

# **WASKADA UNIT NO. 14**

## **WATERFLOOD PROGRESS REPORT**

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

### **PennWest Exploration**

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## TABLE OF CONTENTS

	<u>Page</u>
<b>INTRODUCTION</b>	<b>3</b>
<b>UNIT HISTORY</b>	<b>4</b>
<b>DISCUSSION</b>	<b>5</b>
• Production Performance	
• Voidage Replacement Ratio Calculation	
• Corrosion and Scale Prevention Program	
<b>SUMMARY &amp; RECOMMENDATIONS</b>	<b>6</b>
<b>TABLES</b>	<b>8</b>
• Table 1 - Rates History	
• Table 2 – Pressure Survey	
<b>APPENDICES</b>	
• Appendix A – Area Map	
• Appendix B – Production and Injection History plot	
• Appendix C – Voidage Replacement Ratio VRR	
• Appendix D – Production and Injection Profiles (Individual wells)	

## **INTRODUCTION**

The WASKADA UNIT NO.14 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 Feb. 1, 1988 Board Order - Voluntary

**POOL:** Waskada Lower Amaranth A (03 29A)

This report documents the performance of the Waskada Unit # 14 pressure maintenance project for the period of January 1 to December 31, 2010.

Unit # 14 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 a complex reservoir characterization with 13 - 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 erosion 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. 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 #14 (Unit History)**

Abbreviated Well ID	Date Well Spudded	On Prod YYYY/MM	Org Operator Name	Ground Elevation (m)	TVD (m)
00/01-32-001-25W1/0	10/18/1985	1985/11	Omega Hydcbns Ltd	471.4	958.0
00/02-32-001-25W1/0	9/7/1985	1985/11	Omega Hydcbns Ltd	470.6	952.0
02/03-32-001-25W1/0	11/1/1982	1982/11	Roxy PetrI Ltd	469.8	939.0
00/04-32-001-25W1/0	6/13/1984	1984/06	[%571]	469.0	952.0
00/05-32-001-25W1/0	6/5/1984	1984/06	[%571]	470.5	950.0
00/06-32-001-25W1/0	12/9/1984	1985/01	[%571]	470.4	955.0
00/07-32-001-25W1/0	8/15/1985	1985/09	Omega Hydcbns Ltd	470.6	937.0
00/08-32-001-25W1/2	6/18/1984	1985/02	NCE Petrofund Corp	471.2	950.0

## Waskada Unit #14 (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
00/01-32-001-25W1/0	1985/11	1992/11	1992/10	698	3,913	81.3	2000/02
00/02-32-001-25W1/0	1985/11		1989/05	527	2,700	53.9	
02/03-32-001-25W1/0	1982/11		1996/09	4,052	9,047	70.9	
00/04-32-001-25W1/0	1984/06		2001/03	5,527	15,708	69.4	
00/05-32-001-25W1/0	1984/06	1988/02	1988/02	5,295	14,178	72.9	1993/04
00/06-32-001-25W1/0	1985/01		2002/10	5,073	6,310	47.5	
00/07-32-001-25W1/0	1985/09	1988/02	1988/02	606	250	28.3	1993/04
00/08-32-001-25W1/2	1985/02		2004/01	6,625	5,557	31.4	

### **DISCUSSION:**

#### **Production Performance**

Production Response versus Injection: Since injection began, in 1988, injection rates fluctuated to the same degree amongst the injectors, it is difficult to link any production responses to any specific injector.

#### **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 0.7 (under injected) 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 plan 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**

None

##### **Current Suspended Wells**

1. 00/04-32-001-25W1/0 (since 2001/04)

##### **Abandoned Wells**

1. 00/02-32-001-25W1/0 (since 1989/06)
2. 02/03-32-001-25W1/0 (since 1996/10)

3. 00/06-32-001-25W1/0 (since 2002/11)
4. 00/08-32-001-25W1/2 (since 2004/02)

**[Injectors]**

**Current Injecting Wells**

None

**Current Suspended Wells**

00/01-32-001-25W1/0 (since 2000/03)

**Abandoned Wells**

1. 00/05-32-001-25W1/0 (since 1993/05)
2. 00/07-32-001-25W1/0 (since 1993/05)

The behavior of a Waskada Unit 14 producers are indicated by examining the oil rate versus time plots (see Appendix B). Unit 14 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. This behavior can be explained by drop in the reservoir pressure from initial (approximately 8700 kPag) to a above bubble point (about 4200 kPag) followed by solution gas breakout which adversely affected the relative permeability to oil. (see Table # 2)

Also, 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.

**TABLES**

**Waskada Unit #14**

**Table 1: Rate History**

Date	Oil		Water		Inj Water	
Year	m3/year	m3/day	m3/year	m3/day	m3/year	m3/day
1982	115	0.31	152	0.42	0	0.00
1983	626	1.72	1,657	4.54	0	0.00
1984	2,368	6.49	5,650	15.48	0	0.00
1985	5,679	15.56	8,079	22.13	0	0.00
1986	3,714	10.18	6,567	17.99	0	0.00
1987	3,407	9.34	6,877	18.84	0	0.00
1988	1,772	4.85	4,788	13.12	24,636	67.50
1989	1,848	5.06	3,453	9.46	7,335	20.10
1990	1,606	4.40	3,183	8.72	7,078	19.39
1991	1,372	3.76	2,875	7.88	4,108	11.25
1992	966	2.65	2,699	7.39	5,196	14.24
1993	1,015	2.78	2,351	6.44	8,285	22.70
1994	933	2.56	1,878	5.14	4,441	12.17
1995	1,057	2.90	2,461	6.74	4,881	13.37
1996	725	1.99	1,513	4.14	3,138	8.60
1997	413	1.13	861	2.36	1,419	3.89
1998	271	0.74	734	2.01	223	0.61
1999	212	0.58	798	2.19	53	0.14
2000	155	0.42	711	1.95	54	0.15
2001	50	0.14	126	0.35	0	0.00
2002	73	0.20	221	0.61	0	0.00
2003	23	0.06	27	0.08	0	0.00
2004	1	0.00	1	0.00	0	0.00

