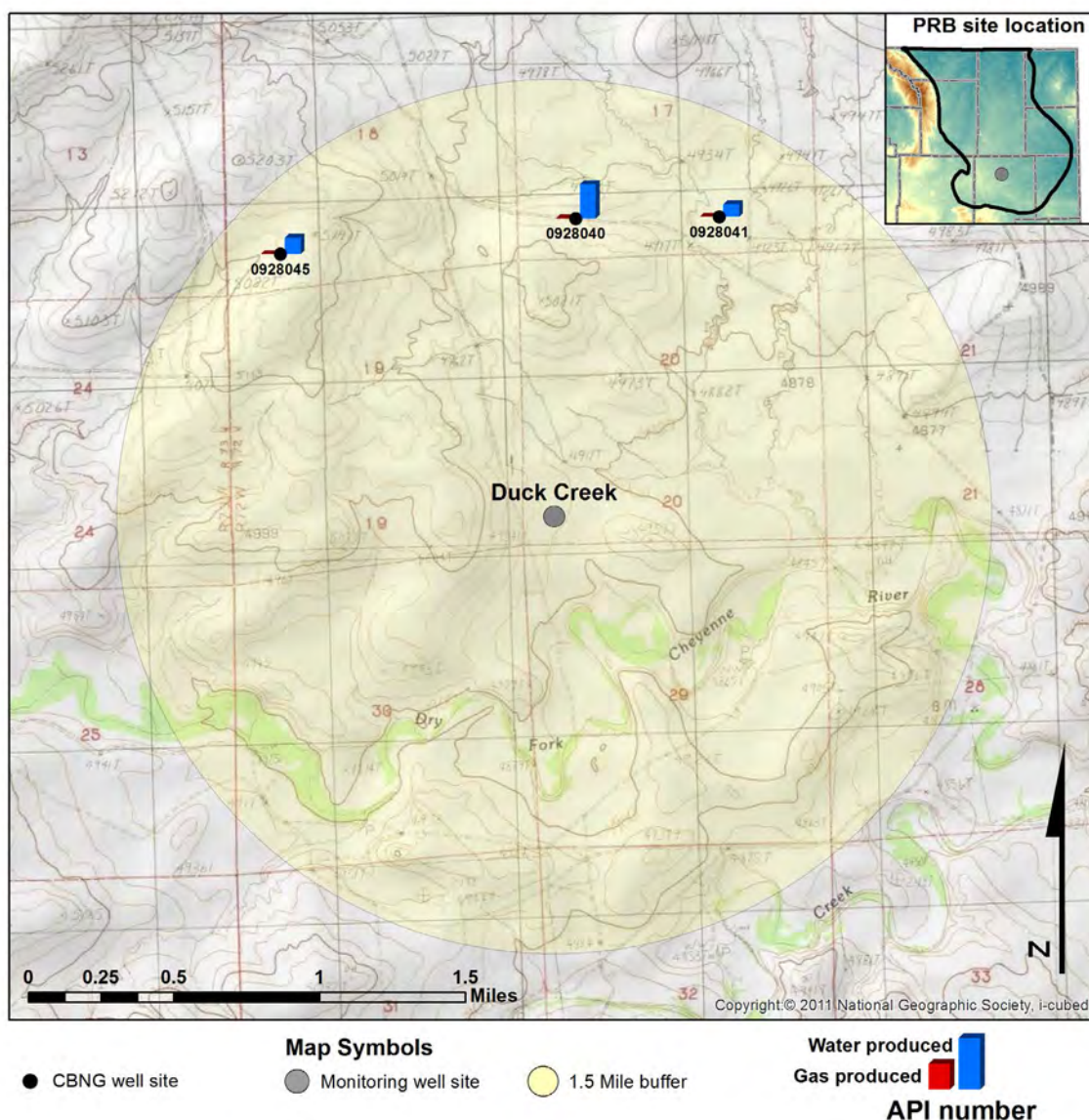
Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2010	Drawdown 2010-2012	Total drawdown (ft.)	Depth to Final water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Pawnee coal	20.00	21.77	-25.55	-3.78	16.22	48.53	10/29/2003

## Duck Creek Monitoring Well Site

Wasatch sand and Pawnee coal  
 Water drawdown and wellhead gas pressure  
 (MR = Manual reading, TR = Transducer reading)



**Figure A.103.** Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Duck Creek monitoring wellsite location.

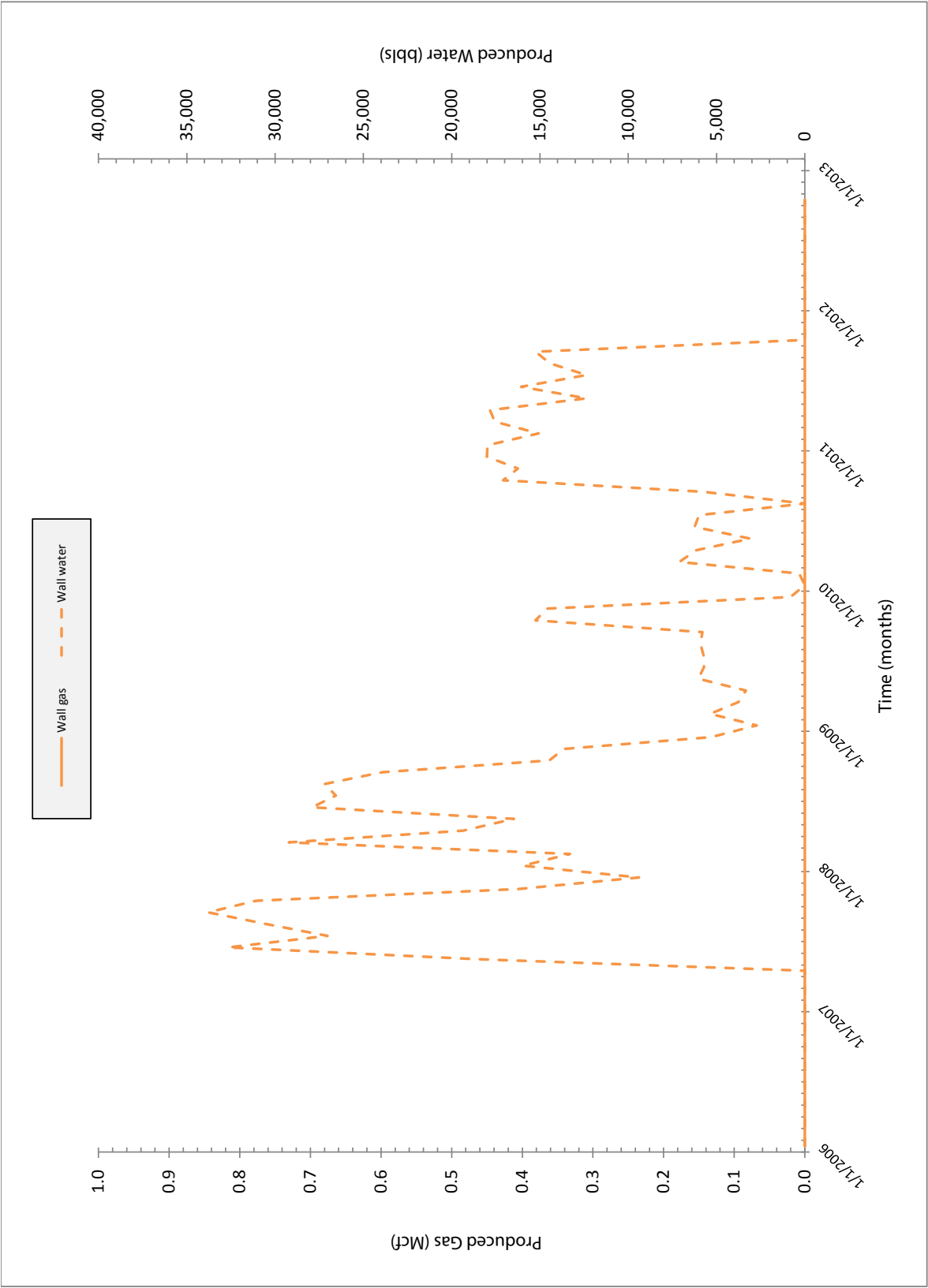


**Figure A.104.** Duck Creek monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

### Production Statistics

Production data were analyzed for CBNG wells within the buffer of the Duck Creek monitoring well site from 2006-2012. Cumulative production for individual CBNG wells is displayed by location on Figure A.104. CBNG and water production are monitored in the Pawnee coal production wells of the Wall coal zone.

Water production in the Wall coal zone began in May 2007, peaked in September 2007 at 33,801 bbls; there has been no water production since October 2011. There has never been any recorded gas production in the buffer area of this monitoring well (Figure A.105).



**Figure A.105.** Water and gas production from CBNB wells associated with the Duck Creek monitoring well site location.

**Durham Ranch Sec 6 Monitoring Well Site**  
**Location: S6 T45N R71W**  
**Date First Monitored: November 10, 1997**

**Drawdown Information**

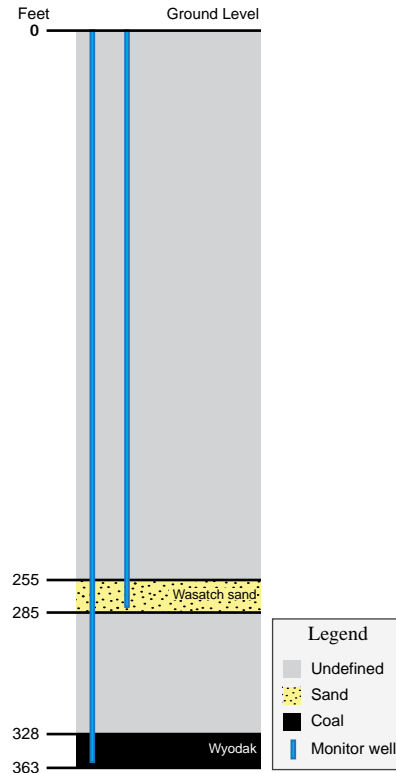
The Durham Ranch Sec 6 monitoring well site includes two wells. One is completed into a Wasatch sandstone and the other into the Wyodak coal of the Upper Wyodak coal zone (Figure A.106; Table A.52). Water levels and wellhead gas pressures were measured during the POR using both manual and automatic transducer and data logger equipment. Transducer data that is missing, randomly fluctuating (noisy) or that substantially differs from concurrent manual measurements may indicate on-site equipment failure, malfunction or requirement for calibration.

**Wasatch Sandstone**

During the 2010-2012 POR, groundwater levels in the Wasatch sandstone declined 5.31 feet. In contrast, over the monitoring period of 1997-2009, groundwater levels declined 72.67 feet from initial static water levels (Figure A.107; Table A.52). Gas pressure was not recorded in the Wasatch sandstone.

**Wyodak Coal**

Groundwater levels remained unchanged during the 2010-2012 POR. Over the monitoring period of 1997-2009 water levels declined a total of 248.85 feet (Figure A.107; Table A.52). A peak gas pressure of 83.67 psi was recorded in June 1999.



**Figure A.106.** Section showing relative positions of coals and sands in feet. Not to scale.

**Table A.52.** Table showing the depth to and thickness of monitored zones at the Durham Ranch Sec 6 monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Wasatch sand	255	285	30	43
Wyodak coal	328	363	35	n/a

**Table A.53.** Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2010	Drawdown 2010-2012	Total drawdown (ft.)	Depth to Final water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	96.20	72.67	5.31	77.98	174.18	n/a	n/a
Wyodak coal	118.15	248.85	0.00	248.85	367.00	83.67	6/8/1999

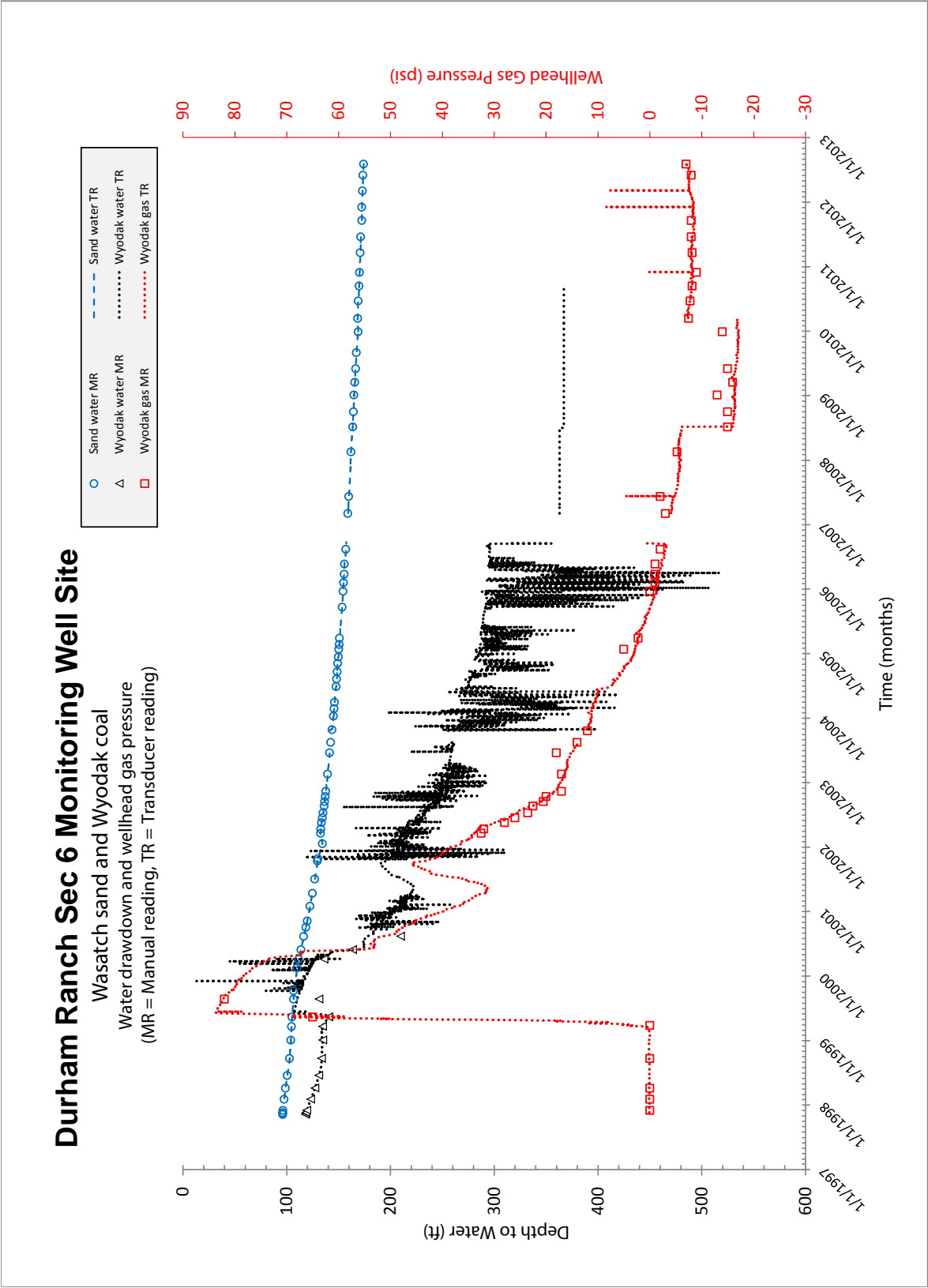
### Production Statistics

Production data were analyzed for CBNG wells within the buffer of the Durham Ranch Sec 6 monitoring well site from 1998-2012. Cumulative production for individual CBNG wells is displayed by location on Figure A.108. CBNG and water production are monitored in Upper Wyodak, multiple, and unmonitored coal zone wells.

Water production in the Wyodak coal zone began in May 1999, peaked in February 2001 at 446,851 bbls; there has been no water production since No-

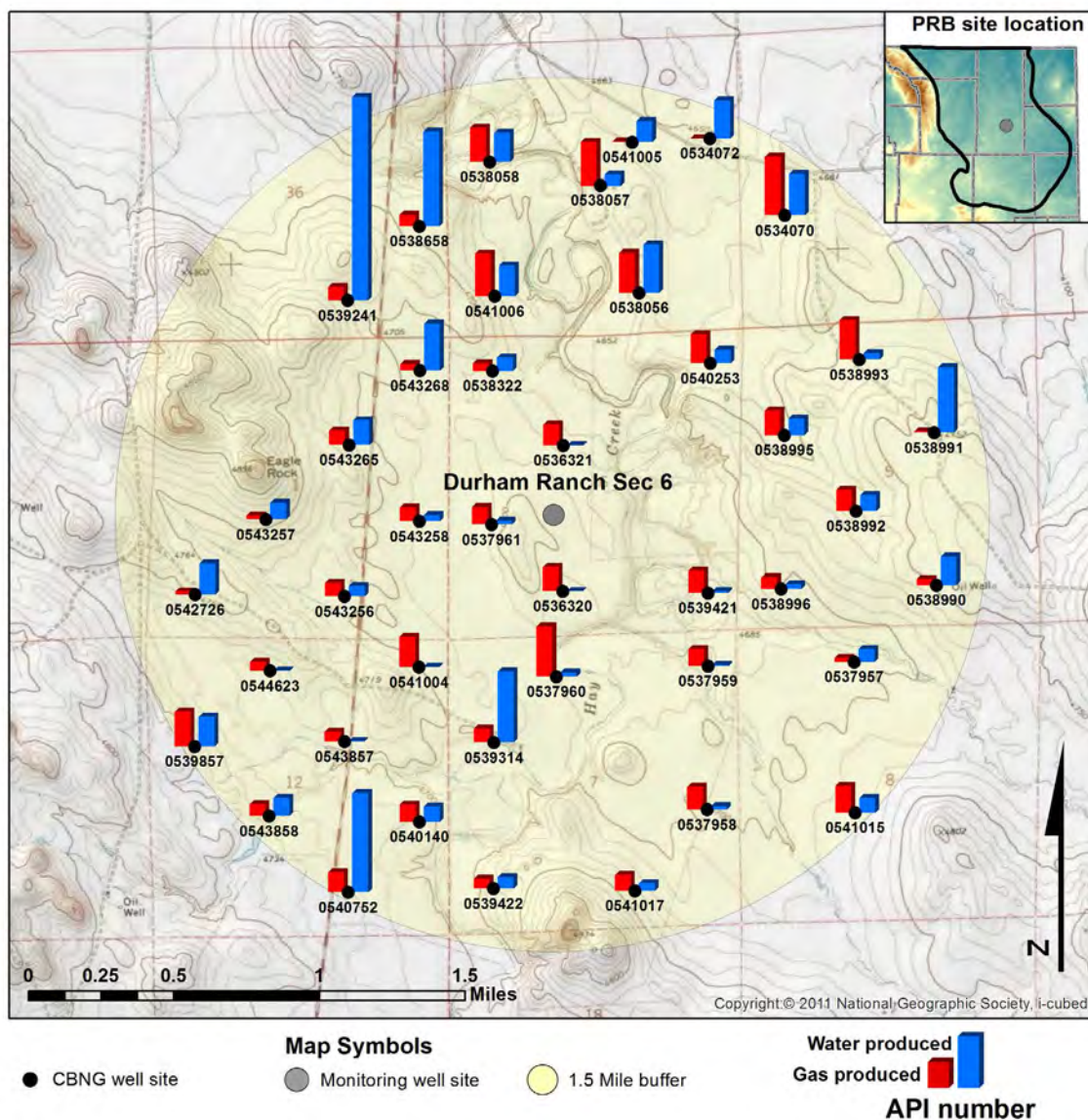
vember 2011. Gas production began in May 1999 and peaked at 183,428 Mcf in May 2002; zero gas production was reported for July – October 2012 (Figure A.109).

Water production in multiple coal zone wells began in October 2008 and reached peak production in December 2008 at 11,751 bbl. Gas production began in March 2009 and peaked in August 2009 at 582 Mcf. There has been no water or gas production in 2012 (Figure A.109).



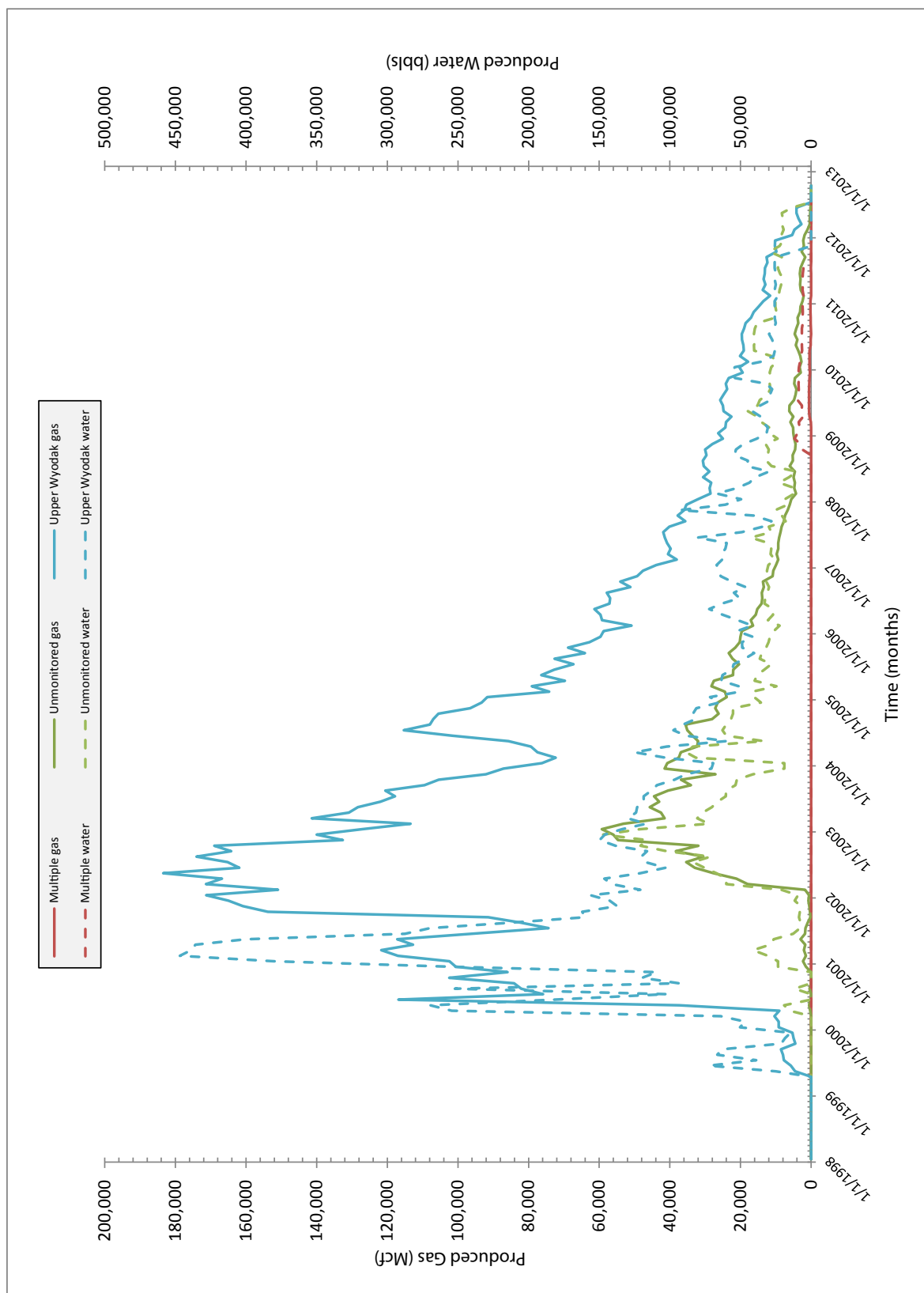
**Figure A.107.** Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Durham Ranch Sec 6 monitoring wellsite location.





**Figure A.108.** Durham Ranch Sec 6 monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

Water production in unmonitored coal zone wells began in April 2000 and reached peak production in December 2002 at 147,273 bbls. Gas production also began in April 2000 and peaked in January 2003 at 59,287 Mcf; zero gas production was reported for July – October 2012 (Figure A.109).



**Figure A.109.** Water and gas production from CBNG wells associated with the Durham Ranch Sec 6 monitoring well site location.

**Durham Ranch Sec 14 Monitoring Well Site**  
**Location: S14 T44N R72W**  
**Date First Monitored: January 13, 1998**

**Drawdown Information**

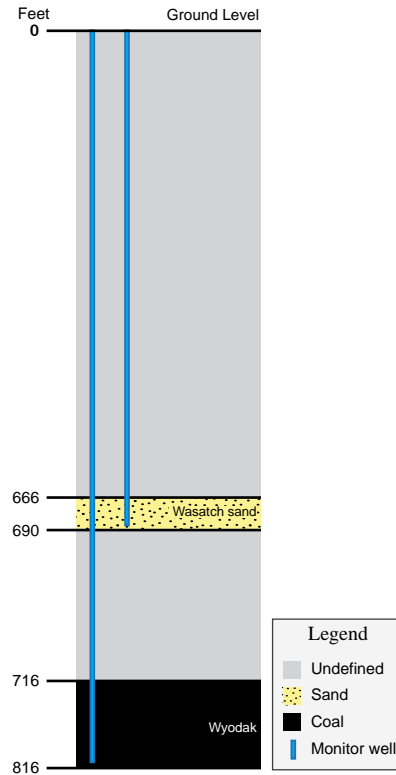
The Durham Ranch Sec 14 monitoring well site includes two wells. One is completed into a Wasatch sandstone and the other into the Wyodak coal of the Upper Wyodak coal zone (Figure A.110; Table A.54). Water levels and wellhead gas pressures were measured during the POR using both manual and automatic transducer and data logger equipment. Transducer data that is missing, randomly fluctuating (noisy) or that substantially differs from concurrent manual measurements may indicate on-site equipment failure, malfunction or requirement for calibration.

**Wasatch Sandstone**

During the 2010-2012 POR, groundwater levels in the Wasatch sandstone rose 2.58 feet. In contrast, over the monitoring period of 1998-2009, groundwater levels declined 22.92 feet from initial static water levels (Figure A.111; Table A.55). Gas pressure was not recorded in the Wasatch sandstone.

**Wyodak Coal**

Groundwater levels rose 164.37 feet during the 2010-2012 POR. Over the monitoring period of 1998-2009 water levels declined a total of 548.00 feet (Figure A.111; Table A.55). A peak gas pressure of 28.09 psi was recorded in November 2002.



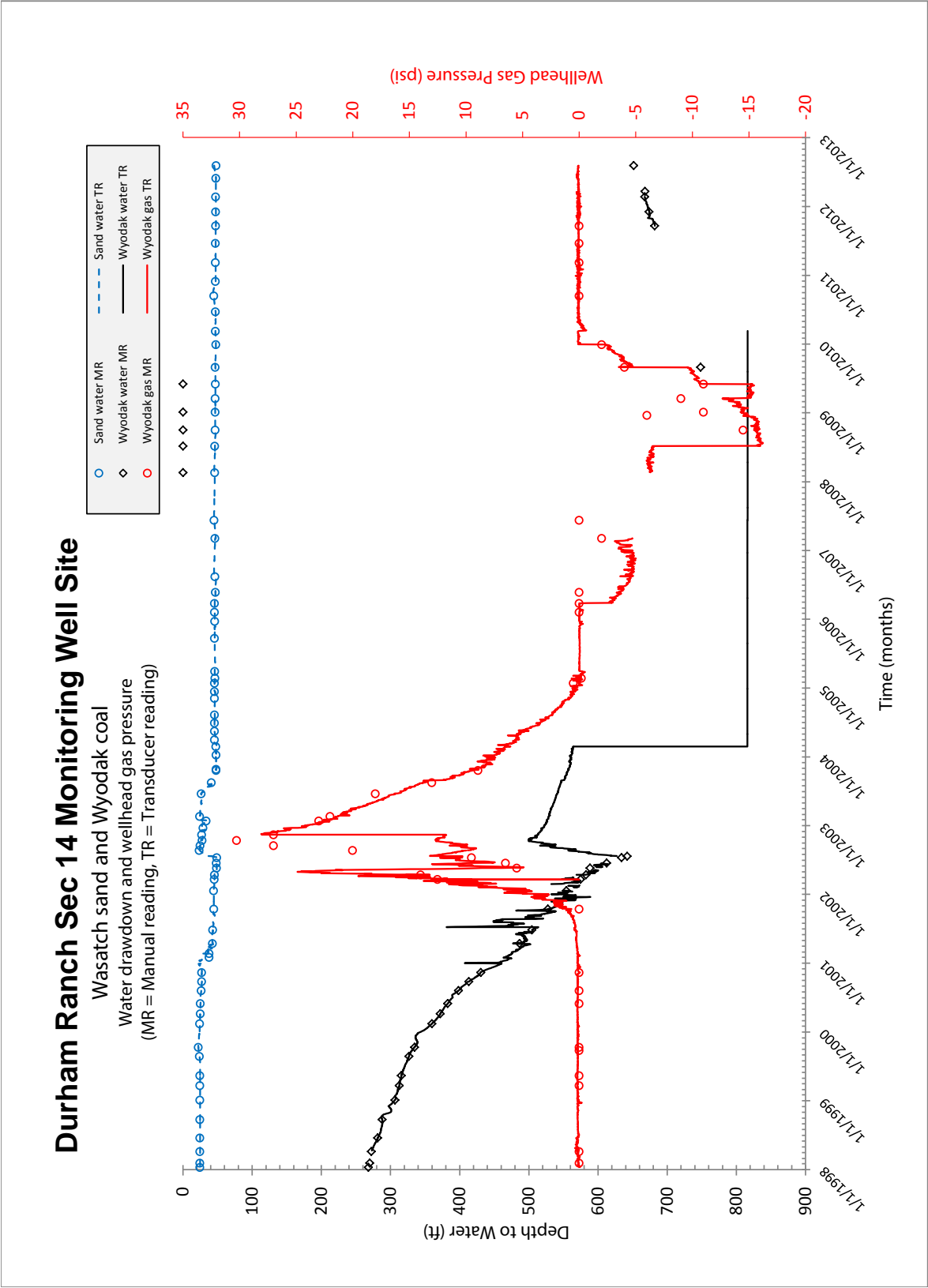
**Figure A.110.** Section showing relative positions of coals and sands in feet. Not to scale.

**Table A.54.** Table showing the depth to and thickness of monitored zones at the Durham Ranch Sec 14 monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Wasatch sand	666	690	24	26
Wyodak coal	716	816	100	n/a

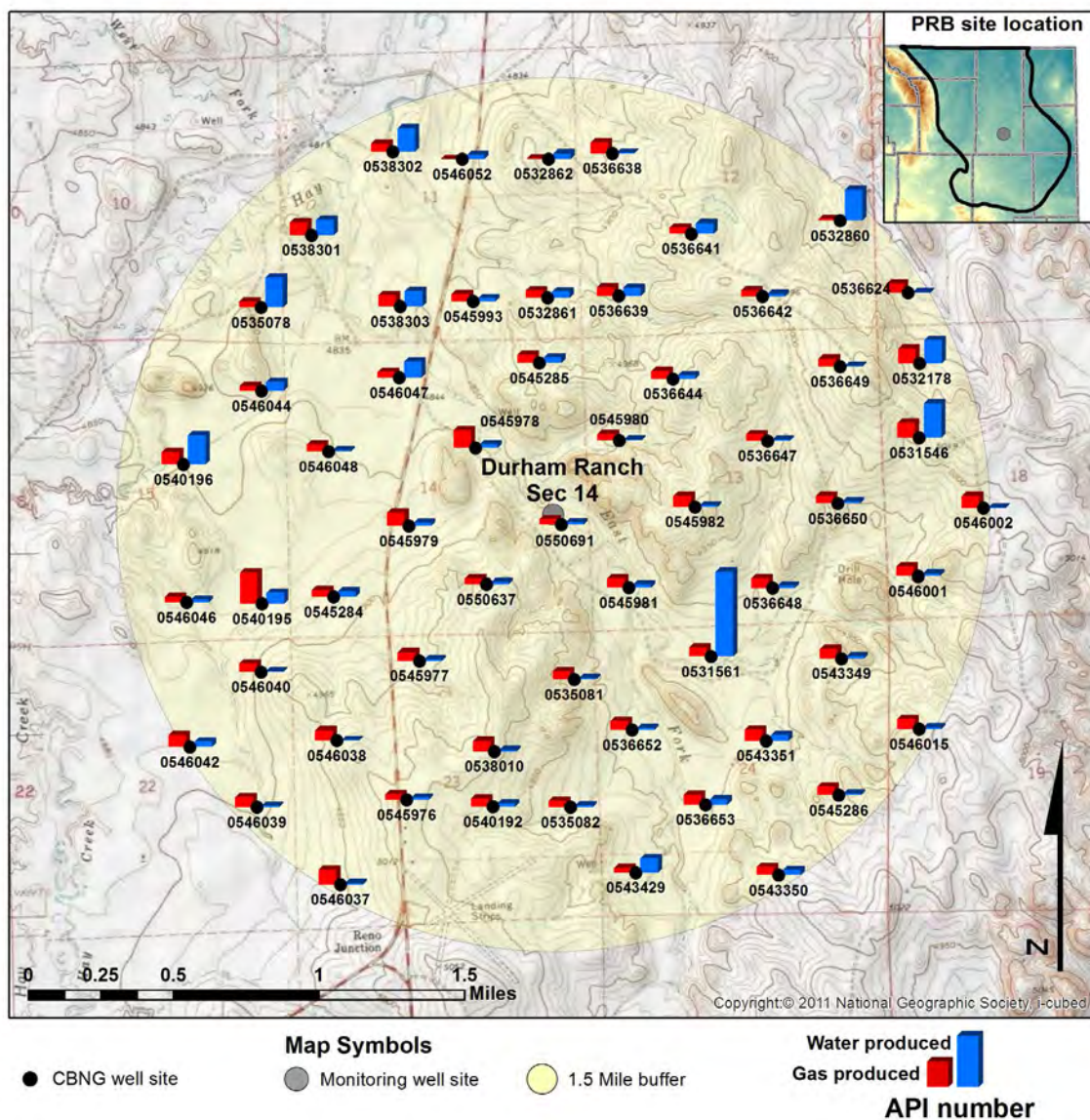
**Table A.55.** Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2010	Drawdown 2010-2012	Total drawdown (ft.)	Depth to Final water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	24.58	22.92	-2.58	20.34	44.92	n/a	n/a
Wyodak coal	268.00	548.00	-164.37	383.63	651.63	28.09	11/17/2002



**Figure A.111.** Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Durham Ranch Sec 14 monitoring wellsite location.



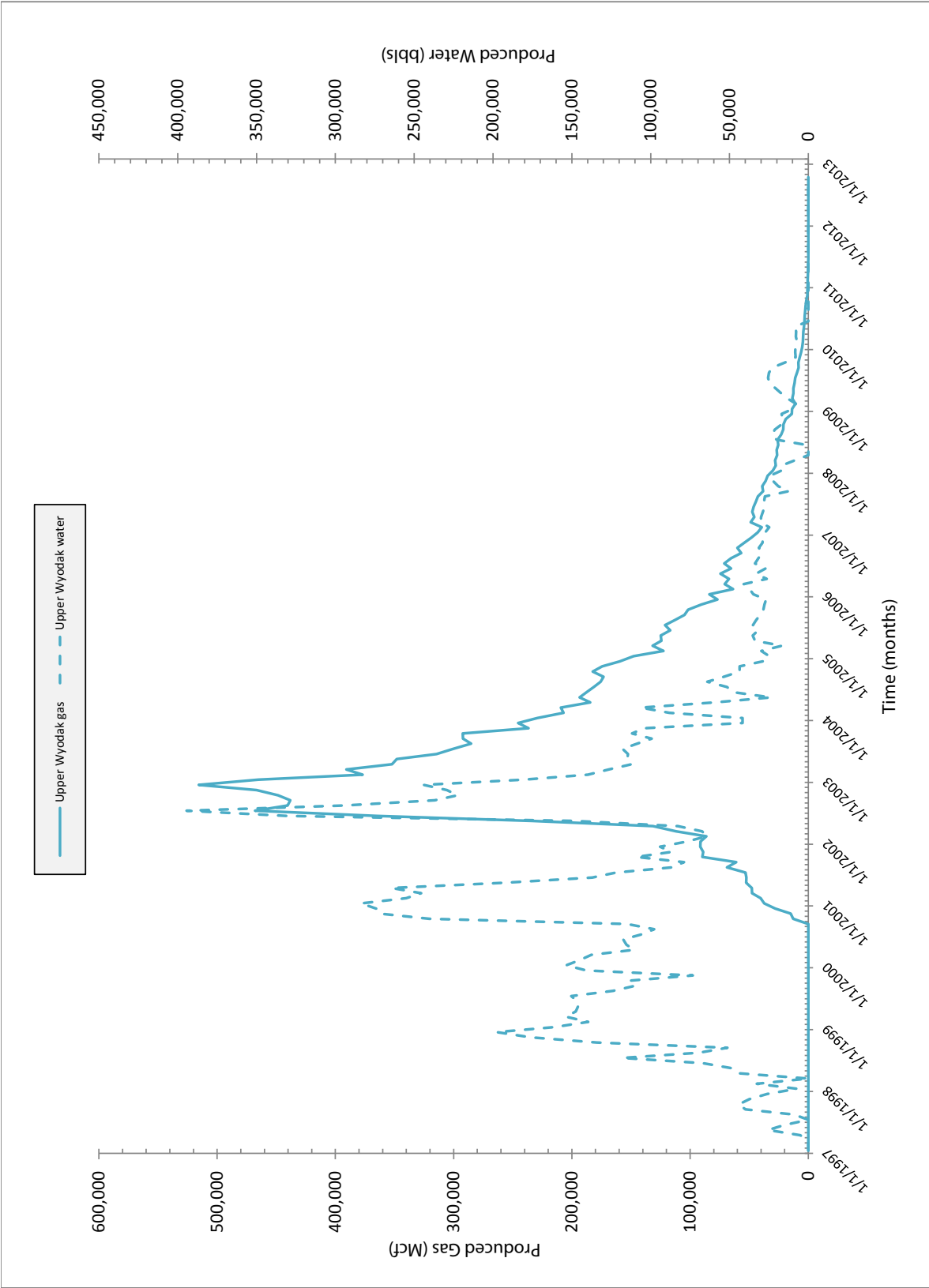


**Figure A.112.** Durham Ranch Sec 14 monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

### Production Statistics

Production data were analyzed for CBNG wells within the buffer of the Durham Ranch Sec 14 monitoring well site from 1997-2012. Cumulative production for individual CBNG wells is displayed by location on Figure A.112. CBNG and water production are monitored in Upper Wyodak coal zone wells.

Water production in the Wyodak coal zone began in April 1997, peaked in July 2002 at 394,439 bbls; there has been no water production since June 2010. Gas production began in October 2000 and peaked at 515,475 Mcf in December 2002; there has been no gas production since July 2011 (Figure A.113).



**Figure A.113.** Water and gas production from CBNG wells associated with the Durham Ranch Sec 14 monitoring well site location.



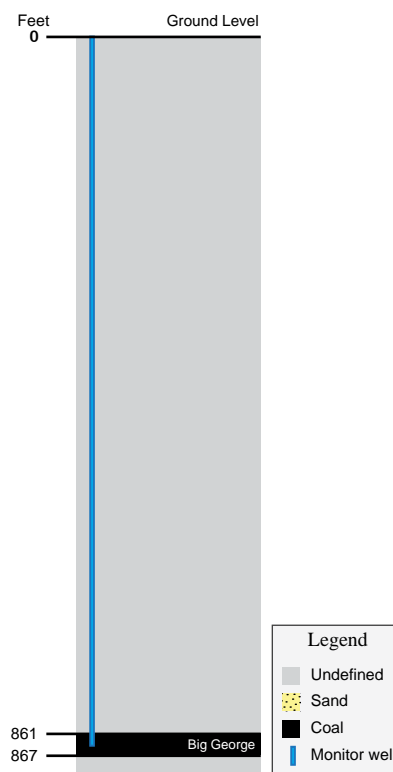
**Echeta Monitoring Well Site**  
**Location: S30 T52N R75W**  
**Date First Monitored: September 21, 1999**

**Drawdown Information**

The Echeta monitoring well site includes one well, which is completed into the Big George coal of the Wyodak Rider coal zone (Figure A.114; Table A.56). Water levels and wellhead gas pressures were measured during the POR using both manual and automatic transducer and data logger equipment. Transducer data that is missing, randomly fluctuating (noisy) or that substantially differs from concurrent manual measurements may indicate on-site equipment failure, malfunction or requirement for calibration.

**Big George Coal**

Groundwater levels declined 31.46 feet during the 2010-2012 POR. Over the monitoring period of 1999-2009 water levels declined a total of 140.30 feet (Figure A.115; Table A.57). A peak gas pressure of 14.02 psi was recorded in October 2005.



**Figure A.114.** Section showing relative positions of coals and sands in feet. Not to scale.

**Table A.56.** Table showing the depth to and thickness of monitored zones at the Echeta monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Big George coal	861	867	6	n/a

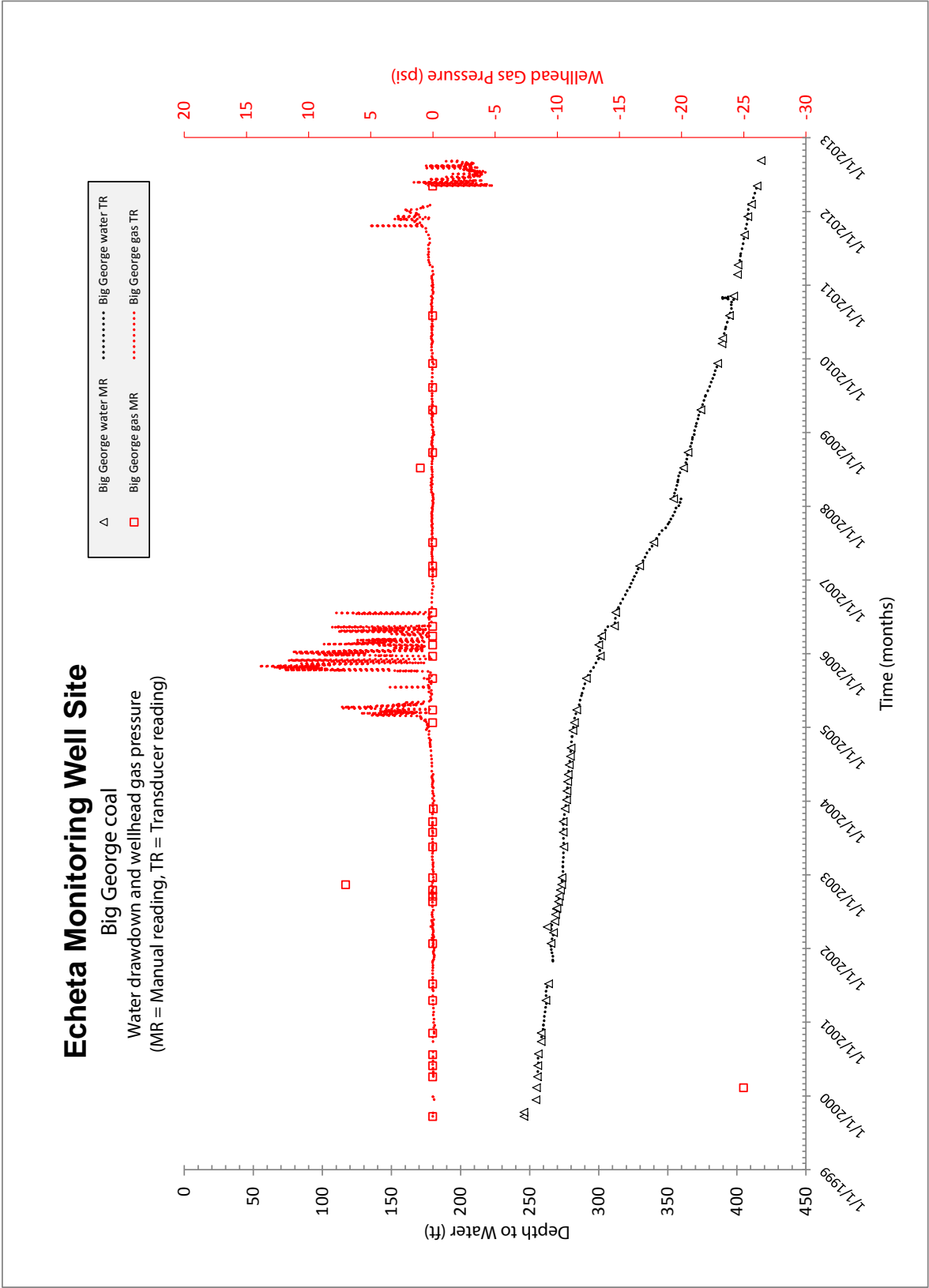
**Table A.57.** Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2010	Drawdown 2010-2012	Total drawdown (ft.)	Depth to Final water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Big George coal	245.90	140.30	31.46	171.76	417.66	14.02	10/31/2005

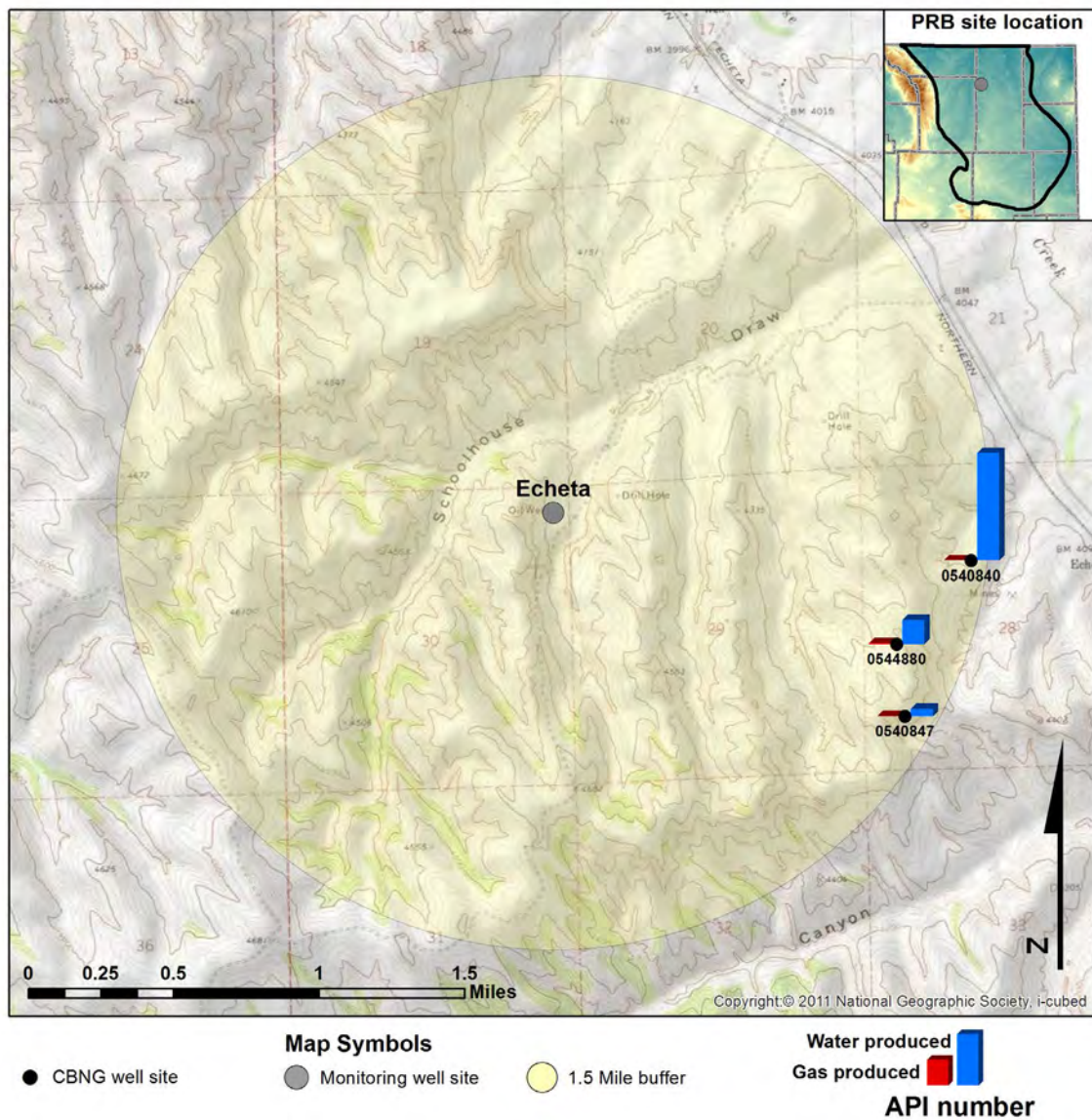
### Production Statistics

Production data were analyzed for CBNG wells within the buffer of the Echeta monitoring well site from 2000-2012, Figure A.116. CBNG and water production are monitored in Wyodak Rider and unmonitored coal zone wells.

Water production in the Wyodak Rider coal zone started in February 2001 and peaked in August 2001 at 12,668 bbls; there has been no water production since September 2002. Gas production began in March 2001 and peaked at 372 Mcf in September 2001; no gas has been produced since October 2001 (Figure A.117).

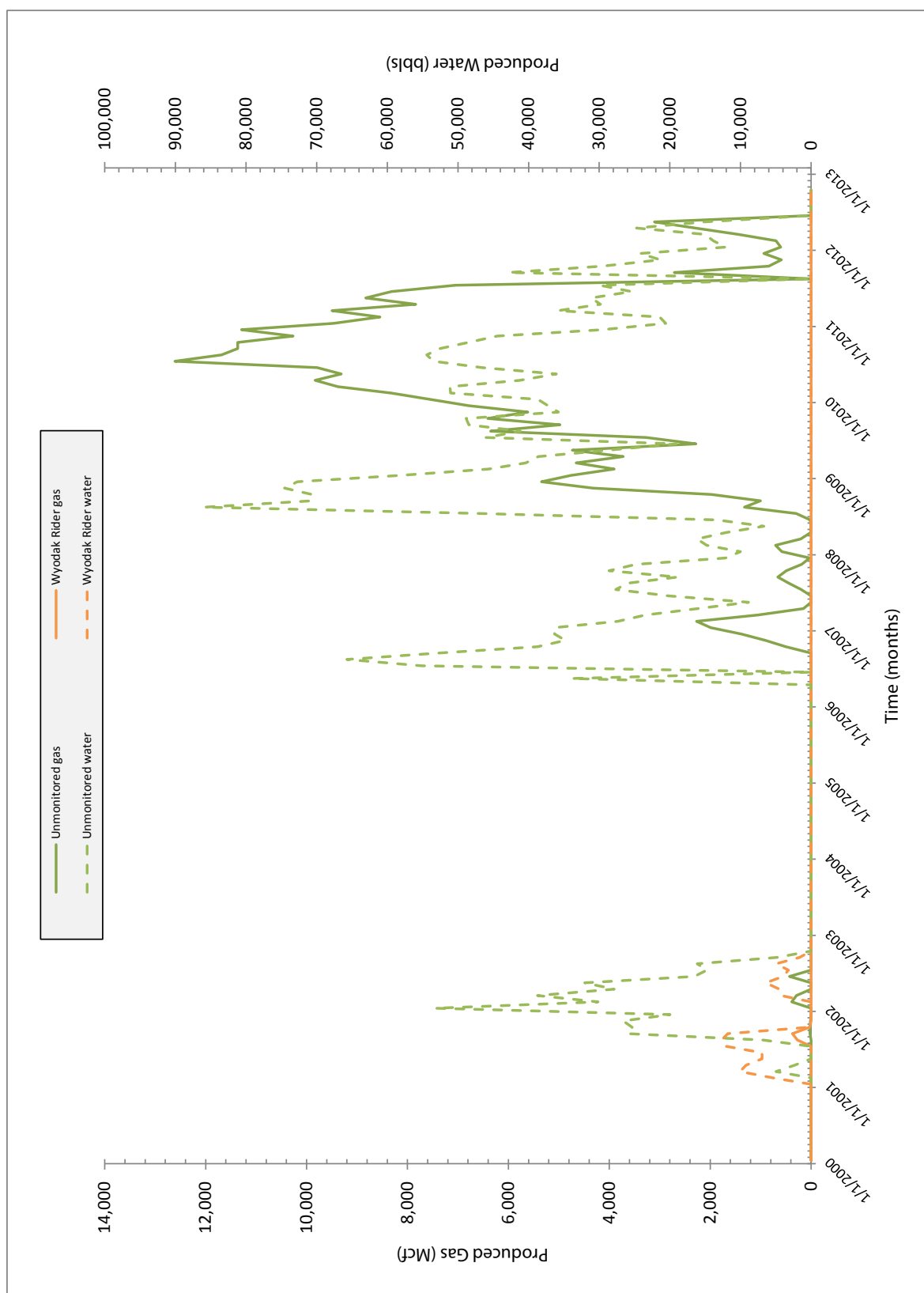


**Figure A.115.** Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Echeta monitoring wellsite location.



**Figure A.116.** Echeta monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

Water production in unmonitored coal zone wells began in March 2001 and reached peak production in August 2008 at 85,903 bbls (Figure A.117). Gas production began in September 2001 and peaked in July 2010 at 12,609 Mcf. There has been no water or gas production since May 2012.



**Figure A.117.** Water and gas production from CBNG wells associated with the Echeta monitoring well site location.

**Fourmile Monitoring Well Site**  
**Location: S11 T43N R75W**  
**Date First Monitored: November 30, 2007**

**Drawdown Information**

The Fourmile monitoring well site includes three wells. One monitoring well is completed in a Wasatch sandstone, the second in the Big George coal of the Wyodak Rider coal zone, and the third in a Fort Union underburden sandstone (Figure A.118; Table A.58). Water levels and wellhead gas pressures were measured during the POR using both manual and automatic transducer and data logger equipment. Transducer data that is missing, randomly fluctuating (noisy) or that substantially differs from concurrent manual measurements may indicate on-site equipment failure, malfunction or requirement for calibration.

**Wasatch Sandstone**

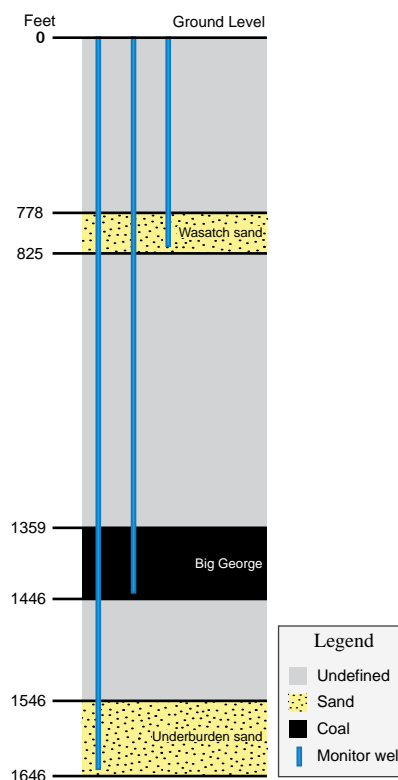
During the 2010-2012 POR, groundwater levels declined 0.06 feet; over the monitoring period of 2007-2009 water levels declined a total of 0.5 feet (Figure A.119; Table A.59). Gas pressure was not recorded in the Wasatch sandstone.

**Big George Coal**

Groundwater levels declined 27.77 feet in the Big George coal during the 2010-2012 POR. Over the monitoring period of 2007-2009 water levels rose a total of 11.69 feet (Figure A.119; Table A.59). A peak gas pressure of 0.93 psi was recorded in April 2011.

**Fort Union Underburden Sandstone**

During the 2010-2012 POR, groundwater levels declined 22.99 feet; over the monitoring period of 2007-2009 water levels rose a total of 32.50 feet (Figure A.119; Table A.59). Gas pressure was not recorded in the Fort Union underburden sand.



**Figure A.118.** Section showing relative positions of coals and sands in feet. Not to scale.

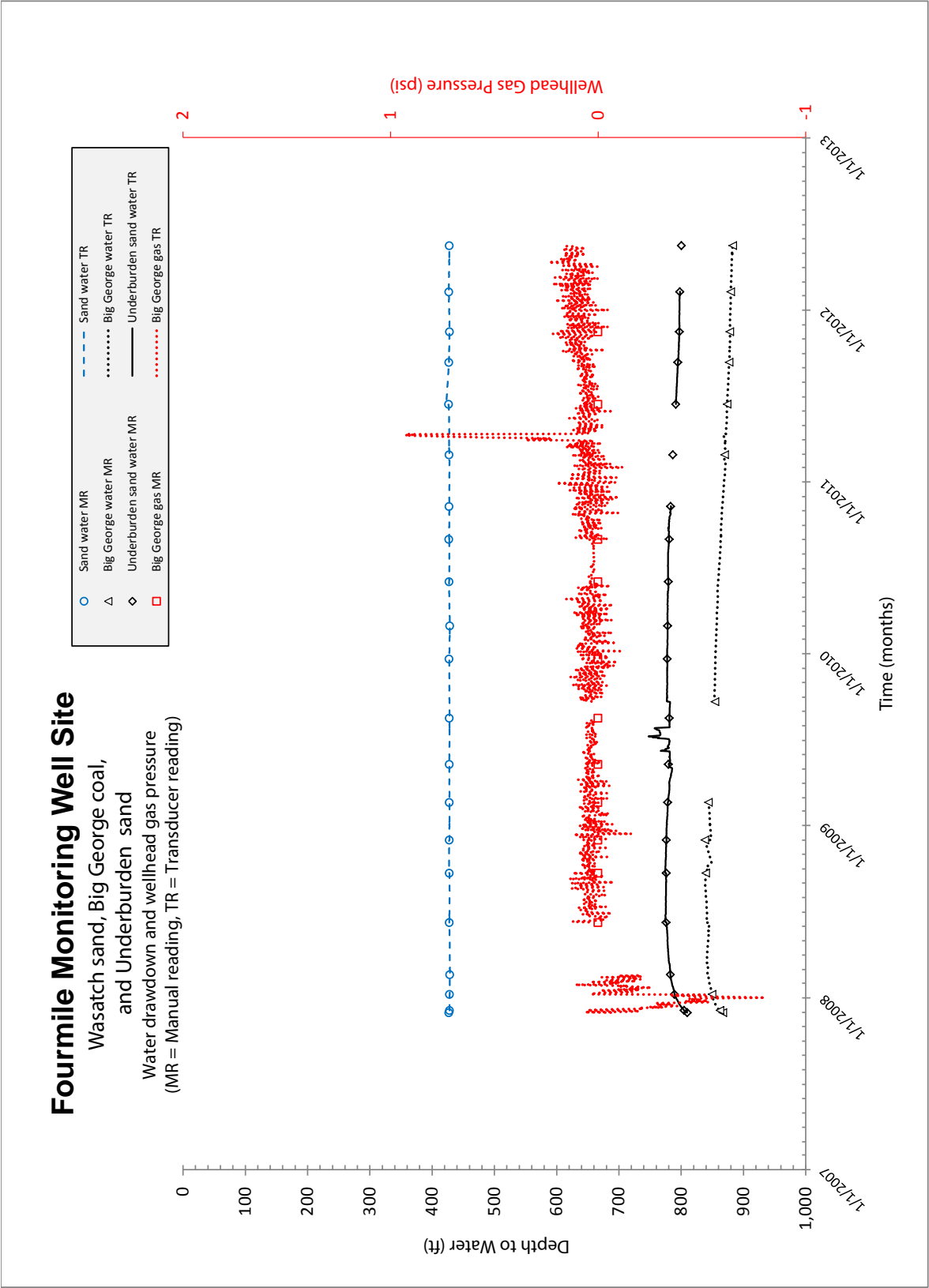
**Table A.58.** Table showing the depth to and thickness of monitored zones at the Fourmile monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Wasatch sand	778	825	47	534
Big George Coal	1,359	1,446	87	n/a
Underburden sand	1,546	1,646	100	100

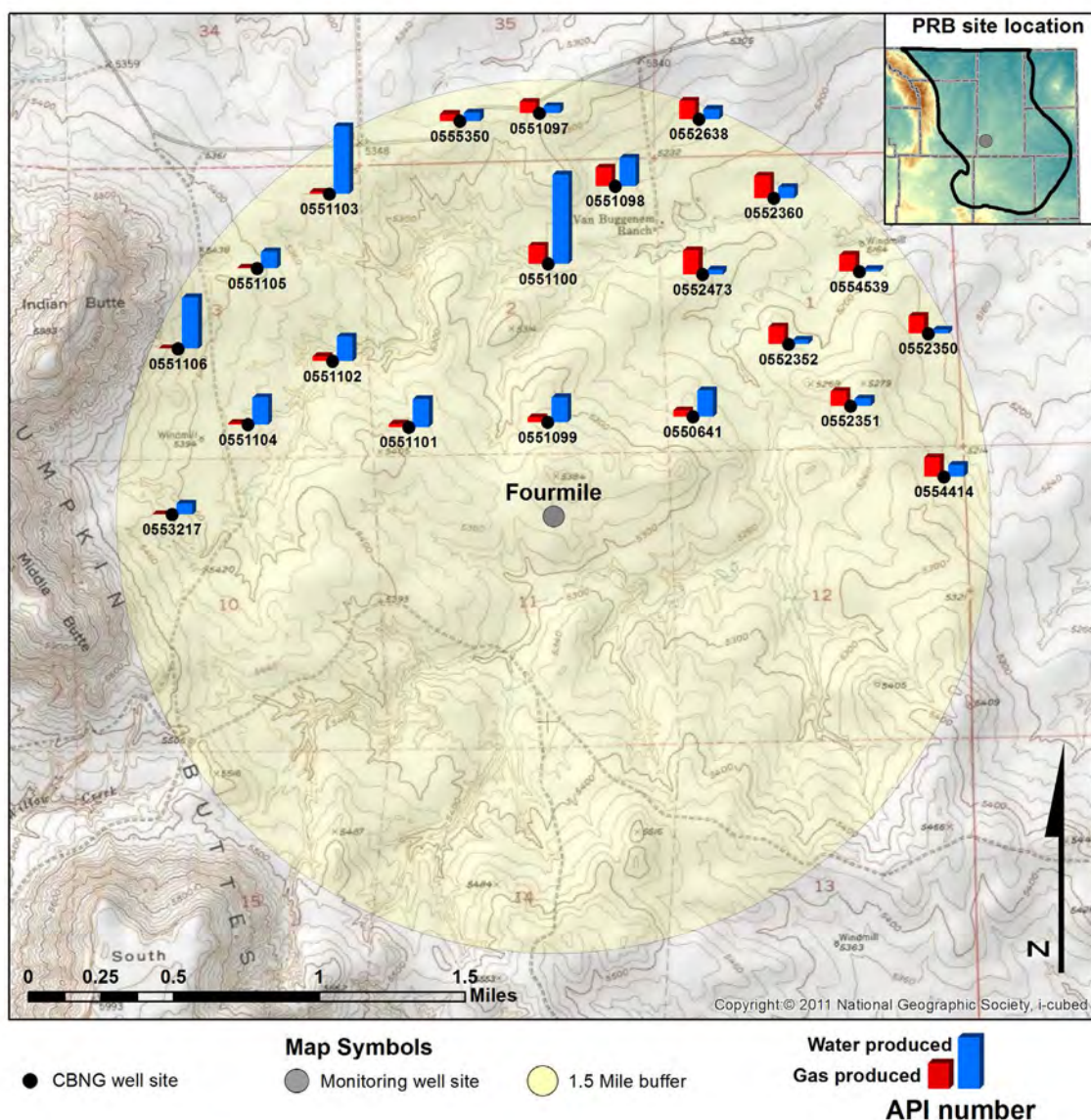
**Table A.59.** Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2010	Drawdown 2010-2012	Total drawdown (ft.)	Depth to Final water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	427.17	0.50	0.06	0.56	427.73	n/a	n/a
Big George Coal	866.89	-11.69	27.77	16.08	882.97	0.93	4/10/2011
Underburden sand	809.96	-32.50	22.99	-9.51	800.45	n/a	n/a





**Figure A.119.** Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Fourmile monitoring wellsite location.



**Figure A.120.** Fourmile monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

### Production Statistics

Production data were analyzed for CBNG wells within the buffer of the Fourmile monitoring well site from 2003-2012. Figure A.120. CBNG and water production are monitored in Wyodak Rider coal zone wells.

Water production in the Wyodak Rider coal zone began in February 2004, peaked in May 2006 at 121,256 bbls; 3,802 bbls were produced in Octo-

ber 2012. Gas production began in January 2005 and peaked at 60,867 Mcf in October 2006; in October 2012, 13,278 Mcf of gas was produced (Figure A.121).

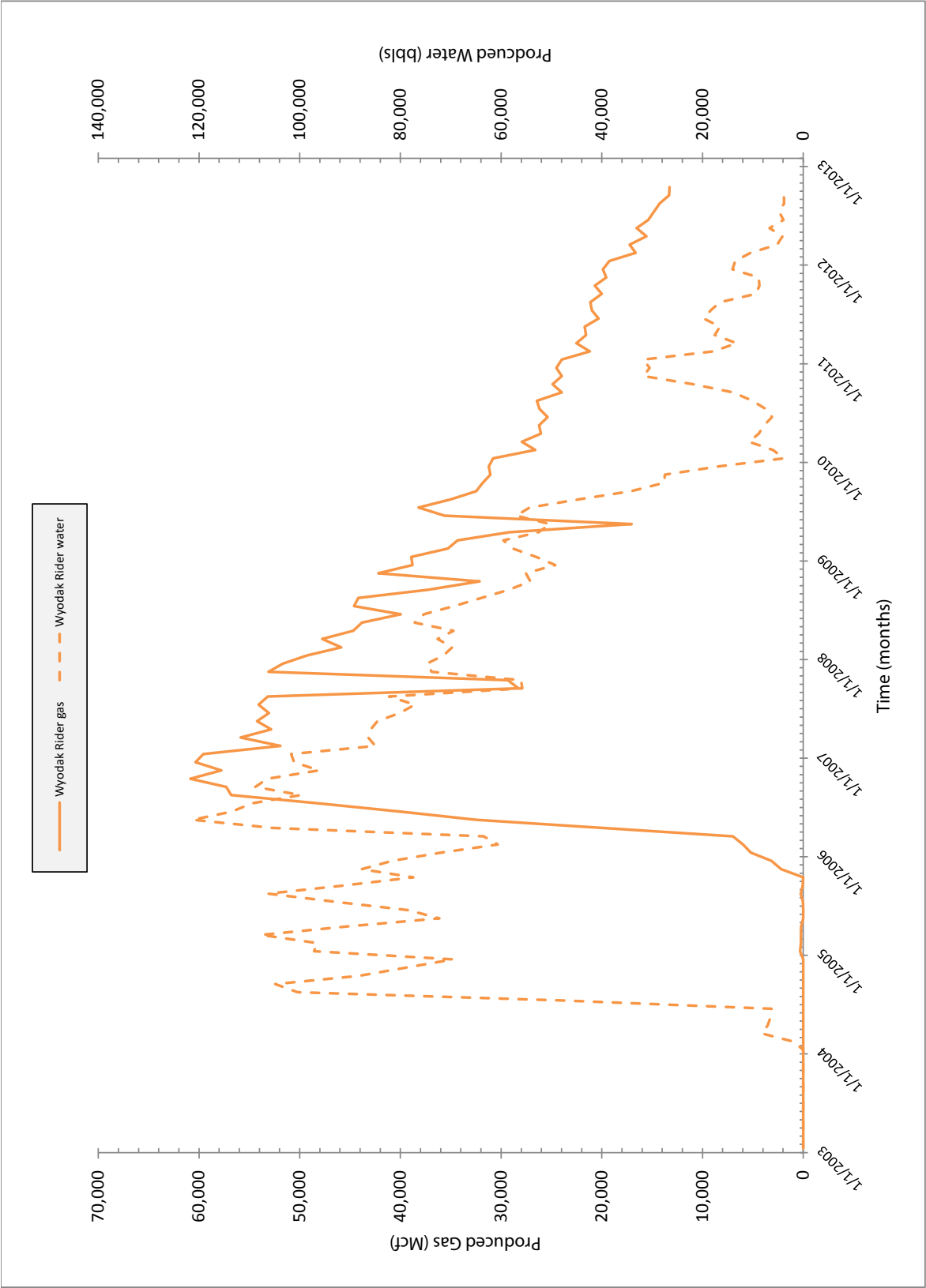


Figure A.121. Water and gas production from CBNG wells associated with the Fourmile monitoring well site location.

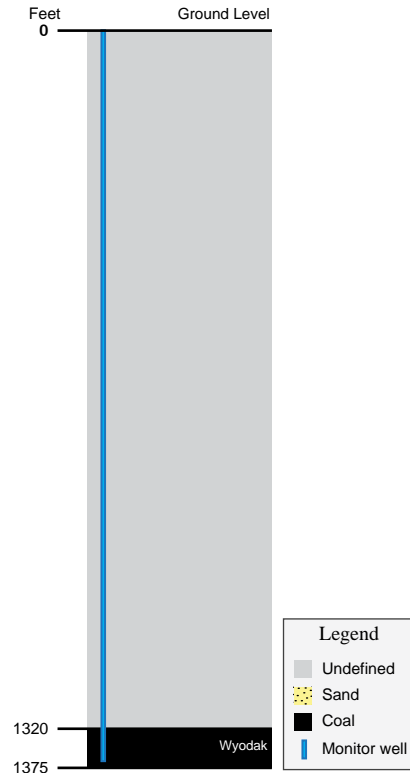
**Gilmore Monitoring Well Site**  
**Location: S1 T49N R77W**  
**Date First Monitored: April 4, 1998**

**Drawdown Information**

The Gilmore monitoring well site includes one well completed into the Wyodak coal of the Upper Wyodak coal zone (Figure A.122; Table A.60). Water levels and wellhead gas pressures were measured during the POR using both manual and automatic transducer and data logger equipment. Transducer data that is missing, randomly fluctuating (noisy) or that substantially differs from concurrent manual measurements may indicate on-site equipment failure, malfunction or requirement for calibration.

**Wyodak Coal**

Groundwater levels declined 2.46 feet during the 2010-2012 POR. Over the monitoring period of 1998-2009 water levels declined a total of 575.46 feet (Figure A.123; Table A.61). A peak gas pressure of 29.79 psi was recorded in July 2012.



