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APPENDICES

APPENDIX A.

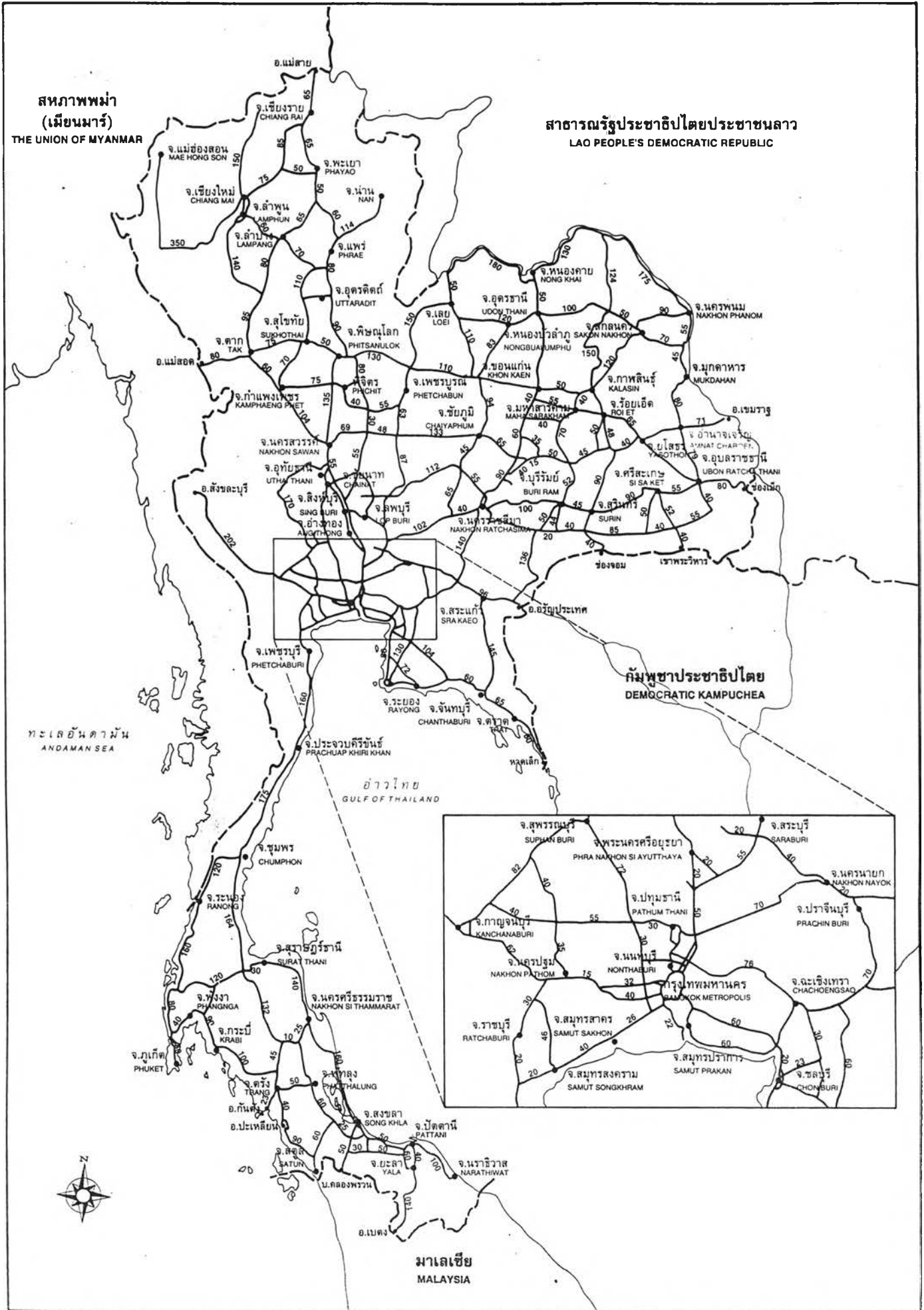
**DISTANCE CHART BETWEEN PROVINCES AND
PROVINCES**

APPENDIX A.

DISTANCE CHART BETWEEN PROVINCES AND PROVINCES (Km.)

	Chaing ma	Chaing rai	Nan	Phayao	Phrae	Mae hongson	Lampang	Lamphun	Kampheng phe	Tak	Nakhon sawan	Phichit	Pitsanulok	Phetchabun	Sukhothai	Uttaradit	Uthai thani
Chaing mai	20	182	318	222	201	349	92	21	337	265	449	406	333	506	298	231	500
Chaing rai	182	20	270	94	235	634	225	295	477	398	542	474	413	583	400	308	591
Nan	318	270	20	176	118	639	227	297	359	362	425	359	295	465	282	191	474
Phayao	222	94	176	20	141	543	131	201	382	304	448	379	319	489	337	214	497
Phrae	201	235	118	141	20	521	109	180	241	244	307	239	178	348	165	74	357
Mae hongson	349	634	639	543	521	20	412	342	569	499	683	656	637	807	578	552	733
Lampang	92	225	227	131	109	412	20	71	241	174	359	332	244	414	207	140	408
Lamphun	21	295	297	201	180	342	71	20	316	244	428	385	312	485	277	210	479
Kampheng phe	337	477	359	382	241	569	241	316	20	68	117	90	103	273	77	177	167
Tak	265	398	362	304	244	499	174	244	68	20	185	157	138	308	79	179	234
Nakhon sawan	449	542	425	448	307	683	359	428	117	185	20	113	129	192	188	247	50
Phichit	406	474	359	379	239	656	332	385	90	157	113	20	73	129	125	189	163
Pitsanulok	333	413	295	319	178	637	244	312	103	138	129	73	20	170	59	118	179
Phetchabun	506	583	465	489	348	807	414	485	273	308	192	129	170	20	229	288	233
Sukhothai	298	400	282	337	165	578	207	277	77	79	188	125	59	229	20	100	238
Uttaradit	231	308	191	214	74	552	140	210	177	179	247	189	118	288	100	20	297
Sthai thani	500	591	474	497	357	733	408	479	167	234	50	163	179	233	238	297	20
SARABURI	625	718	600	624	483	860	535	604	293	361	175	289	305	239	362	423	157

แผนที่ประเทศไทย แสดงระยะทาง(กิโลเมตร)ระหว่างเมือง
ROAD MAP SHOWING DRIVING DISTANCES IN KILOMETERS



APPENDIX B.

**TRANSPORTATION COST RATES FROM SARABURI
OIL DEPOT TO TERMINAL OIL DEPOTS**

APPENDIX B.

Transportation Cost Rates from Saraburi oil depot to Terminal Oil Depots
Source : PTT.

From Saraburi to...	Chaing Mai	Lampang	Pitsanulok	Nakhon Sawan
Transportation Cost (satang / litre)	42.7	34.91	23.91	16.14

NOTE : *Plus Terminal Oil Depot and Tank charge of 4 satang per litre for these provinces*

APPENDIX C.

TRANSPORTATION COST RATES BY DISTANCES

APPENDIX C.

Transportation Cost Rate according to Distance

Source : PTT

Distance (km.)	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	110	120	130	140
Transportation Cost (Satang / Litre)	5.22	5.59	5.95	6.32	6.68	7.05	7.41	7.78	8.15	8.51	8.87	9.24	9.61	9.98	10.37	10.76	11.16	11.84	12.5	13.2	13.88

Distance (km.)	150	160	170	180	190	200	210	220	230	240	250	260	270	280	290	300	310	320	330	340	350
Transportation Cost (Satang / Litre)	14.69	15.35	16.02	16.71	17.36	18.02	18.66	19.32	19.96	20.61	21.31	22.03	22.66	23.21	23.97	24.61	25.19	25.8	26.44	27.09	27.67

Distance (km.)	360	370	380	390	400	410	420	430	440	450	460	470	480	490	500	510	520	530	540	550	560
Transportation Cost (Satang / Litre)	28.27	28.92	29.55	30.15	30.74	31.33	31.93	32.52	33.11	33.69	34.28	34.86	35.47	36.05	36.63	37.23	37.82	38.35	38.88	39.45	40.05

Distance (km.)	570	580	590	600	610	620	630	640	650	660	670	680	690	700	710	720	730	740	750	760	770
Transportation Cost (Satang / Litre)	40.57	41.11	41.7	42.29	42.82	43.25	43.93	44.51	45.05	45.59	46.12	46.65	47.18	47.71	48.4	49.06	49.67	50.28	50.89	51.51	52.12

Distance (km.)	780	790	800	810	820	830	840	850	860	870	880	890	900	910	920	930	940	950
Transportation Cost (Satang / Litre)	52.74	53.35	53.95	54.56	55.19	55.62	56.05	56.34	56.63	56.89	57.16	57.55	57.94	58.13	58.31	59.07	59.82	60.59

APPENDIX D.

**NATIONAL PETROLEUM PRODUCTS DEMAND AND
GROWTH RATE PROJECTION (YEAR 2000-2010)**

Appendix D

National Petroleum Product Demand and Growth Rate Projection

Unit : KBD

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
LPG	47.51 -7.76%	49.66 4.52%	52.29 5.31%	55.51 6.15%	59.21 6.67%	63.35 6.98%	68.07 7.45%	73.06 7.34%	78.33 7.20%	84.22 7.53%	90.5 7.46%	97.4 7.62%	105.07 7.87%
GASOLINE	123.53 -2.65%	123.59 0.05%	126.56 2.40%	130.51 2.91%	135.53 4.05%	141.58 4.46%	147.89 4.46%	154.01 4.14%	160.06 3.93%	166.5 4.03%	172.68 3.71%	178.73 3.50%	184.8 3.40%
DIESEL	263.4 -12.92%	269.44 2.29%	279.8 3.84%	292.19 4.43%	304.6 4.25%	316.62 3.95%	330.38 4.35%	344.02 4.13%	357.35 3.87%	371.43 3.94%	384.86 3.62%	397.99 3.41%	411.19 3.31%
KEROSENE	0.95 -35.20%	0.9 -5.59%	1.03 15.38%	1.12 8.33%	1.21 7.69%	1.21 0.00%	1.21 0.00%	1.21 0.00%	1.21 0.00%	1.21 0.00%	1.21 0.00%	1.21 0.00%	1.21 0.00%
JET FUEL	57.12 -6.57%	56.42 -1.22%	57.55 2.00%	59.61 3.59%	62.17 4.28%	65.08 4.68%	68.19 4.78%	71.32 4.59%	74.52 4.49%	77.86 4.49%	81.59 4.79%	85.42 4.69%	89.42 4.69%
FUEL OIL	137.7 -12.77%	133.57 -3.00%	96.78 -27.55%	95.08 -1.75%	89.4 -5.98%	93.6 4.70%	99.02 5.79%	104.89 5.93%	120.17 14.57%	124.51 3.61%	134.74 8.22%	142.25 5.58%	149.15 4.85%
TOTAL	630.22 -10.14%	633.58 0.53%	614.01 -3.09%	633.76 3.22%	652.11 2.90%	681.43 4.50%	714.75 4.89%	748.51 4.72%	791.63 0.58%	825.73 4.31%	865.58 4.83%	902.99 4.32%	940.83 4.19%

Source : Petroleum Authority of Thailand (PTT.)

APPENDIX E.

**THE SPECIFICATION OF CARBON STEEL PIPE
API 5L GR.B. SCH. 40 (SEAMLESS) / ASTM A106**

Appendix E

Carbon Steel Pipe : ASTM A106 GR.B / API 5L GR.B Sch. 40 (Seamless)

Nominal Bore (NB) (inch)	Outside Diameter (O.D.) (mm)	Sch.40 (mm)	Inside Diameter (I.D.) (mm)	Weight (kg/m)
10" (254 mm.)	273	9.3x2 = 18.6	254.4 (10.02")	60.31
12" (304.8 mm.)	323.8	10.3x2 = 20.6	303.2 (11.94")	79.73
14" (355.6 mm.)	355.6	11.1x2 = 22.2	333.4 (13.13")	94.55
16" (406.4 mm.)	406.4	12.7x2 = 25.4	387 (15")	123.3
18" (457.2 mm.)	457.2	14.3x2 = 28.6	428.6 (16.87")	155.8

Source : Petroleum Authority of Thailand (PTT.) and R.P.B. Industry Co., Ltd.

APPENDIX F.

FRICTION LOSS FOR VISCOUS LIQUIDS

Appendix F

Friction Loss for Viscous Liquids (Based on Darcy's Formula)

Loss in Feet of Liquid per 1000 Feet of pipe 10 Inch (10.02") Sch 40 New Steel Pipe

Source : Ingersoll-Rand : Cameron Hydraulic Data

Flow		Kinematic Viscosity (centistokes)									
US gal per min	Bbl per hr (42 gal)	0.6	1.1	2.1	2.7	4.3	7.4	10.3	13.1	15.7	20.6
		Approx SSU viscosity									
			31.5	33	35	40	50	60	70	80	100
400	571	0.83	0.92	1.03	1.09	1.19	1.35	1.46	1.55	1.63	1.75
500	714	1.27	1.38	1.53	1.600	1.78	2.00	2.16	2.30	2.40	2.59
600	857	1.78	1.91	2.14	2.24	2.47	2.77	2.98	3.15	3.31	3.54
700	1000	2.39	2.55	2.84	3.97	3.26	3.62	3.93	4.14	4.32	4.67
800	1140	3.06	3.29	3.63	3.79	4.12	4.63	4.99	5.25	5.46	5.86
900	1285	3.84	4.12	4.49	4.72	5.09	5.72	6.14	6.46	6.74	7.19
1000	1430	4.68	4.99	5.42	5.70	6.13	6.90	7.36	7.83	8.10	8.63
1100	1570	5.63	5.97	6.49	6.82	7.34	8.20	8.76	9.25	9.62	10.3
1200	1715	6.61	7.05	7.63	7.85	8.65	9.58	10.3	10.8	11.3	11.9
1300	1855	7.71	8.18	8.85	9.16	9.95	11.0	11.8	12.4	13.0	13.7
1400	2000	8.88	9.42	10.2	10.6	11.4	12.6	13.5	14.2	14.7	15.7
1500	2140	10.1	10.8	11.7	12.0	12.9	14.3	15.3	16.1	16.6	17.8
1600	2285	11.5	12.2	13.2	13.6	14.6	16.0	17.2	18.1	18.7	20.2
1800	2570	14.3	15.1	16.2	16.7	17.9	19.7	20.9	22.1	22.9	24.3
2000	2860	17.8	18.6	19.8	20.6	21.8	24.0	25.5	27.0	28.0	29.5
2200	3140	21.3	22.2	23.7	24.6	26.1	28.6	30.3	32.1	31.8	35.0
2400	3430	25.2	26.3	28.0	28.9	30.7	33.4	35.5	37.3	38.9	41.0
2600	3710	29.6	30.6	32.5	33.5	35.6	38.7	41.0	42.9	44.8	47.3
2800	4000	34.1	35.3	37.4	38.4	40.8	44.5	47.1	49.0	51.0	54.1
3000	4285	39.1	40.2	42.7	43.5	46.6	50.7	53.2	55.7	57.7	61.3
3500	5000	52.5	54.4	57.4	58.9	62.3	66.4	70.6	73.6	76.2	80.8
4000	5715	68.0	70.5	73.9	75.9	79.9	85.8	90.2	94.2	97.1	102
4500	6430	86.1	88.6	92.3	94.8	99.2	107	112	117	120	127
5000	7145	106	109	113	116	122	130	136	142	146	153
5500	7855	128	131	135	139	145	156	162	169	173	182
6000	8570	152	154	161	164	172	183	191	197	204	213
6500	9280	177	180	187	191	201	212	221	228	236	246
7000	10000	205	208	217	220	231	243	255	263	369	282
7500	10700	236	239	248	251	262	277	291	298	303	321
8000	11400	266	272	282	286	296	314	329	337	345	360
8500	12100	301	307	318	321	334	352	367	378	387	403
9000	12900	337	341	354	359	372	392	407	422	429	447
10000	14300	416	422	434	441	453	478	492	511	524	542
11000	15700	503	511	522	533	544	574	593	611	626	649
12000	17150	599	603	617	630	643	679	701	719	737	763

