Energy and Environmental Systems Group
Institue for Sustainable Energy, Environment and Economy (ISEEE)

Aquifer Material Balance

WABAMUN AREA CO_2 SEQUESTRATION PROJECT (WASP)

Author

Rob Lavoie

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1	August 3, 2009	Nisku Oil Pool Aquifer Material Balance Analysis	Rob Lavoie
2	December 21, 2009	Nisku Oil Pool Aquifer Material Balance Analysis	Rob Lavoie

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INTRODUCTION

BACKGROUND

One of the most useful methods of characterizing the quality of a reservoir for its deliverability or injectivity on a regional scale is to make use of analogues from similar or adjacent areas to the area of study. Furthermore, material balance analysis on analogue pools or wells can be conducted to characterize the aquifer that is providing pressure support for them. Moreover, material balance analysis is capable of characterising a very large area of investigation, if an oil or gas pool has been on depletion drive for an extended period of time. The Wabamun Area CO_2 Sequestration Project (WASP) study area is an entire 53 township of land area over top of a large portion of the Nisku aquifer in central Alberta, Figure 1. This study area was chosen intentionally to avoid existing hydrocarbon production. As such, there are no depleted pools or mature oil fields producing from the Nisku horizon in the entire study area.

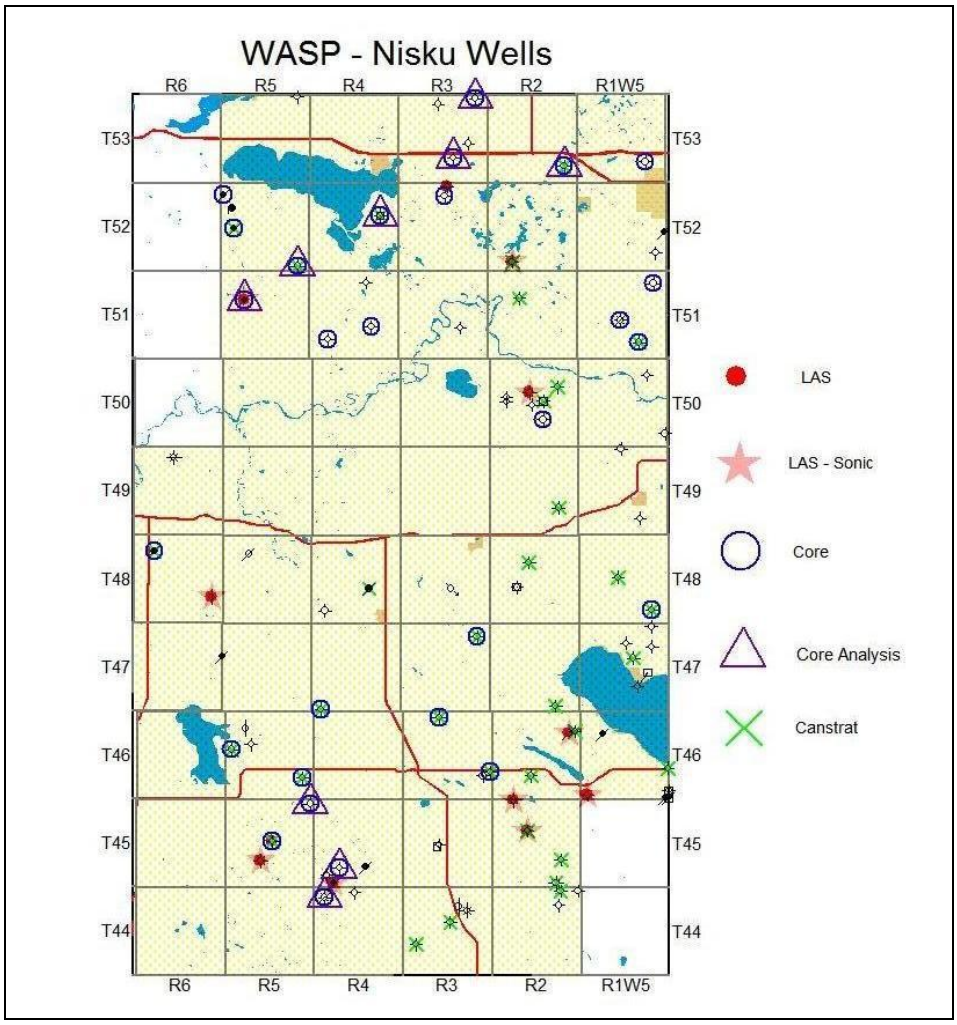

Figure 1: WASP study area.

In an attempt to find additional confirmation of good reservoir quality conditions for the Nisku aquifer, a review of mature oil pools in a study area consisting of 30 townships immediately to the east of the WASP study area was performed. Figure 2 highlights this area along with the locations of six major Nisku oil pools.

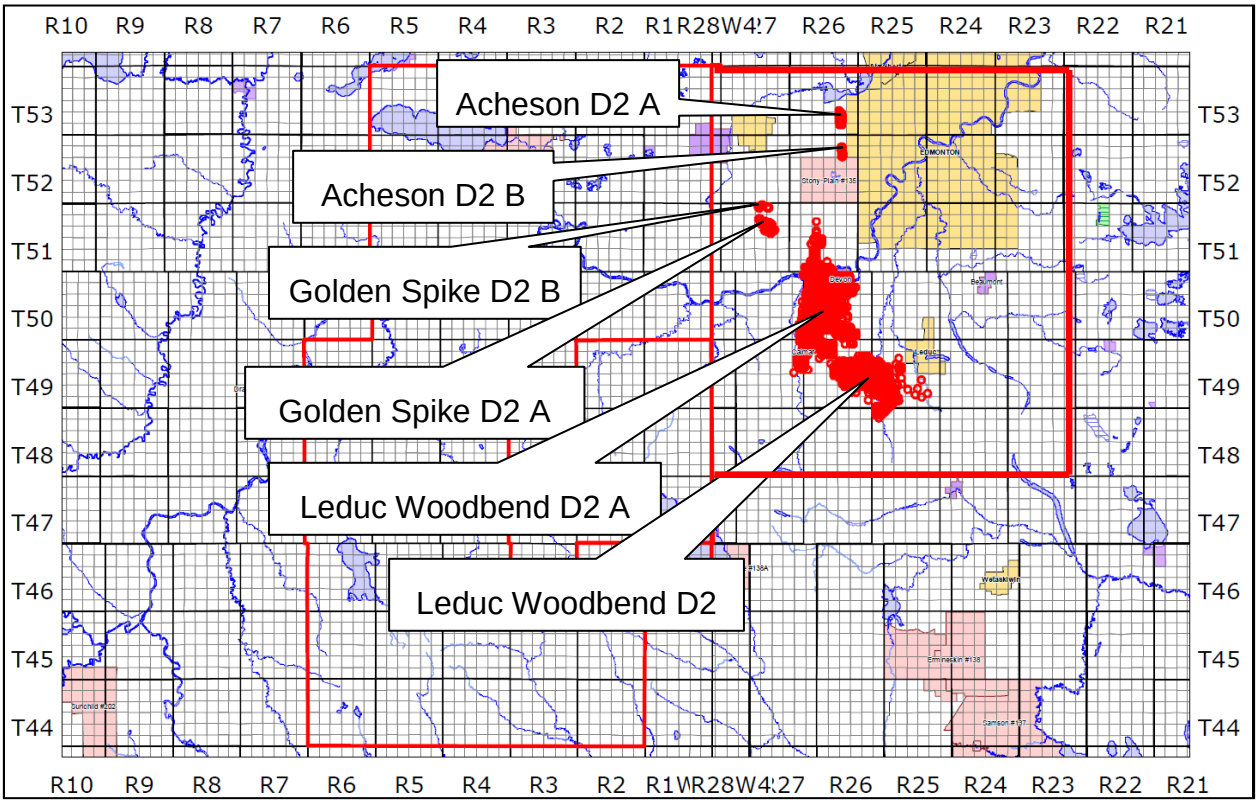

Figure 2: Water disposal well study area.

The discussion that follows provides a summary of attempts to conduct material balance characterizations of the Nisku aquifer for the mature oil pools located in this study area.

DISCUSSION

1. STUDY APPROACH

The rich set of mature oil pools located immediately to the east of the WASP study area compelled one to make the best use of public domain data to characterise the Nisku aquifer from historic production and injection data available at the Energy Resource Conservation Board (ERCB).

The study began with a fact finding mission. Literature reviews were conducted to learn as much as possible about the Nisku reservoirs from existing published engineering papers. The literature search resulted in only minor references to aquifer characterization work or geological information pertaining to the Nisku aquifer.

Given the lack of published results on Nisku aquifer properties, the next best approach is to collect production and injection histories for the oil pools connected to the Nisku aquifer and conduct analytical material balance studies on as many pools as possible. This required a search for reservoir fluid properties—Reservoir Fluid Studies, and production, injection, and pressure

histories on these pools, as well as basic volumetric reserves information for each pool. All of this was available in the ERCB archives.

The reservoir fluid study information, along with production, injection, and pressure histories were entered into Petroleum Expert's MBAL™ application (Reference 1). This application has a rich set of analytical aquifers that can be used to history match the aquifer response to pressure depletion in an oil or gas pool.

Although not all of the pools were easily history matched for a number of reasons discussed in this report, there was an adequate amount of public domain data and results were conclusive enough to make some useful conclusions on aquifer strength, as discussed in the conclusions section of this report.

2. PALEOGEOGRAPHY OF THE WASP STUDY AREA

The red outline in Figure 3 defines the location of the WASP study area. It is located between the Moon Lake Build-ups on the west side and the inboard margin of the Nisku aquifer on the east side. A series of Nisku oil pools extends down the eastern edge of the Nisku aquifer. In fact these oil accumulations are Nisku carbonate reefs that are draping over top of the underlying Leduc D3 reefs. As can be seen in Figure 3 the Nisku pools of interest range from the Big Lake pool in the extreme north down to the Bonnie Glen Pool to the south. Also observable on this diagram is the fact that the inboard margin intersects this trend of Nisku pools at about the level of the Leduc Woodbend pools. This means that pools to the south of Leduc Woodbend D2-A and D2-B will be less well connected to the Nisku aquifer and are less analogous to the type of Nisku reservoir of interest for the WASP study.

Figure 4 provides a cross section of the stratigraphy above and below the Nisku formation. From this diagram it is evident that the Nisku aquifer is located both underneath as bottom water and laterally as edge water to the Nisku oil accumulations. This should provide some indication to the type of analytical aquifer that might best be used to achieve a history match of pressure depletion for oil pools connected to the Nisku aquifer.

