

# Summary of Shale Gas Activity in Northeast British Columbia 2011

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Oil and Gas Division  
Geoscience and Strategic Initiatives Branch



Ministry of  
Energy and Mines



# **SUMMARY OF SHALE GAS ACTIVITY IN NORTHEAST BRITISH COLUMBIA 2011**

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# SUMMARY OF SHALE GAS ACTIVITY IN NORTHEAST BRITISH COLUMBIA 2011

Ministry of Energy and Mines  
Geoscience and Strategic Initiatives Branch  
*Christopher Adams, ASCT, Oil and Gas Specialist<sup>1</sup>*

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## ABSTRACT

*Increased attention to shale gas prospects in northeast British Columbia over the last five years resulted in unprecedented levels of land sale activity. Bonuses garnered from the sale of Crown petroleum and natural gas rights reached a record total of \$2.7 billion in 2008 followed by a combined total of almost \$1.7 billion in 2009 and 2010. Over 90 per cent of these bonus totals were directed toward the exploration and development of British Columbia's shale gas regions. Similarly, in 2011, over 90 per cent of the \$223 million collected in land sale bonuses was the result of operators focusing on the evaluation and extraction of these world-class shale gas resources, which have the potential to hold over 1,200 trillion cubic feet of natural gas. Recoverable resource numbers for these regions continue to be dependent on advances associated with horizontal drilling techniques and hydraulic fracturing procedures, but the Horn River Basin, Liard Basin, Cordova Embayment and the Montney play region are currently playing a significant role in western Canada's gas supply. These regions are key components to the success of British Columbia's recently released Natural Gas Strategy and Liquefied Natural Gas Strategy. In terms of industry drilling activities, northeast British Columbia's Montney play region has become the most active and continues to be one of the most successful and productive natural gas plays in North America.*

*This summary report highlights shale gas activity in the key shale gas regions of northeast British Columbia with most of the statistics presented focussing on the years 2010 and 2011.*

Adams, C. (2012): Summary of shale gas activity in northeast British Columbia 2011, *BC Ministry of Energy and Mines*, pages 1-19.

<sup>1</sup>British Columbia Ministry of Energy, Mines, Geoscience and Strategic Initiatives Branch, PO Box 9323, Stn. Prov. Govt., Victoria, British Columbia, V8W 9N3; 250-953-3763; e-mail: Christopher.Adams@gov.bc.ca

**Key Words:** shale gas, exploration and development, industry activity, northeast British Columbia, petroleum and natural gas rights, resource region, drilling, rig releases, operators, producers, experimental schemes, horizontal drilling, hydraulic fracturing, natural gas, natural gas liquids, Horn River Basin, Cordova Embayment, Montney, Liard Basin, production, reserves.

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## INTRODUCTION

Shale gas prospects and the technology used to extract natural gas from shale have reshaped the exploration and development landscape in northeast British Columbia (BC). World-class shale gas plays such as the Horn River Basin, Cordova Embayment and the Montney play trend have provided oil and gas operators the opportunity to fine tune development techniques such as horizontal drilling combined with multi-stage hydraulic fracturing. As producing companies realize success from these regions, they continue to make significant purchases of petroleum and natural gas (PNG) rights. In 2009, northeast BC's shale gas regions garnered 90 per cent of the province's land sale bonus total of \$893 million. An almost identical scenario unfolded in 2010 with land sale bonuses directed toward shale gas activity reaching 94 per cent of the \$844 million total. Land sale bonus totals dropped in 2011 with only \$223 million directed toward the exploration and development of BC's shale gas regions. The Montney play trend accounted for 89 per cent of the 2011 bonus total while the Horn River Basin saw only a one-per cent allocation. There were

no PNG rights sold within the Cordova Embayment and Liard Basin in 2011.

Over the last decade, the BC Oil and Gas Commission (OGC) has approved over 30 special projects (formerly experimental schemes) for shale gas potential in northeast BC. The OGC issues approvals for special projects under section 75 of the *Oil and Gas Activities Act*. Operators receiving these special project approvals must submit a progress report to the OGC annually. Special projects are designated as such if there is an application of innovative technology or if there is an innovative method of carrying out oil and gas activities and related activities. To date, most special projects approved for shale gas potential in northeast BC have been in relatively low density drilling areas such as the Horn River Basin, however, some schemes have been approved for fields in the northwest extension of the Montney play trend such as Altares, Farrell Creek, Pocketknife and Town. In the Horn River Basin, special project requests are increasingly being denied because proposed

development technology is no longer considered unique to many areas of the basin.

## BACKGROUND

Formations prospective for shale gas in the British Columbia portion of the Western Canada Sedimentary Basin potentially contain large volumes of hydrocarbons (Table 1). Organic rich shales may generate and store methane due to biogenic gas generation during the early diagenesis stage and subsequent catagenic generation at higher levels of maturity. Most shales have low matrix permeabilities and require extensive and widespread natural or induced fracture systems to sustain commercial flow rates. Although there has been much publicity regarding the success of several shale gas plays in the United States, British Columbia's shales are still recognized as having large-scale potential with as much as 1,200 trillion cubic feet (Tcf) of original gas-in-place. Assessments are ongoing to determine the technically recoverable and marketable resource potential. Numerous stratigraphic horizons and play areas in northeast British Columbia have excellent potential for this huge resource and only a relatively small portion has been commercially produced thus far.

**TABLE 1. POTENTIAL SHALE GAS FORMATIONS IN NORTHEAST BRITISH COLUMBIA**

PROSPECTIVE HORIZONS						
	Formations	Description	Depth	Average Thickness	Total Organic Carbon	Gas In Place
LOWER CRETACEOUS	Wilrich and Buckinghamshale shales	Potential interbedded sand/siltstone	800 to 1,200 metres	100 metres	2.3%	60 Bcf per section
JURASSIC	Nordegg and Fernie shales	Recognized source rocks	1,200 to 2,500 metres	Up to 30 m organic rich section	up to 14%	>20 Bcf per section
TRIASSIC	Doig, Doig Phosphate and Montney	Montney turbidites may increase permeability  Phosphate units have high TOC and are excellent source rocks	1,200 to 3,000 metres	300 to 500 metres	0.5 to >10%	10 to 110 Bcf per section
DEVONIAN	Exshaw, Besa River, Fort Simpson Horn River and Muskwa	Exshaw and Muskwa are widely distributed organic shales  Fort Simpson and Besa River are thick basin-filling shales	1,800 to 3,500 metres	Huge thicknesses are common with some high TOC intervals	0.5 to >10%	10 to 100 Bcf per section
GEOLOGIC ANALOGUE						
MISSISSIPPIAN	Barnett Shale (Fort Worth Basin)	Marine-shelf deposit	2,000 to 2,500 metres	100 metres	4.5%	140 Bcf per section

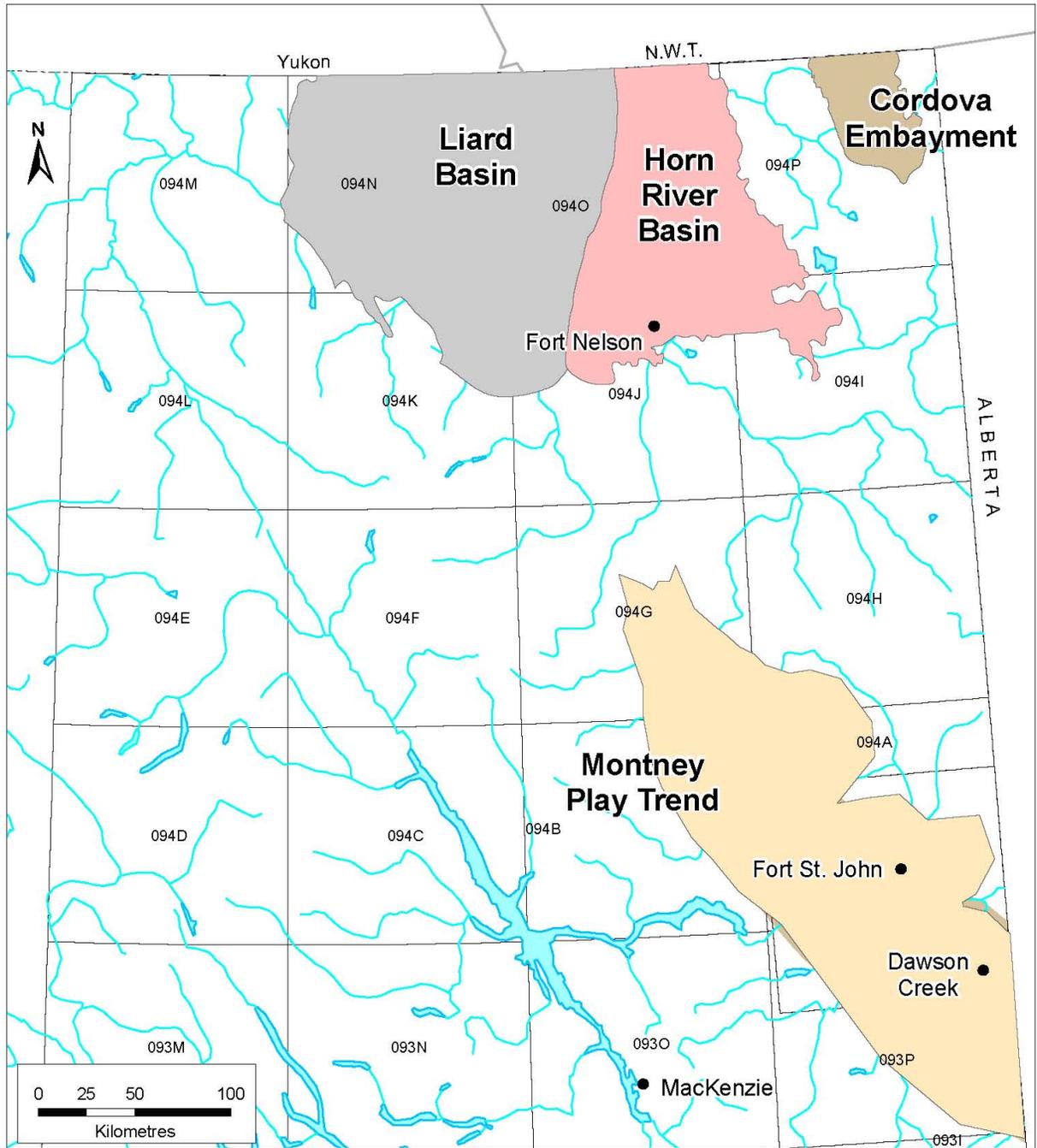
Shale is abundant throughout northeast BC and information in terms of its geology and its vast resource

potential is increasing. A recent energy market assessment by the BC Ministry of Energy and Mines and the National Energy Board (2011) estimated a medium case, ultimate gas-in-place of 448 Tcf in the Horn River Basin and an expected marketable resource estimate of 78 Tcf. The assessment centered on the Upper and Middle Devonian basinal shales of the Evie (Klua), Otter Park, and Muskwa members of the Horn River Formation and accounted for drilling to year-end 2010. In 2006, a petroleum geology open file by the Resource Development and Geoscience Branch of the BC Ministry of Energy, Mines and Petroleum Resources evaluated the regional shale gas potential of the Triassic Doig and Montney Formations of northeast British Columbia (Walsh *et al.*, 2006). That study quantified the potential original gas-in-place via spatial analysis. Triassic shale gas plays include the Doig Phosphate in the Groundbirch area (Middle Triassic) and the Upper Montney (Lower Triassic) in the Swan Lake, Bissette and Dawson Creek areas. The Upper Montney play area is limited by depth, shallowing to the northeast and deepening to the southwest. Walsh *et al.* (2006) provided original gas-in-place estimates of 30 to 200 Tcf for the Upper Montney, 50 to 500 Tcf for the Lower Montney, 40 to 200 Tcf for the Doig Formation and approximately 70 Tcf for the organic rich Doig Phosphate unit. The study noted that original gas-in-place estimates must be taken in context and should not be compared directly with estimates for conventional plays as critical reservoir characteristics remain poorly understood. The Montney is considered by many to be a "hybrid" play (shale/tight gas) so it is included here in this description of shale gas activity. The energy market assessment and the petroleum geology open file are available for downloading or on CD, respectively, from the Geoscience and Strategic Initiatives Branch of the Ministry of Energy and Mines. Also available on CD is the Petroleum Geology Open File entitled *Shale Gas Potential: Core and Cuttings Analysis, Northeast British Columbia* (Walsh *et al.*, 2007) from the Geoscience and Strategic Initiatives Branch.

