3.1.1 DATA SOURCES

This section discusses the data used to prepare the depletion plan for Parsons Lake. Between 1971 and 1977, extensive reservoir information was gathered from the wells drilled in the Parsons Lake area (see Table 3-1). For the locations of the wells drilled between 1971 and 1986, see Figure 3-1.

Data was collected from:

- logs
- well tests
- fluid analyses
- core and special core analyses

Table 3-1: Parsons Lake Area Wells Used in Reservoir Evaluation

Well Name	Pool	Total Depth (m)	Spud Date	Drilling Days
Gulf Mobil Atigi G-04	South	3,734	Jan 7, 1971	99
Gulf Mobil Parsons F-09 (K-09)	North	3,547	Dec 20, 1971	120
Gulf Mobil Siku C-55	North	4,507	May 2, 1972	173
Gulf Mobil Parsons N-10	North	3,205	Feb 4, 1973	93
Gulf Mobil Parsons P-53	South	3,435	Dec 22, 1973	108
Gulf Mobil Parsons O-27	North	3,570	Mar 23, 1974	160
Gulf Mobil Kamik D-58	North	3,191	Nov 26, 1974	108
Gulf Mobil Kamik L-60	North	3,207	Mar 29, 1975	74
Gulf Mobil Parsons A-44	South	3,536	Apr 9, 1975	111
Gulf Mobil Parsons L-43	South	3,305	Dec 10, 1975	84
Gulf Mobil Parsons N-17	North	3,285	Dec 18, 1975	116
Gulf Mobil Kamik D-48	Kamik	3,236	Dec 23, 1975	102
Gulf Mobil Siku C-11	North	3,414	Dec 26, 1975	86
Gulf Mobil Siku A-12	North	3,288	Apr 14, 1976	103
Gulf Mobil Parsons D-20	North	4,130	Apr 21, 1976	215
Gulf Mobil Kamik F-38	North	3,566	Dec 13, 1976	90
Gulf Mobil Parsons L-37	North	3,961	Dec 26, 1976	97
Gulf Mobil Parsons P-41	South	3,556	Dec 29, 1976	98
Gulf Mobil Siku E-21	North	3,428	Apr 17, 1977	65

3.1.1 DATA SOURCES (cont'd)

Production tests and drill-stem tests were analyzed for initial pressure and reservoir permeability. Rock properties were determined from available core samples, and fluid property values were derived from surface and recombined reservoir fluid samples. This information was used in a reservoir simulator (see Section 4.2, Reservoir Simulation) that modelled the reservoir flow behaviour and predicted the results of depletion scenarios.