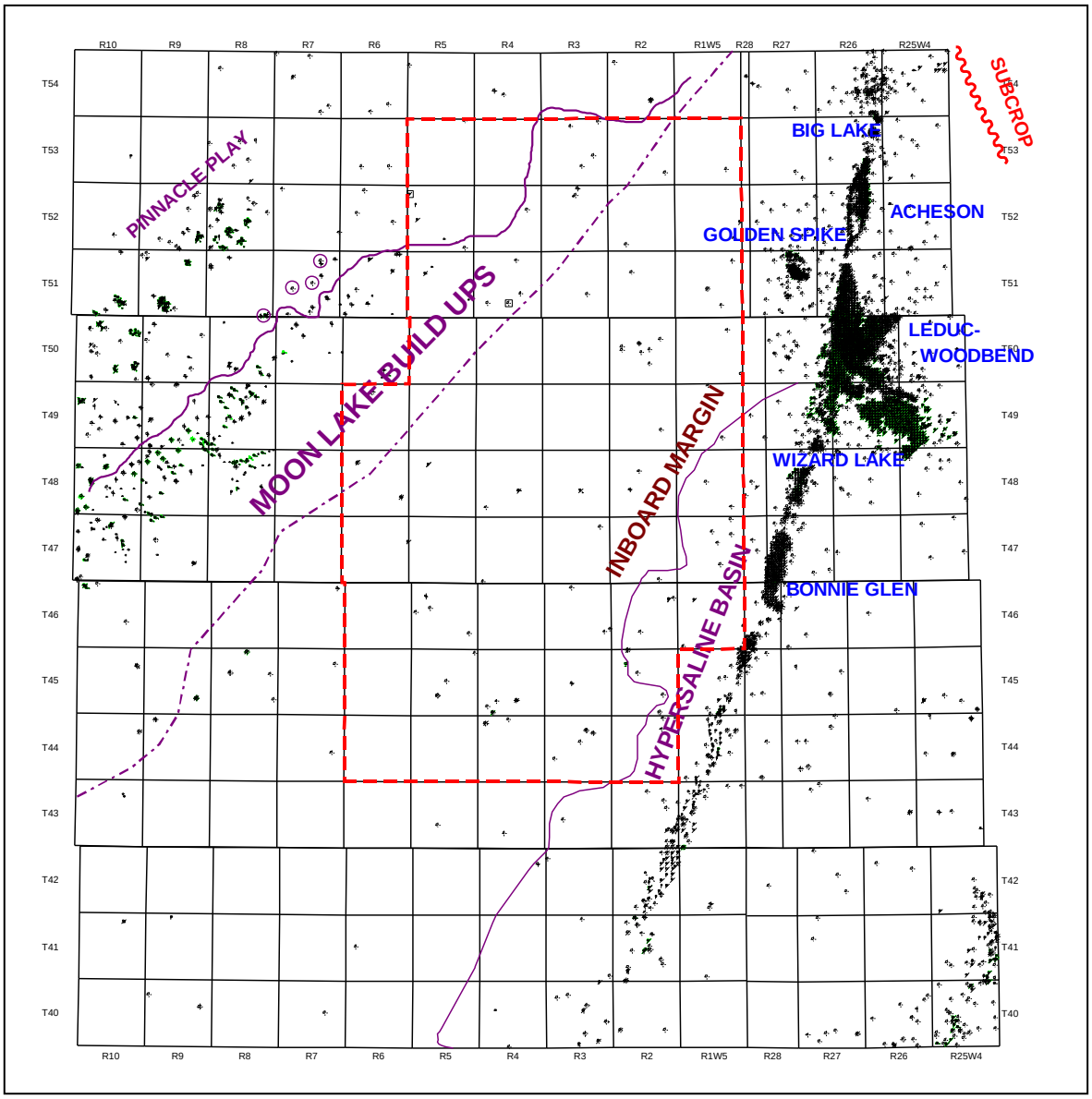

Figure 3: WASP study area.

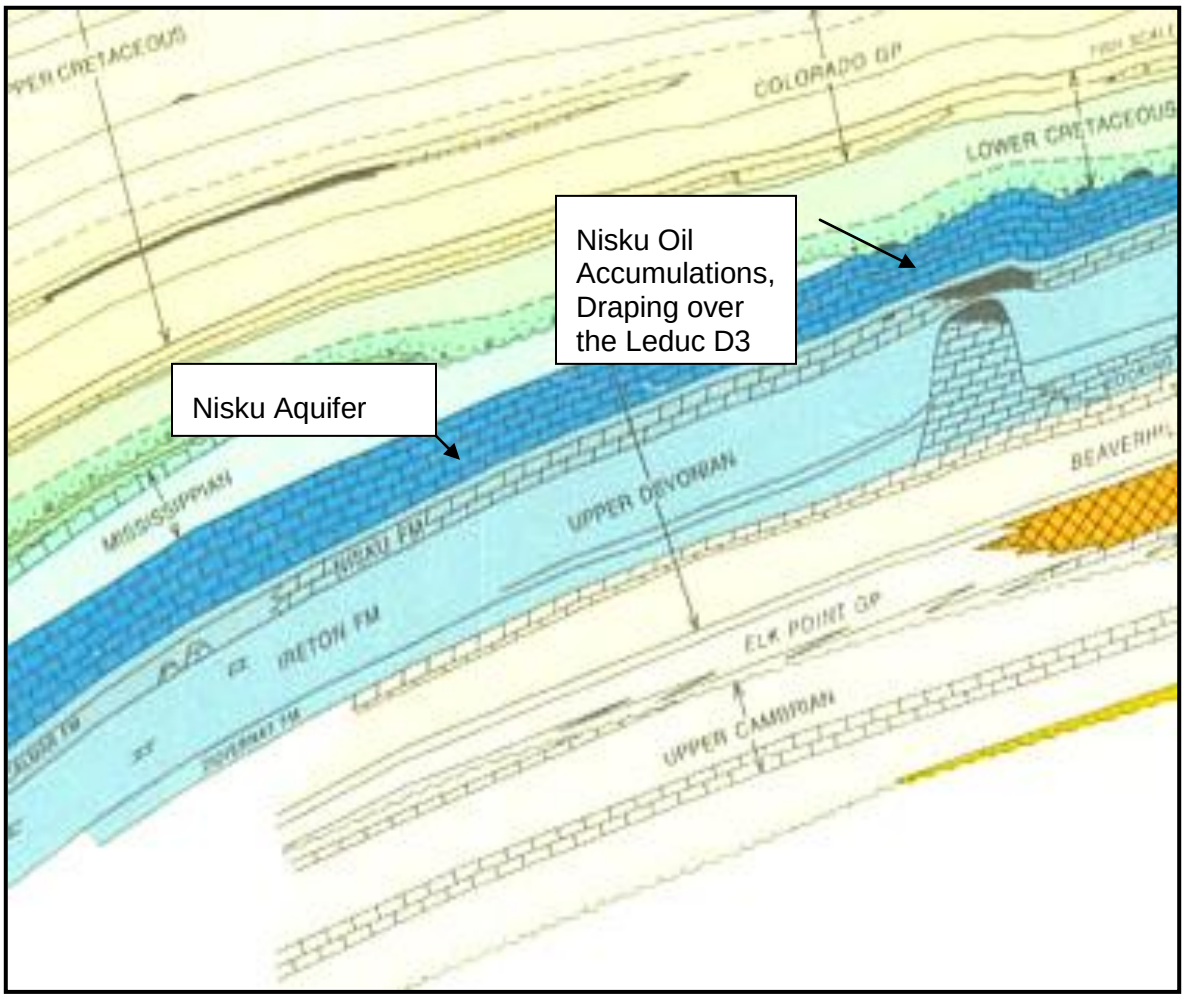

Figure 4: Cross section of the Nisku aquifer and adjacent stratigraphy (Reference 3).

3. RESERVOIR DATA

The following public-domain data are available for the Nisku oil pools:

a. Reservoir Parameters
b. Reserves
c. Production
d. Injection
e. Fluid Studies—i.e., PVT Reports

Tables containing pool reserves data and fluid properties for each of the studied pools are included in Appendix 1.

4. MATERIAL BALANCE RESULTS

The following discussion is a pool by pool account of the results in an attempt to match production and pressure histories with an analytical aquifer model that best simulates the observed pool response. The discussions are more or less complete, depending on availability of data from the ERCB and other difficulties described for each pool.

4.1 Acheson D2-A and D2-B Pools

Figure 5 shows the location of the Acheson D2-A Pool.

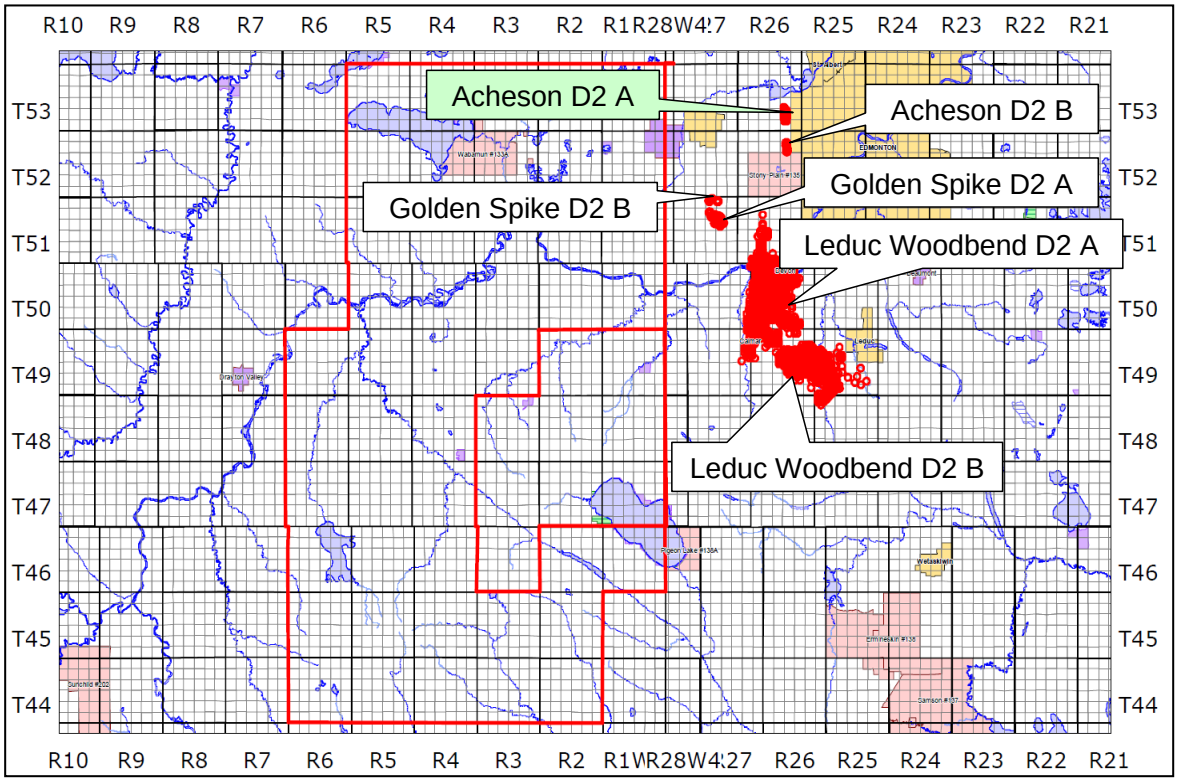

Figure 5: Location of Acheson D2-A Pool.

The Acheson D2-A Pool was first produced in 1952. It consists of twelve (12) producers and one (1) injector, see Table 1. The pool has original oil in place (OOIP) based on ERCB information of 775 e3 m^3 (4,877 e3 bbl). This is a small pool with a small waterflood implemented in it. The pool reserves data sheet and reservoir fluid behaviour parameter information sheets are included in Appendix 1 for this pool.

