WASKADA UNIT NO. 14

WATERFLOOD PROGRESS REPORT

January 1, through December 31, 2012

PennWest Exploration

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Senior Waterflood Exploitation Engineer

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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, 2012.

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^{o} API), predominantly from the Lower Amaranth formation. The interlaminated, shallow marine to subtidal succession of sandstones, siltones, 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)

CPA Pretty Well ID	Date Well Spudded	On Prod YYYY/MM/DD	Org Operator Name	Ground Elevation (m)	TVD (m)
100/01-32-001-25W1/00	10/18/1985	11/1/1985	Omega Hydcbns Ltd	471.4	958
102/01-32-001-25W1/00	11/23/2011	2/1/2012	Penn West Expl Ltd	471.5	903
103/01-32-001-25W1/00	11/9/2011	2/1/2012	Penn West Expl Ltd	471.3	894.9
104/01-32-001-25W1/00	10/27/2011	2/1/2012		471	
100/02-32-001-25W1/00	9/7/1985	11/1/1985	Omega Hydcbns Ltd	470.6	952
102/03-32-001-25W1/00	11/1/1982	11/1/1982	Roxy Petrl Ltd	469.8	939
100/04-32-001-25W1/00	6/13/1984	6/1/1984	[%571]	469	952
100/05-32-001-25W1/00	6/5/1984	6/1/1984	[%571]	470.5	950
100/06-32-001-25W1/00	12/9/1984	1/1/1985	[%571]	470.4	955
100/07-32-001-25W1/00	8/15/1985	9/1/1985	Omega Hydcbns Ltd	470.6	937
100/08-32-001-25W1/02	6/18/1984	2/1/1985	NCE Petrofund Corp	471.2	950
102/08-32-001-25W1/00	11/2/2011	2/1/2012		471.2	895.8
103/08-32-001-25W1/00	11/16/2011	2/1/2012	Penn West Expl Ltd	471.5	
104/08-32-001-25W1/00	2/8/2012	8/1/2012		471.2	891.6
104/09-32-001-25W1/00	2/28/2012	8/1/2012		471.3	

Waskada Unit #14 (Production & Injection History)

CPA Pretty Well ID	First Prod YYYY/MM	On Inject. YYYY/MM/DD	Last Prod. YYYY/MM	Cumulative OIL Prod. (m3)	Cumulative WTR Prod. (m3)	Last Inject. YYYY/MM
100/01-32-001-25W1/00	1985/11	11/1/1992	1992/10	698	3913	2000/02
102/01-32-001-25W1/00	2012/02		2012/10	1076	4683	
103/01-32-001-25W1/00	2012/02		2012/10	1427	4298	
104/01-32-001-25W1/00	2012/02		2012/10	2693	4660	
100/02-32-001-25W1/00	1985/11		1989/05	527	2700	
102/03-32-001-25W1/00	1982/11		1996/09	4052	9047	
100/04-32-001-25W1/00	1984/06		2001/03	5527	15708	
100/05-32-001-25W1/00	1984/06	2/1/1988	1988/02	5295	14178	1993/04
100/06-32-001-25W1/00	1985/01		2002/10	5073	6310	
100/07-32-001-25W1/00	1985/09	2/1/1988	1988/02	606	250	1993/04
100/08-32-001-25W1/02	1985/02		2004/01	6625	5557	
102/08-32-001-25W1/00	2012/02		2012/10	1245	3837	
103/08-32-001-25W1/00	2012/02		2012/10	1554	4229	
104/08-32-001-25W1/00	2012/08		2012/10	772	1106	
104/09-32-001-25W1/00	2012/08		2012/10	418	827	

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.

2012 Waskada Lower Amaranth Waterflood Pilot Location

The pilot producer is 102/12-01-02-26W1/00 (the existing horizontal well) and the injectors are two vertical wells; 100/12-01-02-26W1 and 100/11-01-02-26 (converted to injectors). The pilot started late 2012, but because of some technical issues and cold weather the operation suspended, and it was postponed until spring 2013.

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

102/01-32-001-25W1/00
103/01-32-001-25W1/00
104/01-32-001-25W1/00
102/08-32-001-25W1/00
103/08-32-001-25W1/00
104/08-32-001-25W1/00
104/09-32-001-25W1/00

Current Suspended Wells

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

Abandoned Wells

00/02-32-001-25W1/0 (since 1989/06)

02/03-32-001-25W1/0 (since 1996/10)

00/06-32-001-25W1/0 (since 2002/11)

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

00/05-32-001-25W1/0 (since 1993/05)

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

Production Data						
Date	Oil		Water		Injection Water	
Year	m3/year	m3/day	m3/year	m3/day	m3/year	m3/day
1982	746	2.04	116	0.32	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
2005	0	0.00	0	0.00	0	0.00
2006	0	0.00	0	0.00	0	0.00
2007	0	0.00	0	0.00	0	0.00
2008	0	0.00	0	0.00	0	0.00
2009	0	0.00	0	0.00	0	0.00
2010	0	0.00	0	0.00	0	0.00
2011	0	0.00	0	0.00	0	0.00
2012	9,184	25.16	23,640	64.77	0	0.00

