

# **WASKADA UNIT NO. 13**

## **WATERFLOOD PROGRESS REPORT**

**January 1, through December 31, 2010**

### **PennWest Exploration**

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## **INTRODUCTION**

The WASKADA UNIT NO.13 pressure maintenance project commenced water injection into the Lower Amaranth designed and in accordance with Manitoba Energy and Mines Approval No. PM 58.

PRESSURE MAINTENANCE: Governed by Board Order No. PM 58

### Unit Information:

UNITIZED ZONE: Lower Amaranth

Original Unit Nov.1, 1985 Board Order - Voluntary

POOL: Waskada Lower Amaranth A (03 29A)

This report documents the performance of the Waskada Unit # 13 pressure maintenance project for the period of January 1 to December 31, 2010.

Unit # 13 is part of main Waskada. The Waskada field is situated on the northeast rim of the Williston Basin in southern Manitoba. It comprises a large portion of Township 1 and 2, Ranges 25 and 26 (WPM).

The Waskada Fields produce light density crude (approximately 36° API), predominantly from the Lower Amaranth formation. The interlaminated, shallow marine to subtidal succession of sandstones, siltstones, and shale progressively onlaps the Mississippian unconformity surface from basin center, up dip to the north and eastern basin limits in Saskatchewan and Manitoba. The fine grained reservoir rock has a complex reservoir characterization with 13 to 16 % porosity and permeability on the order of 0.5 to 15 md. The lower Amaranth, the oldest Mesozoic unit is a clastic red bed sequence lying directly on the Paleozoic erosional surface. It consists of a series of dolomitic siltstones and sandstones interbedded with argillaceous siltstones and shales. The section is usually subdivided into a lower sandy unit and an overlying shale unit. The lower sequence is the oil production zone. The bulk of pay is founded in the laminated sandstone/siltstone facies.

The Lower Amaranth has been classified into four general lithological types:

1. Interbedded shale/siltstone/sandstone by grain size, color and texture
2. Siltstone – This lithology occurs in distinct intervals up to two or three meters in thickness. It is generally light green in color and dolomitic.
3. Laminated sandstone – This occurs in distinct sandy intervals with a wide range of grain sizes and primary sedimentary structures.
4. Massive sandstone – This lithology occurs in thin intervals and usually associated with the laminated sandstones facies. Beds are usually light grey to reddish grey in color and coarse to medium – grained.

### **UNIT HISTORY**

#### **Waskada Unit #13 (Unit History)**

<b>Abbreviated Well ID</b>	<b>Date Well Spudded</b>	<b>On Prod YYYY/MM</b>	<b>Org Operator Name</b>	<b>Ground Elevation (m)</b>	<b>TVD (m)</b>
00/01-01-002-26W1/0	8/4/1984	1984/09	Omega Hydcbns Ltd	467.2	953.0
00/02-01-002-26W1/0	8/8/1984	1984/09	Omega Hydcbns Ltd	466.0	956.0
00/03-01-002-26W1/0	5/29/1984	1984/07	Omega Hydcbns Ltd	464.5	950.0
00/04-01-002-26W1/0	6/2/1984	1984/06	Omega Hydcbns Ltd	465.4	950.0
00/05-01-002-26W1/0	5/25/1984	1984/06	Omega Hydcbns Ltd	466.0	949.0
00/06-01-002-26W1/0	5/22/1984	1984/06	Omega Hydcbns Ltd	464.7	949.0
00/07-01-002-26W1/0	8/13/1984	1984/09	Omega Hydcbns Ltd	466.7	952.0
00/08-01-002-26W1/0	7/30/1984	1984/09	Omega Hydcbns Ltd	467.7	950.0
00/09-01-002-26W1/0	6/6/1985	1985/07	Omega Hydcbns Ltd	467.3	946.0
00/10-01-002-26W1/0	10/25/1984	1984/11	Omega Hydcbns Ltd	467.2	955.0
00/11-01-002-26W1/0	11/20/1984	1984/12	Omega Hydcbns Ltd	464.8	949.0
00/12-01-002-26W1/0	12/14/1984	1985/01	Omega Hydcbns Ltd	466.4	960.0
00/13-01-002-26W1/0	12/8/1983	1984/01	Sasko O&G Lmtl	465.4	965.0
00/14-01-002-26W1/0	1/10/1984	1984/02	Sasko O&G Lmtl	468.5	975.0

00/15-01-002-26W1/0	7/9/1985	1985/08	Omega Hydcbns Ltd	469.4	946.0
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### Waskada Unit #13 (Production & Injection History)

Abbreviated Well ID	First Prod YYYY/M M	On Inject. YYYY/M M	Last Prod. YYYY/M M	Cumulative OIL Prod. (m3)	Cumulative WTR Prod. (m3)	First 12 mo. Ave WC %	Last Inject. YYYY/M M
00/01-01-002-26W1/0	1984/09		1989/02	901	1,029	54.8	
00/02-01-002-26W1/0	1984/09		2010/10	6,291	958	27.4	
00/03-01-002-26W1/0	1984/07		2008/05	5,993	2,667	14.9	
00/04-01-002-26W1/0	1984/06		2010/12	7,793	1,382	29.3	
00/05-01-002-26W1/0	1984/06	1987/02	1986/12	2,256	516	19.2	2000/01
00/06-01-002-26W1/0	1984/06		2010/12	7,295	1,124	22.9	
00/07-01-002-26W1/0	1984/09	1987/02	1986/11	1,211	622	37.1	2001/09
00/08-01-002-26W1/0	1984/09		1996/01	1,943	1,681	63.7	
00/09-01-002-26W1/0	1985/07		1988/07	319	626	63.7	
00/10-01-002-26W1/0	1984/11		2010/12	4,691	924	17.1	
00/11-01-002-26W1/0	1984/12		2010/11	5,664	1,526	22.1	
00/12-01-002-26W1/0	1985/01		2010/12	5,432	1,019	24.3	
00/13-01-002-26W1/0	1984/01	1986/12	1986/10	936	315	26.5	1998/04
00/14-01-002-26W1/0	1984/02		1999/11	3,024	498	16.0	
00/15-01-002-26W1/0	1985/08	1987/01	1986/12	486	364	43.6	1998/04

## **DISCUSSION:**

### **Production Performance**

Production Response versus Injection: Since injection began, late 1986, injection rates fluctuated to the same degree amongst the injectors; it is difficult to link any production

responses to any specific injector. Although injection rate was high recently, it did not affect the produced oil and water. Water breakthrough of certain producers could not be identified with over injection of associated injectors. Some wells showed not much change in oil rate when injection was ceased in 2001.

### **Voidage Replacement Ratio Calculation**

What could be described as very limited success, the waterflood was not maintained properly and injection rate was dropped year after year in most cases. The cumulative VRR in the pool is about 1.01 and current monthly VRR is zero. All the injectors are currently shut in, and PennWest has no plan to reactivate any of the old injectors. (see Appendix C )

To understand the past performance of the Lower Amaranth waterflood, we are doing some reservoir engineering work to come up with potential solutions. One of our plans is to do a pilot program in section 2: The objective of the pilot is to:

1. See if we can inject water continuously into the Lower Amaranth Formation
  - i. Particle size less than 1 micron
  - ii. Total Suspended Solid (TSS) less than 10 ppm
  - iii. Oil less than 10 ppm
2. Inject below the frac pressure
3. Test the simulation model that we have built.

### **2011 Waskada Lower Amaranth Waterflood Pilot Location**

The pilot producer will be 102/12-01-02-26W1/00 (The horizontal well) and the injectors will be two vertical wells; 100/12-01-02-26W1 and 100/11-01-02-26 (need to be converted to injectors)

### **Corrosion and Scale Prevention Program**

We currently inject ScalCor down all the new horizontal wells. Plus, PennWest will be installing cathodic protection on the wells. Also, the new gathering system is Fiberglass and as such is not susceptible to corrosion.

## **SUMMARY AND RECOMMENDATIONS**

### **[Producers]**

#### **Current Producing Wells**

1. 00/04-01-002-26W1/0
2. 00/10-01-002-26W1/0

#### **Current Suspended Wells**

1. 00/02-01-002-26W1/0 (since 2010/11)
2. 00/03-01-002-26W1/0 (since 2008/06)
3. 00/06-01-002-26W1/0 (since 2011/01)
4. 00/11-01-002-26W1/0 (since 2010/12)
5. 00/12-01-002-26W1/0 (since 2011/01)
6. 00/14-01-002-26W1/0 (since 1999/12)

#### **Abandoned Wells**

1. 00/01-01-002-26W1/0 (since 1989/03)
2. 00/08-01-002-26W1/0 (since 1996/02)
3. 00/09-01-002-26W1/0 (since 1988/08)

### **[Injectors]**

#### **Current Injecting Wells**

None

#### **Current Suspended Wells**

1. 00/13-01-002-26W1/0 (since 1998/05)

2. 00/15-01-002-26W1/0 (since 1998/05)
- 00/05-01-002-26W1/0 (since 2000/02)

### **Abandoned Wells**

1. 00/07-01-002-26W1/0 (since 2001/10)

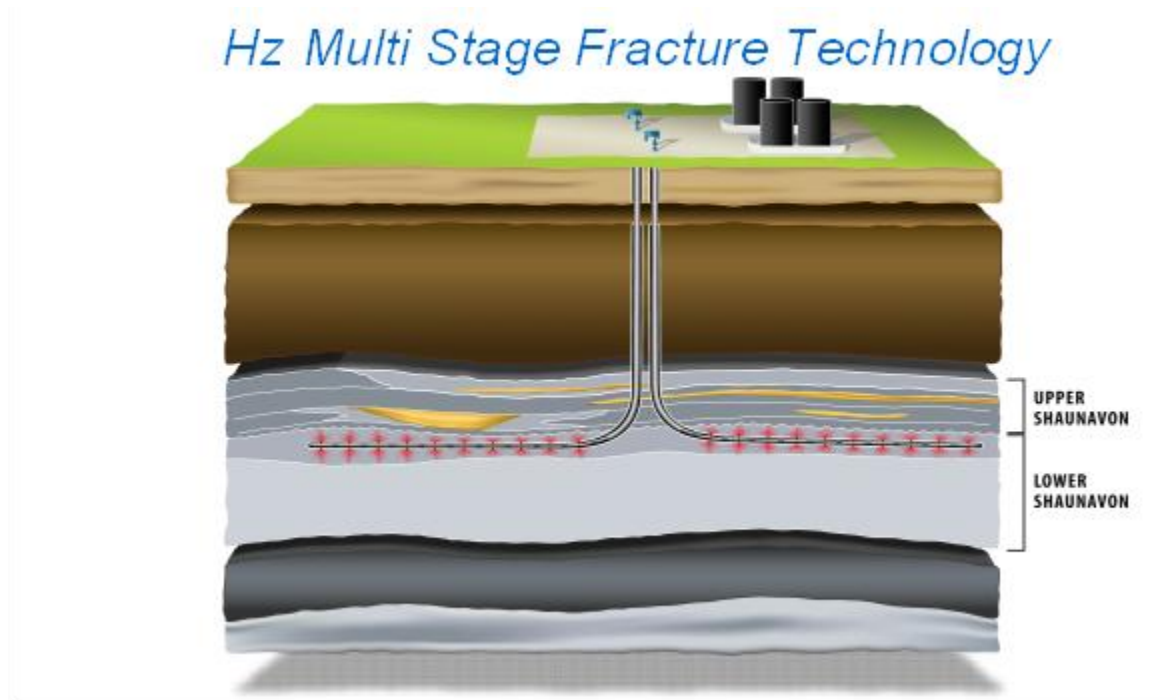
The behavior of a Waskada Unit 13 producers are indicated by examining the oil rate versus time plots (see Appendix B). Unit 13 exhibited relatively high initial oil productivity (most of the wells drilled in the past were verticals), rapidly declining to flat/low decline rates, with almost no discernible water flood response.

It is believed that fracture stimulation treatments, performed on these wells prior to initiation of water injection, “broke” through into the higher productivity Mississippian and that majority of injected water to date has entered this zone. This is one of the major explanations for lack of waterflood response to date and the continued decline in oil productivities.

The Waskada Lower Amaranth is becoming a non-conventional tight oil resources play that utilizes horizontal multistage drilling technology (small multistage stimulations on newly drilled wells will remain “in zone” within the Lower Amaranth) to re-develop the thick low perm oil zones adjacent to the conventional Amaranth zone that was discovered in the 1980’s. PennWest has drilled ten wells in 2010, 102/01-01-002-26W1, 102/04-01-002-26W1, 102/05-01-002-26W1, 103/05-01-002-26W1, 104/05-01-002-26W1, 05/05-01-002-26W1, 102/08-01-002-26W1, 102/09-01-002-26W1, 102/12-01-002-26W1 and 102/13-01-002-26W1. PennWest also is planning to drill three horizontal well in 2011. Our next plan is once we drilled more horizontal well in the unit, convert some of the recent horizontal producing wells to injection wells to increase the sweep efficiency, ultimately increase the recoverable oil in place.