Table 1: Data summary for Acheson D2-A pool.

Description	Pool Characteristics
Depth	1395.1 m
Area	486 ha (1201 acres)
Number of Producers	12
Number of Brine Injectors	1
Net Pay	8.17 m
Porosity	3.4%
API Gravity	38 deg API
Initial Pressure	10,994 kPa (1,595 psi)
Temperature	57 deg C
OOIP	775 e3 m^3 (4,877 e3 bbl)
Initial OOIP Recovered	60.5%

A plot of the production, water injection, and average pressure versus time history for the pool is provided in Figure 6. More detailed pressure data for individual wells in the pool is provided in Figure 7. As can be seen in both of these plots, although substantial production of both water and oil took place from this pool beginning in the early 1950s and extending until the early 1990s, the pressure decline was minimal.

As a result of the minimal pressure decline experienced in this pool, it was not possible to perform a material balance history match since this pressure response leads to the calculation of an infinite sized aquifer providing pressure support. There are two possible reasons for this kind of outcome:

Scenario 1 Pool size is small relative to the size of the attached aquifer. In this scenario, the aquifer associated with the Acheson D2-A Pool is large compared with the pool itself. With an OOIP of less than 5 million barrels, this pool is not large compared to other Alberta oil pools and this could very much be the reason for such a small pressure decline. The total off-take from this pool may not have been large enough to have produced a significant pressure decline in the larger aquifer.

Scenario 2 The aquifer attached to this pool is very large. It may be true that the Nisku aquifer is very large and that the minimal pressure decline is truly the result of an "infinite" aquifer response. In this case, the accuracy of the material balance approach is limited in terms of being able to accurately determine just how large the aquifer is relative to the size of the producing entity.

For the reasons described above, it was not possible to place a definitive size on the aquifer attached to the Acheson D2-A pool. The only conclusion that can be made is that the aquifer is very much larger than the oil pool.

The Acheson D2-B pool is even smaller than the D2-A pool at 49 e3 m^3 (308 e3 bbl). The pressure decline is also minimal and similar material balance history matching difficulties were encountered. The only conclusion relative to aquifer size attached to the D2-B pool is similar to that for the D2-A pool, the aquifer is large relative to the size of these oil accumulations.

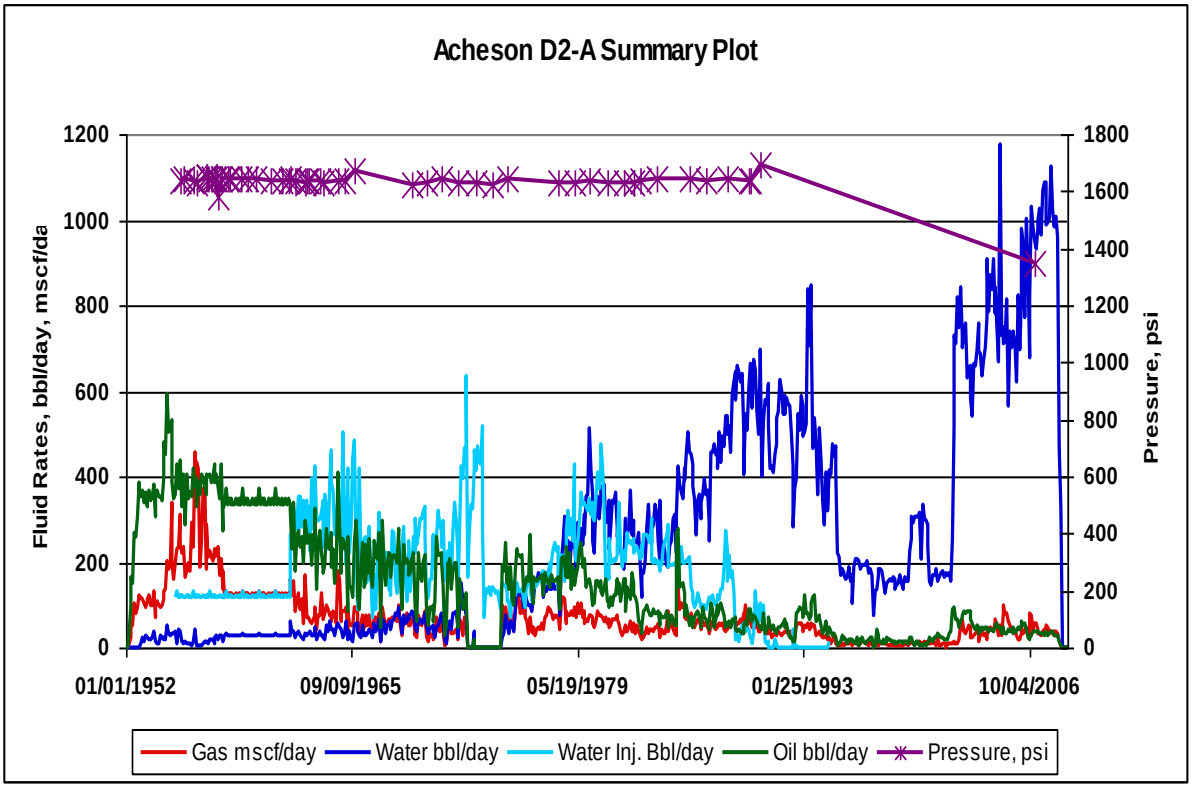

Figure 6: Acheson D2-A pool production, injection, and pressure versus time history.

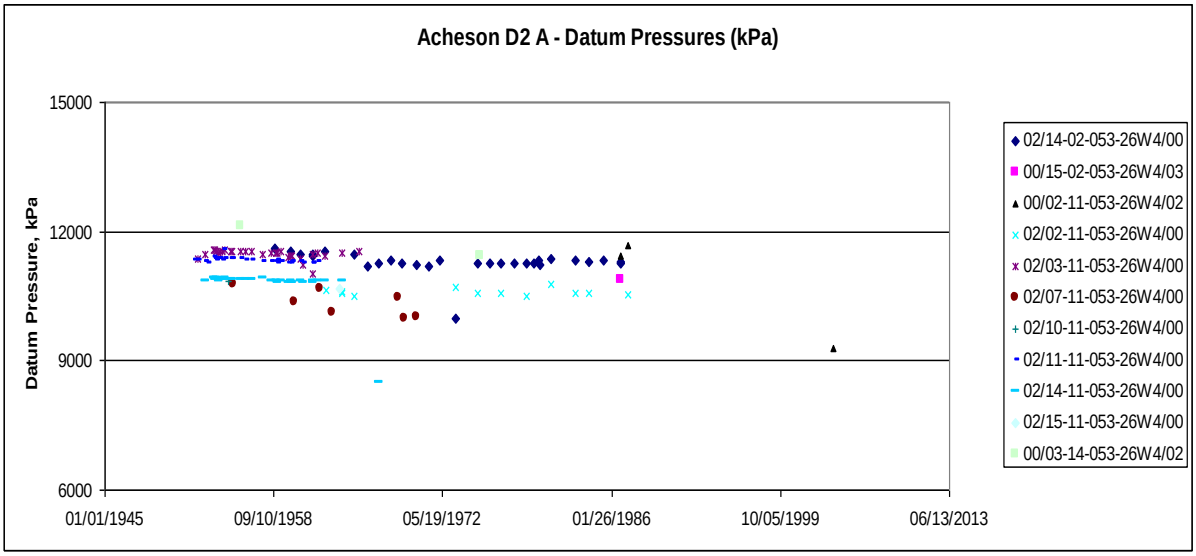

Figure 7: Acheson D2-A pool pressure versus time history.

4.2 Golden Spike D2A

The Golden Spike D2-A pool is located directly south west of the Acheson pools as seen in Figure 8. A summary of pool parameters for Golden Spike D2-A is provided below. This is a much larger pool that the Acheson pools.

Table 2: Data summary for Golden Spike D2-A pool.

Description	Pool Characteristics
Depth	1543.7 m
Area	769 ha (1900 acres)
Number of Producers	16
Number of Brine Injectors	4
Net Pay	13 m
Porosity	5.7%
API Gravity	37 deg API
Initial Pressure	12,422 kPa (1,802 psi)
Temperature	61 deg C
OOIP	2804 e3 m^3 (17,645 e3 bbl)
Initial OOIP Recovered	14.5%

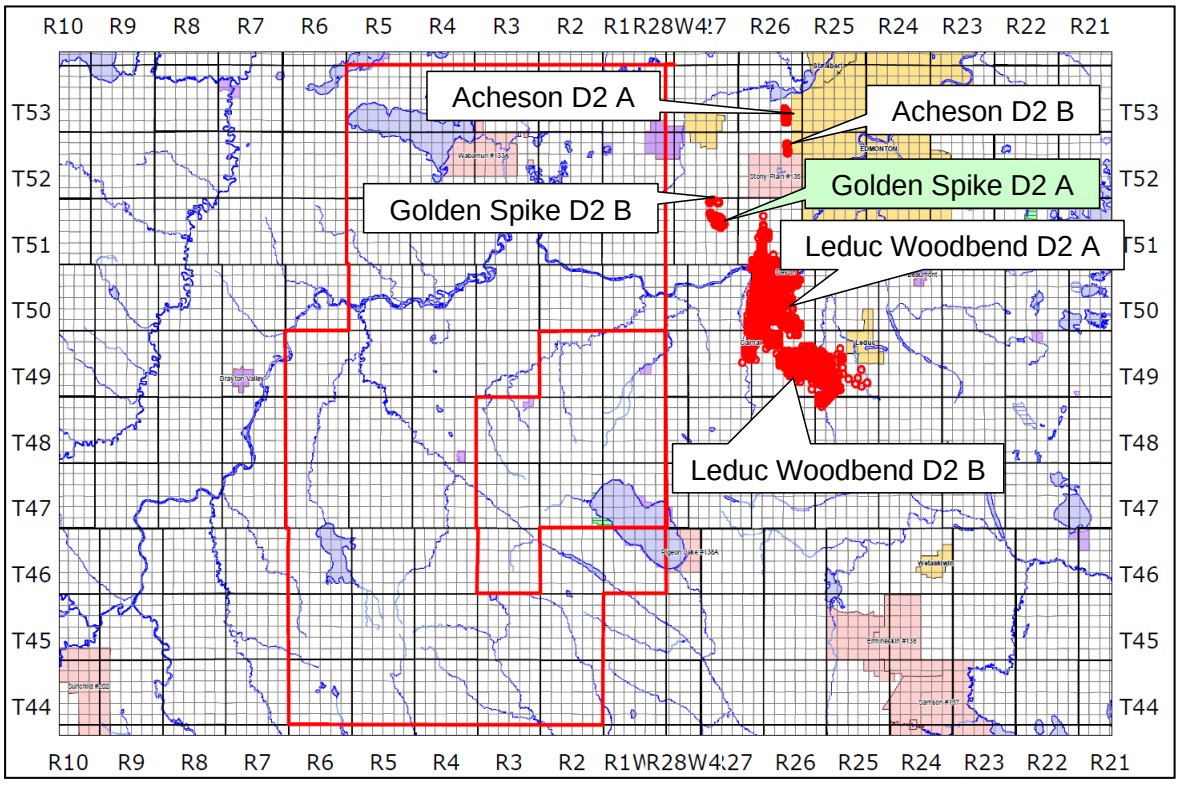

Figure 8: Location of Golden Spike D2-A.