## DATA SOURCES

Data for this report have been collected from available public sources. No confidential data or information have been utilized in its preparation and all results are based on information available at the time of the review.

For ease of analyses and description, the key shale gas regions in northeast British Columbia are displayed in Figure 1. Shale gas activity within the vast region of the Liard Basin (upper left on map figure) is currently taking place within the central and northern areas of the outline shown. The Horn River Basin, north of the town of Fort Nelson, and the Cordova Embayment to the east are bordered by a Middle Devonian carbonate platform succession. Further south, the Montney play trend now encompasses approximately 2.6 million hectares from the south Peace region near the city of Dawson Creek extending up to the Trutch area in map group 94-G-10.



**Shale Gas Play Areas in British Columbia**

- Montney Play Trend
- Horn River Basin
- Liard Basin
- Cordova Embayment


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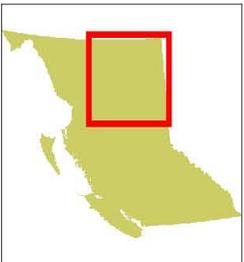


Figure 1. The key shale gas regions of northeast British Columbia

## Horn River Basin

The Horn River Basin covers an area of approximately 1.31 million hectares within the Fort Nelson/Northern Plains region. It lies east of the Kledo-Bovie Lake Fault System and extends east to the Slave Point Platform (Figure 3). Prior to recent shale gas interest, approximately 300 wells had been drilled in the basin mainly targeting carbonate plays of the Mississippian Debolt to Middle Devonian Keg River/Pine Point. Major and intermediate producers approved for special project recognition (experimental scheme approval) over the last few years have been testing potential reservoirs in the Upper Devonian/Lower Mississippian Exshaw shale and the Muskwa/Otter Park members of the Middle Devonian Horn River Basin. They have been extremely successful in unlocking the potential of these organic rich shales, which has now resulted in established production from the area.

## SHALE GAS EXPLORATION ACTIVITY

Bonuses collected from the sale of British Columbia's Crown PNG rights in 2010 totalled \$844 million, down slightly from the previous year. Of that total, \$796 million or 94 per cent was directly attributed to interest in shale gas plays (Figure 2). In 2011, bonuses from PNG rights sales dropped to \$223 million with 90 per cent or \$200.6 million directed toward shale gas interest. The Horn River Basin and the Montney play trend were the only shale gas regions that brought in land sale bonuses over the year.

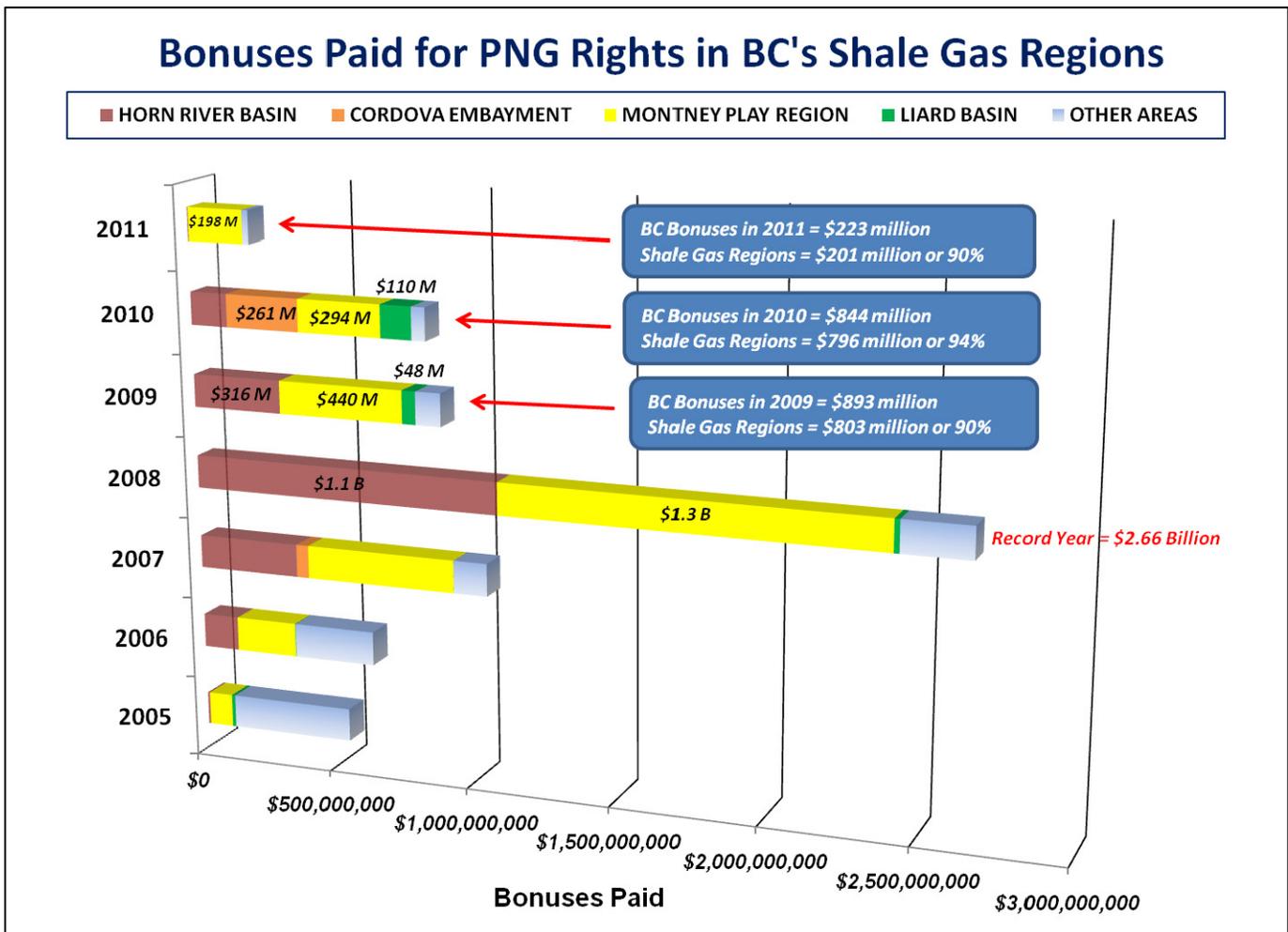


Figure 2. Bonuses collected over the last six years from the sale of British Columbia's Crown petroleum and natural rights in the province's shale gas regions. In 2010, British Columbia saw a total of \$844 million collected in bonuses with 94 per cent amassed from shale gas interest. The Montney play region accounted for almost 89 per cent of the land sale bonus total in 2011.

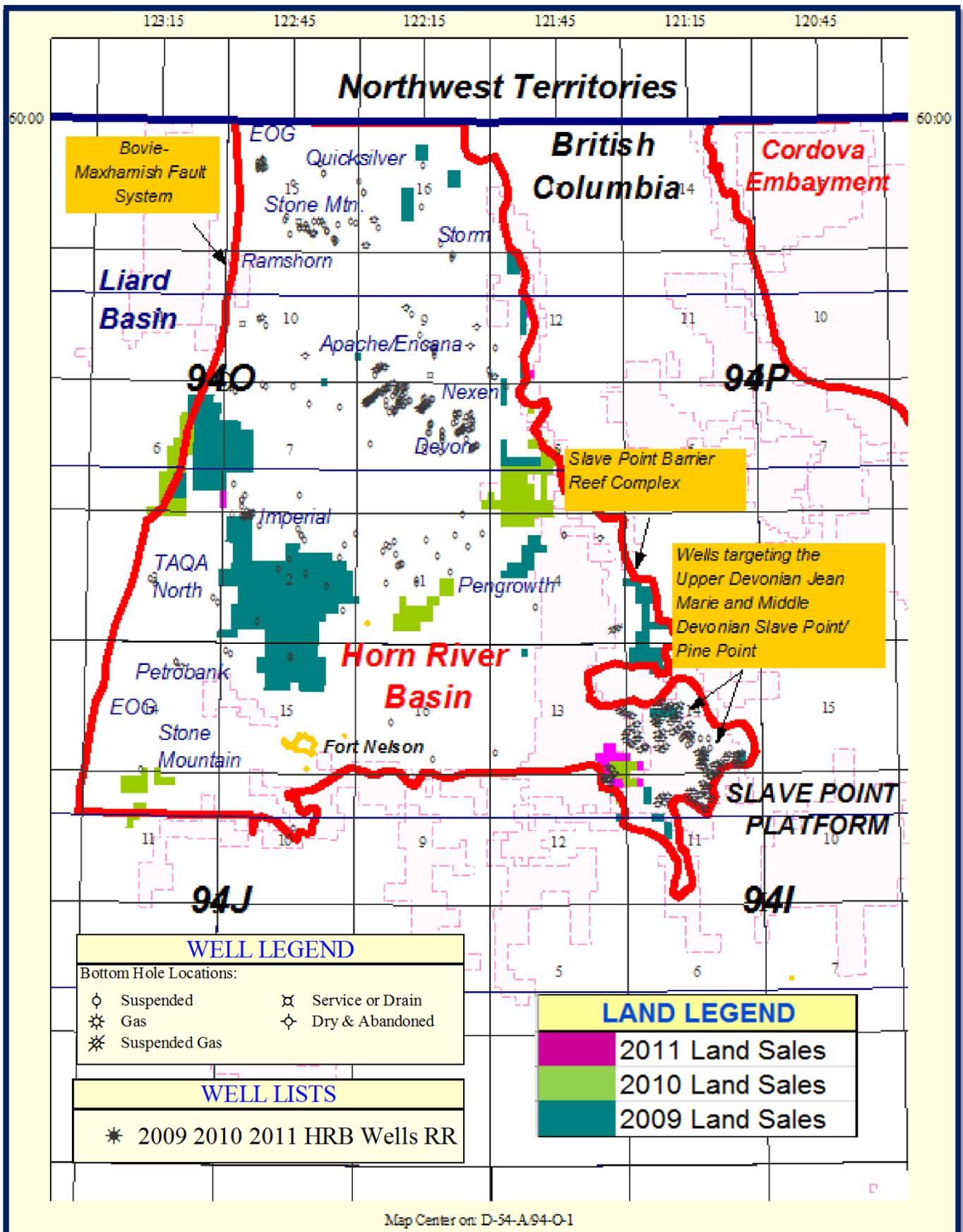


Figure 3. Land sale and drilling activity in the Horn River Basin in 2009, 2010 and 2011.