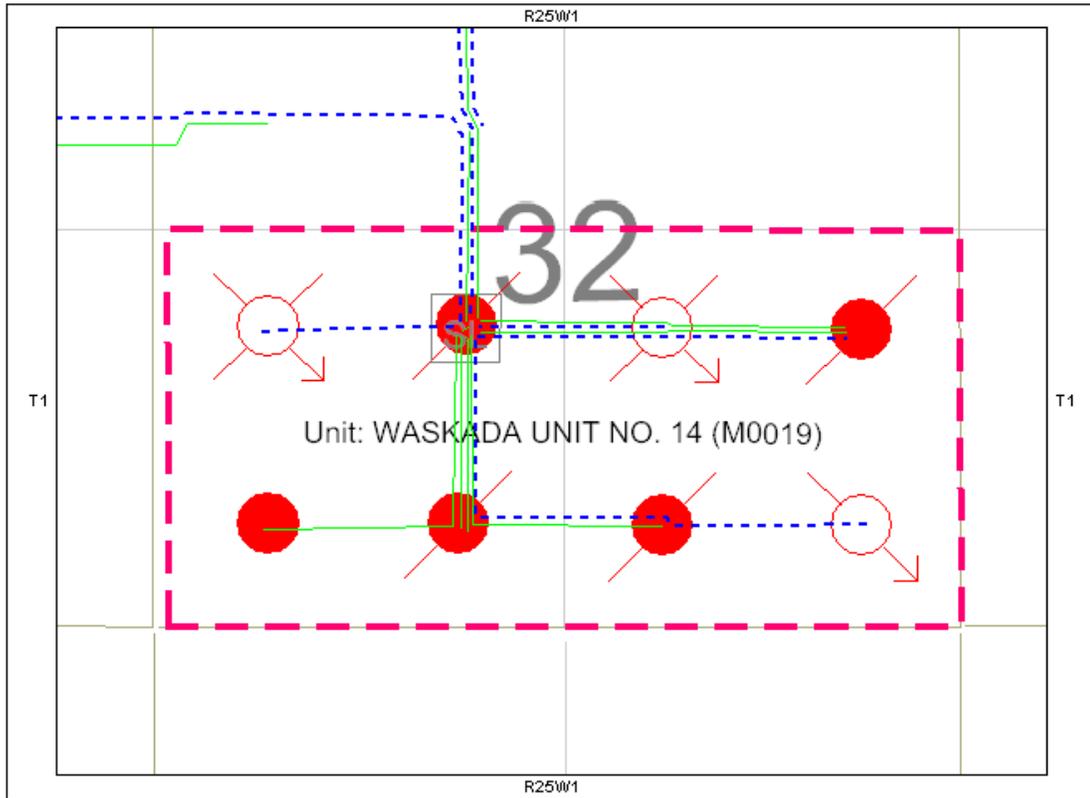
**Waskada Unit #14**

**Table 2: Pressure Survey**

Location	Shut In Date	Date of Survey	Type of Survey	Pressure @ Datum Depth (kPa)
00/04-32-001-25W1/0		10-Jan-10	BHP, Assuming WC from Last Prod'n	6041

## **APPENDIX A**

# Appendix A – Area Map



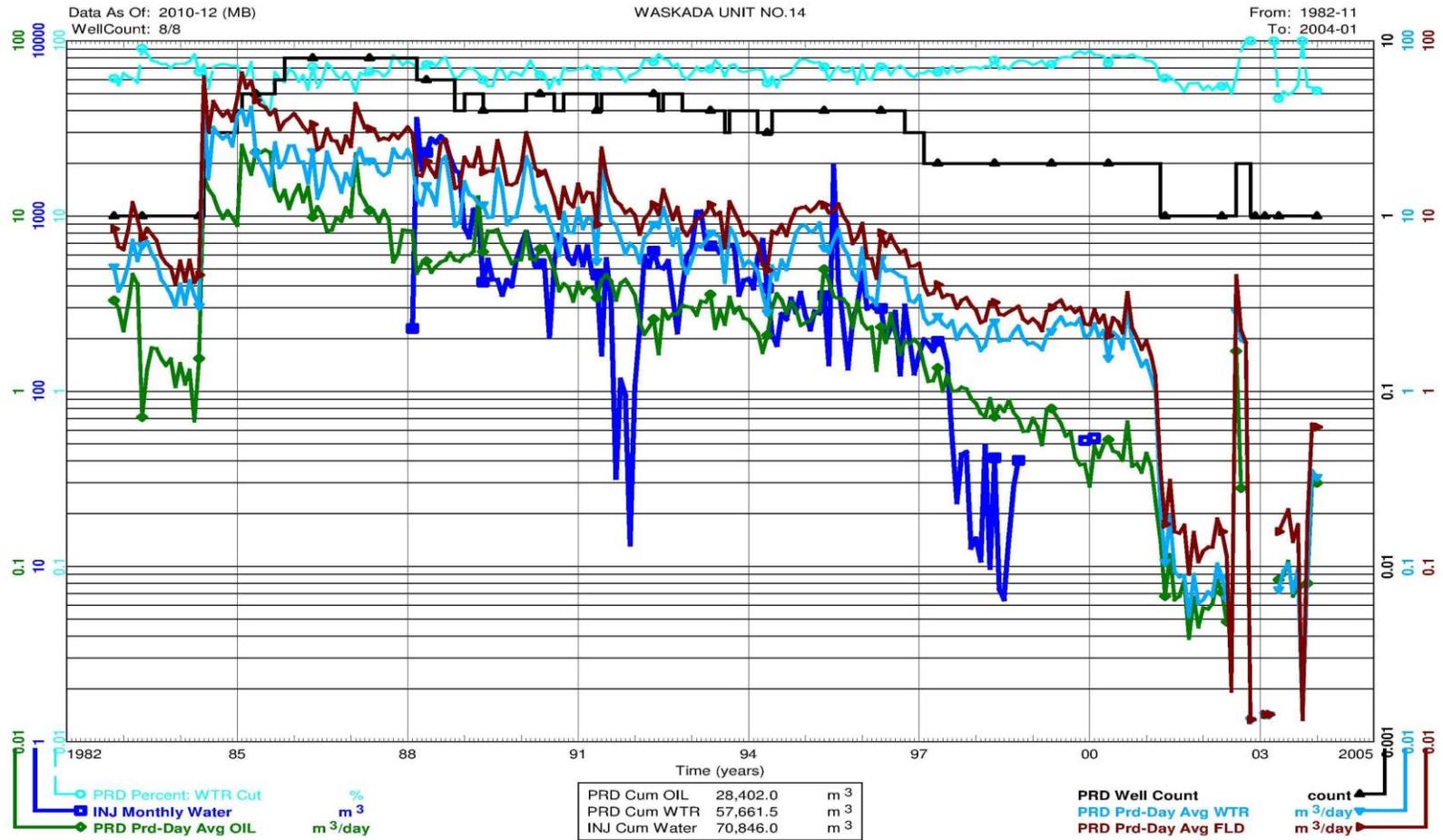
WELL SYMBOLS

• OIL	AG	φ PTH	⊕ DSA	⊕ WI
○ LCT	AWI	φ STN	⊕ CMM	⊕ DRL
⊕ RDR	WD	φ AWS	⊕ A/VD	⊕ SWI
▲ SD	WDC	• J&A	□ SL	

<b>PennWest</b> Exploration					
Waskada Unit #14					
	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="font-size: small;">By :</td> <td style="font-size: small;">Date : 2011/04/14</td> </tr> <tr> <td style="font-size: small;">Scale = 1:10800</td> <td style="font-size: small;">Project : Waskada</td> </tr> </table>	By :	Date : 2011/04/14	Scale = 1:10800	Project : Waskada
By :	Date : 2011/04/14				
Scale = 1:10800	Project : Waskada				

