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

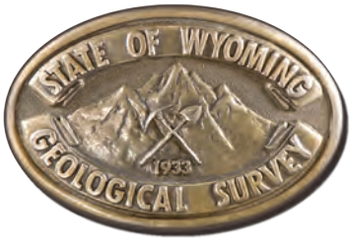
2013 Coalbed Natural Gas Regional Groundwater Monitoring Update: Powder River Basin, Wyoming

Open File Report 2014-01

by
Karl G. Taboga and James E. Stafford

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

Laramie, Wyoming
2014



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Cover: *Active coalbed natural gas well location. Photo courtesy of Bureau of Land Management, Buffalo Field Office, Wyo.*

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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, 2014). 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 sandstones, and sandstones that underlie Fort Union coal zones; 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 through December 2013. 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, the Appendix contains groundwater and associated CBNG production data for the duration that each monitoring well site has been in operation. The term "period of record" (POR), frequently used in this report, generally refers to the entire monitoring period for each well site. The POR may be specified for convenience (i.e. 2007 – 2013 POR) or in cases where the text refers to a portion of the total monitoring period (i.e 2013 POR).

For the purposes of this report, CBNG production data, including water and gas production are assigned to monitoring zones. The Wyoming State Geological Survey (WSGS) compiled data from the Wyoming Oil and Gas Conservation Commission (WOGCC) and the BLM Buffalo Field office and attempted 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 wells are typically housed within a large galvanized steel culvert that encloses the wellhead. A small fiberglass hut contains the instrument panel that is further protected by a surrounding fence which prevents livestock or game from interfering with the monitoring equipment (Figure 2-A).

The BLM employs both automated and manual methods to measure static depth to groundwater (SDGW) in monitoring wells. Automated SDGW measurements are obtained using Vaisala® or Stevens® incremental encoders (Figure 2-C) where groundwater levels are less than 400 feet below ground surface (bgs). In deeper wells, Druck® and Esterline® electronic pressure transducers determine SDGW. Typically, automated devices measure SDGW once daily and the results are stored to a memory card contained within an external Campbell® Scientific data logger. The transducers record 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). Occasionally, equipment failure or transponder error may result in missed electronic measurements.

During an onsite field inspection, a BLM hydrologic technician will first use a pressure gauge to determine wellhead gas pressure. If pressure exceeds 10 psi, the well is deemed unsafe and manual groundwater-level measurements cannot be ob-

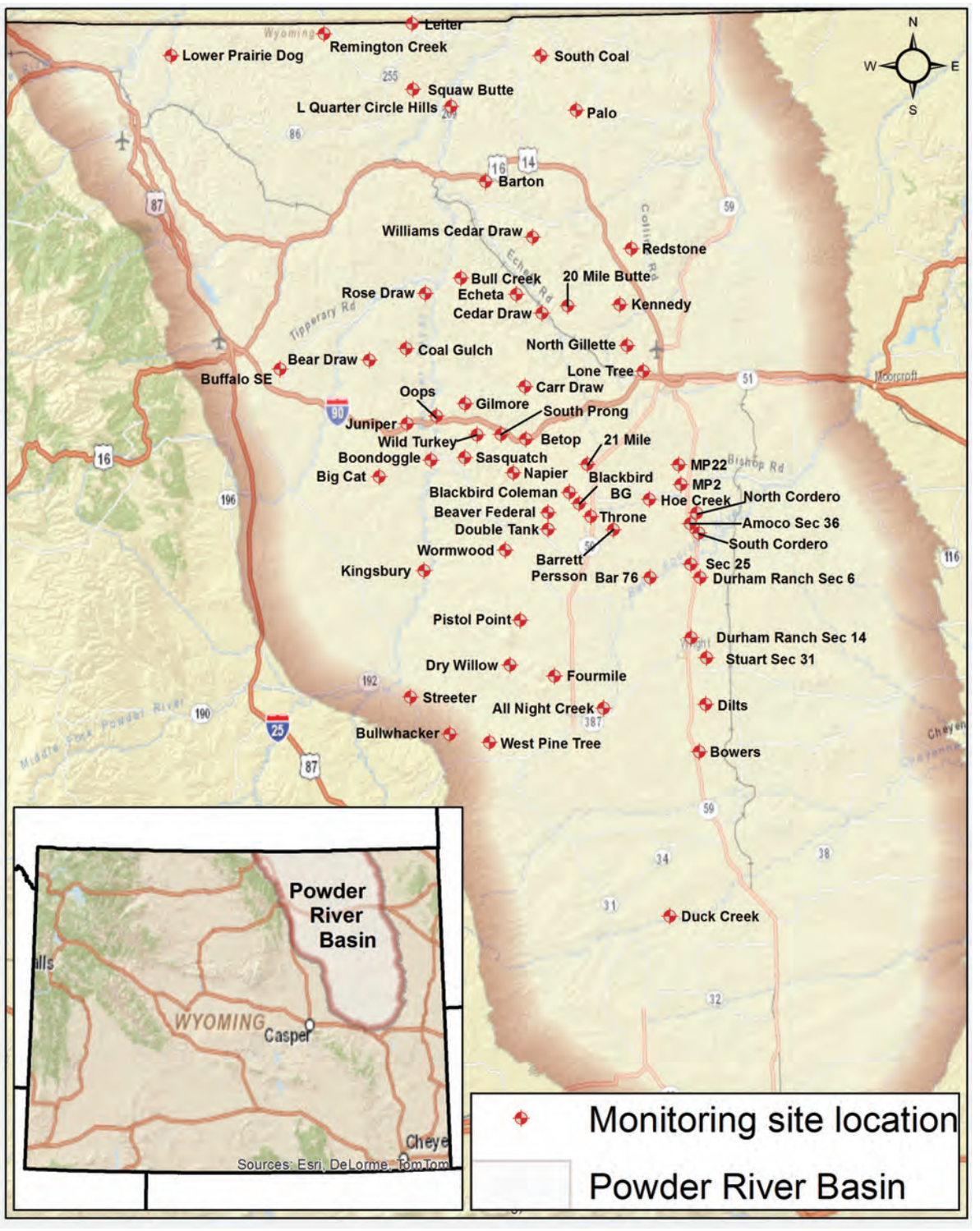

Figure 1. Bureau of Land Management (BLM) groundwater monitoring site locations in the Powder River Basin (PRB), Wyoming.

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				
Campbell	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 N	75 W	1	1	4403	11/06/91
	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				
Converse	Duck Creek	SW SW	20	38 N	72 W	2	2	4923	03/28/05
Johnson	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	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	03/19/98
	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	01/14/98
	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
Sheridan	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
	Remington Creek	SW NE	30	58 N	79 W	4	4	3688	05/23/05
	Squaw Butte	SE NE	1	56 N	78 W	1	1	4055	10/17/01

tained. If the wellhead pressure is less than 10 psi, the wellhead is opened, gas pressure is released and a manual measurement is taken. The measurement is recorded and then compared to the electronic measurement at the instrument panel. An adjustment is made to the data logger if the electronic measurement does not correspond to the manual measurement; any adjustments are recorded in both the technician's and the well site log books. The technician also changes the desiccant used to control moisture within the instrument panel, replaces the memory card, reloads the electronic data logger software, calibrates the data logger, and checks the system for any needed maintenance.

Manual SDGW measurements are collected by BLM field technicians approximately every three months using Solinst® or In-Situ® electronic-measuring tapes (Figure 2-B). Manual measurements are taken to confirm electronic measurements and calibrate the transducers. Periodically, adverse field conditions such as high wellhead gas pressures, poor weather or equipment failure may preclude or delay manual data collection.

Methane (CH_4) 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_4. The higher sensitivity setting is employed on monitored sandstone wells and the lower sensitivity setting is employed for coal wells.

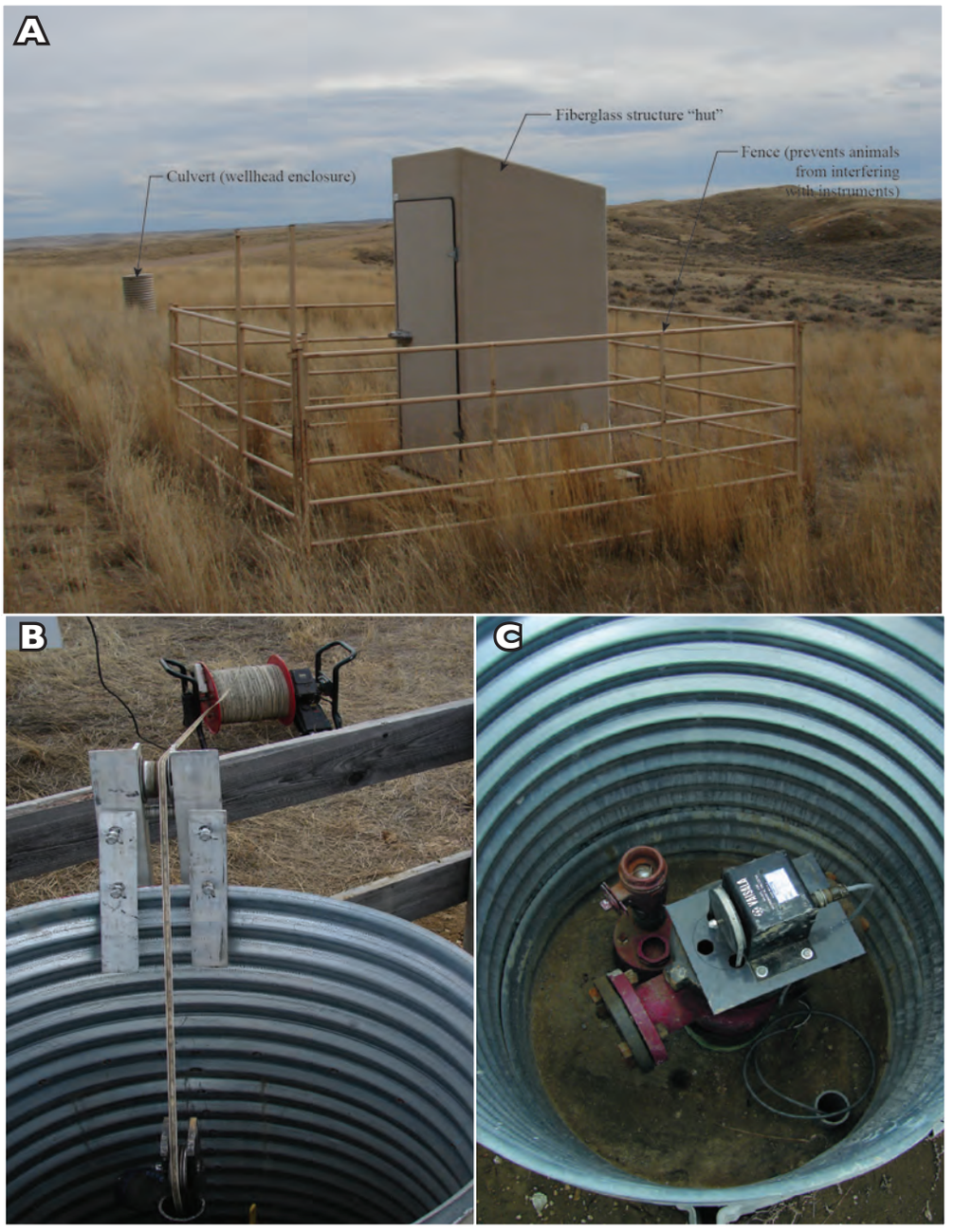

Figure 2. A) Wellhead culvert cover and equipment storage facility for the Napier groundwater monitoring well site, Campbell County, Wyoming. B) Electronic tape measuring system in use at the Juniper groundwater monitoring well site, Johnson County, Wyoming. C) Counterbalance tape used for shallow well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

At the BLM field office, electronic SDGW data is downloaded from the memory card into a Microsoft® Excel spreadsheet. The data is reviewed under BLM QA/QC policy. Notes are added to the dataset regarding data anomalies, equipment calibration, mechanical problems, or maintenance.

BLM transferred monitoring well data to the WSGS on compact disc. The BLM data can also be downloaded from the Wyoming Geographic Information Science Center's (WyGISC), Wyoming GeoLibrary at http://wygl.wygisc.org/wygeolib/catalog/main/home.page.

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.

WSGS prepared the schematic stratigraphic columns from depth and thickness data provided by the BLM. 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).

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 3,080 production wells likely to impact groundwater levels by using GIS software (ESRI® ArcCatalog 10.2 and ArcGIS 10.2) 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 3,080 wells identified, 135 had insufficient completion data to be assigned to the five primary coal zones: Wyodak Rider (Big George), Upper Wyodak, Lower Wyodak, Cook, and Wall. Of the wells with adequate completion data 2,297 had production associated with a monitored zone. Monitoring wells that do not have associated production data are noted in the Appendix.

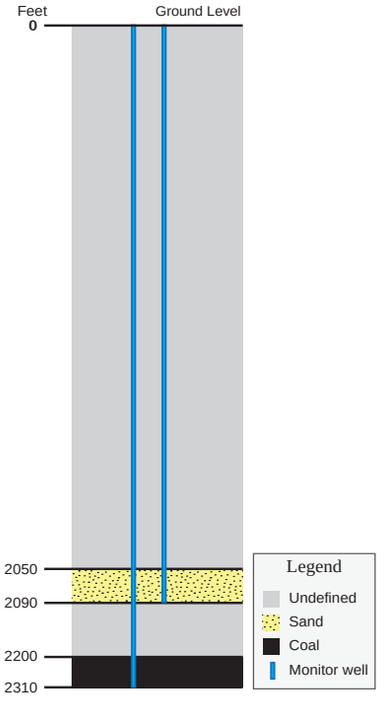

Figure 3. Example of stratigraphic column showing relationship between monitored strata. Not to scale.

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 the Appendix, respectively.

MONITORED ZONES AND COAL ZONE DESIGNATIONS

This report presents all available data from the BLM deep groundwater monitoring well site network through December 2013. As this dataset is exceedingly large, monitoring well data have been assigned to designated coal 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 (Appendix). Coal zones and sandstones are adapted from Jones 2008 (Table 2).

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

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

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

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 this report, Wasatch sandstones are categorized as overburden and may include Fort Union sandstones that lie above monitored coal zones (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, 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

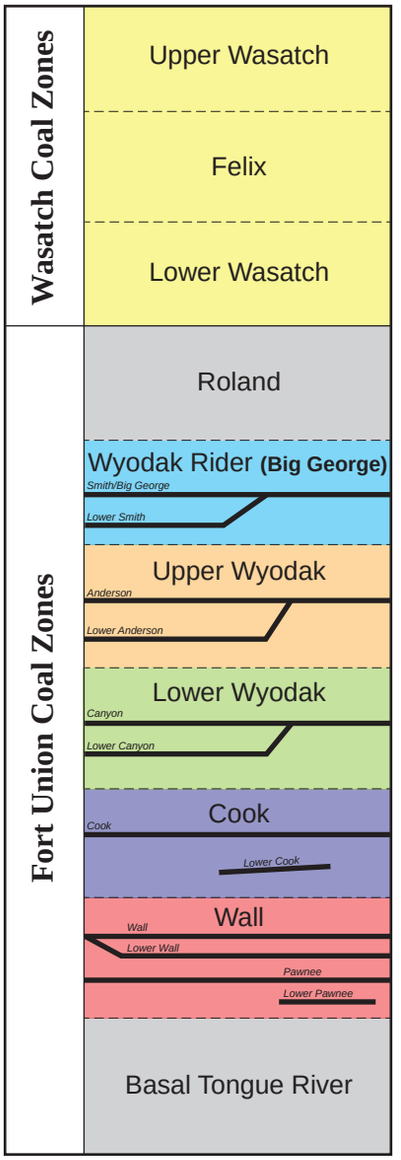

Figure 4. Stratigraphic chart of the geologic formations and associated coal zones in the PRB, Wyoming.

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 underburden sandstones in the Fort Union Formation are also monitored at seven sites 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 monthly production of 49,400,745 thousand cubic feet (Mcf) in January 2009 (Figure 5). The most recent available data show that 23,200,702 Mcf of CBNG was produced in December 2013, a decrease of 26,200,043 Mcf. During the period from 1989 to December 2013, the PRB produced a total of 5,353,602,639 Mcf of CBNG; production during 2013 (312,456,824 Mcf) accounts for almost 6 percent of this total.

Water production associated with CBNG development in the basin has also decreased since reaching peak production of 67,029,234 bbls in the month of October, 2006 (Figure 5). Water production in December 2013 was 21,697,602 bbls. During the period from January 1987 to December 2013, 7,333,751,782 bbls of water were co-produced as a result of CBNG extraction in the PRB, water production during 2013 (301,045,438 bbls) accounted for 4 percent of this total.

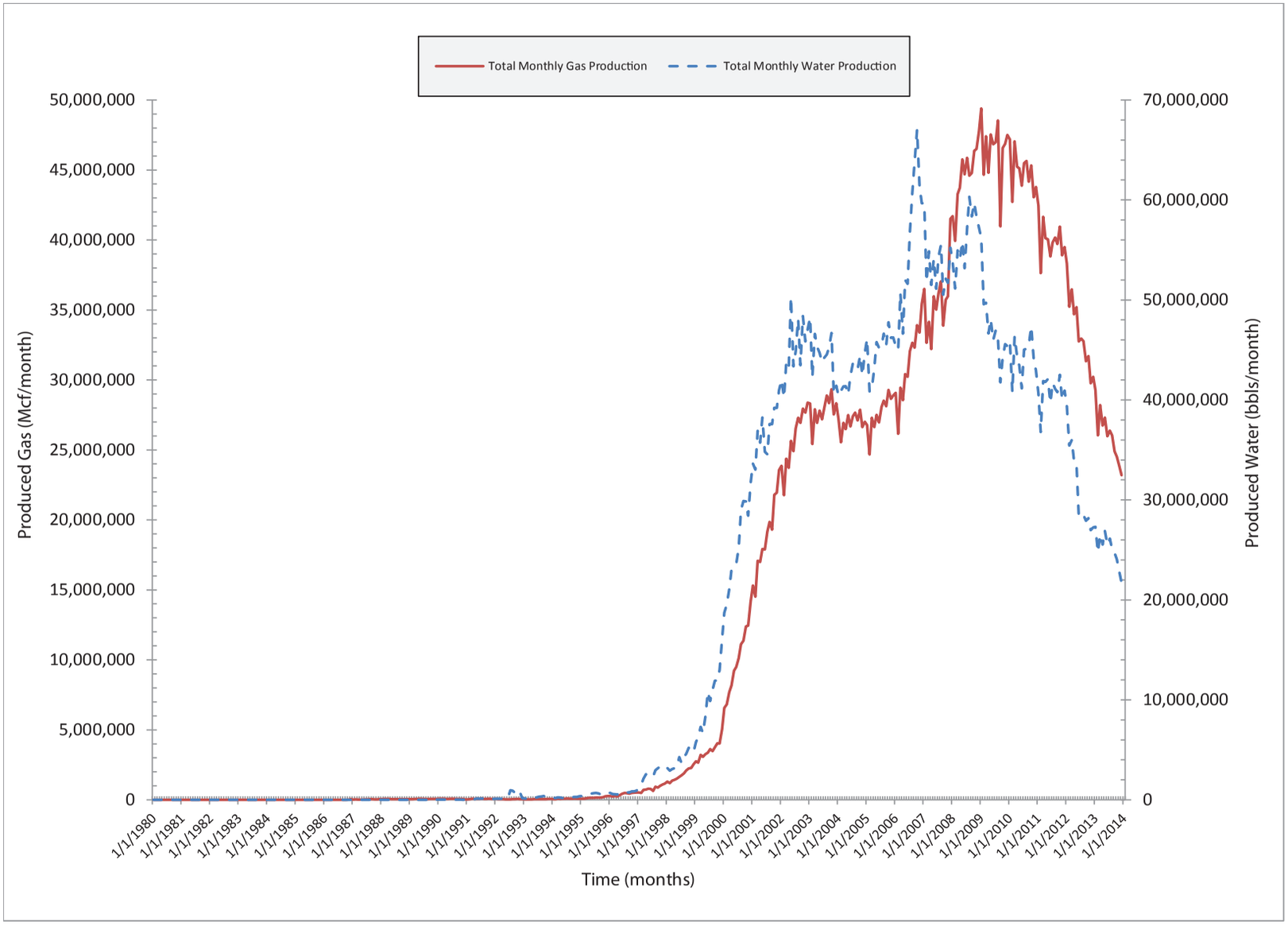

Figure 5. Total monthly coalbed natural gas (CBNG) and water production for all CBNG wells in the PRB, Wyoming (WOGCC,2014).

Monitoring Zone Water Level Changes and Production Data

Wasatch Sandstones

During the 2013 POR, drawdown in monitored Wasatch sandstones varied greatly. The monitoring well sites at Napier (69.39 ft) and Bear Draw (40.20 ft) showed the greatest amount of drawdown (Table 3). On the other hand, water levels recovered at eighteen monitoring well sites; the greatest recovery was observed at the Cedar Draw monitoring site which showed an increase of 68.11 feet in groundwater level (Table 3). The observed water level variations appear to be scattered throughout the basin, and do not exhibit apparent 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.

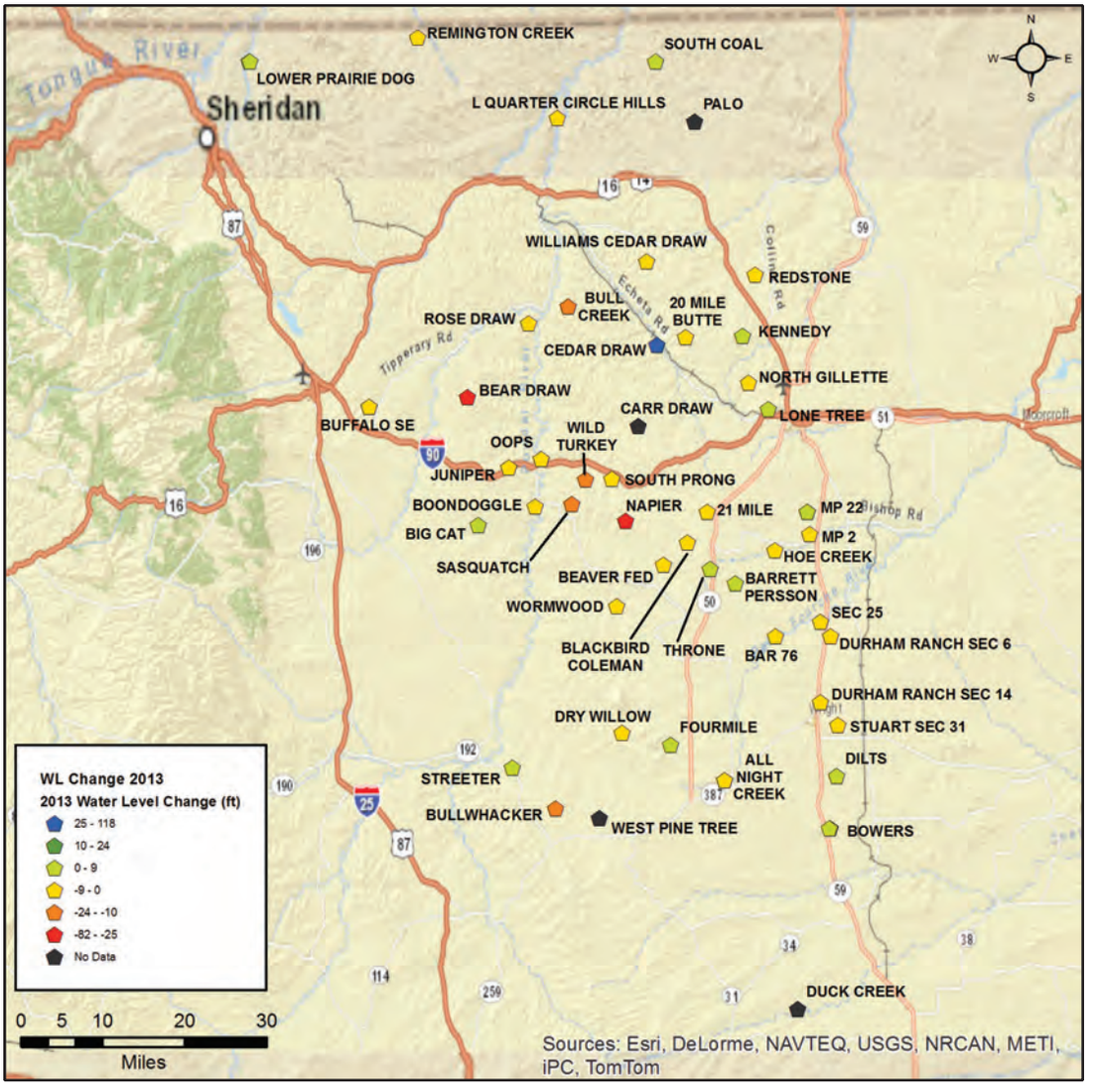

Figure 6. Measured groundwater variation in the Wasatch sandstones during the 2013 POR.

Table 3. Change in water levels by monitoring well site during the 2013 POR in the Wasatch sandstones.

Monitoring Site	Location	Water Level Change (ft)	Monitored Wasatch Sandstones
Napier	SE SE, 24, 48 N, 76 W	-69.39	*Wasatch*
Bear Draw	SW NW, 1, 50 N, 79 W	-40.20	*Wasatch*
Sasquatch	NE SW, 12, 48 N, 77 W	-20.93	*Wasatch*
Wild Turkey	NE SW, 29, 49 N, 76 W	-15.88	*Wasatch*
Bullwhacker	NW SE, 16, 42 N , 77 W	-14.02	*Wasatch*
Bull Creek	NW SE, 12, 52 N, 77 W	-10.20	*Wasatch*
Boondoggle	SE SE, 7, 48 N, 77 W	-7.20	*Wasatch*
Bar 76	NE SE, 1, 45 N, 73 W	-5.10	*Wasatch*
Juniper	SW SW, 14, 49 N, 78 W	-3.78	*Wasatch*
L Quarter Circle Hills	NE SE, 14, 56 N, 77 W	-3.69	*Wasatch*
Rose Draw	NE SE, 19, 52 N, 77 W	-2.67	*Shallow*
Hoe Creek	SW SW, 7, 47 N, 72 W	-2.30	*Wasatch*
South Prong	NW SE, 26, 49 N, 76 W	-1.72	*Wasatch*
Sec 25	SW SW, 25, 46 N, 72 W	-1.60	*Wasatch*
Durham Ranch Sec 6	SW NE, 6, 45 N, 71 W	-1.49	*Wasatch*
All Night Creek	NW SW, 36, 43 N, 74 W	-1.29	*Wasatch*
Blackbird Coleman	SW SE, 5, 47 N, 74 W	-1.08	*Wasatch*
MP 2	NW NW, 2, 47 N, 72 W	-1.05	*Wasatch*
Williams Cedar Draw	NE SW, 15, 53 N, 75 W	-1.04	*Wasatch*
Durham Ranch Sec 14	SE NE, 14, 44 N, 72 W	-1.02	*Wasatch*
Stuart Sec 31	NE SE, 31, 44 N, 71 W	-0.89	*Wasatch*
Beaver Fed	SE NW, 23, 47 N, 75 W	-0.78	*Wasatch*
Remington Creek	SW NE, 30, 58 N, 79 W	-0.68	*Wasatch*
21 Mile	NE NE, 22, 48 N, 74 W	-0.64	*Wasatch*
North Gillette	SW NE, 34, 51 N, 73 W	-0.63	*Wasatch*
Oops	SW SW, 9, 49 N, 77 W	-0.47	*Shallow*
Dry Willow	SE NW, 35, 44 N, 76 W	-0.31	*Wasatch*
Redstone	SE NW, 26, 53 N, 73 W	-0.11	*Wasatch*
Wormwood	NE NW, 14, 46 N, 76 W	-0.11	*Shallow*
20 Mile Butte	SE SE, 32, 52 N, 74 W	-0.09	*Wasatch*
All Night Creek	NW SW, 36, 43 N, 74 W	-0.03	*Shallow*
Bowers	SE SW, 36, 42 N , 72 W	-0.03	*Very Very Shallow*
Buffalo SE	NW NW, 12, 50 N, 81 W	-0.01	*Wasatch*
Buffalo SE	NW NW, 12, 50 N, 81 W	n/a	*Very Very Shallow*
Bull Creek	NW SE, 12, 52 N, 77 W	n/a	*Shallow*
Carr Draw	NE NE, 29, 50 N, 75 W	n/a	*Wasatch*
Duck Creek	SW SW, 20, 38 N, 72 W	n/a	*Wasatch*
MP 22	SE NE, 22, 48 N, 72 W	n/a	*Wasatch*
Oops	SW SW, 9, 49 N, 77 W	n/a	*Wasatch*
Palo	SE NE, 22, 56 N, 74 W	n/a	*Wasatch*
West Pine Tree	SE SE, 20, 42 N , 76 W	n/a	*Wasatch*

Table 3. cont.

Monitoring Site	Location	Water Level Change (ft)	Monitored Wasatch Sandstones
South Coal	NW SW, 13, 57 N, 75 W	0.01	*Wasatch*
MP 22	SE NE, 22, 48 N, 72 W	0.03	*Very Shallow*
Bowers	SE SW, 36, 42 N , 72 W	0.20	*Very Shallow*
MP 22	SE NE, 22, 48 N, 72 W	0.27	*Shallow*
Juniper	SW SW, 14, 49 N, 78 W	0.32	*Shallow*
Big Cat	SE SE, 24, 48 N, 79 W	0.35	*Wasatch*
Lower Prairie Dog	SE NE, 10, 57 N, 83 W	0.35	*Shallow*
Buffalo SE	NW NW, 12, 50 N, 81 W	0.49	*Very Shallow*
Buffalo SE	NW NW, 12, 50 N, 81 W	0.49	*Shallow*
Streeter	SE NW, 22, 43 N, 78 W	0.55	*Wasatch Sand*
All Night Creek	NW SW, 36, 43 N, 74 W	0.60	*Very Very Shallow*
Lone Tree	SW SE, 13, 50 N, 73 W	0.61	*Wasatch*
Fourmile	NW NE, 11, 43 N, 75 W	0.85	*Wasatch*
Kennedy	SE SE, 33, 52 N, 73 W	0.86	*Wasatch*
All Night Creek	NW SW, 36, 43 N, 74 W	0.97	*Very Shallow*
Dilts	SE NW, 31, 43 N, 71 W	1.35	*Shallow*
Bowers	SE SW, 36, 42 N , 72 W	1.83	*Shallow*
Lower Prairie Dog	SE NE, 10, 57 N, 83 W	1.91	*Wasatch*
Throne	NW NW, 26, 47 N, 74 W	4.02	*Wasatch*
Barrett Persson	SW SW, 32, 47 N, 73 W	4.59	*Wasatch*
Bowers	SE SW, 36, 42 N , 72 W	4.68	*Wasatch*
Cedar Draw	NE SW, 2, 51 N, 75 W	68.11	*Wasatch*

Wyodak Rider (Big George)

Although water levels decreased at most of the monitoring well sites in the Wyodak Rider during 2013, the extent of the observed water level changes varied greatly. The Double Tank monitoring well site recorded a decrease of 77.07 feet, while the Wild Turkey site recovered 22.28 feet (Table 4). Water level monitoring has been suspended in past years at twelve Wyodak Rider monitoring sites primarily because data could not be safely recovered due to high wellhead pressures. Two of the three monitoring well sites with water level declines that exceed 20 feet are located in the central part of the basin (Figure 7).

The amounts of water co-produced with CBNG from the Wyodak Rider coal zone vary widely across monitoring well sites (Table 4). CBNG water production was highest, again in 2013, around the Oops (2,568,613 bbls) and South Prong (2,090,006 bbls) monitoring well sites. The South Prong site showed the third highest drawdown (21.60 ft) in the Wyodak Rider coal zone. The second largest water level decline (23.44 ft) occurred at Sasquatch, where surrounding CBNG wells produced only 139,666 bbls of water. Conversely, the area around the Wild Turkey site produced 200,606 bbls of water, but water levels in the monitoring well rose 22.28 feet. Generally, wells located in areas that produced more than 250,000 bbls of water exhibited drawdowns exceeding 10 feet.

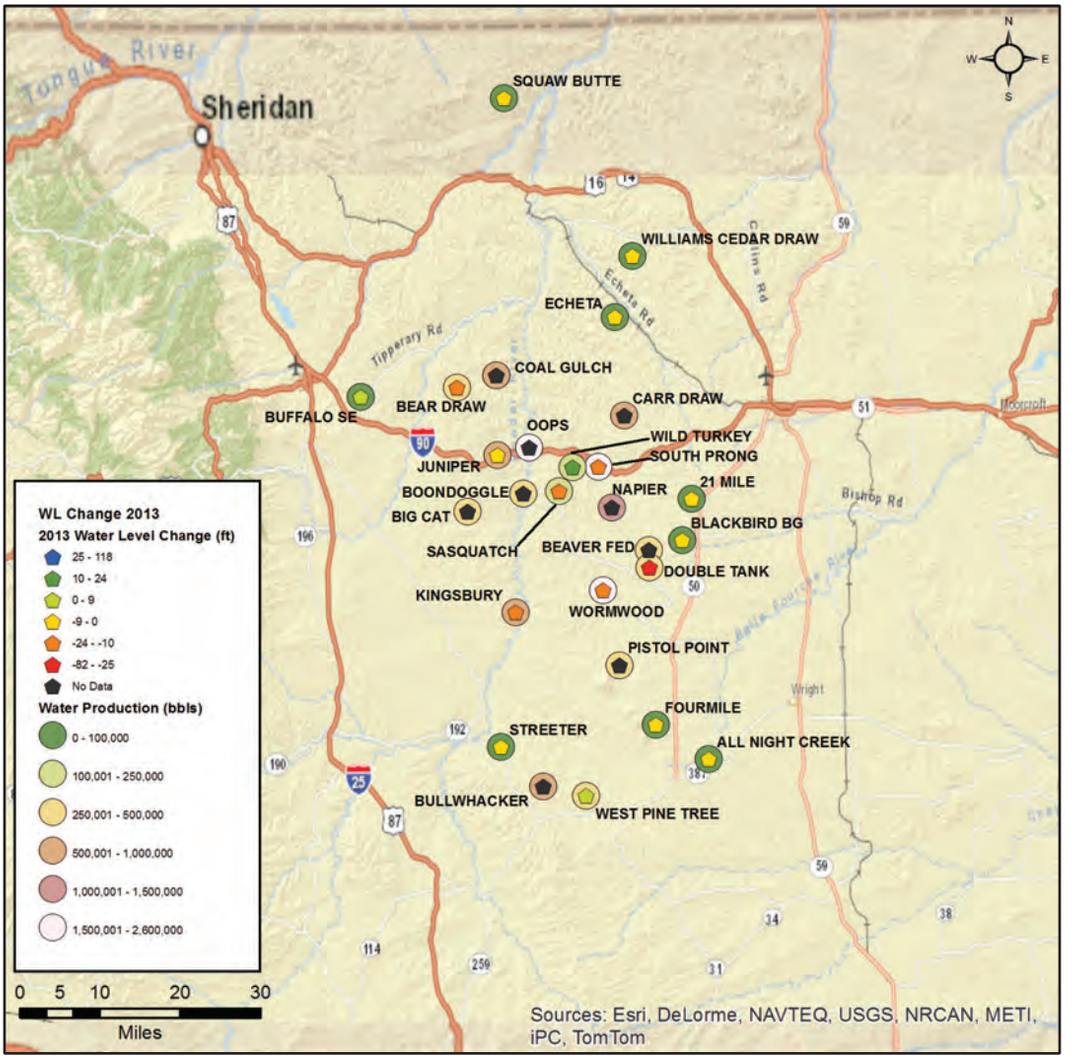

Figure 7. Measured groundwater variation in the Wyodak Rider coal zone during the 2013 POR.

Table 4. Change in water levels by monitoring well site during the 2013 POR in the Wyodak Rider coal zone.

Monitoring Site	Location	Water Level Change (ft)	Water Production (bbls)
Double Tank	NE SW, 35, 47 N, 75 W	-77.07	468,270
Sasquatch	NE SW, 12, 48 N, 77 W	-23.44	139,666
South Prong	NW SE, 26, 49 N, 76 W	-21.60	2,090,006
Bear Draw	SW NW, 1, 50 N, 79 W	-14.15	413,565
Wormwood	NE NW, 14, 46 N, 76 W	-12.48	1,878,272
Kingsbury	NW SE, 25, 46 N, 78 W	-11.20	818,840
Blackbird Bg	SW NE, 16, 47 N, 74 W	-5.39	0
Streeter	SE NW, 22, 43 N, 78 W	-4.93	0
21 Mile	NE NE, 22, 48 N, 74 W	-4.17	0
Echeta	NE NE, 30, 52 N, 75 W	-4.15	0
Fourmile	NW NE, 11, 43 N, 75 W	-3.98	60,777
Williams Cedar Draw	NE SW, 15, 53 N, 75 W	-1.44	0
Squaw Butte	SE NE, 1, 56 N, 78 W	-0.97	0
All Night Creek	NW SW, 36, 43 N, 74 W	0.00	0
Juniper	SW SW, 14, 49 N, 78 W	0.00	707,234
Beaver Fed	SE NW, 23, 47 N, 75 W	n/a	463,237
Big Cat	SE SE, 24, 48 N, 79 W	n/a	497,732
Boondoggle	SE SE, 7, 48 N, 77 W	n/a	324,154
Bullwhacker	NW SE, 16, 42 N , 77 W	n/a	606,621
Carr Draw	NE NE, 29, 50 N, 75 W	n/a	570,774
Coal Gulch (Big George)	SW SW, 26, 51 N, 78 W	n/a	720,483
Coal Gulch (Smith)	SW SW, 26, 51 N, 78 W	n/a	720,483
Napier	SE SE, 24, 48 N, 76 W	n/a	1,421,391
Oops	SW SW, 9, 49 N, 77 W	n/a	2,568,613
Pistol Point	SW NE, 31, 45 N, 75 W	n/a	349,992
Buffalo SE	NW NW, 12, 50 N, 81 W	0.16	0
West Pine Tree	SE SE, 20, 42 N , 76 W	8.55	288,614
Wild Turkey	NE SW, 29, 49 N, 76 W	22.28	200,606

Upper Wyodak

Water levels increased (recovered) at 11 of the monitoring well sites in the Upper Wyodak coal zone during 2013. Water levels rose in excess of 50 feet at the Gilmore (57.14 ft) site (Table 5). Water level rises at other sites ranged from 0.40 feet (Amoco Sec 36) to 42.56 feet (Sec 25). Eleven sites showed drawdowns ranging from 0.25 feet (Bar 76) to 18.44 feet (Double Tank) during the same period. Generally, water levels at monitoring sites in the eastern portion of the PRB showed some recovery or limited (<9 ft) drops in water levels (Figure 8) with the exception of the MP2 and MP22 sites which exhibited 16.30 and 13.45 feet of decline in 2013, respectively. Groundwater levels recovered over 100 feet at the MP2 and MP22 sites starting in the early years of the last decade and lasting until 2012. Since then, groundwater levels have shown declines that have persisted through 2013 although no water was produced from the Upper Wyodak coal seam at either site in over five years. These recent declines may, in effect, be associated with activities of producing surface

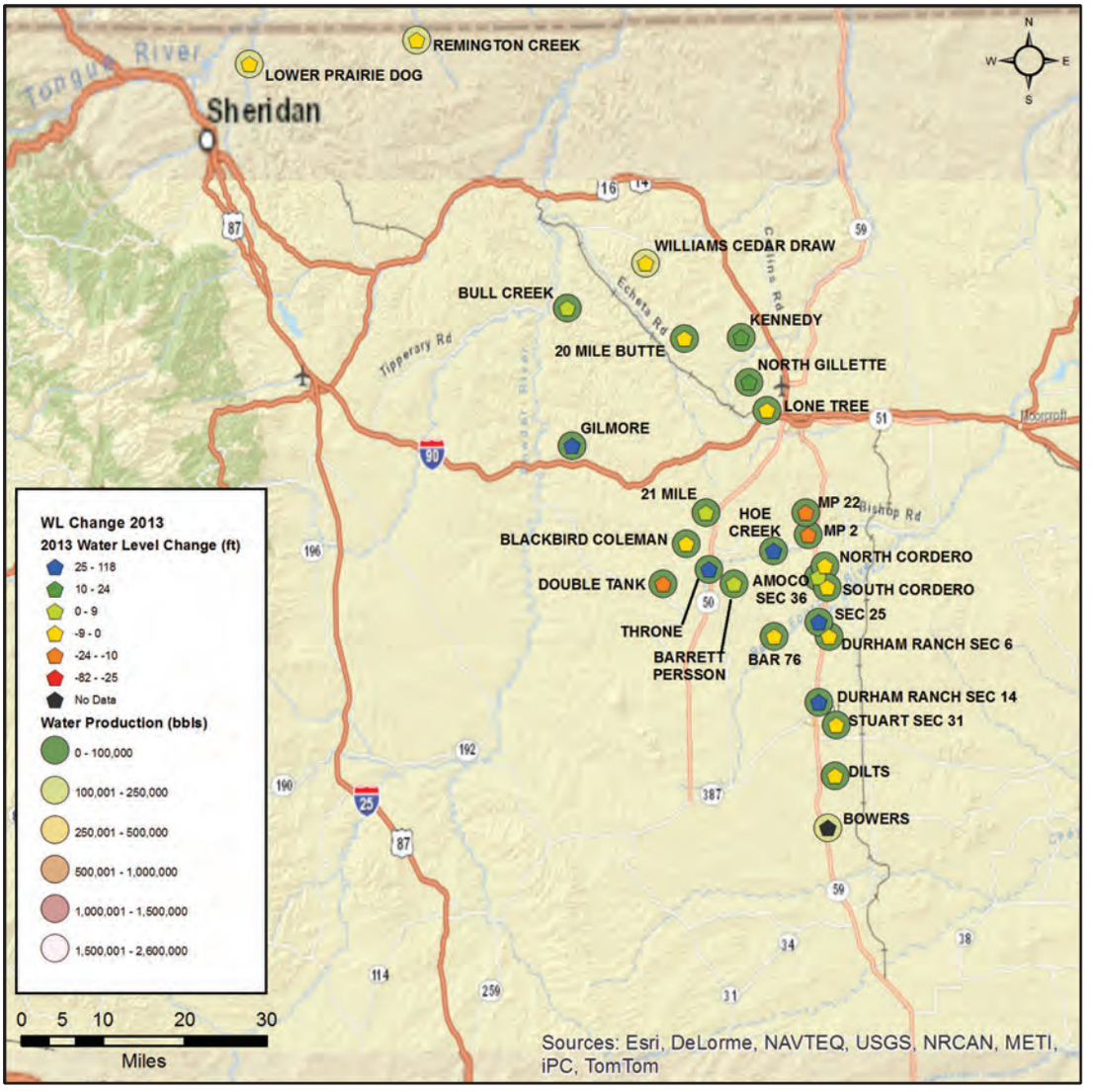

Figure 8. Measured groundwater variation in the Upper Wyodak coal zone during the 2013 POR.

coal mines located within 1.5 miles of both sites. Finally, monitoring wells at four sites (Dilts, Durham Ranch Sec 6, Lone Tree, and Stuart Sec 31) were dry to their full depths and monitoring was discontinued prior to 2013 at the Bowers site.

Water production from the Upper Wydoak coal zone varied greatly across the PRB. No water is currently produced in seventeen of the 27 Upper Wyodak coal zone monitoring well sites. CBNG extraction around the Bowers monitoring well site produced 222,162 bbls of water during the 2013 POR, the highest in the Upper Wyodak monitoring well system (Figure 8; Table 5). There was no water production in any of the five Upper Wydoak sites that recovered more than 25 feet in 2013 (Gilmore, Sec 25, Durham Ranch Sec 14, Hoe Creek, and Throne).

Table 5. Change in water levels by monitoring well site during the 2013 POR in the Upper Wyodak coal zone.

Monitoring Site	Location	Water Level Change (ft)	Water Production (bbls)
Double Tank	NE SW, 35, 47 N, 75 W	-18.44	0
MP 2	NW NW, 2, 47 N, 72 W	-16.30	0
MP 22	SE NE, 22, 48 N, 72 W	-13.45	0
Blackbird Coleman	SW SE, 5, 47 N, 74 W	-9.61	15,775
Lower Prairie Dog	SE NE, 10, 57 N, 83 W	-6.05	124,268
North Cordero	SW SW, 19, 47 N, 71 W	-4.60	0
Williams Cedar Draw	NE SW, 15, 53 N, 75 W	-2.73	192,918
20 Mile Butte	SE SE, 32, 52 N, 74 W	-2.26	46,578
Remington Creek	SW NE, 30, 58 N, 79 W	-1.71	186,582
South Cordero	NE SW, 6, 46 N, 71 W	-1.20	0
Bar 76	NE SE, 1, 45 N, 73 W	-0.25	49,772
Dilts	SE NW, 31, 43 N, 71 W	0.00	50,328
Durham Ranch Sec 6	SW NE, 6, 45 N, 71 W	0.00	0
Lone Tree	SW SE, 13, 50 N, 73 W	0.00	23,923
Stuart Sec 31	NE SE, 31, 44 N, 71 W	0.00	0
Bowers	SE SW, 36, 42 N , 72 W	n/a	222,162
Amoco Sec 36	NW SE, 36, 47 N, 72 W	0.40	0
21 Mile	NE NE, 22, 48 N, 74 W	4.65	0
Bull Creek	NW SE, 12, 52 N, 77 W	6.57	0
Barrett Persson	SW SW, 32, 47 N, 73 W	9.41	30,281
Kennedy	SE SE, 33, 52 N, 73 W	15.82	0
North Gillette	SW NE, 34, 51 N, 73 W	19.68	0
Throne	NW NW, 26, 47 N, 74 W	25.11	0
Hoe Creek	SW SW, 7, 47 N, 72 W	27.47	0
Durham Ranch Sec 14	SE NE, 14, 44 N, 72 W	34.73	0
Sec 25	SW SW, 25, 46 N, 72 W	42.56	0
Gilmore	SE NE, 1, 49 N, 77 W	57.14	0

Lower Wyodak

All four sites that monitor drawdown in the Lower Wyodak coal zone recorded water level recoveries of 2.78 to 54.95 feet (Figure 9; Table 6). The average recovery observed in the Lower Wyodak sites in 2013 was 26.67 feet.

There was no water production during 2013 in the buffer areas around the North Gillette, Redstone and Remington Creek monitoring sites. The average annual recovery at these sites during 2013 was 34.63 feet. In contrast, CBNG wells in proximity to the Palo site produced 115,759 bbls of water during 2013 and water levels only recovered 2.78 feet during 2013.

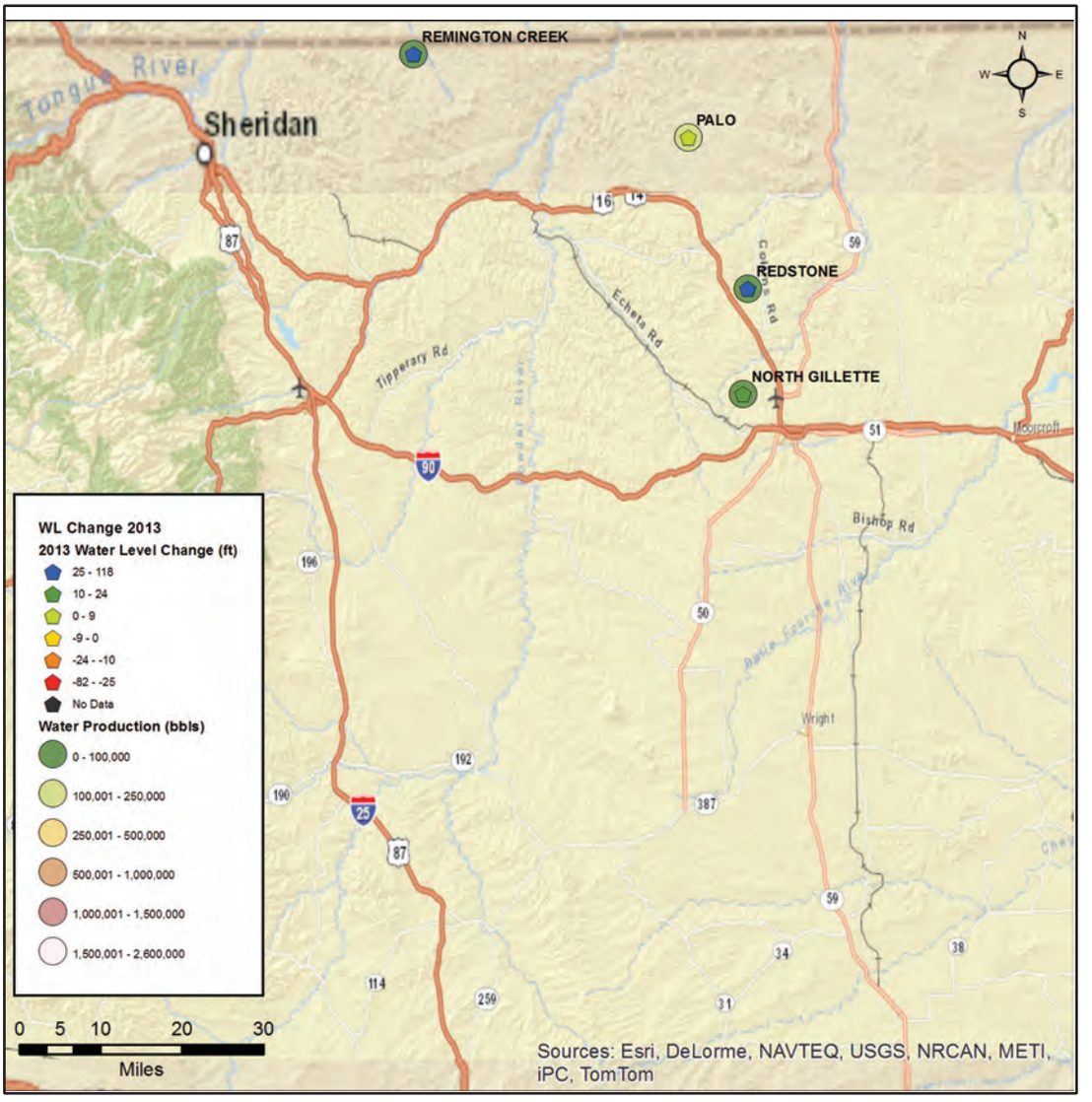

Figure 9. Measured groundwater variation in the Lower Wyodak coal zone during the 2013 POR.

Table 6. Change in water levels by monitoring well site during the 2013 POR in the Lower Wyodak coal zone.

Monitoring Site	Location	Water Level Change (ft)	Water Production (bbls)
Palo	SE NE, 22, 56 N, 74 W	2.78	115,759
North Gillette	SW NE, 34, 51 N, 73 W	22.38	0
Redstone	SE NW, 26, 53 N, 73 W	26.55	0
Remington Creek	SW NE, 30, 58 N, 79 W	54.95	0

Cook

Water levels varied widely in the Cook coal zone (Table 7). During 2013, the Carr Draw monitoring well site recorded a total drawdown of 10.84 feet, while the water level at the Barton site registered 54.46 feet of recovery. Water levels at the L Quarter Circle Hills and Remington Creek sites rose 17.62 and 10.31 feet respectively. Water levels at the Williams Cedar Draw monitoring well site rose by 1.01 feet. As in the 2010 – 2012 POR examined in the previous report, during 2013, 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 widely in the monitored areas. CBNG extraction in the Carr Draw monitoring well site (highest drawdown) produced 20,507 bbls; conversely, 186,180 bbls of water were produced in the buffer area around the L Quarter Circle Hills monitoring well site, which showed the second highest amount of recovery in the Cook coal zone (Table 7). The Barton site, which had no 2013 water production, recorded the greatest water level recovery.

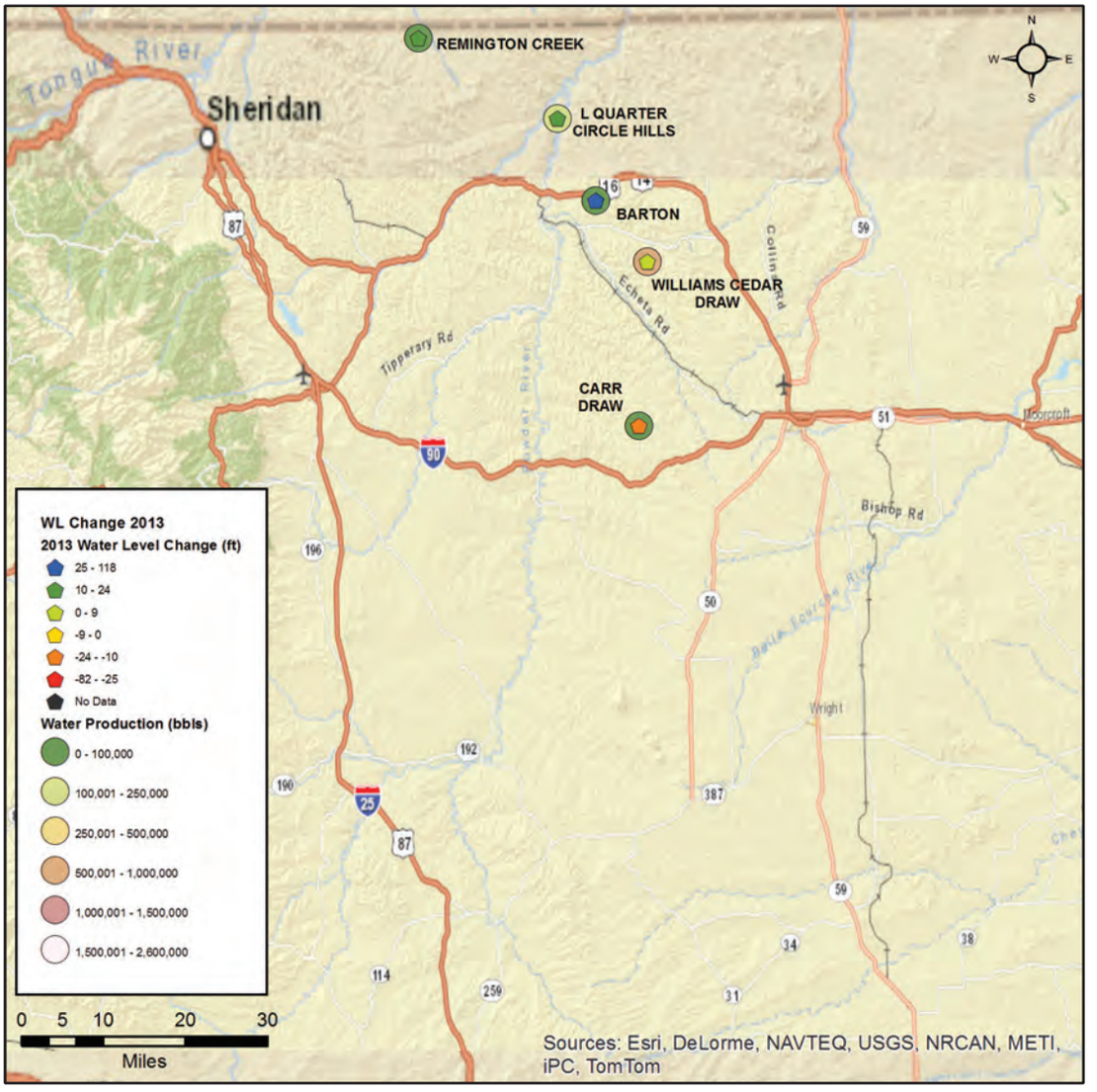

Figure 10. Measured groundwater variation in the Cook coal zone during the 2013 POR.

Table 7. Change in water levels by monitoring well site during the 2013 POR in the Cook coal zone.

Monitoring Site	Location	Water Level Change (ft)	Water Production (bbls)
Carr Draw	NE NE, 29, 50 N, 75 W	-10.84	20,507
Williams Cedar Draw	NE SW, 15, 53 N, 75 W	1.01	518,506
Remington Creek	SW NE, 30, 58 N, 79 W	10.31	0
L Quarter Circle Hills	NE SE, 14, 56 N, 77 W	17.62	186,180
Barton	SE SW, 3, 54 N, 76 W	54.46	0

Cook/Wall

Two of the four monitoring sites in the Cook/Wall coal zone show water level increases during 2013 (Figure 11; Table 8). Water levels at the South Coal monitoring site dropped 0.67 feet, while levels at the Carr Draw and South Prong sites rose by 0.59 and 1.51 feet respectively. Water level measurements at the Williams Cedar Draw site were suspended in October 2009 due to high wellhead pressures.

No water was produced from the buffer zones around the South Coal and Williams Cedar Draw monitoring sites in 2013. Conversely, substantial volumes of water were produced in 2013 from the buffer zones surrounding the recovering sites, Carr Draw (139,009 bbls) and South Prong (1,056,318 bbls).

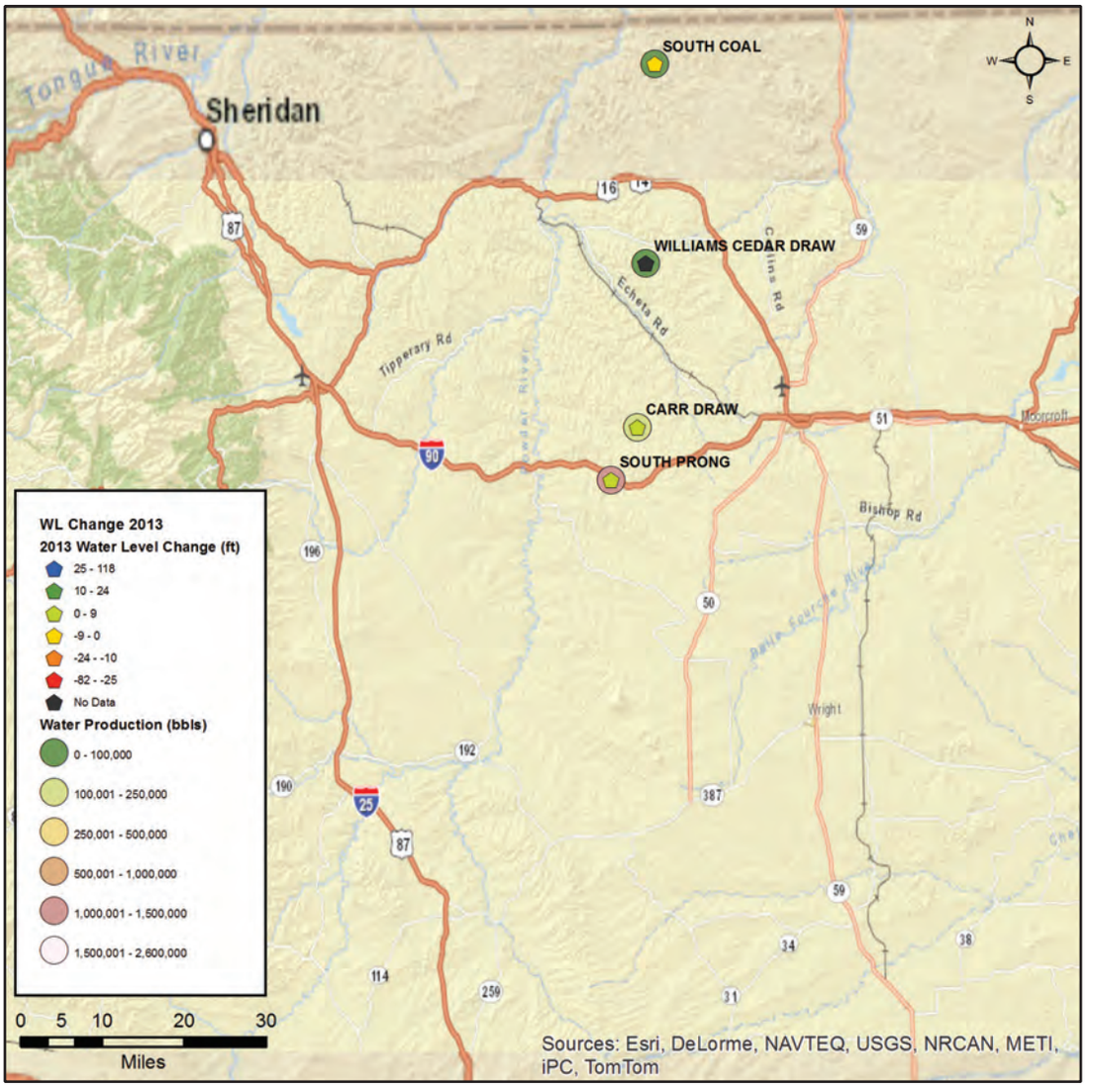

Figure 11. Measured groundwater variation in the Cook/Wall coal zone during the 2013 POR.

Table 8. Change in water levels by monitoring site during the 2013 POR in the Cook/Wall coal zone.

Monitoring Site	Location	Water Level Change (ft)	Water Production (bbls)
South Coal	NW SW, 13, 57 N, 75 W	-0.67	0
Williams Cedar Draw	NE SW, 15, 53 N, 75 W	n/a	0
Carr Draw	NE NE, 29, 50 N, 75 W	0.59	139,009
South Prong	NW SE, 26, 49 N, 76 W	1.51	1,056,318

Wall

Water level changes in the Wall coal zone monitoring well sites ranged from minor declines of 0.98 feet (20 Mile Butte) and less, to recoveries of 117.65 feet (Cedar Draw) and 61.06 feet (Rose Draw) (Figure 12; Table 9). Monitoring at the Duck Creek site was suspended in late 2012.

No water was produced from the CBNG wells in the buffer zones around any of the Wall coal zone monitoring sites (Table 9) in 2013. This lack of water production resulted in water level changes of less than 1 foot at all but two of the Wall coal zone monitoring sites.

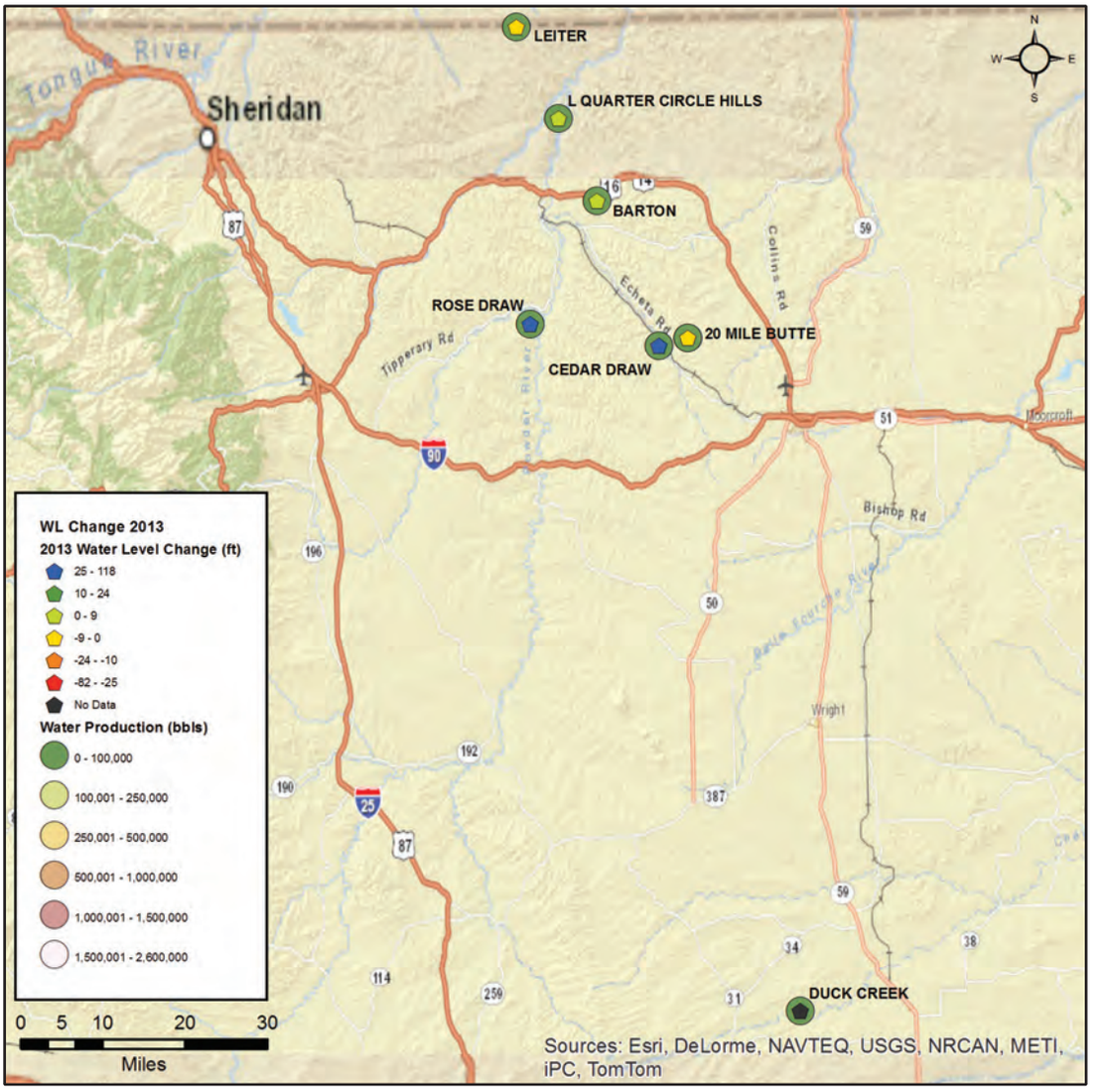

Figure 12. Measured groundwater variation in the Wall coal zone during the 2013 POR.

Table 9. Change in water levels by monitoring site during the 2013 POR in the Wall coal zone.

Monitoring Site	Location	Water Level Change (ft)	Water Production (bbls)
20 Mile Butte (Pawnee)	SE SE, 32, 52 N, 74 W	-0.98	0
20 Mile Butte (Wall)	SE SE, 32, 52 N, 74 W	-0.81	0
Leiter	NW SE, 19, 58 N, 77 W	-0.04	0
Duck Creek	SW SW, 20, 38 N, 72 W	n/a	0
Barton	SE SW, 3, 54 N, 76 W	0.45	0
L Quarter Circle Hills	NE SE, 14, 56 N, 77 W	0.57	0
Rose Draw	NE SE, 19, 52 N, 77 W	61.06	0
Cedar Draw	NE SW, 2, 51 N, 75 W	117.65	0

Underburden Sandstones

Six monitoring well sites recorded water levels in underburden sands across the PRB (Figure 13; Table 10) in 2013. Drawdown varied significantly across the basin, the South Prong monitoring site recorded the largest drawdown of 81.35 feet, while Stuart Sec 31 site showed a recovery of 7.54 feet. Figure 13 shows no regional correlation to observed drawdown data between monitoring wells. CBNG extraction does not occur in the underburden sandstones within the 1.5 mile buffer radii of the BLM monitoring well sites.

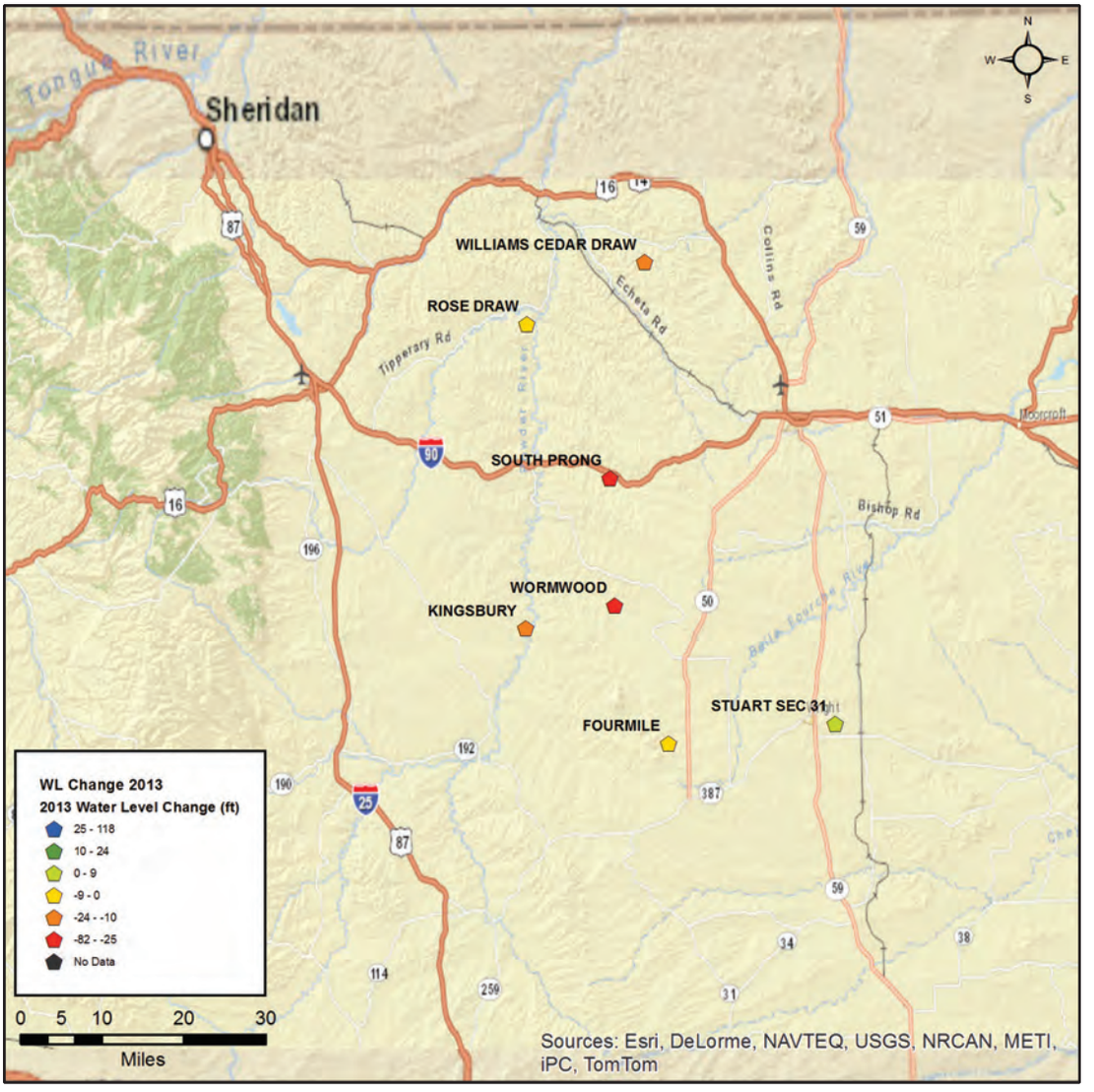

Figure 13. Measured groundwater variation in the Underburden sandstones during the 2013 POR.

Table 10. Change in water levels by monitoring site during the 2013 POR in the Underburden sandstones.

Monitoring Site	Location	Water Level Change (ft)	Monitored Underburden Sandstones
South Prong	NW SE, 26, 49 N, 76 W	-81.35	Fort Union
Wormwood	NE NW, 14, 46 N, 76 W	-49.23	Fort Union
Williams Cedar Draw	NE SW, 15, 53 N, 75 W	-23.59	Fort Union
Kingsbury	NW SE, 25, 46 N, 78 W	-15.51	Fort Union
Fourmile	NW NE, 11, 43 N, 75 W	-3.34	Fort Union
Rose Draw	NE SE, 19, 52 N, 77 W	-1.80	Fort Union
Stuart Sec 31	NE SE, 31, 44 N, 71 W	7.54	Fort Union

CONCLUSIONS

Drawdown levels in all coal zones and sandstones varied widely among the monitored sites during 2013 (Tables 3 – 10). High water level declines were observed at the Double Tank (77.1 ft), South Prong (21.6 ft), and Sasquatch (23.4 ft) sites, in contrast to the significant recoveries seen at Cedar Draw (117.7 ft), Rose Draw (61.1 ft), and Gilmore (57.1 ft) sites. Still, water levels at most sites were relatively stable during 2013; water levels at 71 (60 percent) of the 119 monitored intervals changed less than 10 feet. Generally, the amount of observed drawdown roughly corresponds to CBNG water production; however, there were notable exceptions. A substantial drawdown (18.44 ft) was observed at the Double Tank monitoring well site (Upper Wyodak coal zone), although no water was produced from the site's associated CBNG wells during 2013. In contrast, the Wild Turkey monitoring well site in the Wyodak Rider coal zone recovered 22.28 feet with a reported annual water production of 200,606 bbls.

Average monitored water level changes in individual coal zones (Figure 14) varied widely during 2013 and largely correspond to water production rates. High average water level declines were seen in the Wyodak Rider (8.6 ft per site). The highest average recovery during 2013 occurred in the Lower Wyodak coal zone (34.63 ft). Water levels also recovered, on average, in the Wall (25.4 ft), Cook (14.5 ft) and Upper Wyodak (6.4 ft) coal zones.

Average drawdowns in monitored sandstones varied widely (Figure 14), as well. Wasatch sand zones had a low average drawdown of 2.1 feet, while Fort Union underburden sand zones had a high average drawdown of 23.9 feet.

In summary, it is anticipated that if CBNG production and water co-production in the PRB continue to decrease, then water levels will recover at more monitoring well sites.

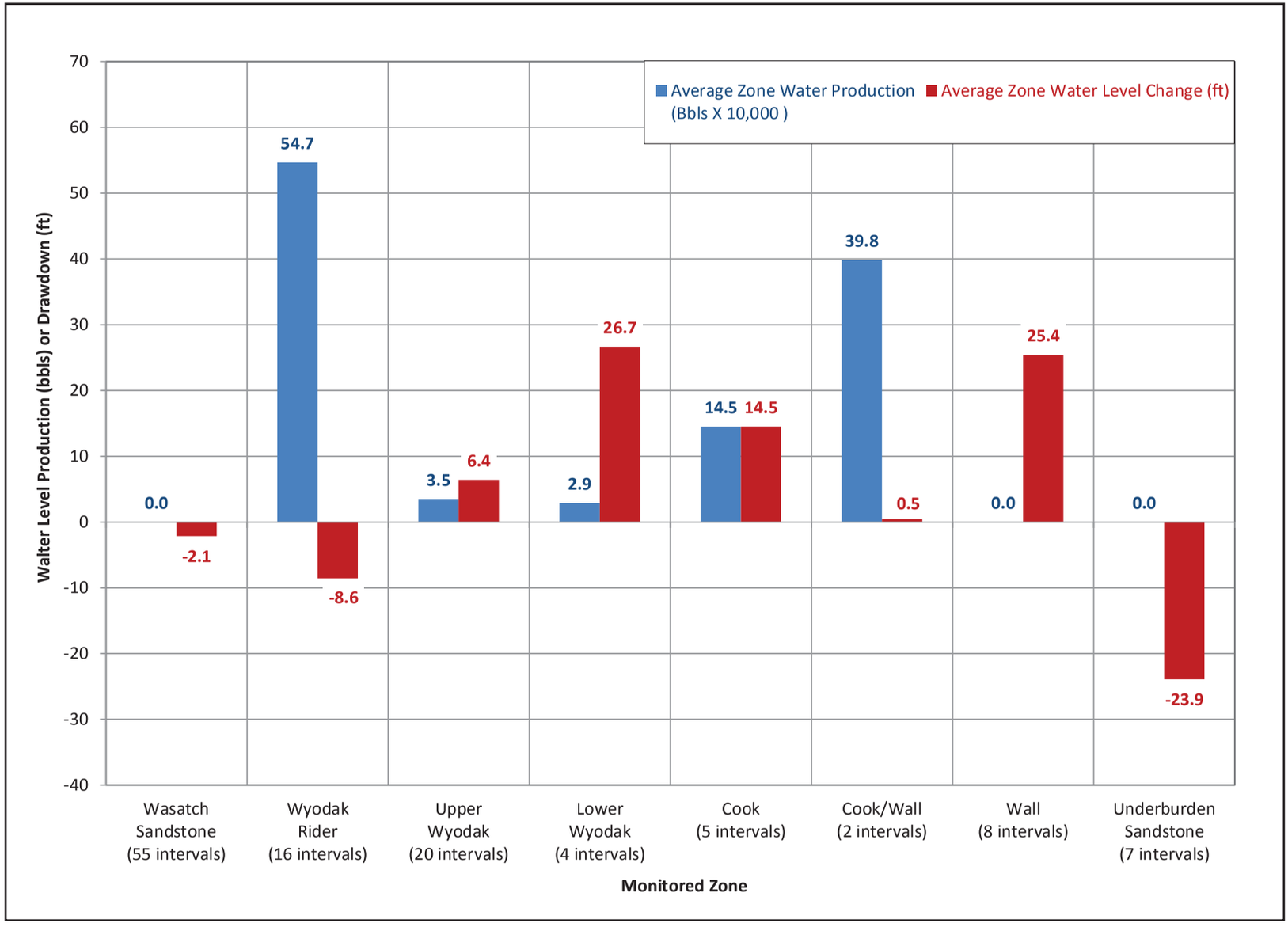

Figure 14. Average water production and drawdown, by zone, for the 2013 monitoring period. The number of intervals in each zone are shown beneath zone names in parentheses.

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Appendix

Appendix Introduction

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 Appendix:

- Declines in water levels are shown as negative numbers in the water level tables; a positive numbers signifies a rise in water level.
- All monitoring well data in the Appendix for the 2013 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).
- Information in the Appendix 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, or as "unknown", "unmonitored", or "multiple". Data from "unknown" zones do not specify the particular coal from which water and CBNG were produced. Production data designated as "unmonitored" indicate that the reported gas and water volumes were extracted from coal zones where water levels are not monitored. Production from multi-completion wells (completed in more than one coal zone) is designated as "multiple" if water levels are monitored in at least one of the producing zones. Gas and water production levels for "unknown" and "unmonitored" wells are not shown on the buffer zone figures.
- On the buffer maps, well sites that are depicted by API number only and do not show production bars have not produced CBNG and/or water during the POR.

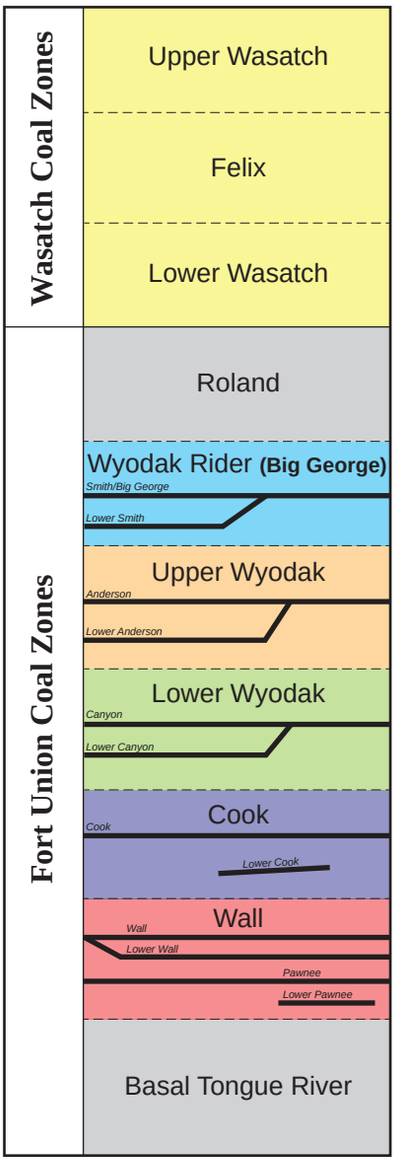

Figure A.1. Stratigraphic chart of the geologic formations and associated coal zones in the PRB, Wyoming.

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 *	Wasatch sandstone	n/a	Campbell	2004	540	40
20 Mile Butte	49-005-50948 *	Upper Wyodak coal	Anderson	Campbell	2004	933	37
20 Mile Butte	49-005-50985 *	Wall coal	Wall	Campbell	2004	1,518	22
20 Mile Butte	49-005-50986 *	Wall coal	Pawnee	Campbell	2004	1,705	13
21 Mile	49-005-07200 *	Wasatch sandstone	n/a	Campbell	2001	1,020	221
21 Mile	49-005-07198 *	Wyodak Rider coal	Big George	Campbell	2001	1,325	47
21 Mile	49-005-07199 *	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 **	Wasatch sandstone	sand	Campbell	2001	860	20
All Night Creek	P128990W **	Wyodak Rider coal	Big George	Campbell	2001	1,051	67
Amoco Sec 36	P72107W **	Upper Wyodak coal	Anderson (Wyodak)	Campbell	1995	-----	-----
Bar 76	49-005-31560 *	Wasatch sandstone	overburden sand	Campbell	1997	679	20
Bar 76	49-005-31560 *	Upper Wyodak coal	Anderson (Wyodak)	Campbell	1997	777	51
Barrett Persson	P127246W **	Wasatch sandstone	overburden sand	Campbell	2001	1,230	50
Barrett Persson	P127245W **	Upper Wyodak coal	Anderson (Wyodak)	Campbell	2001	1,334	68
Barton	49-005-43038 *	Cook coal	Cook	Campbell	2002	1,055	31
Barton	49-005-47264 *	Wall coal	Wall	Campbell	2002	1,245	45
Bear Draw	49-019-25144 *	Wasatch sandstone	overburden sand	Johnson	2006	2,094	42
Bear Draw	49-019-25144 *	Wyodak Rider coal	Big George	Johnson	2006	2,310	105
Beaver Fed	49-005-50085 *	Wasatch sandstone	overburden sand	Campbell	2003	625	73
Beaver Fed	49-005-50085 *	Wyodak Rider coal	Big George	Campbell	2003	1,256	70
Betop	49-005-29688 *	Fort Union coal	unknown coal	Campbell	1991	1,795	67
Big Cat	49-019-06358 *	Wasatch sandstone	overburden sand	Johnson	2003	888	26
Big Cat	49-019-06357 *	Wyodak Rider coal	Big George	Johnson	2003	2,047	77
Blackbird BG	49-005-33383 *	Wyodak Rider coal	Big George	Campbell	2002	1,150	42
Blackbird Coleman	P125798W **	Wasatch sandstone	overburden sand	Campbell	2002	690	20
Blackbird Coleman	49-005-36025 *	Upper Wyodak coal	Anderson (Wyodak)	Campbell	2000	1,500	74
Boondoggle	P64166W **	Wasatch sandstone	overburden sand	Johnson	2003	921	53
Boondoggle	P133197W **	Wyodak Rider coal	Big George	Johnson	2003	1,253	202
Bowers	P145551W **	Wasatch sandstone	very very shallow sand	Campbell	1998	80	15
Bowers	P145550W **	Wasatch sandstone	very shallow sand	Campbell	1998	350	85
Bowers	P145549W **	Wasatch sandstone	shallow sand	Campbell	1998	440	88
Bowers	P145548W **	Wasatch sandstone	sand	Campbell	1998	595	75
Bowers	49-005-31713 *	Upper Wyodak coal	Anderson (Wyodak)	Campbell	2002	752	30
Buffalo SE	-----	Wasatch sandstone	very very shallow sand	Johnson	2002	130	75
Buffalo SE	P144311W **	Wasatch sandstone	very shallow sand	Johnson	2002	230	75
Buffalo SE	P144312W **	Wasatch sandstone	shallow sand	Johnson	2002	595	75
Buffalo SE	49-019-06351 *	Wasatch sandstone	sand	Johnson	2001	1,498	16
Buffalo SE	49-019-06350 *	Wyodak Rider coal	Smith	Johnson	2001	1,596	8
Bull Creek	P153817W **	Wasatch sandstone	shallow sand	Johnson	2005	520	40

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)
Bull Creek	P153819W **	-----	overburden sand	Johnson	2005	927	51
Bull Creek	49-019-06402 *	Upper Wyodak coal	Anderson	Johnson	2005	1,018	44
Bullwhacker	-----	Wasatch sandstone	overburden sand	Johnson	2002	1,238	36
Bullwhacker	P142614W **	Wyodak Rider coal	Big George	Johnson	2002	1,430	92
Carr Draw	49-005-07634 *	Wasatch sandstone	overburden sand	Campbell	2007	800	66
Carr Draw	49-005-07635 *	Wyodak Rider coal	Big George	Campbell	2007	1,463	61
Carr Draw	49-005-07636*	Cook coal	Cook (Werner)	Campbell	2007	1,832	45
Carr Draw	49-005-07636*	Cook/Wall coal	Lower Cook (Gates/ Wall)	Campbell	2007	2,096	166
Cedar Draw	49-005-42272 *	Wasatch sandstone	overburden sand	Campbell	2004	1,470	80
Cedar Draw	49-005-37156 *	Wall coal	Wall	Campbell	2004	1,674	97
Coal Gulch	49-019-24209 *	Wyodak Rider coal	Smith	Johnson	2005	1,495	13
Coal Gulch	49-019-24209 *	Wyodak Rider coal	Big George	Johnson	2005	1,852	214
Dilts	P112454W **	Wasatch sandstone	overburden sand	Campbell	1999	300	40
Dilts	-----	Upper Wyodak coal	Anderson (Wyodak)	Campbell	1999	658	78
Double Tank	49-005-50083*	Wyodak Rider coal	Big George	Campbell	2002	1,230	78
Double Tank	49-005-50084*	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 **	Wasatch sandstone	overburden sand	Campbell	1997	285	30
Durham Ranch Sec 6	P106975W **	Upper Wyodak coal	Anderson (Wyodak)	Campbell	1997	363	35
Durham Ranch Sec 14	P106972W **	Wasatch sandstone	overburden sand	Campbell	1998	690	24
Durham Ranch Sec 14	P106973W **	Upper Wyodak coal	Anderson (Wyodak)	Campbell	1998	816	100
Echeta	-----	Wyodak Rider coal	Big George	Campbell	1999	867	6
Fourmile	49-005-07517 *	Wasatch sandstone	overburden sand	Campbell	2007	825	47
Fourmile	49-005-07645*	Wyodak Rider coal	Big George	Campbell	2007	1,446	87
Fourmile	49-005-07645 *	-----	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 *	Wasatch sandstone	sand	Johnson	2001	1,130	44
Juniper	49-019-06457 *	Wyodak Rider coal	Big George	Johnson	2001	1,614	66
Kennedy	P145907W **	Wasatch sandstone	overburden sand	Campbell	2000	578	58
Kennedy	P145908W **	Upper Wyodak coal	Anderson	Campbell	2000	743	36
Kingsbury	49-019-06437 *	Wyodak Rider coal	Big George	Johnson	2006	1,425	13
Kingsbury	49-019-06437 *	Fort Union sand	underburden sand	Johnson	2007	1,567	36
L Quarter Circle Hills	49-033-25634 *	Wasatch sandstone	overburden sand	Sheridan	2005	517	24
L Quarter Circle Hills	49-033-25633 *	Cook coal	Cook	Sheridan	2005	711	27
L Quarter Circle Hills	49-033-25631 *	Wall coal	Wall/Pawnee	Sheridan	2005	876	14
Leiter	P62919W **	Wall coal	Pawnee	Sheridan	2002	568	393
Lone Tree	P121683W **	Wasatch sandstone	overburden sand	Campbell	2000	530	40

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)
Lone Tree	P121682W **	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 **	Wasatch sandstone	overburden sand	Campbell	1993	310	50
MP 2	-----	Upper Wyodak coal	Anderson (Wyodak)	Campbell	1993	410	74
MP 22	P110021W **	Wasatch sandstone	very shallow sand	Campbell	1998	80	65
MP 22	P110020W **	Wasatch sandstone	shallow sand	Campbell	1998	185	78
MP 22	P90659W **	Wasatch sandstone	sand	Campbell	1993	400	60
MP22	P90658W **	Upper Wyodak coal	Anderson (Wyodak)	Campbell	1993	515	77
Napier	P133776W **	Wasatch sandstone	overburden sand	Campbell	2001	1,522	60
Napier	P133775W **	Wyodak Rider coal	Big George	Campbell	2001	1,674	89
North Cordero	P82851W **	Upper Wyodak coal	Anderson (Wyodak)	Campbell	1995	392	58
North Gillette		Wasatch sandstone	overburden sand	Campbell	2001	320	105
North Gillette	49-005-46837 *	Upper Wyodak coal	Anderson	Campbell	2001	582	48
North Gillette	49-005-46836 *	Lower Wyodak coal	Canyon	Campbell	2001	620	32
Oops	-----	Wasatch sandstone	shallow sand	Johnson	2009	29	10
Oops	-----	Wyodak Rider coal	Big George	Johnson	2009	-----	-----
Oops	-----	Fort Union sand	underburden sand	Johnson	2009	-----	-----
Palo	P129846W **	Wasatch sandstone	overburden sand	Campbell	2001	380	90
Palo	P129847W **	Lower Wyodak coal	Canyon	Campbell	2001	464	38
Pistol Point	P10894W **	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	1998	310	69
Remington Creek	-----	Wasatch sandstone	overburden sand	Sheridan	2005	26	6
Remington Creek	49-033-23127 *	Upper Wyodak coal	Anderson	Sheridan	2005	336	22
Remington Creek	49-033-23126 *	Lower Wyodak coal	Canyon	Sheridan	2005	639	14
Remington Creek	49-033-23107 *	Cook coal	Cook	Sheridan	2005	802	15
Rose Draw	49-019-06453 *	Wasatch sandstone	sand	Johnson	2009	1,080	91
Rose Draw	49-019-25153 *	Wall coal	Wall	Johnson	2009	1,819	45
Rose Draw	-----	Fort Union sand	underburden sand	Johnson	2009	1,870	30
Sasquatch	P133198W **	Wasatch sandstone	overburden sand	Johnson	2001	1,360	64
Sasquatch	P63417W **	Wyodak Rider coal	Big George	Johnson	1998	1,640	205
Sec 25	P103547W **	Wasatch sandstone	overburden sand	Campbell	1996	170	36
Sec 25	49-005-07139 *	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 **	Upper Wyodak coal	Anderson (Wyodak)	Campbell	1995	358	48
South Prong	-----	Wasatch sandstone	shallow sand	Campbell	2008	484	32
South Prong	49-005-07641 *	Wyodak Rider coal	Big George	Campbell	2008	1,216	46
South Prong	49-005-07642 *	Cook/Wall coal	Lower Cook (Gates/ Wall)	Campbell	2008	1,702	8
South Prong	49-005-07644 *	Fort Union sand	underburden sand	Campbell	2008	1,842	52

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)
Squaw Butte	P63739W **	Wyodak Rider coal	Big George	Sheridan	2001	590	20
Streeter	P159898W **	Wasatch sandstone	overburden sand	Johnson	2004	730	208
Streeter	P159897W **	Wyodak Rider coal	Big George	Johnson	2004	1,378	27
Stuart Sec 31	P106970W **	Wasatch sandstone	sand	Campbell	1997	575	20
Stuart Sec 31	P106969W **	Upper Wyodak coal	Anderson (Wyodak)	Campbell	1997	780	116
Stuart Sec 31	-----	Fort Union sand	underburden sand	Campbell	1997	830	36
Throne	P127244W **	Wasatch sandstone	overburden sand	Campbell	2001	1,450	50
Throne	P127243W **	Upper Wyodak coal	Anderson (Wyodak)	Campbell	2001	1,511	5
West Pine Tree	49-005-56980 *	Wasatch sandstone	overburden sand	Campbell	2007	565	27
West Pine Tree	49-005-56980 *	Wyodak Rider coal	Big George	Campbell	2007	1,434	87
Wild Turkey	49-019-06406 *	Wasatch sandstone	overburden sand	Johnson	2004	1,018	20
Wild Turkey	49-019-21363 *	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 *	Wyodak Rider coal	Smith	Campbell	2007	440	30
Williams Cedar Draw	P171911W **	-----	underburden sand	Campbell	2007	634	70
Williams Cedar Draw	49-005-07508 *	Upper Wyodak coal	Anderson	Campbell	2007	790	55
Williams Cedar Draw	49-005-07506 *	Cook coal	Cook (Werner)	Campbell	2008	864	20
Williams Cedar Draw	49-005-07506 *	Cook/Wall coal	Wall (Gates/Wall)	Campbell	2008	1,248	32
Wormwood	-----	Wasatch sandstone	shallow sand	Campbell	2006	520	42
Wormwood	49-005-07518 *	Wyodak Rider coal	Big George	Campbell	2006	1,162	88
Wormwood	-----	Fort Union sand	underburden sand	Campbell	2006	1,350	63

* API numbers from the Wyoming Oil and Gas Conservation Commission

** 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 a Wasatch sandstone, the Anderson coal of the Upper Wyodak zone, the Wall coal of the Wall coal zone, and the Pawnee coal of the Wall coal zone (Figure A.2; Table A.2). Water levels and wellhead gas pressures were measured manually during 2013. Over the entire monitoring period, 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 2013, groundwater levels declined 0.09 feet, in the Wasatch sandstone. During the POR, groundwater levels declined 39.18 feet from initial static water levels (Figure A.3; Table A.3). Gas pressure was not recorded in the Wasatch sandstone.

Anderson Coal
Groundwater levels declined 2.26 feet during 2013. During the monitoring period, groundwater levels dropped 160.50 feet (Figure A.3; Table A.3). During the 2004-2013 monitoring period measured gas pressures ranged from -0.5 - 10.0 psi.

Wall Coal
Groundwater levels declined 0.81 feet during 2013. During the POR, water levels declined a total of 308.01 feet (Figure A.4; Table A.3). During the 2004-2013 monitoring period measured gas pressures ranged from -0.2 – 0.86 psi.

Pawnee Coal
Groundwater levels dropped 0.98 feet in the Pawnee coal during 2013. Water levels declined 203.20 feet during the POR (Figure A.4; Table A.3). During the 2004-2013 monitoring period measured gas pressures ranged from -1.0 – 10.0 psi.

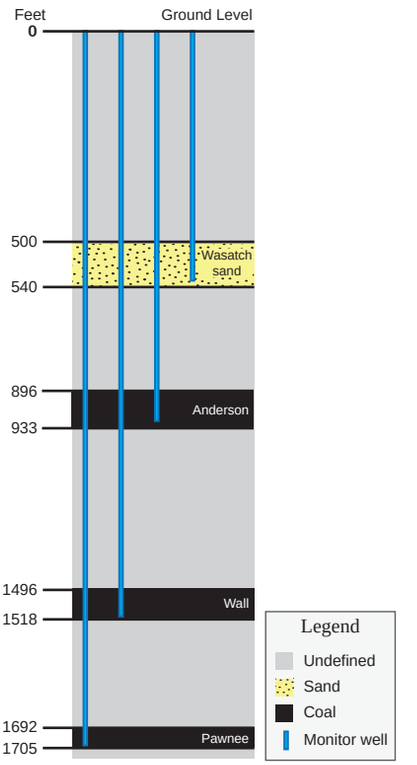

Figure A.2. Section showing relative positions of coals and sand in feet. Not to scale.

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

Monitored interval	Interval characteristics			
	Depth of interval (ft)		Interval 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, water level changes for current monitoring period, water level changes for period of record, and maximum gas pressure.

Monitored interval	DGW - Depth to groundwater (ft), water level (ft), and gas pressure (psi) data					
	Initial DGW	Max DGW [Date]	Final 2013 DGW	Water level change 2013	Net water level change	Max. gas pressure [date]
Wasatch sand	362.77	402.00 11/18/2013	401.95	-0.09	-39.18	n/a
Anderson coal	545.00	705.50 11/18/2013	705.50	-2.26	-160.50	10.00 4/28/2008
Wall coal	521.00	829.00 11/18/2013	829.01	-0.81	-308.01	.86 9/19/2004
Pawnee coal	540.00	743.20 11/18/2013	743.20	-0.98	-203.20	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 2000 to 2013. Cumulative production for individual CBNG wells is displayed by location on Figure A.5. CBNG and water production is monitored in the Upper Wyodak, Wall, multiple, and unmonitored coal zone wells.

Water production surged during 2001-2002 in the Upper Wyodak coal zone to a peak level of almost 58,000 bbls/month and then decreased during 2003-2013 when it ranged from 0-41,000 bbls/month (Figure A.6). During 2013, water production slightly increased over previous years to nearly 5,200 bbls/month. During 2001-2003, gas production increased to over 50,000 Mcf/month and then declined to 4,120 Mcf/month by the end of the 2013.

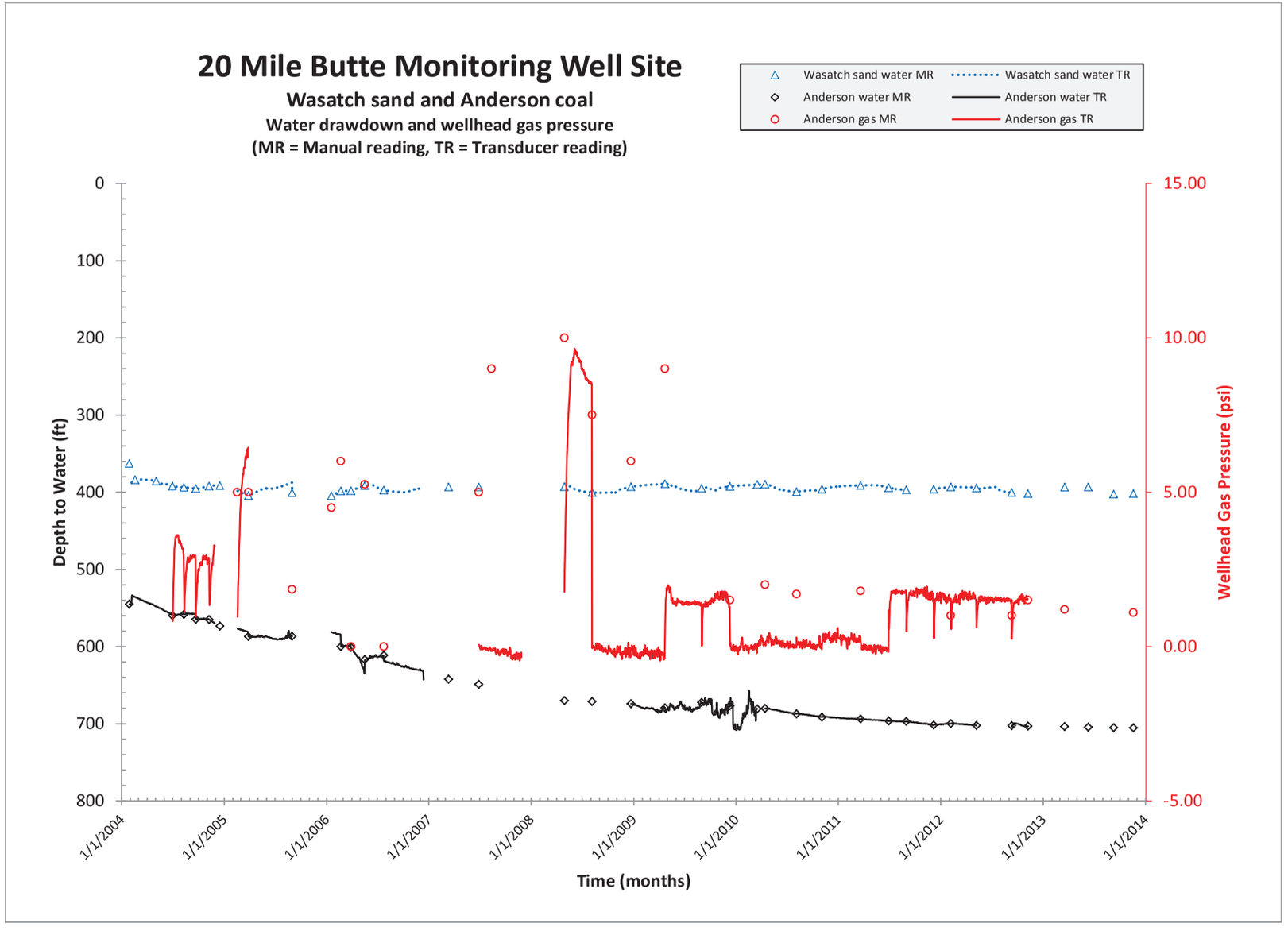

Figure A.3. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored intervals at the 20 Mile Butte monitoring well site location.

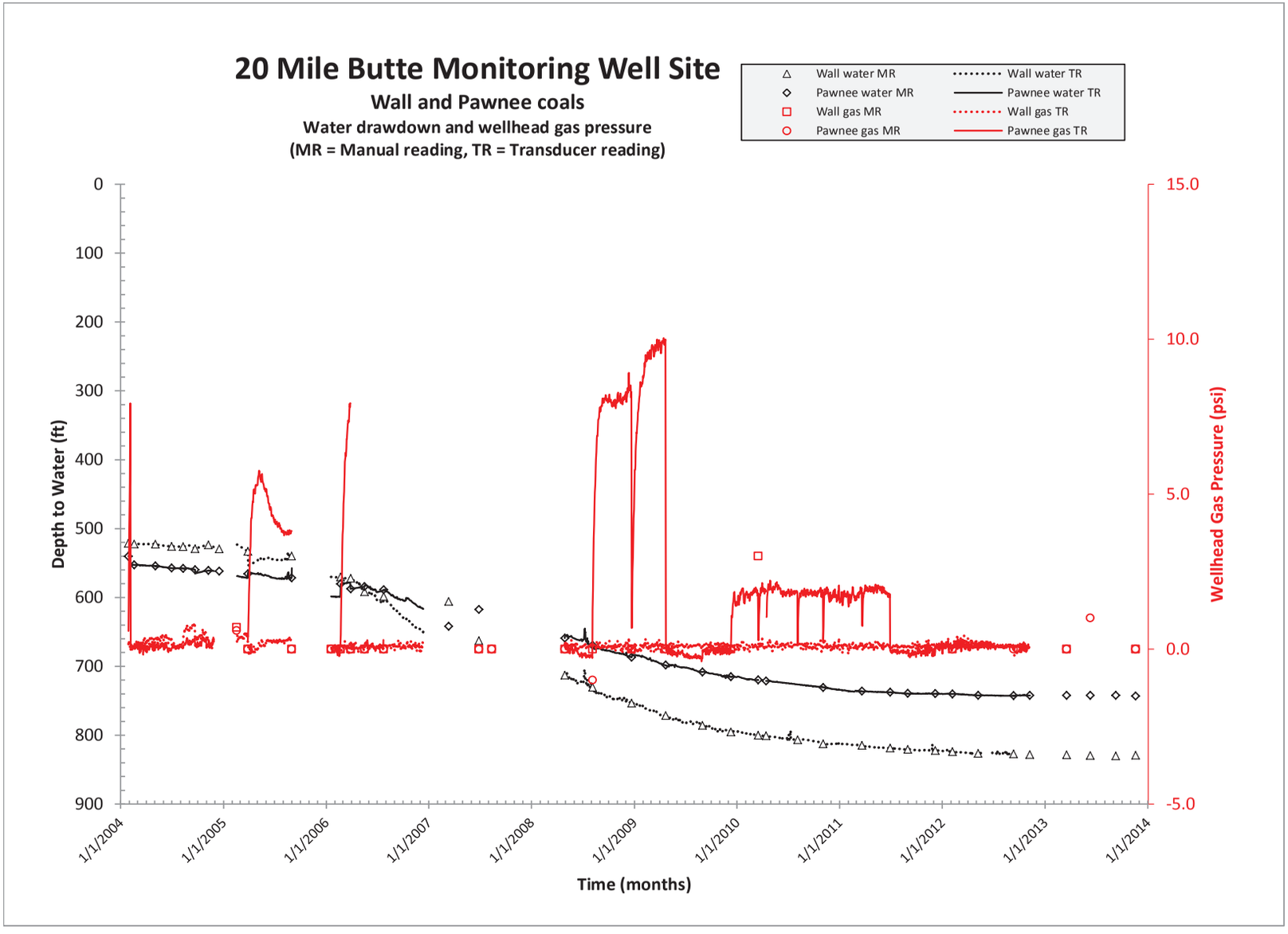

Figure A.4. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored intervals at the 20 Mile Butte monitoring well site location.

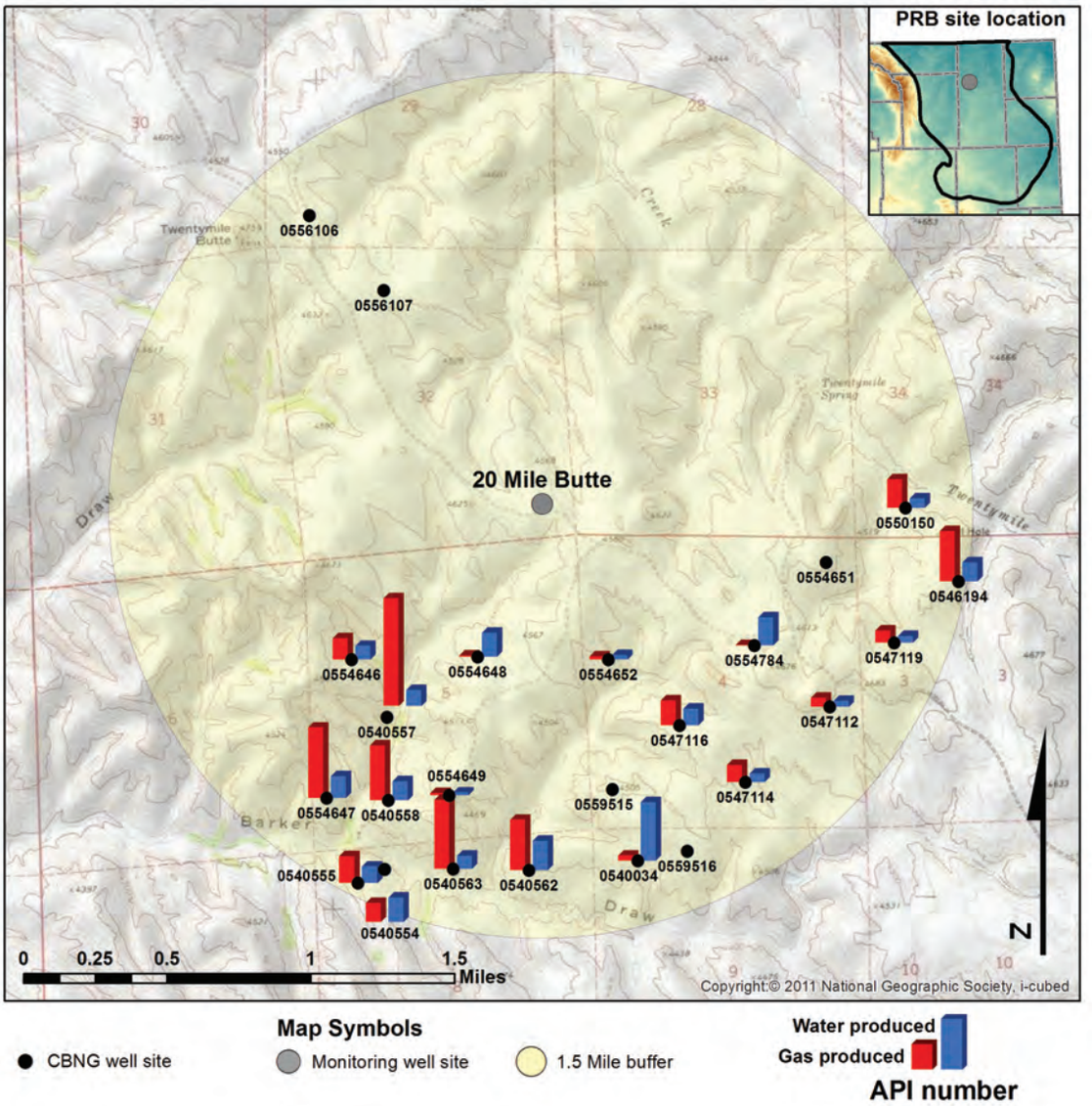

Figure A.5. 20 Mile Butte monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

The Wall coal zone did not produce water or gas during the 2000-2013 monitoring period.

Water produced from multiple coal zone wells rose to over 20,000 bbls/month in 2007 and then generally declined (Figure A.6). 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.

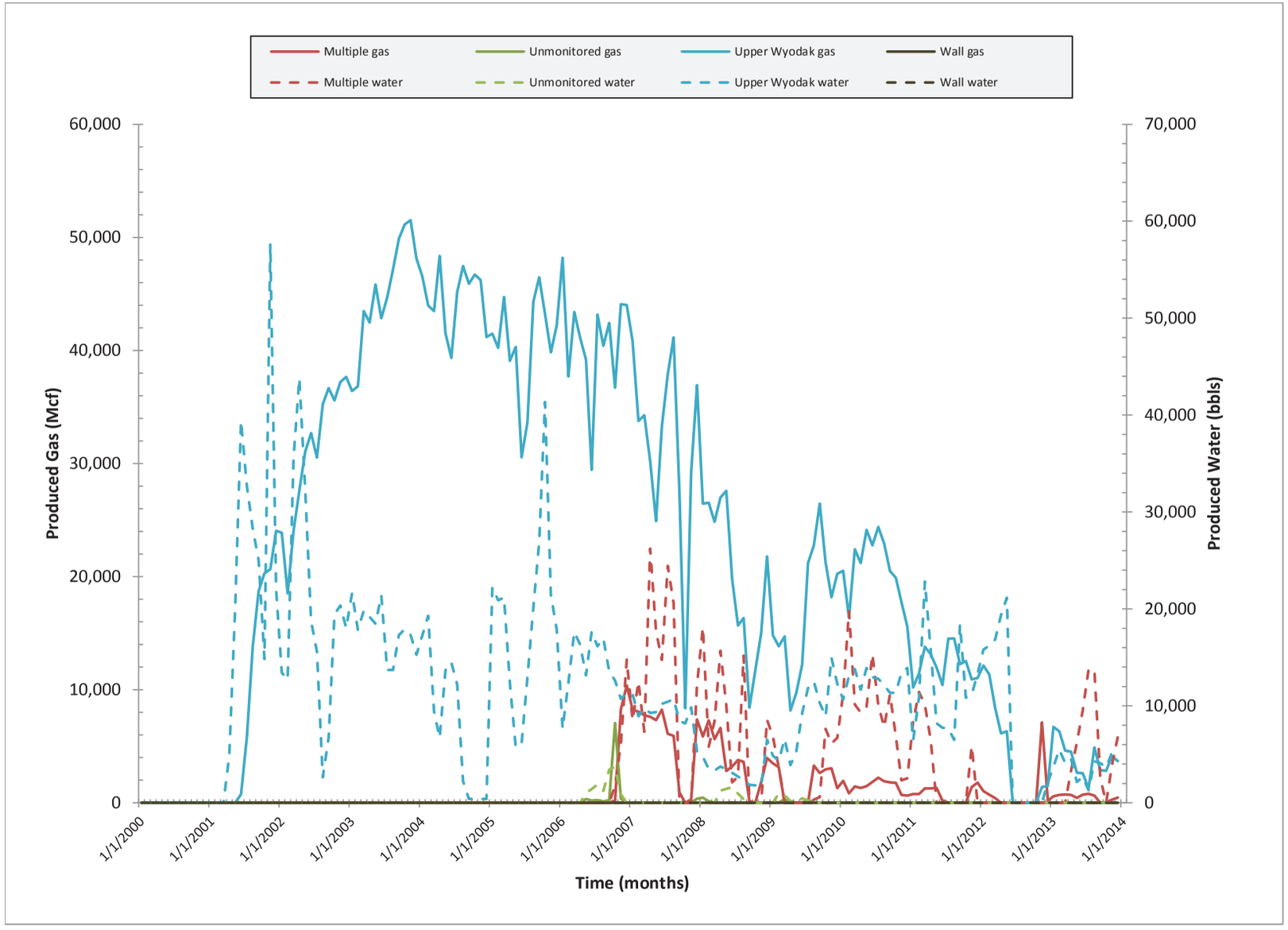

Figure A.6. Water and gas production from CBNG wells associated with the 20 Mile Butte monitoring well site location.

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 a Wasatch sandstone, 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 2013 using both manual and automatic transducer and data logger equipment. Generally, there is good agreement between manual and transducer measurements taken on this site with the exception of gas pressure measurements in the Wyodak zone which vary widely. 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.

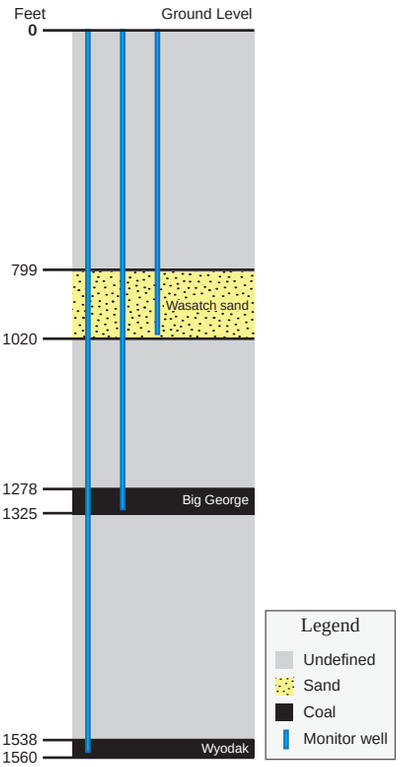

Figure A.7. Section showing relative positions of coals and sand in feet. Not to scale.

Wasatch Sandstone
During 2013, groundwater levels declined 0.64 feet in the Wasatch sandstone. Groundwater levels have declined only 8.62 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 4.17 feet during 2013 in the Big George coal. Groundwater levels have declined a total of 262.52 feet during the POR (Figure A.8; Table A.5). During the 2001-2013 period, measured gas pressures in the Big George coal have ranged from -0.3 – 1.0 psi.

Wyodak Coal
Groundwater levels rose 4.65 feet during 2013 continuing the modest recovery first observed onward from late 2010 (Figure A.8; Table A.5). During the 2001-2013 period, measured gas pressures in the Wyodak coal have ranged from -3.6 – 10.0 psi.

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

Monitored interval	Interval characteristics			
	Depth of interval (ft)		Interval 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, water level changes for current monitoring period, water level changes for period of record, and maximum gas pressure.

Monitored interval	DGW - Depth to groundwater (ft), water level (ft), and gas pressure (psi) data					
	Initial DGW	Max DGW [Date]	Final 2013 DGW	Water level change 2013	Net water level change	Max. gas pressure [date]
Wasatch sand	533.33	542.10 12/11/2013	541.95	-0.64	-8.62	n/a
Big George coal	626.68	889.50 12/6/2013	889.20	-4.17	-262.52	1.00 8/15/2003
Wyodak coal	629.86	1149.00 8/25/2001	932.10	4.65	-302.24	10.00 4/16/2002

Production Statistics

Production data were analyzed for CBNG wells within the buffer of the 21 Mile monitoring well site from 1999 to 2013. Cumulative production for individual CBNG wells is displayed by location on Figure A.9. CBNG and water production is monitored in the Wyodak Rider, Upper Wyodak, unmonitored and multiple coal zones.

Peak water production 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 June 2008.

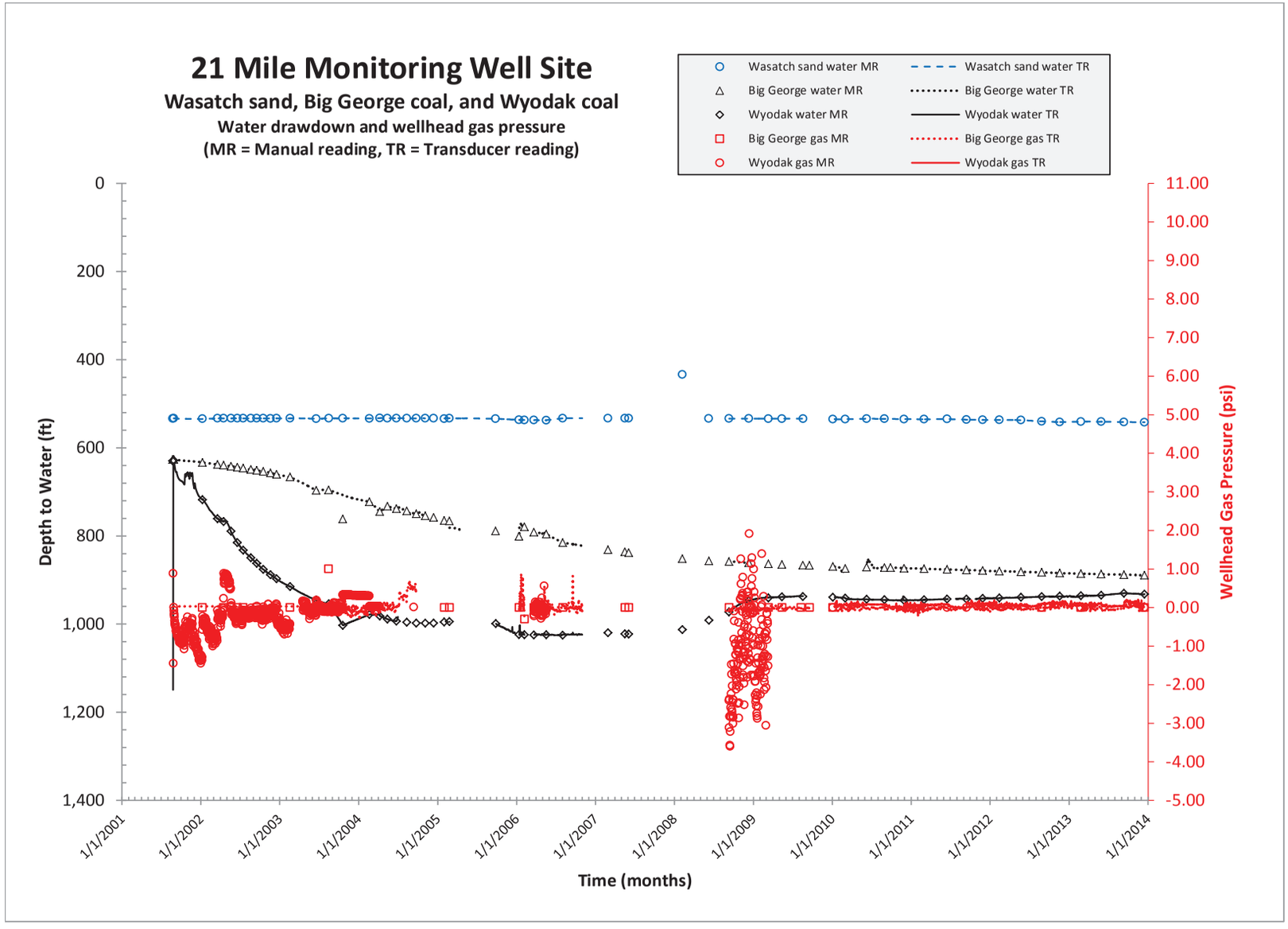

Figure A.8. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored intervals at the 21 Mile monitoring well site location.

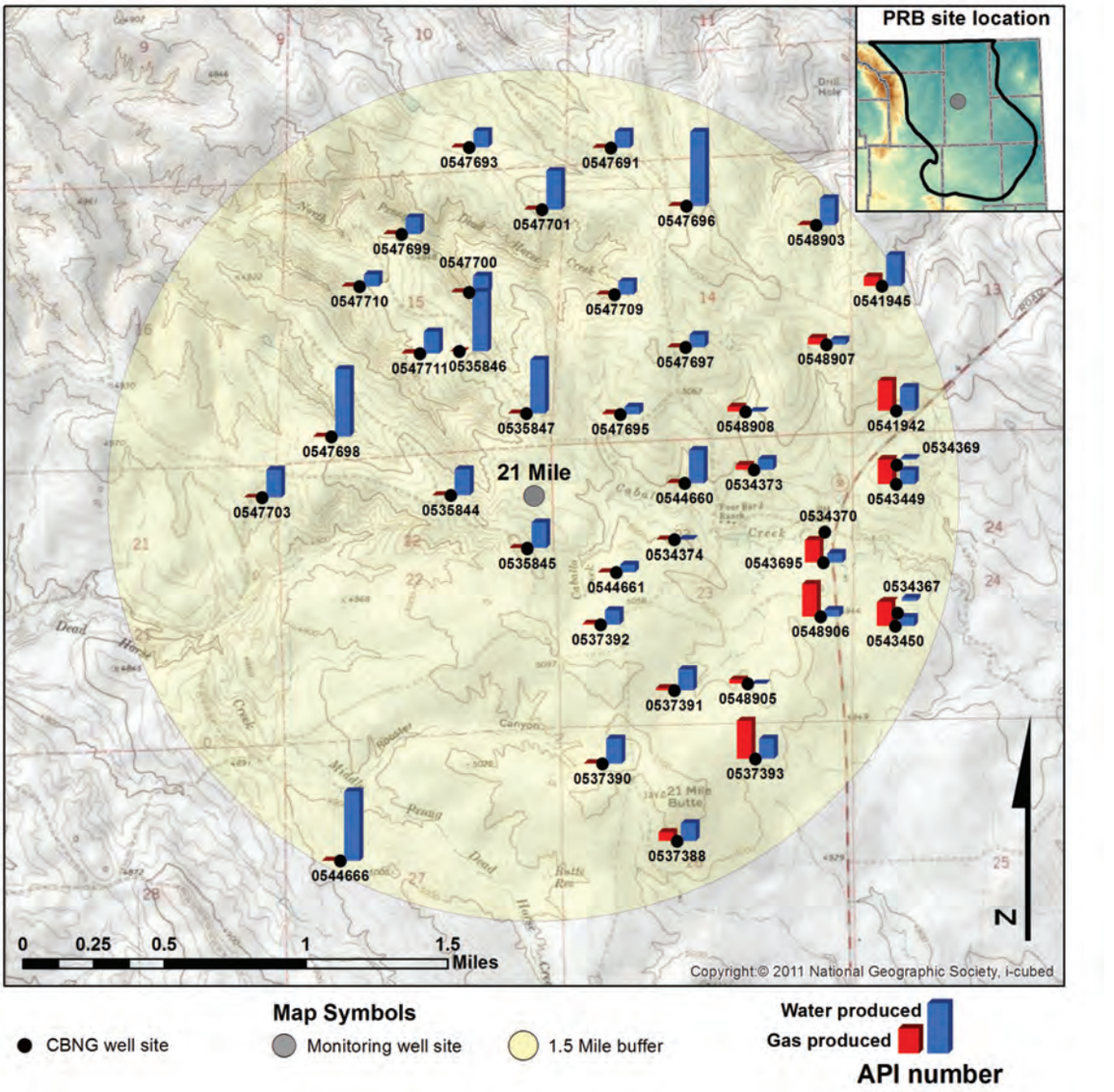

Figure A.9. 21 Mile monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

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). There has been no produced water from the Upper Wyodak since August 2012. Gas production, which peaked in July 2003 at almost 65,000 Mcf has continually declined since then to less than 200 Mcf/month during 2013.

The unmonitored coal zones only produced water during seven months in 2002 (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 (<56,000 bbls/month) and small amounts of gas (<773 Mcf/month) from 2002-2008; there was no water or gas production from multiple zone wells during 2013 (Figure A.10).

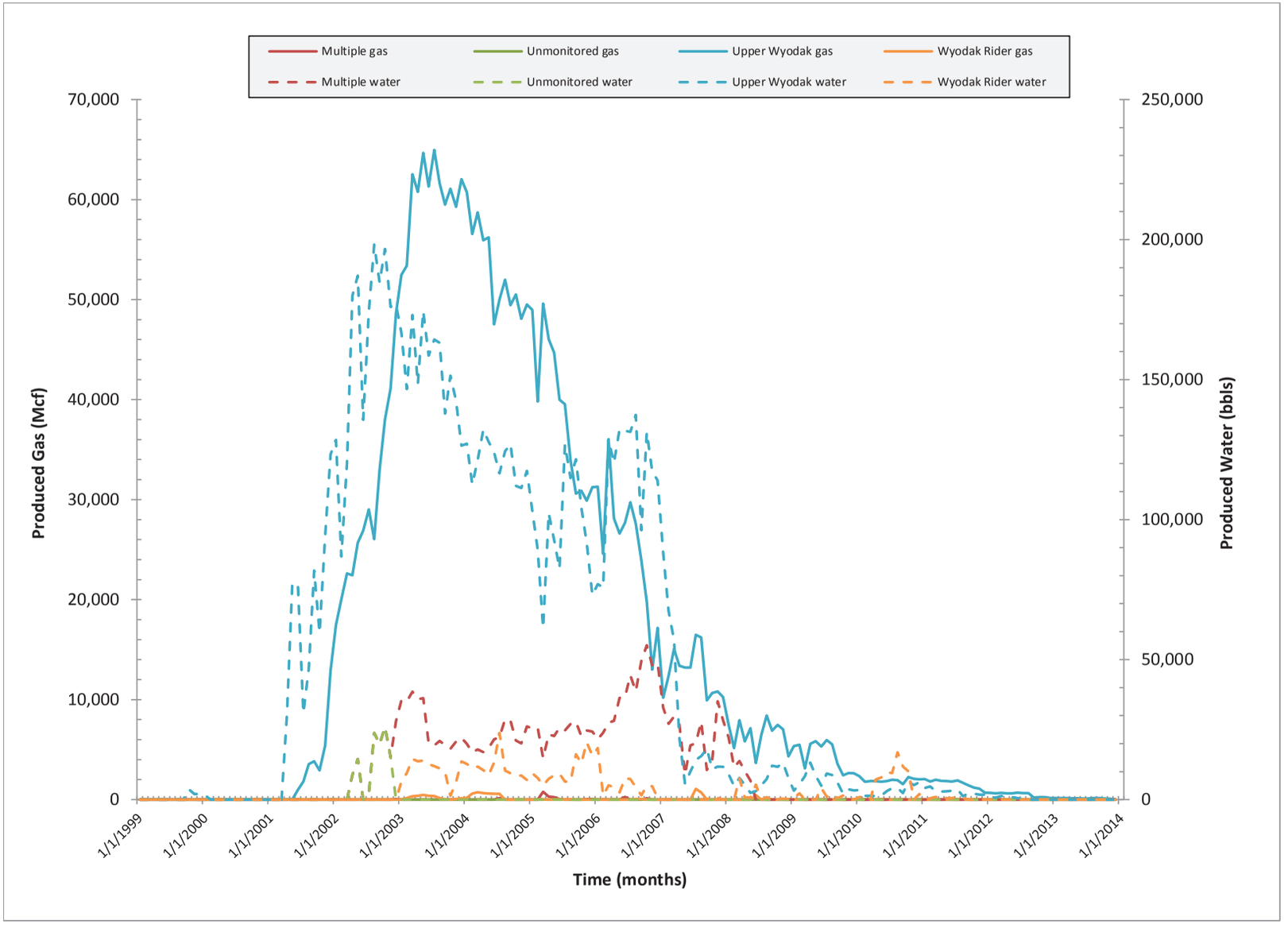

Figure A.10. Water and gas production from CBNG wells associated with the 21 Mile monitoring well site location.

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 consists of 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 2013 using a combination of manual and automatic transducer and data logger equipment. Generally, transducer and manual measurements show substantial agreement where both are present. However, 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. Only manual measurements are available for the three shallowest sandstone wells.

Wasatch Sandstones

During 2013, groundwater levels in the monitored sandstone layers exhibited small changes that ranged from a 0.97 foot rise to 1.29 feet of decline. During the monitoring periods for each well, groundwater level changes ranged from a rise of 14.52 feet to a decline of 6.08 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 dry during 2013; 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 -2013, ending 2013 at approximately 4 psi.

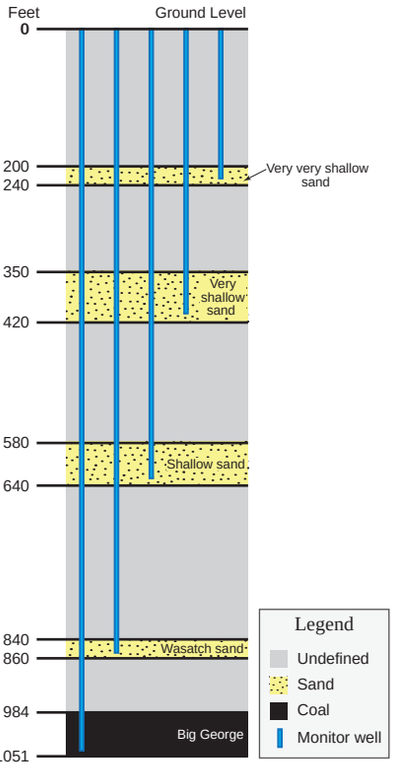

Figure A.11. Section showing relative positions of coal and sands in feet. Not to scale.