Appendix F (continued)

Friction Loss for Viscous Liquids (Based on Darcy's Formula)

Loss in Feet of Liquid per 1000 Feet of pipe 10 Inch (10.02") Sch 40 New Steel Pipe

Source : Ingersoll-Rand : Cameron Hydraulic Data

Flow		Kinematic Viscosity (centistokes)									
US gal per min	Bbl per hr (42 gal)	26.4	32	43.2	65	108.4	162.3	216.5	325	435	650
		Approx SSU viscosity									
		125	150	200	300	500	750	1000	1500	2000	3000
150	241	0.25	0.30	0.40	0.61	1.02	1.52	2.03	3.04	4.08	6.09
200	286	0.58	0.40	0.54	0.810	1.35	2.03	2.71	4.06	5.43	8.12
300	429	1.15	1.22	1.33	1.22	2.03	3.04	4.06	6.09	8.15	12.2
400	571	1.83	1.98	2.17	1.62	2.71	4.06	5.41	8.12	10.9	16.2
500	714	2.75	2.91	3.18	3.60	3.39	5.07	6.77	10.1	13.6	20.3
600	857	3.78	3.97	4.34	4.89	4.06	6.08	8.12	12.2	16.3	24.4
700	1000	4.94	5.19	5.66	6.37	4.74	7.10	9.47	14.2	19.0	28.4
800	1140	6.21	6.55	7.10	7.97	9.31	8.12	10.8	16.2	21.7	32.5
900	1285	7.66	8.04	8.71	9.76	11.4	9.13	12.2	18.3	24.5	36.5
1000	1430	9.21	9.61	10.5	11.7	13.6	10.1	13.5	20.3	27.2	40.6
1100	1570	10.9	11.4	12.3	13.8	16.0	18.0	14.9	22.3	29.9	44.6
1200	1715	12.6	13.4	14.4	16.0	18.6	21.0	16.2	24.4	32.6	48.7
1300	1855	14.5	15.4	16.4	18.4	21.2	24.0	17.6	26.4	35.3	52.8
1400	2000	16.6	17.5	18.7	20.9	24.1	27.2	18.9	28.4	38.0	59.8
1500	2140	18.7	19.6	21.2	23.6	27.2	30.6	33.3	30.4	40.8	60.9
1600	2285	21.0	21.9	23.7	26.3	30.4	34.1	37.2	32.4	43.5	64.9
1800	2570	26.0	27.3	29.2	32.2	37.1	41.7	45.5	36.5	48.9	73.1
2000	2860	31.3	32.7	35.0	38.6	44.4	49.8	54.4	40.6	54.3	81.2
2200	3140	37.0	38.6	41.3	45.8	52.3	58.8	64.0	71.9	59.8	89.3
2400	3430	43.1	45.1	48.3	53.4	60.9	68.3	74.2	83.8	65.2	97.4
2600	3710	49.8	52.1	55.4	61.4	70.0	78.3	85.0	96.2	70.7	105
2800	4000	56.8	59.2	63.5	70.1	79.7	88.9	96.1	109	76.1	114
3000	4285	64.3	66.8	71.8	78.8	89.8	99.8	108	122	133	122
3500	5000	84.9	88.3	94.4	103	117	131	142	159	180	156
4000	5715	108	112	119	131	149	165	178	199	217	162
4500	6430	133	139	147	162	182	202	218	244	266	300
5000	7145	160	168	179	195	218	241	262	293	318	360
5500	7855	191	199	212	231	258	286	309	345	373	423
6000	8570	223	232	247	268	302	334	359	399	435	489
6500	9280	258	267	286	310	348	384	411	460	499	560
7000	10000	296	305	326	355	396	436	468	522	566	637
7500	10700	335	347	369	405	447	492	529	589	638	766
8000	11400	377	389	414	452	505	550	594	659	710	797
9000	12900	469	482	512	557	624	679	729	809	869	976
10000	14300	567	582	619	666	743	817	872	964		

Appendix F (continued)

Friction Loss for Viscous Liquids (Based on Darcy's Formula)

Loss in Feet of Liquid per 1000 Feet of pipe 12 Inch (11.938") Sch 40 New Steel Pipe

Source : Ingersoll-Rand : Cameron Hydraulic Data

Flow		Kinematic Viscosity (centistokes)									
US gal per min	Bbl per hr (42 gal)	0.6	1.1	2.1	2.7	4.3	7.4	10.3	13.1	15.7	20.6
		Approx SSU viscosity									
			31.5	33	35	40	50	60	70	80	100
300	429	0.21	0.24	0.27	0.28	0.31	0.36	0.38	0.41	0.43	0.47
400	571	0.36	0.40	0.45	0.47	0.51	0.59	0.64	0.67	0.70	0.77
500	714	0.54	0.60	0.67	0.70	0.75	0.87	0.95	0.99	1.03	1.12
600	857	0.76	0.83	0.93	0.98	1.04	1.19	1.30	1.39	1.41	1.53
700	1000	0.98	1.11	1.23	1.29	1.37	1.56	1.70	1.82	1.84	2
800	1140	1.26	1.42	1.57	1.64	1.74	1.98	2.15	2.30	2.36	2.51
900	1285	1.57	1.76	1.94	1.96	2.15	2.44	2.65	2.82	2.94	3.08
1000	1430	1.92	2.07	2.36	2.38	2.61	2.94	3.19	3.40	3.57	3.7
1200	1715	2.73	2.91	3.18	3.32	3.62	4.07	4.41	4.68	4.91	5.08
1400	2000	3.67	3.90	4.24	4.41	4.80	5.37	5.79	6.14	6.43	6.65
1600	2285	4.75	5.02	5.43	5.64	6.12	6.83	7.35	7.78	8.14	8.51
1800	2570	5.96	6.29	6.77	7.02	7.59	8.44	9.07	9.59	10.0	10.6
2000	2860	7.32	7.69	8.25	8.54	9.21	10.2	11.0	11.6	12.1	12.9
2500	3570	11.3	11.8	12.6	13.0	13.9	15.3	16.4	17.3	18.0	19.2
3000	4285	16.1	16.8	17.7	18.3	19.5	21.4	22.8	23.9	24.9	26.5
3500	5000	21.8	22.6	23.8	24.4	26.0	28.3	30.1	31.6	32.9	34.9
4000	5715	28.3	29.2	30.7	31.5	33.3	36.2	38.4	40.3	41.8	44.3
4500	6430	35.7	36.8	38.5	39.4	41.6	45.0	47.7	49.9	51.7	54.8
5000	7145	44.0	45.2	47.1	48.2	50.7	54.7	57.8	60.4	62.6	66.2
5500	7855	53.1	54.4	56.6	57.8	60.7	65.3	68.9	71.9	74.4	78.7
6000	8570	63.0	64.5	66.9	68.3	71.6	76.8	80.9	84.3	87.2	92.1
6500	9280	73.8	75.4	78.1	79.6	83.3	89.2	93.8	97.7	101	106
7000	1000	85.4	87.2	90.1	91.8	95.9	102	108	112	116	122
7500	10700	97.9	99.8	103	105	109	117	122	127	131	138
8000	11400	111	113	117	119	124	132	138	143	148	155
9000	12850	141	143	147	149	155	164	172	178	183	192
10000	14300	173	176	180	183	190	200	209	217	223	233
11000	15700	209	212	217	220	228	240	250	269	266	278
12000	17150	249	252	258	261	269	283	294	304	312	326
13000	18550	291	295	301	305	314	330	342	353	363	373
14000	20000	338	342	348	353	363	380	394	406	416	434
15000	21400	387	392	399	403	414	433	449	462	473	493
16000	22850	440	445	453	457	465	490	507	522	534	556
18000	25700	557	561	571	577	590	614	634	651	666	692
20000	28600	687	692	703	709	725	752	775	795	812	842

Appendix F (continued)

Friction Loss for Viscous Liquids (Based on Darcy's Formula)

Loss in Feet of Liquid per 1000 Feet of pipe 12 Inch (11.938") Sch 40 New Steel Pipe

Source : Ingersoll-Rand : Cameron Hydraulic Data

Flow		Kinematic Viscosity (centistokes)									
US gal per min	Bbl per hr (42 gal)	26.4	32.0	43.2	65.0	108.4	162.3	216.5	325	435	650
		Approx SSU viscosity									
		125	150	200	300	500	750	1000	1500	2000	3000
100	143	0.08	0.10	0.13	0.20	0.34	0.51	0.68	1.00	1.35	2.00
200	286	0.16	0.19	0.27	0.40	0.67	1.00	1.37	2.05	2.74	4.01
300	429	0.49	0.53	0.41	0.62	1.01	1.51	2.00	3.08	4.11	6.16
400	571	0.81	0.86	0.94	0.82	1.34	2.02	2.68	3.98	5.46	8.21
500	714	1.22	1.25	1.37	1.02	1.71	2.50	3.37	5.01	6.84	10.3
600	857	1.66	1.71	1.87	2.12	1.97	3.02	4.05	6.03	7.99	12.3
700	1000	2.15	2.30	2.43	2.75	2.37	3.66	4.68	7.05	9.36	13.9
800	1140	2.70	2.88	3.05	3.45	2.63	4.04	5.36	8.09	10.7	15.9
900	1285	3.31	3.52	3.74	4.21	4.93	4.44	6.05	9.30	12.1	18.0
1000	1430	3.97	4.22	4.48	5.04	5.89	5.13	6.84	10.0	13.5	20.0
1200	1715	5.43	5.77	6.33	6.88	8.01	5.91	7.89	12.1	16.2	24.1
1400	2000	7.10	7.53	8.24	8.96	10.4	11.8	9.47	14.6	18.9	28.2
1600	2285	8.96	9.48	10.4	11.3	13.1	14.8	10.5	16.2	21.7	32.4
1800	2570	11.0	11.6	12.7	13.8	16.0	18.0	19.7	17.7	24.2	36.5
2000	2860	13.2	14.0	15.2	16.6	19.1	21.5	23.6	20.5	27.4	40.1
2500	3570	19.6	20.6	22.4	25.3	28.0	31.5	34.3	25.7	34.2	51.3
3000	4285	27.2	28.4	30.8	34.6	38.4	43.0	46.8	53.1	41.1	61.6
3500	5000	36.2	37.3	40.3	45.2	50.2	56.0	60.9	68.8	47.9	71.9
4000	5715	43.4	47.3	51.0	57.0	63.2	70.5	76.5	86.3	94.5	82.1
4500	6430	57.6	58.3	62.8	69.9	77.6	86.4	93.6	105	115	92.4
5000	7145	69.8	70.3	75.6	84.1	93.9	104	112	126	138	103
5500	7855	82.8	83.6	89.5	99.4	110	122	132	148	162	183
6000	8570	96.8	98.2	104	116	128	142	154	172	188	212
6500	9280	112	114	120	133	148	164	176	197	215	243
7000	10000	128	131	137	152	174	186	201	224	244	275
7500	10700	145	148	155	172	196	210	226	253	274	310
8000	11400	163	167	172	192	220	235	253	282	306	345
9000	12850	202	208	215	237	270	289	311	346	375	422
10000	14300	204	253	260	286	325	347	373	415	450	505
11000	15700	290	301	309	338	384	411	441	490	530	594
12000	17150	341	354	361	395	448	479	514	569	616	689
13000	18550	394	409	417	456	516	551	591	655	707	790
14000	20000	452	469	477	521	588	628	673	745	804	898
15000	21400	513	532	541	589	664	710	760	840	906	
16000	22850	578	598	608	662	745	796	851	940		

Appendix F (continued)

Friction Loss for Viscous Liquids (Based on Darcy's Formula)

Loss in Feet of Liquid per 1000 Feet of pipe 14 Inch (13.124") Sch 40 New Steel Pipe

Source : Ingersoll-Rand : Cameron Hydraulic Data

Flow		Kinematic Viscosity (centistokes)									
US gal per min	Bbl per hr (42 gal)	0.6	1.1	2.1	2.7	4.3	7.4	10.3	13.1	15.7	20.6
		Approx SSU viscosity									
			31.5	33	35	40	50	60	70	80	100
400	571	0.22	0.25	0.28	0.30	0.32	0.37	0.41	0.43	0.45	0.49
500	714	0.34	0.38	0.42	0.45	0.48	0.55	0.61	0.62	0.66	0.72
600	857	0.48	0.52	0.59	0.62	0.66	0.76	0.83	0.87	0.90	0.98
700	1000	0.63	0.70	0.78	0.81	0.87	0.99	1.09	1.16	1.18	1.28
800	1140	0.81	0.89	0.99	1.04	1.10	1.26	1.37	1.47	1.49	1.61
900	1285	0.98	1.11	1.23	1.28	1.36	1.55	1.69	1.80	1.85	1.97
1000	1430	1.20	1.34	1.49	1.55	1.65	1.87	2.03	2.16	2.25	2.36
1200	1715	1.69	1.82	2.07	2.09	2.29	2.58	2.80	2.98	3.13	3.24
1400	2000	2.27	2.43	2.55	2.77	3.03	3.40	3.68	3.91	4.09	4.23
1600	2285	2.94	3.13	3.40	3.55	3.86	4.32	4.66	4.94	5.18	5.37
1800	2570	3.69	3.91	4.24	4.41	4.78	5.34	5.75	6.09	6.37	6.67
2000	2860	4.52	4.78	5.16	5.4	5.80	6.56	6.94	7.35	7.68	8.11
2500	3570	6.97	7.32	7.84	8.11	8.73	9.67	10.4	10.9	11.4	12.2
3000	4285	9.91	10.4	11.1	11.4	12.2	13.5	14.4	15.2	15.8	16.8
3500	5000	13.4	14.0	14.8	15.3	16.3	17.8	19.0	20.0	20.8	22.2
4000	5715	17.5	18.1	19.1	19.6	20.9	22.8	24.2	25.5	26.5	28.1
4500	6430	22.0	22.7	23.9	24.5	26.0	28.3	30.0	31.5	32.7	34.7
5000	7145	27.0	27.9	29.2	30.0	31.7	34.4	36.4	38.1	39.6	41.9
5500	7855	32.6	33.6	34.1	35.9	37.9	41.0	43.4	45.4	47.0	49.8
6000	8570	38.7	40.0	41.5	42.4	44.6	48.2	50.9	53.2	55.0	58.2
6500	9280	45.3	46.5	48.4	49.4	51.9	55.9	58.9	61.5	63.7	67.3
7000	10000	52.5	53.7	55.8	57.0	59.7	64.1	67.6	70.5	72.9	76.9
7500	10700	30.1	61.5	63.7	65.0	68.1	72.9	76.8	80.0	82.7	87.1
8000	11400	68.3	69.8	72.2	73.6	76.9	82.3	86.5	90.0	93.0	98.0
9000	12850	86.2	87.9	90.7	92.4	96.3	103	108	112	115	121
10000	14300	106	108	111	113	118	125	131	135	140	147
11000	15700	128	130	134	136	141	150	156	162	167	175
12000	17150	152	155	159	161	167	176	184	191	196	205
13000	18550	179	181	186	188	195	205	214	221	227	238
14000	20000	207	210	215	217	224	236	246	254	261	273
15000	21400	237	240	246	249	256	269	280	289	297	310
16000	22850	270	273	279	282	290	304	316	326	334	349
18000	25700	341	345	351	355	365	381	395	407	417	454
20000	28600	420	425	432	436	447	466	482	496	508	528
25000	35700	655	661	671	676	691	716	737	756	772	800

Appendix F (continued)

Friction Loss for Viscous Liquids (Based on Darcy's Formula)

Loss in Feet of Liquid per 1000 Feet of pipe 14 Inch (13.124") Sch 40 New Steel Pipe

