MUSKWA-KECHIKA MANAGEMENT AREA HELIPORTABLE DRILLING FEASIBILITY STUDY

TECHNICAL REPORT

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BC Ministry of Sustainable
Resource Management,
Muskwa-Kechika
Advisory Board
and the
BC Oil and Gas Commission

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EXECUTIVE SUMMARY

The technical feasibility of heliportable drilling depends in part on the availability of depth rated heliportable drilling rigs and the ability of helicopters to deliver a level of critical support necessary for mobilizing, drilling and completing a deep sour gas well. At least 4 heliportable rigs are available in western Canada and are reported to have capability to drill to 3,400 m depth. Heliportable rigs with capability to drill sour wells to in excess of 5,000 m are working in other parts of the world and can be mobilized via heavy transport aircraft if rapid delivery is required (assuming they are free to be released). Obtaining the services of these larger rigs would require longer pre-planning for mobilization. While re-configuring a conventional rig to be heliportable is technically feasible, and perhaps half the cost of constructing a new heliportable rig, the drilling contractors approached during this study believed the construction of a purpose-built heliportable rig was the more appropriate engineering solution.

A range of heavy-lift helicopters capable of mobilizing all components of heliportable rigs and providing adequate support during potential heliportable operations are available in western Canada. Carefully planning helicopter use is required to maximize the efficiency of rig moves in order to adequately control the overall cost, time and safety of a heliportable drilling operation.

Assessing the ability of a heliportable drilling program in the MK to provide adequate emergency medical response capability and well control capability has been viewed as a fundamental determinant to the technical feasibility of heliportable drilling. While it is technically feasible to provide 24-hour helicopter support to a heliportable drill site, barring some short hourly-duration, extreme weather conditions, it is apparent that numerous remote work sites exist in BC which do not have guaranteed 24-hour emergency access for long-distance medical evacuation and at the same time comply with requirements of the Workers' Compensation Board of BC (WCB). The WCB has expressly stated that it would not prohibit heliportable drilling or require guaranteed 24-hour emergency access, provided normal requirements for remote work site medical facilities are met. Providing 24-hour emergency site access via helicopter would require a range of specific installations, equipment, planning and permitting. A key factor in the occurrence of accidents on drilling programs is the level of worker experience, the quality of supervision and worker attitude. Significant reduction in the likelihood of worker injury on a heliportable drilling program can be achieved by ensuring high levels of experience and training for all rig personnel.

At present the probability of an uncontrolled blow-out during drilling appears to be in the range of 0.3 to 0.6 blow-outs/1,000 wells. The cause of most blow-outs during exploration drilling programs is human error. The potential to significantly reduce the risk of a blow-out on a heliportable drilling program could be achieved by requiring use of only highly trained and experienced crews and ensuring the well site has been stocked with adequate drilling supplies. In order to minimize the environmental risk associated with a blow-out at a heliportable well site, the site needs to be planned in consideration of blow-out response and management. In addition, risk could further be reduced by maintaining a reserve of at least three or more pieces

of heavy equipment on site (*e.g.,* one bulldozer, one crane and one back hoe). A protocol and arrangement for access to other heavy equipment and transport capability at least during more critical phases of the drilling program should also be in place.

During a blow-out where there is a perceived risk to human life, drilling crews are typically evacuated on foot outside of the immediate hazard zone via pre-determined routes. For a conventional road accessed well, the access road is not relied on as the primary emergency escape route but is instead among the alternatives depending on conditions at the time of the blow-out. With provision of adequately planned emergency escape routes (*e.g.,* via foot or hand-cleared ATV routes), temporary accommodations and an air trailer or trailers (for sour gas wells) an equivalent level of worker and equipment protection, as occurs at road accessed sites, can be achieved at a heliportable sour well.

In the event of a significant uncontrolled sour gas release where there is a perceived hazard to workers the rig is typically ignited after a short period in order to eliminate the sour gas hazard and facilitate well control operations. In properly managed situations the hazard associated with a sour gas blow-out at a heliportable drill site would be of short duration (*e.g.,* minutes) and the availability of long distance road access of no clear necessity. In rare cases where large volumes of sour water are being produced rig ignition may be delayed until such time as liquid streams can be diverted to a separator and gas ignition achieved. More prolonged use of emergency air equipment may be required in these circumstances in the immediate vicinity of the well site.