The pressure and production history for the Golden Spike D2-A Pool is provided in Figure 9. This figure illustratates a very pronounced pressure decline followed by a repressurization shortly after the initiation of a waterflood scheme in 1965.

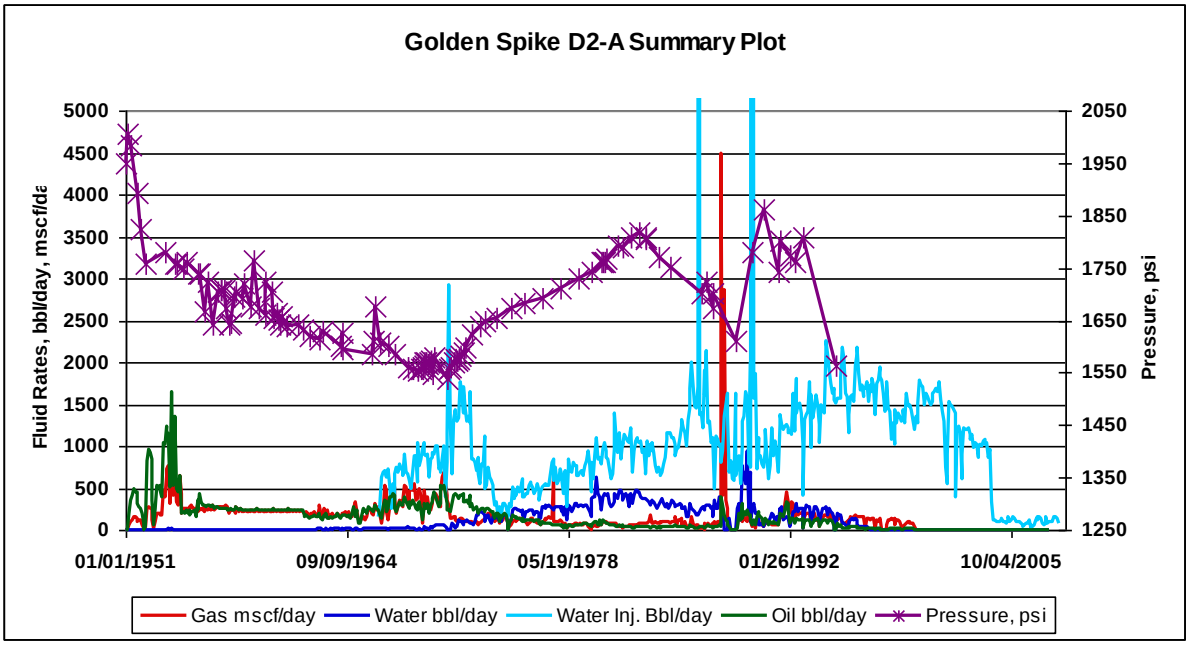

Figure 9: Golden Spike D2-A pressure, production, and injection history.

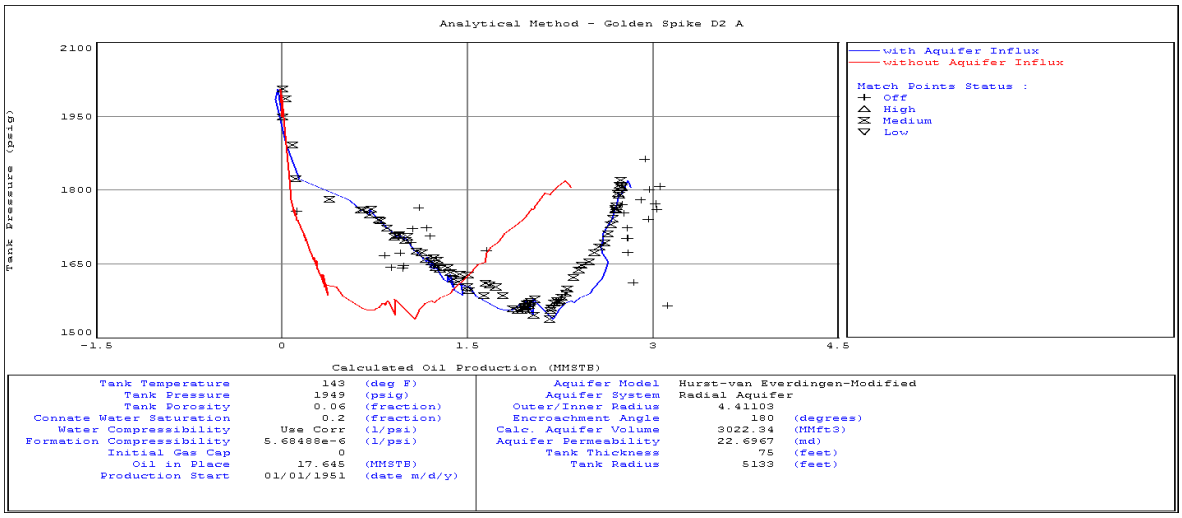

Figure 10: Golden Spike D2-A material balance history match.

The significant pressure decline observed in the early years of producing this pool enables a very accurate pressure match using a radial aquifer with an outer to inner dimension ratio of 4.4. The Hurst-van Everdingen-Modified aquifer model was used to achieve this match. As can be seen in Figure 10, the simulated pressure response without aquifer support (the red line) would have been much different than that observed (the black symbols). From the quality of this match (the blue line) we can state with a high degree of accuracy that the selected aquifer model is a good approximation of the type and size of aquifer associated with the Golden Spike D2-A Pool.

The reservoir pore volume calculated by the simulator is 4.66 e6 m^3 (29.3 e6 bbl), while the aquifer volume is 85.5 e6 m^3 (538 e6 bbl). This is a reservoir to aquifer ratio of 18.4. The oil reservoir radius is about 1,564 m (5,133 ft.). Assuming the aquifer exposure angle is 180 degrees and assuming an aquifer tank thickness of 22.8 m (75 ft.) and permeability of 23 md, it is possible to calculate the radius of the aquifer connected to this pool to be about 7,010 m (23,000 ft.). Figure 11 illustrates this shape relative to the Golden Spike D2-A Pool. This calculated aquifer geometry indicates how much of the Nisku aquifer the Golden Spike D2-A Pool is exposed to. It does not conclusively demonstrate the extent of the larger aquifer itself.

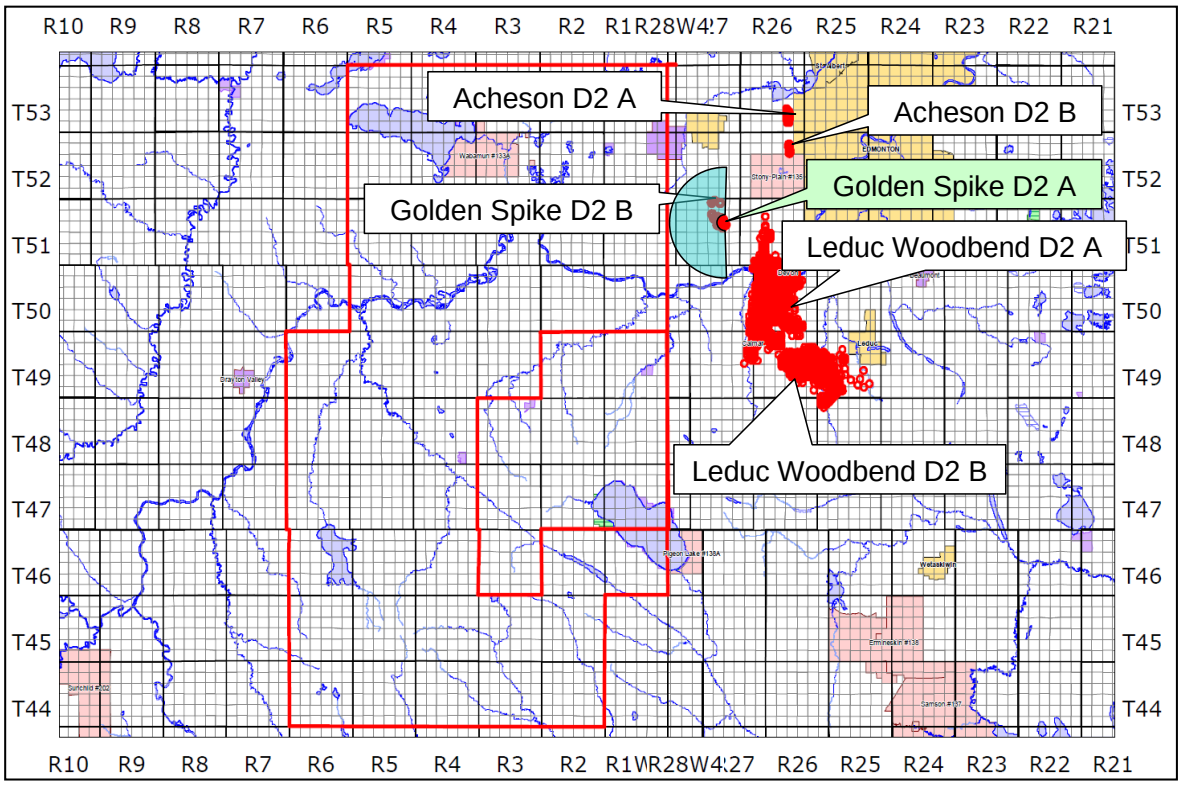

Figure 11: Golden Spike D2-A mapping of aquifer shape and size.

4.3 Golden Spike D2B

The Golden Spice D2-B Pool is considerably smaller than the Golden Spike D2-A Pool. Table 3 provides the basic pool datea for this pool. The OOIP value of 356 e3 m^3 or 2.2 million bbls suggests that this pool is in the size category of the Acheson pools.

Table 3: Data summary for Golden Spike D2-B pool.

Description	Pool Characteristics
Depth	1556.2 m
Area	173 ha (427 acres)
Number of Producers	4
Number of Brine Injectors	1
Net Pay	4 m
Porosity	7.8%
API Gravity	37 deg API
Initial Pressure	12,395 kPa (1,798 psi)
Temperature	61 deg C
OOIP	356 e3 m^3 (2,240 e3 bbl)
Initial OOIP Recovered	15%

Pressure data recorded for the Golden Spike D2-B pool is less complete that for the D2-A pool but since early time pressures were available, it was possible to perform a material balance analysis. Figure 12 provides the pressure, production and injection history for this pool.