Source : Ingersoll-Rand : Cameron Hydraulic Data

Flow		Kinematic Viscosity (centistokes)									
US gal per min	Bbl per hr (42 gal)	26.4	32.0	43.2	65.0	108.4	162.3	216.5	325	435	650
		Approx SSU viscosity									
		125	150	200	300	500	750	1000	1500	2000	3000
200	286	0.11	0.14	0.19	0.28	0.47	0.68	0.93	1.36	1.86	2.77
300	429	0.32	0.34	0.27	0.42	0.69	1.02	1.40	2.09	2.71	4.19
400	571	0.52	0.55	0.60	0.55	0.92	1.39	1.82	2.73	3.72	5.46
500	715	0.78	0.80	0.88	0.67	1.16	1.73	2.28	3.46	4.57	6.73
600	857	1.06	1.09	1.20	1.36	1.42	2.07	2.75	4.19	5.58	8.37
700	1000	1.38	1.47	1.56	1.76	1.57	2.51	3.21	4.82	6.43	9.64
800	1140	1.73	1.85	1.95	2.21	1.82	2.73	3.68	5.55	7.44	10.9
900	1285	2.12	2.26	2.39	2.70	2.07	3.19	4.14	6.18	8.29	12.6
1000	1430	2.54	2.70	2.86	3.22	3.78	3.41	4.65	6.91	9.30	13.8
1200	1715	3.47	3.69	3.92	4.40	5.14	4.09	5.57	8.28	11.2	16.7
1400	2000	4.53	4.81	5.27	5.73	6.67	7.57	6.27	10.0	18.9	19.3
1600	2285	5.71	6.05	6.63	7.21	8.36	9.48	7.28	10.9	14.7	22.2
1800	2570	7.01	7.42	8.11	8.83	10.2	11.6	8.29	12.7	16.6	24.7
2000	2860	8.43	8.91	9.72	10.6	12.2	13.8	15.1	13.6	18.6	27.7
2500	3570	12.5	13.2	14.3	15.6	17.9	20.2	22.0	16.8	22.8	34.4
3000	4285	17.2	18.1	19.6	22.1	24.5	27.5	30.0	34.1	27.1	41.9
3500	5000	22.8	23.7	25.7	28.8	32.0	35.8	39.0	44.1	33.0	48.2
4000	5715	29.2	30.0	32.5	36.6	40.4	45.1	48.9	55.3	60.6	54.6
4500	6430	36.4	37.0	39.9	44.6	49.5	55.2	59.9	57.5	73.9	60.9
5000	7145	44.2	44.6	48.1	53.6	59.5	66.2	71.7	80.7	88.3	67.3
5500	7855	52.5	52.8	56.9	63.3	70.2	78.1	84.5	95.0	104	77.4
6000	8570	61.3	61.9	66.3	73.3	81.8	90.8	98.1	110	120	136
6500	9280	70.8	71.8	76.4	84.8	94.1	104	113	126	138	153
7000	10000	80.9	82.3	87.2	96.6	107	119	128	143	156	177
8000	11400	103	105	111	122	140	150	161	180	196	221
9000	12850	127	131	135	150	172	184	198	221	240	270
10000	14300	154	159	165	181	207	221	238	265	287	323
11000	15700	183	190	195	215	264	261	281	312	339	380
12000	17150	215	223	228	251	285	305	327	363	393	441
13000	18550	248	258	264	289	328	351	376	418	451	506
14000	20000	284	295	302	330	374	400	428	475	513	574
15000	21400	323	335	342	373	422	451	484	536	578	646
16000	22850	363	377	384	419	473	506	542	599	647	722
18000	25700	451	458	476	518	582	623	667	736	793	884
20000	28600	548	567	576	626	703	777	803	885	953	

Appendix F (continued)

Friction Loss for Viscous Liquids (Based on Darcy's Formula)

Loss in Feet of Liquid per 1000 Feet of pipe 16 Inch (15.00") Sch 40 New Steel Pipe

Source : Ingersoll-Rand : Cameron Hydraulic Data

Flow		Kinematic Viscosity (centistokes)									
US gal per min	Bbl per hr (42 gal)	0.6	1.1	2.1	2.7	4.3	7.4	10.3	13.1	15.7	20.6
		Approx SSU viscosity									
			31.5	33	35	40	50	60	70	80	100
600	857	0.25	0.27	0.31	0.32	0.35	0.40	0.44	0.46	0.48	0.52
700	1000	0.33	0.36	0.41	0.43	0.46	0.53	0.58	0.61	0.63	0.68
800	1140	0.42	0.46	0.52	0.54	0.58	0.66	0.73	0.78	0.79	0.86
900	1285	0.52	0.58	0.64	0.67	0.72	0.82	0.89	0.95	0.97	1.05
1000	1430	0.64	0.70	0.78	0.81	0.87	0.99	1.07	1.15	1.17	1.25
1200	1715	0.87	0.98	1.08	1.13	1.20	1.36	1.48	1.58	1.65	1.72
1400	2000	1.16	1.30	1.43	1.50	1.59	1.79	1.94	2.06	2.17	2.25
1600	2285	1.50	1.61	1.79	1.84	2.02	2.27	2.46	2.61	2.74	2.83
1800	2570	1.88	2.01	2.20	2.29	2.50	2.80	3.03	3.21	3.37	3.48
2000	2860	2.30	2.45	2.67	2.78	3.03	3.39	3.65	3.87	4.05	4.23
2200	3140	2.77	2.94	3.19	3.32	3.60	4.02	4.33	4.59	4.80	5.05
2400	3430	3.27	3.46	3.75	3.89	4.22	4.70	5.06	5.35	5.59	5.93
2600	3710	3.82	4.03	4.35	4.52	4.89	5.43	5.84	6.17	6.45	6.88
2800	4000	4.41	4.65	5.00	5.18	5.60	6.21	6.67	7.04	7.35	7.87
3000	4285	5.04	5.30	5.69	5.90	6.35	7.04	7.55	7.97	8.31	8.88
3500	5000	6.80	7.12	7.61	7.86	8.44	9.31	9.96	10.5	10.9	11.7
4000	5715	8.82	9.20	9.79	10.1	10.8	11.9	12.7	13.3	13.9	14.8
4500	6430	11.1	11.5	12.2	12.6	13.5	14.7	15.7	16.5	17.2	18.3
5000	7145	13.6	14.2	14.9	15.4	16.4	17.9	19.0	20.0	20.7	22.0
6000	8570	19.5	20.1	21.2	21.7	23.0	25.0	26.5	27.8	28.8	30.5
7000	10000	26.4	27.2	28.4	29.1	30.7	33.2	35.2	36.8	38.1	40.3
8000	11400	34.4	35.3	36.7	37.6	39.5	42.6	44.9	46.9	48.5	51.3
9000	12850	43.3	44.4	46.1	47.1	49.4	53.0	55.8	58.2	60.2	63.5
10000	14300	53.4	54.5	56.5	57.6	60.3	64.5	67.8	70.6	72.9	76.8
12000	17150	76.5	78.0	80.5	81.9	85.3	90.8	95.1	98.8	102	107
14000	20000	104	106	109	110	114	121	127	131	135	142
16000	22850	135	137	141	143	148	156	163	168	173	181
18000	25700	171	173	177	180	185	195	203	210	216	225
20000	28600	211	213	218	221	227	239	248	256	262	274
22000	31400	255	258	263	266	273	286	297	306	313	326
24000	34300	303	306	312	315	323	338	350	360	369	384
26000	37100	355	359	365	369	394	394	407	418	428	445
28000	40000	411	415	422	426	454	454	468	481	492	511
30000	42850	472	476	484	488	518	518	534	548	560	581
32000	45700	537	541	549	554	587	587	604	620	633	656

Appendix F (continued)

Friction Loss for Viscous Liquids (Based on Darcy's Formula)

Loss in Feet of Liquid per 1000 Feet of pipe 16 Inch (15.00") Sch 40 New Steel Pipe

Source : Ingersoll-Rand : Cameron Hydraulic Data

Flow		Kinematic Viscosity (centistokes)									
US gal per min	Bbl per hr (42 gal)	26.4	32.0	43.2	65.0	108.4	162.3	216.5	325	435	650
		Approx SSU viscosity									
		125	150	200	300	500	750	1000	1500	2000	3000
400	571	0.28	0.29	0.21	0.32	0.54	0.81	1.08	1.61	2.21	3.23
500	714	0.4	0.43	0.47	0.41	0.68	1.01	1.34	2.05	2.73	4.10
600	857	0.57	0.58	0.64	0.50	0.79	1.21	1.63	2.42	3.26	4.97
700	1000	0.74	0.76	0.83	0.94	0.92	1.41	1.89	2.86	3.78	5.59
800	1140	0.92	0.99	1.04	1.18	1.05	1.68	2.15	3.23	4.30	6.46
900	1285	1.13	1.20	1.27	1.44	1.18	1.77	2.41	3.66	4.83	7.33
1000	1430	1.35	1.44	1.52	1.72	1.38	2.02	2.70	4.04	5.46	8.20
1200	1715	1.85	1.96	2.08	2.35	2.75	2.36	3.15	4.84	6.51	9.68
1400	2000	2.41	2.56	2.81	3.05	3.56	2.86	3.67	5.65	7.56	11.4
1600	2285	3.03	3.22	3.53	3.84	4.46	5.07	4.20	6.71	8.61	12.9
1800	2570	3.72	3.94	4.32	4.70	5.45	6.18	4.72	7.08	9.77	14.7
2000	2860	4.47	4.73	5.17	5.63	6.52	7.38	5.52	8.07	10.8	16.1
2200	3140	5.27	5.58	6.09	6.63	7.67	8.67	9.50	9.06	11.5	17.9
2400	3430	6.14	6.49	7.08	7.71	8.90	10.0	11.0	9.44	12.6	19.4
2600	3710	7.06	7.46	8.13	8.86	10.2	11.5	12.6	10.4	13.6	21.1
2800	4000	8.04	8.49	9.24	10.1	11.6	13.0	14.3	11.4	14.7	22.6
3000	4285	9.08	9.58	10.4	11.4	13.1	14.7	16.0	12.4	15.7	24.3
3500	5000	11.9	12.5	13.6	15.3	17.0	19.1	20.8	23.6	18.9	29.2
4000	5715	15.3	15.9	17.2	19.3	21.4	24.0	26.1	29.5	22.1	32.2
4500	6430	19.0	19.5	21.1	23.7	26.3	29.4	31.9	36.0	39.5	35.4
5000	7145	23.1	23.5	25.4	28.4	31.6	35.2	38.2	43.1	47.2	41.0
6000	8570	32.2	32.5	35.0	39.0	43.3	48.2	52.2	58.7	64.2	49.7
7000	10000	42.5	43.0	46.0	51.1	56.7	63.0	68.1	76.4	83.3	94.5
8000	11400	54.0	55.0	58.3	64.6	71.7	79.4	85.7	96.0	105	118
9000	12850	66.7	68.4	71.8	79.5	91.2	97.5	105	118	128	144
10000	14300	80.7	83.2	86.6	95.7	110	117	126	141	153	172
12000	17150	112	117	120	132	151	161	173	193	209	235
14000	20000	148	155	158	174	197	211	227	252	273	306
16000	22850	189	197	201	220	250	267	287	318	343	384
18000	25700	235	244	249	272	308	328	352	390	421	470
20000	28600	285	296	301	329	371	396	424	469	506	564
22000	31400	340	352	358	390	439	486	502	554	597	664
24000	34300	399	413	420	456	512	566	585	645	694	772
26000	37100	462	478	487	527	591	652	674	742	798	886
28000	40000	530	548	559	602	674	743	768	846	909	

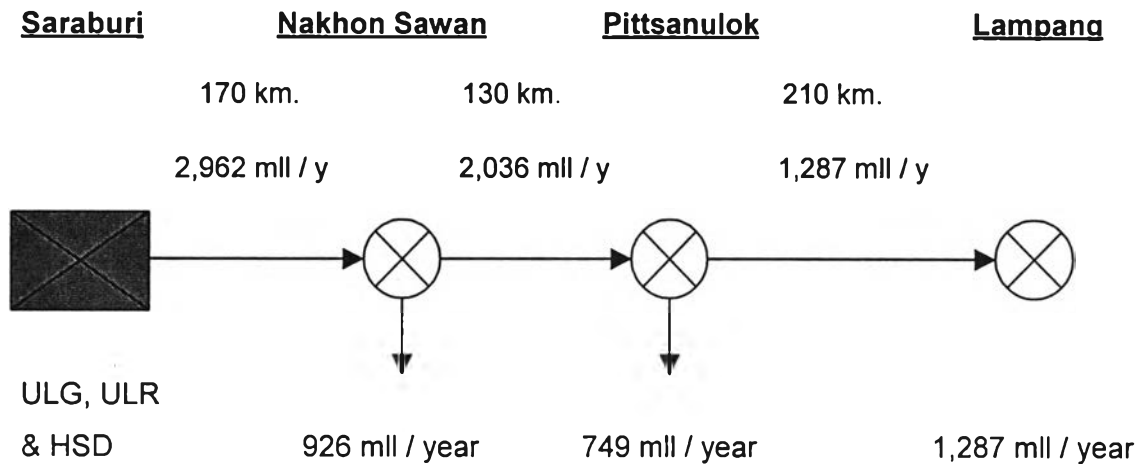
APPENDIX G.

THE CALCULATION OF OPTIMUM PIPE SIZE AND PUMP SELECTION

Appendix G.

The calculation of Optimum Pipe Size

This calculation is referred to the initial criteria in computation of Capital expenditure (clause 4.3.1)



The Capacity of the section from Saraburi oil depot to Nakhon Sawan oil depot

$$\begin{aligned}
 &= 2,962 && \text{million-litre/year} \\
 &= 2.962 \times 10 && \text{m}^3 / \text{year} \\
 &= 8,115 && \text{m}^3 / \text{day} \\
 &= 338 && \text{m}^3 / \text{hr.} \quad (\text{Assume : run 24 hr.})
 \end{aligned}$$

The Capacity of the section from Nakhon Sawan oil depot to Pittsanulok oil depot

$$\begin{aligned}
 &= 2,036 && \text{million-litre/year} \\
 &= 2.036 \times 10 && \text{m}^3 / \text{year} \\
 &= 5,578 && \text{m}^3 / \text{day} \\
 &= 232 && \text{m}^3 / \text{hr.} \quad (\text{Assume : run 24 hr.})
 \end{aligned}$$

The Capacity of the section from Pittsanulok oil depot to Lampang oil depot

$$\begin{aligned}
 &= 1,287 && \text{million-litre/year} \\
 &= 1.287 \times 10 && \text{m}^3 / \text{year} \\
 &= 3,526 && \text{m}^3 / \text{day} \\
 &= 147 && \text{m}^3 / \text{hr.} \quad (\text{Assume : run 24 hr.})
 \end{aligned}$$

Kinematics Viscosity

Unleaded Gasoline (ULG)	:	0.88
Unleaded Regular (ULR)	:	0.88
High Speed Diesel (HSD)	:	4.1

This pipeline system is to transport fluids of differing properties that is a multiproduct system (ULG, ULR and HSD), the design fluid should be considered as the fluid producing the greatest viscosity (with the greatest friction loss at the design operating temperature). In this case, High speed diesel (HSD) has the highest kinematics viscosity, thus the design of this multiproduct pipeline system will be based on HSD. Using this fluid (HSD) assures that all pumping stations have adequate power and all sections between stations have adequate wall thickness to sustain the design pressure and flow rate.