## **APPENDIX B**

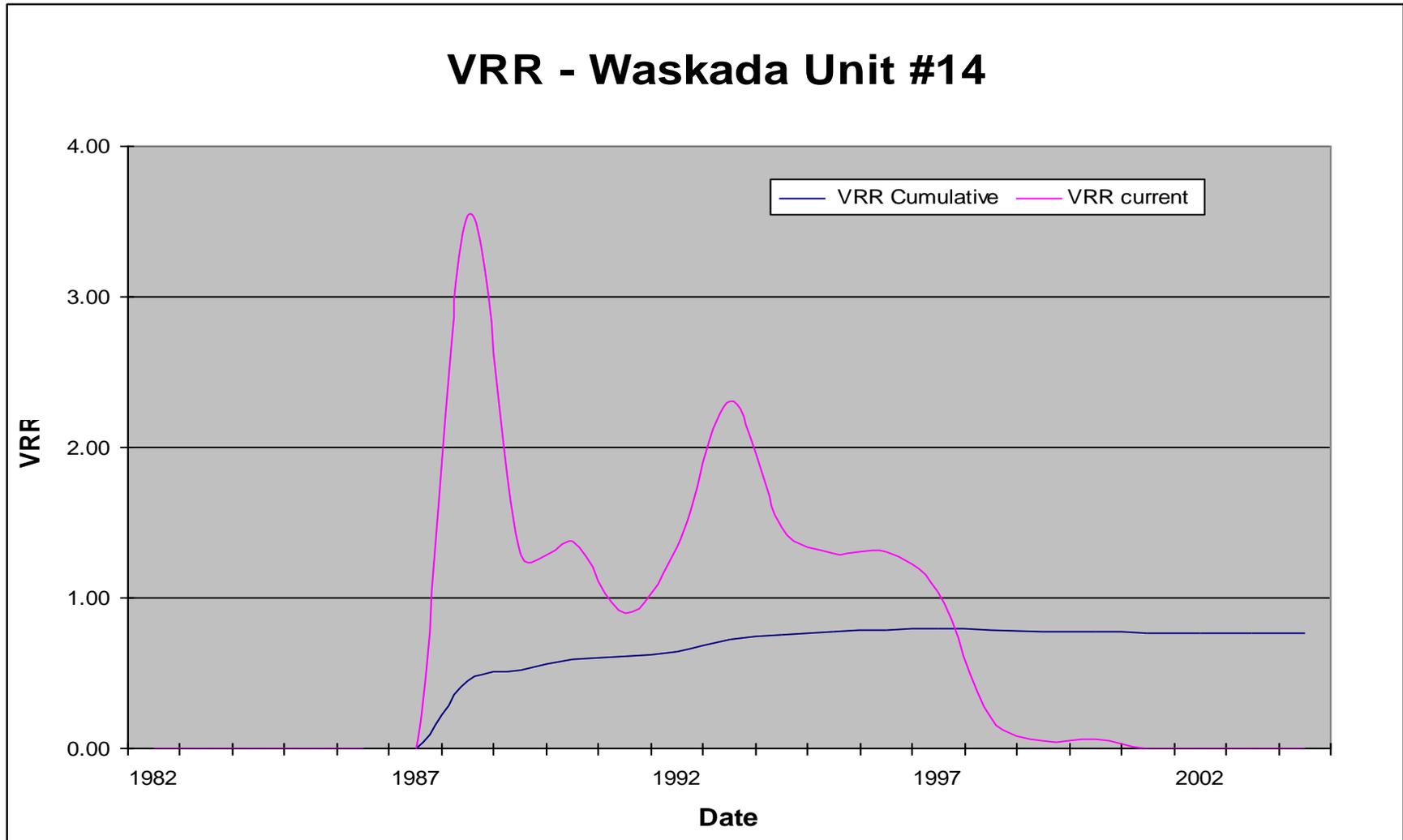
## Appendix B – Production and Injection History Plot



Thursday, March 31, 2011, 05:22 PM

## **APPENDIX C**

Appendix C – Voidage Replacement Ratio VRR



## **APPENDIX D**

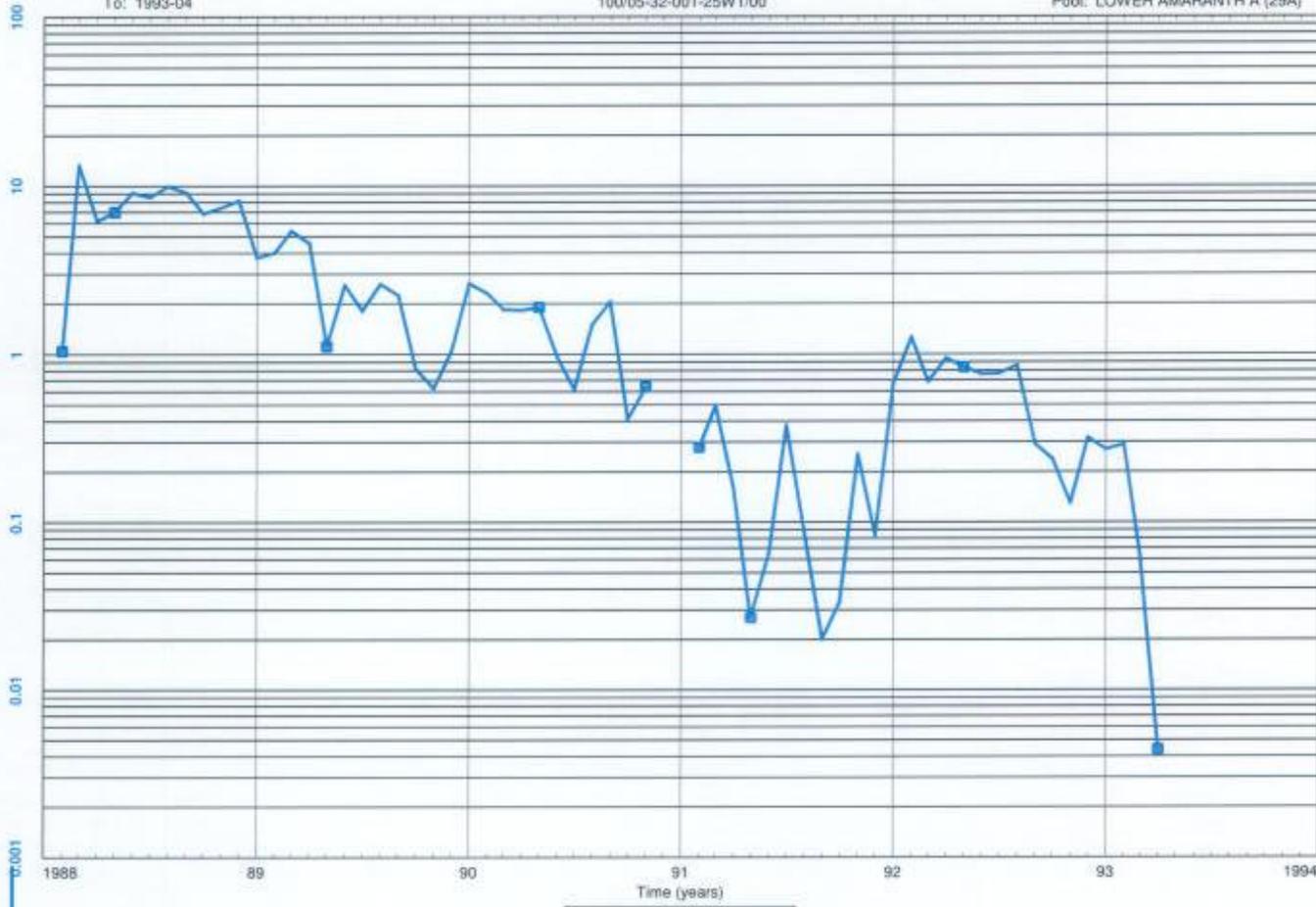
## Appendix D – Production and Injection Profiles