### Land Sale Activity

Land sale activity in the Horn River Basin levelled off over the last three years after achieving record bonus totals of \$1.1 billion in 2008 (Figure 4). In 2009 and 2010, producers began setting the stage for future drilling programs on purchased lands. Despite the drop in land sales, bonus payments garnered from the sale of Crown petroleum and natural gas (PNG) rights still managed to reach impressive totals of \$316 million and \$131 million, respectively. In 2009, Imperial Oil Resources Limited paid the highest bonus totals among purchasers spending \$119.6 million for nine parcels on 47,375 hectares in the Snake River area (map group 94-O-2). The highest bonus paid for a single parcel in the Horn River Basin from the 12 provincial land auctions held in 2009 was by TAQA North Inc. At the June 2009 rights disposition, TAQA North paid \$62.5 million for a 5,315-hectare drilling licence in the Snake River area; that represents an average price per hectare of \$11,766. In 2010, land sale bonuses in the Horn River Basin totalled \$131 million on 38,619 hectares purchased. At the February 2010 PNG rights disposition, two Snake River area parcels, one tendered by Canadian Coastal Resources Ltd. and the other by Plunkett Resources Limited (both land brokers), garnered \$11.3 million with each parcel generating an average price per hectare of \$3,525. Later in the year, the August PNG rights disposition saw another two parcels bring in an impressive \$65 million for an average price of \$7,217 per hectare. These parcels were located in the Kiwigana area on the western side of the basin and were purchased by land broker Standard Land Company Inc. The most significant land purchase in 2011 came at the end of the year when a 529-hectare drilling licence in the Kiwigana area was purchased by Meridian Land Services (90) Ltd. for \$2.53 million, representing 87 per cent of the \$2.9 million in land sale bonuses for 2011.

### Industry Activity

The most active shale gas operator in the Horn River Basin since 2003 has been **Apache Canada Ltd.** (Figure 5). Apache's activity in the Horn River Basin is primarily in the Two Island Lake area (**Etsho** and **Ootla** areas) where it estimates a net marketable gas potential of 10 Tcf (Apache Canada Ltd., 2011). The producer reports that its Horn River Project continues to be a key component in elevating its worldwide and regional exploration focus. A full-scale development plan is underway and, in late April 2010, Apache announced it had finished hydraulic fracture operations on its first 16-well pad in the Horn River Basin (Apache Canada Ltd., 2011). All 16 wells were slated to be on production in the summer of 2010. Other activity in 2010 included the completion of two more pads with another 42 wells coming on production. Apache's Horn River production reached a peak of 100 million cubic feet (mmcf) of gas per day (net to Apache's working interest) in 2010. In 2011, Apache performed completion operations on 27 wells in the basin, most of which were drilled in 2010. Peak working interest production in the third quarter of 2011 reached 122 mmcf per day. Apache was ranked the 15th largest natural gas producer in British Columbia in 2010 with production of 19.7 billion cubic feet (Bcf). Apache Canada has the option to market its natural gas via the proposed \$4.5 billion Kitimat liquefied natural gas (LNG) export terminal where it operates through **KM LNG Operating General Partnership** and holds a 40-per cent interest.

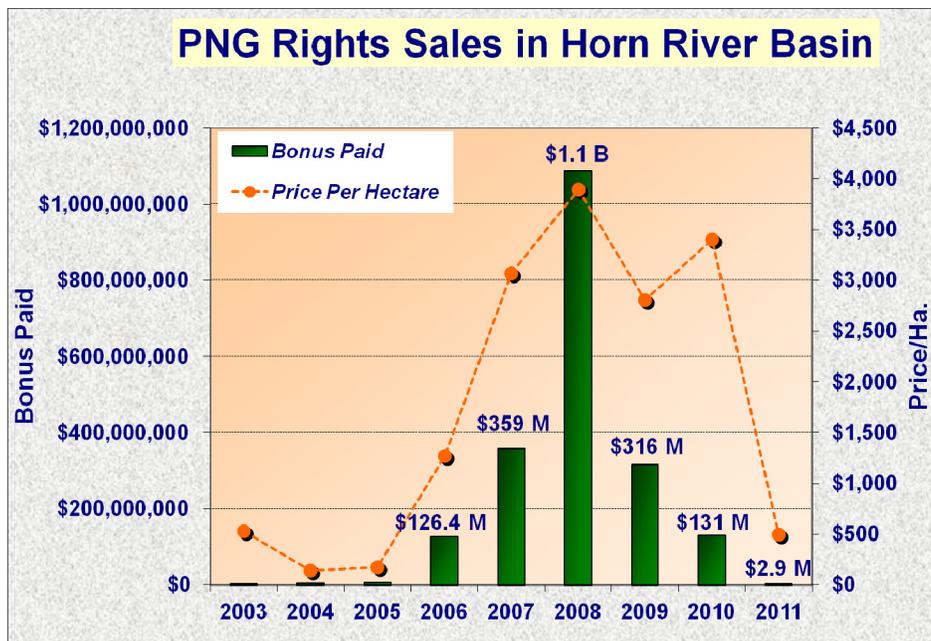


Figure 4. Bonuses from PNG rights sold in the Horn River Basin over the last decade rose considerably in 2006 with record bonus totals of \$1.1 billion achieved in 2008. Bonus totals have moderated since but remained significant in 2009 to 2010.

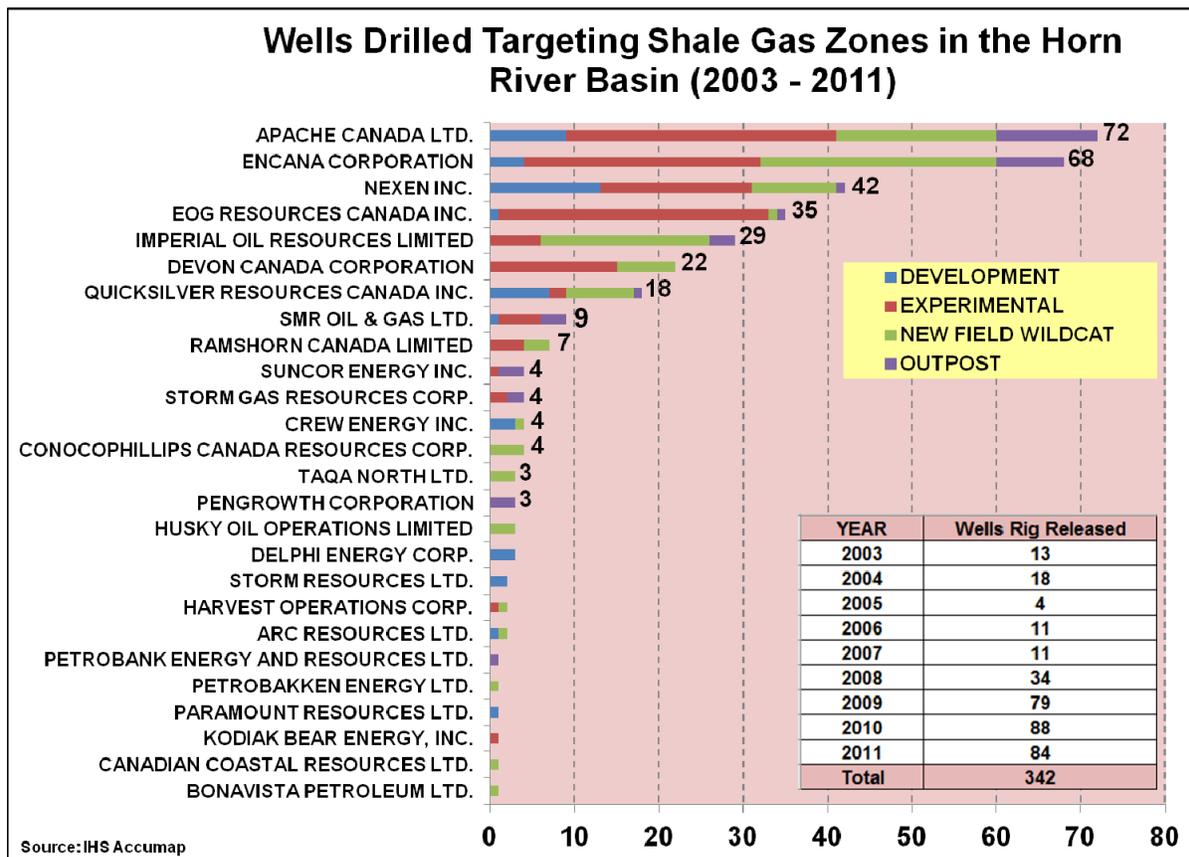


Figure 5. Since 2003, operators in the Horn River Basin have drilled 342 shale gas-directed wells under various Lahee classifications. Many of these operators are major land purchasers in the core area of the basin.

**Encana Corporation** holds over 100,000 net hectares in Horn River Basin and is listed as operator for at least 68 shale gas-directed wells since 2003. Encana has been working with its equity partner Apache Canada Ltd. and has led the way with longer reach laterals (horizontally-drilled section of a well) and the highest number of multiple fracture stimulations per well in the Horn River Basin. With the evolution of its resource play hub design in 2010, a central pad can now access up to six sections of reservoir with horizontal legs reaching three kilometres. To handle the large water requirements for hydraulic fracturing operations in the Horn River, Encana and Apache have designed and built the Debolt water treatment facility (Figure 6). The facility, which has been operating since the summer of 2010, uses the Mississippian Debolt Formation as a water source reservoir. Encana and Apache say the treatment facility has substantially reduced the use of surface water used in fracturing operations and expect the new plant will supply over 80 per cent of its water needs for operations on the **Two Island Lake** property (map groups 94-O-8, 94-O-9). Encana's average production from the Horn River Basin is forecast to reach approximately 95 mmcf equivalent per day in 2011 with 70 wells on line (Encana Corporation, 2011). Encana expected to drill fewer wells in 2011 in the Two Island Lake area; activities were to focus on completion operations. In the **Kiwigana** area, Encana announced, on July 2011, an extended farm-out agreement with **Korea Gas Corporation** to invest \$185 million in approximately 8,100 hectares (20,000 acres). Drilling of

the first well pad in the area has finished and first natural gas production from Kiwigana is expected in the spring of 2012 following completions work this coming winter.



Figure 6. The Debolt water treatment facility taps the Mississippian Debolt Formation as a water source to ultimately support hydraulic fracturing operations. The Debolt is a deep, sub-surface, non-potable aquifer containing saline, sour water. This water source required many innovations including the investigation of several sweetening methods needed to remove the hydrogen sulphide and make the water usable.

**EOG Resources Inc.** stated it will slow down its pace of activity in the Horn River Basin and will allow production to grow incrementally while it works on securing long-term transportation and processing agreements for its gas from the area. EOG completed 11

wells from its 2009/2010 Horn River winter drilling program; flow results from three wells completed in the Evie member (Middle Devonian Horn River Formation) showed initial production rates in the range of 16 to 22 mmcf per day. The producer has closely monitored production performance from its wells drilled from 2008 to 2010 and has noted that performance to date has met or exceeded its expectations. EOG was the first company to nominate and purchase large tracts of land in the Horn River Basin (**Maxhamish, Tattoo**) at relatively low costs in 2004 and 2005. The producer now holds approximately 63,740 net hectares of land in the basin and will obligate only the minimum drilling capital required to hold leases in 2012.

