Norton Basin Play 4: Lower Tertiary Subbasin Fill

Geological Assessment

GRASP UAI: AAAAAIAE
Play Area: 493 square miles
Play Water Depth Range: 40 - 70 feet
Play Depth Range : 12,000 – 23,000 feet
Play Exploration Chance: 0.045

Play 4, Lower Tertiary Subbasin Fill, Norton Basin OCS Planning Area, 2006 Assessment, Undiscovered Technically-Recoverable Oil & Gas

Assessment Results as of November 2005

Resource Commodity (Units)	Resources *		
	F95	Mean	F05
BOE (Mmboe)	0	14	77
Total Gas (Tcfg)	0.000	0.072	0.392
Total Liquids (Mmbo)	0	1	7
Free Gas** (Tcfg)	0.000	0.072	0.392
Solution Gas (Tcfg)	0.000	0.000	0.000
Oil (Mmbo)	0	0	0
Condensate (Mmbc)	0	1	7

** Risked, Technically-Recoverable*

*** Free Gas Includes Gas Cap and Non-Associated Gas*

F95 = 95% chance that resources will equal or exceed the given quantity

F05 = 5% chance that resources will equal or exceed the given quantity

BOE = total hydrocarbon energy, expressed in barrels-of-oil-equivalent, where 1 barrel of oil = 5,620 cubic feet of batural gas

Mmb = millions of barrels

Tcf = trillions of cubic feet

Table 1

Play 4, the Lower Tertiary Subbasin Fill play, is the 4th-ranking play (of 4 plays) in the Norton Basin OCS Planning Area, with 2% (14 Mmboe) of the planning area energy endowment (601 Mmboe). The overall assessment results for Play 4 are shown in table 1. Liquid hydrocarbons consisting of gas-condensate liquids form 7% of the hydrocarbon energy endowment of this play. Table 2 shows the conditional sizes of the 10 largest pools calculated in the *GRASP* computer model of the play. Table 3 summarizes the volumetric input data developed for use in the Play 4 *GRASP* computer model. Table 4 reports the risk model used for the play. Table 5 reports the detailed Play 4 assessment results by commodity.

The location of Norton Basin Play 4 is shown in figure 1, along with the exploratory wells and COST (Continental Offshore Stratigraphic Test) wells (fig. 1) that were drilled in Norton Basin. COST # 1 and COST # 2 were the only wells to penetrate Play 4 sediments, age-dated at those sites as "possible Paleocene" (Turner et al., 1986, figs. 13 and 14).

Norton Basin Play 4 includes all the deep clastic sediments in both subbasins ranging in age from possible latest Cretaceous(?) and Paleocene to early Eocene. These rocks range in depth from approximately 12,000 to 24,000 feet and are predominately continental to transitional alluvial fan and delta plain deposits. Sandstones are common within the Play 4 sedimentary section. Porosities range up to 12.8 percent, but are generally less than 10 % at depths greater than 10,000 feet. Reservoir quality is the element of greatest risk to play 4 (tbl. 4).

Potential hydrocarbon charge for the play derives primarily from gas-prone thermally mature rocks within the Play 4 sedimentary section. These rocks include numerous shales

and coaly intervals that were shown to contain primarily humic type III organic matter in samples recovered from the COST wells. Thermal maturity ranges from the middle of the oil-generation window to over-mature. Hydrocarbon migration would be expected to take place predominantly along horst and graben faulting systems within the basin. The potential trapping mechanisms are anticlines, faulted anticlines, fault traps, and stratigraphic traps.

