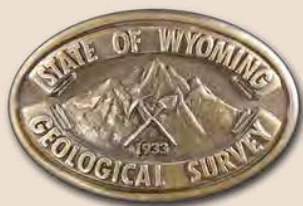


2009 Coalbed Natural Gas Regional Groundwater Monitoring Update:

Powder River Basin, Wyoming

**J. Fred McLaughlin, James R. Rodgers, Nikolaus W. Gribb,
Richard J. Hays, and Kyle D. Cottingham**

Supported by the U.S. Bureau of Land Management
Buffalo Field Office, Buffalo, Wyoming

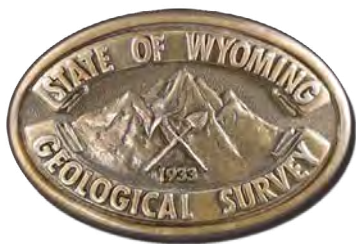


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Open File Report OFR 12-5
Updated December 2012





Director and State Geologist Thomas A. Drea



Prepared for:
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Management
Buffalo Field Office
Buffalo, Wyoming



Layout by:
Chamois L. Andersen

Coalbed natural gas well in the Powder River Basin, Wyoming. Photo by David Lucke.

2009 Coalbed Natural Gas Regional Groundwater Monitoring Update: Powder River Basin, Wyoming

Wyoming State Geological Survey (WSGS) Open File Report **OFR12-5**

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J. Fred McLaughlin, James R. Rodgers, Nikolaus W. Gribb, Richard J. Hays, and Kyle D. Cottingham

Chamois L. Andersen, Layout

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

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



WYOMING STATE GEOLOGICAL SURVEY



CBNG GROUNDWATER MONITORING UPDATE

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INTRODUCTION

In the Powder River Basin (PRB), the Bureau of Land Management (BLM) maintains a network of 62 groundwater monitoring well sites (Figure 1; Table 1). These sites were designed to monitor the impact of coalbed natural gas (CBNG) production on the groundwater resources of the PRB. CBNG production requires the extraction of water from a coal seam. There are nearly 18,000 active CBNG wells in Wyoming's portion of the PRB, for which the groundwater resources require close monitoring.

This report focuses on the BLM monitoring well data for the years 2006, 2007, 2008, and 2009. Though the groundwater data for 2006 was described in the previous report (Clarey et al., 2010), the authors found it was important to begin their analysis from 2006 for several reasons. First, there are several monitoring wells that began collecting data in 2006 (see Appendices). Secondly, this data is continuous regardless of year, and groundwater and production trends are overlapping. In many ways it was more efficient to describe and characterize the data by starting in 2006. Though this report focuses on the years of 2006-2009, all accumulated groundwater and production data are displayed in the Appendix.

This report differs from the prior groundwater monitoring report (Clarey et al., 2010) as it incorporates data from local CBNG production wells and relates all the data to defined, producing coal zones within the PRB. This report is divided into two sections. The first section is the introductory and summary report, which includes locations, methods, descriptions of the major coal zones, general trends in groundwater levels and CBNG production, and a summation. The second section is the Appendices.

The Appendices display data from monitoring well sites, associated CBNG production data, and assessment of both data for the monitored interval. Though this report focuses on the monitored interval of 2006-2009, data from the lifespan of the well is displayed in the Appendices for the benefit of all users.

METHODS

Monitoring Data Collection, Transfer, and Storage

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

Groundwater levels and wellhead gas pressures are recorded both electronically and manually. Electronic measurements are collected once per day by a data logger and stored to a memory card. Electronic measurements record the date, water level in feet, and gas pressure in pounds per square inch (psi) using the American Standard Code of Information Interchange (ASCII) format. Manual measurements are collected on a quarterly basis, depending on accessibility. Missing measurements in electronic and manual data sets are often the result of transponder error, equipment failure, high gas pressure, or inability to access the well site. Manual gas pressure is gauged from the wellhead. Manual groundwater level measurements use two types of recording instruments, preference is determined by depth. The first type is an electronic-measuring tape (Figure 3) with a sensor that indicates when water level is reached. The second type is a counter balance tape (Figure 4) which utilizes a system similar to a surveyor's measuring wheel, with a counter balance that holds the tape in position. Deep wells require the use of the electronic tape measurement, and shallower wells use the counter balance measuring tape.

Once onsite, a BLM hydrologic technician uses a pressure gauge to determine wellhead pressure. If pressure exceeds 10 psi, the well is deemed unsafe and manual groundwater-level measurements are not obtained. If the wellhead pressure is less than 10 psi, the wellhead is opened and pressure is released. When the pressure has dropped, a manual measurement is taken. The measurement is logged and then compared to the electronic measurement

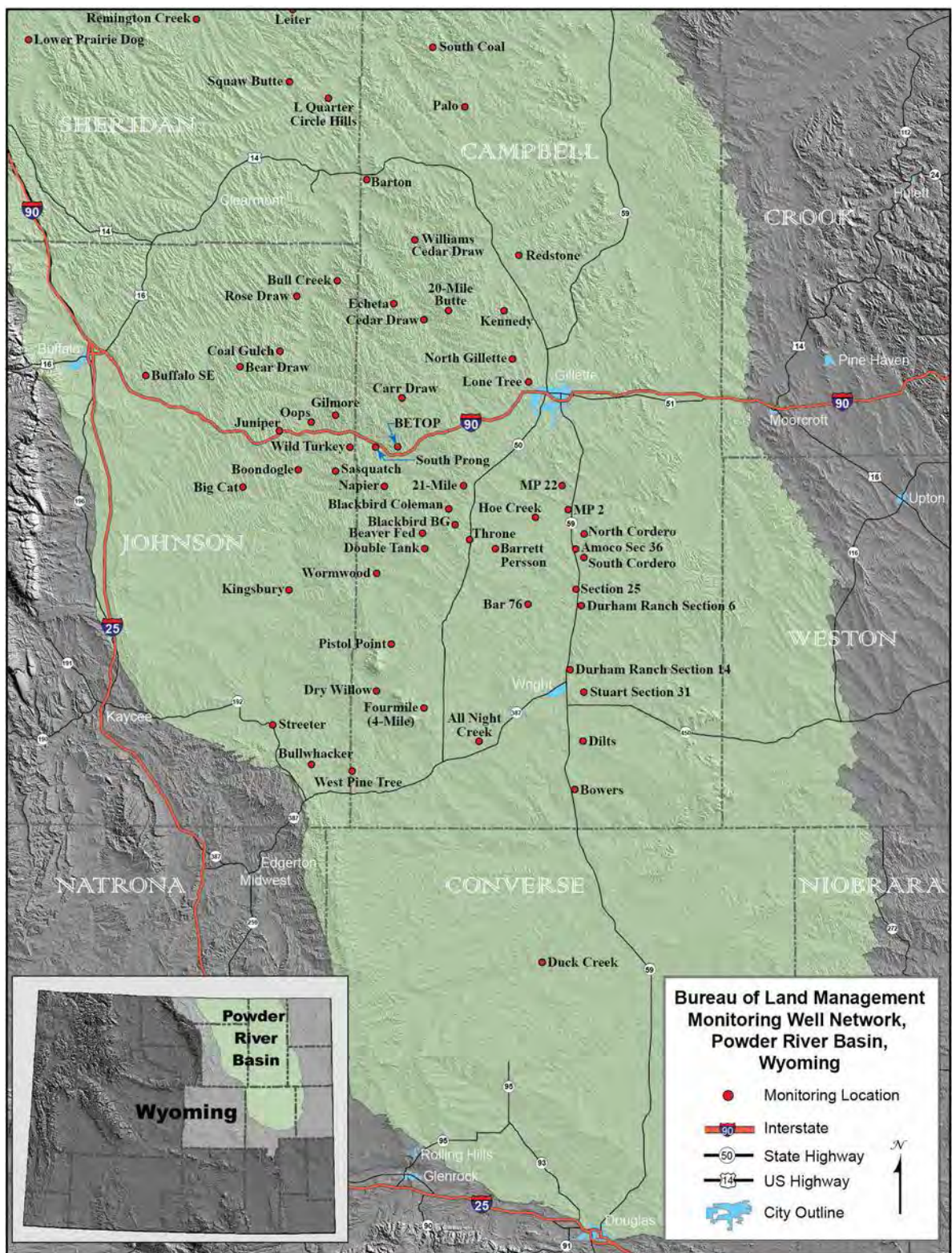


Figure 1. Groundwater monitoring well site locations in Powder River Basin, Wyoming.

Table 1. List of monitoring well site locations in the Powder River Basin. Well sites are separated by county and ordered alphabetically.

County	Well site name	Location				Associated wells	Completed intervals	Approximate elevation (ft.)	Start date
		Qtr/Qtr	Section	Township	Range				
<i>Campbell</i>	20-Mile Butte	SE SE	32	52 N	74 W	4	4	4557	01/28/04
	21-Mile	NE NE	22	48 N	74 W	3	3	5037	08/23/01
	All Night Creek	NW SW	36	43 N	74 W	5	5	5220	03/21/01
	Amoco Sec 36	NW SE	36	47 N	72 W	1	1	4682	04/25/95
	Bar 76	NE SE	1	45 N	73 W	1	2	4768	09/16/97
	Barrett Persson	SW SW	32	47 N	73 W	2	2	4945	12/06/00
	Barton	SE SW	3	54 N	76 W	2	2	3960	01/23/02
	Beaver Fed	SE NW	23	47 N	75 W	2	2	4783	04/18/03
	BETOP ⁽²⁾	NE SE	32	49	75 W	1	----	----	----
	Blackbird BG	SW NE	16	47 N	74 W	1	1	4780	07/17/02
	Blackbird Coleman	SW SE	5	47 N	74 W	2	2	4778	07/12/00
	Bowers	SE SW	36	42 N	72 W	5	5	5018	01/21/98
	Carr Draw	NE NE	29	50 N	75 W	2	4	4653	09/26/07
	Cedar Draw	NE SW	2	51 N	75 W	2	2	4268	01/29/04
	Dilts	SE NW	31	43 N	71 W	2	2	4929	03/24/99
	Double Tank	NE SW	35	47 N	75 W	2	1	4783	12/19/02
	Dry Willow	SE NW	35	44 N	76 W	1	1	4944	09/29/99
	Durham Ranch Section 6	SW NE	6	45 N	71 W	2	2	4697	11/10/97
	Durham Ranch Section 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 (4-Mile)	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
	Section 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 Section 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

Table 1. Continued.

County	Well site name	Location				Associated wells	Completed intervals	Approximate elevation (ft.)	Start date
		Qtr/Qtr	Section	Township	Range				
	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
<i>Converse</i>	Duck Creek	SW SW	20	38 N	72 W	2	2	4923	03/28/05
<i>Johnson</i>	Bear Draw	SW NW	1	50 N	79 W	1	2	4624	03/11/06
	Big Cat	SE SE	24	48 N	79 W	2	2	4480	07/10/03
	Boondogle	SE SE	7	48 N	77 W	1	1	4095	02/18/03
	Buffalo SE ⁽¹⁾	NW NW	12	50 N	81 W	5	5	4542	08/22/01
	Bull Creek	NW SE	12	52 N	77 W	3	3	3909	11/22/05
	Bullwhacker	NW SE	16	42 N	77 W	2	2	5050	04/11/02
	Coal Gulch	SW SW	26	51 N	78 W	1	2	4483	09/08/05
	Gilmore	SE NE	1	49 N	77 W	1	1	4536	04/04/02
	Juniper	SW SW	14	49 N	78 W	3	3	4428	03/21/01
	Kingsbury	NW SE	25	46 N	78 W	1	2	4330	10/23/07
	Oops ⁽²⁾	SW SW	9	49 N	77 W	-----	-----	4023	03/19/09
	Rose Draw	NE SE	19	52 N	77 W	2	3	3914	05/23/09
	Sasquatch	NE SW	12	48 N	77 W	2	2	4472	01/15/98
	Streeter	SE NW	22	43 N	78 W	2	2	4761	08/04/04
	Wild Turkey	NE SW	29	49 N	76 W	2	2	4344	11/16/04
<i>Sheridan</i>	Remington Creek	SW NE	30	58 N	79 W	4	4	3688	05/23/05
	L Quarter Circle Hills	NE SE	14	56 N	77 W	3	3	3618	04/05/05
	Leiter	NW SE	19	58 N	77 W	1	1	5181	05/16/02
	Lower Prairie Dog	SE NE	10	57 N	83 W	3	3	3715	08/24/00
	Squaw Butte	SE NE	1	56 N	78 W	1	1	-----	10/17/01

⁽¹⁾ The very shallow sand monitoring well was returned to the landowner on 5/10/2007 to be used as a cattle watering well and will not be used as a monitoring well at this site. Therefore both the number of wells and monitoring intervals was reduced by one as of May 2007.

⁽²⁾ Both the BETOP and Oops monitoring well sites have a limited set of data. These sites will be added as more data becomes available.

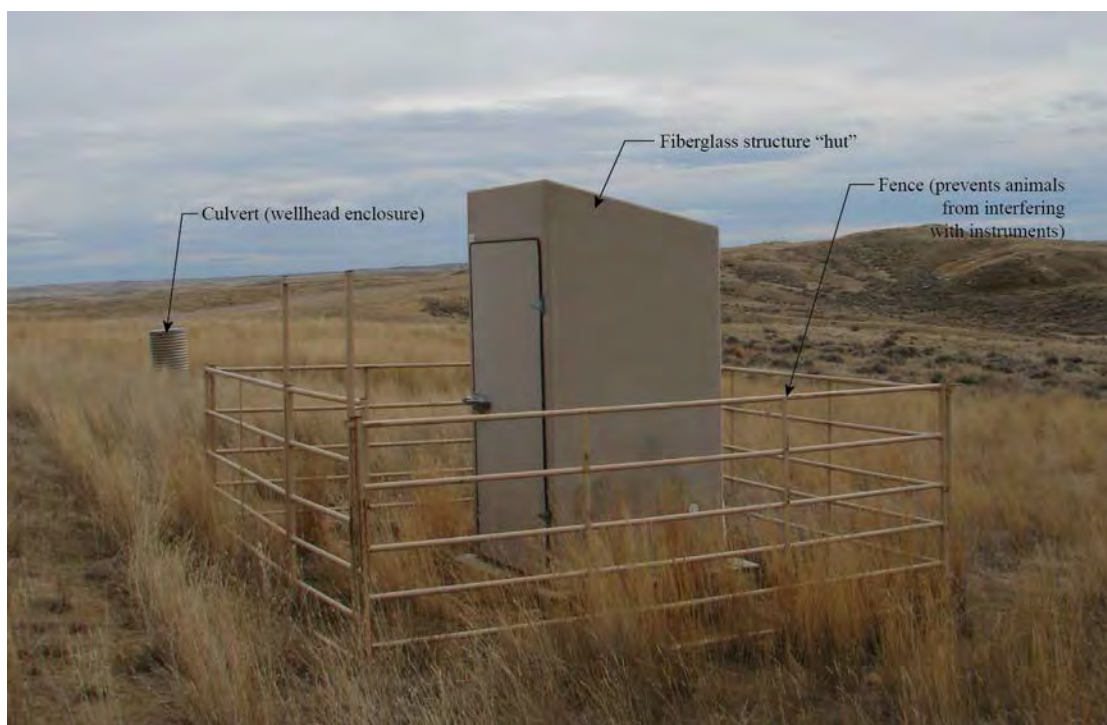


Figure 2. Wellhead culvert cover and equipment storage facility for the Napier monitoring site. Photo by Richard Hays.

at the instrument panel. If the electronic measurement does not correspond to the manual measurement, an adjustment is made to the data logger and a note is made in both the technician's log book and the well site log book. At the instrument panel the technician changes the desiccant, which is 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 maintenance needs.

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

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 methane as a percentage in a given volume of air. The device allows

for sensitivity levels of either 0-5 percent, or 0-100 percent CH_4 . The higher sensitivity setting is employed on monitored sandstone wells and the lower sensitivity setting is employed for coal wells.

In preparation of this report, data were mailed from the Bureau of Land Management (BLM) to the Wyoming State Geological Survey (WSGS) on a compact disc. The disc contained all data from BLM monitoring wells, and each monitored well site location was saved as individual Excel files. The water and gas data was corrected by the BLM and no further modifications were made to the data at the WSGS. Drawdown graphs were created as well as tables. Values for monitor zone characteristics, such as depth of completion, were taken from the data provided by the BLM and inserted into the tables where available. Groundwater level calculations for "Drawdown pre-2006 and "Drawdown 2006-2009 in the tables in the Appendices were determined by subtracting the final water level for the period from the initial water level. Schematic stratigraphic columns were created using depths provided by the BLM. The displayed distances between coals and sands were approximated from



Figure 3. Electronic tape measuring system in use at the Juniper monitor well site location. Photo by Richard Hays.

relative depths of each monitored zone. These figures are not meant to be accurate representations of the stratigraphic section; they were created as pictorial representation for ease of understanding (Figure 5).

CBNG Production Data

Water and gas production data from CBNG wells were downloaded from the Wyoming Oil and Gas Conservation Commission website (<http://wogcc.state.wy.us>). Wells were imported and displayed in ARCMAP alongside BLM groundwater monitoring wells. A 1.5-mile buffer was created around each of the BLM monitoring well sites to identify CBNG wells that could impact monitoring well measurements (Meredith et al., 2009). The buffer area was centered on each BLM monitoring well site, and data from all permitted CBNG wells within the zone were downloaded (WOGCC,

2011). A total of 2,705 CBNG wells are contained within the buffer zones. Wells were sorted according to the completed interval reported on the Wyoming Oil and Gas Conservation Commission website (WOGCC, 2011). Of the initial 2,705 wells, 2,355 had sufficient data to be sorted into five primary coal zones: Wyodak Rider (Big George), Upper Wyodak, Lower Wyodak, Cook, and Wall (Jones, 2010). Due to incomplete reported well data, or vagueness of reported intervals, some monitoring well locations do not have associated production data. After sorting, CBNG wells were coded to correspond with their respective monitoring well by coal zone, and then all water and gas data were exported into Microsoft Access. This master database also contains all monitoring well groundwater monitoring data.

CBNG production data was sorted by buffer area and coal zone, exported into Microsoft Excel and tabulated to create production graphs and cumulative production figures. Cumulative CBNG water and gas production data for each buffer area are displayed in the Appendices (as a dotted line),



Figure 4. Counter balance tape used for deep well measurements. Photo by Richard Hays.

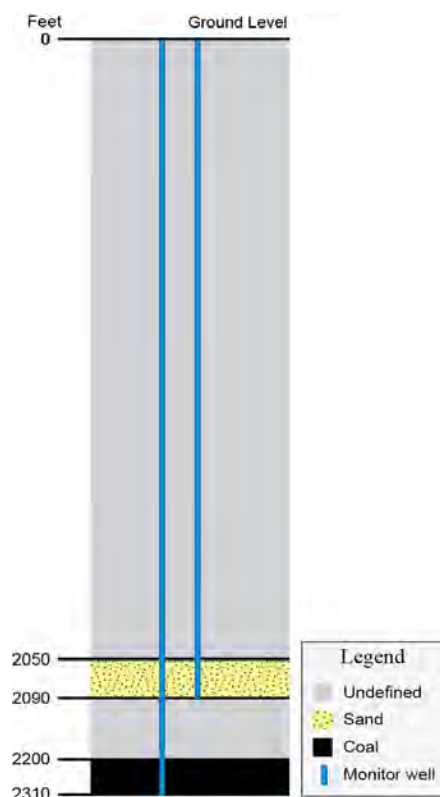


Figure 5. Example of schematic stratigraphic column showing relation between monitored strata.

along with a 3-period moving average (as a solid line). The 3-period moving average was used to filter data inconsistency due to periods of high or low reported production (Davis, 1986). Please see Figure 6 which includes all water and gas production numbers for all CBNG wells within Wyoming's Powder River Basin. This figure is an example of the production graphs created for this report. Note: The production graphs in the Appendices show production for the CBNG wells in their specific buffer zone.

MONITORED ZONES AND COAL ZONE DESIGNATIONS

The purpose of the BLM deep groundwater monitoring well network is to measure and record the effects of CBNG production on related groundwater aquifers. As such, BLM groundwater monitoring wells are compiled into two comprehensive lists by county and location data for all monitoring wells.

Table 2 identifies all monitored coal bed wells and associated well data. Table 3 identifies all monitored sand wells and associated well data. This report presents and analyzes all data from the BLM deep groundwater monitoring well site network through 2009. As this data set is exceedingly large, all monitoring well data have been assigned to coal designated zones for ease of use. Monitoring wells that record groundwater data from overlying Wasatch sandstone aquifers are categorized by associated coal zones.

Fort Union Coal Zones

The primary CBNG-producing coals in the PRB are Paleocene coals in the 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 et al., 2010). Jones (2008) defines a coal zone as a litho-stratigraphic section that contains a recognizable sequence of coal beds across a series of well logs. In the PRB there are seven defined coal zones, and the BLM monitors five producing coal zones (Jones, 2008; Flores et al., 2010; WOGCC, 2011).

The five monitored Fort Union coal zones are the Wyodak Rider (Big George), Upper Wyodak, Lower Wyodak, Cook, and the Wall (Table 4). These coal zones are ordered stratigraphically highest to lowest, or youngest to oldest. Coal beds in the Wyodak Rider (Big George) coal zone include the Smith and Big George. Coal beds in the Upper Wyodak coal zone include the Anderson and Wyodak coals, which are also referred to as the Anderson Rider and Anderson, respectively. The Lower Wyodak coal zone includes the Canyon coal bed. The Cook or Werner and Lower Cook or Gates coal beds are located in the Cook coal zone. The Wall coal zone includes the Wall and Pawnee coal beds. Individual coal beds are monitored by the BLM within the five coal zones (WOGCC, 2011). The groundwater level of three Fort Union sandstones (underburden sands) are also monitored by the BLM.

Wasatch Sandstone Aquifers

The BLM deep groundwater monitoring well network records groundwater data for multiple sandstone aquifers in the Wasatch Formation. Wasatch

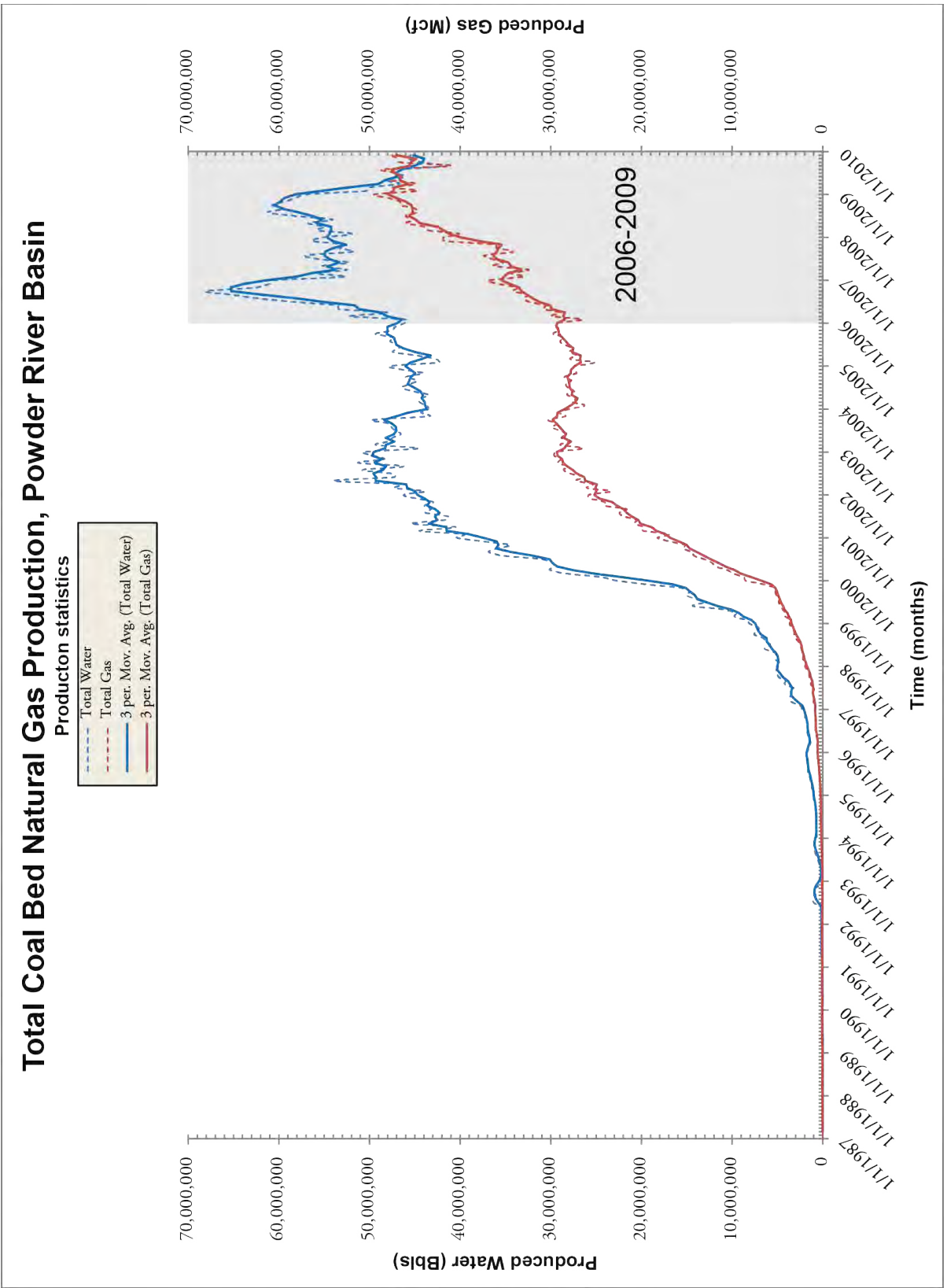


Figure 6. Total water and gas production, with the 3-period moving average, for all CBNG wells in the Powder River Basin, Wyoming.

Table 2. List of coal zone monitoring sites in the PRB. Wells are listed by coal deposits.

Monitoring well site name	Well identifier	Coal deposit(s)	County	Year first monitored	Well total depth (ft)	Completion interval thickness (ft)
20-Mile Butte	49-005-50948 ⁽¹⁾	Anderson	Campbell	2004	937	38
21-Mile	49-005-07199 ⁽¹⁾	Anderson (Wyodak)	Campbell	2001	1560	22
Amoco Sec 36	P72107W ⁽²⁾	Anderson (Wyodak)	Campbell	1995	547	88
Bar 76	49-005-31560 ⁽¹⁾	Anderson (Wyodak)	Campbell	1997	777	51
Barrett Persson	-----	Anderson (Wyodak)	Campbell	2001	1334	68
Blackbird Coleman	49-005-36025 ⁽¹⁾	Anderson (Wyodak)	Campbell	2000	1500	80
Bowers	49-005-31713 ⁽¹⁾	Anderson (Wyodak)	Campbell	2002	768	30
Bull Creek	49-019-06402 ⁽¹⁾	Anderson	Johnson	2005	1030	40
Dilts	-----	Anderson (Wyodak)	Campbell	1999	658	78
Double Tank	49-005-50084 ⁽¹⁾	Anderson (Wyodak)	Campbell	2002	1520	48
Durham Ranch Section 6	P106975W ⁽²⁾	Anderson (Wyodak)	Campbell	1997	363	35
Durham Ranch Section 14	P106973W ⁽²⁾	Anderson (Wyodak)	Campbell	1998	816	100
Gilmore	-----	Anderson (Wyodak)	Johnson	1998	1375	55
Hoe Creek	-----	Anderson (Wyodak)	Campbell	1998	910	80
Kennedy	P145908W ⁽²⁾	Anderson	Campbell	2000	743	36
Lower Prairie Dog	-----	Anderson	Sheridan	2000	669	15
MP2	-----	Anderson (Wyodak)	Campbell	1993	410	74
MP22	P90658W ⁽²⁾	Anderson (Wyodak)	Campbell	1993	515	77
North Cordero	P82851W ⁽²⁾	Anderson (Wyodak)	Campbell	1995	392	58
North Gillette	49-005-46837 ⁽¹⁾	Anderson	Campbell	2001	575	48
Remington Creek	49-033-23127 ⁽¹⁾	Anderson	Sheridan	2005	336	22
Section 25	49-005-07139 ⁽¹⁾	Anderson (Wyodak)	Campbell	1996	535	105
South Cordero	P82852W ⁽²⁾	Anderson (Wyodak)	Campbell	1995	363	48
Stuart Section 31	P106969W ⁽²⁾	Anderson (Wyodak)	Campbell	1998	780	116
Throne	P127243W ⁽²⁾	Anderson (Wyodak)	Campbell	2001	1511	-----
Williams Cedar Draw	49-005-07508 ⁽¹⁾	Anderson	Campbell	2007	803	58
Lone Tree	P121682W ⁽²⁾	Wyodak/Anderson	Campbell	2000	723	76

Table 2. Continued.

Monitoring well site name	Well identifier	Coal deposit(s)	County	Year first monitored	Well total depth (ft)	Completion interval thickness (ft)
21-Mile	49-005-07198 ⁽¹⁾	Big George	Campbell	2001	1325	37
All Night Creek	P128990W ⁽²⁾	Big George	Campbell	2001	1051	67
Bear Draw	49-019-25144 ⁽¹⁾	Big George	Johnson	2006	2448	110
Beaver Fed	49-005-50085 ⁽¹⁾	Big George	Campbell	2003	1256	70
Big Cat	49-019-06357 ⁽¹⁾	Big George	Johnson	2003	2065	77
Blackbird BG	49-005-33383 ⁽¹⁾	Big George	Campbell	2002	1155	37
Bullwhacker	P142614W ⁽²⁾	Big George	Johnson	2002	1447	92
Carr Draw	49-005-07635 ⁽¹⁾	Big George	Campbell	2007	1489	61
Coal Gulch	49-019-24209 ⁽¹⁾	Big George	Johnson	2005	1970	58
Double Tank	49-005-50083 ⁽¹⁾	Big George	Campbell	2002	1515	78
Echeta	-----	Big George	Campbell	1999	880	6
Fourmile (4-Mile)	49-005-07645 ⁽¹⁾	Big George	Campbell	2007	1686	87
Juniper	49-019-06457 ⁽¹⁾	Big George	Johnson	2001	1820	66
Kingsbury	49-019-06437 ⁽¹⁾	Big George	Johnson	2006	1505	-----
Napier	P133775W ⁽²⁾	Big George	Campbell	2001	1705	89
Pistol Point	P10894W ⁽²⁾	Big George	Campbell	1997	1559	10
Sasquatch	P63417W ⁽²⁾	Big George	Johnson	1998	1640	205
South Prong	49-005-07641 ⁽¹⁾	Big George	Campbell	2007	1272	46
Squaw Butte	P63739W ⁽²⁾	Big George	Sheridan	2005	615	-----
Streeter	P159897W ⁽²⁾	Big George	Johnson	2004	1400	27
West Pine Tree	49-005-56980 ⁽¹⁾	Big George	Campbell	2007	1542	93
Wild Turkey	49-019-21363 ⁽¹⁾	Big George	Johnson	2004	1333	86
Wormwood	49-005-07518 ⁽¹⁾	Big George	Campbell	2006	1180	108
Buffalo SE	49-019-06350 ⁽¹⁾	Smith	Johnson	2001	1610	8
Coal Gulch	49-019-24209 ⁽¹⁾	Smith	Johnson	2005	1970	13
Williams Cedar Draw	49-005-07507 ⁽¹⁾	Smith	Campbell	2007	453	30
North Gillette	49-005-46836 ⁽¹⁾	Canyon	Campbell	2001	608	32

Table 2. Continued.

Monitoring well site name	Well identifier	Coal deposit(s)	County	Year first monitored	Well total depth (ft)	Completion interval thickness (ft)
Palo	P129847W ⁽²⁾	Canyon	Campbell	2001	471	38
Redstone	-----	Canyon	Campbell	1988	310	69
Remington Creek	49-033-23126 ⁽¹⁾	Canyon	Sheridan	2005	639	14
Barton	49-005-43038 ⁽¹⁾	Cook	Campbell	2002	1055	31
Carr Draw	49-005-07634 ⁽¹⁾	Cook (Werner)	Campbell	2007	1811	45
L Quarter Circle Hills	49-033-25633 ⁽¹⁾	Cook	Sheridan	2005	711	25
Remington Creek	49-033-23107 ⁽¹⁾	Cook	Sheridan	2005	802	15
Williams Cedar Draw	49-005-07506 ⁽¹⁾	Cook (Werner)	Campbell	2008	1368	20
South Coal	-----	Cook/Lower Wall/Pawnee	Campbell	2001	818	36
Carr Draw	49-005-07636 ⁽¹⁾	Lower Cook (Gates/Wall)	Campbell	2007	2214	166
South Prong	49-005-07642 ⁽¹⁾	Lower Cook (Gates/Wall)	Campbell	2009	1720	8
20-Mile Butte	49-005-50985 ⁽¹⁾	Wall	Campbell	2004	1520	22
Barton	49-005-47264 ⁽¹⁾	Wall	Campbell	2002	1245	47
Carr Draw	49-005-07636 ⁽¹⁾	Wall (Gates/Wall)	Campbell	2007	2214	166
Cedar Draw	49-005-37156 ⁽¹⁾	Wall	Campbell	2004	1679	97
Rose Draw	49-019-25153 ⁽¹⁾	Wall	Johnson	2008	1986	45
Williams Cedar Draw	49-005-07506 ⁽¹⁾	Wall (Gates/Wall)	Campbell	2008	1368	32
L Quarter Circle Hills	49-033-25631 ⁽¹⁾	Wall/Pawnee	Sheridan	2005	954	14
20-Mile Butte	49-005-50986 ⁽¹⁾	Pawnee	Campbell	2004	1850	13
Leiter	P62919W ⁽²⁾	Pawnee	Sheridan	2002	-----	-----

⁽¹⁾ API numbers from the Wyoming Oil and Gas Conservation Commission⁽²⁾ Permit numbers from the Wyoming State Engineer's Office

Table 3. List of sand zone monitoring sites in the PRB. Sites are listed alphabetically.

Monitoring well site name	Well identifier	Lithology	Description	County	Year first monitored	Well total depth (ft.)	Completion interval thickness (ft.)
20-Mile Butte	49-005-50983 ⁽¹⁾	Wasatch sandstone	n/a	Campbell	2004	550	40
21-Mile	49-005-07200 ⁽¹⁾	Wasatch sandstone	n/a	Campbell	2001	899	221
All Night Creek	P128989W ⁽²⁾	Wasatch sandstone	sand	Campbell	2001	969	20
	-----	Wasatch sandstone	shallow sand	Campbell	2002	640	60
	-----	Wasatch sandstone	very shallow sand	Campbell	2002	420	70
	-----	Wasatch sandstone	very very shallow sand	Campbell	2002	240	40
Bar 76	49-005-31560 ⁽¹⁾	Wasatch sandstone	overburden sand	Campbell	1997	777	20
Barrett Persson	-----	Wasatch sandstone	overburden sand	Campbell	2001	1260	50
Bear Draw	P166862W ⁽²⁾	Wasatch sandstone	overburden sand	Johnson	2006	2190	42
Beaver Fed	49-005-50085 ⁽¹⁾	Wasatch sandstone	overburden sand	Campbell	2003	1256	73
Big Cat	49-019-06358 ⁽¹⁾	Wasatch sandstone	overburden sand	Johnson	2003	930	26
Blackbird Coleman	P125798W ⁽²⁾	Wasatch sandstone	overburden sand	Campbell	2002	700	20
Boondogle	P64166W ⁽²⁾	Wasatch sandstone	overburden sand	Johnson	2003	1063	202
Bowers	-----	Wasatch sandstone	sand	Campbell	1998	600	75
	-----	Wasatch sandstone	shallow sand	Campbell	1998	445	88
	-----	Wasatch sandstone	very shallow sand	Campbell	1998	355	85
	-----	Wasatch sandstone	very very shallow sand	Campbell	1998	83	15
Buffalo SE	49-019-06351 ⁽¹⁾	Wasatch sandstone	sand	Johnson	2001	1525	16
	P144312W ⁽²⁾	Wasatch sandstone	shallow sand	Johnson	2002	595	75
	P144311W ⁽²⁾	Wasatch sandstone	very shallow sand	Johnson	2002	230	75
	-----	Wasatch sandstone	very very shallow sand	Johnson	2002	130	75
Bull Creek	P153819W ⁽²⁾	-----	overburden sand	Johnson	2005	978	51
	P153817W ⁽²⁾	Wasatch sandstone	shallow sand	Johnson	2005	1652	40
Bullwhacker	-----	Wasatch sandstone	overburden sand	Johnson	2002	1300	36
Carr Draw	49-005-07634 ⁽¹⁾	Wasatch sandstone	overburden sand	Campbell	2007	1811	-----

Table 3. Continued.

Monitoring well site name	Well identifier	Lithology	Description	County	Year first monitored	Well total depth (ft.)	Completion interval thickness (ft.)
Cedar Draw	49-005-42272 ⁽¹⁾	Wasatch sandstone	overburden sand	Campbell	2004	9756	80
Dilts	P112454W ⁽²⁾	Wasatch sandstone	overburden sand	Campbell	1999	308	40
Dry Willow	-----	Wasatch sandstone	sand	Campbell	1999	1734	54
	-----	Wasatch sandstone	shallow sand	Campbell	1999	-----	-----
Duck Creek	-----	Wasatch sandstone	overburden sand	Converse	2005	-----	-----
Durham Ranch Section 6	P106974W ⁽²⁾	Wasatch sandstone	overburden sand	Campbell	1997	285	30
Durham Ranch Section 14	P106972W ⁽²⁾	Wasatch sandstone	overburden sand	Campbell	1998	690	35
Fourmile (4-mile)	49-005-07517 ⁽¹⁾	Wasatch sandstone	overburden sand	Campbell	2007	868	47
	49-005-07645 ⁽¹⁾	-----	underburden sand	Campbell	2007	1686	87
Hoe Creek	-----	Wasatch sandstone	overburden sand	Campbell	1998	210	60
Juniper	49-019-06352 ⁽¹⁾	Wasatch sandstone	sand	Johnson	2001	1150	44
	-----	Wasatch sandstone	shallow sand	Johnson	2002	640	90
Kennedy	P145907W ⁽²⁾	Wasatch sandstone	overburden sand	Campbell	2000	595	58
Kingsbury	-----	Fort Union sand	lower Big George sand	Johnson	2007	-----	-----
Lone Tree	P121683W ⁽²⁾	Wasatch sandstone	overburden sand	Campbell	2000	550	40
Lower Prairie Dog	-----	Wasatch sandstone	sand	Sheridan	2000	416	48
	-----	Wasatch sandstone	shallow sand	Sheridan	2002	280	45
L Quarter Circle Hills	49-033-25634 ⁽¹⁾	Wasatch sandstone	overburden sand	Sheridan	2005	672	24
MP 2	P90657W ⁽²⁾	Wasatch sandstone	overburden sand	Campbell	1993	310	50
MP 22	P90659W ⁽²⁾	Wasatch sandstone	sand	Campbell	1993	400	60
	P110020W ⁽²⁾	Wasatch sandstone	shallow sand	Campbell	1998	185	78
	P110021W ⁽²⁾	Wasatch sandstone	very shallow sand	Campbell	1998	80	65
Napier	P133776W ⁽²⁾	Wasatch sandstone	overburden sand	Campbell	2001	1700	60
North Gillette	-----	Wasatch sandstone	overburden sand	Campbell	2001	736	6

Table 3. Continued.

Monitoring well site name	Well identifier	Lithology	Description	County	Year first monitored	Well total depth (ft.)	Completion interval thickness (ft.)
Palo	P129846W ⁽²⁾	Wasatch sandstone	overburden sand	Campbell	2001	385	90
Redstone	-----	Wasatch sandstone	overburden sand	Campbell	1998	185	25
Remington Creek	-----	Wasatch sandstone	overburden sand	Sheridan	2005	30	6
Rose Draw	49-019-06453 ⁽¹⁾	Wasatch sandstone	sand	Johnson	2009	-----	-----
	-----	Fort Union sand	underburden sand	Johnson	2009	-----	-----
Sasquatch	P133198W ⁽²⁾	Wasatch sandstone	overburden sand	Johnson	2001	-----	205
Section 25	P103547W ⁽²⁾	Wasatch sandstone	overburden sand	Campbell	1996	170	36
South Coal	-----	Wasatch sandstone	sand	Campbell	2001	575	51
	-----	Wasatch sandstone	shallow sand	Campbell	2005	-----	-----
	-----	Wasatch sandstone	very shallow sand	Campbell	2005	-----	-----
South Prong	-----	Wasatch sandstone	shallow sand	Campbell	2008	484	32
	49-005-07644 ⁽¹⁾	Fort Union sand	underburden sand	Campbell	2008	1847	52
Streeter	P159898W ⁽²⁾	Wasatch sandstone	overburden sand	Johnson	2004	800	208
Stuart Section 31	P106970W ⁽²⁾	Wasatch sandstone	sand	Campbell	1997	580	20
Throne	P127244W ⁽²⁾	Wasatch sandstone	overburden sand	Campbell	2001	1511	50
West Pine Tree	49-005-56980 ⁽¹⁾	Wasatch sandstone	overburden sand	Campbell	2007	1542	27
Wild Turkey	49-019-06406 ⁽¹⁾	Wasatch sandstone	overburden sand	Johnson	2004	1144	20
Williams Cedar Draw	-----	Wasatch sandstone	shallow sand	Campbell	2007	260	32
	P171911W ⁽²⁾	-----	underburden sand	Campbell	2007	680	70
Wormwood	-----	Wasatch sandstone	sand	Campbell	2006	1509	63
	-----	Wasatch sandstone	shallow sand	Campbell	2006	553	42

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

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

Table 4. Coal nomenclature table for the PRB, Wyoming (modified from Jones, 2008).

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

sandstones overlie Fort Union coal beds. They are often permeable and porous, and can hold significant groundwater resources (Jones, 2008; Clarey et al., 2010; Flores et al., 2010). They also consist of coarse- to fine-grained beds that are often lenticular or interbedded with clays, shales, and siltstones (Clarey and Stafford, 2008). Due to complex stratigraphic relationships, it is unlikely that monitored sandstones are continuous, related aquifers even at a local scale (Flores et al., 2010). Groundwater data for Wasatch sandstones are categorized to associated coal zones (see Appendices).

The Eocene Wasatch Formation also includes three defined coal zones (Table 4; Jones, 2008). Currently, Wasatch Formation coal zones are not monitored for groundwater drawdown. They are mentioned here as they are included in figures throughout the Appendices, as a means to bracket the coal stratigraphy of the PRB.

DISCUSSION

Groundwater Drawdown and Recharge Trends in Monitored Coal Zones and Sandstones for 2006 through 2009

Sandstones

BLM groundwater monitoring wells recorded data from sandstone beds in the Wasatch and Fort Union formations between the 2006-2009 monitoring period (Table 3). Eighteen sandstones recorded an increase in groundwater levels. Though it is a general

trend, the majority of monitored sandstones with increased groundwater levels were located around the periphery of the monitoring well site system. This data does not distinguish between a recovering sandstone aquifer where hydrostatic pressure around a depressed area is actively equilibrating, or a recharging sandstone aquifer in which a new water source is increasing groundwater levels.

Several monitoring wells recorded a steep drop in sandstone groundwater levels over the monitoring period (>100 ft.) (Figure 7). These sandstones are ei-

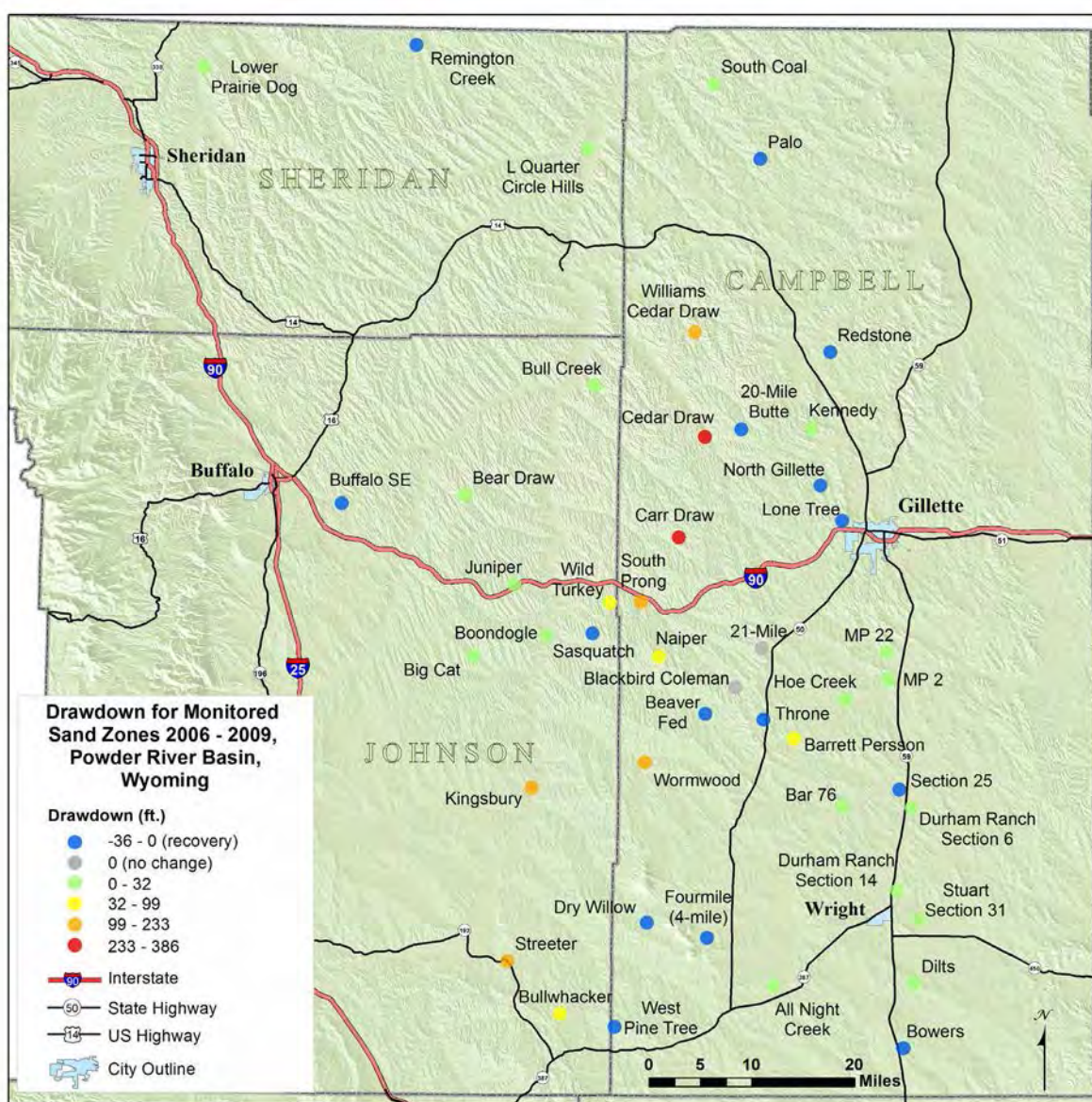


Figure 7. Groundwater level changes in monitored sand zones between 2006-2009.

ther associated with the Wyodak Rider (Big George) (Big George) or Wall coal zones, both of which had relatively substantial water production. Monitored sandstones associated with the Upper Wyodak coal zone, though the most numerous, generally recorded the most stable groundwater levels (lower draw-down values and some recharge). The Upper Wyodak coal zone is located along the eastern margin of the basin and was the location of the first, extensive

CBNG development in the PRB (WOGCC, 2011). Relatively steady groundwater levels in the overlying sandstones could represent effective dewatering of the coal zone, or decreasing water production in many of the older wells.

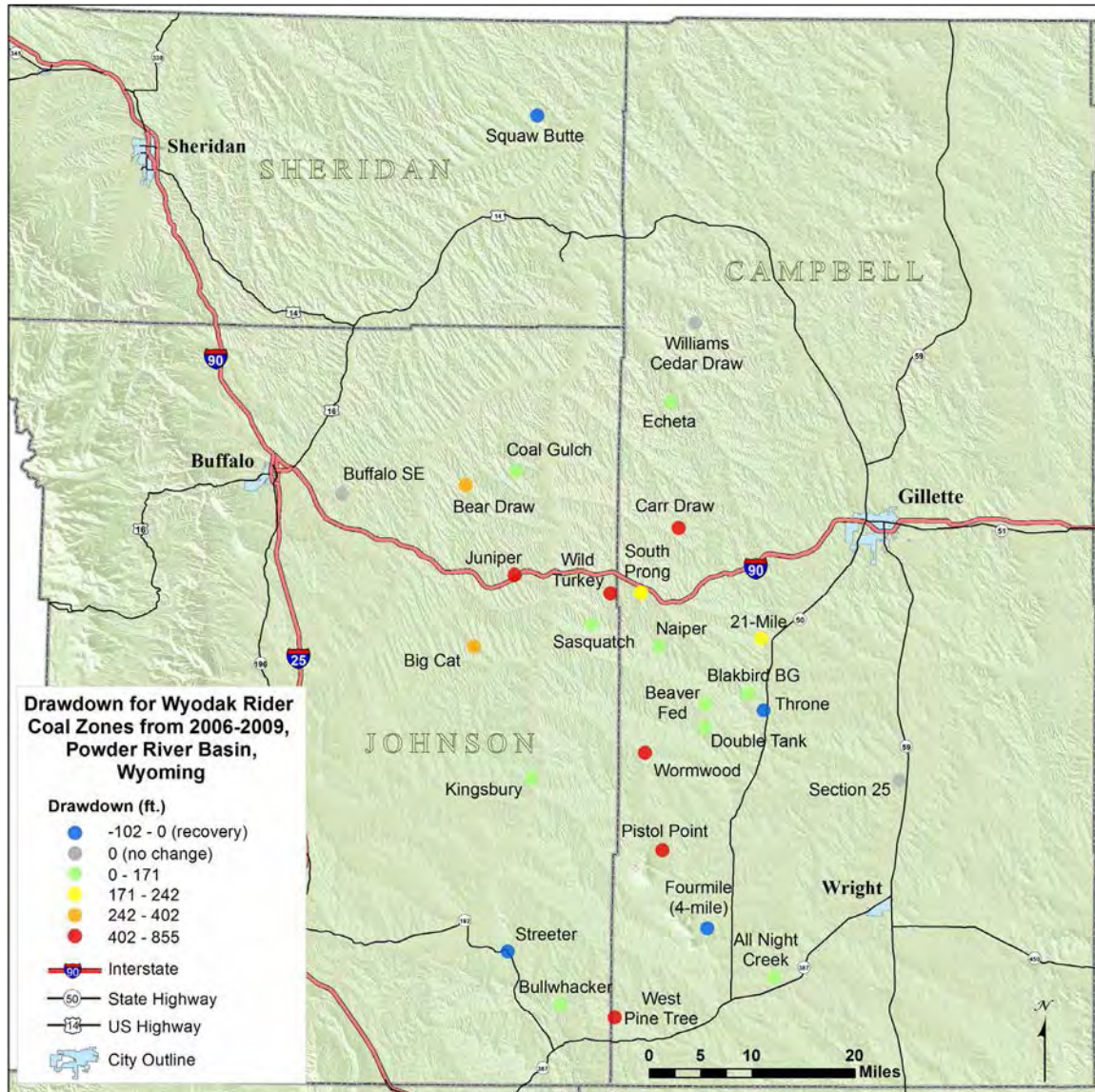


Figure 8. Groundwater level changes in monitored coals in the Wyodak Rider (Big George) coal zone between 2006-2009.

GROUNDWATER DRAWDOWN TRENDS BY COAL ZONE

Wyodak Rider (Big George) Coal Zone Groundwater Trends

Groundwater monitoring in the Wyodak Rider (Big George) coal zone is focused on the west-central basin (Figure 8). Generally, coal aquifers in the Wyodak Rider (Big George) coal zone recorded the highest groundwater level drawdowns during the 2006-2009 monitoring period (Figure 8). Many of the monitored coal beds in the Wyodak Rider (Big

George) zone recorded over 400 feet of total drawdown between the 2006-2009 monitoring period (Figure 8). The Wyodak Rider (Big George) contains the Big George coal bed, which produced more gas over this period than any other coal (WOGCC, 2011). Due to the thickness and depth of this coal, Big George CBNG wells often underwent a longer period of water production than other wells (WOGCC, 2011).

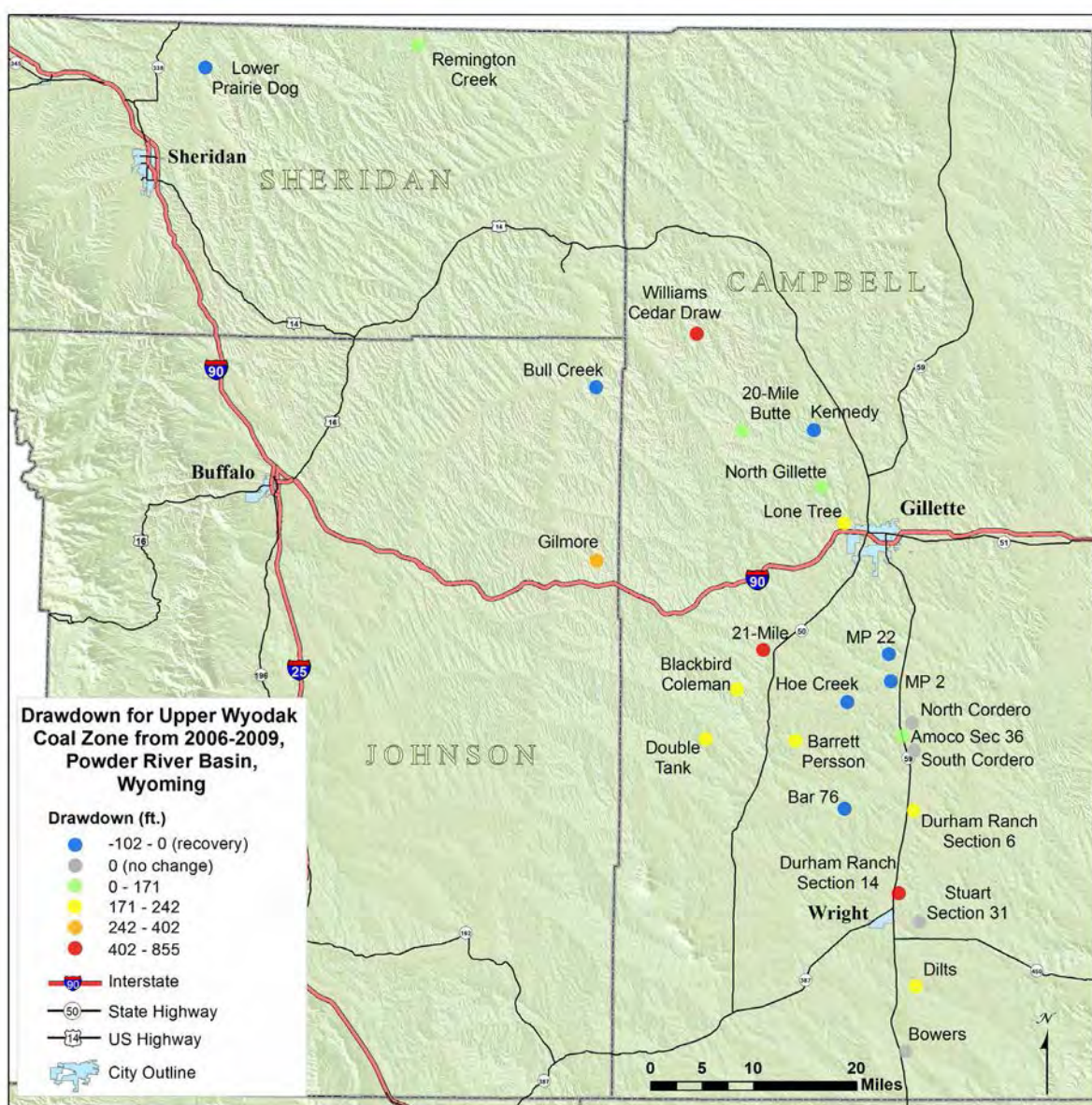


Figure 9. Groundwater level changes in monitored coals in the Upper Wyodak coal zone between 2006-2009.

Upper Wyodak Coal Zone Groundwater Trends

Groundwater monitoring in the Upper Wyodak zone is mainly focused on the eastern basin, although there are two monitoring well sites near the Montana border (Figure 9). Coal aquifers in the Upper Wyodak coal zone recorded relatively moderate groundwater level drawdowns during the 2006-2009 monitoring period (Figure 9). Many monitored coal aquifers in the Upper Wyodak coal zone began to show evidence of groundwater level recovery,

particularly later in the 2006-2009 monitoring period (see Appendix 3). As the Wyodak coal zone was the first to extensively produce CBNG, it is likely these coals will be the first to recover groundwater levels post-production. Therefore, the Wyodak coal zone could provide the best model for characteristics of coal bed groundwater resources post-CBNG production.

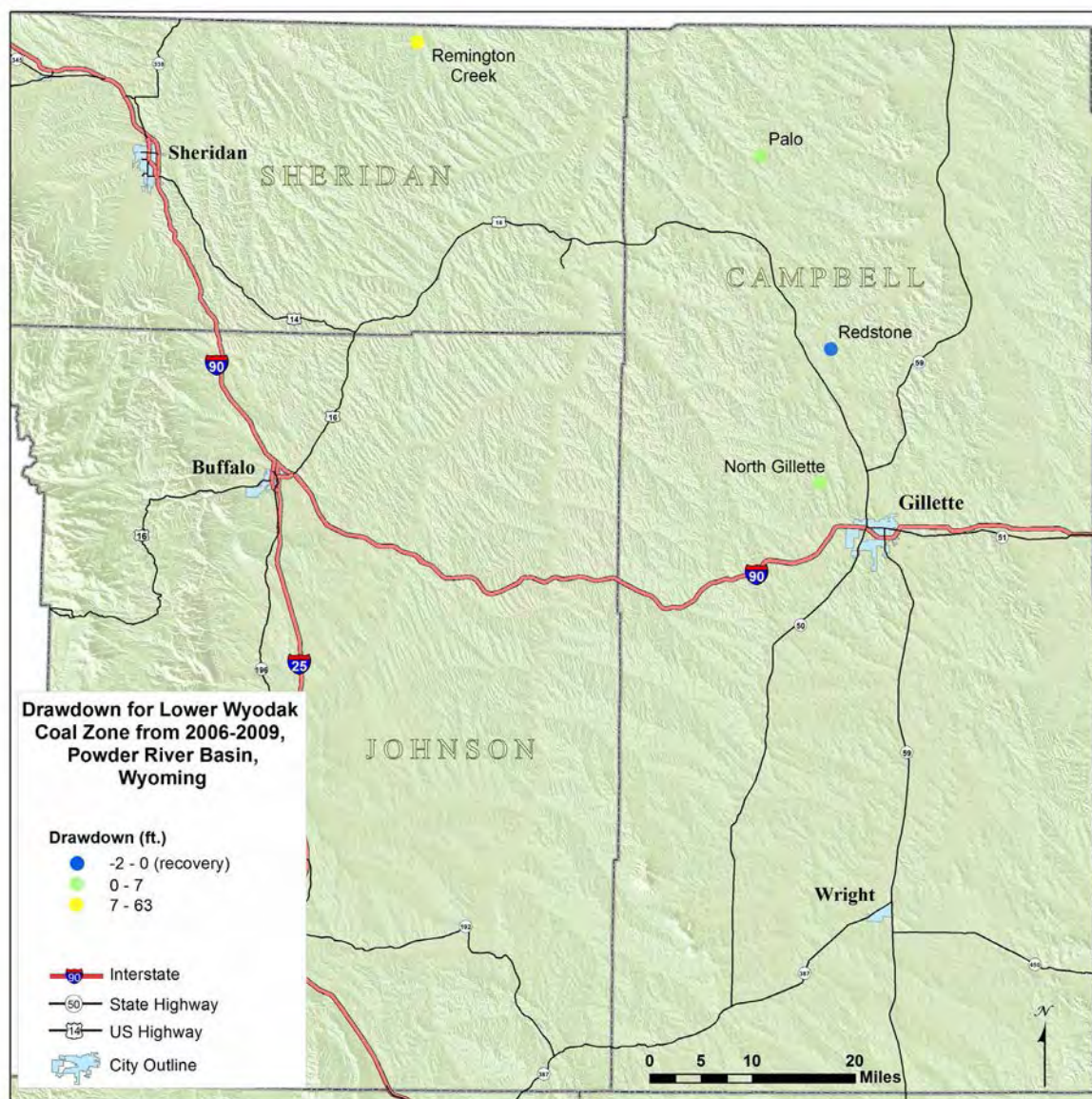


Figure 10. Groundwater level changes in monitored coals in the Lower Wyodak coal zone between 2006-2009.

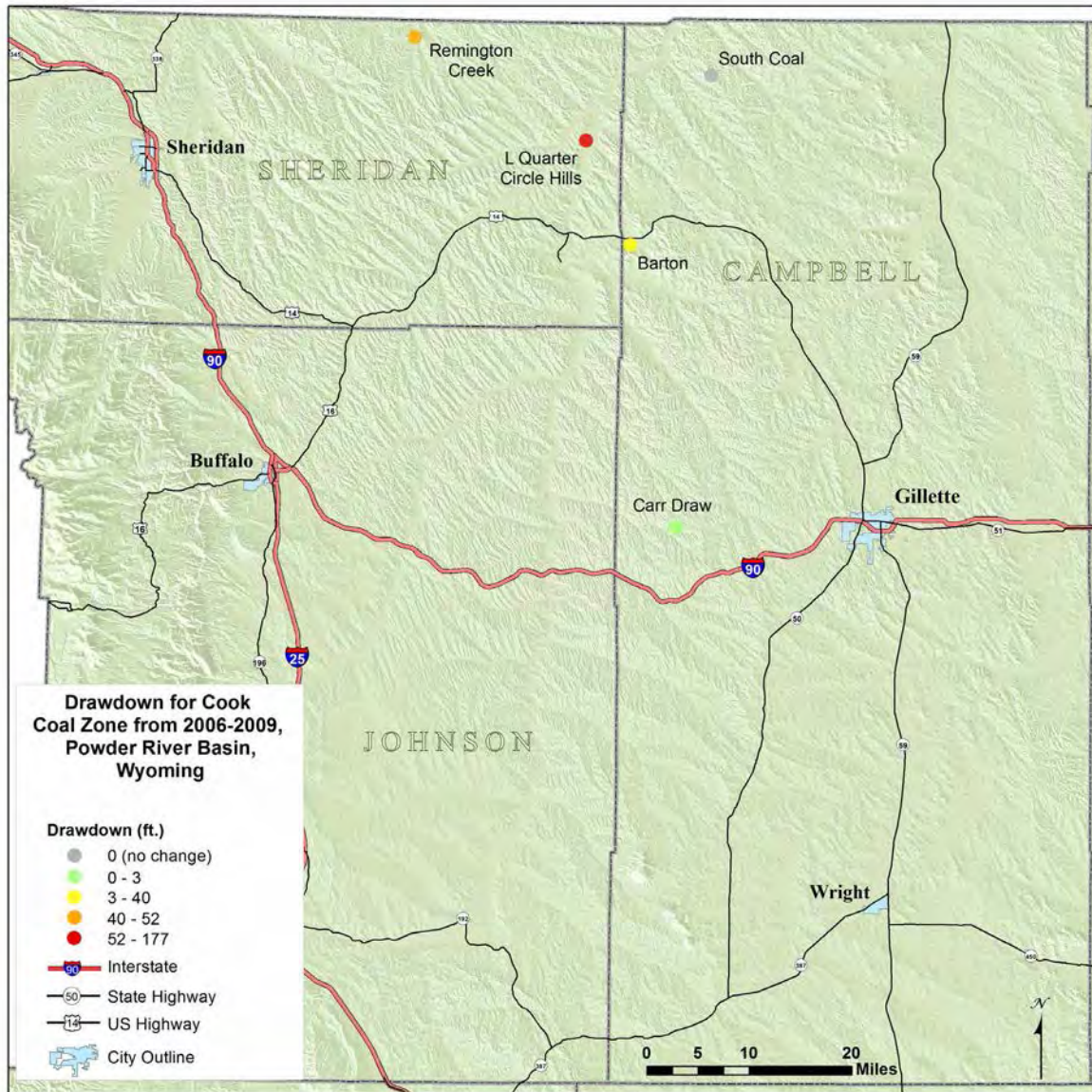


Figure 11. Groundwater level changes in monitored coals in the Cook coal zone between 2006-2009.

Lower Wyodak Coal Zone Groundwater Trends

Groundwater monitoring in the Lower Wyodak zone is focused on the east-central basin, although there is one monitoring well site near the Montana border (Figure 10). This zone only contains four monitoring well sites and groundwater level drawdown was relatively modest, as all sites recorded less than 65 feet of drawdown during the 2006-2009 monitoring period (Figure 10).

Cook Coal Zone Groundwater Trends

Groundwater monitoring in the Cook zone is focused on the north-central basin, although there is one well site between Gillette and Buffalo (Figure 11). This zone only contains five monitoring well sites and groundwater level drawdown was variable during the 2006-2009 monitoring period. Four of the well sites recorded less than 52 feet of drawdown, while the other site recorded over 52 feet of drawdown (Figure 11).

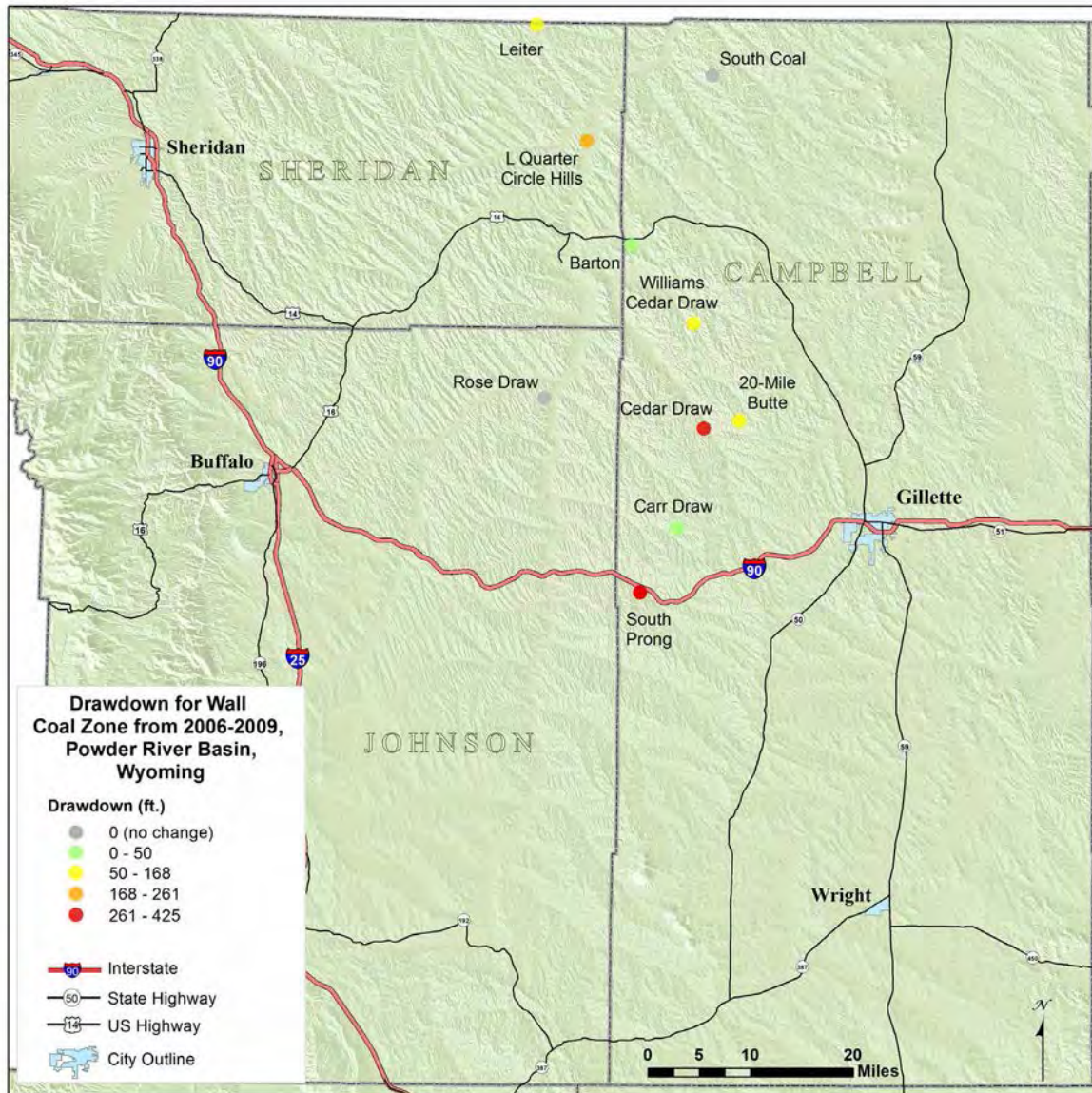


Figure 12. Groundwater level changes in monitored coals in the Wall coal zone between 2006-2009.

Wall Coal Zone Groundwater Trends

Groundwater monitoring in the Wall zone is focused on the north-central basin (Figure 12). Groundwater level drawdown was variable, though sites in the Wall coal zone did record relatively high amounts of drawdown (Figure 12). This zone contains 10 monitoring well sites.

CBNG PRODUCTION TRENDS PROXIMAL TO BLM GROUNDWATER MONITORING WELLS

Wyodak Rider (Big George) Coal Zone Production Trends

The Wyodak Rider (Big George) coal zone includes production data for 673 CBNG wells within the buffered zones (Figure 13). These wells produced a total of 68,093,897 barrels of water, and 56,405,720 Mcf of gas from 2006-2009 (Table 5). The average water/gas ratio of wells within the buffer zone is 1.4 (Table 6).

Water production rose through 2008, and declined in 2009 (Table 5). Gas production rose throughout the monitored interval; water/gas ratios declined.

Table 5. Cumulative water (Bbls) and gas (Mcf) production values for all CBNG wells within the monitoring buffer by coal zone.

Coal Zone	Water Production (Bbls)			Total	Gas Production (Mcf)			Total		
	2006	2007	2008		2009	2006	2007		2008	2009
Wyodak Rider (Big George)	13,535,370	17,729,834	20,004,109	16,824,584	68,093,897	7,146,771	10,490,263	18,951,272	19,817,414	56,405,720
Upper Wyodak	10,662,462	6,836,645	4,454,101	3,580,173	25,533,381	6,249,129	3,339,436	2,434,850	1,660,231	13,683,646
Lower Wyodak	2,105,151	2,342,472	2,845,997	2,719,122	10,012,742	472,252	562,887	576,513	558,357	2,170,009
Cook	1,638,078	1,886,583	2,582,951	2,721,737	8,829,349	270,225	228,303	154,680	180,675	833,883
Wall	1,965,780	3,217,185	3,520,900	3,963,071	12,666,936	214,596	338,120	341,632	220,717	1,115,065
Total	29,906,841	32,012,719	33,408,058	29,808,687	125,136,305	14,352,973	14,959,009	22,458,947	22,437,394	74,208,323

Table 6. Water/gas ratios of all analyzed CBNG wells by coal zone. Data from Table 5.

Coal Zone	Water/Gas Ratio			Average	
	2006	2007	2008		
Wyodak Rider (Big George)	1.9	1.7	1.1	0.8	1.4
Upper Wyodak	1.7	1.9	1.9	2.4	1.9
Lower Wyodak	4.5	4.2	4.9	4.9	4.6
Cook	6.1	8.4	18.2	15.1	11.9
Wall	9.2	10.3	11.2	20.3	12.8
Average	4.7	5.3	7.5	8.7	6.5

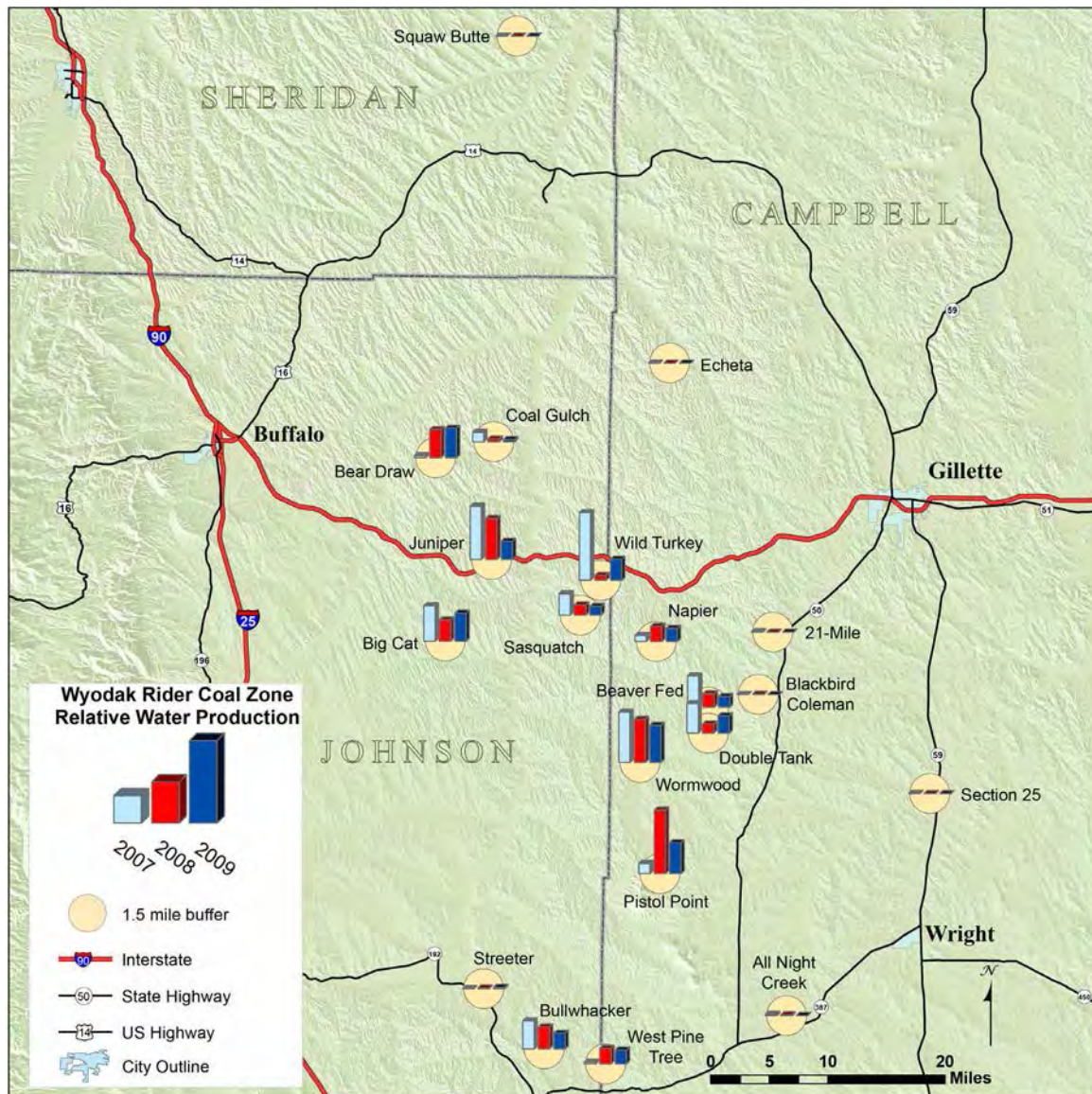


Figure 13. Relative water production for the years 2007-2009 for all Wyodak Rider (Big George) wells within the monitoring well buffer. Production from 2006 was omitted for simplicity of display.

Declining water/gas ratios suggests that these wells have been effectively dewatered. Wyodak Rider (Big George) CBNG wells produced the most water and gas of all buffered coal zones (approximately 54 percent of the total water and 76 percent of the total gas), but were also the most efficient producers relative to the water/gas ratio (Table 6).

Upper Wyodak Coal Zone Production Trends

The Upper Wyodak coal zone includes production data for 542 CBNG wells within the buffered

zones (Figure 14). These wells produced a total of 25,533,381 barrels of water and 13,683,646 cubic feet of gas from 2006-2009. The average water/gas ratio of wells within the buffer zone is 1.9 (Table 6). Water and gas production declined significantly through the monitored interval; water/gas ratios rose slightly (Table 6). Rising water/gas ratios were likely the result of increasing production along the fringes of the coal zone (Figure 14). Upper Wyodak CBNG wells produced approximately 20 percent of the total water and 18 percent of the total gas.

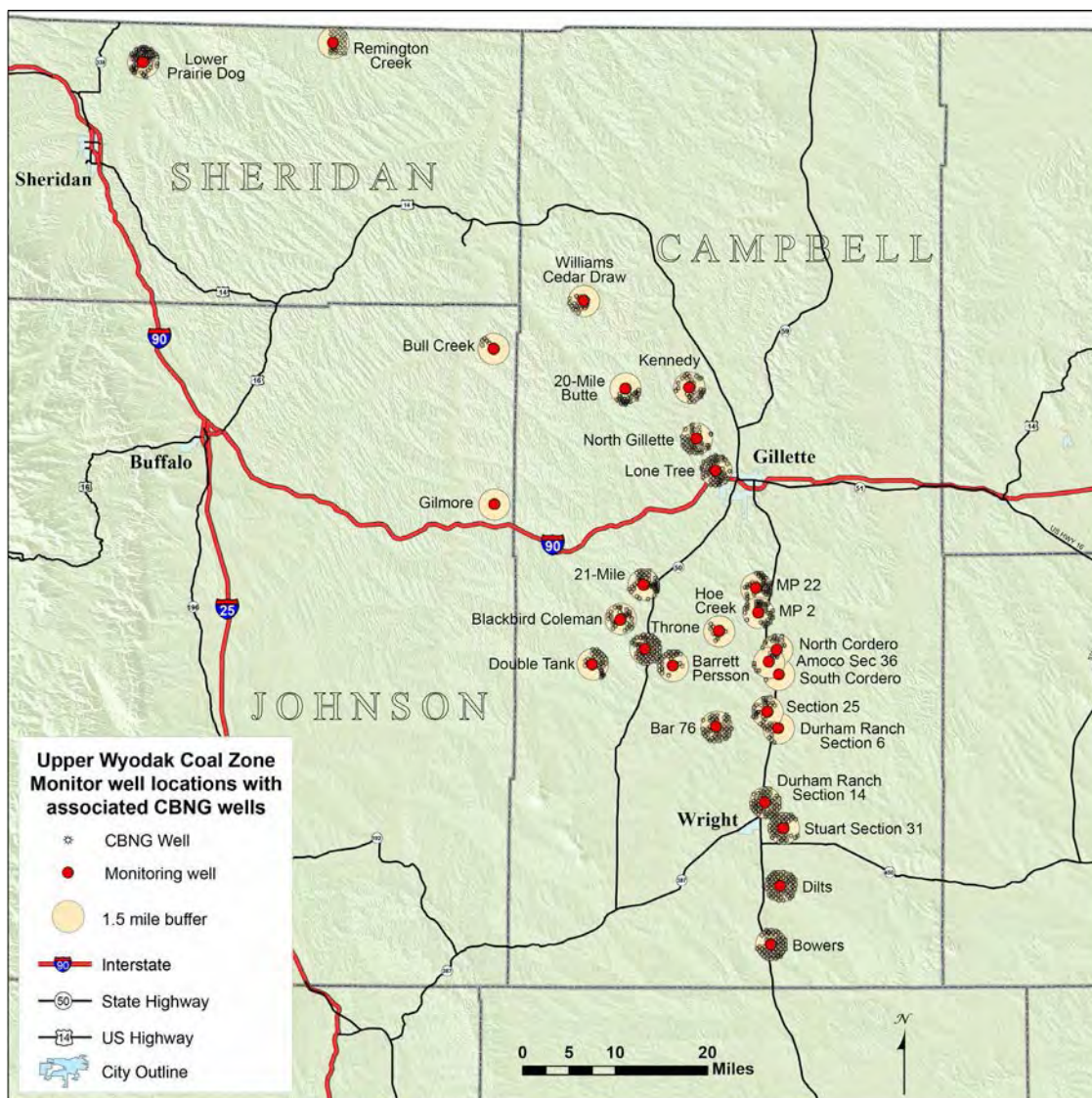


Figure 14. Monitoring well site locations with associated CBNG wells for the upper Wyodak coal zone.

Lower Wyodak Coal Zone Production Trends

The Lower Wyodak coal zone includes production data for 130 CBNG wells within the buffered zones (Figure 15). These wells produced a total of 10,012,742 barrels of water, and 2,170,009 Mcf of gas from 2006-2009. The average water/gas ratio of wells within the buffer zone is 4.6 (Table 6).

Water and gas production declined through the monitored interval; water/gas ratios remained mostly constant (Table 6). Lower Wyodak CBNG wells produced approximately 8 percent of the total water and 3 percent of the total gas.

Cook Coal Zone Production Trends

The Cook coal zone includes production data for 44 CBNG wells within the buffered zones. These wells produced a total of 8,829,349 barrels of water and 833,883 Mcf of gas from 2006-2009. The average water/gas ratio of wells within the buffer zone is 11.9 (Table 6). Bar graphs represent the water produced by year (Figure 16).

Monitored CBNG production in the Cook coal zone is focused on the north-central basin, though there is one well site between Gillette and Buffalo (Figure 16). Water production increased through the monitored interval, although gas production

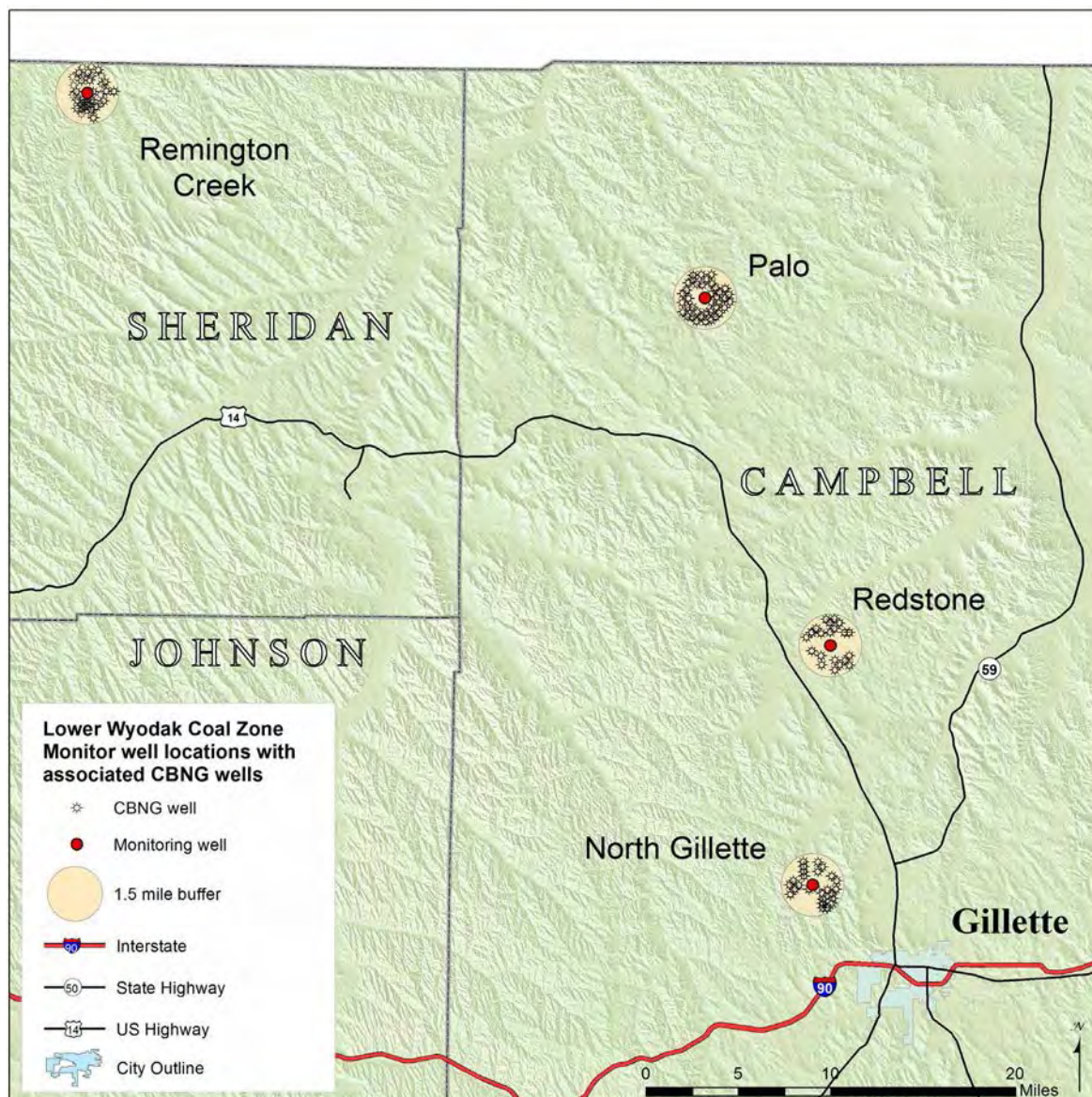


Figure 15. Monitoring well site locations with associated CBNG wells for the Lower Wyodak coal zone.

decreased. Water/gas ratios showed a relatively large increase in 2008, and then a modest decline in 2009 (Table 6). Cook CBNG wells produced approximately 7 percent of the total water and 1 percent of the total gas.

Wall Coal Zone Production Trends

The Wall coal zone includes production data for 155 CBNG wells within the buffered zones (Figure 17). These wells produced a total of 12,666,936 barrels of water and 1,115,065 Mcf of gas from 2006-2009. The Wall CBNG wells have the highest average wa-

ter/gas ratio of wells within the buffer zone at 12.8 (Table 6).

Water production increased through the 2006-2009 interval; however, gas production decreased in 2009. The Wall wells showed the greatest increase in water/gas ratios (Table 6). Wall CBNG wells produced approximately 10 percent of the total water and 1 percent of the total gas.

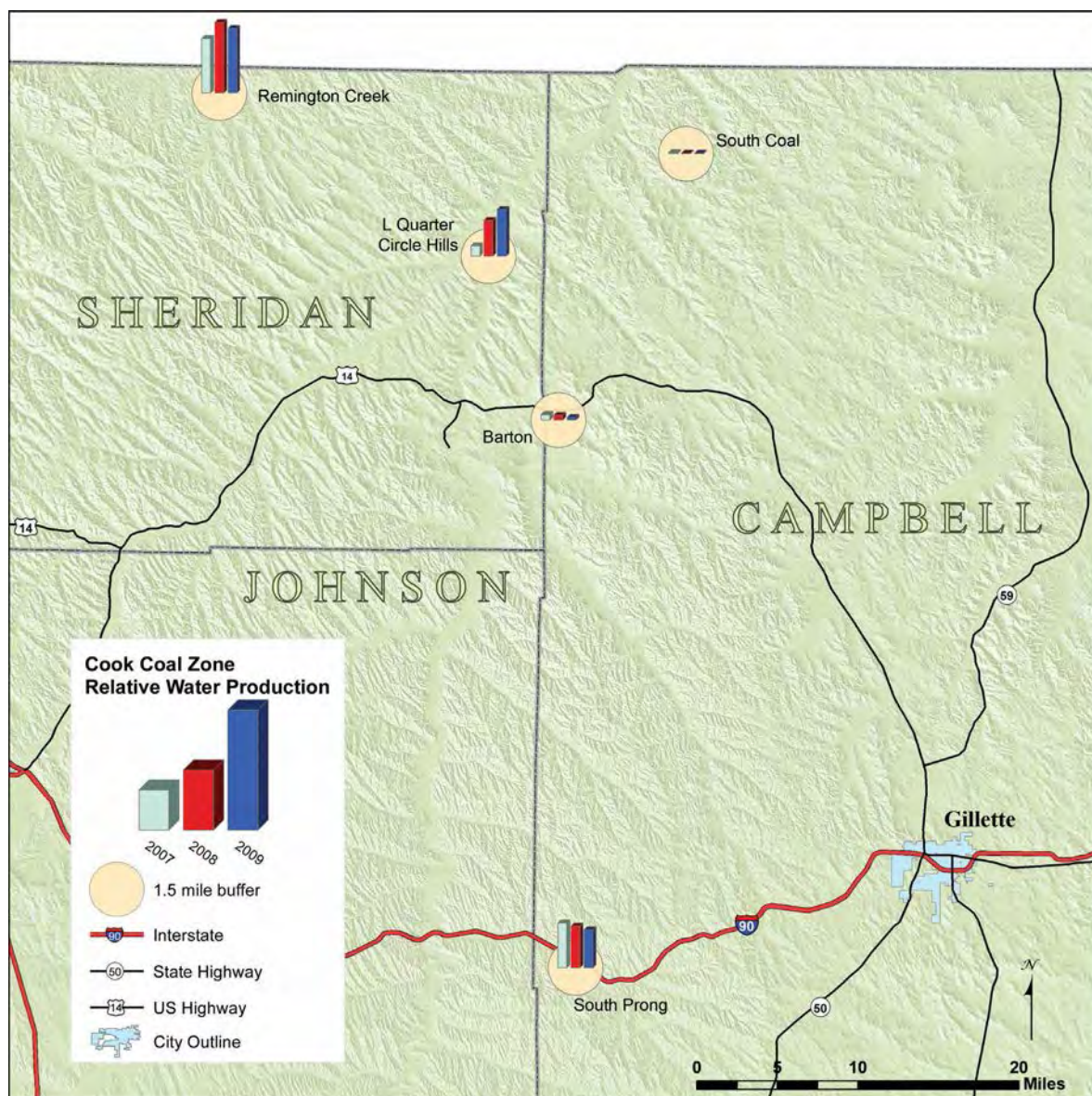


Figure 16. Relative water production for the years 2007-2009 for all Cook wells within the monitoring well buffer. Production from 2006 was omitted for simplicity of display.

Summation of CBNG Production

In the Wyoming portion of the Powder River Basin the total production for all CBNG wells for the period from 1987 through 2009 was 6,048,855,243 Bbls (779,656 acre-feet) of water and 3,744,799,544 Mcf of natural gas. During the 2006-2009 monitoring period the total production was 2,587,150,025 Bbls (333,466 acre-feet) of water and 1,903,598,426 Mcf of natural gas (figure 6). For comparison, during the 2006-2009 monitoring period, CBNG wells in monitored buffer zones produced 125,136,305 Bbls (16,129 acre-feet) of water and 74,208,323

Mcf of natural gas (Table 5). These values represent approximately 5% for and 4% respectively of the total water and natural gas produced in the PRB from CBNG wells. The 16,129 acre-feet of water produced from the wells in the buffer zones would fill Wheatland Reservoir Number 1 in Platte County, or James Lake in the Bighorn Mountains (Stafford and Gracias, 2009). Increased production in the Wyodak Rider (Big George) wells throughout 2008 and 2009 resulted in the most prolific gas producing years (Table 5). Of the five coal zones, the Wyodak Rider (Big George) CBNG wells produced the most

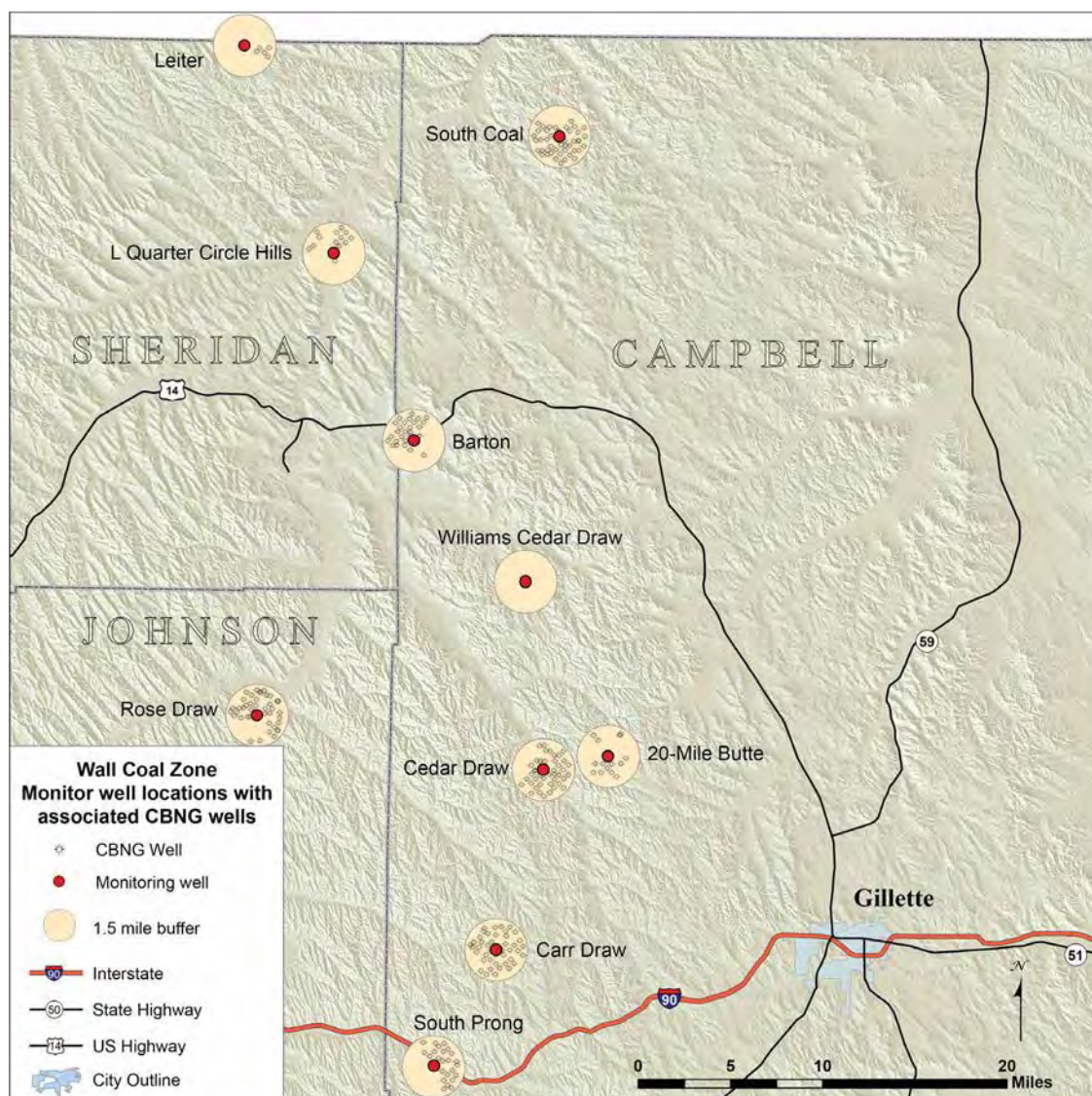


Figure 17. Monitoring well site locations with associated CBNG wells for the Wall coal zone.

water, and the Cook coal wells produced the least water (Table 5). Relative to water/gas ratios, the Wyodak Rider (Big George) CBNG wells were the most efficient producers and the Wall CBNG wells were the least efficient producers. Table 5 also shows that the overall average water/gas ratios appear to increase with coal age and depth.

Methane Analysis and Monitoring Well Gas Pressure

Percent methane was analyzed from both sandstone and coal bed BLM monitoring wells (see Methods for techniques). Percent gas from PRB coals has previously been analyzed by Flores et al. (2008). These

samples were collected directly from the wellhead, reducing the possibility of atmospheric contamination (Flores et al., 2008). The majority of gas samples from Fort Union coals contain more than 85 percent methane, followed by various amounts of carbon dioxide and nitrogen (Flores et al., 2008). Compared to the data collected by Flores et al. (2008), percent methane samples analyzed in this report had a high degree of variability (Appendices). This indicates the possibility of atmospheric contamination during sampling.

Monitoring well gas pressures were measured both electronically and manually during site visits (see

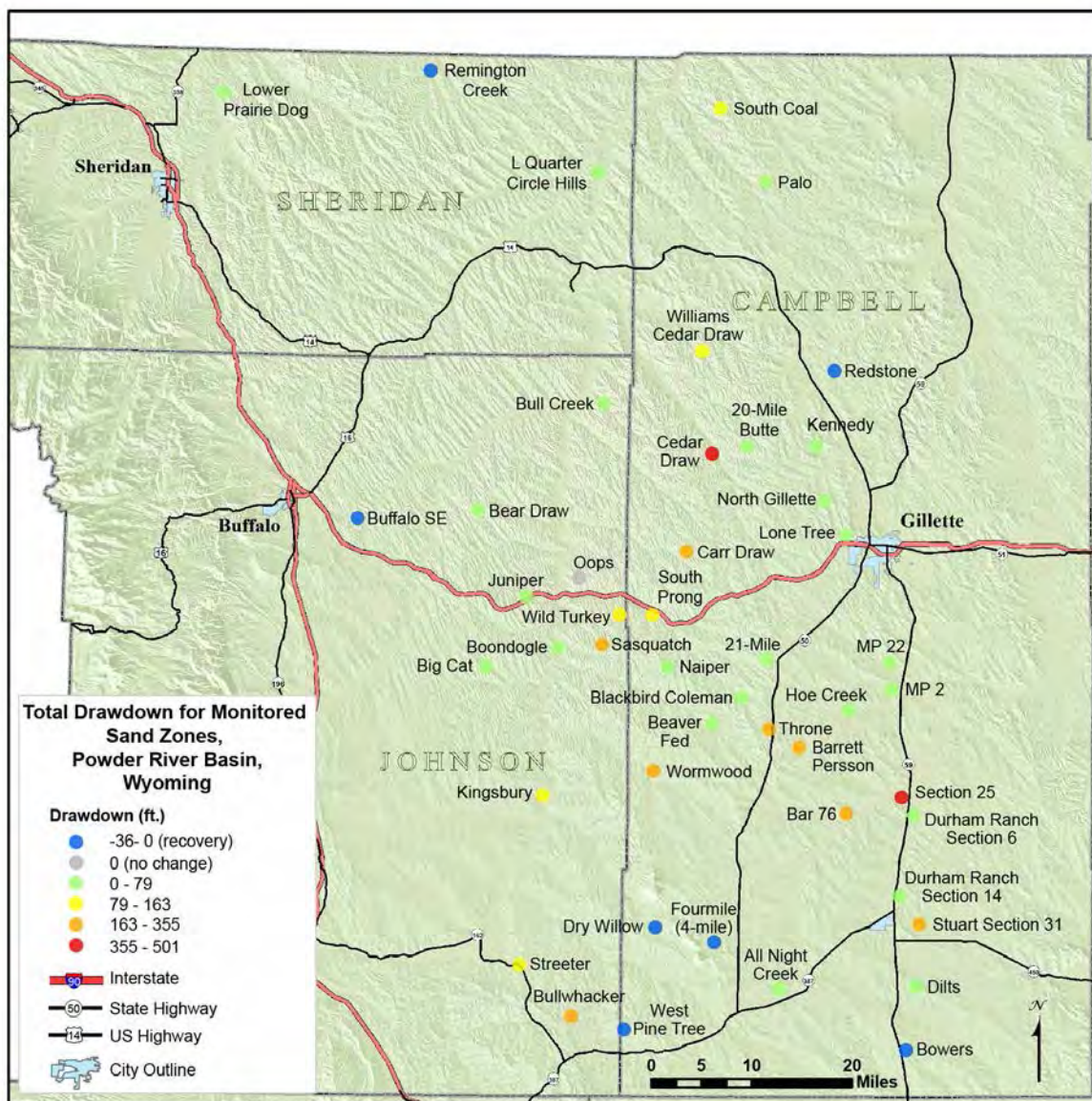


Figure 18. Total drawdown for monitored sand zones in the Powder River Basin, Wyoming.

Methods for techniques). Gas pressure is mostly site-specific; regional or coal zone trends were not apparent (Appendices).

CONCLUSIONS

Documented coal beds in the Wyodak Rider (Big George) coal zone showed an increase in CBNG production and associated groundwater drawdown during the 2006-2009 monitoring period. Wall coal zone CBNG wells were the least efficient producing wells relative to water/gas ratios and associated monitoring wells recorded relatively high amounts

of groundwater drawdown. Monitoring wells in the Upper Wyodak coal zone recorded several instances of groundwater level recovery. The Upper Wyodak has seen many years of CBNG production, and water production declined during the 2006-2009 monitoring period (WOGCC, 2011). Groundwater data from these wells should be examined closely in subsequent reports, and coal beds in the Upper Wyodak coal zone might be the initial location to study the response of Fort Union groundwater resources post-CBNG production.

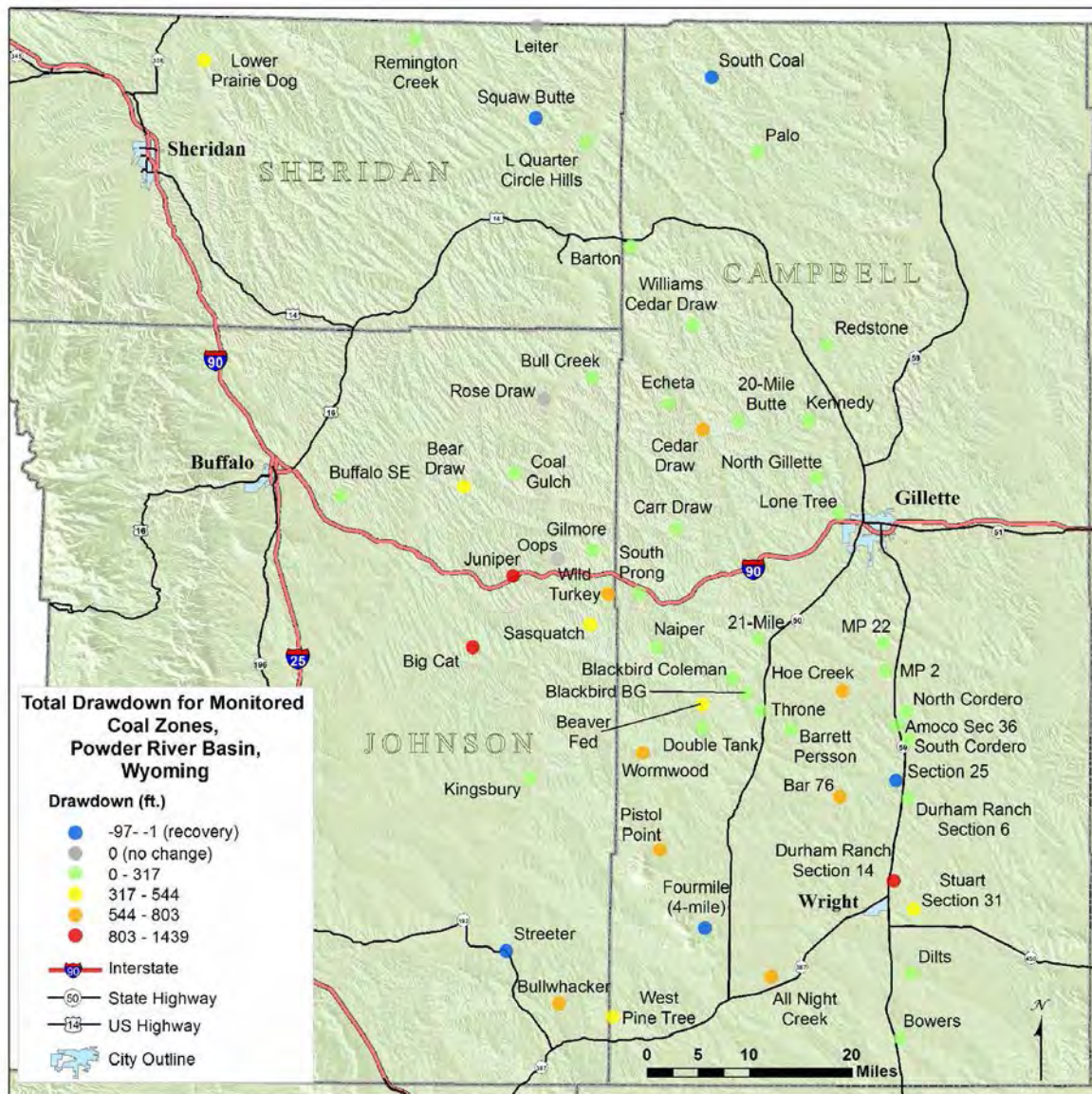


Figure 19. Total drawdown for monitored coal zones in the Powder River Basin, Wyoming.

Figures 18 and 19 show groundwater levels for the entire monitored duration of BLM coal bed and sandstone wells. Figure 19 shows that the majority of monitored coal beds recorded groundwater drawdown, and many wells recorded more than 300 feet of water level decline. Figure 18 shows that the impact of CBNG production on sandstone aquifers in the PRB varies.

Figures 18 and 19 highlight the impact of CBNG production on groundwater aquifers in Wyoming's

PRB. Though production continues to expand across the basin, much of the east-central basin could be considered a mature CBNG field. Production has slowed, or held steady in much of the Upper Wyodak coal zone. This is a new phase of decreasing, or ceased production in the cycle of PRB coal bed resources. Data from the 2006-2009 monitoring period suggest that some groundwater aquifers in the Upper Wyodak coal zone are responding to the new phase and recovering. This shows that data from the BLM groundwater monitoring well-site network

will be as important in modeling the recovery of groundwater aquifers, post-CBNG production, as it was in determining the impact of CBNG production on groundwater aquifers in the PRB.

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APPENDICES

Evaluation of the monitoring wells and well sites of the BLM deep monitoring well network, Powder River Basin (PRB), Wyoming (2006-2009)

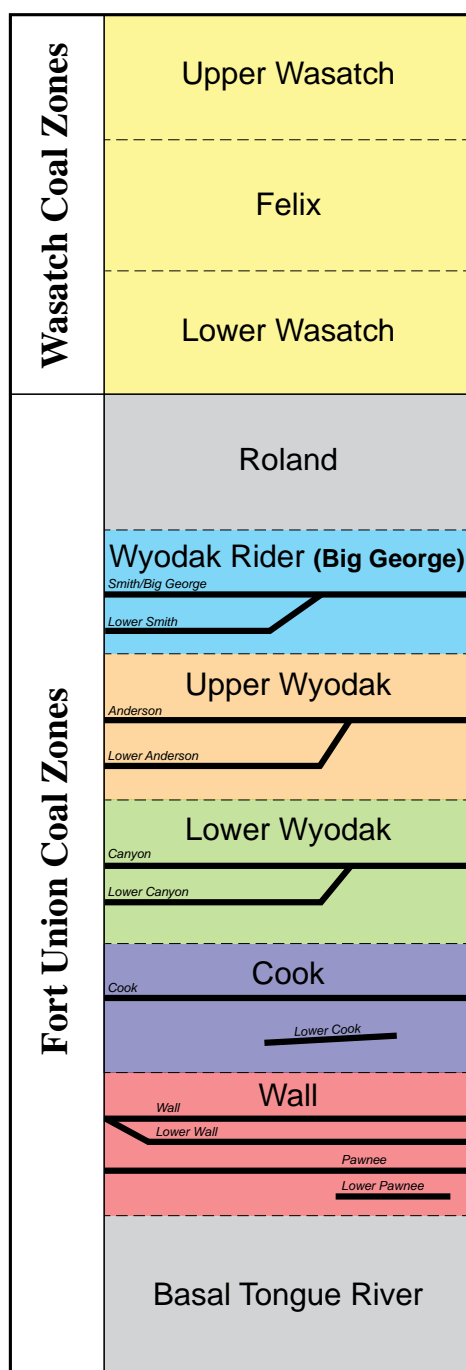


Figure 20. Stratigraphy chart of the geologic formations for coal zones in the Powder River Basin, Wyoming.

Appendices

1. Wasatch Coal Zone.....32
2. Wyodak Rider (Big George) Coal Zone.....39
3. Upper Wyodak Coal Zone.....163
4. Lower Wyodak Coal Zone.....291
5. Cook Coal Zone.....311
6. Wall Coal Zone..... 346

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

MR – Manual Recording

TR – Transducer Recording

Production graphs include the following abbreviations:

(Bbls) for barrels

(Mcf) for thousand cubic feet

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

- The drawdown and production graphs for all the monitoring well sites have a gray area that represents the current monitoring period of 2006-2009.
- It should also be noted that a negative number in the drawdown tables signifies a rise in water levels, while a positive number signifies a drop in the water level.
- All monitoring well data in the Appendix for the 2006-2009 report are classified by the five associated coal zones (see Monitored Zones and Coal Zone Designations). Monitoring wells were assigned to coal zones based on the completion interval and monitored strata. All monitored Wasatch sandstones have also been classified according to the associated monitored coal zones, with the exception of the Boondogle and Dry Willow wells, which are only completed into Wasatch sandstones.

APPENDIX I. Wasatch Coal Zone

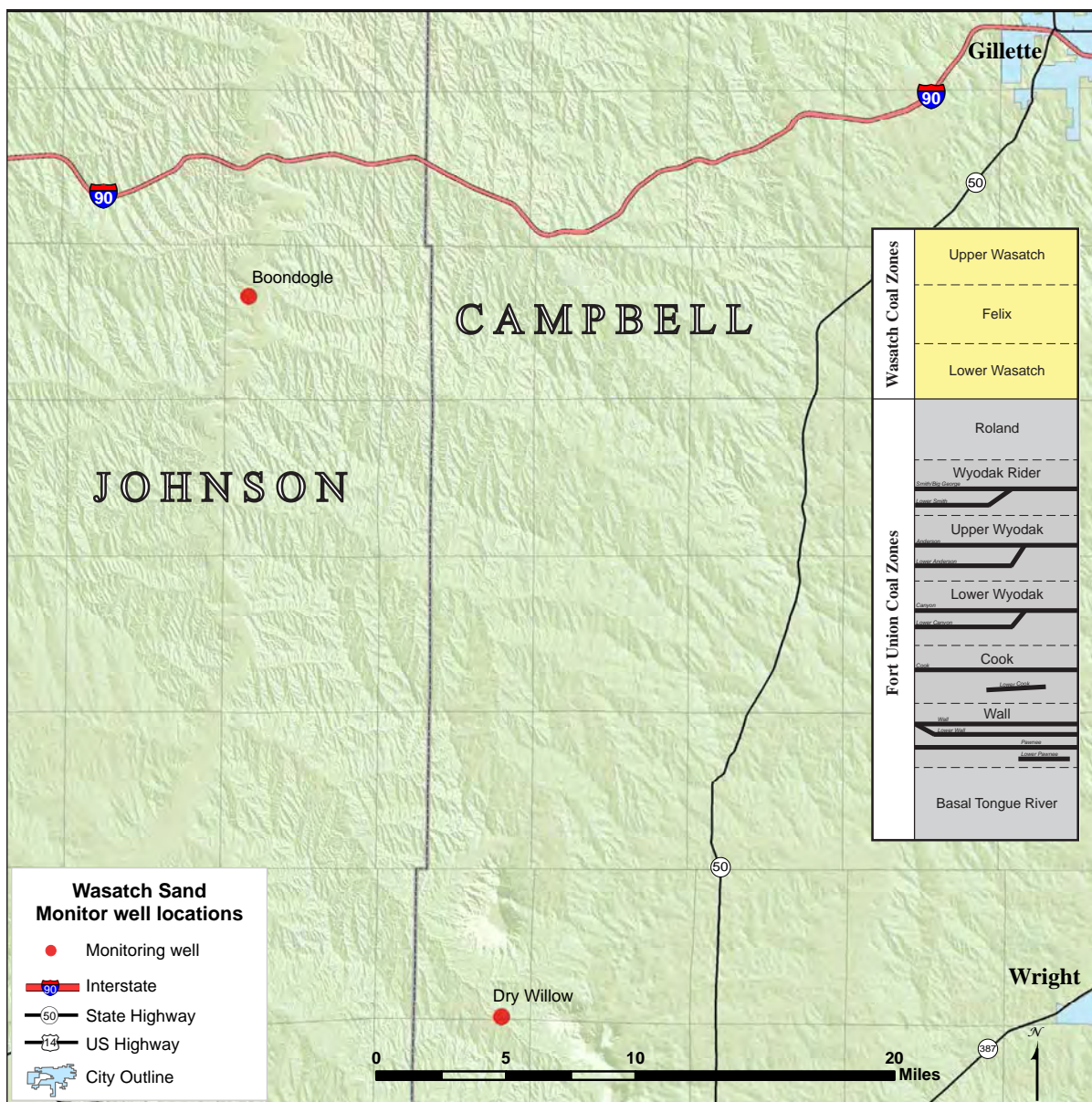


Figure 21. Wasatch coal zone monitoring well site locations in the Powder River Basin, Wyoming.

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

Drawdown Information

The Boondogle monitoring well site in Johnson County consists of one well drilled into a Wasatch sandstone (Figure 22; Table 7). A total of seven manual measurements were taken beginning in 2008.

Groundwater levels in the Wasatch sandstone declined by 24 feet during the 2006-2009 monitoring period; data shows a steady decline in the groundwater level (Figure 23; Table 8). Monitoring data suggests some hydraulic connectivity between this sandstone and producing regional coal zones. Gas pressure readings did not surpass levels possible from transducer error.

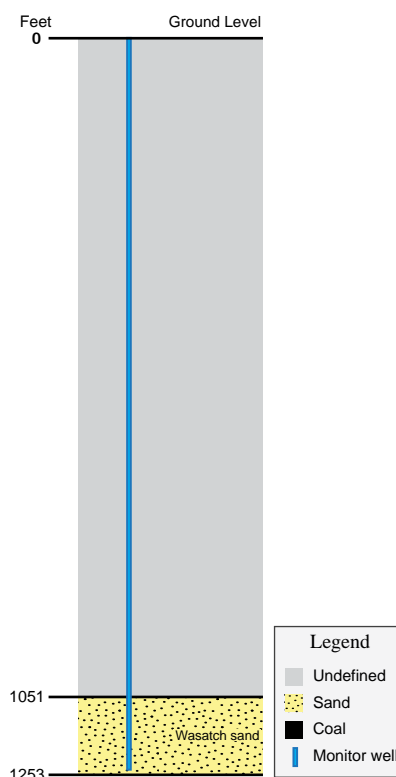


Figure 22. Section showing relative positions of coals and sands in feet. Not to scale.

Table 7. Table showing the depth to and thickness of monitored zones at the Boondogle monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Wasatch sand	1051	1253	202	n/a

Table 8. Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure of each zone.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2006	Drawdown 2006-2009	Total drawdown (ft.)	Depth to 12/30/09 water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	182.55	n/a	23.85	23.85	206.40	n/a	n/a

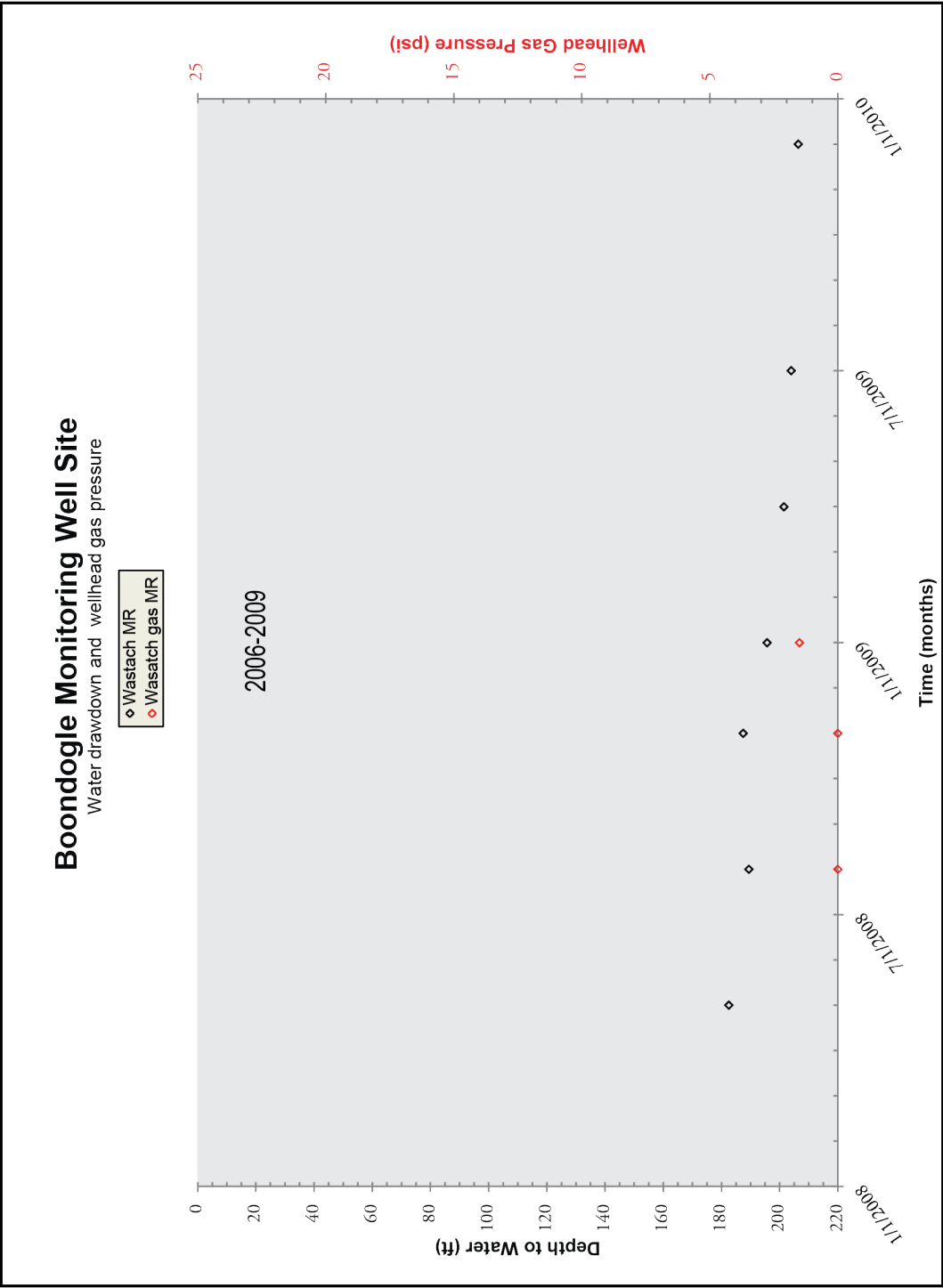


Figure 23. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Boondogle monitoring well site location.

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

Drawdown Information

The Dry Willow monitoring site consists of one well drilled into a Wasatch sandstone (Figure 24; Table 9). Missing and/or fluctuating transducer data is the result of errors with on-site equipment.

Groundwater levels in the Wasatch sandstone were stable during the 2006-2009 monitoring period, as they have been for the life of the well (Figure 25; Table 10). This, along with variable initial water levels, indicates there is no hydraulic connection between the monitored sandstone and producing zones. There are no associated gas pressure data.

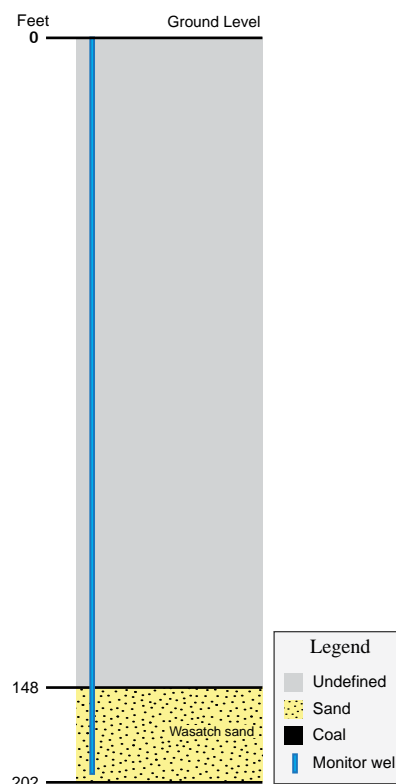


Figure 24. Section showing relative positions of coals and sands in feet. Not to scale.

Table 9. Table showing the depth to and thickness of monitored zones at the Dry Willow monitoring well site location. (measured in feet)

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

Table 10. Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2006	Drawdown 2006-2009	Total drawdown (ft.)	Depth to 12/30/09 water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	93.83	-1.08	0.10	-0.98	92.85	n/a	n/a

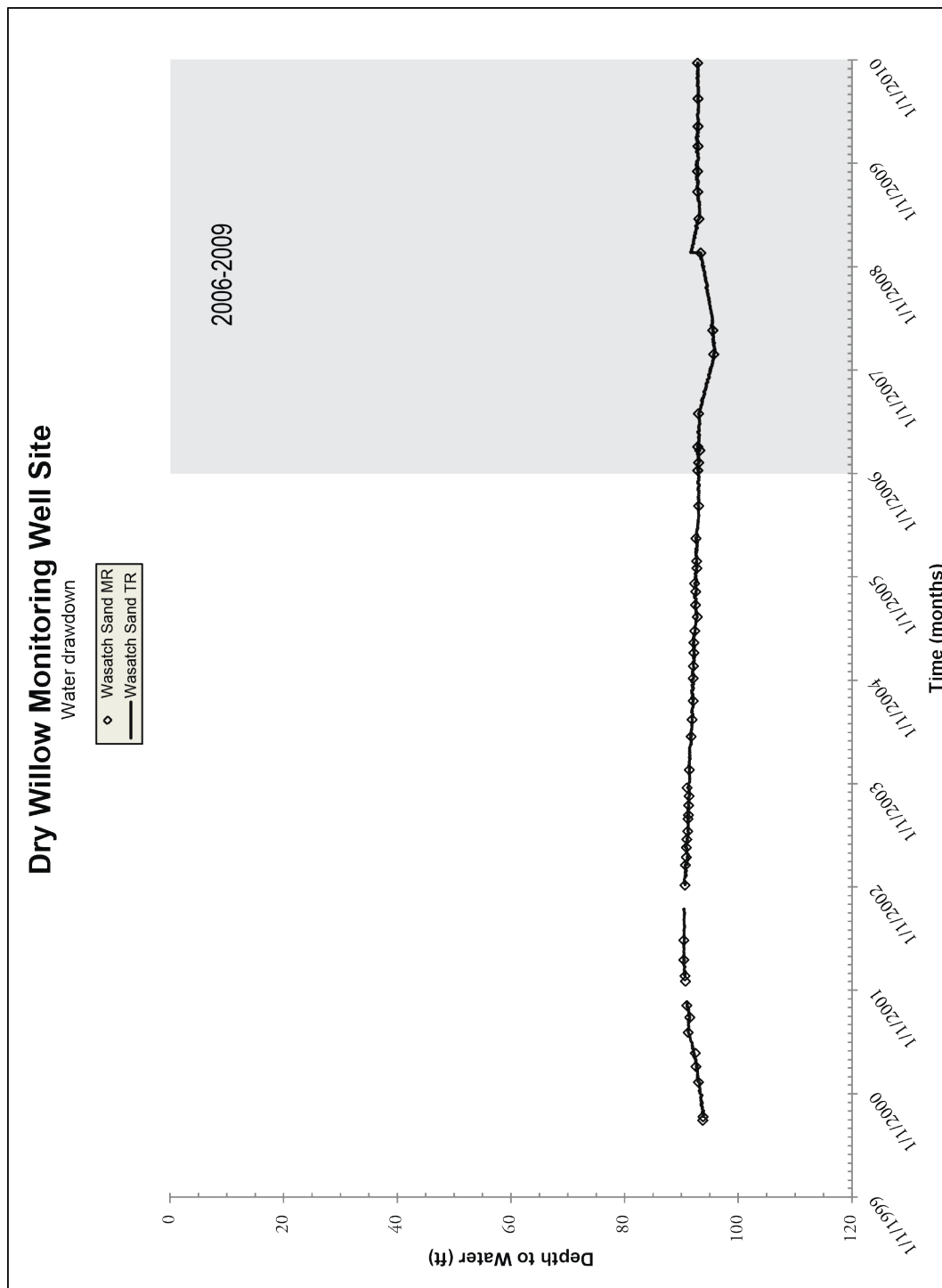


Figure 25. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Dry Willow monitoring well site location.

APPENDIX 2. Wyodak Rider (Big George) Coal Zone

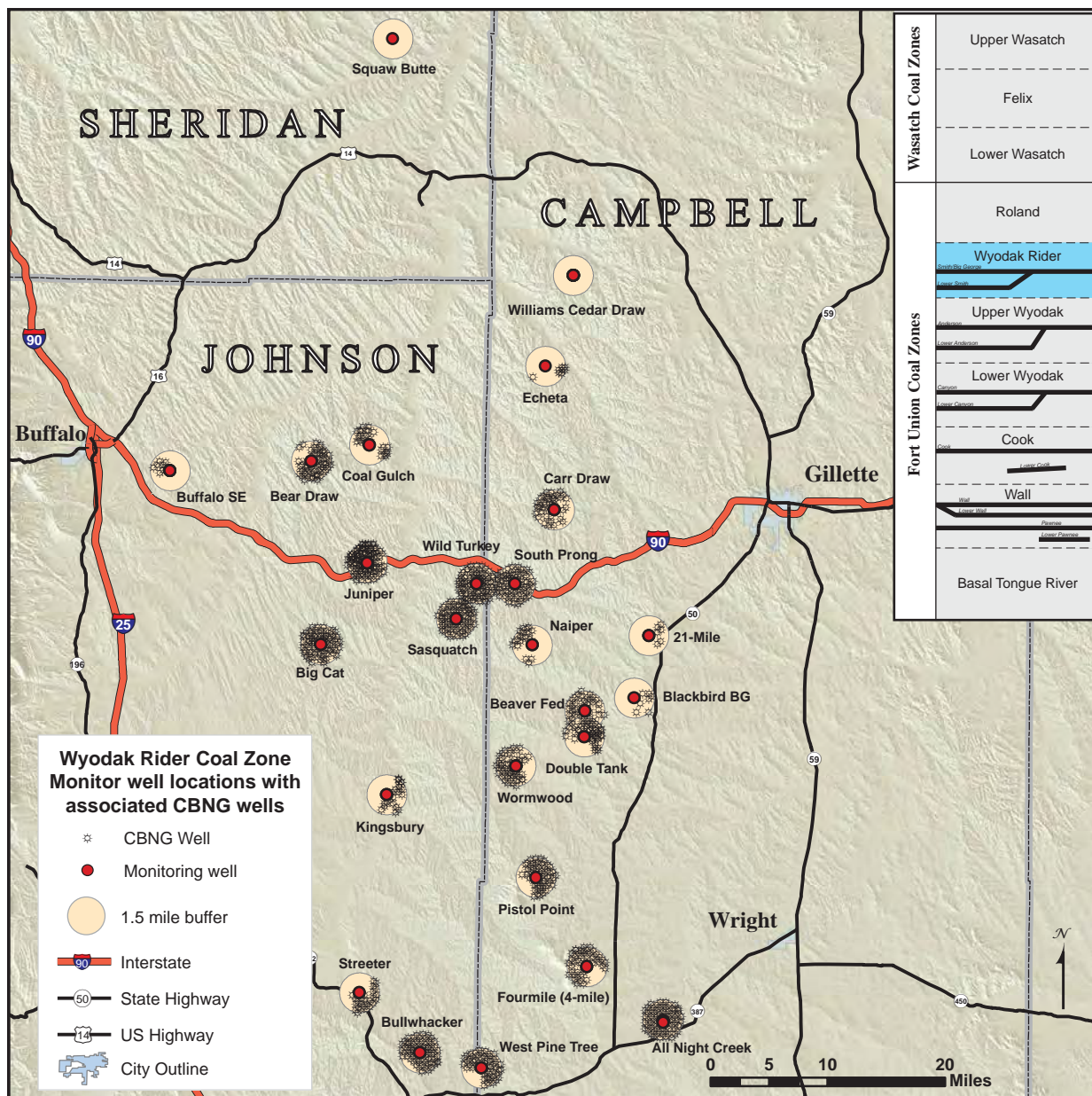


Figure 26. Wyodak Rider (Big George) coal zone monitoring well site locations in the Powder River Basin, Wyoming.

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 wells. One is drilled into the Big George coal, another into the deeper Wyodak coal, and the third in a overlying Wasatch sandstone (Figure 27; Table 11). Missing and/or fluctuating transducer data is the result of errors with on-site equipment.

The Big George coal recorded a groundwater draw-down of 75 feet during the 2006-2009 monitoring period; data shows a slow decline in the groundwater level (Figure 28; Table 12). The Wyodak coal recorded a groundwater increase of 81 feet during the 2006-2009 monitoring period; groundwater levels began to increase in mid to late 2008 and remained relatively stable through 2009 (Figure 28; Table 12). Similar initial groundwater levels, as well as groundwater levels of the Wyodak recovering towards Big George, suggests that these coals may be hydraulically connected. Groundwater levels in the Wasatch sandstone were relatively stable during the 2006-2009 monitoring period, though there was a slight increase of 2 feet (Figure 28; Table 12). A minor overall decline, along with variable initial water levels, suggests there is no hydraulic connection between the monitored Wasatch sandstone and producing zones. Gas pressure readings did not surpass levels possible from transducer error.

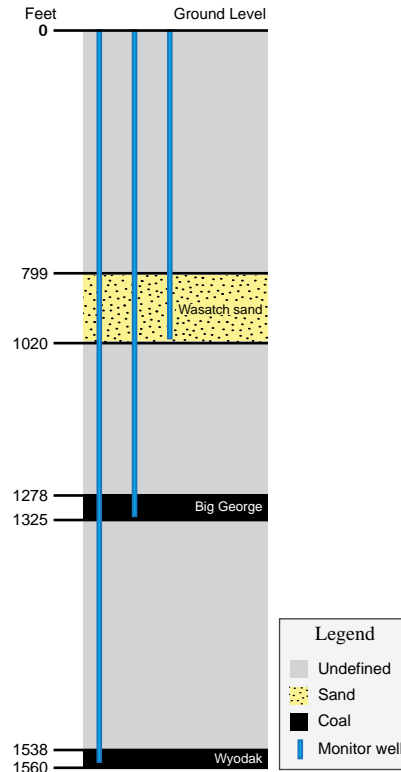


Figure 27. Section showing relative positions of coals and sands in feet. Not to scale.

Table 11. Table showing the depth to and thickness of monitored zones at the 21-Mile monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Wasatch sand	799	1020	221	258
Big George coal	1278	1325	47	n/a
Wyodak coal	1538	1560	22	n/a

Table 12. Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2006	Drawdown 2006-2009	Total drawdown (ft.)	Depth to 12/31/09 water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	533.33	2.68	-2.08	0.60	533.93	n/a	n/a
Big George coal	626.68	173.82	74.97	248.79	875.47	1.00	8/15/03
Wyodak coal	629.86	390.15	-80.99	309.16	939.02	10.00	4/16/02

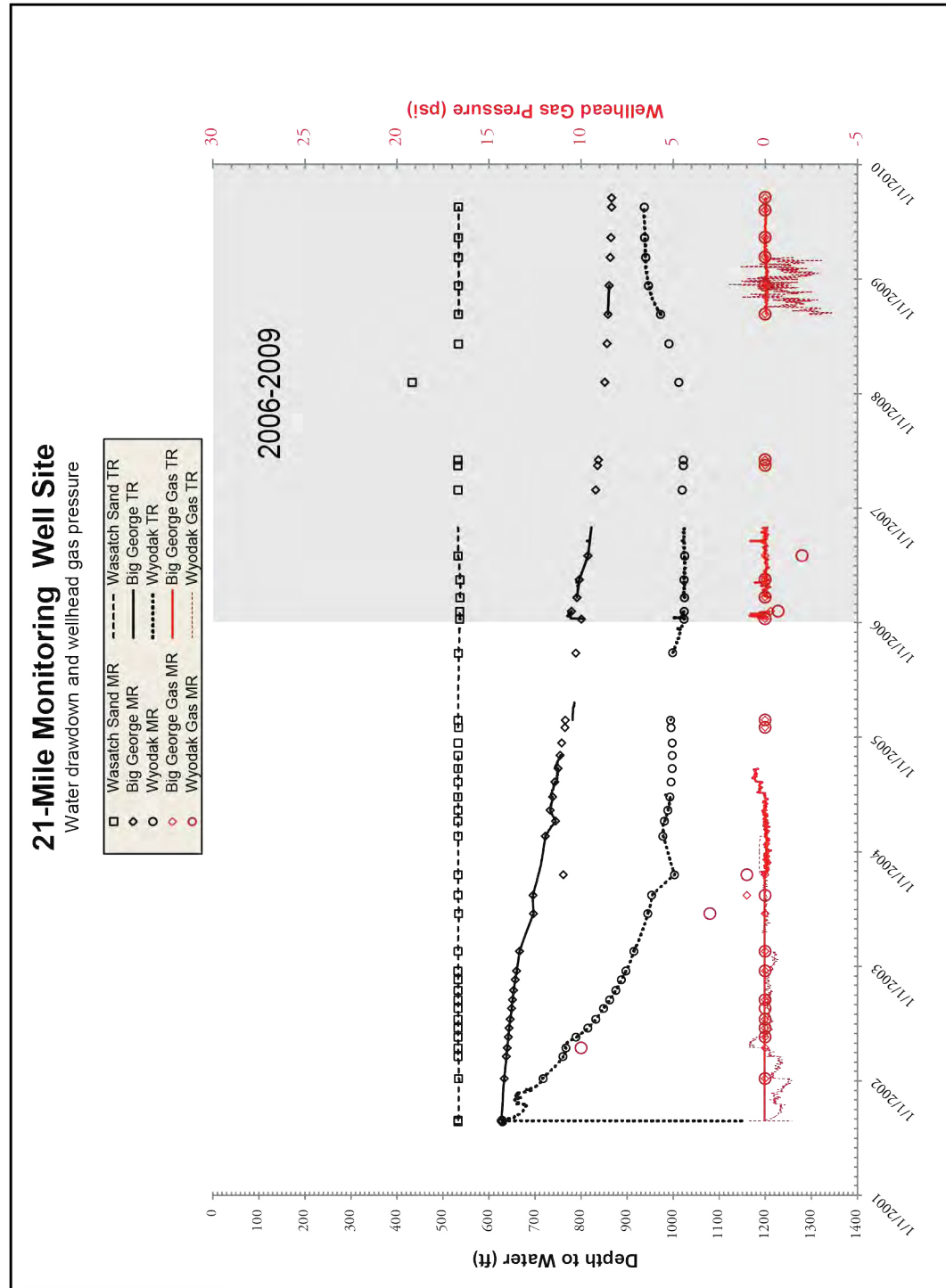


Figure 28. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the 21-Mile well site location.

Production Statistics

Production data was analyzed for CBNG wells within the buffer of the 21-Mile monitoring well site, from January 2002 through December 2009. Cumulative production for individual CBNG wells is displayed by location on Figure 29.

Water production increased in 2002, which is relatively correlative to groundwater drawdown

trends. Gas production increased and water production declined during the 2006 to 2009 monitoring period, and water production ceased in early 2009 (Figure 30). This correlates to increasing groundwater levels in the Wyodak coal bed beginning in 2009. The water/gas ratio of CBNG wells within the buffer is relatively inconsistent from south to north. Percent methane decreased.

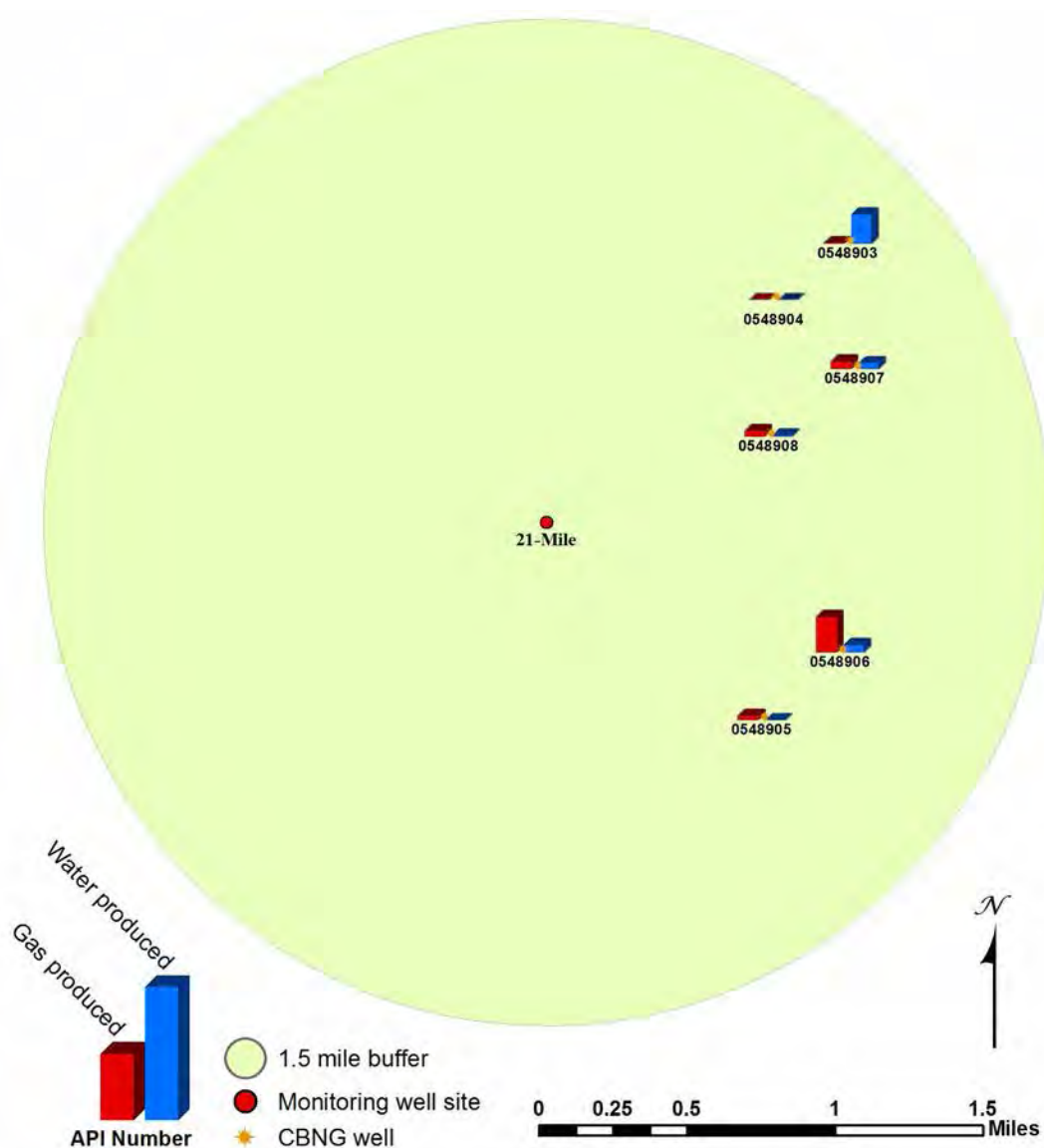


Figure 29. 21-Mile monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (Bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

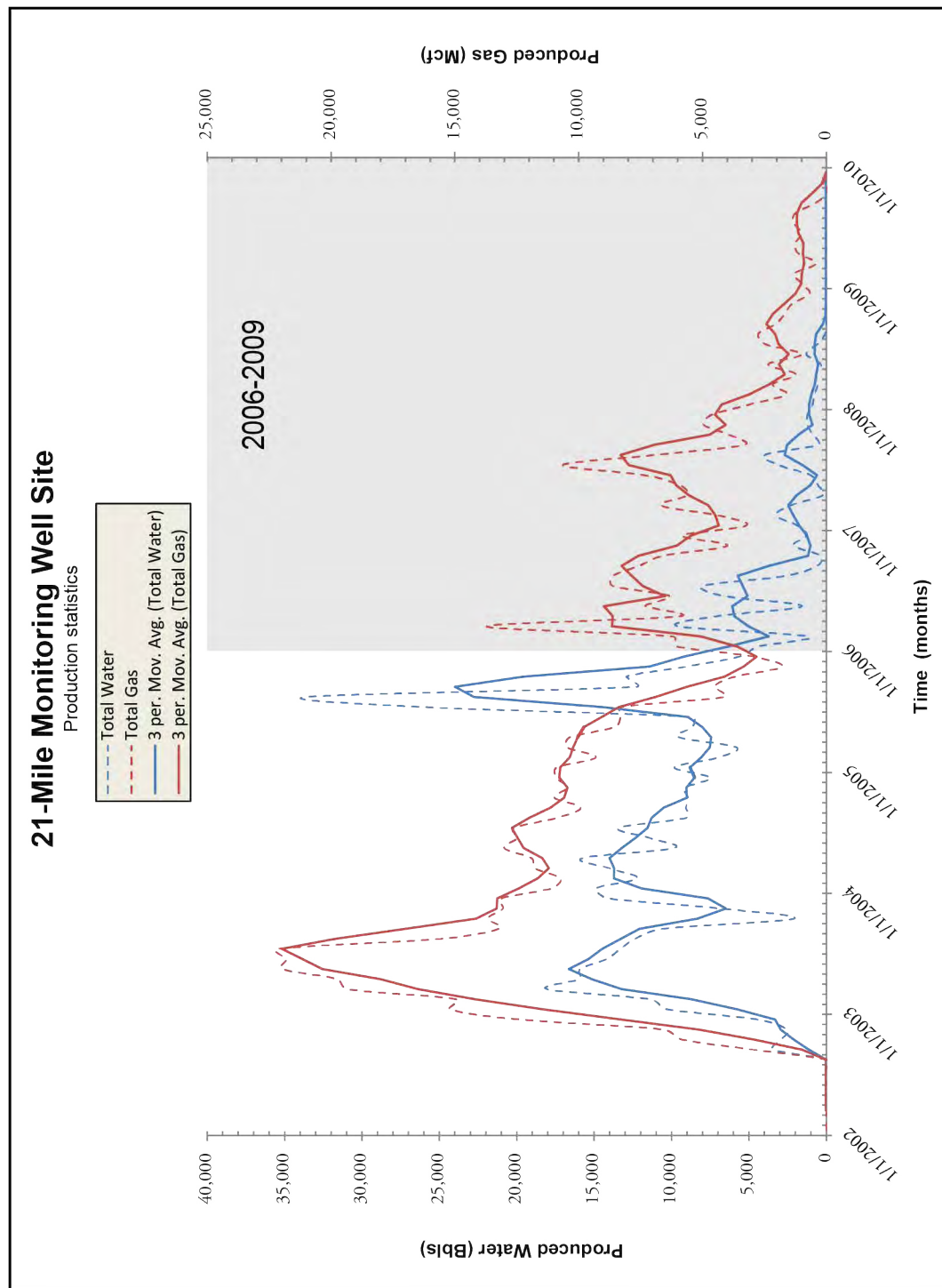


Figure 30. 3-period moving average along with water and gas production from associated CBNG wells.