(1) The section from Saraburi oil depot to Nakhon Sawan oil depot. (Distance 170 km.)

$$\text{Maximum flow rate} = 338 \text{ m}^3 / \text{hr.} \quad (\text{run 24 hr.})$$

Assume : run 21 hr/day (run 3 shifts, 7 hours per shift)

$$\text{Safety factor} = 1.15$$

$$\begin{aligned} \therefore \text{Flow rate} &= 338 \times 1.15 \\ &= 389 \text{ m}^3 / \text{hr.} \\ &= 1,721 \text{ GPM} \end{aligned}$$

$$[\text{Note : US.GPM} \times 0.2271 = \text{m}^3 / \text{hr.}]$$

If using pipe diameter NPS 16"

$$f \text{ } \varnothing 16" = 2.282 \text{ m.} / 1,000 \text{ m.}$$

$$\begin{aligned} \text{Friction loss} &= (170 \text{ km.} \times 1,000 \text{ m.}) \times (2.282 \text{ m.} / 1,000 \text{ m.}) \\ &= 387.9 \text{ m.} \end{aligned}$$

[Note : Friction loss values are from Appendix F]

$$\text{Assume : } \Delta \text{Elevation} = 250 \text{ feet}$$

And h fitting is diminutive compare to the length of pipe (170 km), thus there is no need to concern.

$$\text{Pump must provide pressure of} \quad +387.9 \text{ m.}$$

For Safety factor (Attrition 30 years)

$$\text{S.F.} = 1.15 ; \quad 387.9 \times 1.15 = 446 \text{ m.}$$

$$\begin{aligned} \therefore \text{ Pump Head} &= 696 \quad \text{m.} \\ &= 68.2 \quad \text{bar} \\ \text{at Capacity} &= 389 \quad \text{m}^3 / \text{hr.} \end{aligned}$$

[Note : 1 Metre = 0.098 bar]

If using pipe diameter NPS 14"

$$\begin{aligned} f \text{ } \varnothing 14'' &= 4.370 \text{ m. / 1,000 m.} \\ \text{Friction loss} &= (170 \text{ km. X 1,000 m.}) \times (4.370 \text{ m. / 1,000 m.}) \\ &= 749.9 \quad \text{m.} \end{aligned}$$

$$\text{Assume : } \Delta \text{Elevation} = 250 \quad \text{feet}$$

And h fitting is diminutive compare to the length of pipe (170 km), thus there is no need to concern.

$$\text{Pump must provide pressure of} \quad +749.9 \quad \text{m.}$$

For Safety factor (Attrition 30 years)

$$\text{S.F.} = 1.15 \quad ; \quad 749.9 \times 1.15 = 854 \quad \text{m.}$$

$$\begin{aligned} \therefore \text{ Pump Head} &= 1104 \quad \text{m.} \\ &= 108.2 \quad \text{bar} \\ \text{at Capacity} &= 389 \quad \text{m}^3 / \text{hr.} \end{aligned}$$

[Note : 1 Metre = 0.098 bar]

(2) The section from Nakhon Sawan oil depot to Pittsanulok oil depot. (Distance 130 km.)

$$\text{Maximum flow rate} = 232 \quad \text{m}^3 / \text{hr.} \quad (\text{run 24 hr.})$$

Assume : run 21 hr/day (run 3 shifts, 7 hours per shift)

$$\text{Safety factor} = 1.15$$

$$\begin{aligned} \therefore \text{ Flow rate} &= 232 \times 1.15 \\ &= 267 \quad \text{m}^3 / \text{hr.} \\ &= 1,176 \quad \text{GPM} \end{aligned}$$

$$[\text{ Note : US.GPM} \times 0.2271 = \text{m}^3 / \text{hr.}]$$

If using pipe diameter NPS 14"

$$\begin{aligned} f \text{ } \varnothing 14'' &= 2.19 \text{ m. / 1,000 m.} \\ \text{Friction loss} &= (130 \text{ km. X 1,000 m.}) \times (2.19 \text{ m. / 1,000 m.}) \\ &= 284.7 \quad \text{m.} \end{aligned}$$

$$\text{Assume : } \Delta\text{Elevation} = 0$$

And h fitting is diminutive compare to the length of pipe (130 km), thus there is no need to concern.

$$\text{Pump must provide pressure of } +284.7 \text{ m.}$$

For Safety factor (Attrition 30 years)

$$\text{S.F.} = 1.15 ; 284.7 \times 1.15 = 327.4 \text{ m.}$$

$$\begin{aligned} \therefore \text{ Pump Head} &= 327.4 \text{ m.} \\ &= 32.1 \text{ bar} \\ \text{at Capacity} &= 267 \text{ m}^3 / \text{hr.} \end{aligned}$$

[Note : 1 Metre = 0.098 bar]

If using pipe diameter NPS 12"

$$f \text{ } \varnothing 12'' = 3.46 \text{ m. / 1,000 m.}$$

$$\begin{aligned} \text{Friction loss} &= (130 \text{ km. X 1,000 m.}) \times (3.46 \text{ m. / 1,000 m.}) \\ &= 449.8 \text{ m.} \end{aligned}$$

$$\text{Assume : } \Delta\text{Elevation} = 0$$

And h fitting is diminutive compare to the length of pipe (130 km), thus there is no need to concern.

$$\text{Pump must provide pressure of } +449.8 \text{ m.}$$

For Safety factor (Attrition 30 years)

$$\text{S.F.} = 1.15 ; 449.8 \times 1.15 = 517 \text{ m.}$$

$$\begin{aligned} \therefore \text{ Pump Head} &= 517 \text{ m.} \\ &= 50.7 \text{ bar} \\ \text{at Capacity} &= 267 \text{ m}^3 / \text{hr.} \end{aligned}$$

[Note : 1 Metre = 0.098 bar]

(3) The section from Pittsanulok oil depot to Lampang oil depot. (Distance 210 km.)

$$\text{Maximum flow rate} = 147 \text{ m}^3 / \text{hr.} \quad (\text{run 24 hr.})$$

Assume : run 21 hr/day (run 3 shifts, 7 hours per shift)

$$\text{Safety factor} = 1.15$$

$$\begin{aligned} \therefore \text{ Flow rate} &= 147 \times 1.15 \\ &= 169 \text{ m}^3 / \text{hr.} \end{aligned}$$

$$= 744 \text{ GPM}$$

[Note : US.GPM x 0.2271 = m³ / hr.]

If using pipe diameter NPS 14"

$$f \text{ } \varnothing 14" = 0.96 \text{ m. / 1,000 m.}$$

$$\text{Friction loss} = (210 \text{ km. X 1,000 m.}) \times (0.96 \text{ m. / 1,000 m.})$$

$$= 201.6 \text{ m.}$$

Assume : Δ Elevation = 1000 feet

And h fitting is diminutive compare to the length of pipe (210 km), thus there is no need to concern.

Pump must provide pressure of +201.6 m.

For Safety factor (Attrition 30 years)

$$\text{S.F.} = 1.15 ; 201.6 \times 1.15 = 231.84 \text{ m.}$$

$$\therefore \text{ Pump Head} = 1231.84 \text{ m.}$$

$$= 120.7 \text{ bar}$$

$$\text{at Capacity} = 169 \text{ m}^3 / \text{hr.}$$

[Note : 1 Metre = 0.098 bar]

If using pipe diameter NPS 12"

$$f \text{ } \varnothing 12" = 1.52 \text{ m. / 1,000 m.}$$

$$\text{Friction loss} = (210 \text{ km. X 1,000 m.}) \times (1.52 \text{ m. / 1,000 m.})$$

$$= 319.2 \text{ m.}$$

Assume : Δ Elevation = 1000 feet

And h fitting is diminutive compare to the length of pipe (210 km), thus there is no need to concern.

Pump must provide pressure of +319.2 m.

For Safety factor (Attrition 30 years)

$$\text{S.F.} = 1.15 ; 319.2 \times 1.15 = 367.08 \text{ m.}$$

$$\therefore \text{ Pump Head} = 1367.08 \text{ m.}$$

$$= 134 \text{ bar}$$

$$\text{at Capacity} = 169 \text{ m}^3 / \text{hr.}$$

[Note : 1 Metre = 0.098 bar]

If using pipe diameter NPS 10"

$$f \text{ } \varnothing 10" = 3.60 \text{ m. / 1,000 m.}$$

$$\begin{aligned} \text{Friction loss} &= (210 \text{ km. X 1,000 m.}) \times (3.60 \text{ m. / 1,000 m.}) \\ &= 756 \text{ m.} \end{aligned}$$

$$\text{Assume : } \Delta \text{Elevation} = 1000 \text{ feet}$$

And h fitting is diminutive compare to the length of pipe (210 km), thus there is no need to concern.

$$\text{Pump must provide pressure of } +756 \text{ m.}$$

For Safety factor (Attrition 30 years)

$$\text{S.F.} = 1.15 ; 756 \times 1.15 = 869.4 \text{ m.}$$

$$\therefore \text{ Pump Head} = 1869.4 \text{ m.}$$

$$= 186 \text{ bar}$$

$$\text{at Capacity} = 169 \text{ m}^3 / \text{hr.}$$

[Note : 1 Metre = 0.098 bar]

The Pipe Size and Pump Optimum Selection

- 1) The section from Saraburi oil depot to Nakhon Sawan oil depot (Distance 170 km.)

From the calculation above:

Case I : Selecting pipe diameter NPS 16"

Length 170 km. (28,334 pieces);

$f \text{ } \varnothing 16'' = 2.828 \text{ m. / 1,000 m.}$

Using Pump Size : (1) Pump Head 696 m. (68.2 bar);
 Flow rate (Q) = 389 m³ / hr.
 Amount = 1 Pump
 or (2) Pump Head 348 m. (34.1 bar);
 Flow rate (Q) = 389 m³ / hr.
 Amount = 2 Pumps

Case II : Selecting pipe diameter NPS 14"

Length 170 km. (28,334 pieces);

$f \text{ } \varnothing 14'' = 4.370 \text{ m. / 1,000 m.}$

Using Pump Size : (1) Pump Head 1104 m. (108.2 bar);
 Flow rate (Q) = 389 m³ / hr.
 Amount = 1 Pump
 or (2) Pump Head 552 m. (54.1 bar);
 Flow rate (Q) = 389 m³ / hr.
 Amount = 2 Pumps
 (3) Pump Head 368 m. (36.1 bar);
 Flow rate (Q) = 389 m³ / hr.
 Amount = 3 Pumps

Unit : million-baht

Pipe $\varnothing 16''$	Amount 28,334 pieces (170 km.) @ 700 USD/tons	556.9
Pump	(1) Pump Head 68.2 bar, Q = 389 m ³ / hr. : 1 pump	30.0
	(2) Pump Head 34.1 bar, Q = 389 m ³ / hr. : 2 pumps	38.0

Unit : million-baht

Pipe Ø 14"	Amount 28,334 pieces (170 km.) @ 700 USD/tons	434.12
Pump	(1) Pump Head 108.2 bar, Q = 389 m ³ / hr. : 1 pump	-
	(2) Pump Head 54.1 bar, Q = 389 m ³ / hr. : 2 pumps	60.0*
	(3) Pump Head 36.1 bar, Q = 389 m ³ / hr. : 3 pumps	66.0

So, the optimum pipe size is diameter NPS 14" and the optimum pump size is pump head 41.9 bar; amount 2 pumps.

2) The section from Nakhon Sawan oil depot to Pittsanulok oil depot (Distance 130 km.)

From the calculation above:

Case I : Selecting pipe diameter NPS 14"

Length 130 km. (21,667 pieces);

$f \text{ Ø } 14'' = 2.19 \text{ m. / 1,000 m.}$

Using Pump Size : (1) Pump Head 327.4 m. (32.1 bar);
 Flow rate (Q) = 267 m³ / hr.
 Amount = 1 Pump

Case II : Selecting pipe diameter NPS 12"

Length 130 km. (21,667 pieces);

$f \text{ Ø } 12'' = 3.46 \text{ m. / 1,000 m.}$

Using Pump Size : (1) Pump Head 517 m. (50.7 bar);
 Flow rate (Q) = 267 m³ / hr.
 Amount = 1 Pump
 or (2) Pump Head 259 m. (25.4 bar);
 Flow rate (Q) = 267 m³ / hr.
 Amount = 2 Pumps

Unit : million-baht

Pipe Ø 14"	Amount 21,667 pieces (130 km.) @ 700 USD/tons	326.79
Pump	(1) Pump Head 32.1 bar, Q = 267 m ³ / hr. : 1 pump	15.0

Unit : million-baht

Pipe Ø 12"	Amount 21,667 pieces (130 km.) @ 700 USD/tons	275.42
Pump	(1) Pump Head 50.7 bar, Q = 267 m ³ / hr. : 1 pump	25.0*
	(2) Pump Head 25.4 bar, Q = 267 m ³ / hr. : 2 pumps	28.0

So, the optimum pipe size is diameter NPS 12" and the optimum pump size is pump head 50.7 bar; amount 1 pump.

3) The section from Pittsanulok oil depot to Lampang oil depot (Distance 210 km.)

From the calculation above:

Case I : Selecting pipe diameter NPS 14"

Length 210 km. (35,000 pieces);

f Ø 14" = 0.96 m. / 1,000 m.

Using Pump Size : (1) Pump Head 1231.84 m. (120.7 bar);
 Flow rate (Q) = 169 m³ / hr.
 Amount = 1 Pump

Case II : Selecting pipe diameter NPS 12"

Length 210 km. (35,000 pieces);

f Ø 12" = 1.52 m. / 1,000 m.

Using Pump Size : (1) Pump Head 1367.08 m. (134 bar);
 Flow rate (Q) = 169 m³ / hr.
 Amount = 1 Pump

Case III : Selecting pipe diameter NPS 10"

Length 210 km. (35,000 pieces);

$f \text{ } \varnothing 10'' = 3.60 \text{ m. / 1,000 m.}$

Using Pump Size : (1) Pump Head 1869.4 m. (186 bar);
 Flow rate (Q) = 169 m³ / hr.
 Amount = 1 Pump

(2) Pump Head 934.7 m. (93 bar);
 Flow rate (Q) = 169 m³ / hr.
 Amount = 2 Pumps

(3) Pump Head 623.1 m. (62 bar);
 Flow rate (Q) = 169 m³ / hr.
 Amount = 3 Pumps

Unit : million-baht

Pipe $\varnothing 14''$	Amount 35,000 pieces (210 km.) @ 700 USD/tons	527.88
Pump	(1) Pump Head 120.7 bar, Q = 169 m ³ / hr. : 1 pump	-
	(2) Pump Head 60.4 bar, Q = 169 m ³ / hr. : 2 pump	21.0
	(3) Pump Head 40.2 bar, Q = 169 m ³ / hr. : 3 pump	10.5

Unit : million-baht

Pipe $\varnothing 12''$	Amount 35,000 pieces (210 km.) @ 700 USD/tons	445.02
Pump	(1) Pump Head 134 bar, Q = 169 m ³ / hr. : 1 pump	-
	(2) Pump Head 67 bar, Q = 169 m ³ / hr. : 2 pump	30.0
	(3) Pump Head 44.7 bar, Q = 169 m ³ / hr. : 3 pump	15.0

Unit : million-baht

Pipe Ø 10"	Amount 35,000 pieces (210 km.) @ 700 USD/tons	337.02
Pump	(1) Pump Head 186 bar, Q = 169 m ³ / hr. : 1 pump	-
	(2) Pump Head 93 bar, Q = 169 m ³ / hr. : 2 pumps	42.0*
	(3) Pump Head 62 bar, Q = 169 m ³ / hr. : 3 pumps	39.0

So, the optimum pipe size is diameter NPS 10" and the optimum pump size is pump head 42.6 bar; amount 2 pumps.

[Note : price of pump is referred to Calton International (Thailand) Ltd. (API 610 Centifugal pump)]

APPENDIX H.

**THE PRELIMINARY CALCULATION OF
INITIAL COST**

Appendix H.

The preliminary calculation of Capital Expenditure or Investment cost.

This calculation is depended on the initial criteria in computation of Capital expenditure (clause 4.3.1)

(1) The section from Saraburi to Nakhon Sawan (distance 170 km.)

➤ **Pipe cost**

From API 5L GR.B. SCH 40 (seamless) in Appendix E;

Using Carbon steel pipe diameter NPS 14" = 28,334 pieces
(length 6 m per piece)

Weight of pipe diameter NPS 14" = 567.0 kg / 6m.

$$\begin{aligned} \therefore \text{Pipe cost} &= 28,334 \times 567.0 \times (\text{price of pipe } 700 \text{ USD/tons}) \\ &= 28,334 \times 567.0 \times (700/1,000) \times 38 \\ &= \underline{434.12 \text{ million-baht}} \end{aligned}$$

[Note : 1 USD = 38 Baht]

➤ **Pump cost**

Using Pump size at; Capacity 389 m³ / hr.