Play 4, Lower Tertiary Subbasin Fill, Norton Basin OCS Planning Area, 2006 Assessment, Conditional BOE Sizes of Ten Largest Pools

Assessment Results as of November 2005

Pool Rank	BOE Resources *		
	F95	Mean	F05
1	2.27	34	129
2	1.15	13	41
3	0.81	8	22
4	0.65	5	15
5	0.55	4	11
6	0.49	3.3	9
7	0.44	2.8	7
8	0.40	2.5	6.3
9	0.34	2.2	5.5
10	0.30	1.9	4.8

** Conditional, Technically-Recoverable, Millions of Barrels Energy-Equivalent (Mmboe), from "PSRK.out" file*

F95 = 95% chance that resources will equal or exceed the given quantity

F05 = 5% chance that resources will equal or exceed the given quantity

BOE = total hydrocarbon energy, expressed in barrels-of-oil-equivalent, where 1 barrel of oil = 5,620 cubic feet of natural gas

Table 2

A maximum of 13 hypothetical pools is forecast by the aggregation of the risk model (tbl. 4) and the prospect numbers model for Play 4 (tbl. 3). These pools range in mean conditional (un-risked) recoverable volumes from 1 Mmboe (pool rank 13) to 34 Mmboe (pool rank 1, tbl. 2). Possible conditional recoverable volumes for pool rank 1 range from 2.27 (F95) to 129 Mmboe (F05).

In the computer simulation for Play 4 a total of 6,312 "simulation pools" were sampled for size. These simulation pools can be grouped according to the USGS size class system in which sizes double with each successive class. Table 6 reports the size classes and statistics for the simulation pools (conditional, technically recoverable BOE resources) developed in the *GRASP* computer model for Norton Basin Play 4. Pool size class 9 contains the largest share (1,275, or 20%) of simulation pools for the play. Pool size class 9 ranges from 8 to 16 Mmboe. The largest simulation pool for Play 4 falls within pool size class 16, which ranges in size from 1,024 to 2,048 Mmboe.

The great burial depth of the Play 4 sediments drives reduced porosity and high reservoir temperature that in turn adversely affect gas yield factor. This primarily accounts for the low oil and gas potential of play 4.

Producible hydrocarbons were not encountered in either of the COST wells (fig. 1) that penetrated the play.

GRASP Play Data Form (Minerals Management Service-Alaska Regional Office)

Basin: Norton | **Assessor:** S Banet | **Date:** March, 2006
Play Number: 4 | **Play Name:** Lower Tertiary Subbasin Fill
Play UAI Number: AAAAAIAE | This play was dropped from the assessment because the mean number of pools is less than 1.

Play Area: mi^2 (million acres) 493 mi^2 0.316 million acres
Reservoir Thermal Maturity: % Ro 0.9 - 1.2 - 1.4

Play Depth Range: feet 12,000 - 17,000 - 23,000
Expected Oil Gravity: ^{o} API 45
Play Water Depth Range: feet 40 - 70
Prospect Distance from shore, miles: 41 - 62 - 98

POOLS Module (Volumes of Pools, Acre-Feet)

Fractile	F100	F95	F90	F75	F50	Mean/Std. Dev.	F25	F15	F10	F05	F02	F01	F00
Prospect Area (acres)-Model Input*	25	407.0373	620.7136	1256.3357	2749.9968	5660.4 / 9569.3	6019.4755	9164.9575	12183.5287	18579.3325	29873.443	41000.5602	130000
Prospect Area (acres)-Model Output**													
Fill Fraction (Fraction of Area Filled)*	0.1	0.2005	0.2223	0.2642	0.32	.34012 / .10889	0.3876	0.4297	0.4607	0.5108	0.5738	0.62	1
Productive Area of Pool (acres)***	10	122.549	190.358	397.337	900	1932.974 / 3626.748	2038.576	3161.345	4255.143	6609.58	10850.15	15098.9	68122
Pay Thickness (feet)	50	89.71	100.496	121.491	150	157.594 / 51.065	185.199	207.379	223.889	250.809	284.998	310.343	400

* model fit to prospect area, fill fraction data from NA95 in *BESTFIT*

** output from *@RISK* after aggregation with fill fraction

*** from *@RISK* aggregation of probability distributions for prospect area and fill fraction

MPRO Module (Numbers of Pools)

Input Play Level Chance	0.3	Prospect Level Chance	0.15	Exploration Chance	0.045
Output Play Level Chance*	0.2598				