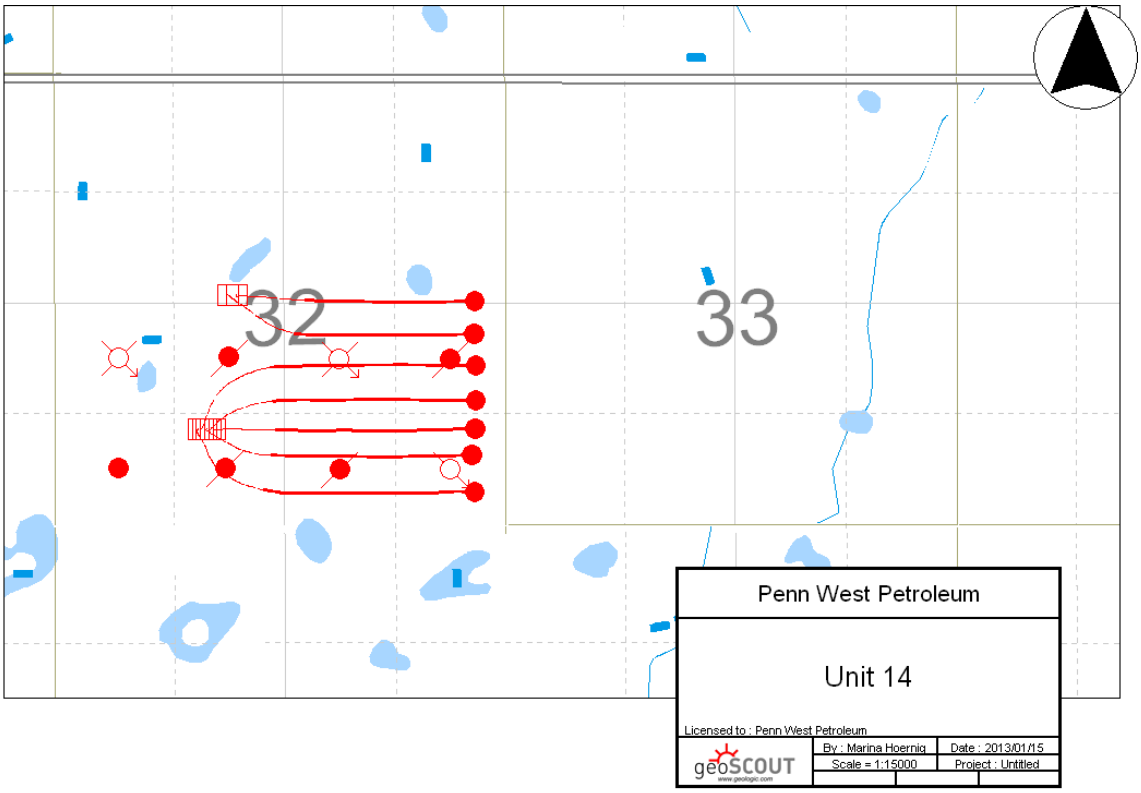
Waskada Unit #14

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

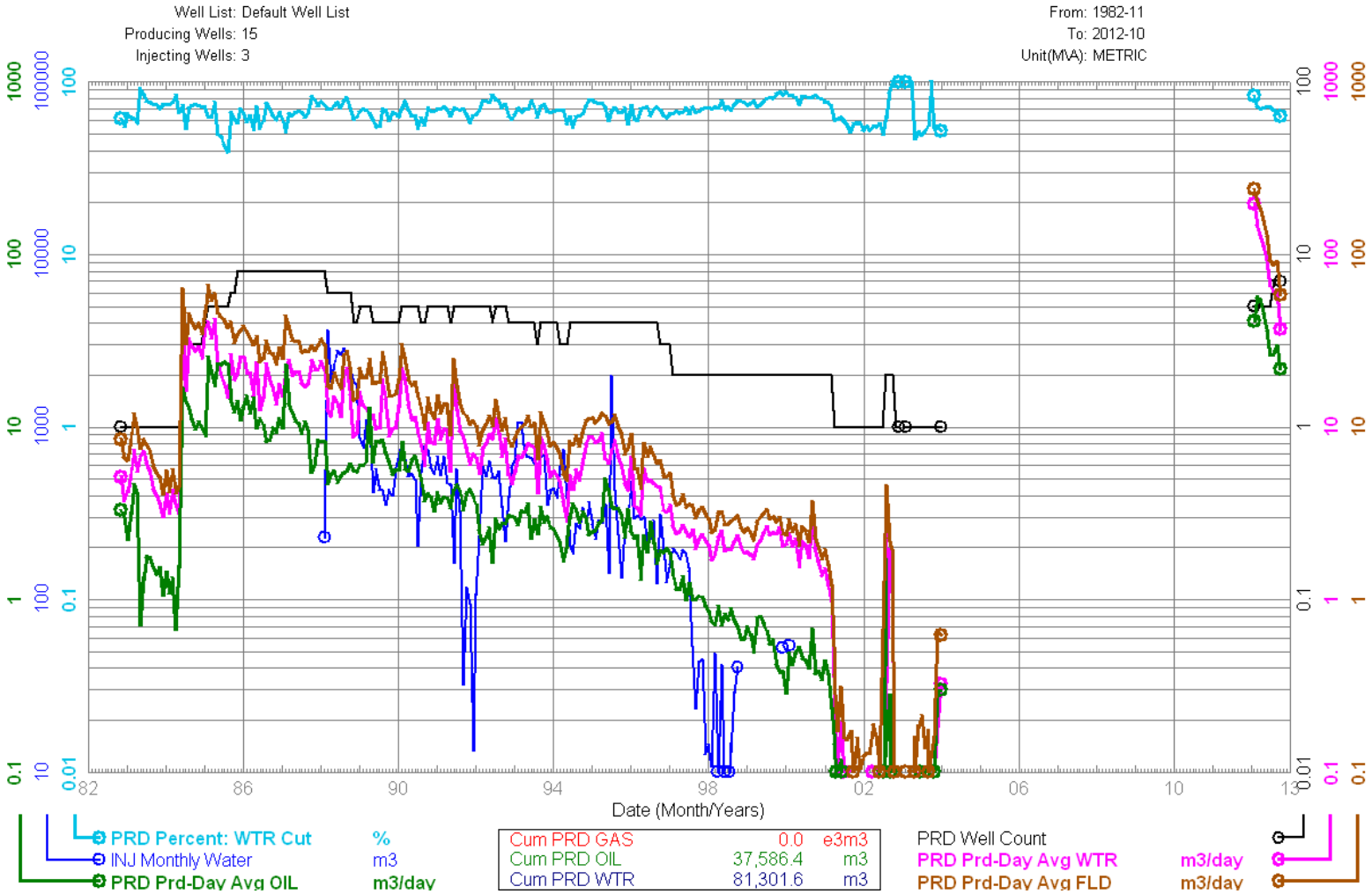
APPENDIX A

Appendix A – Area Map



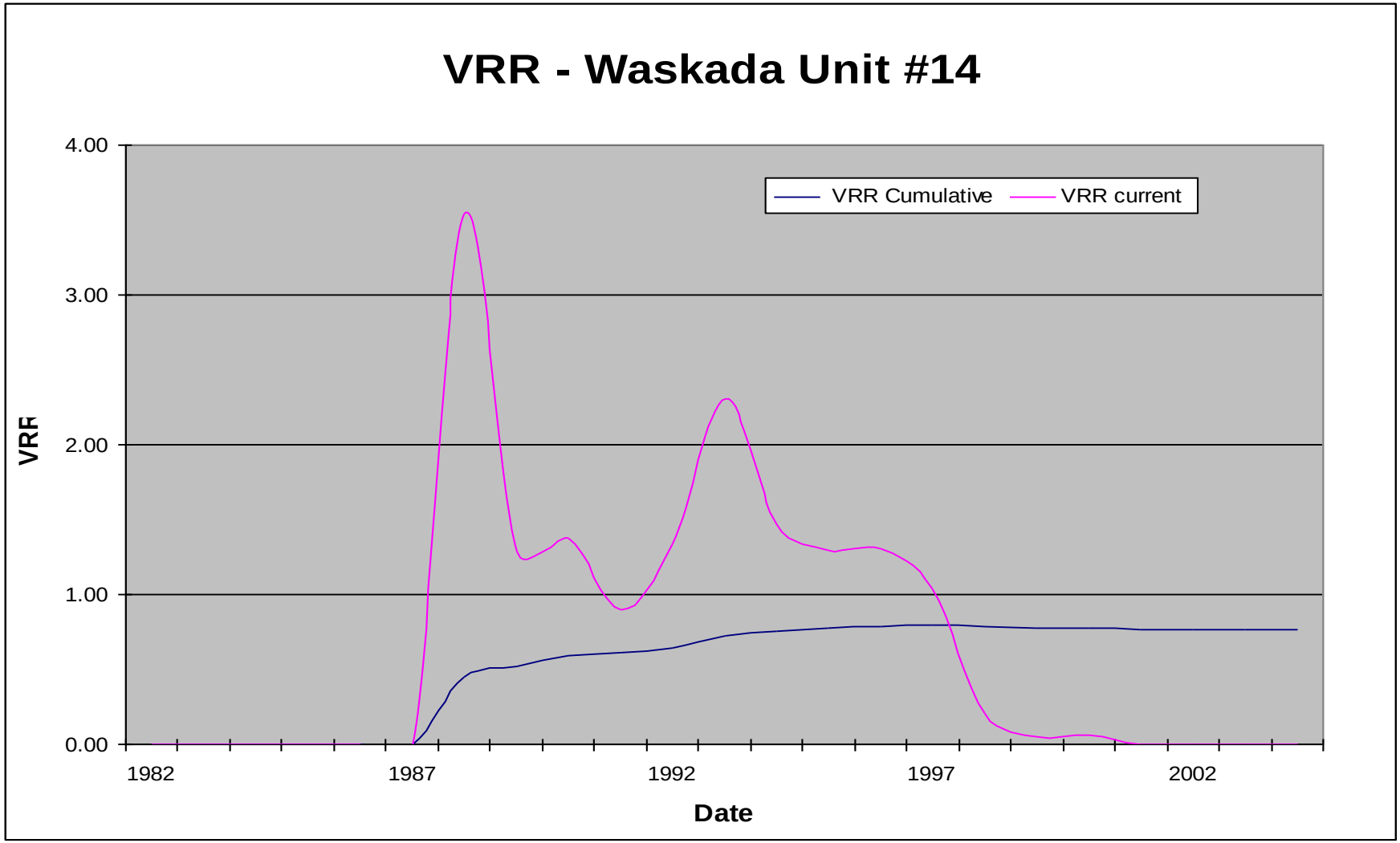
APPENDIX B

Appendix B – Production and Injection History Plot



APPENDIX C

Appendix C – Voidage Replacement Ratio VRR



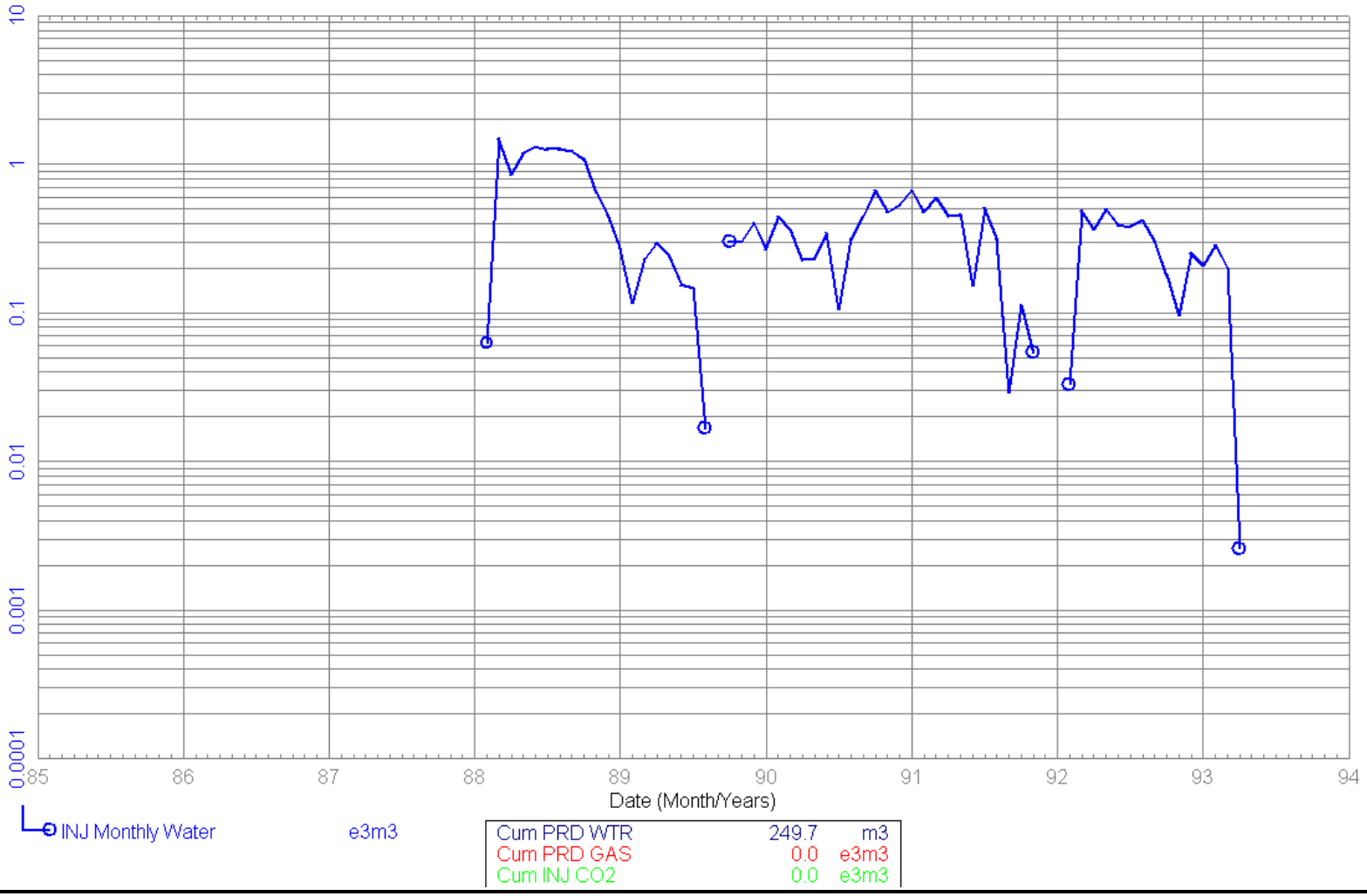
APPENDIX D

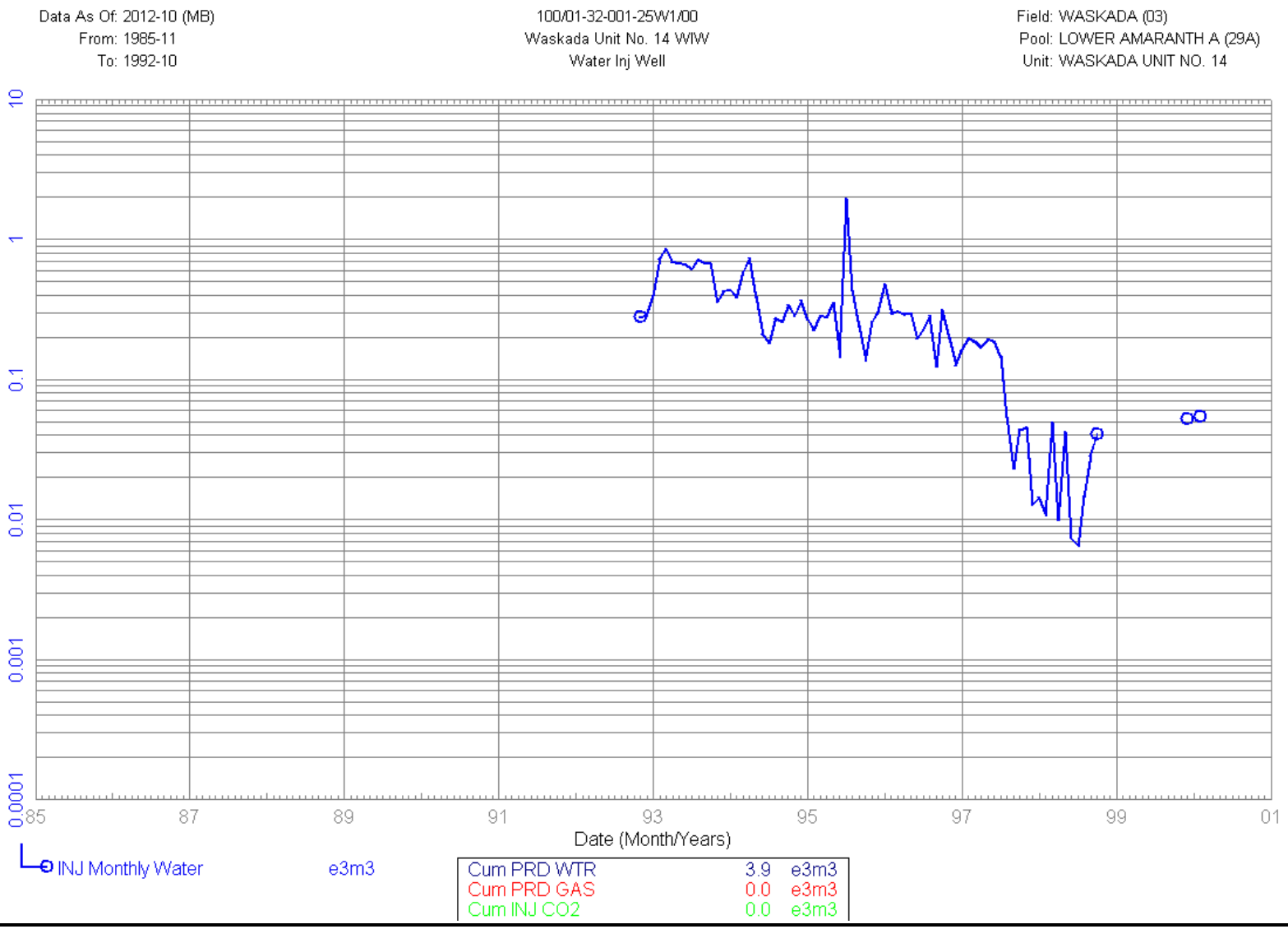
Appendix D – Production and Injection Profiles

