Nova Scotia
OFFSHORE

Nova Scotia Offshore Exploration Wells

Exploration Drilling Performance Review

NOVA SCOTIA
Department of Energy
CANADA

TABLE OF CONTENTS

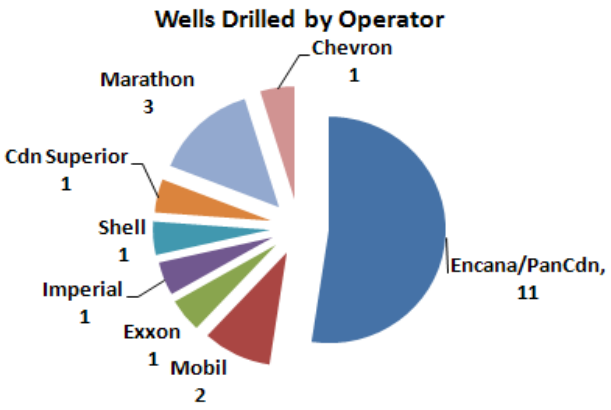
1.0 EXECUTIVE SUMMARY

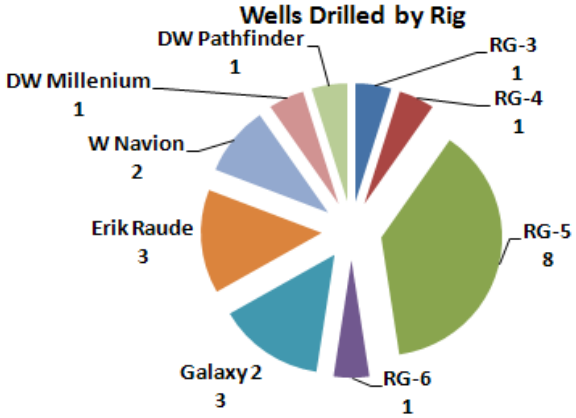
Since 2000, a total of 24 exploration wells, including 3 sidetrack wells, have been drilled offshore Nova Scotia. The period of drilling activity spanned a total of five and a half years, with the first well being spud in July 2000, and demobilization after the last well in January 2006. A schedule indicating the offshore Nova Scotia drilling activity is provided in Appendix 1 - Figure 1.

The wells, which were differentiated by well characteristics, encompassed a range of different technical challenges. These well categories or Well Types are as follows:

- **Shelf/Normal pressured (SNP)**: A total of eight wells (excluding three sidetracks) which were jack-up drilled in shallow water (30-48 m) to depths up to 5600 m, where reservoir pressures were hydrostatic.
- **Shelf/Overpressured (SOP)**: A total of 5 wells which were jack-up drilled in shallow water (17-57 m) to depths up to 5400 m, where reservoir pressures required drilling fluids in the 1,500-1,800 kg/m^3 range)
- **Shelf/Geopressured (SGP)**: A single well which was jack-up drilled in shallow water (60 m) to 5019 m, where reservoir pressures required drilling fluids in excess of 2000 kg/m^3)
- **Deep Water/Low Complexity (DWL)**: A total of three wells which were drilled using either a deepwater semi-sub or a drillship in water depths in the 1700-1800 m range, and where no more than two intermediate casing strings were required.
- **Deep Water/High Complexity (DWH)**: A total of four wells which were drilled using either a deepwater semi-sub or a drillship in water depths in the 1000-2000 m range; and where three or more intermediate casing strings were required.

The wells were drilled by a number of operators using different drilling rigs as shown below:





As can be seen, Encana (or its predecessor company PanCanadian) drilled about half of the wells, with seven other operators responsible for the remainder. Of these, only two companies, Marathon (3 wells) and Mobil (2 wells), drilled multiple wells.

The most active drilling rig during this period was the harsh environment jack-up Rowan Gorilla 5 which drilled a total of 8 wells (6 of which were for Encana) on the shelf. A number of other rigs also drilled

multiple wells, including the Galaxy 2 jack-up (3 wells), the Erik Raude fifth generation semi (3 wells), and the West Navion deepwater drillship (2 wells). A summary of rig utilization by operator is as follows:

Wells Drilled by Operator										
Rig Type	**Jack-up**					**Semi / Drillship**				
Operator	**RG-3**	**RG-4**	**RG-5**	**RG-6**	**Galaxy 2**	**E Raude**	**W Navion**	**Millenium**	**Pathfinder**	**TOTAL**
Encana/PanCdn	1	1	6	1		2				11
Mobil					2					2
Exxon			1							1
Imperial						1				1
Shell					1					1
Cdn Superior			1							1
Marathon							2		1	3
Chevron								1		1
TOTAL	**1**	**1**	**8**	**1**	**3**	**3**	**2**	**1**	**1**	**21**

An overview of the key performance metrics for the wells is provided in Appendix 1–Table 1. The key metrics by well category are summarized as follows.