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

Monitored interval	Interval characteristics			
	Depth of interval (ft)		Interval 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, water level changes for current monitoring period, water level changes for period of record, and maximum gas pressure.

Monitored interval	DGW - Depth to groundwater (ft), water level (ft), and gas pressure (psi) data					
	Initial DGW	Max DGW [Date]	Final 2013 DGW	Water level change 2013	Net water level change	Max. gas pressure [date]
Very very shallow sand	95.47	97.70 11/10/2010	95.80	0.60	-0.33	n/a
Very shallow sand	200.71	201.80 9/16/2002	199.95	0.97	0.76	n/a
Shallow sand	252.45	258.60 2/7/2013	258.53	-0.03	-6.08	n/a
Wasatch sand	320.59	306.20 12/11/2013	306.07	-1.29	14.52	n/a
Big George coal*	439.92	1064.00 5/7/2009	1064.00	n/a	-624.08	48.53 10/29/2003

*Well dry to total depth 5/23/2007

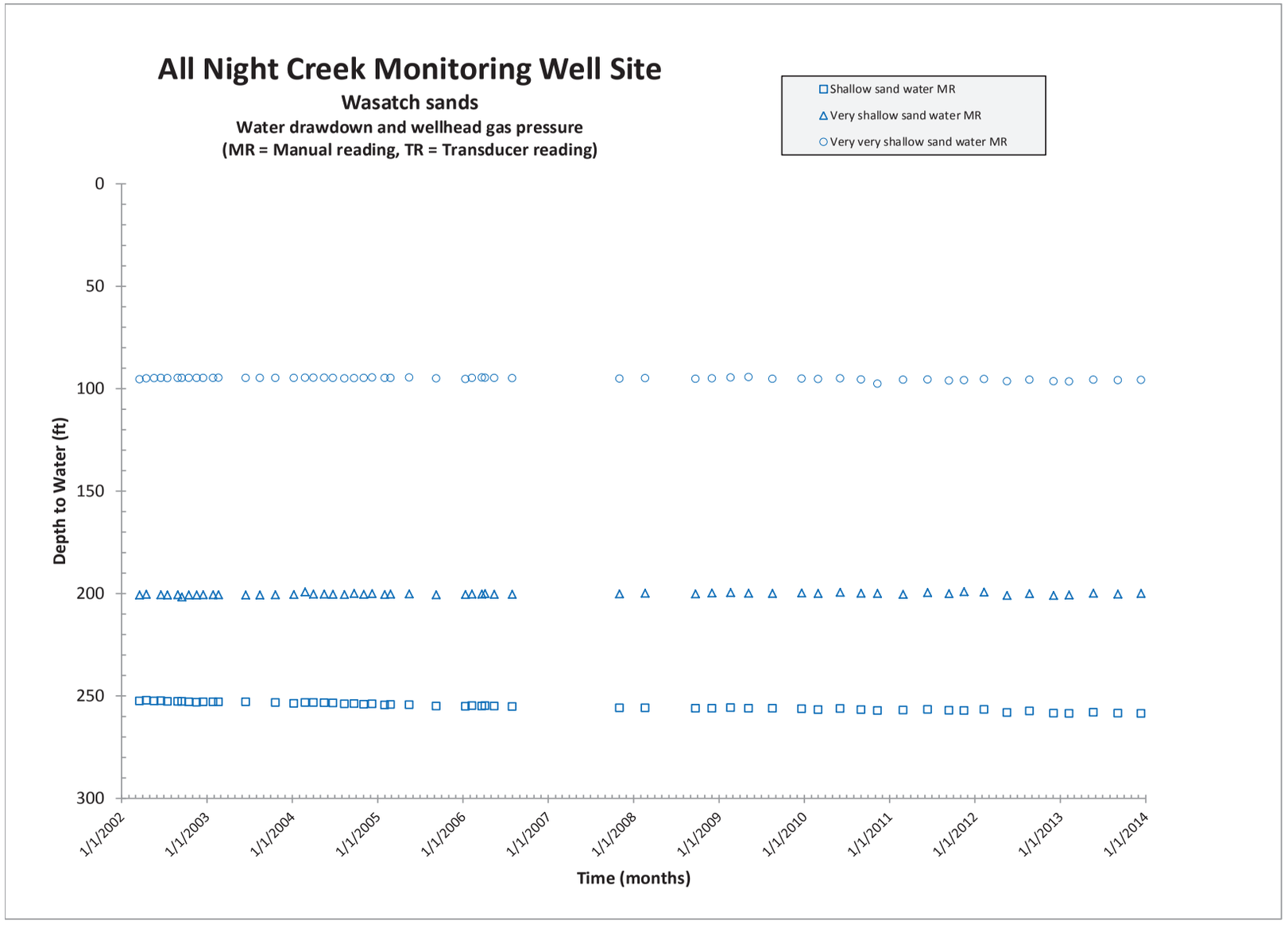

Figure A.12. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored intervals at the All Night Creek monitoring well site location.

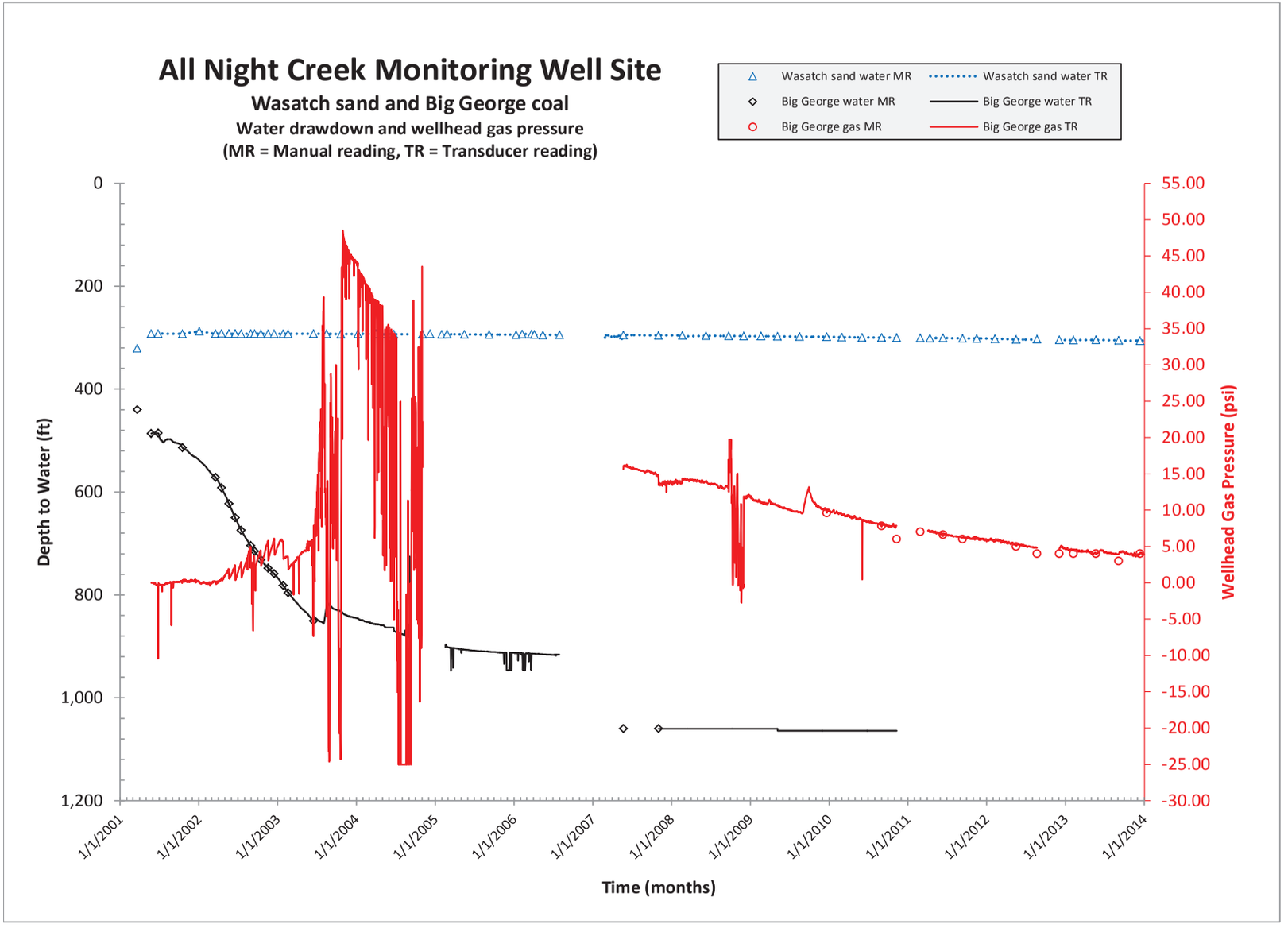

Figure A.13. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored intervals at the All Night Creek monitoring well site location.

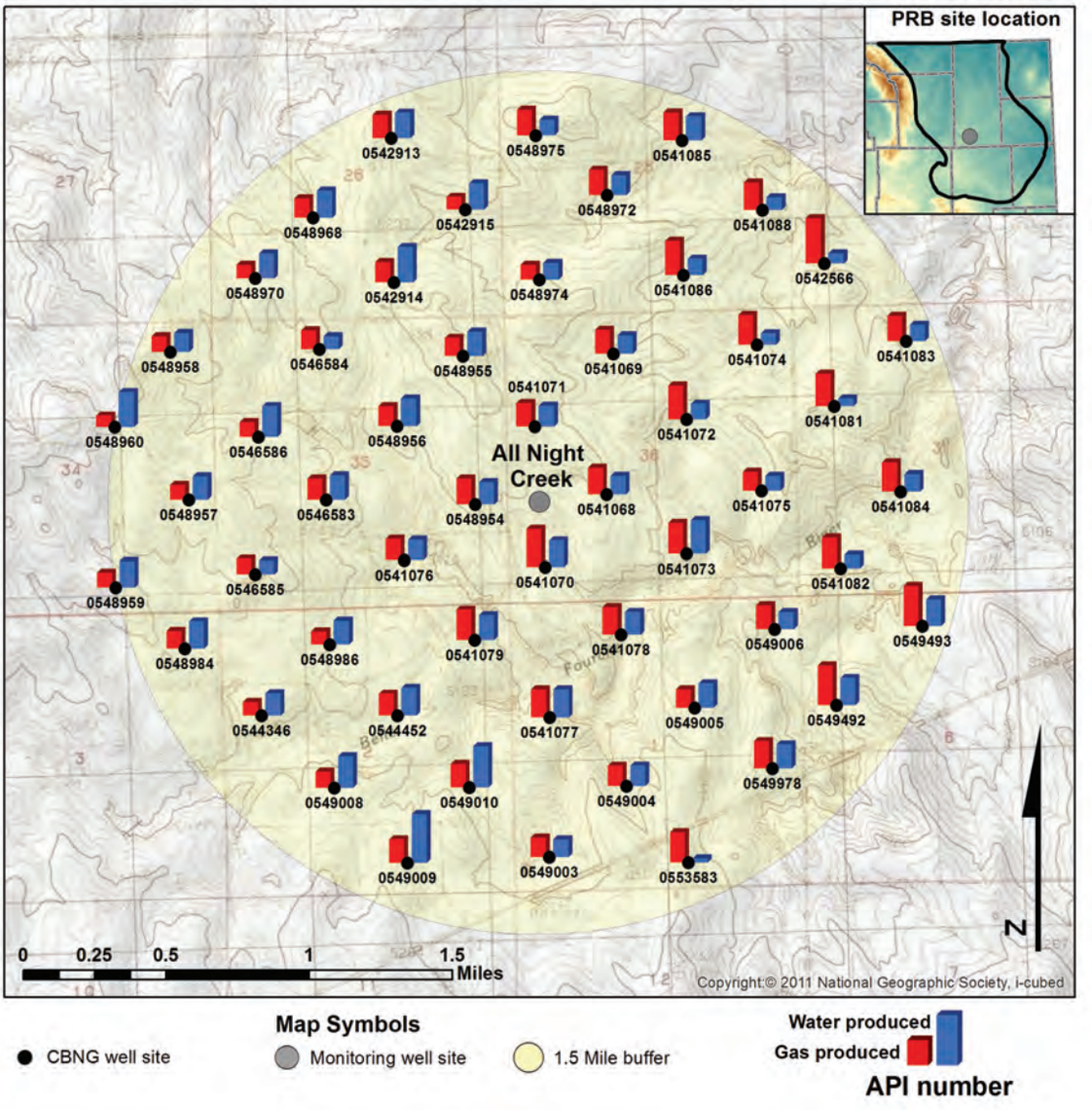

Figure A.14. All Night Creek monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

Production Statistics

Production data were analyzed for CBNG wells within the buffer of the All Night Creek monitoring well site from 2000-2013. Cumulative production for individual CBNG wells is displayed by location on Figure A.14. CBNG and water 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). No water has been produced from this coal zone since June 2012. Gas production began in 2001, rapidly increased, and peaked at 238,000 Mcf in October 2003. Gas production gradually decreased from its peak to 15,700 Mcf/month at the end of 2013.

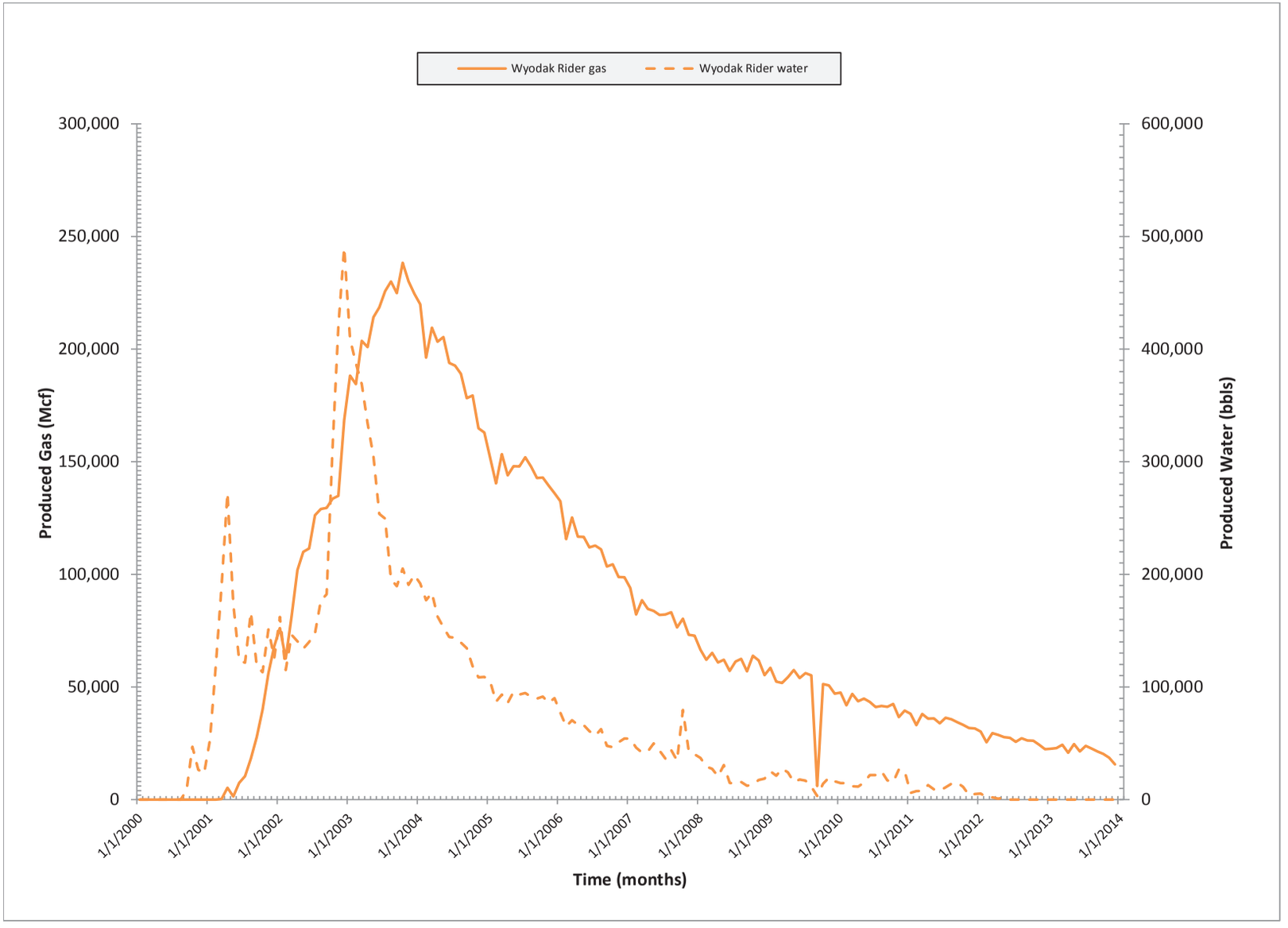

Figure A.15. Water and gas production from CBNG wells associated with the All Night Creek monitoring well site location.

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 one well that is completed in the Wyodak coal of the Upper Wyodak coal zone, (Figure A.16; Table A.8). Water levels have only been measured manually. Wellhead gas pressure was measured both manually and with pressure transducers until September 2010. Since then gas pressure was measured only manually.

Wyodak Coal
Groundwater levels rose 0.4 feet during the 2013. Overall, water levels declined 239.95 feet during the monitoring period of 1995-2013 (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 6.6 to 7.0 psi over 2013.

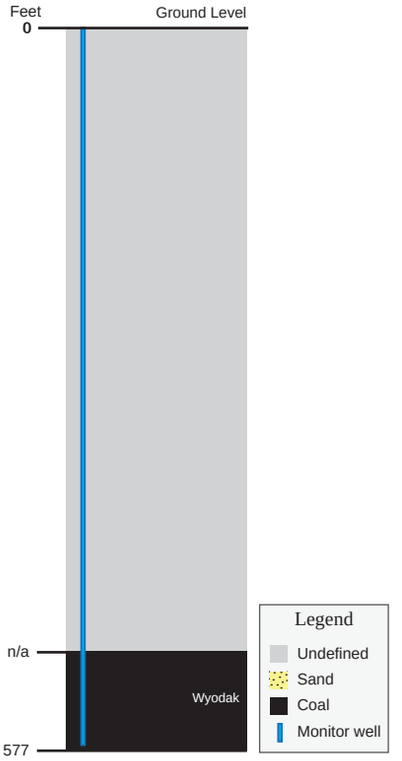

Figure A.16. Section showing relative position of coal in feet. Not to scale.

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

Monitored interval	Interval characteristics			
	Depth of interval (ft)		Interval thickness (ft)	Separation from coal (ft)
	Top	Bottom		
Wyodak coal	n/a	577	n/a	n/a

Table A.9. Table showing depths to water from ground level, water level changes for current monitoring period, water level changes for period of record, and maximum gas pressure.

Monitored interval	DGW - Depth to groundwater (ft), water level (ft), and gas pressure (psi) data					
	Initial DGW	Max DGW [Date]	Final 2013 DGW	Water level change 2013	Net water level change	Max. gas pressure [date]
Wyodak coal	244.00	494.90 10/16/2002	483.95	0.40	-239.95	34.11 10/12/1997

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 unknown coal production zones.

Water production in unknown coal zones began in 1995 and rapidly increased, peaking in 1997 at 327,000 bbls/month; reported water production then sharply declined to zero bbls in July 1999 (Figure A.19). Initial gas and water production in this monitoring area was reported as unknown coals but most of the gas production and all of the water production was reclassified as Upper Wyodak

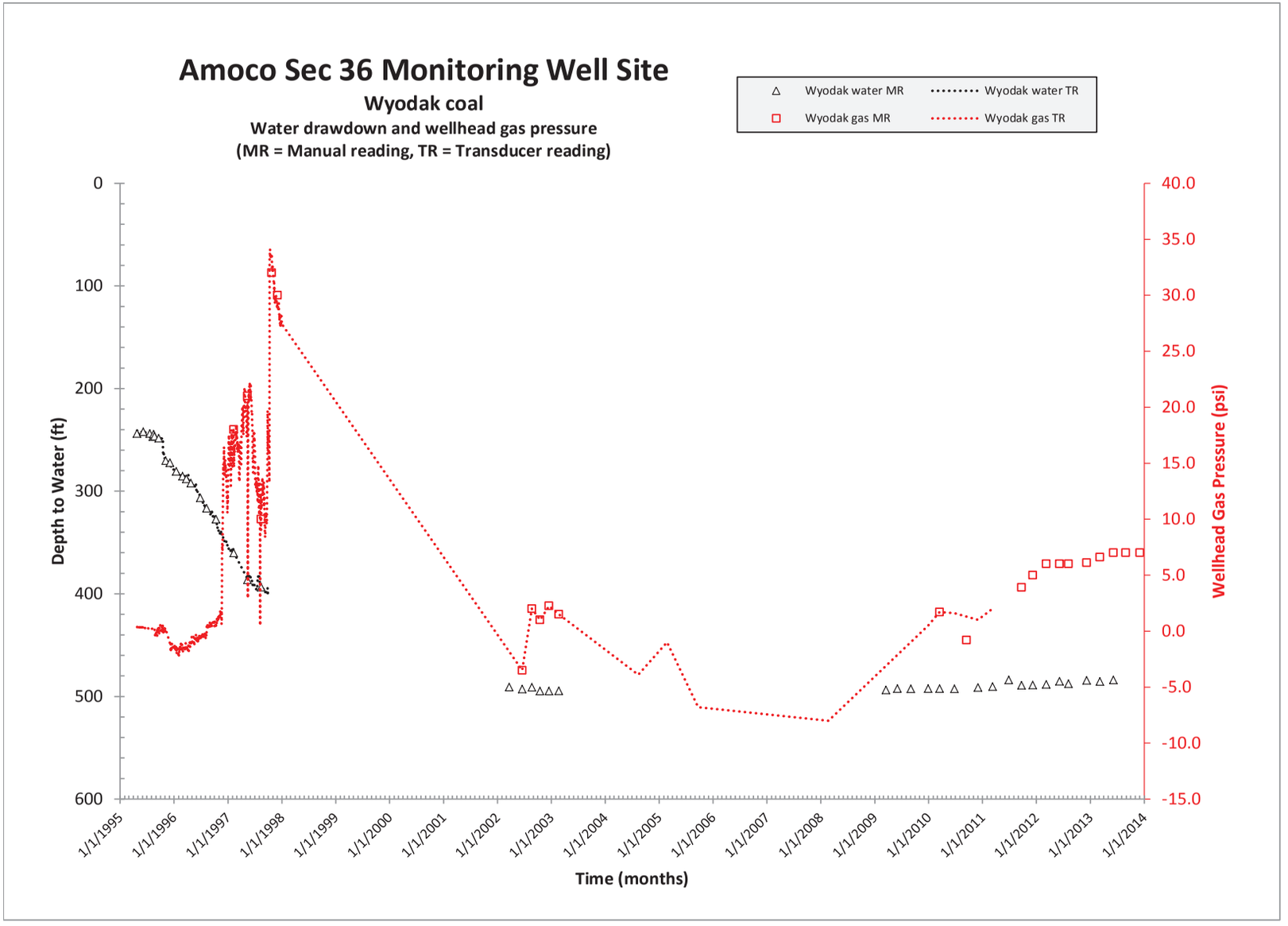

Figure A.17. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored intervals at the Amoco Sec 36 monitoring well site location.

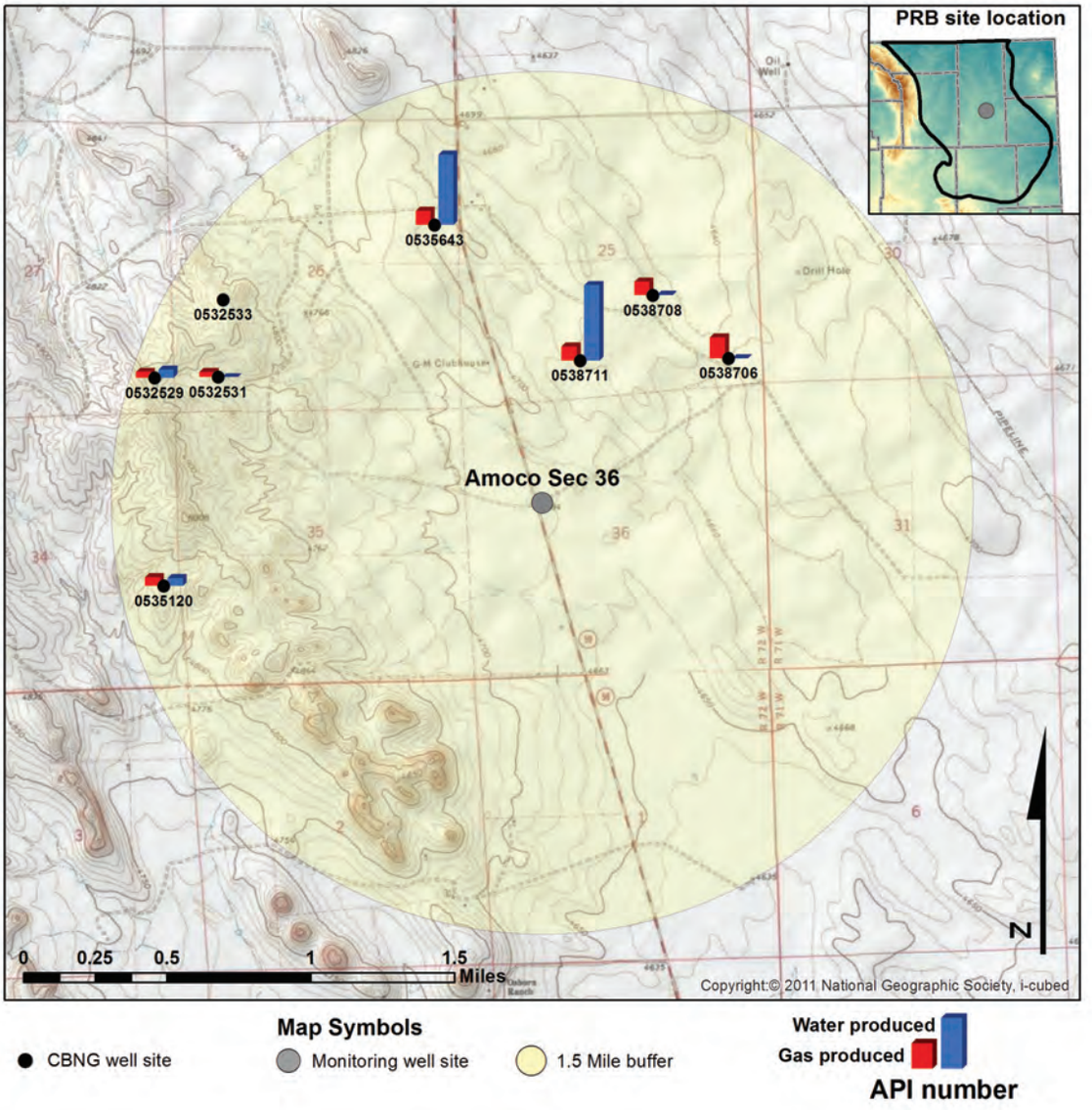

Figure A.18. Amoco Sec 36 monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

in July 1999. Gas production in unknown coal zones followed a similar trend peaking at 214,000 Mcg/month in 1997 and dropping off after the 1999 reclassification and ceasing entirely in 2008. Production began being recorded as Upper Wyodak coal zone in July 1999. Water production peaked in August 1999 at 86,000 bbls and declined slowly until production stopped in February 2008. Gas production followed a similar trend beginning and peaking in 1999 and slowly declined, but continued until early 2012 when production ceased.

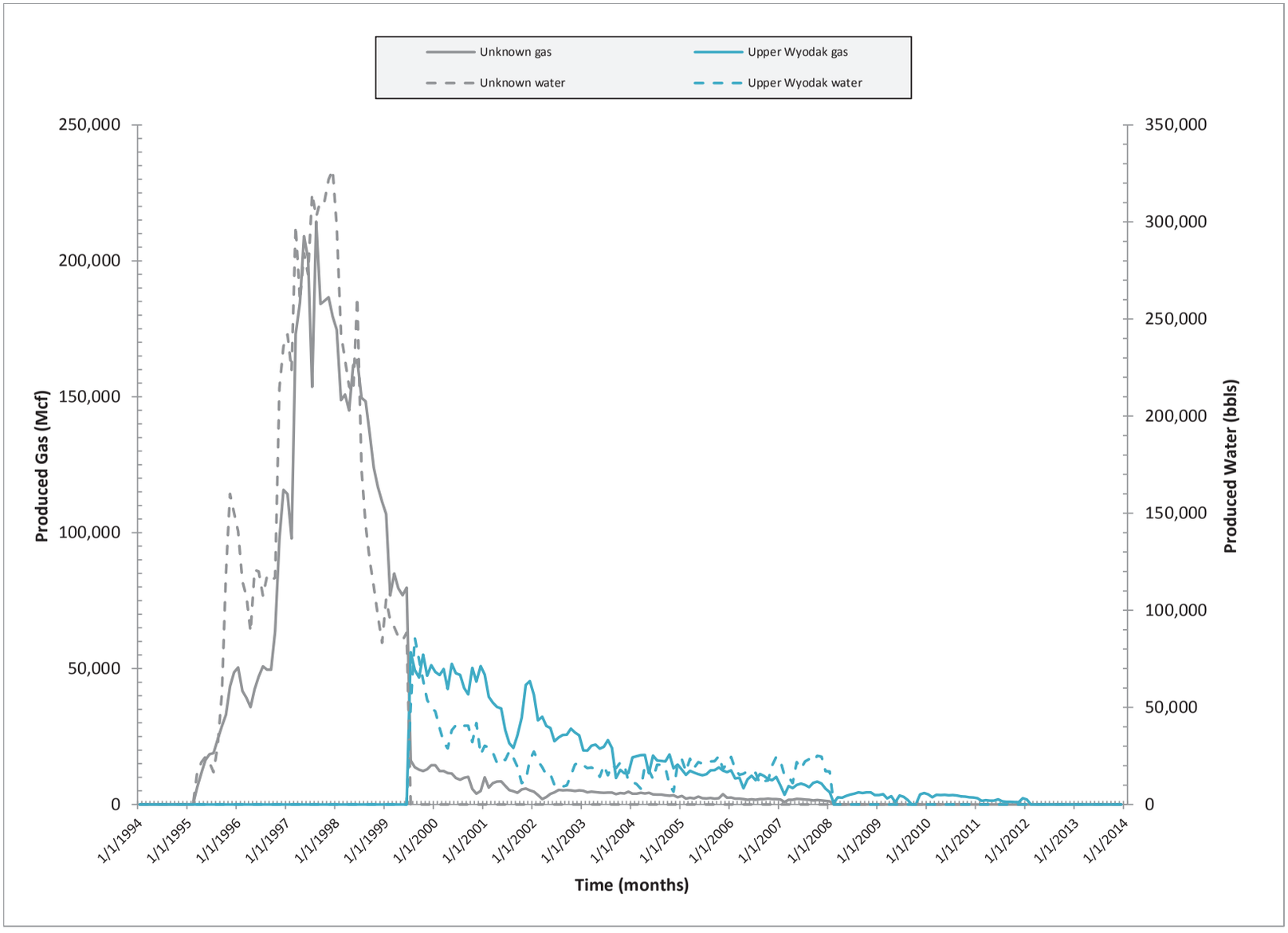

Figure A.19. Water and gas production from CBNG wells associated with the Amoco Sec 36 monitoring well site location.

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 pressure in the Wyodak coal were measured during 2013 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 2013, groundwater levels declined 5.10 feet in the Wasatch sandstone; groundwater levels declined 285.03 feet over the 1997 – 2013 POR. (Figure A.21; Table A.11). Gas pressure was not recorded in the Wasatch sandstone.

Wyodak Coal
Groundwater levels declined 0.25 feet during 2013. During the 1997 - 2013 POR, groundwater levels show a net decline of 597.89 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 has remained negative since.

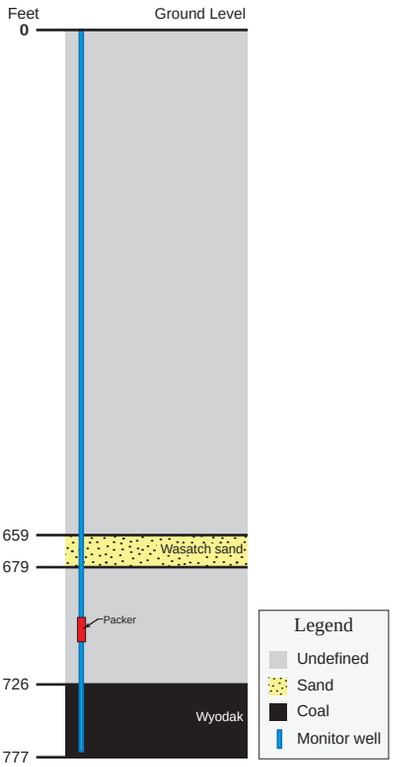

Figure A.20. Section showing relative positions of coal and sand in feet. Not to scale.

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

Monitored interval	Interval characteristics			
	Depth of interval (ft)		Interval 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, water level changes for current monitoring period, water level changes for period of record, and maximum gas pressure.

Monitored interval	DGW - Depth to groundwater (ft), water level (ft), and gas pressure (psi) data					
	Initial DGW	Max DGW [Date]	Final 2013 DGW	Water level change 2013	Net water level change	Max. gas pressure [date]
Wasatch sand	175.97	461.00 12/7/2013	461.00	-5.10	-285.03	n/a
Wyodak coal	161.81	781.90 1/26/2008	759.70	-0.25	-597.89	62.00 6/18/2003

Production Statistics

Production data were analyzed for CBNG wells within the buffer of the Bar 76 monitoring well site from 2000-2013. Cumulative production for individual CBNG wells is displayed by location on Figure A.22. CBNG and water production is monitored in the Upper Wyodak, multiple, and unmonitored coal zones.

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 during 2013 was only 6,200 bbls/month. Gas production in the Upper Wyodak increased rapidly in early 2002, peaked at 163,000 Mcf/month in 2004, and declined to 0 Mcf/month by the end of 2013.

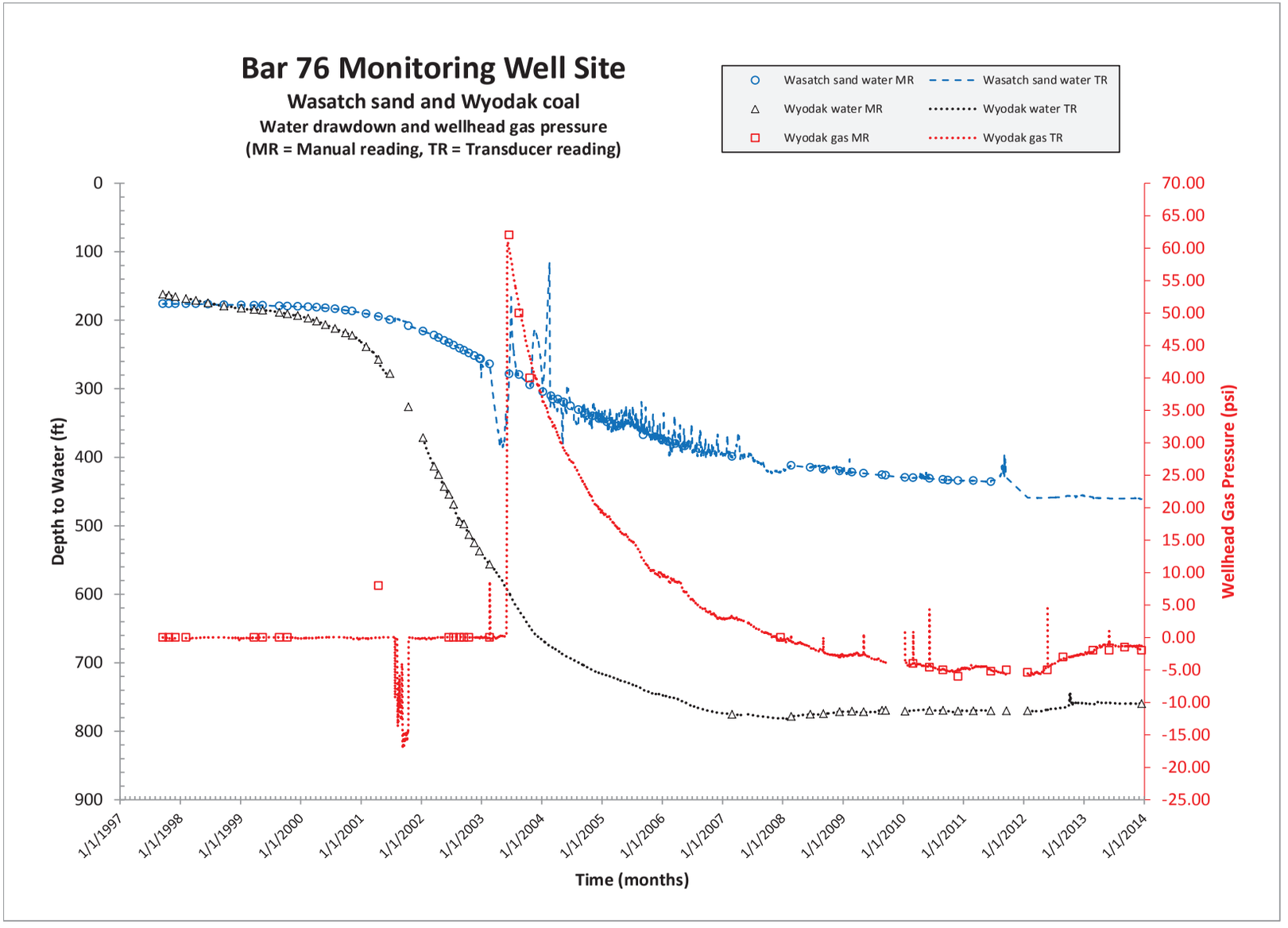

Figure A.21. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored intervals at the Bar 76 monitoring well site location.

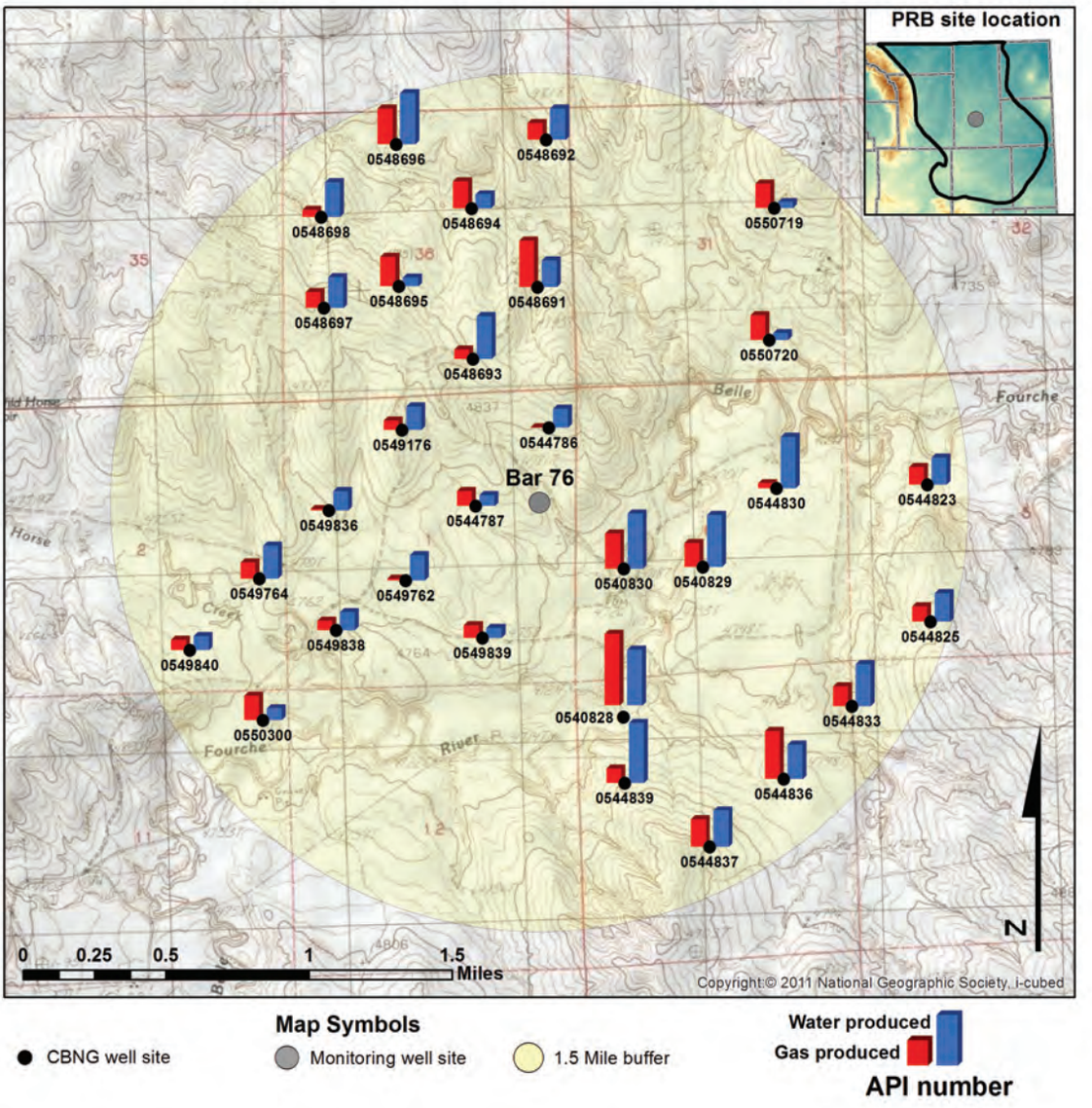

Figure A.22. Bar 76 monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

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 to zero during 2013. (Figure A.23). Gas production in unmonitored coal zones peaked at 135,000 Mcf in May of 2004 and then declined to zero by the end of 2012 and remained the same during 2013.

Wells completed in multiple coal zones began producing water in late 2004, peaked at 35,000 bbls/month in 2010, and tapered off to zero in 2013 (Figure A.23). Gas production peaked a year after it began at 25,000 Mcf/month in 2006. Gas production in multiple zone completions ceased in 2012.

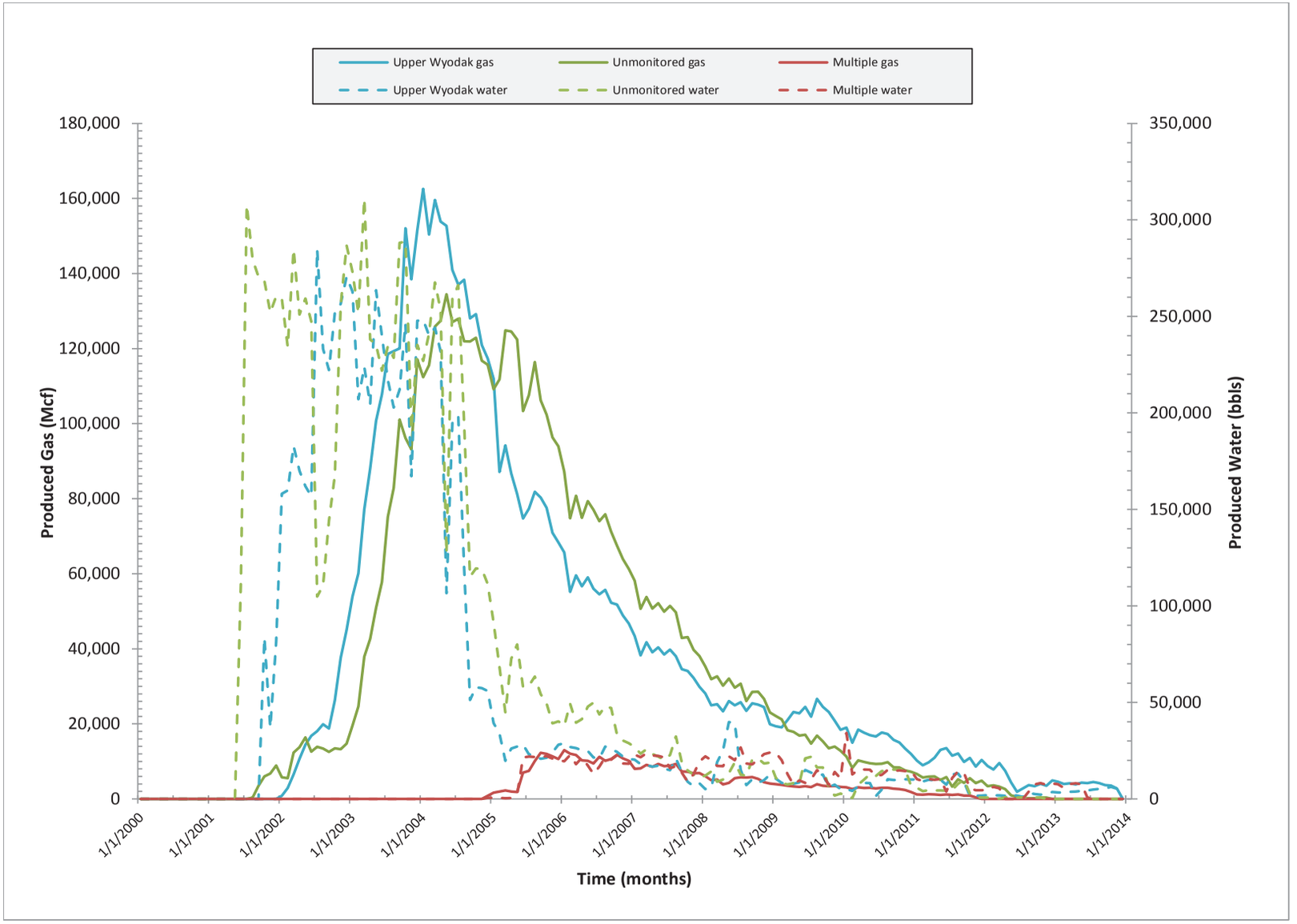

Figure A.23. Water and gas production from CBNG wells associated with the Bar 76 monitoring well site location.

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

Drawdown Information
The Barrett Persson 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.24; Table A.12). Water levels and wellhead gas pressure were measured during 2013 using both manual and automatic transducer and data logger equipment. Generally, transducer data and manual measurements are in substantial agreement on this site. However, 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 2013, groundwater levels rose 4.59 feet in the Wasatch sandstone; groundwater levels have declined 298.19 feet during the POR. (Figure A.25; Table A.13). Gas pressure was not recorded in the Wasatch sandstone.

Wyodak Coal
Groundwater levels rose 9.41 feet during 2013. Groundwater levels have declined a total of 175.69 feet during the POR. (Figure A.25; Table A.13). The gas pressure data record exhibits apparent frequent random fluctuations, and gaps where transducer measurements were not obtained. Measured gas pressure in the Wyodak coal peaked at 18 psi in 2008 and has been zero since 2010.

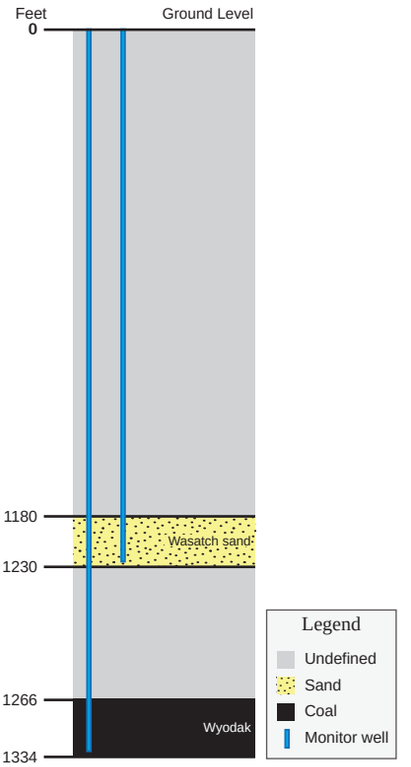

Figure A.24. Section showing relative positions of coal and sand in feet. Not to scale.

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

Monitored interval	Interval characteristics			
	Depth of interval (ft)		Interval 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, water level changes for current monitoring period, water level changes for period of record, and maximum gas pressure.

Monitored interval	DGW - Depth to groundwater (ft), water level (ft), and gas pressure (psi) data					
	Initial DGW	Max DGW [Date]	Final 2013 DGW	Water level change 2013	Net water level change	Max. gas pressure [date]
Wasatch sand	507.76	817.80 9/12/2013	806.03	4.59	-298.19	n/a
Wyodak coal	826.27	1041.70 6/24/2008	1001.96	9.41	-175.69	18.00 6/24/2008

Production Statistics

Production data were analyzed for CBNG wells within the buffer of the Barrett Persson monitoring well site from 1998-2013. Cumulative production for individual CBNG wells is displayed by location on Figure A.26. CBNG and water 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 continued to decline to less than 3,000 bbls/month for 2013. 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 2013 at 0 Mcf.

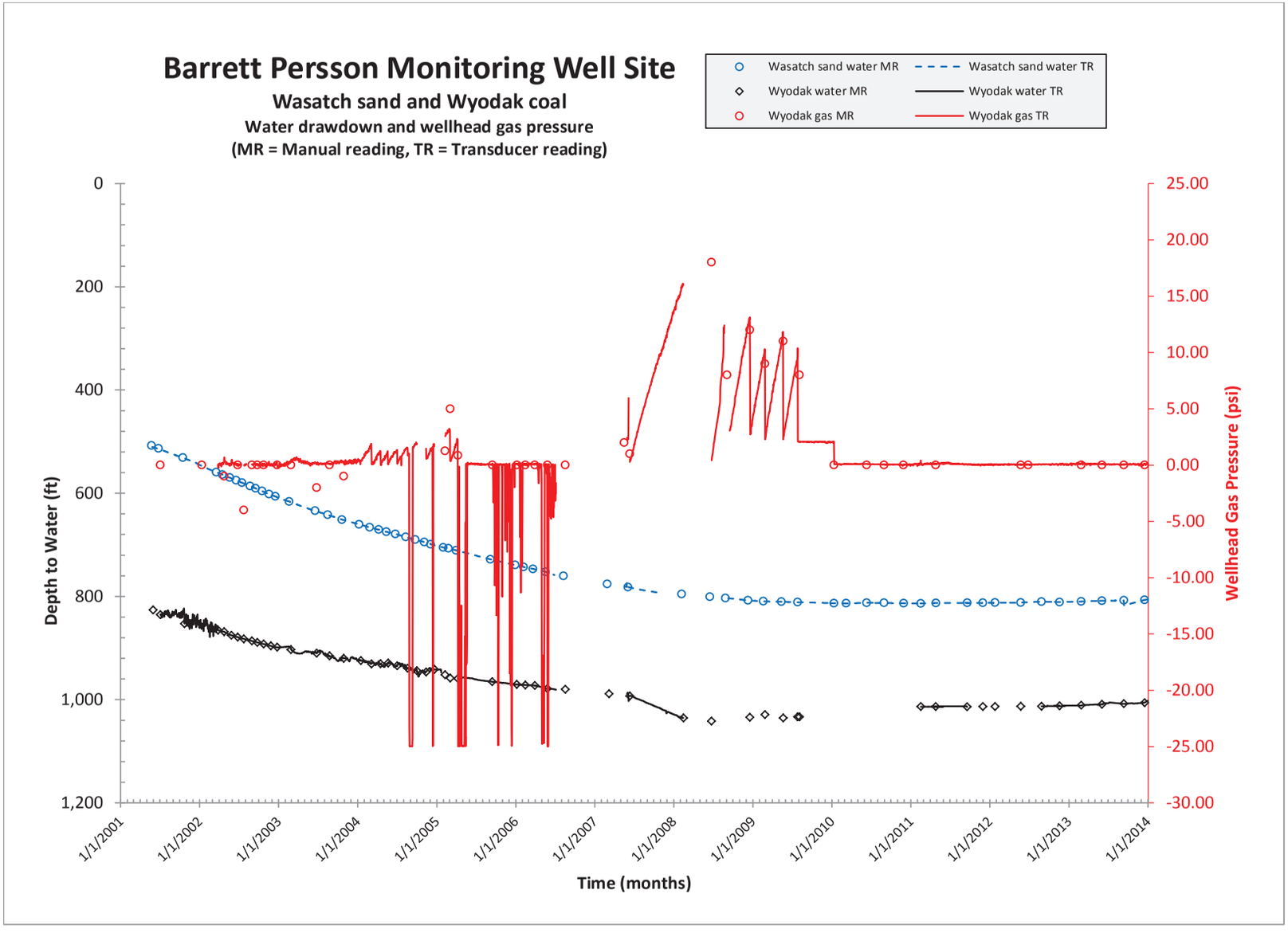

Figure A.25. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored intervals at the Barrett Persson monitoring well site location.

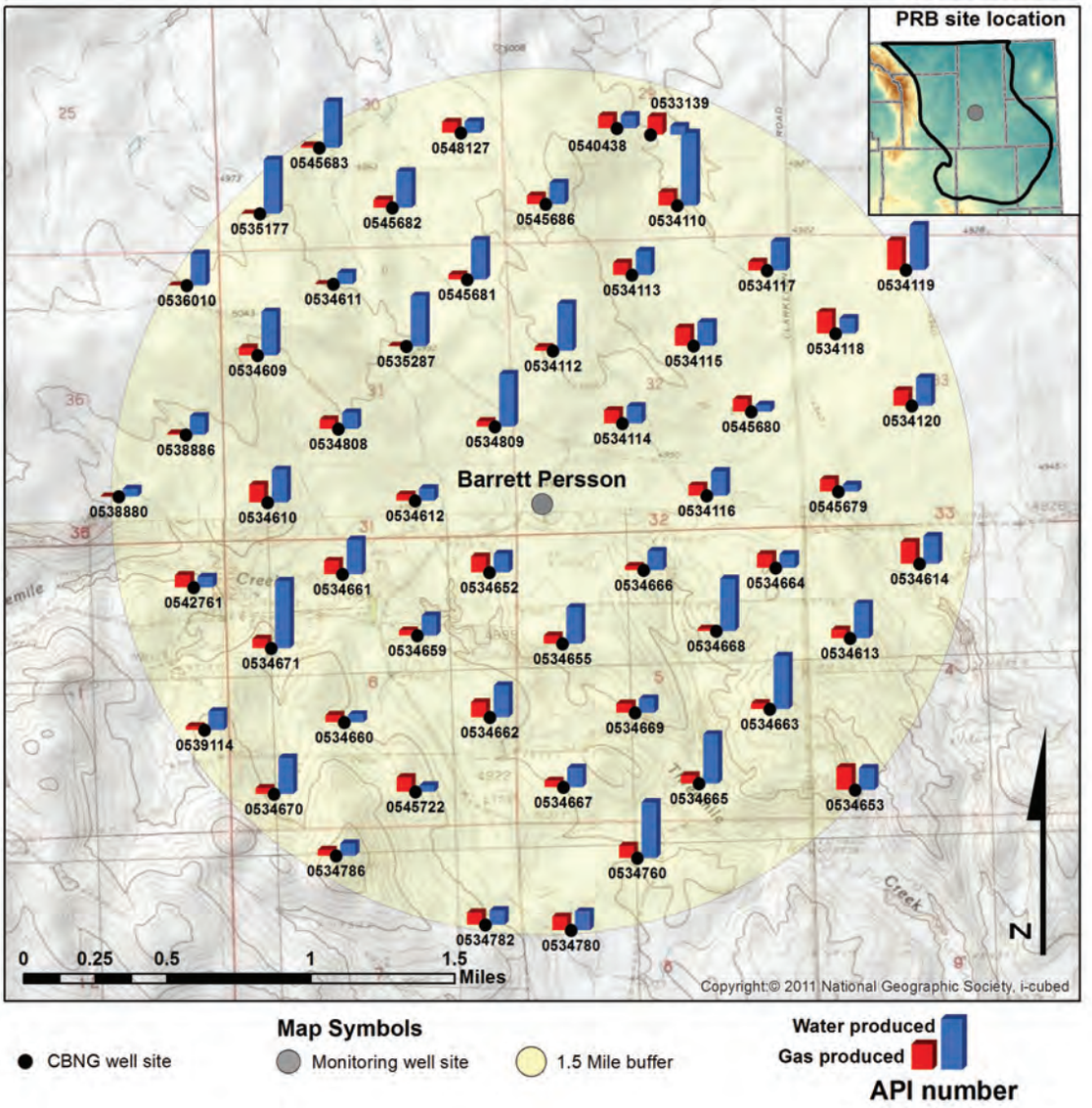

Figure A.26. Barrett Persson monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

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.

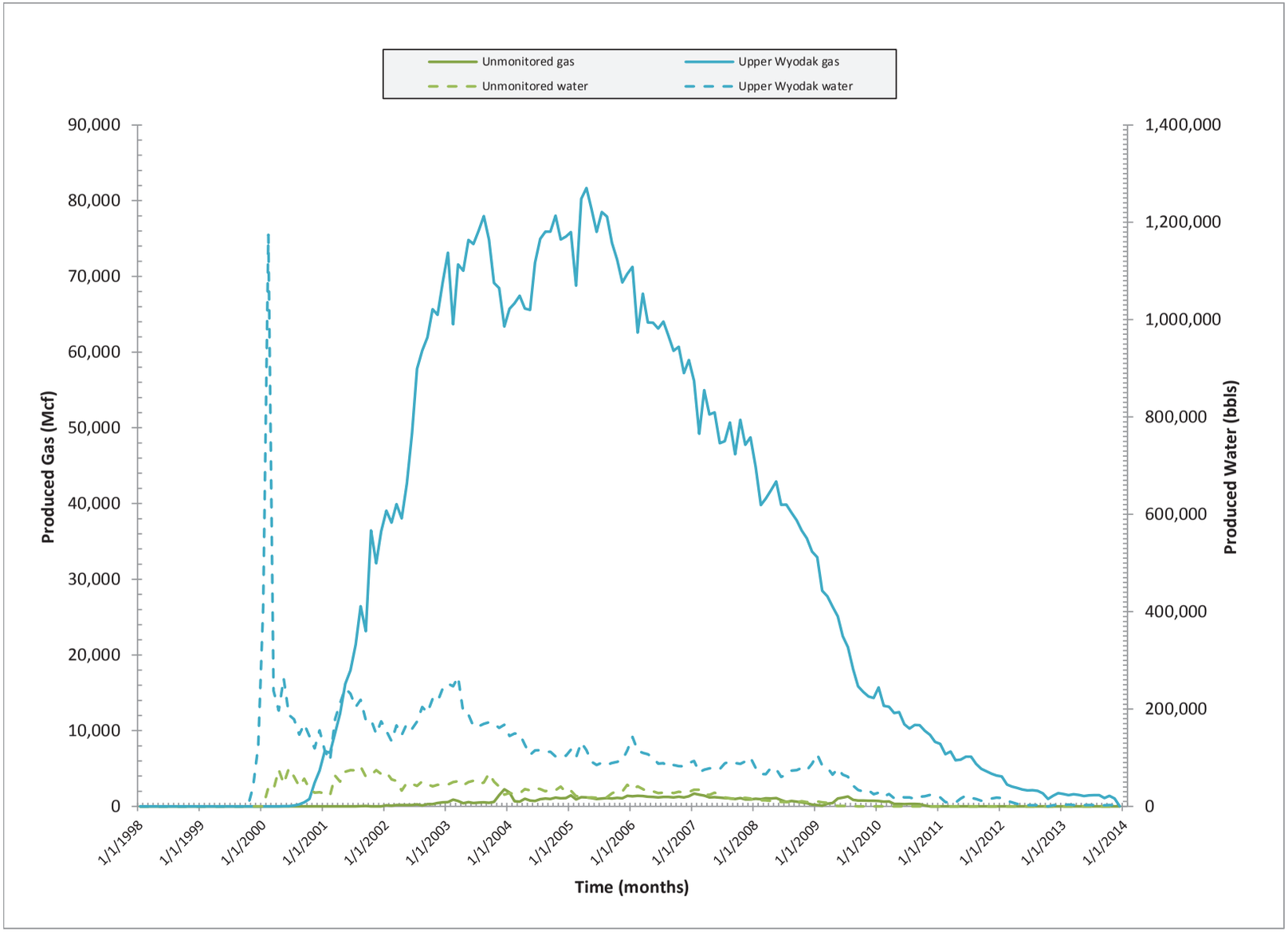

Figure A.27. Water and gas production from CBNG wells associated with the Barrett Persson monitoring well site location.

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

Drawdown Information

The Barton monitoring well site includes two coal zone 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 2013 using both manual and automatic transducer and data logger equipment in the Cook coal zone. Only manual water level measurements were obtained for the Wall coal zone in 2013. 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 2013, groundwater levels rose 54.46 feet in the Cook coal. According to recorded manual measurements, groundwater levels have risen over 112 feet since December 2008, but still remain 63 feet below initial water levels. Gas pressure in the Cook coal remained relatively stable near 0 psi over the monitoring period of 2002-2013 peaking at 0.4 psi in 2002.

Wall Coal

Groundwater levels rose 0.45 feet during 2013. Over the 2002 – 2013 POR, water levels declined 16.51 feet (Figure A.29; Table A.15). During the monitoring period (2002-2013), measured gas pressure fluctuated somewhat over small intervals and peaked at 4.0 psi.

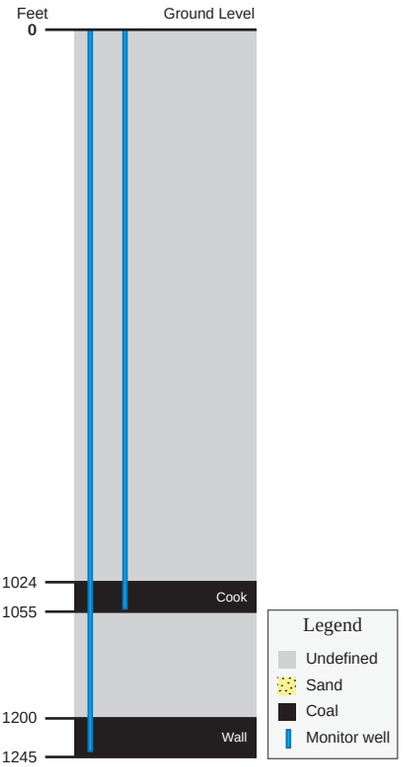

Figure A.28. Section showing relative positions of coals in feet. Not to scale.

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

Monitored interval	Interval characteristics			
	Depth of interval (ft)		Interval 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, water level changes for current monitoring period, water level changes for period of record, and maximum gas pressure.

Monitored interval	DGW - Depth to groundwater (ft), water level (ft), and gas pressure (psi) data					
	Initial DGW	Max DGW [Date]	Final 2013 DGW	Water level change 2013	Net water level change	Max. gas pressure [date]
Cook coal	364.56	540.50 9/26/2008	428.03	54.46	-63.47	0.40 4/17/2002
Wall coal	200.48	218.40 7/11/2013	216.99	0.45	-16.51	4.00 2/6/2002

Production Statistics

Production data were analyzed for CBNG wells within the buffer of the Barton monitoring well site from 2000-2013. 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 2001 at 110,178 bbls; then declined to 0.00 bbls/month by 2012 (Figure A.31) where it remained during 2013. Gas production increased gradually from 2002-2007 and peaked at nearly 17,000 Mcf/month. Production declined to zero by mid 2012; no gas was produced in 2013.

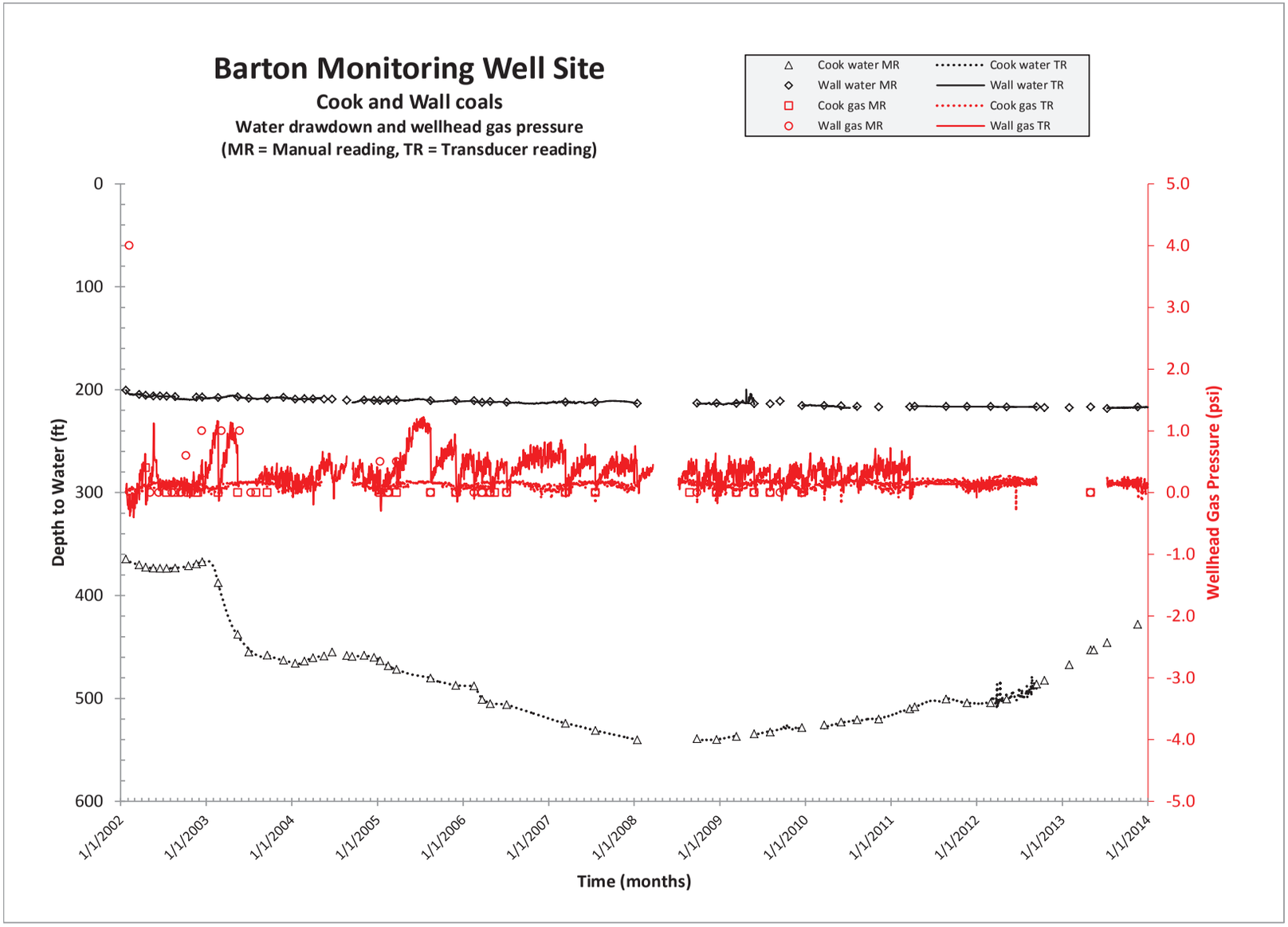

Figure A.29. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored intervals at the Barton monitoring well site location.

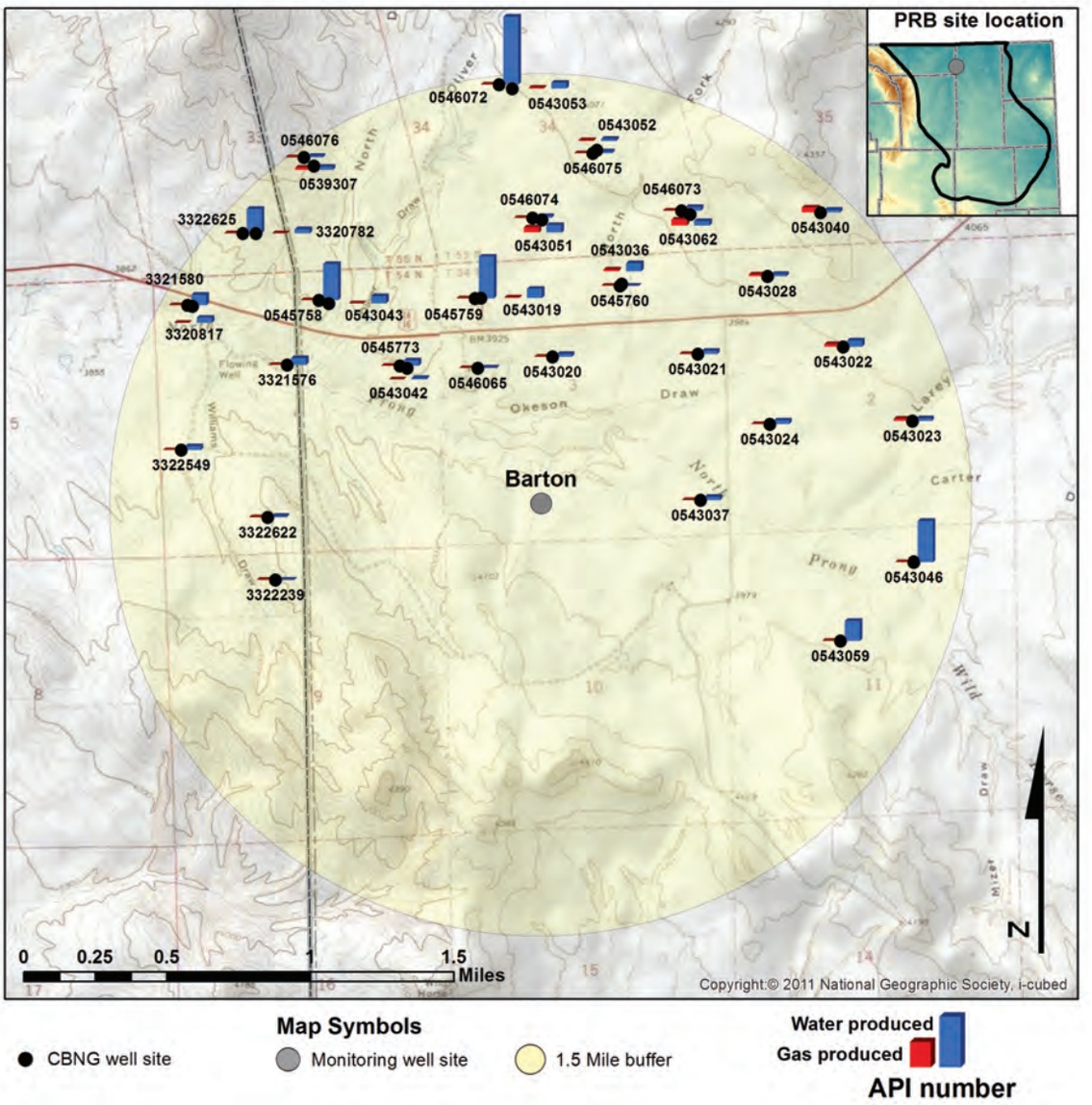

Figure A.30. Barton monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

Water production in the Wall coal zone reached several sharp peaks in 2003, 2007, and late 2008; there was no water production during 2013 (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 rose during 2000-2002, peaked at 160,289 bbls in January 2002 and declined to zero bbls/month in 2012 (Figure A.31) where it remained during 2013. Gas production in unmonitored coal zones peaked in January 2002 at about 161,000 Mcf/month. No gas has been produced in the unmonitored coal zone since May 2012.

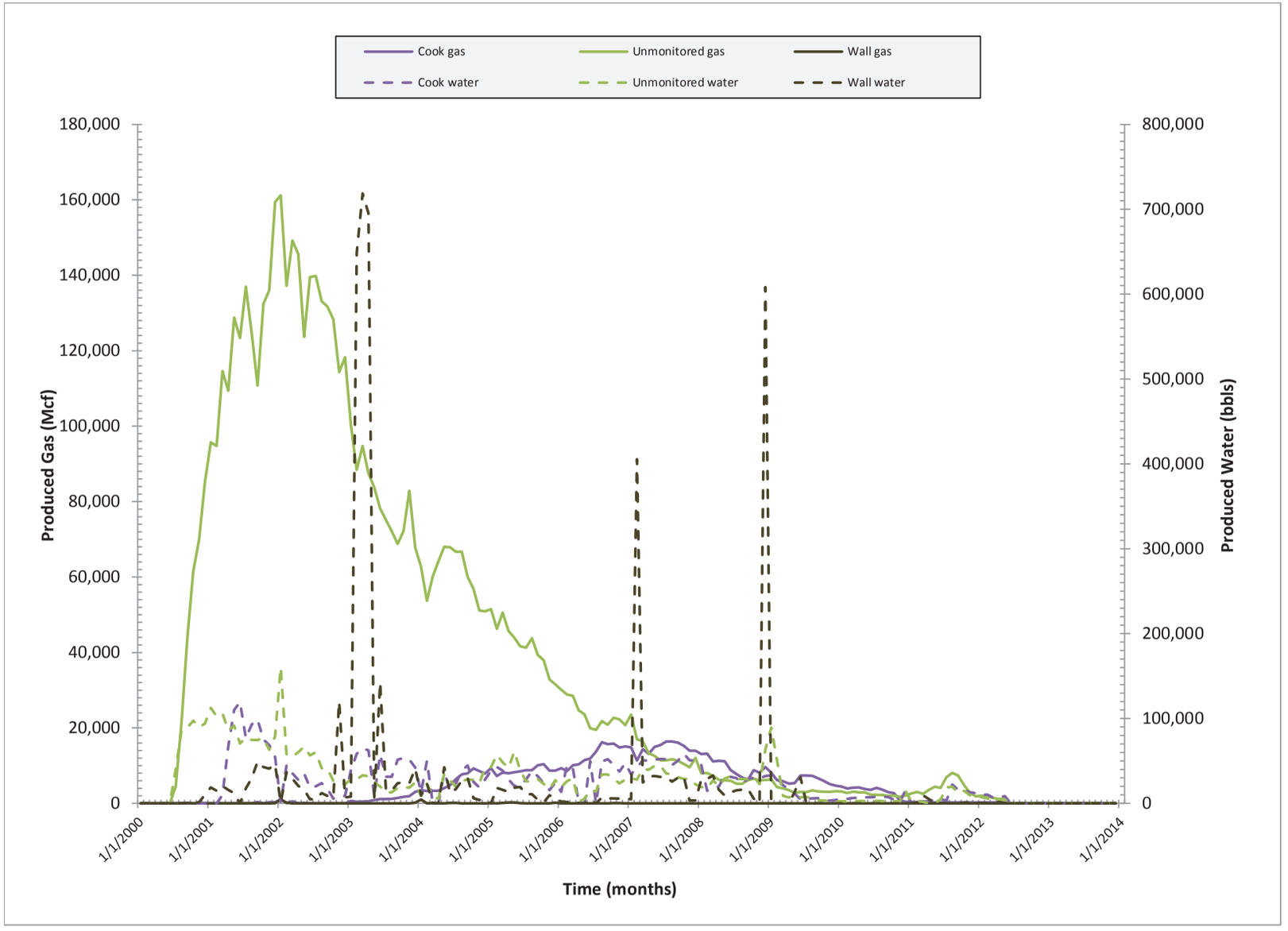

Figure A.31. Water and gas production from CBNG wells associated with the Barton monitoring well site location.

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 pressure in the Big George coal were measured during 2013 using both manual and automatic transducer and data logger equipment. Only manual measurements of groundwater levels were made during 2013 in the Wasatch sandstone. 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 2013, groundwater levels fell 40.20 feet in the Wasatch sandstone; groundwater levels have declined 227.65 feet over the POR. (Figure A.33; Table A.17). Gas pressure was not recorded in the Wasatch sandstone.

Big George Coal
Groundwater levels declined 14.15 feet during 2013. Water levels have declined 747.90 feet (Figure A.33; Table A.17) during the 2006 – 2013 monitoring period. Manual measurements show good agreement with concurrent transducer records. Gas pressures in the Big George, which have remained relatively stable over the monitoring period of 2006-2013, peaked at 0.23 psi in June 2007.

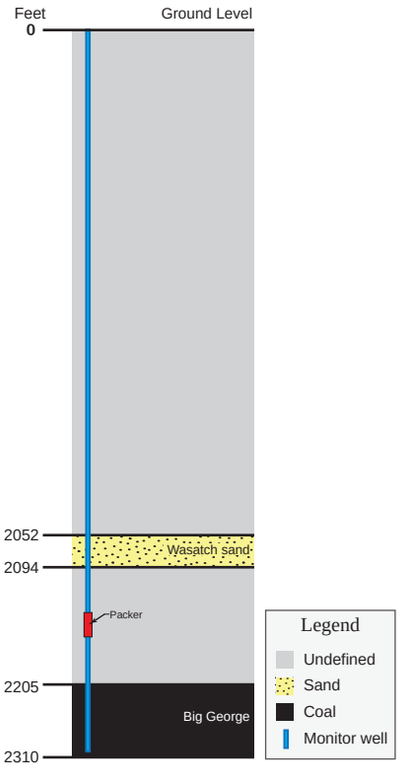

Figure A.32. Section showing relative positions of coal and sand in feet. Not to scale.

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

Monitored interval	Interval characteristics			
	Depth of interval (ft)		Interval 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, water level changes for current monitoring period, water level changes for period of record, and maximum gas pressure.

Monitored interval	DGW - Depth to groundwater (ft), water level (ft), and gas pressure (psi) data					
	Initial DGW	Max DGW [Date]	Final 2013 DGW	Water level change 2013	Net water level change	Max. gas pressure [date]
Wasatch sand	494.20	721.90 12/2/2013	721.85	-40.20	-227.65	n/a
Big George coal	499.30	1256.00 6/24/2013	1247.20	-14.15	-747.90	0.23 6/6/2007

Production Statistics

Production data were analyzed for CBNG wells within the buffer of the Bear Draw monitoring well site from 2005-2013. Cumulative production for individual CBNG wells is displayed by location on Figure A.34. CBNG and water production is monitored in the Wyodak Rider, multiple coal and unmonitored coal zones.

Water production in the Wyodak Rider coal zone declined to 50,810 bbls/month by the end of 2013 from the peak reached in May 2011 of 195,000 bbls (Figure A.35). Wyodak Rider coal zone gas production began in 2008, peaked January 2012 near 30,000 Mcf/month, and after falling under 10,000 Mcf/month has surged ending 2013 at over 16,000 Mcf/month.

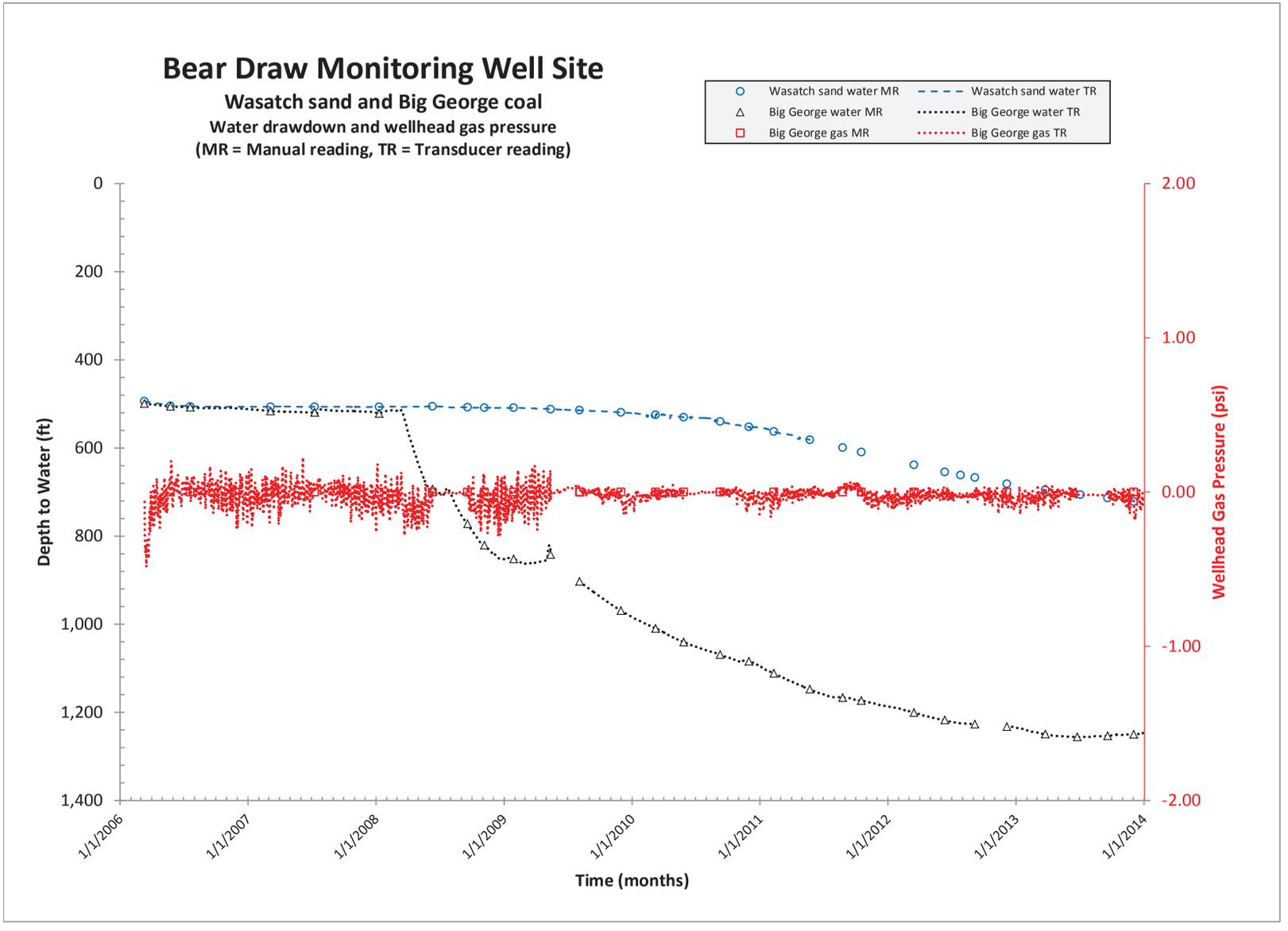

Figure A.33. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored intervals at the Bear Draw monitoring well site location.

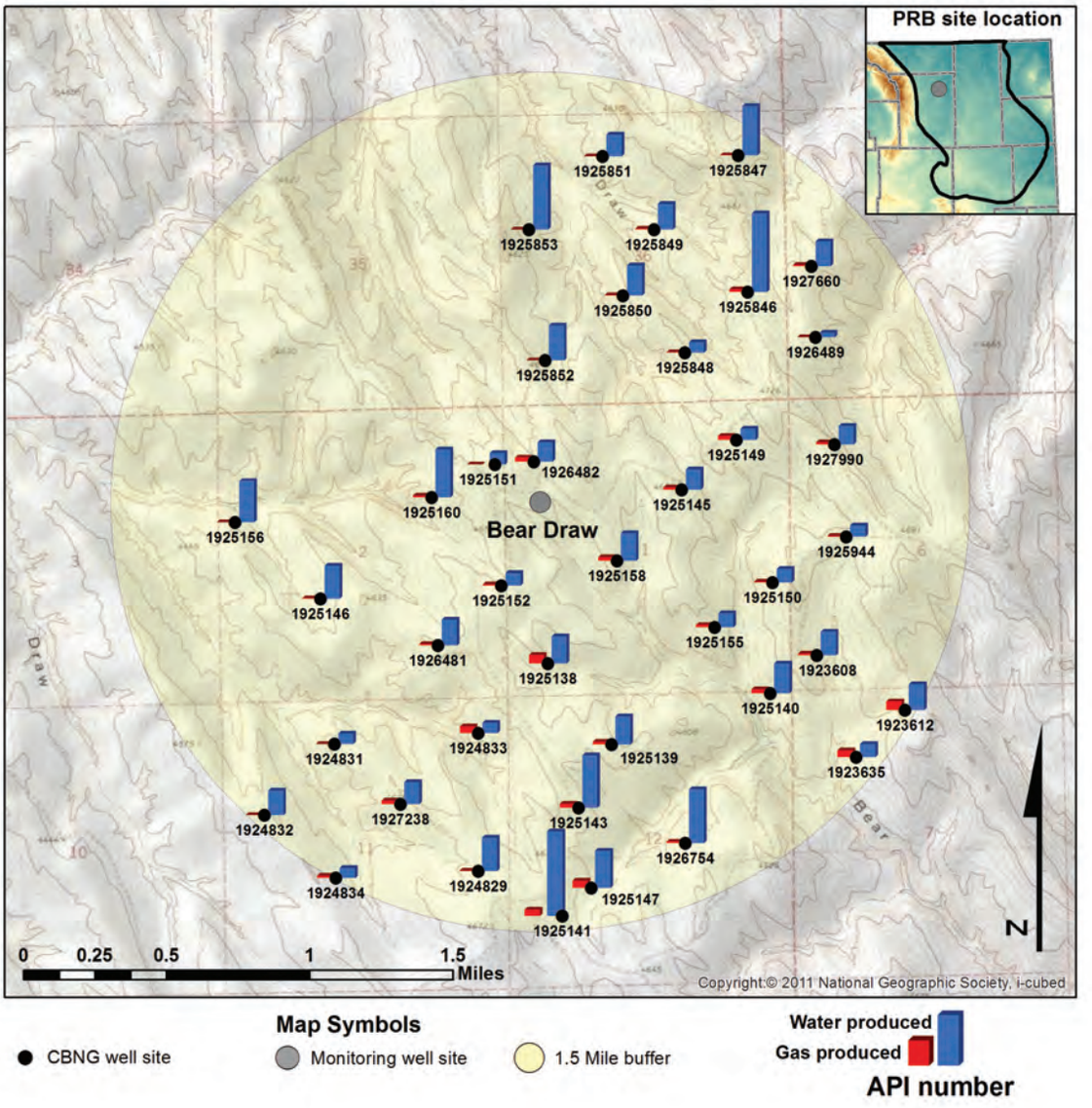

Figure A.34. Bear Draw monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

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 during 2013.

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 2013.

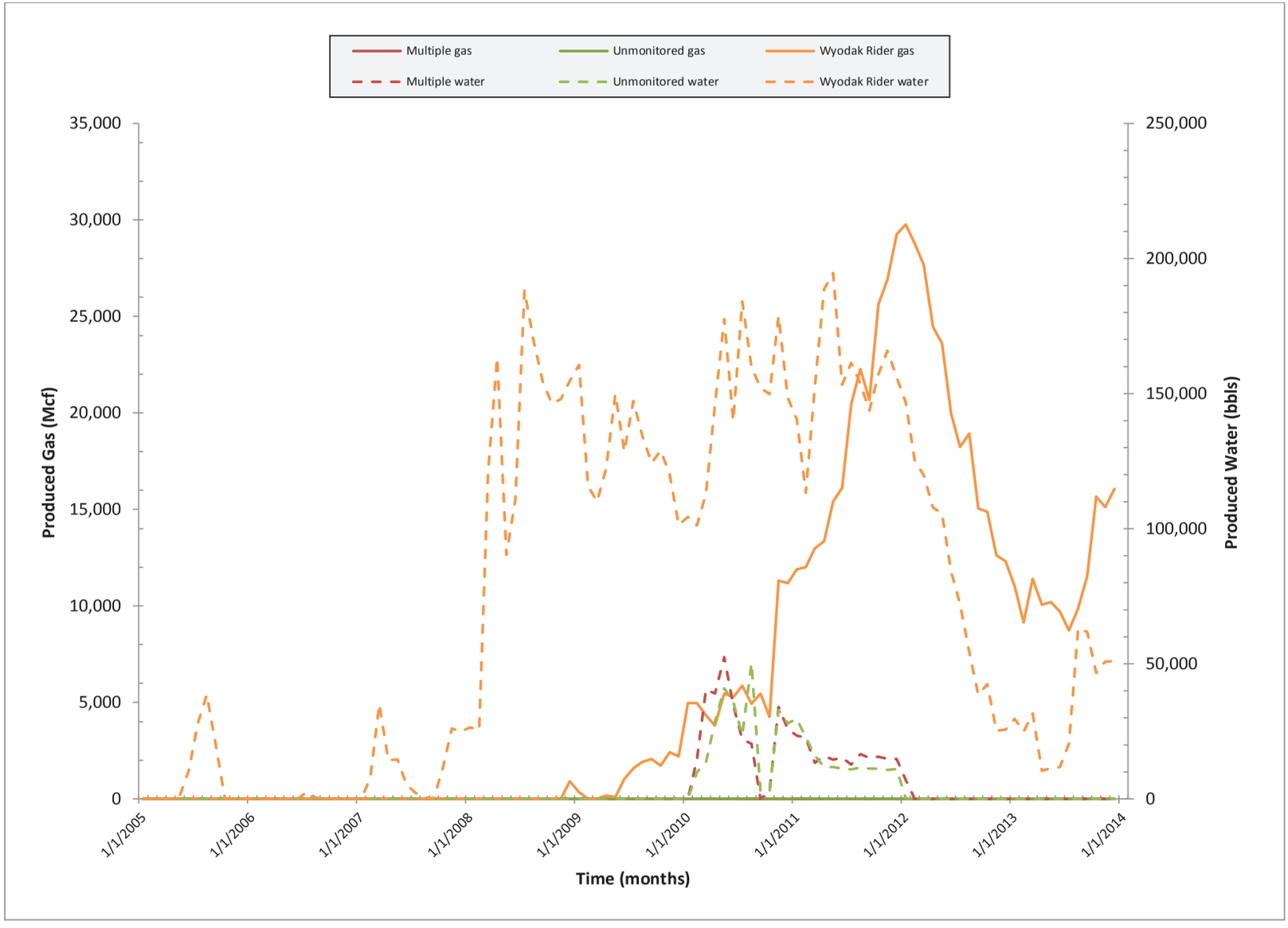

Figure A.35. Water and gas production from CBNG wells associated with the Bear Draw monitoring well site location.

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 a Wasatch sandstone and the other in the Big George coal of the Wyodak Rider coal zone (Figure A.36; Table A.18). Water levels in the Wasatch sandstone and gas pressures in the Big George coal were measured during 2013 using both manual and automatic transducer and data logger equipment. Generally, manual and transducer measurements showed good agreement with one another. However, 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 2013, groundwater levels fell 0.78 feet in the Wasatch sandstone; groundwater levels declined 4.91 feet during 2003 – 2013 POR. (Figure A.37; Table A.19). Gas pressure has not been recorded in the Wasatch sandstone.

Big George Coal

Groundwater levels declined 494.42 feet during the 2003-2008 monitoring period. The last reliable groundwater level reading was obtained on 9/18/2008. Due to high gas pressure water level measurements have not be taken since 2009. Gas pressure peaked in September 2009 at 155.0 psi (Figure A.37; Table A.19).

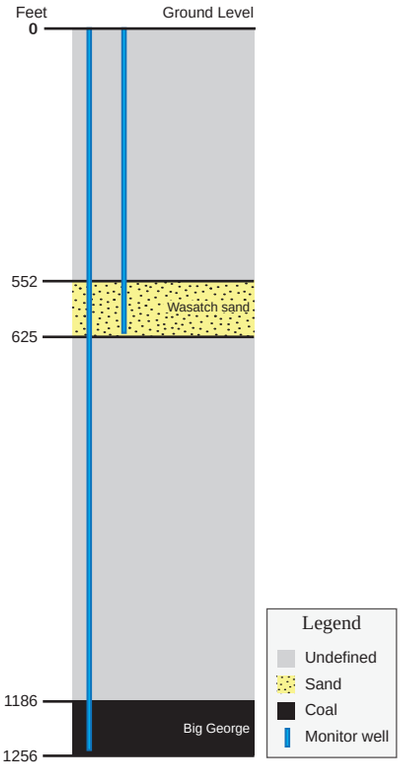

Figure A.36. Section showing relative positions of coal and sand in feet. Not to scale.

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

Monitored interval	Interval characteristics			
	Depth of interval (ft)		Interval 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, water level changes for current monitoring period, water level changes for period of record, and maximum gas pressure.

Monitored interval	DGW - Depth to groundwater (ft), water level (ft), and gas pressure (psi) data					
	Initial DGW	Max DGW [Date]	Final 2013 DGW	Water level change 2013	Net water level change	Max. gas pressure [date]
Wasatch sand	245.66	265.60 6/26/2003	250.57	-0.78	-4.91	n/a
Big George coal*	330.80	831.50 5/14/2009	n/a	n/a	-494.42	155.00 8/4/2009

*Last reliable reading 9/18/2008

Production Statistics

Production data were analyzed for CBNG wells within the buffer of the Beaver Fed monitoring well site from 2001-2013. Cumulative production for individual CBNG wells is displayed by location on Figure A.38. CBNG and water production is monitored in the Wyodak Rider and unmonitored coal zones.

Water production in the Wyodak Rider coal zone peaked at 141,699 bbls in January 2007 (Figure A.39), and has since been sporadic but high, ending 2013 near 38,000 bbls/month. Gas production levels peaked at nearly 67,000 Mcf/month in 2011 and finished 2013 at 45,700 Mcf/month.

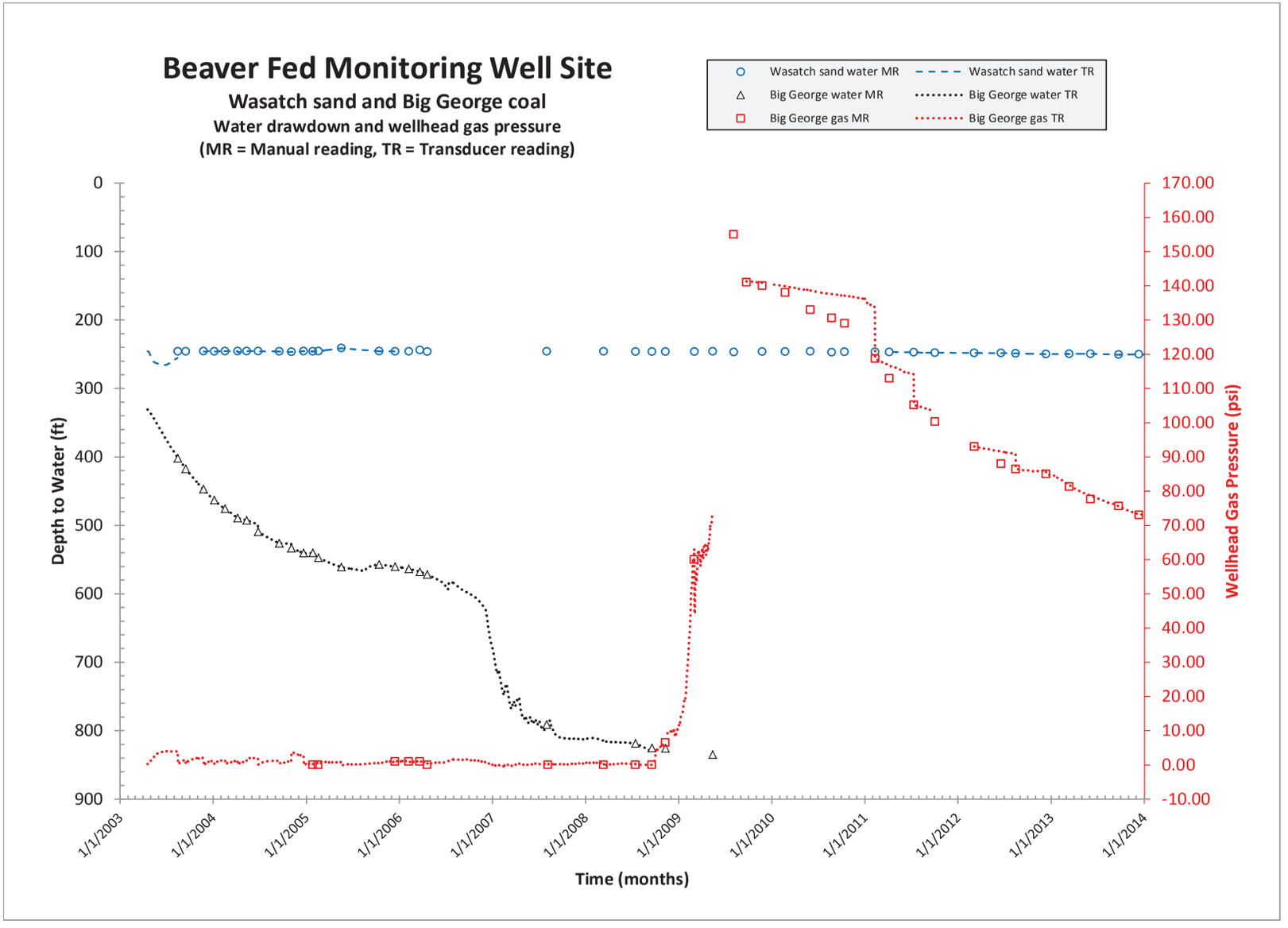

Figure A.37. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored intervals at the Beaver Fed monitoring well site location.

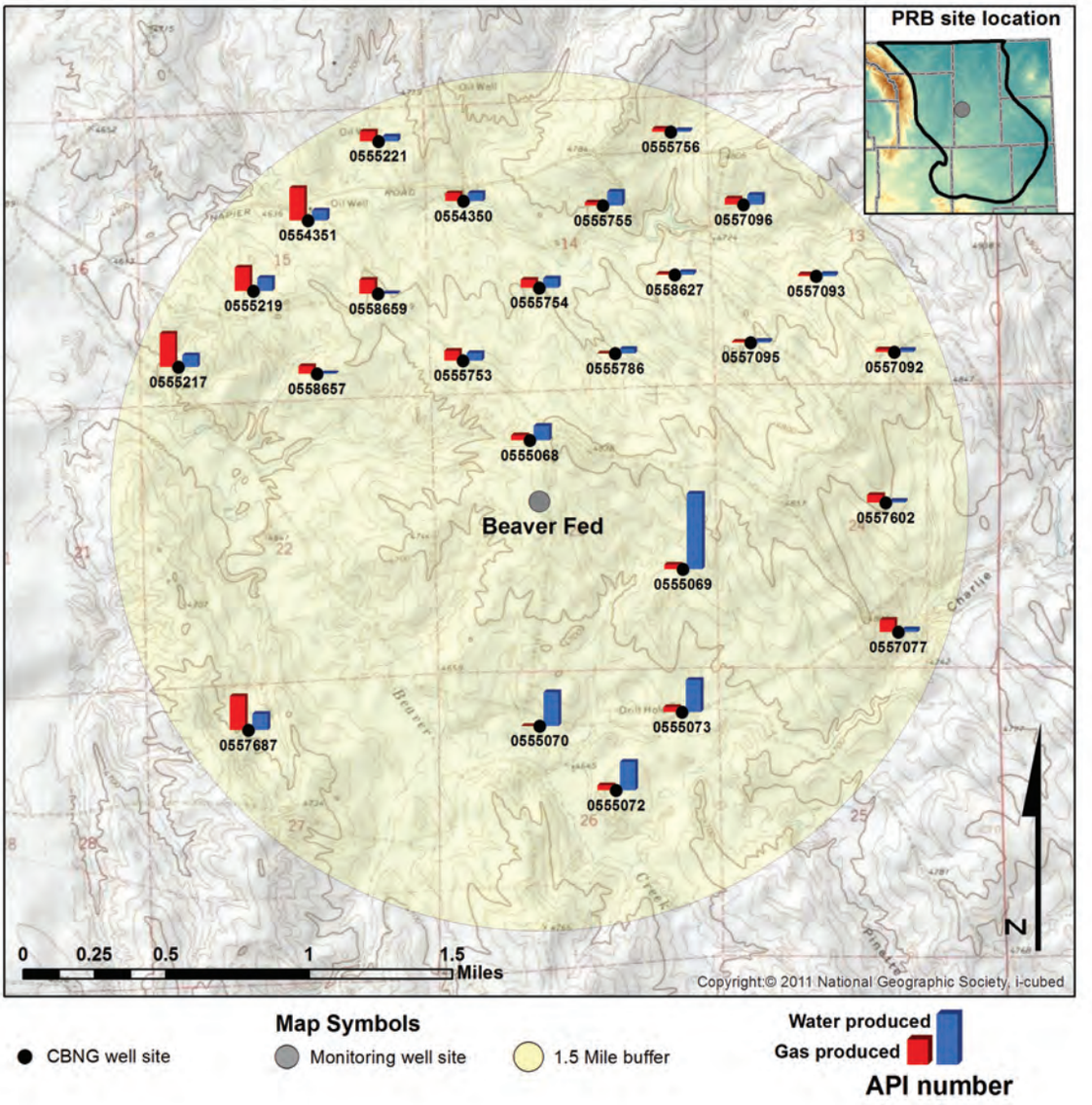

Figure A.38. Beaver Fed monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

Water production in the unmonitored coal zone wells peaked at nearly 19,000 bbls in May 2009 and declined by the end of 2013 to 298 bbls/ month (Figure A.39). Gas production has been low but is increasing slowly, reaching its maximum in December 2013 at 651 Mcf.

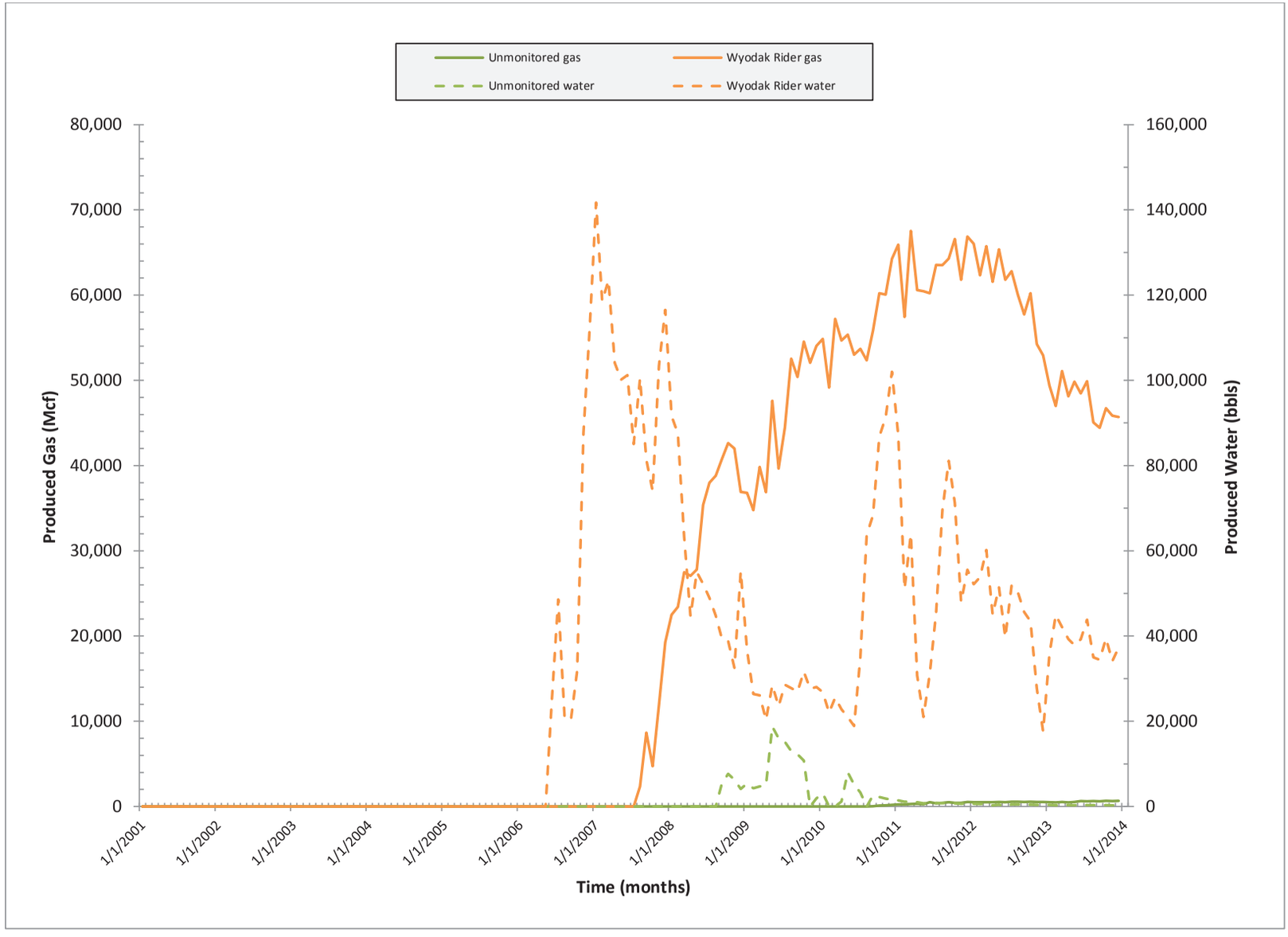

Figure A.39. Water and gas production from CBNG wells associated with the Beaver Fed monitoring well site location.

Betop Monitoring Well Site
Location: S32 T49N R75W
Date First Monitored: November 6, 1991

Drawdown Information
The Betop monitoring well site includes one well completed in a 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. Only manual measurements were made during 2013. The well has been reported to have a petroleum product in the water.

Fort Union Coal
During 2013, groundwater levels fell 31.17 feet in the Fort Union coal; water levels declined 142.53 feet over the 1991 – 2013 POR (Figure A.41; Table A.21). Gas pressure in the Fort Union coal was not recorded.

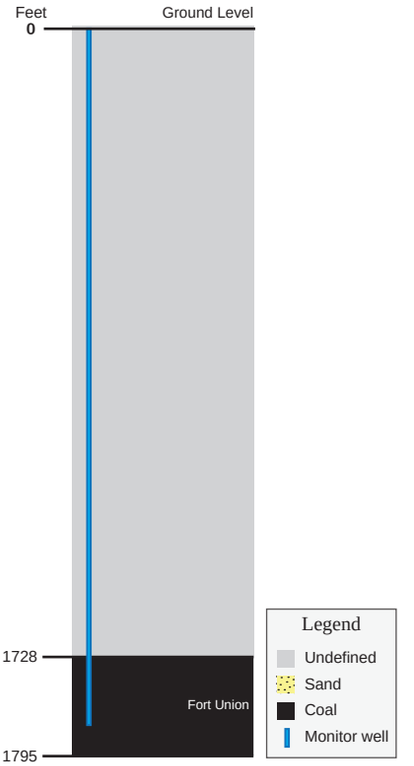

Figure A.40. Section showing relative positions of coal in feet. Not to scale.

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

Monitored interval	Interval characteristics			
	Depth ofinterval (ft)		Interval 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, water level changes for current monitoring period, water level changes for period of record, and maximum gas pressure.

Monitored interval	DGW - Depth to groundwater (ft), water level (ft), and gas pressure (psi) data					
	Initial DGW	Max DGW [Date]	Final 2013 DGW	Water level change 2013	Net water level change	Max. gas pressure [date]
Fort Union coal	179.49	322.00 12/11/2013	322.02	-31.17	-142.53	n/a

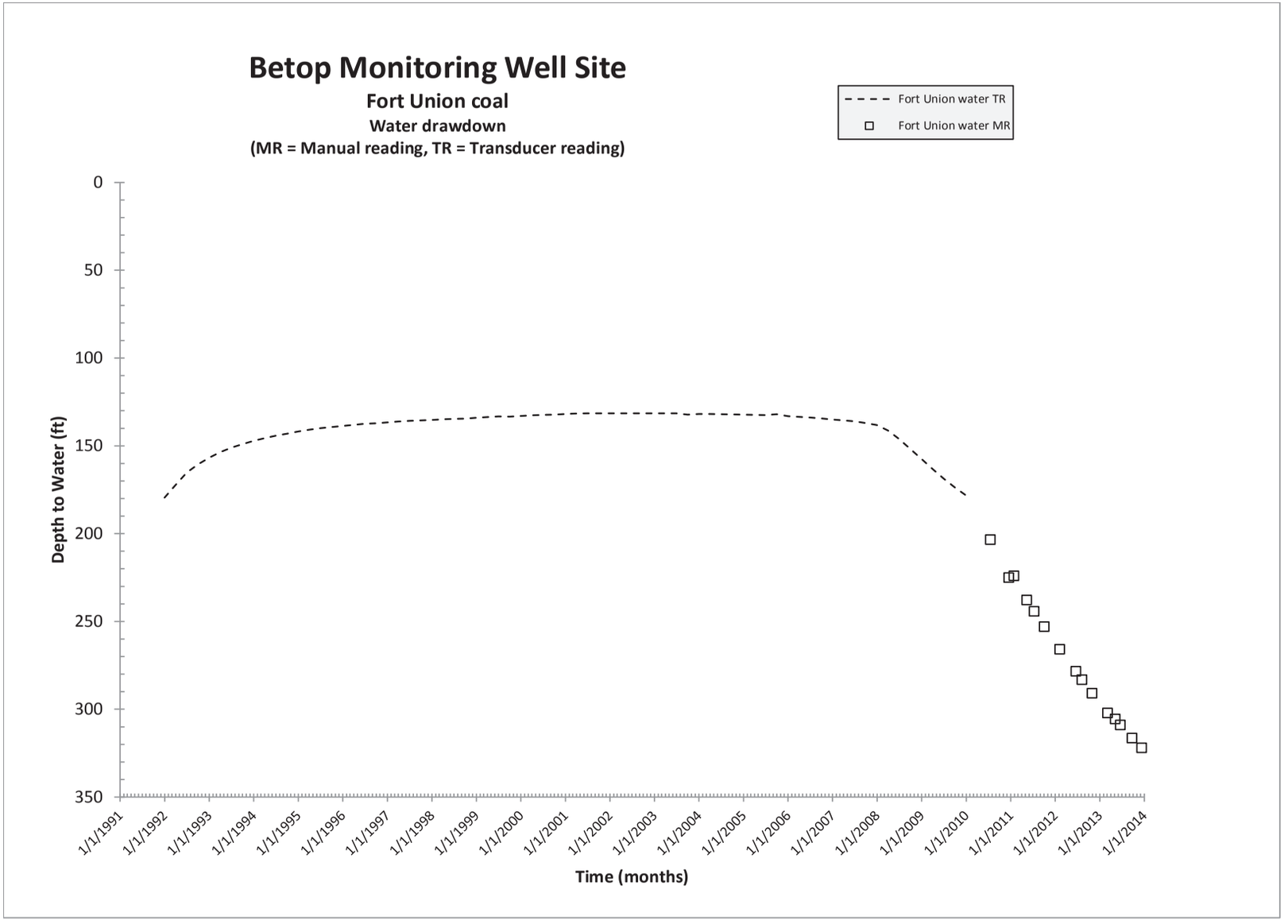

Figure A.41. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored intervals at the Betop monitoring well site location.

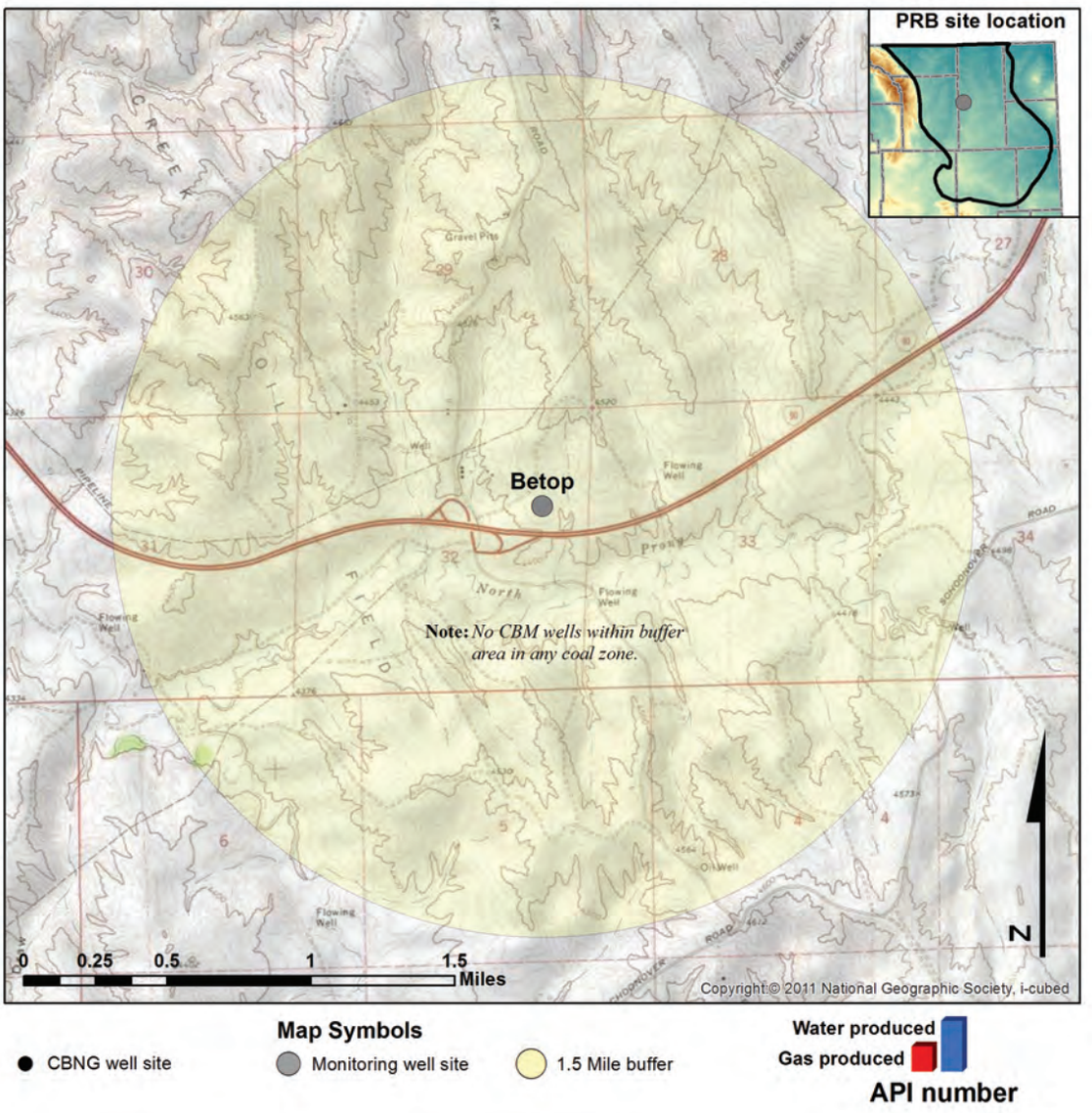

Figure A.42. Betop monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

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 from any coal zone (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 a Wasatch sandstone and the other in the Big George coal of the Wyodak Rider coal zone (Figure A.43; Table A.22). Water levels in the Wasatch sandstone and wellhead gas pressure in the Big George coal were measured during 2013 using both manual and automatic transducer and data logger equipment. Generally, the manual and transducer measurements show good agreement. However, 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. No groundwater measurements were made in the Big George coal in 2013 due to high gas pressures; the last reliable groundwater measurement was obtained in June 2010.

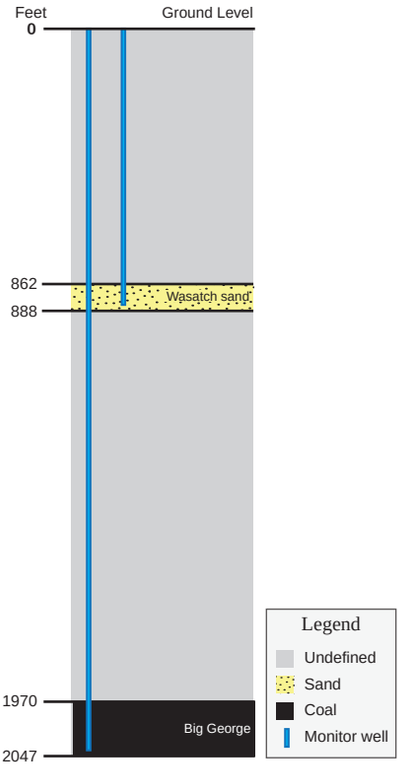

Figure A.43. Section showing relative positions of coal and sand in feet. Not to scale.

Wasatch Sandstone

During 2013, groundwater levels declined 0.35 feet in the Wasatch sandstone; groundwater levels declined 1.89 feet during the 2003 -2013 POR (Figure A.44; Table A.23). Gas pressure was not recorded in the Wasatch sandstone.

Big George Coal

No reliable groundwater measurements were obtained in the Big George coal during 2013; the last reliable groundwater measurement, obtained in September 2010, indicates that groundwater levels declined 982.76 feet over the 2003-2010 monitoring period (Figure A.44; Table A.23). Gas pressure in the Big George coal peaked at 42.06 psi in 2012. During 2013, gas pressures ranged from 10.9 to 30.8 psi.

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

Monitored interval	Interval characteristics			
	Depth of interval (ft)		Interval 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, water level changes for current monitoring period, water level changes for period of record, and maximum gas pressure.

Monitored interval	DGW - Depth to groundwater (ft), water level (ft), and gas pressure (psi) data					
	Initial DGW	Max DGW [Date]	Final 2013 DGW	Water level change 2013	Net water level change	Max. gas pressure [date]
Wasatch sand	357.30	368.00 11/20/2008	359.19	0.35	-1.89	n/a
Big George coal*	200.24	1359.00 8/22/2011	n/a	n/a	-982.76	42.08 6/22/2012

*last reliable reading 9/9/2010

Production Statistics

Production data were analyzed for CBNG wells within the buffer of the Big Cat monitoring well site from 2003-2013. Cumulative production for individual CBNG wells is displayed by location on Figure A.45. CBNG and water production are monitored in Wyodak Rider and multiple coal zone wells.

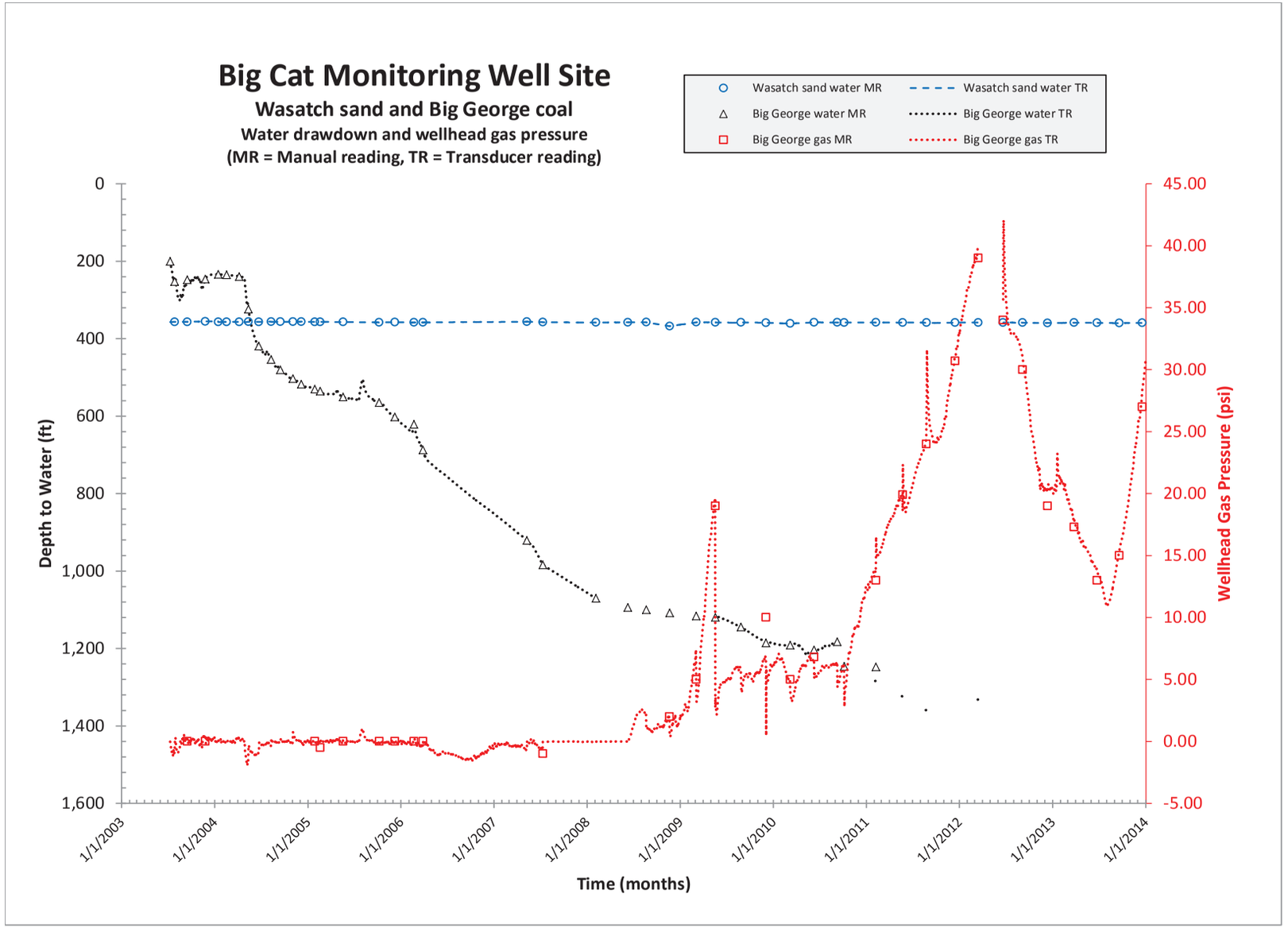

Figure A.44. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored intervals at the Big Cat monitoring well site location.

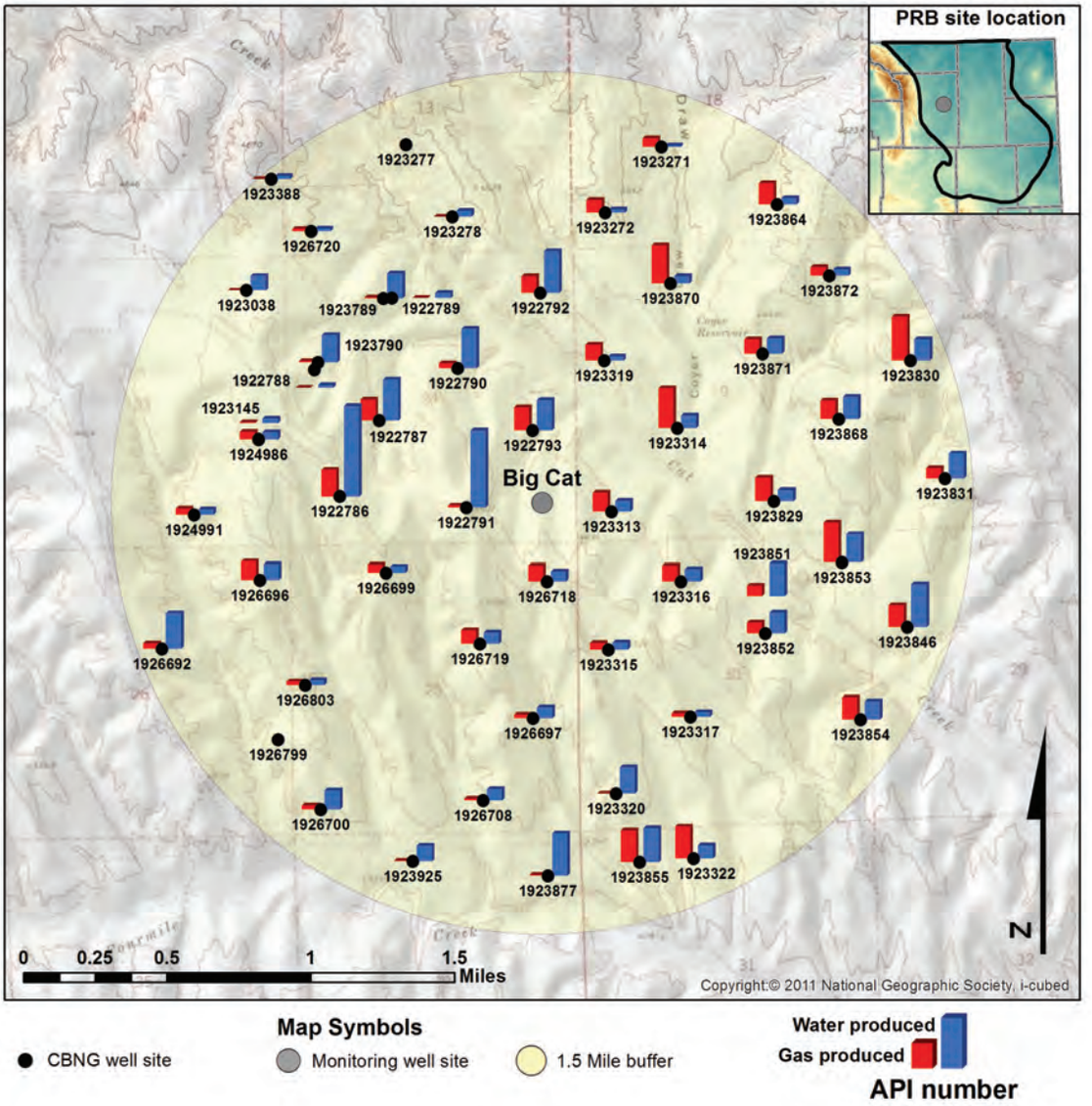

Figure A.45. Big Cat monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

Initial water production rates in the Wyodak Rider coal zonewere quite high and peaked in July 2004 at 446,647 bbls. Water production leveled off somewhat after February 2005 and declined to 42,816 bbls/month by the end of 2013 (Figure A.46). Gas production in the Wyodak Rider coal zone began in 2006 and rapidly increased during 2008-2011 to a peak production rate of 229,604 Mcf in October 2011. Gas production in December 2013 was 153,410 Mcf.

No water or gas production has been recorded in the multiple coal zone wells for the 2003-2013 monitoring period (Figure A.46).

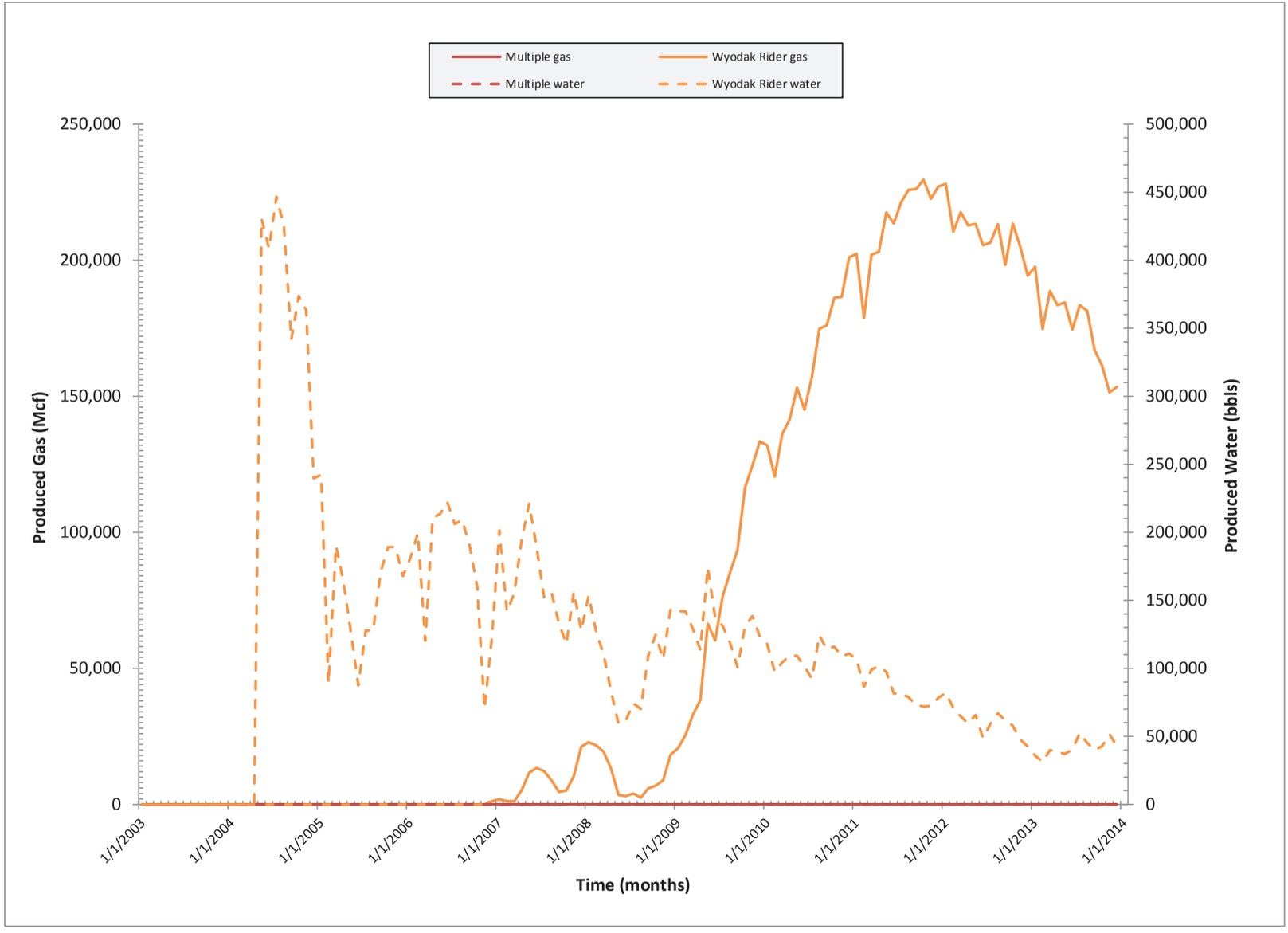

Figure A.46. Water and gas production from CBNG wells associated with the Big Cat monitoring well site location.

