

**CANADIAN NATURAL RESOURCES**

**Approval No. 9467  
North Horsetail Waterflood Pilot**

**Performance Presentation 4**

**ENHANCED RECOVERY OF CRUDE BITUMEN BY WATER INJECTION  
Athabasca Wabiskaw-McMurray Oil Sands Deposit  
Brintnell Area**

22-Sep-05

Presented by: Robin Zabek, Michael Moriarty, Stephen Terry

## Approval No. 9467 Summary

- Waterflood Demonstration of the Wabiskaw zone in the Brintnell Area at 082-22W4
- 12 Horizontal Water Injection Wells
- 16 Horizontal Production Wells plus 1 Horizontal Road Well (Road Well shut-in)
- 200 meter Well Spacing
- 2 Grosmont Water Source Wells with current capacity of 4800 m<sup>3</sup>/day
- Grosmont Water is approximately 0.1% H<sub>2</sub>S

## Summary of Activities and Operations

Dec 2002 Submitted Application No. 1287680 for Enhanced Recovery by Water Injection

Jan-May 2003 12 Injection Well Conversions

Jan-Apr 2003 Drill and Complete 2 Grosmont Water Source Wells  
00/06-02-082-22W4, 03/14-11-082-22W4

Apr-May 2003 Submit G-51 Applications for 12 Water Injectors

May 2003 Additional Information Request for Application No. 1287680

Jun-03 Prelim approval received, Injection into 12 injectors commences

Jul 2003 Approval No. 9467 Issued; injection target 225 m<sup>3</sup>/day/well

Aug 2003 Increase Water Source Deliverability

Aug-03 First Flood response seen 3 months after injection commenced.  
- increase in water production  
- GOR on field decreases

Sep-Oct 2003 Increase Injection Target to 375 m<sup>3</sup>/day/well

Oct 2003 Chemical Tracers Injected into 12 Water Injectors

Feb 2004 Stabilization of oil decline. From this point Oil production begins to increase

Apr 2004 Fill up stage on several patterns considered complete, pattern balancing begun

## Scheme Performance

- Water injection rate started at 225 m<sup>3</sup>/day/well at 0 injection pressure
- Water Injection rates currently averaging 165 m<sup>3</sup>/day/well with surface injection pressure averaging 850 kPa; maximum allowable injection pressure is 3500 kPa

- Cumulative Injection to Sept 17th, 2005 is 2,148,325 m<sup>3</sup> (average 179,019 m<sup>3</sup>/well)
- Best overall response on west side of flood. Wells being optimized.  
Good response in northeast quadrant of flood. Wells being optimized.  
Southeast quadrant of flood experienced early breakthrough. Area closest to gas cap - potential pathway contributing to fingering. With controlled injection rates and balanced voidage replacement, southeast wells have begun producing oil.
- 2 Grosmont water source wells. Currently only one operating/required.  
Current injection rate 1730 m<sup>3</sup>/day.
- OOIP for Waterflood patterns: 68.9 mmstb (10.95 e6m<sup>3</sup>)
- Primary Recovery Factor: 6.5%
- Incremental Waterflood Recovery Factor: 7.5% to 10%
- Cumulative Reservoir VRR to Sept 17th, 2005: 0.31
- Cumulative Liquid VRR to Sept 17th, 2005: 2.85

#### **Challenges and New Findings**

- Tracer data indicated that water was travelling from East side to West side via road well.  
Road well shut-in indefinitely.
- Water was fingering prematurely from injectors to producers, particularly in the SE quadrant of the flood. This can be seen by water cuts which reached 100% in some producing wells. Proximity to a gas cap may have contributed to early breakthrough. Through Q2 and Q3 2005, controlled injection and balanced voidage replacement have resulted in oil production from previously wet wells.
- One north-south well (2B-04-82-22W4) that offsets the flood continues to show flood response.
- Facilities have been debottlenecked, including upsizing transfer pump at NHP9 and upgrading North Brintnell battery. Oil production from flood has increased from 290 m<sup>3</sup>/day at last report to 430 m<sup>3</sup>/day.

#### **Compliance Issues**

- CNRL is compliant with Regulatory Requirements
- CNRL is compliant with Approval No. 9467 Conditions including the G-51 requirement for a temperature log when the surface injection pressure reaches 2000 kPa.
- CNRL is compliant with Gas Conservation guidelines.
- CNRL Field Staff and Contractors are respecting Landowner/Occupant concerns.