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

Drawdown Information

The All Night Creek monitoring well site includes five wells. One well is drilled into the Big George coal and the other four wells are constructed in overlying Wasatch sandstones (Figure 31; Table 13). Missing and/or fluctuating transducer data is the result of errors with on-site equipment.

The Big George coal recorded a groundwater draw-down of 151 feet during the 2006-2009 monitoring period; data shows a steady decline in the groundwater level (Figure 32; Table 14). Groundwater levels for all monitored sandstones were stable during the 2006-2009 monitoring period, as they have been for the life of the well (Figure 32; Table 14). This, along with variable initial water levels, indicates there is no hydraulic connection between the monitored Wasatch sandstone and producing zones. Though there is missing data and fluctuations from transducer error, gas pressures in the Big George coal recorded a steady decline between 2006-2009.

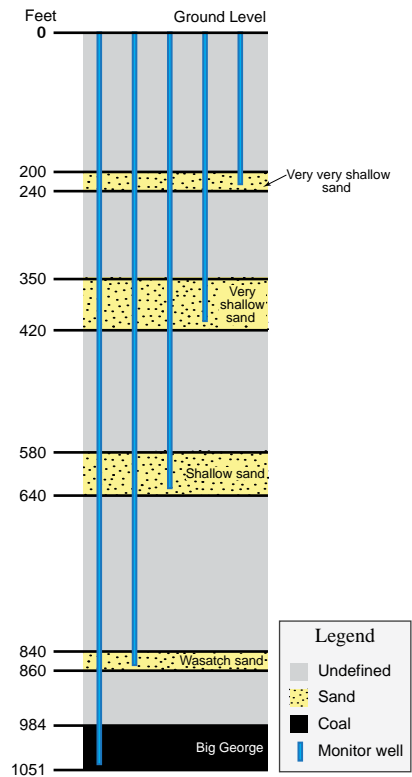


Figure 31. Section showing relative positions of coals and sands in feet. Not to scale.

Table 13. Table showing the depth to and thickness of monitored zones at the All Night Creek well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Very very shallow sand	200	240	40	744
Very shallow sand	350	420	70	564
Shallow sand	580	640	60	344
Wasatch sand	840	860	20	124
Big George coal	984	1051	67	n/a

Table 14. Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2006	Drawdown 2006-2009	Total drawdown (ft.)	Depth to 12/31/09 water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Very very shallow sand	95.47	-0.48	0.12	-0.36	95.11	n/a	n/a
Very shallow sand	200.71	-0.04	-0.95	-0.99	199.72	n/a	n/a
Shallow sand	252.45	2.50	1.40	3.90	256.35	n/a	n/a
Wasatch sand	320.59	-26.37	4.41	-21.96	298.63	n/a	n/a
Big George coal	439.92	472.68	151.40	624.08	1064.00	48.53	10/29/03

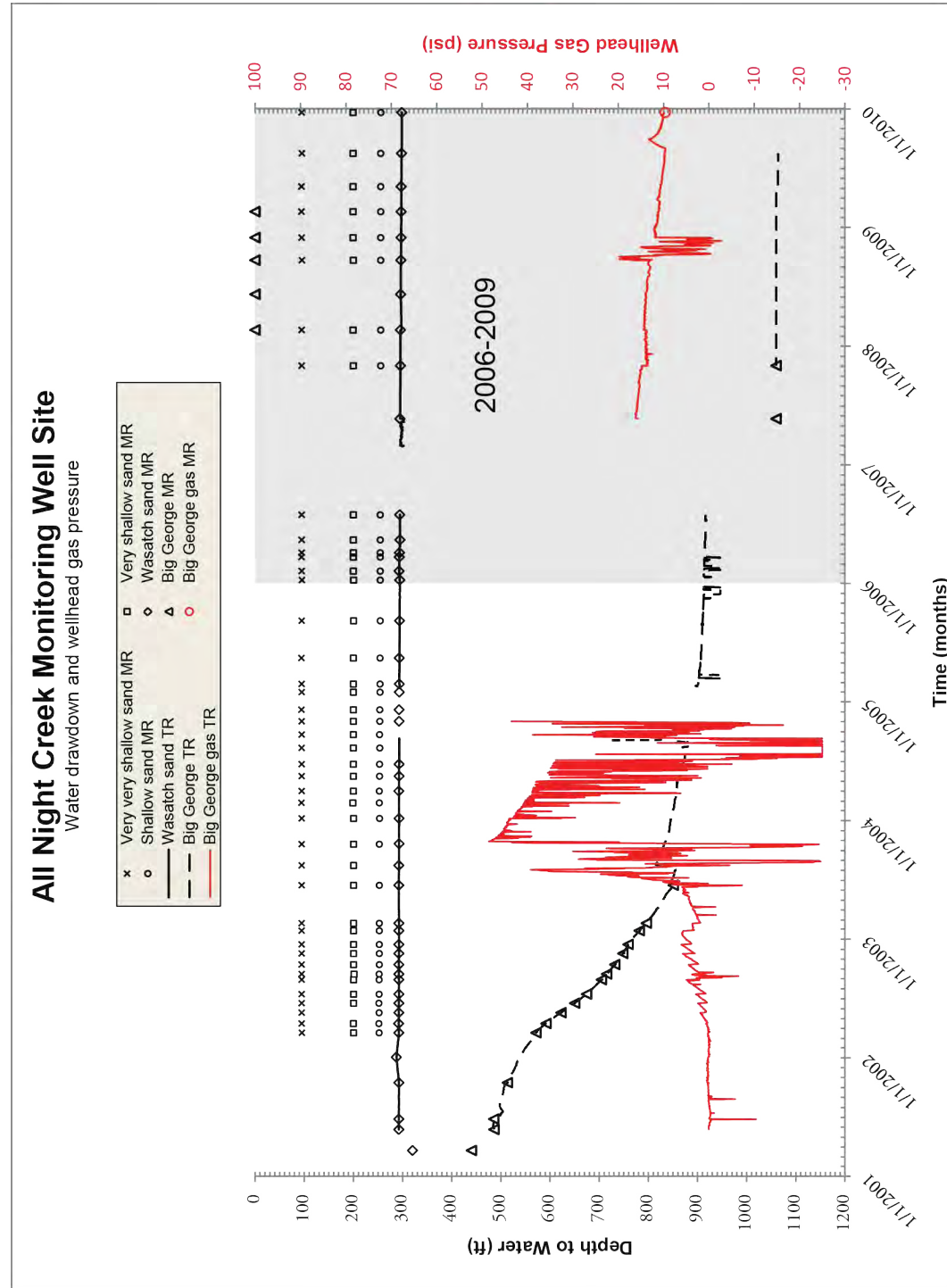


Figure 32. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the All Night Creek well site location.

Production Statistics

Production data was analyzed for CBNG wells within the buffer of the All Night Creek monitoring well site from January 2000 through December 2009. Cumulative production for individual CBNG wells is displayed by location on Figure 33.

Water production peaked in 2001, which is consistent with groundwater drawdown trends. Most wa-

ter was produced prior to the 2006-2009 monitoring period, though these wells continued to produce gas (Figure 34). The water/gas ratio of CBNG wells within the buffer is relatively consistent for all wells. Percent methane increased rapidly and remained consistent.

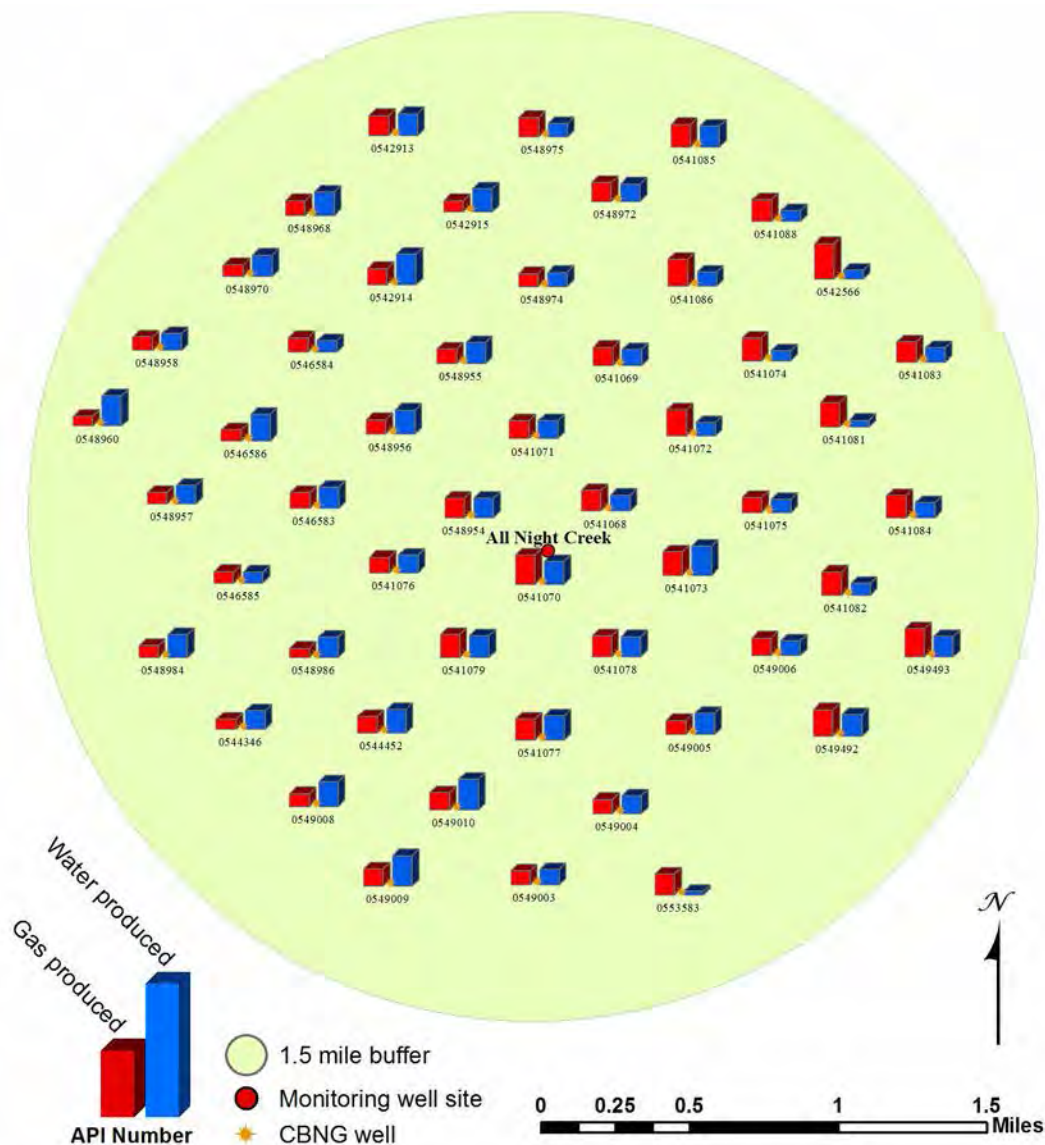


Figure 33. All Night Creek monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (Bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

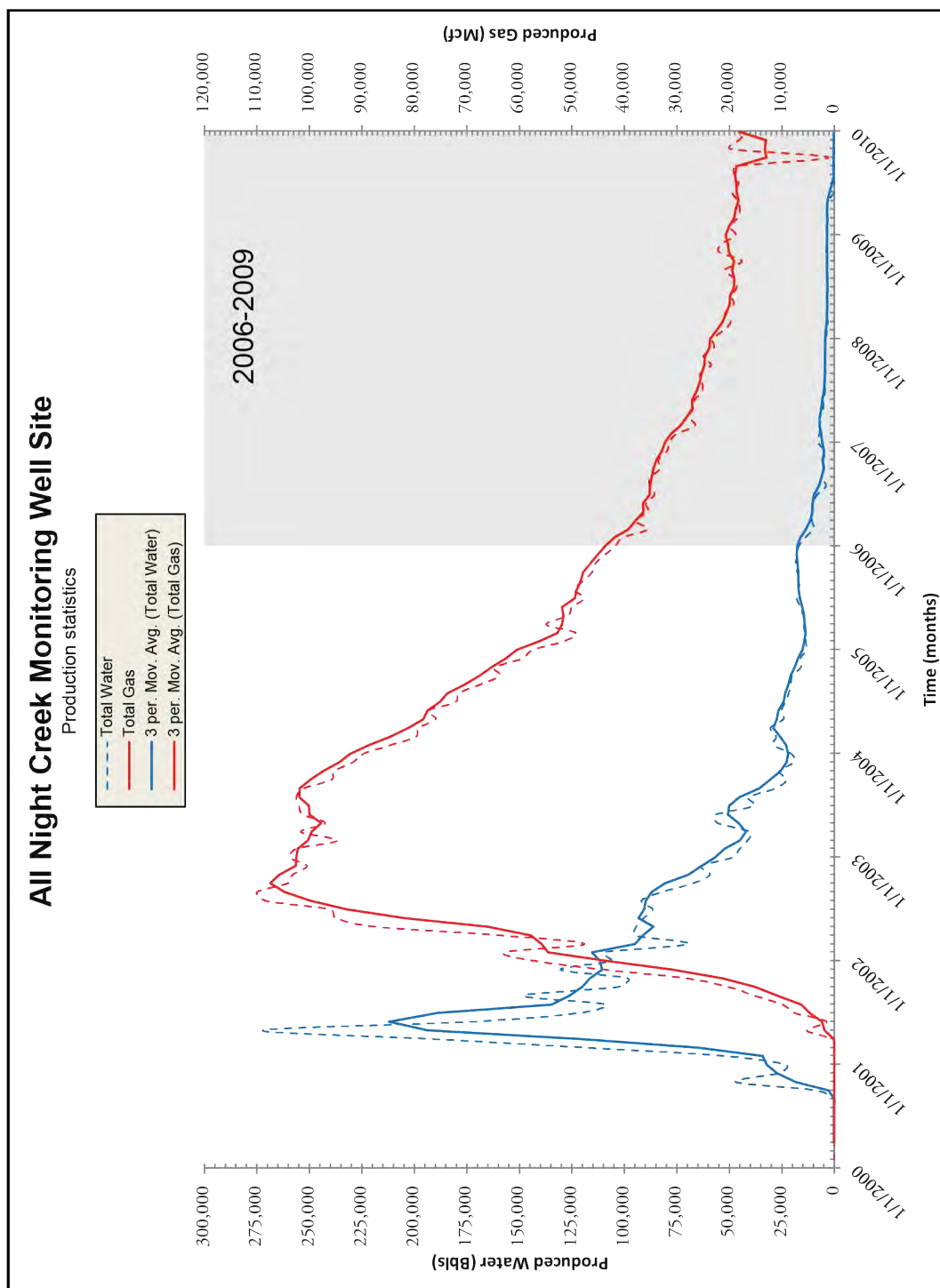


Figure 34. 3-period moving average along with water and gas production from associated CBNG wells.

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

Drawdown Information

The Bear Draw monitoring well site includes one well within the completed zones, separated by a packer. The Big George coal completion is below the depth that the packer is set and the Wasatch sand is completed above the packer and monitored through the annular space (Figure 35; Table 15). Missing and/or fluctuating transducer data is the result of errors with on-site equipment.

The Big George coal recorded a groundwater draw-down of 484 feet during the 2006-2009 monitoring period; data shows groundwater levels remained stable until 2008 followed by a steep groundwater decline (Figure 36; Table 16). Groundwater levels in the Wasatch sandstone declined by 27 feet during the 2006-2009 monitoring period, and most of the decline happened after 2008 (Figure 36; Table 16). Gas pressure readings did not surpass levels possible from transducer error.

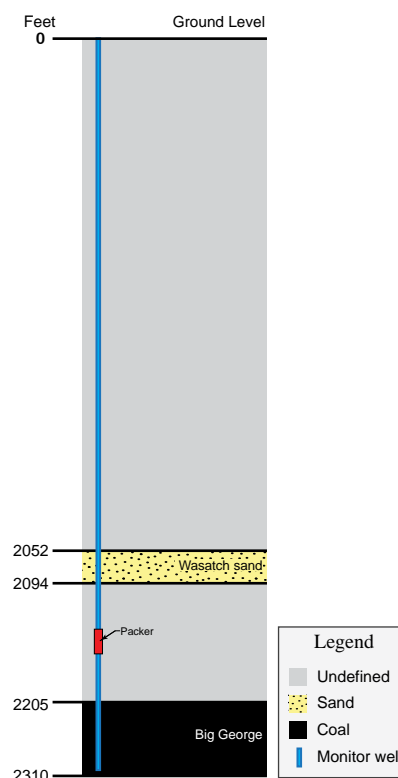


Figure 35. Section showing relative positions of coals and sands in feet. Not to scale.

Table 15. Table showing the depth to and thickness of monitored zones at the Bear Draw monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Wasatch sand	2052	2094	42	111
Big George coal	2205	2310	105	n/a

Table 16. Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2006	Drawdown 2006-2009	Total drawdown (ft.)	Depth to 12/31/09 water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	494.20	n/a	26.74	26.74	520.94	n/a	n/a
Big George coal	499.60	n/a	483.72	483.72	983.32	n/a	n/a

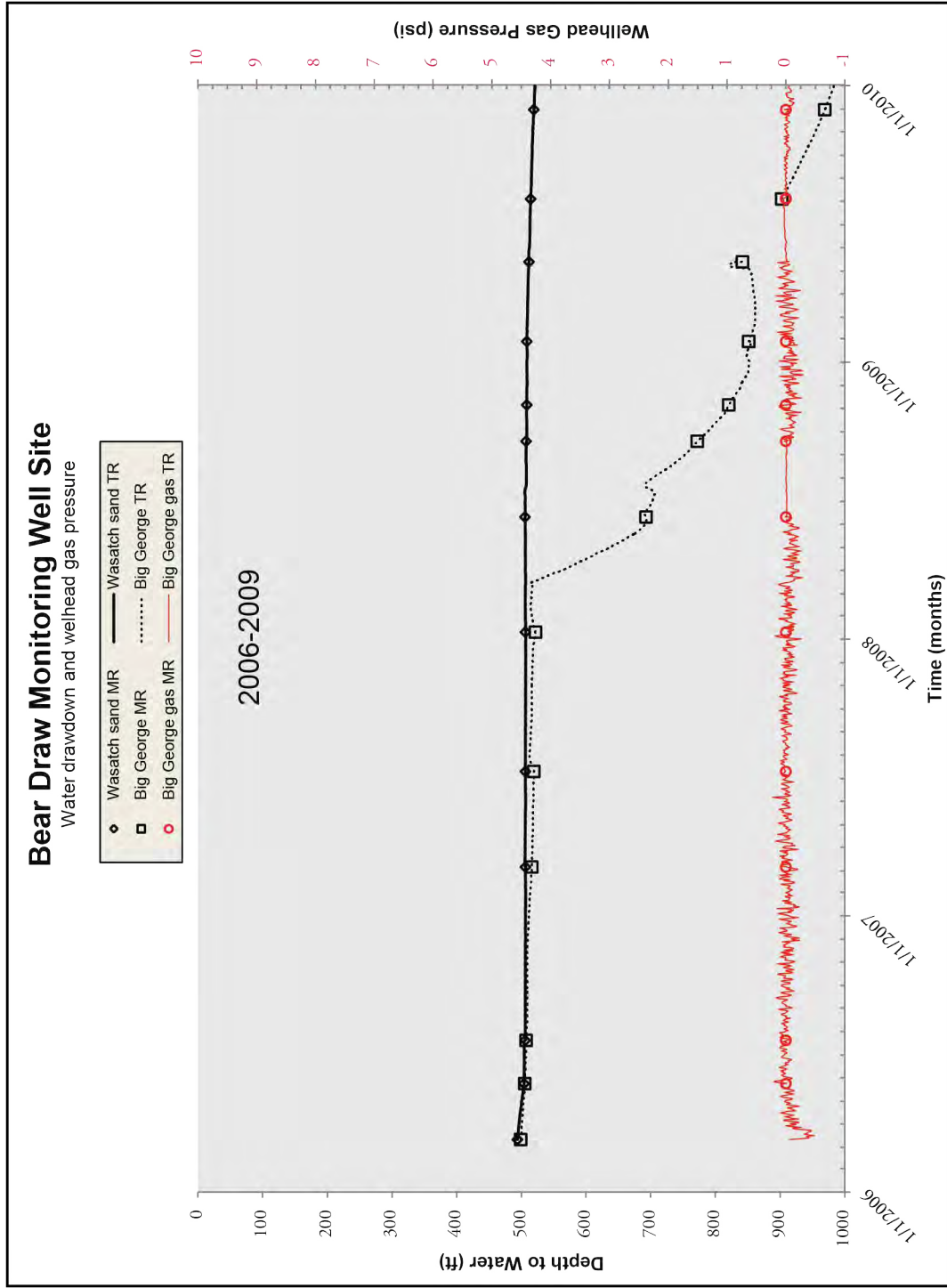


Figure 36. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Bear Draw monitoring well site location.

Production Statistics

Production data was analyzed for CBNG wells within the buffer of the Bear Draw monitoring well site from May 2005 through December 2009. Cumulative production for individual CBNG wells is displayed by location on Figure 37.

Water and gas production increased during the 2006 to 2009 monitoring period with a peak in water production in 2008 (Figure 38). This correlates to the groundwater drawdown trends. The water/gas ratio of CBNG wells within the buffer is relatively inconsistent. Percent methane is minimal.

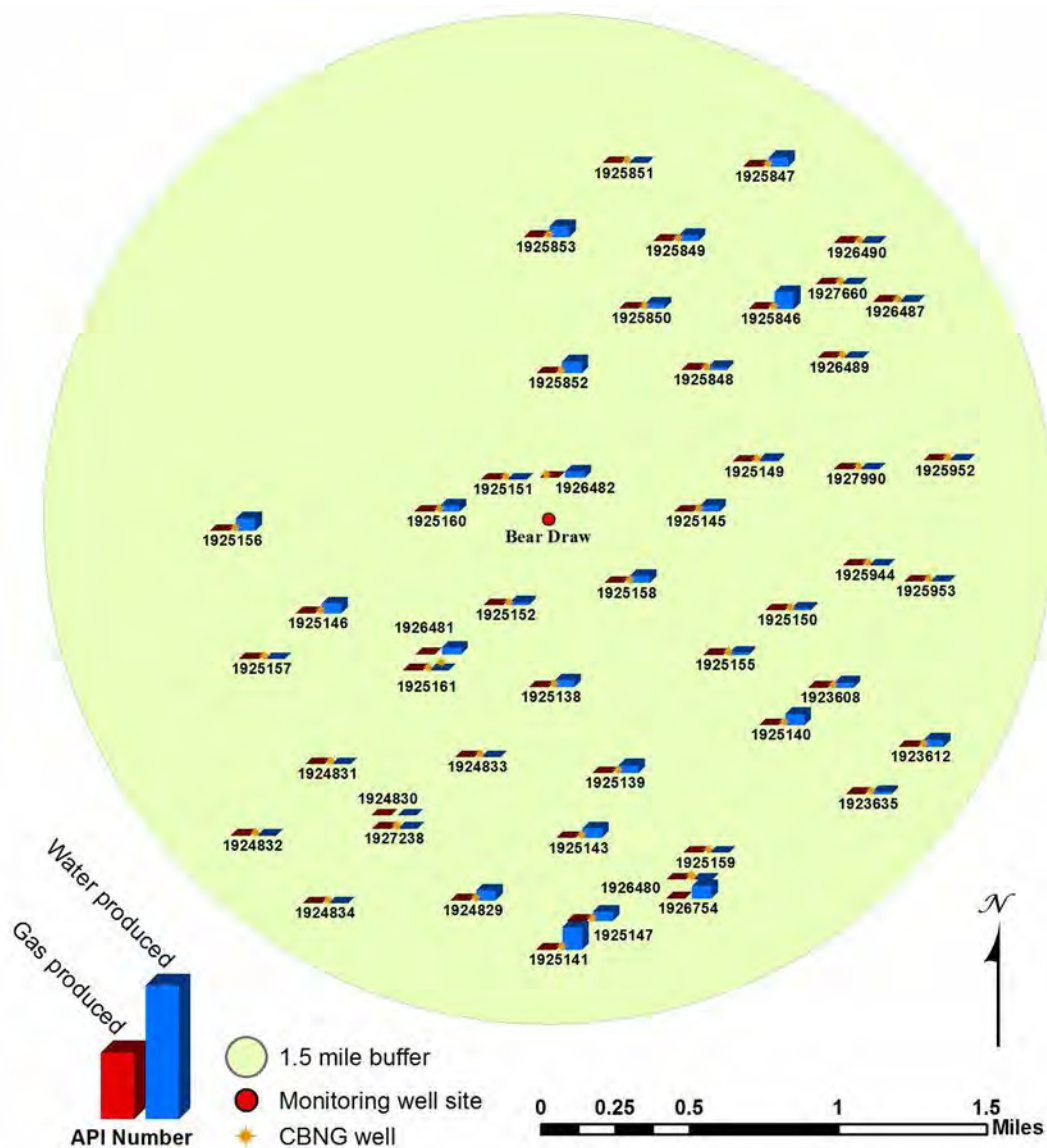


Figure 37. Bear Draw monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (Bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

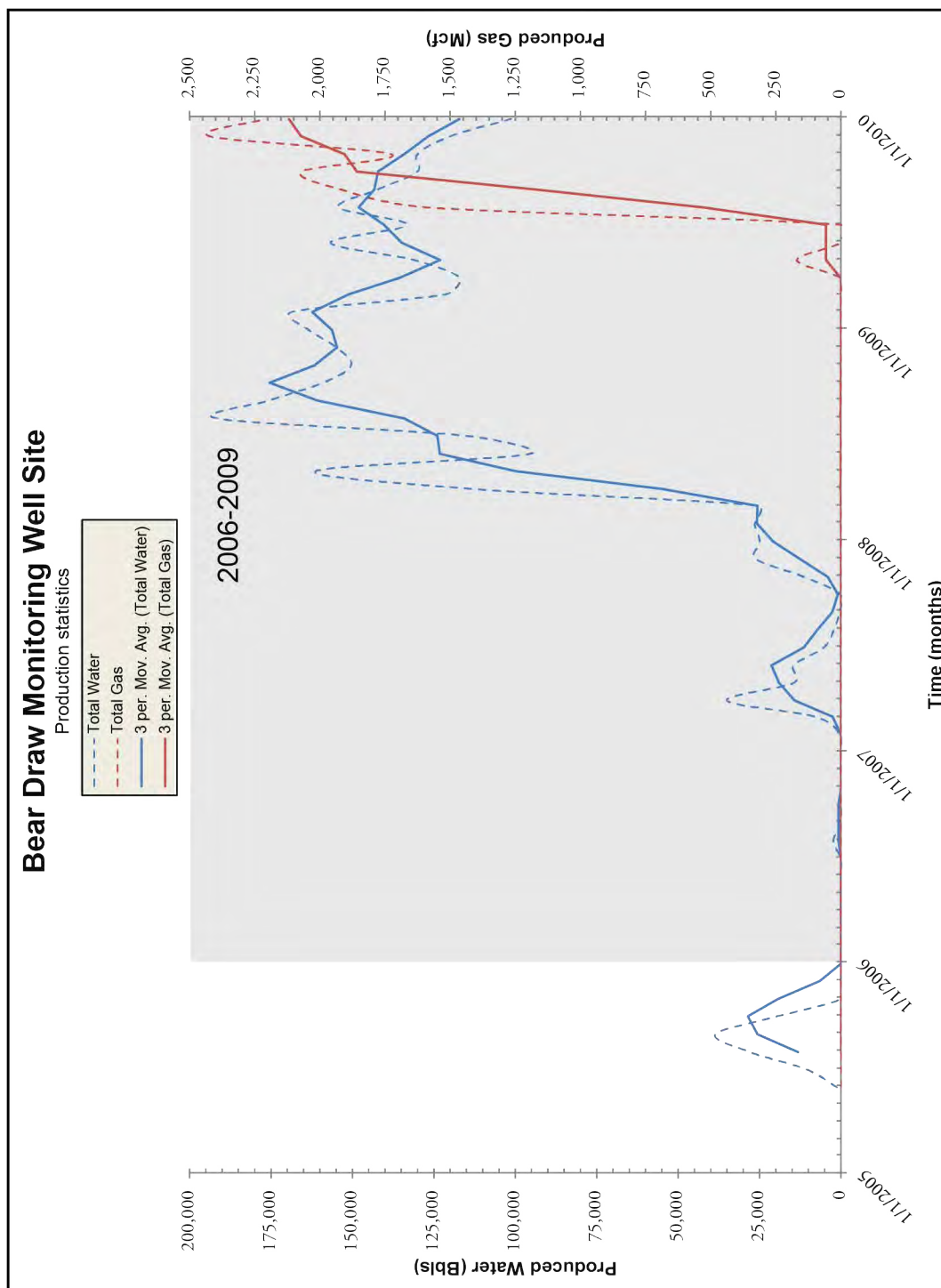


Figure 38. 3-period moving average along with water and gas production from associated CBNG wells.

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 drilled into the Big George coal and the other into a overlying Wasatch sandstone (Figure 39; Table 17). Missing and/or fluctuating transducer data is the result of errors with on-site equipment.

The Big George coal recorded a groundwater draw-down of 274 feet during the 2006-2009 monitoring period; data shows a steep drop in the groundwater level in early 2007, followed by a steady decline (Figure 40; Table 18). Groundwater levels in the Wasatch sandstone were stable during the 2006-2009 monitoring period, as they have been for the life of the well (Figure 40; Table 18). This, along with variable initial water levels, indicates there is no hydraulic connection between the monitored sandstone and producing zones. Gas pressure recorded a rapid increase beginning in 2009.

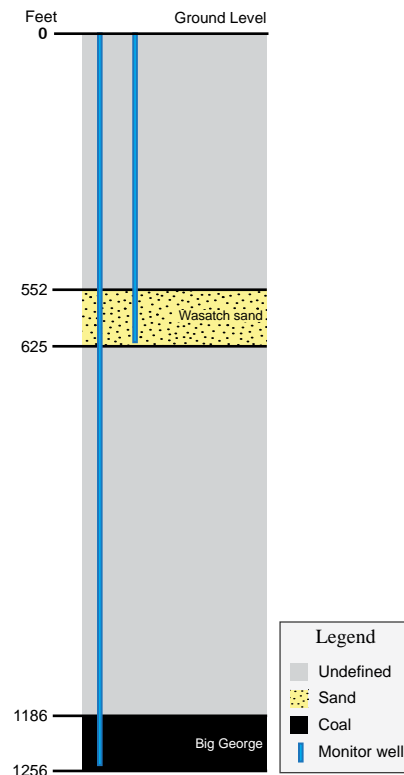


Figure 39. Section showing relative positions of coals and sands in feet. Not to scale.

Table 17. Table showing the depth to and thickness of monitored zones at the Beaver Fed monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Wasatch sand	552	625	73	561
Big George coal	1186	1256	70	n/a

Table 18. Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2006	Drawdown 2006-2009	Total drawdown (ft.)	Depth to 12/31/09 water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	245.66	0.17	0.42	0.59	246.25	n/a	n/a
Big George coal ⁽¹⁾	330.80	230.09	274.16	504.25	835.05	155	8/4/09

⁽¹⁾ The water level for the coal was taken on 5/14/09 and not on 12/31/09. The reading on 5/14/09 was the last recorded data for 2009.

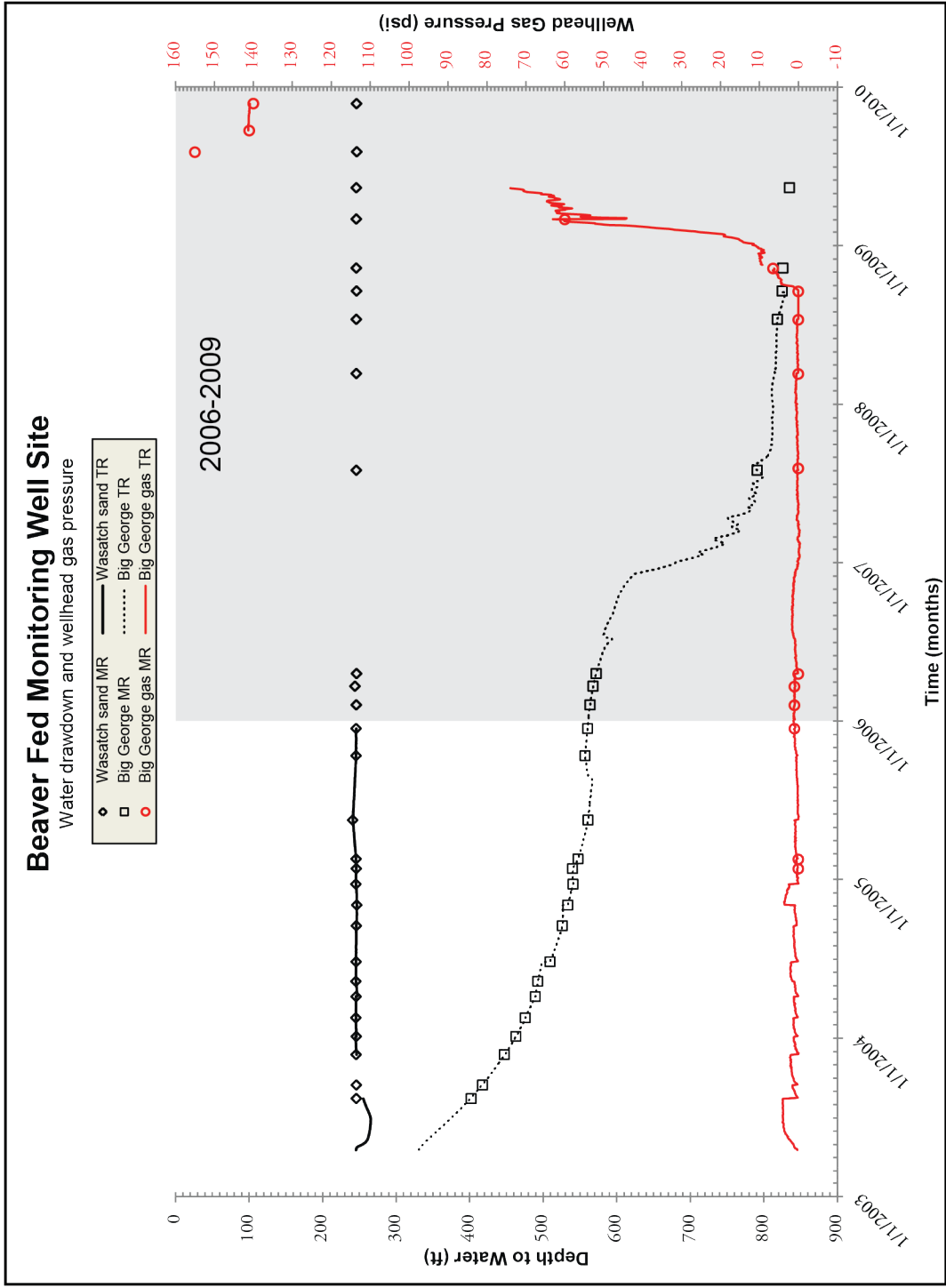


Figure 40. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Beaver Federal monitoring well site location.

Production Statistics

Production data was analyzed for CBNG wells within the buffer of the Beaver Fed monitoring well sites from January 2006 through December 2009. The data was summed, by month, from the reported production for water and gas. Cumulative production for each CBNG well is displayed by location on Figure 41.

Wells in this area have varying water to gas ratios. Production data shows maximum water production in mid-2007, at this time gas production started to increase. CBNG production is consistent with groundwater drawdown trends from mid-2007 through December 2009 in the Big George coal.

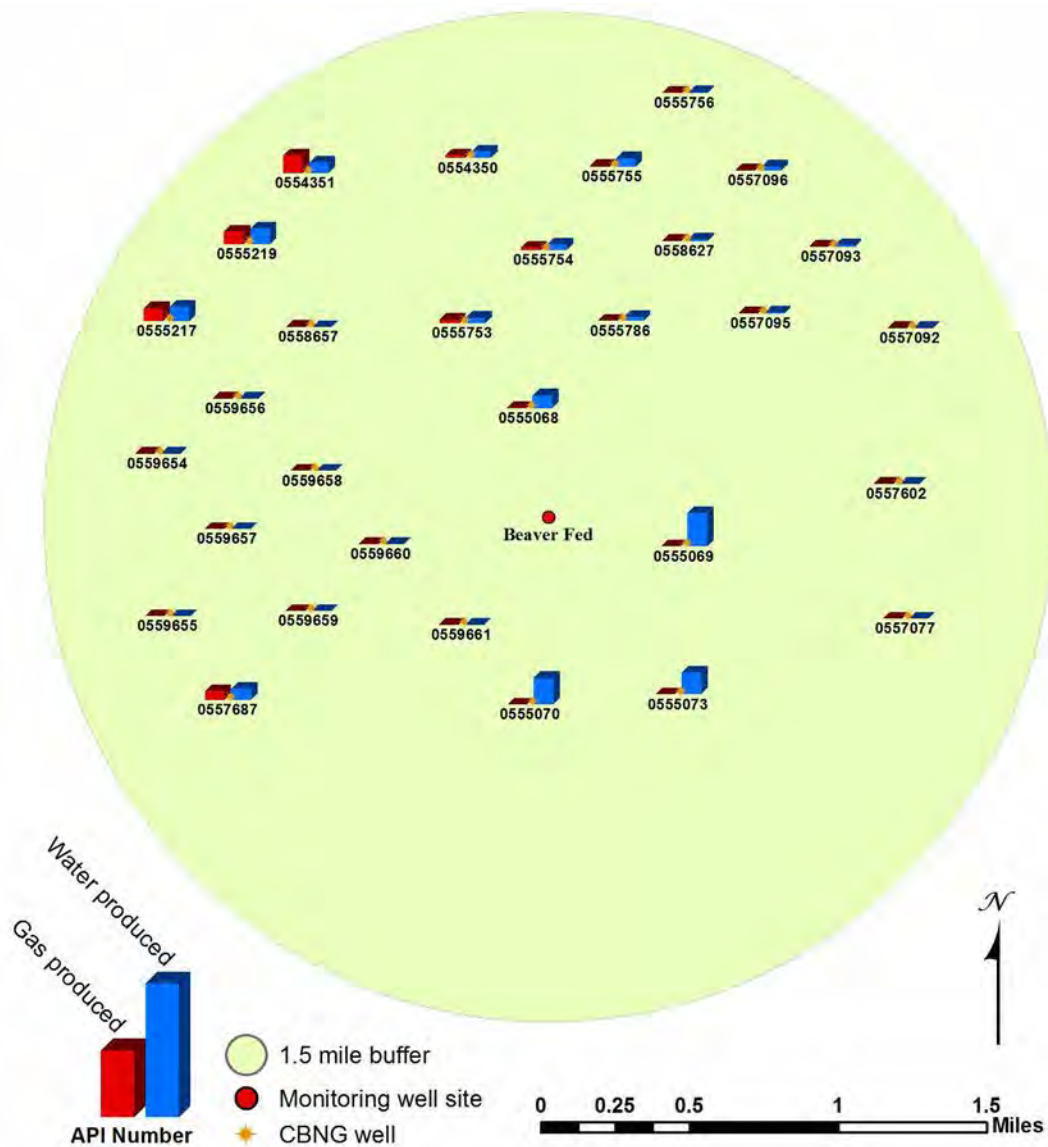


Figure 41. Beaver Fed monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (Bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

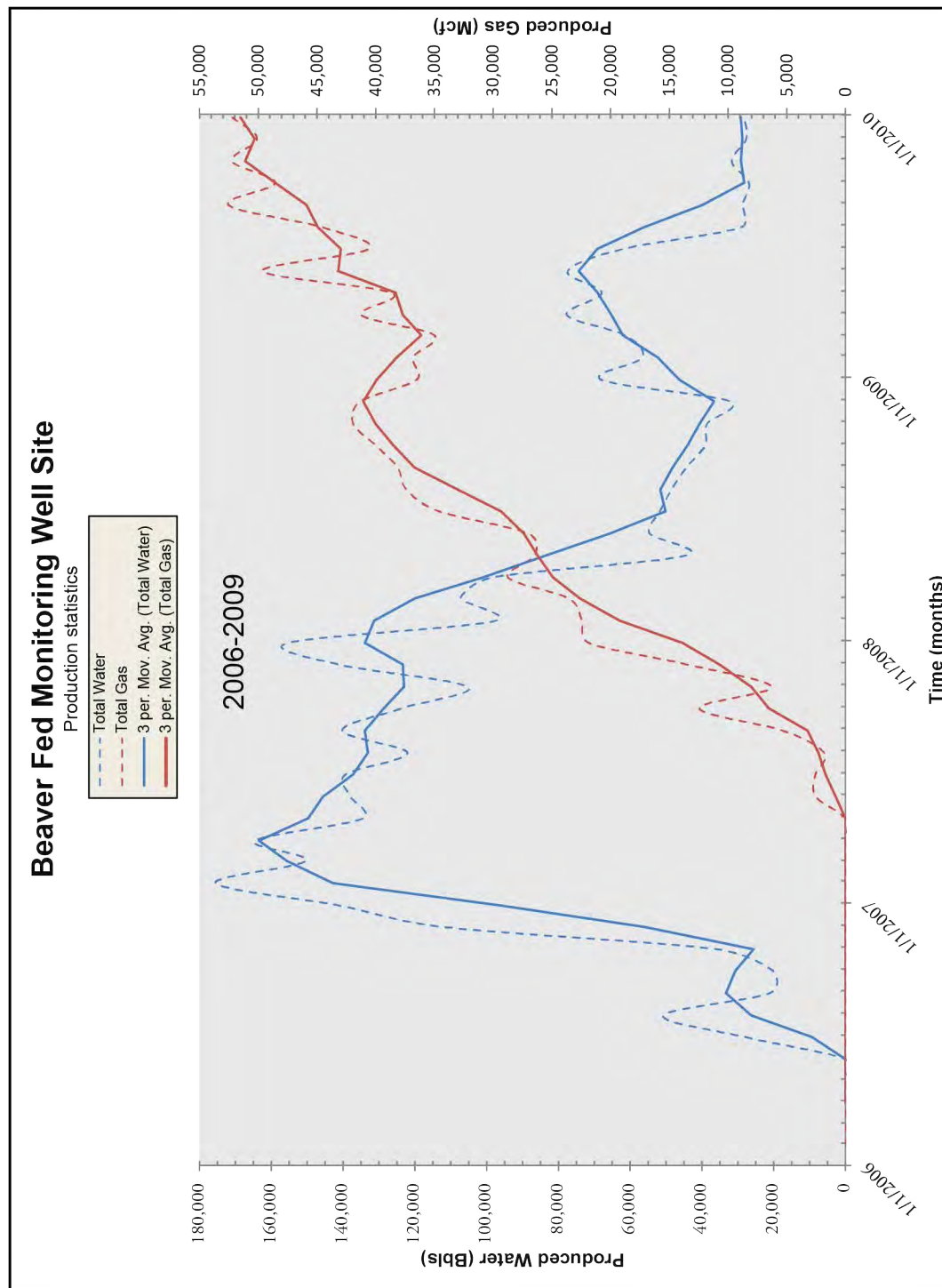


Figure 42. 3-period moving average along with water and gas production from associated CBNG wells.

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 drilled into the Big George coal and the other into a overlying Wasatch sandstone (Figure 43; Table 19). Missing and/or fluctuating transducer data is the result of errors with on-site equipment.

The Big George coal recorded a groundwater draw-down of 570 feet during the 2006-2009 monitoring period; data shows in a relatively steady decline in the groundwater level after 2007 (Figure 44; Table 20). Groundwater levels in the Wasatch sandstone were stable during the 2006-2009 monitoring period, as they have been for the life of the well (Figure 44; Table 20). This, along with variable initial water levels, indicates there is no hydraulic connection between the monitored Wasatch sandstone and producing zones. Gas pressure recorded a relatively steady increase beginning in the second half of 2008.

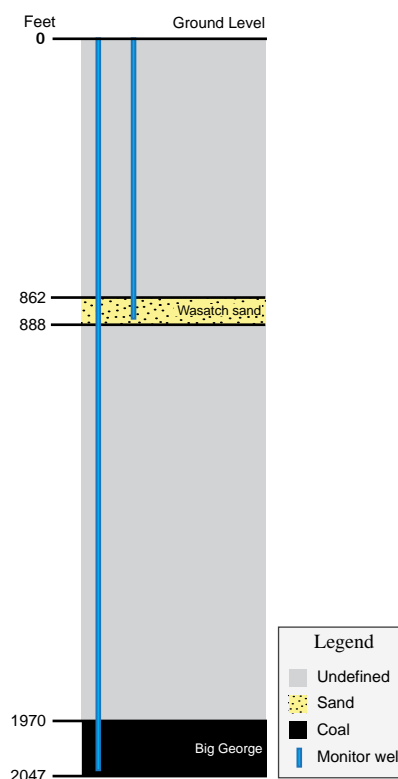


Figure 43. Section showing relative positions of coals and sands in feet. Not to scale.

Table 19. Table showing the depth to and thickness of monitored zones at the Big Cat monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Wasatch sand	862	888	26	1082
Big George coal	1970	2047	77	n/a

Table 20. Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2006	Drawdown 2006-2009	Total drawdown (ft.)	Depth to 12/31/09 water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	357.30	0.08	2.16	2.24	359.54	n/a	n/a
Big George coal	200.24	415.82	570.20	986.02	1186.26	19	5/18/09

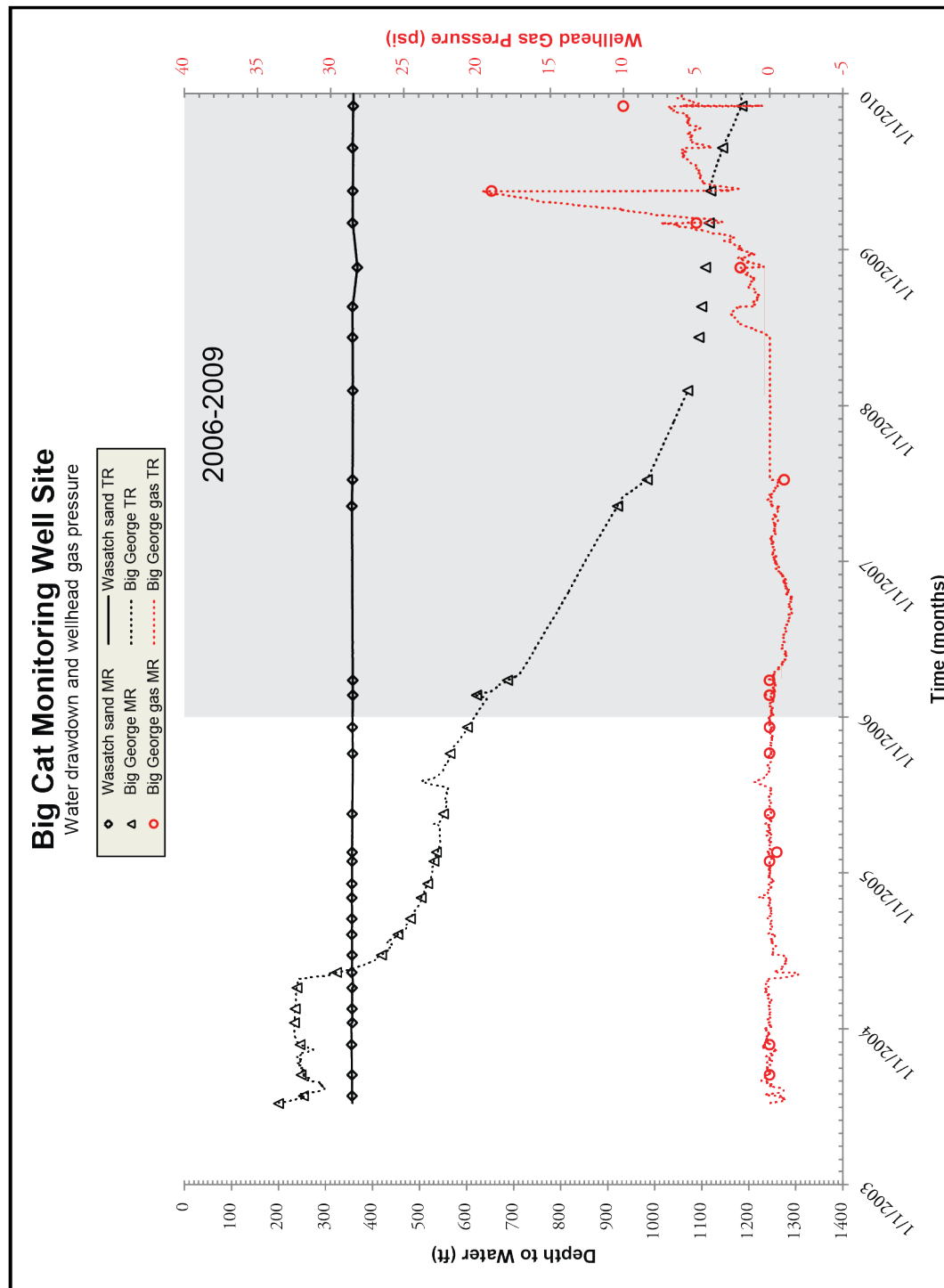


Figure 44. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Big Cat monitoring well location.

Production Statistics

Production data was analyzed for CBNG wells within the buffer of the Big Cat monitoring well site from January 2003 to December 2009. Cumulative production for individual CBNG wells is displayed by location on Figure 45.

increased and water production declined during the 2006 to 2009 monitoring period (Figure 46). The water/gas ratio of CBNG wells within the buffer is relatively inconsistent. Percent methane is variable.

Water production peaked in 2004, which correlates to groundwater drawdown trends. Gas production

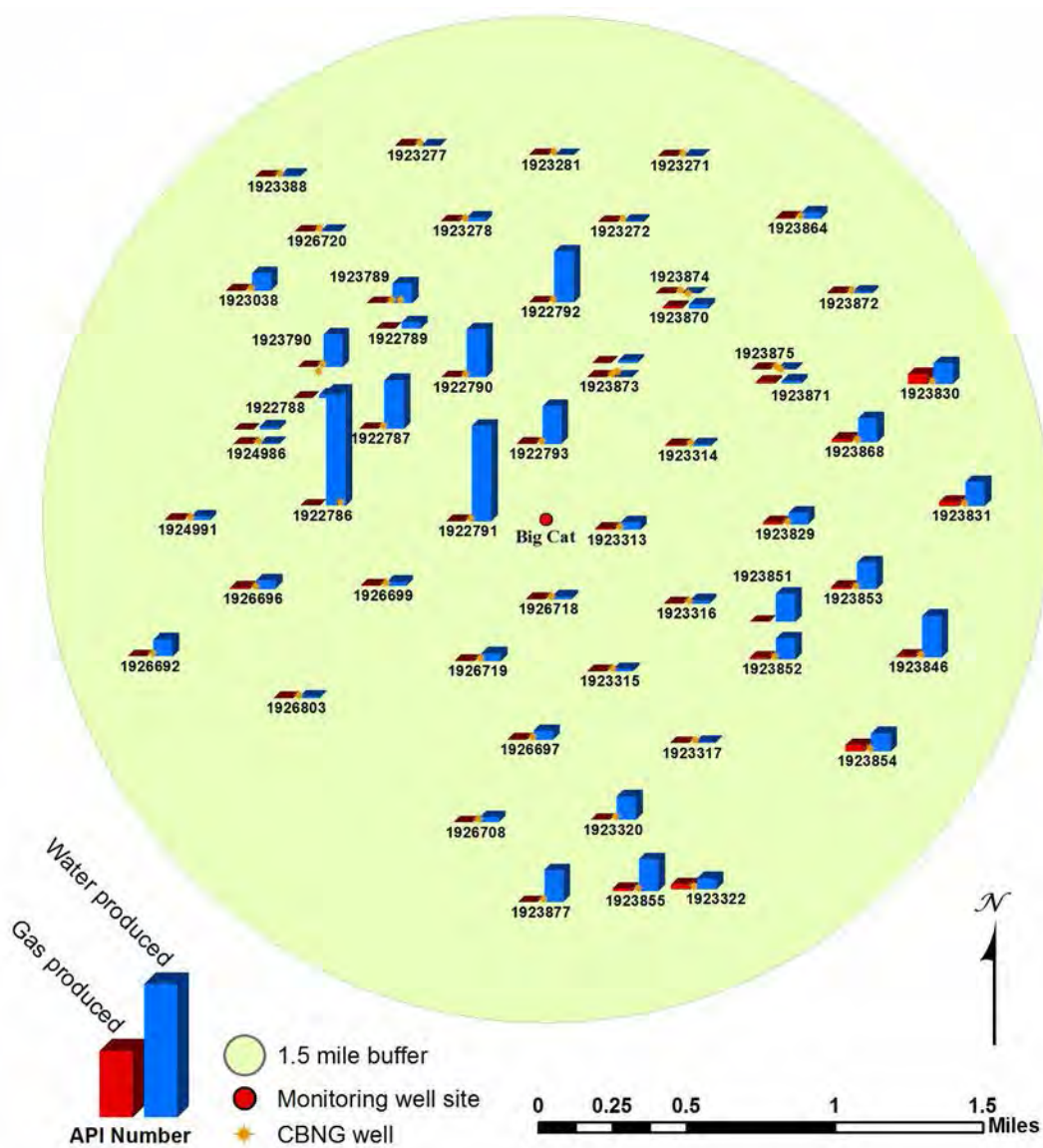


Figure 45. Big Cat monitoring well and associated CBNG wells within 1.5 mile buffer showing cumulative water (Bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

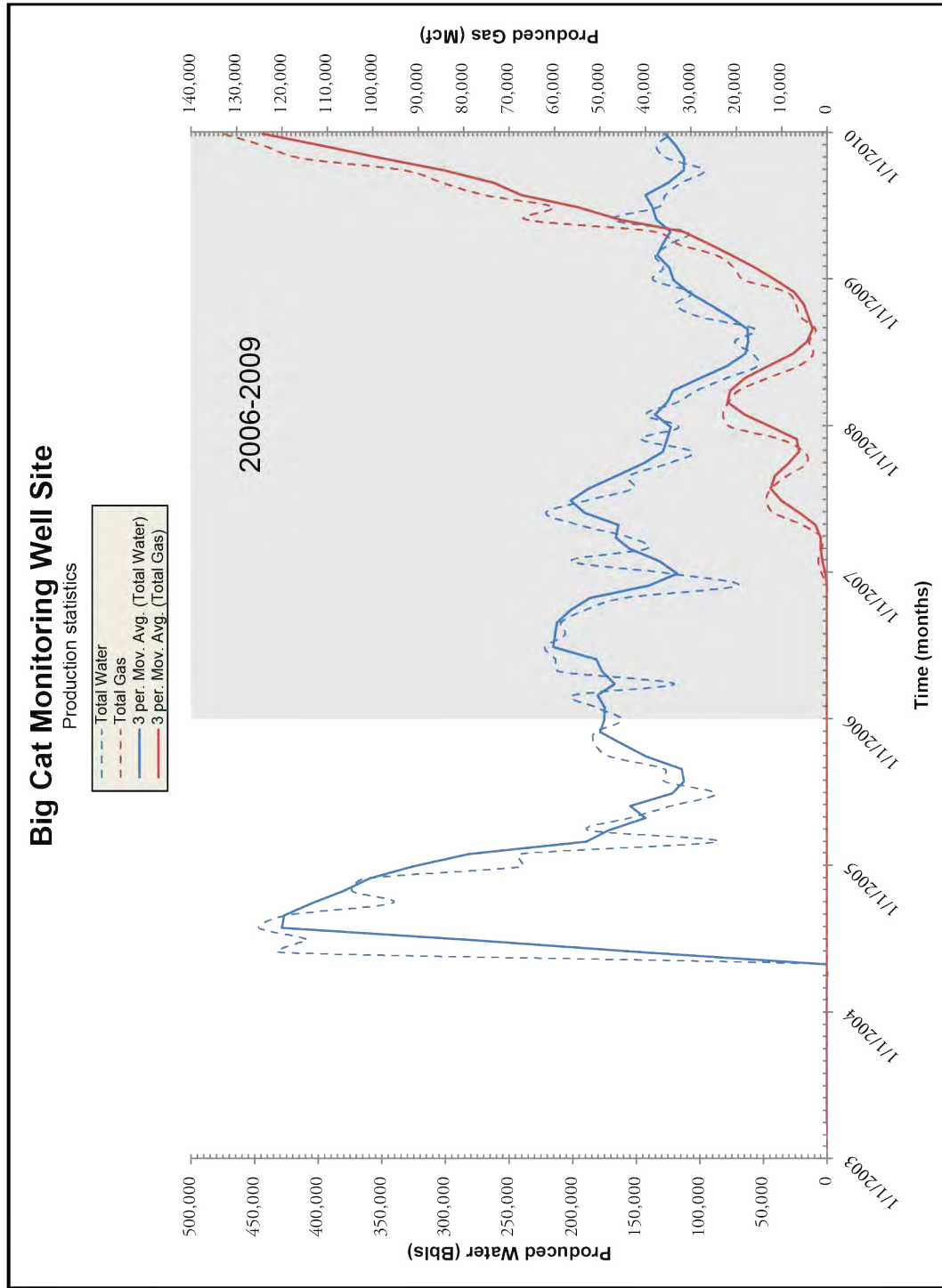


Figure 46. 3-period moving average along with water and gas production from associated CBNG wells.

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

Drawdown Information

The Blackbird BG monitoring site consists of one well completed into the Big George coal (Figure 47; Table 21). Missing and/or fluctuating transducer data is the result of errors with on-site equipment.

The Big George coal recorded a groundwater draw-down of 61 feet during the 2006-2009 monitoring period; data shows a steady decline in the groundwater level (Figure 48; Table 22). Gas pressure readings did not surpass levels possible from transducer error.

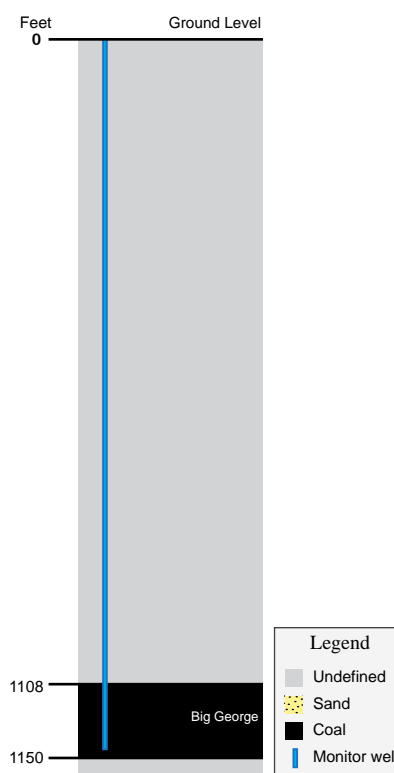


Figure 47. Section showing relative positions of coals and sands in feet. Not to scale.

Table 21. Table showing the depth to and thickness of monitored zones at the Blackbird BG monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Big George coal	1108	1150	42	n/a

Table 22. Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2006	Drawdown 2006-2009	Total drawdown (ft.)	Depth to 12/31/09 water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Big George coal	489.07	24.02	60.91	84.93	574.00	n/a	n/a

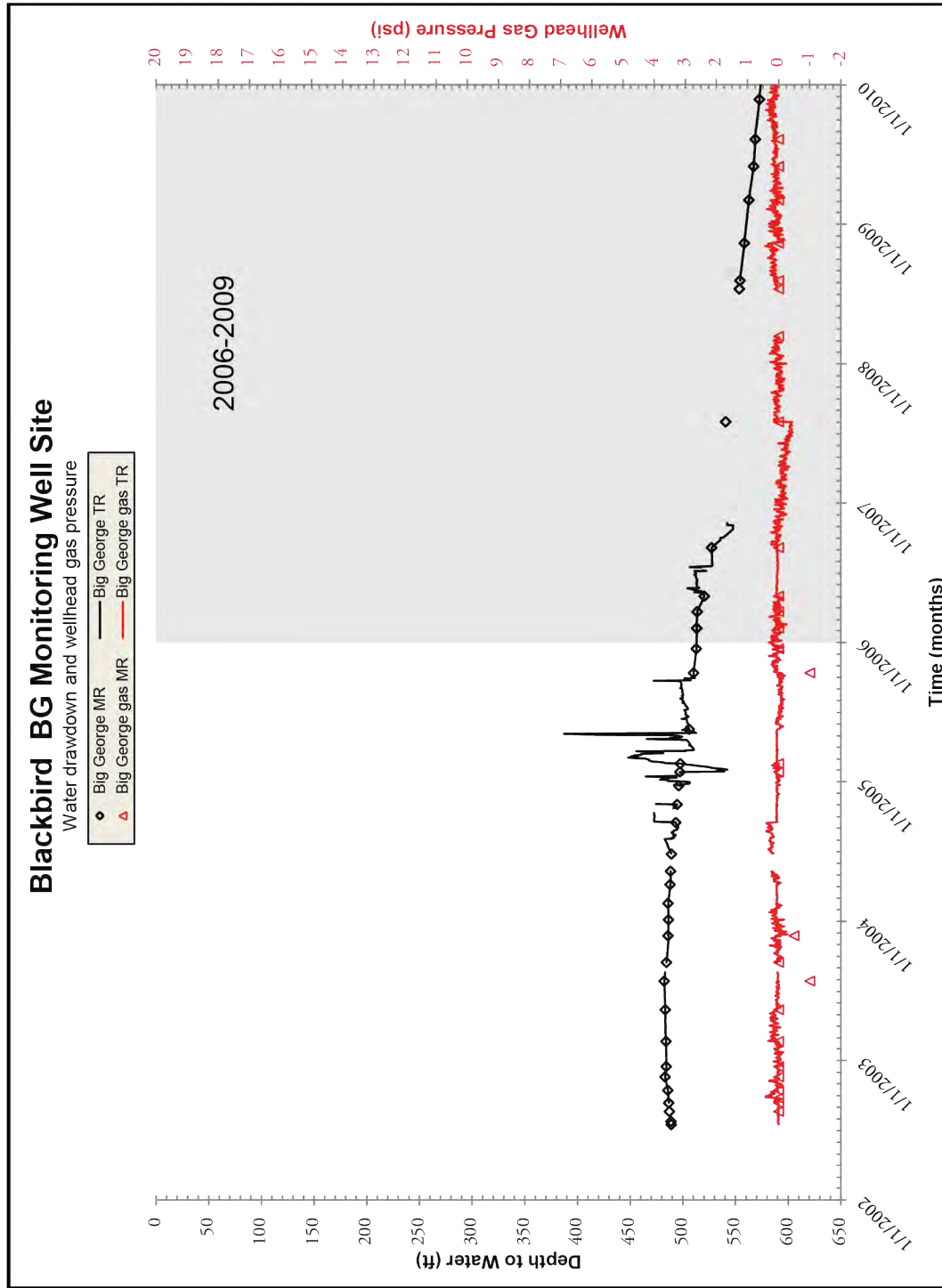


Figure 48. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Blackbird BG monitoring well site location.

Production Statistics

Production data was analyzed for CBNG wells within the buffer of the Blackbird BG monitoring well site from January 2000 through December 2009. Cumulative production for individual CBNG wells is displayed by location on Figure 49.

the 2006 to 2009 monitoring period (Figure 50). The water/gas ratio of CBNG wells within the buffer is relatively consistent for all wells. Percent methane is variable.

Water production peaked in 2001 and again in 2003. Water and gas production was variable during

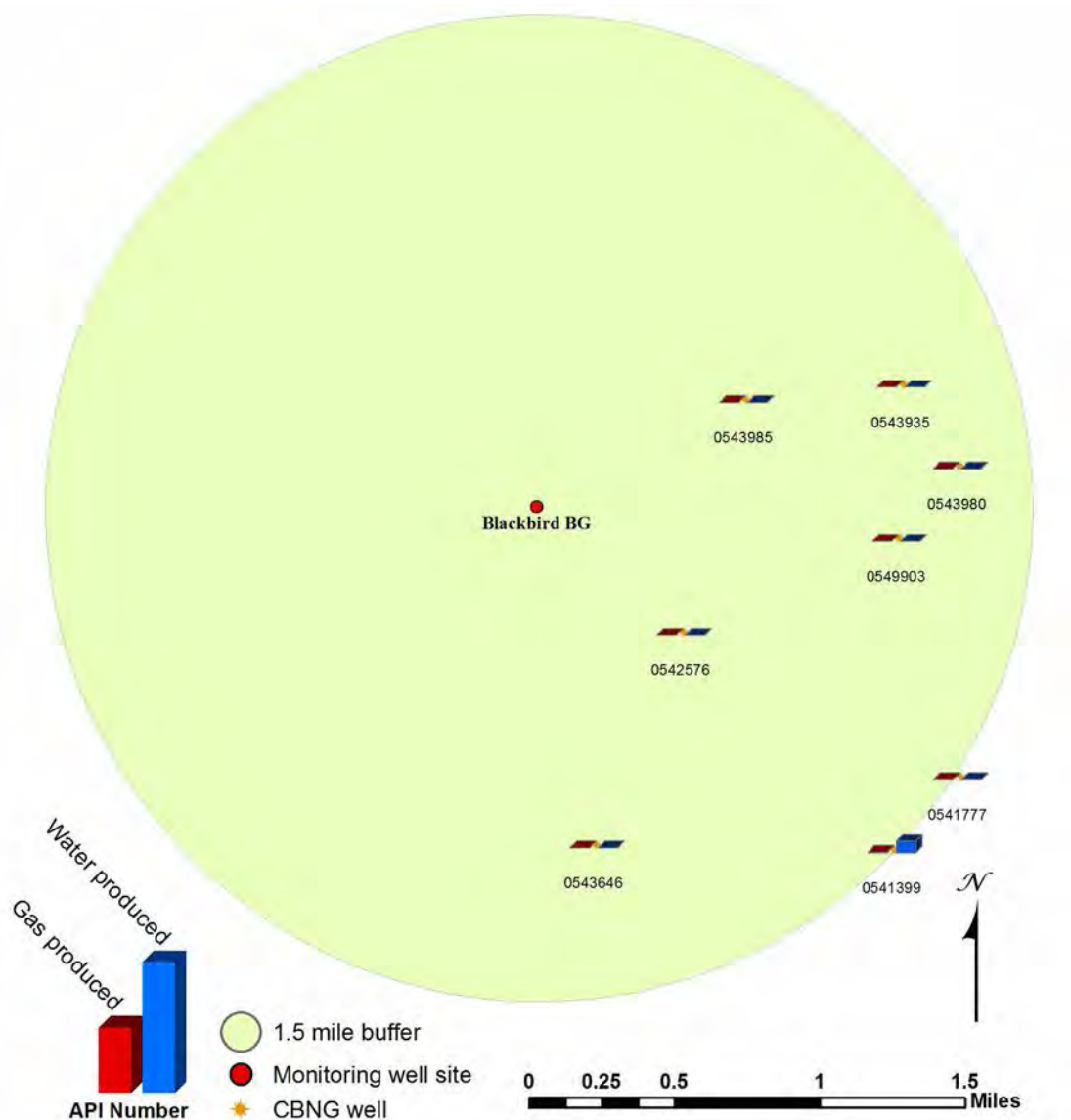


Figure 49. Blackbird BG monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (Bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

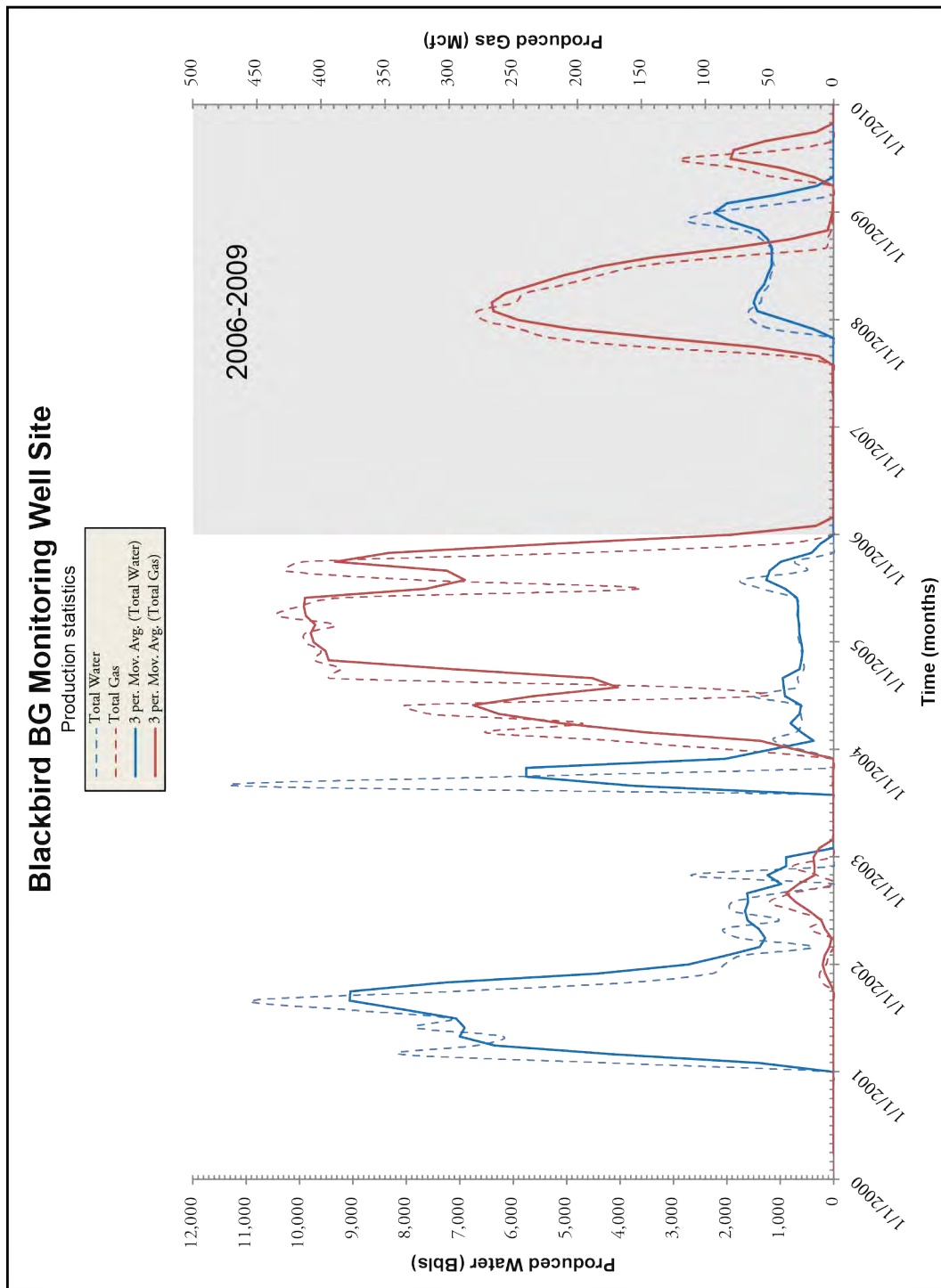


Figure 50. 3-period moving average along with water and gas production from associated CBNG wells.

Buffalo SE Monitoring Well Site
Location: S12 T50N R81W
Date First Monitored: May 03, 2001

Drawdown Information

The Buffalo SE monitoring well site includes five wells. One well is constructed into the Smith coal and the other four wells are constructed into overlying sandstones (Figure 51; Table 23).

There was negligible drawdown in the Smith coal during the 2006-2009 monitoring period (Figure 52; Table 24). Groundwater levels for all monitored sandstones were stable during the 2006-2009 monitoring period, as they have been for the life of the well (Figure 52; Table 24). Gas pressure readings did not surpass levels possible from transducer error.

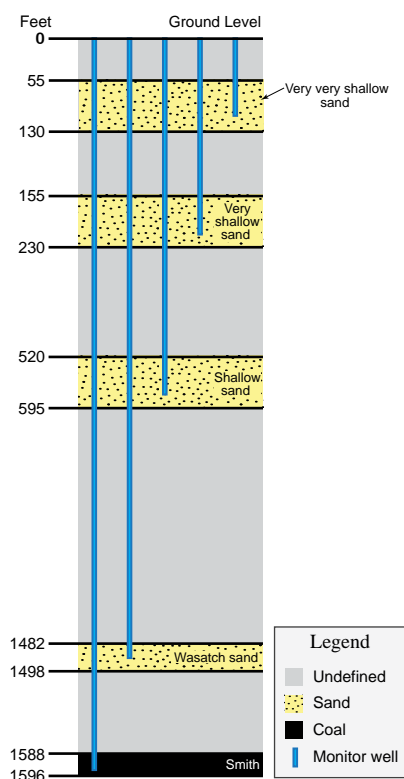


Figure 51. Section showing relative positions of coals and sands in feet. Not to scale.

Table 23. Table showing the depth to and thickness of monitored zones at the Buffalo SE monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Very very shallow sand	55	130	75	1458
Very shallow sand	155	230	75	1358
Shallow sand	520	595	75	993
Wasatch sand	1482	1498	16	90
Smith coal	1588	1596	8	n/a

Table 24. Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2006	Drawdown 2006-2009	Total drawdown (ft.)	Depth to 12/31/09 water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Very very shallow sand ⁽¹⁾	47.81	3.19	0.80	3.99	51.80	n/a	n/a
Very shallow sand	143.92	-0.42	1.32	0.90	144.82	n/a	n/a
Shallow sand	419.23	-11.14	-8.29	-19.43	399.80	n/a	n/a
Wasatch sand	337.51	-5.87	0.78	-5.09	332.42	n/a	n/a
Smith coal	280.97	24.64	0.71	25.35	306.32	n/a	n/a

(1) The transducer was pulled from this well on 5/10/07. The well will be used by landowner to establish a watering well for cattle. Therefore, as of 5/10/07 the well is no longer part of the data collection for this site.

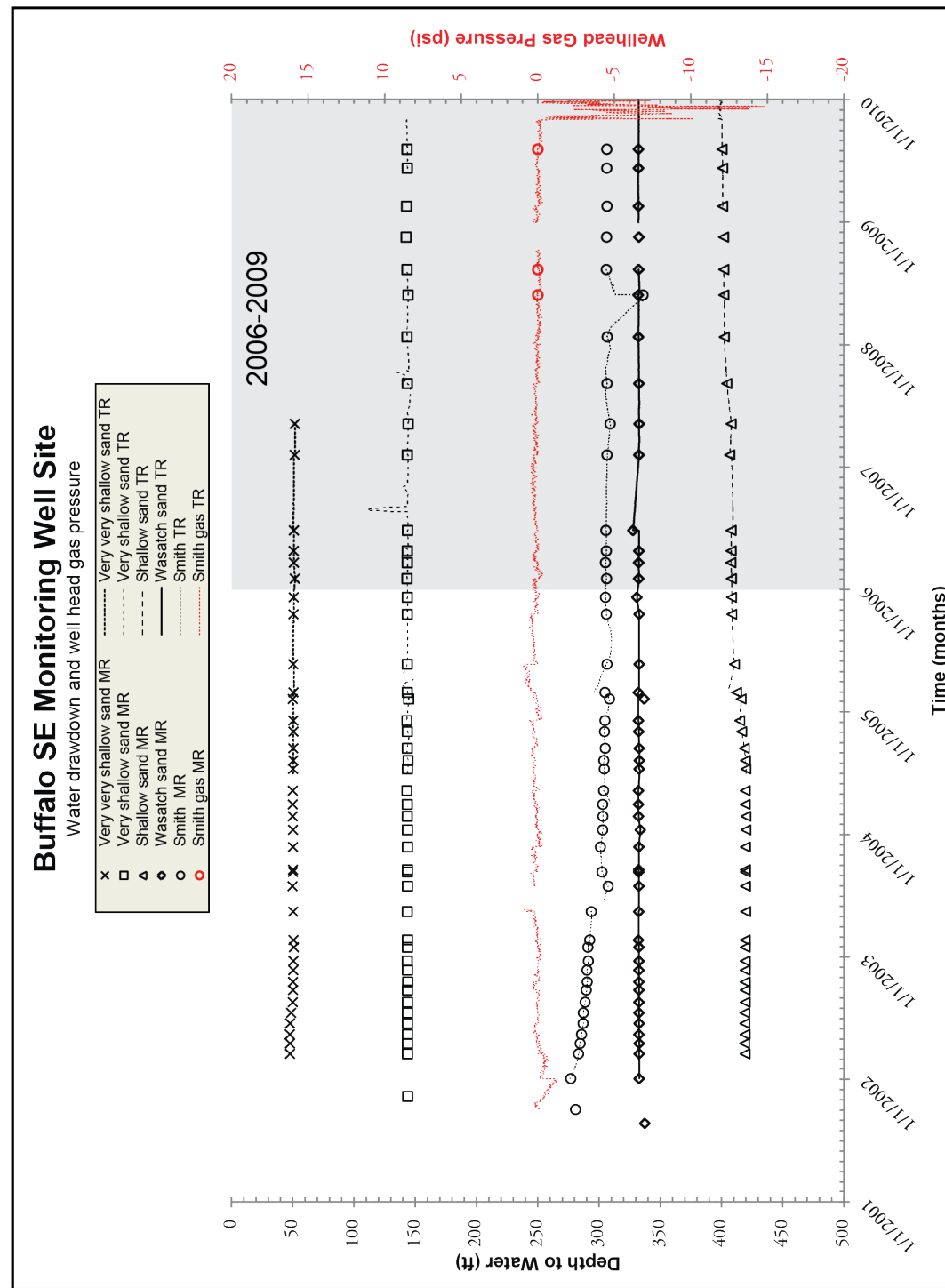


Figure 52. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Buffalo SE monitoring well site location.

Production Statistics

Production data was analyzed for CBNG wells within the buffer of the Buffalo SE monitoring wells from January 2003 through December 2009. Cumulative production for individual CBNG wells is displayed by location on Figure 53.

no production, or associated drawdown, during the 2006 to 2009 monitoring period (Figure 54). The water/gas ratio of CBNG wells within the buffer is relatively consistent for all wells, though this is to be expected as no gas was produced from the cumulative wells. Percent methane is variable.

Water production peaked in 2003, which correlates to groundwater drawdown trends. There was

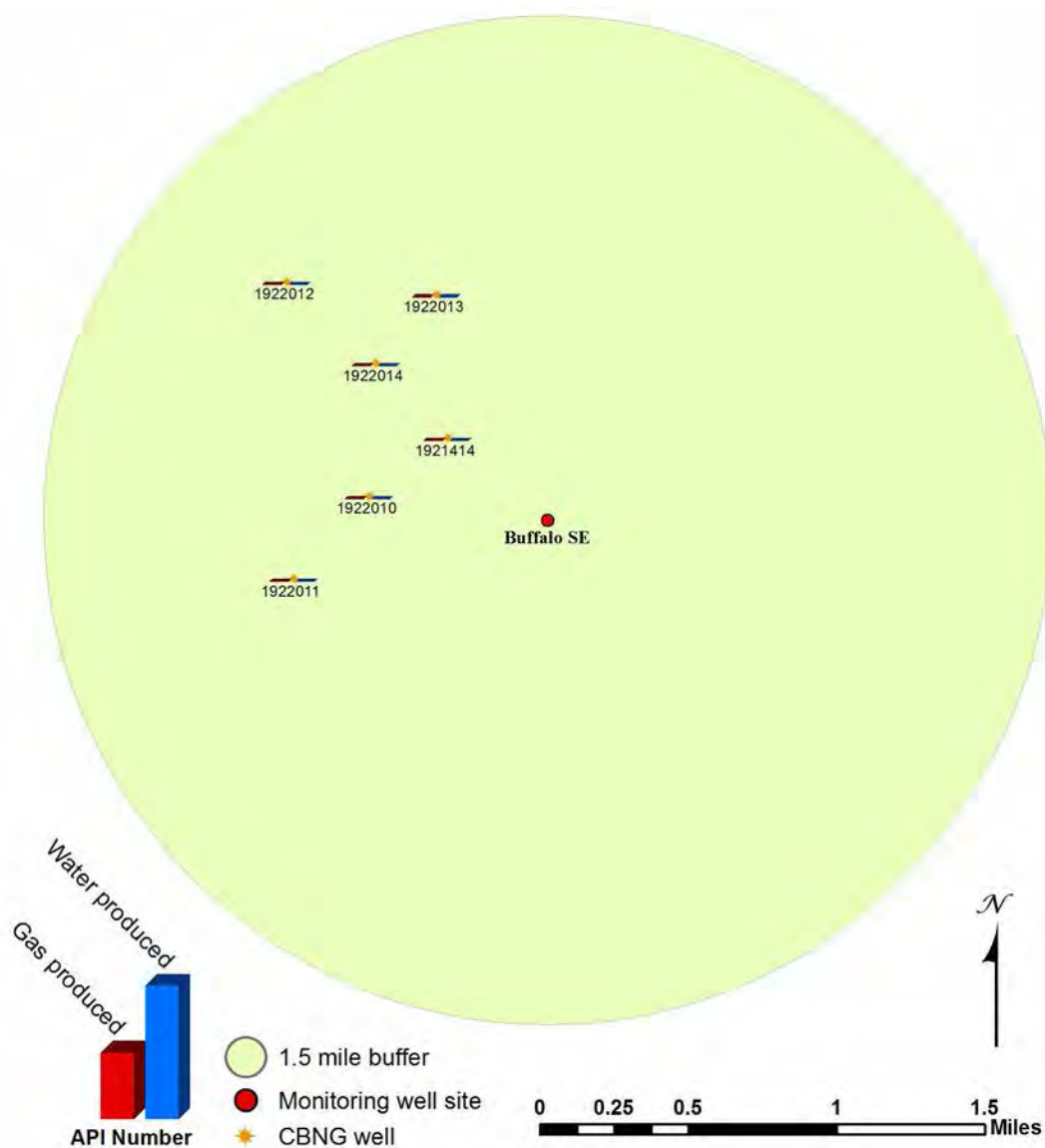


Figure 53. Buffalo SE monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (Bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

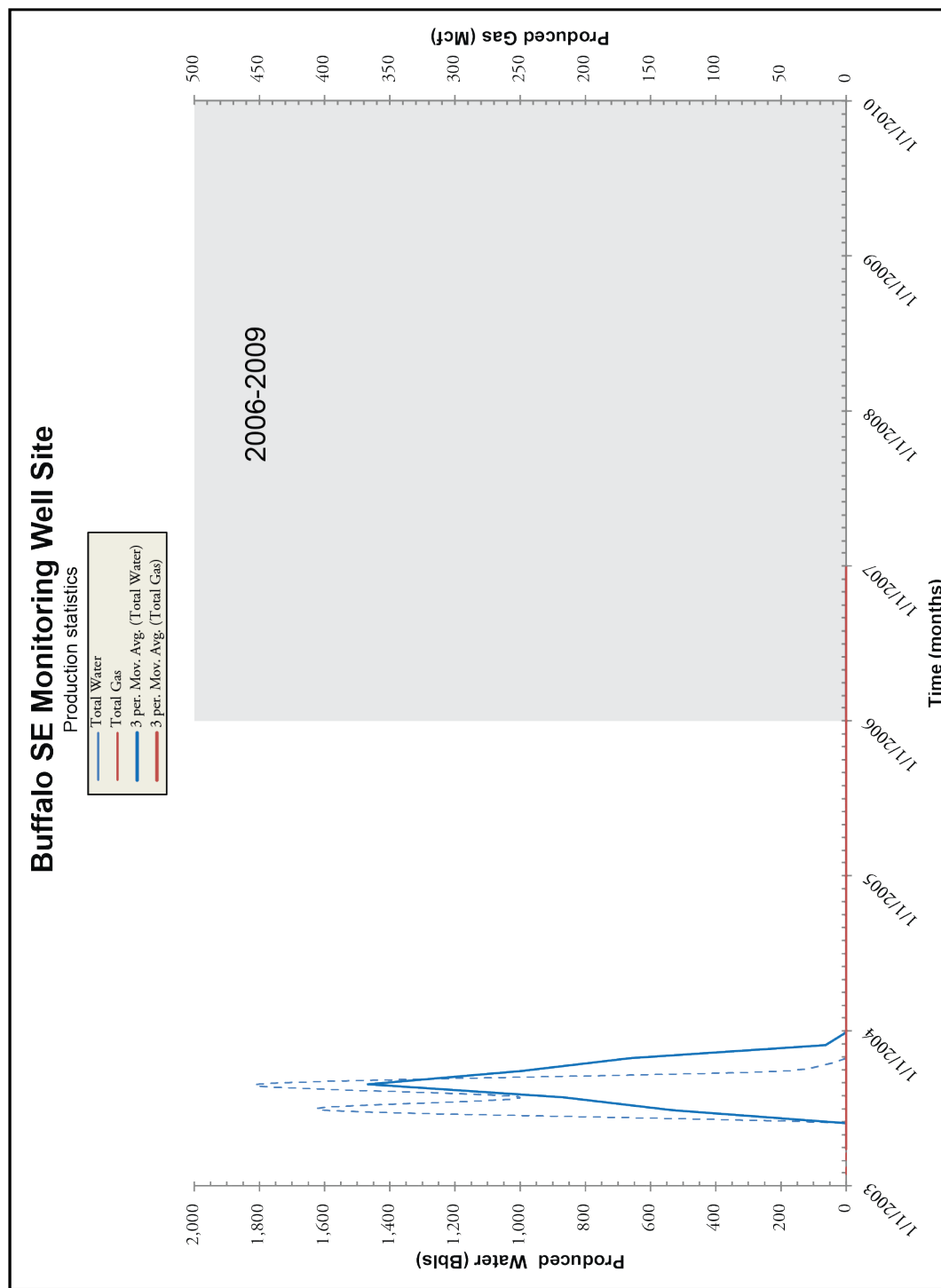


Figure 54. 3-period moving average along with water and gas production from associated CBNG wells.

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

Drawdown Information

The Bullwhacker well set includes two wells. One is constructed into the Big George coal and the other is constructed into a overlying Wasatch sandstone (Figure 55; Table 25). Missing transducer data is the result of errors with on-site equipment.

The Big George coal recorded a groundwater draw-down of 621 feet during the 2006-2009 monitoring period; data shows a steady decline in the groundwater level (Figure 56; Table 26). Groundwater levels in the Wasatch sandstone declined by 96 feet during the 2006-2009 monitoring period (Figure 56; Table 26). This suggests the possibility of a hydraulic connection between the monitored Wasatch sandstone and producing zones. Gas pressures in the Big George coal recorded a steady decline between 2006-2009.

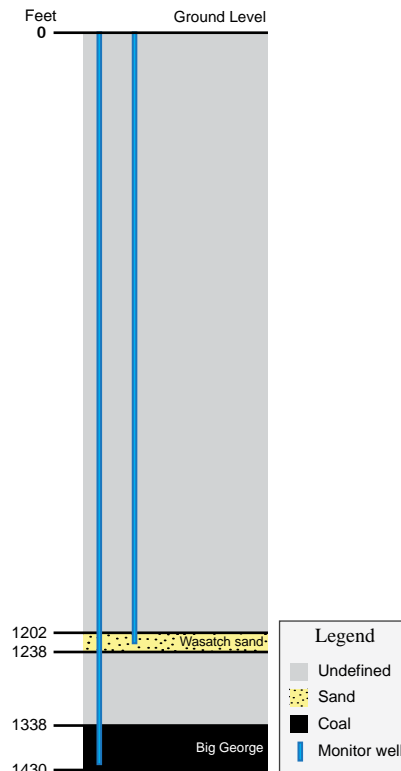


Figure 55. Section showing relative positions of coals and sands in feet. Not to scale.

Table 25. Table showing the depth to and thickness of monitored zones at the Bullwhacker monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Wasatch sand	1202	1238	36	100
Big George coal	1338	1430	92	n/a

Table 26. Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2006	Drawdown 2006-2009	Total drawdown (ft.)	Depth to 12/31/09 water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	25.41	113.59	95.78	209.37	234.78	n/a	n/a
Big George coal	92.77	449.63	621.10	1070.73	1163.50	311	10/23/03

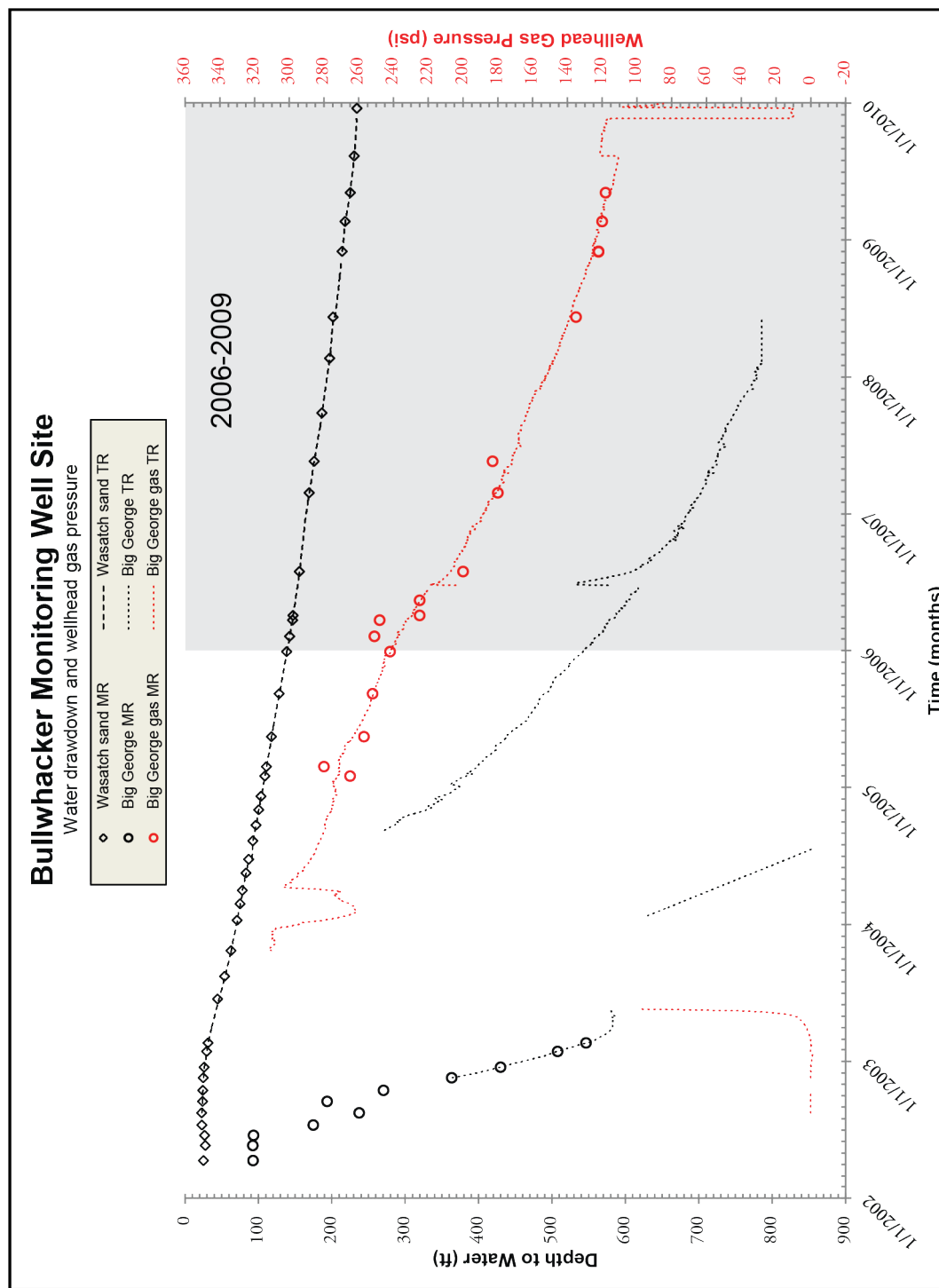


Figure 56. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Bullwhacker monitoring well site location.

Production Statistics

Production data was analyzed for CBNG wells within the buffer of the Bullwhacker monitoring well site from January 2000 through December 2009. Cumulative production for individual CBNG wells is displayed by location on Figure 57.

increased and water production declined during the 2006 to 2009 monitoring period (Figure 58). The water/gas ratio of CBNG wells within the buffer is relatively inconsistent from south to north. Percent methane is relatively consistent.

Water production peaked in 2003, which correlates to groundwater drawdown trends. Gas production

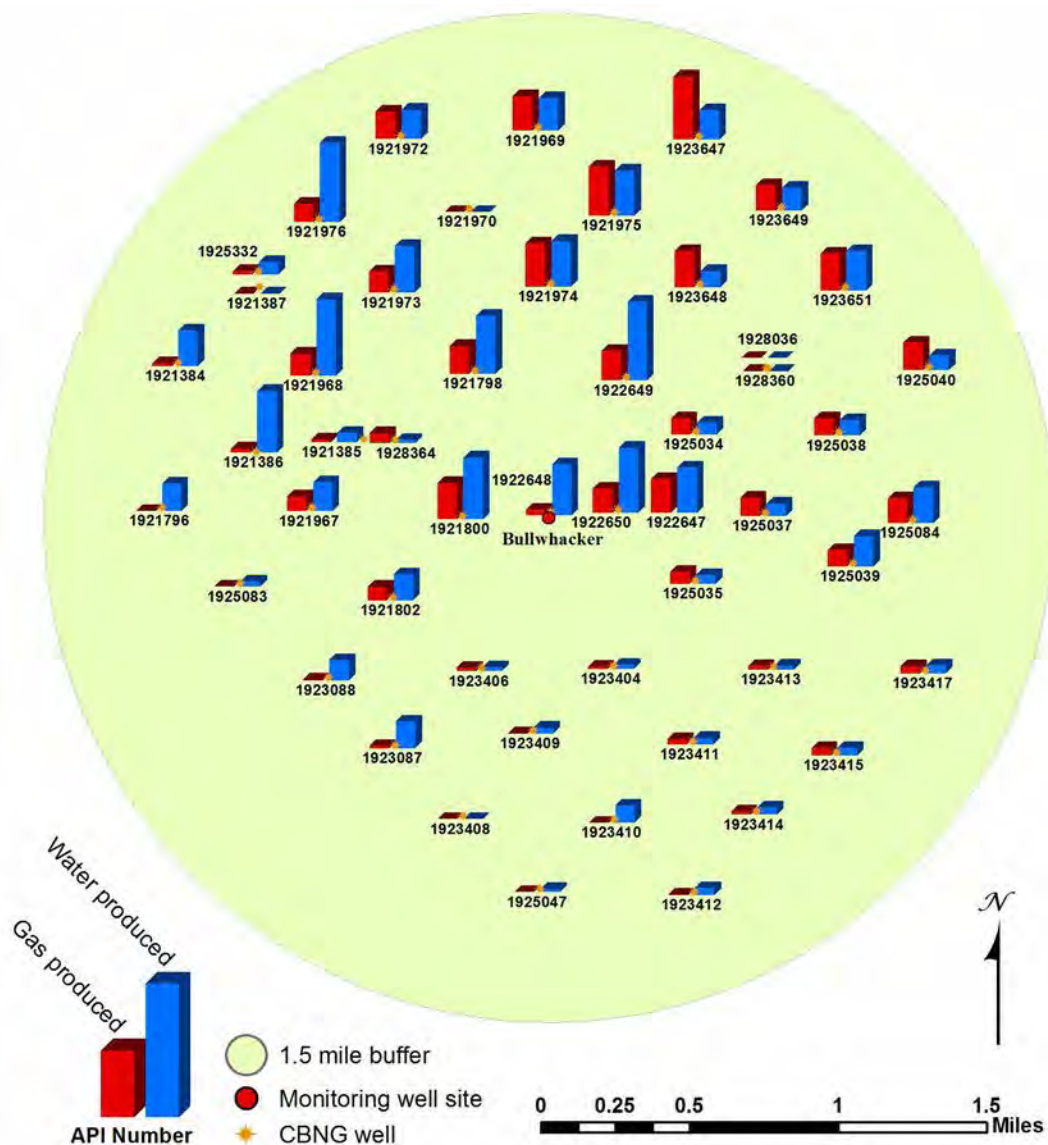


Figure 57. Bullwhacker monitoring well and associated CBNG wells within 1.5 mile buffer showing cumulative water (Bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

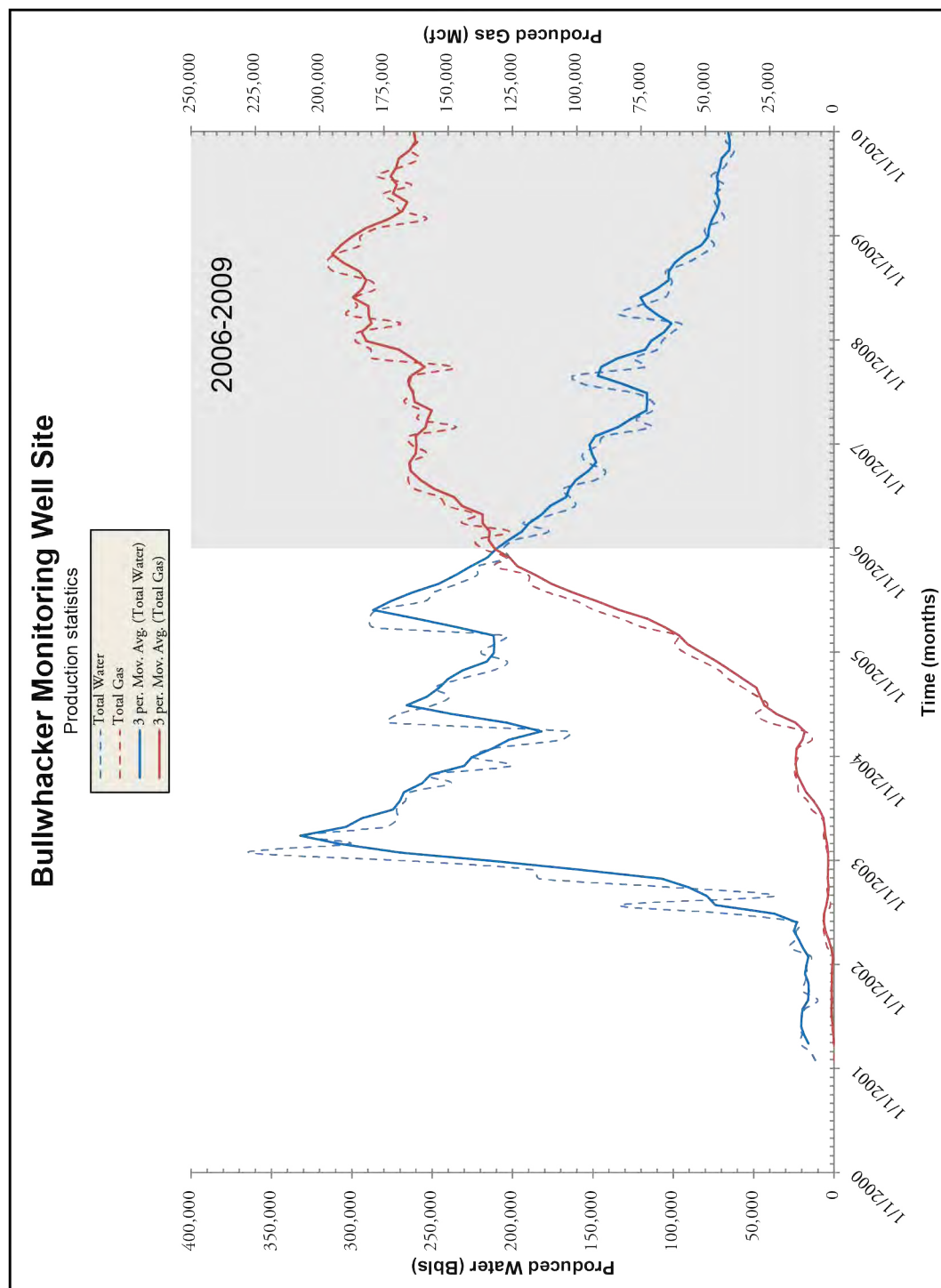


Figure 58. 3-period moving average along with water and gas production from associated CBNG wells.

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

Drawdown Information

The Carr Draw monitoring well site consists of two wells with dual completions, separated by packers. One well is completed into the Big George coal and an overlying Wasatch sandstone. The second well is completed into the Werner and Gates/Wall coals (Figure 59; Table 27). Missing and/or fluctuating transducer data is the result of errors with on-site equipment.

Initial data that was collected was from manual measurements, 2009 data includes some transducer recorded data. The depth to initial water levels for the Wasatch sandstone (342 ft.) and Werner coal (344 ft.) were similar despite the approximate 1,000 feet separation between the two zones. Likewise, the Big George (492 ft.) and Gates/Wall (491 ft.) coal zones had similar initial water levels despite 500 feet in separation. The Big George coal had the most drawdown during the 2006-2009 monitoring period at 546 feet. The Wasatch sandstone and Werner coal had similar drawdowns with 355 feet and 320 feet respectively. The Gates/Wall coal water level rose by 144 feet over the same 2006-2009 monitoring period (Figure 60; Table 28). With equipment and packer issues on this site no conclusions on hydrologic connection between zones can be made at this time. The gas readings did not surpass levels possible from transducer error.

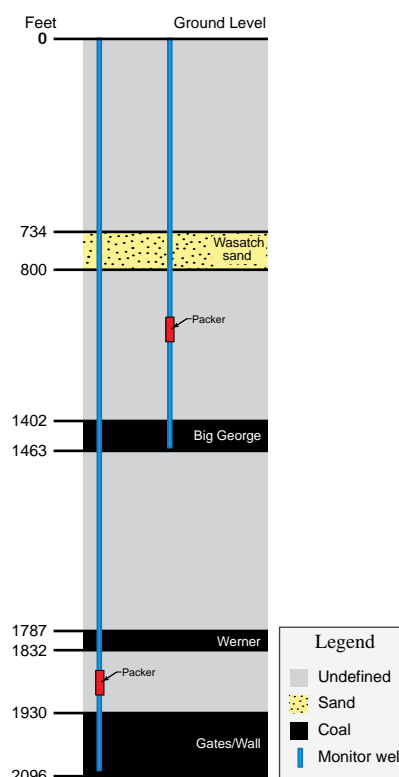


Figure 59. Section showing relative positions of coals and sands in feet. Not to scale.

Table 27. Table showing the depth to and thickness of monitored zones at the Carr Draw monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Wasatch sand	734	800	66	602
Big George coal	1402	1463	61	n/a
Werner coal	1787	1832	45	n/a
Gates/Wall coal	1930	2096	166	n/a

Table 28. Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2006	Drawdown 2006-2009	Total drawdown (ft.)	Depth to 12/31/09 water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	341.66	n/a	355.39	355.39	697.05	n/a	n/a
Big George coal	492.30	n/a	546.15	546.15	1038.45	n/a	n/a
Werner coal	344.00	n/a	320.26	320.26	664.26	n/a	n/a
Gates/Wall coal	490.50	n/a	-143.52	-143.52	346.98	n/a	n/a

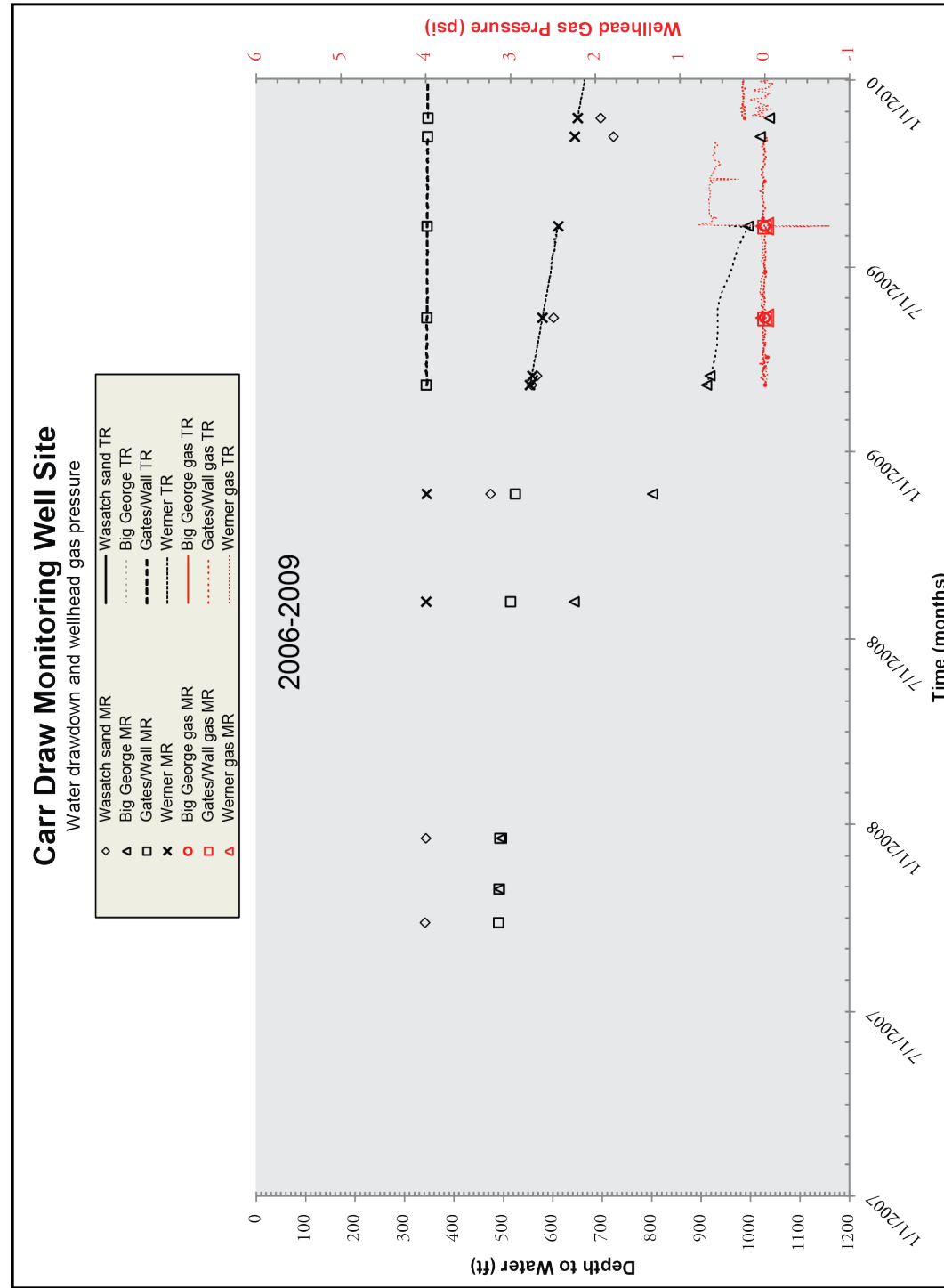


Figure 60. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Carr Draw monitoring well site location.

Production Statistics

Production data was analyzed for CBNG wells within the buffer of the Carr Draw monitoring well site from January 2002 through December 2009. Cumulative production for individual CBNG wells is displayed by location on Figure 61.

down recorded in the Big George coal bed. Water and gas production increased during the 2006 to 2009 monitoring period (Figure 62). The water/gas ratio of CBNG wells within the buffer is relatively inconsistent from southwest to northeast. Percent methane remained relatively consistent.

Water production peaked in 2004. Renewed water production in 2008 correlates to groundwater draw-

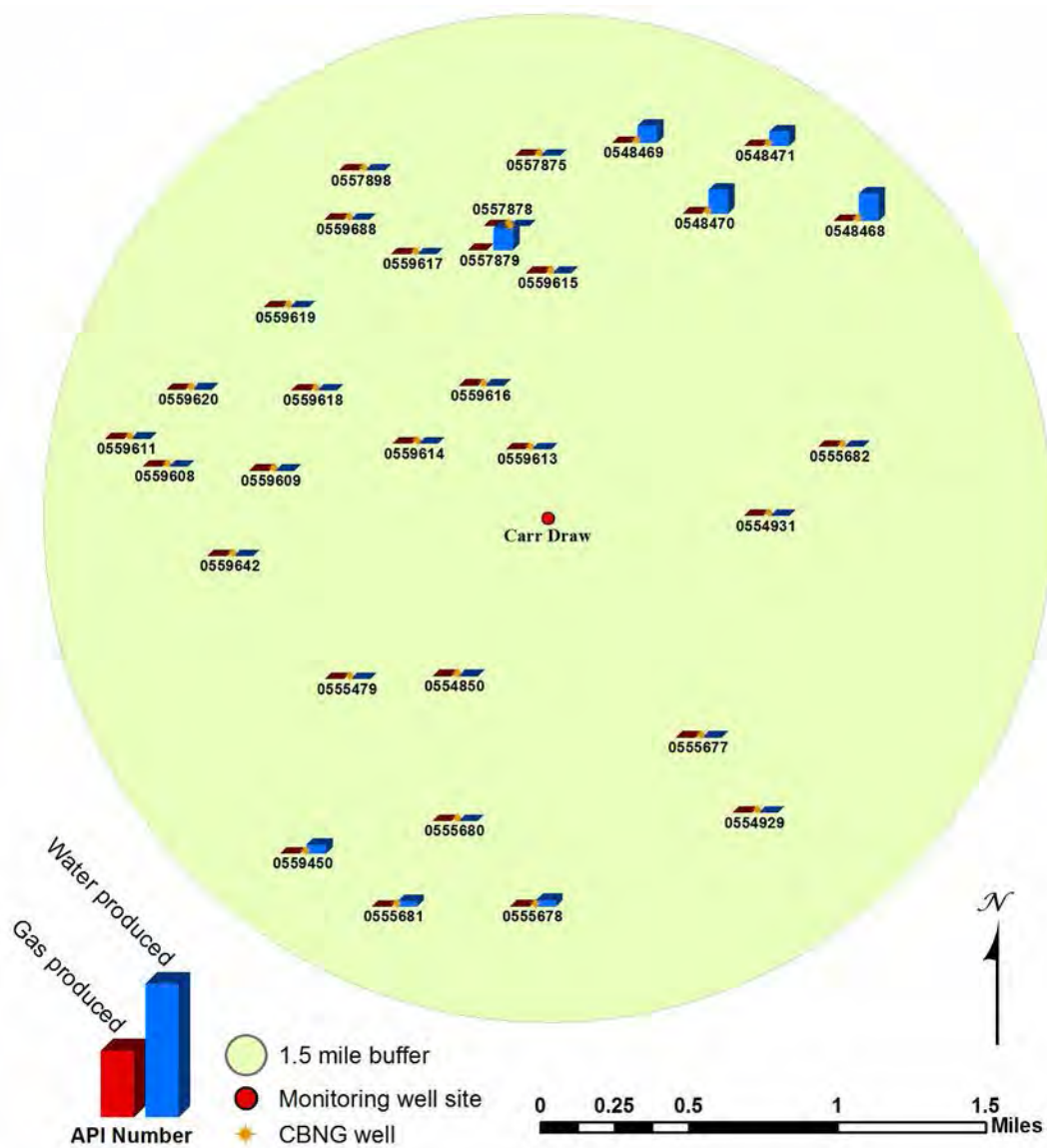


Figure 61. Carr Draw monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (Bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

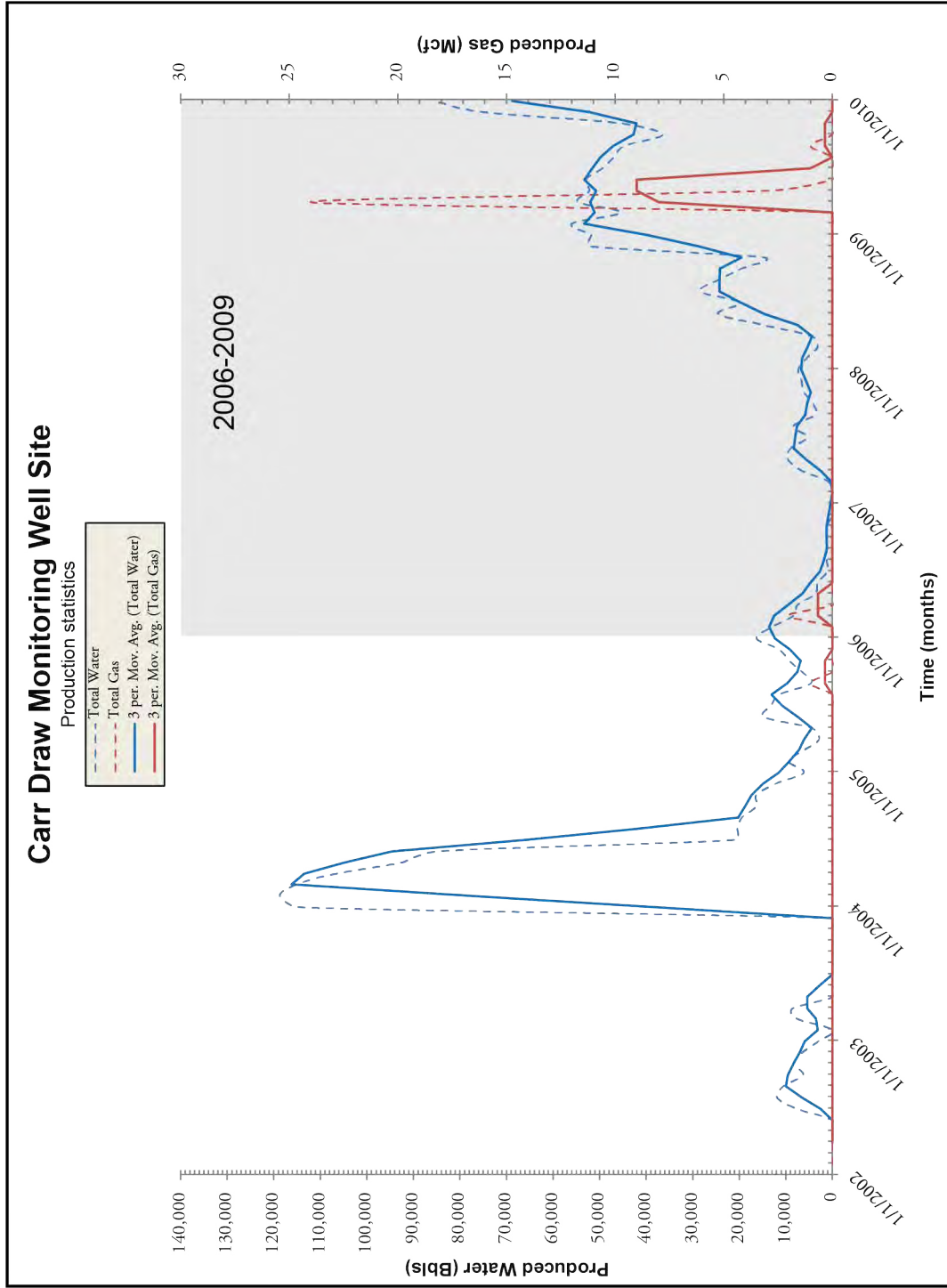


Figure 62. 3-period moving average along with water and gas production from associated CBNG wells.

Coal Gulch Monitoring Well Site
Location: S26 T51 N R78W
Date First Monitored: September 8, 2005

The Coal Gulch monitoring well site includes one well completed in the Big George and Smith coals and separated by a packer (Figure 63; Table 29). Missing and/or fluctuating transducer data is the result of errors with on site equipment.

The Big George coal recorded a groundwater drawdown of 263 feet during the 2006-2009 monitoring period; data shows a steady decline in the groundwater level until January of 2009 at which time the groundwater level rose 36 feet (Figure 64; Table 30). The Smith coal recorded a groundwater drawdown of 211 feet during the 2006-2009 monitoring period; data shows a steady decline in the groundwater level until January of 2009, at which time the groundwater level began to rise (Figure 64; Table 30). Similar initial groundwater depths and equivalent water level trends during drawdown and recovery indicates that these coals maybe hydraulically connected, or the packer maybe leaking which allows the zones to equilibrate and exhibit similar drawdown trends.

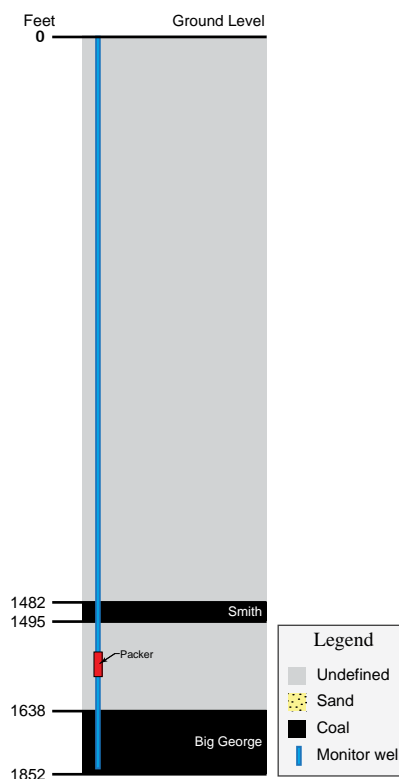


Figure 63. Section showing relative positions of coals and sands in feet. Not to scale.

Table 29. Table showing the depth to and thickness of monitored zones at the Coal Gulch monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Smith coal	1482	1495	13	n/a
Big George coal	1638	1852	214	n/a

Table 30. Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2006	Drawdown 2006-2009	Total drawdown (ft.)	Depth to 12/31/09 water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Smith coal	467.17	53.83	211.29	265.12	732.29	n/a	n/a
Big George coal	469.20	6.70	263.19	269.89	739.09	2.19	10/19/05

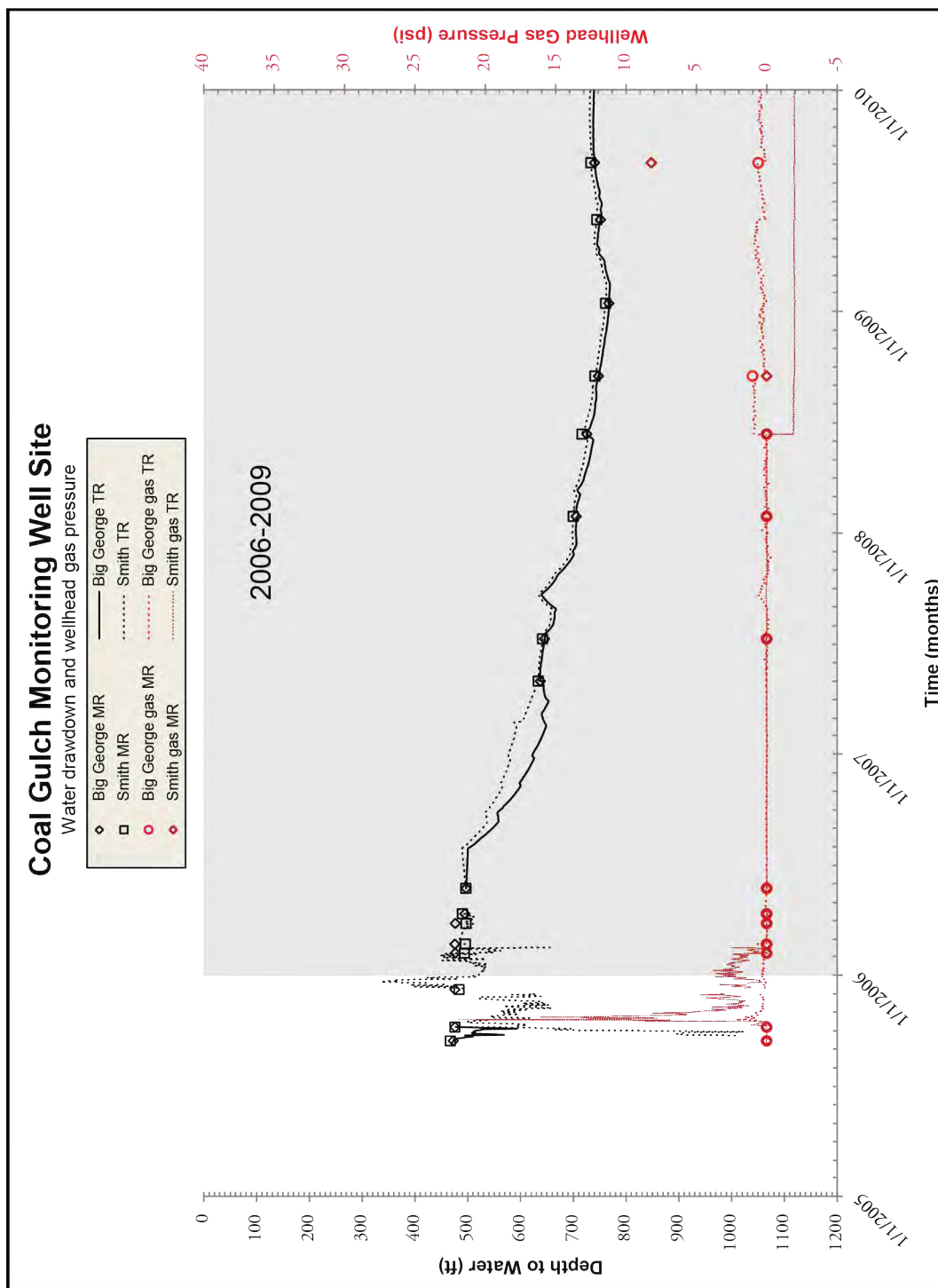


Figure 64. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Coal Gulch monitoring well site location.

Production Statistics

Production data was analyzed for CBNG wells within the buffer of the Coal Gulch monitoring well site from January 2003 through December 2009. Cumulative production for individual CBNG wells is displayed by location on Figure 65.

Within the buffer, the CBNG wells have an inconsistent water/gas ratio from north to south. CBNG water production peaked in 2003 prior to monitor-

ing. Continued production from the zone is consistent with groundwater drawdown trends, though water and gas production declined during the 2006 to 2009 monitoring period (Figure 66). The water/gas ratio of CBNG wells within the buffer is relatively inconsistent from south to north. Percent methane is variable.

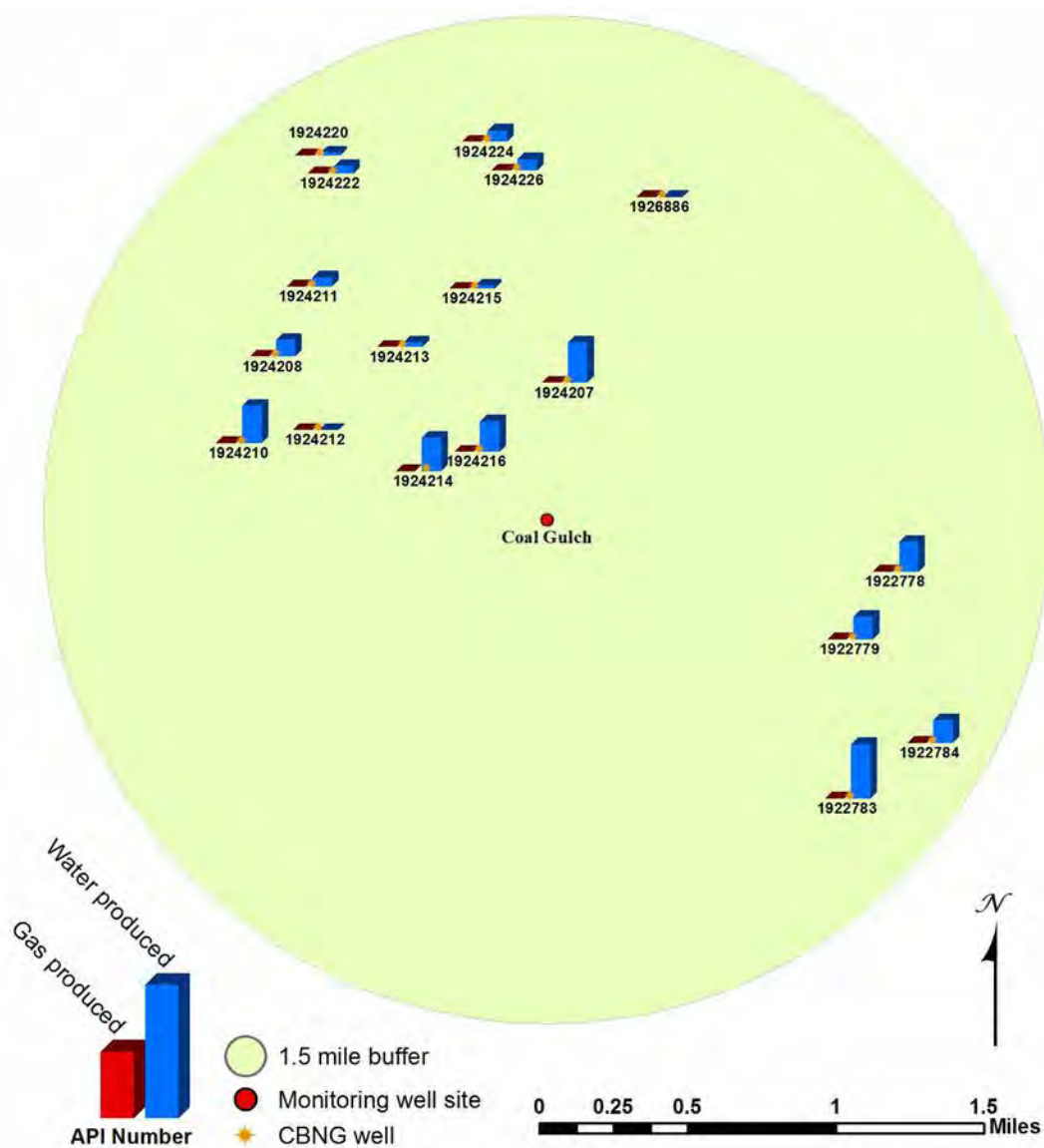


Figure 65. Coal Gulch monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (Bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

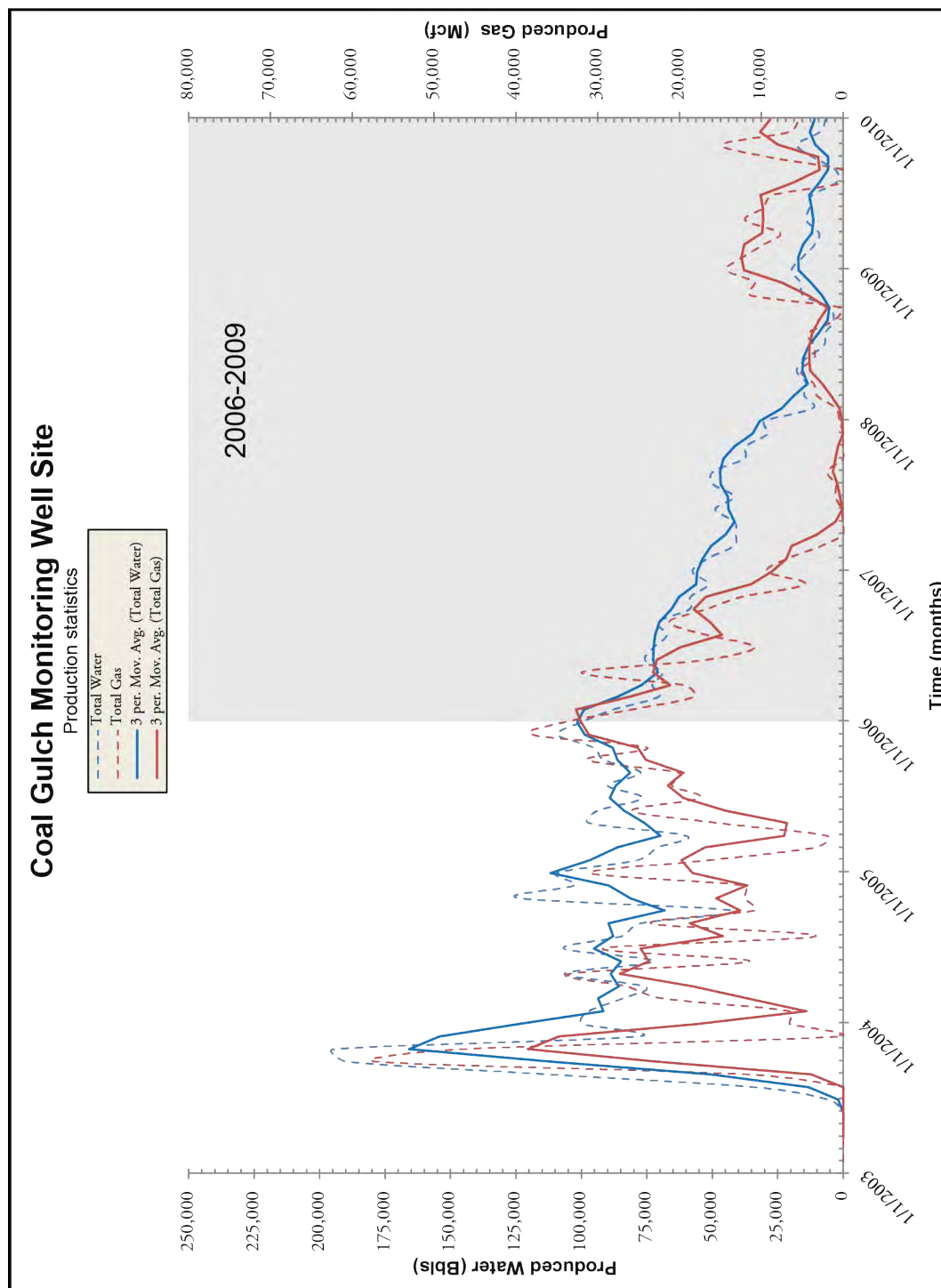


Figure 66. 3-period moving average along with water and gas production from associated CBNG wells.

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 constructed into the Big George coal and the other into the deeper Wyodak coal (Figure 67; Table 31). Missing and/or fluctuating transducer data is the result of errors with on-site equipment.

The Big George coal recorded a groundwater draw-down of 116 feet during the 2006-2009 monitoring period; data shows a steady decline in the groundwater level (Figure 68; Table 32). The Wyodak coal recorded a groundwater drawdown of 25 feet during the 2006-2009 monitoring period; data shows a steady decline in the groundwater level (Figure 68; Table 32). Monitoring data suggests these coals are not hydraulically connected. Gas pressure readings did not surpass levels possible from transducer error.

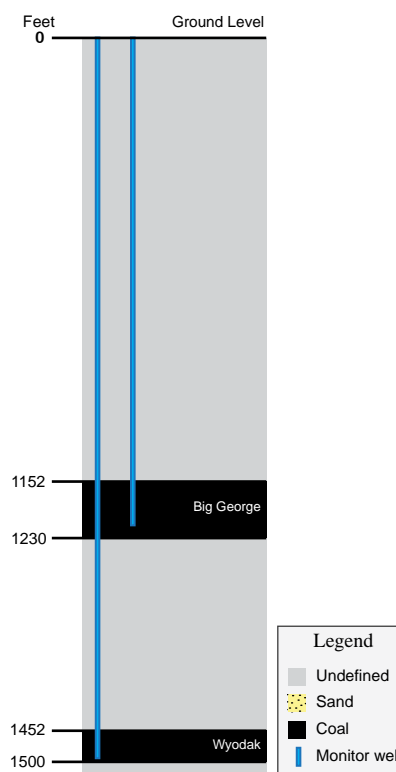


Figure 67. Section showing relative positions of coals and sands in feet. Not to scale.

Table 31. Table showing the depth to and thickness of monitored zones at the Double Tank monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Big George coal	1152	1230	78	n/a
Wyodak coal	1452	1500	48	n/a

Table 32. Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2006	Drawdown 2006-2009	Total drawdown (ft.)	Depth to 12/31/09 water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Big George coal	294.61	399.17	115.75	514.92	809.53	n/a	n/a
Wyodak coal	148.86	221.57	74.55	296.12	444.98	n/a	n/a

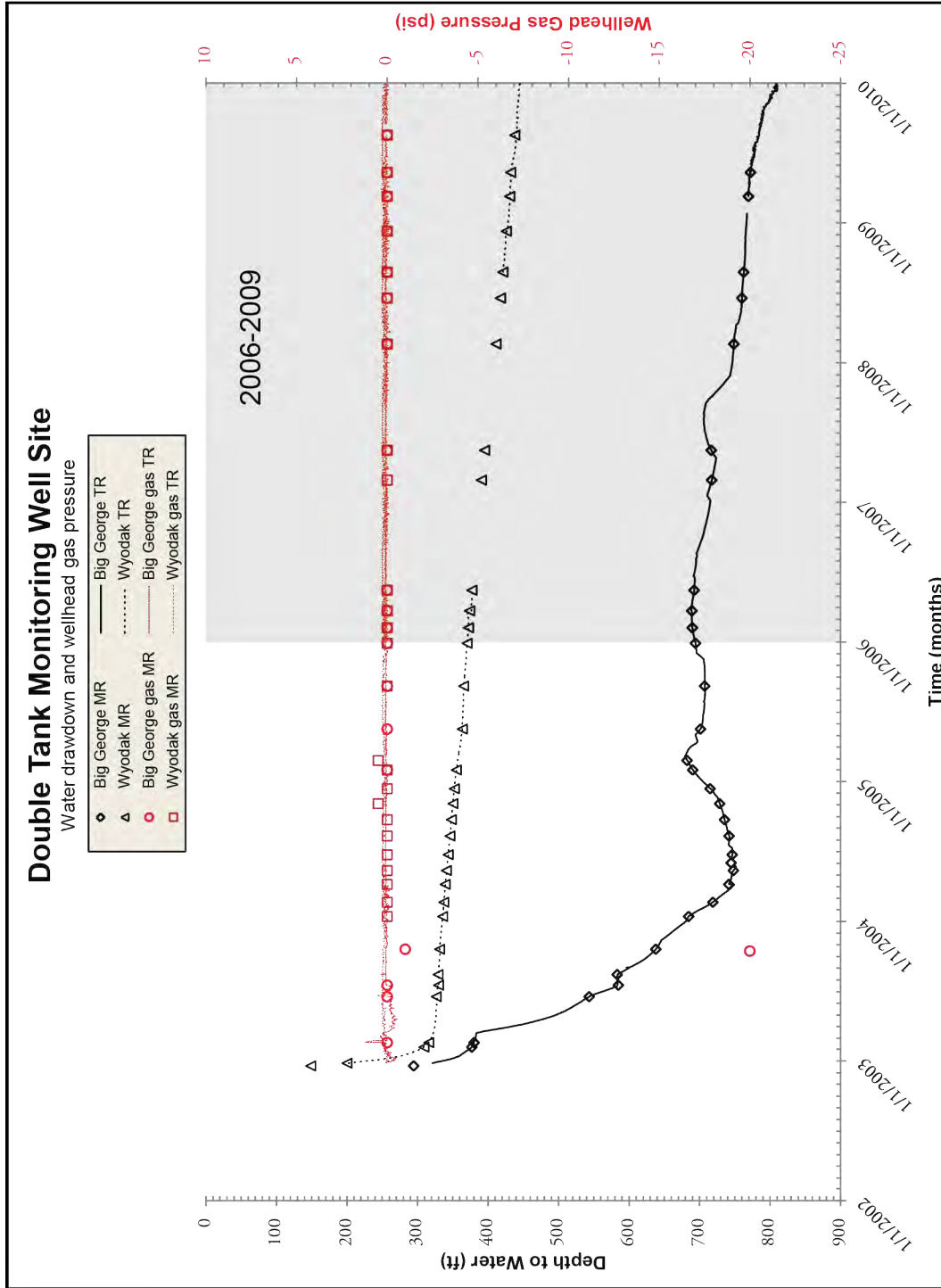


Figure 68. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Double Tank monitoring well site location.

Production Statistics

Production data was analyzed for CBNG wells within the buffer of the Double Tank monitoring well site from January 2002 to December 2009. Cumulative production for individual CBNG wells is displayed by location on Figure 69.

Water production peaked in 2003, which correlates to rapid groundwater drawdown trends. Water and gas production increased during the 2006 to 2009

monitoring period (Figure 70). The water/gas ratio of CBNG wells within the buffer is relatively inconsistent from south to north. Percent methane is relatively consistent.

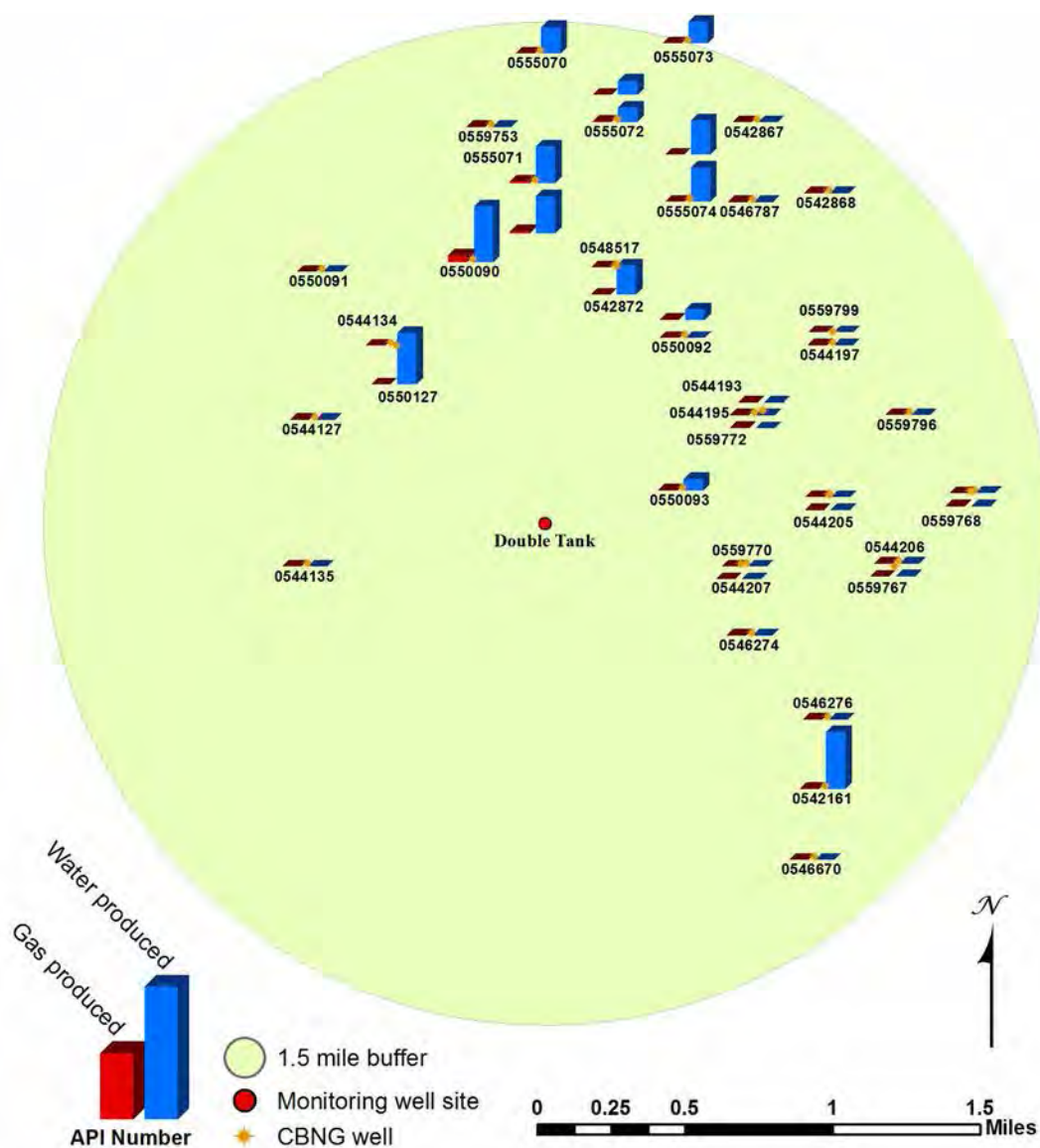


Figure 69. Double Tank monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (Bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

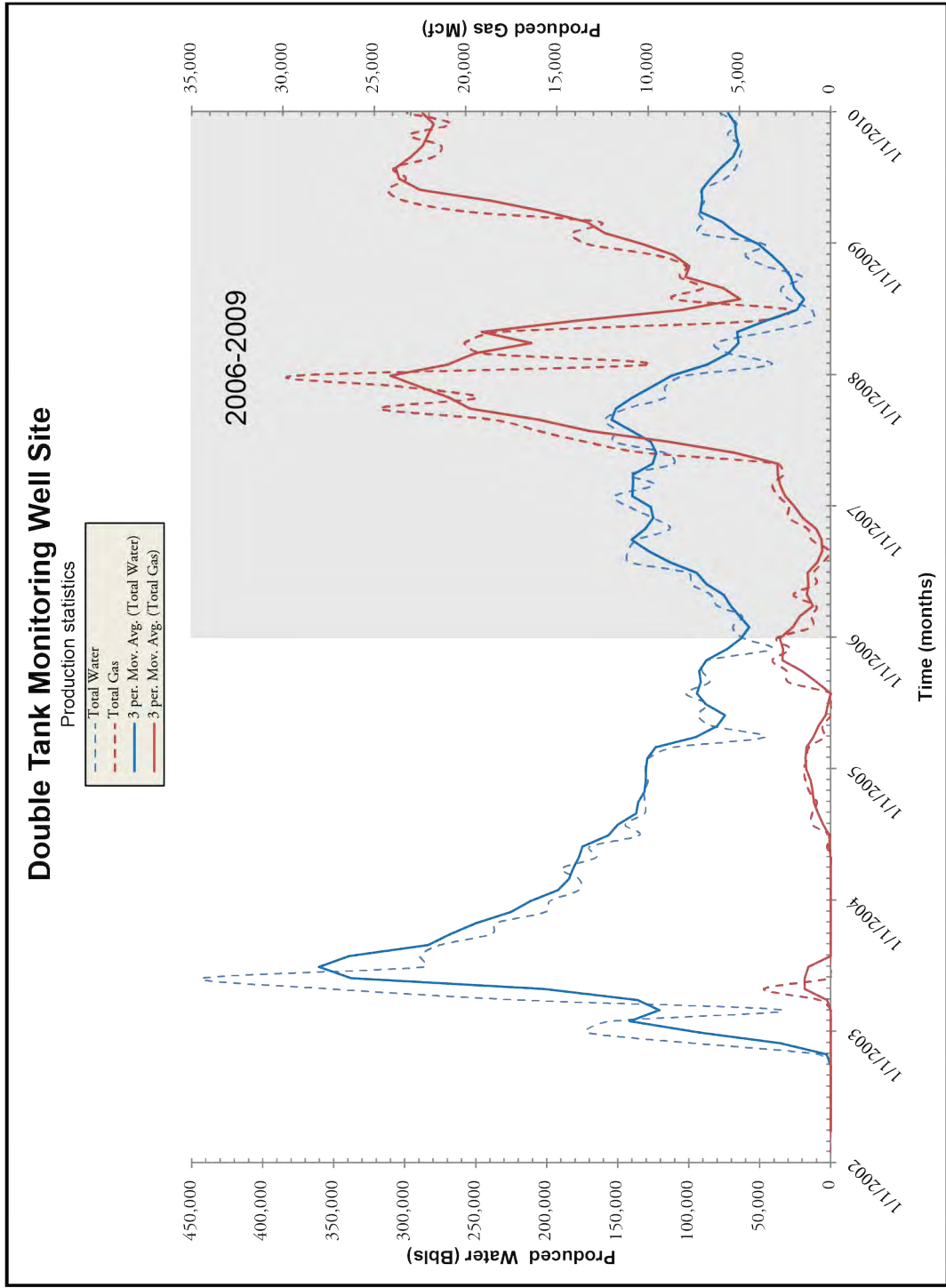


Figure 70. 3-period moving average along with water and gas production from associated CBNG wells.