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 pressure 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 2013, groundwater levels declined 5.39 feet in the Big George coal; groundwater levels have declined 114.43 feet over the 2002 – 2013 monitoring period (Figure A.48; Table A.25). Gas pressure in the Big George coal peaked at 0.50 psi in 2010.

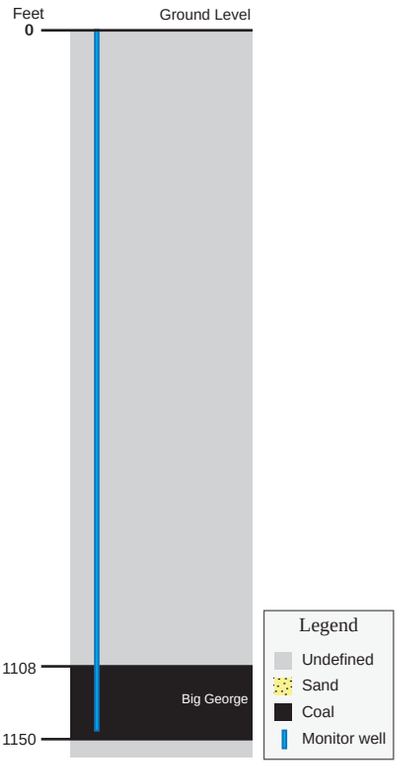

Figure A.47. Section showing relative positions of coal in feet. Not to scale.

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

Monitored interval	Interval characteristics			
	Depth of interval (ft)		Interval 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, water level changes for current monitoring period, water level changes for period of record, and maximum gas pressure.

Monitored interval	DGW - Depth to groundwater (ft), water level (ft), and gas pressure (psi) data					
	Initial DGW	Max DGW [Date]	Final 2013 DGW	Water level change 2013	Net water level change	Max. gas pressure [date]
Big George coal	489.07	603.50 12/25/2013	603.50	-5.39	-114.43	0.50 10/25/2010

Production Statistics

Production data were analyzed for CBNG wells within the buffer of the Blackbird BG monitoring well site from 2000-2013. Cumulative production for individual CBNG wells is displayed by location on Figure A.49. CBNG and water production are monitored in Wyodak Rider, unmonitored and unknown coal zone wells.

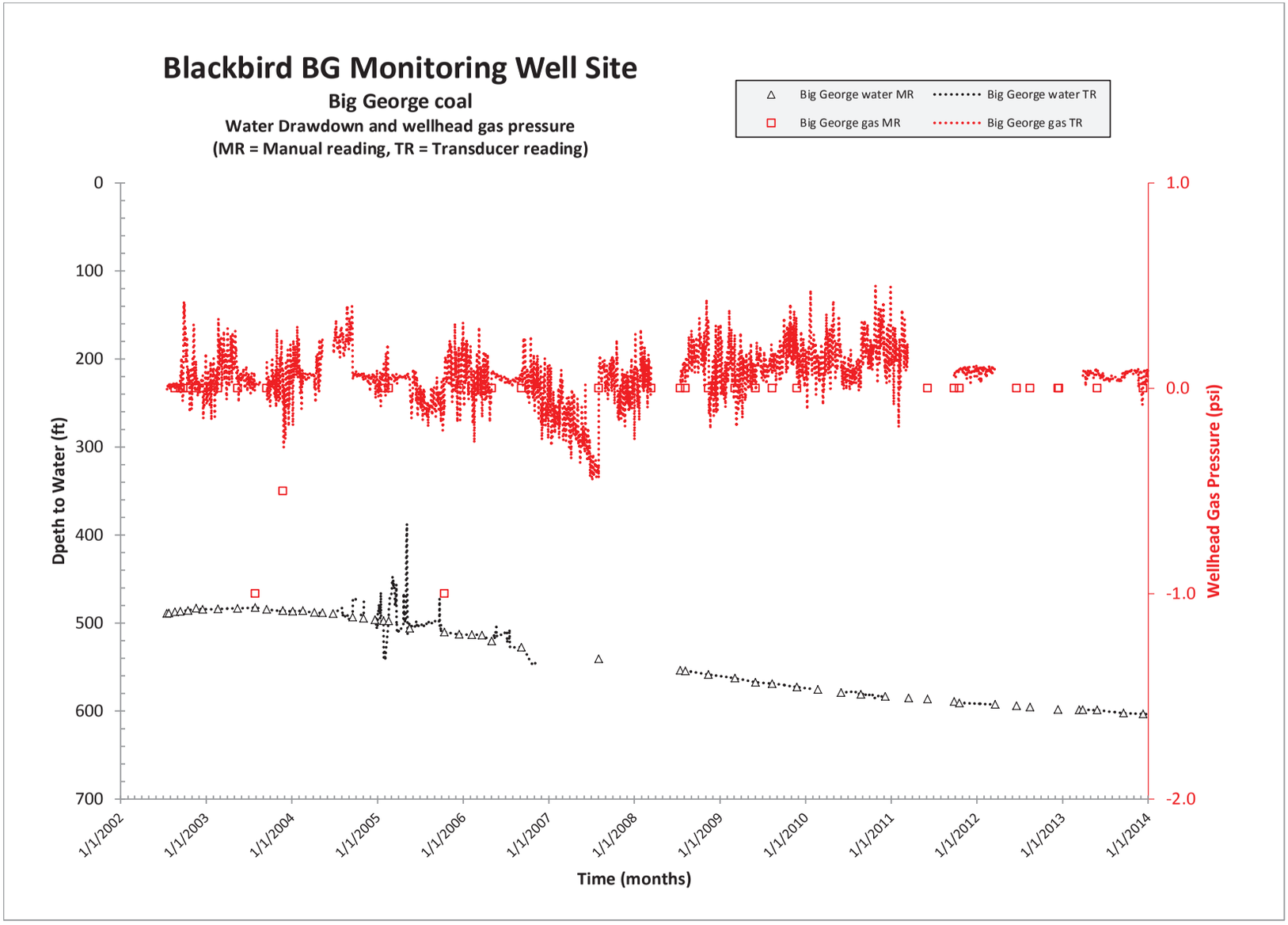

Figure A.48. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored intervals at the Blackbird BG monitoring well site location.

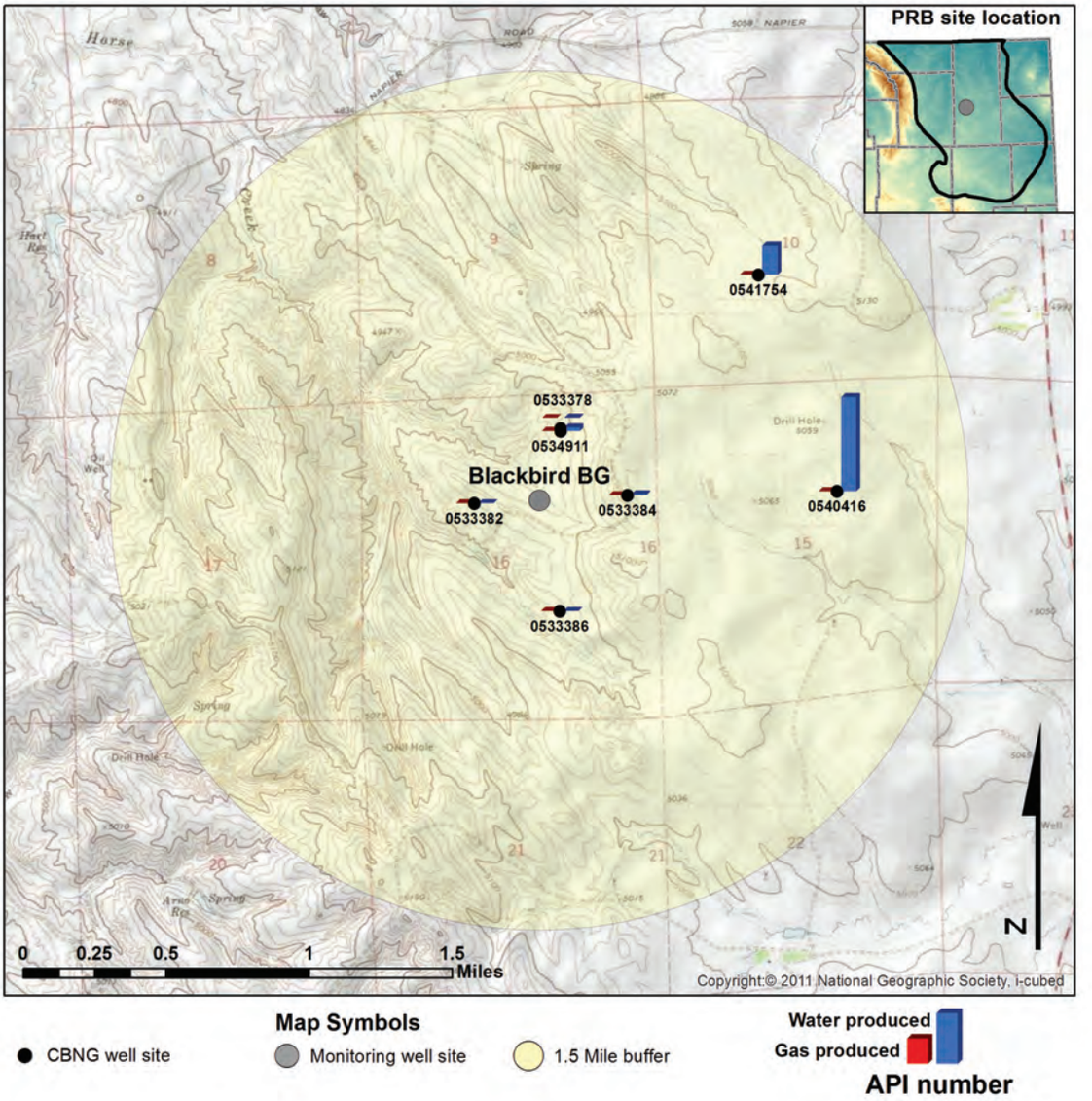

Figure A.49. Blackbird BG monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

Water production rates in the Wyodak Rider coal zone have generally been low and peaked in September 2001 at 31,859 bbls. There has been no water production recorded since April 2009. No gas was produced from the Wyodak Rider coal zone during the monitoring period of 2000-2013 (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 - 2013 (Figure A.50).

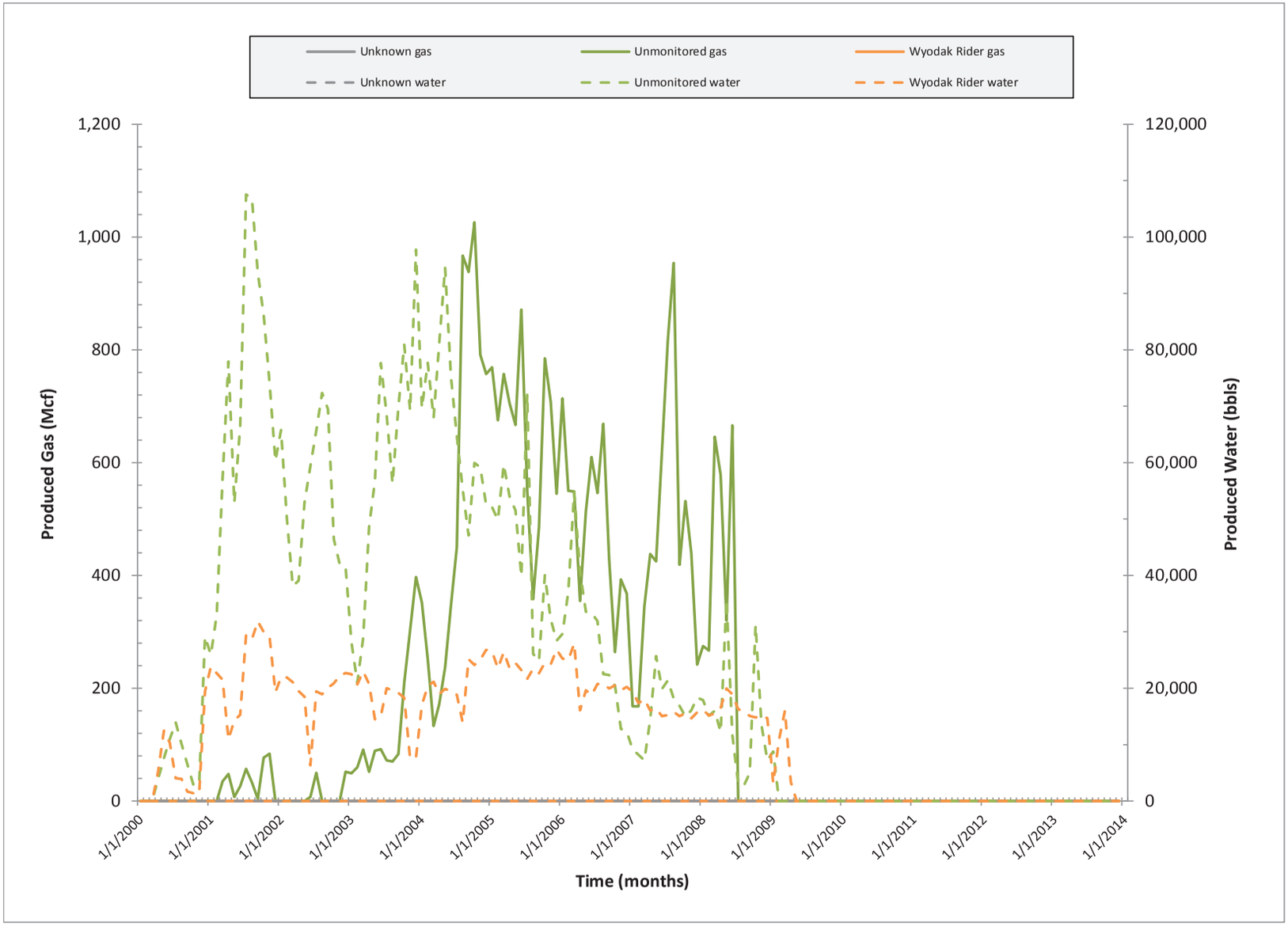

Figure A.50. Water and gas production from CBNG wells associated with the Blackbird BG monitoring well site location.

Blackbird Coleman Monitoring Well Site
Location: S5 T47N R74W
Date First Monitored: July 12, 2000

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 pressure were measured during 2003 using both manual and automatic transducer and data logger equipment. Generally, manual and transducer measurements show close agreement at this site. 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 2013, groundwater levels declined 1.08 feet in the Wasatch sandstone; groundwater levels declined 4.90 feet during the 2000 – 2013 POR (Figure A.52; Table A.27). Gas pressure was not recorded in the Wasatch sandstone.

Wyodak Coal

During 2013, groundwater levels declined 9.61 feet in the Wyodak coal; groundwater levels have declined 166.52 feet during 2000 - 2013 (Figure A.52; Table A.27). Gas pressure in the Wyodak coal peaked at 0.6 psi in 2010.

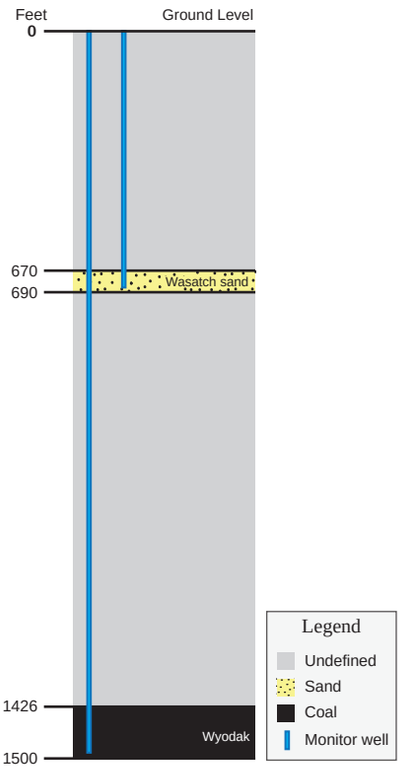

Figure A.51. Section showing relative positions of coal and sand in feet. Not to scale.

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

Monitored interval	Interval characteristics			
	Depth of interval (ft)		Interval 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, water level changes for current monitoring period, water level changes for period of record, and maximum gas pressure.

Monitored interval	DGW - Depth to groundwater (ft), water level (ft), and gas pressure (psi) data					
	Initial DGW	Max DGW [Date]	Final 2013 DGW	Water level change 2013	Net water level change	Max. gas pressure [date]
Wasatch sand	250.88	255.90 9/11/2013	255.78	-1.08	-4.90	n/a
Wyodak coal	370.88	537.50 12/27/2013	537.40	-9.61	-166.52	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 2000-2013. 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.

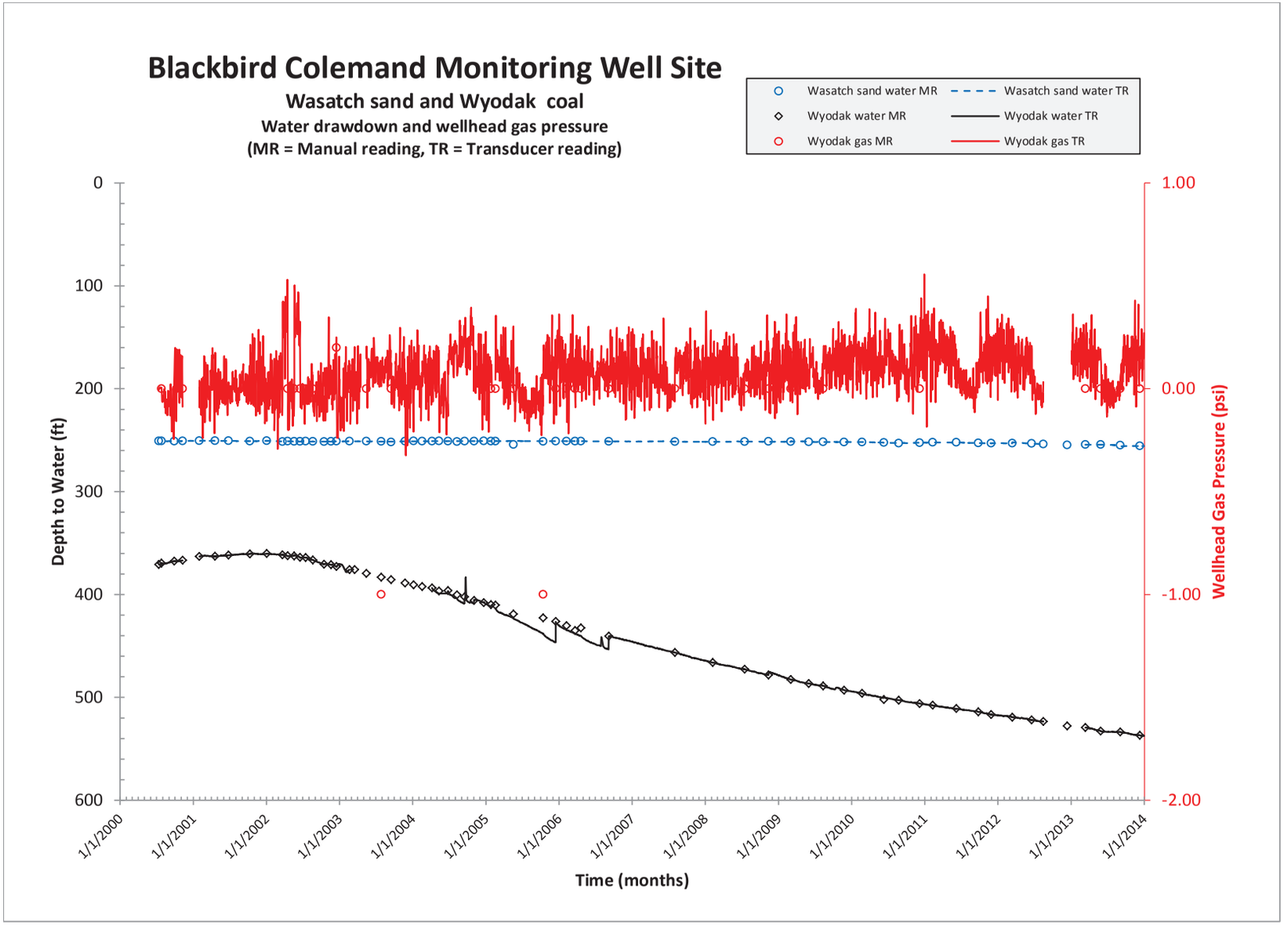

Figure A.52. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored intervals at the Blackbird Coleman monitoring well site location.

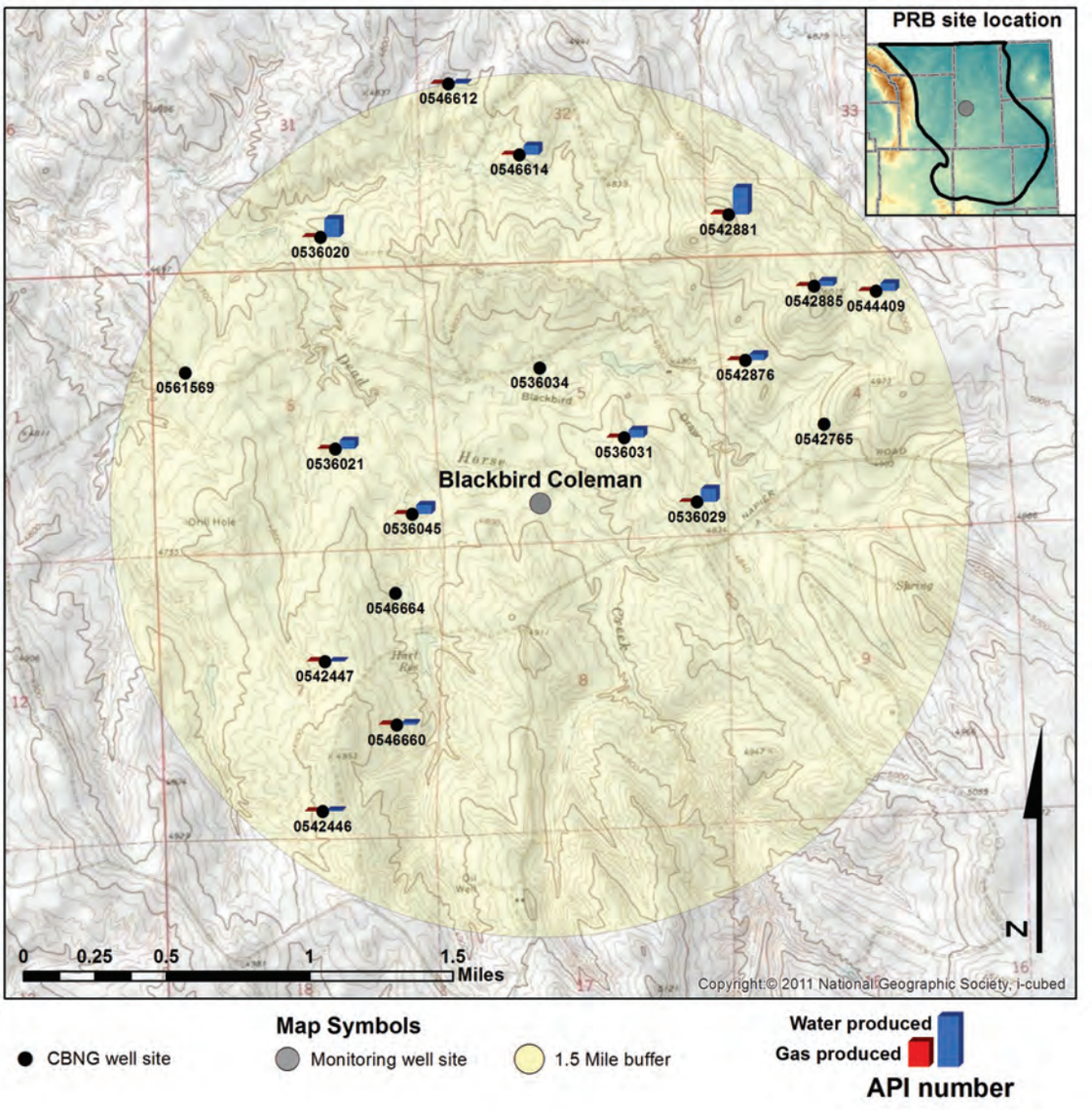

Figure A.53. Blackbird Coleman monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

Water production in the Upper Wyodak coal zone peaked in July 2004 at 180,049 bbls. Water production during 2013 has not exceeded 1,500 bbls/month. Gas production in the Upper Wyodak coal zone increased steadily from 364 Mcf in January 2013 to 1081 Mcf by December 2013 (Figure A.54).

Water production in unmonitored coal zones peaked in November 2008 at 13,699 bbls (Figure A.54). Gas production began in 2008, rose rapidly, has steadily increased, and 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 2000-2013 (Figure A.54).

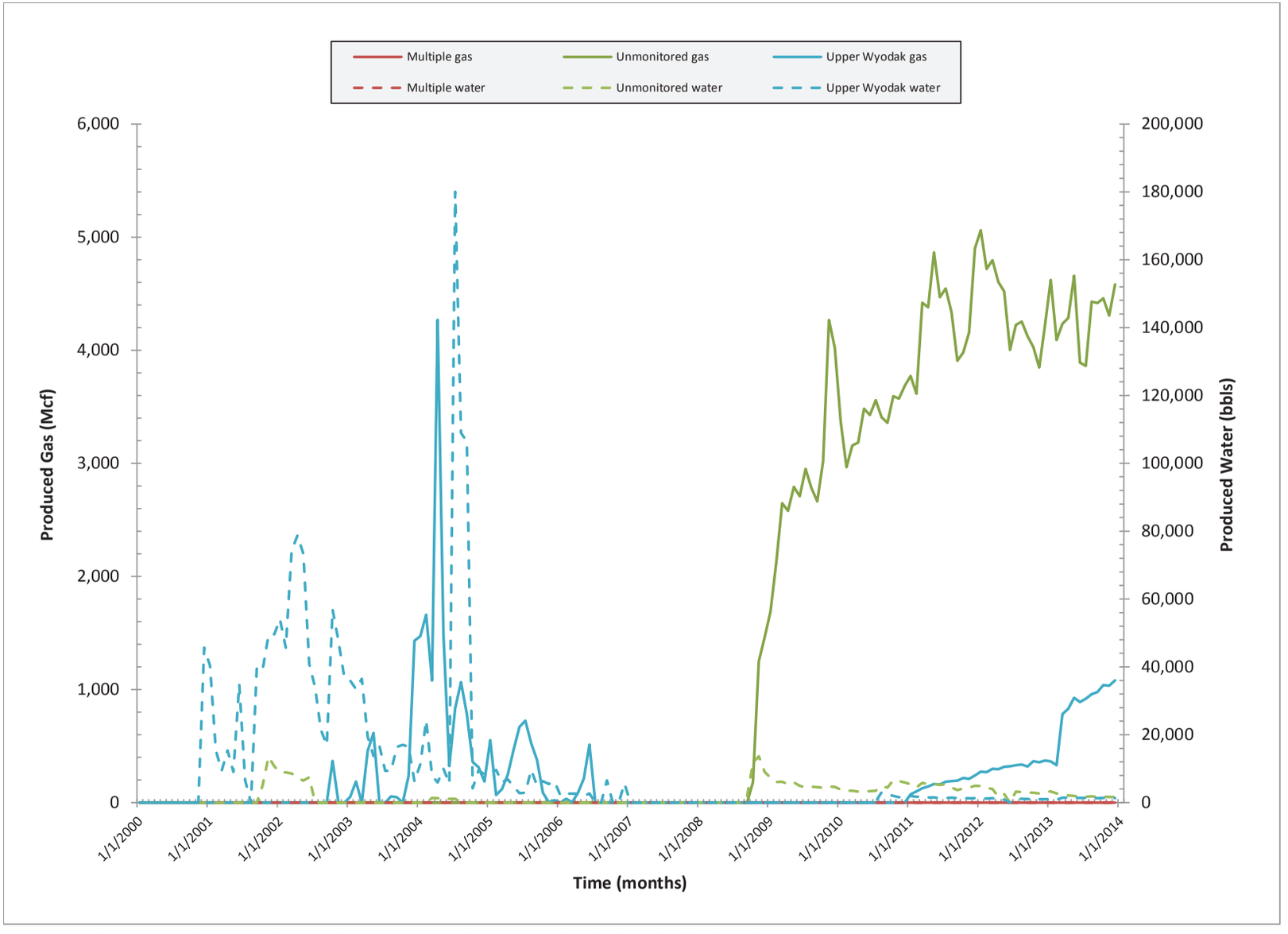

Figure A.54. Water and gas production from CBNG wells associated with the Blackbird Coleman monitoring well site location.

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 a 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 2013, groundwater levels declined 7.20 feet in the Wasatch sandstone; groundwater levels declined 41.82 feet over the 2008 – 2013 monitoring period (Figure A.56; Table A.29). Manual measurements, made in the Wasatch sand over the monitoring period of 2008-2013, indicate that gas pressure remained relatively stable over this period peaking at 2.0 psi in 2013.

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

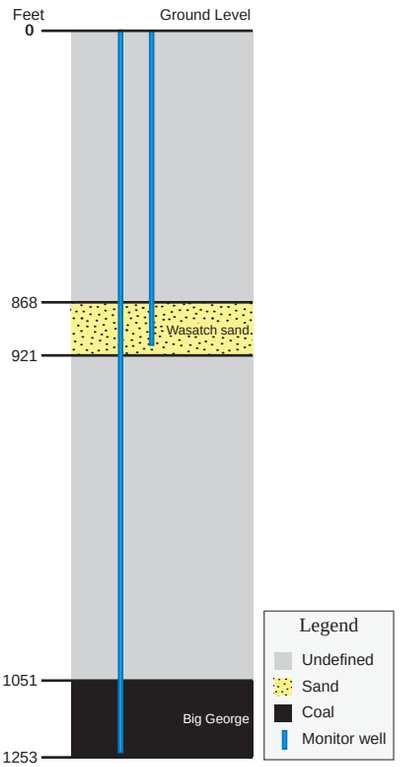

Figure A.55. Section showing relative positions of coals and sands in feet. Not to scale.

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

Monitored interval	Interval characteristics			
	Depth of interval (ft)		Interval 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, water level changes for current monitoring period, water level changes for period of record, and maximum gas pressure.

Monitored interval	DGW - Depth to groundwater (ft), water level (ft), and gas pressure (psi) data					
	Initial DGW	Max DGW [Date]	Final 2013 DGW	Water level change 2013	Net water level change	Max. gas pressure [date]
Wasatch sand	182.55	224.40 12/17/2013	224.37	-7.20	-41.82	2.00 6/20/2013
Big George coal*	n/a	n/a	n/a	n/a	n/a	n/a

*Well returned to operator

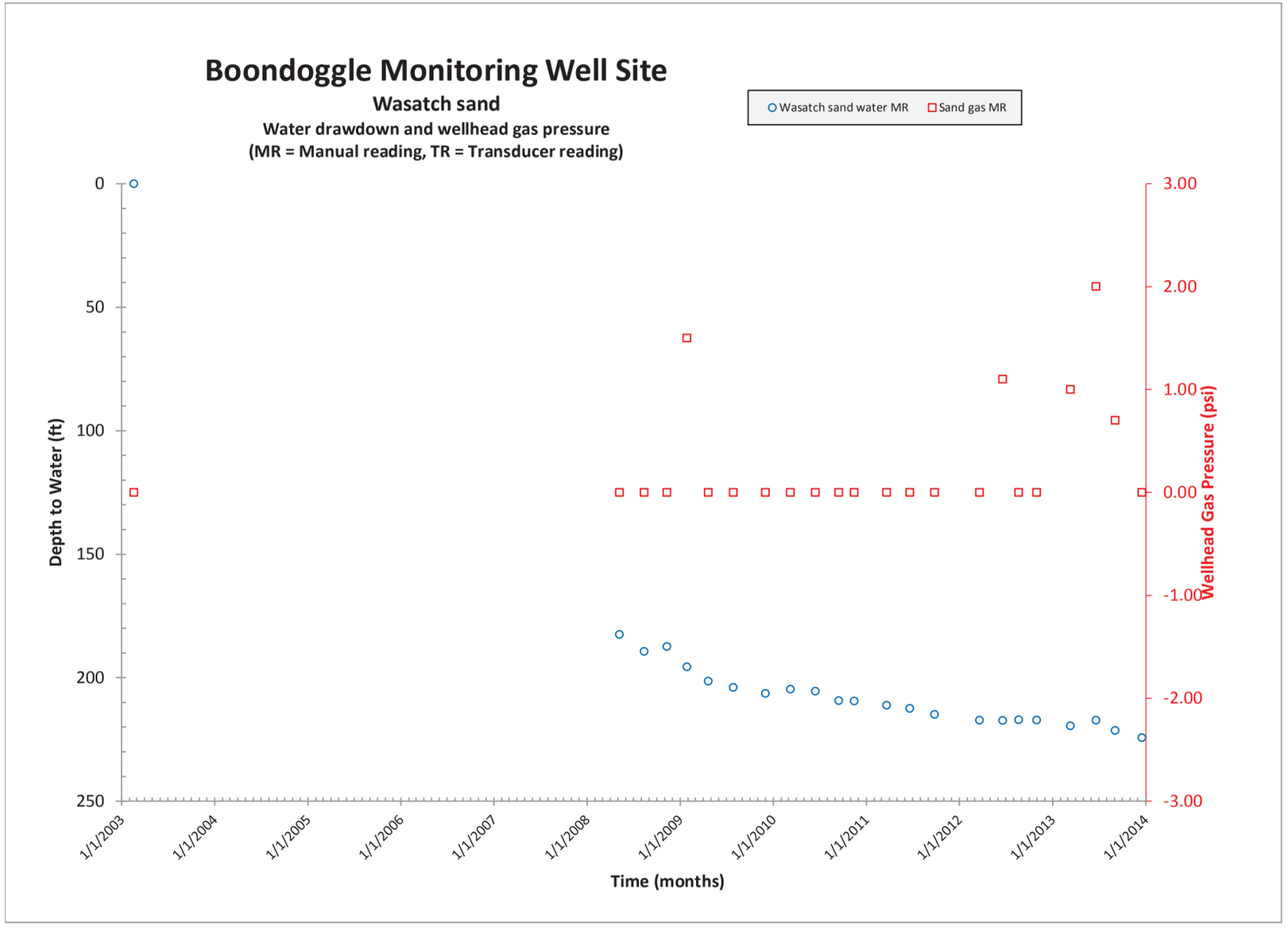

Figure A.56. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored intervals at the Boondoggle monitoring well site location.

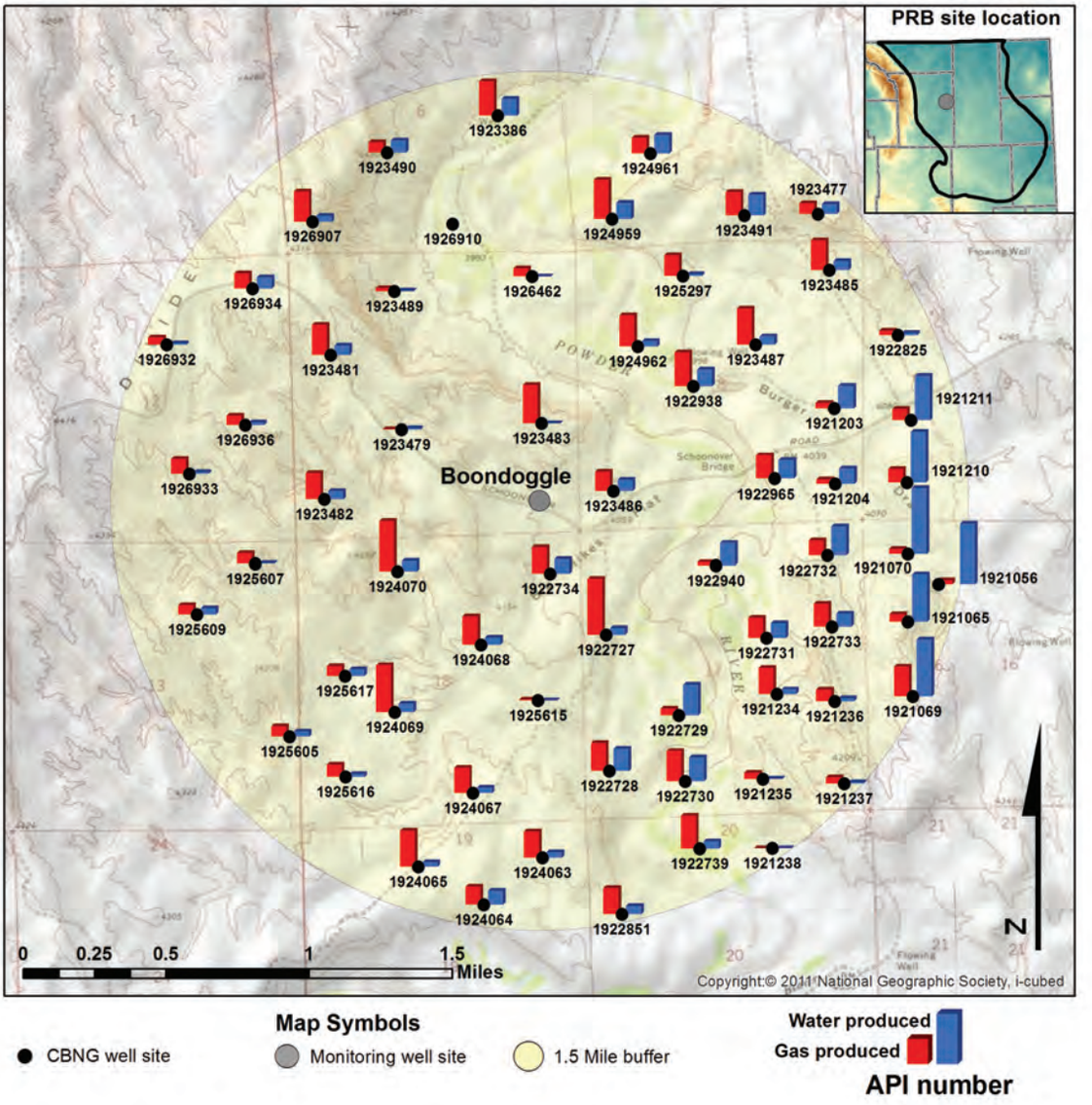

Figure A.57. Boondoggle monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

Production Statistics

Production data were analyzed for CBNG wells within the buffer of the Boondoggle monitoring well site from 1999-2013. Cumulative production for individual CBNG wells is displayed by location on Figure A.57. CBNG and water production are monitored in the Wyodak Rider coal zone wells only.

Water production in the Wyodak Rider peaked in August 2005 at 805,799 bbls then gradually declined to 22,235 bbls in December 2013 (Figure A.58). Gas production peaked at over 1.1 million Mcf in May 2007 and has declined to less than 107,000 Mcf/month since then.

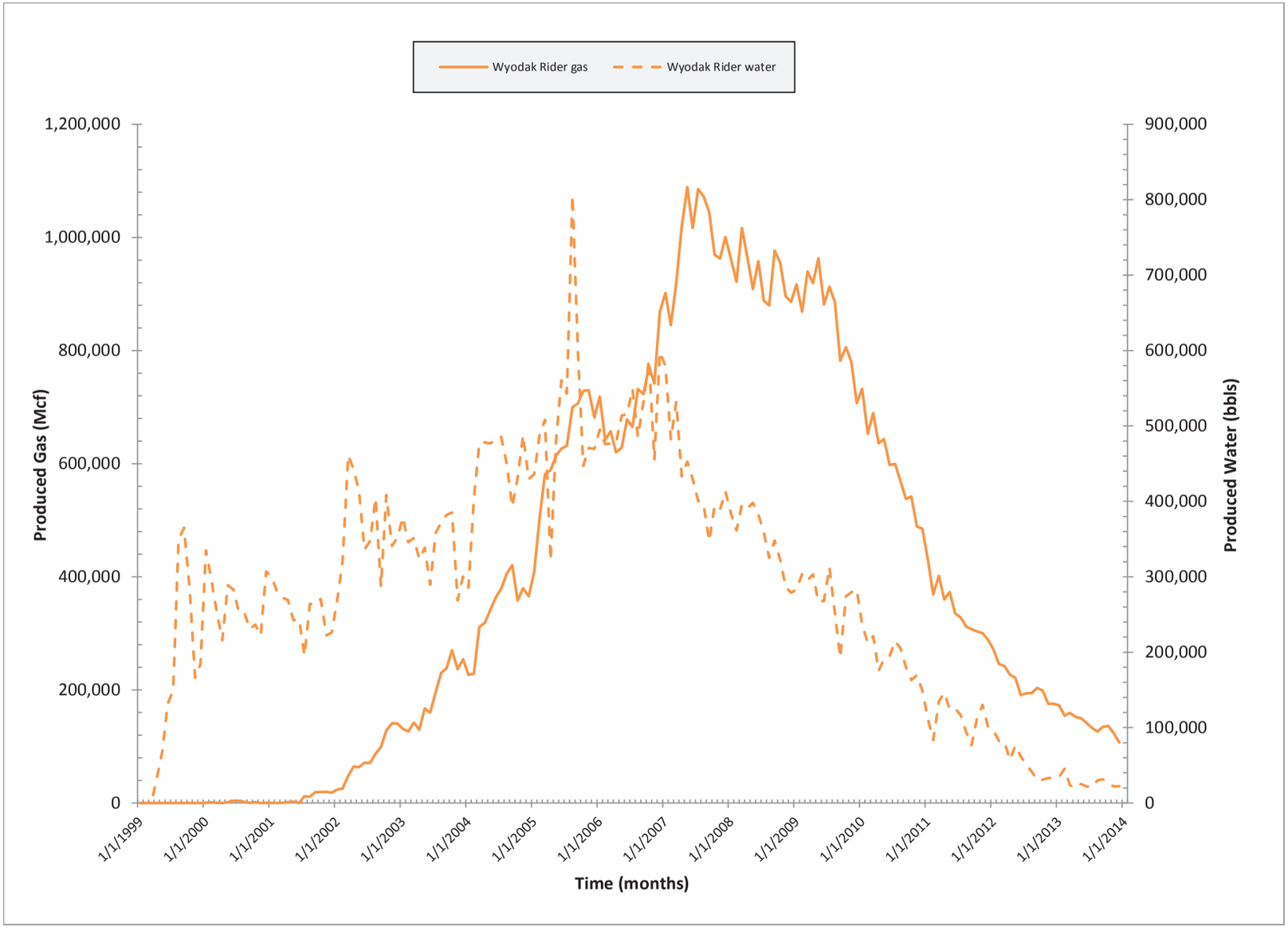

Figure A.58. Water and gas production from CBNG wells associated with the Boondoggle monitoring well site location.

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 in Wasatch sandstones and one is completed in the Wyodak coal of the Upper Wyodak coal zone (Figure A.59; Table A.30). Water levels and wellhead gas pressure were not measured in the Wyodak coal zone well during 2013.

Wasatch Sandstones
During 2013, the four monitored sandstone layers exhibited groundwater level changes that ranged from a rise of 4.68 feet to a decline of 0.03 feet. In contrast, over the monitoring period of 1998-2013, groundwater level changes ranged from a rise of 0.44 feet to a decline of 6.11 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 2013. However, during the 1998 -2005 monitoring period, groundwater levels declined 288.65 feet in the Wyodak coal. (Figure A.61; Table A.31). Measured gas pressure in the Wyodak coal remained relatively stable over the monitoring period of 1998-2005 with the exception of a peak measurement of 40.0 psi in August 2002.

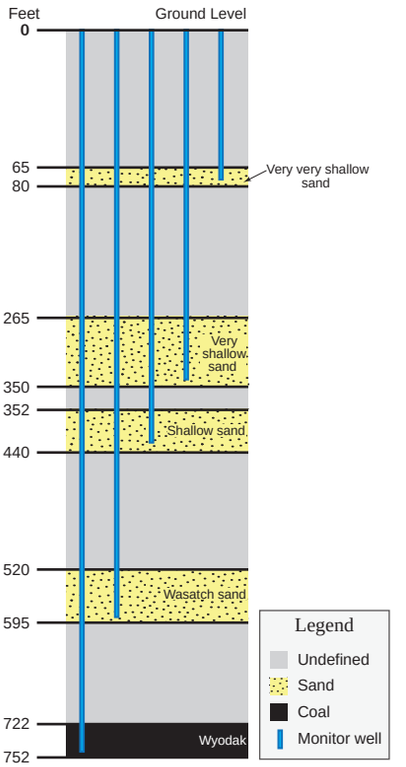

Figure A.59. Section showing relative positions of coal and sands in feet. Not to scale.

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

Monitored interval	Interval characteristics			
	Depth of interval (ft)		Interval 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, water level changes for current monitoring period, water level changes for period of record, and maximum gas pressure.

Monitored interval	DGW - Depth to groundwater (ft), water level (ft), and gas pressure (psi) data					
	Initial DGW	Max DGW [Date]	Final 2013 DGW	Water level change 2013	Net water level change	Max. gas pressure [date]
Very very shallow sand	60.17	71.98 3/30/2005	61.62	-0.03	-1.45	n/a
Very shallow sand	256.54	286.18 12/21/2005	256.10	0.20	0.44	n/a
Shallow sand	301.01	318.34 5/31/2012	302.25	1.83	-1.24	n/a
Wasatch sand	334.57	359.40 5/31/2012	340.68	4.68	-6.11	n/a
Wyodak coal*	419.85	719.90 10/21/2003	n/a	n/a	-288.65	40.00 8/23/2002

*Monitoring ceased 1/29/2005

Production Statistics

Production data were analyzed for CBNG wells within the buffer of the Bowers monitoring well site from 1997-2013. 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 coal zone peaked in October 2003 at 420,200 bbls. Gas production in the Upper Wyodak peaked at 193,032 Mcf in January 2004. Low and declining amounts (< 21,000 Mcf/month) of gas have been produced from the Upper Wyodak since December 2009.

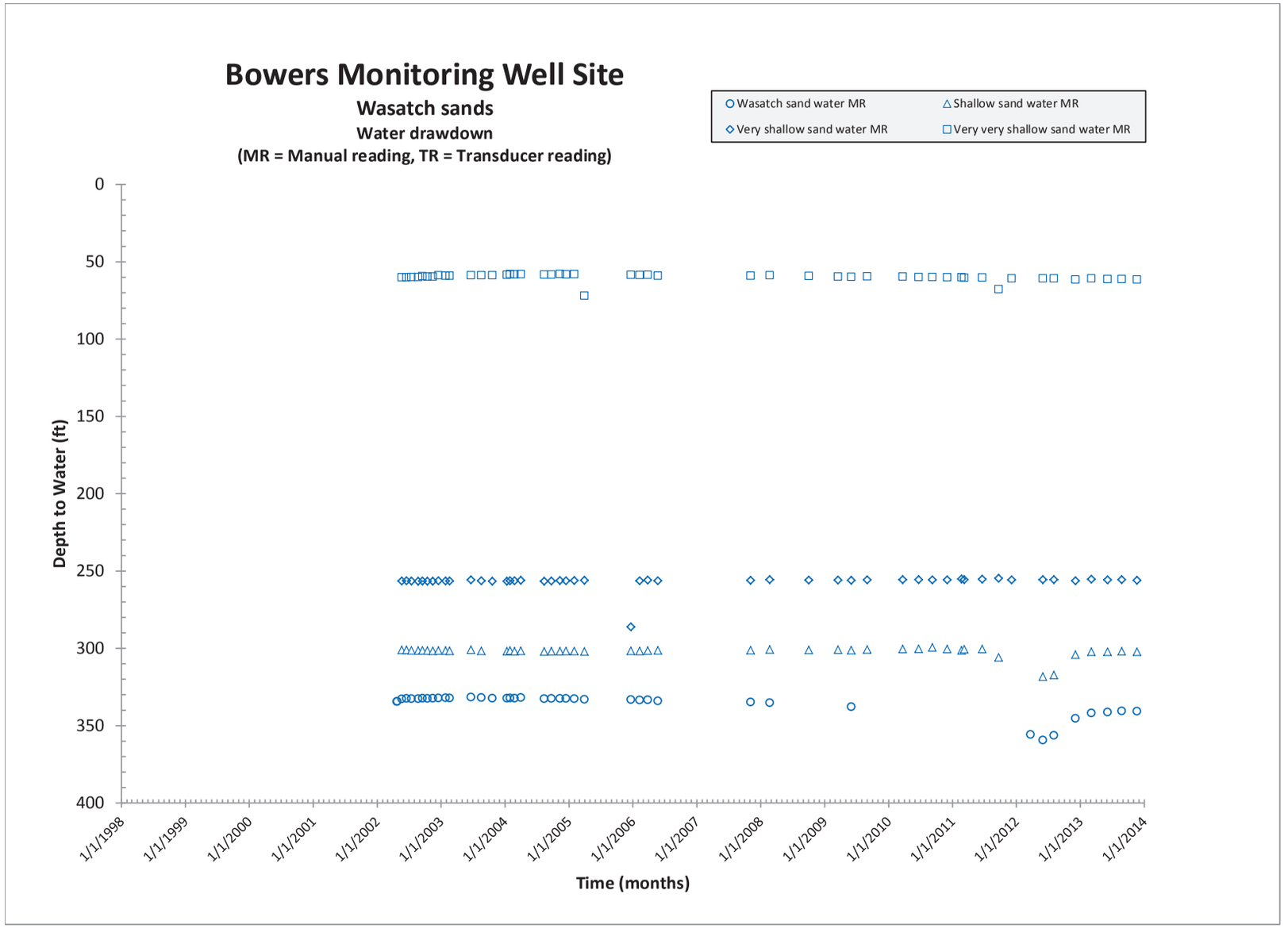

Figure A.60. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored intervals at the Bowers monitoring well site location.

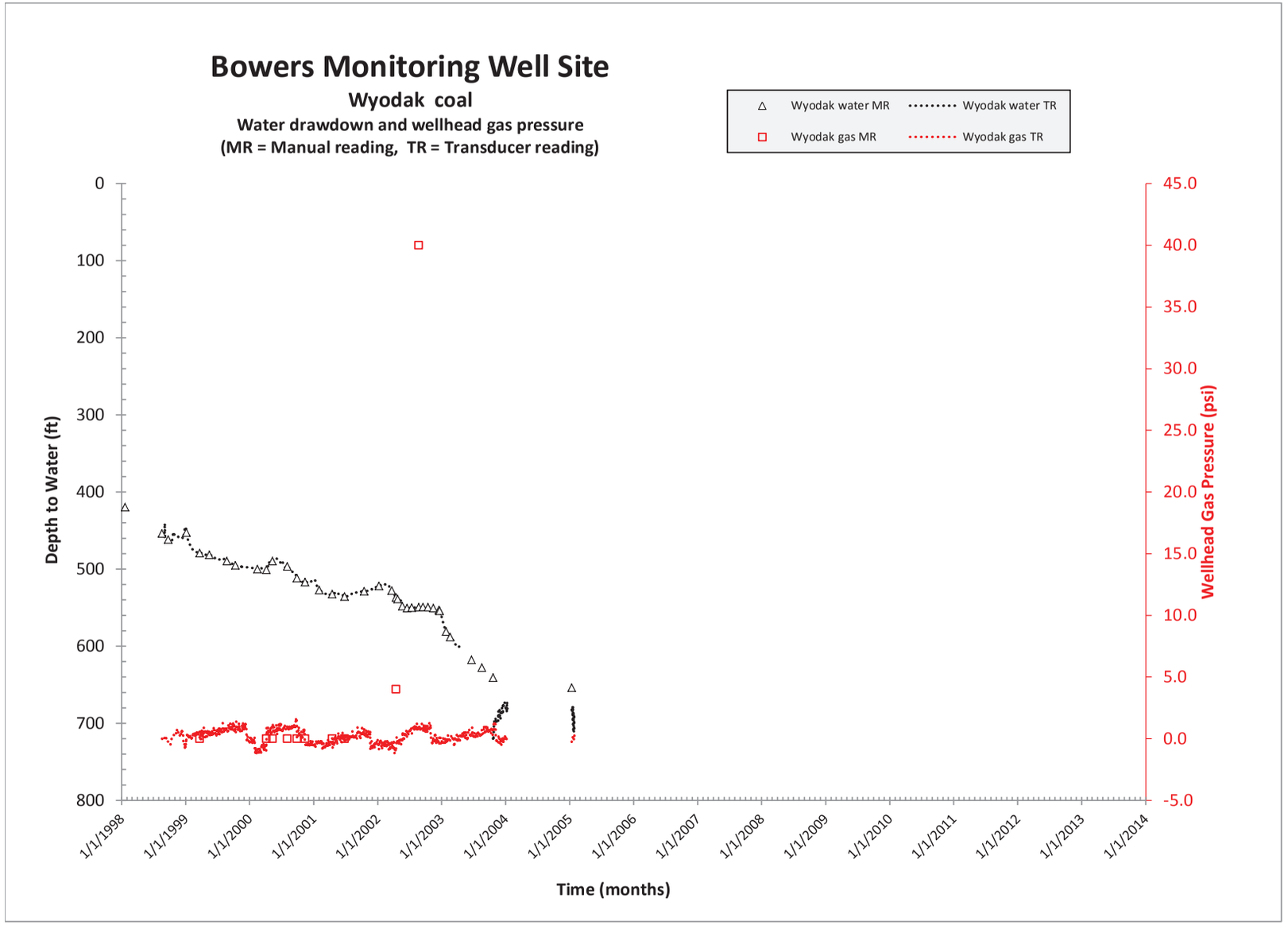

Figure A.61. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored intervals at the Bowers monitoring well site location.

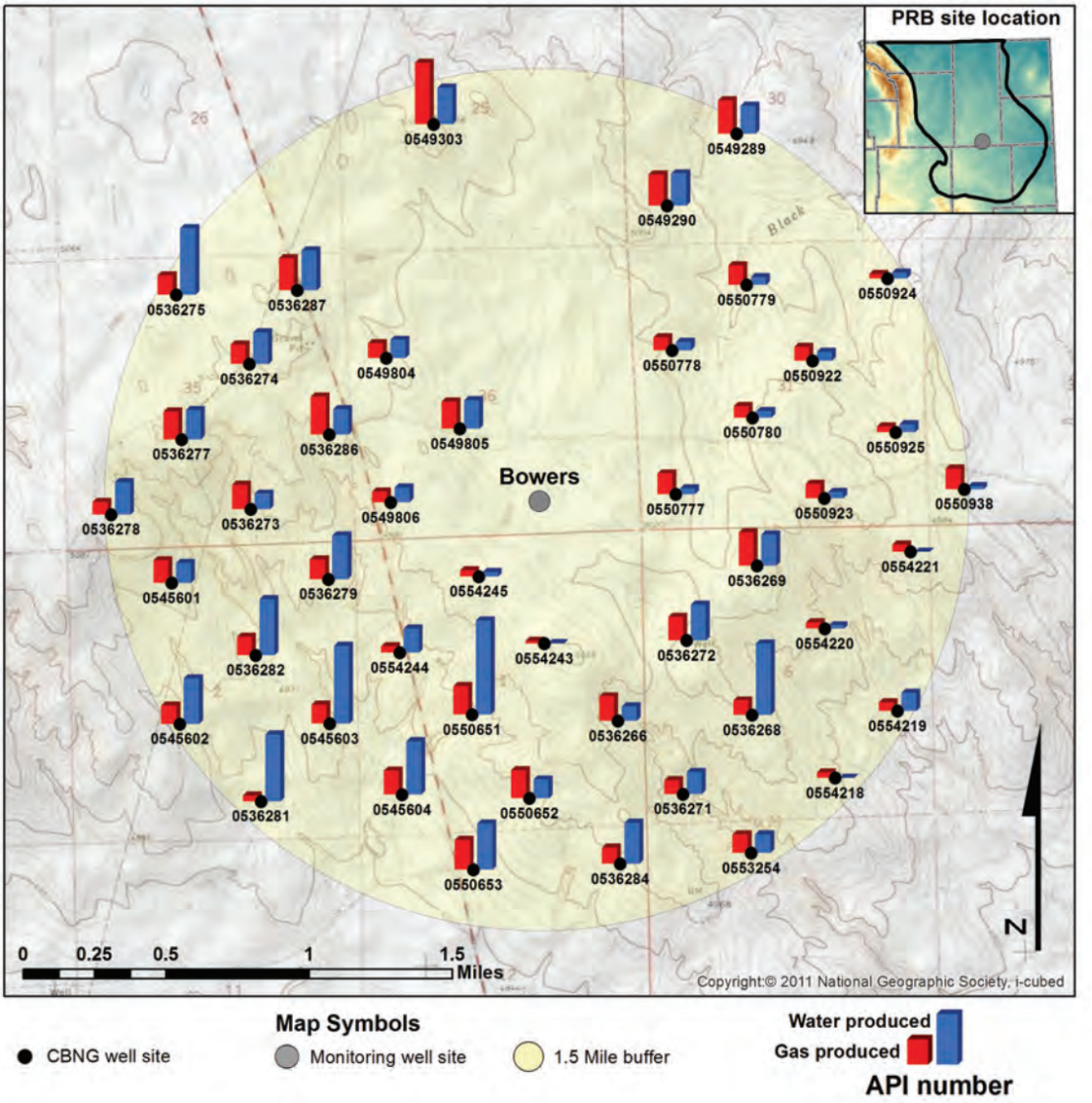

Figure A.62. Bowers monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

Gas production in multiple coal zone production wells peaked in January 2006 at 2,597 Mcf (Figure A.63). These wells have never produced any water.

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; these wells did not produce any gas during 2013.

Unmonitored coal zone production wells have not produced any water or gas during any year (Figure A.63).

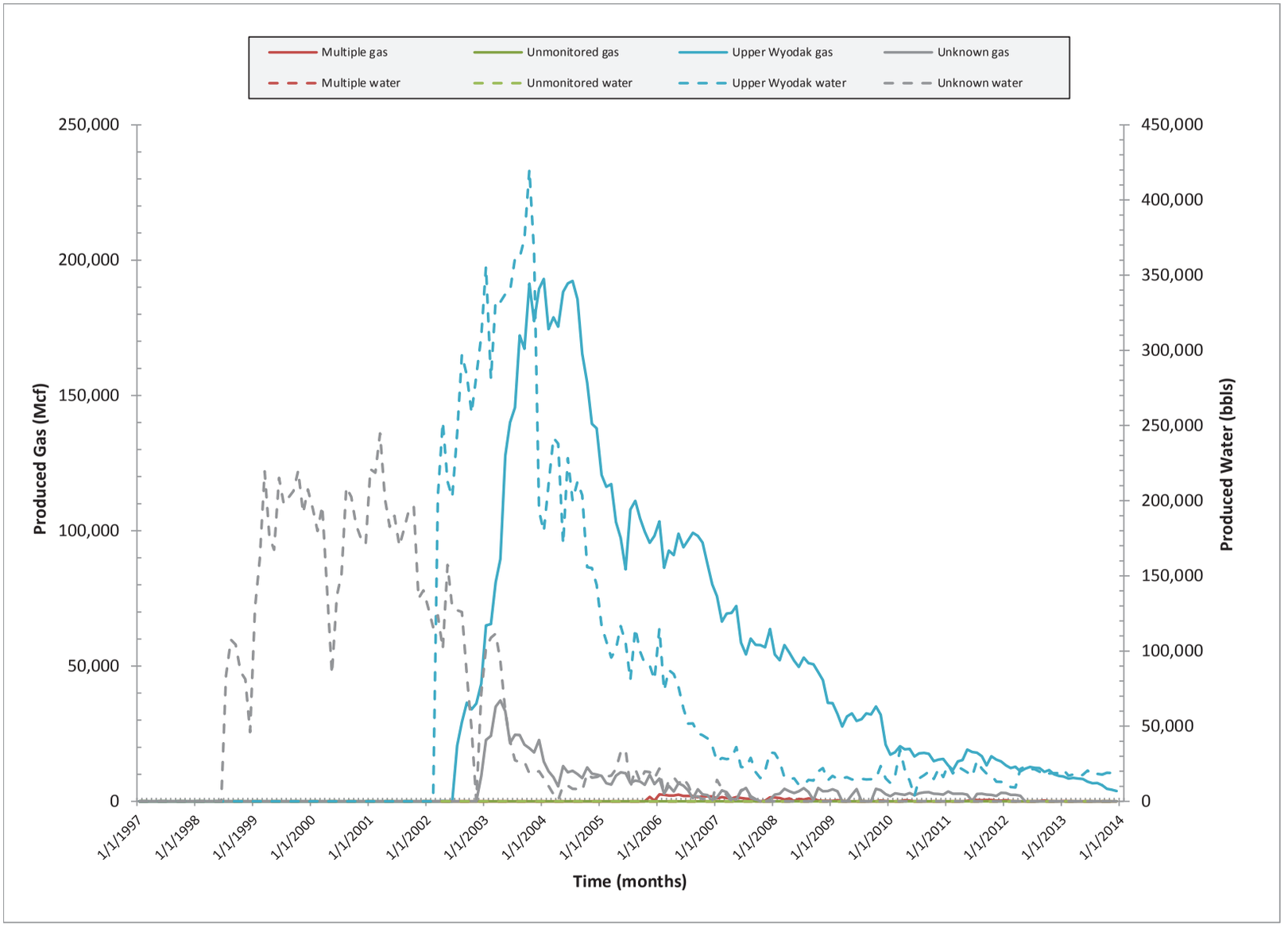

Figure A.63. Water and gas production from CBNG wells associated with the Bowers monitoring well site location.

Buffalo SE Monitoring Well Site
Location: S12 T50N R81W
Date First Monitored: August 22, 2001

Drawdown Information

The Buffalo SE monitoring well site includes five wells. Four wells are completed in Wasatch sandstones and one is completed in the Smith coal of the Wyodak Rider coal zone (Figure A.64; Table A.32). Water levels and wellhead gas pressures were measured during 2013 using both manual and automatic transducer and data logger equipment. Generally, transducer measurements agree with manual measurements at this site. 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.

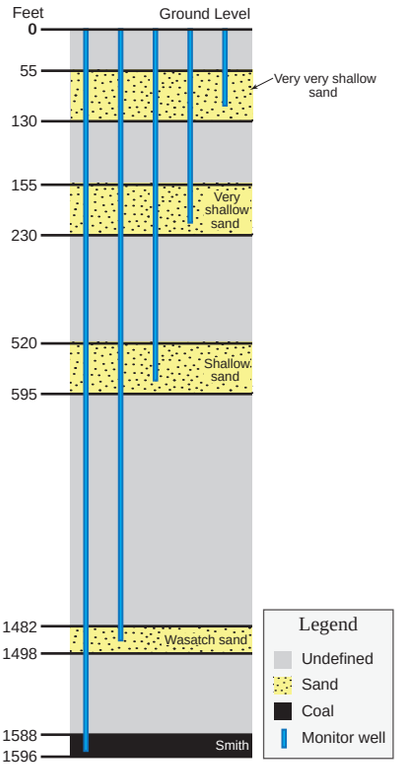

Figure A.64. Section showing relative positions of coal and sands in feet. Not to scale.

Wasatch Sandstones

During 2013, monitored sandstone strata exhibited groundwater level changes ranging from a decline of 0.01 feet to rises of 0.49 feet (Figure A.65; Figure A.66; Table A.33). All currently monitored sandstones exhibited groundwater level rises that ranged from 0.75 to 20.24 feet from initial static water levels. Monitoring was discontinued in the very very shallow sand well in May of 2007. Gas pressure was not recorded in the Wasatch sandstones.

Smith Coal

During 2013, groundwater levels rose 0.16 feet in the Smith coal; water levels declined 26.11 feet during the 2001-2013 monitoring period (Figure A.66; Table A.33). Gas pressure in the Smith remained relatively stable over the monitoring period of 2001 – 2013 with the exception of one manual measurement in June 2006 that peaked at 51.7 psi.

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

Monitored interval	Interval characteristics			
	Depth of interval (ft)		Interval 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, water level changes for current monitoring period, water level changes for period of record, and maximum gas pressure.

Monitored interval	DGW - Depth to groundwater (ft), water level (ft), and gas pressure (psi) data					
	Initial DGW	Max DGW [Date]	Final 2013 DGW	Water level change 2013	Net water level change	Max. gas pressure [date]
Very very shallow sand*	47.81	52.00 3/29/2007	n/a	n/a	-3.99	n/a
Very shallow sand	143.80	150.70 4/16/2005	143.10	0.49	0.75	n/a
Shallow sand	419.23	420.10 7/14/2004	398.99	0.49	20.24	n/a
Wasatch sand	337.51	337.50 8/22/2001	332.85	-0.01	4.66	n/a
Smith coal	280.97	336.40 10/7/2007	307.08	0.16	-26.11	51.70 6/18/2006

*Monitoring discontinued 5/10/2007

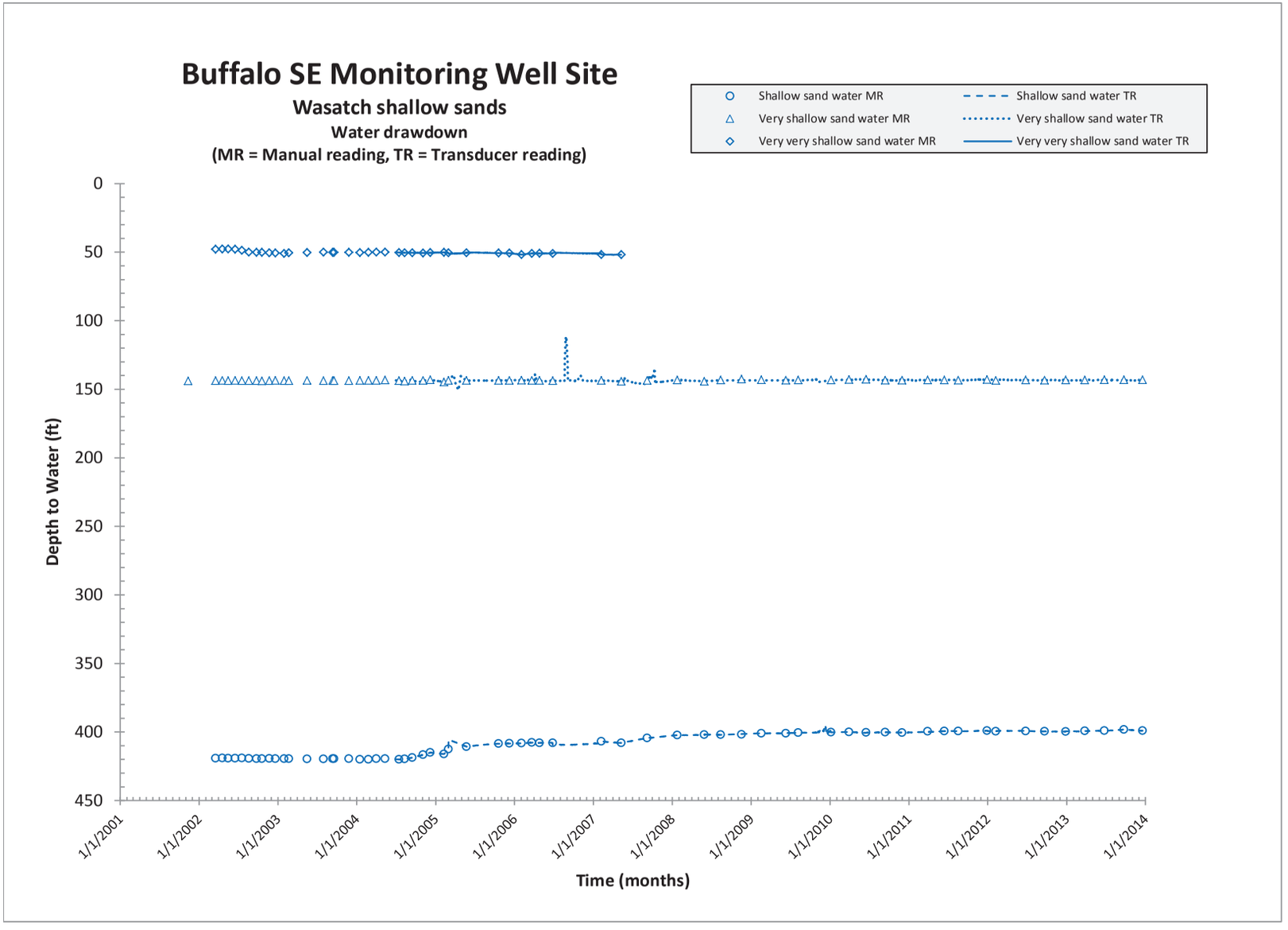

Figure A.65. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored intervals at the Buffalo SE monitoring well site location.

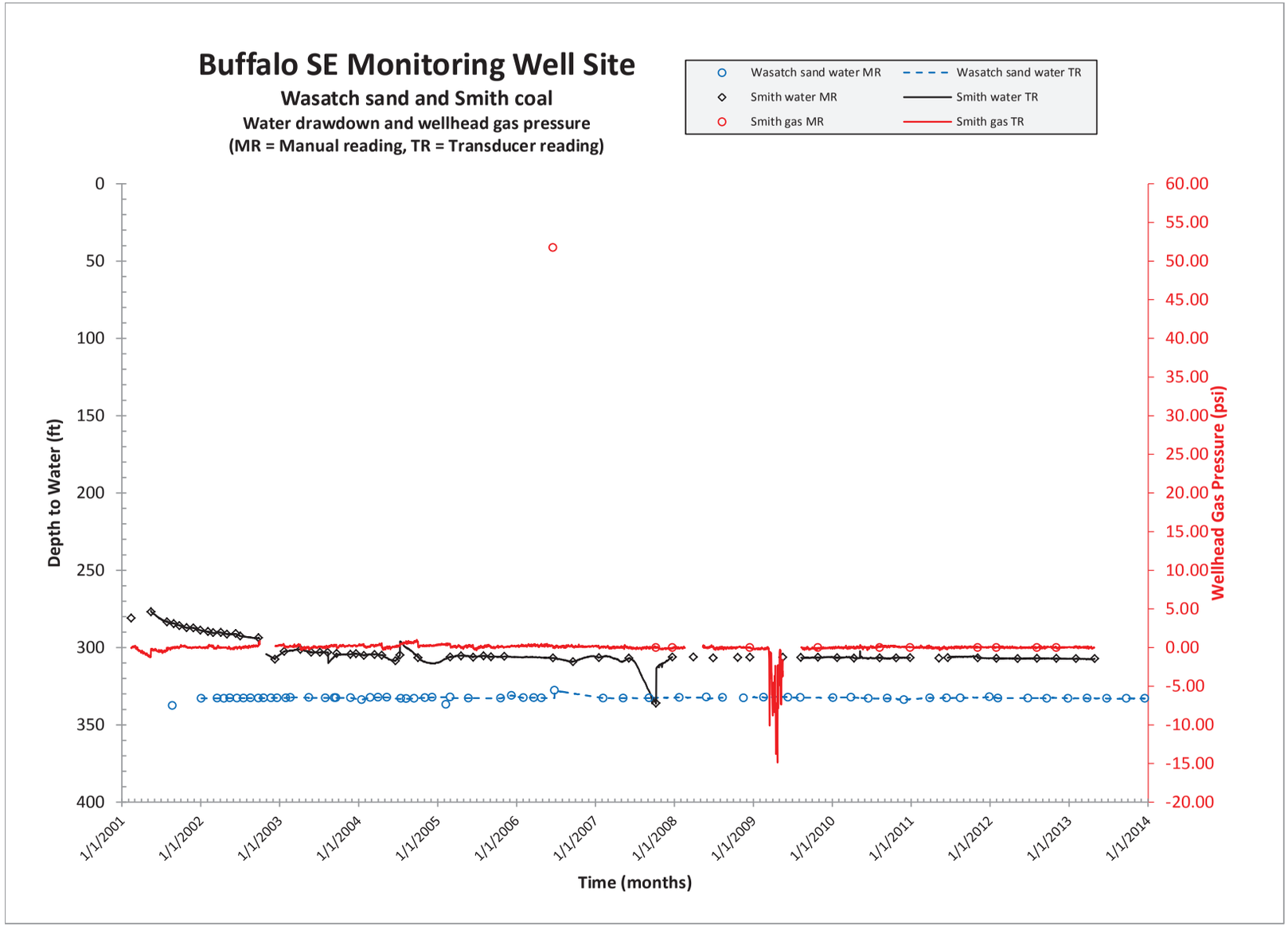

Figure A.66. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored intervals at the Buffalo SE monitoring well site location.

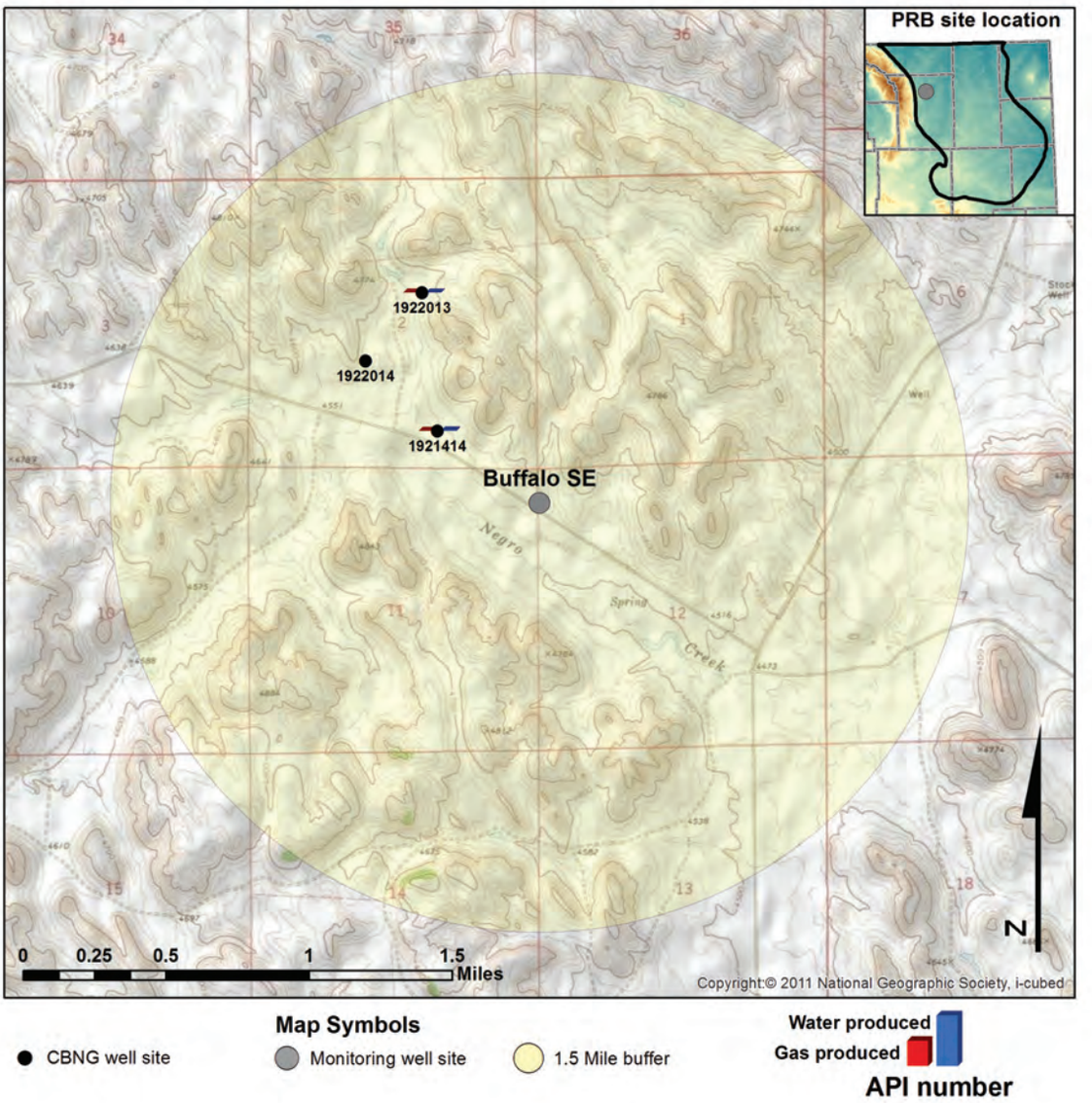

Figure A.67. Buffalo SE monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

Production Statistics

Production data were analyzed for CBNG wells within the buffer of the Buffalo SE monitoring well site from 2001-2013. Cumulative production for individual CBNG wells is displayed by location on Figure A.67. CBNG and water production are monitored in Wyodak Rider coal zone and unmonitored coal zone wells.

Water was produced from the Wyodak Rider coal zone for only for a four-month period in 2003. Water production peaked in August 2003 at 1,800 bbls. There has been no gas production in the Wyodak Rider coal zone during the monitoring period of 2001-2013 (Figure A.68).

Unmonitored coal zone production wells have not produced any water or gas over the monitoring period of 2001-2013 (Figure A.68).

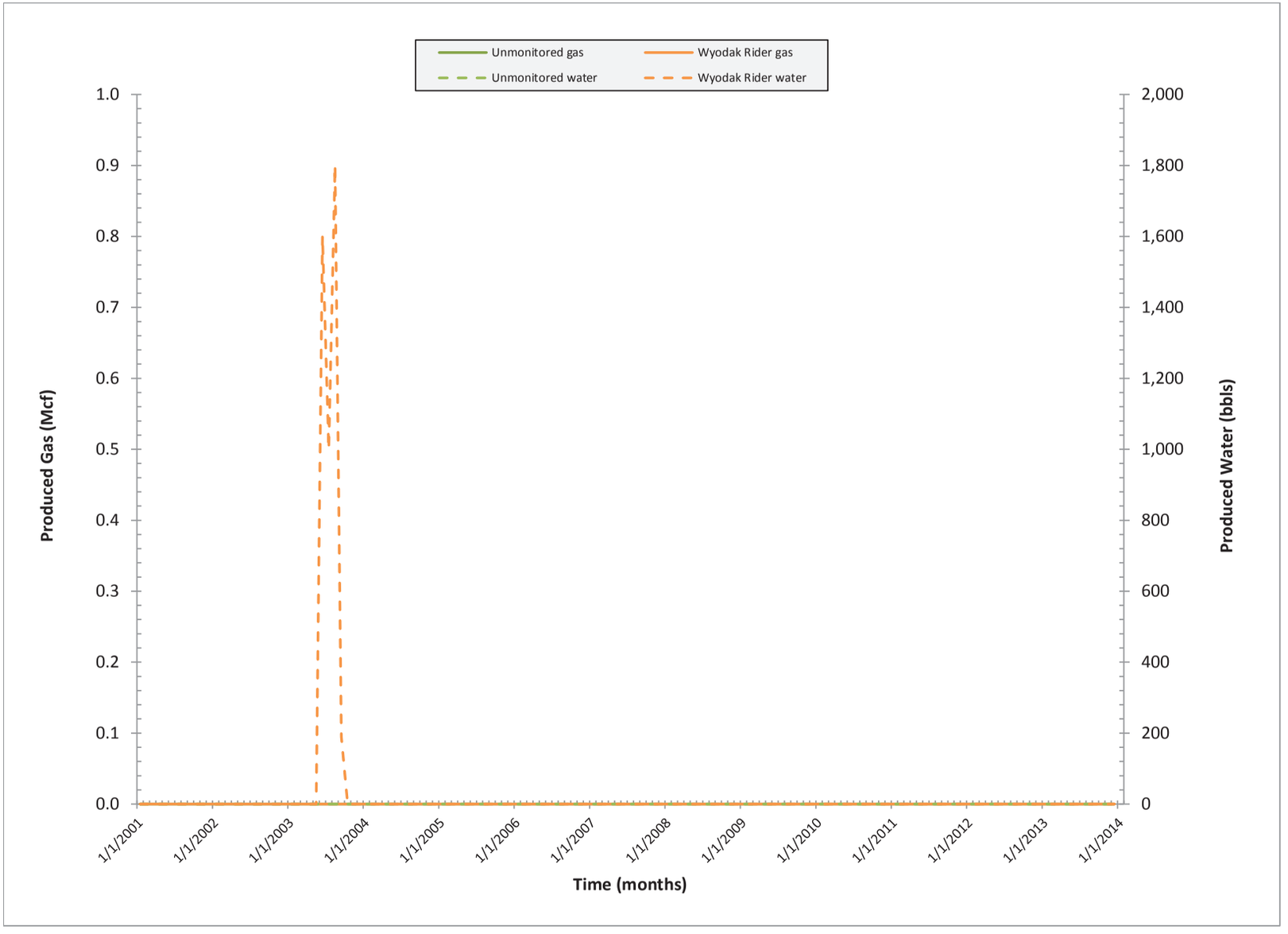

Figure A.68. Water and gas production from CBNG wells associated with the Buffalo SE monitoring well site location.

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 in 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 2013 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

The monitoring well completed in the shallow sandstone is a flowing well. So, groundwater level data were collected only for the deeper sandstone unit, listed as the Wasatch sand in Table A.35. During 2013, groundwater levels in this monitored sandstone, declined 10.20 feet. Groundwater levels have declined 72.31 feet from initial static water levels (Figure A.70). Gas pressure was not recorded in the Wasatch sandstones.

Anderson Coal

During 2013 POR, groundwater levels rose 6.57 feet in the Anderson coal; overall, water levels rose 17.88 feet during the 2005 - 2013 POR (Figure A.70; Table A.35). Gas pressure in the Anderson coal varied over the monitoring period of 2005-2013 peaking at 3.07 psi in October 2007.

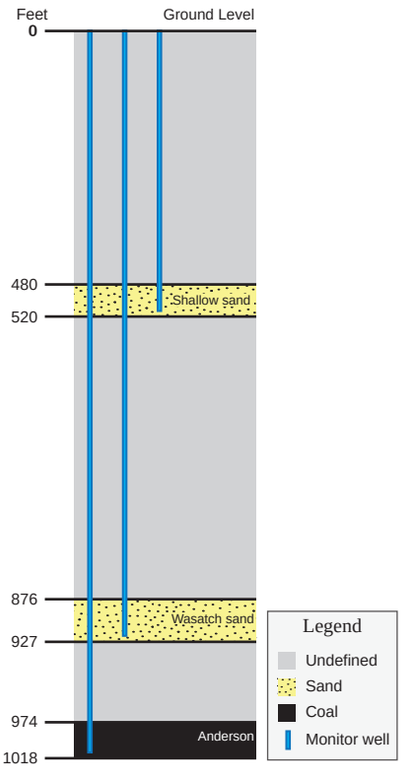

Figure A.69. Section showing relative positions of coal and sands in feet. Not to scale.

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

Monitored interval	Interval characteristics			
	Depth of interval (ft)		Interval 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, water level changes for current monitoring period, water level changes for period of record, and maximum gas pressure.

Monitored interval	DGW - Depth to groundwater (ft), water level (ft), and gas pressure (psi) data					
	Initial DGW	Max DGW [Date]	Final 2013 DGW	Water level change 2013	Net water level change	Max. gas pressure [date]
Shallow sand*	n/a	0.50 3/15/2011	n/a	0.00	0.00	n/a
Wasatch sand	91.57	164.00 12/28/2013	163.88	-10.20	-72.31	n/a
Anderson coal	215.00	390.90 8/7/2012	197.12	6.57	17.88	3.07 10/5/2007

*Well flowing artesian

Production Statistics

Production data were analyzed for CBNG wells within the buffer of the Bull Creek monitoring well site from 2003-2013. 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 coal zone peaked in September 2006 at nearly 28,000 bbls. Gas production in the Upper Wyodak coal zone began in 2004 and peaked in March 2008 at 1429 Mcf (Figure A.72). These wells produced neither water nor gas during 2013.

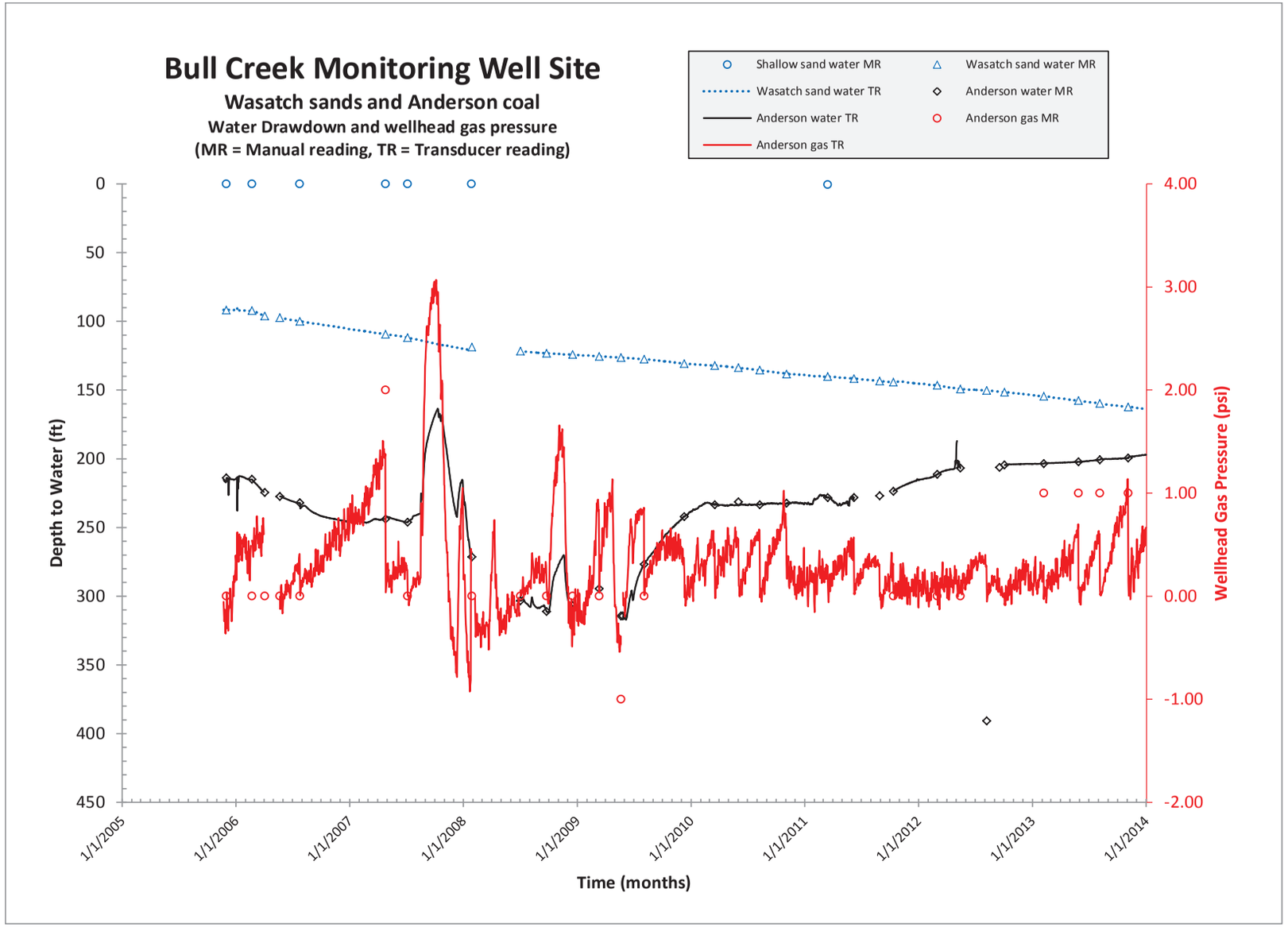

Figure A.70. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored intervals at the Bull Creek monitoring well site location.

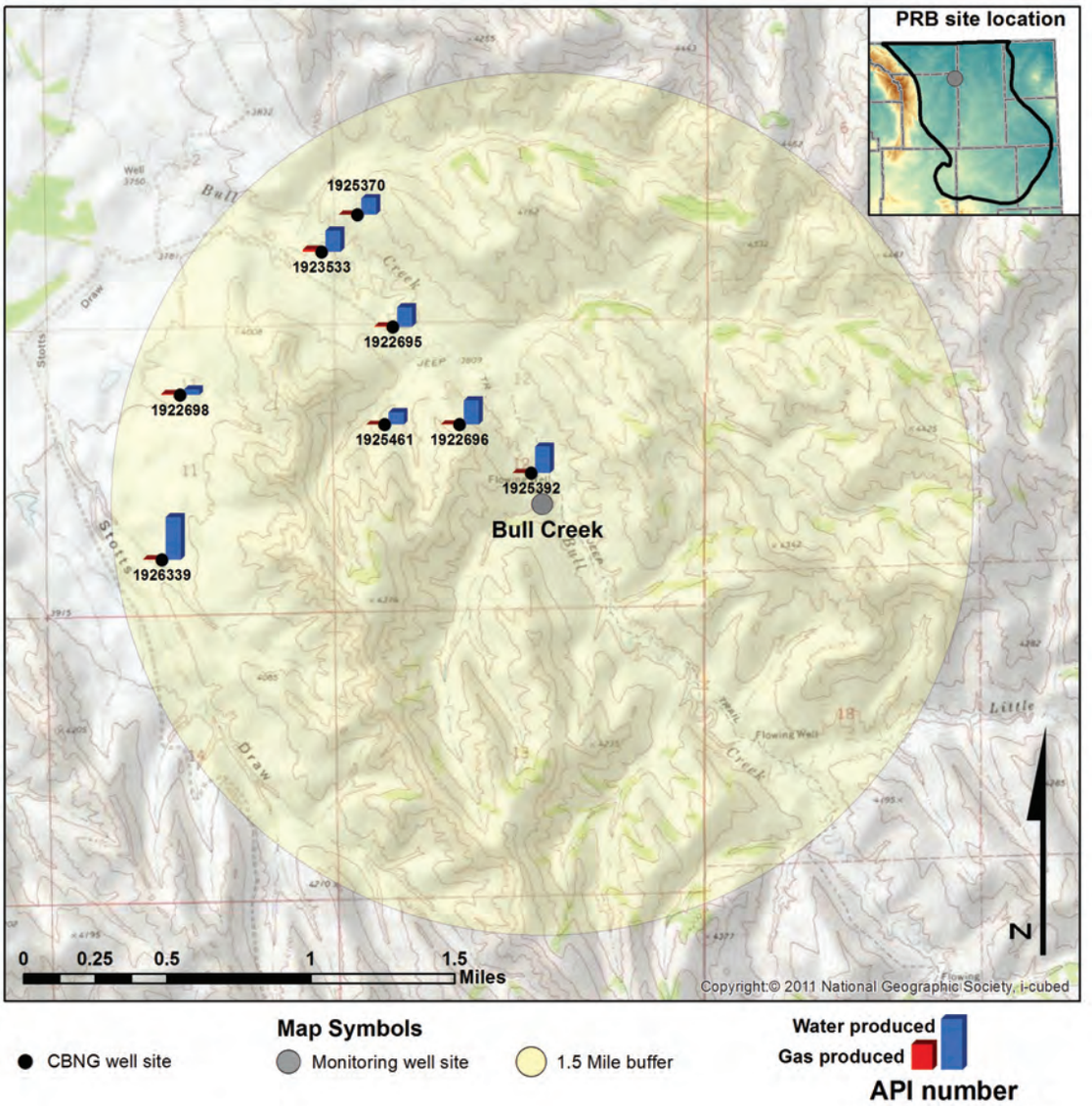

Figure A.71. Bull Creek monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

Water production in the multiple coal zone production wells peaked at 93,337 bbls in October 2008; water production had ceased in these wells by June 2012 (Figure A.72). Gas production in the multple coal zone wells began in 2008 and peaked at 805 Mcf in September of the same year. Gas production was zero during 2013.

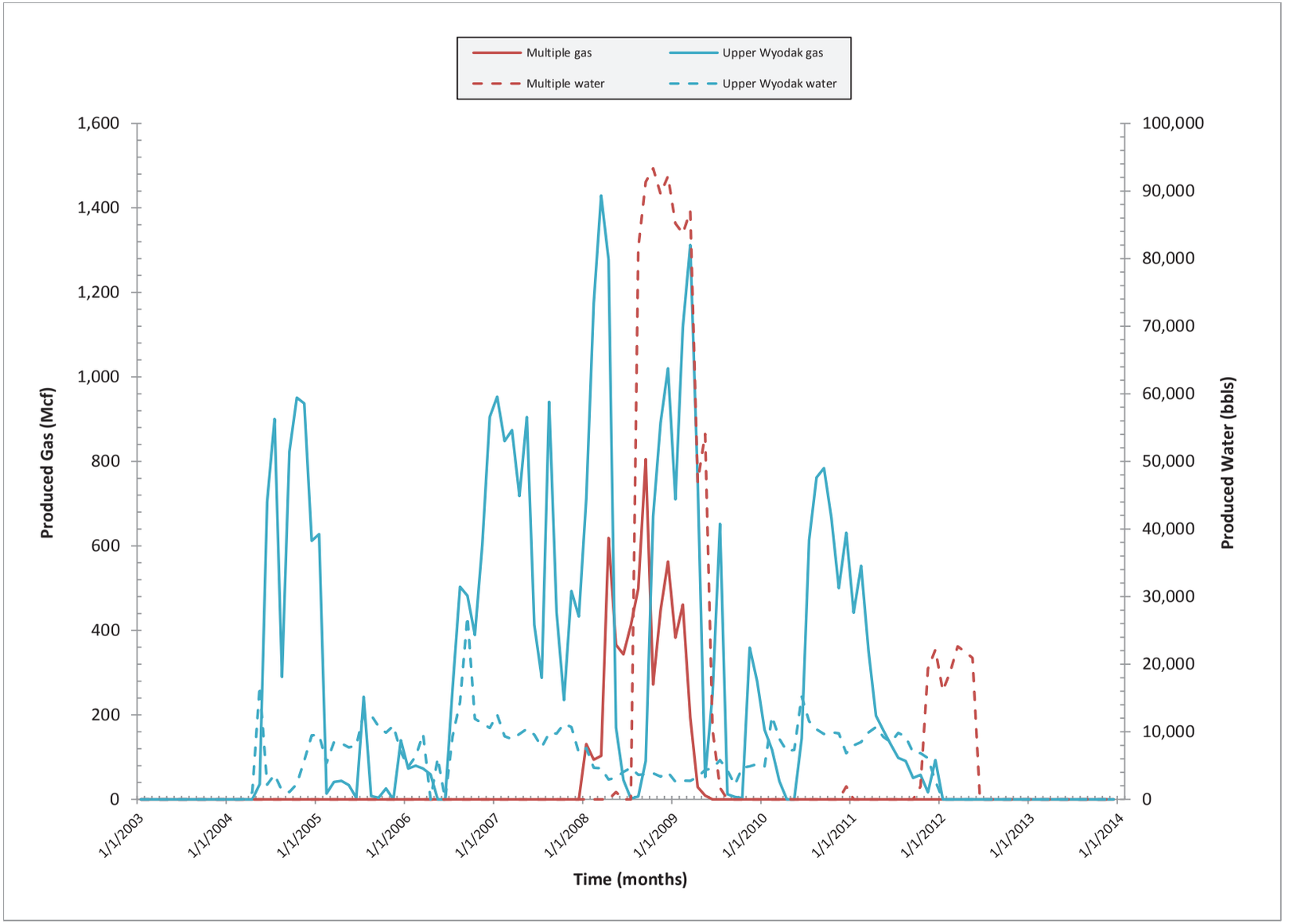

Figure A.72. Water and gas production from CBNG wells associated with the Bull Creek monitoring well site location.

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 a 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 pressure were measured during 2013 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 2013, groundwater levels in the monitored sandstone declined 14.02 feet. In contrast, groundwater levels declined 265.29 feet from initial static water levels (Figure A.74; Table A.37). Gas pressure was not recorded in the Wasatch sandstone.

Big George Coal

Water level data were not recorded during 2013 due to high gas pressures. Water levels have declined 1,070.73 feet over the 2002 – 2009 POR (Figure A.74; Table A.37). Over the monitoring period of 2002-2013, gas pressures in the Big George decreased steadily from a peak value of 311.1 psi in October 2003 to 59 psi by the end of 2013.

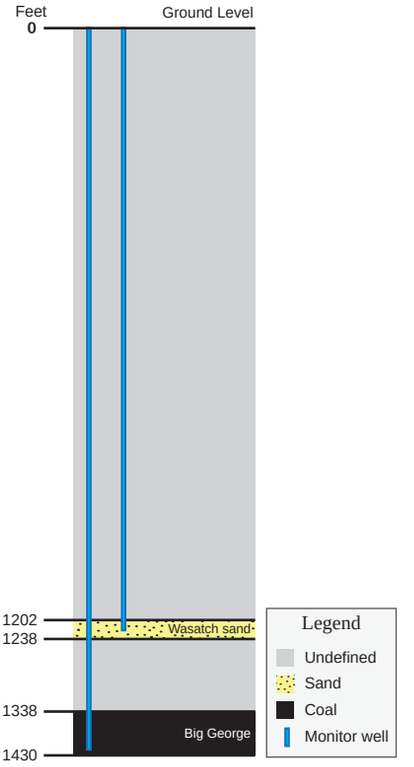

Figure A.73. Section showing relative positions of coal and sand in feet. Not to scale.

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

Monitored interval	Interval characteristics			
	Depth of interval (ft)		Interval 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, water level changes for current monitoring period, water level changes for period of record, and maximum gas pressure.

Monitored interval	DGW - Depth to groundwater (ft), water level (ft), and gas pressure (psi) data					
	Initial DGW	Max DGW [Date]	Final 2013 DGW	Water level change 2013	Net water level change	Max. gas pressure [date]
Wasatch sand	25.41	290.70 12/31/2013	290.70	-14.02	-265.29	n/a
Big George coal*	92.77	1163.50 12/18/2009	n/a	n/a	-1070.73	311.10 10/30/2003

*Last reliable measurement 12/18/2009

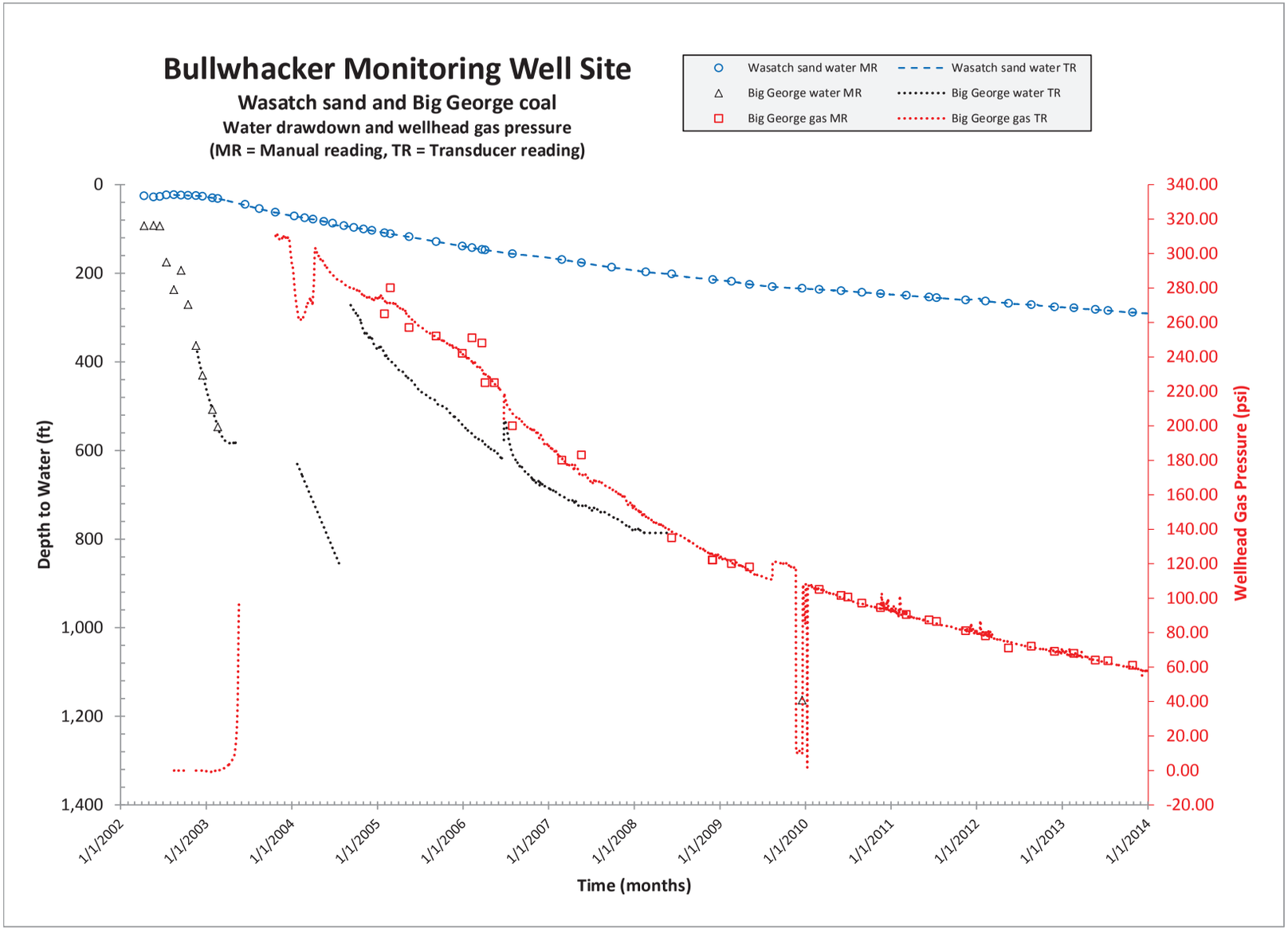

Figure A.74. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored intervals at the Bullwhacker monitoring well site location.

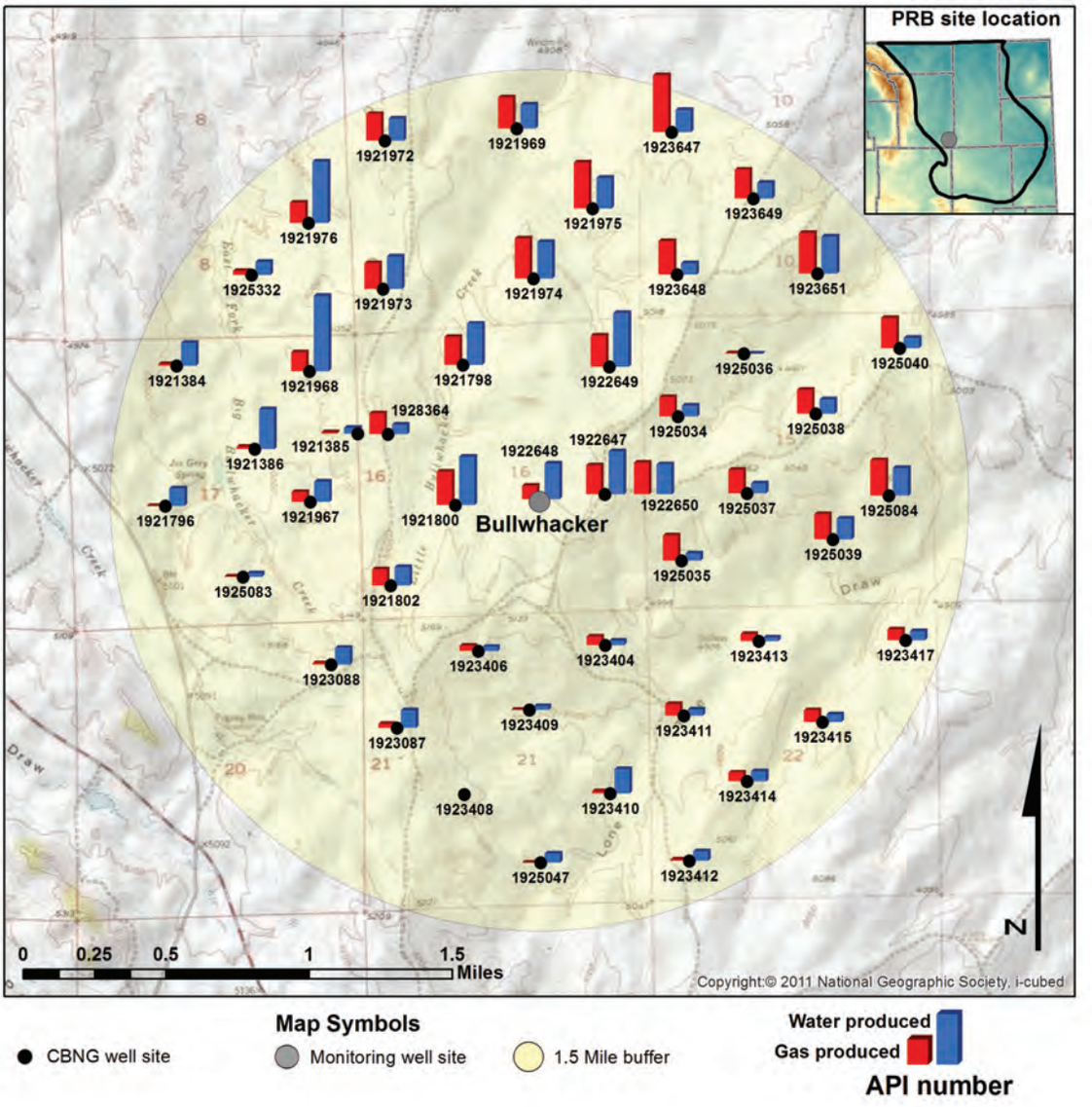

Figure A.75. Bullwhacker monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

Production Statistics

Production data were analyzed for CBNG wells within the buffer of the Bullwhacker monitoring well site from 1999-2013. 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.

Water production rates in the Wyodak Rider coal zone peaked in January 2003 at 368,412 bbls; production has declined steadily since then and finished 2013 at 52,077 bbls/month. Gas production in the Wyodak Rider coal zone began in 2003, peaked in October 2008 at 201,205 Mcf (Figure A.76, and levels declined to about 93,000 Mcf/month by the end of 2013.

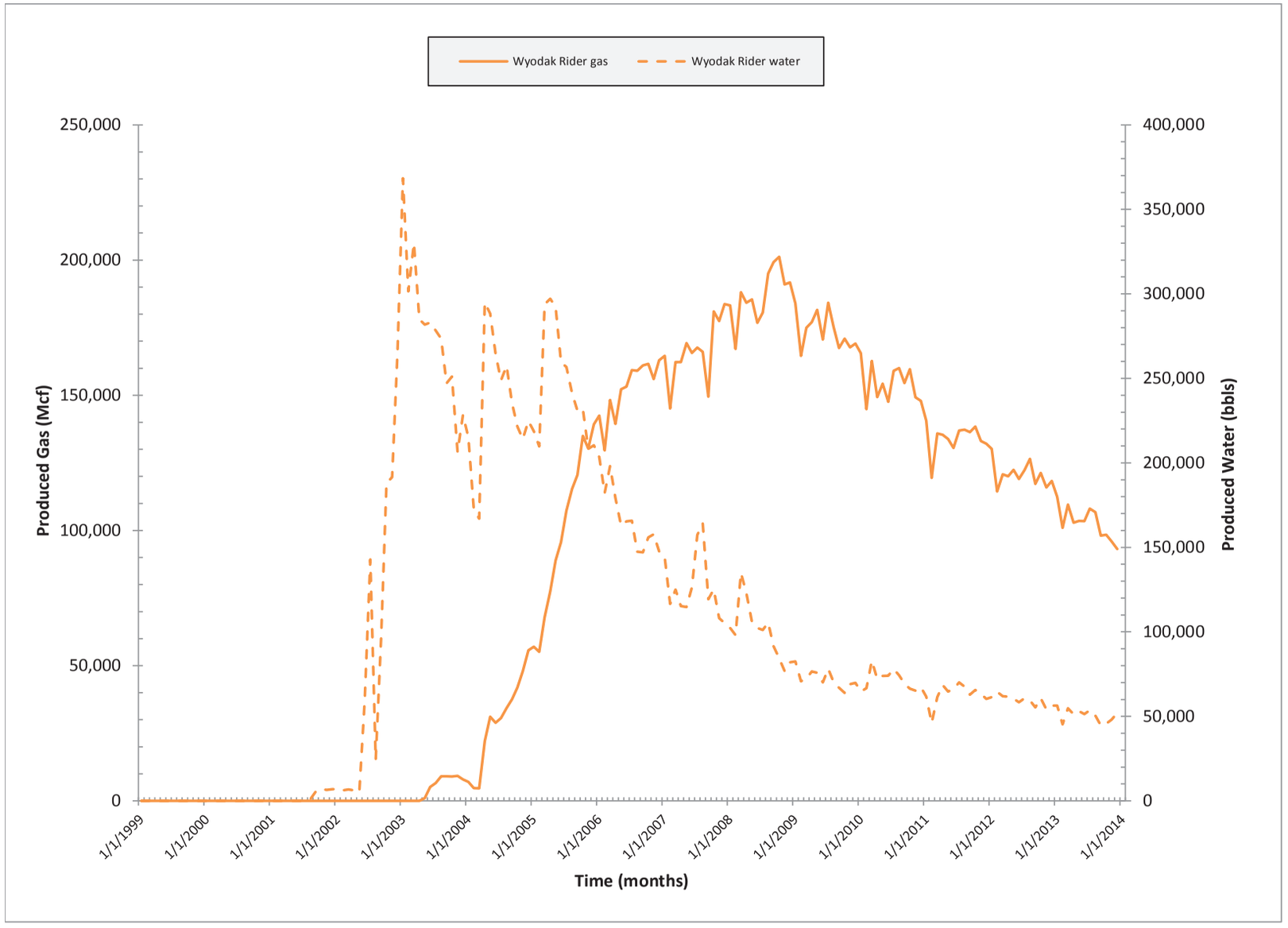

Figure A.76. Water and gas production from CBNG wells associated with the Bullwhacker monitoring well site location.

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 a 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 2013 in the Gates/ Wall and Werner coals using both manual and automatic transducer and data logger equipment. Careful examination of Figure A.77 and Table A.38 suggest that the locations of the Gates/ Wall and Werner monitoring wells were switched during initial manual measurements. For this report, the data is presented as received from the BLM. Wellhead gas pressures in the Big George coal were measured manually during 2013. 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.

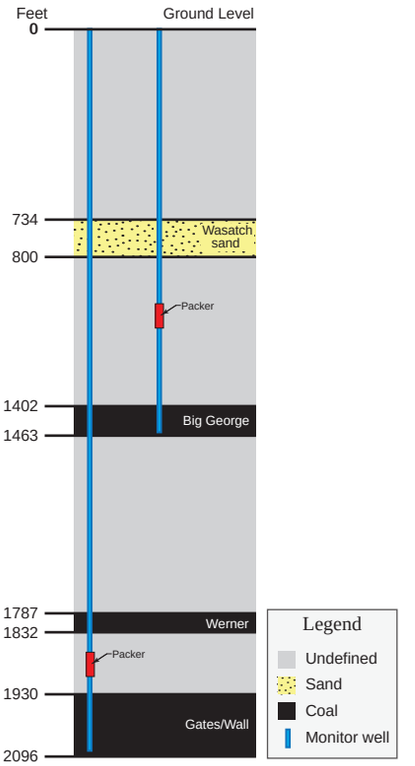

Figure A.77. Section showing relative positions of coals and sand in feet. Not to scale.

Wasatch Sandstone

Groundwater levels were not measured in the monitored sandstone during 2013. In contrast, groundwater levels declined 634.74 feet from initial static water levels (Figure A78; Table A.39). Gas pressure was not recorded in the Wasatch sandstone.

Big George Coal

Groundwater levels were not measured in the Big George coal in 2013. Water levels declined 915.20 feet prior to 2013 (Figure A78; Table A.39). Gas pressure in the Big George varied from 22.0 to 201.8 psi during 2013, reaching a peak value of 201.8 psi in December 2013.

Werner Coal

Groundwater levels declined 10.84 feet during 2013. During the 2008 – 2013 POR, groundwater levels dropped 518.85 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 December 2010 at 1.0 psi and ending 2013 at 0.0 psi.

Gates/Wall Coal

Groundwater levels declined 0.59 feet during 2013. Over the 2007 – 2013 monitoring period, water levels rose a total of 131.63 feet (Figure A79; Table A.39). Gas pressure has remained below 1 psi during the monitoring period of 2004-2013, peaking at 0.30 psi in 2010.

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

Monitored interval	Interval characteristics			
	Depth of interval (ft)		Interval 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, water level changes for current monitoring period, water level changes for period of record, and maximum gas pressure.

Monitored interval	DGW - Depth to groundwater (ft), water level (ft), and gas pressure (psi) data					
	Initial DGW	Max DGW [Date]	Final 2013 DGW	Water level change 2013	Net water level change	Max. gas pressure [date]
Overburden sand*	341.66	976.40 5/21/2012	n/a	n/a	-634.74	n/a
Big George coal**	492.30	1407.50 12/4/2012	n/a	n/a	-915.20	201.80 12/18/2013
Werner coal	344.00	864.80 5/8/2013	862.85	-10.84	-518.85	1.00 12/6/2010
Gates/Wall coal	490.50	524.40 11/21/2008	358.87	0.59	131.63	0.30 4/27/2010

*Last reliable measurement 5/21/2012

**Last reliable measurement 12/4/2012

Production Statistics

Production data were analyzed for CBNG wells within the buffer of the Carr Draw monitoring well site from 2002-2013. 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, and in multiple coal zone production wells.

Water production in the Wyodak Rider coal zone began in 2002, peaked in December 2009 at 109,507 bbls and finished 2013 at 34,801 bbls/month. Gas production in the Wyodak Rider began in March 2009 and peaked in October 2013 at 4,478 Mcf (Figure A.81).

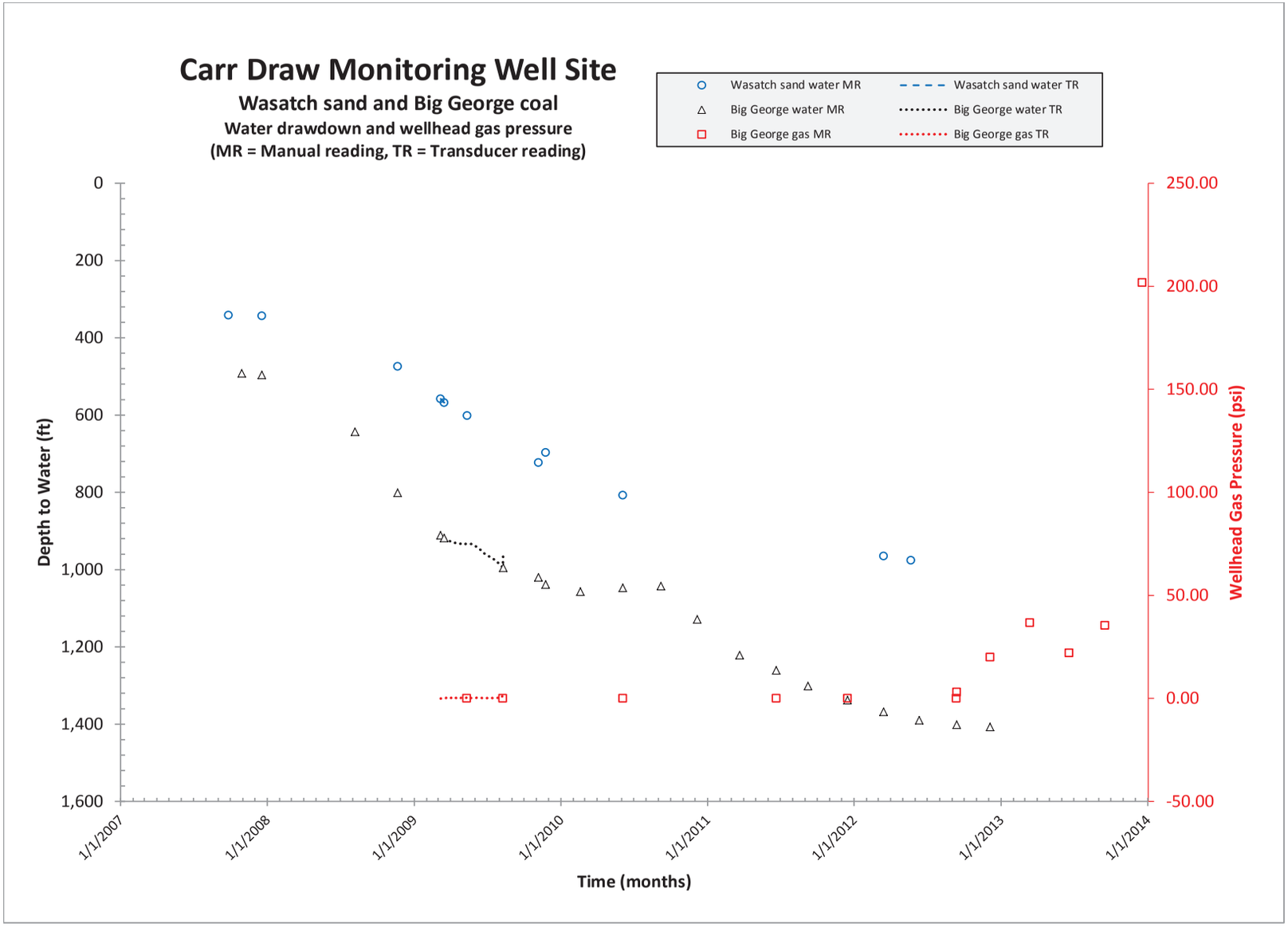

Figure A.78. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored intervals at the Carr Draw monitoring well site location.

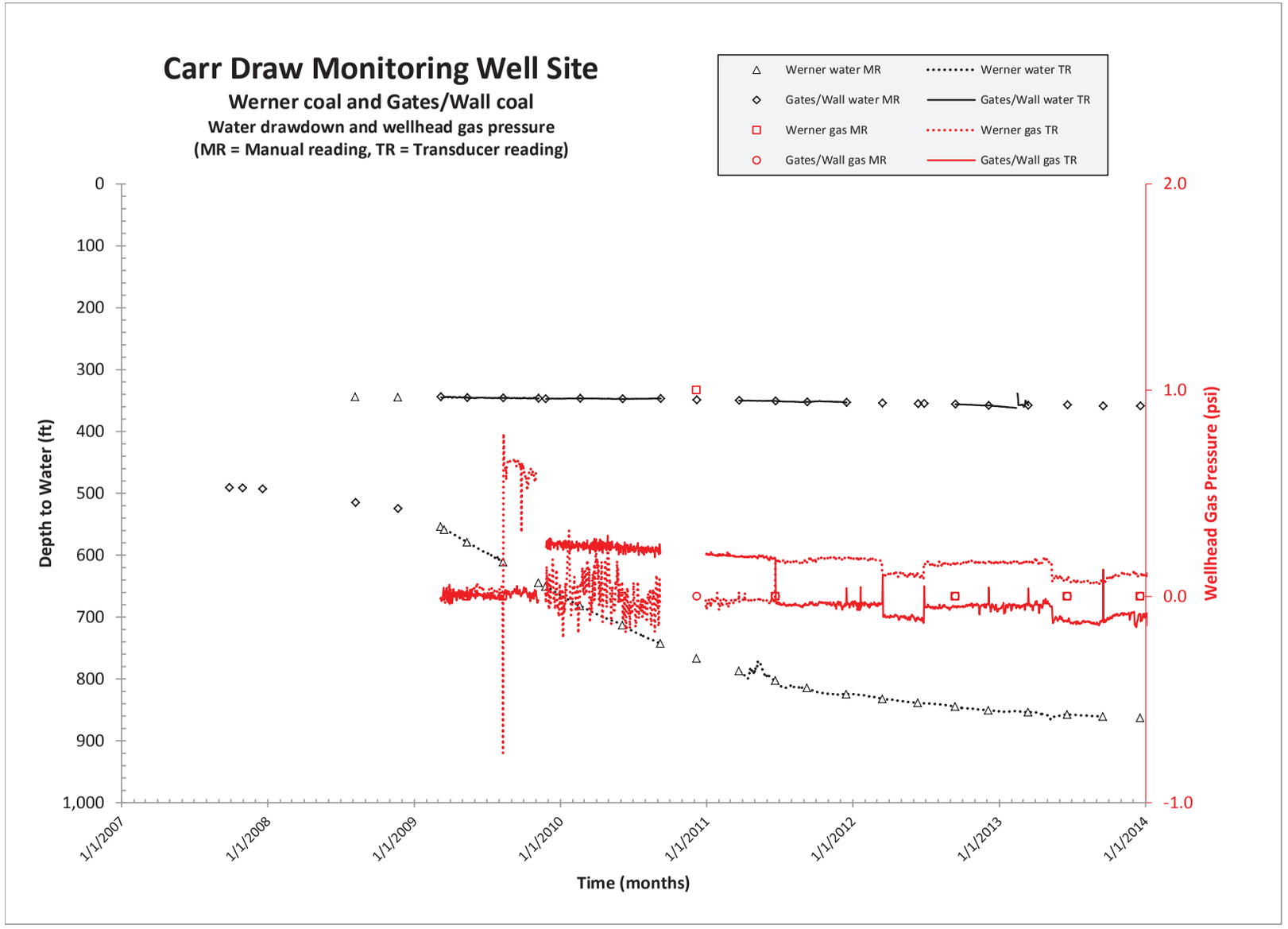

Figure A.79. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored intervals at the Carr Draw monitoring well site location.

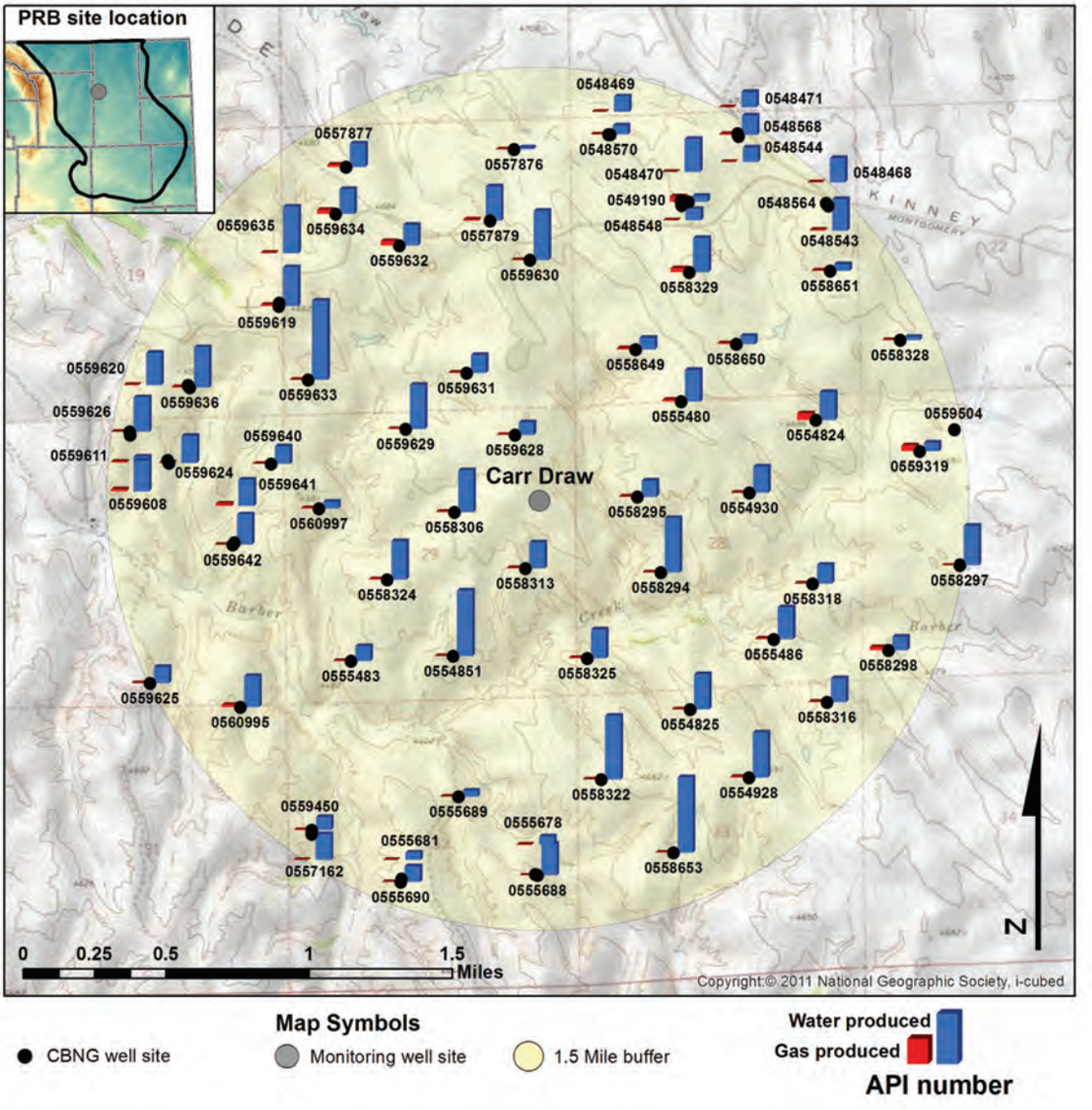

Figure A.80. Carr Draw monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

Cook coal zone wells reached peak water production of 94,597 bbls in February 2004 and peak gas production of 3,328 Mcf in December 2011. Gas production rates showed a general increase during 2013.

Water produced from multiple coal zone wells reached a peak value of 460,552 bbls in December 2009 and then generally declined to about 160,000 bbls/month in 2013 (Figure A.81). Gas production in multiple zone wells reached a peak in May 2013 at 25,067 bbls and it appears that gas production will continue to increase into 2014.