**Future Plans**

- Continue to optimize wells and maintain balanced voidage.
- Reviewing conformance treatments for high water cut wells. EUB approval received for treatment on NHP8. Currently sourcing chemical and mixing equipment.

**Voidage**

INJ WELLNAME	Cum Inj (m3)	Cum Liq VRR	Cum Res VRR
CNRES NHP9-15A BRINTNELL 15-9-82-22	197685	0.89	0.28
CNRES NHP8-10A BRINTNELL 10-9-82-22	116288	0.69	0.29
CNRES NHP8-7A BRINTNELL 7-9-82-22	157026	0.80	0.26
CNRES NHP6-10D BRINTNELL 9-4-82-22	131579	1.44	0.22
CNRES NHP6-7D BRINTNELL 8-4-82-22	136216	1.32	0.31
CNRES NHP5-2D BRINTNELL 2-4-82-22	135529	1.34	0.23
CNRES NHP6-8D BRINTNELL 8-1-82-22	224056	2.16	0.61
CNRES NHP6-9D BRINTNELL 9-1-82-22	223348	2.53	0.37
CNRES NHP7-16D BRINTNELL 16-1-82-22	222139	3.42	0.42
CNRES NHP8-8A BRINTNELL 8-12-82-22	210986	2.02	0.31
CNRES NHP8-9A BRINTNELL 9-12-82-22	212681.7	1.78	0.30
CNRES NHP9-16A BRINTNELL 16-12-82-22	180702	1.57	0.27
TOTAL		2.85	0.31