Well Category	Well Depth (m)			Well Time (Days spud-TD)			Effective ROP (m/day)			% NPT			No of Wait On Weather Days		
	Min	Max	Average	Min	Max	Average	Min	Max	Average	Min	Max	Average	Min	Max	Average
SNP	3625	4598	4030	43	78	55	56	97	74	3%	21%	11%	0	3.6	1.2
SOP	3945	5408	4744	62	93	78	47	76	61	8%	31%	17%	0	4.7	1.4
SGP		5019			153			32			33%			0	
DWL	3496	4750	3949	45	89	62	20	57	40	24%	72%	54%	0	4.5	1.5
DWH	6070	6676	6362	63	195	113	25	73	50	14%	37%	27%	0	0.6	0.2
All Wells	3496	6676	4669	43	195	77	20	97	59	3%	72%	28%	0	4.7	1.0

Spud to TD time and effective Rates of Penetration (ROP) were calculated to compare drilling performance. As well complexity increased, drilling times also increased. ROP also supports this trend with the one exception being Deep Water Low complexity (DWL) primarily due to one well with extensive problem time – Annapolis B-24. Non-productive time comparison demonstrates the DWL category anomalous NPT percent for DWL wells at 54%. This is due to Annapolis B-24 having 72% NPT.

While drilling performance is a key factor affecting well cost, it is not the only factor. Regionally, local day rates for rigs and support services are influenced by availability and local competition as well as the region's operating expense environment. There are significant day rate variations between different areas. For example the IHS QUE$TOR cost estimation system currently (2Q 2011) indicates the following fully supported day rates for East Coast Canada, UK North Sea, Norway North Sea and the Gulf of Mexico:

Rig Type	East Coast Canada	UK Northern North Sea	Norway North Sea	Gulf of Mexico
Jack-up				
Rig Supported Day Rate (US$K)	$298	$185	$229	$95
Ratio to Canada	1	0.62	1.14	0.33
5th Generation Semi				
Rig Supported Day Rate (US$K)	$536	$534	$586	$540
Ratio to Canada	1	1	1.09	1.01

Well Costs

To compare well costs, normalized well times for each of the well types was prepared and cost estimates using Que$tor were prepared. The following table presents the normalized complete well times and resultant costs for a 2011 well.

Type Well	Shelf Normal Pressure	Shelf Over-pressure	Shelf Geo-pressure	Deep Water Low Complexity	Deep Water High Complexity
Days	60	101	180	70	145
Cost (MM Can$)	$35	$52	$83	$66	$121
Rig Type	Jack-Up			5th Generation Semi	

Overall, 21 exploration wells (24, including sidetracked wells) were drilled offshore Nova Scotia in the period 2000-2006.

CONCLUSIONS

The following conclusions have been drawn from a review of this data:

1. There is a wide scatter in effective ROP performance across the 21 wells drilled, as would be expected in an exploration environment, where uncertainties in formation and pressure conditions are significant. However, the general trend of faster drilling performance for the shallow water shelf wells compared to the deepwater wells is as expected.

2. The non-productive time (NPT) experienced in drilling the Nova Scotia wells (28% average for all wells) is generally well within the levels to be expected (typically 25-35%) in an exploration drilling environment. Average NPT for Nova Scotia shelf wells, at less than 20%, is considered good in comparison to other areas; while the 27% NPT for the high complexity deepwater (DWH) wells is considered within industry norms. The 54% average NPT for deepwater low complexity (DWL) wells is heavily influenced by the Annapolis B-24 well which experienced 72% NPT as a result of riser problems on the West Navion drillship.

3. In addition to the Annapolis B-24 well, which experienced very high NPT, there were two other wells, Onondaga B-84 (geopressured well on the shelf) and Weymouth A-45 (deepwater complex well), in which drilling performance was very slow, 32m/day and 25 m/day ROP respectively. These wells, while a small subset of the total are often sighted as being typical in terms of time and cost over-runs. This is clearly not the case, since these wells are outliers on what is on average (59 m/day) a much better performance.

4. Very little time was expended waiting on weather, averaging only 1 day per well, which is excellent, given that about half of the wells were drilled through the winter season.

5. The low total number of exploration wells (21 wells) drilled during the period in question (2000-2005) is a factor which must be considered when comparing the Nova Scotia performance with other areas such as Norway or the Gulf of Mexico (GoM). This “low on the learning curve” factor is further compounded by the fact that most of the operators involved in Nova Scotia offshore exploration during this period only drilled 1 well.

6. The Jack-up day rates are significantly higher on the East Coast Canada and the Norwegian North Sea compared to the high volume markets in the UK and the GoM.

7. The limited availability of 5th Generation semi–submersible drilling rigs results in rate rates that are on par on the East Coast with the UK and the GoM, while the Norwegian North Sea is ~10% higher.

8. This two rig type comparison demonstrates the significance of rig availability and market at the time the well is drilled. A larger well program and rig fleet than has been the norm in the past would reduce rig rates and well costs significantly.

2.0 INTRODUCTION

A commonly held industry perspective of East Coast Canada Offshore Exploration drilling is the wells are costly due to the:

- harsh drilling environment
- restricted availability of drilling equipment and services

While Nova Scotia does have some challenging wells, the wells span a wide range in depth with a resultant range in drilling times and costs. To substantiate the drilling performance the latest 10 years of Nova Scotia offshore exploration wells were examined. A total of 24 wells were drilled in this time frame.