Data As Of: 2011-02 (MB)  
From: 1988-02  
To: 1993-04

INDIVIDUAL INJECTION  
Waskada Unit No. 14 WIW  
100/05-32-001-25W1/00

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



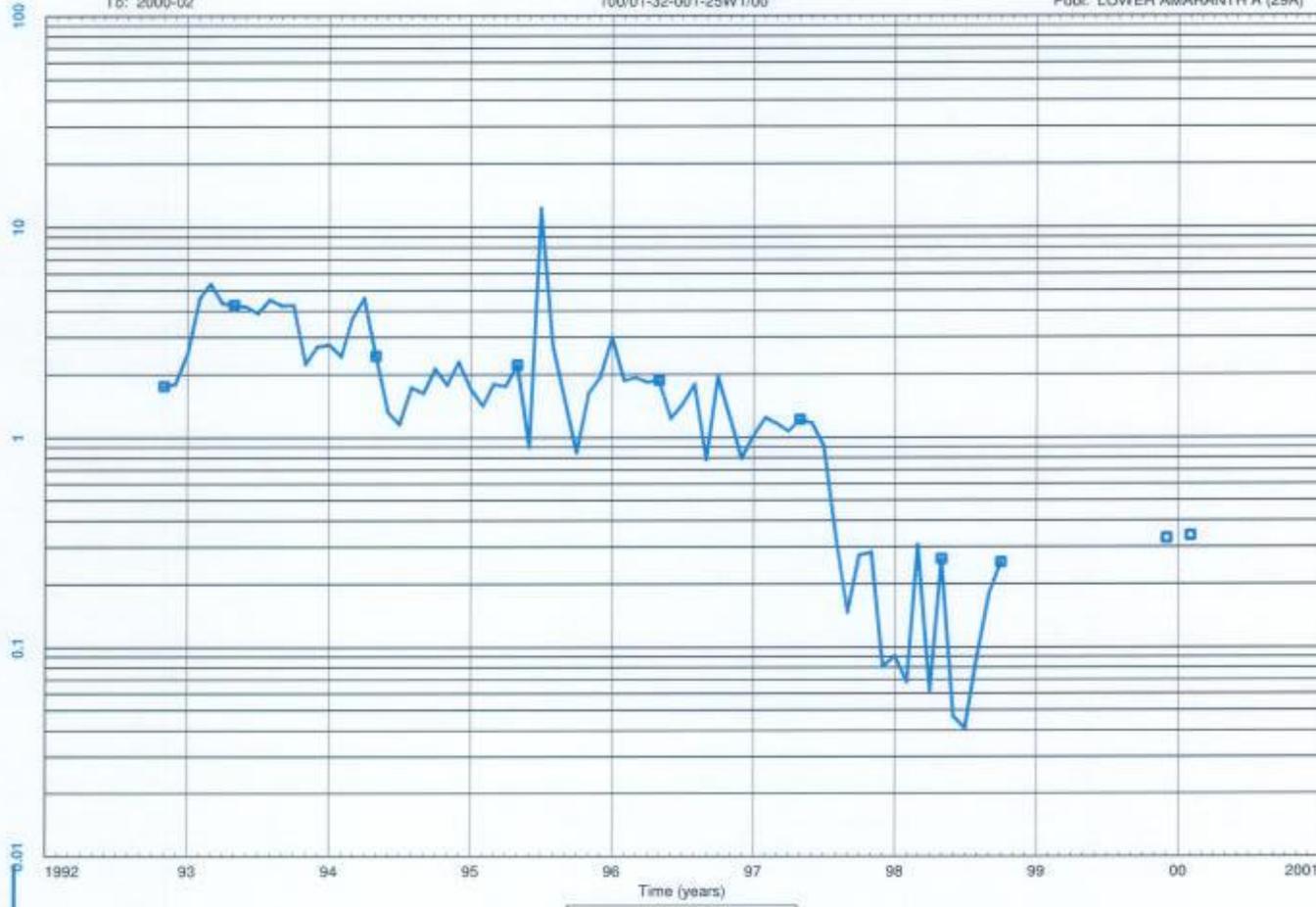
Monthly Water MBbl

Cum Water	144,364.0	Bbl
Cum Gas	0.0	Mcf
Cum CO2	0.0	Mcf

Data As Of: 2011-02 (MB)  
From: 1992-11  
To: 2000-02

INDIVIDUAL INJECTION  
Waskada Unit No. 14 WIW  
100/01-32-001-25W1/00