**Recent Production/Injection**

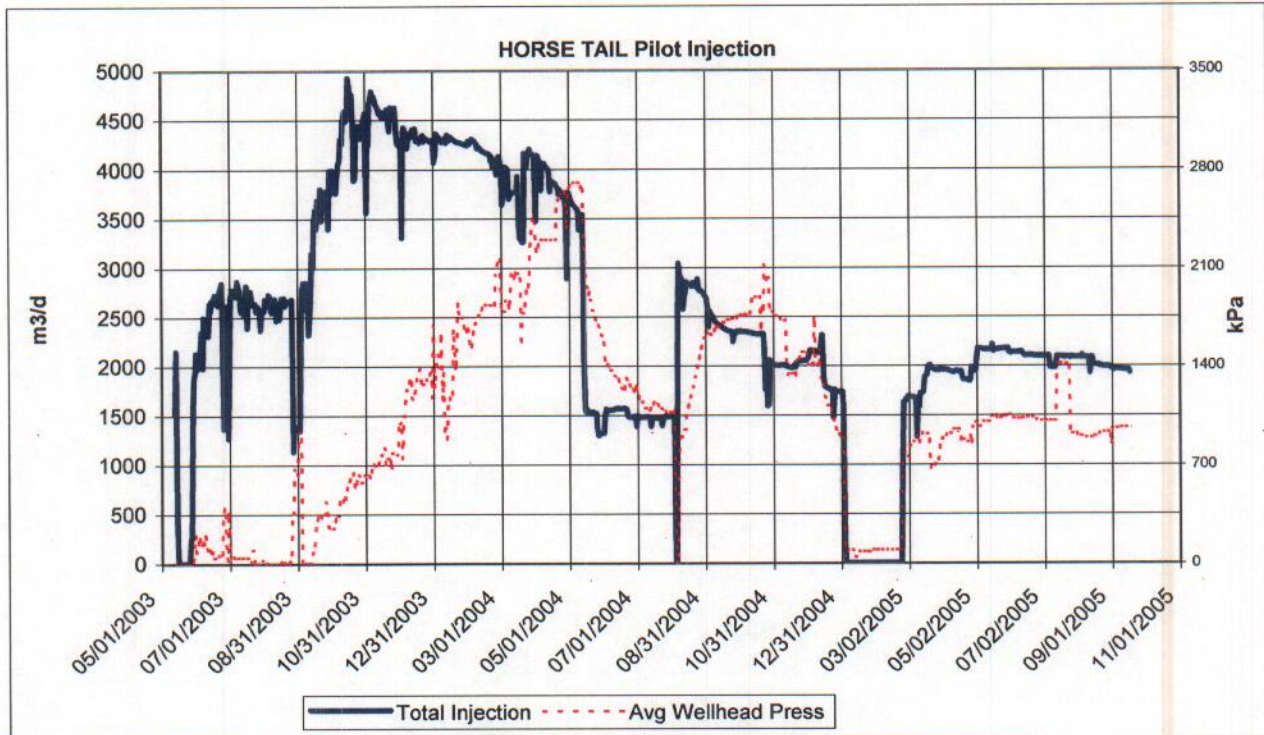
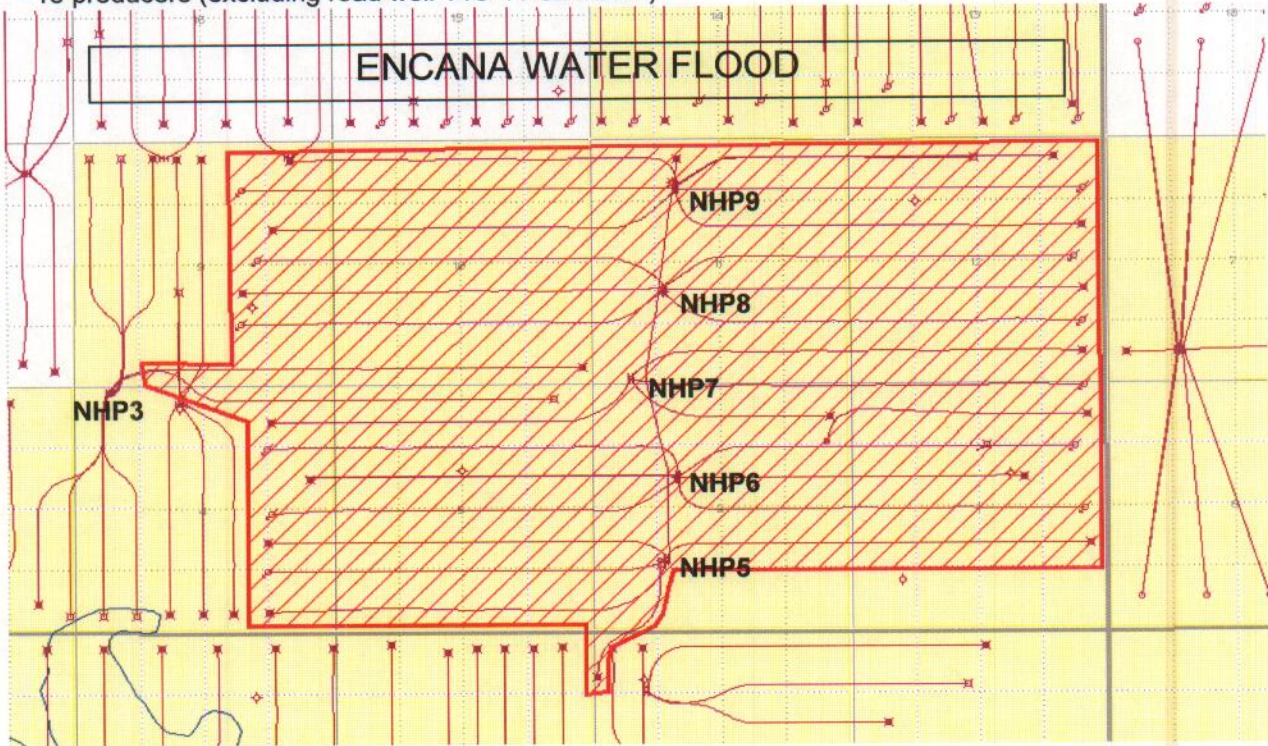
17 Producers/12 Injectors	Water Inj bpd	Oil Prod (bbl/d)	Water Prod (bbl/d)	Gas Prod (mscf/d)	Fluid Prod (bbl/d)	Water Cut (%)
Jun-05	13538	2168	13390	169	15559	86%
Jul-05	13259	2575	13280	152	15856	84%
Aug-05	12997	2783	10659	148	13442	79%