**Figure A.122.** Section showing relative positions of coals and sands in feet. Not to scale.

**Table A.60.** Table showing the depth to and thickness of monitored zones at the Gilmore monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Wyodak coal	1,320	1,375	55	n/a

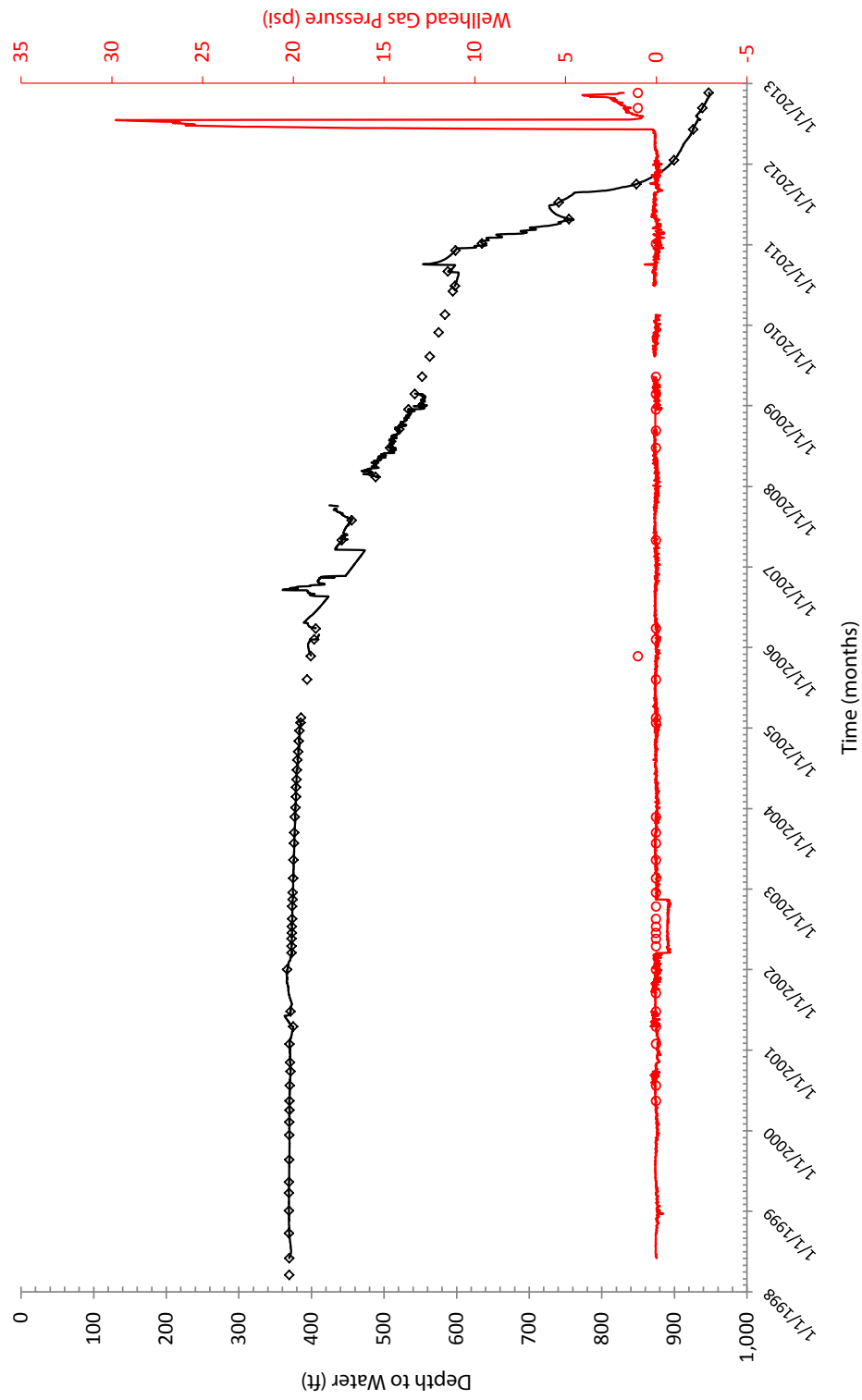
**Table A.61.** Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2010	Drawdown 2010-2012	Total drawdown (ft.)	Depth to Final water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wyodak coal	369.41	575.46	2.46	577.92	947.33	29.79	7/19/2012

## Gilmore Monitoring Well Site

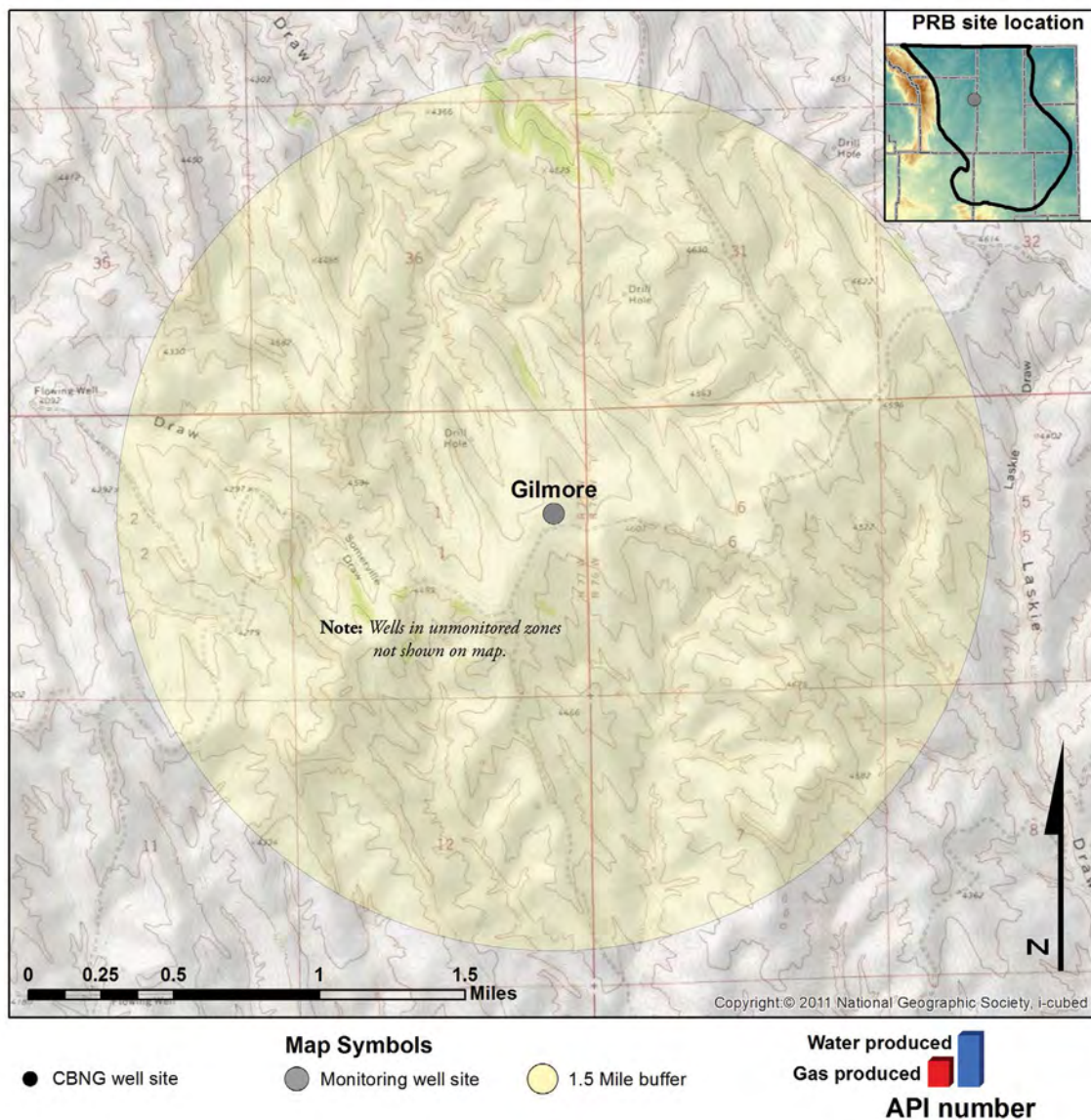
Wyodak coal

Water drawdown and wellhead gas pressure  
(MR = Manual reading, TR = Transducer reading)



**Figure A.123.** Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Gilmore monitoring wellsite location.





**Figure A.124.** Gilmore monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

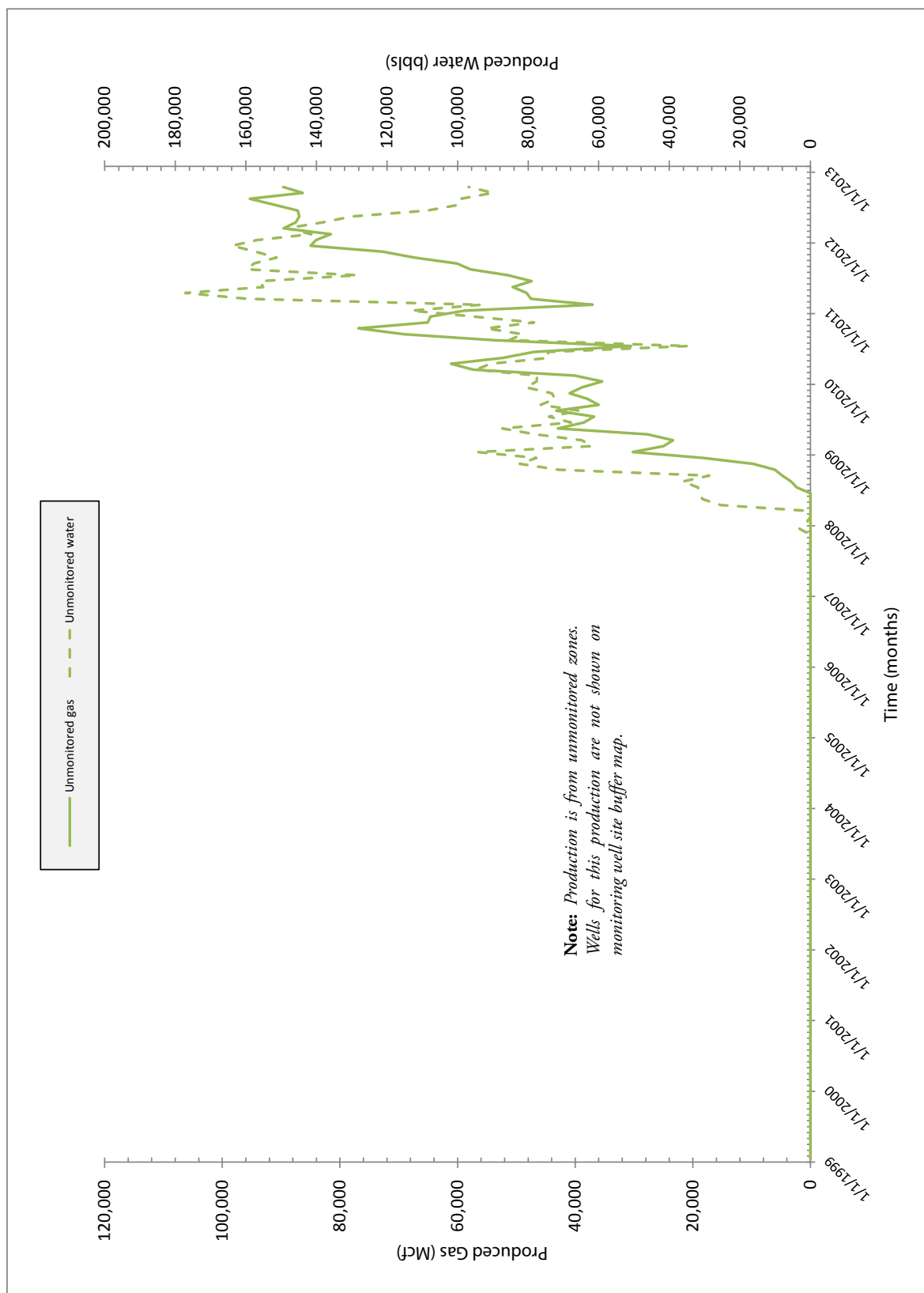
### Production Statistics

Production data were analyzed for CBNG wells within the buffer of the Gilmore monitoring well site from 1999-2012. Cumulative production for individual CBNG wells is displayed by location on Figure A.124. CBNG and water production are monitored in Upper Wyodak Rider coal zone wells.

2011 at 177,107 bbls; 96,830 bbls of water was produced in October 2012. Gas production began in July 2008 and peaked at 95,312 Mcf in August 2012, (Figure A.125).

Water production in the Upper Wyodak Rider coal zone began in December 2007 and peaked in April





**Figure A.125.** Water and gas production from CBNG wells associated with the Gilmore monitoring well site location.

**Hoe Creek Monitoring Well Site**  
**Location: S7 T47N R72W**  
**Date First Monitored: January 5, 1998**

**Drawdown Information**

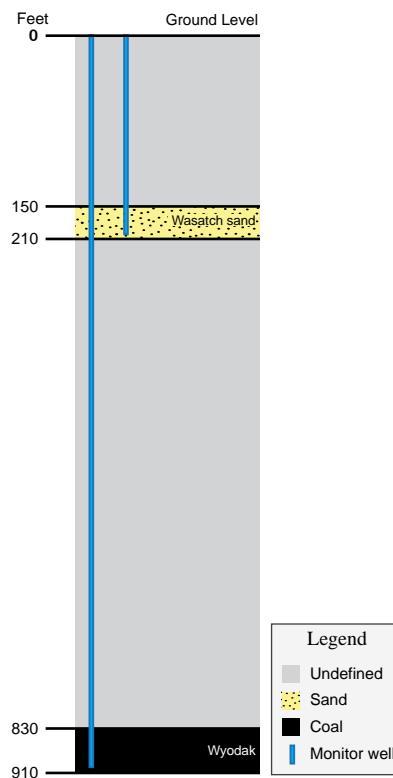
The Hoe Creek monitoring well site includes two wells. One is completed into a Wasatch sandstone and the other into the Wyodak coal of the Upper Wyodak coal zone (Figure A.126; Table A.62). Water levels and wellhead gas pressures were measured during the POR using both manual and automatic transducer and data logger equipment. Transducer data that is missing, randomly fluctuating (noisy) or that substantially differs from concurrent manual measurements may indicate on-site equipment failure, malfunction or requirement for calibration.

**Wasatch Sandstone**

During the 2010-2012 POR, groundwater levels in the Wasatch sandstone declined 1.35 feet. In contrast, over the monitoring period of 1998-2009, groundwater levels declined 5.01 feet from initial static water levels (Figure A.127; Table A.63). Gas pressure was not recorded in the Wasatch sandstone.

**Wyodak Coal**

Groundwater levels rose 176.55 during the 2010-2012 POR. Over the monitoring period of 1998-2009 water levels declined a total of 601.75 feet (Figure A.127; Table A.63). A peak gas pressure of 60.36 psi was recorded in April 2000.



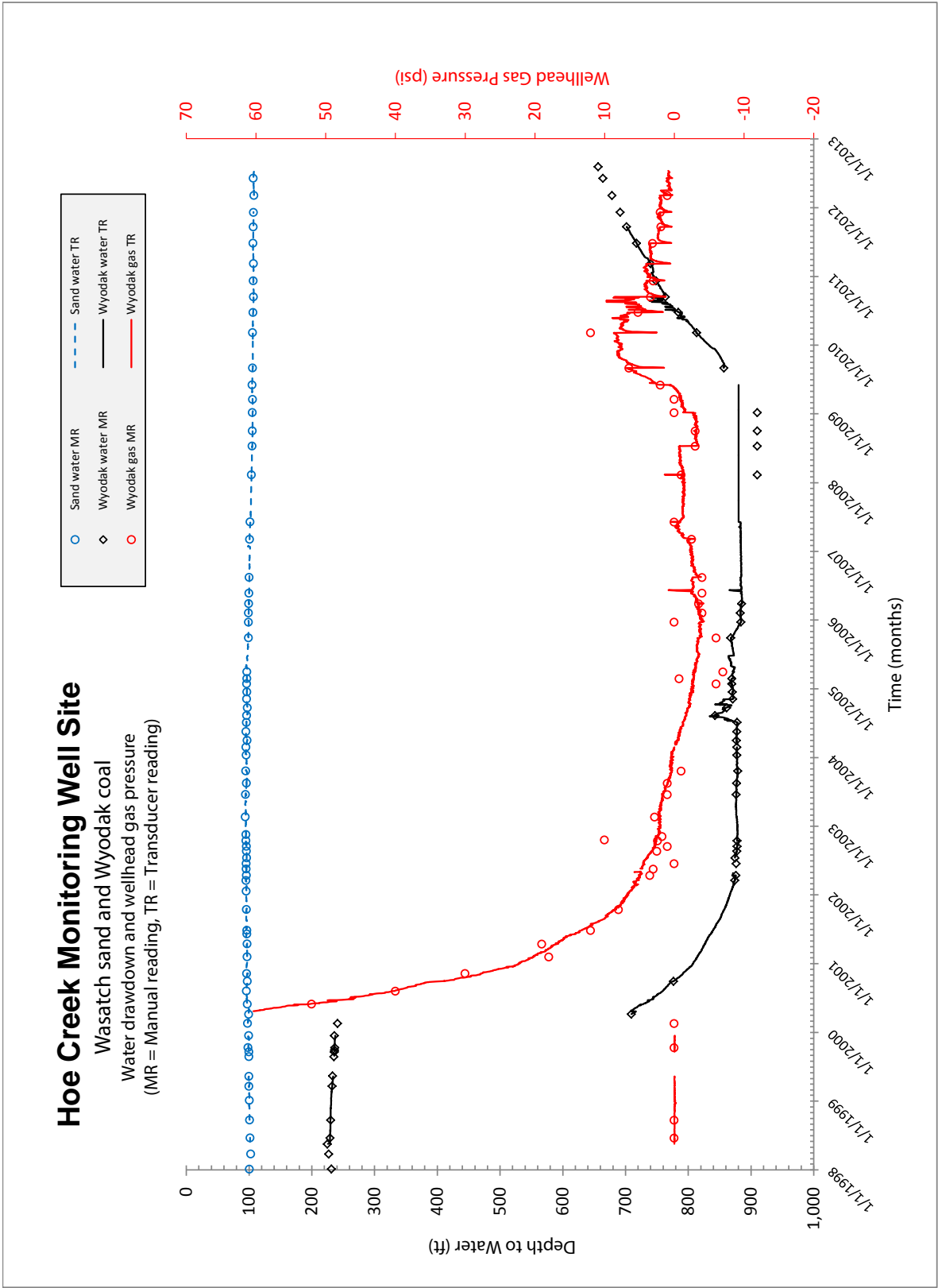
**Figure A.126.** Section showing relative positions of coals and sands in feet. Not to scale.

**Table A.62.** Table showing the depth to and thickness of monitored zones at the Hoe Creek monitoring well site location. (measured in feet)

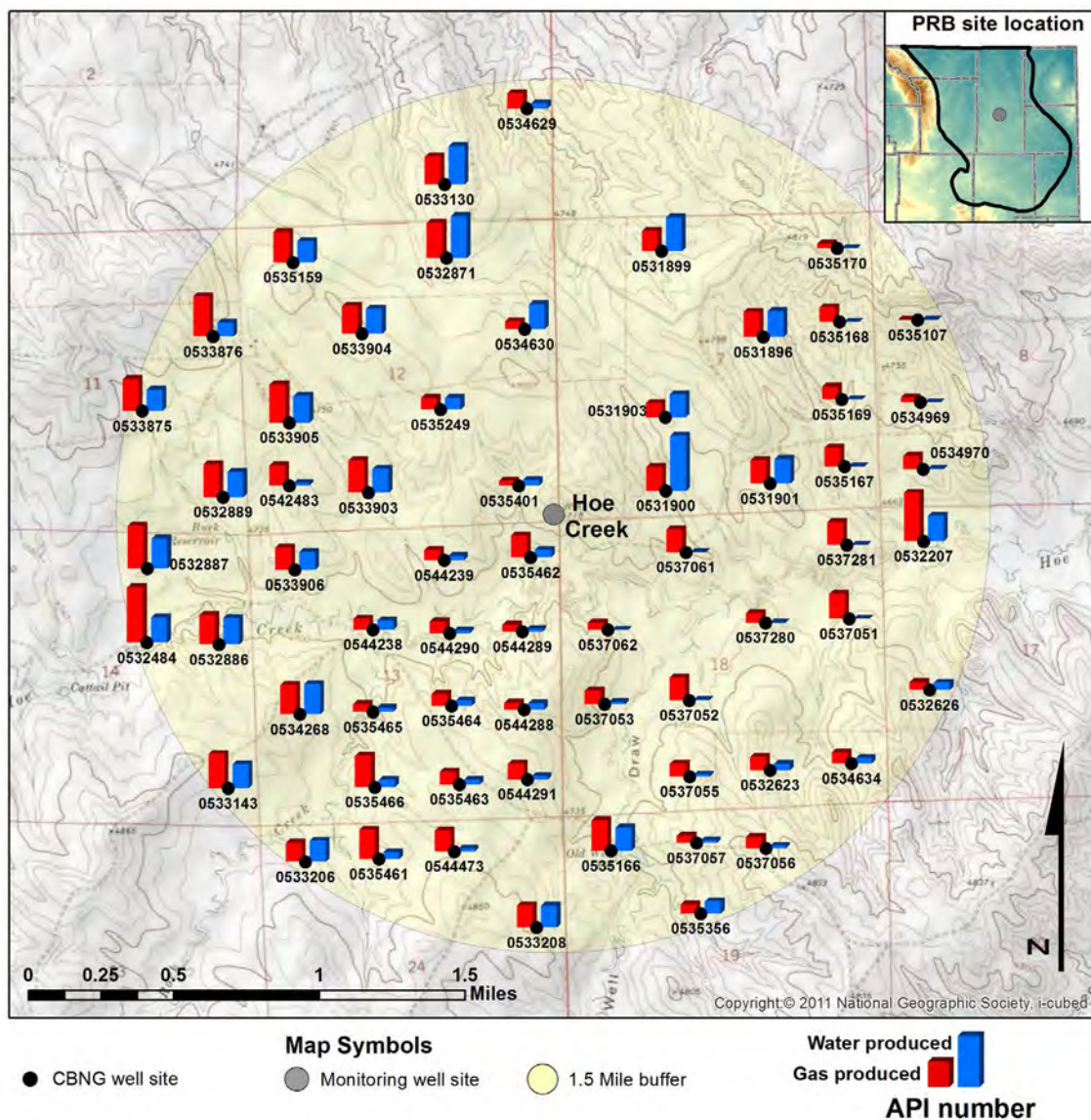
Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Wasatch sand	150	210	60	620
Wyodak coal	830	910	80	n/a

**Table A.63.** Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2010	Drawdown 2010-2012	Total drawdown (ft.)	Depth to Final water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	100.85	5.01	1.35	6.36	107.21	n/a	n/a
Wyodak coal	231.25	601.75	-176.55	425.20	656.45	60.36	4/23/2000



**Figure A.127.** Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Hoe Creek monitoring wellsite location.



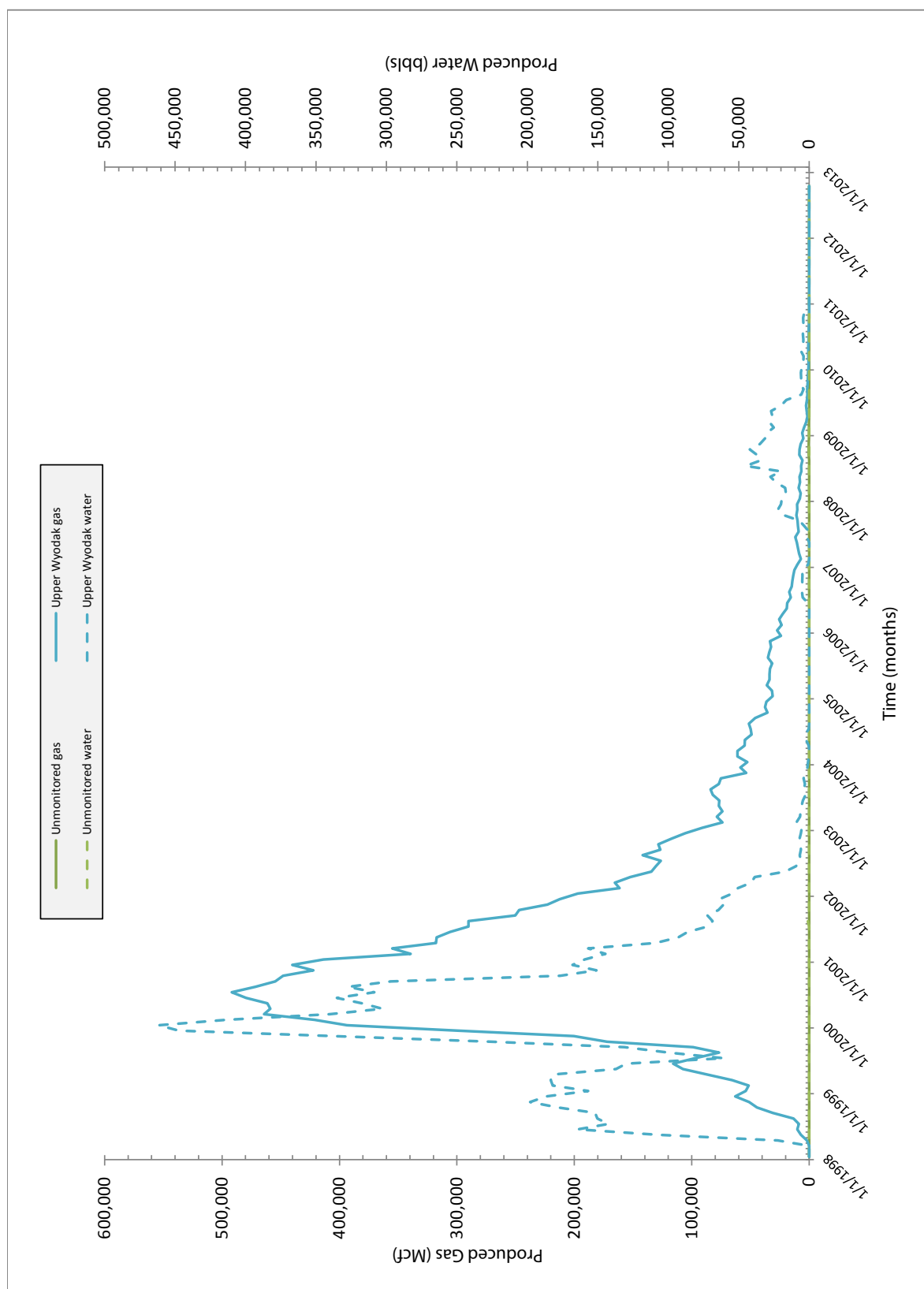
**Figure A.128.** Hoe Creek monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

### Production Statistics

Production data were analyzed for CBNG wells within the buffer of the Hoe Creek monitoring well site from 1998-2012. Cumulative production for individual CBNG wells is displayed by location on Figure A.128. CBNG and water production are monitored in Upper Wyodak and unmonitored coal zone wells.

Water production in the Wyodak coal zone began in April 1998, peaked in January 2000 at 461,598 bbls; there has been no water production since November 2010 (Figure A.129). Gas production began in April 1998 and peaked at 491,699 Mcf in July 2000; no water or gas has been produced since late 2010.

No water or gas has been produced since 2009 in unmonitored coal zone wells (Figure A.129).



**Figure A.129.** Water and gas production from CBNG wells associated with the Hoe Creek monitoring well site location.

# **Juniper Monitoring Well Site** **Location: S14 T49N R78W** **Date First Monitored: March 21, 2001**

## **Drawdown Information**

The Juniper monitoring well site includes three wells. Two wells are completed in Wasatch sandstones and one is completed in the Big George coal of the Wyodak Rider coal zone (Figure A.130; Table A.64). Water levels and wellhead gas pressures were measured during the POR using both manual and automatic transducer and data logger equipment. Transducer data that is missing, randomly fluctuating (noisy) or that substantially differs from concurrent manual measurements may indicate on-site equipment failure, malfunction or requirement for calibration.

## **Wasatch Sandstones**

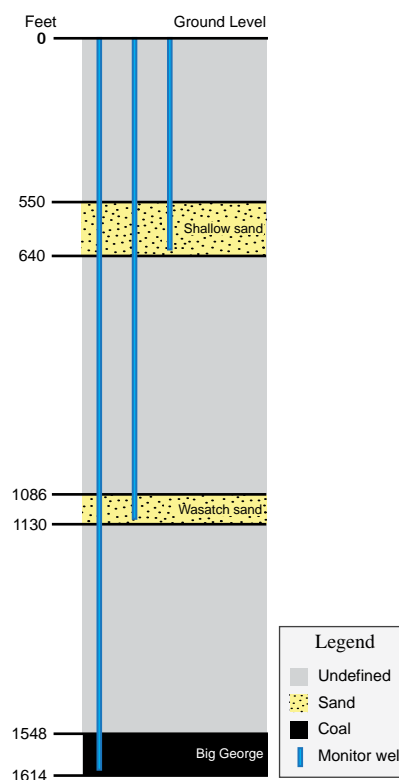
During the 2010-2012 POR, the groundwater levels in the shallow Wasatch sandstone declined 0.47 feet (Figure A.131; Table A.65). In contrast, over the monitoring period of 2001-2009, groundwater levels declined 1.07 feet from initial static water levels.

Water level in the deeper Wasatch sandstone declined 25.77 feet during the 2010-2012 POR and 5.98 feet during the monitoring period of 2001-2009 (Figure A.131; Table A.65).

Gas pressure was not recorded in the Wasatch sandstones.

## **Big George Coal**

This well was reported dry on June 10, 2008 and has remained unchanged during the 2010-2012 POR. Over the monitoring period of 2001-2009 water levels declined a total of 1,445.53 feet (Figure A.131; Table A.65). A peak gas pressure of 221.30 psi was recorded in November 2003.



**Figure A.130.** Section showing relative positions of coals and sands in feet. Not to scale.

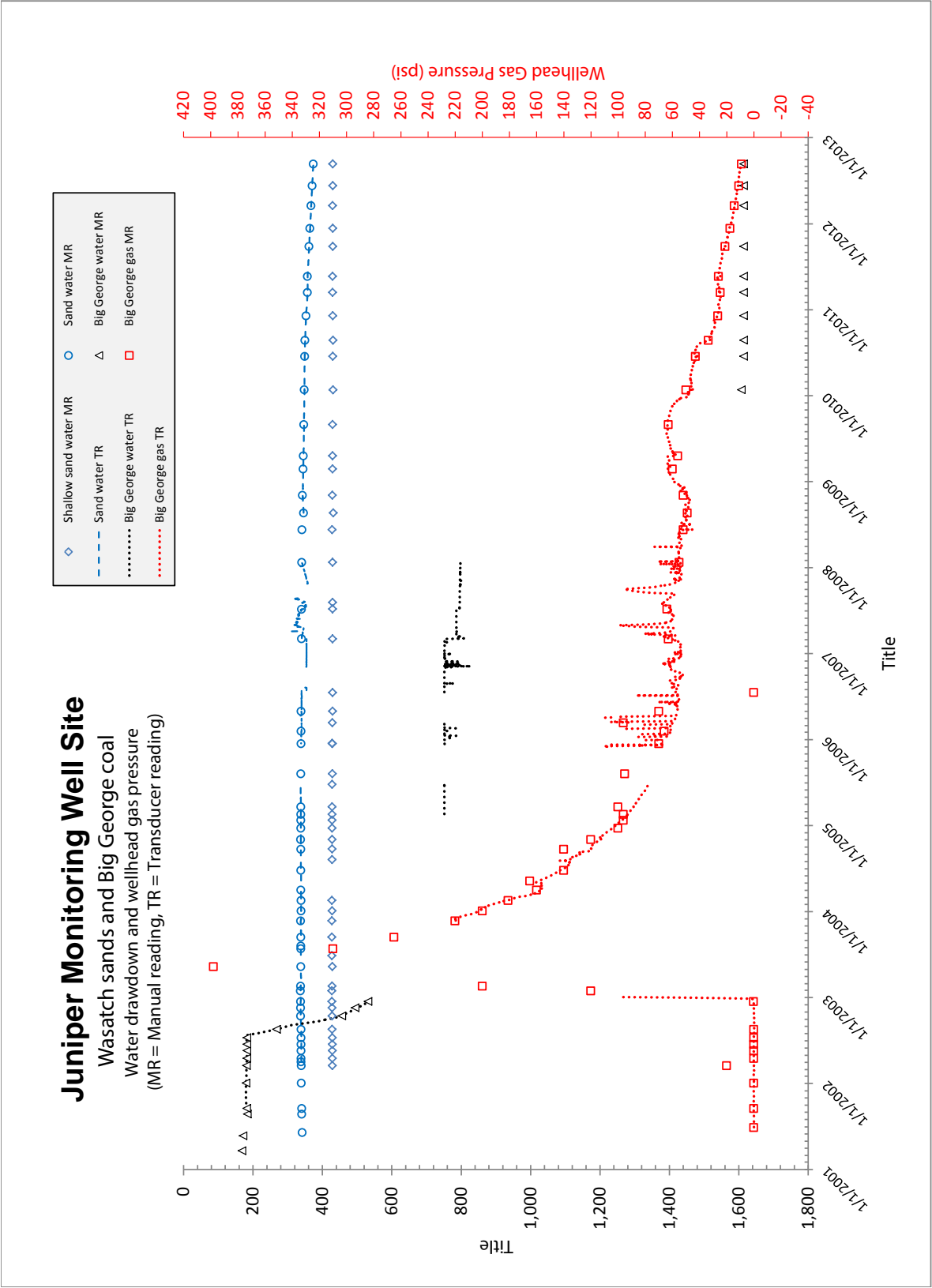


**Table A.64.** Table showing the depth to and thickness of monitored zones at the Juniper monitoring well site location. (measured in feet)

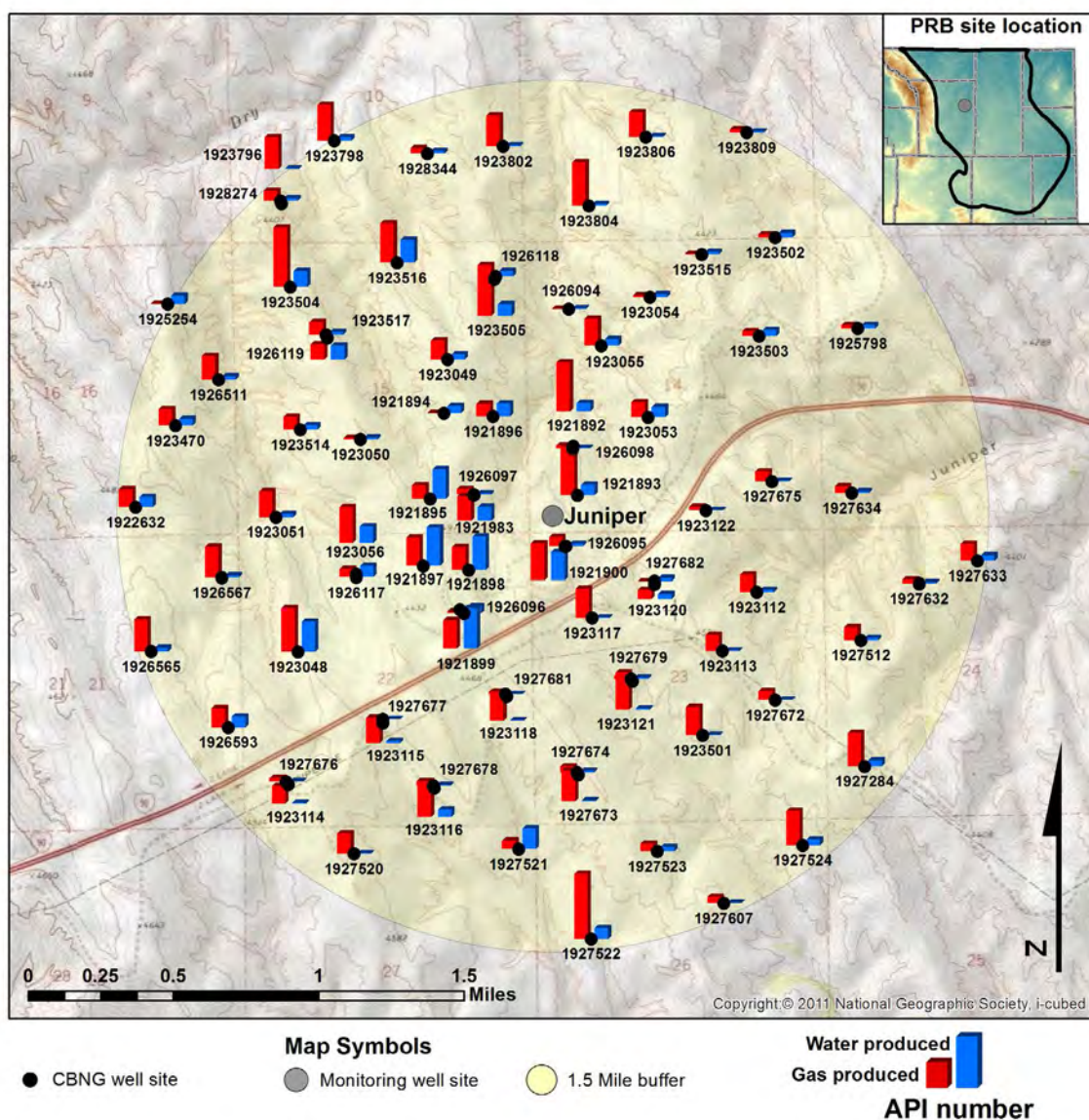
Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Shallow sand	550	640	90	908
Wasatch sand	1,086	1,130	44	418
Big George coal	1,548	1,614	66	n/a

**Table A.65.** Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2010	Drawdown 2010-2012	Total drawdown (ft.)	Depth to Final water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Shallow sand	428.51	1.07	0.47	1.54	430.05	n/a	n/a
Wasatch sand	342.00	5.98	25.77	31.75	373.75	n/a	n/a
Big George coal	168.47	1445.53	0.00	1445.53	1614.00	221.30	11/29/2003



**Figure A.131.** Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Juniper monitoring wellsite location.



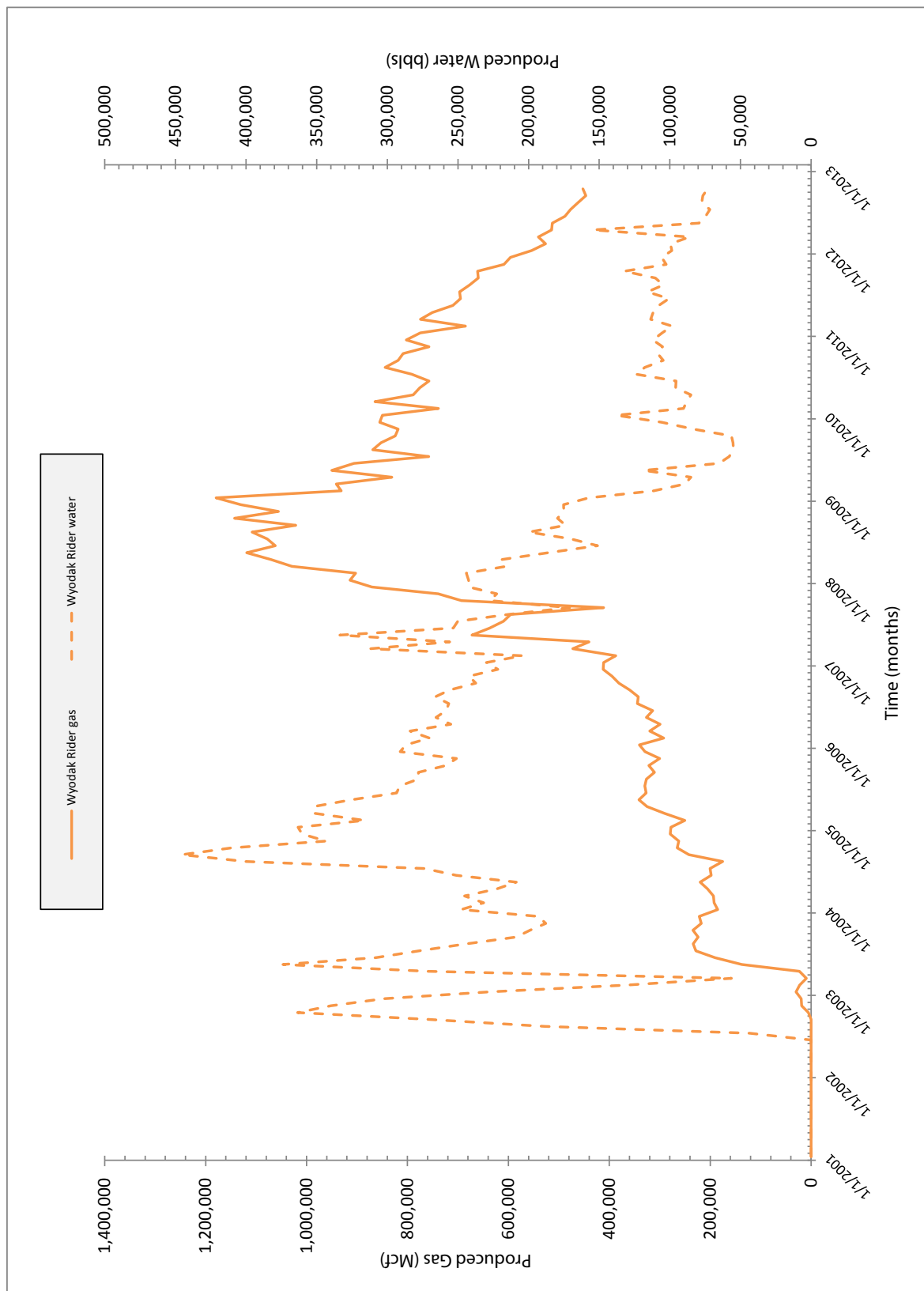
**Figure A.132.** Juniper monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

### Production Statistics

Production data were analyzed for CBNG wells within the buffer of the Juniper monitoring well site from 2001-2012. Cumulative production for individual CBNG wells is displayed by location on Figure A.132. CBNG and water production are monitored in Wyodak Rider coal zone wells.

Water production in the Wyodak Rider coal zone began in July 2002, peaked in September 2004 at

445,330 bbls and continued into late 2012 (Figure A.133). Gas production began in October 2008 and peaked at 1,179,473 Mcf in January 2009; gas production has continued into 2012.



**Figure A.133.** Water and gas production from CBNG wells associated with the Juniper monitoring well site location.

**Kennedy Monitoring Well Site**  
**Location: S33 T52N R73W**  
**Date First Monitored: May 24, 2000**

**Drawdown Information**

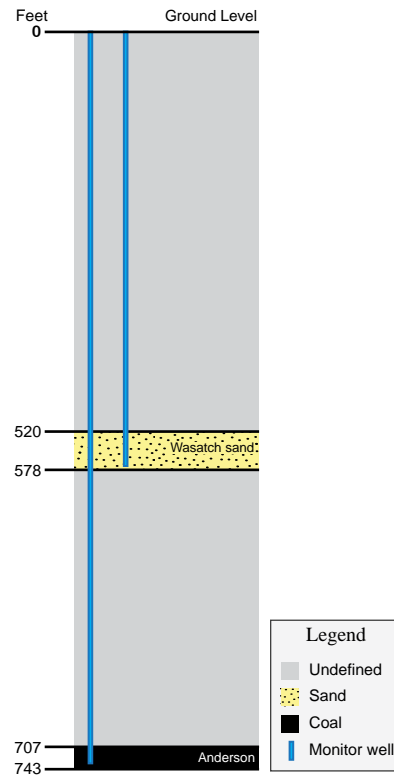
The Kennedy monitoring well site includes two wells. One is completed in a Wasatch sandstone and the other in the Anderson coal of the Upper Wyodak coal zone (Figure A.134; Table A.66). Water levels and wellhead gas pressures were measured during the POR using both manual and automatic transducer and data logger equipment. Transducer data that is missing, randomly fluctuating (noisy) or that substantially differs from concurrent manual measurements may indicate on-site equipment failure, malfunction or requirement for calibration.

**Wasatch Sandstone**

Groundwater levels declined 0.19 feet during the 2010-2012 POR and 17.08 feet during the monitoring period of 2000-2009 (Figure A.135; Table A.67). Gas pressure was not recorded in the Wasatch sandstone.

**Anderson Coal**

Groundwater levels in the Anderson coal monitoring well rose 68.41 feet during the 2010-2012 POR. Over the monitoring period of 2000-2009, water levels declined a total of 221.28 feet (Figure A.135; Table A.67). A peak gas pressure of 0.96 psi was recorded in May 2004.



**Figure A.134.** Section showing relative positions of coals and sands in feet. Not to scale.

**Table A.66.** Table showing the depth to and thickness of monitored zones at the Kennedy monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Wasatch sand	520	578	58	129
Anderson coal	707	743	36	n/a

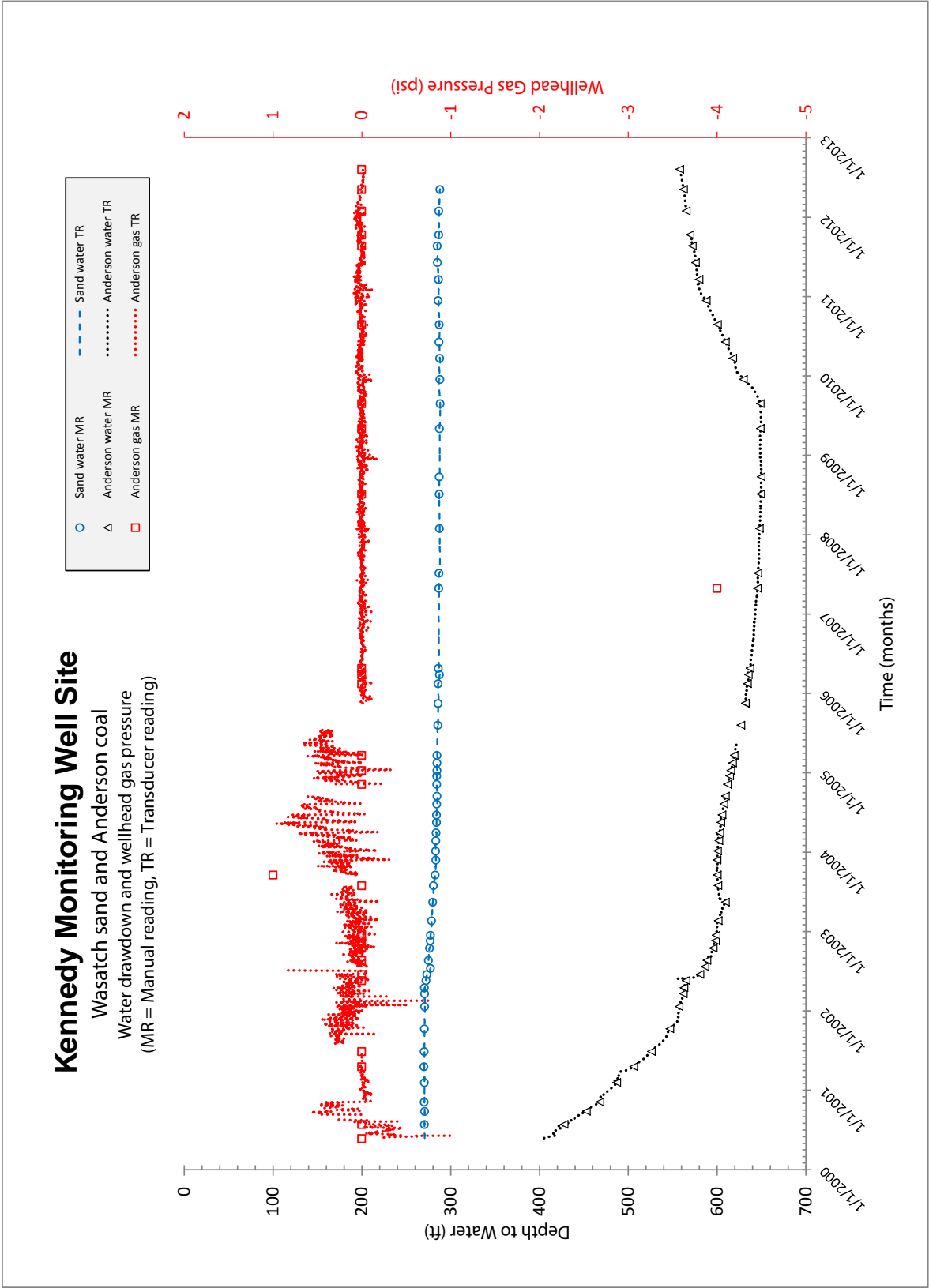
**Table A.67.** Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2010	Drawdown 2010-2012	Total drawdown (ft.)	Depth to Final water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	270.70	17.08	0.19	17.27	287.97	n/a	n/a
Anderson coal	405.21	221.28	-68.41	152.87	558.08	0.96	5/11/2004

### Production Statistics

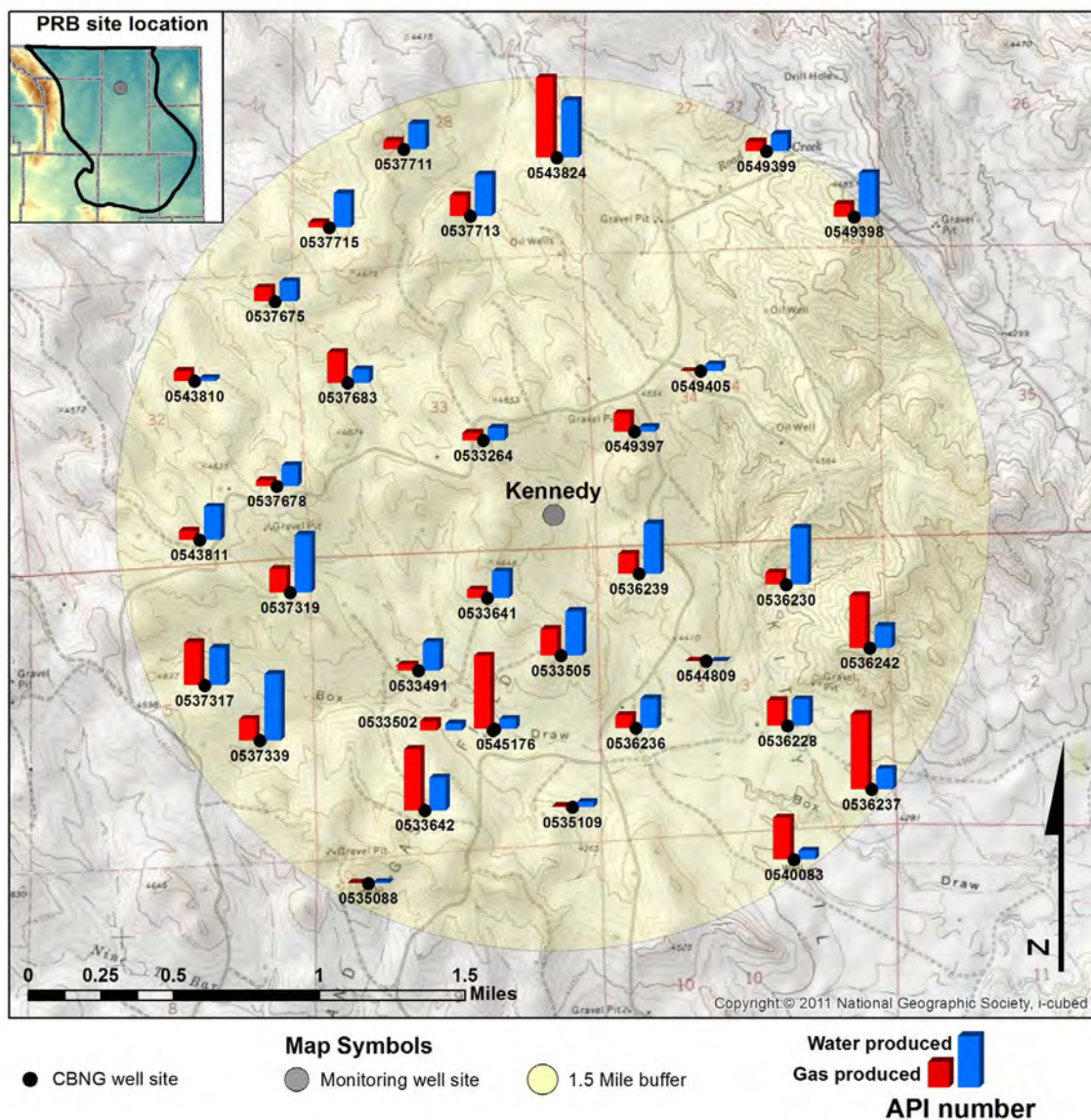
Production data were analyzed for CBNG wells within the buffer of the Kennedy monitoring well site from 1998-2012. Cumulative production for individual CBNG wells is displayed by location on

Figure A.136. CBNG production is monitored in the Upper Wyodak and some production in this area occurs in the unmonitored coal zones.



**Figure A.135.** Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Kennedy monitoring wellsite location.





**Figure A.136.** Kennedy monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute

Consistent monthly water production in both the Upper Wyodak and unmonitored coal zones began in December 1999. Water production in the Upper Wyodak coal zone peaked in January 2001 at 117,968 bbls; water production in the unmonitored coal zones reached a maximum of 262,957 bbls in November 2001 (Figure A.137). Gas production in the Upper Wyodak reached its maximum level in November 2001 at 63,386 Mcf;

maximum gas production in the unmonitored coal zones was 259,774 Mcf in December 2001.

There has been no water production since January 2010 in either the Upper Wyodak or unmonitored coal zones. Gas production in both zones ceased in April 2010 (Figure A.137).

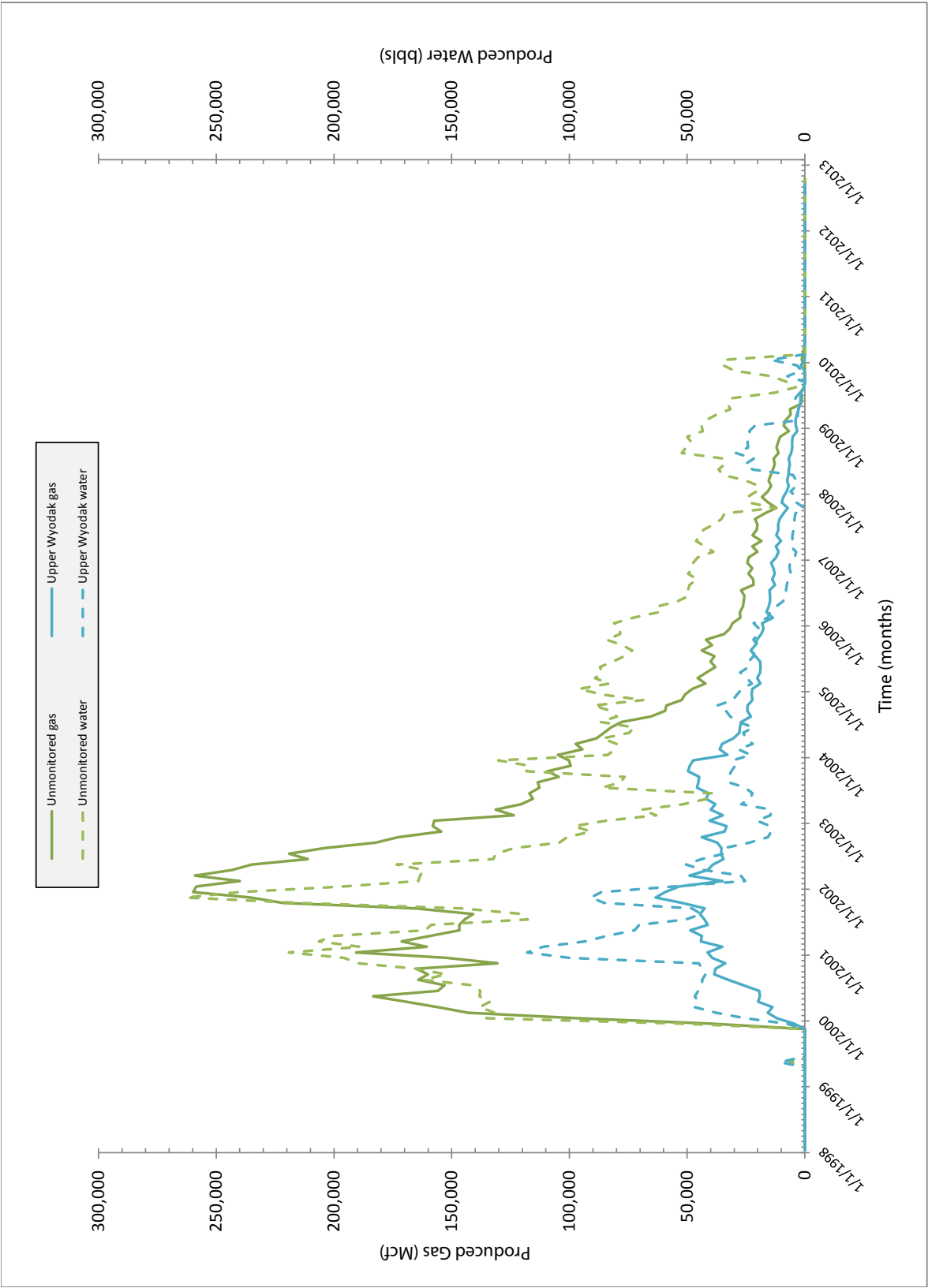


Figure A.137. Water and gas production from CBNG wells associated with the Kennedy monitoring well site location.

**Kingsbury Monitoring Well Site**  
**Location: S25 T46N R78W**  
**Date First Monitored: October 23, 2007**

**Drawdown Information**

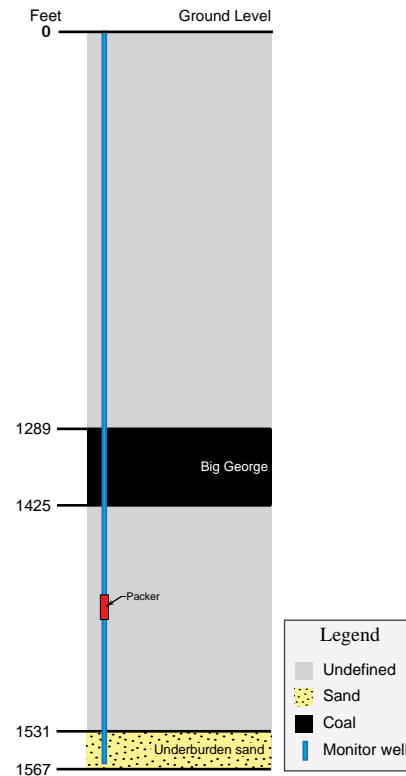
The Kingsbury monitoring well site includes one dual completion well, separated by a packer. The well is completed in the Big George coal of the Wyodak Rider coal zone and in a Fort Union underburden sandstone (Figure A.138; Table A.68). Missing and/or fluctuating transducer data is the result of errors with on-site equipment. Water levels and wellhead gas pressures were measured during the POR using both manual and automatic transducer and data logger equipment. Transducer data that is missing, randomly fluctuating (noisy) or that substantially differs from concurrent manual measurements may indicate on-site equipment failure, malfunction or requirement for calibration. Similar water level measurements may indicate communication between wells, possibly due to a faulty packer. It was reported on June 1, 2010 that the packer was not isolating the Big George coal from the Fort Union underburden sand. So, the drawdown level of the sandstone was following that of the Big George coal.

**Big George Coal**

Groundwater levels in the Big George coal monitoring well declined 144.61 feet during the 2010-2012 POR. Over the monitoring period of 2007-2009, water levels declined a total of 167.49 feet (Figure A.139; Table A.69). A peak gas pressure of 0.18 psi was recorded in August 2011.

**Fort Union Underburden Sandstone**

Groundwater levels in the Fort Union underburden sandstone monitoring well declined 185.02 feet during the 2010-2012 POR, and 100.75 feet during the monitoring period of 2007-2009 (Figure A.139; Table A.69). Gas pressure was not recorded in the underburden sandstone.



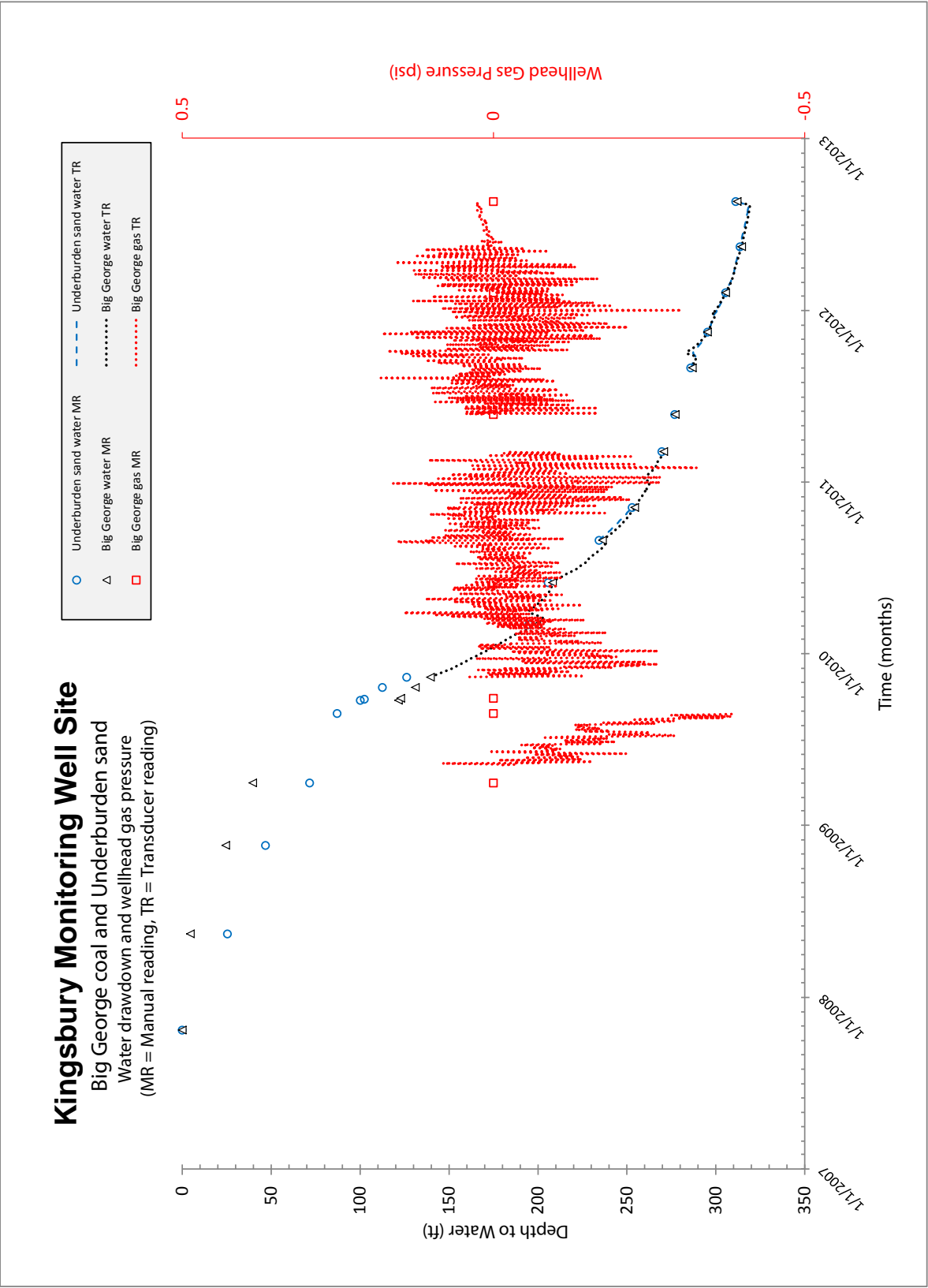
**Figure A.138.** Section showing relative positions of coals and sands in feet. Not to scale.

**Table A.68.** Table showing the depth to and thickness of monitored zones at the Kingsbury monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Big George coal	1,289	1,425	136	n/a
Underburden sand	1,531	1,567	36	106

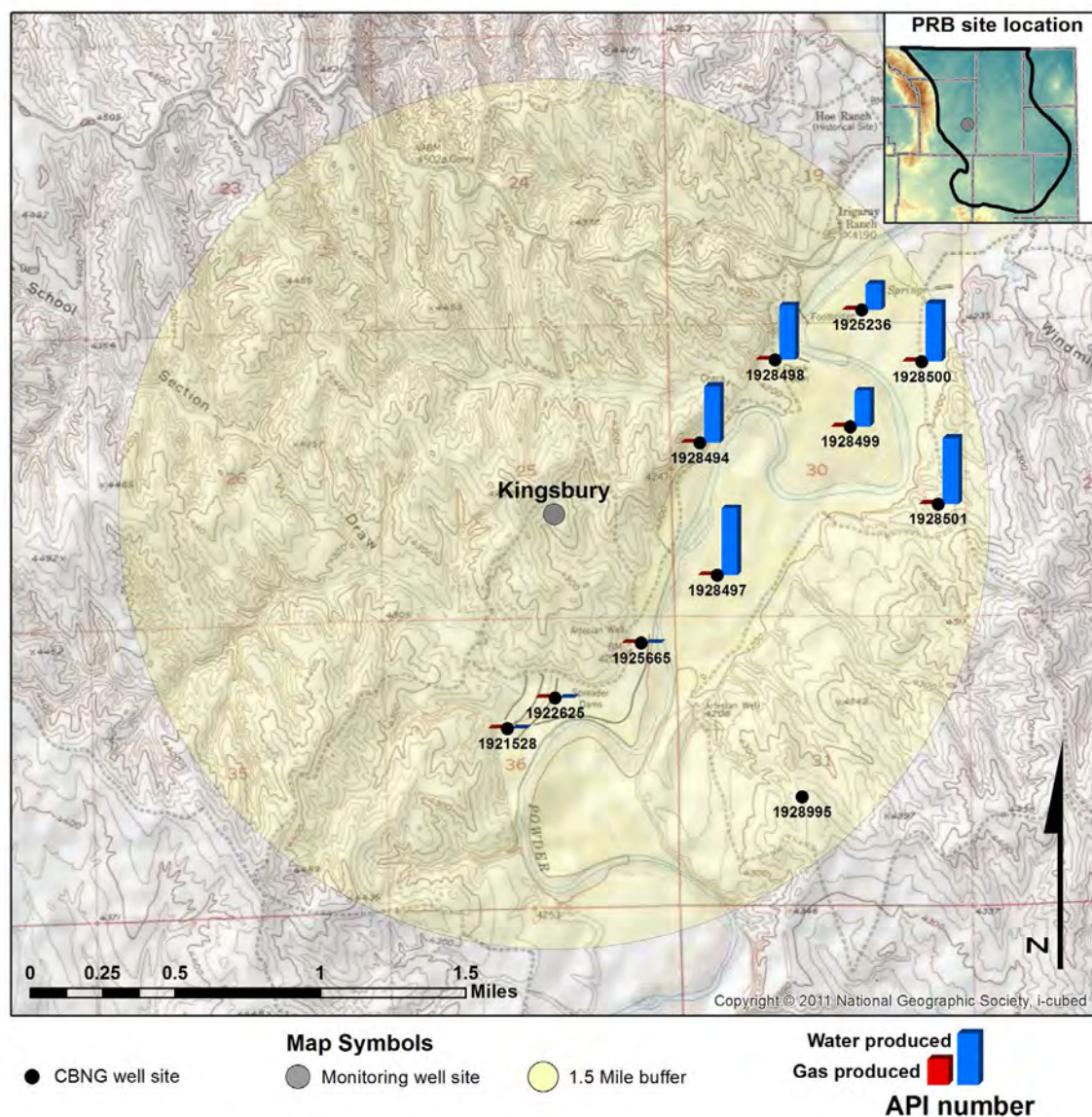
**Table A.69.** Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2010	Drawdown 2010-2012	Total drawdown (ft.)	Depth to Final water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Big George coal	0.00	167.49	144.61	312.10	312.10	0.18	8/10/2011
Underburden sand	25.50	100.75	185.02	285.77	311.27	n/a	n/a



**Figure A.139.** Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Kingsbury monitoring wellsite location.





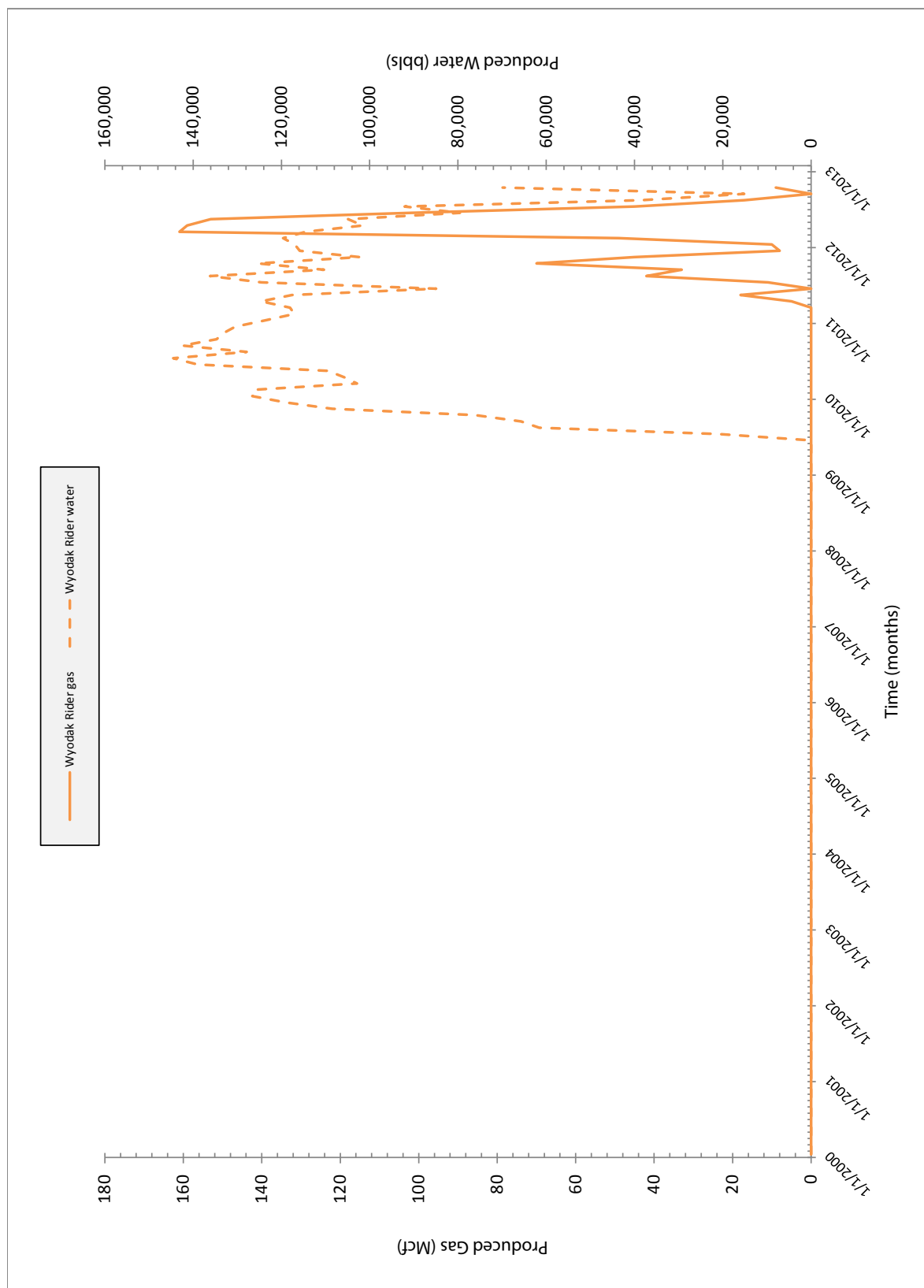
**Figure A.140.** Kingsbury monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

### Production Statistics

Production data were analyzed for CBNG wells within the buffer of the Kingsbury monitoring well site from 2007-2012. Cumulative production for individual CBNG wells is displayed by location on Figure A.140. CBNG production is monitored in the Wyodak Rider.

of 144,510 bbls in July 2010 (Figure A.141). Gas was first produced from the Wyodak Rider in April 2011 and has not exceeded 200 Mcf/month since then.

Consistent monthly water production in the Wyodak Rider began in July 2009 and reached a peak



**Figure A.141.** Water and gas production from CBNG wells associated with the Kingsbury monitoring well site location.



## L Quarter Circle Hills Monitoring Well Site

Location: S14 T56N R77W

Date First Monitored: April 5, 2005

### Drawdown Information

The Lower Quarter Circle Hills monitoring well site includes three wells. One is completed in a Wasatch sandstone, another in the Cook coal of the Cook coal zone, and the last in the Wall coal of the Wall coal zone (Figure A.142; Table A.70). Water levels and wellhead gas pressures were measured during the POR using both manual and automatic transducer and data logger equipment. Transducer data that is missing, randomly fluctuating (noisy) or that substantially differs from concurrent manual measurements may indicate on-site equipment failure, malfunction or requirement for calibration.

### Wasatch Sandstone

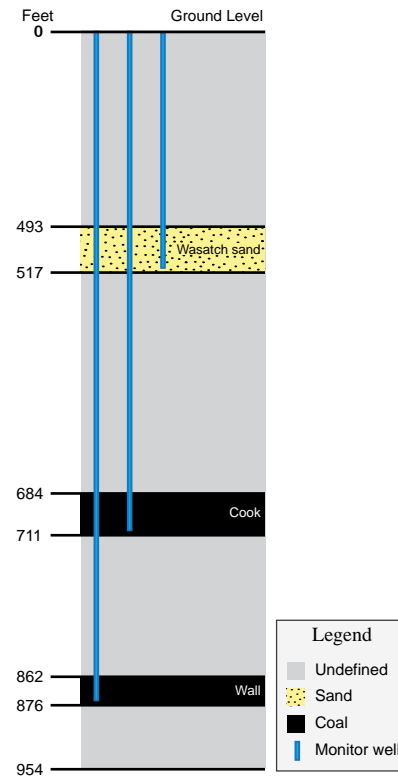
During the 2010-2012 POR, groundwater levels in the Wasatch sandstone declined 7.75 feet. In contrast, over the monitoring period of 2005-2009, groundwater levels declined 10.95 feet from initial static water levels (Figure A.143; Table A.71). Gas pressure was not recorded in the Wasatch sandstone.