* First Occurrence of Non Zero Pools As Reported in PSUM Module

Risk Model

Play Chance	Petroleum System Factors	Prospect Chance
0.5	Effective reservoir: minimum porosity, permeability	
0.6	Presence of a trap with minimum rock volume	
	Efficient source rock: sufficient volume, maturity; drainage	0.15

Fractile	F99	F95	F90	F75	F50	Mean/Std. Dev.	F25	F15	F10	F05	F02	F01	F00
Numbers of Prospects in Play	6	7	8	10	12	14.04 / 5.1	16	19	21	24	28	29	30
Numbers of Pools in Play					0	0.63 / 1.28	1	2	3	4	5	5	13

Minimum Number of Pools	0	Mean Number of Pools	1	Maximum Number of Pools	13

POOLS/PSRK/PSUM Modules (Play Resources)

Fractile	F100	F95	F90	F75	F50	Mean/Std. Dev.	F25	F15	F10	F05	F02	F01	F00
Oil Recovery Factor (bbl/acre-foot)	0	constant											
Gas Recovery Factor (Mcfg/acre-foot)	99	203.88	228.261	275.678	340	357.129 / 115.623	419.329	469.276	506.438	567	643.867	700.818	1170
Gas Oil Ratio (Sol'n Gas)(cf/bbl)	0	constant											
Condensate Yield ((bbl/Mmcfg)	7.5	12.96	13.935	15.731	18	18.358 / 3.732	20.596	22.14	23.25	25	27.127	28.645	33

Pool Size Distribution Statistics from *POOLS* (1,000 BOE): μ (mu)= 9.1080918 σ^2 (sigma squared)= 1.70108056 | **Random Number Generator Seed=** 846732

BOE Conversion Factor (cf/bbl)	5620	Probability Any Pool Contains Both Oil and Free Gas (Gas Cap)	0
Probability Any Pool is 100% Oil	0	Fraction of Pool Volume Gas-Bearing in Oil Pools with Gas Cap	1
Probability Any Pool is 100% Gas	1		

Table 3. Input data for Norton basin play 4, 2006 assessment.

Risk Analysis Form - 2005 National Assessment

Assessment Province:	Norton Basin	**Play Number, Name:**	4, Lower Tertiary Subbasin Fill
Assessor(s):	S Banet	**Play UAI:**	AAAAAIAE
Date:	March, 2006		

For each component, a *quantitative* probability of success (i.e., between zero and one, where zero indicates no confidence and one indicates absolute certainty) based on consideration of the *qualitative* assessment of **ALL** elements within the component was assigned. This is the assessment of the probability that the minimum geologic parameter assumptions have been met or exceeded.

			Play Chance Factors	Averge Conditional Prospect Chance[1]
1.	**Hydrocarbon Fill component** (1a * 1b * 1c)	**1**	***1.0000***	***0.1500***
	a. Presence of a Quality, Effective, Mature Source Rock			
	Probability of efficient source rock in terms of the existence of sufficient volume of mature source rock of adequate quality located in the drainage area of the reservoirs.	1a	1.00	0.15
	b. Effective Expulsion and Migration			
	Probability of effective expulsion and migration of hydrocarbons from the source rock to the reservoirs.	1b	1.00	1.00
	c. Preservation			
	Probability of effective retention of hydrocarbons in the prospects after accumulation.	1c	1.00	1.00
2.	**Reservoir component** (2a * 2b)	**2**	***0.5000***	***1.0000***
	a. Presence of reservoir facies			
	Probability of presence of reservoir facies with a minimum net thickness and net/gross ratio (as specified in the resource assessment).	2a	1.00	1.00
	b. Reservoir quality			
	Probability of effectiveness of the reservoir, with respect to minimum effective porosity, and permeability (as specified in the resource assessment).	2b	0.50	1.00
3.	**Trap component** (3a * 3b)	**3**	***0.6000***	***1.0000***
	a. Presence of trap			
	Probability of presence of the trap with a minimum rock volume (as specified in the resource assessment).	3a	0.60	1.00
	b. Effective seal mechanism			
	Probability of effective seal mechanism for the trap.	3b	1.00	1.00
Overall Play Chance (Marginal Probability of hydrocarbons, MPhc)			***0.3000***	
	(1 * 2 * 3) *Product of All Subjective Play Chance Factors*			
Average Conditional Prospect Chance[1]				***0.1500***
	(1 * 2 * 3) *Product of All Subjective Conditional Prospect Chance Factors*			
	[1] Assumes that the Play exists (where all play chance factors = 1.0)			
	Must be consistent with play chance and prospect distribution -- See discussion on Page 3 of Guide			
Exploration Chance			***0.0450***	
	(Product of Overall Play Chance and Average Conditional Prospect Chance)			