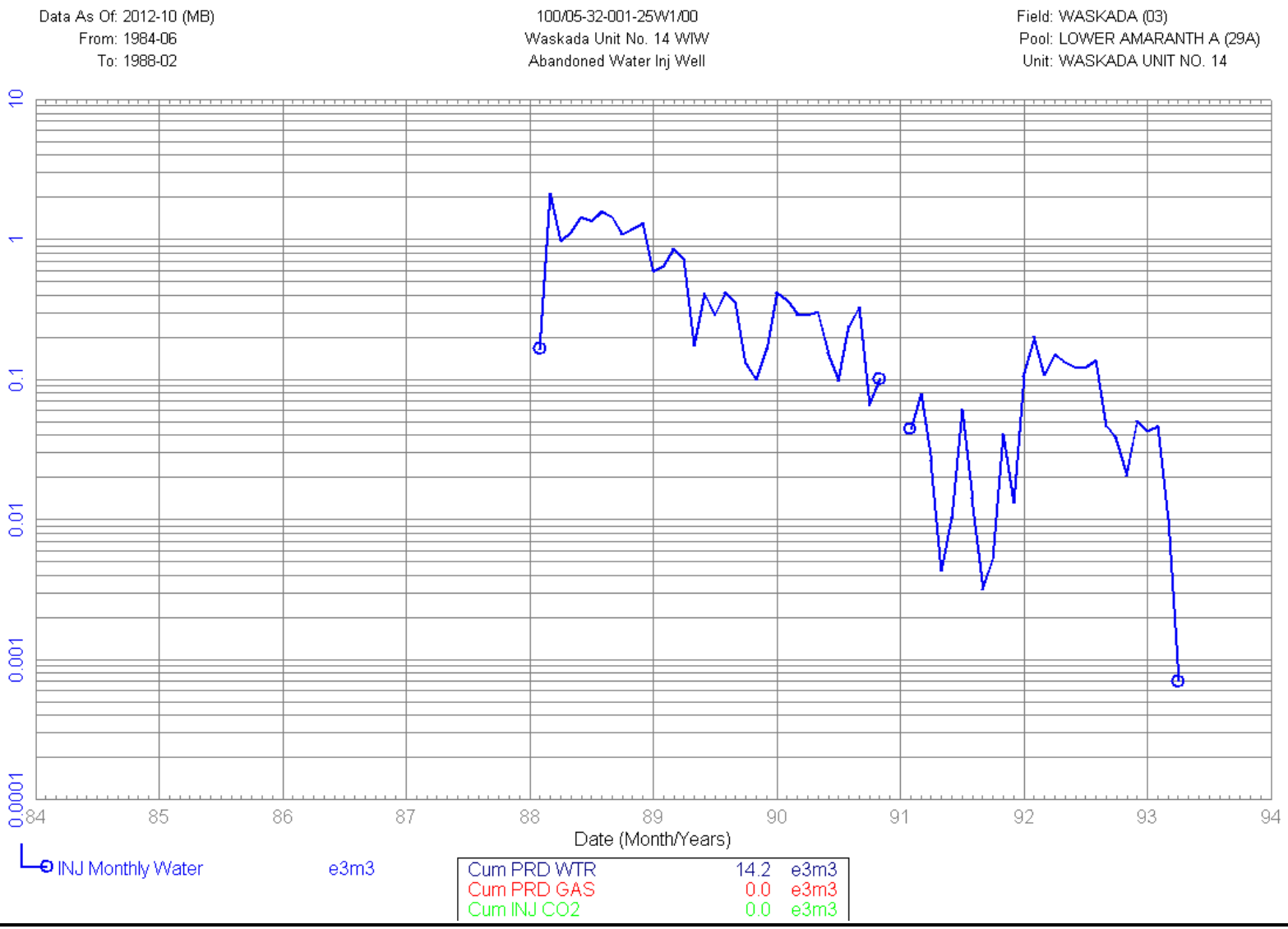
Data As Of: 2012-10 (MB)
From: 1985-09
To: 1988-02

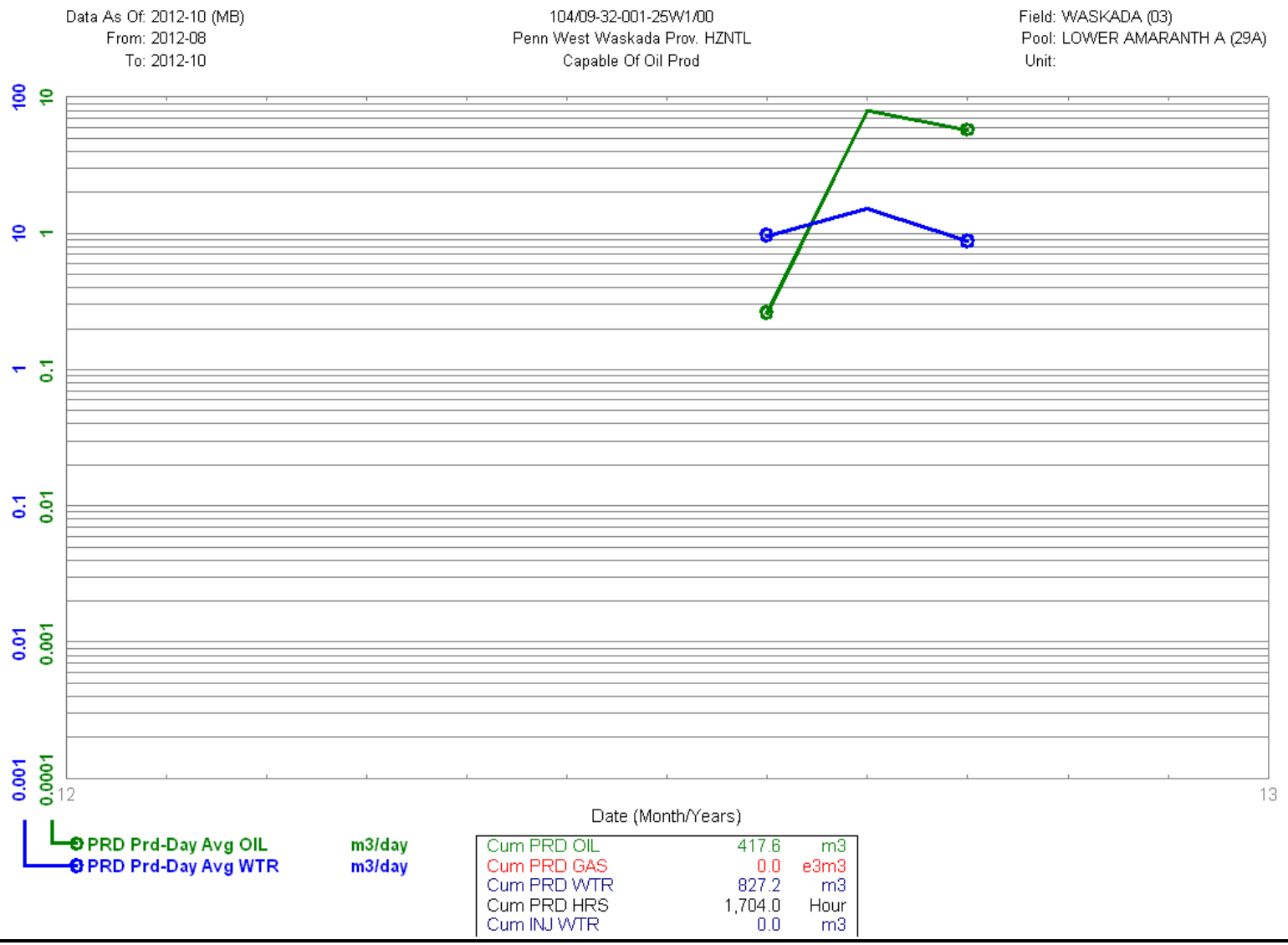
100/07-32-001-25W1/00
Waskada Unit No. 14 WIW
Abandoned Water Inj Well

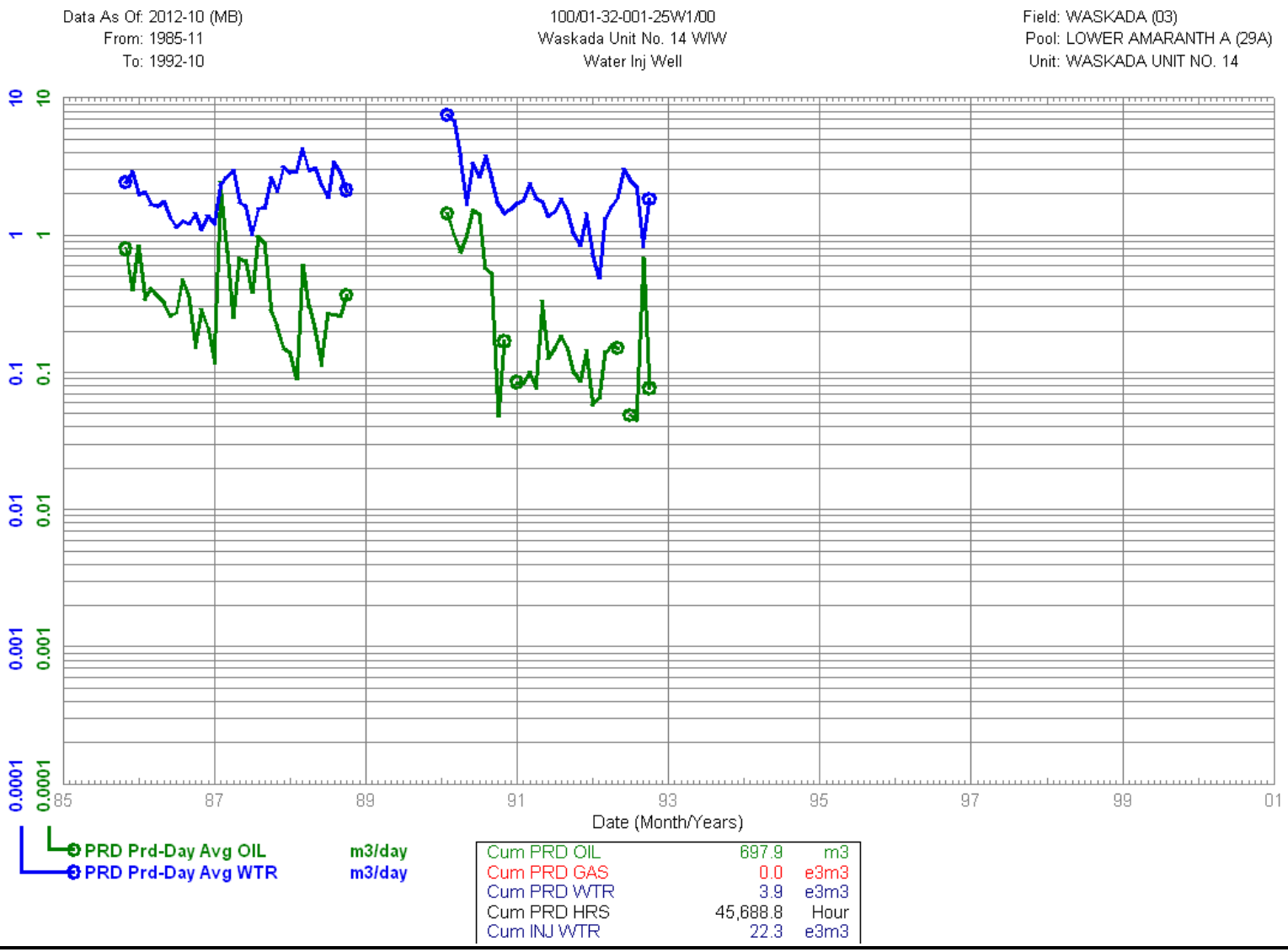
Field: WASKADA (03)
Pool: LOWER AMARANTH A (29A)
Unit: WASKADA UNIT NO. 14