The science and techniques used for blow-out control has advanced significantly in recent years such that more immediate well control or partial control (where the flow can be directed) can be achieved more rapidly by capping the existing well bore than by drilling a relief well. Controlling most blow-outs can be achieved within a period of days, or in some cases weeks. Once the flow is stopped by capping, a second rig can be deployed in a less urgent fashion. All of the equipment used for well capping can be maintained on a heliportable site or quickly flown in for this purpose. In rare cases where the drill casing cannot be reached by excavation, a relief rig may still be required. Where a relief rig is deemed necessary for control of a blow-out, conventionally accessed drilling sites are at an advantage since the pool of available relief rigs is in theory much larger and these can be delivered onsite and assembled in a more timely fashion. For a heliportable drill site, providing relief well capability would require prior arrangement for a heliportable rig and paying standby charges or relying on assumed availability. Services of heavy-lift helicopter for a contingency relief drilling rig move are generally available on short notice. An alternate scenario involves construction of a conventional access road for relief well mobilization and incurring the associated environmental impacts.

A second major concern during a blow-out concerns the release of liquids. Release volumes of salt water and other liquids can at times be large. Conventional road accessed well sites afford the opportunity to rapidly mobilize heavy equipment and transport large volumes of liquids. This ability is not practically achievable on a heliportable well site but could be managed by contingency planning, proper site selection, ensuring proper site drainage, as well as having a reserve of heavy equipment on site or readily available for transport and assembly.

It is recommended that if heliportable drilling is ultimately promoted in the MK a set of best practices should be developed which would focus on the needs for overall heliportable planning and coordination, training requirements, supervision, environmental protection, blow-out prevention and response. The influence of underbalanced drilling on blow-out risk should be further evaluated. The potential applicability of emerging technology such as “casing drilling” to significantly extend the depth range and possible safety of heliportable rigs should also be further monitored and explored. These undertakings should be collaboratively pursued through the Canadian Petroleum Safety Council or equivalent provincial body.

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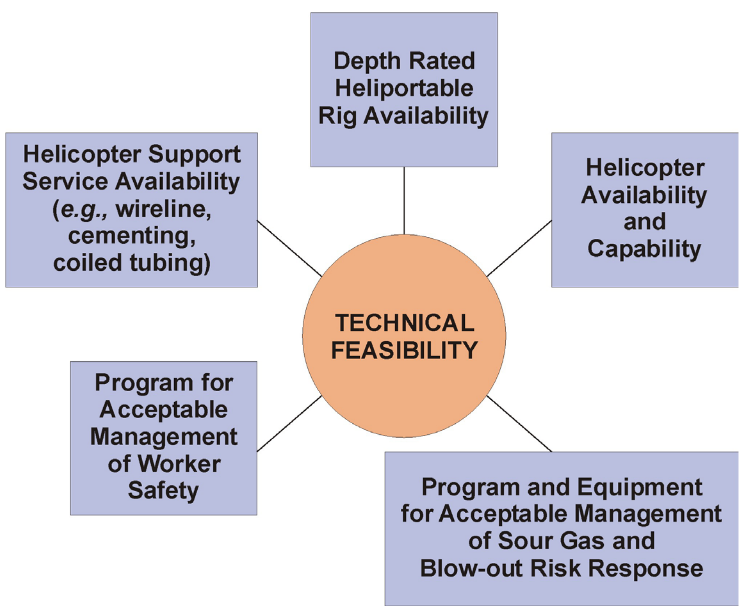
1.0 INTRODUCTION

The technical feasibility of an exploratory heliportable drilling operation is dependent on whether or not the transportation needs associated with lease construction, rig mobilization and drilling can be met using helicopters as the primary means of site access. Important technical considerations for heliportable drilling in the Muskwa-Kechika Management Area (herein referred to as the MK) include the following (see Figure 1):

- the availability of heliportable rigs and support equipment suitable for the geological conditions encountered in the MK;
- the availability of helicopters which can lift the anticipated range of loads under the conditions that may be anticipated during a typical drilling program in the MK;
- the ability of helicopters to provide adequate support during the drilling and completions process;
- the ability to effectively avoid and manage emergency medical response; and
- the ability to effectively avoid and manage blow-outs.

Each of these considerations is discussed in the sections that follow. Discussion is also provided concerning the technical feasibility and considerations associated with helicopter-based production, operations and abandonment.