Pump Head 41.9 bar.

Amount 2 pumps

Price of pump = 30 million-baht each

[Note : price of pump is referred to Calton International (Thailand) Ltd. (API 610 Centifugal pump)]

$$\begin{aligned} \therefore \text{Pump cost} &= 30 \times 2 \text{ million-baht} \\ &= \underline{60 \text{ million-baht}} \end{aligned}$$

➤ **Cathodic Protection cost**

From Clause 4.3.1; Cathodic Protection cost = 2,000 USD / Km.

$$\begin{aligned} \therefore \text{Cathodic Protection cost} &= 2,000 \times 170 \times 38 \\ &= \underline{12.92 \text{ million-baht}} \end{aligned}$$

➤ **Tank costs**

From Clause 4.3.1; Tank and other Facilities costs = 15 baht per litre of tank.

$$\begin{aligned}
 &\text{Constructed Tank size} &&= && 23 && \text{million-litres} \\
 \therefore &\text{Tank costs} &&= && 23 \times 15 \\
 &&&= && \underline{345} && \text{million-baht}
 \end{aligned}$$

➤ **Damaged-assets Compensation and Land Restoration costs**

From Clause 4.3.1; Damaged-assets (during construction) Compensation and Land Restoration costs equal to 300 baht per metres

$$\begin{aligned}
 \therefore &\text{Damaged-assets Compensation and Land Restoration costs} \\
 &= 300 \times 170 \times 1,000 \\
 &= \underline{51} \text{ million-baht}
 \end{aligned}$$

(2) The section from Nakhon Sawan to Pittsanulok (distance 130 km.)

➤ **Pipe cost**

From API 5L GR.B. SCH 40 (seamless) in Appendix E;

$$\begin{aligned}
 \text{Using Carbon steel pipe diameter NPS 12"} &= 21,667 \text{ pieces} \\
 &\text{(length 6 m per piece)}
 \end{aligned}$$

$$\text{Weight of pipe diameter NPS 12"} = 478.0 \text{ kg / 6m.}$$

$$\begin{aligned}
 \therefore &\text{Pipe cost} = 21,667 \times 478.0 \times (\text{price of pipe 700 USD/tons}) \\
 &= 21,667 \times 478.0 \times (700/1,000) \times 38 \\
 &= \underline{275.49} \text{ million-baht}
 \end{aligned}$$

[Note : 1 USD = 38 Baht]

➤ **Pump cost**

Using Pump size at; Capacity 267 m³ / hr.

Pump Head 50.7 bar.

Amount 1 pumps

$$\text{Price of pump} = 25.0 \text{ million-baht each}$$

[Note : price of pump is referred to Calton International (Thailand) Ltd. (API 610 Centifugal pump)]

$$\therefore \text{Pump cost} = \underline{25} \text{ million-baht}$$

➤ **Cathodic Protection cost**

From Clause 4.3.1; Cathodic Protection cost = 2,000 USD / Km.

$$\begin{aligned}
 \therefore &\text{Cathodic Protection cost} = 2,000 \times 130 \times 38 \\
 &= \underline{9.88} \text{ million-baht}
 \end{aligned}$$

➤ **Tank costs**

From Clause 4.3.1; Tank and other Facilities costs = 15 baht per litre of tank.

Constructed Tank size	=	17	million-litres
∴ Tank costs	=	17 x 15	
	=	<u>255</u>	million-baht

➤ **Damaged-assets Compensation and Land Restoration costs**

From Clause 4.3.1; Damaged-assets (during construction) Compensation and Land Restoration costs equal to 300 baht per metres

∴ Damaged-assets Compensation and Land Restoration costs	=	300 x 130 x 1,000	
	=	<u>39</u>	million-baht

(3) The section from Pittsanulok to Lampang (distance 210 km.)

➤ **Pipe cost**

From API 5L GR.B. SCH 40 (seamless) in Appendix E;

Using Carbon steel pipe diameter NPS 10" = 35,000 pieces
(length 6 m per piece)

Weight of pipe diameter NPS 10" = 362.0 kg / 6m.

∴ Pipe cost	=	35,000 x 362.0 x (price of pipe 700 USD/tons)	
	=	35,000 x 362.0 x (700/1,000) x 38	
	=	<u>337.02</u>	million-baht

[Note : 1 USD = 38 Baht]

➤ **Pump cost**

Using Pump size at; Capacity 169 m³ / hr.

Pump Head 42.6 bar.

Amount 2 pumps

Price of pump = 21 million-baht each

[Note : price of pump is referred to Calton International (Thailand) Ltd. (API 610 Centifugal pump)]

∴ Pump cost	=	21 x 2	million-baht
	=	<u>42</u>	million-baht

➤ **Cathodic Protection cost**

From Clause 4.3.1; Cathodic Protection cost = 2,000 USD / Km.

$$\begin{aligned} \therefore \text{Cathodic Protection cost} &= 2,000 \times 210 \times 38 \\ &= \underline{15.96} \text{ million-baht} \end{aligned}$$

➤ **Tank costs**

From Clause 4.3.1; Tank and other Facilities costs = 15 baht per litre of tank.

$$\begin{aligned} \text{Constructed Tank size} &= 14 \text{ million-litres} \\ \therefore \text{Tank costs} &= 14 \times 15 \\ &= \underline{210} \text{ million-baht} \end{aligned}$$

➤ **Damaged-assets Compensation and Land Restoration costs**

From Clause 4.3.1; Damaged-assets (during construction) Compensation and Land Restoration costs equal to 300 baht per metres

$$\begin{aligned} \therefore \text{Damaged-assets Compensation and Land Restoration costs} &= 300 \times 210 \times 1,000 \\ &= \underline{63} \text{ million-baht} \end{aligned}$$

▪ **Construction cost of the project**

From Clause 4.3.1; Construction cost 40% of pipeline cost.

$$\begin{aligned} \therefore \text{Construction cost} &= 1,047 \times (140/100) \\ &= \underline{1,466} \text{ million-baht} \end{aligned}$$

APPENDIX I.

PIPELINE – UNIT COSTS

APPENDIX I.

Schedule 5.1 Pipeline - Unit Cost

Project Life (Yr.)	1	2	3	4	5	6	7	8	9	10
Calender Year	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Expense (mmb.)	271	285	299	314	330	346	364	382	401	421
Volume (mml.)	1342	1540	1751	1970	2205	2430	2513	2597	2684	2775
Cost (St./Litre)	20.19	18.51	17.08	15.94	14.97	14.24	14.48	14.71	14.94	15.17

Project Life (Yr.)	11	12	13	14	15	16	17	18	19	20
Calender Year	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Expense (mmb.)	442	464	487	512	537	564	593	622	653	686
Volume (mml.)	2867	2962	2962	2962	2962	2962	2962	2962	2962	2962
Cost (St./Litre)	15.42	15.67	16.44	17.29	18.13	19.04	20.02	21.00	22.05	23.16

Project Life (Yr.)	21	22	23	24	25	26	27	28	29	30
Calender Year	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Expense (mmb.)	720	756	794	834	875	919	965	1013	1064	1117
Volume (mml.)	2962	2962	2962	2962	2962	2962	2962	2962	2962	2962
Cost (St./Litre)	24.31	25.52	26.81	28.16	29.54	31.03	32.58	34.20	35.92	37.71

Average Cost (St./Litre)	21.88
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Appendix I.

Schedule 5.1 Pipeline – Unit Cost (continued)

Pipeline Costs Per Year¹ :

For example; Pipeline Cost Per Year in 1st year (2003)

Length	510	Km.
O & m Costs	271,000	000's Baht

Total Costs Per Year (000's Baht)	271,000
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Total Volume (000's Litres)	1,342,000
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$$\begin{aligned} \therefore \text{Costs (Satang/Litre)} &= (271,000/1,342,000) \times 100 \\ &= \underline{\underline{20.19}} \end{aligned}$$

$$\begin{aligned} \therefore \text{Costs (Satang/Litre/Km.)} &= 20.19 / 510 \\ &= \underline{\underline{0.040}} \end{aligned}$$

Finally, the Average Cost of Pipeline Project = **21.88 Satang/Litre**
(Project life 30 years)

So, Tariff Rate at Nakhon Sawan Oil Depot	7.31	Satang/Litre
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Tariff Rate at Pitsanulok Oil Depot	12.90	Satang/Litre
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Tariff Rate at Lampang Oil Depot	21.93	Satang/Litre
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¹ This calculation is depended on Clause 5.3.

APPENDIX J.

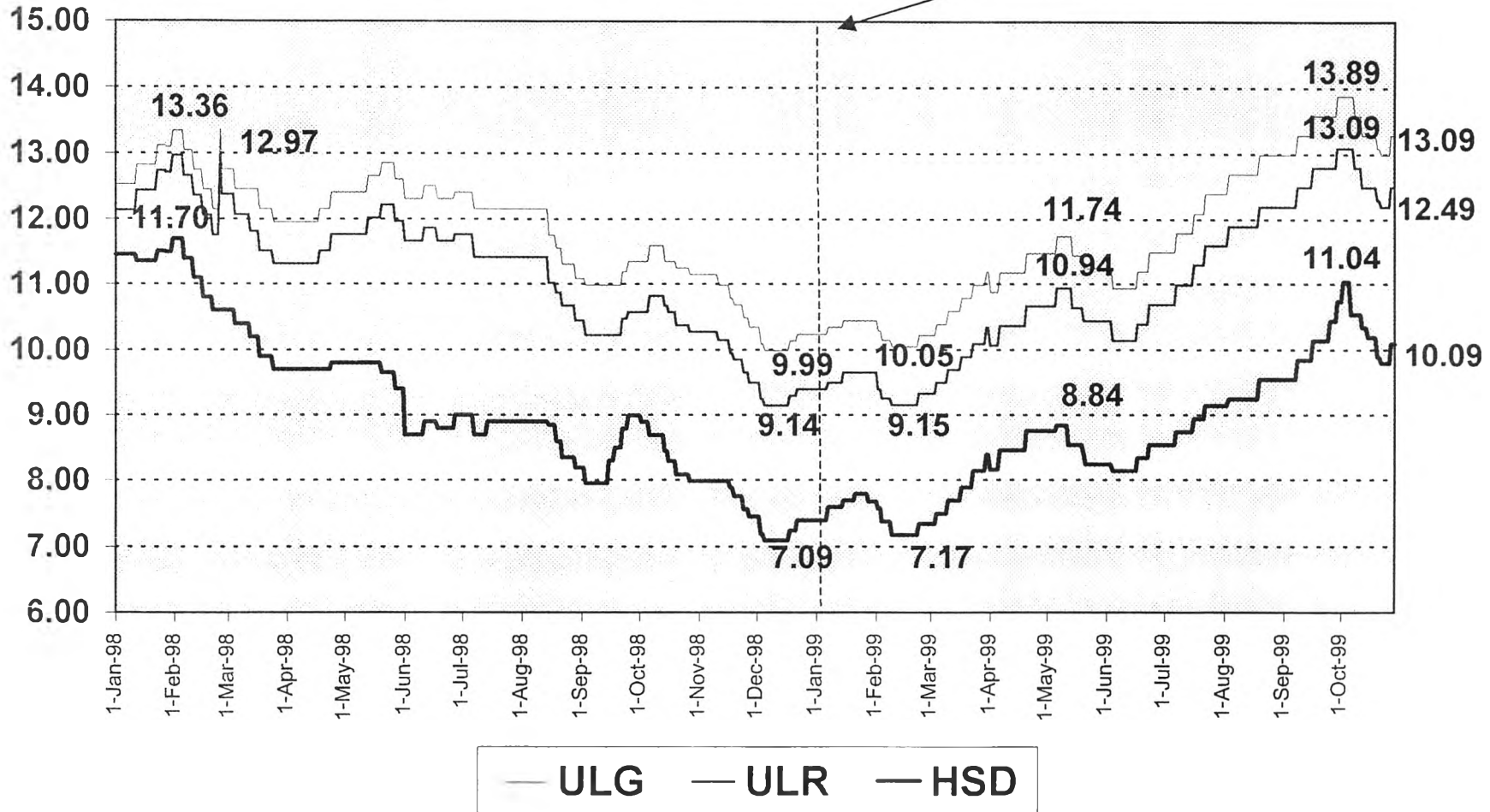
RETAIL PRICE OF ULG, ULR AND HSD

(1 Jan 98 – 29 Oct 99)

Retail Price

Baht/Litre

(1 Jan 98 - 29 Oct 99) 1 Jan 99



APPENDIX K.

CASH FLOW STATEMENT, IRR, NPV, PAYBACK

PERIOD AND B/C RATIO

Table Cash Flow Statement, IRR, NPV, Payback Period and B/C Ratio

Case : Investment increased 10%

Project Life (Yr.)	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13
Items / Calendar year	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Throughput (mml)	0	0	0	0	1,342	1,540	1,751	1,970	2,205	2,430	2,513	2,597	2,684	2,775	2,867	2,962	2,962
- Nakhon Sawan	0	0	0	0	427	490	557	627	701	761	787	813	840	869	897	926	926
- Pittsanulok	0	0	0	0	337	387	440	495	554	614	635	656	678	701	724	749	749
- Lampang	0	0	0	0	578	663	754	848	950	1,055	1,091	1,128	1,166	1,205	1,246	1,287	1,287
Escalation (%)		5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
Escalation Factor		1.05	1.10	1.16	1.22	1.28	1.34	1.41	1.48	1.55	1.63	1.71	1.80	1.89	1.98	2.08	2.18
Tariff Rate (St / Lt)																	
- Nakhon Sawan	16.14	16.95	17.80	18.69	19.62	20.60	21.63	22.71	23.85	25.04	26.29	27.06	28.41	29.83	31.32	32.89	34.53
- Pittsanulok	23.91	25.11	26.37	27.69	29.07	30.52	32.05	33.65	35.33	37.10	38.96	40.91	42.96	45.11	47.37	49.74	52.23
- Lampang	34.91	36.66	38.49	40.41	42.43	44.55	46.78	49.12	51.58	54.16	56.87	59.71	62.70	65.84	69.13	72.59	76.22
Benefit (mmb)																	
- Throughput Revenue					427	515	614	725	853	990	1,075	1,166	1,266	1,374	1,491	1,617	1,698
- Salvage Value																	
Total Benefit					427	515	614	725	853	990	1,075	1,166	1,266	1,374	1,491	1,617	1,698
Cost (mmb)																	
- O & M					-299	-314	-329	-346	-363	-381	-400	-420	-441	-463	-486	-511	-536
- Investment			-2,388	-3,584													
Total Cost			-2,388	-3,584	-299	-314	-329	-346	-363	-381	-400	-420	-441	-463	-486	-511	-536
NET CASH FLOW			-2,388	-3,584	128	201	285	380	490	609	675	746	824	911	1,004	1,106	1,162

IRR = 11.72% NPV (i = 10%) 1,290 million-baht Payback Period 10.72 Years B/C Ratio 1.15

Table Cash Flow Statement, IRR, NPV, Payback Period and B/C Ratio (continue)