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

Drawdown Information

The Echeta monitoring well site consists of one well constructed into the Big George coal (Figure 71; Table 33). Missing and/or fluctuating transducer data is the result of errors with on-site equipment.

The Big George coal recorded a groundwater draw-down of 85 feet during the 2006-2009 monitoring period; data shows a steady decline in the groundwater level (Figure 72; Table 34). Gas pressure readings fluctuated in the early part of 2006, but afterwards did not surpass levels possible from transducer error.

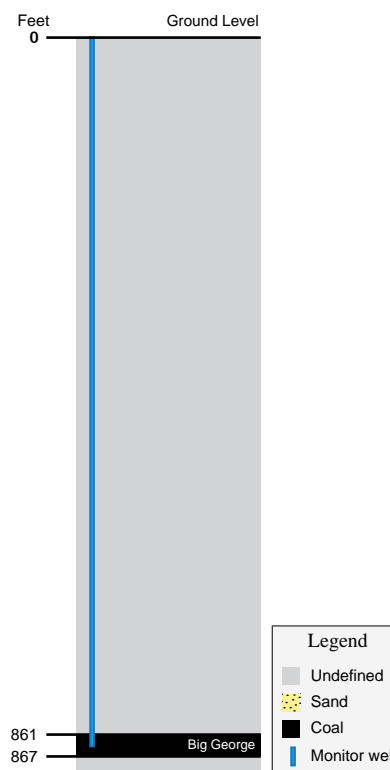


Figure 71. Section showing relative positions of coals and sands in feet. Not to scale.

Table 33. Table showing the depth to and thickness of monitored zones at the Echeta monitoring well site location. (measured in feet)

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

Table 34. Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2006	Drawdown 2006-2009	Total drawdown (ft.)	Depth to 12/31/09 water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Big George coal	245.90	55.16	85.14	140.30	386.20	n/a	n/a

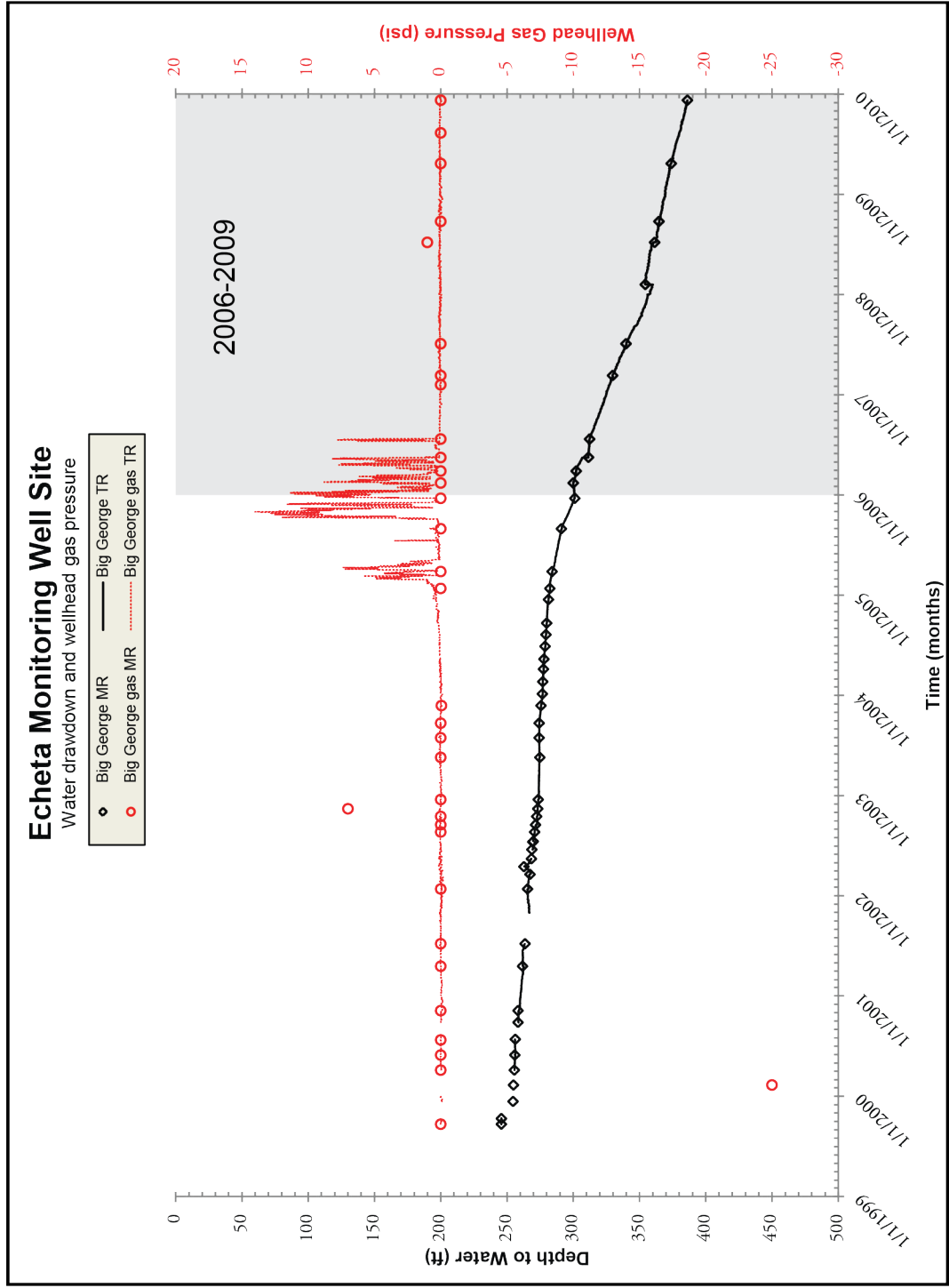


Figure 72. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Echeta monitoring well site location.

Production Statistics

Production data was analyzed for five CBNG wells within the buffer of the Echeta monitoring well site from January 2000 through December 2009. Cumulative production for individual CBNG wells is displayed by location on Figure 73.

Water production peaked in 2001, which correlates to groundwater drawdown trends. There is no re-

ported production during the 2006 to 2009 monitoring period, though groundwater levels continue to decline (Figure 74). This is likely the result of wells that were omitted due to incomplete data or generalized reported completion interval. The water/gas ratio of CBNG wells within the buffer is relatively inconsistent. Percent methane is variable.

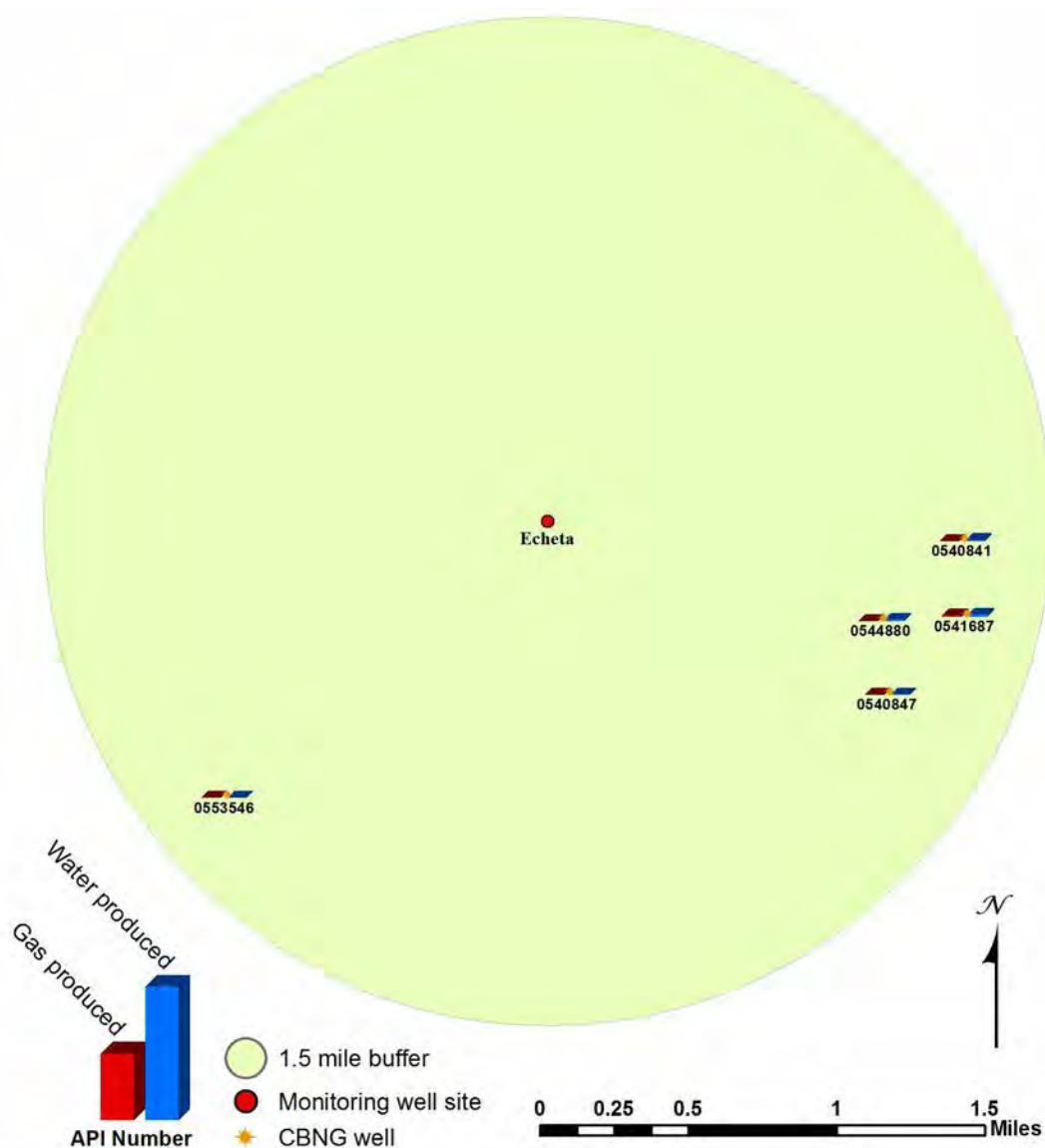


Figure 73. Echeta monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (Bbls) and gas (Mcf) production. The six digit number below the well point corresponds to the wells American Petroleum Institute (API) number.

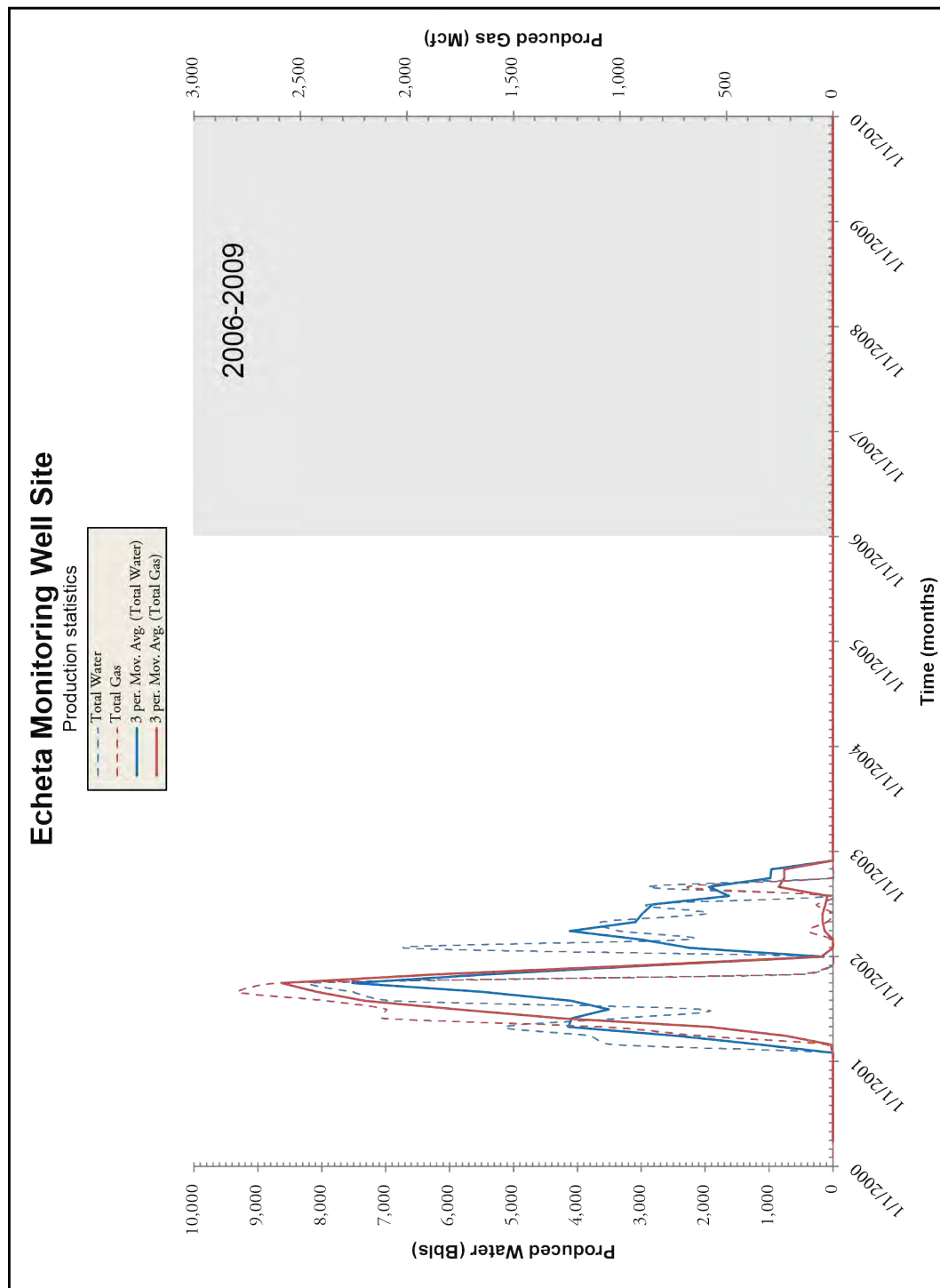


Figure 74. 3-period moving average along with water and gas production from associated CBNG wells.

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

Drawdown Information

The Fourmile monitoring well site includes three wells. One well is completed into the Big George coal, the second well is completed into a Fort Union underburden sandstone, the third well is completed into overlying Wasatch sandstone (Figure 75; Table 35). Missing and/or fluctuating transducer data is the result of errors with on-site equipment.

The Big George coal recorded a groundwater rise of 11 feet during the 2006-2009 monitoring period; data shows a slight increase followed by a slow decline in the groundwater level (Figure 76; Table 36). Groundwater levels in the underburden sandstone rose by 32 feet during the 2006-2009 monitoring period; data shows a slight increase followed by a slow decline in the groundwater level (Figure 76; Table 36). Similar groundwater level trends indicates there may be a hydraulic connection between the monitored underburden sandstone and producing zone (Figure 77). Groundwater levels in the Wasatch sandstone remained nearly constant during the 2006-2009 monitoring period, suggesting there is no hydraulic connection between the Wasatch sandstone and producing zone. Gas pressure readings did not surpass levels possible from transducer error.

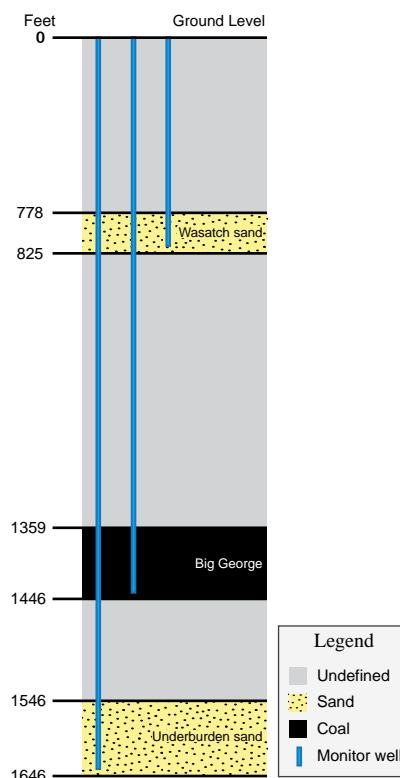


Figure 75. Section showing relative positions of coals and sands in feet. Not to scale.

Table 35. Table showing the depth to and thickness of monitored zones at the Fourmile monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Wasatch sand	778	825	47	534
Big George coal	1359	1446	87	n/a
Underburden sand	1546	1646	100	100

Table 36. Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2006	Drawdown 2006-2009	Total drawdown (ft.)	Depth to 12/31/09 water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	427.17	n/a	0.50	0.50	427.67	n/a	n/a
Big George coal	866.50	n/a	-11.30	-11.30	855.20	n/a	n/a
Underburden sand	809.60	n/a	-32.14	-32.14	777.46	n/a	n/a

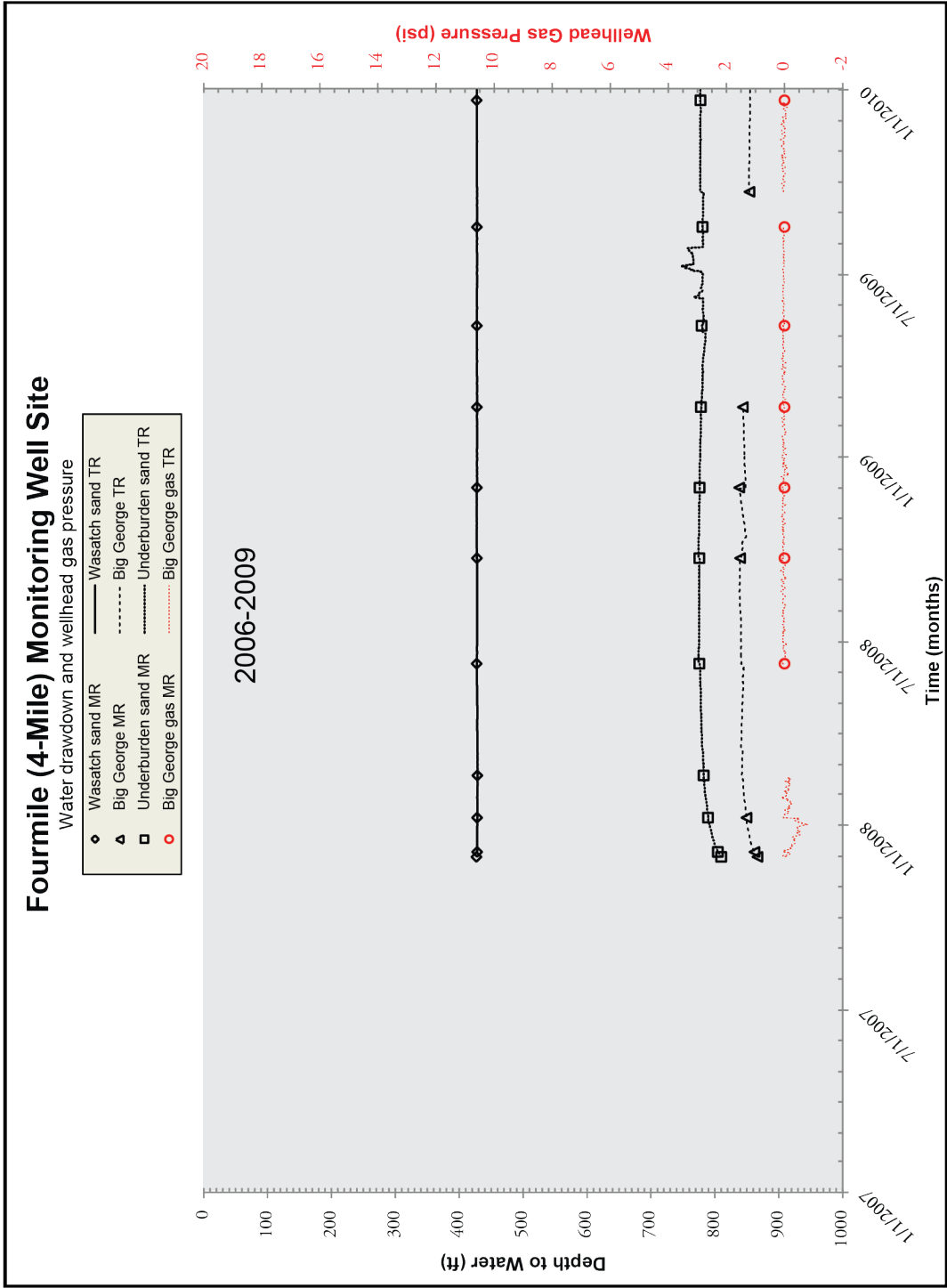


Figure 76. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Fourmile monitoring well site location.

Production Statistics

Production data was analyzed for CBNG wells within the buffer of the Fourmile monitoring well site from January 2003 through December 2009. The data was summed, by month, from the reported production for water and gas. Cumulative production for each CBNG well is displayed by location on Figure 77.

Locally, water production progressed before gas production which peaked in December 2006 (Figure 78). CBNG production is not consistent with groundwater drawdown trends from January 2006 to December 2009 in the Wyodak Rider (Big George) coal zone. Throughout the production period the percent methane has remained consistent.

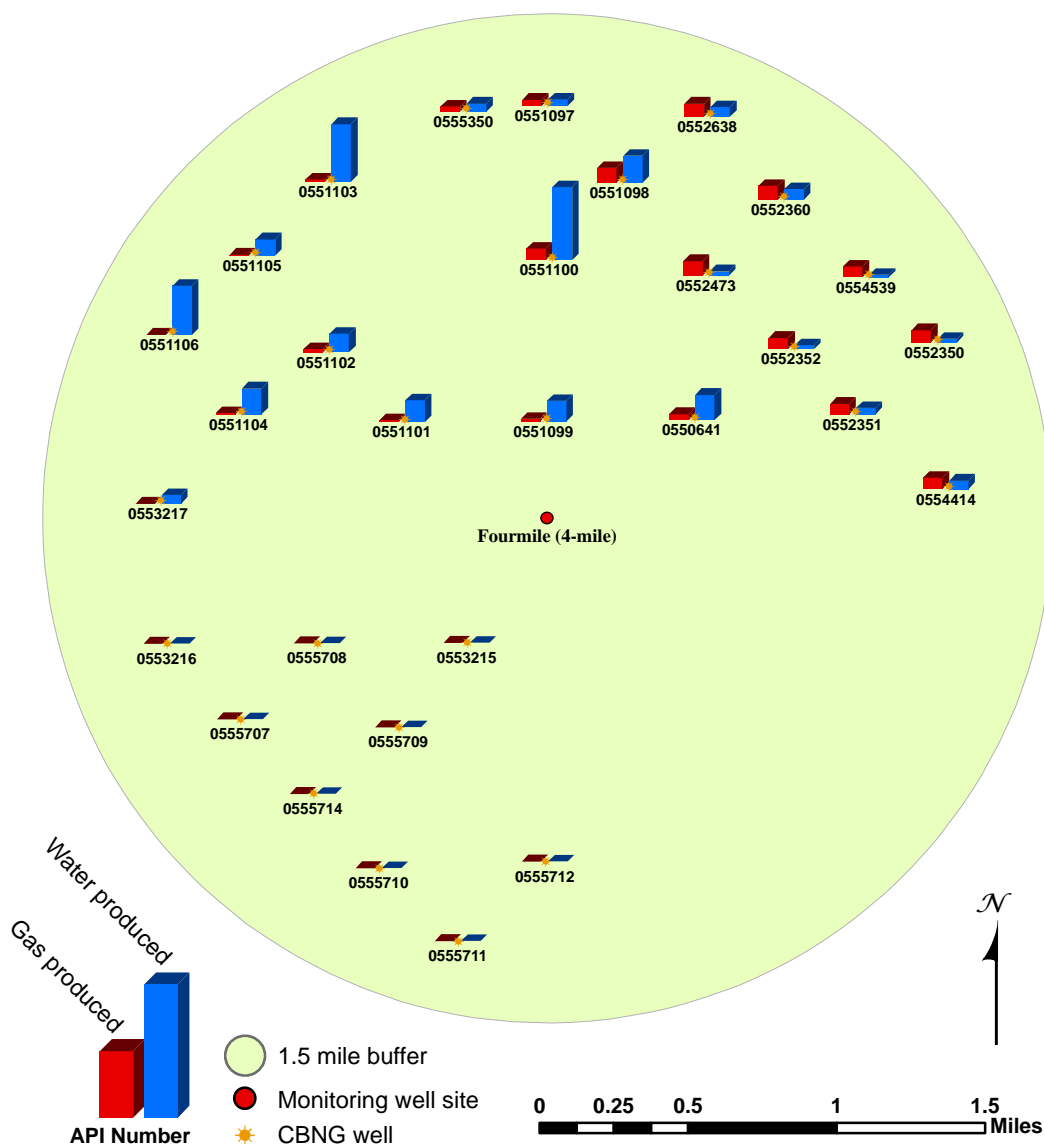


Figure 77. Fourmile monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (Bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

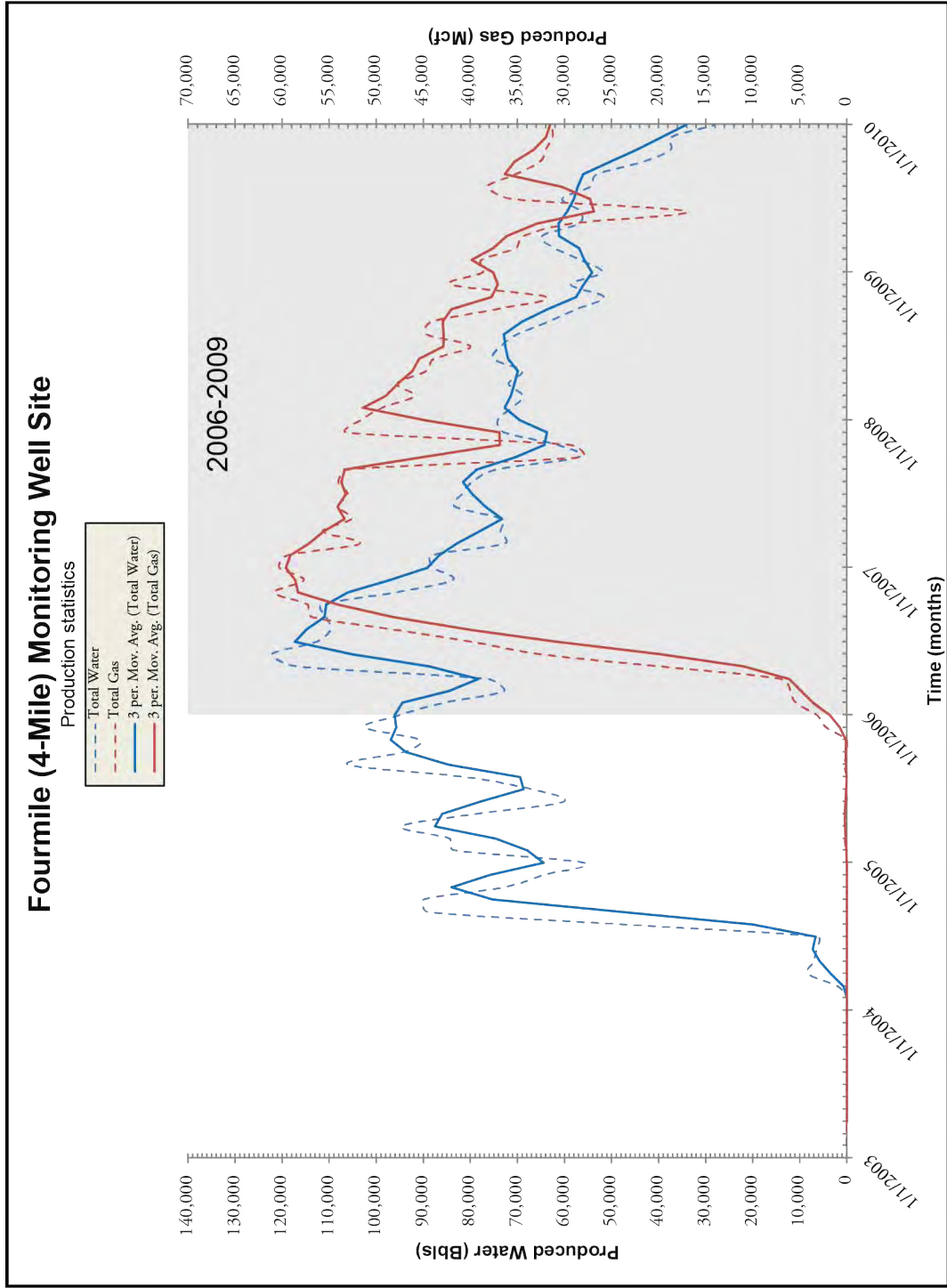


Figure 78. 3-period moving average along with water and gas production from associated CBNG wells.

Juniper Monitoring Well Site
Location: SW14 T49N R78W
Date First Monitored: March 21, 2001

Drawdown Information

The Juniper monitoring well site includes three wells. One is constructed into the Big George coal and the other two are constructed in overlying Wasatch sandstones (Figure 79; Table 37). Missing and/or fluctuating transducer data is the result of errors with on-site equipment.

The Big George coal recorded a groundwater draw-down of 862 feet during the 2006-2009 monitoring period; data shows a steady decline in the groundwater level through 2007 followed by a steep drop (Figure 80; Table 38). Groundwater levels for monitored sandstones were relatively stable between 2006-2009, though the deeper Wasatch sandstone recorded 10 feet of drawdown during the 2006-2009 monitoring period (6 feet of total drawdown through the life of the well)(Figure 80; Table 38). Manual gas measurements taken during the period of high gas pressure were calculated from transducer airline pressures. Notes in the data sheets indicate that high gas pressure is affecting the water measurements and are likely inaccurate. The well was reported as dry in June of 2005. This sandstone is relatively deep and any decline could be the result of CBNG production. Gas pressures in the Big George coal recorded a steady decline between 2006-2009.

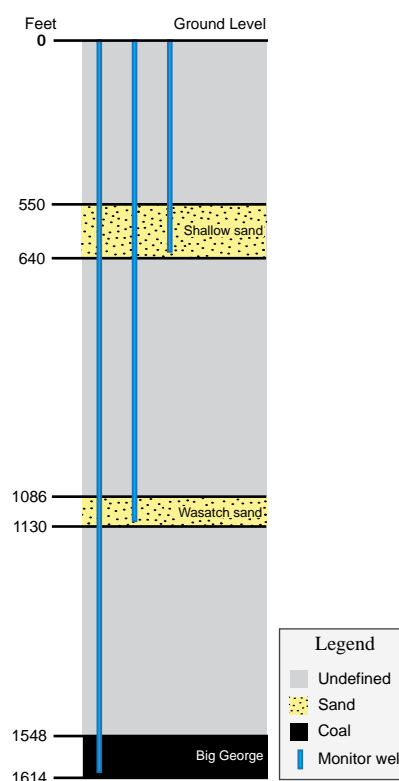


Figure 79. Section showing relative positions of coals and sands in feet. Not to scale.

Table 37. Table showing the depth to and thickness of monitored zones at the Juniper monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Shallow sand	550	640	90	908
Wasatch sand	1086	1130	44	418
Big George coal	1548	1614	66	n/a

Table 38. Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2006	Drawdown 2006-2009	Total drawdown (ft.)	Depth to 12/31/09 water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Shallow sand	428.51	-0.22	1.29	1.07	429.58	n/a	n/a
Wasatch sand	342.00	-3.57	9.55	5.98	347.98	n/a	n/a
Big George coal	168.47	583.23	862.30	1445.53	1614.00	398	5/13/03

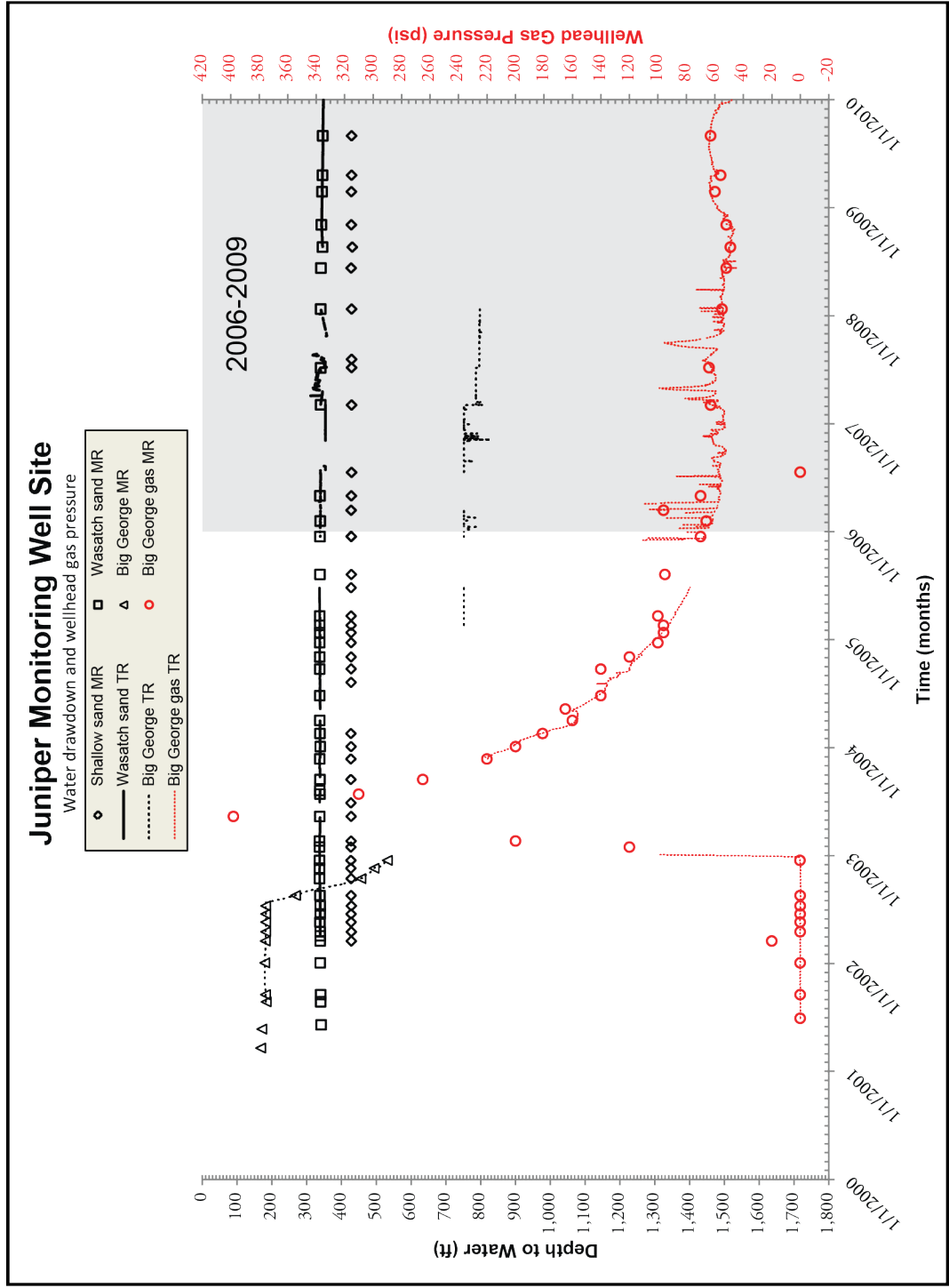


Figure 80. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Juniper Draw monitoring well site location.

Production Statistics

Production data was analyzed for CBNG wells within the buffer of the Juniper monitoring well site from January 2002 through December 2009. Cumulative production for individual CBNG wells is displayed by location on Figure 81.

Water production increased rapidly in 2002, which correlates to groundwater drawdown trends. Gas production increased and water production declined during the 2006 to 2009 monitoring period (Figure 82). The water/gas ratio of CBNG wells within the buffer is relatively inconsistent from east to west.

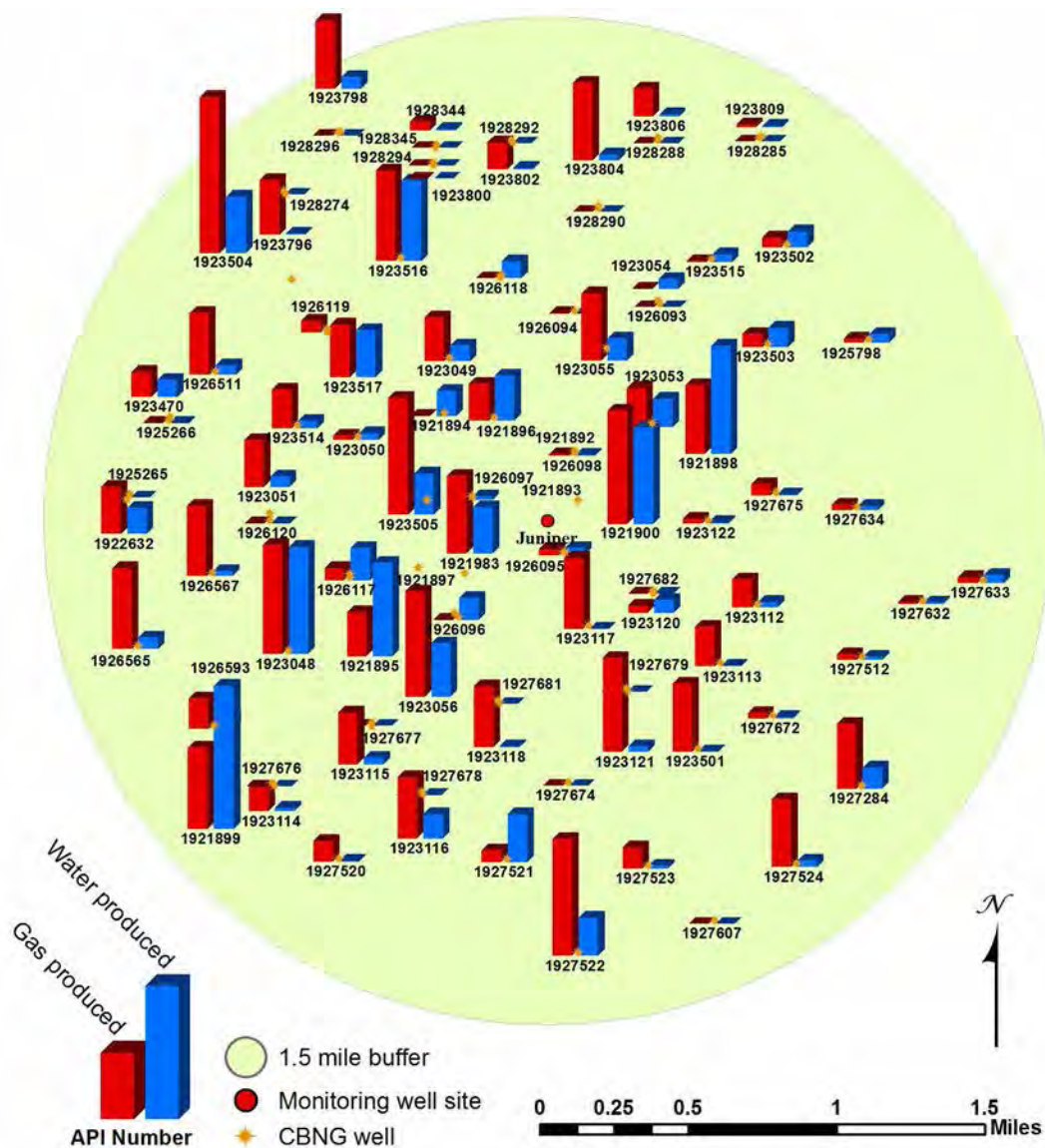


Figure 81. Juniper monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (Bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

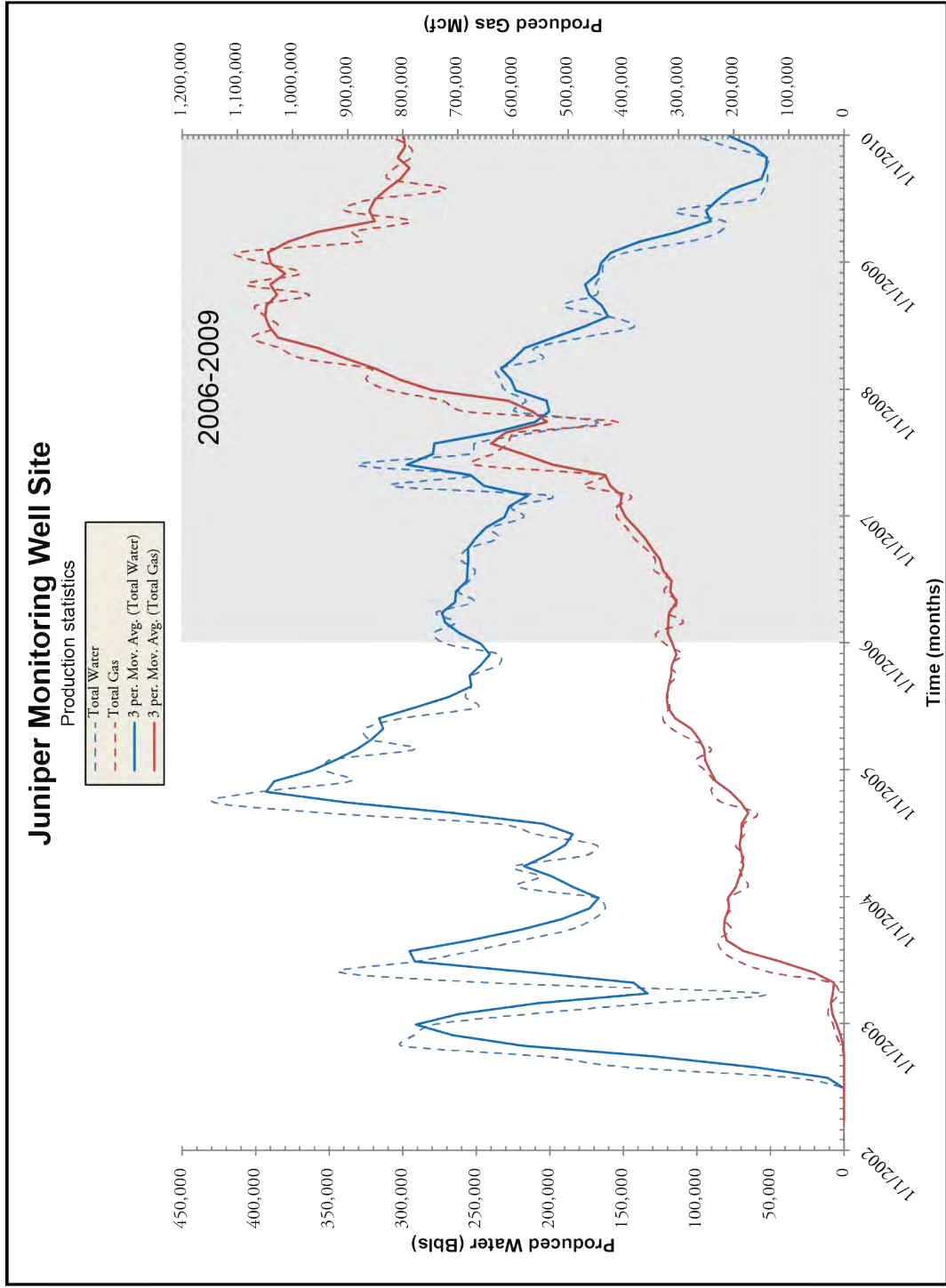


Figure 82. 3-period moving average along with water and gas production from associated CBNG wells.

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

Drawdown Information

The Kingsbury monitoring well site includes one well completed into two intervals separated by a packer. The well is completed into the Big George coal and into an underburden sand (Figure 83; Table 39). Missing and/or fluctuating transducer data is the result of errors with on-site equipment.

The Big George coal recorded a groundwater draw-down of 167 feet during the 2006-2009 monitoring period; data shows a steady decline in the groundwater level through 2008, followed by a steep drop (Figure 84; Table 40). Groundwater levels in the Big George sandstone declined by 126 feet during the 2006-2009 monitoring period (Figure 84; Table 40). Similar initial groundwater depths and equivalent drawdown trends indicate that the monitored underburden sandstone and the Big George coal may be hydraulically connected, or the packer is leaking which allows zones to equilibrate and exhibit similar drawdown trends. Limited gas pressure readings did not surpass levels possible from transducer error.

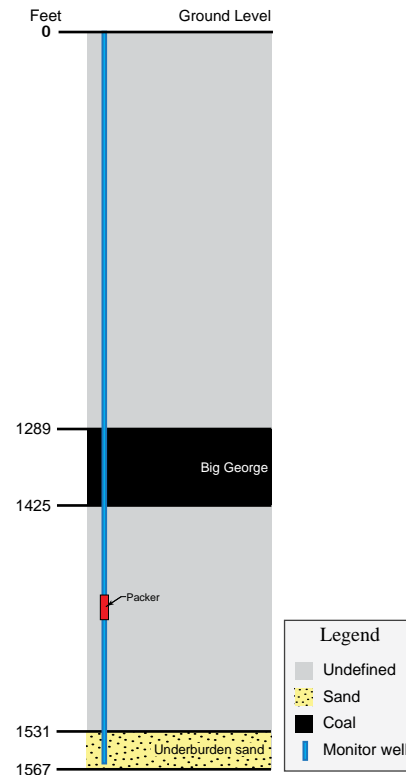


Figure 83. Section showing relative positions of coals and sands in feet. Not to scale.

Table 39. Table showing the depth to and thickness of monitored zones at the Kingsbury monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Big George coal	1289	1425	136	n/a
Underburden sand	1531	1567	36	106

Table 40. Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2006	Drawdown 2006-2009	Total drawdown (ft.)	Depth to 12/31/09 water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Big George coal	0.00	n/a	167.49	167.49	167.49	n/a	n/a
Underburden sand ⁽¹⁾	0.00	n/a	126.25	126.25	126.25	n/a	n/a

⁽¹⁾ The depth to water level was taken on 11/12/09 and not 12/31/09. The 11/12/09 reading was the last for the underburden sand for 2009.

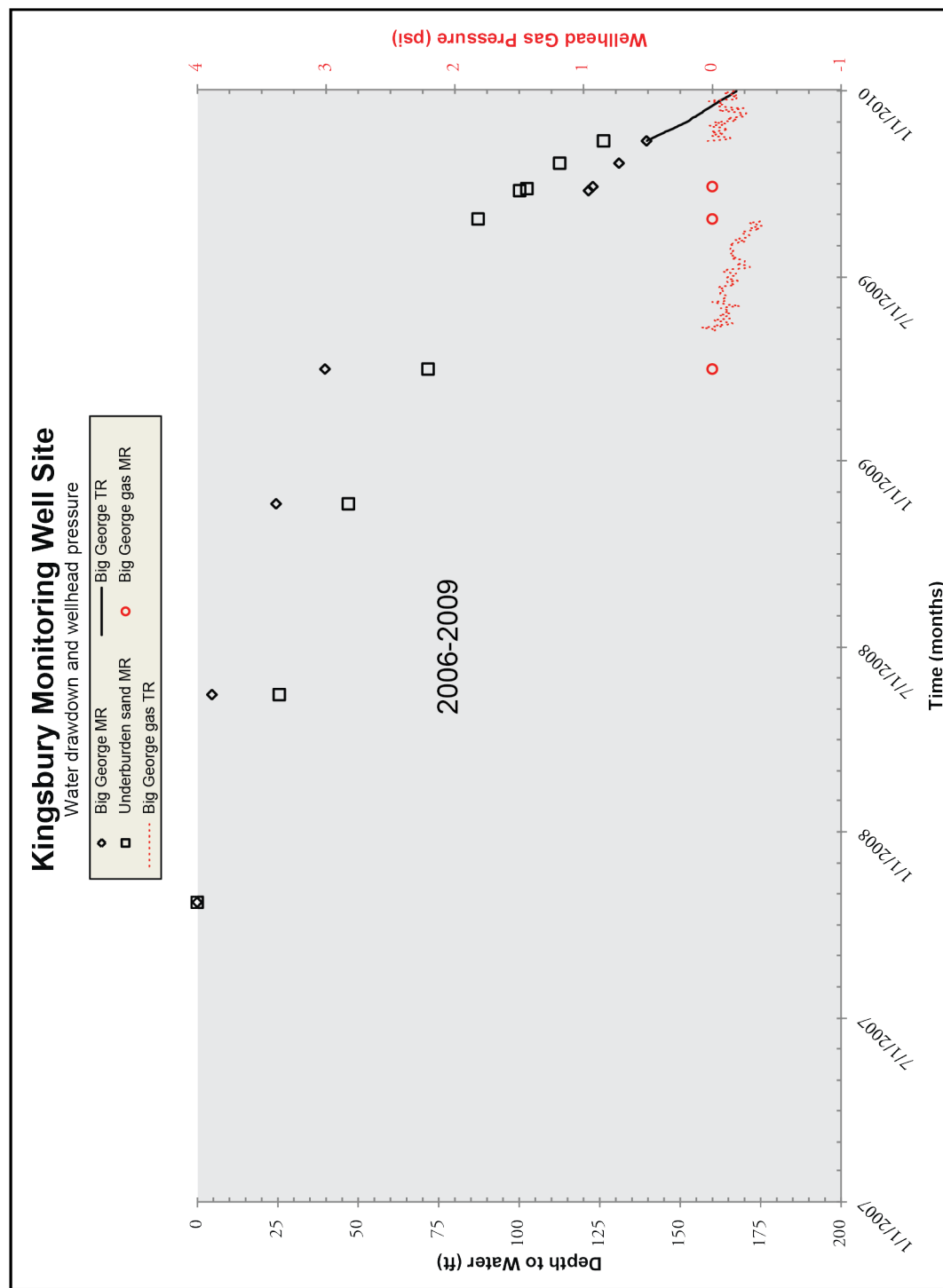


Figure 84. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Kingsbury monitoring well site location.

Production Statistics

Production data was analyzed CBNG wells within the buffer of the Kingsbury monitoring well site from January 2008 through December 2009. Cumulative production for individual CBNG wells is displayed by location on Figure 85.

Water production peaked in 2009, which correlates to groundwater drawdown trends. Water production increased during the 2006 to 2009 monitoring period; gas production was minimal (Figure 86). The water/gas ratio of CBNG wells within the buffer is relatively inconsistent. Percent methane is variable.

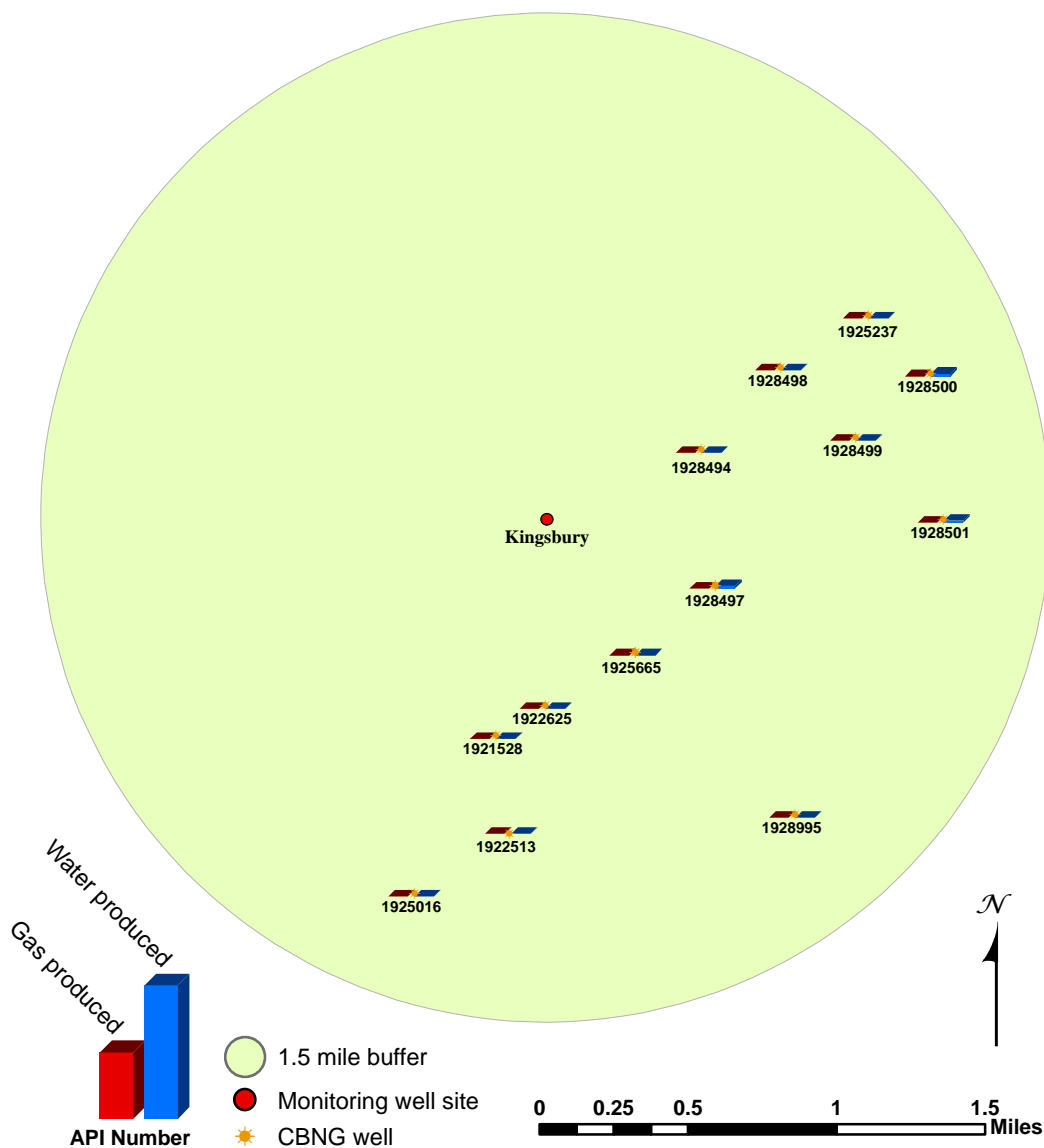


Figure 85. Kingsbury monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (Bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

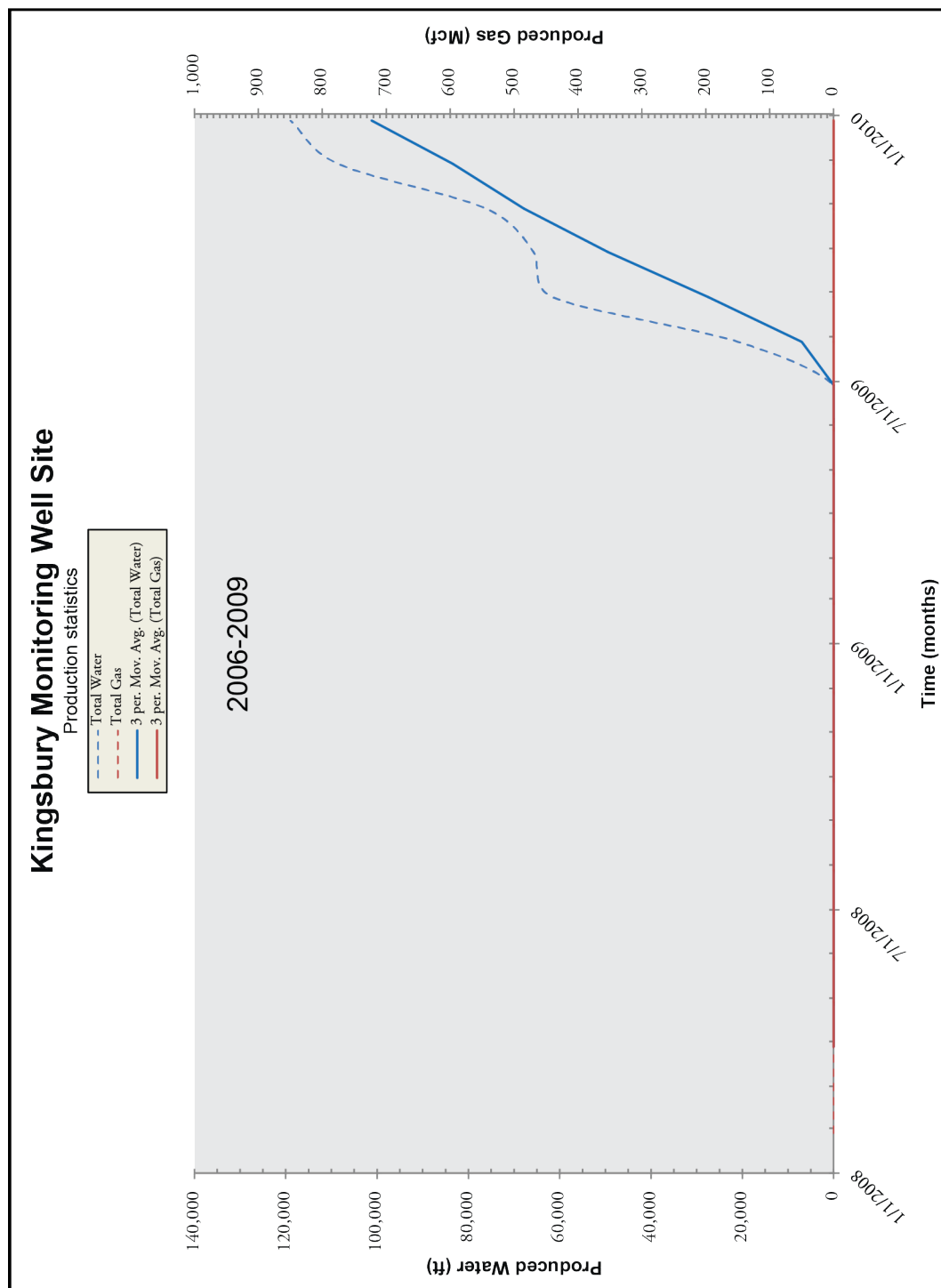


Figure 86. 3-period moving average along with water and gas production from associated CBNG wells.

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 is drilled into the Big George coal and the other is drilled into a overlying Wasatch sandstone (Figure 87; Table 41). Missing and/or fluctuating transducer data is the result of errors with on-site equipment.

The Big George coal recorded a groundwater drawdown of 187 feet during the 2006-2009 monitoring period; data shows a steep drop in the groundwater level through 2007, followed by a steady decline (Figure 88; Table 42). Groundwater levels in the Wasatch sandstone declined by 51 feet during the 2006-2009 monitoring period (Figure 88; Table 42). Similar initial groundwater depths and equivalent drawdown trends indicate that the monitored Wasatch sandstone and the Big George coal may be hydraulically connected in this area. Gas pressure readings did not surpass levels possible from transducer error.

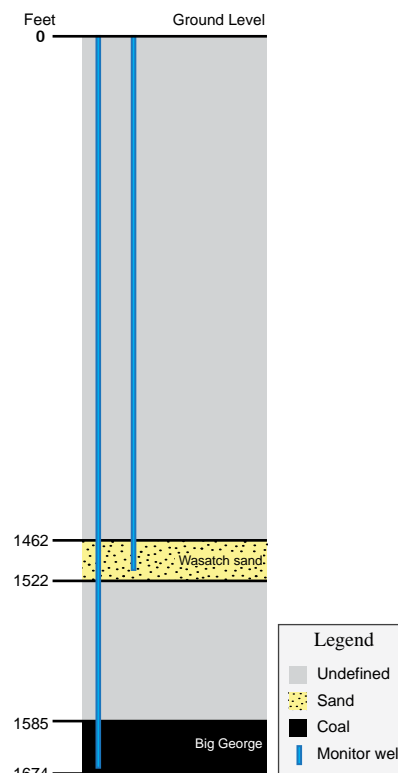


Figure 87. Section showing relative positions of coals and sands in feet. Not to scale.

Table 41. Table showing the depth to and thickness of monitored zones at the Napier monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Wasatch sand	1462	1522	60	63
Big George coal	1585	1674	89	n/a

Table 42. Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2006	Drawdown 2006-2009	Total drawdown (ft.)	Depth to 12/31/09 water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	402.50	11.92	51.33	63.25	465.75	n/a	n/a
Big George coal	432.00	103.15	187.09	290.24	722.24	n/a	n/a

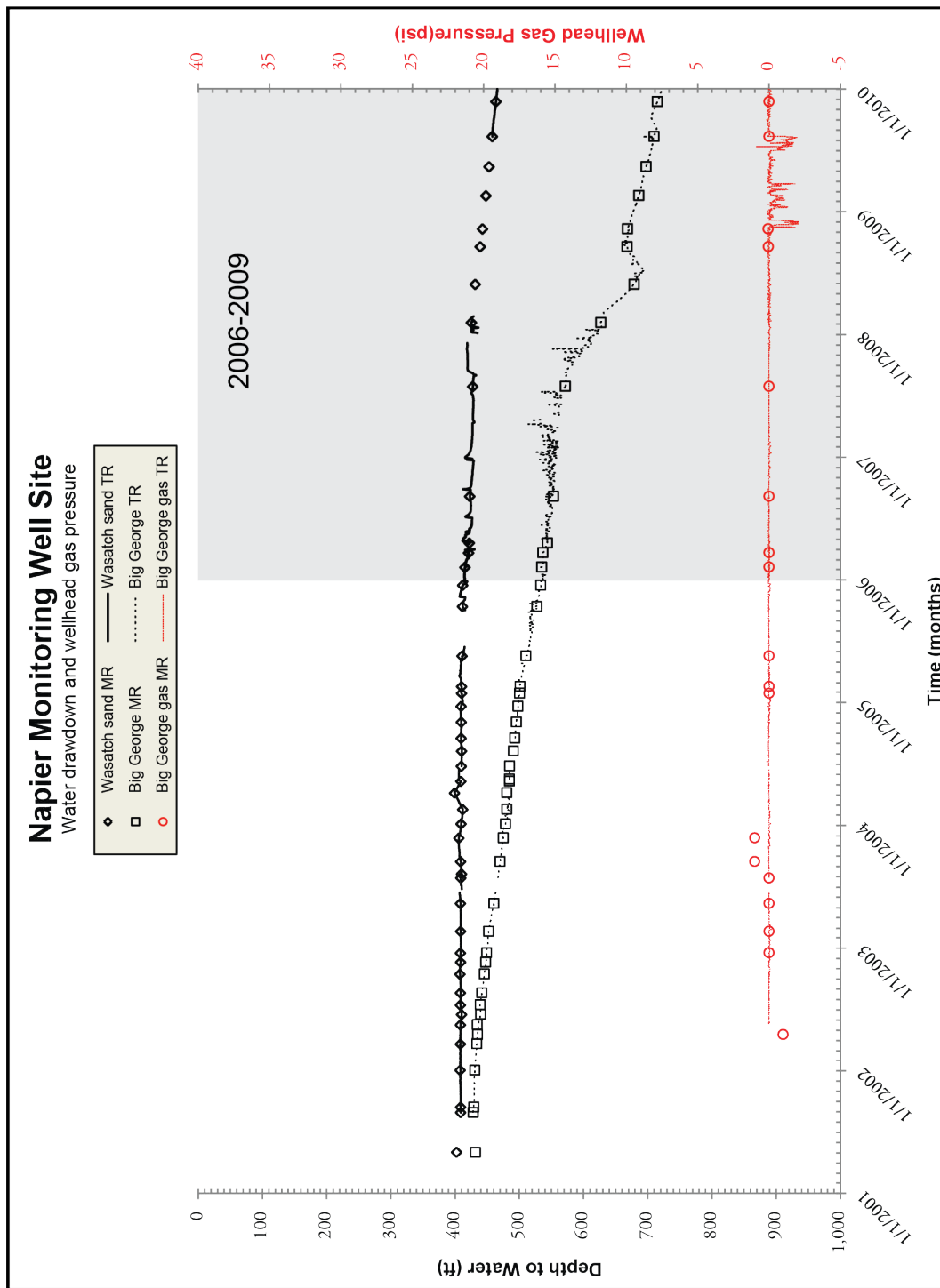


Figure 88. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Napier monitoring well site location.

Production Statistics

Production data was analyzed for CBNG wells within the buffer of the Napier monitoring well site from January 2004 through December 2009. Cumulative production for individual CBNG wells is displayed by location on Figure 89.

Water production peaked in 2008, which correlates to groundwater drawdown trends. Water and gas production increased during the 2006 to 2009 monitoring period (Figure 90). The water/gas ratio of CBNG wells within the buffer is relatively inconsistent from south to north. Percent methane is minimal.

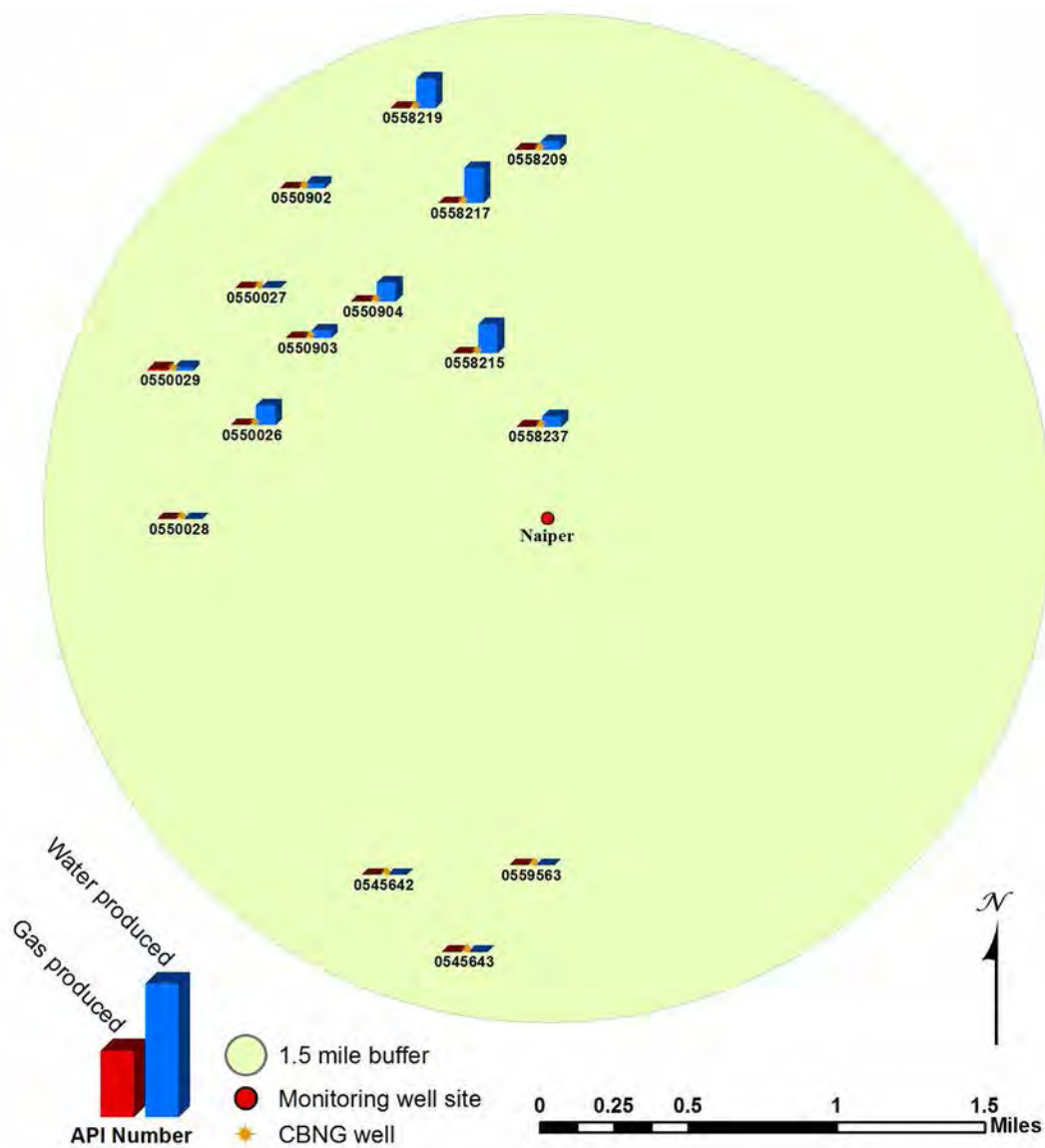


Figure 89. Napier monitoring well and associated CBNG wells within 1.5 mile buffer showing cumulative water (Bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

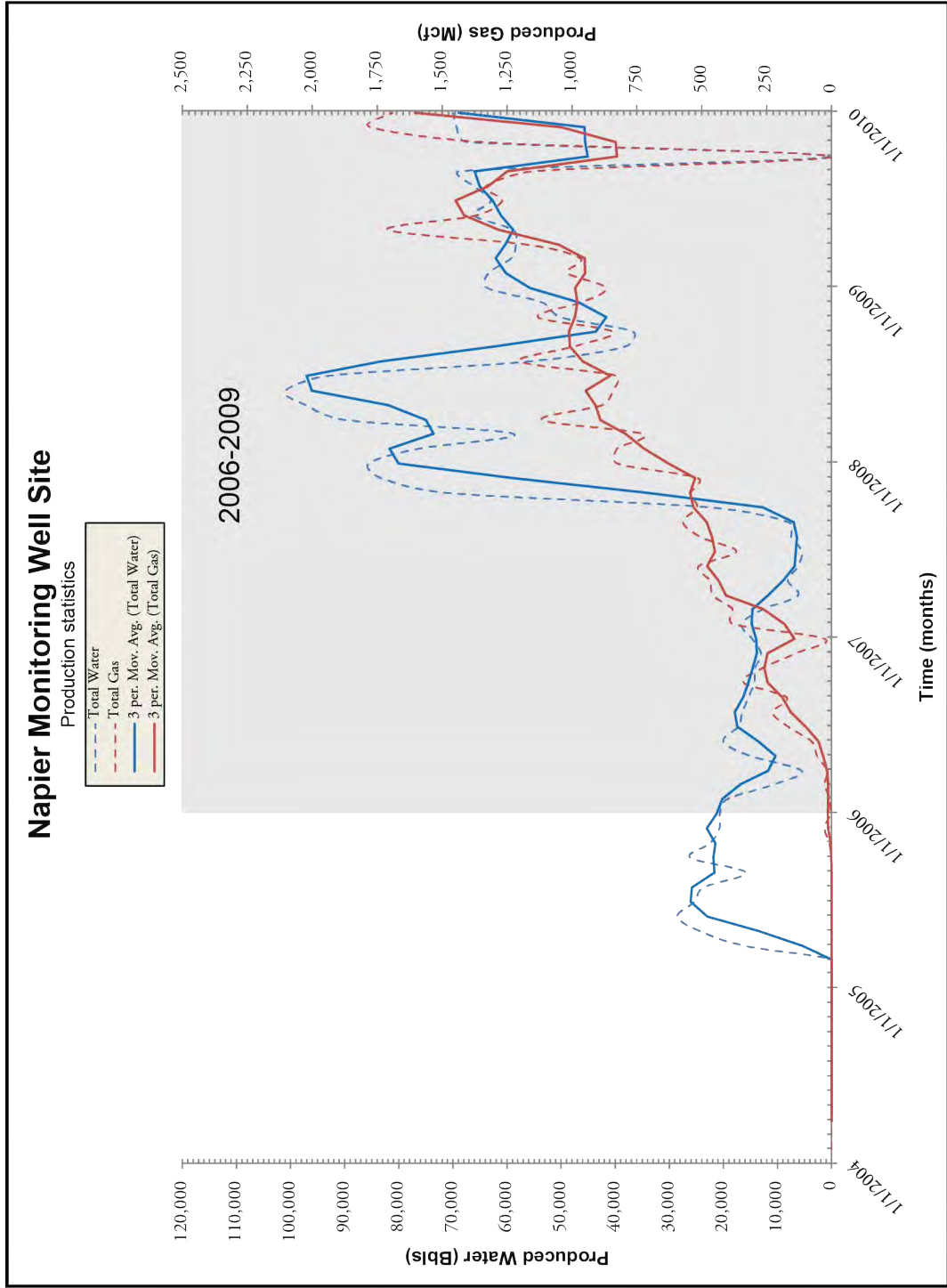


Figure 90. 3-period moving average along with water and gas production from associated CBNG wells..

Pistol Point Monitoring Well Site
Location: S31 T45N R75W
Date First Monitored: February 26, 1997

Drawdown Information

The Pistol Point monitoring well site consists of one well drilled into the Big George coal (Figure 91; Table 43). Missing and/or fluctuating transducer data is the result of errors with on-site equipment.

The Big George coal recorded a groundwater draw-down of 736 feet during the 2006-2009 monitoring period; data shows a steady water level through most of 2007 followed by dramatic levels of draw-down (Figure 92; Table 44). Gas pressure readings did not surpass levels possible from transducer error.

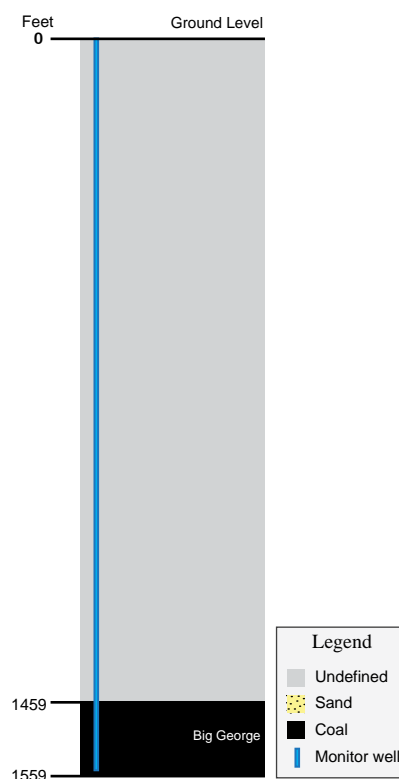


Figure 91. Section showing relative positions of coals and sands in feet. Not to scale.

Table 43. Table showing the depth to and thickness of monitored zones at the Pistol Point monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Big George coal	1459	1559	100	n/a

Table 44. Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2006	Drawdown 2006-2009	Total drawdown (ft.)	Depth to 5/11/09 water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Big George coal ⁽¹⁾	456.70	-4.66	735.90	731.24	1187.94	n/a	n/a

⁽¹⁾ The depth to water level was taken on 5/11/09 and not on 12/31/09 because the 5/11/09 depth was the last for 2009.

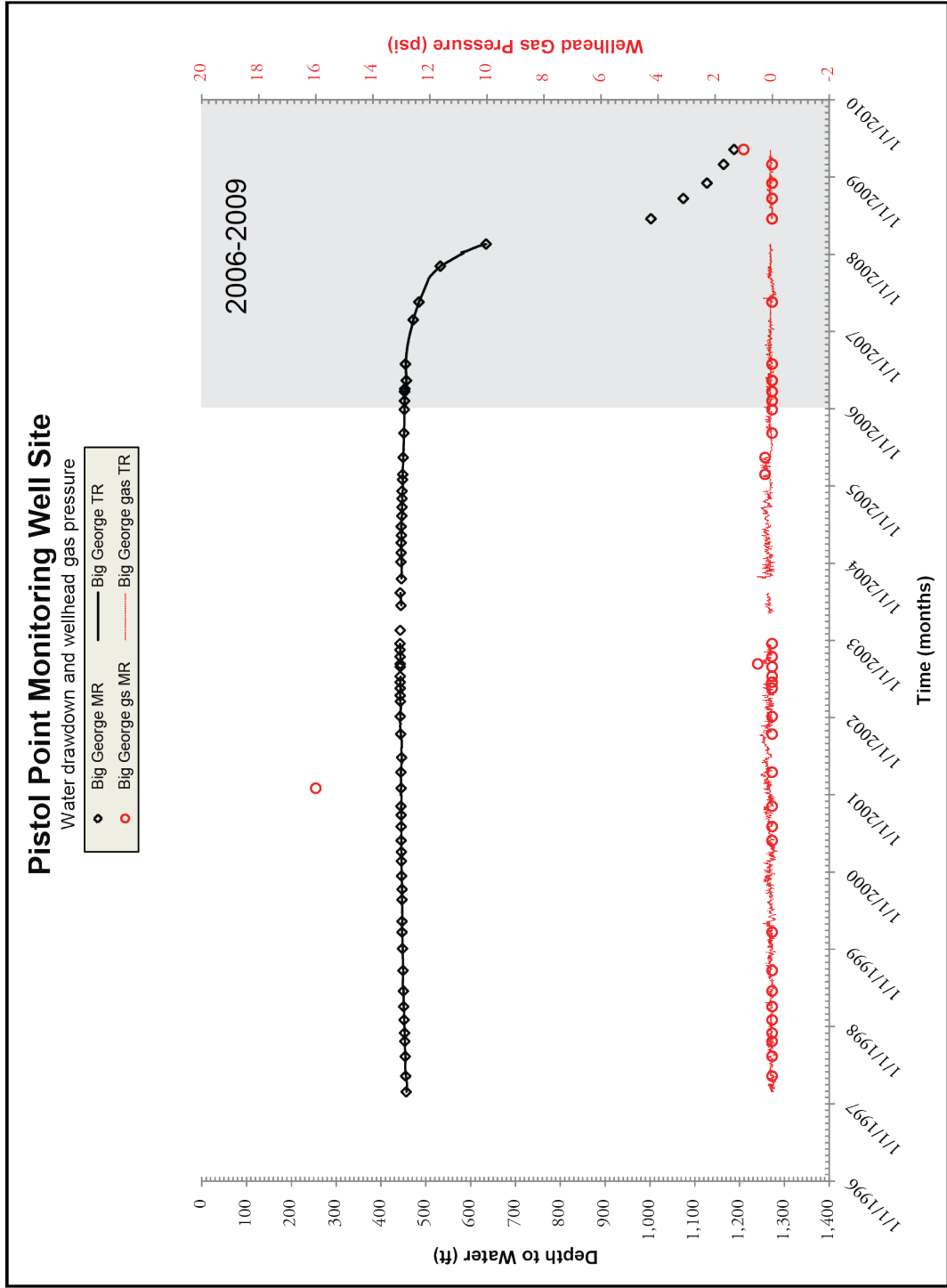


Figure 92. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Pistol Point monitoring well site location.

Production Statistics

Production data was analyzed for CBNG wells within the buffer of the Pistol Point monitoring well site from January 2007 through December 2009. Cumulative production for individual CBNG wells is displayed by location on Figure 93.

Water production peaked in 2008, which correlates to groundwater drawdown trends. Water produc-

tion peaked and decreased during the 2006 to 2009 monitoring period; gas production increased (Figure 94). The water/gas ratio of CBNG wells within the buffer is relatively inconsistent. Percent methane is variable.

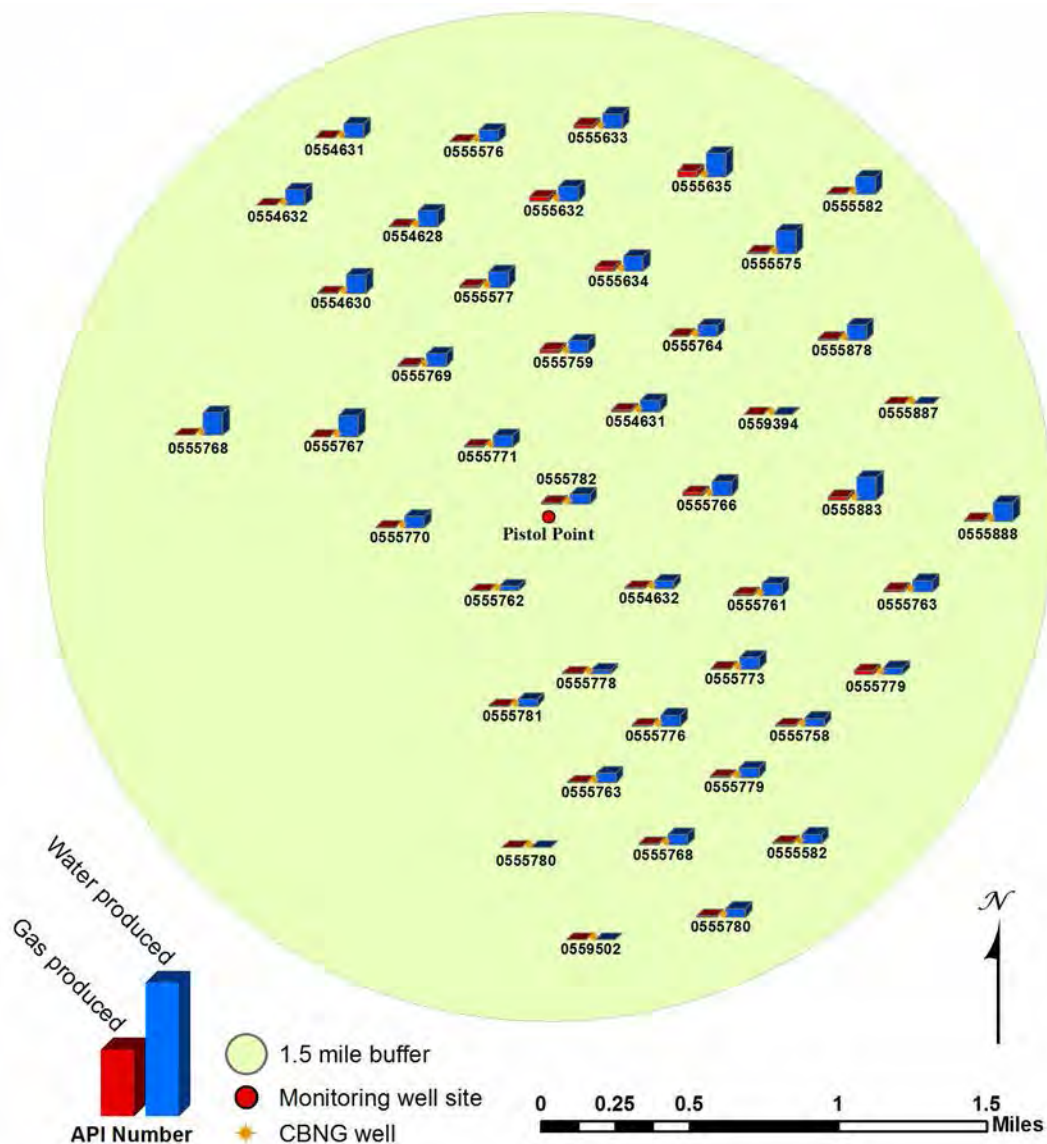


Figure 93. Pistol Point monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (Bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

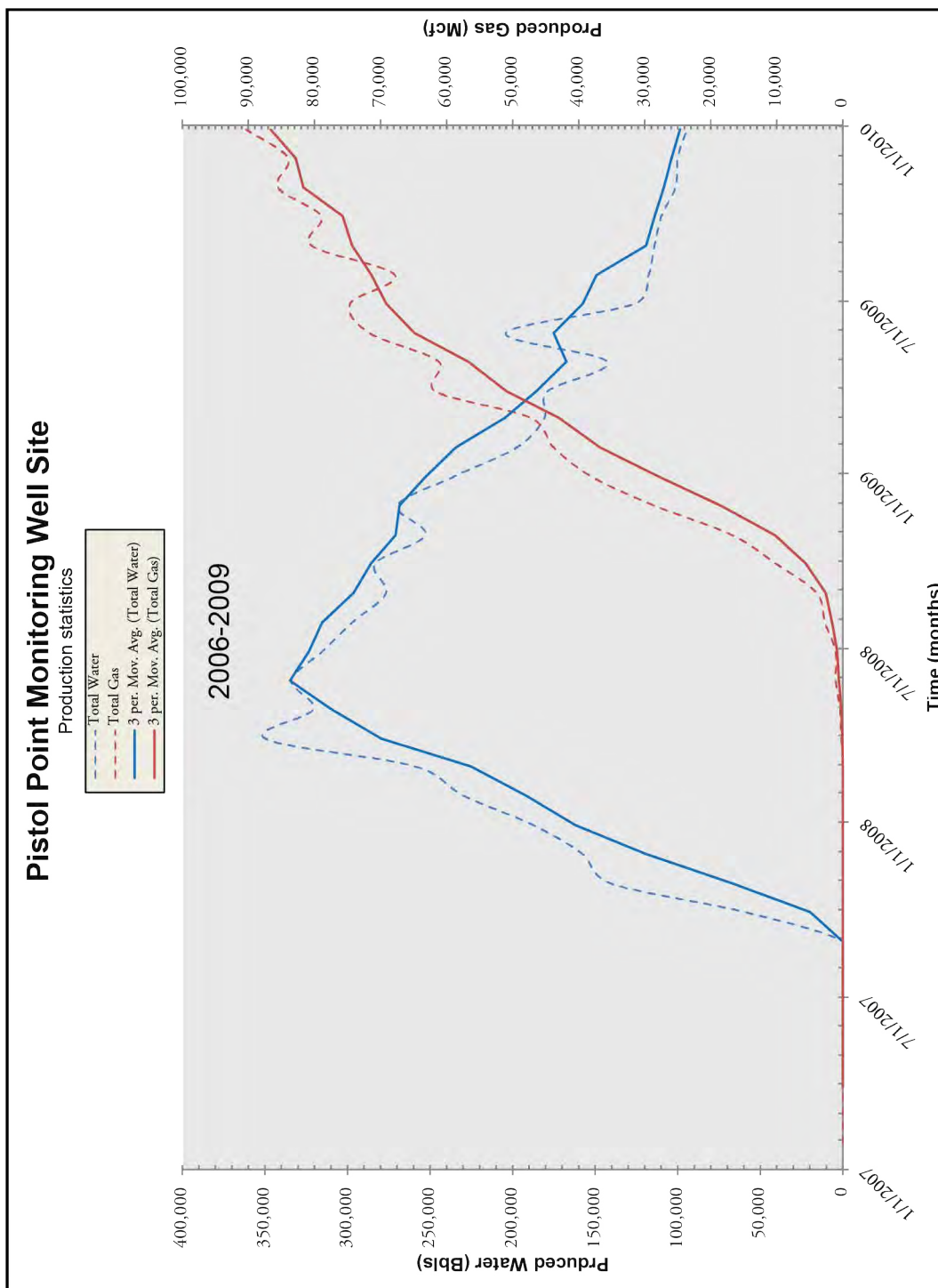


Figure 94. 3-period moving average along with water and gas production from associated CBNG wells.

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

Drawdown Information

Sasquatch monitoring well site includes two wells. One is constructed into the Big George coal and the other is constructed into a overlying Wasatch sandstone (Figure 95; Table 45). Missing and/or fluctuating transducer data is the result of errors with on-site equipment.

The Big George coal recorded a groundwater drawdown of 234 feet during the 2006-2009 monitoring period; data shows a steep drop in the groundwater level through 2006 followed by a steady decline (Figure 96; Table 46). Groundwater levels in the Wasatch sandstone show a drawdown of 195 feet during the 2006-2009 monitoring period. (Figure 96; Table 46). This, along with variable initial water levels, indicates there may be a hydraulic connection between the monitored sandstone and producing zones. Gas pressure readings did not surpass levels possible from transducer error.

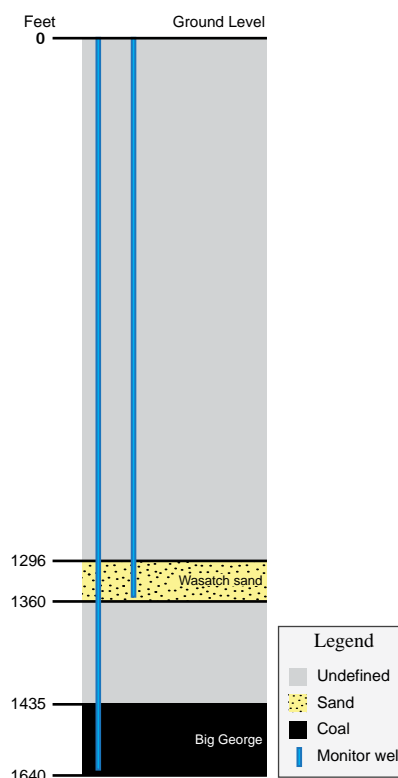


Figure 95. Section showing relative positions of coals and sands in feet. Not to scale.

Table 45. Table showing the depth to and thickness of monitored zones at the Sasquatch monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Wasatch sand	1296	1360	64	75
Big George coal	1435	1640	205	n/a

Table 46. Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2006	Drawdown 2006-2009	Total drawdown (ft.)	Depth to 12/31/09 water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	224.98	74.81	194.56	269.37	494.35	n/a	n/a
Big George coal	229.76	215.85	233.82	449.67	679.43	n/a	n/a

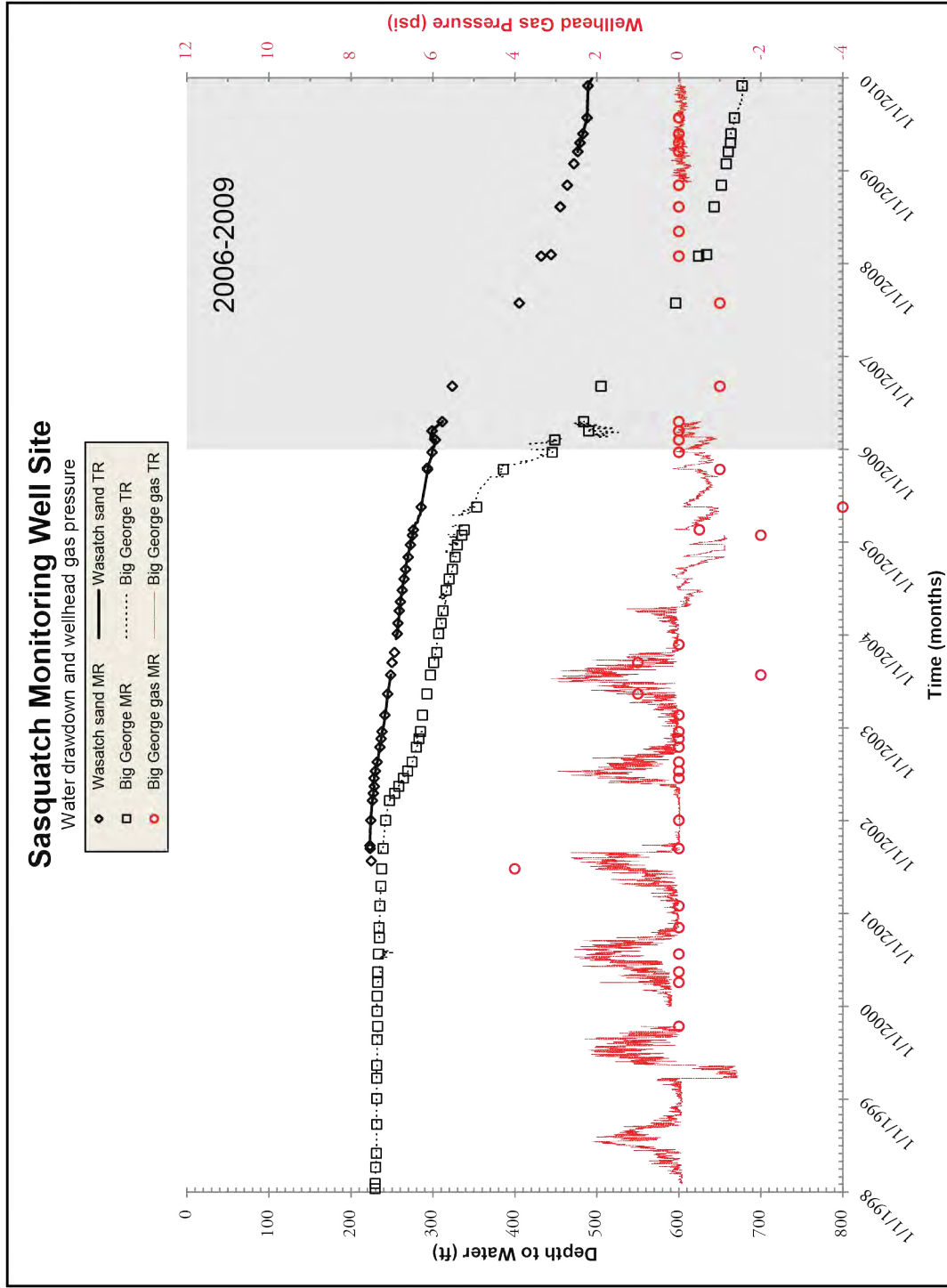


Figure 96. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Sasquatch monitoring well site location.

Production Statistics

Production data was analyzed for CBNG wells within the buffer of the Sasquatch monitoring well site from January 2004 to December 2009. Cumulative production for individual CBNG wells is displayed by location on Figure 97.

and gas production peaked early in 2006 to 2009 monitoring period, then declined (Figure 98). The water/gas ratio of CBNG wells within the buffer is relatively inconsistent. Percent methane is relatively consistent.

Water production peaked in late 2005, which correlates to groundwater drawdown trends. Water

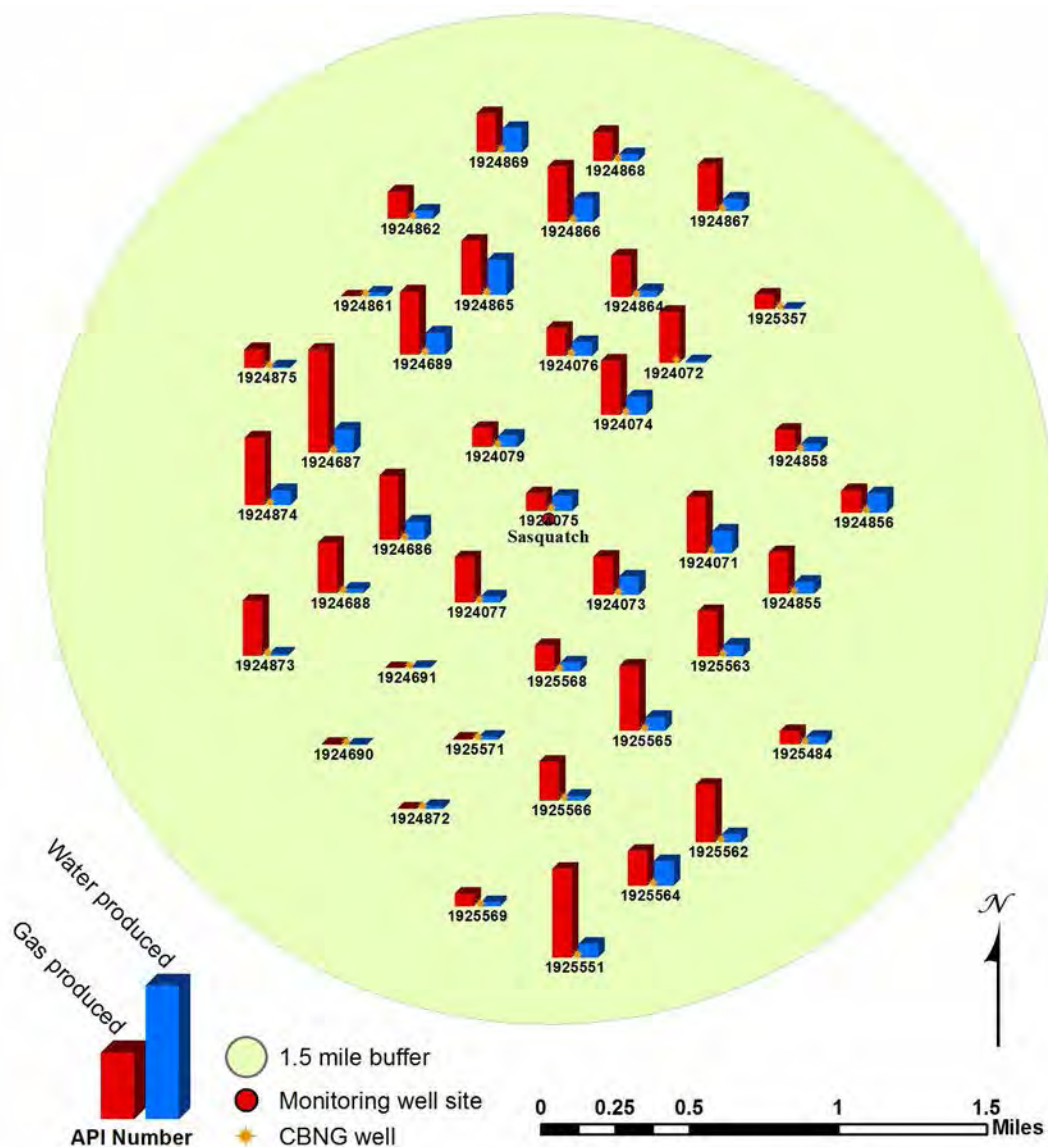


Figure 97. Sasquatch monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (Bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

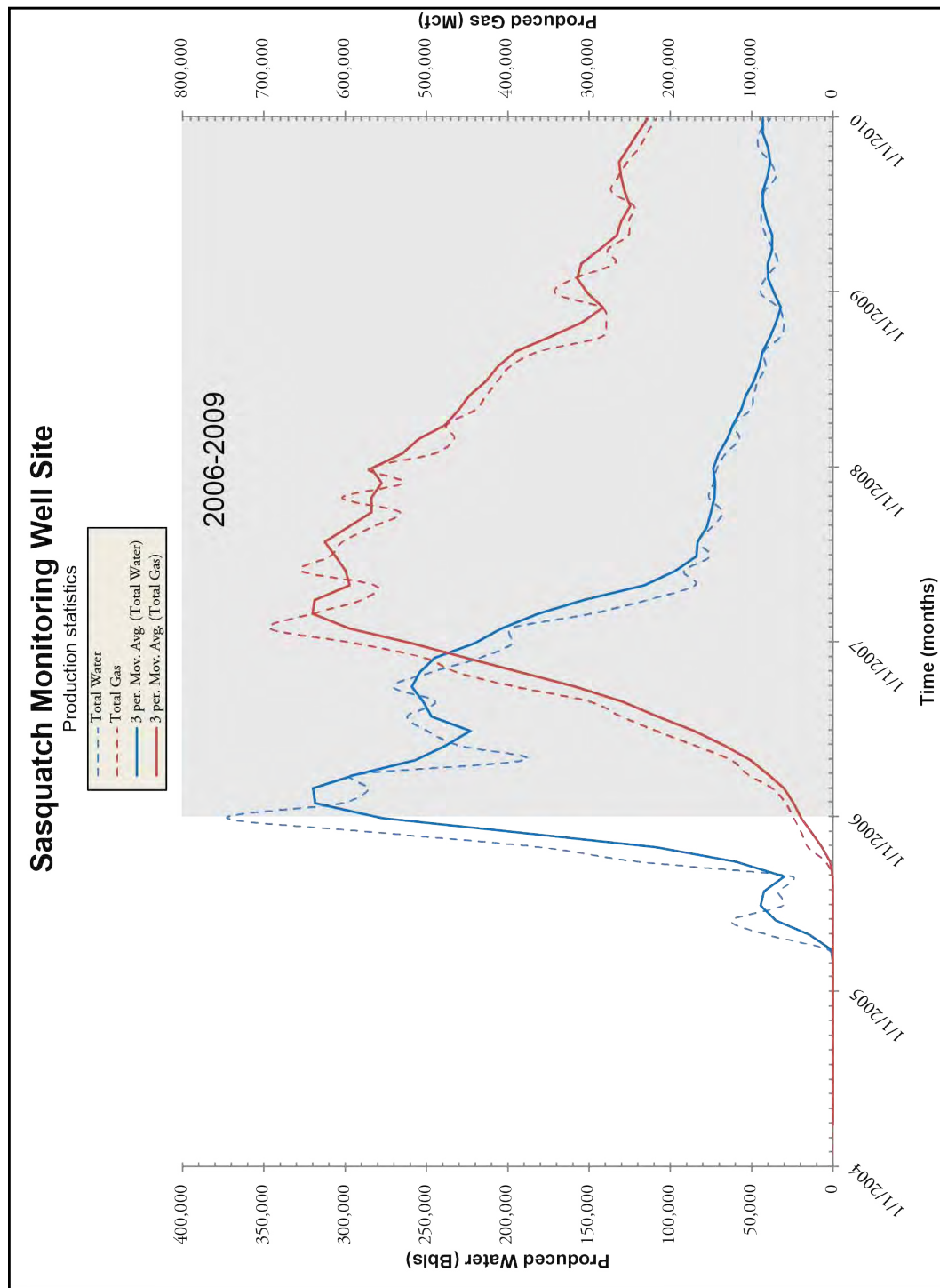


Figure 98. 3-period moving average along with water and gas production from associated CBNG wells.

South Prong Monitoring Well Site
Location: S26 T49N R76W
Date First Monitored: January 1, 2008

Drawdown Information

The South Prong monitoring well site consists of two wells with dual completions, separated by packers. One well is completed into the Big George coal and overlying Wasatch sandstone. The second well is completed into the Gates/Wall coal and an underburden sandstone (Figure 99; Table 47). Missing transducer data is the result of errors with on site equipment.

The depth to initial water levels for the Wasatch sandstone and Big George coal zones are approximately the same at 142 feet as well as the water levels for the Gates/Wall coal and underburden sandstone zones at 117 feet. The similarity of the initial water levels despite the difference in zone depths is likely due to the packers being improperly set. The packers were properly reset on November 2, 2009, after which there is limited data. Due to the improperly set packers, all measurements were considered not to be accurate enough to make any conclusions at this time (Figure 100; Table 48). Wellhead gas pressure for the coals remained at zero for the monitoring history of the wells.

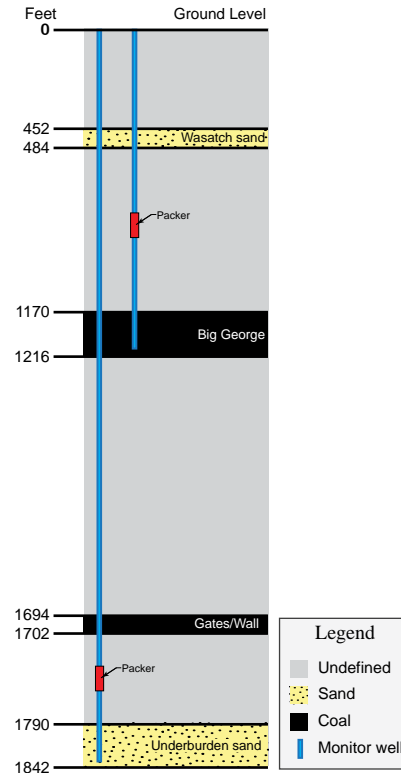


Figure 99. Section showing relative positions of coals and sands in feet. Not to scale.

Table 47. Table showing the depth to and thickness of monitored zones at the South Prong monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Wasatch sand	452	484	32	686.00
Big George coal	1170	1216	46	n/a
Gates/Wall coal	1694	1702	8	n/a
Underburden sand	1790	1842	52	88.00

Table 48. Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2006	Drawdown 2006-2009	Total drawdown (ft.)	Depth to 11/9/09 water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	142.79	n/a	8.20	8.20	150.99	n/a	n/a
Big George coal	141.95	n/a	207.45	207.45	349.40	n/a	n/a
Gates/Wall coal ⁽¹⁾	117.55	n/a	425.45	425.45	543.00	n/a	n/a
Underburden sand	116.95	n/a	139.65	139.65	256.60	n/a	n/a

Note: The last water level measurements for this site was taken on 11/9/09 as shown. These are the last taken in the 2009 monitoring year.

⁽¹⁾ It was reported that for this zone the water level on 11/9/09 was below 600 ft and measurements could not be take below this depth. Therefore, the measurement of 543 ft was taken on 11/5/09.

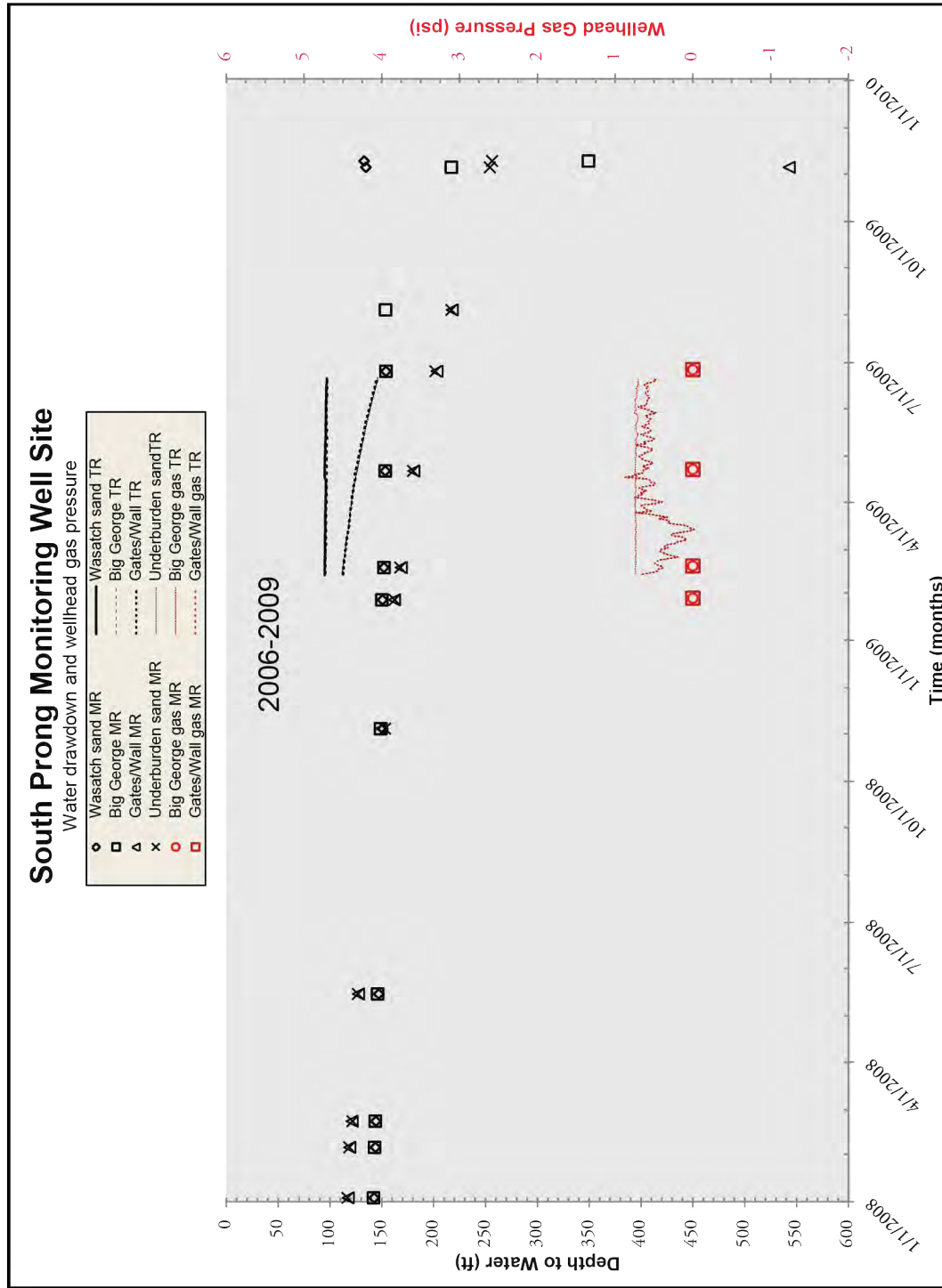


Figure 100. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the South Prong monitoring well site location.

Production Statistics

Production data was analyzed for CBNG wells within the buffer of the South Prong monitoring well site from January 1999 through December 2009. Cumulative production for individual CBNG wells is displayed by location on Figure 101.

Water production peaked in 2008, which correlates to groundwater drawdown trends. Water and gas production increased during the 2006 to 2009 monitoring period (Figure 102). The water/gas ratio of CBNG wells within the buffer is relatively inconsistent. Percent methane is relatively consistent.

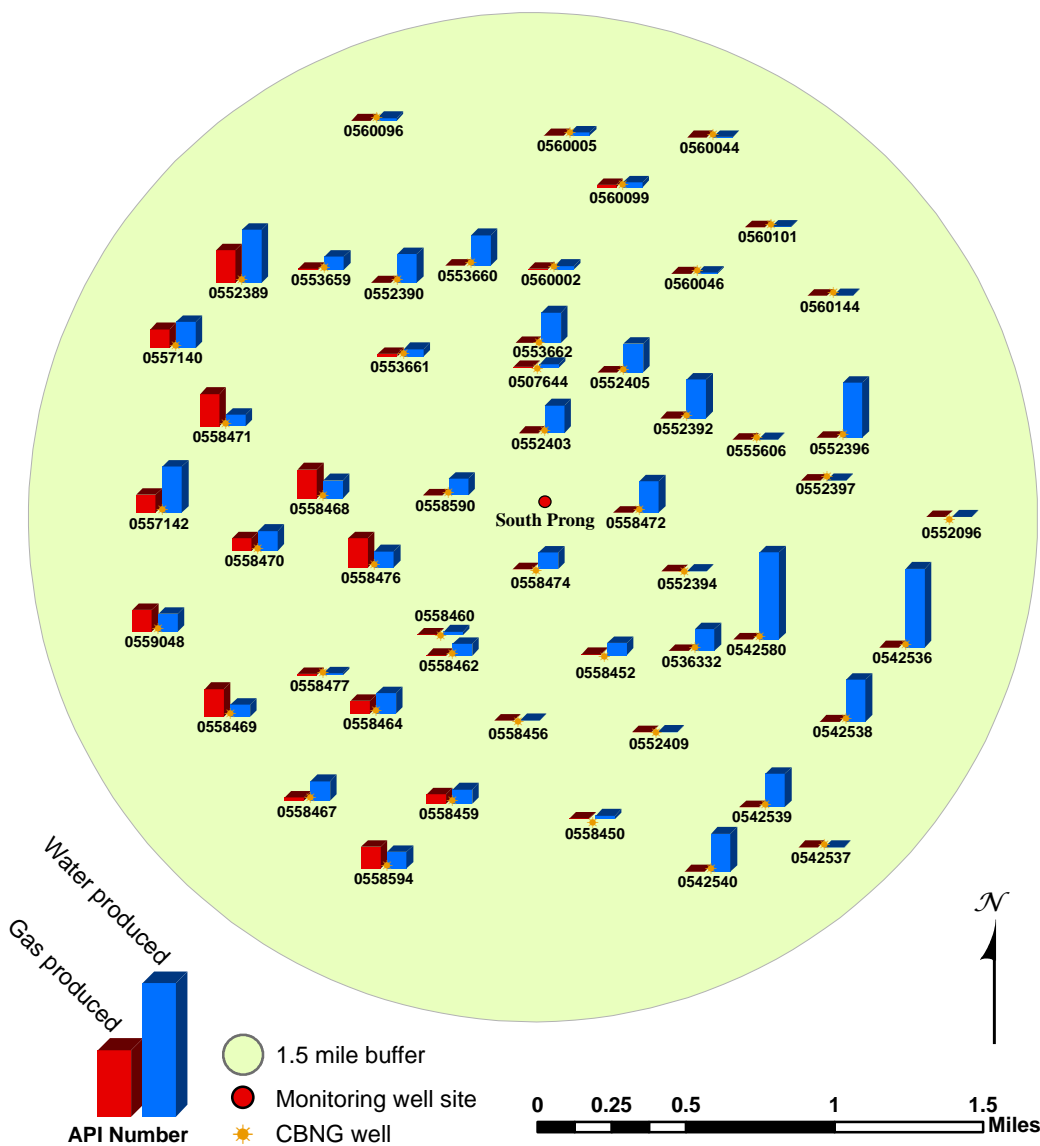


Figure 101. South Prong monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (Bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

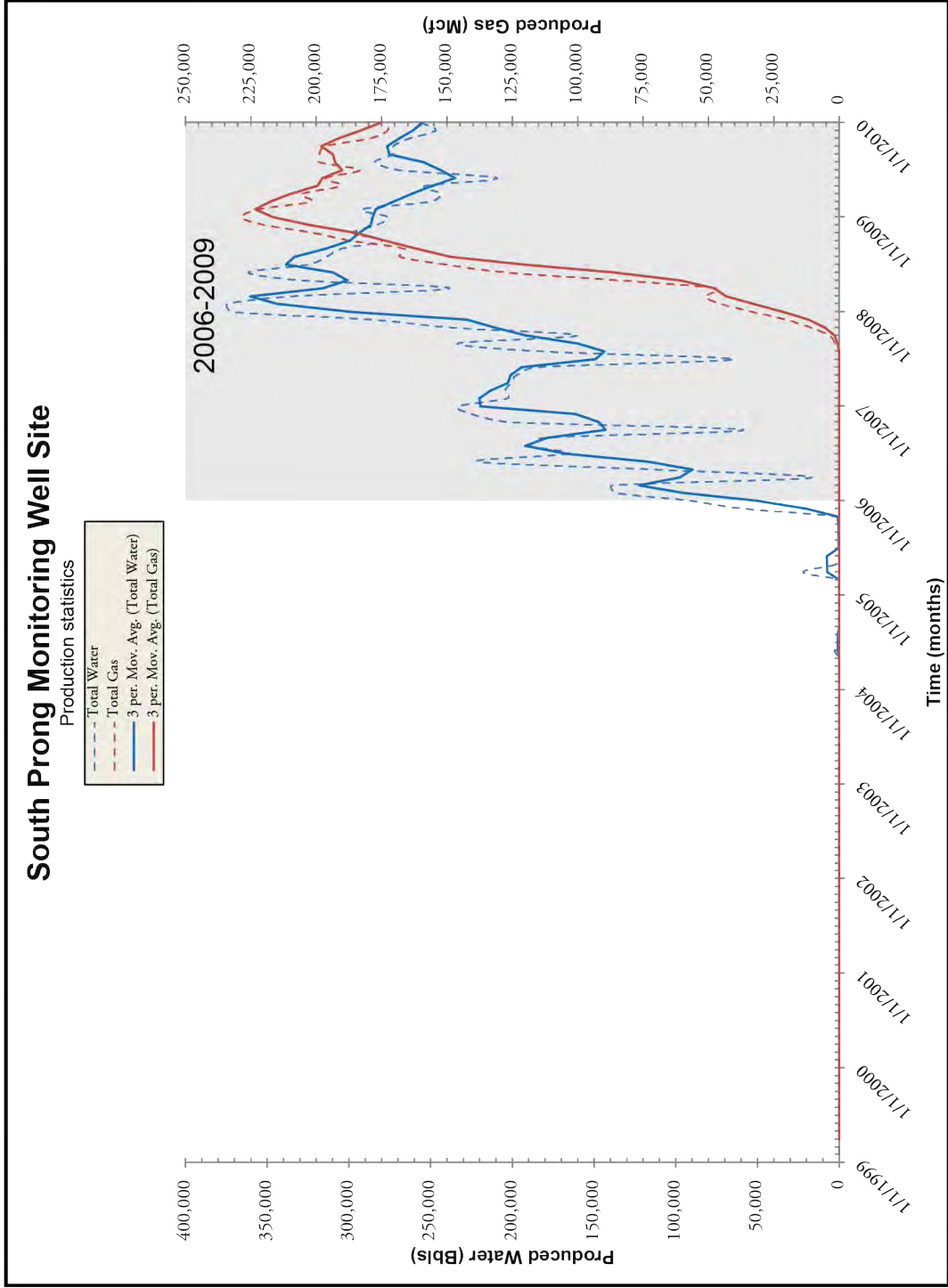


Figure 102. 3-period moving average along with water and gas production from associated CBNG wells.

Squaw Butte Monitoring Well Site

Location: SI T56N R78W

Date First Monitored: May 17, 2005

Drawdown Information

The Squaw Butte monitoring well site consists of one well drilled into the Big George coal (Figure 103; Table 49). Missing and/or fluctuating transducer data is the result of errors with on-site equipment.

The Big George coal recorded a total groundwater increase of 49 feet from 2001 to 2009. After initial monitoring in 2001 the well was not monitored again until November 2009. This well has difficult year round access and is monitored for ground water levels with manual instrument readings. Little data was collected for this location. (Figure 104; Table 50). Gas pressure was not monitored at this location.

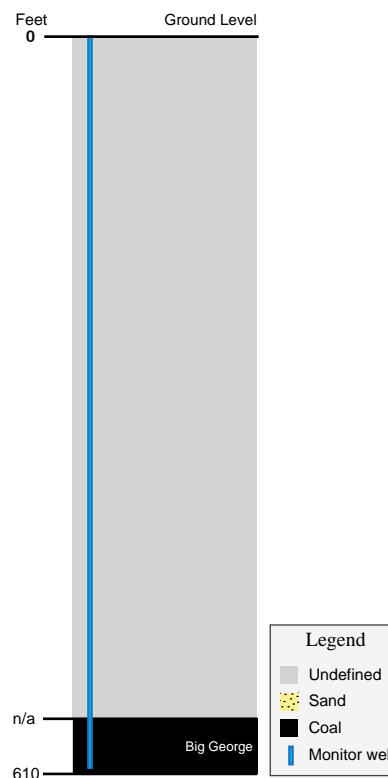


Figure 103. Section showing relative positions of coals and sands in feet. Not to scale.

Table 49. Table showing the depth to and thickness of monitored zones at the Squaw Butte monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Big George coal	n/a	610	n/a	n/a

Table 50. Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2006	Drawdown 2006-2009	Total drawdown (ft.)	Depth to 12/31/09 water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Big George coal	355.92	n/a	n/a	-49.47	306.45	n/a	n/a

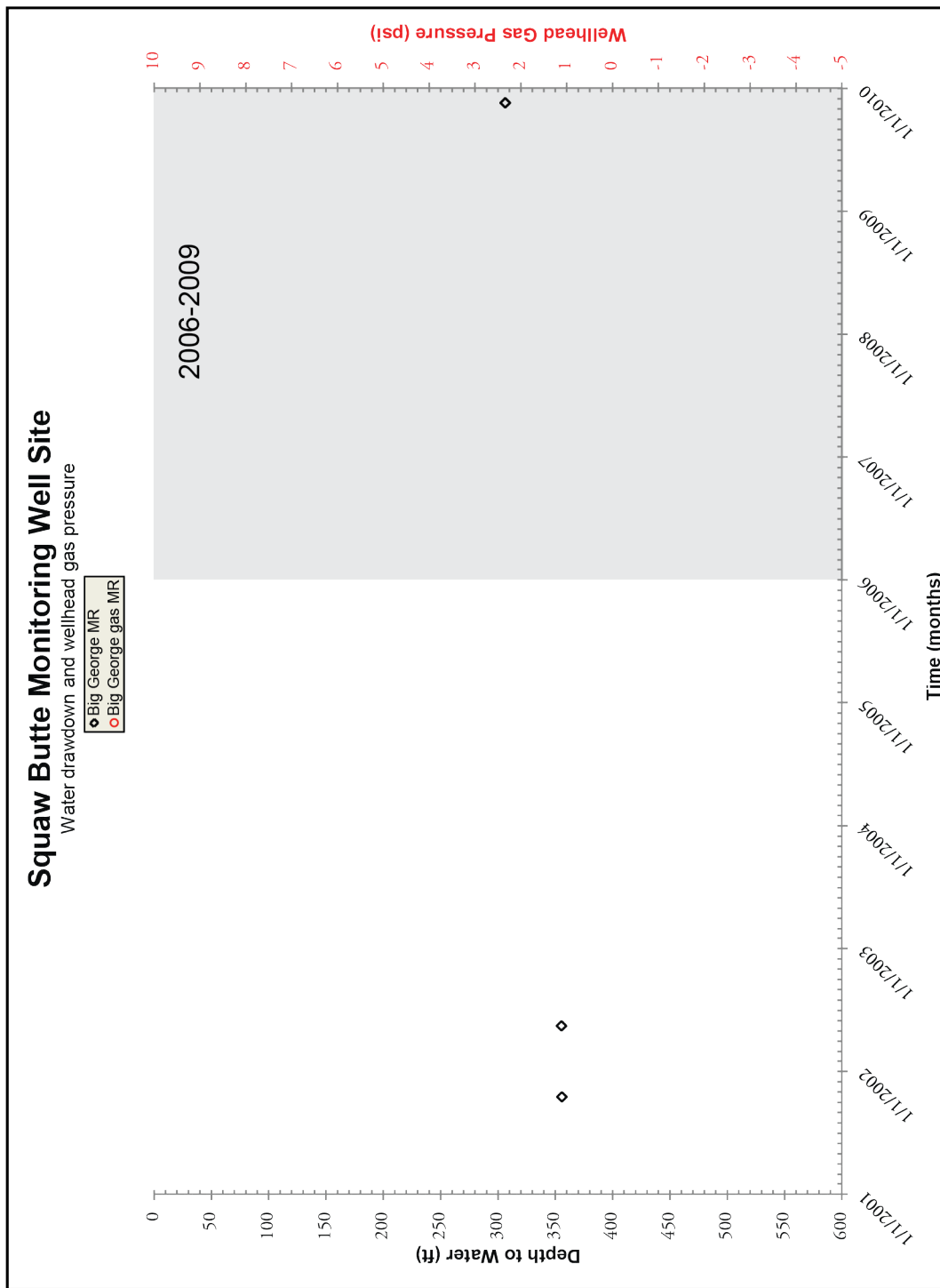


Figure 104. Graph showing manual measurements for water levels and methane content for the monitored zone at the Squaw Butte monitoring well site location.

Production Statistics

Production data for the Squaw Butte Coal monitoring well site was not reported due to incomplete or generalized completion data for local CBNG wells.

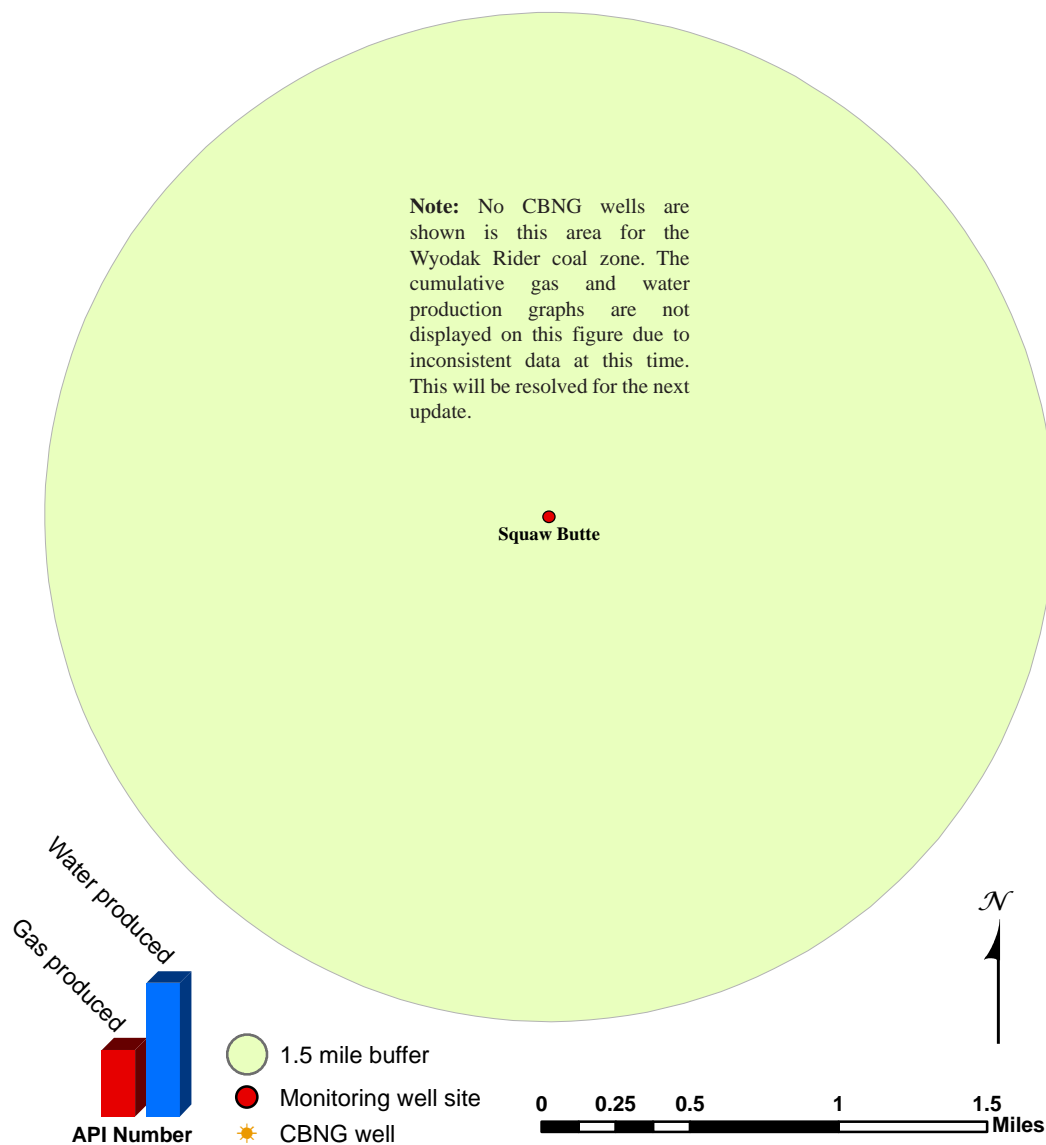


Figure 105. Squaw Butte Coal monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (Bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

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 drilled into the Big George coal, and the other is constructed into an overlying Wasatch sandstone (Figure 106; Table 51). Missing and/or fluctuating transducer data is the result of errors with on-site equipment.

The Big George coal recorded a groundwater draw-down of 144 feet during the 2006-2009 monitoring period; data shows a slow decline in the groundwater level followed by an increased drop in 2009 (Figure 107; Table 52). In October of 2009 the Big George began to experience recharge gaining 12 feet by the end of the monitoring period. Groundwater levels in the Wasatch sandstone were relatively stable during the 2006-2009 monitoring period and actually recorded an increase of 1 foot (Figure 107; Table 52). This, along with variable initial water levels, indicates there is no hydraulic connection between the monitored Wasatch sandstone and the Big George coal. Gas pressure readings did not surpass levels possible from transducer error.

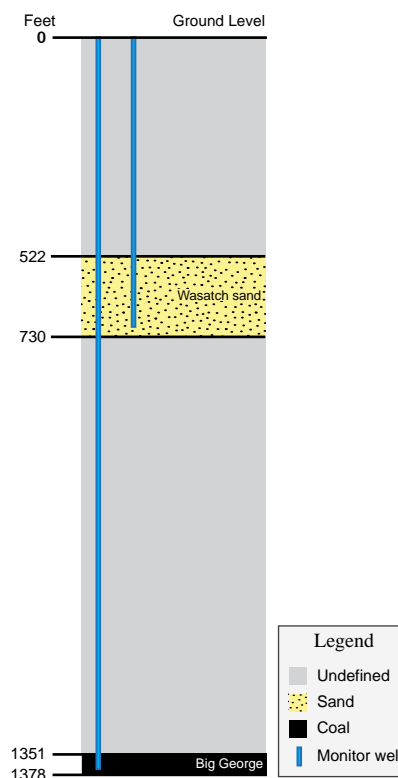


Figure 106. Section showing relative positions of coals and sands in feet. Not to scale.

Table 51. Table showing the depth to and thickness of monitored zones at the Streeter Road monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Wasatch sand	522	730	208	621
Big George coal	1351	1378	27	n/a

Table 52. Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2006	Drawdown 2006-2009	Total drawdown (ft.)	Depth to 12/31/09 water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	213.50	8.61	1.08	9.69	223.19	n/a	n/a
Big George coal	158.80	7.15	144.34	151.49	310.29	n/a	n/a

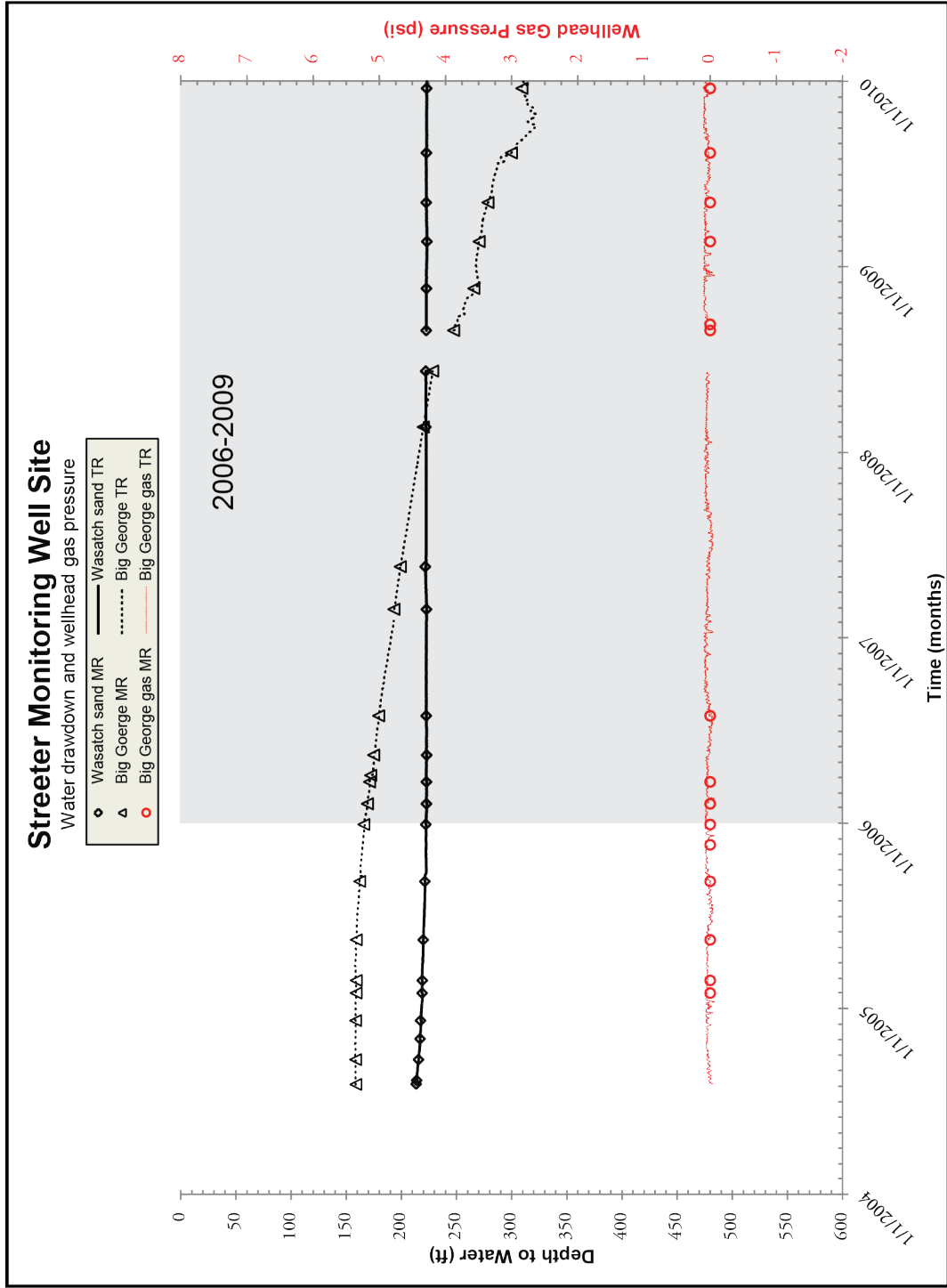


Figure 107. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Streeter monitoring well site location. Gray area represents the current monitoring period of 2006-2009.

Production Statistics

Production data was analyzed for CBNG wells within the buffer of the Streeter monitoring wells from January 1999 to December 2009. Cumulative production for individual CBNG wells is displayed by location on Figure 108.

Water production peaked in 2009, which correlates to groundwater drawdown trends. Water produc-

tion increased during the 2006 to 2009 monitoring period; gas production was minimal (Figure 109).

The water/gas ratio of CBNG wells within the buffer is relatively consistent. Percent methane is variable.

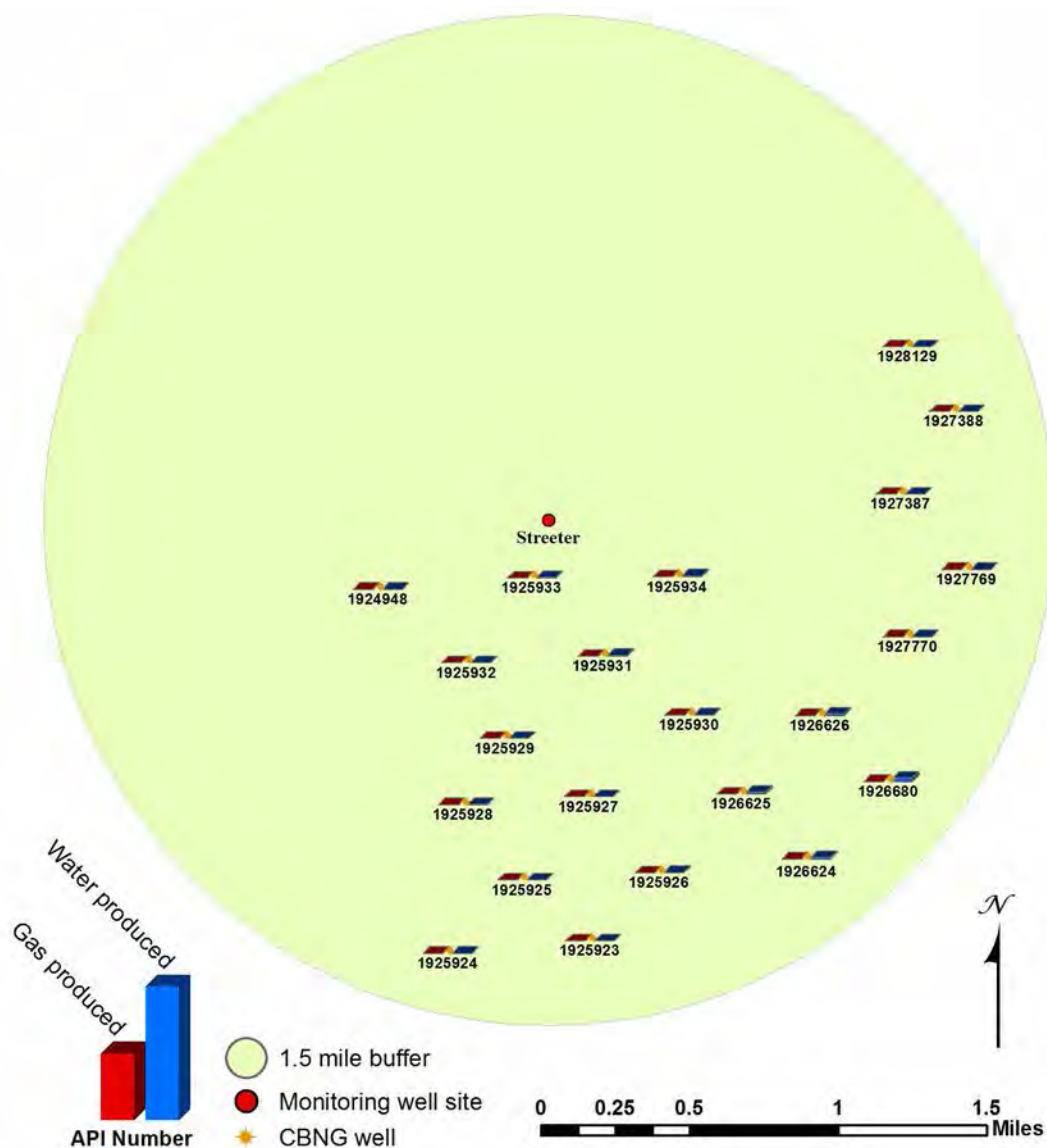


Figure 108. Streeter monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (Bbls) and gas (Mcf) production. The seven digit number below corresponds to the American Petroleum Institute (API) well number.

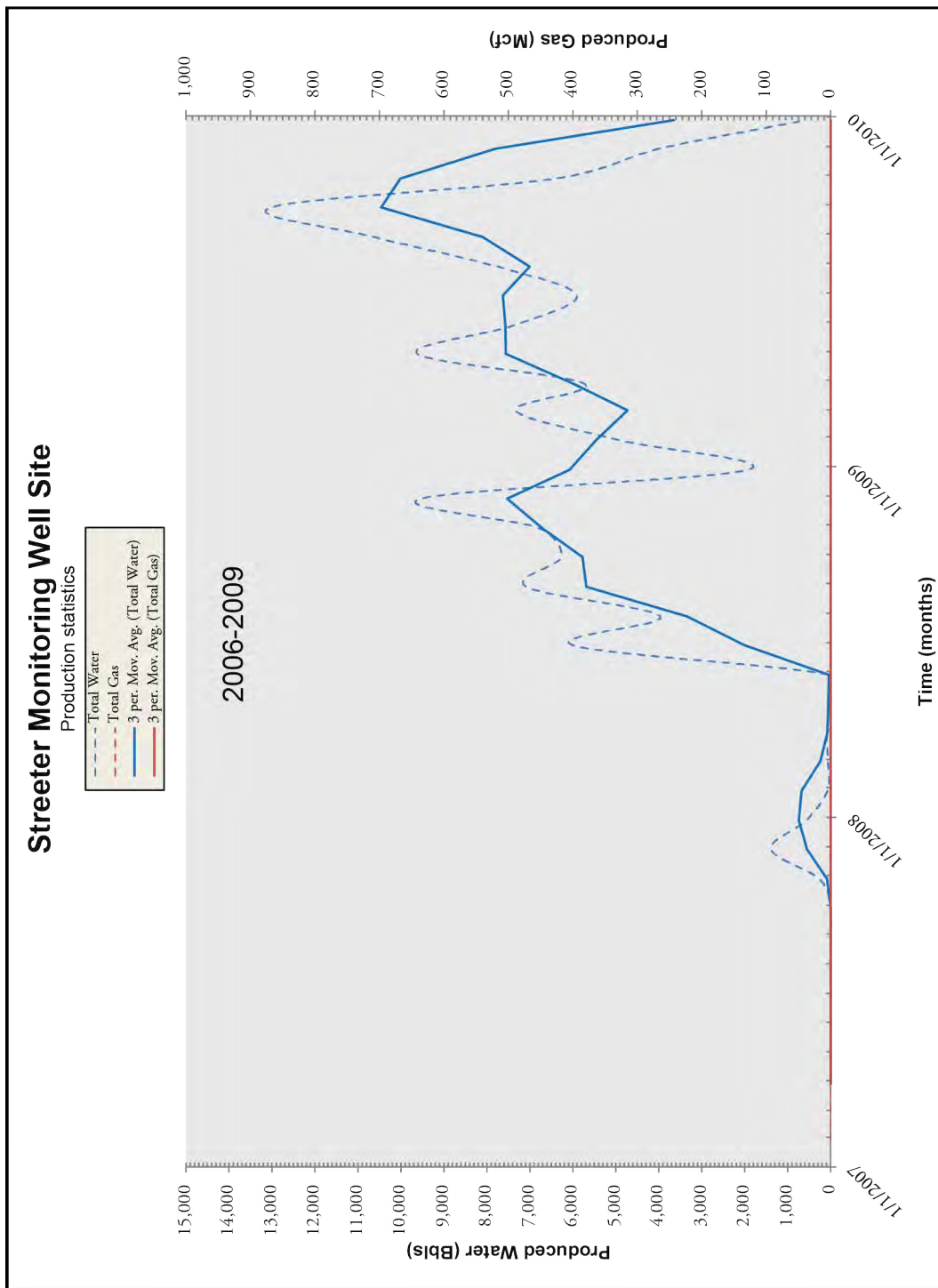


Figure 109. 3-period moving average along with water and gas production from associated CBNG wells.

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 consists of one dual completion well, separated by a packer. The well is drilled into a Wasatch sandstone and the Big George coal (Figure 110; Table 53). Missing and/or fluctuating transducer data is the result of errors with on-site equipment.

The Big George coal recorded a groundwater draw-down of 546 feet during the 2006-2009 monitoring period; data shows a steep drop in the groundwater level midway through 2008 followed by a steady decline. The Wasatch sandstone during the same monitoring period recorded a groundwater rise of 35 feet (Figure 111; Table 54). Similar initial groundwater depths and significant drawdown differences indicate that the monitored Wasatch sandstone and Big George coal are not hydraulically connected. Gas pressure readings did not surpass levels possible from transducer error.

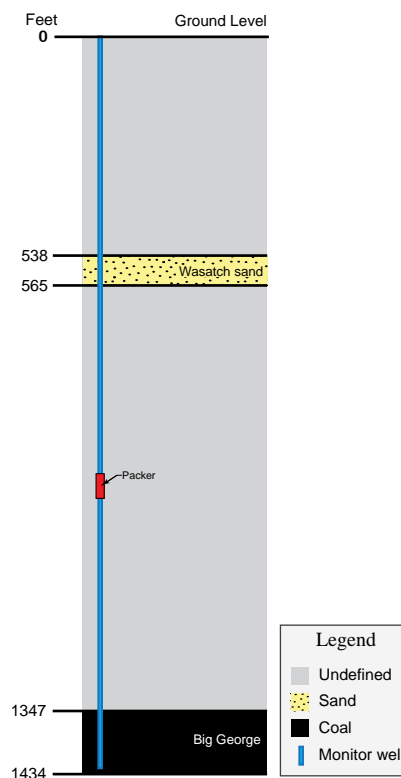


Figure 110. Section showing relative positions of coals and sands in feet. Not to scale.