### Recovery Factors

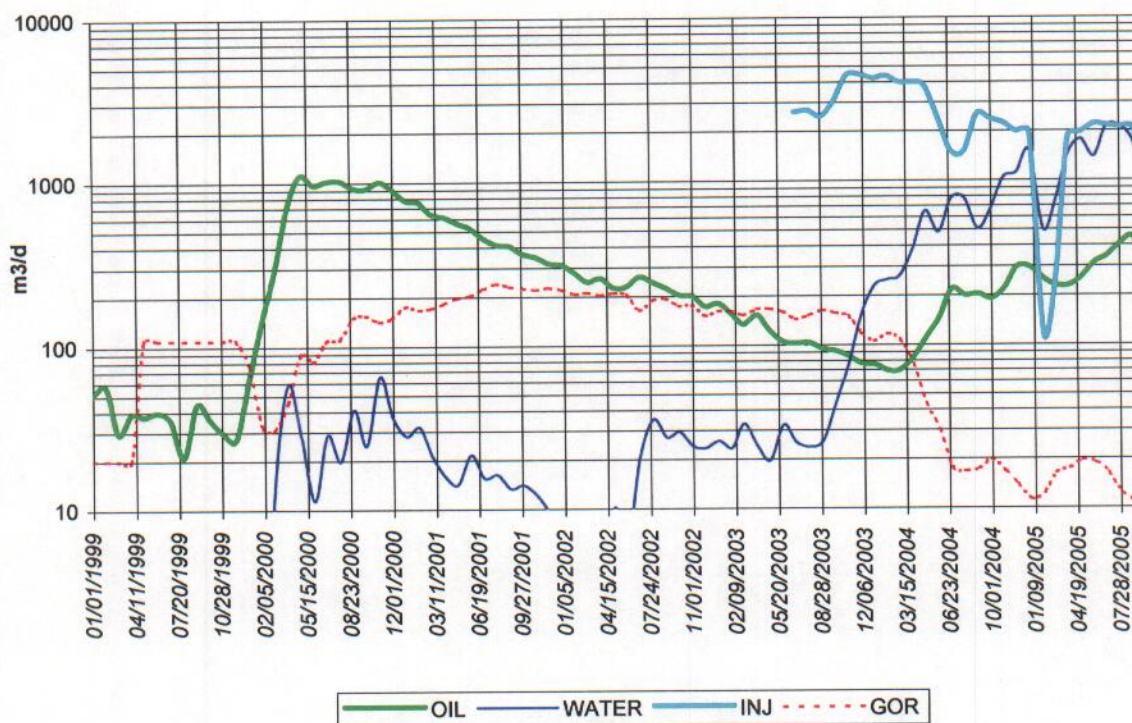
PAD	UWI	OOIP E3m3	Cum Oil Primary m3	Primary RF	Oil Since WF Start m3	Incremental RF on WF
<b>INJECTORS</b>						
NHP06	00/08-01-082-22W4/0	488	11,933	2.4%	0	
NHP06	02/09-01-082-22W4/3	479	12,759	2.7%	0	
NHP07	02/16-01-082-22W4/0	514	16,426	3.2%	0	
NHP05	03/02-04-082-22W4/0	433	27,140	6.3%	0	
NHP06	00/08-04-082-22W4/0	459	22,411	4.9%	0	
NHP06	00/09-04-082-22W4/0	433	23,618	5.5%	0	
NHP08	02/07-09-082-22W4/0	456	18,919	4.2%	0	
NHP08	00/10-09-082-22W4/0	425	21,991	5.2%	0	
NHP09	03/15-09-082-22W4/0	460	28,150	6.1%	0	
NHP08	00/08-12-082-22W4/2	469	15,746	3.4%	0	
NHP08	02/09-12-082-22W4/0	467	16,524	3.5%	0	
NHP09	00/16-12-082-22W4/0	462	16,742	3.6%	0	
	Inj Total	5544	232,358		0	
	Inj Average	462	19,363	4.2%	0	
<b>PRODUCERS</b>						
NHP05	02/08-01-082-22W4/0	518	3,717	0.7%	1,091	0.21%
NHP06	03/10-01-082-22W4/0	409	10,411	2.5%	163	0.04%
NHP07A	00/16-01-082-22W4/0	307	2,634	0.9%	640	0.21%
NHP07	00/16-02-082-22W4/0	215	14,745	6.9%	775	0.36%
NHP05	00/01-04-082-22W4/0	463	27,644	6.0%	1,819	0.39%
NHP05	02/07-04-082-22W4/0	439	34,516	7.9%	8,648	1.97%
NHP06	00/10-04-082-22W4/0	397	33,011	8.3%	9,460	2.38%
NHP07	00/16-04-082-22W4/0	380	27,407	7.2%	2,423	0.64%
NHP08	03/07-09-082-22W4/0	445	26,540	6.0%	2,226	0.50%
NHP09	00/09-09-082-22W4/0	436	27,676	6.4%	1,623	0.37%
NHP09	00/16-09-082-22W4/0	406	28,046	6.9%	3,671	0.90%
NHP03	00/01-10-082-22W4/2	944	49,443	5.2%	2,690	0.28%
NHP07	02/01-12-082-22W4/0	508	17,942	3.5%	344	0.00%
NHP08	02/08-12-082-22W4/0	477	16,730	3.5%	291	0.07%
NHP09	03/09-12-082-22W4/0	462	15,819	3.4%	574	0.06%
NHP09	02/16-12-082-22W4/2	431	27,495	6.4%	2,792	0.13%
	Producer Total	7235	363,774		39,232	0.5%
	Producer Average	452	22,736	5.1%	2,452	0.5%