Case : Investment increased 10%

Project Life (Yr.)	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Items / Calendar year	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Throughput (mmi)	2,962	2,962	2,962	2,962	2,962	2,962	2,962	2,962	2,962	2,962	2,962	2,962	2,962	2,962	2,962	2,962	2,962
- Nakhon Sawan	926	926	926	926	926	926	926	926	926	926	926	926	926	926	926	926	926
- Pittsanulok	749	749	749	749	749	749	749	749	749	749	749	749	749	749	749	749	749
- Lampang	1,287	1,287	1,287	1,287	1,287	1,287	1,287	1,287	1,287	1,287	1,287	1,287	1,287	1,287	1,287	1,287	1,287
Escalation (%)	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
Escalation Factor	2.29	2.41	2.53	2.65	2.79	2.93	3.07	3.23	3.39	3.56	3.73	3.92	4.12	4.32	4.54	4.76	5.00
Tariff Rate (St / Lt)																	
- Nakhon Sawan	36.26	38.07	39.97	41.97	44.07	46.27	48.58	51.01	53.56	56.24	59.05	62.00	65.10	68.36	71.78	75.37	79.14
- Pittsanulok	54.84	57.58	60.46	63.48	66.65	69.98	73.48	77.15	81.01	85.06	89.31	93.78	98.47	103.39	108.56	113.99	119.69
- Lampang	80.03	84.03	88.23	92.64	97.27	101.88	106.97	112.32	117.94	123.84	130.03	136.53	143.36	150.53	158.06	165.96	174.26
Benefit (mmb)																	
- Throughput Revenue	1,783	1,872	1,966	2,064	2,167	2,275	2,389	2,509	2,634	2,766	2,904	3,049	3,202	3,362	3,530	3,706	3,892
- Salvage Value																	1,194
Total Benefit	1,783	1,872	1,966	2,064	2,167	2,275	2,389	2,509	2,634	2,766	2,904	3,049	3,202	3,362	3,530	3,706	5,086
Cost (mmb)																	
- O & M	-563	-591	-621	-652	-684	-719	-755	-792	-832	-873	-917	-963	-1,011	-1,062	-1,115	-1,171	-1,229
- Investment																	
Total Cost	-563	-591	-621	-652	-684	-719	-755	-792	-832	-873	-917	-963	-1,011	-1,062	-1,115	-1,171	-1,229
NET CASH FLOW	1,220	1,281	1,345	1,412	1,483	1,557	1,635	1,716	1,802	1,892	1,987	2,086	2,191	2,300	2,415	2,536	3,857

Table Cash Flow Statement, IRR, NPV, Payback Period and B/C Ratio

Case : Investment decreased 10%

Project Life (Yr.)	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13
Items / Calendar year	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Throughput (nmml)	0	0	0	0	1,342	1,540	1,751	1,970	2,205	2,430	2,513	2,597	2,684	2,775	2,867	2,962	2,962
- Nakhon Sawan	0	0	0	0	427	490	557	627	701	761	787	813	840	869	897	926	926
- Pittsanulok	0	0	0	0	337	387	440	495	554	614	635	656	678	701	724	749	749
- Lampang	0	0	0	0	578	663	754	848	950	1,055	1,091	1,128	1,166	1,205	1,246	1,287	1,287
Escalation (%)		5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
Escalation Factor		1.05	1.10	1.16	1.22	1.28	1.34	1.41	1.48	1.55	1.63	1.71	1.80	1.89	1.98	2.08	2.18
Tariff Rate (St / Lt)																	
- Nakhon Sawan	16.14	16.95	17.80	18.69	19.62	20.60	21.63	22.71	23.85	25.04	26.29	27.06	28.41	29.83	31.32	32.89	34.53
- Pittsanulok	23.91	25.11	26.37	27.69	29.07	30.52	32.05	33.65	35.33	37.10	38.96	40.91	42.96	45.11	47.37	49.74	52.23
- Lampang	34.91	36.66	38.49	40.41	42.43	44.55	46.78	49.12	51.58	54.16	56.87	59.71	62.70	65.84	69.13	72.59	76.22
Benefit (mmb)																	
- Throughput Revenue					427	515	614	725	853	990	1,075	1,166	1,266	1,374	1,491	1,617	1,698
- Salvage Value																	
Total Benefit					427	515	614	725	853	990	1,075	1,166	1,266	1,374	1,491	1,617	1,698
Cost (mmb)																	
- O & M					-244	-257	-269	-283	-297	-312	-327	-344	-361	-379	-398	-418	-439
- Investment			-1,954	-2,932													
Total Cost			-1,954	-2,932	-244	-257	-269	-283	-297	-312	-327	-344	-361	-379	-398	-418	-439
NET CASH FLOW			-1,954	-2,932	183	258	345	443	556	678	747	823	905	995	1,093	1,199	1,259

IRR = 14.34% NPV (i = 10%) 2,887 million-baht Payback Period 8.94 Years B/C Ratio 1.40

Table Cash Flow Statement, IRR, NPV, Payback Period and B/C Ratio (continue)

Case : Investment decreased 10%

Project Life (Yr.)	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Items / Calendar year	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Throughput (mml)	2,962	2,962	2,962	2,962	2,962	2,962	2,962	2,962	2,962	2,962	2,962	2,962	2,962	2,962	2,962	2,962	2,962
- Nakhon Sawan	926	926	926	926	926	926	926	926	926	926	926	926	926	926	926	926	926
- Pittsanulok	749	749	749	749	749	749	749	749	749	749	749	749	749	749	749	749	749
- Lampang	1,287	1,287	1,287	1,287	1,287	1,287	1,287	1,287	1,287	1,287	1,287	1,287	1,287	1,287	1,287	1,287	1,287
Escalation (%)	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
Escalation Factor	2.29	2.41	2.53	2.65	2.79	2.93	3.07	3.23	3.39	3.56	3.73	3.92	4.12	4.32	4.54	4.76	5.00
Tariff Rate (St / Lt)																	
- Nakhon Sawan	36.26	38.07	39.97	41.97	44.07	46.27	48.58	51.01	53.56	56.24	59.05	62.00	65.10	68.36	71.78	75.37	79.14
- Pittsanulok	54.84	57.58	60.46	63.48	66.65	69.98	73.48	77.15	81.01	85.06	89.31	93.78	98.47	103.39	108.56	113.99	119.69
- Lampang	80.03	84.03	88.23	92.64	97.27	101.88	106.97	112.32	117.94	123.84	130.03	136.53	143.36	150.53	158.06	165.96	174.26
Benefit (mmb)																	
- Throughput Revenue	1,783	1,872	1,966	2,064	2,167	2,275	2,389	2,509	2,634	2,766	2,904	3,049	3,202	3,362	3,530	3,706	3,892
- Salvage Value																	977
Total Benefit	1,783	1,872	1,966	2,064	2,167	2,275	2,389	2,509	2,634	2,766	2,904	3,049	3,202	3,362	3,530	3,706	4,869
Cost (mmb)																	
- O & M	-461	-484	-508	-533	-560	-588	-617	-648	-681	-715	-750	-788	-827	-869	-912	-958	-1,006
- Investment																	
Total Cost	-461	-484	-508	-533	-560	-588	-617	-648	-681	-715	-750	-788	-827	-869	-912	-958	-1,006
NET CASH FLOW	1,322	1,388	1,458	1,531	1,607	1,687	1,772	1,860	1,953	2,051	2,154	2,261	2,374	2,493	2,618	2,749	3,863

Table Cash Flow Statement, IRR, NPV, Payback Period and B/C Ratio

Case : Tariff Rate increased 10%

Project Life (Yr.)	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13
Items / Calendar year	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Throughput (mml)	0	0	0	0	1,342	1,540	1,751	1,970	2,205	2,430	2,513	2,597	2,684	2,775	2,867	2,962	2,962
- Nakhon Sawan	0	0	0	0	427	490	557	627	701	761	787	813	840	869	897	926	926
- Pittsanulok	0	0	0	0	337	387	440	495	554	614	635	656	678	701	724	749	749
- Lampang	0	0	0	0	578	663	754	848	950	1,055	1,091	1,128	1,166	1,205	1,246	1,287	1,287
Escalation (%)		5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
Escalation Factor		1.05	1.10	1.16	1.22	1.28	1.34	1.41	1.48	1.55	1.63	1.71	1.80	1.89	1.98	2.08	2.18
Tariff Rate (St / Lt)																	
- Nakhon Sawan	17.75	18.64	19.57	20.55	21.58	22.66	23.79	24.98	26.23	27.54	28.92	30.37	31.89	33.48	35.15	36.91	38.76
- Pittsanulok	26.30	27.62	29.00	30.45	31.97	33.57	35.25	37.01	38.86	40.80	42.84	44.98	47.23	49.59	52.07	54.67	57.40
- Lampang	38.40	40.32	42.34	44.46	46.68	49.01	51.46	54.03	56.73	59.57	62.55	65.68	68.96	72.41	76.03	79.83	83.82
Benefit (mmb)																	
- Throughput Revenue					470	566	675	798	938	1,089	1,182	1,283	1,392	1,511	1,640	1,779	1,868
- Salvage Value																	
Total Benefit					470	566	675	798	938	1,089	1,182	1,283	1,392	1,511	1,640	1,779	1,868
Cost (mmb)																	
- O & M					-271	-285	-299	-314	-330	-346	-364	-382	-401	-421	-442	-464	-487
- Investment			-2,172	-3,257													
Total Cost			-2,172	-3,257	-271	-285	-299	-314	-330	-346	-364	-382	-401	-421	-442	-464	-487
NET CASH FLOW			-2,172	-3,257	198	281	376	484	608	742	818	901	991	1,090	1,198	1,314	1,380

IRR = 14.20% NPV (i = 10%) 3,095 million-baht Payback Period 9.03 Years B/C Ratio 1.38

Table Cash Flow Statement, IRR, NPV, Payback Period and B/C Ratio (continue)

Case : Tariff Rate increased 10%

Project Life (Yr.)	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Items / Calendar year	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Throughput (mmi)	2,962	2,962	2,962	2,962	2,962	2,962	2,962	2,962	2,962	2,962	2,962	2,962	2,962	2,962	2,962	2,962	2,962
- Nakhon Sawan	926	926	926	926	926	926	926	926	926	926	926	926	926	926	926	926	926
- Pittsanulok	749	749	749	749	749	749	749	749	749	749	749	749	749	749	749	749	749
- Lampang	1,287	1,287	1,287	1,287	1,287	1,287	1,287	1,287	1,287	1,287	1,287	1,287	1,287	1,287	1,287	1,287	1,287
Escalation (%)	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
Escalation Factor	2.29	2.41	2.53	2.65	2.79	2.93	3.07	3.23	3.39	3.56	3.73	3.92	4.12	4.32	4.54	4.76	5.00
Tariff Rate (St / Lt)																	
- Nakhon Sawan	40.70	42.74	44.88	47.12	49.48	51.95	54.55	57.28	60.14	63.15	66.31	69.63	73.11	76.77	80.61	84.64	88.87
- Pittsanulok	60.27	63.28	66.44	69.76	73.25	76.91	80.76	84.80	89.04	93.49	98.16	103.07	108.22	113.63	119.31	125.28	131.54
- Lampang	88.01	92.41	97.03	101.88	106.97	112.32	117.94	123.84	130.03	136.53	143.36	150.53	158.06	165.96	174.26	182.97	192.12
Benefit (mmb)																	
- Throughput Revenue	1,961	2,059	2,162	2,270	2,384	2,503	2,628	2,759	2,897	3,042	3,194	3,354	3,522	3,698	3,883	4,077	4,281
- Salvage Value																	1,086
Total Benefit	1,961	2,059	2,162	2,270	2,384	2,503	2,628	2,759	2,897	3,042	3,194	3,354	3,522	3,698	3,883	4,077	5,367
Cost (mmb)																	
- O & M	-512	-537	-564	-593	-622	-653	-686	-720	-756	-794	-834	-875	-919	-965	-1,013	-1,064	-1,117
- Investment																	
Total Cost	-512	-537	-564	-593	-622	-653	-686	-720	-756	-794	-834	-875	-919	-965	-1,013	-1,064	-1,117
NET CASH FLOW	1,449	1,522	1,598	1,678	1,761	1,850	1,942	2,039	2,141	2,248	2,360	2,479	2,602	2,733	2,869	3,013	4,249

Table Cash Flow Statement, IRR, NPV, Payback Period and B/C Ratio

Case : Tariff Rate decreased 10%

Project Life (Yr.)	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13
Items / Calendar year	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Throughput (mml)	0	0	0	0	1,342	1,540	1,751	1,970	2,205	2,430	2,513	2,597	2,684	2,775	2,867	2,962	2,962
- Nakhon Sawan	0	0	0	0	427	490	557	627	701	761	787	813	840	869	897	926	926
- Pittsanulok	0	0	0	0	337	387	440	495	554	614	635	656	678	701	724	749	749
- Lampang	0	0	0	0	578	663	754	848	950	1,055	1,091	1,128	1,166	1,205	1,246	1,287	1,287
Escalation (%)		5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
Escalation Factor		1.05	1.10	1.16	1.22	1.28	1.34	1.41	1.48	1.55	1.63	1.71	1.80	1.89	1.98	2.08	2.18
Tariff Rate (St / Lt)																	
- Nakhon Sawan	14.53	15.26	16.02	16.82	17.66	18.54	19.47	20.44	21.46	22.53	23.66	24.84	26.08	27.38	28.75	30.19	31.70
- Pittsanulok	21.52	22.60	23.73	24.92	26.17	27.48	28.85	30.29	31.80	33.39	35.06	36.81	38.65	40.58	42.61	44.74	46.98
- Lampang	31.42	32.99	34.64	36.37	38.19	40.10	42.11	44.22	46.43	48.75	51.19	53.75	56.44	59.26	62.22	65.33	68.60
Benefit (mmb)																	
- Throughput Revenue					384	463	553	653	768	891	967	1,050	1,139	1,237	1,342	1,455	1,528
- Salvage Value																	
Total Benefit					384	463	553	653	768	891	967	1,050	1,139	1,237	1,342	1,455	1,528
Cost (mmb)																	
- O & M					-271	-285	-299	-314	-330	-346	-364	-382	-401	-421	-442	-464	-487
- Investment			-2,172	-3,257													
Total Cost			-2,172	-3,257	-271	-285	-299	-314	-330	-346	-364	-382	-401	-421	-442	-464	-487
NET CASH FLOW			-2,172	-3,257	113	178	254	339	438	544	604	668	738	816	900	991	1,041

IRR = 11.59% NPV (i = 10%) 1,081 million-baht Payback Period 10.82 Years B/C Ratio 1.13

Table Cash Flow Statement, IRR, NPV, Payback Period and B/C Ratio (continue)

Case : Tariff Rate decreased 10%

Project Life (Yr.)	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Items / Calendar year	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Throughput (mml)	2,962	2,962	2,962	2,962	2,962	2,962	2,962	2,962	2,962	2,962	2,962	2,962	2,962	2,962	2,962	2,962	2,962
- Nakhon Sawan	926	926	926	926	926	926	926	926	926	926	926	926	926	926	926	926	926
- Pittsanulok	749	749	749	749	749	749	749	749	749	749	749	749	749	749	749	749	749
- Lampang	1,287	1,287	1,287	1,287	1,287	1,287	1,287	1,287	1,287	1,287	1,287	1,287	1,287	1,287	1,287	1,287	1,287
Escalation (%)	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
Escalation Factor	2.29	2.41	2.53	2.65	2.79	2.93	3.07	3.23	3.39	3.56	3.73	3.92	4.12	4.32	4.54	4.76	5.00
Tariff Rate (St / Lt)																	
- Nakhon Sawan	33.29	34.95	36.25	38.06	39.96	41.96	44.06	46.26	48.57	51.00	53.55	56.23	59.04	61.99	65.09	68.34	71.76
- Pittsanulok	49.33	51.80	54.39	57.11	59.97	62.97	66.12	69.23	72.69	76.32	80.14	84.15	88.36	92.78	97.42	102.29	107.40
- Lampang	72.03	75.63	79.41	83.38	87.55	91.93	96.53	101.36	106.43	111.75	117.34	123.21	129.37	135.84	142.63	149.76	157.25
Benefit (mmb)																	
- Throughput Revenue	1,605	1,685	1,769	1,858	1,950	2,048	2,150	2,258	2,371	2,489	2,614	2,745	2,882	3,026	3,177	3,336	3,503
- Salvage Value																	1,086
Total Benefit	1,605	1,685	1,769	1,858	1,950	2,048	2,150	2,258	2,371	2,489	2,614	2,745	2,882	3,026	3,177	3,336	4,589
Cost (mmb)																	
- O & M	-512	-537	-564	-593	-622	-653	-686	-720	-756	-794	-834	-875	-919	-965	-1,013	-1,064	-1,117
- Investment																	
Total Cost	-512	-537	-564	-593	-622	-653	-686	-720	-756	-794	-834	-875	-919	-965	-1,013	-1,064	-1,117
NET CASH FLOW	1,093	1,147	1,205	1,265	1,328	1,395	1,465	1,538	1,616	1,695	1,780	1,869	1,963	2,061	2,164	2,272	3,471