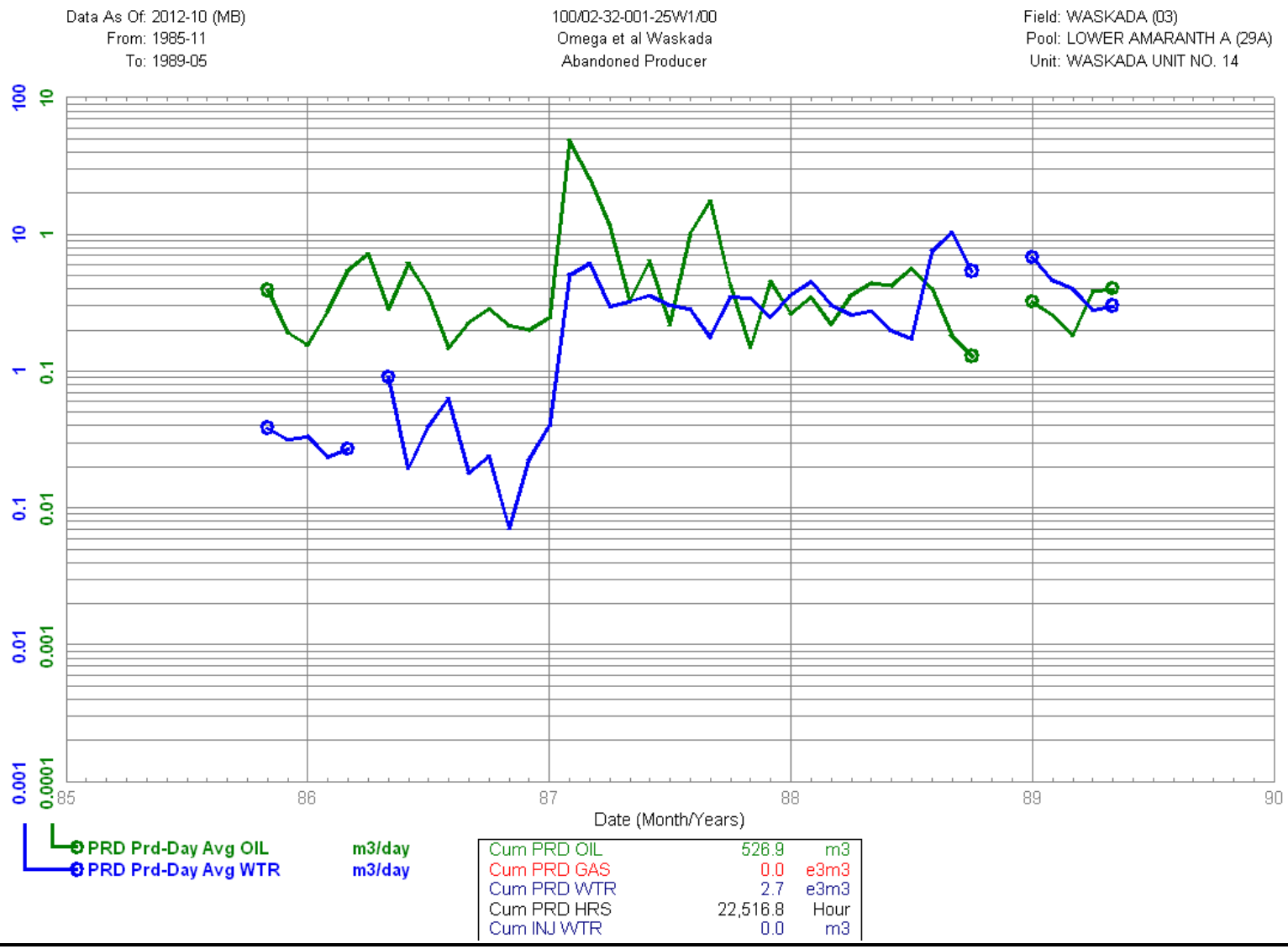


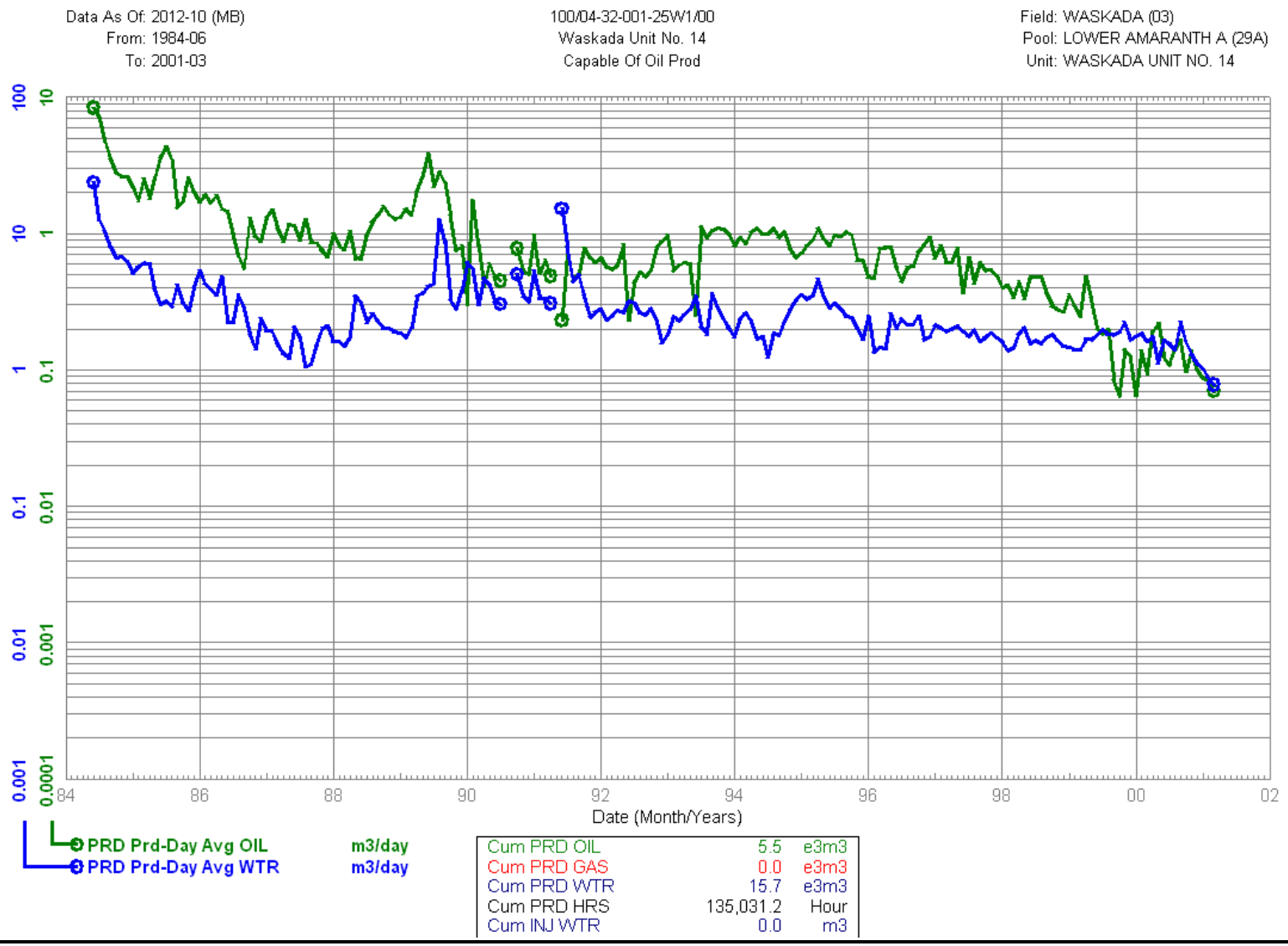

Data As Of: 2012-10 (MB)
From: 1985-11
To: 1992-10
100/01-32-001-25W1/00
Waskada Unit No. 14 WIW
Water Inj Well
Field: WASKADA (03)
Pool: LOWER AMARANTH A (29A)
Unit: WASKADA UNIT NO. 14
10
1
0.1
0.01
0.001
0.0001
85
87
89
91
93
95
97
99
01
Date (Month/Years)
INJ Monthly Water
e3m3
Cum PRD WTR 3.9 e3m3
Cum PRD GAS 0.0 e3m3
Cum INJ CO2 0.0 e3m3

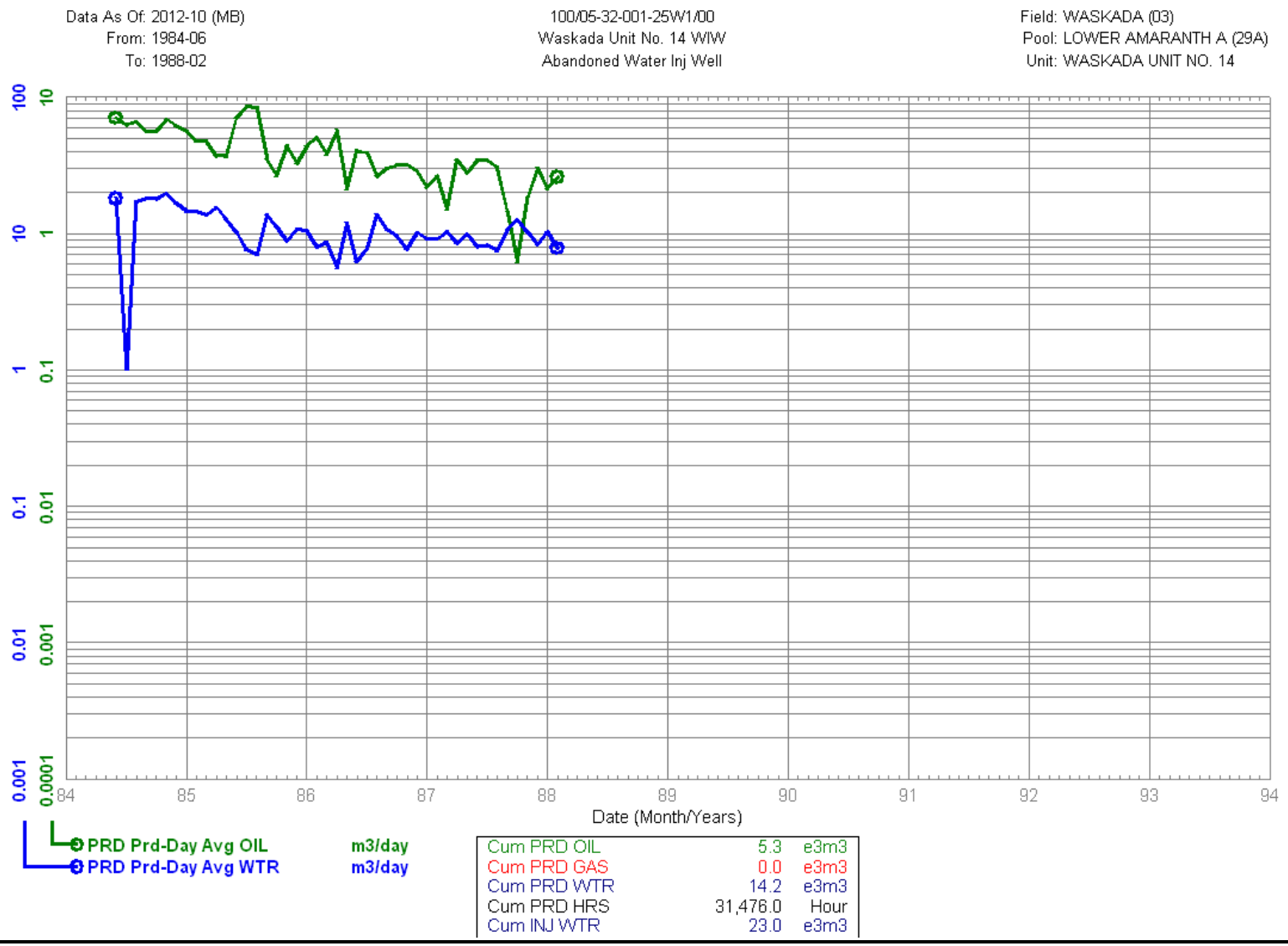

Data As Of: 2012-10 (MB)
From: 1984-06
To: 1988-02
100/05-32-001-25W1/00
Waskada Unit No. 14 WIW
Abandoned Water Inj Well
Field: WASKADA (03)
Pool: LOWER AMARANTH A (29A)
Unit: WASKADA UNIT NO. 14
10
1
0.1
0.01
0.001
0.0001
84
85
86
87
88
89
90
91
92
93
94
Date (Month/Years)
INJ Monthly Water
e3m3
Cum PRD WTR 14.2 e3m3
Cum PRD GAS 0.0 e3m3
Cum INJ CO2 0.0 e3m3