Table 1 - Nova Scotia Exploration Wells - Latest 10 Years

Well Name		Company	Drilling Unit	Spud Date	Well Termination Date	Water Depth (m)	Total Depth (m MD)
Emma	N-03	Mobil Oil	Galaxy II	2-Aug-00	1-Nov-00	50.6	4,600
Panuke	M-79	PanCanadian	Rowan Gorilla IV	12-Jul-00	2-Oct-00	43.5	4,598
Panuke	F-09	PanCanadian	Rowan Gorilla III	23-Aug-00	11-Nov-00	42.0	3,815
Panuke	M-79A	PanCanadian	Rowan Gorilla V	11-Oct-00	17-Dec-00	43.5	3,934
Adamant	N-97	Mobil et al	Galaxy II	5-Nov-00	4-Feb-01	16.9	4,708
Musquodoboit	E-23	PanCanadian	Rowan Gorilla V	1-Jul-01	2-Sep-01	47.3	3,818
Southampton	A-25	PanCanadian	Rowan Gorilla V	3-Sep-01	12-Dec-01	47.0	5,058
Onondaga	B-84	Shell Canada	Galaxy II	17-Nov-01	12-May-02	59.7	5,019
Annapolis	B-24	Marathon Cda	West Navion	26-Dec-01	24-Apr-02	1,737.0	3,496
Queensland	M-88	PanCanadian-	Rowan Gorilla V	14-Dec-01	10-Feb-02	38.0	4,443
Newburn	H-23	Chevron Cda	Deepwater Millennium	22-May-02	21-Aug-02	977.0	6,070
Annapolis	G-24	Marathon Cda	West Navion	17-Apr-02	16-Aug-02	1,711.00	6,182
Marquis	L-35	Canadian Sup.	Rowan Gorilla V	6-Jul-02	14-Sep-02	48.0	4,552
Marquis	L-35A	Canadian Sup.	Rowan Gorilla V	27-Aug-02	14-Sep-02	48.0	4,552
Torbrook	C-15	EnCana Corp.	Eirik Raude	16-Nov-02	14-Jan-03	1674.5	3,600
Margaree	F-70	EnCana Corp.	Rowan Gorilla V	21-May-03	6-Aug-03	42.5	3,677
Balvenie	B-79	Imperial Oil	Eirik Raude	6-Jul-03	6-Sep-03	1803.0	4,750
MarCoh	D-41	EnCana Corp.	Rowan Gorilla V	28-Aug-03	23-Oct-03	43.4	3,625
Weymouth	A-45	EnCana Shell	Eirik Raude	27-Oct-03	8-Mar-04	1689.7	6,520
Mariner	I-85	Candian Sup/	Rowan Gorilla V	19-Nov-03	16-Mar-04	55.5	5,408
Cree	I-34	ExxonMobil	Rowan Gorilla V	15-May-04	14-Aug-04	57.0	3,945
Crimson	F-81	Marathon Cda	Deepwater	18-Jun-04	27-Aug-04	2091.5	6,676
Dominion	J-14	Encana-Marauder	Rowan Gorilla VI	18-Nov-05	30-Jan-06	29.5	3,700
Dominion	J-14A	Encana-Marauder	Rowan Gorilla VI	30-Dec-05	24-Jan-06	29.5	4,440

2.1 Objectives

The objectives of the offshore drilling study were to:

- Review recent NOVA SCOTIA offshore exploration well drilling performance with particular attention paid to well duration versus depth and Non-Productive Time (NPT)
- Prepare current well cost estimates for the Nova Scotia wells
- Compare drilling costs to other offshore regions

2.2 Analysis Approach

To compare the drilling performance of the Nova Scotia wells, determining the significant factors that differentiate the wells provides a basis for the comparison. Because offshore exploration well costs are largely determined by drilling times, the factors that influence drilling time are critical. These could include:

- Well Depth
- Water Depth/Rig Type
- Extent of Overpressure
- Number of Casing Strings (Complexity)
- Weather State/Time of the Year

These factors were investigated to identify logical categories or well types. Given groups of similar wells are identified, the drilling performance can be compared and the group's performance analysed to generate representative average drilling curves and technical limit curves.

Because these wells are exploration wells, the evaluation time can vary significantly based on Geologic success and the Operators evaluation strategy. Consequently, using end of the well time singularly could result in a misleading time estimate when it comes to determining a "normal" time. The approach used was to break the well into depth sections based on hole and casing intervals and generate all in interval Rates Of Penetration (ROP) and interval flat times. The average ROPs and average flat times were then applied to average interval depths to generate average or expected well times including NPT.

Selecting the fastest ROP by interval and the shortest flat time will generate a Technical Limit curve which includes actual NPT. The technical limit curve is taken to Total Depth only because the shortest evaluation flat time does not make sense to use because of the lack of a common evaluation and abandonment program.