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



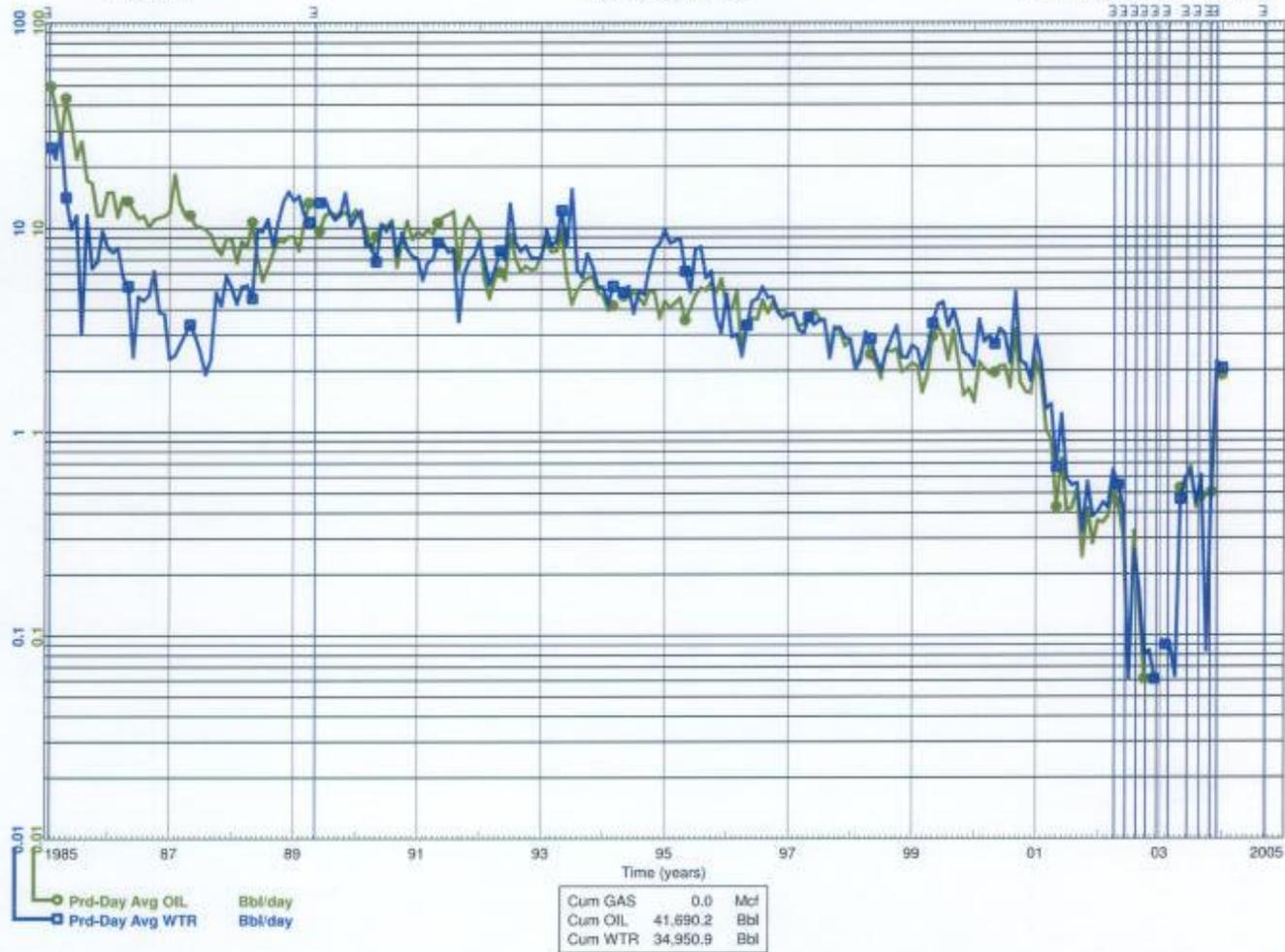
Monthly Water MBbl

Cum Water	140,040.2	Bbl
Cum Gas	0.0	Mcf
Cum CO2	0.0	Mcf

Data As Of: 2011-02 (MB)  
From: 1985-02  
To: 2004-01

INDIVIDUAL PRODUCTION  
Waskada Unit No. 14 COM  
100/08-32-001-25W1/02

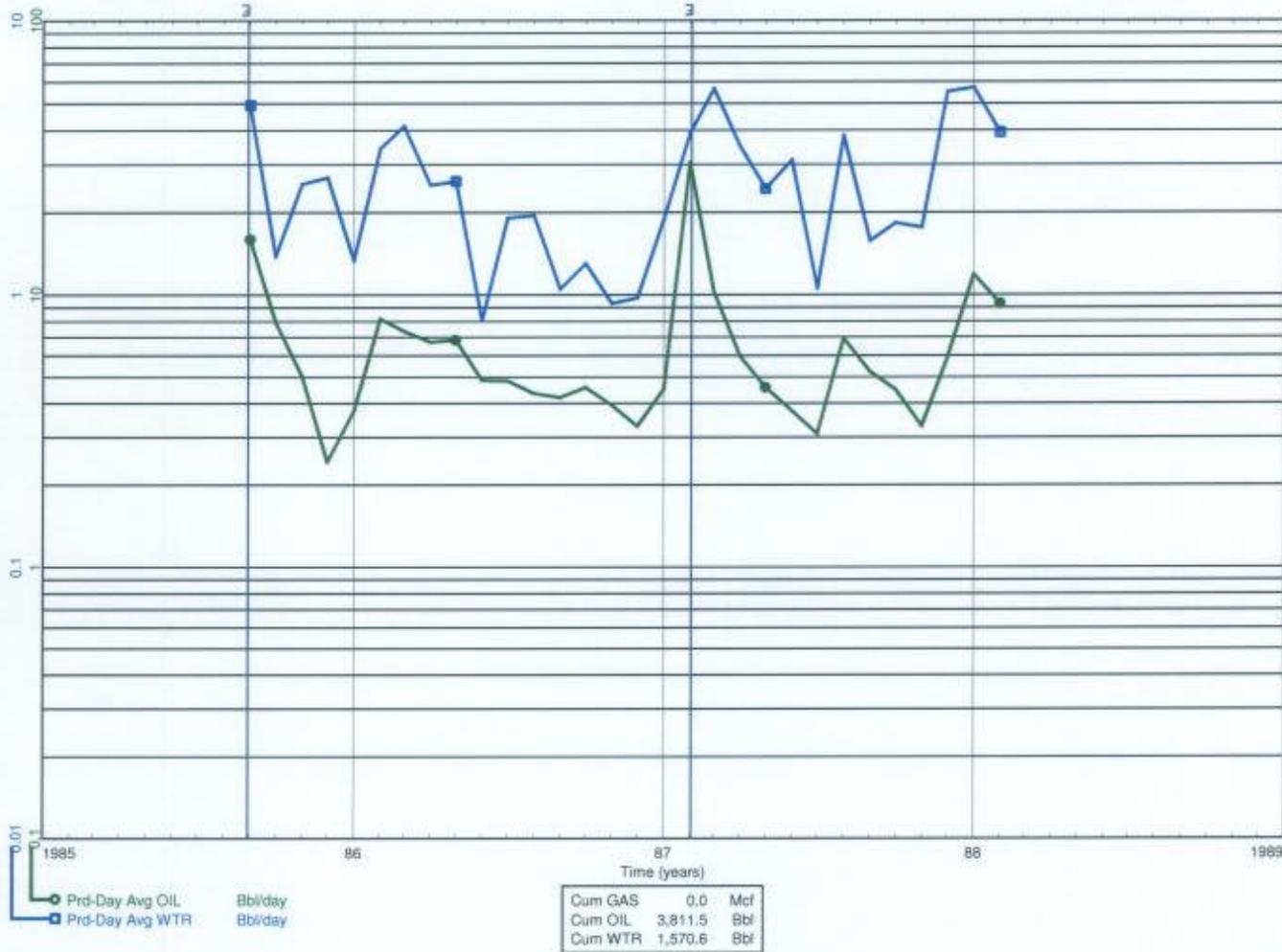
Status: Abandoned Producer  
Field: WASKADA (03)  
Pool: LOWER AMARANTH A (29A)