**Nexen Inc.** holds approximately 36,000 hectares of 100-per cent working interest in the **Dilly Creek** area of the Horn River Basin. The producer has secured tenure for 10 more years on the majority of its Dilly Creek lands and has stated it could contain as much as six Tcf of recoverable contingent resources (assuming a 20-per cent recovery factor). In 2009, the producer utilized significant improvements in equipment; the result was longer-reaching wells with additional reservoir length and a higher number of fracs per well. In early 2010, Nexen drilled eight wells in the **Etsho** and **Komie** areas; fracture stimulation and test work was performed and these wells are now on stream. A nine-well pad in these same areas was fracture stimulated and completed in the third quarter of 2011. With the completion of this pad, it is expected Nexen will ramp up production to more than 50 mmcf per day in the Horn River Basin. Drilling is also underway on an 18-well pad with production volumes expected in late 2012. Nexen could be producing as much as 200 mmcf per day out of the Horn River by early 2013. In November 2011, the producer announced it had made agreement to create a strategic partnership with **INPEX CORPORATION**, a consortium led by Japanese oil and natural gas producers, to develop shale gas in the Horn River Basin, Cordova Embayment and Liard Basin (Nexen Inc., 2011). The agreement is significant in terms of Nexen's shale gas strategy in northeast BC as it provides substantial upstream expertise and offers a joint effort in studying the feasibility of potential downstream projects and the export of liquefied natural gas (LNG).

**Devon Canada Corp.** continues to drill and complete vertical and horizontal wells in the **Komie, Petitot River** and **Tattoo** areas of the Horn River Basin. Capital spending in these areas will be down almost 40 per cent in 2011 after spending of \$165 million in 2010. Drilling in 2010 consisted of seven horizontal wells being drilled and four horizontal wells completed and brought online. Devon conducted minimal drilling in the Horn River Basin in 2011 in order to hold its acreage. The producer holds over 70,000 net hectares with the potential to produce up to 700 mmcf per day with a net risked resource of 10 Tcf equivalent from about 1,600 locations (Devon Canada Corporation, 2011). Devon holds an interest of 27 per cent in the 71-per cent **Enbridge Inc.** owned Cabin Gas Plant, which is now under construction and will process natural gas from areas within the Horn River Basin. Devon has participated in the Province's Infrastructure Royalty Credit Program with four projects approved as of September 2011.

**Storm Resources Ltd.** along with its 22-per cent equity ownership position with **Storm Gas Resource**

**Corp.** (now **ExploreCo**) continues to expand its land inventory on eastern edge of the Horn River Basin. **Storm Gas Resource Corp.**, a private company set up specifically to pursue unconventional gas, is focusing on a 19-section core project in the **Gote** area where the gross shale thickness for the Middle Devonian Muskwa/Otter Park averages about 92 metres. As many as 43 horizontal wells could ultimately be developed in this project area where the estimated gross discovered petroleum initially in place is between 2.8 to 3.4 Tcf (Storm Resources Ltd., 2011). Only two vertical wells were completed in the core project area in 2009; testing and coring results from those two wells have shown similar results compared to other operators working nearby. Storm's first horizontal well in the area (a-11-A/94-O-9) was drilled in October 2010 to 1,800 metres (laterally) into the Muskwa/Otter Park. The well was completed with a 12-stage fracture stimulation in December 2010 and was on production in March of 2011. The drilling of a second horizontal well is now complete.

**ExxonMobil Canada Energy** and **Imperial Oil Resources Limited** are 50/50 partners in the Horn River Basin and have been encouraged by their results on the 130,000 hectares leased in the basin. Imperial drilled 10 exploration wells and participated in 3-D seismic acquisition during the 2009-2010 winter drilling season. The work has resulted in multiple productive reservoir intervals with average test rates in the range of 500 thousand cubic feet (mcf) to 1.5 mmcf per day from a single stage fracture stimulation over a 30-day test period (Nickle's Daily Oil Bulletin, 2011). Recoveries of up to 800 mmcf per fracture stage have also been modelled. Although Imperial recognizes uncertainty around the distribution and quality of these productive reservoir intervals, it went ahead with a horizontal multi-well pad pilot development project in the **Komie** area (map group 94-O-1) in early 2011 to evaluate longer-term well productivity.

**Quicksilver Resources Inc.** continued with its horizontal well program in the **Fortune** area of the Horn River Basin where 12 horizontal wells were drilled in 2011 (Nickle's Daily Oil Bulletin, 2012). Four wells have now been completed in the area with the latest one completed at c-29-D/94-O-16. It tested a 1,400-metre lateral section of the Devonian-aged Muskwa shale and has been the most productive well to date averaging over 10 mmcf per day since it began production in October of 2010. Quicksilver also announced that it saw significant mobile oil saturation from sidewall cores results taken from its shale gas wells in the Horn River Basin. Plans are underway to drill a horizontal leg from an existing vertical gas well that encountered oil potential at approximately 1,325 metres in what's called the "Exshaw/Bakken" zone. Quicksilver, a Texas-based oil and gas producer, owns 100-per cent interest on approximately 52,600 hectares in the Horn River Basin. It is planning to convert virtually all of its 20 exploratory licences to 10-year development leases in 2012. The producer is also looking for an upstream partner for its Horn River Basin property after recently completing a midstream partnership arrangement with **Kohlberg Kravis Roberts & Co. L.P. (KKR)**.

In 2009, **TAQA North Inc.**, a subsidiary of the Abu Dhabi National Energy Company PJSC (TAQA), acquired two large blocks in the **Snake River** area of the Horn River Basin for \$63 million. Three test wells were drilled in the winter of 2009/2010; sample study data from these wells were expected over the course of 2010. TAQA budgeted \$39 million in total capital spending for Horn River in 2010 and plans are under way to build an all-weather road and pipeline in the area. Two horizontal wells will be drilled to further evaluate shale characteristics in the Snake River area.

Plans for processing and transportation are well underway in the Horn River Basin. The first phase of the 400-mmcf per day **Cabin** gas plant should be on stream by September 2012, with further expansion of up to 800 mmcf per day slated for the third quarter of 2014 (Nickle's Daily Oil Bulletin, 2011). In October 2011, **Enbridge Inc.** reached an agreement with **Encana Corporation** to acquire a 57.6-per cent interest in the plant, which is located 60 kilometres northeast of Fort Nelson and approximately 6.7 kilometres from the proposed Fort Nelson North processing facility. Enbridge acquired another 13.3 per cent interest in November, bringing its total ownership in Cabin gas plant development to 71 per cent and marking its first venture into the Canadian midstream market.

### Production

The OGC reports in the *2010 Hydrocarbon and By-Product Reserves in British Columbia* that the gas trend daily rate from the Horn River Basin reached 392 mmcf per day from 98 producing wells at year-end 2010. The region had cumulative gas production of approximately 74 Bcf. Many wells in the Horn River Basin remain on confidential status according to terms of special project/experimental scheme approvals (BC Oil and Gas Commission, 2011).

### Liard Basin

Straddling the borders of the Northwest and Yukon Territories with the Province of British Columbia, the Liard Basin and Fold Belt region remains a relatively unexplored area situated on the eastern margin of the Cordilleran Fold and Thrust Belt (Adams *et al.*, 2009). In northeast British Columbia, the region covers an area of approximately 1.25 million hectares and contains over five kilometres of sedimentary strata of Cambrian to Upper Cretaceous age. Potential hydrocarbon objectives occur in the Devonian Dunedin/Nahanni Formation, the Mississippian Banff, Debolt, and Mattson formations, the Permo-Pennsylvanian Kindle and Fantasque formations, the Triassic Toad Formation, and the Cretaceous Chinkeh and Scatter formations. The Nahanni holds significant potential in dolomitized reservoirs in the structural belt. The Debolt, Mattson, Kindle, Fantasque, and possibly the Triassic Grayling and Toad formations are potential objectives in structural closures on the Bovie Lake structure on the margin of the basin. The Banff and Debolt formations are also potential objectives in stratigraphic traps on the platform to the east (Walsh *et al.*, 2005).

### Land Sale Activity

Interest continues to develop in and around the Patry area located in the central region of the Liard Basin, approximately 110 kilometres northwest of the city of Fort Nelson. The area is a potentially high-impact shale gas play that may have prospects comparable to the adjacent Horn River Basin. In 2009, the most significant land sale in the Liard Basin occurred at the July 15<sup>th</sup> Crown reserve PNG rights disposition where land brokers purchased seven drilling licences for \$31.3 million on 46,258 hectares. The purchased parcels were located just north of the Patry area at map groups 94-O-12 and 94-O-13. At the June 23, 2010 PNG rights disposition, fourteen licences were purchased to the northwest and southwest of the Patry area totalling an impressive \$110.4 million on 66,645 hectares (Figure 7). Well activity in the area indicates that Apache Canada Ltd. drilled two experimental vertical wells in 2010, one of which was released in late December at d-34-K/94-O-5. The d-34-K well lists the Upper Devonian Fort Simpson as the projected formation. There were no PNG rights sales in the Liard Basin in 2011.

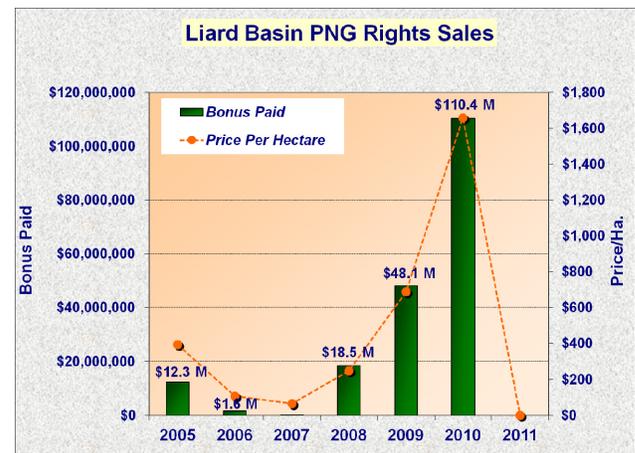


Figure 7. Bonus totals in 2010 reached \$110 million at the June 23 Crown petroleum and natural gas rights sale. Fourteen licenses covering 66,645 hectares were sold in the La Jolie/Beaver River areas (map groups 94-N-9, 94-N-16) and to the southwest of the Patry area (map groups 94-O-5, 94-N-8).

### Industry Activity

The **Beaver River** area lies west of the Kledo-Bovie Lake Fault and is located near the border of the Yukon Territory and British Columbia. This relatively unexplored area, 160 kilometres northwest of Fort Nelson, has captured the interest of producers looking to evaluate shale gas prospects in the extensive Devonian-Mississippian Besa River and basal Pennsylvanian Golata/Mattson intervals. Some encouraging results have emerged from testing completed to date. **Questerre Energy Corporation** and **Transeuro Energy Corp.** have been conducting joint operations in the Beaver River field to evaluate these shales as a potential resource play. As of June 2011, Transeuro Energy owned a 100-per cent interest in the field. The Beaver River natural gas field on surface is expressed as an anticline approximately 16 kilometres long and four kilometres wide. It has a series of shale formations over an approximate total thickness of 3,000 metres, which are thought to contain producible gas columns. The potential for a significant enhanced shale

gas play in the shallow sections of the Beaver River field was identified in three distinct horizons: the Mattson/Golata interval from approximately 1200 to 2,100 metres, the Besa River shale from 2,000 to 3,000 metres, and the Muskwa shales from 3,000 to 4,000 metres. Re-entry and perforating operations were conducted in three old wells named A-2, A-6 and B-2 (Figure 8). Wells A-2 and A-6 were re-completed in the Mattson and hydraulically fractured to stimulate production. Well A-2 has been on production since March 2006 with gas rates increasing gradually from 1.6 to 4.2 mmcf per day. Well A-6 produced successfully at around 0.5 mmcf per day prior to fracturing, but has had some water production issues. Operations on well B-2 were suspended and the wellbore was retained for a future deep sidetrack into the Middle Devonian Nahanni Formation.