Table 53. Table showing the depth to and thickness of monitored zones at the West Pine Tree monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Wasatch sand	538	565	27	782
Big George coal	1347	1434	87	n/a

Table 54. Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2006	Drawdown 2006-2009	Total drawdown (ft.)	Depth to 12/31/09 water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	272.00	n/a	-35.45	-35.45	236.55	n/a	n/a
Big George coal	272.00	n/a	546.45	546.45	818.45	n/a	n/a

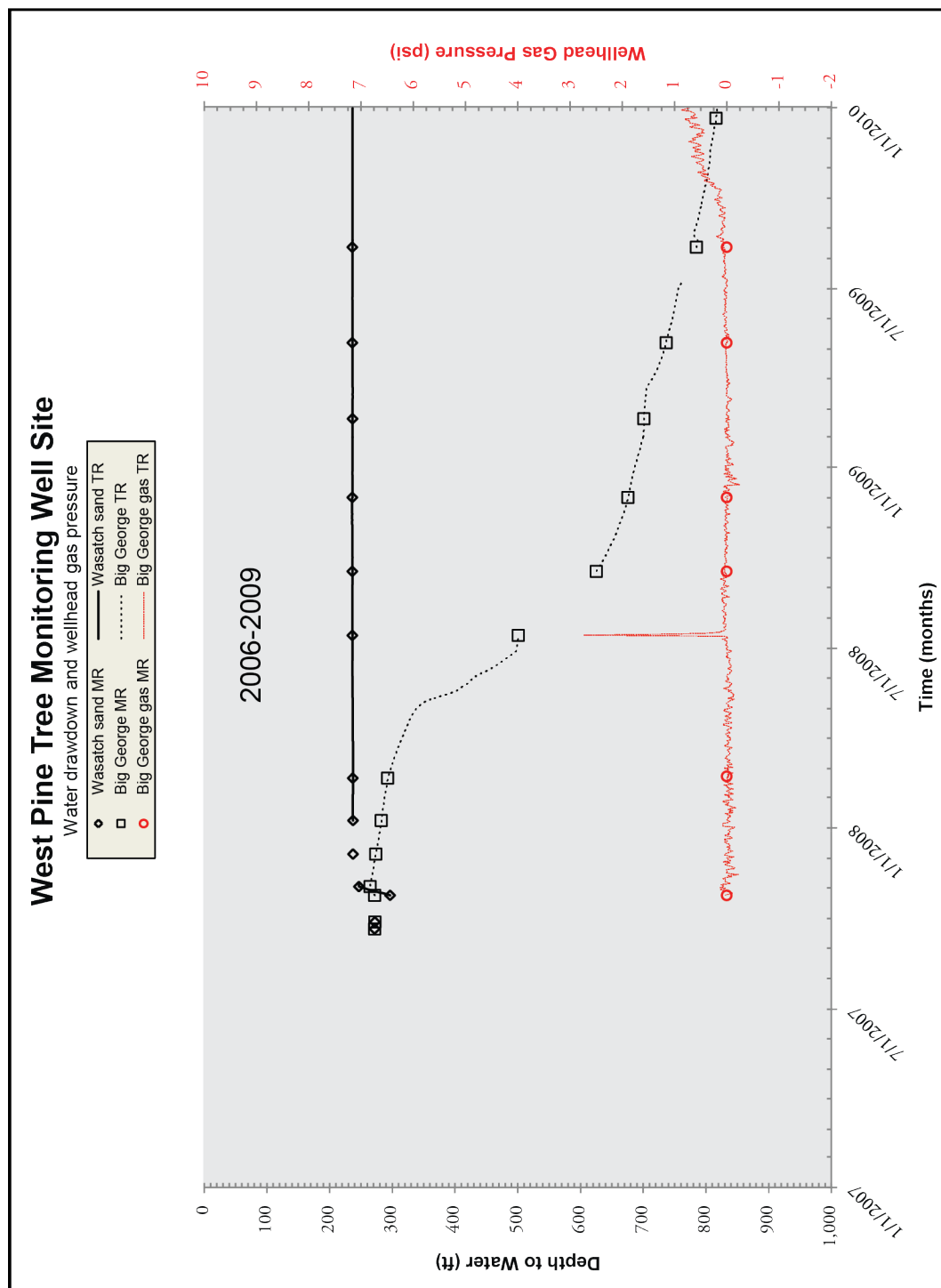


Figure 111. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the West Pine Tree monitoring well site location.

Production Statistics

Production data was analyzed for CBNG wells within the buffer of the West Pine monitoring well site from January 2004 through December 2009. Cumulative production for individual CBNG wells is displayed by location on Figure 112.

Water production peaked in late 2008, which correlates to groundwater drawdown trends. Water and gas production increased during the 2006 to 2009 monitoring period (Figure 113). The water/gas ratio of CBNG wells within the buffer is relatively inconsistent. Percent methane is variable.

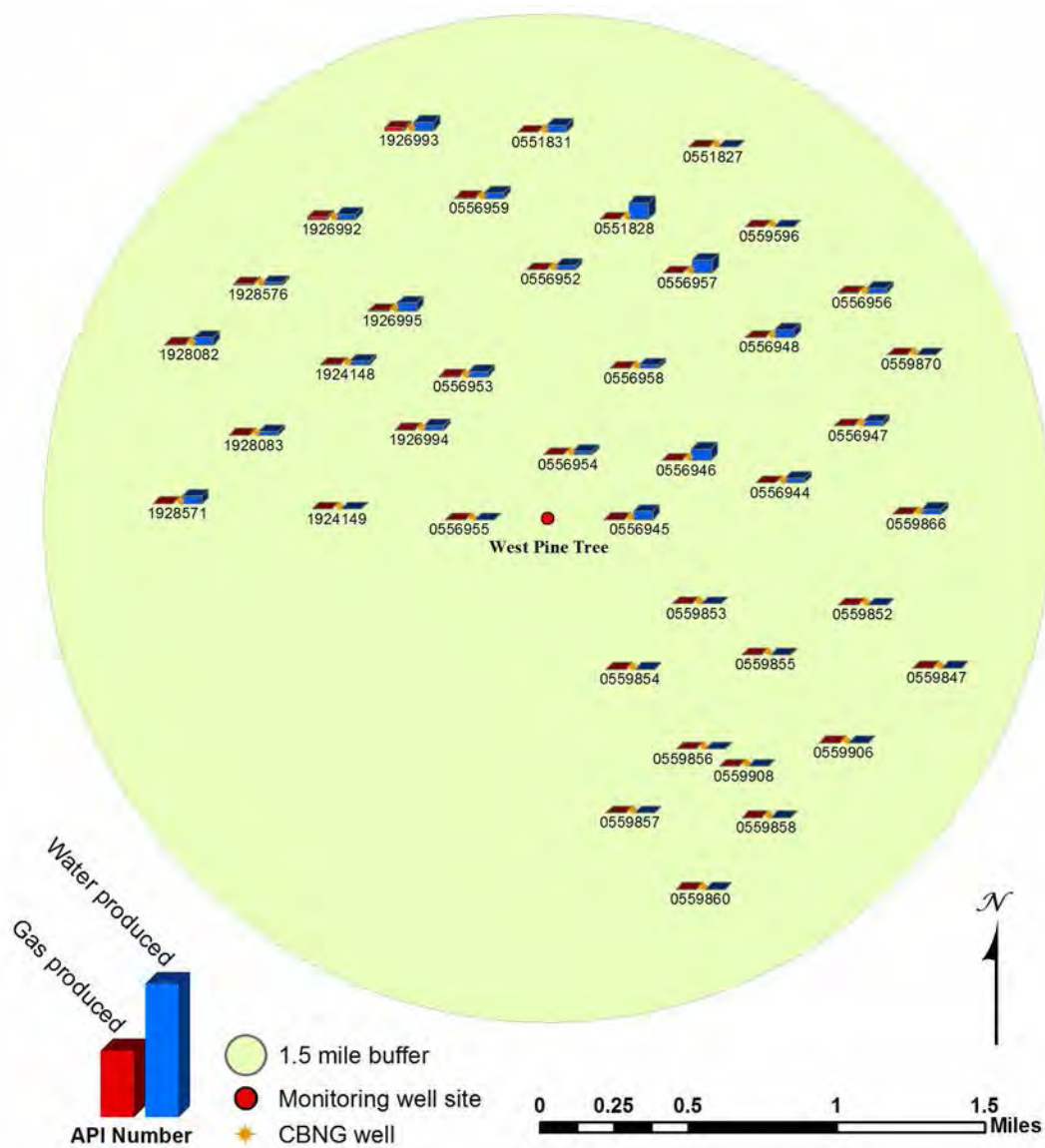


Figure 112. West Pine Tree monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (Bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

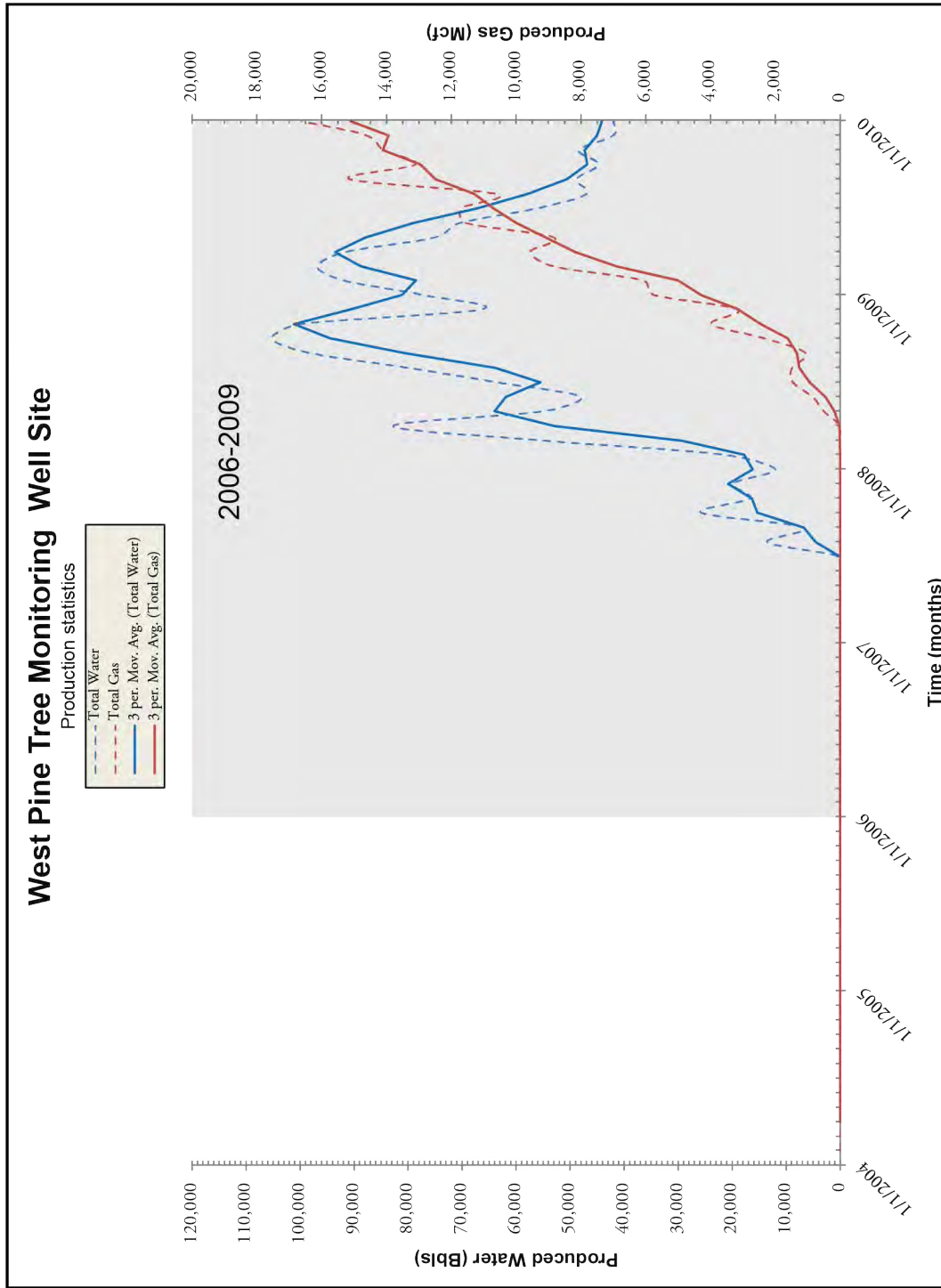


Figure 113. 3-period moving average along with water and gas production from associated CBNG wells.

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 drilled into the Big George coal and the other is constructed into a overlying Wasatch sandstone (Figure 114; Table 55). Missing and/or fluctuating transducer data is the result of errors with on-site equipment.

The Big George coal recorded a groundwater draw-down of 664 feet during the 2006-2009 monitoring period; data shows a steep drop in the groundwater level early in 2006 followed by a steady decline (Figure 115; Table 56). Groundwater levels in the Wasatch sandstone declined by 109 feet during the 2006-2009 monitoring period (Figure 115; Table 56). Monitoring well data suggesting the possibility that the monitored Wasatch sandstone and producing zones are hydraulically connected. Gas pressure increased rapidly the second half of 2006, rapidly declined late in 2007, and remained steady through 2009.

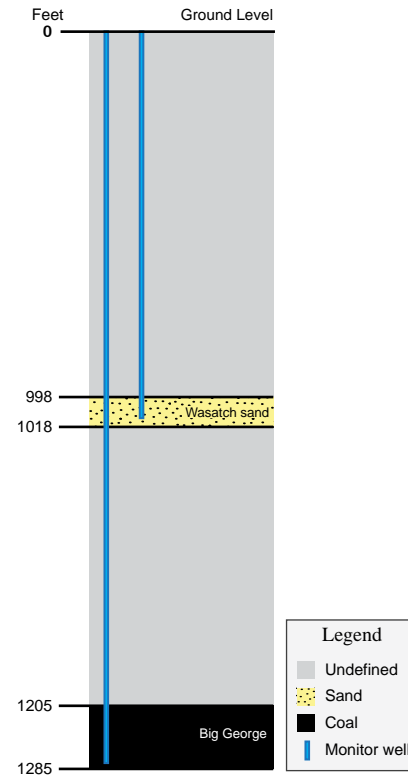


Figure 114. Section showing relative positions of coals and sands in feet. Not to scale.

Table 55. Table showing the depth to and thickness of monitored zones at the Wild Turkey monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Wasatch sand	998	1018	20	187
Big George coal	1205	1285	80	n/a

Table 56. Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2006	Drawdown 2006-2009	Total drawdown (ft.)	Depth to 12/31/09 water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	128.10	-2.76	108.61	105.85	233.95	n/a	n/a
Big George coal	267.70	201.12	664.02	865.14	1132.84	102	11/26/07

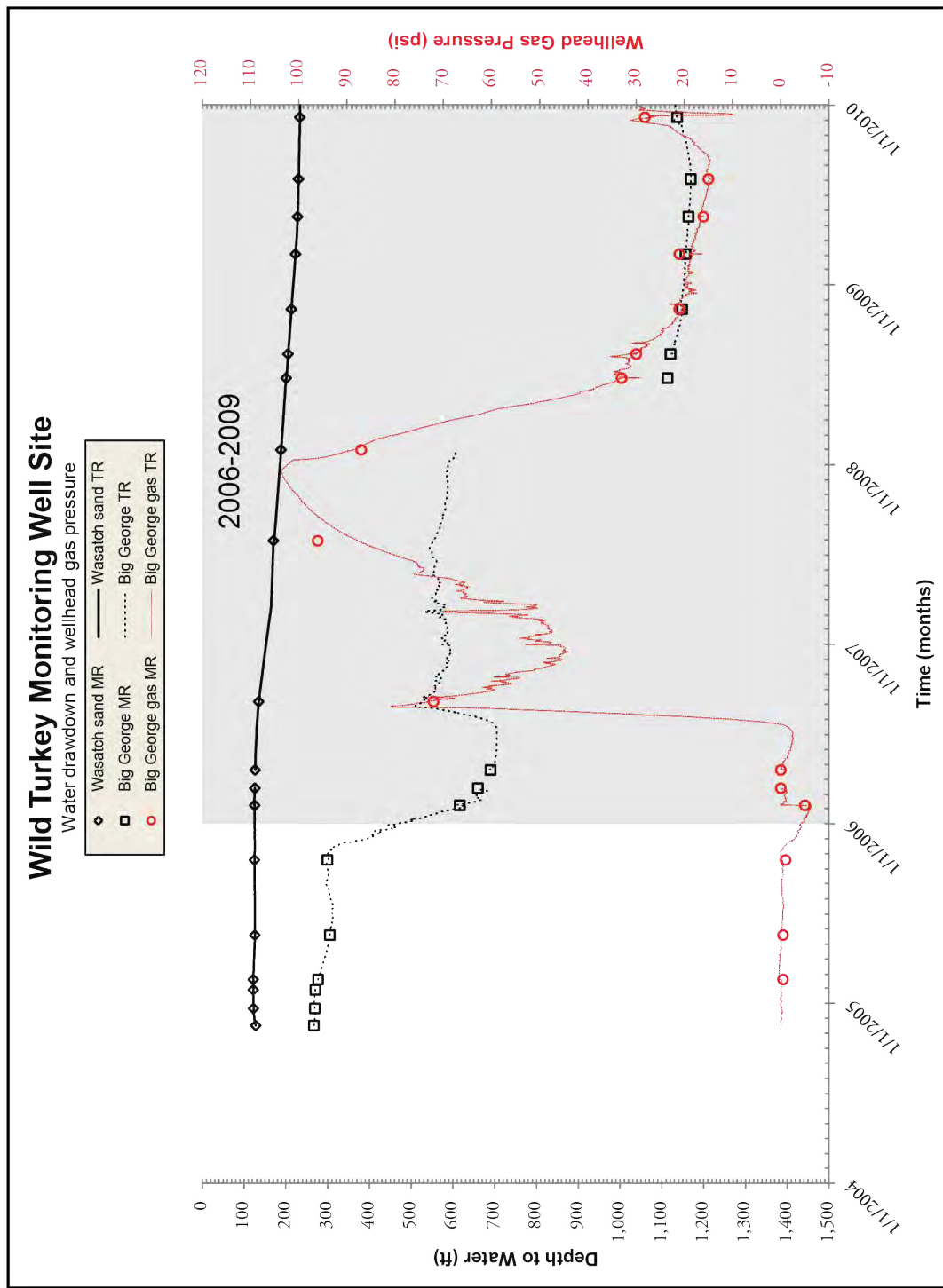


Figure 115. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Wild Turkey monitoring well site location.

Production Statistics

Production data was analyzed for CBNG wells within the buffer of the Wild Turkey monitoring well site from January 2004 through December 2009. Cumulative production for individual CBNG wells is displayed by location on Figure 116.

Water production peaked in 2006, which correlates to groundwater drawdown trends. Water and gas production peaked and declined during the 2006 to 2009 monitoring period (Figure 117). The water/gas ratio of CBNG wells within the buffer is relatively inconsistent. Percent methane increased.

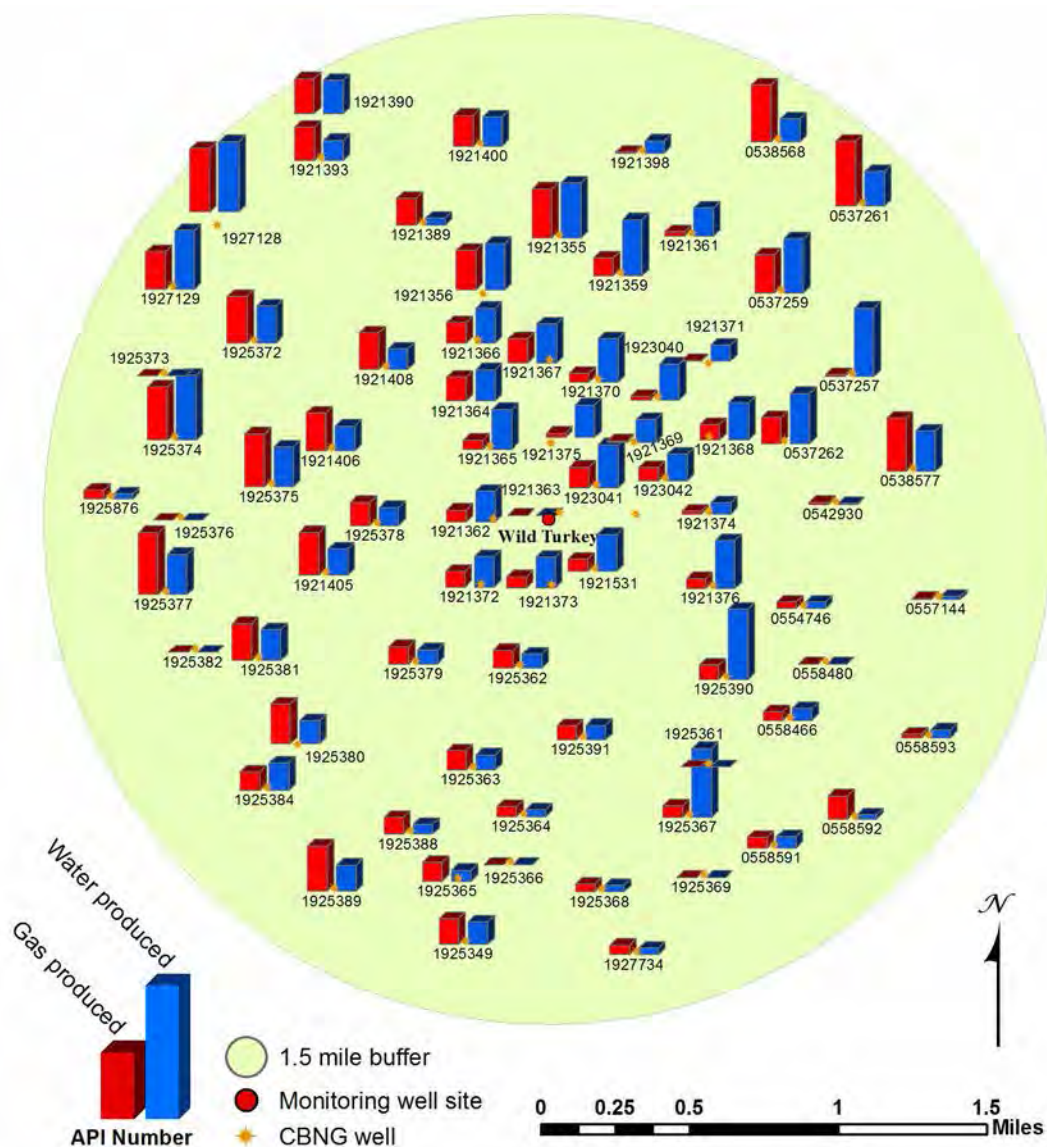


Figure 116. Wild Turkey monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (Bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

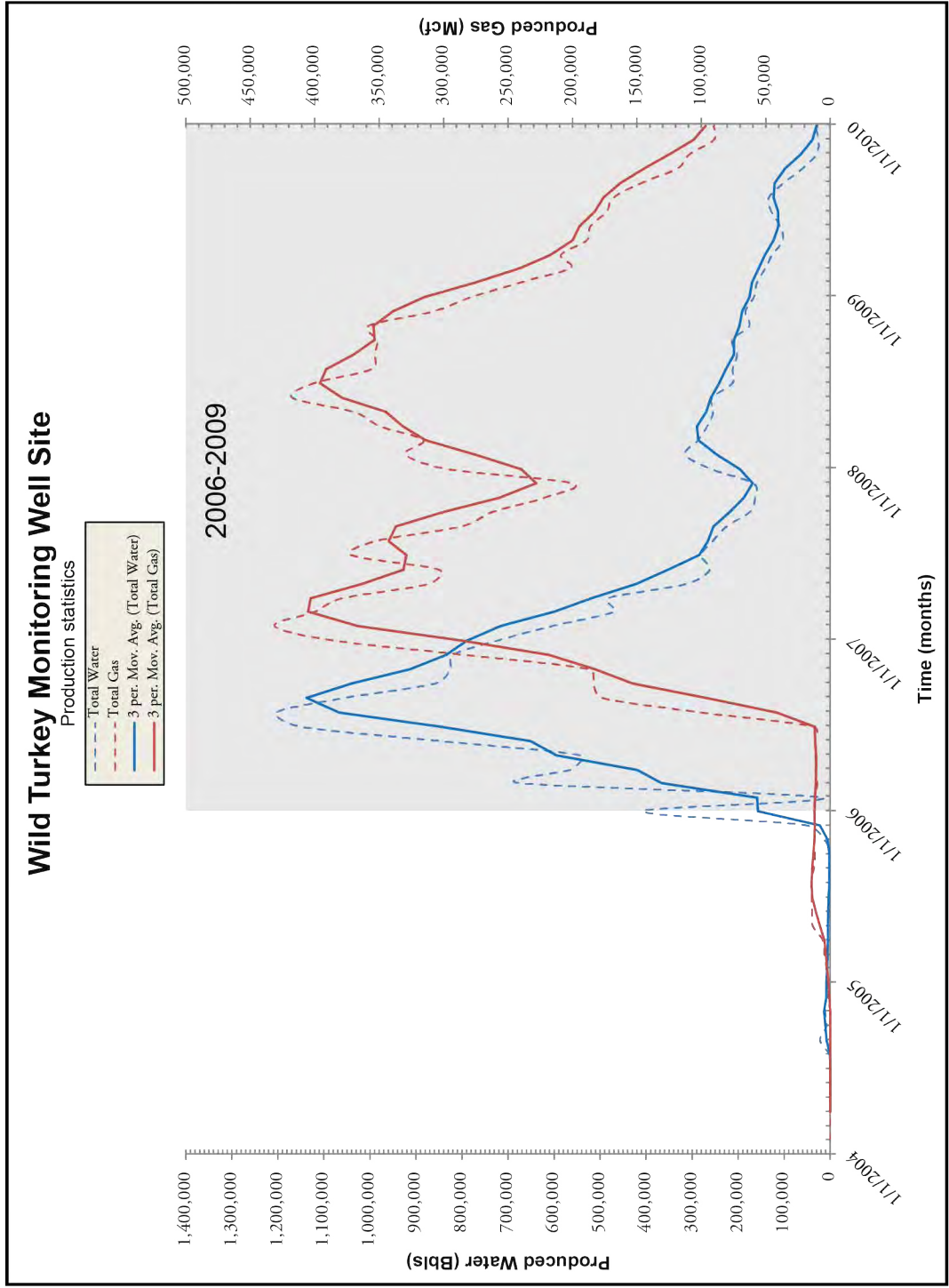


Figure 117. 3-period moving average along with water and gas production from associated CBNG wells.

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. One well is drilled into the Wall coal and also completed in the shallower Werner coal. The second well is drilled to the Anderson coal and also completed into an underburden sand. The third well is drilled to the shallow Smith coal and also completed in the shallow Wasatch sand. (Figure 118; Table 57). Missing transducer data is the result of errors with on site equipment.

The Wall and Anderson coals record groundwater drawdown beginning in mid-2009 and mid-2008 respectively. There was little impact on water levels in the Smith and Werner coals between 2006-2009. This indicates they are confined relative to the Wall and Werner coals. The underburden sand shows a gradual drawdown throughout the period of drawdown in the coals. This suggests that there may be a hydrologic connection between the underburden sand and the coals above it. Water levels in the Wasatch sand remained constant through the monitoring period. This suggests that there is no hydrologic connection between the coals and the shallow Wasatch sandstone (Figure 119; Table 58). Wellhead gas pressure at this location stayed around zero for the entirety of the monitoring period with the exception of one occurrence. One manual measurement of 55 psi and 52 psi for the Smith and Wall coals respectively in 2007 were recorded (Figure 119). No other measurements above zero outside of transducer error were recorded.

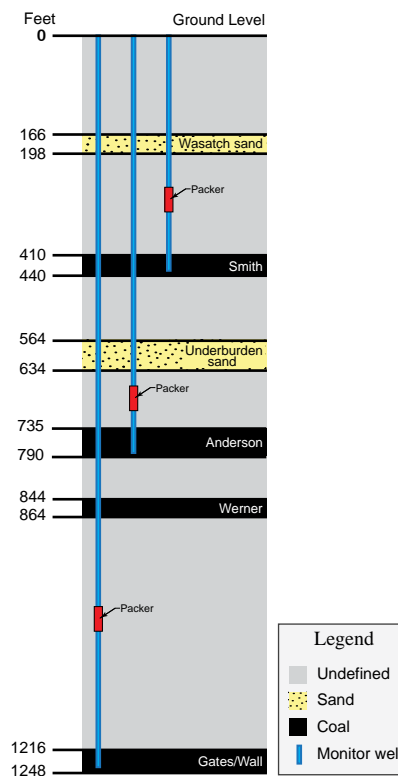


Figure 118. Section showing relative positions of coals and sands in feet. Not to scale.

Table 57. Table showing the depth to and thickness of monitored zones at the Williams Cedar Draw monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Wasatch sand	166	198	32	212
Smith coal	410	440	30	n/a
Underburden sand	564	634	70	101
Anderson coal	735	790	55	n/a
Werner coal	844	864	20	n/a
Gates/Wall coal	1216	1248	32	n/a

Table 58. Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2006	Drawdown 2006-2009	Total drawdown (ft.)	Depth to 12/31/09 water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	115.79	n/a	-1.59	-1.59	114.20	n/a	n/a
Smith coal	169.15	n/a	-0.02	-0.02	169.13	55	8/21/07
Underburden sand	259.77	n/a	163.28	163.28	423.05	n/a	n/a
Anderson coal	243.95	n/a	293.95	293.95	537.90	8	8/21/07
Werner coal	143.90	n/a	19.79	19.79	163.69	n/a	n/a
Gates/Wall coal	216.50	n/a	123.70	123.70	340.20	155	12/17/09

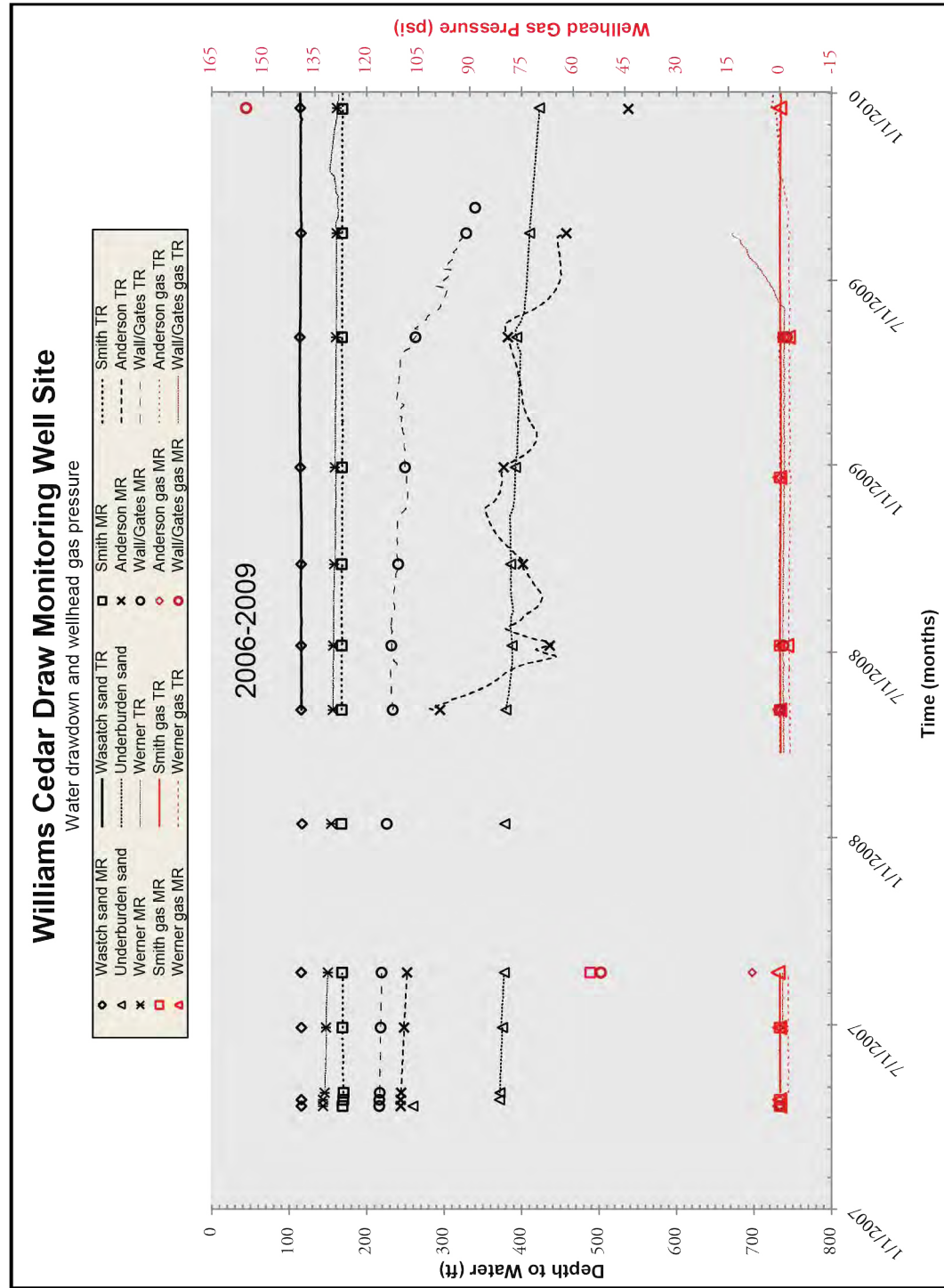


Figure 119. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Williams Cedar Draw monitoring well site location.

Production Statistics

Production data for the Williams Cedar Draw monitoring well site was not reported due to incomplete or generalized completion data for local CBNG wells.

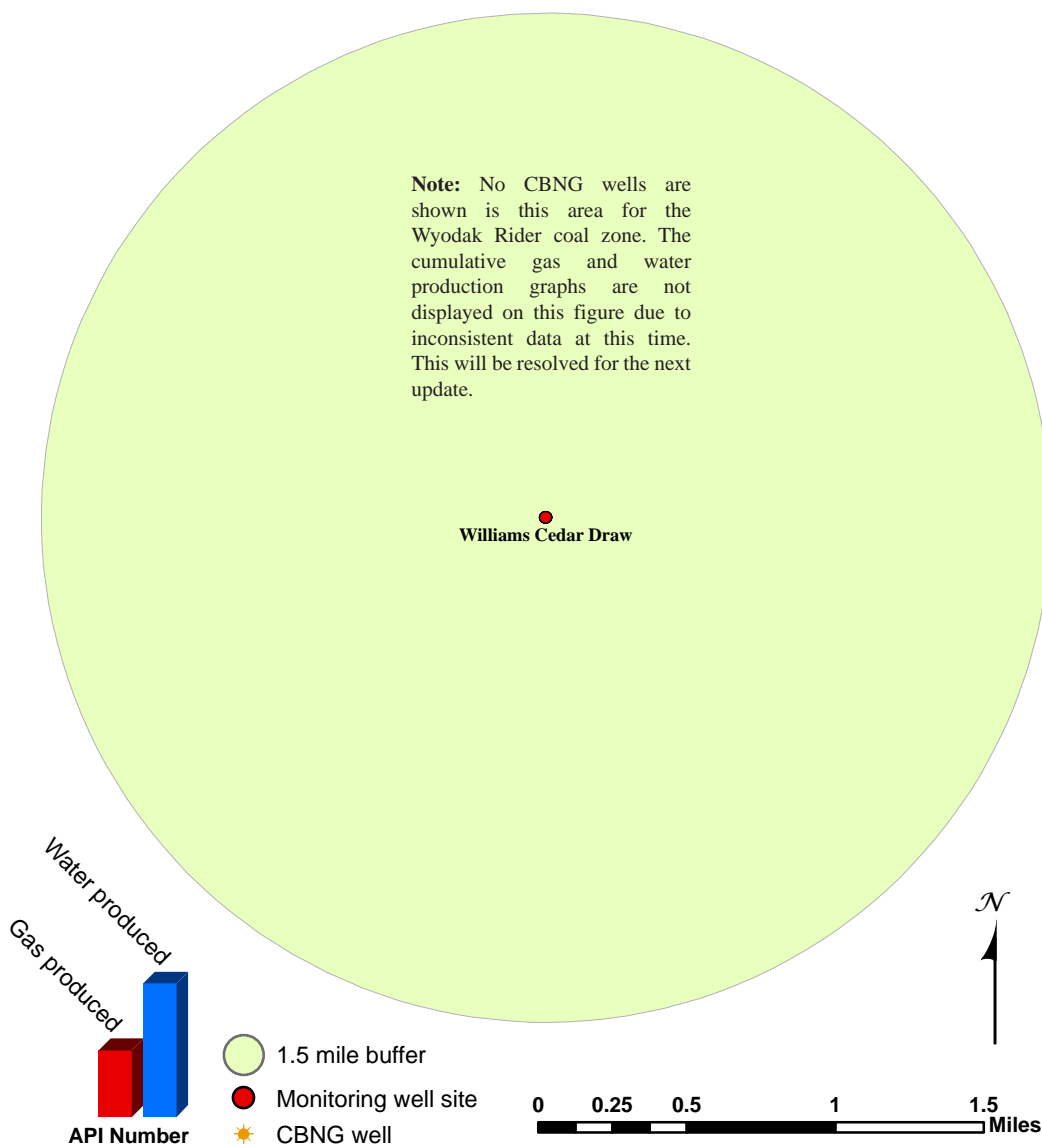


Figure 120. Williams Cedar Draw monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (Bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

Wormwood Monitoring Well Site
Location: S14 T46N R76W
Date First Monitored: December 13, 2006

Drawdown Information

The Wormwood monitoring well site consists of two wells, one of which is a dual completion well, separated by a packer. The dual completion well is completed in the Wasatch sandstone and an underburden sandstone. The second well is completed in the Big George Coal (Figure 121; Table 59). Missing and/or fluctuating transducer data is the result of errors with on-site equipment.

The Big George coal recorded a groundwater draw-down of 683 feet during the 2006-2009 monitoring period; data shows a steep drop in the groundwater level through half of 2007 followed by a steady decline (Figure 122; Table 60). During the 2006-2009 monitoring period the groundwater levels in the Wasatch sandstone rose by 5 feet and in the underburden sandstone the level declined by 236 feet (Figure 122; Table 60). The approximate drawdown trends, as well as a significant groundwater decline, indicate that the deeper underburden sandstone and Big George coal may be hydraulically connected. The groundwater level decline recorded in the underburden sandstone is worth noting; this sandstone is relatively deep and any decline could be the result of CBNG production. Gas pressure readings did not surpass levels possible from transducer error.

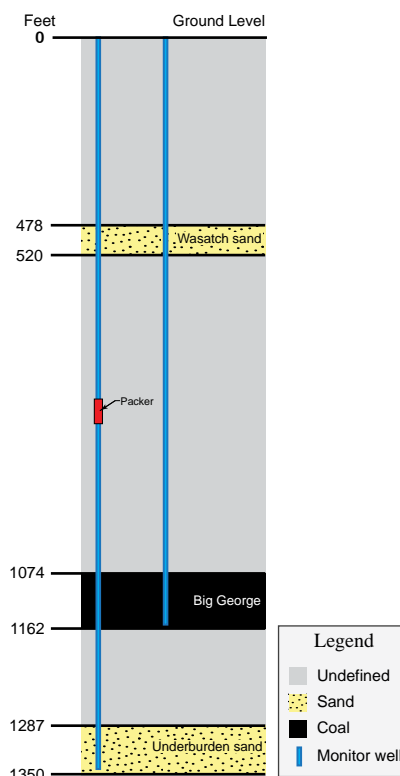


Figure 121. Section showing relative positions of coals and sands in feet. Not to scale.

Table 59. Table showing the depth to and thickness of monitored zones at the Wormwood monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Wasatch sand	478	520	42	554
Big George coal	1074	1162	88	n/a
Underburden sand	1287	1350	63	125

Table 60. Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2006	Drawdown 2006-2009	Total drawdown (ft.)	Depth to 12/31/09 water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	77.30	n/a	-4.76	-4.76	72.54	n/a	n/a
Big George coal	262.00	n/a	683.31	683.31	945.31	n/a	n/a
Underburden sand	115.20	n/a	235.60	235.60	350.80	n/a	n/a

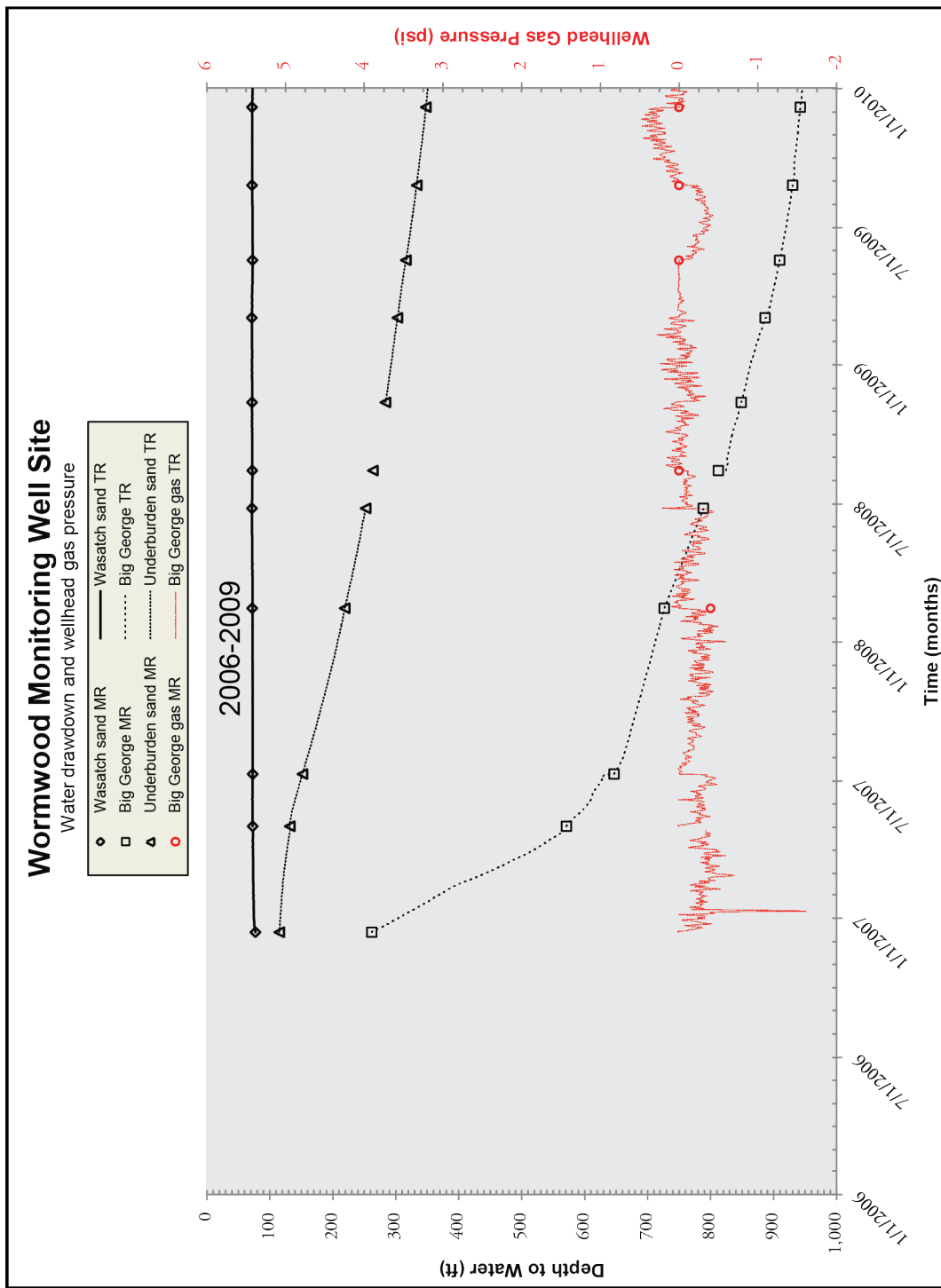


Figure 122. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Wormwood monitoring well site location.

Production Statistics

Production data was analyzed for 18 CBNG wells within the buffer of the Wormwood monitoring wells from January 2002 through December 2009. Cumulative production for individual CBNG wells is displayed by location on Figure 123.

Water production peaked in 2007, which correlates to groundwater drawdown trends. Water and gas production increased during the 2006 to 2009 monitoring period (Figure 124). The water/gas ratio of CBNG wells within the buffer is relatively inconsistent. Percent methane is variable.

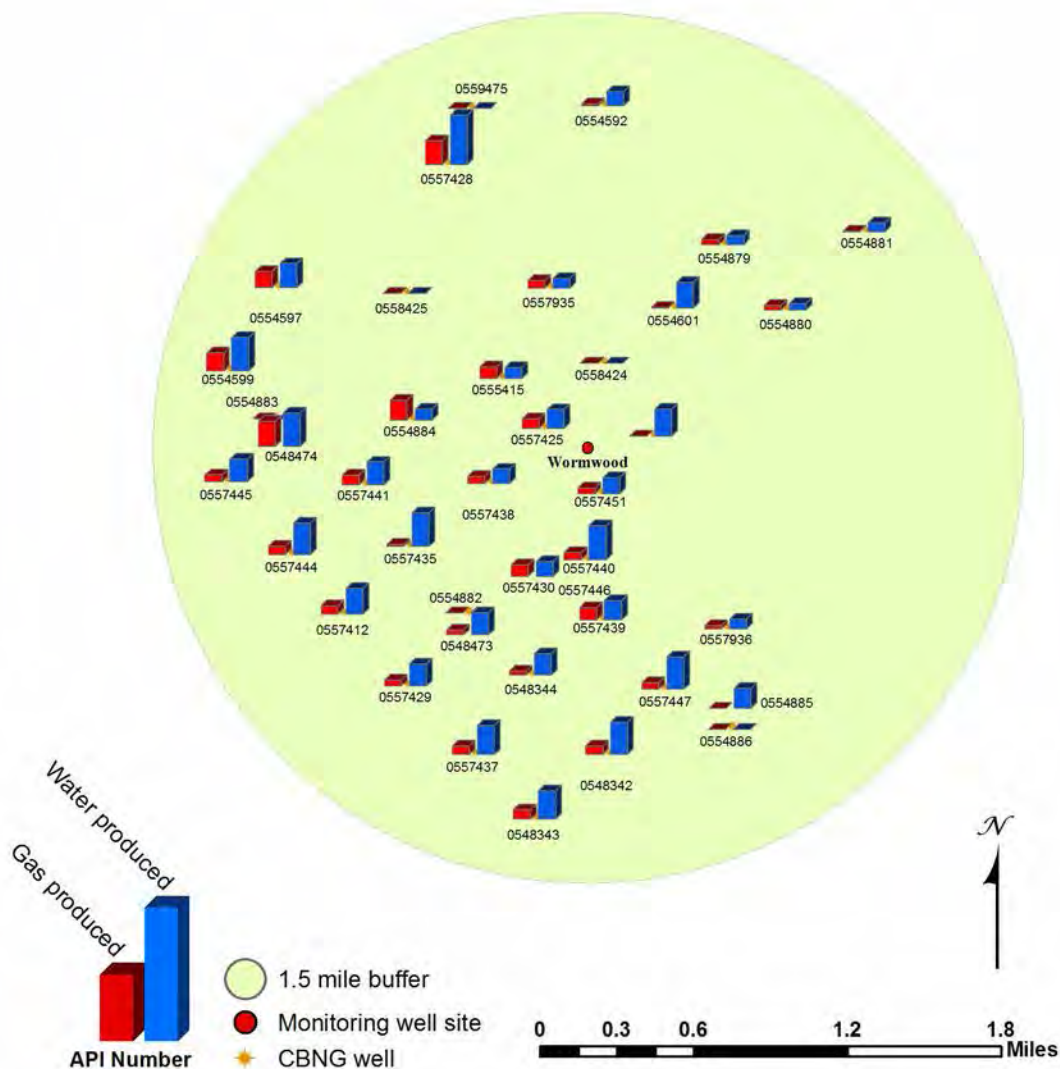


Figure 123. Wormwood monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (Bbls) and gas (Mcf) production. The seven digit number below corresponds to the American Petroleum Institute (API) well number.

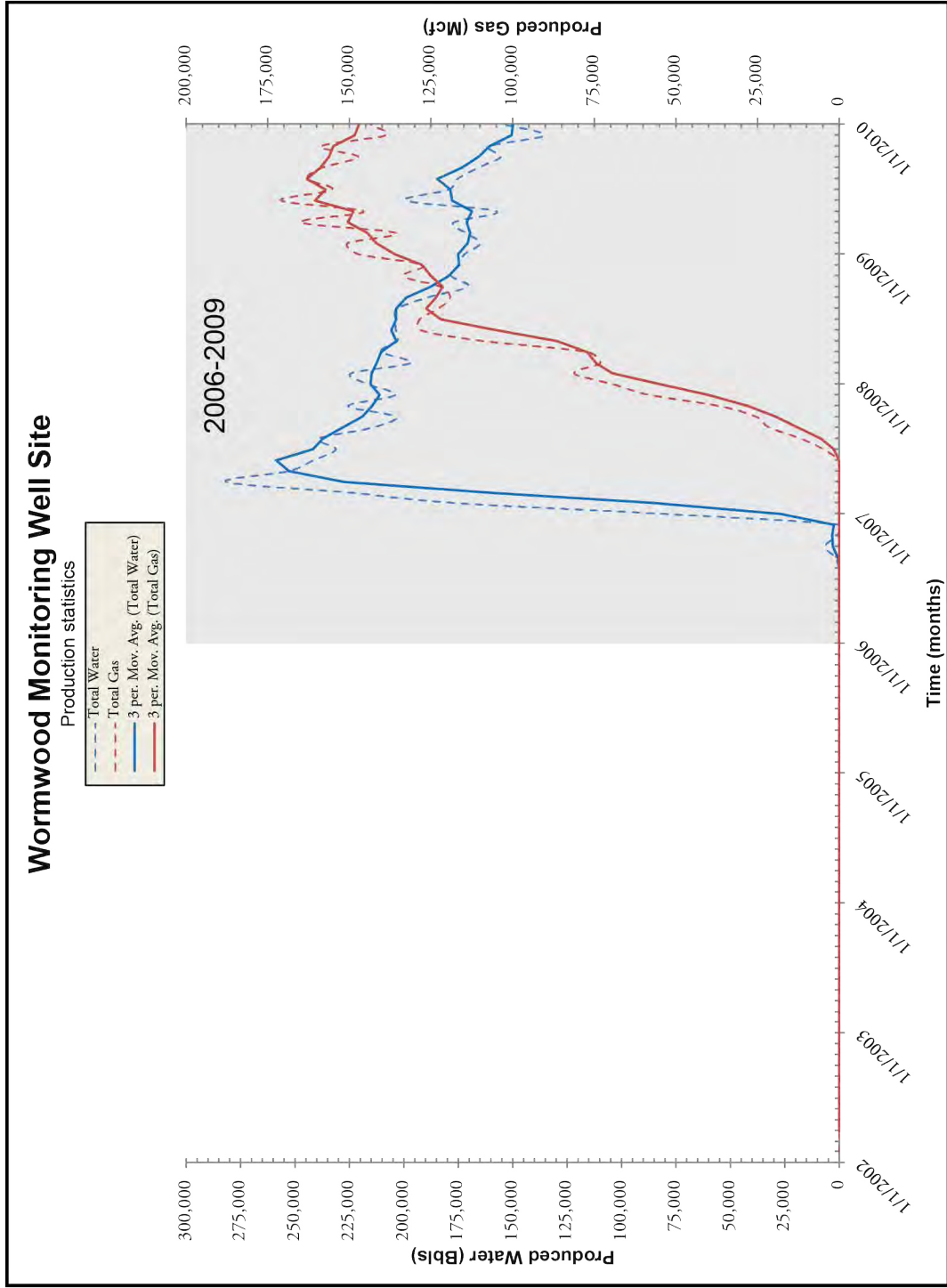


Figure 124. 3-period moving average along with water and gas production from associated CBNG wells.

APPENDIX 3. Upper Wyodak Coal Zone

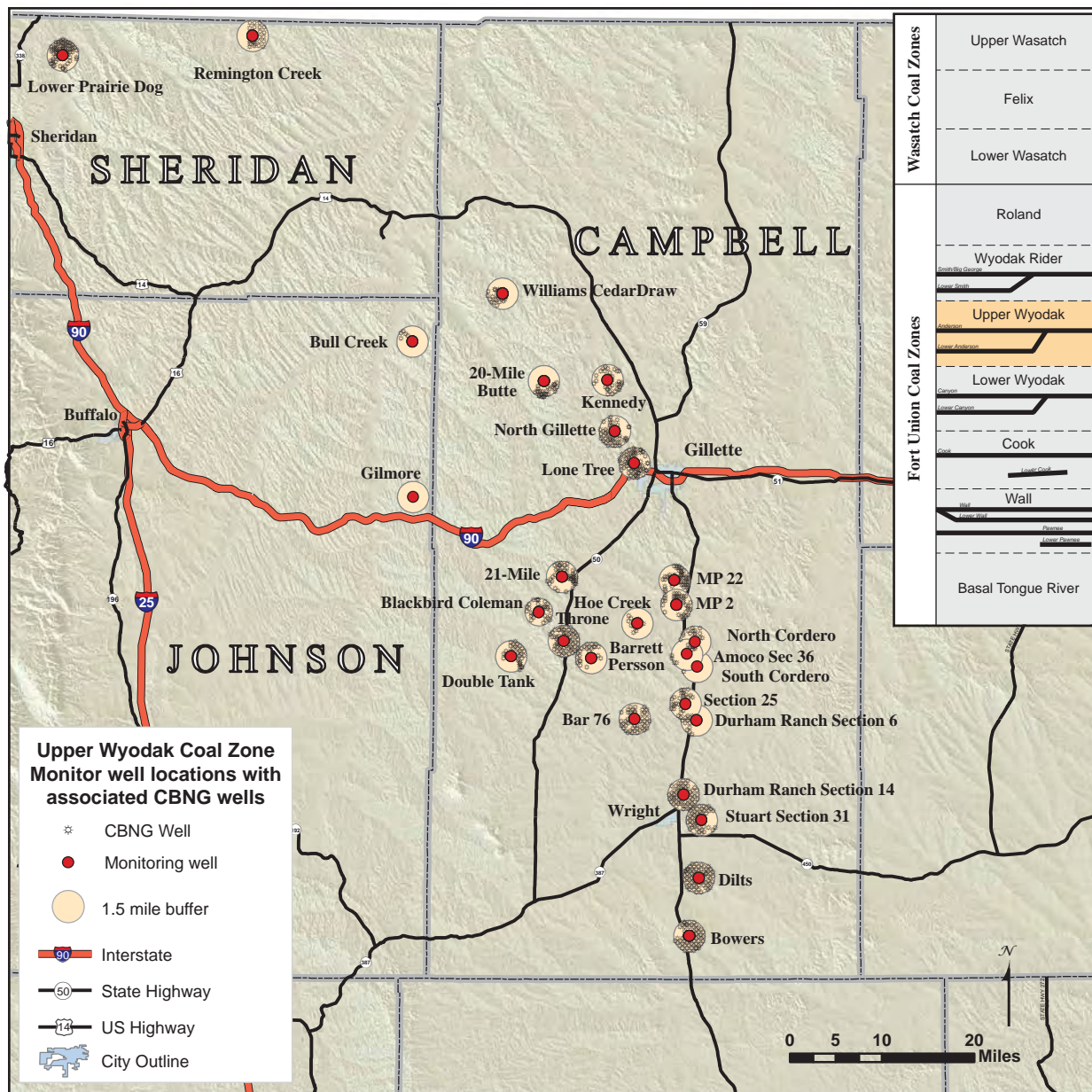


Figure 125. Upper Wyodak coal zone monitoring well site locations in the Powder River Basin, Wyoming.

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 consists of four wells. One well is constructed into each of the Anderson, Pawnee, and Wall coal beds and the remaining well is completed into a Wasatch sandstone (Figure 126; Table 61). Missing transducer data is the result of errors with on site equipment.

Initial water levels in all three coal zones were similar even though the shallowest and deepest coals are separated by 759 feet. All three monitored coals experienced drawdown during the monitoring period. Drawdown in the coals varies between the monitored zones but overall show similar drawdown trends. This suggests a hydrologic connection between the coals in this monitor location. During the 2006-2009 monitoring period, the water level in the Wasatch sand increased by 9 feet, decreasing the overall drawdown for the duration of monitoring to 29 feet (Figure 127; Table 62). The continued production of water from the coals and the rise in water levels in the Wasatch suggest that there is no hydrologic connection between the producing coal zones and the sand. Anderson coal wellhead gas pressures peaked at 10 psi, no other coal experienced a gas pressure breaching zero.

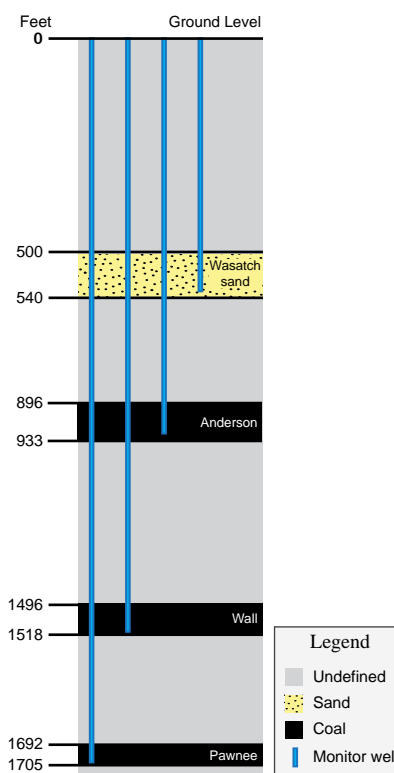


Figure 126. Section showing relative positions of coals and sands in feet. Not to scale.

Table 61. Table showing the depth to and thickness of monitored zones at the 20-Mile Butte monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Wasatch sand	500	540	40	356
Anderson coal	896	933	37	n/a
Wall coal	1496	1518	22	n/a
Pawnee coal	1692	1705	13	n/a

Table 62. Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2006	Drawdown 2006-2009	Total drawdown (ft.)	Depth to 12/31/09 water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	362.77	37.94	-8.94	29.00	391.77	n/a	n/a
Anderson coal	545.00	41.68	121.23	162.91	707.91	10.00	4/28/03
Wall coal	521.20	18.87	254.39	273.26	794.46	n/a	n/a
Pawnee coal	540.30	17.10	158.10	175.20	715.50	n/a	n/a

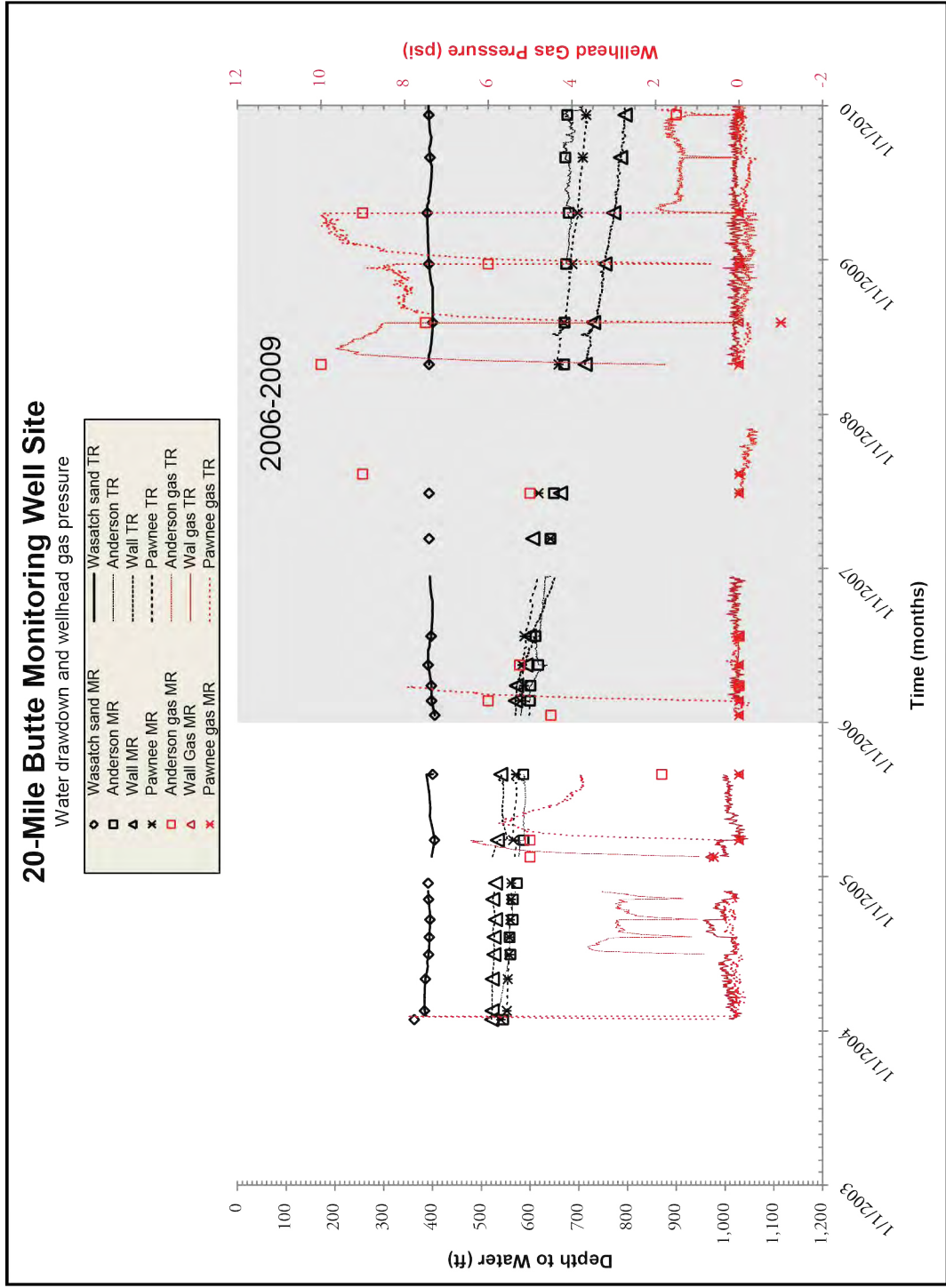


Figure 127. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the 20-Mile Butte monitoring well site location.

Production Statistics

Production data for the 20-Mile Butte monitoring well site was not reported due to incomplete or completion data for local CBNG wells.

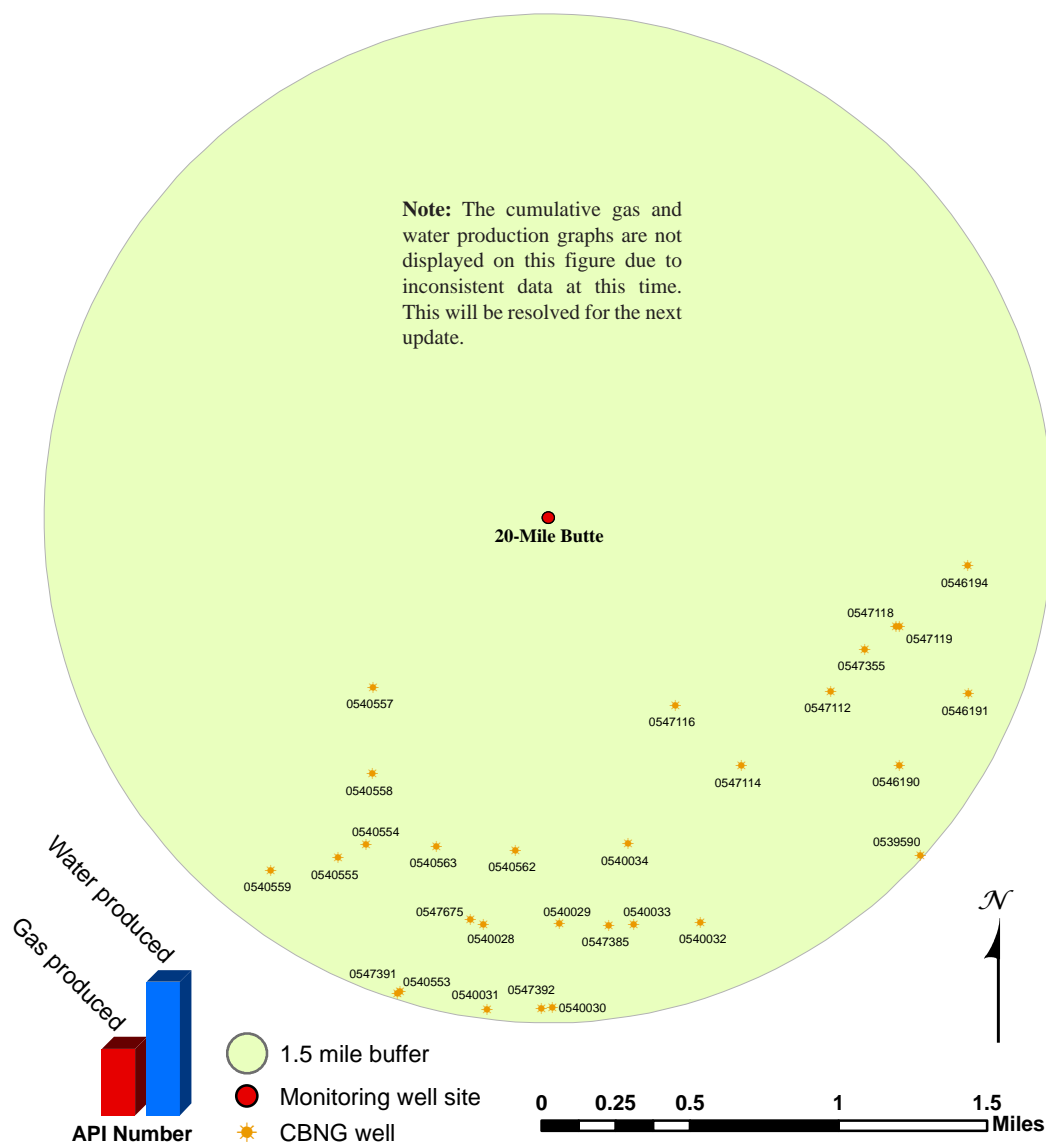


Figure 128. 21-Mile Butte monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (Bbls) and gas (Mcf) production. The seven digit number below corresponds to the American Petroleum Institute (API) well number.

21-Mile Monitoring Well Site
Location: S22 T48N R74W
Date First Monitored: August 23, 2001

Drawdown Information

The 21-Mile monitoring well site includes three wells. One is drilled into the Big George coal, another into the deeper Wyodak coal, and the third in a overlying Wasatch sandstone (Figure 129; Table 63). Missing and/or fluctuating transducer data is the result of errors with on-site equipment.

The Big George coal recorded a groundwater draw-down of 75 feet during the 2006-2009 monitoring period; data shows a slow decline in the groundwater level (Figure 130; Table 64). The Wyodak coal recorded a groundwater increase of 81 feet during the 2006-2009 monitoring period; groundwater levels began to increase in mid to late 2008 and remained relatively stable through 2009 (Figure 130; Table 64). Similar initial groundwater levels, as well as groundwater levels of the Wyodak recovering towards Big George, suggests that these coals are hydraulically connected. Groundwater levels in the Wasatch sandstone were relatively stable during the 2006-2009 monitoring period, though there was a slight increase of 2 feet (Figure 130; Table 64). A minor overall decline, along with variable initial water levels, suggests there is no hydraulic connection between the monitored Wasatch sandstone and producing zones. Gas pressure readings did not surpass levels possible from transducer error.

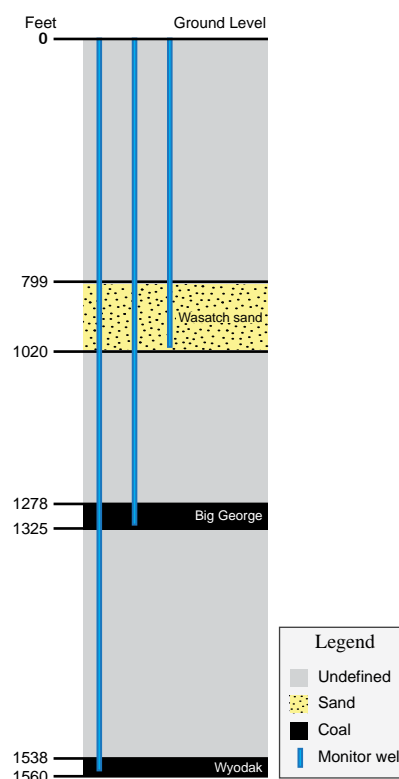


Figure 129. Section showing relative positions of coals and sands in feet. Not to scale.

Table 63. Table showing the depth to and thickness of monitored zones at the 21-Mile monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Wasatch sand	799	1020	221	258
Big George coal	1278	1325	47	n/a
Wyodak coal	1538	1560	22	n/a

Table 64. Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2006	Drawdown 2006-2009	Total drawdown (ft.)	Depth to 12/31/09 water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	533.33	2.68	-2.08	0.60	533.93	n/a	n/a
Big George coal	626.68	173.82	74.97	248.79	875.47	1.00	8/15/03
Wyodak coal	629.86	390.15	-80.99	309.16	939.02	10.00	4/16/02

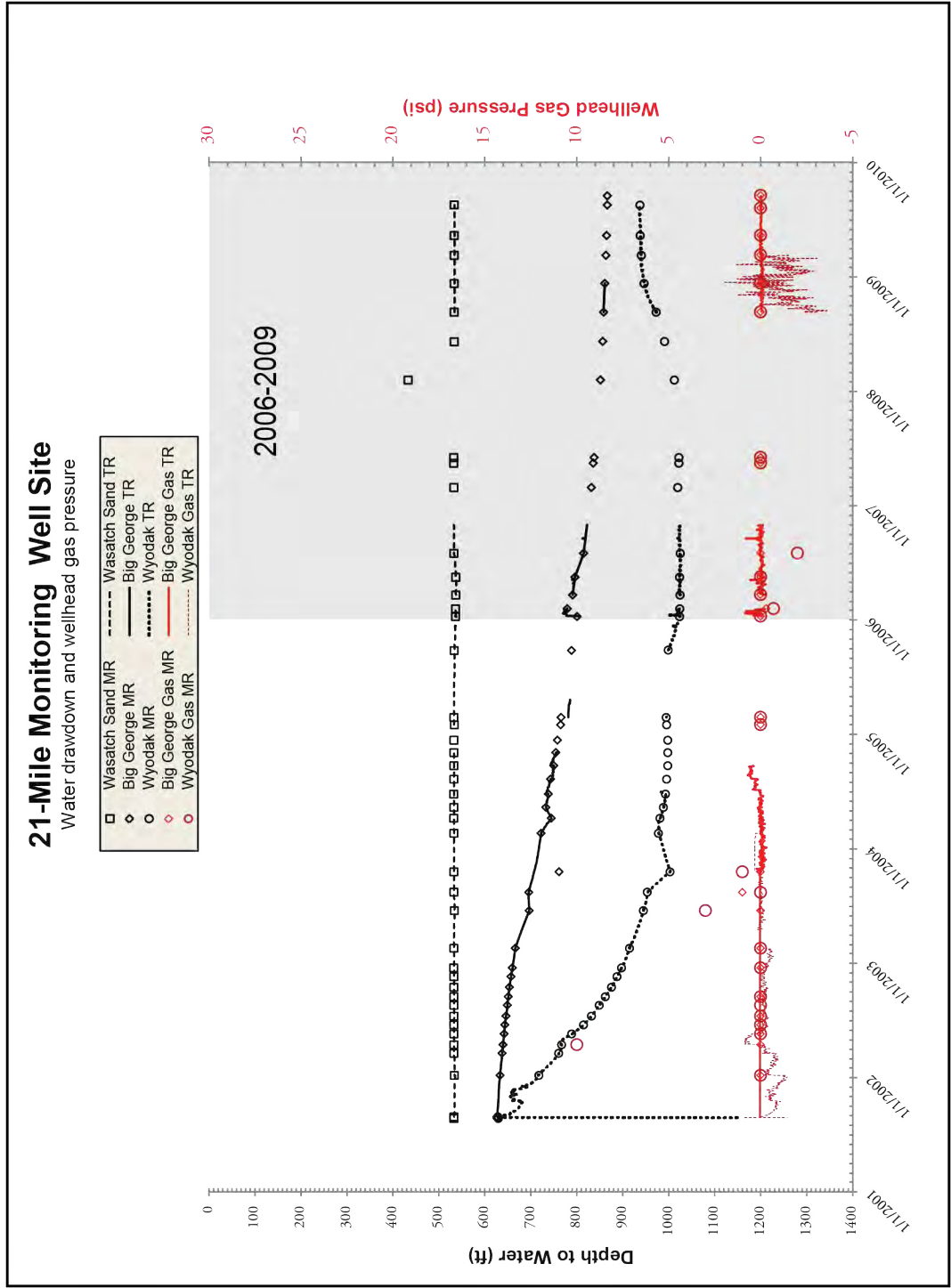


Figure 130. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the 21-Mile monitoring well site location.

Production Statistics

Production data was analyzed for CBNG wells within the buffer of the 21-Mile monitoring wells site from January 1999 through December 2009. Cumulative production for individual CBNG wells is displayed by location on Figure 131.

Water production peaked in 2002, which correlates to groundwater drawdown trends. Water and gas production declined during the 2006 to 2009 monitoring period (Figure 132). The water/gas ratio of CBNG wells within the buffer is relatively inconsistent. Percent methane generally decreased.

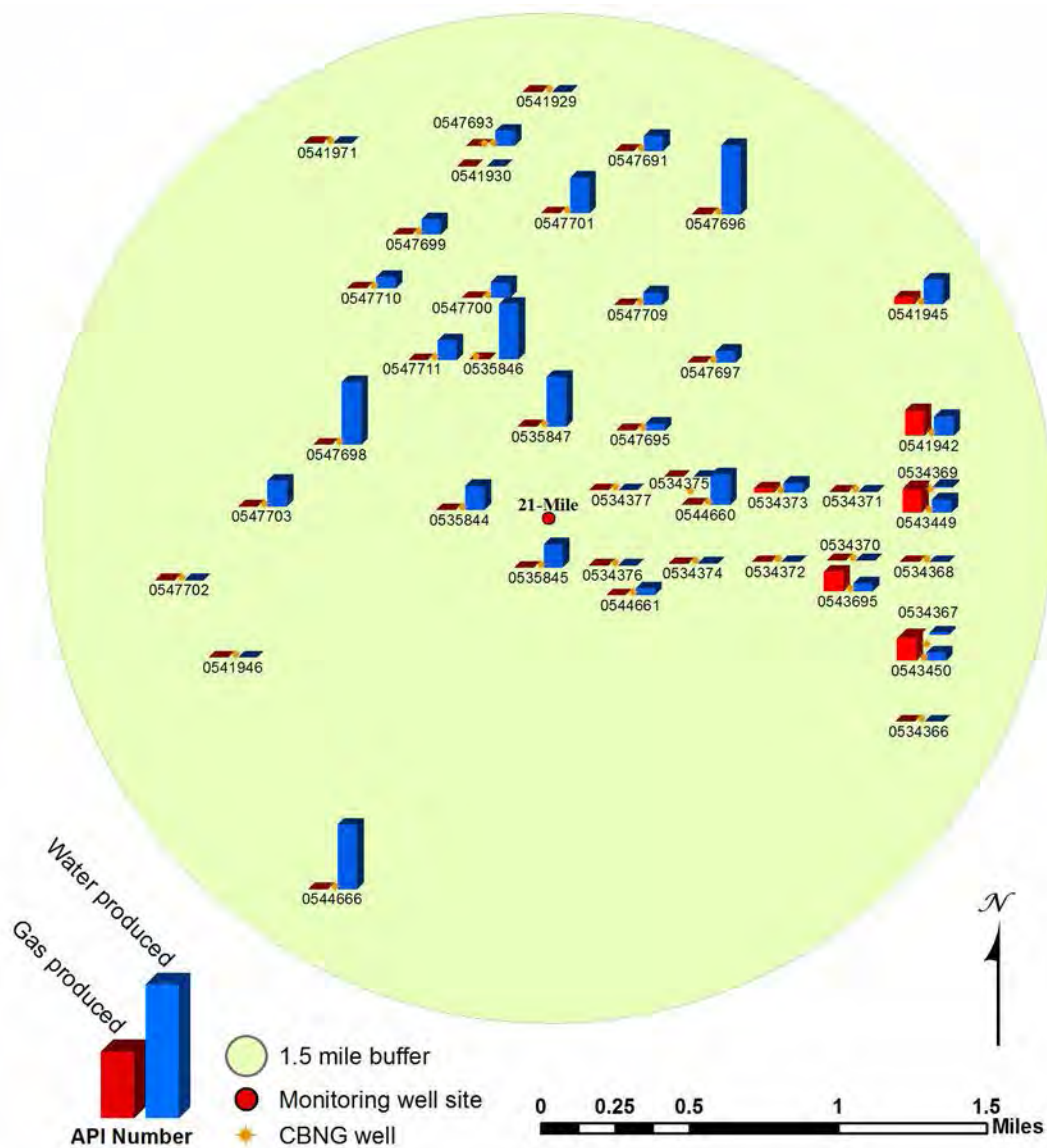


Figure 131. 21-Mile monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (Bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

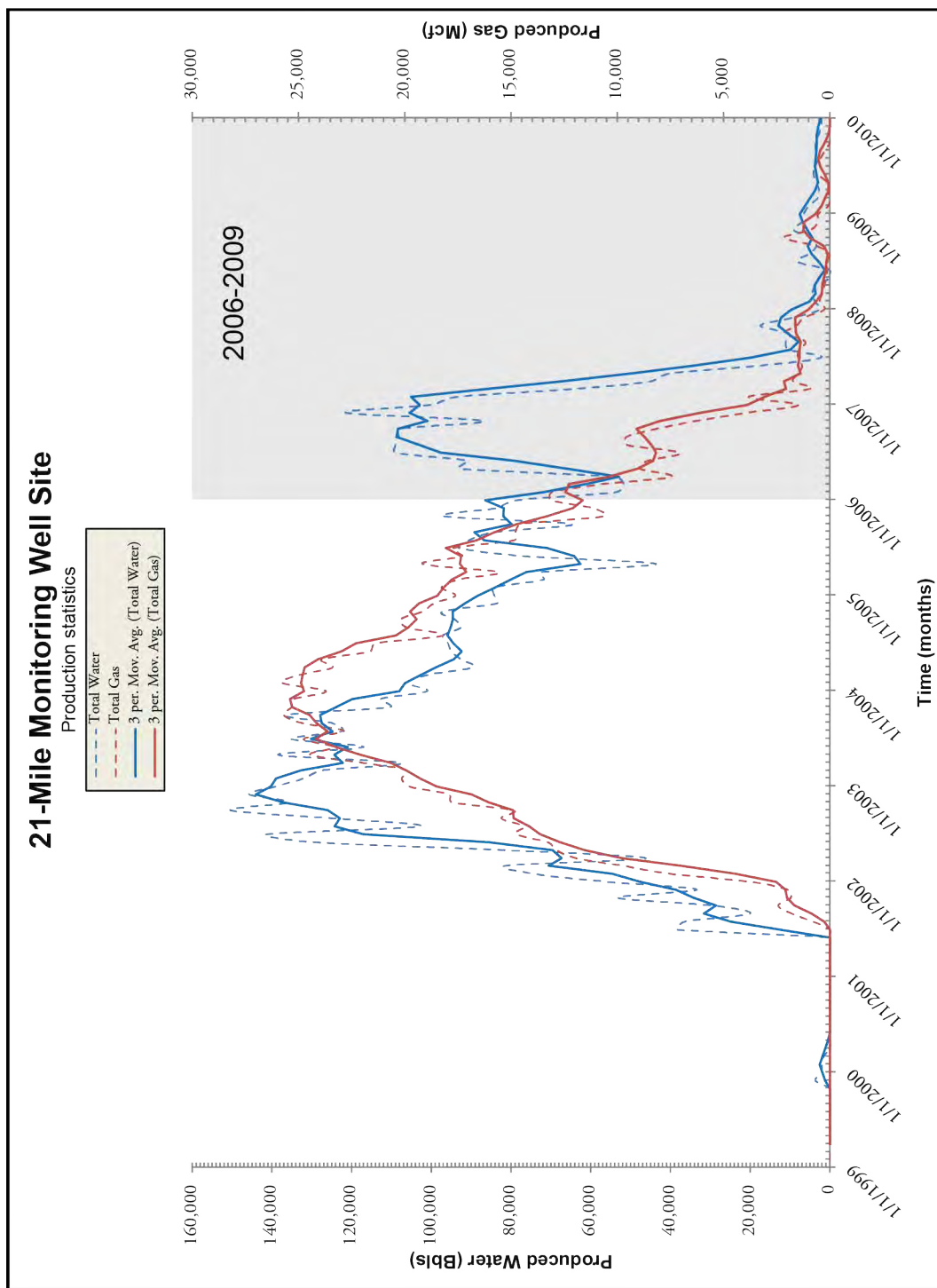


Figure 132. 3-period moving average along with water and gas production from associated CBNG wells.

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 consists of one well drilled into the Wyodak coal. (Figure 133; Table 65). A total of three manual measurements were taken during the 2006-2009 monitoring period. The Wyodak coal recorded a groundwater draw-down of 12 feet during the 2006-2009 monitoring period; data indicates a slow decline in the groundwater level (Figure 134; Table 66).

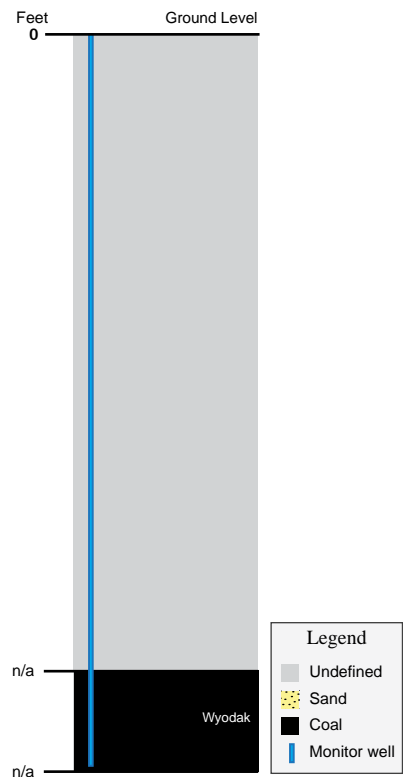


Figure 133. Section showing relative positions of coals and sands in feet. Not to scale.

Table 65. Table showing the depth to and thickness of monitored zones at the Amoco Sec 36 monitoring well site location. (measured in feet)

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

Table 66. Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2006	Drawdown 2006-2009	Total drawdown (ft.)	Depth to 12/31/09 water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wyodak coal	241.03	238.97	12.33	251.30	492.33	33	10/10/97

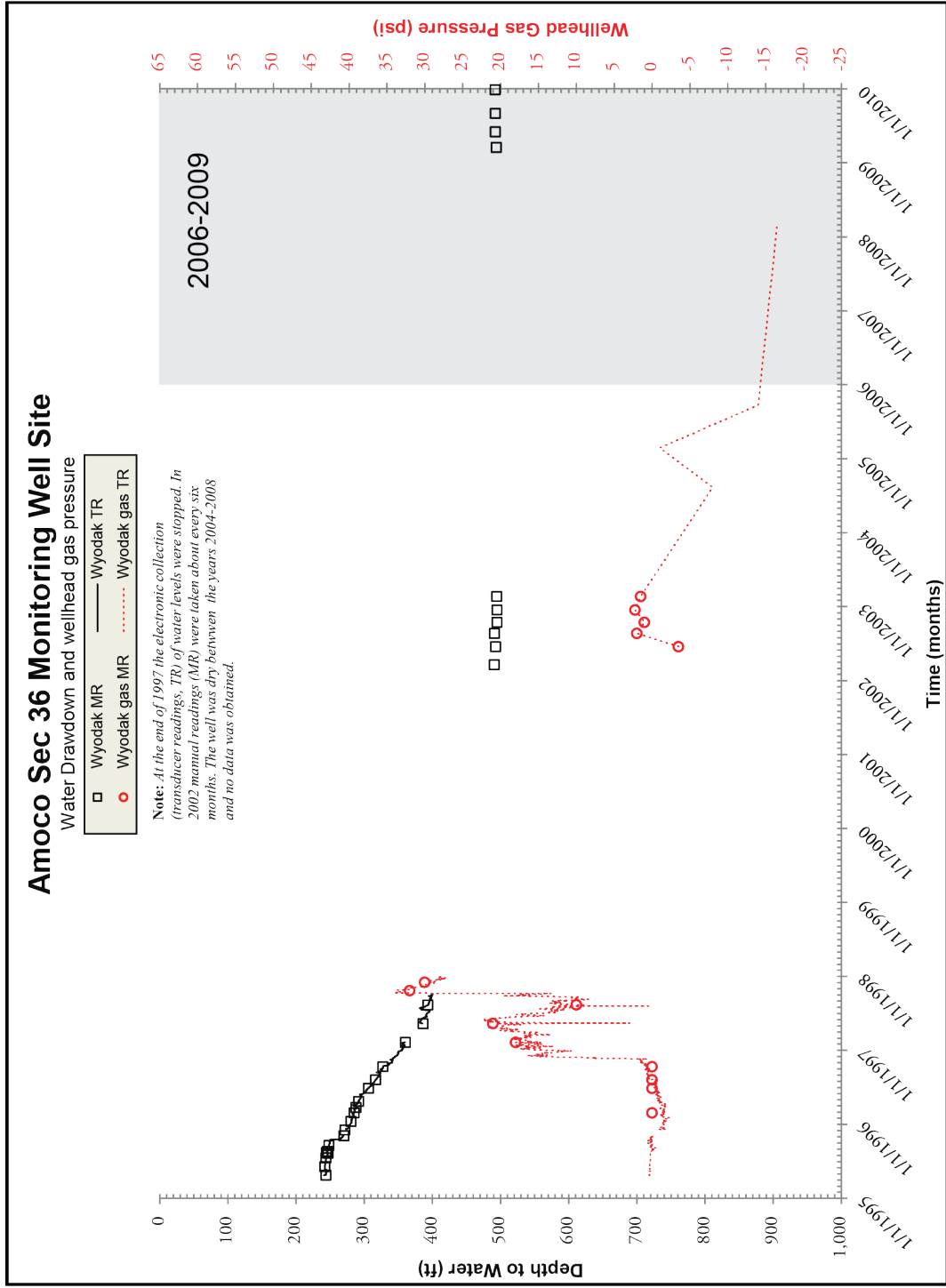


Figure 134. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Amoco Sec 36 monitoring well site location.

Production Statistics

Production data was analyzed for CBNG wells within the buffer of the Amoco Sec 36 monitoring well site from January 1997 to December 2009. Cumulative production for individual CBNG wells is displayed by location on Figure 135.

Water production peaked in 2000. Drawdown trends are missing from 2004-2008, as is ground-water monitoring data (Figure 136). The water/gas ratio of CBNG wells within the buffer is relatively inconsistent. Percent methane is variable.

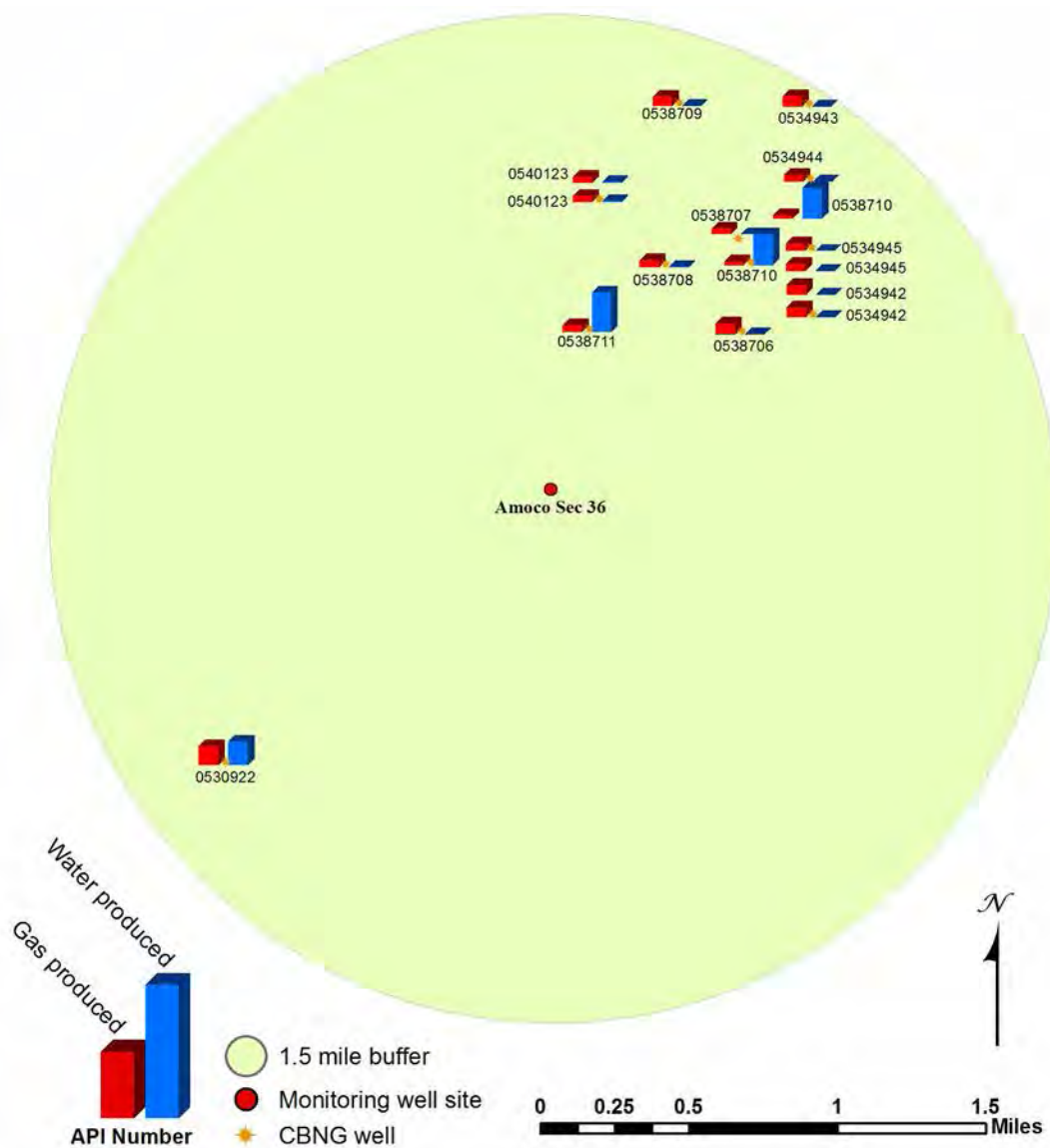


Figure 135. Amoco Sec 36 monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (Bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

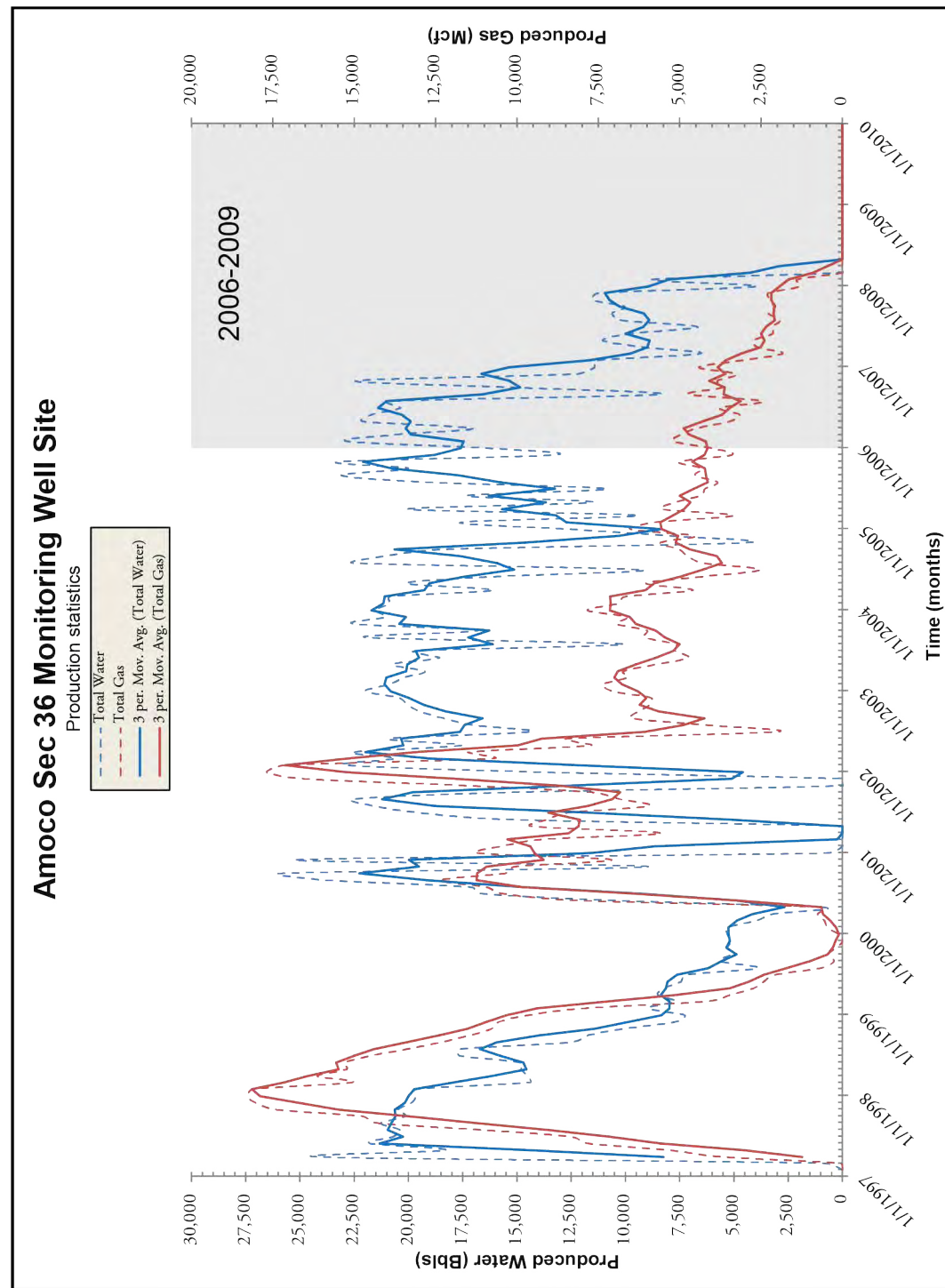


Figure 136. 3-period moving average along with water and gas production from associated CBNG wells.

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

Drawdown Information

The Bar 76 monitoring well site consists of one dual completion well, separated by a packer. This well is drilled into a Wasatch sandstone and the Wyodak coal (Figure 137; Table 67). Missing and/or fluctuating transducer data is the result of errors with on-site equipment.

The Wyodak coal recorded a groundwater drawdown of 23 feet during the 2006-2009 monitoring period; data shows a drawdown of approximately 35 feet after 2006 that began to increase late in 2009. Groundwater levels in the Wasatch sandstone declined by 51 feet during the 2006-2009 monitoring period (Figure 138; Table 68). Similar initial groundwater depth and equivalent drawdown trends indicate that the monitored Wasatch sandstone and the Wyodak coal may be hydraulically connected. Gas pressures in the Wyodak coal declined until late in 2007, after which they did not surpass levels possible from transducer error.

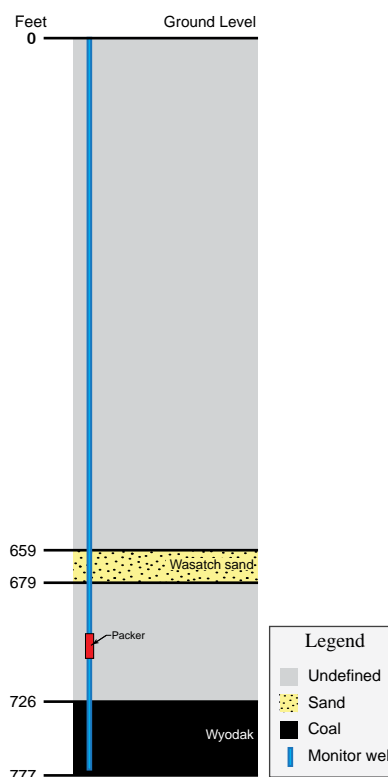


Figure 137. Section showing relative positions of coals and sands in feet. Not to scale.

Table 67. Table showing the depth to and thickness of monitored zones at the Bar 76 monitoring well site location. (measured in feet)

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

Table 68. Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2006	Drawdown 2006-2009	Total drawdown (ft.)	Depth to 12/31/09 water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	176.00	199.53	50.77	250.30	426.30	n/a	n/a
Wyodak coal	161.80	584.98	22.85	607.83	769.63	62.00	6/18/03

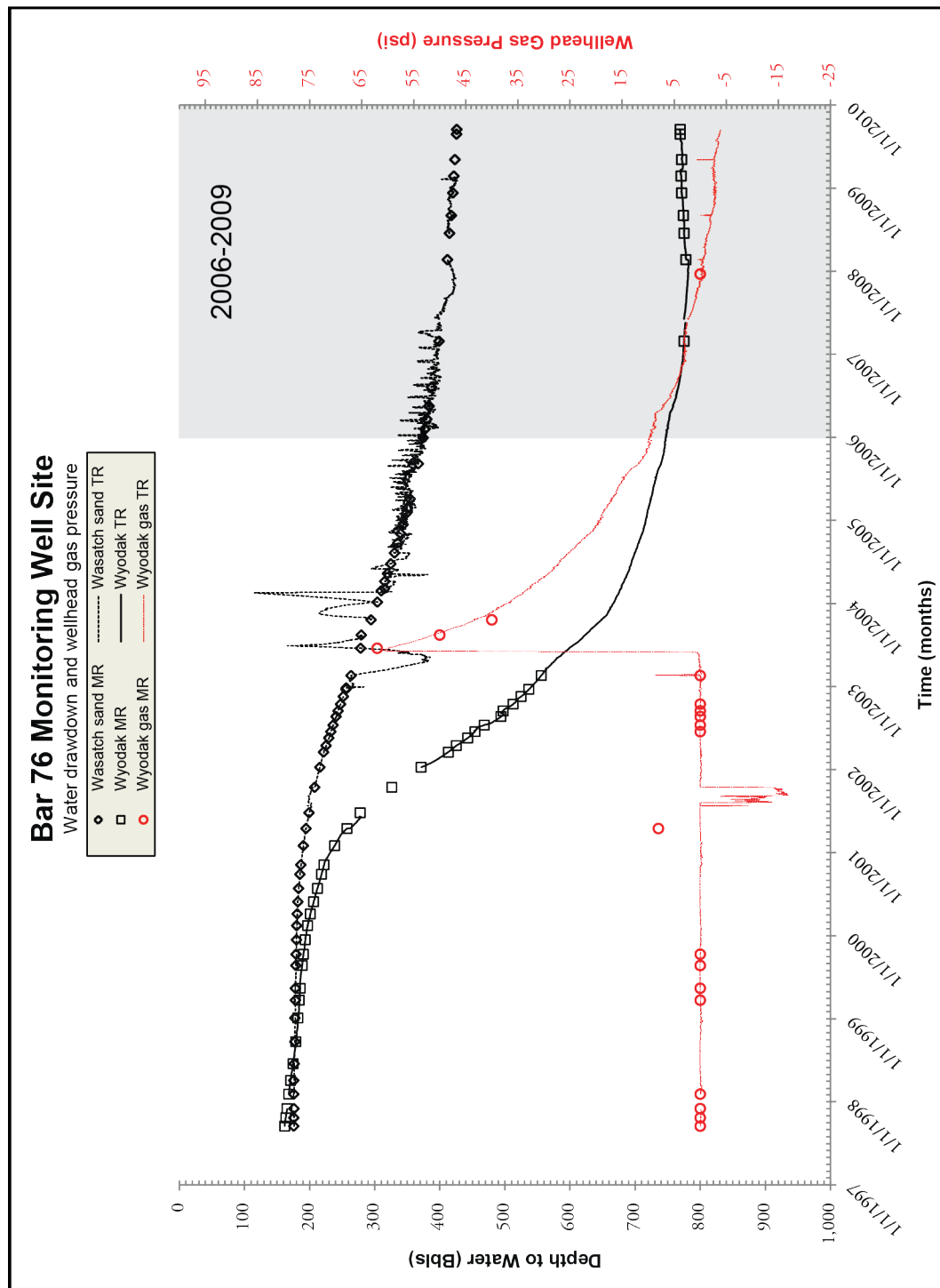


Figure 138. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Bar 76 monitoring well site location.

Production Statistics

Production data was analyzed for CBNG wells within the buffer of the Bar 76 monitoring well site from January 2001 through December 2009. Cumulative production for individual CBNG wells is displayed by location on Figure 139.

Water production peaked in 2002 which is consistent with groundwater drawdown trends from January 1998 to December 2009 in the Upper Wyodak coal zone (Figure 138). The water/gas ratio of CBNG wells within the buffer is relatively inconsistent. Percent methane is variable.

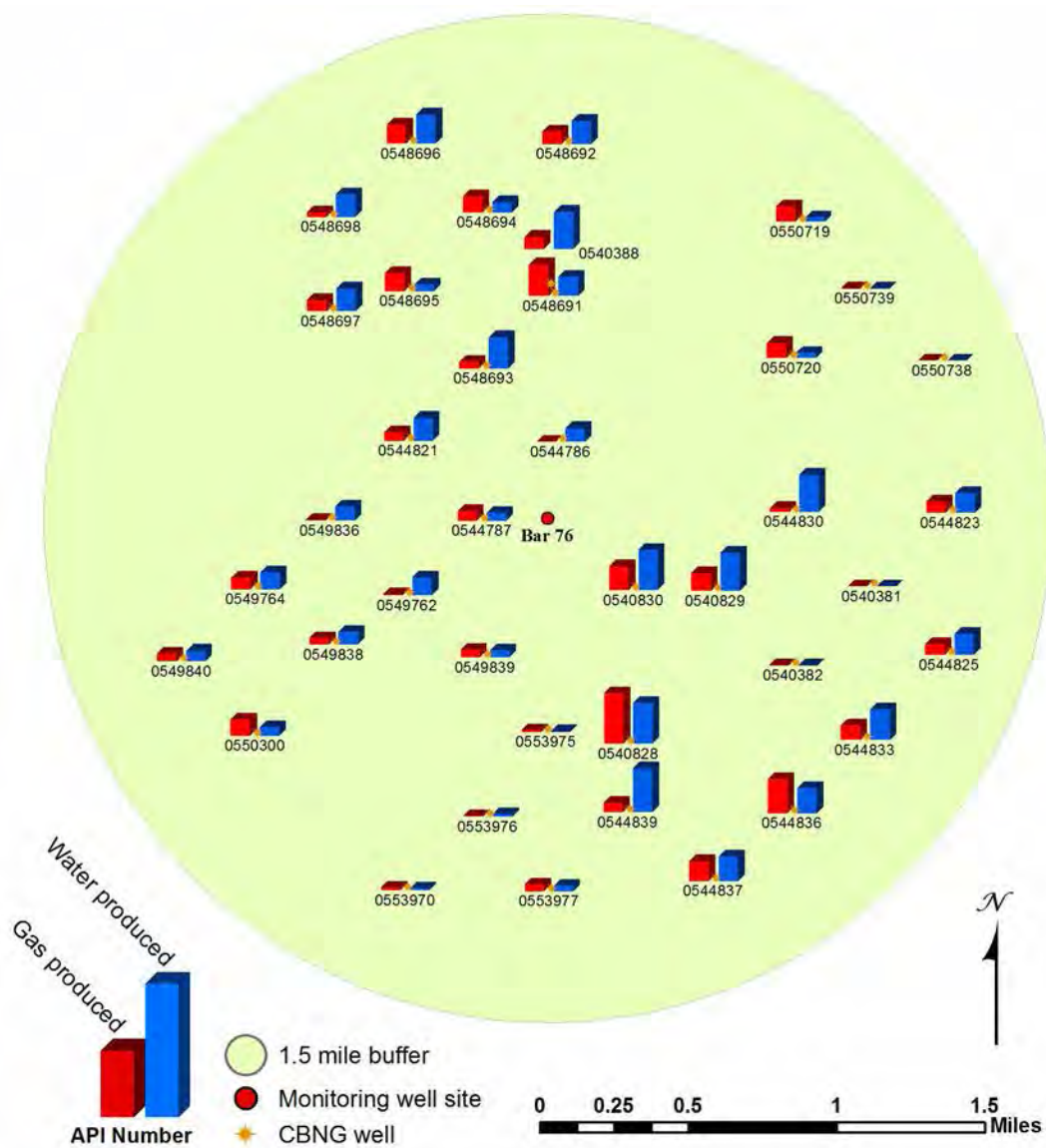


Figure 139. Bar 76 monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (Bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

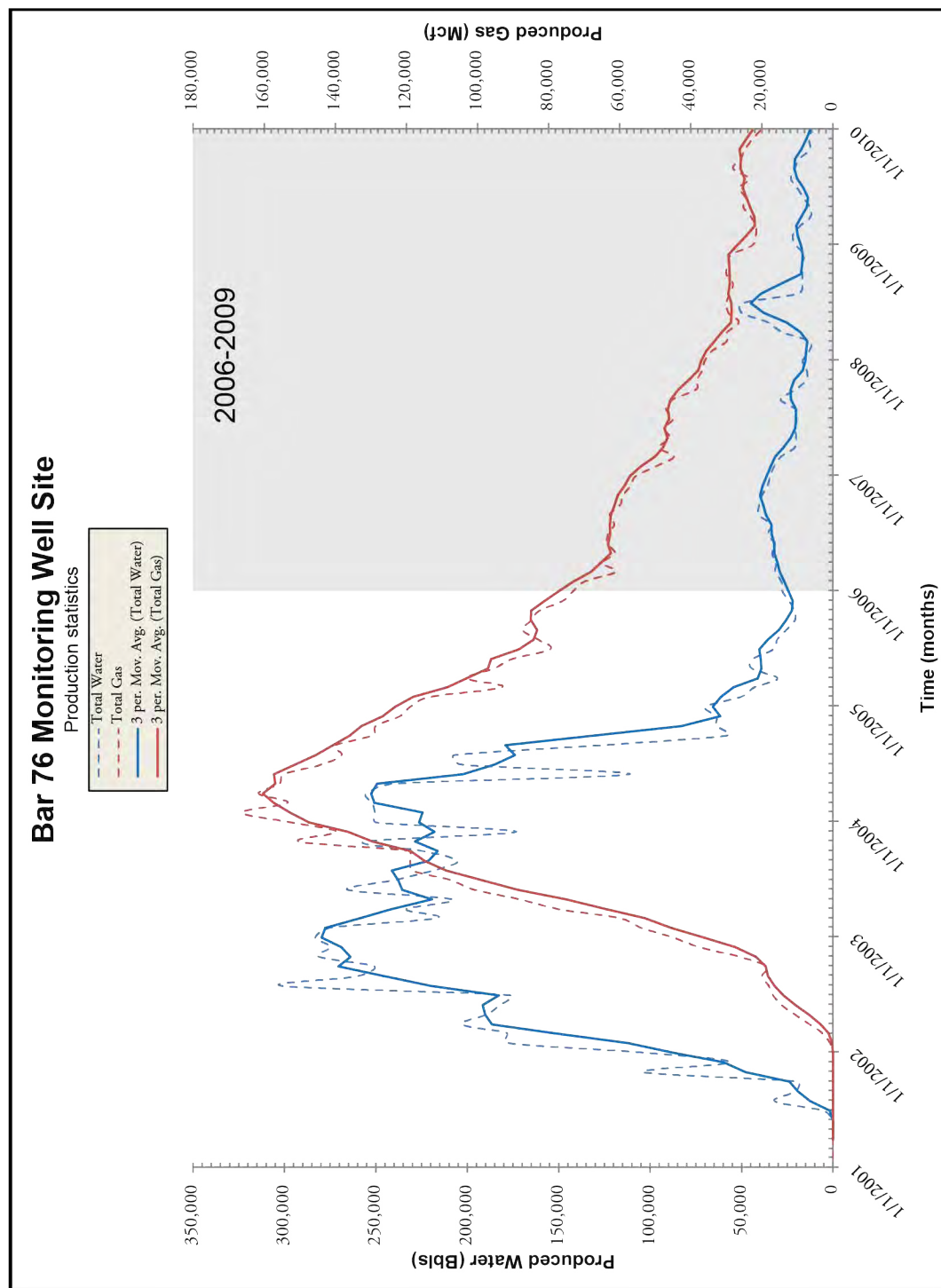


Figure 140. 3-period moving average along with water and gas production from associated CBNG well.

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 drilled into the Wyodak coal and the other is drilled into an overlying Wasatch sandstone (Figure 141; Table 69). Missing and/or fluctuating transducer data is the result of errors with on-site equipment.

The Wyodak coal recorded a groundwater drawdown of 63 feet during the 2006-2009 monitoring period; data indicates a steady decline in the groundwater level (Figure 142; Table 70). Groundwater levels in the Wasatch sandstone declined by 74 feet during the 2006-2009 monitoring period (Figure 142; Table 70). Equivalent drawdown trends indicate that the monitored Wasatch sandstone and the Wyodak coal may be hydraulically connected. Both transducer and manual recordings of Wyodak gas pressures fluctuated randomly between 2005 and 2009, after which they did not surpass levels possible from transducer error.

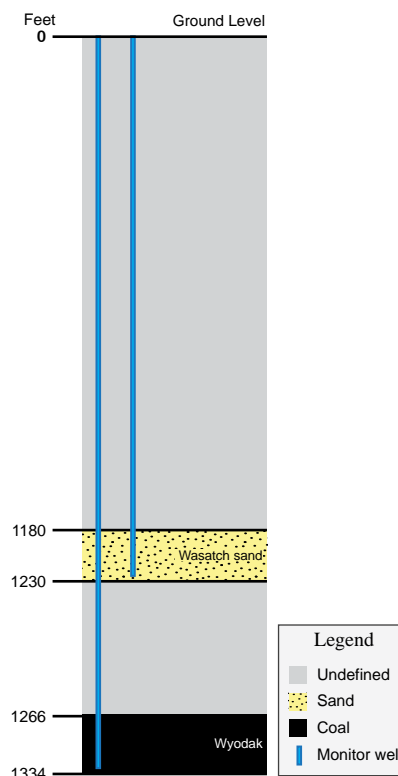


Figure 141. Section showing relative positions of coals and sands in feet. Not to scale.

Table 69. Table showing the depth to and thickness of monitored zones at the Barrett Persson monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Wasatch sand	1180	1230	50	36
Wyodak coal	1266	1334	68	n/a

Table 70. Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2006	Drawdown 2006-2009	Total drawdown (ft.)	Depth to 12/31/09 water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	507.76	231.30	74.00	305.30	813.06	n/a	n/a
Wyodak coal	826.27	144.23	62.80	207.03	1033.30	18.00	6/24/08

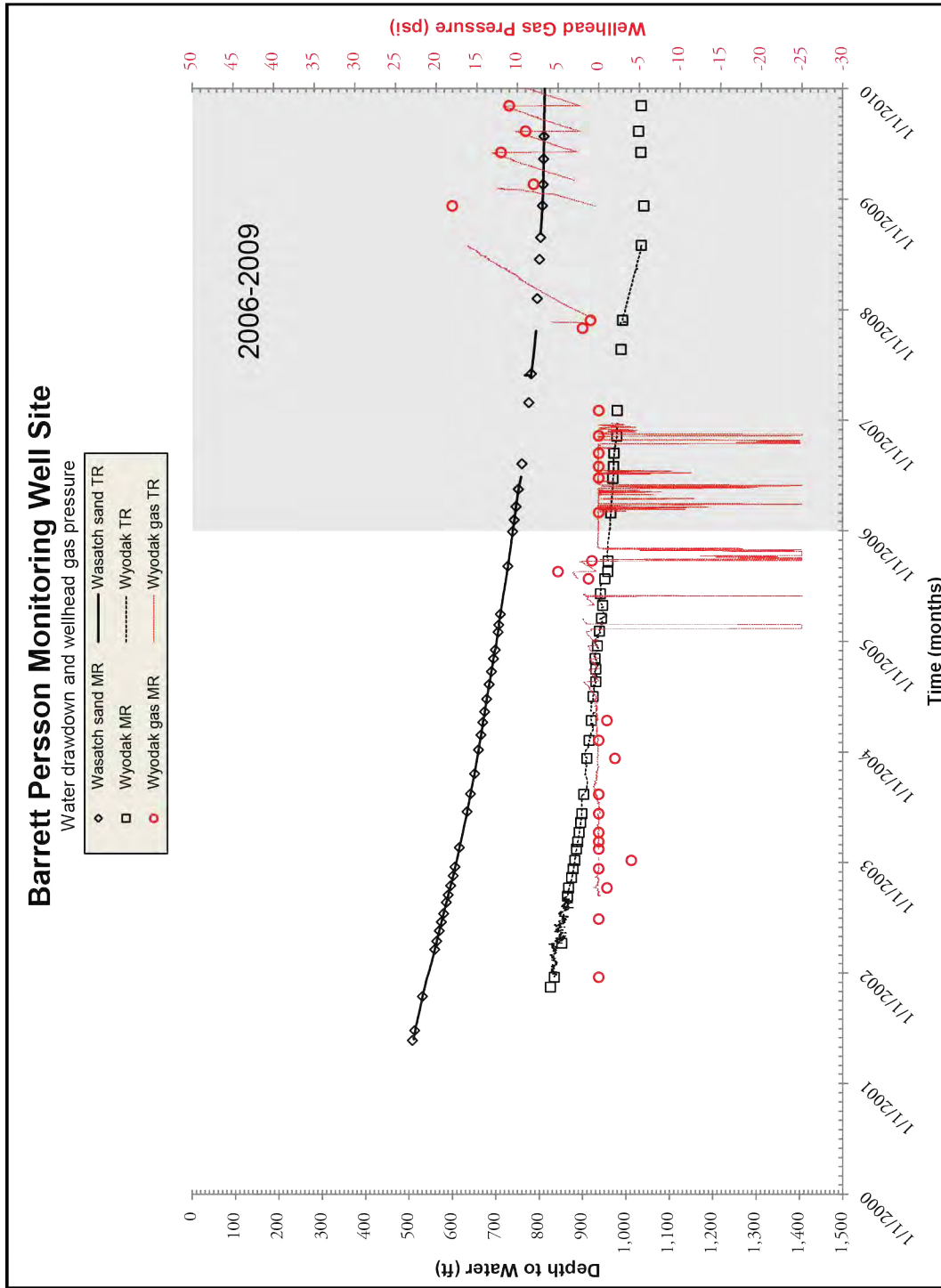


Figure 142. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Barrett Persson monitoring well site location.

Production Statistics

Production data was analyzed for CBNG well sites within the buffer of the Barrett Persson monitoring well site from January 1999 through December 2009. Cumulative production for individual CBNG wells is displayed by location on Figure 143.

Water production increased between late 2000 and 2003, which correlates to groundwater drawdown trends. Water and gas production declined during the 2006 to 2009 monitoring period (Figure 144). The water/gas ratio of CBNG wells within the buffer is relatively inconsistent. Percent methane is variable.

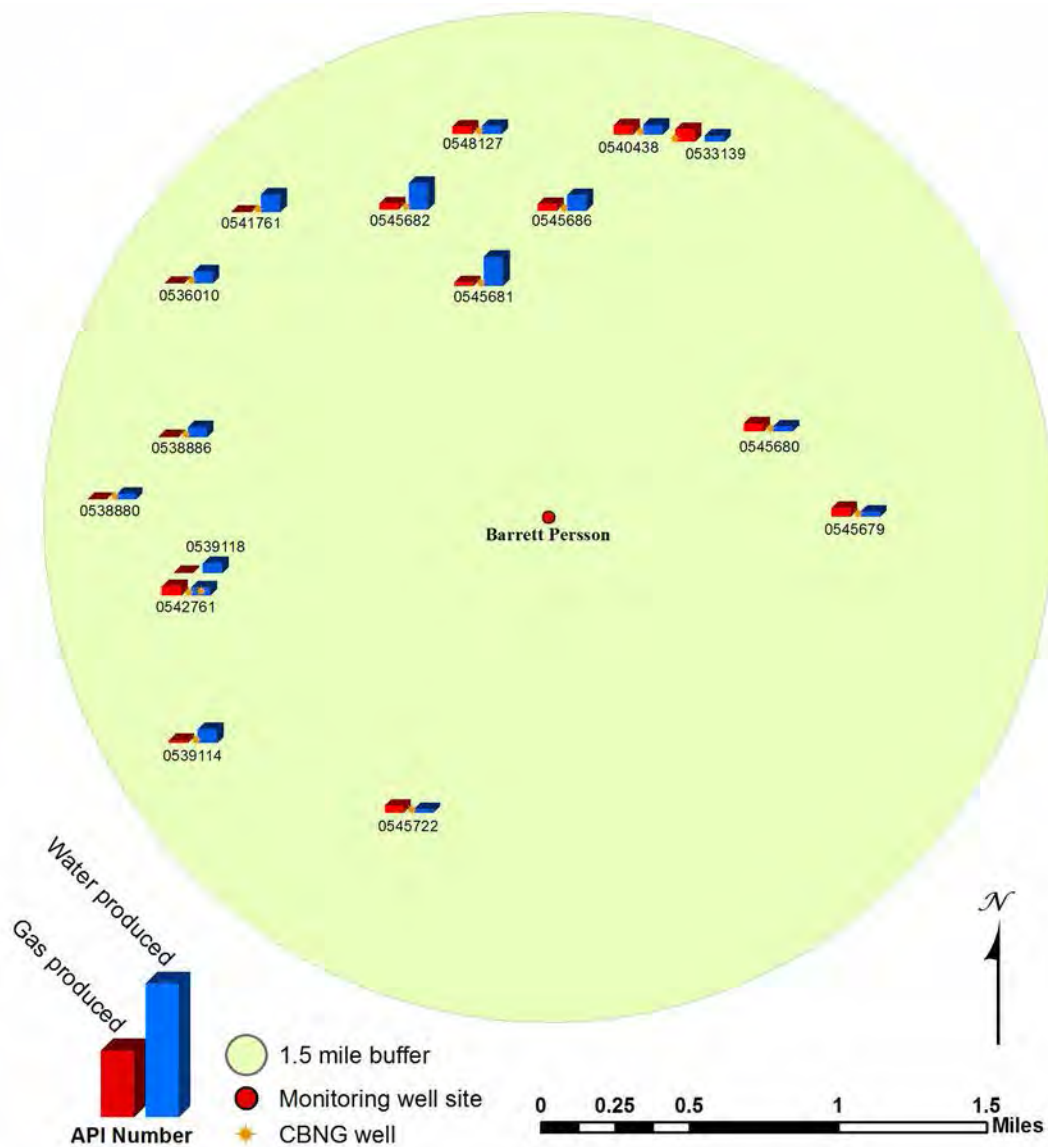


Figure 143. Barrett Persson monitoring well and associated CBNG wells within 1.5 mile buffer showing cumulative water (Bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

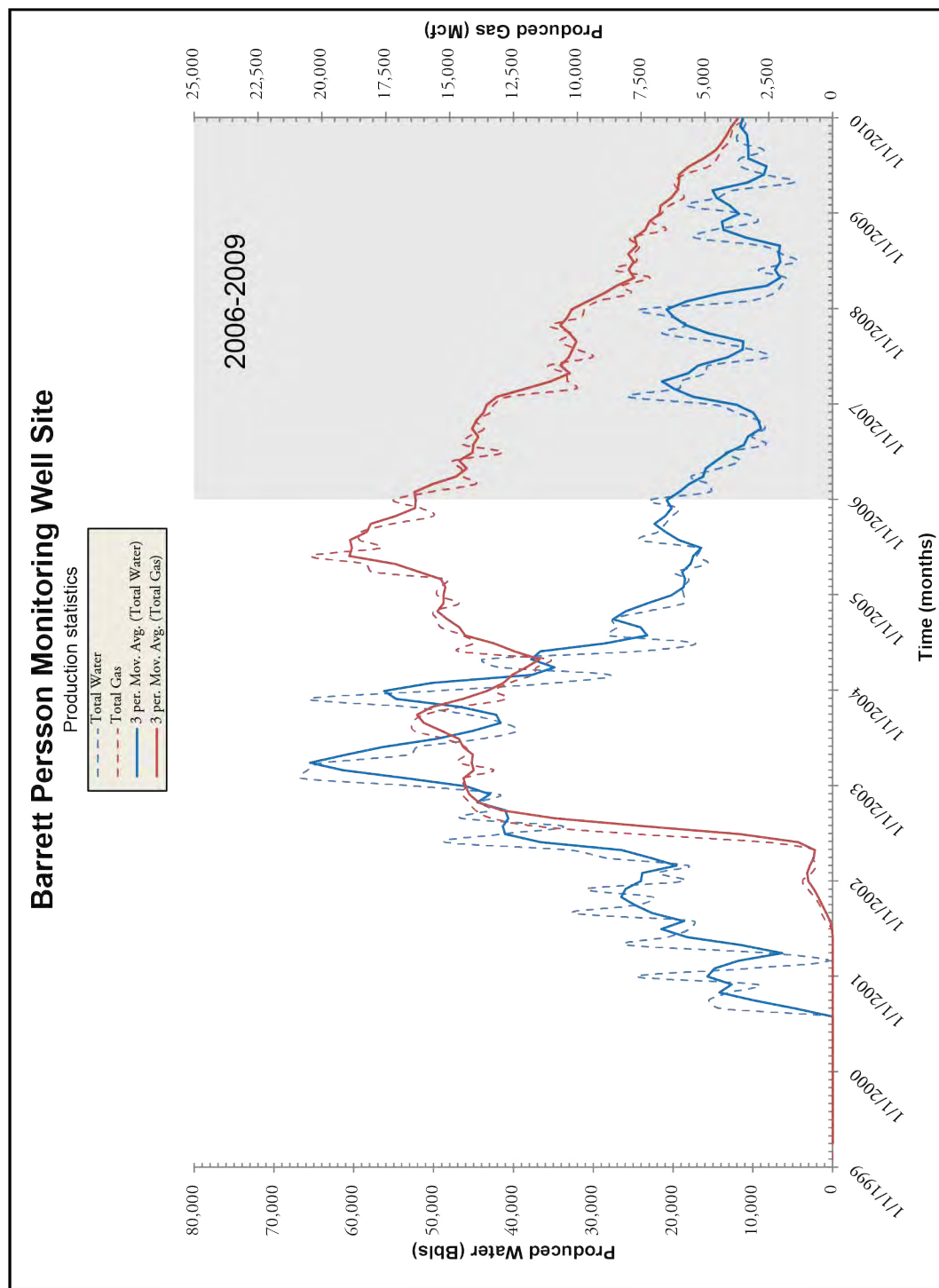


Figure 144. 3-period moving average along with water and gas production from associated CBNG wells.

Blackbird Coleman Monitoring Well Site
Location: S5 T47N R74W
Date First Monitored: July 12, 2002

Drawdown Information

The Blackbird Coleman monitoring well site includes two wells. One is drilled into the Wyodak coal, and one into the overlying Wasatch sandstone (Figure 145; Table 71). Missing and/or fluctuating transducer data is the result of errors with on-site equipment.

The Wyodak coal recorded a groundwater draw-down of 64 feet during the 2006-2009 monitoring period; data shows a steady groundwater decline between 2002 through 2009 (Figure 146; Table 72). Groundwater levels for the monitored sandstone was stable during the 2006-2009 monitoring period, as it has been for the life of the well (Figure 146; Table 72). This, along with variable initial water levels, indicates there is no hydraulic connection between the monitored Wasatch sandstone and producing zone. Gas pressure readings did not surpass levels possible from transducer error.

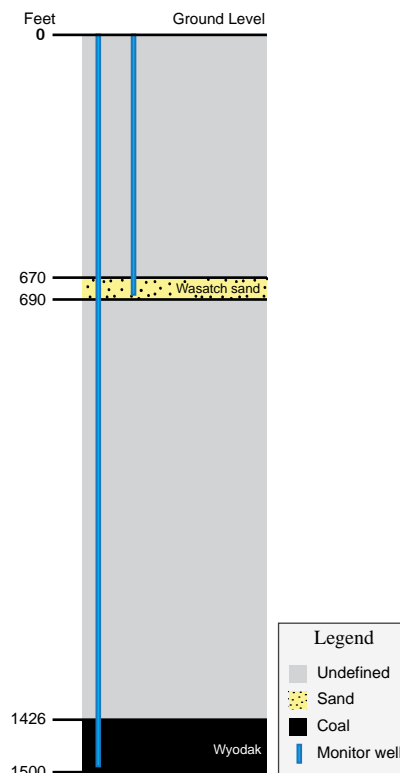


Figure 145. Section showing relative positions of coals and sands in feet. Not to scale.

Table 71. Table showing the depth to and thickness of monitored zones at the Blackbird Coleman monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Wasatch sand	670	690	20	736
Wyodak coal	1426	1500	74	n/a

Table 72. Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2006	Drawdown 2006-2009	Total drawdown (ft.)	Depth to 12/31/09 water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	250.88	-0.18	1.03	0.85	251.73	n/a	n/a
Wyodak coal	370.88	58.92	64.38	123.30	494.18	n/a	n/a

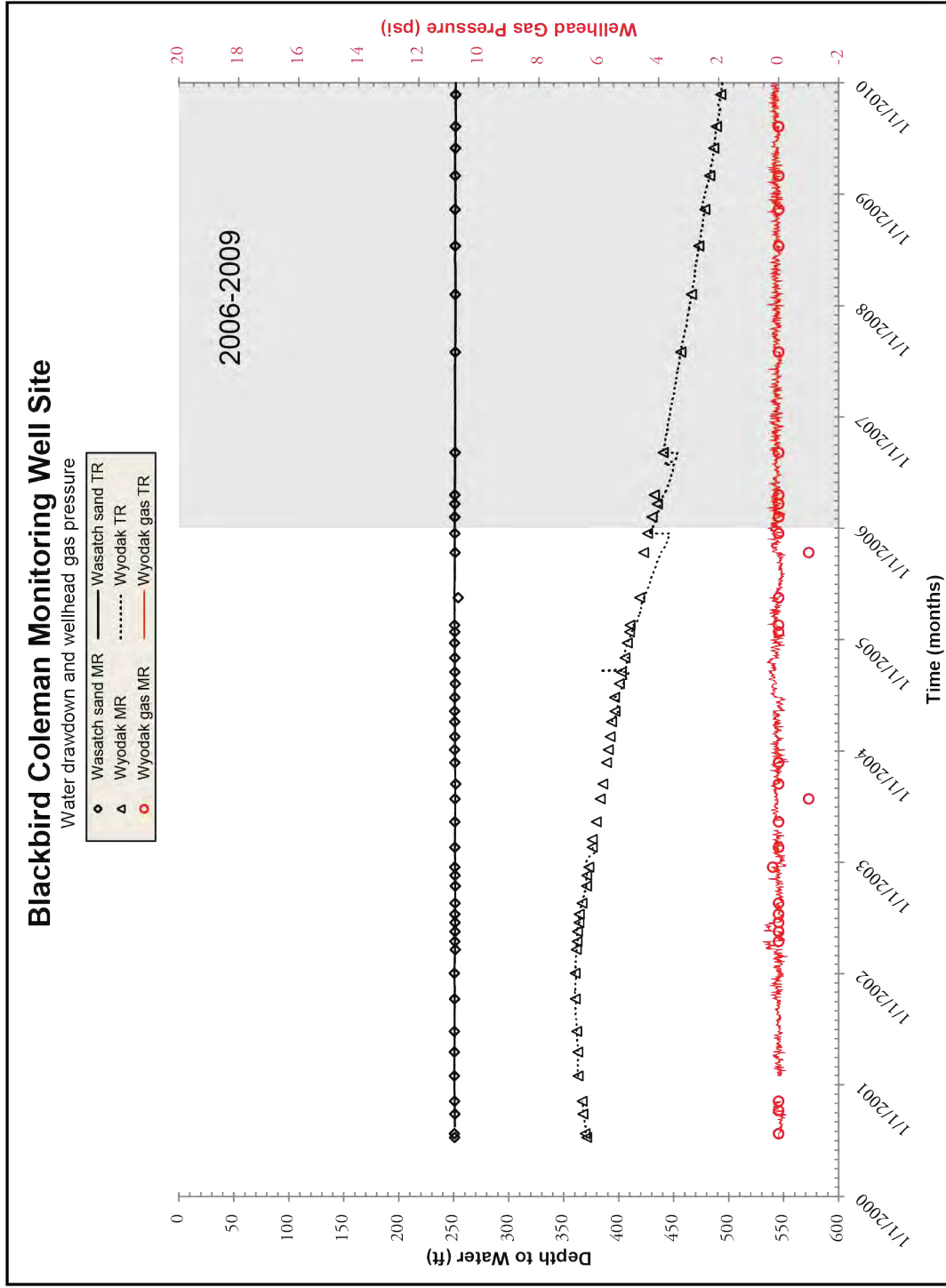


Figure 146. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Blackbird Coleman monitoring well site location. Gray area represents the current monitoring period of 2006-2009.

Production Statistics

Production data for the Blackbird Coleman monitoring site was not reported due to incomplete or completion data for local CBNG wells. The incomplete data will be addressed in the next update.

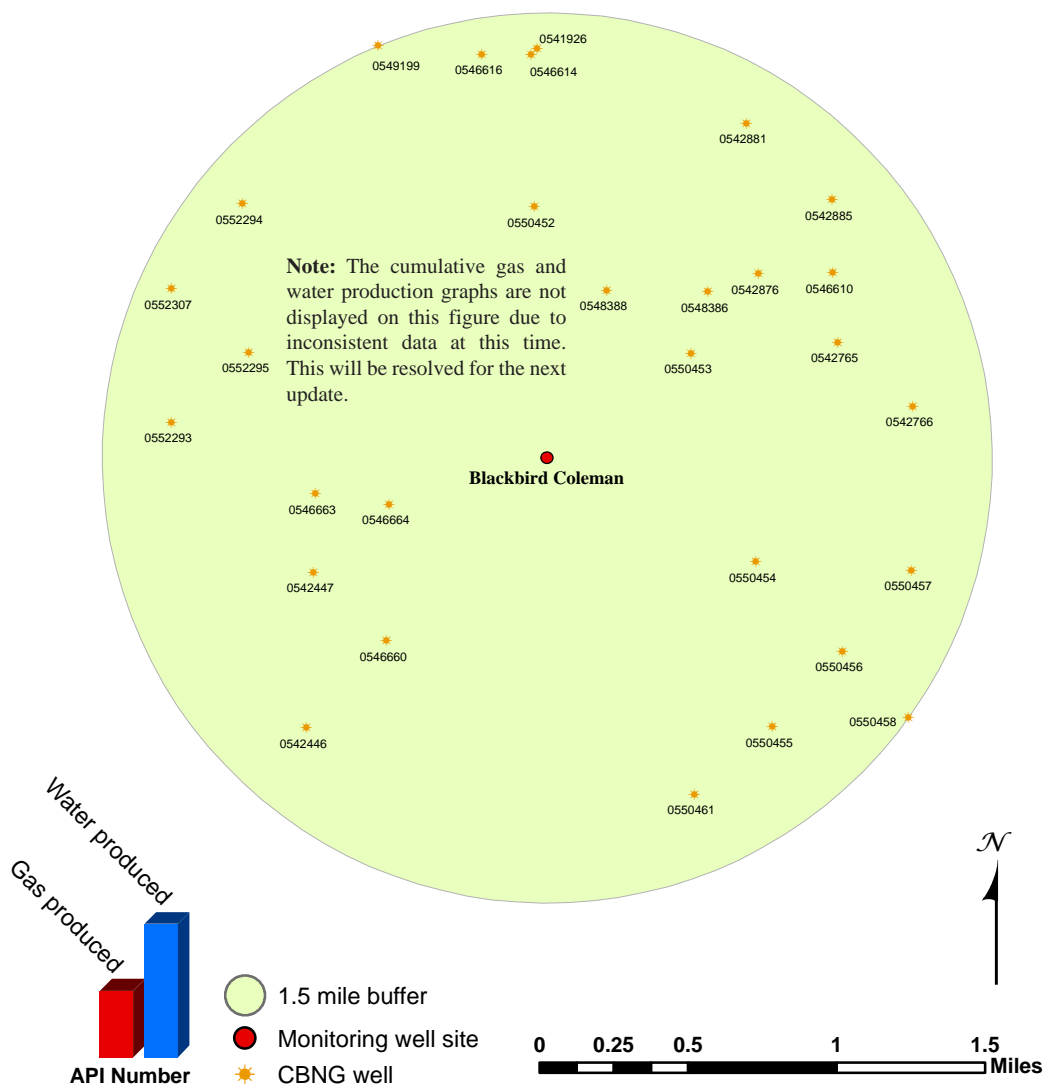


Figure 147. Blackbird Coleman monitoring well and associated CBNG wells within 1.5 mile buffer showing cumulative water (Bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

Bowers Monitoring Well Site
Location: S36 T42N R72W
Date First Monitored: January 21, 1998

Drawdown Information

The Bowers monitoring well site consists of five wells. One is completed into the Wyodak coal while the other four wells are completed into overburden Wasatch sandstones. These four sandstones are labeled Wasatch sand, Shallow sand, Very shallow sand, and Very very shallow sand (Figure 148; Table 73). Missing and/or fluctuating transducer data is the result of errors with on-site equipment.

The Wyodak coal recorded a drawdown of 289 feet from 1997-2005. Due to the fact the Wyodak well was returned to the operator in 2005 and converted to a producing gas well, no measurements were recorded during the 2006-2009 monitoring period. Groundwater levels for all of the sandstone wells were stable during the 2006-2009 monitoring period, as they have been for the life of the wells (Figure 149; Table 74). This, along with variable initial water levels, indicates there is no hydraulic connection between the monitored sands and the Wyodak coal. The maximum gas pressure for the Wyodak coal was recorded in 2002 with no measurements taken in the 2006-2009 monitoring period because the coal well was returned to the operator. The sand wells are open casing wells with no gas pressure restriction to monitor pressures in these four wells.

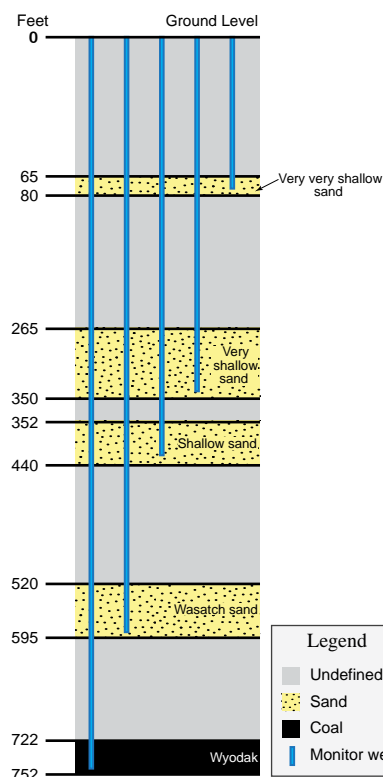


Figure 148. Section showing relative positions of coals and sands in feet. Not to scale.

Table 73. Table showing the depth to and thickness of monitored zones at the Bowers monitoring well site location. (measured in feet)

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

Table 74. Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2006	Drawdown 2006-2009	Total drawdown (ft.)	Depth to 12/31/09 water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Very very shallow sand	60.17	-1.14	0.55	-0.59	59.58	n/a	n/a
Very shallow sand	256.54	-0.22	-0.54	-0.76	255.78	n/a	n/a
Shallow sand	301.01	0.40	-0.56	-0.16	300.85	n/a	n/a
Wasatch sand	334.57	-0.45	3.75	3.30	337.87	n/a	n/a
Wyodak coal ⁽¹⁾	419.85	288.65	n/a	288.65	n/a	40	8/23/02

(1) Monitoring of the Wyodak coal well stopped in 2005 when the well was returned to the operator and converted to a producing gas well.

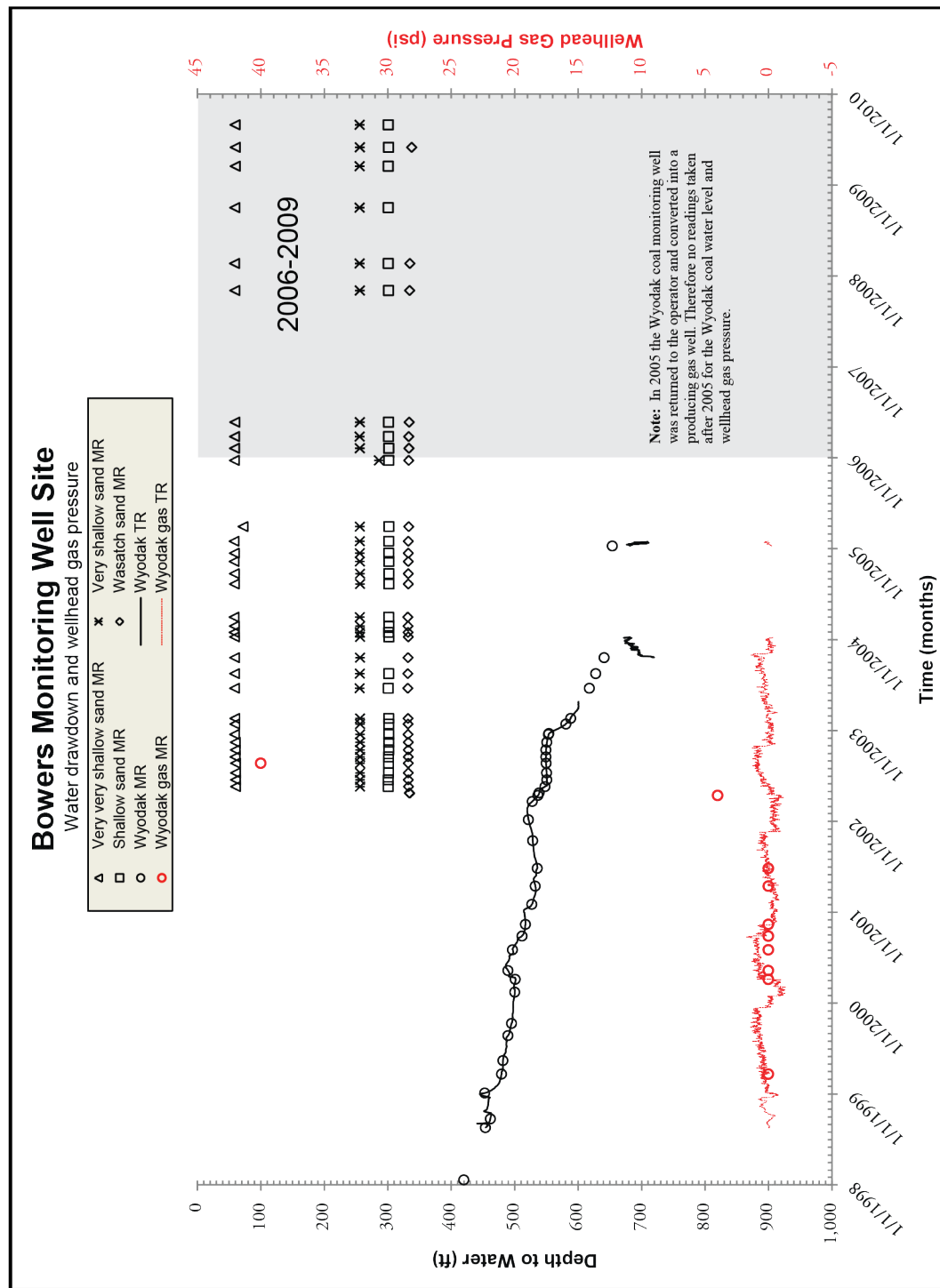


Figure 149. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Bowers monitoring well site location.

Production Statistics

Production data was analyzed for CBNG wells within the buffer of the Bowers monitoring well site from January 1999 through December 2009. Cumulative production for individual CBNG wells is displayed by location on Figure 150.

and drawdown in 2002 (Figure 151). However, the 2006 to 2009 monitoring period is missing groundwater level data. The water/gas ratio of CBNG wells within the buffer is relatively inconsistent. Percent methane is minimal during the monitored period.