**North Horse Tail Water Flood Pilot**

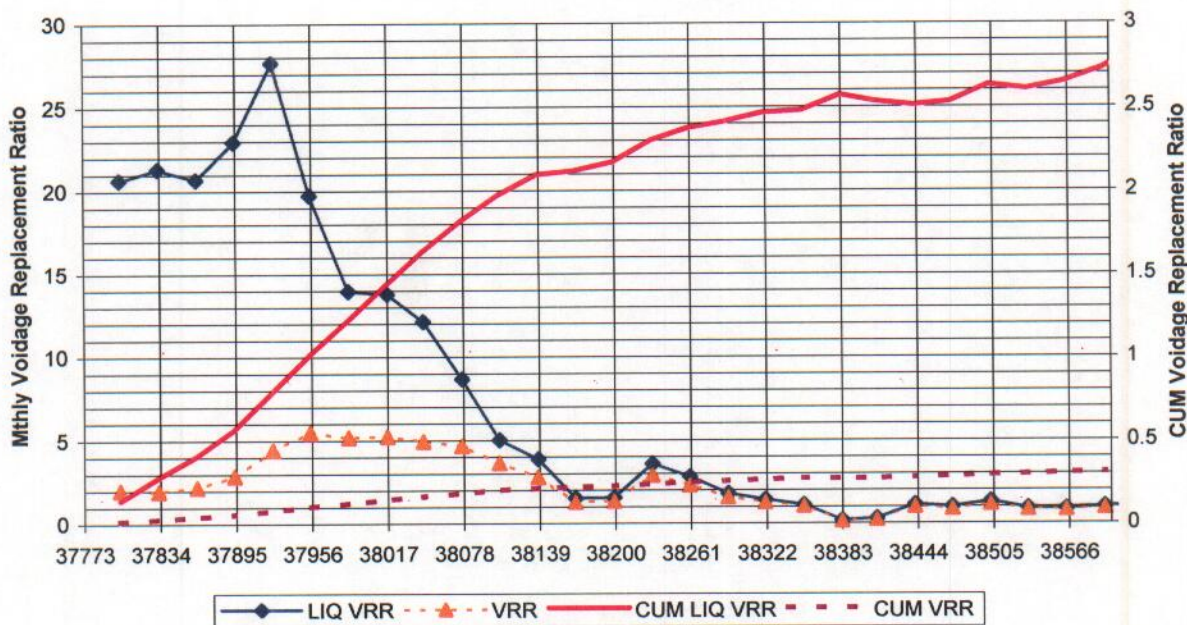
- 12 injectors
- 16 producers (excluding road well 14C-11-82-22W4)



North Horse Tail Water Flood PVR Prorated Prod



NORTH HORSE TAIL Pilot VRR Calculations



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**Performance Presentation 3**

**ENHANCED RECOVERY OF CRUDE BITUMEN BY WATER INJECTION  
Athabasca Wabiskaw-McMurray Oil Sands Deposit  
Brintnell Area**

21-Jan-05

Presented by: Robin Zabek, Sarshar Ahmad, Stephen Terry

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- 12 Horizontal Water Injection Wells
- 16 Horizontal Production Wells plus 1 Horizontal Road Well (Road Well shut-in)
- 200 meter Well Spacing
- 2 Grosmont Water Source Wells with current capacity of 4800 m<sup>3</sup>/day
- Grosmont Water is approximately 0.1% H<sub>2</sub>S

## **Summary of Activities and Operations**

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Aug-03 First Flood response seen 3 months after injection commenced.  
- increase in water production  
- GOR on field decreases

Sep-Oct 2003 Increase Injection Target to 375 m<sup>3</sup>/day/well

Oct 2003 Chemical Tracers Injected into 12 Water Injectors

Feb 2004 Stabilization of oil decline. From this point Oil production begins to increase

Apr 2004 Fill up stage on several patterns considered complete, pattern balancing begun

## **Scheme Performance**

- 
- Water Injection rates currently averaging 165 m<sup>3</sup>/day/well with surface injection

pressure averaging 1300 kPa; maximum allowable injection pressure is 3500 kPa

- Cumulative Injection to Dec 30, 2004 is 1,723,461 m<sup>3</sup> (average 143,622 m<sup>3</sup>/well)

- 

Southeast quadrant of flood experiencing early breakthrough. Area closest to gas cap - potential pathway contributing to fingering. Pumps will be upsized and wells will be optimized.