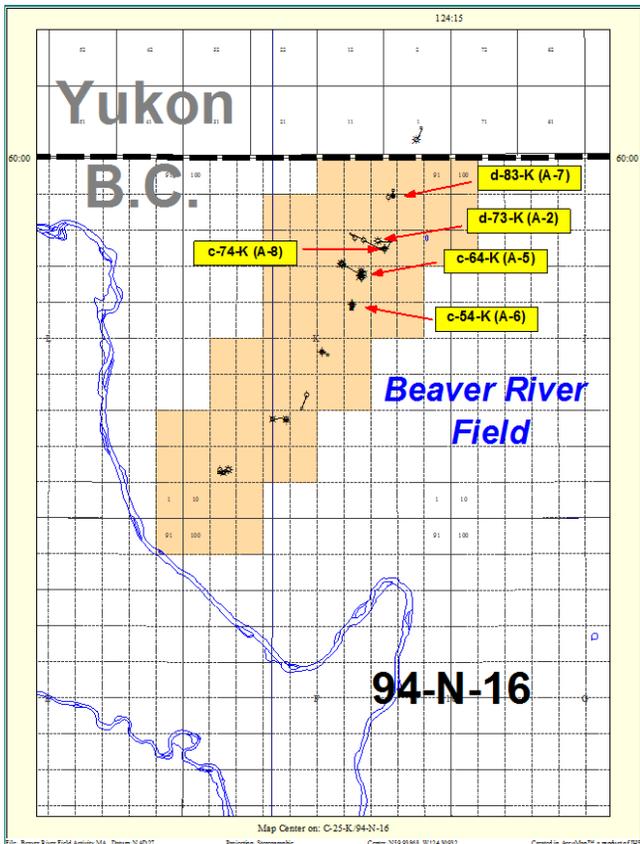


Figure 8. Questerre Energy Corporation and Transeuro Energy Corp. have been conducting joint operations at Beaver River to evaluate Mississippian-aged shales of the Mattson/Besa River as a potential resource play. Shallow shows in the Mississippian Mattson in the Beaver River area are likely due to the presence of a significant shale gas reservoir.

Questerre and Transeuro continued with their development program in 2008. In the summer of that year, compression was added to the A-2 well with good initial results (production increased to more than 4.0 mmcf per day). In November 2008, another well called A-5 was tied into a local gathering system. The tested interval was a brittle layer, rich in dolomite at the top of a thick sequence of organic rich shale. The appraisal strategy for this well was to target the more brittle rock intervals that contain higher carbonate and silica content, which is expected to respond favourably to stimulation. The brittle rocks contain free gas and may serve as a pathway for the shale gas to enter the well. The A-5 well has been producing at a rate of three mmcf per day with periodic interruptions

due to operating issues (Traneuro Energy Corp., 2011). As the well produces, Transeuro hopes to see clear evidence of the surrounding shales contributing gas into the carbonate sequence and that the well rates and pressures stabilize. Another well called A-7 was the first shallow well at Beaver River and was drilled in the north section of the field to target the same intervals producing successfully in the A-2 well. Following drilling and mechanical problems, A-7 failed to reach the target and was completed and fractured in the Mattson. The well is currently on production. Both wells A-2 and A-7 have experienced relatively low decline rates.

The next phase in shale appraisal for the Beaver River area is a review of the fracturing technology completed to date and installing compression to reduce wellhead pressures and increase production from the A-2 and A-7 wells. The appraisal will also target up to 14 horizons in six wells across the field to assess the commercial potential of all three horizons (Mattson, Besa River and Muskwa).

### Cordova Embayment

The Cordova Embayment covers an area of 379,000 hectares and sits approximately 150 kilometres northeast of Fort Nelson in far northeastern corner of the province. The area lies east of the well-established Devonian Jean Marie gas production and deeper exploration targets such as the Slave Point and Pine Point (Keg River) carbonates. Over 320 wells have been drilled in the basin since the early 1960s; most of those in the Helmet, Helmet North and Midwinter West areas. Since 2008, approximately 20 of those wells have targeted shale gas.

### Land Sale Activity

The Cordova Embayment saw a sizable increase in the level of land sale activity in 2010 with bonuses reaching a high of \$261 million. These were the highest bonus totals since 2007 when PNG rights sold totalled \$43.7 million (Figure 9). To date, most parcels purchased in the Cordova Embayment have been by land brokers, clearly an indicator of the increasing competitiveness of the region and the growing interest in shale gas play assessment.

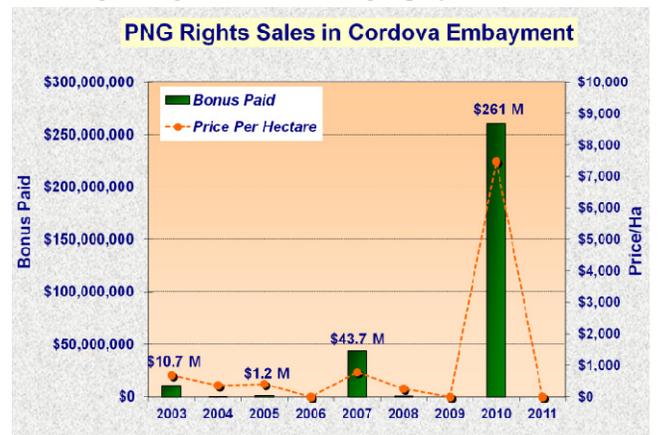


Figure 9. Bonuses from PNG rights sales in the Cordova Embayment.

## **Industry Activity**

Because of geological similarity with the Horn River Basin, the Cordova Embayment is a logical place to conduct exploration for shale gas plays. The presence of free gas in natural fractures was evident in a well drilled in 1976 by Chevron Standard Ltd. in the **North Helmet** area. A core description from a Devonian shale section noted that the entire core had "bleeding gas from hairline fracture planes." With increasing depth of coverage in the Cordova Embayment, appropriate testing and completion strategies can be determined and the evaluation of the relative success of recompletion vs. new drills can be determined.

Since 2008, **Penn West Exploration Ltd.** has been evaluating the Devonian shale sequence in the **Helmet North** area of the Cordova Embayment. The producer acquired over 70,000 hectares in the region and has continued to direct more capital towards development. Its 2011 drilling program remained on schedule with 24 appraisal wells drilled by the end of the year (14 of those were rig released by the end of August 2011). Completion operations are underway on an eight-well pad with initial production testing to be conducted in early 2012. Penn West has stated that existing gathering and processing infrastructure in the Cordova Embayment and the surrounding area enables the joint venture project to move at a quicker pace with enhanced economic returns. In August 2010, **Mitsubishi Corporation** of Japan announced a joint venture with Penn West to assist in the development of its Cordova Embayment assets. A new Canadian subsidiary called **Cordova Gas Resources Ltd.** was created, which owns 50 per cent of Penn West's Cordova Project. The goal of the Cordova Joint Venture is to increase production from assets in the region to 500 mmcf per day. Also, in May of 2011, a group of Japanese utilities agreed also to acquire a stake in Penn West's Cordova Embayment project through shares of Mitsubishi Corporation. **Chubu Electric Power, Tokyo Gas** and **Osaka Gas** agreed to acquire a 7.5-per cent stake in Cordova Resources Ltd. The Japanese participation aims to diversify the Japanese utilities' import sources with intentions to discuss importing Canadian shale gas as liquefied natural gas in the future.

**Nexen Inc.** remains in the initial planning and exploratory stages of development in the Cordova Embayment. It has acquired over 3,300 hectares in the region with 100-per cent working interest. In May of 2008, Nexen was given its first special project (experimental scheme) approval to explore, evaluate and test the shale gas potential of the Muskwa, Otter Park and

Evie formations in the **Helmet** area of the Cordova Embayment. Since that time, the company has drilled two vertical and two horizontal wells. The intent of Nexen's program in the Cordova Embayment is to progressively gather information and knowledge through a series of drilling, well completion and production testing programs. This will be aided considerably with Nexen's recent agreement with **INPEX CORPORATION** of Japan (as discussed in "Horn River Basin" section of this report).

In August of 2009, **Canadian Natural Resources Ltd.** (CNRL) was given special project approval to explore and evaluate the shale gas potential of the Devonian shale sequence, specifically the Muskwa and Evie formations within the **Helmet** area of the Cordova Embayment. CNRL continues to allocate long-term capital to the experimental stage of its Cordova Embayment project.

## **Production**

To October 2011, five wells have recorded approximately 2.0 Bcf of gas production from shale gas zones (Evie, Muskwa, and Otter Park) in the Cordova Embayment. The producing wells were drilled by CNRL and Penn West Exploration Ltd. Ten wells that were drilled between January 2009 and December 2011 remain on confidential status until at least 2012. Prior to shale gas exploration, the Cordova Embayment had cumulative gas production of approximately 600 Bcf, primarily from the Upper Devonian Jean Marie and the Middle Devonian Slave Point and Keg River in the Helmet North and Midwinter areas.

## **Montney Play Trend**

The Montney play region is now one of the most active natural gas plays in North America. The Triassic Montney is a thick, regionally charged formation of unconventional tight gas and shale gas distributed over an area extending from north central Alberta to the northwest of the city of Fort St. John in northeast British Columbia (*Figure 10*). The fairway covers approximately 2.6 million hectares in the South Peace region of northeast BC and includes major facies of fine-grained shoreface, shelf siltstone to shale, fine-grained sandstone turbidites, and an organic-rich phosphatic shale. Development of the Montney continues to evolve as oil and gas producers push drilling activity further northward in the play region.