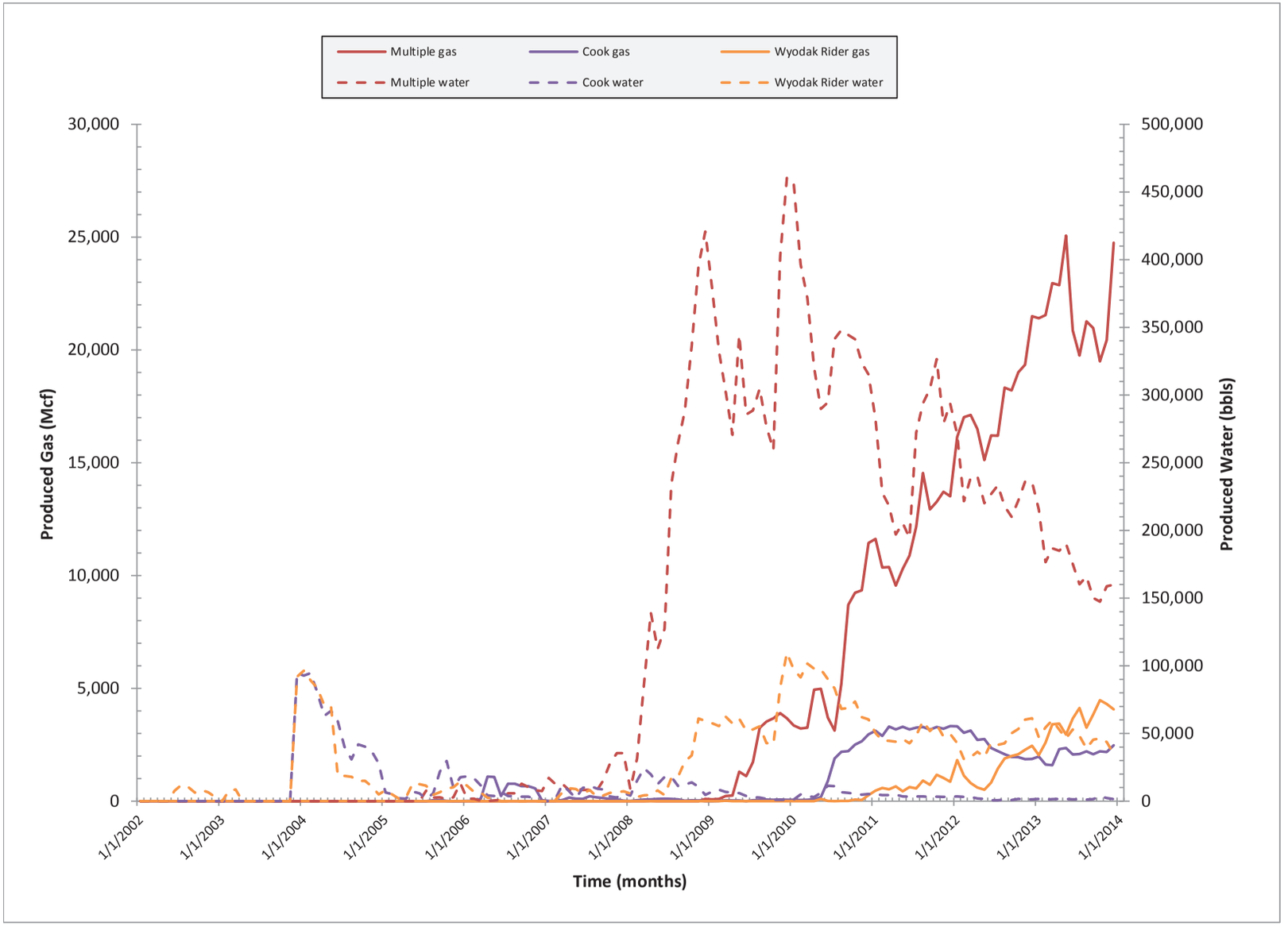

Figure A.81. Water and gas production from CBNG wells associated with the Carr Draw monitoring well site location.

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 a Wasatch sandstone and the other in the Wall coal of the Wall coal zone (Figure A.82; Table A.40). Only wellhead gas pressures were measured during 2013 using both manual and automatic transducer and data logger equipment, water levels for both wells were taken manually. 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. Water levels were measured manually only.

Wasatch Sandstone

During the 2013, groundwater levels in the monitored sandstone rose 68.11 feet. In contrast, during the 2004 - 2013, groundwater levels declined 464.59 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 rose 117.65 feet during 2013. Over the monitoring period of 2004-2013 water levels declined a total of 468.32 feet (Figure A.83; Table A.41). Gas pressure has remained below 1.5 psi for most of the 2004-2013 monitoring period, but peaked at 5.0 psi in 2011.

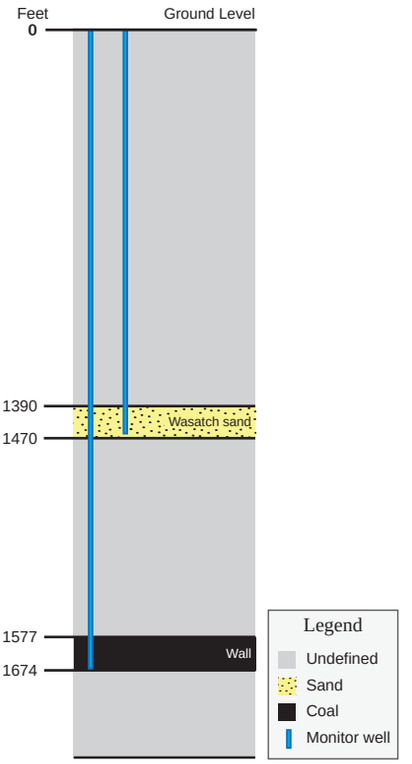

Figure A.82. Section showing relative positions of coal and sand in feet. Not to scale.

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

Monitored interval	Interval characteristics			
	Depth of interval (ft)		Interval 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, water level changes for current monitoring period, water level changes for period of record, and maximum gas pressure.

Monitored interval	DGW - Depth to groundwater (ft), water level (ft), and gas pressure (psi) data					
	Initial DGW	Max DGW [Date]	Final 2013 DGW	Water level change 2013	Net water level change	Max. gas pressure [date]
Wasatch sand	229.50	765.40 9/7/2011	694.09	68.11	-464.59	n/a
Wall coal	230.78	872.90 9/29/2011	699.10	117.65	-468.32	5.00 9/7/2011

Production Statistics

Production data were analyzed for CBNG wells within the buffer of the Cedar Draw monitoring well site from 1999-2013. 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 wells.

Consistent water production in the Wall coal zone began in January 2004, peaked in November 2006 at 542,823 bbls; there was no water production in 2013. Gas production in the Wall coal zone began in November 2004 and peaked in July 2009 at 17,100 Mcf (Figure A.85). Monthly gas production declined in 2013 from 4,992 Mcf in January to 1,788 Mcf in December.

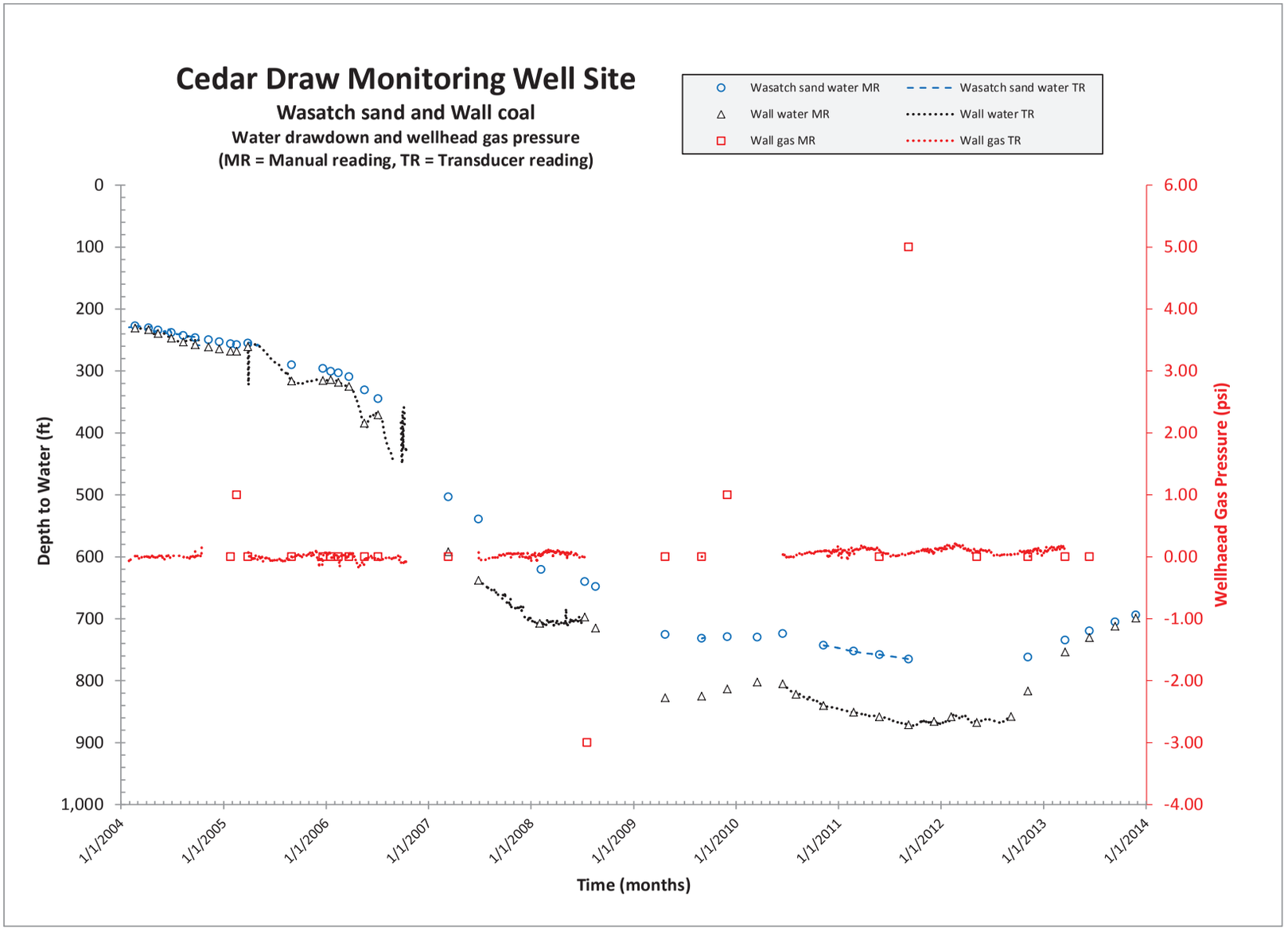

Figure A.83. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored intervals at the Cedar Draw monitoring well site location.

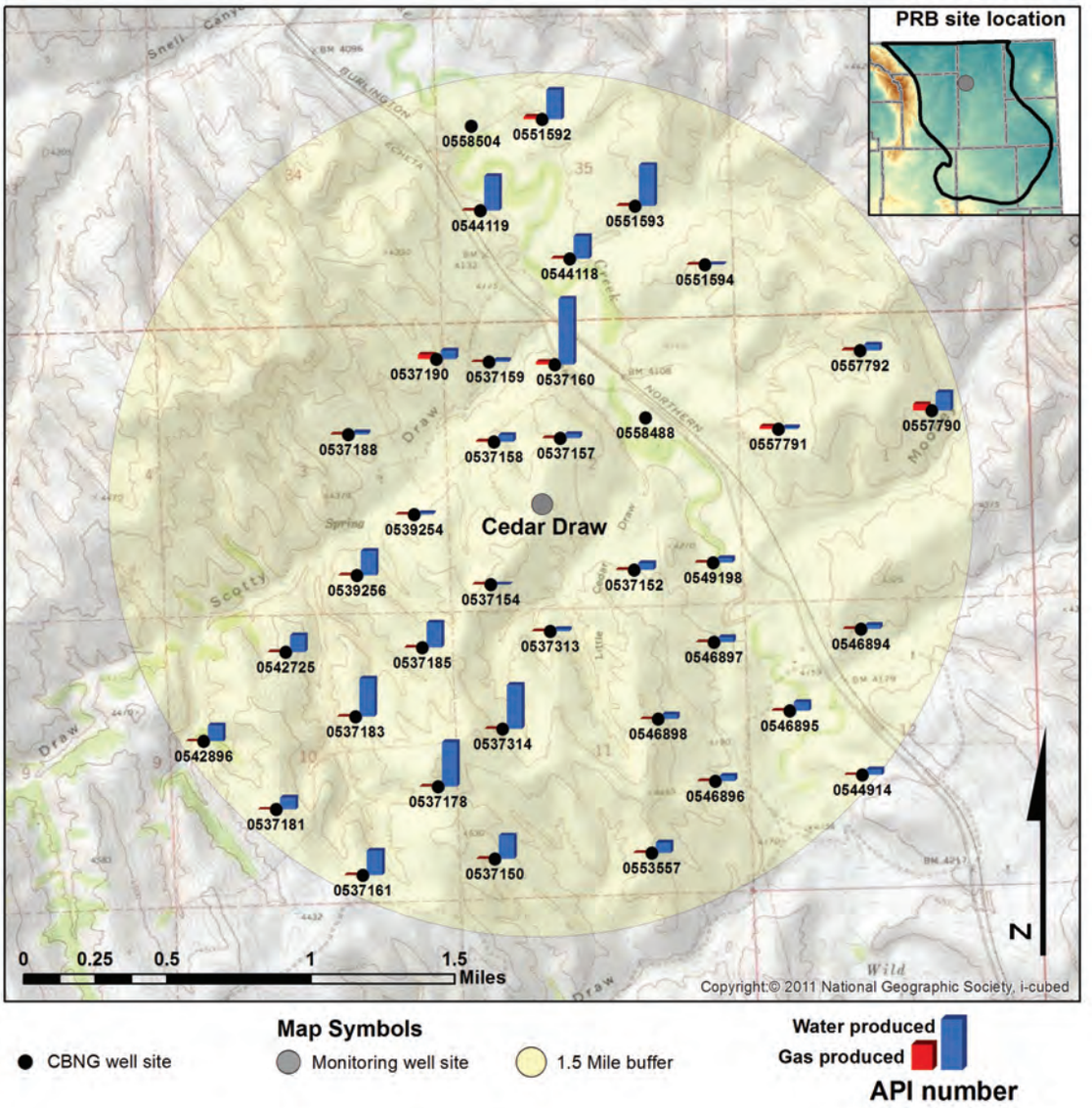

Figure A.84. Cedar Draw monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

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). Gas production in multiple zone wells peaked in February 2009 at 24,411 Mcf, and was only 753 Mcf in December 2013.

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 5,187 Mcf in December 2013.

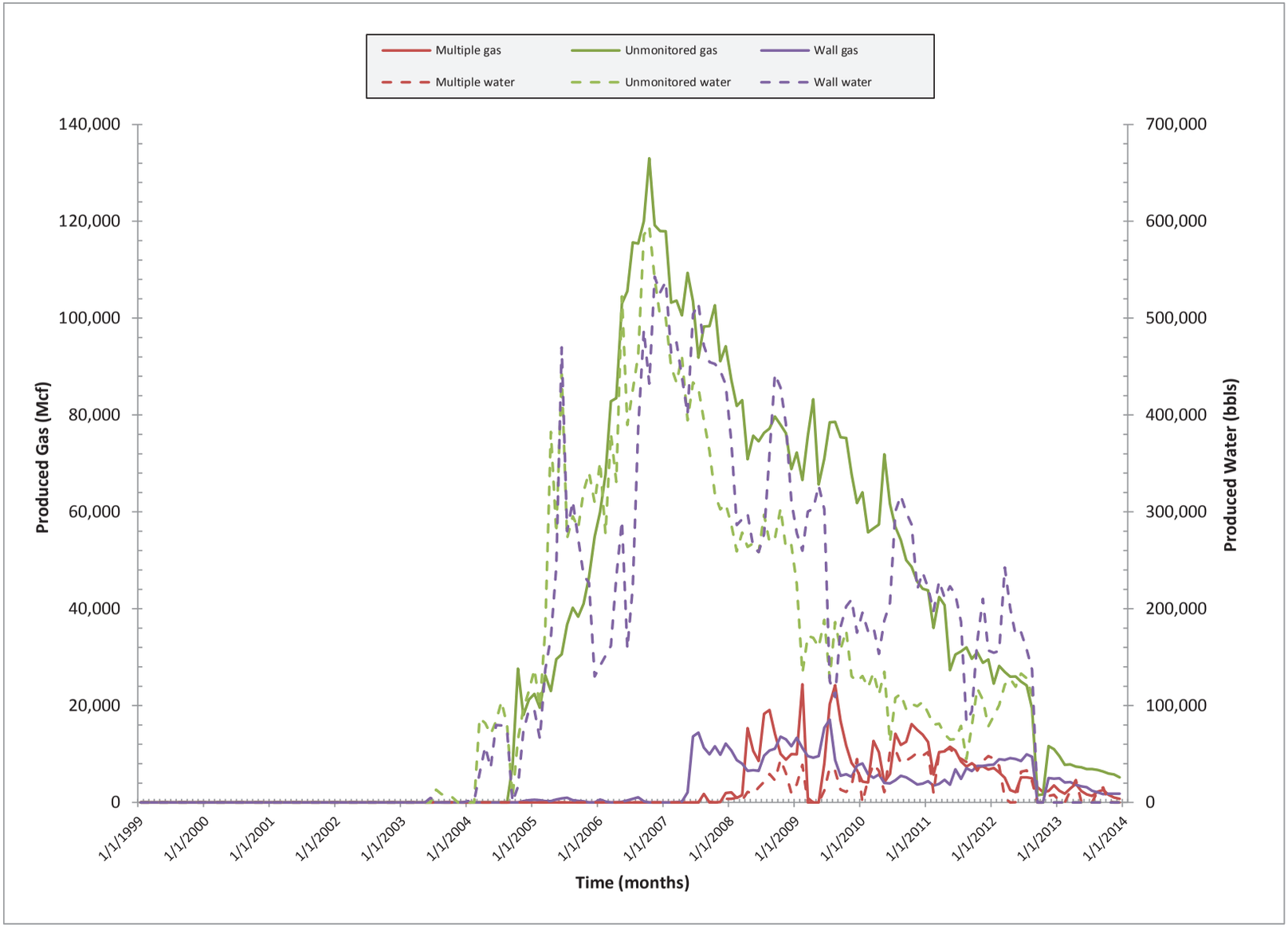

Figure A.85. Water and gas production from CBNG wells associated with the Cedar Draw monitoring well site location.

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). Only wellhead gas pressures were measured during 2013, 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. Water levels were not measured during 2013.

Smith Coal

There is no groundwater level data for the Smith coal during 2013 due to high wellhead gas pressures. However, over the monitoring period of 2005 -2012, groundwater levels declined 308.20 feet from initial static water levels (Figure A.87; Table A.43). Maximum gas pressure was 314.70 psi in March 2013.

Big George Coal

There is no groundwater level data for the Big George coal during 2013. Over the monitoring period of 2005-2012 water levels declined a total of 363.00 feet (Figure A.87; Table A.43). A peak wellhead gas pressure of 338.20 psi was recorded in July 2012.

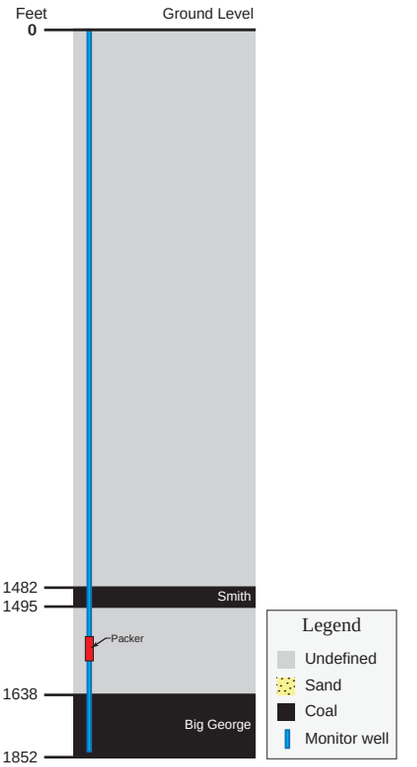

Figure A.86. Section showing relative positions of coals in feet. Not to scale.

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

Monitored interval	Interval characteristics			
	Depth of interval (ft)		Interval 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, water level changes for current monitoring period, water level changes for period of record, and maximum gas pressure.

Monitored interval	DGW - Depth to groundwater (ft), water level (ft), and gas pressure (psi) data					
	Initial DGW	Max DGW [Date]	Final 2013 DGW	Water level change 2013	Net water level change	Max. gas pressure [date]
Smith coal*	513.00	1023.00 9/29/2005	n/a	n/a	-308.20	314.70 3/20/2013
Big George/ Smith coal*	469.20	832.20 2/2/2012	n/a	n/a	-363.00	338.20 7/31/2012

*Last reliable measurement 2/2/2012

Production Statistics

Production data were analyzed for CBNG wells within the buffer of the Coal Gulch monitoring well site from 2002-2013. Cumulative production for individual CBNG wells is displayed by location on Figure A.88. CBNG and water production are monitored in the Wyodak Rider, multiple and in unmonitored coal zone wells.

Water production in the Wyodak Rider coal zone began in August 2003, peaked in October 2006 at 128,873 bbls; 45,066 bbls were produced in December 2013. Gas production in the Wyodak Rider coal zone began in February 2008 and peaked in October 2013 at 172,871 Mcf (Figure A.88).

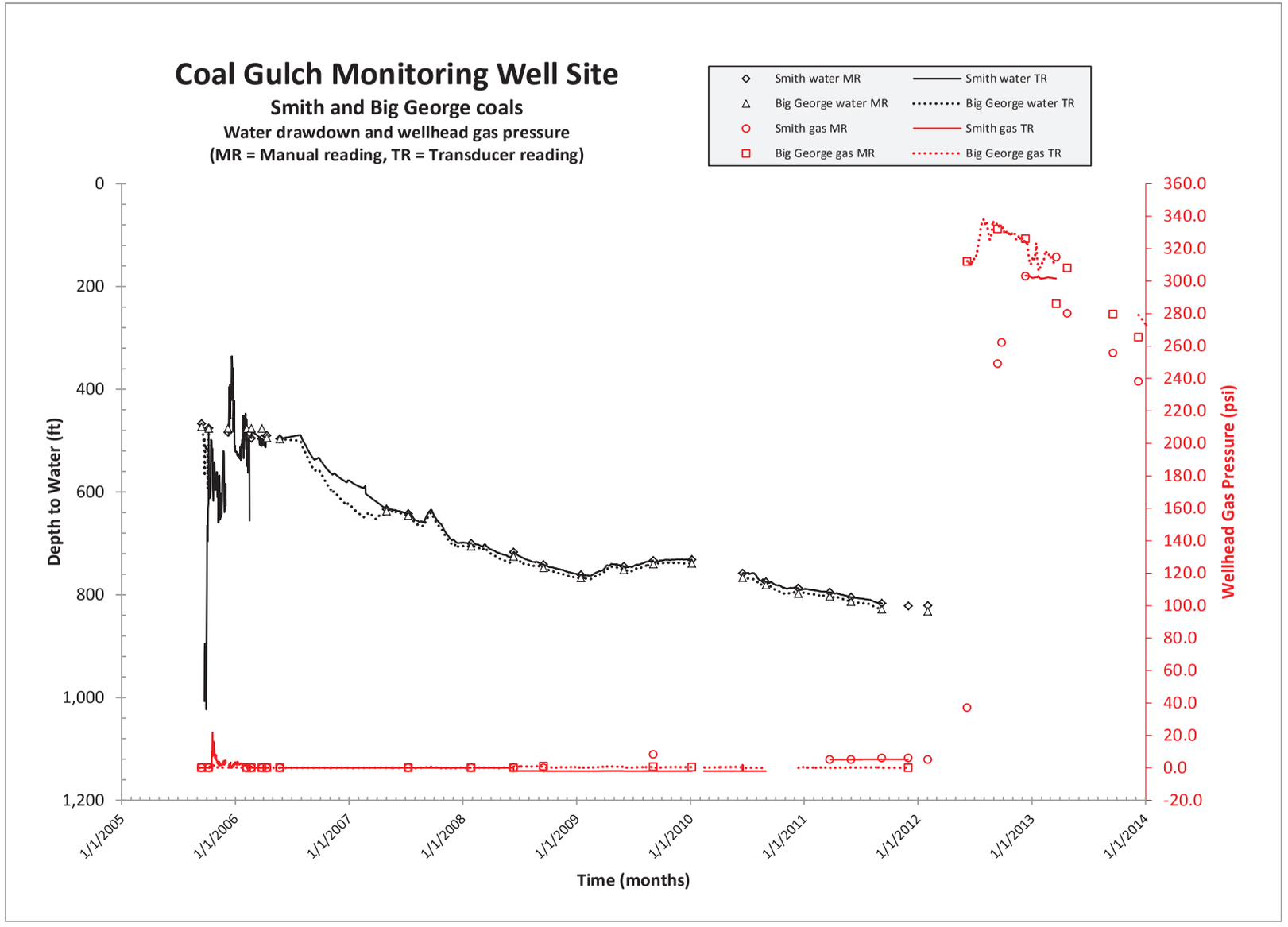

Figure A.87. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored intervals at the Coal Gulch monitoring well site location.

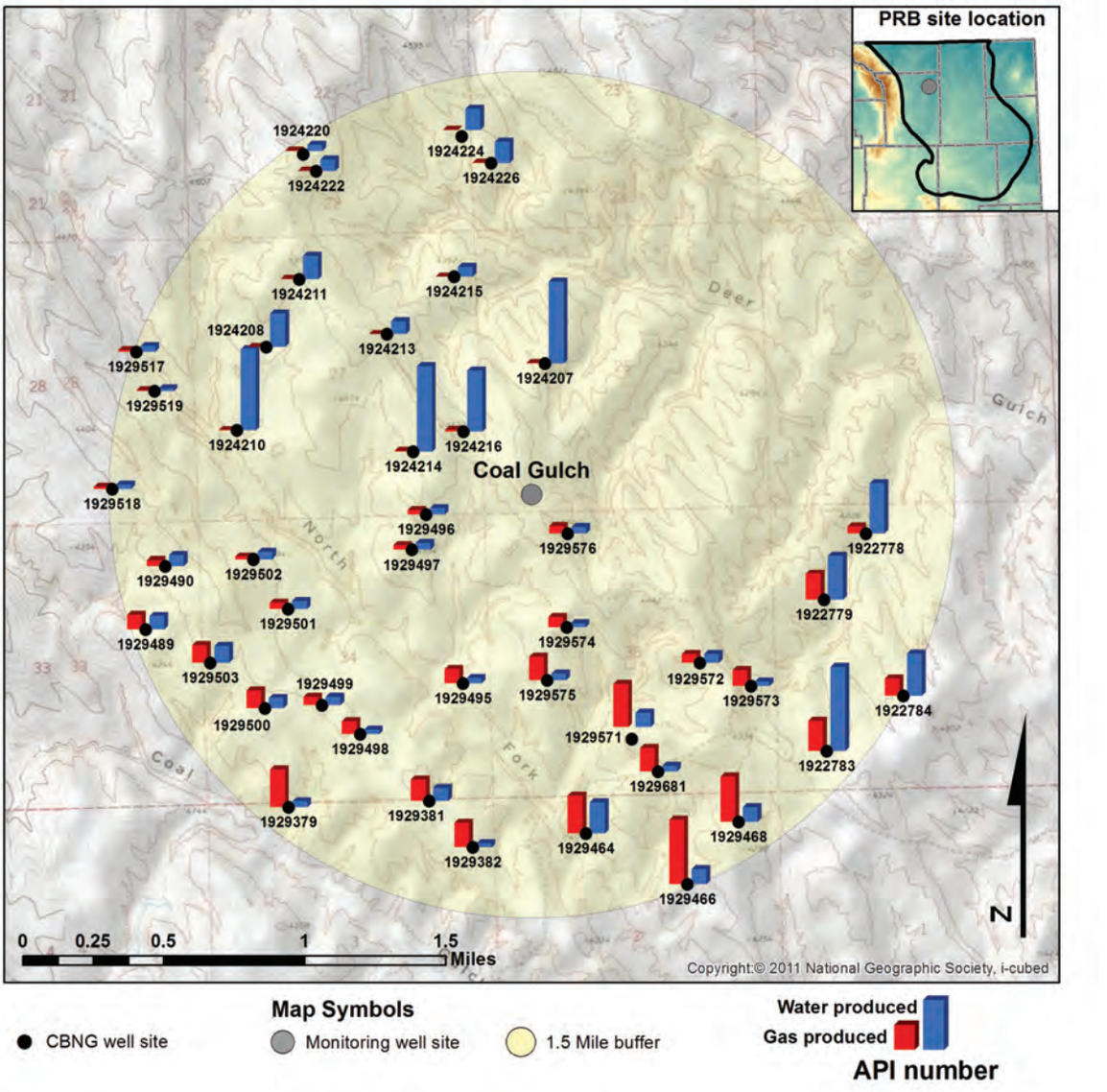

Figure A.88. Coal Gulch monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

Water production from multiple coal zone wells began in December 2011 and reached a peak value of 117,532 bbls in April 2013 (Figure A.89). Gas production in multiple zone wells began in December 2011 and peaked in December 2013 at 211,869 Mcf. Water and gas production rates will probably continue to increase into 2014.

Unmonitored coal zone wells have not produced recorded levels of water or gas during 2013 (Figure A.89).

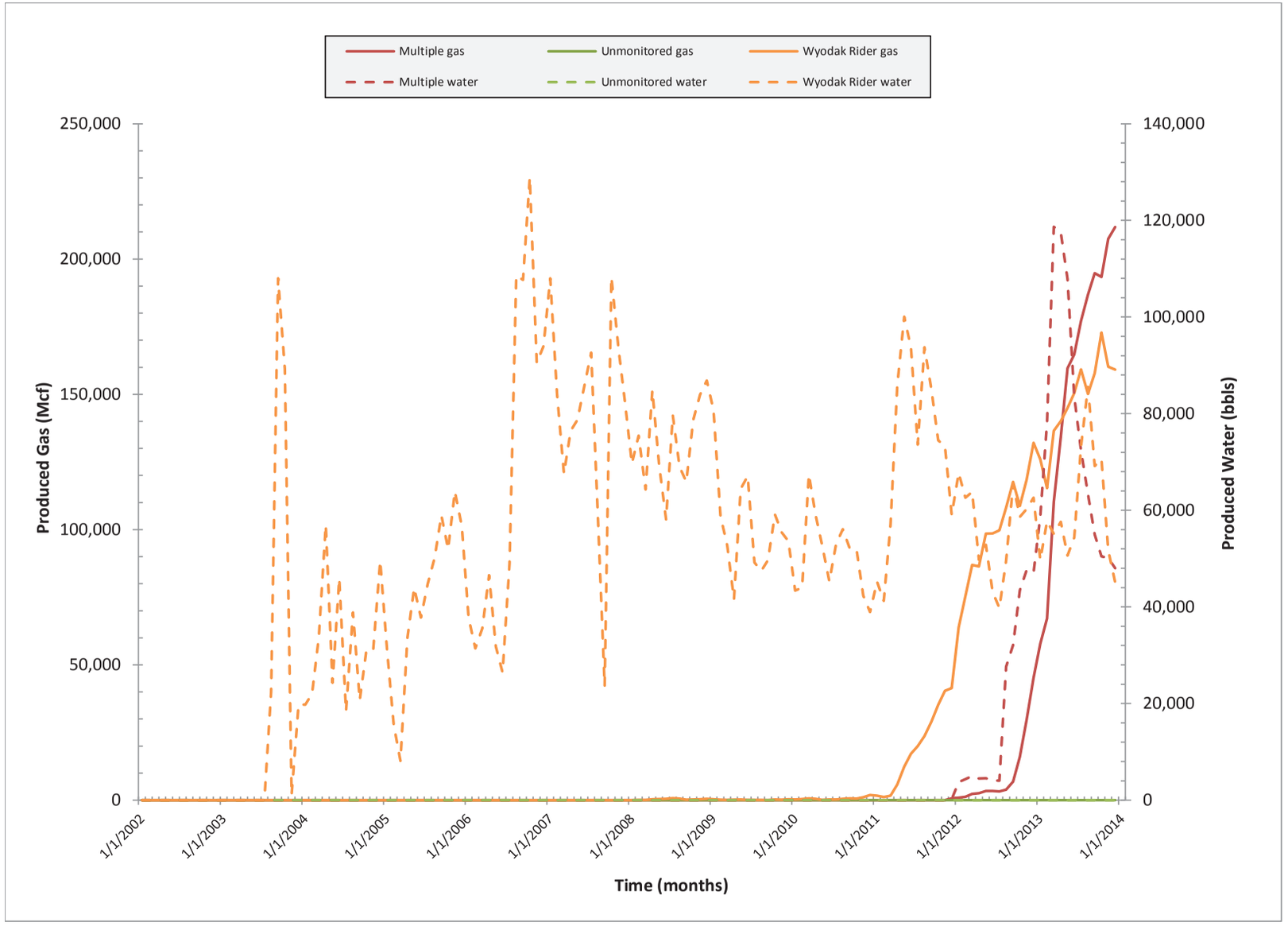

Figure A.89. Water and gas production from CBNG wells associated with the Coal Gulch monitoring well site location.

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 2013 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 2013, groundwater levels in the Wasatch sandstone rose 1.35 feet. In contrast, over the POR, groundwater levels declined 4.68 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 are unknown; the well was observed to be dry in November 2004 and remained dry through 2013. Over the monitoring period of 1999-2004 water levels declined a total of 317.40 feet (Figure A.91; Table A.45). A peak gas pressure of 92.6 psi was recorded in February 2000.

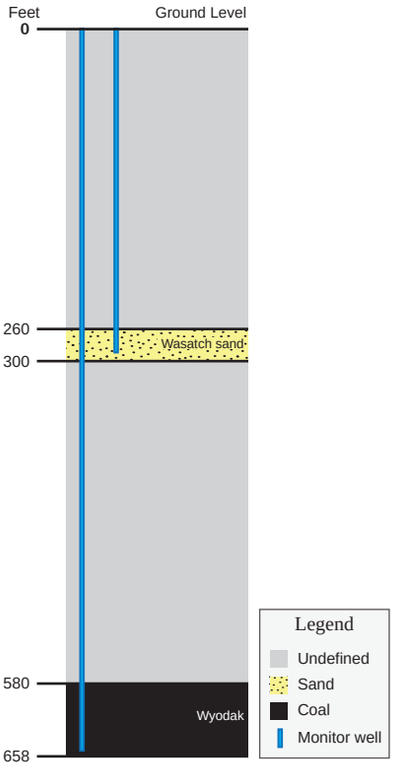

Figure A.90. Section showing relative positions of coal and sand in feet. Not to scale.

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

Monitored interval	Interval characteristics			
	Depth of interval (ft)		Interval 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, water level changes for current monitoring period, water level changes for period of record, and maximum gas pressure.

Monitored interval	DGW - Depth to groundwater (ft), water level (ft), and gas pressure (psi) data					
	Initial DGW	Max DGW [Date]	Final 2013 DGW	Water level change 2013	Net water level change	Max. gas pressure [date]
Shallow sand	119.80	126.40 10/26/2008	124.48	1.35	-4.68	n/a
Wyodak coal*	340.60	658.00 11/9/2004	658.00	n/a	-317.40	92.56 2/9/2000

*Well dry to total depth 11/9/2004

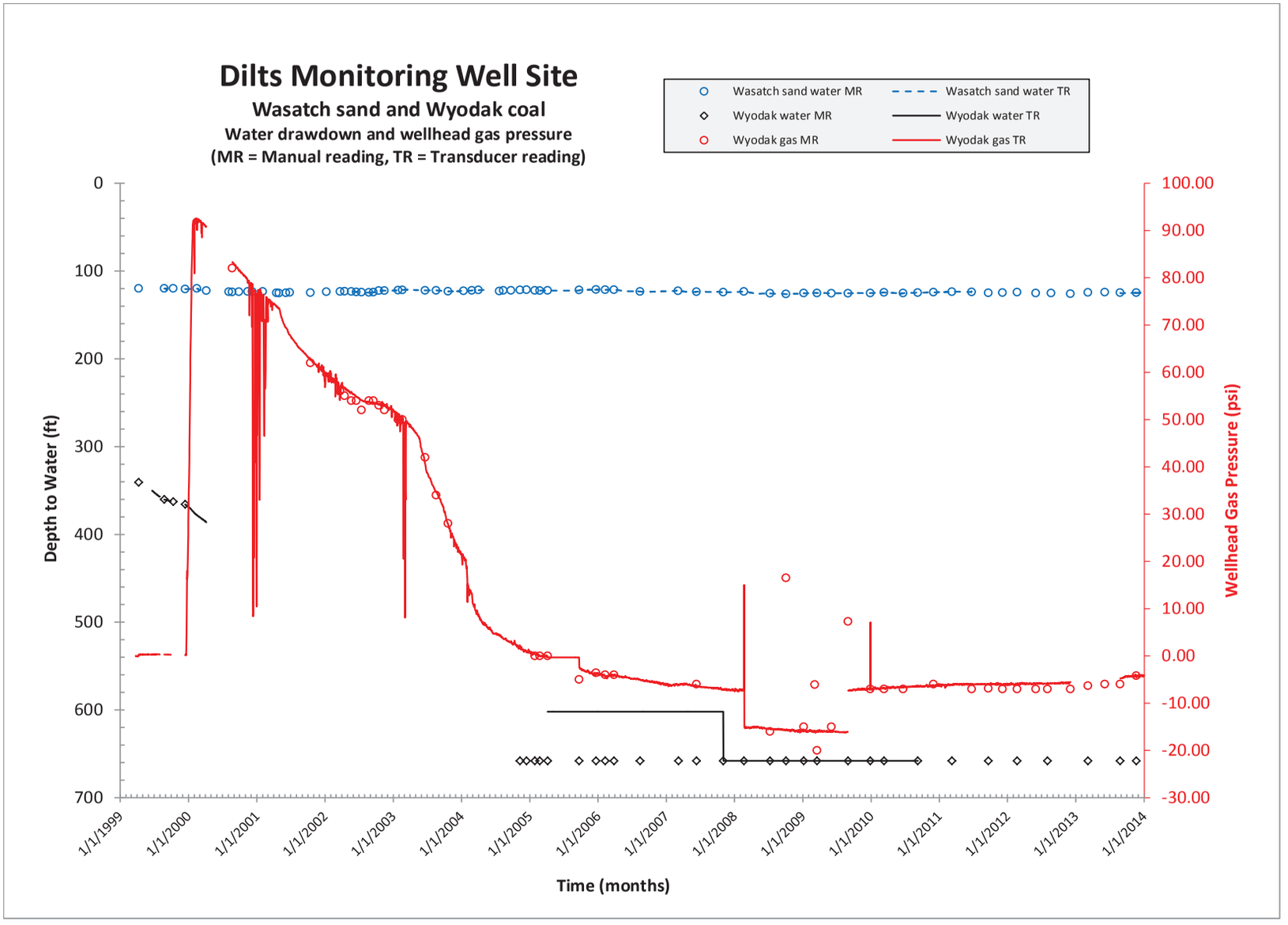

Figure A.91. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored intervals at the Dilts monitoring well site location.

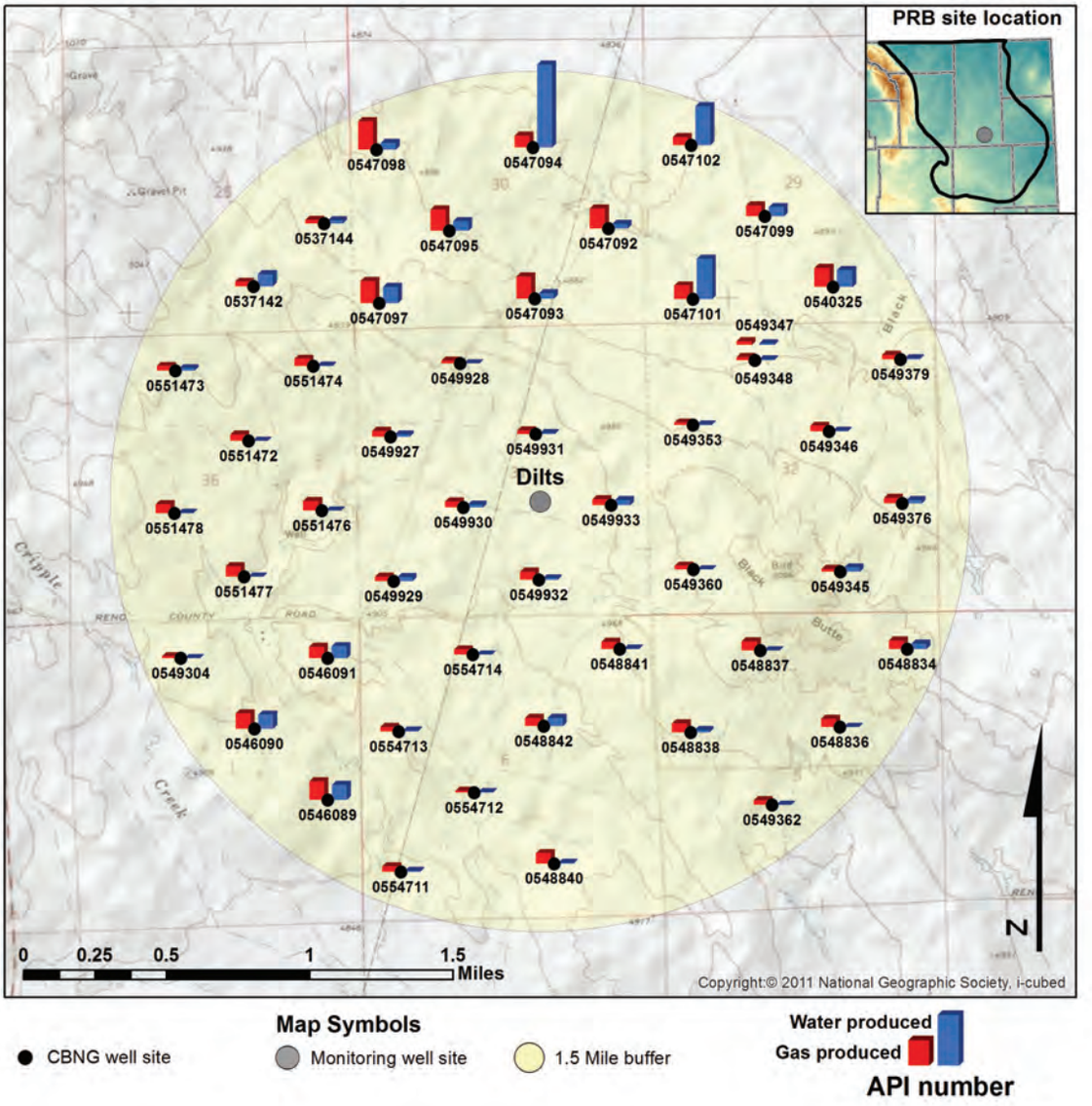

Figure A.92. Dilts monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

Production Statistics

Production data were analyzed for CBNG wells within the buffer of the Dilts monitoring well site from 2000-2013. 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; and declined to 5,101 bbls during June 2013; water production ceased in July 2013. Gas production in the Wyodak Rider coal zone began in May 2001 and peaked in March 2004 at 407,188 Mcf (Figure A.93) and ceased in June 2013.

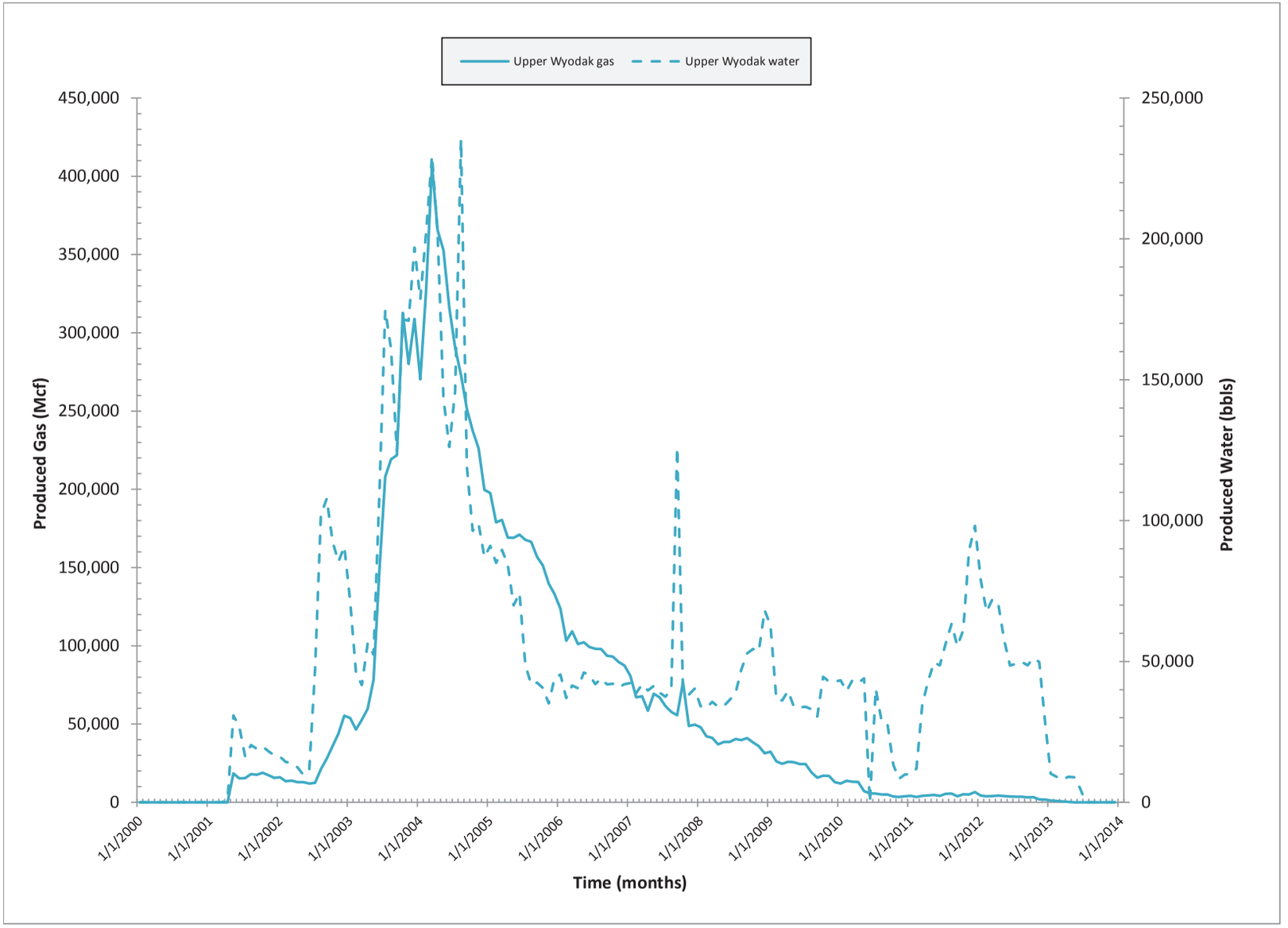

Figure A.93. Water and gas production from CBNG wells associated with the Dilts monitoring well site location.

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 2013 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 2013, groundwater levels in the Big George coal declined 77.07 feet. Over the 2002 – 2013 monitoring period prior to 2013, groundwater levels declined 672.09 feet from initial static water levels (Figure A.95; Table A.47). A peak gas pressure of 1.2 psi was recorded in February 2003.

Wyodak Coal

Groundwater levels declined 18.44 feet during 2013. Water levels declined a total of 347.76 feet (Figure A.95; Table A.47) over the 2002 – 2013 POR. A peak gas pressure of 0.5 psi was recorded in June 2003.

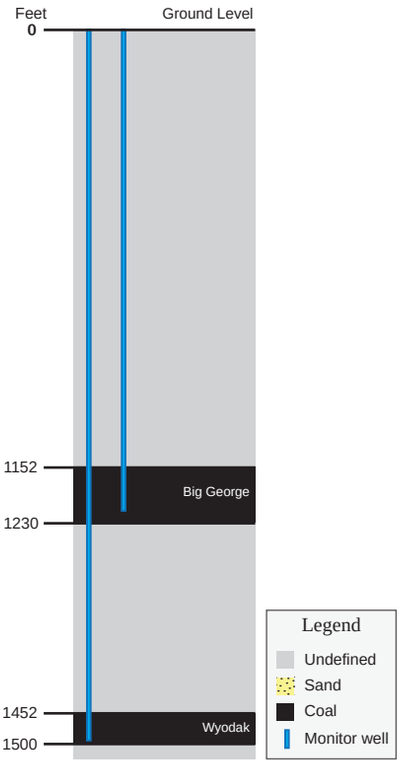

Figure A.94. Section showing relative positions of coals in feet. Not to scale.

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

Monitored interval	Interval characteristics			
	Depth of interval (ft)		Interval 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, water level changes for current monitoring period, water level changes for period of record, and maximum gas pressure.

Monitored interval	DGW - Depth to groundwater (ft), water level (ft), and gas pressure (psi) data					
	Initial DGW	Max DGW [Date]	Final 2013 DGW	Water level change 2013	Net water level change	Max. gas pressure [date]
Big George coal	294.61	969.30 10/10/2013	966.70	-77.07	-672.09	1.21 2/19/2003
Wyodak coal	148.86	522.60 12/16/2013	522.62	-18.44	-373.76	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 2013. 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 coal zone wells.

Water production rates in the Wyodak Rider peaked in May 2003 at 488,410 bbls; production has declined steadily since then and finished 2013 at 38,122 bbls/month. Consistent gas production in the Wyodak Rider coal zone began in 2004, peaked in December 2010 at 79,402 Mcf (Figure A.97). Gas production levels have declined to 30,395 Mcf by December 2013.

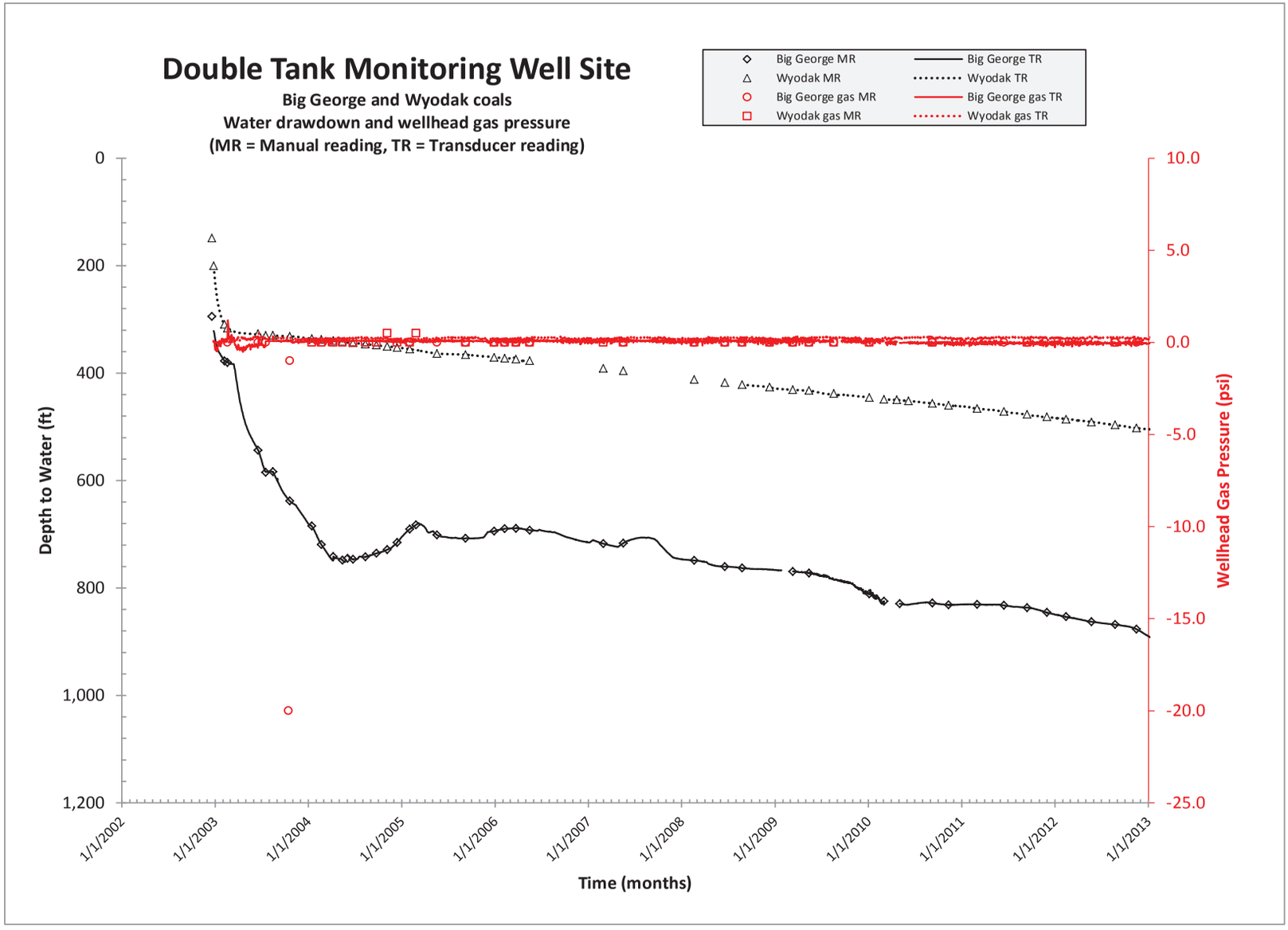

Figure A.95. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored intervals at the Double Tank monitoring well site location.

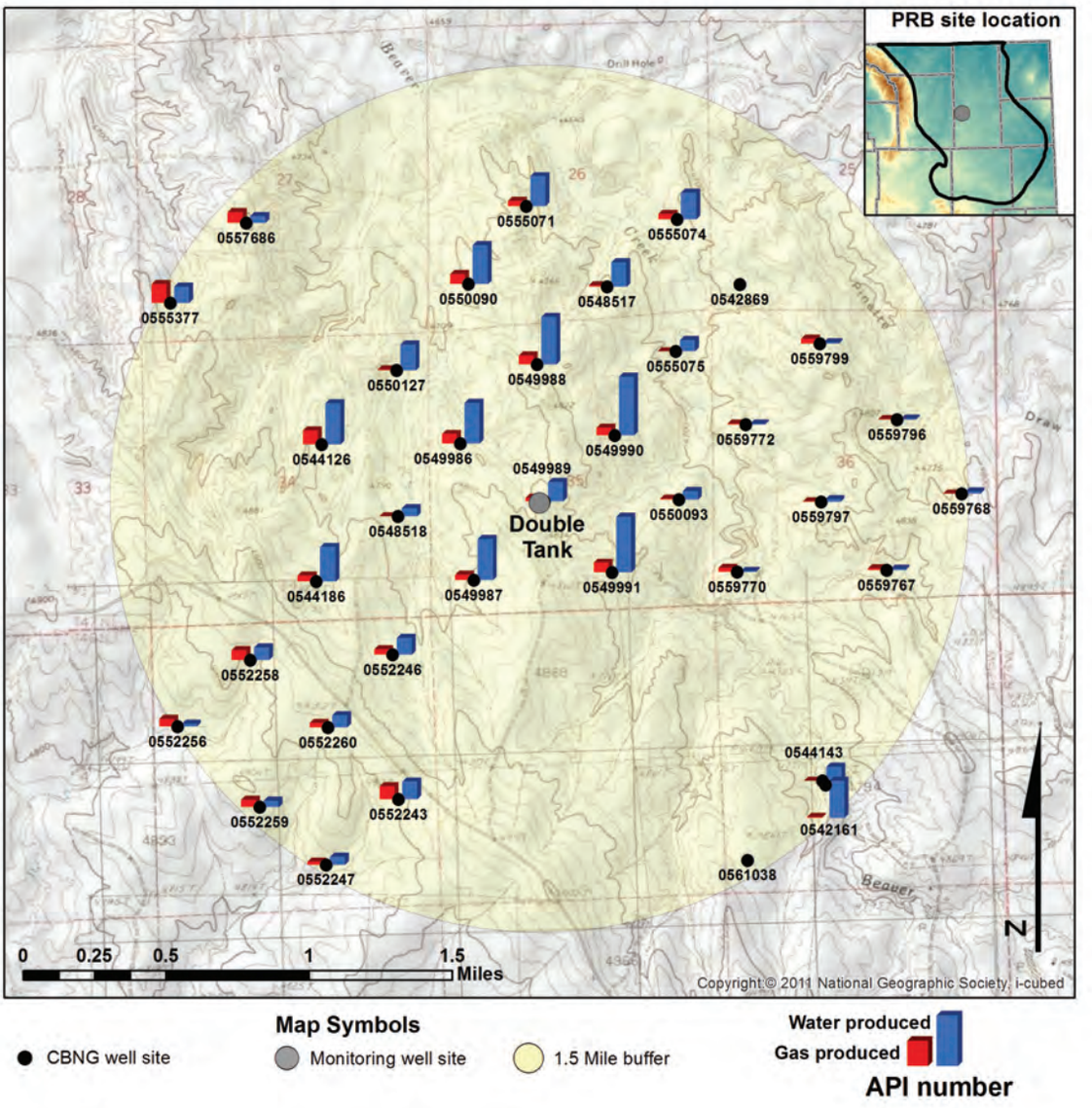

Figure A.96. Double Tank monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

Water production 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 2002-2013. Gas production has been recorded in only three months over 2010-2013, and peak production reached in January 2005, was only 42 Mcf. (Figure A.97).

Consistent water production in unmonitored coal zone wells began in 2005 and peaked at 4,804 bbls in June 2005. Gas production reached a peak level of 3,152 Mcf in December 2009 and continued at low levels through 2013 (<1300 Mcf/month) (Figure A.97).

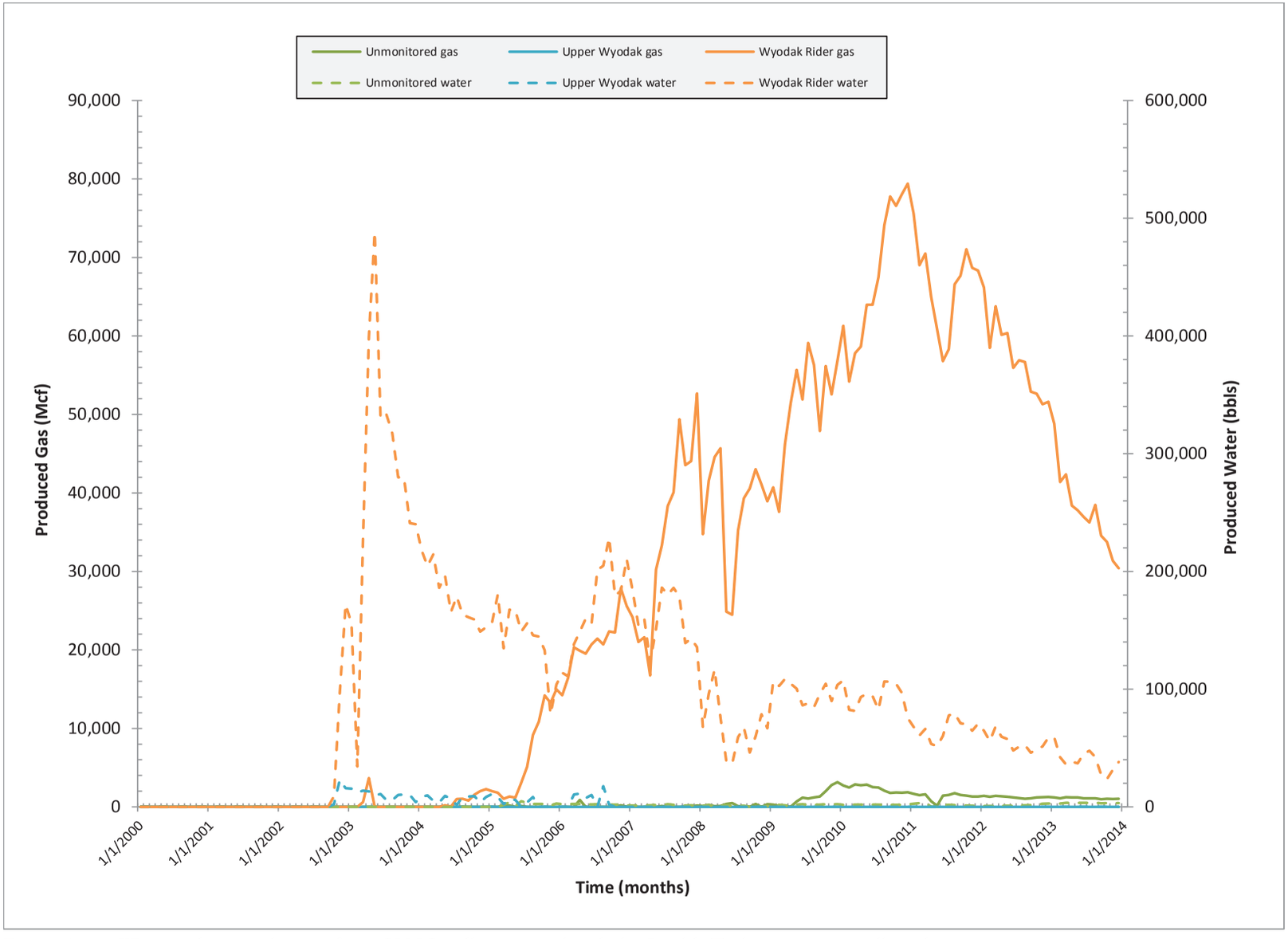

Figure A.97. Water and gas production from CBNG wells associated with the Double Tank monitoring well site location.

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 a Wasatch sandstone (Figure A.98; Table A.48). Water levels were measured during 2013 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 2013, groundwater levels in the Wasatch sandstone declined 0.31 feet. In contrast, over the monitoring period of 1999-2013, groundwater levels declined 1.73 feet from initial static water levels (Figure A.99; Table A.49). Gas pressure was not recorded in the Wasatch sandstone.

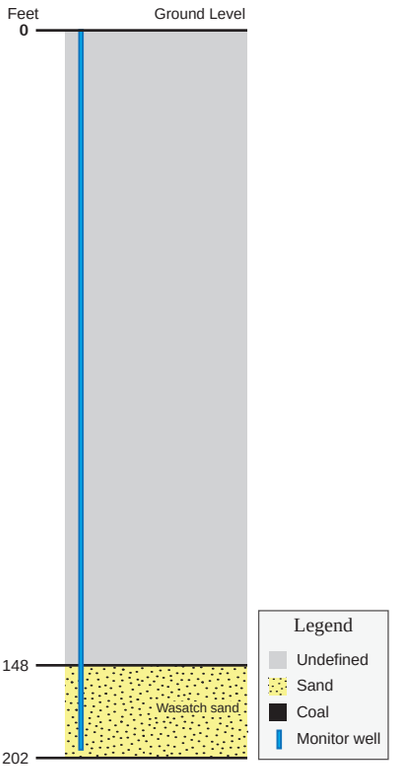

Figure A.98. Section showing relative position of sand in feet. Not to scale.

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

Monitored interval	Interval characteristics			
	Depth of interval (ft)		Interval 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, water level changes for current monitoring period, water level changes for period of record, and maximum gas pressure.

Monitored interval	DGW - Depth to groundwater (ft), water level (ft), and gas pressure (psi) data					
	Initial DGW	Max DGW [Date]	Final 2013 DGW	Water level change 2013	Net water level change	Max. gas pressure [date]
Wasatch sand	93.80	96.50 12/16/2013	95.53	-0.31	-1.73	n/a

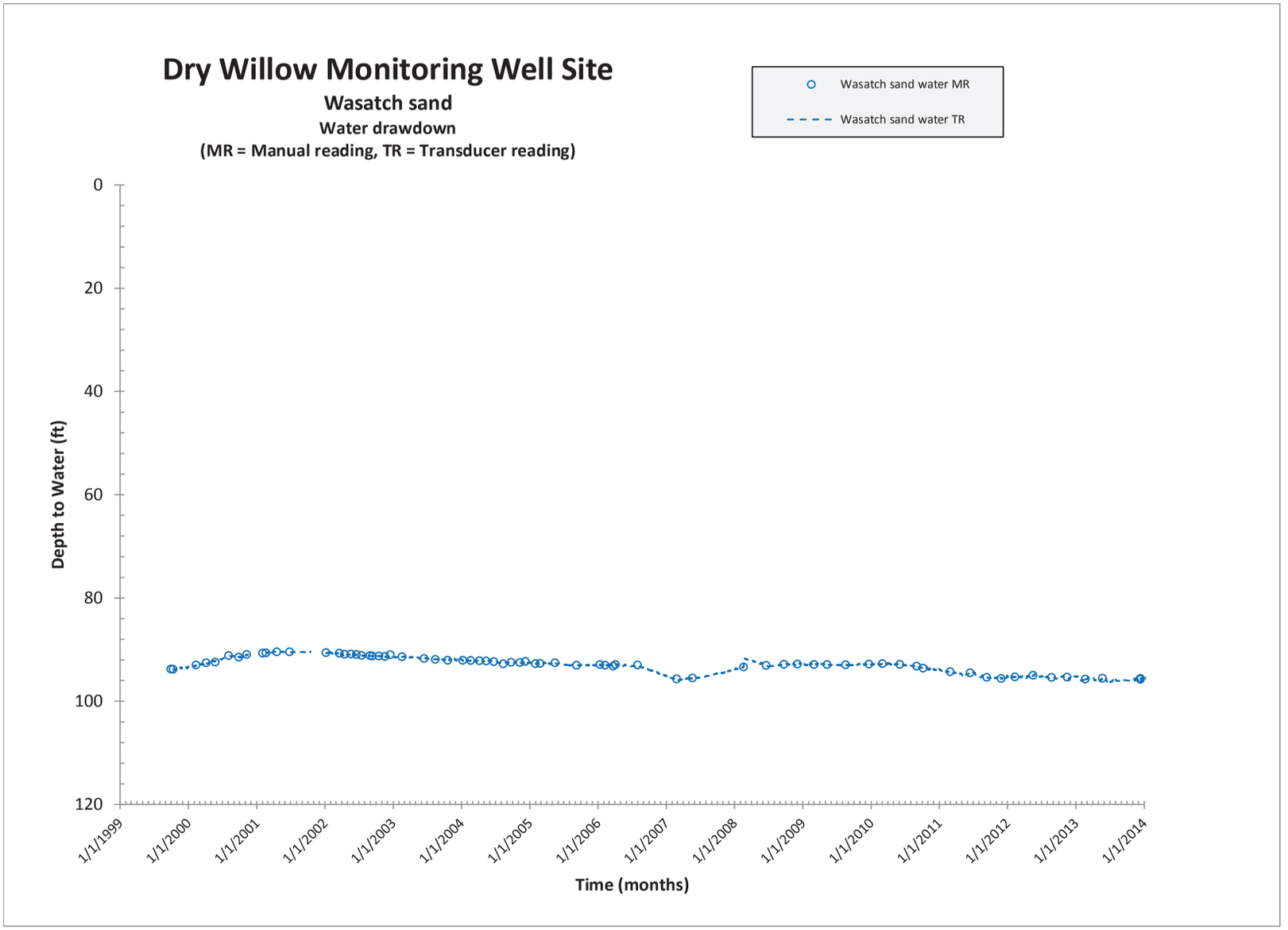

Figure A.99. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored intervals at the Dry Willow monitoring well site location.

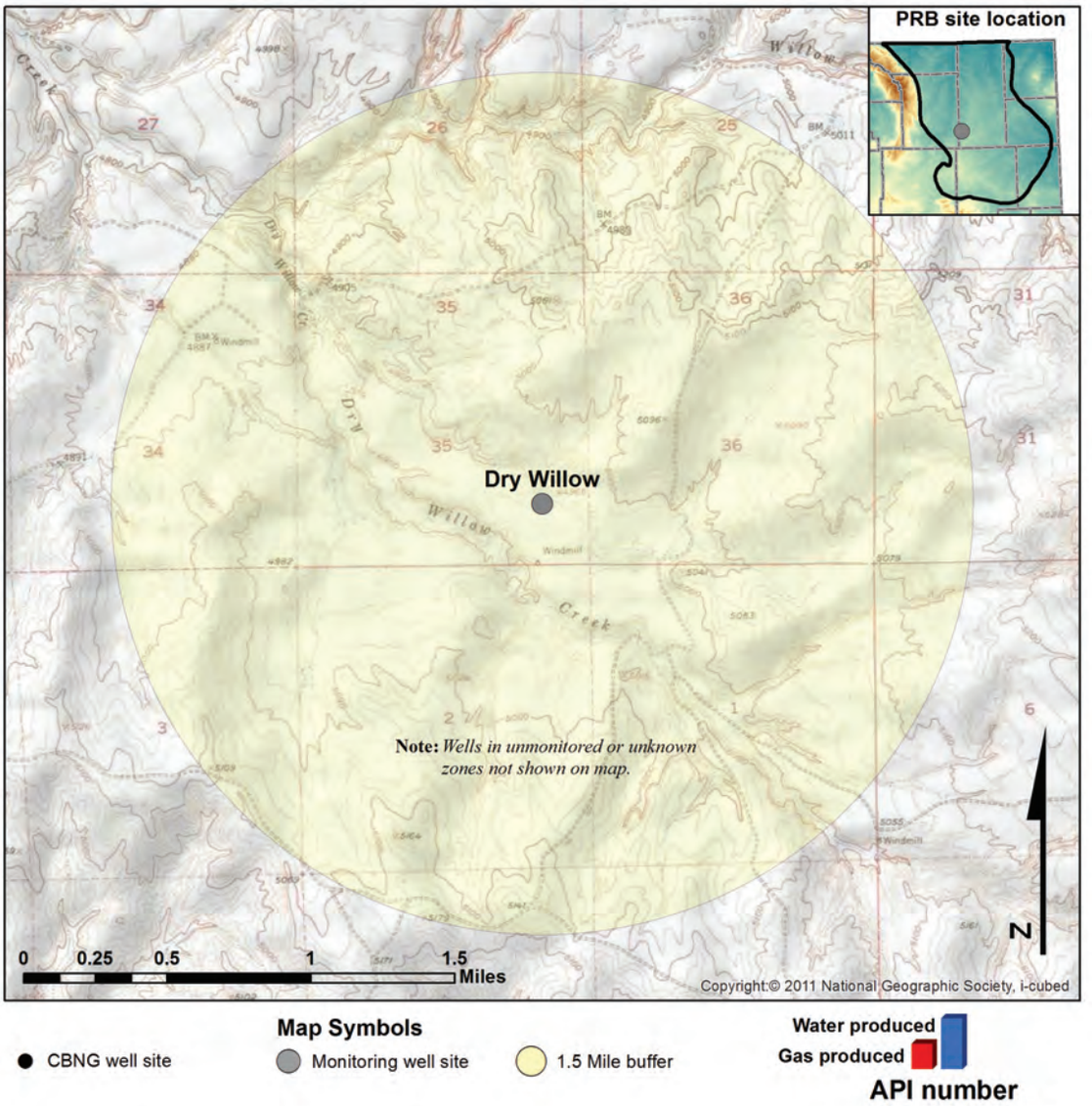

Figure A.100. Dry Willow monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

Production Statistics

Production data were analyzed for CBNG wells within the buffer of the Dry Willow monitoring well site from 1999-2013. 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, peaked at 836,123 bbls in October 2008 and declined to 58,083 bbls by December 2013. Significant gas production (>25,000 Mcf/month) began in May 2009 and reached a peak level of 236,689 Mcf in January 2012.

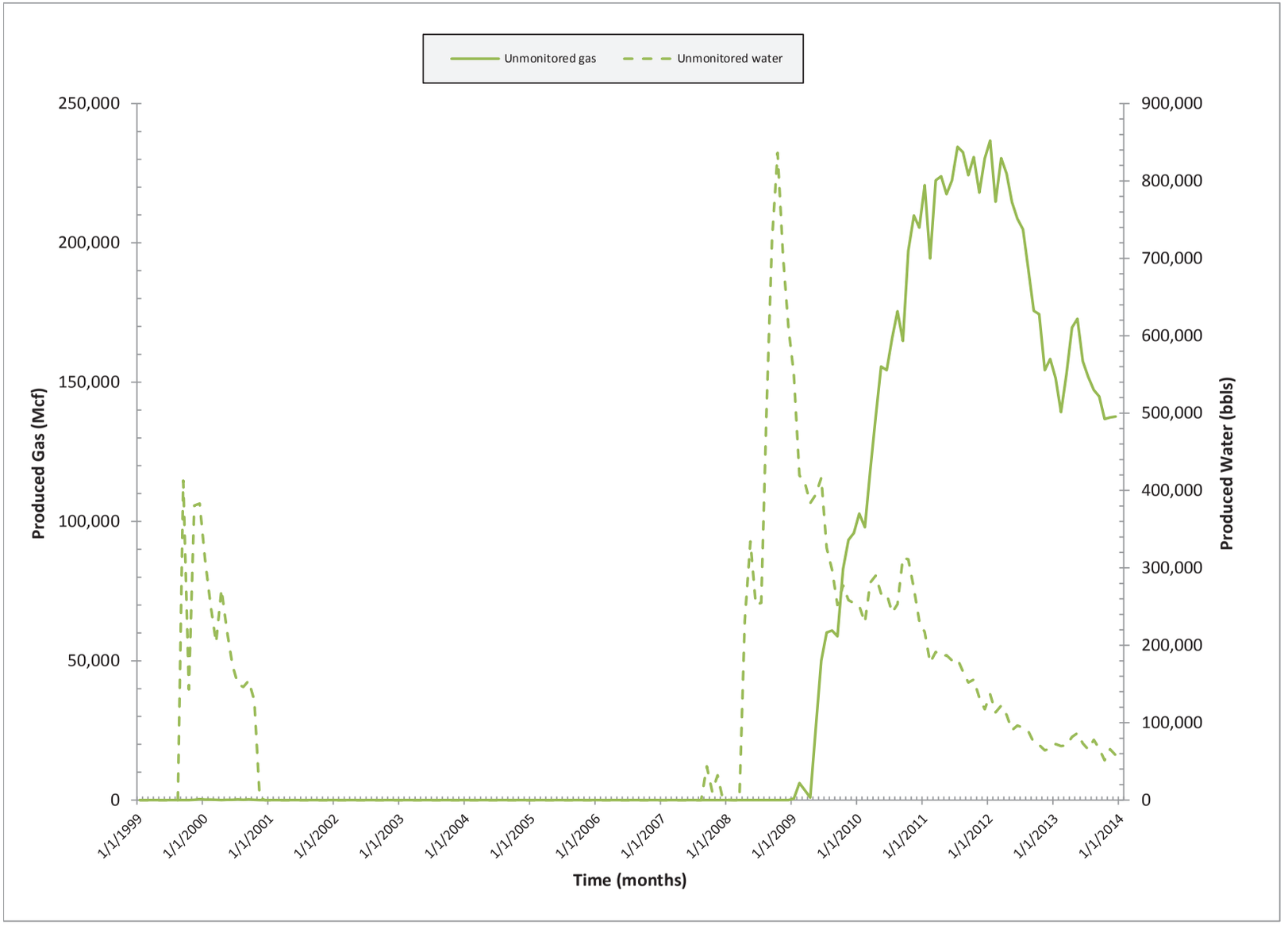

Figure A.101. Water and gas production from CBNG wells associated with the Dry Willow monitoring well site location.

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 not measured at this site during 2013.

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 >0 feet (artesian flow) and a low of 19.72 feet (Figure A.103; Table A.51). 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

There is no groundwater level data for this well in 2013. The last measurement was taken in November 2012. Over the monitoring period of 2005-2012 water levels rose a total of 5.00 feet (Figure A.104; Table A.51). A peak gas pressure of 4.8 psi was recorded in March 2010. The well was plugged and abandoned on November 28, 2012 and will no longer be used as a monitoring site.

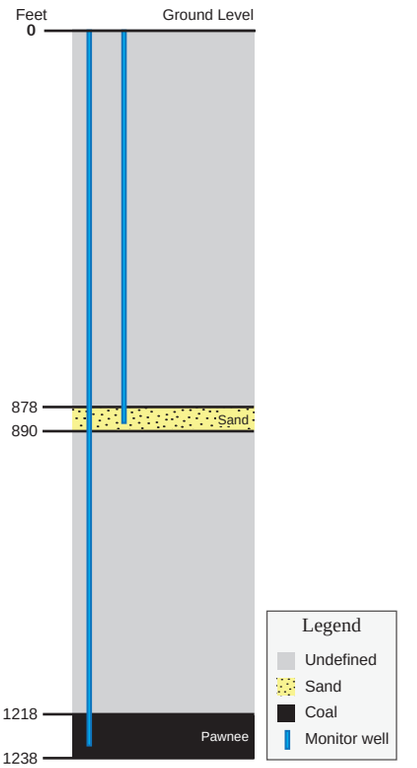

Figure A.102. Section showing relative positions of coal and sand in feet. Not to scale.

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

Monitored interval	Interval characteristics			
	Depth of interval (ft)		Interval thickness (ft)	Separation from coal (ft)
	Top	Bottom		
Wasatch sand	878	890	12	328
Pawnee coal	1,218	1,238	20	n/a

Table A.51. Table showing depths to water from ground level, water level changes for current monitoring period, water level changes for period of record, and maximum gas pressure.

Monitored interval	DGW - Depth to groundwater (ft), water level (ft), and gas pressure (psi) data					
	Initial DGW	Max DGW [Date]	Final 2013 DGW	Water level change 2013	Net water level change	Max. gas pressure [date]
Wasatch sand*	n/a	19.70 3/9/2006	n/a	n/a	0.00	n/a
Pawnee coal**	20.00	41.80 4/28/2009	n/a	n/a	5.00	4.39 3/13/2010

*Well flowing artesian, returned to landowner 11/28/2012

**Well plugged and abandoned 11/28/2012

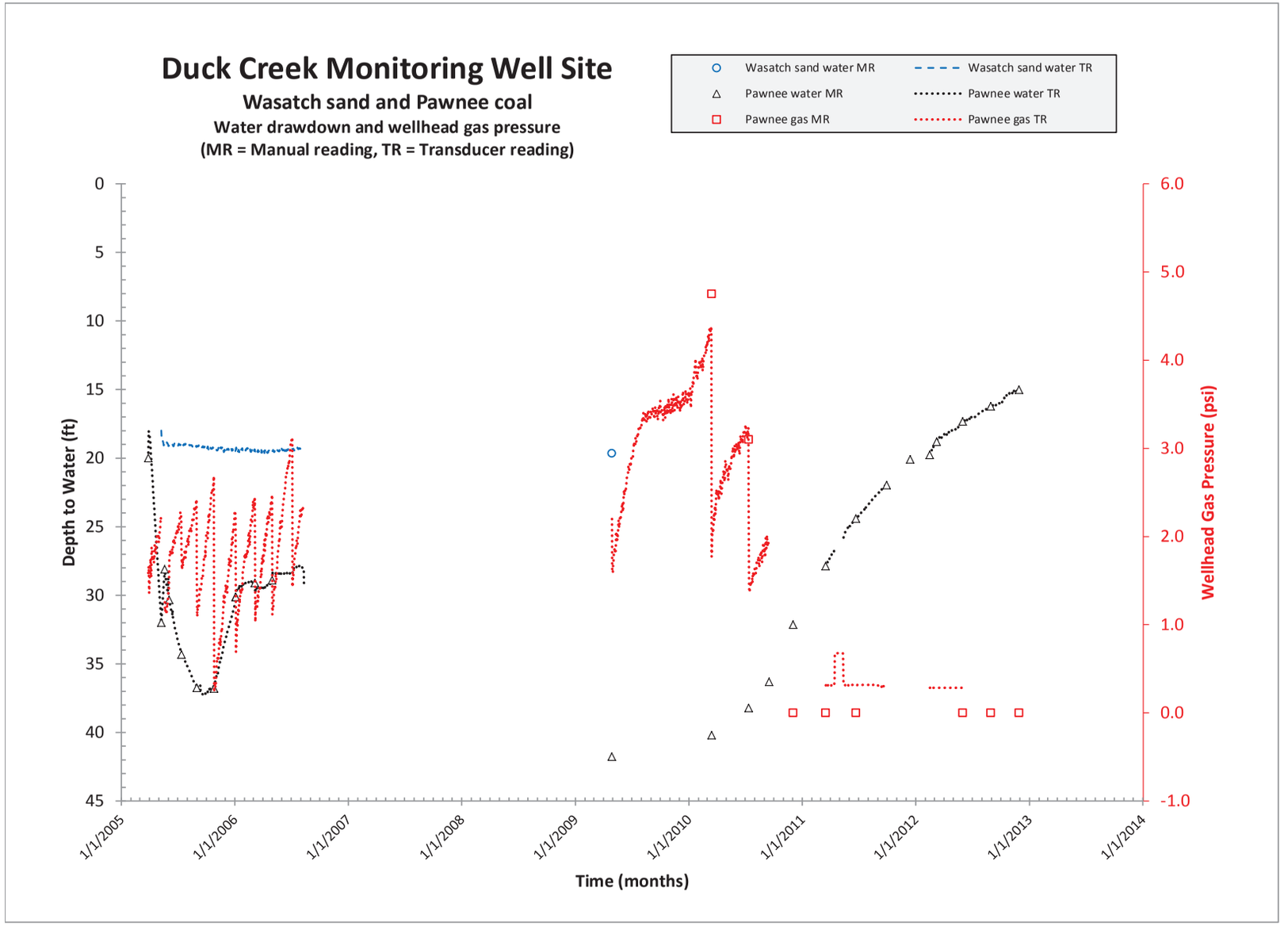

Figure A.103. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored intervals at the Duck Creek monitoring well site location.

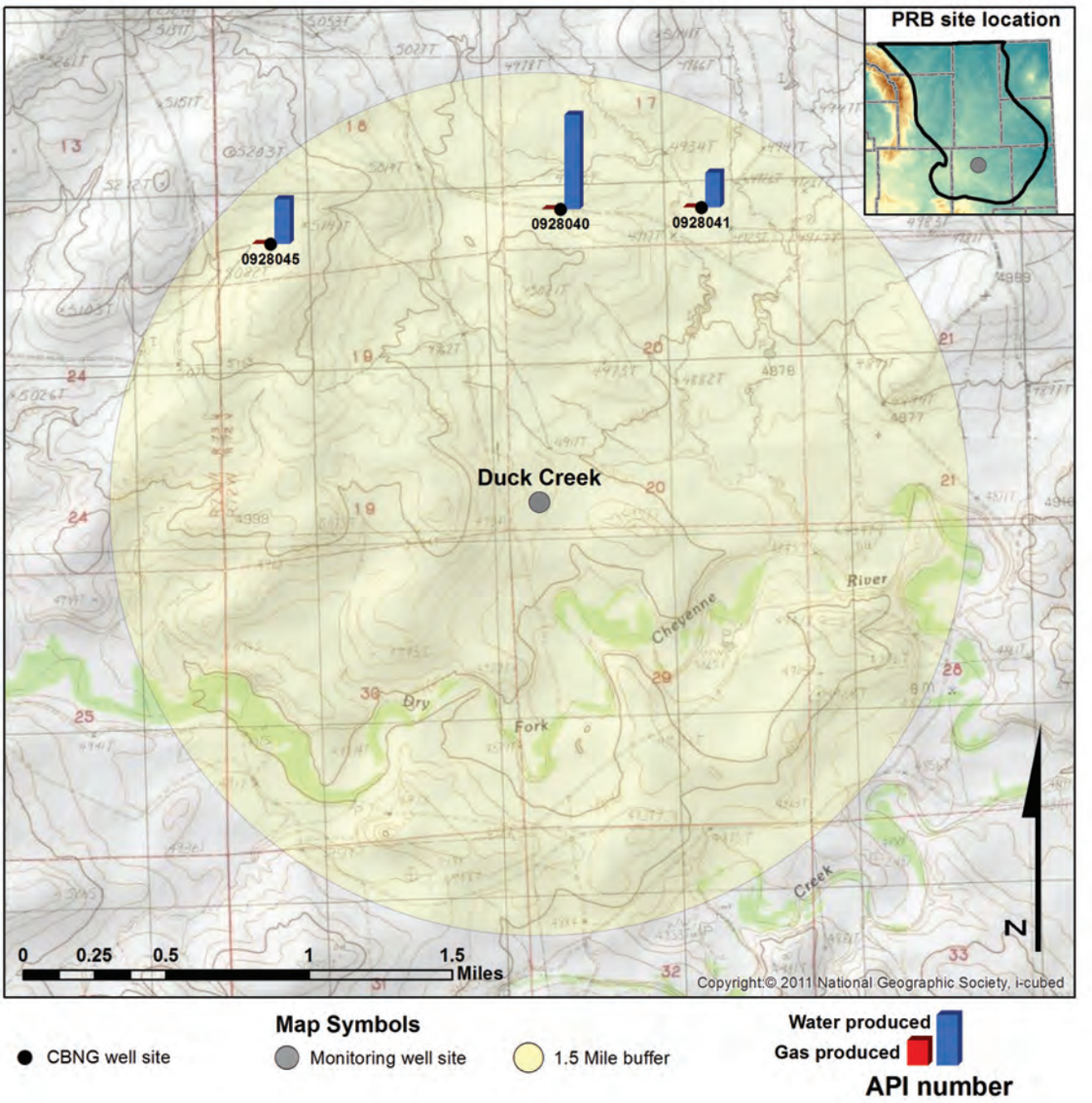

Figure A.104. Duck Creek monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

Production Statistics

Production data were analyzed for CBNG wells within the buffer of the Duck Creek monitoring well site from 2006-2013. Cumulative production for individual CBNG wells is displayed by location on Figure A.104. CBNG and water production are monitored in 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).

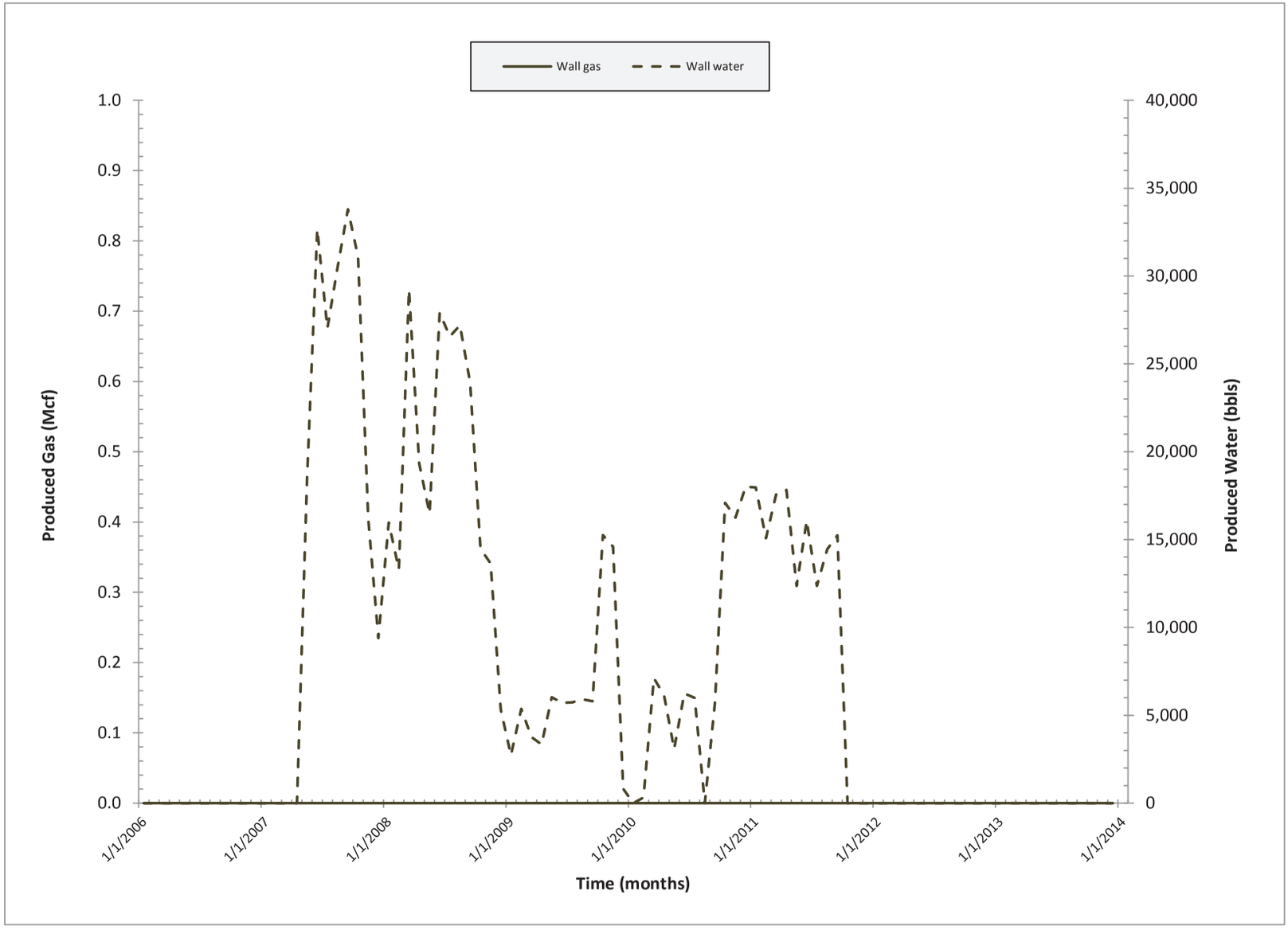

Figure A.105. Water and gas production from CBNG wells associated with the Duck Creek monitoring well site location.

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 in a Wasatch sandstone and the other in the Wyodak coal of the Upper Wyodak coal zone (Figure A.106; Table A.52). Water levels and wellhead gas pressures were measured during 2013 using a combination of 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 2013, groundwater levels in the Wasatch sandstone declined 1.49 feet. In contrast, over the 1997 - 2013 POR, groundwater levels declined 80.82 feet from initial static water levels (Figure A.107; Table A.52). Gas pressure was not recorded in the Wasatch sandstone.

Wyodak Coal

This monitoring well was observed to be dry to its total depth in March 2007 and has remained dry since. Over the monitoring period of 1997-2007 water levels declined a total of 244.85 feet (Figure A.107; Table A.52). A peak gas pressure of 83.7 psi was recorded in June 1999.

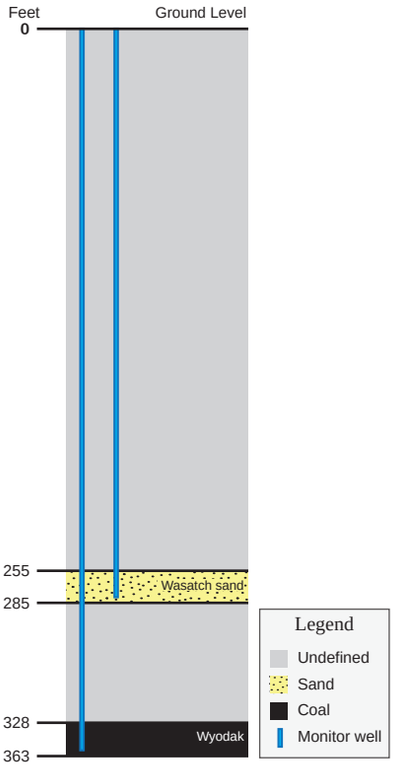

Figure A.106. Section showing relative positions of coal and sand in feet. Not to scale.

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

Monitored interval	Interval characteristics			
	Depth of interval (ft)		Interval 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, water level changes for current monitoring period, water level changes for period of record, and maximum gas pressure.

Monitored interval	DGW - Depth to groundwater (ft), water level (ft), and gas pressure (psi) data					
	Initial DGW	Max DGW [Date]	Final 2013 DGW	Water level change 2013	Net water level change	Max. gas pressure [date]
Wasatch sand	96.20	177.00 12/31/2013	177.02	-1.49	-80.82	n/a
Wyodak coal*	118.15	517.30 4/2/2006	367.00	n/a	244.85	83.67 6/8/1999

*Well dry to total depth 3/7/2007

Production Statistics

Production data were analyzed for CBNG wells within the buffer of the Durham Ranch Sec 6 monitoring well site from 1998-2013. Cumulative production for individual CBNG wells is displayed by location on Figure A.108. CBNG and water production are monitored in Upper Wyodak, multiple, unmonitored, and unknown coal zone wells.

Water production in the Wyodak coal zone began in May 1999, peaked in April 2001 at 439,913 bbls; there has been no water production since November 2011. Gas production began in July 1999 and peaked at 184,201 Mcf in May 2002; there has been no gas production since June 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 since July 2011 (Figure A.109).

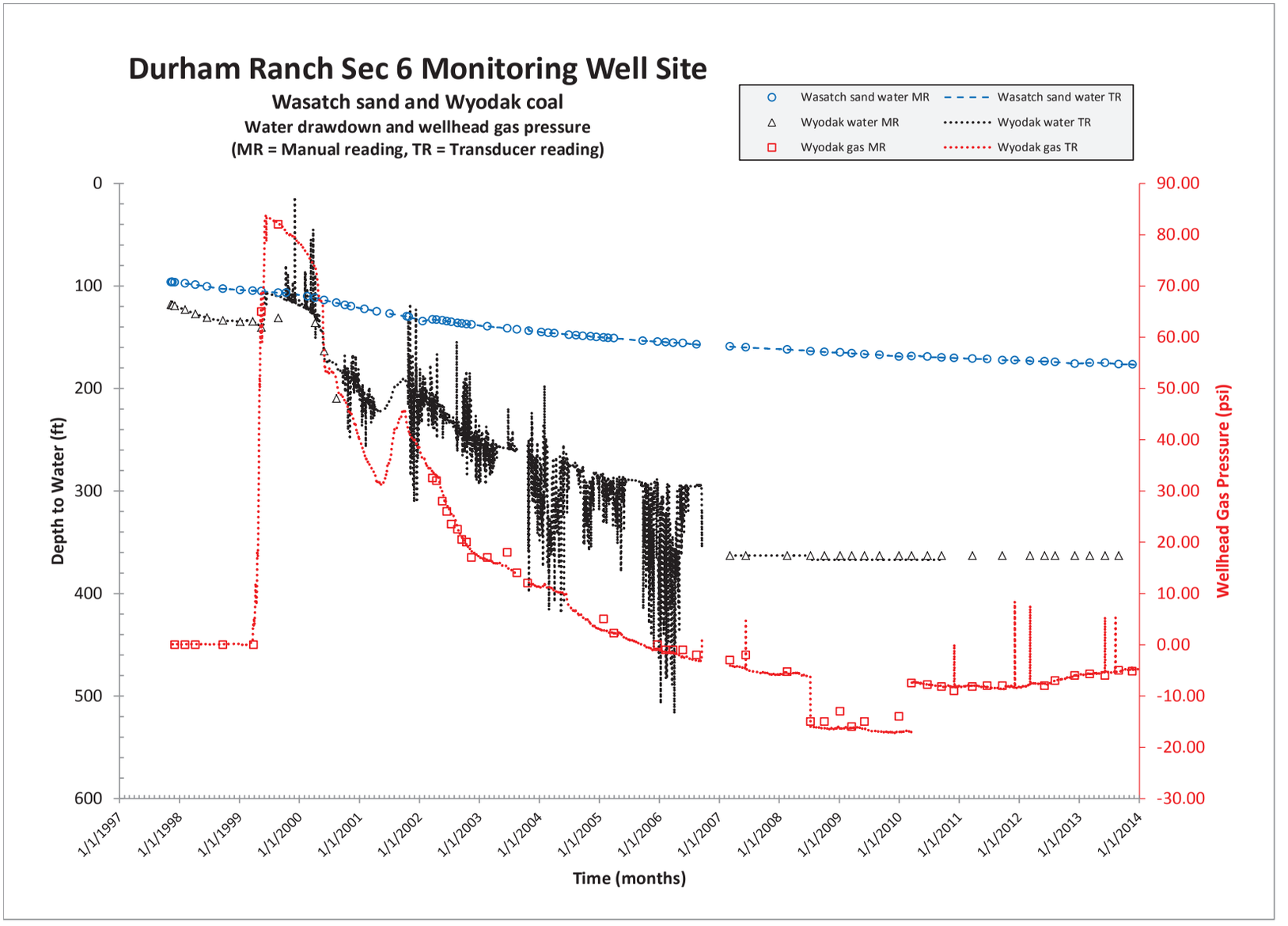

Figure A.107. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored intervals at the Durham Ranch Sec 6 monitoring well site location.

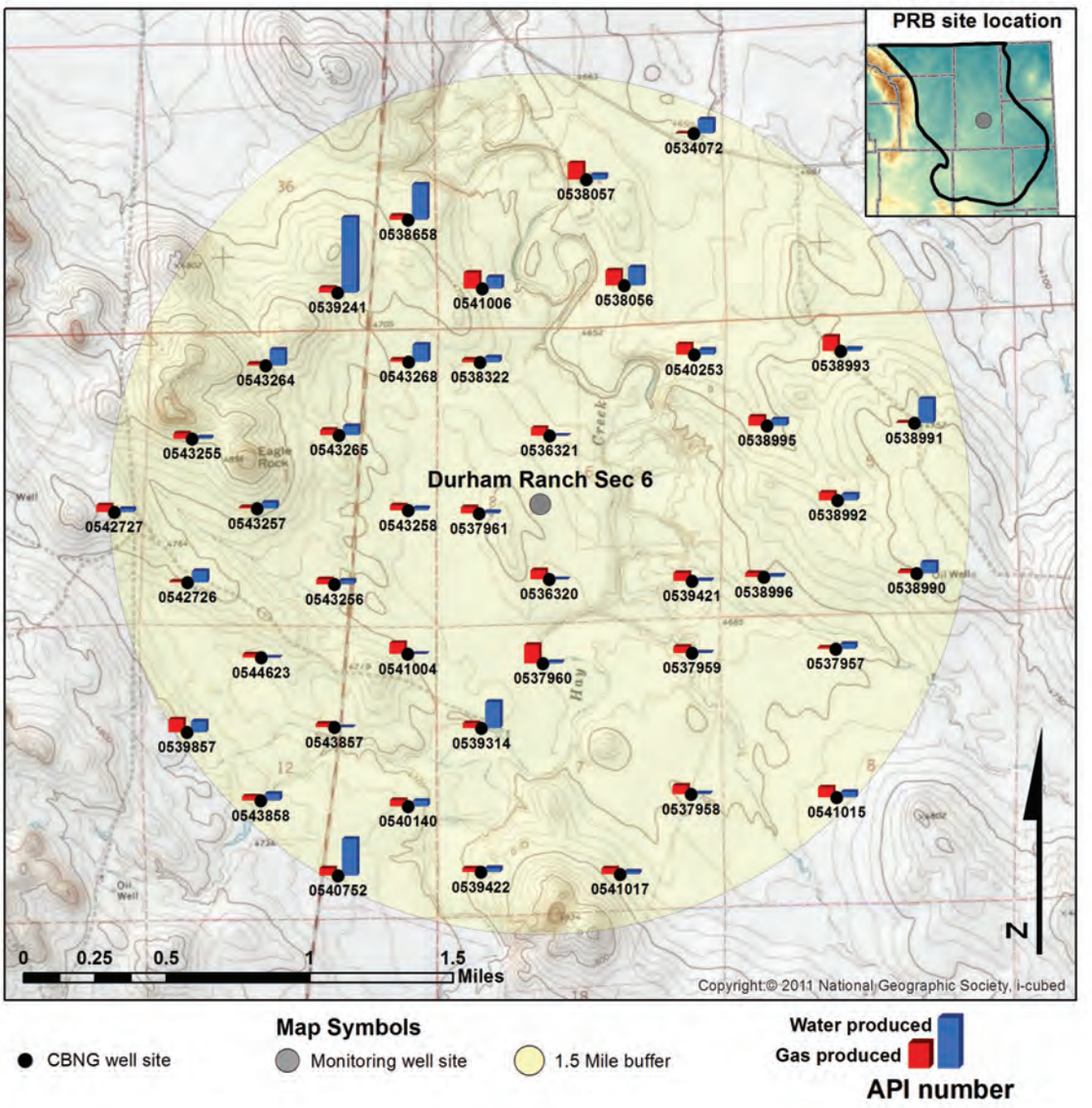

Figure A.108. Durham Ranch Sec 6 monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

Water production in unmonitored coal zone wells began in April 2000 and reached peak production in December 2002 at 153,752 bbls. Gas production also began in April 2000 and peaked in January 2003 at 61,901 Mcf; there has been no water or gas production since June 2012 (Figure A.109).

Water and gas production from unknown coal zones occurred during only two months (May and June 1999) with a maximum of 2,029 bbls of water and 54,514 Mcf being produced in June 1999.

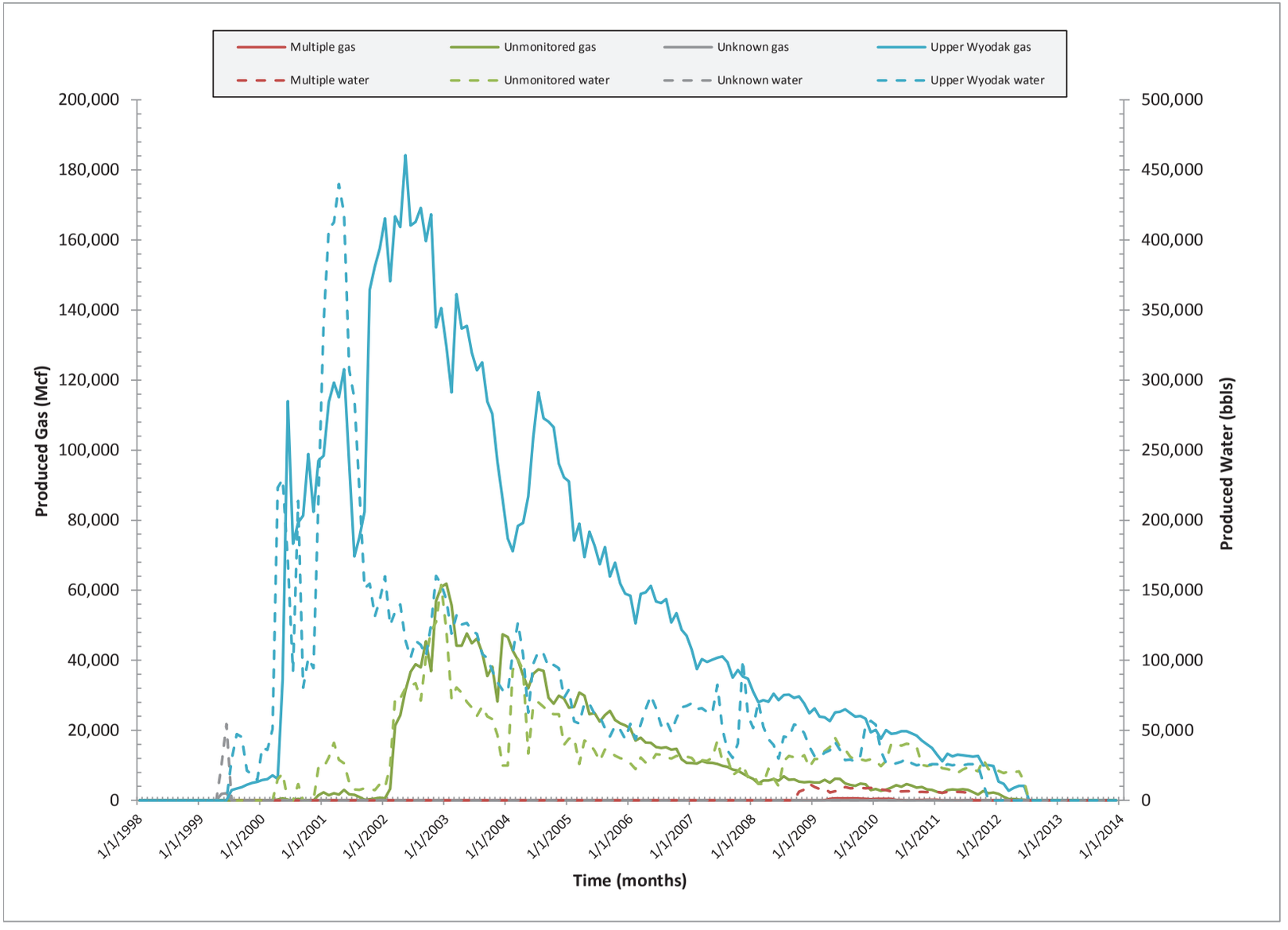

Figure A.109. Water and gas production from CBNG wells associated with the Durham Ranch Sec 6 monitoring well site location.

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 in a Wasatch sandstone and the other in the Wyodak coal of the Upper Wyodak coal zone (Figure A.110; Table A.54). Water levels and wellhead gas pressures were measured during 2013 using a combination of 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 2013, groundwater levels in the Wasatch sandstone declined 1.02 feet. In contrast, over the 1998 – 2013 POR, groundwater levels declined 24.40 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 34.73 feet during 2013. Over the monitoring period of 1998-2013 water levels declined a total of 335.58 feet (Figure A.111; Table A.55). A peak gas pressure of 28.09 psi was recorded in November 2002.

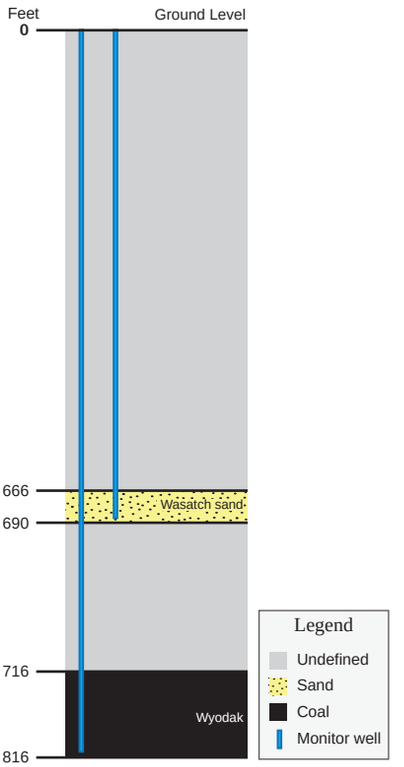

Figure A.110. Section showing relative positions of coal and sand in feet. Not to scale.

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

Monitored interval	Interval characteristics			
	Depth of interval (ft)		Interval 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, water level changes for current monitoring period, water level changes for period of record, and maximum gas pressure.

Monitored interval	DGW - Depth to groundwater (ft), water level (ft), and gas pressure (psi) data					
	Initial DGW	Max DGW [Date]	Final 2013 DGW	Water level change 2013	Net water level change	Max. gas pressure [date]
Wasatch sand	24.58	49.70 2/26/2004	48.08	-1.02	-24.40	n/a
Wyodak coal	268.00	816.30 6/11/2007	603.58	34.73	-335.58	28.09 11/17/2002

Production Statistics

Production data were analyzed for CBNG wells within the buffer of the Durham Ranch Sec 14 monitoring well site from 1997-2013. Cumulative production for individual CBNG wells is displayed by location on Figure A.112. CBNG and water production are monitored in the Upper Wyodak and unknown 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 May 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).

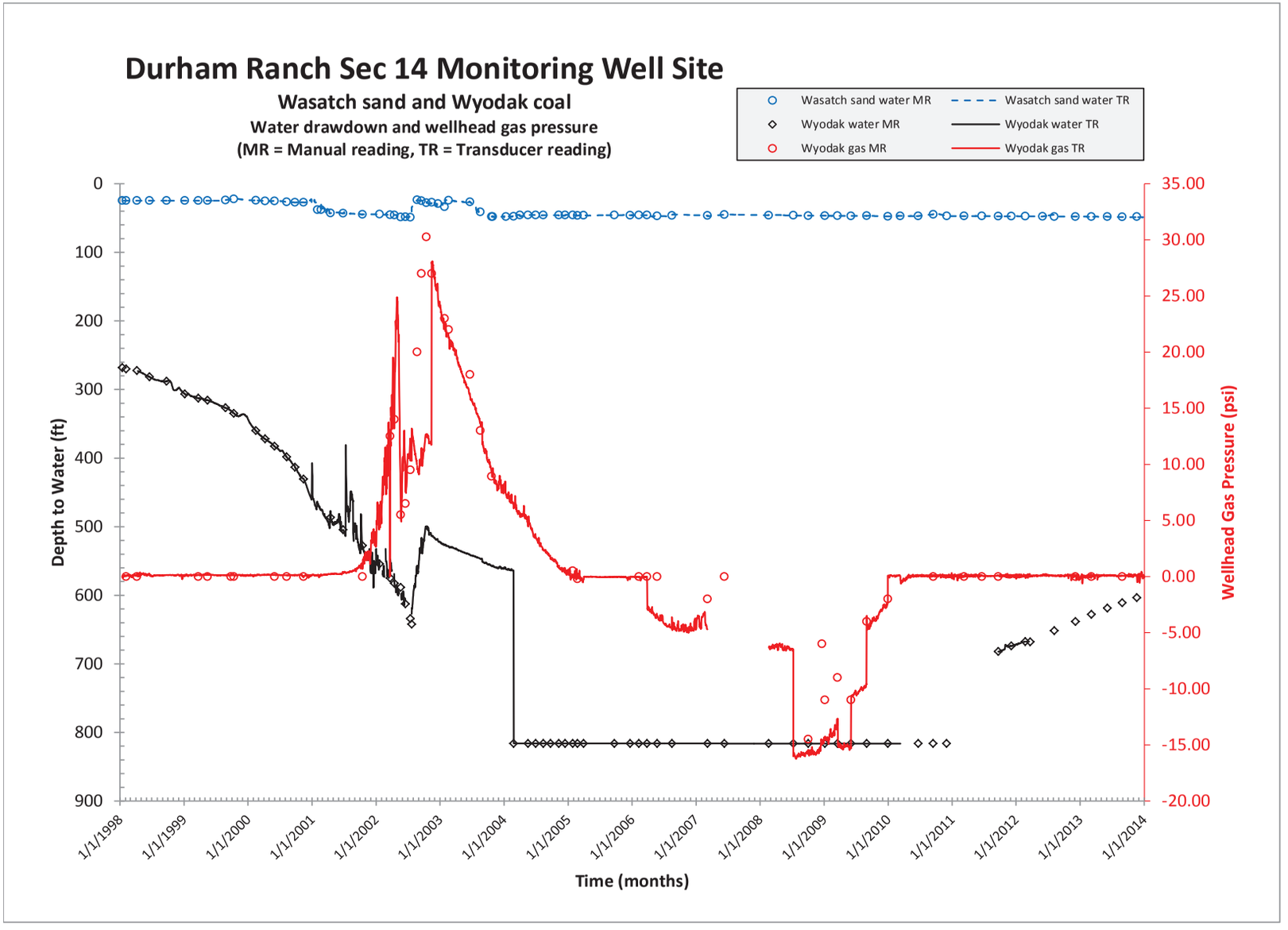

Figure A.111. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored intervals at the Durham Ranch Sec 14 monitoring well site location.

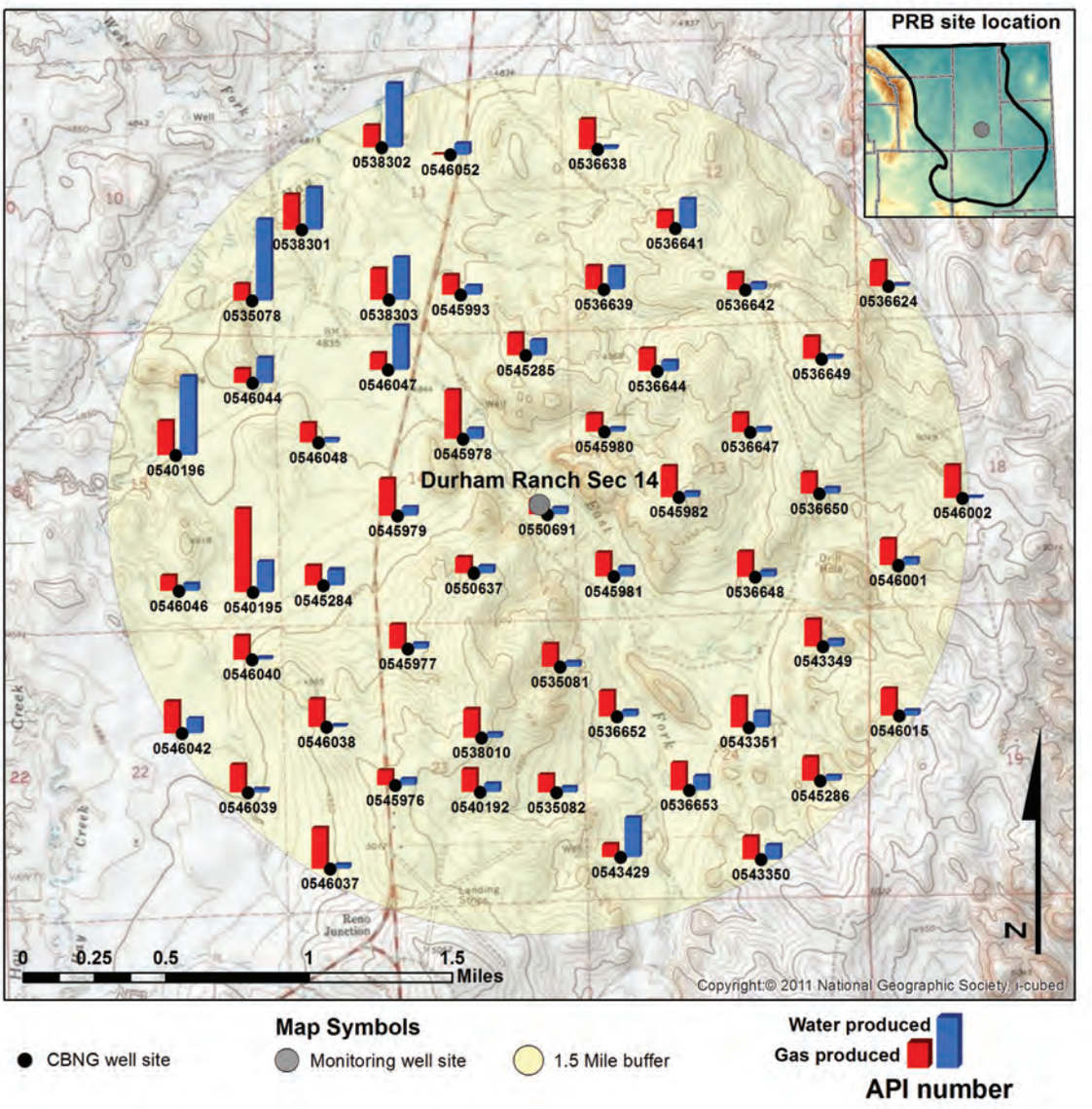

Figure A.112. Durham Ranch Sec 14 monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

Water production in unknown coal zones began in March 1997 and peaked at 197,664 bbls in December 1998. Unknown coal zone water production ceased after April 1999, likely because the production was reclassified to Upper Wyodak coal zone production. No gas production has been recorded from unknown coal zones.

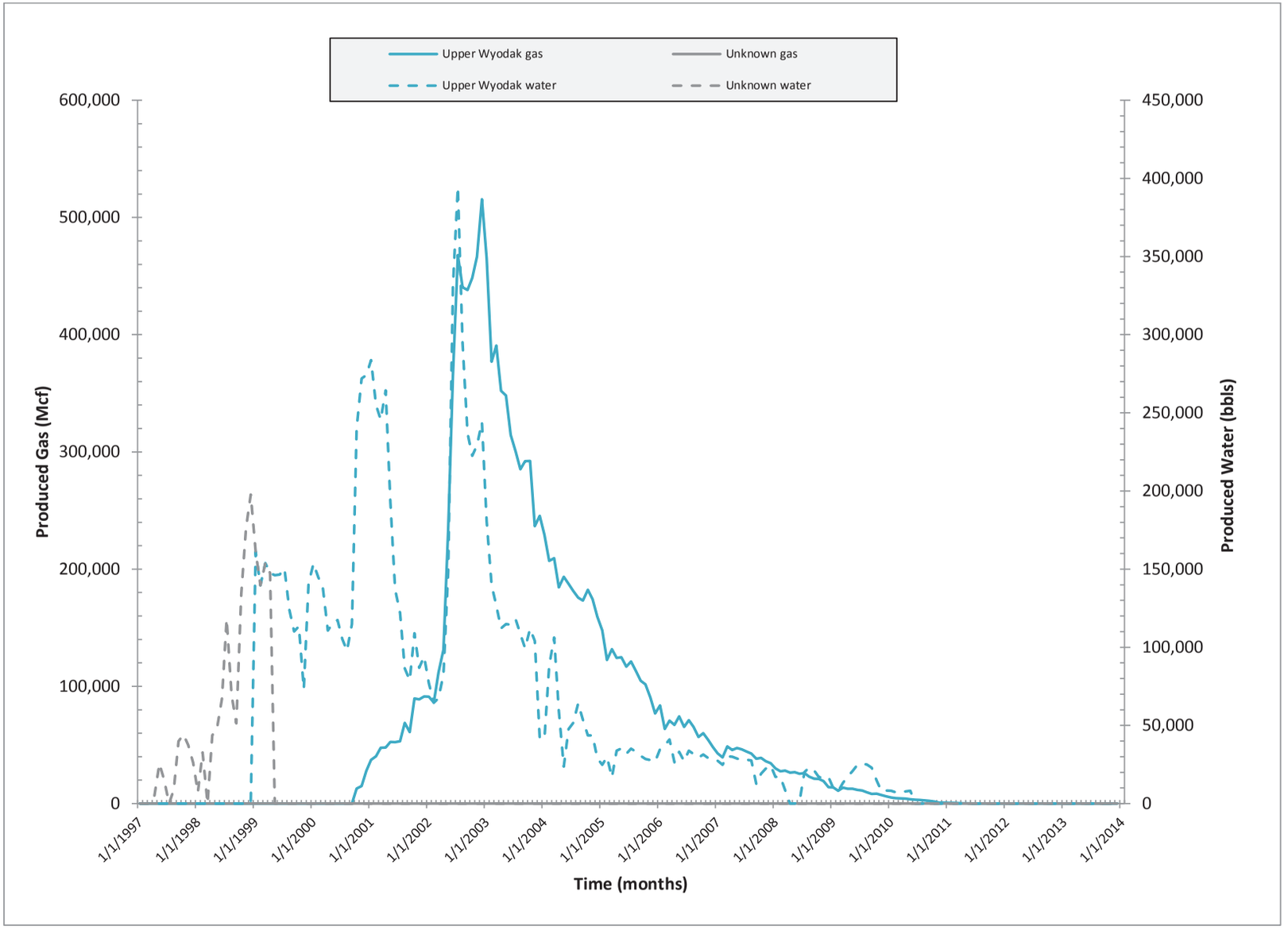

Figure A.113. Water and gas production from CBNG wells associated with the Durham Ranch Sec 14 monitoring well site location.

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 pressure were measured during 2013 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 4.15 feet during 2013. Over the monitoring period of 1999-2013 water levels declined a total of 178.15 feet (Figure A.115; Table A.57). A peak gas pressure of 14.0 psi was recorded in October 2005.

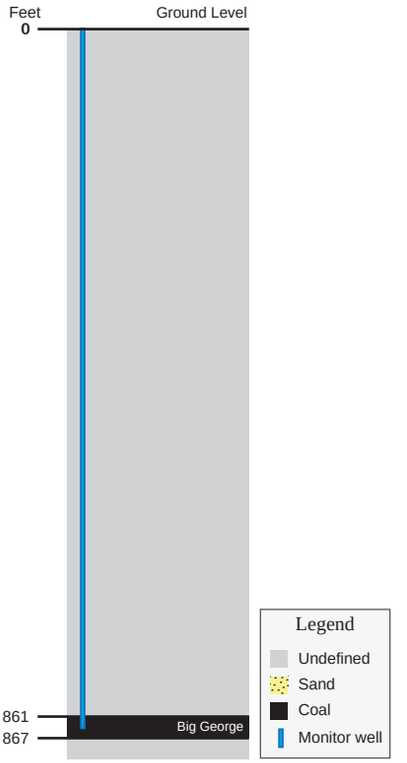

Figure A.114. Section showing relative position of coal in feet. Not to scale.

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

Monitored interval	Interval characteristics			
	Depth of interval (ft)		Interval 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, water level changes for current monitoring period, water level changes for period of record, and maximum gas pressure.

Monitored interval	DGW - Depth to groundwater (ft), water level (ft), and gas pressure (psi) data					
	Initial DGW	Max DGW [Date]	Final 2013 DGW	Water level change 2013	Net water level change	Max. gas pressure [date]
Big George coal	245.90	437.60 9/6/2013	424.05	-4.15	-178.15	14.02 10/31/2005

Production Statistics

Production data were analyzed for CBNG wells within the buffer of the Echeta monitoring well site from 2000-2013, Figure A.116. CBNG and water production were 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).

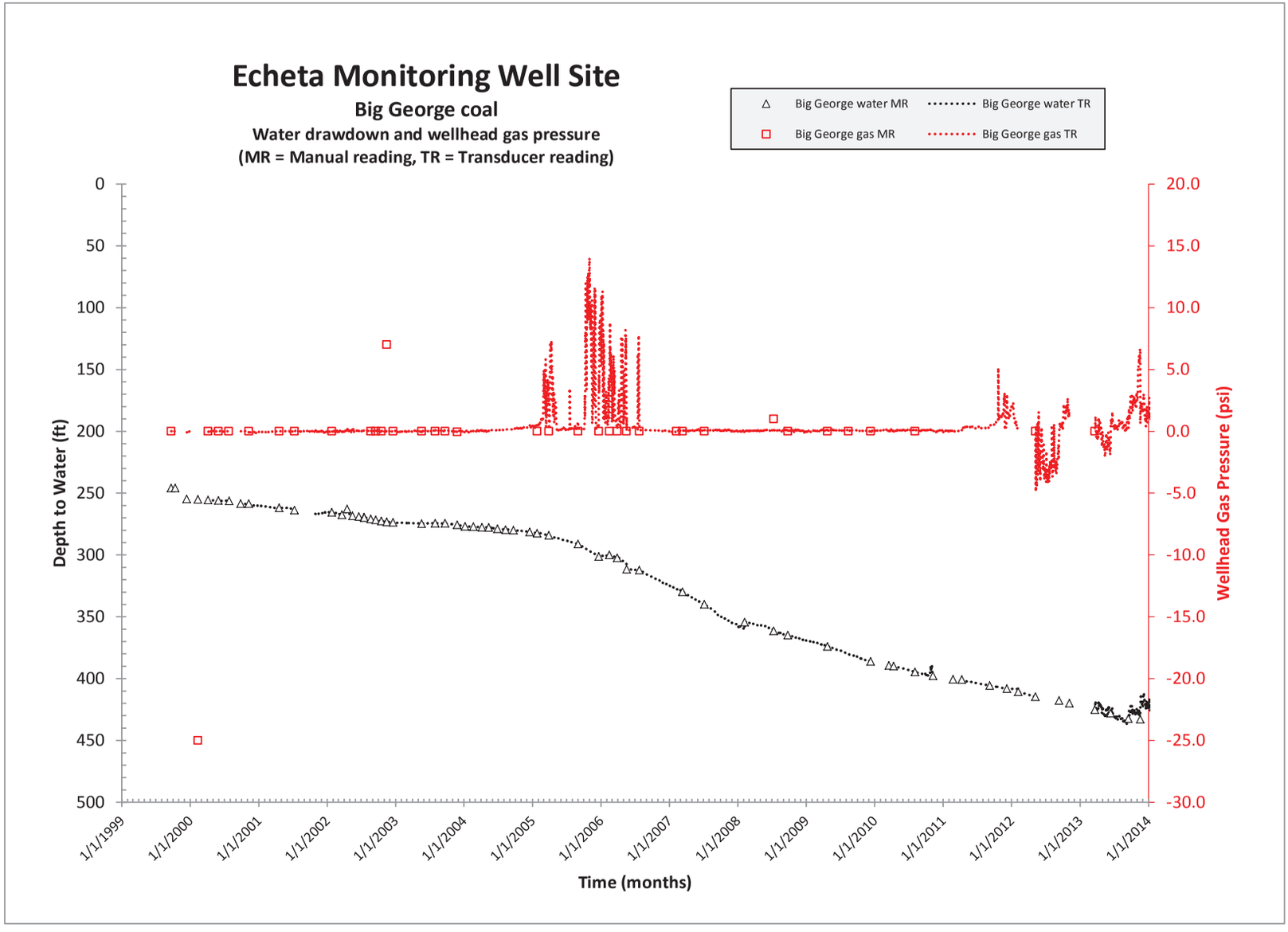

Figure A.115. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored intervals at the Echeta monitoring well site location.

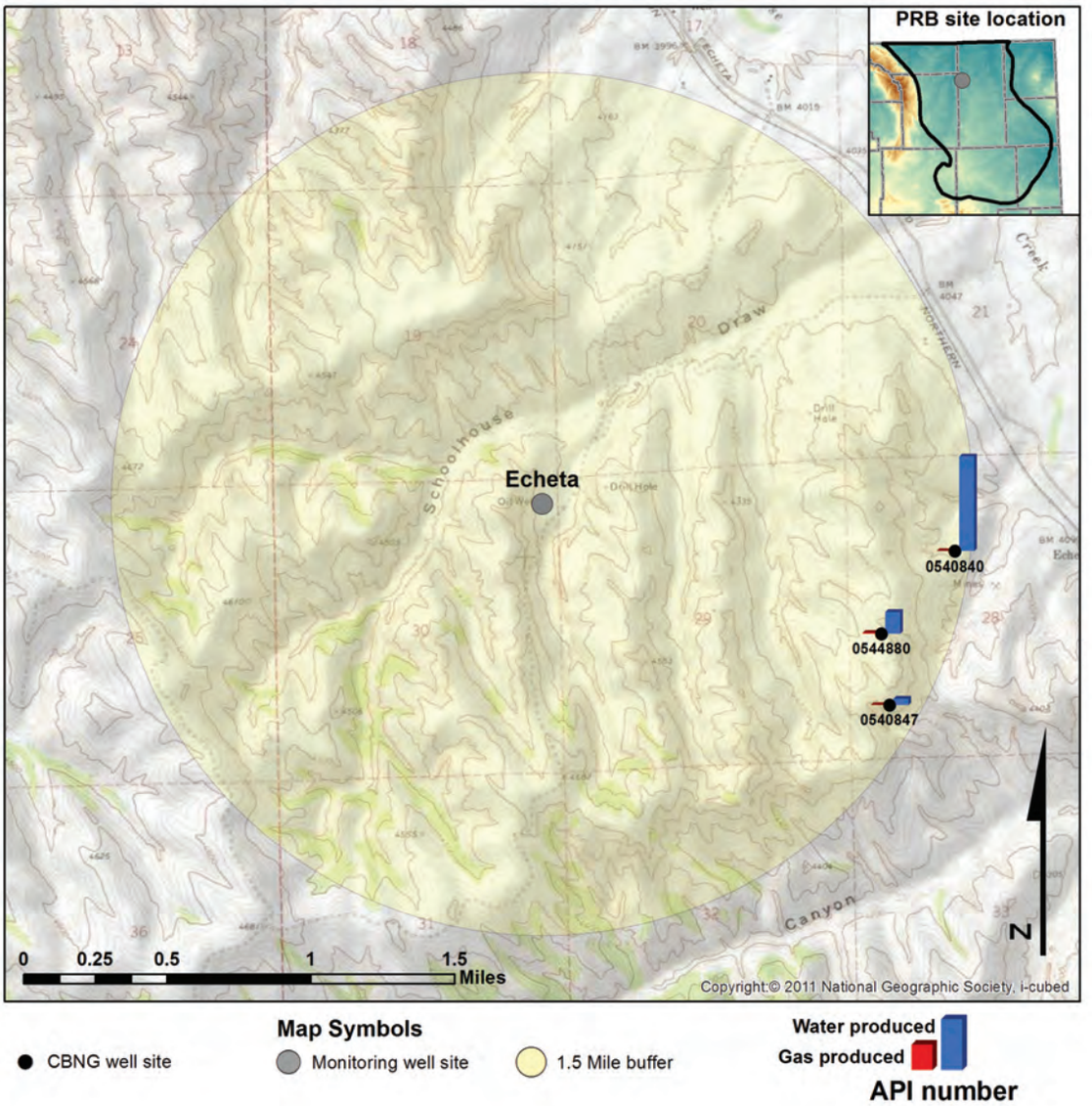

Figure A.116. Echeta monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

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.