- 2 Grosmont water source wells. Currently only one operating/required. Current injection rate 1730 m<sup>3</sup>/day.
- OOIP for Waterflood patterns: 68.9 mmstb (10.95 e6m<sup>3</sup>)
- Primary Recovery Factor: 6.5%
- Incremental Waterflood Recovery Factor: 5%
- Cumulative Reservoir VRR to January 5, 2005: 0.25
- Cumulative Liquid VRR to January 5, 2005: 2.53

### **Challenges and New Findings**

- Tracer data indicated that water was travelling from East side to West side via road well. Road well shut-in.
- Water is fingering prematurely from injectors to producers, particularly in the SE quadrant of the flood. This can be seen by water cuts of up to 100% in producing wells. Proximity to a gas cap may be contributing to early breakthrough.
- One north-south well (2B-04-82-22W4) that offsets the NHT flood is showing flood response.
- Facilities have been debottlenecked, including upsizing transfer pump at NHP9 and upgrading North Brintnell battery. Oil production from flood has increased from 190 m<sup>3</sup>/day at last report to 290 m<sup>3</sup>/day. Further increases expected following liner pull currently taking place.

### **Compliance Issues**

- CNRL is compliant with Regulatory Requirements
- CNRL is compliant with Approval No. 9467 Conditions including the G-51 requirement for a temperature log when the surface injection pressure reaches 2000 kPa. Surface injection pressure has reached 2000 kPa on 10 of the 12 injectors and temperature logs have been submitted to the EUB as per G-51 requirements. Injectors 8D-01 and 9A-12 have not yet reached a surface injection pressure of 2000 kPa.
- CNRL is compliant with Gas Conservation guidelines.
- CNRL Field Staff and Contractors are respecting Landowner/Occupant concerns.

**Future Plans**

- Wells being optimized.
- Assessing options/technologies to improve conformance in SE quadrant of flood.
- If pilot is economically successful will be expanded to other areas. Prospective pads include NHP1, NHP2, NHP3 and NHP4.

**Voidage**

INJ WELLNAME	Cum Inj (m3)	Cum Liq VRR	Cum Res VRR
CNRES NHP9-15A BRINTNELL 15-9-82-22	98865	0.74	0.16
CNRES NHP8-10A BRINTNELL 10-9-82-22	85029	0.67	0.23
CNRES NHP8-7A BRINTNELL 7-9-82-22	136638	0.81	0.24
CNRES NHP6-10D BRINTNELL 9-4-82-22	102344	1.32	0.18
CNRES NHP6-7D BRINTNELL 8-4-82-22	107005	1.29	0.25
CNRES NHP5-2D BRINTNELL 2-4-82-22	105501	1.19	0.18
CNRES NHP6-8D BRINTNELL 8-1-82-22	221506	3.96	0.75
CNRES NHP6-9D BRINTNELL 9-1-82-22	200281	4.33	0.36
CNRES NHP7-16D BRINTNELL 16-1-82-22	192137	5.13	0.40
CNRES NHP8-8A BRINTNELL 8-12-82-22	162977	2.66	0.26
CNRES NHP8-9A BRINTNELL 9-12-82-22	159779.7	2.05	0.24
CNRES NHP9-16A BRINTNELL 16-12-82-22	124935	1.44	0.19
TOTAL		2.55	0.26