Table Cash Flow Statement, IRR, NPV, Payback Period and B/C Ratio

Case : Throughput increased 10%

Project Life (Yr)	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13
Items / Calendar year	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Throughput (mml)	0	0	0	0	1,477	1,694	1,926	2,168	2,425	2,673	2,765	2,857	2,953	3,053	3,154	3,259	3,259
- Nakhon Sawan	0	0	0	0	470	539	613	690	771	837	866	894	924	956	987	1,019	1,019
- Pittsanulok	0	0	0	0	371	426	484	545	609	675	699	722	746	771	796	824	824
- Lampang	0	0	0	0	636	729	829	933	1,045	1,161	1,200	1,241	1,283	1,326	1,371	1,416	1,416
Escalation (%)		5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
Escalation Factor		1.05	1.10	1.16	1.22	1.28	1.34	1.41	1.48	1.55	1.63	1.71	1.80	1.89	1.98	2.08	2.18
Tariff Rate (St / Lt)																	
- Nakhon Sawan	16.14	16.95	17.80	18.69	19.62	20.60	21.63	22.71	23.85	25.04	26.29	27.06	28.41	29.83	31.32	32.89	34.53
- Pittsanulok	23.91	25.11	26.37	27.69	29.07	30.52	32.05	33.65	35.33	37.10	38.96	40.91	42.96	45.11	47.37	49.74	52.23
- Lampang	34.91	36.66	38.49	40.41	42.43	44.55	46.78	49.12	51.58	54.16	56.87	59.71	62.70	65.84	69.13	72.59	76.22
Benefit (mmb)																	
- Throughput Revenue					470	566	676	798	938	1,089	1,182	1,283	1,392	1,511	1,640	1,779	1,868
- Salvage Value																	
Total Benefit					470	566	676	798	938	1,089	1,182	1,283	1,392	1,511	1,640	1,779	1,868
Cost (mmb)																	
- O & M					-271	-285	-299	314	-330	-346	-364	-382	-401	-421	-442	-464	-487
- Investment			-2,172	-3,257													
Total Cost			-2,172	-3,257	-271	-285	-299	-314	-330	-346	-364	-382	-401	-421	-442	-464	-487
NET CASH FLOW			-2,172	-3,257	198	281	376	484	608	742	818	901	991	1,090	1,198	1,315	1,380

IRR = 14.20% NPV (i = 10%) 3,096 million-baht Payback Period 9.03 Years B/C Ratio 1.38

Table Cash Flow Statement, IRR, NPV, Payback Period and B/C Ratio (continue)

Case : Throughput increased 10%

Project Life (Yr.)	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Items / Calendar year	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Throughput (mml)	3,259	3,259	3,259	3,259	3,259	3,259	3,259	3,259	3,259	3,259	3,259	3,259	3,259	3,259	3,259	3,259	3,259
- Nakhon Sawan	1,019	1,019	1,019	1,019	1,019	1,019	1,019	1,019	1,019	1,019	1,019	1,019	1,019	1,019	1,019	1,019	1,019
- Pittsanulok	824	824	824	824	824	824	824	824	824	824	824	824	824	824	824	824	824
- Lamphang	1,416	1,416	1,416	1,416	1,416	1,416	1,416	1,416	1,416	1,416	1,416	1,416	1,416	1,416	1,416	1,416	1,416
Escalation (%)	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
Escalation Factor	2.29	2.41	2.53	2.65	2.79	2.93	3.07	3.23	3.39	3.56	3.73	3.92	4.12	4.32	4.54	4.76	5.00
Tariff Rate (St / Lt)																	
- Nakhon Sawan	36.26	38.07	39.97	41.97	44.07	46.27	48.58	51.01	53.56	56.24	59.05	62.00	65.10	68.36	71.78	75.37	79.14
- Pittsanulok	54.84	57.58	60.46	63.48	66.65	69.98	73.48	77.15	81.01	85.06	89.31	93.78	98.47	103.39	108.56	113.99	119.69
- Lamphang	80.03	84.03	88.23	92.64	97.27	101.88	106.97	112.32	117.94	123.84	130.03	136.53	143.36	150.53	158.06	165.96	174.26
Benefit (mmb)																	
- Throughput Revenue	1,961	2,059	2,162	2,270	2,384	2,503	2,628	2,759	2,897	3,042	3,194	3,354	3,522	3,698	3,883	4,077	4,281
- Salvage Value																	1,086
Total Benefit	1,961	2,059	2,162	2,270	2,384	2,503	2,628	2,759	2,897	3,042	3,194	3,354	3,522	3,698	3,883	4,077	5,367
Cost (mmb)																	
- O & M	-512	-537	-564	-593	-622	-653	-686	-720	-756	-794	-834	-875	-919	-965	-1,013	-1,064	-1,117
- Investment																	
Total Cost	-512	-537	-564	-593	-622	-653	-686	-720	-756	-794	-834	-875	-919	-965	-1,013	-1,064	-1,117
NET CASH FLOW	1,449	1,522	1,598	1,678	1,762	1,850	1,942	2,039	2,141	2,248	2,361	2,479	2,603	2,733	2,869	3,013	4,250

Table Cash Flow Statement, IRR, NPV, Payback Period and B/C Ratio

Case : Throughput decreased 10%

Project Life (Yr.)	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13
Items / Calendar year	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Throughput (mm)	0	0	0	0	1,207	1,386	1,576	1,773	1,985	2,188	2,262	2,337	2,415	2,498	2,580	2,665	2,665
- Nakhon Sawan	0	0	0	0	384	441	501	564	631	685	708	732	756	782	807	833	833
- Pittsanulok	0	0	0	0	303	348	396	446	499	553	572	590	610	631	652	674	674
- Lampang	0	0	0	0	520	597	679	763	855	950	982	1,015	1,049	1,085	1,121	1,158	1,158
Escalation (%)		5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
Escalation Factor		1.05	1.10	1.16	1.22	1.28	1.34	1.41	1.48	1.55	1.63	1.71	1.80	1.89	1.98	2.08	2.18
Tariff Rate (St / Lt)																	
- Nakhon Sawan	16.14	16.95	17.80	18.69	19.62	20.60	21.63	22.71	23.85	25.04	26.29	27.06	28.41	29.83	31.32	32.89	34.53
- Pittsanulok	23.91	25.11	26.37	27.69	29.07	30.52	32.05	33.65	35.33	37.10	38.96	40.91	42.96	45.11	47.37	49.74	52.23
- Lampang	34.91	36.66	38.49	40.41	42.43	44.55	46.78	49.12	51.58	54.16	56.87	59.71	62.70	65.84	69.13	72.59	76.22
Benefit (mmb)																	
- Throughput Revenue					384	463	553	653	768	891	967	1,050	1,139	1,237	1,342	1,455	1,528
- Salvage Value																	
Total Benefit					384	463	553	653	768	891	967	1,050	1,139	1,237	1,342	1,455	1,528
Cost (mmb)																	
- O & M					-271	-285	-299	-314	-330	-346	-364	-382	-401	-421	-442	-464	-487
- Investment			-2,172	-3,257													
Total Cost			-2,172	-3,257	-271	-285	-299	-314	-330	-346	-364	-382	-401	-421	-442	-464	-487
NET CASH FLOW			-2,172	-3,257	113	178	253	339	438	544	603	668	738	815	900	991	1,041

IRR = 11.59% NPV (i = 10%) 1,080 million-baht Payback Period 10.82 Years B/C Ratio 1.13

Table Cash Flow Statement, IRR, NPV, Payback Period and B/C Ratio (continue)

Case : Throughput decreased 10%

Project Life (Yr)	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Items / Calendar year	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Throughput (mml)	2,665	2,665	2,665	2,665	2,665	2,665	2,665	2,665	2,665	2,665	2,665	2,665	2,665	2,665	2,665	2,665	2,665
- Nakhon Sawan	833	833	833	833	833	833	833	833	833	833	833	833	833	833	833	833	833
- Pittsanulok	674	674	674	674	674	674	674	674	674	674	674	674	674	674	674	674	674
- Lampang	1,158	1,158	1,158	1,158	1,158	1,158	1,158	1,158	1,158	1,158	1,158	1,158	1,158	1,158	1,158	1,158	1,158
Escalation (%)	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
Escalation Factor	2.29	2.41	2.53	2.65	2.79	2.93	3.07	3.23	3.39	3.56	3.73	3.92	4.12	4.32	4.54	4.76	5.00
Tariff Rate (St / Lt)																	
- Nakhon Sawan	36.26	38.07	39.97	41.97	44.07	46.27	48.58	51.01	53.56	56.24	59.05	62.00	65.10	68.36	71.78	75.37	79.14
- Pittsanulok	54.84	57.58	60.46	63.48	66.65	69.98	73.48	77.15	81.01	85.06	89.31	93.78	98.47	103.39	108.56	113.99	119.69
- Lampang	80.03	84.03	88.23	92.64	97.27	101.88	106.97	112.32	117.94	123.84	130.03	136.53	143.36	150.53	158.06	165.96	174.26
Benefit (mmb)																	
- Throughput Revenue	1,605	1,685	1,769	1,857	1,950	2,048	2,150	2,258	2,371	2,489	2,614	2,744	2,882	3,026	3,177	3,336	3,502
- Salvage Value																	1,086
Total Benefit	1,605	1,685	1,769	1,857	1,950	2,048	2,150	2,258	2,371	2,489	2,614	2,744	2,882	3,026	3,177	3,336	4,588
Cost (mmb)																	
- O & M	-512	-537	-564	-593	-622	-653	-686	-720	-756	-794	-834	-875	-919	-965	-1,013	-1,064	-1,117
- Investment																	
Total Cost	-512	-537	-564	-593	-622	-653	-686	-720	-756	-794	-834	-875	-919	-965	-1,013	-1,064	-1,117
NET CASH FLOW	1,093	1,147	1,205	1,265	1,328	1,395	1,464	1,538	1,614	1,695	1,780	1,869	1,962	2,060	2,163	2,272	3,471

Table Cash Flow Statement, IRR, NPV, Payback Period and B/C Ratio

Case : O & M increased 10%

Project Life (Yr.)	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13
Items / Calendar year	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Throughput (mml)	0	0	0	0	1,342	1,540	1,751	1,970	2,205	2,430	2,513	2,597	2,684	2,775	2,867	2,962	2,962
- Nakhon Sawan	0	0	0	0	427	490	557	627	701	761	787	813	840	869	897	926	926
- Pittsanulok	0	0	0	0	337	387	440	495	554	614	635	656	678	701	724	749	749
- Lampang	0	0	0	0	578	663	754	848	950	1,055	1,091	1,128	1,166	1,205	1,246	1,287	1,287
Escalation (%)		5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
Escalation Factor		1.05	1.10	1.16	1.22	1.28	1.34	1.41	1.48	1.55	1.63	1.71	1.80	1.89	1.98	2.08	2.18
Tariff Rate (St / Lt)																	
- Nakhon Sawan	16.14	16.95	17.80	18.69	19.62	20.60	21.63	22.71	23.85	25.04	26.29	27.06	28.41	29.83	31.32	32.89	34.53
- Pittsanulok	23.91	25.11	26.37	27.69	29.07	30.52	32.05	33.65	35.33	37.10	38.96	40.91	42.96	45.11	47.37	49.74	52.23
- Lampang	34.91	36.66	38.49	40.41	42.43	44.55	46.78	49.12	51.58	54.16	56.87	59.71	62.70	65.84	69.13	72.59	76.22
Benefit (mmb)																	
- Throughput Revenue					427	515	614	725	853	990	1,075	1,166	1,266	1,374	1,491	1,617	1,698
- Salvage Value																	
Total Benefit					427	515	614	725	853	990	1,075	1,166	1,266	1,374	1,491	1,617	1,698
Cost (mmb)																	
- O & M					-298	-313	-329	-345	-362	-380	-399	-419	-440	-462	-485	-510	-535
- Investment			-2,172	-3,257													
Total Cost			-2,172	-3,257	-298	-313	-329	-345	-362	-380	-399	-419	-440	-462	-485	-510	-535
NET CASH FLOW			-2,172	-3,257	129	202	286	380	491	609	675	747	825	912	1,005	1,107	1,163

IRR = 12.50% NPV (i = 10%) 1,758 million-baht Payback Period 10.17 Years B/C Ratio 1.21

Table Cash Flow Statement, IRR, NPV, Payback Period and B/C Ratio (continue)

Case : O & M increased 10%

Project Life (Yr.)	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Items / Calendar year	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Throughput (mml)	2,962	2,962	2,962	2,962	2,962	2,962	2,962	2,962	2,962	2,962	2,962	2,962	2,962	2,962	2,962	2,962	2,962
- Nakhon Sawan	926	926	926	926	926	926	926	926	926	926	926	926	926	926	926	926	926
- Pittsanulok	749	749	749	749	749	749	749	749	749	749	749	749	749	749	749	749	749
- Lampang	1,287	1,287	1,287	1,287	1,287	1,287	1,287	1,287	1,287	1,287	1,287	1,287	1,287	1,287	1,287	1,287	1,287
Escalation (%)	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
Escalation Factor	2.29	2.41	2.53	2.65	2.79	2.93	3.07	3.23	3.39	3.56	3.73	3.92	4.12	4.32	4.54	4.76	5.00
Tariff Rate (St / Lt)																	
- Nakhon Sawan	36.26	38.07	39.97	41.97	44.07	46.27	48.58	51.01	53.56	56.24	59.05	62.00	65.10	68.36	71.78	75.37	79.14
- Pittsanulok	54.84	57.58	60.46	63.48	66.65	69.98	73.48	77.15	81.01	85.06	89.31	93.78	98.47	103.39	108.56	113.99	119.69
- Lampang	80.03	84.03	88.23	92.64	97.27	101.88	106.97	112.32	117.94	123.84	130.03	136.53	143.36	150.53	158.06	165.96	174.26
Benefit (mmb)																	
- Throughput Revenue	1,783	1,872	1,966	2,064	2,167	2,275	2,389	2,509	2,634	2,766	2,904	3,049	3,202	3,362	3,530	3,706	3,892
- Salvage Value																	1,086
Total Benefit	1,783	1,872	1,966	2,064	2,167	2,275	2,389	2,509	2,634	2,766	2,904	3,049	3,202	3,362	3,530	3,706	4,978
Cost (mmb)																	
- O & M	-562	-590	-620	-650	-683	-717	-753	-791	-830	-872	-915	-961	-1,009	-1,060	-1,113	-1,168	-1,227
- Investment																	
Total Cost	-562	-590	-620	-650	-683	-717	-753	-791	-830	-872	-915	-961	-1,009	-1,060	-1,113	-1,168	-1,227
NET CASH FLOW	1,221	1,282	1,346	1,413	1,484	1,558	1,636	1,718	1,804	1,894	1,989	2,088	2,193	2,302	2,417	2,538	3,751