Data As Of: 2010-11 (MB)  
From: 1985-09  
To: 1988-02

INDIVIDUAL PRODUCTION  
Waskada Unit No. 14 WIW  
100/07-32-001-25W1/00

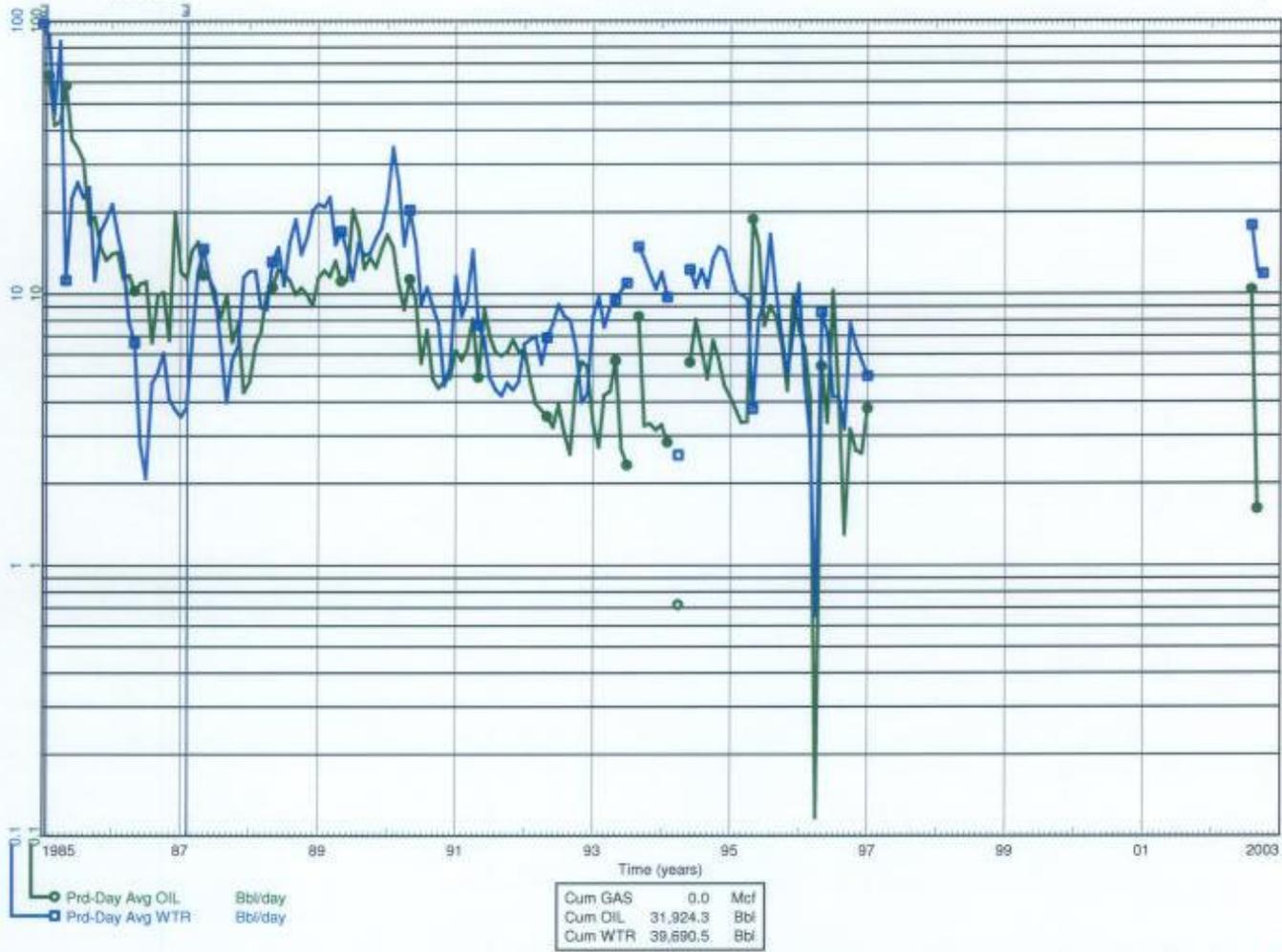
Status: Abandoned Water Inj Well  
Field: WASKADA (03)  
Pool: LOWER AMARANTH A (29A)



Data As Of: 2010-11 (MB)  
From: 1985-01  
To: 2002-10

INDIVIDUAL PRODUCTION  
Waskada Unit No. 14  
100/06-32-001-25W1/00

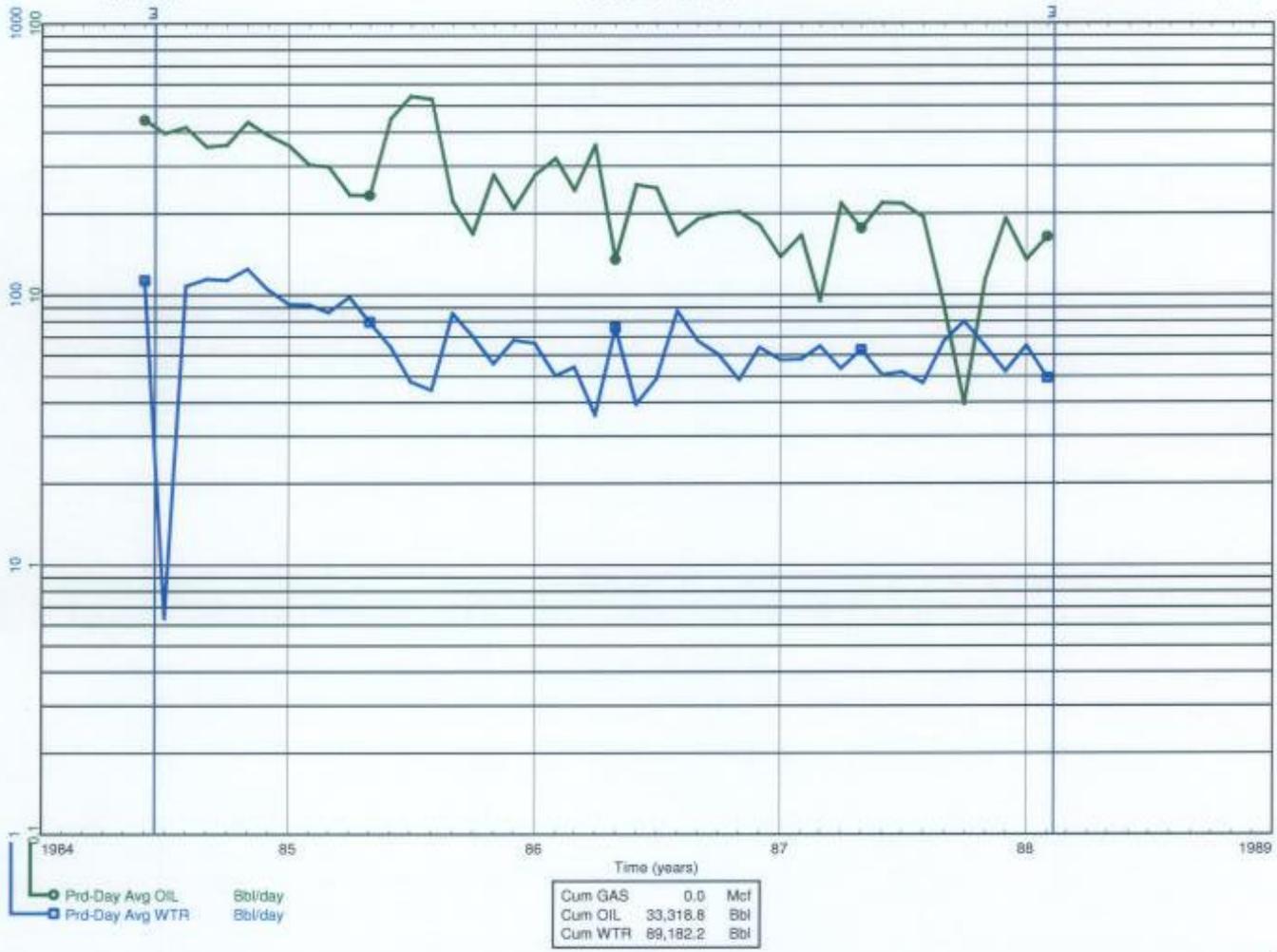
Status: Abandoned Producer  
Field: WASKADA (03)  
Pool: LOWER AMARANTH A (29A)