The following is the HZ Multi Stage Fracture Technology development programs that we are using:



## **TABLES**

### **Waskada Unit #13**

**Table 1: Rate History**

Date	OIL		Water		Inj Water	
Year	m3/year	m3/day	m3/year	m3/day	m3/year	m3/day
1984	5,912	16.20	2,244	6.15	0	0.00
1985	7,234	19.82	3,043	8.34	0	0.00
1986	4,259	11.67	1,699	4.66	1,530	4.19
1987	2,417	6.62	1,118	3.06	27,340	74.90
1988	2,887	7.91	1,045	2.86	12,821	35.12
1989	2,393	6.56	516	1.41	5,873	16.09
1990	2,733	7.49	330	0.90	3,919	10.74
1991	2,966	8.12	373	1.02	2,521	6.91
1992	2,638	7.23	365	1.00	3,493	9.57
1993	2,518	6.90	306	0.84	6,013	16.47
1994	2,516	6.89	724	1.98	4,084	11.19
1995	2,613	7.16	1,488	4.08	3,903	10.69
1996	1,903	5.21	430	1.18	3,873	10.61
1997	1,282	3.51	214	0.59	2,950	8.08
1998	729	2.00	44	0.12	1,354	3.71
1999	509	1.39	51	0.14	816	2.24
2000	982	2.69	107	0.29	1,696	4.65
2001	680	1.86	87	0.24	463	1.27
2002	805	2.20	57	0.16	0	0.00
2003	994	2.72	37	0.10	0	0.00
2004	1,160	3.18	49	0.13	0	0.00
2005	773	2.12	39	0.11	0	0.00
2006	1,067	2.92	312	0.86	0	0.00
2007	746	2.04	303	0.83	0	0.00
2008	677	1.86	107	0.29	0	0.00
2009	379	1.04	77	0.21	0	0.00
2010	463	1.27	86	0.24	0	0.00

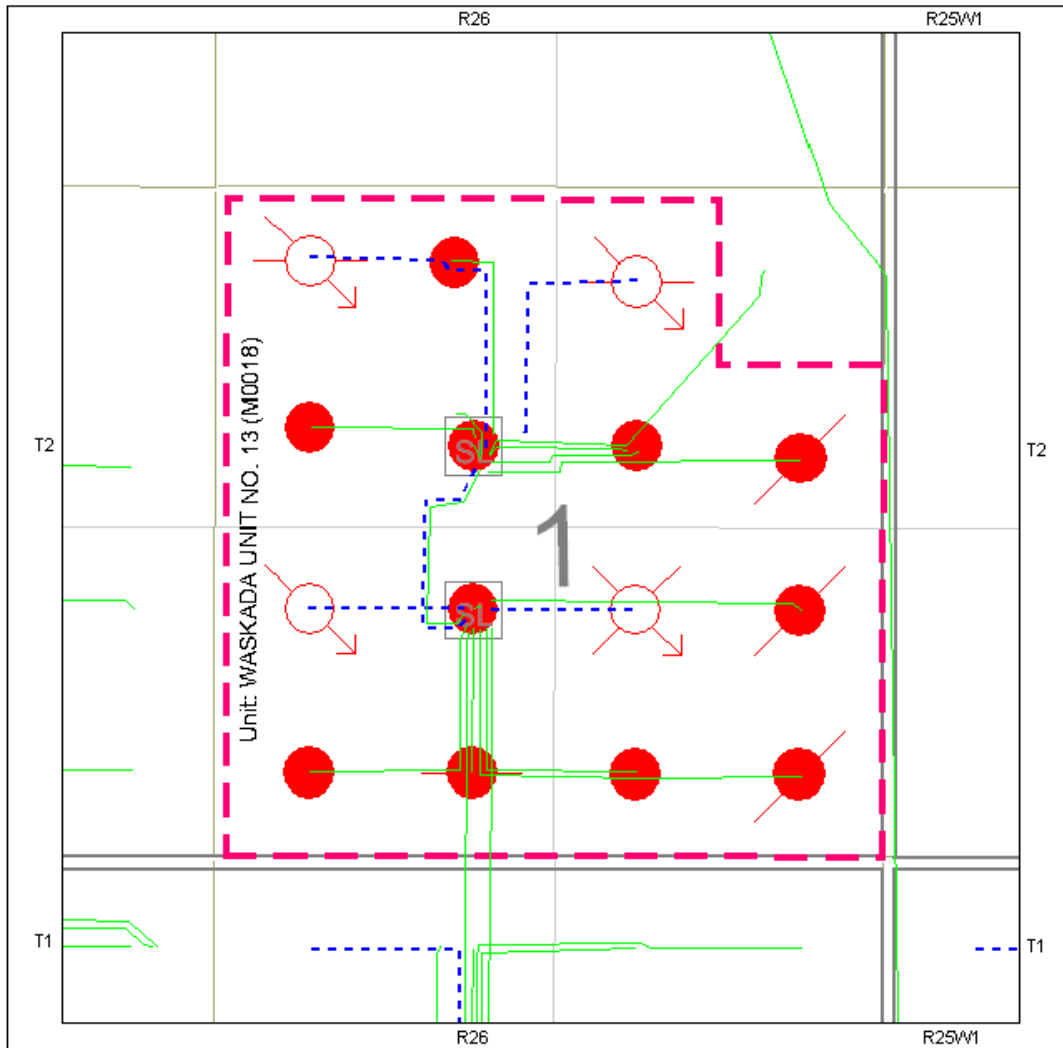
### Waskada Unit #13

**Table 2: Pressure Survey**


<b>Location</b>	<b>Shut In Date</b>	<b>Date of Survey</b>	<b>Type of Survey</b>	<b>Pressure @ Datum Depth (kPa)</b>
00/03-01-002-26W1/0		10-Jan-10	BHP, Assuming WC from Last Prod'n	9338
00/06-01-002-26W1/0	(16 days)	11-Dec-06	Acoustic Build Up	7229
00/14-01-002-26W1/0		10-Jan-10	BHP, Assuming WC from Last Prod'n	7887

## **APPENDIX A**

## Appendix A – Area Map

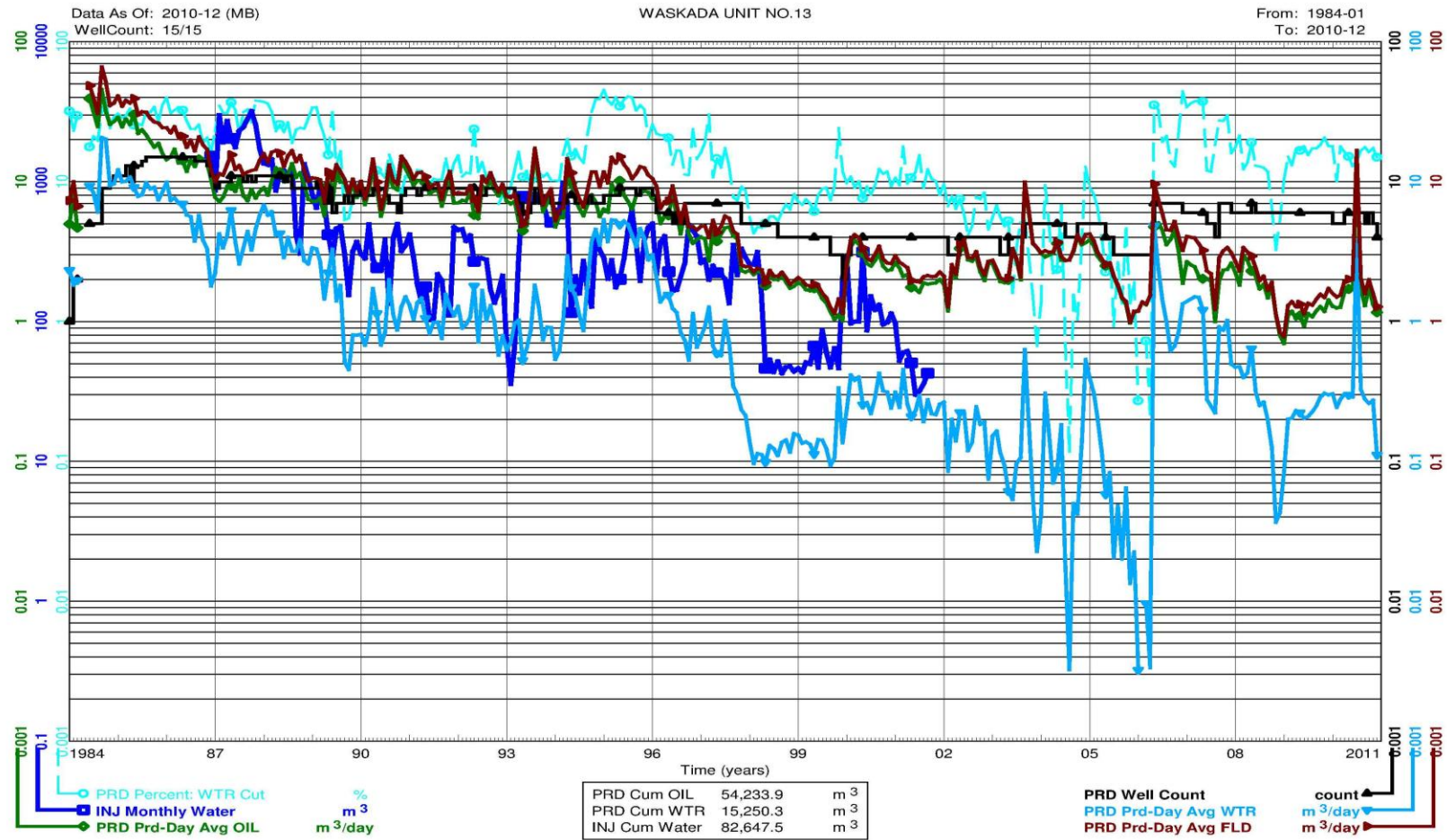


WELL SYMBOLS									
• OIL	✂ AO	◊ PTN	◊ D&A	◊ WI					
○ LCT	✂ A/WI	◊ STN	◊ CMM	◊ DRL					
◊ RDR	◊ WD	✂ A/WI	✂ A/WI	✂ SWI					
✂ SO	✂ WSC	◊ J&A	◊ SL						

<b>PennWest</b> Exploration	
Waskada Unit #13	
	By : Scale = 1:13056
Date : 2011/04/14 Project : Waskada	

## **APPENDIX B**

## Appendix B – Production and Injection History plot



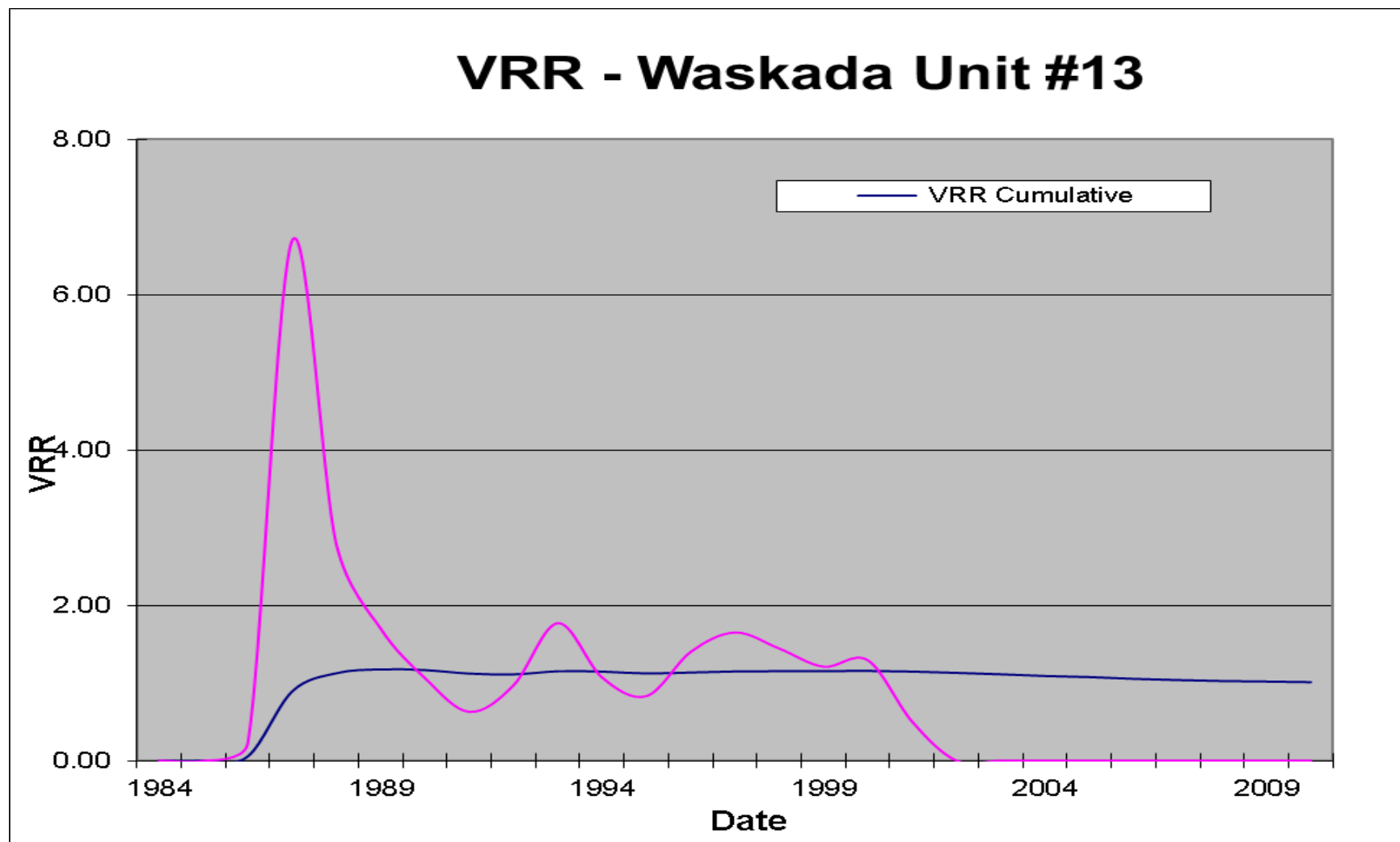
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geoSCOUT  
www.geologic.com