Early water production correlates to groundwater drawdown trends, particularly increased production

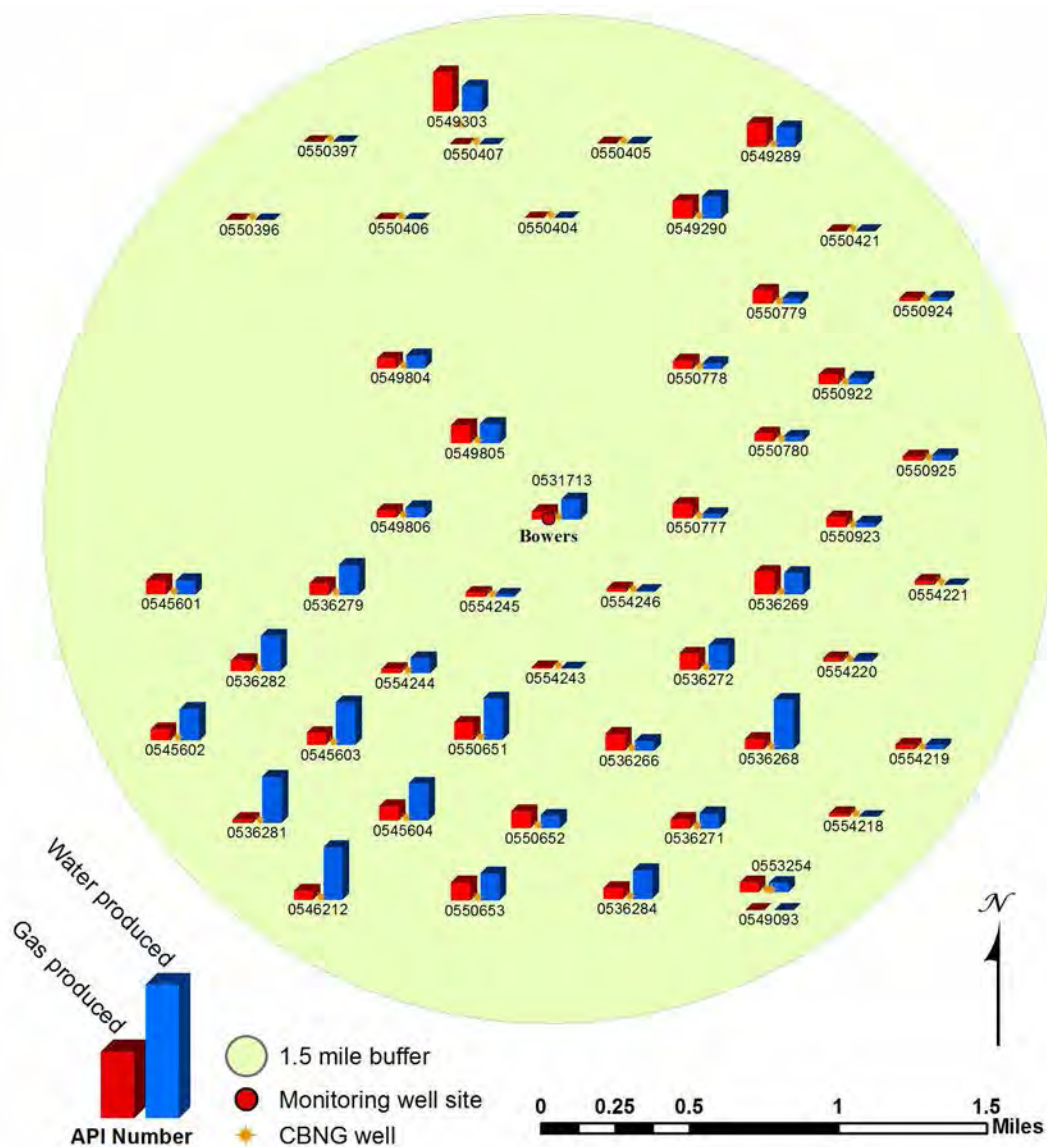


Figure 150. Bowers monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (Bbls) and gas (Mcf) production. The seven digit number below the well point corresponds to the American Petroleum Institute (API) well number.

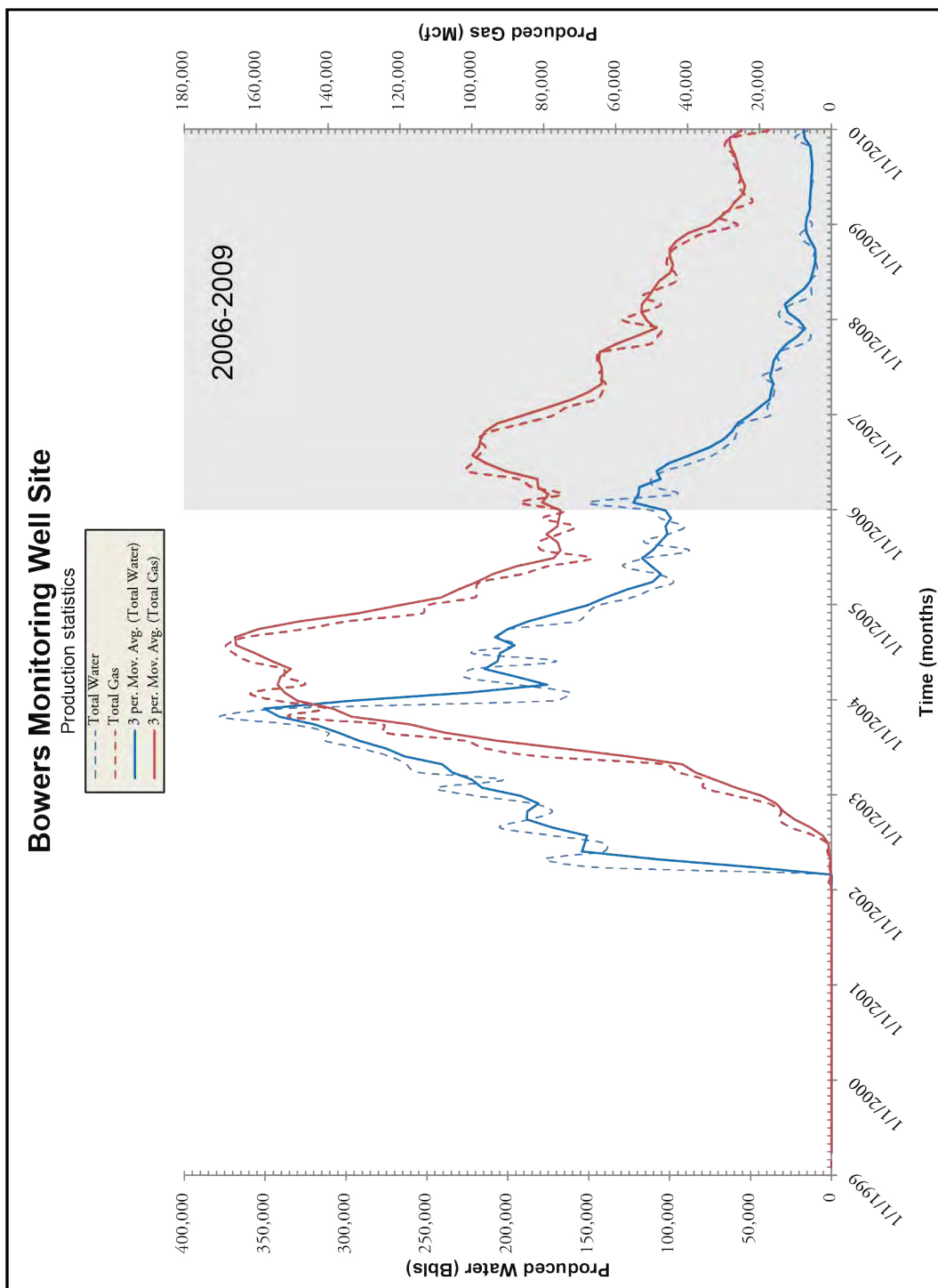


Figure 151. 3-period moving average along with water and gas production from associated CBNG wells.

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. One is drilled into the Anderson coal and the other two are drilled in overlying Wasatch sandstones (Figure 152; Table 75). Missing and/or fluctuating transducer data is the result of errors with on-site equipment.

The Anderson coal recorded a groundwater drawdown of 24 feet during the 2006-2009 monitoring period; data shows a steady increase in groundwater levels beginning in mid-2009 after reaching a total drawdown level of 317 feet below ground level on June 6, 2009. Groundwater levels in the Anderson coal have therefore recovered approximately 70 percent of original levels. Groundwater levels in the Wasatch sandstone declined by 39 feet during the 2006-2009 monitoring period (Figure 153; Table 76). Drawdown trends suggest that the monitored Wasatch sandstone may be hydraulically connected to the Anderson Coal. Groundwater levels in the shallow sandstone were stable during the 2006-2009 monitoring period, as they have been for the life of the well (Figure 153; Table 76). Gas pressures in the Anderson fluctuated throughout the monitoring period, with some small peaks that correlated with transducer spikes.

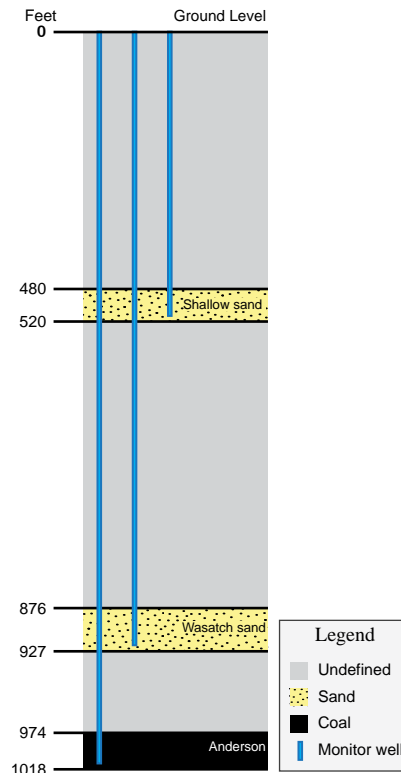


Figure 152. Section showing relative positions of coals and sands in feet. Not to scale.

Table 75. Table showing the depth to and thickness of monitored zones at the Bull Creek monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Shallow sand	480	520	40	454
Wasatch sand	876	927	51	47
Anderson	974	1018	44	n/a

Table 76. Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2006	Drawdown 2006-2009	Total drawdown (ft.)	Depth to 12/31/09 water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Shallow sand ⁽¹⁾	0.00	n/a	n/a	n/a	0.00	n/a	n/a
Wasatch sand	91.86	-0.22	39.45	39.23	131.09	n/a	n/a
Anderson	215.00	-0.50	23.99	23.49	238.49	3	10/5/07

⁽¹⁾ This is an artesian well so the water level is at the top of the well casing.

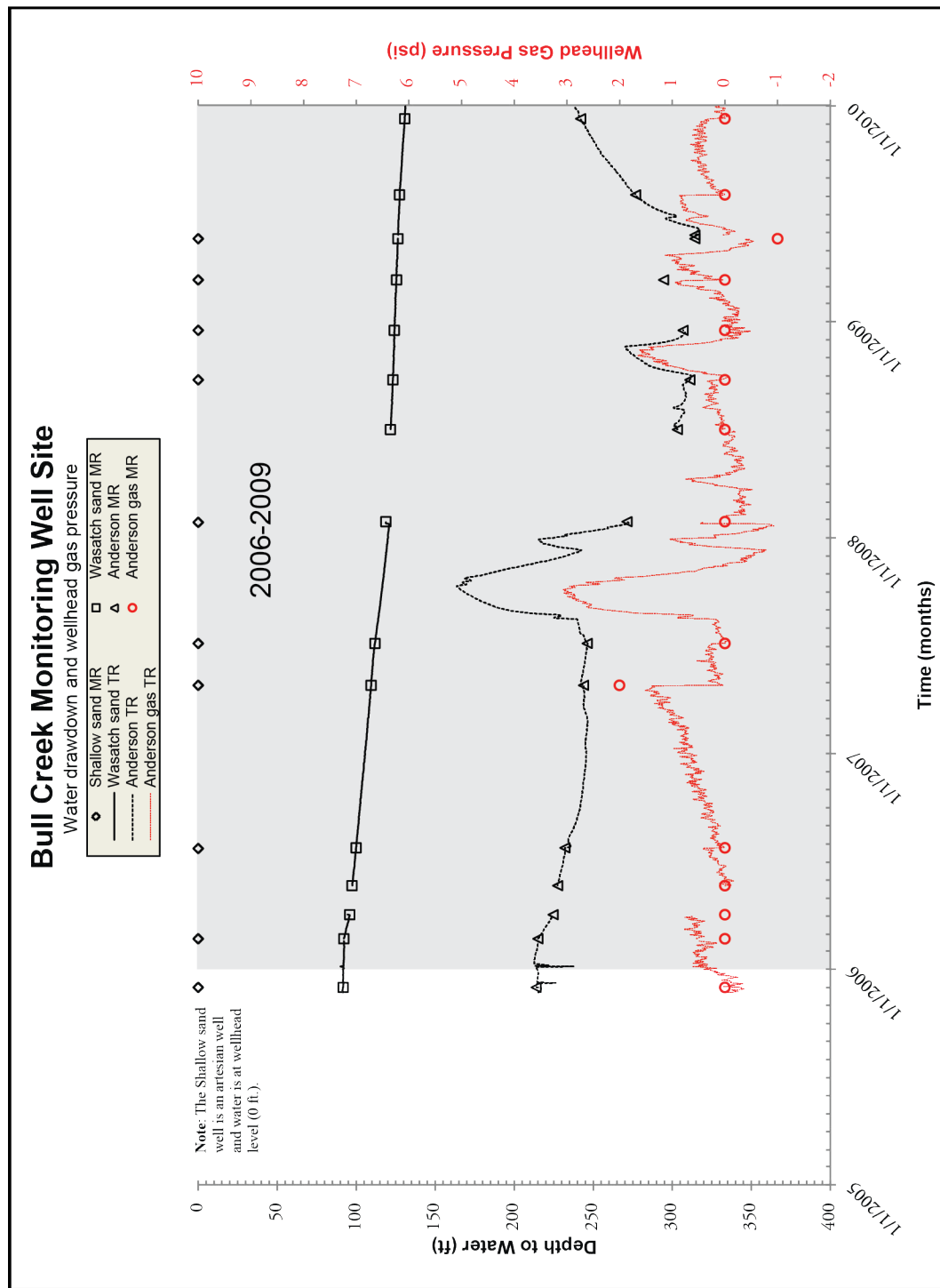


Figure 153. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Bull Creek monitoring well site location. Gray area represents the current monitoring period of 2006-2009.

Production Statistics

Production data was analyzed for CBNG wells within the buffer of the Bull Creek monitoring well site from January 2003 through December 2009. Cumulative production for individual CBNG wells is displayed by location on Figure 154.

Water production was steady from 2004 through mid-2008, at which time it increased. Groundwa-

ter drawdown trends steadily declined, and then recharged in 2009. This trend generally correlates with production data, as relatively little water was produced in the second half of 2009. Gas production increased during the 2006 to 2009 monitoring period, though production mostly ceased in the second half of 2009 (Figure 155). The water/gas ratio of CBNG wells within the buffer is relatively inconsistent. Percent methane is variable.

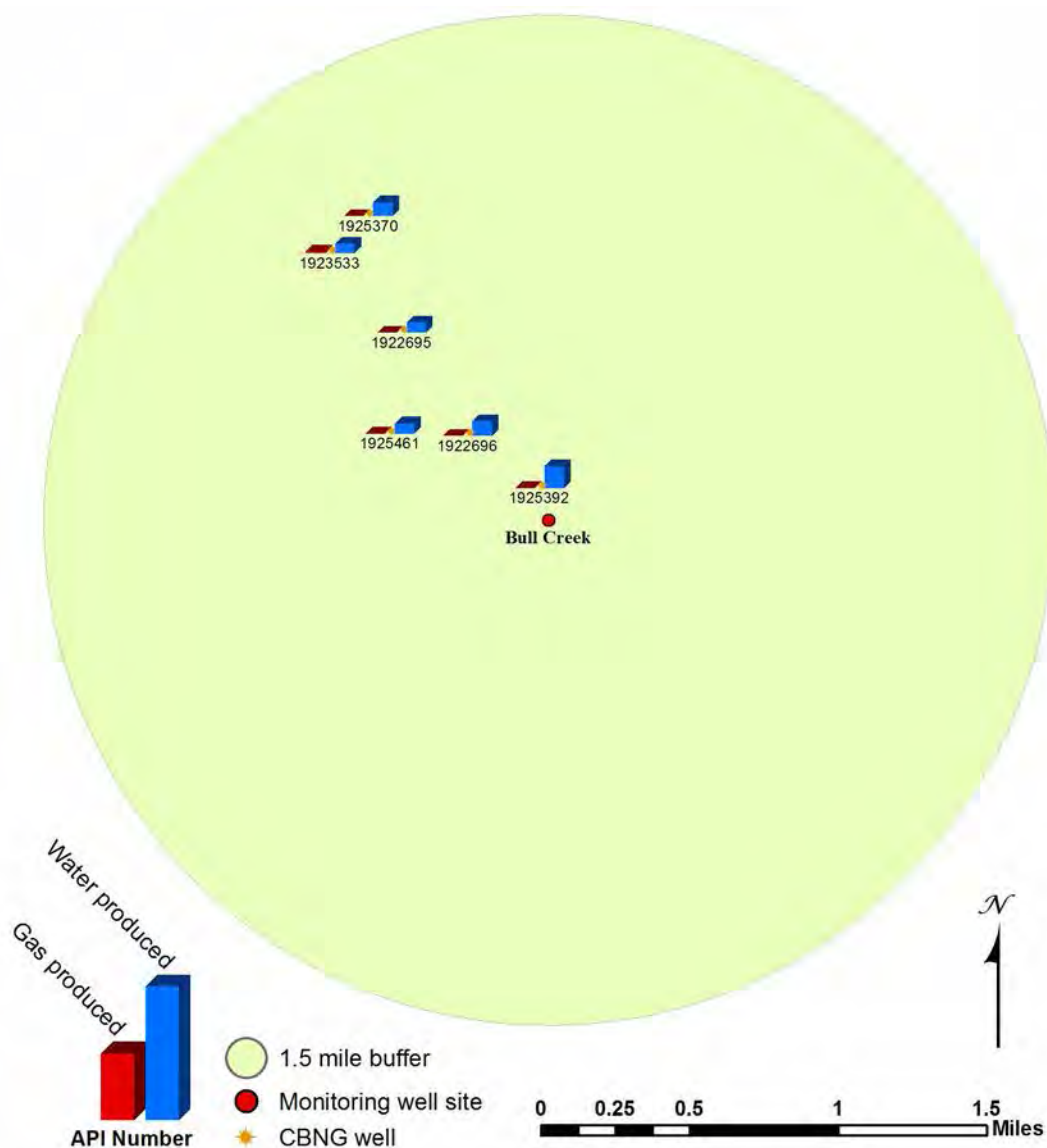


Figure 154. Bull Creek monitoring well and associated CBNG wells within 1.5 mile buffer showing cumulative water (Bbls) and gas (Mcf) production. The seven digit number below the well point corresponds to the American Petroleum Institute (API) well number.

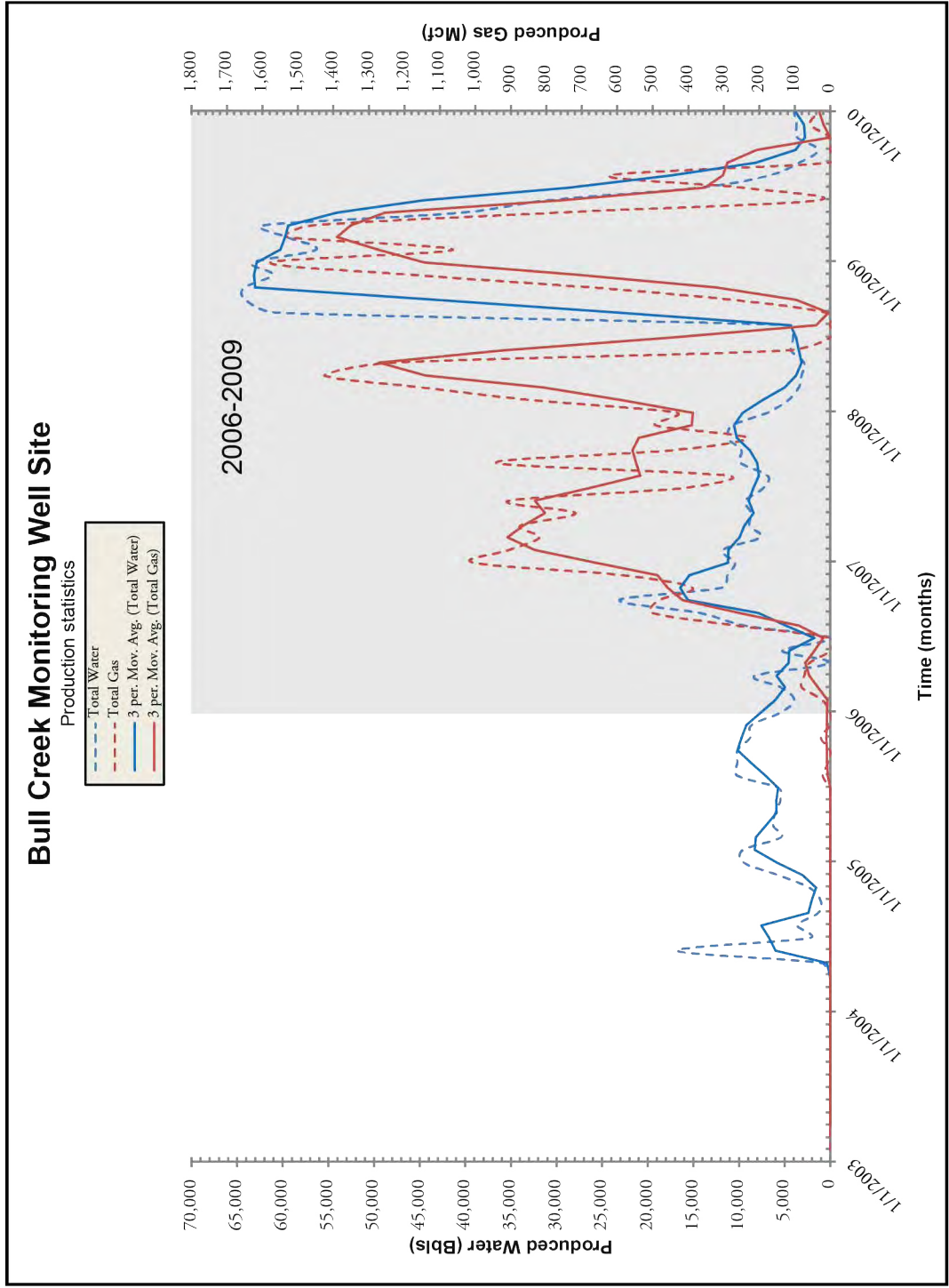


Figure 155. 3-period moving average along with water and gas production from associated CBNG wells.

Dilts Monitoring Well Site
Location: S31 T43N R71W
Date First Monitored: March 24, 1999

Drawdown Information

The Dilts monitoring well site consists of two wells. One well is completed into the Wyodak coal, while the second is completed into an overlying Wasatch sandstone (Figure 156; Table 77). Missing and/or fluctuating transducer data is the result of errors with on-site equipment.

The Wyodak coal well was dry to a total depth of 658 feet during the 2006-2009 monitoring period. Previously high gas pressures in the well restricted manual and transducer readings. Groundwater levels in the Wasatch sandstone declined by 4 feet during the 2006-2009 monitoring period, the levels have remained nearly constant throughout the life of the well (Figure 157; Table 78). This indicates there is no hydraulic connection between the monitored Wasatch sandstone and Wyodak coal. Two manual gas pressure measurements were taken during the 2006-2009 monitoring period and did record some gas in the system.

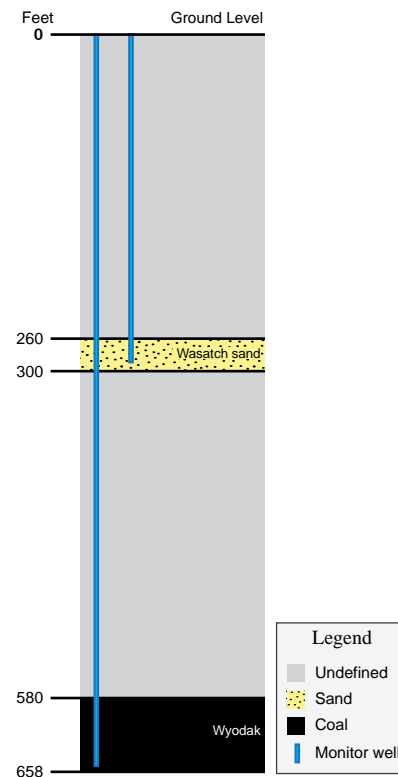


Figure 156. Section showing relative positions of coals and sands in feet. Not to scale.

Table 77. Table showing the depth to and thickness of monitored zones at the Dilts monitoring well site location. (measured in feet)

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

Table 78. Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2006	Drawdown 2006-2009	Total drawdown (ft.)	Depth to 12/31/09 water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	119.80	1.17	4.13	5.30	125.10	n/a	n/a
Wyodak coal ⁽¹⁾	340.60	261.40	56.00	317.40	658.00	90.00	11/23/03

⁽¹⁾ The Wyodak coal well was recorded as a dry well at 658.00 feet during the 2006-2009 monitoring period.

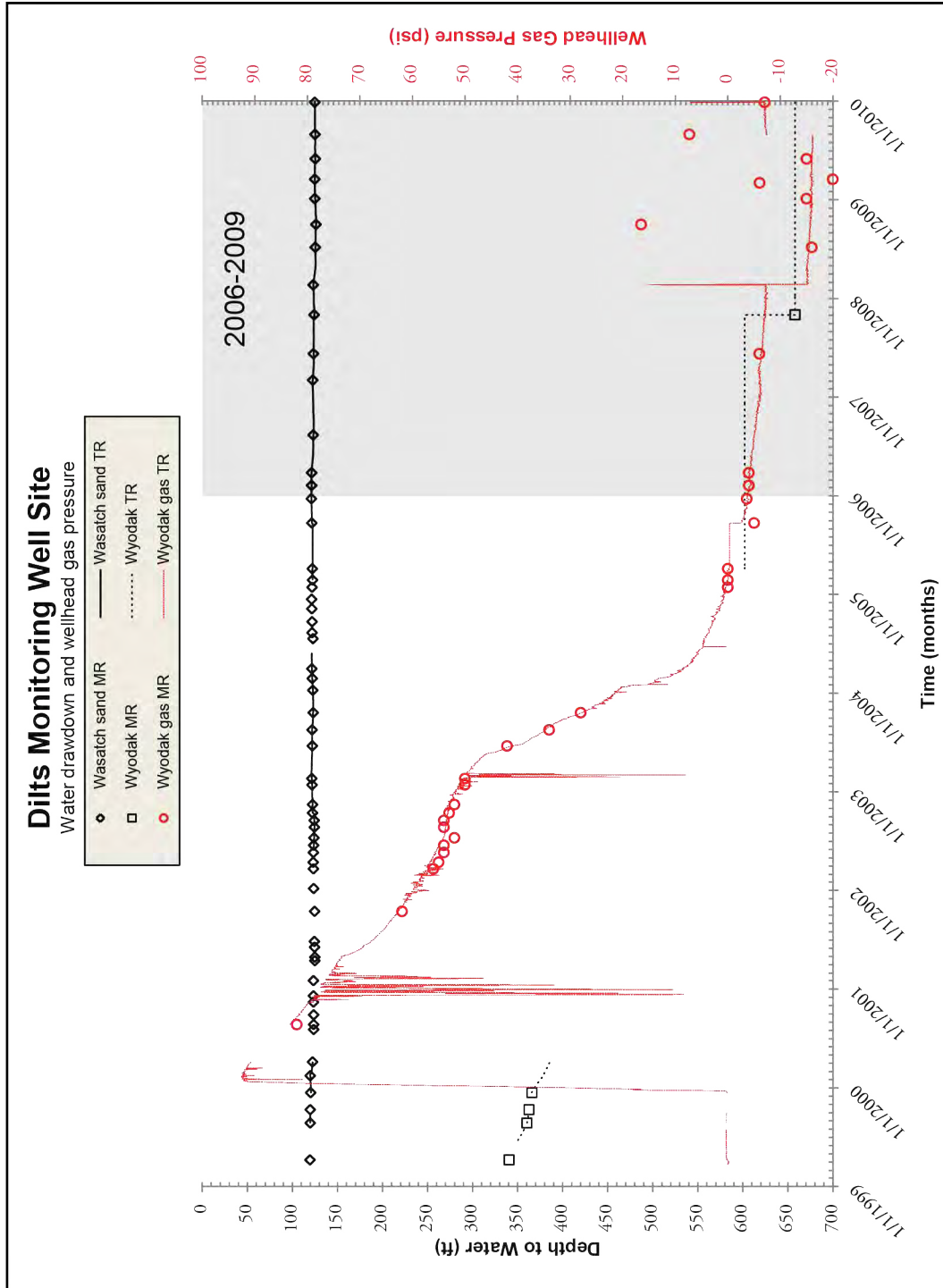


Figure 157. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Dils monitoring well site location.

Production Statistics

Production data was analyzed for CBNG wells within the buffer of the Dilts monitoring well site from January 2001 through December 2009. Cumulative production for individual CBNG wells is displayed by location on Figure 158.

The effect on groundwater drawdown trends from 1999 to 2009 is unknown due to incomplete monitoring history (Figure 158). The water/gas ratio of CBNG wells within the buffer is relatively inconsistent. Percent methane is minimal during the monitored period.

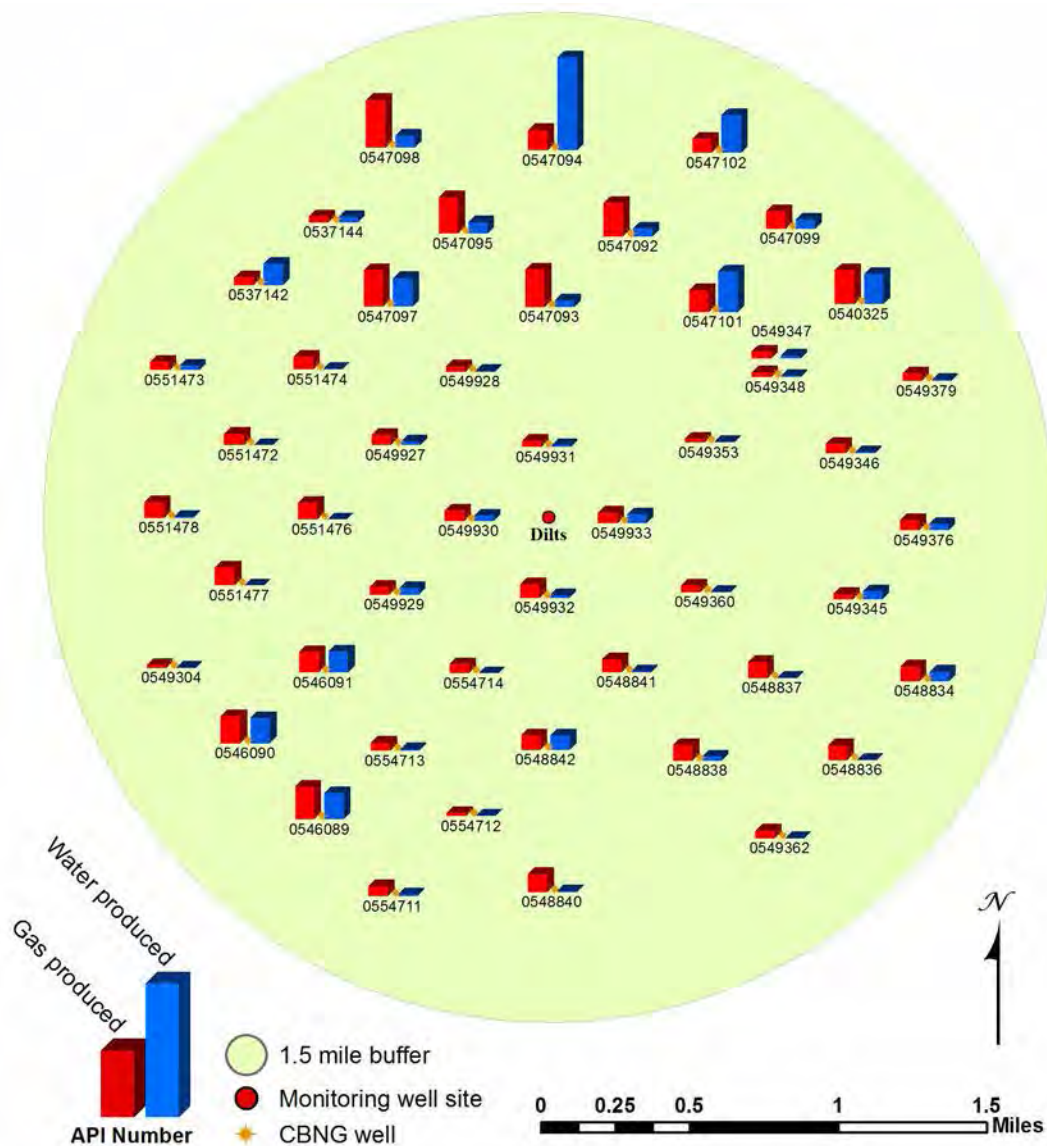


Figure 158. Dilts monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (Bbls) and gas (Mcf) production. The seven digit number below the well point corresponds to the American Petroleum Institute (API) well number.

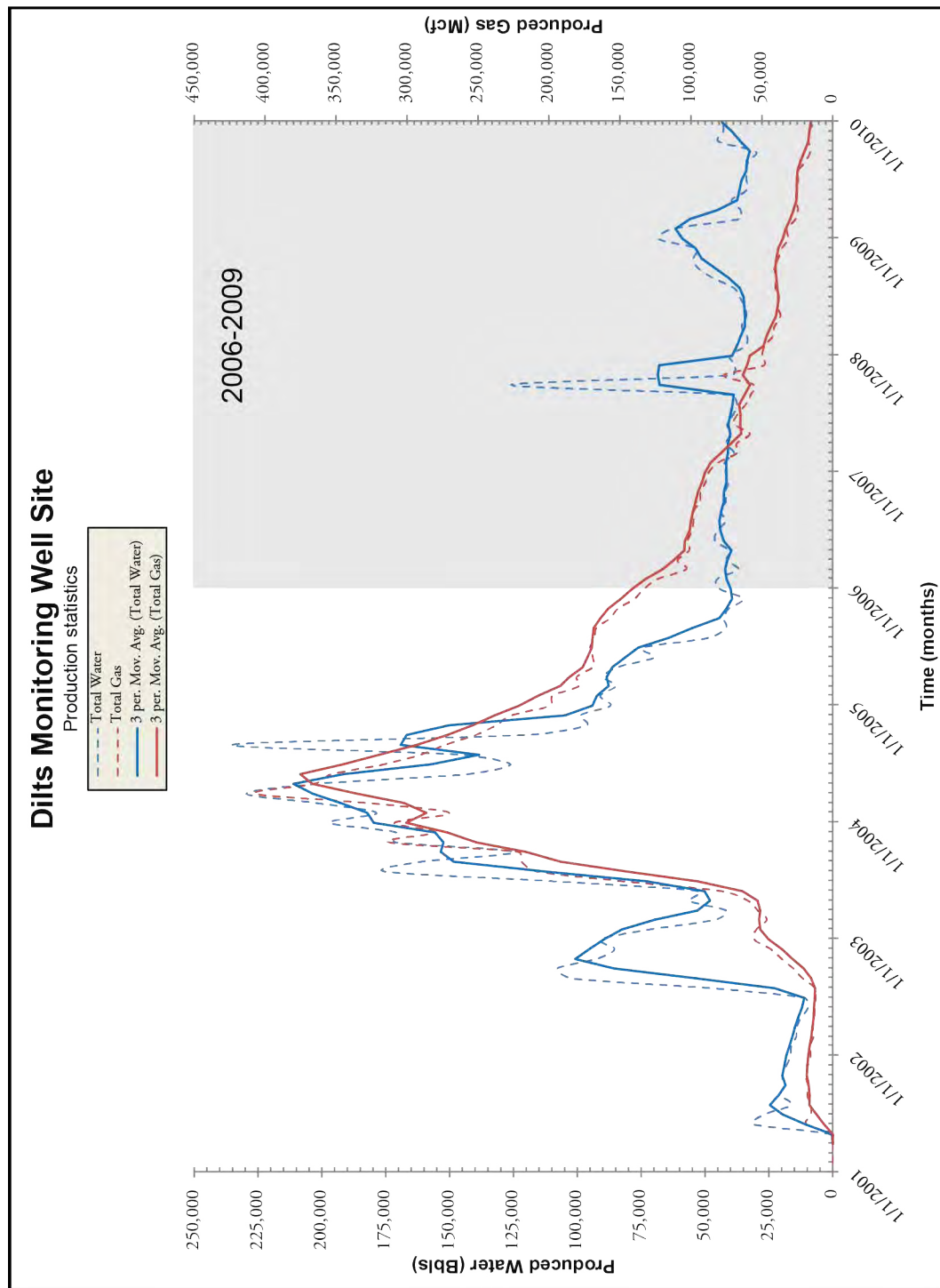


Figure 159. 3-period moving average along with water and gas production from associated CBNG wells.

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 constructed into the Big George coal and the other into the deeper Wyodak coal (Figure 160; Table 79). Missing and/or fluctuating transducer data is the result of errors with on-site equipment.

The Big George coal recorded a groundwater drawdown of 116 feet during the 2006-2009 monitoring period; data shows a rapid decline in the groundwater level from 2003 to mid-2004, which correlates to the increase in water production from CBNG wells in the area (Figure 161; Table 80). The Wyodak coal recorded a groundwater drawdown of 75 feet during the 2006-2009 monitoring period; data shows a steady decline in the groundwater level (Figure 161; Table 80). Monitoring data suggests these coals are not hydraulically connected. Gas pressure readings did not surpass levels possible from transducer error.

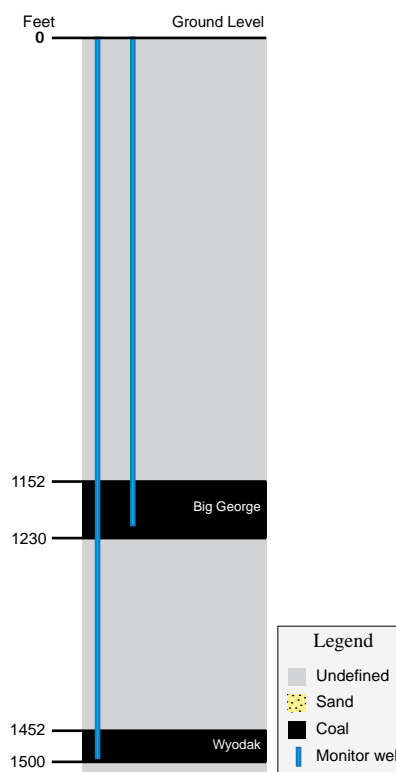


Figure 160. Section showing relative positions of coals and sands in feet. Not to scale.

Table 79. Table showing the depth to and thickness of monitored zones at the Double Tank monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Big George coal	1152	1230	78	n/a
Wyodak coal	1452	1500	48	n/a

Table 80. Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2006	Drawdown 2006-2009	Total drawdown (ft.)	Depth to 12/31/09 water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Big George coal	294.61	399.17	115.75	514.92	809.53	n/a	n/a
Wyodak coal	148.86	221.57	74.55	296.12	444.98	n/a	n/a

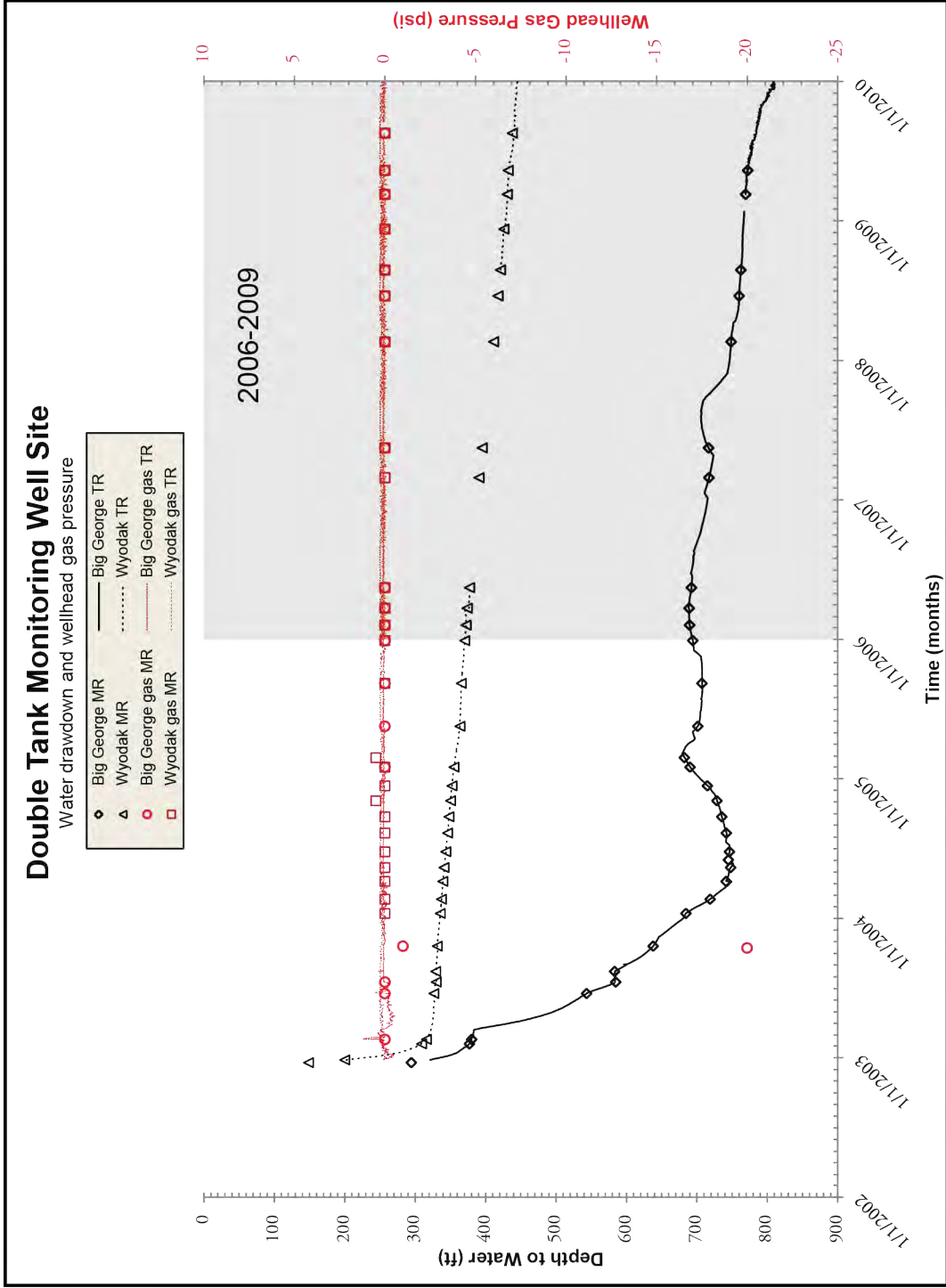


Figure 161. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Double Tank monitoring well site location.

Production Statistics

Production data was analyzed for CBNG wells within the buffer of the Double Tank monitoring wells from January 2002 to December 2009. Cumulative production for individual CBNG wells is displayed by location on Figure 162.

production increased and water production declined during the 2006 to 2009 monitoring period (Figure 163). The water/gas ratio of CBNG wells within the buffer is relatively inconsistent. Percent methane is minimal during the monitored period.

CBNG water production peaked in 2003, which correlates to groundwater drawdown trends. Gas

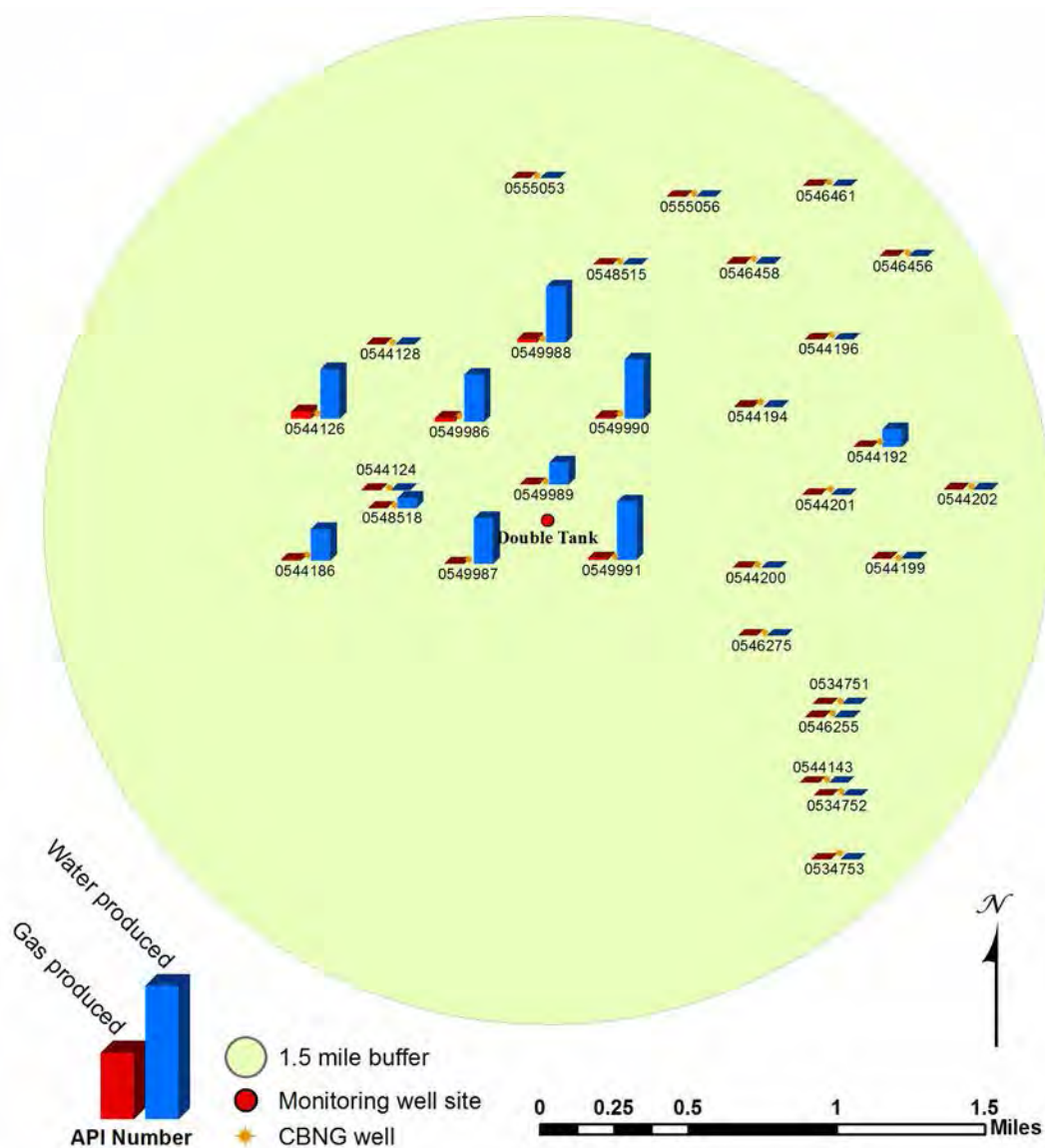


Figure 162. Double Tank monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (Bbls) and gas (Mcf) production. The seven digit number below the well point corresponds to the American Petroleum Institute (API) well number.

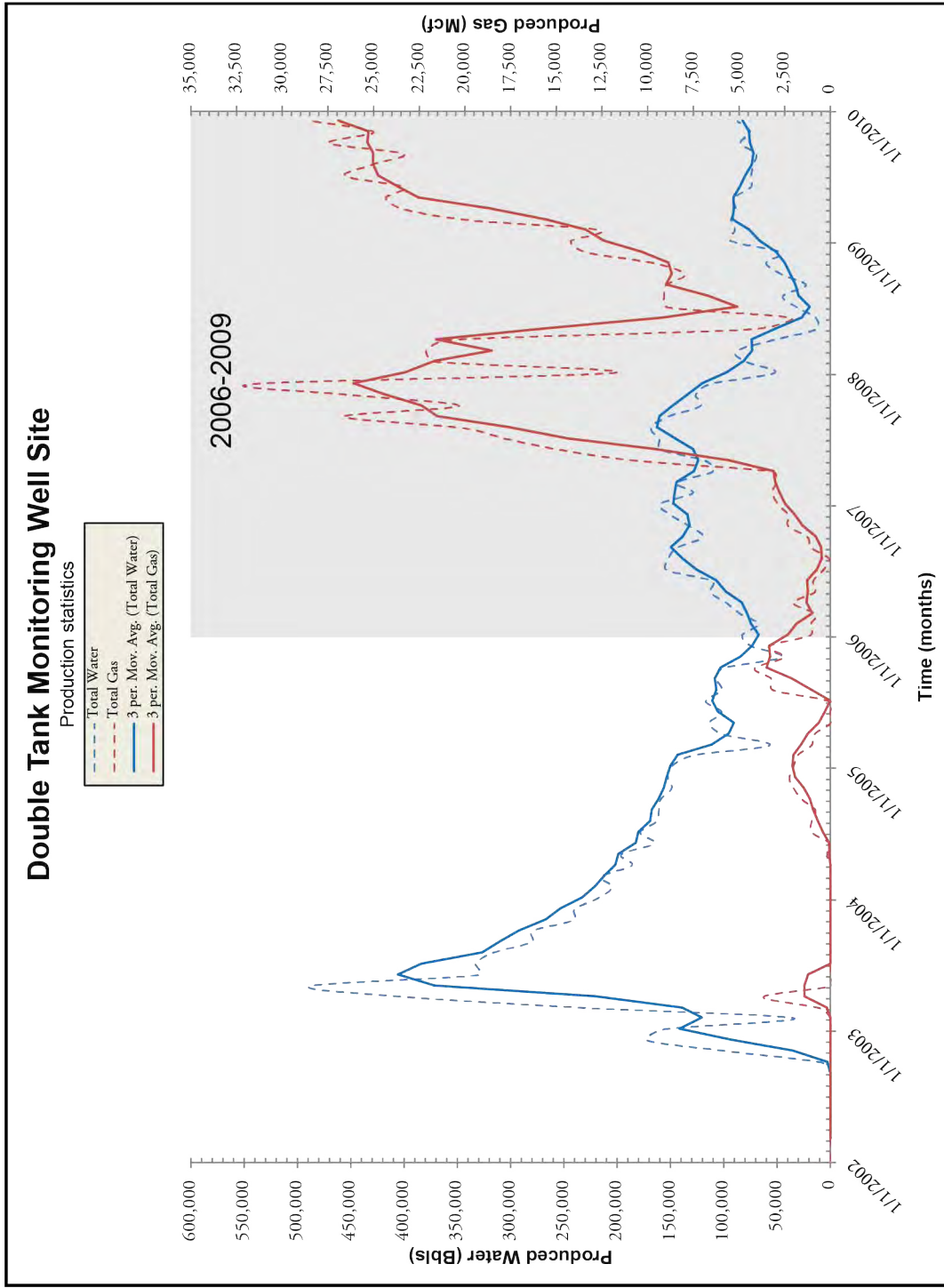


Figure 163. 3-period moving average along with water and gas production from associated CBNG wells.

Durham Ranch Section 6 Monitoring Well Site

Location: S6 T45N R71W

Date First Monitored: November 10, 1997

Drawdown Information

The Durham Ranch Section 6 monitoring well site includes two wells. One is drilled into the Wyodak coal and the other is drilled into a overlying Wasatch sandstone (Figure 164; Table 81). Missing and/or fluctuating transducer data is the result of errors with on-site equipment.

The Wyodak coal recorded a groundwater draw-down of 7 feet during the 2006-2009 monitoring period; data shows a steep drop in the groundwater in 2006 followed by a near stable levels (Figure 165; Table 82). It should be noted that this steep drop could likely be the result of transducer error, and not true data. Groundwater levels in the Wasatch sandstone declined by 15 feet during the 2006-2009 monitoring period (Figure 165; Table 82). Equivalent drawdown trends suggest the possibility that the monitored Wasatch sandstone and the Wyodak coal are hydraulically connected. Gas pressure readings did not surpass levels possible from transducer error.

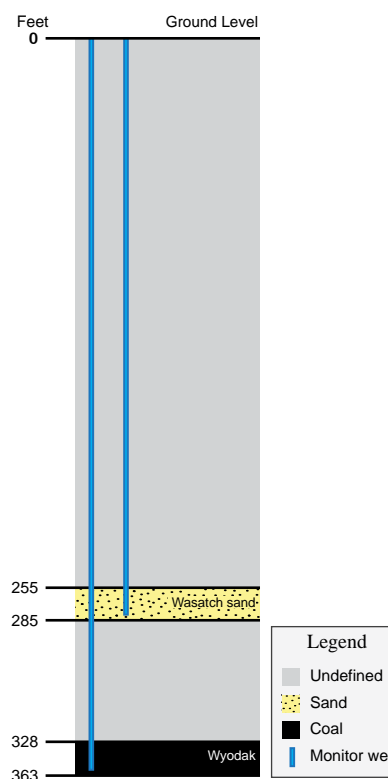


Figure 164. Section showing relative positions of coals and sands in feet. Not to scale.

Table 81. Table showing the depth to and thickness of monitored zones at the Durham Ranch Section 6 monitoring well site location. (measured in feet)

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

Table 82. Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2006	Drawdown 2006-2009	Total drawdown (ft.)	Depth to 12/31/09 water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	96.20	58.17	14.50	72.67	168.87	n/a	n/a
Wyodak coal ⁽¹⁾	118.15	241.95	6.93	248.88	367.03	84.00	6/15/99

⁽¹⁾ The value of 367.03 feet for the Wyodak coal represents a dry well.

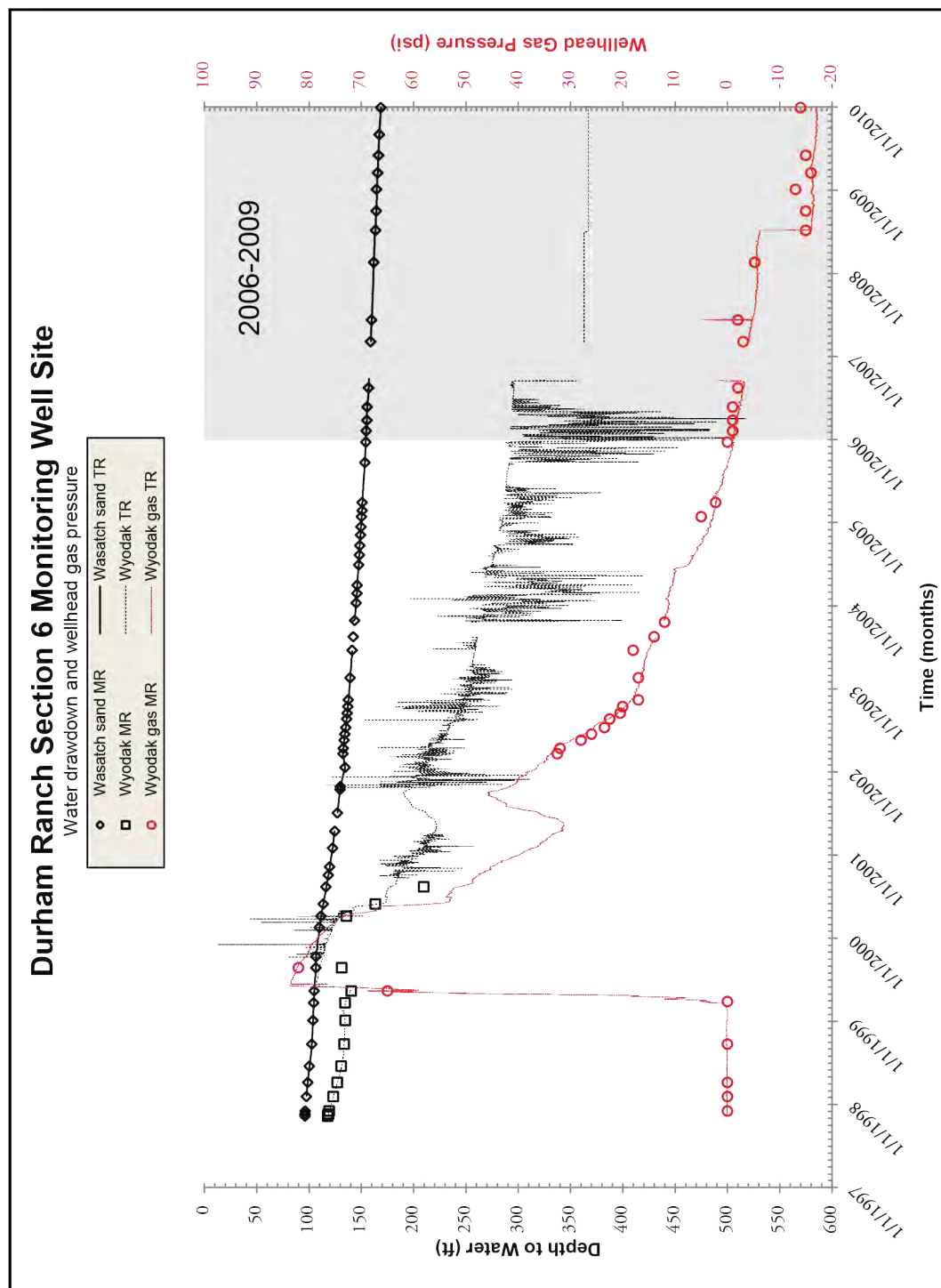


Figure 165. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Durham Ranch Section 6 monitoring well site location.

Production Statistics

Production data was analyzed for CBNG wells within the buffer of the Durham Ranch Section 6 monitoring well site from January 2000 through December 2009. Cumulative production for individual CBNG wells is displayed by location on Figure 166.

Water production peaked in 2001, which generally correlates with groundwater drawdown trends. The

water/gas ratio of CBNG wells within the buffer is relatively consistent. Water and gas production declined during the 2006 to 2009 monitoring period (Figure 167). The water/gas ratio of CBNG wells within the buffer is relatively inconsistent. Percent methane is relatively consistent, though there is no coal bed data during the 2006 to 2009 monitoring period.

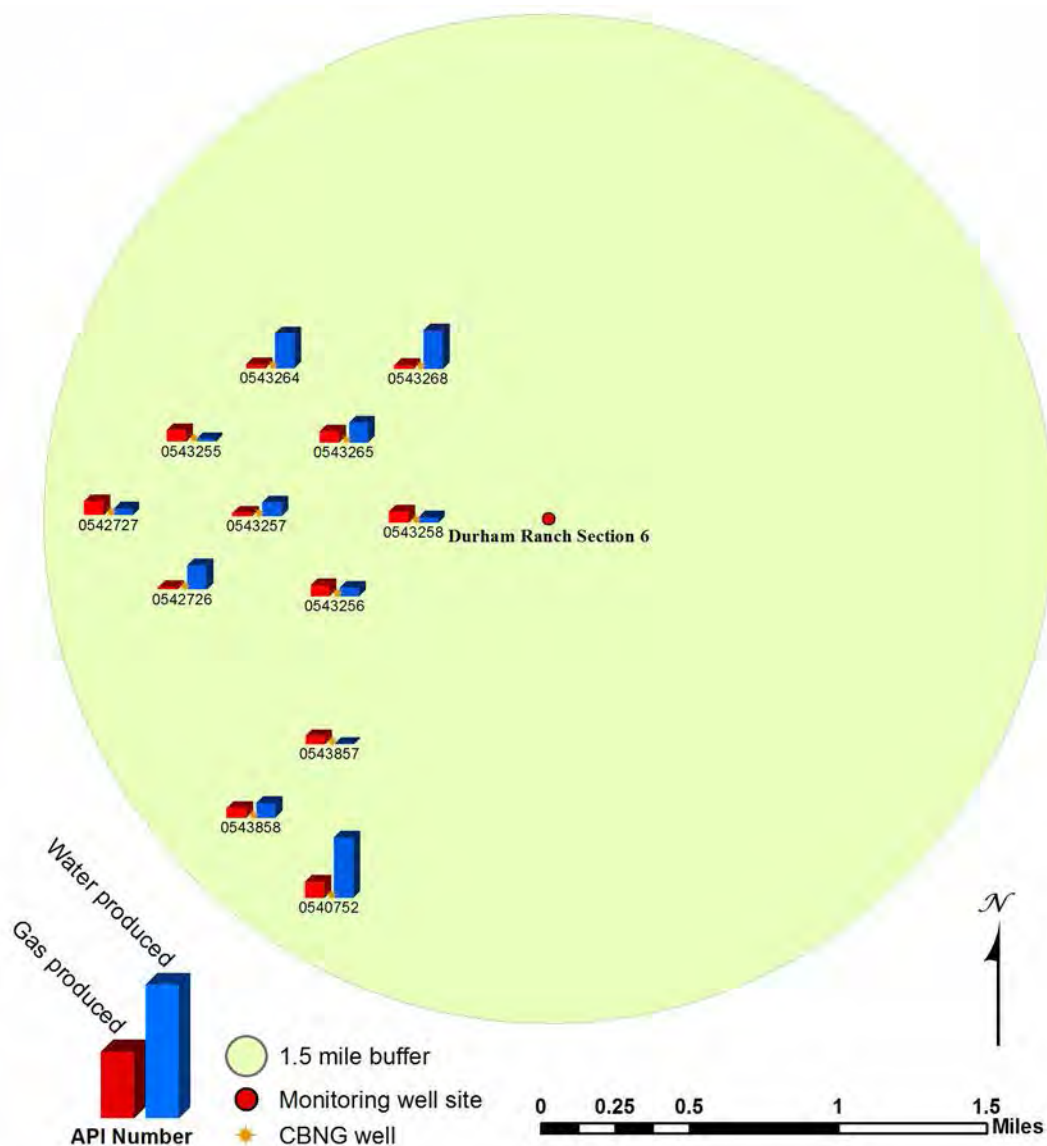


Figure 166. Durham Ranch Section 6 monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (Bbls) and gas (Mcf) production. The seven digit number below the well point corresponds to the American Petroleum Institute (API) well number.

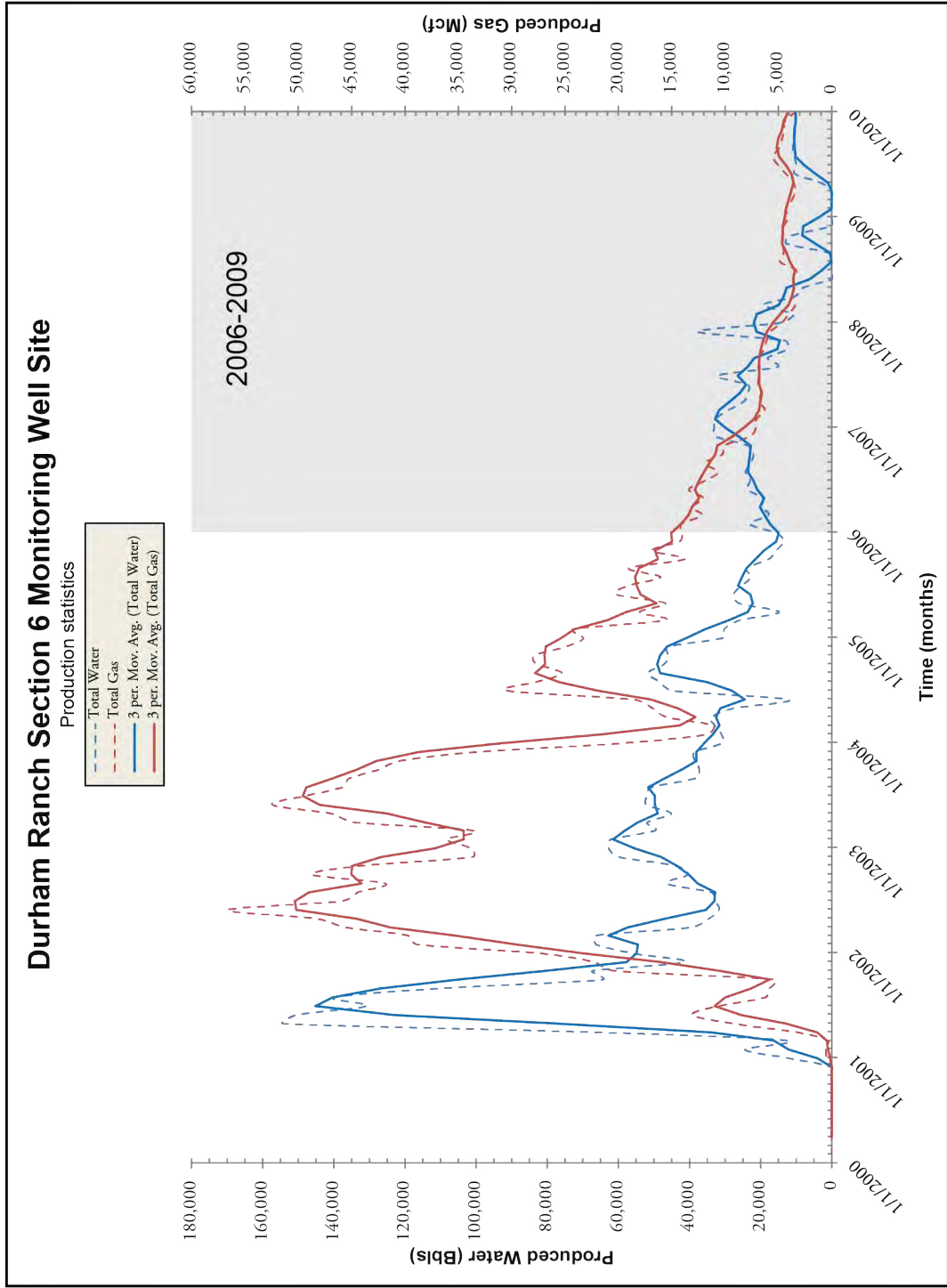


Figure 167. 3-period moving average along with water and gas production from associated CBNG wells.

Durham Ranch Section 14 Monitoring Well Site

Location: S14 T44N R72W

Date First Monitored: January 13, 1998

Drawdown Information

The Durham Ranch Section 14 monitoring well site includes two wells. One is drilled into the Wyodak coal and the other is drilled into a overlying Wasatch sandstone (Figure 168; Table 83). Missing and/or fluctuating transducer data is the result of errors with on-site equipment.

The Wyodak coal recorded negligible groundwater drawdown during the 2006-2009 monitoring period; transducer data showed no water level changes as the well was reported dry in February of 2005 (Figure 169; Table 84). Groundwater levels in the Wasatch sandstone declined by just under 2 feet during the 2006-2009 monitoring period, and they have remained nearly constant throughout the life of the well (Figure 169; Table 84). This indicates there is no hydraulic connection between the monitored sandstone and producing zones. Gas pressure readings did not surpass levels possible from transducer error.

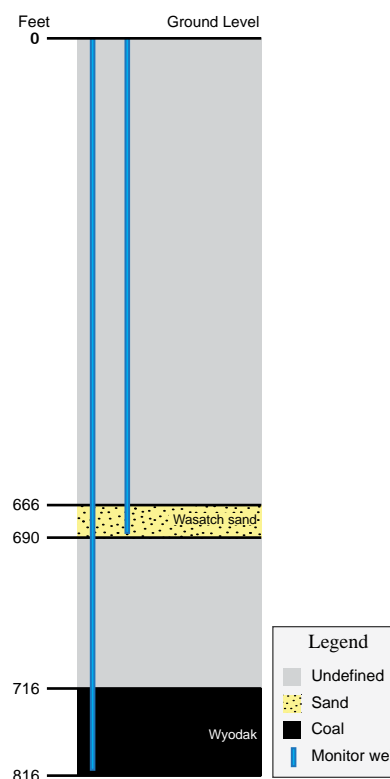


Figure 168. Section showing relative positions of coals and sands in feet. Not to scale.

Table 83. Table showing the depth to and thickness of monitored zones at the Durham Ranch Section 14 monitoring well site location. (measured in feet)

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

Table 84. Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2006	Drawdown 2006-2009	Total drawdown (ft.)	Depth to 12/31/09 water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	24.58	21.45	1.46	22.91	47.49	n/a	n/a
Wyodak coal ⁽¹⁾	268.00	548.03	0.27	548.30	816.30	30.00	10/15/02

⁽¹⁾ The value of 816.30 feet for the Wyodak coal represents a dry well. This well was reported dry in 2005 which continued throughout the monitoring period

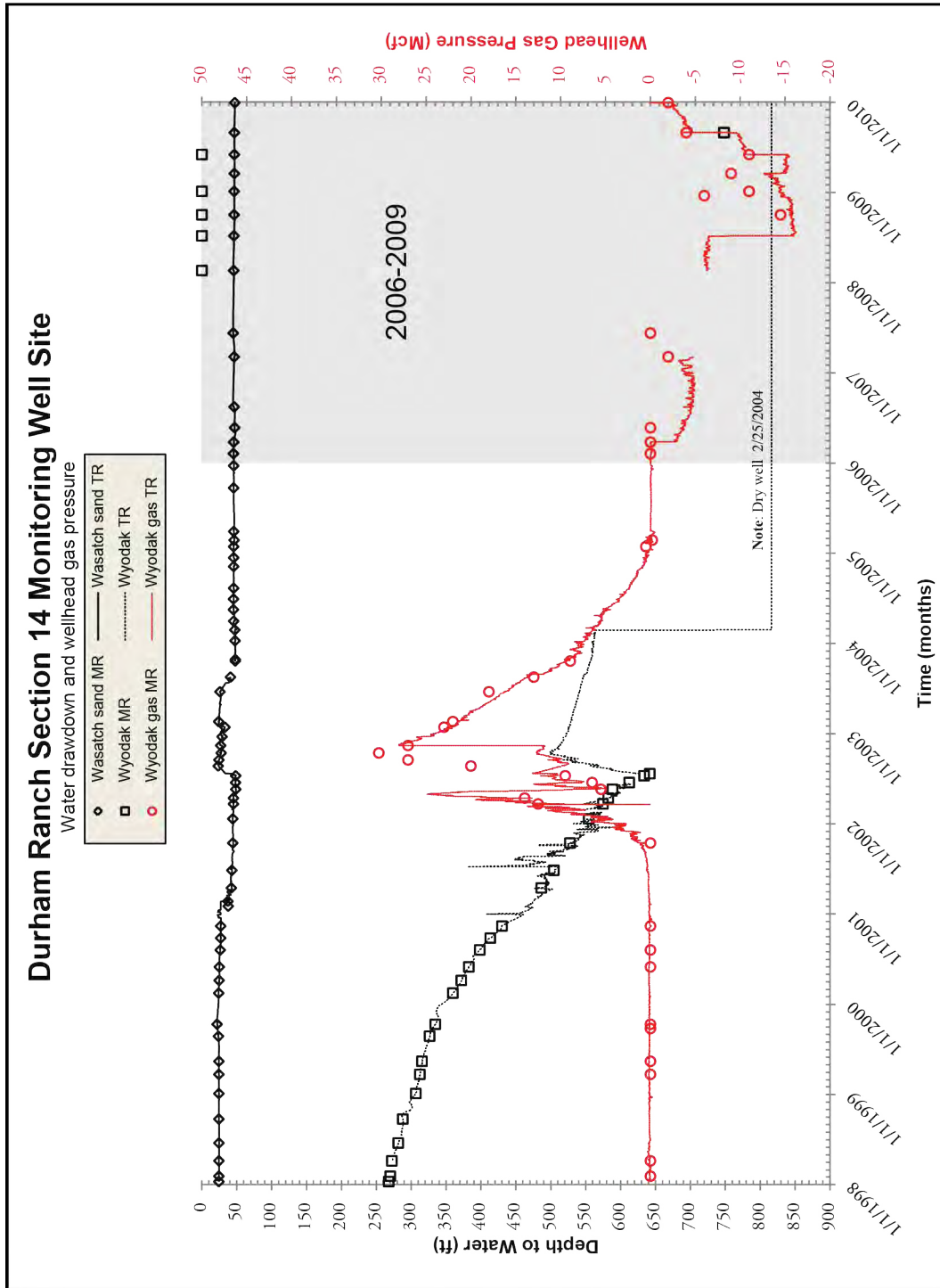


Figure 169. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Durham Ranch Section 14 monitoring well site location.

Production Statistics

Production data was analyzed for CBNG wells within the buffer of the Durham Ranch Section 14 monitoring well site from January 2000 through December 2009. Cumulative production for individual CBNG wells is displayed by location on Figure 170.

Water production peaked in 2002, which correlates to groundwater drawdown trends. The water/gas ratio of CBNG wells within the buffer is relatively inconsistent. Water and gas production declined during the 2006 to 2009 monitoring period (Figure 171). The water/gas ratio of CBNG wells within the buffer is relatively inconsistent. Percent methane is variable.

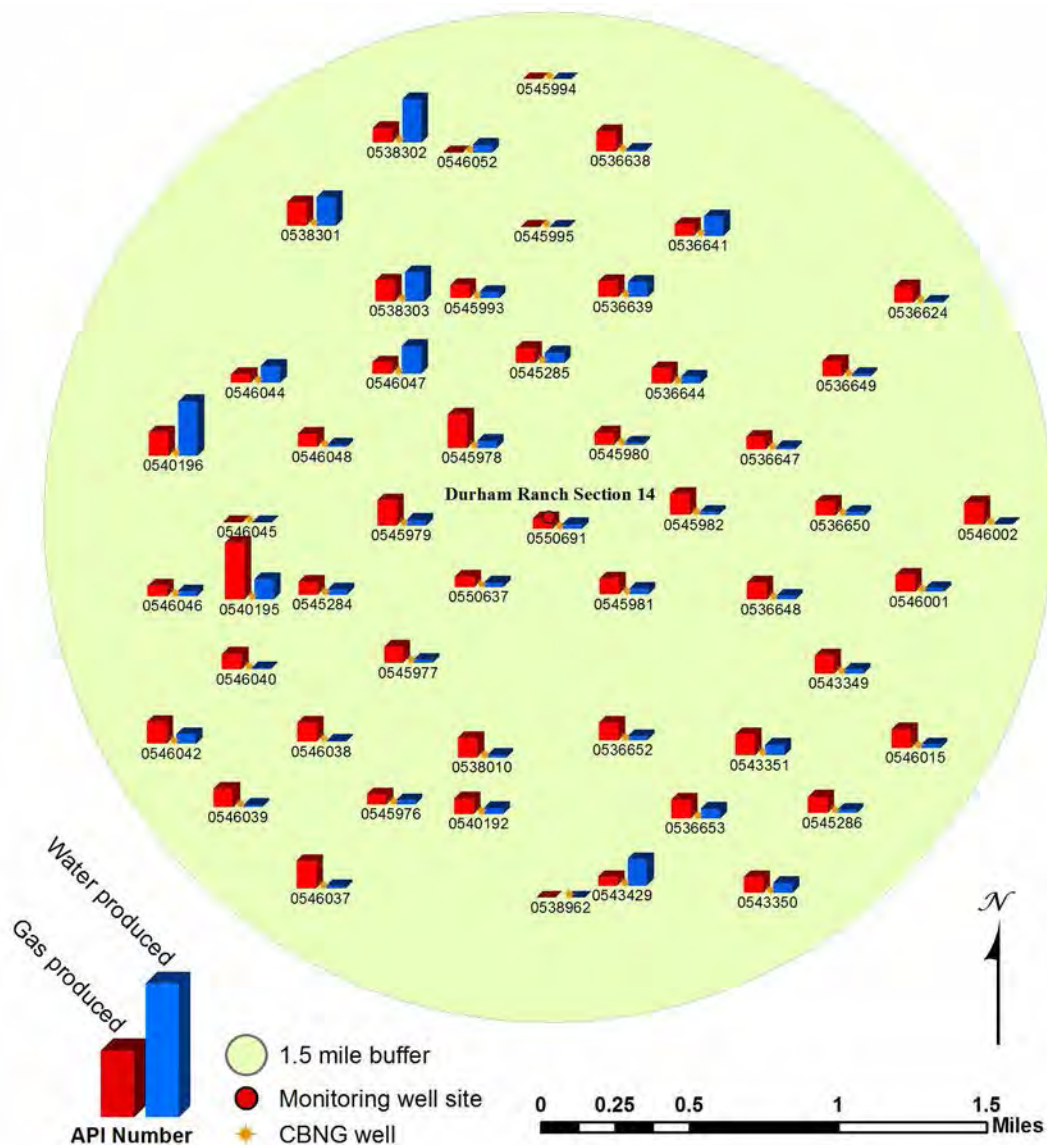


Figure 170. Durham Ranch Section 14 monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (Bbls) and gas (Mcf) production. The seven digit number below the well point corresponds to the American Petroleum Institute (API) well number.

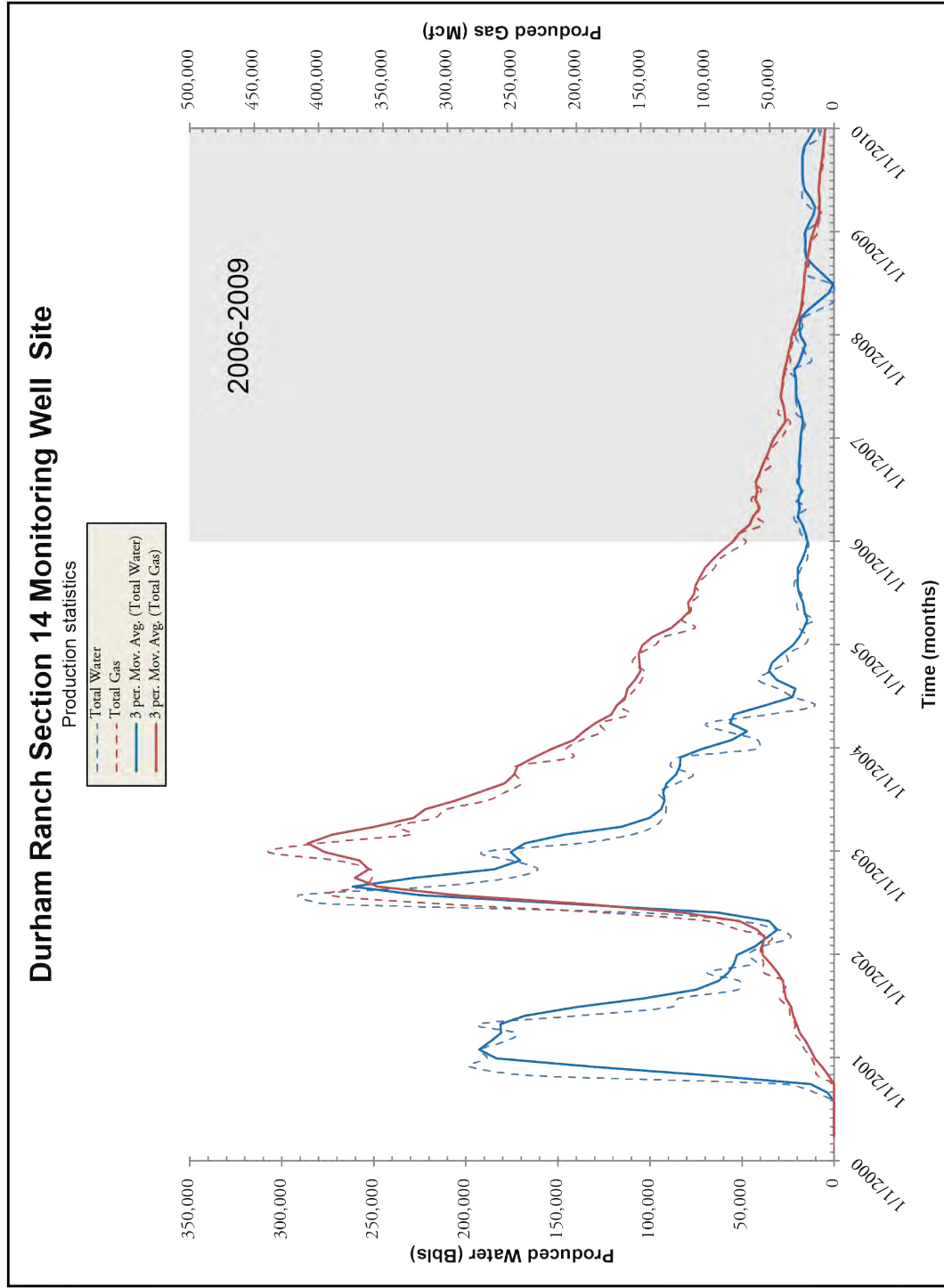


Figure 171. 3-period moving average along with water and gas production from associated CBNG wells.

Gilmore Monitoring Well Site
Location: S31T49N R77W
Date First Monitored: April 4, 1998

Drawdown Information

The Gilmore monitoring well site consists of one well drilled into the Wyodak coal. Missing and/or fluctuating transducer data is the result of errors with on-site equipment. (Figure 172; Table 85).

The Wyodak coal recorded a groundwater draw-down of 180 feet during the 2006-2009 monitoring period; data indicates a steady decline in the groundwater level (Figure 173; Table 86). Gas pressure readings did not surpass levels possible from transducer error.

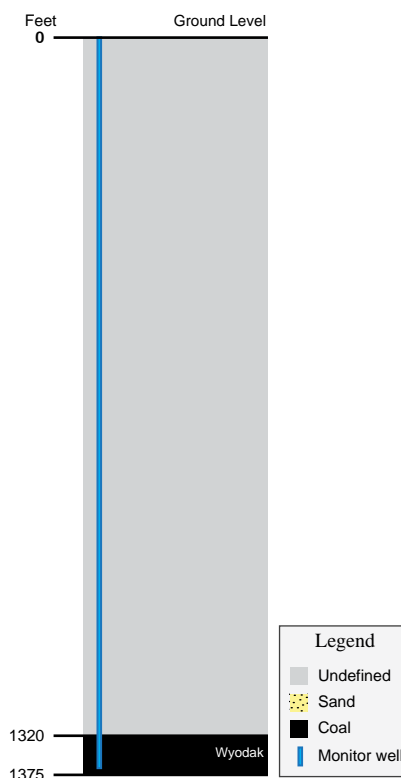


Figure 172. Section showing relative positions of coals and sands in feet. Not to scale.

Table 85. Table showing the depth to and thickness of monitored zones at the Gilmore monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Wyodak coal	1320	1375	55	n/a

Table 86. Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2006	Drawdown 2006-2009	Total drawdown (ft.)	Depth to 12/31/09 water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wyodak coal	369.41	26.24	179.81	206.05	575.46	1.00	11/23/05

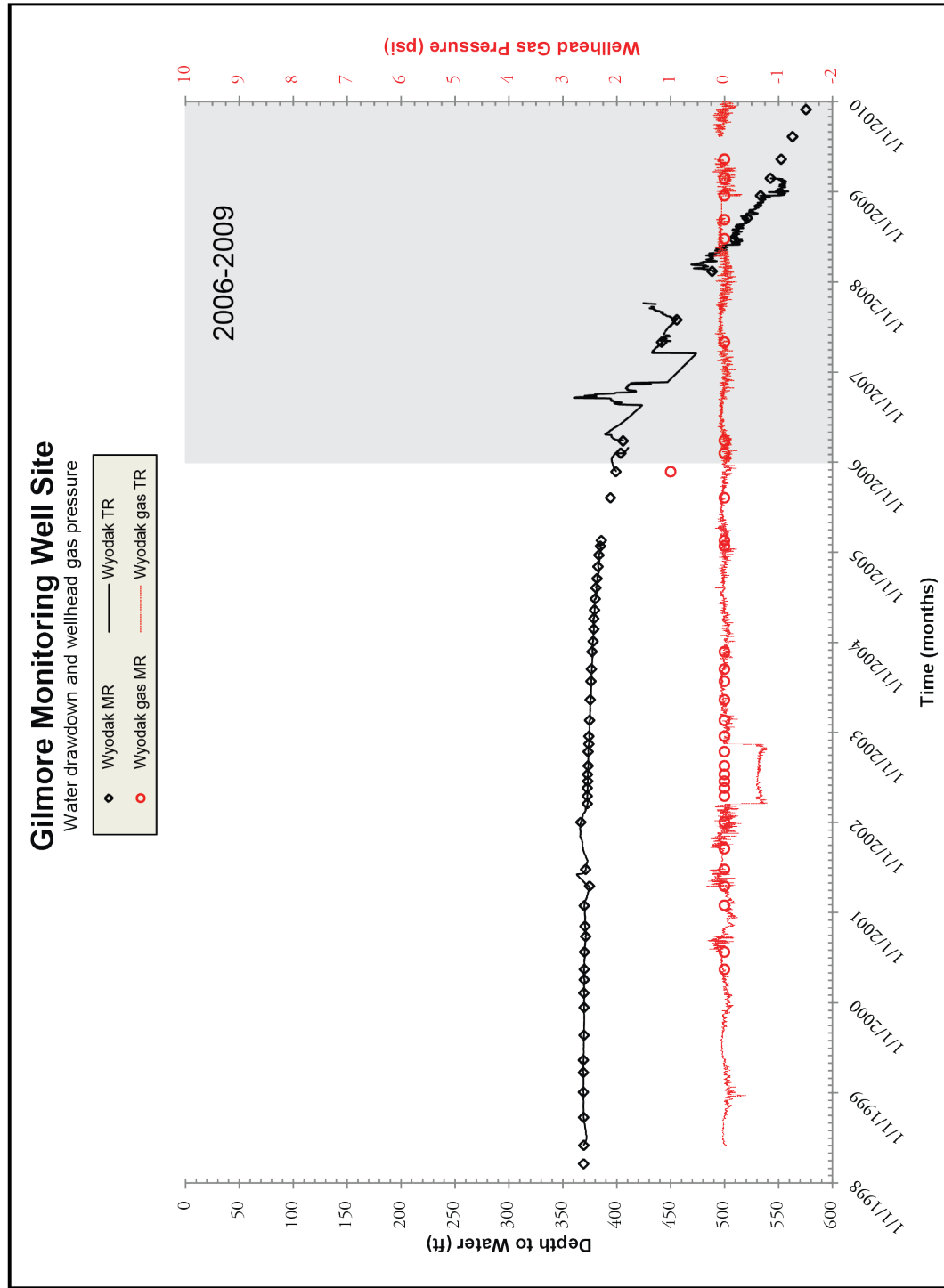


Figure 173. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Gilmore monitoring well site location. Gray area represents the current monitoring period of 2006-2009.

Production Statistics

Production data for the Gilmore monitoring well site was not reported due to incomplete or generalized completion data for local CBNG wells.

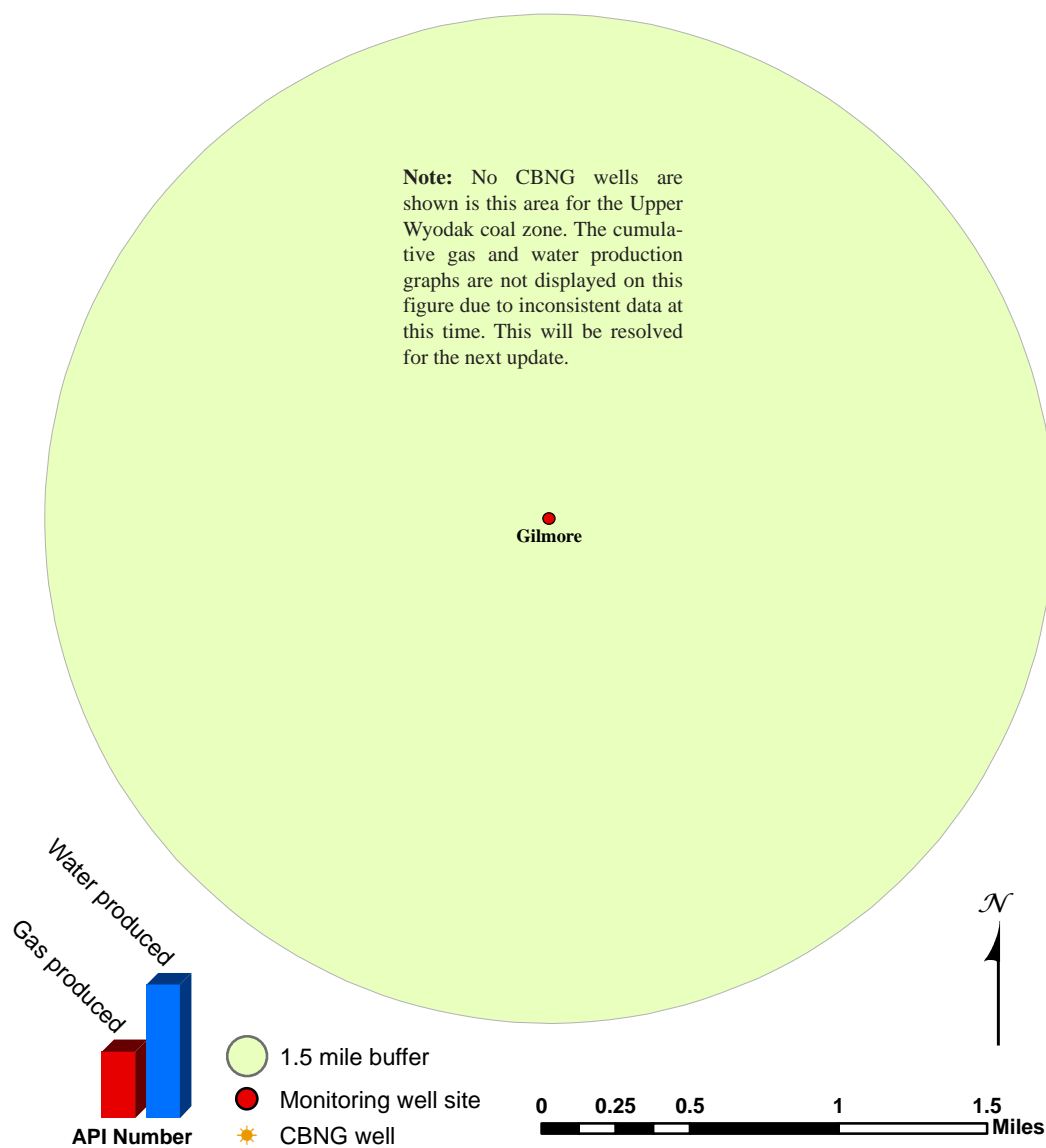


Figure 174. Gilmore monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (Bbls) and gas (Mcf) production. The seven digit number below the well point corresponds to the American Petroleum Institute (API) well number.

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

Drawdown Information

The Hoe Creek well site includes two wells. One is drilled into the Wyodak coal and the other is drilled into a overlying Wasatch sandstone (Figure 175; Table 87). Missing and/or fluctuating transducer data is the result of errors with on-site equipment.

The Wyodak coal recorded a groundwater increase of 51 feet during the 2006-2009 monitoring period; data shows relatively steady groundwater levels after 2006 that begin to increase late in 2009. Groundwater levels in the Wyodak coal have therefore recovered approximately 4 percent. Groundwater levels in the Wasatch sandstone declined by 5 feet during the 2006-2009 monitoring period, and they were nearly constant throughout the life of the well (Figure 176; Table 88). Nearly constant groundwater levels suggest it is not hydraulically connected to the Wyodak coal. Gas pressure readings did not surpass levels possible from transducer error, except towards the end of 2009, when pressures show a slight spike.

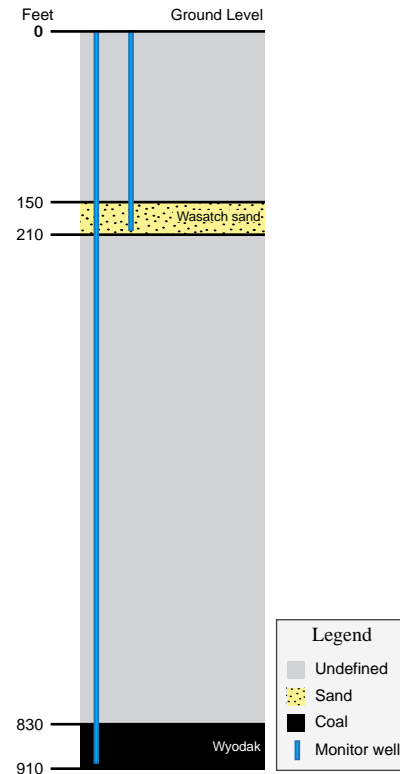


Figure 175. Section showing relative positions of coals and sands in feet. Not to scale.

Table 87. Table showing the depth to and thickness of monitored zones at the Hoe Creek monitoring well site location. (measured in feet)

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

Table 88. Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2006	Drawdown 2006-2009	Total drawdown (ft.)	Depth to 12/31/09 water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	100.85	-1.84	6.85	5.01	105.86	n/a	n/a
Wyodak coal	231.25	652.50	-50.75	601.75	833.00	60.00	4/23/00

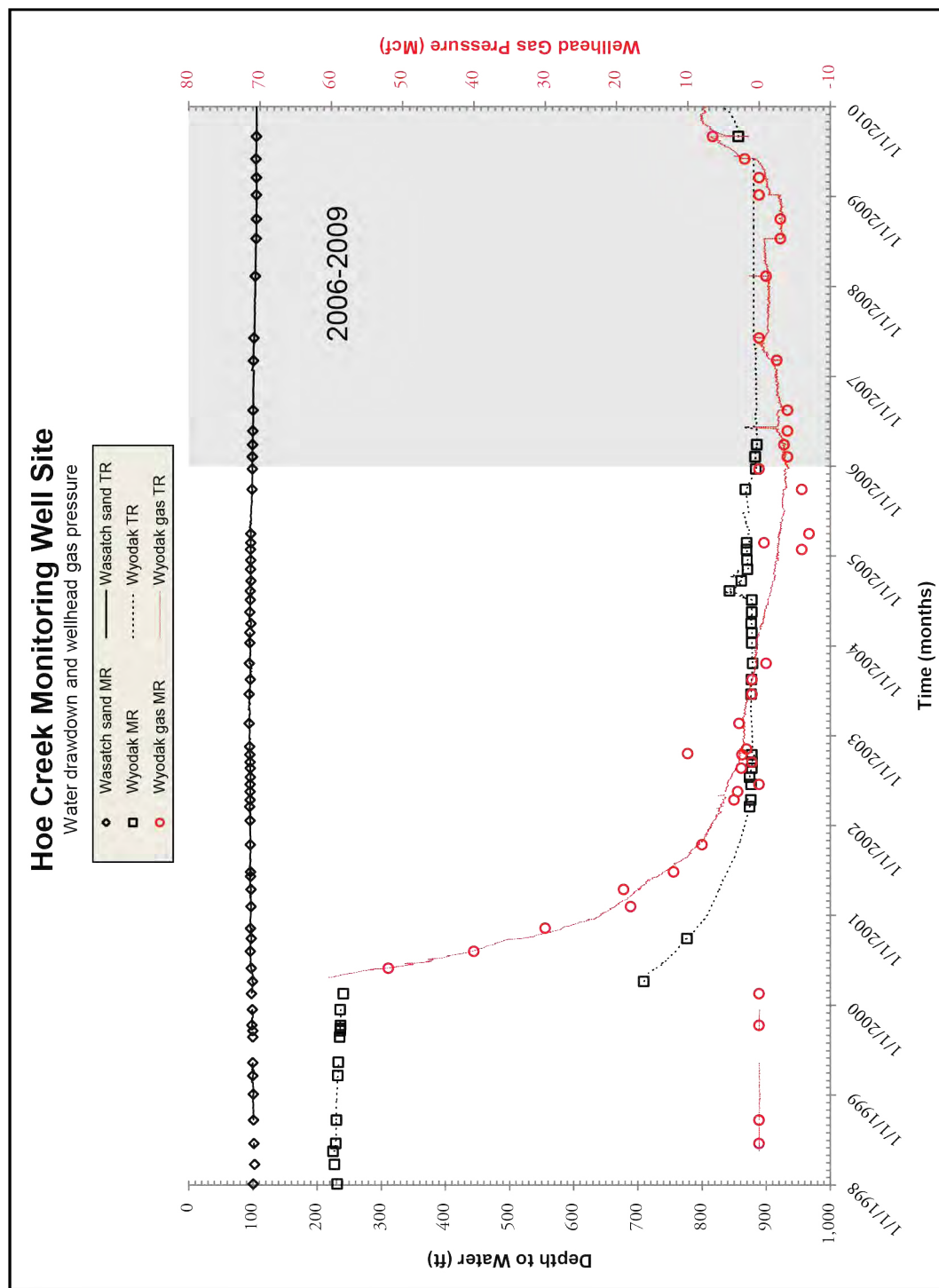


Figure 176. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Hoe Creek monitoring well site.

Production Statistics

Production data was analyzed for CBNG wells within the buffer of the Hoe Creek monitoring well site from January 2000 to December 2009. Cumulative production for individual CBNG wells is displayed by location on Figure 177.

declined and water production was minimal during the 2006 to 2009 monitoring periods (Figure 178). The water/gas ratio of CBNG wells within the buffer is relatively inconsistent. Percent methane is variable.

Water production peaked in 2002 which correlates to groundwater drawdown trends. Gas production

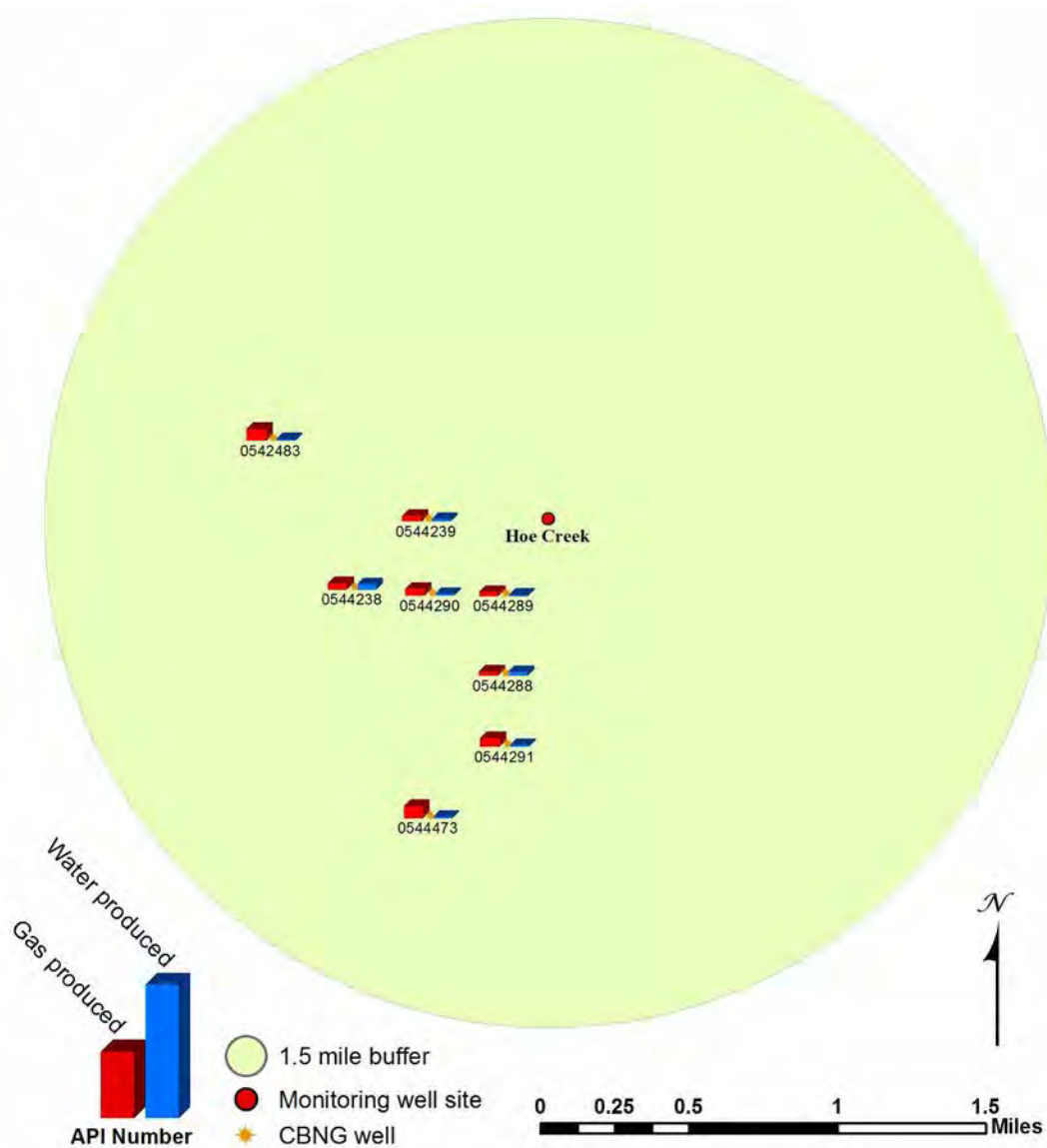


Figure 177. Hoe Creek monitoring well site and associated CBNG wells within 1.5 mile buffer showing cumulative water (Bbls) and gas (Mcf) production. The seven digit number below the well point corresponds to the American Petroleum Institute (API) well number.

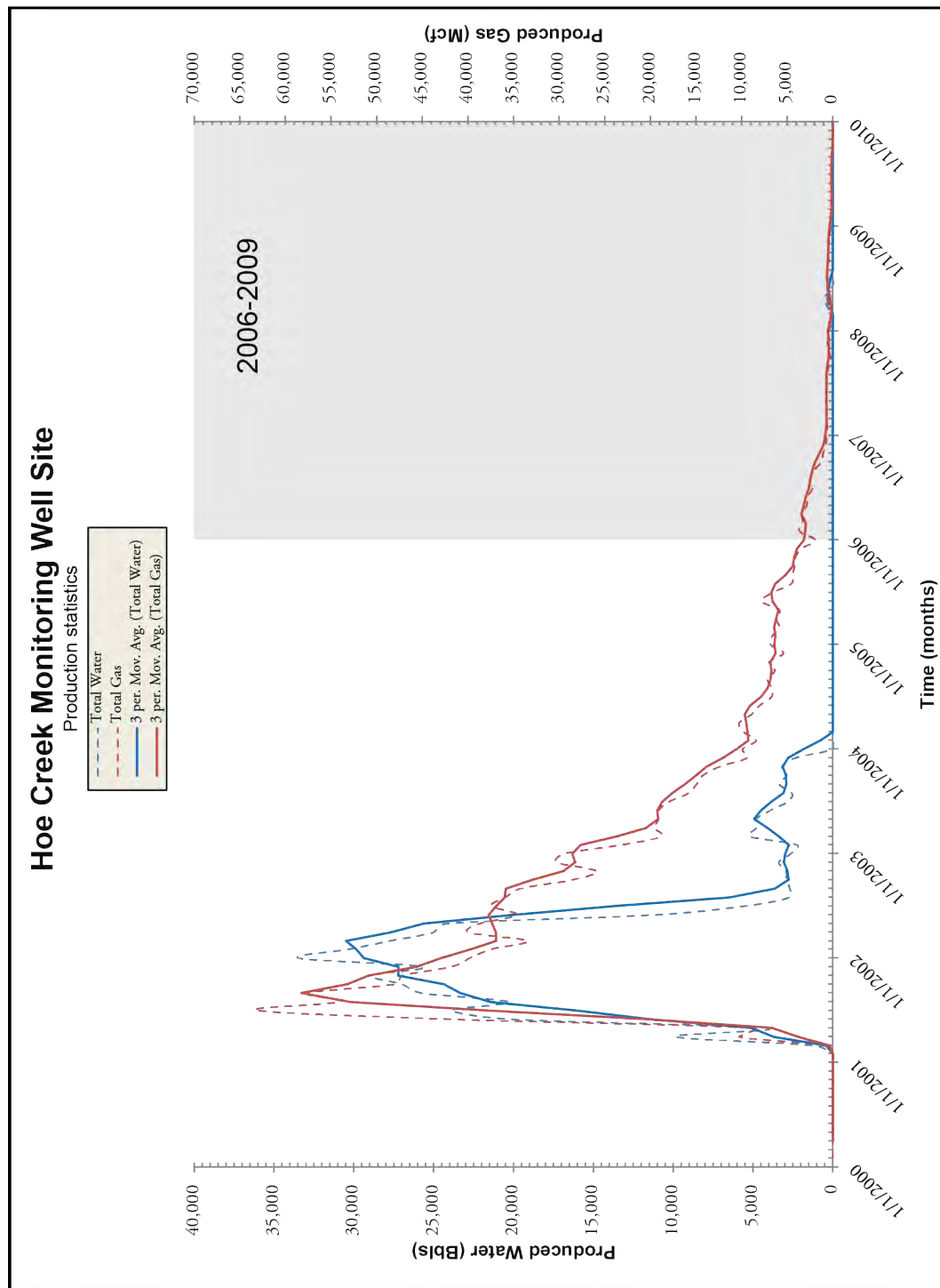


Figure 178. 3-period moving average along with water and gas production from associated CBNG wells.

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 drilled into the Anderson coal and the other is drilled into a overlying Wasatch sandstone (Figure 179; Table 89). Missing and/or fluctuating transducer data is the result of errors with on-site equipment.

The Anderson coal recorded a groundwater increase of 6 feet during the 2006-2009 monitoring period; data shows relatively steady groundwater levels during 2006-2009 period that begin to increase late in 2009. Groundwater levels in the Wasatch sandstone declined by 2 feet during the 2006-2009 monitoring period, though data shows groundwater levels have remained mostly stable during the life of the well (total drawdown of 17 feet) (Figure 180; Table 90). This suggests there could be some influence of CBNG production on this sandstone, though draw-down trends indicate it is most likely a regional response and it is not directly hydraulically connected to the Anderson coal. Gas pressure readings did not surpass levels possible from transducer error.

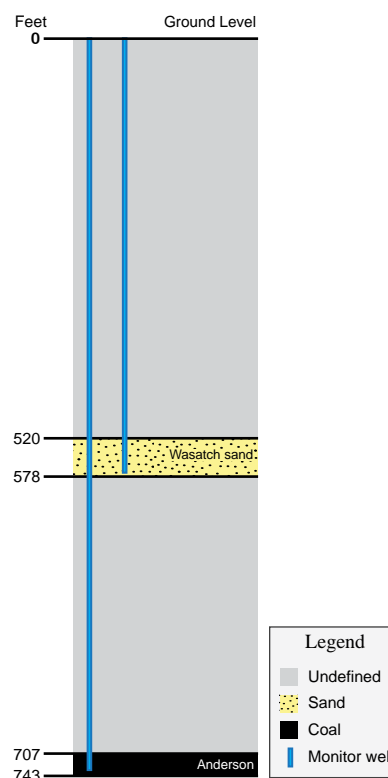


Figure 179. Section showing relative positions of coals and sands in feet. Not to scale.

Table 89. Table showing the depth to and thickness of monitored zones at the Kennedy monitoring well site location. (measured in feet)

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

Table 90. Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2006	Drawdown 2006-2009	Total drawdown (ft.)	Depth to 12/31/09 water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	270.70	15.43	1.65	17.08	287.78	n/a	n/a
Anderson coal	405.21	227.13	-5.85	221.28	626.49	43.00	2/15/03

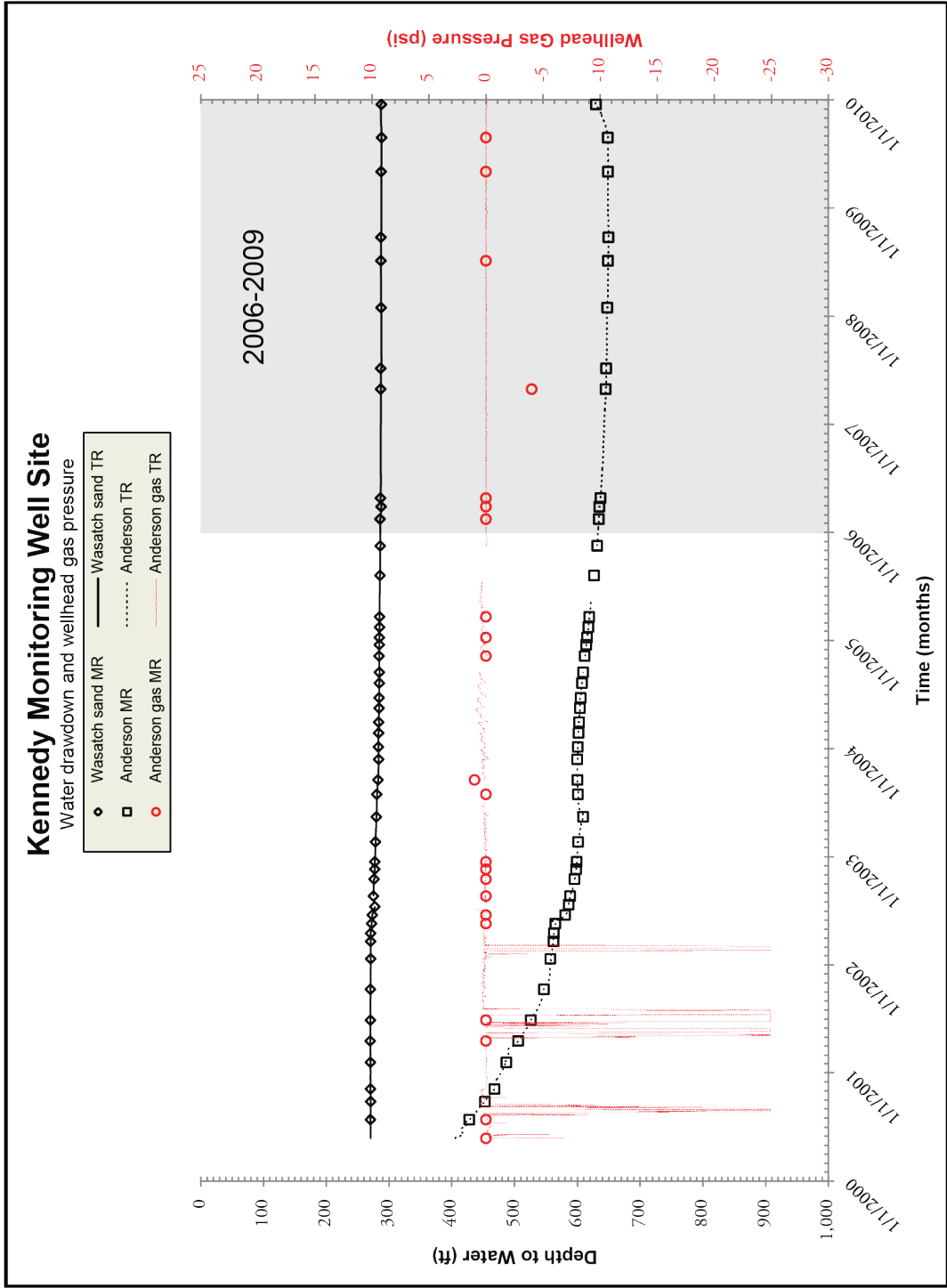


Figure 180. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Kennedy monitoring well site location.

Production Statistics

Production data was analyzed for CBNG wells within the buffer of the Kennedy monitoring well site from July 2001 through December 2009. CBNG wells are displayed by location on Figure 181.

Water production peaked in 2002, which correlates to groundwater drawdown trends. Gas production declined during the 2006 to 2009 monitoring pe-

riod (Figure 182). Water production increased briefly in the second half of 2008, and was minimal by the end of 2009 (Figure 182). This correlates to the slight recovery in the Anderson coal bed in late 2009 (Figure 180). The water/gas ratio of CBNG wells within the buffer is relatively inconsistent. Percent methane is variable, though it generally decreases.

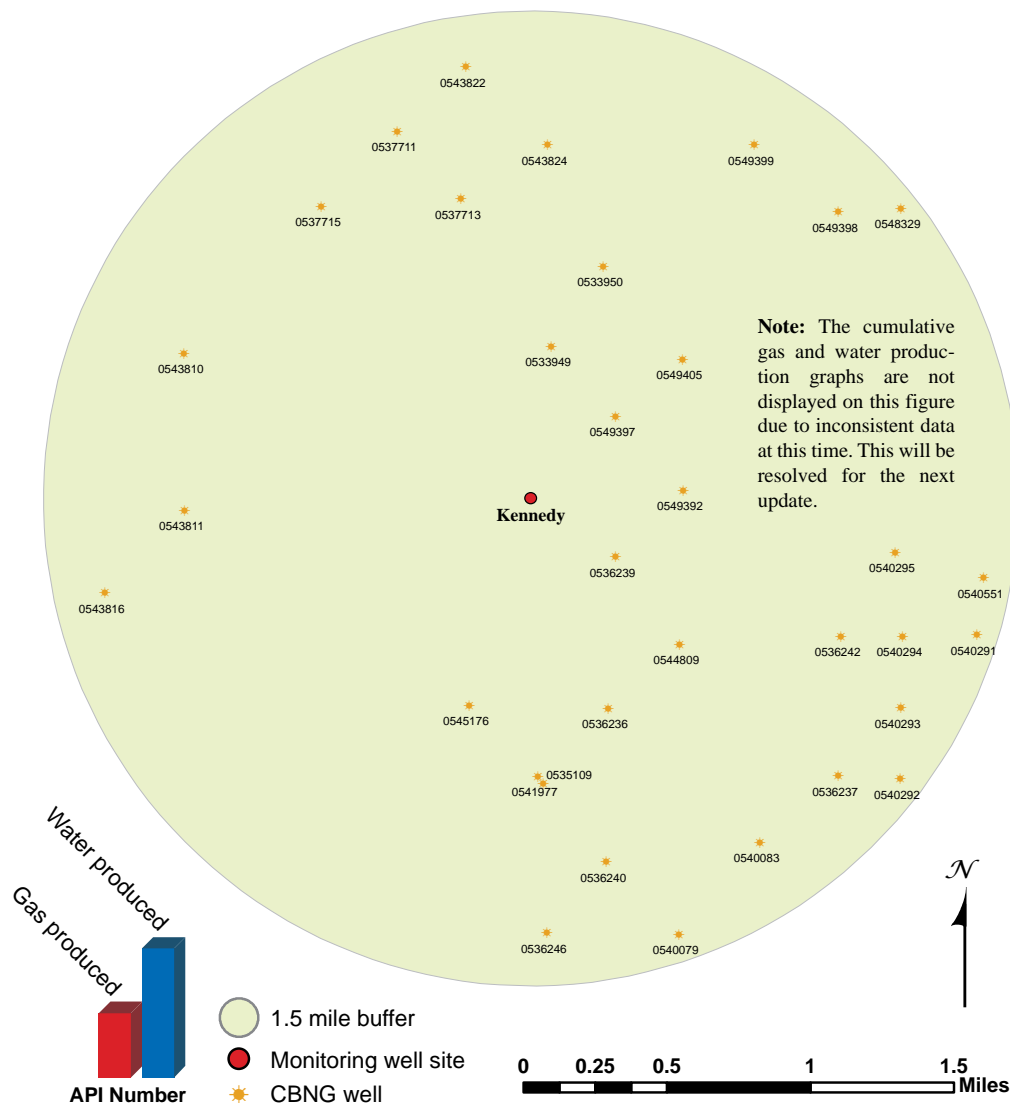


Figure 181. Kennedy monitoring well and associated CBNG wells within 1.5 mile buffer showing cumulative water (Bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

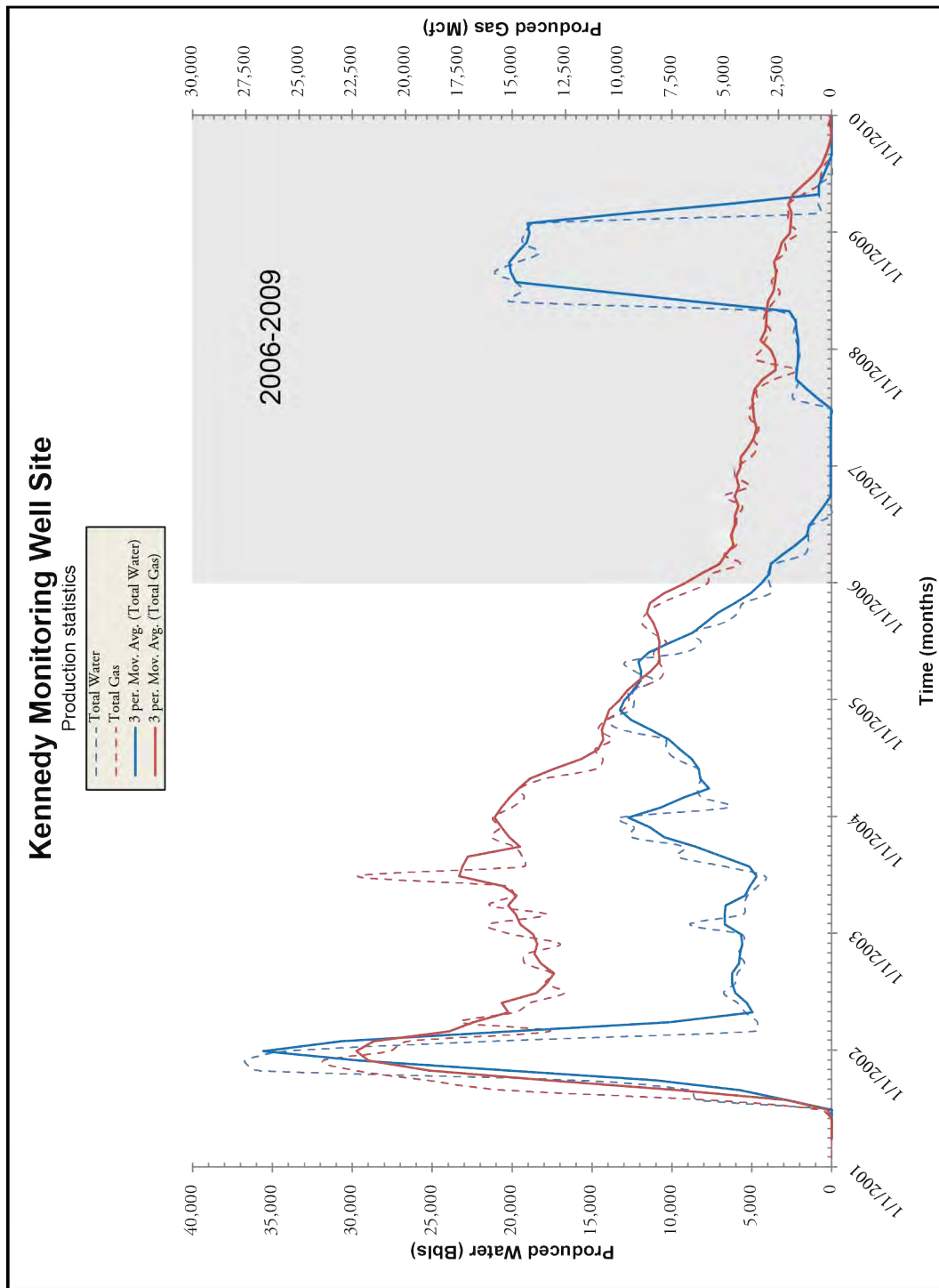


Figure 182. 3-period moving average along with water and gas production from associated CBNG wells.

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 constructed into the Wyodak-Anderson coal and the other is constructed into an overlying Wasatch sandstone (Figure 183; Table 91). Missing and/or fluctuating transducer data is the result of errors with on-site equipment.

The Wyodak-Anderson coal recorded a groundwater drawdown of 3 feet during the 2006-2009 monitoring period; data shows a slow decline in the groundwater level (Figure 184; Table 92). Groundwater levels in the Wasatch sandstone were stable during the 2006-2009 monitoring period, as they have been for the life of the well (Figure 184; Table 92). This, along with variable initial water levels, indicates there is no hydraulic connection between the monitored sandstone and producing zones. Gas pressures slowly declined during the 2006-2009 monitoring period.

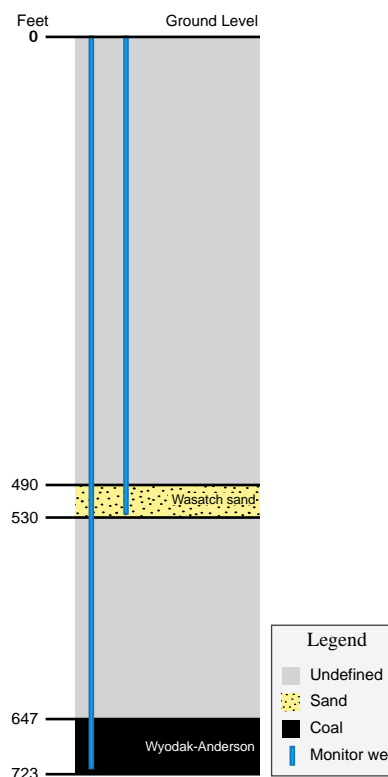


Figure 183. Section showing relative positions of coals and sands in feet. Not to scale.

Table 91. Table showing the depth to and thickness of monitored zones at the Lone Tree monitoring well site location. (measured in feet)

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

Table 92. Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2006	Drawdown 2006-2009	Total drawdown (ft.)	Depth to 12/31/09 water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	286.31	5.81	-0.27	5.54	291.85	n/a	n/a
Wyodak-Anderson coal ⁽¹⁾	453.10	205.70	3.40	209.10	662.20	61.00	5/21/02

⁽¹⁾ As of 11/30/09 the water level was measured at 662.20 feet and was noted as being a dry well at this time.

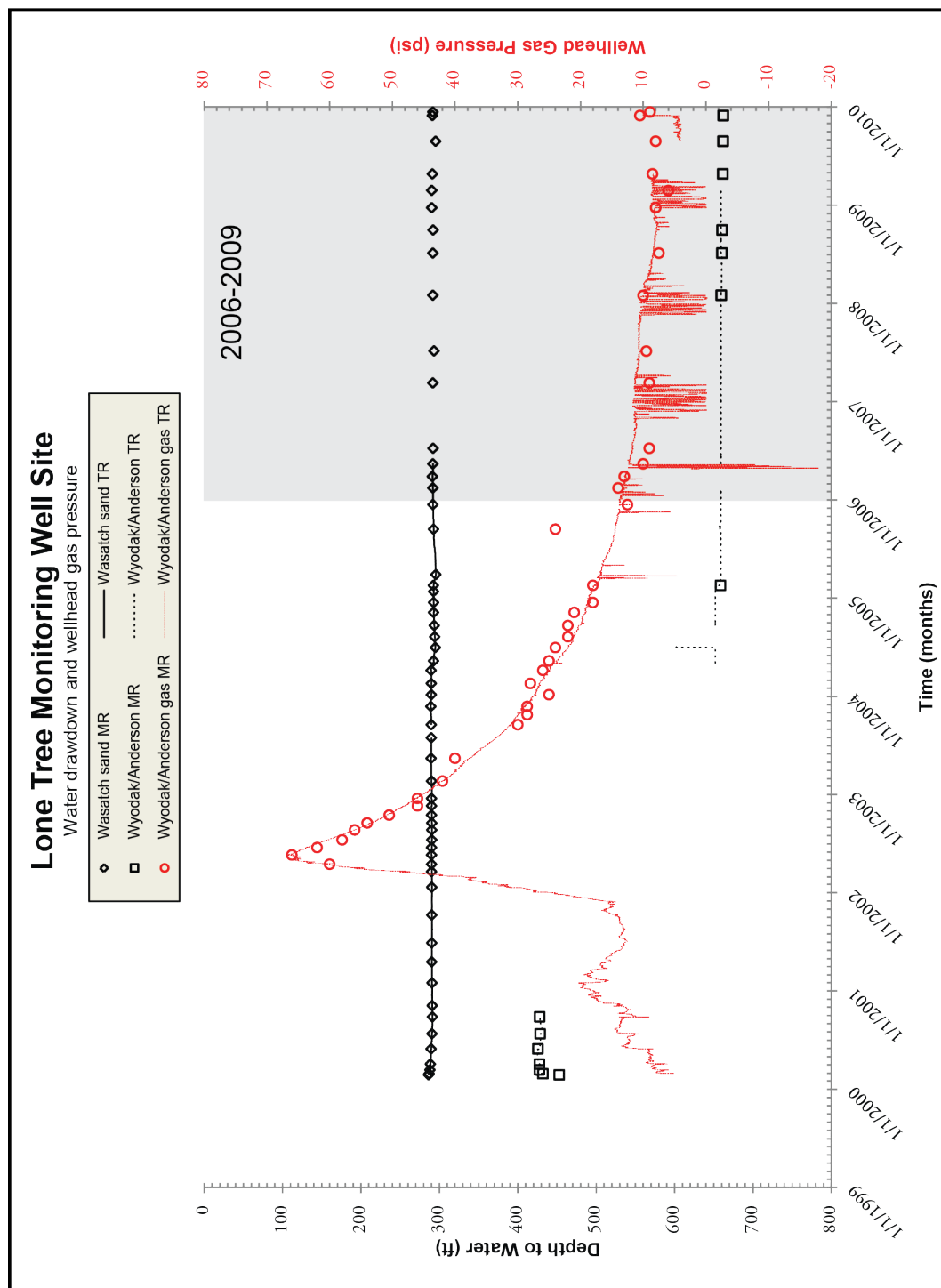


Figure 184. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Lone Tree monitoring well site location.

Production Statistics

Production data for the Lone Tree monitoring well site was not reported due to incomplete or generalized completion data for local CBNG wells.

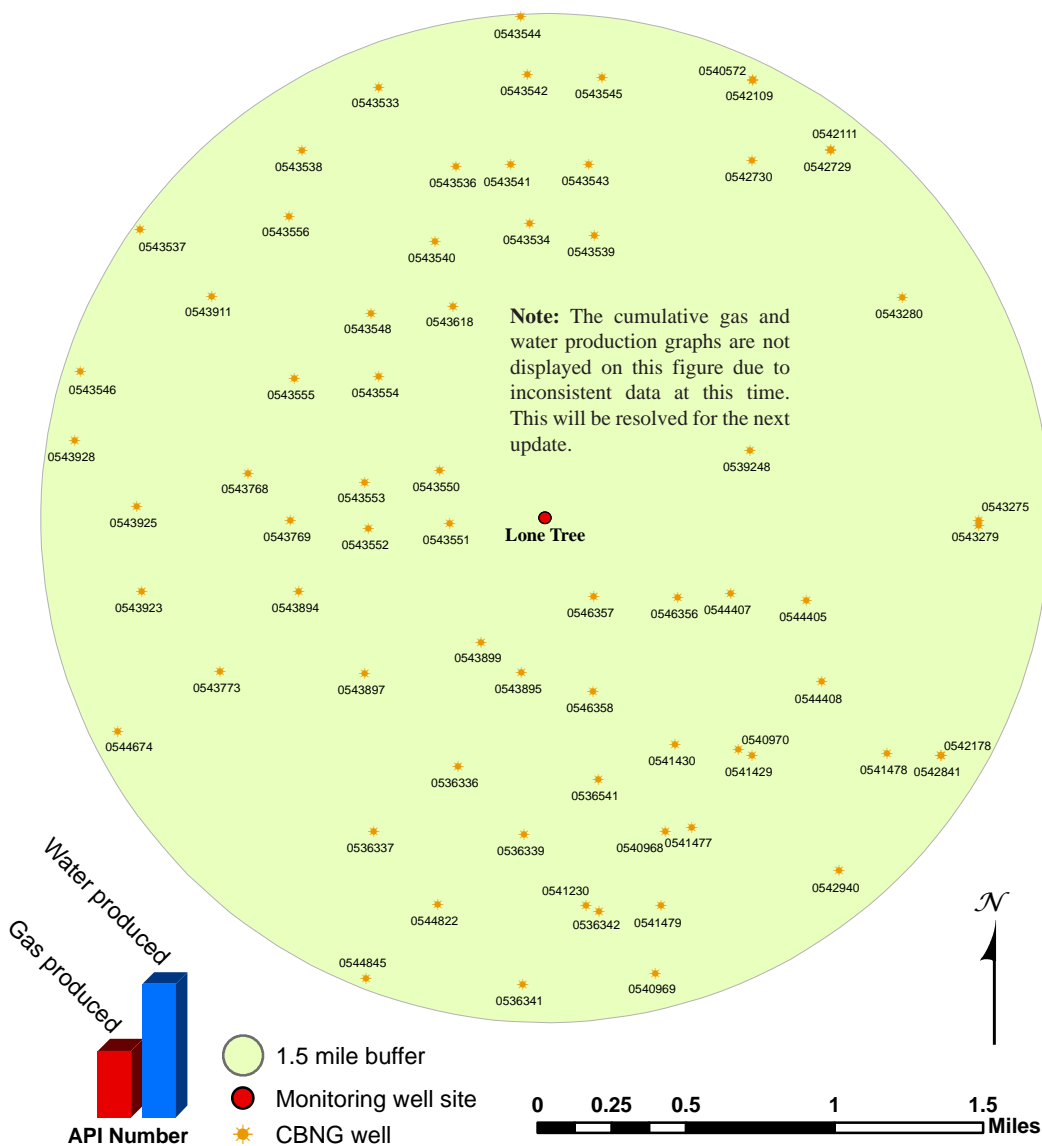


Figure 185. Lone Tree monitoring well and associated CBNG wells within 1.5 mile buffer showing cumulative water (Bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

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. One is drilled into the Anderson coal and the other two are drilled in overlying Wasatch sandstones (Figure 186; Table 93). Missing and/or fluctuating transducer data is the result of errors with on-site equipment.

The Anderson coal recorded a groundwater decrease of 8 feet during the 2006-2009 monitoring period; data shows relatively steady groundwater levels during 2006-2009 period. Groundwater levels in the Wasatch sandstone declined by 13 feet during the 2006-2009 monitoring period; data shows a steady decline (Figure 187; Table 94). This suggests there could be some influence of CBNG production on this sandstone, though drawdown trends indicate it is most likely a regional response and it is not directly hydraulically connected to the Anderson coal. Groundwater levels in the Wasatch Shallow sandstone were stable during the 2006-2009 monitoring period, as they have been for the life of the well (Figure 187; Table 94). This, along with variable initial water levels, indicates there is no hydraulic connection between the monitored sandstone and producing zones. Gas pressures in the Anderson coal declined abruptly towards the end of 2007, and since have not surpassed levels possible from transducer error.

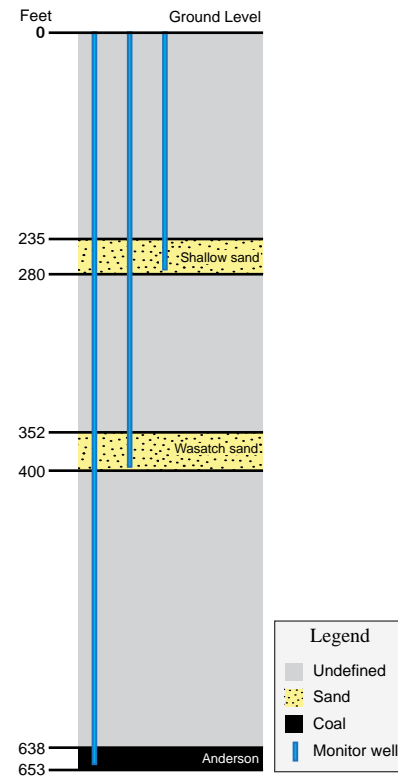


Figure 186. Section showing relative positions of coals and sands in feet. Not to scale.

Table 93. Table showing the depth to and thickness of monitored zones at the Lower Prairie Dog monitoring well site location. (measured in feet)

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

Table 94. Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2006	Drawdown 2006-2009	Total drawdown (ft.)	Depth to 12/31/09 water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Shallow sand	193.35	1.06	-0.50	0.56	193.91	n/a	n/a
Wasatch sand	197.60	3.40	12.85	16.25	213.85	n/a	n/a
Anderson coal	168.20	460.90	8.10	469.00	637.20	43	2/15/03

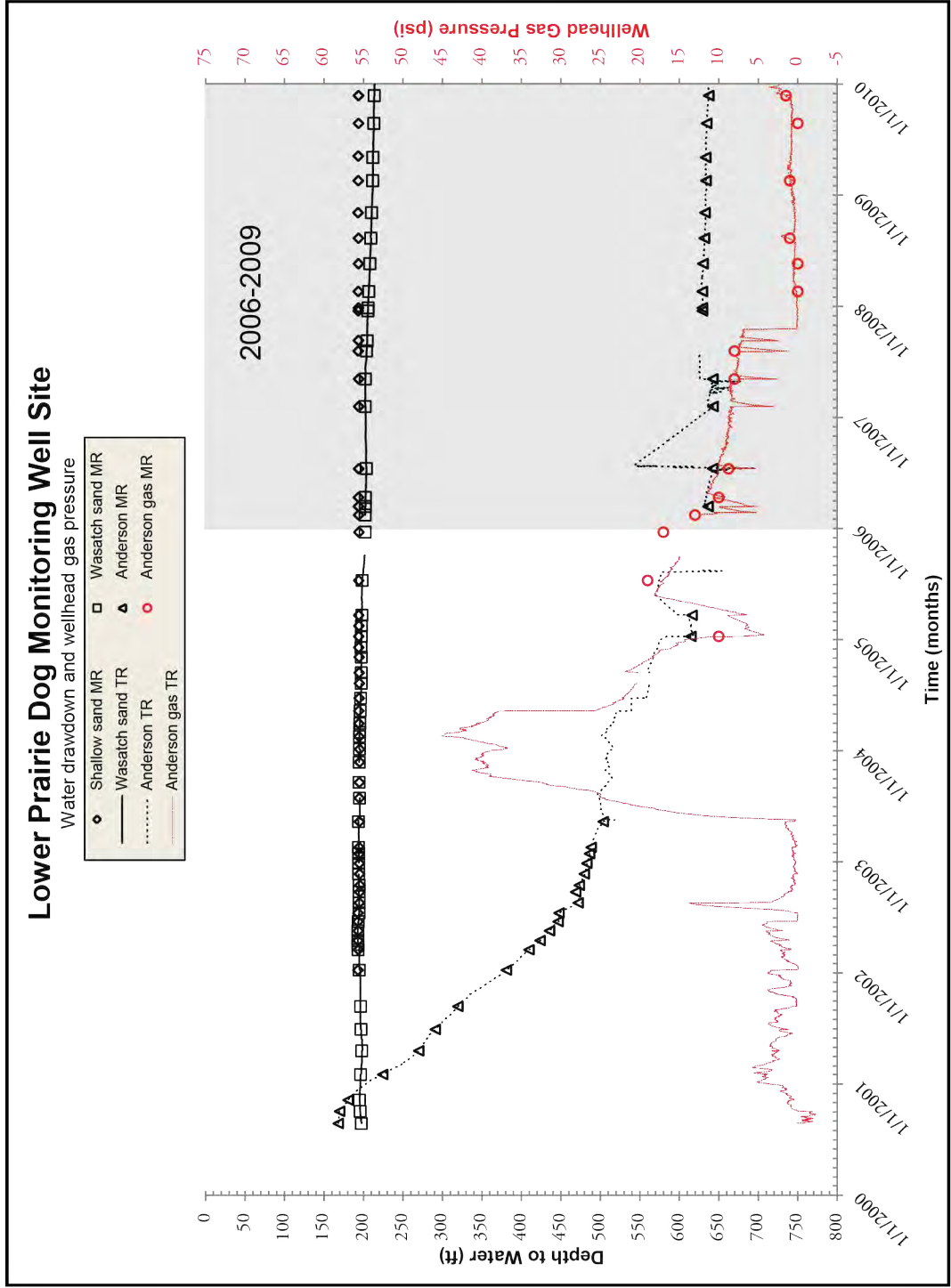


Figure 187. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Lower Prairie Dog monitoring well site location.

Production Statistics

Production data was analyzed for CBNG wells within the buffer of the Lower Prairie Dog monitoring well site from January 2000 through December 2009. Cumulative production for individual CBNG wells is displayed by location on Figure 188.

mained relatively constant and gas production declined during the 2006 to 2009 monitoring period (Figure 189). The water/gas ratio of CBNG wells within the buffer is relatively inconsistent. Percent methane is variable, though it generally decreases.

Water production increased in 2001, which correlates to groundwater drawdown trends. Water re-

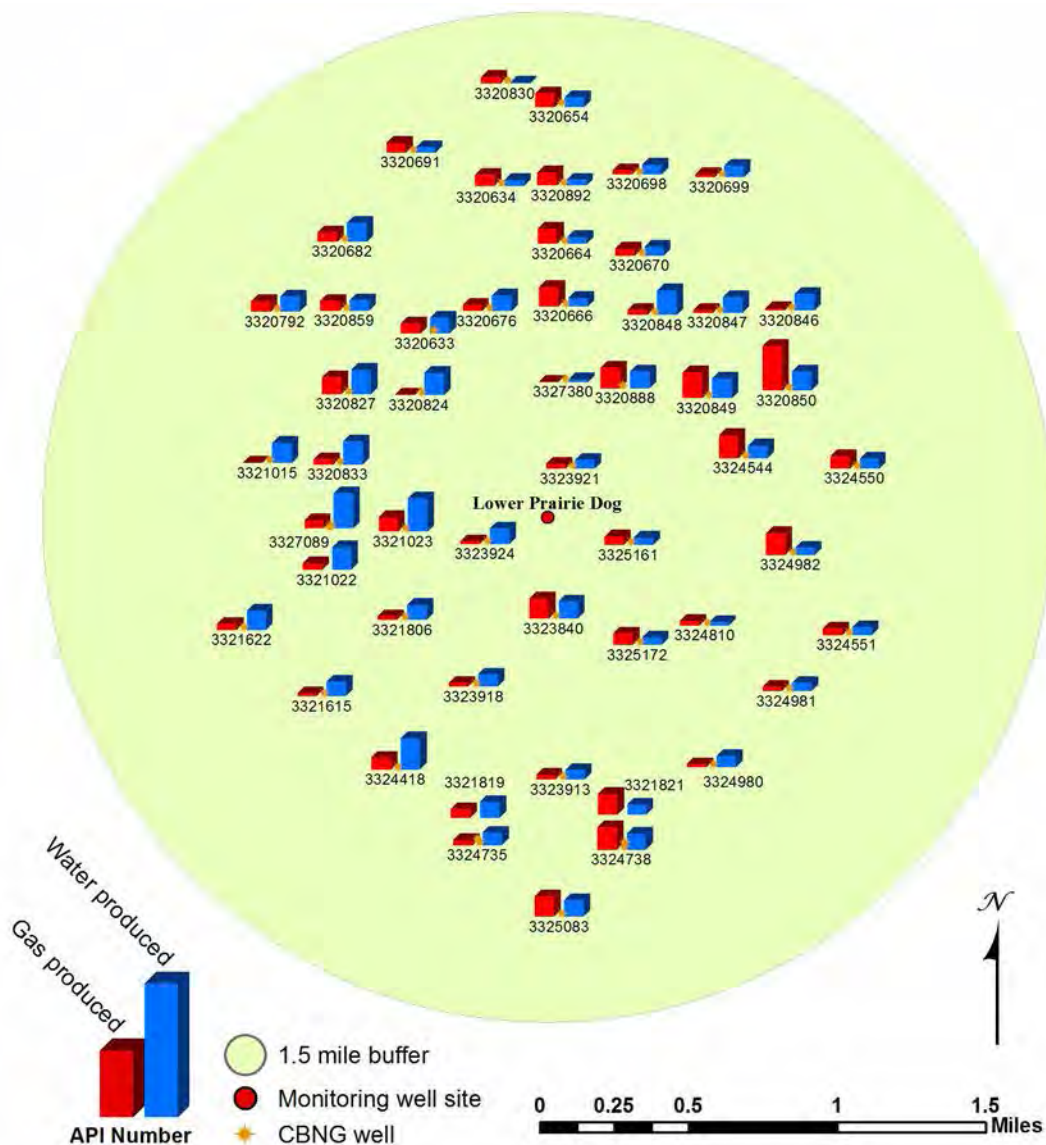


Figure 188. Lower Prairie Dog monitoring well and associated CBNG wells within 1.5 mile buffer showing cumulative water (Bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

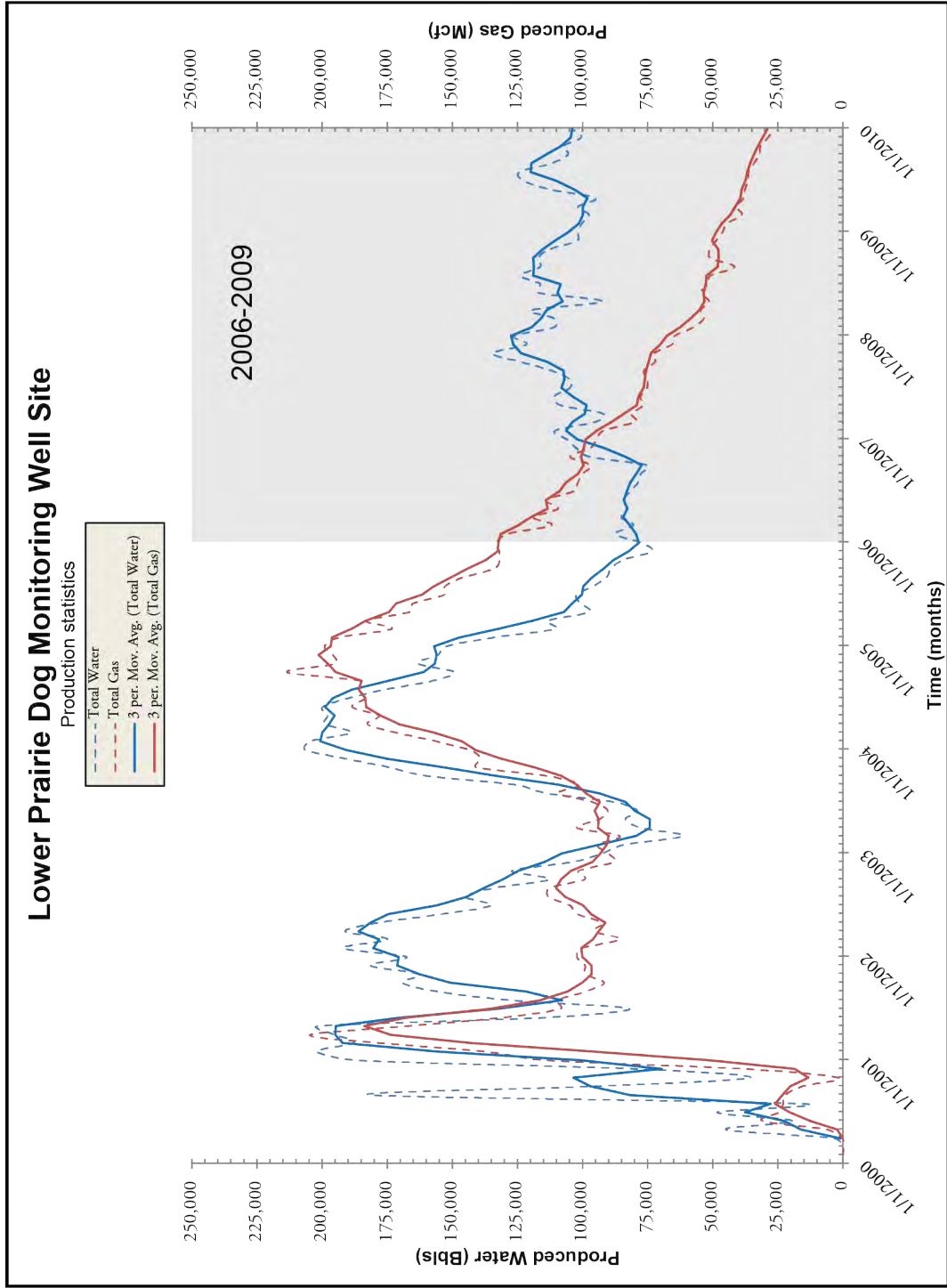


Figure 189. 3-period moving average along with water and gas production from associated CBNG wells.