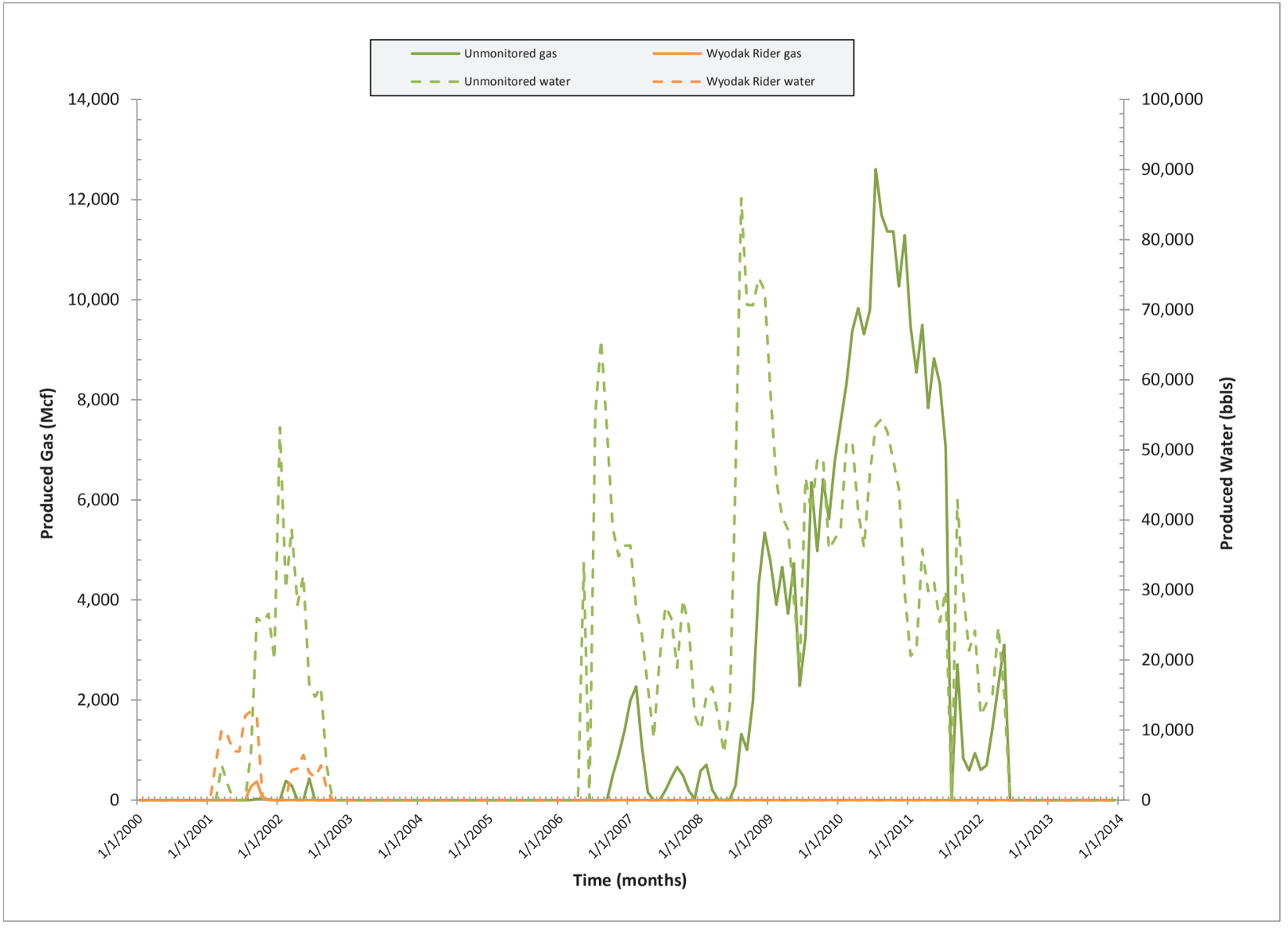

Figure A.117. Water and gas production from CBNG wells associated with the Echeta monitoring well site location.

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

Drawdown Information
The Fourmile monitoring well site includes two wells. One monitoring well is completed in a Wasatch sandstone. The second well is a dual completion (separated by packer) in the Big George coal of the Wyodak Rider coal zone, and in a Fort Union underburden sandstone (Figure A.118; Table A.58). Water levels and wellhead gas pressures were measured during 2013 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
Generally, water levels have remained stable over the monitoring period. During 2013, groundwater levels rose 0.85 feet; during the 2007 – 2013 POR, water levels rose a total of 0.01 feet (Figure A.119; Table A.59). Gas pressure was not recorded in the Wasatch sandstone.

Big George Coal
Groundwater levels declined 3.98 feet in the Big George coal during 2013. Over the monitoring period of 2007-2013 water levels declined a total of 21.43 feet (Figure A.119; Table A.59). A peak gas pressure of 0.9 psi was recorded in April 2011.

Fort Union Underburden Sandstone
During 2013, groundwater levels declined 3.34 feet; during the 2007 – 2013 POR, water levels rose a total of 4.82 feet Figure A.119; Table A.59). Gas pressure was not recorded in the Fort Union underburden sand.

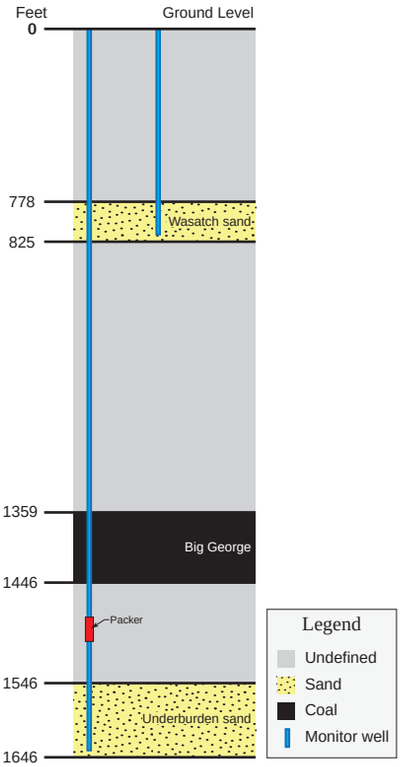

Figure A.118. Section showing relative positions of coal and sands in feet. Not to scale.

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

Monitored interval	Interval characteristics			
	Depth of interval (ft)		Interval 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, water level changes for current monitoring period, water level changes for period of record, and maximum gas pressure.

Monitored interval	DGW - Depth to groundwater (ft), water level (ft), and gas pressure (psi) data					
	Initial DGW	Max DGW [Date]	Final 2013 DGW	Water level change 2013	Net water level change	Max. gas pressure [date]
Wasatch sand	427.17	428.70 2/19/2008	427.16	0.85	0.01	n/a
Big George coal	866.89	888.70 8/31/2013	888.32	-3.98	-21.43	0.93 4/10/2011
Underburden sand	809.96	810.00 11/30/2007	805.14	-3.34	4.82	n/a

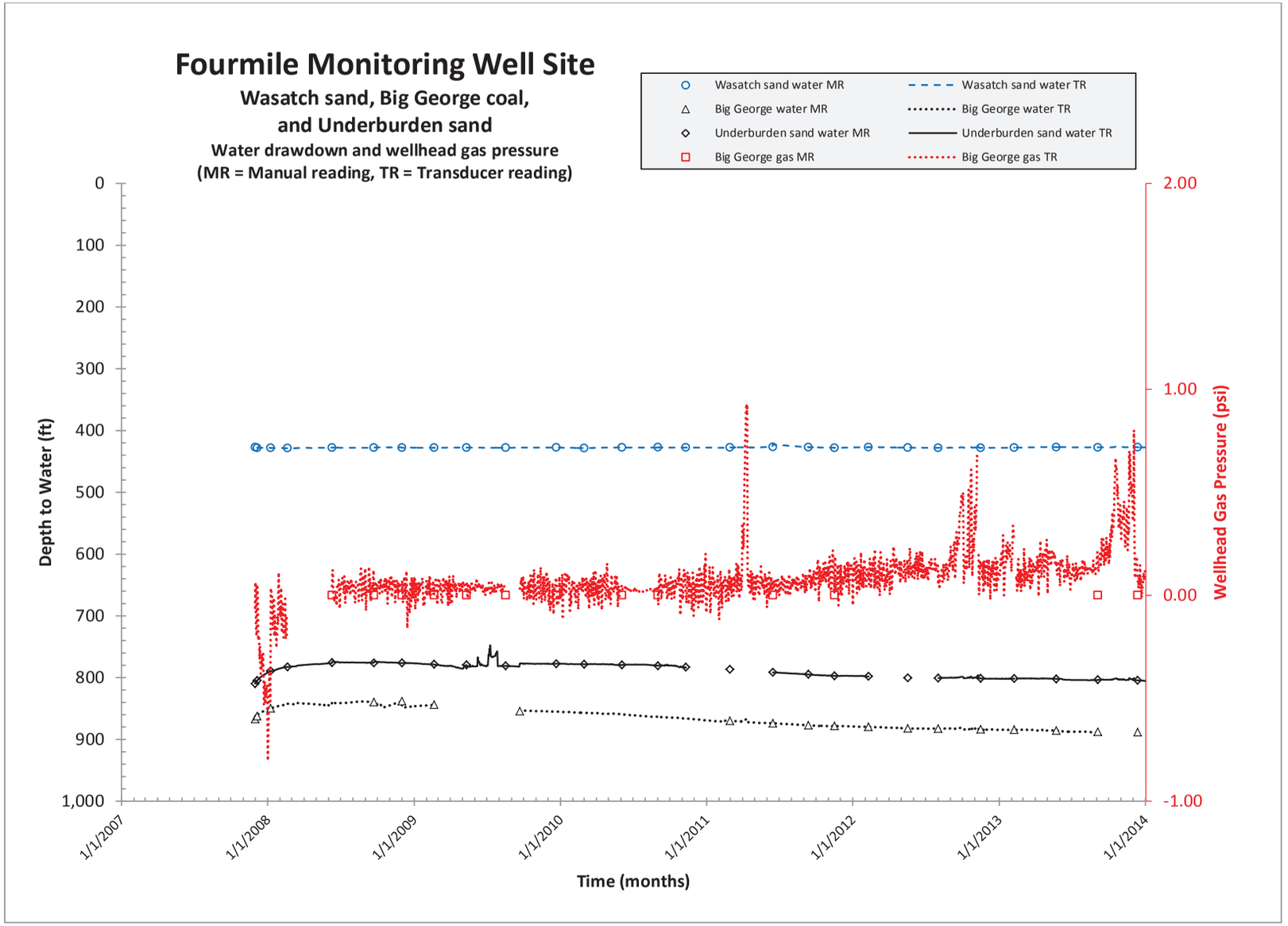

Figure A.119. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored intervals at the Fourmile monitoring well site location.

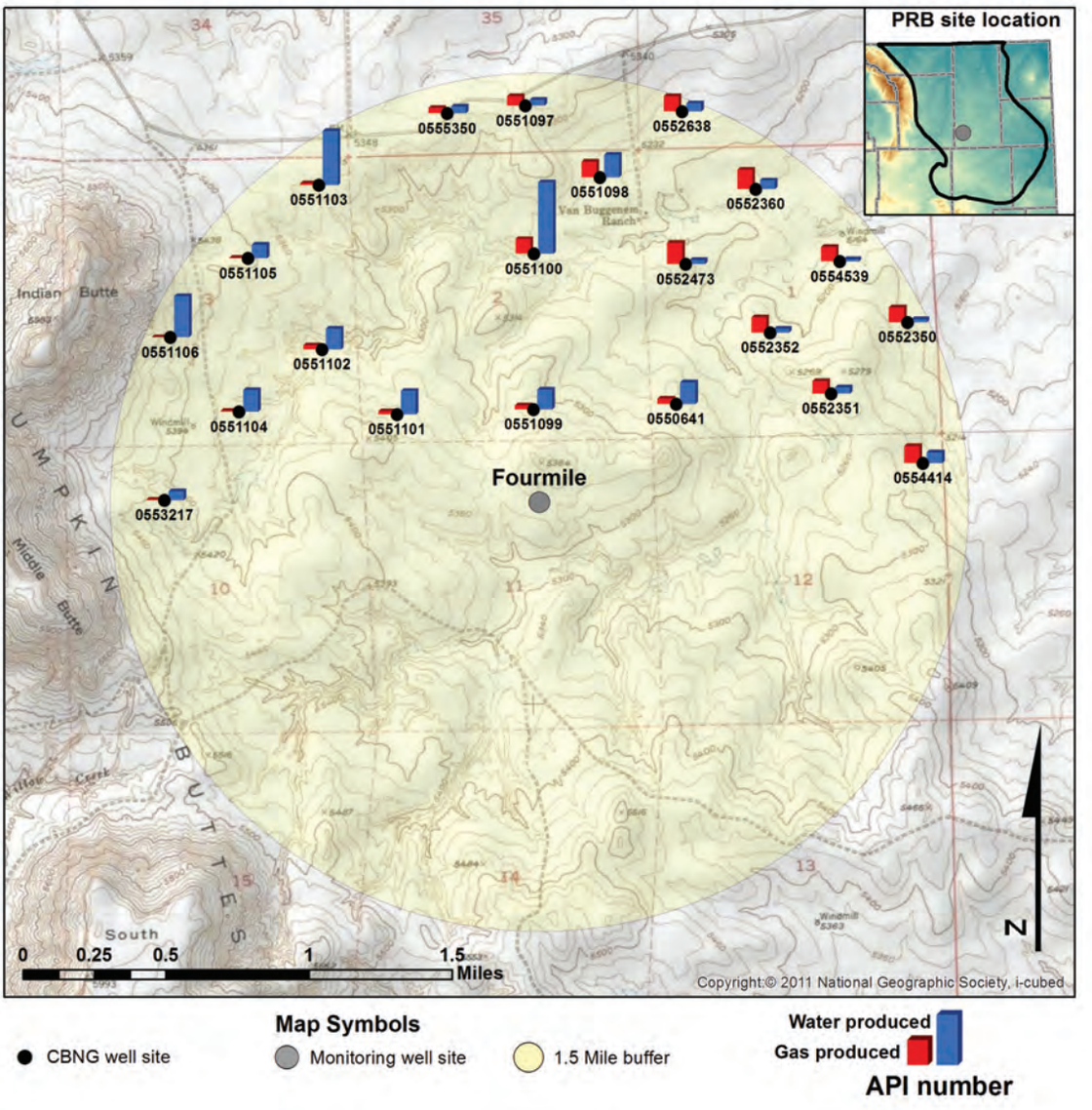

Figure A.120. Fourmile monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

Production Statistics

Production data were analyzed for CBNG wells within the buffer of the Fourmile monitoring well site from 2003-2013. Figure A.120. CBNG and water production are monitored in the 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; 4,533 bbls were produced in December 2013. Gas production began in January 2005 and peaked at 60,867 Mcf in October 2006; in December 2013, 11,541 Mcf of gas was produced (Figure A.121).

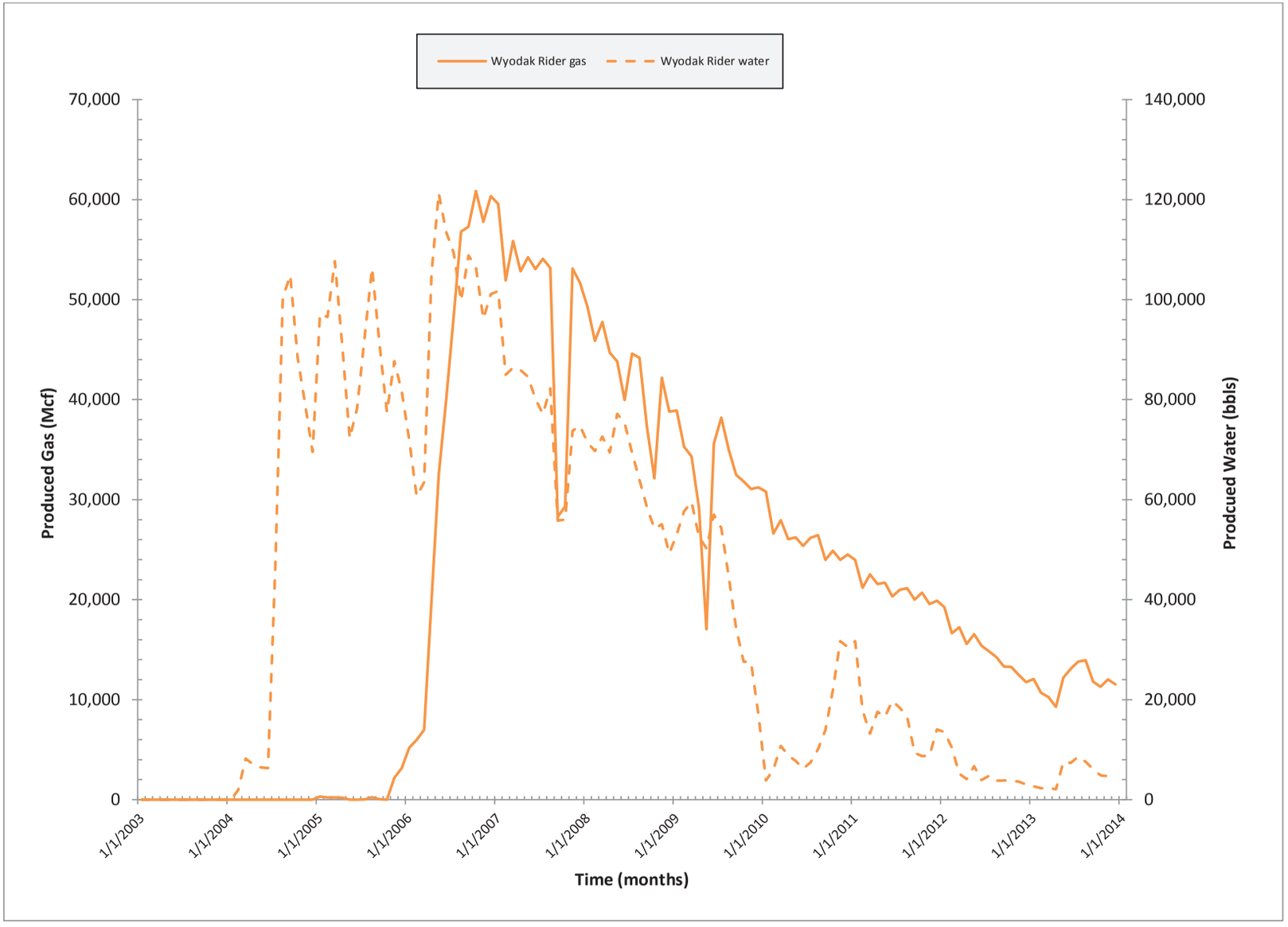

Figure A.121. Water and gas production from CBNG wells associated with the Fourmile monitoring well site location.

Gilmore Monitoring Well Site
Location: S1 T49N R77W
Date First Monitored: March 19, 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 pressure were measured during 2013 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 57.14 feet during 2013. Water levels have declined a total of 512.78 feet (Figure A.123; Table A.61) during the 1998 – 2013 POR. A peak gas pressure of 29.8 psi was recorded in July 2012.

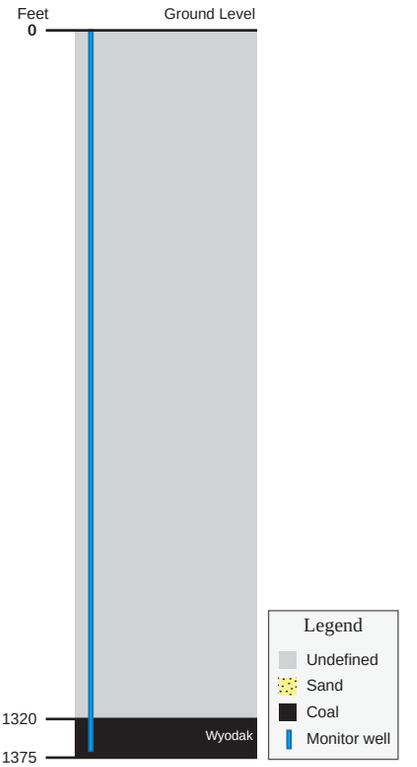

Figure A.122. Section showing relative position of coal in feet. Not to scale.

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

Monitored interval	Interval characteristics			
	Depth of interval (ft)		Interval 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, water level changes for current monitoring period, water level changes for period of record, and maximum gas pressure.

Monitored interval	DGW - Depth to groundwater (ft), water level (ft), and gas pressure (psi) data					
	Initial DGW	Max DGW [Date]	Final 2013 DGW	Water level change 2013	Net water level change	Max. gas pressure [date]
Wyodak coal	369.41	949.50 11/12/2012	882.19	57.14	-512.78	29.80 7/19/2012

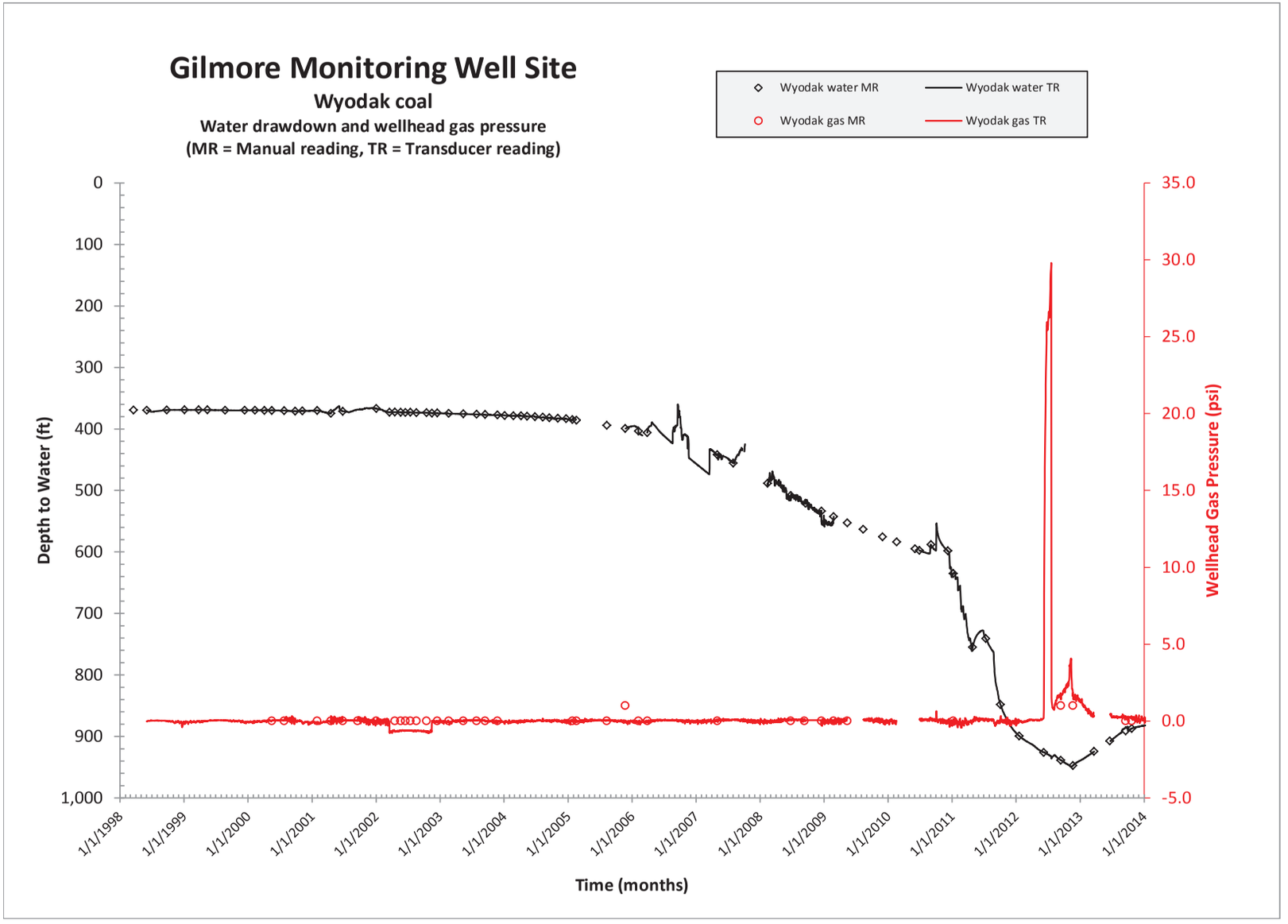

Figure A.123. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored intervals at the Gilmore monitoring well site location.

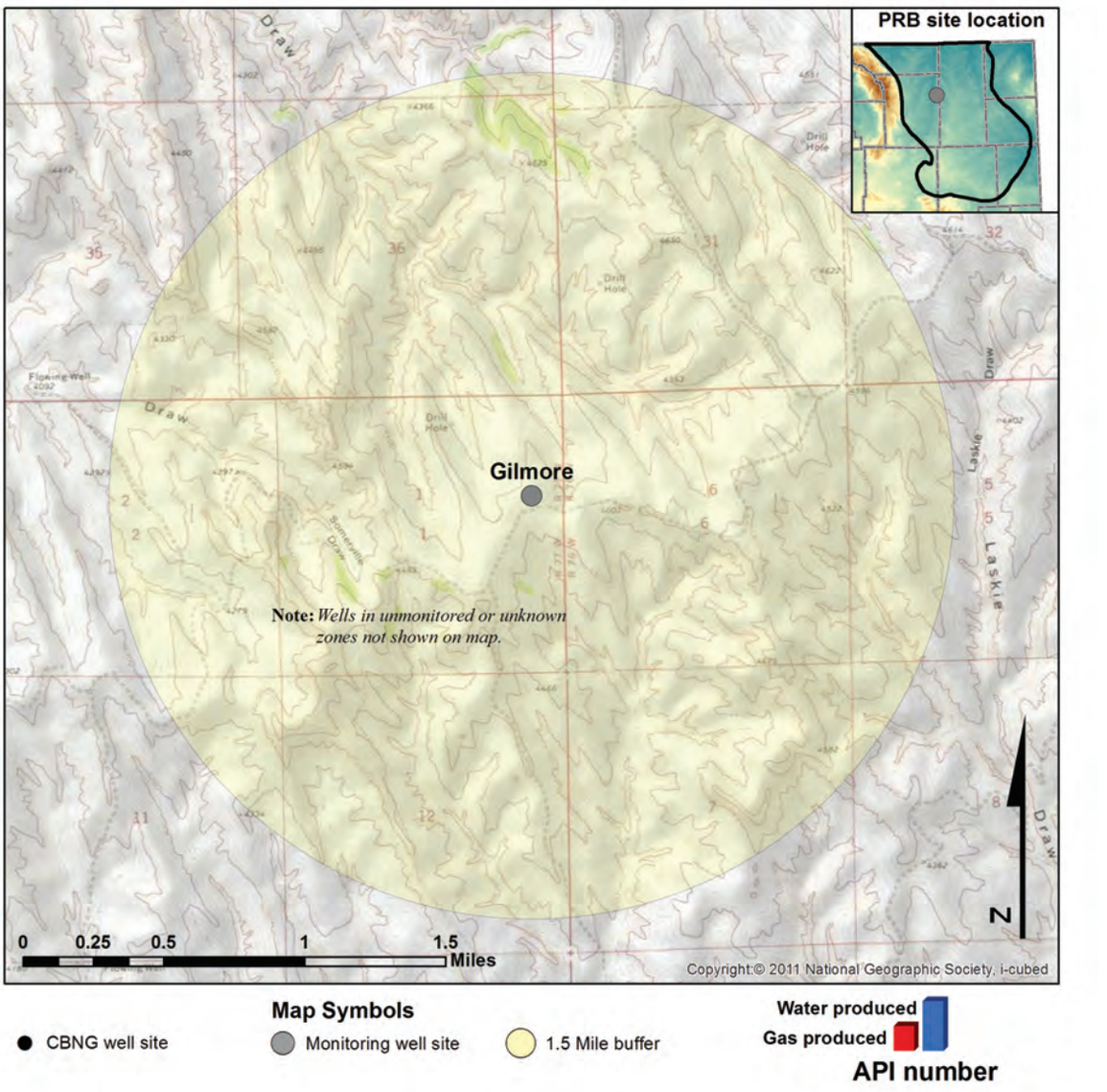

Figure A.124. Gilmore monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

Production Statistics

Production data were analyzed for CBNG wells within the buffer of the Gilmore monitoring well site from 1999-2013. Cumulative production for individual CBNG wells is displayed by location on Figure A.124. CBNG and water production are monitored in unmonitored coal zone wells, no production occurs in the Upper Wyodak.

Water production in unknown coal zones began in December 2007, increased rapidly, and peaked in April 2011 at 177,107 bbls; 75,239 bbls of water was produced in December 2013. Gas production began in July 2008, peaked at 95,312 Mcf in August 2012 and declined to 91,194 Mcf in December 2013, (Figure A.125).

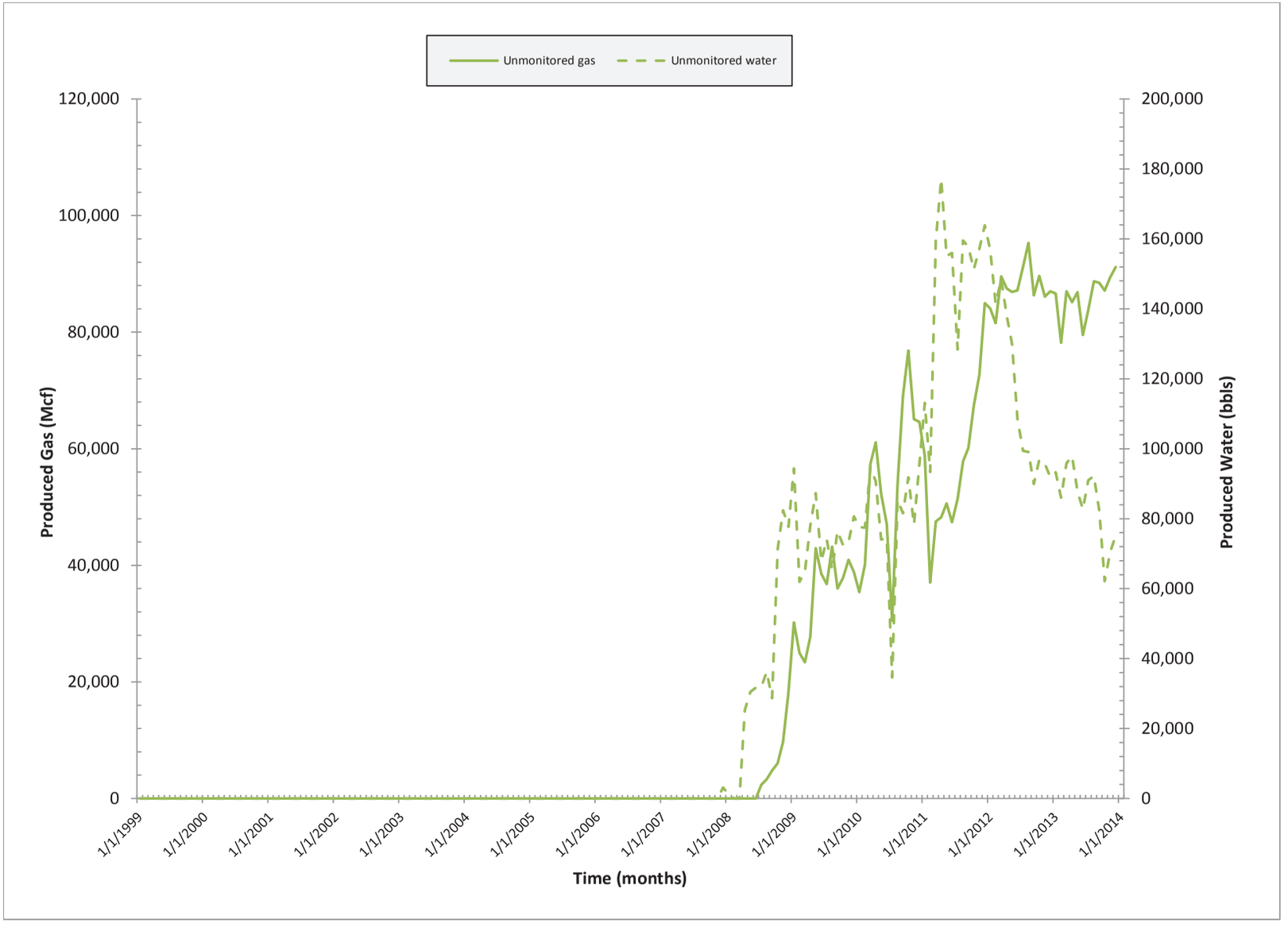

Figure A.125. Water and gas production from CBNG wells associated with the Gilmore monitoring well site location.

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 in a Wasatch sandstone and the other in the Wyodak coal of the Upper Wyodak coal zone (Figure A.126; Table A.62). Water levels and wellhead gas pressures were measured during 2013 using a combination of 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 2013, groundwater levels in the Wasatch sandstone declined 2.30 feet. In contrast, during the 2000 – 2013 POR, groundwater levels declined 9.40 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 27.47 during 2013. Over the monitoring period of 1998-2013 water levels declined a total of 386.50 feet (Figure A.127; Table A.63). A peak gas pressure of 60.4 psi was recorded in April 2000.

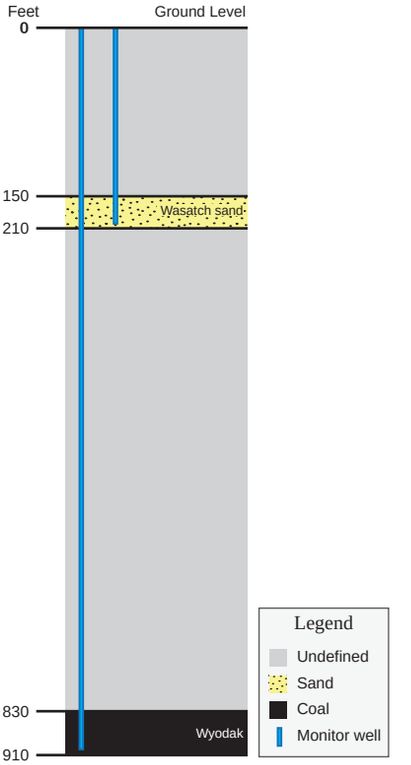

Figure A.126. Section showing relative positions of coal and sand in feet. Not to scale.

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

Monitored interval	Interval characteristics			
	Depth of interval (ft)		Interval 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, water level changes for current monitoring period, water level changes for period of record, and maximum gas pressure.

Monitored interval	DGW - Depth to groundwater (ft), water level (ft), and gas pressure (psi) data					
	Initial DGW	Max DGW [Date]	Final 2013 DGW	Water level change 2013	Net water level change	Max. gas pressure [date]
Wasatch sand	100.85	110.40 12/29/2013	n/a	-2.30	-9.40	n/a
Wyodak coal	231.25	910.00 5/24/2006	617.75	27.47	-386.50	60.36 4/23/2000

Production Statistics

Production data were analyzed for CBNG wells within the buffer of the Hoe Creek monitoring well site from 1998-2013. Cumulative production for individual CBNG wells is displayed by location on Figure A.128. CBNG and water production are monitored in Upper Wyodak, unmonitored, and unknown coal zone wells.

Water production in the Upper 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 gas has been produced since late 2010.

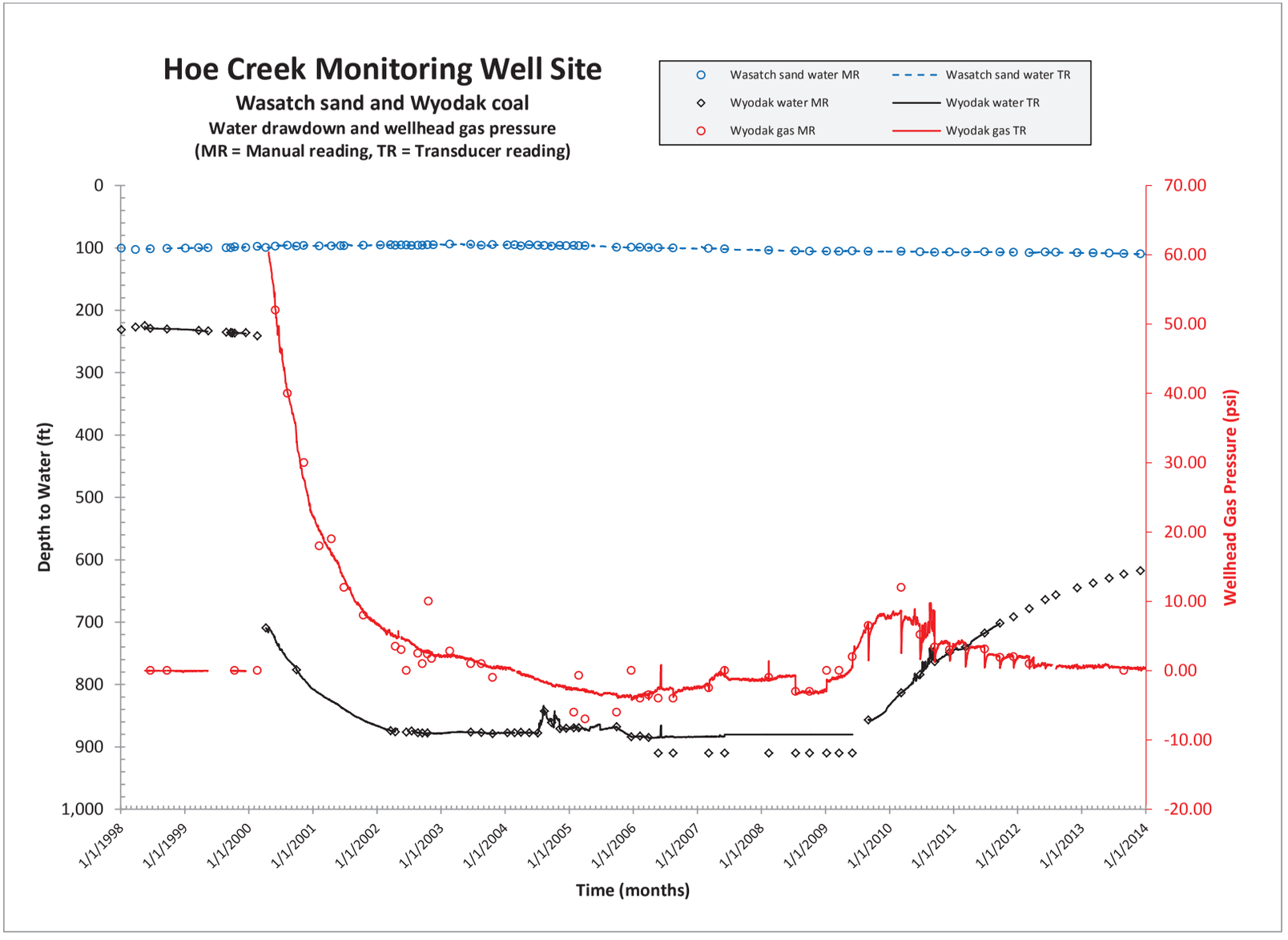

Figure A.127. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored intervals at the Hoe Creek monitoring well site location.

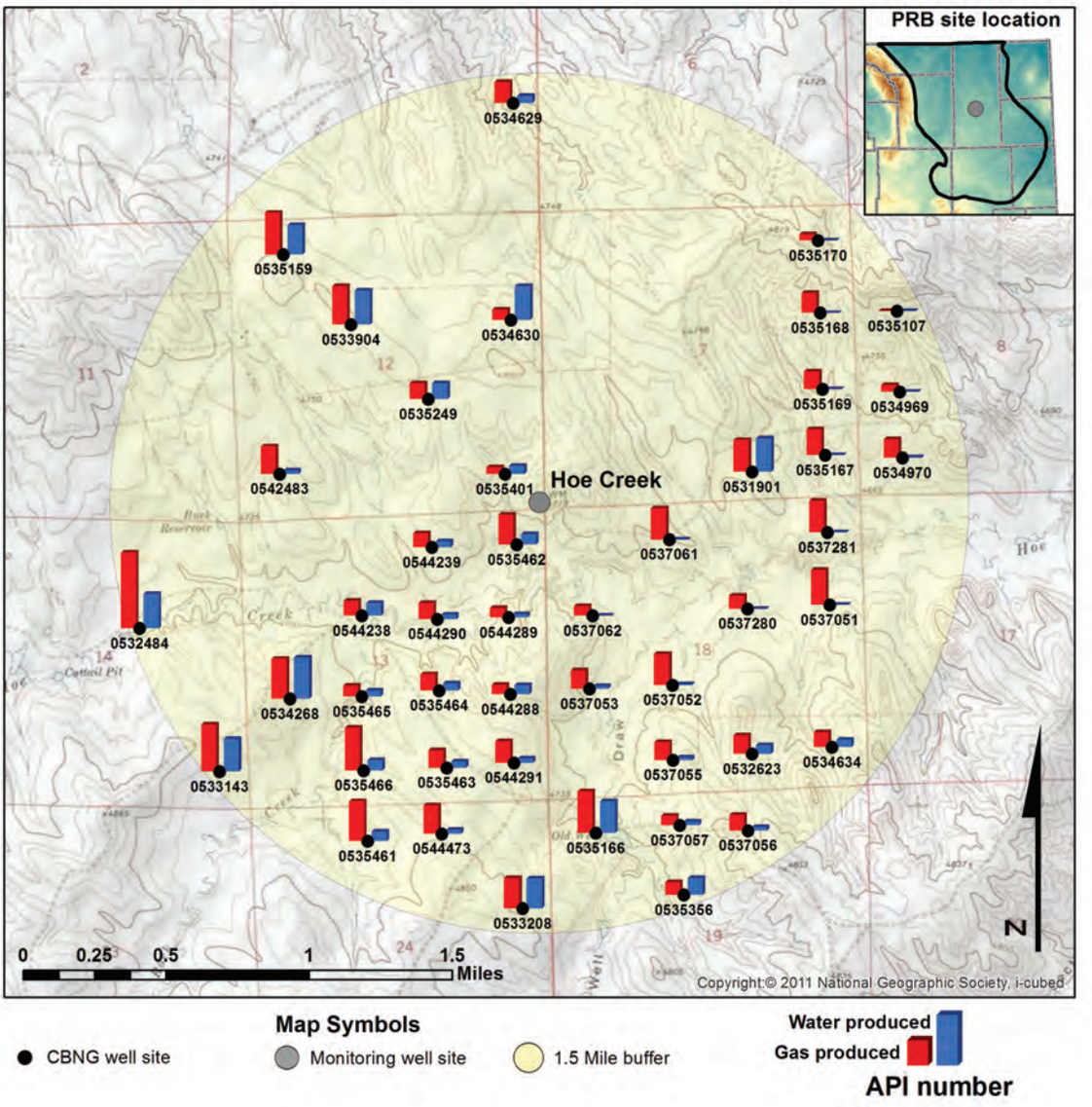

Figure A.128. Hoe Creek monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

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

Water production from unknown coal zones began in April 1998 and peaked at 129,738 bbls in June 1999. Gas production in unknown coal zones began in April 1998 and peaked in June 1999 at 115,856 Mcf. Water and gas production in unknown zones ceased in December 1999 and has remained at zero through 2013.

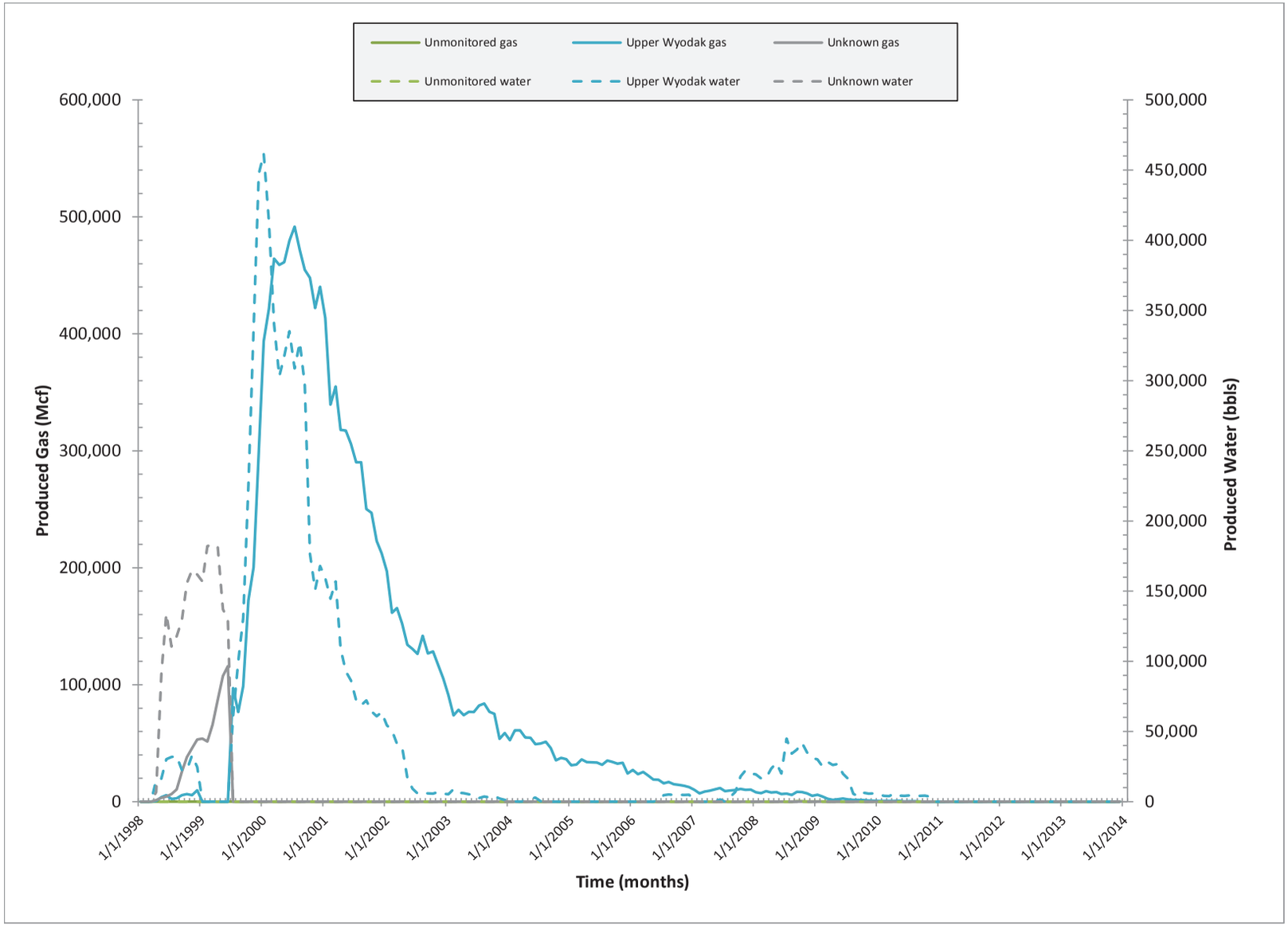

Figure A.129. Water and gas production from CBNG wells associated with the Hoe Creek monitoring well site location.

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 2013 using a combination of manual and automatic transducer and data logger equipment. At this site, agreement between manual and transducer measurements is generally good. 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 2013, the groundwater levels in the shallow Wasatch sandstone rose 0.32 feet (Figure A.131; Table A.65). In contrast, during the 2002 – 2013 monitoring period, groundwater levels declined 1.97 feet from initial static water levels.

Water level in the deeper Wasatch sandstone declined 3.78 feet during 2013 and 39.96 feet during the monitoring period of 2001-2013 (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 11, 2008 and has remained unchanged during 2013. Over the monitoring period of 2001-2013 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.

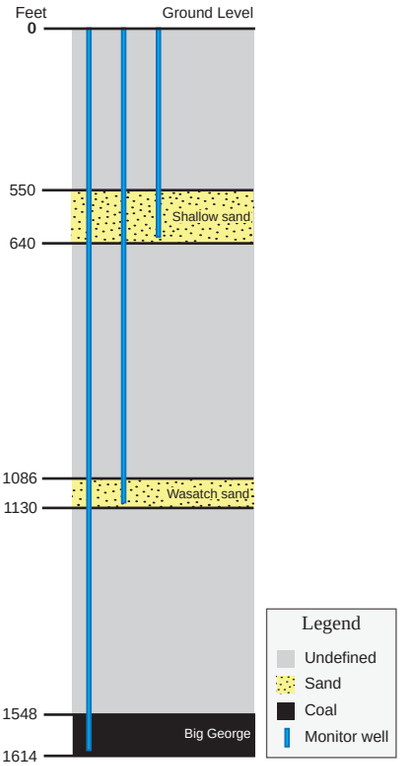

Figure A.130. Section showing relative positions of coal and sands in feet. Not to scale.

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

Monitored interval	Interval characteristics			
	Depth of interval (ft)		Interval 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, water level changes for current monitoring period, water level changes for period of record, and maximum gas pressure.

Monitored interval	DGW - Depth to groundwater (ft), water level (ft), and gas pressure (psi) data					
	Initial DGW	Max DGW [Date]	Final 2013 DGW	Water level change 2013	Net water level change	Max. gas pressure [date]
Shallow sand	428.51	431.20 8/21/2008	430.48	0.32	-1.97	n/a
Deep Wasatch sand	342.00	383.30 9/20/2013	381.96	-3.78	-39.96	n/a
Big George coal*	168.47	1614.00 6/11/2008	1614.00	n/a	-1445.53	221.30 11/29/2003

*Well dry to total depth 6/11/2008

Production Statistics

Production data were analyzed for CBNG wells within the buffer of the Juniper monitoring well site from 2001-2013. Cumulative production for individual CBNG wells is displayed by location on Figure A.132. CBNG and water production are monitored in the Wyodak Rider and multiple 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 through 2013 at less than 70,000 bbls/month (Figure A.133). Gas production began in October 2008 and peaked at 1,179,473 Mcf in January 2009 and steadily decreased during 2013 from 359,855 Mcf in January to 228,828 Mcf in December.

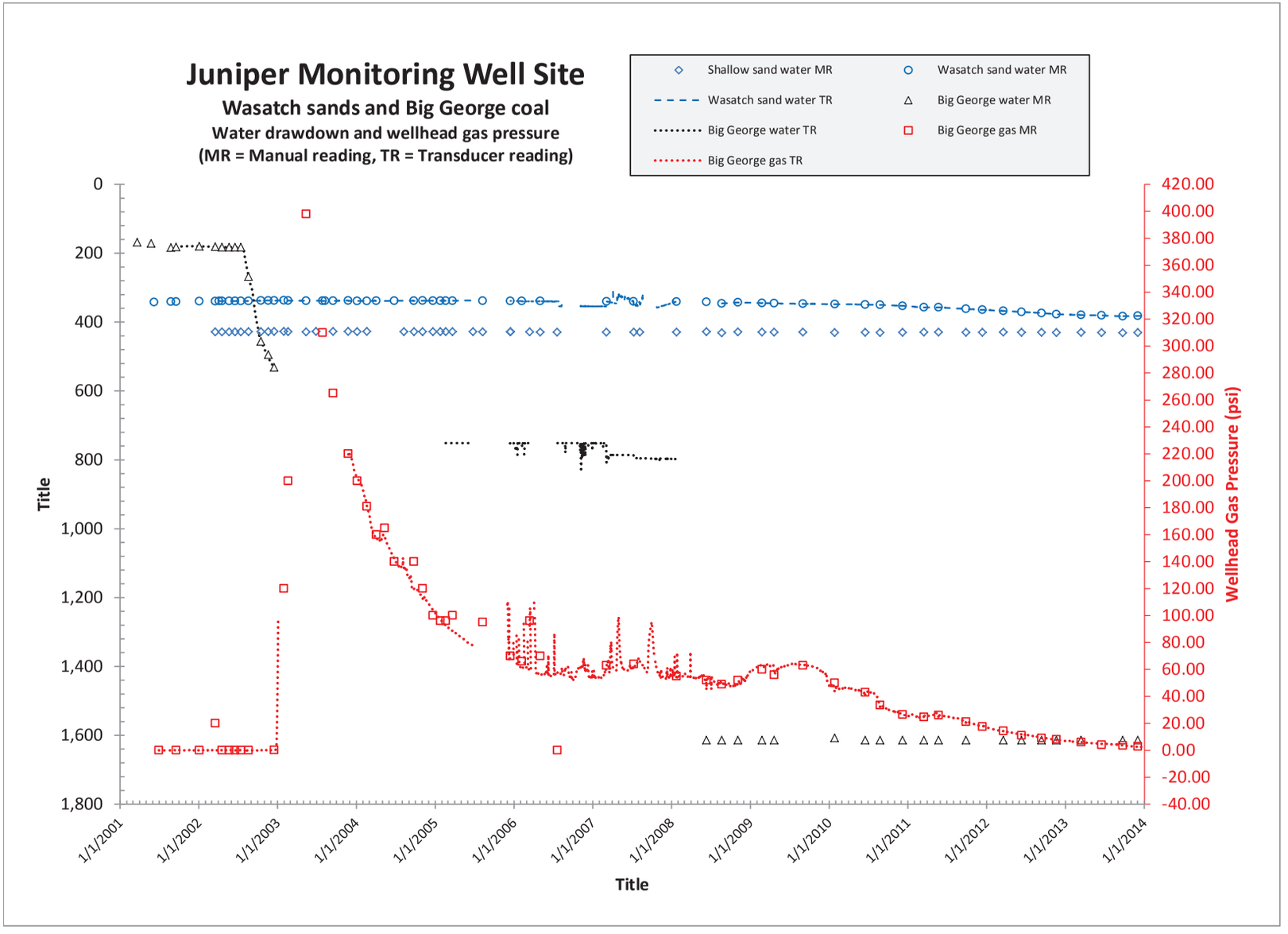

Figure A.131. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored intervals at the Juniper monitoring well site location.

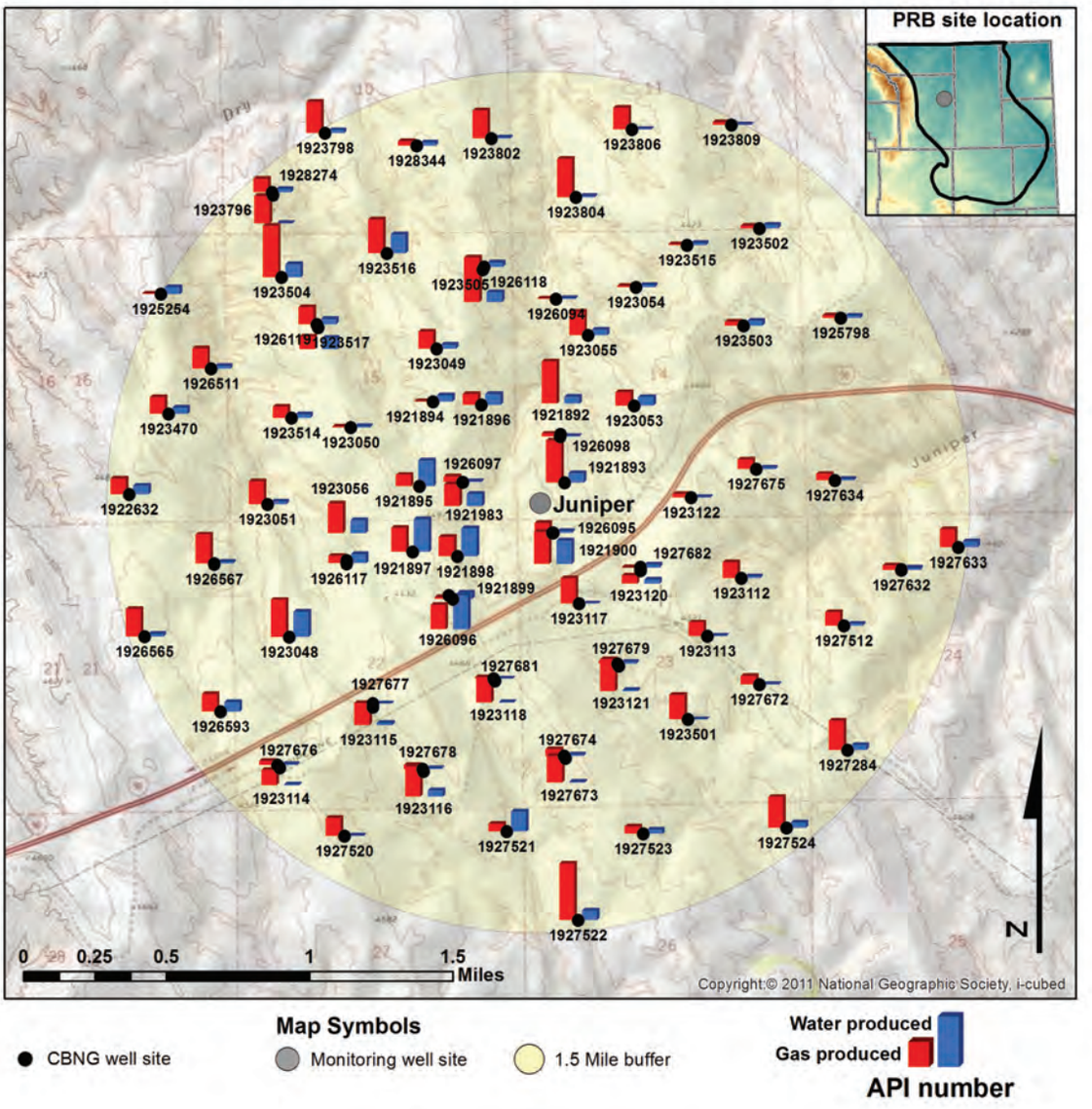

Figure A.132. Juniper monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

Water production in multiple coal zone wells began in October 2010 and has ranged from 1,000 to 15,000 bbls/month. Gas production also began in October 2010 and peaked April 2011 at 26,278 Mcf and remained fairly steady ending 2013 at 20,299 bbls/month.

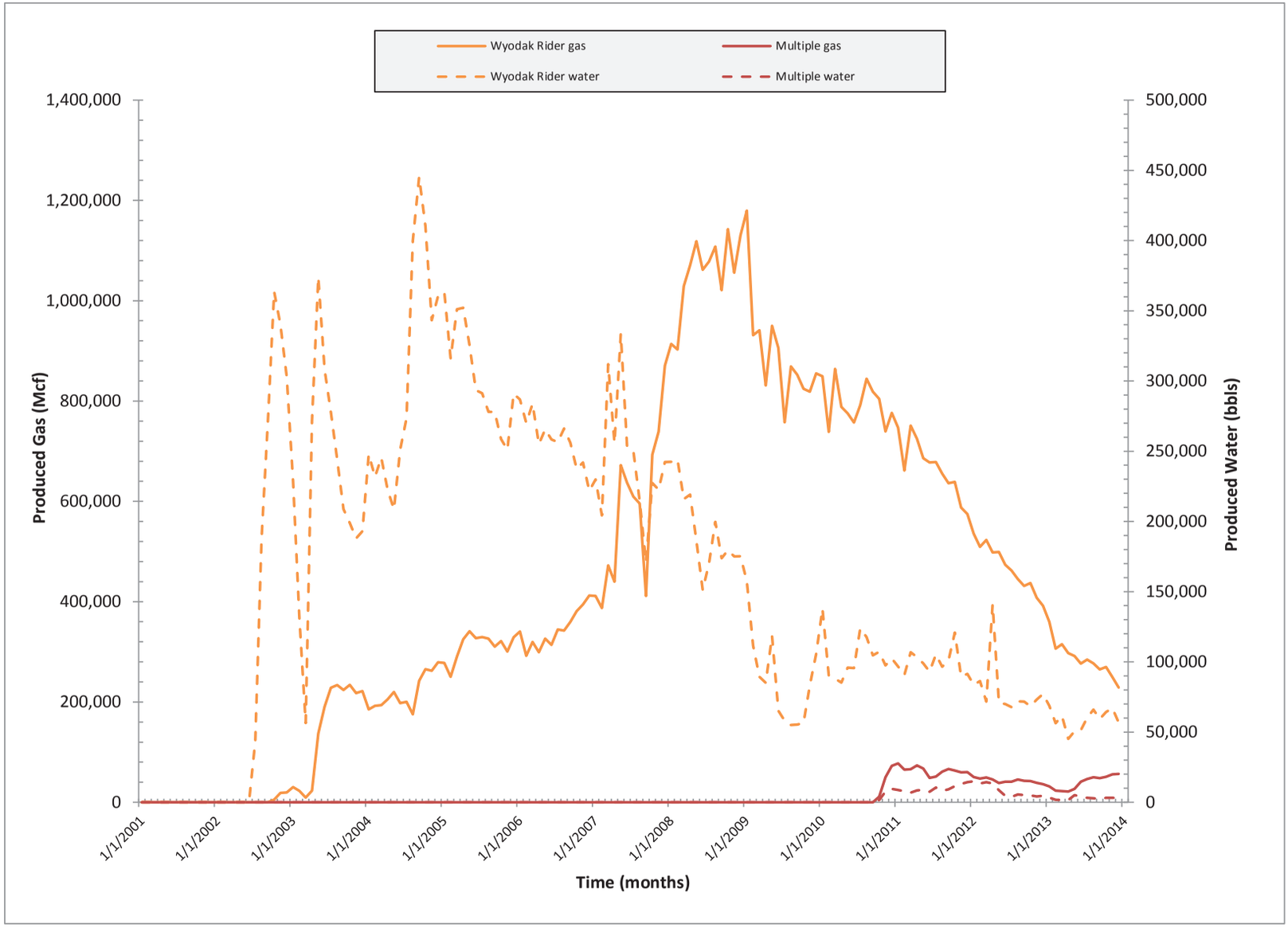

Figure A.133. Water and gas production from CBNG wells associated with the Juniper monitoring well site location.

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 2013 using both manual and automatic transducer and data logger equipment. On this site, agreement is generally good where both manual and transducer measurements are present. 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 0.86 feet during 2013; during the 2000 – 2013 POR, water levels declined 15.70 feet (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 15.82 feet during 2013. During the POR, water levels declined a total of 132.20 feet (Figure A.135; Table A.67). A peak gas pressure of 0.96 psi was recorded in May 2004.

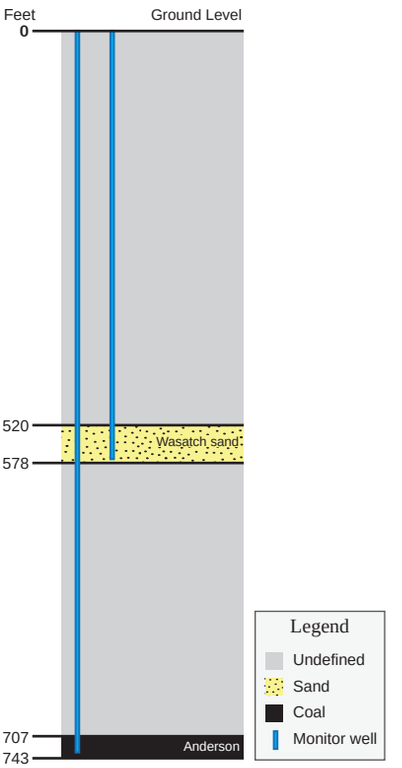

Figure A.134. Section showing relative positions of coal and sand in feet. Not to scale.

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

Monitored interval	Interval characteristics			
	Depth of interval (ft)		Interval 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, water level changes for current monitoring period, water level changes for period of record, and maximum gas pressure.

Monitored interval	DGW - Depth to groundwater (ft), water level (ft), and gas pressure (psi) data					
	Initial DGW	Max DGW [Date]	Final 2013 DGW	Water level change 2013	Net water level change	Max. gas pressure [date]
Wasatch sand	270.70	288.60 2/14/2010	286.40	0.86	-15.70	n/a
Anderson coal	405.21	650.00 10/26/2008	537.41	15.82	-132.20	0.96 5/11/2004

Production Statistics

Production data were analyzed for CBNG wells within the buffer of the Kennedy monitoring well site from 1998-2013. Cumulative production for individual CBNG wells is displayed by location on Figure A.136. CBNG and water production are monitored in the Upper Wyodak and unmonitored coal zone wells.

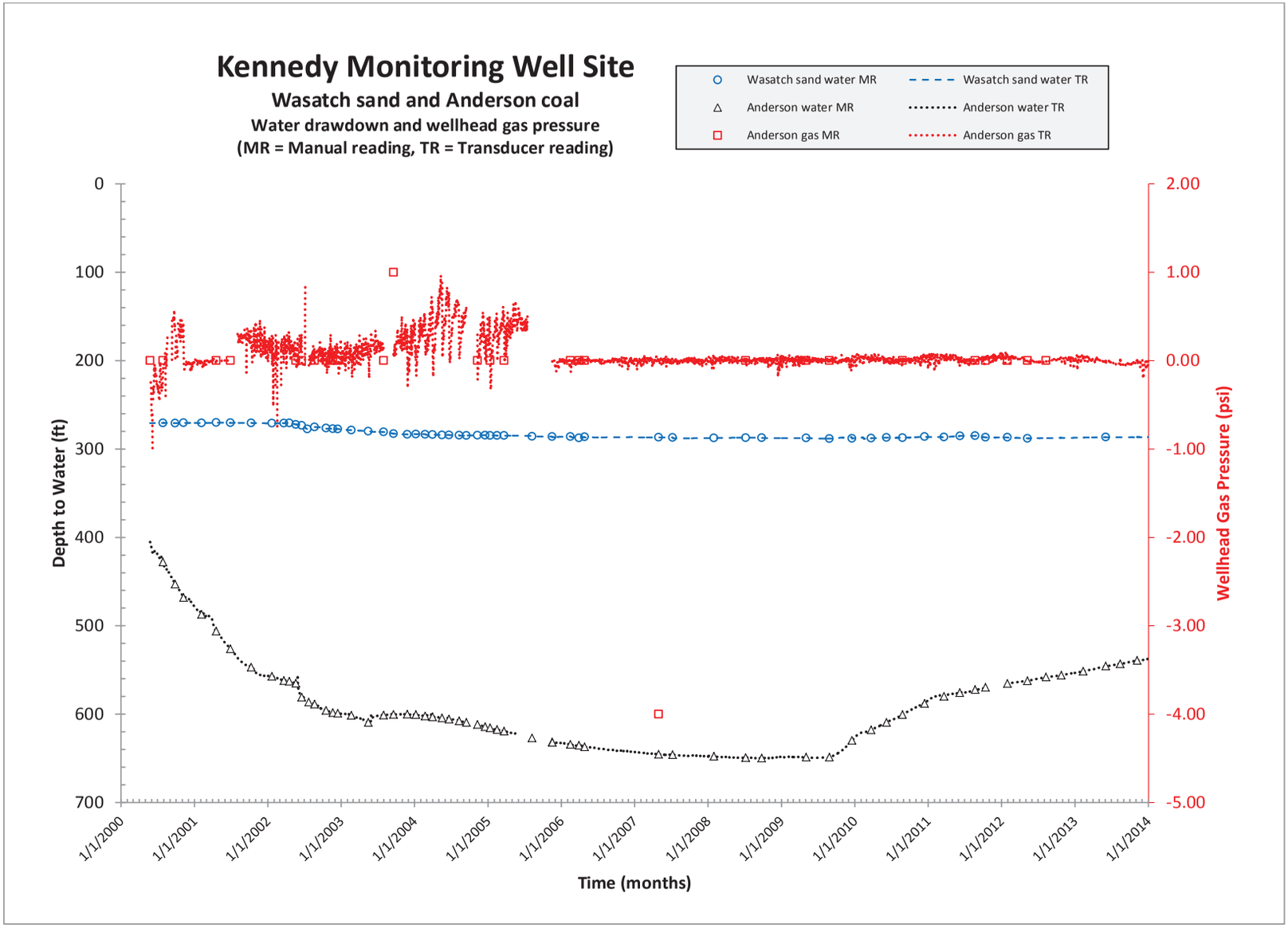

Figure A.135. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored intervals at the Kennedy monitoring well site location.

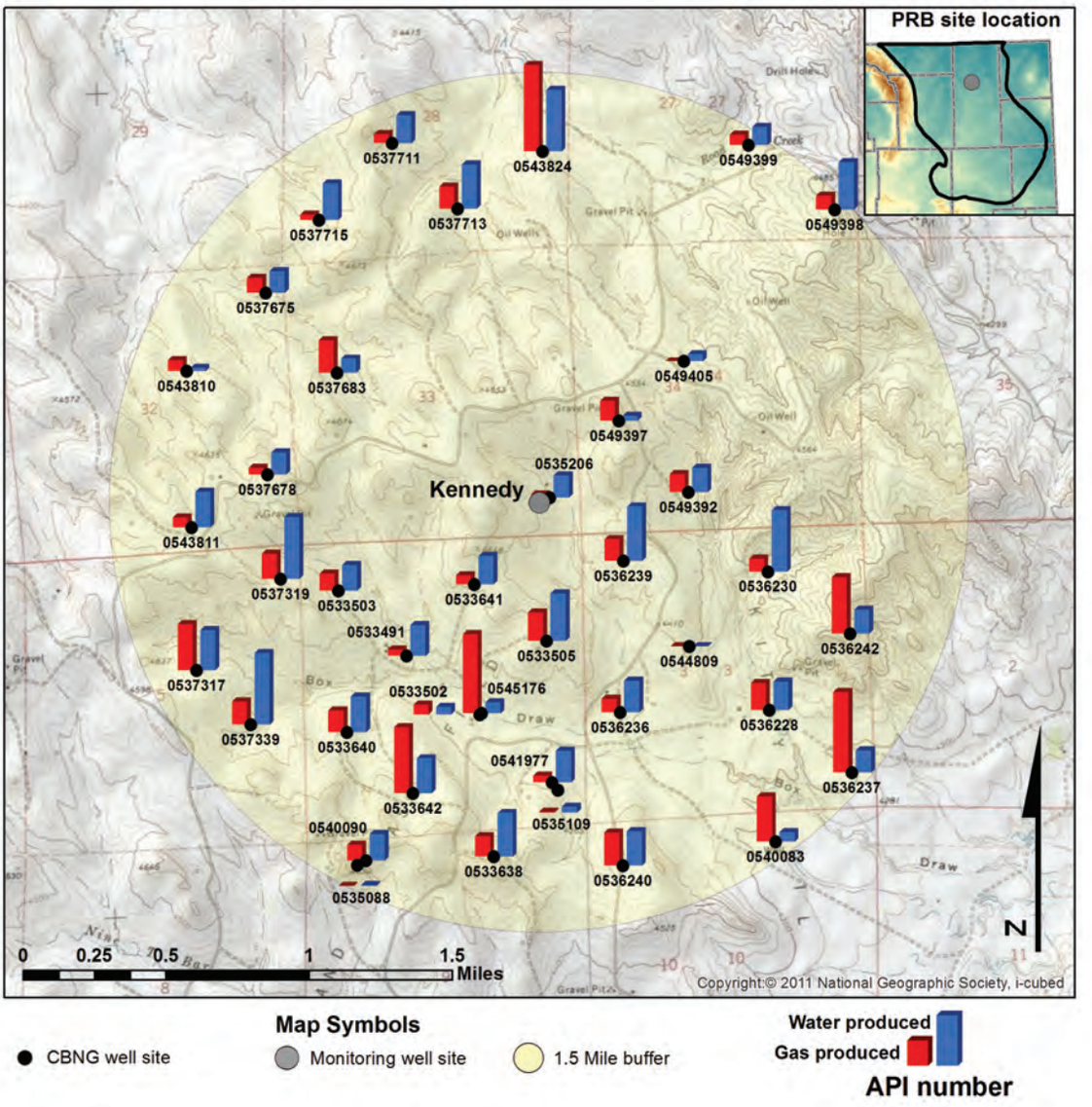

Figure A.136. Kennedy monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

Consistent monthly water production in both the Upper Wyodak coal zone 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 coal zone 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).

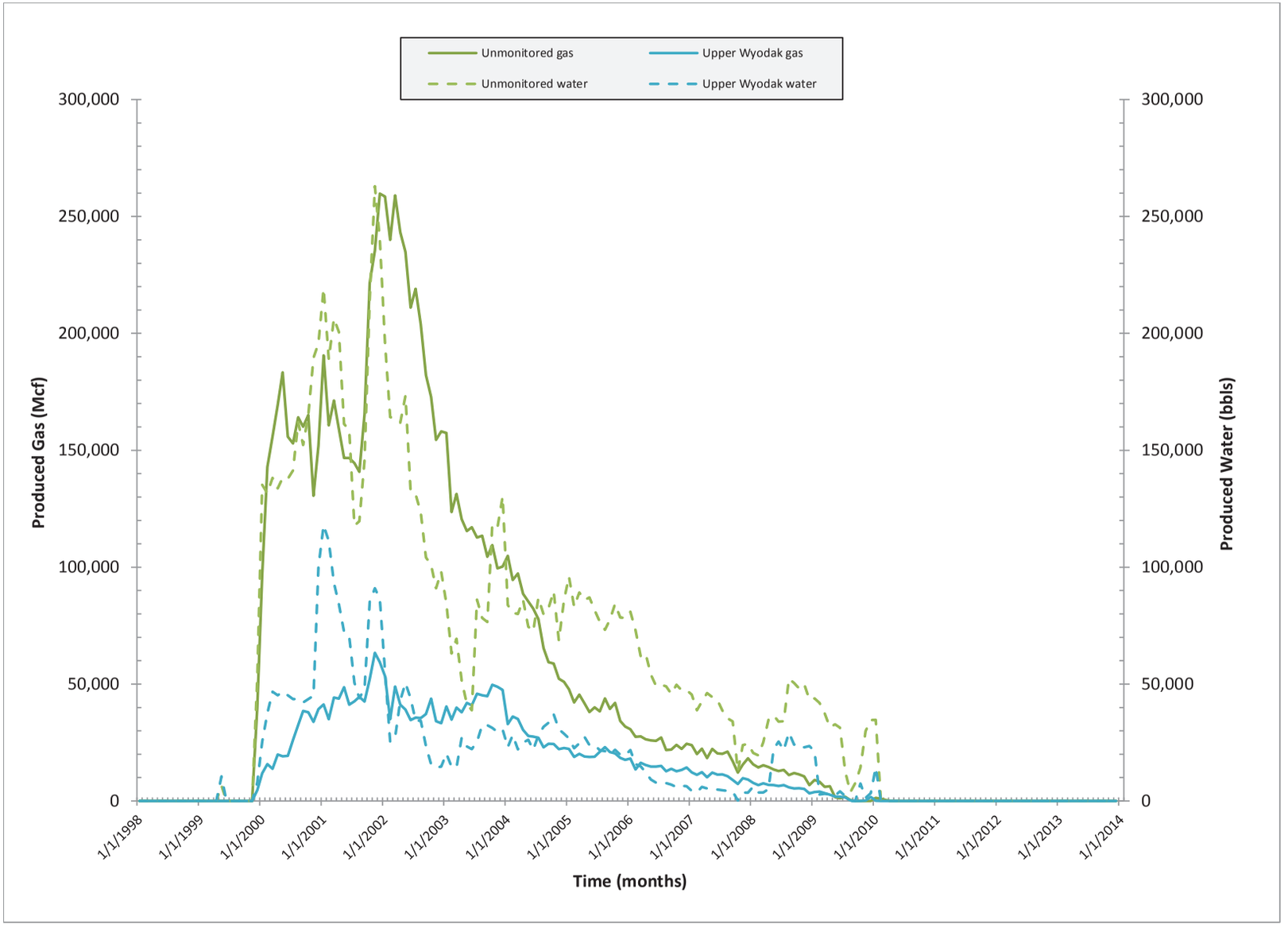

Figure A.137. Water and gas production from CBNG wells associated with the Kennedy monitoring well site location.

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). Water levels and wellhead gas pressure were measured during 2013 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. This apparently continued throughout 2013; the groundwater level of the sandstone is nearly identical to that of the Big George coal from 2010 forward.

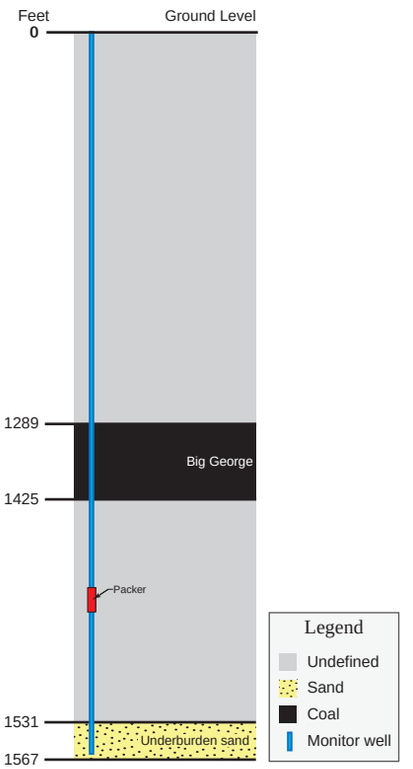

Figure A.138. Section showing relative positions of coal and sand in feet. Not to scale.

Big George Coal

Groundwater levels in the Big George coal monitoring well declined 11.20 feet during 2013. During the 2007 – 2013 POR, water levels declined a total of 327.11 feet (Figure A.139; Table A.69) from initial levels. A peak gas pressure of 1.40 psi was recorded in May 2013.

Fort Union Underburden Sandstone

Groundwater levels in the Fort Union underburden sandstone monitoring well declined 305.02 feet during the 2007-2013 monitoring period and 15.51 feet during 2013 (Figure A.139; Table A.69). Gas pressure was not recorded in the underburden sandstone.

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

Monitored interval	Interval characteristics			
	Depth of interval (ft)		Interval 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, water level changes for current monitoring period, water level changes for period of record, and maximum gas pressure.

Monitored interval	DGW - Depth to groundwater (ft), water level (ft), and gas pressure (psi) data					
	Initial DGW	Max DGW [Date]	Final 2013 DGW	Water level change 2013	Net water level change	Max. gas pressure [date]
Big George coal	0.00	327.10 7/15/2013	327.11	-11.20	-327.11	1.40 5/13/2013
Wasatch sand	25.50	330.70 10/26/2013	330.52	-15.51	-305.02	n/a

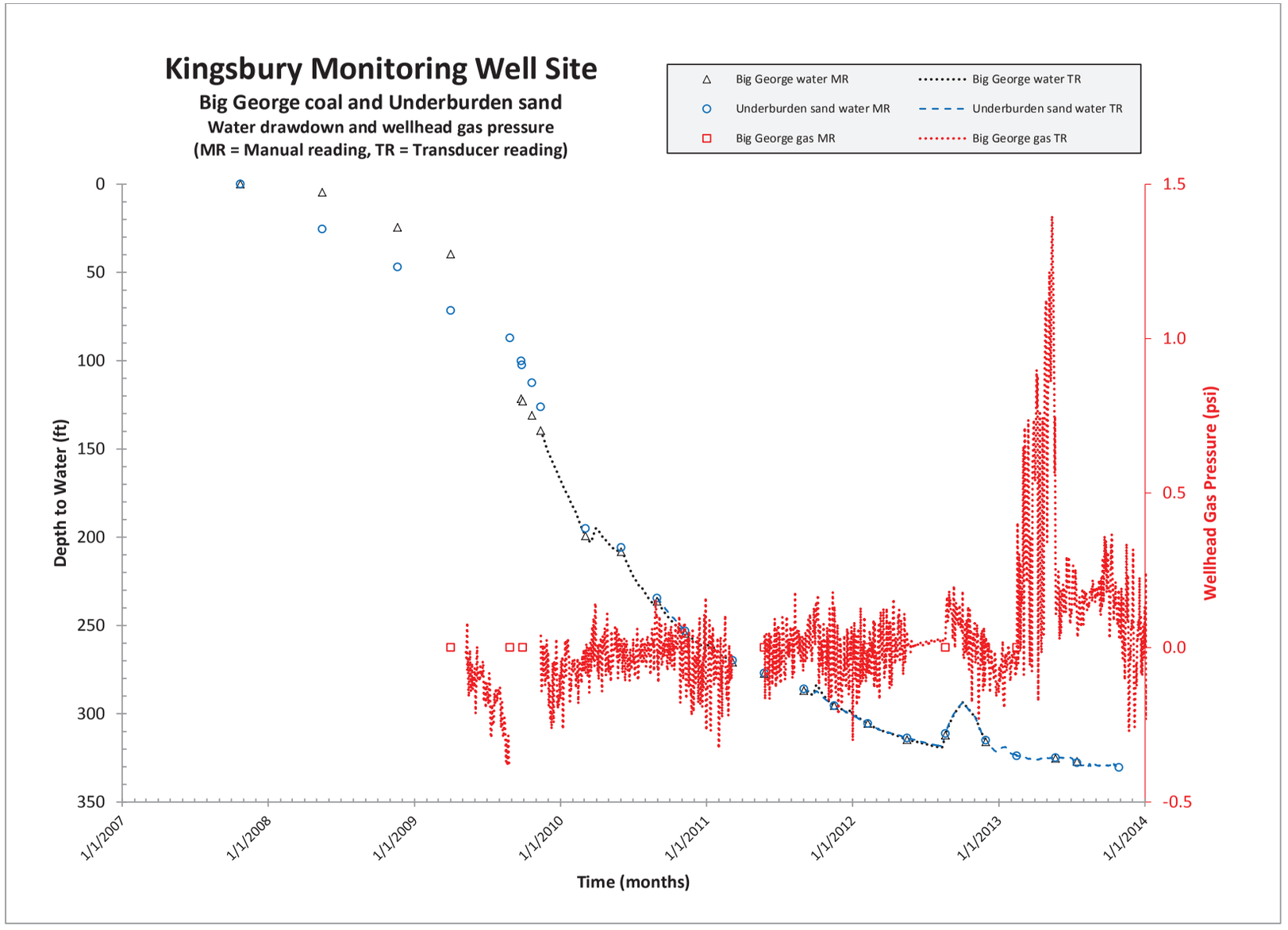

Figure A.139. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored intervals at the Kingsbury monitoring well site location.

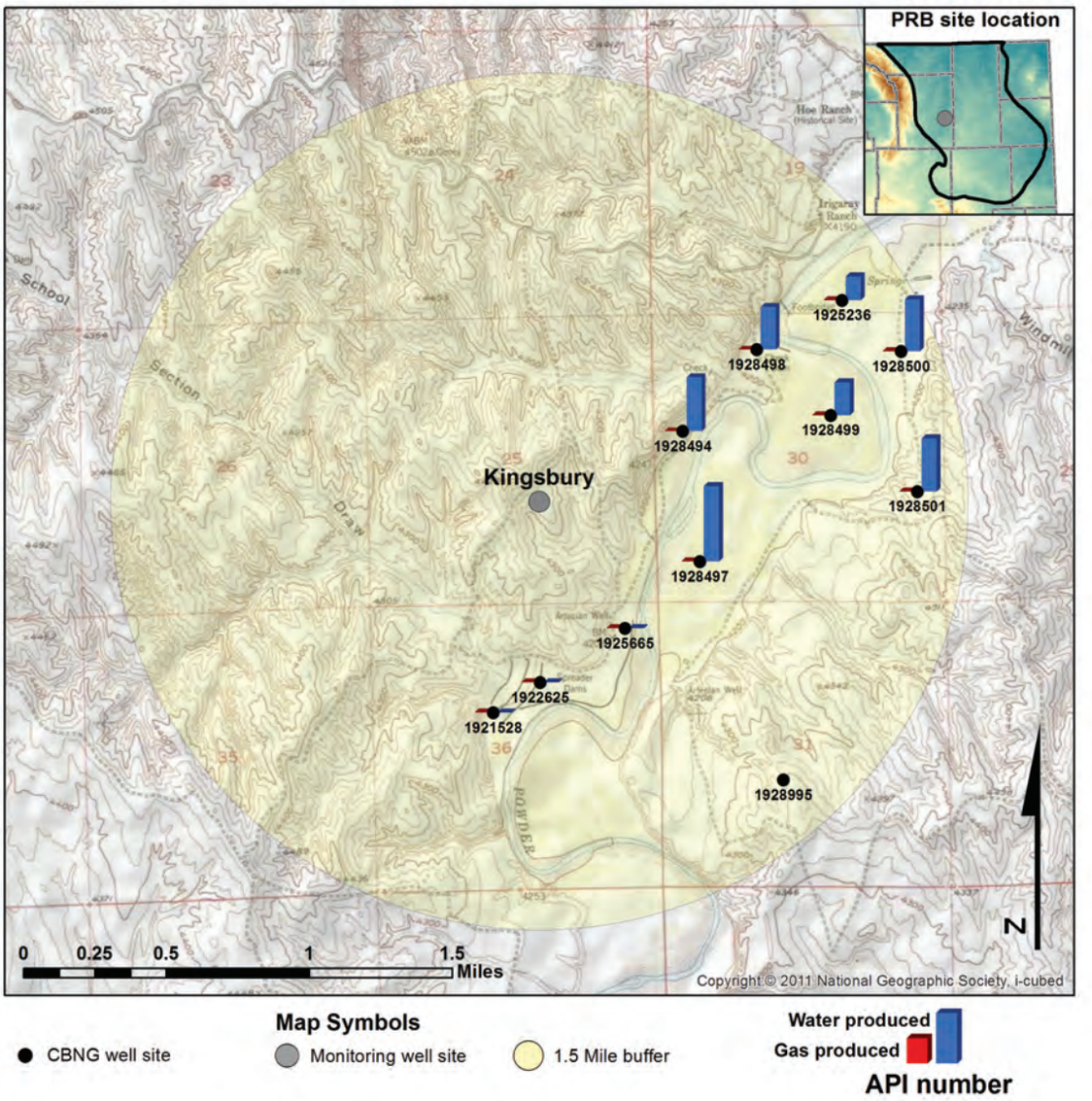

Figure A.140. Kingsbury monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

Production Statistics

Production data were analyzed for CBNG wells within the buffer of the Kingsbury monitoring well site from 2000-2013. Cumulative production for individual CBNG wells is displayed by location on Figure A.140. CBNG and water production are monitored in the Wyodak Rider coal zone wells.

Consistent monthly water production in the Wyodak Rider coal zone began in July 2009 and reached a peak of 144,510 bbls in July 2010 (Figure A.141). Monthly water production during 2013 dropped below 100,000 bbls. Gas was first produced from the Wyodak Rider coal zone in April 2011 and has not exceeded 200 Mcf /month since.

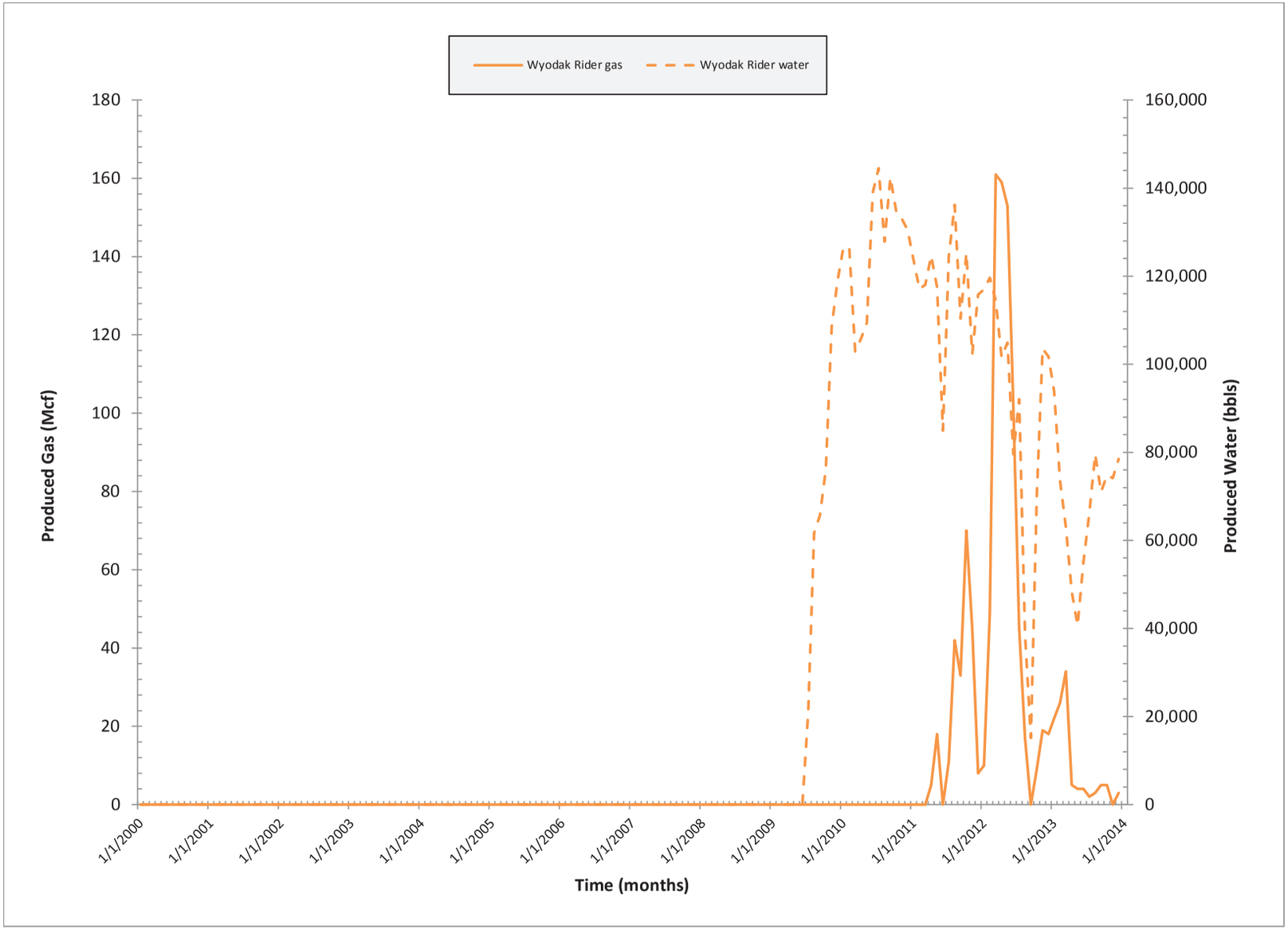

Figure A.141. Water and gas production from CBNG wells associated with the Kingsbury monitoring well site location.

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 2013 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 2013, groundwater levels in the Wasatch sandstone declined 3.69 feet. In contrast, over the monitoring period of 2005-2013, groundwater levels declined 23.25 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 17.62 feet during 2013. During the 2005-2013 monitoring period, water levels declined a total of 90.32 feet (Figure A.143; Table A.71). A peak gas pressure of 13.55 psi was recorded in January 2012.

Wall coal
Groundwater levels rose 0.57 feet during 2013. During the monitoring period of 2005-2013, water levels declined 301.81 feet (Figure A.143; Table A.71). Gas pressure in the Wall coal peaked at 23.00 psi in February 2012.

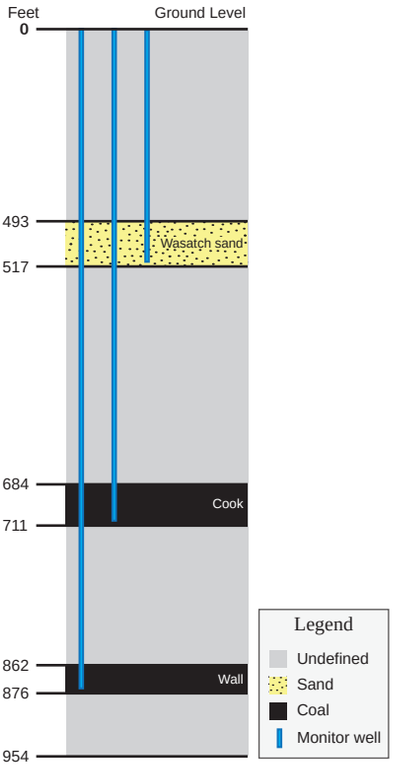

Figure A.142. Section showing relative positions of coals and sand in feet. Not to scale.

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

Monitored interval	Interval characteristics			
	Depth of interval (ft)		Interval 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, water level changes for current monitoring period, water level changes for period of record, and maximum gas pressure.

Monitored interval	DGW - Depth to groundwater (ft), water level (ft), and gas pressure (psi) data					
	Initial DGW	Max DGW [Date]	Final 2013 DGW	Water level change 2013	Net water level change	Max. gas pressure [date]
Wasatch sand	41.38	64.70 12/25/2013	64.63	-3.69	-23.25	n/a
Cook coal	22.86	294.80 1/12/2012	113.18	17.62	-90.32	13.55 1/18/2012
Wall coal	15.39	348.30 2/15/2012	317.20	0.57	-301.81	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 2001-2013. Cumulative production for individual CBNG wells is displayed by location on Figure A.144. CBNG and water production are monitored in the Cook, the Wall, and multiple coal zone wells.

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 coal zone peaked in September 2004 at 50,213 Mcf and has steadily declined, producing 843 Mcf in December 2013.

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). Gas production in the Wall coal zone has never exceeded 50 Mcf/month, and there has been no gas production since December 2011.

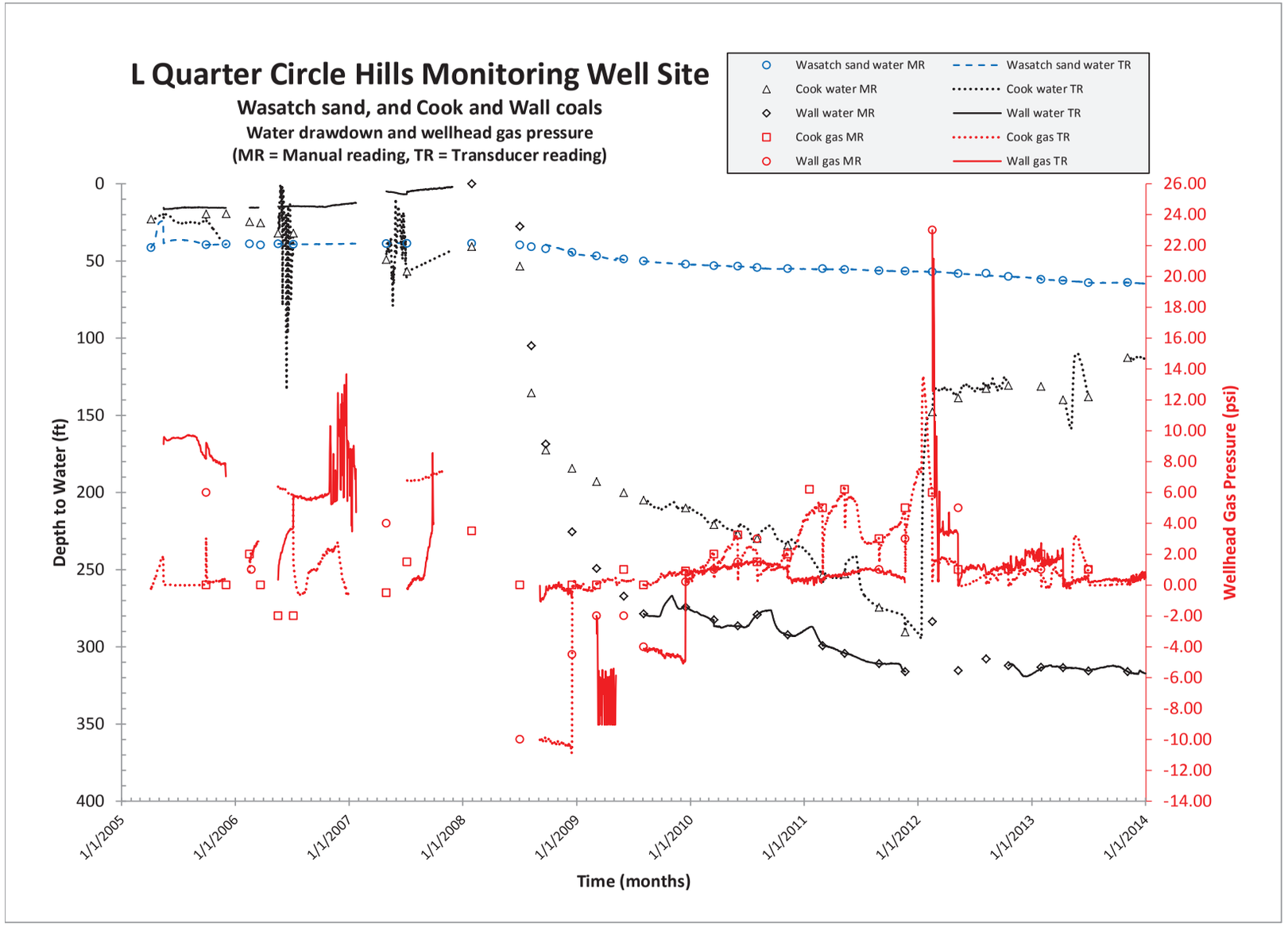

Figure A.143. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored intervals at the L Quarter Circle Hills monitoring well site location.

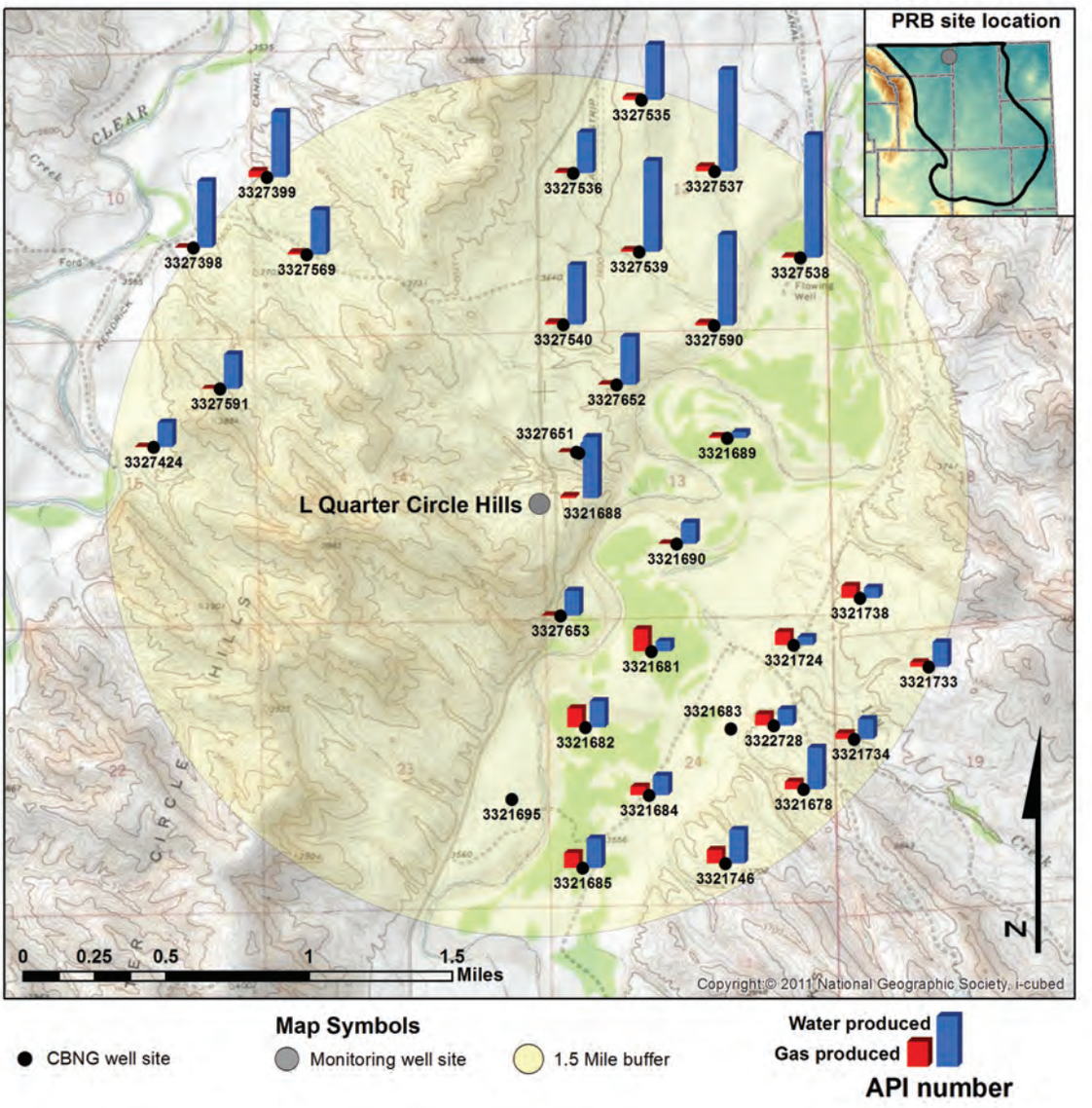

Figure A.144. L Quarter Circle Hills monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

Water production in multiple coal zone wells began in August 2007, reached a maximum of 365,155 bbls in August 2008 and declined to around 100,000 bbls/month by the end of 2013 (Figure A.145). Gas production began in April 2008 and has been low but relatively constant since 2009 never exceeding 10,000 Mcf/month.

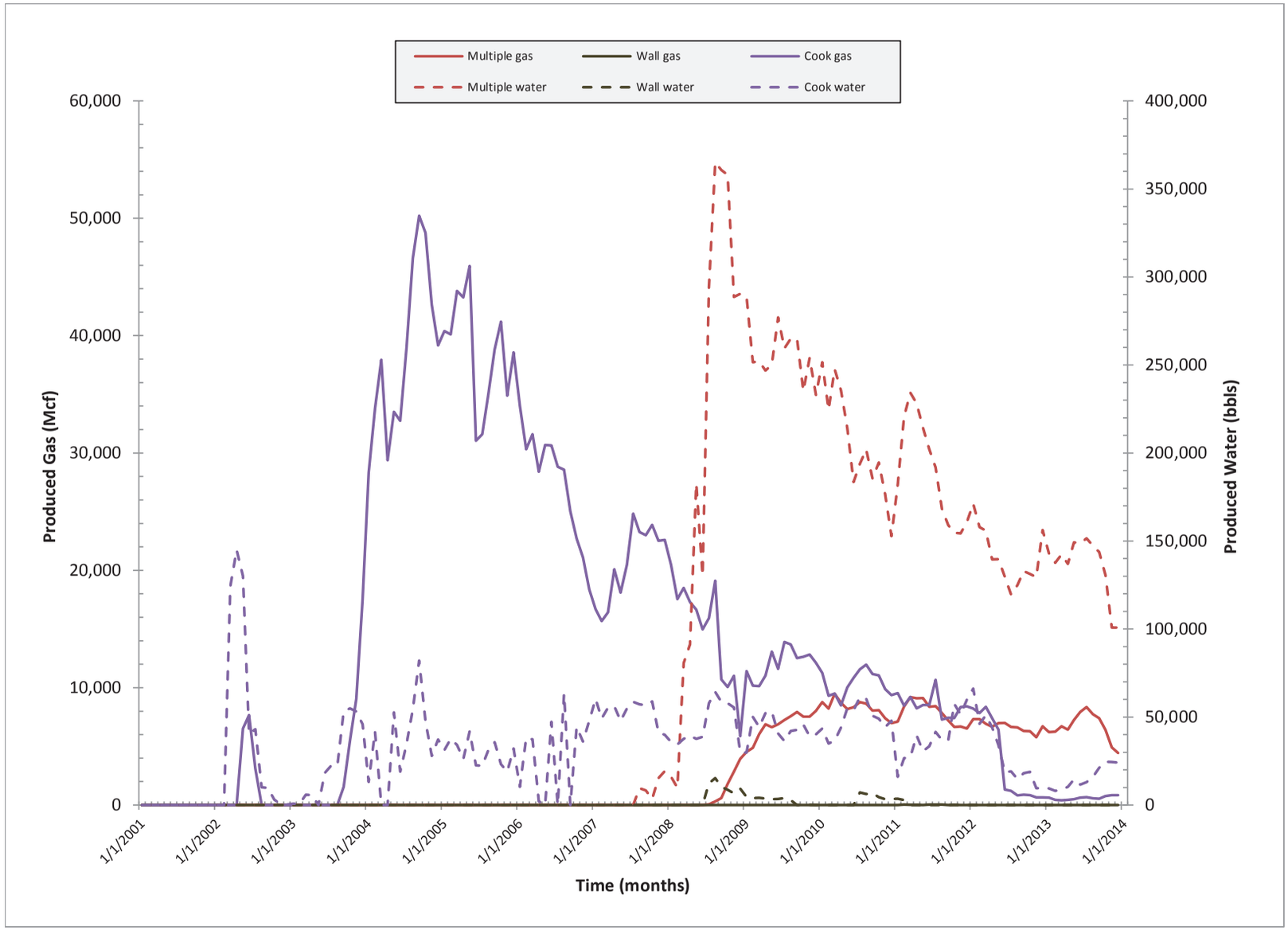

Figure A.145. Water and gas production from CBNG wells associated with the L Quarter Circle Hills monitoring well site location.

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 0.04 feet during 2013 and 0.56 feet during the monitoring period of 2002-2013. (Figure A.147; Table A.73). This monitoring site was plugged and abandoned on 8/20/2013. Gas pressure was not recorded for this well.

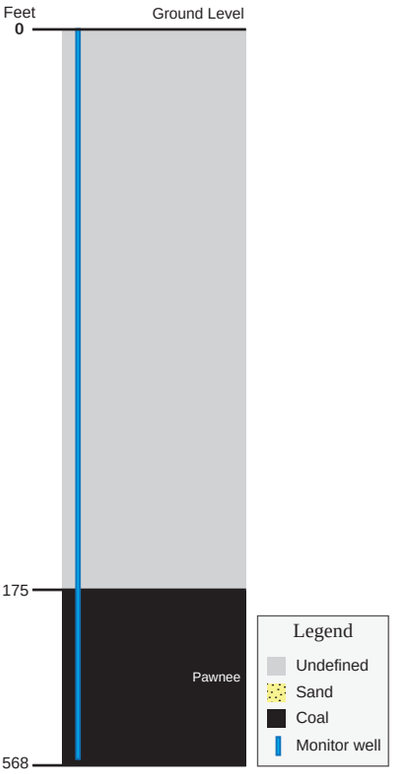

Figure A.146. Section showing relative position of coal in feet. Not to scale.

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

Monitored interval	Interval characteristics			
	Depth of interval (ft)		Interval 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, water level changes for current monitoring period, water level changes for period of record, and maximum gas pressure.

Monitored interval	DGW - Depth to groundwater (ft), water level (ft), and gas pressure (psi) data					
	Initial DGW	Max DGW [Date]	Final 2013 DGW	Water level change 2013	Net water level change	Max. gas pressure [date]
Pawnee coal*	168.05	168.60 7/11/2013	168.57	-0.04	-0.56	n/a

*Well plugged and abandoned 8/20/2013

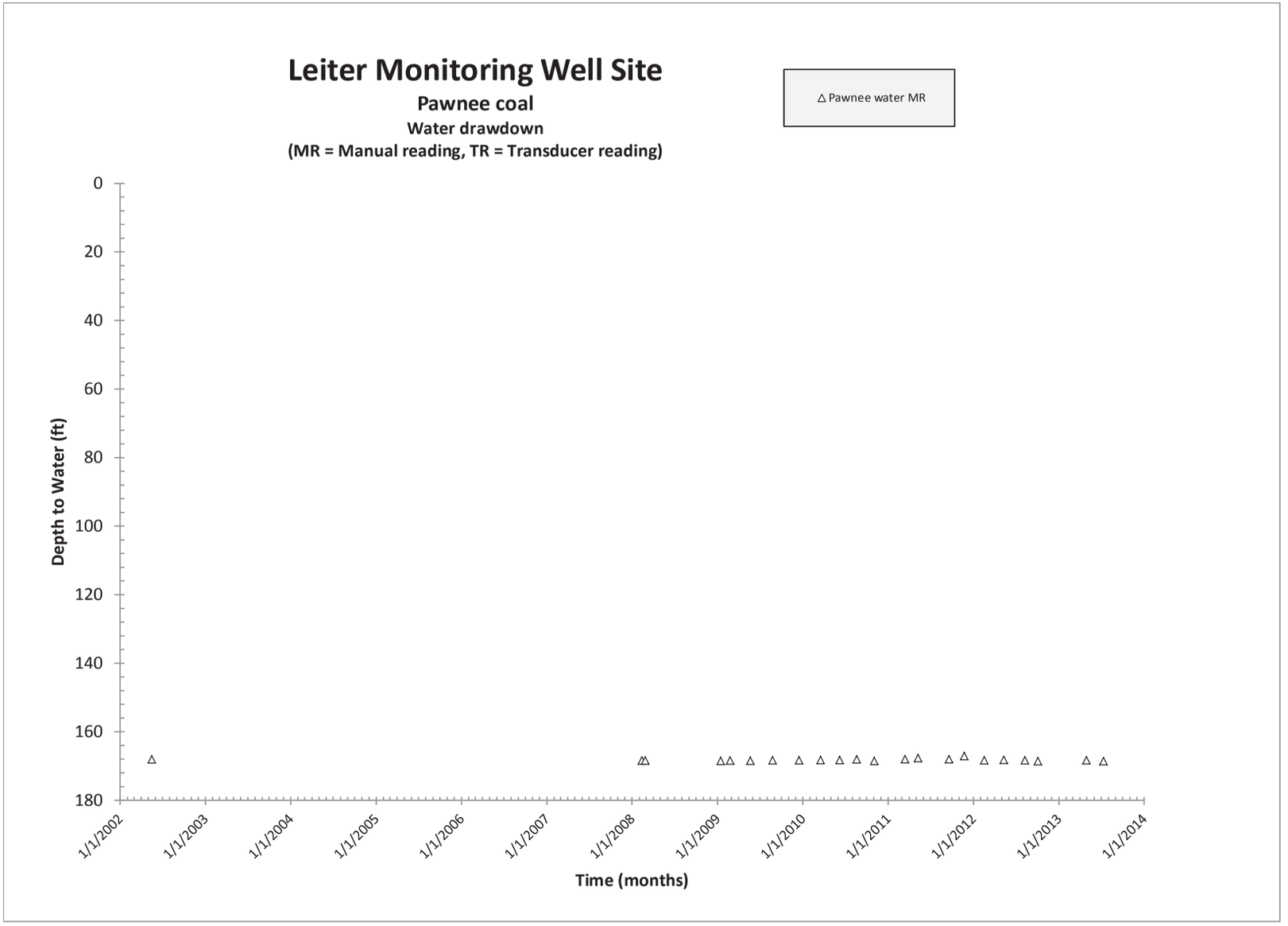

Figure A.147. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored intervals at the Leiter monitoring well site location

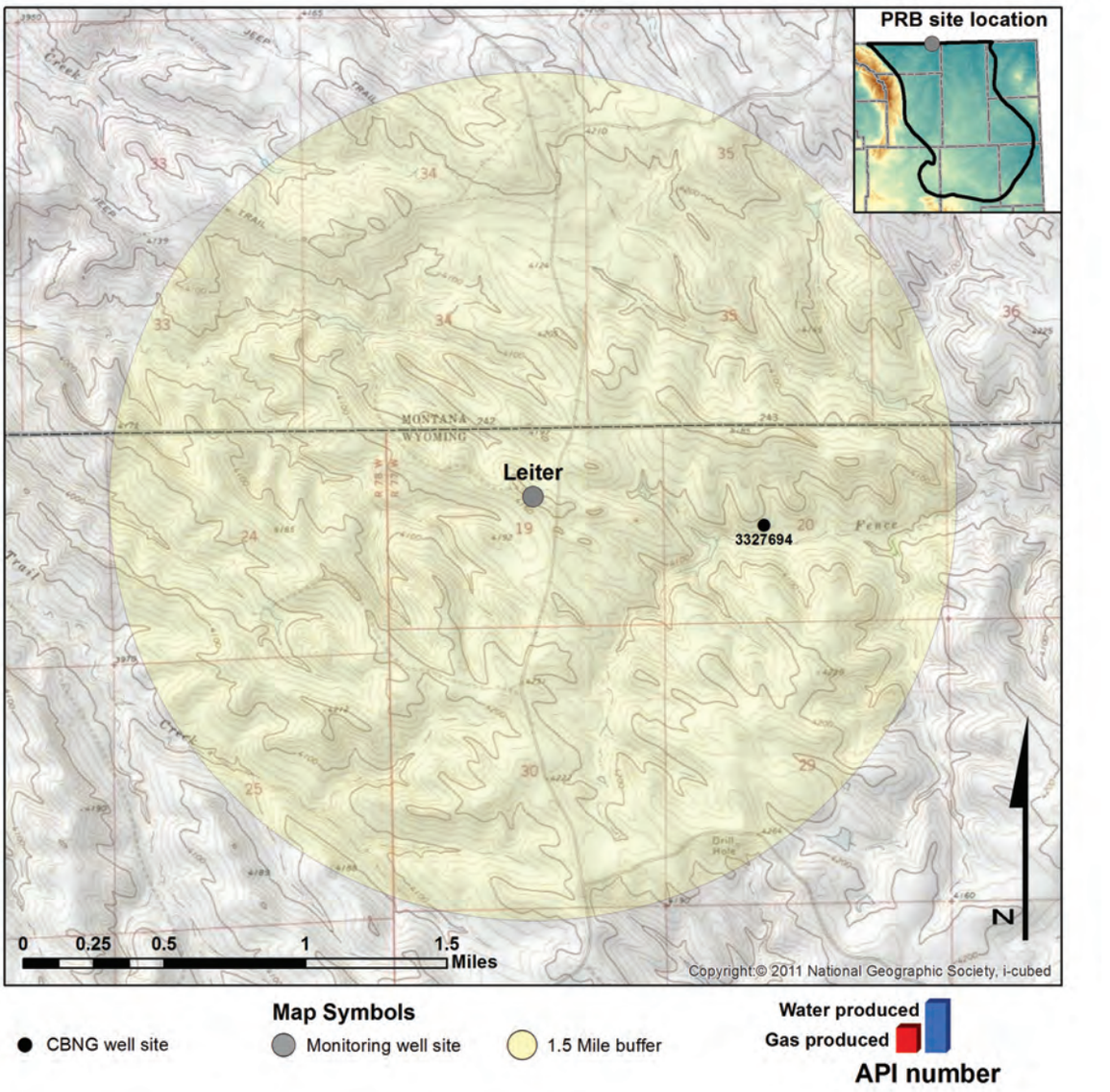

Figure A.148. Leiter monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

Production Statistics

Production data were analyzed for CBNG wells within the buffer of the Leiter monitoring well site from 2007-2013. Cumulative production for individual CBNG wells is displayed by location in Figure A.148. CBNG and water production are monitored in multiple coal zone wells.

There was no water or gas production reported within the buffer zone of the monitoring site (Figure A.149).

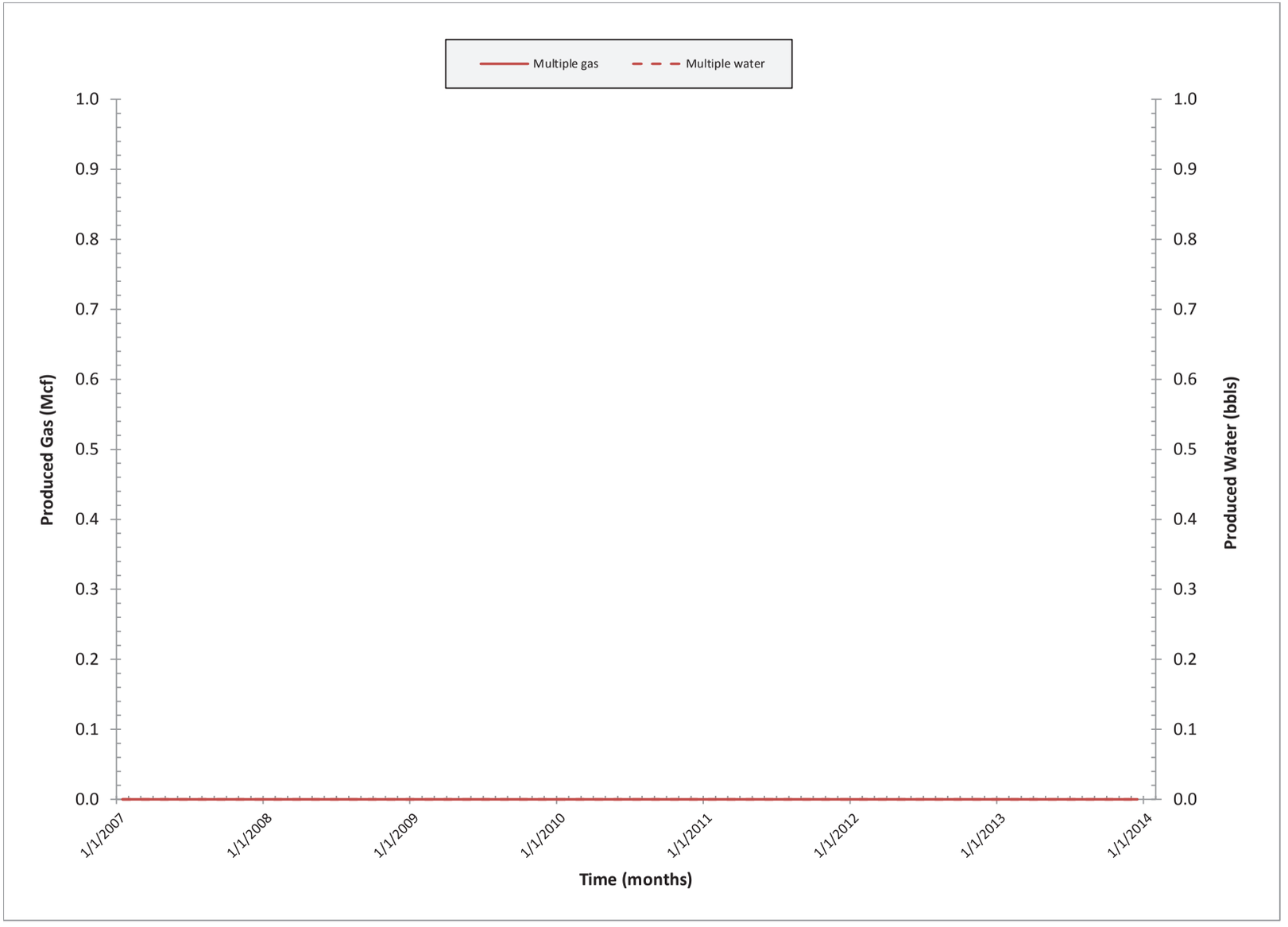

Figure A.149. Water and gas production from CBNG wells associated with the Leiter monitoring well site location.

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 2013 using a combination of 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 2013, groundwater levels rose 0.61 feet; during the 2000-2013 monitoring period, water levels declined a total of 3.46 feet (Figure A.151; Table A.75). Gas pressure was not recorded in the Wasatch sandstone.

Wyodak-Anderson Coal

In December 2009, it was reported that the well was dry to its total depth and it has remained dry during 2013 (Figure A.151; Table A.75). A peak gas pressure of 66.66 psi was recorded in May 2002. This well partially collapsed and the monitoring zone depth changed from 723 feet to 660 feet.

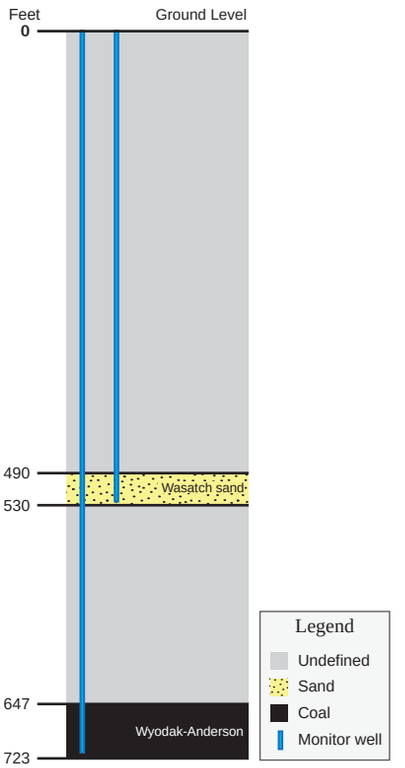

Figure A.150. Section showing relative positions of coal and sand in feet. Not to scale.

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

Monitored interval	Interval characteristics			
	Depth of interval (ft)		Interval thickness (ft)	Separation from coal (ft)
	Top	Bottom		
Wasatch sand	490	530	40	117
Wyodak-Anderson coal*	647	660	13	n/a

*Well partially collapsed, bottom of monitoring zone changed from 723 ft to 660 ft

Table A.75. Table showing depths to water from ground level, water level changes for current monitoring period, water level changes for period of record, and maximum gas pressure.

Monitored interval	DGW - Depth to groundwater (ft), water level (ft), and gas pressure (psi) data					
	Initial DGW	Max DGW [Date]	Final 2013 DGW	Water level change 2013	Net water level change	Max. gas pressure [date]
Wasatch sand	286.31	295.70 3/29/2005	289.77	0.61	-3.46	n/a
Wyodak/Anderson coal*	453.10	662.20 11/30/2009	660.00	n/a	-206.90	66.66 5/22/2002

*Well dry to total depth 12/14/2009

Production Statistics

Production data were analyzed for CBNG wells within the buffer of the Lone Tree monitoring well site from 1991-2013. Cumulative production for individual CBNG wells is displayed by location on Figure A.152. CBNG and water production are monitored in the Upper Wyodak coal zone and in coal production zones that are not monitored.

Water production in the Upper Wyodak zone was low from 1991-2000, peaked in October 2001 at 171,313 bbls (Figure A.153). In July 2012, water production receded to zero, followed by an eight month period of low production (<1020 bbls/month) and the declined to zero again by July 2013. Gas production was low until 2000, then rapidly increased to a peak level of 115,297 Mcf in December 2001.

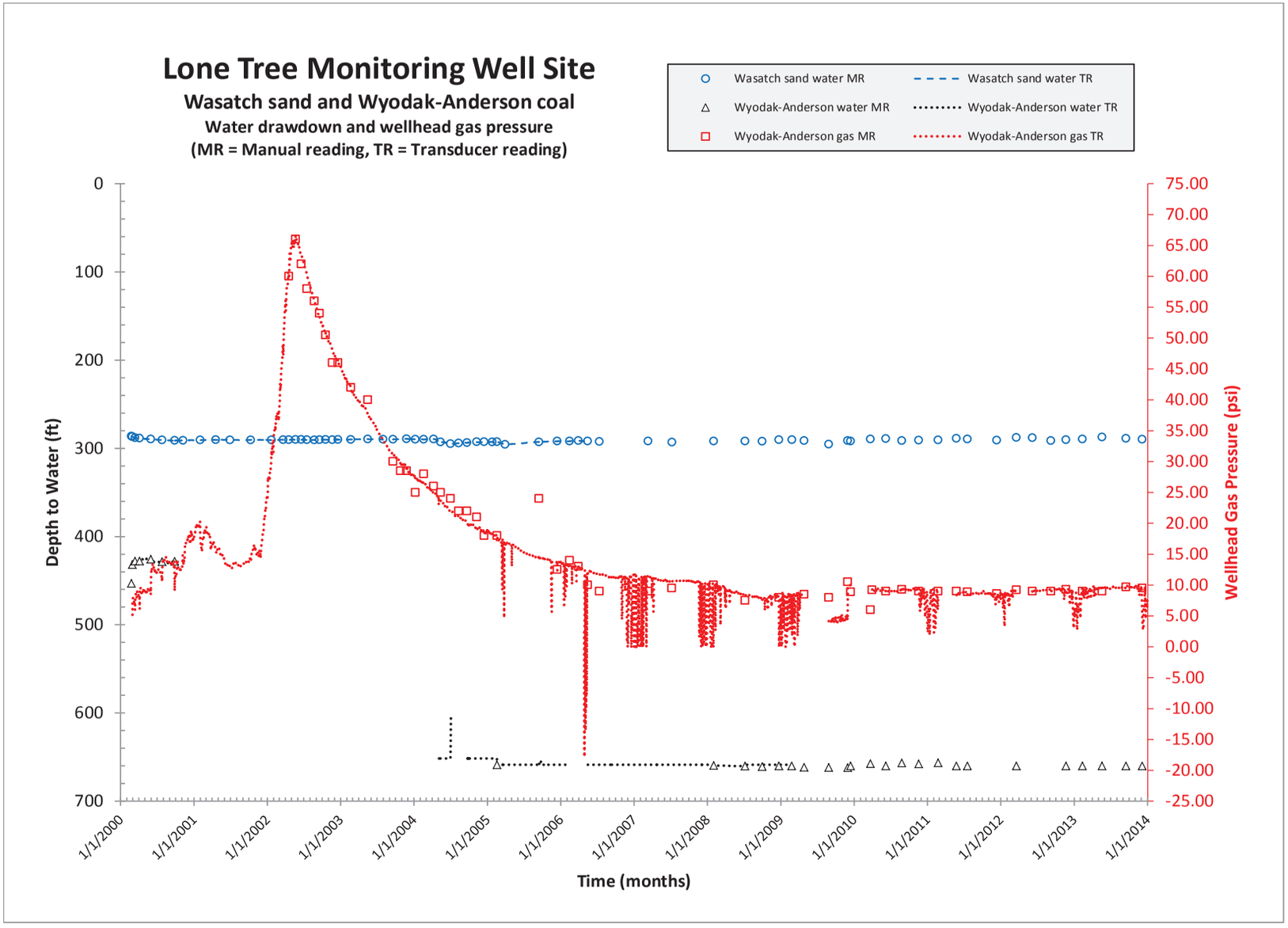

Figure A.151. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored intervals at the Lone Tree monitoring well site location.

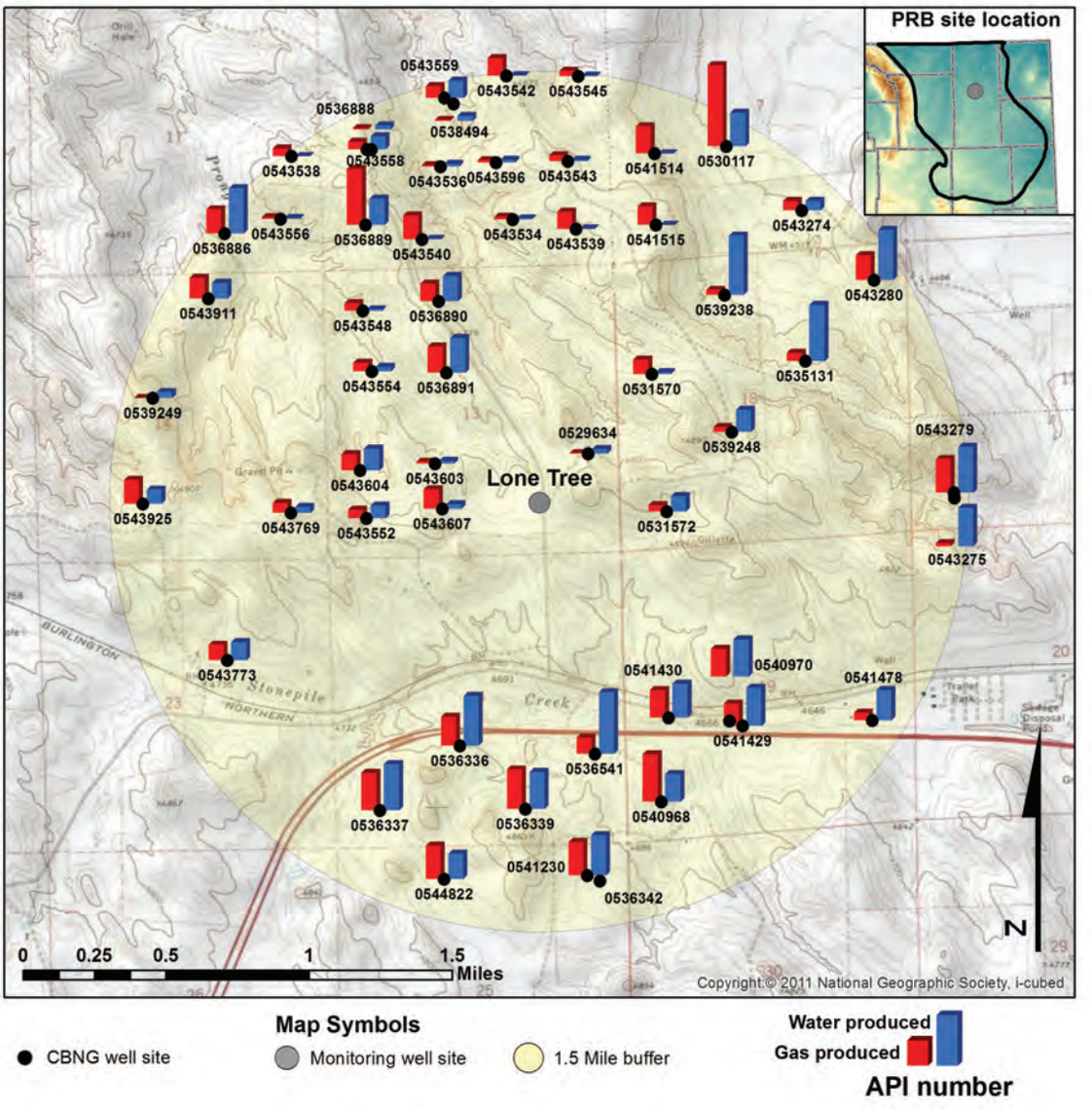

Figure A.152. Lone Tree monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

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 unmonitored coal zones peaked in March 2002 at nearly 9,844 Mcf and remained low until April 2012 when gas production ceased.