## **APPENDIX C**

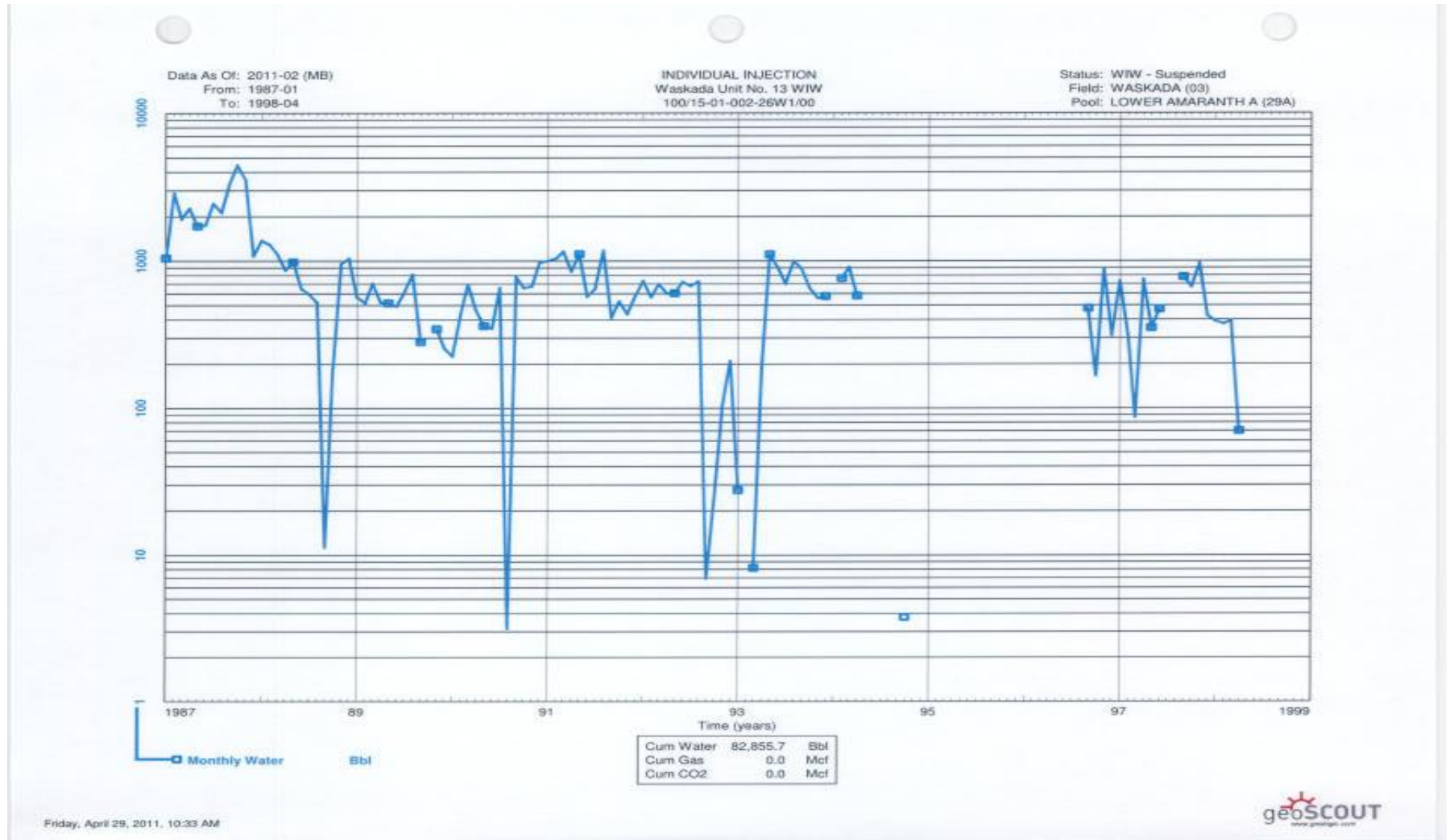


## Appendix C – Voidage Replacement Ratio VRR



## **APPENDIX D**

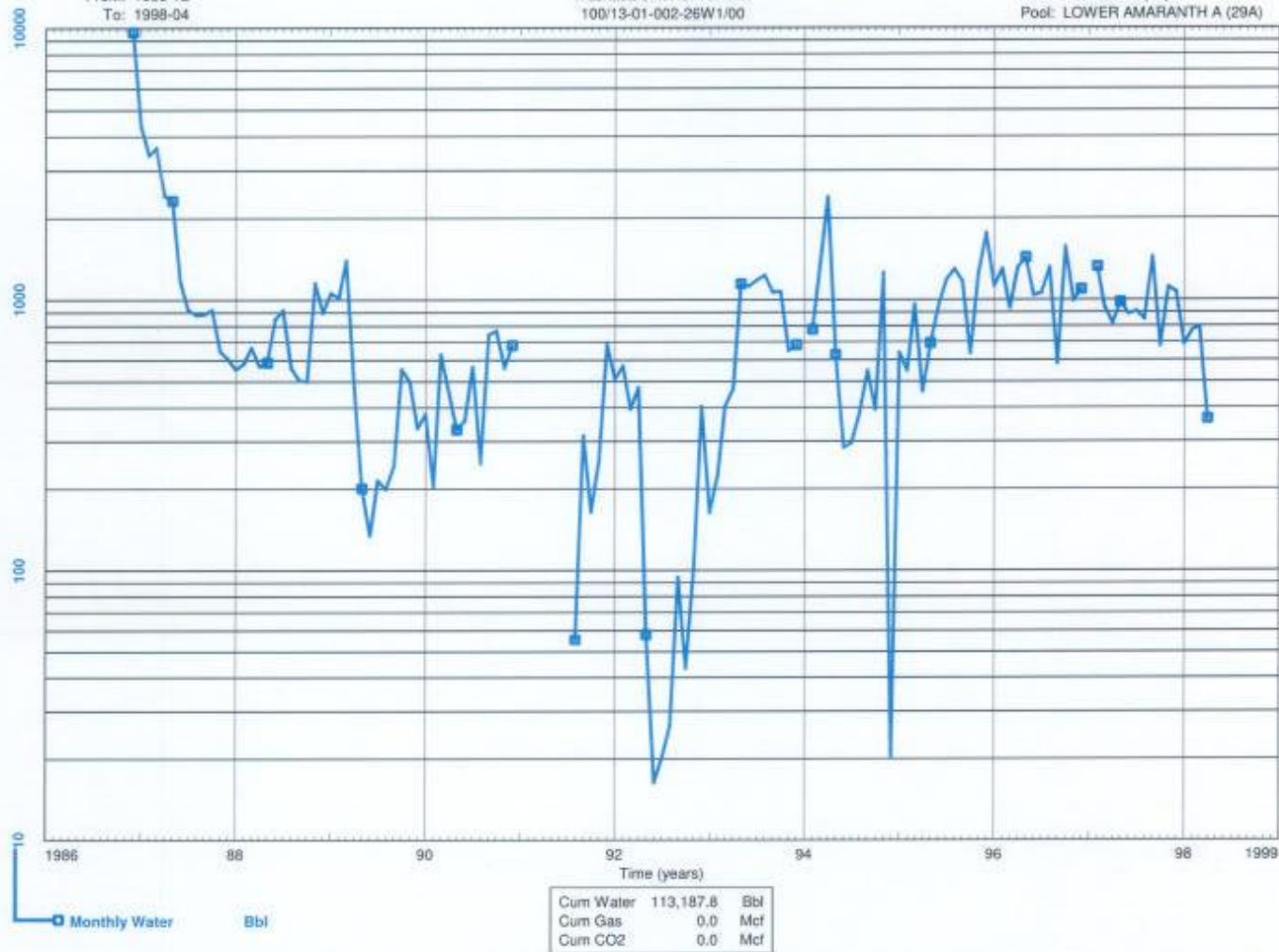
## Appendix D – Production and Injection Profiles

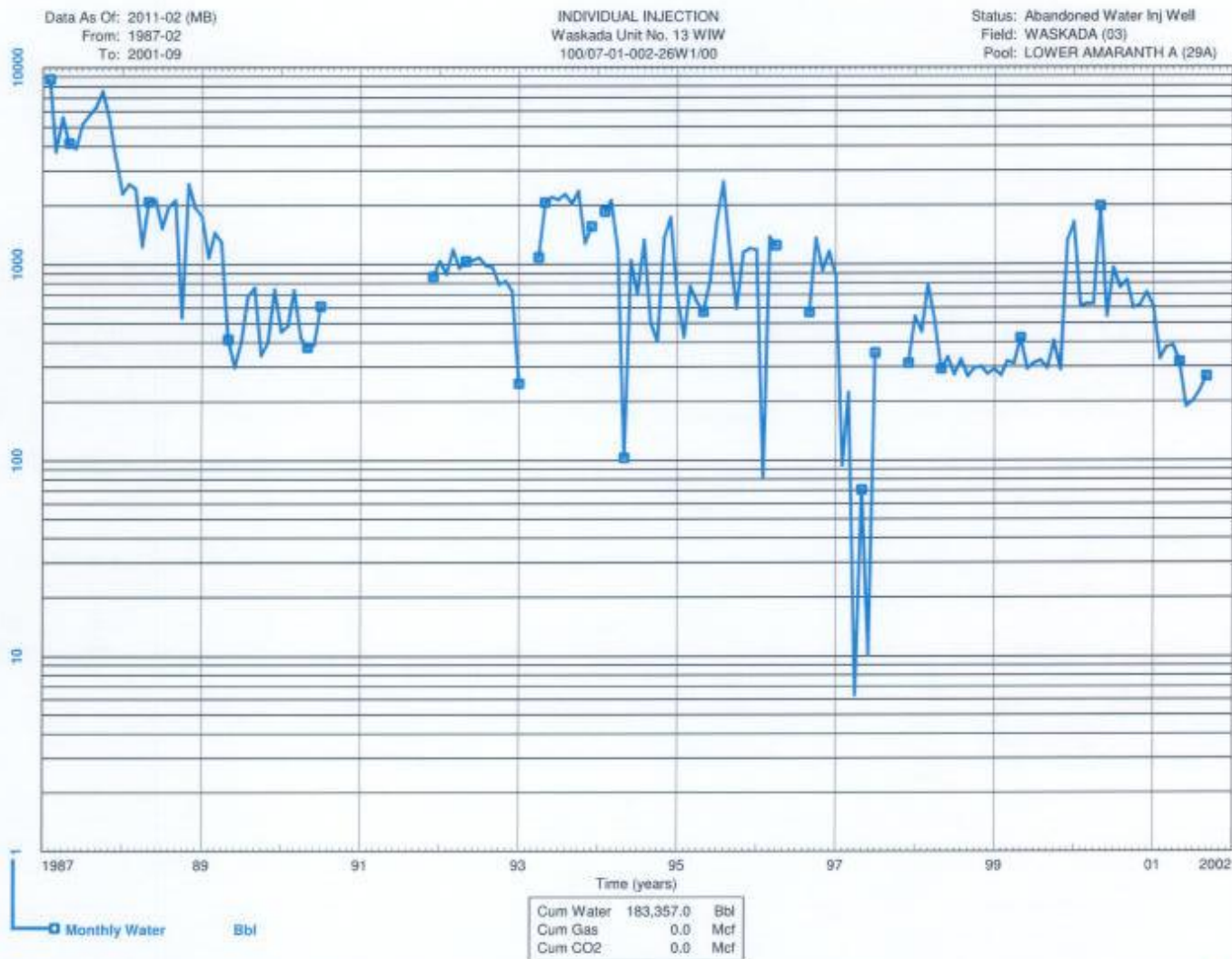


Data As Of: 2011-02 (MB)  
From: 1986-12  
To: 1998-04

INDIVIDUAL INJECTION  
Waskada Unit No. 13 WIW  
100/13-01-002-26W1/00

Status: WIW - Suspended  
Field: WASKADA (03)  
Pool: LOWER AMARANTH A (29A)