Figure 1 Technical Factors Influencing Heliportable Drilling



2.0 DRILLING RIG REQUIREMENTS AND AVAILABILITY

The size of a drilling rig required for deep gas drilling within the MK in part, depends on the drilling target. As discussed in Section 2.2 of the Environmental Report, there are three potential geological formations of interest within the MK. These are the Mississippian, Triassic and Devonian. The deeper Devonian drilling targets (Pine Point) typically range in depth from approximately 2,500 m to 5,000 m (Ziebell pers. comm.). The deeper the target, the larger the required drilling rig to handle the weight of the drill string and to meet the mud circulation requirements. The larger components in turn, have the potential to limit the rig availability for deeper wells. In Murphy Oil Company's analysis of rig requirements for its initial Chicken Creek well in the southern MK it was determined that, after consideration of the disturbed, fractured and steeply dipping nature of the formations as well as anticipated high pressures of any gas present, that a rig rated for 3,500 m was required to provide adequate pumping and hoisting requirements to drill a well with a measured depth of 2,760 m (Murphy 1996). For the Imperial Oil Limited (IOL) well near Belcourt Creek (also subject to a heliportable drilling feasibility study) it was determined that a minimum 3,000 m depth rated rig would be required (IOL 1995).

2.1 Heliportable Drilling Rigs

What have been typically referred to as heliportable rigs are drilling rigs that can be broken down into relatively small weight packages that can be transported by heavy-lift helicopters. Heavier single component weights of conventional rigs such as draw-works, mud pumps, mud tanks and generator sets can weigh between 31,750 and 40,825 kg (70,000 and 90,000 lb). At the present time, the maximum rig package size that can be transported by readily accessed heavy-lift helicopters is about 11,000 kg (24,000 lb). Available heliportable rigs have been specifically designed with component weights below this weight limit. At the time of this review, there are four heliportable rigs in western Canada with the remainder operating in South America and the South Pacific region (see Appendix A). Western Canada rig availability for moderate drilling depths (*e.g.,* 3,400 m) appears to be greater than for deeper drilling.

Companies which maintain heliportable rigs include Drillers Technology Corp. (four heliportable rigs), Parker Drilling (15 heliportable rigs) and Helmerich and Payne Drilling (three heliportable rigs) (see Appendix A). The location of these rigs varies depending on rig demand in both North America and abroad. Many of the international rigs have maximum depth ratings in excess of 5,500 m. Maximum depth ratings of heliportable rigs available in western Canada is about 3,400 m.

The advent of "Casing Drilling", where the hole is drilled with casing instead of drill pipe has potentially broad significance to the drilling industry (Journal of Petroleum Technology 2001) and significant implications for heliportable drilling feasibility. For example the depth capability of a 3,400 m depth rated heliportable rig could potentially be increased from 3,400 m to 4,500 m using casing drilling (Pare. pers. comm.). This technology is very new to the industry but has been claimed to potentially reduce drilling time by as much as 30% and be safer (Oil and Gas

International 2002). At the present time, this technology is reported to be best suited to drilling softer formations with larger casing sizes (Journal of Petroleum Technology 2001).

Slim hole heliportable rigs (3 3/8" inch final hole size) are apparently available with 3,000 m depth capability and are many times smaller than rigs designed for conventional sized well bores (Hunley pers. comm.). These rigs have a number of constraints and may or may not be practical for heliportable drilling in the MK.

2.2 Conventional Rigs

Conventional drilling rigs are typically broken down into the fewest loads that can be moved by truck transport on local roads. The weights and loads associated with conventional drilling rigs are largely dependent on the drilling depth required such that deeper wells require larger components. Individual rig packages have been, in part, designed with the fewest components possible that can be moved by available heavy haul truck transport. As discussed above, the weights involved far exceed the lift capacity of heavy-lift helicopters (maximum 10,885 kg or 24,000 lb).

During the course of consultations undertaken for this study, it was suggested that in theory, any conventional drilling rig can be broken down into smaller package sizes such that they can be made to be heliportable. To the extent this is true, then rig availability becomes a non-issue from a technical perspective. During discussions with the larger North American drilling contractors (Parker Drilling and Precision Drilling) it was acknowledged that while conventional rigs could be broken down, this would be relatively expensive and time consuming. By one estimate, this conversion would take perhaps 4 to 6 months and could cost $5 to $8 million CDN (Crowson pers. comm.). This approach would require taking a conventional rig out of service for the additional time required to modify it and then to re-assemble it following the drilling program, unless it was to remain as a heliportable unit. Custom building a large heliportable rig from the ground up was roughly estimated to cost between $12 million and $30 to $33 million CDN (Pare, Crowson pers. comm.). Drilling contractors believe that modifying a conventional deep capability rig to be heliportable is less desirable than specifically designing a rig to this purpose.