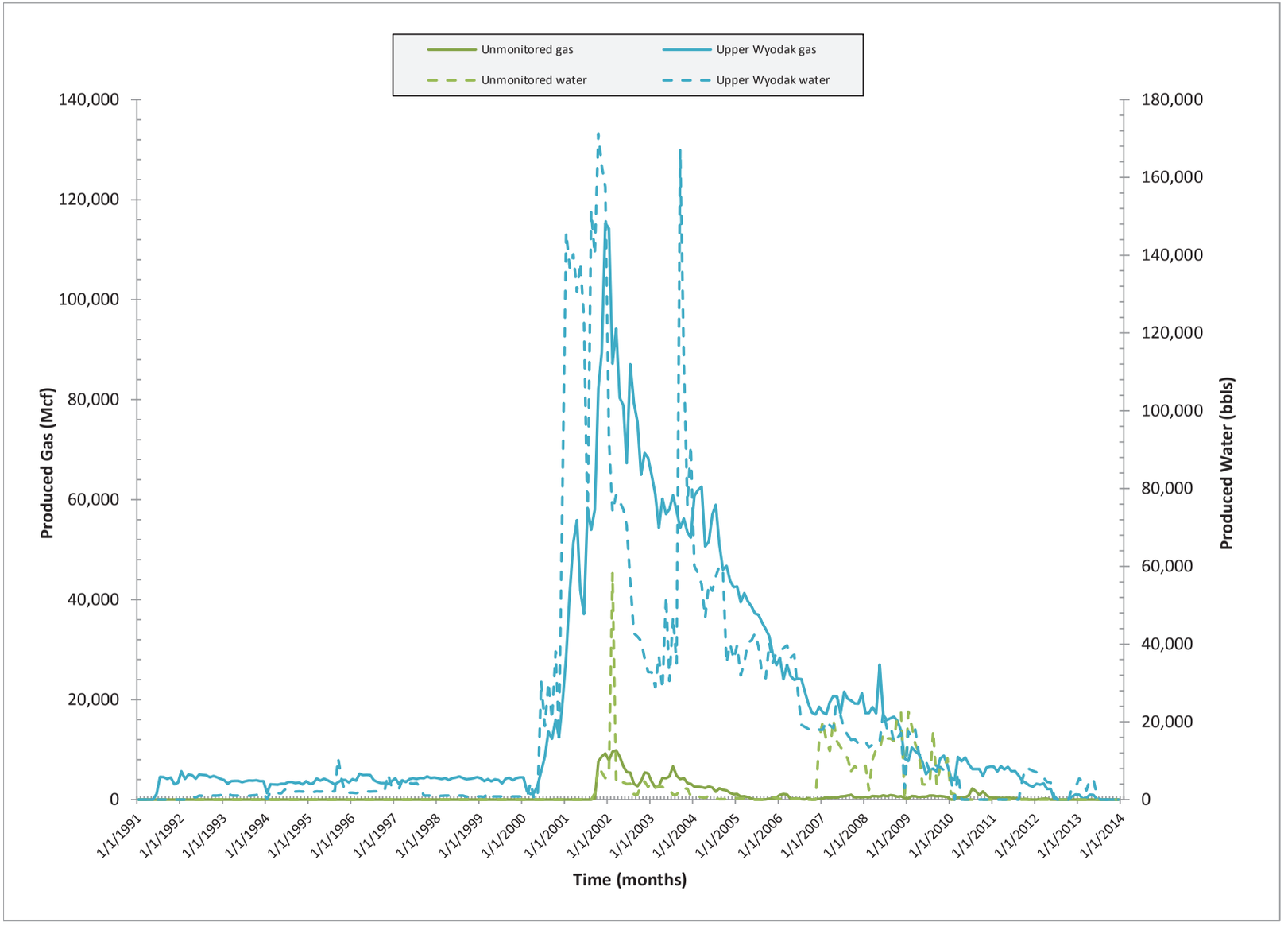

Figure A.153. Water and gas production from CBNG wells associated with the Lone Tree monitoring well site location.

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 in 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 2013 using both manual and automatic transducer and data logger equipment. There is good agreement between concurrent transducer and manual measurements where both are present. 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 2013, groundwater levels in the monitored shallow Wasatch sandstone rose 0.35 feet (Figure A.155; Table A.77). During the 2000 - 2013 monitoring period, groundwater levels rose 0.10 feet from initial static water levels.

The monitoring well in the deeper Wasatch sandstone recorded a groundwater rise of 1.91 feet during 2013; water levels declined 16.92 feet during the 2000 - 2013 monitoring period (Figure A.155; Table A.77). Gas pressure was not recorded in the Wasatch sandstones.

Anderson Coal
During 2013, groundwater levels declined 6.05 feet in the Anderson coal monitoring well; water levels declined 476.56 feet during the monitoring period of 2000-2013 (Figure A.155; Table A.77). Gas pressure in the Anderson coal varied over the monitoring period of 2000-2013 peaking at 45.10 psi in February 2004.

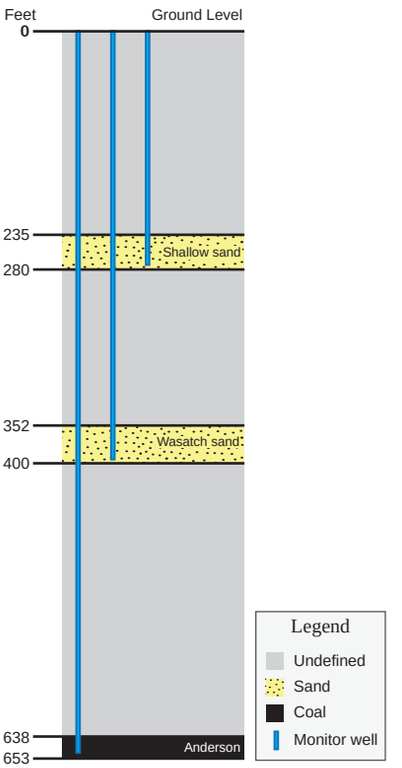

Figure A.154. Section showing relative positions of coal and sands in feet. Not to scale.

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

Monitored interval	Interval characteristics			
	Depth of interval (ft)		Interval 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, water level changes for current monitoring period, water level changes for period of record, and maximum gas pressure.

Monitored interval	DGW - Depth to groundwater (ft), water level (ft), and gas pressure (psi) data					
	Initial DGW	Max DGW [Date]	Final 2013 DGW	Water level change 2013	Net water level change	Max. gas pressure [date]
Shallow sand	193.35	197.20 5/16/2010	193.25	0.35	0.10	n/a
Wasatch sand	197.40	216.90 5/14/2010	214.32	1.91	-16.92	n/a
Anderson coal	168.15	696.30 7/17/2006	644.70	-6.05	-476.56	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 1999-2013. Cumulative production for individual CBNG wells is displayed by location on Figure A.156. CBNG and water production are 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 513,234 bbls, and gradually decreased, finishing 2013 at 13,805 bbls/month (Figure A.157). Gas production began in March 2000 in the Upper Wyodak coal zone, peaked at 359,702 Mcf in March 2001, and leveled off to less than 4,200 Mcf/month during 2013.

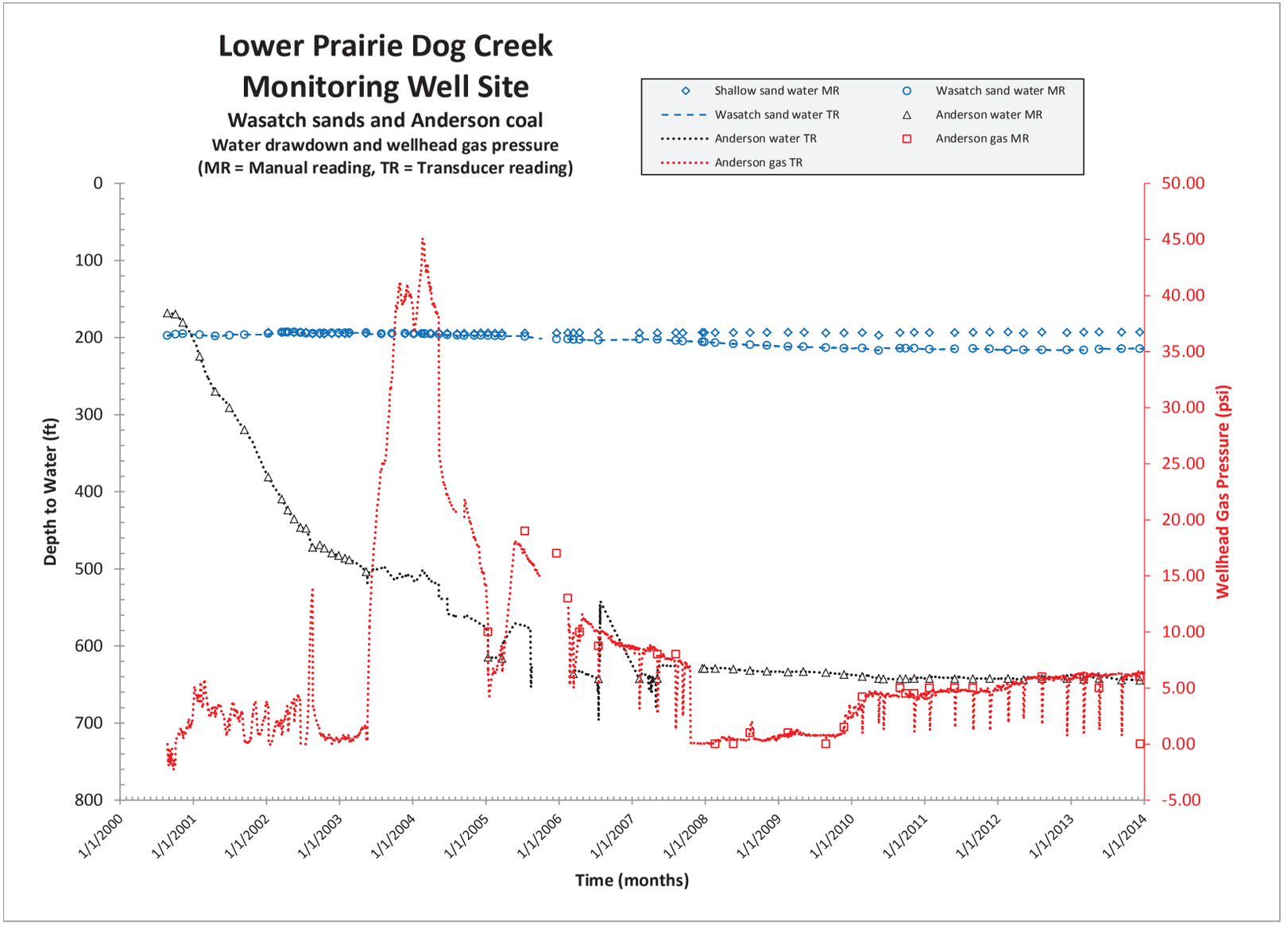

Figure A.155. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored intervals at the Lower Prairie Dog monitoring well site location.

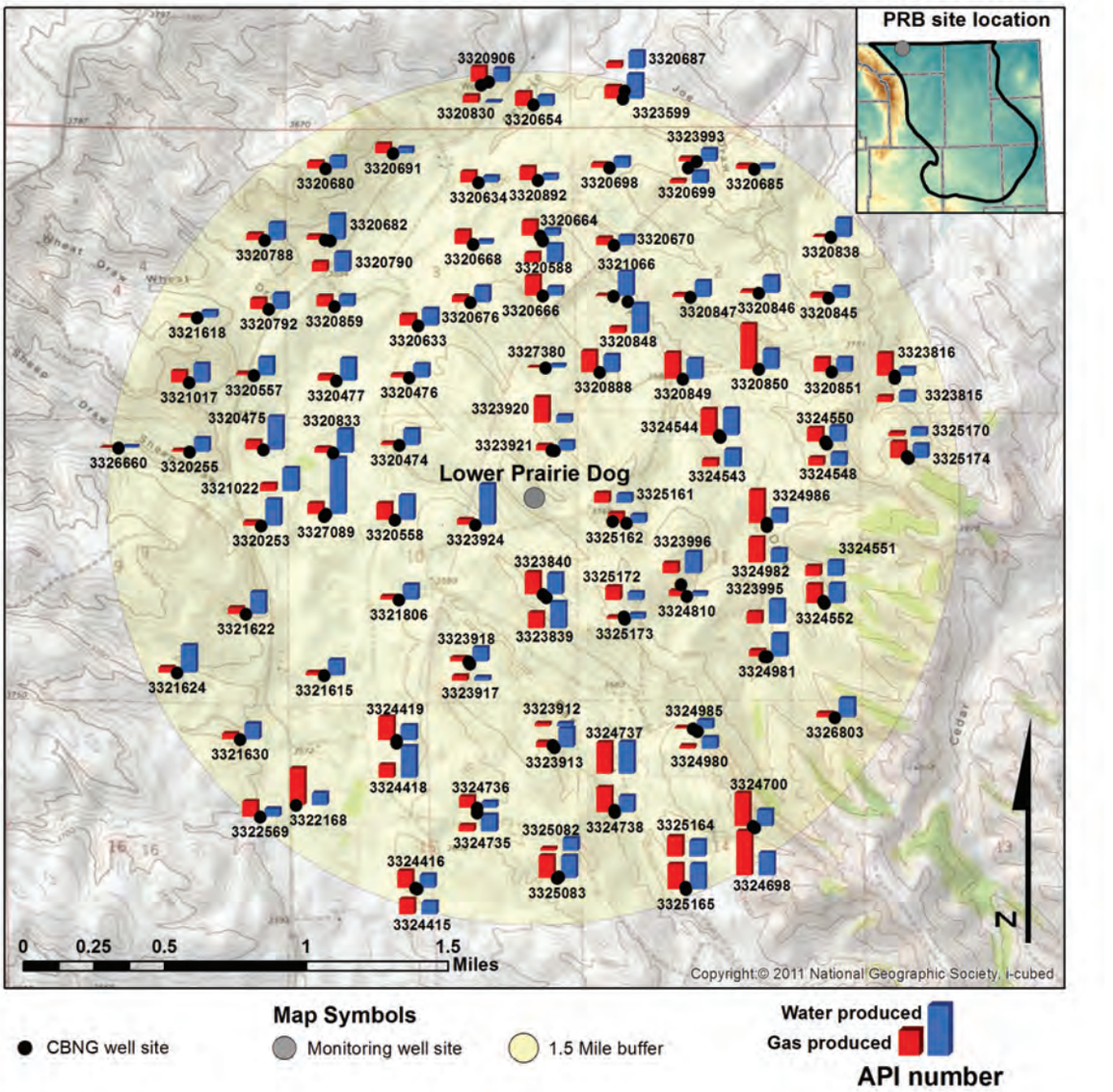

Figure A.156. Lower Prairie Dog monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

Water production in the unmonitored zone peaked in 2001 at nearly 800,000 bbls and has decreased gradually (Figure A.157). Gas production in 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 2004. Gas production in 2013 was less than 22,000 Mcf/month.

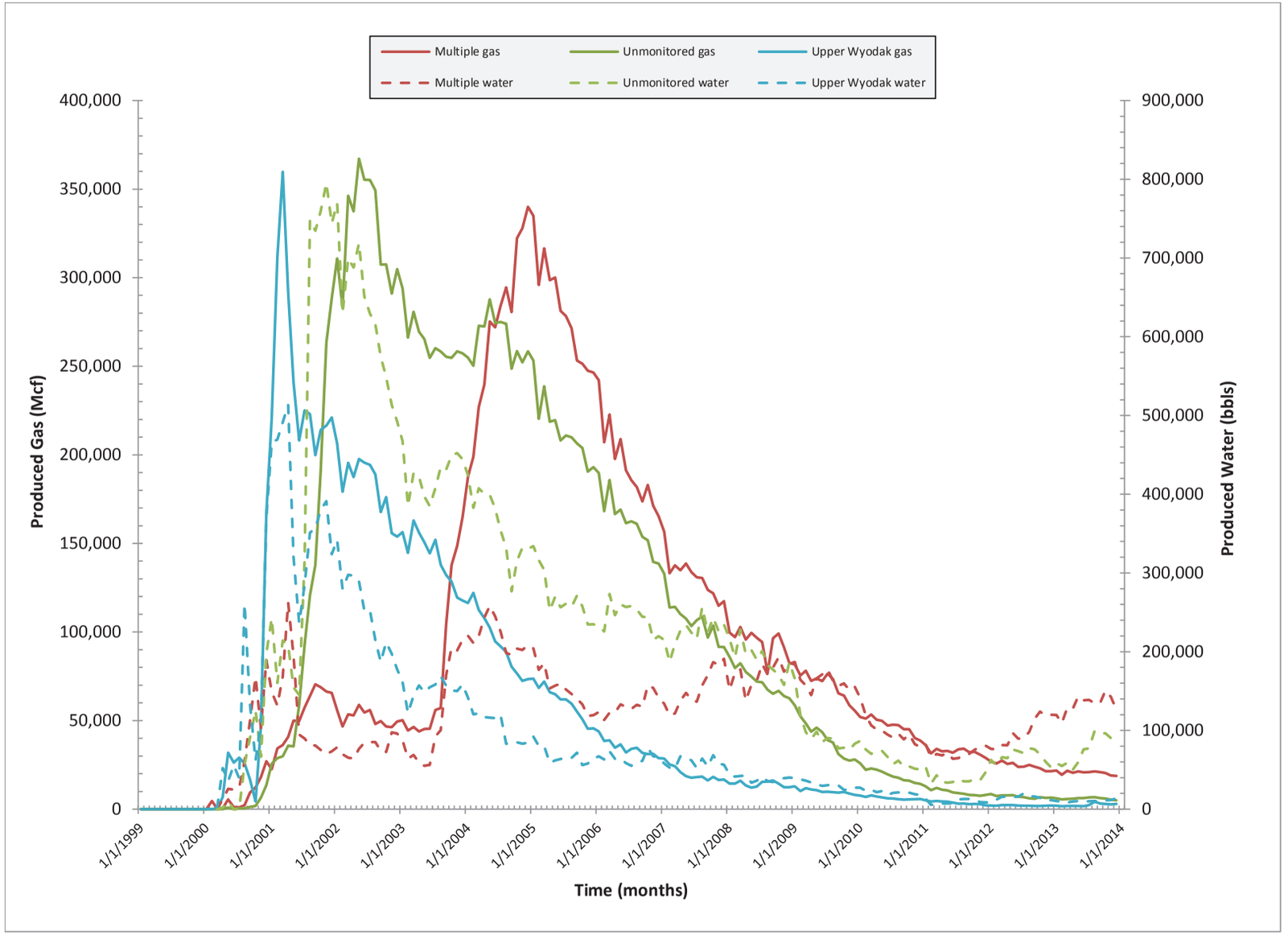

Figure A.157. Water and gas production from CBNG wells associated with the Lower Prairie Dog monitoring well site location.

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 2013 using both manual and automatic transducer and data logger equipment. There is good agreement between concurrent transducer and manual measurements. 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 22.82 feet during 2013. It should be noted, however, that groundwater levels underwent a steady, long term recovery at MP 2 of over 116 feet from May 2004 – December 2011. Groundwater levels have since declined through 2013 although no water was produced from the Upper Wyodak coal seam since October 2006. The recent decline may, in effect, be associated with producing surface coal mines located within 1.0 mile of MP 2. Overall, during the 1993-2013 monitoring period, the site has shown a net groundwater decline of 63.37 feet. (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 declined 16.30 feet during 2013. Levels declined 170.02 feet during the monitoring period of 1993-2013 (Figure A.159; Table A.79). Gas pressure in the Wyodak coal reached a maximum of 26.76 psi in January 1997.

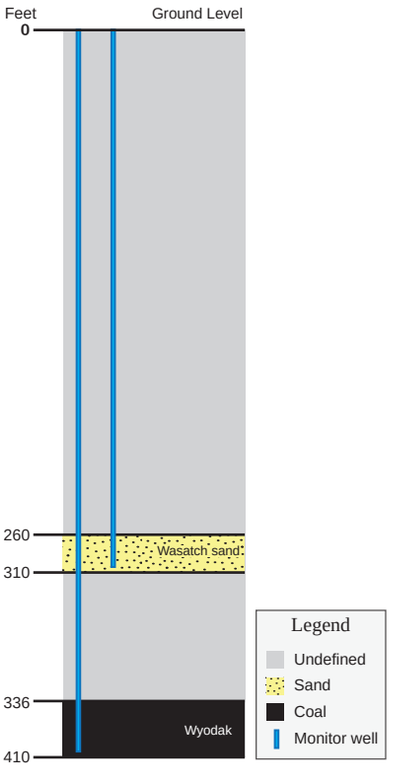

Figure A.158. Section showing relative positions of coal and sand in feet. Not to scale.

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

Monitored interval	Interval characteristics			
	Depth of interval (ft)		Interval 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, water level changes for current monitoring period, water level changes for period of record, and maximum gas pressure.

Monitored interval	DGW - Depth to groundwater (ft), water level (ft), and gas pressure (psi) data					
	Initial DGW	Max DGW [Date]	Final 2013 DGW	Water level change 2013	Net water level change	Max. gas pressure [date]
Wasatch sand	52.00	115.40 11/24/2013	115.37	-1.05	-63.37	n/a
Wyodak coal	163.05	405.50 5/8/2004	333.07	-16.30	-170.02	26.76 1/27/1997

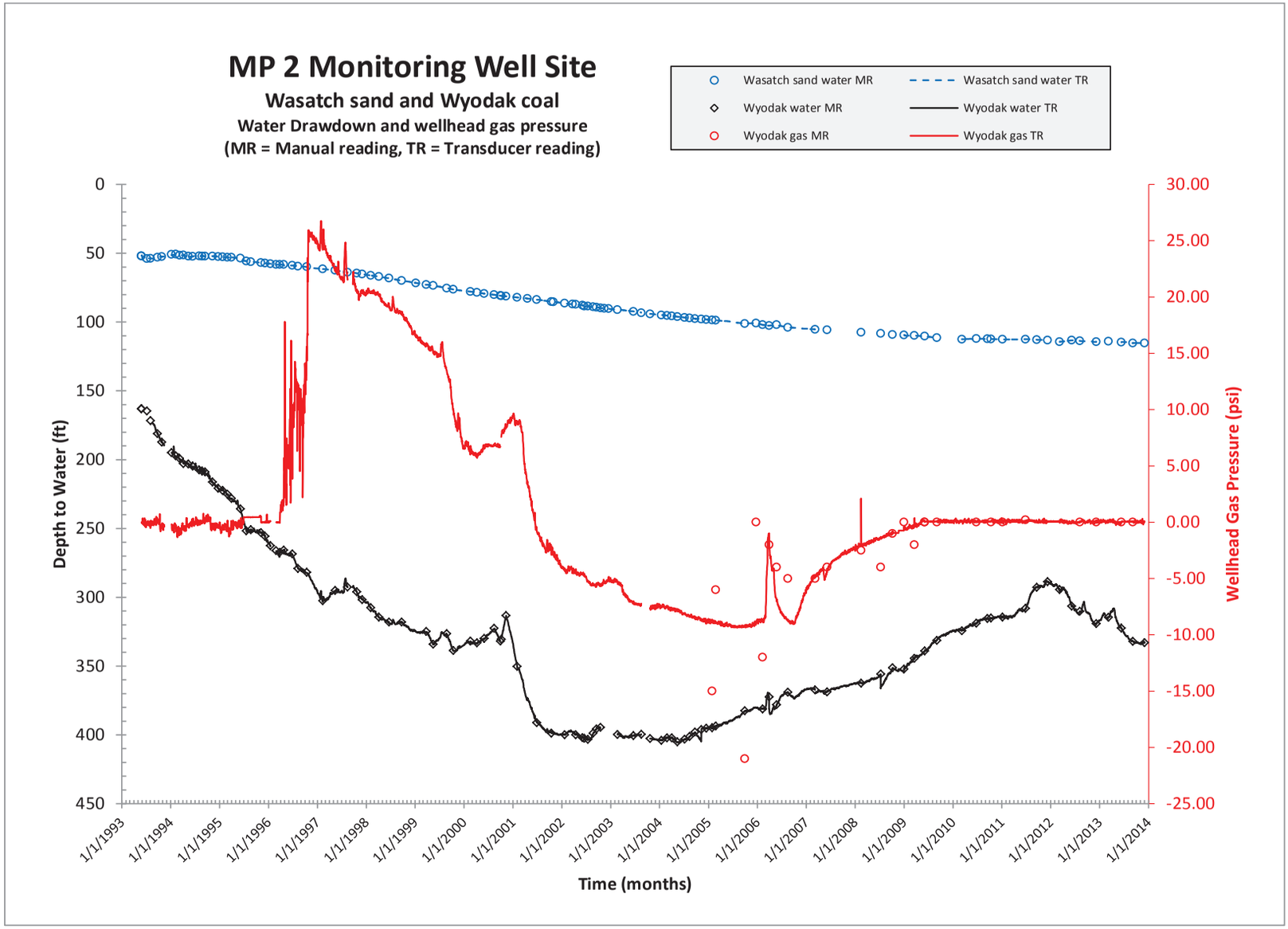

Figure A.159. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored intervals at the MP 2 monitoring well site location.

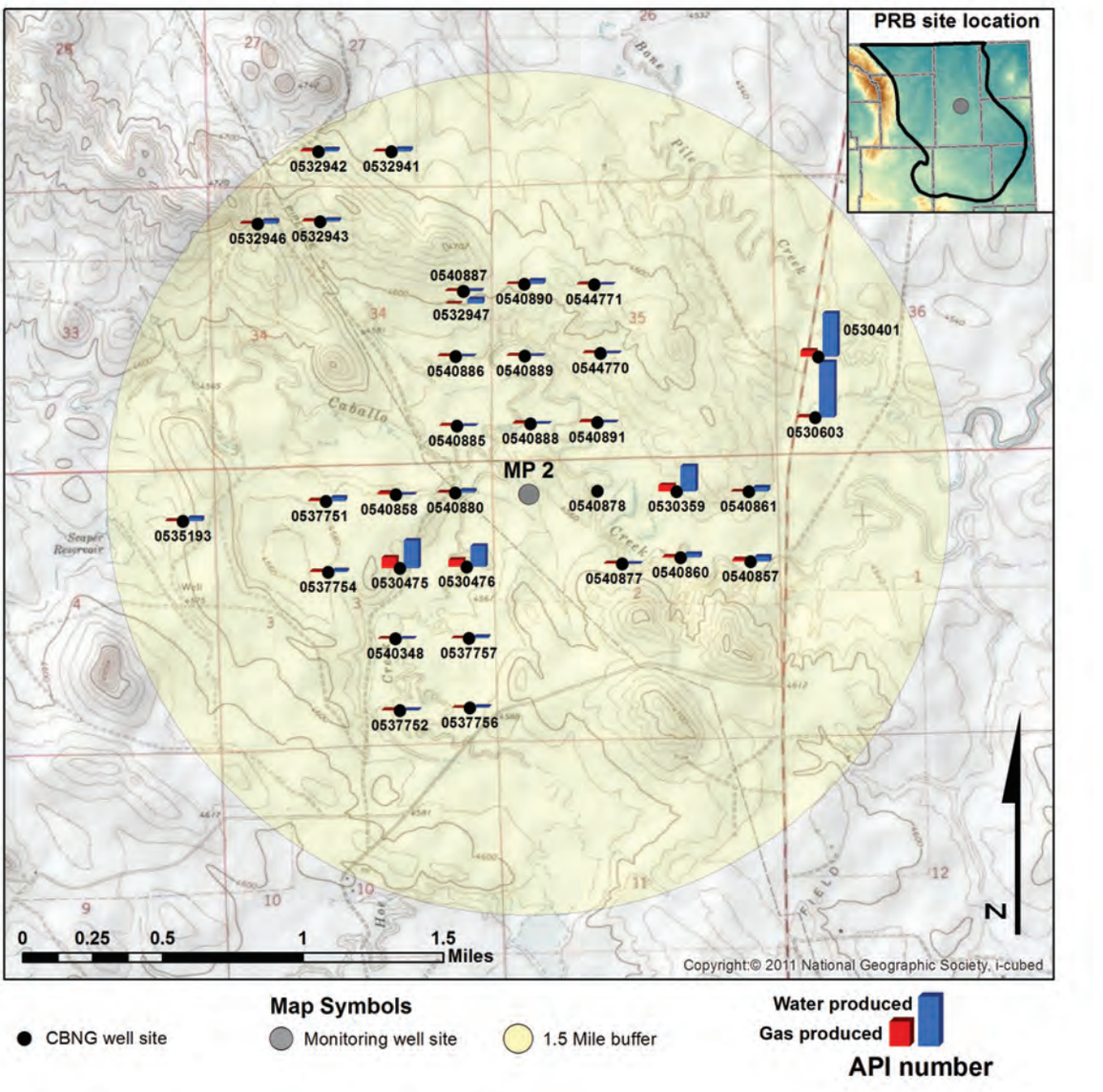

Figure A.160. MP 2 monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

Production Statistics

Production data for CBNG wells was analyzed within the buffer of the MP 2 monitoring well site from 1992-2013. Cumulative production for individual CBNG wells is displayed by location on Figure A.160. CBNG and water production are monitored in the Upper Wyodak coal zone, where all local production has occurred.

Water production in the Upper Wyodak coal zone reached a maximum level of 305,922 bbls in November 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 November 2006.

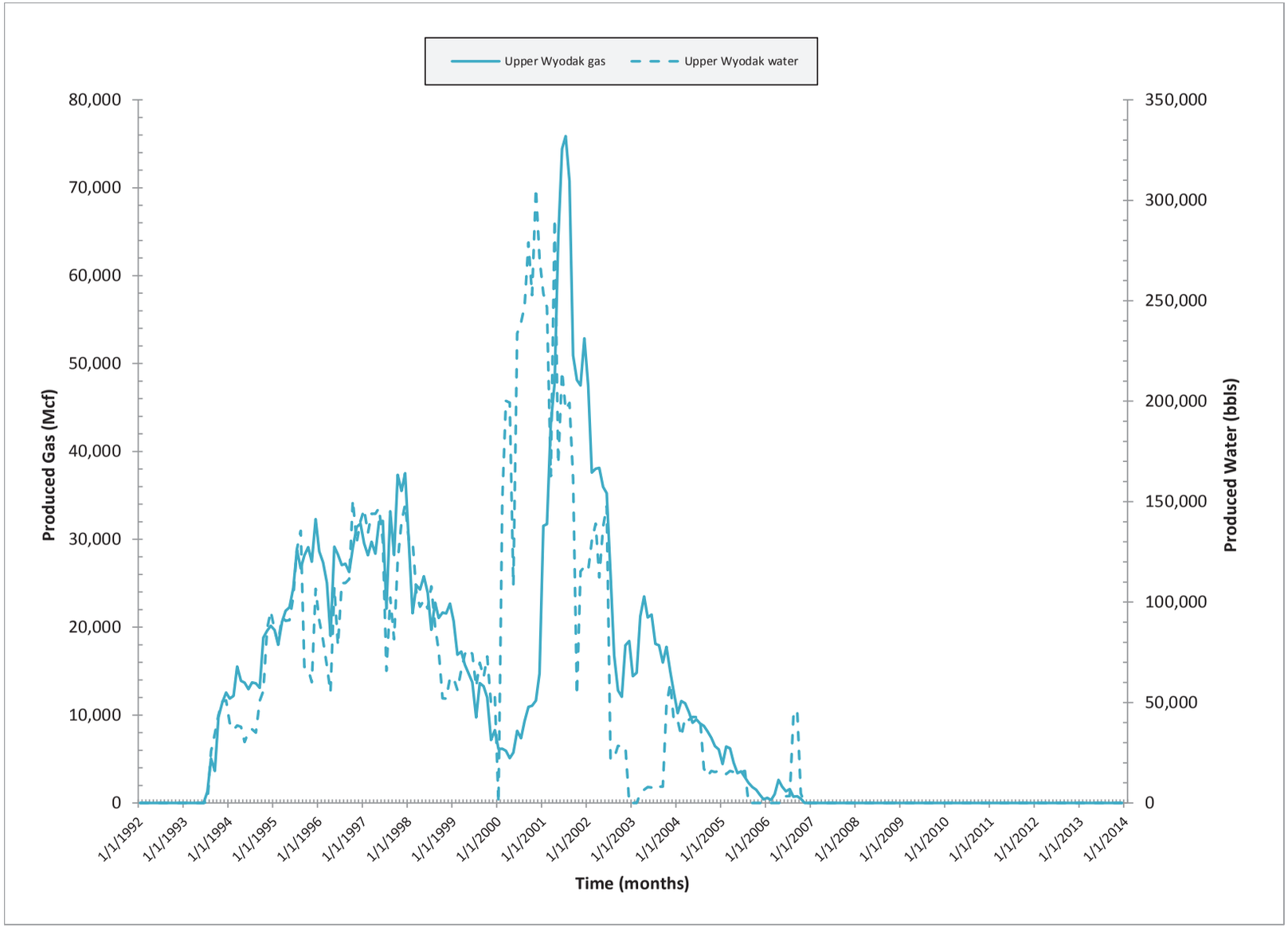

Figure A.161. Water and gas production from CBNG wells associated with the MP 2 monitoring well site location.

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 in Wasatch sandstones and one 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 2013 using both manual and automatic transducer and data logger equipment. There is good agreement between concurrent transducer and manual measurements. 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.

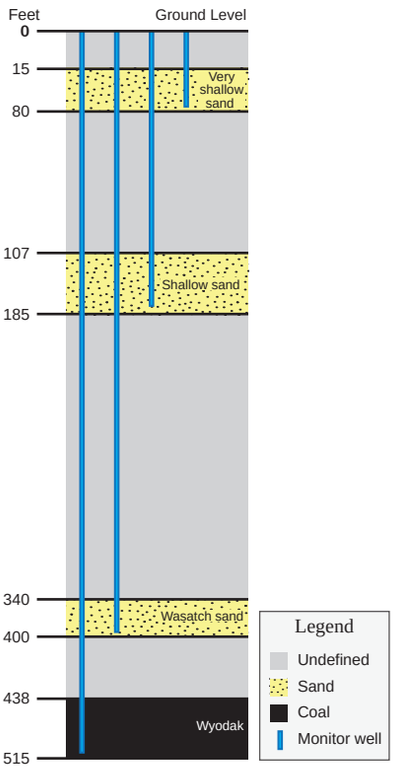

Figure A.162. Section showing relative positions of coal and sands in feet. Not to scale.

Wasatch Sandstones
Groundwater levels in the very shallow Wasatch sandstone rose 0.03 feet during 2013 and declined 2.33 feet during the 1993-2013 monitoring period (Figure A.163; Table A.81).

Groundwater levels in the shallow Wasatch sandstone rose 0.27 feet during 2013 and declined 0.54 feet during the 1993-2013 monitoring period (Figure A.163; Table A.81).

Groundwater levels in the Wasatch sandstone were unavailable for 2013. Levels declined 51.74 feet during the monitoring period from 1993 until December 2011 when the last reliable measurement was taken (Figure A.163; Table A.81). Gas pressure was not recorded in any of the Wasatch sandstones.

Wyodak Coal
Groundwater levels dropped 13.45 feet during 2013. However, groundwater levels recovered nearly 185 feet from January 2002 – March 2012 at MP22. Groundwater levels have since declined through 2013 although no water was produced from the Upper Wyodak coal seam at this site since March 2008. The recent decline may, in effect, be associated with producing surface coal mines located within 1.5 miles of MP 22. Overall, during the 1993-2013 monitoring period, the site has shown a net groundwater decline of 151.93 feet (Figure A.163; Table A.81). Gas pressure in the Wyodak coal reached its maximum in August 1995 at 61.18 psi.

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

Monitored interval	Interval characteristics			
	Depth of interval (ft)		Interval 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, water level changes for current monitoring period, water level changes for period of record, and maximum gas pressure.

Monitored interval	DGW - Depth to groundwater (ft), water level (ft), and gas pressure (psi) data					
	Initial DGW	Max DGW [Date]	Final 2013 DGW	Water level change 2013	Net water level change	Max. gas pressure [date]
Very shallow sand	20.20	23.10 10/4/2013	22.53	0.03	-2.33	n/a
Shallow sand	38.29	39.80 9/1/2009	38.83	0.27	-0.54	n/a
Wasatch sand*	83.29	135.00 12/8/2011	n/a	n/a	-51.74	n/a
Wyodak coal	173.80	490.00 1/21/2002	325.73	-13.45	-151.93	61.18 8/30/1995

*Last reliable measurement 12/8/2011

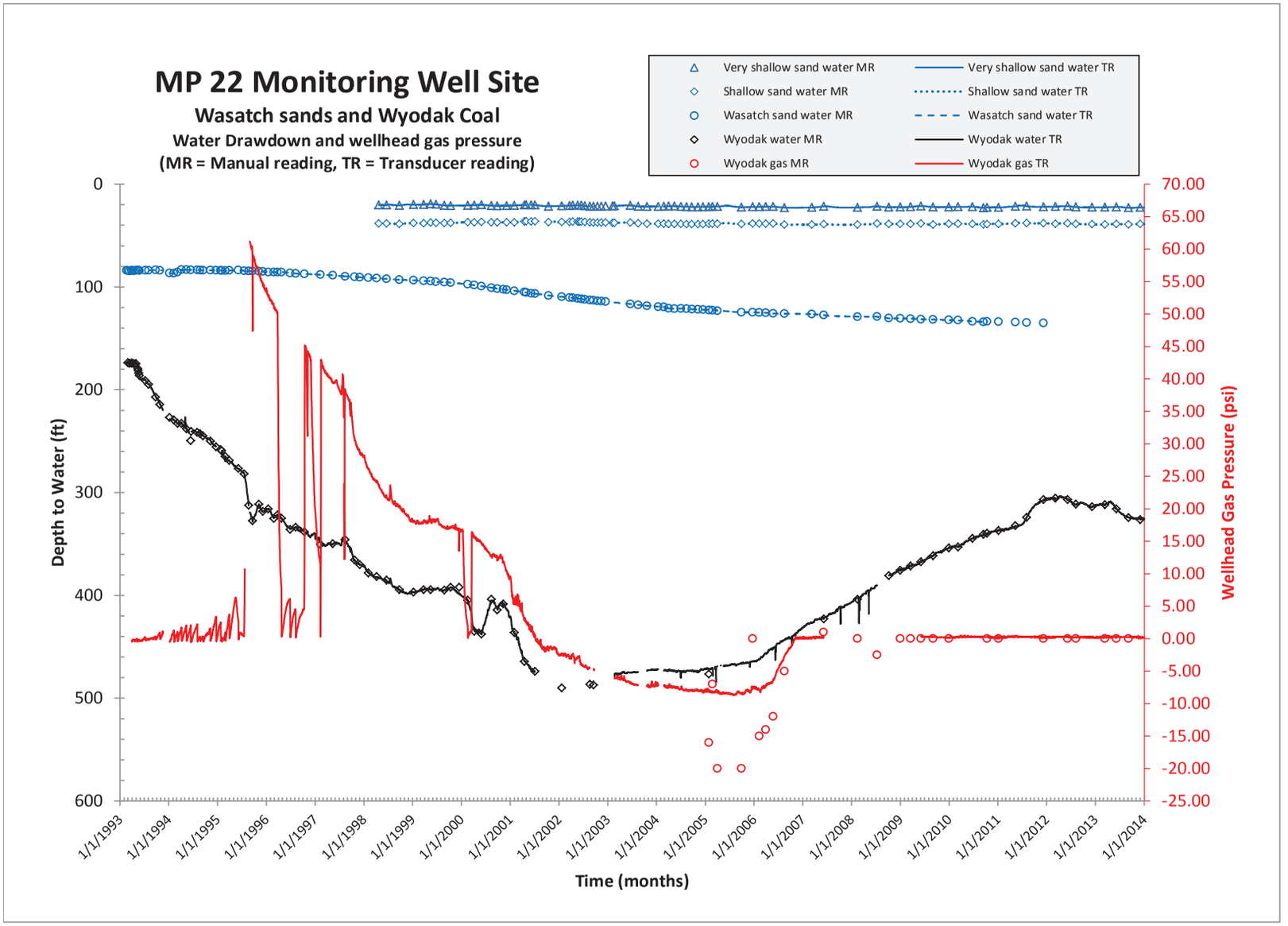

Figure A.163. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored intervals at the MP 22 monitoring well site location.

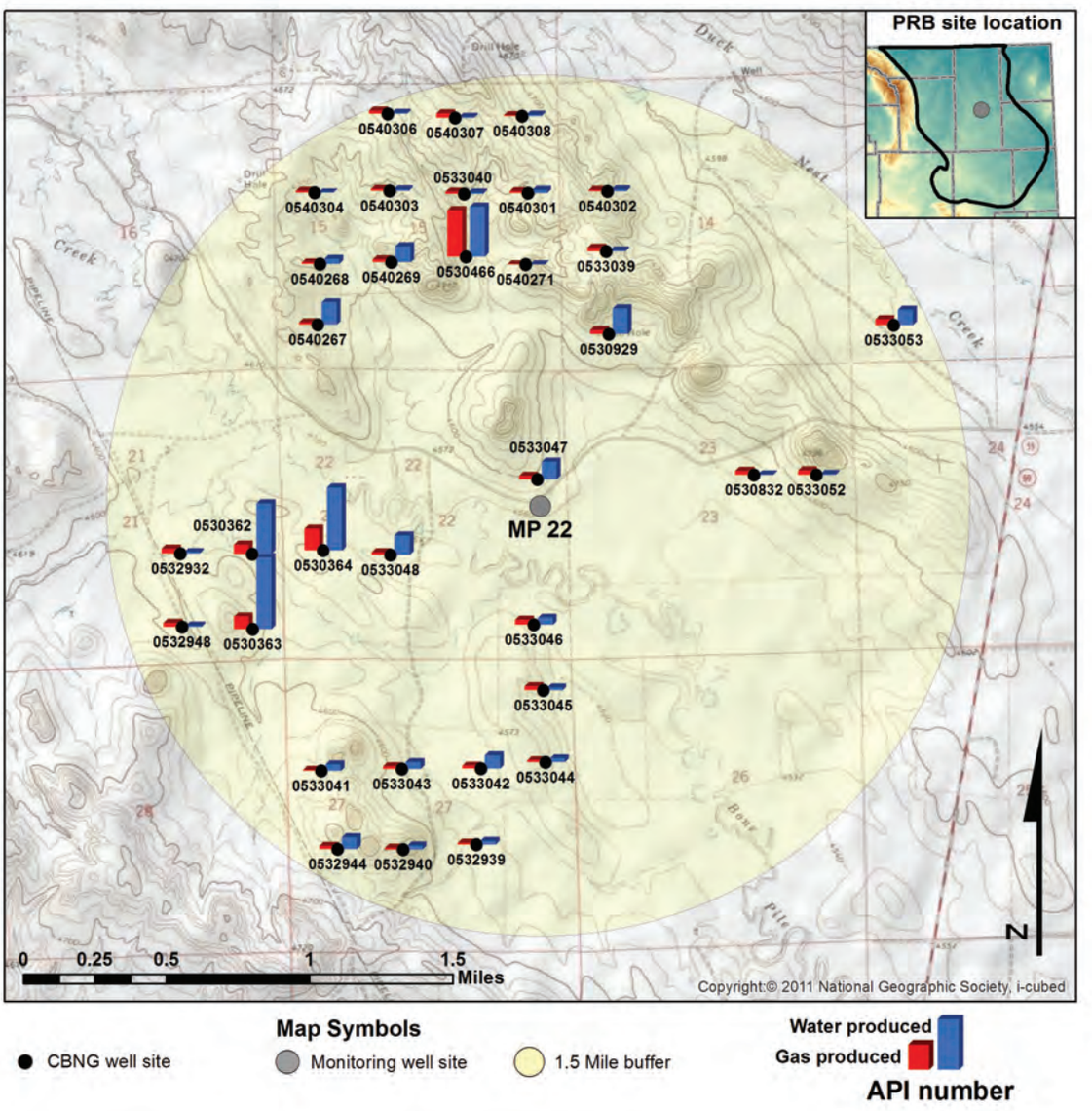

Figure A.164. MP 22 monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

Production Statistics

Production data were analyzed for CBNG wells within the buffer of the MP 22 monitoring well site from 1992-2013. Cumulative production for individual CBNG wells is displayed by location in Figure A.164. CBNG and water production are monitored in the Upper Wyodak coal zone only.

Water and gas production in the Upper Wyodak began in May 1993 and ceased in 2007. Water 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. No water or gas was produced in 2013.

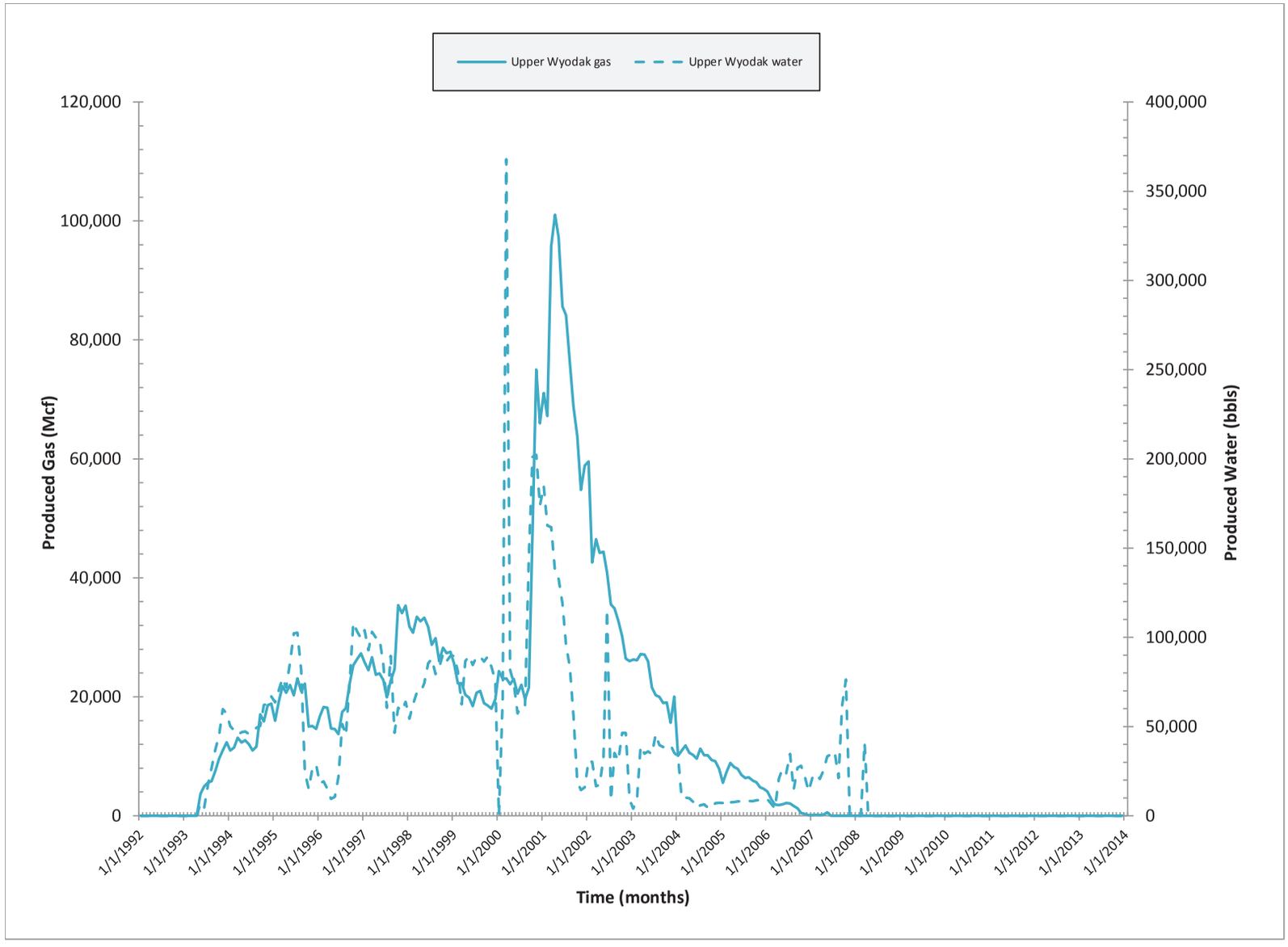

Figure A.165. Water and gas production from CBNG wells associated with the MP 22 monitoring well site location.

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 in 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 2013 using both manual and automatic transducer and data logger equipment. There is good agreement between concurrent transducer and manual measurements. 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 69.39 feet during 2013 and 231.10 feet over the 2001-2013 monitoring period (Figure A.167; Table A.83). Gas pressure was not recorded in the Wasatch sandstone.

Big George Coal
Groundwater levels were not measured in this well during 2013, Groundwater levels declined 500.40 feet during the 2001 – 2012 monitoring period (Figure A.167; Table A.83). Gas pressure in the Big George coal has been relatively stable, never exceeding 1 psi.

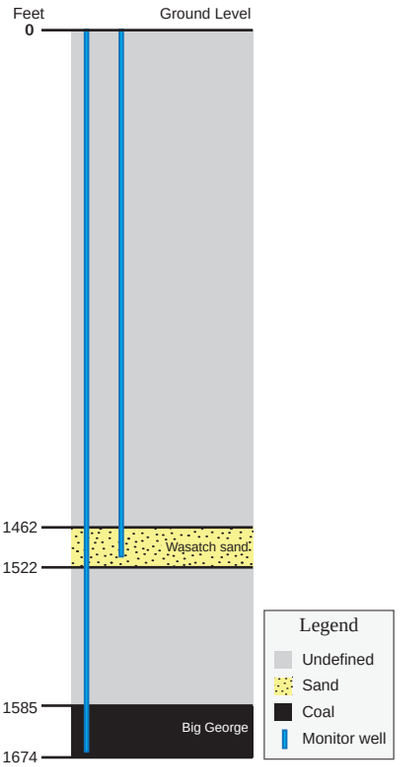

Figure A.166. Section showing relative positions of coal and sand in feet. Not to scale.

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

Monitored interval	Interval characteristics			
	Depth of interval (ft)		Interval thickness (ft)	Separation from coal (ft)
	Top	Bottom		
Wasatch sand	1,462	1,522	60	63
Big George coal	1,585	1,674	89	n/a

Table A.83. Table showing depths to water from ground level, water level changes for current monitoring period, water level changes for period of record, and maximum gas pressure.

Monitored interval	DGW - Depth to groundwater (ft), water level (ft), and gas pressure (psi) data					
	Initial DGW	Max DGW [Date]	Final 2013 DGW	Water level change 2013	Net water level change	Max. gas pressure [date]
Wasatch sand	402.50	633.60 12/18/2013	633.60	-69.39	-231.10	n/a
Big George coal*	432.00	932.40 8/15/2012	n/a	n/a	-500.40	0.88 7/12/2009

*Last reliable measurement 8/15/2012

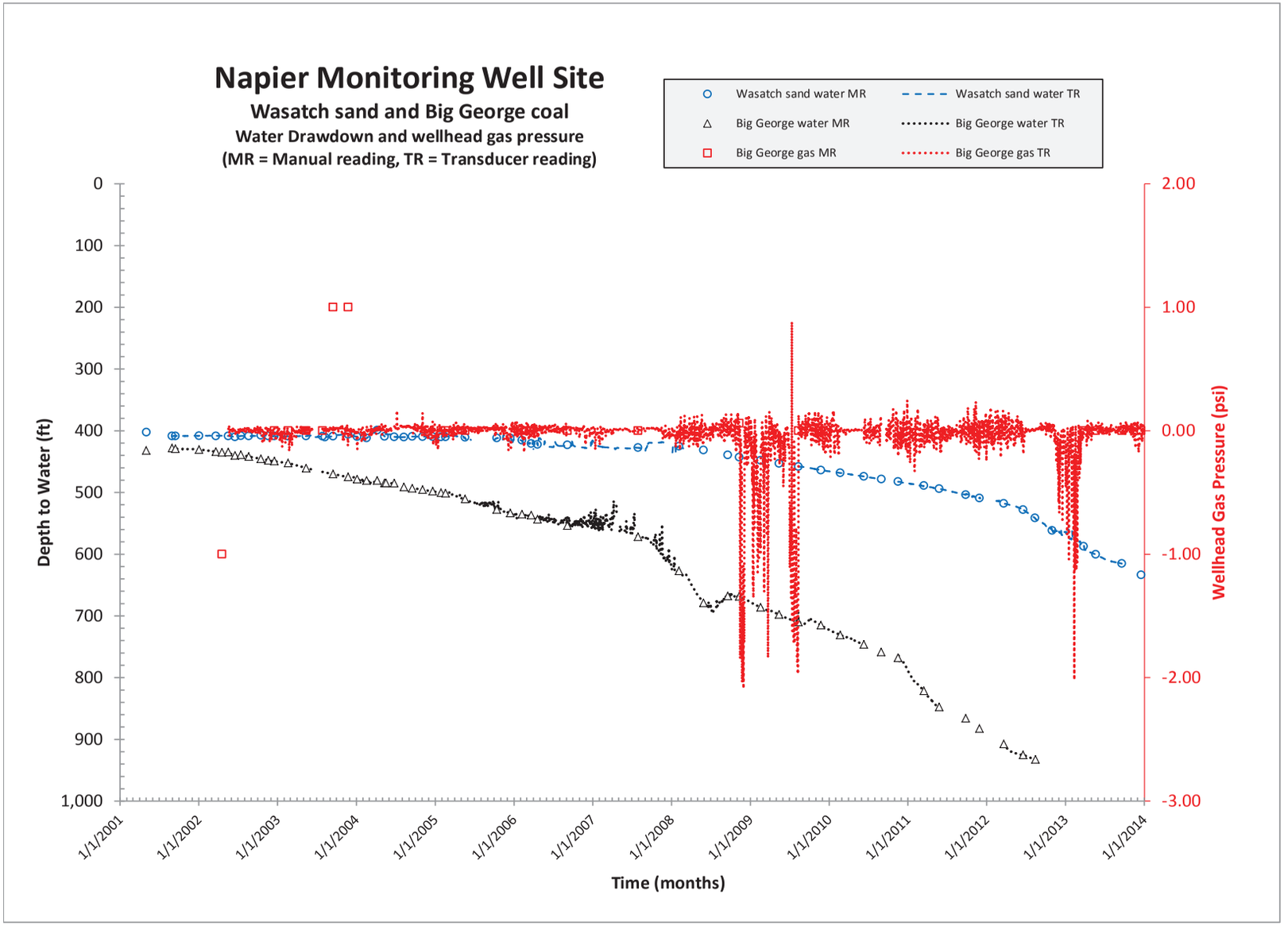

Figure A.167. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored intervals at the Napier monitoring well site location.

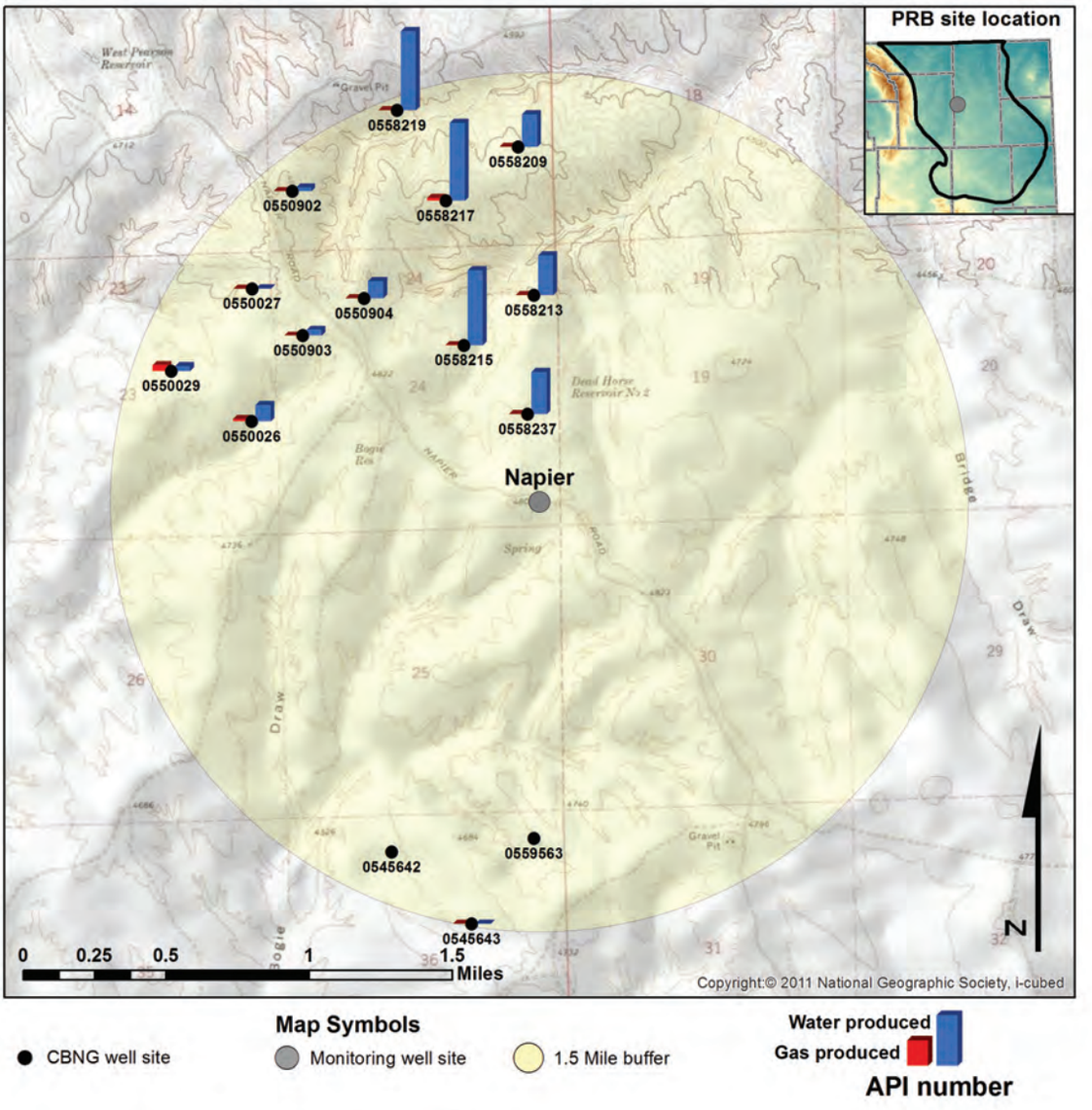

Figure A.168. Napier monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

Production Statistics

Production data were analyzed for CBNG wells within the buffer of the Napier monitoring well site from 2002-2013. Cumulative production for individual CBNG wells is displayed by location on Figure A.168. CBNG and water production are monitored in the Wyodak Rider coal zone wells.

Water production in the Wyodak Rider began in March 2005, peaked in December 2012 at 130,330 bbls (Figure A.169) and ended 2013 at 113,028 bbls/month. Gas production began in October 2005 and peaked at 7,063 Mcf in April 2012.

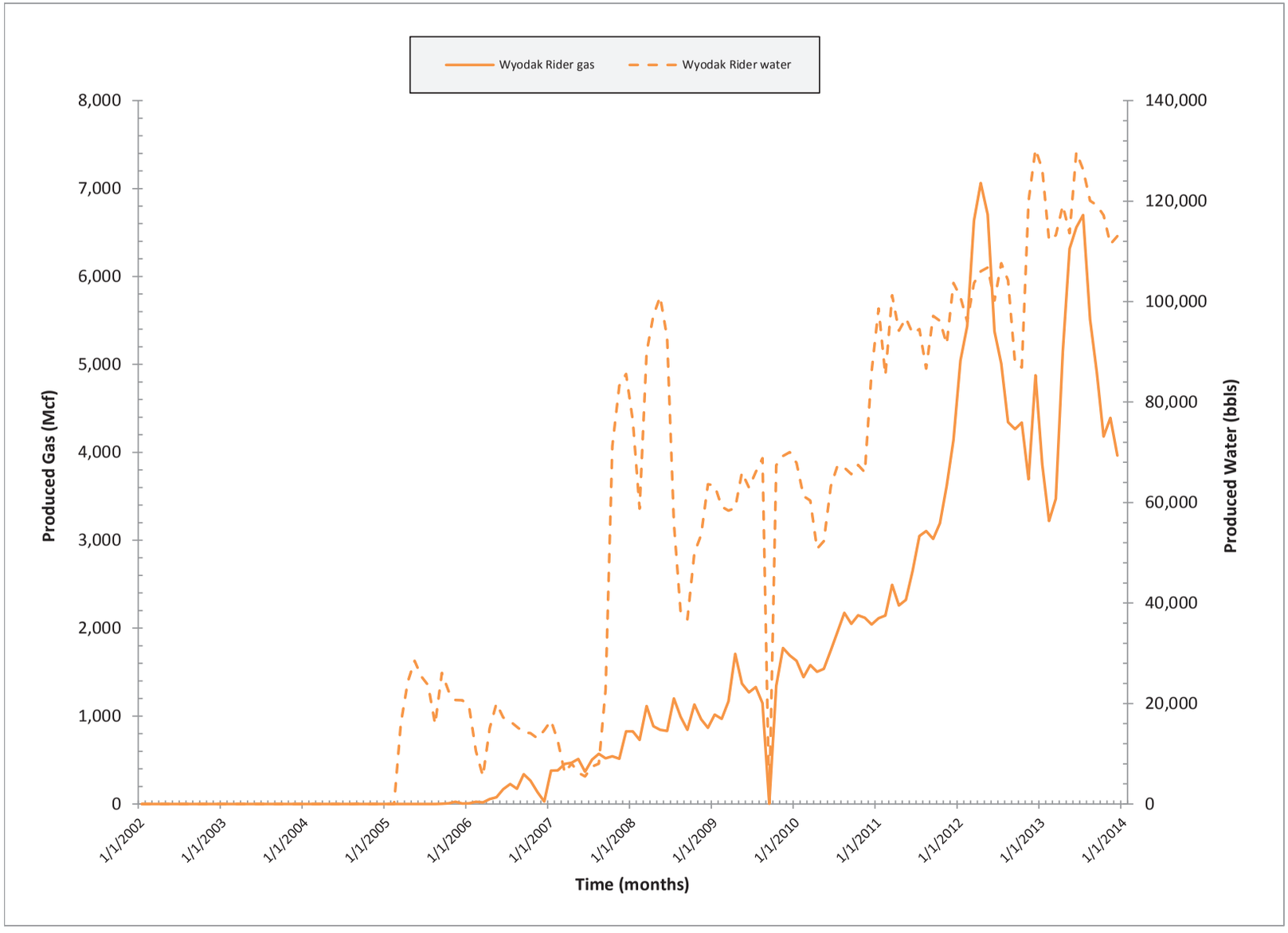

Figure A.169. Water and gas production from CBNG wells associated with the Napier monitoring well site location.

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 pressure were measured during 2013 using a combination of 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 was dry at the end of 2013. During the 1995 - 2013 monitoring period the water level declined 146.90 feet (Figure A.171; Table A.85). Gas pressure in the Wyodak coal reached its maximum in April 1996 at 33.79 psi.

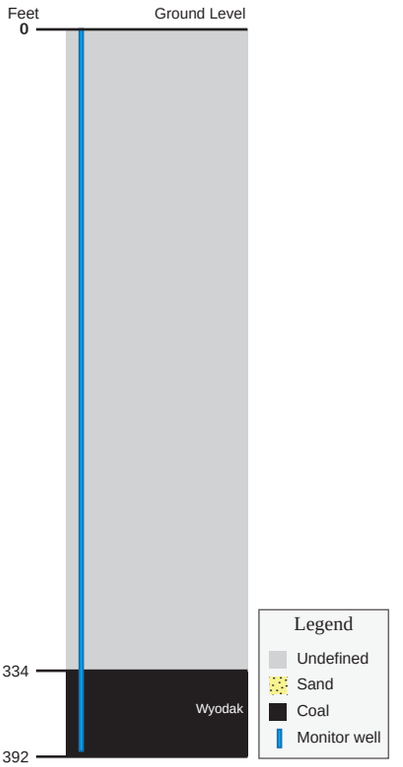

Figure A.170. Section showing relative positions of coal in feet. Not to scale.

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

Monitored interval	Interval characteristics			
	Depth of interval (ft)		Interval 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, water level changes for current monitoring period, water level changes for period of record, and maximum gas pressure.

Monitored interval	DGW - Depth to groundwater (ft), water level (ft), and gas pressure (psi) data					
	Initial DGW	Max DGW [Date]	Final 2013 DGW	Water level change 2013	Net water level change	Max. gas pressure [date]
Wyodak coal*	245.10	392.00 8/12/2004	392.00	-4.60	-146.90	33.79 4/25/1996

*Well dry to total depth 3/7/2013

Production Statistics

Production data were analyzed for CBNG wells within the buffer of the North Cordero monitoring well site from 1994-2013. Cumulative production for individual CBNG wells is displayed by location on Figure A.172. CBNG and water production are monitored in the Upper Wyodak coal zone wells, and production in this area also occurs in unknown coal zone wells.

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. Both water and gas production remained at zero during 2013.

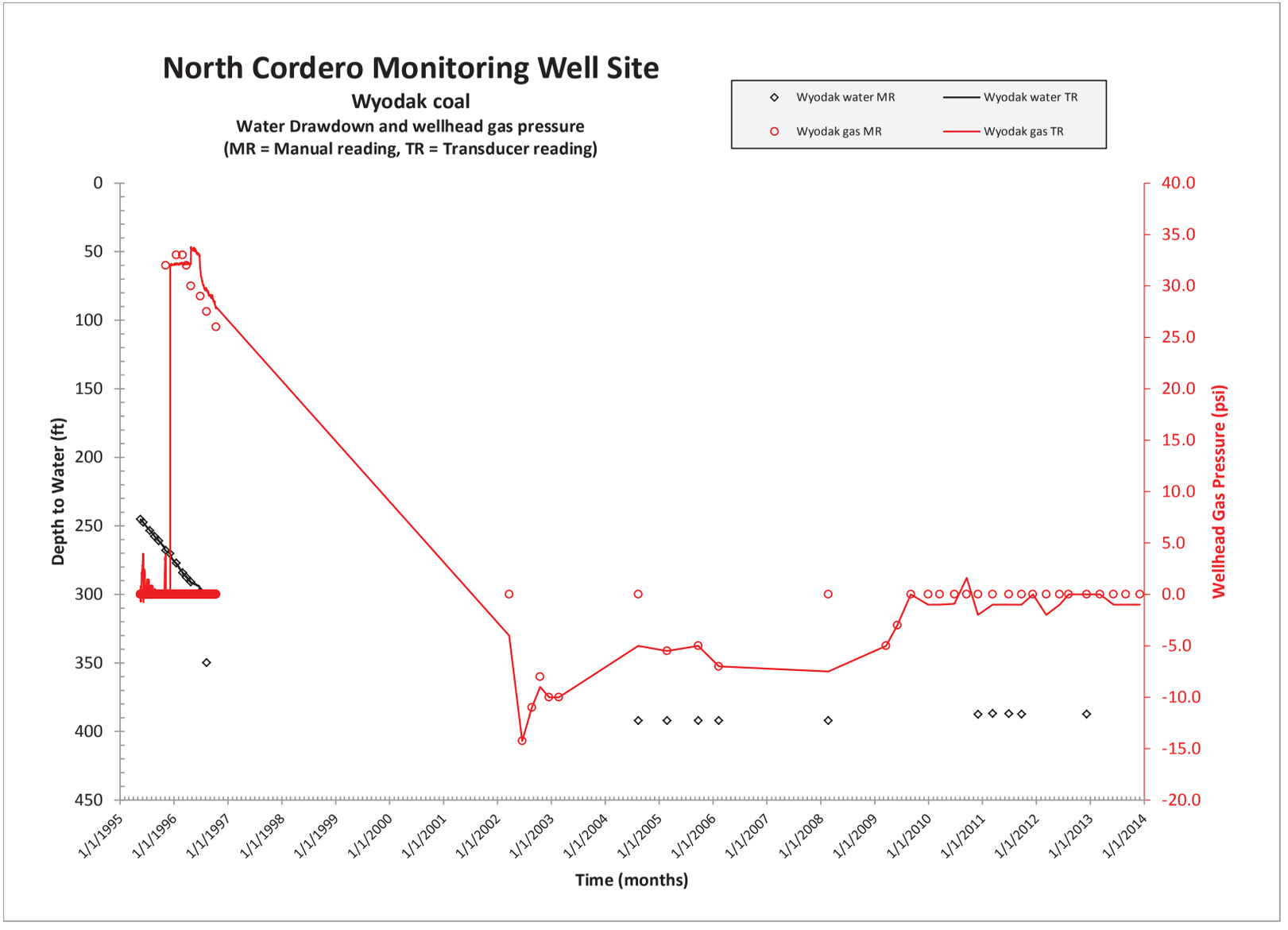

Figure A.171. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored intervals at the North Cordero monitoring well site location.

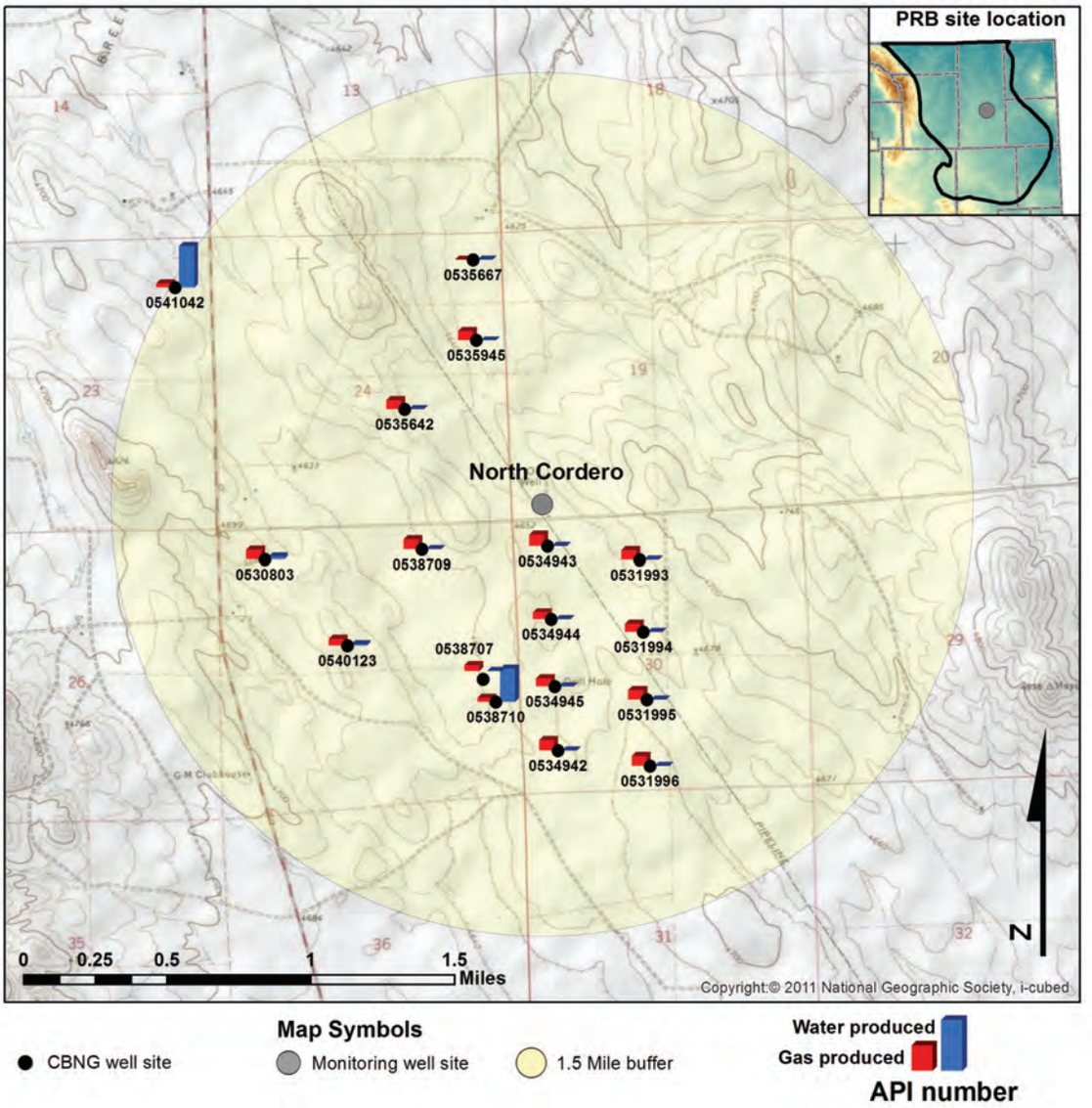

Figure A.172. North Cordero monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

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, reached a maximum level of 13,897 Mcf in March 1997 and declined to zero in February 2008.

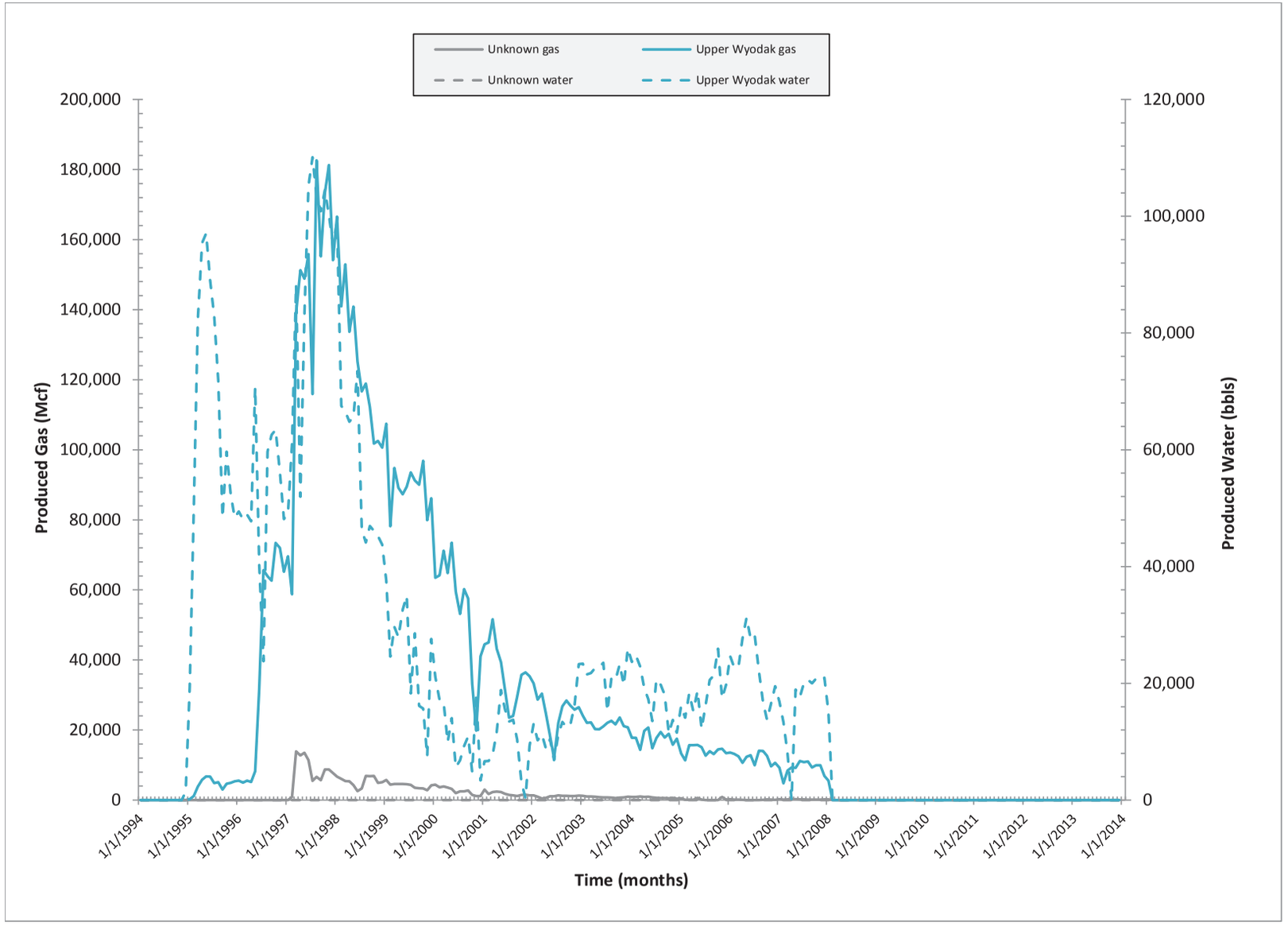

Figure A.173. Water and gas production from CBNG wells associated with the North Cordero monitoring well site location.

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 2013 using a combination of manual methods 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 fell 0.63 feet during 2013 and declined 5.05 feet (Figure A.175; Table A.87) during the 2001-2013 monitoring period. Gas pressure was not measured in the Wasatch sandstone.

Anderson Coal

Groundwater levels in the Anderson coal rose 19.68 feet during 2013 and has risen 9.63 feet overall during the 2001-2013 monitoring period (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 22.38 feet during 2013, groundwater levels have declined 47.70 feet during the 2001-2013 monitoring period (Figure A.175; Table A.87). Gas pressure in the Canyon coal peaked at 1.54 psi in July 2003.

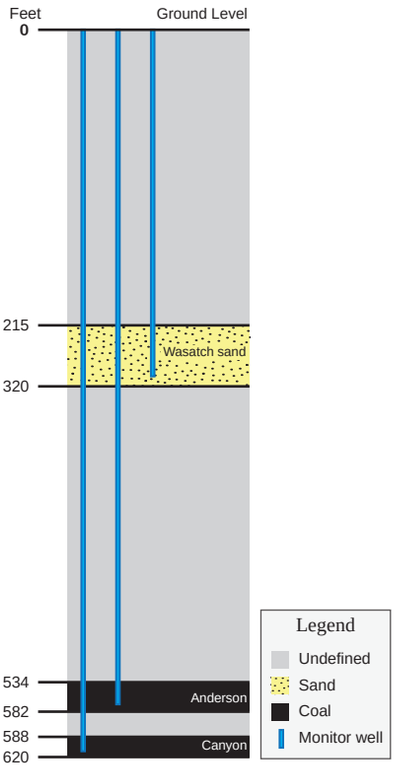

Figure A.174. Section showing relative positions of coals and sand in feet. Not to scale.

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

Monitored interval	Interval characteristics			
	Depth of interval (ft)		Interval 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, water level changes for current monitoring period, water level changes for period of record, and maximum gas pressure.

Monitored interval	DGW - Depth to groundwater (ft), water level (ft), and gas pressure (psi) data					
	Initial DGW	Max DGW [Date]	Final 2013 DGW	Water level change 2013	Net water level change	Max. gas pressure [date]
Wasatch sand	122.17	128.00 8/1/2007	127.22	-0.63	-5.05	n/a
Anderson coal	500.03	576.00 1/8/2004	490.40	19.68	9.63	4.59 5/14/2002
Canyon coal	447.75	620.00 3/23/2010	495.45	22.38	-47.70	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 1999-2013. Cumulative production for individual CBNG wells is displayed by location on Figure A.176. CBNG and water production are monitored in the Upper Wyodak, Lower Wyodak, unmonitored, and unknown coal zone wells.

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. No water or gas was produced from Upper Wyodak wells in 2013.

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). No water or gas was produced from Lower Wyodak wells in 2013.

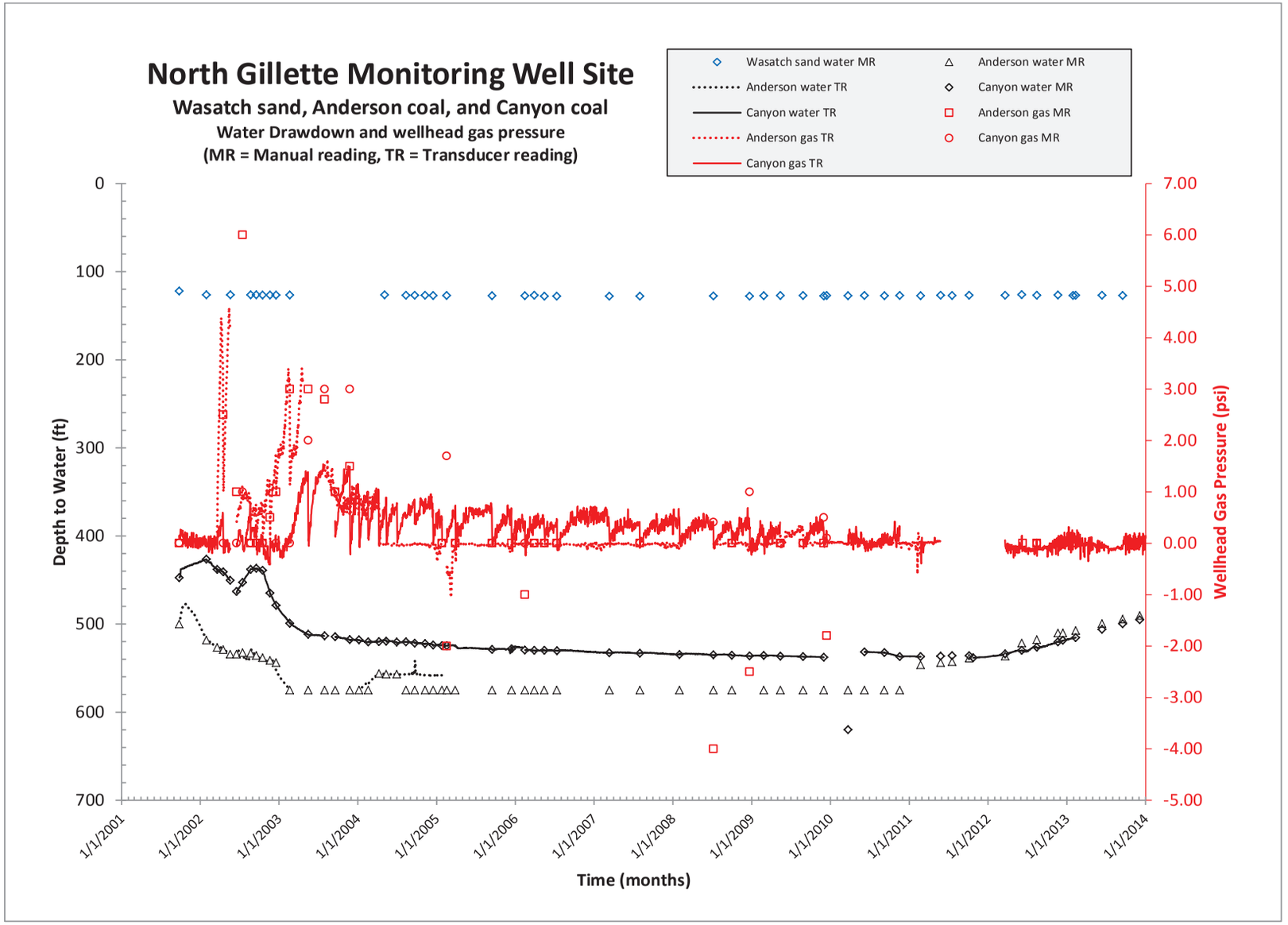

Figure A.175. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored intervals at the North Gillette monitoring well site location.

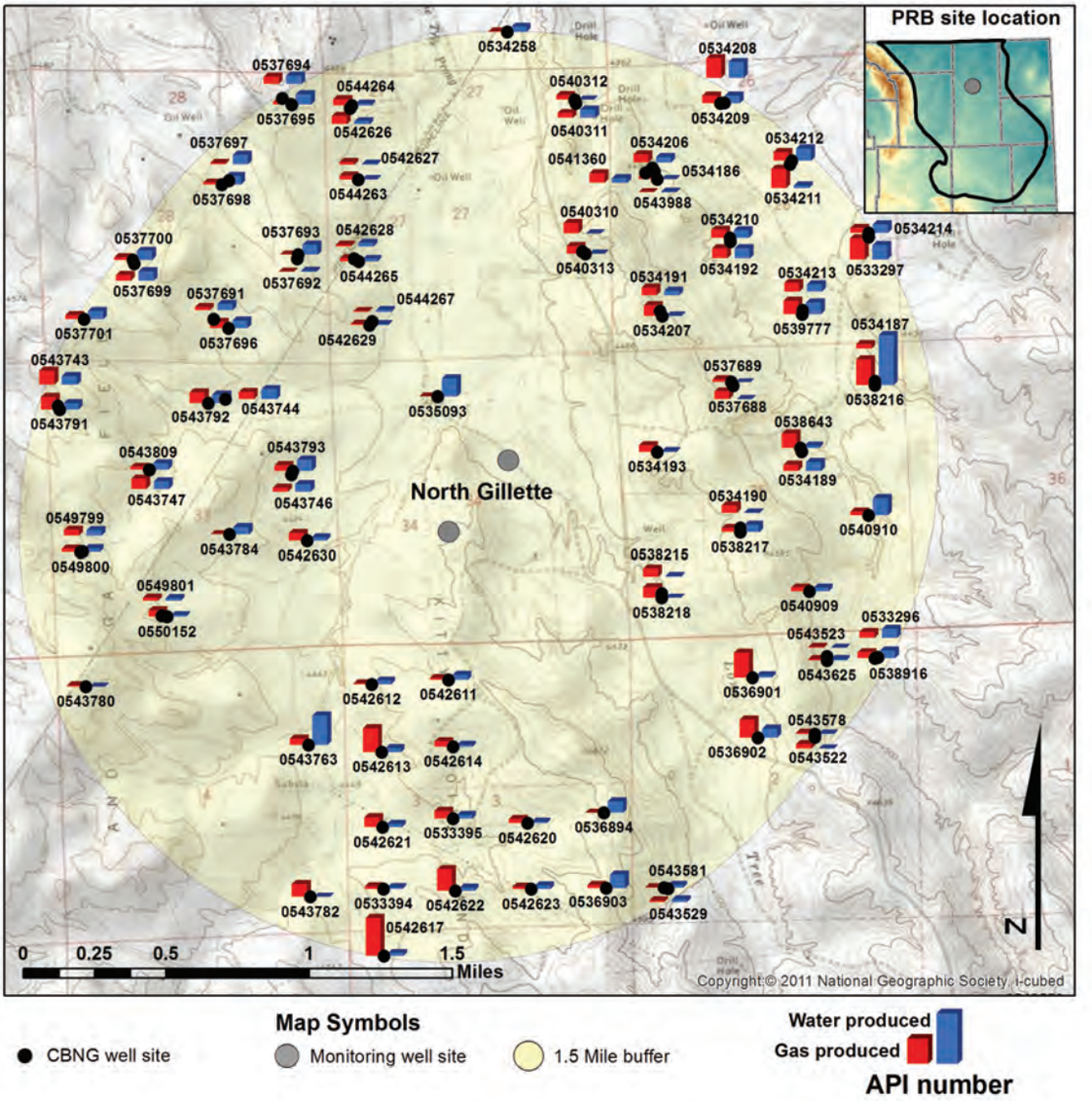

Figure A.176. North Gillette monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

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 unmonitored coal zones during 2003-2010. No gas or water was produced from unmonitored coal zones during 2013.

No water or gas has been produced from wells in unknown coal zone wells.

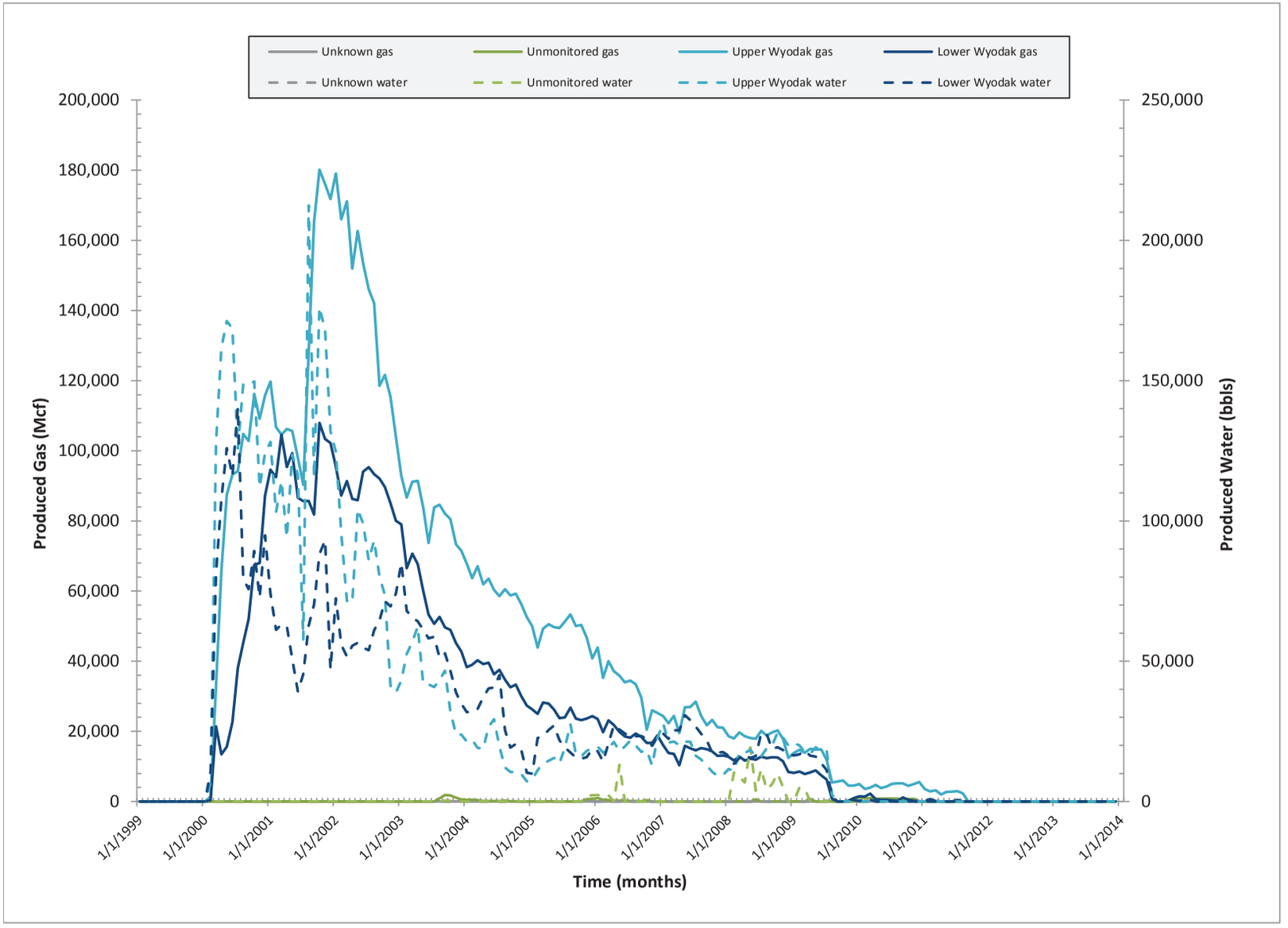

Figure A.177. Water and gas production from CBNG wells associated with the North Gillette monitoring well site location.

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 a Wasatch sandstone and the Big George coal of the Wyodak Rider coal zone (Figure A.178; Table A.88). Water levels and wellhead gas pressures were measured manually during 2013.

Wasatch Sandstones
Groundwater levels in the shallow Wasatch sandstone declined 0.47 feet in 2013 (Table A.89) since the first measurement was taken in February 2013.

The Wasatch sandstone monitoring well is flowing artesian. No water level measurements were taken at this well in 2013. Gas pressure data was not recorded for either Wasatch sandstone well.

Big George Coal
Groundwater levels in the Big George coal have not been recorded due to excessive wellhead gas pressures (Table A.89). Gas pressure in the Big George coal peaked at 105 psi in May 2009.

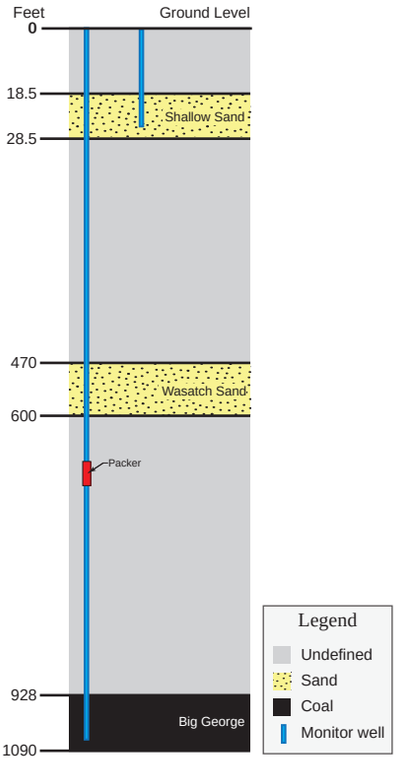

Figure A.178. Section showing relative positions of coal and sands in feet. Not to scale.

Table A.88. Table showing the depth to and thickness of monitored intervals at the Oops monitoring well site location (measured in feet).

Monitored interval	Interval characteristics			
	Depth of interval (ft)		Interval thickness (ft)	Separation from coal (ft)
	Top	Bottom		
Shallow sand	18.5	28.5	10	900
Wasatch sand	470	600	130	328
Big George coal	928	1,090	162	n/a

Table A.89. Table showing depths to water from ground level, water level changes for current monitoring period, water level changes for period of record, and maximum gas pressure.

Monitored interval	DGW - Depth to groundwater (ft), water level (ft), and gas pressure (psi) data					
	Initial DGW	Max DGW [Date]	Final 2013 DGW	Water level change 2013	Net water level change	Max. gas pressure [date]
Shallow sand*	17.10	18.30 9/23/2013	17.57	-0.47	-0.47	n/a
Wasatch sand**	n/a	n/a	n/a	0.00	0.00	n/a
Big George coal***	n/a	n/a	n/a	n/a	n/a	105.00 5/19/2009

*Well first measured 2/13/2013

**Well flowing artesian

***Well water level not measured due to excessive pressure

Production Statistics

Production data were analyzed for CBNG wells within the buffer of the Oops monitoring well site from 2001-2013. Cumulative production for individual CBNG wells is displayed by location on Figure A.180. CBNG and water production are monitored in the Wyodak Rider and unmonitored coal zone wells.

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 201,197 bbls in December 2013. 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. Wyodak Rider coal zone gas production remained high until 2010, then began decreasing rapidly, ending December 2013 at 173,686 Mcf.

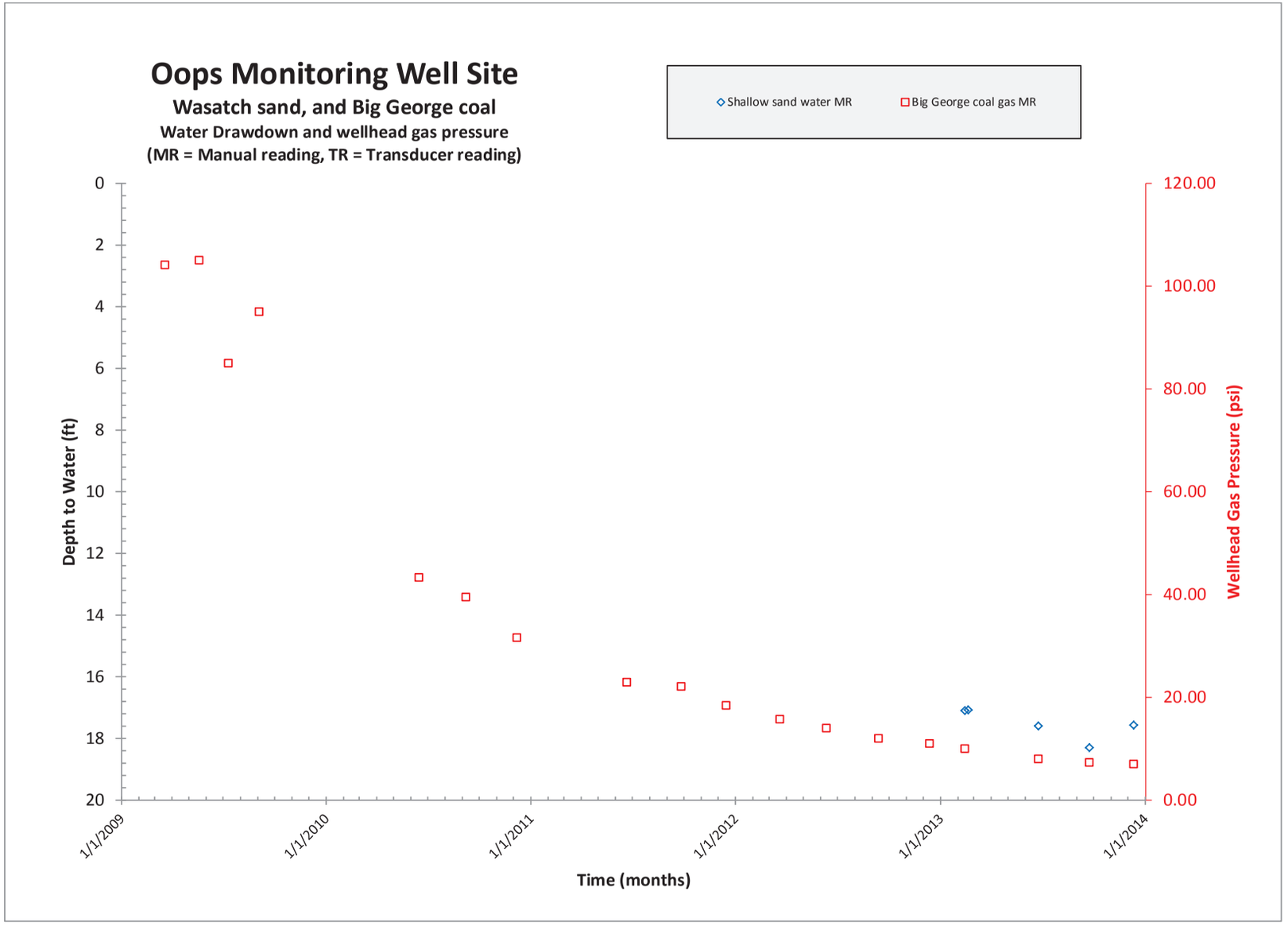

Figure A.179. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored intervals at the Oops well site location.

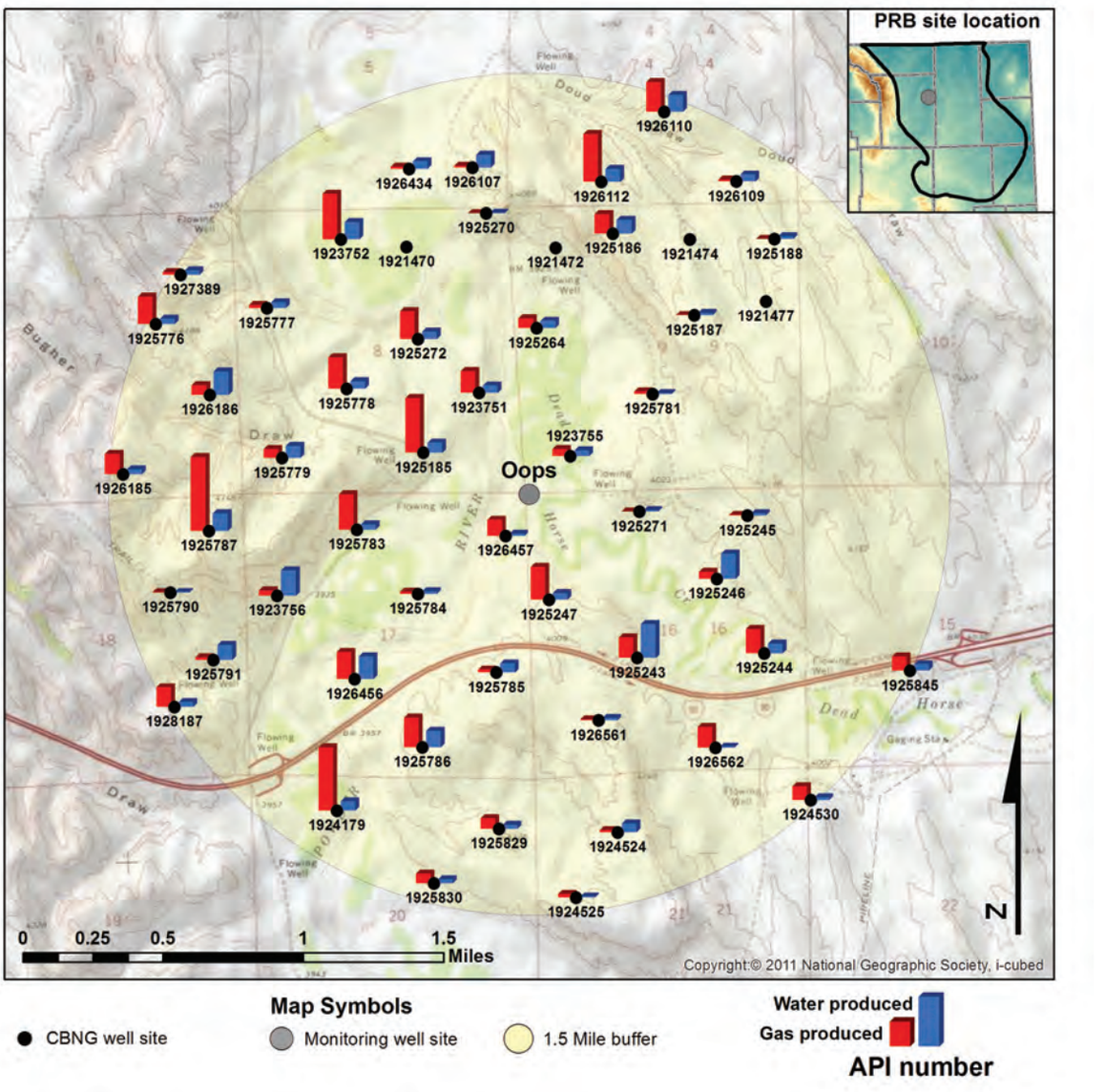

Figure A.180. Oops monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

Water production in the unmonitored coal zones began in November 2007 and continued sporadically until January 2010 (Figure A.181); water production levels never exceeded 23,000 bbls/month. Gas was also sporadic, and peaked in July 2009 at 47,021 Mcf, and ceased in February 2010.

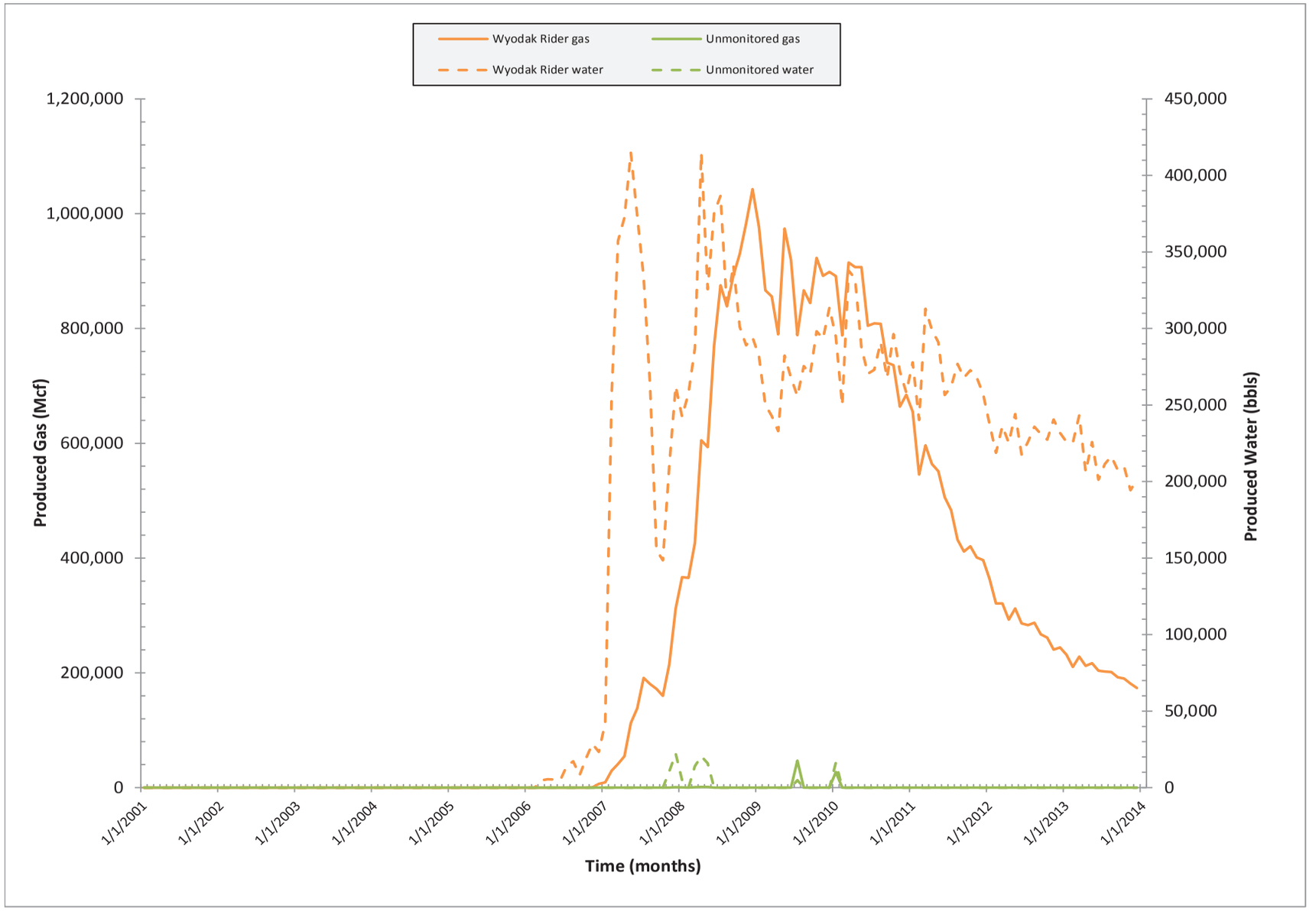

Figure A.181. Water and gas production from CBNG wells associated with the Oops monitoring well site location.

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.182; Table A.90). Water levels and wellhead gas pressures were measured during 2013 in the Canyon coal well using a combination of manual methods 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 were not measured during 2013 in the Wasatch sandstone due to a well obstruction. Prior to 2013, groundwater levels rose 22.72 feet (Figure A.183; Table A.91). Gas pressure was not recorded in the Wasatch sandstone.

Canyon Coal

Groundwater levels in the Canyon coal rose 2.**78** feet during 2013, and declined 1**39.54 feet** during the 2007-2013 monitoring period (Figure A.183; Table A.91). Gas pressure in the Canyon coal peaked at 55.92 psi in March 2001.

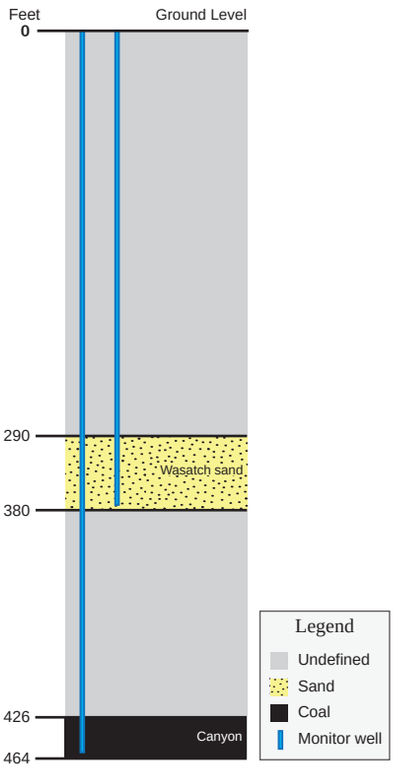

Figure A.182. Section showing relative positions of coal and sand in feet. Not to scale.

Table A.90. Table showing the depth to and thickness of monitored intervals at the Palo monitoring well site location (measured in feet).

Monitored interval	Interval characteristics			
	Depth of interval (ft)		Interval 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, water level changes for current monitoring period, water level changes for period of record, and maximum gas pressure.

Monitored interval	DGW - Depth to groundwater (ft), water level (ft), and gas pressure (psi) data					
	Initial DGW	Max DGW [Date]	Final 2013 DGW	Water level change 2013	Net water level change	Max. gas pressure [date]
Wasatch sand*	246.32	248.20 5/18/2004	n/a	n/a	22.72	n/a
Canyon coal	298.68	448.70 5/18/2004	438.22	2.78	-139.54	55.92 3/16/2001

*Well obstructed, last reliable measurement 3/12/2012

Production Statistics

Production data were analyzed for CBNG wells within the buffer of the Palo monitoring well site from 1991-2013. Cumulative production for individual CBNG wells is displayed by location on Figure A.184. CBNG and water production are monitored in the Lower Wyodak, multiple, unmonitored, and unknown coal zone wells.

The Lower Wyodak zone produced water and gas from 2001-2013. Water production reached a maximum monthly production of 37,647 bbls in March 2001(Figure A.185). 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 through 2013. Water production peaked at 94,748 bbls (Figure A.185) in January 2009. Gas production levels in multiple zone wells have been consistently low, peaking at 26,744 Mcf in December 2009.

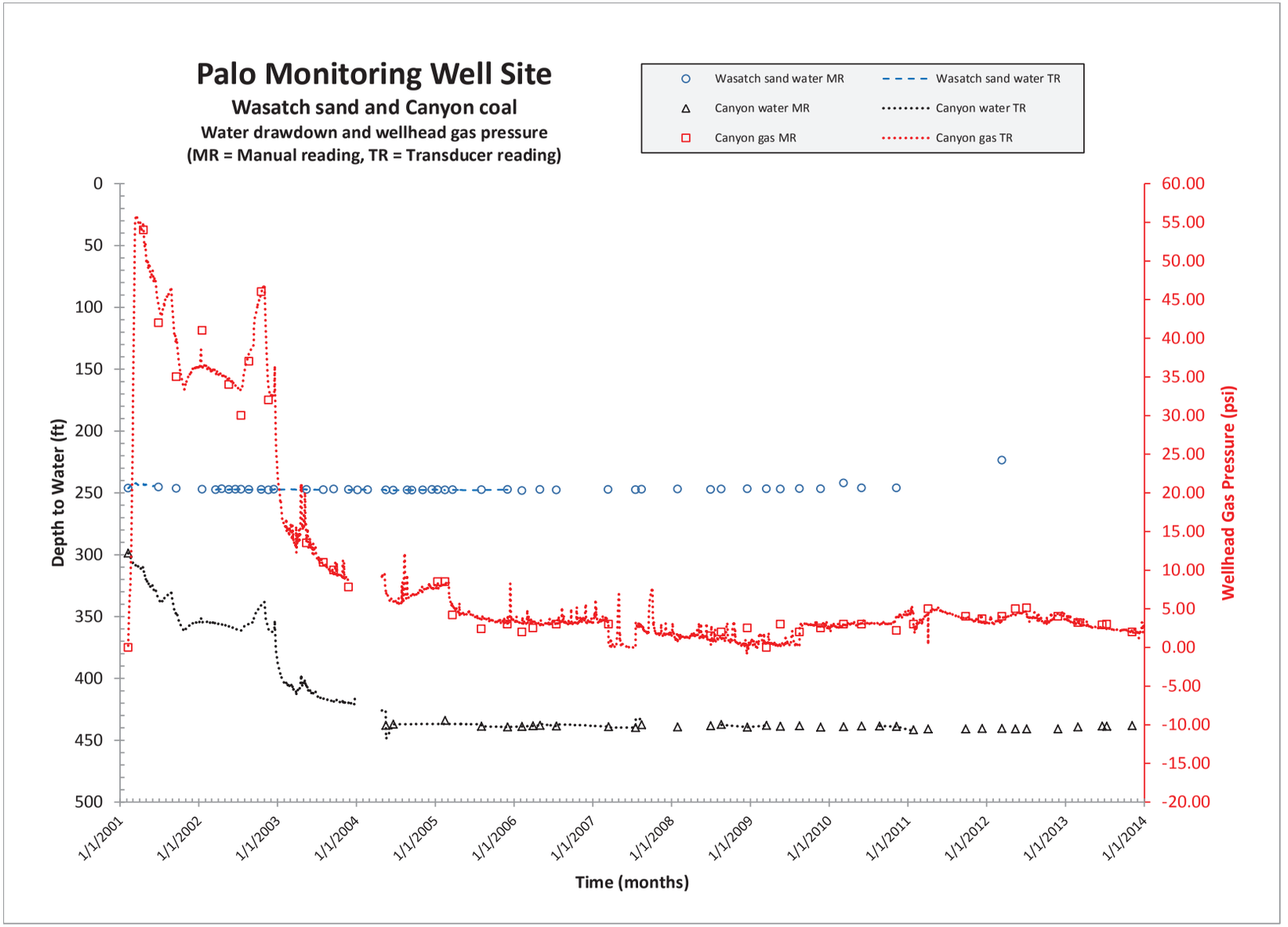

Figure A.183. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored intervals at the Palo monitoring well site location.

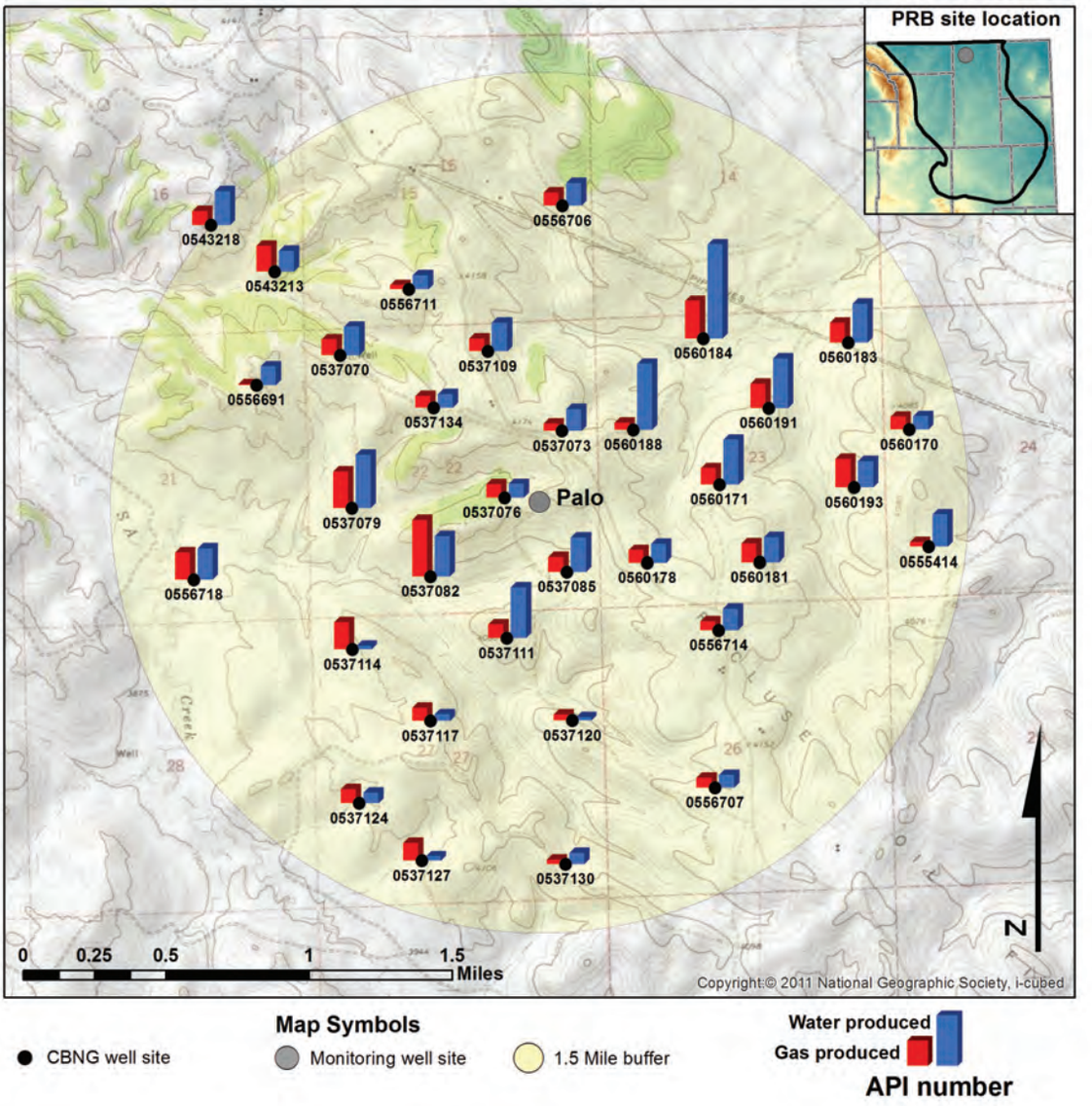

Figure A.184. Palo monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

Gas and water production began in January 2001 and continued through 2013 in unmonitored coal zones. Water production reached a monthly maximum of 169,029 bbls (Figure A.185) in November 2007. Gas production peaked in June 2003 at 89,312 Mcf.

The unknown coal zones have not produced water during the 1991-2013 monitoring period (Figure A.185). The unknown coal zones produced low (< 8,412 Mcf) levels of gas intermittently from 1991 until August 1993.

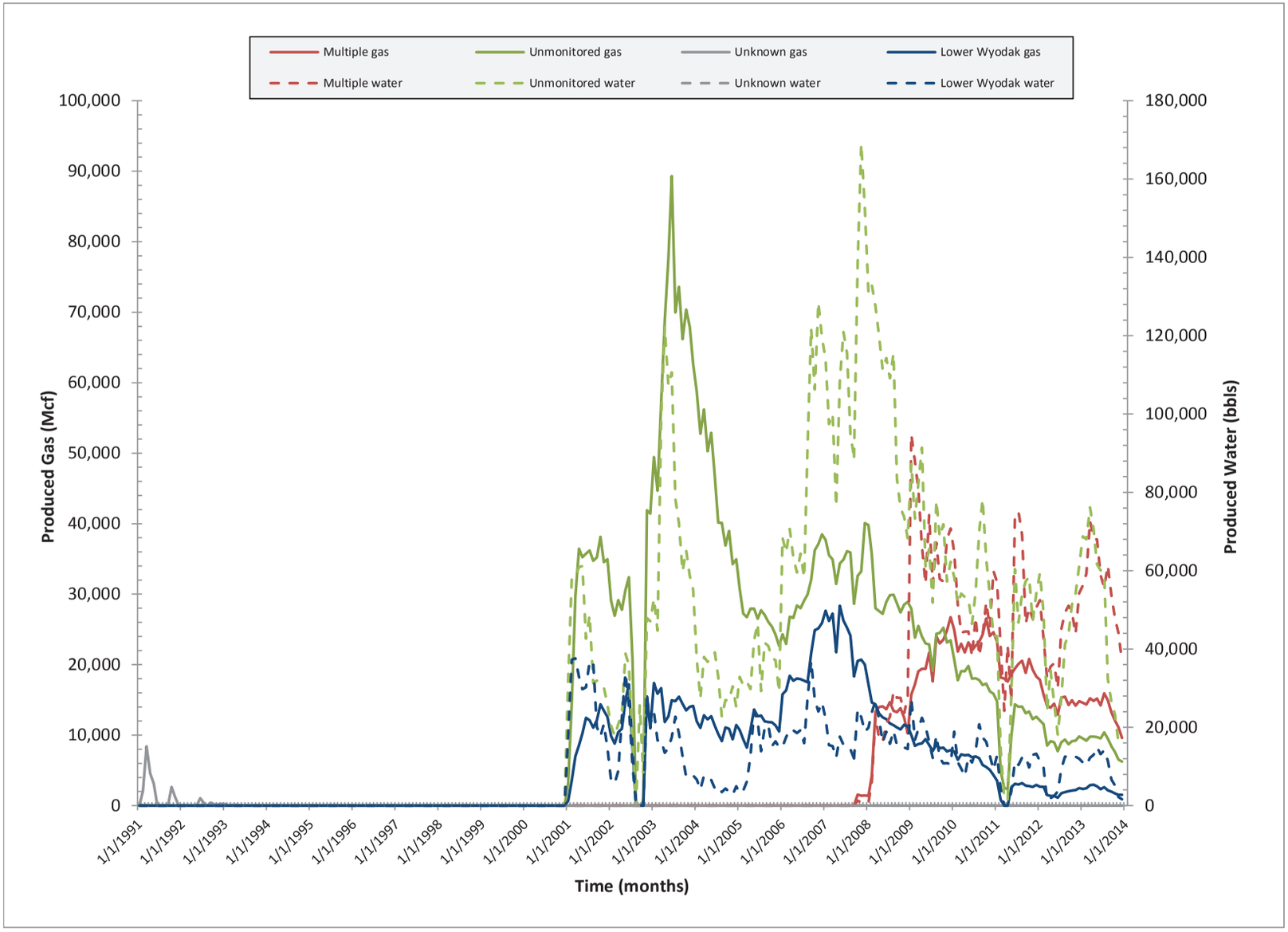

Figure A.185. Water and gas production from CBNG wells associated with the Palo monitoring well site location.

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.186; Table A.92). Wellhead gas pressure was measured during 2013 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

The last reliable groundwater level measurement in the Big George was obtained in February 2011. Before that the groundwater level fell 806.87 feet (Figure A.187; Table A.93). Gas pressure in the Big George peaked at 66.96 psi in May 2011.

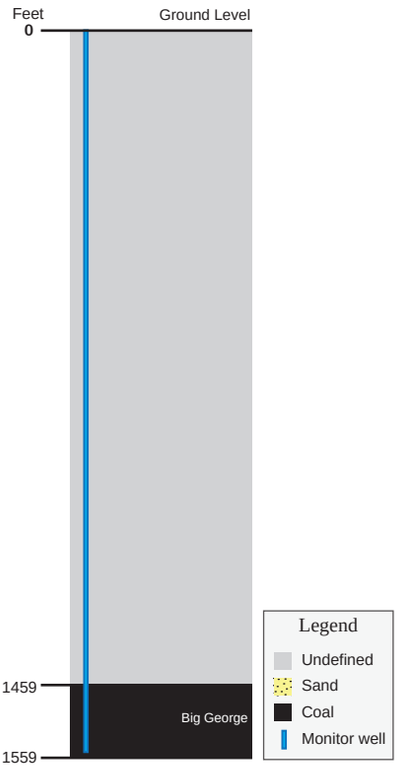

Figure A.186. Section showing relative position of coal in feet. Not to scale.

Table A.92. Table showing the depth to and thickness of monitored intervals at the Pistol Point monitoring well site location (measured in feet).

Monitored interval	Interval characteristics			
	Depth of interval (ft)		Interval 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, water level changes for current monitoring period, water level changes for period of record, and maximum gas pressure.

Monitored interval	DGW - Depth to groundwater (ft), water level (ft), and gas pressure (psi) data					
	Initial DGW	Max DGW [Date]	Final 2013 DGW	Water level change 2013	Net water level change	Max. gas pressure [date]
Big George coal*	456.63	1,289.50 12/27/2010	n/a	n/a	-806.87	66.96 5/12/2011

*Last reliable measurement 2/16/2011

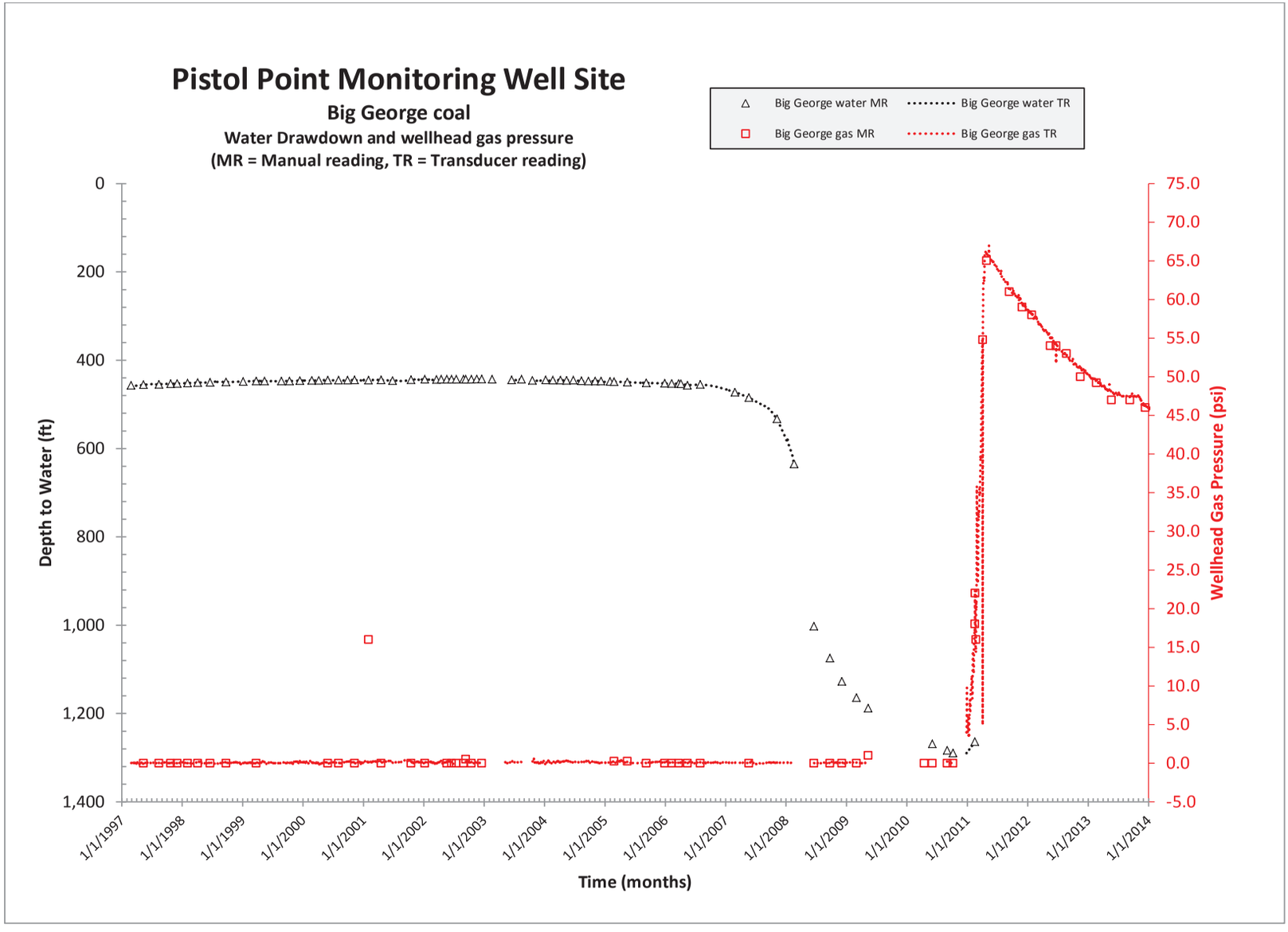

Figure A.187. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored intervals at the Pistol Point monitoring well site location.