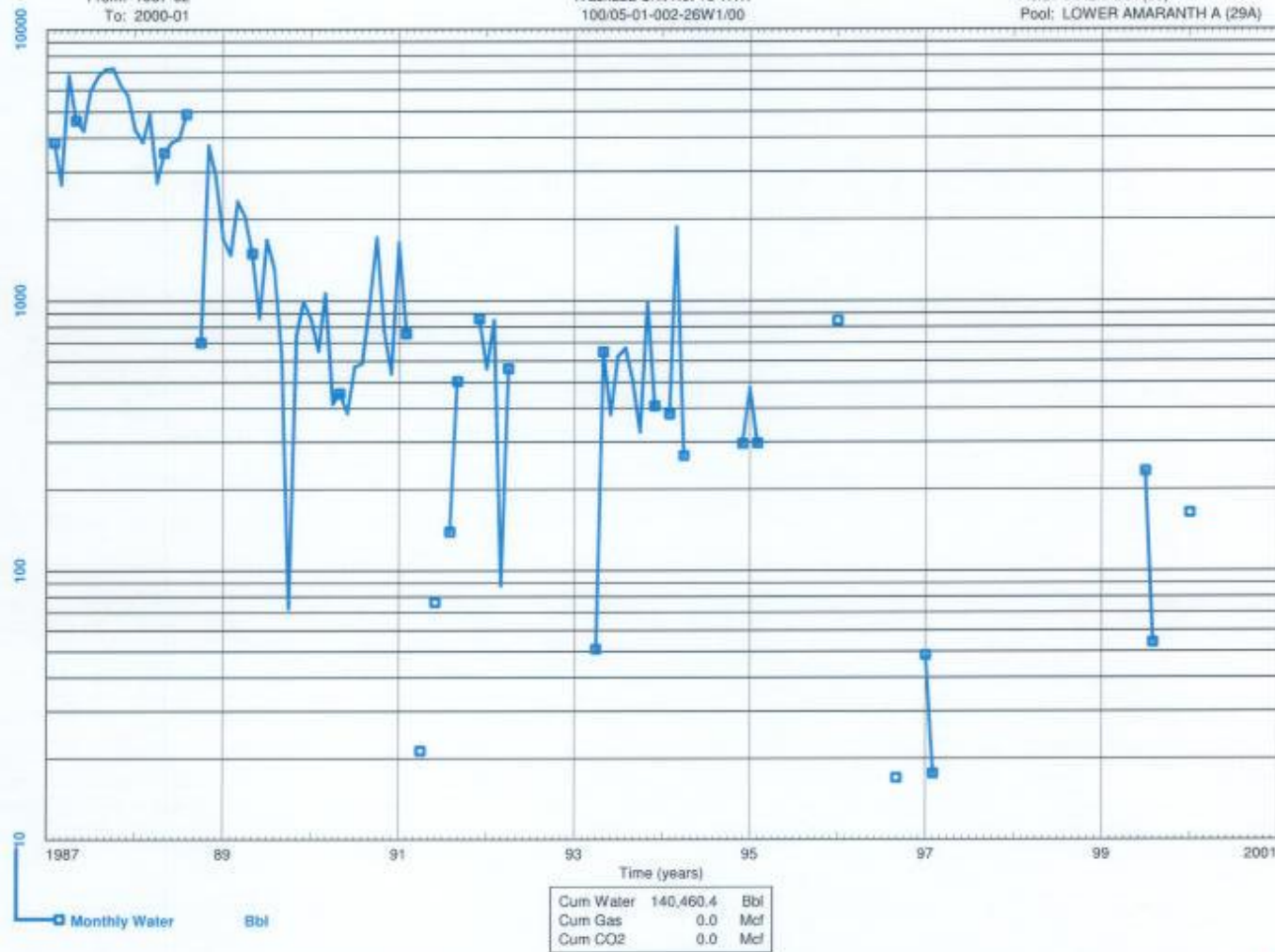




Data As Of: 2011-02 (MB)  
From: 1987-02  
To: 2000-01

INDIVIDUAL INJECTION  
Waskada Unit No. 13 WIW  
100/05-01-002-26W1/00

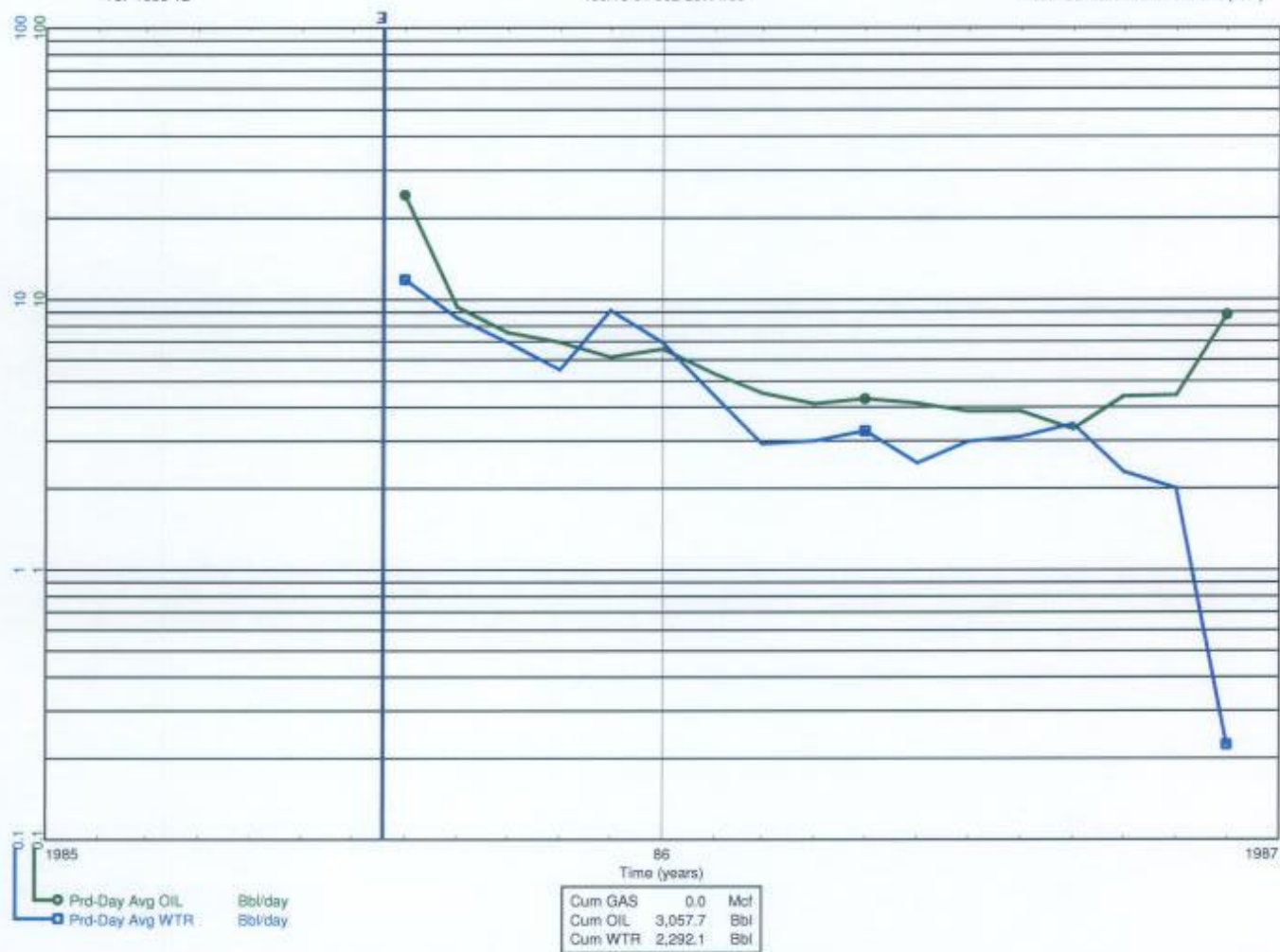
Status: Water Inj Well  
Field: WASKADA (03)  
Pool: LOWER AMARANTH A (29A)



Data As Of: 2010-11 (MB)  
 From: 1985-08  
 To: 1986-12

INDIVIDUAL PRODUCTION  
 Waskada Unit No. 13 WIW  
 100/15-01-002-26W1/00

Status: WIW - Suspended  
 Field: WASKADA (03)  
 Pool: LOWER AMARANTH A (29A)



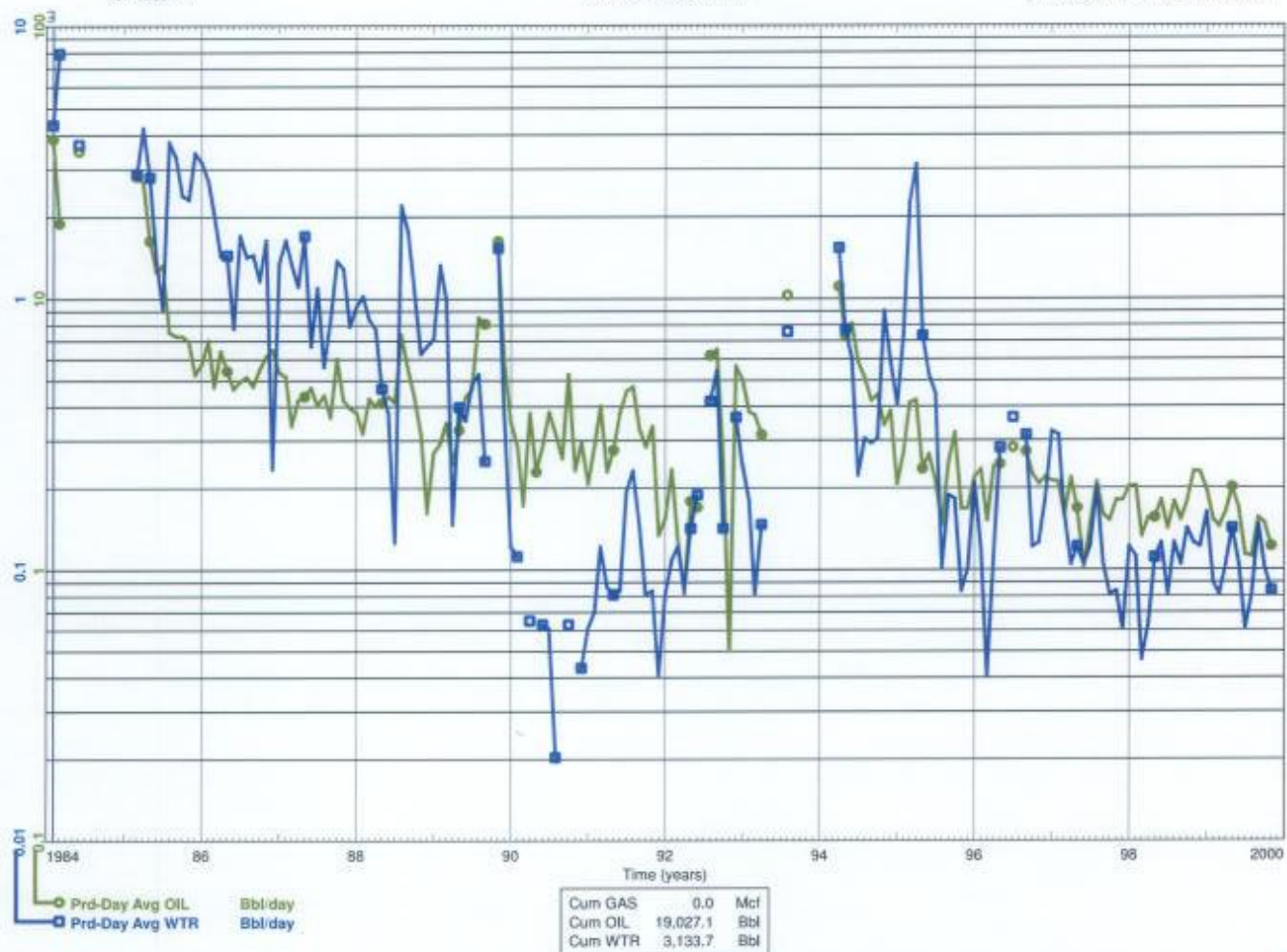
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Data As Of: 2011-02 (MB)  
From: 1984-02  
To: 1999-11