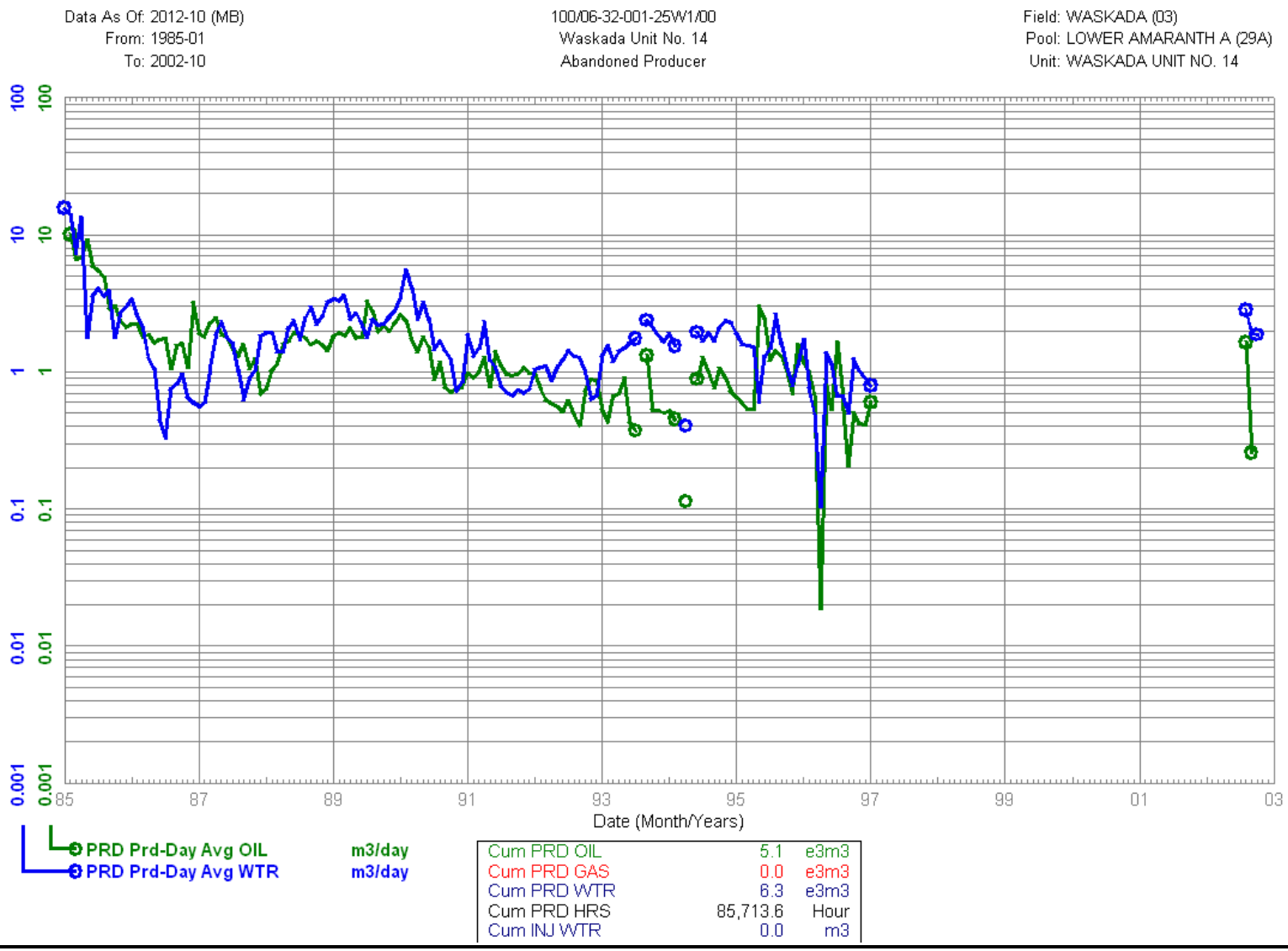

Data As Of: 2012-10 (MB)
From: 2012-08
To: 2012-10
104/09-32-001-25W1/00
Penn West Waskada Prov. HZNTL
Capable Of Oil Prod
Field: WASKADA (03)
Pool: LOWER AMARANTH A (29A)
Unit:
100
10
1
0.1
0.01
0.001
10
1
0.1
0.01
0.001
0.0001
12
13
Date (Month/Years)
PRD Prd-Day Avg OIL m3/day
PRD Prd-Day Avg WTR m3/day
Cum PRD OIL 417.6 m3
Cum PRD GAS 0.0 e3m3
Cum PRD WTR 827.2 m3
Cum PRD HRS 1,704.0 Hour
Cum INJ WTR 0.0 m3

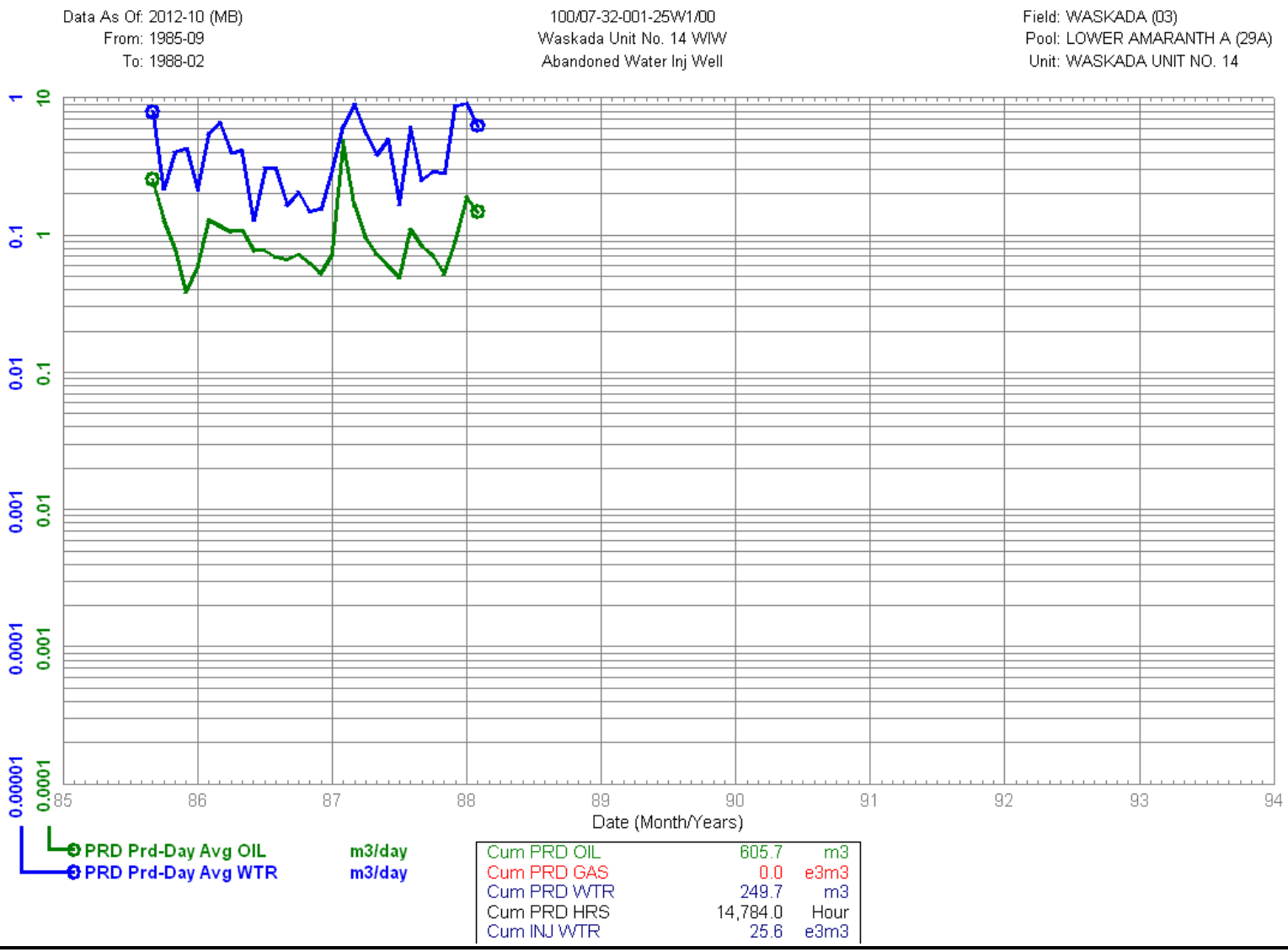

Data As Of: 2012-10 (MB)
From: 1985-11
To: 1992-10
100/01-32-001-25W1/00
Waskada Unit No. 14 WIW
Water Inj Well
Field: WASKADA (03)
Pool: LOWER AMARANTH A (29A)
Unit: WASKADA UNIT NO. 14
10
1
0.1
0.01
0.001
0.0001
85
87
89
91
93
95
97
99
01
Date (Month/Years)
PRD Prd-Day Avg OIL m3/day
PRD Prd-Day Avg WTR m3/day
Cum PRD OIL 697.9 m3
Cum PRD GAS 0.0 e3m3
Cum PRD WTR 3.9 e3m3
Cum PRD HRS 45,688.8 Hour
Cum INJ WTR 22.3 e3m3

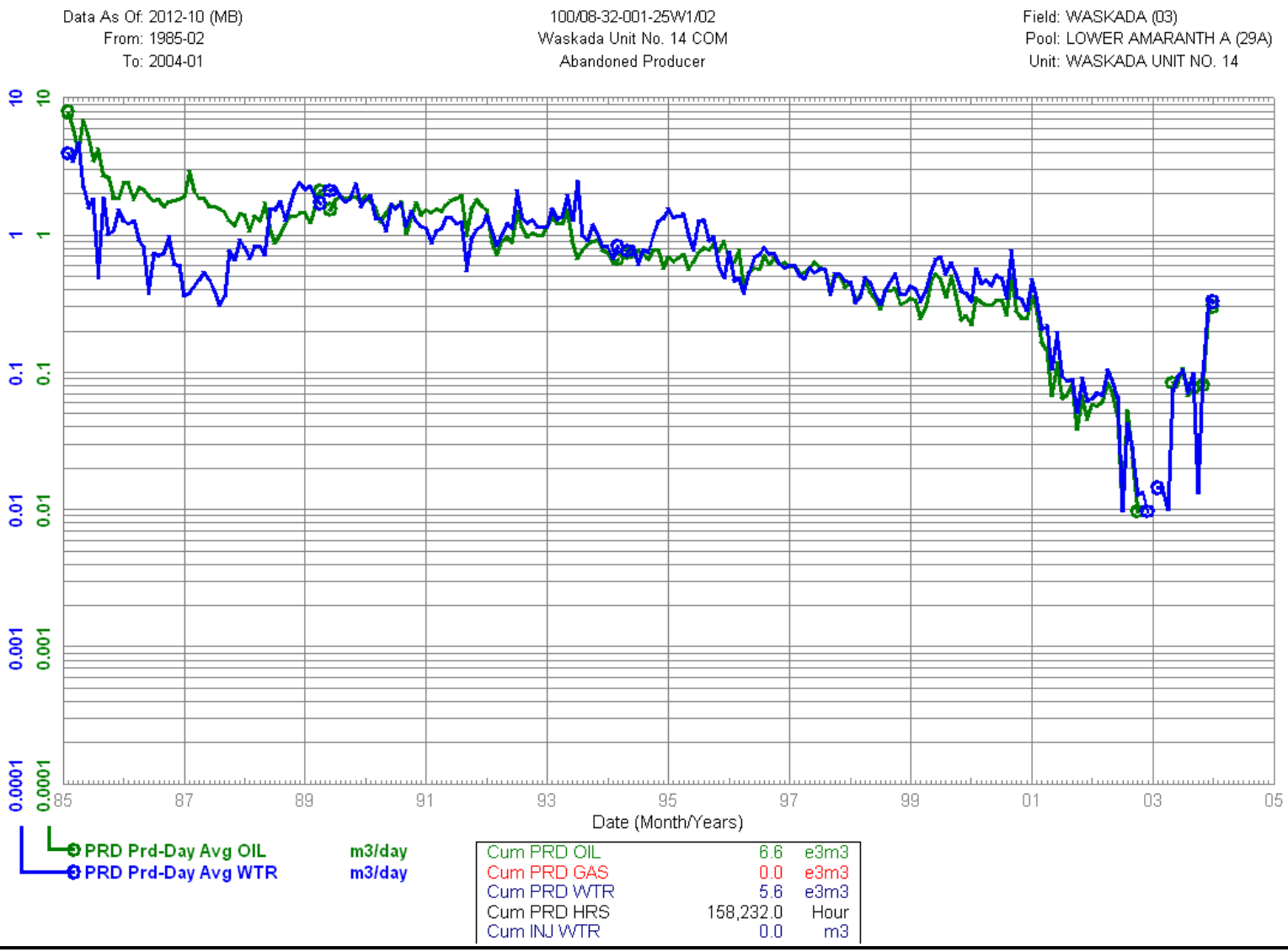

Data As Of: 2012-10 (MB)
From: 1985-11
To: 1989-05
100/02-32-001-25W1/00
Omega et al Waskada
Abandoned Producer
Field: WASKADA (03)
Pool: LOWER AMARANTH A (29A)
Unit: WASKADA UNIT NO. 14
100
10
1
0.1
0.01
0.001
10
1
0.1
0.01
0.001
0.0001
85
86
87
88
89
90
Date (Month/Years)
PRD Prd-Day Avg OIL m3/day
PRD Prd-Day Avg WTR m3/day
Cum PRD OIL 526.9 m3
Cum PRD GAS 0.0 e3m3
Cum PRD WTR 2.7 e3m3
Cum PRD HRS 22,516.8 Hour
Cum INJ WTR 0.0 m3