Data As Of: 2010-11 (MB)  
 From: 1984-06  
 To: 1988-02

INDIVIDUAL PRODUCTION  
 Waskada Unit No. 14 WIW  
 100/05-32-001-25W1/00

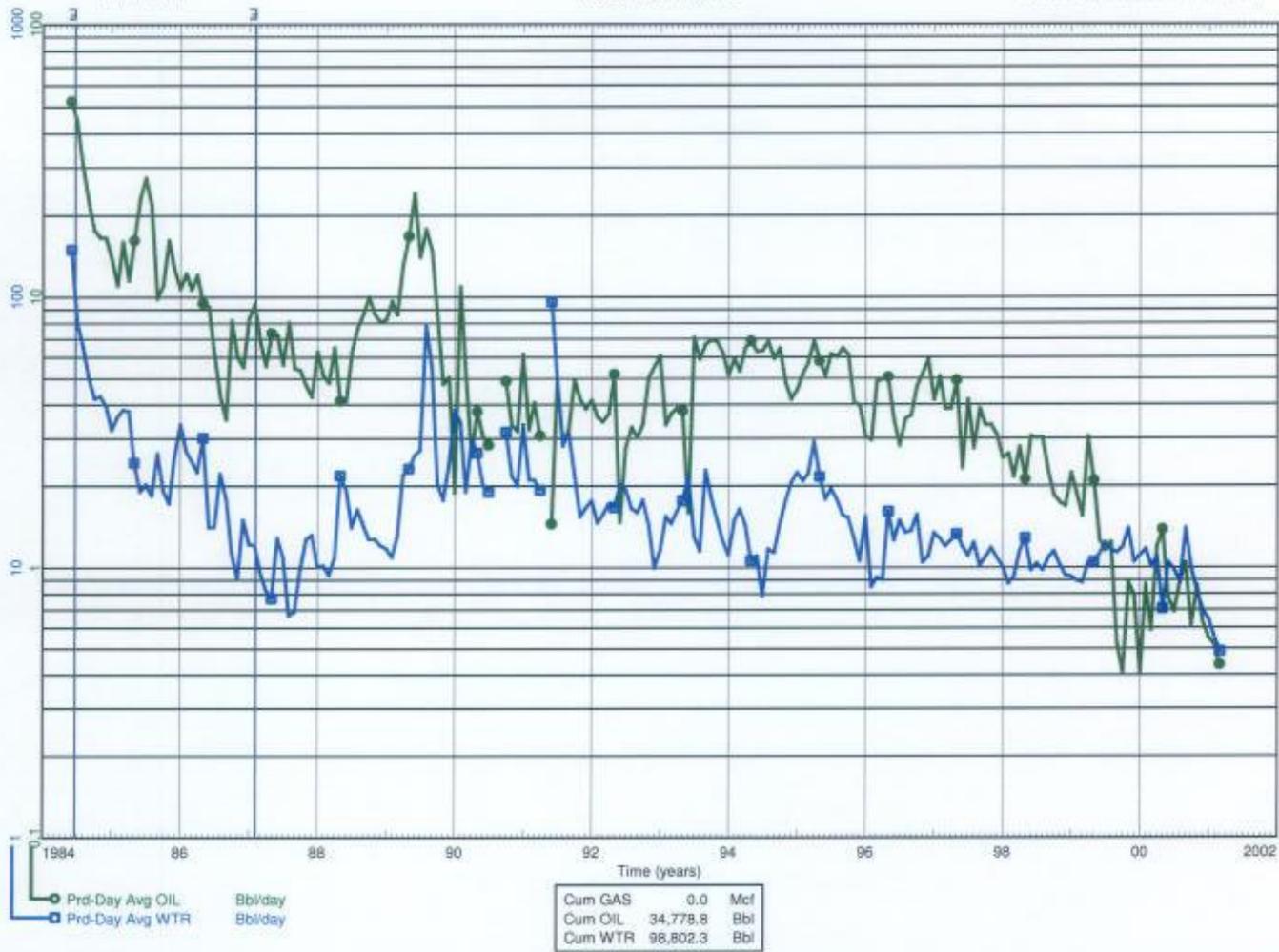
Status: Abandoned Water Inj Well  
 Field: WASKADA (03)  
 Pool: LOWER AMARANTH A (29A)