### Cook Coal

Groundwater levels rose 79.29 feet during the 2010-2012 POR. Over the monitoring period of 2005-2009 water levels declined a total of 187.23 feet (Figure A.143; Table A.71). A peak gas pressure of 13.55 psi was recorded in January 2012.

### Wall coal

Groundwater levels declined 36.12 feet during the 2010-2012 POR. During the monitoring period of 2005-2009, water levels declined 260.64 feet (Figure A.143; Table A.71). Gas pressure in the Wall coal peaked at 23.00 psi in February 2012.



**Figure A.142.** Section showing relative positions of coals and sands in feet. Not to scale.

**Table A.70.** Table showing the depth to and thickness of monitored zones at the L Quarter Circle Hills monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Wasatch sand	493	517	24	167
Cook coal	684	711	27	n/a
Wall coal	862	876	14	n/a

**Table A.71.** Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

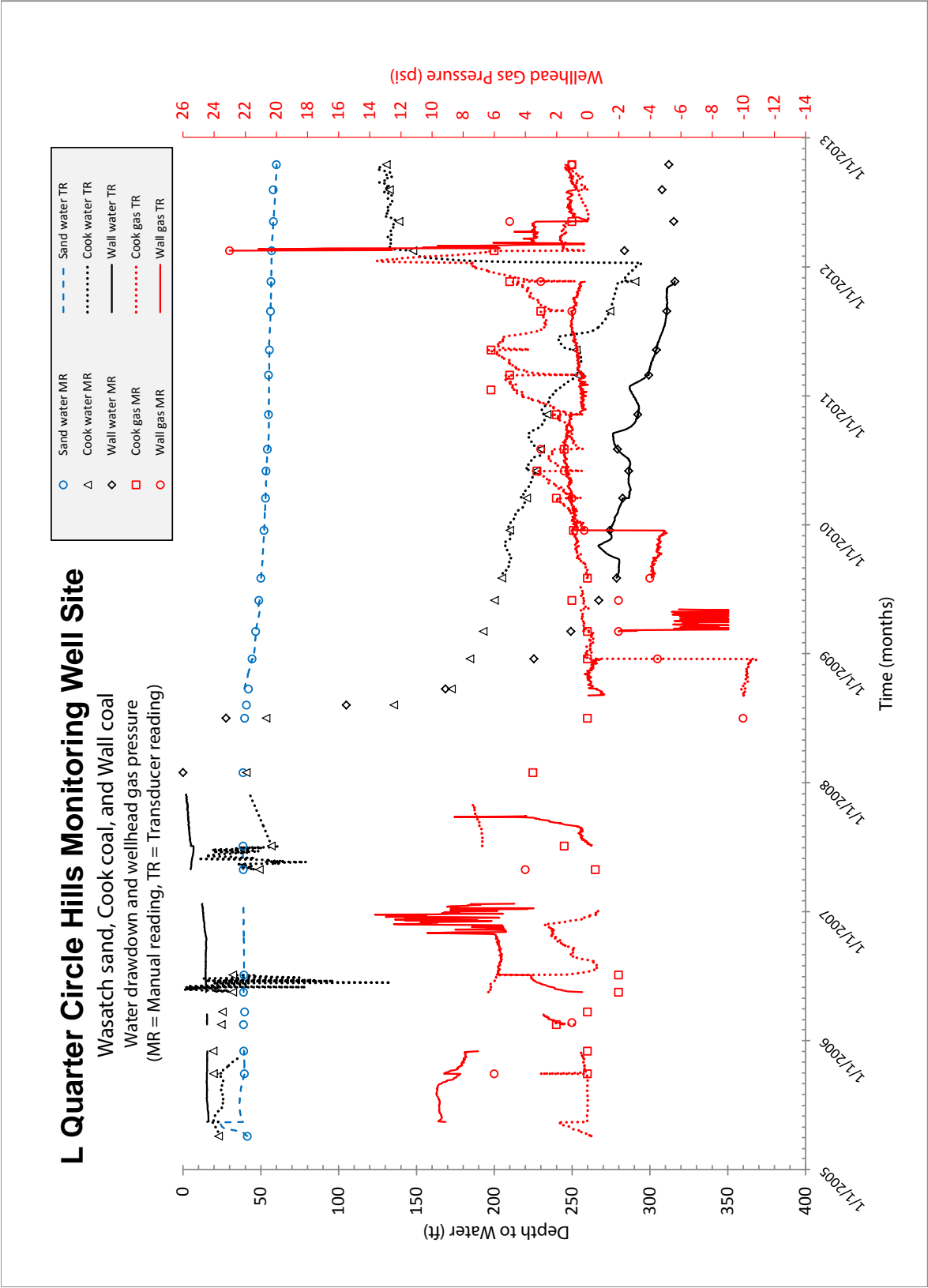
Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2010	Drawdown 2010-2012	Total drawdown (ft.)	Depth to Final water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	41.38	10.95	7.75	18.70	60.08	n/a	n/a
Cook coal	22.86	187.23	-79.29	107.94	130.80	13.55	1/18/2012
Wall coal	15.39	260.64	36.12	296.76	312.15	23.00	2/16/2012

### Production Statistics

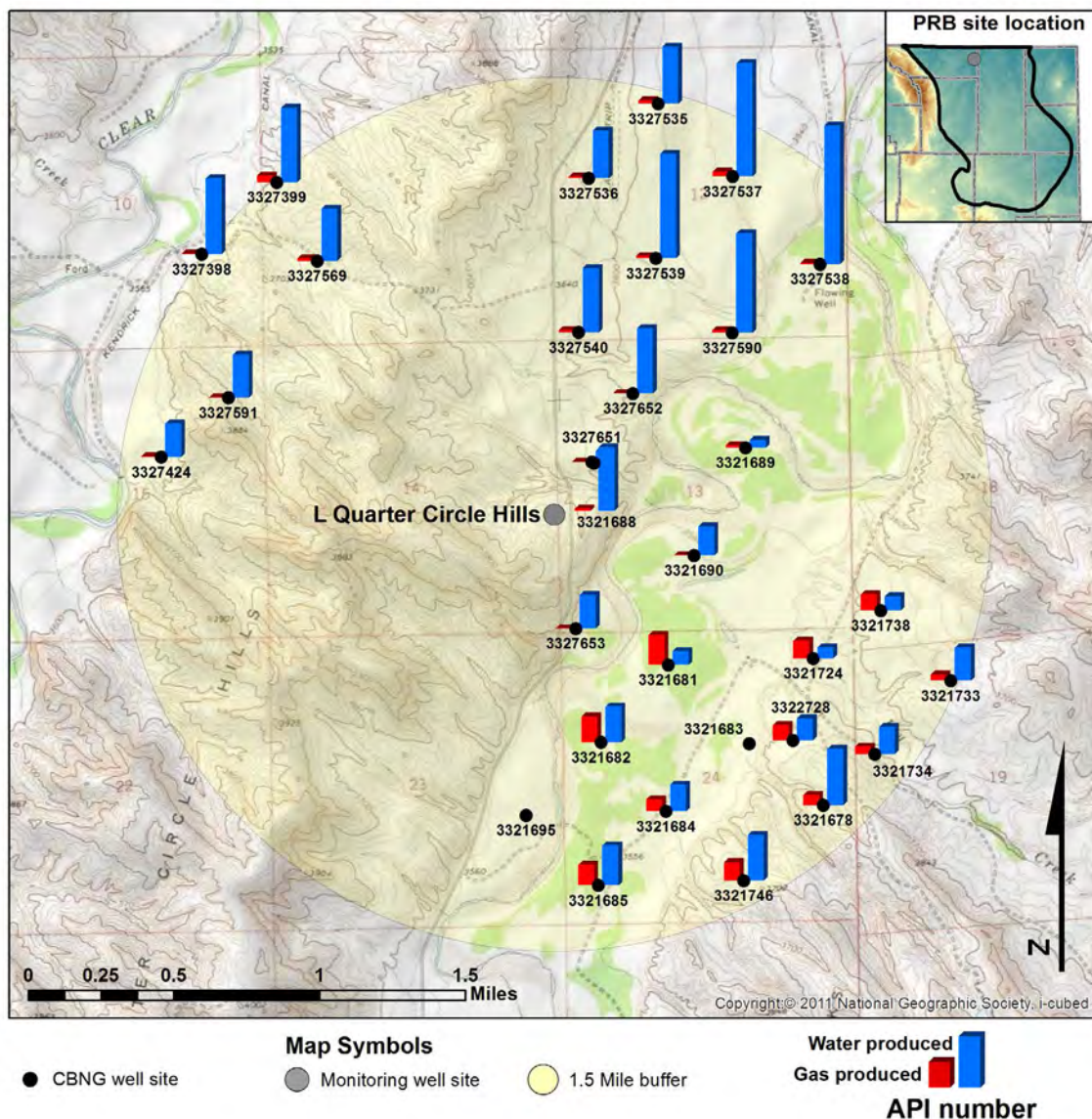
Production data were analyzed for CBNG wells within the buffer of the Lower Quarter Circle Hills monitoring well site from 2001-2012. Cumulative production for individual CBNG wells is displayed by location on Figure A.144. CBNG production is monitored in the Cook coal zone and the Wall coal

zone, some production in this area occurs in the multiple monitored coal zones.

The Cook coal zone began to produce water consistently in March 2002 and peaked at 144,853 bbls in April of the same year (Figure A.145). Gas production in the Cook peaked in September 2004 at 50,213 Mcf.



**Figure A.143.** Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the L Quarter Circle Hills monitoring wellsite location.

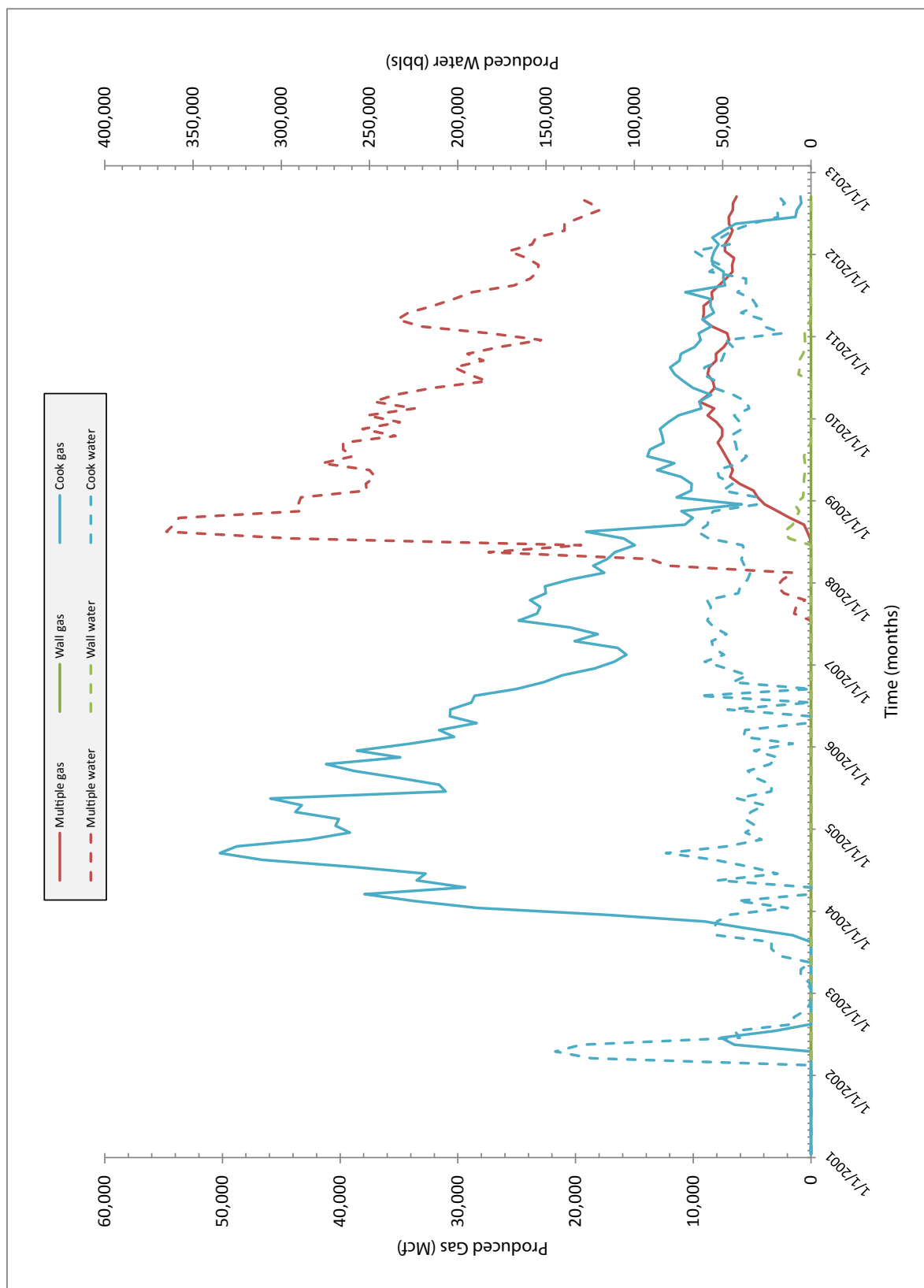


**Figure A.144.** L Quarter Circle Hills monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

Water production began in the Wall coal zone in July 2008 and peaked at 15,325 bbls in August 2008. No water production is recorded after February 2011 (Figure A.145). Locally, gas production in the Wall has been very low, never exceeding 47 Mcf/month.

Water production in multiple coal zone wells began in August 2007, reached a maximum of 360,838

bbls in September 2008 and declined to around 130,000 bbls/month by the end of the 2010-2012 POR (Figure A.145). Gas production began in April 2008 and has been low but relatively constant since 2009 never exceeding 10,000 Mcf/month.



**Figure A.145.** Water and gas production from CBNG wells associated with the L Quarter Circle Hills monitoring well site location.

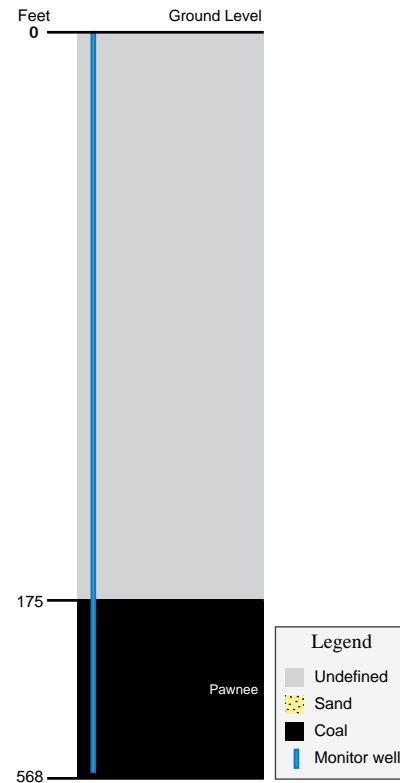
**Leiter Monitoring Well Site**  
**Location: S19 T58N R77W**  
**Date First Monitored: May 16, 2002**

**Drawdown Information**

The Leiter monitoring well site includes one well, which is completed in the Pawnee coal of the Wall coal zone (Figure A.146; Table A.72). Water levels were measured using manual measurements only.

**Pawnee Coal**

Groundwater levels in the Pawnee coal declined 0.25 feet during the 2010-2012 POR and 0.27 feet during the monitoring period of 2002-2009. (Figure A.147; Table A.73). Gas pressure was never recorded for this well.



**Figure A.146.** Section showing relative positions of coals and sands in feet. Not to scale.

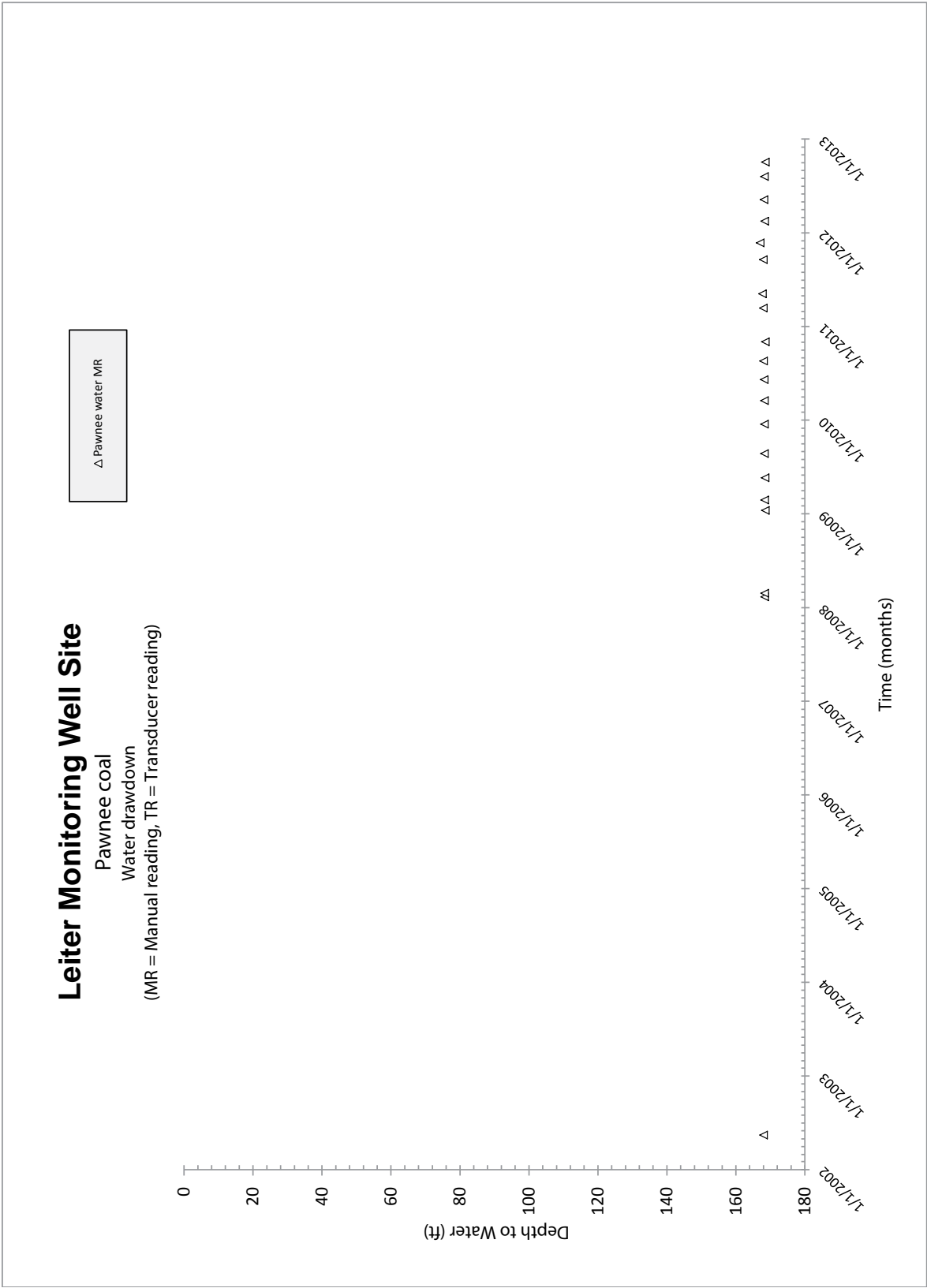
**Table A.72.** Table showing the depth to and thickness of monitored zones at the Leiter monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Pawnee coal	175	568	393	n/a

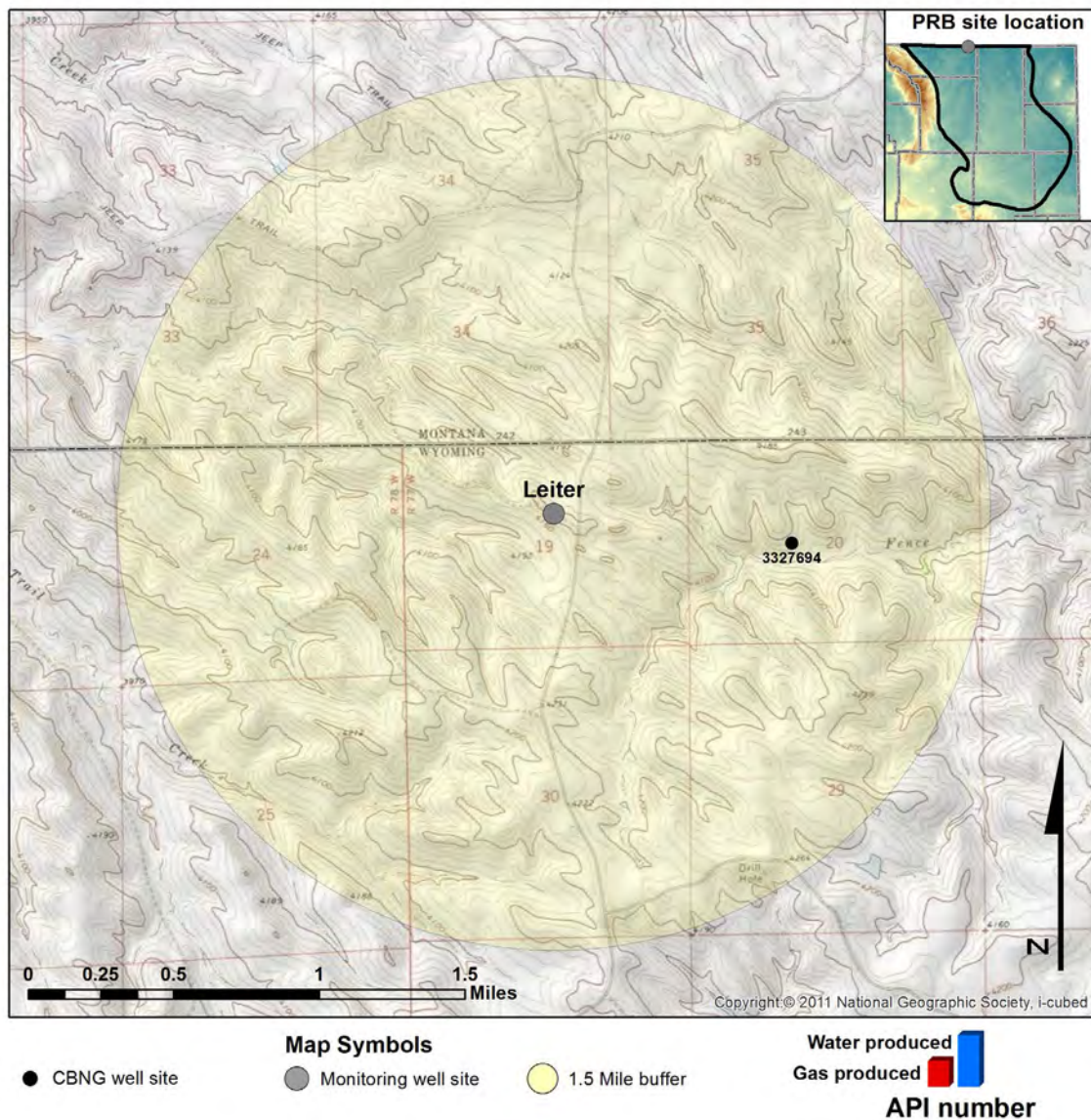
**Table A.73.** Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2010	Drawdown 2010-2012	Total drawdown (ft.)	Depth to Final water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Pawnee coal	168.05	0.27	0.25	0.52	168.57	n/a	n/a





**Figure A.147.** Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Leiter monitoring wellsite location



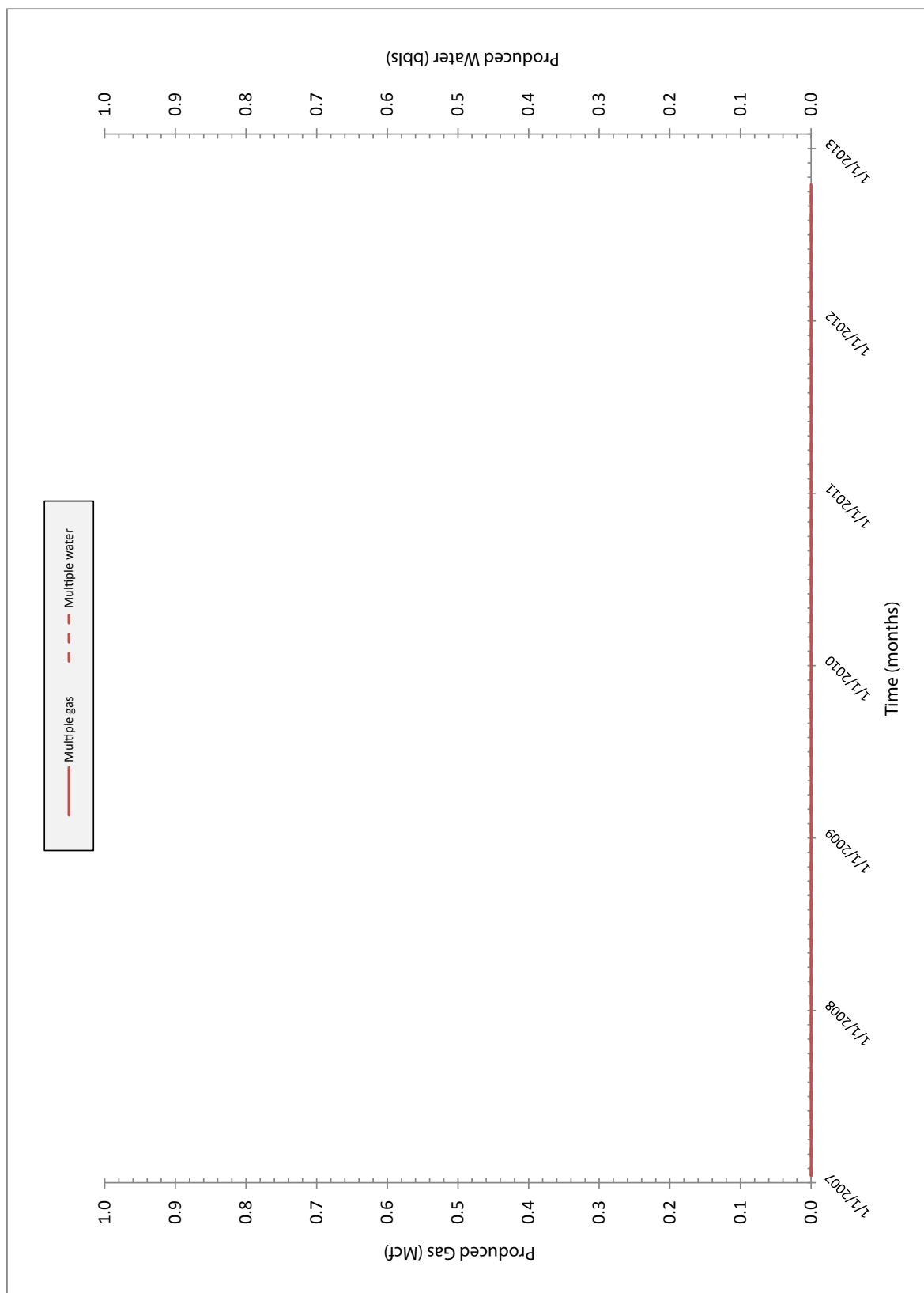
**Figure A.148.** Leiter monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

### Production Statistics

Production data were analyzed for CBNG wells within the buffer of the Leiter monitoring well site from 2007-2012. Cumulative production for individual CBNG wells is displayed by location on Figure A.148. CBNG production is monitored in multiple coal zones.

Wyoming Oil and Gas Conservation Commission (Figure A.149).

There was no water or gas production reported within the buffer zone of the monitoring site by the



**Figure A.149.** Water and gas production from CBNG wells associated with the Leiter monitoring well site location.

**Lone Tree Monitoring Well Site**  
**Location: S13 T50N R73W**  
**Date First Monitored: February 24, 2000**

**Drawdown Information**

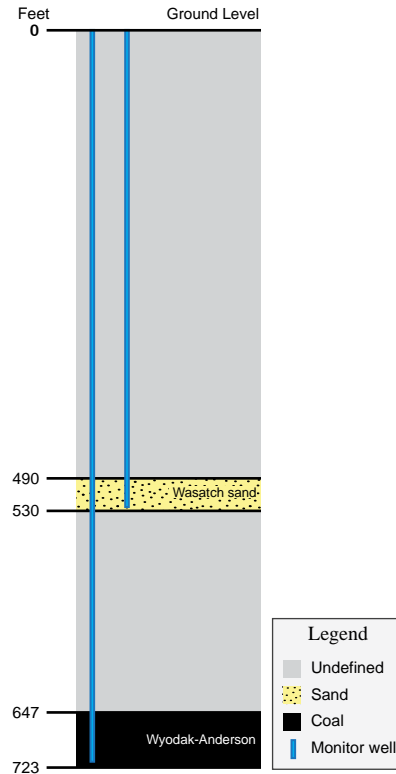
The Lone Tree monitoring well site includes two wells. One is completed in a Wasatch sandstone and the other in the Wyodak-Anderson coal of the Upper Wyodak coal zone (Figure A.150; Table A.74). Water levels and wellhead gas pressures were measured during the POR using both manual and automatic transducer and data logger equipment. Transducer data that is missing, randomly fluctuating (noisy) or that substantially differs from concurrent manual measurements may indicate on-site equipment failure, malfunction or requirement for calibration.

**Wasatch Sandstone**

During the 2010-2012 POR, groundwater levels rose 0.59 feet; over the monitoring period of 2000-2009 water levels declined a total of 5.54 feet (Figure A.151; Table A.75). Gas pressure was not recorded in the Wasatch sandstone.

**Wyodak-Anderson Coal**

Over the monitoring period of 2000-2009 water levels declined a total of 269.90 feet (Figure A.151; Table A.75) to a level below the bottom of the monitoring well. The well remained dry during the 2010-2012 POR. A peak gas pressure of 66.66 psi was recorded in May 2002.



**Figure A.150.** Section showing relative positions of coals and sands in feet. Not to scale.

**Table A.74.** Table showing the depth to and thickness of monitored zones at the Lone Tree monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Wasatch sand	490	530	40	117
Wyodak-Anderson coal	647	723	76	n/a

**Table A.75.** Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2010	Drawdown 2010-2012	Total drawdown (ft.)	Depth to Final water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	286.31	5.54	-0.59	4.95	291.26	n/a	n/a
Wyodak-Anderson coal	453.10	269.90	0.00	269.90	723.00	66.66	5/22/2002

### Production Statistics

Production data were analyzed for CBNG wells within the buffer of the Lone Tree monitoring well site from 1991-2012. Cumulative production for individual CBNG wells is displayed by location on Figure A.152. CBNG production is monitored in the Upper Wyodak coal zone and in coal production zones where water levels are not monitored.

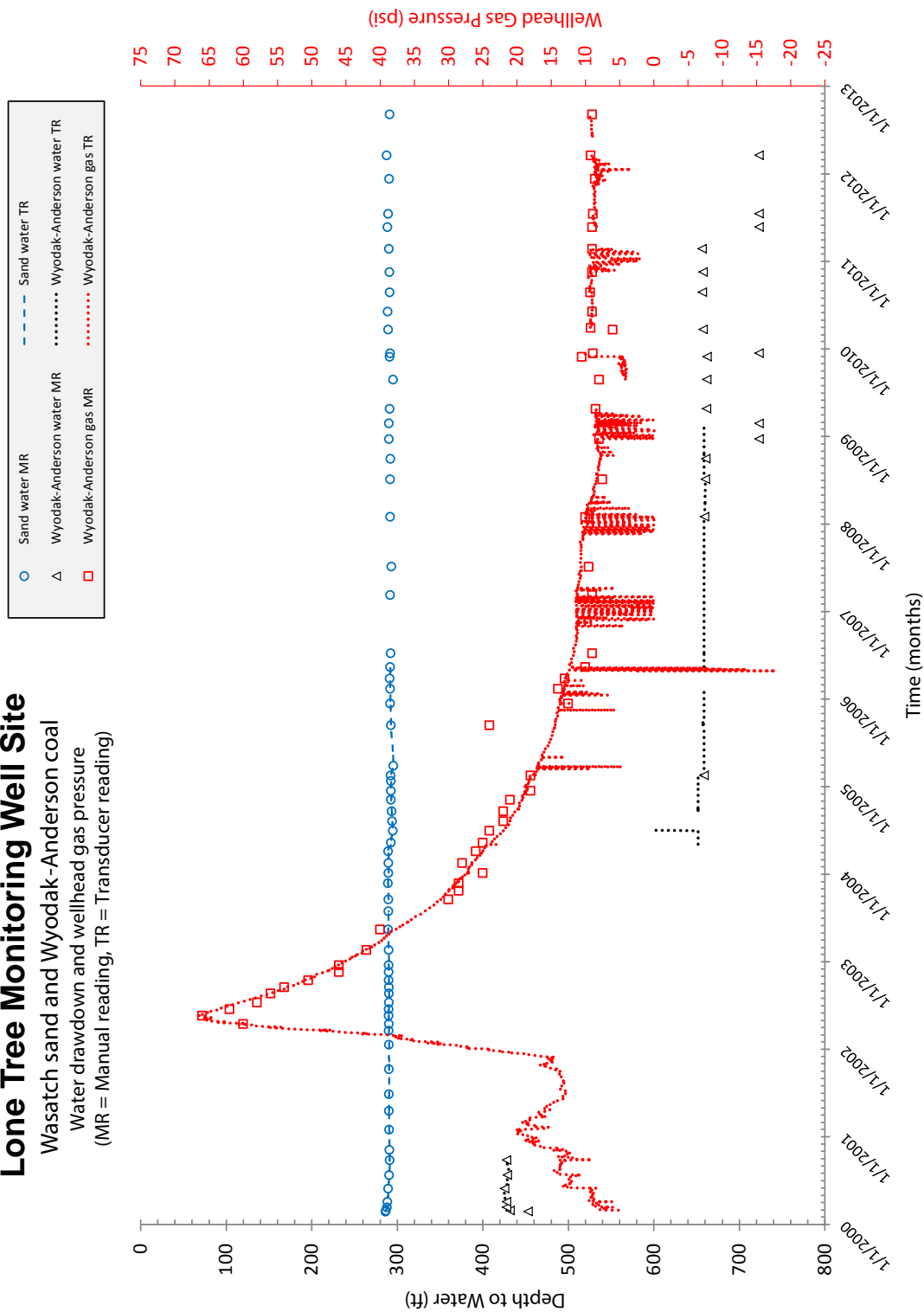
Water production in the Upper Wyodak zone was low from 1991-2000, peaked in October 2001 at 171,313 bbls and then receded to zero by the end of the 2010-2012 POR (Figure A.153). Gas production was low until 2000, then rapidly increased to a peak level of 115,297 Mcf in October 2001 and receded to zero by the end of the 2010-2012 POR.

## Lone Tree Monitoring Well Site

Wasatch sand and Wyodak-Anderson coal

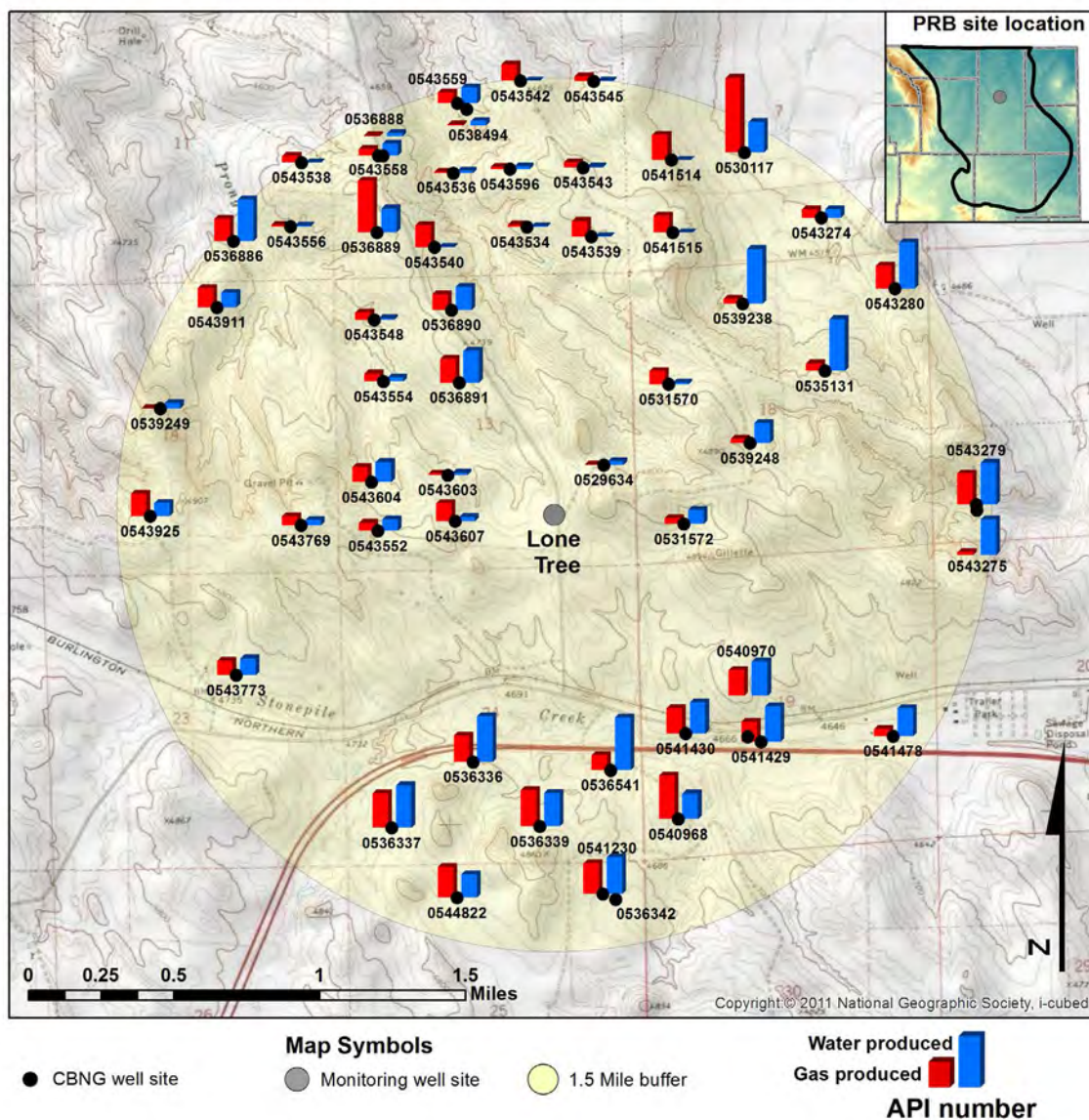
Water drawdown and wellhead gas pressure

(MR = Manual reading, TR = Transducer reading)



**Figure A.151.** Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Lone Tree monitoring wellsite location.

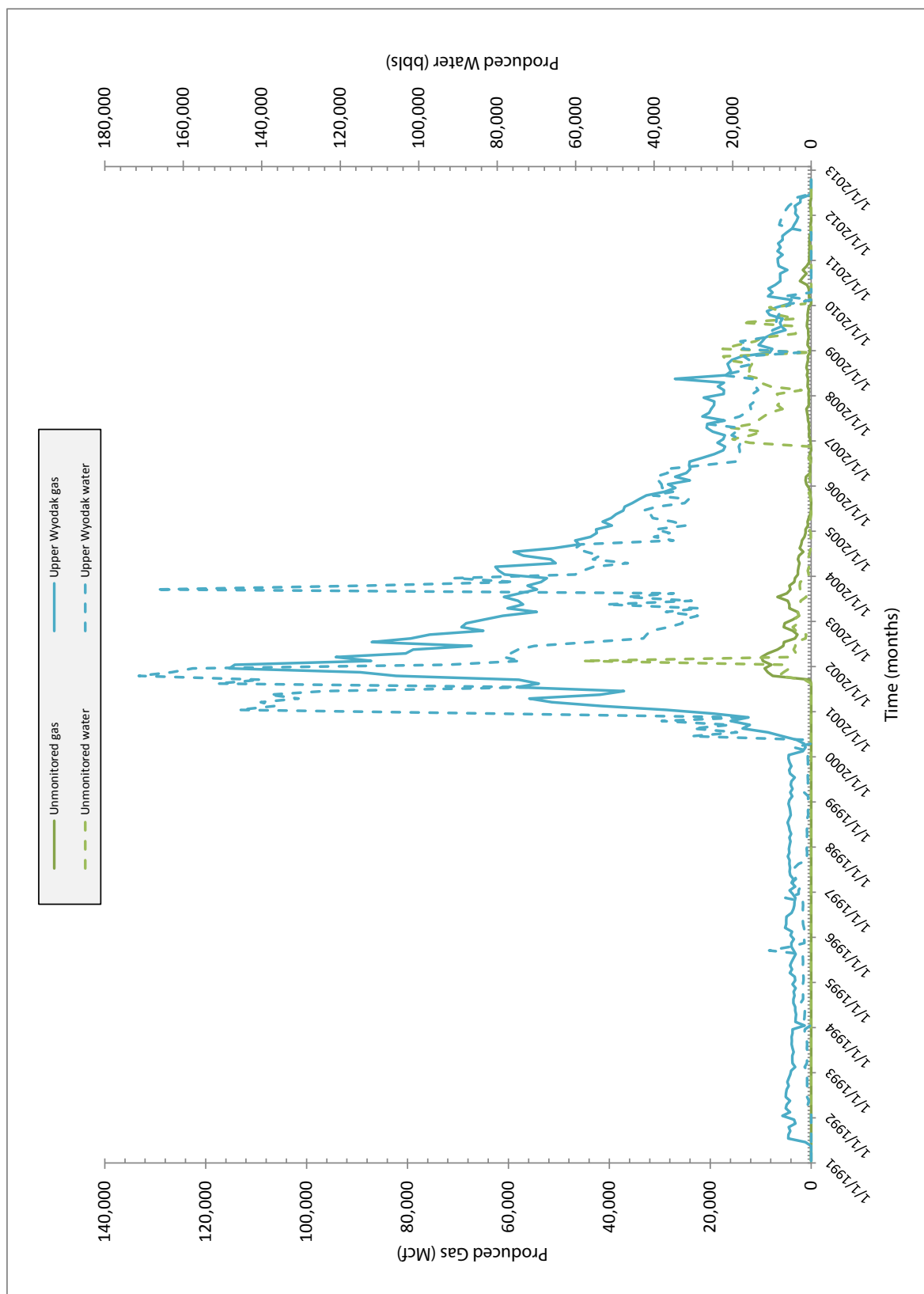




**Figure A.152.** Lone Tree monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

The unmonitored coal zones began consistently producing water in September 2001. Water production peaked at 58,233 bbls in February 2002, and dropped to zero in March 2010 (Figure A.153). Gas production in the unmonitored coal zones peaked in February 2001 at nearly 9,586 Mcf and remained low until February 2010 when gas production ceased.





**Figure A.153.** Water and gas production from CBNG wells associated with the Lone Tree monitoring well site location.

**Lower Prairie Dog Monitoring Well Site**  
**Location: S10 T57N R83W**  
**Date First Monitored: August 24, 2000**

**Drawdown Information**

The Lower Prairie Dog monitoring well site includes three wells. Two of the wells are completed into Wasatch sandstones and one is completed in the Anderson coal of the Upper Wyodak coal zone (Figure A.154; Table A.76). Water levels and wellhead gas pressures were measured during the POR using both manual and automatic transducer and data logger equipment. Transducer data that is missing, randomly fluctuating (noisy) or that substantially differs from concurrent manual measurements may indicate on-site equipment failure, malfunction or requirement for calibration.

**Wasatch Sandstones**

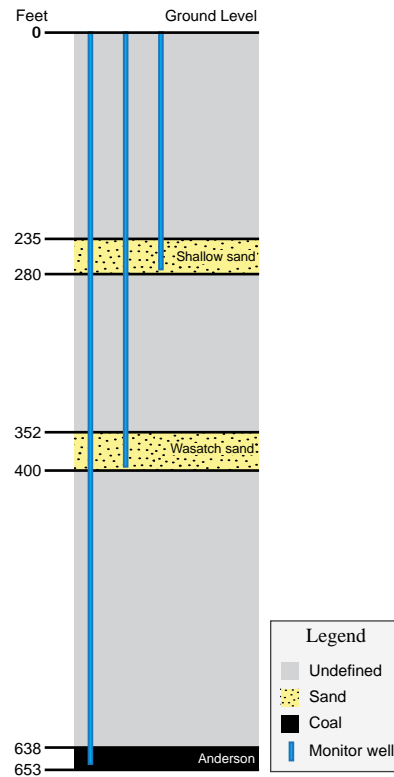
During the 2010-2012 POR, groundwater levels in the monitored shallow Wasatch sandstone rose 0.71 feet (Figure A.155; Table A.77). In contrast, over the monitoring period of 2000-2009, groundwater levels declined 0.56 feet from initial static water levels.

The monitoring well in the deeper Wasatch sandstone recorded a groundwater drawdown of 1.84 feet during the 2010-2012 POR; water levels declined 16.74 feet during the monitoring period of 2000-2009 (Figure A.155; Table A.77).

Gas pressure was not recorded in the Wasatch sandstones.

**Anderson Coal**

During the 2010-2012 POR, groundwater levels declined 4.67 feet in the Anderson coal monitoring well; water levels declined 469.53 feet during the monitoring period of 2000-2009 (Figure A.155; Table A.77). Gas pressure in the Anderson coal varied over the monitoring period of 2000-2012 peaking at 45.10 psi in February 2004.



**Figure A.154.** Section showing relative positions of coals and sands in feet. Not to scale.

**Table A.76.** Table showing the depth to and thickness of monitored zones at the Lower Prairie Dog monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Shallow sand	235	280	45	358
Wasatch sand	352	400	48	238
Anderson coal	638	653	15	n/a

**Table A.77.** Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2010	Drawdown 2010-2012	Total drawdown (ft.)	Depth to Final water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Shallow sand	193.35	0.56	-0.71	-0.15	193.20	n/a	n/a
Wasatch sand	197.40	16.74	1.84	18.58	215.98	n/a	n/a
Anderson coal	168.15	469.53	4.67	474.20	642.35	45.10	2/19/2004

### Production Statistics

Production data were analyzed for CBNG wells within the buffer of the Lower Prairie Dog monitoring well site from 1999-2012. Cumulative production for individual CBNG wells is displayed by location on Figure A.156. CBNG production is monitored in the Upper Wyodak coal zone, in

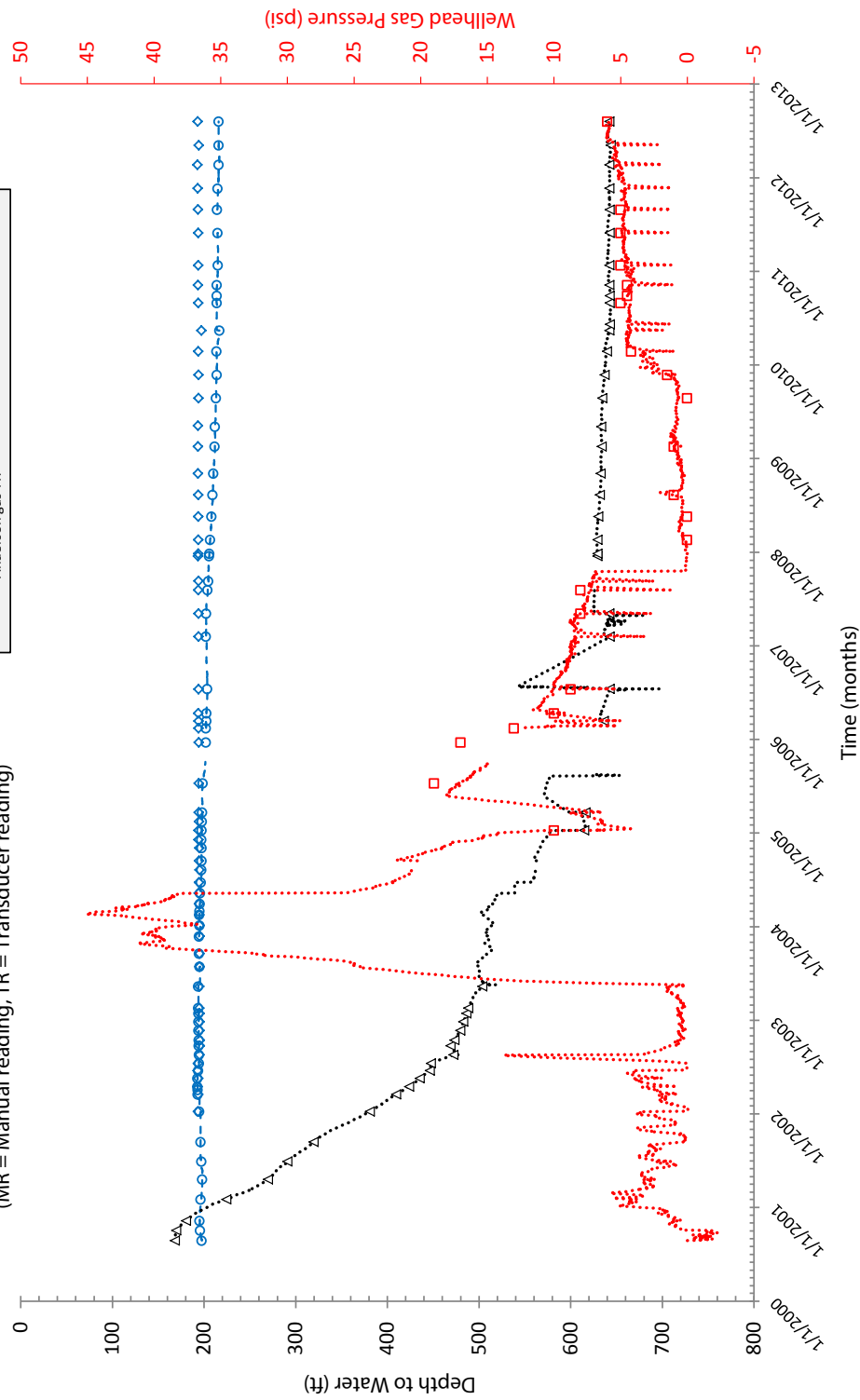
zones where groundwater levels are not monitored (unmonitored wells) and in multiple production zones.

Water production in the Upper Wyodak began in March 2000, peaked in April 2001 at 513,000 bbls, and gradually decreased, finishing 2012 at

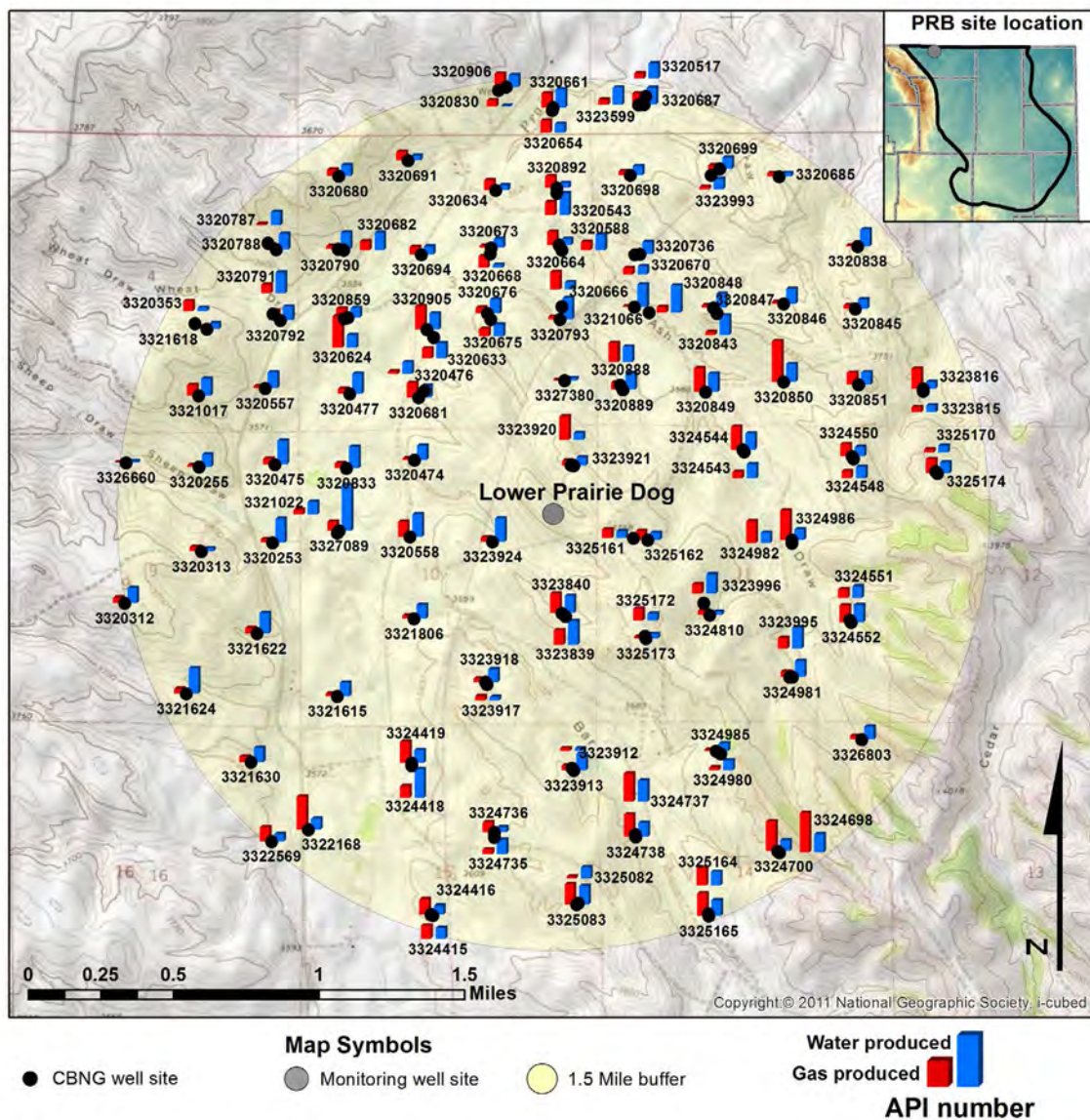
## Lower Prairie Dog Creek

### Monitoring Well Site

Wasatch sands and Anderson coal  
 Water drawdown and wellhead gas pressure  
 (MR = Manual reading, TR = Transducer reading)



**Figure A.155.** Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Lower Prairie Dog monitoring wellsite location.



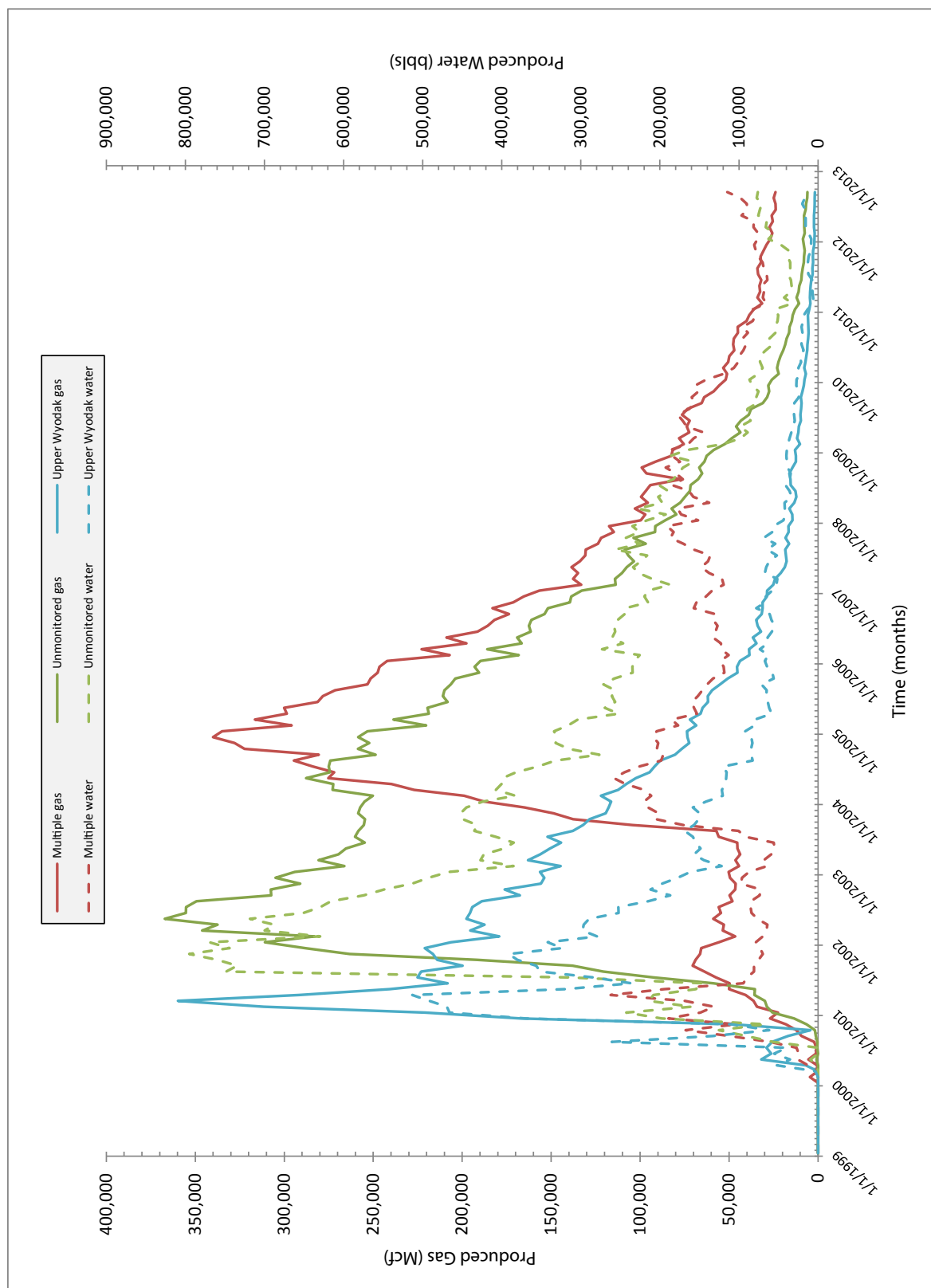
**Figure A.156.** Lower Prairie Dog monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

16,000 bbls/month (Figure A.157). Gas production began in March 2000 in the Upper Wyodak, peaked at 359,702 Mcf in March 2001, and leveled off to less than 8,000 Mcf/month during the 2010-2012 POR.

Water production in the unmonitored production zones peaked in 2001 at nearly 800,000 bbls and has decreased gradually (Figure A.157). Locally, gas production in the unmonitored zones has been

gradually decreasing after reaching a peak production of 367,109 Mcf in May 2002.

Water production in the multiple coal zone wells peaked at 257,990 bbls in May 2004 and has remained fairly constant since 2000 (Figure A.157). Gas production was initially low but rapidly increased to a peak level of 340,031 Mcf in December 2005. Gas production in late 2012 was only 23,917 Mcf/month.



**Figure A.157.** Water and gas production from CBNG wells associated with the Lower Prairie Dog monitoring well site location.

**MP 2 Monitoring Well Site**  
**Location: S2 T47N R72W**  
**Date First Monitored: May 26, 1993**

**Drawdown Information**

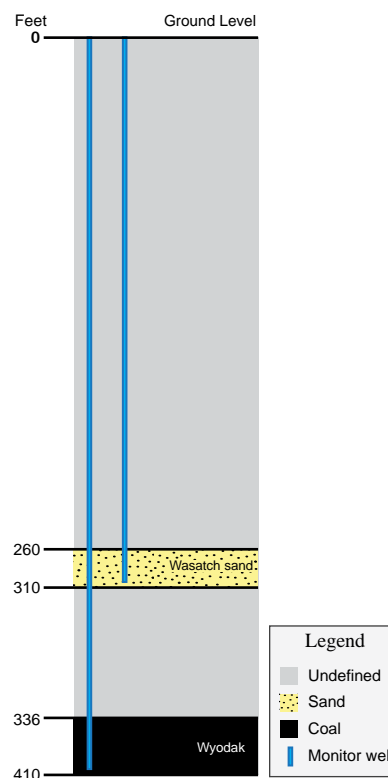
The MP 2 monitoring well site includes two wells. One is completed in a Wasatch sandstone and the other in the Wyodak coal of the Upper Wyodak coal zone (Figure A.158; Table A.78). Water levels and wellhead gas pressures were measured during the POR using both manual and automatic transducer and data logger equipment. Transducer data that is missing, randomly fluctuating (noisy) or that substantially differs from concurrent manual measurements may indicate on-site equipment failure, malfunction or requirement for calibration.

**Wasatch Sandstone**

Groundwater levels in the Wasatch sandstone monitoring well declined 2.34 feet during the 2010-2012 POR. Groundwater levels declined 61.75 feet over the monitoring period of 1993-2009. (Figure A.159; Table A.79). Gas pressure was not recorded in the Wasatch sandstone.

**Wyodak Coal**

Groundwater levels in the Wyodak coal monitoring well rose 14.06 feet during the 2010-2012 POR; levels declined 161.26 feet during the monitoring period of 1993-2009 (Figure A.159; Table A.79). Gas pressure in the Wyodak coal reached a maximum of 26.76 psi in January 1997.



**Figure A.158.** Section showing relative positions of coals and sands in feet. Not to scale.

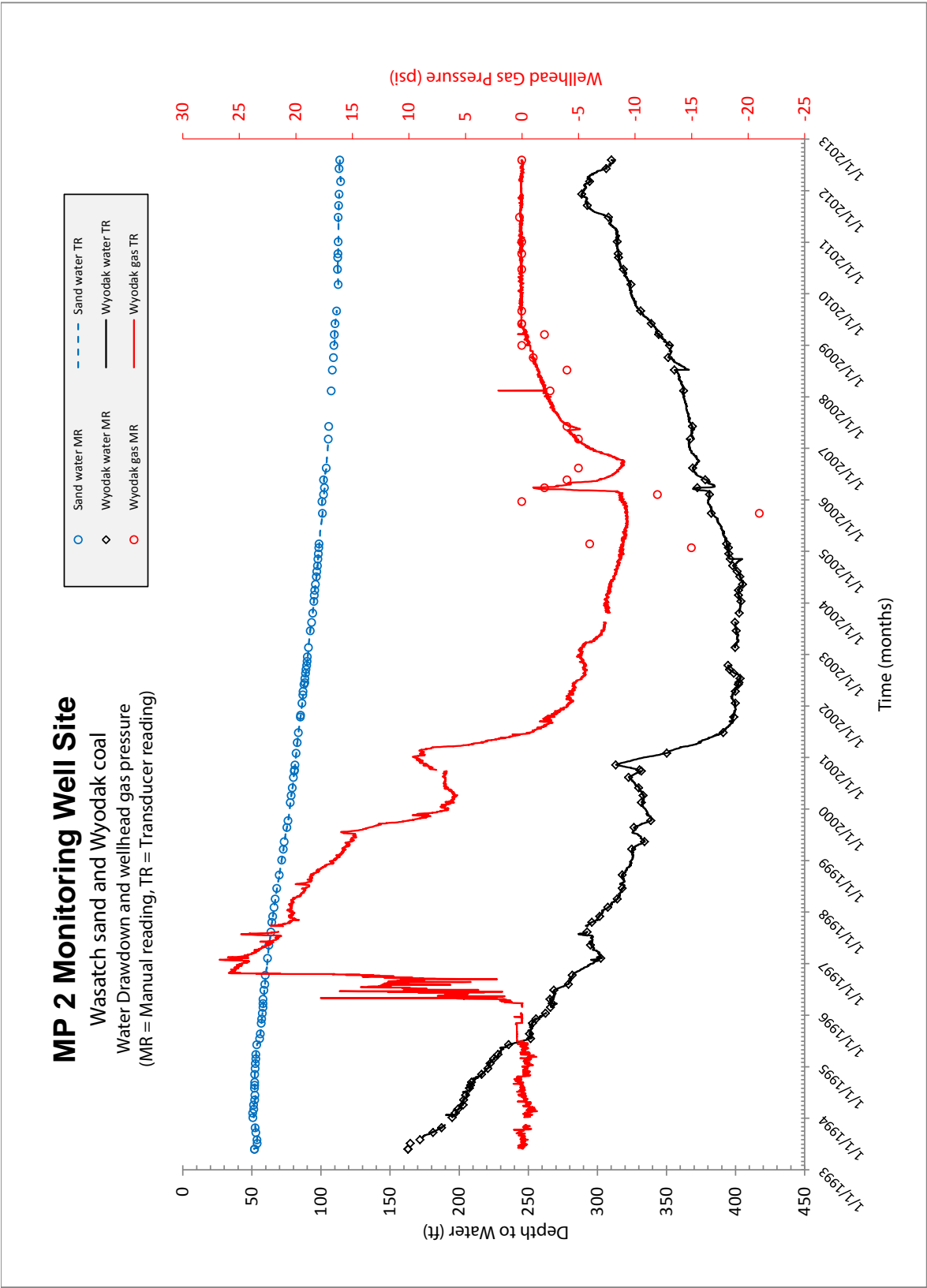


**Table A.78.** Table showing the depth to and thickness of monitored zones at the MP 2 monitoring well site location. (measured in feet)

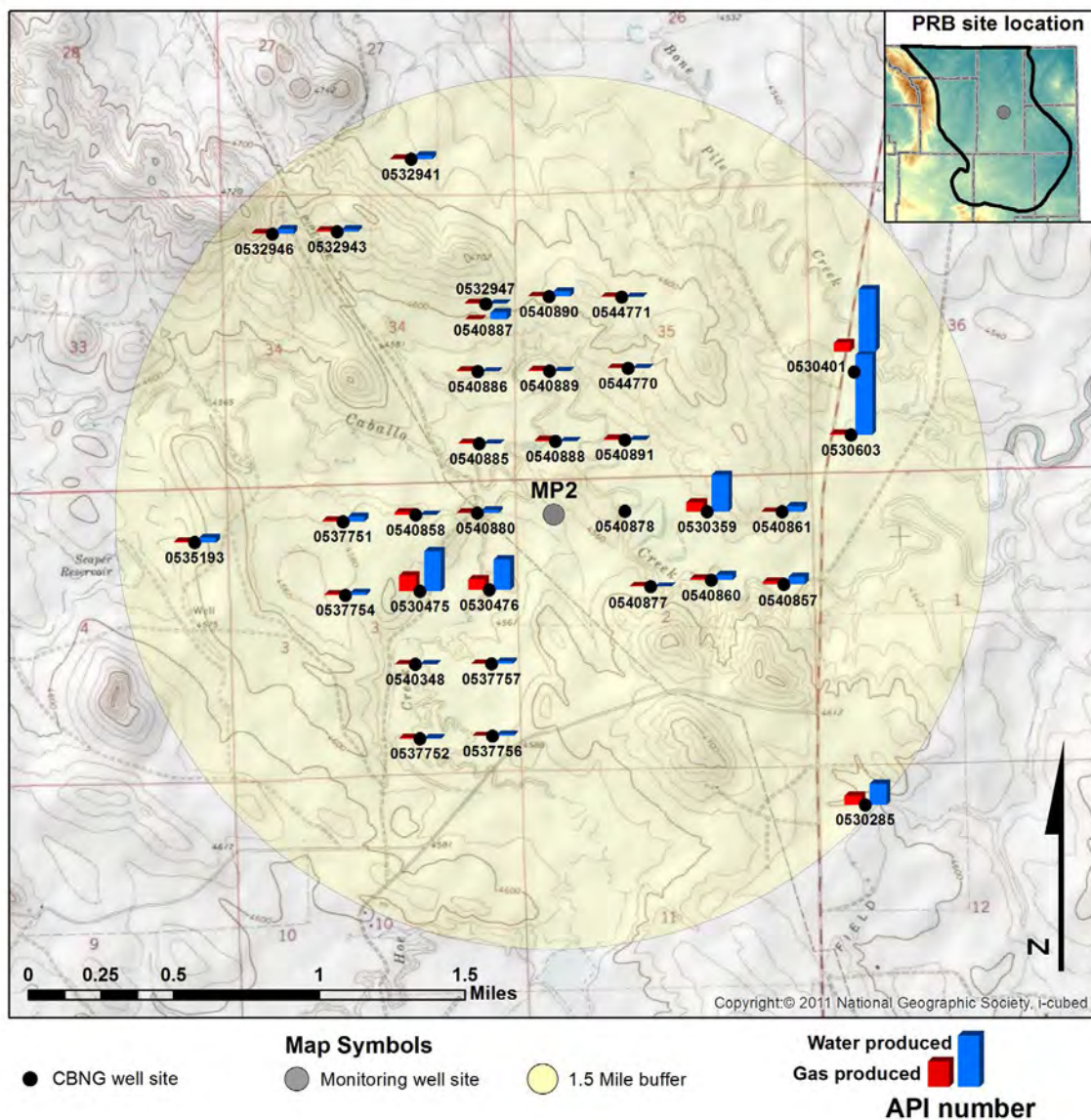
Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Wasatch sand	260	310	50	26
Wyodak coal	336	410	74	n/a

**Table A.79.** Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2010	Drawdown 2010-2012	Total drawdown (ft.)	Depth to Final water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	52.00	59.41	2.34	61.75	113.75	n/a	n/a
Wyodak coal	163.05	161.26	-14.06	147.20	310.25	26.76	1/27/1997



**Figure A.159.** Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the MP 2 monitoring wellsite location.



**Figure A.160.** MP 2 monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

### Production Statistics

Production data for CBNG wells was analyzed within the buffer of the MP 2 monitoring well site from 1992-2012. Cumulative production for individual CBNG wells is displayed by location on Figure A.160. CBNG production is monitored in the Upper Wyodak, where all local production has occurred.

Water production in the Upper Wyodak reached a maximum level of 305,922 bbls/month in 2000 (Figure A.161). Gas production at the MP 2 monitoring site occurred from 1993-2006 and peaked in 2001 at 75,881 Mcf/month. Gas and water production ceased at this site in 2006.