Table Cash Flow Statement, IRR, NPV, Payback Period and B/C Ratio

Case : O & M decreased 10%

Project Life (Yr.)	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13
Items / Calendar year	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Throughput (mml)	0	0	0	0	1,342	1,540	1,751	1,970	2,205	2,430	2,513	2,597	2,684	2,775	2,867	2,962	2,962
- Nakhon Sawan	0	0	0	0	427	490	557	627	701	761	787	813	840	869	897	926	926
- Pittsanulok	0	0	0	0	337	387	440	495	554	614	635	656	678	701	724	749	749
- Lampang	0	0	0	0	578	663	754	848	950	1,055	1,091	1,128	1,166	1,205	1,246	1,287	1,287
Escalation (%)		5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
Escalation Factor		1.05	1.10	1.16	1.22	1.28	1.34	1.41	1.48	1.55	1.63	1.71	1.80	1.89	1.98	2.08	2.18
Tariff Rate (St / Lt)																	
- Nakhon Sawan	16.14	16.95	17.80	18.69	19.62	20.60	21.63	22.71	23.85	25.04	26.29	27.06	28.41	29.83	31.32	32.89	34.53
- Pittsanulok	23.91	25.11	26.37	27.69	29.07	30.52	32.05	33.65	35.33	37.10	38.96	40.91	42.96	45.11	47.37	49.74	52.23
- Lampang	34.91	36.66	38.49	40.41	42.43	44.55	46.78	49.12	51.58	54.16	56.87	59.71	62.70	65.84	69.13	72.59	76.22
Benefit (mmb)																	
- Throughput Revenue					427	515	614	725	853	990	1,075	1,166	1,266	1,374	1,491	1,617	1,698
- Salvage Value																	
Total Benefit					427	515	614	725	853	990	1,075	1,166	1,266	1,374	1,491	1,617	1,698
Cost (mmb)																	
- O & M					-244	-256	-269	-282	-297	-311	-327	-343	-360	-379	-397	-417	-438
- Investment			-2,172	-3,257													
Total Cost			-2,172	-3,257	-244	-256	-269	-282	-297	-311	-327	-343	-360	-379	-397	-417	-438
NET CASH FLOW			-2,172	-3,257	183	258	345	443	556	678	748	823	905	995	1,093	1,200	1,260

IRR = 13.40% NPV (i = 10%) 2,429 million-baht Payback Period 9.49 Years B/C Ratio 1.32

Table Cash Flow Statement, IRR, NPV, Payback Period and B/C Ratio (continue)

Case : O & M decreased 10%

Project Life (Yr.)	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Items / Calendar year	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Throughput (mml)	2,962	2,962	2,962	2,962	2,962	2,962	2,962	2,962	2,962	2,962	2,962	2,962	2,962	2,962	2,962	2,962	2,962
- Nakhon Sawan	926	926	926	926	926	926	926	926	926	926	926	926	926	926	926	926	926
- Pittsanulok	749	749	749	749	749	749	749	749	749	749	749	749	749	749	749	749	749
- Lampang	1,287	1,287	1,287	1,287	1,287	1,287	1,287	1,287	1,287	1,287	1,287	1,287	1,287	1,287	1,287	1,287	1,287
Escalation (%)	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
Escalation Factor	2.29	2.41	2.53	2.65	2.79	2.93	3.07	3.23	3.39	3.56	3.73	3.92	4.12	4.32	4.54	4.76	5.00
Tariff Rate (St / Lt)																	
- Nakhon Sawan	36.26	38.07	39.97	41.97	44.07	46.27	48.58	51.01	53.56	56.24	59.05	62.00	65.10	68.36	71.78	75.37	79.14
- Pittsanulok	54.84	57.58	60.46	63.48	66.65	69.98	73.48	77.15	81.01	85.06	89.31	93.78	98.47	103.39	108.56	113.99	119.69
- Lampang	80.03	84.03	88.23	92.64	97.27	101.88	106.97	112.32	117.94	123.84	130.03	136.53	143.36	150.53	158.06	165.96	174.26
Benefit (mmb)																	
- Throughput Revenue	1,783	1,872	1,966	2,064	2,167	2,275	2,389	2,509	2,634	2,766	2,904	3,049	3,202	3,362	3,530	3,706	3,892
- Salvage Value																	1,086
Total Benefit	1,783	1,872	1,966	2,064	2,167	2,275	2,389	2,509	2,634	2,766	2,904	3,049	3,202	3,362	3,530	3,706	4,978
Cost (mmb)																	
- O & M	-460	-483	-507	-533	-559	-587	-617	-647	-680	-714	-749	-787	-826	-868	-911	-957	-1,004
- Investment																	
Total Cost	-460	-483	-507	-533	-559	-587	-617	-647	-680	-714	-749	-787	-826	-868	-911	-957	-1,004
NET CASH FLOW	1,323	1,389	1,458	1,531	1,608	1,688	1,773	1,861	1,954	2,052	2,155	2,262	2,375	2,494	2,619	2,750	3,973

APPENDIX L.

**CASH FLOW STATEMENT OF 50% AND 25% OF
PTT'S EQUITY**

Table L-1 Cash Flow Statement, IRR, NPV, Payback Period and B/C Ratio

Case : 50% Equity of PTT.

Project Life (Yr.)	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13
Items / Calendar year	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Throughput (mml)	0	0	0	0	1,342	1,540	1,751	1,970	2,205	2,430	2,513	2,597	2,684	2,775	2,867	2,962	2,962
- Nakhon Sawan	0	0	0	0	427	490	557	627	701	761	787	813	840	869	897	926	926
- Pittsanulok	0	0	0	0	337	387	440	495	554	614	635	656	678	701	724	749	749
- Lampang	0	0	0	0	578	663	754	848	950	1,055	1,091	1,128	1,166	1,205	1,246	1,287	1,287
Escalation (%)		5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
Escalation Factor		1.05	1.10	1.16	1.22	1.28	1.34	1.41	1.48	1.55	1.63	1.71	1.80	1.89	1.98	2.08	2.18
Tariff Rate (St / Lt)																	
- Nakhon Sawan	16.14	16.95	17.80	18.69	19.62	20.60	21.63	22.71	23.85	25.04	26.29	27.06	28.41	29.83	31.32	32.89	34.53
- Pittsanulok	23.91	25.11	26.37	27.69	29.07	30.52	32.05	33.65	35.33	37.10	38.96	40.91	42.96	45.11	47.37	49.74	52.23
- Lampang	34.91	36.66	38.49	40.41	42.43	44.55	46.78	49.12	51.58	54.16	56.87	59.71	62.70	65.84	69.13	72.59	76.22
Benefit (mmb)																	
- Throughput Revenue					427	515	614	725	853	990	1,075	1,166	1,266	1,374	1,491	1,617	1,698
- Salvage Value																	
Total Benefit					427	515	614	725	853	990	1,075	1,166	1,266	1,374	1,491	1,617	1,698
Cost (mmb)																	
- O & M					-136	-143	-150	-157	-165	-173	-182	-191	-201	-211	-221	-232	-244
- Investment			-1,086	-1,629													
Debt			-1,086	-1,629													
Repayment							-272	-272	-272	-272	-272	-272	-272	-272	-272	-272	-272
Debt Outstanding			-1,086	-2,715	-2,715	-2,715	-2,443	-2,172	-1,900	-1,629	-1,357	-1,086	-814	-543	-272	0.0	
Interest Expense							-272	-244	-217	-190	-163	-136	-109	-81	-54	-27	
Total Cost			-2,172	-3,257	-136	-143	-150	-157	-165	-173	-182	-191	-201	-211	-221	-232	-244
NET CASH FLOW			-2,172	-3,257	291	372	78	53	199	355	459	568	686	811	944	1,086	1,454

IRR = 12.39% NPV (i = 10%) 1,896 million-baht Payback Period 11.71 Years B/C Ratio 1.23

Table L-1 Cash Flow Statement, IRR, NPV, Payback Period and B/C Ratio (continue)

Case : 50% Equity of PTT.

Project Life (Yr)	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Items / Calendar year	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Throughput (mmt)	2,962	2,962	2,962	2,962	2,962	2,962	2,962	2,962	2,962	2,962	2,962	2,962	2,962	2,962	2,962	2,962	2,962
- Nakhon Sawan	926	926	926	926	926	926	926	926	926	926	926	926	926	926	926	926	926
- Pittsanulok	749	749	749	749	749	749	749	749	749	749	749	749	749	749	749	749	749
- Lampang	1,287	1,287	1,287	1,287	1,287	1,287	1,287	1,287	1,287	1,287	1,287	1,287	1,287	1,287	1,287	1,287	1,287
Escalation (%)	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
Escalation Factor	2.29	2.41	2.53	2.65	2.79	2.93	3.07	3.23	3.39	3.56	3.73	3.92	4.12	4.32	4.54	4.76	5.00
Tariff Rate (St / Lt)																	
- Nakhon Sawan	36.26	38.07	39.97	41.97	44.07	46.27	48.58	51.01	53.56	56.24	59.05	62.00	65.10	68.36	71.78	75.37	79.14
- Pittsanulok	54.84	57.58	60.46	63.48	66.65	69.98	73.48	77.15	81.01	85.06	89.31	93.78	98.47	103.39	108.56	113.99	119.69
- Lampang	80.03	84.03	88.23	92.64	97.27	101.88	106.97	112.32	117.94	123.84	130.03	136.53	143.36	150.53	158.06	165.96	174.26
Benefit (mmb)																	
- Throughput Revenue	1,783	1,872	1,966	2,064	2,167	2,275	2,389	2,509	2,634	2,766	2,904	3,049	3,202	3,362	3,530	3,706	3,892
- Salvage Value																	543
Total Benefit	1,783	1,872	1,966	2,064	2,167	2,275	2,389	2,509	2,634	2,766	2,904	3,049	3,202	3,362	3,530	3,706	4,978
Cost (mmb)																	
- O & M	-256	-269	-282	-296	-311	-327	-343	-360	-378	-397	-417	-438	-460	-483	-507	-532	-559
- Investment																	
Debt																	
Repayment																	
Debt Outstanding																	
Interest Expense																	
Total Cost	-256	-269	-282	-296	-311	-327	-343	-360	-378	-397	-417	-438	-460	-483	-507	-532	-559
NET CASH FLOW	1,527	1,603	1,686	1,768	1,856	1,949	2,046	2,149	2,256	2,369	2,487	2,612	2,742	2,879	3,023	3,174	3,876

Table L-2 Cash Flow Statement, IRR, NPV, Payback Period and B/C Ratio

Case : 25% Equity of PTT.

Project Life (Yr.)	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13
Items / Calendar year	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Throughput (mm)	0	0	0	0	1,342	1,540	1,751	1,970	2,205	2,430	2,513	2,597	2,684	2,775	2,867	2,962	2,962
- Nakhon Sawan	0	0	0	0	427	490	557	627	701	761	787	813	840	869	897	926	926
- Pittsanulok	0	0	0	0	337	387	440	495	554	614	635	656	678	701	724	749	749
- Lampang	0	0	0	0	578	663	754	848	950	1,055	1,091	1,128	1,166	1,205	1,246	1,287	1,287
Escalation (%)		5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
Escalation Factor		1.05	1.10	1.16	1.22	1.28	1.34	1.41	1.48	1.55	1.63	1.71	1.80	1.89	1.98	2.08	2.18
Tariff Rate (St / Lt)																	
- Nakhon Sawan	15.14	16.95	17.80	18.80	19.62	20.60	21.63	22.71	23.85	25.04	26.29	27.06	28.41	29.83	31.32	32.89	34.53
- Pittsanulok	23.91	25.11	26.37	27.69	29.07	30.52	32.05	33.65	35.33	37.10	38.96	40.91	42.96	45.11	47.37	49.74	52.23
- Lampang	34.91	36.66	38.49	40.41	42.43	44.55	46.78	49.12	51.58	54.16	56.87	59.71	62.70	65.84	69.13	72.59	76.22
Benefit (mmb)																	
- Throughput Revenue					427	515	614	725	853	990	1,075	1,166	1,266	1,374	1,491	1,617	1,698
- Salvage Value																	
Total Benefit					427	515	614	725	853	990	1,075	1,166	1,266	1,374	1,491	1,617	1,698
Cost (mmb)																	
- O & M					-68	-71	-75	-79	-82	-87	-91	-95	-100	-105	-111	-116	-122
- Investment			-543	-814													
Debt			-1,629	-2,443													
Repayment							-407	-407	-407	-407	-407	-407	-407	-407	-407	-407	-407
Debt Outstanding			-1,629	-4,072	-4,072	-4,072	-3,995	-3,258	-2,850	-2,443	-2,036	-1,629	-1,222	-814	-407	0.0	
Interest Expense							-407	-367	-326	-287	-244	-204	-163	-122	-81	-41	
Total Cost			-2,172	-3,257	-68	-71	-75	-79	-82	-87	-91	-95	-100	-105	-111	-116	-122
NET CASH FLOW			-2,172	-3,257	359	443	-275	-127	38	211	332	460	595	739	892	1,053	1,576

IRR = 12.16% NPV (i = 10%) 1,800 million-baht Payback Period 12.67 Years B/C Ratio 1.22

Table L-2 Cash Flow Statement, IRR, NPV, Payback Period and B/C Ratio (continue)

Case : 25% Equity of PTT.

Project Life (Yr.)	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Items / Calendar year	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Throughput (rnmil)	2,962	2,962	2,962	2,962	2,962	2,962	2,962	2,962	2,962	2,962	2,962	2,962	2,962	2,962	2,962	2,962	2,962
- Nakhon Sawan	926	926	926	926	926	926	926	926	926	926	926	926	926	926	926	926	926
- Pittsanulok	749	749	749	749	749	749	749	749	749	749	749	749	749	749	749	749	749
- Lampang	1,287	1,287	1,287	1,287	1,287	1,287	1,287	1,287	1,287	1,287	1,287	1,287	1,287	1,287	1,287	1,287	1,287
Escalation (%)	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
Escalation Factor	2.29	2.41	2.53	2.65	2.79	2.93	3.07	3.23	3.39	3.56	3.73	3.92	4.12	4.32	4.54	4.76	5.00
Tariff Rate (S1 / L1)																	
- Nakhon Sawan	36.26	38.07	39.97	41.97	44.07	46.27	48.58	51.01	53.56	56.24	59.05	62.00	65.10	68.36	71.78	75.37	79.14
- Pittsanulok	54.84	57.58	60.46	63.48	66.65	69.98	73.48	77.15	81.01	85.06	89.31	93.78	98.47	103.39	108.56	113.99	119.69
- Lampang	80.03	84.03	88.23	92.64	97.27	101.88	106.97	112.32	117.94	123.84	130.03	136.53	143.36	150.53	158.06	165.96	174.26
Benefit (mmb)																	
- Throughput Revenue	1,783	1,872	1,966	2,064	2,167	2,275	2,389	2,509	2,634	2,766	2,904	3,049	3,202	3,362	3,530	3,706	3,892
- Salvage Value																	271
Total Benefit	1,783	1,872	1,966	2,064	2,167	2,275	2,389	2,509	2,634	2,766	2,904	3,049	3,202	3,362	3,530	3,706	4,978
Cost (mrnb)																	
- O & M	-128	-134	-141	-148	-156	-183	-171	-180	-189	-198	-208	-219	-230	-241	-253	-266	-279
- Investment																	
Debt																	
Repayment																	
Debt Outstanding																	
Interest Expense																	
Total Cost	-128	-134	-141	-148	-156	-183	-171	-180	-189	-198	-208	-219	-230	-241	-253	-266	-279
NET CASH FLOW	1,655	1,738	1,825	1,916	2,012	2,112	2,218	2,329	2,445	2,567	2,696	2,830	2,972	3,121	3,277	3,440	3,884

APPENDIX M.

THE RESULTS OF SENSITIVITY ANALYSIS

BASED ON %IRR

Appendix M. The results of Sensitivity Analysis based on %IRR

%	Percentage of IRR			
	Investment	Tariff Rate	O & M Cost	Throughput
-70	34.21	0	16	0
-60	27.69	1.09	15.58	1.09
-50	23.4	4.24	15.15	4.24
-40	20.3	6.56	14.72	6.56
-30	17.9	8.47	14.28	8.46
-20	15.96	10.11	13.84	10.11
-10	14.34	11.59	13.4	11.59
0	12.94	12.94	12.94	12.94
10	11.72	14.2	12.5	14.2
20	10.62	15.39	12.03	15.39
30	9.63	16.52	11.56	16.52
40	8.71	17.6	11.09	17.6
50	7.86	18.64	10.06	18.64
60	7.07	19.65	10.11	19.65
70	6.31	20.62	9.6	20.62
Slope	-0.172	0.146	-0.047	0.146

BIOGRAPHY

Miss Thunyarat Attaprecha was born on January 18, 1977 at Bangkok, Thailand and graduated Bachelor of Engineering in Chemical Engineering from Faculty of Engineering, Srinakharinwirot University in 1997. She has been admitted to the Master Degree Program of Engineering in Engineering Management, Regional Centre for Manufacturing Systems Engineering, Chulalongkorn University since 1998.