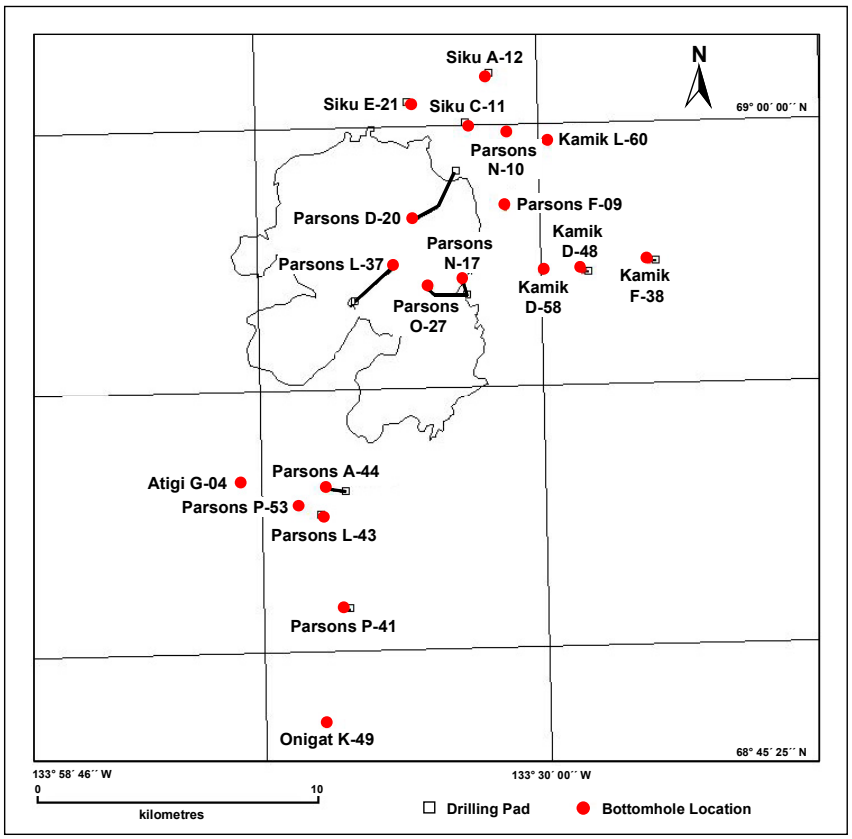

Figure 3-1: SDL 30 and SDL 32 Wells Drilled Between 1971 and 1986

3.1.2 RESERVOIR DESCRIPTION

The Parsons Lake field has two main structural closures, the north and south pools, with four major divisions of the Kamik sands. For further details of the field geology, see Section 2.1, Geological Description.

Petrophysical and well test data indicates that the sands have:

- excellent reservoir quality
- potentially high productivity

The 3-D seismic data shows several faults, which are generally parallel and oriented southwest to northeast.

3.1.3 WELL TEST DATA

Table 3-2 shows well tests and calculated properties, such as initial reservoir pressure and temperature, productivity, permeability (k) and wellbore conditions, such as skin damage.

3.1.3.1 Pressure Versus Depth

Figure 3-2 is a plot of reservoir pressure versus depth. Based on the proponents' understanding of the Parsons Lake area well data and the regional aquifer, the Parsons Lake field is likely connected to the aquifer.

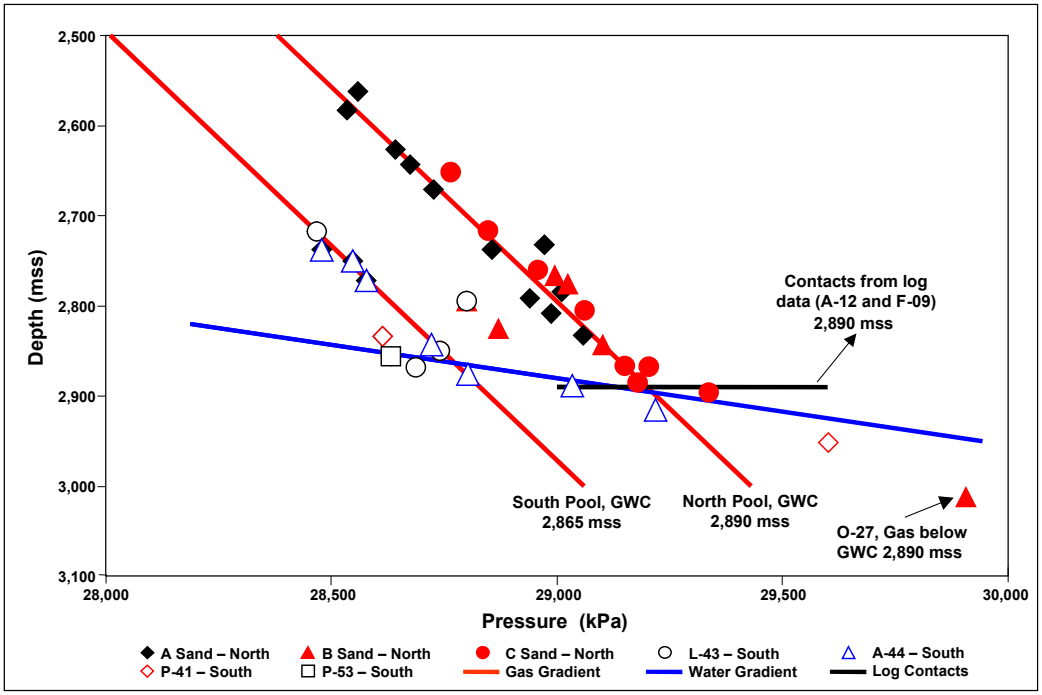

Figure 3-2: Plot of Reservoir Pressure Versus Depth

The initial pressures in the Parsons Lake field are between 28.3 MPa (4,105 psi) and 29.9 MPa (4,340 psi), depending on the sand and the pool. These pressures indicate normal hydrostatic pressure. The north pool has a common gas–water contact (GWC) at 2,890 mss, and the south pool has a gas–water contact at 2,865 mss.

Test data from well O-27 was anomalous and has now been interpreted as being related to an isolated structural trap seen on seismic data below the main north pool gas–water contact.

3.1.3.2 Temperature Versus Depth

Figure 3-3 is a plot of temperature versus depth. Temperatures were obtained from drill-stem tests, and a gradient of 4°C per 100 m was calculated. The temperature ranged from 80°C at 2,600 mss to 90°C at the gas–water contact of 2,890 mss.