INDIVIDUAL PRODUCTION  
Waskada Unit No. 13  
100/14-01-002-26W1/00

Status: Capable Of Oil Prod  
Field: WASKADA (03)  
Pool: LOWER AMARANTH A (29A)



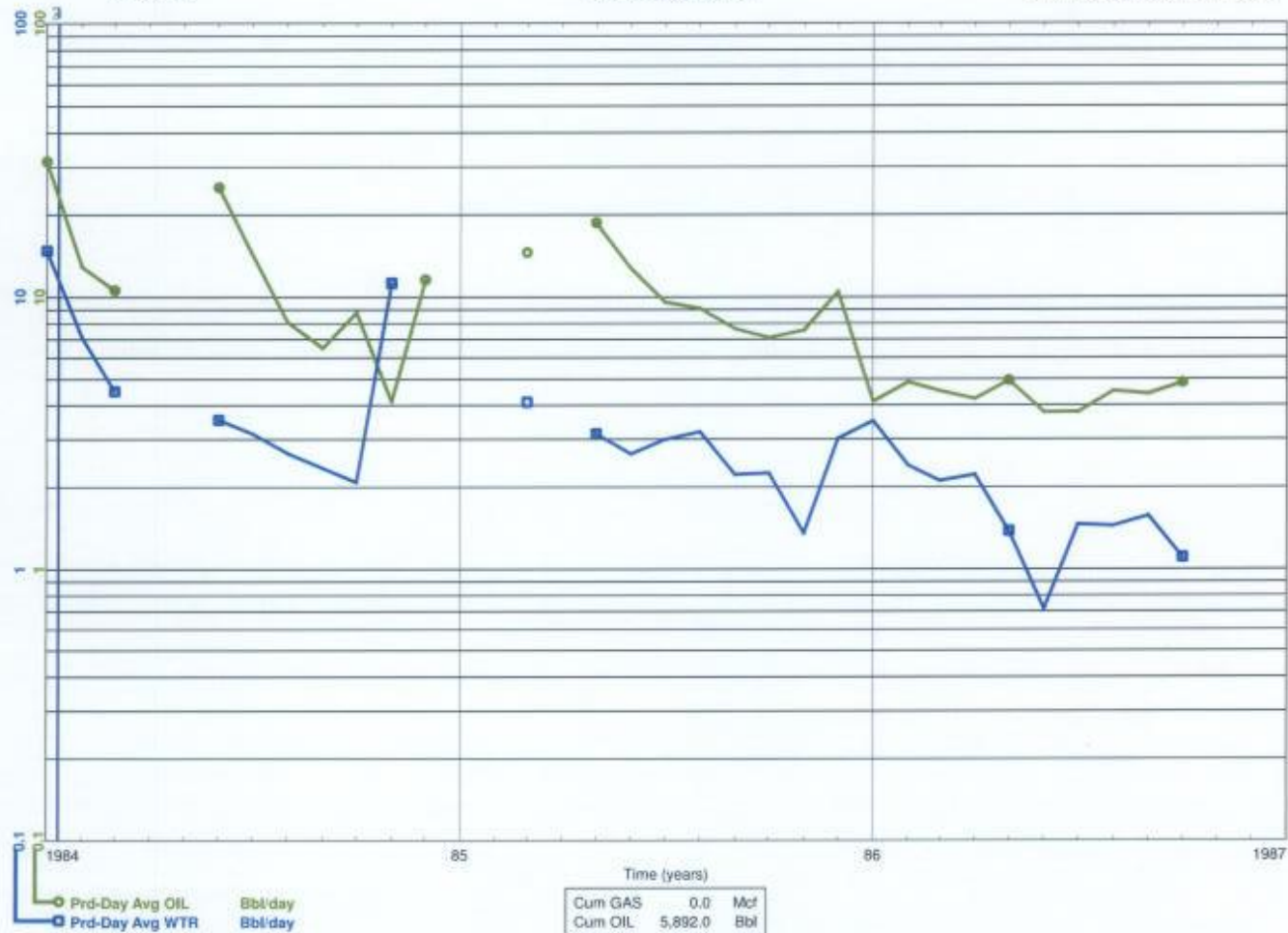
Friday, April 29, 2011, 10:31 AM



Data As Of: 2011-02 (MB)  
 From: 1984-01  
 To: 1986-10

INDIVIDUAL PRODUCTION  
 Waskada Unit No. 13 WIW  
 100/13-01-002-26W1/00

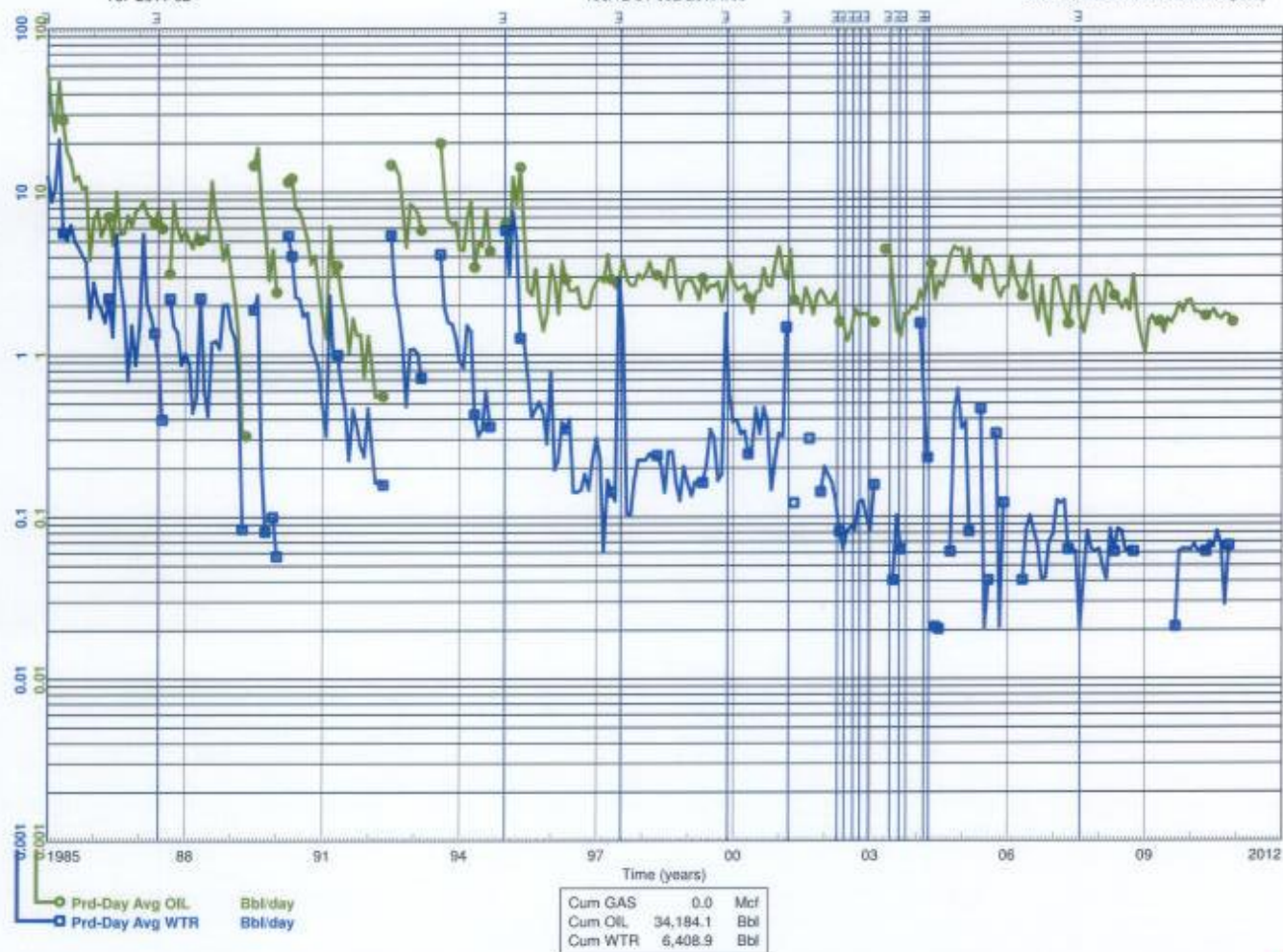
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 Field: WASKADA (03)  
 Pool: LOWER AMARANTH A (29A)



Data As Of: 2011-02 (MB)  
 From: 1985-01  
 To: 2011-02

INDIVIDUAL PRODUCTION  
 Waskada Unit No. 13  
 100/12-01-002-26W1/00

Status: Capable Of Oil Prod  
 Field: WASKADA (03)  
 Pool: LOWER AMARANTH A (29A)

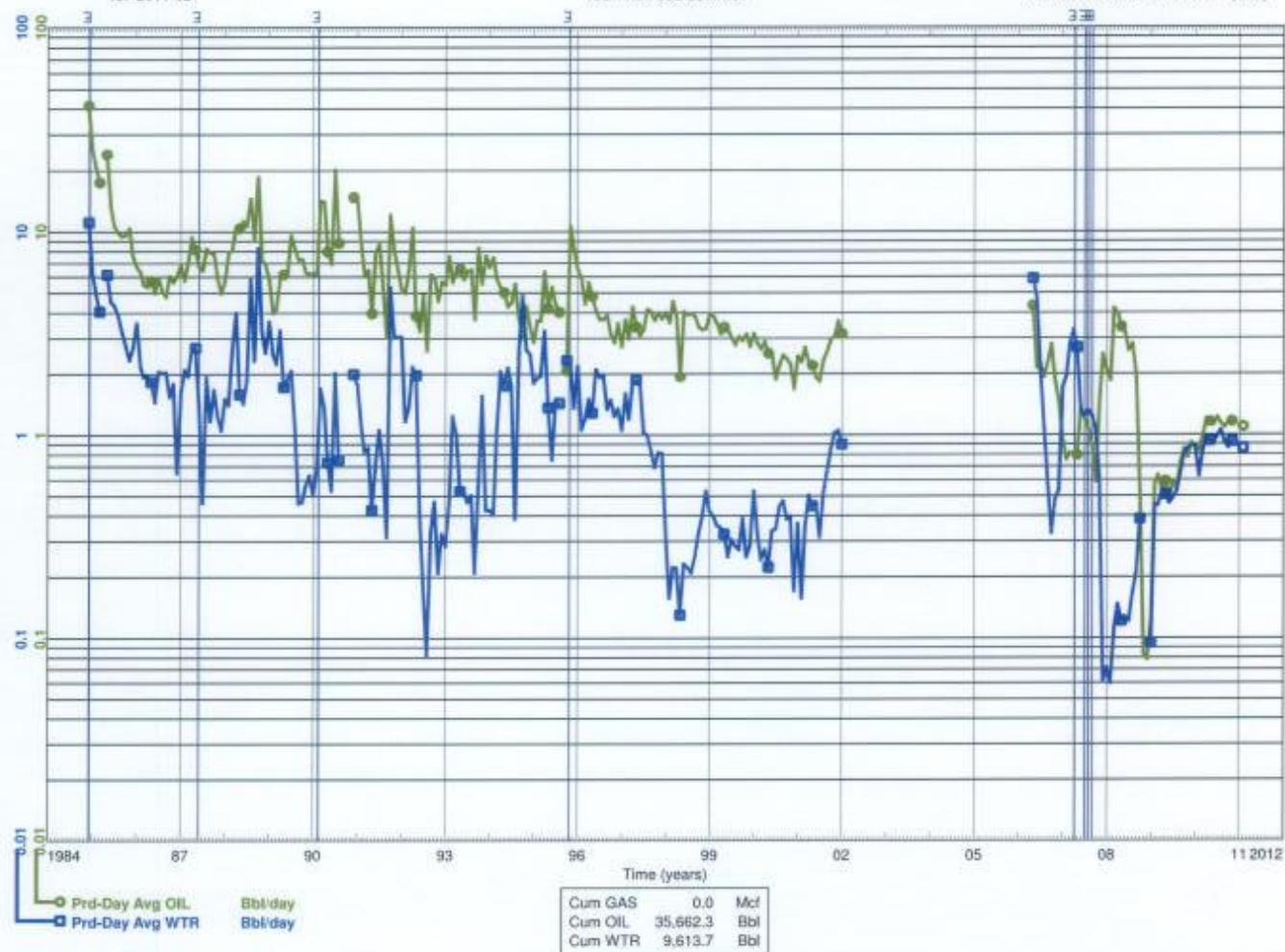


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Data As Of: 2011-02 (MB)  
From: 1984-12  
To: 2011-02