**Recent Production/Injection**

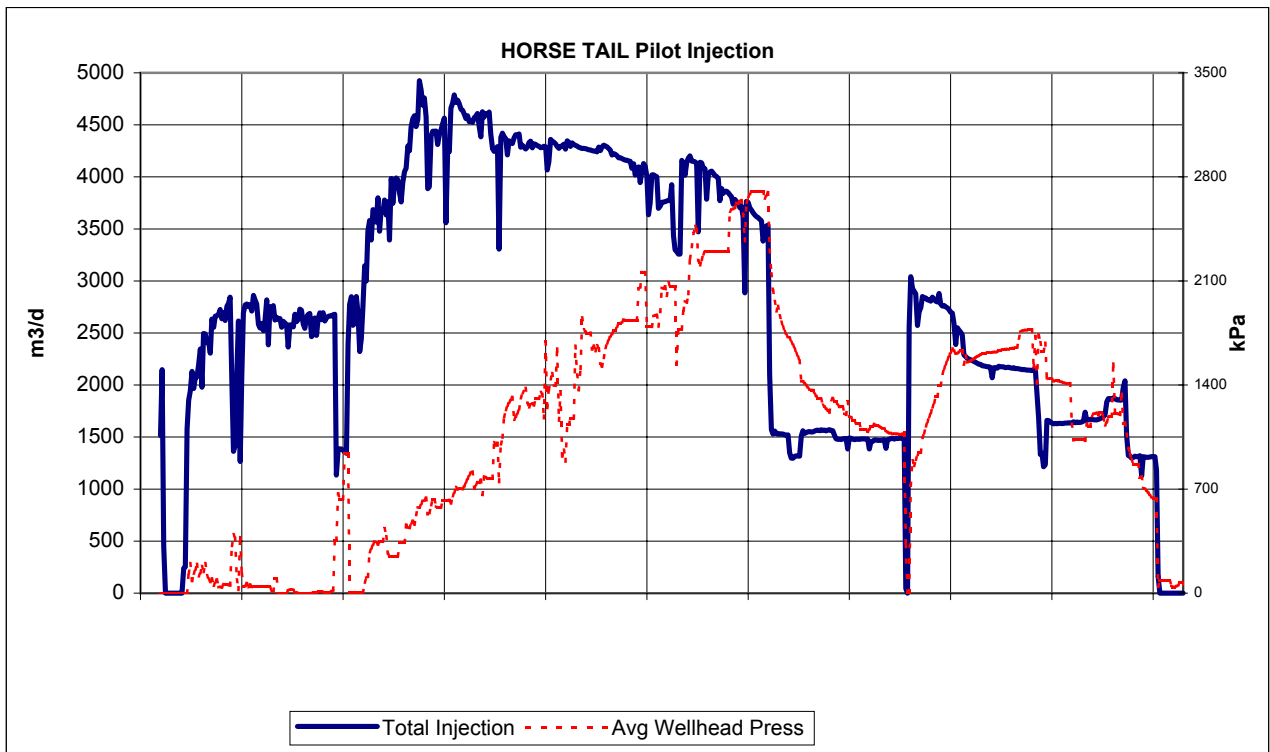
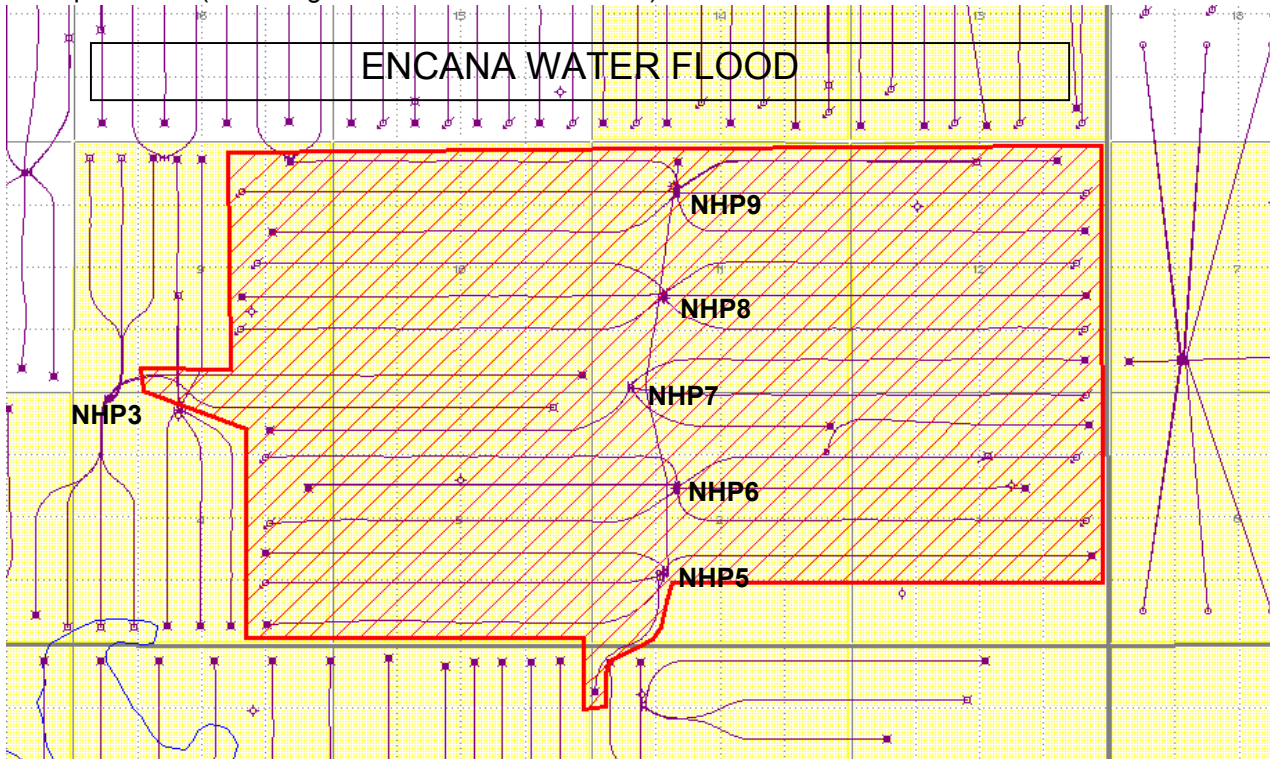
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Dec 11 - Dec 17	12882	1870	9574	113	11444	84%
Dec 18 - Dec 24	10828	1801	9938	101	11739	85%
Dec 25 - Dec 31	10941	1843	9748	95	11591	84%