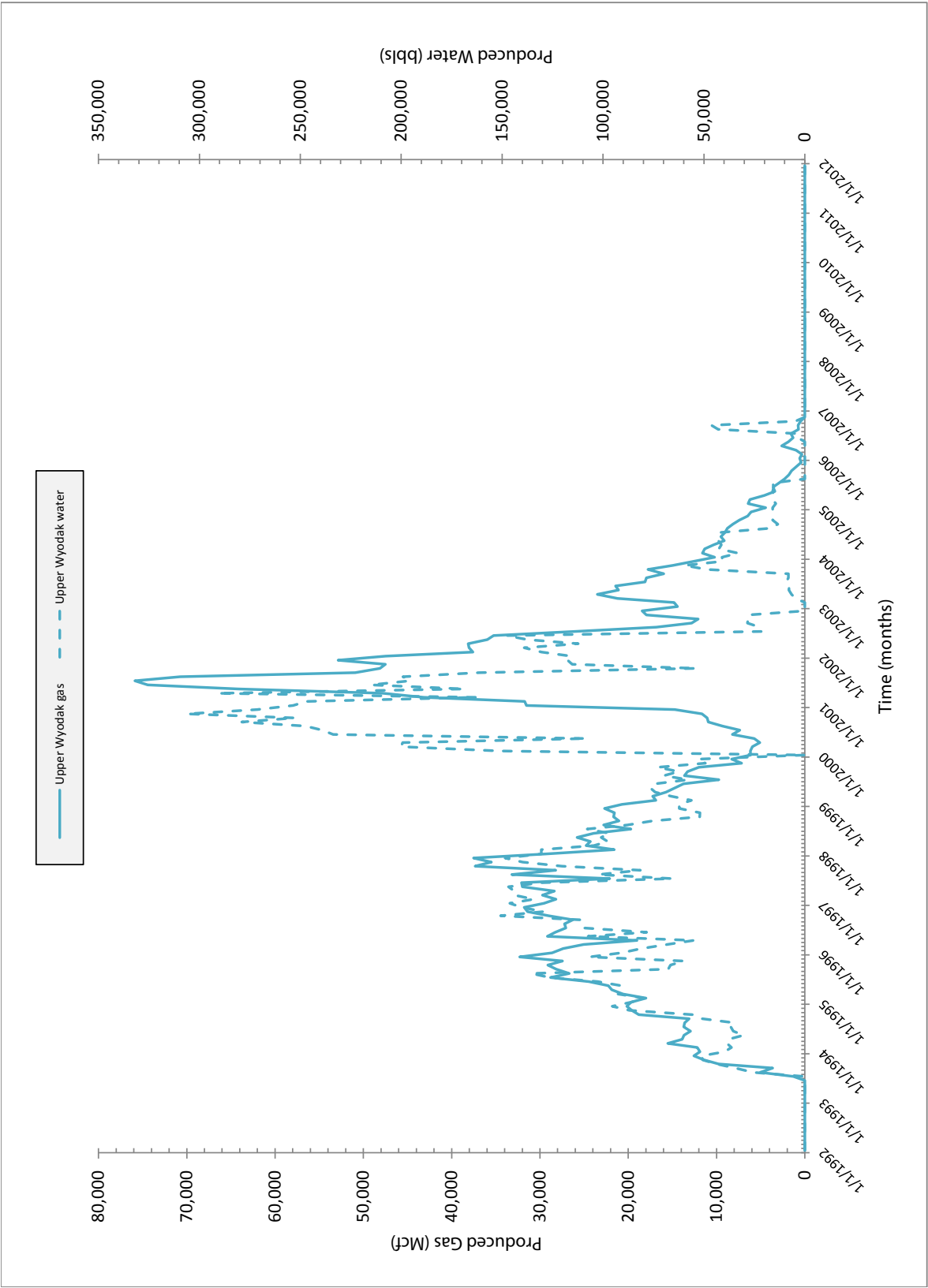


Figure A.161. Water and gas production from CBNG wells associated with the MP 2 monitoring well site location.

# **MP 22 Monitoring Well Site** **Location: S22 T48N R72W** **Date First Monitored: February 18, 1993**

## **Drawdown Information**

The MP 22 monitoring well site includes four wells. Three are completed into Wasatch sandstones and the other is completed in the Wyodak coal of the Upper Wyodak coal zone (Figure A.162; Table A.80). Water levels and wellhead gas pressures were measured during the POR using both manual and automatic transducer and data logger equipment. Transducer data that is missing, randomly fluctuating (noisy) or that substantially differs from concurrent manual measurements may indicate on-site equipment failure, malfunction or requirement for calibration.

## **Wasatch Sandstones**

Groundwater levels in the very shallow Wasatch sandstone declined 0.02 feet during the 2010-2012 POR and 2.00 feet during the monitoring period of 1993-2009 (Figure A.163; Table A.81).

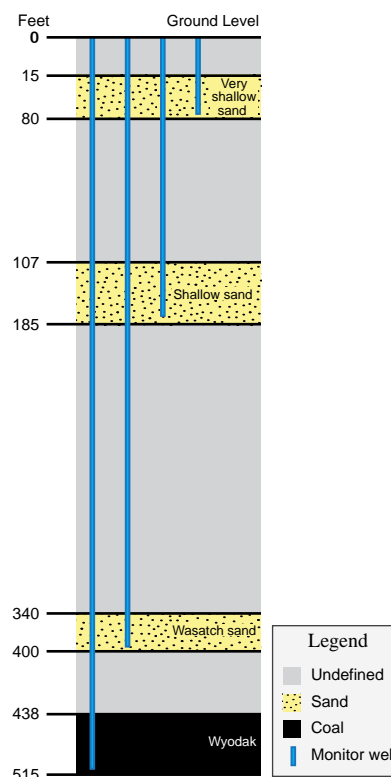
Groundwater levels in the shallow Wasatch sandstone declined 0.19 feet during the 2010-2012 POR and 0.18 feet during the monitoring period of 1993-2009 (Figure A.163; Table A.81).

Groundwater levels in the Wasatch sandstone declined 2.80 feet during the 2010-2012 POR and 48.31 feet during the monitoring period of 1993-2009 (Figure A.163; Table A.81).

Gas pressure was not recorded in any of the Wasatch sandstones.

## **Wyodak Coal**

Groundwater levels rose 42.22 feet during the 2010-2012 POR and declined 179.74 feet over the monitoring period of 1993-2009 (Figure A.163; Table A.81). Gas pressure in the Wyodak coal reached its maximum in August 1995 at 61.18 psi.



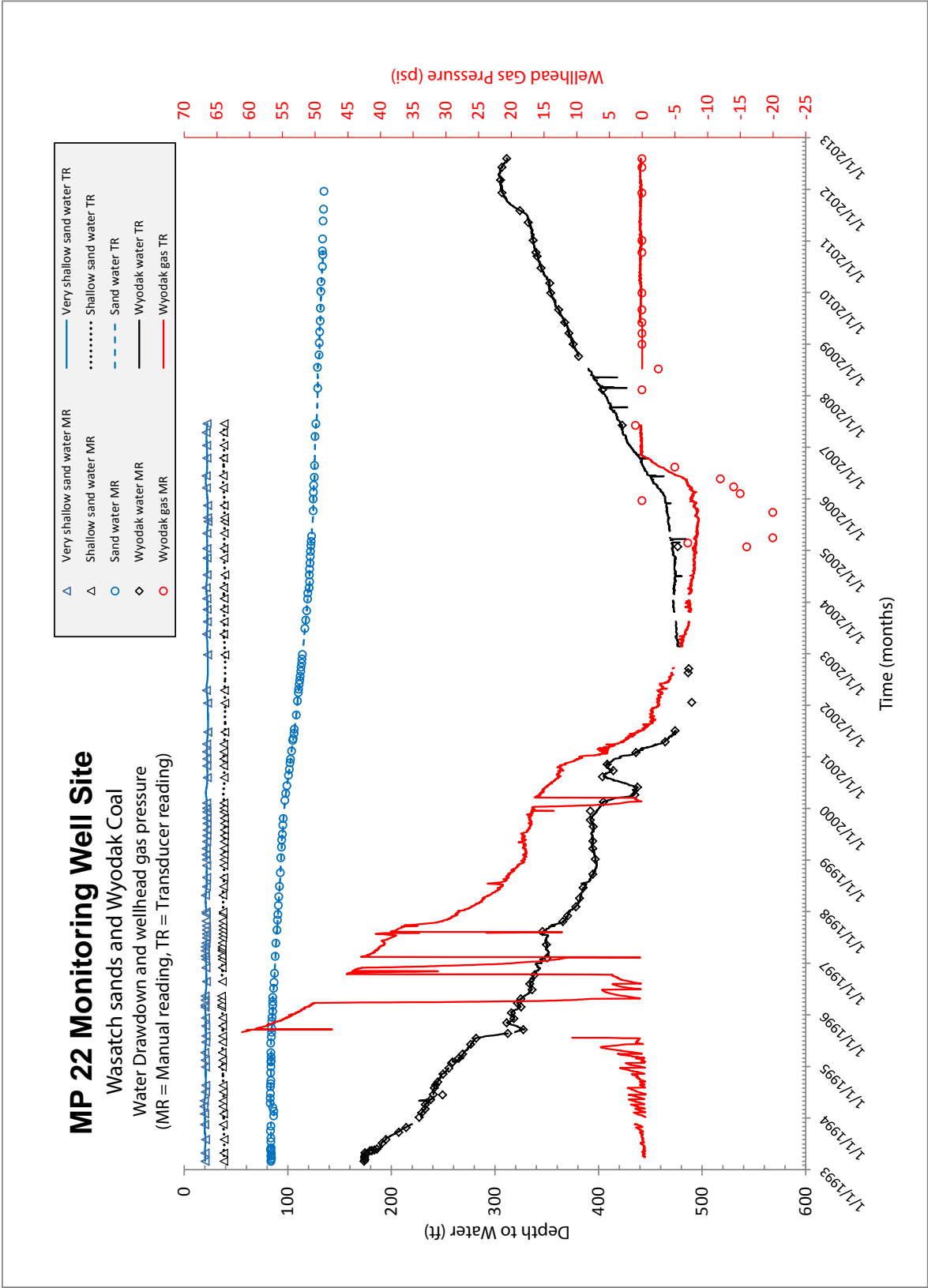
**Figure A.162.** Section showing relative positions of coals and sands in feet. Not to scale.

**Table A.80.** Table showing the depth to and thickness of monitored zones at the MP 22 monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Very shallow sand	15	80	65	358
Shallow sand	107	185	78	253
Wasatch sand	340	400	60	38
Wyodak coal	438	515	77	n/a

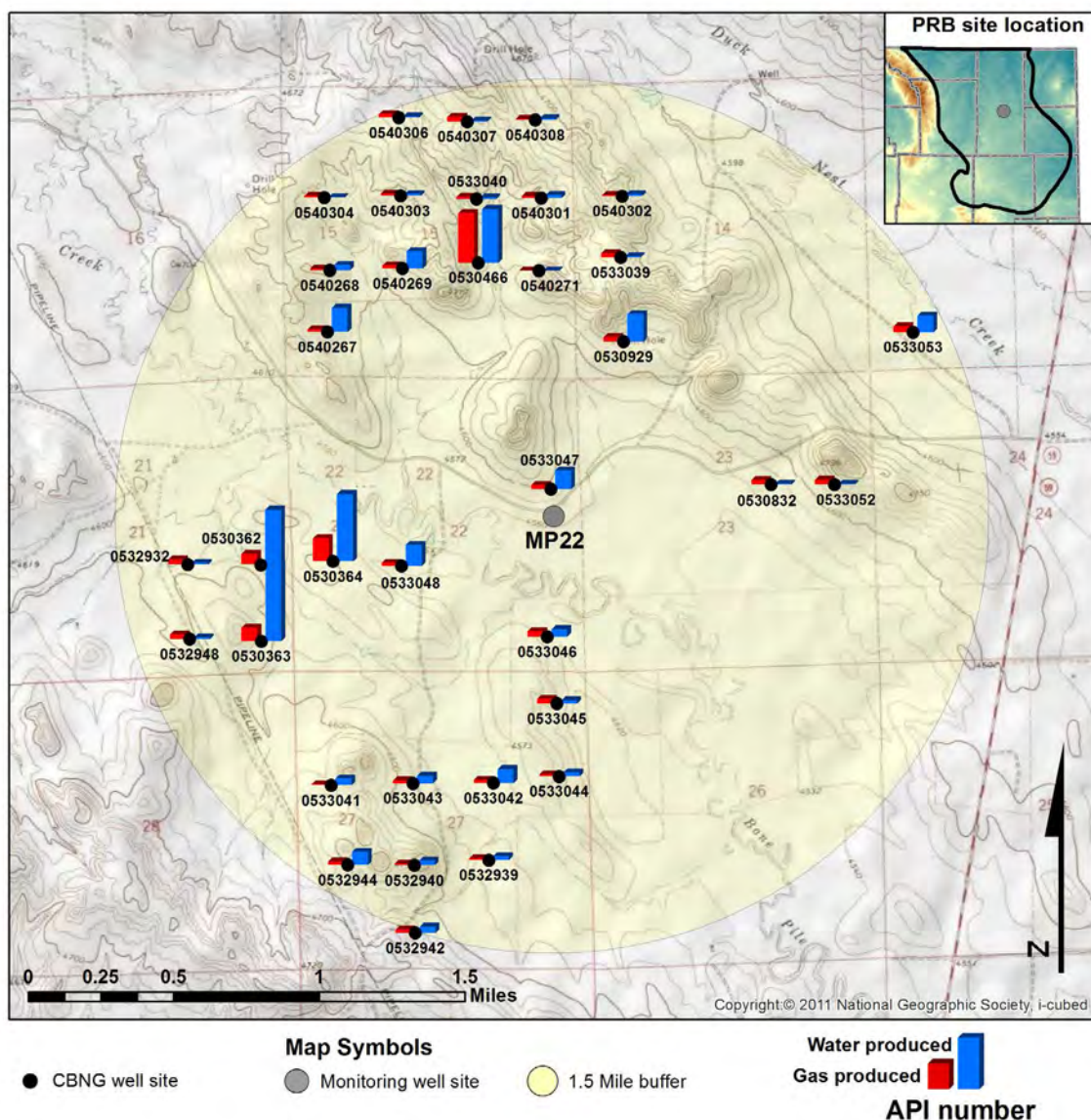
**Table A.81.** Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2010	Drawdown 2010-2012	Total drawdown (ft.)	Depth to Final water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Very shallow sand	20.20	2.00	0.02	2.02	22.22	n/a	n/a
Shallow sand	38.29	0.18	0.19	0.37	38.66	n/a	n/a
Wasatch sand	83.92	48.31	2.80	51.11	135.03	n/a	n/a
Wyodak coal	173.80	179.74	-42.22	137.52	311.32	61.18	8/30/1995



**Figure A.163.** Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the MP 22 monitoring wellsite location.





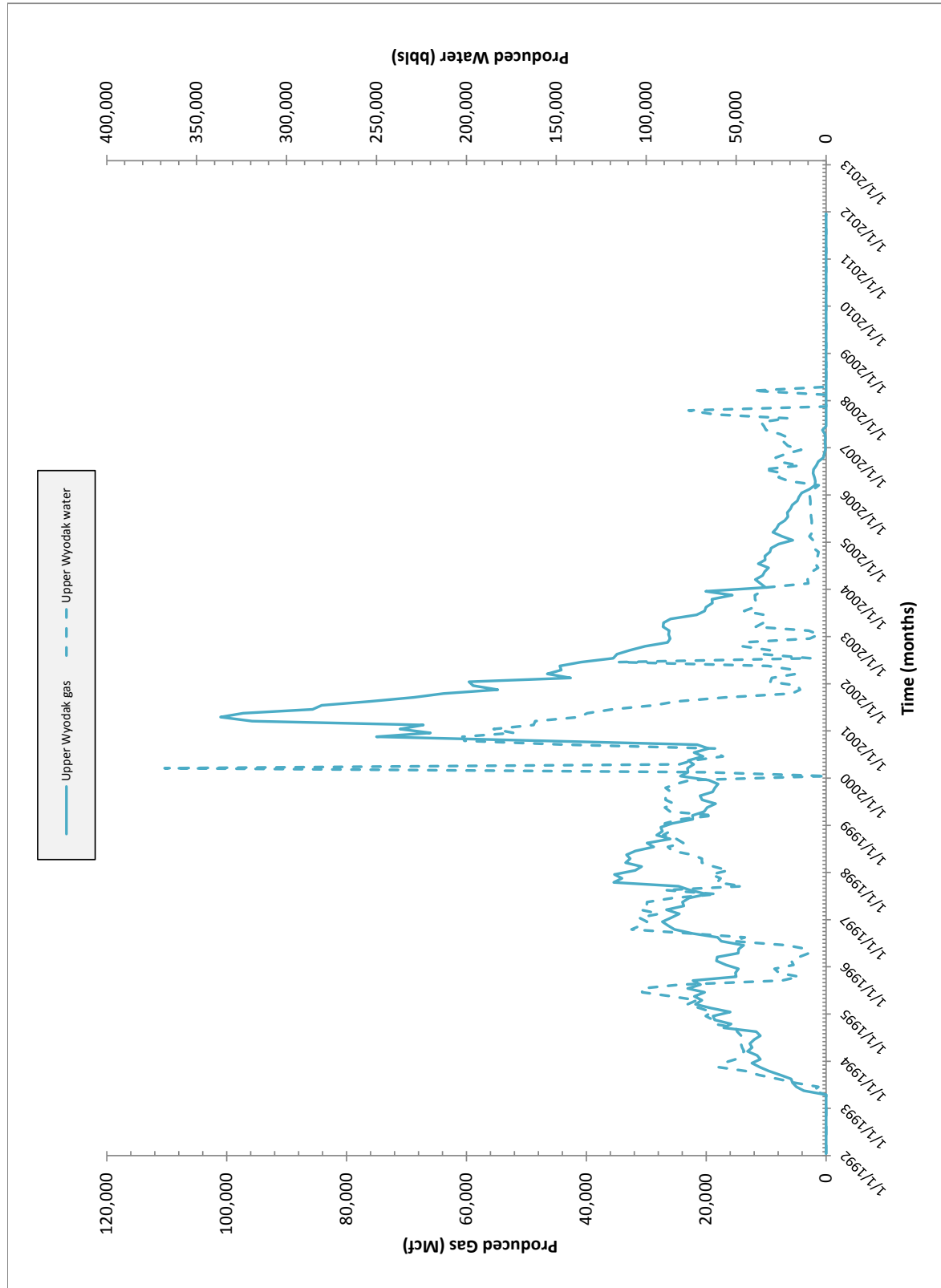
**Figure A.164.** MP 22 monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

### Production Statistics

Production data were analyzed for CBNG wells within the buffer of the MP 22 monitoring well site from 1992-2012. Cumulative production for individual CBNG wells is displayed by location on Figure A.164. CBNG production is monitored in the Upper Wyodak coal zone only.

production peaked at 367,887 bbls in March 2000 (Figure A.165) and gas production reached a maximum in April 2001 of 101,030 Mcf.

Water and gas production in the Upper Wyodak began in May 1993 and ceased in 2007. Water



**Figure A.165.** Water and gas production from CBNG wells associated with the MP 22 monitoring well site location.

**Napier Monitoring Well Site**  
**Location: S24 T48N R76W**  
**Date First Monitored: March 2, 2001**

**Drawdown Information**

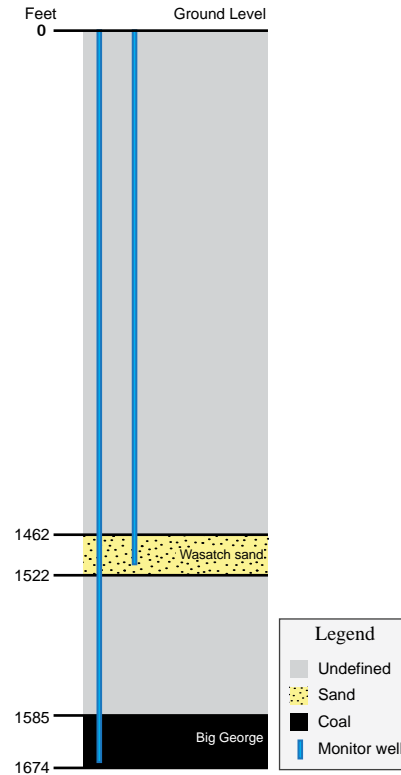
The Napier monitoring well site includes two wells. One well is completed in a Wasatch sandstone and one into the Big George coal of the Wyodak Rider coal zone (Figure A.166; Table A.82). Water levels and wellhead gas pressures were measured during the POR using both manual and automatic transducer and data logger equipment. Transducer data that is missing, randomly fluctuating (noisy) or that substantially differs from concurrent manual measurements may indicate on-site equipment failure, malfunction or requirement for calibration.

**Wasatch Sandstone**

Groundwater levels in the Wasatch sand declined 95.91 feet during the 2010-2012 POR and 159.16 feet over the monitoring period of 2001-2009 (Figure A.167; Table A.83). Gas pressure was not recorded in the Wasatch sandstone.

**Big George Coal**

Groundwater levels declined 210.16 feet during the 2010-2012 POR, and 290.24 feet during the monitoring period of 2001-2009 (Figure A.167; Table A.83). Gas pressure in the Big George coal has been relatively stable, never exceeding 1 psi.



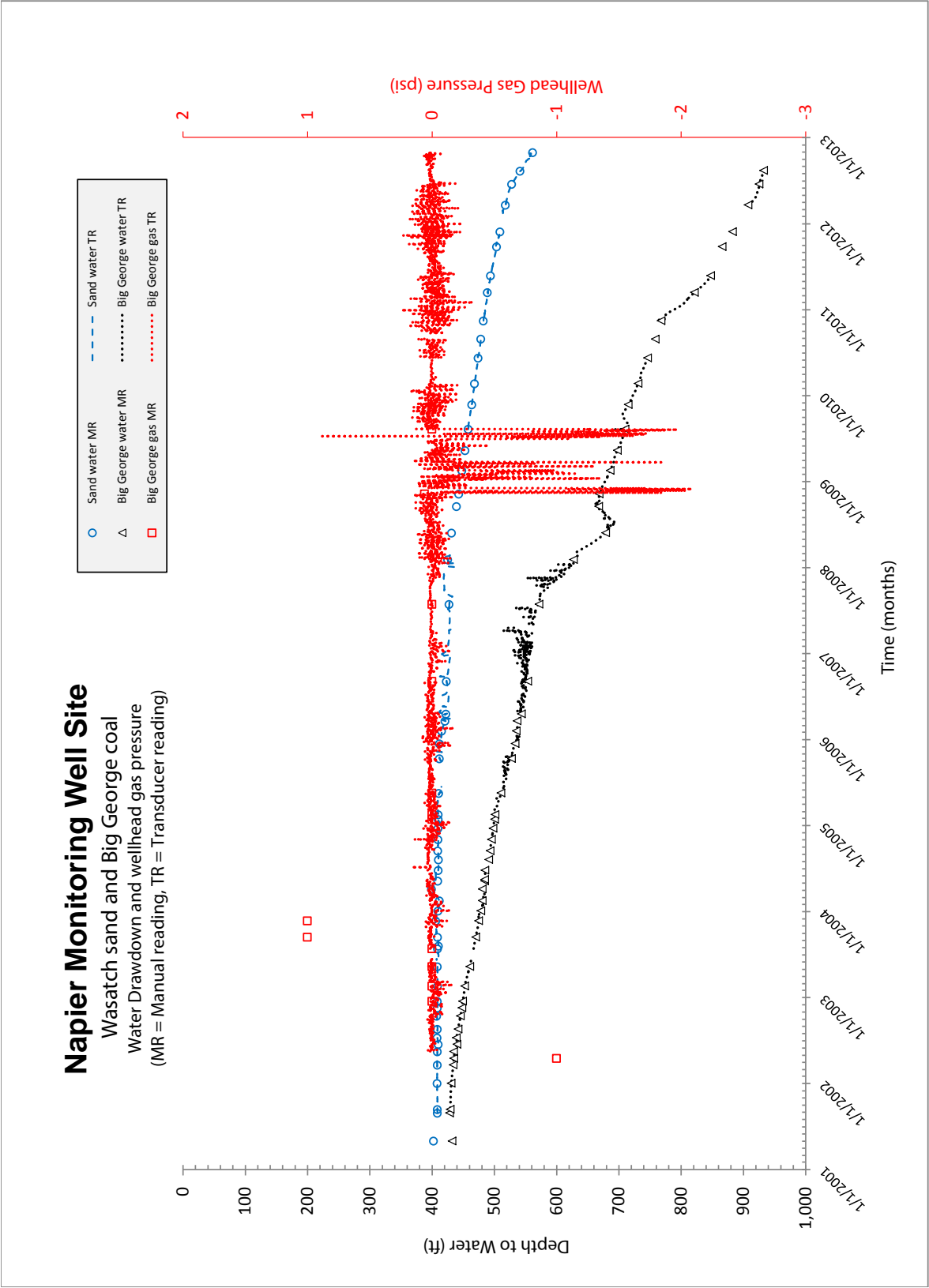
**Figure A.166.** Section showing relative positions of coals and sands in feet. Not to scale.

**Table A.82.** Table showing the depth to and thickness of monitored zones at the Napier monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Wasatch sand	1462	1,522	60	63
Big George coal	1585	1674	89	n/a

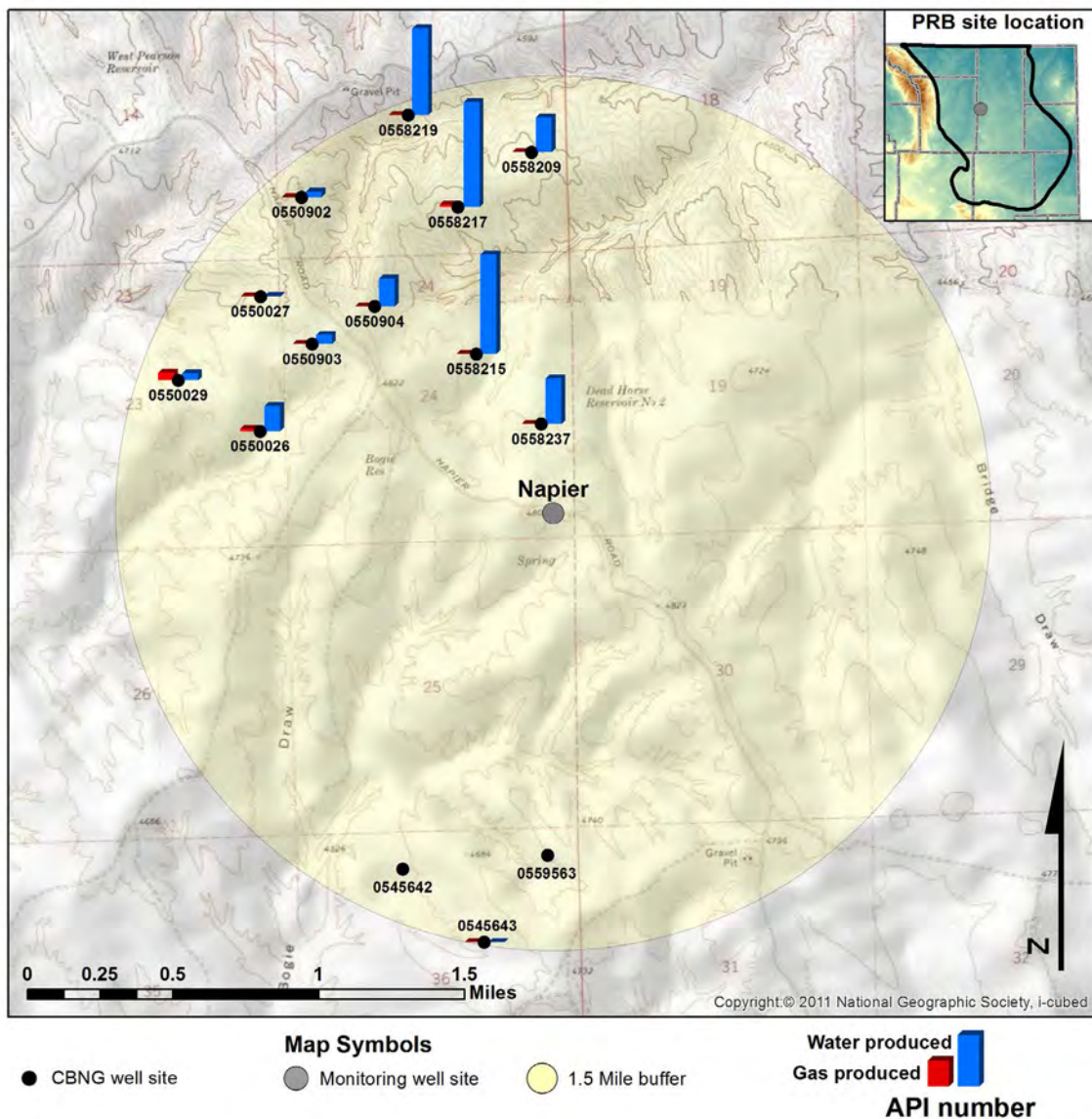
**Table A.83.** Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2010	Drawdown 2010-2012	Total drawdown (ft.)	Depth to Final water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	402.50	63.25	95.91	159.16	561.66	n/a	n/a
Big George coal	432.00	290.24	210.16	500.40	932.40	0.88	7/12/2009



**Figure A.167.** Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Napier monitoring wellsite location.



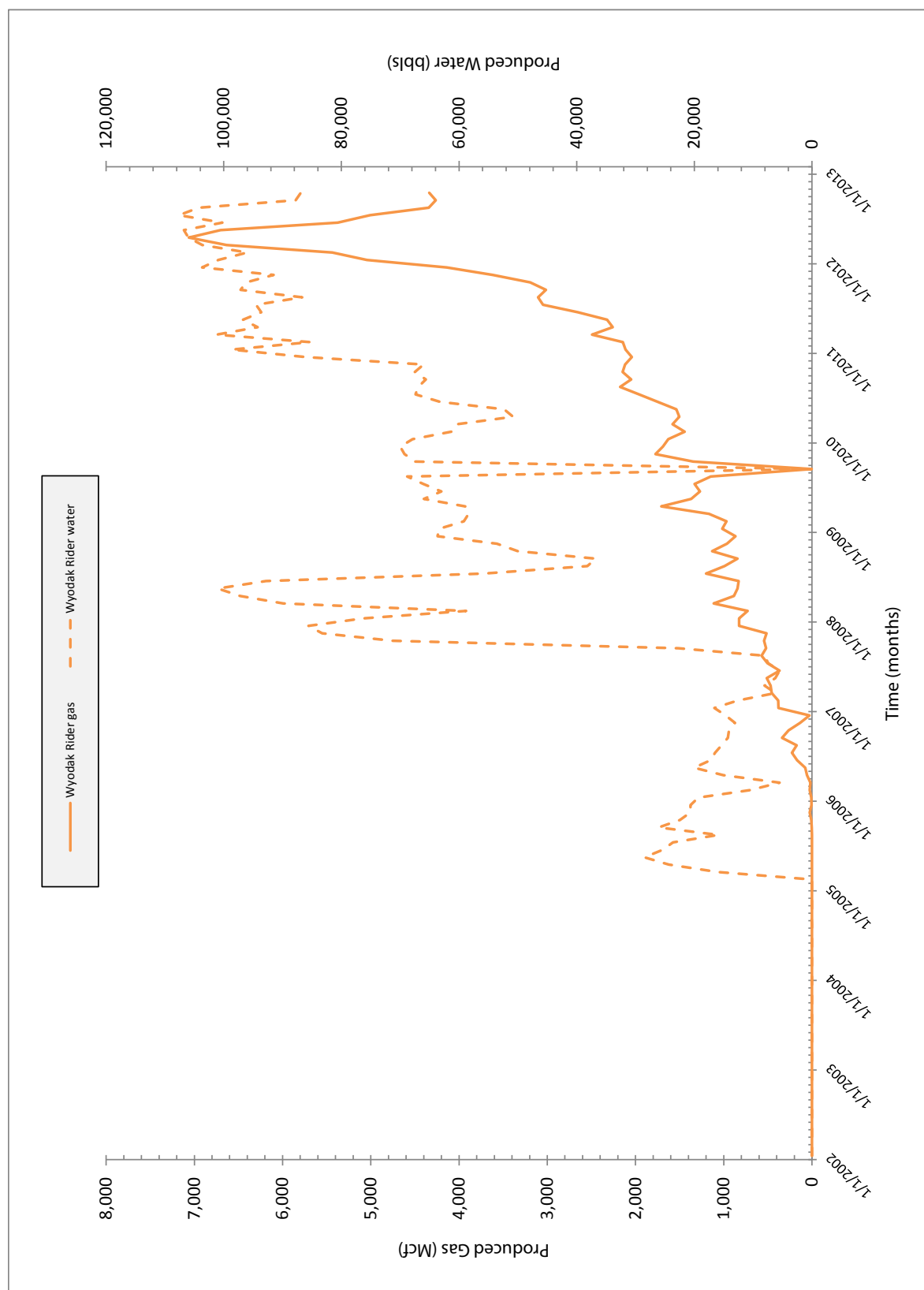


**Figure A.168.** Napier monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

### Production Statistics

Production data were analyzed for CBNG wells within the buffer of the Napier monitoring well site from 2002-2012. Cumulative production for individual CBNG wells is displayed by location on Figure A.168. CBNG production is monitored in the Wyodak Rider coal zone, where all of the production in proximity to the monitoring site occurs.

Water production in the Wyodak Rider began in March 2005 and peaked in July 2012 at 107,621 bbls (Figure A.169). Gas production began in October 2005 and peaked at 7,063 Mcf in April 2012.



**Figure A.169.** Water and gas production from CBNNG wells associated with the Napier monitoring well site location.



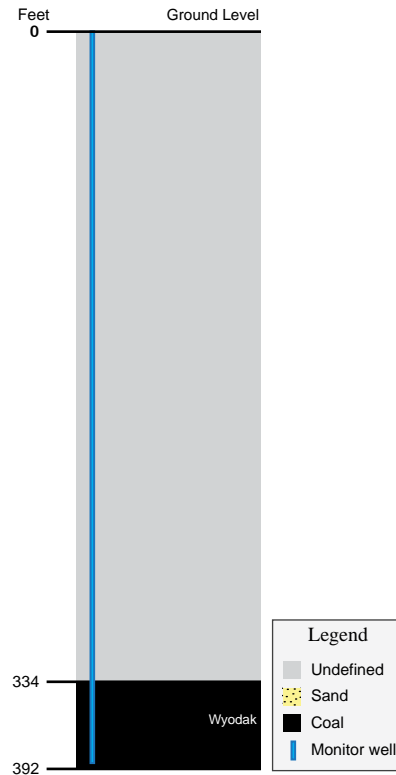
**North Cordero Monitoring Well Site**  
**Location: S19 T47N R71W**  
**Date First Monitored: May 17, 1995**

**Drawdown Information**

The North Cordero monitoring well site includes one well that is completed in the Wyodak coal of the Upper Wyodak coal zone (Figure A.170; Table A.84). Water levels and wellhead gas pressures were measured during the POR using both manual and automatic transducer and data logger equipment. Transducer data that is missing, randomly fluctuating (noisy) or that substantially differs from concurrent manual measurements may indicate on-site equipment failure, malfunction or requirement for calibration.

**Wyodak Coal**

The Wyodak coal well was reported dry on August 12, 2004 and remained unchanged during the 2010-2012 POR. So the groundwater level change for the 2010-2012 POR was zero feet. During the pre-2010 monitoring period the water level declined 146.9 feet.(Figure A.171; Table A.85). Gas pressure in the Wyodak coal reached its maximum in April 1996 at 33.79 psi.



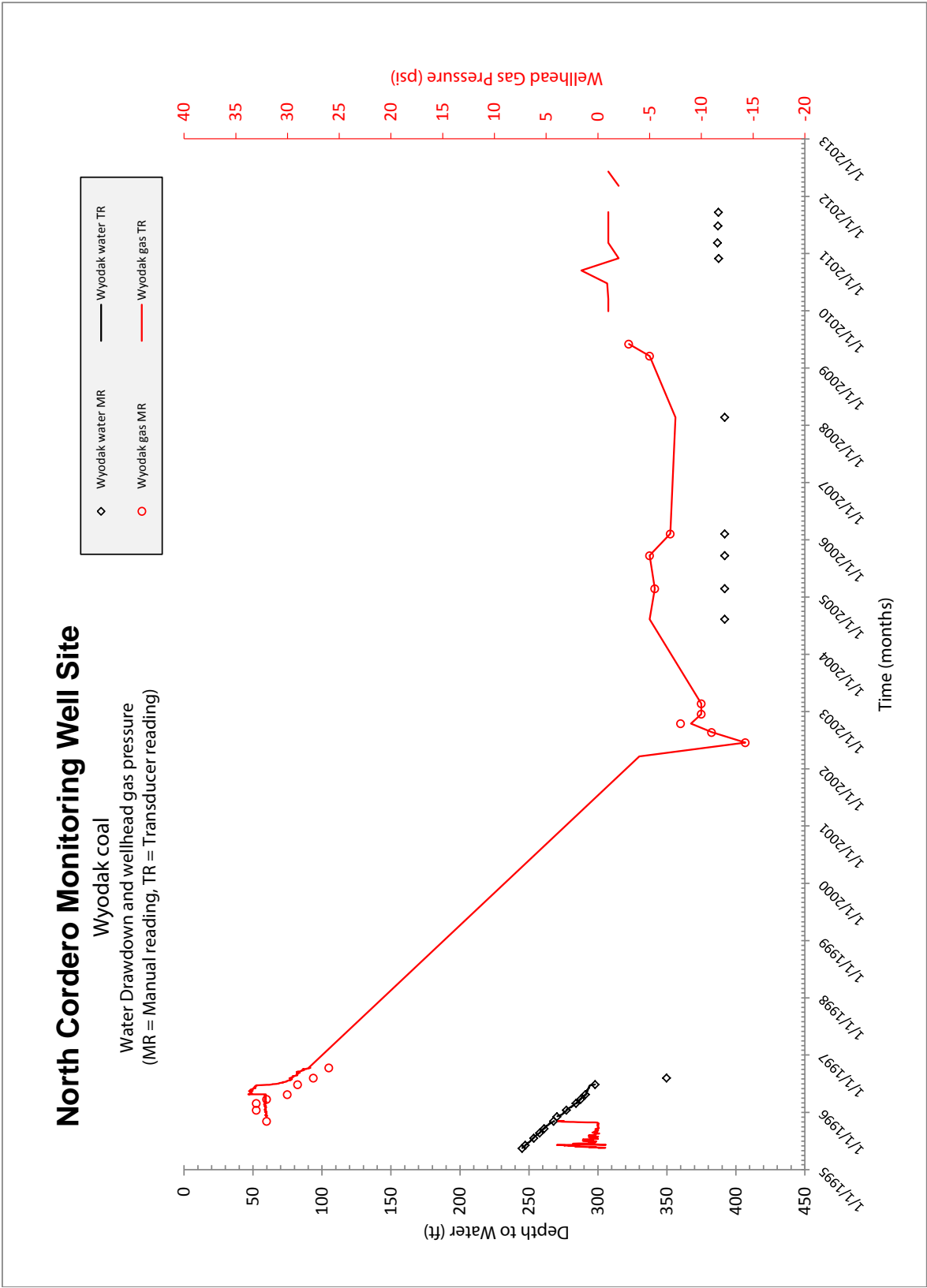
**Figure A.170.** Section showing relative positions of coals and sands in feet. Not to scale.

**Table A.84.** Table showing the depth to and thickness of monitored zones at the North Cordero monitoring well site location. (measured in feet)

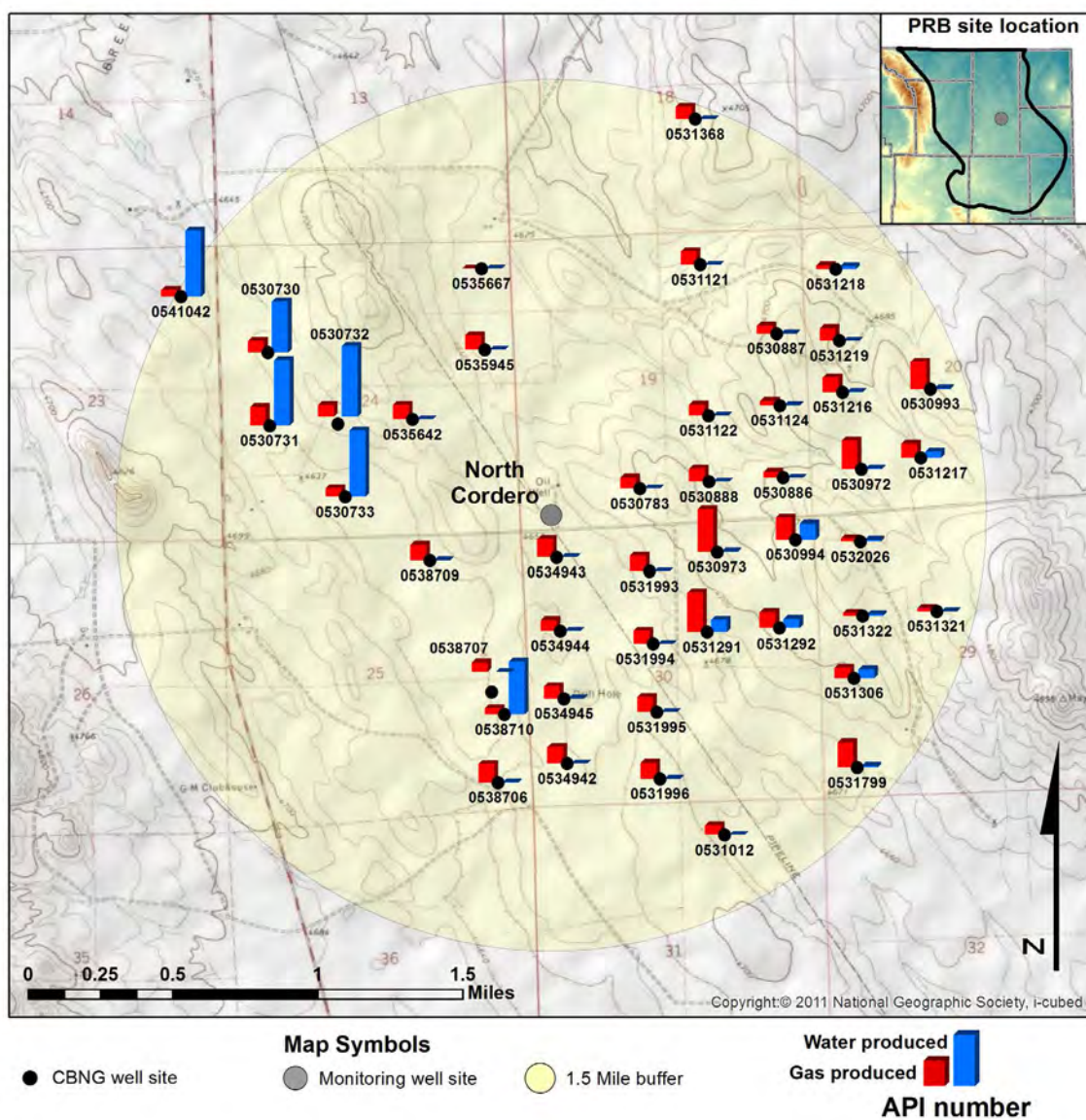
Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Wyodak coal	334	392	58	n/a

**Table A.85.** Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2010	Drawdown 2010-2012	Total drawdown (ft.)	Depth to Final water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wyodak coal	245.10	146.90	0.00	146.90	392.00	33.79	4/25/1996



**Figure A.171.** Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the North Cordero monitoring wellsite location.



**Figure A.172.** North Cordero monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

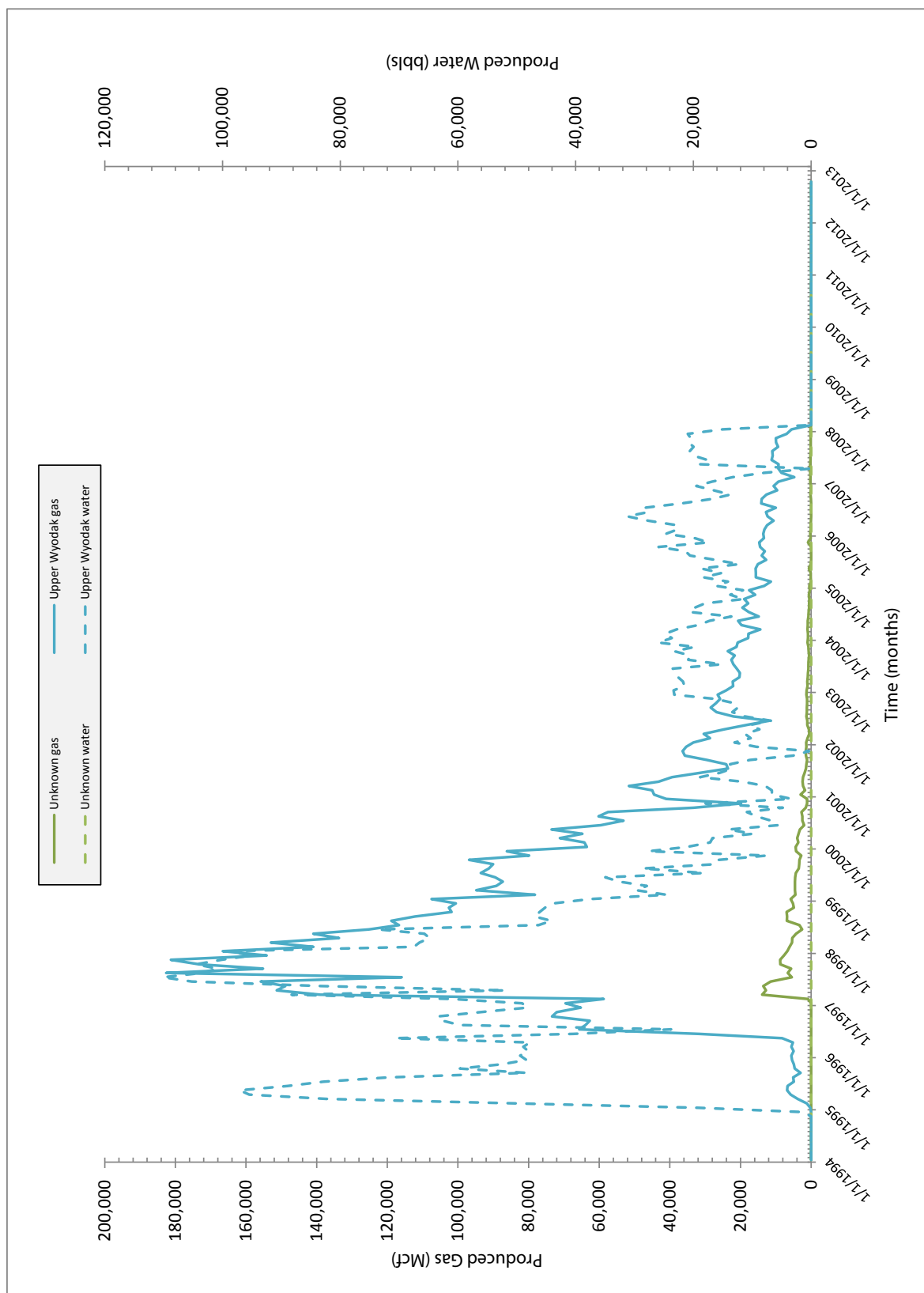
### Production Statistics

Production data were analyzed for CBNG wells within the buffer of the North Cordero monitoring well site from 1994-2012. Cumulative production for individual CBNG wells is displayed by location on Figure A.172. CBNG production is monitored in the Upper Wyodak coal zone, and some production in this area occurs in unknown coal zones.

Water production in the Upper Wyodak began in December 1994 and peaked in July 1997 at

110,113 bbls (Figure A.173). Gas production in the Upper Wyodak began in January 1995, peaked in 1997 at 182,590 Mcf/month and then gradually declined to zero by the end of 2008.

No water production has been recorded in the unknown coal zones (Figure A.173). Gas production in the unknown coal zones occurred at low levels from 1997-2008, and reached a maximum level of 13,897 Mcf in March 1997.



**Figure A.173.** Water and gas production from CBNNG wells associated with the North Cordero monitoring well site location.

**North Gillette Monitoring Well Site**  
**Location: S34 T51N R73W**  
**Date First Monitored: September 25, 2001**

**Drawdown Information**

The North Gillette monitoring well site includes three wells. One is completed in a Wasatch sandstone, another in the Anderson coal of the Upper Wyodak coal zone, and the third in the Canyon coal of the Lower Wyodak coal zone (Figure A.174; Table A.86). Water levels and wellhead gas pressures were measured during the POR using both manual and automatic transducer and data logger equipment. Transducer data that is missing, randomly fluctuating (noisy) or that substantially differs from concurrent manual measurements may indicate on-site equipment failure, malfunction or requirement for calibration.

**Wasatch Sandstone**

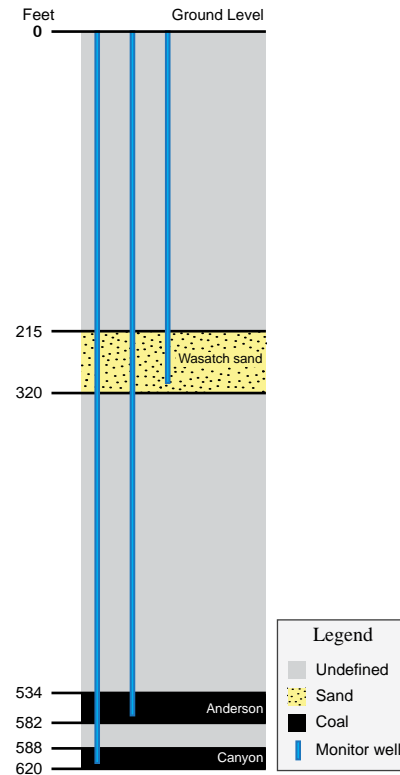
Groundwater levels in the Wasatch sandstone rose 0.29 feet during the 2010-2012 POR but declined 4.88 feet over the monitoring period of 2001-2009 (Figure A.175; Table A.87). Gas pressure was not measured in the Wasatch sandstone.

**Anderson Coal**

Groundwater levels in the Anderson coal rose 64.92 feet during the 2010-2012 POR but declined 74.97 feet over the monitoring period of 2001-2009 (Figure A.175; Table A.87). Gas pressure in the Anderson coal peaked at 4.59 psi in May 2002.

**Canyon Coal**

Although the Canyon coal monitoring well recorded a rise in groundwater level of 19.13 feet during the 2010-2012 POR, groundwater levels declined 90.31 feet during the monitoring period of 2001-2009 (Figure A.175; Table A.87). Gas pressure in the Canyon coal peaked at 1.54 psi in July 2003.



**Figure A.174.** Section showing relative positions of coals and sands in feet. Not to scale.

**Table A.86.** Table showing the depth to and thickness of monitored zones at the North Gillette monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Wasatch sand	215	320	105	214
Anderson coal	534	582	48	n/a
Canyon coal	588	620	32	n/a

**Table A.87.** Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2010	Drawdown 2010-2012	Total drawdown (ft.)	Depth to Final water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	122.17	4.88	-0.29	4.59	126.76	n/a	n/a
Anderson coal	500.03	74.97	-64.92	10.05	510.08	4.59	5/14/2002
Canyon coal	447.45	90.31	-19.13	71.18	518.63	1.54	7/24/2003

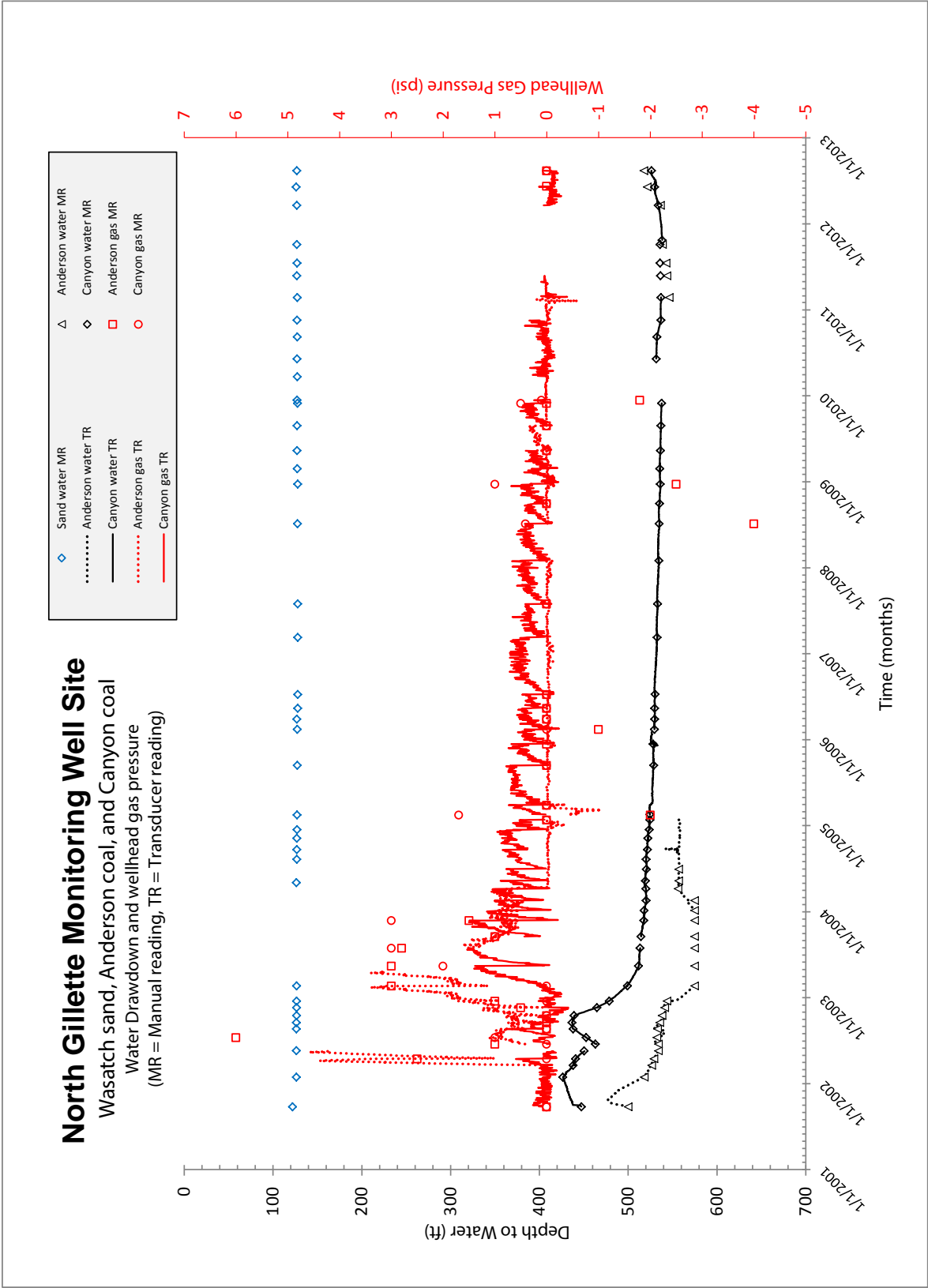
### Production Statistics

Production data were analyzed for CBNG wells within the buffer of the North Gillette monitoring well site from 1999-2012. Cumulative production for individual CBNG wells is displayed by location on Figure A.176. CBNG production is monitored in the Upper Wyodak coal zone and the Lower Wyodak coal zone, some production in this area occurs in coal zones where water levels

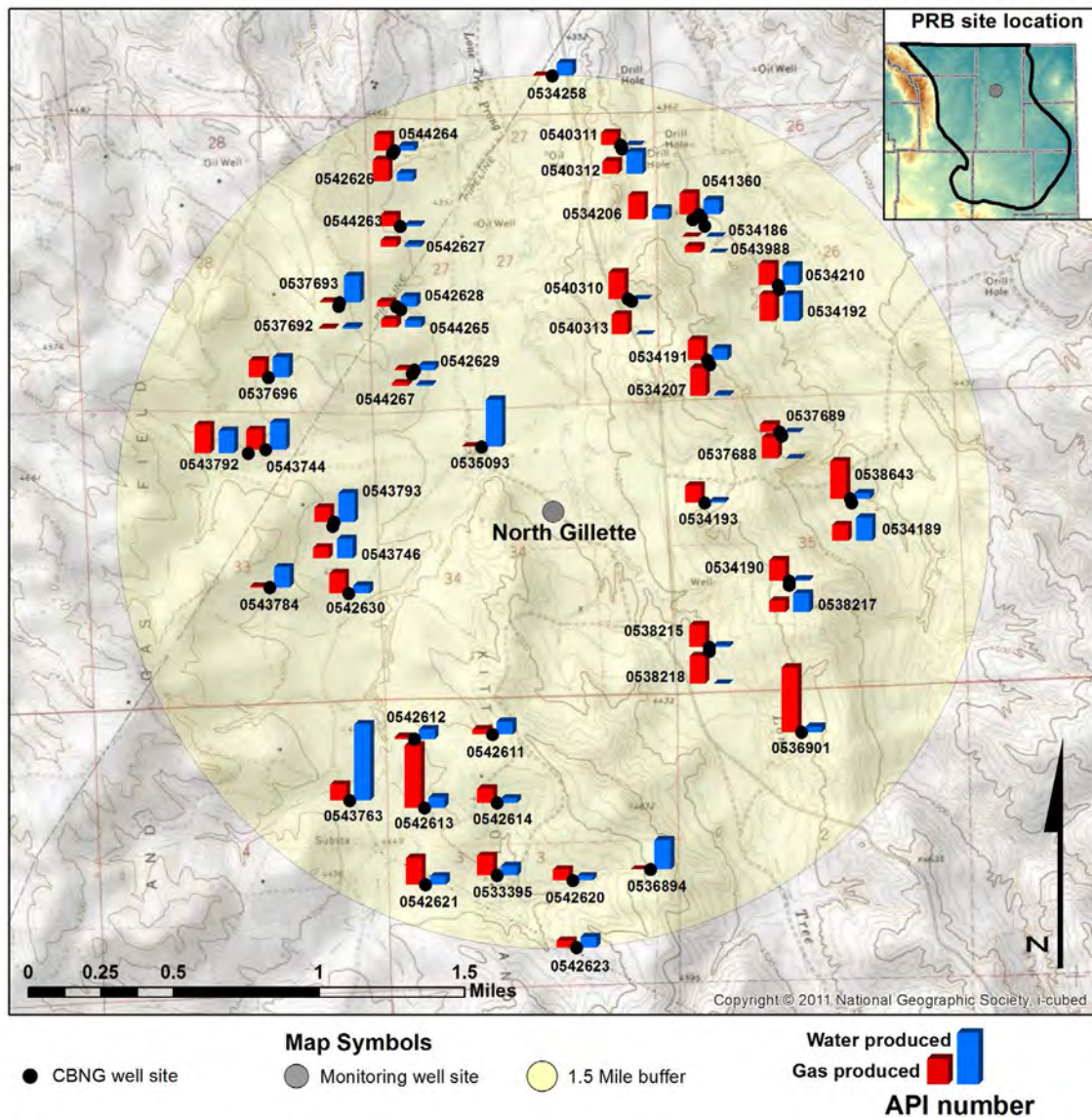
are not monitored (unmonitored coal zones) or in unknown coal zones.

Water and gas production in the Upper Wyodak began in February 2000. Water production peaked in August 2001 at 212,441 bbls (Figure A.177). Gas production peaked in October 2001 at 180,116 Mcf.





**Figure A.175.** Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the North Gillette monitoring wellsite location.

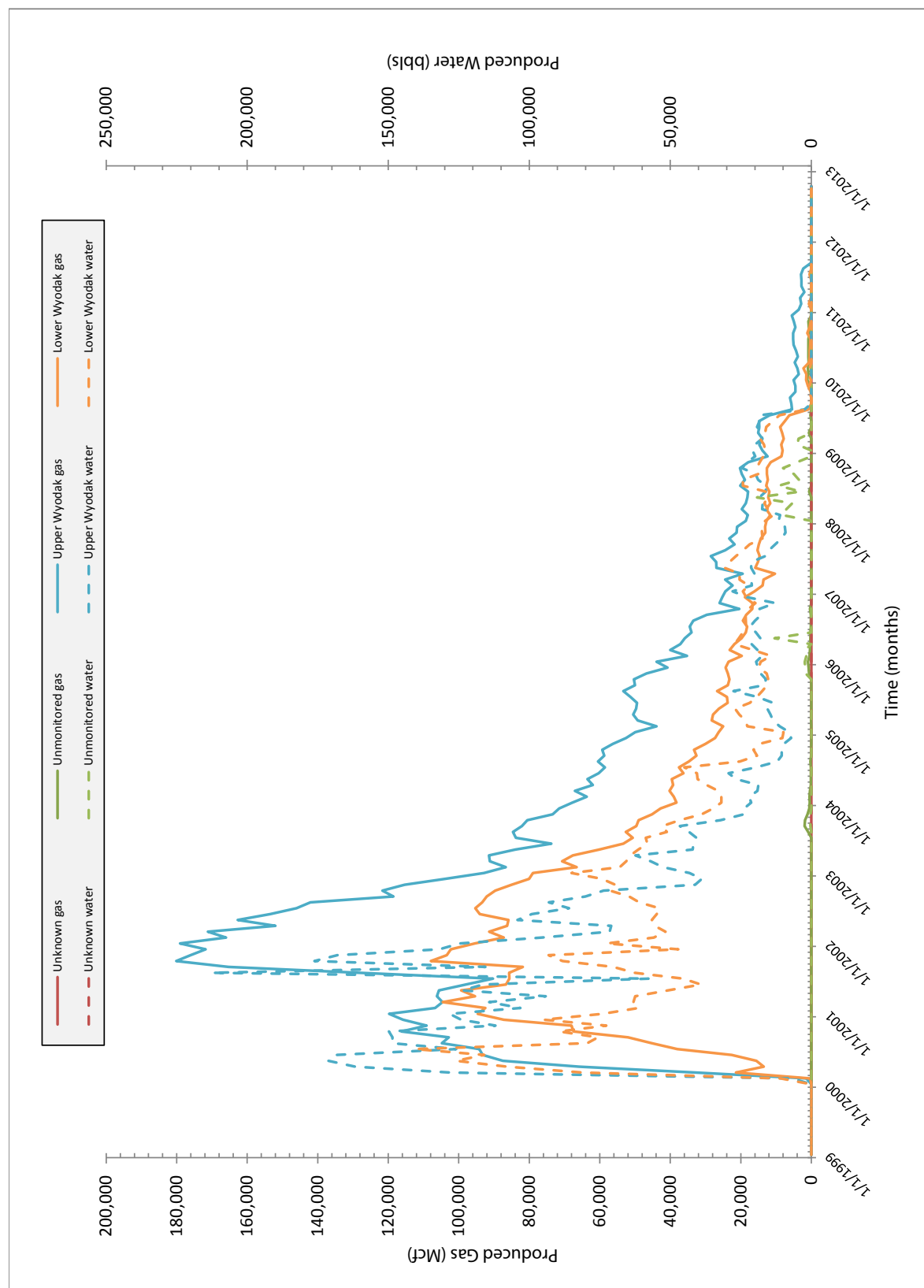


**Figure A.176.** North Gillette monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

The Lower Wyodak produced water from February 2000 to March 2010. Water production peaked at 140,400 bbls (Figure A.177) in July 2000. Gas production in the Lower Wyodak reached a maximum level of 104,546 Mcf in March 2001 (Figure A.177).

Water production in the unmonitored coal zones was sporadic from 2003-2009 and peaked at

19,279 bbls in May 2008 (Figure A.177). Low levels of gas, that never exceeded 2,000 Mcf/month, were intermittently produced from the unmonitored coal zones during 2003-2010. No gas or water were produced from unknown coal zones during the monitoring period of 1999-2012.



**Figure A.177.** Water and gas production from CBNG wells associated with the North Gillette monitoring well site location.

# **Oops Monitoring Well Site** **Location: S16 T49N R77W** **Date First Monitored: March 19, 2009**

## **Drawdown Information**

The Oops monitoring well site includes two wells. One of the wells is a dual completion well, separated by a packer. The first well is completed in a shallow Wasatch sandstone. The dual completion well is completed in the Big George coal of the Wyodak Rider coal zone and in a Fort Union underburden sandstone (Figure A.178; Table A.88). Water levels and wellhead gas pressures were measured during the POR using both manual and automatic transducer and data logger equipment. Transducer data that is missing, randomly fluctuating (noisy) or that substantially differs from concurrent manual measurements may indicate on-site equipment failure, malfunction or requirement for calibration.

## **Wasatch Sandstone**

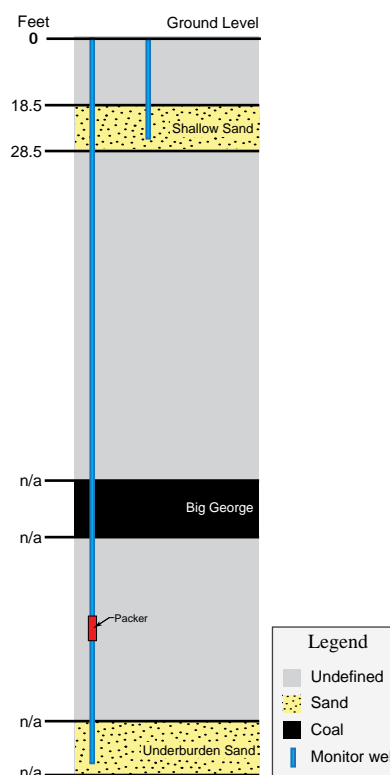
Groundwater levels in the shallow Wasatch sandstone has no data available. (Table A.89). Gas pressure data were not recorded for the Wasatch sandstone.

## **Big George Coal**

The groundwater levels in the Big George coal have not been able to be recorded due to the high pressure the well is under (Table A.89). Gas pressure in the Big George coal peaked at 105 psi in May 2009.

## **Fort Union Underburden Sandstone**

The underburden sandstone well water level is reported at the well head and is flowing artesian. Pressure in the well was reported at 30 psi.



**Figure A.178.** Section showing relative positions of coals and sands in feet. Not to scale.

**Table A.88.** Table showing the depth to and thickness of monitored zones at the Ops monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Shallow sand	18.5	28.5	10.0	n/a
Big George coal	n/a	n/a	n/a	n/a
Underburden sand	n/a	n/a	n/a	n/a

**Table A.89.** Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2010	Drawdown 2010-2012	Total drawdown (ft.)	Depth to Final water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Shallow sand	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Big George coal	n/a	n/a	n/a	n/a	n/a	105	5/19/09
Underburden sand	n/a	n/a	n/a	n/a	n/a	n/a	n/a

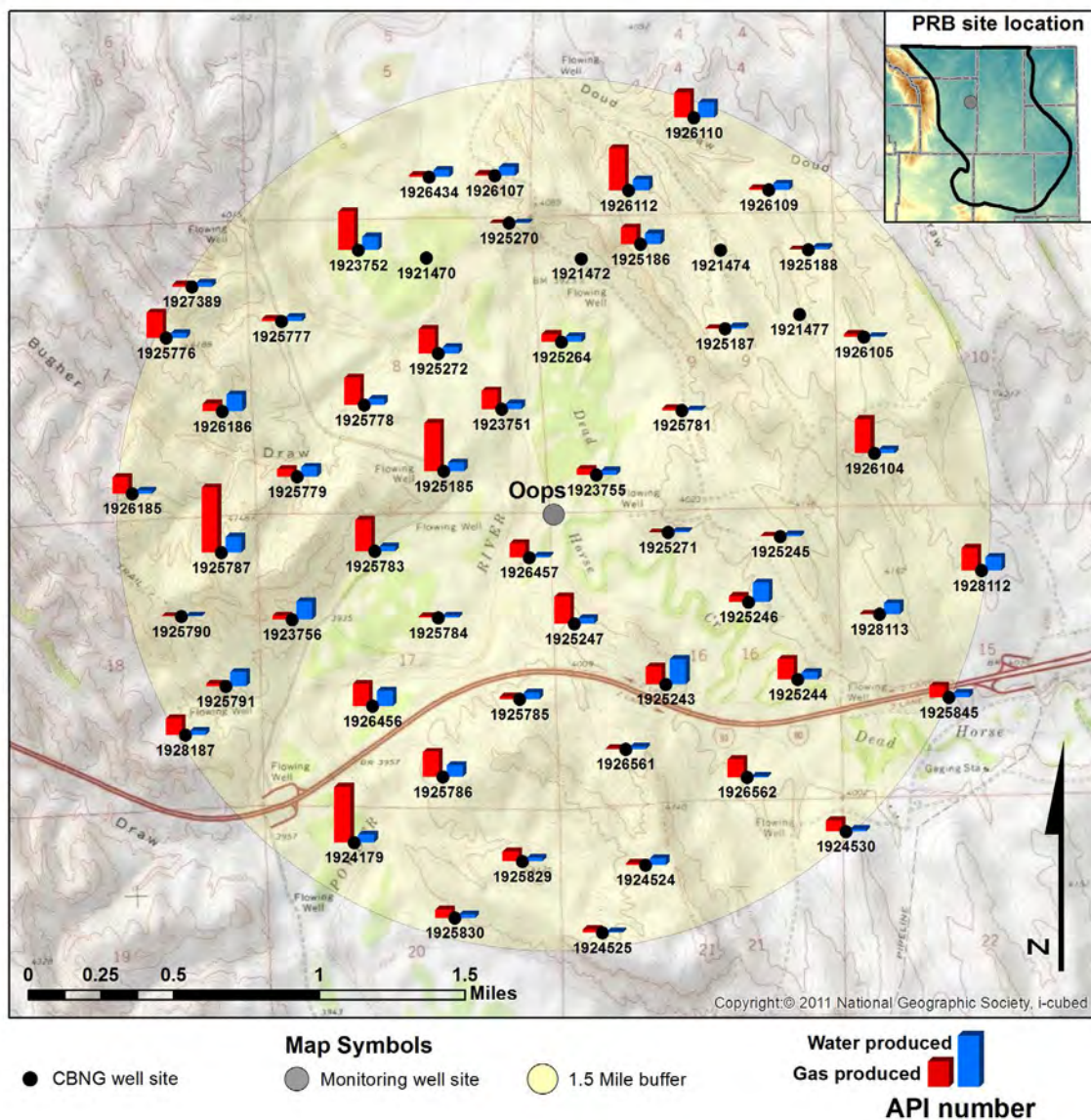
### Production Statistics

Production data were analyzed for CBNG wells within the buffer of the Ops monitoring well site from 2001-2012. Cumulative production for individual CBNG wells is displayed by location on Figure A.179. CBNG production is monitored in the Wyodak Rider coal zone, some production

occurs in coal zones where groundwater levels were not monitored (unmonitored coal zones).

The Wyodak Rider coal zone started producing water in 2006 and peaked in 2007 at 414,749 bbls/month, after which water production then gradually decreased to 227,406 bbls in October 2012.





**Figure A.179.** Oops monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

Gas production in the Wyodak Rider coal zone also began in 2006 and rapidly increased to its peak in December 2008 at 1,042,706 Mcf. The Wyodak Rider coal zone gas production remained high until 2010 and began decreasing rapidly, ending October 2012 at 266,992 Mcf.

The unmonitored coal zones saw water production beginning in 2007 peaked in 2008 at 20,428 bbls/month and ended 2010 at 16,278 bbls/month (Figure A.180). Gas production peaked in July 2009 at 47,021 Mcf, and has since receded to 0 Mcf/month.

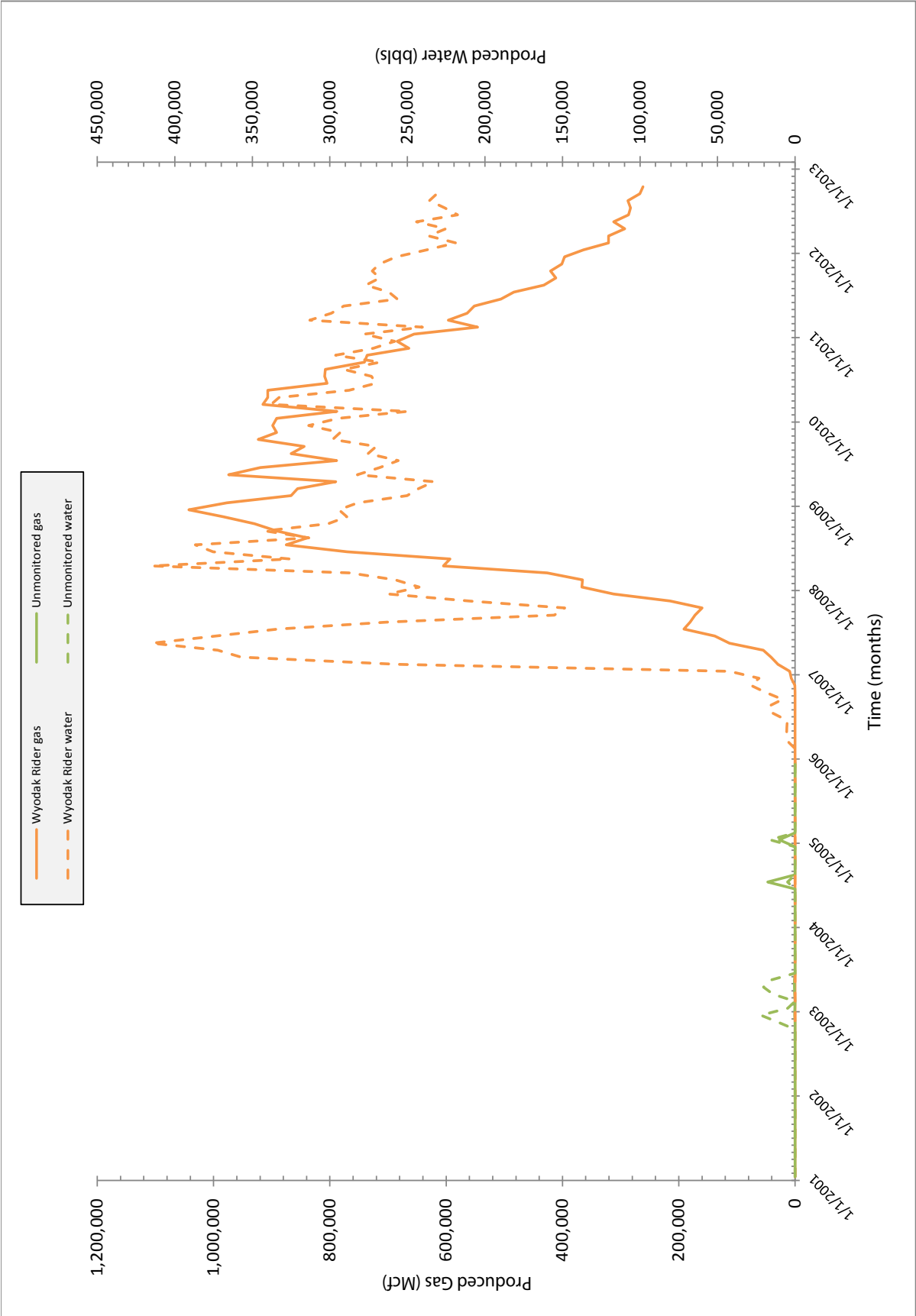


Figure A.180. Water and gas production from CBNB wells associated with the Oops monitoring well site location.