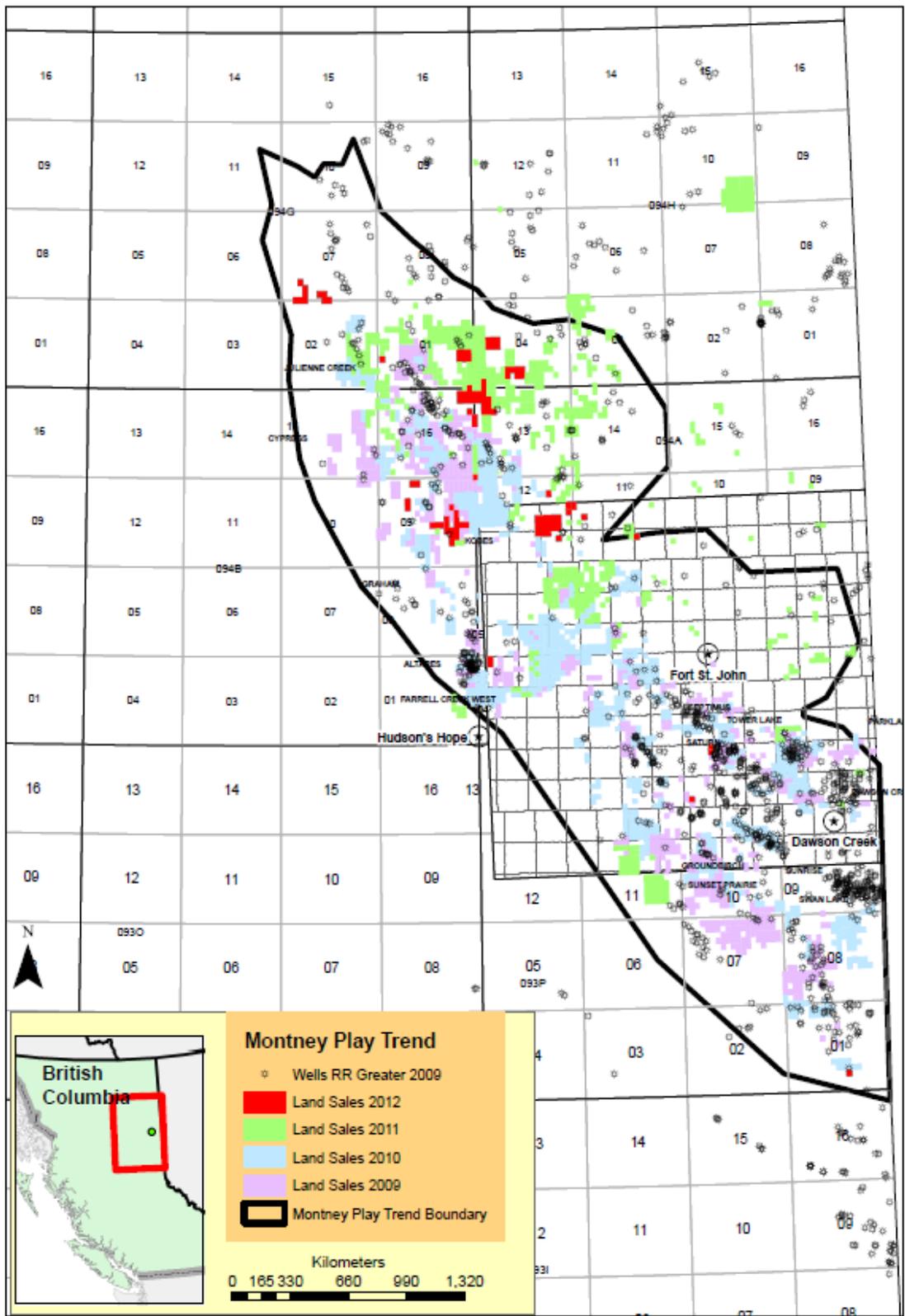


Figure 10. PNG rights sold and wells drilled within Montney play region from 2009 to 2011. The main play area of the Montney trend covers 2.64 million hectares (6.5 million acres) in the Fort St. John/Dawson Creek region.

## Land Sale Activity

Since 2005, the South Peace region of northeast BC has seen record PNG rights sales. The increase in land sales and the higher prices paid for parcels since then can be directly correlated with an industry shift to incorporate unconventional gas reservoirs, which include Triassic-aged targets such as the Upper, Middle and Lower Montney as well as the Doig and Doig Phosphate, particularly within the Montney play region.

Annual bonuses garnered from PNG rights sold within the greater Montney exploration and development fairway rose from \$85 million in 2005 to a record \$1.3 billion in 2008 (Figure 11). In 2009, land sale bonuses reached \$440.3 million from the sale of 87,980 hectares with an average price per hectare of \$5,004. Many high bonus bids throughout 2009 were notable but of particular interest were two drilling licences purchased by Talisman Energy Inc. at the October PNG rights disposition, the sixth largest on record. Both licences were purchased in the Greater Cypress area in the northwest portion of the Montney play trend (map group 94-O-8) where Talisman's focus is the Triassic Doig and Montney. One of the purchases was a 6,288-hectare drilling licence acquired for \$117.3 million (\$18,650 per hectare). In 2010, Montney region land sale bonuses amounted to \$259 million, down 33 per cent from 2009. At the April 2010 auction, 17 drilling licences and four leases, all for Montney rights, accounted for 75 per cent of the \$84.4 million bonus total. Some of the most expensive parcels purchased were 20 kilometres east of Chetwynd in the Groundbirch area. Standard Land Company Inc. paid the highest bonus with a \$24 million payment for a 3,167-hectare licence (\$7,596 per hectare) covering all PNG rights from surface to basement. Drilling records indicate that Shell Canada Limited is the primary operator in this area.

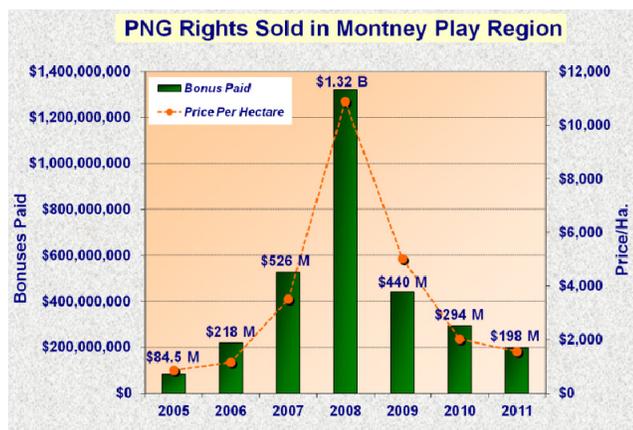


Figure 11. Bonuses from PNG right sales in the Upper Montney play trend since 2005.

## Industry Activity

The Triassic Upper Montney zone continues to offer exceptional growth in production, particularly from such fields as **Monias**, **Dawson Creek**, **Swan Lake** and **Tupper Creek**. The Upper Montney is limited by depth within the Montney play region; it is shallow in the northeast and deepens to the southwest. Technological advances and the application of new horizontal well techniques are a major component to unlocking the potential of the Montney

resource. These techniques are giving producers such as **Progress Energy Resources Corp.** and **Talisman Energy Inc.** the opportunity to target the Upper, Middle and Lower Montney, and Doig in areas of the northern Montney play region, which is bounded by the **Caribou**, **Lily Lake**, **Altaires**, **Town** and **Gundy Creek** fields. This widespread expansion of productive north Montney fairway has been experiencing a surge of interest over the last two years and is located in a relatively undrilled region of northeast BC. In addition to unconventional Montney gas, conventional Debolt gas thrust traps are targeted in this region. Over 400 wells were rig released within the Montney play region in 2011 (Table 2). Almost 85 per cent listed the Triassic Doig and Montney formations as the projected target.

TABLE 2. OPERATORS ACTIVE IN THE MONTNEY REGION IN 2011

Operator	Wells Rig Released
SHELL CANADA LIMITED	64
MURPHY OIL COMPANY LTD.	60
TALISMAN ENERGY INC.	57
ENCANA CORPORATION	43
PROGRESS ENERGY LTD.	39
ARC RESOURCES LTD.	34
CANADIAN NATURAL RESOURCES LIMITED	23
TOURMALINE OIL CORP.	14
CREW ENERGY INC.	13
PAINTED PONY PETROLEUM LTD.	9
CANBRIAM ENERGY INC.	7
HURON ENERGY CORPORATION	7
APACHE CANADA LTD.	7
YOHO RESOURCES INC.	4
CINCH ENERGY CORP.	4
PENGROWTH CORPORATION	4
ARTEK EXPLORATION LTD.	4
CONOCOPHILLIPS CANADA RESOURCES CORP.	3
TERRA ENERGY CORP.	3
SUNCOR ENERGY INC.	3
HYPERION EXPLORATION CORP.	3
STORM RESOURCES LTD.	3
NAL PETROLEUM (ACE) LTD.	3
CHINOOK ENERGY (2010) INC.	2
BONAVISTA PETROLEUM LTD.	2
CROCOTTA ENERGY INC.	2
UGR BLAIR CREEK LTD	1
CCS CORPORATION	1
SECURE ENERGY SERVICES INC.	1
PETROBAKKEN ENERGY LTD.	1
PARAMOUNT RESOURCES LTD.	1
ENERPLUS CORPORATION	1
PAVILION ENERGY CORP.	1
DAYLIGHT ENERGY LTD.	1
NORTHPOINT ENERGY LTD.	1
<b>Total</b>	<b>426</b>

Source: IHS Accumap

**Shell Canada Limited** continues to expand its program in the **Sunset Prairie-Groundbirch** complex of the Montney play region. Production from the complex in early 2011 reached 150 mmcf per day from 225 wells on 40 pads. Wells drilled at Groundbirch are at moderate target depths of 2,200 to 3,000 metres. To date, Shell Canada has drilled less than five per cent of its planned wells for the area; it still considers its Sunset-Groundbirch area a young asset. Shell has holdings of 243,000 hectares of prime Montney gas fairway with a resource estimate of 8.0 Tcf equivalent. Gas production from Groundbirch can now be easily transported to the Alberta market. The Groundbirch Mainline Project, which consists of approximately 77 kilometres of 36-inch pipe and a capacity of 1.66 Bcf per

day, is currently transporting sweet natural gas supply from the Groundbirch area to the TransCanada Alberta System.

**Murphy Oil Corporation** has seen strong Canadian natural gas production growth over the last two years, much of it due to development of Triassic shale gas potential from the Montney turbidites in the **Tupper Creek** area (Tupper West, Tupper Main). Murphy's acreage in the south Montney region now totals approximately 63,000 hectares. Daily production from the Montney play is over 250 mmcf per day. Gas production from Tupper Main reached 100 mmcf per day in 2011 with 84 wells producing. The estimated ultimate recovery (EUR) per well is approximately 3.5 Bcf per well gross (Murphy Oil Corporation, 2012). Production from Murphy's Tupper West project is up to 150 mmcf per day with 59 wells flowing and an EUR per well of 3.3 Bcf (gross). The Tupper West gas processing facility commenced operations in February 2011 and has a capacity of 180 mmcf per day. It is located 20 kilometres west of the city of Dawson Creek.

**ARC Resources Ltd. (ARC)**, which converted to a dividend paying corporation on January 1, 2011, is a dominant producer of Upper Montney shale gas in the **Dawson** and **Parkland** areas as well as in its West Montney lands at **Tower Lake**, **Septimus**, **Sunset**, **Sunrise**, **Sundown** and further north at **Attachie** and **Blueberry** (Figure 12). ARC entered the Montney play region over seven years ago and has since developed significant operational expertise in developing tight, low permeability formations. Its land base in the main Montney fairway, including the **Pouce Coupe** area in Alberta, is up to 434 net sections (one section equals 259 hectares) and is a major growth engine for the company. The use of horizontal drilling technology along with improved completion techniques to exploit its Montney properties continues to reduce costs and enhance economics. The discovered resource potential at ARC's Montney properties is significant at 25.5 Tcf of discovered gas initially in place (DGIIIP) (ARC Resources Ltd., 2011). At year-end 2011, daily production from these assets was 235 mmcf per day and 1,800 barrels per day of liquids. ARC projects that it could sustain rates of up to 800 mmcf per day of natural gas and 17,000 barrels per day of liquids for a period of ten years. ARC's busiest area is the Dawson field where 12 wells were drilled in 2011 with field production increasing to 165 mmcf per day. The first of three 60-mmcf per day gas plants at Dawson came on stream in May of 2010. The second plant started up in April 2011; both are running at full capacity. In the Attachie and Tower Lake areas, ARC proved up discoveries of liquids-rich gas during its 2011 drilling programs. The liquids content in these areas range from 30 to 200 barrels/mmcf. In the Parkland area, where the Upper Montney section is approximately 100 metres thick, ARC drilled its first well in the lower portion of the section and realized a one-month initial production rate of 4.7 mmcf per day.