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 drilled into the Wyodak coal and the other is drilled into a overlying Wasatch sandstone (Figure 190; Table 95). Missing and/or fluctuating transducer data is the result of errors with on-site equipment.

The Wyodak coal recorded a groundwater increase of 56 feet during the 2006-2009 monitoring period; data shows a steady rise in groundwater levels during the 2006-2009 monitoring period. With total drawdown of 161 feet during the life of the well. Groundwater levels in the Wasatch sandstone declined by 10 feet during the 2006-2009 monitoring period; (Figure 191; Table 96). Gas pressure readings did not surpass levels possible from transducer error.

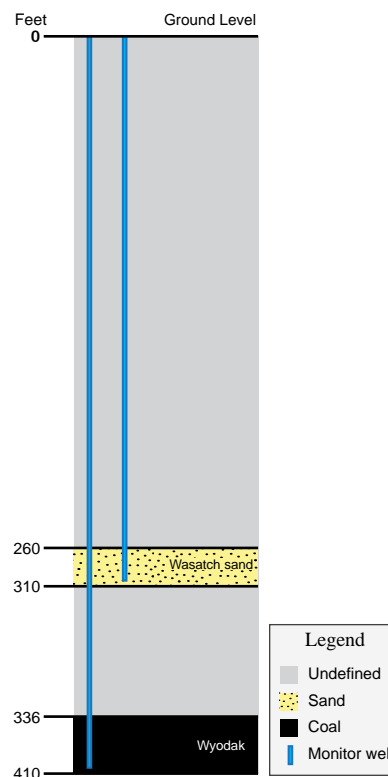


Figure 190. Section showing relative positions of coals and sands in feet. Not to scale.

Table 95. Table showing the depth to and thickness of monitored zones at the MP 2 monitoring well site location. (measured in feet)

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

Table 96. Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2006	Drawdown 2006-2009	Total drawdown (ft.)	Depth to 12/31/09 water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	51.51	49.45	10.45	59.90	111.41	n/a	n/a
Wydak coal	163.00	217.39	-56.08	161.31	324.31	43.00	10/23/96

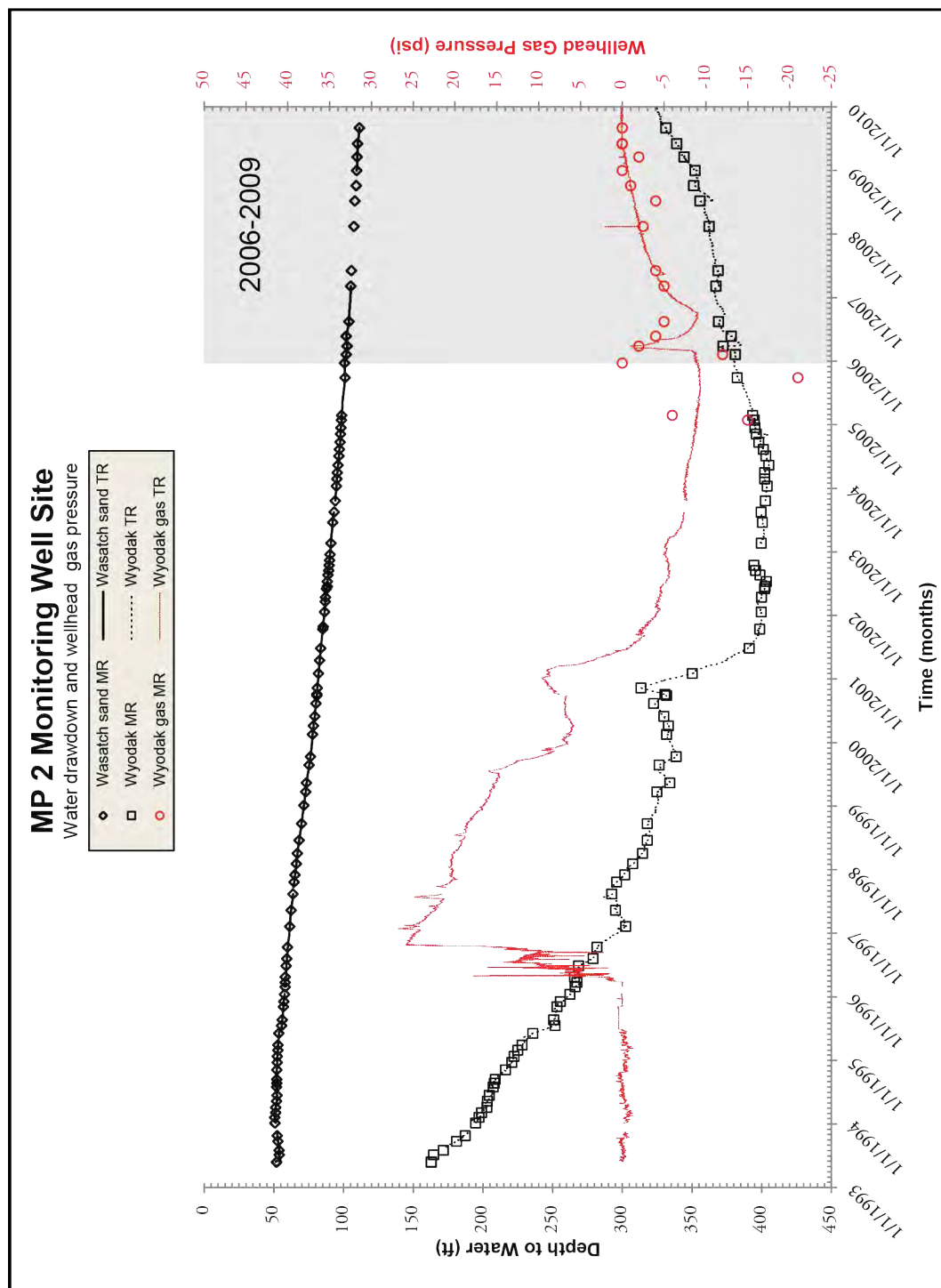


Figure 191. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the MP 2 monitoring well site location.

Production Statistics

Production data was analyzed for CBNG wells within the buffer of the MP 2 monitoring well site from January 1992 through December 2009. Cumulative production for individual CBNG wells is displayed by location on Figure 192.

production increased briefly in mid-2006, but both were minimal by 2007 (Figure 193). This correlates to the recovery in groundwater levels of the Wyodak coal bed (Figure 191). The water/gas ratio of CBNG wells within the buffer is relatively inconsistent. Percent methane is minimal.

Water production peaked in 2001, which correlates to groundwater drawdown trends. Water and gas

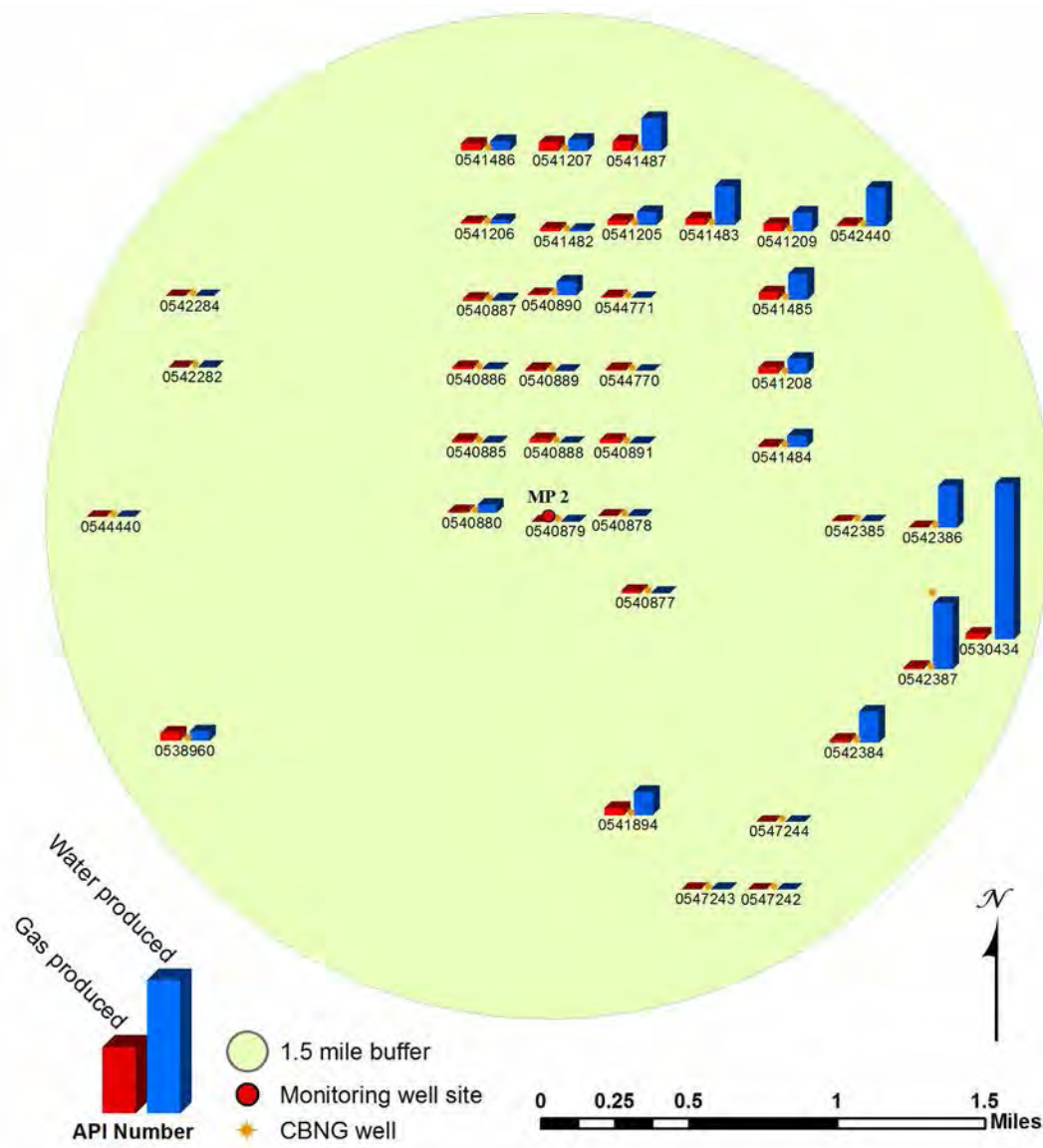


Figure 192. MP 2 monitoring well and associated CBNG wells within 1.5 mile buffer showing cumulative water (Bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

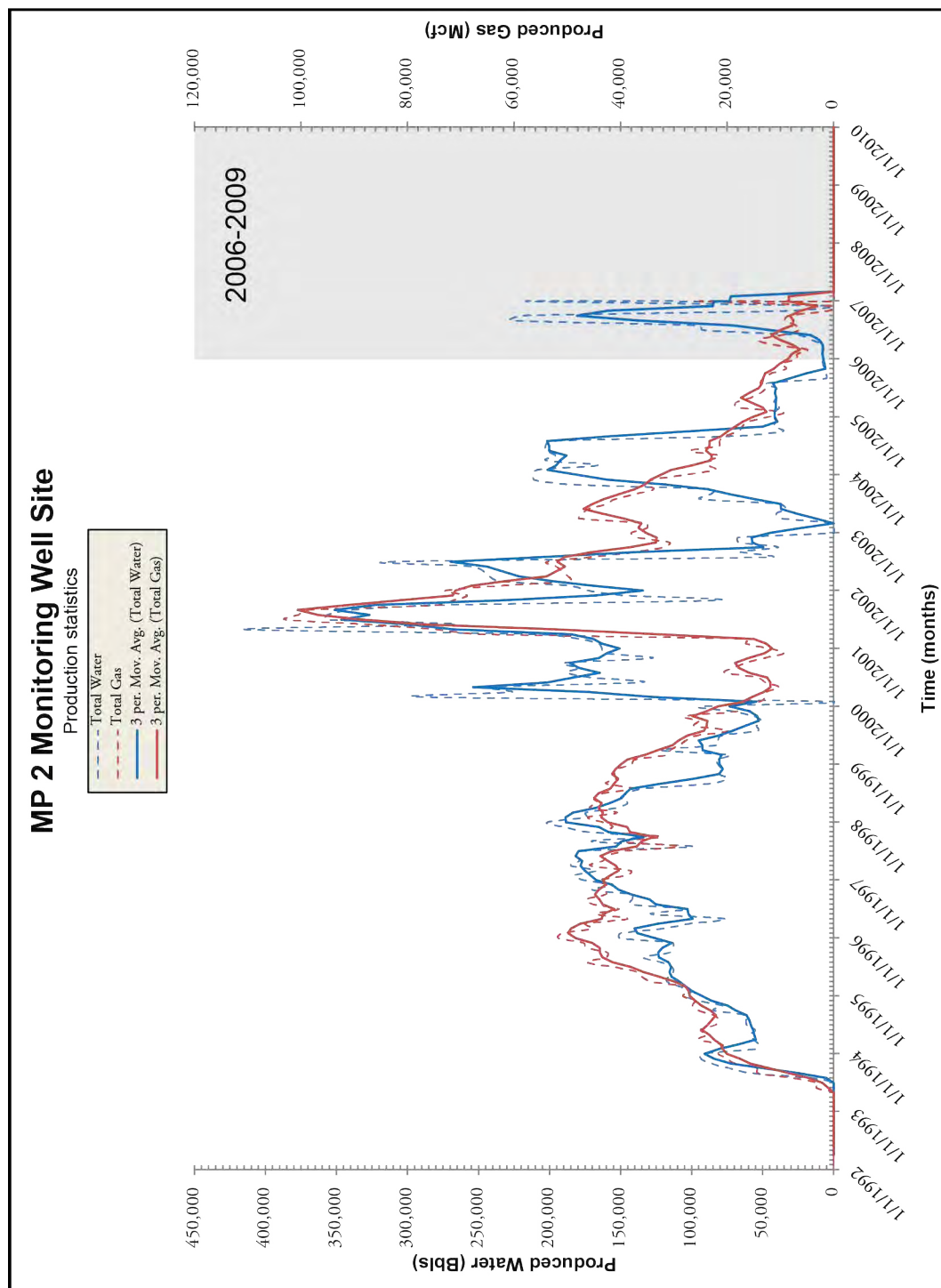


Figure 193. 3-period moving average along with water and gas production from associated CBNG wells.

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. One is drilled into the Wyodak coal and the other three are drilled into overlying Wasatch sandstone (Figure 194; Table 97). Missing and/or fluctuating transducer data is the result of errors with on-site equipment.

The Wyodak coal recorded a groundwater increase of 110 feet during the 2006-2009 monitoring period; data shows a steady rise in groundwater levels during the 2006-2009 monitoring period (this follows 290 feet of drawdown from 1999 to 2006). Groundwater levels in the deepest sandstone, labeled simply as Wasatch, declined by 8 feet during the 2006-2009 monitoring period (Figure 195; Table 98). This suggests there could be some influence of CBNG production on this sandstone, though drawdown trends indicate it is most likely a regional response and it is not directly hydraulically connected to the Wyodak coal. Groundwater levels in the remaining Wasatch sandstones (Shallow Sand and Very Shallow Sand) were stable during the 2006-2009 monitoring period, as they have been for the life of the well (Figure 195; Table 98). This, along with variable initial water levels, indicates there is no hydraulic connection between these monitored sandstones and producing zones. Gas pressure readings did not surpass levels possible from transducer error.

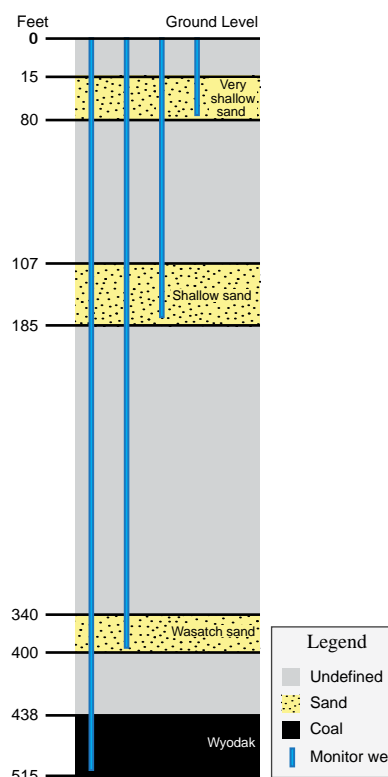


Figure 194. Section showing relative positions of coals and sands in feet. Not to scale.

Table 97. Table showing the depth to and thickness of monitored zones at the MP 22 monitoring well site location. (measured in feet)

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

Table 98. Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2006	Drawdown 2006-2009	Total drawdown (ft.)	Depth to 12/31/09 water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Very shallow sand	20.18	1.84	0.22	2.06	22.24	n/a	n/a
Shallow sand	38.29	-0.07	0.25	0.18	38.47	n/a	n/a
Wasatch sand	83.92	40.72	7.49	48.21	132.13	n/a	n/a
Wyodak coal	174.30	289.50	-110.26	179.24	353.54	61.00	8/30/91

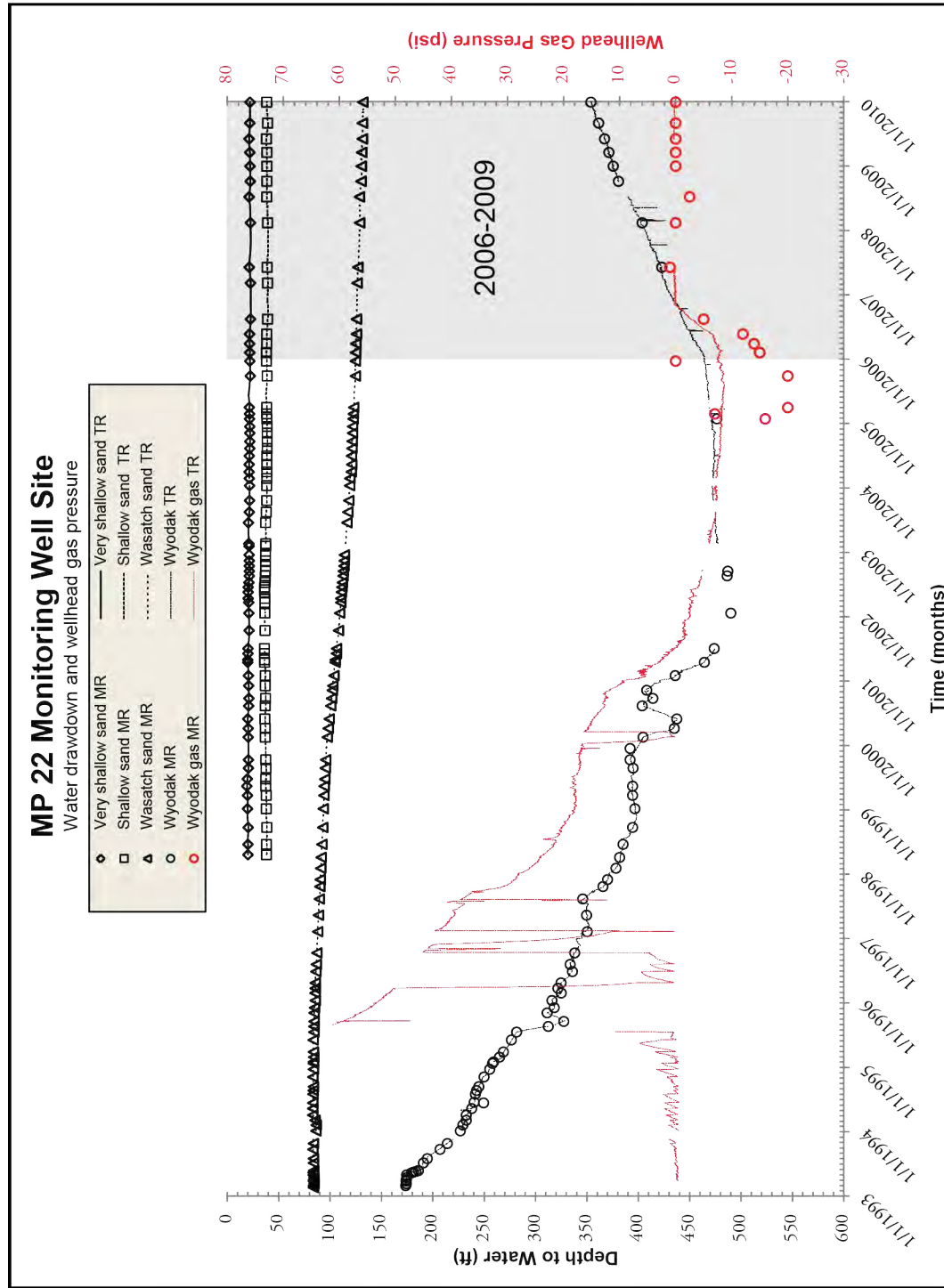


Figure 195. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the MP 22 monitoring well site location.

Production Statistics

Production data was analyzed for CBNG wells within the buffer of the MP 22 monitoring well site from January 1993 through December 2009. Cumulative production for individual CBNG wells is displayed by location on Figure 196.

production declined during the 2006 to 2009 monitoring period, and was minimal by 2007 (Figure 197). This correlates to the recovery in groundwater levels of the Wyodak coal bed (Figure 195). The water/gas ratio of CBNG wells within the buffer is relatively inconsistent. Percent methane is minimal.

Water production peaked in 1998, which correlates to groundwater drawdown trends. Water and gas

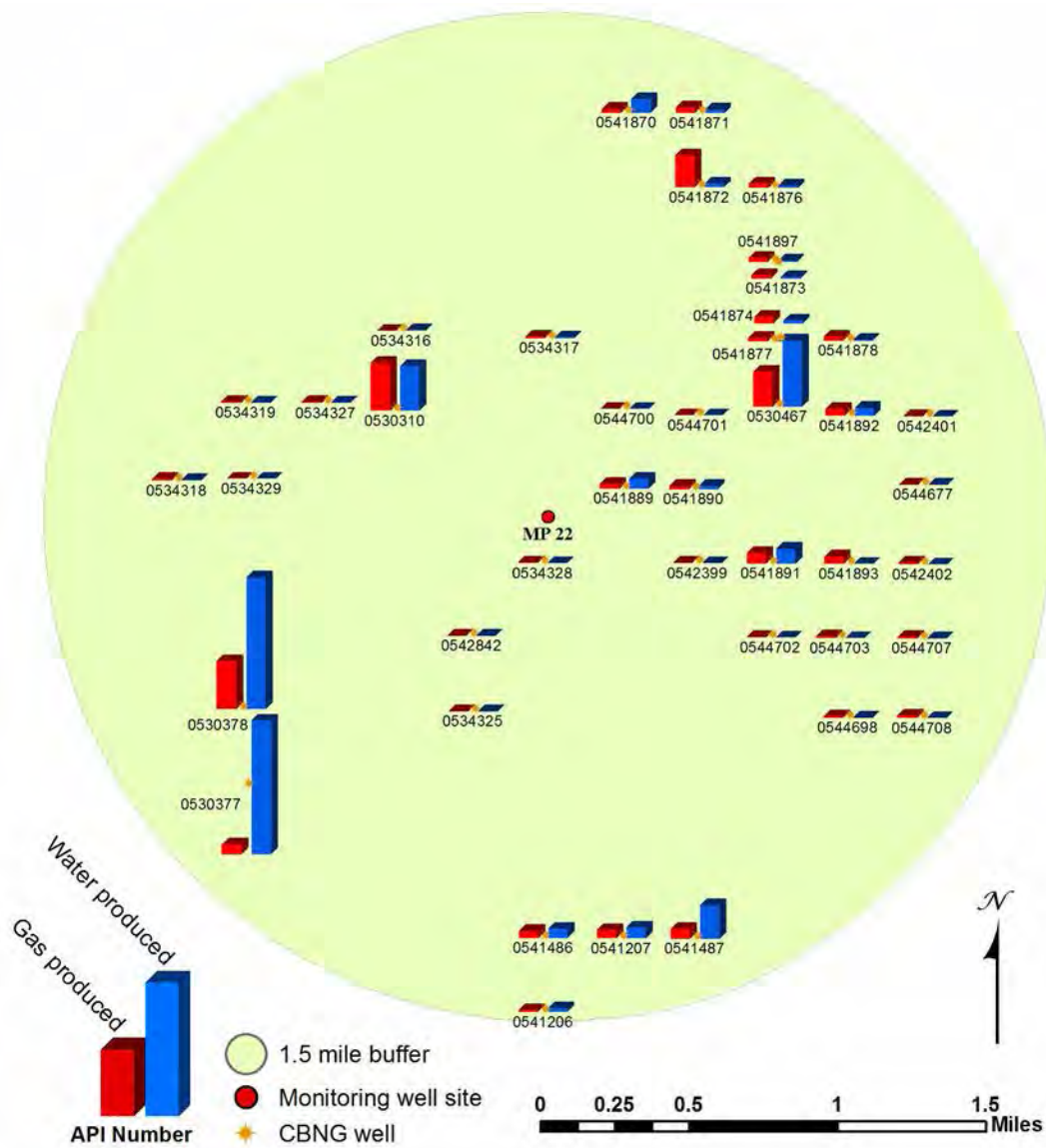


Figure 196. MP 22 monitoring well and associated CBNG wells within 1.5 mile buffer showing cumulative water (Bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

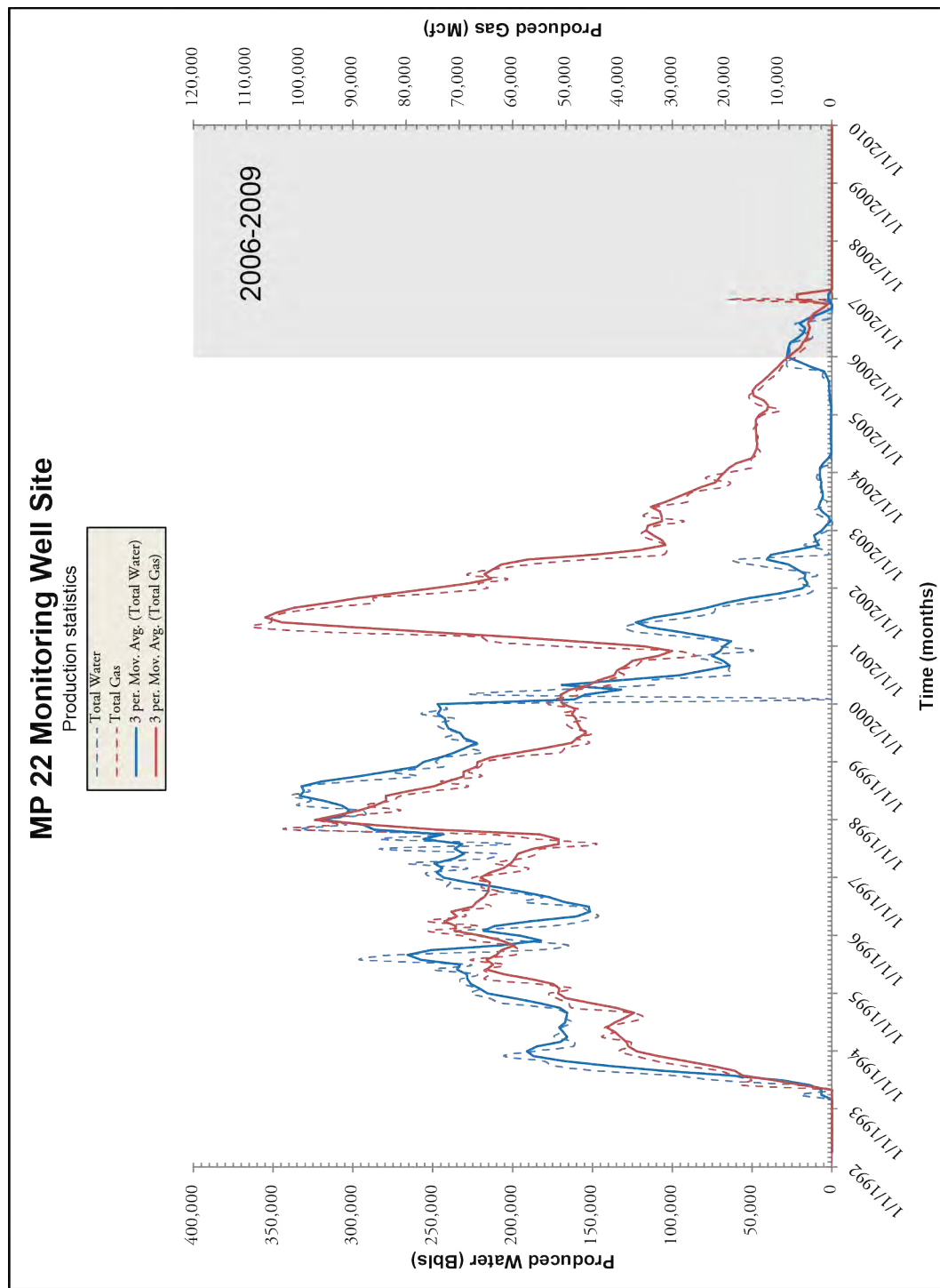


Figure 197. 3-period moving average along with water and gas production from associated CBNG wells.

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

Drawdown Information

The North Cordero monitoring well site consists of one well drilled into the Wyodak coal. Manual measurements were taken during the 2006-2009 monitoring period and showed no associated groundwater drawdown or increase (Figure 198; Table 99). The well was reported dry at 392 feet on August 12, 2004. Three notes were made in 2009 that the well was dry, no depths were recorded. Missing data from 1996-2002 is not discussed in the data received.

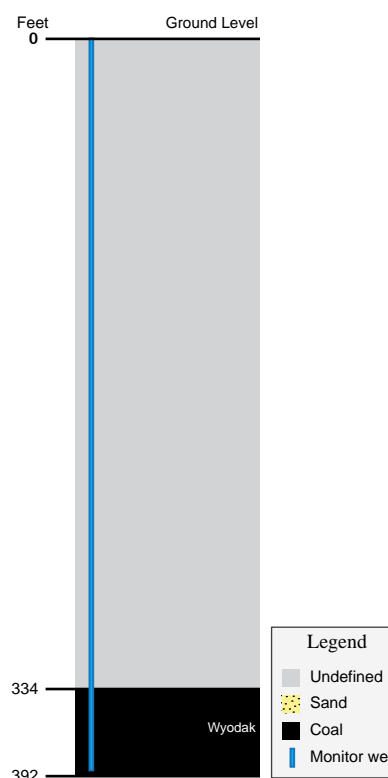


Figure 198. Section showing relative positions of coals and sands in feet. Not to scale.

Table 99. Table showing the depth to and thickness of monitored zones at the North Cordero monitoring well site location. (measured in feet)

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

Table 100. Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2006	Drawdown 2006-2009	Total drawdown (ft.)	Depth to 12/31/09 water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wyodak coal ⁽¹⁾	245.18	146.82	0.00	146.82	392.00	33.00	2/27/96

⁽¹⁾ The electronic collection of water level data stopped in 10/96, after which the well was monitored for water level every six months. Starting on 8/12/04 the well was reported dry at a total depth of the well of 392 feet.

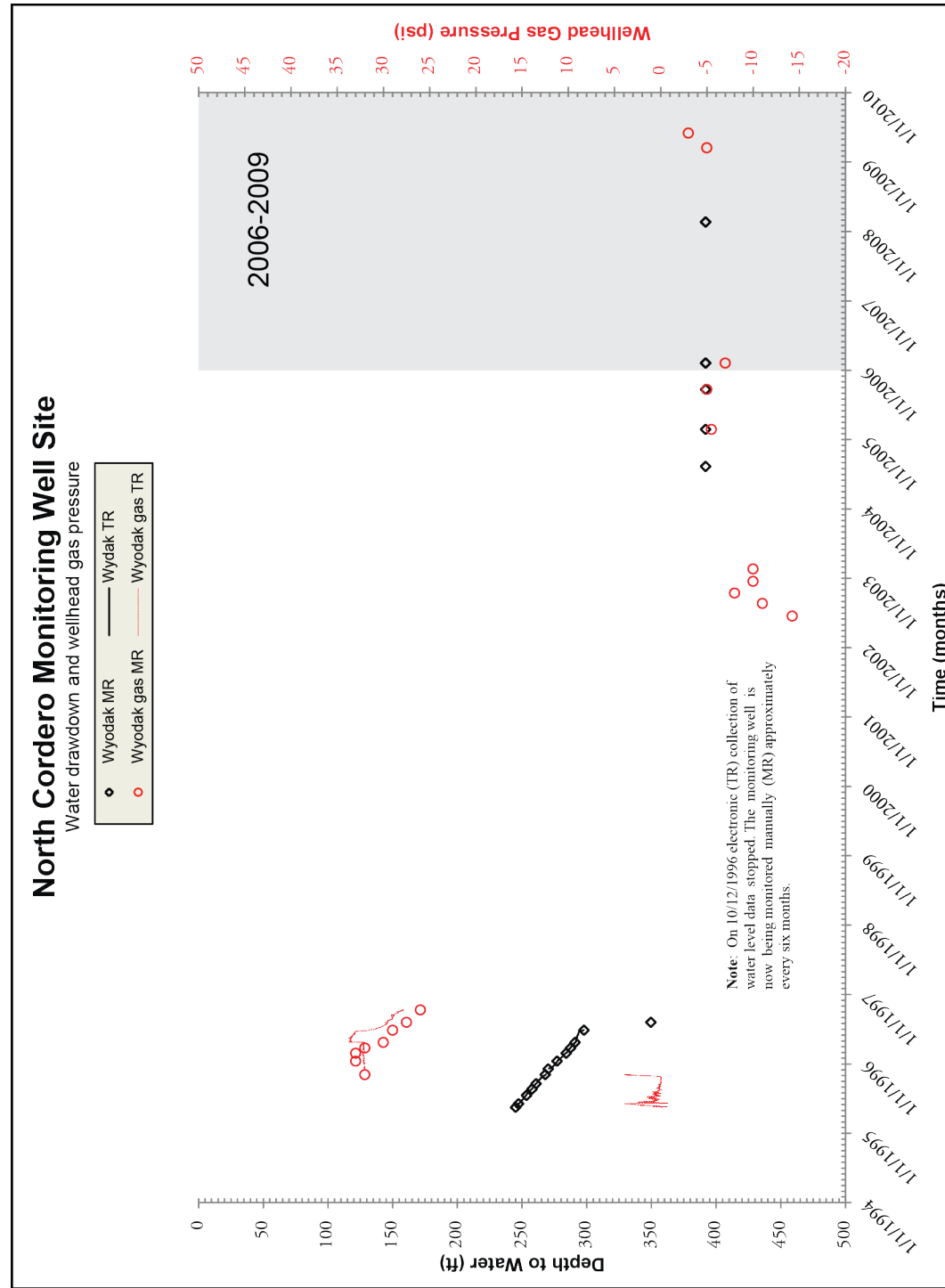


Figure 199. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the North Cordero monitoring well site location.

Production Statistics

Production data was analyzed for CBNG wells within the buffer of the North Cordero monitoring well site from January 1997 through December 2009. Cumulative production for individual CBNG wells is displayed by location on Figure 200.

cernible trends. Water and gas production declined during the 2006 to 2009 monitoring period, and were minimal by 2008 (Figure 199). The water/gas ratio of CBNG wells within the buffer is relatively inconsistent. Percent methane is variable.

Water production peaked in 2000. There is limited groundwater monitoring data, so there are no dis-

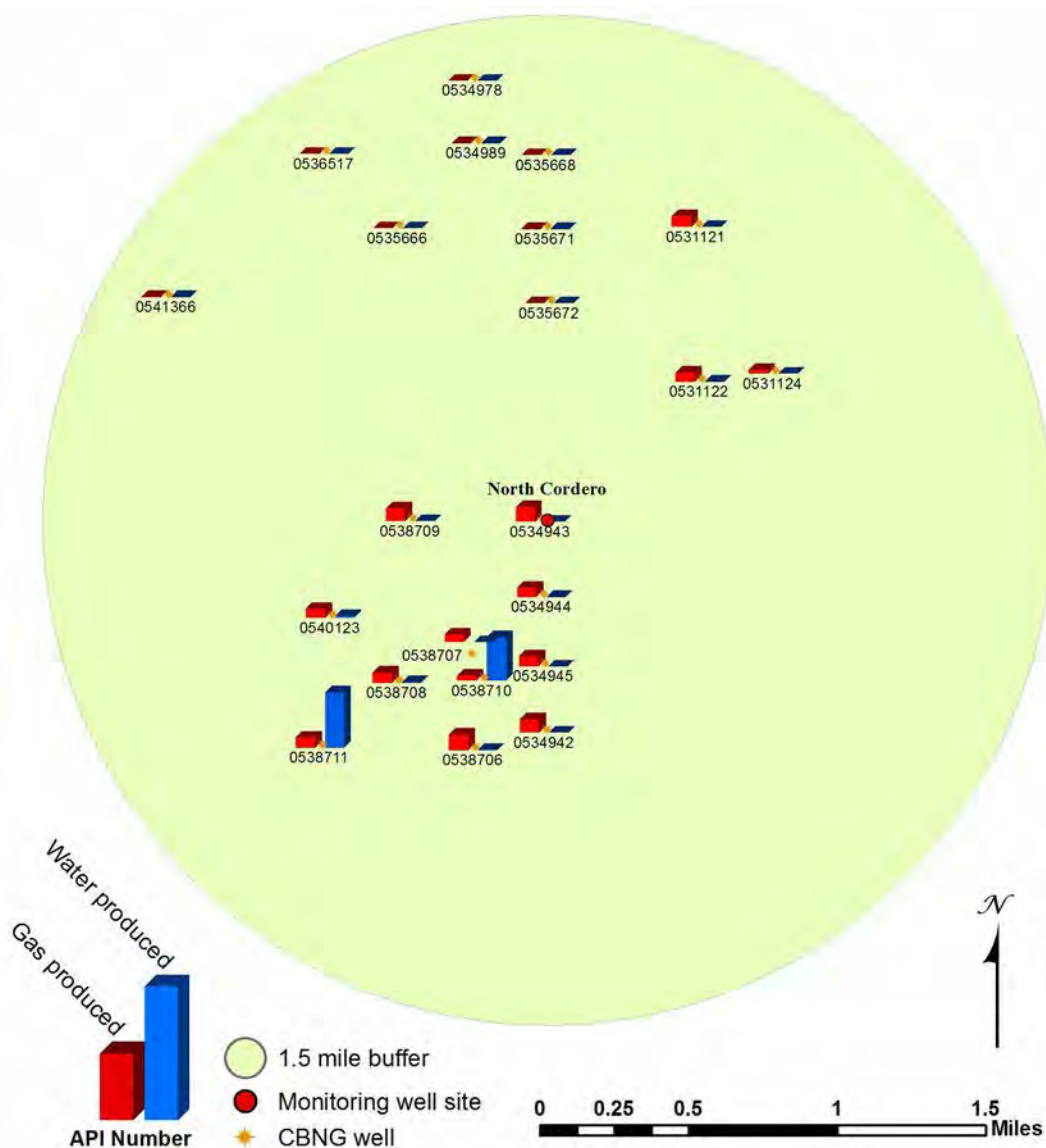


Figure 200. North Cordero monitoring well and associated CBNG wells within 1.5 mile buffer showing cumulative water (Bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

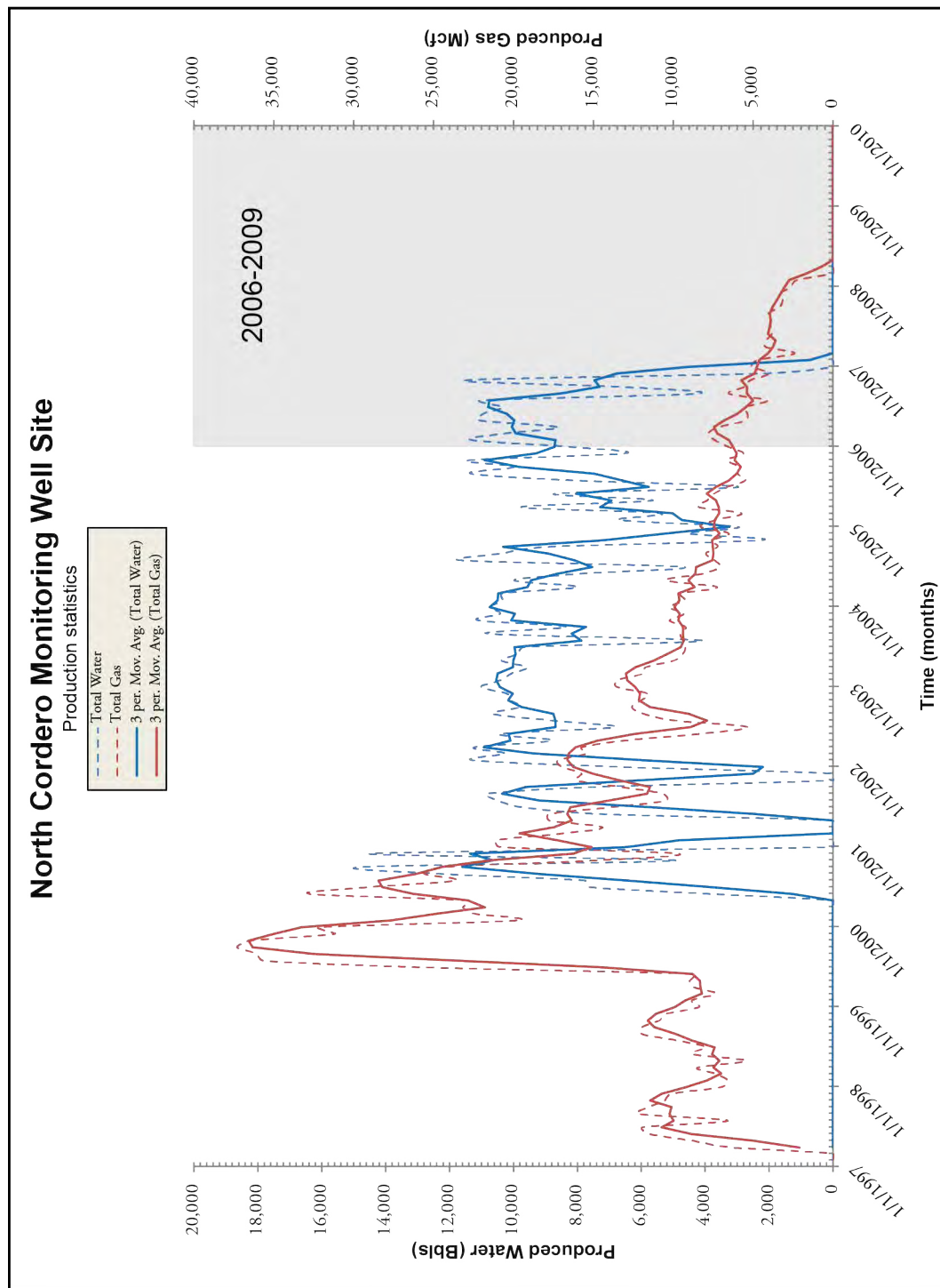


Figure 201. 3-period moving average along with water and gas production from associated CBNG wells.

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 well is drilled into the Anderson coal, one is drilled into the deeper Canyon coal, and the third is drilled into an overlying Wasatch sandstone (Figure 202; Table 101). Missing and/or fluctuating transducer data is the result of errors with on-site equipment.

The Anderson coal has no recorded groundwater decrease during the 2006-2009 monitoring period due to the hole being dry at 575 feet (Figure 203; Table 102). The Canyon coal showed a drawdown of 12 feet during the 2006-2009 monitoring period (Figure 203; Table 102). Though they are proximal depth-wise, there is not enough data to determine if the Anderson and Canyon coals are hydraulically connected. Groundwater levels in the Wasatch sandstone remained steady during the 2006-2009 monitoring period, and they have remained nearly constant throughout the life of the well (Figure 203; Table 102). This suggests that there is no hydraulic connection between the monitored sandstone and producing zones. Gas pressure readings did not surpass levels possible from transducer error.

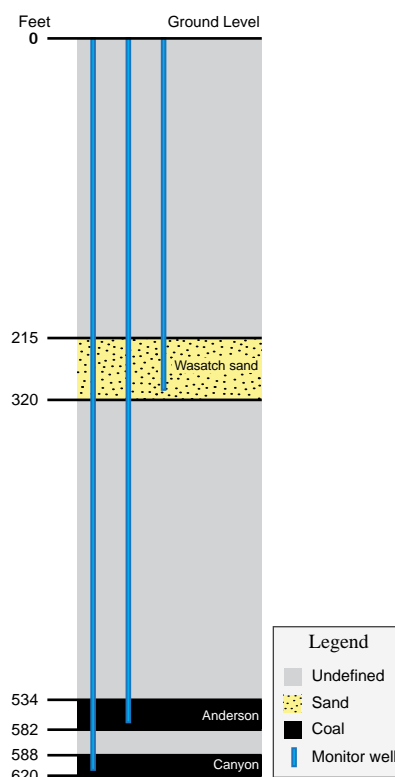


Figure 202. Section showing relative positions of coals and sands in feet. Not to scale.

Table 101. Table showing the depth to and thickness of monitored zones at the North Gillette monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Wasatch sand	215	320	105	214
Anderson coal	534	582	48	n/a
Canyon coal	588	620	32	n/a

Table 102. Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2006	Drawdown 2006-2009	Total drawdown (ft.)	Depth to 12/31/09 water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	122.17	5.17	-0.29	4.88	127.05	n/a	n/a
Anderson coal ⁽¹⁾	499.20	75.80	0.00	75.80	575.00	4.60	5/14/02
Canyon coal	447.30	78.00	12.46	90.46	537.76	0.70	2/23/07

⁽¹⁾ Well was dry after 2/14/07 at total depth of well of 575 feet.

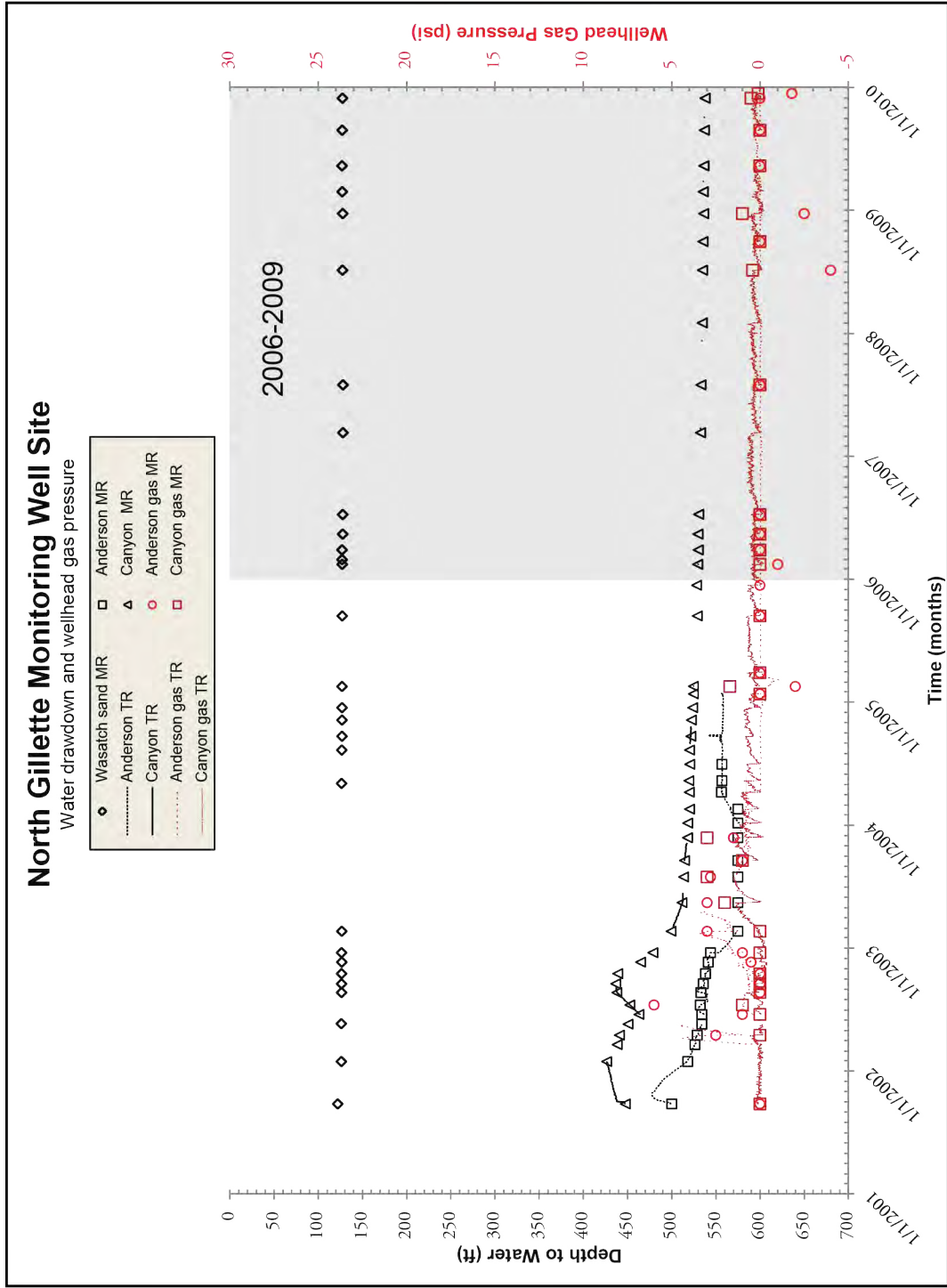


Figure 203. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the North Gillette monitoring well site location.

Production Statistics

Production data for the North Gillette monitoring well site was not reported due to incomplete or generalized completion data for local CBNG wells.

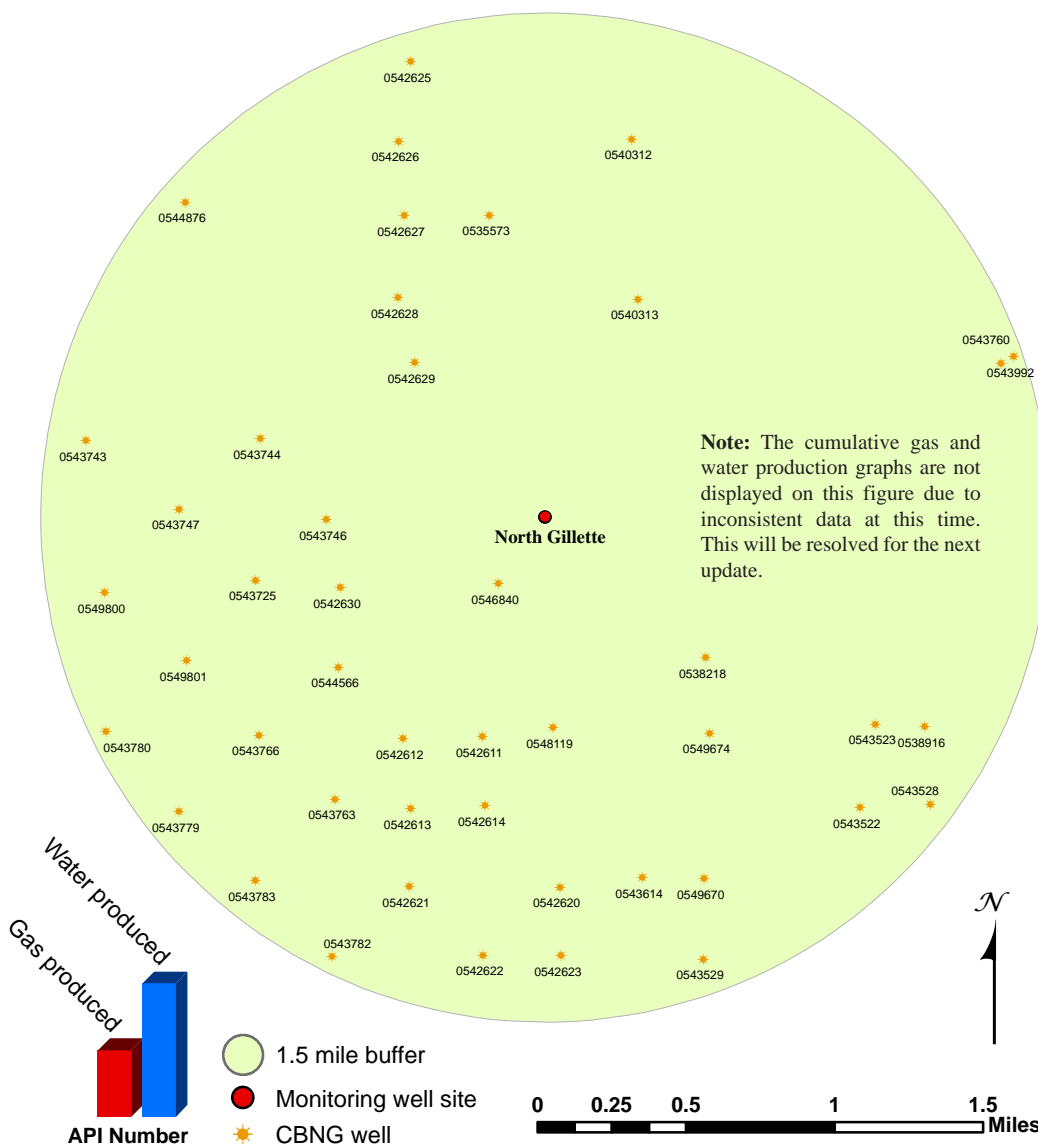


Figure 204. North Gillette monitoring well and associated CBNG wells within 1.5 mile buffer showing cumulative water (Bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

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 well is drilled into the Anderson coal, one is drilled into the deeper Canyon coal, one is drilled into the still deeper Cook coal, and the fourth is drilled into a overlying Wasatch sandstone (Figure 205; Table 103). Missing and/or fluctuating transducer data is the result of errors with on-site equipment.

The Anderson coal recorded a groundwater decrease of 83 feet during the 2006-2009 monitoring period; data shows a slow decline in the groundwater level (Figure 206; Table 104). The Canyon coal recorded a groundwater decrease of 104 feet during the 2006-2009 monitoring period; data shows a steady decline in the groundwater level (Figure 206; Table 104). The Cook coal recorded a groundwater decrease of 59 feet during the 2006-2009 monitoring period; data shows a steady decline in the groundwater level (Figure 206; Table 104). Groundwater levels in the Wasatch sandstone increased by 2 feet during the 2006-2009 monitoring period, and they have remained nearly constant throughout the life of the well (Figure 206; Table 104). This indicates there is no hydraulic connection between the monitored sandstone and producing zones.

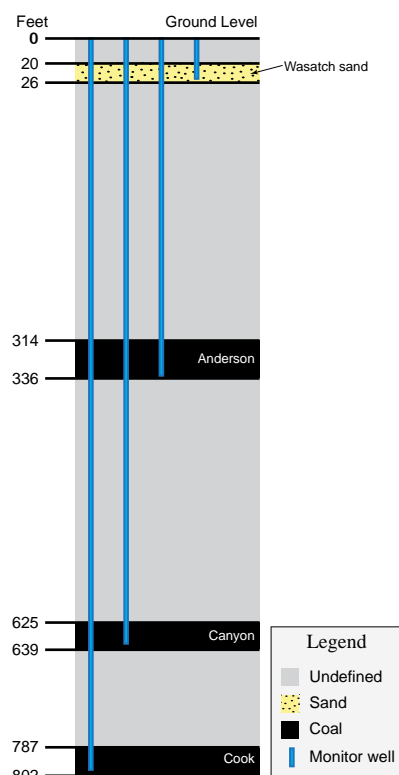


Figure 205. Section showing relative positions of coals and sands in feet. Not to scale.

Table 103. Table showing the depth to and thickness of monitored zones at the Remington Creek monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Wasatch sand	20	26	6	288
Anderson coal	314	336	22	n/a
Canyon coal	625	639	14	n/a
Cook coal	787	802	15	n/a

Table 104. Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2006	Drawdown 2006-2009	Total drawdown (ft.)	Depth to 12/31/09 water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	4.64	0.00	-2.33	-2.33	2.31	n/a	n/a
Anderson coal	160.00	60.20	82.57	142.77	302.77	60.00	8/30/05
Canyon coal	378.40	33.36	104.24	137.60	516.00	n/a	n/a
Cook coal	378.00	72.59	59.11	131.70	509.70	n/a	n/a

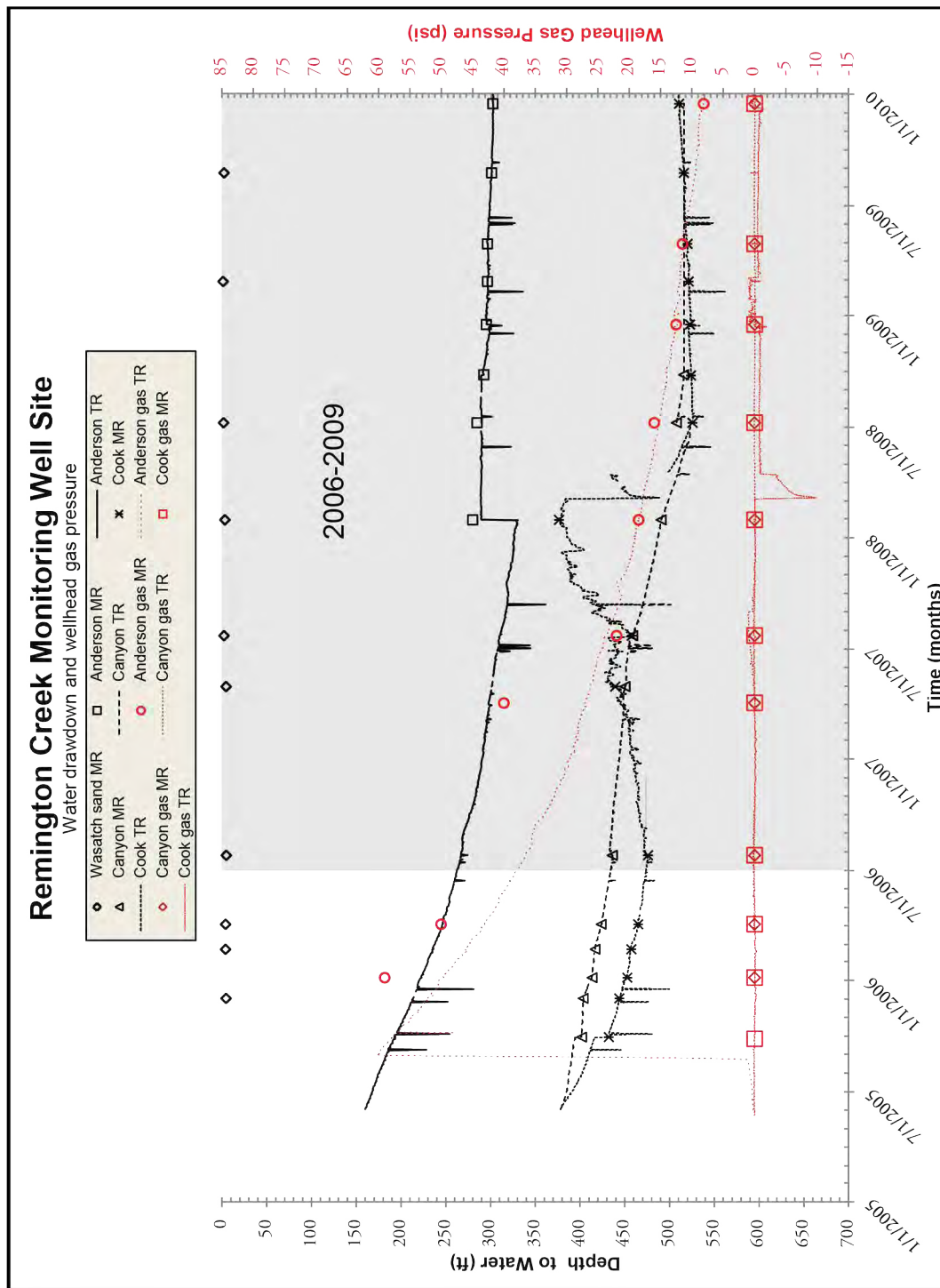


Figure 206. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Remington Creek monitoring well site location. Gray area represents the current monitoring period of 2006-2009.

Production Statistics

Production data was analyzed for CBNG wells within the buffer of the Remington Creek monitoring well site from January 2004 through December 2009. Cumulative production for individual CBNG wells is displayed by location on Figure 207.

at which time they remained nearly constant (Figure 206). Water and gas production increased (for the most part) during the 2006 to 2009 monitoring period (Figure 208). The water/gas ratio of CBNG wells within the buffer is relatively inconsistent. Percent methane is relatively consistent.

Water production increased in 2004 and peaked in mid-2008. Groundwater levels declined until 2008,

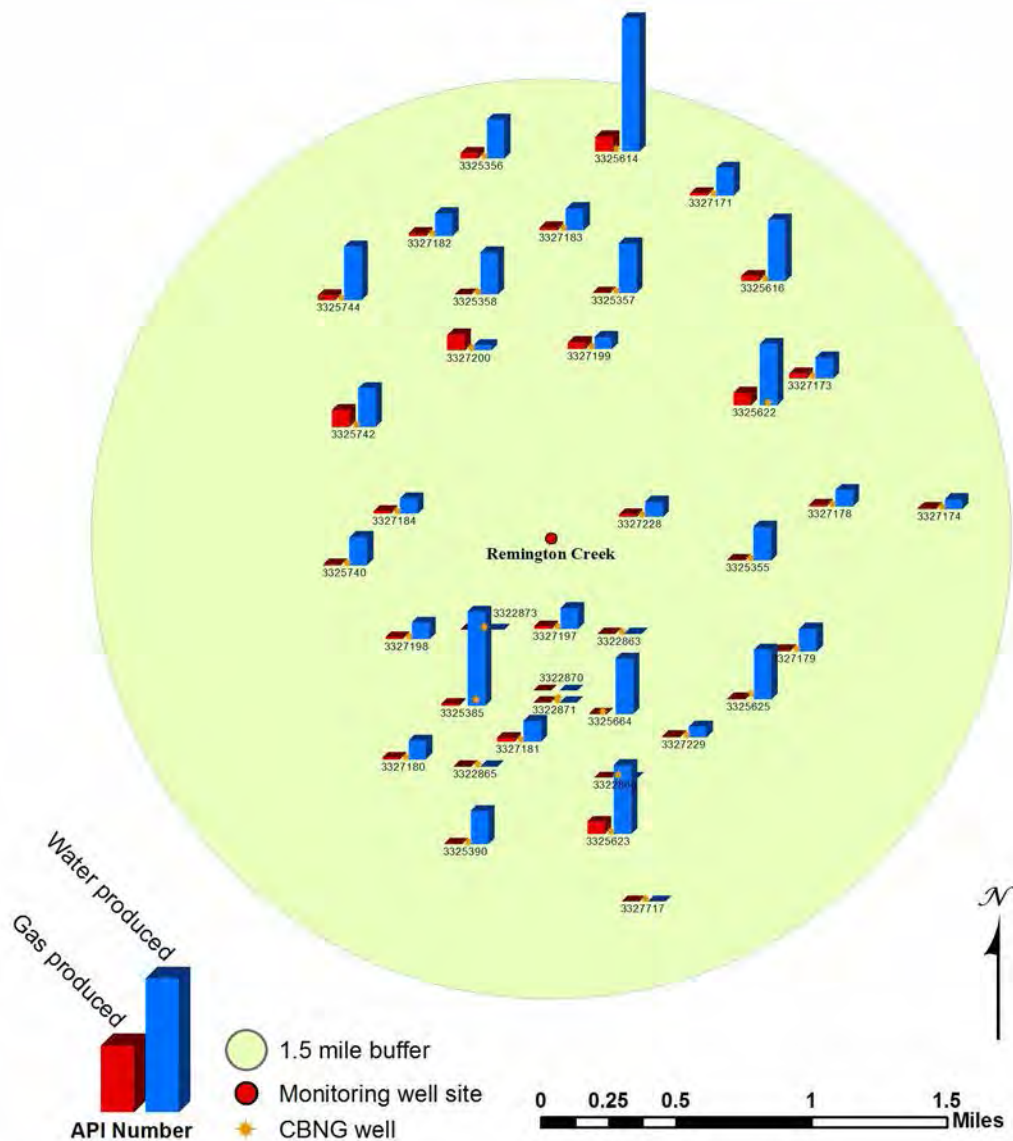


Figure 207. Remington Creek monitoring well and associated CBNG wells within 1.5 mile buffer showing cumulative water (Bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

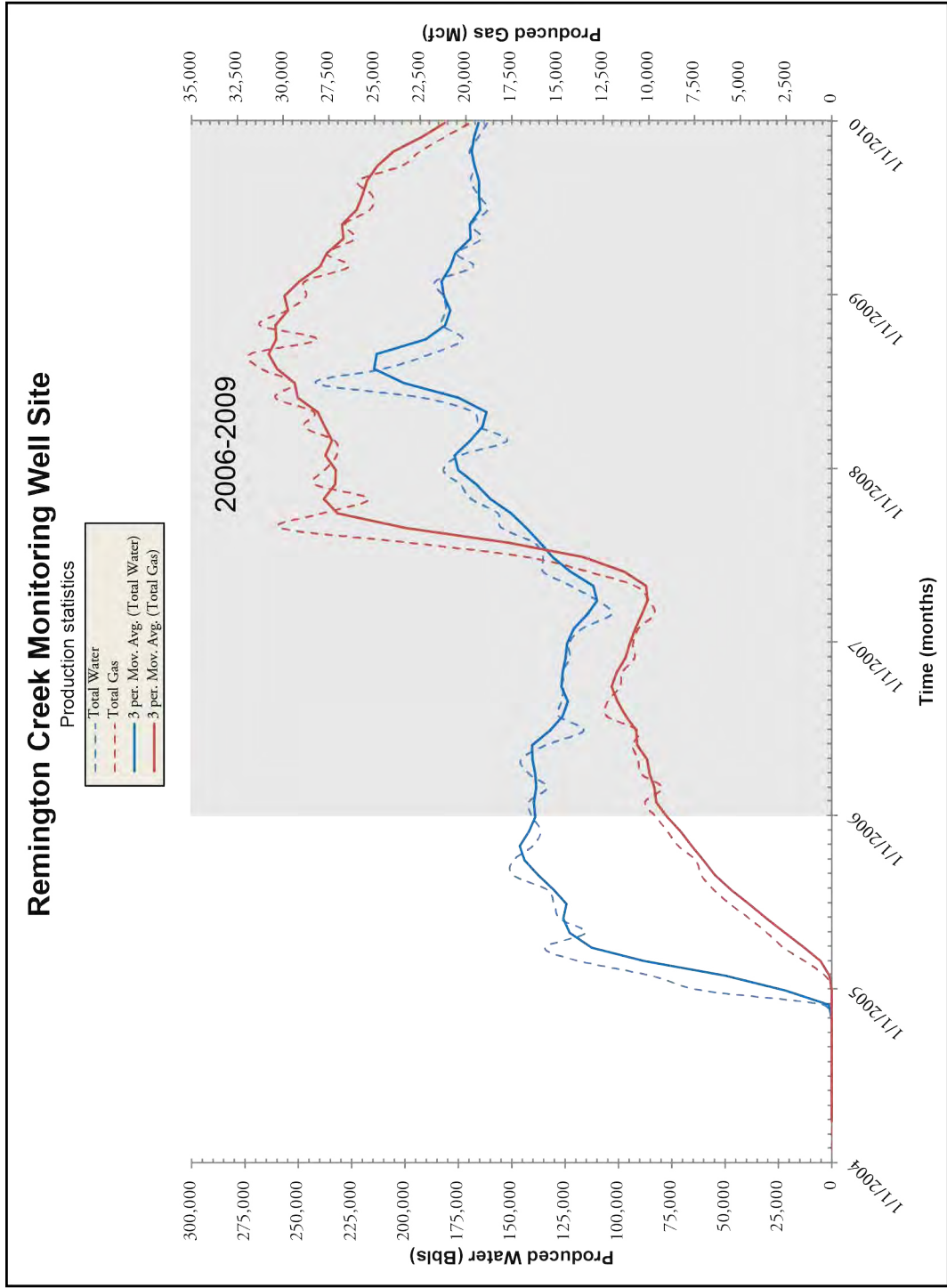


Figure 208. 3-period moving average along with water and gas production from associated CBNG wells.

Section 25 Monitoring Well Site
Location: S25 T46N R72W
Date First Monitored: November 9, 1996

Drawdown Information

The Section 25 monitoring well site includes two wells. One is drilled into the Wyodak coal and the other is drilled into an overlying Wasatch sandstone (Figure 209; Table 105). Missing and/or fluctuating transducer data is the result of errors with on-site equipment.

The Wyodak coal recorded a groundwater draw-down of 68 feet during the 2006-2009 monitoring period; data shows groundwater level was mostly stable after 2004 (Figure 210; Table 106). Groundwater levels in the Wasatch sandstone were stable during the 2006-2009 monitoring period, as they have been for the life of the well (Figure 210; Table 106). This, along with variable initial water levels, indicates there is no hydraulic connection between the monitored Wasatch sandstone and producing zones. Gas pressure readings did not surpass levels possible from transducer error.

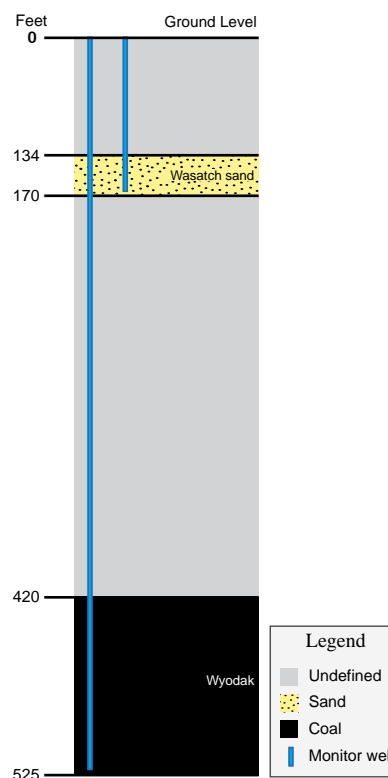


Figure 209. Section showing relative positions of coals and sands in feet. Not to scale.

Table 105. Table showing the depth to and thickness of monitored zones at the Section 25 monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Wasatch sand	134	170	36	250
Wyodak coal	420	525	105	n/a

Table 106. Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2006	Drawdown 2006-2009	Total drawdown (ft.)	Depth to 12/31/09 water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	28.09	1.45	-1.81	-0.36	27.73	n/a	n/a
Wyodak coal ⁽¹⁾	48.31	408.59	68.10	476.69	525.00	63.78	1/10/01

(1) Well dry to total depth of 525 feet as of 9/2/09.

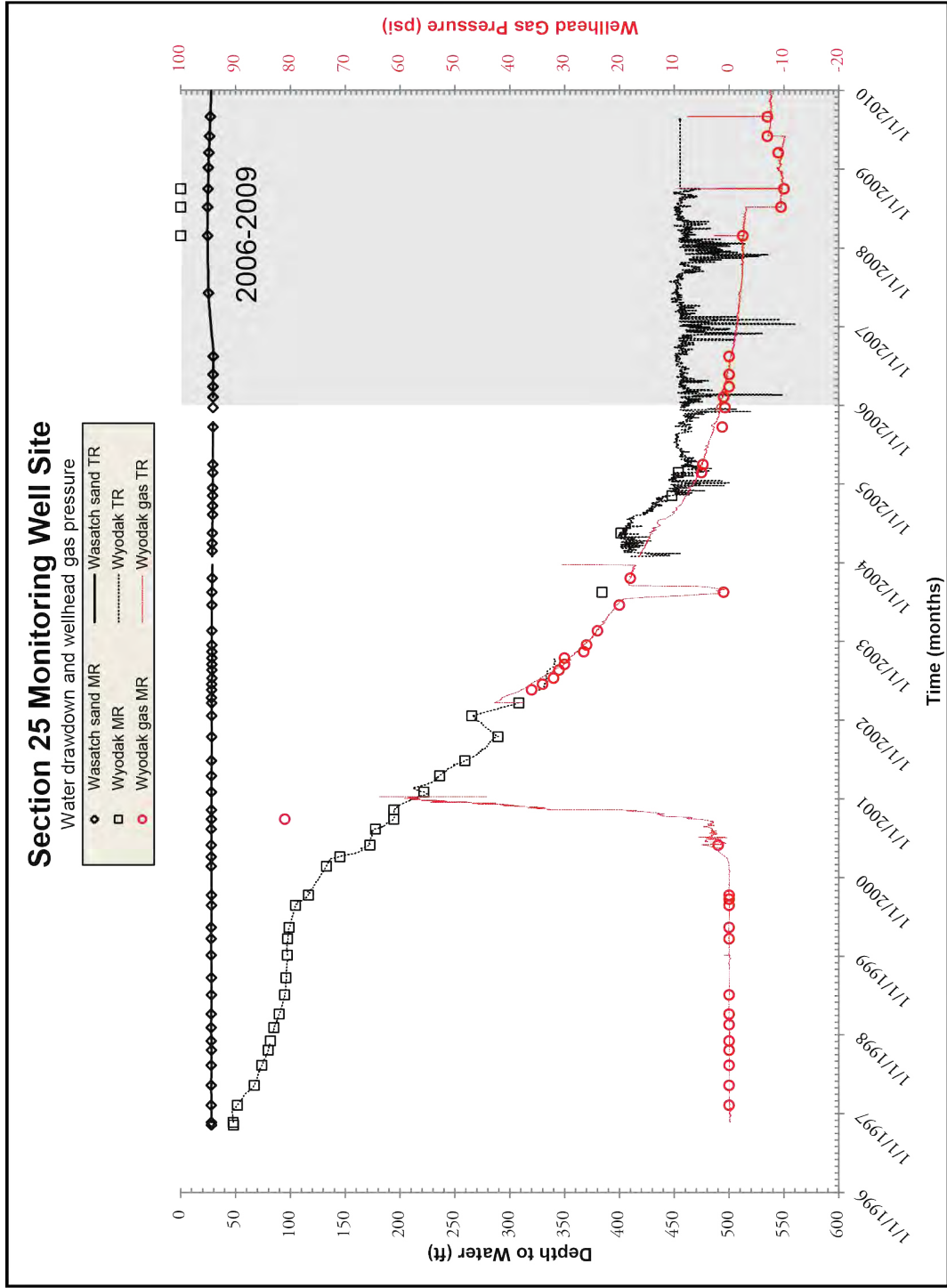


Figure 210. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Section 25 monitoring well site location.

Production Statistics

Production data for the Section 25 monitoring well was not reported due to generalized completion data for the local CBNG wells.

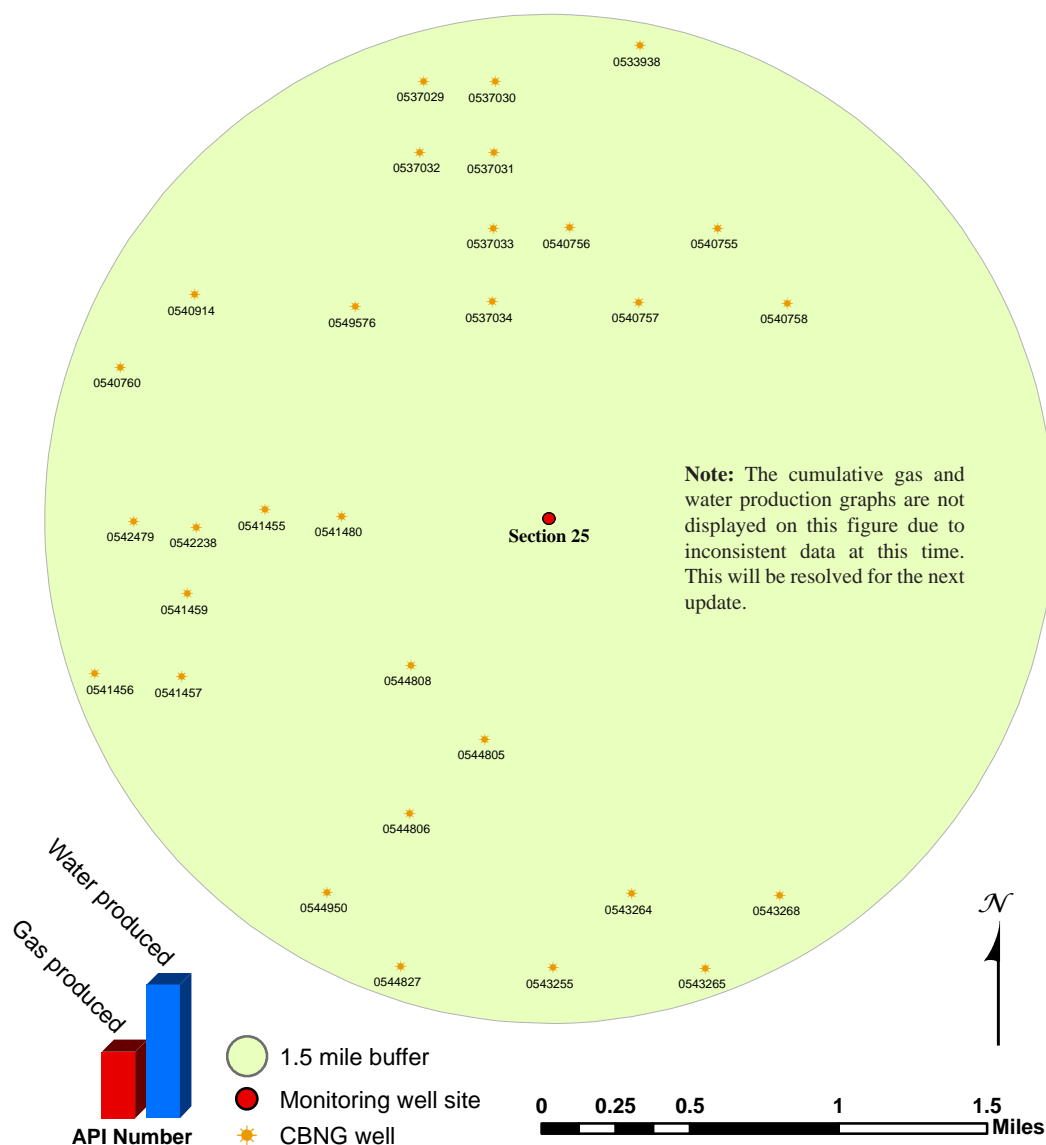


Figure 211. Section 25 monitoring well and associated CBNG wells within 1.5 mile buffer showing cumulative water (Bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

South Cordero Monitoring Well Site
Location: S6 T46N R71W
Date First Monitored: May 21, 1995

Drawdown Information

The South Cordero monitoring well site consists of one well drilled into the Wyodak coal (Figure 212; Table 107). A total of five manual measurements were taken during the 2006-2009 monitoring period and showed no associated groundwater draw-down or increase (Figure 213; Table 108). Recent measurements show the depth to water at 357 feet below the surface. First reporting of the well as dry was in early 2002. There are similar associated gas pressure data.

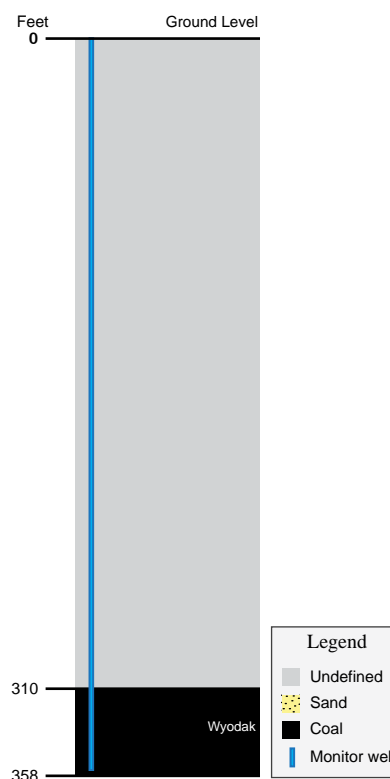


Figure 212. Section showing relative positions of coals and sands in feet. Not to scale.

Table 107. Table showing the depth to and thickness of monitored zones at the South Cordero monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Wyodak coal	310	358	48	n/a

Table 108. Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2006	Drawdown 2006-2009	Total drawdown (ft.)	Depth to 12/31/09 water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wyodak coal ⁽¹⁾	158.56	198.79	-0.38	198.41	356.97	55.00	3/19/97

⁽¹⁾ The electronic collection of water level data stopped in 7/98, after which the well was monitored for water level every six months.

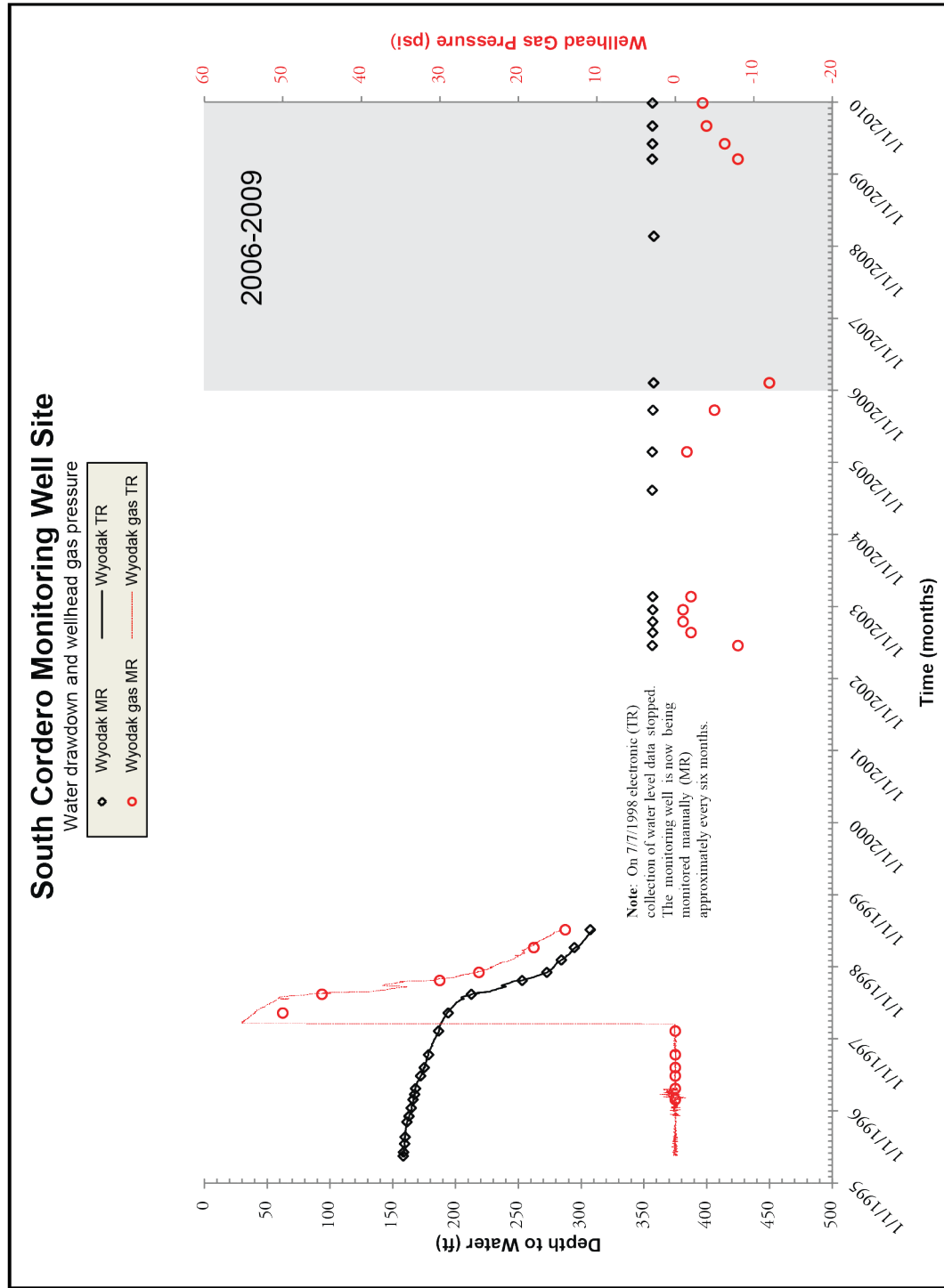


Figure 213. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the South Cordero monitoring well site location.

Production Statistics

Production data for the South Cordero monitoring well site was not reported due to incomplete or generalized completion data for local CBNG wells.

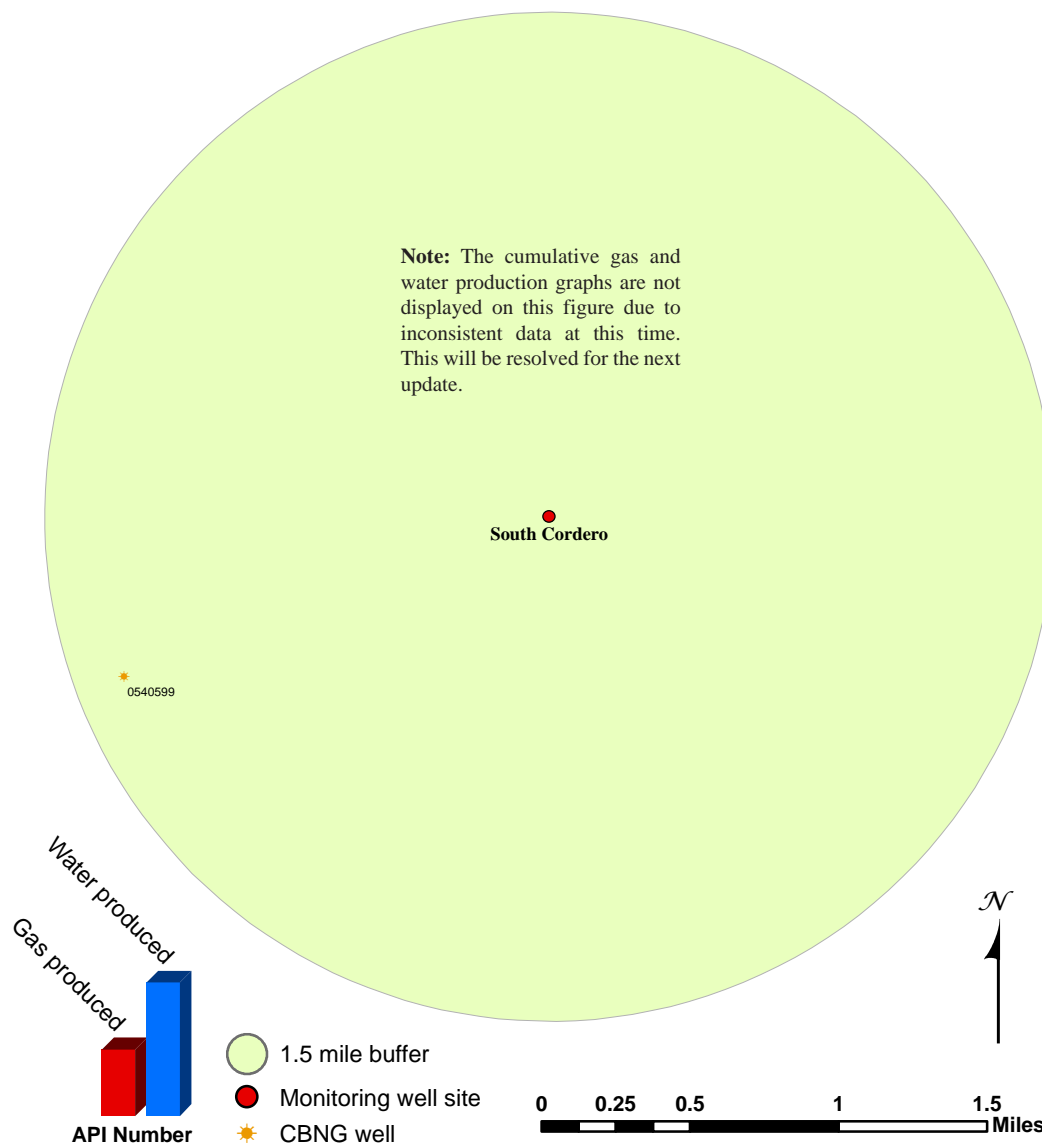


Figure 214. South Cordero monitoring well and associated CBNG wells within 1.5 mile buffer showing cumulative water (Bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

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 well is drilled into the Wyodak coal, one is drilled into a underburden sandstone below the coal, and the third is drilled into a overlying Wasatch sandstone (Figure 215; Table 109). Missing and/or fluctuating transducer data is the result of errors with on-site equipment.

The Wyodak coal recorded a groundwater of 123 feet during the 2006-2009 monitoring period. The Wyodak coal was reported as dry in August of 2004 at a depth of 780 feet (Figure 216; Table 110). Groundwater levels in the underburden sandstone declined by 3 feet during the 2006-2009 monitoring period (Figure 216; Table 110). Similar initial groundwater depths and equivalent drawdown trends prior to 2006 indicate that the monitored underburden sandstone and the Wyodak coal may be hydraulically connected. Groundwater levels in the Wasatch sandstone declined by 21 feet during the 2006-2009 monitoring period (Figure 216; Table 110). Drawdown trends approximate to the Wyodak coal indicate that the monitored Wasatch sandstone may be hydraulically connected to the producing zone. All gas pressure data was manually recorded.

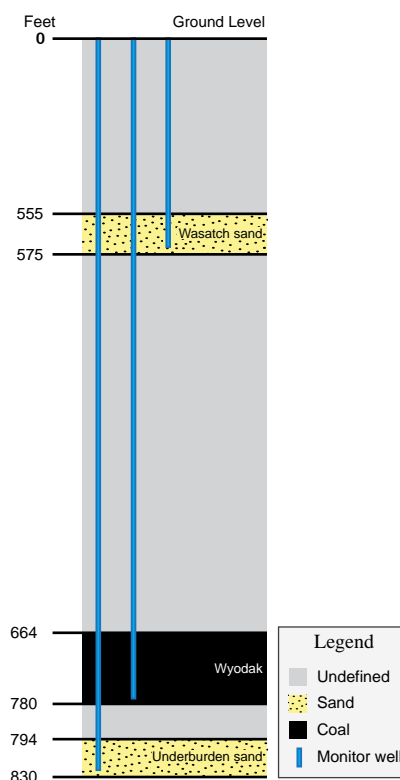


Figure 215. Section showing relative positions of coals and sands in feet. Not to scale.

Table 109. Table showing the depth to and thickness of monitored zones at the Stuart Sec 31 monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Wasatch sand	555	575	20	89
Wyodak coal	664	780	116	n/a
Underburden sand	794	830	36	14

Table 110. Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2006	Drawdown 2006-2009	Total drawdown (ft.)	Depth to 12/31/09 water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	252.95	58.48	20.57	79.05	332.00	n/a	n/a
Wyodak coal ⁽¹⁾	322.00	335.00	123.00	458.00	780.00	38.00	6/26/01
Underburden sand	335.90	248.01	3.46	251.47	587.37	n/a	n/a

⁽¹⁾ The Wyodak coal well was recorded as dry at 780.00 feet. This is also the total depth of the well

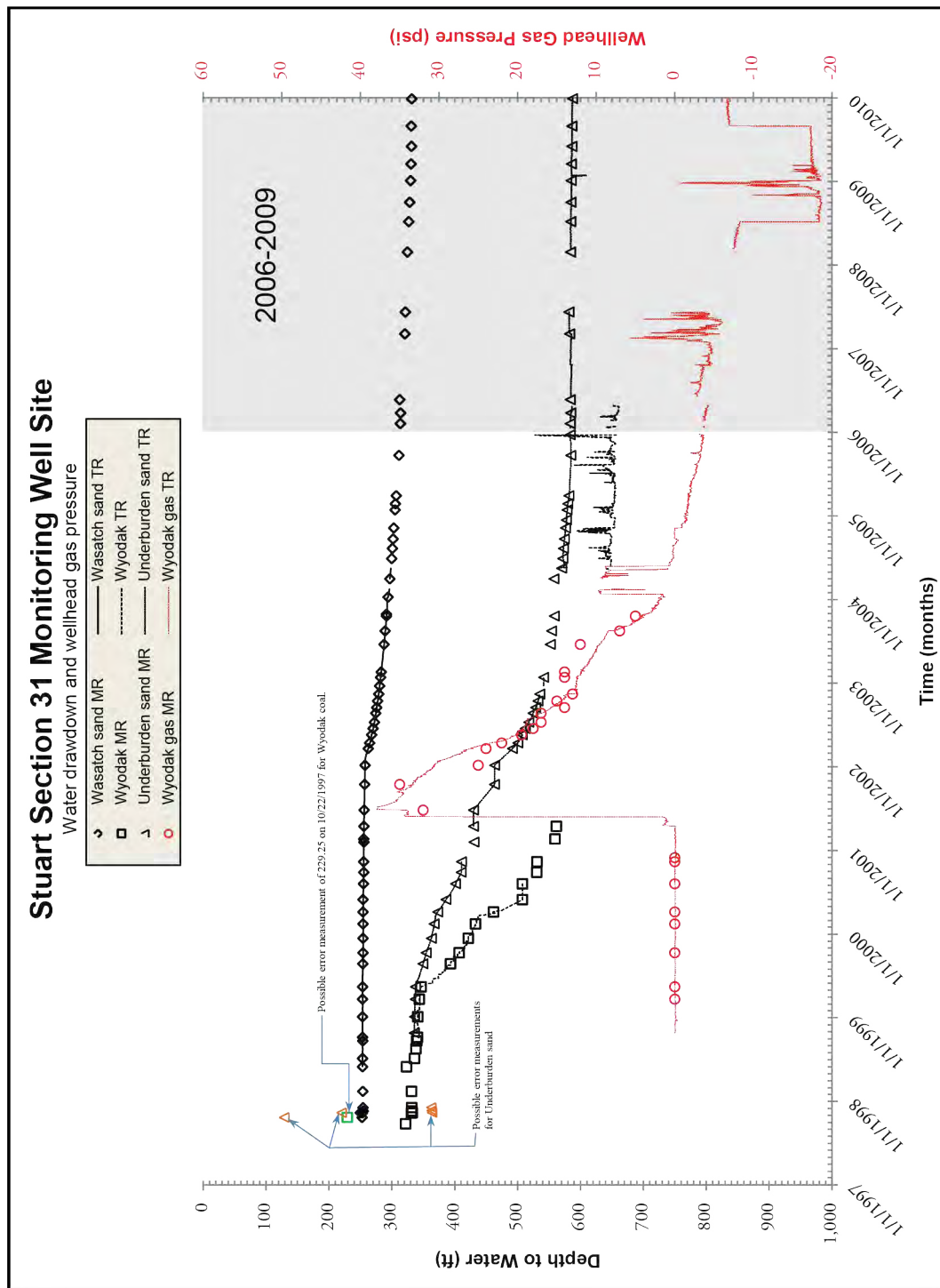


Figure 216. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Stuart Sec 31 monitoring well site location.

Production Statistics

Production data was analyzed for CBNG wells within the buffer of the Stuart Sec 31 monitoring well site from January 1999 through December 2009. Cumulative production for individual CBNG wells is displayed by location on Figure 217.

production declined during the 2006 to 2009 monitoring period, and were minimal by late 2009 (Figure 218). The water/gas ratio of CBNG wells within the buffer is relatively inconsistent. Percent methane is variable.

Water production increased in 2000, which correlates to groundwater level drawdown trends. Water and gas

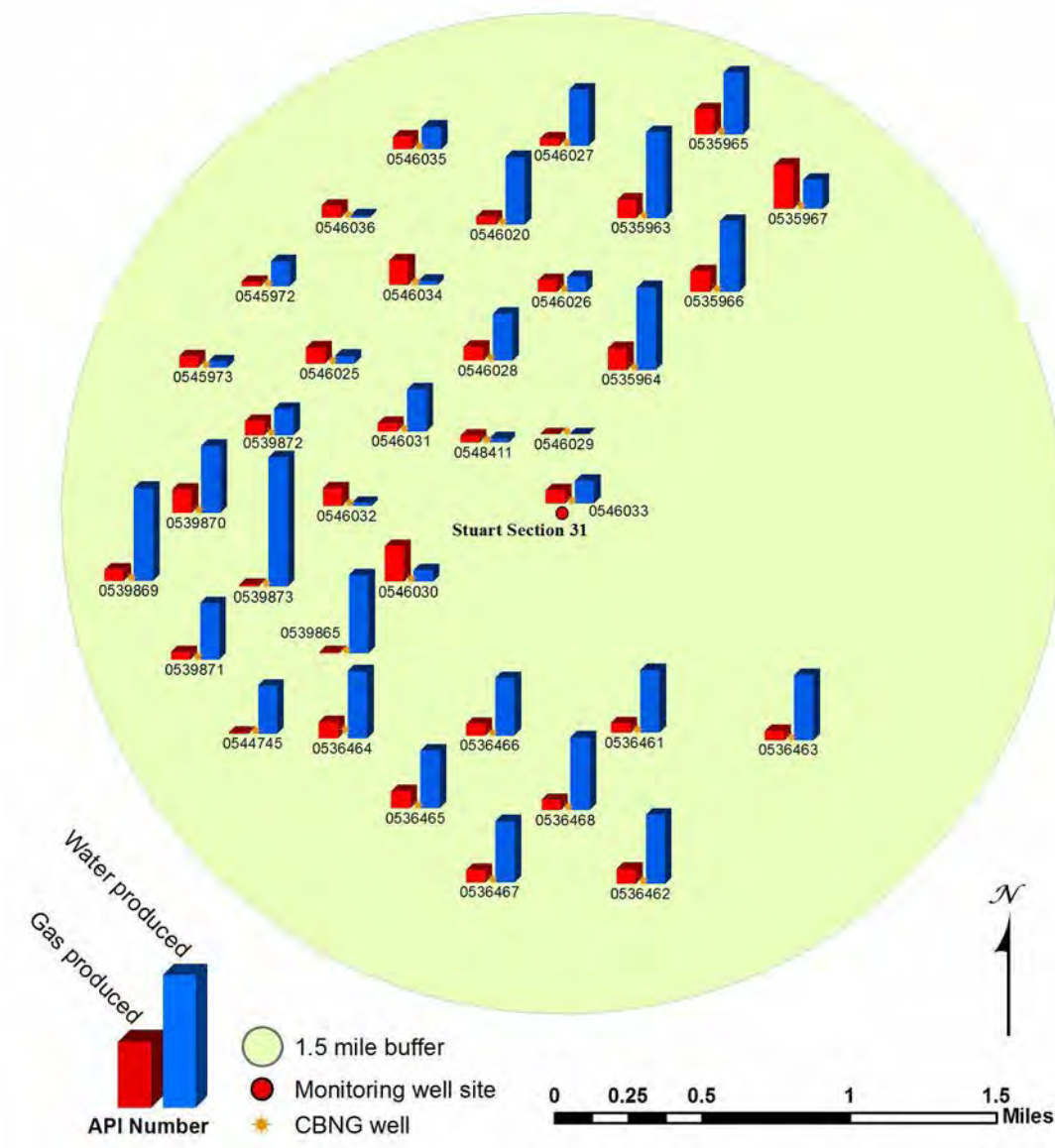


Figure 217. Stuart Sec 31 monitoring well and associated CBNG wells within 1.5 mile buffer showing cumulative water (Bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

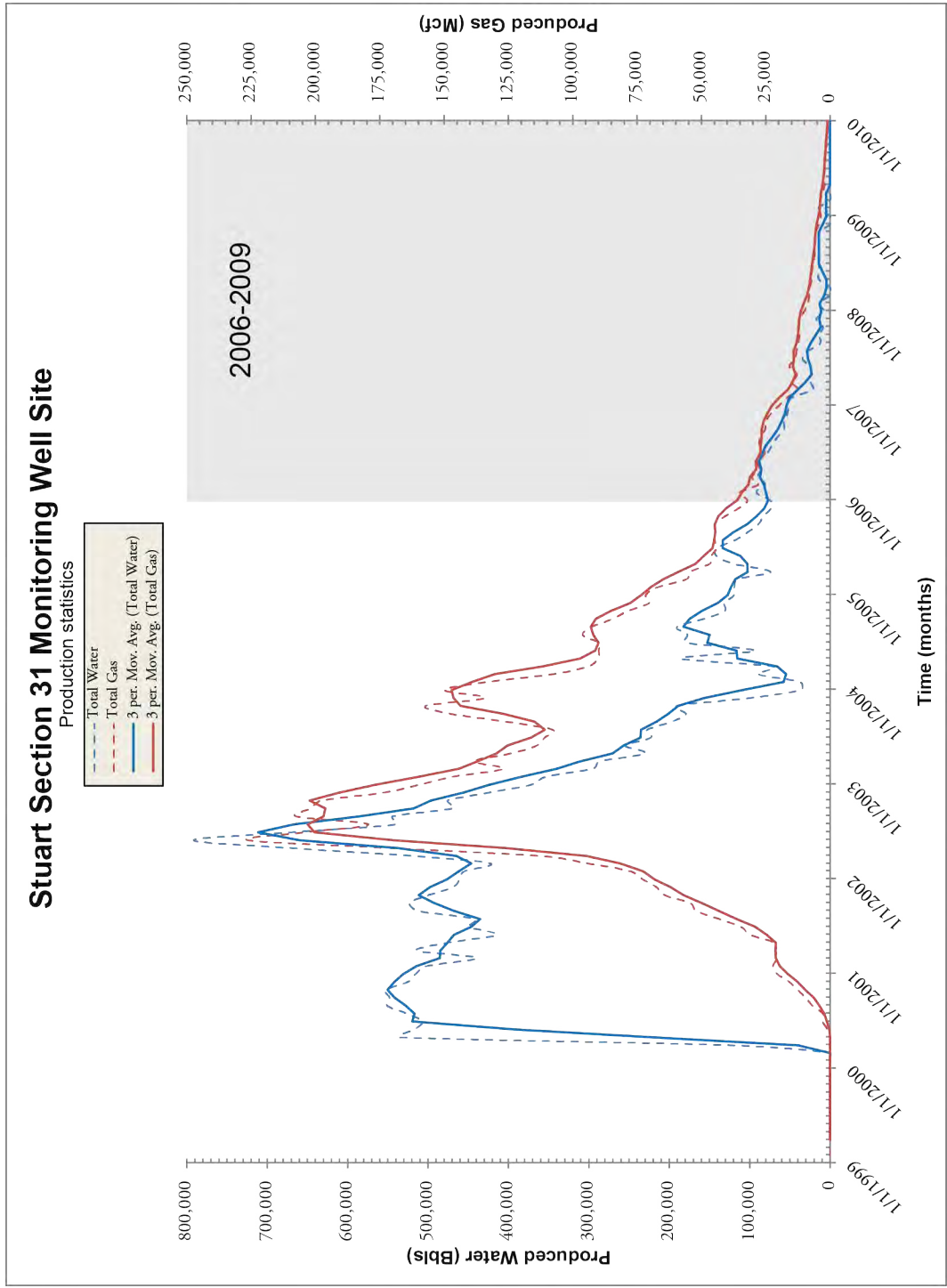


Figure 218. 3-period moving average along with water and gas production from associated CBNG wells.

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 drilled into the Wyodak coal and the other is drilled into a overlying Wasatch sandstone (Figure 219; Table 111). Missing and/or fluctuating transducer data is the result of errors with on-site equipment.

The Wyodak coal recorded a groundwater rise of 99 feet during the 2006-2009 monitoring period; data indicates a steady increase in the groundwater level (Figure 220; Table 112). Groundwater levels in the Wasatch sandstone decreased by 79 feet during the 2006-2009 monitoring period (Figure 220; Table 112). Equivalent drawdown trends indicate that the monitored Wasatch sandstone and the Wyodak coal may be hydraulically connected. Both transducer and manual recordings of Wyodak gas pressures fluctuated randomly between 2006 and 2008, after which they did not surpass levels possible from transducer error.

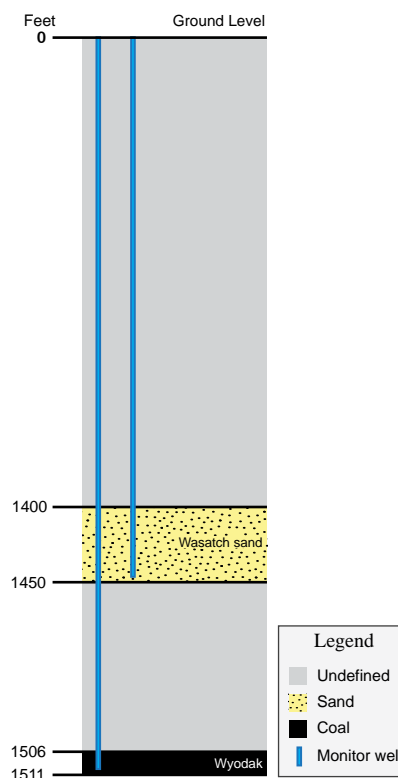


Figure 219. Section showing relative positions of coals and sands in feet. Not to scale.

Table 111. Table showing the depth to and thickness of monitored zones at the Throne monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Wasatch sand	1400	1450	50	56
Wyodak coal	1506	1511	5	n/a

Table 112. Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2006	Drawdown 2006-2009	Total drawdown (ft.)	Depth to 12/31/09 water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	601.34	191.12	79.19	270.31	871.65	n/a	n/a
Wyodak coal	815.24	303.59	-98.55	205.04	1020.28	n/a	n/a

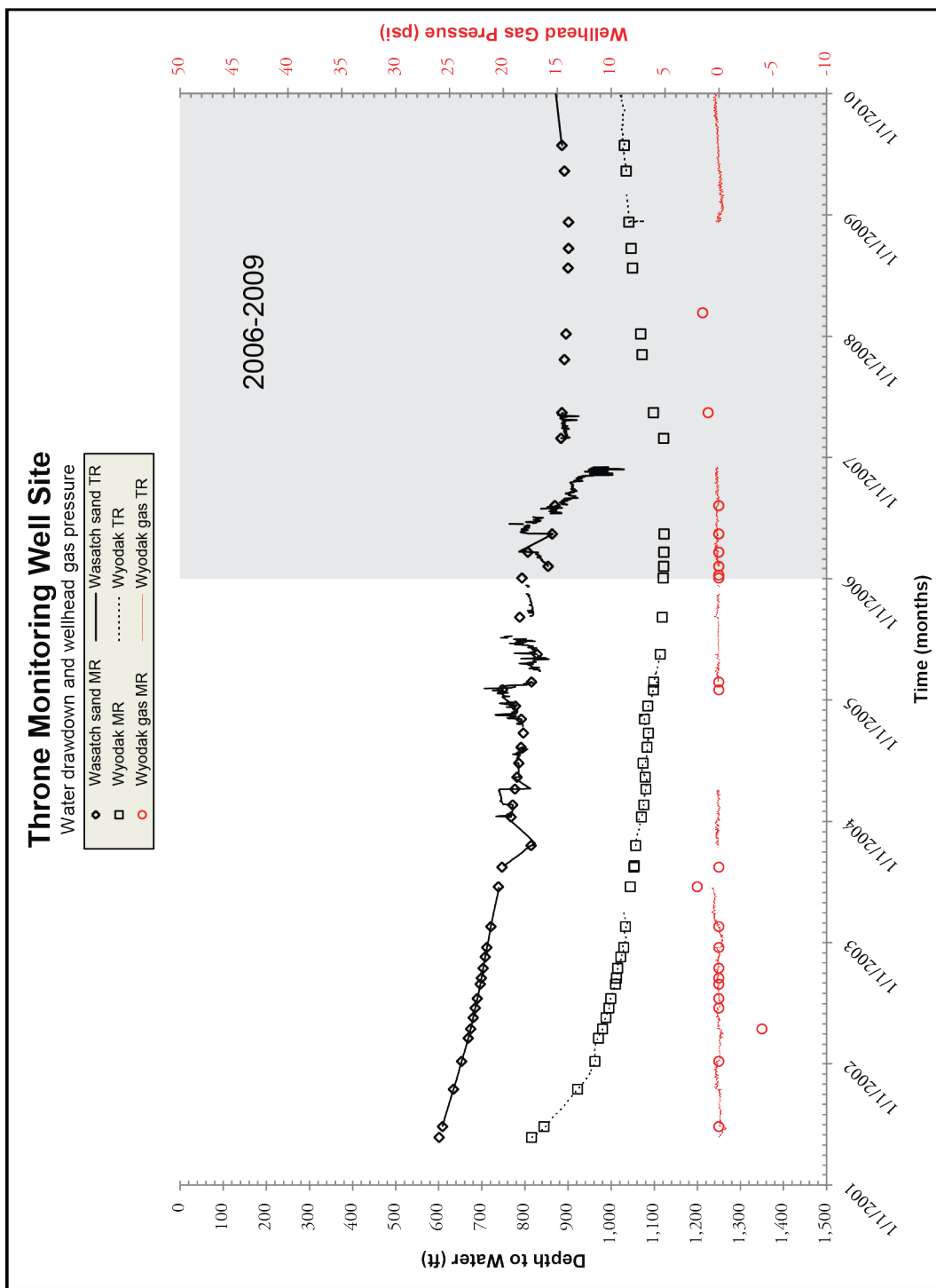


Figure 220. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Throne monitoring well site location. Gray area represents the current monitoring period of 2006–2009.

Production Statistics

Production data was analyzed for CBNG wells within the buffer of the Throne monitoring well site from January 2000 through December 2009. Cumulative production for individual CBNG wells is displayed by location on Figure 221.

Water production increased in 2002, which correlates to groundwater drawdown trends. Water

and gas production was variable during the 2006 to 2009 monitoring period, though discontinued water production in late 2009 correlates to increased groundwater levels in the Wasatch sandstone and Wyodak coal bed (Figure 220). The water/gas ratio of CBNG wells within the buffer is relatively inconsistent. Percent methane is variable.

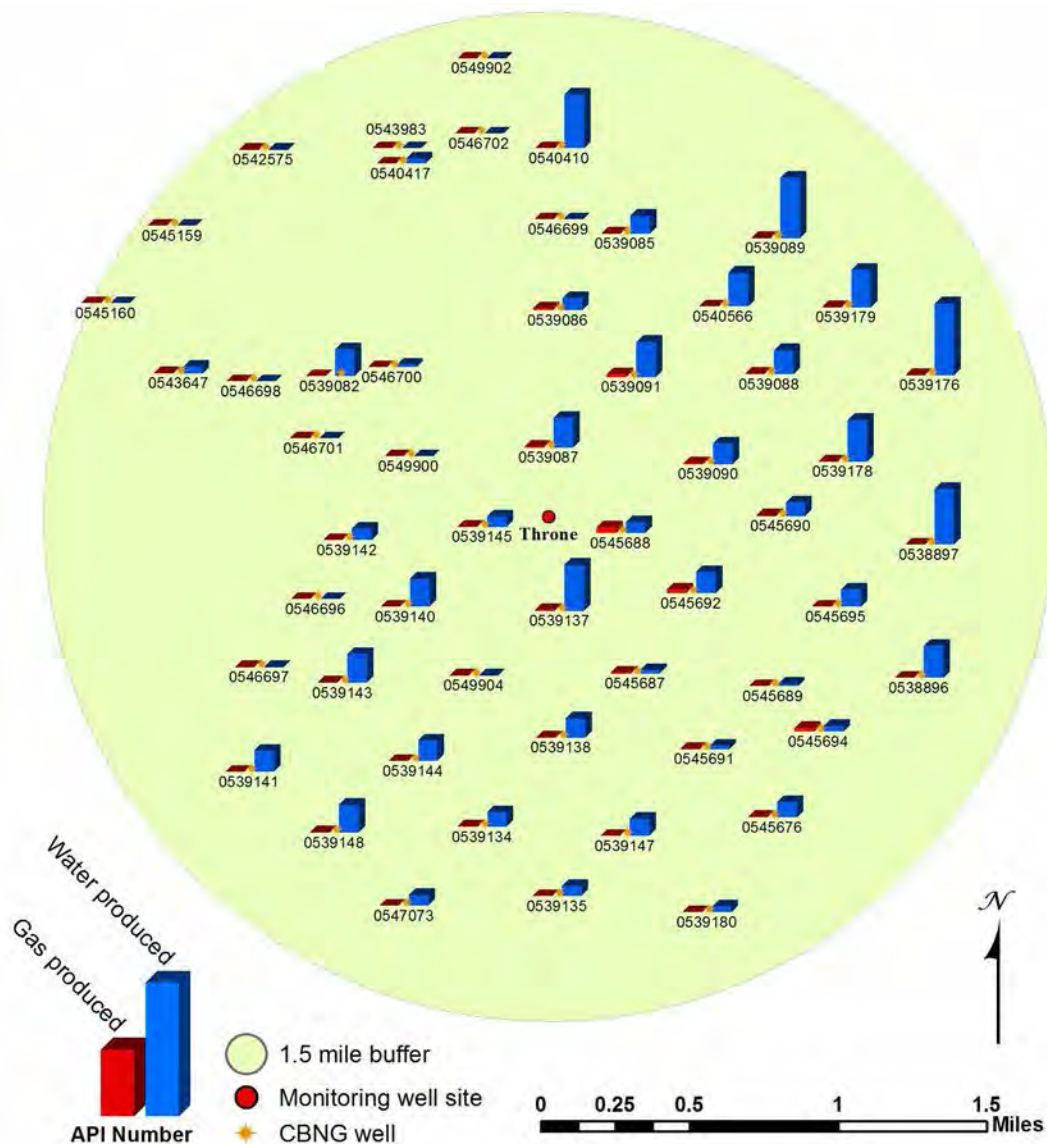


Figure 221. Throne monitoring well and associated CBNG wells within 1.5 mile buffer showing cumulative water (Bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

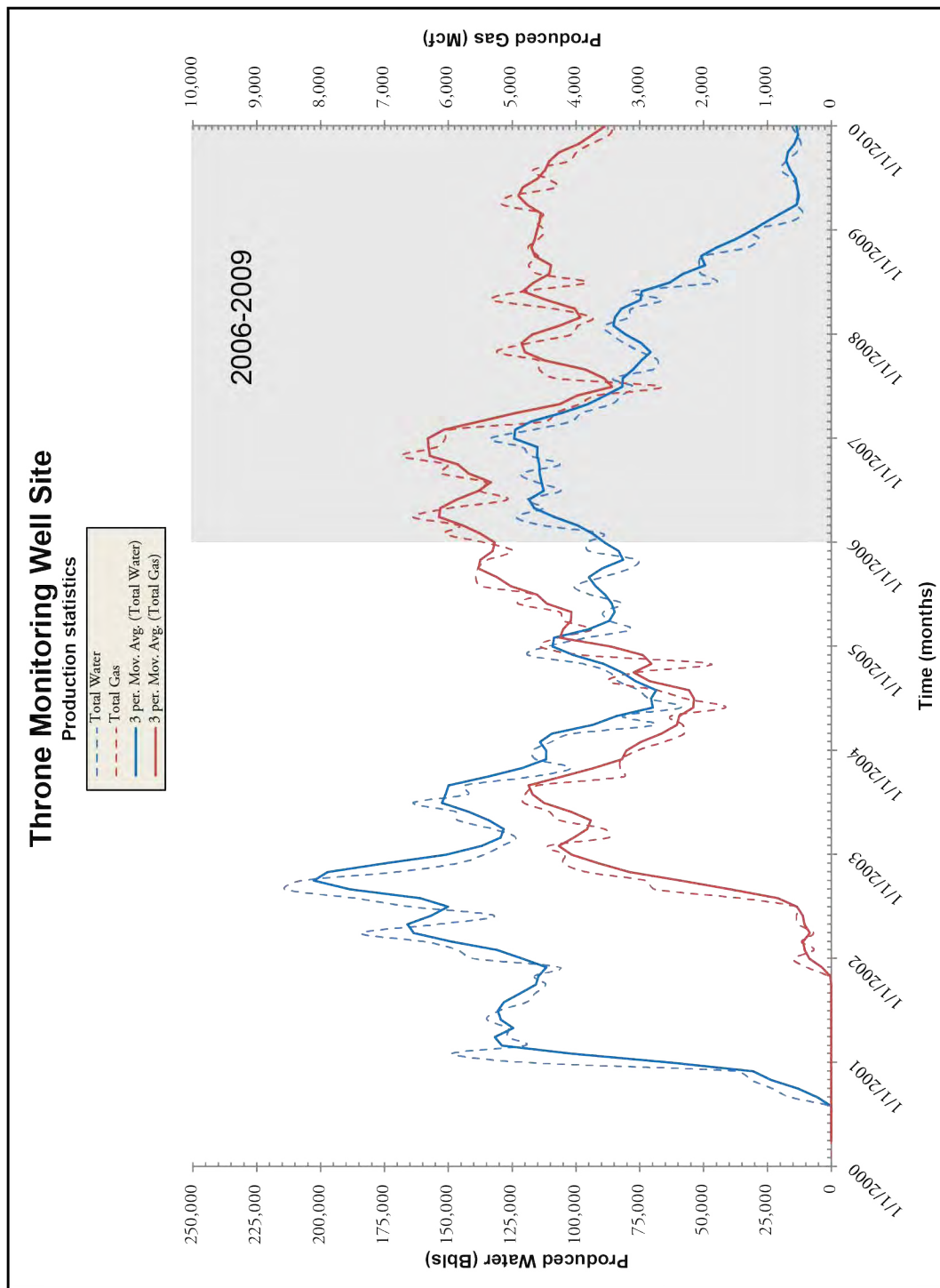


Figure 222. 3-period moving average along with water and gas production from associated CBNG wells.

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. One well is drilled into the Wall coal and also completed in the shallower Werner coal. The second well is drilled to the Anderson coal and also completed into an underburden sand. The third well is drilled to the shallow Smith coal and also completed in the shallow Wasatch sand. (Figure 223; Table 113). Missing transducer data is the result of errors with on site equipment.

The Wall and Anderson coals record groundwater drawdown beginning in mid-2009 and mid-2008 respectively. There was little impact on water levels in the Smith and Werner coals between 2006-2009. This indicates they are confined relative to the Wall and Werner coals. The underburden sand shows a gradual drawdown throughout the period of drawdown in the coals. This suggests that there may be a hydrologic connection between the underburden sand and the coals above it. Water levels in the Wasatch sand remained constant through the monitoring period. This suggests that there is no hydrologic connection between the coals and the shallow Wasatch sandstone (Figure 224; Table 114). Wellhead gas pressure at this location stayed around zero for the entirety of the monitor period with the exception of one occurrence. One manual measurement of 55 psi and 52 psi for the Smith and Wall coals respectively in 2007 were recorded (Figure 210). No other measurements above zero outside of transducer error were recorded.

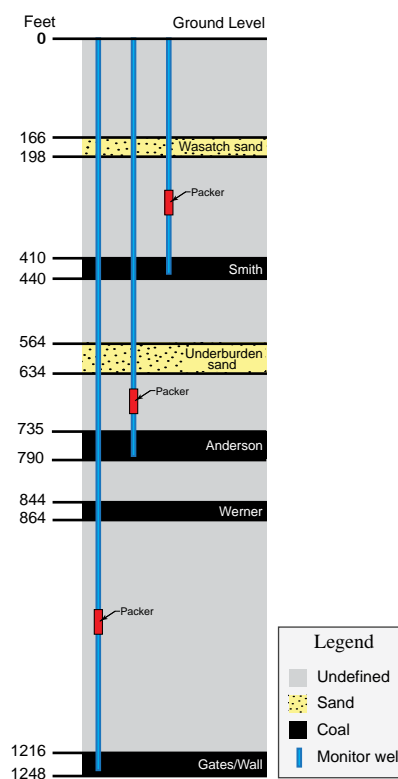


Figure 223. Section showing relative positions of coals and sands in feet. Not to scale.

Table 113. Table showing the depth to and thickness of monitored zones at the Williams Cedar Draw monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Wasatch sand	166	198	32	212
Smith coal	410	440	30	n/a
Underburden sand	564	634	70	101
Anderson coal	735	790	55	n/a
Werner coal	844	864	20	n/a
Gates/Wall coal	1216	1248	32	n/a

Table 114. Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2006	Drawdown 2006-2009	Total drawdown (ft.)	Depth to 12/31/09 water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	115.79	n/a	-1.59	-1.59	114.20	n/a	n/a
Smith coal	169.15	n/a	-0.02	-0.02	169.13	55	8/21/07
Underburden sand	259.77	n/a	163.28	163.28	423.05	n/a	n/a
Anderson coal	243.95	n/a	293.95	293.95	537.90	8	8/21/07
Werner coal	143.90	n/a	19.79	19.79	163.69	n/a	n/a
Gates/Wall coal	216.50	n/a	123.70	123.70	340.20	155	12/17/09

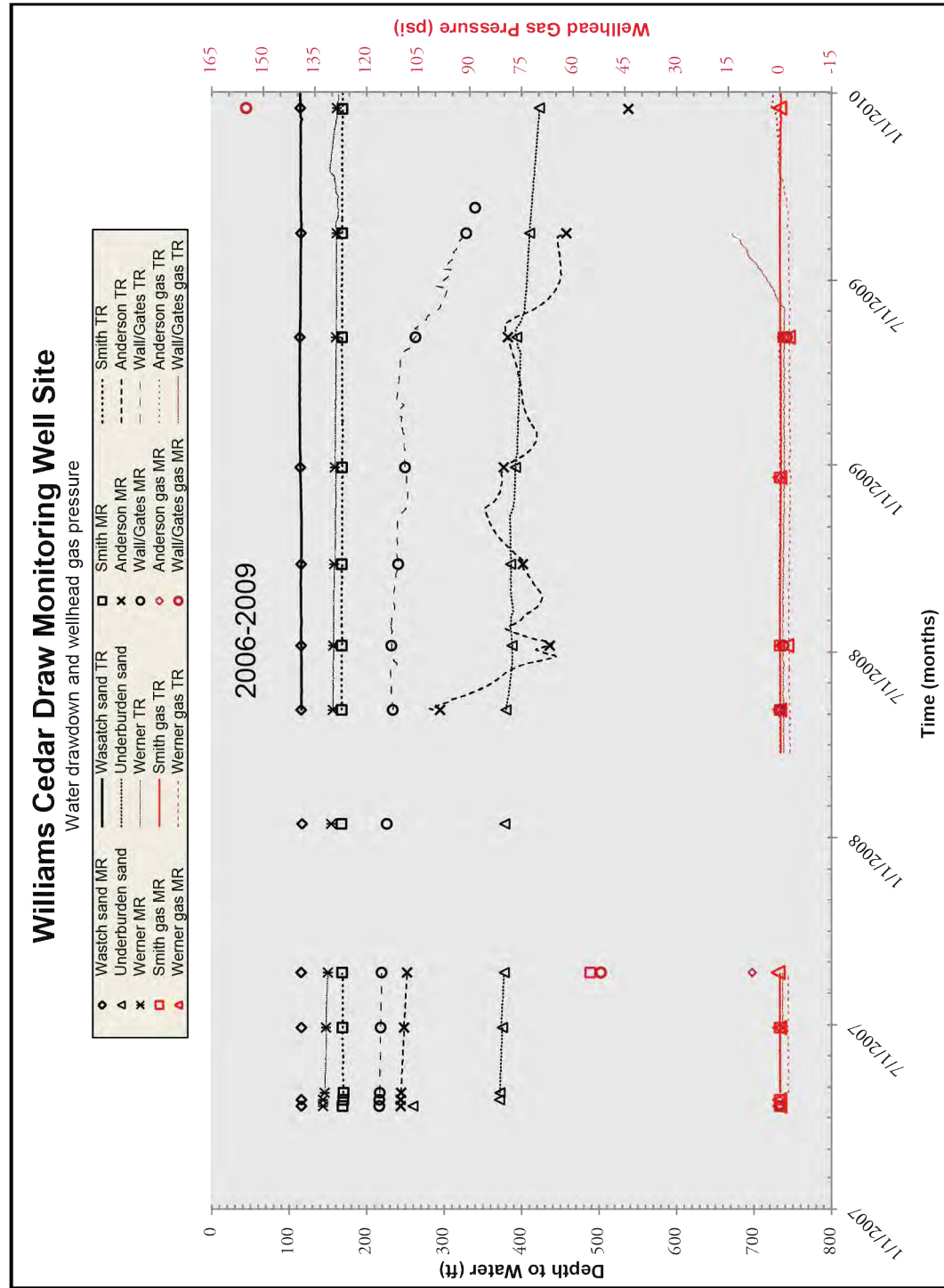


Figure 224. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Williams Cedar Draw monitoring well site location.

Production Statistics

Production data for the Williams Cedar Draw monitoring well site was not reported due to incomplete or generalized completion data for local CBNG wells.

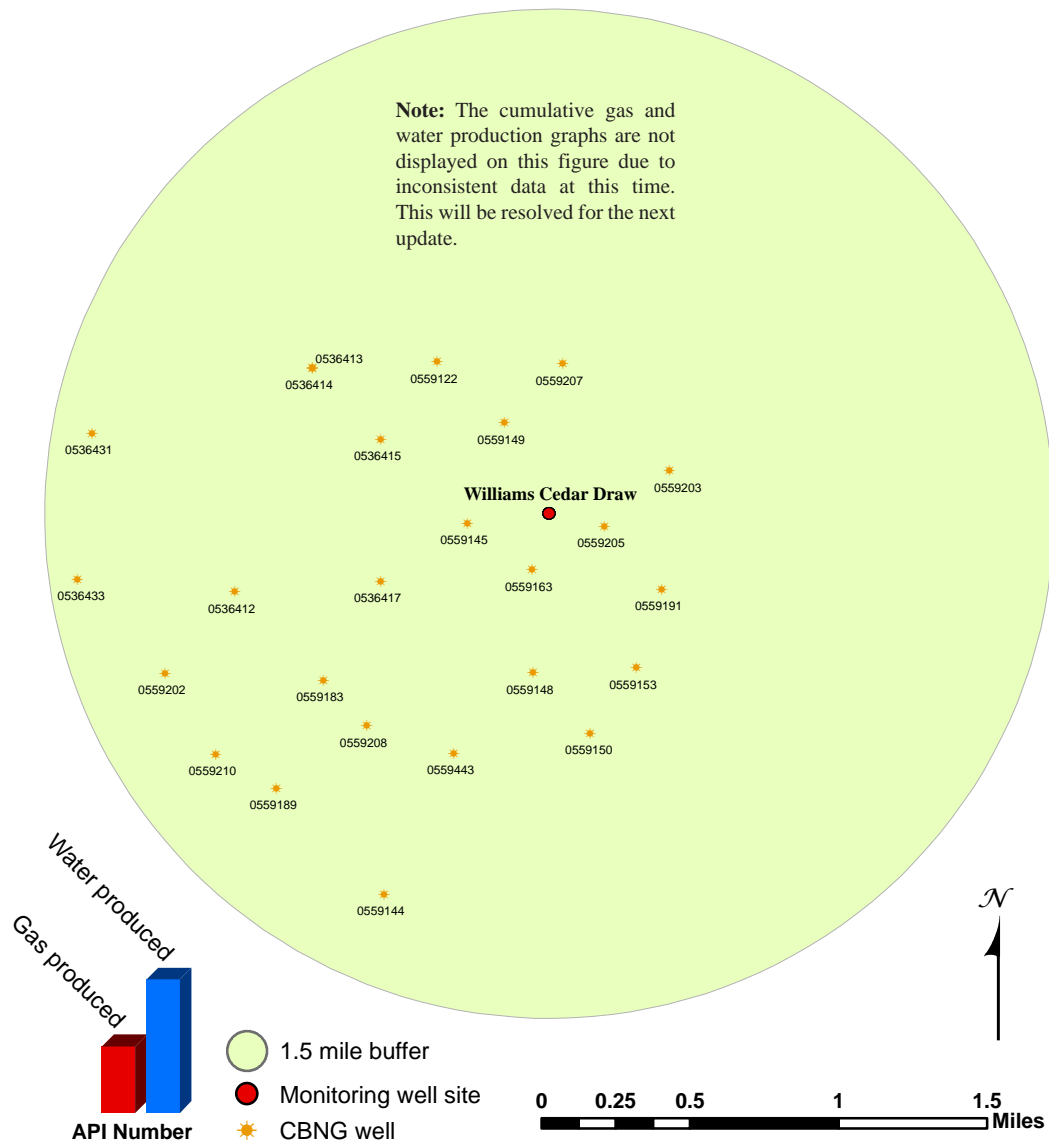


Figure 225. Williams Cedar Draw monitoring well and associated CBNG wells within 1.5 mile buffer showing cumulative water (Bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

APPENDIX 4. Lower Wyodak Coal Zone

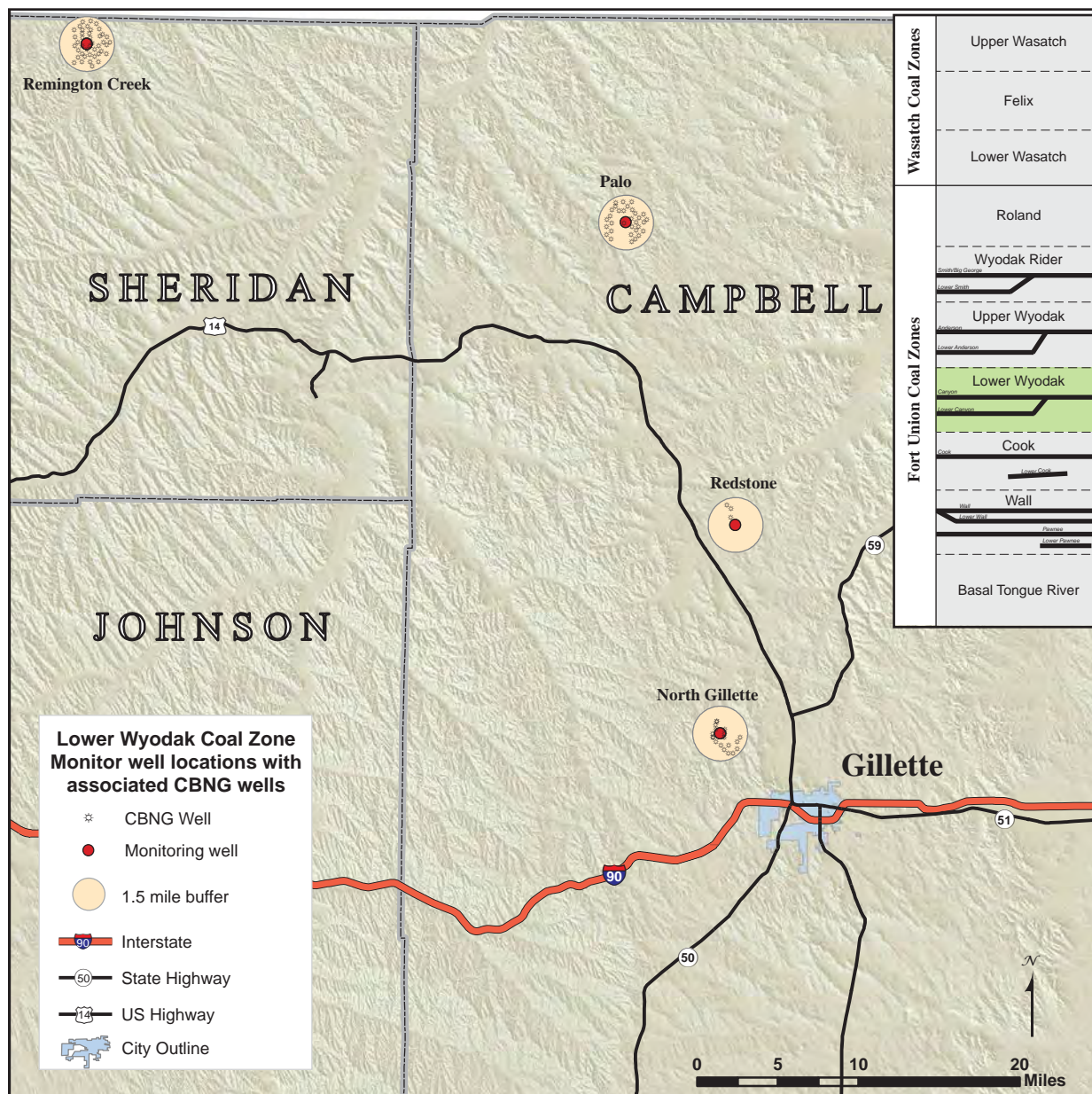


Figure 226. Lower Wyodak coal zone monitoring well site locations in the Powder River Basin, Wyoming.

North Gillette Monitoring Well Site
Location: S34 T51 N R73W
Date First Monitored: September 25, 2001

Drawdown Information

The North Gillette monitoring well site includes three wells. One well is drilled into the Anderson coal, one is drilled into the deeper Canyon coal, and the third is drilled into an overlying Wasatch sandstone (Figure 227; Table 115). Missing and/or fluctuating transducer data is the result of errors with on-site equipment.

The Anderson coal has no recorded groundwater decrease during the 2006-2009 monitoring period due to the hole being dry at 575 feet (Figure 228; Table 116). The Canyon coal showed a drawdown of 12 feet during the 2006-2009 monitoring period (Figure 228; Table 116). Though they are proximal depth-wise, there is not enough data to determine if the Anderson and Canyon coals are hydraulically connected. Groundwater levels in the Wasatch sandstone remained steady during the 2006-2009 monitoring period, and they have remained nearly constant throughout the life of the well (Figure 228; Table 116). This suggests that there is no hydraulic connection between the monitored sandstone and producing zones. Gas pressure readings did not surpass levels possible from transducer error.

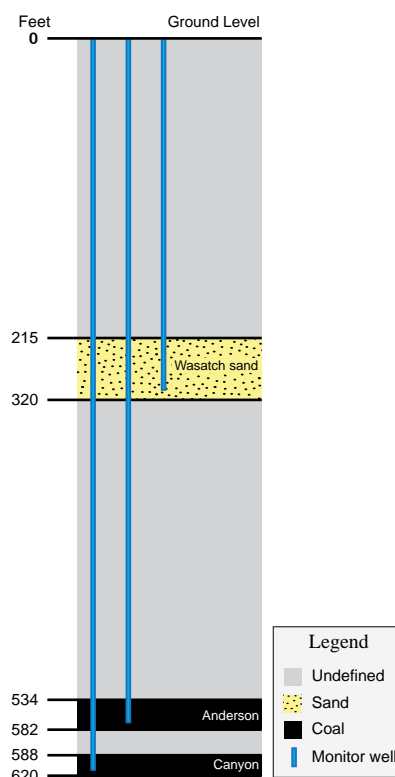


Figure 227. Section showing relative positions of coals and sands in feet. Not to scale.

Table 115. Table showing the depth to and thickness of monitored zones at the North Gillette monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Wasatch sand	215	320	105	214
Anderson coal	534	582	48	n/a
Canyon coal	588	620	32	n/a

Table 116. Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2006	Drawdown 2006-2009	Total drawdown (ft.)	Depth to 12/31/09 water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	122.17	5.17	-0.29	4.88	127.05	n/a	n/a
Anderson coal ⁽¹⁾	499.20	75.80	0.00	75.80	575.00	4.60	5/14/02
Canyon coal	447.30	78.00	12.46	90.46	537.76	0.70	2/23/07

⁽¹⁾ Well was dry after 2/14/07 at total depth of well of 575 feet.

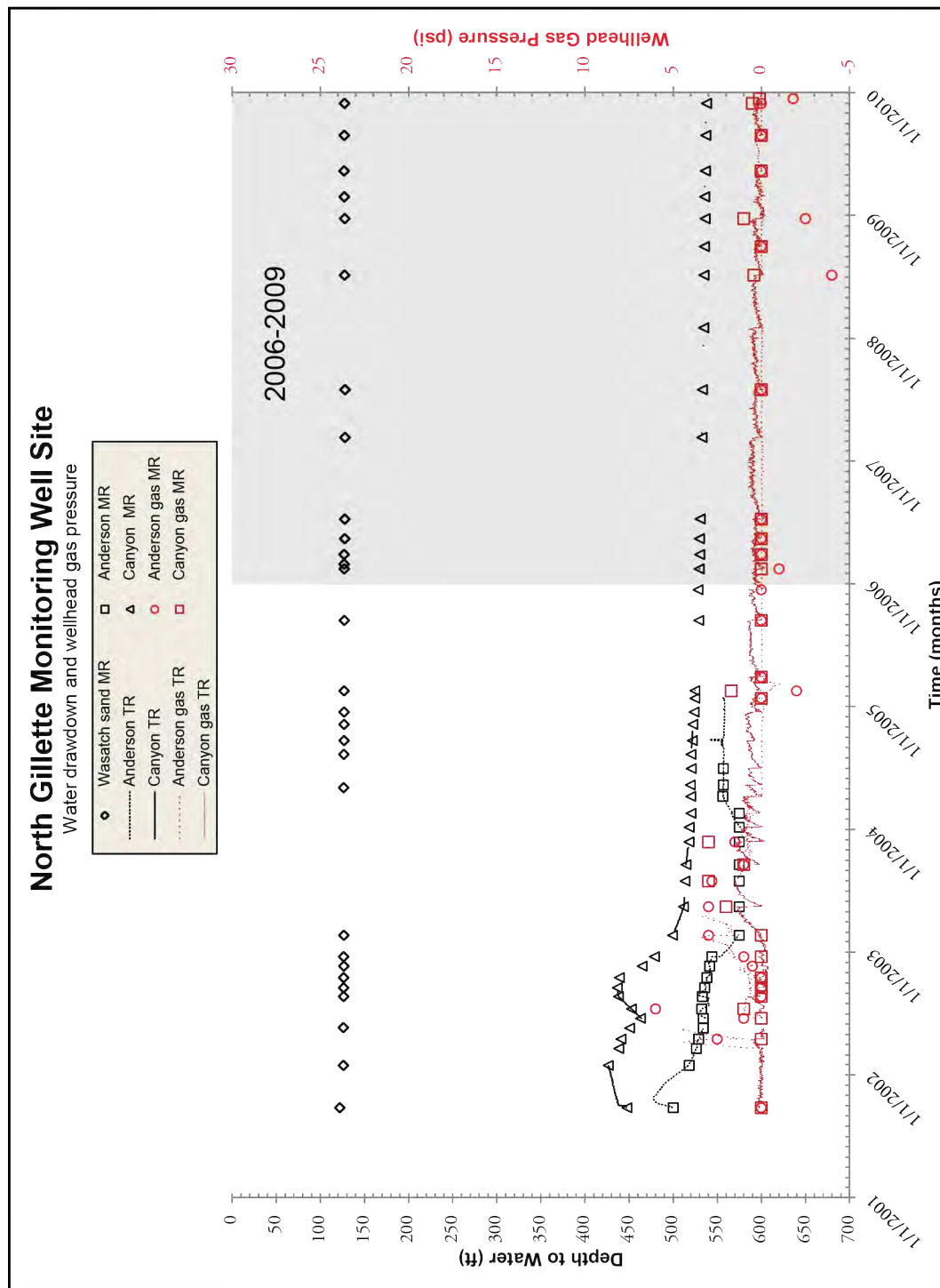


Figure 228. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the North Gillette monitoring well site location. Gray area represents the current monitoring period of 2006-2009.

Production Statistics

Production data for the North Gillette monitoring well site was not reported due to incomplete or generalized completion data for local CBNG wells.

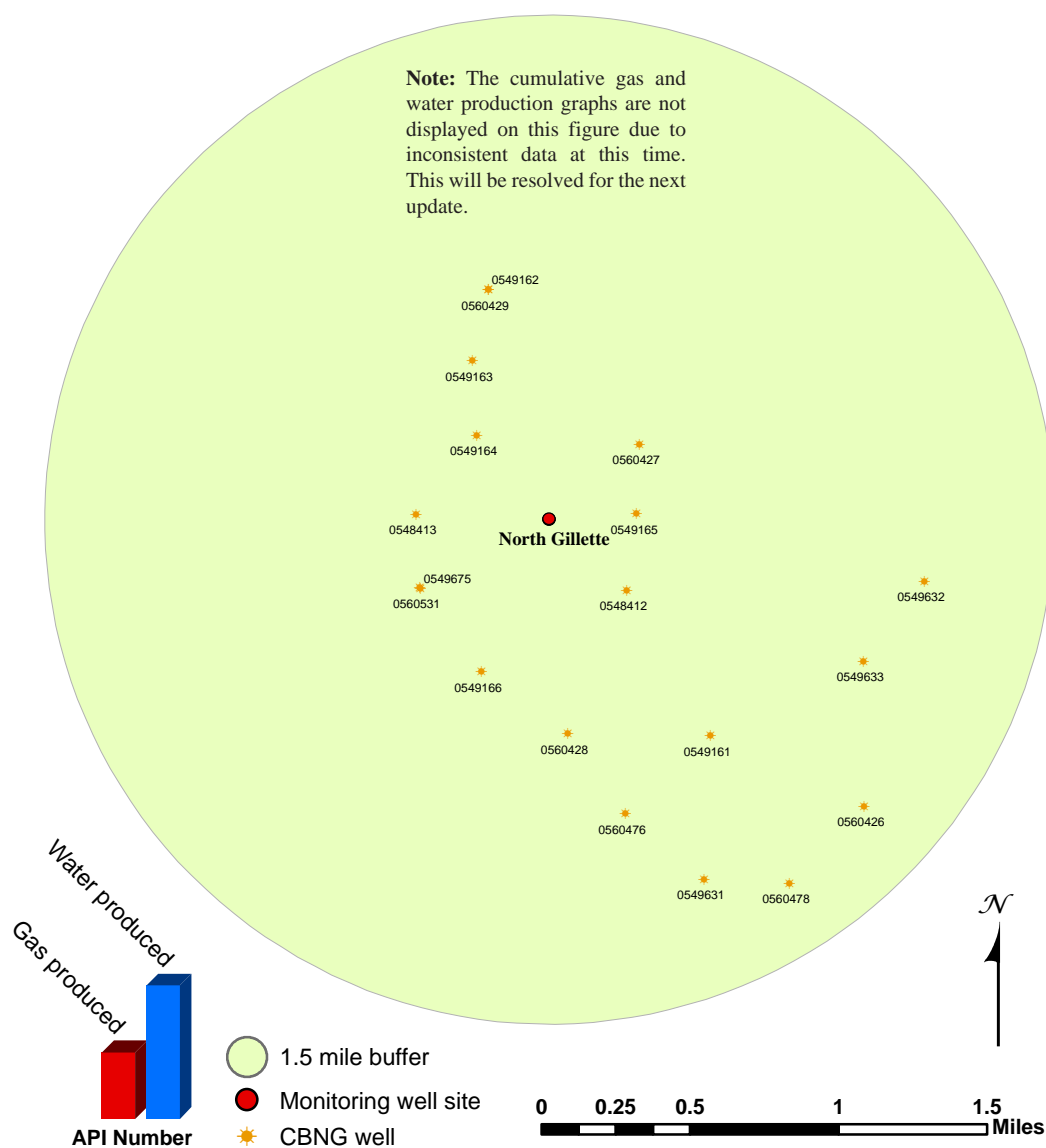


Figure 229. North Gillette monitoring well and associated CBNG wells within 1.5 mile buffer showing cumulative water (Bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

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 drilled into the Canyon coal and the other is drilled into a overlying Wasatch sandstone (Figure 230; Table 117). Missing and/or fluctuating transducer data is the result of errors with on-site equipment.