**Palo Monitoring Well Site**  
**Location: S22 T56N R74W**  
**Date First Monitored: February 7, 2001**

**Drawdown Information**

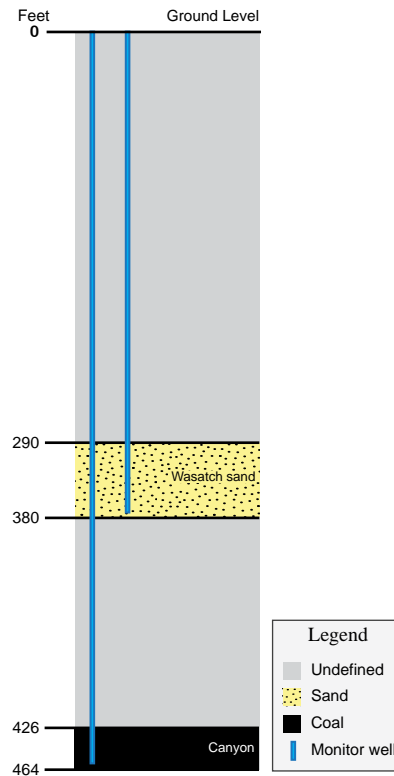
The Palo monitoring well site includes two wells. One is completed in a Wasatch sandstone and the other in the Canyon coal of the Lower Wyodak coal zone (Figure A.181; Table A.90). Water levels and wellhead gas pressures were measured during the POR using both manual and automatic transducer and data logger equipment. Transducer data that is missing, randomly fluctuating (noisy) or that substantially differs from concurrent manual measurements may indicate on-site equipment failure, malfunction or requirement for calibration.

**Wasatch Sandstone**

Groundwater levels rose 23.2 feet during the 2010-2012 POR and declined only 0.48 feet over the monitoring period of 2001-2009 (Figure A.182; Table A.91). Gas pressure was not recorded in the Wasatch sandstone.

**Canyon Coal**

Groundwater levels in the Canyon coal declined 1.03 feet during the 2010-2012 POR, and 140.82 feet over the monitoring period of 2001-2009 (Figure A.182; Table A.91). Gas pressure in the Canyon coal peaked at 55.92 psi in March 2001.



**Figure A.181.** Section showing relative positions of coals and sands in feet. Not to scale.

**Table A.90.** Table showing the depth to and thickness of monitored zones at the Palo monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Wasatch sand	290	380	90	46
Canyon coal	426	464	38	n/a

**Table A.91.** Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2010	Drawdown 2010-2012	Total drawdown (ft.)	Depth to Final water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	246.32	0.48	-23.20	-22.72	233.60	n/a	n/a
Canyon coal	298.68	140.82	1.03	141.85	440.53	55.92	3/16/2001

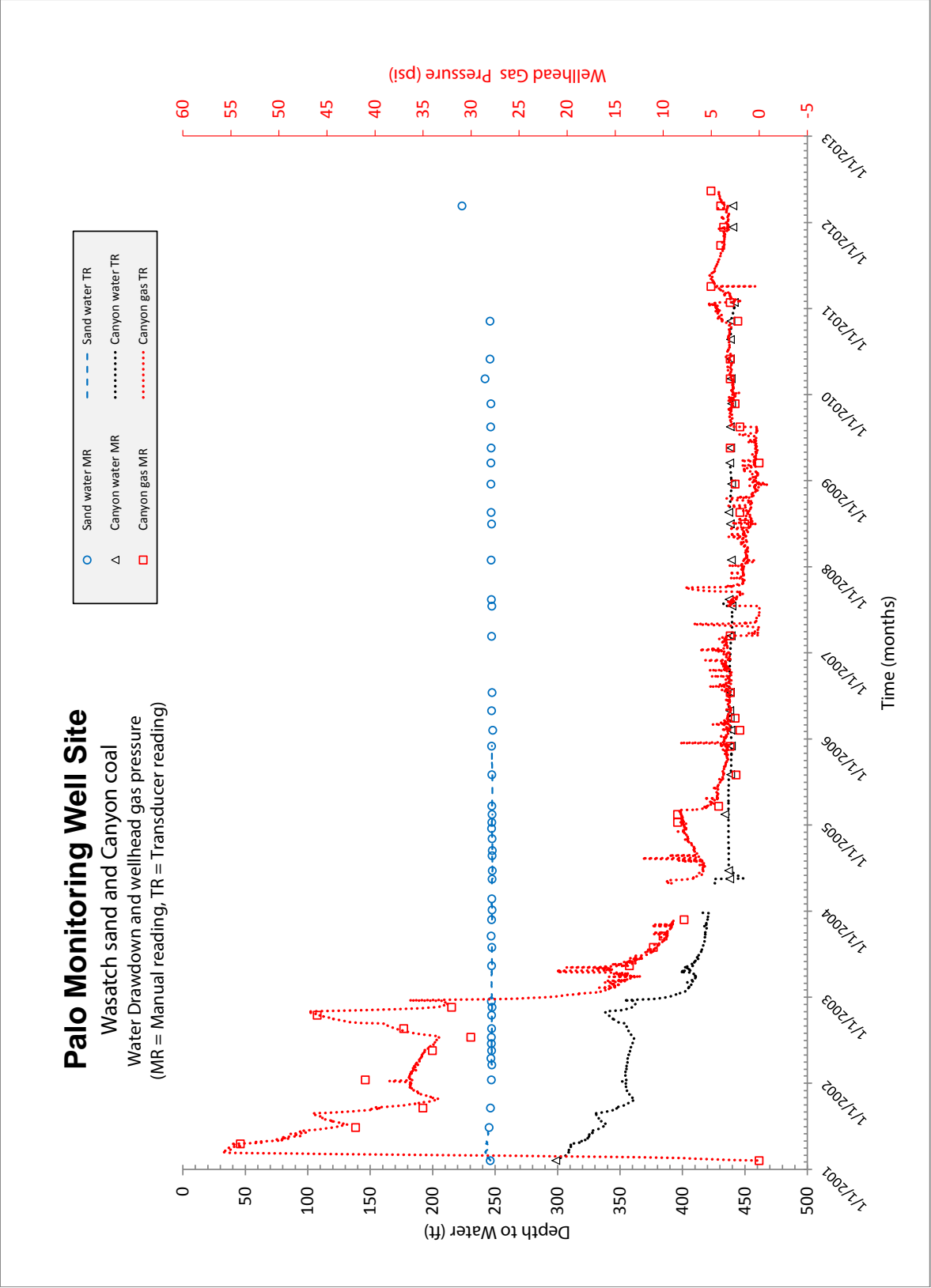
### Production Statistics

Production data were analyzed for CBNG wells within the buffer of the Palo monitoring well site from 1991-2012. Cumulative production for individual CBNG wells is displayed by location on Figure A.183. CBNG production is monitored in the Lower Wyodak coal zone. Additionally, in this area gas and water are produced from wells completed in unknown and multiple coal zones. Some producing wells are also completed in coal zones where gas and water production are monitored

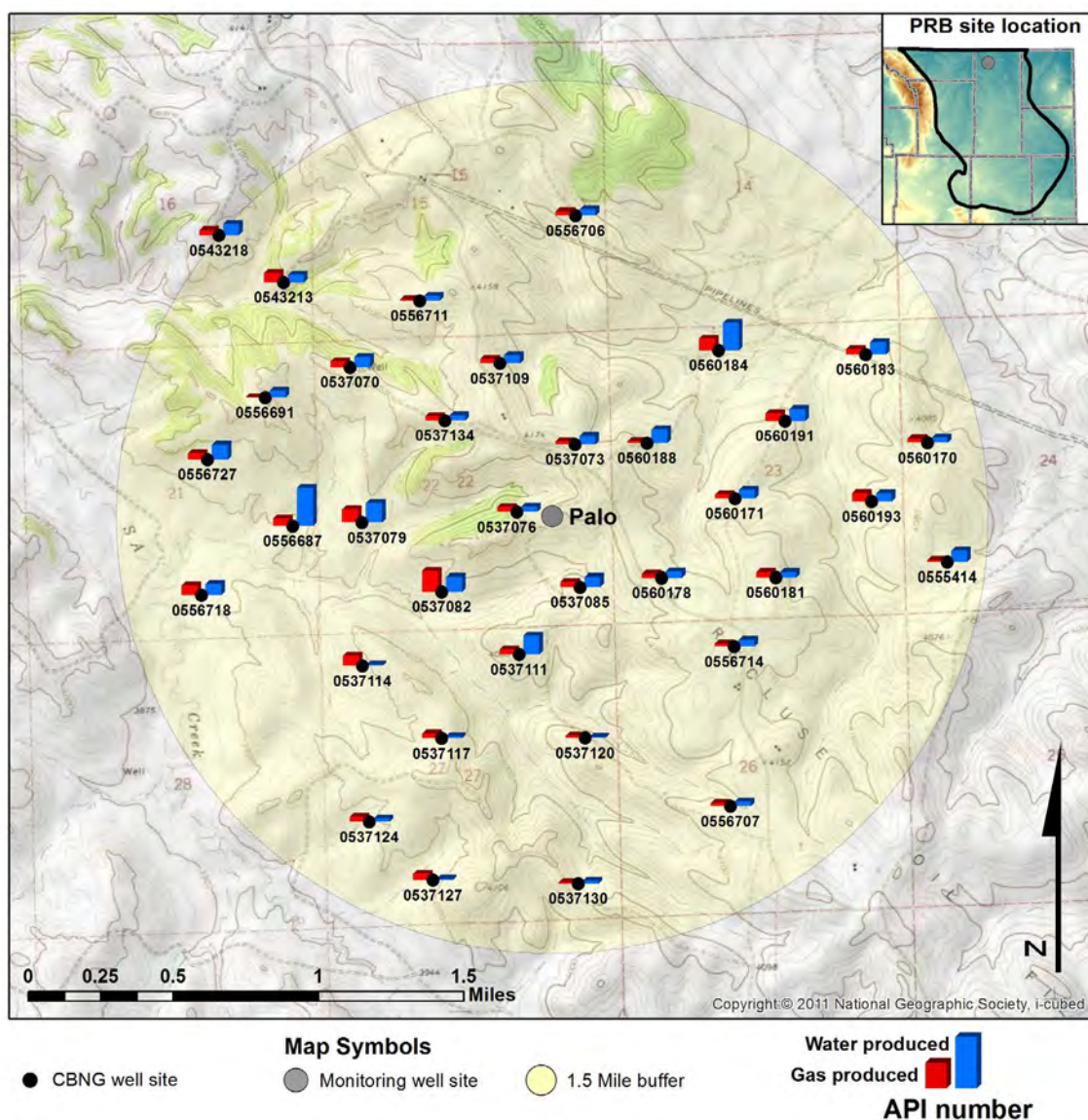
but groundwater levels are not (unmonitored coal zones).

The Lower Wyodak zone has produced water and gas from 2001-2012. Water production reached a maximum monthly production of 37,647 bbls in March 2001 (Figure A.184). The maximum gas production level reached 28,345 Mcf in May 2007.

Water and gas were produced from multiple coal zone wells from October 2007 into late 2012.



**Figure A.182.** Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Palo monitoring wellsite location.



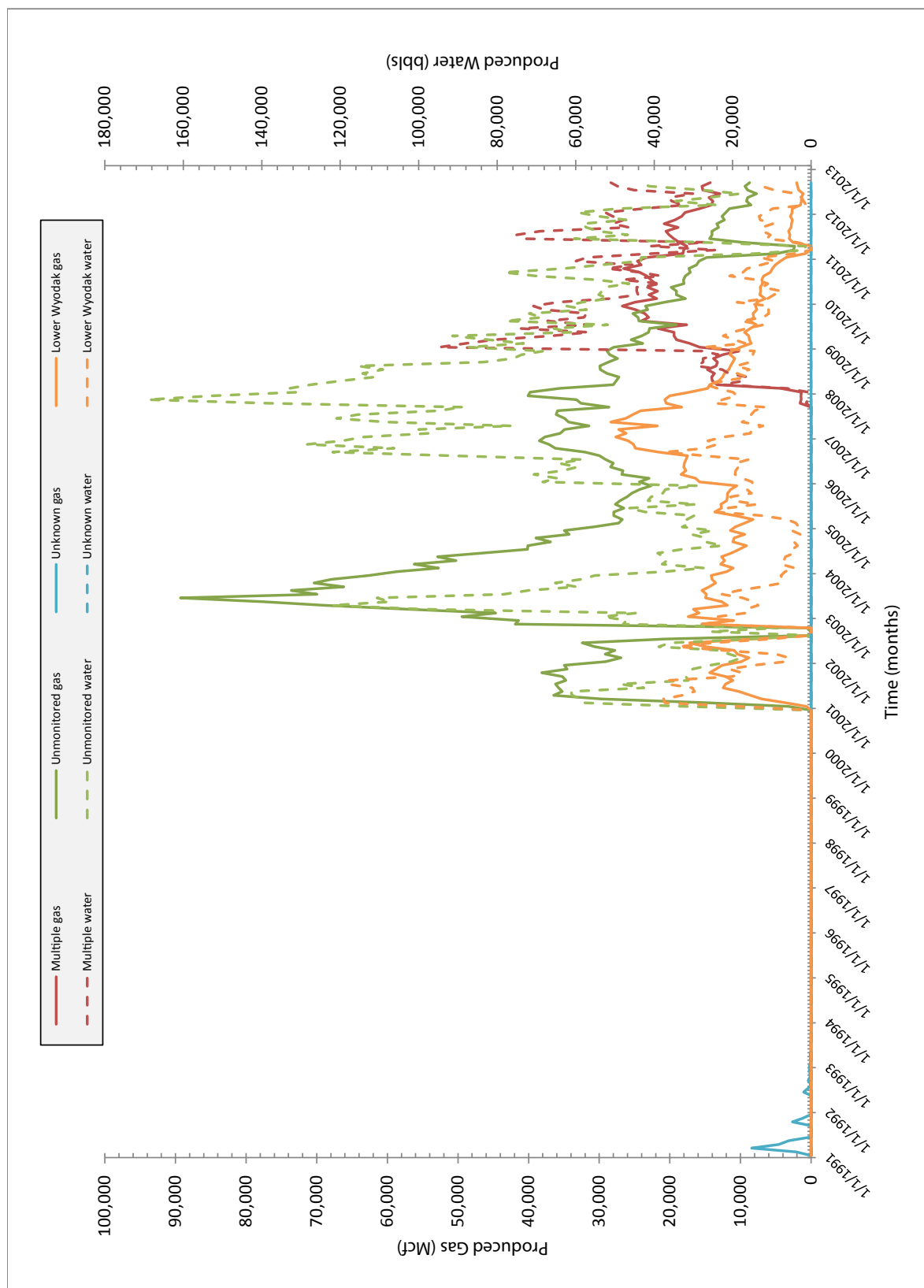
**Figure A.183.** Palo monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

Water production peaked at 94,748 bbls (Figure A.184) in January 2009. Gas production levels in multiple zone wells have been consistently low, peaking at 26,744 Mcf in December 2009.

Gas and water production began in January 2001 and continued into late 2012 in the unmonitored coal zones. Water production reached a monthly maximum of 169,029 bbls (Figure A.184) in

November 2007. Gas production peaked in June 2003 at 89,312 Mcf.

The unknown coal zones have not produced water over the monitoring period of 1991-2012 (Figure A.184). The unknown coal zones produced low (< 8,412 Mcf) levels of gas intermittently from 1991 until August 1993.



**Figure A.184.** Water and gas production from CBNG wells associated with the Palo monitoring well site location.

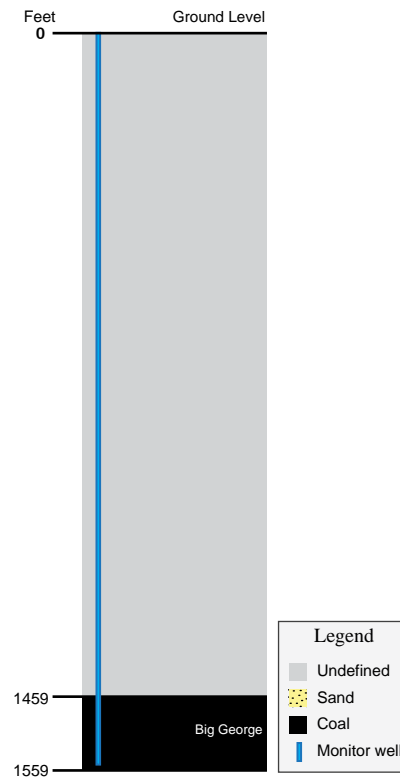
**Pistol Point Monitoring Well Site**  
**Location: S31 T45N R75W**  
**Date First Monitored: February 26, 1997**

**Drawdown Information**

The Pistol Point monitoring well site includes one well that is completed in the Big George coal of the Wyodak Rider coal zone (Figure A.185; Table A.92). Water levels and wellhead gas pressures were measured during the POR using both manual and automatic transducer and data logger equipment. Transducer data that is missing, randomly fluctuating (noisy) or that substantially differs from concurrent manual measurements may indicate on-site equipment failure, malfunction or requirement for calibration.

**Big George Coal**

Groundwater levels in the Big George declined 75.56 feet during the 2010-2012 POR and 806.87 feet (Figure A.186; Table A.93) over the monitoring period of 1997-2009. Gas pressure in the Big George peaked at 66.96 psi in May 2011.



**Figure A.185.** Section showing relative positions of coals and sands in feet. Not to scale.

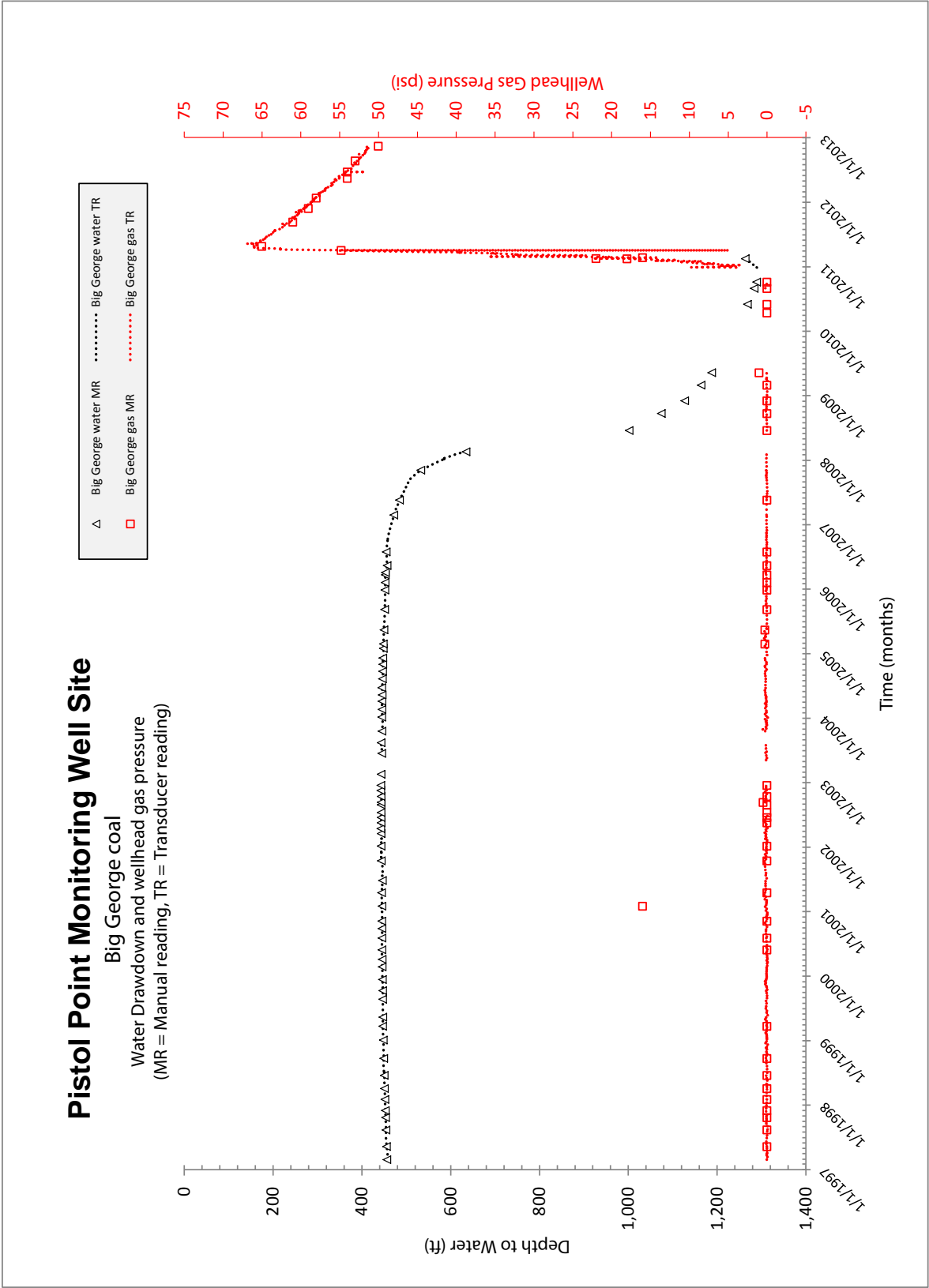
**Table A.92.** Table showing the depth to and thickness of monitored zones at the Pistol Point monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Big George coal	1,459	1,559	100	n/a

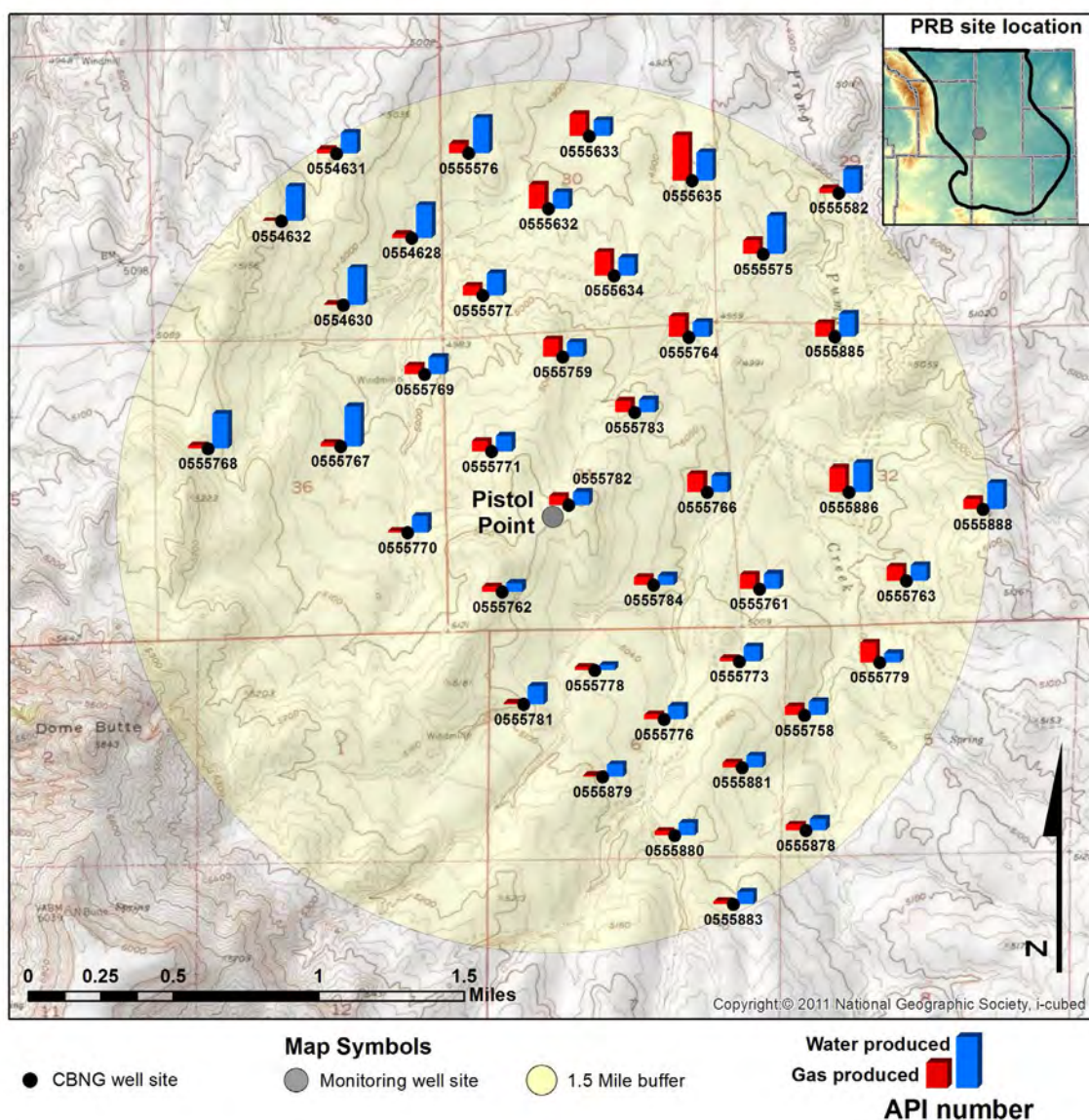
**Table A.93.** Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2010	Drawdown 2010-2012	Total drawdown (ft.)	Depth to Final water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Big George coal	456.63	731.31	75.56	806.87	1263.50	66.96	5/12/2011





**Figure A.186.** Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Pistol Point monitoring wellsite location.



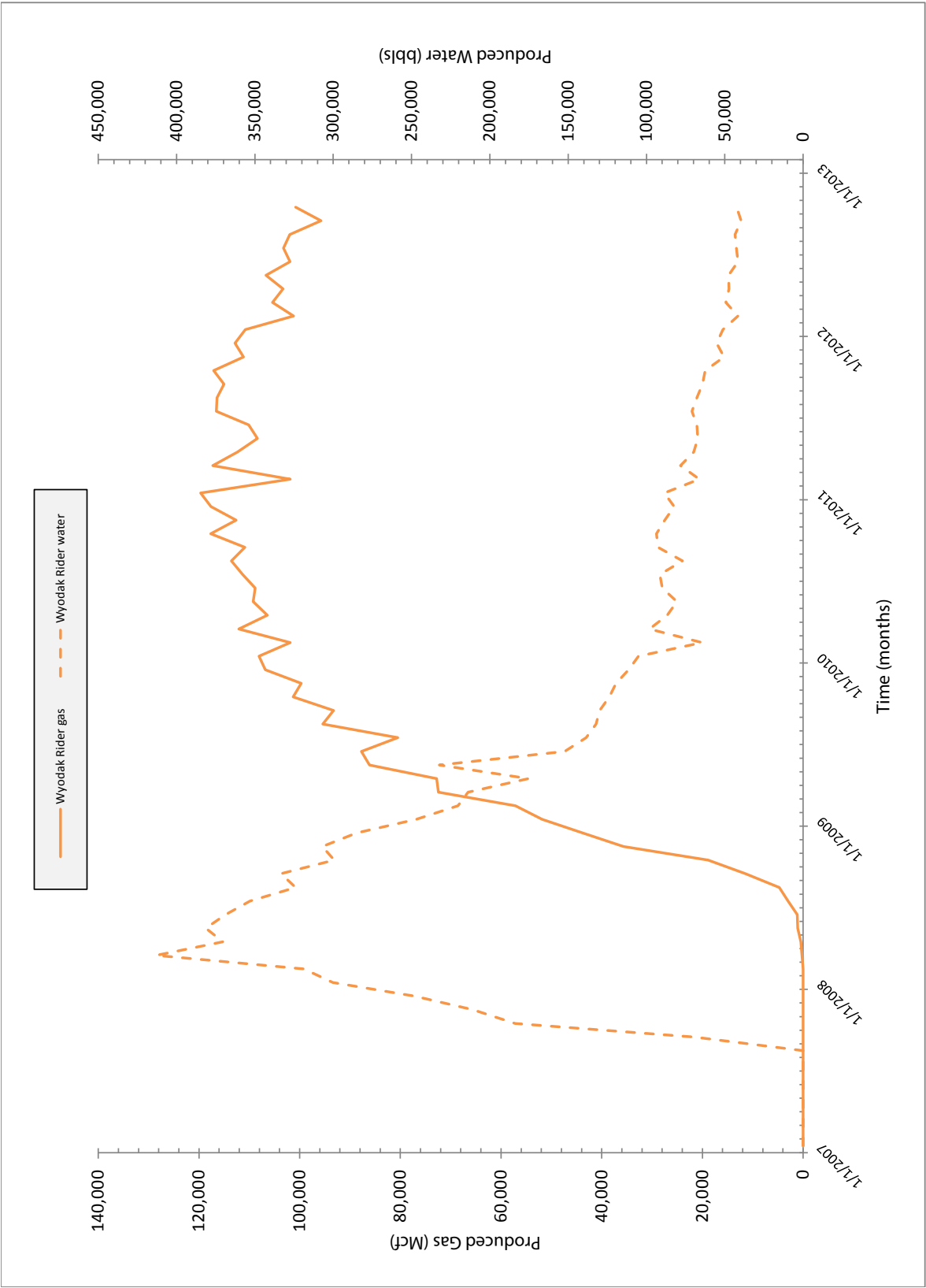
**Figure A.187.** Pistol Point monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

### Production Statistics

Production data were analyzed for CBNG wells within the buffer of the Pistol Point monitoring well site from 2007-2012. Cumulative production for individual CBNG wells is displayed by location on Figure A.187. CBNG production is monitored in the Wyodak Rider.

Water production in the Wyodak Rider began in 2007, peaked in March 2008 at 413,070 bbls, then

decreased and ended 2012 at 42,465 bbls/month (Figure A.188). Gas production in the Wyodak Rider began in March 2008 and continued into 2012 at a relatively stable high production level between 300,000 and 400,000 Mcf/month.



**Figure A.188.** Water and gas production from CBNG wells associated with the Pistol Point monitoring well site location.

**Redstone Monitoring Well Site**  
**Location: S26 T53N R73W**  
**Date First Monitored: October 9, 1998**

**Drawdown Information**

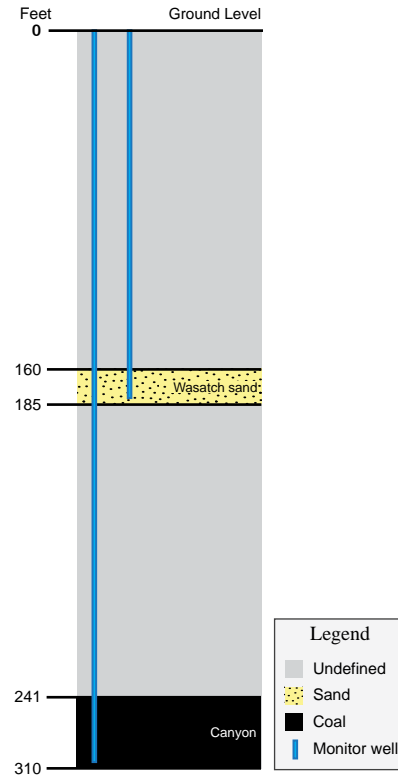
The Redstone monitoring well site includes two wells. One is completed in Wasatch sandstone and the other in the Canyon coal of the Lower Wyodak coal zone (Figure A.189; Table A.94). Water levels and wellhead gas pressures were measured during the POR using both manual and automatic transducer and data logger equipment. Transducer data that is missing, randomly fluctuating (noisy) or that substantially differs from concurrent manual measurements may indicate on-site equipment failure, malfunction or requirement for calibration.

**Wasatch Sandstone**

Groundwater levels in the Wasatch sandstone declined 0.49 feet during the 2010-2012 POR but rose 2.2 feet over the monitoring period of 1998-2009 (Figure A.190; Table A.95). Gas pressure was not recorded in the Wasatch sandstone.

**Canyon Coal**

Groundwater levels in the Canyon coal rose 57.09 feet during the 2010-2012 POR but declined 218.86 feet over the monitoring period of 1998-2009 (Figure A.190; Table A.95). Gas pressure in the Canyon coal peaked at 58.43 psi in April 2000.



**Figure A.189.** Section showing relative positions of coals and sands in feet. Not to scale.

**Table A.94.** Table showing the depth to and thickness of monitored zones at the Redstone monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Wasatch sand	160	185	25	56
Canyon coal	241	310	69	n/a

**Table A.95.** Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

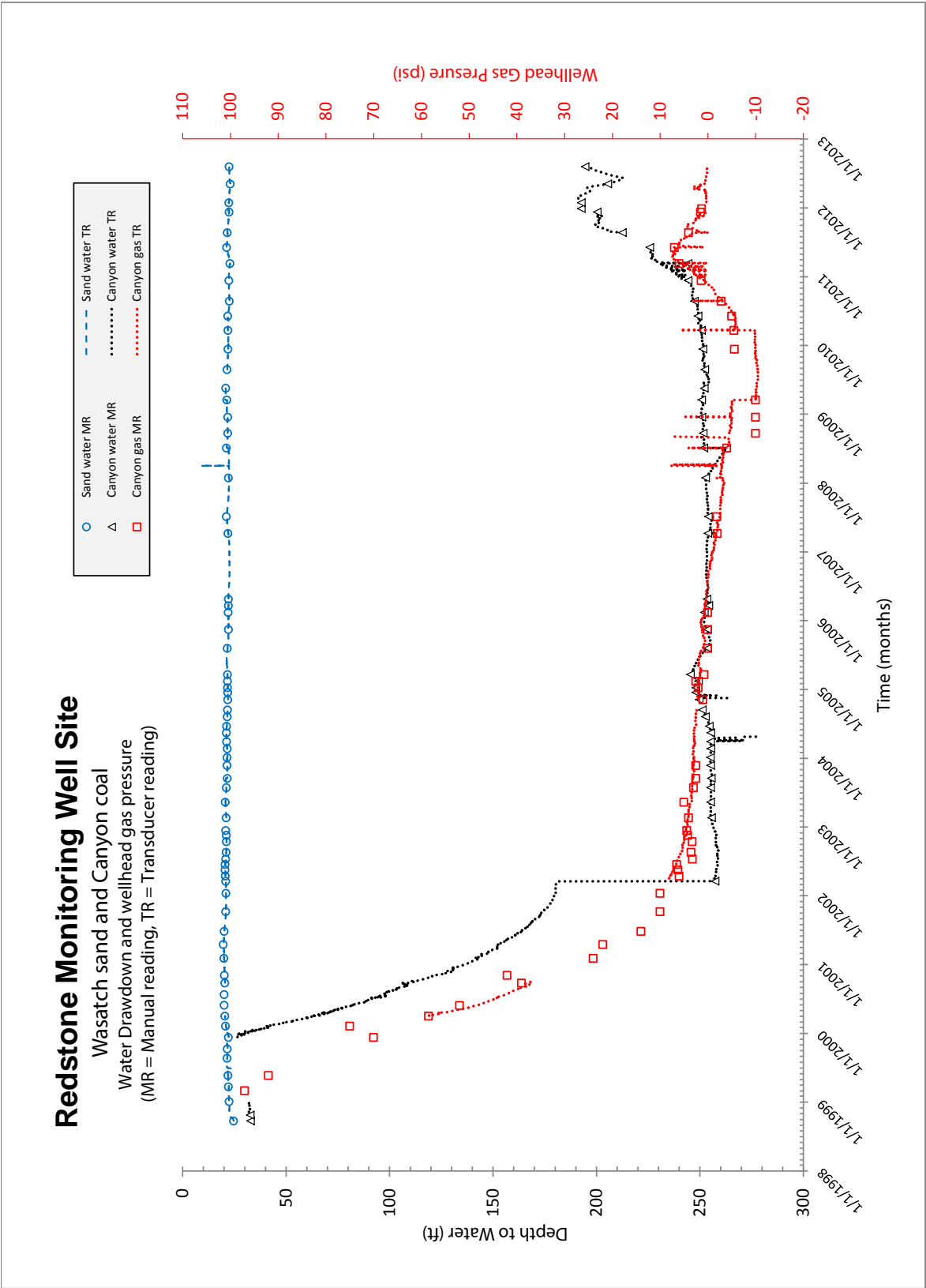
Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2010	Drawdown 2010-2012	Total drawdown (ft.)	Depth to Final water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	24.70	-2.69	0.49	-2.20	22.50	n/a	n/a
Canyon coal	32.80	218.86	-57.09	161.77	194.57	58.43	4/5/2000

### Production Statistics

Production data were analyzed for CBNG wells within the buffer of the Redstone monitoring well site from 1996-2012. Cumulative production for individual CBNG wells is displayed by location on Figure A.191. CBNG production is monitored in the Lower Wyodak coal zone. Additionally, in this area gas and water are produced from wells completed in unknown and multiple coal zones. Some producing wells are also completed in coal zones

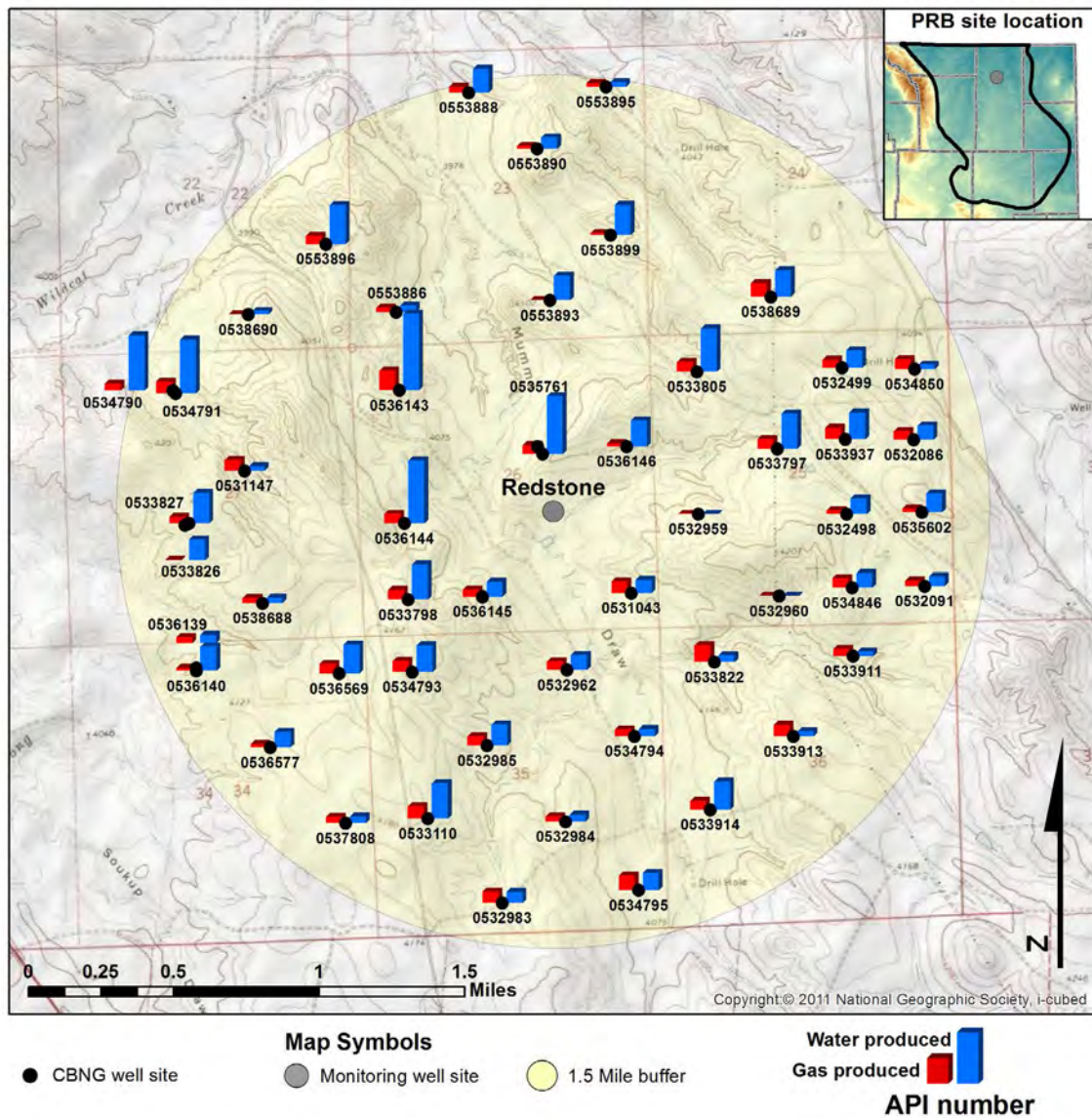
where gas and water production are monitored but groundwater levels are not (unmonitored coal zones).

The Lower Wyodak produced water and gas consistently from 1999-2009 and intermittently thereafter. Water production reached its maximum at 421,473 bbls in September 1999 (Figure A.192). Gas production peaked in January 2001 at 230,470 Mcf then decreased rapidly.



**Figure A.190.** Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Redstone monitoring wellsite location.





**Figure A.191.** Redstone monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

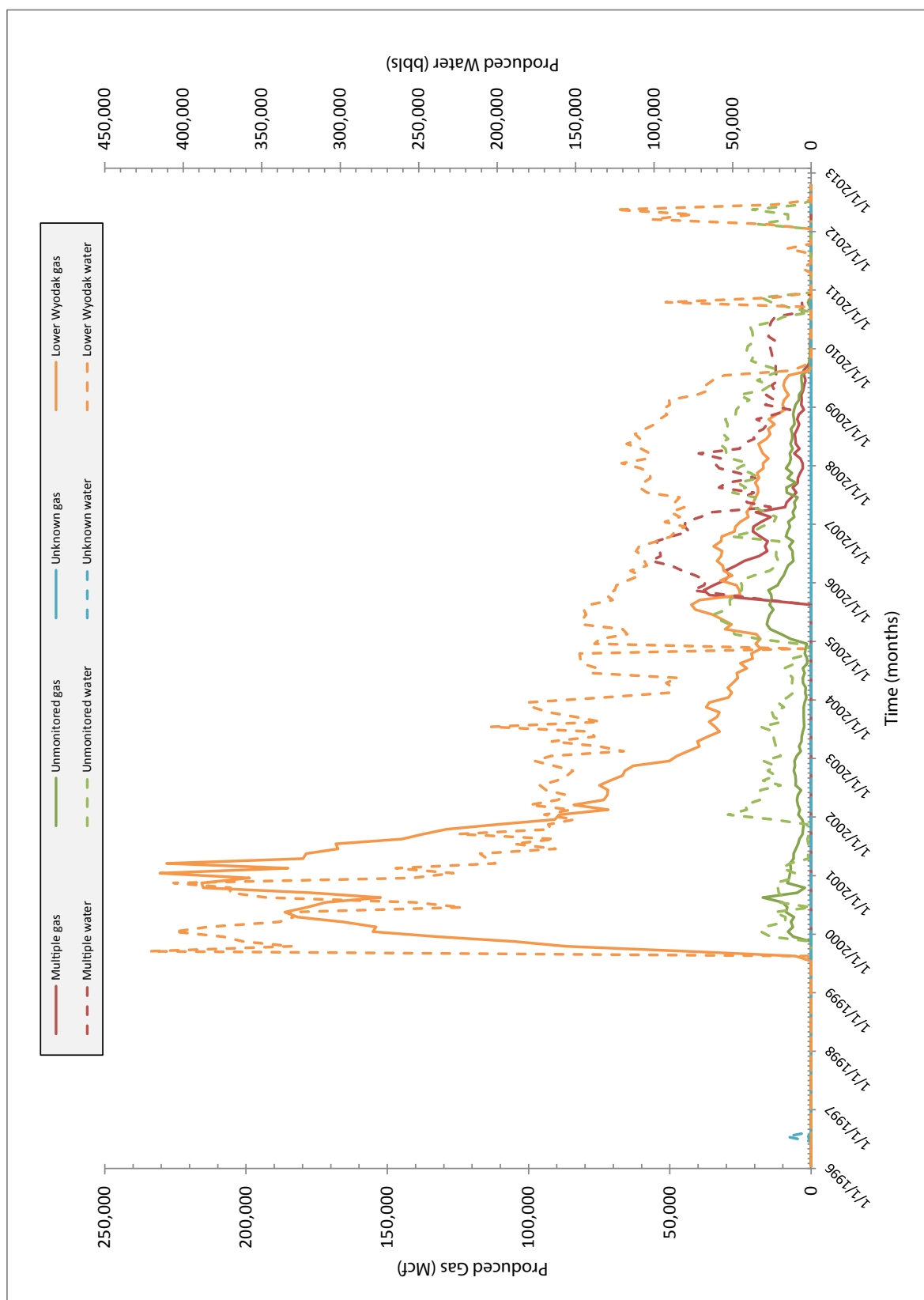
Multiple coal zone wells produced water and gas from September 2005 into late 2010. Water and gas production peaked at 102,012 bbls in May 2006 and 37,918 Mcf in November 2005, respectively (Figure A.192).

Unmonitored coal zone wells produced water and gas consistently from December 1999 into late 2010 and intermittently thereafter. Water production declined from a maximum of 62,136 bbls in

June 2005 to zero near the end of the 2010-2012 POR.. (Figure A.192). Gas production levels in the unmonitored coal zones were low but steady from 1999-2010 never exceeding 20,000 Mcf/month.

Unknown coal zones produced water (15,709 bbls) and gas (1000 Mcf) only in July 1996 (Figure A.192).





**Figure A.192.** Water and gas production from CBNG wells associated with the Redstone monitoring well site location.

## Remington Creek Monitoring Well Site

Location: S30 T58N R79W

Date First Monitored: May 23, 2005

### Drawdown Information

The Remington Creek monitoring well site includes four wells. One is completed in a Wasatch sandstone, another in the Anderson coal of the Upper Wyodak coal zone, a third in the Canyon coal of the Lower Wyodak coal zone, and the last in the Cook coal of the Cook coal zone (Figure A.193; Table A.96). Water levels and wellhead gas pressures were measured during the POR using both manual and automatic transducer and data logger equipment. Transducer data that is missing, randomly fluctuating (noisy) or that substantially differs from concurrent manual measurements may indicate on-site equipment failure, malfunction or requirement for calibration.

### Wasatch Sandstone

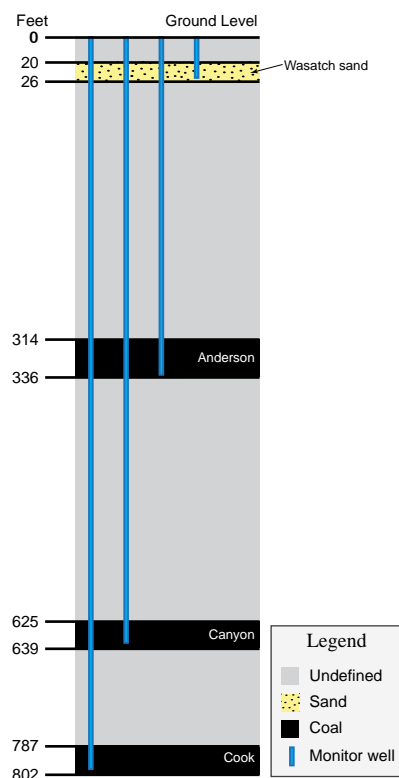
Groundwater levels declined 1.33 feet during the 2010-2012 POR but rose 2.33 feet over the monitoring period of 2005-2009 (Figure A.194; Table A.97). Gas pressure was not recorded in the Wasatch sandstone.

### Anderson Coal

Groundwater levels declined 12.23 feet during the 2010-2012 POR and 142.77 feet over the monitoring period of 2005-2009 (Figure A.194; Table A.97). Gas pressure in the Anderson coal initially peaked at 60.44 psi in August 2005 and declined to about 5 psi by the end of 2011.

### Canyon Coal

Groundwater levels remained unchanged in the Canyon coal over the 2010-2012 POR due to the fact that the well was reported as dry or obstructed during this time. Groundwater levels fell 141.60 feet over the monitoring period of 2005-2009 (Figure A.195; Table A.97). Gas pressure in the Canyon coal remained relatively stable at around 1 psi over the life of the well.



**Figure A.193.** Section showing relative positions of coals and sands in feet. Not to scale.

### Cook Coal

Groundwater levels in the Cook coal rose 46.42 feet during the 2010-2012 POR but declined 131.70 feet over the monitoring period of 2005-2009 (Figure A.195; Table A.97). Gas pressure in the Cook coal remained relatively stable at about 1 psi over the life of the well.

**Table A.96.** Table showing the depth to and thickness of monitored zones at the Remington Creek monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Wasatch sand	20	26	6	288
Anderson coal	314	336	22	n/a
Canyon coal	625	639	14	n/a
Cook coal	787	802	15	n/a

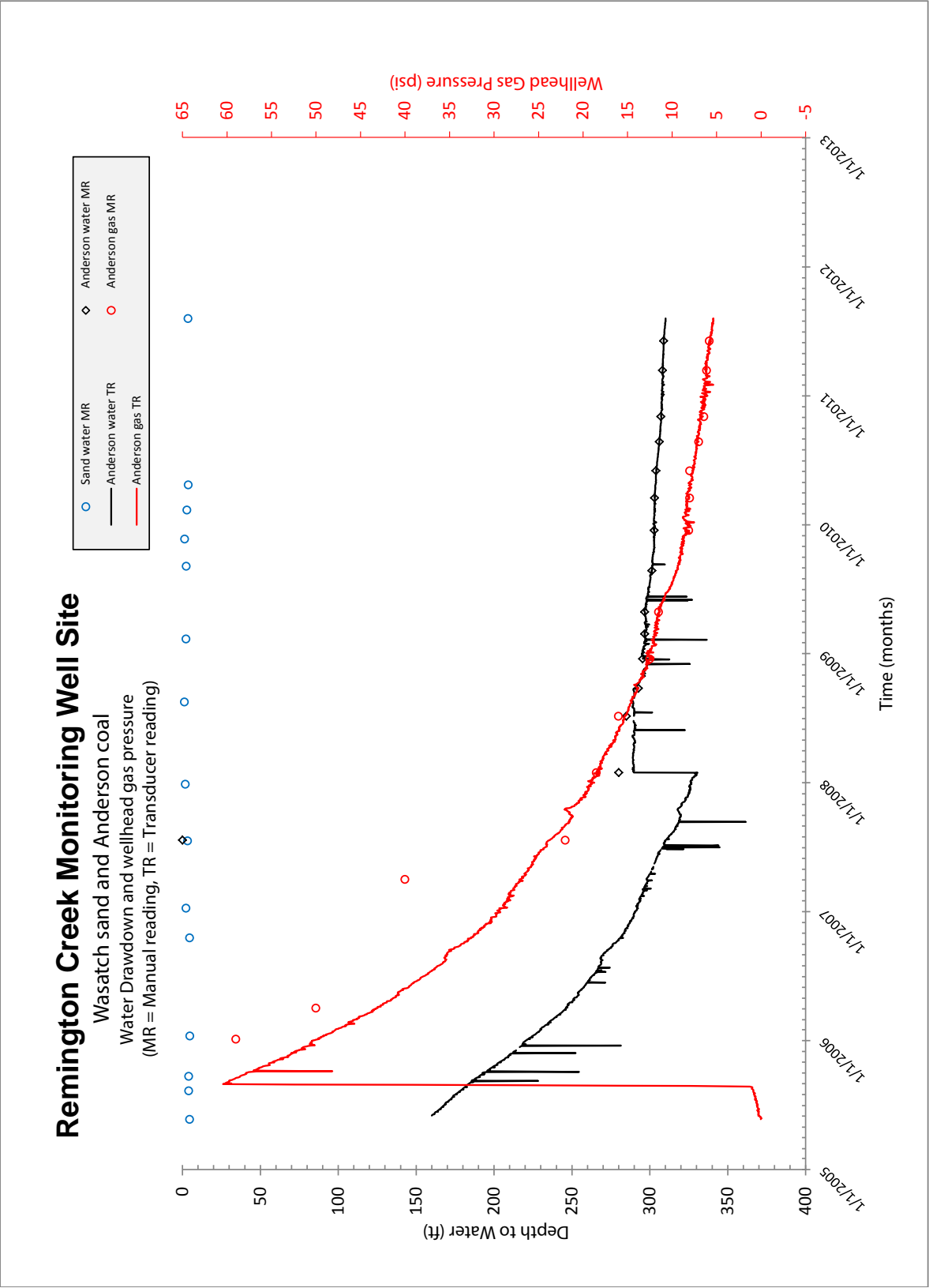
**Table A.97.** Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2010	Drawdown 2010-2012	Total drawdown (ft.)	Depth to Final water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	4.64	-2.33	1.33	-1.00	3.64	n/a	n/a
Anderson coal	160.00	142.77	12.23	155.00	315.00	60.44	8/30/2005
Canyon coal	378.40	141.60	0.00	141.60	520.00	1.07	8/26/2007
Cook coal	378.00	131.70	-46.42	85.28	463.28	1.00	2/12/2011

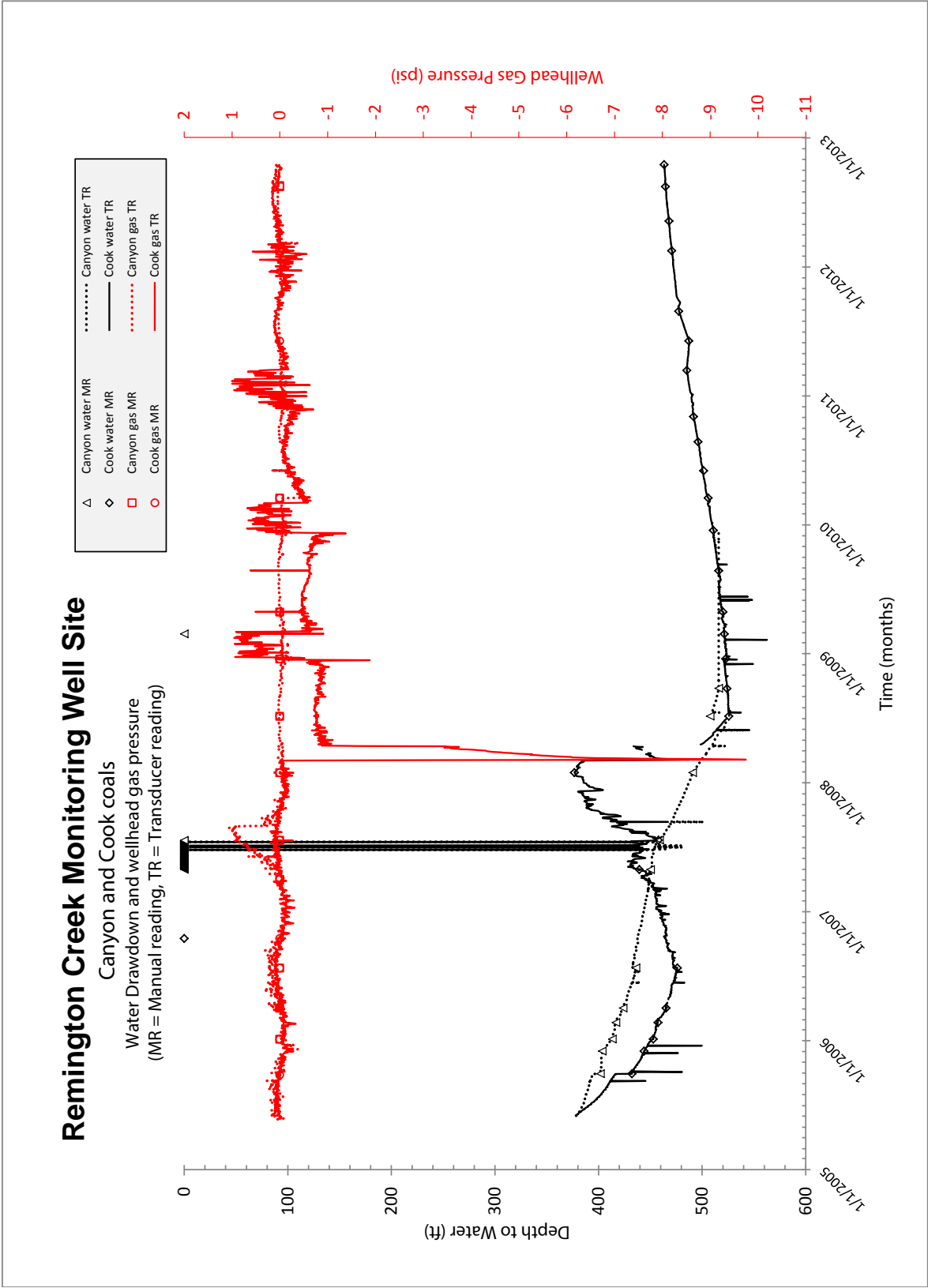
### Production Statistics

Production data were analyzed for CBNG wells within the buffer of the Remington Creek monitoring well site from 2002-2012. Cumulative production for individual CBNG wells is displayed by location on Figure A.196. CBNG production is monitored in the Upper Wyodak coal zone and some production in this area occurs in multiple production coal zones or coal zones where water levels are not monitored (unmonitored zones).

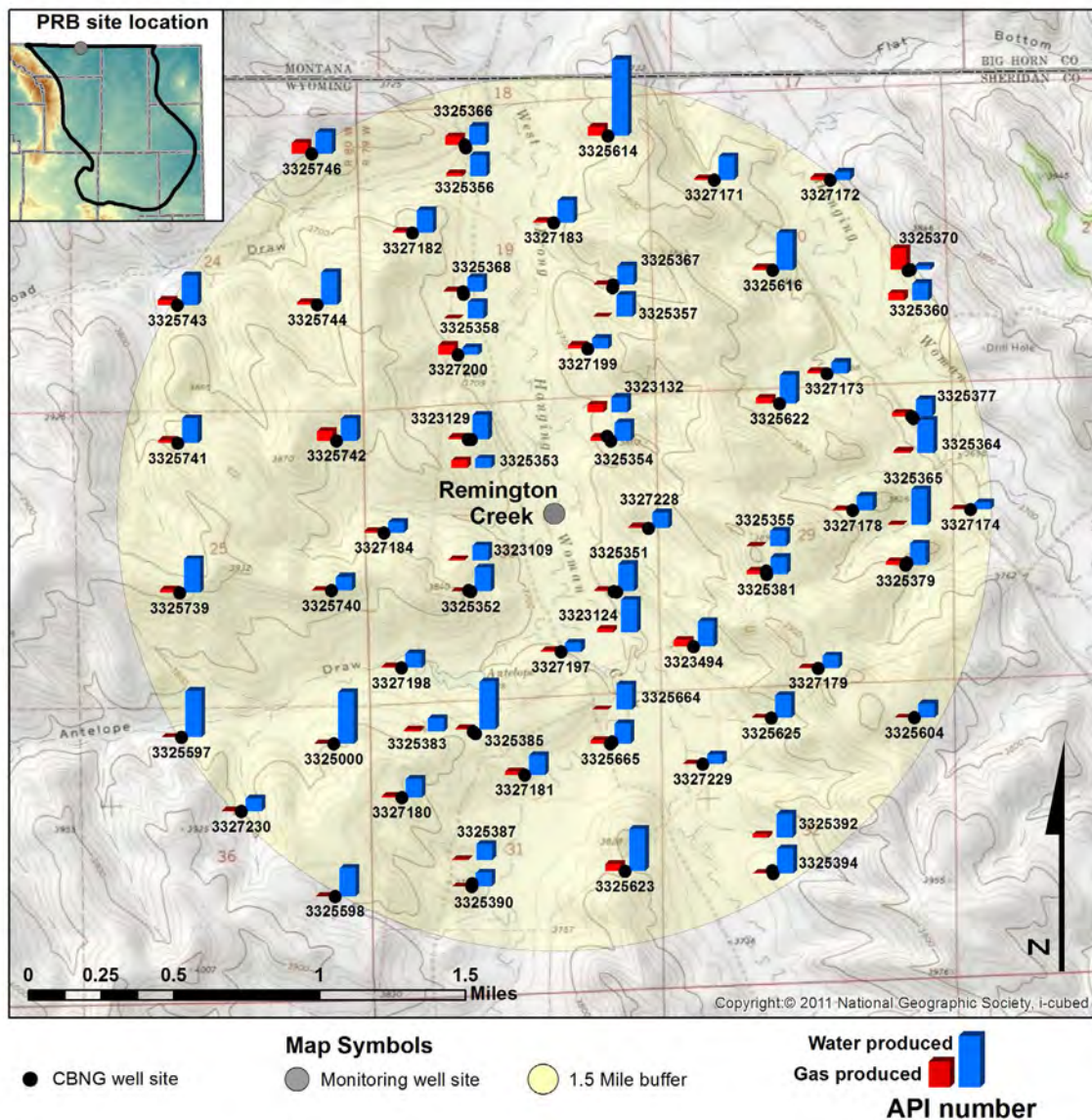
The Upper Wyodak began producing water and gas consistently in 2004 following a brief production period in 2002. Water production peaked at 108,819 bbls in January 2005 and gradually decreased to 20,676 bbls/month by the end of the 2010-2012 POR (Figure A.197). Gas production reached its maximum in January 2006 at 34,704 Mcf, and gradually declined to end the 2010-2012 POR at a monthly production rate of 3,811 Mcf.



**Figure A.194.** Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Remington Creek monitoring wellsite location.



**Figure A.195.** Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Remington Creek monitoring wellsite location.

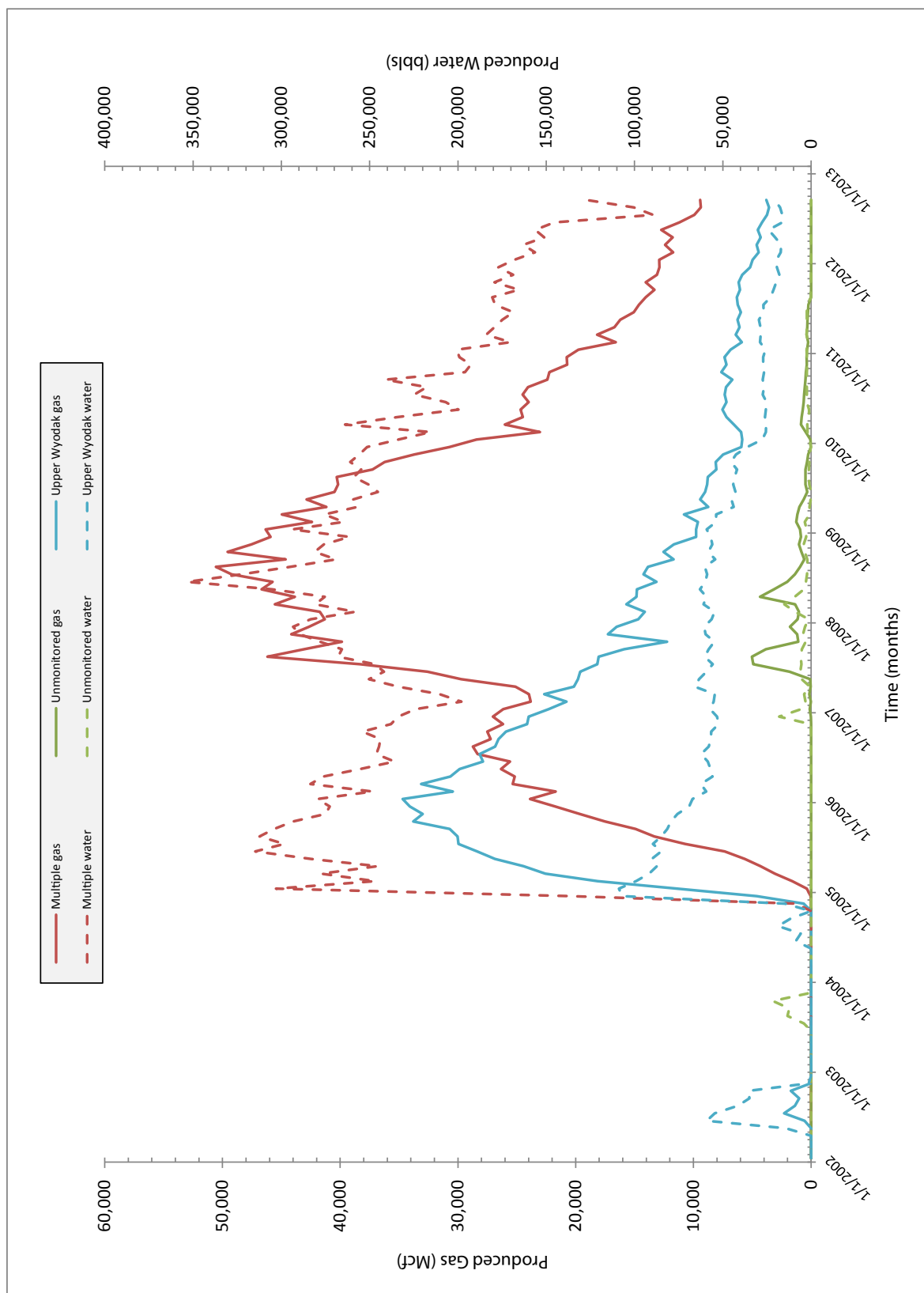


**Figure A.196.** Remington Creek monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

Multiple zone wells produced water and gas from 2004-2012. Water production peaked at 353,315 bbls in June 2008 (Figure A.197). Gas production peaked at 50,565 Mcf in August 2008 then declined to 9,359 Mcf/month by the end of the 2010-2012 POR..

Unmonitored coal zones have produced water and gas intermittently at low levels (Figure A.197) from 2003 to mid-2011. Gas production never exceed-

ed 5,029 Mcf/month and water production never exceeded 21,731 bbls/month.



**Figure A.197.** Water and gas production from CBNG wells associated with the Remington Creek monitoring well site location.



**Rose Draw Monitoring Well Site**  
**Location: S19 T52N R77W**  
**Date First Monitored: May 23, 2009**

**Drawdown Information**

The Rose Draw monitoring well site includes two wells, of which one is a dual completion well, separated by a packer. The dual completion well is completed in a Wasatch sandstone and the Wall coal of the Wall coal zone, the second well is completed into a Fort Union underburden sandstone (Figure A.198; Table A.98). Water levels and wellhead gas pressures were measured during the POR using both manual and automatic transducer and data logger equipment. Transducer data that is missing, randomly fluctuating (noisy) or that substantially differs from concurrent manual measurements may indicate on-site equipment failure, malfunction or requirement for calibration.

**Wasatch Sandstone**

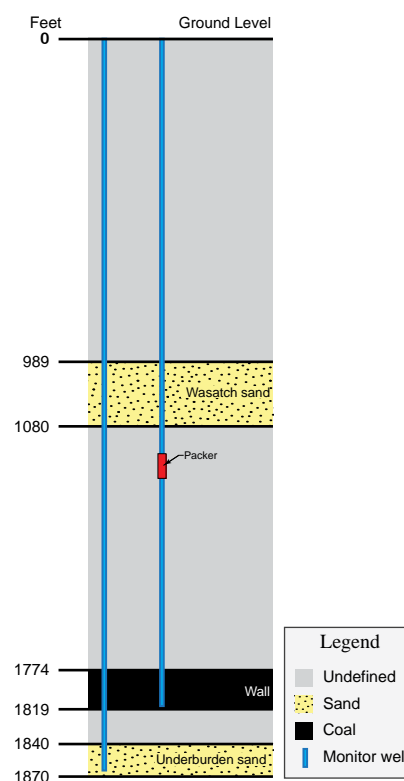
Groundwater levels declined 12.5 feet during the 2010-2012 POR and 0.86 feet during 2009 (Figure A.199; Table A.99). Gas pressure was not recorded in the Wasatch sandstone.

**Wall Coal**

Groundwater levels declined 170.95 feet during the 2010-2012 POR compared to 0.54 feet decline in December 2009 (Figure A.199; Table A.99). Gas pressure in the Wall coal remained relatively stable at < 1 psi over the life of the well.

**Fort Union Underburden Sandstone**

Groundwater levels in the Fort Union underburden sand declined 49.69 feet during the 2010-2012 POR and 13.41 feet during 2009 (Figure A.199; Table A.99). Gas pressure in the underburden sand remained relatively stable over this period, never exceeding 2 psi.