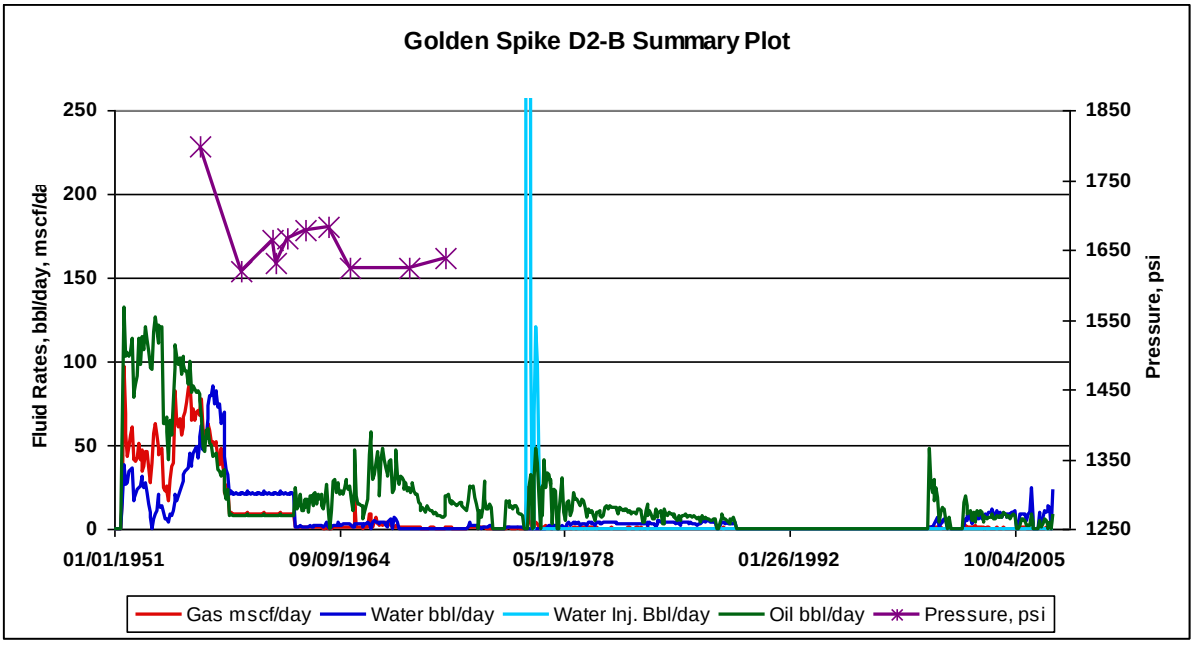

Figure 12: Golden Spike D2-B pressure, production, and injection history.

A material balance history match was obtained using the same analytical radial model as was used for the D2-A pool. This time the dimensionless outer to inner radius value was 23.2 (Figure 13).

However the oil pool radius is slightly smaller at 741 m (2,433 ft.). This yields an aquifer radius of 17,068 m or 17 km (56,000 ft. or 10 miles). Figure 14 illustrates this aquifer model on the same map as before. An aquifer permeability of 38 md was assumed to achieve this match.

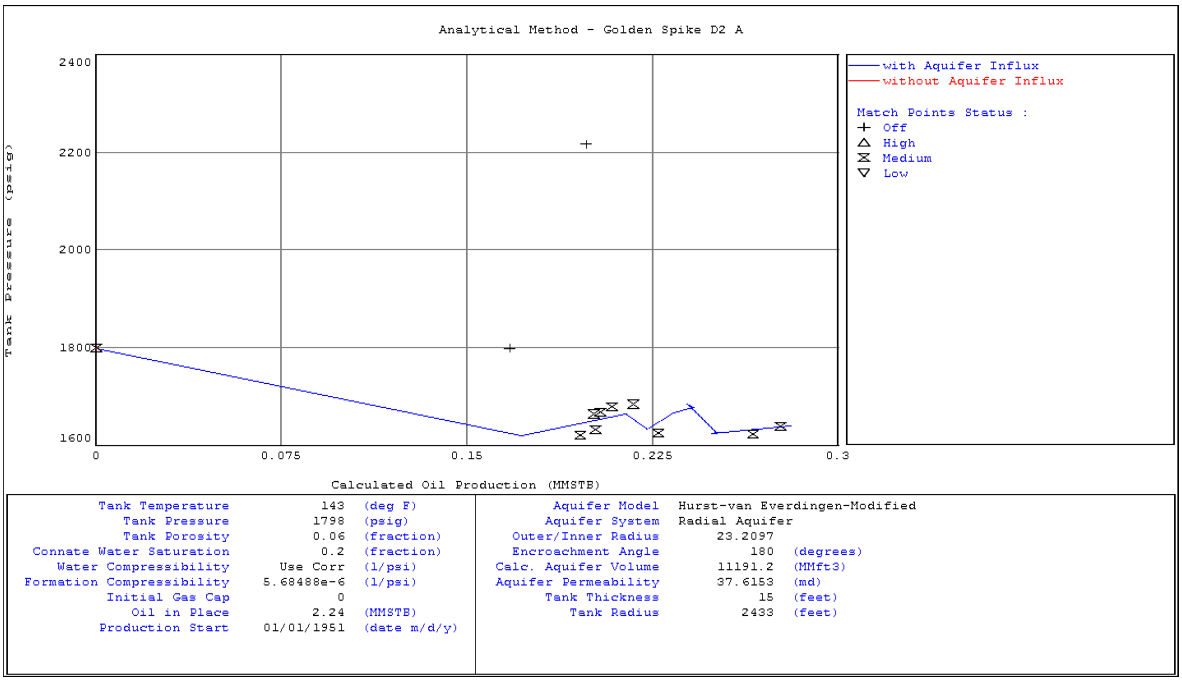

Figure 13: Golden Spike D2-B pressure, production, and injection history.

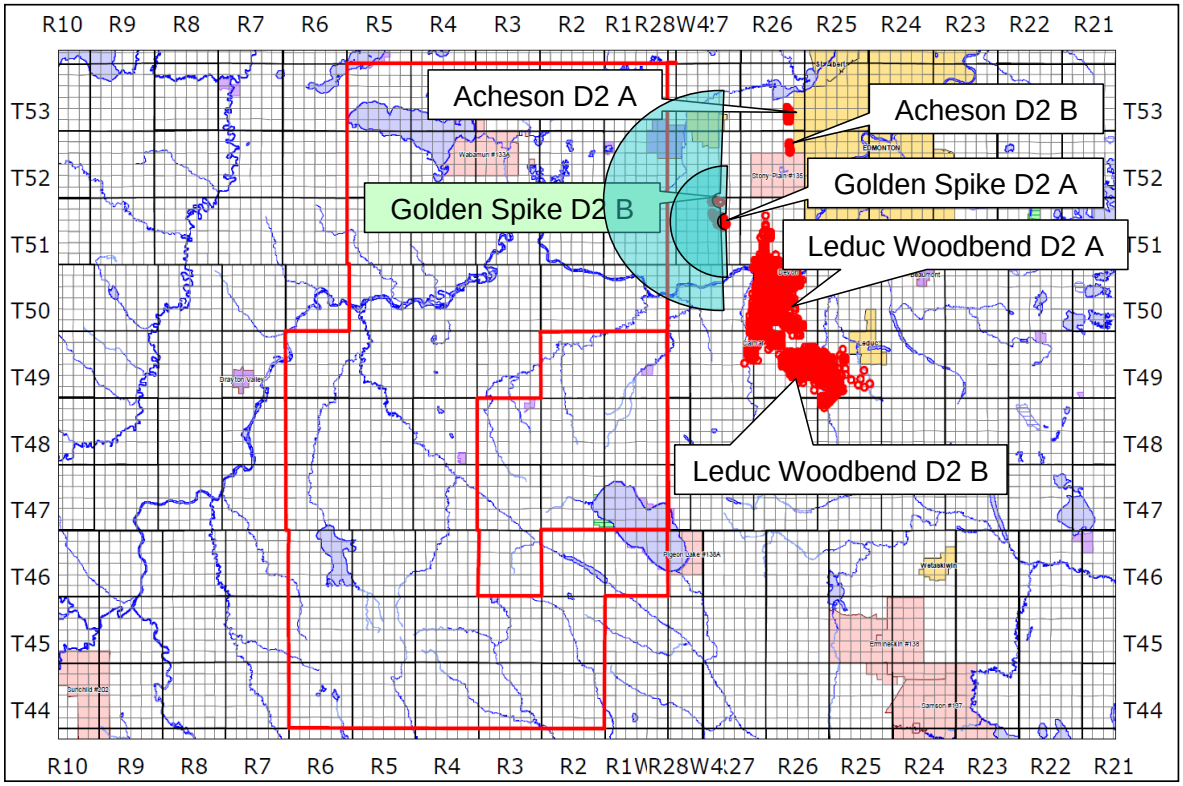

Figure 14: Golden Spike D2-B pressure, production, and injection history.

As can be seen from Figure 14, the Golden Spike D2-B aquifer solution suggests a larger radius aquifer than for the D2-A pool. This outcome must be tempered by the fact that the D2-B pool is significantly smaller than the D2-A pool and as such it does not enable as highly accurate a results for materal balance matchhing purposes as was possible for the D2-A pool.

4.4 Leduc Woodbend D2A and D2B Pools

The Leduce Woodbend D2-A and D2-B Pools are by far the largest Nisku reef oil accumulations in the province and the largest considered for this study. Tables 4 and 5 provide reservoir parameters for both of these pools. As can be seen from these tables, large OOIP values 33 million cubic metres and 25 million cubic metres respectively for the D2-A and D2-B pools are recorded in the ERCB databases. Unfortunately, what is not recorded in the ERCB electronic database is the early years of production from these pools. The ERCB holds only production from 1962 forward. All of the previous years of data are stored in paper or micro fiche databases. This was true for the Acheson and Golden Spike pools as well, but there are so few wells associated with these pools, that it wasn't difficult to pull the prior history from paper reports to establish the full production history for material balance purposes. Since this effort would have taken an extreme amount of time for the Leduc Woodbend D2-A and D2-B pools, it was not practical to have it done.

Table 4: Data summary for Leduc Woodbend D2-A pool.

Description	Pool Characteristics
Depth	1570.2 m
Area	9217 ha (22,776 acres)
Number of Producers	502
Number of Brine Injectors	52
Net Pay	30 m
Porosity	7%
API Gravity	38 deg API
Initial Pressure	12,581 kPa (1,825 psi)
Temperature	63 deg C
OOIP	32,830 e3 m^3 (206,595 e3 bbl)
Initial OOIP Recovered	43.9%

Table 5: Data summary for Leduc Woodbend D2-B pool.

Description	Pool Characteristics
Depth	1601.3 m
Area	7106 ha (17,559 acres)
Number of Producers	250
Number of Brine Injectors	35
Net Pay	14.3 m
Porosity	5%
API Gravity	38 deg API
Initial Pressure	12,834 kPa (1,861 psi)
Temperature	60 deg C
OOIP	24,606 e3 m^3 (151,406 e3 bbl)
Initial OOIP Recovered	13.8%

Since practical material balance analysis for the Leduc Woodbend pools was not possible, due to missing data, only a review of the production and pressure response data was possible. By inference, a review of the pressure histories in Figure 15 and 18 along with the production and injection data (post 1961) in Figures 16,17 and 19, 20 for the D2-A and D2-B pools, respectively, suggests that the aquifer strength associated with the Leduc Woodbend pools is similar to that observed for the Golden Spike Pools.