Comments: *See guidance document for explanation of the Risk Analysis Form*

Table 4. Risk model for Norton basin play 4, 2006 assessment.

GRASP - Geologic and Economic Resource Assessment Model - PSUM Module Results

Minerals Management Service - Alaska OCS Region
GRASP Model Version: 8.29.2005)
Computes the Geologic Resource Potential of the Play

Play UAI:	**AAAAAIAE**		**Play No.**		**4**		
World	Level	-	World	Level		Resources	
Country	Level	-	UNITED	STATES		OF	AMERICA
Region	Level	-	MMS	-		ALASKA	REGION
Basin	Level	-	**NORTON**	**BASIN**			
Play	**Level**	**-**	**Play**		**4**	**Lower Tertiary Subbasin Fill Play**	
Geologist	Sue	Banet					

Run Date & Time: Date 19-Sep-05 Time 14:09:22

Summary of Play Potential

Product	MEAN	Standard Deviation
BOE (Mboe)	14,186	53,322
Oil (Mbo)	0	0
Condensate (Mbc)	1,315	4,810
Free (Gas Cap & Nonassociated) Gas (Mmcfg)	72,336	273,000
Solution Gas (Mmcfg)	0	0

10000 (Number of Trials in Sample)
0.2598 (MPhc [Probability] of First Occurrence of Non-Zero Resource)
Windowing Feature: used

Empirical Probability Distributions of the Products

Greater Than Percentage	BOE (Mboe)	Oil (Mbo)	Condensate (Mbc)	Free (Gas Cap & Nonassociated) Gas (Mmcfg)	Solution Gas (Mmcfg)
100	0	0	0	0	0
99.99	0	0	0	0	0
99	0	0	0	0	0
95	0	0	0	0	0
90	0	0	0	0	0
85	0	0	0	0	0
80	0	0	0	0	0
75	0	0	0	0	0
70	0	0	0	0	0
65	0	0	0	0	0
60	0	0	0	0	0
55	0	0	0	0	0
50	0	0	0	0	0
45	0	0	0	0	0
40	0	0	0	0	0
35	0	0	0	0	0
30	0	0	0	0	0
25	2,033	0	187	10,376	0
20	10,401	0	959	53,060	0
15	22,713	0	2,146	115,590	0
10	40,344	0	3,757	205,620	0
8	51,840	0	4,914	263,730	0
6	67,220	0	6,344	342,120	0
5	76,881	0	7,141	391,940	0
4	90,584	0	8,647	460,480	0
2	144,630	0	13,791	735,310	0
1	222,120	0	21,338	1,128,400	0
0.1	634,380	0	38,660	3,347,900	0
0.01	1,468,900	0	101,850	7,682,700	0
0.001	1,834,700	0	175,750	9,323,400	0

Table 5. Assessment results by commodity for Norton basin play 4, 2006 assessment.