2.2.1 Conclusion

There are currently 4 heliportable rigs with capability to drill sour gas wells to 3,400 m depth available in Canada. A relatively large pool of deeper-rated heliportable rigs are available elsewhere in the world that would allow drilling sour gas wells to in excess of 5,500 m. Contingent on availability, these rigs can be transported from these more remote locations by large cargo aircraft. Mobilization charges for an international rig could range from $1.5 million to about $2.5 million. Drilling deeper wells will require scheduling/reserving a deeper rated rig, undertaking specialized modifications to an existing conventional rig or planning the construction of a completely new heliportable rig. Both of these latter two options would be less time and cost effective than mobilizing a rig from a remote location.

3.0 OTHER SERVICES AND EQUIPMENT

A broad range of technologically advanced, purpose-built heliportable equipment has been developed by the industry in Western Canada to support and service typical wells that may be drilled in the shallower Mississippian and Triassic formations encountered in the MK and which may also be adaptable to deeper plays (Hunley pers. comm.).

3.1 Supervision and Crew Requirements

In the interest of absolutely minimizing the onsite risks at a heliportable well site, it is imperative the drilling contractor has staffed the drilling rig with personal that are fully trained and have been made aware of the sensitivity of the area and anticipated drilling conditions. The supervision and crew requirements should be modeled after offshore standards in this regard. Drilling rig crews should be structured so as to ensure that maximum experience is available at all times. It is with this in mind the following rig crew structure should be considered.

- Rig Foreman: Responsible for the overall operation and maintenance of the rig and all related equipment, whether owned, rented, leased or contracted. He will also be responsible for the handling of drilling crews made up of the following personal for each tower.
- Tower Push: answers directly to the Rig Foreman.
- Driller: responsible for the drilling crew under the direction of the Tower Push.
- Assistant Driller: assists the driller and derrick man.
- Derrick man: responsible for the drilling fluid and related equipment as directed by the driller.
- Motorman: as directed by the driller.
- Rough necks (2): as directed by the driller.
- Lease Hand: general roustabout as directed by the driller.

All crew members should have demonstrated advanced experience in the area of responsibility.

3.2 Drilling Mud, Tubulars and Related Consumables

No technical limitations are associated with the provision of typical well supplies such as drilling mud or drill string components. In a heliportable drilling program, the key element in this regard involves ensuring that both anticipated and backup supplies are stockpiled on site in order to allow management of contingencies and minimization of down time. The diverse range of seasonal operating constraints and site conditions encountered by the oil and gas industry has resulted in the significant advancement in the service industries ability to provide a range of portable equipment and rapid service response to remote locations. The key services required during drilling programs are discussed in the subsections which follow.

3.3 Water and Water Well Rigs

Provision of water for drilling can either be met through pumping from a local surface water source to the well site or drilling a separate water well. In a conventional drilling program, options for hauling from more remote sources are much more feasible than a heliportable option where a heavy-lift helicopter would be required for long-term support. Pumping over particularly long distances becomes more complex at below zero temperatures, though problems associated with freezing could likely be resolved by various means.

Conventional water well drilling rigs weigh in the vicinity of 5,000 kg (11,000 lb) to 24,545 kg (54,000 lb) depending on the size of the rig (Sroka pers. comm.). During discussions with water well drillers, it was apparent that all of these rigs could likely be stripped down for helicopter transport. An air-drill rig as opposed to a water/mud type, may be required depending on the availability of water for water well drilling purposes. A 1-ton truck-mounted water well drilling rig with capability to drill a 30 m (100 ft.) to about 76 m (250 ft.) well could be stripped down to about a 5,000 kg maximum package weight (Sroka pers. comm.). This same rig could be used to establish a conductor hole to at least 12 m (40 ft.) depth. In order to mobilize this equipment, the water well would need to be broken out into 5 or 6 helicopter loads (*e.g.,* rig, drill pipe, compressor, mud pump, air hammer). While somewhat slower, cable tool rigs weighing in the vicinity of 5,454 kg (12,000 lb) and capable of drilling to 91 m (300 ft.) are also available (Wolford pers. com.). Drilling a water well with these rigs could take 2 to 5 days. These same cable tool rigs can also be modified to drill up to 50 cm (20") conductor holes.