Table 3-2: Well Test Results Summary

Well	DST	Sand	MPP[1] (mss)	Pi[2] (kPa)	Pwf[3] (kPa)	Press. DD[4] (%)	Por[5] (%)	Net Pay (m)	S_w[6] (%)	Flow Rate (Mm^3/d)	Multi-rates	S_c[7]	Slope[8] (n)	AOF[9] n = 1		AOF n = 0.69		Perm.[11] (mD)	Remarks
														S_c (Mm^3/d)	s[10] = 0 (Mm^3/d)	S_c (Mm^3/d)	s = 0 (Mm^3/d)		
D-20	1	C2	2,867	29,150	21,640	25.8	13.2	6.2	17.6	0.557		175		1.241	2.699	0.968	2.105	400	Boundary detected within 40 m, severe damage
D-20	3	B	2,776	29,020	19,360	33.3	11.4	5.8	25.5	0.538		39		0.969	1.831	0.808	1.525	80	Boundary detected within 100 m, severe damage
D-20	7	LA1	2,671	28,730	26,380	8.2	12.6	6.8	31.8	0.499				3.180	3.180	1.791	1.791	78	Boundary detected within 170 m, severe damage
N-10	6	LC3	2,760	28,975	27,505	5.1	8.9	10.4	15.4	0.183	4	9	0.69	1.850	2.109	0.903	1,029	95	Multirate test with high turbulent flow
N-10	7	UC3	2,717	28,865	28,625	0.8	16.2	32.8	16.7	0.407	5	2	0.58	24.577	26.565	6.894	7.451	152	Multirate test with high turbulent flow
N-10	8	B	2,652	28,780	26,930	6.4	15.2	6.6	36.1	0.341	4		0.69	2.741	2.741	1.436	1.436	86	Multirate test with high turbulent flow
N-10	9	A	2,562	28,598	8,015	72.0	15.3	1.4	57.0	0.120				0.130	0.130	0.127	0.127	153	Unstable flow
C-11	1	UC3	2,893	29,337	28,324	3.5	14.8	4.0	30.8	0.340		-5		5,010	5.010	2.176	2.176	84	Boundary detected within 40 m
C-11	2	C2	2,868	29,200	28,970	0.8	14.3	9.8	18.8	0.492		-3		31.355	31.355	8.649	8.649	204	Boundary detected within 110 m
C-11	3	B	2,825	28,965	27,931	3.6	10.4	2.4	12.3	0.655		19		9.341	10.966	4.098	4.811	3,635	No condensate, high perm. May be due to fracture.
C-11	5	LA1	2,732	28,970	27,320	5.7	13.8	7.5	25.9	0.889				8.033	8.033	4.060	4.060	205	Boundary detected within 110 m and depleted on test
A-12	1	C2	2,885	29,178	23,158	20.6	12.0	9.3	28.3	0.694		28		1.875	2.535	1.378	1.863	137	
A-12	2		2,805	29,040	28,040	3.4	18.3	7.5	7.2	0.924				13.652	13.652	5.924	5.924	298	
A-12	4	LA1	2,643	28,655	22,675	20.9	15.3	4.1	43.5	0.646				1.728	1.728	1.274	1.274	52	
A-12	5	UA1	2,632	28,622	25,542	10.8	11.5	4.4	42.5	0.872				4.282	4.282	2.615	2.615	255	
L-37	1	B	2,843	29,340	23,740	19.1	12.8	8.8	27.0	0.654		48		1.894	3.686	1.362	2.651	138	
F-09	3	B	2,769	28,980	26,690	7.9	16.5	9.3	29.5	0.480		5		3.162	3.327	1.763	1.854	246	
N-17	2	LA1	2,833	29,060	27,509	5.3	16.0	14.3	34.1	0.603				5.804	5.804	2.876	2.876		Misrun; not reliable
D-58	4	LA1	2,809	30,314	11,814	61.0	15.4	2.0	40.9	0.100		78		0.118	0.155	0.112	0.148	70	225 m water recovered

Table 3-2: Well Test Results Summary (cont'd)