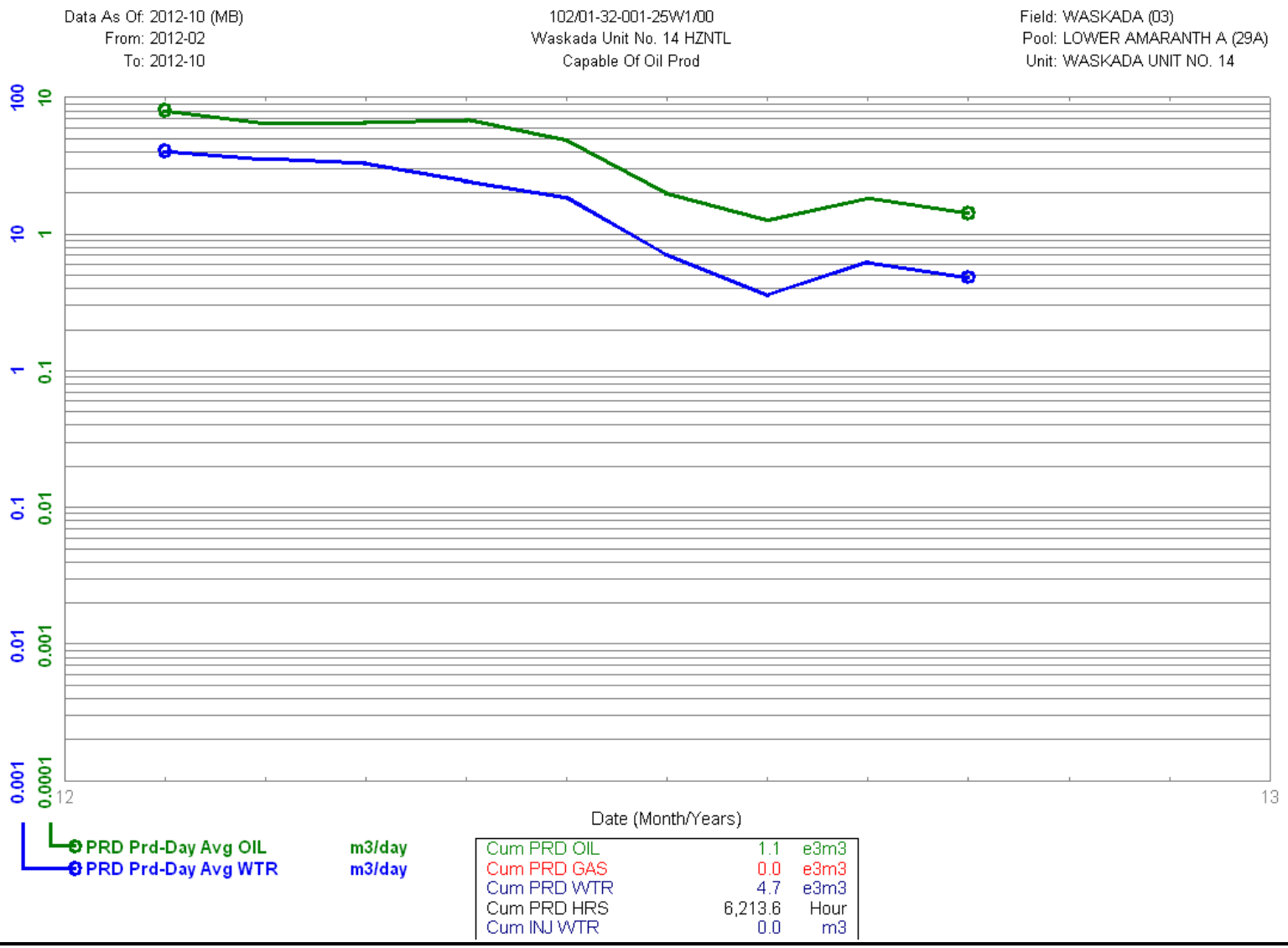

Data As Of: 2012-10 (MB)
From: 1984-06
To: 2001-03
100/04-32-001-25W1/00
Waskada Unit No. 14
Capable Of Oil Prod
Field: WASKADA (03)
Pool: LOWER AMARANTH A (29A)
Unit: WASKADA UNIT NO. 14
100
10
1
0.1
0.01
0.001
10
1
0.1
0.01
0.001
0.0001
84
86
88
90
92
94
96
98
00
02
Date (Month/Years)
PRD Prd-Day Avg OIL m3/day
PRD Prd-Day Avg WTR m3/day
Cum PRD OIL 5.5 e3m3
Cum PRD GAS 0.0 e3m3
Cum PRD WTR 15.7 e3m3
Cum PRD HRS 135,031.2 Hour
Cum INJ WTR 0.0 m3

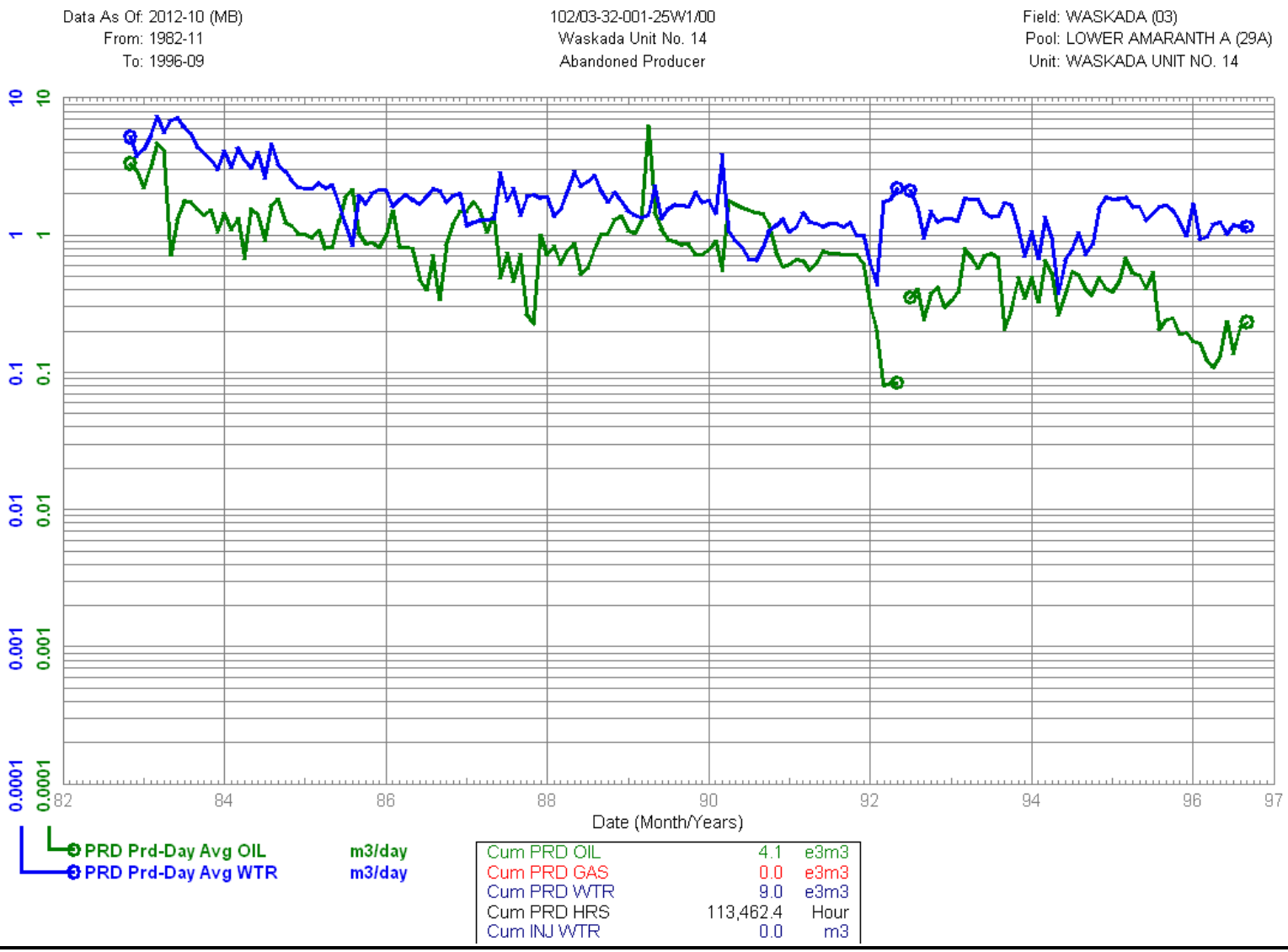

Data As Of: 2012-10 (MB)
From: 1984-06
To: 1988-02
100/05-32-001-25W1/00
Waskada Unit No. 14 WIW
Abandoned Water Inj Well
Field: WASKADA (03)
Pool: LOWER AMARANTH A (29A)
Unit: WASKADA UNIT NO. 14
100
10
1
0.1
0.01
0.001
10
1
0.1
0.01
0.001
0.0001
84
85
86
87
88
89
90
91
92
93
94
Date (Month/Years)
PRD Prd-Day Avg OIL m3/day
PRD Prd-Day Avg WTR m3/day
Cum PRD OIL 5.3 e3m3
Cum PRD GAS 0.0 e3m3
Cum PRD WTR 14.2 e3m3
Cum PRD HRS 31,476.0 Hour
Cum INJ WTR 23.0 e3m3