**Figure A.198.** Section showing relative positions of coals and sands in feet. Not to scale.

**Table A.98.** Table showing the depth to and thickness of monitored zones at the Rose Draw monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Wasatch sand	989	1,080	91	694
Wall coal	1,774	1,819	45	n/a
Underburden sand	1,840	1,870	30	21

**Table A.99.** Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

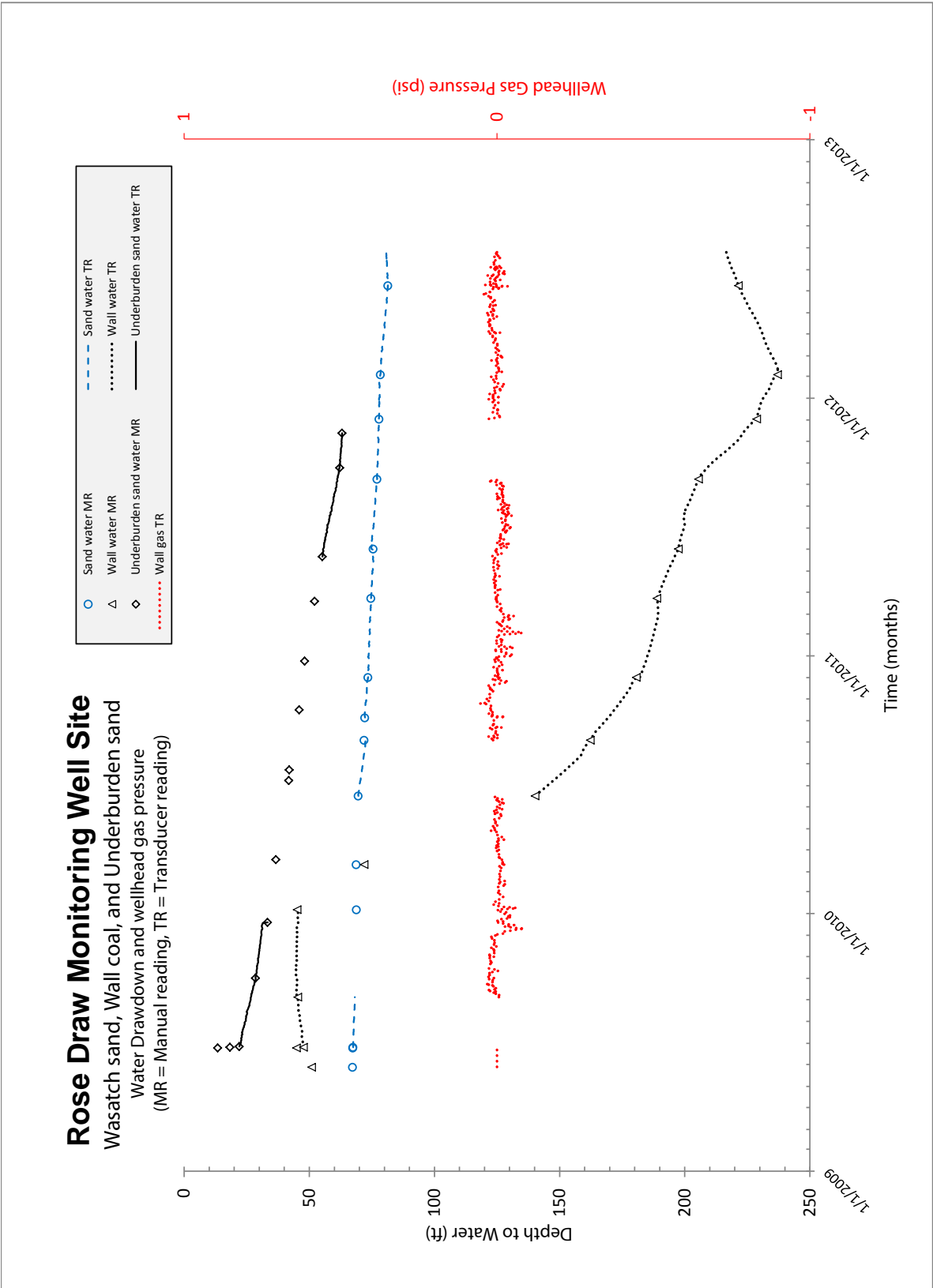
Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2010	Drawdown 2010-2012	Total drawdown (ft.)	Depth to Final water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	67.32	0.86	12.50	13.36	80.68	n/a	n/a
Wall coal	44.91	0.54	170.95	171.49	216.40	0.06	10/24/2010
Underburden sand	0.00	13.41	49.69	63.10	63.10	2.00	3/22/2011

### Production Statistics

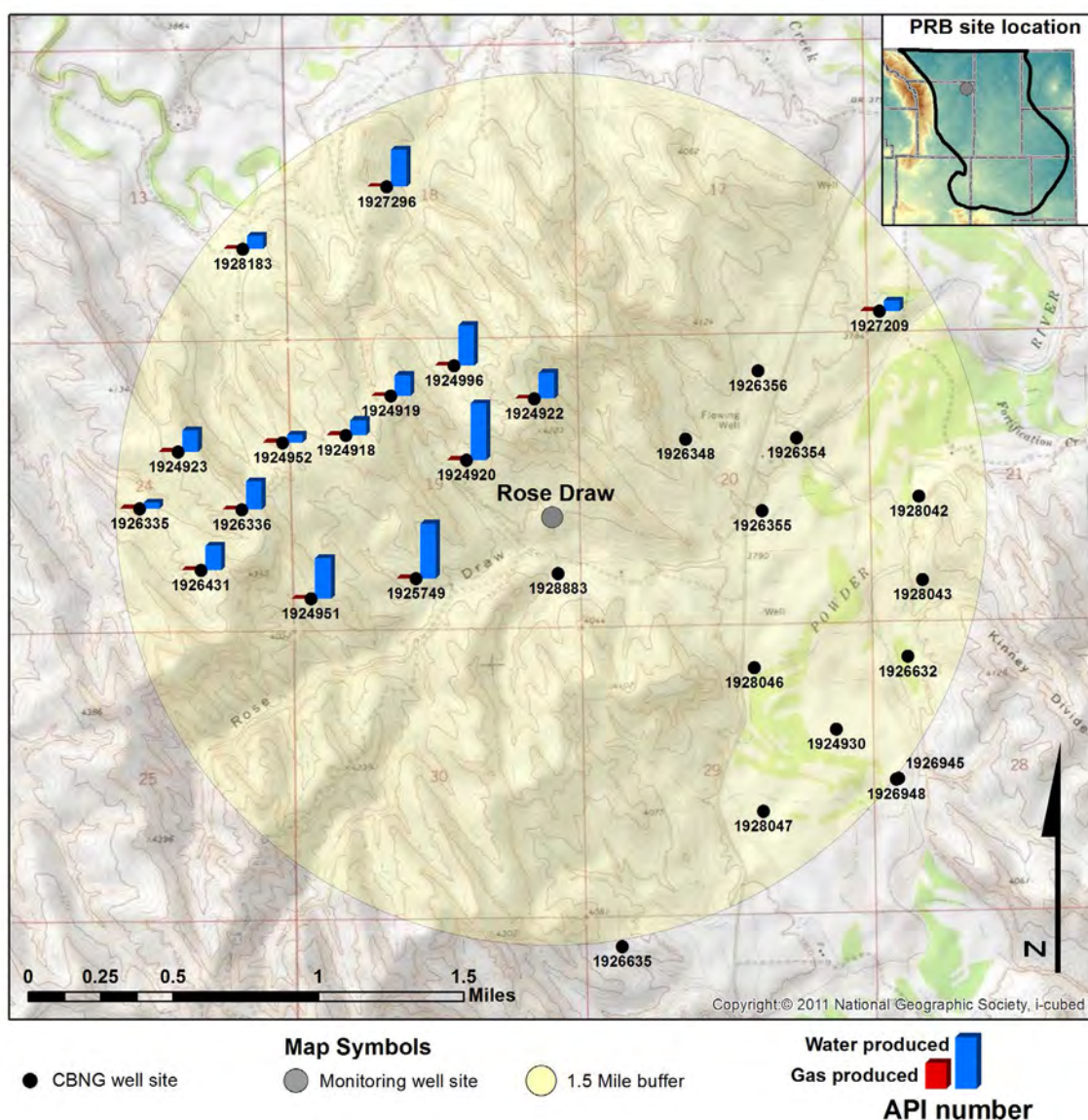
Production data were analyzed for CBNG wells within the buffer of the Rose Draw monitoring well site from 2005-2012. Cumulative production for individual CBNG wells is displayed by location on Figure A.200. CBNG production is monitored in the Wall coal zone. Additionally, in this area gas and water are produced from wells completed in multiple coal zones or in coal zones where gas and

water production are monitored but groundwater levels are not (unmonitored coal zones).

The Wall coal zone produced water consistently from December 2009 to late 2012. Water production reached its maximum at 124,019 Mcf in April 2010 (Figure A.201). Locally, gas production in the Wall zone has been low and intermittent, never exceeding 50 Mcf /month.



**Figure A.199.** Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Rose Draw monitoring wellsite location.

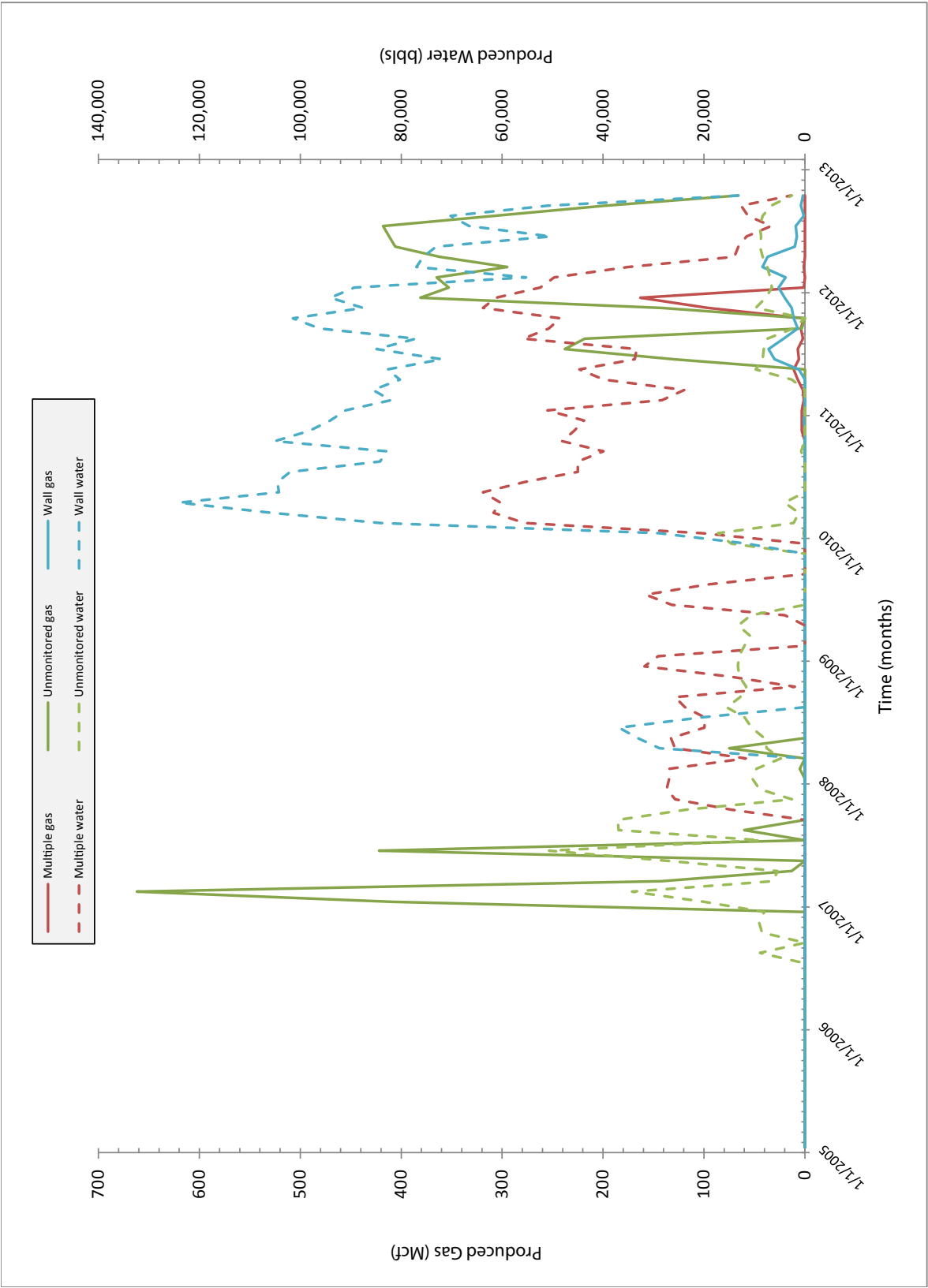


**Figure A.200.** Rose Draw monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

Multiple coal zone wells produced water from October 2007 into late 2012. Water production peaked at 63,803 bbls in May 2010 (Figure A.201). Locally, gas production in the multiple zones has been low and intermittent, never exceeding 200 Mcf a month.

Unmonitored coal zones produced water intermittently from August 2006 and into 2012, peaking at 50,700 bbls in June 2007 (Figure A.201). Gas

production in the unmonitored coal zones has not exceeded 700 Mcf/month over the life of the well, and has experienced low intermittent levels of gas production.



**Figure A.201.** Water and gas production from CBNG wells associated with the Rose Draw monitoring well site location.

**Sasquatch Monitoring Well Site**  
**Location: S12 T48N R77W**  
**Date First Monitored: January 14, 1998**

**Drawdown Information**

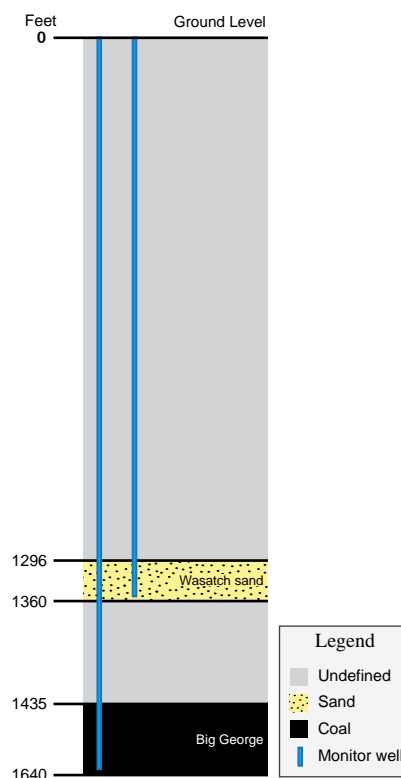
The Sasquatch monitoring well site includes two wells. One is completed in a Wasatch sandstone and the other in the Big George coal of the Wyodak Rider coal zone (Figure A.202; Table A.100). Water levels and wellhead gas pressures were measured during the POR using both manual and automatic transducer and data logger equipment. Transducer data that is missing, randomly fluctuating (noisy) or that substantially differs from concurrent manual measurements may indicate on-site equipment failure, malfunction or requirement for calibration.

**Wasatch Sandstone**

Groundwater levels declined 66.83 feet during the 2010-2012 POR and 269.37 feet over the monitoring period of 1998-2009 (Figure A.203; Table A.101). Gas pressure was not recorded in the Wasatch sandstone.

**Big George Coal**

Groundwater levels declined 50.91 feet during the 2010-2012 POR and 449.67 feet over the monitoring period of 1998-2009 (Figure A.203; Table A.101). Gas pressure in the Big George remained relatively stable over the life of the well.



**Figure A.202.** Section showing relative positions of coals and sands in feet. Not to scale.

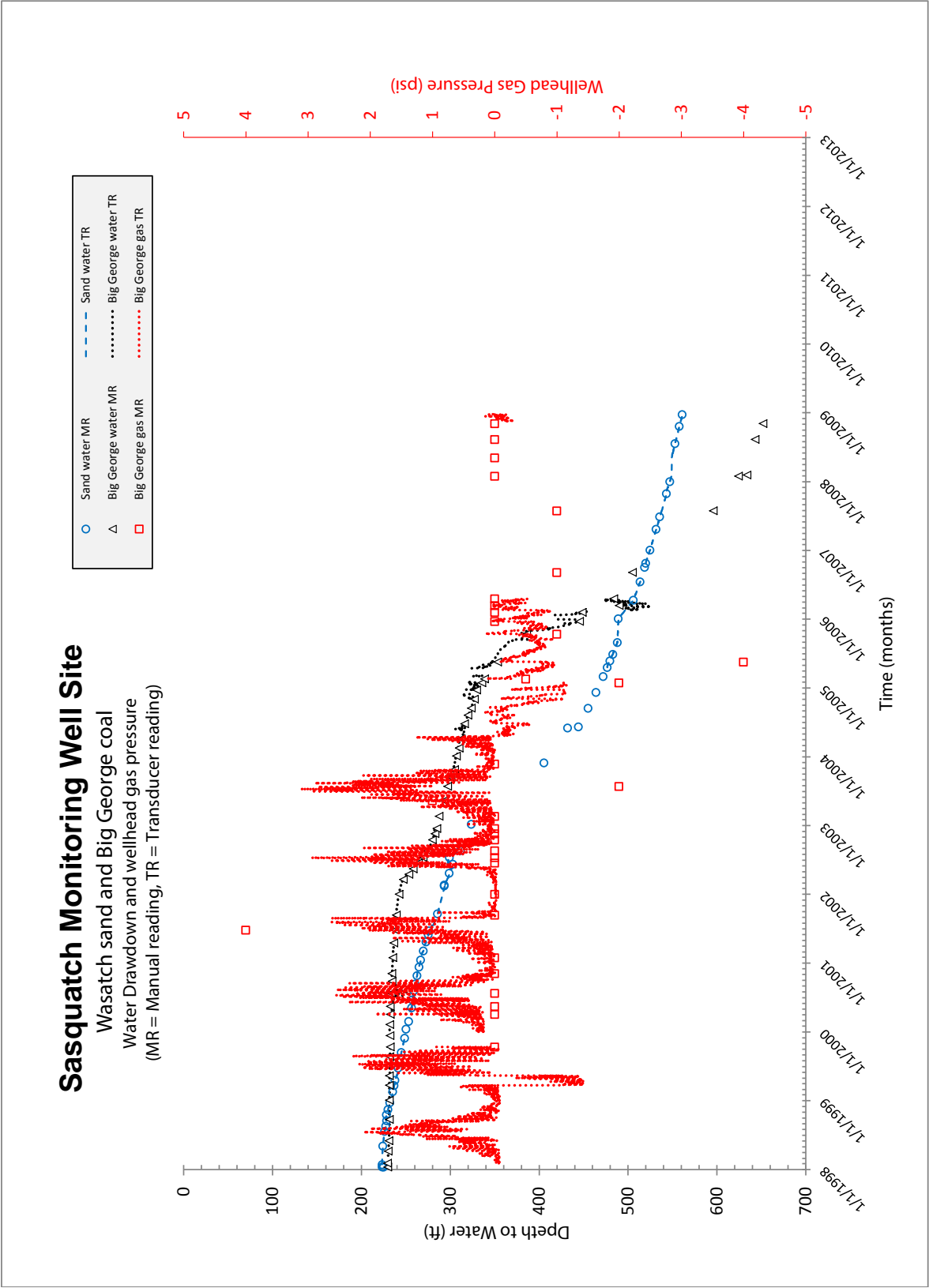
**Table A.100.** Table showing the depth to and thickness of monitored zones at the Sasquatch monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Wasatch sand	1,296	1,360	64	75
Big George coal	1,435	1,640	205	n/a

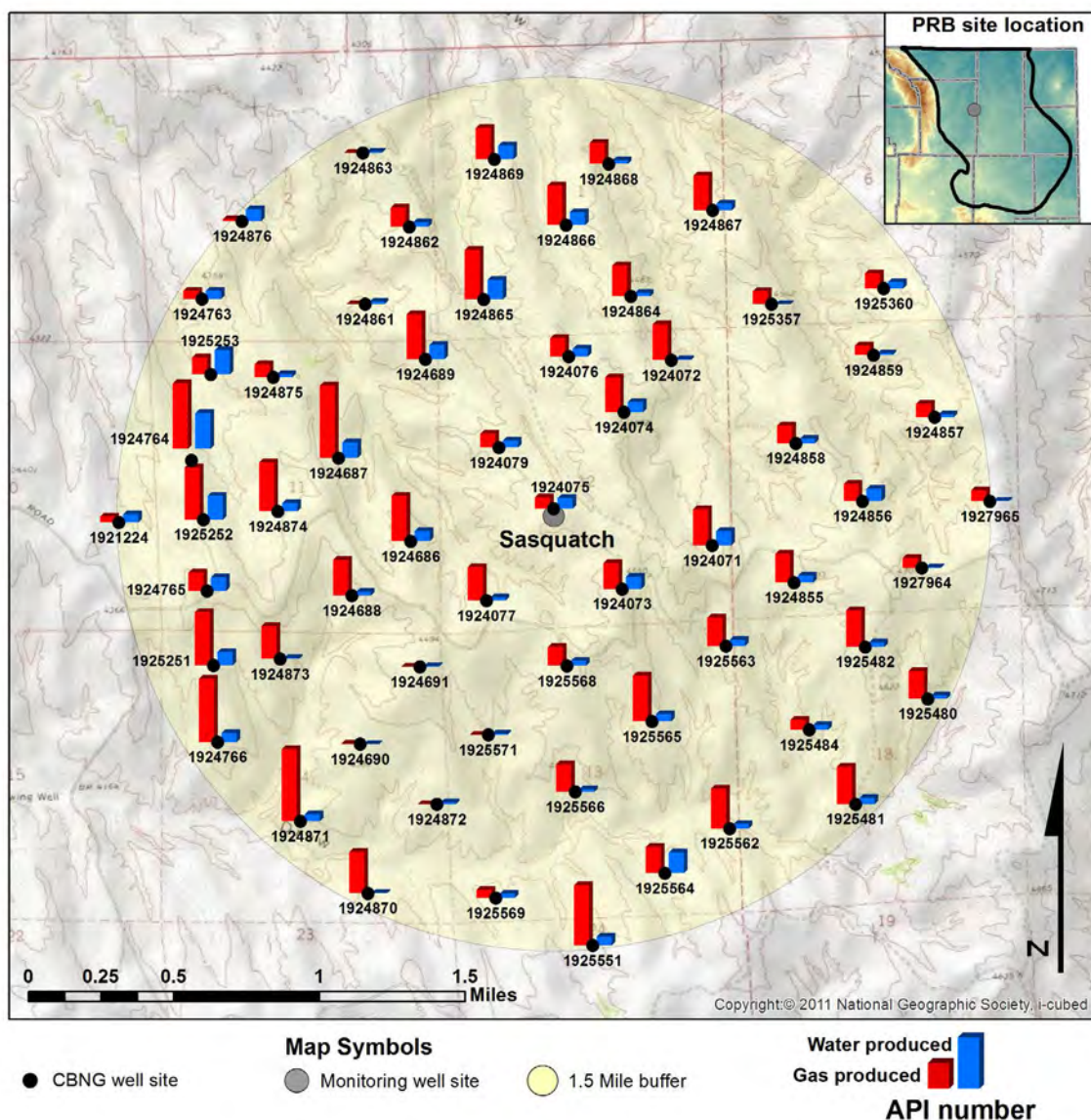
**Table A.101.** Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2010	Drawdown 2010-2012	Total drawdown (ft.)	Depth to Final water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	224.98	269.37	66.83	336.20	561.18	n/a	n/a
Big George coal	229.76	449.67	50.91	500.58	730.34	3.12	7/13/2003





**Figure A.203.** Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Sasquatch monitoring wellsite location



**Figure A.204.** Sasquatch monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

### Production Statistics

Production data were analyzed for CBNG wells within the buffer of the Sasquatch monitoring well site from 2001-2012. Cumulative production for individual CBNG wells is displayed by location on Figure A.204. CBNG production is monitored in the Wyodak Rider, in which all local CBNG production occurs.

The Wyodak Rider has consistently produced water and gas from early 2002-2012. Water production peaked in June 2005 at 790,079 bbls and then decreased to under 40,000 bbls/month from 2008-2012 (Figure A.205). Gas production in the Wyodak Rider coal zone was low and intermittent from 2002-2005, then rapidly started to increase in early 2005 to a peak monthly production level in January 2007 of 992,930 Mcf, and gradually decreased to below 100,000 Mcf/month in 2012.

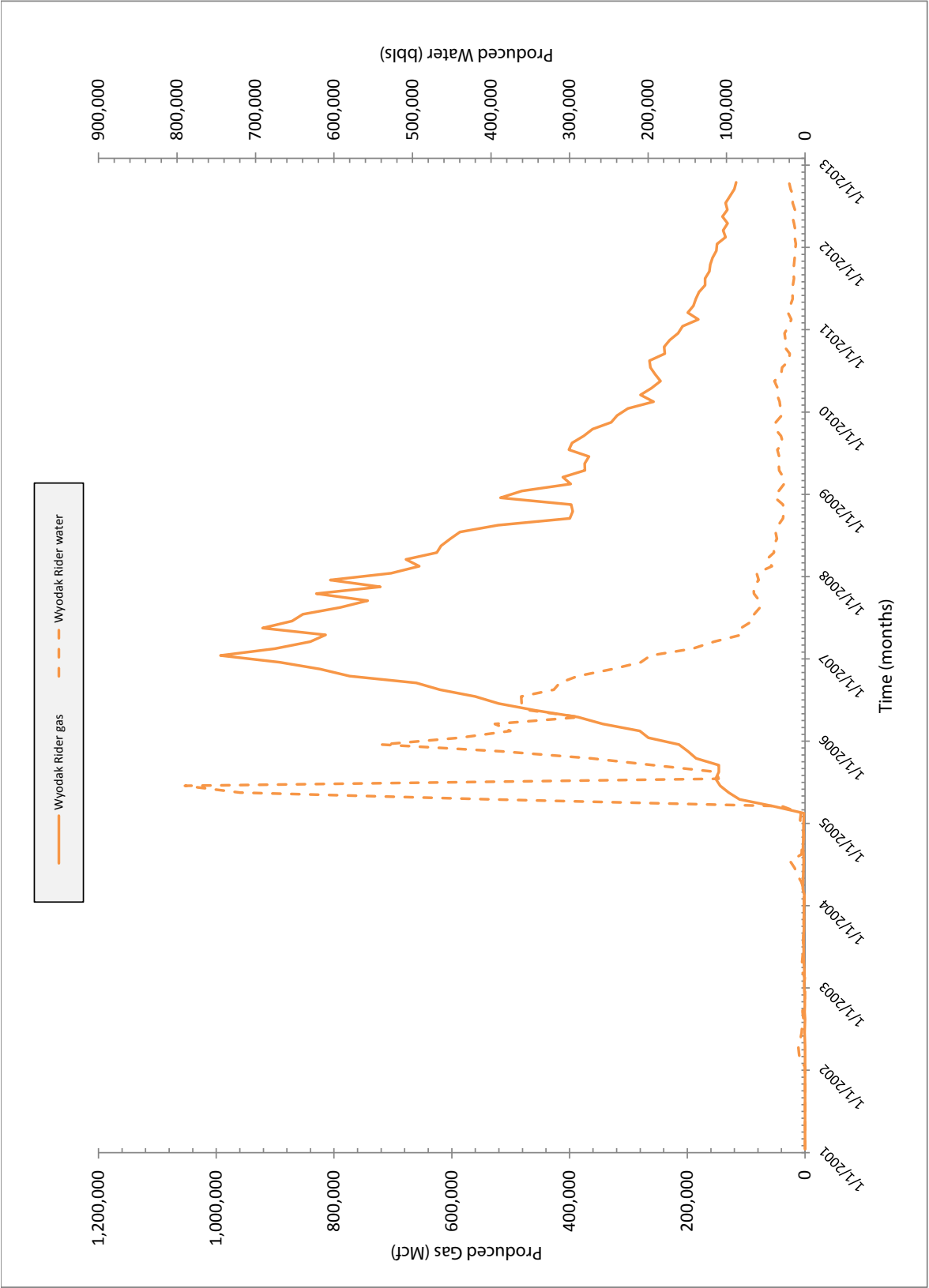


Figure A.205. Water and gas production from CBNG wells associated with the Sasquatch monitoring well site location.

**Sec 25 Monitoring Well Site**  
**Location: S25 T46N R72W**  
**Date First Monitored: November 9, 1996**

**Drawdown Information**

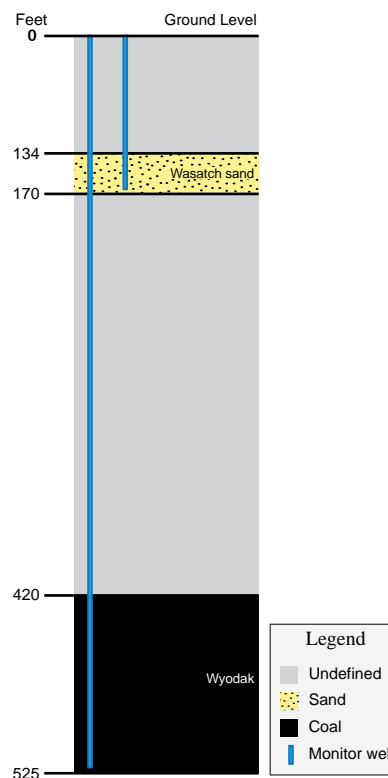
The Sec 25 monitoring well site includes two wells. One is completed in a Wasatch sandstone and the other in the Wyodak coal of the Upper Wyodak coal zone (Figure A.206; Table A.102). Water levels and wellhead gas pressures were measured during the POR using both manual and automatic transducer and data logger equipment. Transducer data that is missing, randomly fluctuating (noisy) or that substantially differs from concurrent manual measurements may indicate on-site equipment failure, malfunction or requirement for calibration.

**Wasatch Sandstone**

Groundwater levels declined 3.02 feet during the 2010-2012 POR, and rose 0.36 feet during the monitoring period of 1996-2009 (Figure A.207; Table A.103). Gas pressure was not recorded in the Wasatch sandstone.

**Wyodak Coal**

Groundwater levels rose 16.57 feet during the 2010-2012 POR. In contrast, groundwater levels declined 394.69 feet during the monitoring period of 1996-2009 (Figure A.207; Table A.103). Gas pressure in the Wyodak coal peaked at 63.78 psi in January 2001.



**Figure A.206.** Section showing relative positions of coals and sands in feet. Not to scale.

**Table A.102.** Table showing the depth to and thickness of monitored zones at the Sec 25 monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Wasatch sand	134	170	36	250
Wyodak coal	420	525	105	n/a

**Table A.103.** Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

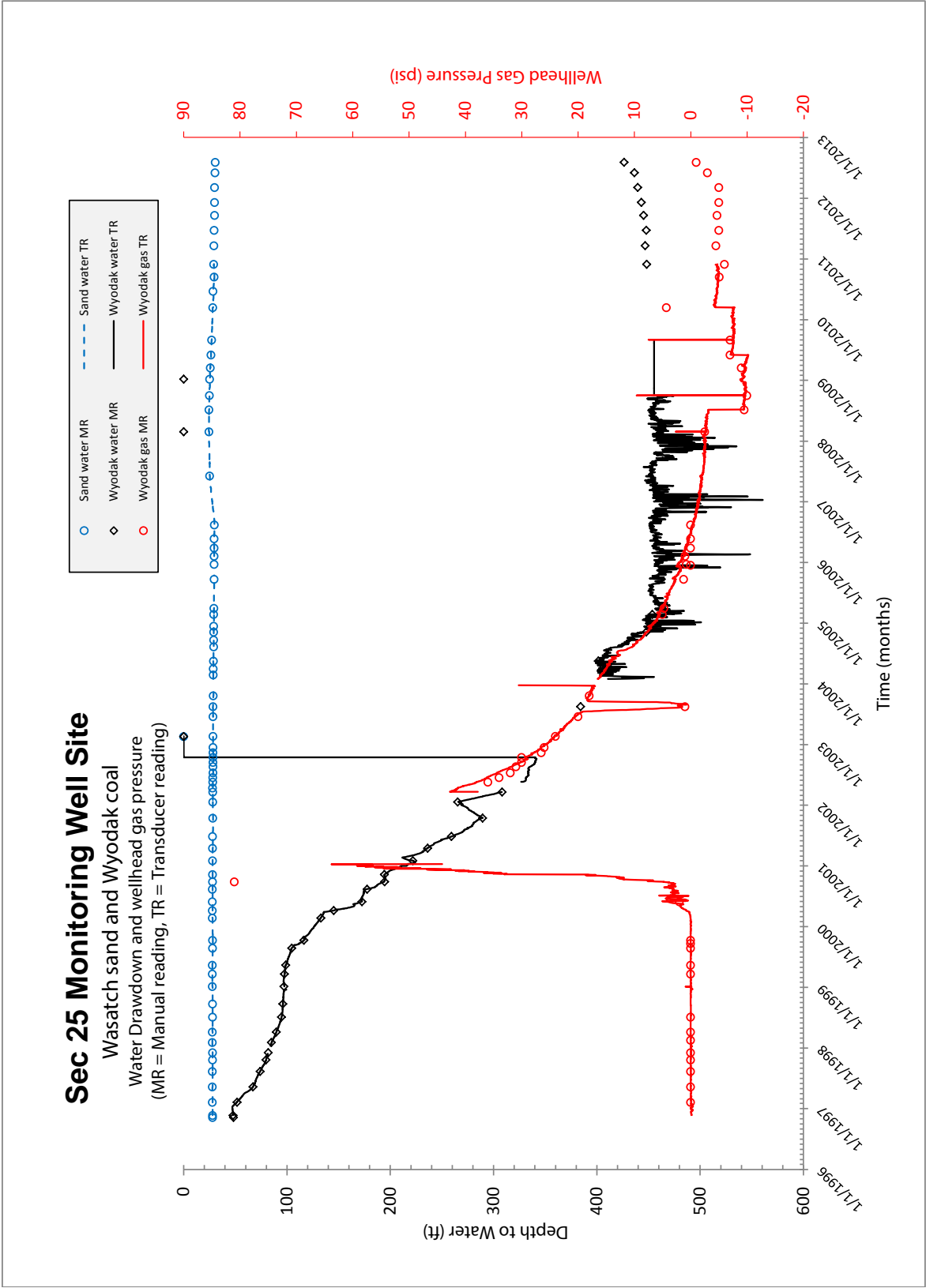
Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2010	Drawdown 2010-2012	Total drawdown (ft.)	Depth to Final water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	28.09	-0.36	3.02	2.66	30.75	n/a	n/a
Wyodak coal	48.31	394.69	-16.57	378.12	426.43	63.78	1/10/2001

### Production Statistics

Production data were analyzed for CBNG wells within the buffer of the Sec 25 monitoring well site from 1994-2012. Cumulative production for individual CBNG wells is displayed by location on Figure A.208. CBNG production is monitored in the Upper Wyodak coal zone, some production in

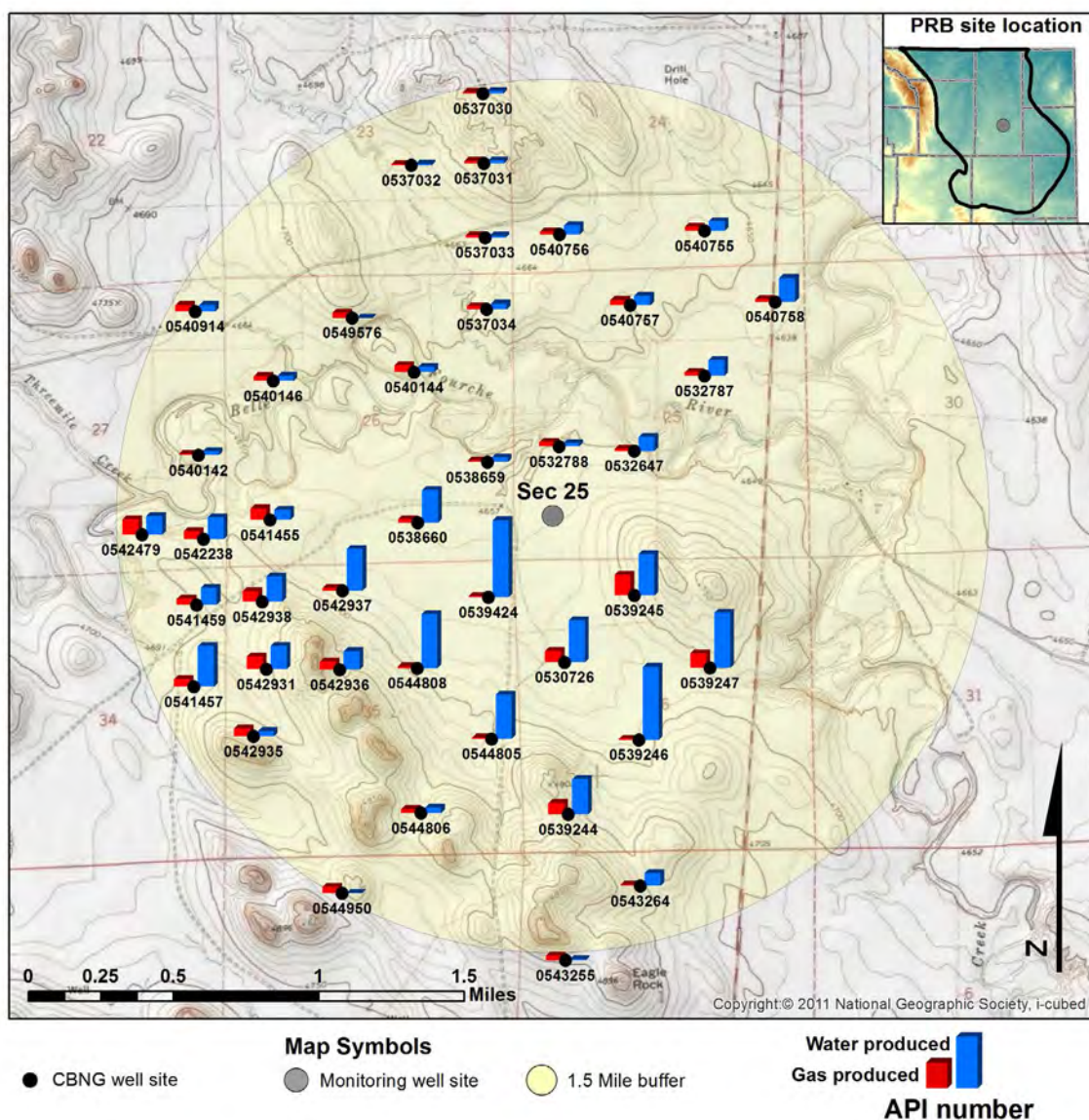
this area occurs in coal zones where water levels are not monitored (unmonitored zones).

The Upper Wyodak coal zone produced water and gas consistently during 1999-2012. Water production peaked in March 2007 at 536,697 bbls (Figure A.208). Gas production peaked in January 2002 at



**Figure A.207.** Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Sec 25 monitoring wellsite location.



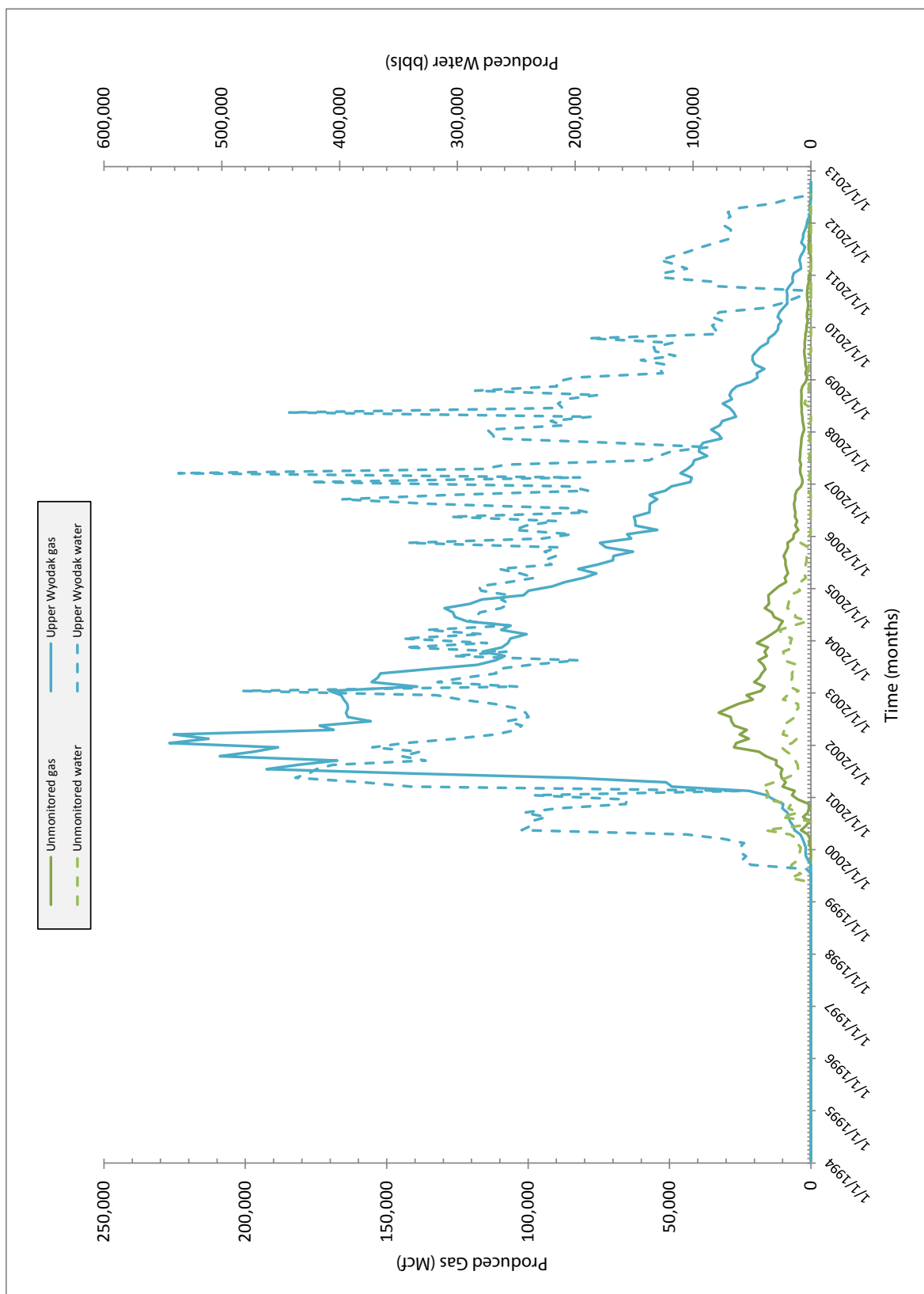


**Figure A.208.** Sec 25 monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

225,323 Mcf. No water or gas was produced from July - October 2012.

The unmonitored coal zones produced low levels of water from 1999-2012, never exceeding 40,000 bbls/month (Figure A.209). Gas production in the unmonitored coal zones gradually increased from 2000 to its peak in August 2002 of 32,613 Mcf, then decreased to zero by the end of the 2010-2012 POR.





**Figure A.209.** Water and gas production from CBNG wells associated with the Sec 25 monitoring well site location.

# **South Coal Monitoring Well Site** **Location: S13 T57N R75W** **Date First Monitored: September 18, 2001**

## **Drawdown Information**

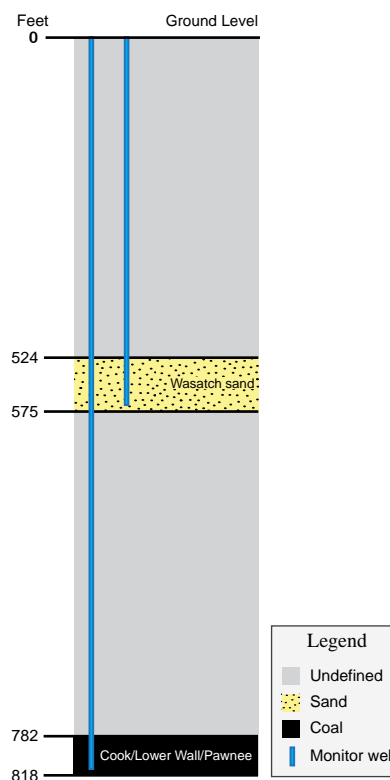
The South Coal monitoring well site includes two wells. One is completed in a Wasatch sandstone and the other in the Cook/Lower Wall/Pawnee coal of the Wall coal zone (Figure A.210; Table A.104). Water levels and wellhead gas pressures were measured during the POR using both manual and automatic transducer and data logger equipment. Transducer data that is missing, randomly fluctuating (noisy) or that substantially differs from concurrent manual measurements may indicate on-site equipment failure, malfunction or requirement for calibration.

## **Wasatch Sandstone**

Groundwater levels rose 0.22 feet during the 2010-2012 POR but declined by 1.60 feet over the monitoring period of 2001-2009 (Figure A.211; Table A.105). Gas pressure was not recorded in the Wasatch sandstone.

## **Cook/Lower Wall/Pawnee Coal**

Groundwater levels declined 0.08 feet during the 2010-2012 POR and 42.95 feet over the monitoring period of 2001-2009. (Figure A.211; Table A.105). Gas pressure in the Cook/Lower Wall/Pawnee coal reached a maximum of 12.71 psi in November 2004.



**Figure A.210.** Section showing relative positions of coals and sands in feet. Not to scale.

**Table A.104.** Table showing the depth to and thickness of monitored zones at the South Coal monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Wasatch sand	524	575	51	207
Cook/Lower Wall/Pawnee coal	782	818	36	n/a

**Table A.105.** Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

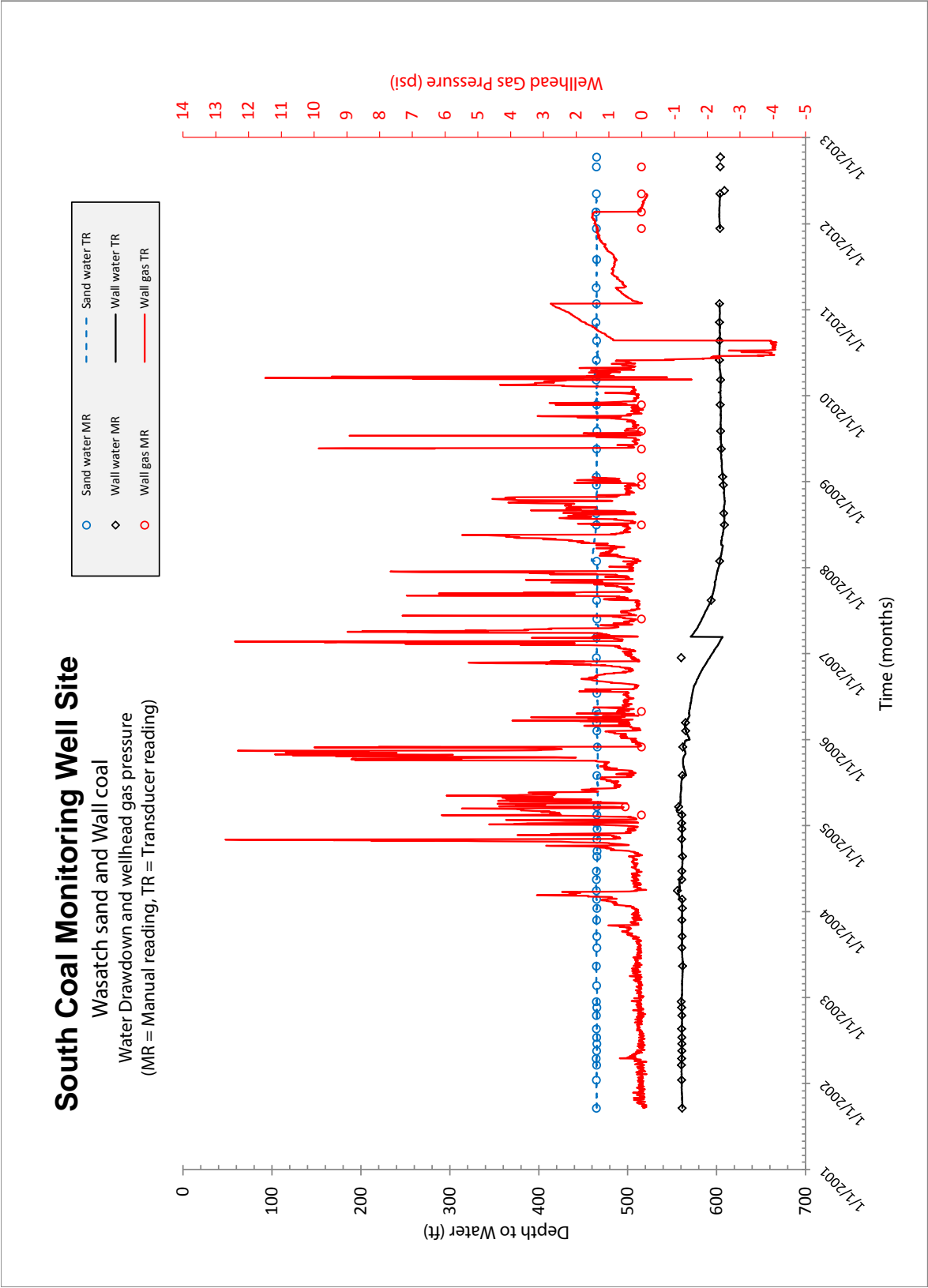
Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2010	Drawdown 2010-2012	Total drawdown (ft.)	Depth to Final water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	463.85	1.60	-0.22	1.38	465.23	n/a	n/a
Cook/Lower Wall/Pawnee coal	561.37	42.95	0.08	43.03	604.40	12.71	11/2/2004

### Production Statistics

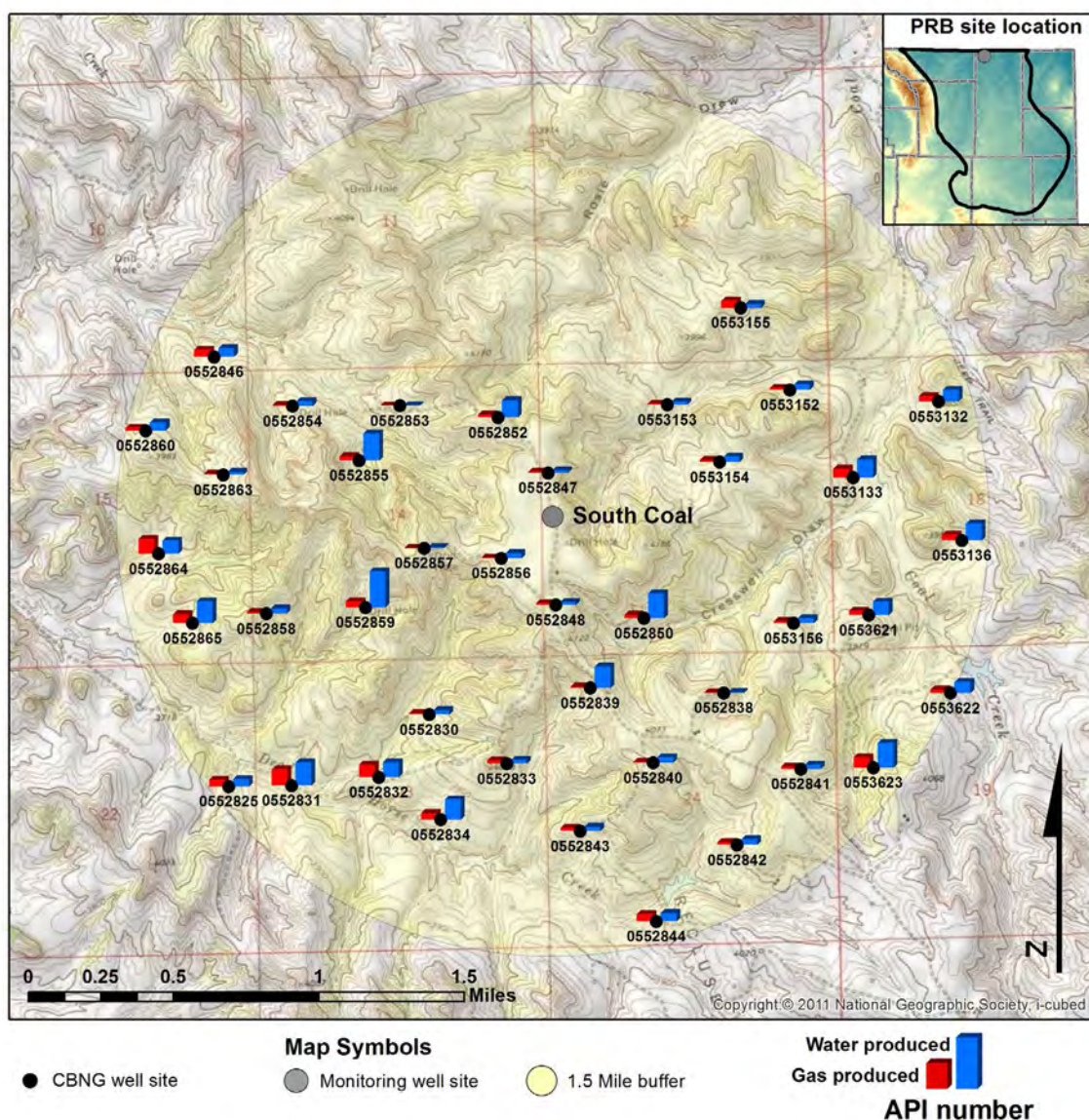
Production data were analyzed for CBNG wells within the buffer of the South Coal monitoring well site from 2005-2012. Cumulative production for individual CBNG wells is displayed by location on Figure A.212. CBNG production is monitored in the Wall coal zone, some production in this area

occurs in multiple production coal zones or coal zones where water levels are not monitored (un-monitored zones).

The Wall coal zone produced water from May 2005 - September 2009. Water production peaked at 25,565 bbls in September 2007 then decreased



**Figure A.211.** Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the South Coal monitoring wellsite location.



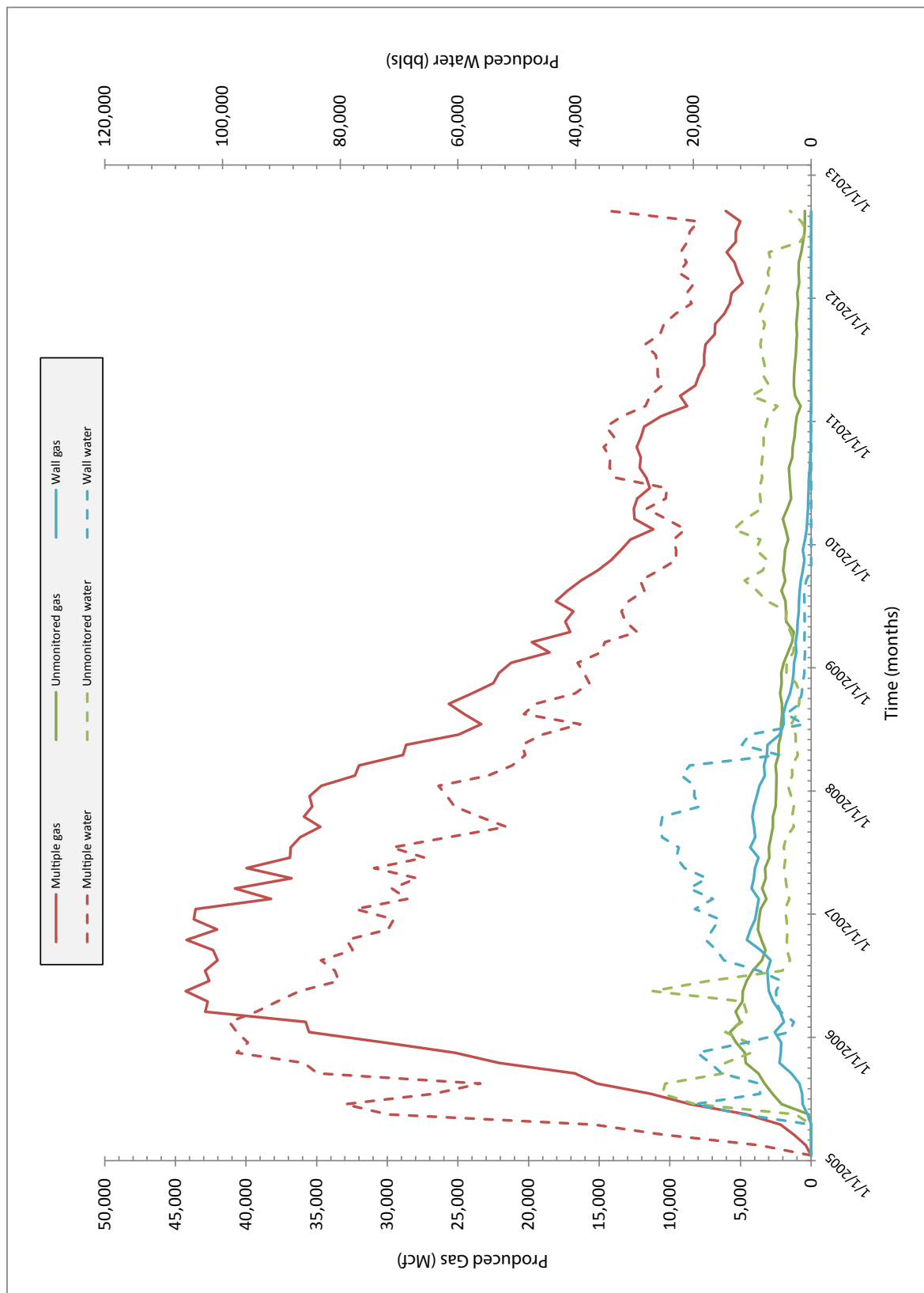
**Figure A.212.** South Coal monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

to zero by the end of 2009 (Figure A.213). Gas production reached its maximum level in October 2006 at 4,548 Mcf, and gradually declined to zero by January 2011.

Water production in multiple coal zone wells peaked at 98,830 bbls in February 2006 and ended 2012 at 34,248 bbls/month (Figure A.213). Gas was produced from 2005-2012 peaking in May

2006 at 44,274 Mcf and gradually declined to 6,037 Mcf/month in late 2012.

Unmonitored coal zone wells produced water at a maximum level of 26,904 bbls in May 2006, and then declined to a low, relatively constant production thereafter (Figure A.213). Gas production has been relatively low peaking at 5,737 Mcf in January 2006 and ending 2012 at 445 Mcf/month.



**Figure A.213.** Water and gas production from CBNG wells associated with the South Coal monitoring well site location.

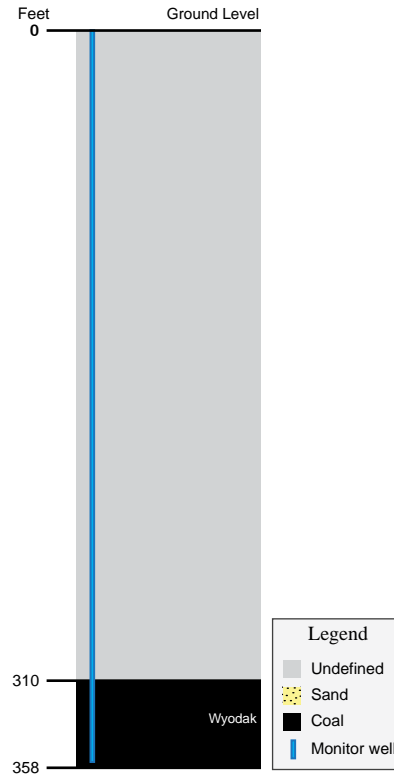
**South Cordero Monitoring Well Site**  
**Location: S6 T46N R71W**  
**Date First Monitored: May 21, 1995**

**Drawdown Information**

The South Cordero monitoring well site includes one well completed in the Wyodak coal of the Upper Wyodak coal zone (Figure A.214; Table A.106). Water levels and wellhead gas pressures were measured during the POR using both manual and automatic transducer and data logger equipment. Transducer data that is missing, randomly fluctuating (noisy) or that substantially differs from concurrent manual measurements may indicate on-site equipment failure, malfunction or requirement for calibration.

**Wyodak Coal**

Groundwater levels rose 0.42 feet during the 2010-2012 POR but declined 198.47 feet over the monitoring period of 1995-2009 (Figure A.215; Table A.107). Gas pressure in the Wyodak coal has varied considerably over the life of the well, from less than 0 psi to 55.28 psi in March 1997.



**Figure A.214.** Section showing relative positions of coals and sands in feet. Not to scale.



**Table A.106.** Table showing the depth to and thickness of monitored zones at the South Cordero monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Wyodak coal	310	358	48	n/a

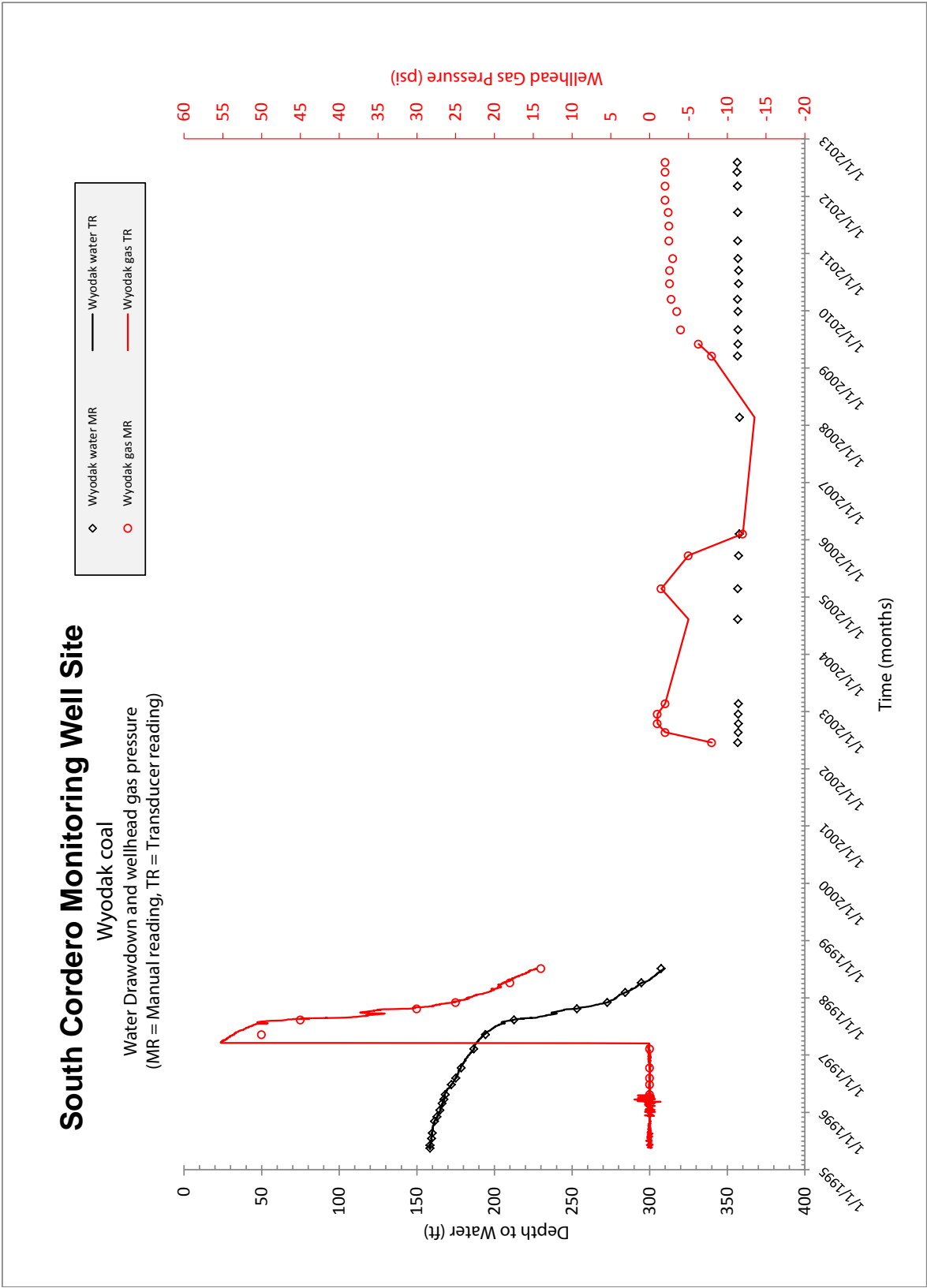
**Table A.107.** Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2010	Drawdown 2010-2012	Total drawdown (ft.)	Depth to Final water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wyodak coal	158.50	198.47	-0.42	198.05	356.55	55.28	3/21/97

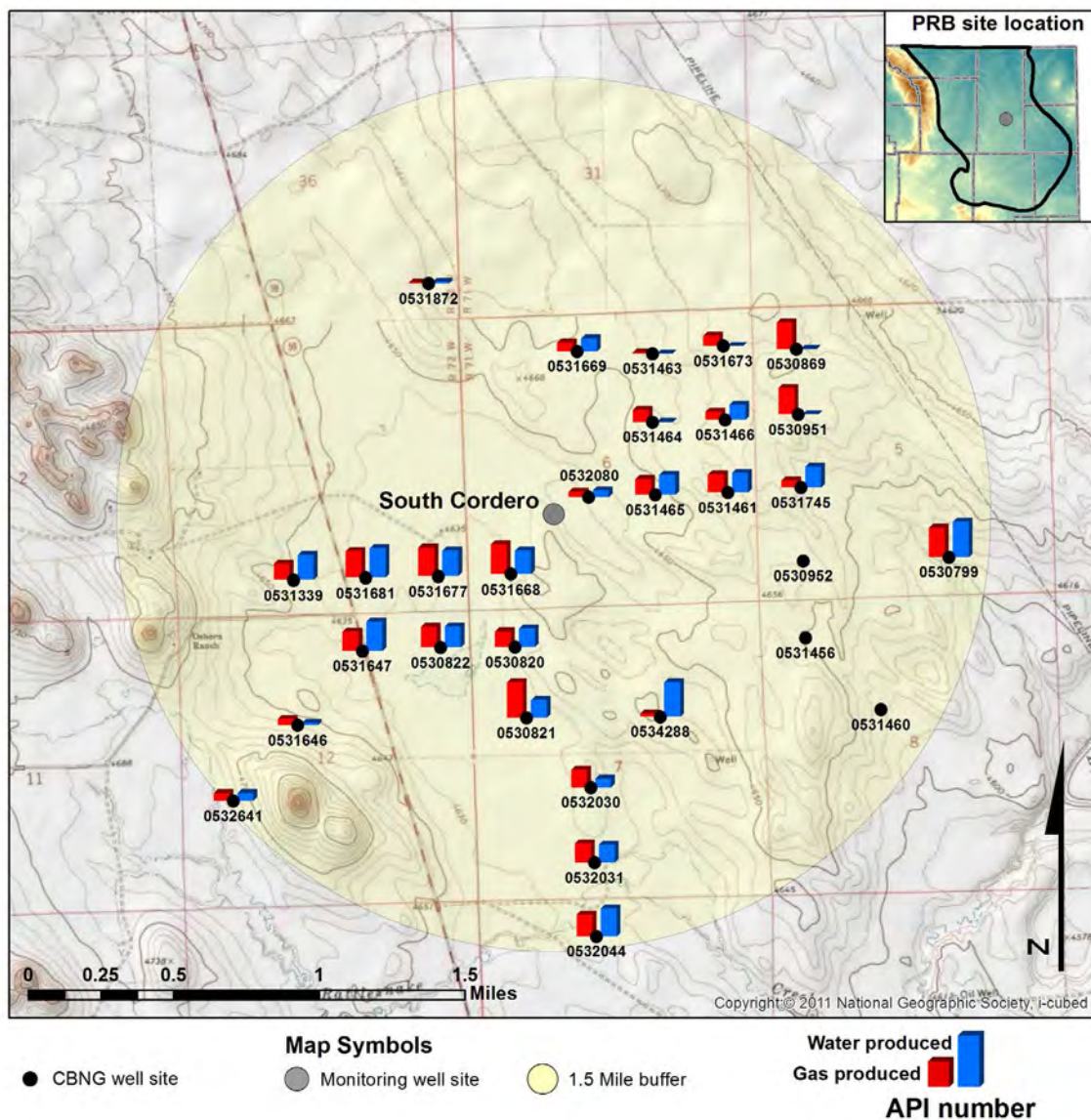
### Production Statistics

Production data were analyzed for CBNG wells within the buffer of the South Cordero monitoring well site from 1996-2012. Cumulative production for individual CBNG wells is displayed by location on Figure A.216. CBNG production is monitored in the Upper Wyodak coal zone and some production in this area occurs in coal zones where water levels are not monitored (unmonitored zones).

The Upper Wyodak coal zone began producing water consistently in early 1997. Water production peaked at 277,869 bbls in September 1997, and then rapidly declined to end 2012 at 0 bbls/month (Figure A.217). Gas was initially produced in the absence of water production until March 1997. Gas production rates increased rapidly when water production began, and peaked at 143,260 Mcf in January 1998, and then decreased to zero by July 2012.



**Figure A.215.** Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the South Cordero monitoring wellsite location.



**Figure A.216.** South Cordero monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

Unknown coal zone wells produced low volumes of water that never exceeded 7,000 bbls/month from 1997-1998, (Figure A.217). Gas production peaked in May 1997 at 49,860 Mcf and continued in the absence of water production after April 1998, and ceased in February 2008.

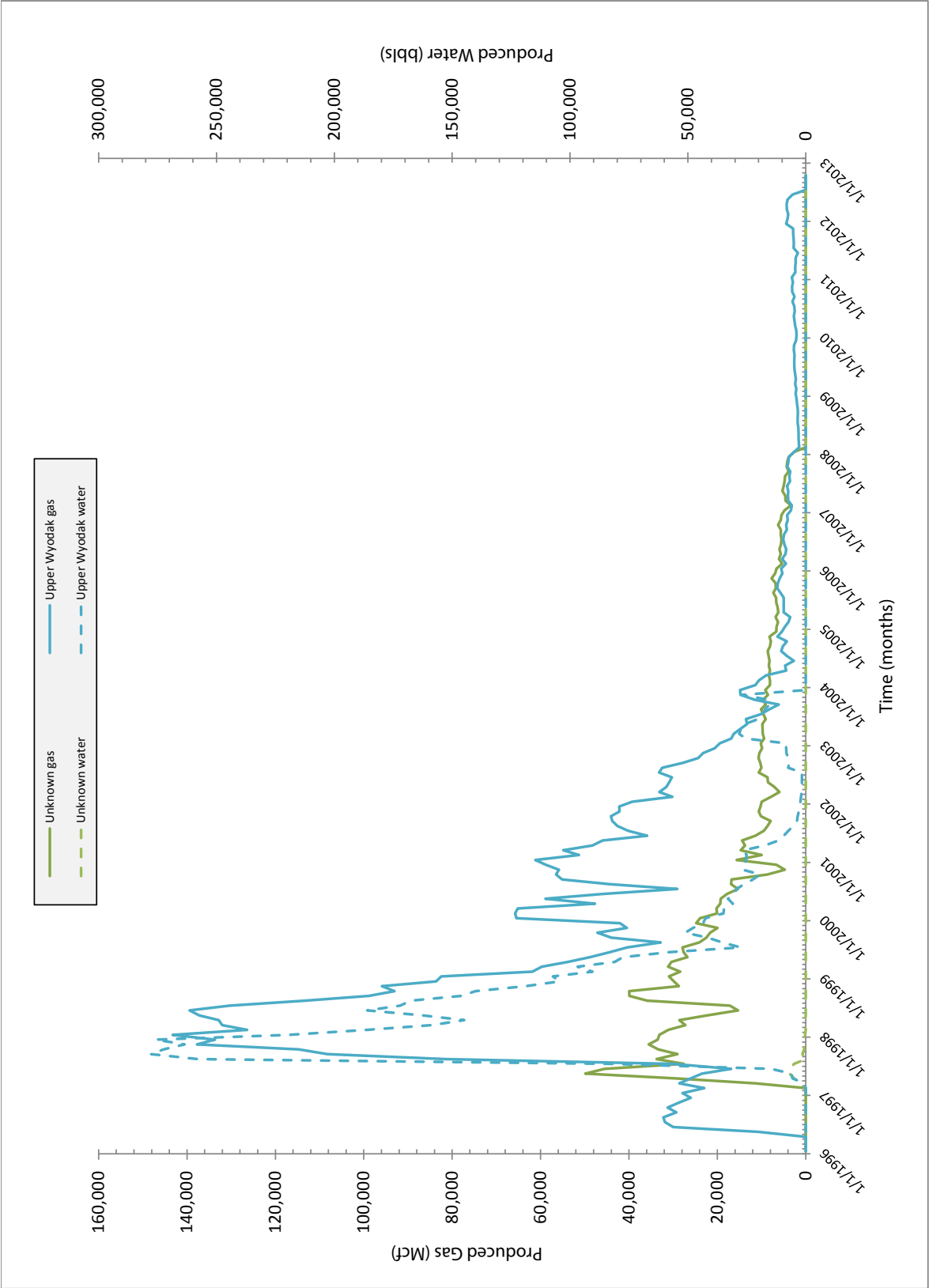


Figure A.217. Water and gas production from CBNG wells associated with the South Cordero monitoring well site location.

# **South Prong Monitoring Well Site** **Location: S26 T49N R76W** **Date First Monitored: January 1, 2008**

## **Drawdown Information**

The South Prong monitoring well site includes two wells, separated by packers, and completed into four zones. The first well is completed in a Wasatch sandstone and the Big George coal of the Wyodak Rider coal zone. The second well is completed in the Gates/Wall coal of the Cook and Wall coal zones and in a Fort Union underburden sandstone (Figure A.218; Table A.108). Water levels and wellhead gas pressures were measured during the POR using both manual and automatic transducer and data logger equipment. Transducer data that is missing, randomly fluctuating (noisy) or that substantially differs from concurrent manual measurements may indicate on-site equipment failure, malfunction or requirement for calibration.

## **Wasatch Sandstone**

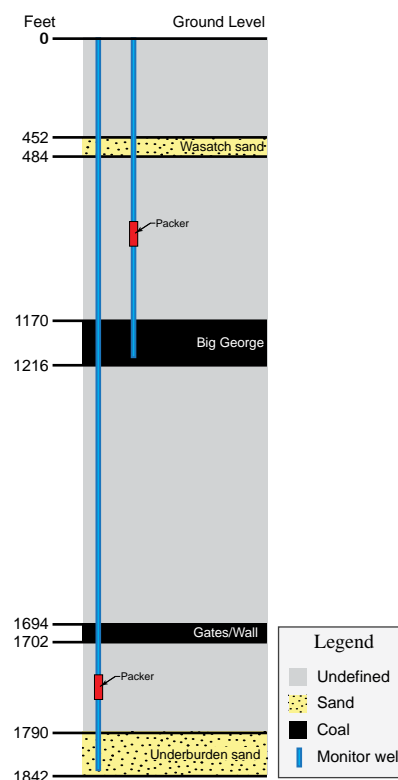
Groundwater levels rose 3.06 feet during the 2010-2012 POR and 1.65 feet over the monitoring period of 2008-2009 (Figure A.219; Table A.109). Gas pressure was not recorded in the Wasatch sandstone.