Well	DST	Sand	MPP[1] (mss)	Pi[2] (kPa)	Pwf[3] (kPa)	Press. DD[4] (%)	Por[5] (%)	Net Pay (m)	S_w[6] (%)	Flow Rate (Mm^3/d)	Multi-rates	S_c[7]	Slope[8] (n)	AOF[9] n = 1		AOF n = 0.69		Perm.[11] (mD)	Remarks
														S_c (Mm^3/d)	s[10] = 0 (Mm^3/d)	S_c (Mm^3/d)	s = 0 (Mm^3/d)		
E-21	1	LA1	2,785	29,004	25,619	11.7	17.0	6.0	28.6	0.650		30		2.832	4.613	1.770	2.884	287	
E-21	2	LA1	2,785	29,439	25,553	13.2	17.0	6.0	28.6	0.784	5		0.90	3.179	3.179	2.060	2.060	188	Overpressure 73 psi
E-21	3	A	2,738	28,853	22,613	21.6	13.7	9.2	33.9	0.600				1.555	1.555	1.158	1.158	18	
P-53	1	LA1	2,856	29,182	6,282	78.5	15.4	5.2	29.3	0.040				0.042	0.042	0.041	0.041	4.0	Multiboundaries detected within 15 m and depleted on test
P-41	3	A shale	2,834	28,610	16,210	43.3	11.8	5.5	35.9	0.353		83		0.520	1.488	0.461	1.320	67	Good radial flow
L-43	3	C1	2,850	28,920	26,831	7.2	12.6	3.0	34.8	0.387				2.779	2.779	1.508	1.508	148	No condensate and has not reached radial flow; high CO_2
L-43	4	B	2,795	28,800	24,546	14.8	16.8	9.2	33.0	0.695		-3		2.540	2.540	1.700	1.700	21	High CO_2 content
L-43	5	LA1	2,718	28,450	19,742	30.6	13.3	6.4	45.0	0.534				1.030	1.030	0.840	0.840	41	Boundary detected within 60 m; high CO_2
O-27	5	B	3,012	27,327	10,327	62.2	9.1	11.9	63.8	0.059		-1							Open hole test; depletion detected

Note:

1. MPP = mid-point perforation
2. Pi = initial reservoir pressure
3. Pwf = bottomhole flow pressure
4. Press. DD = pressure drawdown
5. Por = porosity
6. S_w = water saturation
7. S_c = calculated skin from well test
8. Slope = back-pressure slope for multirate test
9. AOF = sandface absolute open flow
10. s = skin
11. Perm. = permeability