**Recovery Factors**

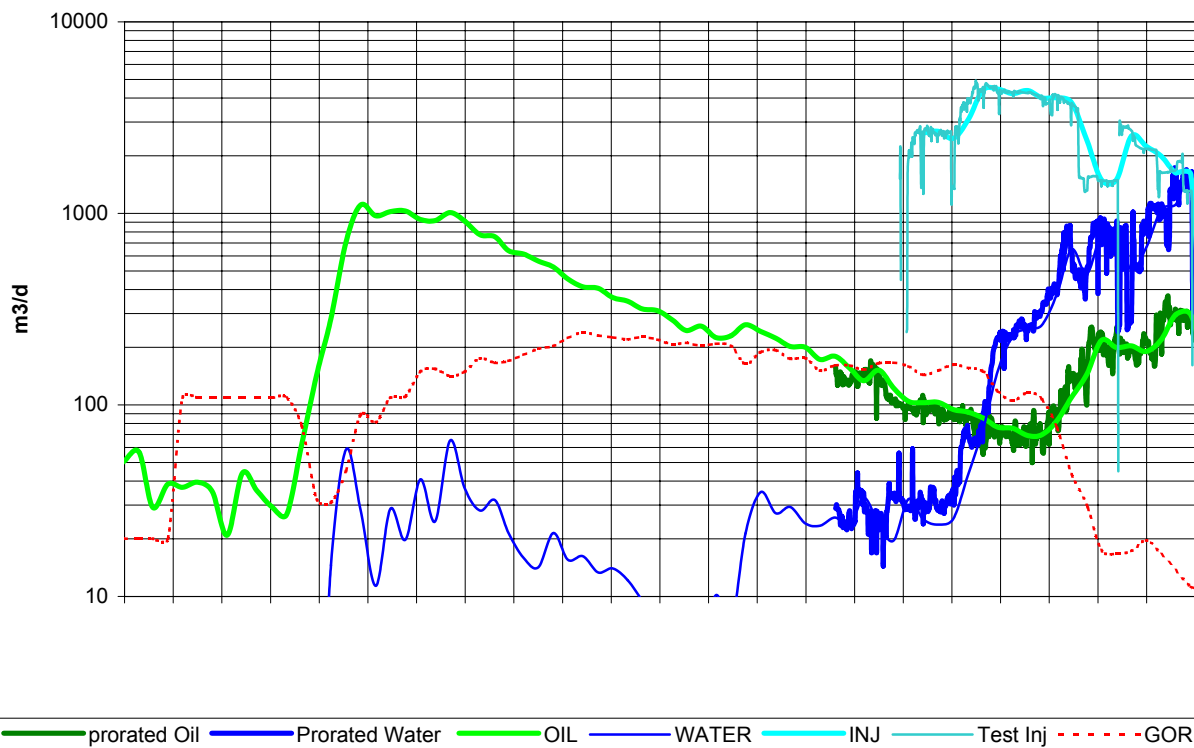
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North Horse Tail Water Flood PVR Prorated Prod



NORTH HORSE TAIL Pilot VRR Calculations