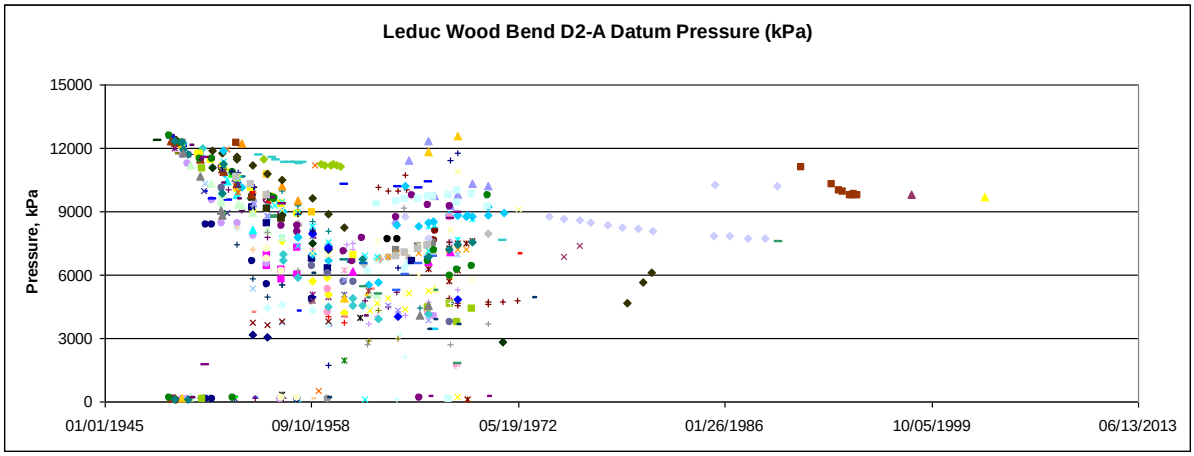

Figure 15: Leduc Woodbend D2-A pressure history.

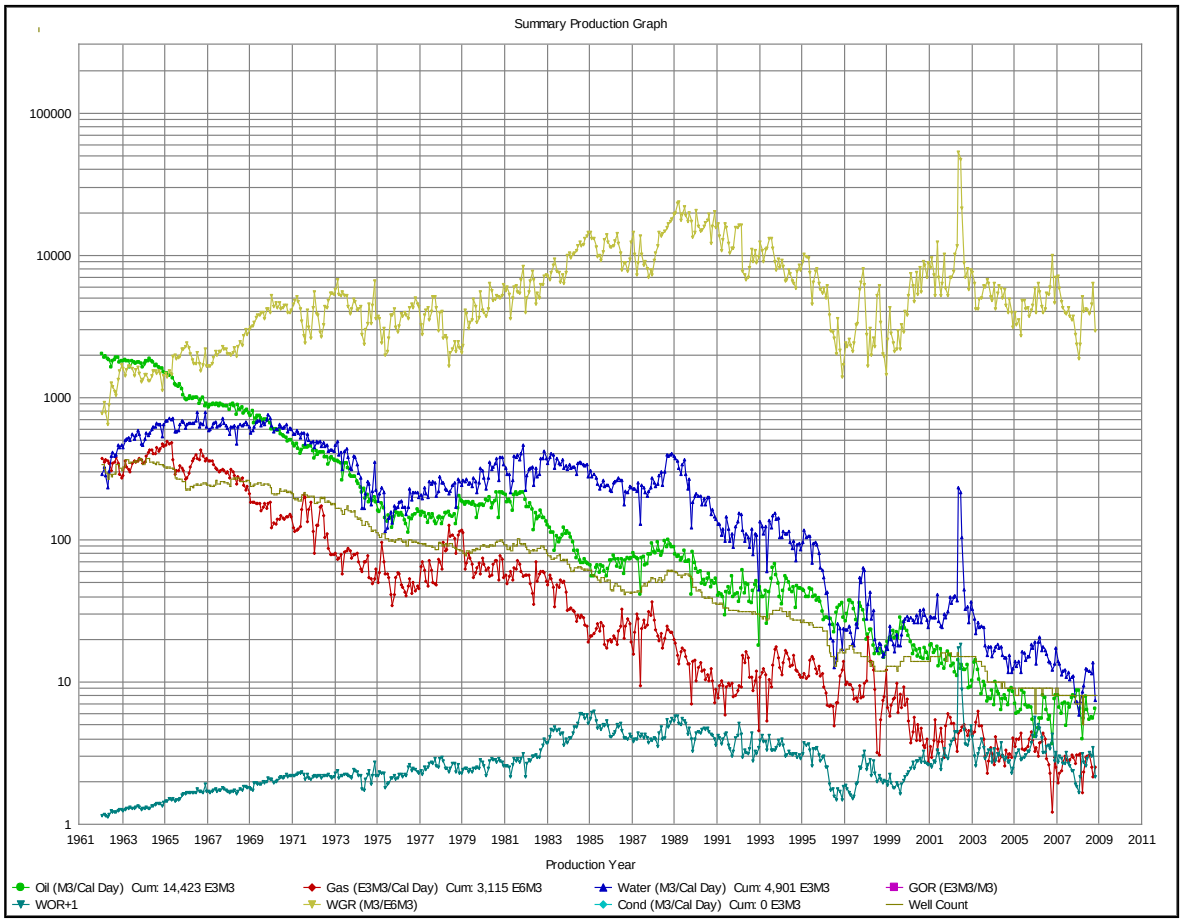

Figure 16: Leduc Woodbend D2-A production history (post 1961).

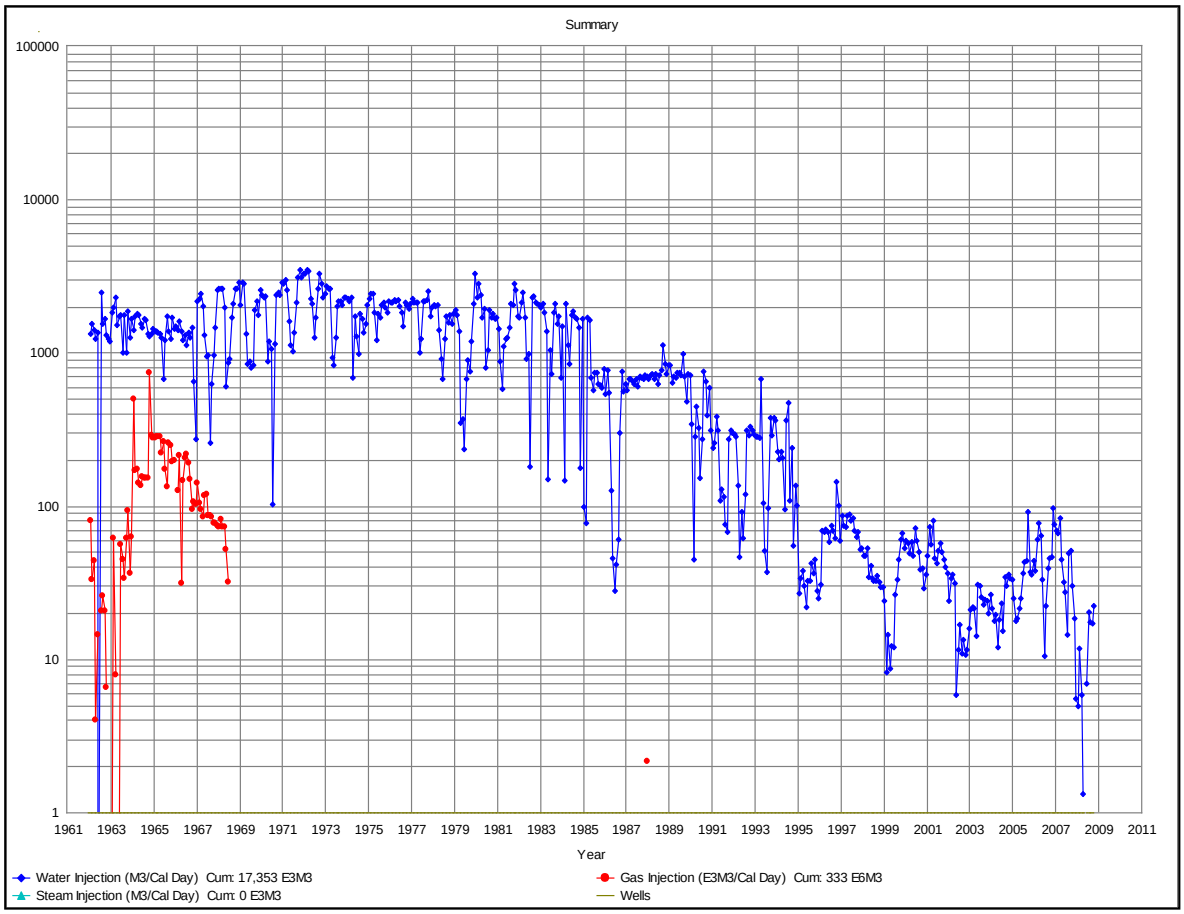

Figure 17: Leduc Woodbend D2-A injection history (post 1961).

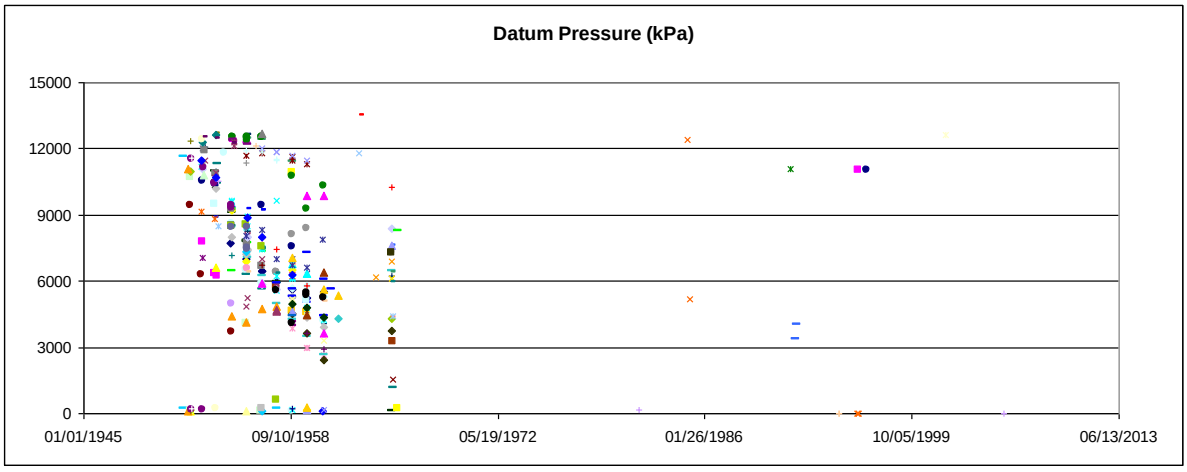

Figure 18: Leduc Woodbend D2-B pressure history.