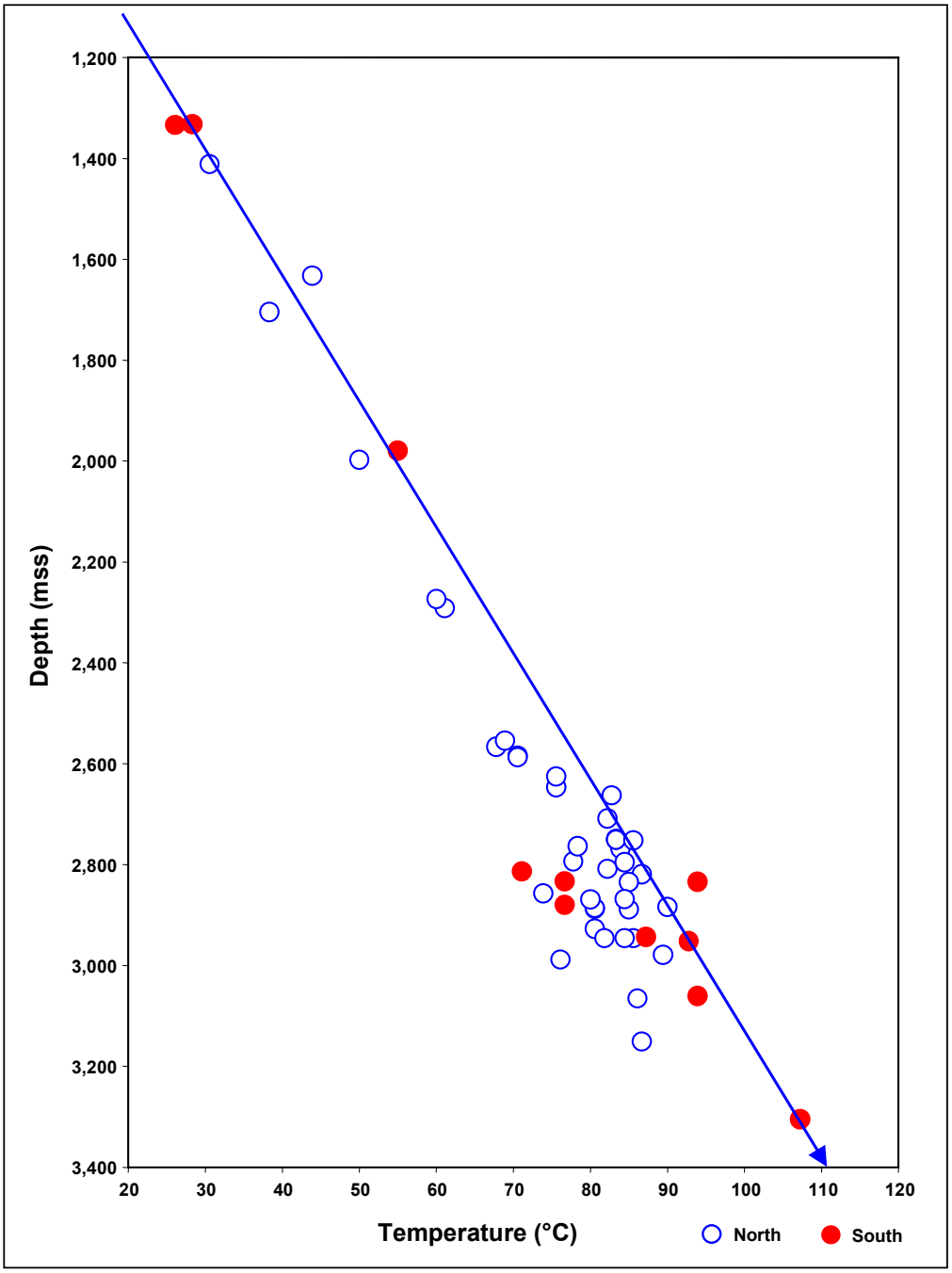

Figure 3-3: Reservoir Temperature Versus Depth

3.1.3.3 Reservoir Assessment

No appreciable pressure depletion was identified during drill-stem testing, except for DST 3 in well D-48 and DST 5 in well O-27. Possible depletion in these zones might be related to near wellbore faulting and small isolated compartments. This was observed at O-27, where the tested sands contact shale on the opposite side of the fault. Fault boundaries were observed at some drill-stem tests (see Table 3-2).

3.1.4 CORE DATA

Core was acquired from eight wells in the Parsons Lake area during the 1970s. Five of the eight wells provided core for analysis from the productive Kamik sands:

- Parsons N-10
- Parsons P-41
- Parsons L-43
- Siku A-12
- Siku E-21

Rock properties were determined from:

- well logs
- core data
- production test data

The assumptions, analytical techniques and results of the analyses of the log and core data are discussed in Section 2, Geology, Geophysics and Petrophysics. Routine core porosity and permeability analysis (see Figure 3-4) shows:

- porosity values from 4 to 21% (average 13%)
- permeability values from 0.1 to 1,000 mD (average 30 mD)