3.4 Sumps and Tanks

The use of open tanks for collection of drilled solids will help reduce the risk of ground contamination. These would be used in conjunction with a "high G" shaker and centrifuge system to ensure solids are dry. Fluids would be returned to the active system or a storage tank until ready for re-use. The decision to land farm solids onsite or have them removed to a remote location would be best made on a site specific basis. In the latter case, costs for heli-transport of solids would have to be considered. A number of 400 bbl tanks would be required to store additional fluid and fuel stockpiles. Spare tankage would be used in the event of a lost circulation problem or for well control in the event of an influx of formation water into the well bore.

3.5 Cementing

Heliportable electric or diesel mud pumps with up to 2000 Hhp capacity can also be used for cementing or alternately an independent unit could be used for the re-circulating cement mixing system. These skid-mounted units are available in both Canada and the US. Heliportable fluid pumping units (maximum pumping rate is 0.520 m^3/min, pressure is 10,000 PSI, maximum lift of 3400 lb) specifically designed to be heliportable are available in western Canada and can be transported by a Bell 205 in 4 loads (Hunley pers. comm.).

3.6 Nitrogen Services

Nitrogen pumping services are a critical component of the bundle of services associated with servicing a completed well. It is often used in association with a coil tubing unit. Nitrogen is used during the servicing of wells. When there is gas produced in association with liquids and the threat of combustion exists, nitrogen, as an inert gas, is used to service the well in place of air. Heliportable cryogenic nitrogen pumping units (maximum pumping rate of 85 m^3/min and pressure of 10,000 psi) are available and can be transported by a Bell 205 in three loads (plus tanks) (Hunley pers. comm.).

3.7 Completions and Service Rigs

Well completions are undertaken at such time as a well has proven successful and requires installation of a range of down hole equipment (*e.g.,* tubulars, packers) or perforation below the well head to enable long-term production. Typically a truck-mounted completions rig or service rig is deployed for this purpose. Heliportable drilling operations rely on the primary drill rig for this function. Subsequent well servicing required once the well is tied in would involve bringing in a conventional truck-mounted rig where road access was subsequently developed following the discovery or flying in a heliportable rig if no production road was built.

Heliportable electric line units are available in Western Canada and have been used many times. These units perform logging and perforating services required in well completions, are skid mounted and intended to be helicopter deployed. These units are deployed with a Hughes 500 helicopter (Hunley pers. comm.).

Heliportable derricks are also available, and have been used in oil production operations, for rod pulling to service a producing oil well. There is a significant amount of well testing equipment that is heliportable as well. Specifically designed and off-the-shelf heliportable flow testing equipment including: gas water ratio testing equipment, separators, tanks, surface data acquisition systems, flares etc are available. This equipment has all been used in remote applications, deployed by helicopters. Helicopter deployment is usually with a Robinson 44 or a Bell 206 helicopter.

3.8 Wireline Services

Wireline services can be required to lower mechanical tools (*e.g.,* valves, logging equipment, fishing equipment) into the well bore for various purposes. Single component weights for portable wireline services used in offshore operations can weigh in the vicinity of 8 metric tons (Matheson pers. comm.). Heliportable slickline and electric line units have been designed and are in current use in Alberta and BC. Maximum depth for slickline operations is 2,500 m. These units can be moved with a Robinson 44 or Hughes 500 helicopter, depending on unit size (Hunley pers. comm.). Wireless down hole tools which can be attached to the drill pipe weigh considerably less. In either case, it appears wireline services can be adapted to a heliportable drilling program.

3.9 Coiled Tubing

Coiled tubing is typically inserted into the well bore to convey gas to surface and for pumping methanol down hole where the well has frozen in. In the event road access was not allowed for the purpose of production, there are some implications for the use of continuous coiled tubing on a heliportable well. Continuous or endless coiled tubing is preferred due to the speed at which it can be run, as well as having somewhat greater integrity than jointed tubing. A 2-inch production tubing weighs approximately 4 kg/m. A 3,000 m deep heliportable well would require a 12,000 kg spool of tubing and require perhaps four trips to transport the associated injector, power pack and work spool (Thatcher pers. comm.). Tubing weights go up considerably as diameter increases. For example, two 7/8" tubing weighs 8 kg/m and its use, without welding, would restrict drilling depth to about 1,500 m. Heliportable continuous coiled tubing units capable of >2,000 m depth service are in production (Hunley pers. comm.). For deeper holes, tubing would have to be welded together. While less preferred, this practice is not uncommon.