## **Big George Coal**

Groundwater levels declined 392.64 feet during the 2010-2012 POR and 207.45 feet over the monitoring period of 2008-2009 (Figure A.219; Table A.109). Gas pressure in the Big George remained near zero psi over the monitoring period of 2008-2012.

## **Gates/Wall Coal**

Groundwater levels declined 447.40 feet during the 2010-2012 POR and 0.00 feet over the monitoring period of 2008-2009 (Figure A.220; Table A.109). Gas pressure in the Gates/Wall coal remained near zero psi over the monitoring period of 2008-2012.



**Figure A.218.** Section showing relative positions of coals and sands in feet. Not to scale.

## **Fort Union Underburden Sand**

Groundwater levels declined 419.52 feet during the 2010-2012 POR and 2.4 feet over the monitoring period of 2008-2009 (Figure A.220; Table A.109). Gas pressure was not recorded in the underburden sandstone over this period.

**Table A.108.** Table showing the depth to and thickness of monitored zones at the South Prong monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Wasatch sand	452	484	32	686
Big George coal	1,170	1,216	46	n/a
Gates/Wall coal	1,694	1,702	8	n/a
Underburden sand	1,790	1,842	52	88

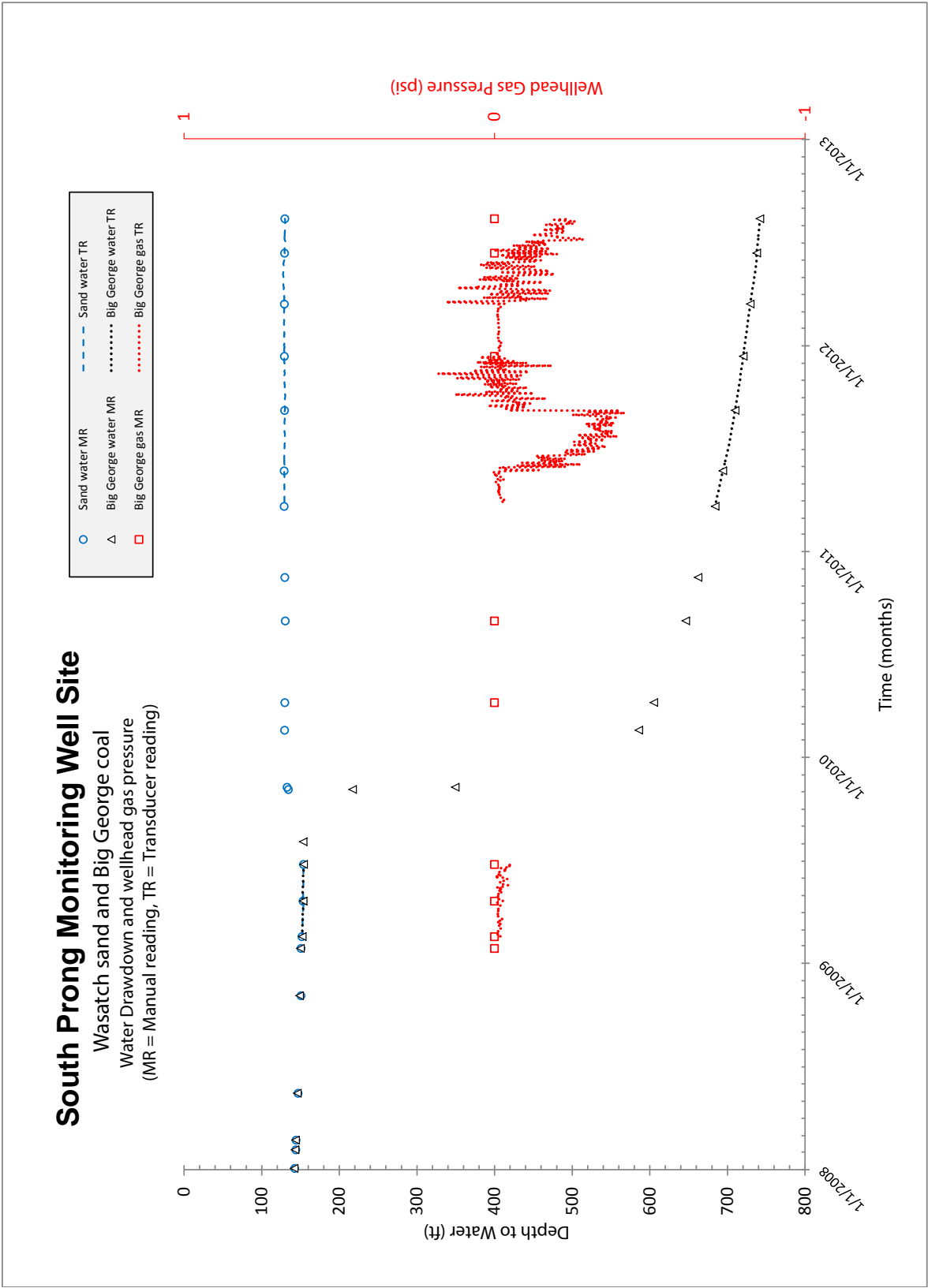
**Table A.109.** Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2010	Drawdown 2010-2012	Total drawdown (ft.)	Depth to Final water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	134.70	-1.65	-3.06	-4.71	129.99	n/a	n/a
Big George coal	141.95	207.45	392.64	600.09	742.04	0.18	11/12/2011
Gates/Wall coal	543.00	0.00	447.40	447.40	990.40	0.17	11/12/2011
Underburden sand	254.20	2.40	419.52	421.92	676.12	n/a	n/a

### Production Statistics

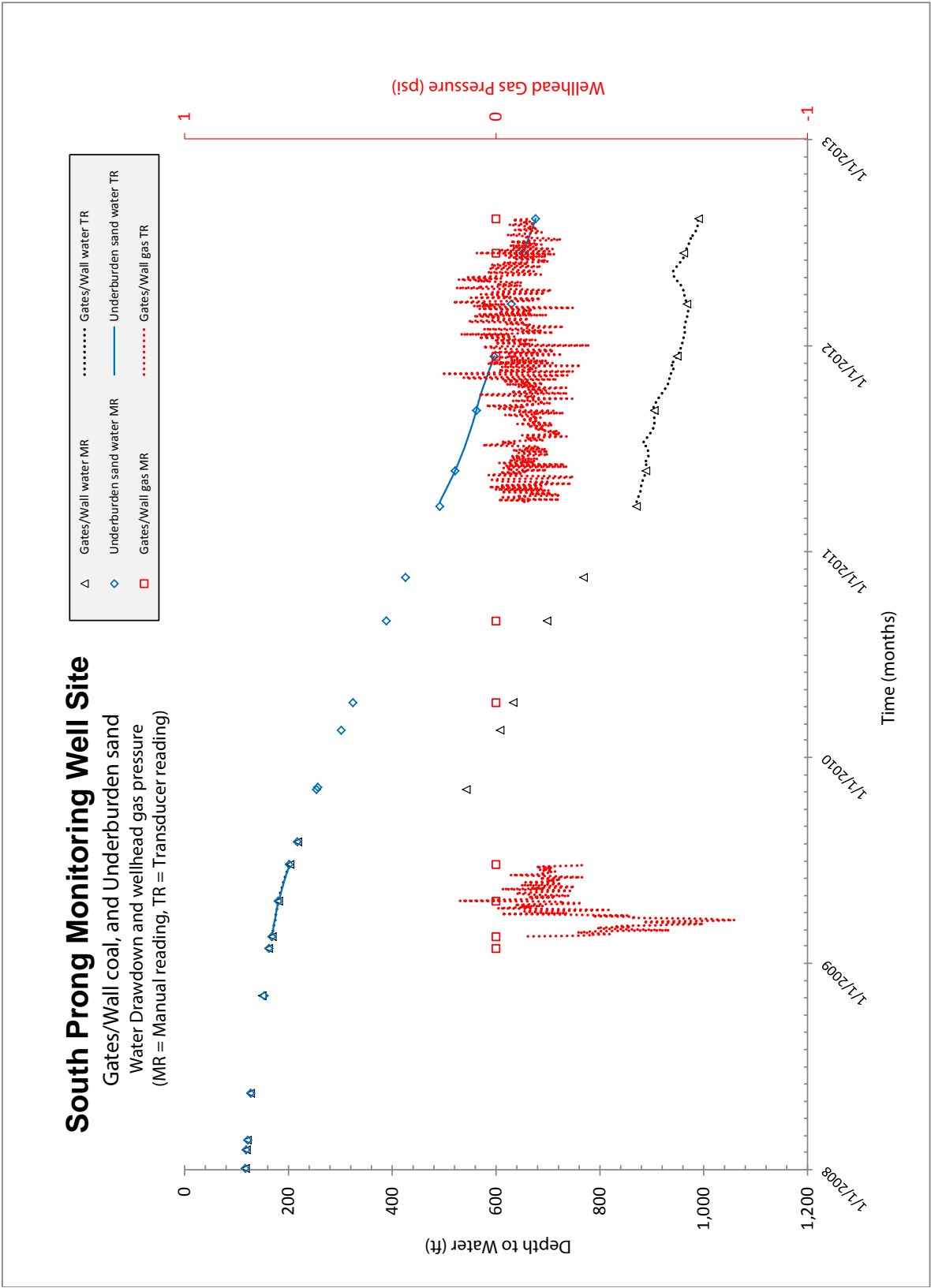
Production data were analyzed for CBNG wells within the buffer of the South Prong monitoring well site from 1999-2012. Cumulative production for individual CBNG wells is displayed by location on Figure A.221. CBNG production is monitored in the Wyodak Rider coal zone and some production in this area occurs in multiple production coal zones or coal zones where water levels are not monitored (unmonitored zones).

The Wyodak Rider began producing water consistently in July 2005. Water production peaked in January 2008 at 439,389 bbls (Figure A.222). Gas production in the Wyodak Rider began in July 2007 and peaked in December 2008 at 252,668 Mcf then decreased to 126,226 Mcf/month by the end of the 2010-2012 POR.

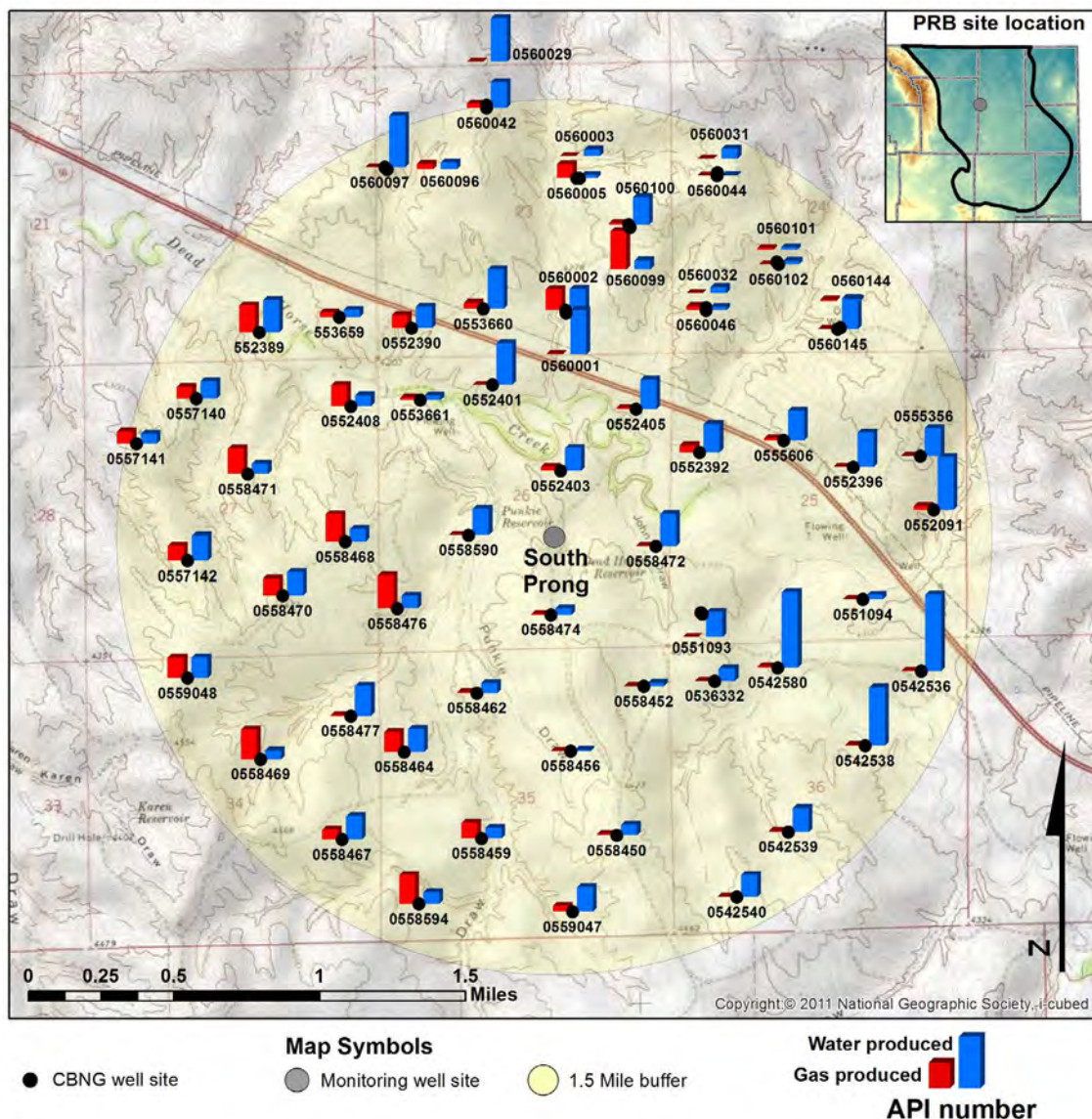


**Figure A.219.** Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the South Prong monitoring wellsite location.





**Figure A.220.** Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the South Prong monitoring wellsite location.

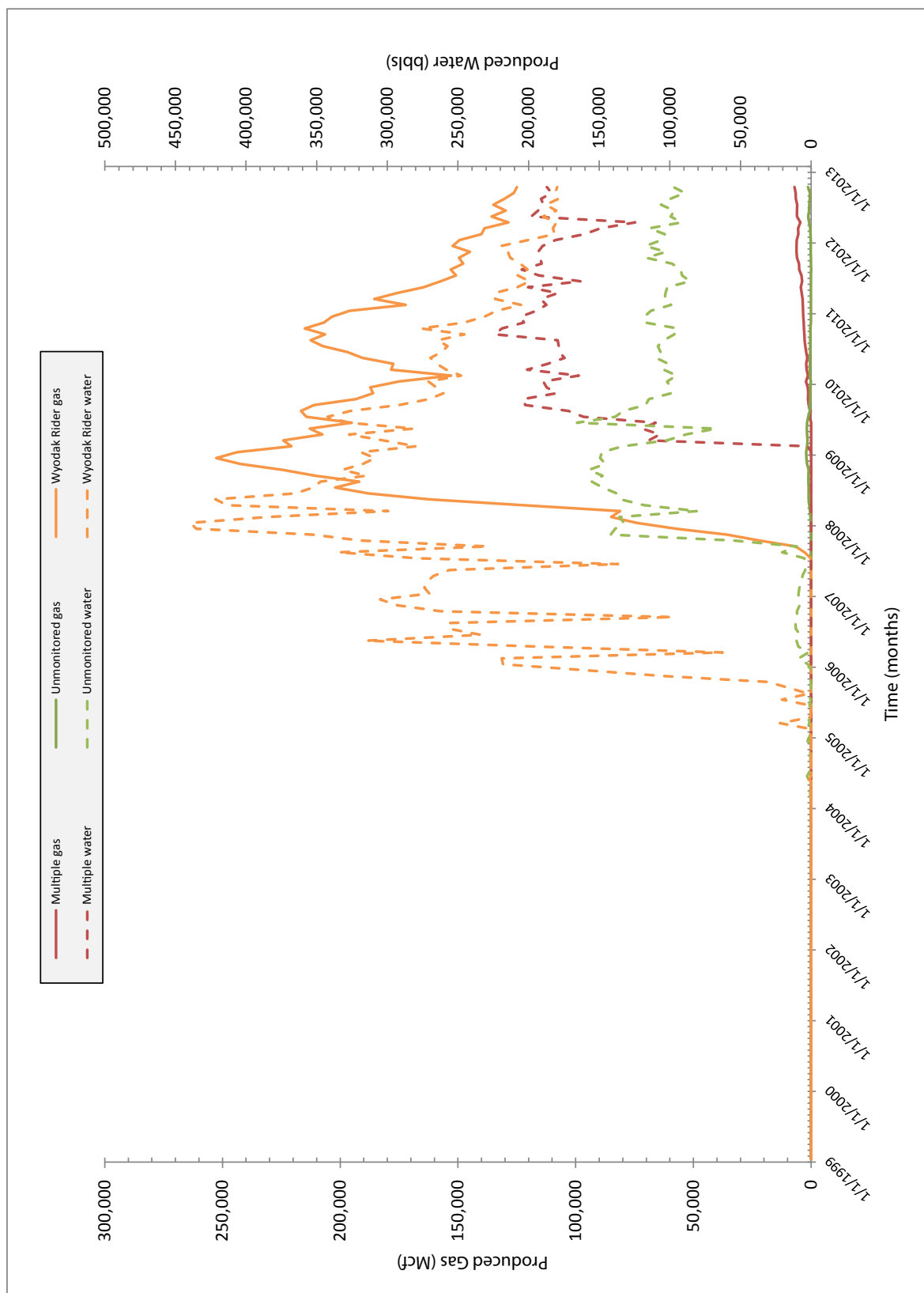


**Figure A.221.** South Prong monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

Water production in multiple coal zone wells began in 2009, rapidly increased to a peak production of 223,975 bbls in September 2010, and has averaged about 175,00 bbls/month in 2012 (Figure A.222). Locally, gas production has been low but increasing and finished 2012 at 7,091 Mcf/month.

Gas production in the unmonitored coal zones has been low and constant from 2007-2012 at a monthly rate between 38 and 2,116 Mcf.

The unmonitored coal zones began producing water in 2004. Water production peaked at 165,675 bbls in June 2009 and finished 2012 at 97,530 bbls



**Figure A.222.** Water and gas production from CBNG wells associated with the South Prong monitoring well site location.

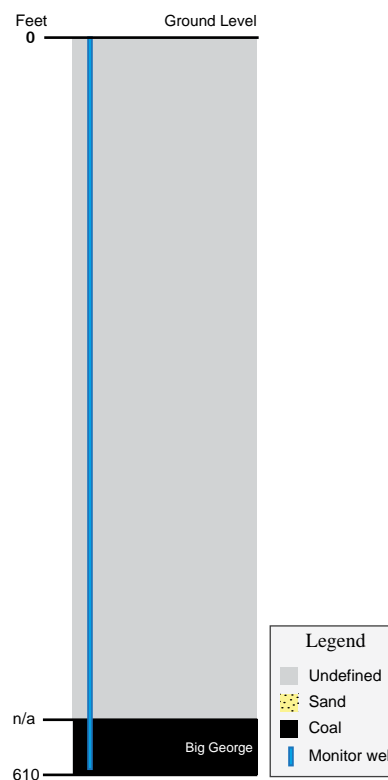
**Squaw Butte Monitoring Well Site**  
**Location: S1 T56N R78W**  
**Date First Monitored: May 17, 2005**

**Drawdown Information**

The Squaw Butte monitoring well site includes one well completed in the Big George coal of the Wyodak Rider coal zone (Figure A.223; Table A.110). Water levels were measured during the POR using manual measurements only

**Big George Coal**

Water levels in the Big George rose 15.45 feet during the 2010-2012 POR and 49.47 feet over the monitoring period of 2005-2009 (Figure A.224; Table A.111). Gas pressure in the Big George coal was not recorded at this site.



**Figure A.223.** Section showing relative positions of coals and sands in feet. Not to scale.

**Table A.110.** Table showing the depth to and thickness of monitored zones at the Squaw Butte monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Big George coal	570	590	20	n/a

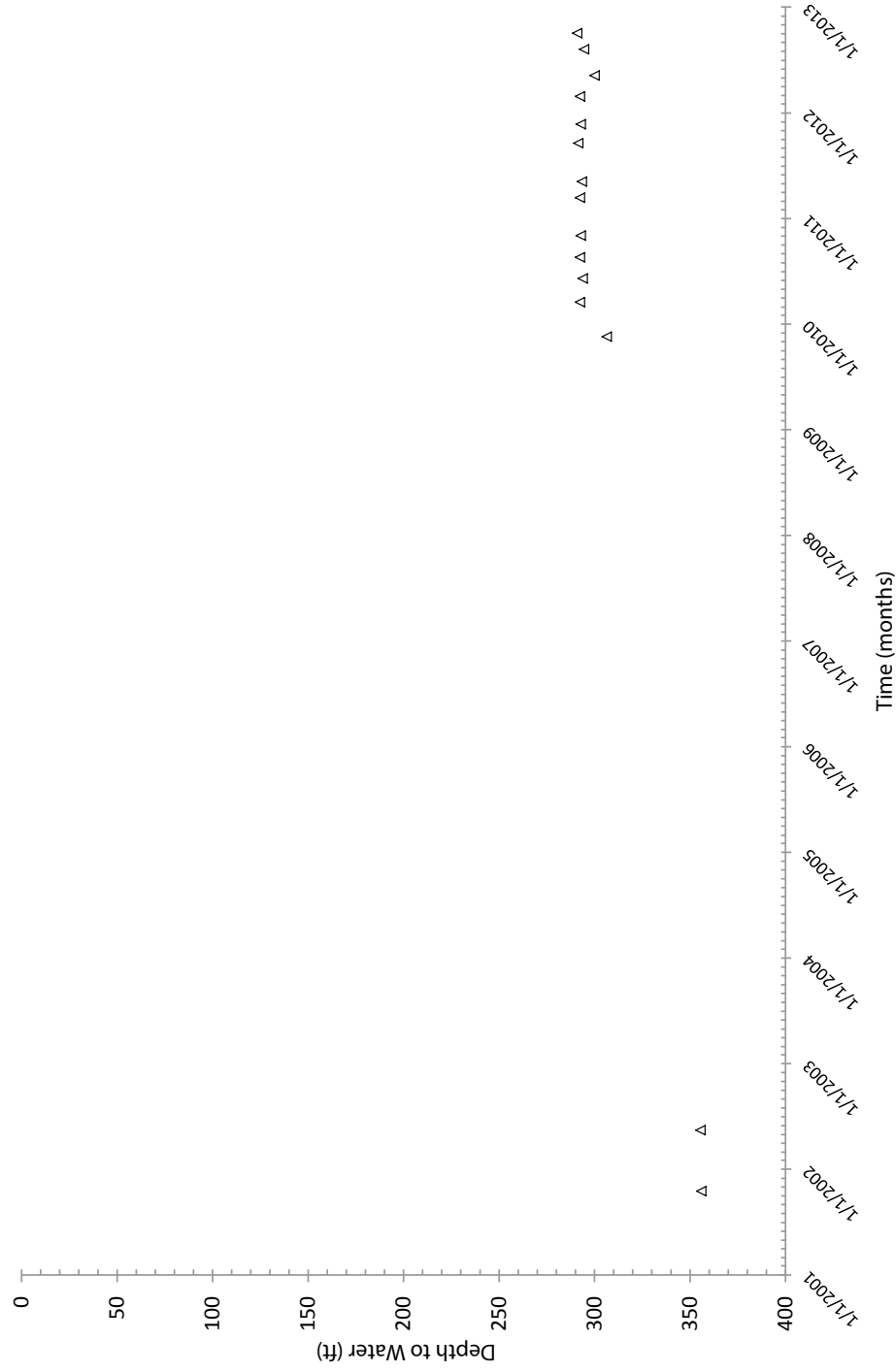
**Table A.111.** Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2010	Drawdown 2010-2012	Total drawdown (ft.)	Depth to Final water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Big George coal	355.92	-49.47	-15.45	-64.92	291.00	n/a	n/a

## Squaw Butte Monitoring Well Site

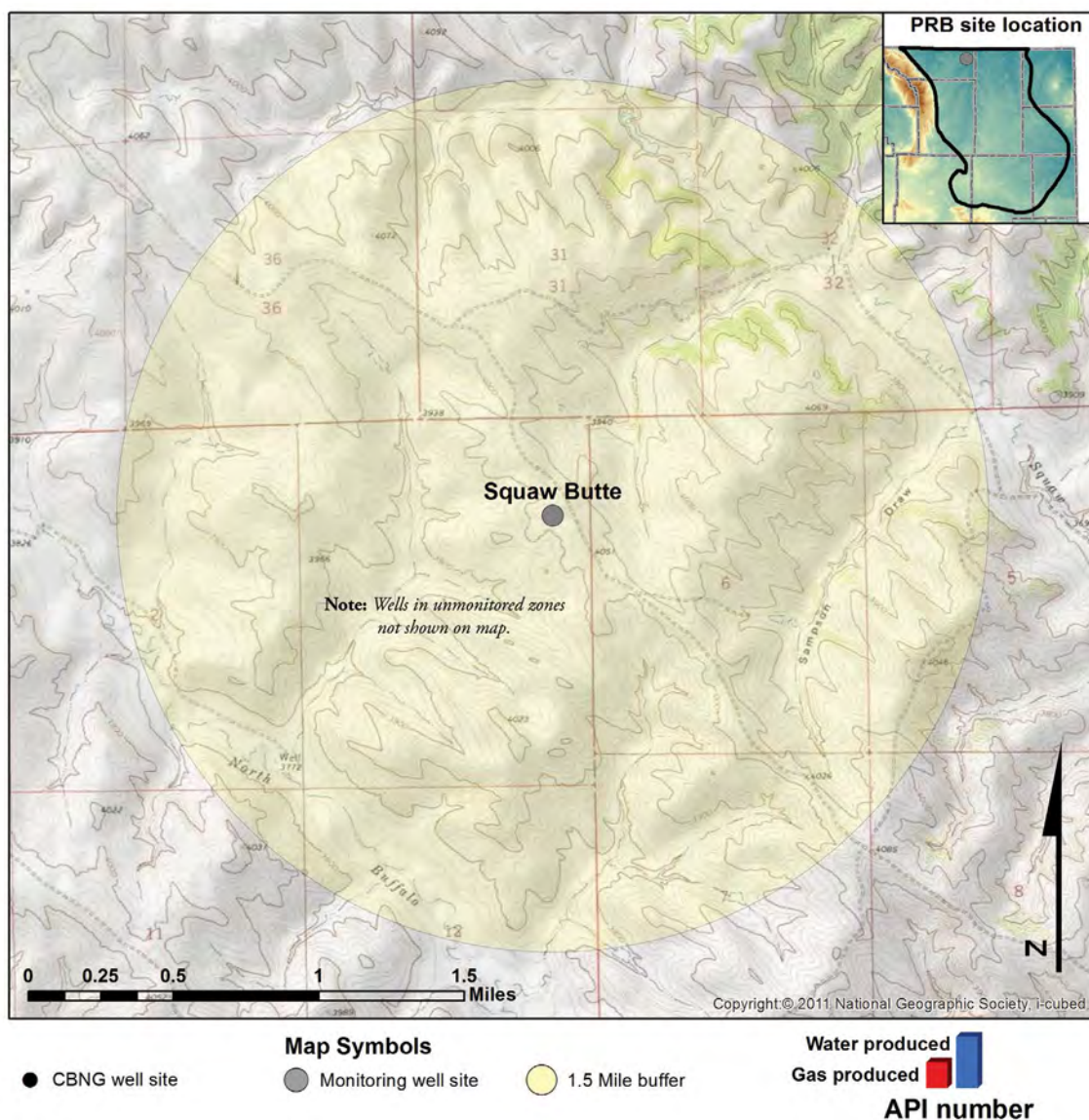
Big George coal  
Water Drawdown  
(MR = Manual reading, TR = Transducer reading)

△ Big George water MR



**Figure A.224.** Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Squaw Butte monitoring wellsite location.





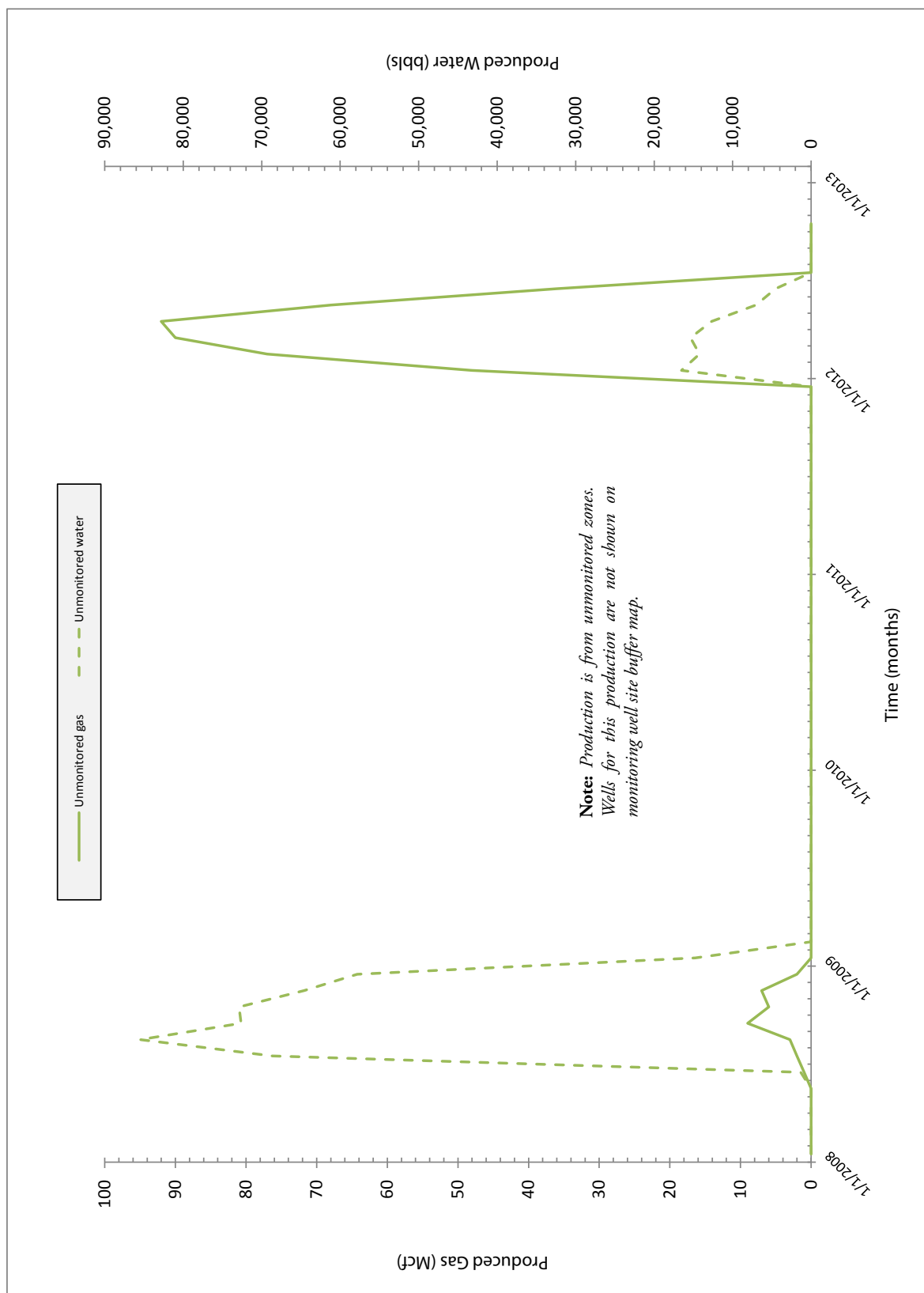
**Figure A.225.** Squaw Butte monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

### Production Statistics

Production data were analyzed for CBNG wells within the buffer of the Squaw Butte monitoring well site from 2008-2012. Cumulative production for individual CBNG wells is displayed by location on Figure A.225. CBNG production is monitored in coal zones where water levels are not monitored (unmonitored zones).

Water production from the unmonitored coal zones spiked once in 2008-2009, peaking at 85,509 bbls in August 2008, and a second time in January 2012 at 20,000 bbls (Figure A.226). Gas production has been less than 100 Mcf/month during both periods. Gas and water production ceased before the end of the 2010-2012 POR.





**Figure A.226.** Water and gas production from CBNG wells associated with the Squaw Butte monitoring well site location.

**Streeter Monitoring Well Site**  
**Location: S22 T43N R78W**  
**Date First Monitored: August 4, 2004**

**Drawdown Information**

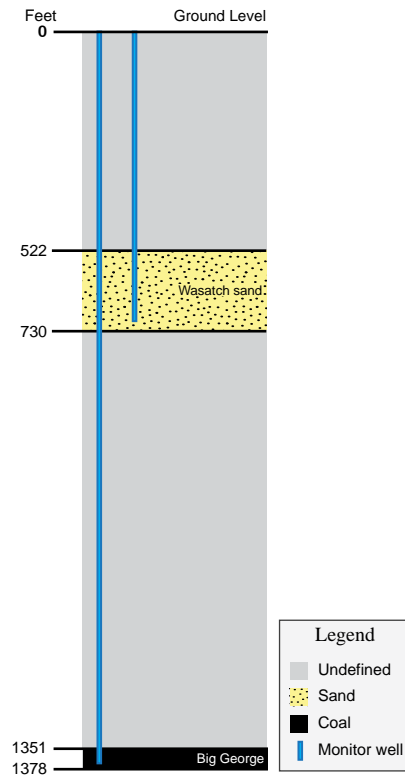
The Streeter monitoring well site includes two wells. One is completed in a Wasatch sandstone and the other in the Big George coal of the Wyodak Rider coal zone (Figure A.227; Table A.112). Water levels and wellhead gas pressures were measured during the POR using both manual and automatic transducer and data logger equipment. Transducer data that is missing, randomly fluctuating (noisy) or that substantially differs from concurrent manual measurements may indicate on-site equipment failure, malfunction or requirement for calibration.

**Wasatch Sandstone**

Groundwater levels declined 0.22 feet during the 2010-2012 POR and 151.49 feet over the monitoring period of 2004-2009 (Figure A.228; Table A.113). Gas pressure was not reported in the Wasatch sandstone.

**Big George Coal**

Groundwater levels rose 7.51 feet during the 2010-2012 POR but declined 151.49 feet over the monitoring period of 2004-2009 (Figure A.228; Table A.113). Gas pressure in the Big George remained relatively stable near zero psi over the life of the well.



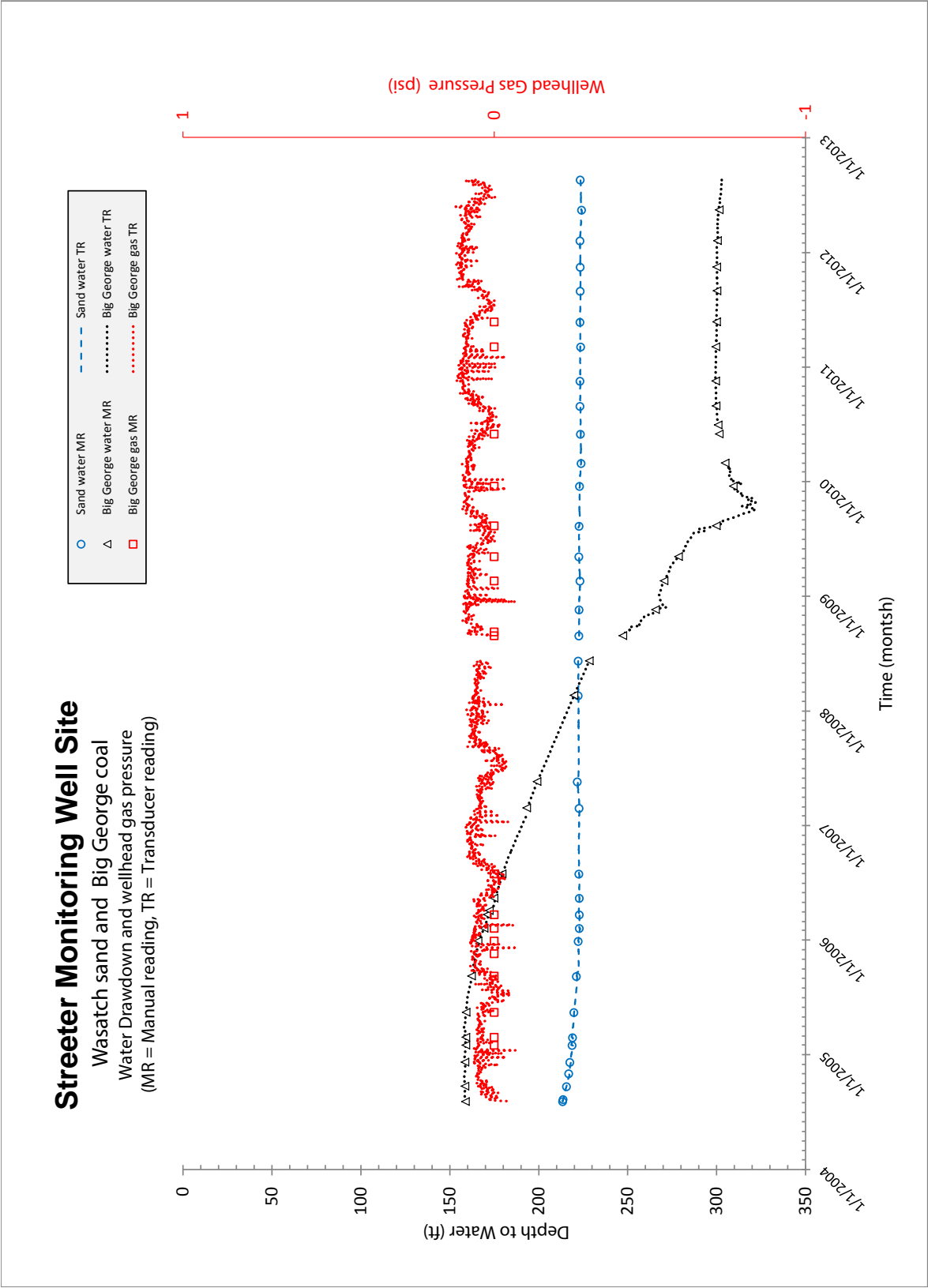
**Figure A.227.** Section showing relative positions of coals and sands in feet. Not to scale.

**Table A.112.** Table showing the depth to and thickness of monitored zones at the Streeter monitoring well site location. (measured in feet)

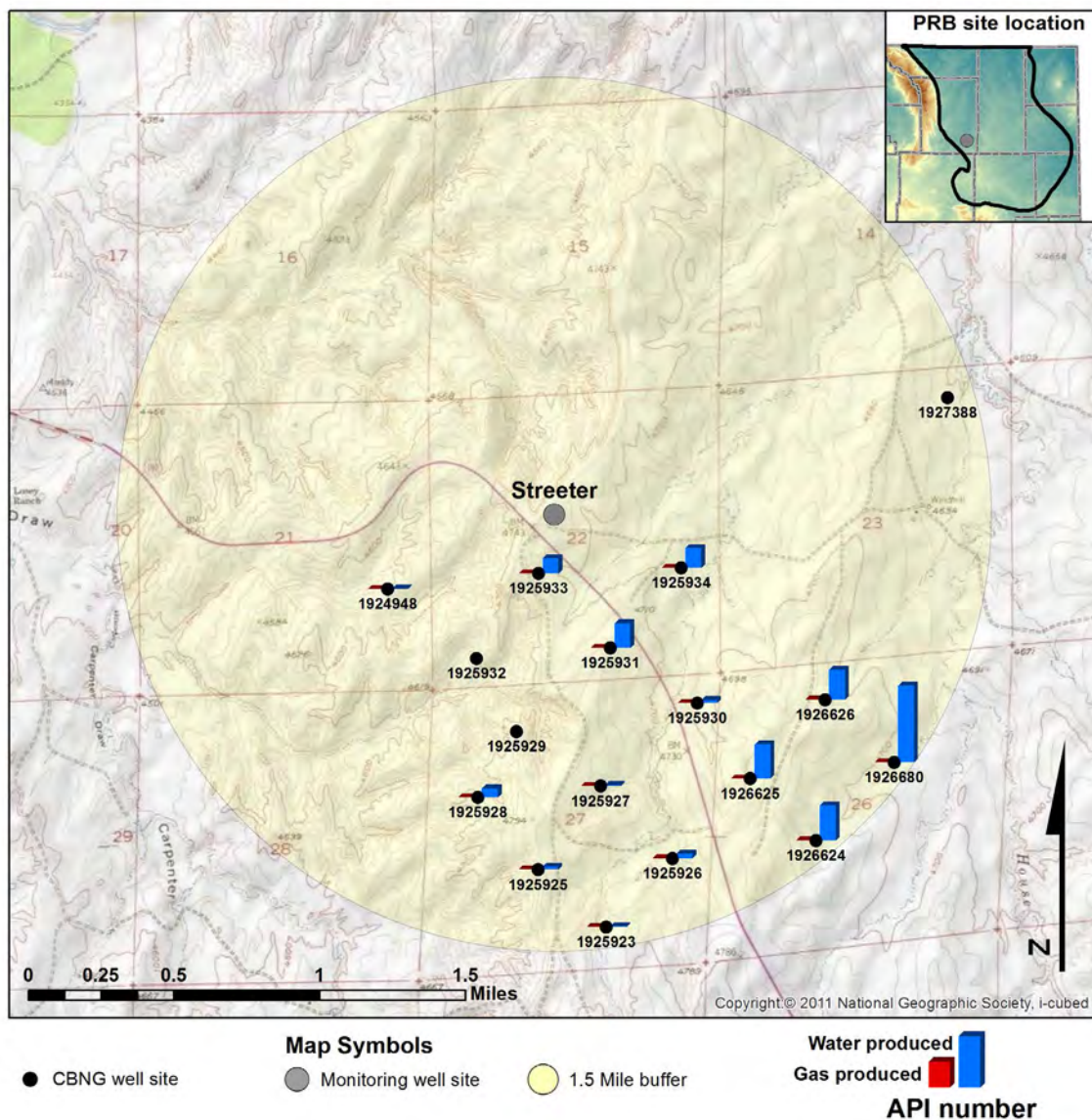
Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Wasatch sand	522	730	208	621
Big George coal	1,351	1,378	27	n/a

**Table A.113.** Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2010	Drawdown 2010-2012	Total drawdown (ft.)	Depth to Final water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	213.50	9.69	0.22	9.91	223.41	n/a	n/a
Big George coal	158.80	151.49	-7.51	143.98	302.78	0.12	10/8/2011



**Figure A.228.** Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Streeter monitoring wellsite location.

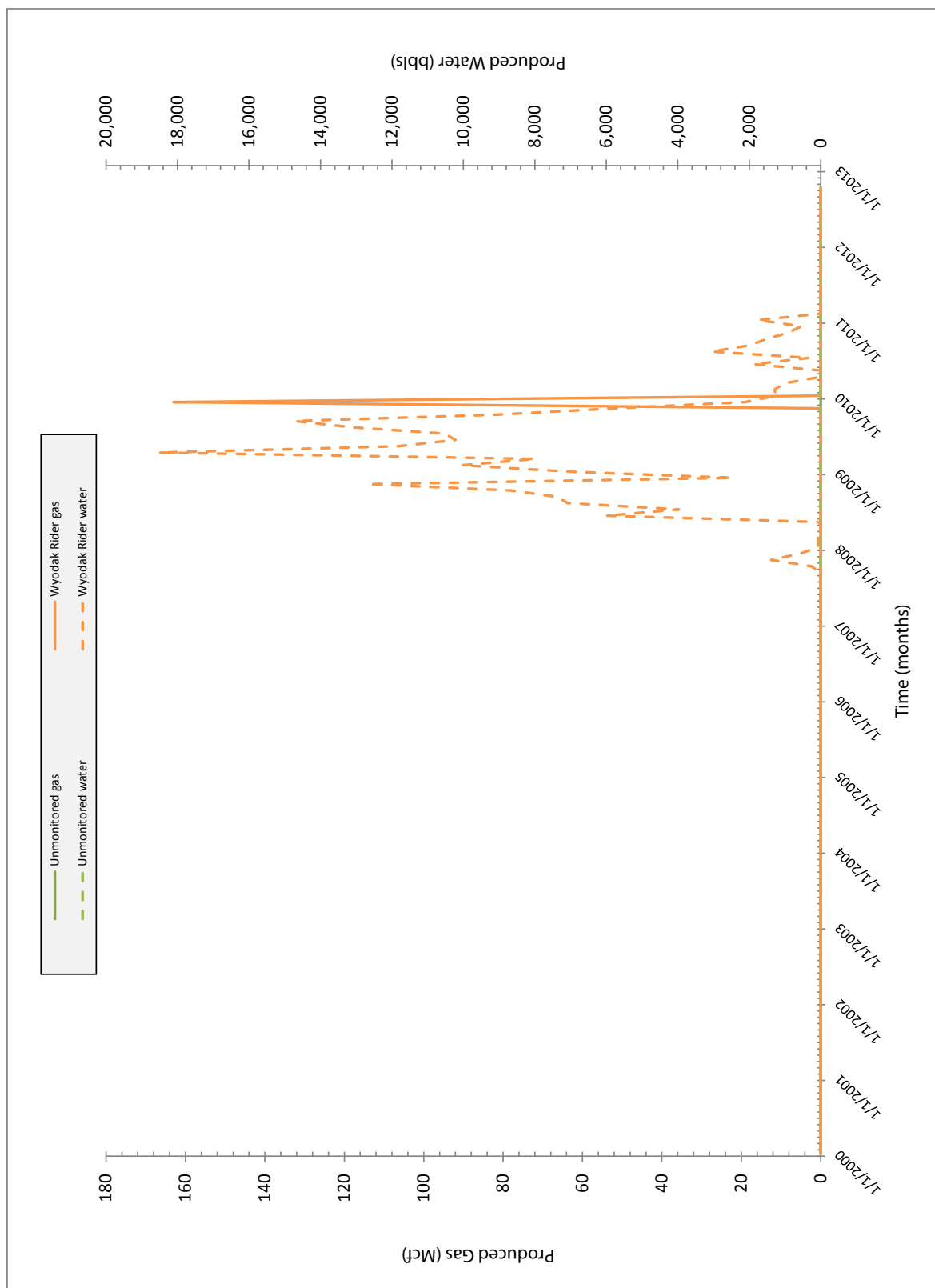


**Figure A.229.** Streeter monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

### Production Statistics

Production data were analyzed for CBNG wells within the buffer of the Streeter monitoring well site from 2000-2012. Cumulative production for individual CBNG wells is displayed by location on Figure A.229. CBNG production is monitored in the Wyodak Rider coal zone and some production in this area occurs in coal zones where water levels are not monitored (unmonitored zones).

Water was produced in the Wyodak Rider coal zone from October 2007 until January 2011. Peak water production was reached in April 2009 at 18,518 bbls (Figure A.230). Gas production in the Wyodak Rider occurred only in December 2009 at 163 Mcf. Unmonitored coal zone wells have produced no reported water or gas production over the 2010-2012 POR.



**Figure A.230.** Water and gas production from CBNG wells associated with the Streeter monitoring well site location.

**Stuart Sec 31 Monitoring Well Site**  
**Location: S31 T44N R71W**  
**Date First Monitored: August 18, 1997**

**Drawdown Information**

The Stuart Sec 31 monitoring well site includes three wells. One is completed in a Wasatch sandstone, another in the Wyodak coal of the Upper Wyodak coal zone, and the third in a Fort Union underburden sandstone (Figure A.231; Table A.114). Water levels and wellhead gas pressures were measured during the POR using both manual and automatic transducer and data logger equipment. Transducer data that is missing, randomly fluctuating (noisy) or that substantially differs from concurrent manual measurements may indicate on-site equipment failure, malfunction or requirement for calibration.

**Wasatch Sandstone**

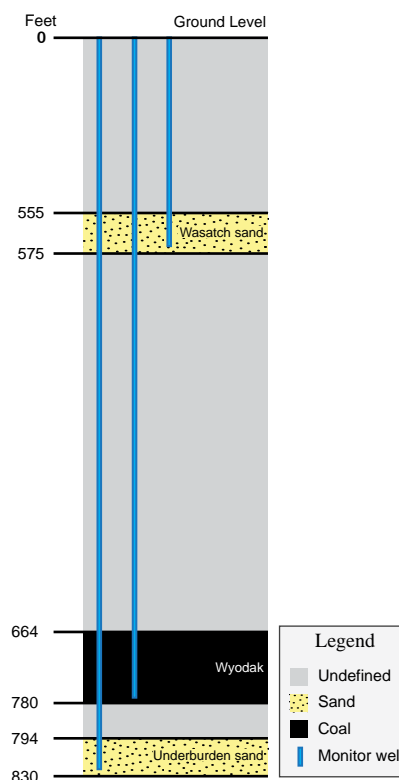
Groundwater levels rose 15.72 feet during the 2010-2012 POR but declined 79.05 feet during the monitoring period of 1997-2009 (Figure A.232; Table A.115). Gas pressure was not reported in the Wasatch sandstone.

**Wyodak Coal**

The Wyodak coal well was reported dry on January 12, 2004 and did not change during the 2010-2012 POR, so no water changes could be recorded. Prior to the well going dry, in 2004, a groundwater level decline of 448.50 feet was recorded. (Figure A.232; Table A.115). Gas pressure in the Wyodak coal peaked at 37.92 psi in June 2001.

**Fort Union Underburden Sandstone**

Groundwater levels rose 8.99 feet during the 2010-2012 POR but declined 251.46 feet during the monitoring period of 1997-2009 (Figure A.232; Table A.115). Gas pressure was not recorded in the underburden sandstone.



**Figure A.231.** Section showing relative positions of coals and sands in feet. Not to scale.



**Table A.114.** Table showing the depth to and thickness of monitored zones at the Stuart Sec 31 monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Wasatch sand	555	575	20	89
Wyodak coal	664	780	116	n/a
Underburden sand	794	830	36	14

**Table A.115.** Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

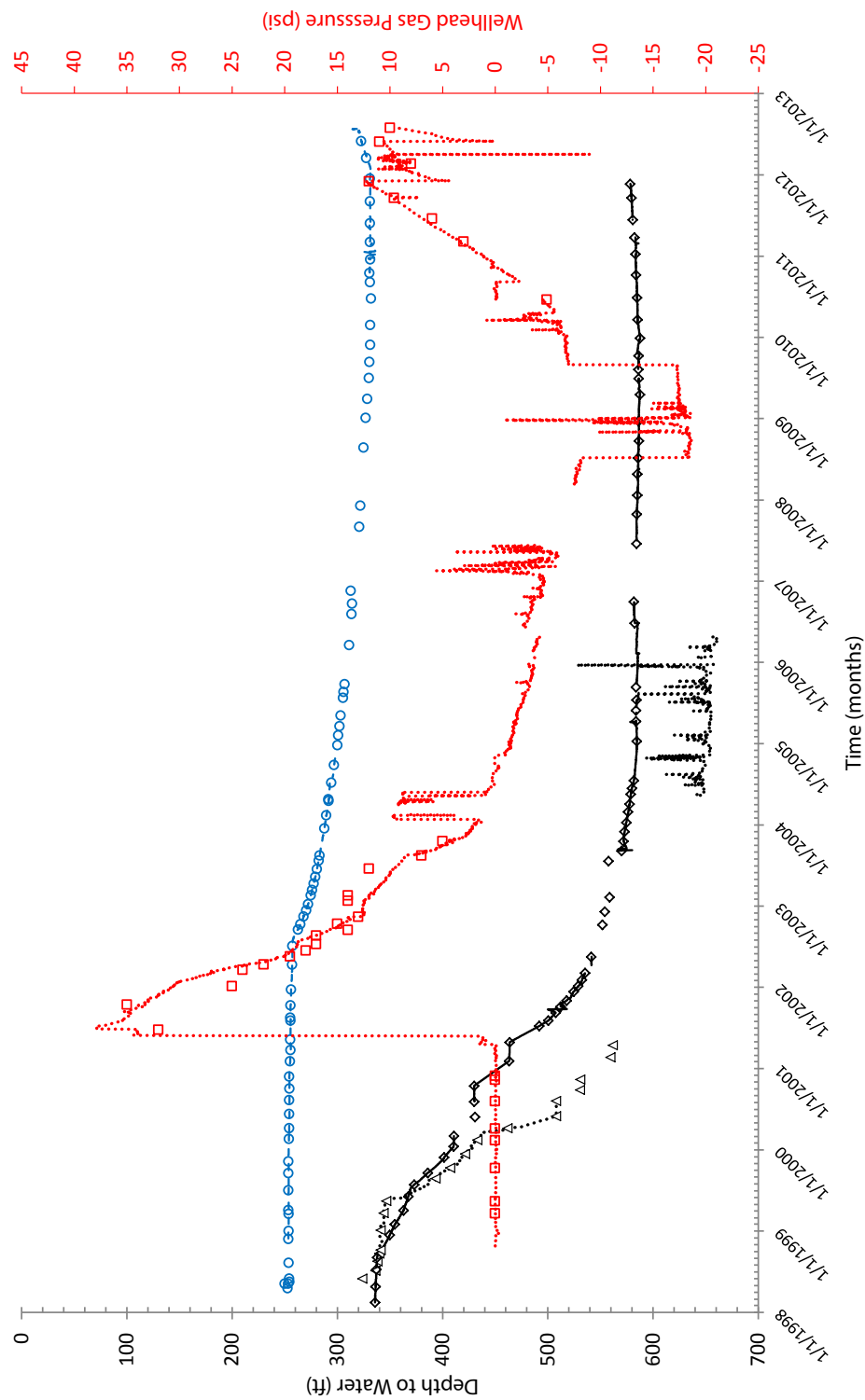
Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2010	Drawdown 2010-2012	Total drawdown (ft.)	Depth to Final water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	252.95	79.05	-15.72	63.33	316.28	n/a	n/a
Wyodak coal	331.50	448.50	0.00	448.50	780.00	37.92	6/28/2001
Underburden sand	335.91	251.46	-8.99	242.47	578.38	n/a	n/a

## Stuart Sec 31 Monitoring Well Site

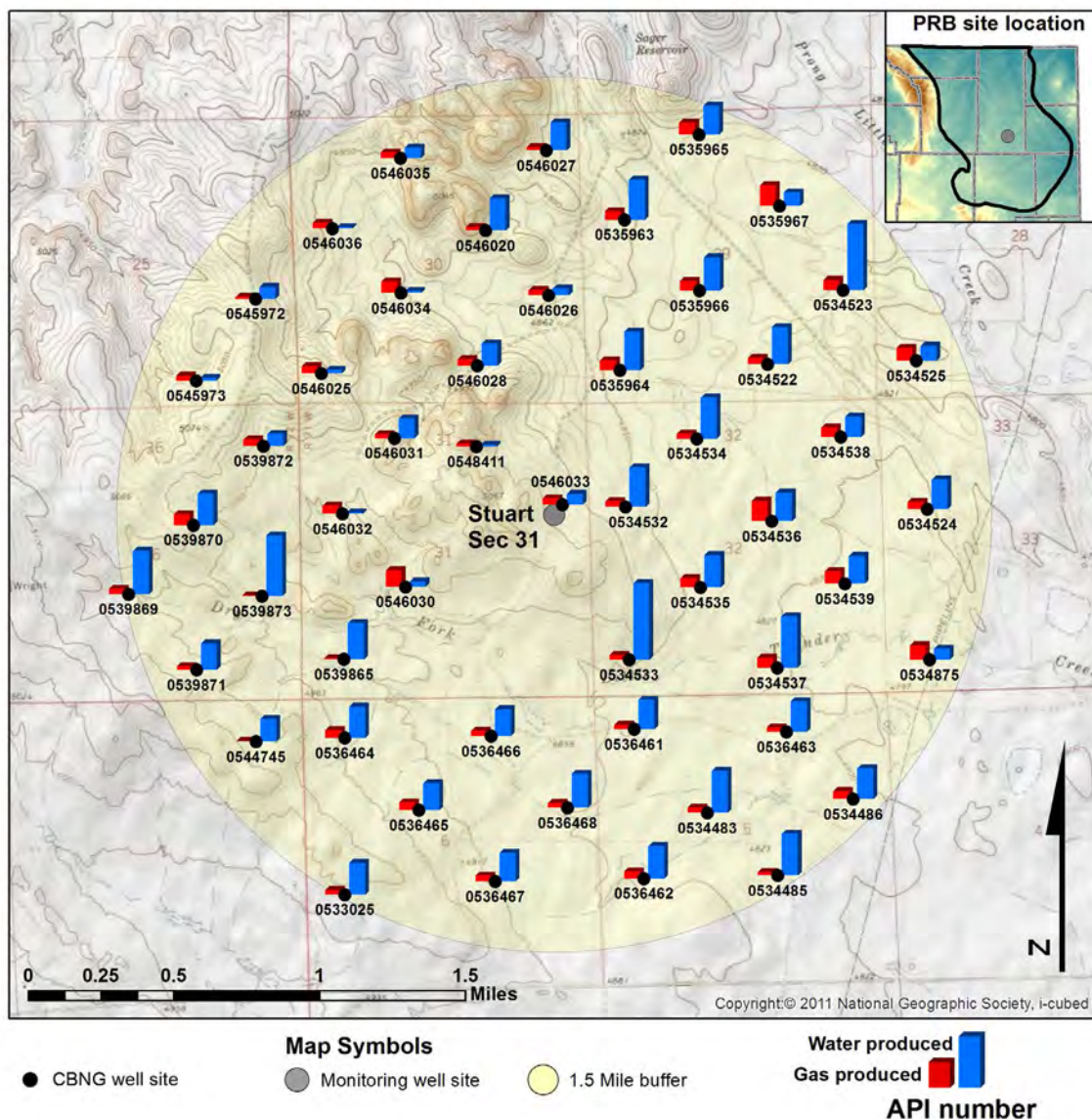
Wasatch sand, Wyodak coal, and Underburden sand

Water Drawdown and wellhead gas pressure

(MR = Manual reading, TR = Transducer reading)



**Figure A.232.** Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Stuart Sec 31 monitoring wellsite location

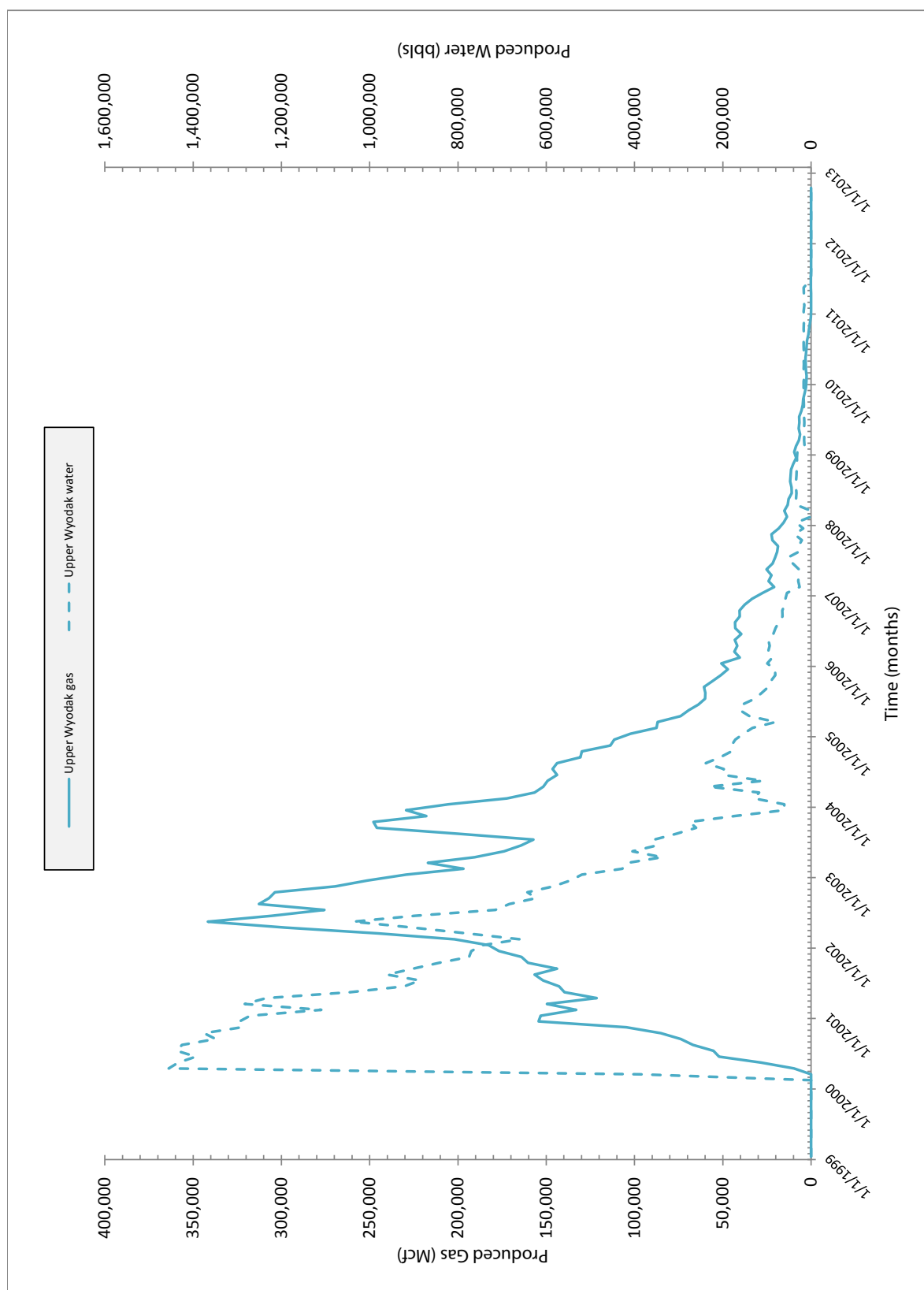


**Figure A.233.** Stuart Sec 31 monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

### Production Statistics

Production data were analyzed for CBNG wells within the buffer of the Stuart Sec 31 monitoring well site from 1999-2012. Cumulative production for individual CBNG wells is displayed by location on Figure A.233. CBNG production is monitored in the Upper Wyodak coal zone.

The Upper Wyodak coal zone produced water and gas from early 2000 through mid-2011. Water production peaked at 1,455,235 bbls in April 2000. Gas production peaked at 341,607 Mcf in May 2002 (Figure A.234). Water and gas production both ceased after July 2011.



**Figure A.234.** Water and gas production from CBNG wells associated with the Stuart Sec 31 monitoring well site location.

**Throne Monitoring Well Site**  
**Location: S26 T47N R74W**  
**Date First Monitored: May 24, 2001**

**Drawdown Information**

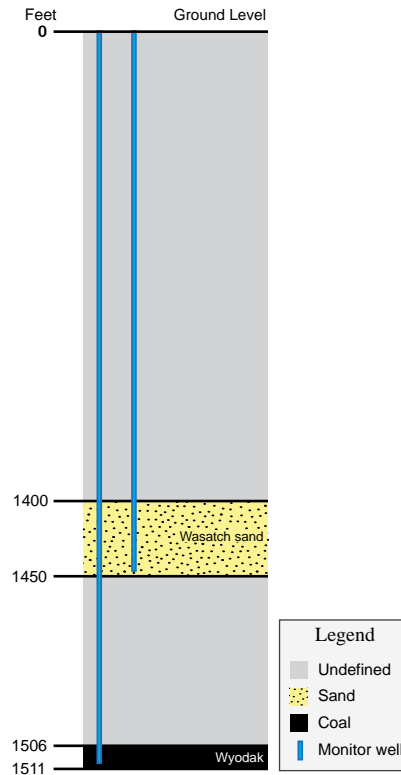
The Throne monitoring well site includes two wells. One is completed in a Wasatch sandstone and the other in the Wyodak coal of the Upper Wyodak coal zone (Figure A.235; Table A.116). Water levels and wellhead gas pressures were measured during the POR using both manual and automatic transducer and data logger equipment. Transducer data that is missing, randomly fluctuating (noisy) or that substantially differs from concurrent manual measurements may indicate on-site equipment failure, malfunction or requirement for calibration.

**Wasatch Sandstone**

Groundwater levels rose 37.30 feet during the 2010-2012 POR after declining 270.31 feet over the monitoring period of 2001-2009 (Figure A.236; Table A.117). Gas pressure was not recorded in the Wasatch sandstone.

**Wyodak Coal**

Groundwater levels rose 57.38 feet during the 2010-2012 POR after declining 205.04 feet over the monitoring period of 2001-2009 (Figure A.236; Table A.117). Gas pressure in the Wyodak remained relatively stable near zero over the life of the well.



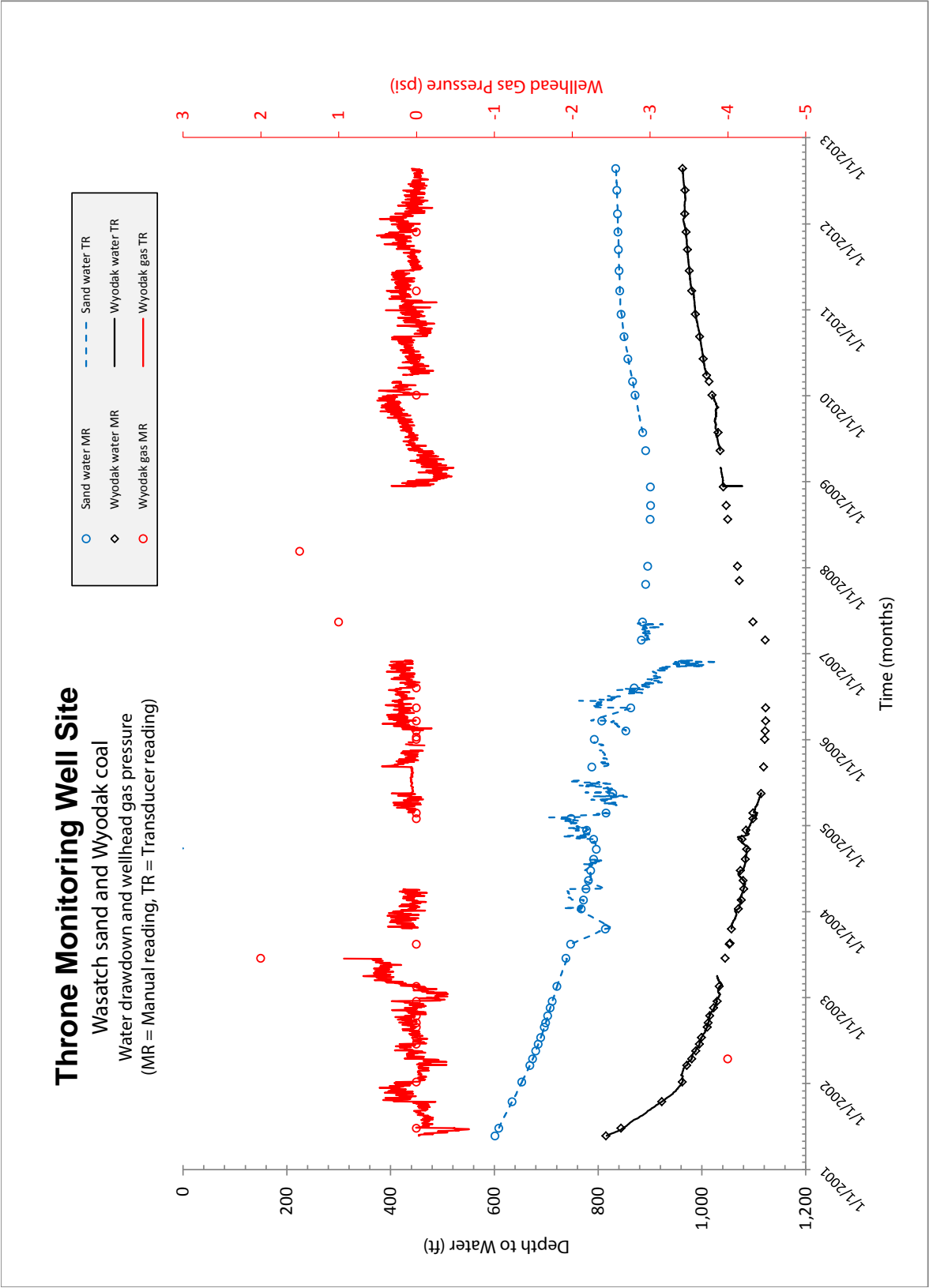
**Figure A.235.** Section showing relative positions of coals and sands in feet. Not to scale.