INDIVIDUAL PRODUCTION  
Waskada Unit No. 13  
100/11-01-002-26W1/00

Status: Capable Of Oil Prod  
Field: WASKADA (03)  
Pool: LOWER AMARANTH A (29A)

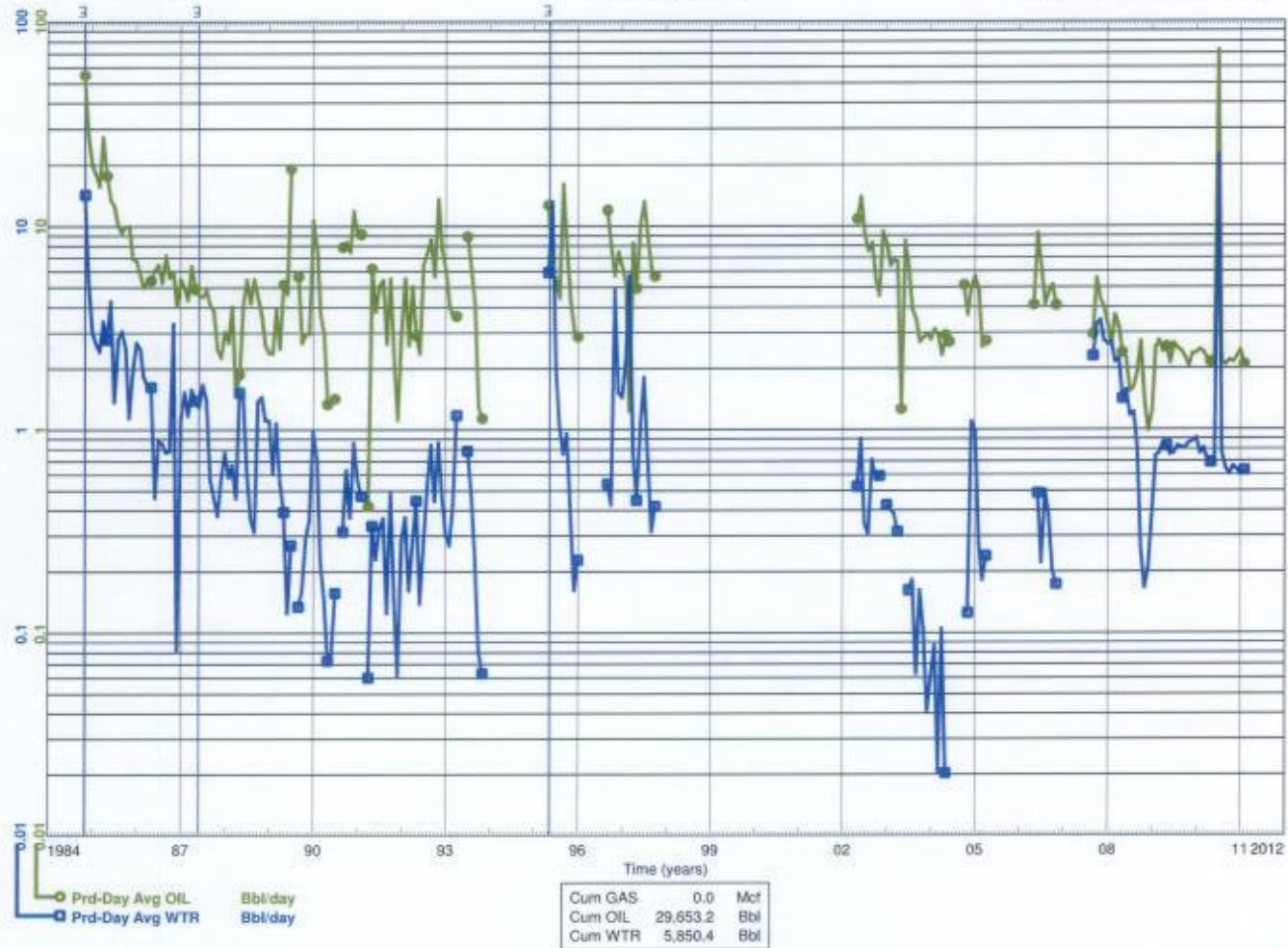


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Data As Of: 2011-02 (MB)  
 From: 1984-11  
 To: 2011-02

INDIVIDUAL PRODUCTION  
 Waskada Unit No. 13  
 100/10-01-002-26W1/00

Status: Capable Of Oil Prod  
 Field: WASKADA (03)  
 Pool: LOWER AMARANTH A (29A)

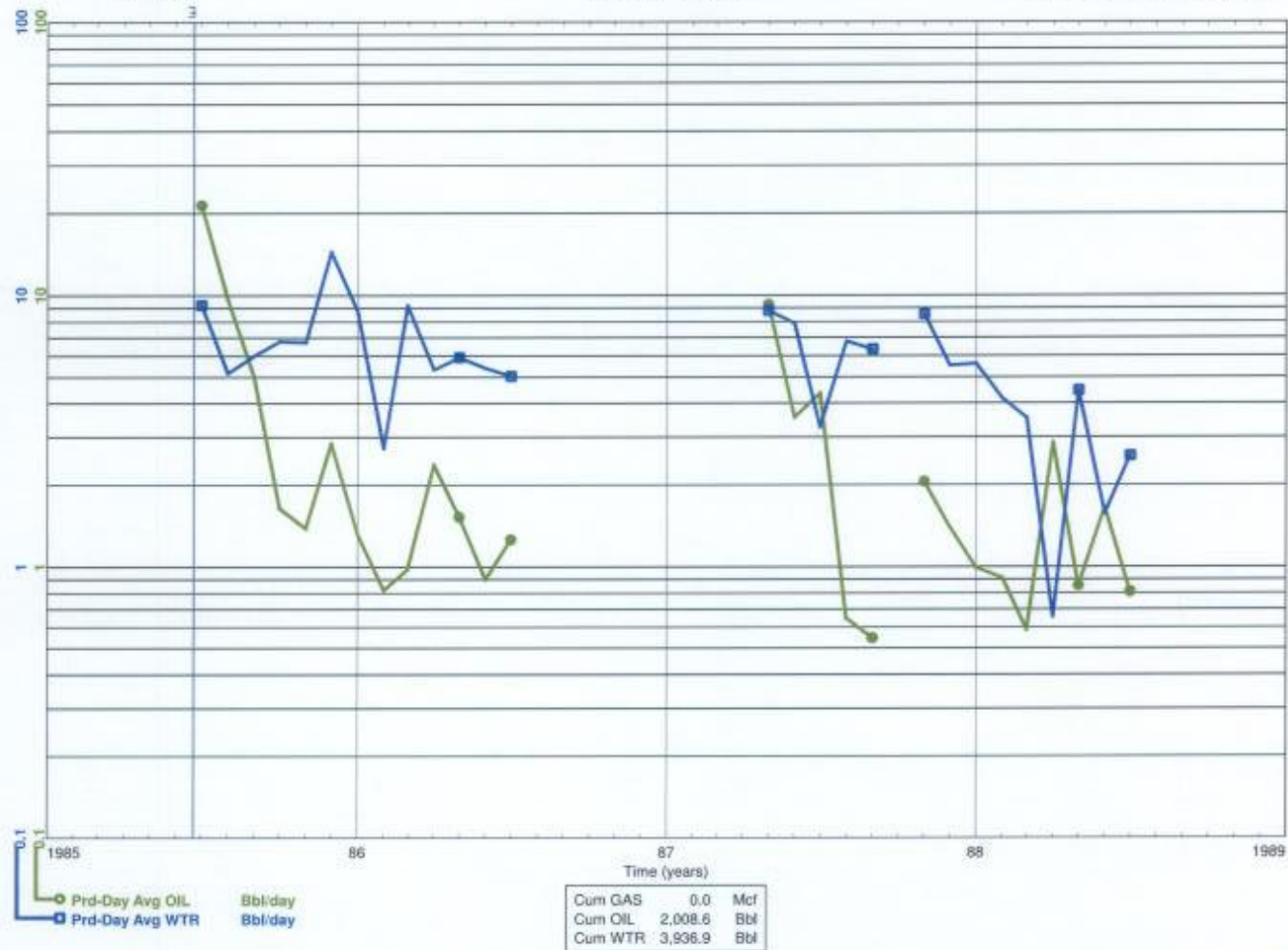




Data As Of: 2011-02 (MB)  
 From: 1985-07  
 To: 1988-07

INDIVIDUAL PRODUCTION  
 Omega et al Waskada  
 100/09-01-002-26W1/00

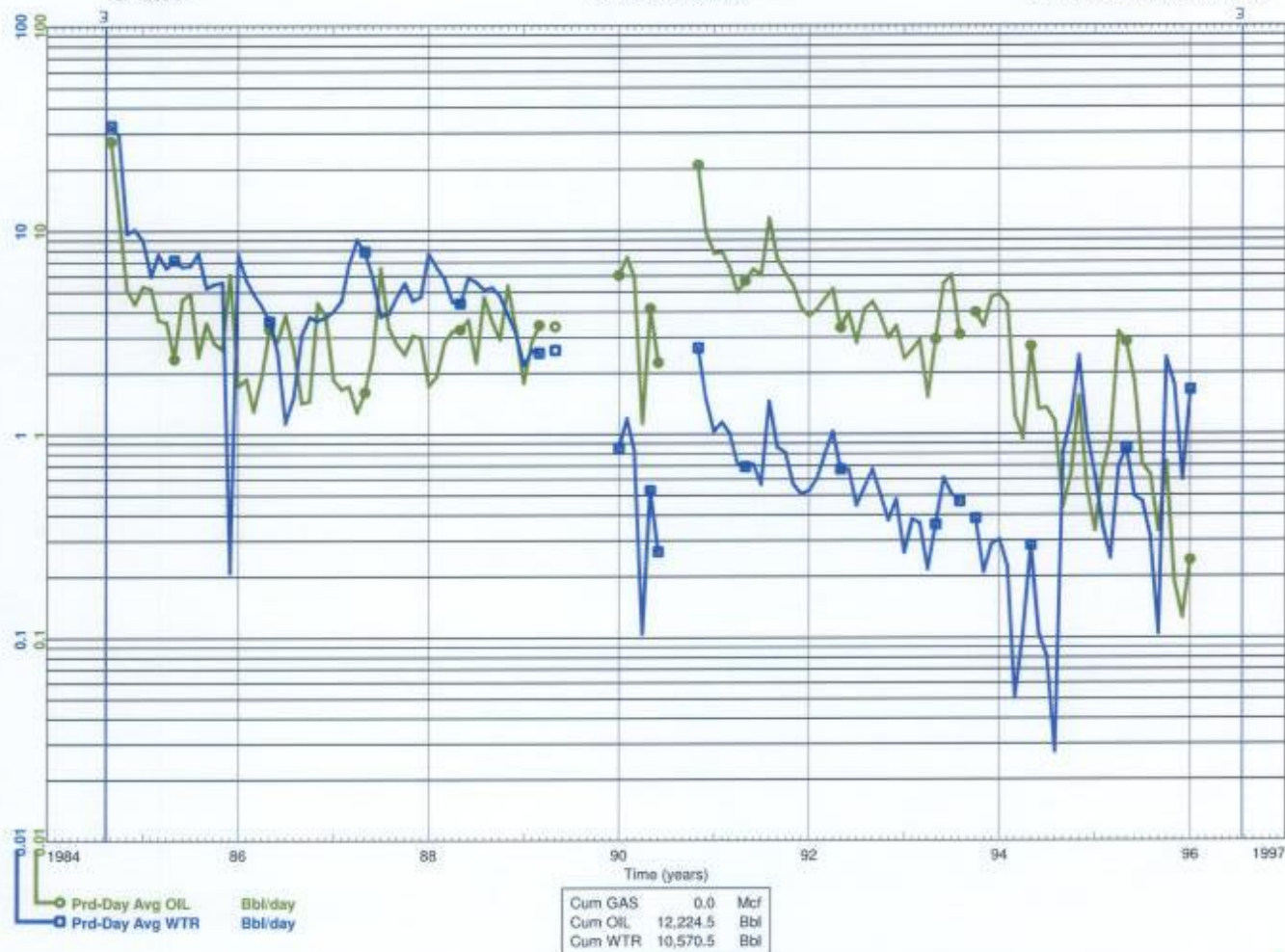
Status: Abandoned Producer  
 Field: WASKADA (03)  
 Pool: LOWER AMARANTH A (29A)