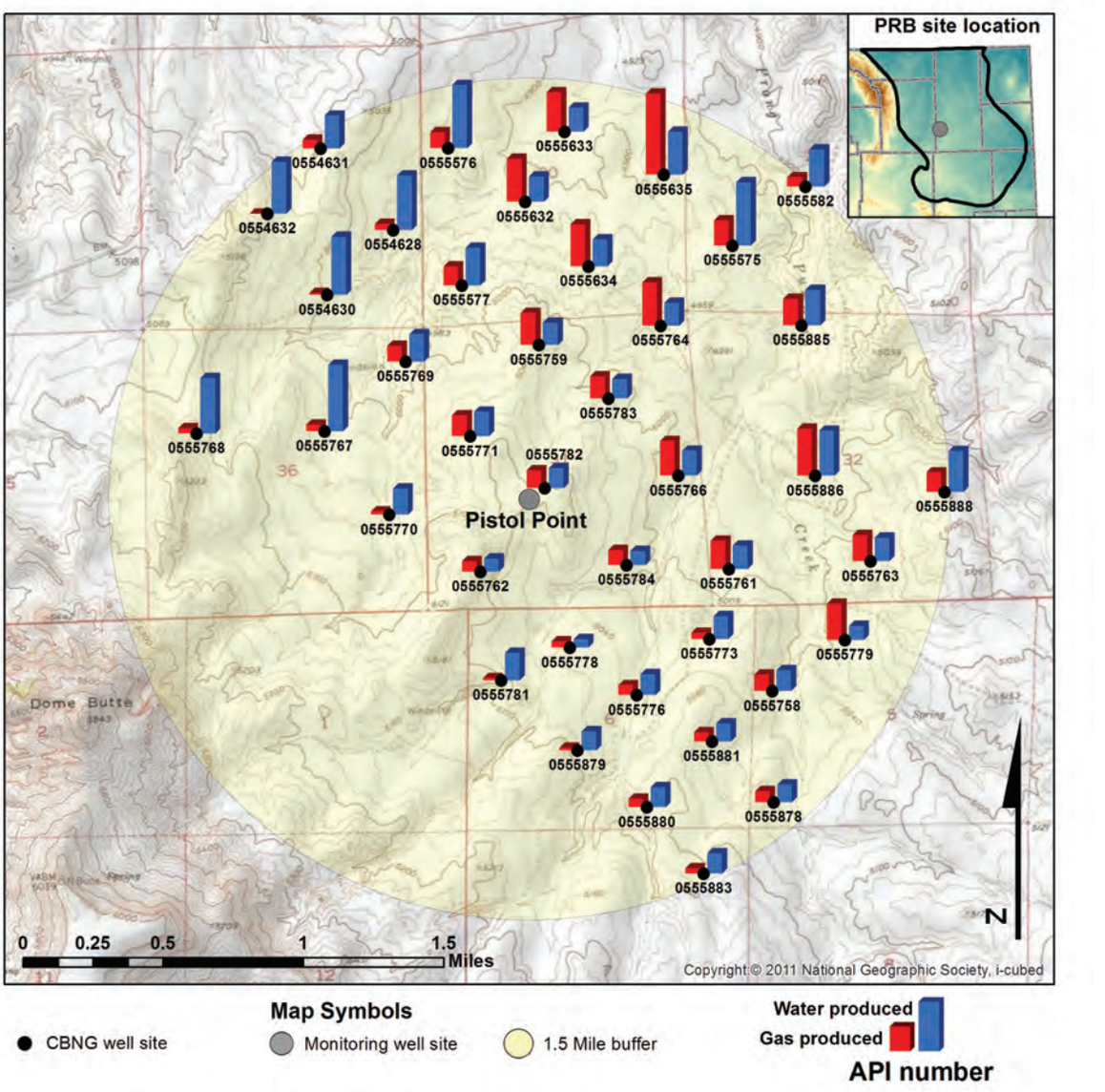

Figure A.188. Pistol Point monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

Production Statistics

Production data were analyzed for CBNG wells within the buffer of the Pistol Point monitoring well site from 2007-2013. Cumulative production for individual CBNG wells is displayed by location on Figure A.188. CBNG and water production are monitored in the Wyodak Rider coal zone wells.

Water production in the Wyodak Rider began in 2007, peaked in March 2008 at 413,070 bbls, then decreased and ended 2013 at 28,208 bbls/month (Figure A.189). Gas production in the Wyodak Rider began in March 2008 and continued into 2013 at a relatively stable high production level between 74,000 and 95,000 Mcf/month.

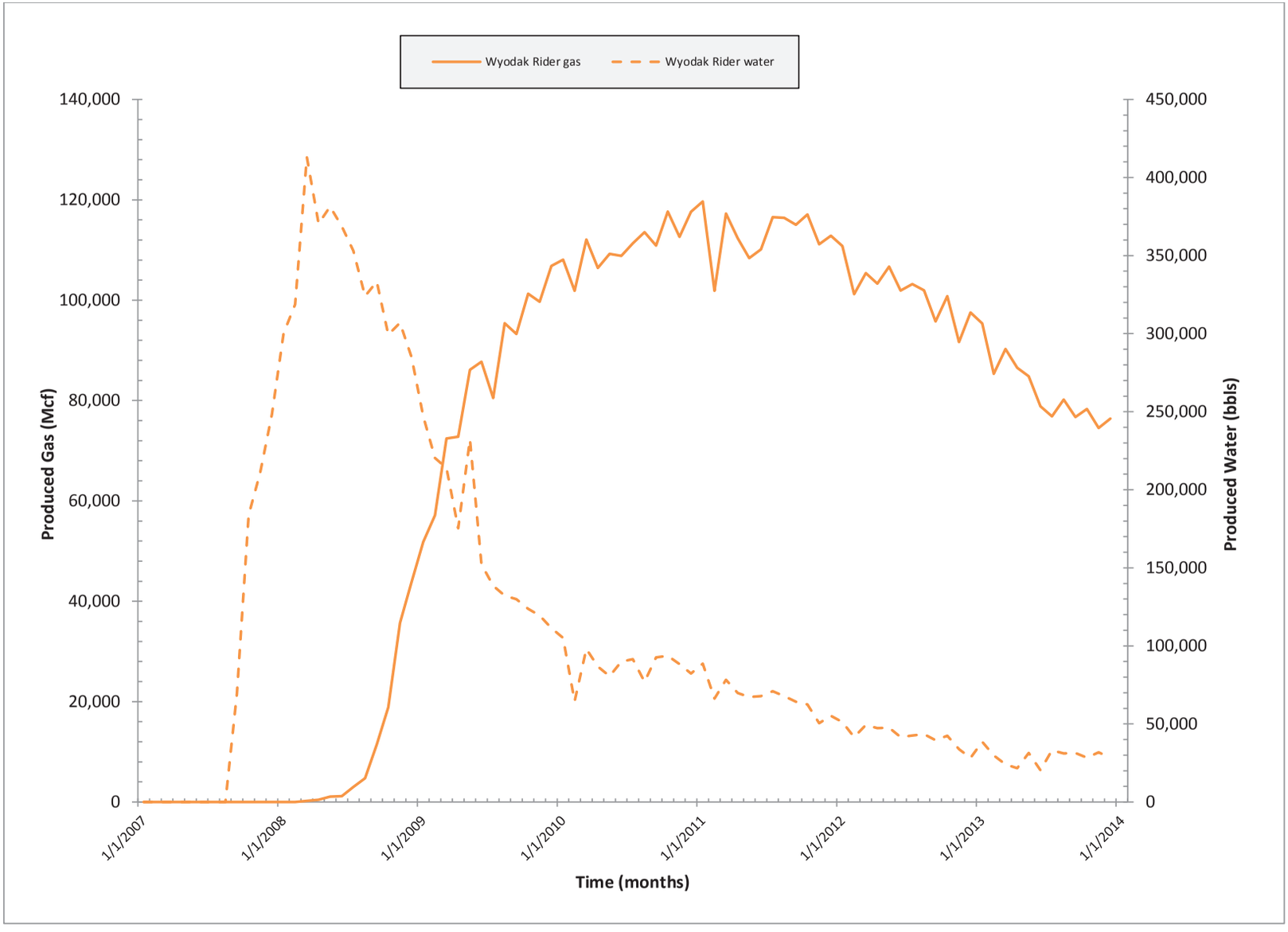

Figure A.189. Water and gas production from CBNG wells associated with the Pistol Point monitoring well site location.

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 a Wasatch sandstone and the other in the Canyon coal of the Lower Wyodak coal zone (Figure A.190; Table A.94). Water levels and wellhead gas pressures were measured during 2013 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 0.11 feet during 2013 but rose 0.75 feet during the 1998-2013 monitoring period (Figure A.191; Table A.95). Gas pressure was not recorded in the Wasatch sandstone.

Canyon Coal

Groundwater levels in the Canyon coal rose 26.55 feet during 2013 but have declined 118.37 feet over the 1998-2013 monitoring period (Figure A.191; Table A.95). Gas pressure in the Canyon coal peaked at 58.43 psi in April 2000.

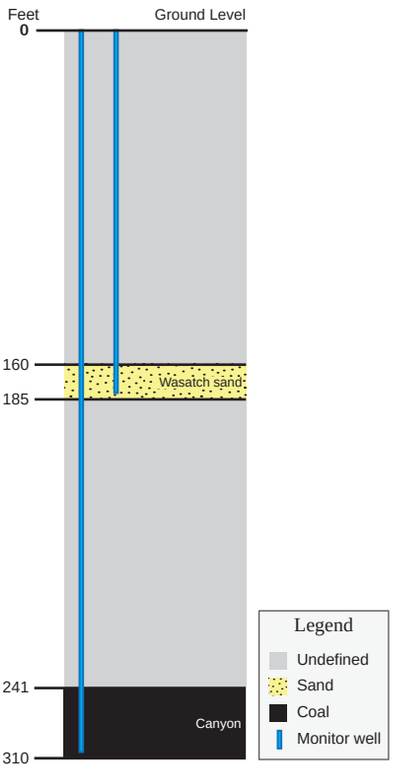

Figure A.190. Section showing relative positions of coal and sand in feet. Not to scale.

Table A.94. Table showing the depth to and thickness of monitored intervals at the Redstone monitoring well site location (measured in feet).

Monitored interval	Interval characteristics			
	Depth of interval (ft)		Interval 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, water level changes for current monitoring period, water level changes for period of record, and maximum gas pressure.

Monitored interval	DGW - Depth to groundwater (ft), water level (ft), and gas pressure (psi) data					
	Initial DGW	Max DGW [Date]	Final 2013 DGW	Water level change 2013	Net water level change	Max. gas pressure [date]
Wasatch sand	24.70	24.70 10/9/1998	23.95	-0.11	0.75	n/a
Canyon coal	32.80	278.00 4/26/2004	151.17	26.55	-118.37	58.43 4/5/2000

Production Statistics

Production data were analyzed for CBNG wells within the buffer of the Redstone monitoring well site from 1996-2013. Cumulative production for individual CBNG wells is displayed by location on Figure A.192. CBNG and water production are monitored in the Lower Wyodak, multiple, unmonitored, and unknown, coal zone wells.

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.193). Gas production peaked in January 2001 at 230,470 Mcf then decreased rapidly. No gas or water were produced from the Lower Wyodak in 2013.

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.193). No gas or water was produced from multiple coal zone wells in 2013.

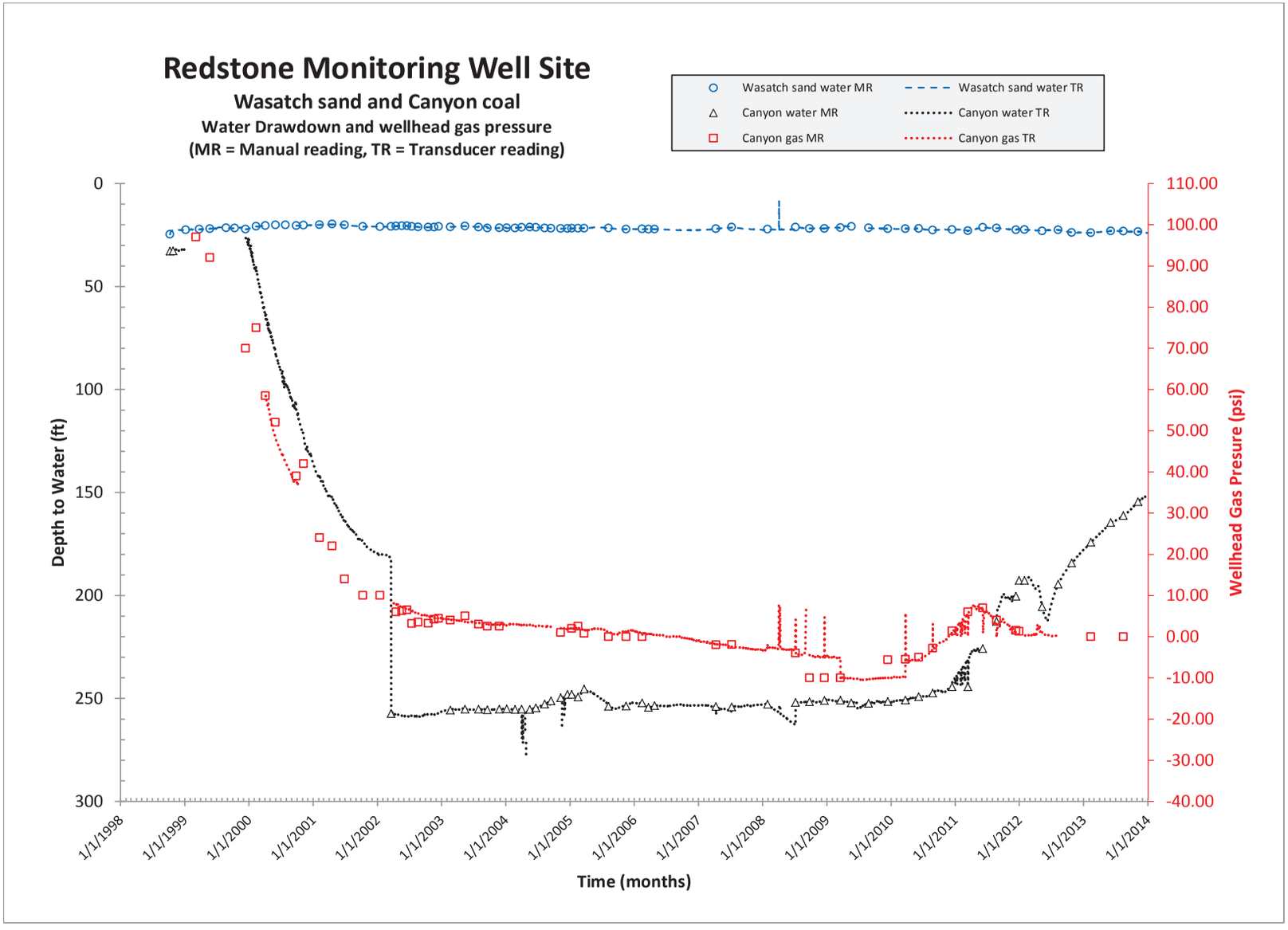

Figure A.191. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored intervals at the Redstone monitoring well site location.

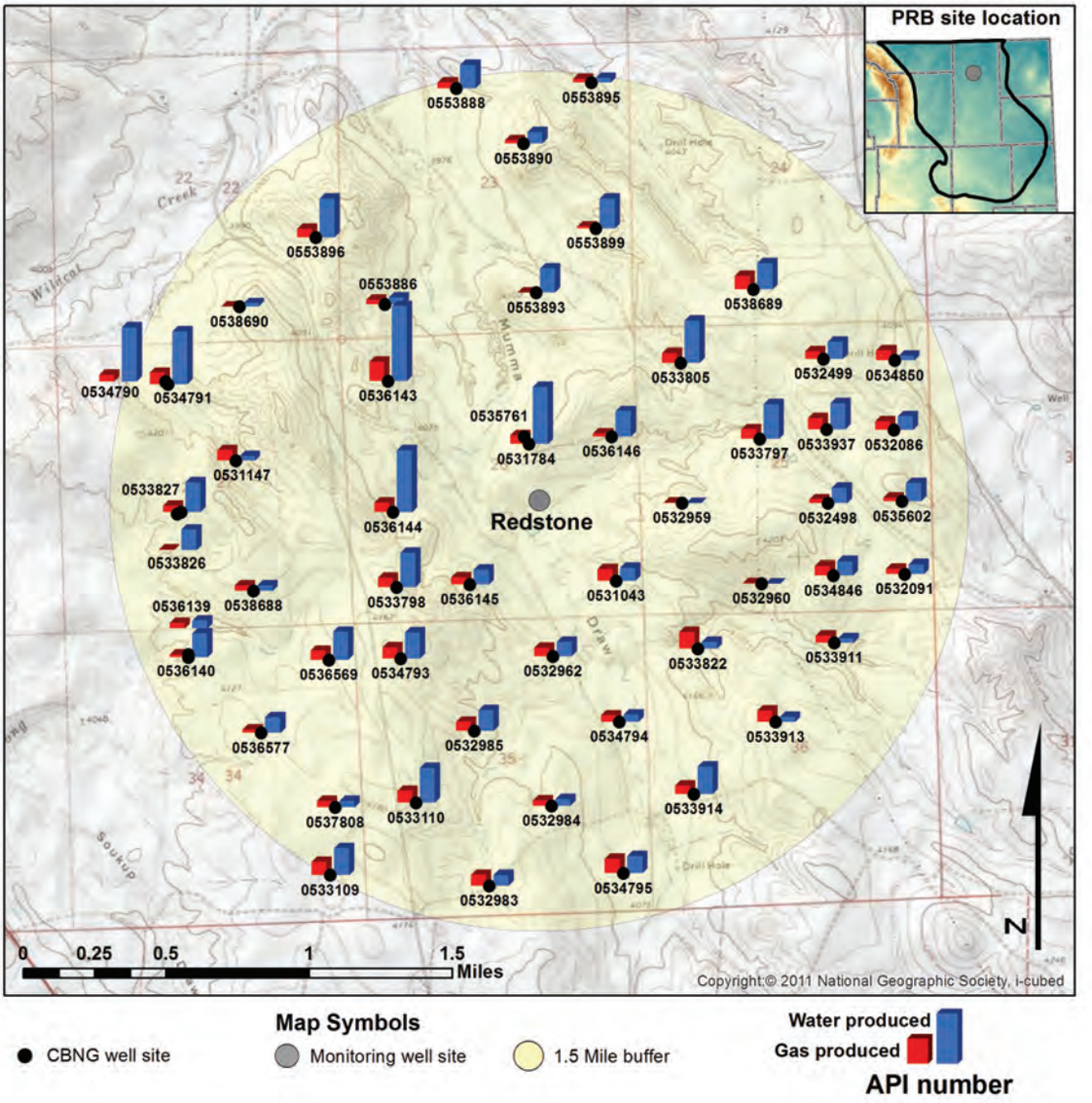

Figure A.192. Redstone monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

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 by mid-2012. (Figure A.193). Gas production levels in unmonitored coal zones were low but steady from 1999-2010 never exceeding 18,000 Mcf/month. No gas or water were produced from unmonitored coal zone wells in 2013.

Unknown coal zones produced water (15,709 bbls) and gas (1,000 Mcf) only in July 1996 (Figure A.193).

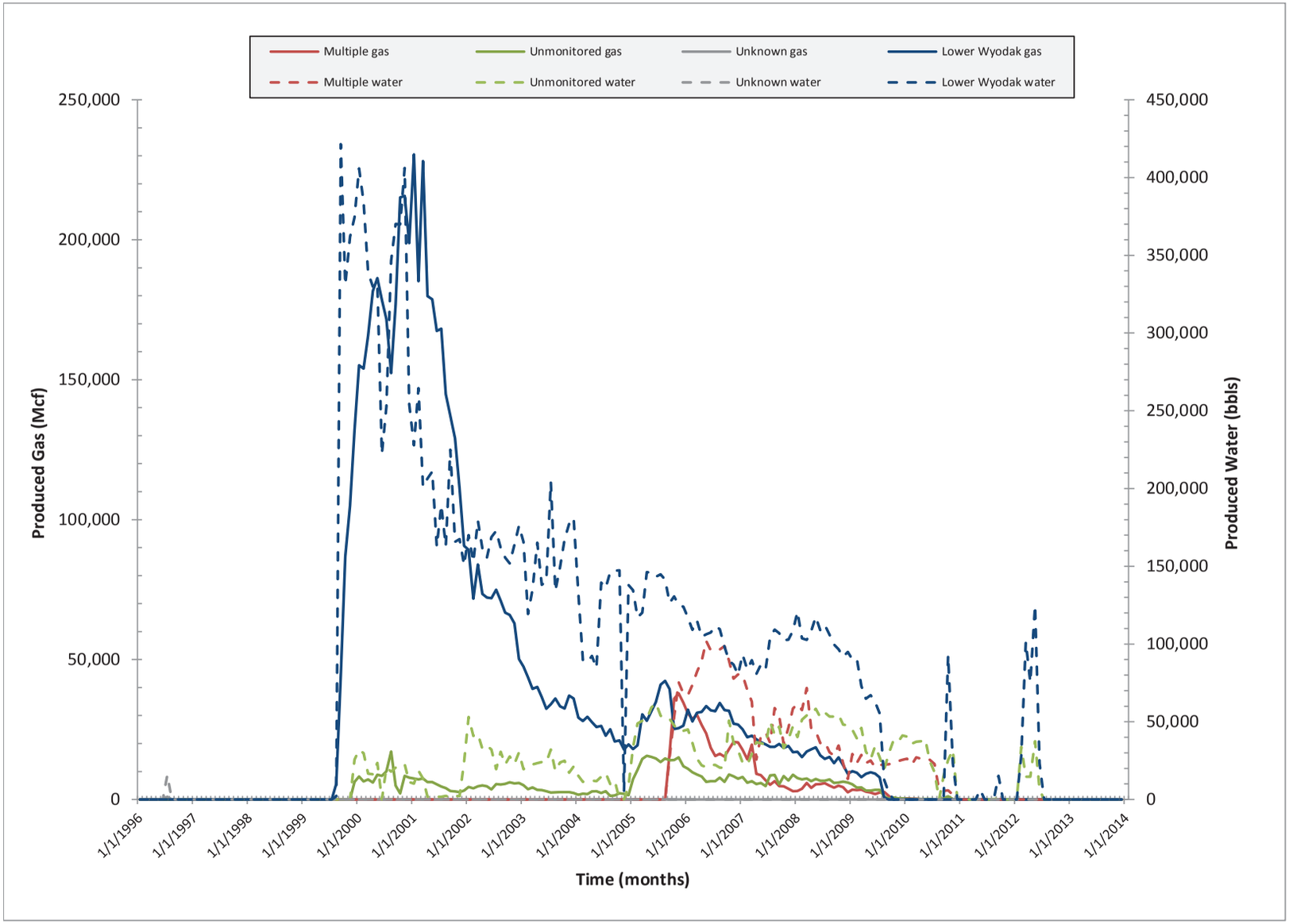

Figure A.193. Water and gas production from CBNG wells associated with the Redstone monitoring well site location.

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.194; Table A.96). Water levels and wellhead gas pressures were measured during 2013 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.

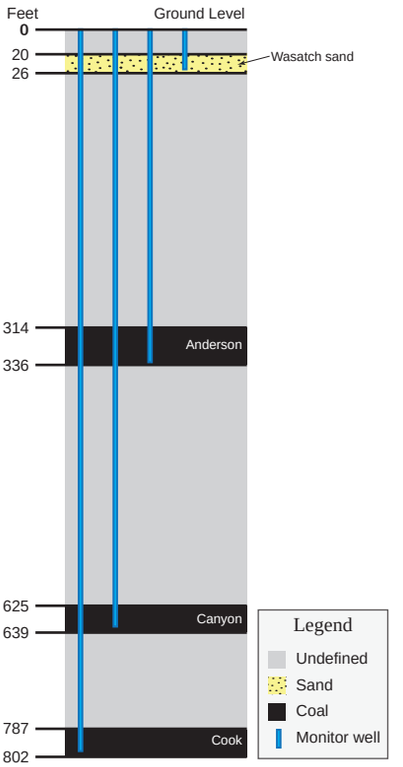

Figure A.194. Section showing relative positions of coals and sand in feet. Not to scale.

Wasatch Sandstone

Groundwater levels declined 0.68 feet during 2013 but have risen 0.32 feet overall during the 2005 - 2013 monitoring period (Figure A.195; Table A.97). Gas pressure was not recorded in the Wasatch sandstone.

Anderson Coal

Groundwater levels declined 1.71 feet during 2013 and 159.05 feet over the 2005 - 2013 monitoring period (Figure 12.195; Table A.97). Gas pressure in the Anderson coal initially peaked at 60.44 psi in August 2005 and declined steadily to about 1 psi by the end of 2013.

Canyon Coal

Groundwater levels rose 54.95 feet in the Canyon coal during 2103. Groundwater levels fell 94.47 feet over the monitoring period of 2005 - 2013 (Figure A.196; Table A.97). Gas pressure in the Canyon coal remained relatively stable at around 1 psi over the life of the well.

Cook Coal

Groundwater levels in the Cook coal rose 10.31 feet during 2013 but show an overall decline of 73.49 feet over the monitoring period of 2005 - 2013 (Figure A.196; 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 intervals at the Remington Creek monitoring well site location (measured in feet).

Monitored interval	Interval characteristics			
	Depth of interval (ft)		Interval 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, water level changes for current monitoring period, water level changes for period of record, and maximum gas pressure.

Monitored interval	DGW - Depth to groundwater (ft), water level (ft), and gas pressure (psi) data					
	Initial DGW	Max DGW [Date]	Final 2013 DGW	Water level change 2013	Net water level change	Max. gas pressure [date]
Wasatch sand	4.64	4.90 7/26/2006	4.32	-0.68	0.32	n/a
Anderson coal	160.00	377.50 7/13/2013	319.05	-1.71	-159.05	60.44 8/30/2005
Canyon coal	378.40	569.50 3/27/2012	472.87	54.95	-94.47	1.07 8/26/2007
Cook coal	378.00	562.70 2/9/2009	451.49	10.31	-73.49	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 2002-2013. Cumulative production for individual CBNG wells is displayed by location on Figure A.197. CBNG and water production are monitored in the Upper Wyodak, Cook, multiple, and unmonitored coal zone wells.

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 8,313 bbls/month by the end of 2013 (Figure A.198). Gas production reached its maximum in January 2006 at 34,704 Mcf, and gradually declined to end 2013 at a monthly production rate of 1,980 Mcf.

The Cook coal zone produced water for 5 months in 2003, never exceeding 22,000 bbls/month, and ceased afterward. No gas production has been recorded in this zone except for 1 Mcf in August 2003.

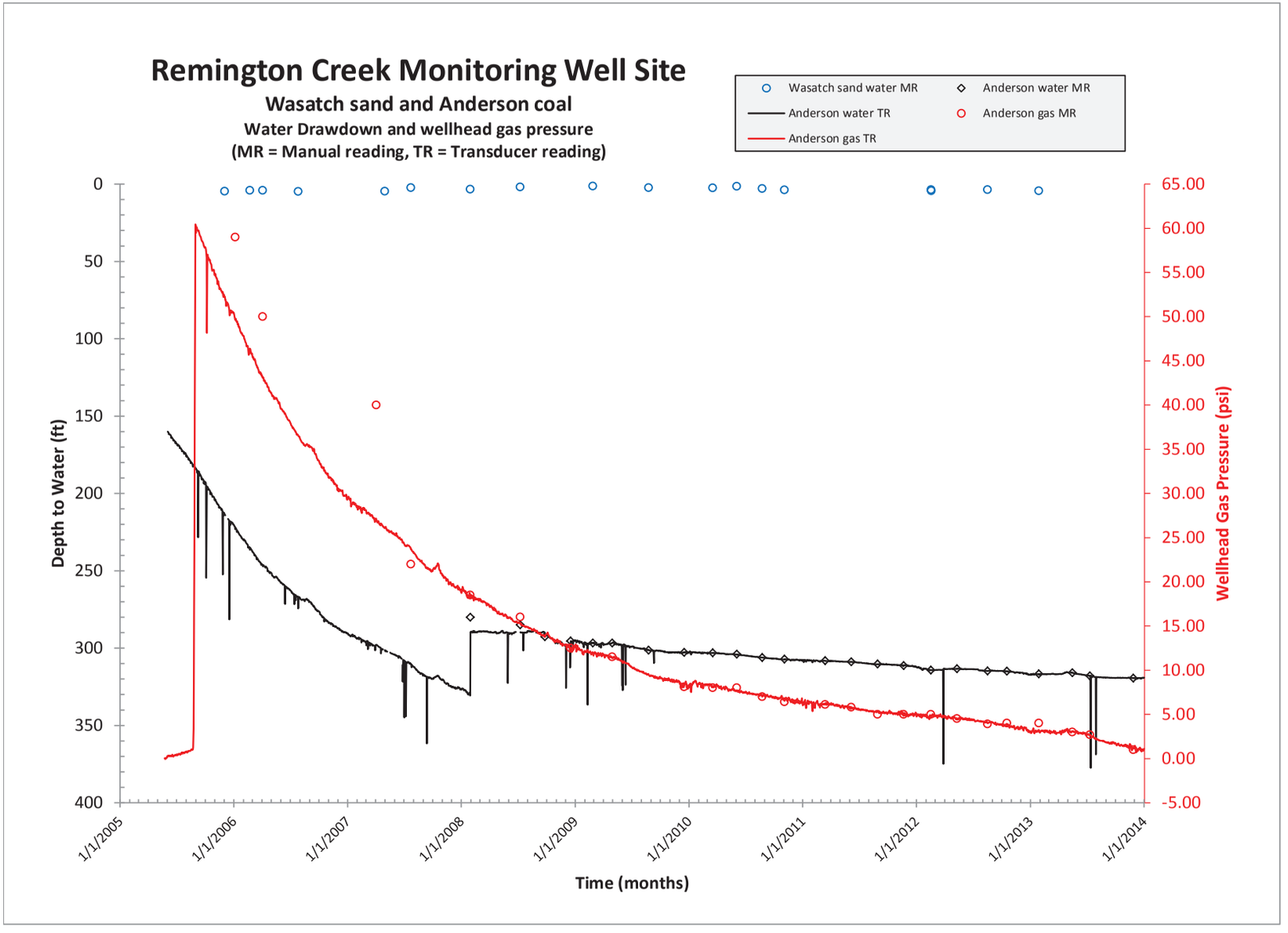

Figure A.195. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored intervals at the Remington Creek monitoring well site location.

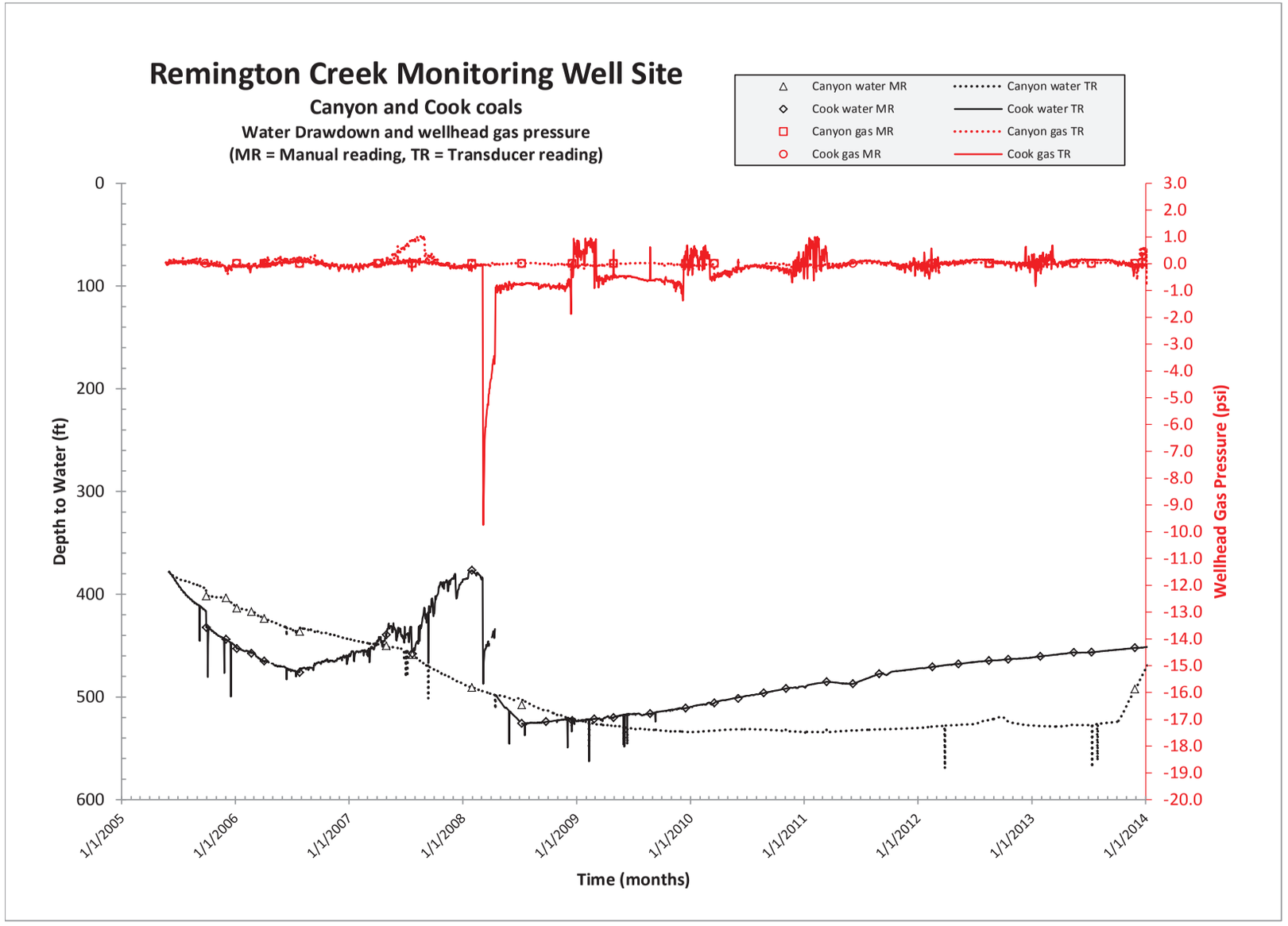

Figure A.196. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored intervals at the Remington Creek monitoring well site location.

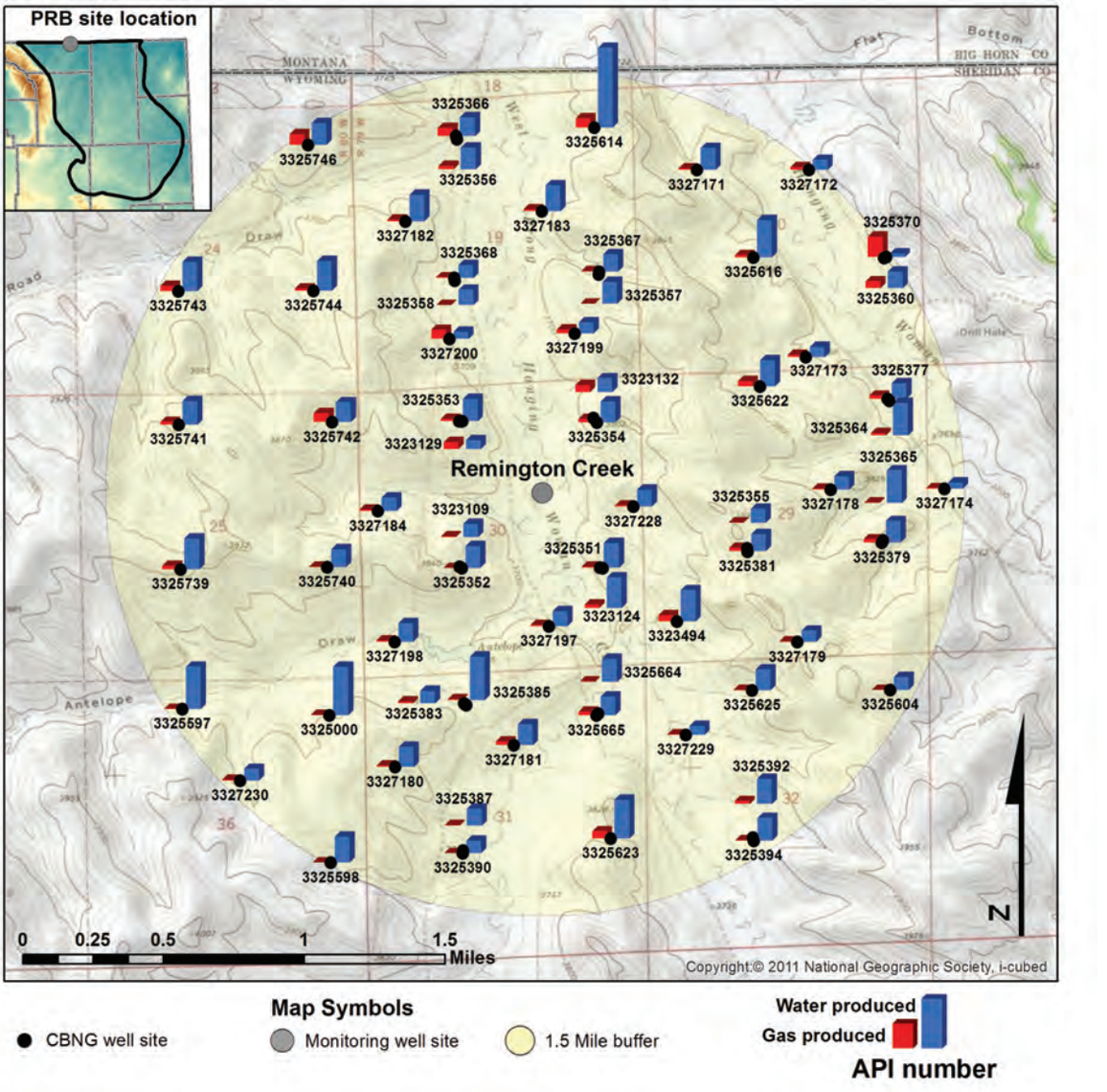

Figure A.197. Remington Creek monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

Multiple zone wells produced water and gas from 2004-2013. Water production peaked at 353,315 bbls in June 2008, then declined to 31,101 bbls/month by the end of 2013 (Figure A.198). Gas production peaked at 50,565 Mcf in August 2008 then declined to 7,197 Mcf/month by the end of 2013.

Unmonitored coal zones have produced water and gas intermittently at low levels (Figure A.198) from 2003 to mid-2011. Gas production never exceeded 5,029 Mcf/month and water production never exceeded 18,142 bbls/month. No gas or water was produced from unmonitored coal zone wells in 2013.

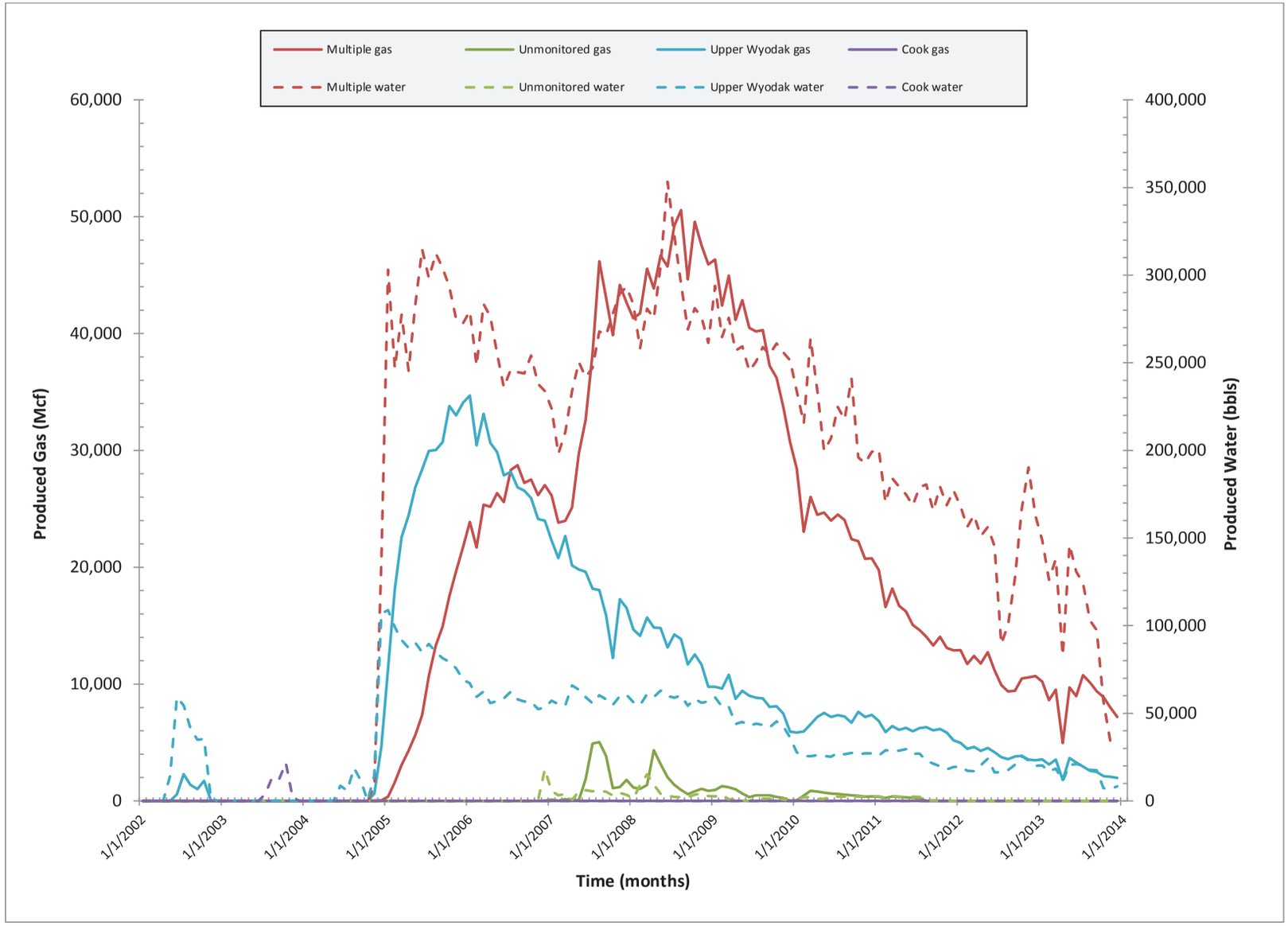

Figure A.198. Water and gas production from CBNG wells associated with the Remington Creek monitoring well site location.

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 in a Fort Union underburden sandstone (Figure A.199; Table A.98). Water levels and wellhead gas pressures were measured during 2013 using both manual and automatic transducer and data logger equipment. There is good agreement between concurrent transducer and manual measurements. 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 2.67 feet during 2013 and 18.42 feet during the 2009-2013 monitoring period (Figure A.200; Table A.99). Gas pressure was not recorded in the Wasatch sandstone.

Wall Coal
Groundwater levels rose 61.06 feet during 2013 (Figure A.200; Table A.99). Groundwater levels still remain 73.06 feet below initial levels of 2009. Gas pressures 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 1.80 feet during 2013 and 72.82 feet during the 2009-2013 monitoring period (Figure A.200; Table A.99). Gas pressure in the underburden sand remained relatively stable over this period, not exceeding 2 psi.

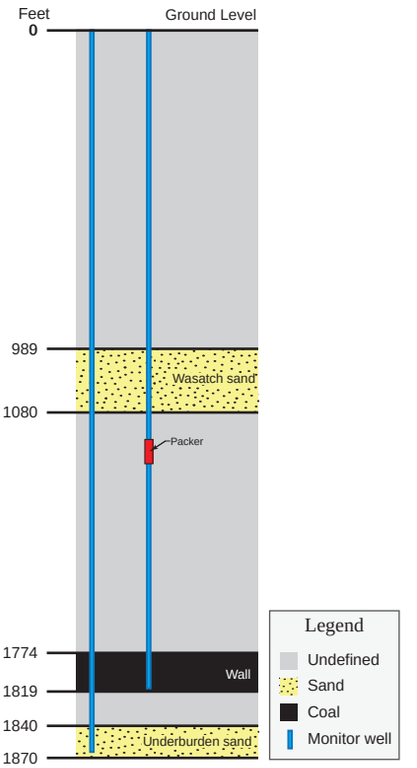

Figure A.199. Section showing relative positions of coal and sands in feet. Not to scale.

Table A.98. Table showing the depth to and thickness of monitored intervals at the Rose Draw monitoring well site location (measured in feet).

Monitored interval	Interval characteristics			
	Depth of interval (ft)		Interval 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, water level changes for current monitoring period, water level changes for period of record, and maximum gas pressure.

Monitored interval	DGW - Depth to groundwater (ft), water level (ft), and gas pressure (psi) data					
	Initial DGW	Max DGW [Date]	Final 2013 DGW	Water level change 2013	Net water level change	Max. gas pressure [date]
Shallow sand	67.32	85.90 12/25/2013	85.74	-2.67	-18.42	n/a
Wall coal	44.91	237.20 2/6/2012	117.97	61.06	-73.06	0.06 10/24/2010
Underburden sand*	0.00	73.20 10/7/2013	71.88	-1.80	-72.82	2.00 3/22/2011

*Well initially flowing artesian

Production Statistics

Production data were analyzed for CBNG wells within the buffer of the Rose Draw monitoring well site from 2005-2013. Cumulative production for individual CBNG wells is displayed by location on Figure A.201. CBNG and water production are monitored in the Wall, multiple, and unmonitored coal zone wells.

The Wall coal zone produced low volumes of water consistently from March 2011 to late 2012. Water production reached its maximum at 36,852 bbls in June 2008 (Figure A.202). Gas production in the Wall coal zone has been low and intermittent, never exceeding 4 Mcf /month. No water or gas was produced from the Wall coal zone wells in 2013.

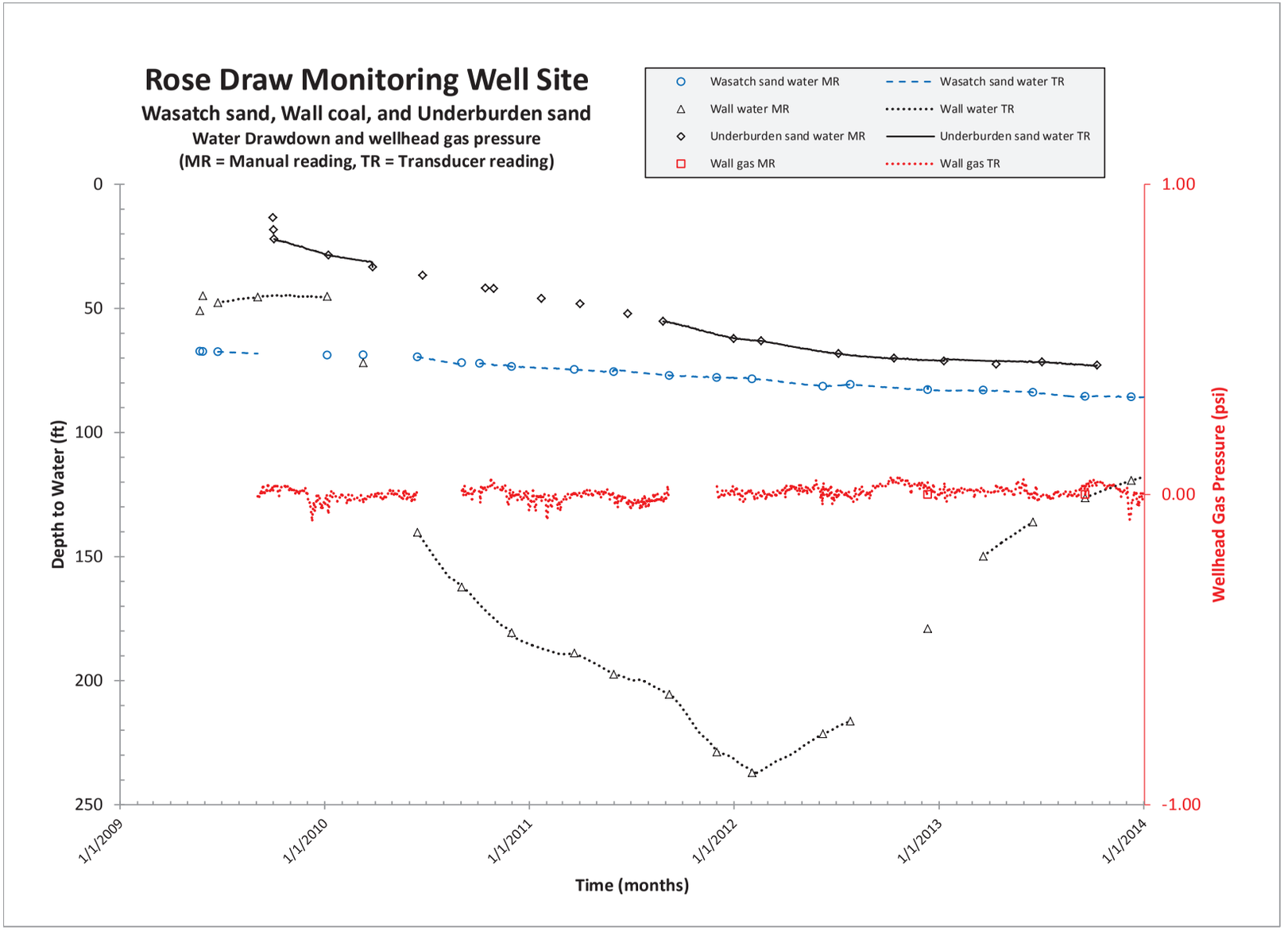

Figure A.200. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored intervals at the Rose Draw monitoring well site location.

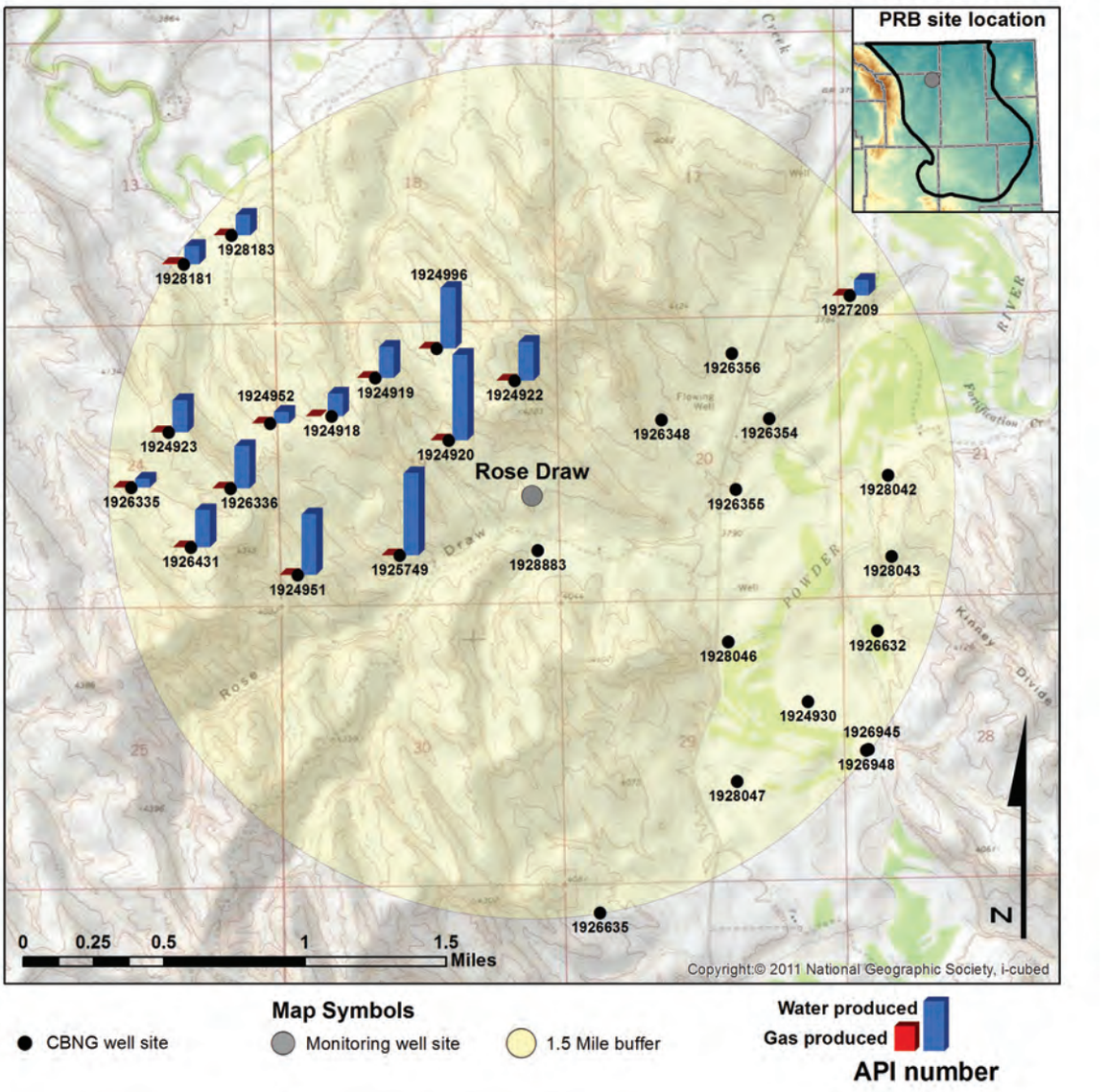

Figure A.201. Rose Draw monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

Multiple coal zone wells produced water from October 2007 into late 2012. Water production peaked at 153,402 bbls in April 2010 (Figure A.202). Gas production in the multiple zones has been low and intermittent, never exceeding 200 Mcf/month. No water or gas was produced from multiple coal zone wells in 2013

Unmonitored coal zones produced water beginning August 2006 and into 2012, peaking at 50,700 bbls in June 2007 (Figure A.202). Gas production in unmonitored coal zones has not exceeded 700 Mcf/month over the life of the well, and has experienced low intermittent levels of gas production. No water or gas was produced from unmonitored coal zone wells in 2013

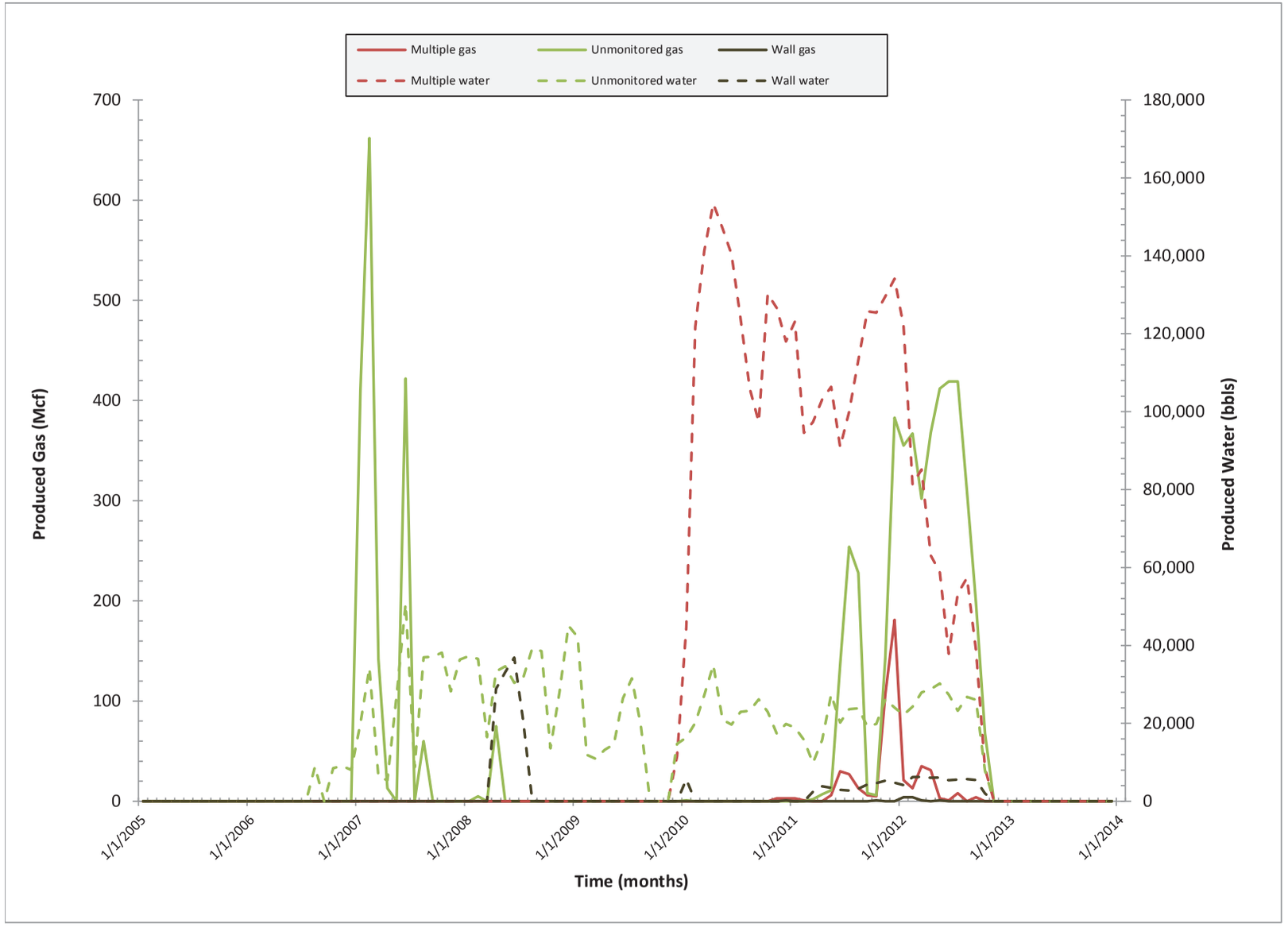

Figure A.202. Water and gas production from CBNG wells associated with the Rose Draw monitoring well site location.

Sasquatch Monitoring Well Site
Location: S12 T48N R77W
Date First Monitored: January 14, 1998

Drawdown Information
The Sasquatch monitoring well site consists of 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.203; Table A.100). Water levels and wellhead gas pressures were measured during 2013 using both manual and automatic transducer and data logger equipment. There is good agreement between concurrent transducer and manual measurements. 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 20.93 feet during 2013 and have steadily decreased 360.75 feet over the 1998-2013 monitoring period (Figure A.204; Table A.101). Gas pressure was not recorded in the Wasatch sandstone.

Big George Coal
Groundwater levels declined 23.44 feet during 2013 and 531.99 feet over the 1998-2012 monitoring period (Figure A.204; Table A.101). Gas pressure in the Big George remained relatively stable over the life of the well.

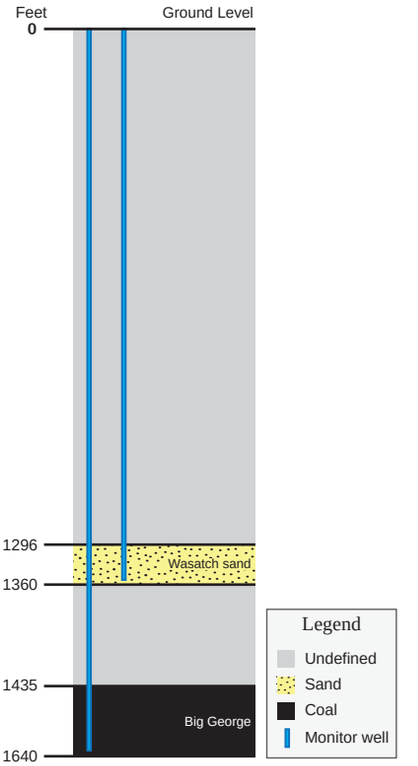

Figure A.203. Section showing relative positions of coal and sand in feet. Not to scale.

Table A.100. Table showing the depth to and thickness of monitored intervals at the Sasquatch monitoring well site location (measured in feet).

Monitored interval	Interval characteristics			
	Depth of interval (ft)		Interval 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, water level changes for current monitoring period, water level changes for period of record, and maximum gas pressure.

Monitored interval	DGW - Depth to groundwater (ft), water level (ft), and gas pressure (psi) data					
	Initial DGW	Max DGW [Date]	Final 2013 DGW	Water level change 2013	Net water level change	Max. gas pressure [date]
Wasatch sand	224.98	592.30 6/27/2013	585.73	-20.93	-360.75	n/a
Big George coal	229.76	761.80 12/31/2013	761.75	-23.44	-531.99	3.12 7/13/2003

Production Statistics

Production data were analyzed for CBNG wells within the buffer of the Sasquatch monitoring well site from 2001-2013. Cumulative production for individual CBNG wells is displayed by location on Figure A.205. CBNG and water production are monitored in the Wyodak Rider, in which all local CBNG production occurs.

The Wyodak Rider has consistently produced water and gas from early 2002-2013. Water production peaked in June 2005 at 790,079 bbls and then decreased to under 100,000 bbls/month from April 2007 to the end of 2013 (Figure A.206). Gas production in the Wyodak Rider coal zone was low and rose slowly 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 2013.

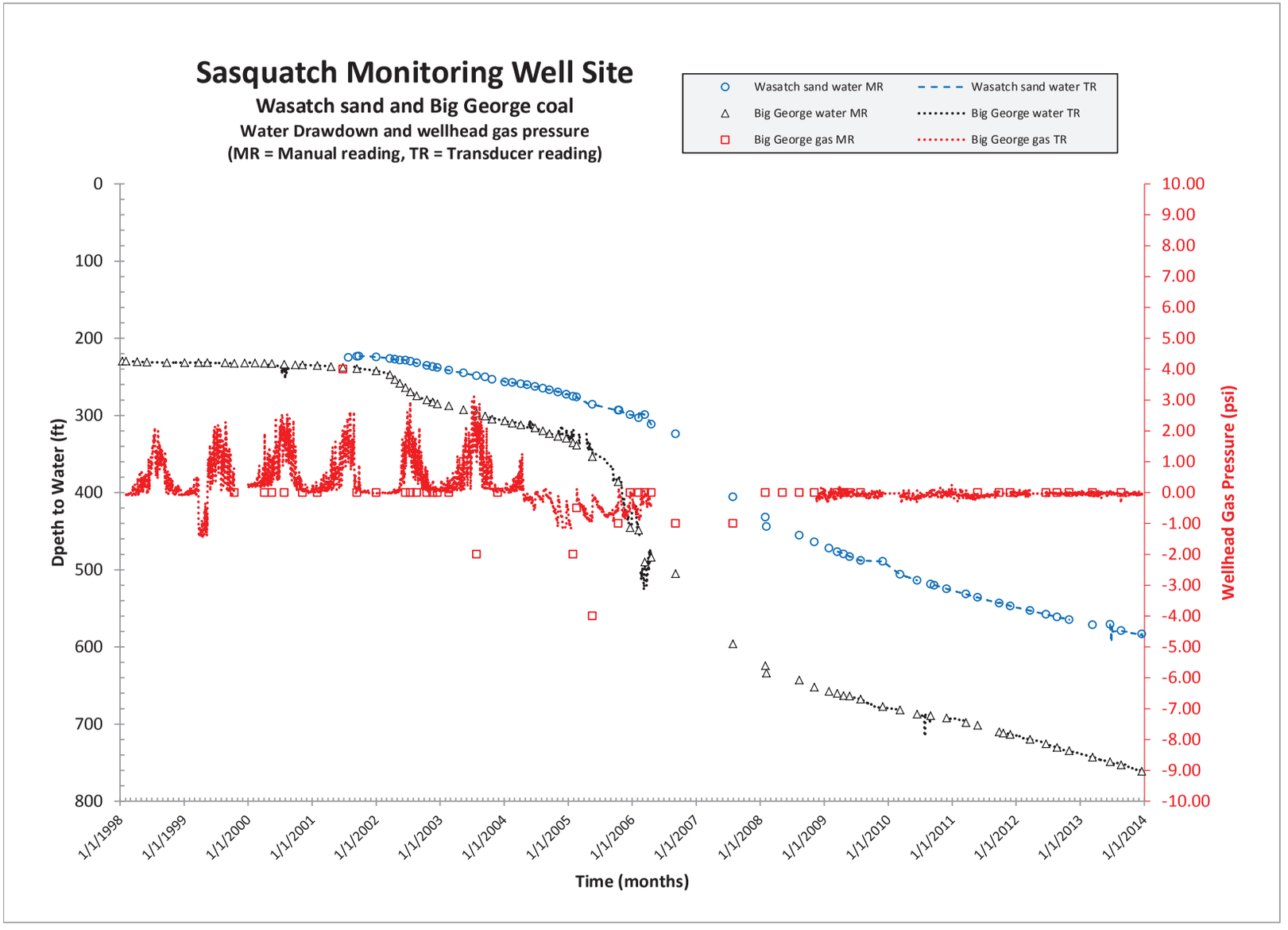

Figure A.204. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored intervals at the Sasquatch monitoring well site location

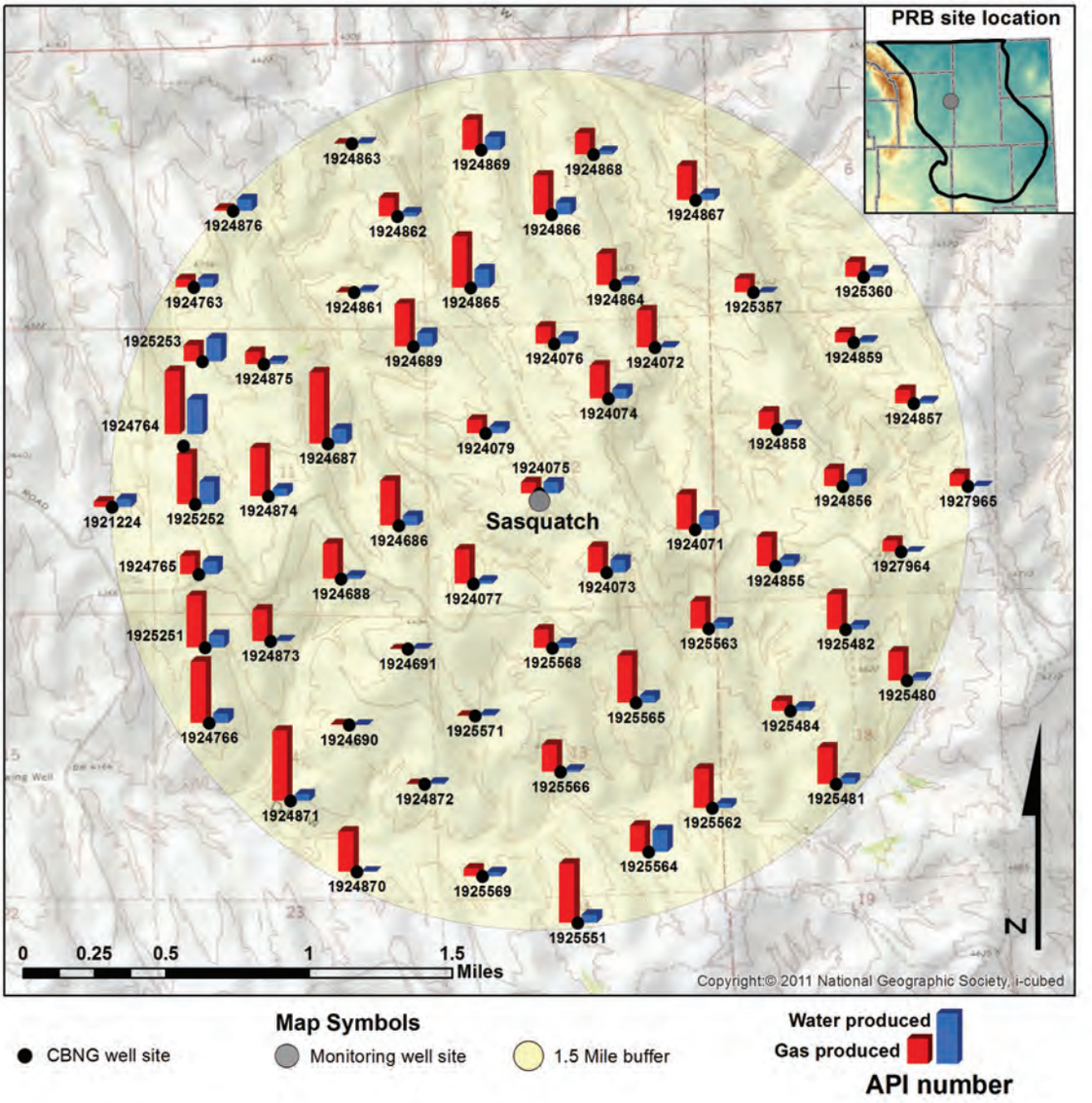

Figure A.205. Sasquatch monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

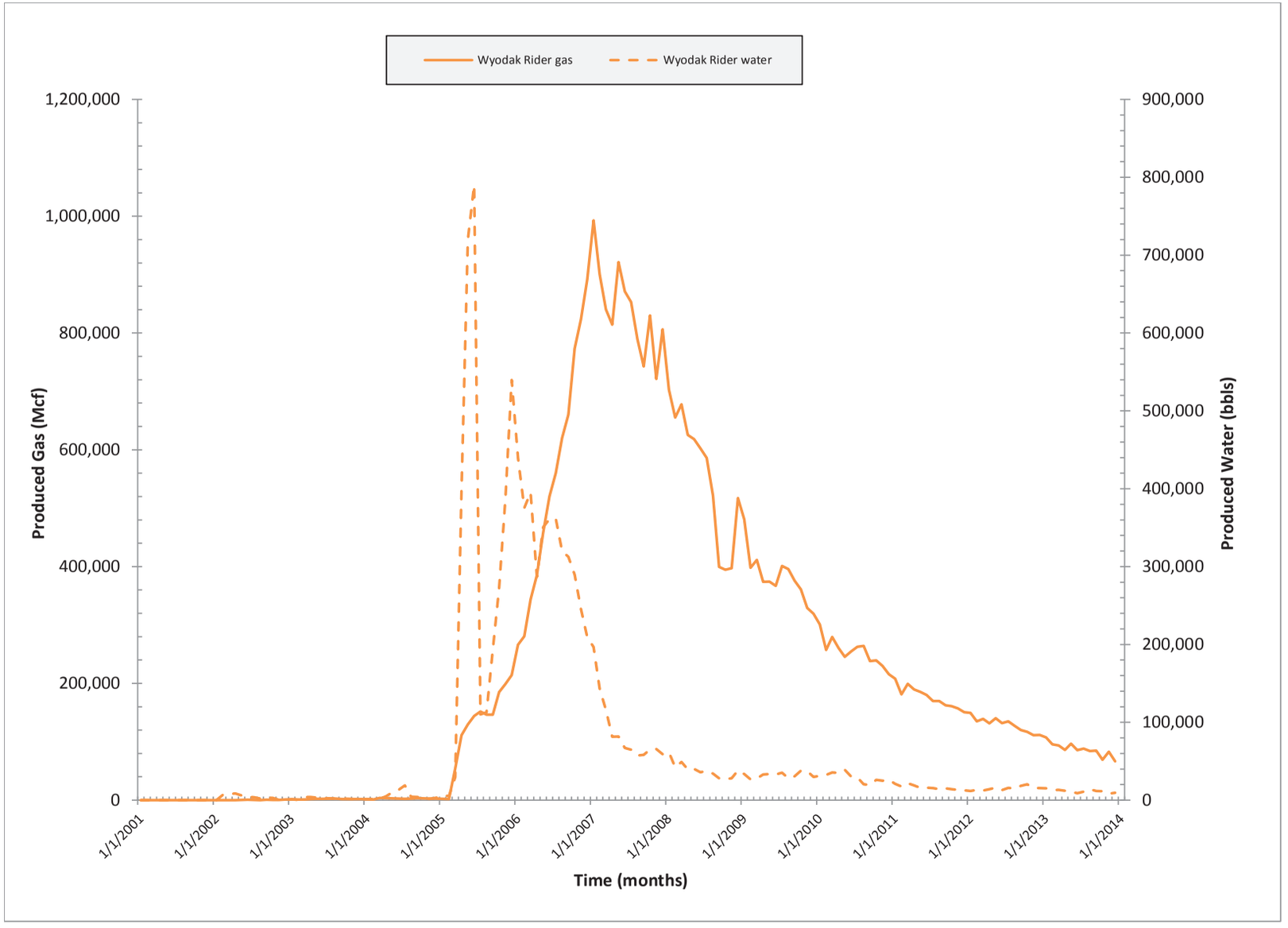

Figure A.206. Water and gas production from CBNG wells associated with the Sasquatch monitoring well site location.

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.207; Table A.102). Water levels and wellhead gas pressures were measured during 2013 using a combination of 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 level measurements indicate the site has declined 1.60 feet during 2013, and declined 4.54 feet during the 1996-2013 monitoring period (Figure A.208; Table A.103). Gas pressure was not recorded in the Wasatch sandstone.

Wyodak Coal

Groundwater levels recovered 42.56 feet during 2013. Groundwater levels remain 317.94 feet below the initial levels measured in 1996 (Figure A.208; Table A.103). Gas pressure in the Wyodak coal peaked at 63.78 psi in January 2001.

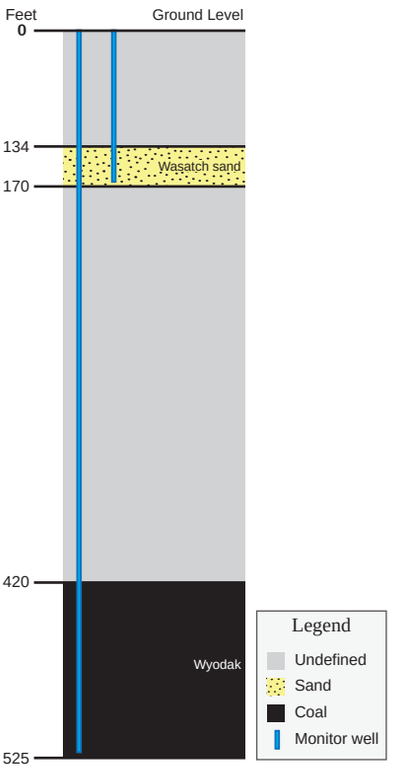

Figure A.207. Section showing relative positions of coal and sand in feet. Not to scale.

Table A.102. Table showing the depth to and thickness of monitored intervals at the Sec 25 monitoring well site location (measured in feet).

Monitored interval	Interval characteristics			
	Depth of interval (ft)		Interval 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, water level changes for current monitoring period, water level changes for period of record, and maximum gas pressure.

Monitored interval	DGW - Depth to groundwater (ft), water level (ft), and gas pressure (psi) data					
	Initial DGW	Max DGW [Date]	Final 2013 DGW	Water level change 2013	Net water level change	Max. gas pressure [date]
Wasatch sand	28.09	32.70 12/26/2013	32.63	-1.60	-4.54	n/a
Wyodak coal	48.31	560.60 1/12/2007	366.25	42.56	-317.94	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 1994-2013. Cumulative production for individual CBNG wells is displayed by location on Figure A.209. CBNG and water production are monitored in the Upper Wyodak and unmonitored coal zone wells.

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.209). Gas production peaked in January 2002 at 226,810 Mcf. No water or gas was produced during 2013.

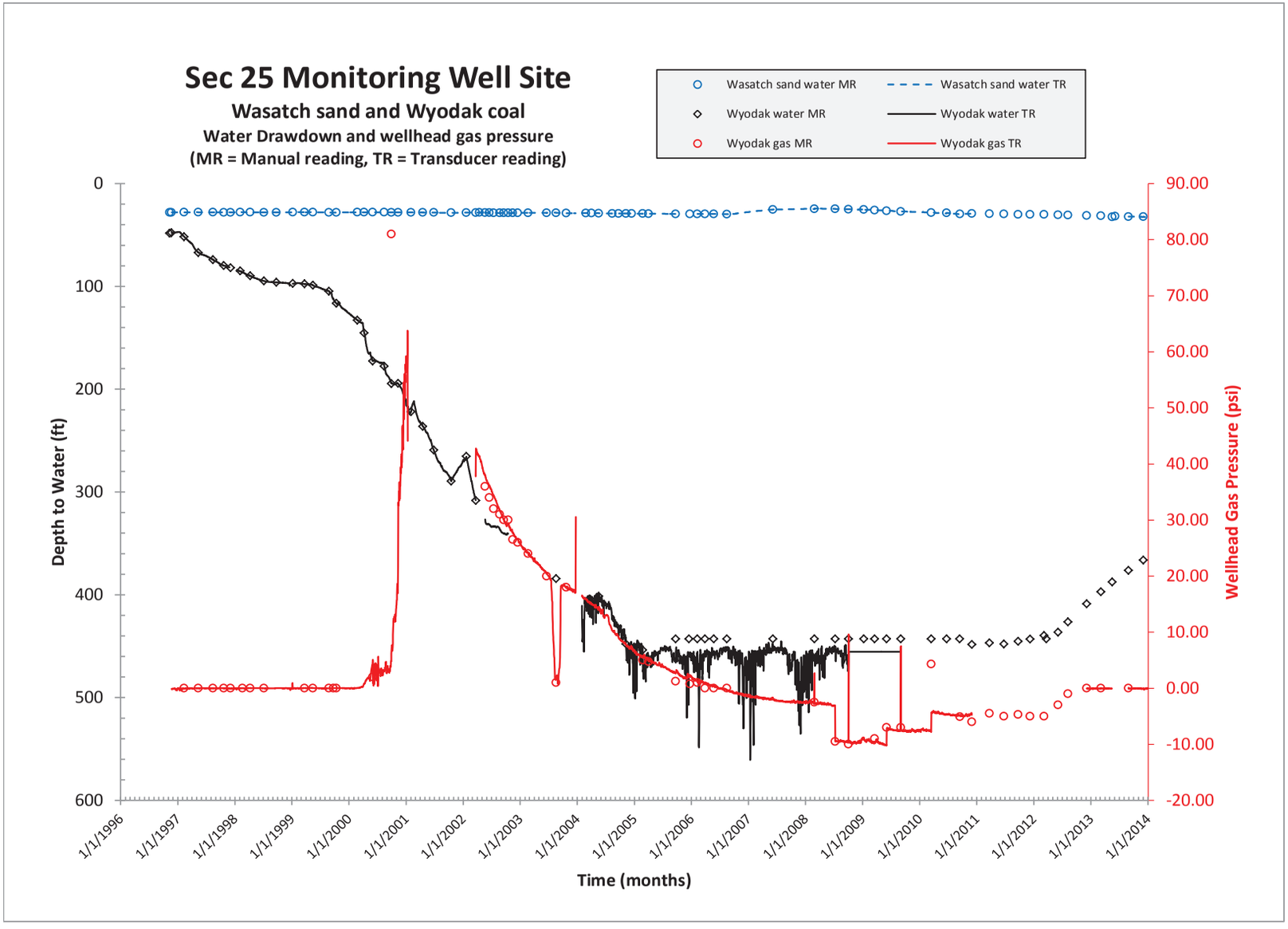

Figure A.208. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored intervals at the Sec 25 monitoring well site location.

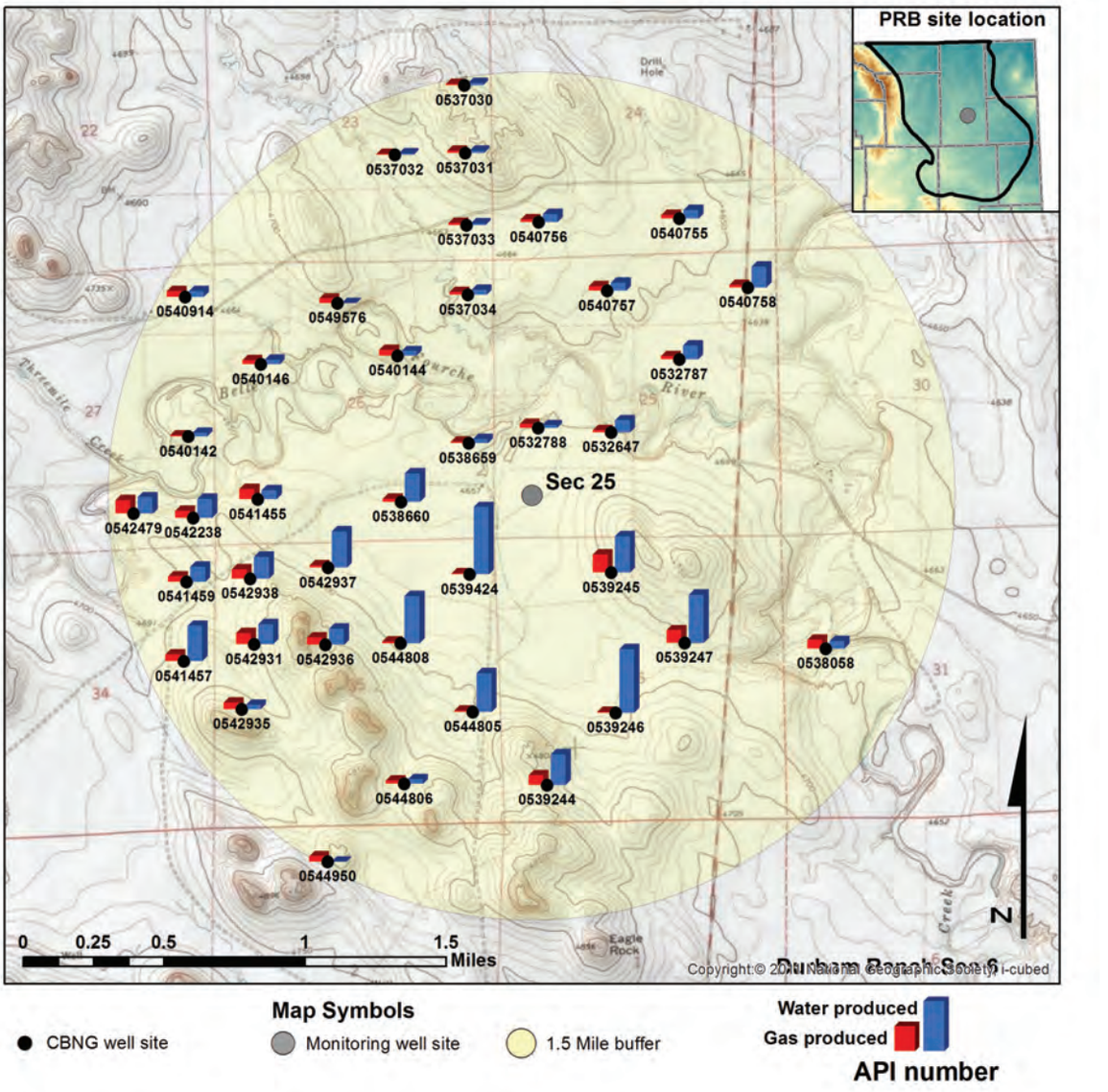

Figure A.209. Sec 25 monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

The unmonitored coal zones produced low levels of water from 1999-2012, not exceeding 42,000 bbls/month (Figure A.210). Gas production in unmonitored coal zones gradually increased from 2000 to its peak in August 2002 of 32,613 Mcf, then decreased to zero by the July 2012. No water or gas was produced during 2013.

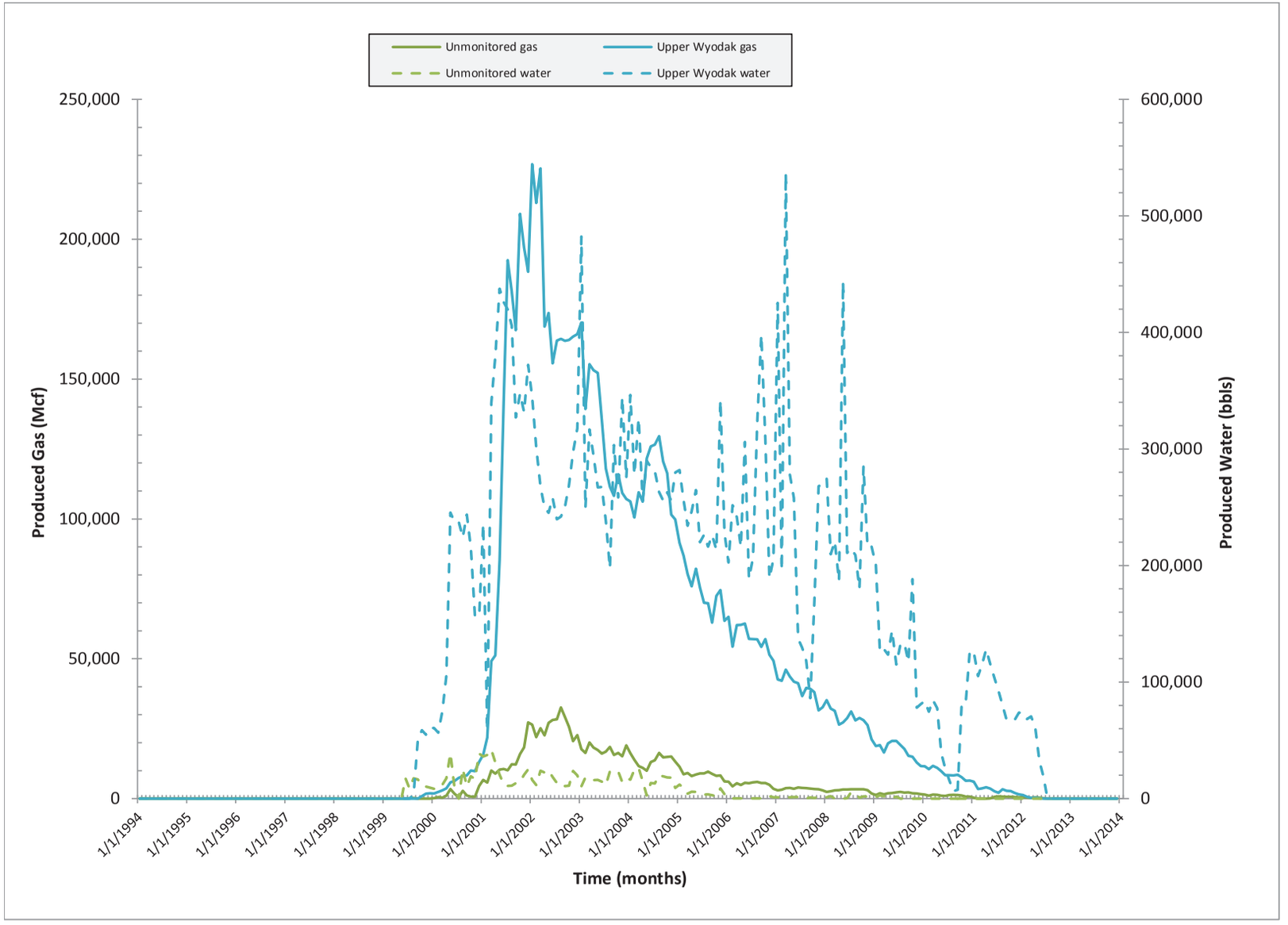

Figure A.210. Water and gas production from CBNG wells associated with the Sec 25 monitoring well site location.

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 Cook/Wall coal zone (Figure A.211; Table A.104). Water levels and wellhead gas pressures were measured during 2013 using a combination of 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 have been relatively stable since monitoring began; levels rose 0.01 feet during 2013 and declined by 1.28 feet over the 2001-2013 monitoring period (Figure A.212; Table A.105). Gas pressure was not recorded in the Wasatch sandstone.

Cook/Lower Wall/Pawnee Coal

Groundwater levels declined 0.67 feet during 2013 and 42.81 feet over the 2001-2013 monitoring period. (Figure A.212; Table A.105). Gas pressure in the Cook/Lower Wall/Pawnee coal reached a maximum of 12.71 psi in November 2004.

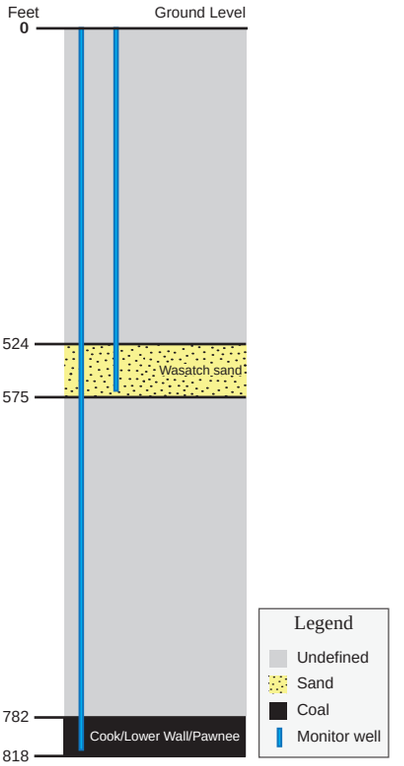

Figure A.211. Section showing relative positions of coal and sand in feet. Not to scale.

Table A.104. Table showing the depth to and thickness of monitored intervals at the South Coal monitoring well site location (measured in feet).

Monitored interval	Interval characteristics			
	Depth of interval (ft)		Interval 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, water level changes for current monitoring period, water level changes for period of record, and maximum gas pressure.

Monitored interval	DGW - Depth to groundwater (ft), water level (ft), and gas pressure (psi) data						
	Initial DGW	Max DGW [Date]	Final 2013 DGW	Water level change 2013	Net water level change	Max. gas pressure [date]
Wasatch sand	463.85	467.10 5/31/2005	465.13	0.01	-1.28	n/a
Cook/Wall/ Pawnee coal	561.37	609.30 10/8/2008	604.18	-0.67	-42.81	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 2005-2013. Cumulative production for individual CBNG wells is displayed by location on Figure A.213. CBNG and water production are monitored in the Wall, multiple, and unmonitored coal zone wells. Gas and water production in the Cook/Wall zone is represented as multiple zone production.

The Wall coal zone produced water from May 2005 - September 2009. Water production peaked at 25,565 bbls in September 2007 then decreased to zero by the end of 2009 (Figure A.214). Gas production reached its maximum level in October 2006 at 4,548 Mcf, and gradually declined to zero by January 2011. No water or gas was produced from Wall coal zone wells in 2013.

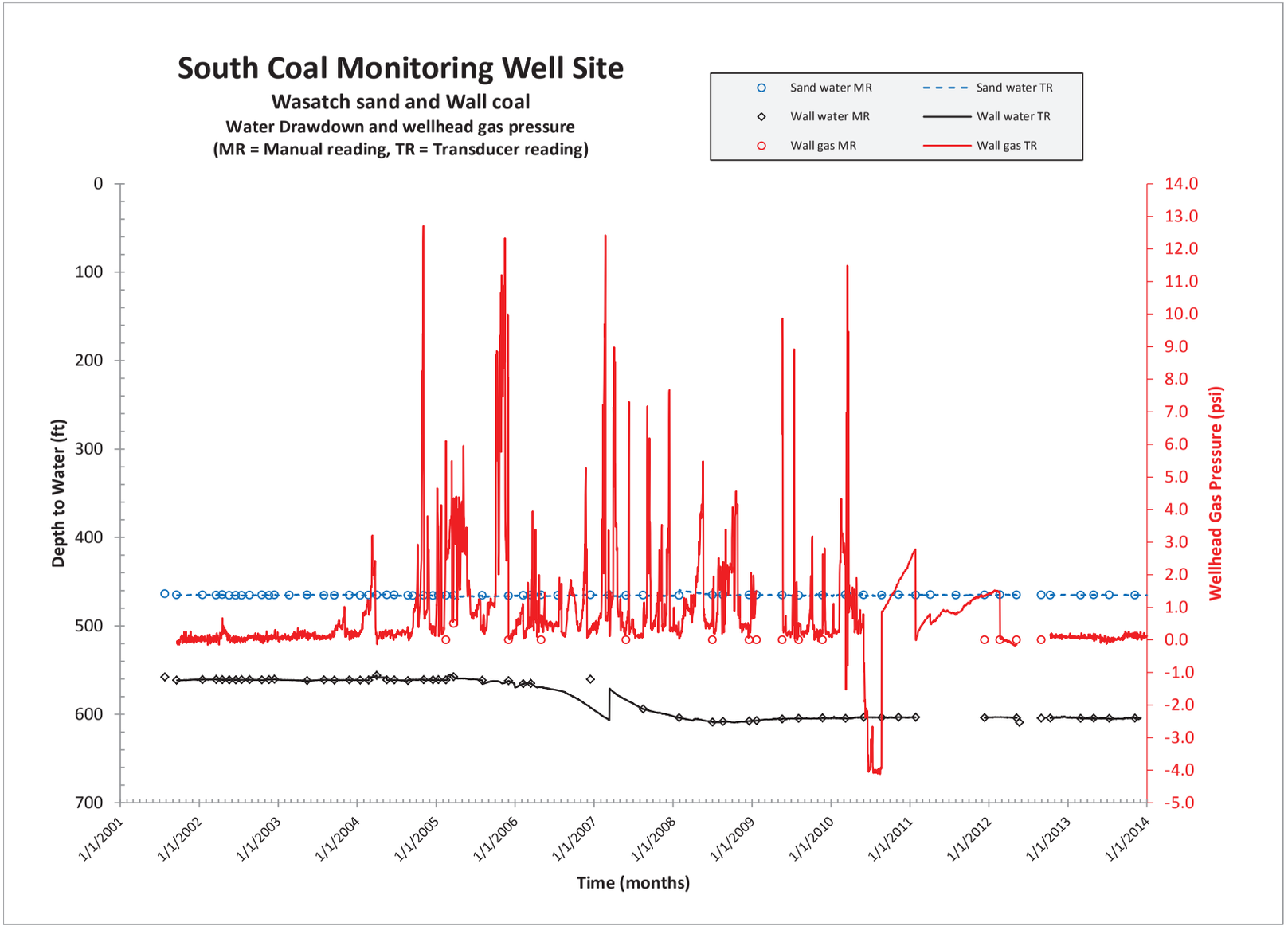

Figure A.212. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored intervals at the South Coal monitoring well site location.

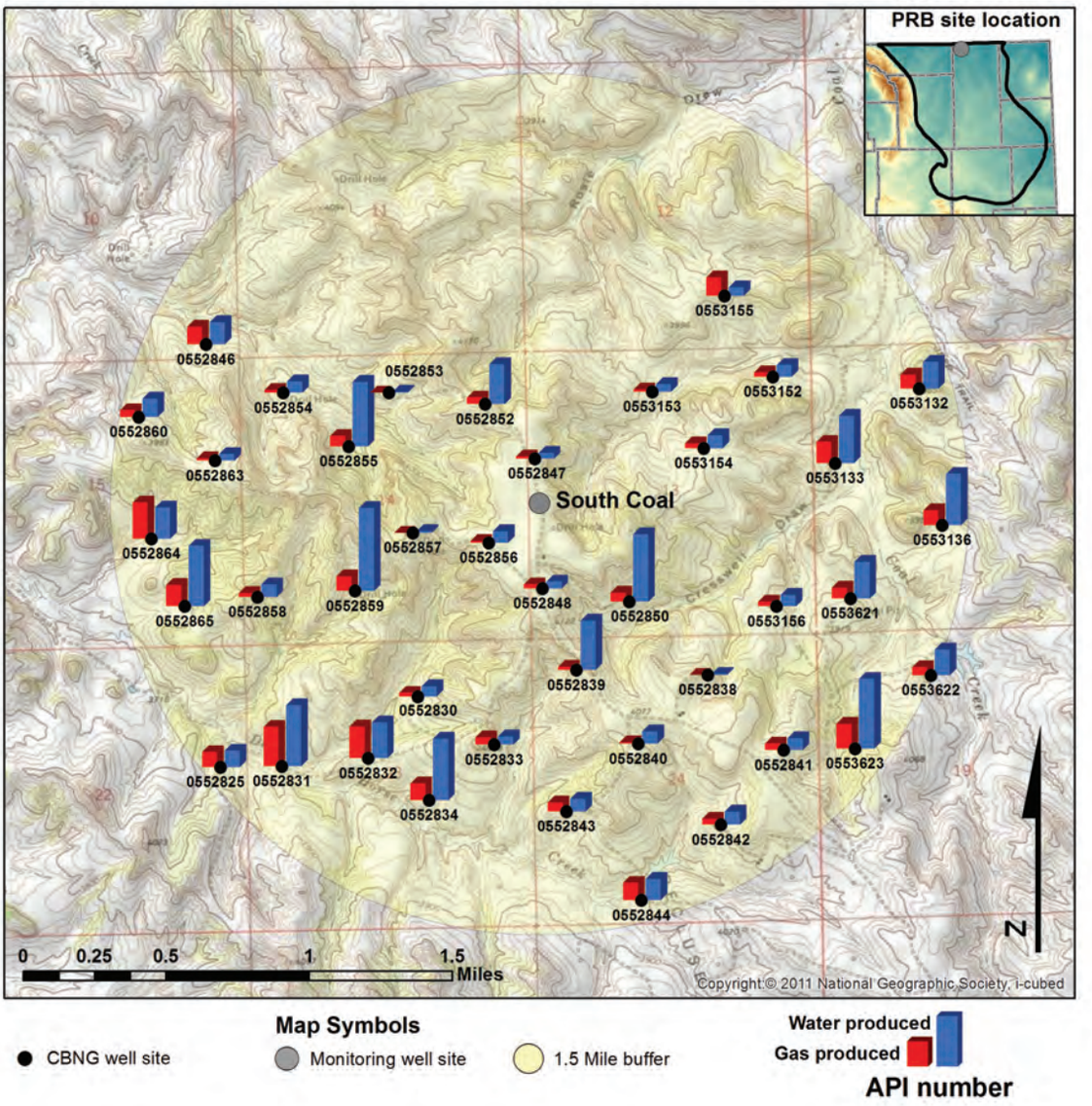

Figure A.213. South Coal monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

Water production in multiple coal zone wells peaked at 98,830 bbls in February 2006 and ended 2013 at 26,583 bbls/month (Figure A.214). Gas was produced from 2005-2012 peaking in May 2006 at 44,274 Mcf and gradually declined to 5,676 Mcf/month in late 2013.

Unmonitored coal zone wells produced water peaked at 26,904 bbls in May 2006, and then declined to a low, relatively constant production until mid-2012(Figure A.214). Water production declined again to end 2013 at 680 bbls/month. Gas production has been relatively low peaking at 5,737 Mcf in January 2006 and ending 2013 at 214 Mcf/month.

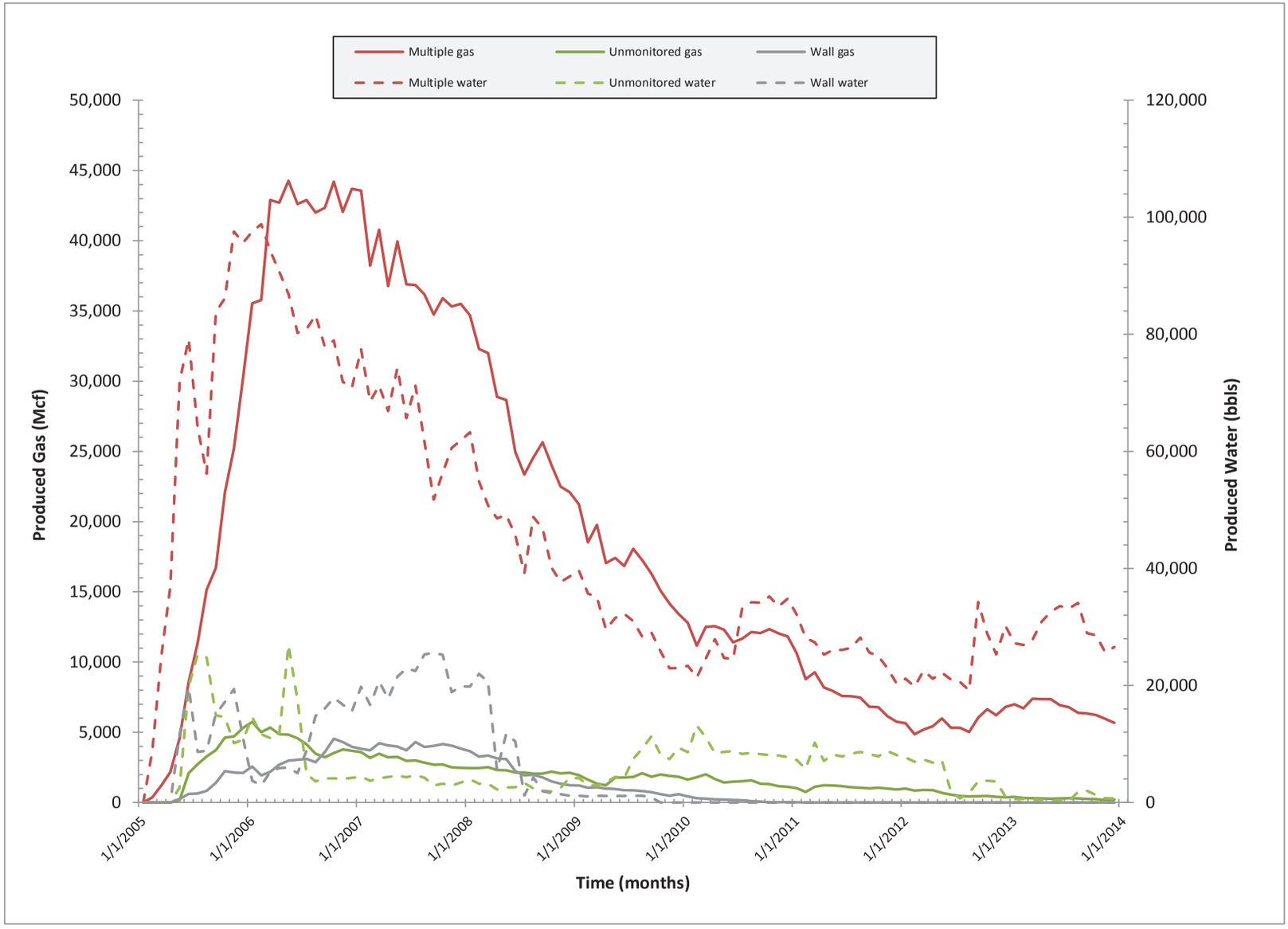

Figure A.214. Water and gas production from CBNG wells associated with the South Coal monitoring well site location.

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.215; Table A.106). Water levels and wellhead gas pressures were measured manually during 2013.

Wyodak Coal
Groundwater levels fell 1.20 feet during 2013 but have declined 199.50 feet over the 1995-2013 monitoring period (Figure A.216; Table A.107). Gas pressure in the Wyodak coal has varied considerably over the life of the well, from less than 0 psi to a maximum of 55.28 psi in March 1997.

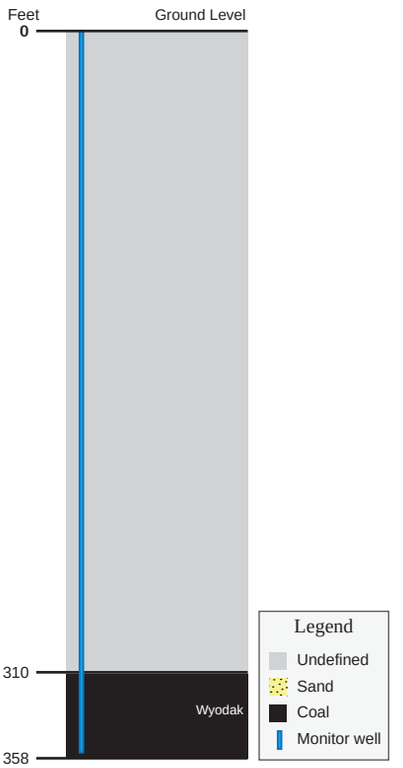

Figure A.215. Section showing relative position of coal in feet. Not to scale.

Table A.106. Table showing the depth to and thickness of monitored intervals at the South Cordero monitoring well site location (measured in feet).

Monitored interval	Interval characteristics			
	Depth of interval (ft)		Interval 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, water level changes for current monitoring period, water level changes for period of record, and maximum gas pressure.

Monitored interval	DGW - Depth to groundwater (ft), water level (ft), and gas pressure (psi) data					
	Initial DGW	Max DGW [Date]	Final 2013 DGW	Water level change 2013	Net water level change	Max. gas pressure [date]
Wyodak coal*	158.50	358.00 2/21/2008	358.00	-1.20	-199.50	55.28 3/21/1997

*Well dry to total depth 6/6/2013

Production Statistics

Production data were analyzed for CBNG wells within the buffer of the South Cordero monitoring well site from 1996-2013. Cumulative production for individual CBNG wells is displayed by location on Figure A.217. CBNG and water production are monitored in the Upper Wyodak and unknown coal zone wells.

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 0 bbls/month by late 2003 (Figure A.218). 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. No water or gas was produced from Upper Wyodak wells in 2013.

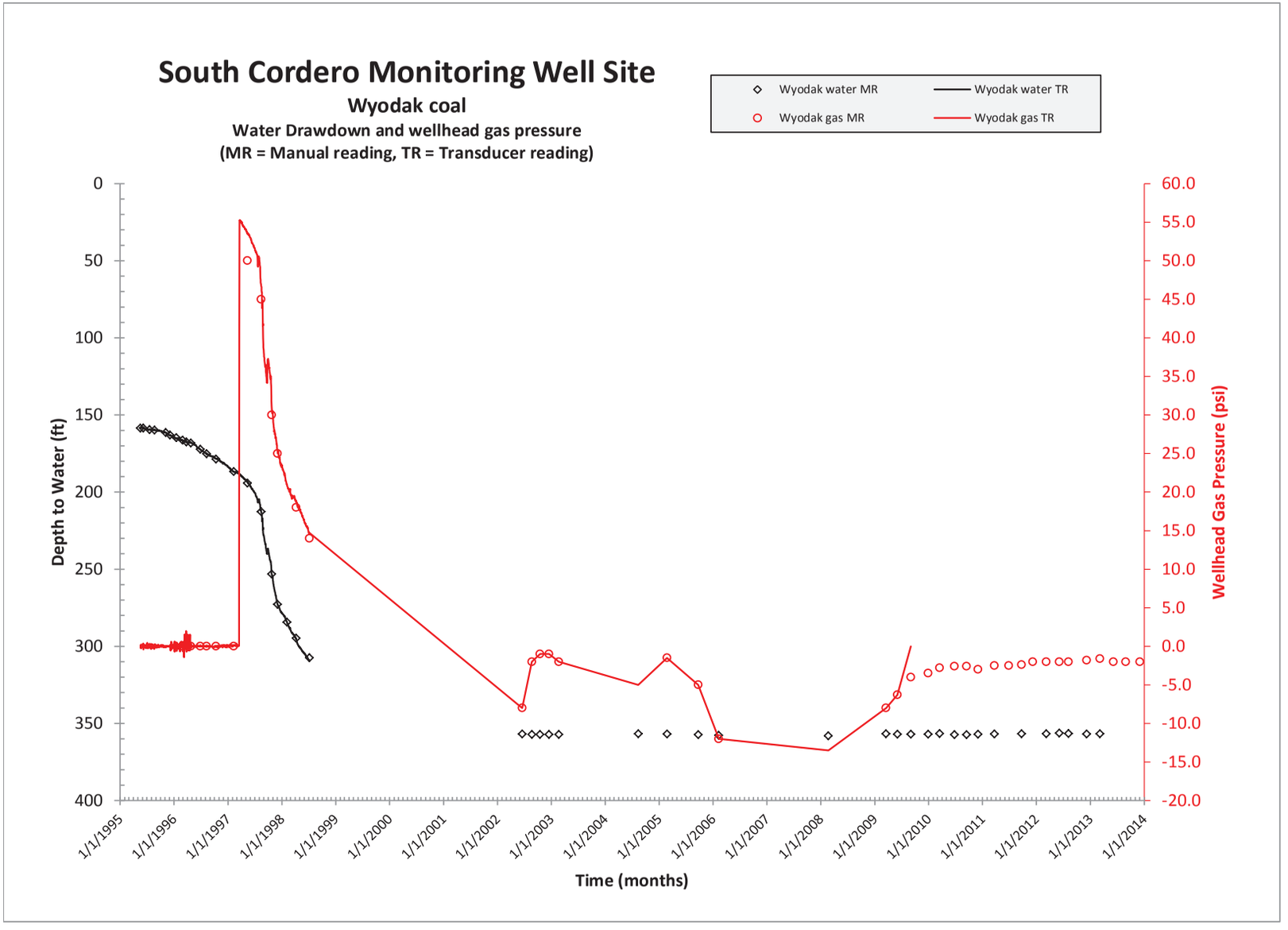

Figure A.216. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored intervals at the South Cordero monitoring well site location.

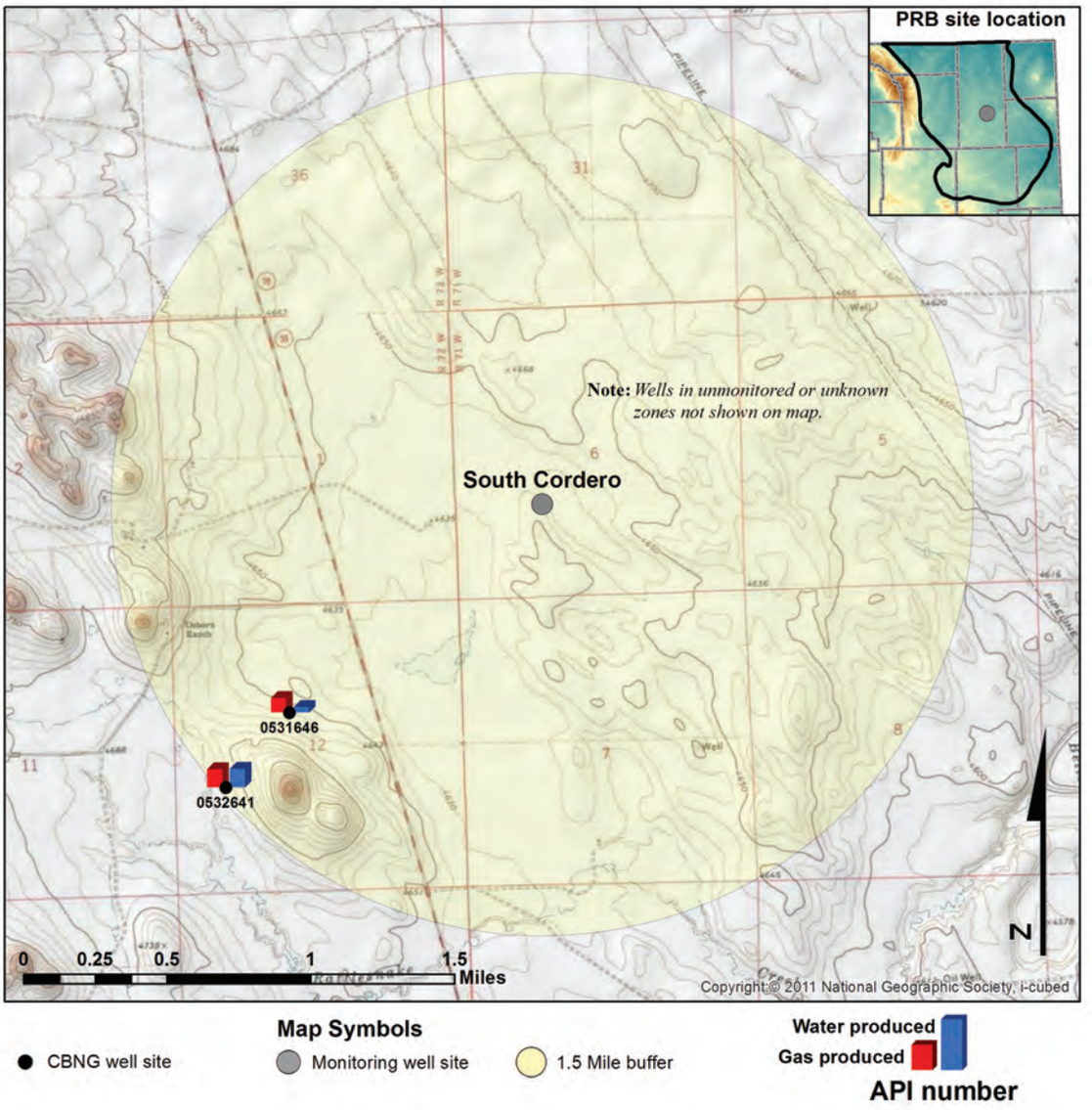

Figure A.217. South Cordero monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

Unknown coal zone wells produced low volumes of water that did not exceed 7,000 bbls/month from 1997-1998, (Figure A.218). Gas production peaked in May 1997 at 49,860 Mcf, and continued at low levels in the absence of water production from April 1998 to February 2008, and which point gas production also ceased.

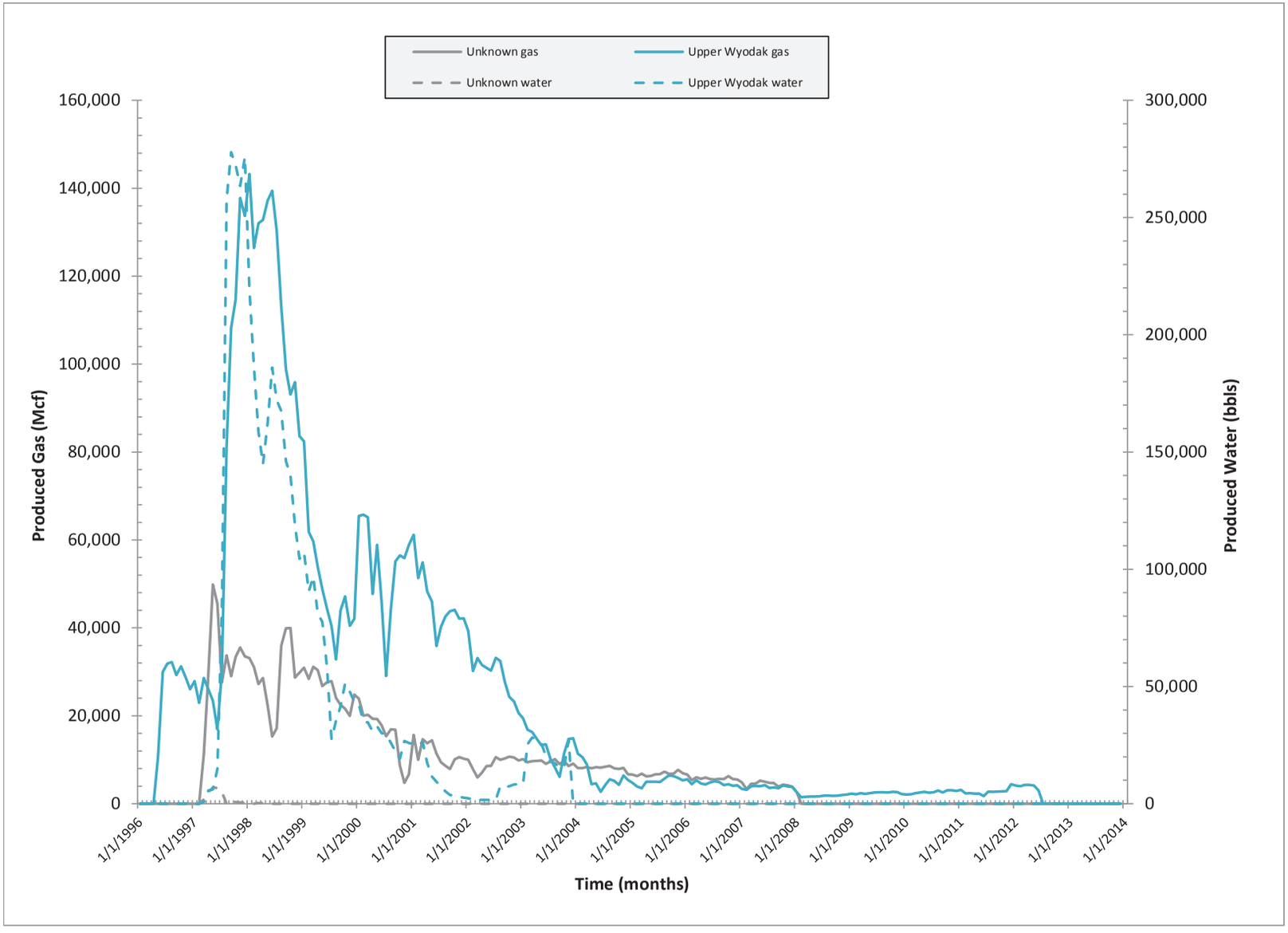

Figure A.218. Water and gas production from CBNG wells associated with the South Cordero monitoring well site location.

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 dual completion wells, separated by packers, and completed in four intervals. 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.219; Table A.108). Water levels and wellhead gas pressures were measured during 2013 using a combination of 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.

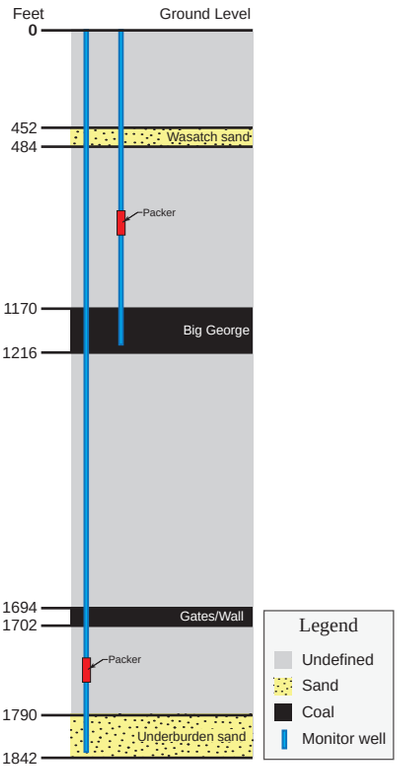

Figure A.219. Section showing relative positions of coals and sands in feet. Not to scale.

Wasatch Sandstone

Groundwater levels declined 1.72 feet during 2013 and rose 3.78 feet over the 2008 – 2013 monitoring period (Figure A.220; Table A.109). Gas pressure was not recorded in the Wasatch sandstone.

Big George Coal

Groundwater levels declined 21.60 feet during 2013 and 632.72 feet during the 2008 - 2013 monitoring period (Figure A.220; Table A.109). Gas pressure in the Big George remained near zero psi from 2008 – 2013.

Gates/Wall Coal

Groundwater levels rose 1.51 feet during 2013 but remain 470.60 feet below initial levels measured in 2009 (Figure A.221; Table A.109). Gas pressure in the Gates/Wall coal remained near zero psi from 2008 – 2013.

Fort Union Underburden Sand

Groundwater levels declined 81.35 feet during 2013 and 553.12 feet over the 2008-2013 monitoring period (Figure A.221; 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 intervals at the South Prong monitoring well site location (measured in feet).

Monitored interval	Interval characteristics			
	Depth of interval (ft)		Interval 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, water level changes for current monitoring period, water level changes for period of record, and maximum gas pressure.

Monitored interval	DGW - Depth to groundwater (ft), water level (ft), and gas pressure (psi) data					
	Initial DGW	Max DGW [Date]	Final 2013 DGW	Water level change 2013	Net water level change	Max. gas pressure [date]
Wasatch sand	134.70	154.00 6/25/2009	130.92	-1.72	3.78	n/a
Big George coal	141.95	774.70 12/18/2013	774.67	-21.60	-632.72	9.89 3/4/2013
Gates/Wall coal	543.00	1046.20 9/16/2013	1013.60	1.51	-470.60	0.65 11/8/2012
Underburden sand	254.20	807.30 12/18/2013	807.32	-81.35	-553.12	n/a

Production Statistics

Production data were analyzed for CBNG wells within the buffer of the South Prong monitoring well site from 1999-2013. Cumulative production for individual CBNG wells is displayed by location on Figure A.222. CBNG and water production are monitored in the Wyodak Rider and multiple coal zone wells.

The Wyodak Rider coal zone began producing water consistently in July 2005. Water production peaked in December 2007 at 473,247 bbls (Figure A.223) and has declined steadily since then to finish 2013 at 167,028 bbls. Gas production in the Wyodak Rider coal zone began in July 2007 and peaked in December 2008 at 254,207 Mcf then decreased to 88,243 Mcf/month by the end of 2013.

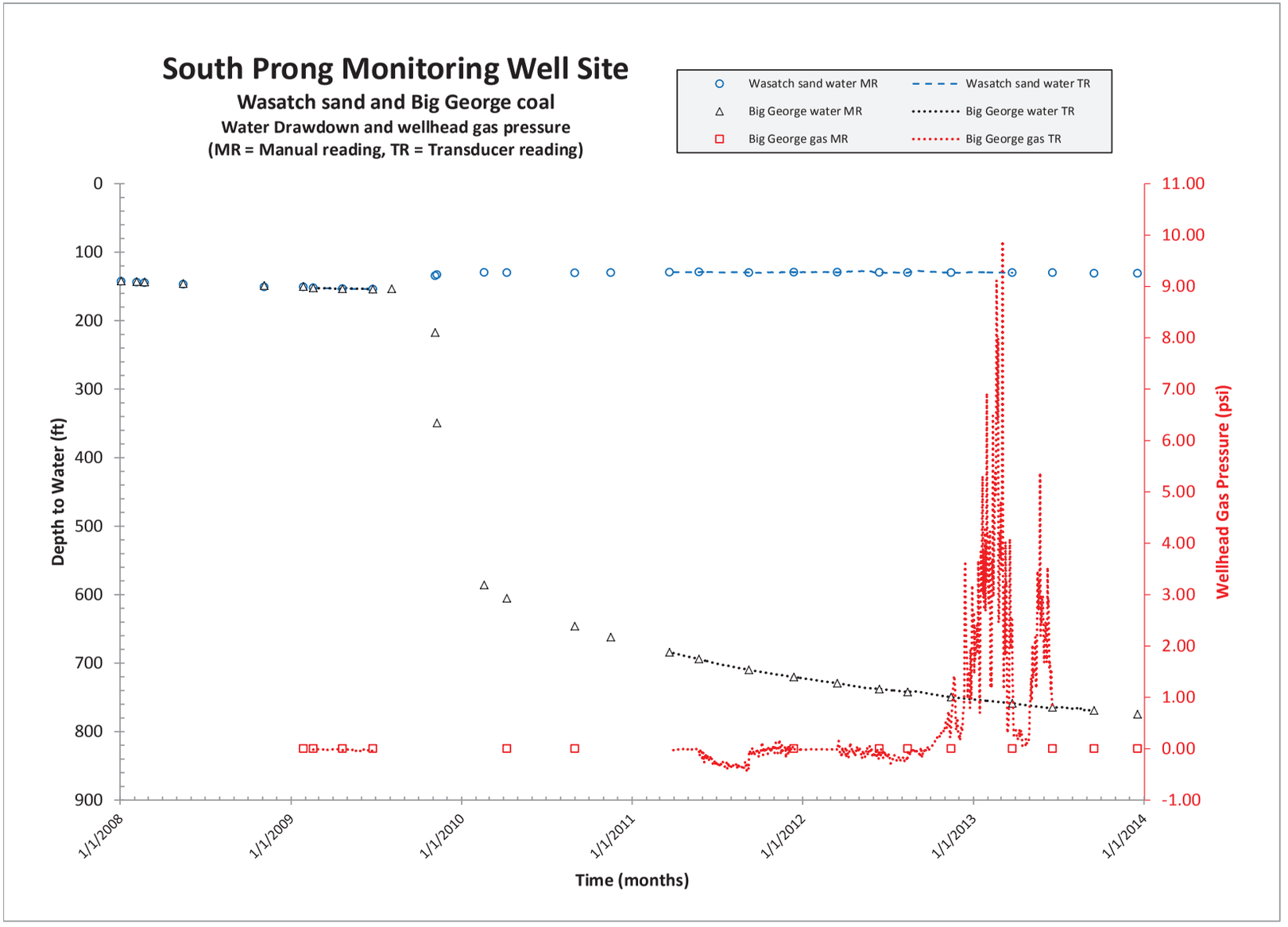

Figure A.220. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored intervals at the South Prong monitoring well site location.

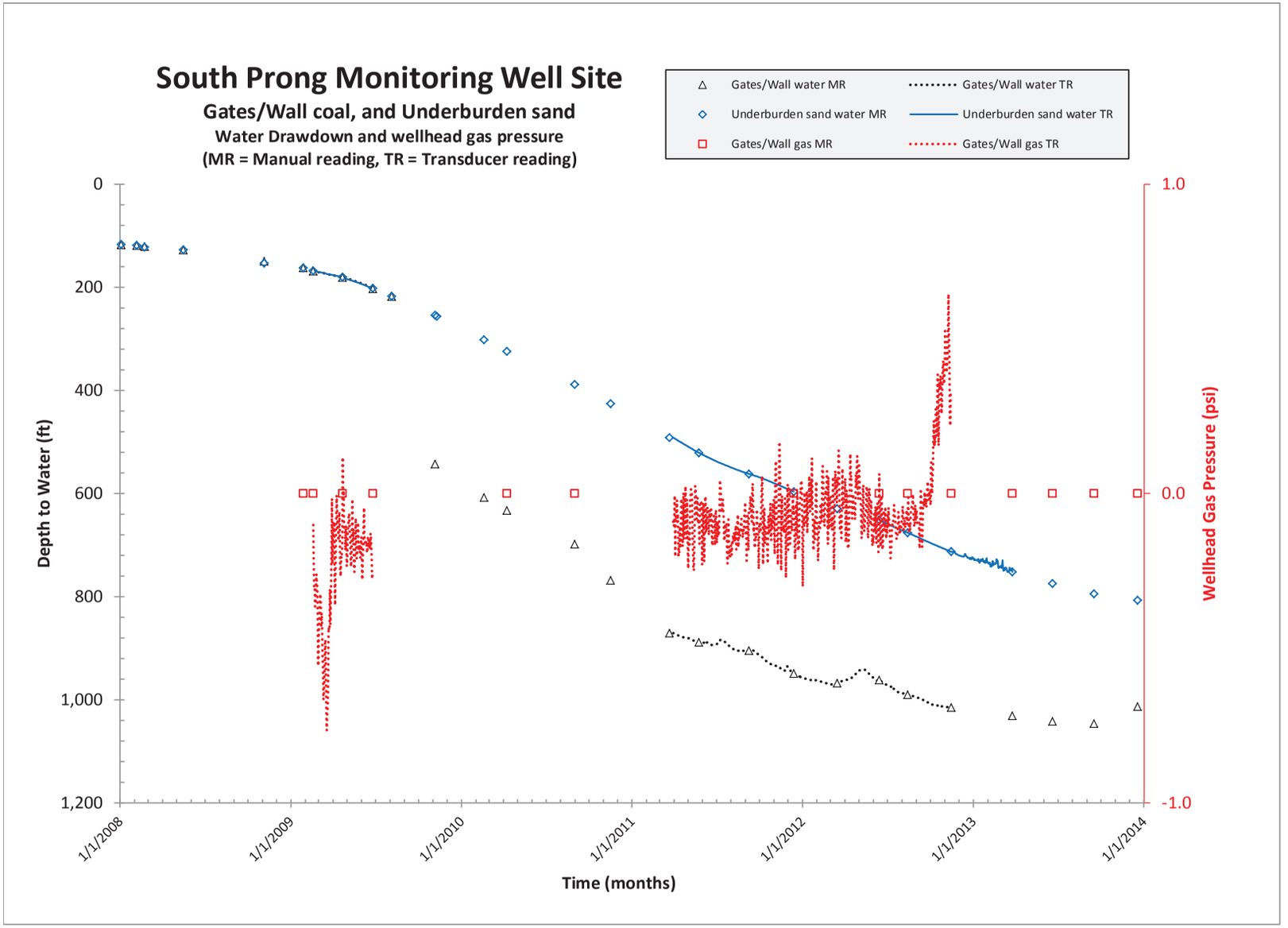

Figure A.221. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored intervals at the South Prong monitoring well site location.