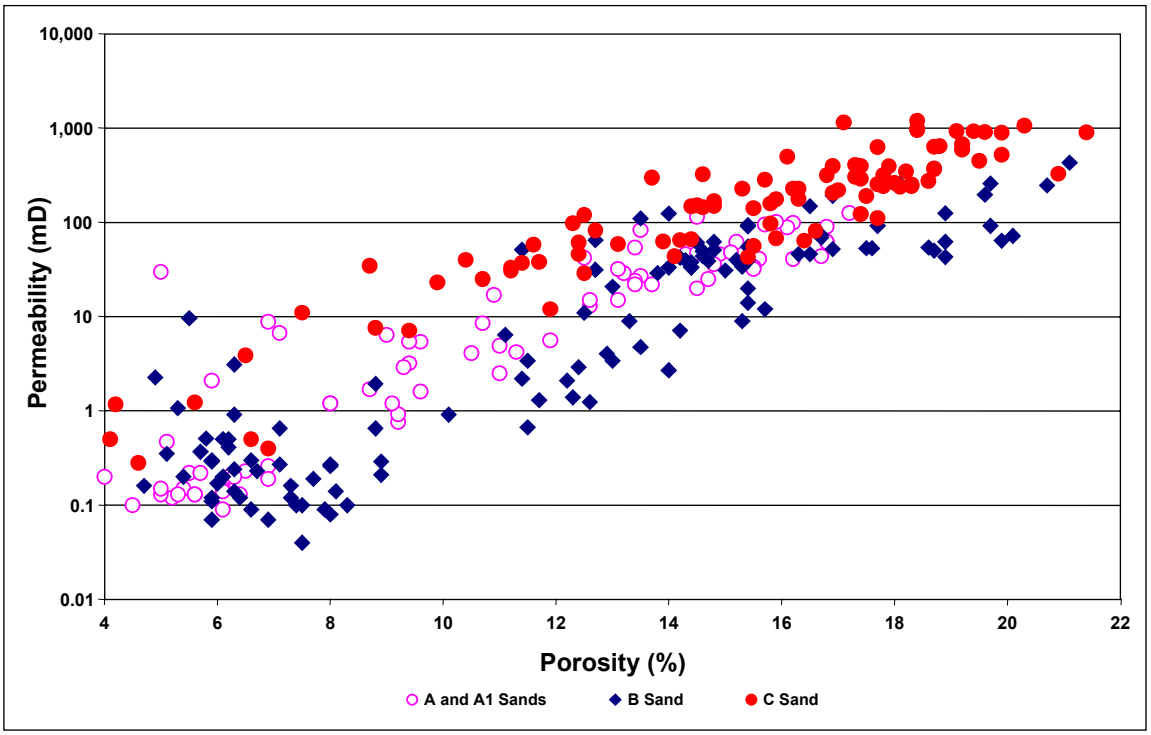

Figure 3-4: Porosity Versus Permeability

3.1.4 CORE DATA (cont'd)

Special core analysis studies were done on core plugs in 2002 and 2003. Samples were selected to represent the various facies and to encompass the range of porosity and permeability values of the reservoir sands. This data was incorporated into the reservoir simulation described in Section 4.2, Reservoir Simulation. Trapped gas experiments from these studies show residual gas saturation values from 16.5 to 43%. Capillary pressure tests indicate the end points of initial water saturations, varying from 10 to 45%, and are correlated with the facies.

3.1.5 RESERVOIR FLUID PROPERTIES

Many individual gas, natural gas liquid (NGL) and water samples were obtained and analyzed from the production and drill stem tests done at Parsons Lake (see Table 3-3). The reservoir data shown in the remainder of this section is for the north and south pools.

The specific gravity values are:

- 0.65 for gas
- 0.80 for NGLs

The liquid-to-gas ratio averages about 60 m^3/Mm^3 (10.6 bbl/MMcf).

Using recombined fluid analysis, the representative dew point pressure in the Kamik sands has been calculated to be 28.6 MPa (4,150 psi) at the north pool gas–water contact of 2,890 mss and 90ºC.

Table 3-4 provides the average pressure-volume-temperature (PVT) data for gas and condensate used in reservoir engineering studies. The PVT properties are shown graphically in Figure 3-5.

The average composition of the reservoir water is shown in Table 3-5.

3.1.6 FLUID INJECTION

Water from Parsons Lake wells will be separated from other produced fluids in the north pad gas conditioning facility. This produced water will be disposed of by injecting it through a waste disposal well into the Kamik reservoir downdip of the gas-bearing C sands and into the water leg. Because the water is being returned to its zone of origin, there will be no compatibility issues.

The waste disposal well will be drilled directionally from the north pad and end in the Kamik C sands about 3 km west. The disposal zones will be below the gas–water contact of the Parsons Lake north pool and into its source in the regional aquifer. The current bottomhole of the waste disposal well is F-30, but more work is planned to confirm this as the best location.