The Canyon coal recorded a groundwater decrease of 1 foot during the 2006-2009 monitoring period; data shows nearly stable groundwater levels during the 2006-2009 monitoring period (this follows a 140 feet of drawdown from 2000 to 2006). Groundwater levels in the Wasatch sandstone increased by 1 foot during the 2006-2009 monitoring period, and they have remained nearly constant throughout the life of the well (Figure 231; Table 118). This indicates there is no hydraulic connection between the monitored sandstone and producing zones. Gas pressure readings did not surpass levels possible from transducer error.

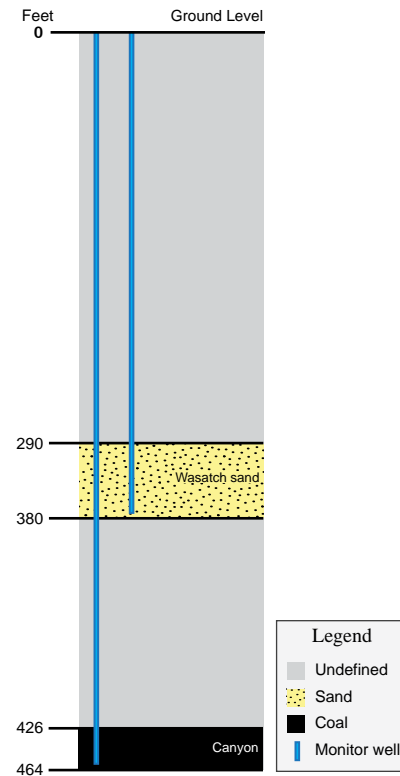


Figure 230. Section showing relative positions of coals and sands in feet. Not to scale.

Table 117. Table showing the depth to and thickness of monitored zones at the Palo monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Wasatch sand	290	380	90	46
Canyon coal	426	464	38	n/a

Table 118. Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2006	Drawdown 2006-2009	Total drawdown (ft.)	Depth to 12/31/09 water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	246.25	1.16	-0.61	0.55	246.80	n/a	n/a
Canyon coal	298.80	140.33	0.67	141.00	439.80	55	5/11/01

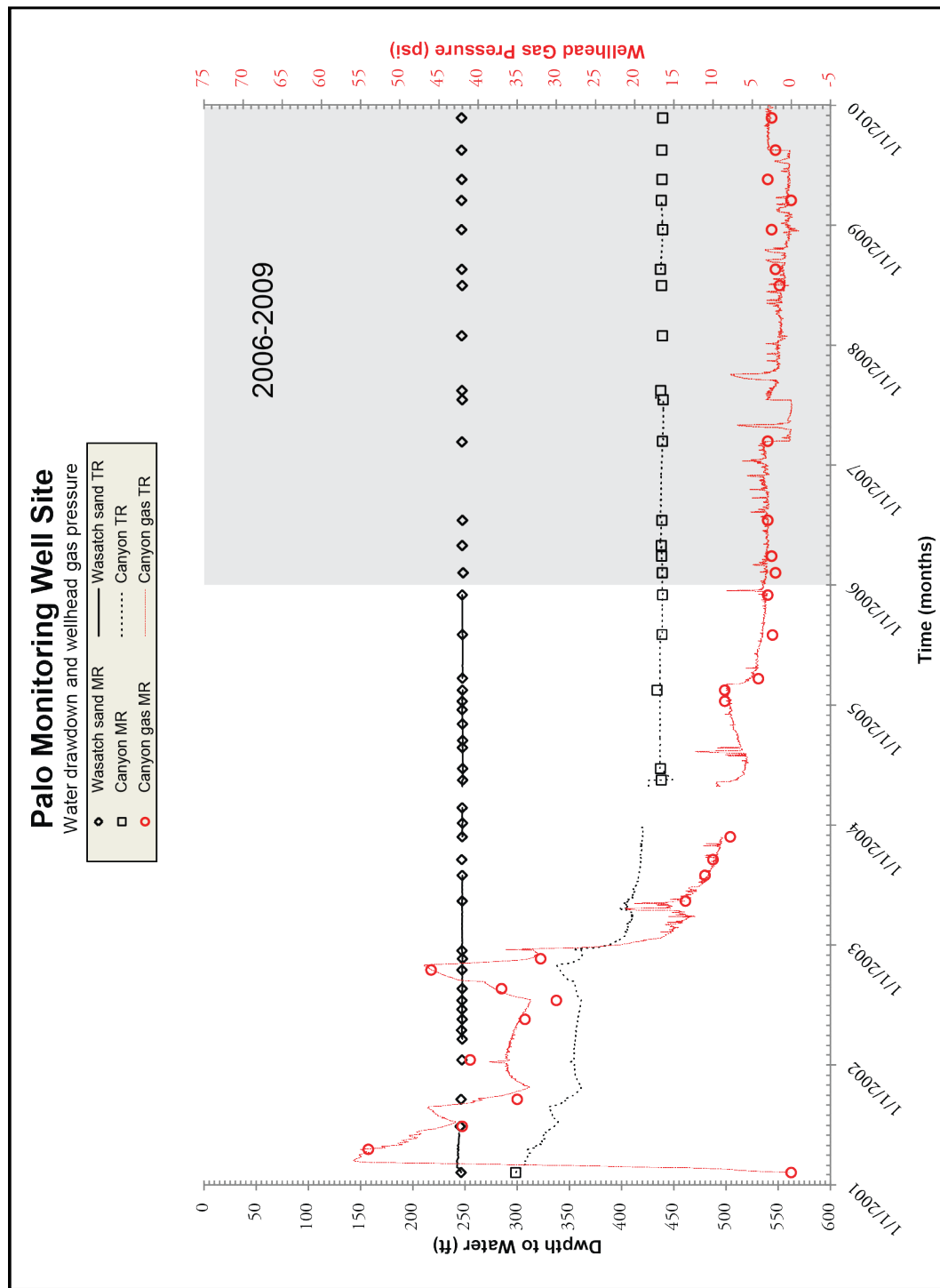


Figure 231. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Palo monitoring well site location. Gray area represents the current monitoring period of 2006-2009.

Production Statistics

Production data was analyzed for CBNG wells within the buffer of the Palo monitoring well site from January 2005 through December 2009. Cumulative production for individual CBNG wells is displayed by location on Figure 232.

Water production increased in 2006 and peaked in 2009 (Figure 233), which does not correlate with

groundwater drawdown trends (Figure 231). This could be the result of reported intervals on the WOGCC website. Water and gas production increased during the 2006 to 2009 monitoring period (Figure 233). The water/gas ratio of CBNG wells within the buffer is relatively consistent. Percent methane is variable.

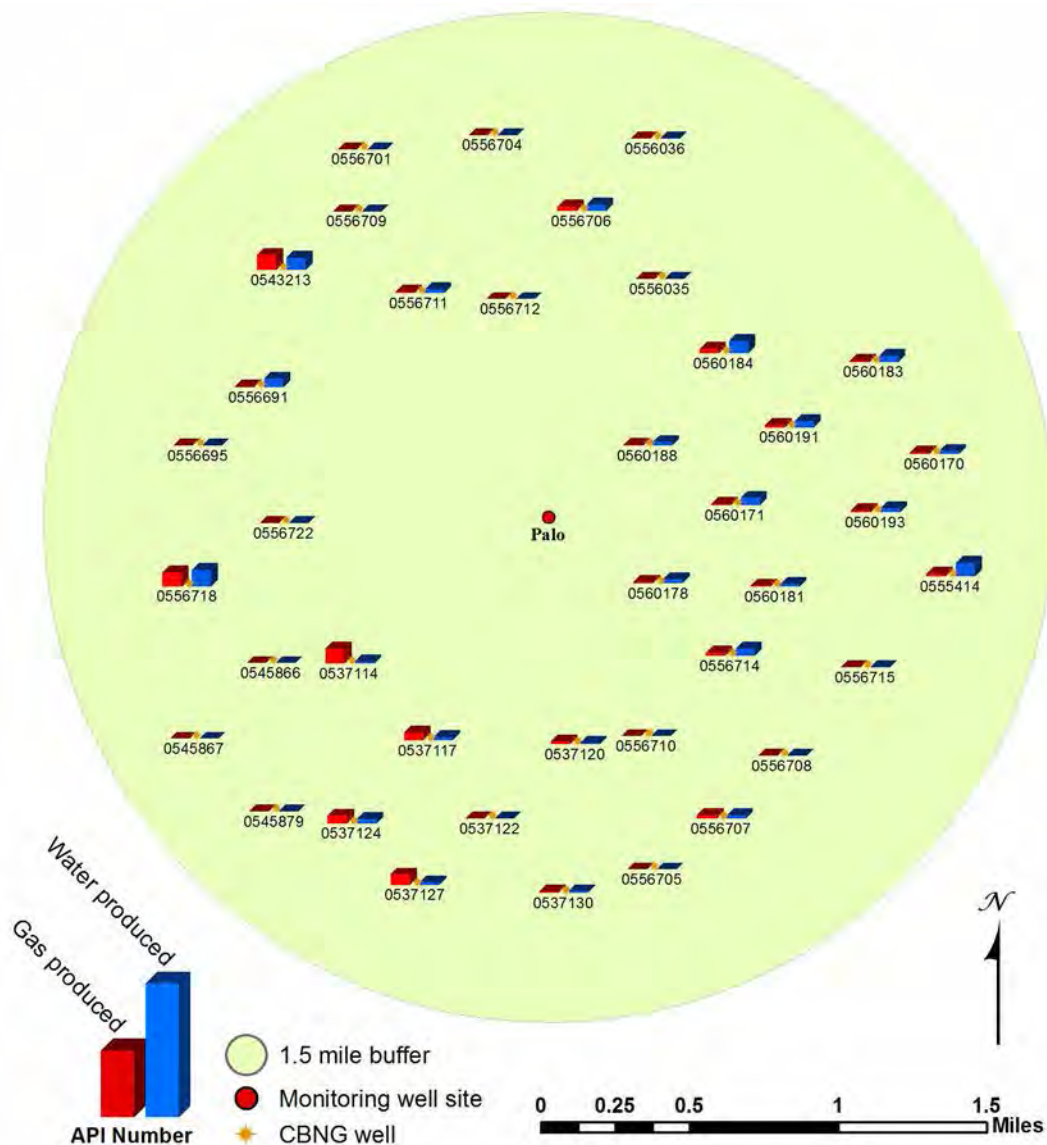


Figure 232. Palo monitoring well and associated CBNG wells within 1.5 mile buffer showing cumulative water (Bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

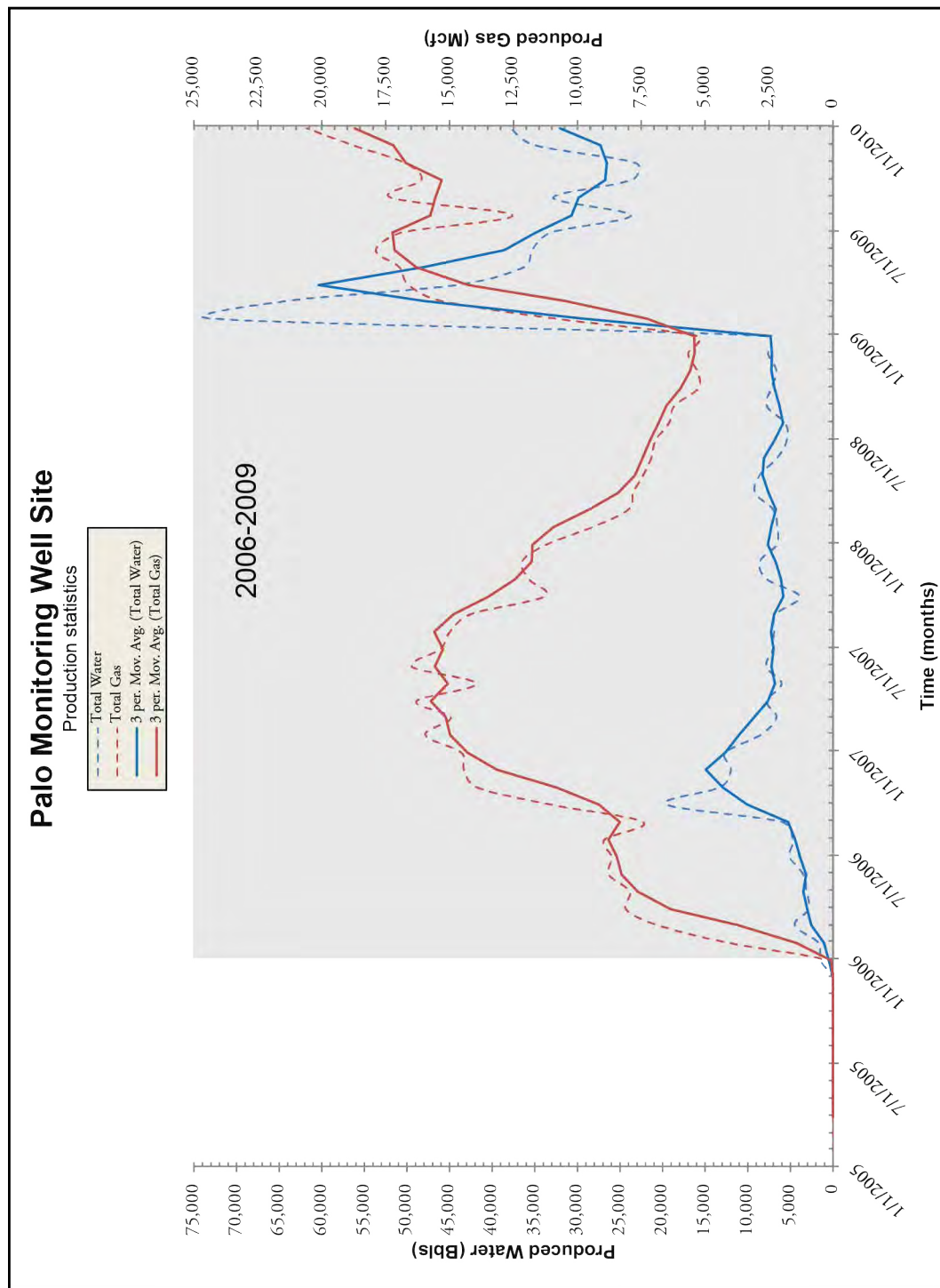


Figure 233. 3-period moving average along with water and gas production from associated CBNG wells.

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 constructed into the Canyon coal and the other is constructed into an overlying Wasatch sandstone (Figure 234; Table 119). Missing and/or fluctuating transducer data is the result of errors with on-site equipment.

The Canyon coal recorded a minimal groundwater increase during the 2006-2009 monitoring period; data shows nearly stable groundwater levels during the 2006-2009 monitoring period. Groundwater levels in the Wasatch sandstone did not change during the 2006-2009 monitoring period, and they have remained nearly constant throughout the life of the well (Figure 235; Table 120). This indicates there is no hydraulic connection between the monitored sandstone and producing zones. Gas pressure readings did not surpass levels possible from transducer error.

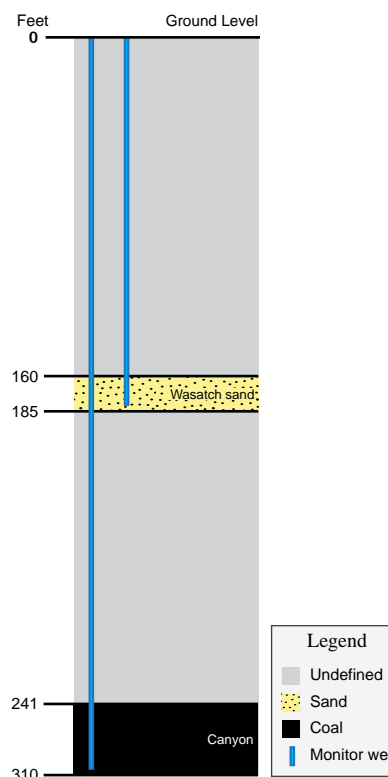


Figure 234. Section showing relative positions of coals and sands in feet. Not to scale.

Table 119. Table showing the depth to and thickness of monitored zones at the Palo monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Wasatch sand	160	185	25	56
Canyon coal	241	310	69	n/a

Table 120. Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2006	Drawdown 2006-2009	Total drawdown (ft.)	Depth to 12/31/09 water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	24.70	-2.69	0.00	-2.69	22.01	n/a	n/a
Canyon coal	32.80	219.03	-0.17	218.86	251.66	99	3/5/99

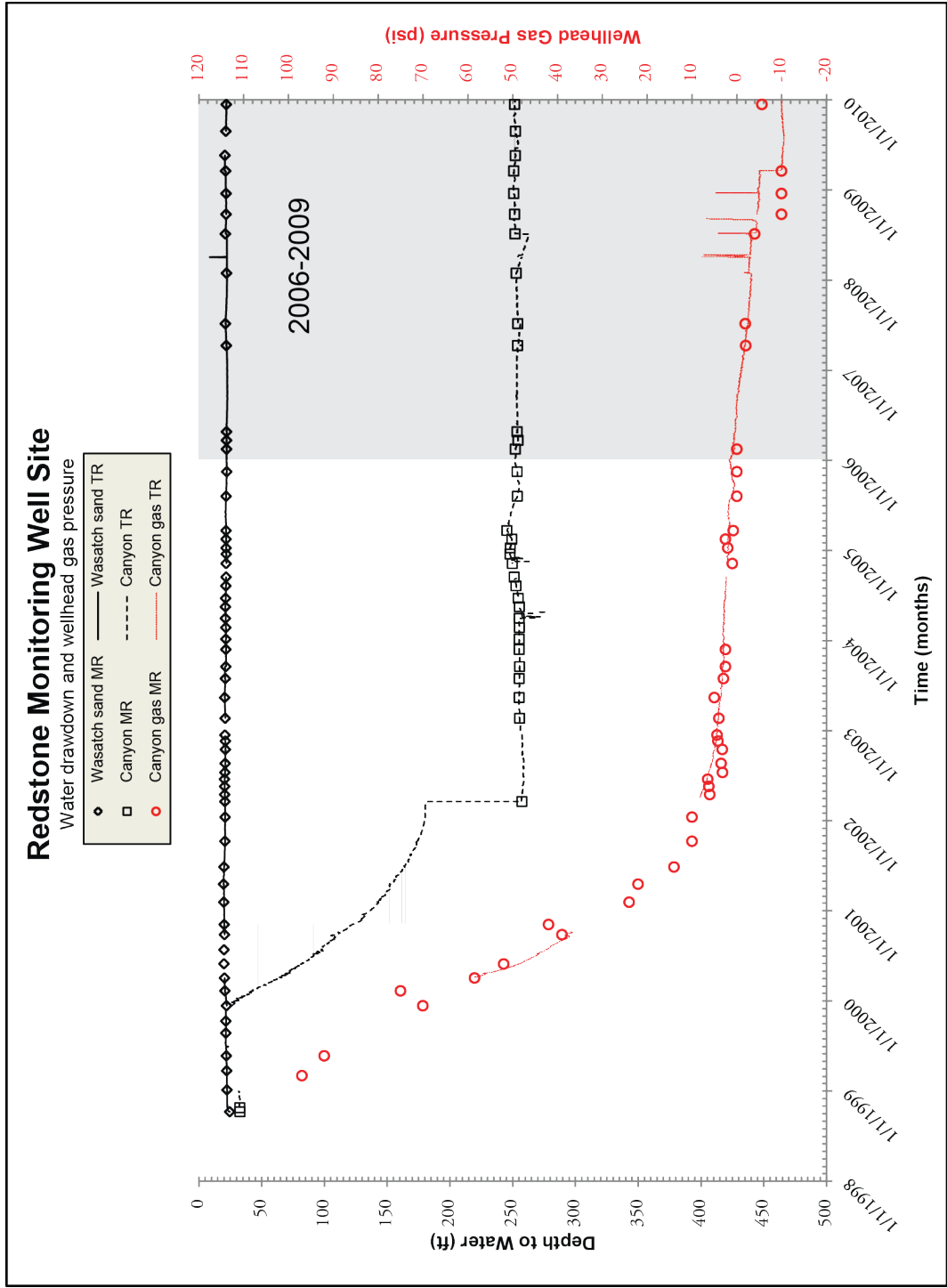


Figure 235. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Redstone monitoring well site location.

Production Statistics

Production data was analyzed for CBNG wells within the buffer of the Redstone monitoring well site from January 1999 through December 2009. Cumulative production for individual CBNG wells is displayed by location on Figure 236.

production declined during the 2006 to 2009 monitoring period (Figure 237). The water/gas ratio of CBNG wells within the buffer is relatively consistent. Percent methane is variable.

Water production peaked in 2000, which correlates to groundwater drawdown trends. Water and gas

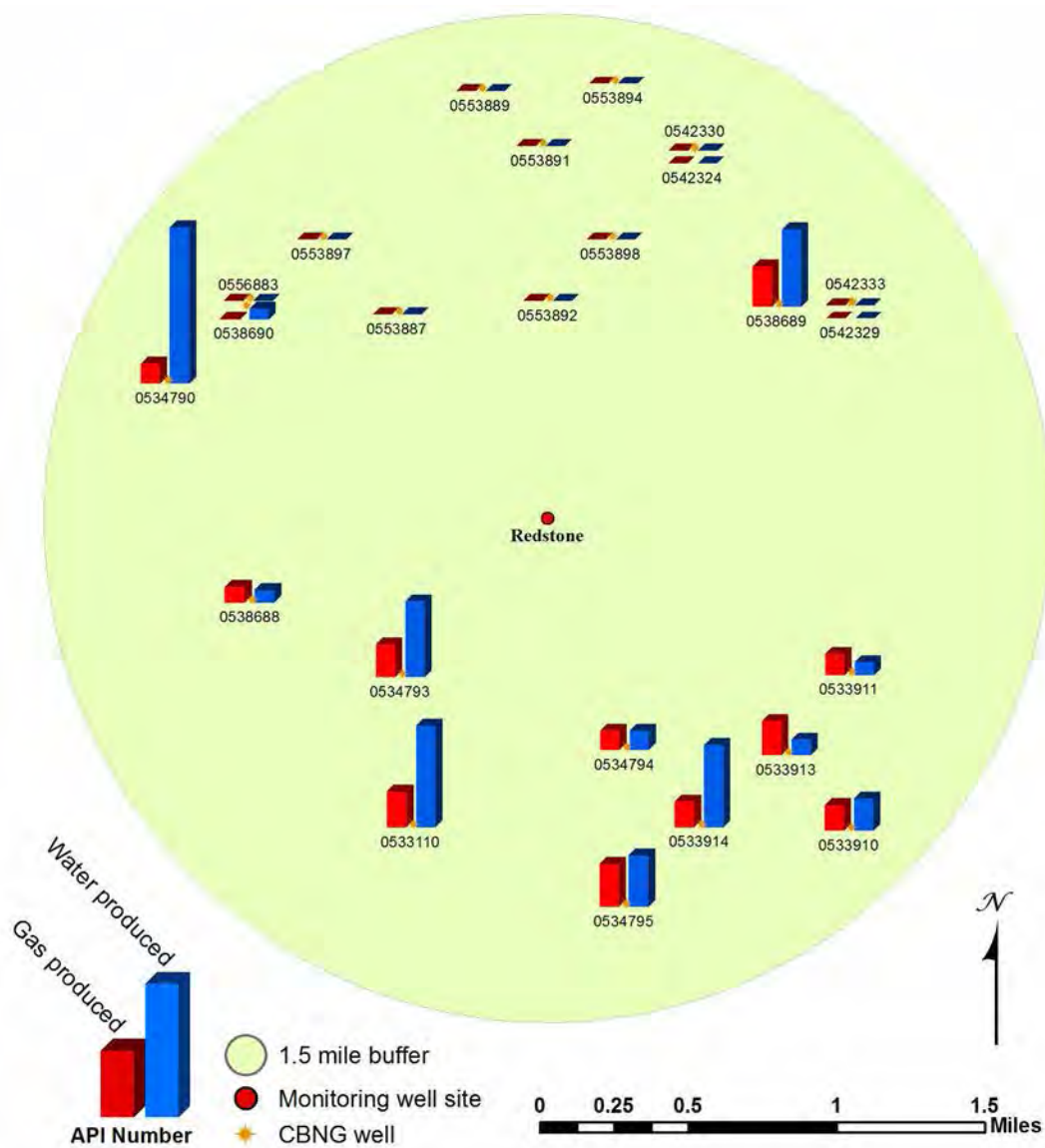


Figure 236. Redstone monitoring well and associated CBNG wells within 1.5 mile buffer showing cumulative water (Bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

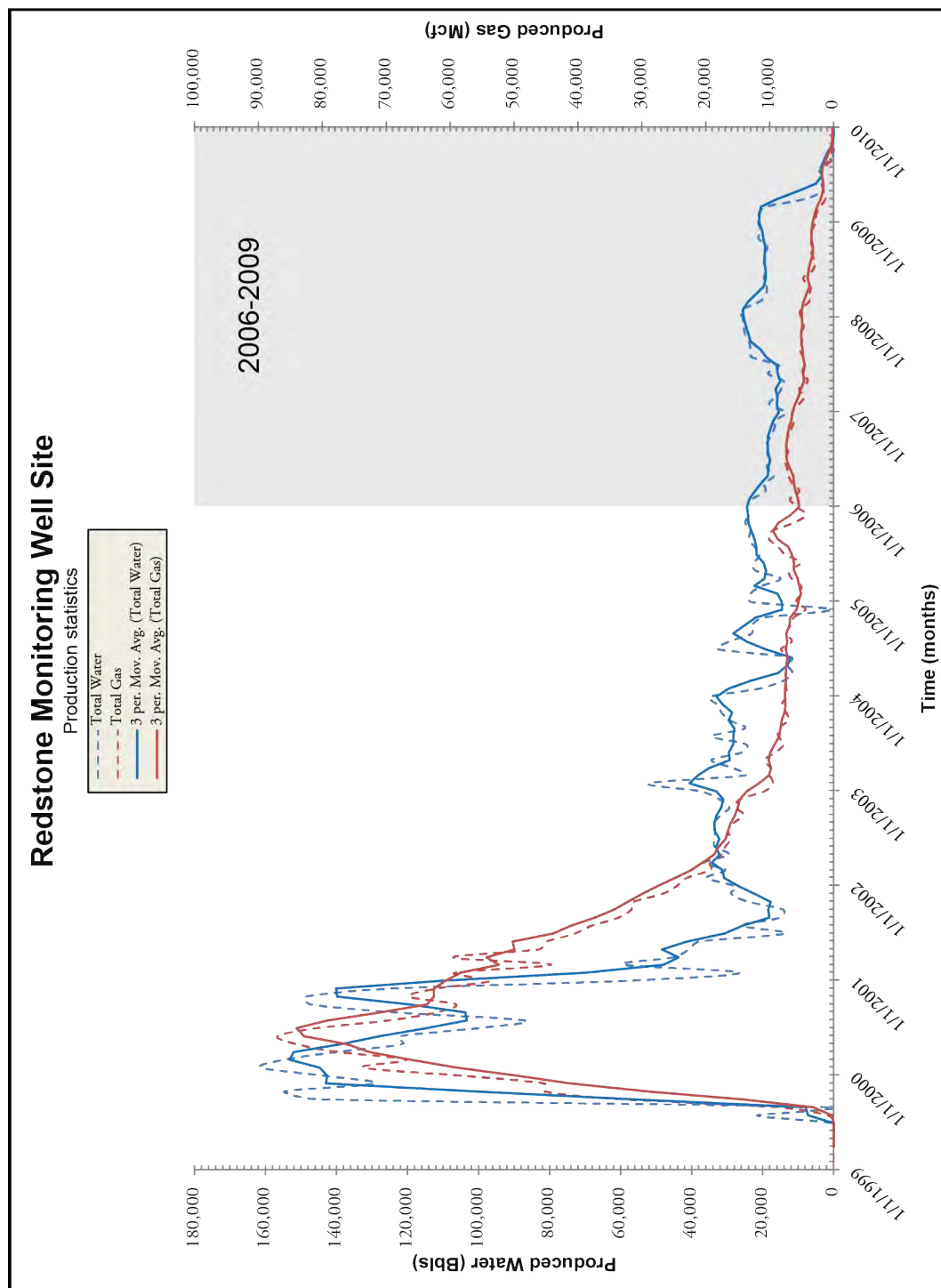


Figure 237. 3-period moving average along with water and gas production from associated CBNG wells.

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 well is drilled into the Anderson coal, one is drilled into the deeper Canyon coal, one is drilled into the still deeper Cook coal, and the fourth is drilled into a overlying Wasatch sandstone (Figure 238; Table 121). Missing and/or fluctuating transducer data is the result of errors with on-site equipment.

The Anderson coal recorded a groundwater decrease of 83 feet during the 2006-2009 monitoring period; data shows a slow decline in the groundwater level (Figure 239; Table 122). The Canyon coal recorded a groundwater decrease of 104 feet during the 2006-2009 monitoring period; data shows a steady decline in the groundwater level (Figure 239; Table 122). The Cook coal recorded a groundwater decrease of 59 feet during the 2006-2009 monitoring period; data shows a steady decline in the groundwater level (Figure 239; Table 122). Groundwater levels in the Wasatch sandstone increased by 2 feet during the 2006-2009 monitoring period, and they have remained nearly constant throughout the life of the well (Figure 239; Table 122). This indicates there is no hydraulic connection between the monitored sandstone and producing zones.

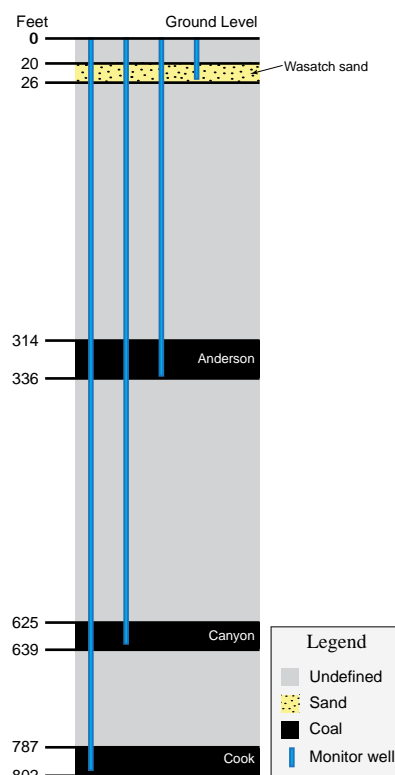


Figure 238. Section showing relative positions of coals and sands in feet. Not to scale.

Table 121. Table showing the depth to and thickness of monitored zones at the Remington Creek monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Wasatch sand	20	26	6	288
Anderson coal	314	336	22	n/a
Canyon coal	625	639	14	n/a
Cook coal	787	802	15	n/a

Table 122. Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2006	Drawdown 2006-2009	Total drawdown (ft.)	Depth to 12/31/09 water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	4.64	0.00	-2.33	-2.33	2.31	n/a	n/a
Anderson coal	160.00	60.20	82.57	142.77	302.77	60.00	8/30/05
Canyon coal	378.40	33.36	104.24	137.60	516.00	n/a	n/a
Cook coal	378.00	72.59	59.11	131.70	509.70	n/a	n/a

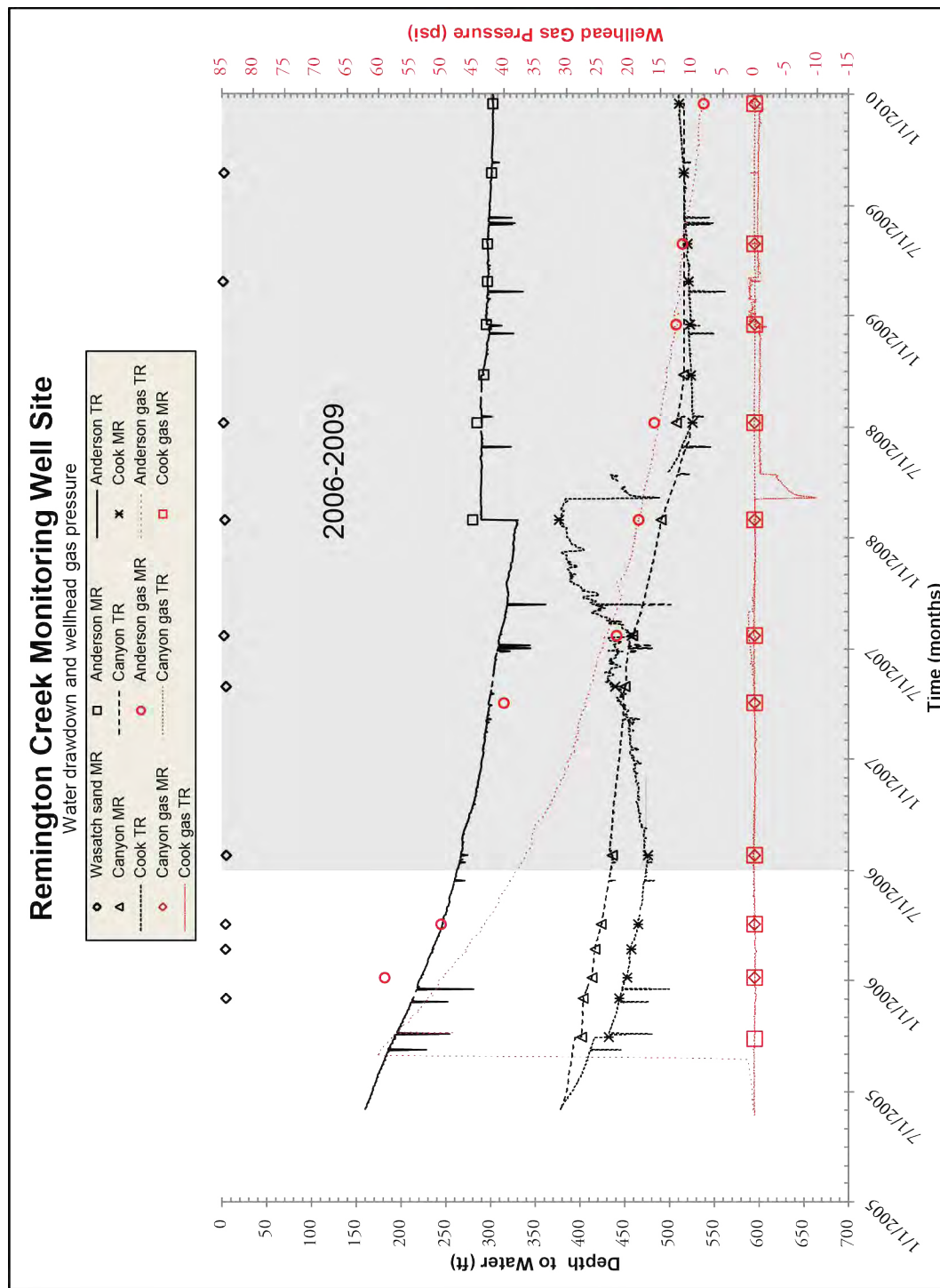


Figure 239. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Remington Creek monitoring well site location. Gray area represents the current monitoring period of 2006-2009.

Production Statistics

Production data was analyzed for CBNG wells within the buffer of the Remington Creek monitoring well sites from January 2004 through December 2009. Cumulative production for individual CBNG wells is displayed by location on Figure 240.

Water production started to increase in 2004, which generally correlates to groundwater drawdown trends. Water and gas production increased during the 2006 to 2009 monitoring period (Figure 241). The water/gas ratio of CBNG wells within the buffer is relatively inconsistent. Percent methane is variable.

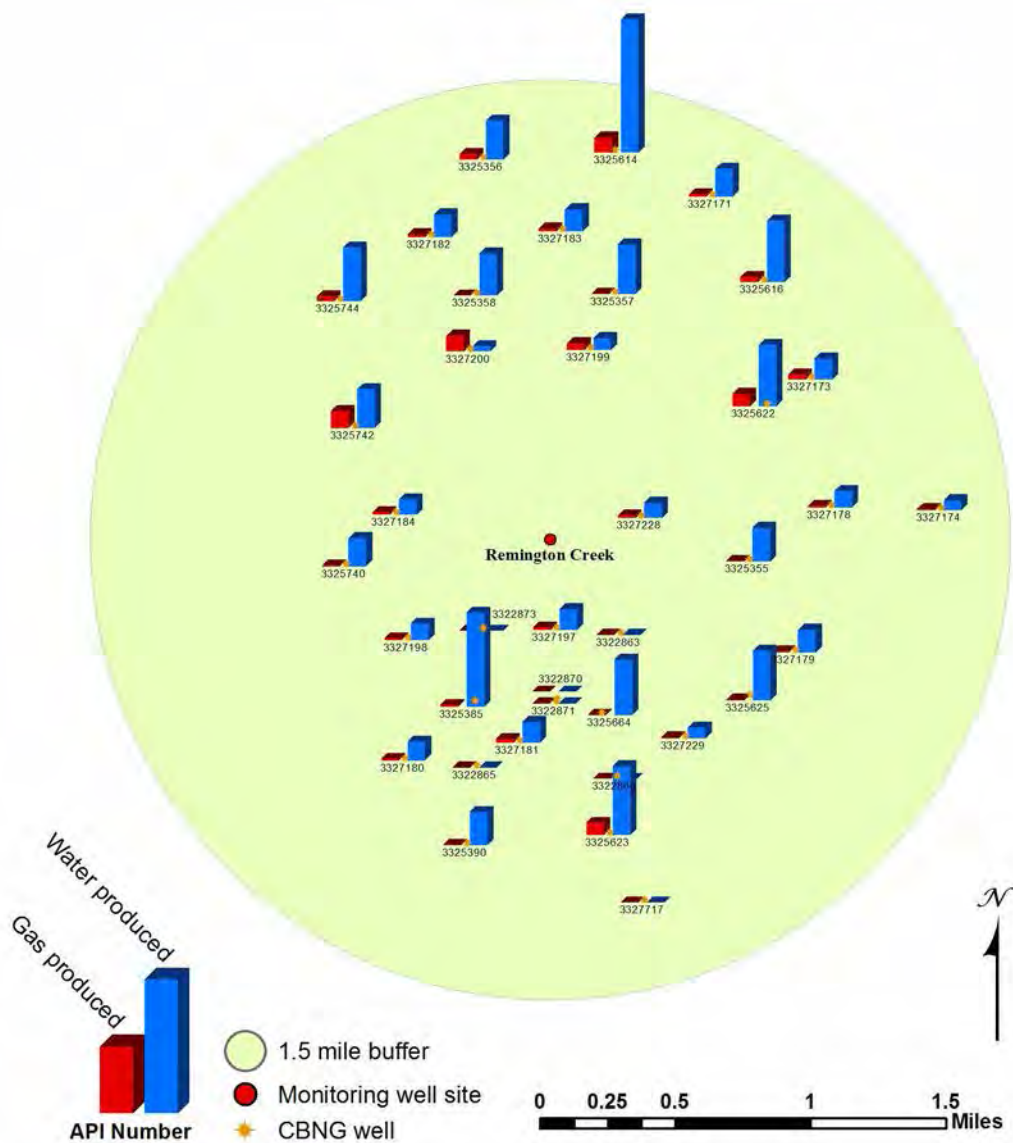


Figure 240. Remington Creek monitoring well and associated CBNG wells within 1.5 mile buffer showing cumulative water (Bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

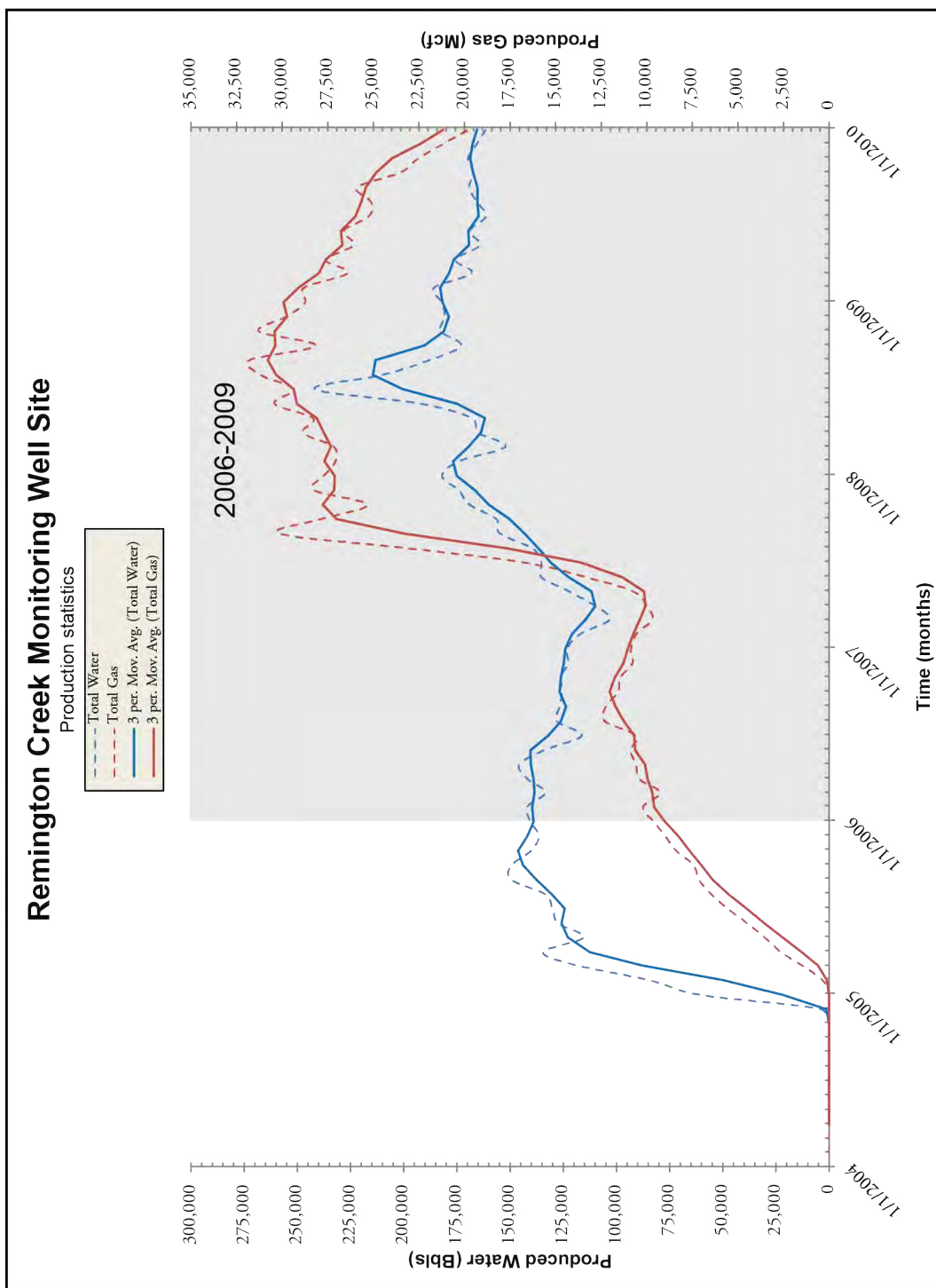


Figure 241. 3-period moving average along with water and gas production from associated CBNG wells.

APPENDIX 5. Cook Coal Zone

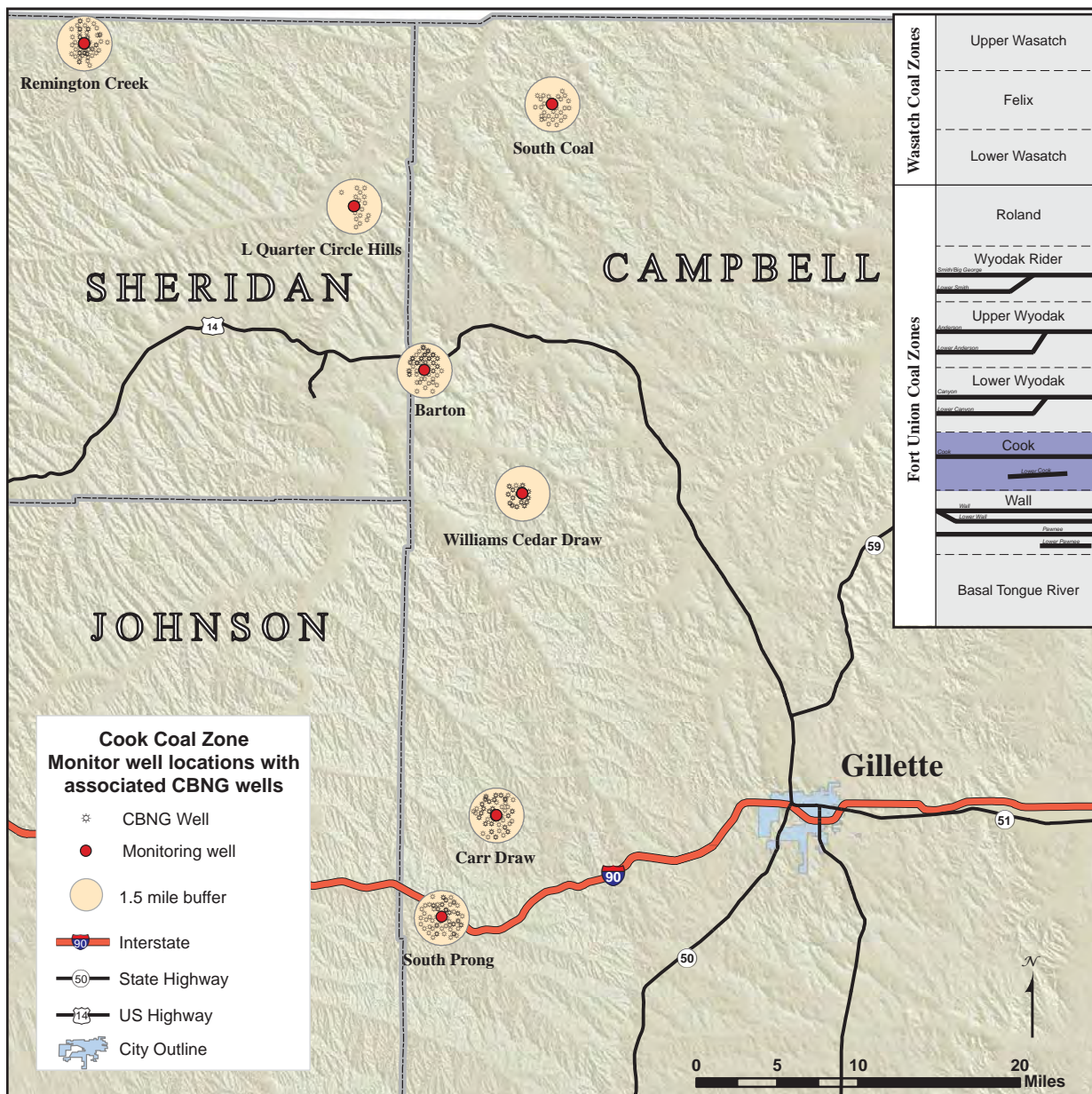


Figure 242. Cook coal zone monitoring well site locations in the Powder River Basin, Wyoming.

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

Drawdown Information

The Barton monitoring well site includes two wells. One is drilled into the shallower Cook coal and the other into the deeper Wall coal (Figure 243; Table 123). There is no monitoring well associated with a Wasatch sand at this location. Missing transducer data is the result of errors with on site equipment.

During the current monitoring period of 2006-2009 the water level in the Wall coal decreased by 4 feet. The water level in the Cook coal decreased by 41 feet during the 2006-2009 monitoring period. (Figure 244; Table 124). The hydrologic connections between the coal and Wasatch sands packages are not monitored in this location. The wellhead gas pressure in both the Cook and Wall wells remained nearly zero. The fluctuation of readings throughout the monitoring period reflects variations in the monitoring equipment (Figure 245).

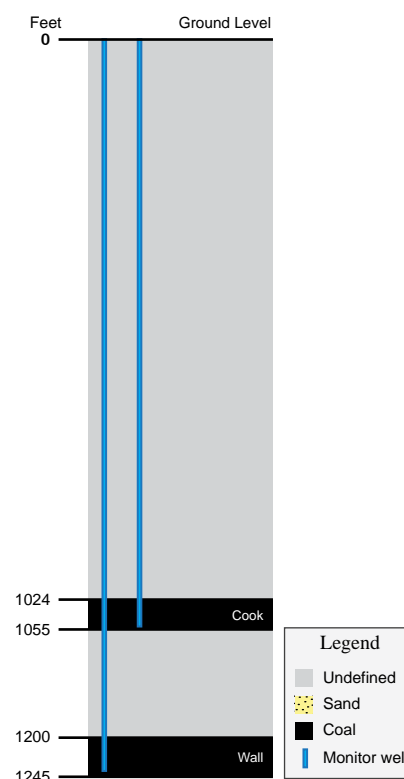


Figure 243. Section showing relative positions of coals and sands in feet. Not to scale.

Table 123. Table showing the depth to and thickness of monitored zones at the Barton monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Cook coal	1024	1055	31	n/a
Wall coal	1200	1245	45	n/a

Table 124. Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2006	Drawdown 2006-2009	Total drawdown (ft.)	Depth to 12/31/09 water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Cook coal	365.00	122.65	40.75	163.40	528.40	n/a	n/a
Wall coal	200.50	10.74	4.13	14.87	215.37	n/a	n/a

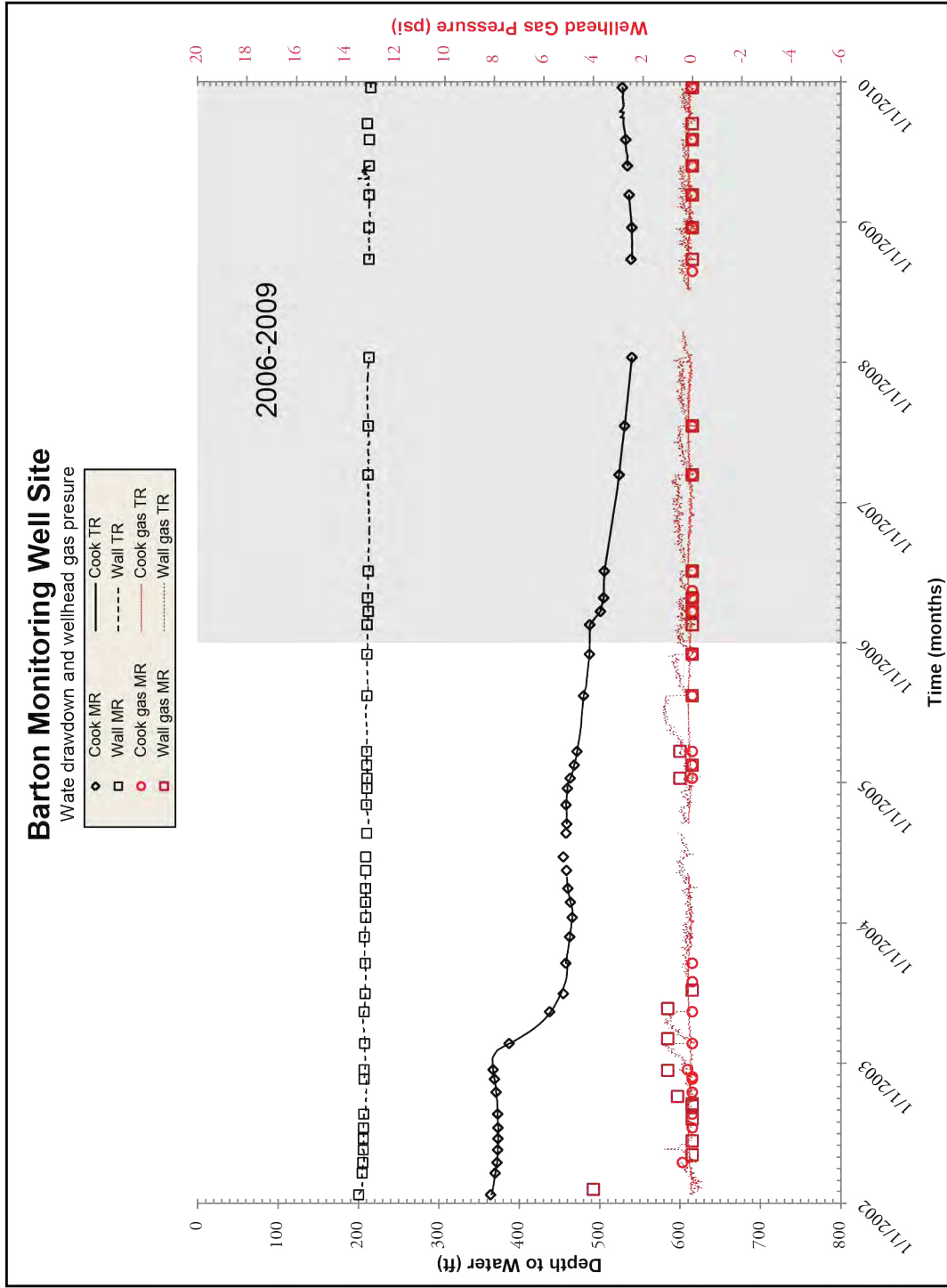


Figure 244. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Barton monitoring well site location.

Production Statistics

Production data was analyzed for CBNG wells within the buffer of the Barton monitoring well site from January 2001 through December 2009. Cumulative production for individual CBNG wells is displayed by location on Figure 245.

Water production peaked in 2001, which correlates to groundwater drawdown trends. Gas production in-

creased and water production remained relatively constant during the 2006 to 2009 monitoring period (Figure 246). The water/gas ratio of CBNG wells within the buffer is inconsistent. Percent methane is variable.

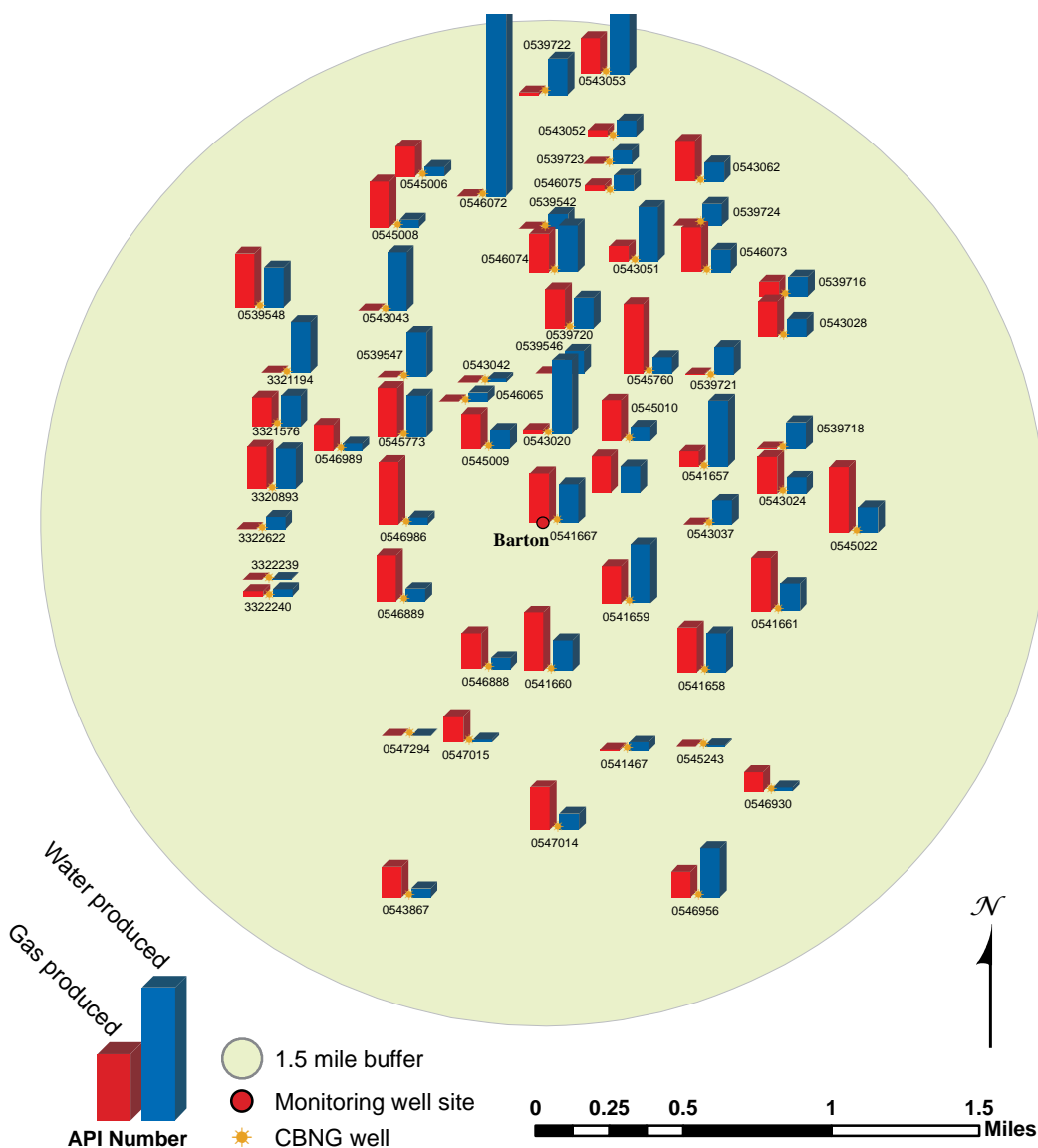


Figure 245. Barton monitoring well and associated CBNG wells within 1.5 mile buffer showing cumulative water (Bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

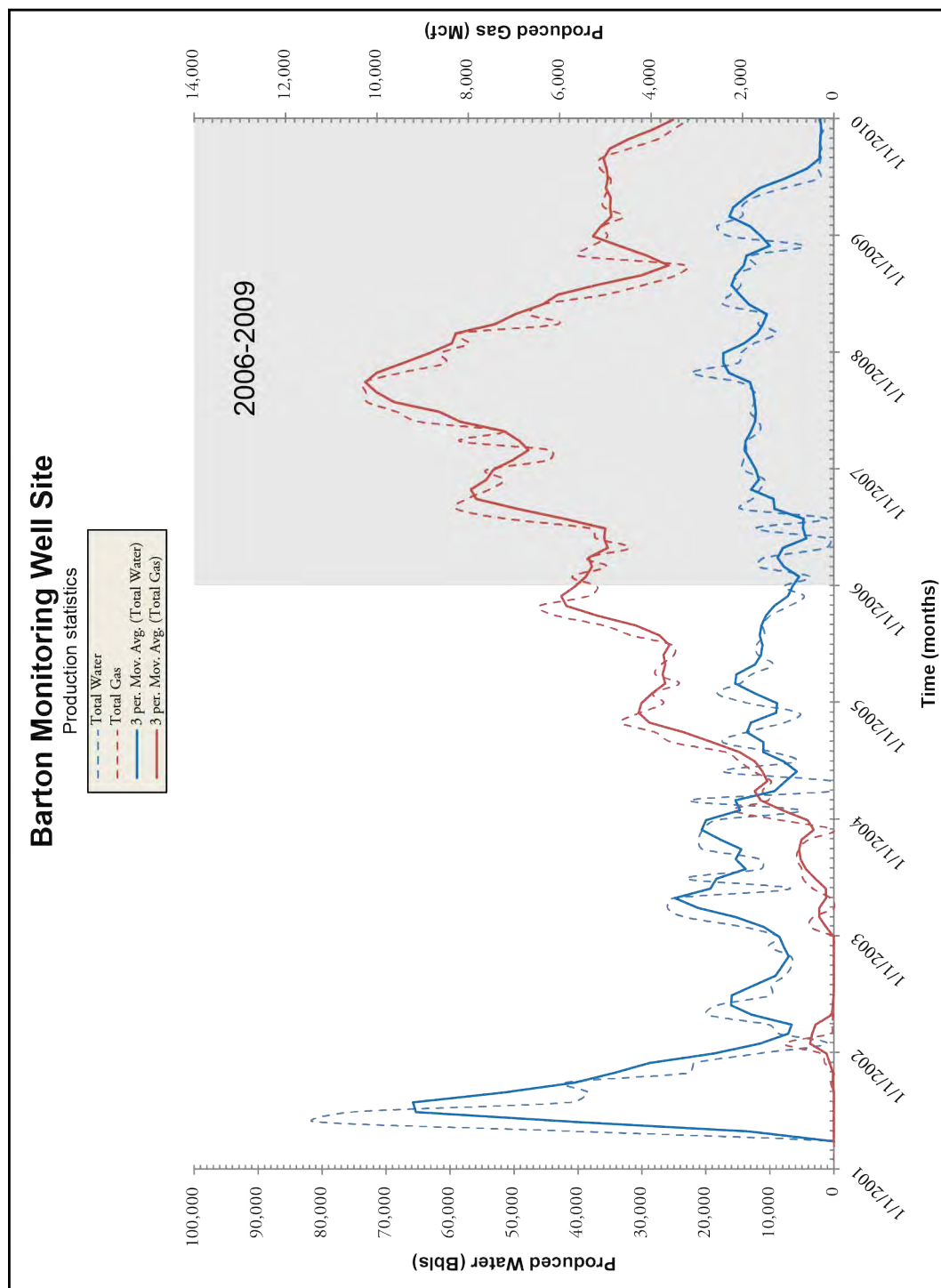


Figure 246. 3-period moving average along with water and gas production from associated CBNG wells.

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

Drawdown Information

The Carr Draw monitoring well site consists of two wells with dual completions, separated by packers. One well is completed into the Big George coal and an overlying Wasatch sandstone. The second well is completed into the Werner and Gates/Wall coals (Figure 247; Table 125). Missing and/or fluctuating transducer data is the result of errors with on-site equipment.

Initial data that was collected was from manual measurements, 2009 data includes some transducer recorded data. The depth to initial water levels for the Wasatch sandstone (342 ft.) and Werner coal (344 ft.) were similar despite the approximate 1,000 feet separation between the two zones. Likewise, the Big George (492 ft.) and Gates/Wall (491 ft.) coal zones had similar initial water levels despite 500 feet in separation. The Big George coal had the most draw-down during the 2006-2009 monitoring period at 546 feet. The Wasatch sandstone and Werner coal had similar drawdowns with 355 feet and 320 feet respectively. The Gates/Wall coal water level rose by 144 feet over the same 2006-2009 monitoring period (Figure 248; Table 126). With equipment and packer issues on this site no conclusions on hydrologic connection between zones can be made at this time. The gas readings did not surpass levels possible from transducer error.

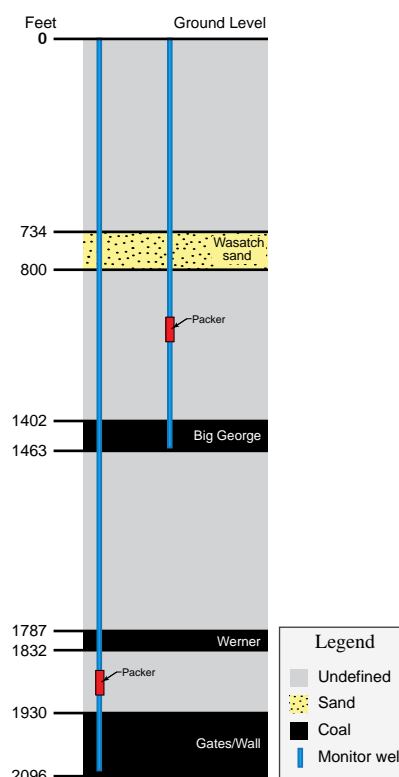


Figure 247. Section showing relative positions of coals and sands in feet. Not to scale.

Table 125. Table showing the depth to and thickness of monitored zones at the Carr Draw monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Wasatch sand	734	800	66	602
Big George coal	1402	1463	61	n/a
Werner coal	1787	1832	45	n/a
Gates/Wall coal	1930	2096	166	n/a

Table 126. Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2006	Drawdown 2006-2009	Total drawdown (ft.)	Depth to 12/31/09 water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	341.66	n/a	355.39	355.39	697.05	n/a	n/a
Big George coal	492.30	n/a	546.15	546.15	1038.45	n/a	n/a
Werner coal	344.00	n/a	320.26	320.26	664.26	n/a	n/a
Gates/Wall coal	490.50	n/a	-143.52	-143.52	346.98	n/a	n/a

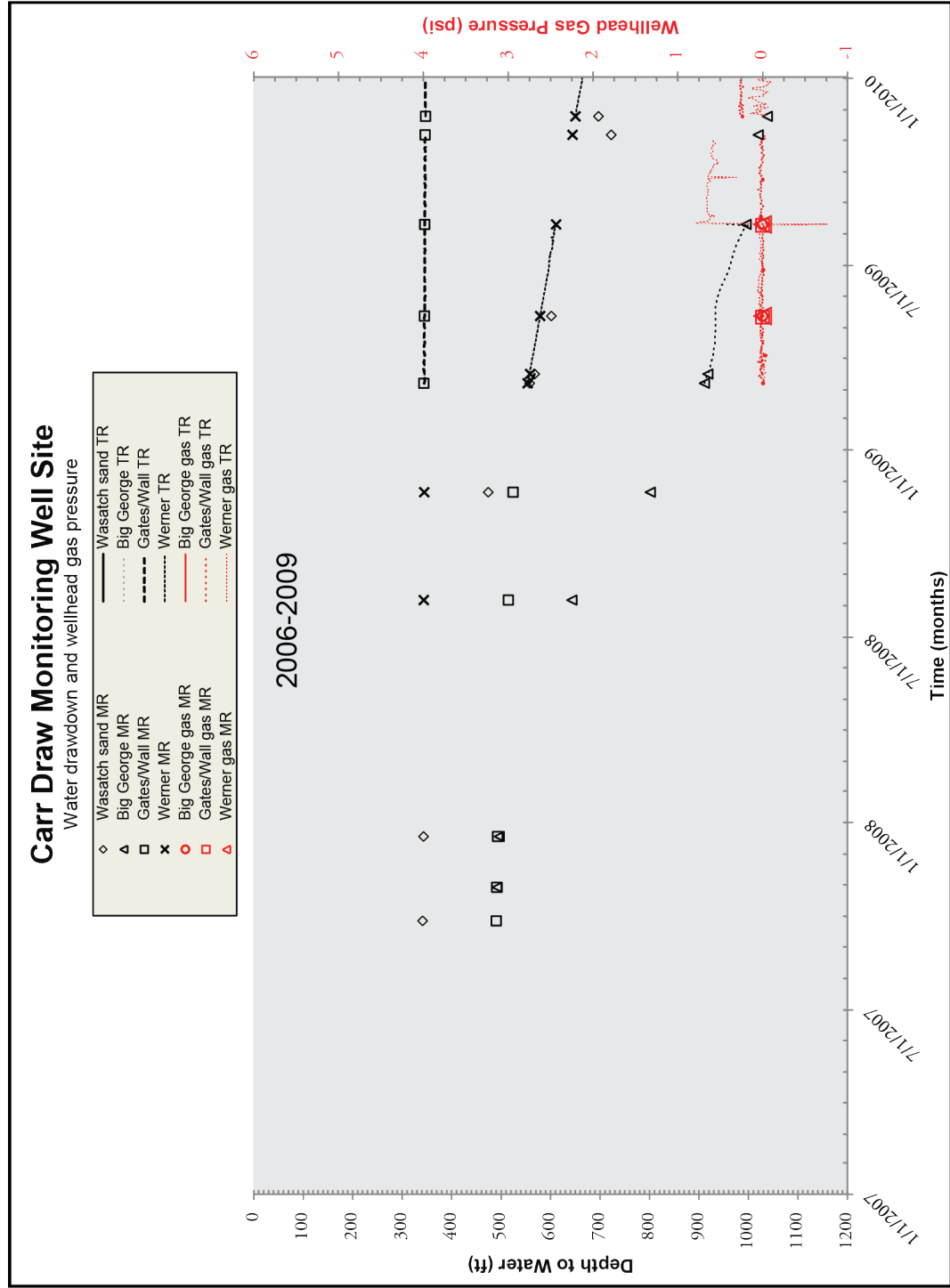


Figure 248. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Carr Draw monitoring well site location.

Production Statistics

Production data was analyzed for CBNG wells within the buffer of the Carr Draw monitoring well site from January 2002 through December 2009. Cumulative production for individual CBNG wells is displayed by location on Figure 249.

down recorded in the Big George coal bed. Water and gas production increased during the 2006 to 2009 monitoring period (Figure 250). The water/gas ratio of CBNG wells within the buffer is relatively inconsistent from southwest to northeast. Percent methane remained relatively consistent.

Water production peaked in 2004. Renewed water production in 2008 correlates to groundwater draw-

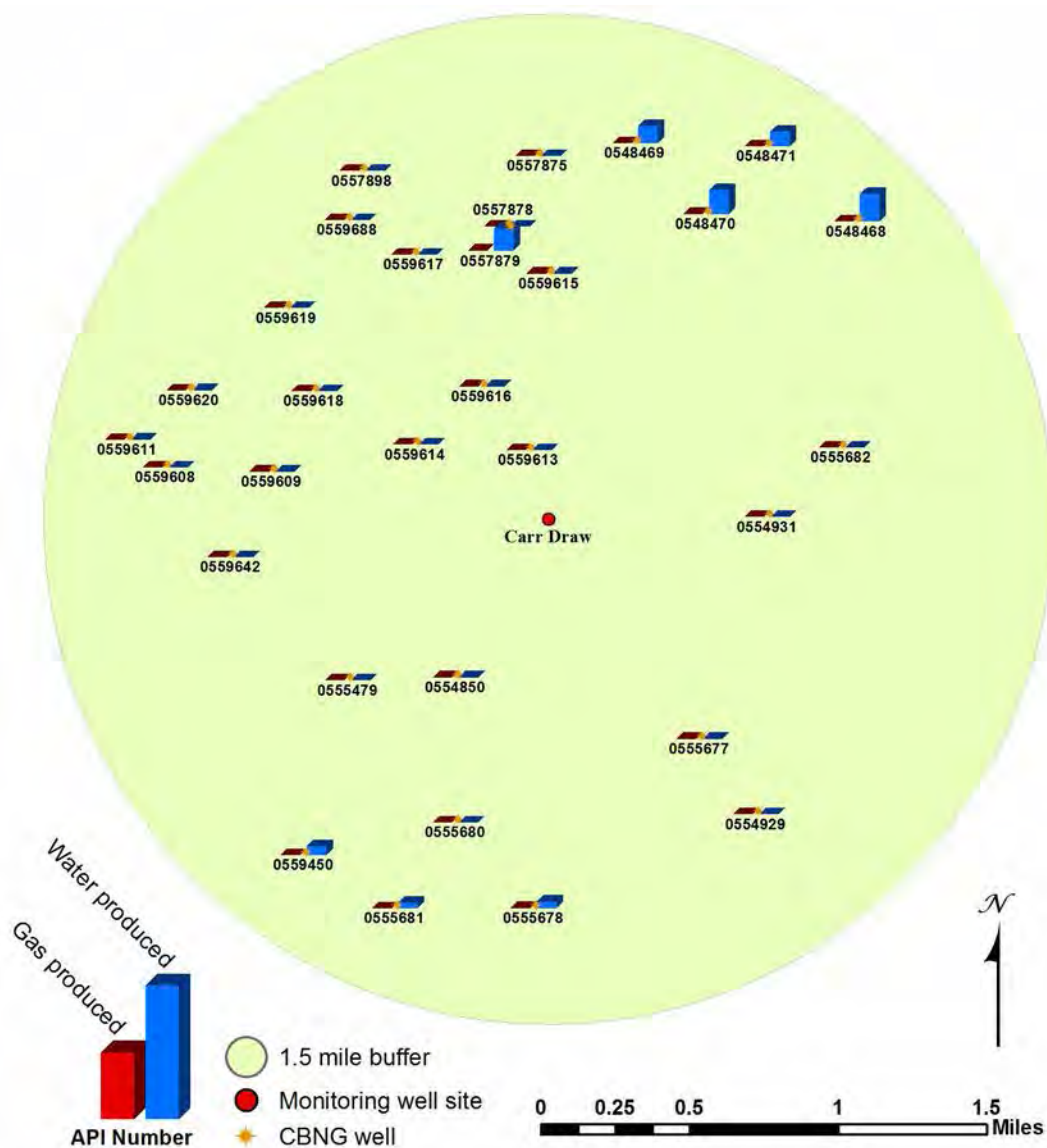


Figure 249. Carr Draw monitoring well and associated CBNG wells within 1.5 mile buffer showing cumulative water (Bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

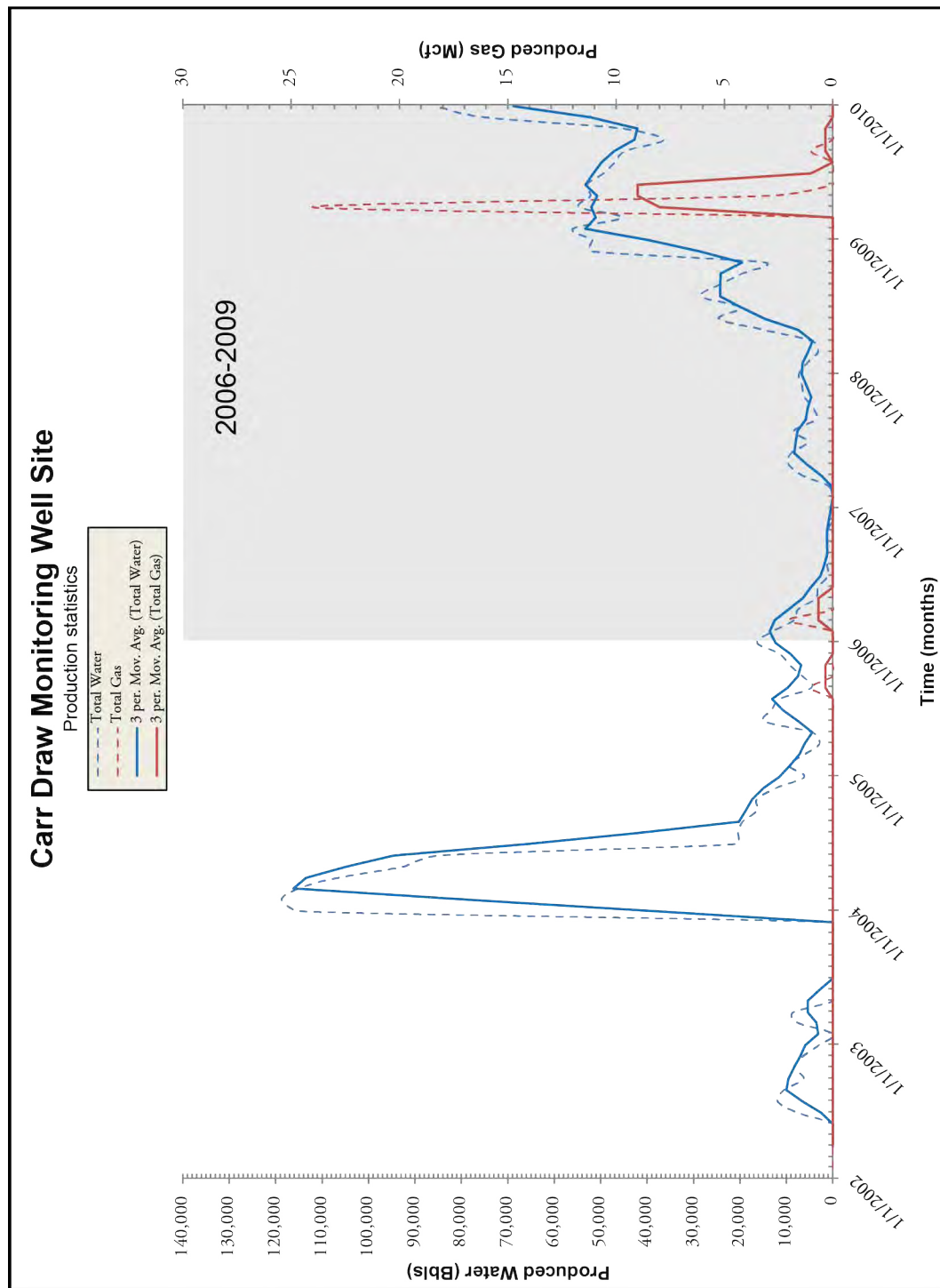


Figure 250. 3-period moving average along with water and gas production from associated CBNG wells.

L Quarter Circle Hills Monitoring Well Site

Location: S14 T56N R77W

Date First Monitored: April 5, 2005

Drawdown Information

The L Quarter Circle Hills monitoring well site includes three wells. One is constructed into the shallower Cook coal, another into the deeper Wall coal, and the third into an overlying Wasatch sandstone (Figure 251; Table 127). Missing transducer data is the result of errors with on site equipment.

Between 2006-2009 the Cook and Wall coals experienced drawdown. During July and August of 2008 the water levels in both coals dropped by over 100 feet. This drawdown coincides with the increase in produced water in the area. Water levels continued to drop after that period but at a slower rate. The trends in drawdown for the two coals are similar suggesting possible hydrologic connection between the coals (Figure 252). The Wasatch sand shows a less severe drawdown beginning at the same time period and continuing through the last reported date (Figure 252; Table 128). Though the impacts were minor, drawdown suggests that there may be hydrologic connectivity between the coals and sand. Gas pressures remained nearly zero during the period of maximum drawdown.

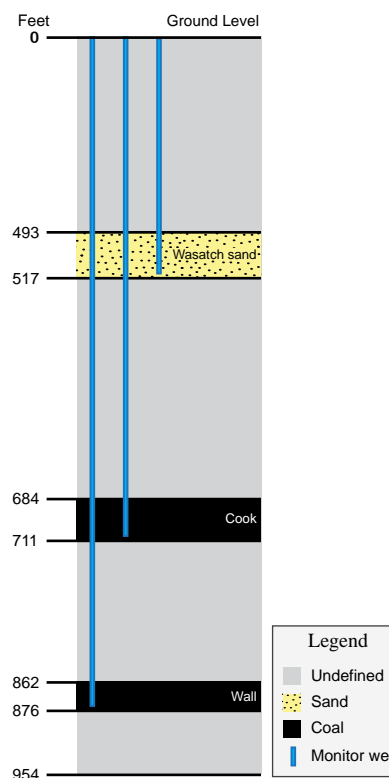


Figure 251. Section showing relative positions of coals and sands in feet. Not to scale.

Table 127. Table showing the depth to and thickness of monitored zones at the L Quarter Circle Hills monitoring well site location. (measured in feet)

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

Table 128. Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2006	Drawdown 2006-2009	Total drawdown (ft.)	Depth to 12/31/09 water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	41.38	-2.32	13.27	10.95	52.33	n/a	n/a
Cook coal	22.86	-3.37	190.60	187.23	210.09	7.00	10/18/07
Wall coal	15.39	0.26	260.38	260.64	276.03	13.00	12/17/06

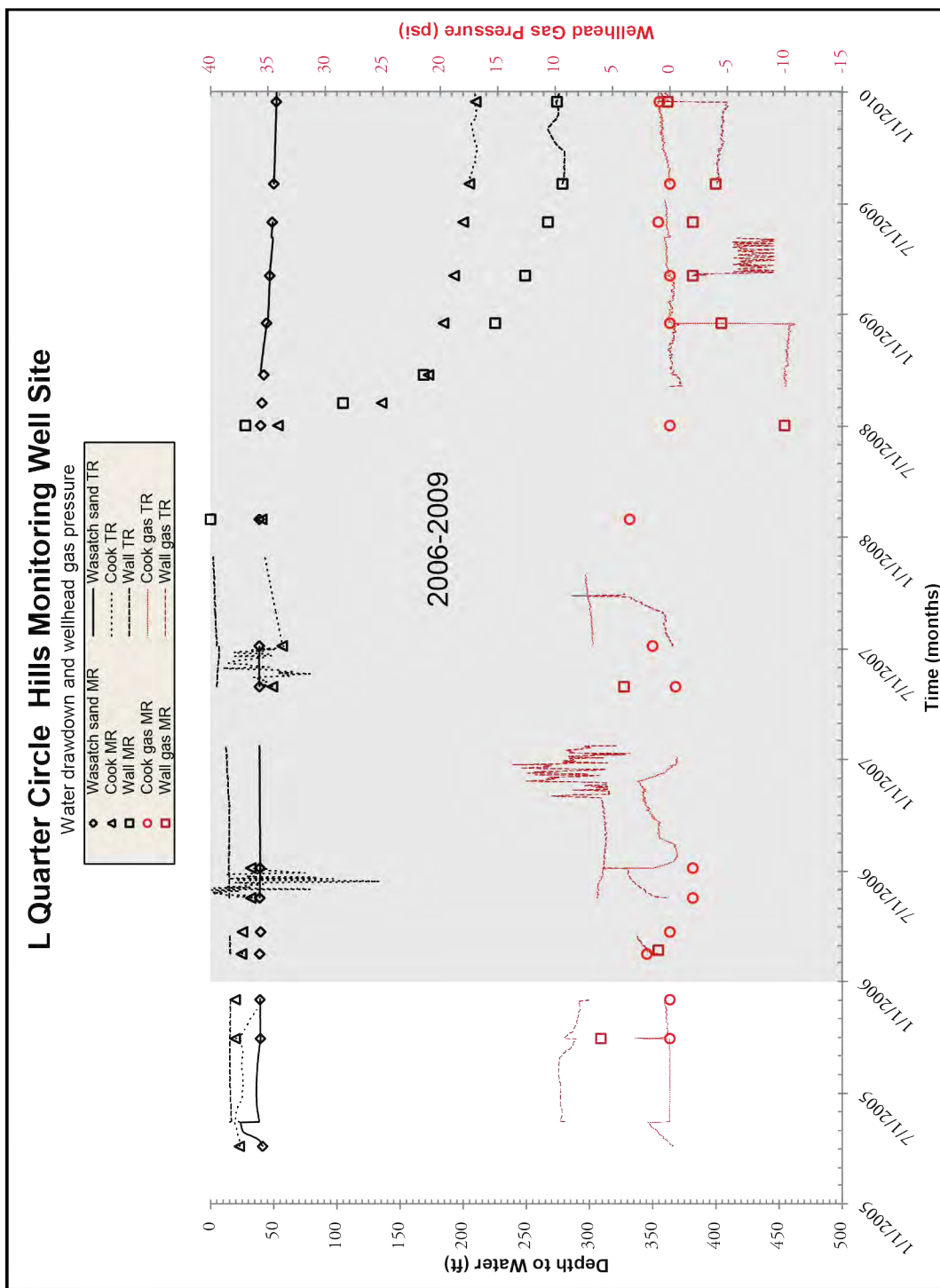


Figure 252. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the L Quarter Circle Hills monitoring well site location.

Production Statistics

Production data was analyzed for CBNG wells within the buffer of the L Quarter Circle Hills monitoring well site from January 2001 through December 2009. Cumulative production for individual CBNG wells is displayed by location on Figure 253.

CBNG water production increased in 2002 and peaked in 2008, which generally correlates to groundwater drawdown trends (though this data is sporadic) (Figure 254). The water/gas ratio of CBNG wells within the buffer is inconsistent. Percent methane is variable.

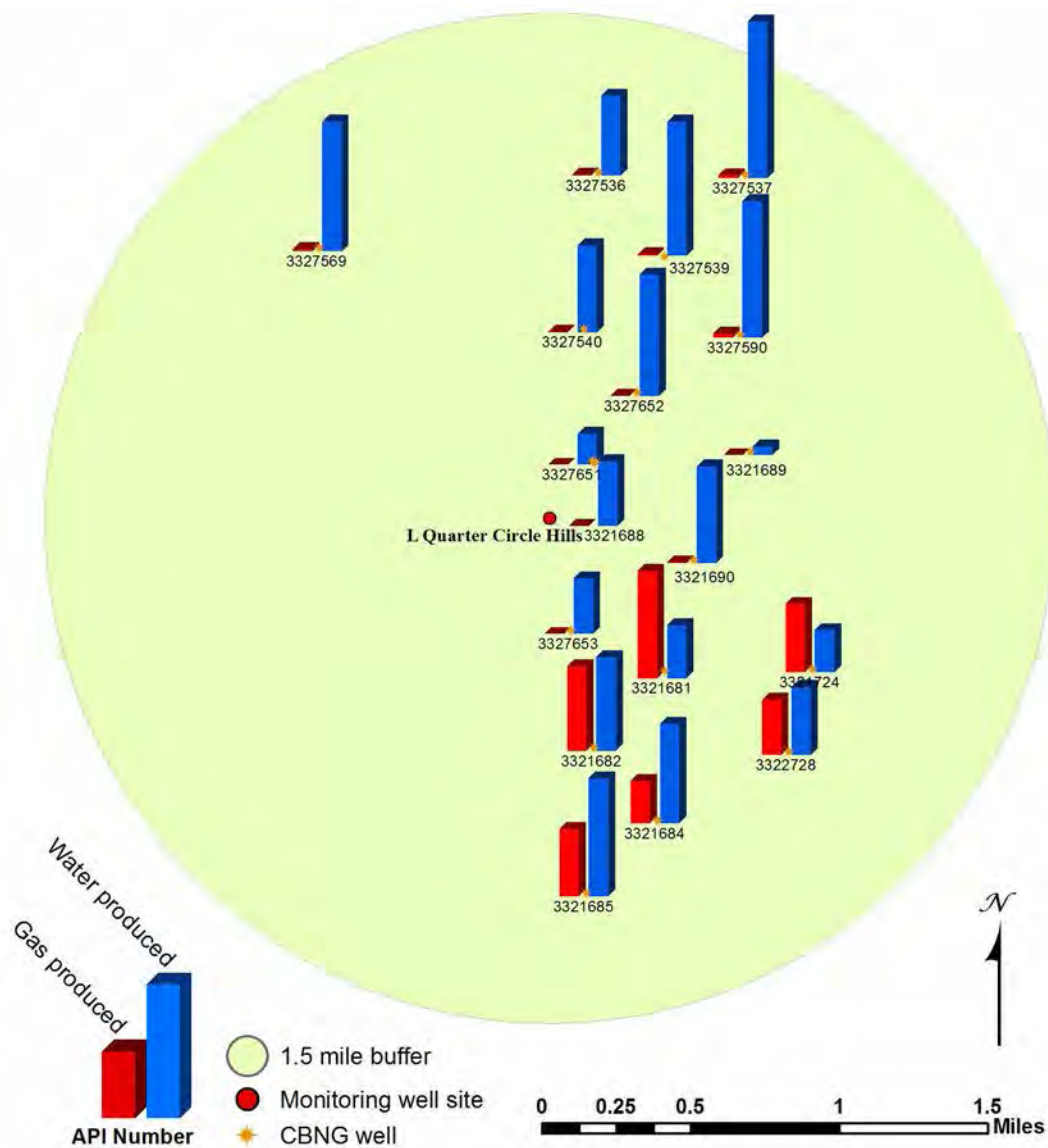


Figure 253. L Quarter Circle Hills monitoring well and associated CBNG wells within 1.5 mile buffer showing cumulative water (Bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

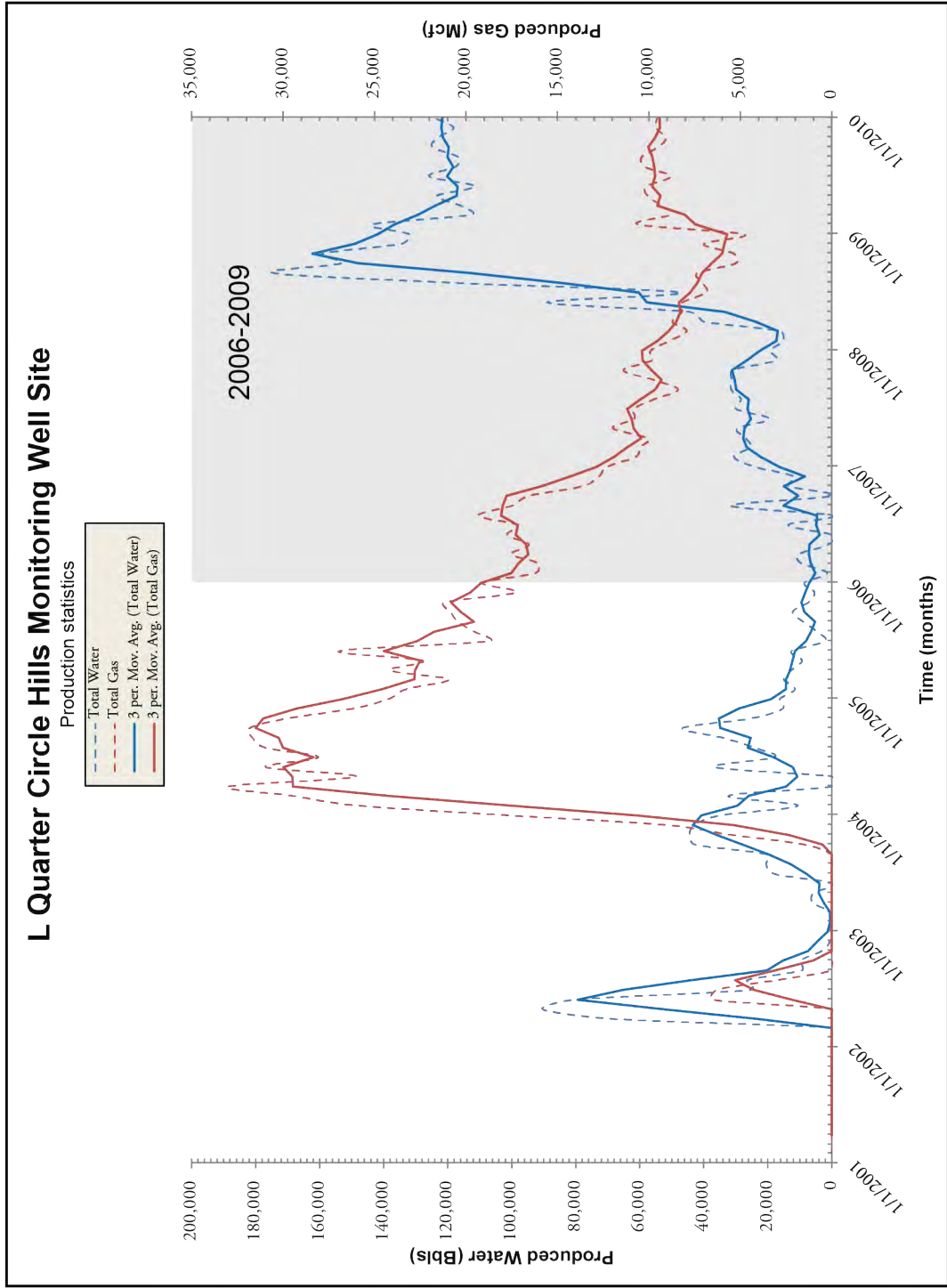


Figure 254. 3-period moving average along with water and gas production from associated CBNG wells.

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 well is drilled into the Anderson coal, one is drilled into the deeper Canyon coal, one is drilled into the still deeper Cook coal, and the fourth is drilled into a overlying Wasatch sandstone (Figure 255; Table 129). Missing and/or fluctuating transducer data is the result of errors with on-site equipment.

The Anderson coal recorded a groundwater decrease of 82 feet during the 2006-2009 monitoring period; data shows a slow decline in the groundwater level (Figure 256; Table 130). The Canyon coal recorded a groundwater decrease of 104 feet during the 2006-2009 monitoring period; data shows a steady decline in the groundwater level (Figure 256; Table 130). The Cook coal recorded a groundwater decrease of 59 feet during the 2006-2009 monitoring period; data shows a steady decline in the groundwater level (Figure 256; Table 130). Groundwater levels in the Wasatch sandstone increased by 2 feet during the 2006-2009 monitoring period, and they have remained nearly constant throughout the life of the well (Figure 256; Table 130). This indicates there is no hydraulic connection between the monitored sandstone and producing zones.

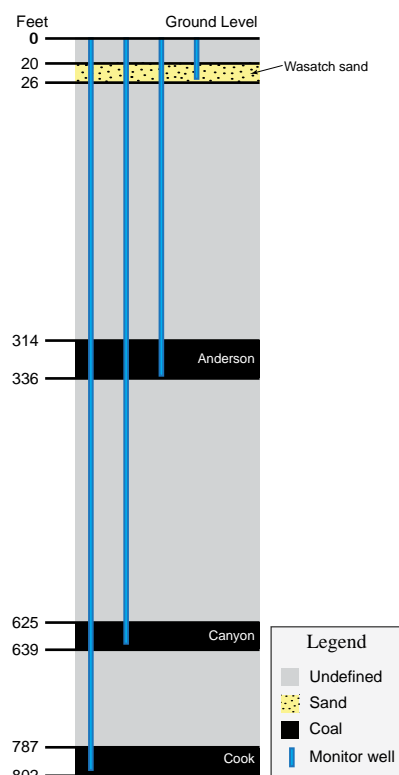


Figure 255. Section showing relative positions of coals and sands in feet. Not to scale.

Table 129. Table showing the depth to and thickness of monitored zones at the Remington Creek monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Wasatch sand	20	26	6	288
Anderson coal	314	336	22	n/a
Canyon coal	625	639	14	n/a
Cook coal	787	802	15	n/a

Table 130. Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2006	Drawdown 2006-2009	Total drawdown (ft.)	Depth to 12/31/09 water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	4.64	0.00	-2.33	-2.33	2.31	n/a	n/a
Anderson coal	160.00	60.20	82.57	142.77	302.77	60.00	8/30/05
Canyon coal	378.40	33.36	104.24	137.60	516.00	n/a	n/a
Cook coal	378.00	72.59	59.11	131.70	509.70	n/a	n/a

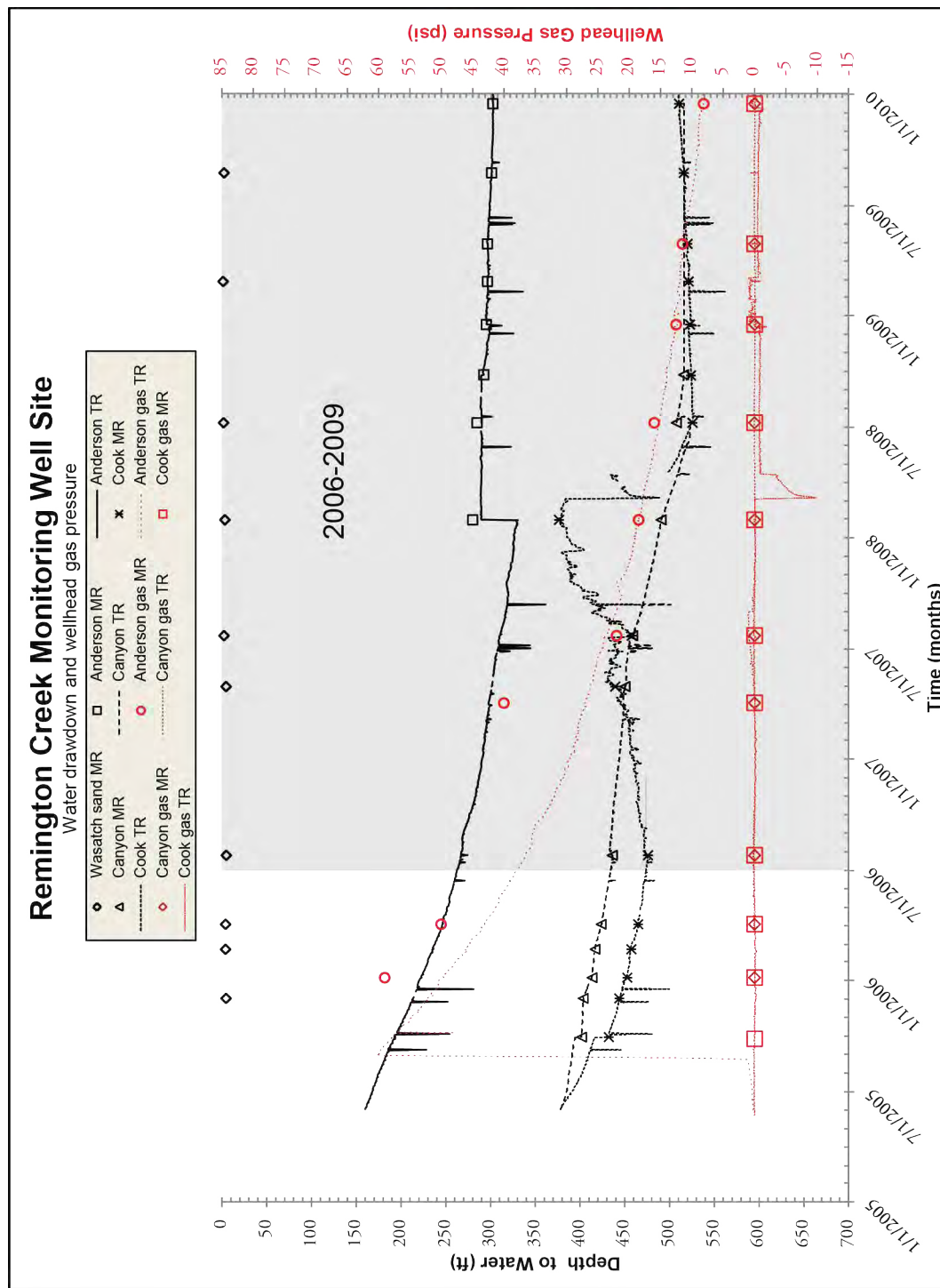


Figure 256. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Remington Creek monitoring well site location.

Production Statistics

Production data was analyzed for CBNG wells within the buffer of the Remington Creek monitoring well sites from January 2004 through December 2009. Cumulative production for individual CBNG wells is displayed by location on Figure 257.

Water production increased in 2005, which correlates to groundwater drawdown trends. Water and gas production increased during the 2006 to 2009 monitoring period (Figure 258). The water/gas ratio of CBNG wells within the buffer is inconsistent. Percent methane is variable.

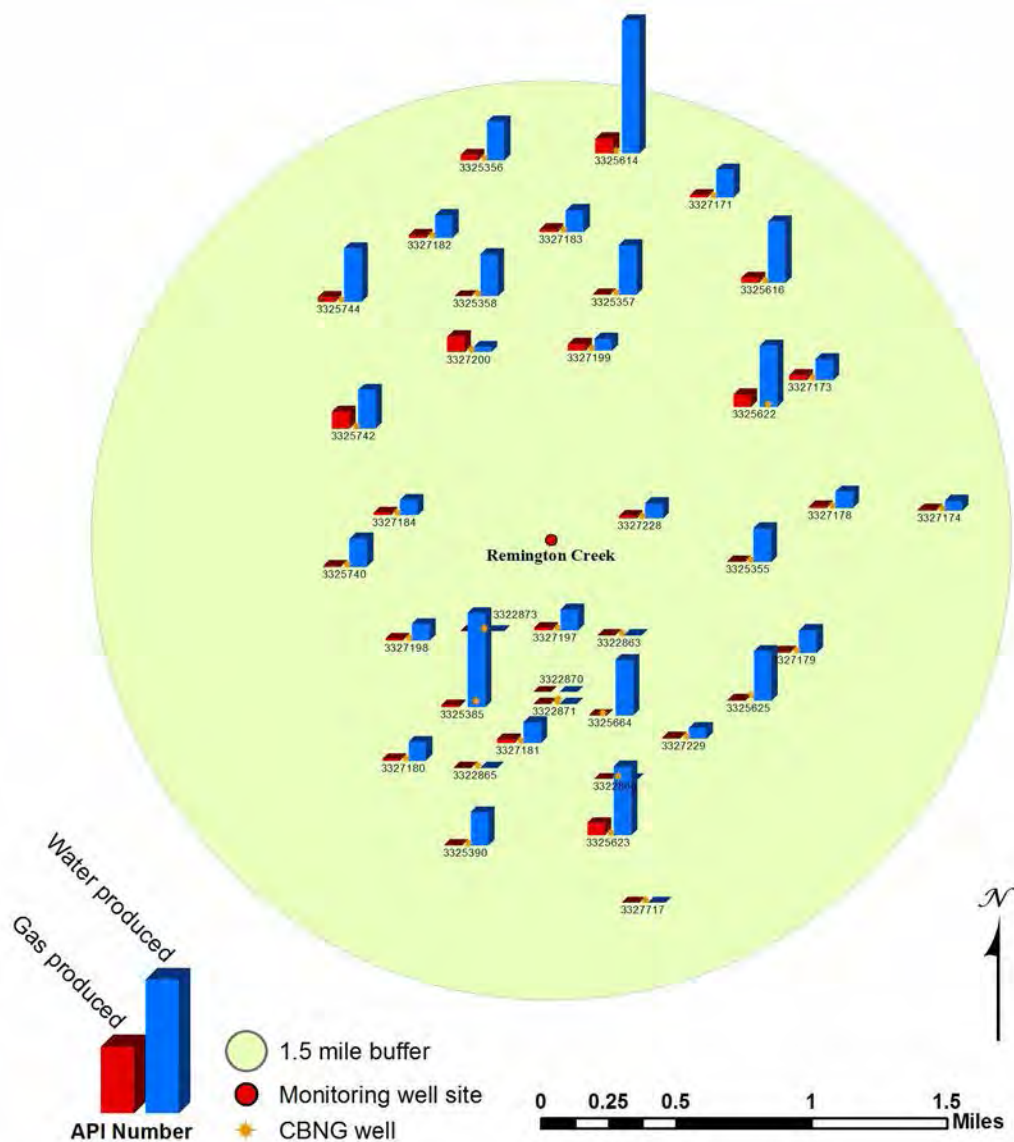


Figure 257. Remington Creek monitoring well and associated CBNG wells within 1.5 mile buffer showing cumulative water (Bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

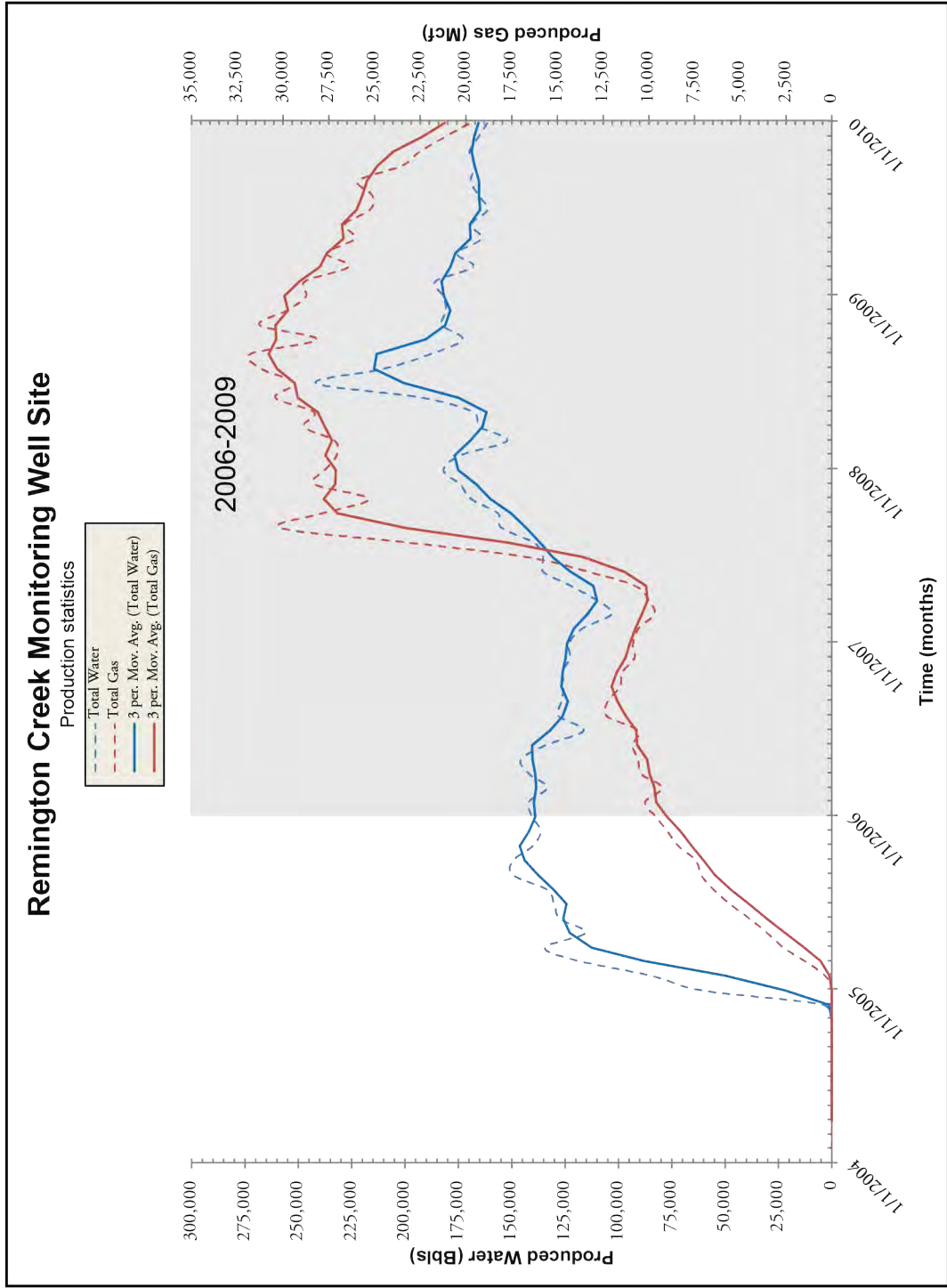


Figure 258. 3-period moving average along with water and gas production from associated CBNG wells.

South Coal Monitoring Well Site
Location: S13 T57N R75W
Date First Monitored: September 18, 2001

Drawdown Information

The South Coal monitoring well set includes two wells. One is drilled into the combined Cook/Lower Wall/Pawnee coal beds and the other into an overlying Wasatch sandstone bed (Figure 259; Table 131). Missing transducer data is the result of errors with on site equipment.

Between 2006-2009 the water levels in the coal decreased by 34 feet (Figure 260; Table 132). A 30 foot error occurred in the transducer data and was corrected in March of 2007. The water levels in the overlying Wasatch sand remained constant throughout the monitoring period. This suggests that there is no hydrologic connectivity between the monitored sand and coal at this location. Gas pressure readings were sporadic starting in 2004, with the highest reading in December of 2004 at 14psi.

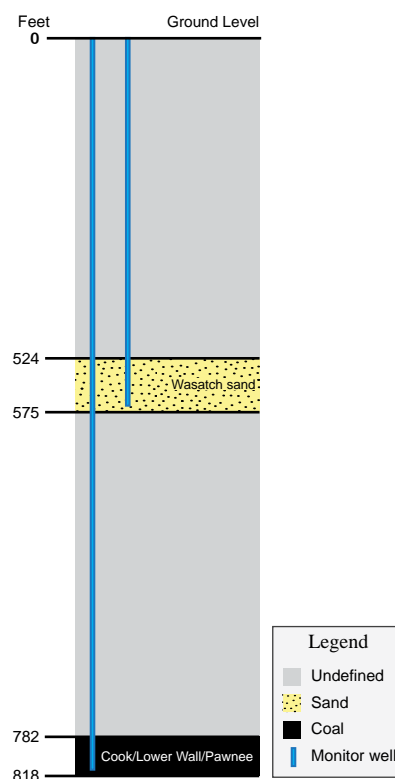


Figure 259. Section showing relative positions of coals and sands in feet. Not to scale.

Table 131. Table showing the depth to and thickness of monitored zones at the South Coal monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Wasatch sand	524	575	51	207
Cook/Lower Wall/Pawnee coal	782	818	36	n/a

Table 132. Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2006	Drawdown 2006-2009	Total drawdown (ft.)	Depth to 12/31/09 water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	463.85	1.69	-0.09	1.60	465.45	n/a	n/a
Cook/Lower Wall/ Pawnee coal	561.37	8.52	34.43	42.95	604.32	14	12/2/04

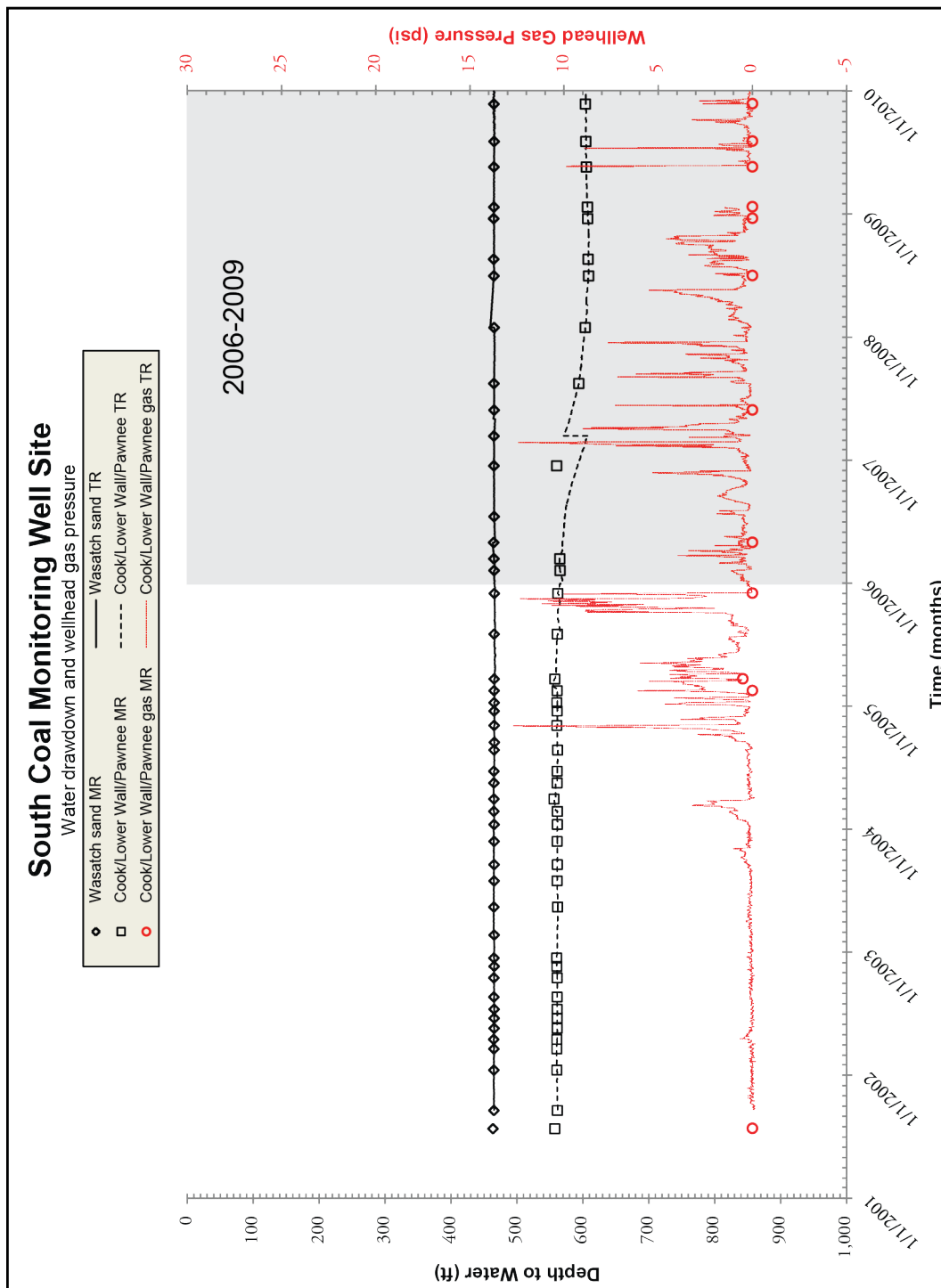


Figure 260. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the South Coal monitoring well site location.

Production Statistics

Production data was analyzed for CBNG wells within the buffer of the South Coal monitoring well sites from January 2005 through December 2009. CBNG wells are displayed by location on Figure 261.

CBNG production increased in 2005, which correlates to groundwater drawdown trends. Water and gas production declined during the 2006 to 2009 monitoring period (Figure 262). The water/gas ratio of CBNG wells within the buffer is inconsistent. Percent methane increased.

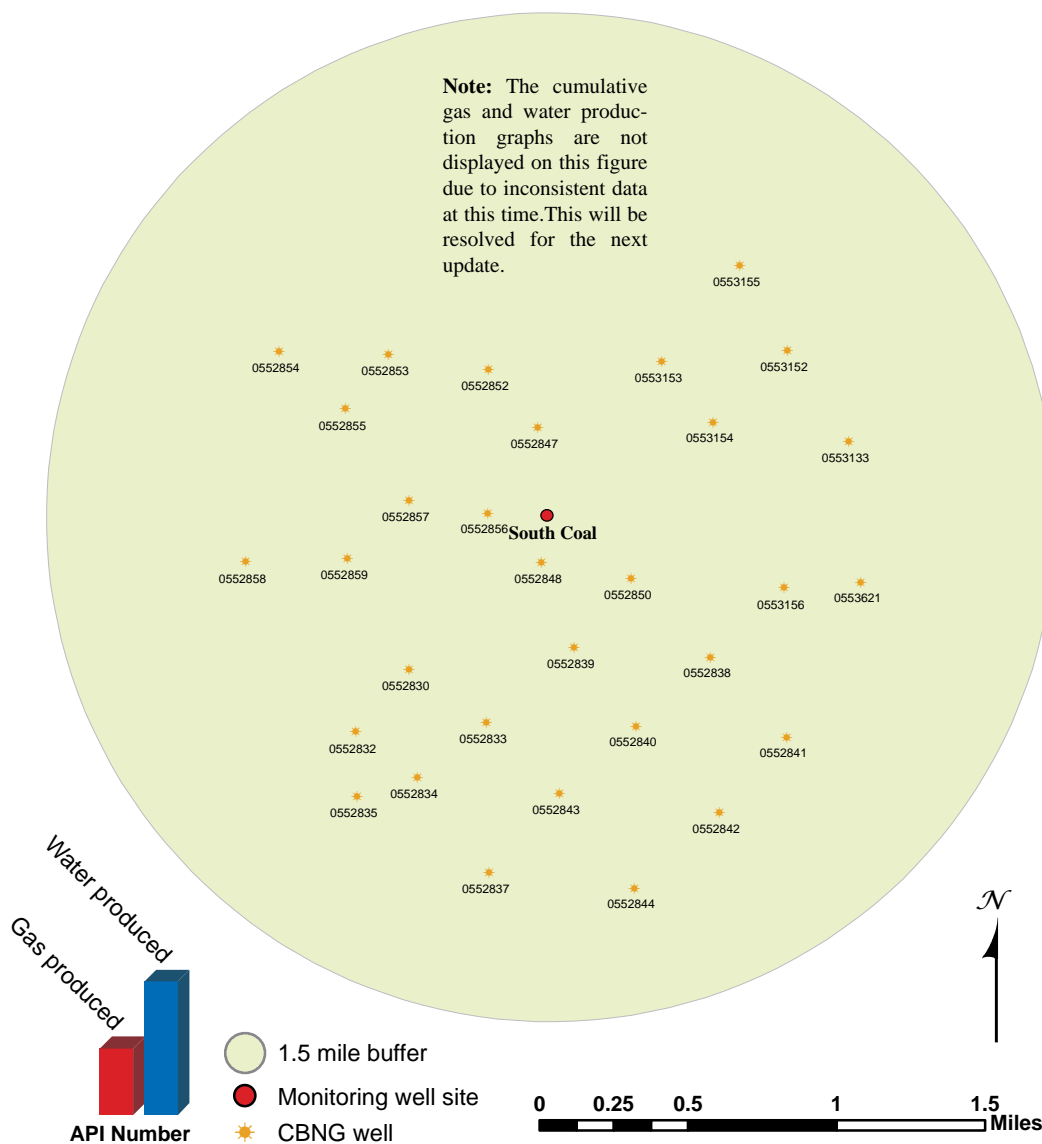


Figure 261. South Coal monitoring well and associated CBNG wells within 1.5 mile buffer showing cumulative water (Bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

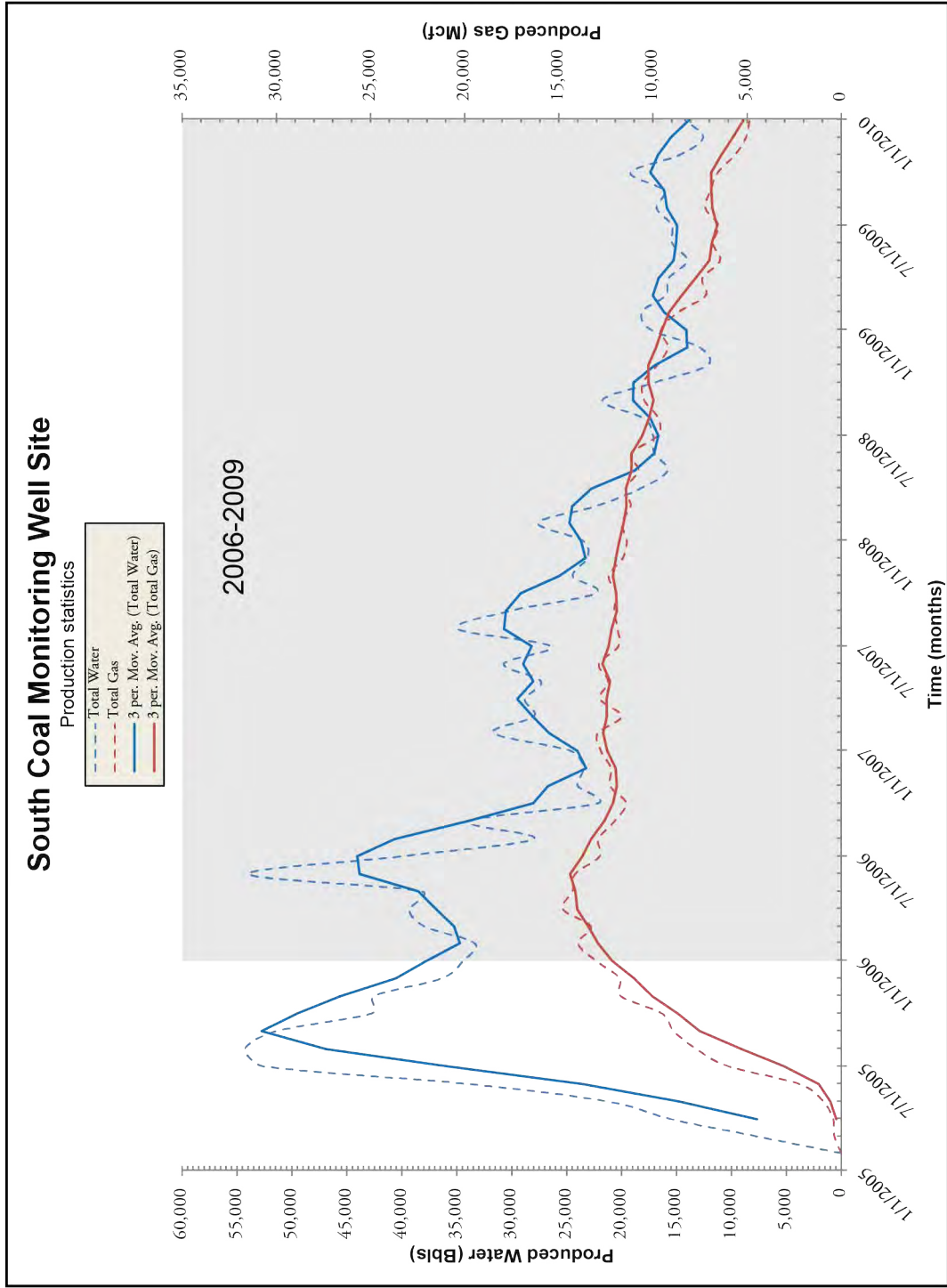


Figure 262. 3-period moving average along with water and gas production from associated CBNG wells.

South Prong Monitoring Well Site
Location: S26 T49N R76W
Date First Monitored: January 1, 2008

Drawdown Information

The South Prong monitoring well site consists of two wells with dual completions, separated by packers. One well is completed into the Big George coal and overlying Wasatch sandstone. The second well is completed into the Gates/Wall coal and an underburden sandstone (Figure 263; Table 133). Missing transducer data is the result of errors with on site equipment.

The depth to initial water levels for the Wasatch sandstone and Big George coal zones are approximately the same at 142 feet as well as the water levels for the Gates/Wall coal and underburden sandstone zones at 117 feet. The similarity of the initial water levels despite the difference in zone depths is likely due to the packers being improperly set. The packers were properly reset on November 2, 2009, after which there is limited data. Due to the improperly set packers, all measurements were considered not to be accurate enough to make any conclusions at this time (Figure 264; Table 134). Wellhead gas pressure for the coals remained at zero for the monitoring history of the wells.

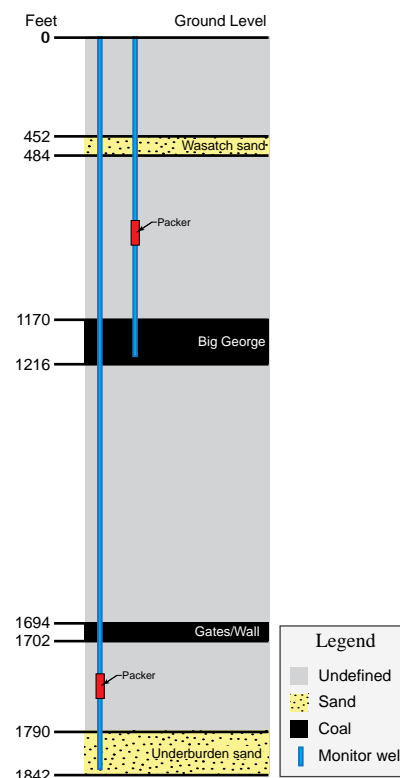


Figure 263. Section showing relative positions of coals and sands in feet. Not to scale.

Table 133. Table showing the depth to and thickness of monitored zones at the South Prong monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Wasatch sand	452	484	32	686.00
Big George coal	1170	1216	46	n/a
Gates/Wall coal	1694	1702	8	n/a
Underburden sand	1790	1842	52	88.00

Table 134. Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2006	Drawdown 2006-2009	Total drawdown (ft.)	Depth to 11/9/09 water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	142.79	n/a	8.20	8.20	150.99	n/a	n/a
Big George coal	141.95	n/a	207.45	207.45	349.40	n/a	n/a
Gates/Wall coal ⁽¹⁾	117.55	n/a	425.45	425.45	543.00	n/a	n/a
Underburden sand	116.95	n/a	139.65	139.65	256.60	n/a	n/a

Note: The last water level measurements for this site was taken on 11/9/09 as shown. These are the last taken in the 2009 monitoring year.

⁽¹⁾ It was reported that for this zone the water level on 11/9/09 was below 600 ft and measurements could not be take below this depth. Therefore, the measurement of 543 ft was taken on 11/5/09.

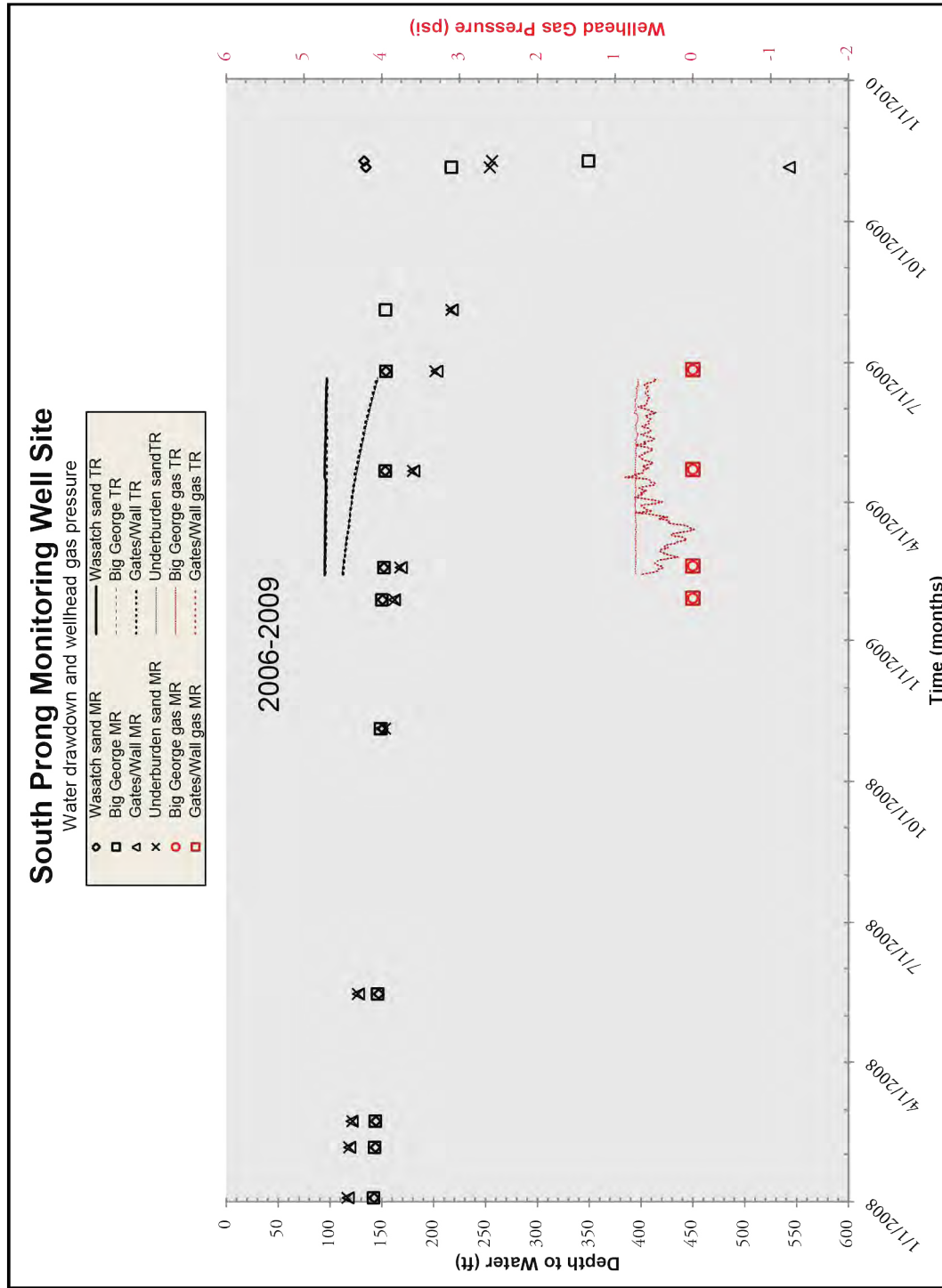


Figure 264. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the South Prong monitoring well site location.

Production Statistics

Production data was analyzed for CBNG wells within the buffer of the South Prong monitoring well site from January 1999 through December 2009. Cumulative production for individual CBNG wells is displayed by location on Figure 265.

Water production increased in 2006, which does not correlate with groundwater drawdown trends. Water and gas production increased during the 2006 to 2009 monitoring period (Figure 266). The water/gas ratio of CBNG wells within the buffer is inconsistent. Percent methane is variable.

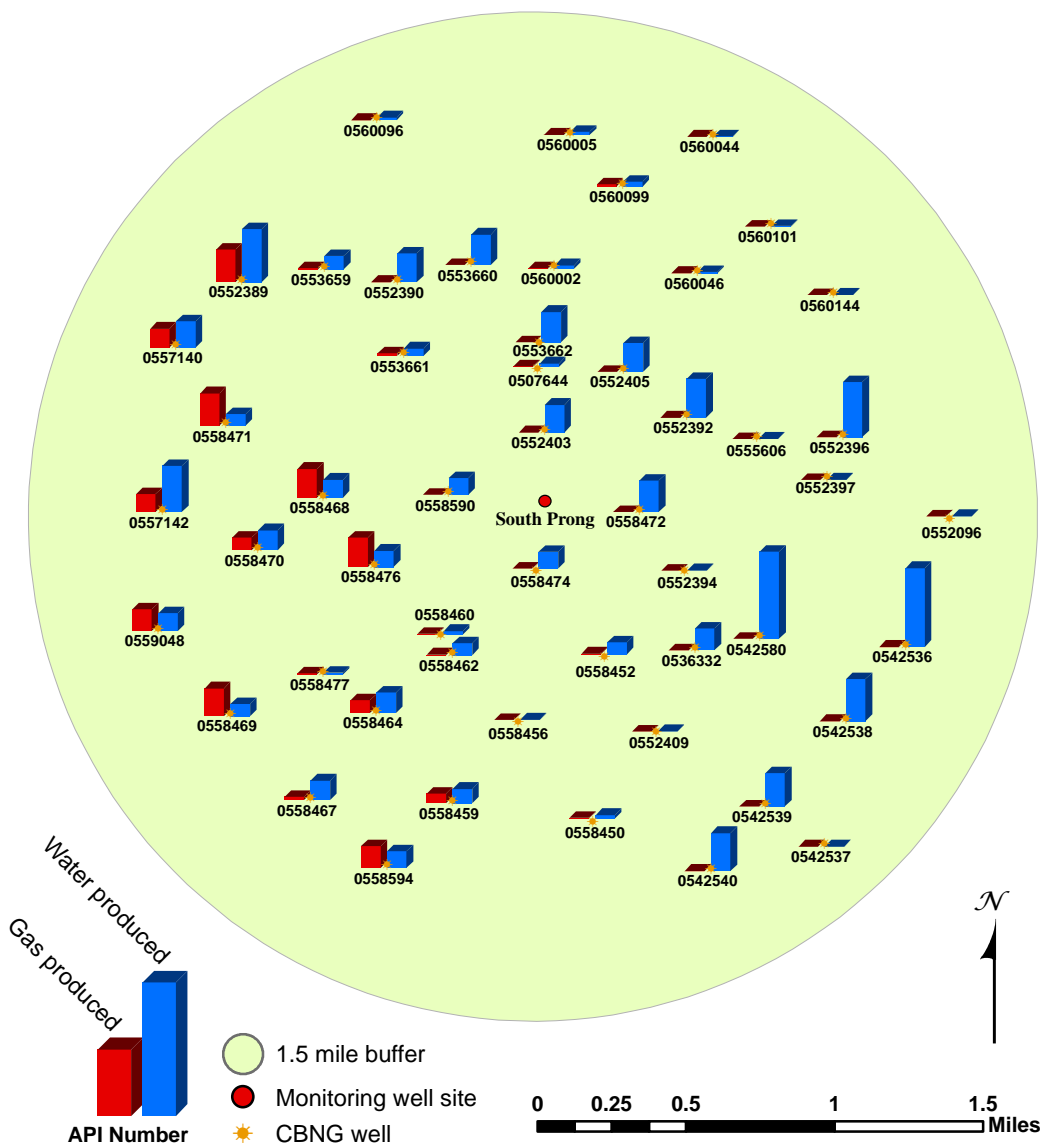


Figure 265. South Prong monitoring well and associated CBNG wells within 1.5 mile buffer showing cumulative water (Bbbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

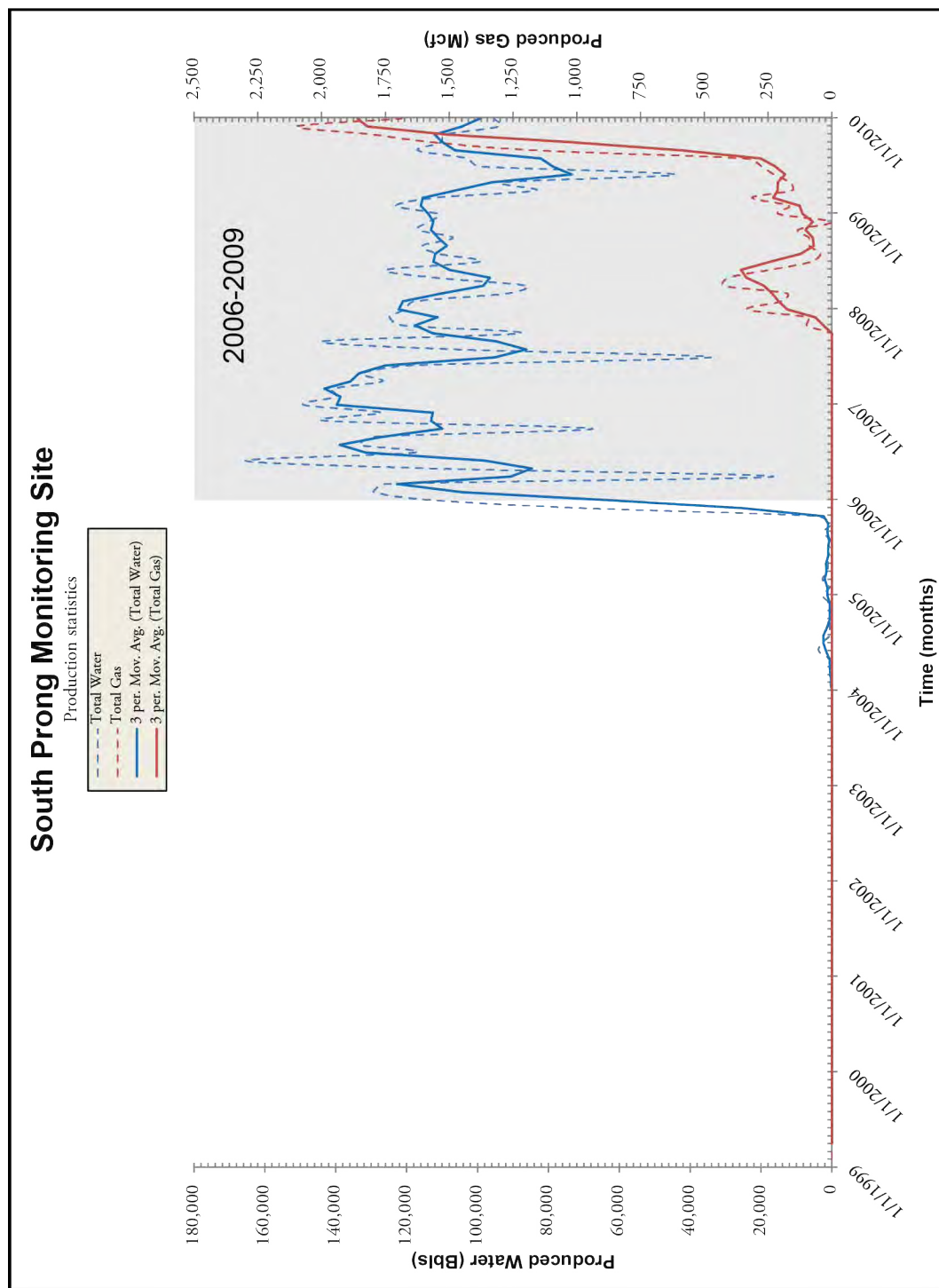


Figure 266. 3-period moving average along with water and gas production from associated CBNG wells.

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 dual completion wells. One well is drilled into the Wall coal and also completed in the shallower Werner coal. The second well is drilled to the Anderson coal and also completed into an underburden sand. The third well is drilled to the shallow Smith coal and also completed in the shallow Wasatch sand. (Figure 267; Table 135). Missing transducer data is the result of errors with on site equipment.

The Wall and Anderson coals record groundwater drawdown beginning in mid-2009 and mid-2008 respectively. There was little impact on water levels in the Smith and Werner coals between 2006-2009. This indicates they are confined relative to the Wall and Werner coals. The underburden sand shows a gradual drawdown throughout the period of drawdown in the coals. This suggests that there may be a hydrologic connection between the underburden sand and the coals above it. Water levels in the Wasatch sand remained constant through the monitoring period. This suggests that there is no hydrologic connection between the coals and the shallow Wasatch sandstone (Figure 268; Table 136). Wellhead gas pressure at this location stayed around zero for the entirety of the monitor period with the exception of one occurrence. One manual measurement of 55 psi and 52 psi for the Smith and Wall coals respectively in 2007 were recorded (Figure 268). No other measurements above zero outside of transducer error were recorded.

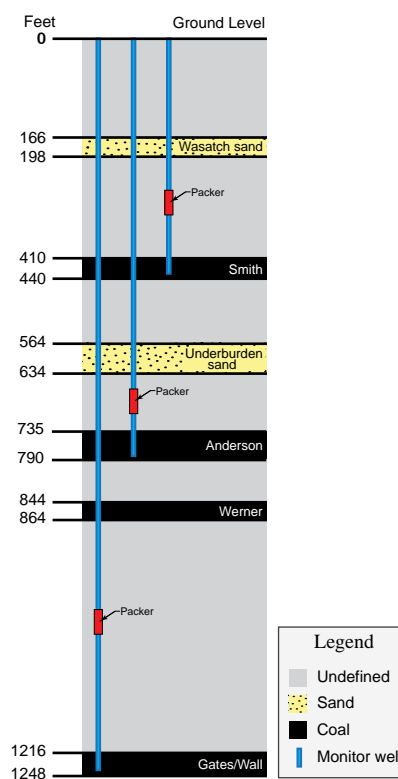


Figure 267. Section showing relative positions of coals and sands in feet. Not to scale.

Table 135. Table showing the depth to and thickness of monitored zones at the Williams Cedar Draw monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Wasatch sand	166	198	32	212
Smith coal	410	440	30	n/a
Underburden sand	564	634	70	101
Anderson coal	735	790	55	n/a
Werner coal	844	864	20	n/a
Gates/Wall coal	1216	1248	32	n/a

Table 136. Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2006	Drawdown 2006-2009	Total drawdown (ft.)	Depth to 12/31/09 water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	115.79	n/a	-1.59	-1.59	114.20	n/a	n/a
Smith coal	169.15	n/a	-0.02	-0.02	169.13	55	8/21/07
Underburden sand	259.77	n/a	163.28	163.28	423.05	n/a	n/a
Anderson coal	243.95	n/a	293.95	293.95	537.90	8	8/21/07
Werner coal	143.90	n/a	19.79	19.79	163.69	n/a	n/a
Gates/Wall coal	216.50	n/a	123.70	123.70	340.20	155	12/17/09

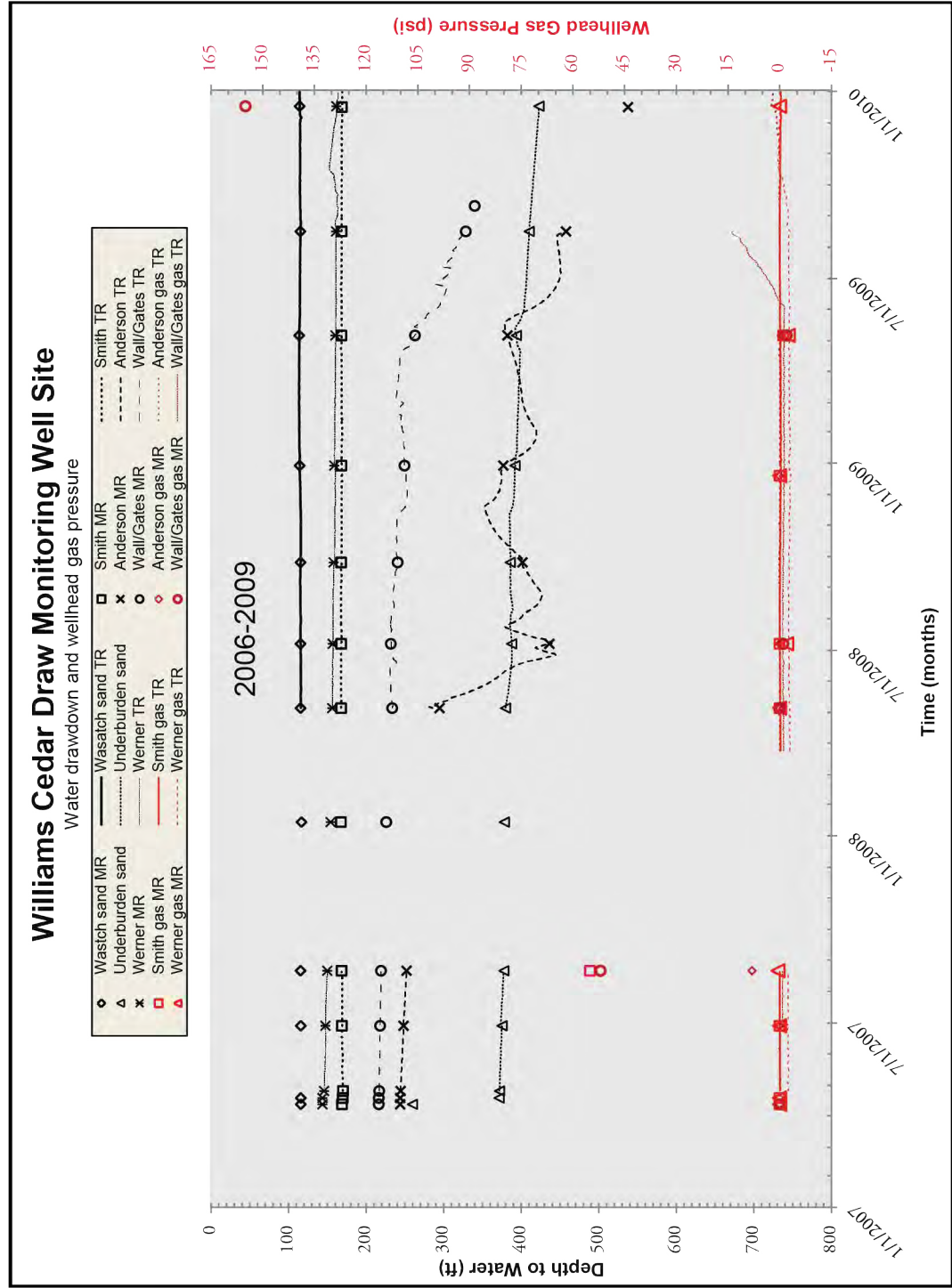


Figure 268. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Williams Cedar Draw monitoring well site location.