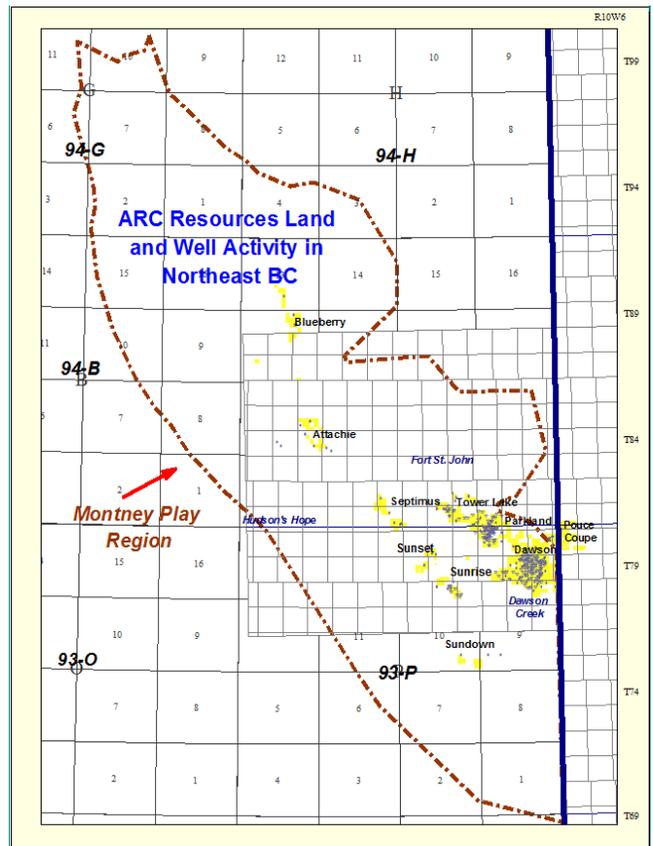


Figure 12. ARC Resources Ltd. has substantially increased production from its Montney land base in northeast BC. From 2003 to 2011, production from region ramped up from 17 mmcf per day to 235 mmcf per day. ARC has recently tested liquids-rich gas and light oil in the Attachie, Septimus and Tower Lake areas.

Development of gas from the sandstone, siltstone and shale sequences of the Triassic Montney continues to exceed expectations for **Encana Corporation**. Its resource play hub design and development procedure, which entails pad drilling with a highly efficient gas factory process, has substantially reduced supply costs in the Montney region over the last five years. Encana's evolution of Montney completions is impressive as it now averages 13 fracture intervals per well at an average cost of \$320,000 per interval (Figure 13). EnCana holds over 280,000 net hectares of Montney rights in its **Cutbank Ridge** resource play, where it produces over 400 mmcf per day equivalent (Encana Corporation, 2011). This includes production from the Montney, Cadomin and Doig formations. Most of Encana's Montney-directed wells, which numbered 57 in both 2009 and 2010, were in the **Swan Lake** and **Sunrise** areas of the **Regional Heritage** field. Encana plans to focus more capital into areas of liquids content within existing Montney developments (Encana Corporation, 2011). Encana recently announced the sale of 40 per cent of its undeveloped Cutbank Ridge assets to **Mitsubishi Corporation** for \$2.9 billion.

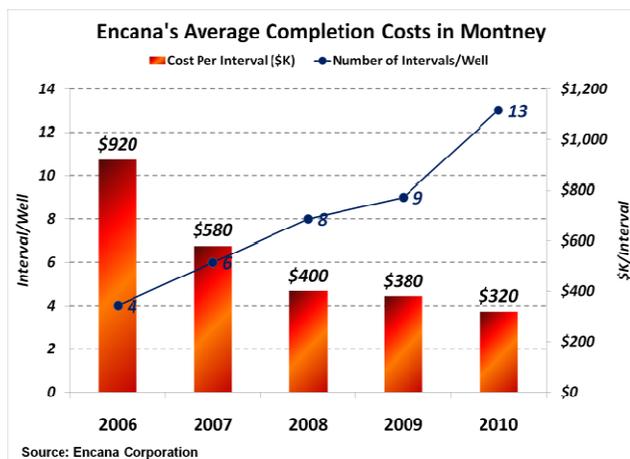


Figure 13. Encana has significantly reduced the cost of its production volumes in the Montney region with increased fracked intervals per well at a lower cost per interval.

In 2010, **Progress Energy Resources Corp.** acquired the Foothills assets of Suncor Energy Inc., which included additional deep rights in the Montney formation. The acquisition gave Progress Energy the largest land holdings in the Montney fairway with a total acreage of 333,866 hectares (1,289 sections). Progress' capital program continues to be weighted towards its Montney North fairway activities with a further investment of \$345 million slated for the 2012 (Progress Energy Resources Corp., 2011). The goal is to expand the areal extent of productive Montney fairway in the Foothills to the north with vertical delineation wells and re-completions. Progress Energy was one of the first movers in the North Montney region and has now identified a potential drilling inventory of 2,500 to 7,500 locations, encompassing both the Upper and Lower Montney targets of the Lower Triassic. The producer has full scale commercial developments in the **Caribou, Town South, Town North, Gundy Creek, Kobes and Altares** areas (all located in the Montney north region). Progress now uses development pods in its drilling process; each pod lays out 80 drilling locations in a concentrated area with a centralized facility capable of processing 50 mmcf per day. The Town South area is Progress' most developed pod to date with 21 wells drilled since the first quarter of 2009. Progress drilled seven wells in 2010; all were brought on stream in the third and fourth quarters of 2010. In the Town North area, pod development saw three horizontal wells drilled and completed in the first quarter of 2011 with initial production rates averaging 4.1 mmcf per day. Progress currently produces approximately 70 mmcf per day from its pod developments in the Montney play region. In early August 2011, Progress closed a \$1.07 billion transaction with the Malaysian national oil and gas company, **PETRONAS**, which created a 50/50 joint venture to develop Progress' northeast BC properties of **Altares, Lily Lake and Kahta**.

**Terra Energy Inc.** is looking to develop its Montney assets to its full potential in 2012. The natural gas-weighted company is seeking new capital for the region through either a joint venture arrangement or a private equity source. Although most of Terra's \$29 million investment on exploration and development in 2011 was to be spent outside its main Montney lands on operations directed towards liquids-rich projects, it still ranks the Montney trend as one of the top shale gas plays in North

America in terms of its technical advantages, resource size and economics. Terra recently stated that its Montney lands in the **Monias** area (Twp 82-21W6) are highly prospective with higher porosity and reservoir pressures, with liquids yields at approximately 20 barrels per mmcf. Terra's Montney holdings (mostly in the Monias and **Tower Lake** areas) indicate a total resource estimate of 5.5 Tcf of discovered petroleum initially in place (DPIIP) and 6.4 Tcf of undiscovered resources. In 2010, Terra drilled seven (net) Montney tests to hold its 190 net sections of land within the fairway.

**Talisman Energy Inc.** continues to assemble a considerable land position in the Montney fairway. It now holds approximately 85,000 net hectares along the fairway with contingent resources of 33 Tcf equivalent and 6,300 net well locations in the **Farrell Creek, Greater Cypress and Groundbirch** areas (Talisman Energy Inc., 2011). Talisman is targeting the Upper and Lower Montney and Doig in the Farrell Creek area. Plans were to drill 25 wells at Farrell Creek in 2011 and bring 15 of those on stream. Estimated ultimate recoveries are now 7.0 Bcf per Montney well with initial production rates of 4.5 mmcf equivalent per day. Production averaged 56 mmcf per day (gross) from the area in the first quarter of 2011, doubling that of the same quarter in 2010. Talisman recently brought its expanded Farrell Creek facility online, which takes its capacity in the area to 120 mmcf per day. The Cypress area has also been active for Talisman. Its continuing pilot program has seen some encouraging results from the same three zones as Farrell Creek (Upper and Lower Montney, Doig). Nine wells were brought onstream at Cypress in 2010 and three more were slated to be brought on stream in early 2011. Also in early 2011, Talisman sold a 50-per cent net working interest in its Cypress A Montney assets to South Africa's Sasol Limited. The \$1.05 billion deal encompasses a plan to develop stranded gas in northeast BC by converting Talisman's significant Montney gas resource into liquids using Sasol's expertise in gas-to-liquids conversion. A similar deal with Sasol was closed in late 2010 with Talisman's Farrell Creek assets.

**Canadian Spirit Resources Inc.** (CSRI) continues to evaluate the productive capability of its Montney program with partner Canbriam Energy Inc. CSRI's 2011 capital budget was principally directed toward development of its Montney program in the **Farrell Creek** area. Its joint venture land holdings are approximately 41 net sections with an estimated total of 5.02 Tcf of gross natural gas initially-in-place (raw) on its Montney evaluated lands (Canadian Spirit Resources Inc., 2011). The first known horizontal well drilled into the Lower Montney in the Farrell Creek area was successfully tested in July of 2010 at 3.5 mmcf per day (c-A48-I/94-B-1). Flow test results from another Lower Montney well at b-17-I/94-B-1 were similar, while a third well at c-B18-I/94-B-1 was placed on production in October 2011 with a flow rate of approximately five mmcf per day. Five Montney wells are now tied into the 10-mmcf per day Farrell Creek gas plant facility. Activity for the remainder of 2011 included two Upper Montney wells, which were to be fracture stimulated and tied in during the third quarter of 2011. In addition, a vertical Montney well in CSRI's eastern Farrell Creek lands was slated to be fracture stimulated in the fourth quarter of 2011. The well will be fracture stimulated in several Montney intervals and is intended to evaluate the potential for natural gas liquids. Other producers operating

in the area of Farrell Creek are reporting a liquids content ratio of 30 barrels per mmcf from the Montney Formation.

**Canadian Natural Resources Ltd.** (CNRL) continues to look at tight gas/shale gas reservoirs in the Montney trend. The company holds approximately 262,000 net hectares along Montney fairway and one of its main project areas is the **Septimus** field, where it targets the Upper Montney. CNRL estimates a contingent resource of 1.3 Tcf equivalent (best case estimate) in its Septimus Montney development project with 0.3 Tcf equivalent of proved plus probable reserves (Canadian Natural Resources Ltd., 2011). In 2010, the producer drilled 15 wells in the liquids-rich area of Septimus. In the second half of 2011, another eight horizontal wells were drilled to keep its Septimus plant full through 2012. CNRL's 2012 program involves the expansion of the Septimus plant to 130 mmcf per day by the first quarter of 2013. Another 20 horizontal wells will be drilled in 2012 to fill the expanded plant. CNRL produces approximately 60 mmcf per day and 1,800 barrels of natural gas liquids at Septimus. It's looking to increase liquid recoveries in the area from 30 barrels per mmcf to 50 barrels per mmcf. Initial expectations for reserves in Montney fairway are for about 4.0 Bcf per well, which would result in production of about 200 mmcf per day of gas and 10,800 barrels per day of liquids.

**Tourmaline Oil Corp.** is pursuing the Triassic Montney in the **Groundbirch**, **Sunrise** and **Dawson** areas where it alleges the Montney is the thickest, most over-pressured, and charged with liquids-rich sweet gas (Tourmaline Oil Corp., 2011). In the Dawson-Sunrise area, Tourmaline drilled through spring breakup in 2011. The result was an additional nine new Montney horizontal wells, bringing the total number of horizontals in the area to 31 over the period of 2010 and the first half of 2011. This Montney play area has three distinct over-pressured Montney horizons to exploit and all are exhibiting high deliverability horizontal gas wells with a reasonably strong liquids content of 35 to 50 barrels per mmcf. The two initial wells drilled on the Sunrise 1-12 pad during the second quarter of 2011 (1-12-80-18W6 and A1-12-80-18W6) tested at stable rates of 11 mmcf a day and 12 mmcf a day of sweet gas, respectively, with 35 barrels per mmcf of condensate and gas over a seven-day test period. Tourmaline expects to drill an additional 12 to 15 horizontal wells this year in the Dawson-Sunrise complex. The company also expects to have the Sunrise gas facility expansion completed by the end of 2011 from the current 35-mmcf per day capacity to 75 mmcf per day.

**Pengrowth Energy Corporation** has significant exposure in the **Groundbirch** area of the Montney play region after completing a business combination with **Monterey Exploration Ltd.** in September of 2010. Pengrowth's land position in its Montney Groundbirch project consists of 19 net sections with a 90-per cent working interest. A total of 15 Montney wells have now been completed at Groundbirch with production volumes of approximately 18 mmcf per day. The Doig zone has also been tested at economic rates; a vertical Doig well tested at 750 mcf per day in 2011. A horizontal well targeting the Doig is planned for early 2012.