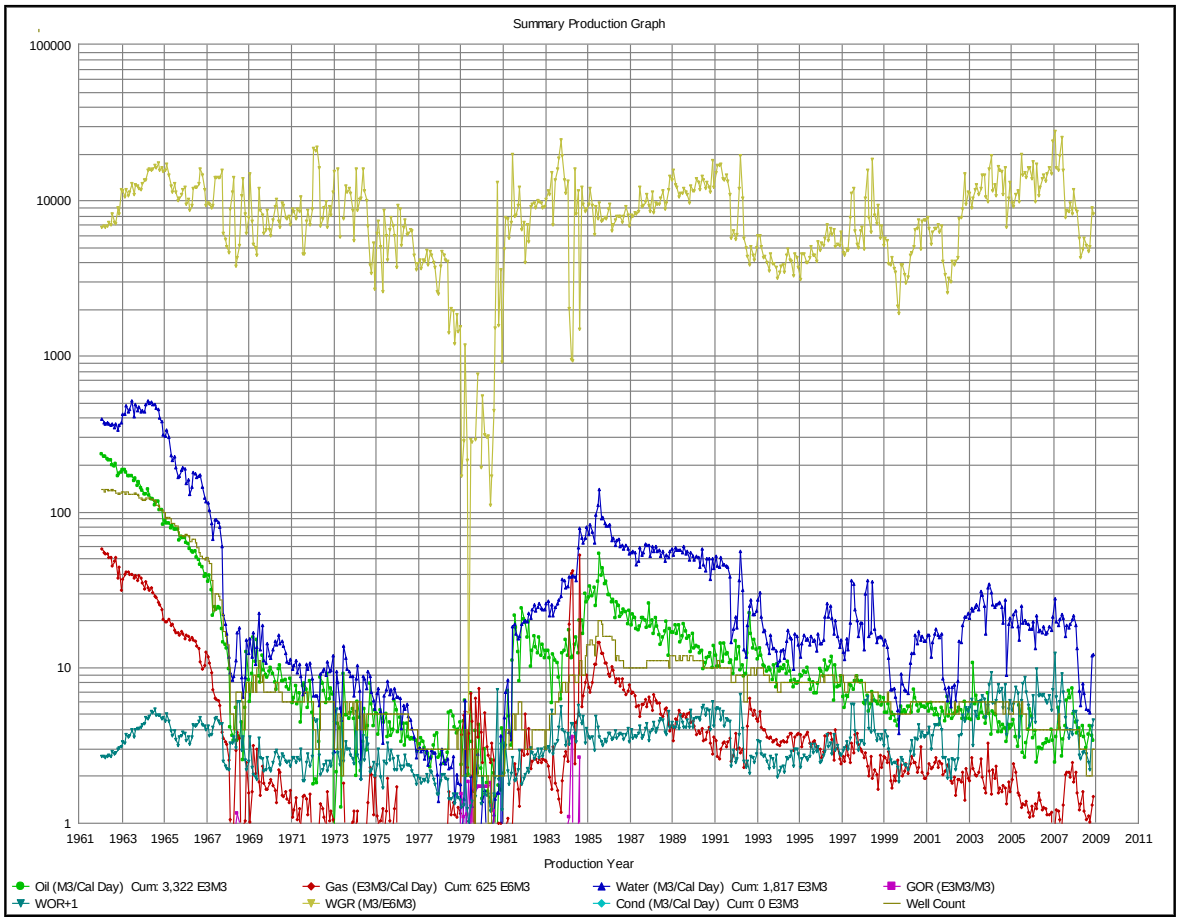

Figure 19: Leduc Woodbend D2-B production history (post 1961).

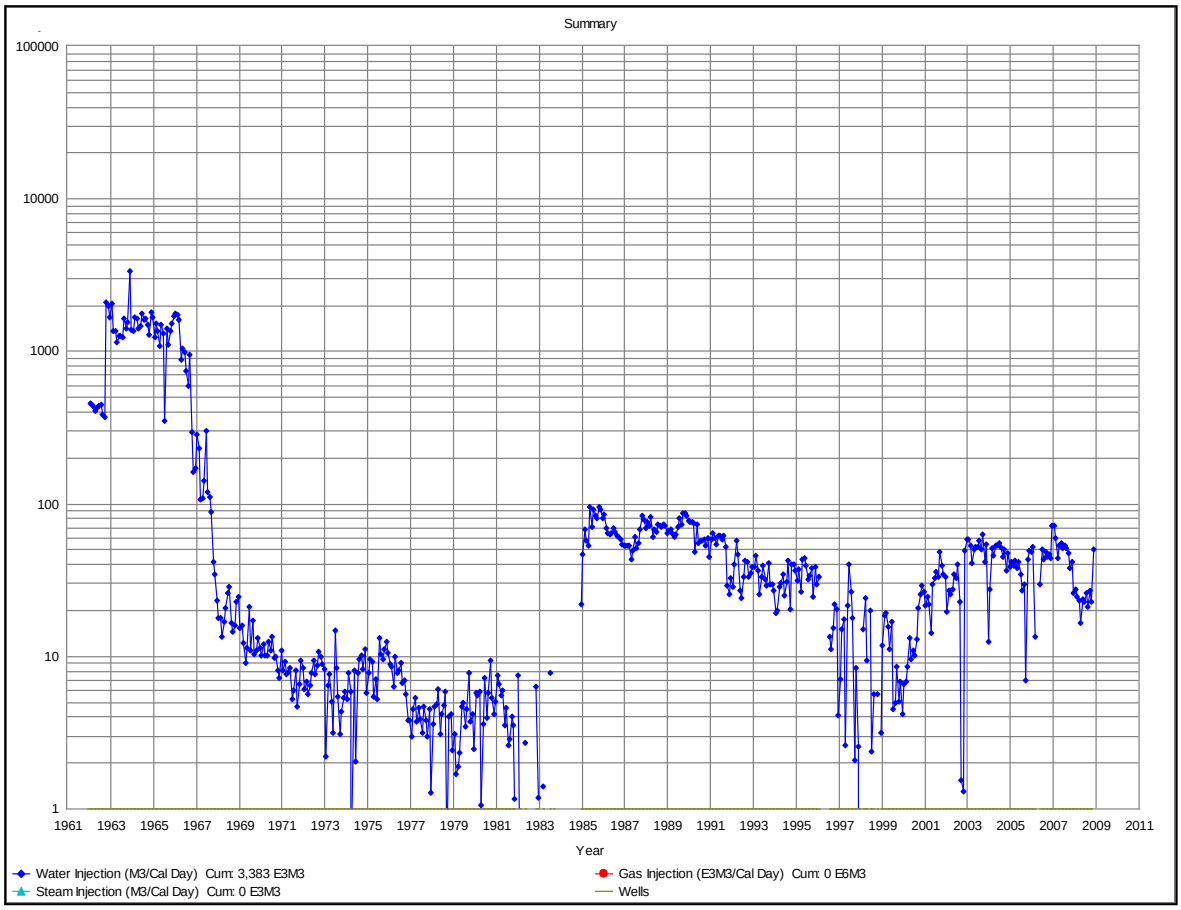

Figure 20: Leduc Woodbend D2-B injection history (post 1961).

CONCLUSIONS

Conclusions relative to aquifer strength, permeability, and size (radius), for the Nisku oil fields directly to the east of the WASP study are as follows:

- The Nisku aquifer can generally be classified as a "strong aquifer" with some variability in connectivity depending on location.
- Strong connections exist for distances ranging from a few kilometres to tens of kilometres.
- Weak connections may exist but this is, as yet, inconclusive.
- Average permeability is in the order of 10 to 40 md.

REFERENCES

1. Bob Michenson, Public Knowledge, “Oil and Gas Reserves Database”, Version 2008 1.01.
2. Petroleum Experts Ltd. “MBAL Reservoir Analytical Simulation”, Version 8.
3. Geological Survey of Canada, 1981.

APPENDIX 1

Table Number	Table Name
1	Acheson D2-A Reserve Report
2	Acheson D2-B Reserve Report
3	Golden Spike D2-A Reserve Report
4	Golden Spike D2-B Reserve Report
5	Leduc Woodbend D2-A Reserve Report
6	Leduc Woodbend D2-B Reserve Report
7	Acheson Flash Corrected PVT Data
8	Golden Spike Flash Corrected PVT Data

OIL RESERVES Detailed Report

Database Date: Dec. 31, 2007

Field Code :	9	**Pool Code :**	696001
Field Name :	ACHESON	**Pool Name :**	D-2 A
Field Location :	053-26W4	**Pool Type :**	Primary
Discovery Year :	1952	**Pool Class :**	Light-Medium Oil

	Metric		*Imperial*	
KB (reference elevation):	705.9	m	2316	ft
Mean Formation Depth:	1395.1	m	4577	ft
Datum Elevation:	-689.2	m	-2261	ft
Area:	486	ha	1201	acres
Net Pay:	8.17	m	26.8	ft
Volume:	3971	e4 m3	32190	acre ft
Porosity:	0.034		3.4	%
Water Saturation:	0.3		30.0	%
Shrinkage:	0.82		82.0	%
Oil Density:	834.3	kg/m3	52.1	lbs/SCF
API Gravity:	38.10	deg API	38.10	deg API
Solution Gas Oil Ratio:	64	m3/m3	361	SCF/Bbl
Initial Pressure	10,994	kPa	1,595	psi
Temperature:	57	deg C	135	deg F
Initial OIP Volume:	775	e3 m3	4877	e3 bbl
Primary Recovery Factor:	0.615		61.5	%
Enhanced Recovery Factor:	0.000		0.0	%
Primary Initial Reserves:	477.0	e3 m3	3002	e3 bbl
Enhanced Initial Reserves:	0.0	e3 m3	0	e3 bbl
Total Initial Reserves:	477.0	e3 m3	3002	e3 bbl
Cumulative Production:	468.7	e3 m3	2949	e3 bbl
Remaining Reserves:	8.3	e3 m3	52	e3 bbl
Initial OIP Recovered:	0.605		60.5	%

Remarks: 2007-10 GPP

OIL RESERVES Detailed Report

Database Date: Dec. 31, 2007

Field Code :	9	**Pool Code :**	696002
Field Name :	ACHESON	**Pool Name :**	D-2 B
Field Location :	053-26W4	**Pool Type :**	Primary
Discovery Year :	1952	**Pool Class :**	Light-Medium Oil

	Metric		*Imperial*	
KB (reference elevation):	714.7	m	2345	ft
Mean Formation Depth:	1420.4	m	4660	ft
Datum Elevation:	-705.7	m	-2315	ft
Area:	64	ha	158	acres
Net Pay:	6.01	m	19.7	ft
Volume:	385	e4 m3	3118	acre ft
Porosity:	0.024		2.4	%
Water Saturation:	0.36		36.0	%
Shrinkage:	0.83		83.0	%
Oil Density:	834.3	kg/m3	52.1	lbs/SCF
API Gravity:	38.10	deg API	38.10	deg API
Solution Gas Oil Ratio:	64	m3/m3	361	SCF/Bbl
Initial Pressure	11,093	kPa	1,609	psi
Temperature:	56	deg C	133	deg F
Initial OIP Volume:	49	e3 m3	308	e3 bbl
Primary Recovery Factor:	0.600		60.0	%
Enhanced Recovery Factor:	0.000		0.0	%
Primary Initial Reserves:	29.4	e3 m3	185	e3 bbl
Enhanced Initial Reserves:	0.0	e3 m3	0	e3 bbl
Total Initial Reserves:	29.4	e3 m3	185	e3 bbl
Cumulative Production:	29.4	e3 m3	185	e3 bbl
Remaining Reserves:	0.0	e3 m3	0	e3 bbl
Initial OIP Recovered:	0.600		60.0	%

Remarks: 2006-12 GPP

OIL RESERVES Detailed Report

Database Date: Dec. 31, 2007

Field Code :	421	**Pool Code :**	696001
Field Name :	GOLDEN SPIKE	**Pool Name :**	D-2 A TOTAL
Field Location :	051-27W4	**Pool Type :**	Primary
Discovery Year :	1952	**Pool Class :**	Light-Medium Oil