Data As Of: 2011-02 (MB)  
From: 1984-09  
To: 1996-01

INDIVIDUAL PRODUCTION  
Waskada Unit No. 13  
100/08-01-002-26W1/00

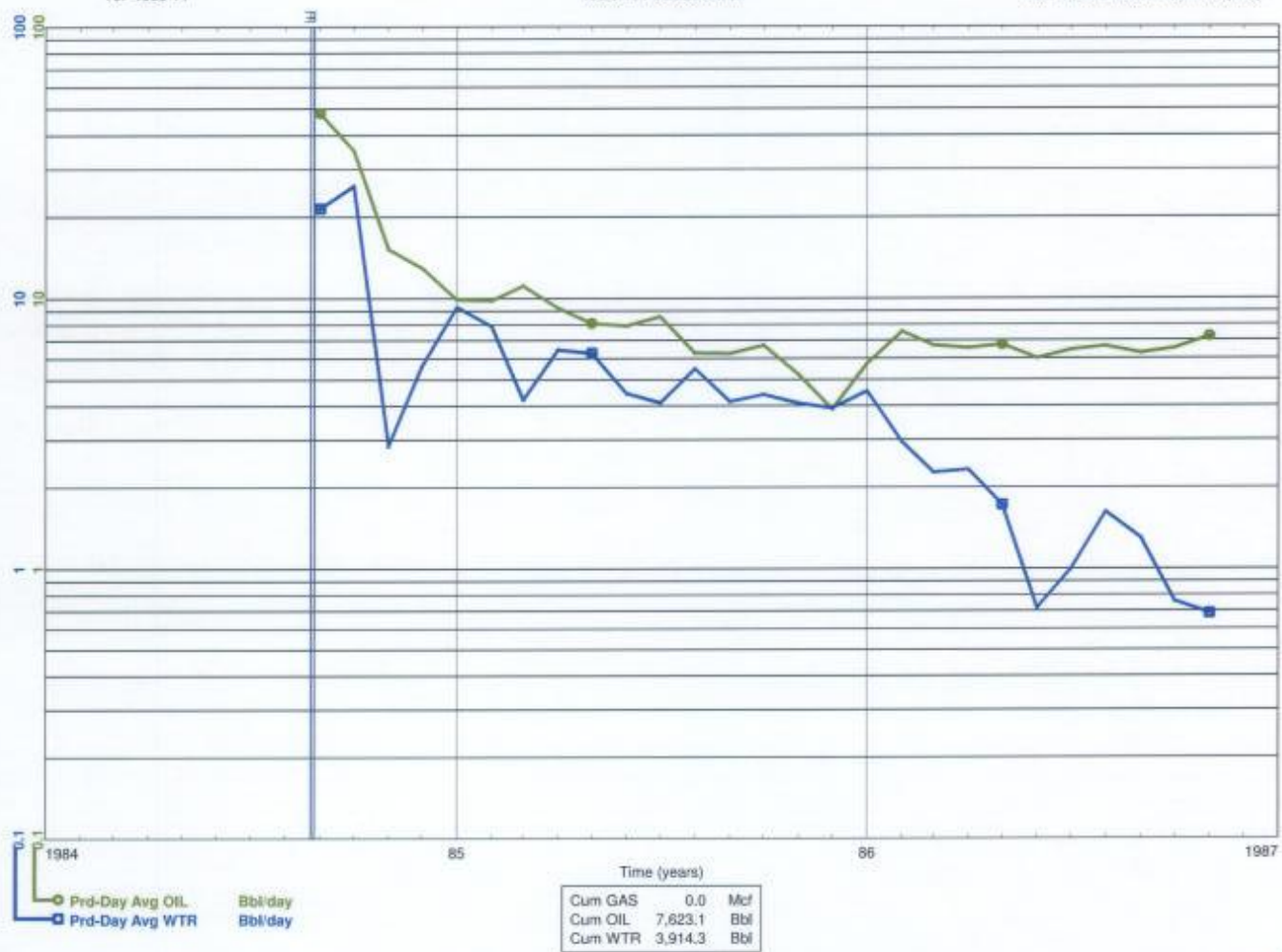
Status: Abandoned Producer  
Field: WASKADA (03)  
Pool: LOWER AMARANTH A (29A)



Data As Of: 2011-02 (MB)  
 From: 1984-09  
 To: 1986-11

INDIVIDUAL PRODUCTION  
 Waskada Unit No. 13 WIW  
 100/07-01-002-26W1/00

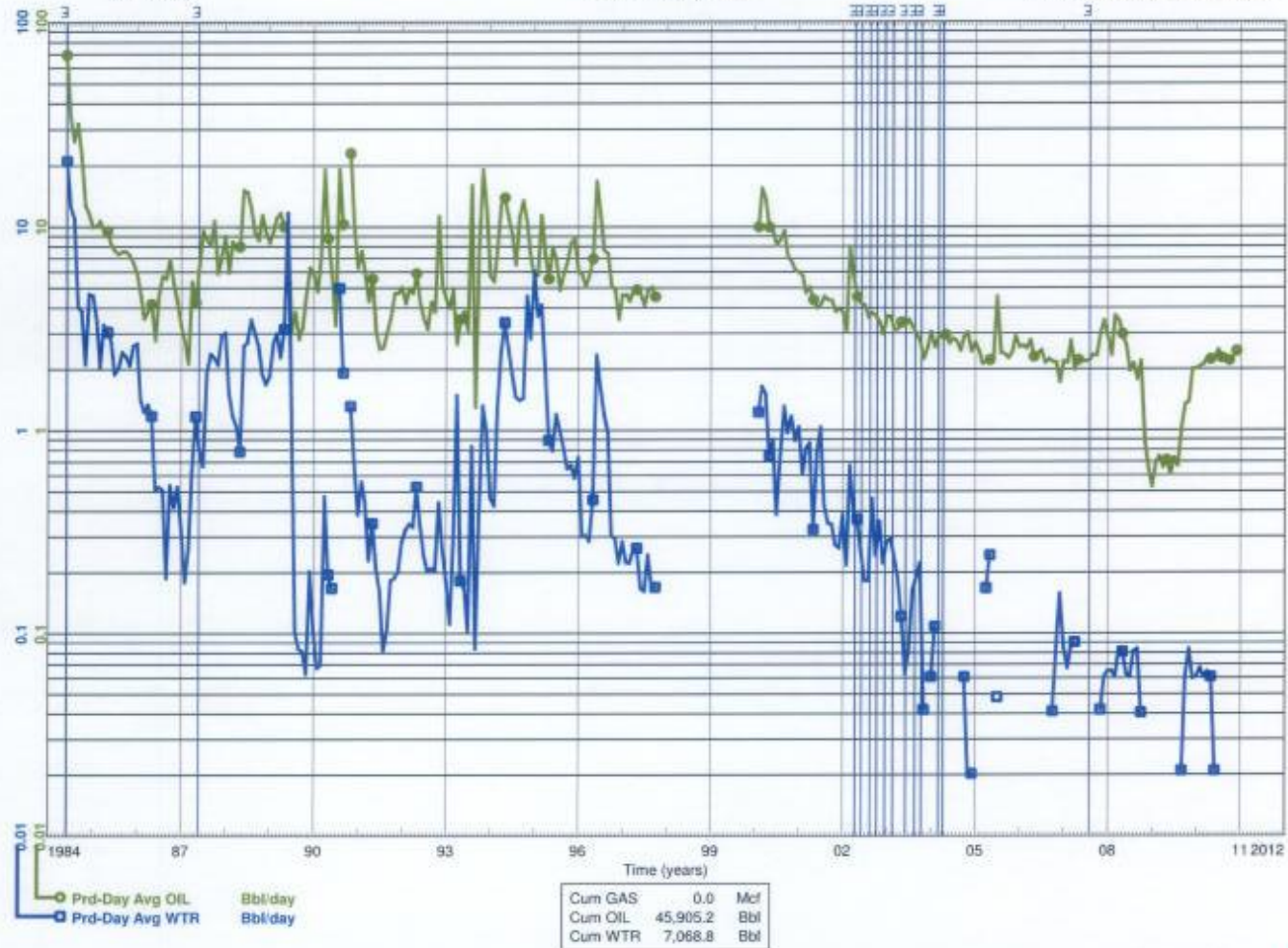
Status: Abandoned Water Inj Well  
 Field: WASKADA (03)  
 Pool: LOWER AMARANTH A (29A)



Data As Of: 2011-02 (MB)  
 From: 1984-06  
 To: 2011-02

INDIVIDUAL PRODUCTION  
 Waskada Unit No. 13  
 100/06-01-002-26W1/00

Status: Capable Of Oil Prod  
 Field: WASKADA (03)  
 Pool: LOWER AMARANTH A (29A)

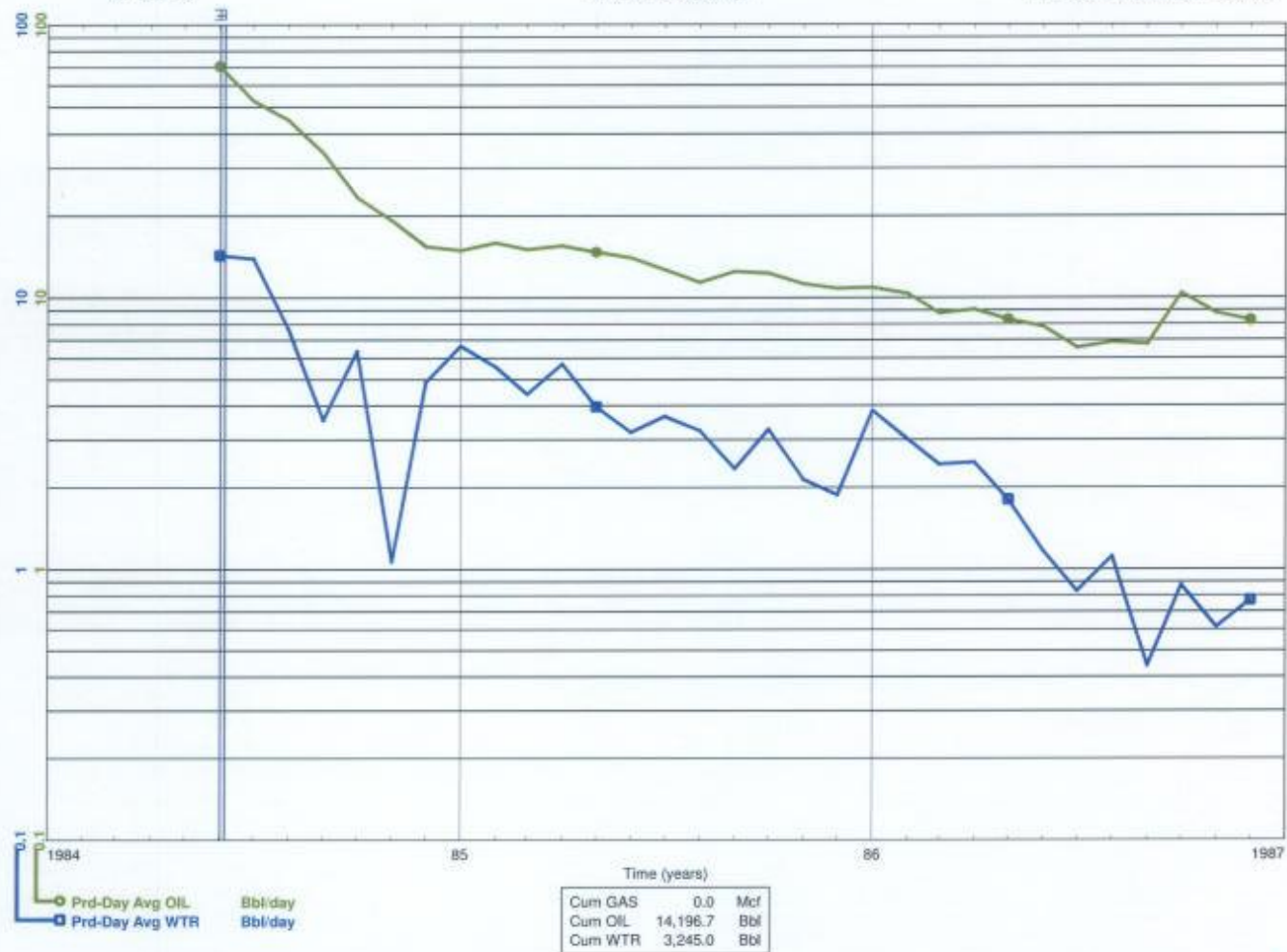




Data As Of: 2011-02 (MB)  
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 To: 1986-12