Table 3-3: Analyzed Samples

No.	Well	DST No.	Sand	N_2	CO_2	H_2S	C_1	C_2	C_3	iC_4	nC_4	iC_5	nC_5	C_6	C_7+	Total	Flow Time Hours	Gas Rate Mm^3/d	Field NGLs. m^3/m^3	Pressure Drawdown (%)
1	N-17	2	LA1	1.73	2.97	0.00	87.25	3.69	1.66	0.31	0.53	0.21	0.20	0.26	1.15	100.0	3.0	607	9.29E-05	5
2	A-12	4	LA1	1.44	3.22	0.00	87.97	3.52	1.49	0.27	0.46	0.17	0.15	0.16	1.16	100.0	2.0	646	9.49E-05	21
3	A-12	4	LA1	1.46	3.21	0.00	87.95	3.53	1.49	0.27	0.46	0.17	0.15	0.16	1.14	100.0	2.0	646	9.49E-05	21
4	A-12	5	UA1	2.33	2.75	0.00	87.59	3.44	1.46	0.27	0.45	0.17	0.15	0.20	1.20	100.0	2.0	648	1.13E-04	8
5	A-12	5	UA1	1.51	3.20	0.00	88.19	3.50	1.48	0.27	0.44	0.16	0.14	0.16	0.95	100.0	8.0	872	7.45E-05	11
6	A-12	5	UA1	1.50	2.99	0.00	88.32	3.51	1.48	0.27	0.45	0.16	0.14	0.17	1.01	100.0	8.0	872	7.45E-05	11
7	A-12	2	C2	1.87	3.28	0.00	87.77	3.53	1.50	0.27	0.45	0.16	0.14	0.15	0.89	100.0	2.0	664	8.57E-05	2
8	A-12	2	C2	1.61	3.28	0.00	88.12	3.50	1.45	0.26	0.43	0.15	0.13	0.14	0.93	100.0	8.0	910	7.40E-05	3
9	A-12	2	C2	1.51	3.09	0.00	88.16	3.56	1.51	0.28	0.46	0.17	0.15	0.14	0.94	100.0	8.0	924	7.52E-05	3
10	C-11	5	UA1	1.63	3.33	0.00	87.77	3.57	1.50	0.27	0.46	0.17	0.15	0.16	0.97	100.0	2.0	648	1.15E-04	6
11	C-11	5	UA1	1.56	3.33	0.00	87.78	3.54	1.52	0.28	0.47	0.18	0.17	0.17	0.98	100.0	6.0	889	7.52E-05	6
12	C-11	3	B	1.60	3.33	0.00	89.06	3.54	1.41	0.23	0.36	0.11	0.09	0.11	0.16	100.0	5.5	655	N/A	4
13	C-11	2	C2	1.68	3.35	0.00	87.41	3.59	1.54	0.29	0.50	0.20	0.20	0.22	1.00	100.0	6.5	492	8.05E-05	1
14	L-37	1	B	1.49	2.12	0.00	91.09	2.39	1.06	0.20	0.34	0.12	0.11	0.25	0.82	100.0	6.0	654	6.24E-05	19
15	D-20	7	LA1	1.50	3.33	0.00	88.37	3.52	1.48	0.27	0.44	0.16	0.14	0.14	0.65	100.0	1.9	499	5.69E-05	8
16	D-20	3	B	1.49	3.11	0.00	88.58	3.53	1.49	0.27	0.44	0.16	0.14	0.14	0.65	100.0	6.0	538	4.07E-05	33
17	D-20	1	C2	1.76	3.08	0.00	88.41	3.52	1.47	0.26	0.43	0.15	0.13	0.15	0.62	100.0	2.1	557	4.81E-05	26
18	N-10	8	B	1.47	2.71	0.00	88.36	3.80	1.58	0.28	0.47	0.17	0.16	0.16	0.83	100.0	22.5	791	3.92E-05	23
19	N-10	8	B	1.48	2.74	0.00	88.34	3.81	1.59	0.28	0.46	0.17	0.15	0.16	0.82	100.0	39.0	341	4.16E-05	6
20	N-10	6	LC3	1.48	2.85	0.00	88.38	3.81	1.58	0.28	0.48	0.18	0.16	0.14	0.66	100.0	8.0	681	3.68E-05	29
21	N-10	6	LC3	1.49	2.87	0.00	88.48	3.81	1.56	0.26	0.45	0.16	0.14	0.12	0.66	100.0	18.5	183	3.64E-05	5
22	N-10	7	UC3	1.97	2.81	0.00	88.27	3.75	1.52	0.26	0.42	0.15	0.13	0.13	0.59	100.0	10.0	1097	4.42E-05	5

Table 3-3: Analyzed Samples (cont'd)

No	Well	DST No.	Sand	N_2	CO_2	H_2S	C_1	C_2	C_3	iC_4	nC_4	iC_5	nC_5	C_6	C_7+	Total	Flow Time Hours	Gas Rate Mm^3/d	Field NGLs m^3/m^3	Pressure Drawdown (%)
23	N-10	7	UC3	1.50	2.84	0.00	88.18	3.80	1.59	0.27	0.47	0.17	0.15	0.16	0.86	100.0	22.5	407	6.06E-05	1
24	E-21	3	A	1.33	2.78	0.00	88.81	3.39	1.45	0.28	0.48	0.19	0.18	0.23	0.87	100.0	2.0	600	3.85E-05	22
25	E-21	2	UA1	1.32	3.22	0.00	88.95	3.31	1.39	0.26	0.42	0.15	0.13	0.14	0.71	100.0	6.5	784	4.06E-05	13
26	L-43	5	LA1	0.59	4.92	0.00	90.28	2.39	0.72	0.12	0.18	0.07	0.06	0.10	0.56	100.0	5.2	534	4.29E-05	31
27	L-43	4	B	0.59	5.10	0.00	90.18	2.37	0.72	0.11	0.18	0.07	0.06	0.11	0.51	100.0	7.3	695	3.91E-05	15
28	L-43	3	C1	0.59	5.13	0.00	90.35	2.50	0.80	0.15	0.22	0.08	0.06	0.03	0.09	100.0	1.0	387	N/A	7
29	P-41	3	Ashale	1.18	2.73	0.00	89.54	1.77	0.62	0.11	0.17	0.06	0.06	0.12	3.64	100.0	5.7	353	1.52E-04	43