Basin: NORTON BASIN
Play 04 - Lower Tertiary Subbasin Fill Play
UAI Key: AAAAAIAE

Model Simulation "Pools" Reported by "Fieldsize.out" *GRASP* Module

Classification and Size				Pool Count Statistics				Pool Types Count			Mixed Pool Range		Oil Pool Range		Gas Pool Range		Total Pool Range			Pool Resource Statistics (MMBOE)			
Class	Min (MMBOE)	Max (MMBOE)	Pool Count	Percentage	Trial Average	Trials w/Pool Avg		Mixed Pool	Oil Pool	Gas Pool	Min	Max	Min	Max	Min	Max	Min	Max		Min	Max	Total Resource	Average Resource
1	0.0312	0.0625	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0		0.000000	0.000000	0.000000	0.000000
2	0.0625	0.125	3	0.047529	0.0003	0.001154		0	0	3	0	0	0	0	1	1	1	1		0.092073	0.123369	0.317896	105.965391
3	0.125	0.25	18	0.285171	0.0018	0.006926		0	0	18	0	0	0	0	1	1	1	1		0.140845	0.230273	3.519252	195.513994
4	0.25	0.5	65	1.029785	0.0065	0.02501		0	0	65	0	0	0	0	1	2	1	2		0.261441	0.499713	25.122368	386.497974
5	0.5	1	213	3.374525	0.0213	0.081955		0	0	213	0	0	0	0	1	2	1	2		0.502516	0.995783	161.010914	755.919755
6	1	2	477	7.557034	0.0477	0.183532		0	0	477	0	0	0	0	1	3	1	3		1.000730	1.999738	715.107288	1.499177
7	2	4	952	15.082383	0.0952	0.366295		0	0	952	0	0	0	0	1	4	1	4		2.001453	3.999765	2800.240000	2.941429
8	4	8	1224	19.391636	0.1224	0.47095		0	0	1224	0	0	0	0	1	5	1	5		4.009052	7.998252	7180.565000	5.866475
9	8	16	1275	20.199619	0.1275	0.490573		0	0	1275	0	0	0	0	1	4	1	4		8.005015	15.961050	14709.015000	11.536482
10	16	32	1076	17.046894	0.1076	0.414005		0	0	1076	0	0	0	0	1	4	1	4		16.009877	31.976567	24420.342000	22.695486
11	32	64	575	9.109632	0.0575	0.221239		0	0	575	0	0	0	0	1	5	1	5		32.004377	63.942647	25351.332000	44.089272
12	64	128	278	4.404309	0.0278	0.106964		0	0	278	0	0	0	0	1	2	1	2		64.026769	127.138007	23929.051000	86.075722
13	128	256	107	1.695184	0.0107	0.04117		0	0	107	0	0	0	0	1	1	1	1		130.226452	254.888587	18746.946000	175.205093
14	256	512	37	0.586185	0.0037	0.014236		0	0	37	0	0	0	0	1	1	1	1		260.033756	466.487972	12789.764000	345.669312
15	512	1024	9	0.142586	0.0009	0.003463		0	0	9	0	0	0	0	1	1	1	1		561.194414	855.178121	6398.674000	710.963806
16	1024	2048	3	0.047529	0.0003	0.001154		0	0	3	0	0	0	0	1	1	1	1		1315.646000	1856.768000	4628.542000	1.542847
17	2048	4096	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0		0.000000	0.000000	0.000000	0.000000
18	4096	8192	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0		0.000000	0.000000	0.000000	0.000000
19	8192	16384	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0		0.000000	0.000000	0.000000	0.000000
20	16384	32768	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0		0.000000	0.000000	0.000000	0.000000
21	32768	65536	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0		0.000000	0.000000	0.000000	0.000000
22	65536	131072	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0		0.000000	0.000000	0.000000	0.000000
23	131072	262144	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0		0.000000	0.000000	0.000000	0.000000
24	262144	524288	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0		0.000000	0.000000	0.000000	0.000000
25	524288	1048576	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0		0.000000	0.000000	0.000000	0.000000
Not Classified			0	0	0	0	Below Class	0	0	0									Below Class	0.000000	0.000000	0.000000	0.000000
	Totals		6312	100	0.6312	2.428626	Above Class	0	0	0									Above Class	0.000000	0.000000	0.000000	0.000000

Number of Pools not Classified: 0
Number of Pools below Class 1: 0
Number of Trials with Pools: 2599

Min and Max refer to numbers of pools of the relevant size class that occur within any single trial in the simulation.