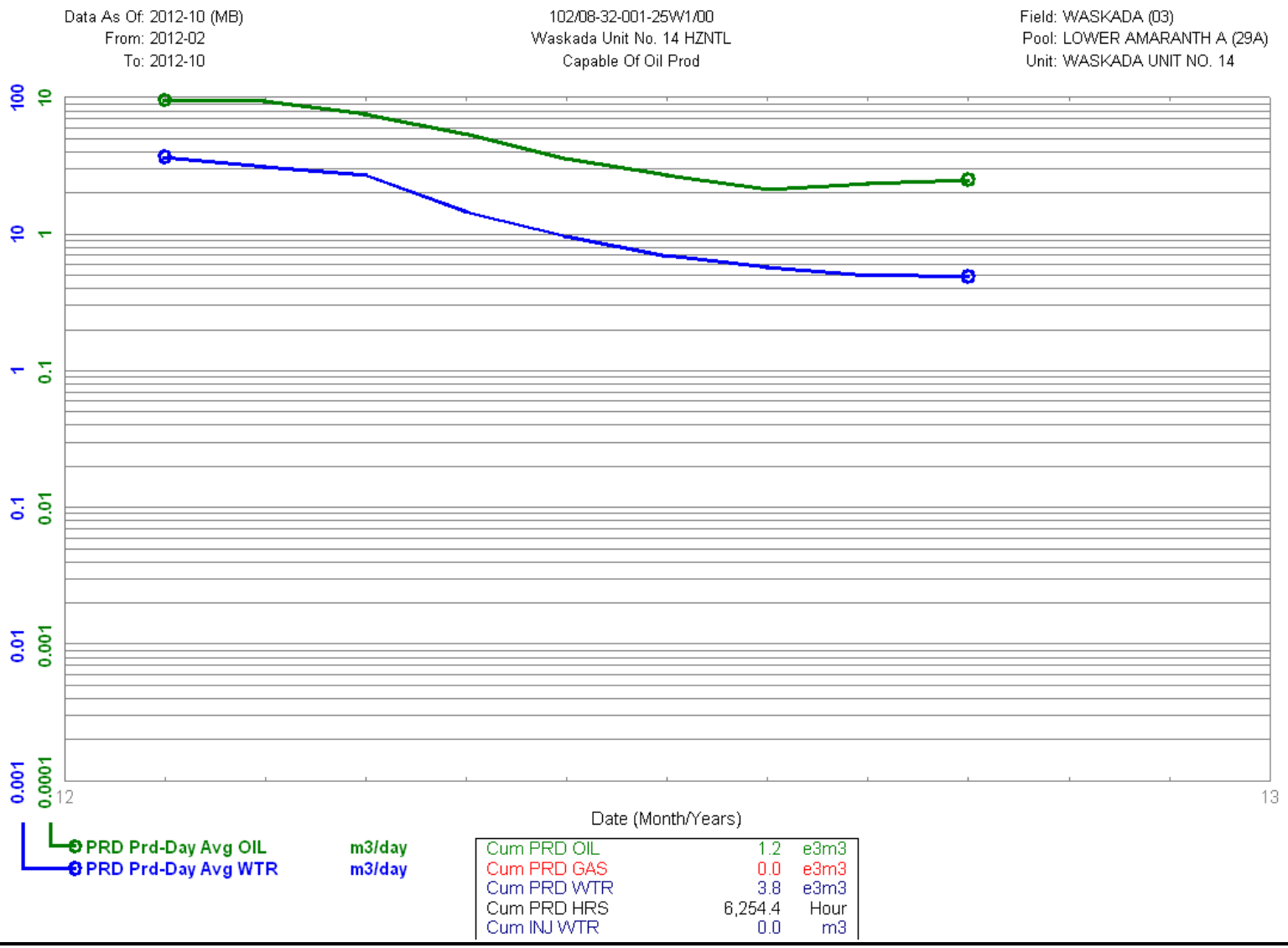

Data As Of: 2012-10 (MB)
From: 1985-01
To: 2002-10
100/06-32-001-25W1/00
Waskada Unit No. 14
Abandoned Producer
Field: WASKADA (03)
Pool: LOWER AMARANTH A (29A)
Unit: WASKADA UNIT NO. 14
100
10
1
0.1
0.01
0.001
85
87
89
91
93
95
97
99
01
03
Date (Month/Years)
PRD Prd-Day Avg OIL m3/day
PRD Prd-Day Avg WTR m3/day
Cum PRD OIL 5.1 e3m3
Cum PRD GAS 0.0 e3m3
Cum PRD WTR 6.3 e3m3
Cum PRD HRS 85,713.6 Hour
Cum INJ WTR 0.0 m3

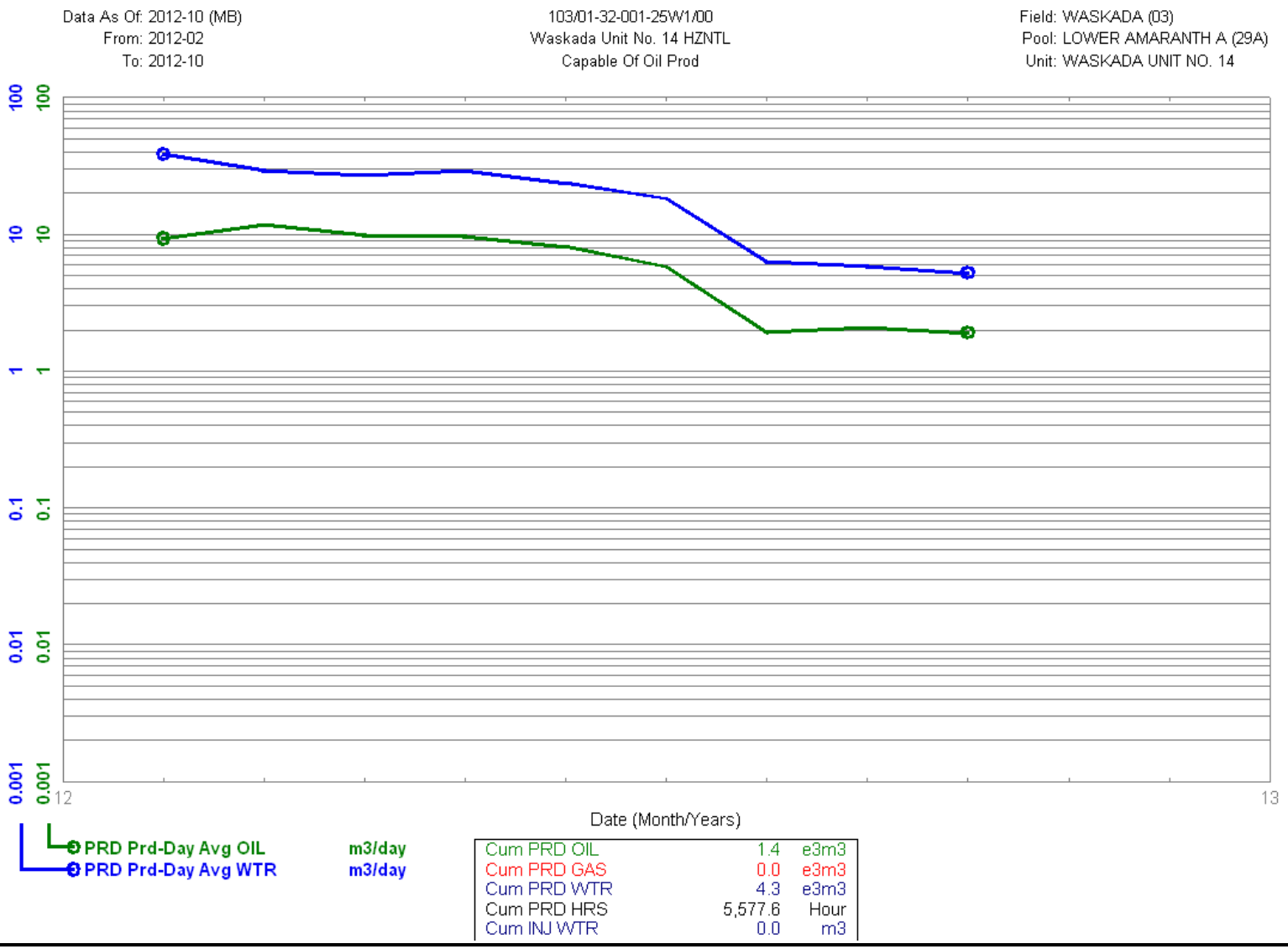

Data As Of: 2012-10 (MB)
From: 1985-09
To: 1988-02
100/07-32-001-25W1/00
Waskada Unit No. 14 WIW
Abandoned Water Inj Well
Field: WASKADA (03)
Pool: LOWER AMARANTH A (29A)
Unit: WASKADA UNIT NO. 14
1
0.1
0.01
0.001
0.0001
0.00001
10
1
0.1
0.01
0.001
0.0001
85
86
87
88
89
90
91
92
93
94
Date (Month/Years)
PRD Prd-Day Avg OIL m3/day
PRD Prd-Day Avg WTR m3/day
Cum PRD OIL 605.7 m3
Cum PRD GAS 0.0 e3m3
Cum PRD WTR 249.7 m3
Cum PRD HRS 14,784.0 Hour
Cum INJ WTR 25.6 e3m3

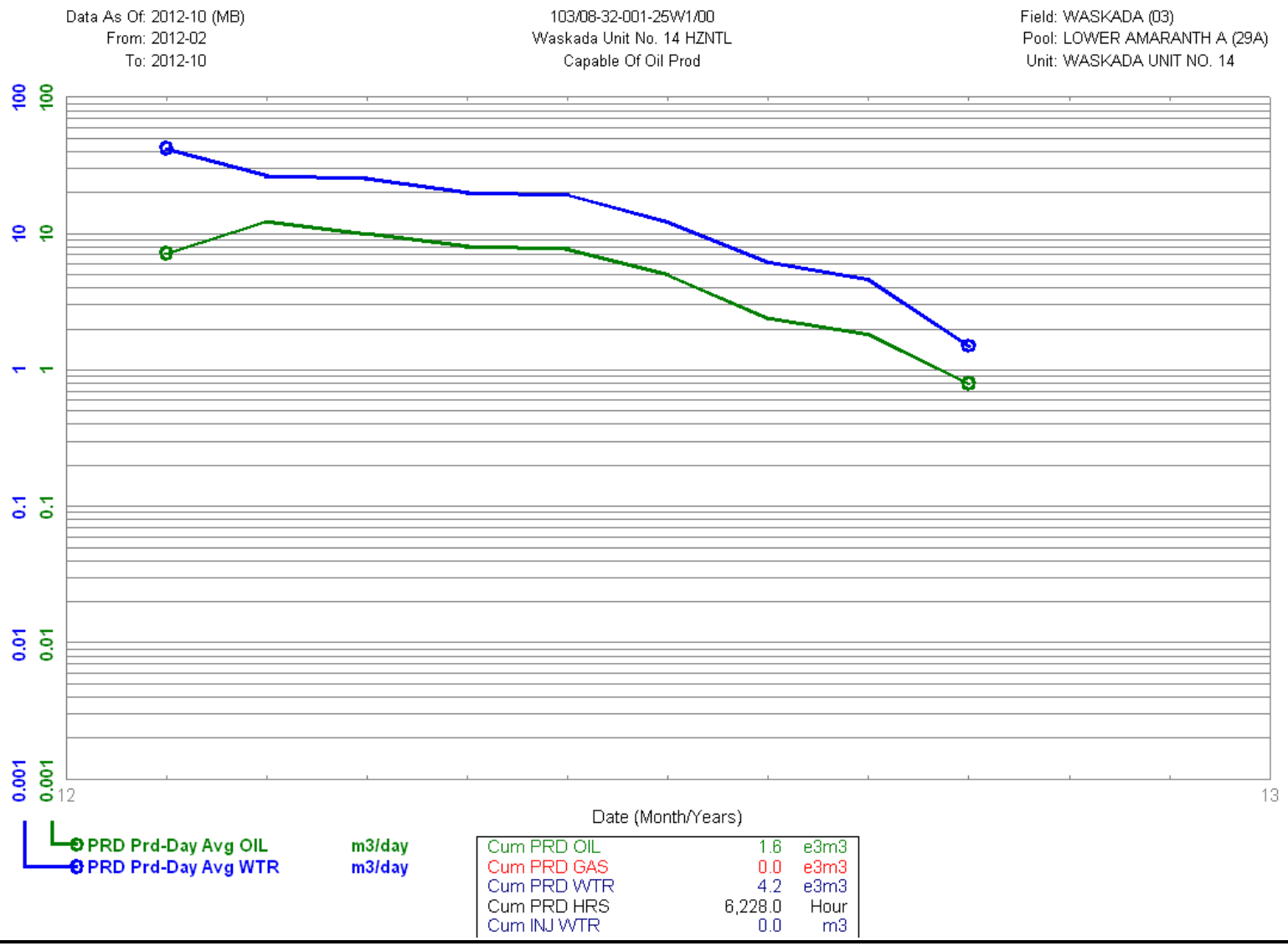

Data As Of: 2012-10 (MB)
From: 1985-02
To: 2004-01
100/08-32-001-25W1/02
Waskada Unit No. 14 COM
Abandoned Producer
Field: WASKADA (03)
Pool: LOWER AMARANTH A (29A)
Unit: WASKADA UNIT NO. 14
10
1
0.1
0.01
0.001
0.0001
85
87
89
91
93
95
97
99
01
03
05
Date (Month/Years)
PRD Prd-Day Avg OIL m3/day
PRD Prd-Day Avg WTR m3/day
Cum PRD OIL 6.6 e3m3
Cum PRD GAS 0.0 e3m3
Cum PRD WTR 5.6 e3m3
Cum PRD HRS 158,232.0 Hour
Cum INJ WTR 0.0 m3