Data As Of: 2010-11 (MB)  
From: 1994-06  
To: 2001-03

INDIVIDUAL PRODUCTION  
Waskada Unit No. 14  
100/04-32-001-25W1/00

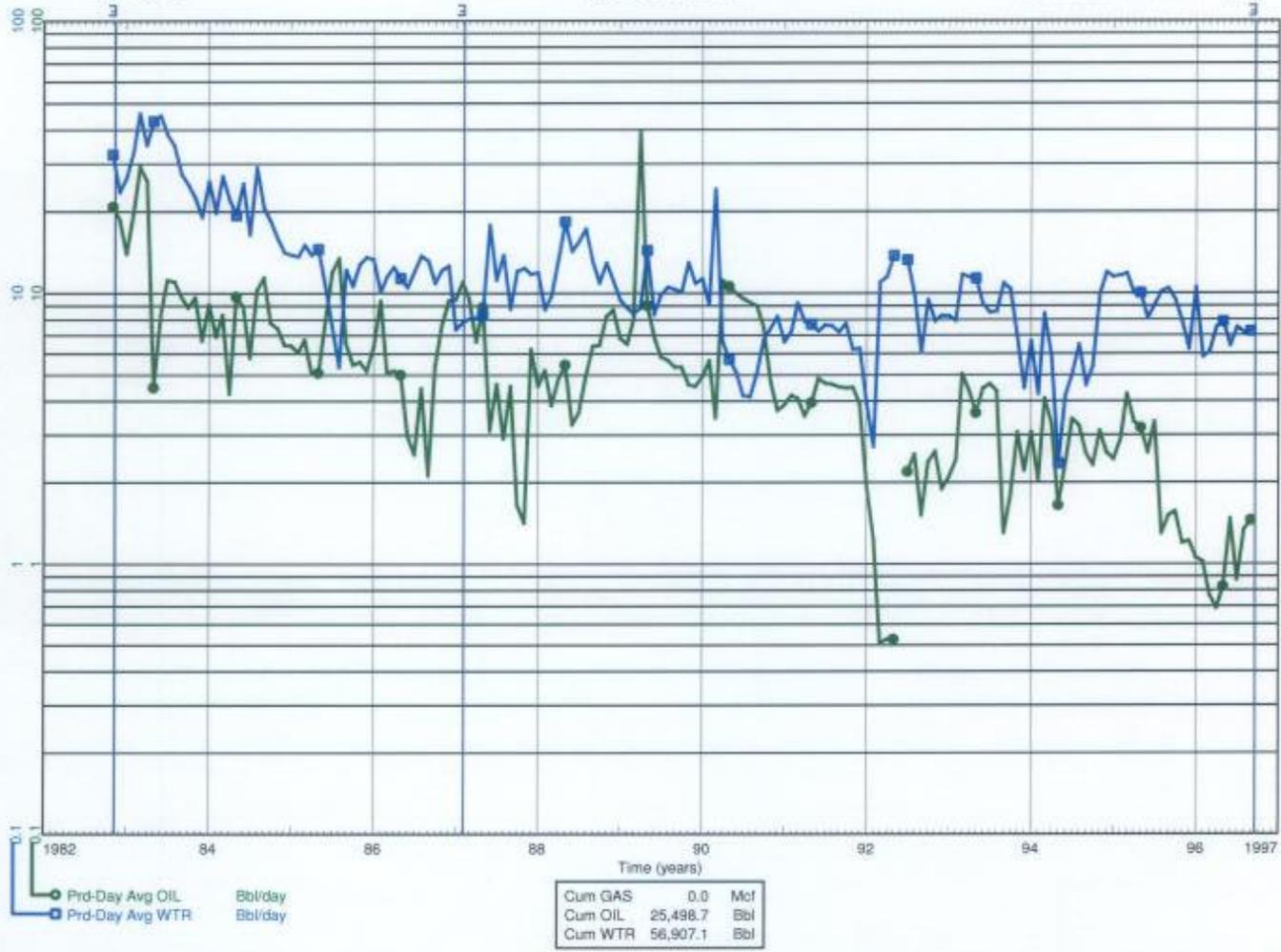
Status: Capable Of Oil Prod  
Field: WASKADA (03)  
Pool: LOWER AMARANTH A (29A)



Data As Of: 2010-11 (MB)  
From: 1982-11  
To: 1996-09

INDIVIDUAL PRODUCTION  
Waskada Unit No. 14  
102/03-32-001-25W1/00

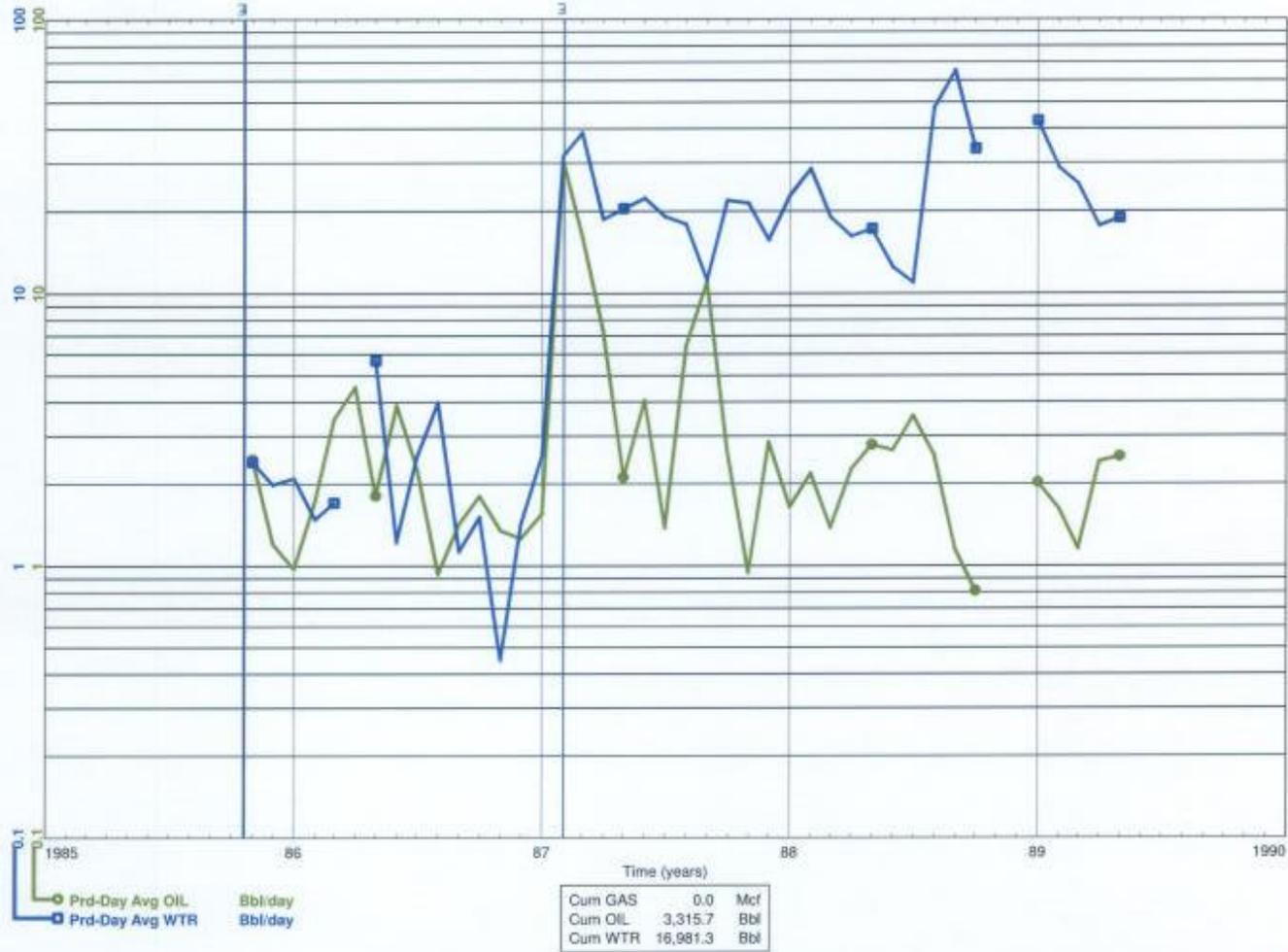
Status: Abandoned Producer  
Field: WASKADA (03)  
Pool: LOWER AMARANTH A (29A)



Data As Of: 2011-02 (MB)  
 From: 1985-11  
 To: 1989-05

INDIVIDUAL PRODUCTION  
 «Omega» at WASKADA  
 100/02-32-001-25W1/00

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



Data As Of: 2010-11 (MB)  
From: 1985-11  
To: 1992-10

INDIVIDUAL PRODUCTION  
Waskada Unit No. 14 WIW  
100/01-32-001-25W1/00

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