Min and Max refer to aggregate resources of the relevant size class that occur within any single trial in the simulation.

Table 6. Statistics for simulation pools created in computer sampling run for Norton basin play 4, 2006 assessment.

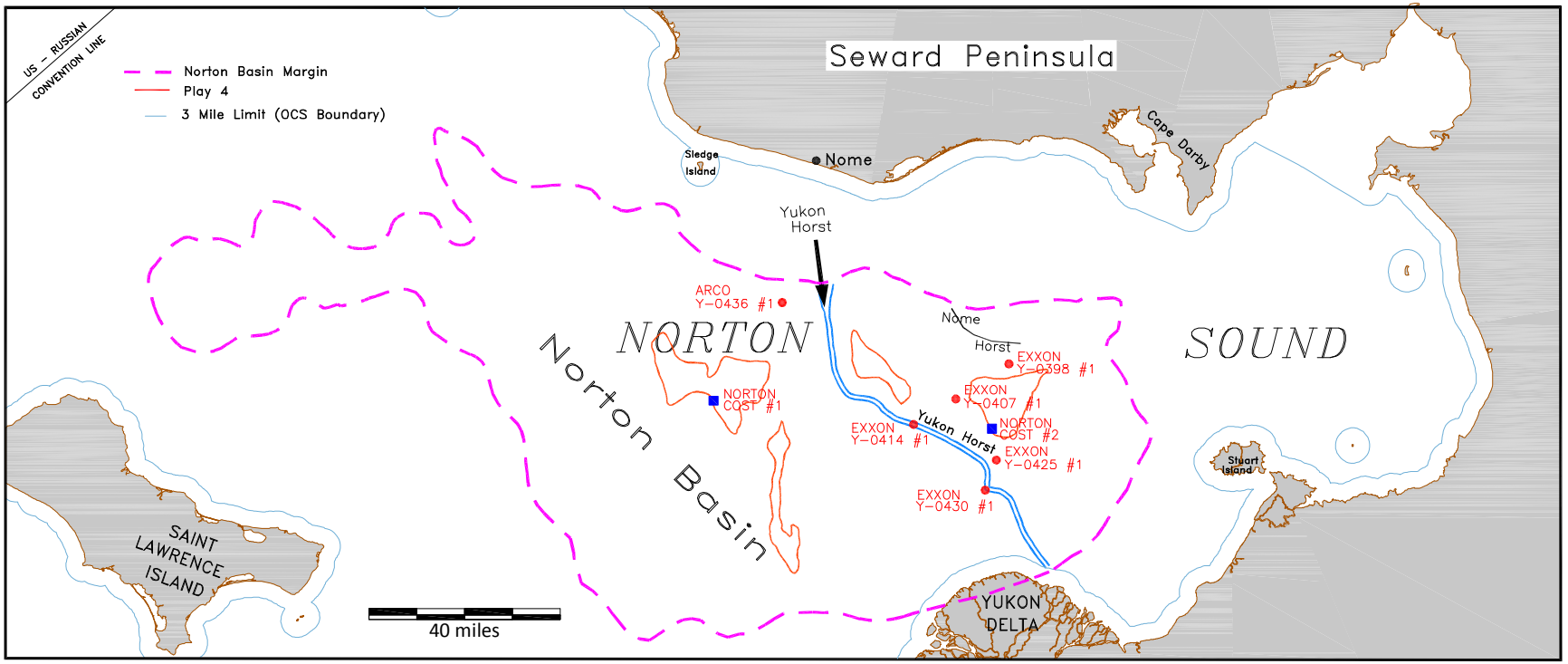

Figure 1. Location map for Norton Basin Play 4, the Lower Tertiary Subbasin Fill play (2006 assessment). Also shown are the locations of the two COST wells and six exploration wells drilled in Norton Basin. Play 4 underlies portions of both the Mid-Tertiary East Subbasin Fill play (Play 2) and the Mid-Tertiary West Subbasin Fill play (Play 3). Play 4 sediments were encountered in the two COST wells only.