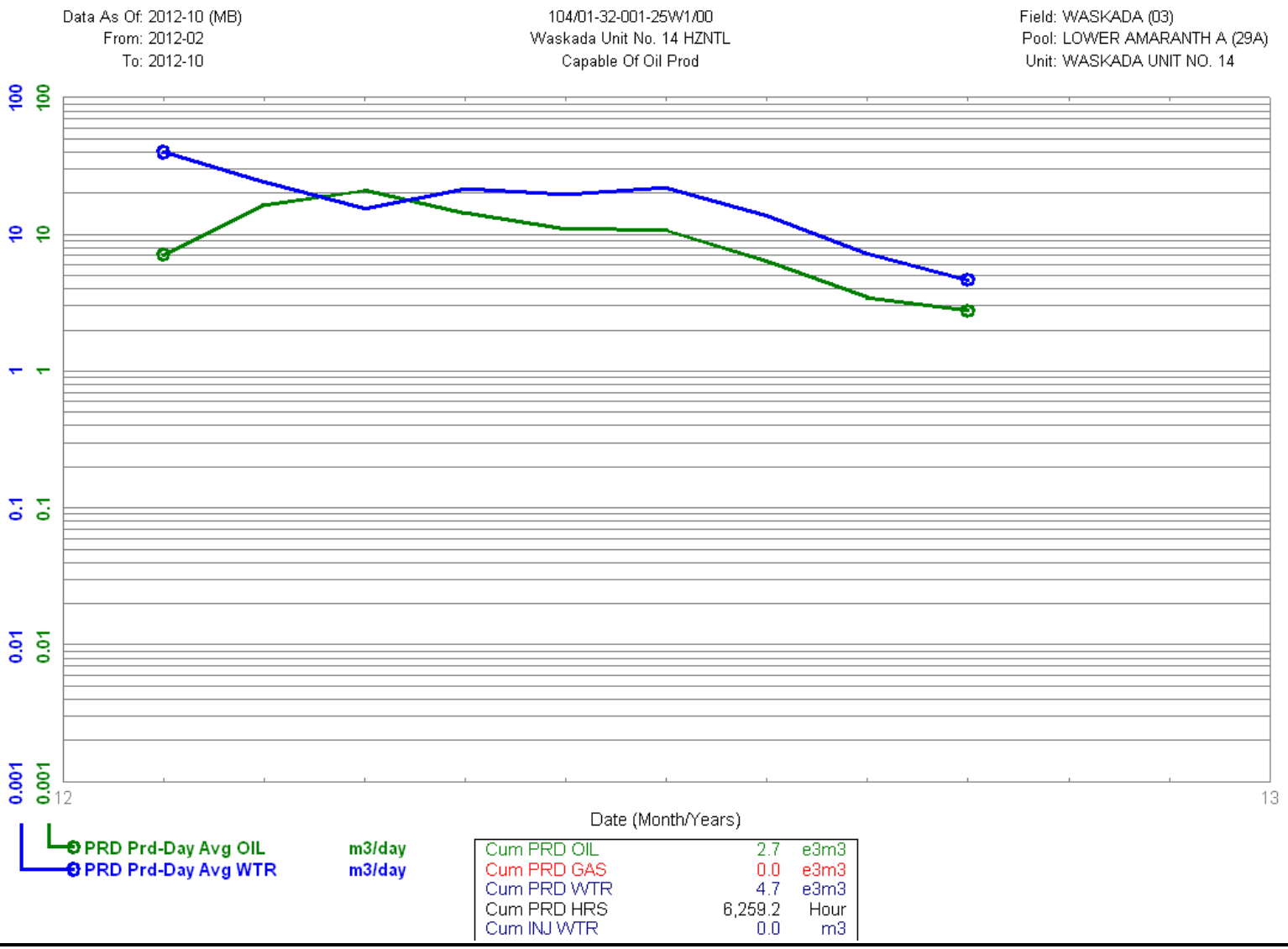

Data As Of: 2012-10 (MB)
From: 2012-02
To: 2012-10
102/01-32-001-25W1/00
Waskada Unit No. 14 HZNTL
Capable Of Oil Prod
Field: WASKADA (03)
Pool: LOWER AMARANTH A (29A)
Unit: WASKADA UNIT NO. 14
100
10
1
0.1
0.01
0.001
10
1
0.1
0.01
0.001
0.0001
12
13
Date (Month/Years)
PRD Prd-Day Avg OIL m3/day
PRD Prd-Day Avg WTR m3/day
Cum PRD OIL 1.1 e3m3
Cum PRD GAS 0.0 e3m3
Cum PRD WTR 4.7 e3m3
Cum PRD HRS 6,213.6 Hour
Cum INJ WTR 0.0 m3

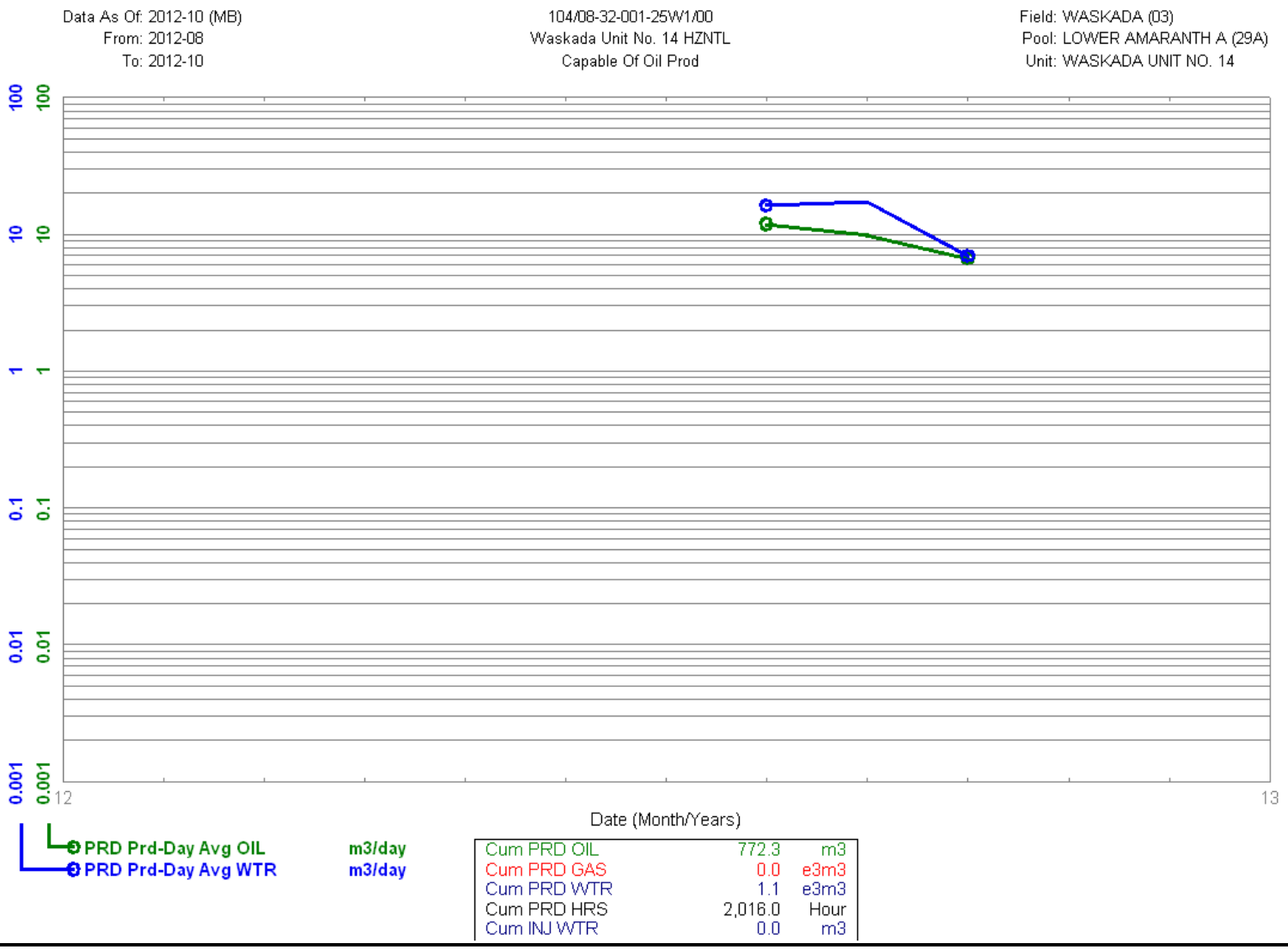

Data As Of: 2012-10 (MB)
From: 1982-11
To: 1996-09
102/03-32-001-25W1/00
Waskada Unit No. 14
Abandoned Producer
Field: WASKADA (03)
Pool: LOWER AMARANTH A (29A)
Unit: WASKADA UNIT NO. 14
10
1
0.1
0.01
0.001
0.0001
82
84
86
88
90
92
94
96
97
Date (Month/Years)
PRD Prd-Day Avg OIL m3/day
PRD Prd-Day Avg WTR m3/day
Cum PRD OIL 4.1 e3m3
Cum PRD GAS 0.0 e3m3
Cum PRD WTR 9.0 e3m3
Cum PRD HRS 113,462.4 Hour
Cum INJ WTR 0.0 m3


Data As Of: 2012-10 (MB)
From: 2012-02
To: 2012-10
102/08-32-001-25W1/00
Waskada Unit No. 14 HZNTL
Capable Of Oil Prod
Field: WASKADA (03)
Pool: LOWER AMARANTH A (29A)
Unit: WASKADA UNIT NO. 14
100
10
1
0.1
0.01
0.001
10
1
0.1
0.01
0.001
0.0001
12
13
Date (Month/Years)
PRD Prd-Day Avg OIL m3/day
PRD Prd-Day Avg WTR m3/day
Cum PRD OIL 1.2 e3m3
Cum PRD GAS 0.0 e3m3
Cum PRD WTR 3.8 e3m3
Cum PRD HRS 6,254.4 Hour
Cum INJ WTR 0.0 m3


Data As Of: 2012-10 (MB)
From: 2012-02
To: 2012-10
103/01-32-001-25W1/00
Waskada Unit No. 14 HZNTL
Capable Of Oil Prod
Field: WASKADA (03)
Pool: LOWER AMARANTH A (29A)
Unit: WASKADA UNIT NO. 14
100
10
1
0.1
0.01
0.001
12
13
Date (Month/Years)
PRD Prd-Day Avg OIL m3/day
PRD Prd-Day Avg WTR m3/day
Cum PRD OIL 1.4 e3m3
Cum PRD GAS 0.0 e3m3
Cum PRD WTR 4.3 e3m3
Cum PRD HRS 5,577.6 Hour
Cum INJ WTR 0.0 m3


Data As Of: 2012-10 (MB)
From: 2012-02
To: 2012-10
103/08-32-001-25W1/00
Waskada Unit No. 14 HZNTL
Capable Of Oil Prod
Field: WASKADA (03)
Pool: LOWER AMARANTH A (29A)
Unit: WASKADA UNIT NO. 14
100
10
1
0.1
0.01
0.001
12
13
Date (Month/Years)
PRD Prd-Day Avg OIL m3/day
PRD Prd-Day Avg WTR m3/day
Cum PRD OIL 1.6 e3m3
Cum PRD GAS 0.0 e3m3
Cum PRD WTR 4.2 e3m3
Cum PRD HRS 6,228.0 Hour
Cum INJ WTR 0.0 m3


Data As Of: 2012-10 (MB)
From: 2012-02
To: 2012-10
104/01-32-001-25W1/00
Waskada Unit No. 14 HZNTL
Capable Of Oil Prod
Field: WASKADA (03)
Pool: LOWER AMARANTH A (29A)
Unit: WASKADA UNIT NO. 14
100
10
1
0.1
0.01
0.001
12
13
Date (Month/Years)
PRD Prd-Day Avg OIL m3/day
PRD Prd-Day Avg WTR m3/day
Cum PRD OIL 2.7 e3m3
Cum PRD GAS 0.0 e3m3
Cum PRD WTR 4.7 e3m3
Cum PRD HRS 6,259.2 Hour
Cum INJ WTR 0.0 m3


Data As Of: 2012-10 (MB)
From: 2012-08
To: 2012-10
104/08-32-001-25W1/00
Waskada Unit No. 14 HZNTL
Capable Of Oil Prod
Field: WASKADA (03)
Pool: LOWER AMARANTH A (29A)
Unit: WASKADA UNIT NO. 14
100
10
1
0.1
0.01
0.001
12
13
Date (Month/Years)
PRD Prd-Day Avg OIL m3/day
PRD Prd-Day Avg WTR m3/day
Cum PRD OIL 772.3 m3
Cum PRD GAS 0.0 e3m3
Cum PRD WTR 1.1 e3m3
Cum PRD HRS 2,016.0 Hour
Cum INJ WTR 0.0 m3