INDIVIDUAL PRODUCTION  
 Waskada Unit No. 13 WIW  
 100/05-01-002-26W1/00

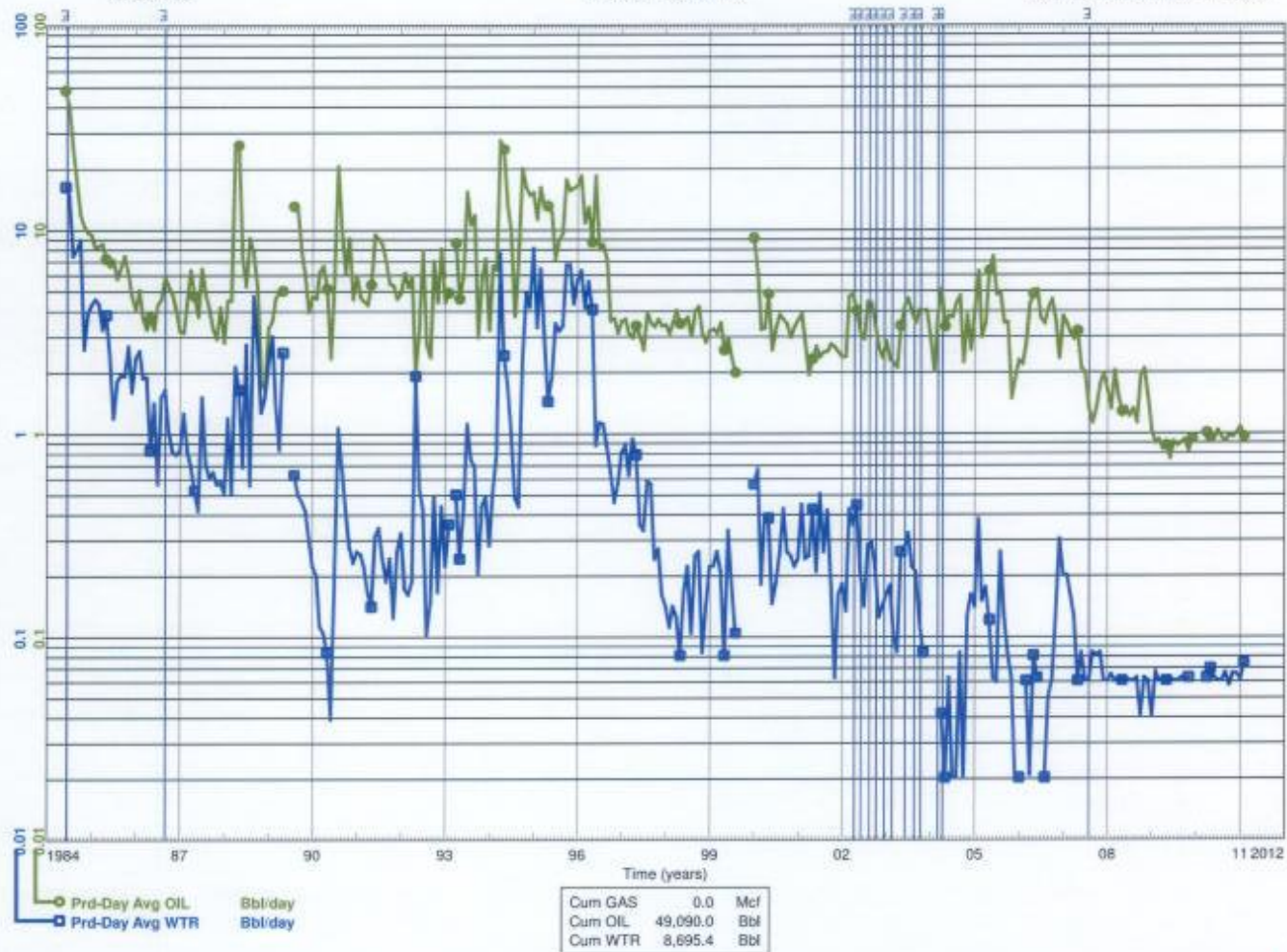
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 Field: WASKADA (03)  
 Pool: LOWER AMARANTH A (29A)



Data As Of: 2011-02 (MB)  
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 To: 2011-02

INDIVIDUAL PRODUCTION  
 Waskada Unit No. 13  
 100/04-01-002-26W1/00

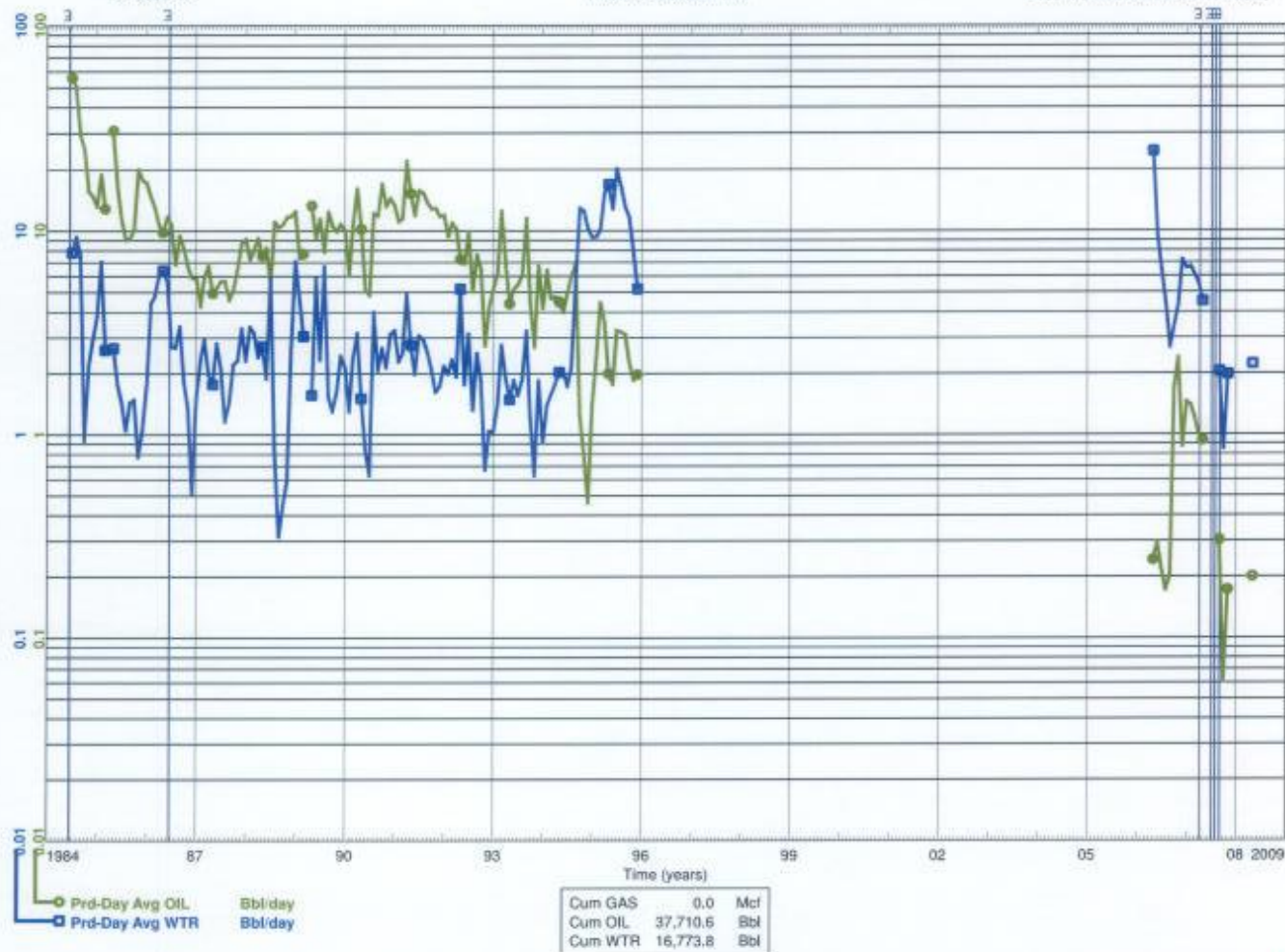
Status: Capable Of Oil Prod  
 Field: WASKADA (03)  
 Pool: LOWER AMARANTH A (29A)



Data As Of: 2011-02 (MB)  
 From: 1984-07  
 To: 2008-05

INDIVIDUAL PRODUCTION  
 Waskada Unit No. 13  
 100/03-01-002-26W1/00

Status: COOP - Suspended  
 Field: WASKADA (03)  
 Pool: LOWER AMARANTH A (29A)

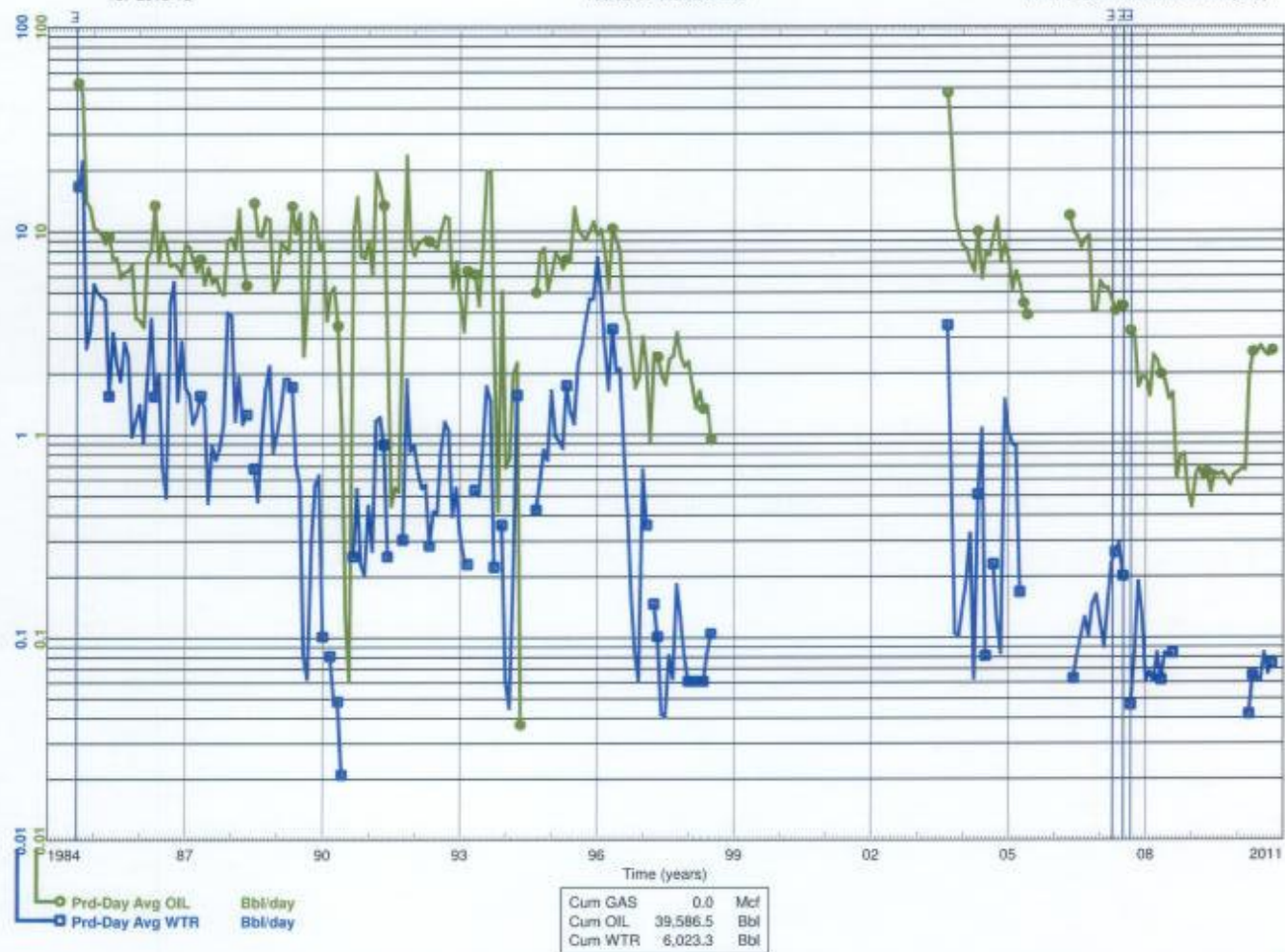


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Data As Of: 2011-02 (MB)  
From: 1984-09  
To: 2010-10

INDIVIDUAL PRODUCTION  
Waskada Unit No. 13  
100/02-01-002-26W1/00

Status: Capable Of Oil Prod  
Field: WASKADA (03)  
Pool: LOWER AMARANTH A (29A)



Friday, April 29, 2011, 10:28 AM



Data As Of: 2011-02 (MB)  
 From: 1984-09  
 To: 1989-02

INDIVIDUAL PRODUCTION  
 Omega Andex Waskada  
 100/01-01-002-26W1/00

Status: Abandoned Producer  
 Field: WASKADA (03)  
 Pool: LOWER AMARANTH A (29A)