**Painted Pony Petroleum Ltd.** continues to delineate and develop its Montney natural gas assets. The company's Montney rights now total 34,479 hectares (133 net sections) and it remains one of the most active producers in the northwest section of the Montney play trend. Painted Pony is targeting Montney intervals in the **Blair Creek/Town** areas (map group 94-B-16) and to the south in the **Cameron/Kobes** areas (map group 94-B-09). Multiple wells have been drilled in each of these areas into three productive Montney intervals (Upper, Lower and Middle). Over the second half of 2011, Painted Pony completed drilling on six wells (gross) in its Blair-Cameron project area. Well test results have recorded initial flow rates of five to 10 mmcf per day from the Upper Montney and seven to eight mmcf per day from the Lower Montney. In fact, one the company's 50-per cent operated horizontal wells at d-44-C/94-B-16 in the **Daiber** area tested at a stabilized rate of 24.5 mmcf per day at a flowing pressure of 2,700 pounds per square inch (psi). The well is expected to be tied in to production facilities before the end of 2011. In terms of development economics for the Blair-Cameron area, Painted Pony expects 30-day initial production rates to average 4.5 mmcf per day, reserves per well of 5.0 Bcf and liquids ratios ranging between 20 and 40 barrels per mmcf. The producer has negotiated expansion of its Blair Creek gas processing facility from 24 mmcf per day to 70 mmcf per day. The plant expansion, which is funded by a midstream operator, is expected to be completed by the end of June 2012. The company is also building a new production facility at its d-44-C/94-B-16 pad, which will deliver production from the north Cameron area directly to the Spectra Energy Transmission sales system (Painted Pony Petroleum Ltd., 2011).

**Crew Energy Inc.** controls 184 net sections of undeveloped lands in northeast BC that are prospective for Montney gas. The producer continues to focus its efforts in the liquids-rich area of **Septimus**, where it has experienced exceptional results with wells testing at initial rates as high as 15 mmcf per day. Located approximately 50 kilometres southeast of the city of Fort St. John, the Montney Formation at Septimus is approximately 300 metres thick with gas saturated rock and is accessed through long-reach horizontal wells with up to five multi-stage, water-based fracture treatments. The area holds significant potential for Crew with 2.7 Tcf of DPIIP and only 13 of 56 sections with assigned reserves (Crew Energy Inc., 2012). Crew's 2010 drilling program at Septimus increased reserves per well to 2.9 Bcf, which represents a seven-per cent increase from 2009. Reserves currently assigned in this area represent an estimated 14 per cent recovery factor. To accommodate an 81-per cent growth in production over a one-year period, Crew proceeded with the expansion of the Septimus area's gas processing facility by doubling its capacity to 50 mmcf per day. Crew is the operator of the **Aux Sable Canada Inc.**-owned facility and has retained the option to re-purchase a 50-per cent interest in the facility on or before Jan. 1, 2014. Crew also holds 23 contiguous net sections in the **Kobes** area, a multiple pay zone field within the Montney play region. Two horizontal wells have been drilled and completed on Crew's 23 net sections. One is producing at 1.7 mmcf per day with liquids production of 85 barrels per mmcf, while the other is producing at 6.0 mmcf per day with a liquids cut of 60 barrels per mmcf. Crew believes it may ultimately require 8 to 12 wells per section to

sufficiently deplete the resource. In the Portage area (near the town of Hudson's Hope), Crew Energy drilled and completed two Montney exploration wells where initial testing yielded rates of up to 4.4 mmcf per day. The Portage area offers a large resource, which offsets some of the major Montney development areas.

**Production**

Improvement in horizontal drilling and completion techniques has resulted in significant production from areas within the Montney play region. The application of these techniques and the added value of liquids-rich gas production have been key to

unlocking the economic potential of the region. Gas production from the Montney formation within the play tend has increased considerably since 2001 with the average calendar daily rate reaching 1.38 Bcf per day from 885 producing wells at the end of October 2011 (Figure 14). The play region has seen cumulative gas production of approximately 912 Bcf. The OGC reports that an overall reserves evaluation will be conducted for the 2011 Hydrocarbon and By-Product Reserves in British Columbia (BC Oil and Gas Commission, 2011).

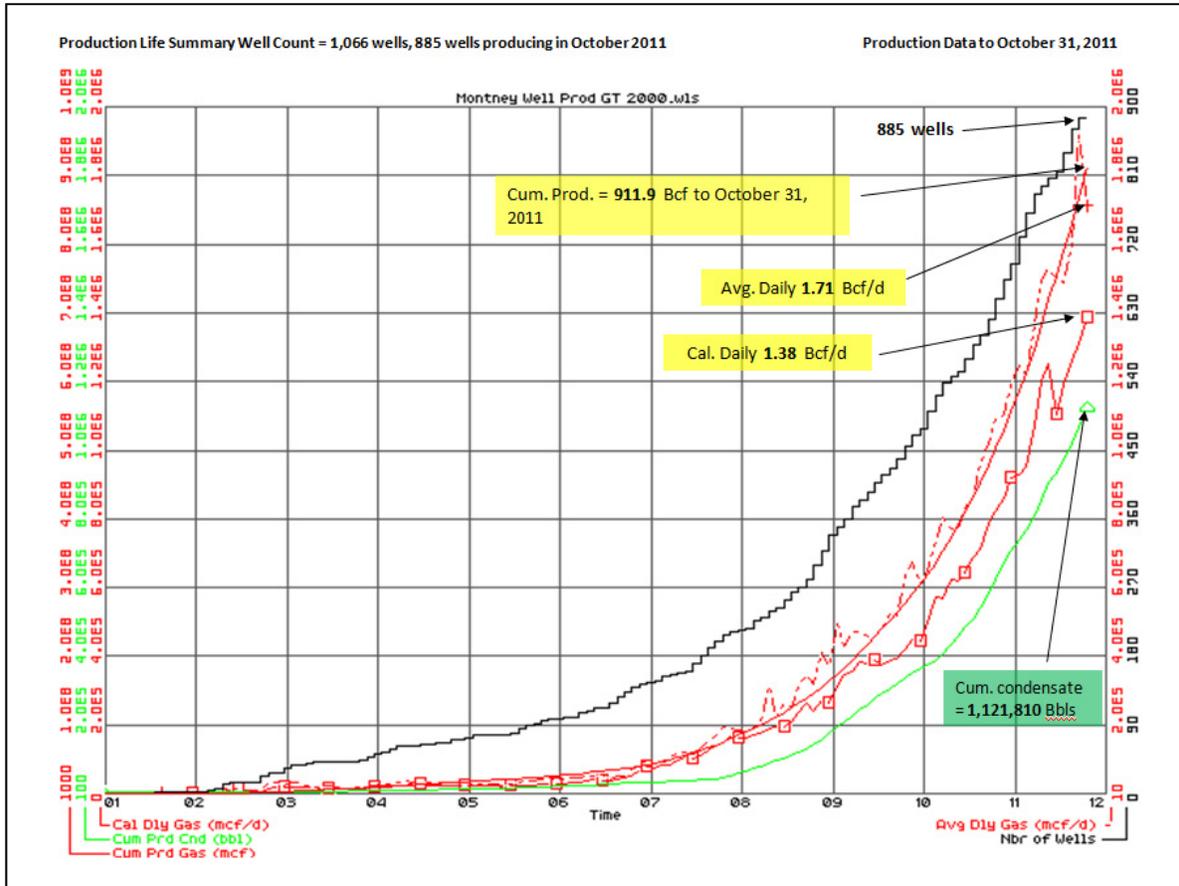


Figure 14. Approximately 912 Bcf of natural gas has been produced from the Lower Triassic Montney Formation from 2001 to October 2011. The average daily calendar rate in October 2011 was 1.38 Bcf per day from 885 producing wells. Cumulative condensate production to October 31, 2011 was 1,121,810 barrels.

**Cretaceous Shale Gas Activity** (Fort St. John and Northern Foothills Regions)

Shale gas activity directed towards Cretaceous horizons in northeast British Columbia continues to be assessed in several areas of the Fort St. John and Northern Foothills resource regions. Lower Cretaceous sequences are the exploration focus in the Beg/Jedney areas and further south in the Blair Creek and Farrell Creek areas. Each of these areas has unique characteristics in terms of shale gas potential. Companies currently operating in these areas are evaluating fracture stimulation programs and continue to optimize completion methods that could

result in increased well productivity. In northeast British Columbia, the Buckingham Formation is about 1,000 metres thick and extends in a north-westerly direction in a broad, low lying belt along the eastern edge of the Foothills between the Halfway and Muskwa rivers (Glass, 1997).

**Industry Activity**

**Painted Pony Petroleum Ltd.** continued with its Lower Cretaceous Buckingham shale gas operations in 2011. The company has amassed 33,387 hectares (129 sections) of prospective Buckingham rights in the Blair

**Creek** area. Its 2011 well program consisted of drilling two wells in the area along with the recompletion and testing of another three wells in the Buckingham Formation (Painted Pony Petroleum Ltd., 2011). A hydraulic fracturing program is planned for the first half of 2012. Painted Pony has been experimenting with drilling and completion techniques throughout over the last two years and feels that there is a thick section that's suitable for vertical development of 16 to 32 wells per section. The company also believes the Buckingham shale may have potential further north in the **Julienne Creek** area and to the south in the **Cameron** area.

In May of 2009, **Unconventional Gas Resources** (UGR) was granted special project approval by the OGC for two experimental schemes in the **Town** area within the Montney play trend. The purpose of the schemes was to test the commercial viability of shale gas potential in the Fort St. John Group. One of UGR's wells in the **Blair Creek** area (b-87-G/94-B-16) began production from the Lower Cretaceous Shafstbury in December of 2008 with an initial average daily rate of 283 mcf per day. In October of 2011, the well was producing at an average rate of 83 mcf per day and cumulative production reached 19.7 mmcf. UGR's net resource in place for the Buckingham shale is 25 Tcf equivalent (Unconventional Gas Resources, 2011).

## OUTLOOK

Despite an unfavourable natural gas price regime and lower level of land sale activity in 2011, the shale gas industry in British Columbia continues to provide the province with a distinct competitive advantage as an oil and gas jurisdiction. Natural gas producers looking to unlock the vast potential of unconventional gas resources in northeast British Columbia are clearly meeting the technical challenges inherent with this type of play development. Innovative oil and gas royalty programs, such as the Infrastructure Royalty Credit Program, continue to have a noteworthy impact on shale gas activities. This unique Program greatly enhances British Columbia's ability to compete for new areas of oil and gas investment and positions the province well for the opportunity of exporting liquefied natural gas (LNG).

Continued industry announcements of higher resource and recovery estimates from British Columbia's shale gas regions have spread the message to all industry participants and observers that tangible results are being achieved and that conversion of shale gas resources into reserves and actual production is practicable, as notably evidenced along the Montney play trend and in sections of the Horn River Basin. The oil and gas industry in British Columbia has seen unparalleled growth and investment over the last decade with industry spending on exploration and development activity almost tripling from \$1.8 billion in 2000 to \$7.1 billion in 2010. The trend towards unconventional resource play development continues to climb and results from these types of discoveries will contribute to the bulk of BC's natural gas reserves additions going forward.

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For more information, please contact:  
Ministry of Energy and Mines  
Oil and Gas Division  
Geoscience and Strategic Initiatives Branch