Production Statistics

Production data for the Williams Cedar Draw monitoring well was not reported due to incomplete or generalized completion data for local CBNG wells.

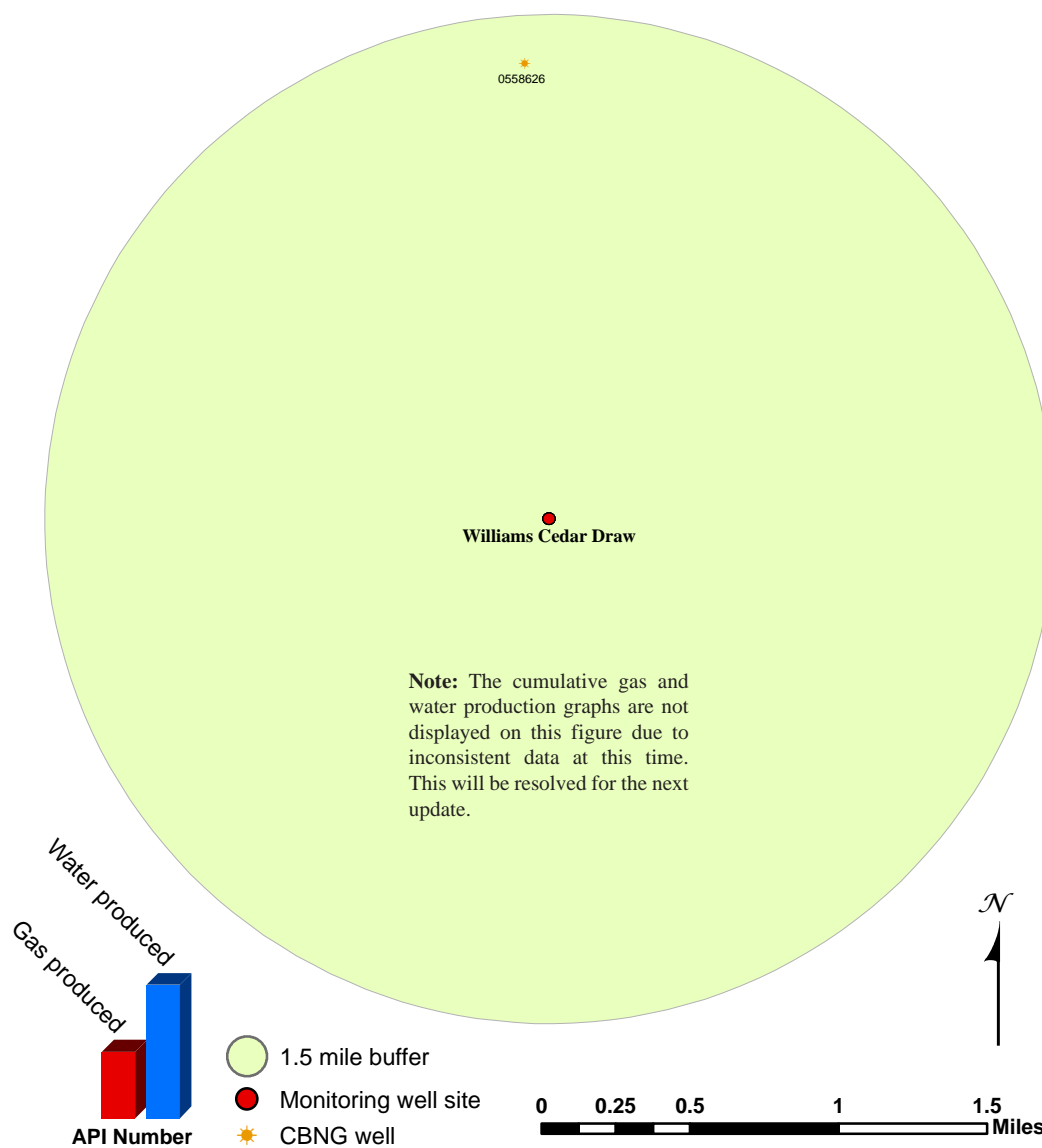


Figure 269. Williams Cedar Draw monitoring well and associated CBNG wells within 1.5 mile buffer showing cumulative water (Bbbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

APPENDIX 6. Wall Coal Zone

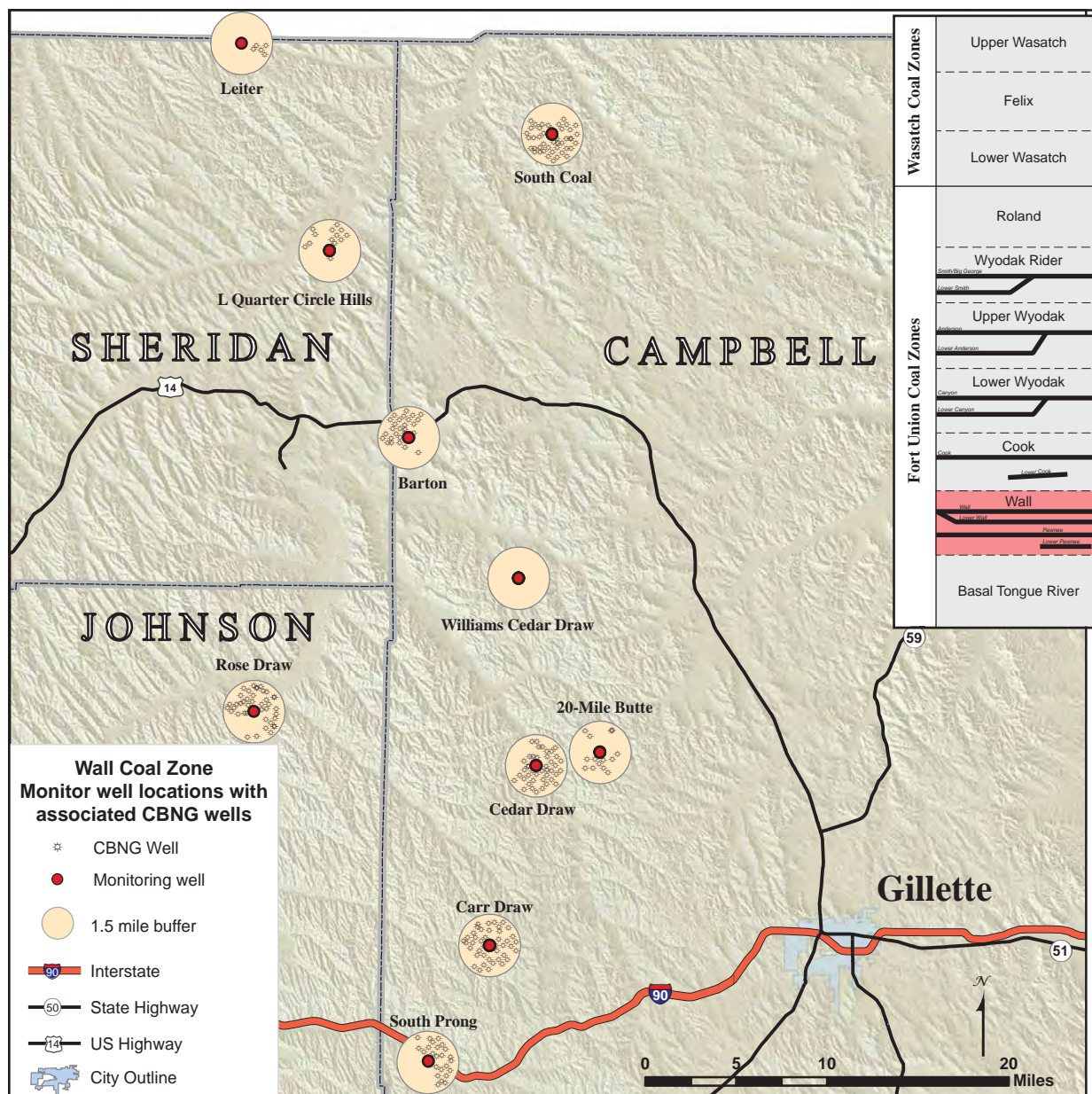


Figure 270. Wall coal zone monitoring well site locations in the Powder River Basin, Wyoming.

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 consists of four wells. One well is constructed into each of the Anderson, Pawnee, and Wall coal beds and the remaining well is completed into a Wasatch sandstone (Figure 271; Table 137). Missing transducer data is the result of errors with on site equipment.

Initial water levels in all three coal zones were similar even though the shallowest and deepest coals are separated by 759 feet (Table 138). All three monitored coals experienced drawdown during the monitoring period. Drawdown in the coals varies between the monitored zones but overall show similar drawdown trends. This suggests a hydrologic connection between the coals in this monitor location. During the 2006-2009 monitoring period, the water level in the Wasatch sand increased by 9 feet, decreasing the overall drawdown for the duration of monitoring to 29 feet (Figure 272; Table 138). The continued production of water from the coals and the rise in water levels in the Wasatch suggest that there is no hydrologic connection between the producing coal zones and the sand. Anderson coal wellhead gas pressures peaked at 10 psi, no other coal experienced a gas pressure breaching zero.

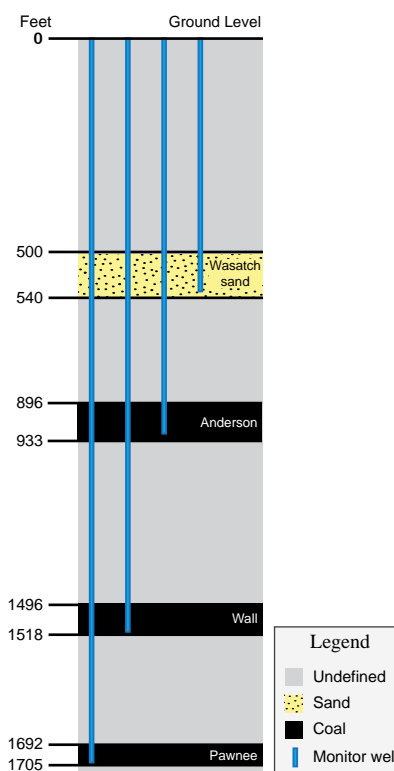


Figure 271. Section showing relative positions of coals and sands in feet. Not to scale.

Table 137. Table showing the depth to and thickness of monitored zones at the 20-Mile Butte monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Wasatch sand	500	540	40	356
Anderson coal	896	933	37	n/a
Wall coal	1496	1518	22	n/a
Pawnee coal	1692	1705	13	n/a

Table 138. Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2006	Drawdown 2006-2009	Total drawdown (ft.)	Depth to 12/31/09 water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	362.77	37.94	-8.94	29.00	391.77	n/a	n/a
Anderson coal	545.00	41.68	121.23	162.91	707.91	10.00	4/28/03
Wall coal	521.20	18.87	254.39	273.26	794.46	n/a	n/a
Pawnee coal	540.30	17.10	158.10	175.20	715.50	n/a	n/a

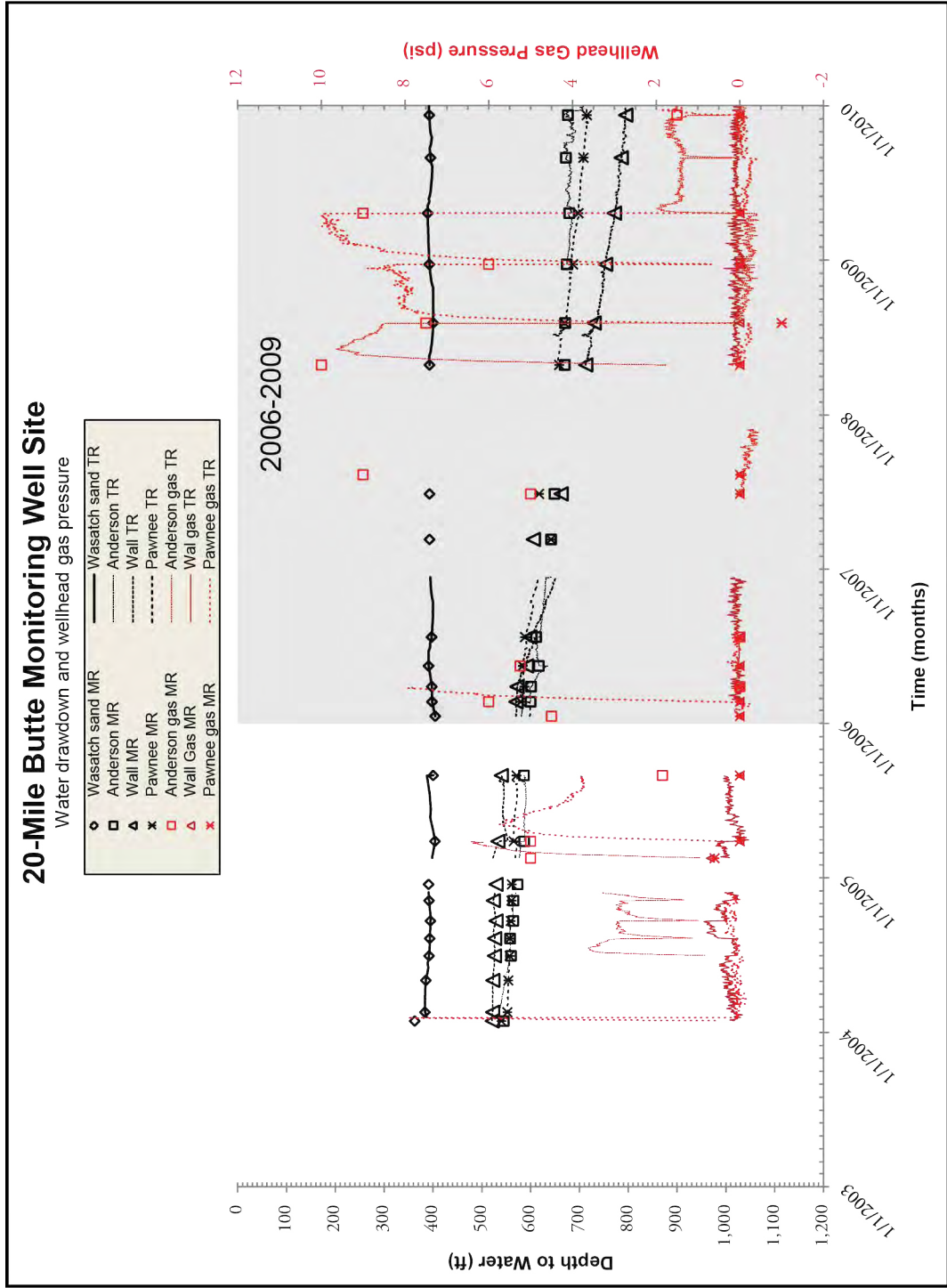


Figure 272. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the 20-Mile Butte monitoring well site location.

Production Statistics

Production data was analyzed for CBNG wells within the buffer of the 20 Mile Butte monitoring well site from January 2006 through December 2009. Cumulative production for individual CBNG wells is displayed by location on Figure 273.

ure 272). Water and gas production generally declined during the 2006 to 2009 monitoring period, though there are several pulses of production (Figure 274). The water/gas ratio of CBNG wells within the buffer is inconsistent. Percent methane is relatively consistent.

Water production started to increase in 2006, which correlates with groundwater drawdown trends (Fig-

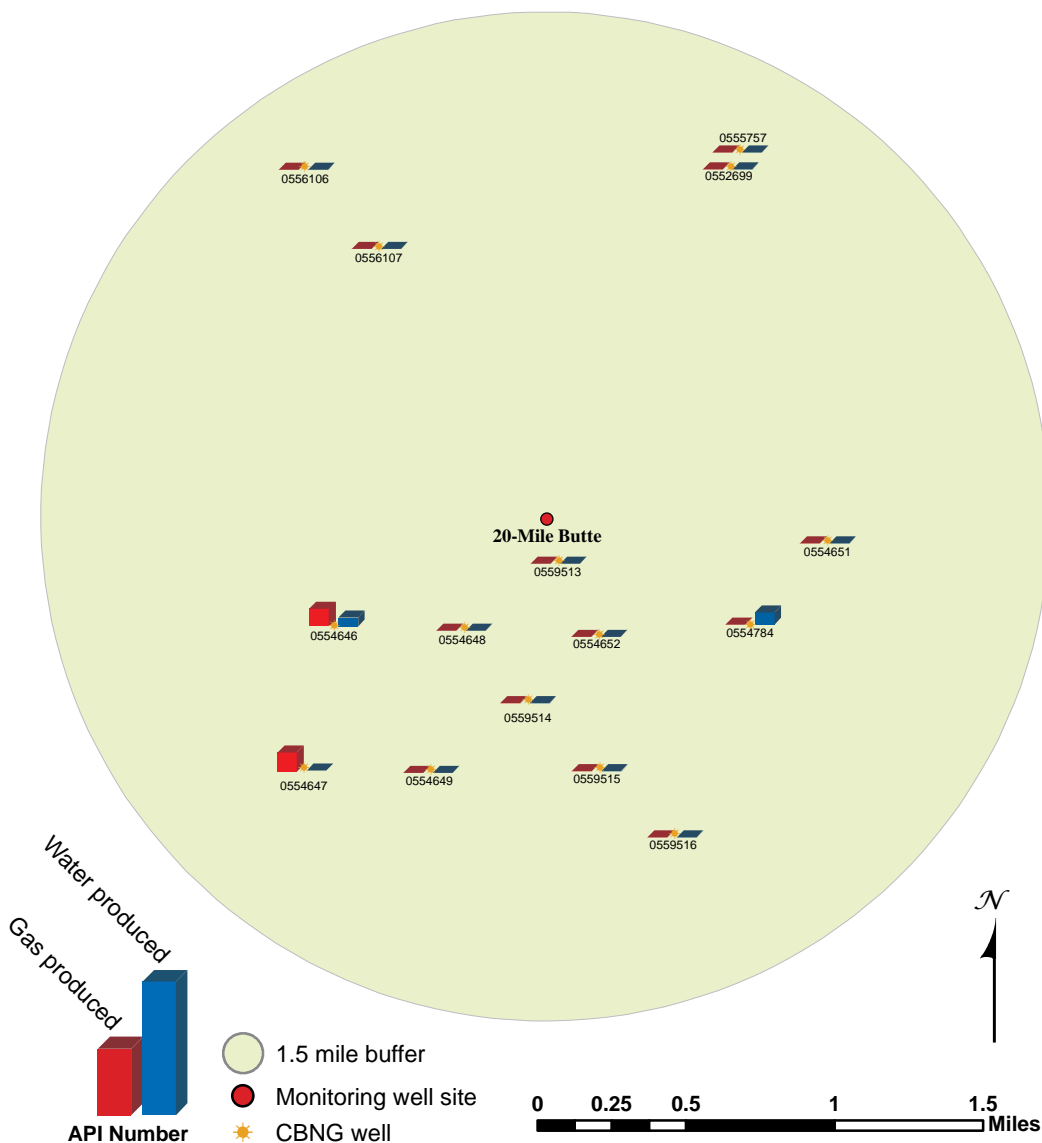


Figure 273. 20-Mile Butte monitoring well and associated CBNG wells within 1.5 mile buffer showing cumulative water (Bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

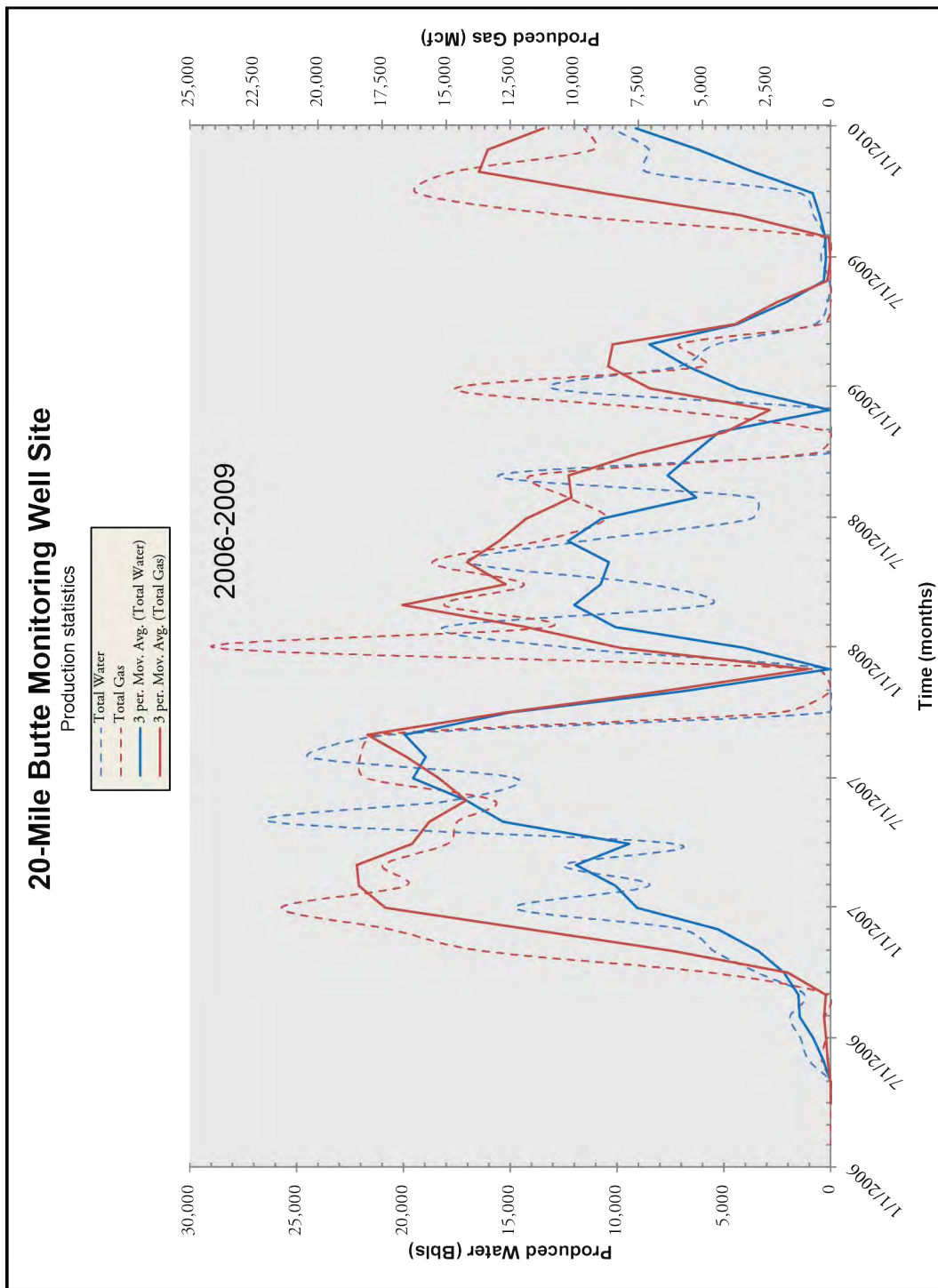


Figure 274. 3-period moving average along with water and gas production from associated CBNG wells.

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

Drawdown Information

The Barton monitoring well site includes two wells. One is drilled into the shallower Cook coal and the other into the deeper Wall coal (Figure 275; Table 139). There is no monitoring well associated with a Wasatch sand at this location. Missing transducer data is the result of errors with on site equipment.

During the current monitoring period of 2006-2009 the water level in the Wall coal decreased by 4 feet. The water level in the Cook coal decreased by 41 feet during the 2006-2009 monitoring period. (Figure 276; Table 140). The hydrologic connections between the coal and Wasatch sands packages are not monitored in this location. The wellhead gas pressure in both the Cook and Wall wells remained nearly zero. The fluctuation of readings throughout the monitoring period reflects variations in the monitoring equipment.

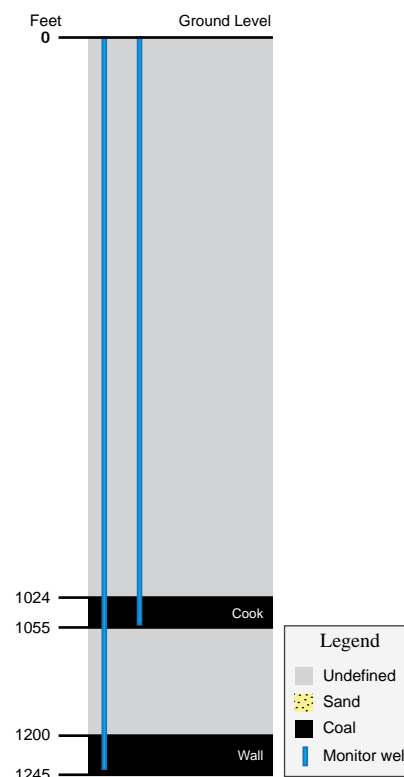


Figure 275. Section showing relative positions of coals and sands in feet. Not to scale.

Table 139. Table showing the depth to and thickness of monitored zones at the Barton monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Cook coal	1024	1055	31	n/a
Wall coal	1200	1245	45	n/a

Table 140. Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2006	Drawdown 2006-2009	Total drawdown (ft.)	Depth to 12/31/09 water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Cook coal	365.00	122.65	40.75	163.40	528.40	n/a	n/a
Wall coal	200.50	10.74	4.13	14.87	215.37	n/a	n/a

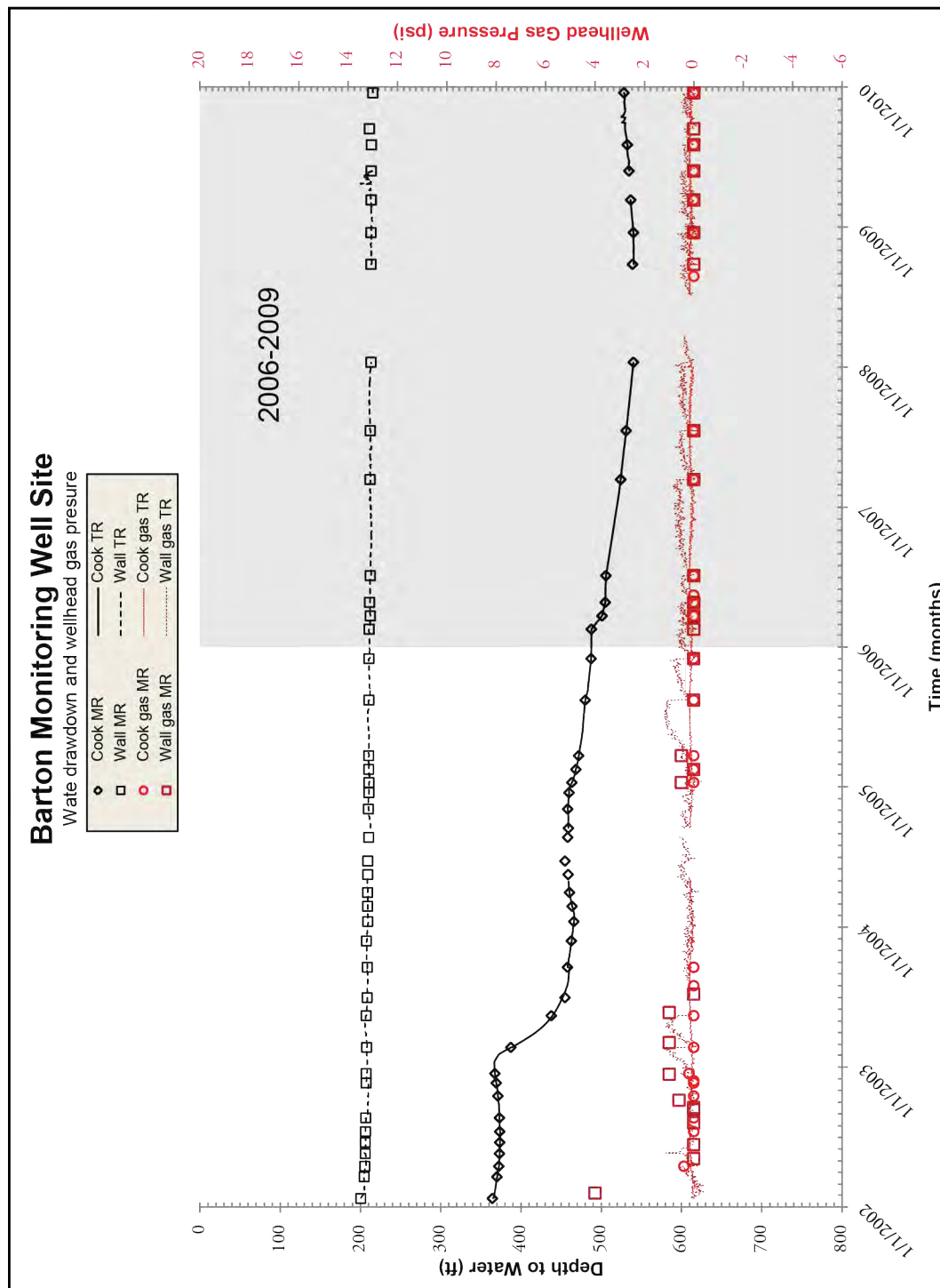


Figure 276. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Barton monitoring well site location. Gray area represents the current monitoring period of 2006-2009.

Production Statistics

Production data was analyzed for CBNG wells within the buffer of the Barton monitoring well sites from January 2001 through December 2009. Cumulative production for individual CBNG wells is displayed by location on Figure 277.

tion increased and water production remained relatively constant during the 2006 to 2009 monitoring period (Figure 278). The water/gas ratio of CBNG wells within the buffer is inconsistent. Percent methane is variable.

CBNG water production peaked in 2001, which correlates to groundwater drawdown trends. Gas produc-

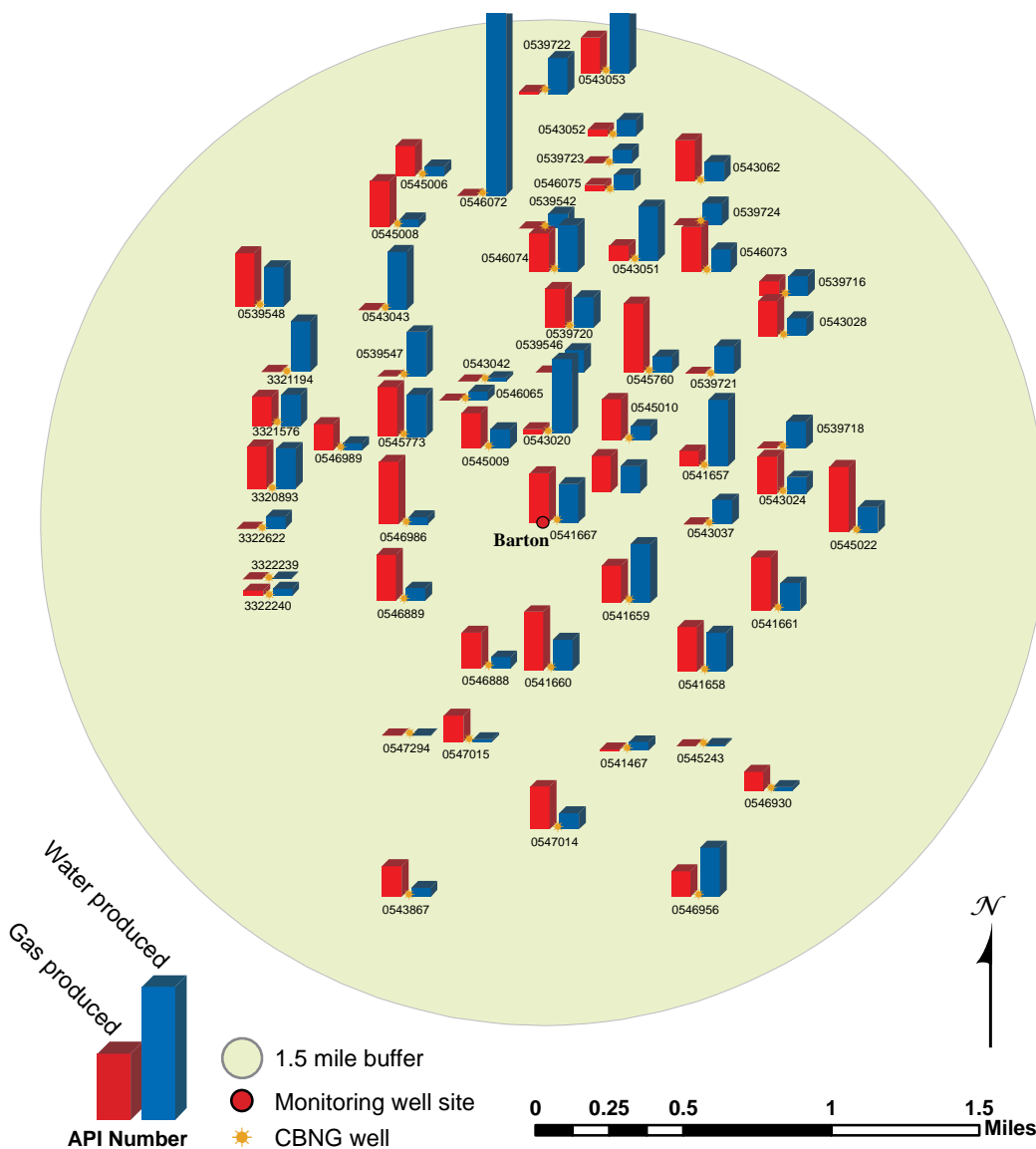


Figure 277. Barton monitoring well and associated CBNG wells within 1.5 mile buffer showing cumulative water (Bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

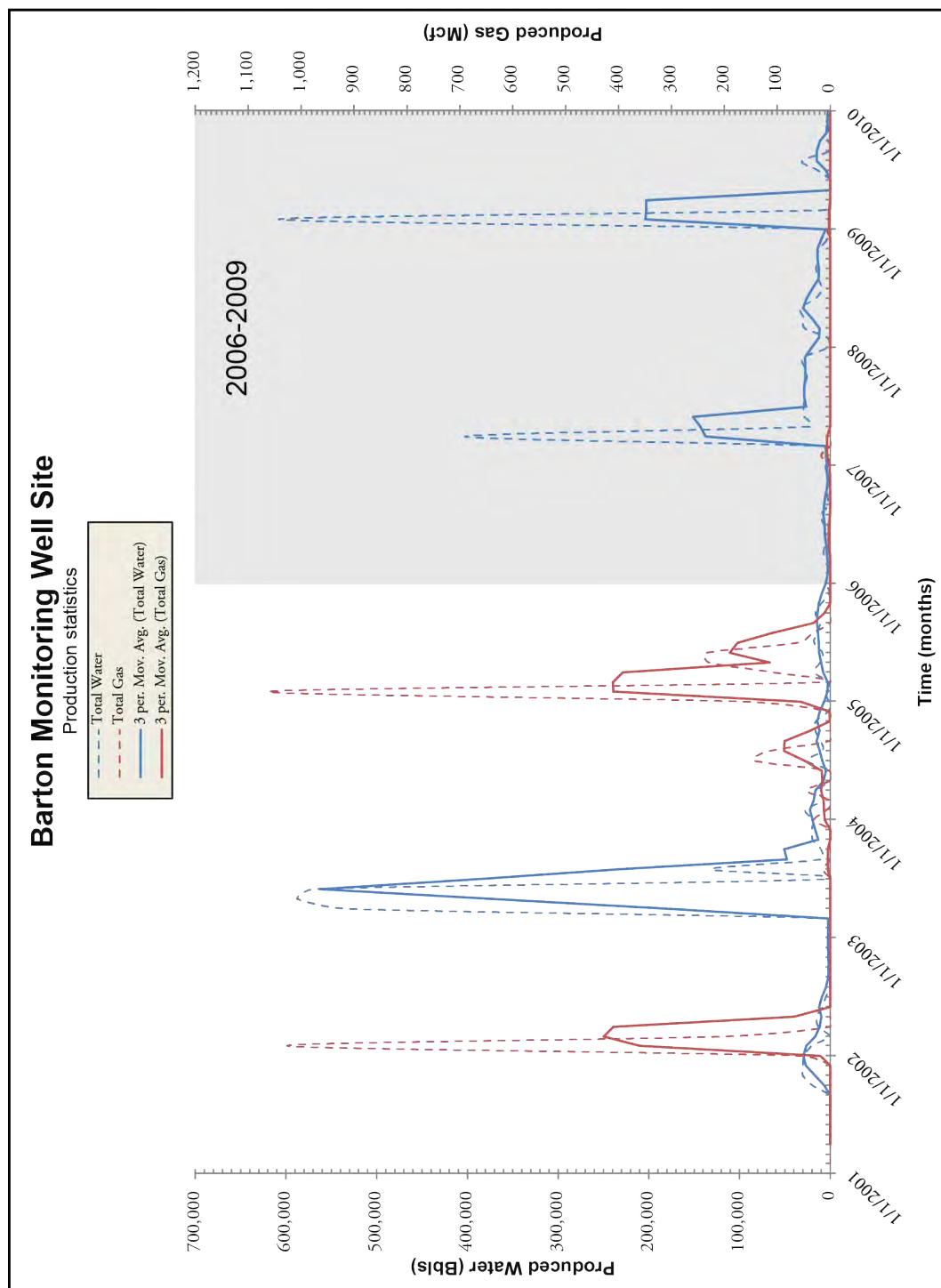


Figure 278. 3-period moving average along with water and gas production from associated CBNG wells.

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

Drawdown Information

The Carr Draw monitoring well site consists of two wells with dual completions, separated by packers. One well is completed into the Big George coal and an overlying Wasatch sandstone. The second well is completed into the Werner and Gates/Wall coals (Figure 279; Table 141). Missing and/or fluctuating transducer data is the result of errors with on-site equipment.

Initial data that was collected was from manual measurements, 2009 data includes some transducer recorded data. The depth to initial water levels for the Wasatch sandstone (342 ft.) and Werner coal (344 ft.) were similar despite the approximate 1,000 feet separation between the two zones. Likewise, the Big George (492 ft.) and Gates/Wall (491 ft.) coal zones had similar initial water levels despite 500 feet in separation. The Big George coal had the most drawdown during the 2006-2009 monitoring period at 546 feet. The Wasatch sandstone and Werner coal had similar drawdowns with 355 feet and 320 feet respectively. The Gates/Wall coal water level rose by 144 feet over the same 2006-2009 monitoring period (Figure 280; Table 142). With equipment and packer issues on this site no conclusions on hydrologic connection between zones can be made at this time. The gas readings did not surpass levels possible from transducer error.

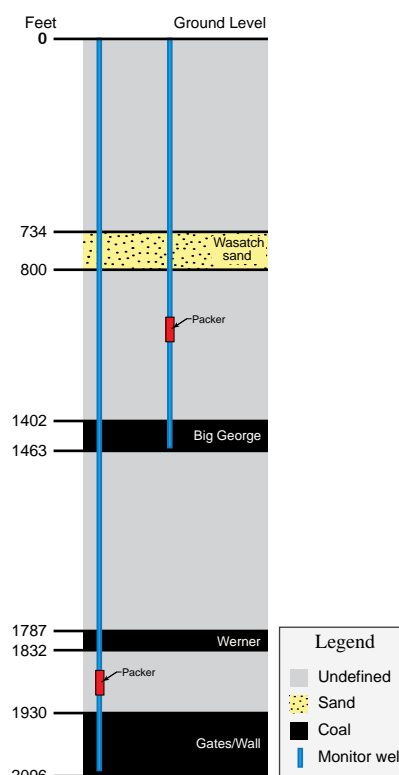


Figure 279. Section showing relative positions of coals and sands in feet. Not to scale.

Table 141. Table showing the depth to and thickness of monitored zones at the Carr Draw monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Wasatch sand	734	800	66	602
Big George coal	1402	1463	61	n/a
Werner coal	1787	1832	45	n/a
Gates/Wall coal	1930	2096	166	n/a

Table 142. Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2006	Drawdown 2006-2009	Total drawdown (ft.)	Depth to 12/31/09 water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	341.66	n/a	355.39	355.39	697.05	n/a	n/a
Big George coal	492.30	n/a	546.15	546.15	1038.45	n/a	n/a
Werner coal	344.00	n/a	320.26	320.26	664.26	n/a	n/a
Gates/Wall coal	490.50	n/a	-143.52	-143.52	346.98	n/a	n/a

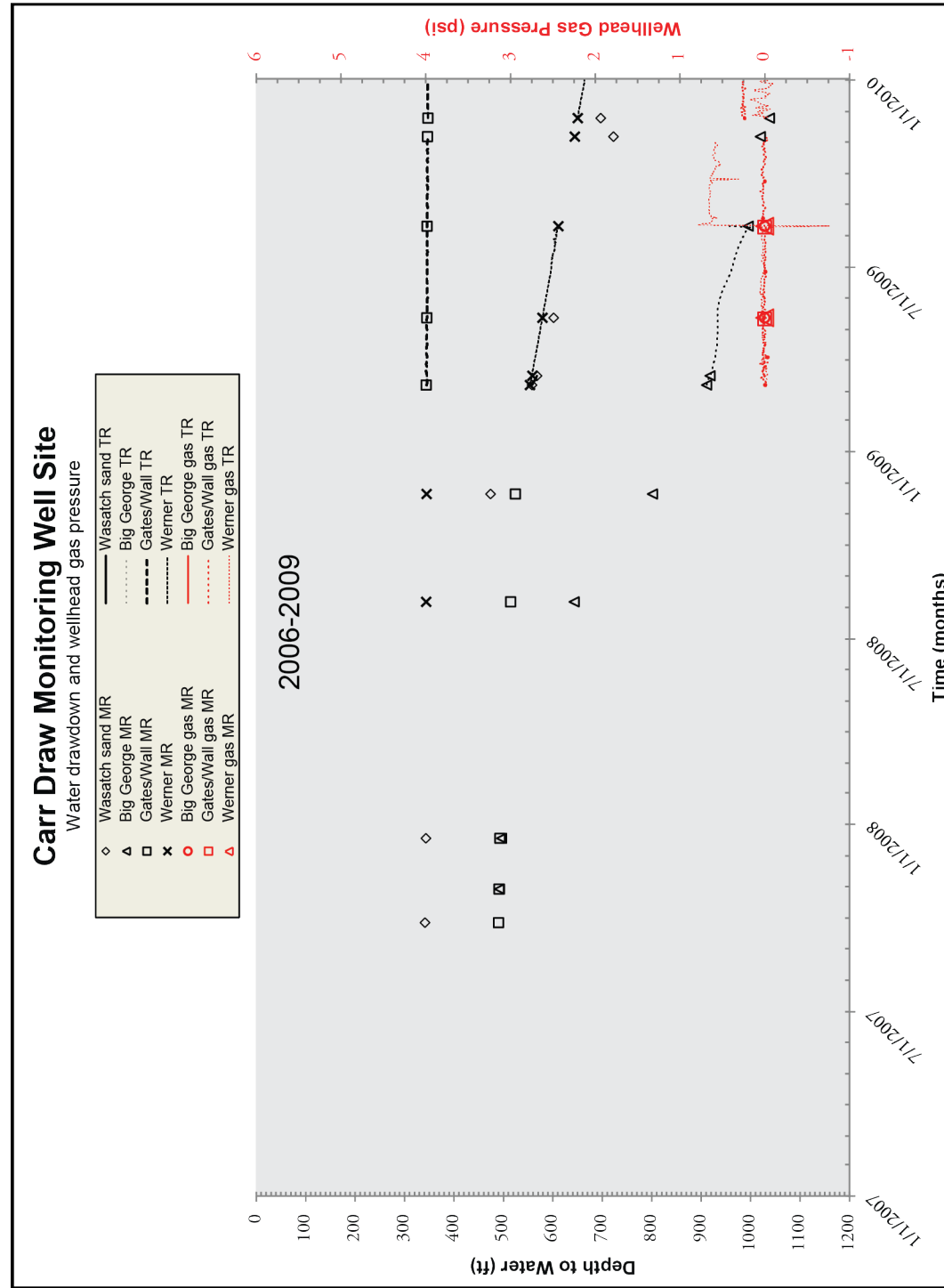


Figure 280. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Carr Draw monitoring well site location.

Production Statistics

Production data was analyzed for CBNG wells within the buffer of the Carr Draw monitoring well site from January 2002 through December 2009. Cumulative production for individual CBNG wells is displayed by location on Figure 281.

recorded in the Big George coal bed. Water and gas production increased during the 2006 to 2009 monitoring period (Figure 282). The water/gas ratio of CBNG wells within the buffer is relatively inconsistent from southwest to northeast. Percent methane remained relatively consistent.

Water production peaked in 2004. Renewed water production in 2008 correlates to groundwater drawdown

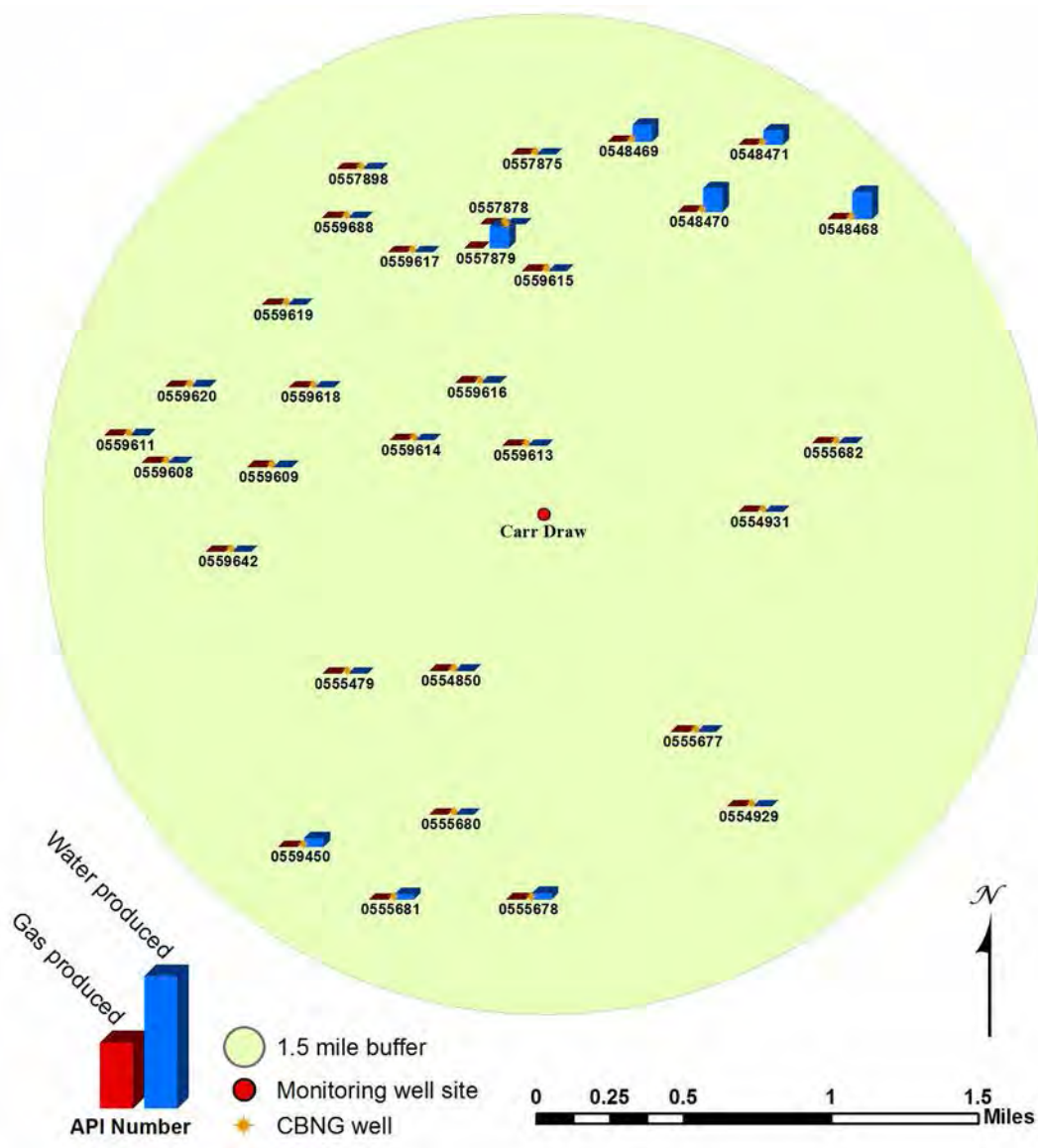


Figure 281. Carr Draw monitoring well and associated CBNG wells within 1.5 mile buffer showing cumulative water (Bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

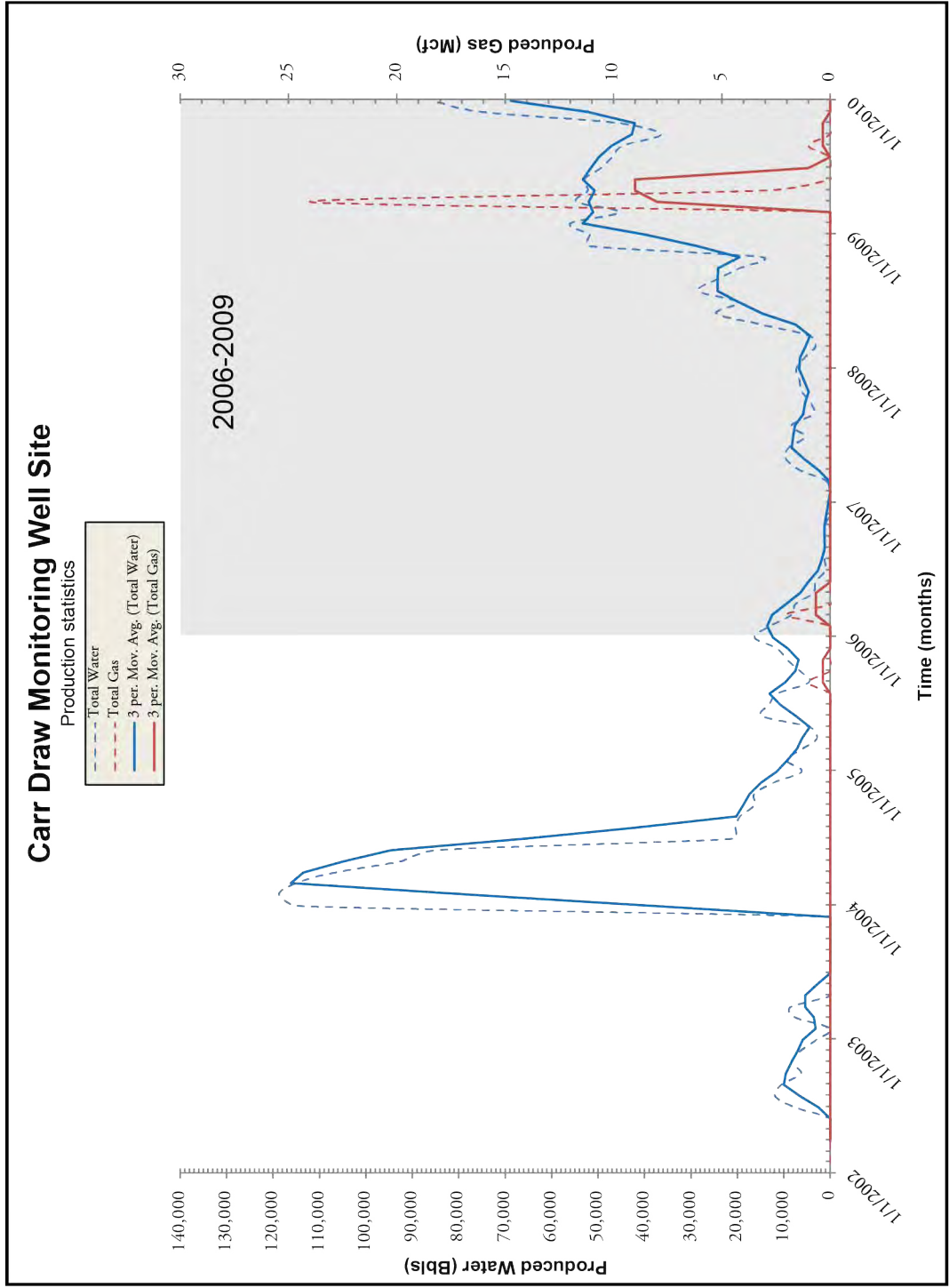


Figure 282. 3-period moving average along with water and gas production from associated CBNG wells.

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 drilled into the Wall coal and the other into an overlying Wasatch sandstone (Figure 283; Table 143). Missing transducer data is the result of errors with on site equipment.

During the 2006-2009 monitoring period, the Wall coal recorded a drawdown of 498 feet, while the Wasatch sandstone recorded a drawdown of 433 feet. Drawdown in the Wasatch sand mirrors the drawdown in the Wall coal indicating that there may be hydrologic connection between the two monitored zones (Figure 284; Table 144). The gas pressure did not breach zero throughout the monitoring period.

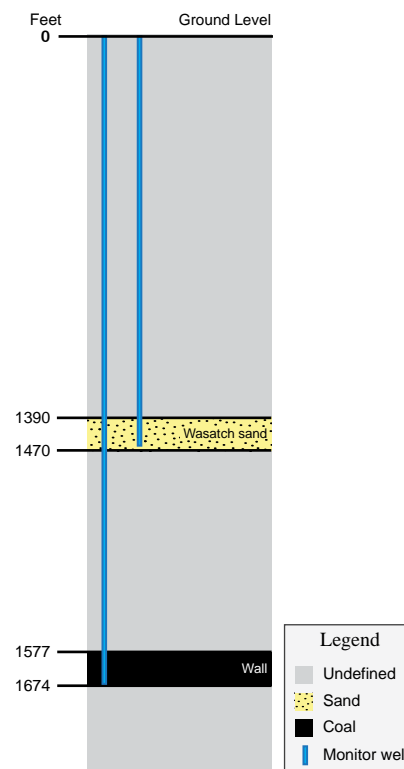


Figure 283. Section showing relative positions of coals and sands in feet. Not to scale.

Table 143. Table showing the depth to and thickness of monitored zones at the Cedar Draw monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Wasatch sand	1390	1470	80	107
Wall coal	1577	1674	97	n/a

Table 144. Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2006	Drawdown 2006-2009	Total drawdown (ft.)	Depth to 12/31/09 water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	229.50	66.57	432.94	499.51	729.01	n/a	n/a
Wall coal	230.78	84.47	498.05	582.52	813.30	n/a	n/a

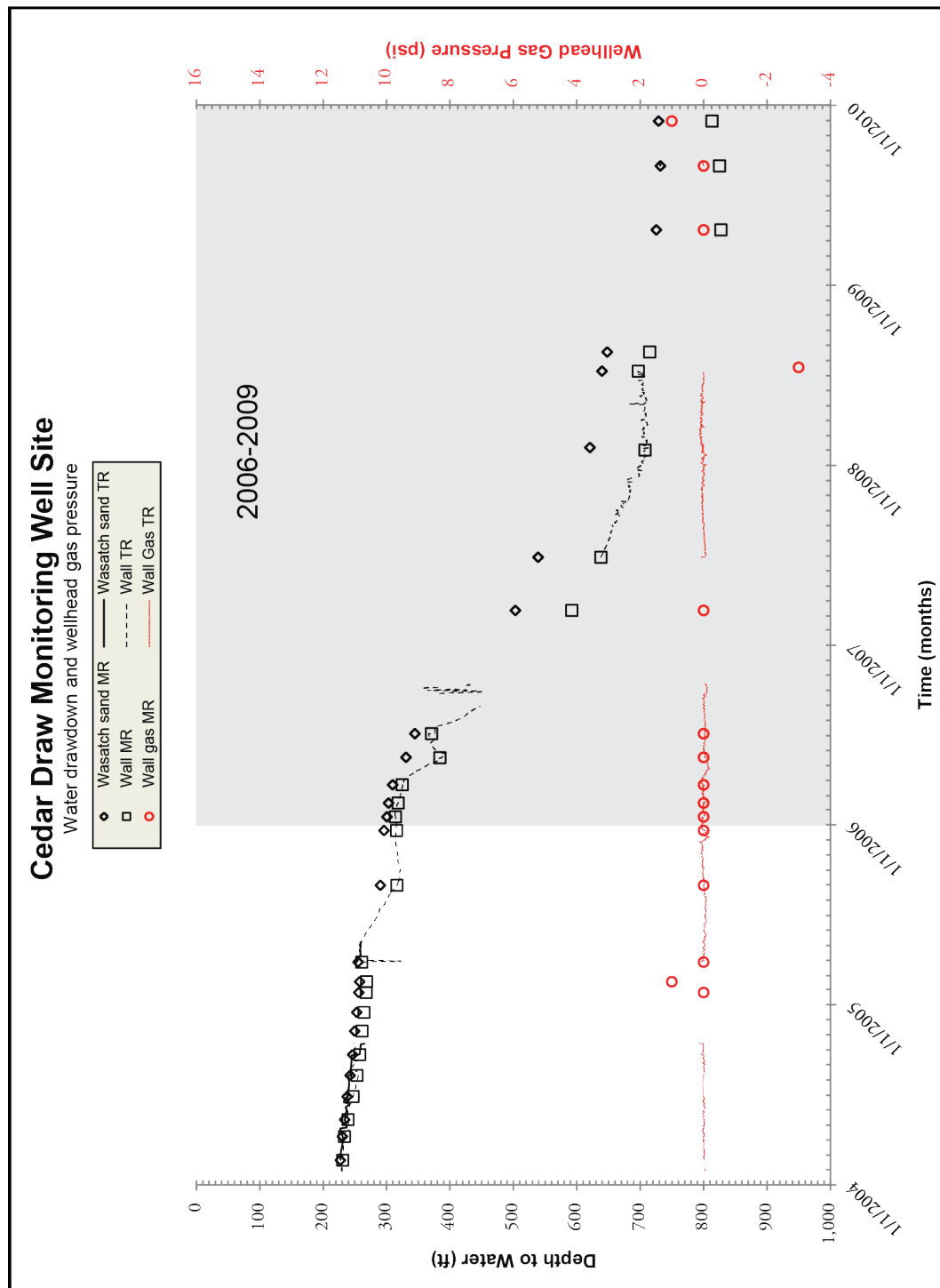


Figure 284. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Cedar Draw monitoring well site location.

Production Statistics

Production data was analyzed for CBNG wells within the buffer of the Cedar Draw monitoring well site from January 2002 through December 2009. CBNG wells are displayed by location on Figure 285.

Water production started to increase in 2004, which correlates to groundwater drawdown trends.

Water production peaked in late 2005, which also correlates to groundwater drawdown trends (Figure 286). Water and gas production increased during the 2006 to 2009 monitoring period (Figure 286). The water/gas ratio of CBNG wells within the buffer is inconsistent. Percent methane is variable.

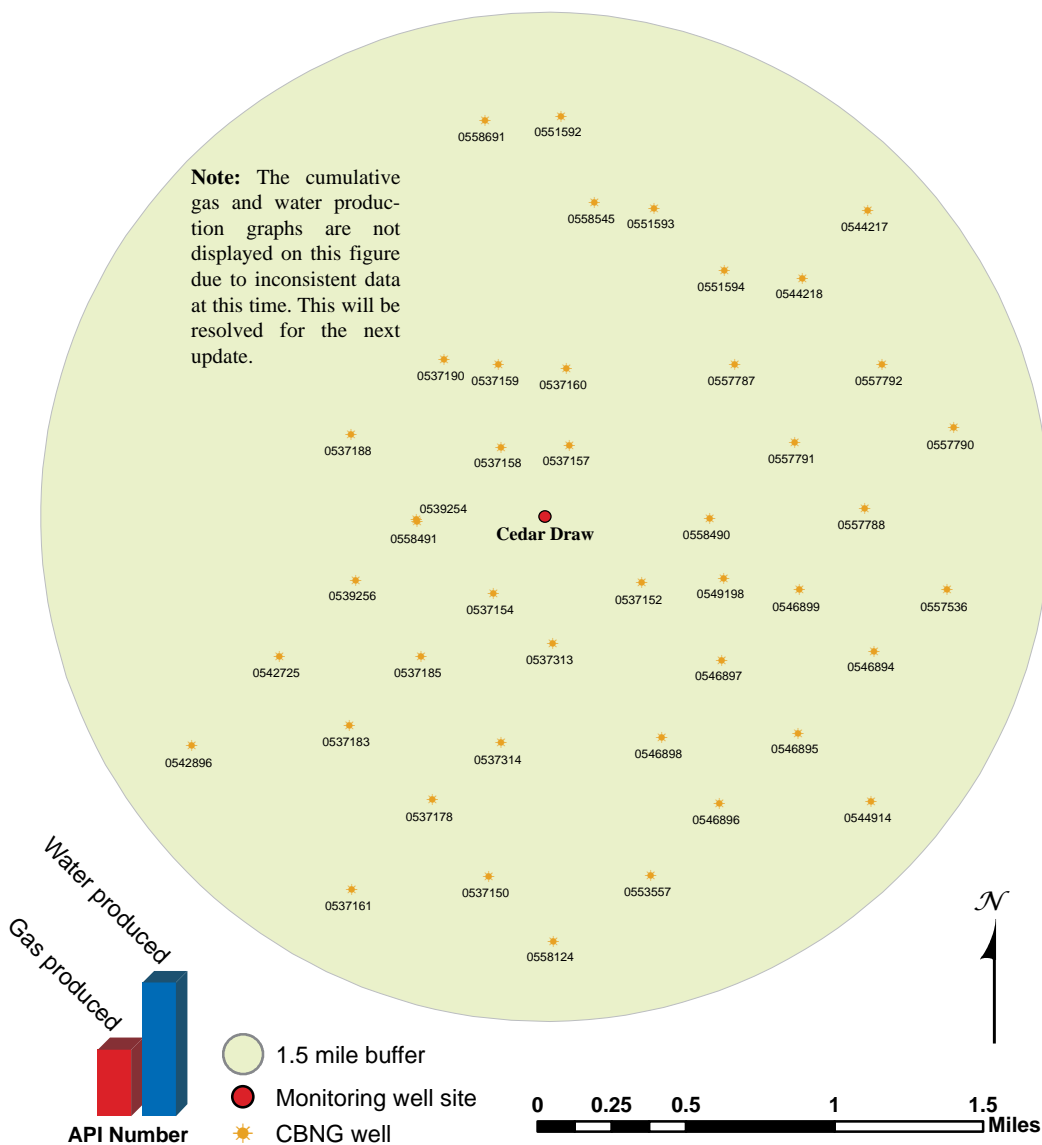


Figure 285. Cedar Draw monitoring well and associated CBNG wells within 1.5 mile buffer showing cumulative water (Bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

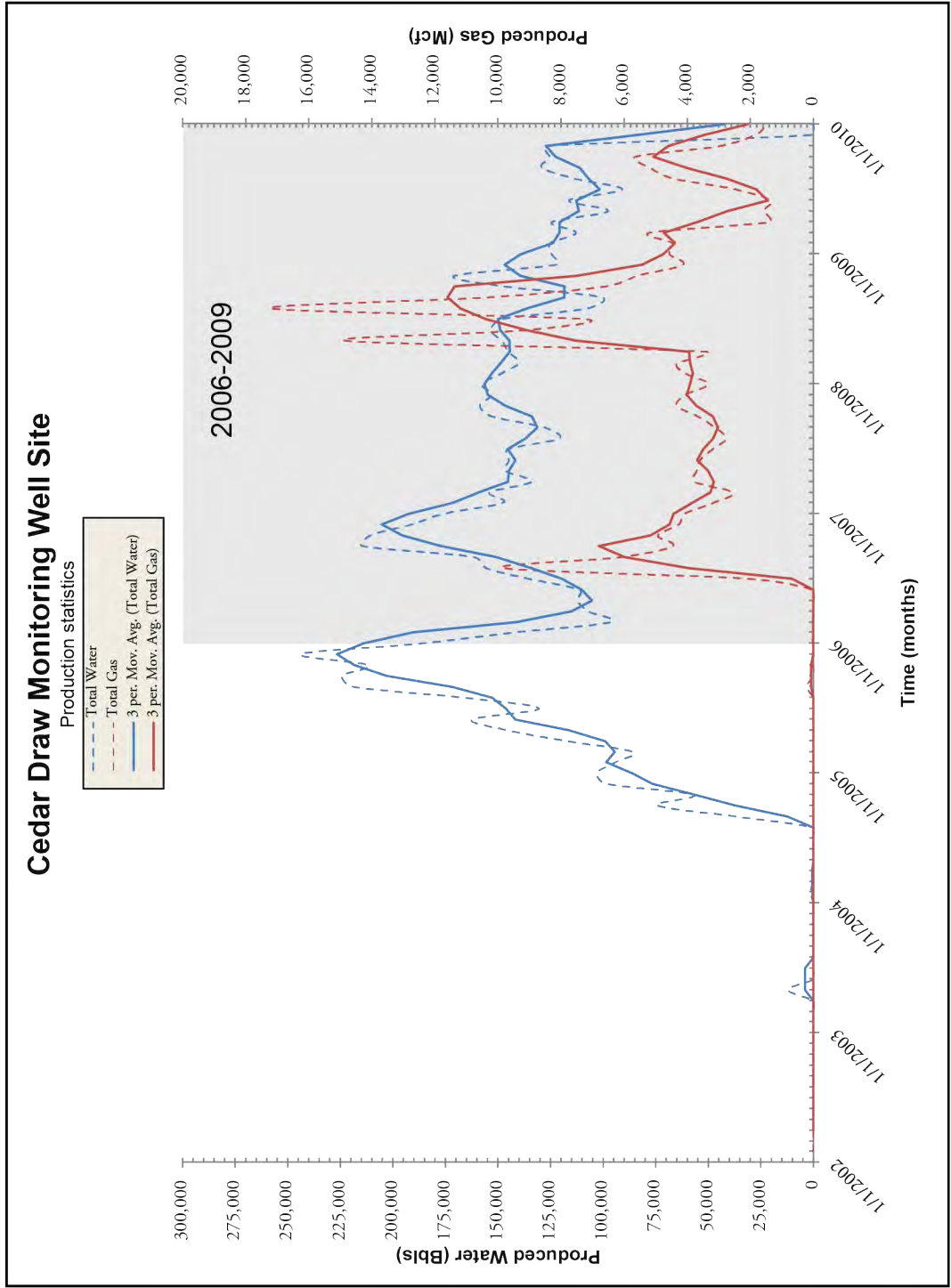


Figure 286. 3-period moving average along with water and gas production from associated CBNG wells.

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

Drawdown Information

The Leiter monitoring well site consists of one well completed into the Pawnee coal. A total of eight measurements were taken over the eight year monitoring period, seven of which were taken during the 2006-2009 monitoring period. The measurements show no drawdown. Available data is displayed in Tables 145 and 146 and Figures 287 and 288.

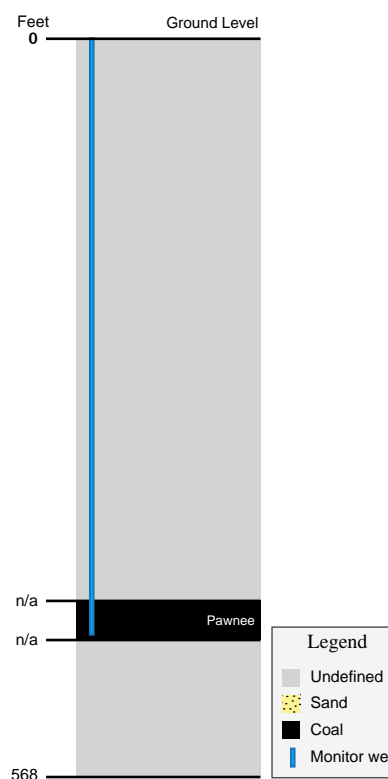


Figure 287. Section showing relative positions of coals and sands in feet. Not to scale.

Table 145. Table showing the depth to and thickness of monitored zones at the Leiter monitoring well site location. (measured in feet)

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

Table 146. Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2006	Drawdown 2006-2009	Total drawdown (ft.)	Depth to 12/31/09 water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Pawnee coal ⁽¹⁾	168.05	n/a	n/a	0.27	168.32	n/a	n/a

⁽¹⁾ No water level measurements were recorded between 5/17/02 and 2/12/08, therefore pre-2006 and 2006-2009 drawdowns could not be separated and only a total drawdown is shown.

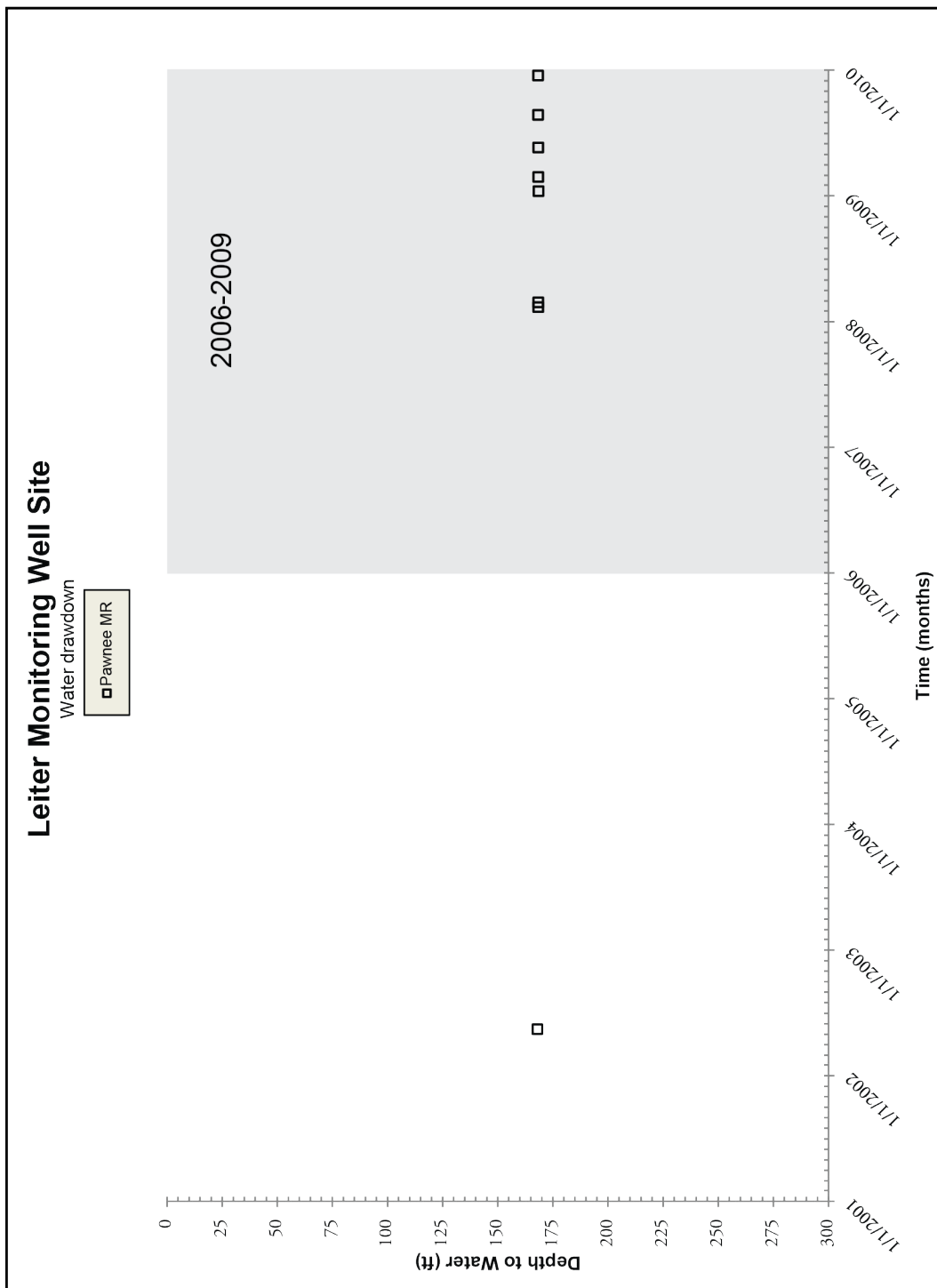


Figure 288. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Leiter monitoring well site location.

Production Statistics

Production data for the Leiter monitoring well site was not reported due to incomplete or generalized completion data for local CBNG wells.

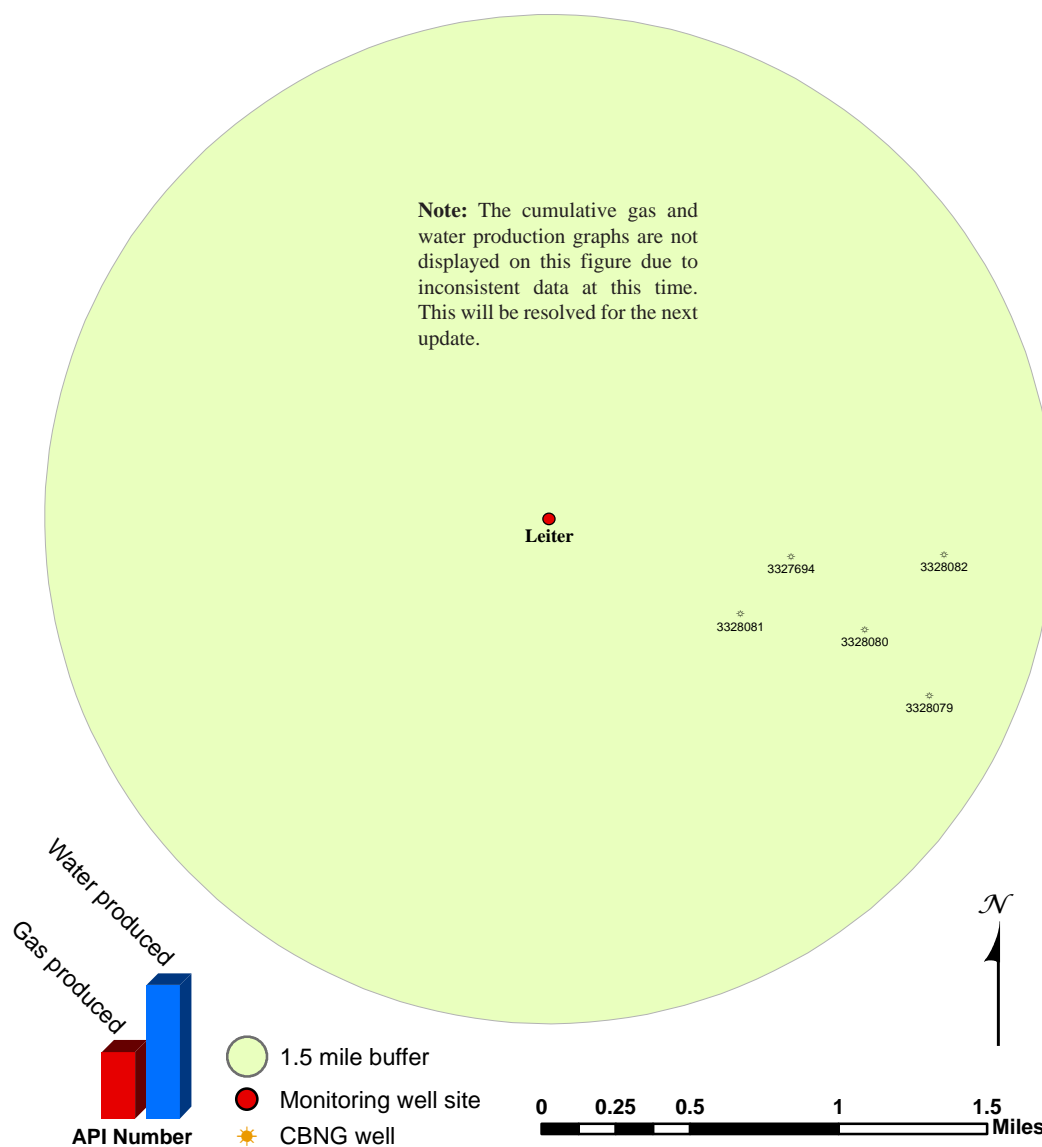


Figure 289. Leiter monitoring well and associated CBNG wells within 1.5 mile buffer showing cumulative water (Bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

L Quarter Circle Hills Monitoring Well Site

Location: S14 T56N R77W

Date First Monitored: April 5, 2005

Drawdown Information

The L Quarter Circle Hills monitoring well site includes three wells. One is constructed into the shallower Cook coal, another into the deeper Wall coal, and the third into an overlying Wasatch sandstone (Figure 290; Table 147). Missing transducer data is the result of errors with on site equipment.

Between 2006-2009 the Cook and Wall coals experienced drawdown. During July and August of 2008 the water levels in both coals dropped by over 100 feet. This drawdown coincides with the increase in produced water in the area. Water levels continued to drop after that period but at a slower rate. The trends in drawdown for the two coals are similar suggesting possible hydrologic connection between the coals (Figure 291). The Wasatch sand shows a less severe drawdown beginning at the same time period and continuing through the last reported date (Figure 291; Table 148). Though the impacts were minor, drawdown suggests that there may be hydrologic connectivity between the coals and sand. Gas pressures remained nearly zero during the period of maximum drawdown.

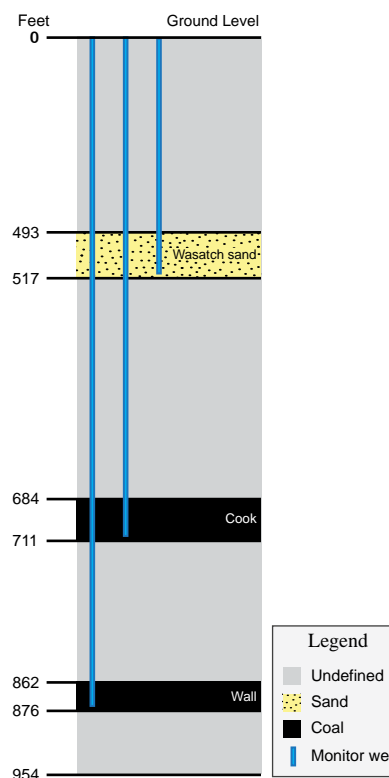


Figure 290. Section showing relative positions of coals and sands in feet. Not to scale.

Table 147. Table showing the depth to and thickness of monitored zones at the L Quarter Circle Hills monitoring well site location. (measured in feet)

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

Table 148. Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2006	Drawdown 2006-2009	Total drawdown (ft.)	Depth to 12/31/09 water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	41.38	-2.32	13.27	10.95	52.33	n/a	n/a
Cook coal	22.86	-3.37	190.60	187.23	210.09	7.00	10/18/07
Wall coal	15.39	0.26	260.38	260.64	276.03	13.00	12/17/06

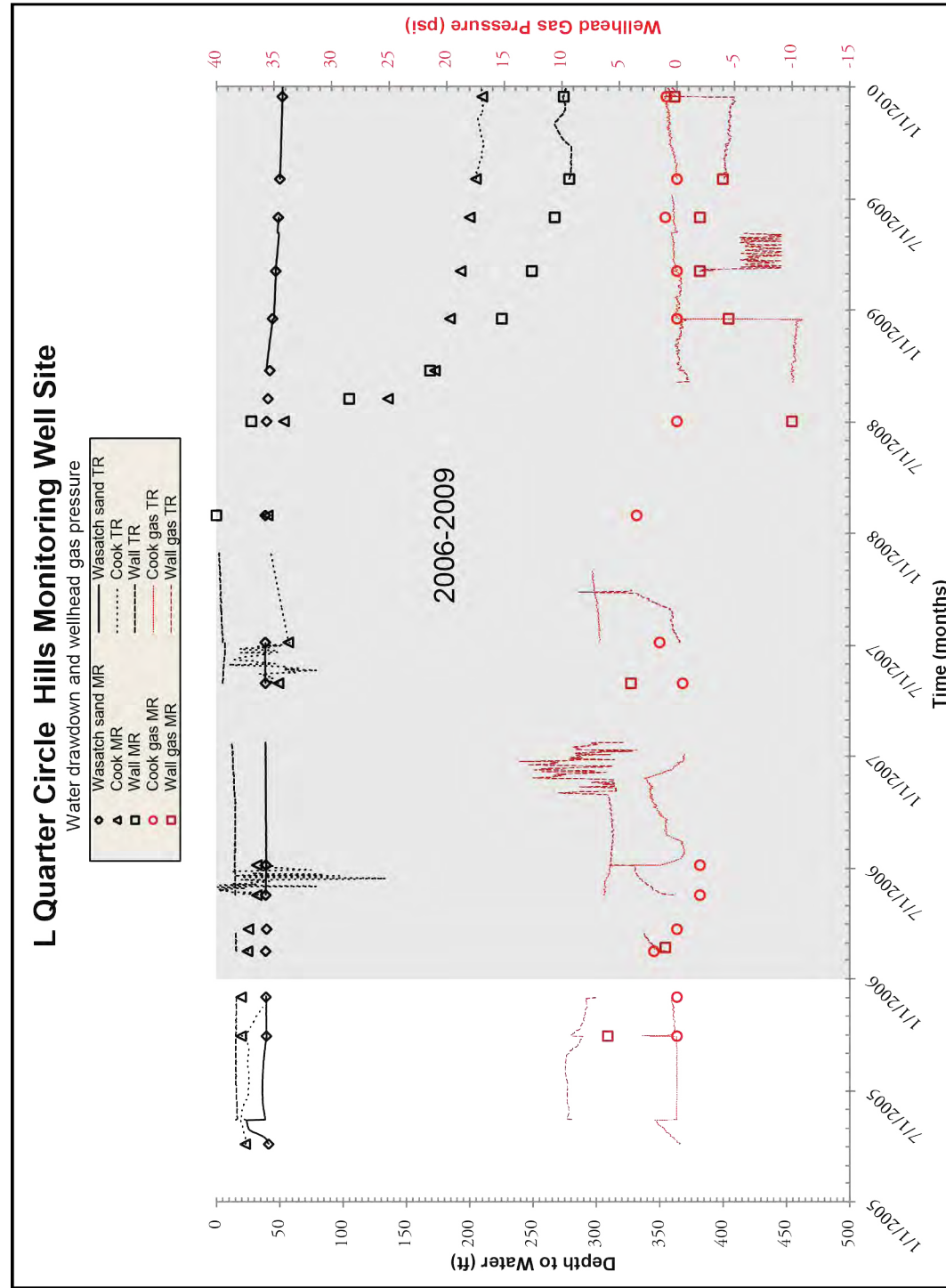


Figure 291. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the L Quarter Circle Hills monitoring well site location.

Production Statistics

Production data was analyzed for CBNG wells within the buffer of the L Quarter Circle Hills monitoring well site from January 2001 through December 2009. Cumulative production for individual CBNG wells is displayed by location on Figure 292.

Water production increased in 2002 and peaked in 2008, which generally correlates to groundwater drawdown trends (though this data is sporadic) (Figure 293). The water/gas ratio of CBNG wells within the buffer is inconsistent. Percent methane is variable.

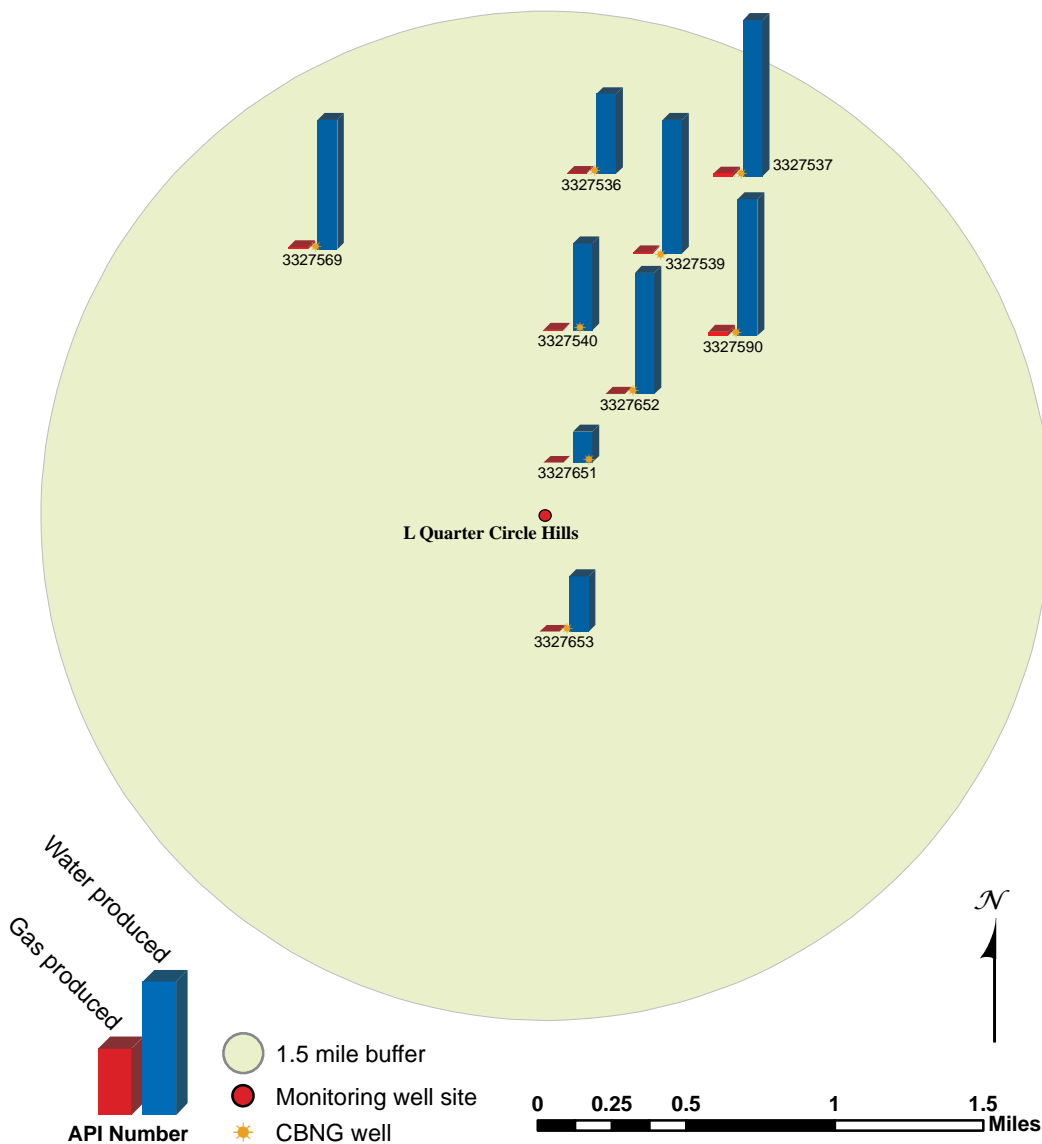


Figure 292. L Quarter Circle Hills monitoring well and associated CBNG wells within 1.5 mile buffer showing cumulative water (Bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

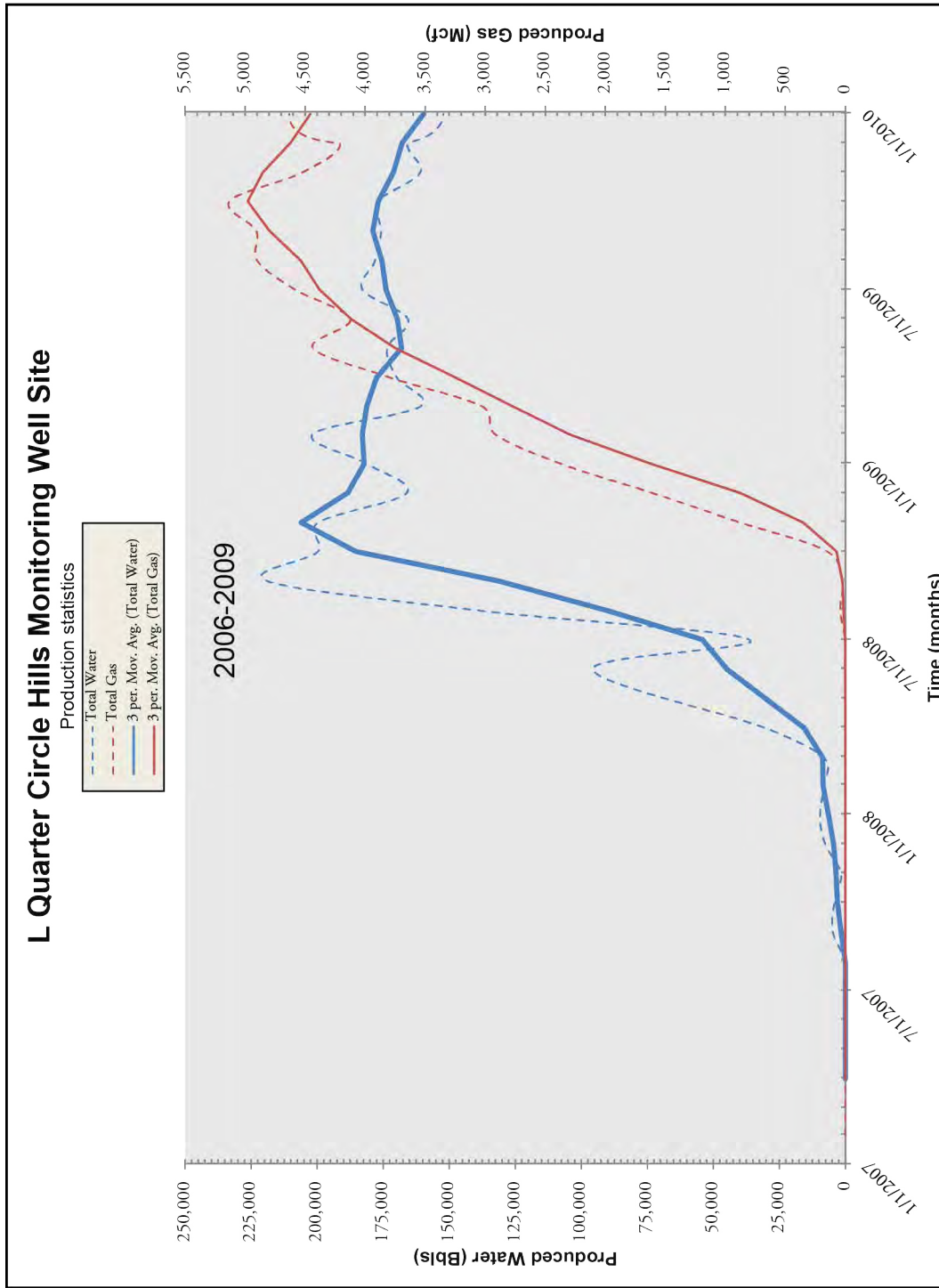


Figure 293. 3-period moving average along with water and gas production from associated CBNB wells.

Rose Draw Monitoring Well Site
Location: S19 T52N R77W
Date First Monitored: May 23, 2009

Drawdown Information

The Rose Draw monitoring well site consists of two wells, one of which is a dual completion well, separated by a packer. The dual completion well is completed in the Gates/Wall coal and into an overburden Wasatch sandstone. The second well is completed in an underburden sandstone (Figure 294; Table 149). Missing and/or fluctuating transducer data is the result of errors with on-site equipment. The Gates/Wall coal recorded a groundwater rise of approximately 2 feet during the 2006-2009 monitoring period. Groundwater levels in the Wasatch sandstone declined by 1 foot, while the underburden sandstone declined by 13 feet (Figure 295; Table 150). With so little data available no conclusions have been made on the hydrologic connection at this time.

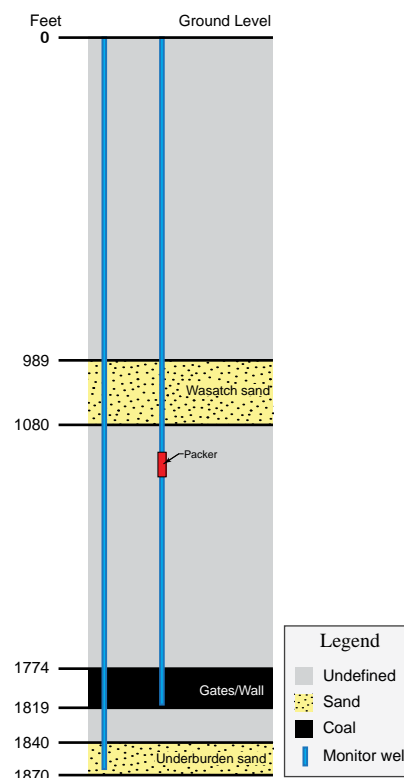


Figure 294. Section showing relative positions of coals and sands in feet. Not to scale.

Table 149. Table showing the depth to and thickness of monitored zones at the Rose Draw monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Wasatch sand	989	1080	91	694
Gates/Wall coal	1774	1819	45	n/a
Underburden sand	1840	1870	30	21

Table 150. Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2006	Drawdown 2006-2009	Total drawdown (ft.)	Depth to 12/31/09 water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	67.55	n/a	0.63	0.63	68.18	n/a	n/a
Gates/Wall coal	47.68	n/a	-2.23	-2.23	45.45	n/a	n/a
Underburden sand ⁽¹⁾	0.00	n/a	13.41	13.41	13.41	n/a	n/a

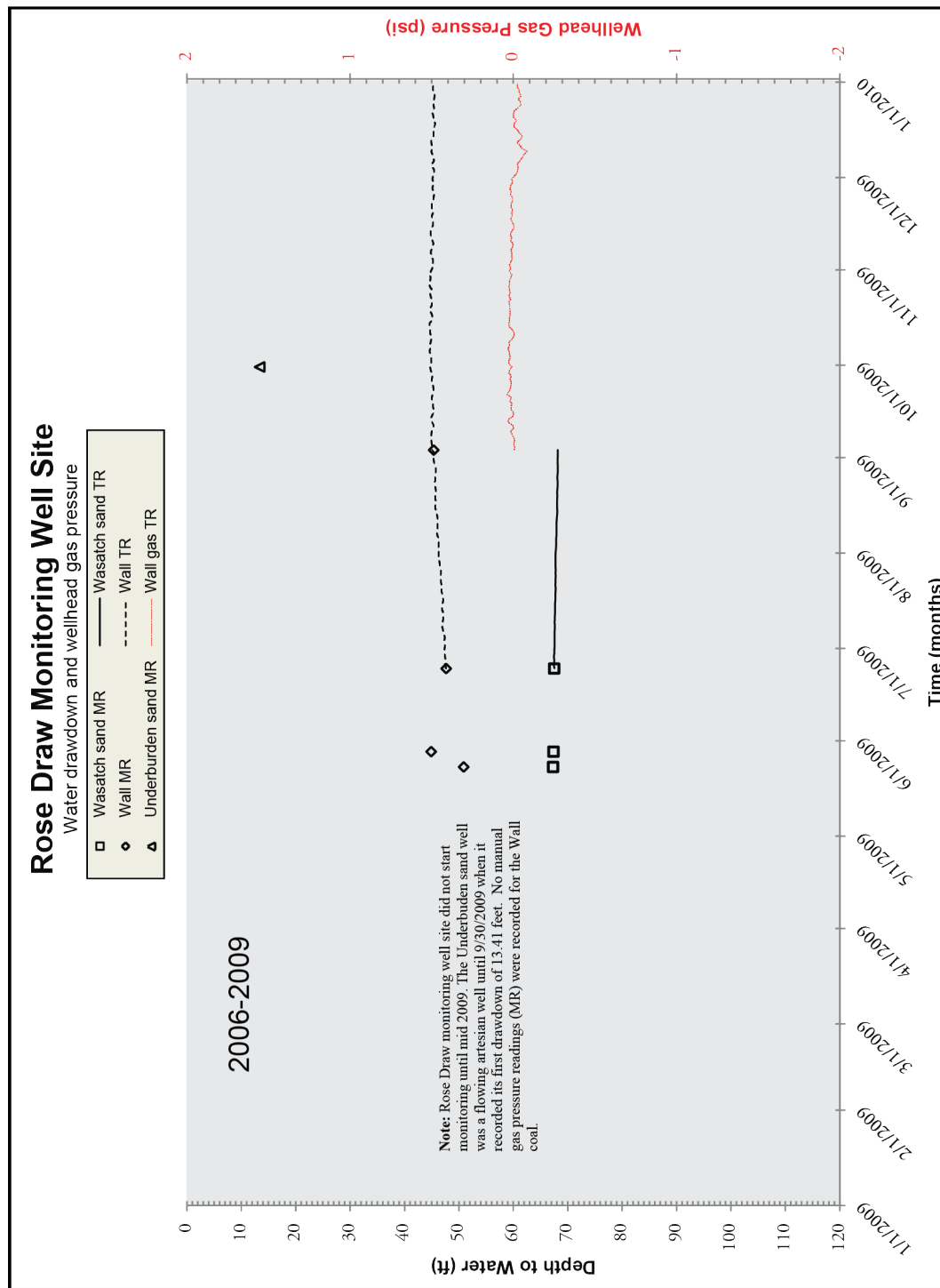


Figure 295. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Rose Draw monitoring well site location.

Production Statistics

Production data for the Rose Draw monitoring well site was not reported due to incomplete or generalized completion data for local CBNG wells.

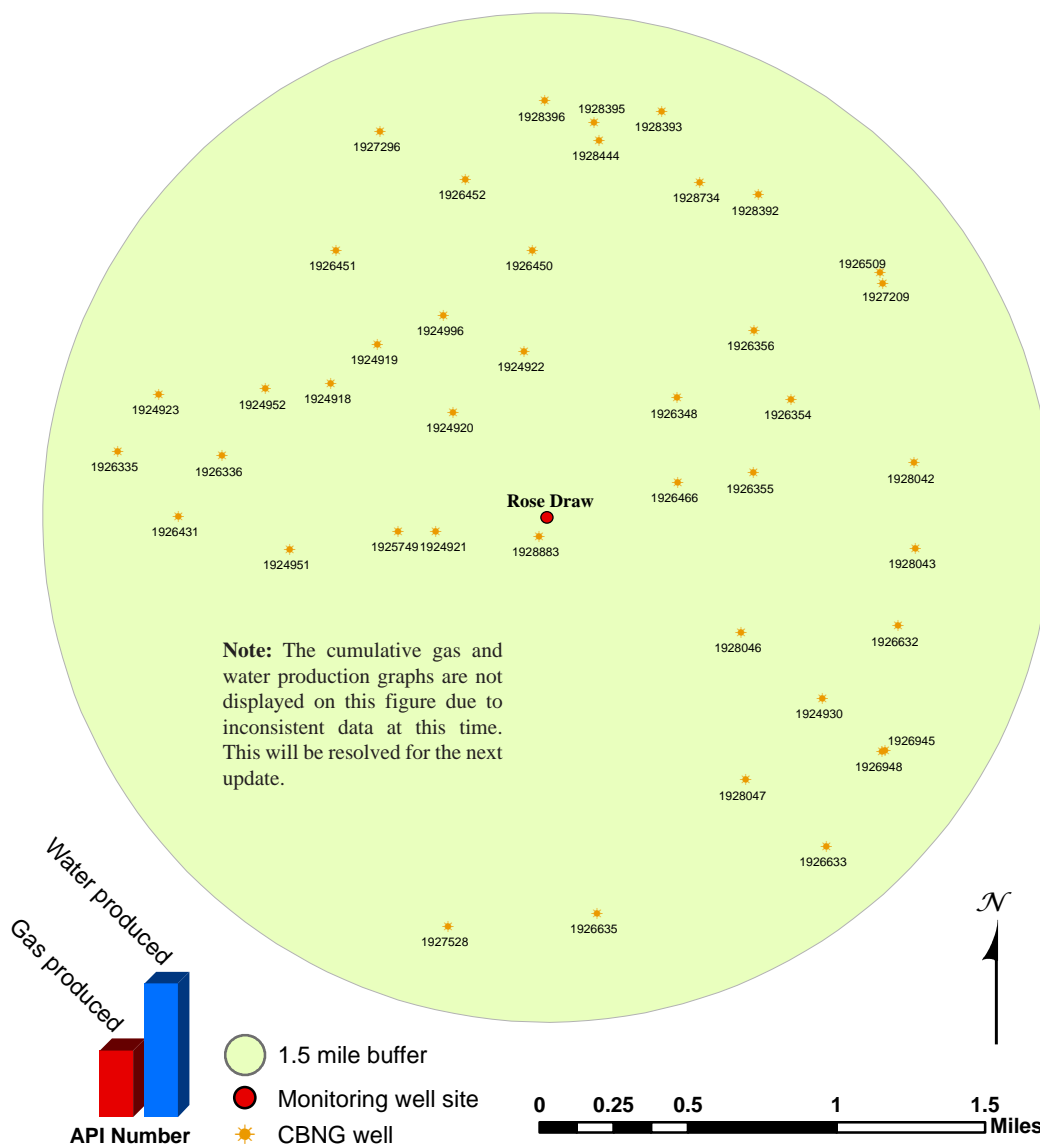


Figure 296. Rose Draw monitoring well and associated CBNG wells within 1.5 mile buffer showing cumulative water (Bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

South Coal Monitoring Well Site
Location: S13 T57N R75W
Date First Monitored: September 18, 2001

Drawdown Information

The South Coal monitoring well set includes two wells. One is drilled into the combined Cook/Lower Wall/Pawnee coal beds and the other into an overlying Wasatch sandstone bed (Figure 297; Table 151). Missing transducer data is the result of errors with on site equipment.

Between 2006-2009 the water levels in the coal decreased by 34 feet (Figure 298; Table 152). A 30 foot error occurred in the transducer data and was corrected in March of 2007. The water levels in the overlying Wasatch sand remained constant throughout the monitoring period. This suggests that there is no hydrologic connectivity between the monitored sand and coal at this location. Gas pressure readings were sporadic starting in 2004, with the highest reading in December of 2004 at 14 psi.

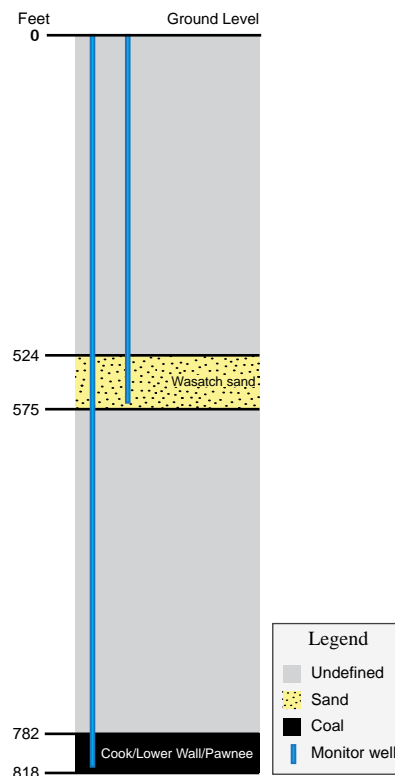


Figure 297. Section showing relative positions of coals and sands in feet. Not to scale.

Table 151. Table showing the depth to and thickness of monitored zones at the South Coal monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Wasatch sand	524	575	51	207
Cook/Lower Wall/Pawnee coal	782	818	36	n/a

Table 152. Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2006	Drawdown 2006-2009	Total drawdown (ft.)	Depth to 12/31/09 water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	463.85	1.69	-0.09	1.60	465.45	n/a	n/a
Cook/Lower Wall/ Pawnee coal	561.37	8.52	34.43	42.95	604.32	14	12/2/04

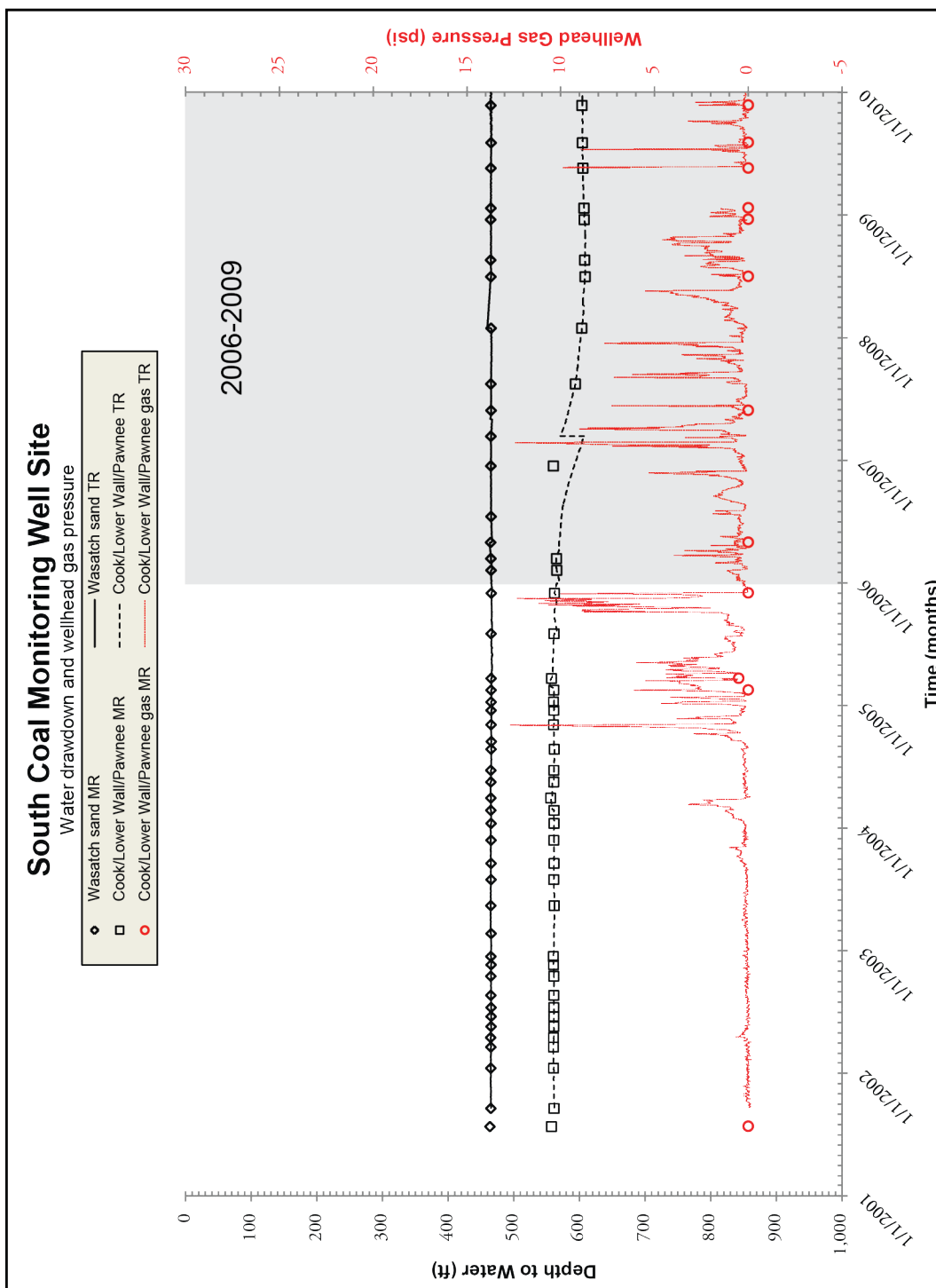


Figure 298. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the South Coal monitoring well site location.

Production Statistics

Production data was analyzed for CBNG wells within the buffer of the South Coal monitoring well site from January 2005 through December 2009. CBNG wells are displayed by location on Figure 299.

CBNG production increased in 2005, which correlates to groundwater drawdown trends. Water and gas production declined during the 2006 to 2009 monitoring period (Figure 300). The water/gas ratio of CBNG wells within the buffer is inconsistent. Percent methane increased,

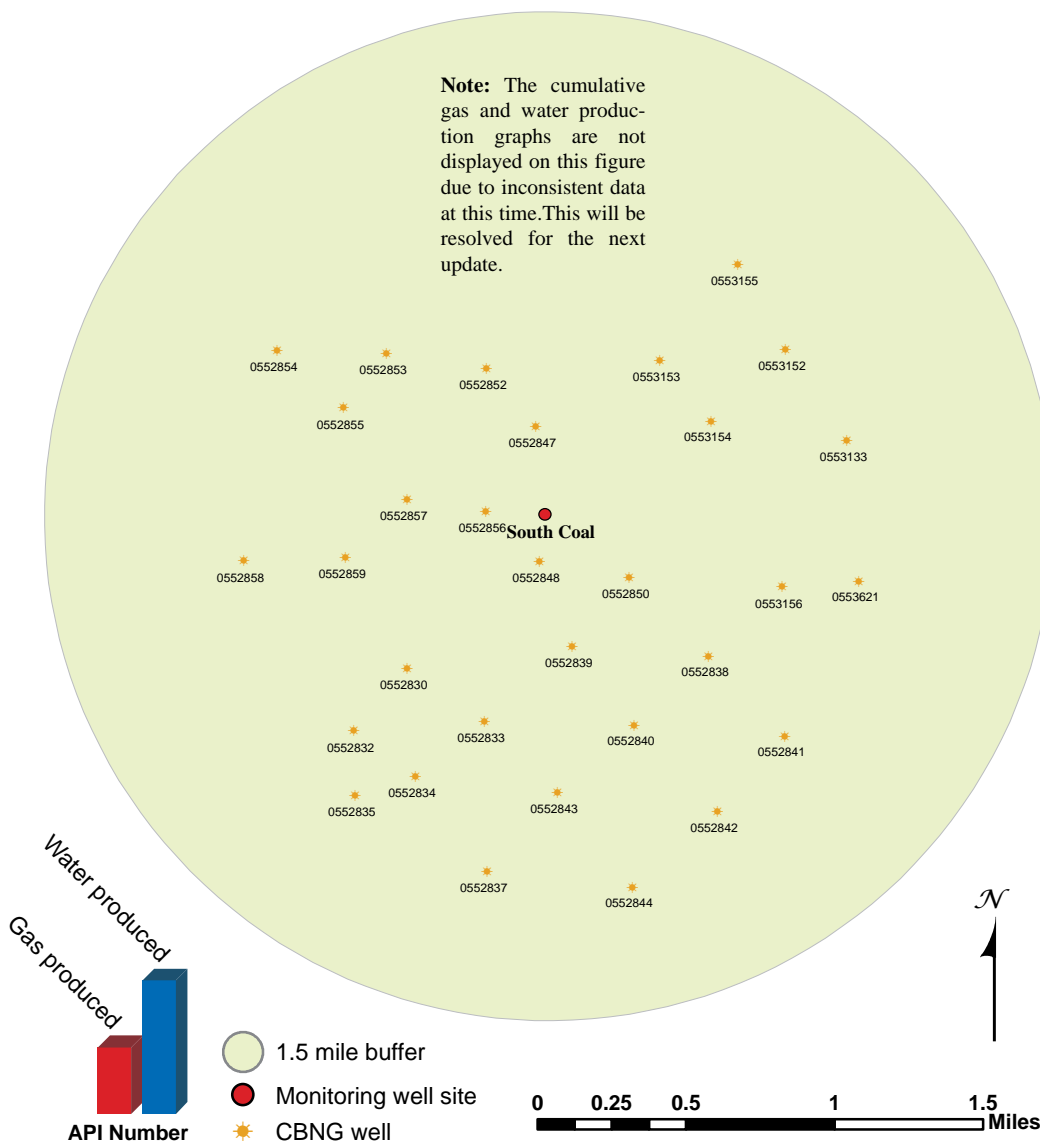


Figure 299. South Coal monitoring well and associated CBNG wells within 1.5 mile buffer showing cumulative water (Bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

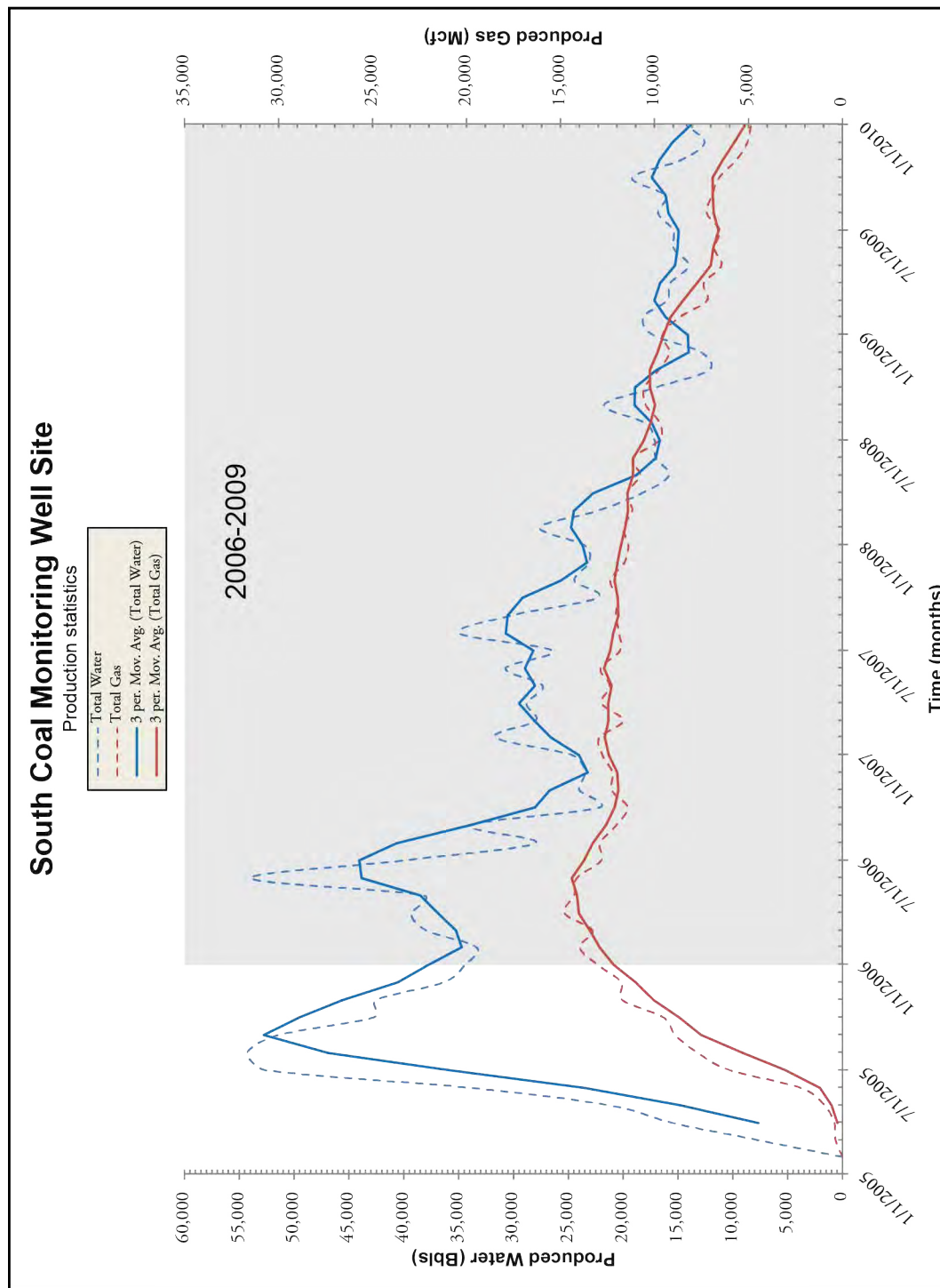


Figure 300. 3-period moving average along with water and gas production from associated CBNG wells.

South Prong Monitoring Well Site
Location: S26 T49N R76W
Date First Monitored: January 1, 2008

Drawdown Information

The South Prong monitoring well site consists of two wells with dual completions, separated by packers. One well is completed into the Big George coal and overlying Wasatch sandstone. The second well is completed into the Gates/Wall coal and an underburden sandstone (Figure 301; Table 153). Missing transducer data is the result of errors with on site equipment.

The depth to initial water levels for the Wasatch sandstone and Big George coal zones are approximately the same at 142 feet as well as the water levels for the Gates/Wall coal and underburden sandstone zones at 117 feet. The similarity of the initial water levels despite the difference in zone depths is likely due to the packers being improperly set. The packers were properly reset on November 2, 2009, after which there is limited data. Due to the improperly set packers, all measurements were considered not to be accurate enough to make any conclusions at this time (Figure 302; Table 154). Wellhead gas pressure for the coals remained at zero for the monitoring history of the wells.

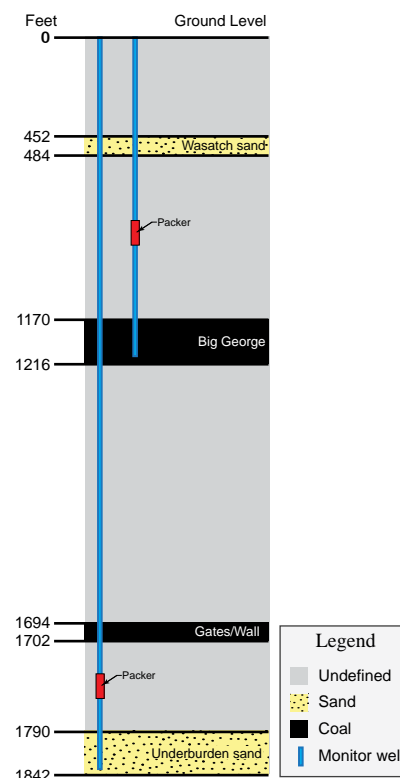


Figure 301. Section showing relative positions of coals and sands in feet. Not to scale.

Table 153. Table showing the depth to and thickness of monitored zones at the South Prong monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Wasatch sand	452	484	32	686.00
Big George coal	1170	1216	46	n/a
Gates/Wall coal	1694	1702	8	n/a
Underburden sand	1790	1842	52	88.00

Table 154. Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2006	Drawdown 2006-2009	Total drawdown (ft.)	Depth to 11/9/09 water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	142.79	n/a	8.20	8.20	150.99	n/a	n/a
Big George coal	141.95	n/a	207.45	207.45	349.40	n/a	n/a
Gates/Wall coal ⁽¹⁾	117.55	n/a	425.45	425.45	543.00	n/a	n/a
Underburden sand	116.95	n/a	139.65	139.65	256.60	n/a	n/a

Note: The last water level measurements for this site was taken on 11/9/09 as shown. These are the last taken in the 2009 monitoring year.

⁽¹⁾ It was reported that for this zone the water level on 11/9/09 was below 600 ft and measurements could not be take below this depth. Therefore, the measurement of 543 ft was taken on 11/5/09.

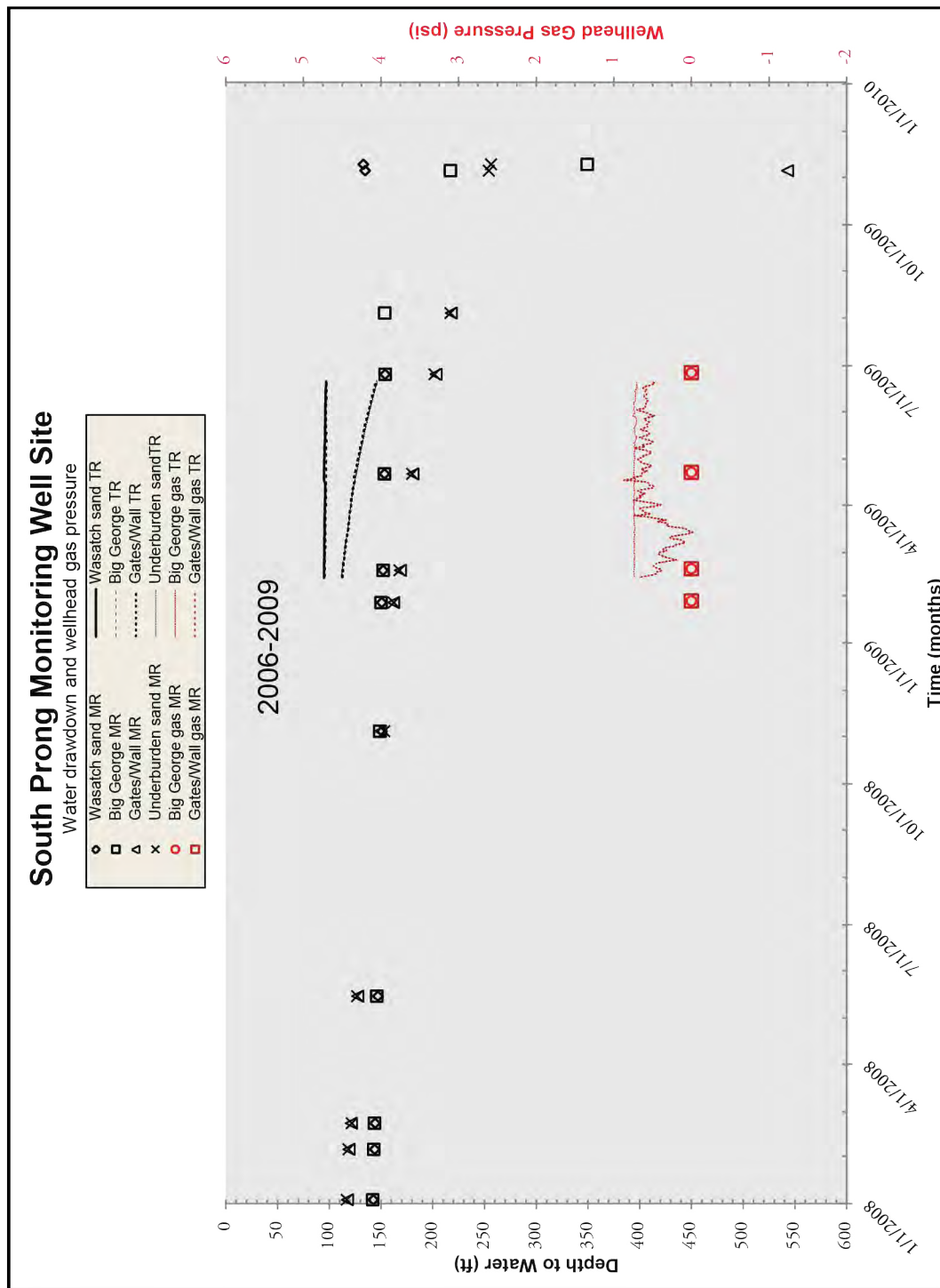


Figure 302. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the South Prong monitoring well site location.

Production Statistics

Production data was analyzed for CBNG wells within the buffer of the South Prong monitoring well site from January 1999 through December 2009. Cumulative production for individual CBNG wells is displayed by location on Figure 303.

Water production increased in 2006, which does not correlate with groundwater drawdown trends. Water and gas production increased during the 2006 to 2009 monitoring period (Figure 304). The water/gas ratio of CBNG wells within the buffer is inconsistent. Percent methane is variable.

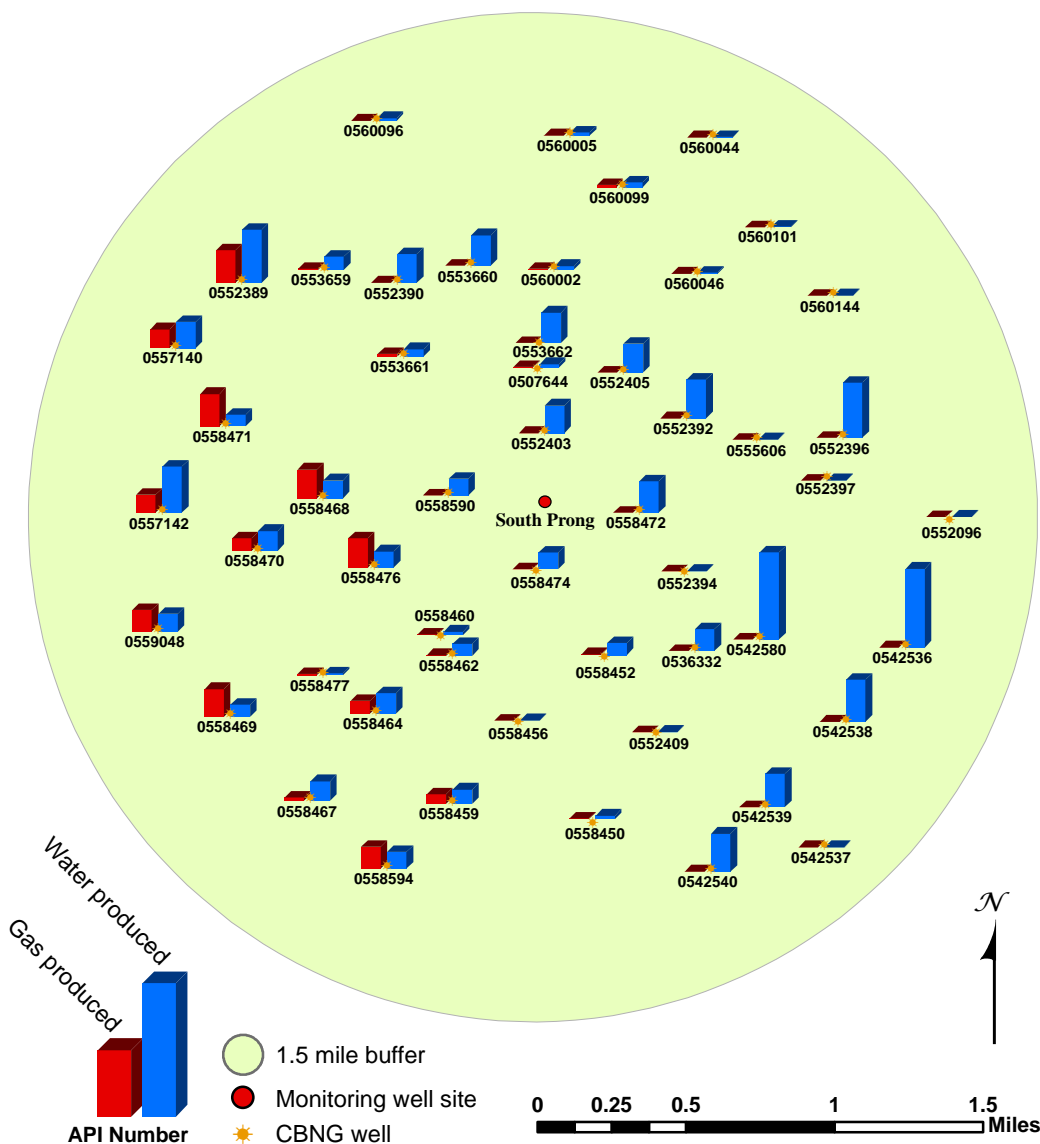


Figure 303. South Prong monitoring well and associated CBNG wells within 1.5 mile buffer showing cumulative water (Bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.

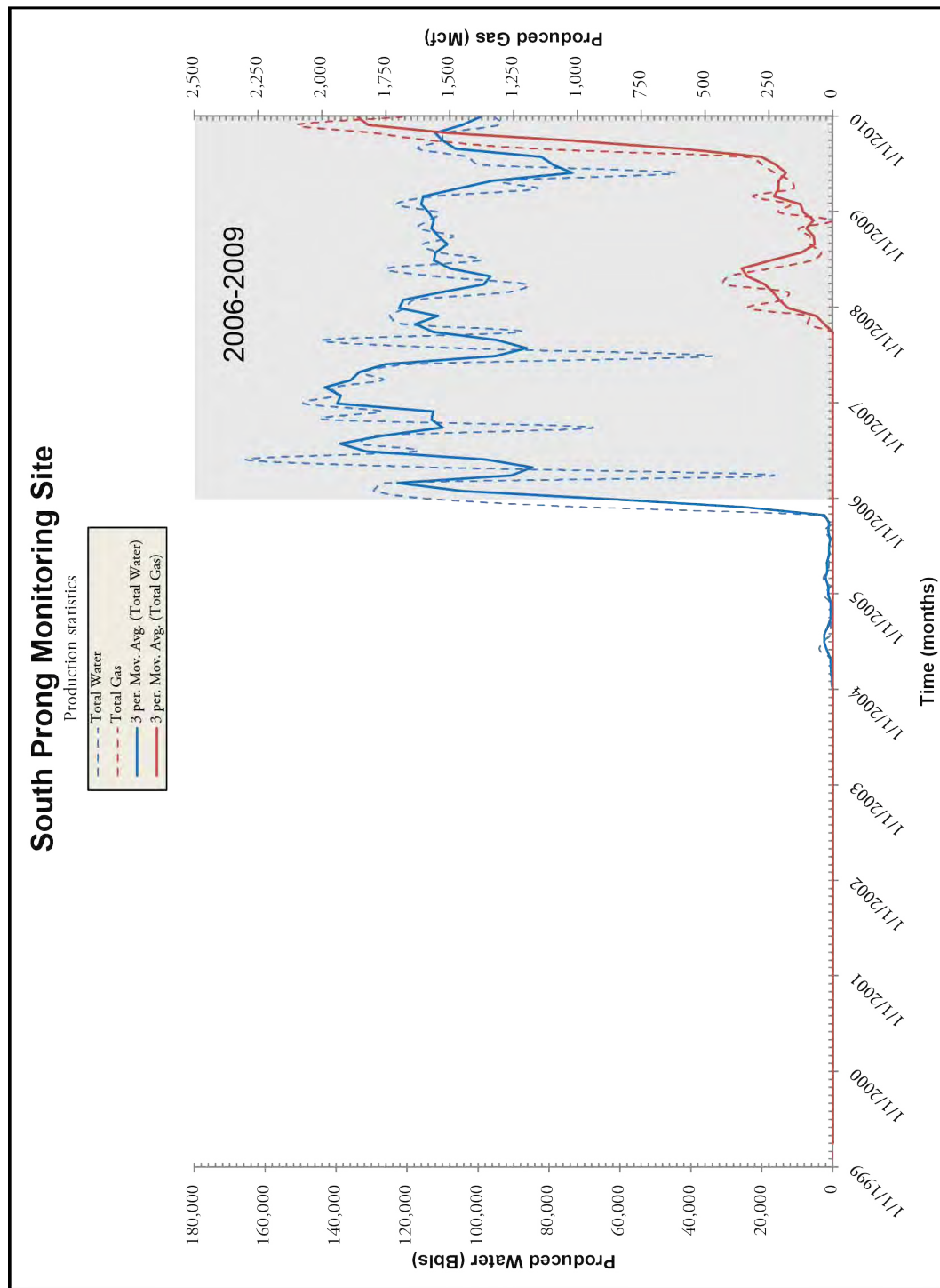


Figure 304. 3-period moving average along with water and gas production from associated CBNG wells.

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. One well is drilled into the Wall coal and also completed in the shallower Werner coal. The second well is drilled to the Anderson coal and also completed into an underburden sand. The third well is drilled to the shallow Smith coal and also completed in the shallow Wasatch sand. (Figure 305; Table 155). Missing transducer data is the result of errors with on site equipment.

The Wall and Anderson coals record groundwater drawdown beginning in mid-2009 and mid-2008 respectively. There was little impact on water levels in the Smith and Werner coals between 2006-2009. This indicates they are confined relative to the Wall and Werner coals. The underburden sand shows a gradual drawdown throughout the period of drawdown in the coals. This suggests that there may be a hydrologic connection between the underburden sand and the coals above it. Water levels in the Wasatch sand remained constant through the monitoring period. This suggests that there is no hydrologic connection between the coals and the shallow Wasatch sandstone (Figure 306; Table 156). Wellhead gas pressure at this location stayed around zero for the entirety of the monitor period with the exception of one occurrence. One manual measurement of 55 psi and 52 psi for the Smith and Wall coals respectively in 2007 were recorded (Figure 306). No other measurements above zero outside of transducer error were recorded.

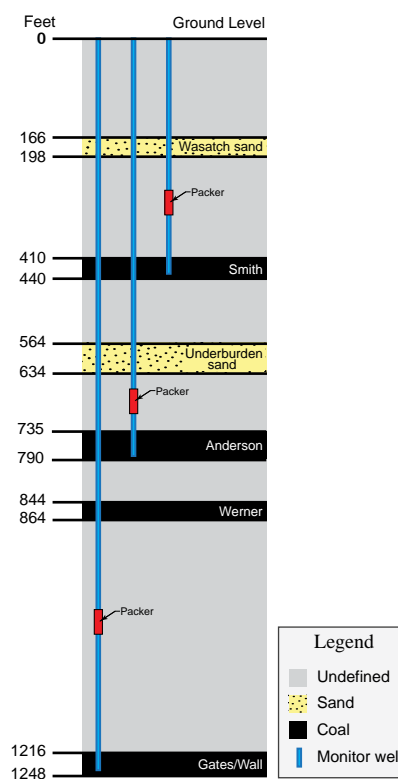


Figure 305. Section showing relative positions of coals and sands in feet. Not to scale.

Table 155. Table showing the depth to and thickness of monitored zones at the Williams Cedar Draw monitoring well site location. (measured in feet)

Monitor zone	Zone characteristics			
	Depth of zone (ft.)		Zone thickness (ft.)	Separation from coal (ft.)
	Top	Bottom		
Wasatch sand	166	198	32	212
Smith coal	410	440	30	n/a
Underburden sand	564	634	70	101
Anderson coal	735	790	55	n/a
Werner coal	844	864	20	n/a
Gates/Wall coal	1216	1248	32	n/a

Table 156. Table showing depths to water from ground level, drawdown for previous monitoring period, drawdown for current monitoring period, maximum gas pressure, and date of maximum gas pressure.

Monitor zone	Water and Gas characteristics						
	Depth to Initial water level (ft.)	Drawdown pre-2006	Drawdown 2006-2009	Total drawdown (ft.)	Depth to 12/31/09 water level (ft.)	Max. gas pressure (psi)	Date of max. gas pressure
Wasatch sand	115.79	n/a	-1.59	-1.59	114.20	n/a	n/a
Smith coal	169.15	n/a	-0.02	-0.02	169.13	55	8/21/07
Underburden sand	259.77	n/a	163.28	163.28	423.05	n/a	n/a
Anderson coal	243.95	n/a	293.95	293.95	537.90	8	8/21/07
Werner coal	143.90	n/a	19.79	19.79	163.69	n/a	n/a
Gates/Wall coal	216.50	n/a	123.70	123.70	340.20	155	12/17/09

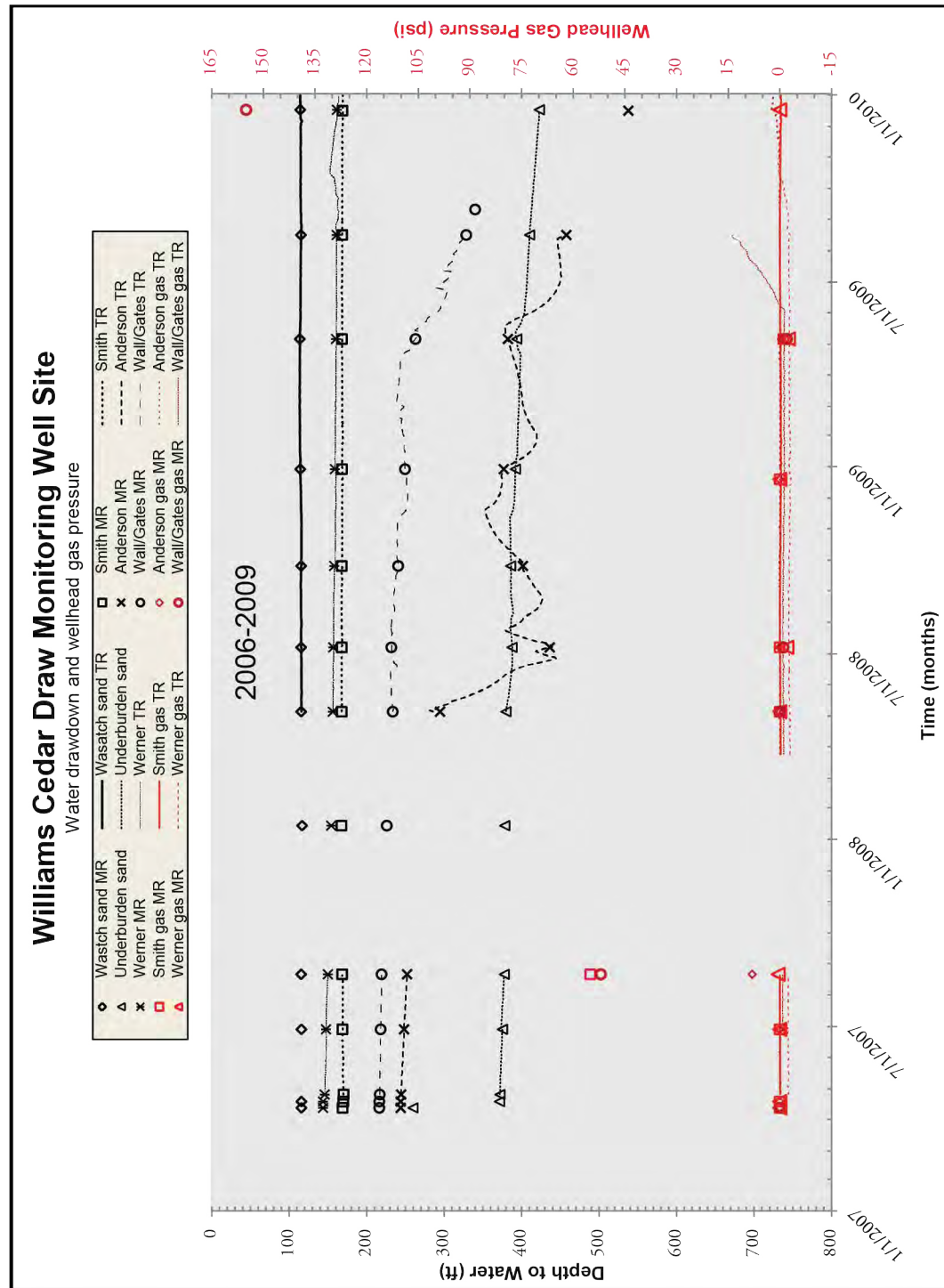


Figure 306. Graph showing the manual and transducer recorded measurements for water levels and gas pressure for the monitored zones at the Williams Cedar Draw monitoring well site location.

Production Statistics

Production data for the Williams Cedar Draw monitoring well was not reported due to incomplete or generalized completion data for local CBNG wells.

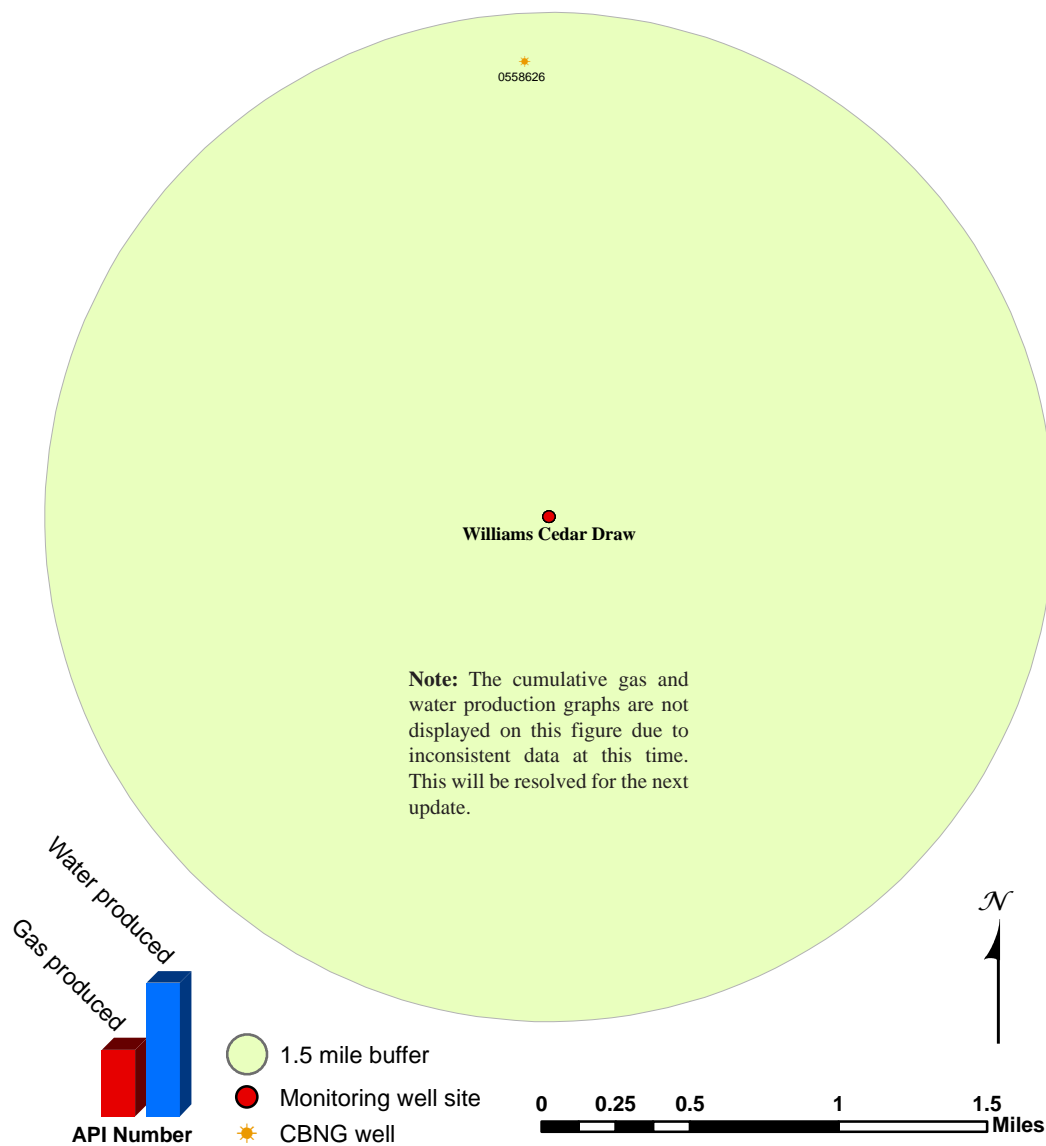
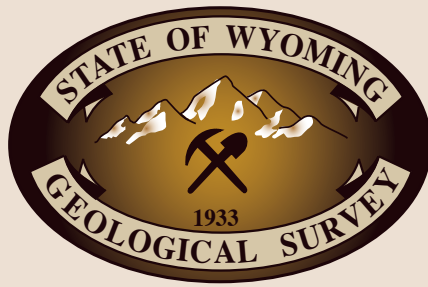


Figure 307. Williams Cedar Draw monitoring well and associated CBNG wells within 1.5 mile buffer showing cumulative water (Bbls) and gas (Mcf) production. The seven digit number corresponds to the American Petroleum Institute (API) well number.



WSGS

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Mission Statement

The Wyoming State Geological Survey's (WSGS) mission is to promote the beneficial and environmentally sound use of Wyoming's vast geologic, mineral, and energy resources while helping protect the public from geologic hazards. By providing accurate information and expanding knowledge through the application of geologic principles, the WSGS contributes to economic growth and improvement in the quality of life for Wyoming's residents.

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