Table 3-4: Average PVT Data

P_g (kPa(g))	R_s (m^3/m^3)	B_g (m^3/m^3)	μ_g (cp)
2,101	0.0000384	0.05852	0.0132
4,755	0.0000309	0.02504	0.0136
5,272	0.0000305	0.02247	0.0137
6,307	0.0000303	0.01859	0.0139
8,385	0.0000315	0.01368	0.0144
12,512	0.0000363	0.00903	0.0159
15,959	0.0000420	0.00707	0.0175
20,096	0.0000510	0.00568	0.0197
24,233	0.0000582	0.00483	0.0221
26,601	0.0000590	0.00448	0.0234
28,403	0.0000595	0.00426	0.0244
28,577	0.0000595	0.00424	0.0245

P_g = gas pressure
R_s = gas-oil ratio
B_g = formation volume factor
μ_g (cp) = viscosity of gas in centipoise

Table 3-5: Representative Water Composition of Parsons Lake Reservoir

Component	Formula	ppm(w)
Bicarbonate	HCO_3	1,230
Calcium	Ca^{2+}	240
Chloride	Cl^-	10,480
Magnesium	Mg^+	60
Sodium	Na^+	6,950
Sulphate	SO_4^{2-}	160
Note: Based on analyses of produced water from Parsons Lake field wells.		

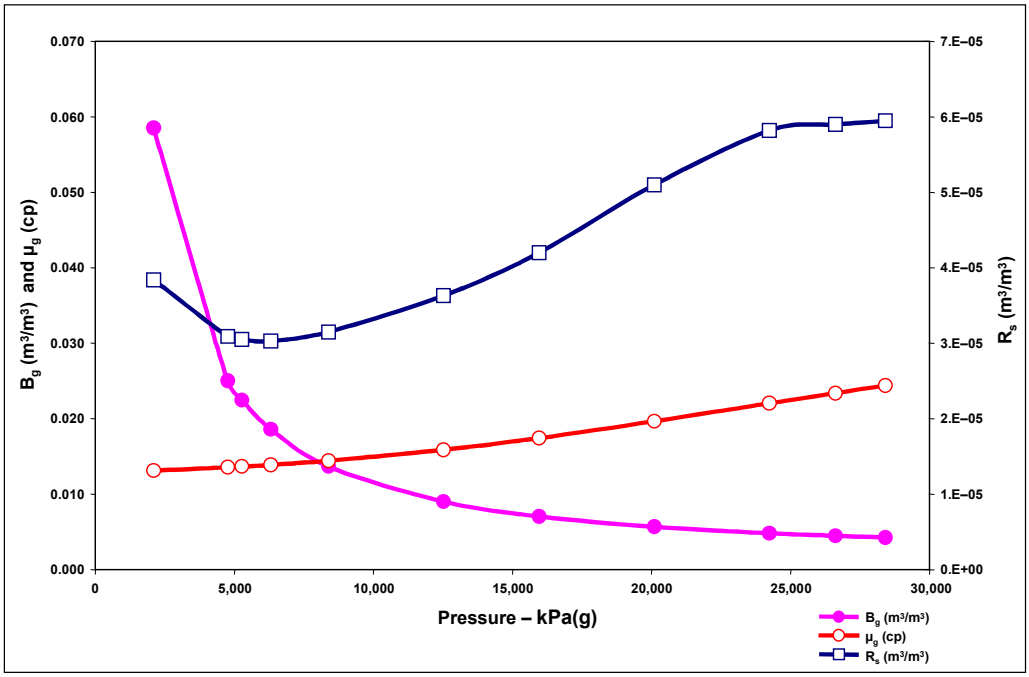

Figure 3-5: PVT Properties

3.2.1 MODEL EVALUATION OF ORIGINAL GAS-IN-PLACE

A geocellular model was used to build and assess the original gas-in-place (OGIP). A permeability cut-off of 0.5 mD was used for net pay calculations within the model.

Several geological models were created to evaluate the:

- upper and lower limits of the structure
- best case, worst case and most likely facies
- best case, worst case and most likely water saturation

A distribution of gas-in-place volumes was generated using these geological models. The base case OGIP value for the analysis in this development plan approximates the mode of the distribution at 97.7 Gm^3 (3.45 Tcf). Refinement of the models is ongoing.