	Metric		*Imperial*	
KB (reference elevation):	712.0	m	2336	ft
Mean Formation Depth:	1543.7	m	5065	ft
Datum Elevation:	-831.7	m	-2729	ft
Area:	769	ha	1900	acres
Net Pay:	0	m	0.0	ft
Volume:	0	e4 m3	0	acre ft
Porosity:	0		0.0	%
Water Saturation:	0		0.0	%
Shrinkage:	0		0.0	%
Oil Density:	839.3	kg/m3	52.4	lbs/SCF
API Gravity:	37.09	deg API	37.09	deg API
Solution Gas Oil Ratio:	87	m3/m3	491	SCF/Bbl
Initial Pressure	12,422	kPa	1,802	psi
Temperature:	61	deg C	142	deg F
Initial OIP Volume:	2804	e3 m3	17645	e3 bbl
Primary Recovery Factor:	0.000		0.0	%
Enhanced Recovery Factor:	0.000		0.0	%
Primary Initial Reserves:	275.0	e3 m3	1731	e3 bbl
Enhanced Initial Reserves:	131.0	e3 m3	824	e3 bbl
Total Initial Reserves:	406.0	e3 m3	2555	e3 bbl
Cumulative Production:	405.9	e3 m3	2554	e3 bbl
Remaining Reserves:	0.1	e3 m3	1	e3 bbl
Initial OIP Recovered:	0.145		14.5	%

Remarks: 2001-12 GPP

OIL RESERVES Detailed Report

Database Date: Dec. 31, 2007

Field Code :	421	**Pool Code :**	696002
Field Name :	GOLDEN SPIKE	**Pool Name :**	D-2 B
Field Location :	051-27W4	**Pool Type :**	Primary
Discovery Year :	1951	**Pool Class :**	Light-Medium Oil

	Metric		*Imperial*	
KB (reference elevation):	708.7	m	2325	ft
Mean Formation Depth:	1556.2	m	5106	ft
Datum Elevation:	-847.5	m	-2781	ft
Area:	173	ha	427	acres
Net Pay:	3.93	m	12.9	ft
Volume:	680	e4 m3	5512	acre ft
Porosity:	0.078		7.8	%
Water Saturation:	0.14		14.0	%
Shrinkage:	0.78		78.0	%
Oil Density:	839.3	kg/m3	52.4	lbs/SCF
API Gravity:	37.09	deg API	37.09	deg API
Solution Gas Oil Ratio:	87	m3/m3	491	SCF/Bbl
Initial Pressure	12,395	kPa	1,798	psi
Temperature:	61	deg C	142	deg F
Initial OIP Volume:	356	e3 m3	2240	e3 bbl
Primary Recovery Factor:	0.150		15.0	%
Enhanced Recovery Factor:	0.000		0.0	%
Primary Initial Reserves:	53.4	e3 m3	336	e3 bbl
Enhanced Initial Reserves:	0.0	e3 m3	0	e3 bbl
Total Initial Reserves:	53.4	e3 m3	336	e3 bbl
Cumulative Production:	53.1	e3 m3	334	e3 bbl
Remaining Reserves:	0.3	e3 m3	2	e3 bbl
Initial OIP Recovered:	0.149		14.9	%

Remarks: 2000-11 GPP

OIL RESERVES Detailed Report

Database Date: Dec. 31, 2007

Field Code :	551	**Pool Code :**	696001
Field Name :	LEDUC-WOODBEND	**Pool Name :**	D-2 A TOTAL
Field Location :	050-26W4	**Pool Type :**	Primary
Discovery Year :	1947	**Pool Class :**	Light-Medium Oil

	Metric		*Imperial*	
KB (reference elevation):	718.9	m	2359	ft
Mean Formation Depth:	1570.2	m	5152	ft
Datum Elevation:	-851.3	m	-2793	ft
Area:	9217	ha	22776	acres
Net Pay:	0	m	0.0	ft
Volume:	0	e4 m3	0	acre ft
Porosity:	0		0.0	%
Water Saturation:	0		0.0	%
Shrinkage:	0		0.0	%
Oil Density:	834	kg/m3	52.1	lbs/SCF
API Gravity:	38.16	deg API	38.16	deg API
Solution Gas Oil Ratio:	115	m3/m3	649	SCF/Bbl
Initial Pressure	12,581	kPa	1,825	psi
Temperature:	63	deg C	145	deg F
Initial OIP Volume:	32830	e3 m3	206595	e3 bbl
Primary Recovery Factor:	0.000		0.0	%
Enhanced Recovery Factor:	0.000		0.0	%
Primary Initial Reserves:	11160.0	e3 m3	70228	e3 bbl
Enhanced Initial Reserves:	3270.0	e3 m3	20578	e3 bbl
Total Initial Reserves:	14430.0	e3 m3	90806	e3 bbl
Cumulative Production:	14421.2	e3 m3	90751	e3 bbl
Remaining Reserves:	8.8	e3 m3	55	e3 bbl
Initial OIP Recovered:	0.439		43.9	%

Remarks: 2007-12 GPP

OIL RESERVES Detailed Report

Database Date: Dec. 31, 2007

Field Code :	551	**Pool Code :**	696002
Field Name :	LEDUC-WOODBEND	**Pool Name :**	D-2 B
Field Location :	050-26W4	**Pool Type :**	Primary
Discovery Year :	1950	**Pool Class :**	Light-Medium Oil

	Metric		*Imperial*	
KB (reference elevation):	734.7	m	2410	ft
Mean Formation Depth:	1601.3	m	5254	ft
Datum Elevation:	-866.6	m	-2843	ft
Area:	7106	ha	17559	acres
Net Pay:	14.33	m	47.0	ft
Volume:	101829	e4 m3	825541	acre ft
Porosity:	0.05		5.0	%
Water Saturation:	0.37		37.0	%
Shrinkage:	0.75		75.0	%
Oil Density:	834.3	kg/m3	52.1	lbs/SCF
API Gravity:	38.10	deg API	38.10	deg API
Solution Gas Oil Ratio:	98	m3/m3	553	SCF/Bbl
Initial Pressure	12,834	kPa	1,861	psi
Temperature:	60	deg C	140	deg F
Initial OIP Volume:	24060	e3 m3	151406	e3 bbl
Primary Recovery Factor:	0.139		13.9	%
Enhanced Recovery Factor:	0.000		0.0	%
Primary Initial Reserves:	3344.0	e3 m3	21043	e3 bbl
Enhanced Initial Reserves:	0.0	e3 m3	0	e3 bbl
Total Initial Reserves:	3344.0	e3 m3	21043	e3 bbl
Cumulative Production:	3320.3	e3 m3	20894	e3 bbl
Remaining Reserves:	23.7	e3 m3	149	e3 bbl
Initial OIP Recovered:	0.138		13.8	%

Remarks: 2007-12 GPP

Flash Corrected PVT Data

Reservoir Fluid Study for	**Calstan Acheson 11-11 Mu 53-26**							
Well	**02/11-11-53-26W4**							
Location	**Acheson D-2 A**							
California Research Corp.	**Project 8036 File 568.22**							
Date of Cover Letter	**19158**							
Date of Sample	**19086**							
Flash Corrected PVT								
						GOR		
Adjusted PVT data Separator Flash Conditions		**psig**		**psig**		**scf/bbl**		
First Stage Flash	**from**	**1305**	**to**	**70**	**at**	**286**		
Second Stage Flash at	**from**	**70**		**0**	**at**	**77**		
Total Flash GOR	**363**	**scf/bbl**				**363**		
Flash FVF	**1.221**	**rvol/svol**						
Tres	**Pressure**	**Bubble Pt.**	**Soln GOR**	**Oil FVF**	**Visc**	**Oil Density**		
(deg F)	**(psig)**	**(psig)**	**(scf/bbl)**	**(rvol/svol)**	**(cp)**	**gm/cc**		
134	3000	1305	363.0	1.2006				
134	2800	1305	363.0	1.2031	0.98			
134	2600	1305	363.0	1.2054	0.96			
134	2400	1305	363.0	1.2078	0.94			
134	2200	1305	363.0	1.2103	0.92			
134	2000	1305	363.0	1.2127	0.91			
134	1800	1305	363.0	1.2150	0.89			
134	1600	1305	363.0	1.2175	0.88			
134	1400	1305	363.0	1.2198	0.86			
134	1305	1305	363.0	1.2210	0.85		Bubble Point	
134	1200	1305			0.88			
134	1118	1305	332.0					
134	1000	1305			0.93			Rem GOR
134	973	1305	302.9				EUB Database	276.02
134	846	1305	276.7					
134	800	1305			0.99		Material Bal.	276.02
134	603	1305	218.5	1.1430				
134	600	1305			1.07			
134	458	1305	180.6	1.1225				
134	400	1305			1.17			
134	299	1305	132.1	1.0962				
134	201	1305	103.0	1.0825				
134	200	1305			1.34			
134	104	1305	57.4	1.0609				
134	51	1305	17.7	1.0056				
134	14.7	1305		0.9700	1.86			

Flash Corrected PVT Data

Reservoir Fluid Study for	**Imperial Golden Spike No. 17**							
Well	**08-27-057-27W4**							
Location								
Imperial Oil Laboratories	**L-39053**							
Date of Cover Letter	**September 1 1953**							
Date of Sample	**June 18 1953**							
API Gravity of Residual Oil	30.8							
Specific Gravity of Liberated Gas (Air = 1)	1.044							
Flash Corrected PVT						**GOR**		
Adjusted PVT data Separator Flash Conditions		**psig**		**psig**		**scf/bbl**		
First Stage Flash	**from**	**1775**	**to**	**50**	**at**	**461**		
Second Stage Flash at	**from**	**50**		**0**	**at**	**31**		
Total Flash GOR	**492**	**scf/bbl**				**492**		
Flash FVF	**1.339**	**rvol/svol**						
Tres	**Pressure**	**Bubble Pt.**	**Soln GOR**	**Oil FVF**	**Visc**	**Oil Density**		
(deg F)	**(psig)**	**(psig)**	**(scf/bbl)**	**(rvol/svol)**	**(cp)**	**gm/cc**		
143	3000	1775	492.0	1.3209	0.708			
143	2750	1775	492.0	1.3247	0.694			
143	2500	1775	492.0	1.3283	0.68			
143	2250	1775	492.0	1.3319	0.664			
143	2000	1775	492.0	1.3357	0.65			
143	1800	1775	492.0	1.3386	0.64			
143	1775	1775	492.0	1.3390			Bubble Point	
143	1700	1775						
143	1650	1775			0.648			
143	1600	1775						
143	1500	1775	415.7	1.3064	0.653			
143	1250	1775	347.1	1.2790	0.676			
143	1000	1775	277.6	1.2521	0.712			
143	750	1775	208.0	1.2239	0.783			
143	500	1775	131.7	1.1904	0.889			
143	250	1775	48.6	1.1527	1.03			
143	100	1775	24.0	1.1176	1.184			
143	50	1775	12.0	1.0932	1.3			
143	0	1775	0.0	1.0206	1.87			