**Table A.116.** Table showing the depth to and thickness of monitored zones at the Throne monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Wasatch sand	1,400	1,450	50	56
Wyodak coal	1,506	1,511	5	n/a

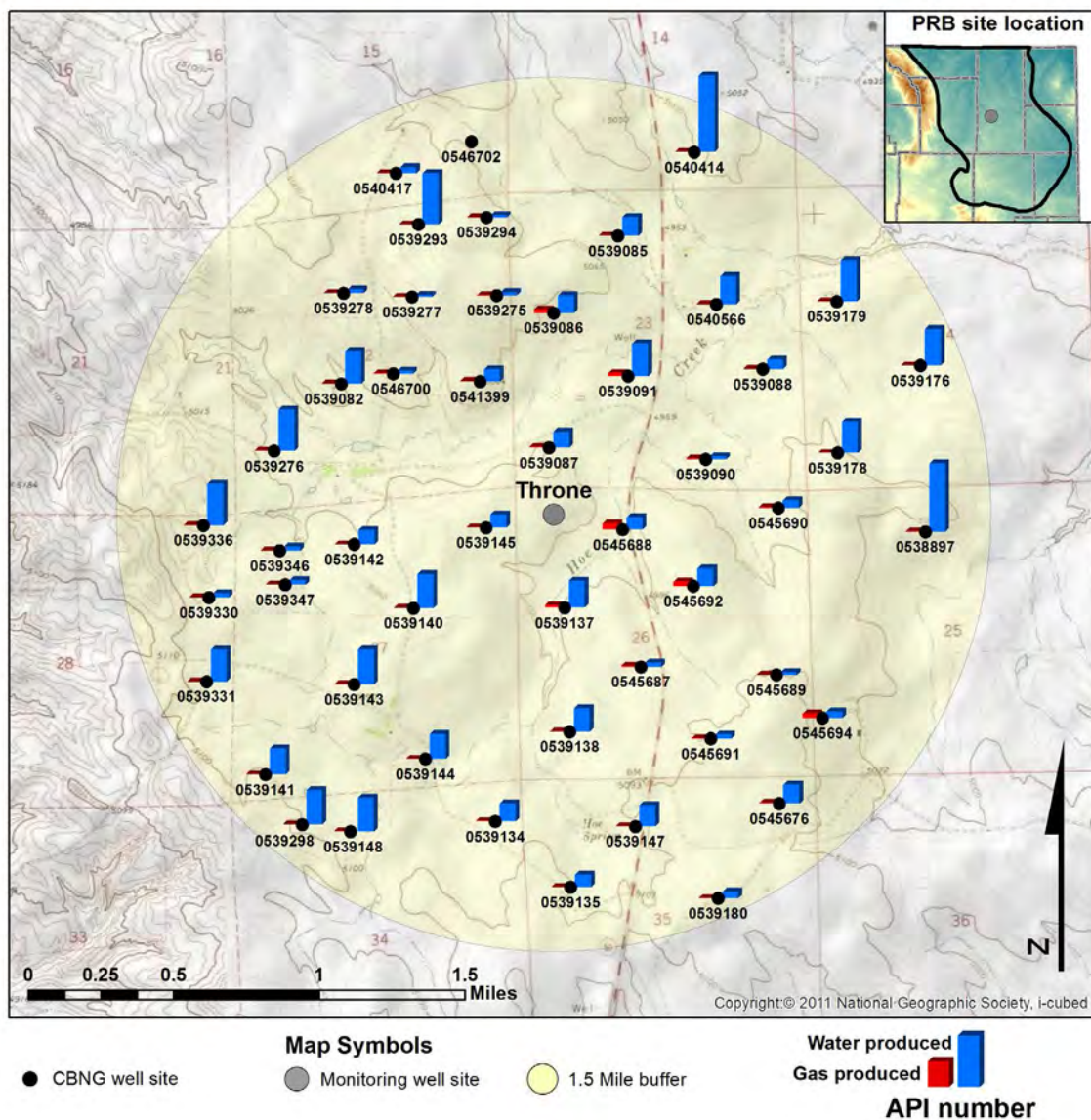
**Table A.117.** Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2010	Drawdown 2010-2012	Total drawdown (ft.)	Depth to Final water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	601.34	270.31	-37.30	233.01	834.35	n/a	n/a
Wyodak coal	815.24	205.04	-57.38	147.66	962.90	0.93	6/15/2003



**Figure A.236.** Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Throne monitoring wellsite location.





**Figure A.237.** Throne monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

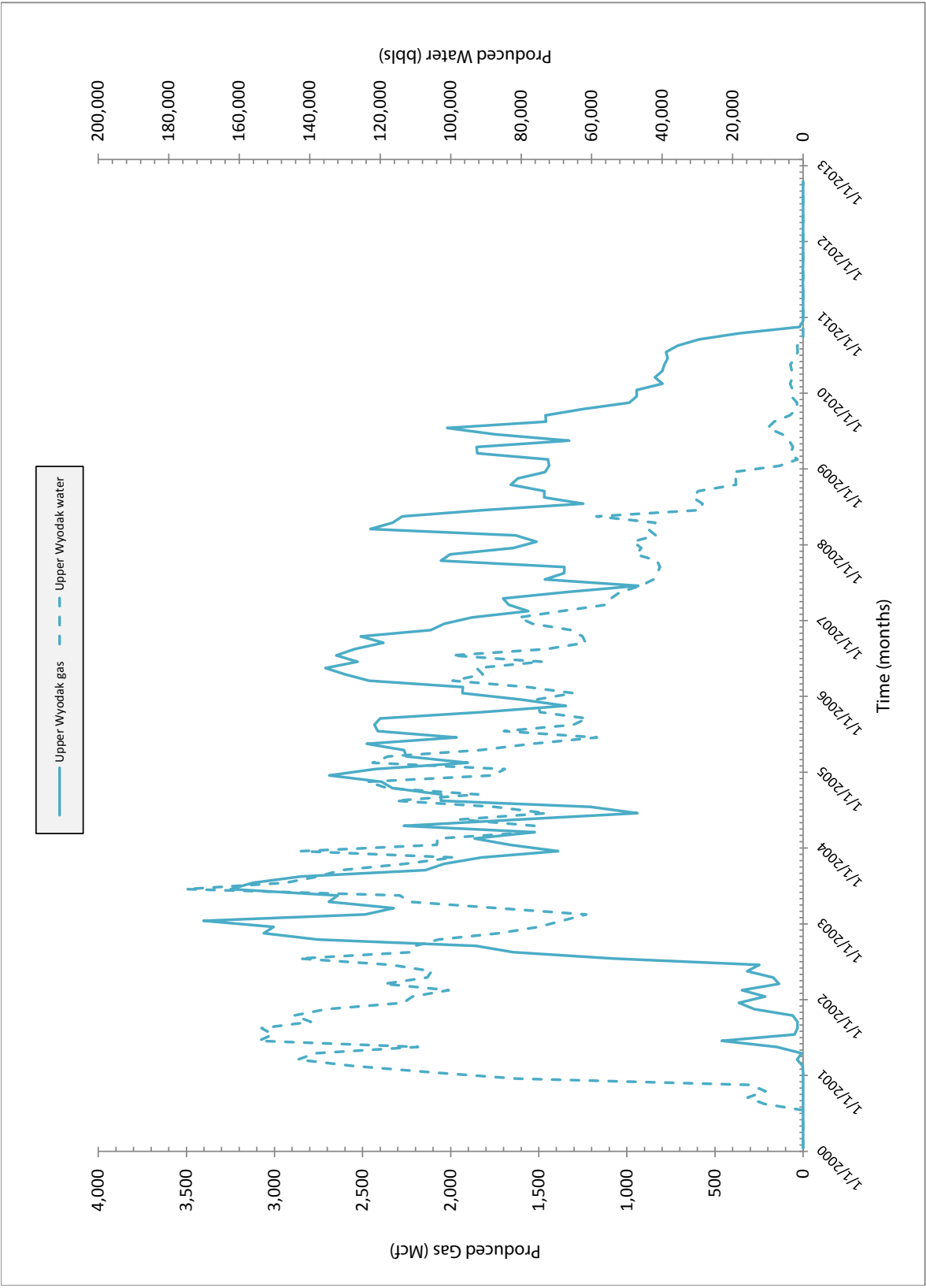
### Production Statistics

Production data were analyzed for CBNG wells within the buffer of the Throne monitoring well site from 2000-2012. Cumulative production for individual CBNG wells is displayed by location on Figure A.237. CBNG production is monitored in the Upper Wyodak coal zone.

The Upper Wyodak saw initial water production in 2000 which peaked in 2003 (175,160 bbls)

and gradually decreased to zero barrels of monthly production by 2010 (Figure A.238).

The Upper Wyodak produced water consistently from August 2000 to August 2010. Water production peaked at 175,160 bbls in June 2003 and gradually decreased to zero by September 2010. Gas was produced from February 2001 through November 2010 (Figure A.238). Gas production reached its maximum in January 2006 at 3,402 Mcf, and ceased in December 2010.



**Figure A.238.** Water and gas production from CBNG wells associated with the Throne monitoring well site location.

# West Pine Tree Monitoring Well Site

## Location: S20 T42N R76W

### Date First Monitored: September 20, 2007

#### Drawdown Information

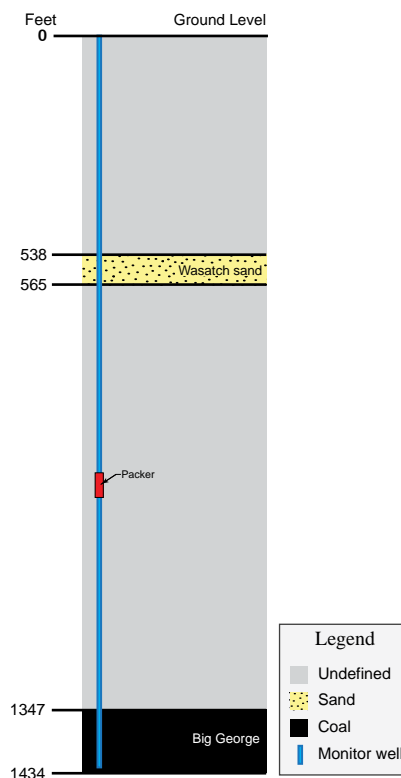
The West Pine Tree monitoring well site includes one well with dual completion, separated by a packer. The well is completed in a Wasatch sandstone and the Big George coal of the Wyodak Rider coal zone (Figure A.239; Table A.118). Water levels and wellhead gas pressures were measured during the POR using both manual and automatic transducer and data logger equipment. Transducer data that is missing, randomly fluctuating (noisy) or that substantially differs from concurrent manual measurements may indicate on-site equipment failure, malfunction or requirement for calibration.

#### Wasatch Sandstone

Groundwater levels declined 1.57 feet during the 2010-2012 POR after recovering 35.45 feet over the monitoring period of 2007-2009 (Figure A.240; Table A.119). Gas pressure was not recorded in the Wasatch sandstone.

#### Big George Coal

Groundwater levels declined 132.17 feet during the 2010-2012 POR and 546.45 feet over the monitoring period of 2007-2009 (Figure A.240; Table A.119). Gas pressure in the Big George coal ranged from near zero to 26.86 psi in March 2012.



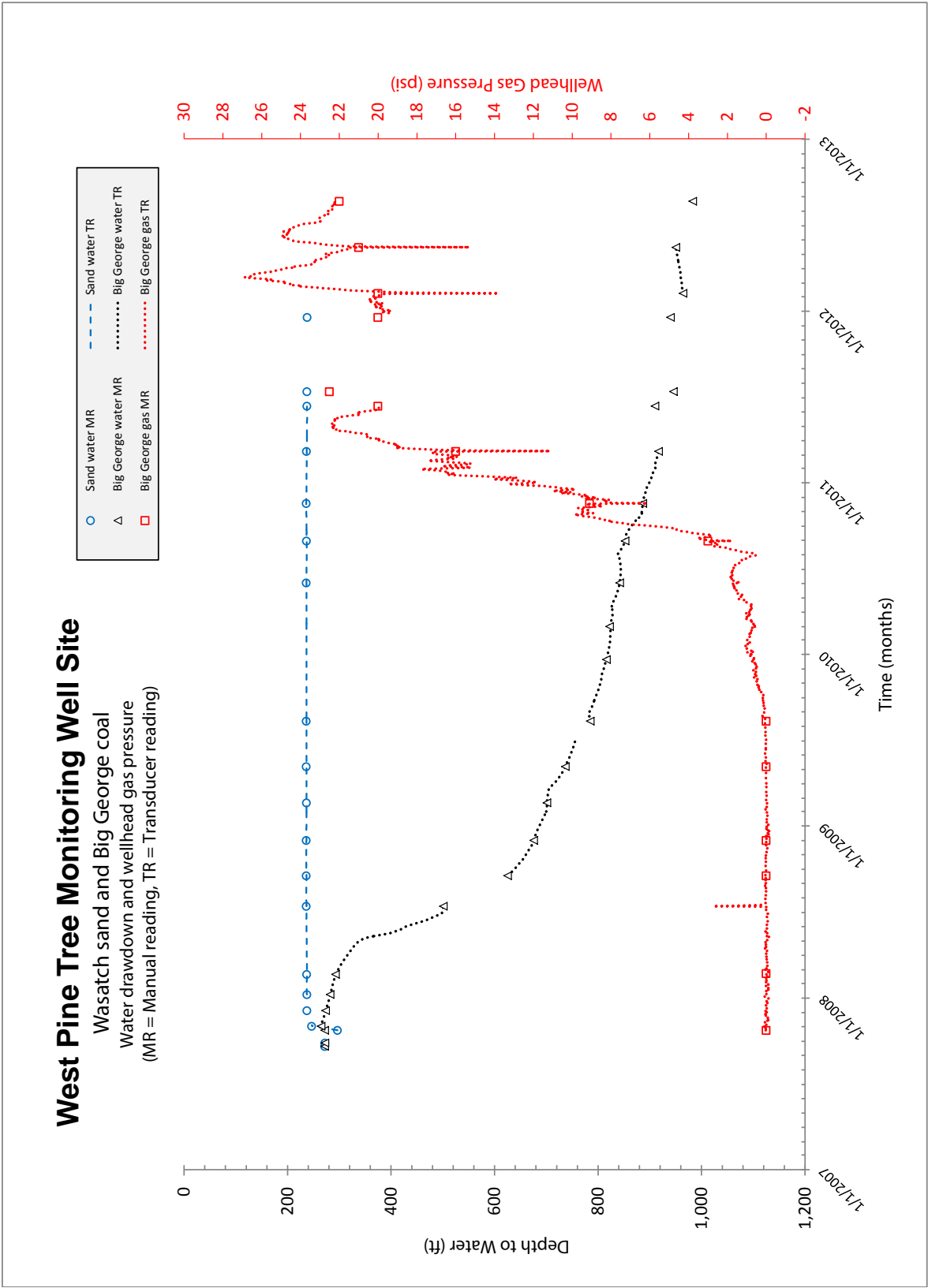
**Figure A.239.** Section showing relative positions of coals and sands in feet. Not to scale.

**Table A.118.** Table showing the depth to and thickness of monitored zones at the West Pine Tree monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Wasatch sand	538	565	27	782
Big George coal	1,347	1,434	87	n/a

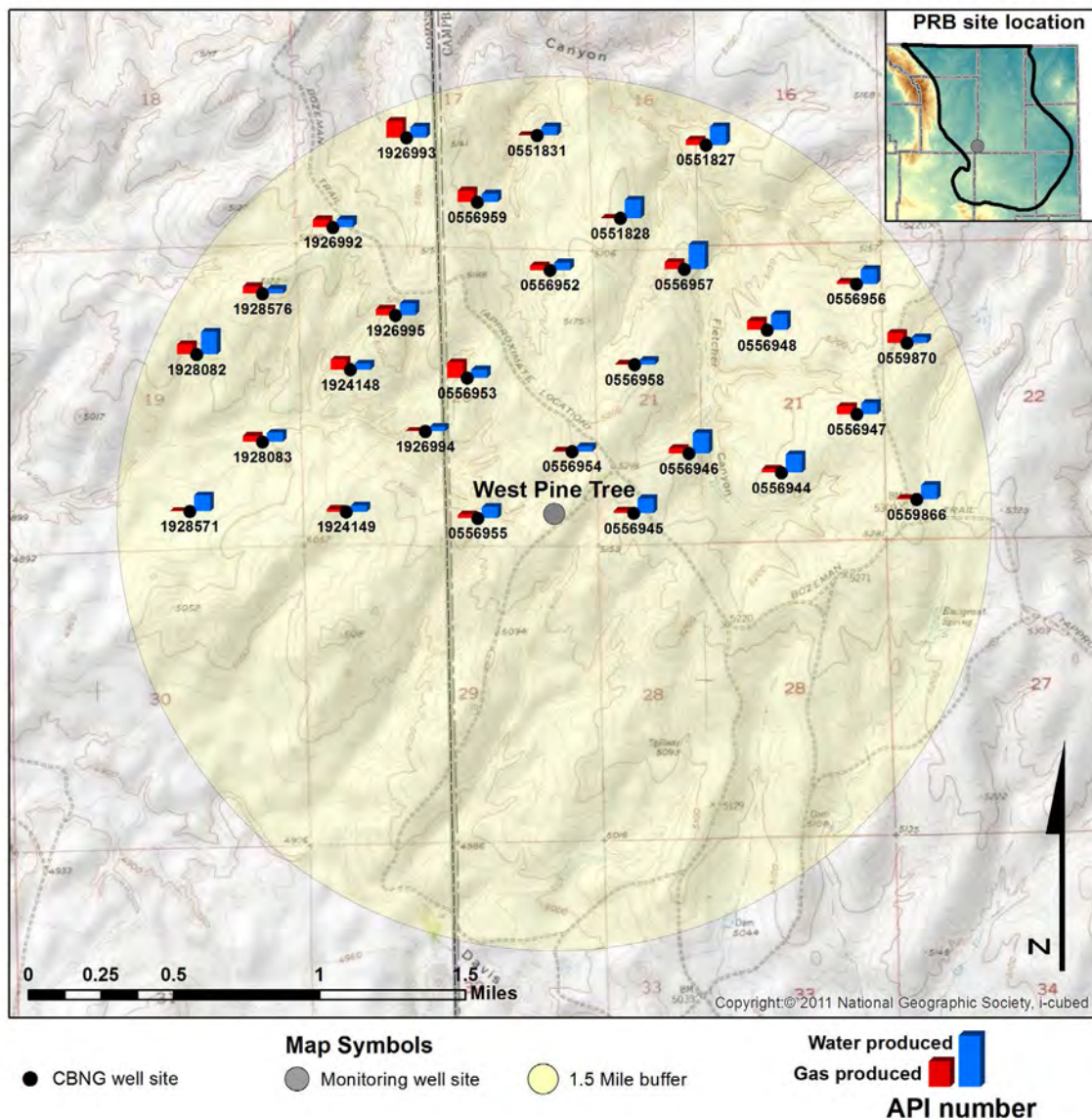
**Table A.119.** Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2010	Drawdown 2010-2012	Total drawdown (ft.)	Depth to Final water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	272.00	-35.45	1.57	-33.88	238.12	n/a	n/a
Big George coal	272.00	546.45	132.17	678.62	950.62	26.86	3/13/2012



**Figure A.240.** Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the West Pine Tree monitoring wellsite location.





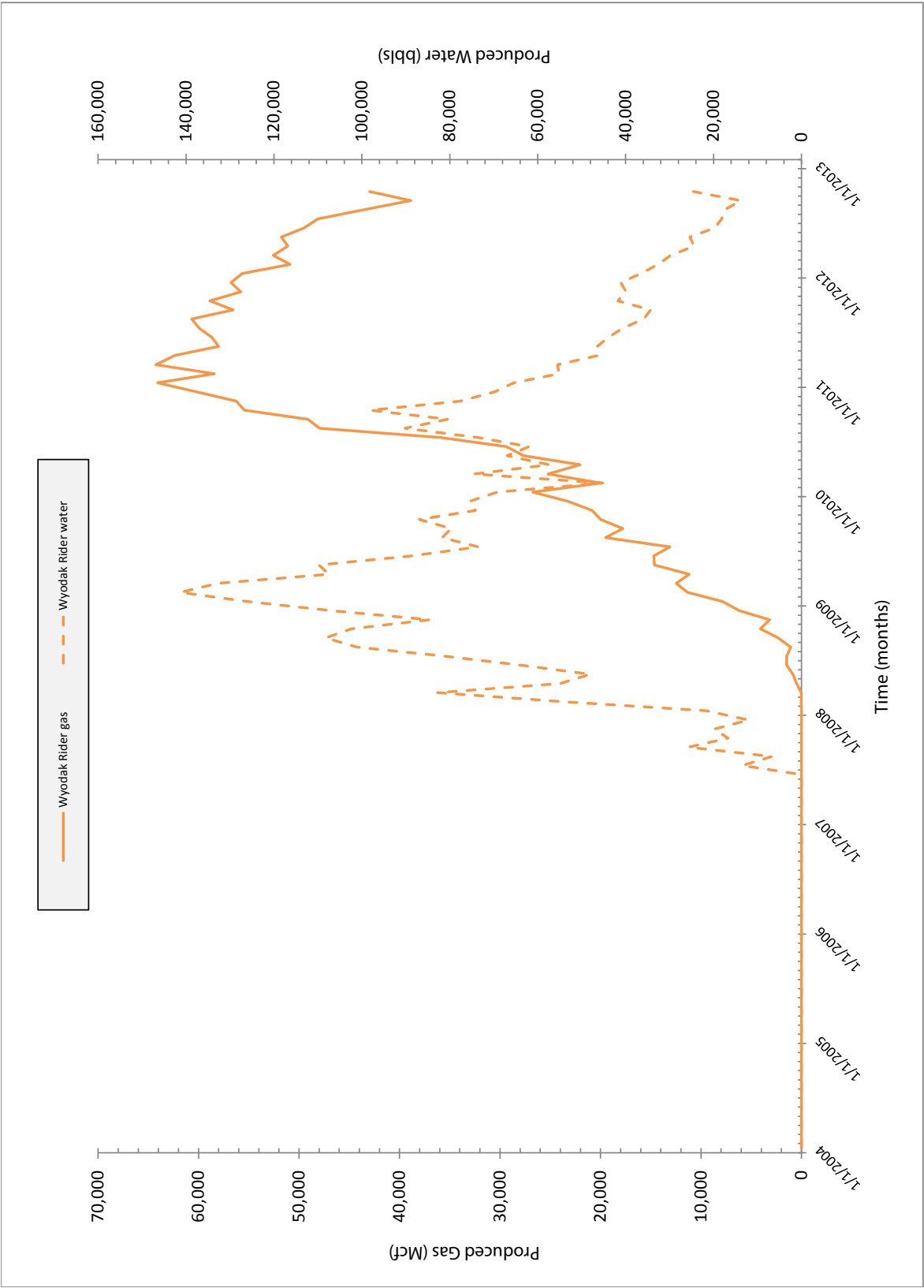
**Figure A.241.** West Pine Tree monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

### Production Statistics

Production data were analyzed for CBNG wells within the buffer of the West Pine Tree monitoring well site from 2004-2012. Cumulative production for individual CBNG wells is displayed by location on Figure A.241. CBNG production is monitored in the Wyodak Rider coal zone.

141,249 bbls and finished 2012 at 24,598 bbls/month (Figure A.242). Gas production in the Wyodak Rider coal zone began in March 2008, reached its peak in March 2011 (64,244 Mcf) and remained at nearly 43,000 Mcf/month at the end of the 2010-2012 POR.

Water production in the Wyodak Rider coal zone began in July 2007, peaked in February 2009 at



**Figure A.242.** Water and gas production from CBNG wells associated with the West Pine Tree monitoring well site location.



**Wild Turkey Monitoring Well Site**  
**Location: S29 T49N R76W**  
**Date First Monitored: November 16, 2004**

**Drawdown Information**

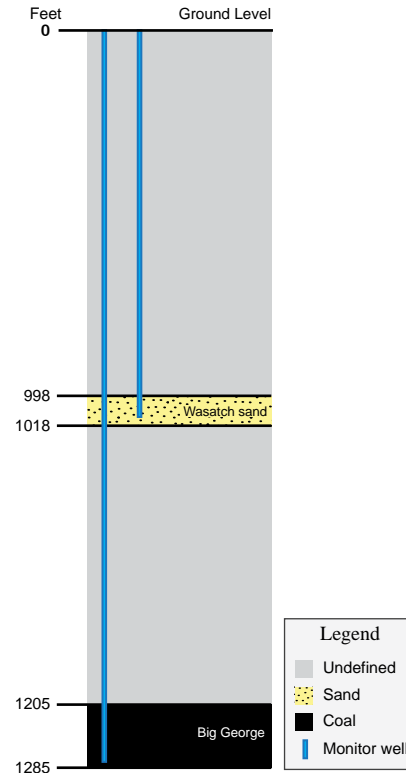
The Wild Turkey monitoring well site includes two wells. One is completed in a Wasatch sandstone and the other in the Big George coal of the Wyodak Rider coal zones (Figure A.243; Table A.120). Water levels and wellhead gas pressures were measured during the POR using both manual and automatic transducer and data logger equipment. Transducer data that is missing, randomly fluctuating (noisy) or that substantially differs from concurrent manual measurements may indicate on-site equipment failure, malfunction or requirement for calibration.

**Wasatch Sandstone**

Groundwater levels declined 37.45 feet during the 2010-2012 POR and 105.85 feet over the monitoring period of 2004-2009 (Figure A.244; Table A.121). Gas pressure was not recorded in the Wasatch sandstone.

**Big George Coal**

Groundwater levels declined 64.36 feet during the 2010-2012 POR and 865.14 feet over the monitoring period of 2004-2009 (Figure A.244; Table A.121). Gas pressure in the Big George coal varied widely, from near zero to 103.60 psi, over the life of the well.



**Figure A.243.** Section showing relative positions of coals and sands in feet. Not to scale.

**Table A.120.** Table showing the depth to and thickness of monitored zones at the Wild Turkey monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Wasatch sand	998	1,018	20	187
Big George coal	1,205	1,285	80	n/a

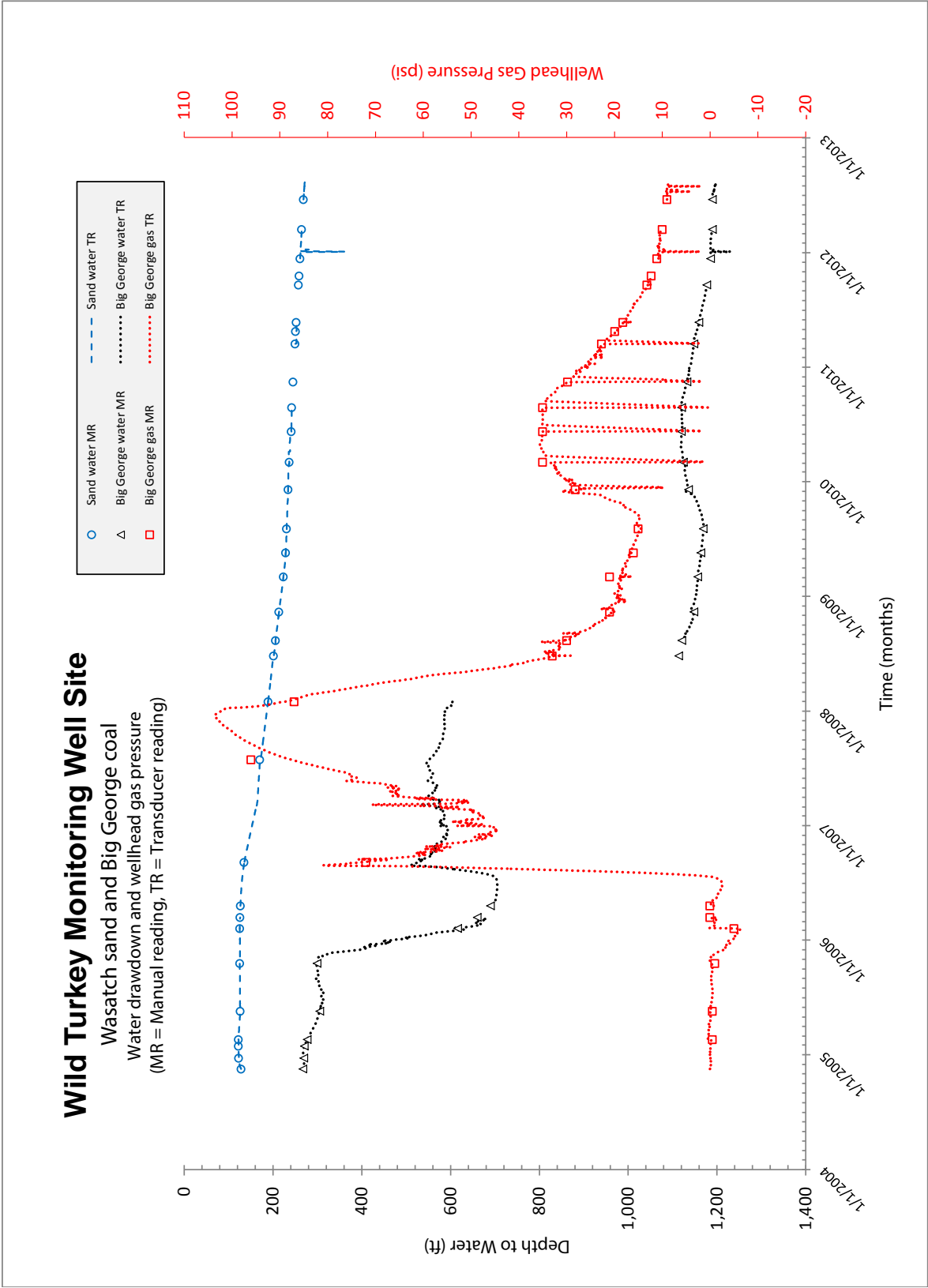
**Table A.121.** Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2010	Drawdown 2010-2012	Total drawdown (ft.)	Depth to Final water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	128.10	105.85	37.45	143.30	271.40	n/a	n/a
Big George coal	267.70	865.14	64.36	929.50	1197.20	103.60	12/17/2007

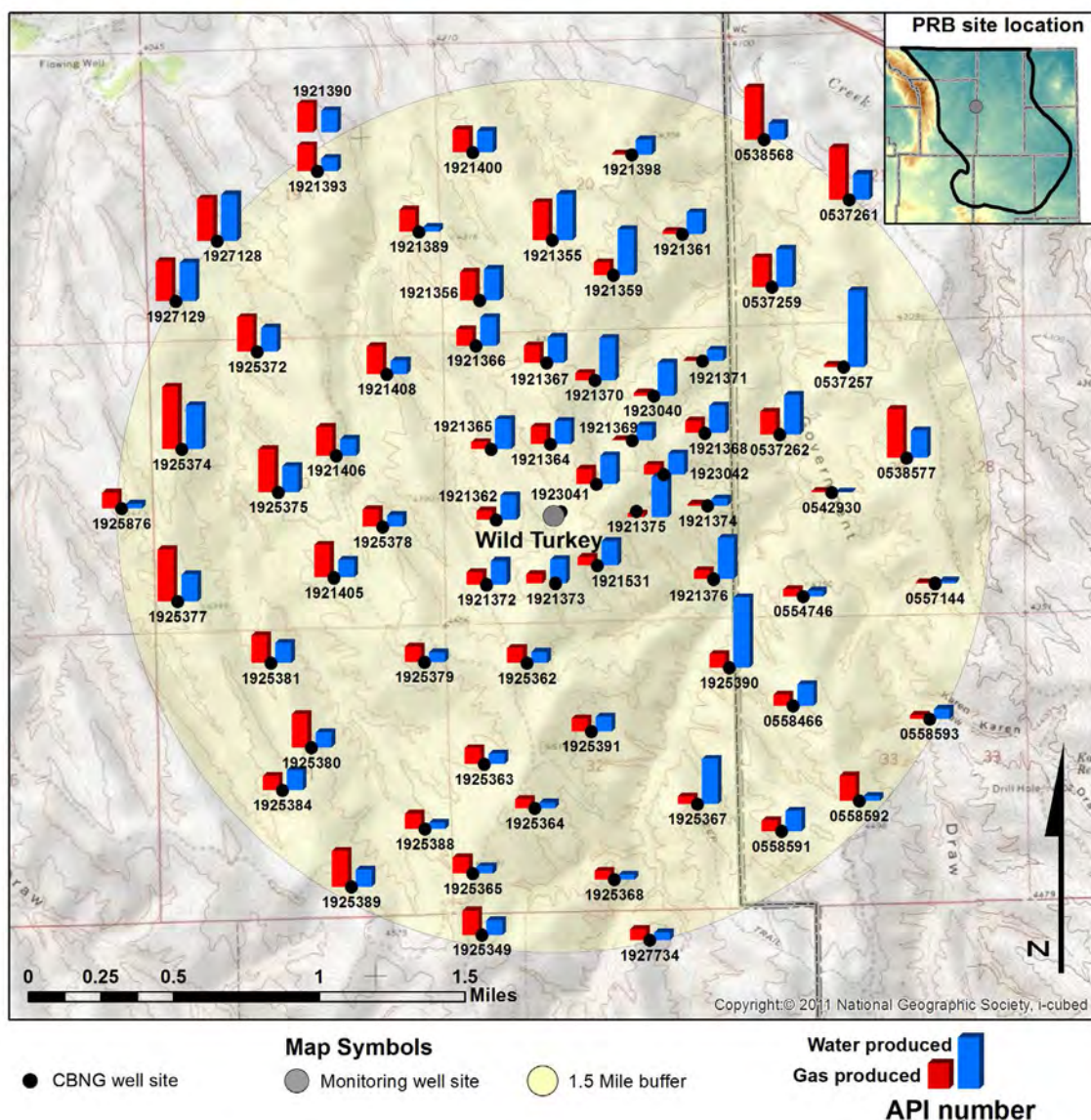
### Production Statistics

Production data were analyzed for CBNG wells within the buffer of the Wild Turkey monitoring well site from 1989-2012. Cumulative production for individual CBNG wells is displayed by location

on Figure A.245. CBNG production is monitored in the Wyodak Rider coal zone and some production in this area occurs in unknown coal zones.



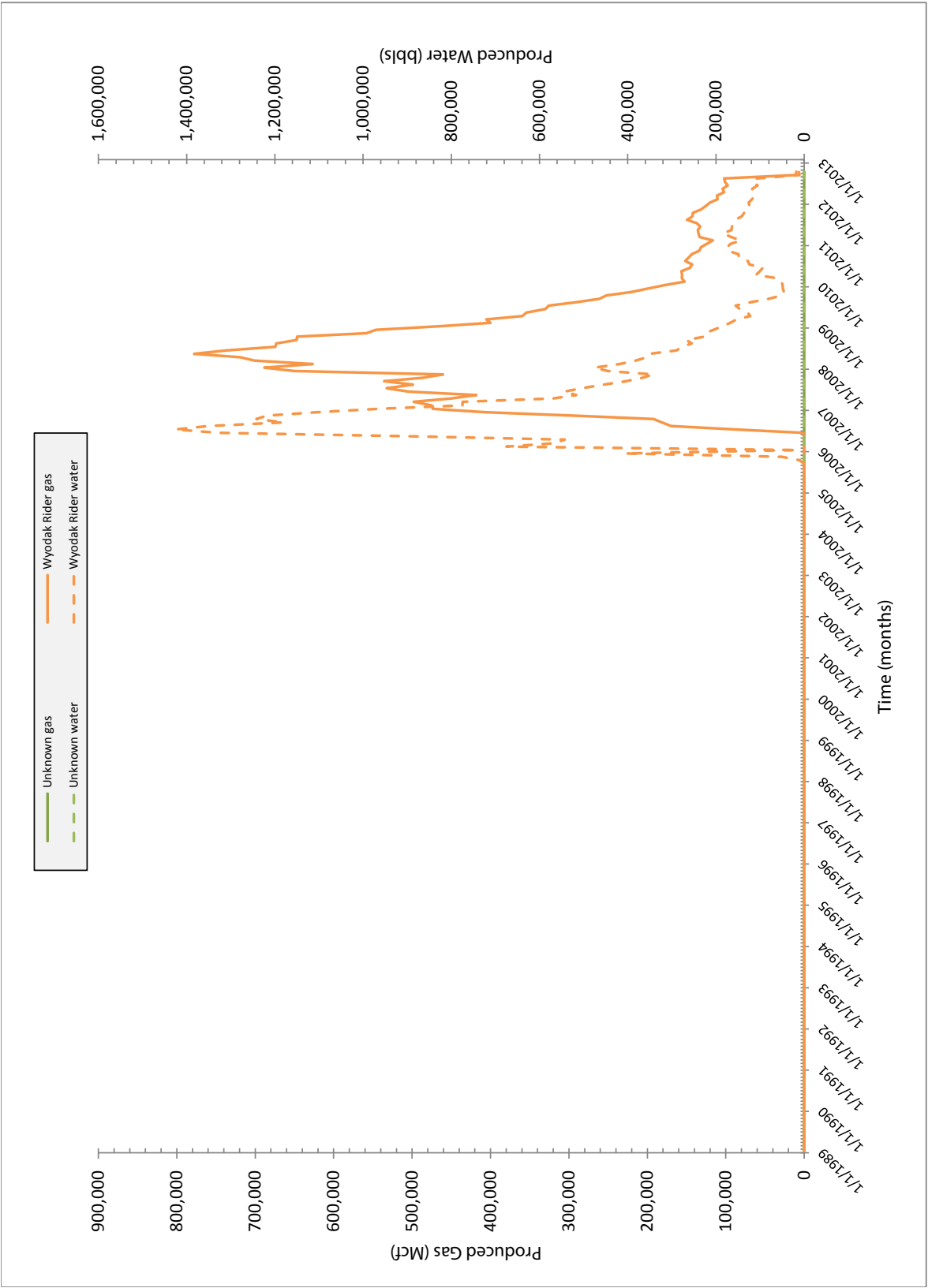
**Figure A.244.** Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Wild Turkey monitoring wellsite location.



**Figure A.245.** Wild Turkey monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

Water production in the Wyodak Rider coal zone began in October 2005, peaked at 1,425,974 bbls in July 2006 and ended 2012 at 12,048 bbls/month (Figure A.246). Gas production in the Wyodak Rider coal zone began in June 2006 and has continued into 2012. Gas production reached a maximum at 777,979 Mcf in May 2008.

The WOGCC did not report any gas or water production for wells completed in the unknown coal zones over the life of the well (Figure A.246).



**Figure A.246.** Water and gas production from CBNG wells associated with the Wild Turkey monitoring well site location.

## Williams Cedar Draw Monitoring Well Site

Location: S15 T53N R75W

Date First Monitored: April 12, 2007

### Drawdown Information

The Williams Cedar Draw monitoring well site includes three wells with dual completions, separated by packers. The three wells are completed into six zones. One well is completed into a Wasatch sandstone and the Smith coal of the Wyodak Rider coal zone. The second well is completed into the Fort Union underburden sandstone and the Anderson coal of the Upper Wyodak coal zone. The third well is completed in the Werner coal of the Cook coal zone and the Gates/Wall coal of the Cook and Wall coal zones (Figure A.247; Table A.122). Water levels and wellhead gas pressures were measured during the POR using both manual and automatic transducer and data logger equipment. Transducer data that is missing, randomly fluctuating (noisy) or that substantially differs from concurrent manual measurements may indicate on-site equipment failure, malfunction or requirement for calibration.

### Wasatch Sandstone

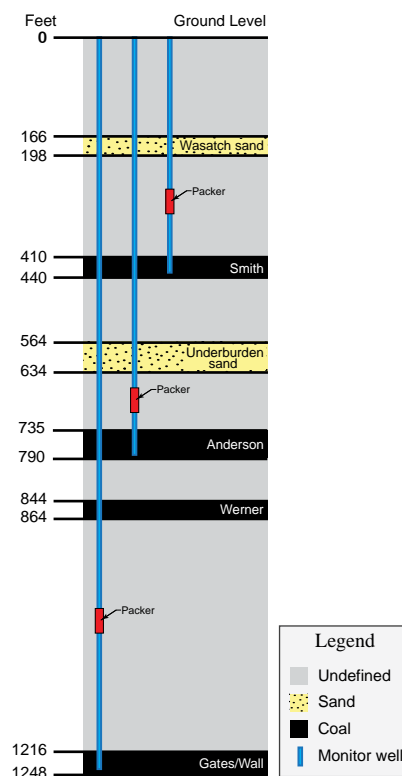
Groundwater levels rose 1.15 feet during the 2010-2012 POR and 1.59 feet over the monitoring period of 2007-2009 (Figure A.248; Table A.123). Gas pressure was not recorded in the Wasatch sandstone.

### Smith Coal

A groundwater decline of 1.39 feet was observed during the 2010-2012 POR. Groundwater levels rose 0.02 feet over the monitoring period of 2007-2009 (Figure A.248; Table A.123). Gas pressure in the Smith coal remained near zero psi over the life of the well.

### Fort Union Underburden Sandstone

Groundwater levels declined 113.27 feet during the 2010-2012 POR and 163.28 feet over the monitoring period of 2007-2009 (Figure A.248; Table A.123). Gas pressure was not recorded in the underburden sand.



**Figure A.247.** Section showing relative positions of coals and sands in feet. Not to scale.

### Anderson Coal

Groundwater levels rose 0.86 feet during the 2010-2012 POR but showed a decline of 293.95 feet over the monitoring period of 2007-2009 (Figure A.249; Table A.123). Gas pressure in the Anderson coal remained relatively stable, near zero psi, over the life of the well.

### Werner Coal

Groundwater levels declined 1.44 feet during the 2010-2012 POR and 19.79 feet over the monitoring period of 2007-2009 (Figure A.249; Table A.123). Gas pressure remained relatively stable over the life of the well at about 3 psi.

**Table A.122.** Table showing the depth to and thickness of monitored zones at the Williams Cedar Draw monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Wasatch sand	166	198	32	212
Smith coal	410	440	30	n/a
Underburden sand	564	634	70	124 - Smith 101 - Anderson
Anderson coal	735	790	55	n/a
Werner coal	844	864	20	n/a
Gates/Wall coal	1,216	1,248	32	n/a

**Table A.123.** Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2010	Drawdown 2010-2012	Total drawdown (ft.)	Depth to Final water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	115.79	-1.59	-1.15	-2.74	113.05	n/a	n/a
Smith coal	169.15	-0.02	1.39	1.37	170.52	0.28	3/2/2012
Underburden sand	259.77	163.28	113.27	276.55	536.32	n/a	n/a
Anderson coal	243.95	293.95	-0.86	293.09	537.04	2.45	12/19/2009
Werner coal	143.90	19.79	1.44	21.23	165.13	2.46	6/28/2007
Gates/Wall coal	216.50	123.70	n/a	340.20	n/a	155.00	12/17/2009

#### **Gates/Wall Coal**

Groundwater levels were not recorded in the Gates/Wall coal during the 2010-2012 POR due to high gas pressure. Groundwater levels declined 123.70 feet over the monitoring period of 2007-2009 (Figure A.249; Table A.123). Gas pressure varied from 87-155 psi over the life of the well.

#### **Production Statistics**

Production data were analyzed for CBNG wells within the buffer of the Williams Cedar Draw monitoring well site from 1999-2012. Cumulative production for individual CBNG wells is displayed by location on Figure A.250. CBNG production is monitored in the Cook and Upper Wyodak coal

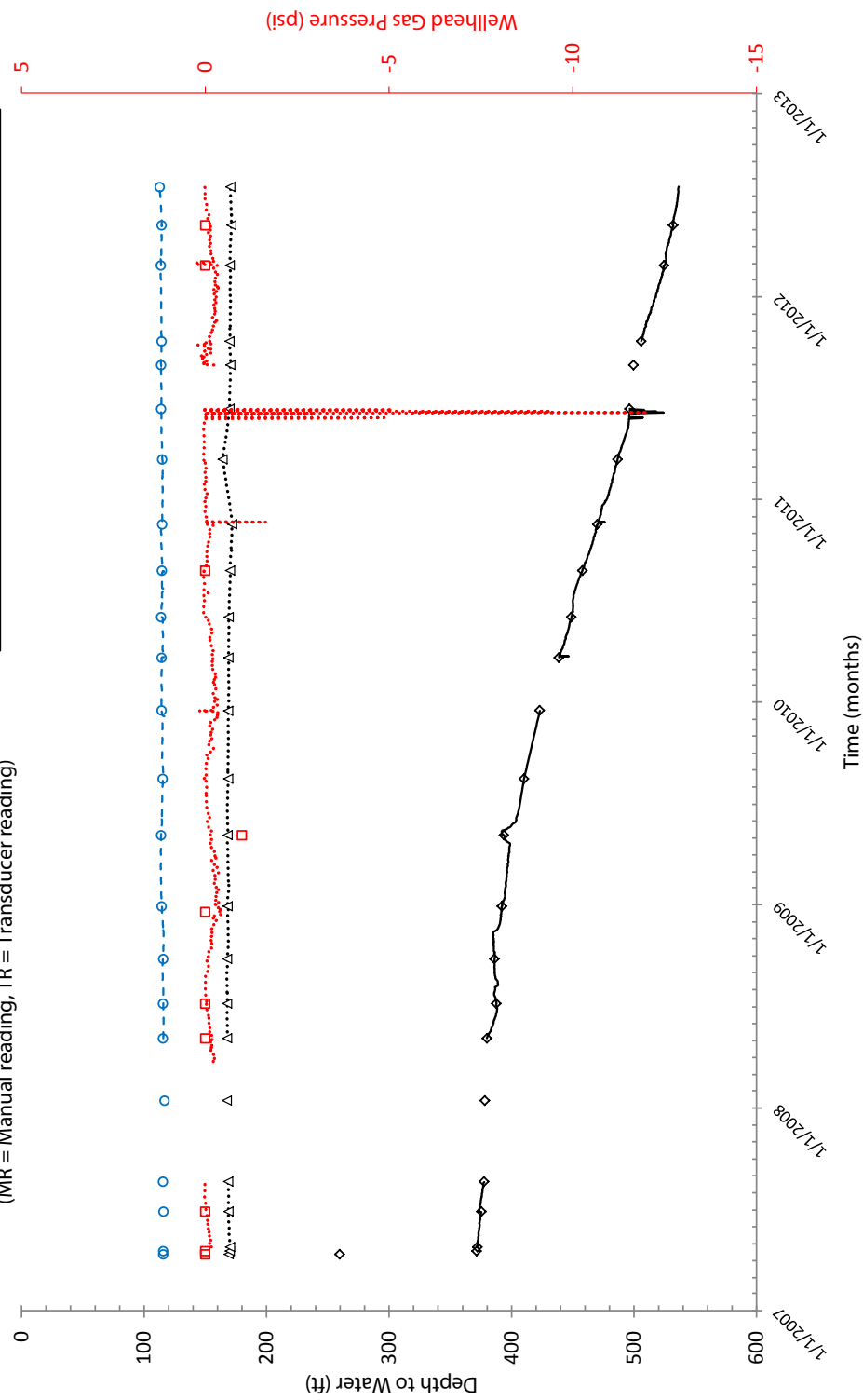
zones and some production in this area occurs in multiple production coal zones or coal zones where water levels are not monitored (unmonitored zones).

Water and gas production in the Cook coal zone began in October 2000 and January 2001, respectively. Water production rates from the Cook coal zone were relatively low until mid-2008 when they increased nearly tenfold, peaking at 87,561 bbls in August 2009 and ending 2012 at 36,992 bbls/month (Figure A.251). Gas production in the Cook has remained between 20,000 and 50,000 Mcf/month since April 2002.

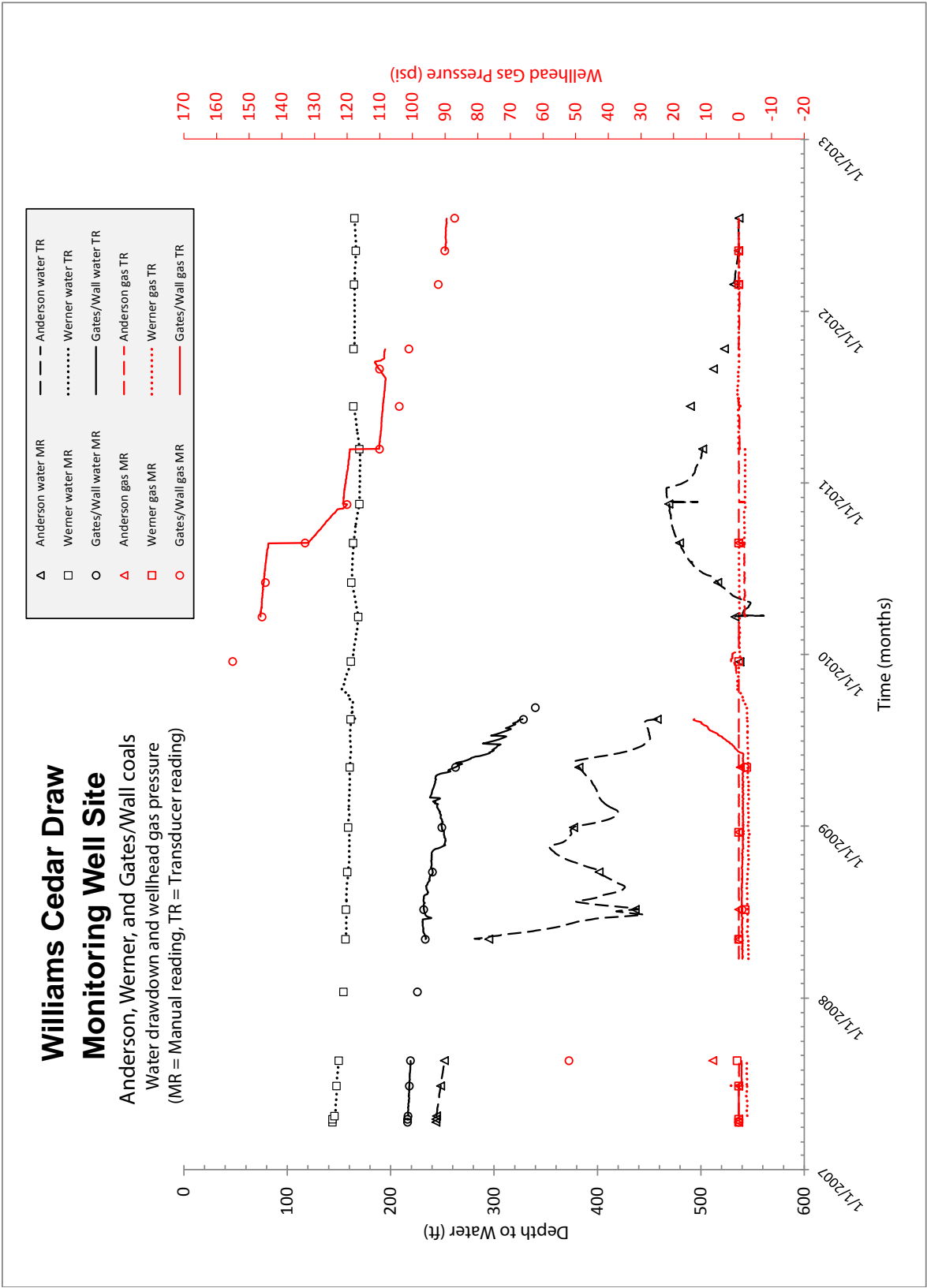


## Williams Cedar Draw Monitoring Well Site

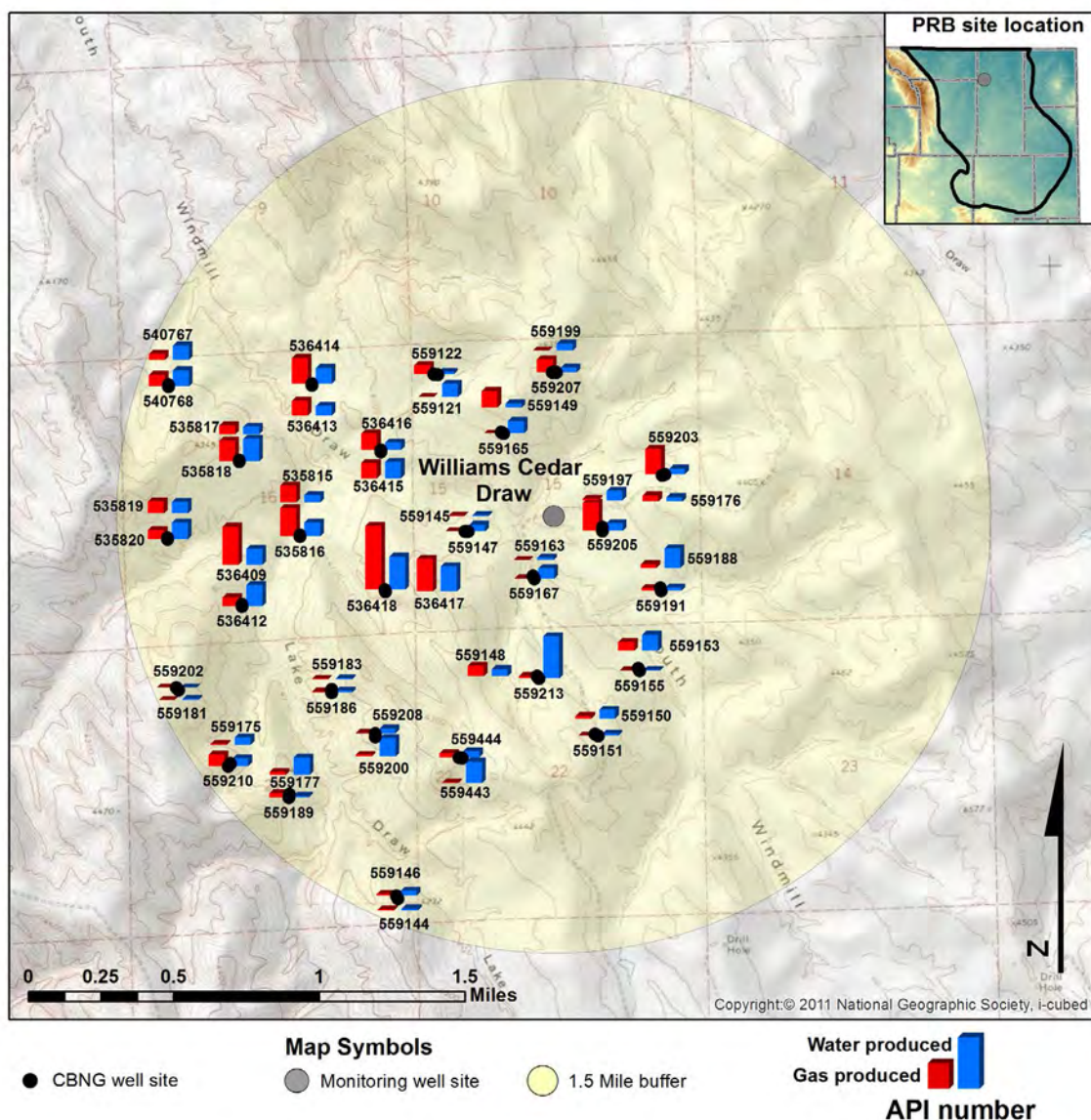
Wasatch sand, Smith coal, and Underburden sand  
Water drawdown and wellhead gas pressure  
(MR = Manual reading, TR = Transducer reading)



**Figure A.248.** Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Williams Cedar Draw monitoring wellsite location.



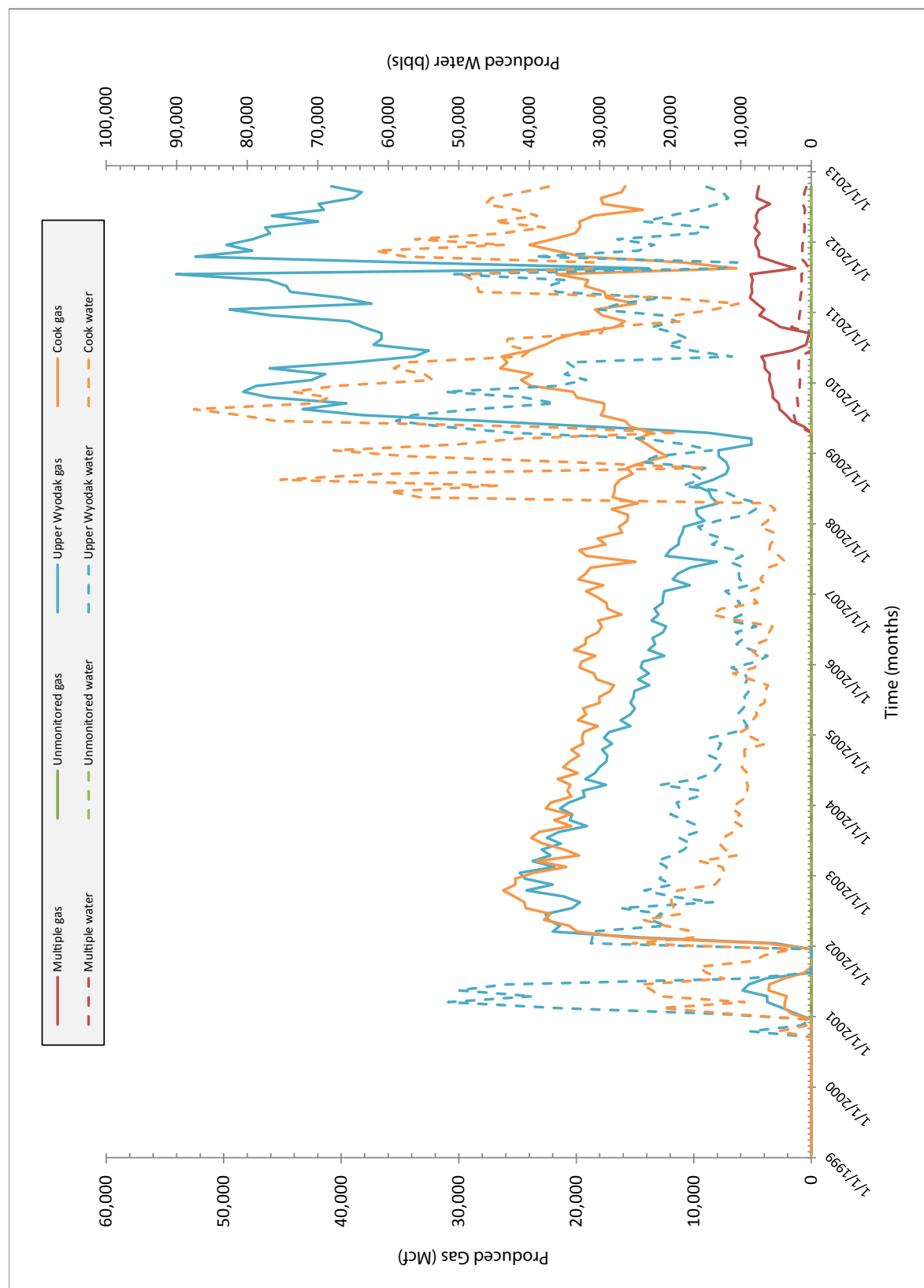
**Figure A.249.** Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Williams Cedar Draw monitoring wellsite location.



**Figure A.250.** Williams Cedar Draw monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

Like the Cook coal zone, water and gas production in the Upper Wyodak coal zone began in October 2000 and January 2001, respectively. Water production peaked at 58,920 bbls in June 2009 (Figure A.251) and then decreased to an average monthly production of 17,114 bbls in 2012. Locally, gas production in the Upper Wyodak peaked at 54,050 Mcf in July 2011.

The WOGCC reports that there was no water and gas production in the unmonitored coal zone wells for the monitoring period of 1999-2012. Water was produced consistently from multiple coal zone wells from May 2009-2012. Water production reached its maximum level of 2,832 bbls in October 2010 and averaged <1000 bbls/month in 2012 (Figure A.251). Locally, gas production began in May 2009, peaked at 5,220 Mcf in March 2011 and averaged 4,494 Mcf/month in 2012.



**Figure A.251.** Water and gas production from CBNG wells associated with the Williams Cedar Draw monitoring well site location.

**Wormwood Monitoring Well Site**  
**Location: S14 T46N R76W**  
**Date First Monitored: December 13, 2006**

**Drawdown Information**

The Wormwood monitoring well site includes two wells one of which is a dual completion well, separated by a packer. The dual completion well is completed in a Wasatch sandstone and a Fort Union underburden sandstone. The second well is completed in the Big George Coal of the Wyodak Rider coal zone. (Figure A.252; Table A.124). Water levels and wellhead gas pressures were measured during the POR using both manual and automatic transducer and data logger equipment. Transducer data that is missing, randomly fluctuating (noisy) or that substantially differs from concurrent manual measurements may indicate on-site equipment failure, malfunction or requirement for calibration.

**Wasatch sandstone**

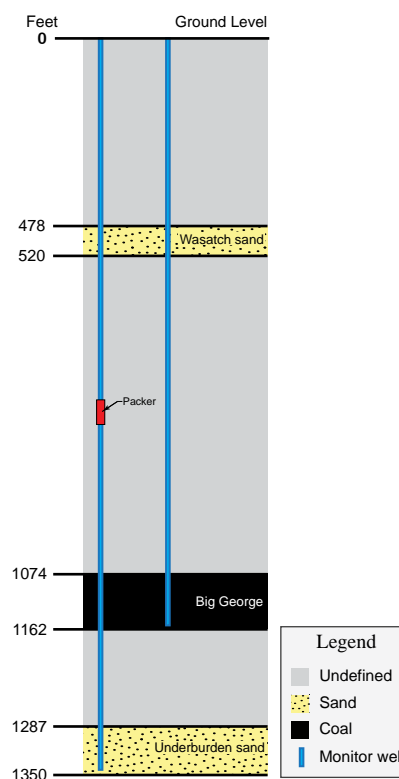
The Wasatch sandstone recorded a groundwater decline of 0.7 feet during the 2010-2012 POR but a rise in groundwater level of 4.76 feet over the monitoring period of 2006-2009 (Figure A.253; Table A.125). Gas pressure was not recorded in the Wasatch sandstone.

**Big George Coal**

Groundwater levels in the Big George coal declined 68.01 feet during the 2010-2012 POR compared to a decline of 683.31 feet over the monitoring period of 2006-2009 (Figure A.253; Table A.125). Gas pressure in the Big George coal remained relatively stable, near zero, over the life of the well.

**Fort Union Underburden Sandstone**

The Fort Union underburden sandstone recorded groundwater declines of 137.77 feet during the 2010-2012 POR and 235.60 feet over the monitoring period of 2006-2009 (Figure A.253; Table A.125). Gas pressure was not recorded in the underburden sand.



**Figure A.252.** Section showing relative positions of coals and sands in feet. Not to scale.

**Table A.124.** Table showing the depth to and thickness of monitored zones at the Wormwood monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Wasatch sand	478	520	42	554
Big George coal	1,074	1,162	88	n/a
Underburden sand	1,287	1,350	63	125

**Table A.125.** Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

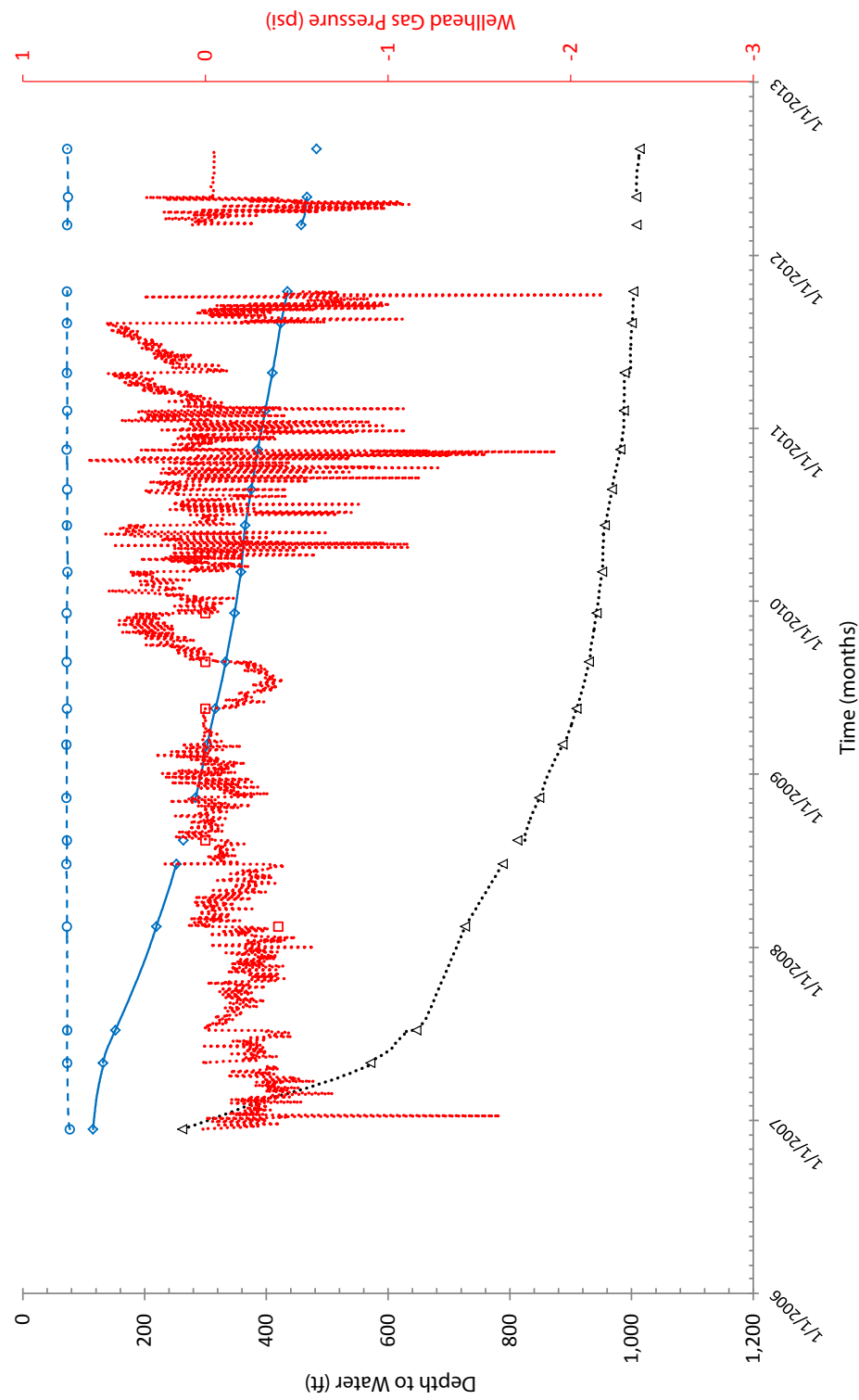
Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2010	Drawdown 2010-2012	Total drawdown (ft.)	Depth to Final water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	77.30	-4.76	0.70	-4.06	73.24	n/a	n/a
Big George coal	262.00	683.31	68.01	751.32	1013.32	0.65	10/25/2010
Underburden sand	115.20	235.60	137.77	373.37	488.57	n/a	n/a

## Wormwood Monitoring Well Site

Wasatch sand, Big George coal, and Underburden sand

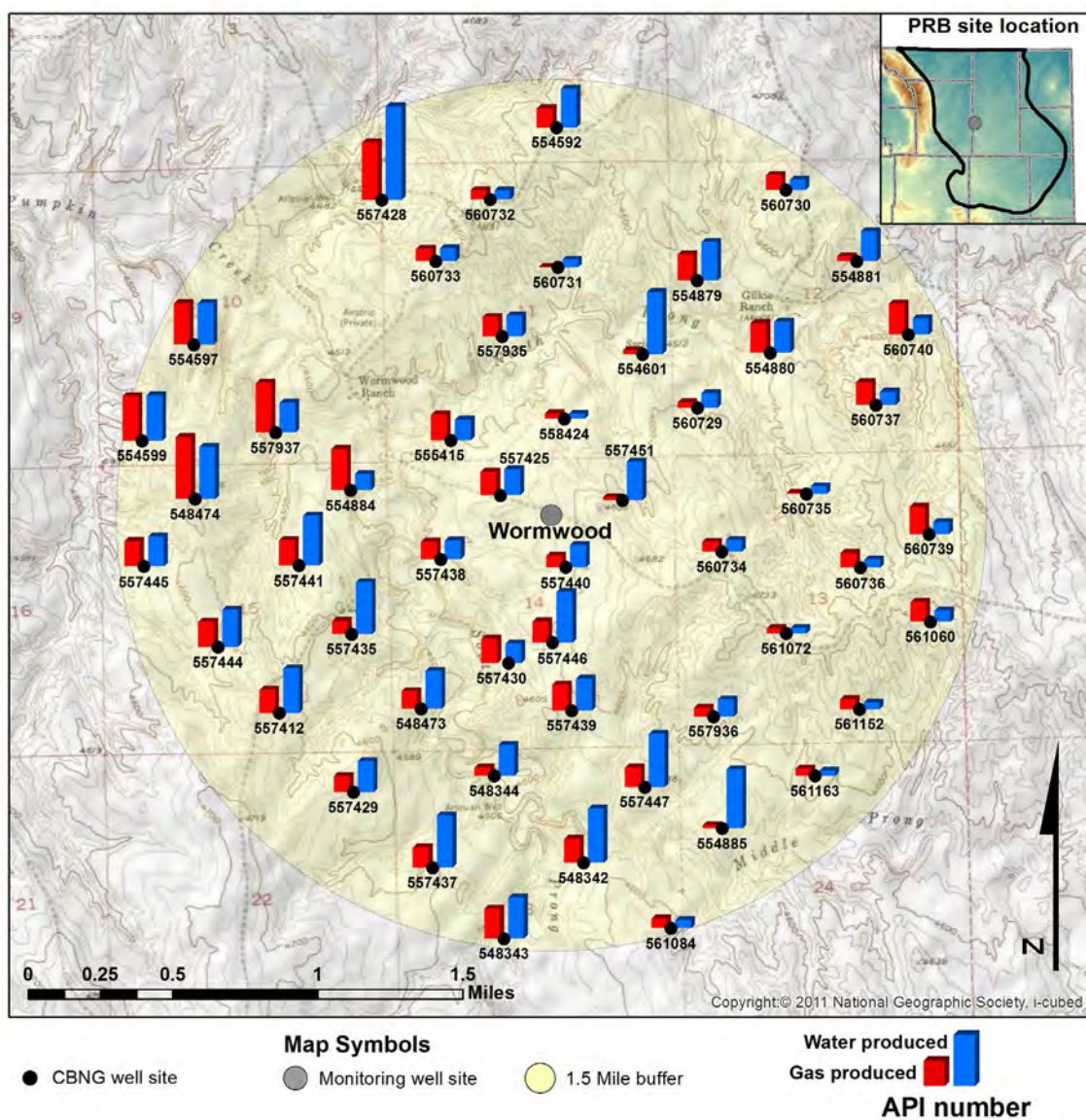
Water drawdown and wellhead gas pressure

(MR = Manual reading, TR = Transducer reading)



**Figure A.253.** Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Wormwood monitoring wellsite location.





**Figure A.254.** Wormwood monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

### Production Statistics

Production data were analyzed for CBNG wells within the buffer of the Wormwood monitoring well site from 2002-2012. Cumulative production for individual CBNG wells is displayed by location on Figure A.254. CBNG production is monitored only in the Wyodak Rider coal zone; this is the only coal zone in which production occurs.

Water production in the Wyodak Rider coal zone began in August 2006, peaked at 504,162 bbls in March 2007, and then declined to an average of 157,097 bbls/month in 2012 (Figure A.255). Gas production in the Wyodak Rider coal zone began in 2007, peaked in March 2009 at 255,163 Mcf, and has remained above 150,000 Mcf per month during 2010-2012 POR.

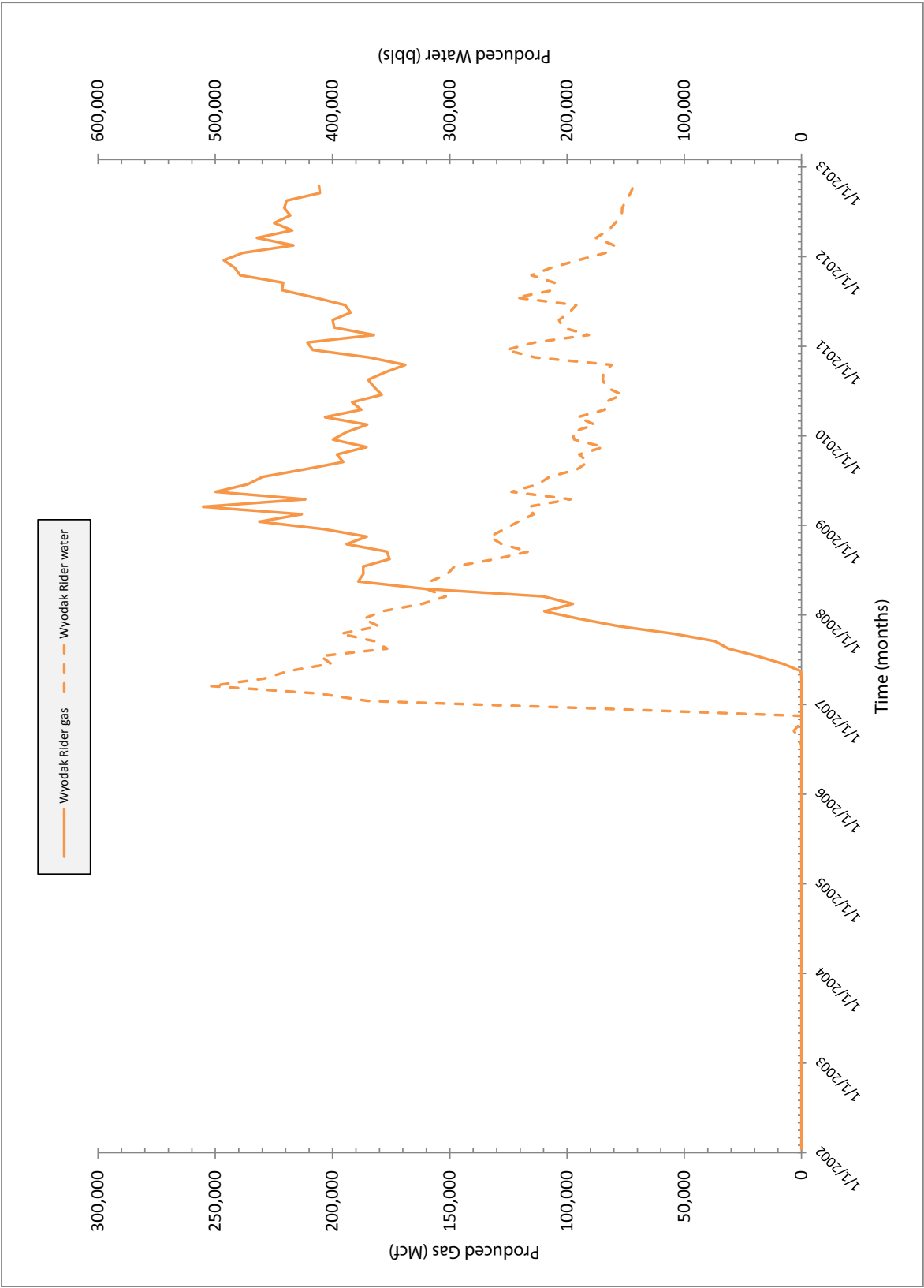


Figure A.255. Water and gas production from CBNB wells associated with the Wormwood monitoring well site location.









*Geology - Interpreting the past - providing for the future*