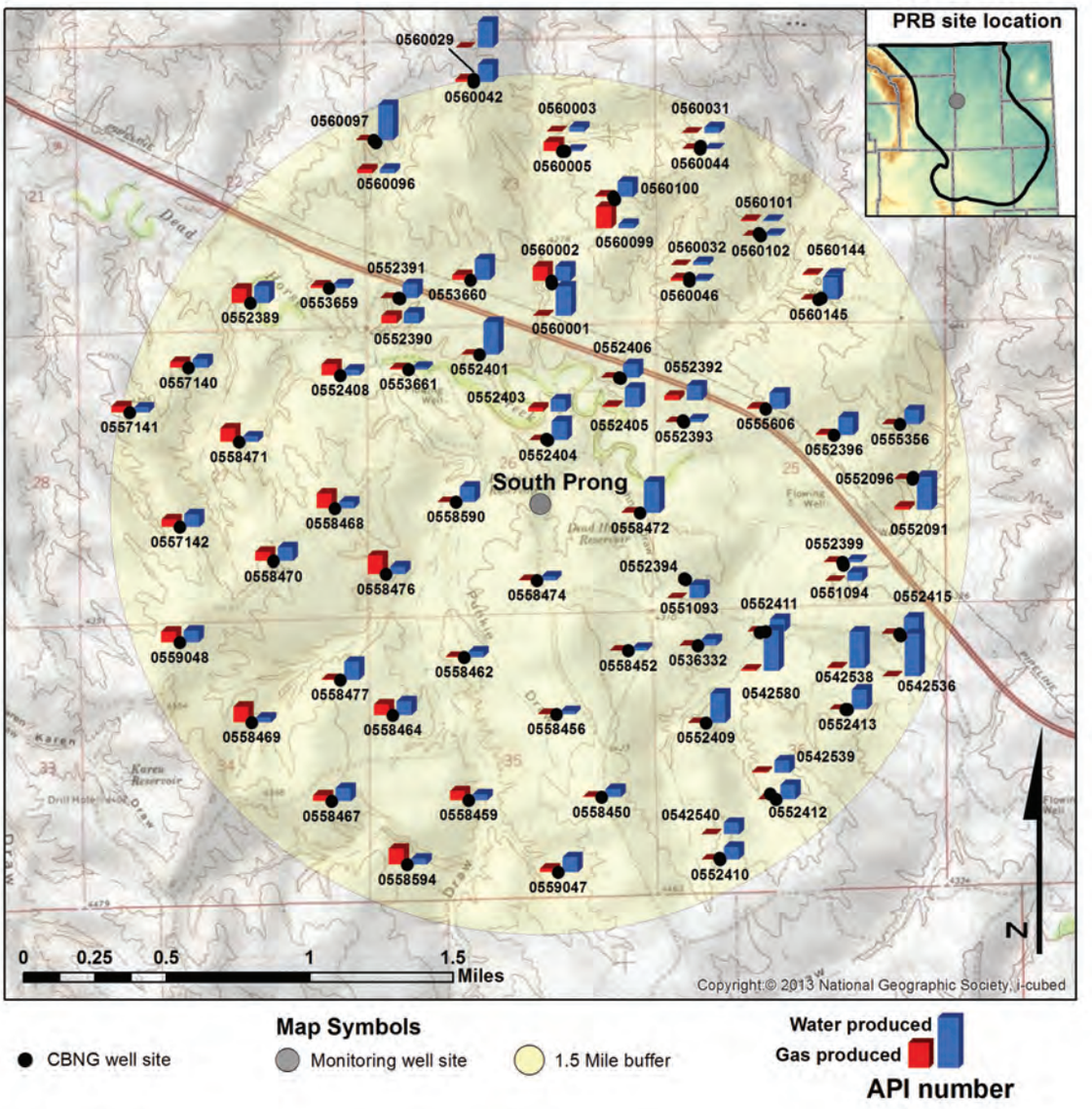

Figure A.222. South Prong monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

Water production in multiple coal zone wells began in 2004, rapidly increased to a peak production of 327,383 bbls in September 2009, and has averaged about 222,500 bbls/month in 2013 (Figure A.223). Gas production began in December 2007, low but steadily increasing to finish 2013 at 13,113 Mcf/month.

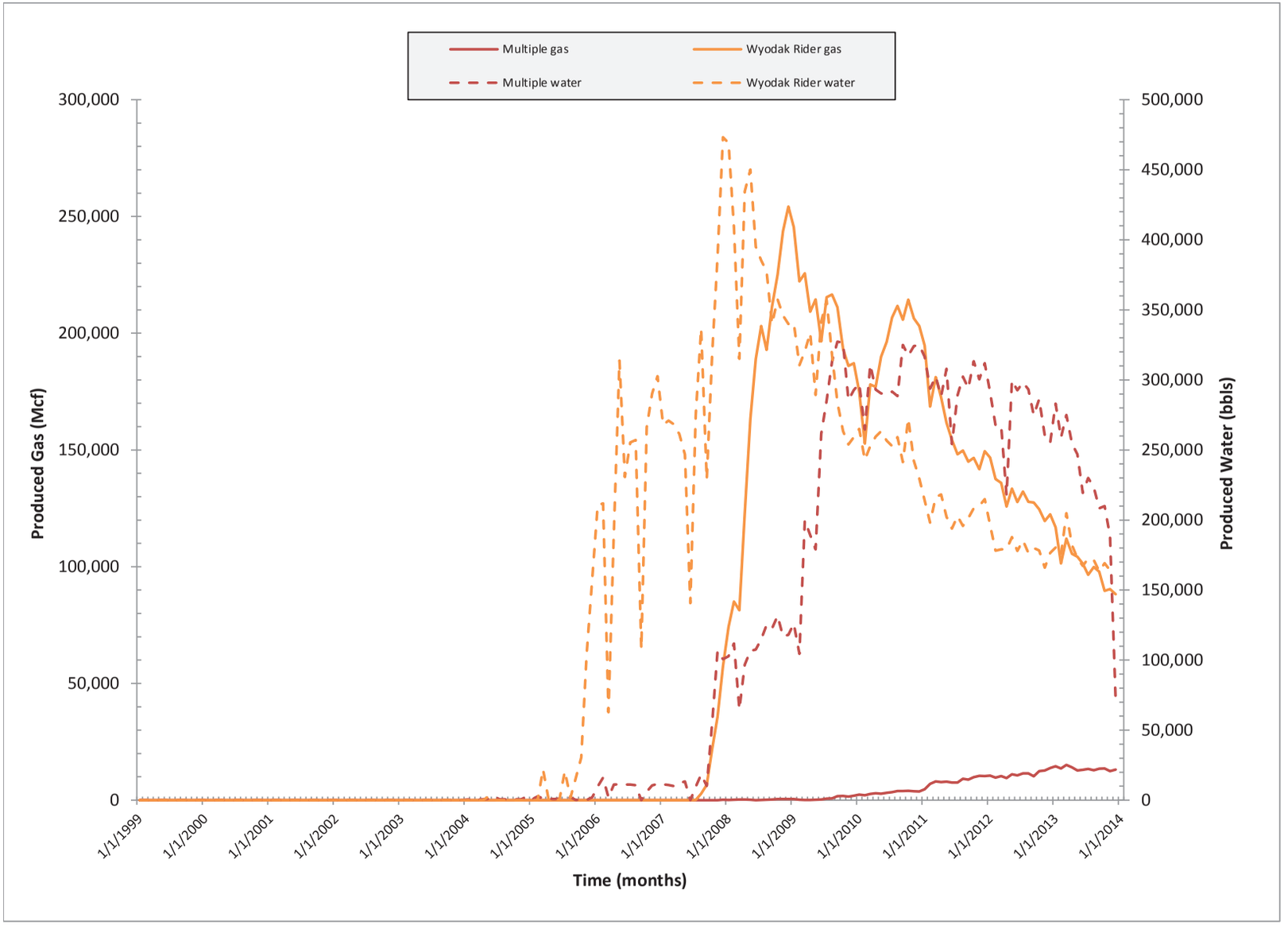

Figure A.223. Water and gas production from CBNG wells associated with the South Prong monitoring well site location.

Squaw Butte Monitoring Well Site
Location: S1 T56N R78W
Date First Monitored: October 17, 2001

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.224; Table A.110). Water levels were only manually measured during 2013.

Big George Coal

Water levels in the Big George fell 0.97 feet during 2013 but rose 63.95 feet during the 2001-2013 monitoring period (Figure A.225; Table A.111). Gas pressure in the Big George coal was not recorded at this site.

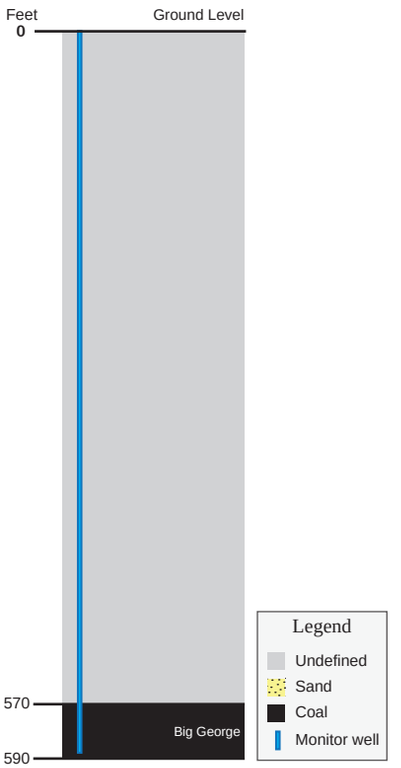

Figure A.224. Section showing relative position of coal in feet. Not to scale.

Table A.110. Table showing the depth to and thickness of monitored intervals at the Squaw Butte monitoring well site location (measured in feet).

Monitored interval	Interval characteristics			
	Depth of interval (ft)		Interval 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, water level changes for current monitoring period, water level changes for period of record, and maximum gas pressure.

Monitored interval	DGW - Depth to groundwater (ft), water level (ft), and gas pressure (psi) data					
	Initial DGW	Max DGW [Date]	Final 2013 DGW	Water level change 2013	Net water level change	Max. gas pressure [date]
Big George coal	355.92	355.90 10/17/2001	291.97	-0.97	63.95	n/a

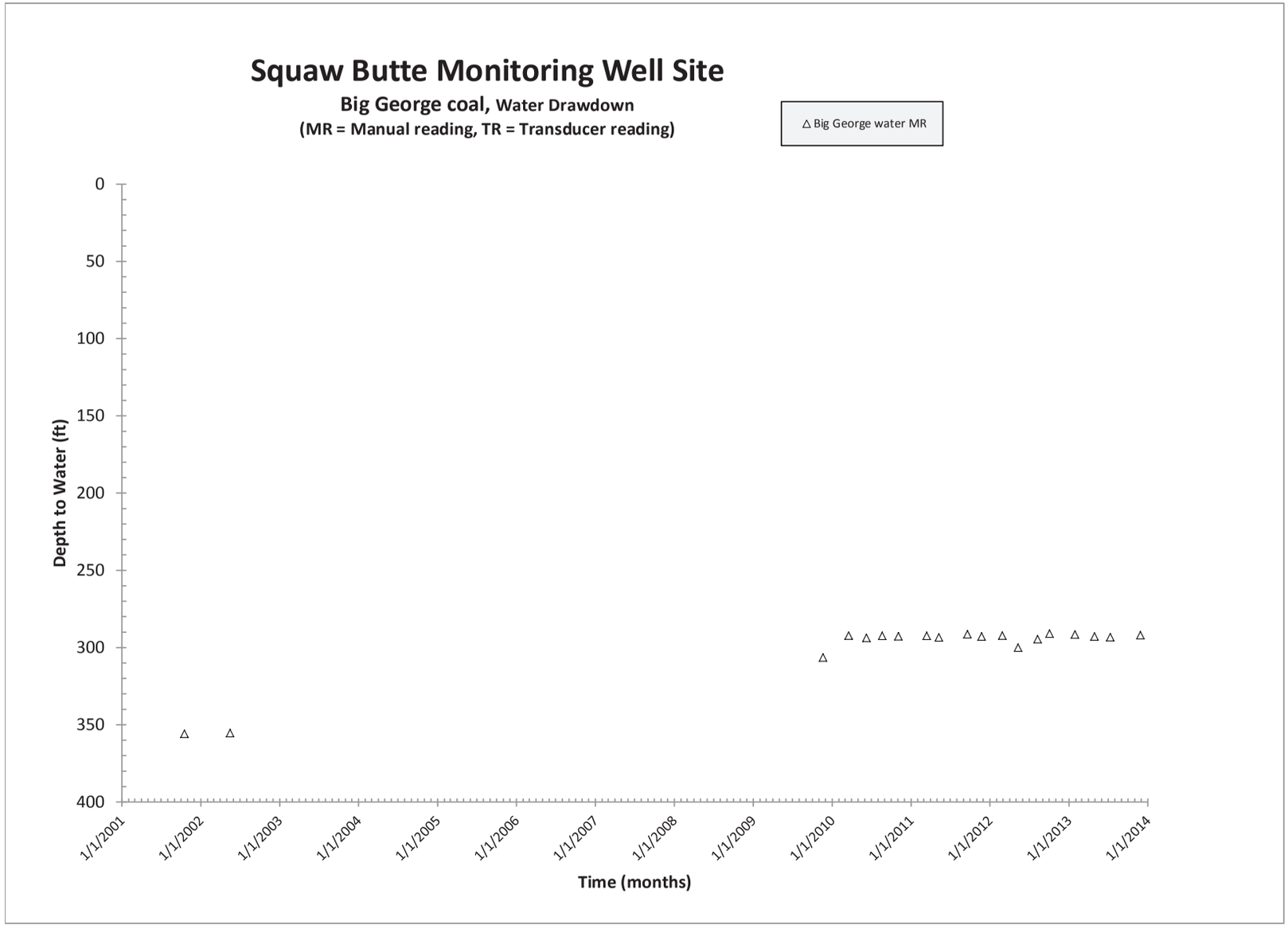

Figure A.225. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored intervals at the Squaw Butte monitoring well site location.

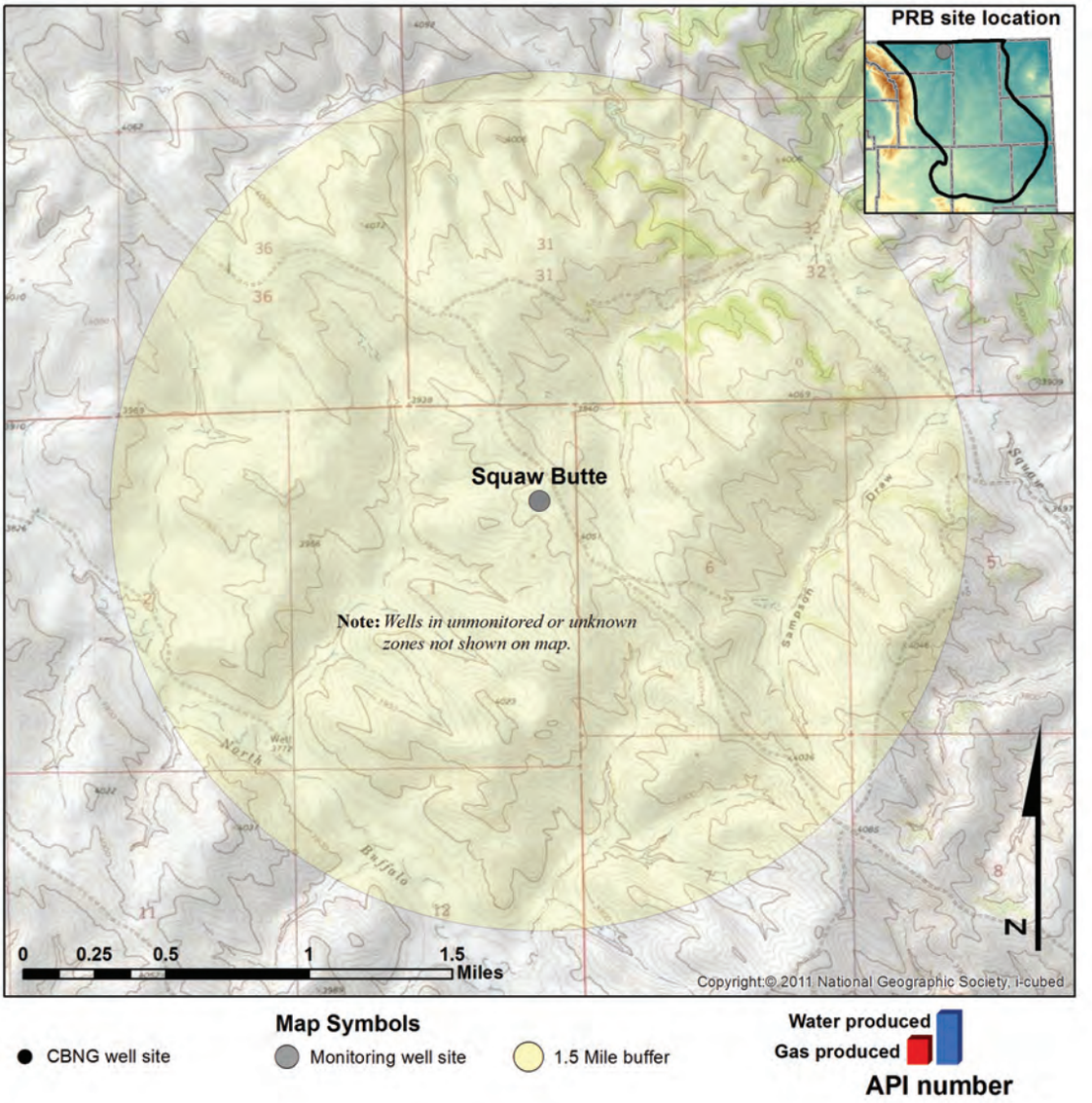

Figure A.226. Squaw Butte monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

Production Statistics

Production data were analyzed for CBNG wells within the buffer of the Squaw Butte monitoring well site from 2008-2013. Cumulative production for individual CBNG wells is displayed by location on Figure A.226. CBNG and water production are monitored in unmonitored coal zone wells.

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 16,511 bbls (Figure A.227). Gas production has been less than 100 Mcf/month during both periods. Gas and water production ceased in July 2012. No water or gas were produced in 2013

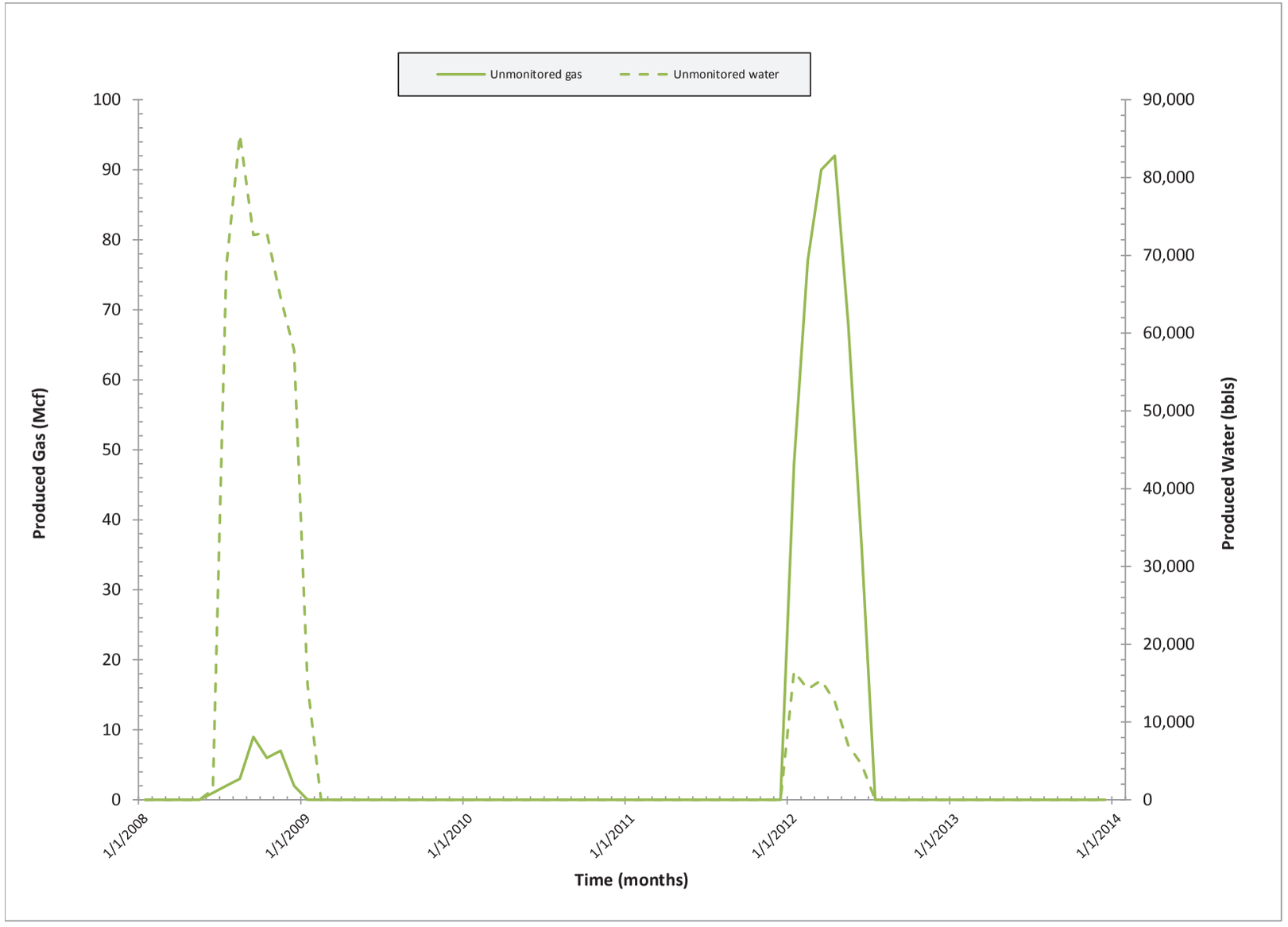

Figure A.227. Water and gas production from CBNG wells associated with the Squaw Butte monitoring well site location.

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.228; Table A.112). Water levels and wellhead gas pressures were measured during 2013 using both manual and automatic transducer and data logger equipment. There is good agreement between concurrent transducer and manual measurements where both are present. 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 0.55 feet during 2013 but remain 9.57 feet below the initial level measured in August 2004 (Figure A.229; Table A.113). Gas pressure was not reported in the Wasatch sandstone.

Big George Coal
Groundwater levels declined 4.93 feet during 2013 and 151.76 feet over the 2004-2013 monitoring period (Figure A.229; Table A.113). Gas pressure in the Big George remained relatively stable near zero psi over the life of the well.

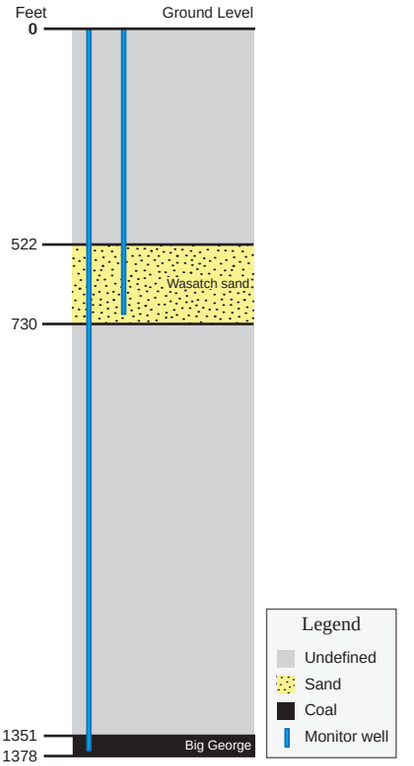

Figure A.228. Section showing relative positions of coal and sand in feet. Not to scale.

Table A.112. Table showing the depth to and thickness of monitored intervals at the Streeter monitoring well site location (measured in feet).

Monitored interval	Interval characteristics			
	Depth of interval (ft)		Interval 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, water level changes for current monitoring period, water level changes for period of record, and maximum gas pressure.

Monitored interval	DGW - Depth to groundwater (ft), water level (ft), and gas pressure (psi) data					
	Initial DGW	Max DGW [Date]	Final 2013 DGW	Water level change 2013	Net water level change	Max. gas pressure [date]
Wasatch sand	213.50	224.30 5/15/2012	223.07	0.55	-9.57	n/a
Big George coal	158.80	322.10 10/5/2009	310.56	-4.93	-151.76	0.13 10/20/2013

Production Statistics

Production data were analyzed for CBNG wells within the buffer of the Streeter monitoring well site from 2000-2013. Cumulative production for individual CBNG wells is displayed by location on Figure A.230. CBNG and water production are monitored in the Wyodak Rider and unmonitored coal zone wells.

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.231). Gas production in the Wyodak Rider occurred only in December 2009 at 163 Mcf. No water of gas production was reported in 2013

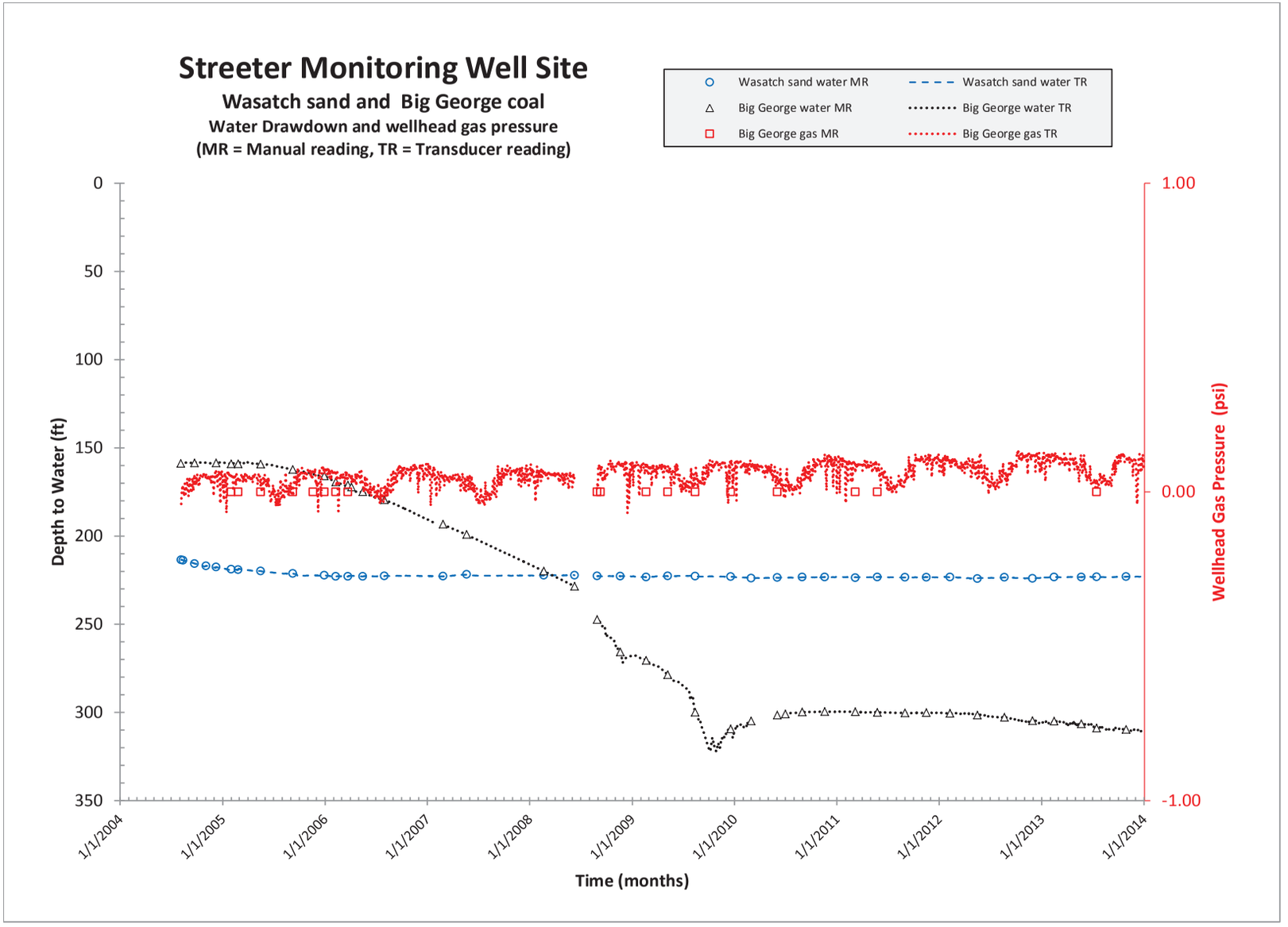

Figure A.229. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored intervals at the Streeter monitoring well site location.

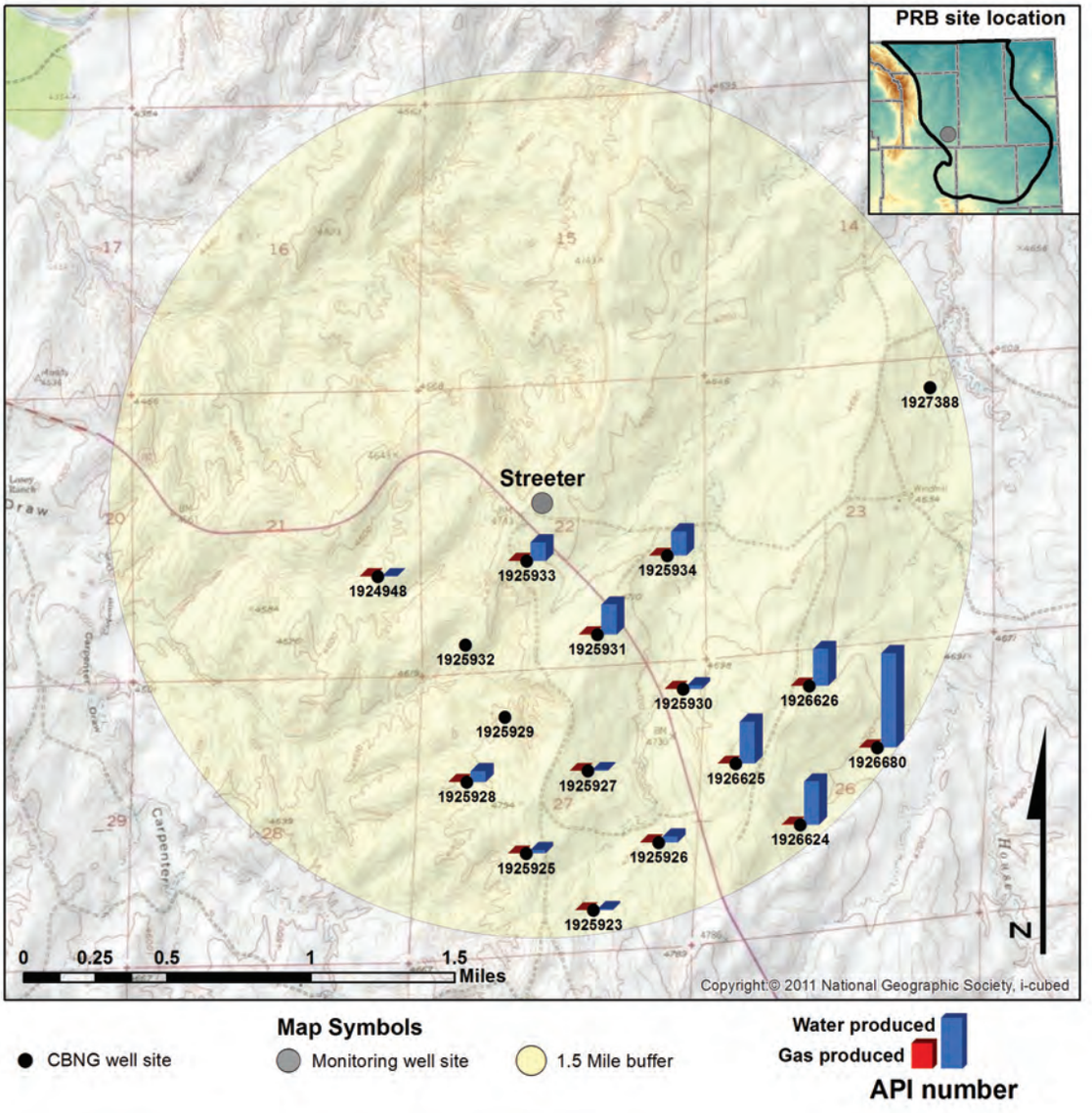

Figure A.230. Streeter monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

Unmonitored coal zone wells produced no water or gas production over the 2000-2012 POR. No water or gas was produced from wells in either coal in 2013 (Figure A.231).

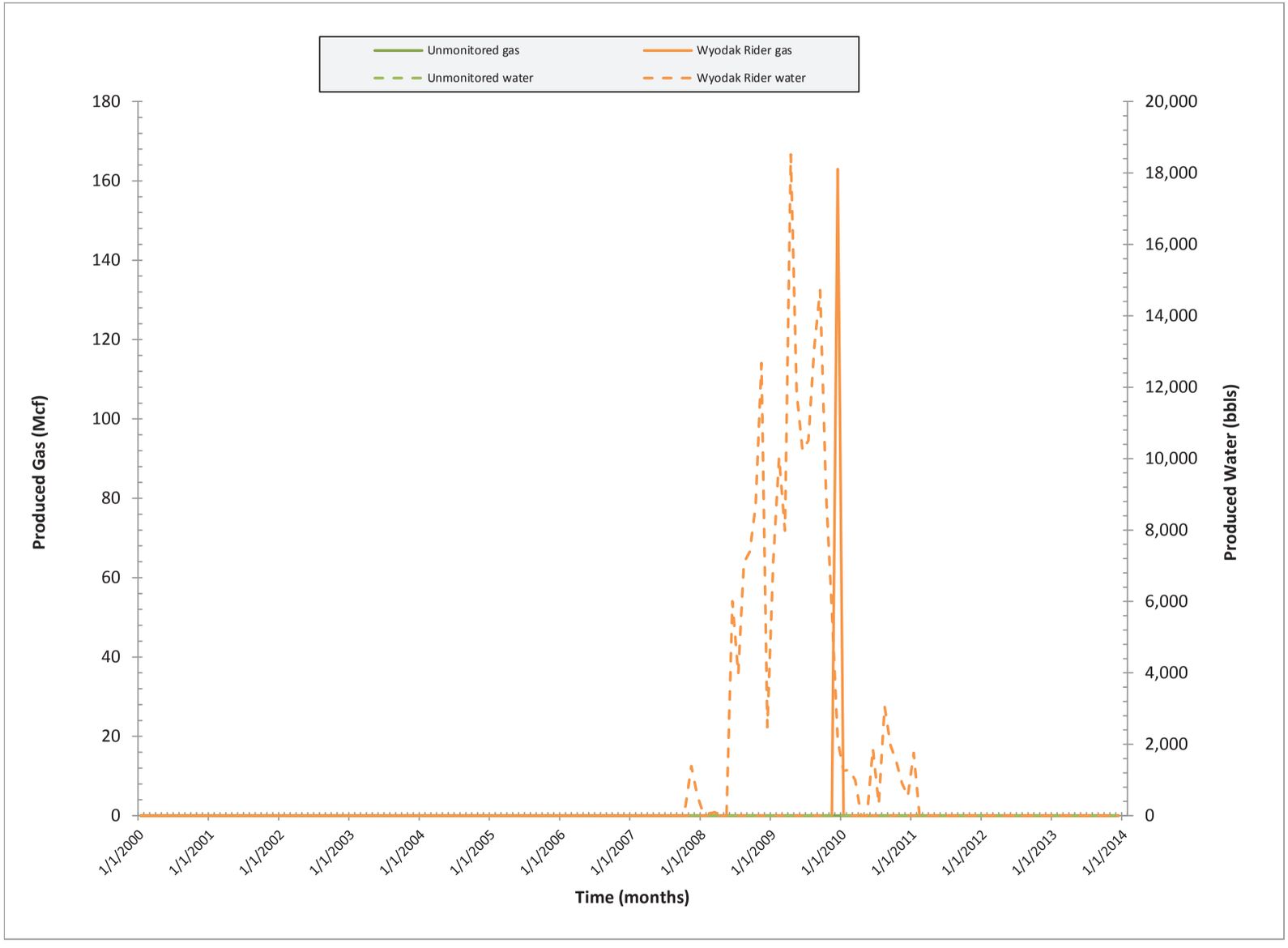

Figure A.231. Water and gas production from CBNG wells associated with the Streeter monitoring well site location.

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.232; Table A.114). Water levels and wellhead gas pressures were measured during 2013 using a combination of manual and automatic transducer and data logger equipment. There is good agreement between concurrent transducer and manual measurements. 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 fell 0.89 feet during 2013 and declined 64.41 feet during the 1997–2013 monitoring period (Figure A.233; 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 has remained dry since, therefore 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.233; Table A.115). Gas pressure in the Wyodak coal peaked at 37.92 psi in June 2001.

Fort Union Underburden Sandstone
Groundwater levels rose 7.54 feet during 2013 but are still 232.06 feet below levels first measured in October 1998 (Figure A.233; Table A.115). Gas pressure was not recorded in the underburden sandstone.

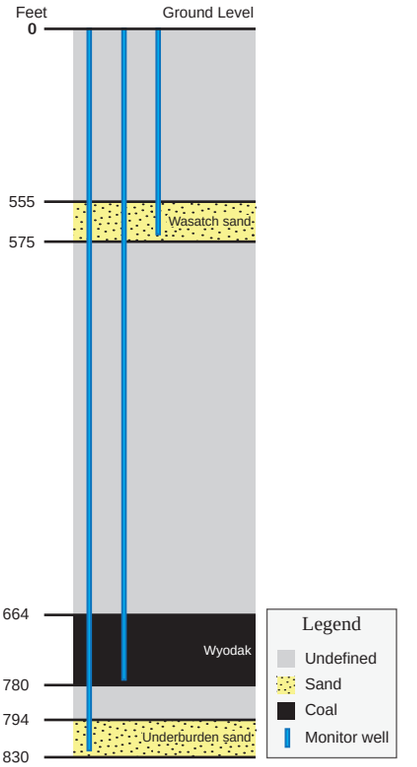

Figure A.232. Section showing relative positions of coal and sands in feet. Not to scale.

Table A.114. Table showing the depth to and thickness of monitored intervals at the Stuart Sec 31 monitoring well site location (measured in feet).

Monitored interval	Interval characteristics			
	Depth of interval (ft)		Interval 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, water level changes for current monitoring period, water level changes for period of record, and maximum gas pressure.

Monitored interval	DGW - Depth to groundwater (ft), water level (ft), and gas pressure (psi) data					
	Initial DGW	Max DGW [Date]	Final 2013 DGW	Water level change 2013	Net water level change	Max. gas pressure [date]
Wasatch sand	252.95	337.30 7/14/2010	317.36	-0.89	-64.41	n/a
Wyodak coal*	331.50	780.00 1/12/2004	n/a	n/a	-448.50	37.92 6/28/2001
Underburden sand	335.91	587.80 9/8/2010	567.97	7.54	-232.06	n/a

*Well dry to total depth 1/12/2004

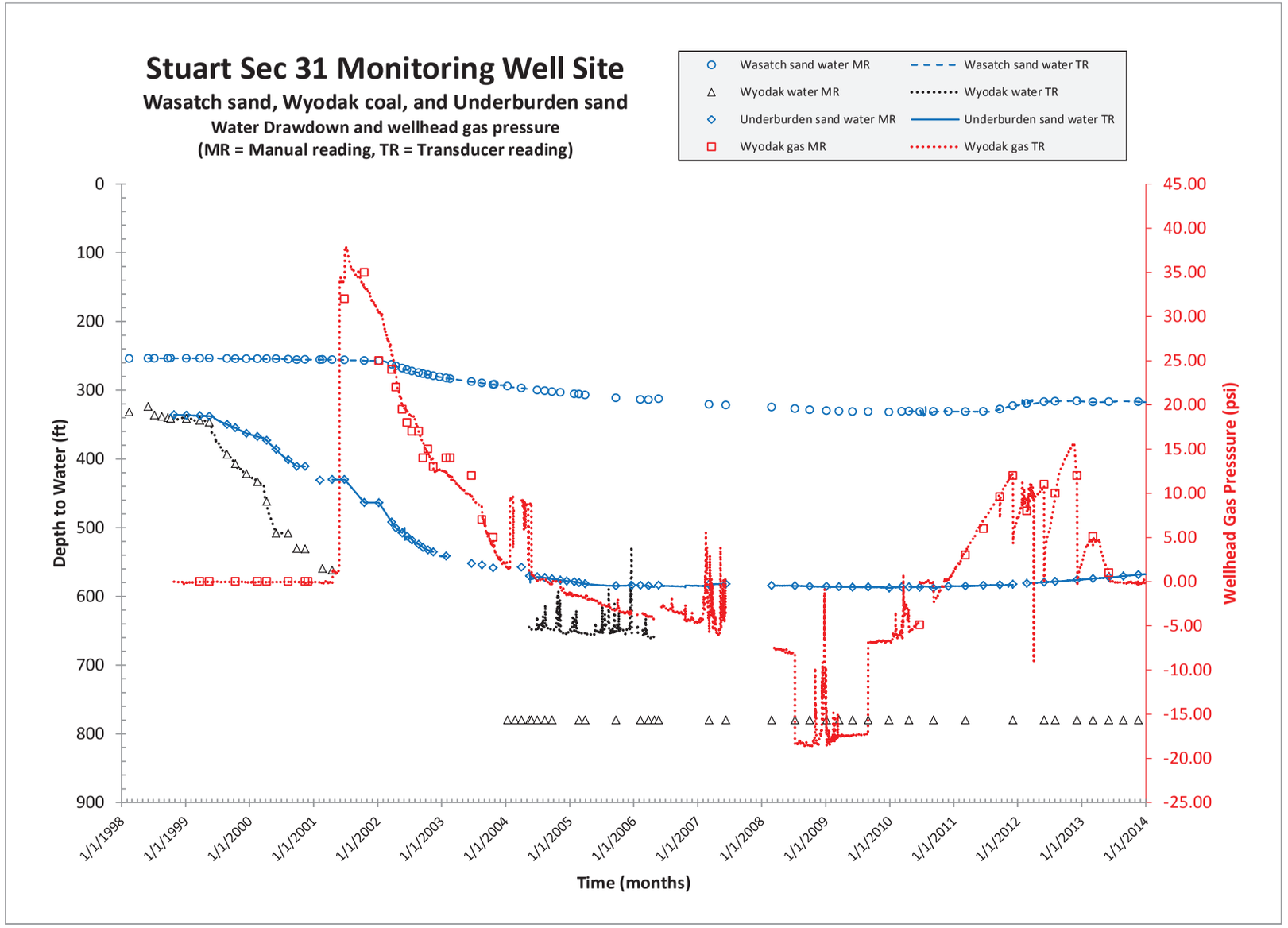

Figure A.233. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored intervals at the Stuart Sec 31 monitoring well site location

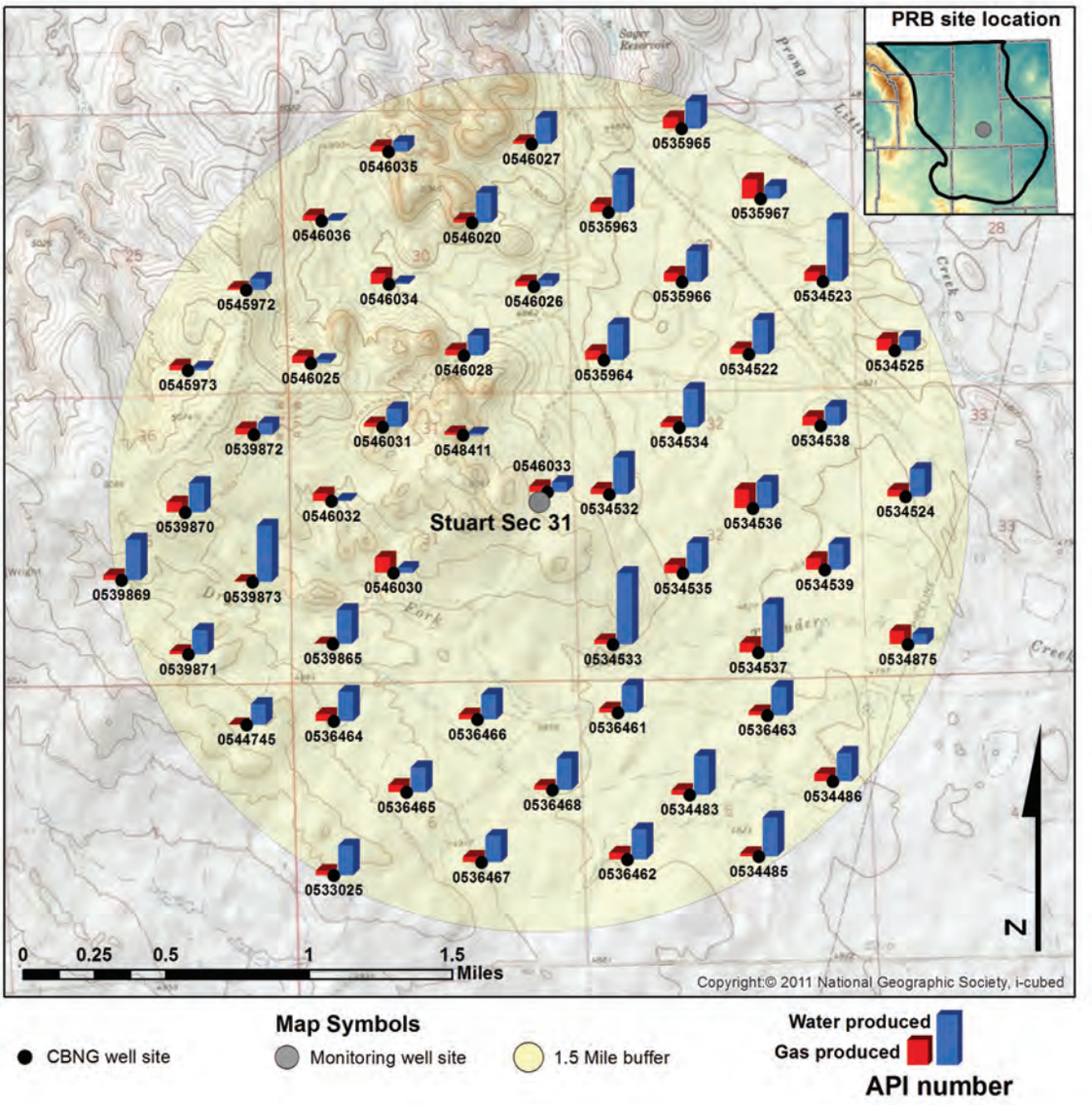

Figure A.234. Stuart Sec 31 monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

Production Statistics

Production data were analyzed for CBNG wells within the buffer of the Stuart Sec 31 monitoring well site from 1999-2013. Cumulative production for individual CBNG wells is displayed by location on Figure A.234. CBNG and water production are 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.235). Water and gas production both ceased after July 2011 and no water or gas has been produced since.

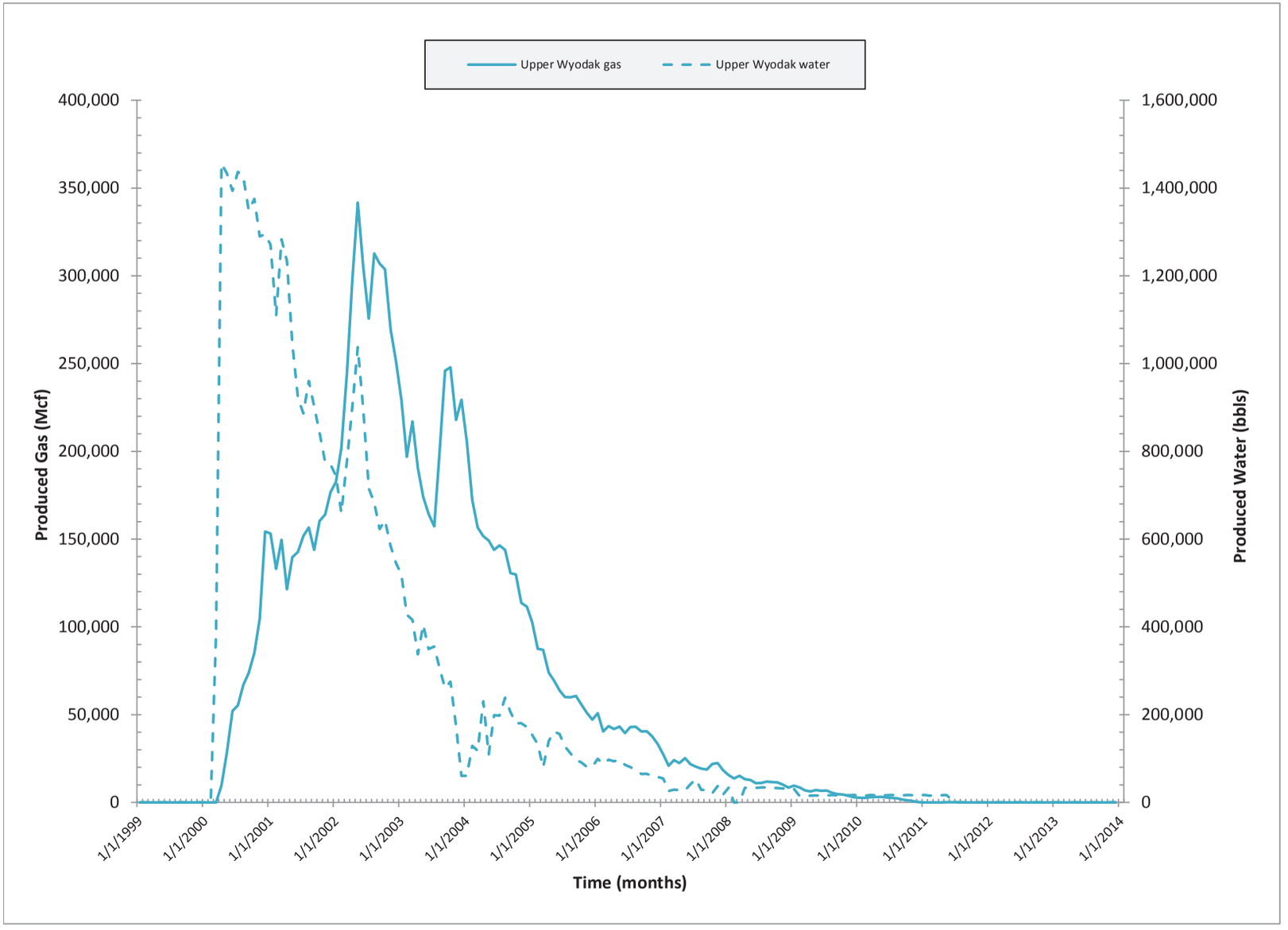

Figure A.235. Water and gas production from CBNG wells associated with the Stuart Sec 31 monitoring well site location.

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.236; Table A.116). Water levels and wellhead gas pressures were measured during 2013 using a combination of manual and automatic transducer and data logger equipment. There is good agreement between concurrent transducer and manual measurements. 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 4.02 feet during 2013 but show a net decline of 226.62 feet during the 2001 - 2013 monitoring period (Figure A.237; Table A.117). Gas pressure was not recorded in the Wasatch sandstone.

Wyodak Coal
Groundwater levels rose 25.11 feet during 2013 (Figure A.237; Table A.117). The net decline at the end of 2013 was 120.91 feet below initial depth to groundwater. Gas pressure in the Wyodak remained relatively stable near zero over the life of the well.

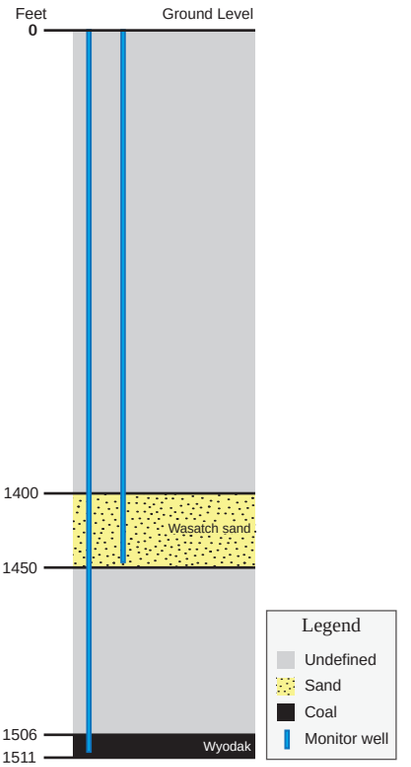

Figure A.236. Section showing relative positions of coal and sand in feet. Not to scale.

Table A.116. Table showing the depth to and thickness of monitored intervals at the Throne monitoring well site location (measured in feet).

Monitored interval	Interval characteristics			
	Depth of interval (ft)		Interval 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, water level changes for current monitoring period, water level changes for period of record, and maximum gas pressure.

Monitored interval	DGW - Depth to groundwater (ft), water level (ft), and gas pressure (psi) data					
	Initial DGW	Max DGW [Date]	Final 2013 DGW	Water level change 2013	Net water level change	Max. gas pressure [date]
Wasatch sand	601.34	1030.00 11/26/2006	827.96	4.02	-226.62	n/a
Wyodak coal	815.24	1123.00 5/16/2006	936.15	25.11	-120.91	0.93 6/15/2003

Production Statistics

Production data were analyzed for CBNG wells within the buffer of the Throne monitoring well site from 2000-2013. Cumulative production for individual CBNG wells is displayed by location on Figure A.238. CBNG and water production are monitored in the Upper Wyodak coal zone. Additional production from unmonitored and multiple coal zone wells occur in proximity to the monitoring site.

The Upper Wyodak produced water consistently from August 2000 to August 2010. Water production peaked at 255,181 bbls in June 2003 and gradually decreased to zero by September 2010. Gas was produced from February 2001 through November 2010 (Figure A.239). Gas production reached its maximum in June 2003 at 5,395 Mcf.

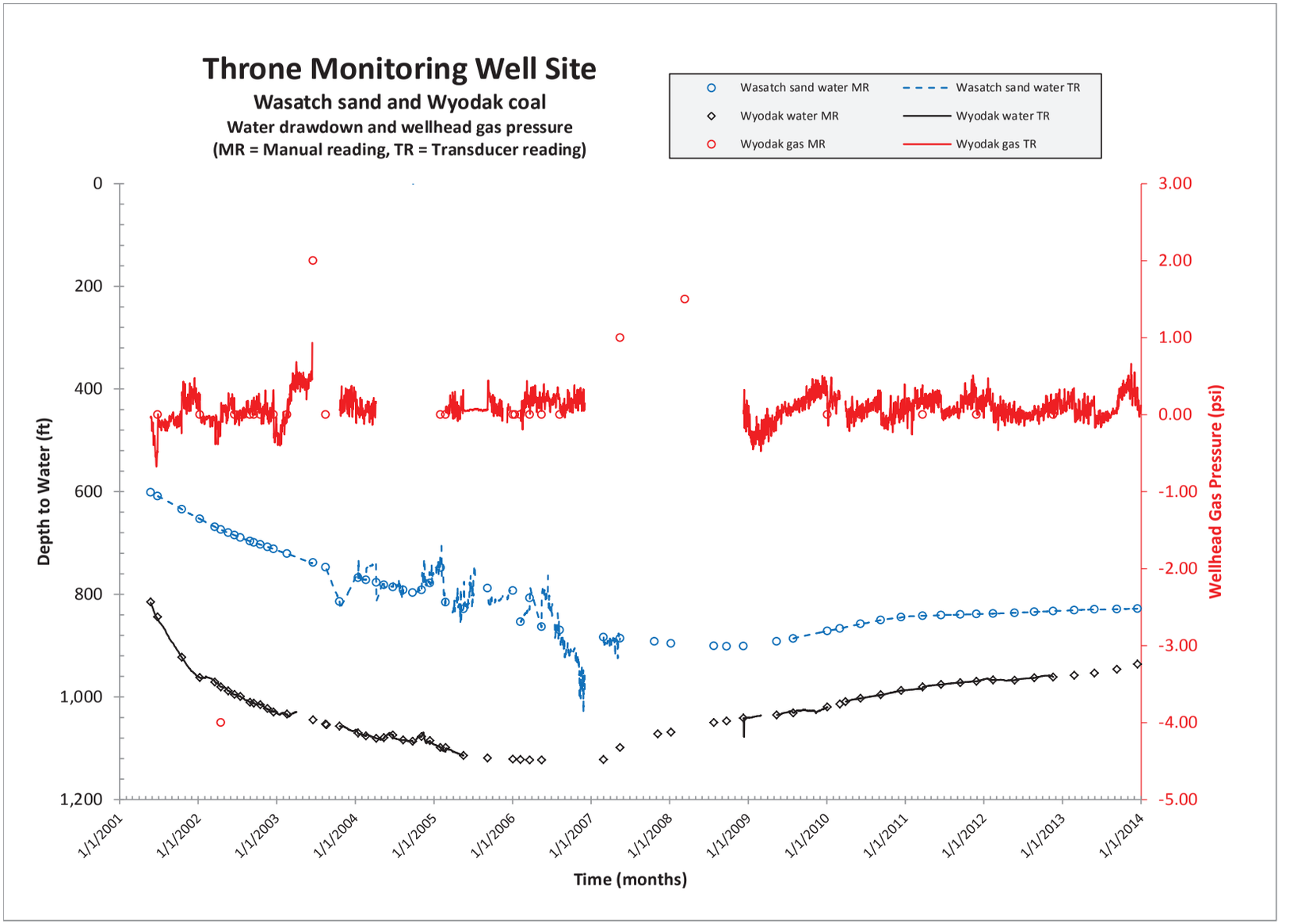

Figure A.237. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored intervals at the Throne monitoring well site location.

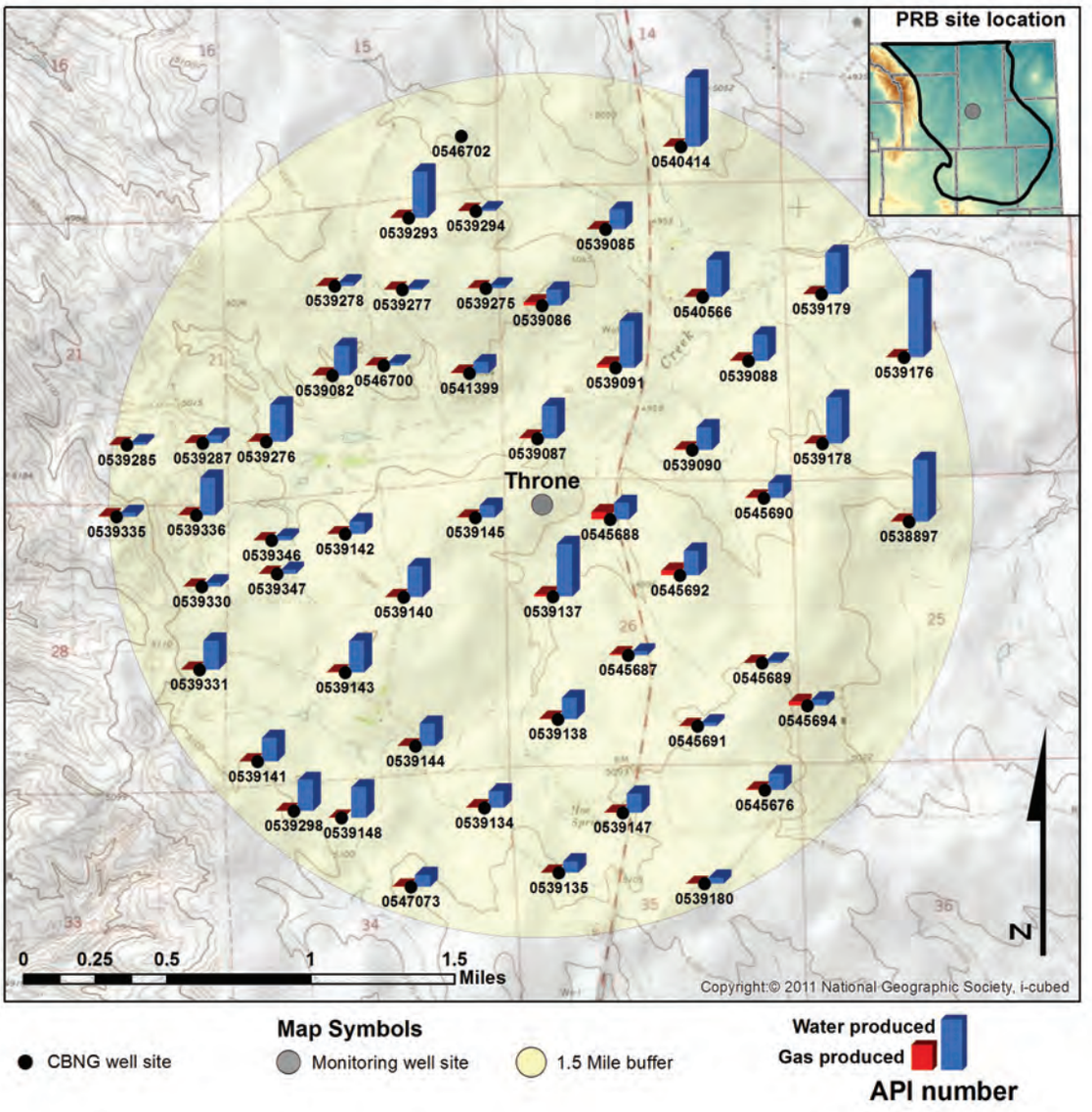

Figure A.238. Throne monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

Unmonitored coal zones produced water from August 2000 to December 2008, peaking at 85,478 bbls in December 2003. Gas production in unmonitored coal zones was sporadic and peaked in June 2005 at 1,116 Mcf.

Water and gas production in multiple coal zones began in June 2004, rose rapidly, began declining in 2009 and ceased in June 2012. Water production peaked at 94,213 bbls in December 2006, and gas production peaked at 4,611 Mcf in March 2006 (Figure A.239).

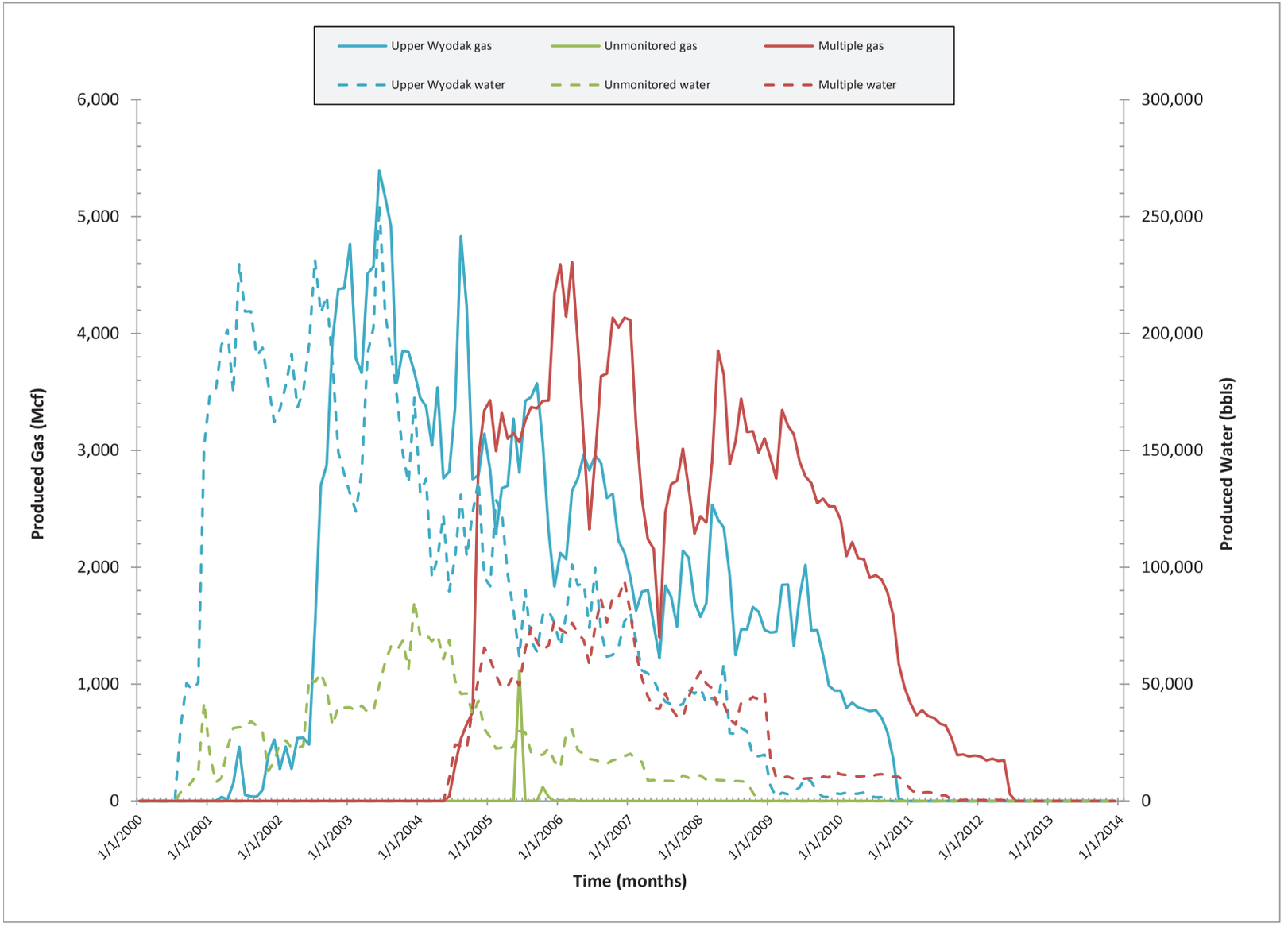

Figure A.239. Water and gas production from CBNG wells associated with the Throne monitoring well site location.

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 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.240; Table A.118). Water levels and wellhead gas pressures were measured during 2013 using a combination of 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

No groundwater level measurements were obtained for this well in 2013. Well levels rose 33.88 feet prior to 2013 (Figure A.241; Table A.119). Gas pressure was not recorded in the Wasatch sandstone.

Big George Coal

Groundwater levels rose 8.55 feet during 2013 but have declined 705.00 feet during the 2007-2013 monitoring period (Figure A.241; Table A.119). Gas pressure in the Big George coal ranged from near zero to a high of 46.46 psi in June 2013.

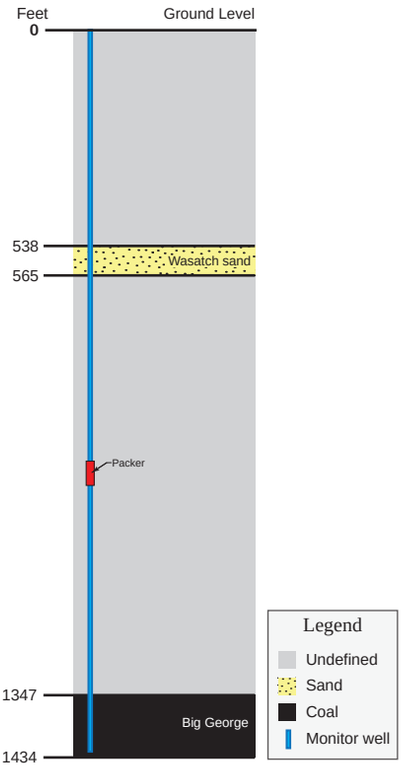

Figure A.240. Section showing relative positions of coal and sand in feet. Not to scale.

Table A.118. Table showing the depth to and thickness of monitored intervals at the West Pine Tree monitoring well site location (measured in feet).

Monitored interval	Interval characteristics			
	Depth of interval (ft)		Interval 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, water level changes for current monitoring period, water level changes for period of record, and maximum gas pressure.

Monitored interval	DGW - Depth to groundwater (ft), water level (ft), and gas pressure (psi) data					
	Initial DGW	Max DGW [Date]	Final 2013 DGW	Water level change 2013	Net water level change	Max. gas pressure [date]
Wasatch sand*	272.00	296.50 10/24/2007	n/a	n/a	33.88	n/a
Big George coal	272.00	988.20 11/28/2012	977.00	8.55	-705.00	46.46 6/11/2013

*Last reliable measurement 12/19/2011

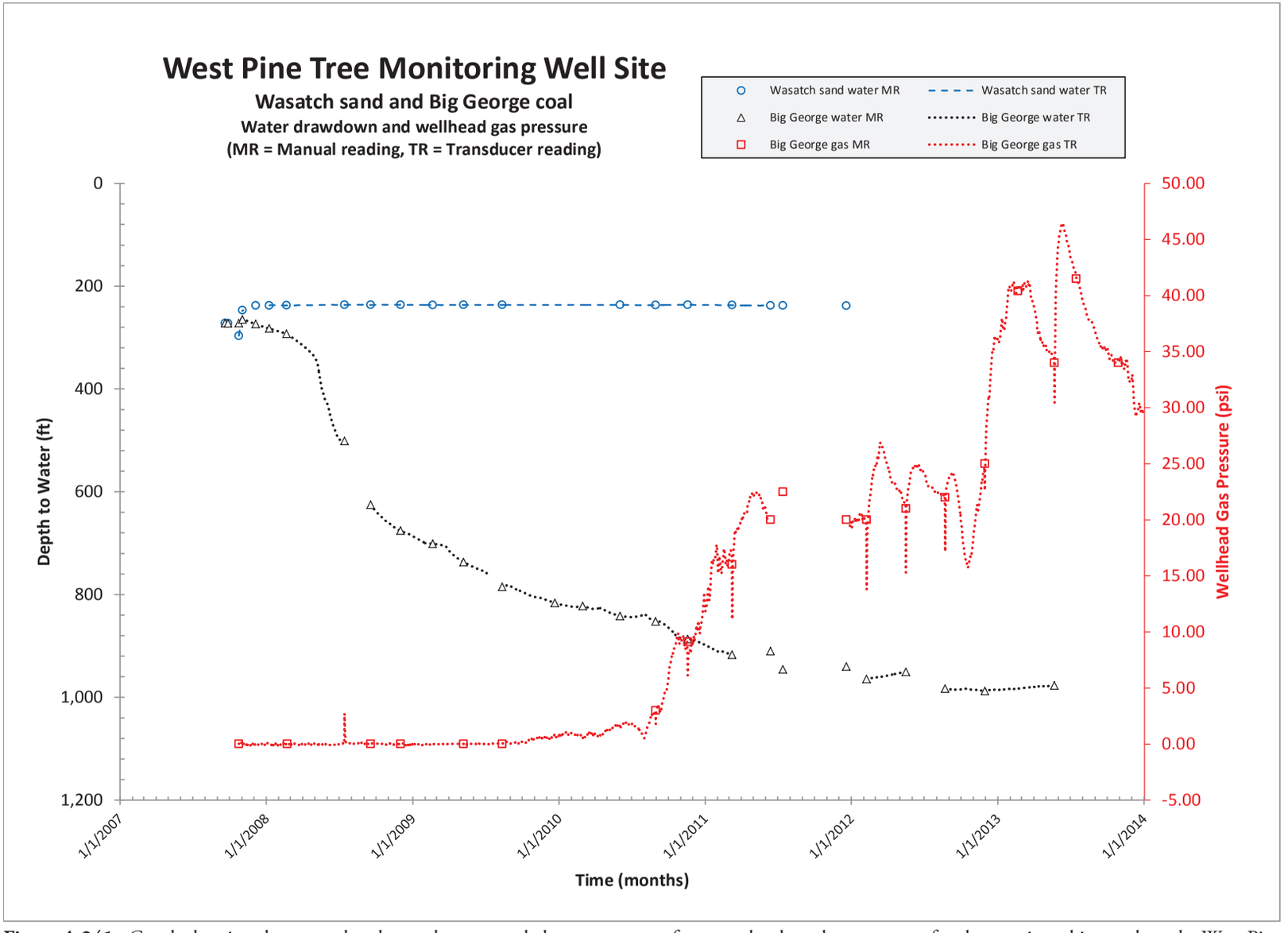

Figure A.241. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored intervals at the West Pine Tree monitoring well site location.

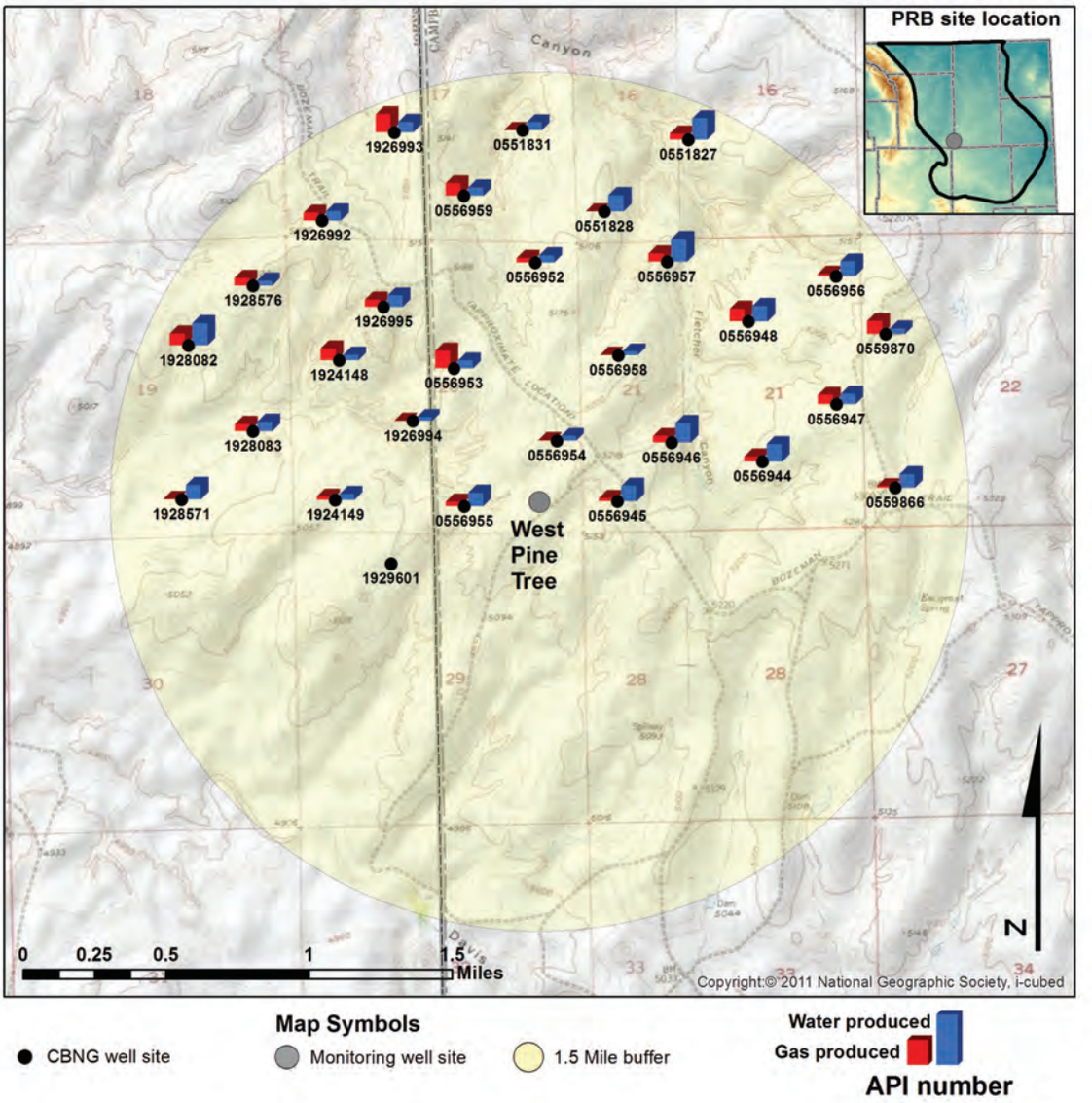

Figure A.242. West Pine Tree monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

Production Statistics

Production data were analyzed for CBNG wells within the buffer of the West Pine Tree monitoring well site from 2004-2013. Cumulative production for individual CBNG wells is displayed by location on Figure A.242. CBNG and water production are monitored in the Wyodak Rider coal zone wells.

Water production in the Wyodak Rider coal zone began in July 2007, peaked in February 2009 at 141,249 bbls and finished 2013 at 30,670 bbls/month (Figure A.243). 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 33,000 Mcf/month at the end of 2013.

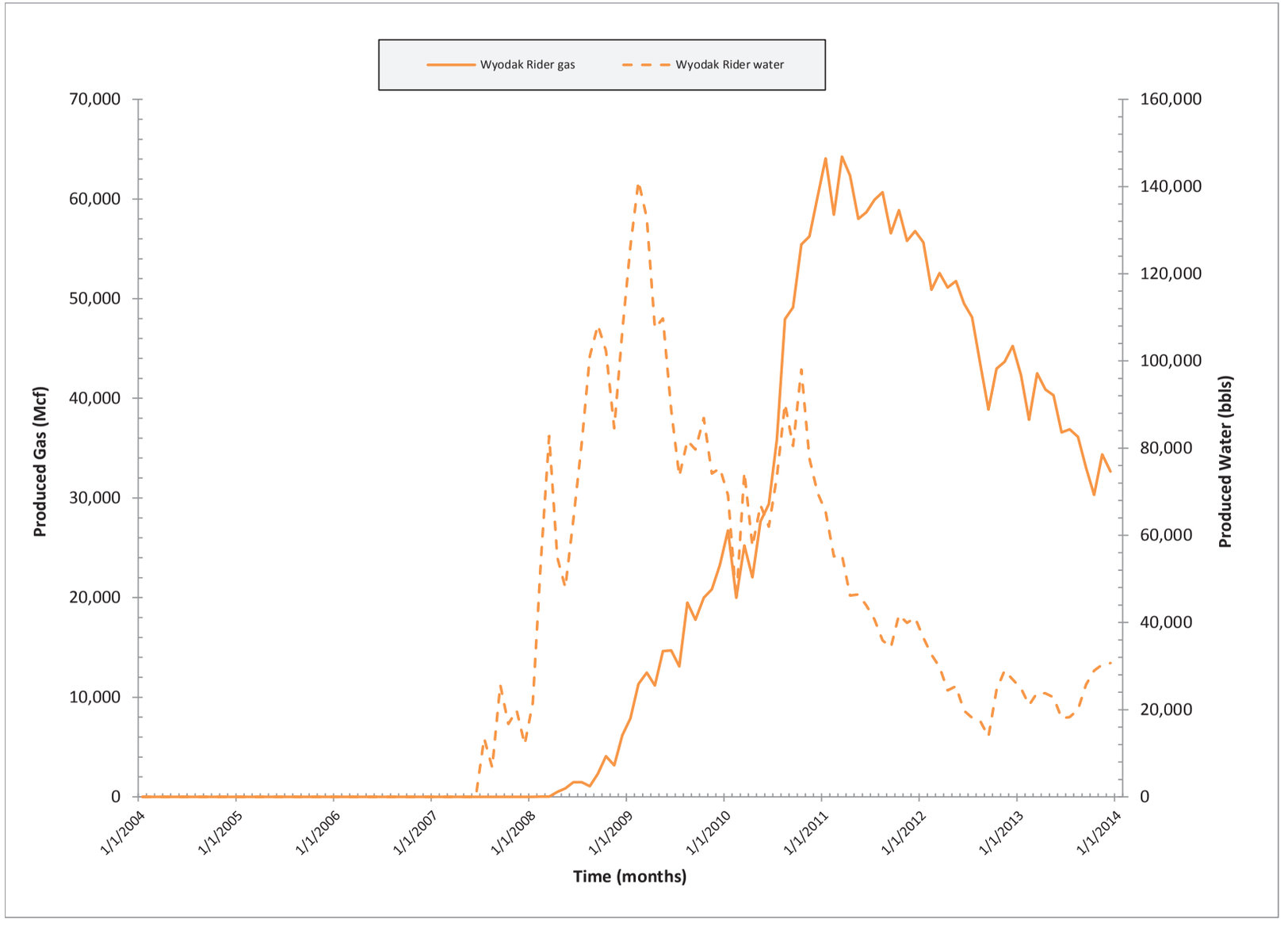

Figure A.243. Water and gas production from CBNG wells associated with the West Pine Tree monitoring well site location.

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.244; Table A.120). Water levels and wellhead gas pressures were measured during 2013 using both manual and automatic transducer and data logger equipment. Generally, there is good agreement between concurrent transducer and manual measurements where both are present. 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 15.88 feet during 2013 and 165.08 feet over the 2004-2013 monitoring period (Figure A.245; Table A.121). Gas pressure was not recorded in the Wasatch sandstone.

Big George Coal
Groundwater levels rose 22.28 feet during 2013 but have declined 913.85 feet during the 2004-2013 monitoring period (Figure A.245; 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.

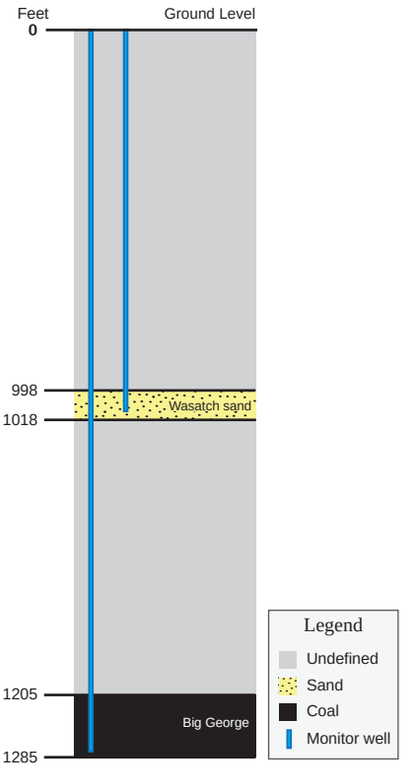

Figure A.244. Section showing relative positions of coal and sand in feet. Not to scale.

Table A.120. Table showing the depth to and thickness of monitored intervals at the Wild Turkey monitoring well site location (measured in feet).

Monitored interval	Interval characteristics			
	Depth of interval (ft)		Interval 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, water level changes for current monitoring period, water level changes for period of record, and maximum gas pressure.

Monitored interval	DGW - Depth to groundwater (ft), water level (ft), and gas pressure (psi) data					
	Initial DGW	Max DGW [Date]	Final 2013 DGW	Water level change 2013	Net water level change	Max. gas pressure [date]
Wasatch sand	128.10	293.20 12/29/2013	293.18	-15.88	-165.08	n/a
Big George coal	267.70	1230.90 1/3/2012	1181.55	22.28	-913.85	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 1989-2013. Cumulative production for individual CBNG wells is displayed by location on Figure A.246. CBNG and water production are monitored in the Wyodak Rider and unknown coal zone wells.

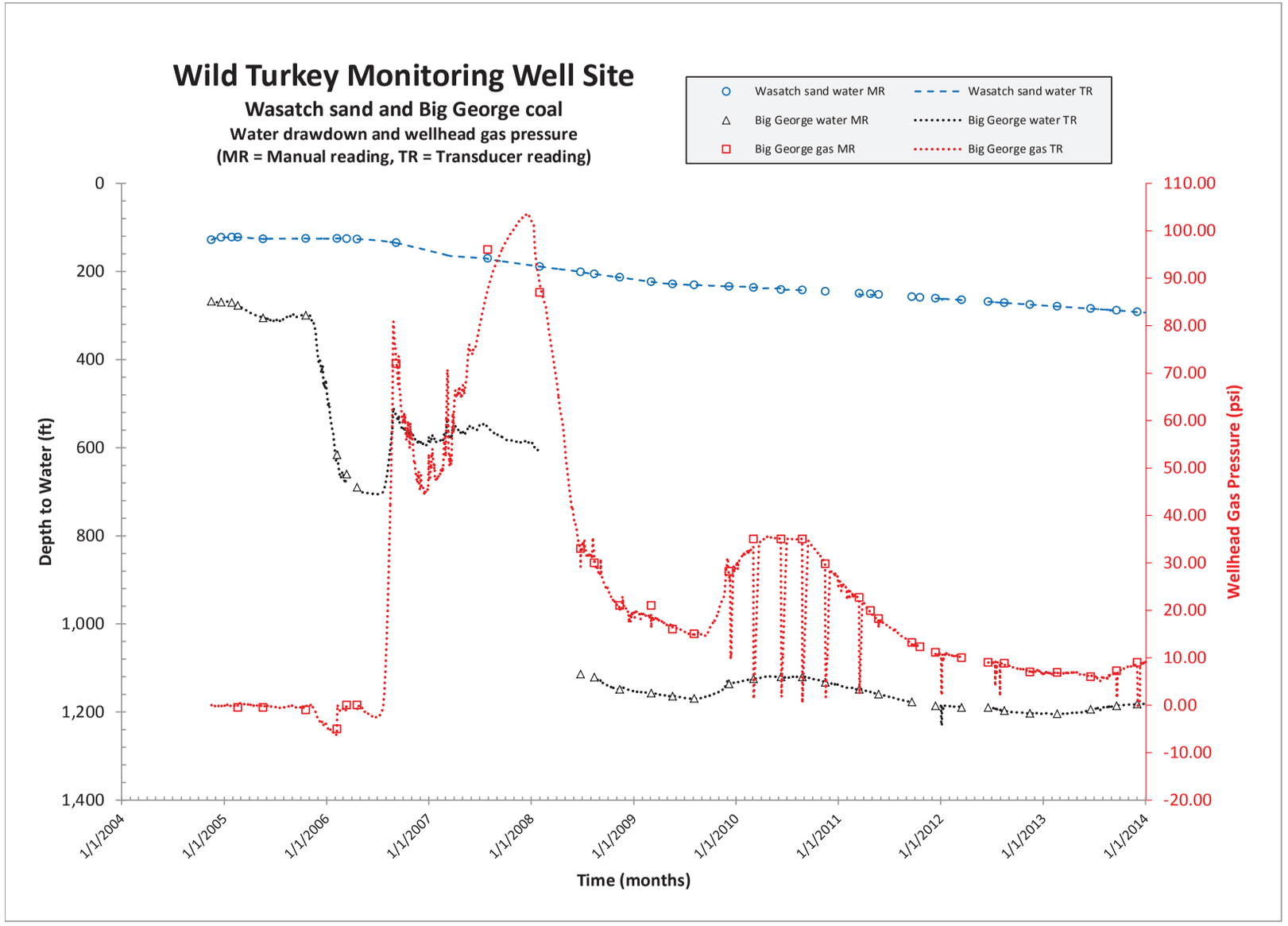

Figure A.245. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored intervals at the Wild Turkey monitoring well site location.

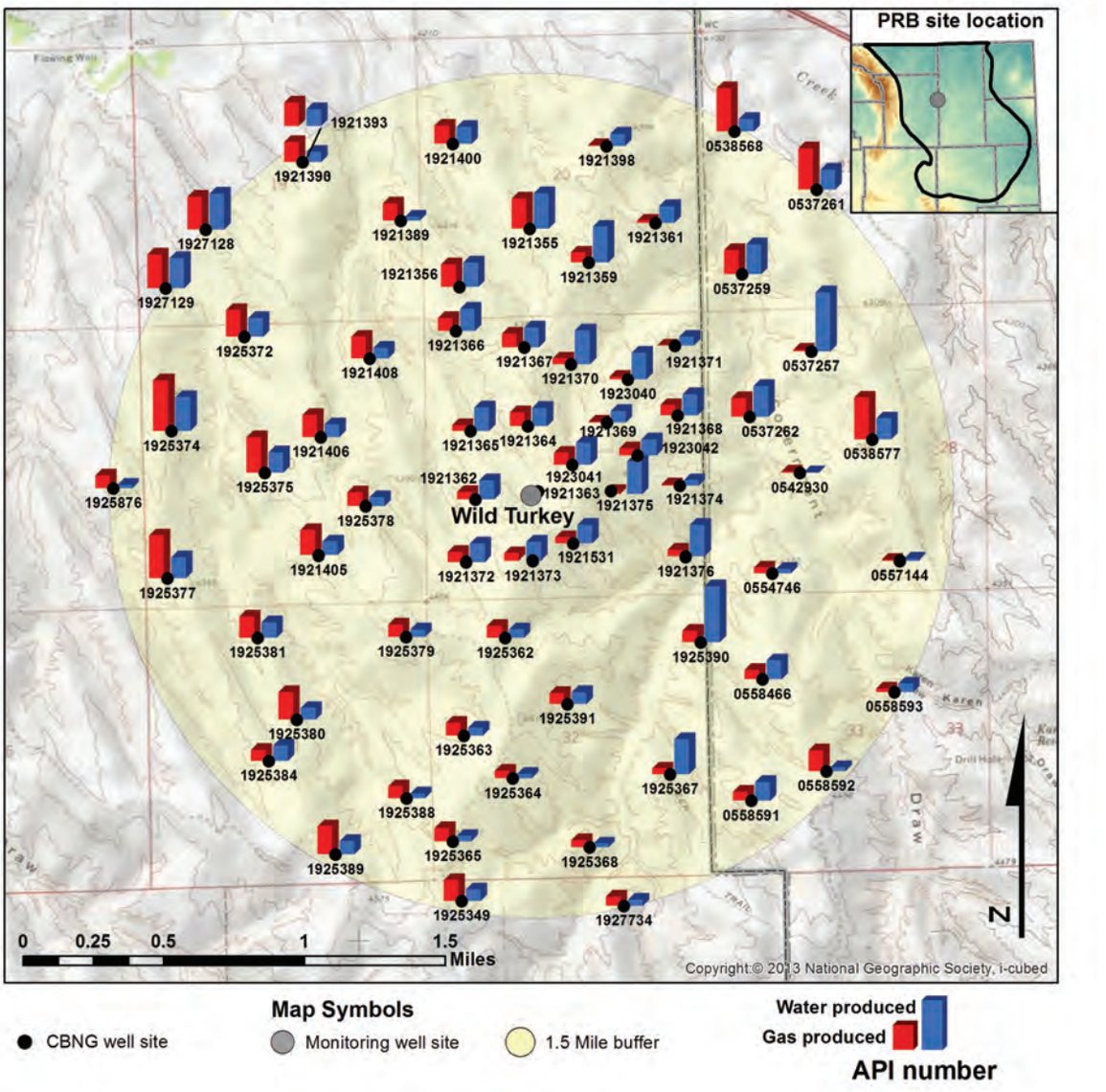

Figure A.246. Wild Turkey monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

Water production in the Wyodak Rider coal zone began in October 2005, peaked at 1,425,974 bbls in July 2006 and ended 2013 at 12,965 bbls/month (Figure A.247). Gas production in the Wyodak Rider coal zone began in June 2006 and has continued through 2013. 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 wells (Figure A.247).

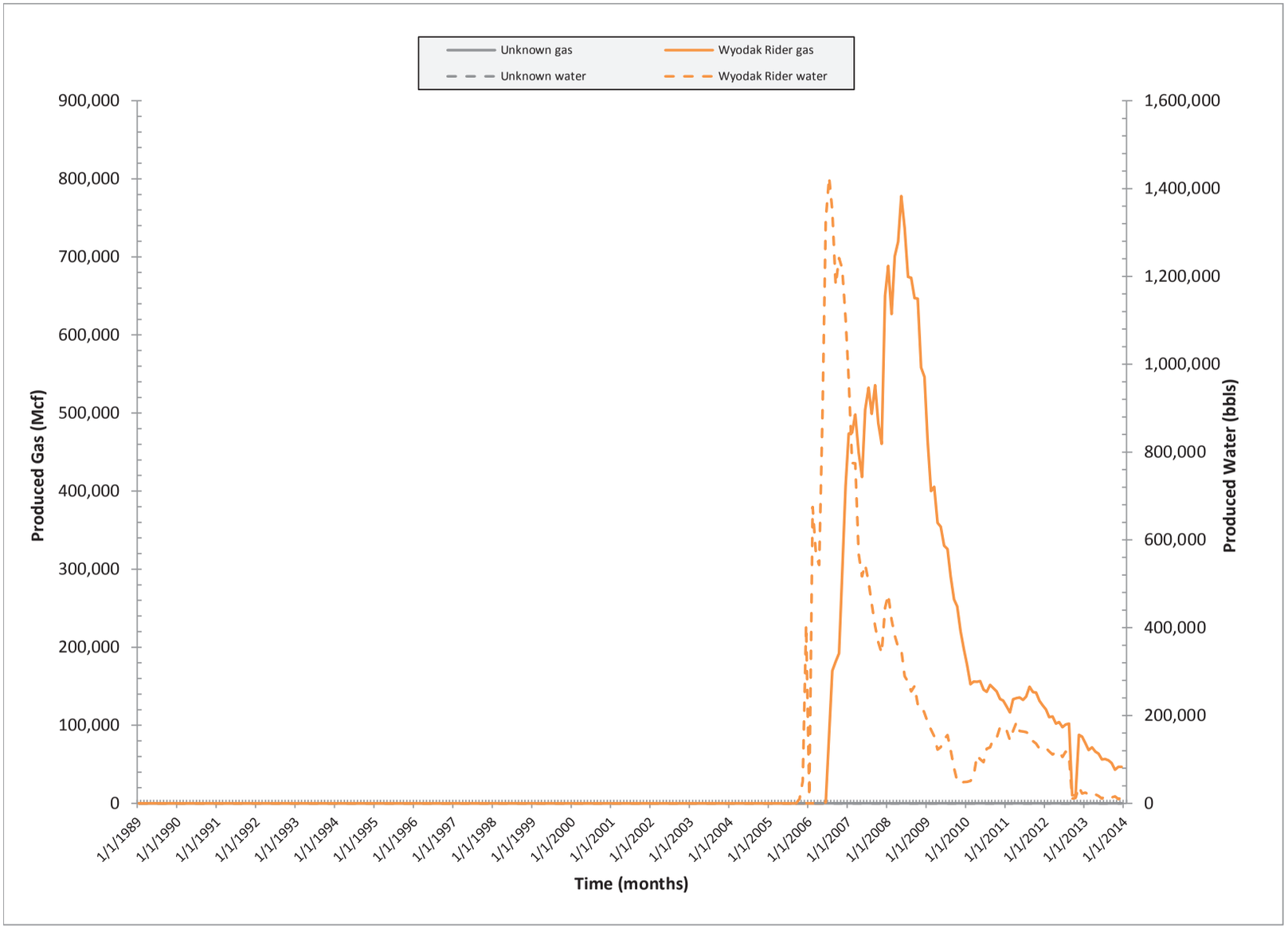

Figure A.247. Water and gas production from CBNG wells associated with the Wild Turkey monitoring well site location.

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 in six zones. One well is completed in a Wasatch sandstone and the Smith coal of the Wyodak Rider coal zone. The second well is completed in a 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.248; Table A.122). Water levels and wellhead gas pressures were measured during 2013 using 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.

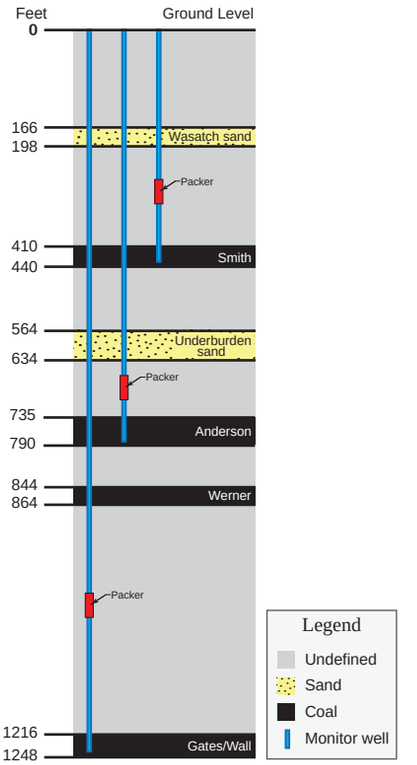

Figure A.248. Section showing relative positions of coals and sands in feet. Not to scale.

Wasatch Sandstone

Groundwater levels dropped 1.04 feet during 2013 but have risen 1.20 feet during the 2007-2013 monitoring period (Figure A.249; Table A.123). Gas pressure was not recorded in the Wasatch sandstone.

Smith Coal

A groundwater decline of 1.44 feet was observed during 2013. Groundwater levels declined 3.91 feet during the 2007-2013 monitoring period (Figure A.249; 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 23.59 feet during 2013 and 313.56 feet during the 2007-2013 monitoring period (Figure A.249; Table A.123). Gas pressure was not recorded in the underburden sand.

Anderson Coal

Groundwater levels declined 2.73 feet during 2013 and have declined 300.67 feet from initial levels first measured in 2007 (Figure A.250; 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 rose 1.01 feet during 2013 and 22.25 feet over the 2007-20013 monitoring period (Figure A.250; 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 intervals at the Williams Cedar Draw monitoring well site location (measured in feet).

Monitored interval	Interval characteristics			
	Depth of interval (ft)		Interval 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, water level changes for current monitoring period, water level changes for period of record, and maximum gas pressure.

Monitored interval	DGW - Depth to groundwater (ft), water level (ft), and gas pressure (psi) data					
	Initial DGW	Max DGW [Date]	Final 2013 DGW	Water level change 2013	Net water level change	Max. gas pressure [date]
Wasatch sand	115.79	117.50 3/24/2010	114.59	-1.04	1.20	n/a
Smith coal	169.15	181.20 11/1/2013	173.06	-1.44	-3.91	0.28 3/2/2012
Underburden sand	259.77	573.30 11/18/2013	573.33	-23.59	-313.56	n/a
Anderson coal	243.95	561.00 3/24/2010	544.62	-2.73	-300.67	2.45 12/19/2009
Werner coal	143.90	170.80 2/1/2011	166.15	1.01	-22.25	2.46 6/28/2007
Gates/Wall coal*	216.50	340.20 9/10/2009	n/a	n/a	-123.70	155.00 12/17/2009

*Last reliable measurement 9/10/2009

Gates/Wall Coal

Groundwater levels were not recorded in the Gates/Wall coal during 2013 due to excessive pressure. Groundwater levels declined 123.70 feet over the 2007-2013 monitoring period (Figure A.250; Table A.123). Wellhead gas pressure varied from 68-155 psi over the life of the well.

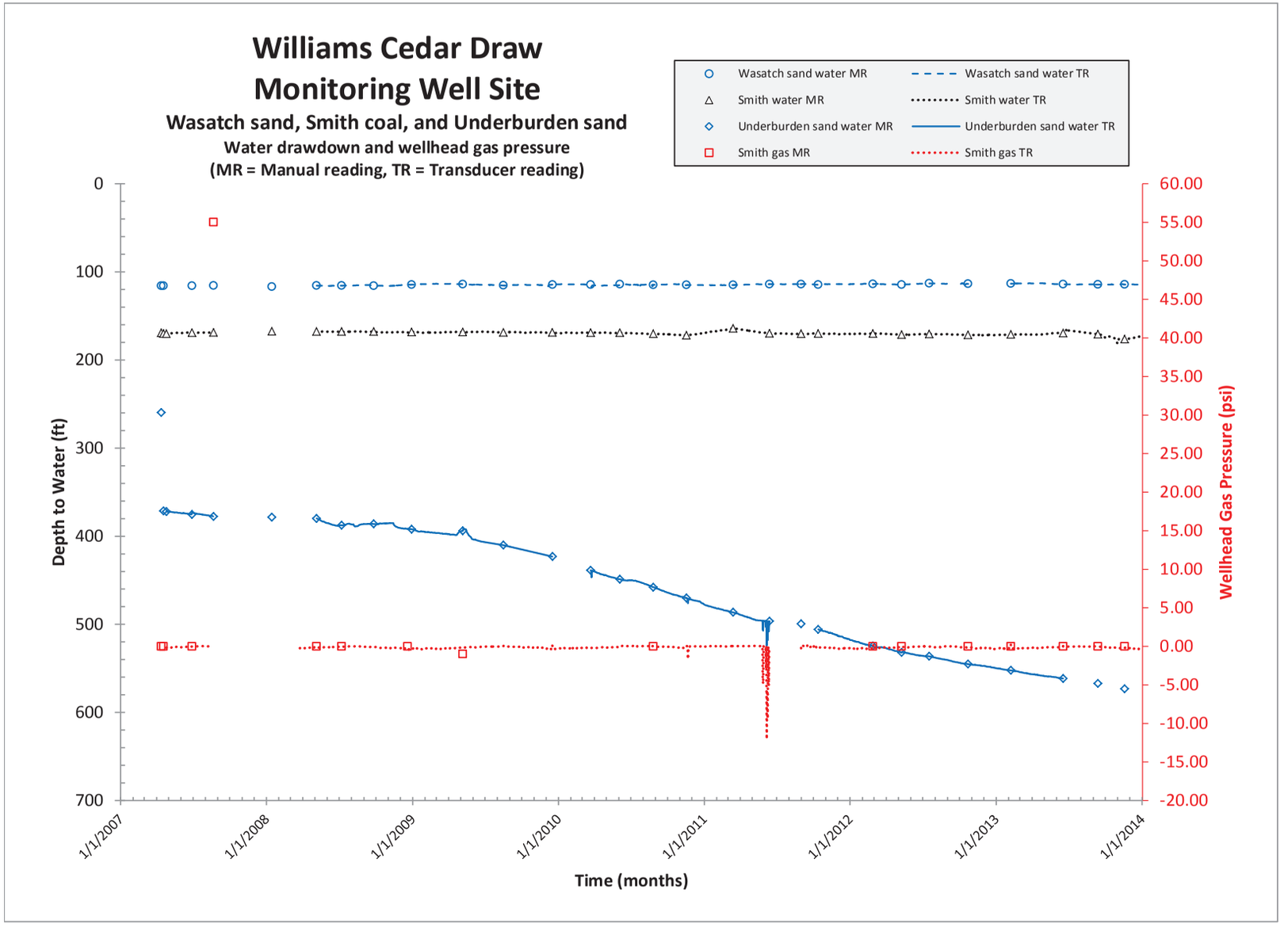

Figure A.249. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored intervals at the Williams Cedar Draw monitoring well site location.

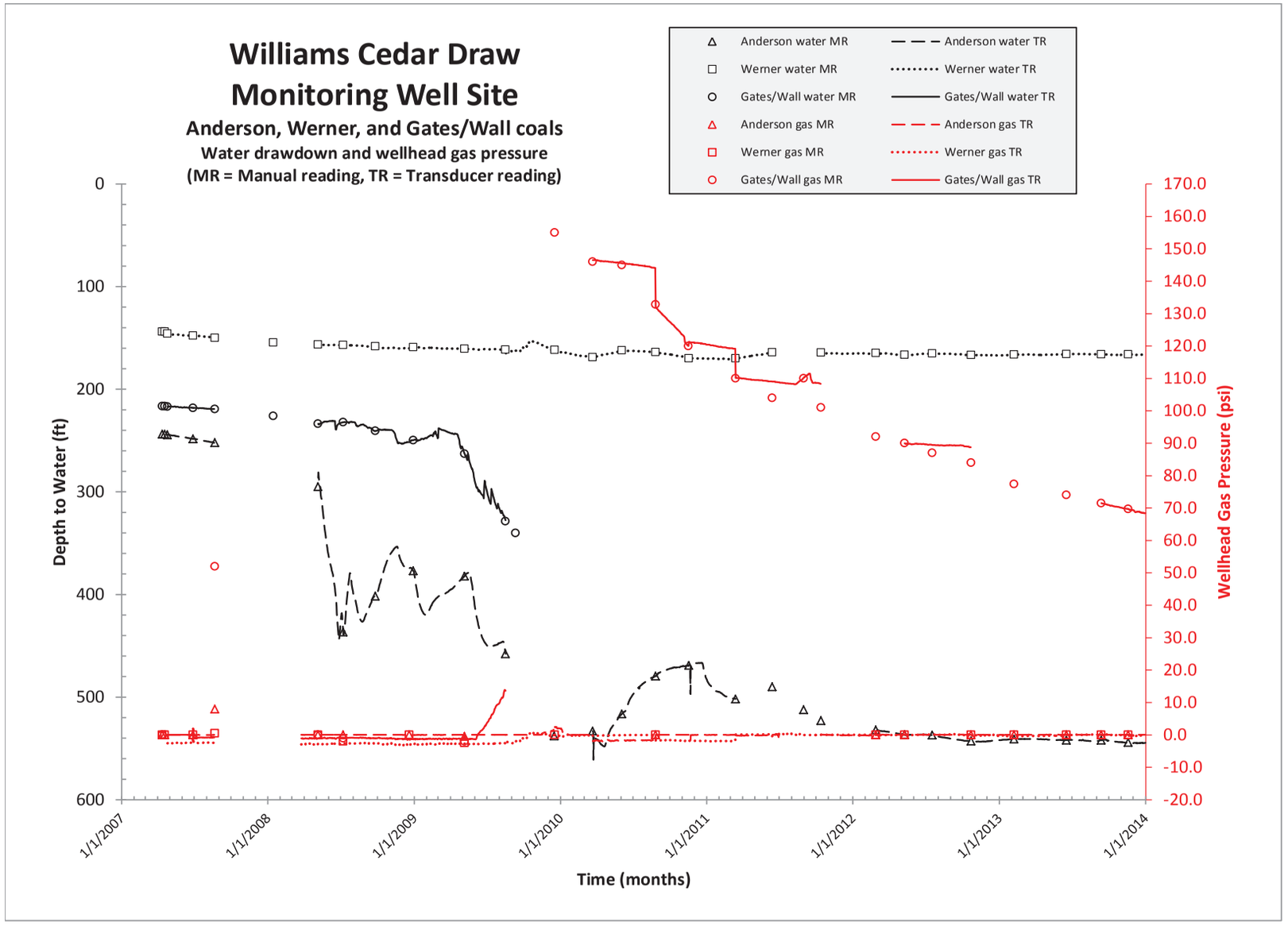

Figure A.250. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored intervals at the Williams Cedar Draw monitoring well site location.

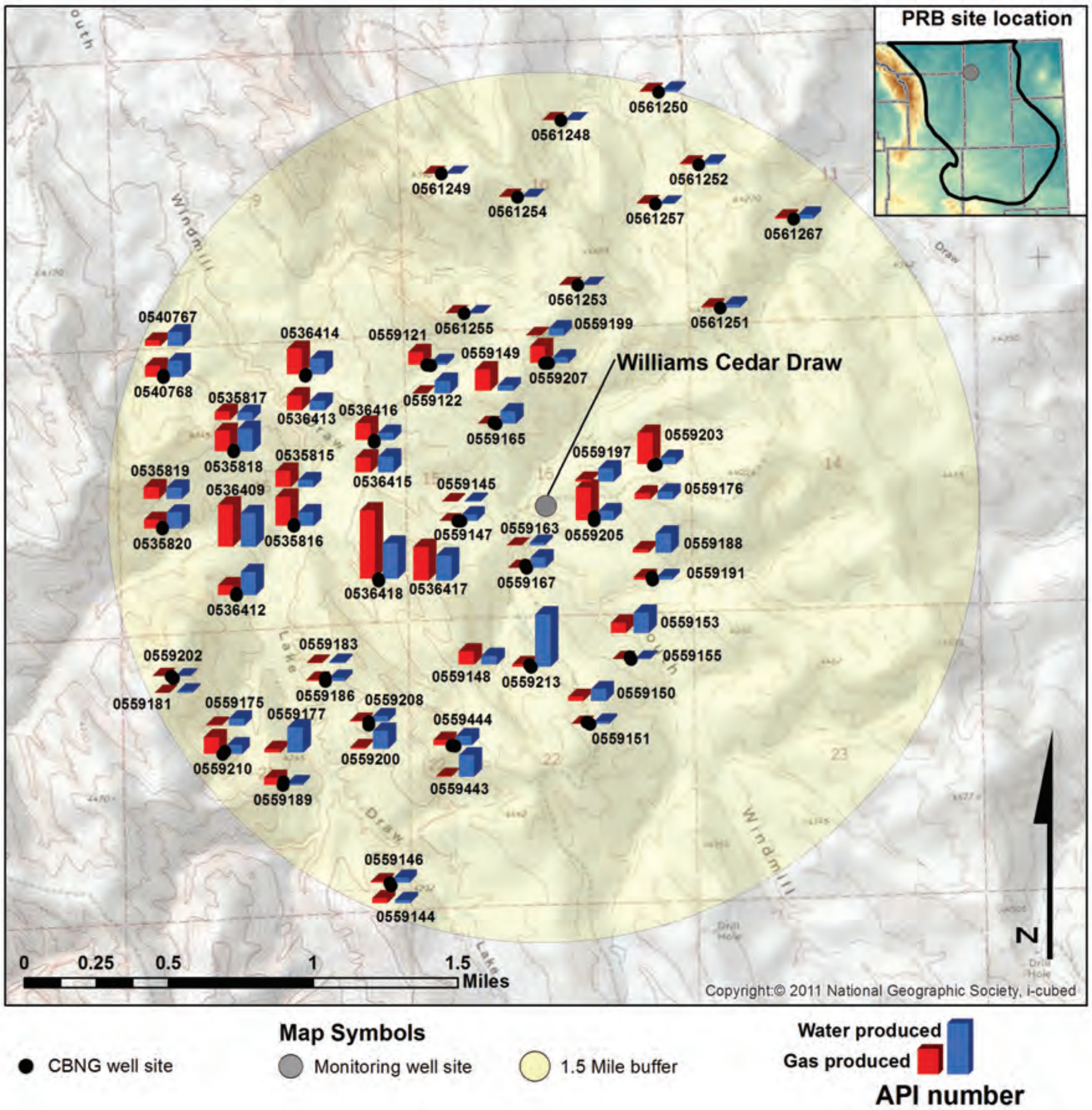

Figure A.251. Williams Cedar Draw monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

Production Statistics

Production data were analyzed for CBNG wells within the buffer of the Williams Cedar Draw monitoring well site from 1999-2013. Cumulative production for individual CBNG wells is displayed by location on Figure A.251. CBNG and water production are monitored in the Cook, Upper Wyodak, multiple, and unmonitored coal zone wells.

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.252) and then decreased to an average monthly production of 16,077 bbls in 2013. Gas production in the Upper Wyodak coal zone peaked at 54,050 Mcf in July 2011.

Like the Upper Wyodak coal zone, 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 2013 at 40,368 bbls/month (Figure A.252). Gas production in the Cook coal zone has remained between 6,000 and 50,000 Mcf/month since February 2002.

Water was produced consistently from multiple coal zone wells from May 2009-2013. Water production reached its maximum level of 34,302 bbls in December 2013 and averaged around 12,000 bbls/month in 2013 (Figure A.252). Gas production began in May 2009, and peaked at 19,580 Mcf in December 2013.

The WOGCC reports that there has been no water and gas production in the unmonitored coal zone wells from 1999-2013.

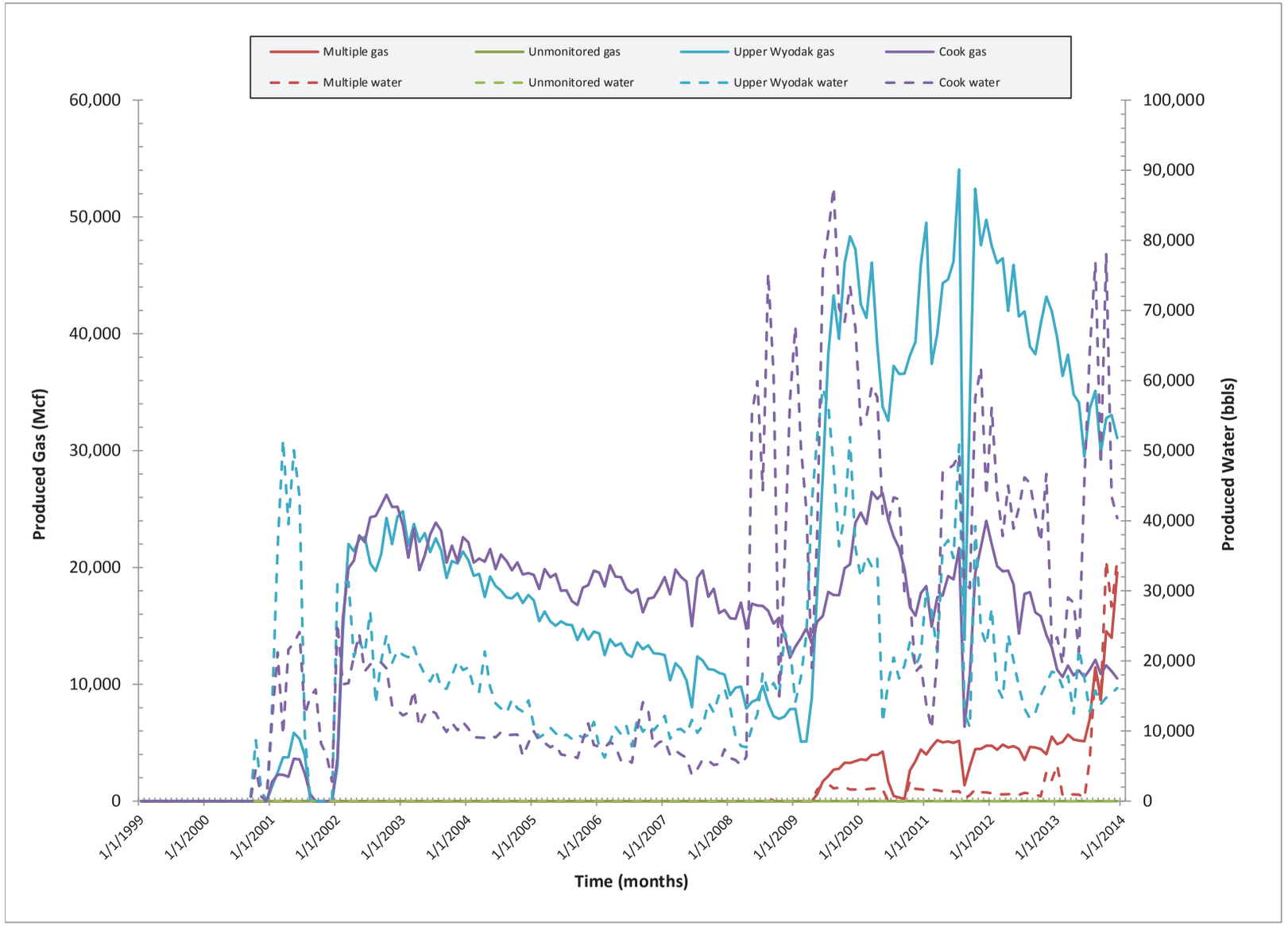

Figure A.252. Water and gas production from CBNG wells associated with the Williams Cedar Draw monitoring well site location.

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.253; Table A.124). Water levels and wellhead gas pressures were measured during 2013 using a combination of manual and automatic transducer and data logger equipment. Generally, there is good agreement between concurrent transducer and manual measurements where both are present. 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.

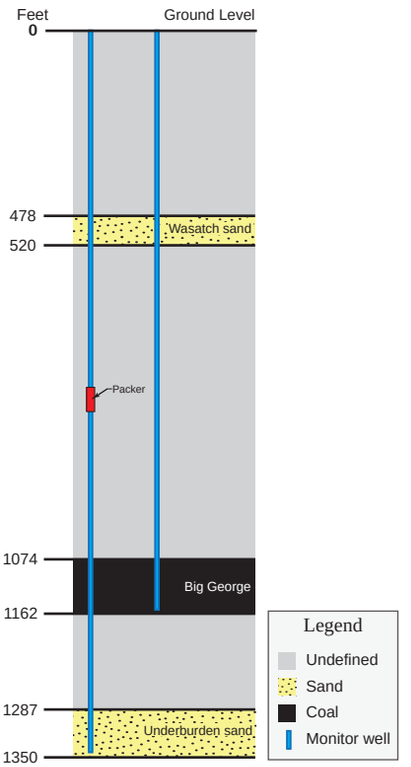

Figure A.253. Section showing relative positions of coal and sands in feet. Not to scale.

Wasatch sandstone
The Wasatch sandstone recorded a groundwater decline of 0.11 feet during 2013 but a rise in groundwater level of 3.69 feet over the monitoring period of 2006-2013 (Figure A.254; Table A.125). Gas pressure was not recorded in the Wasatch sandstone.

Big George Coal
Groundwater levels in the Big George coal declined 12.48 feet during 2013 compared to a decline of 773.38 feet during the 2006-2013 monitoring period (Figure A.254; 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 49.23 feet during 2013 and 429.20 feet over the 2006-2013 monitoring period (Figure A.254; Table A.125). Gas pressure was not recorded in the underburden sand.

Table A.124. Table showing the depth to and thickness of monitored intervals at the Wormwood monitoring well site location (measured in feet).

Monitored interval	Interval characteristics			
	Depth of interval (ft)		Interval 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, water level changes for current monitoring period, water level changes for period of record, and maximum gas pressure.

Monitored interval	DGW - Depth to groundwater (ft), water level (ft), and gas pressure (psi) data					
	Initial DGW	Max DGW [Date]	Final 2013 DGW	Water level change 2013	Net water level change	Max. gas pressure [date]
Wasatch sand	77.30	77.30 12/13/2006	73.61	-0.11	3.69	n/a
Big George coal	262.00	1036.40 12/30/2013	1,035.38	-12.48	-773.38	0.85 11/16/2013
Underburden sand	115.20	544.40 12/2/2013	544.40	-49.23	-429.20	n/a

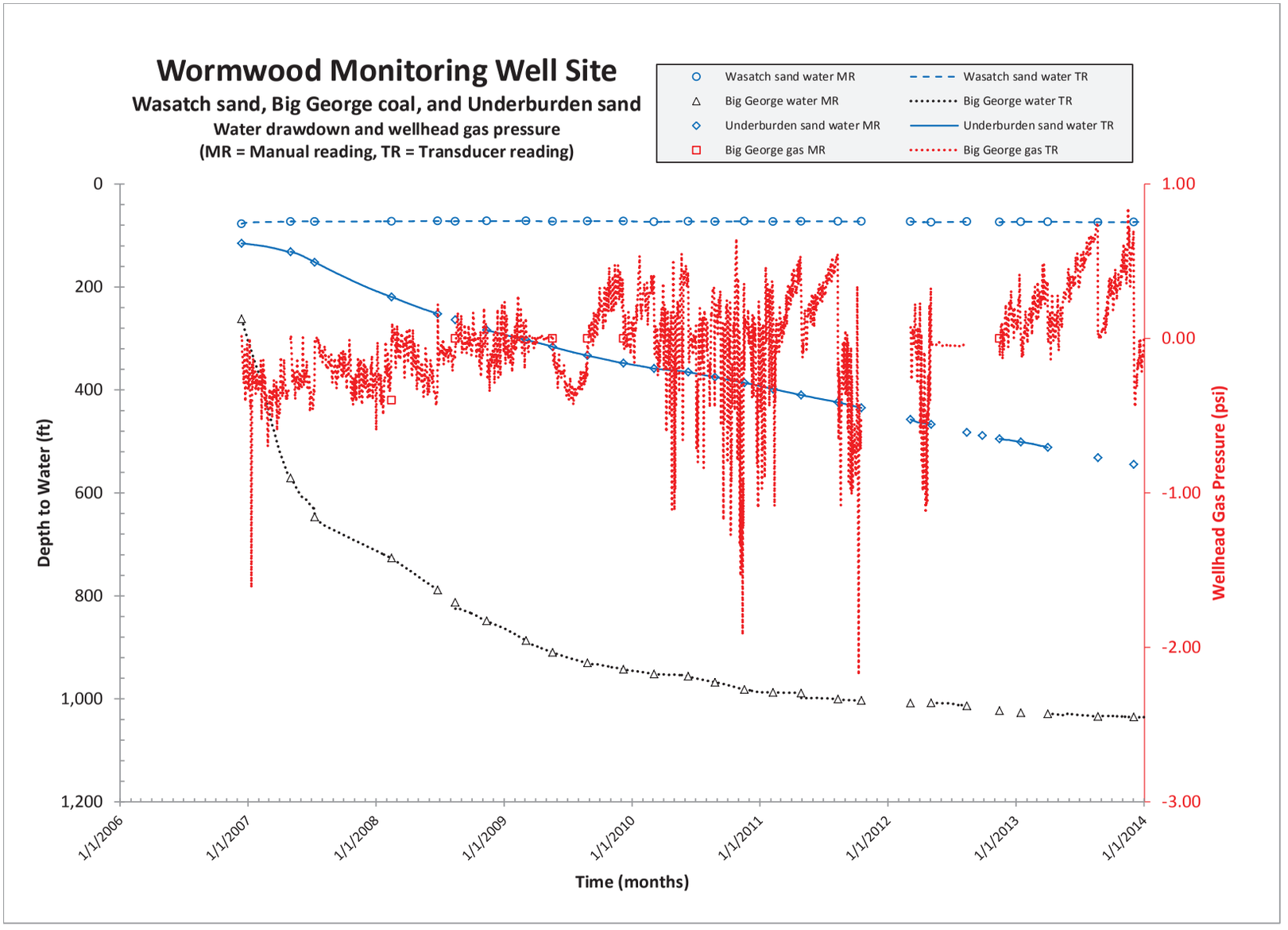

Figure A.254. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored intervals at the Wormwood monitoring well site location.

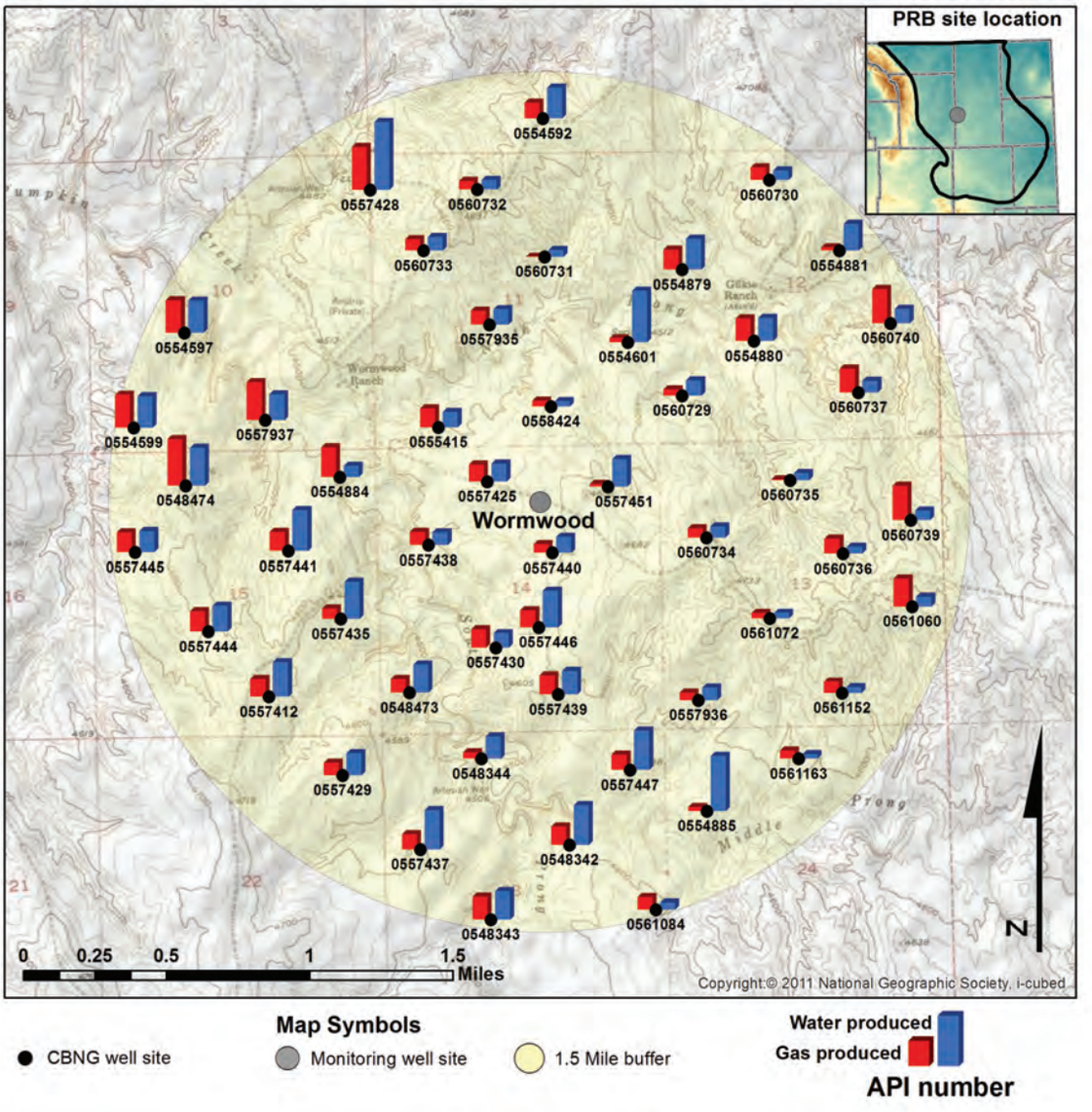

Figure A.255. Wormwood monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

Production Statistics

Production data were analyzed for CBNG wells within the buffer of the Wormwood monitoring well site from 2002-2013. Cumulative production for individual CBNG wells is displayed by location on Figure A.255. CBNG and water production are 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 179,996 bbls/month by the end of 2013 (Figure A.256). Gas production in the Wyodak Rider coal zone began in 2007, peaked in March 2009 at 255,163 Mcf, and has remained above 160,000 Mcf/month during 2013.

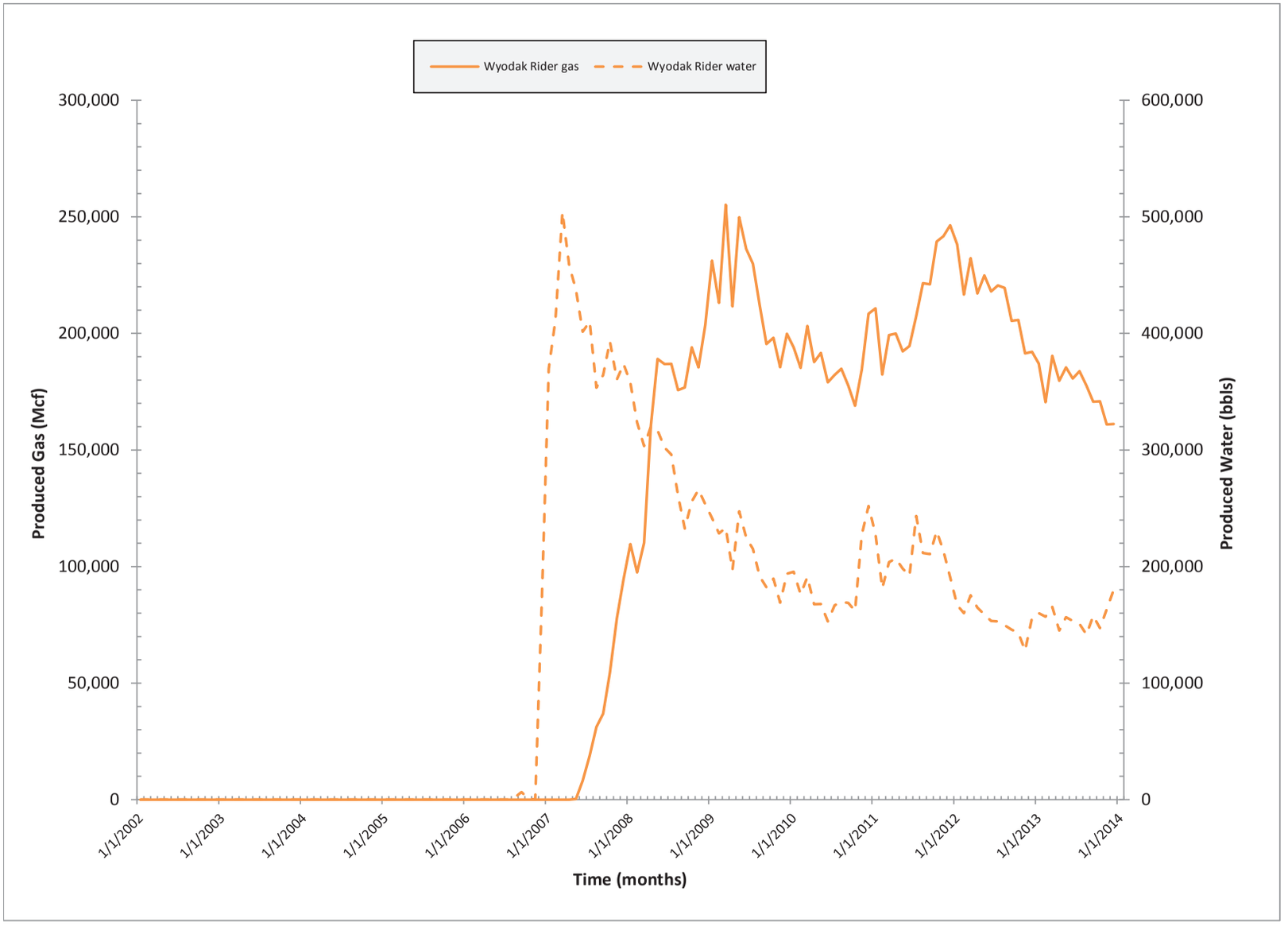

Figure A.256. Water and gas production from CBNG wells associated with the Wormwood monitoring well site location.

Interpreting the past, providing for the future.