Shallow (950 m 1" CT) and intermediate (2,400 m 1" CT) depth coil tubing units, specifically designed to be heliportable are available. The shallow units can be transported by a Bell 205 in seven loads including tank and flow line, while the intermediate unit will require a Vertol 107 (Hunley pers. comm.).

3.10 Fracturing

Formation fracturing is typically done as part of completions or work-overs to facilitate flow of gas or oil out of the formation. Conventional fracturing units are truck mounted and weigh in the vicinity of 24,040 kg (53,000 lb). Heliportable skid-mounted fracing units are available from various suppliers. Haliburton Energy Services, for example has diesel powered fracturing pump units up to 2000 Hhp which would could be broken down into 9,091 kg (20,000 lb) packages (Braden pers. comm.).

3.11 Drilling Camp

Modular components of conventional rig camps can range between about 9,000 kg (20,000 lb) for an 11 x 40 ft. accommodation unit to about 15,900kg (35,000 lb) for a kitchen or washroom unit (Clark pers. comm.). While these heavier units exceed helicopter lift capability, they can be further modified to reduce weights to be readily transportable by heavy-lift helicopters and they do not pose a technical constraint on heliportable drilling. Portable gray and black water treatment and/or containment facilities would be required at remote campsites. As an alternate approach to this, the camp could be located at the road accessible staging area. In this latter case, regular helicopter transport would be required for crew changes.

3.12 Conclusion

All normal, supporting well services can be adapted to heliportable service. From a tubing perspective, heliportable wells 3,000 m deep or less which can be adequately served by 2-inch tubing lend themselves to heliportable service slightly better than deep wells or wells requiring larger diameter tubing, since this would avoid having welded sections.

4.0 HEAVY-LIFT HELICOPTER AVAILABILITY AND CAPABILITY

4.1 Availability and Capability of Heavy Lift Helicopters

Helicopters have been used for drilling rig moves on a large number of wells worldwide. For example, Columbia Helicopters of Portland, Oregon has completed over 150 drilling rig moves using helicopters, including four in the United States (Peterson pers. comm.). Within North America, there are a number of heavy lift helicopters that have or could be used for mobilization and servicing of a heliportable drilling rig. A list of heavy and medium lift helicopters are listed in Appendix B. In North America, heavy-lift helicopters are primarily engaged in heliportable logging and other specialized remote heavy-lift requirements.

Early heliportable rigs were initially designed to be flown using relatively small helicopters such as the Super Puma and Boeing Vertol 107. Individual package weights were in the 3,600 kg range (Crowson pers. comm.). Development of larger lift capacity helicopters has increased the efficiency of heliportable rig moves considerably. The primary heavy-lift helicopter for heliportable rig moves is the Boeing Chinook 234 (Plate 1). The Chinook 234 generally works with loads ranging from 8,165 to 10,886 kg (18,000 to 24,000 lb). There are a total of 11 Chinook 234 helicopters in the commercial fleet worldwide. Of these, eight are owned by Columbia Helicopters and five are operating in North America (Peterson pers. comm.). Scheduling for Chinook 234 service would ideally involve approximately two months of lead time, however, where quick response is required, a machine can be onsite within one or two days (Peterson pers. comm.).

Plate 1 Chinook 234 heavy lift helicopter (photo courtesy of Helifor Industries Limited).

Other generally available heavy-lift helicopters include the Sikorsky S-64 Model E and F. Model E has a lift capability of 6,350 to 7,711 kg (14,000 to 17,000 lb) and Model F has a lift capability of 7,257 to 9,525 kg (16,000 to 21,000 lb). The Vertol 107 has a lift capability of 3,175 to 4,082 kg (7,000 to 9,000 lb) (see Appendix B). To maximize efficiency, it has been suggested that it is best to select the primary heavy-lift helicopter on the basis of the majority of loads rather than use an excessively large helicopter which may only be required for relatively few loads (Taylor pers. comm.). During the actual drilling program, the need for heavy-lift helicopters is not required and medium lift helicopters such as the Bell 212 or potentially an A-Star become more practical. These helicopters are usually readily available from helicopter companies operating in Fort St. John and Fort Nelson.

4.2 Conclusion

A range of helicopters with significant lift capacity suitable for heliportable drilling rig moves are available in North America. While these helicopters are available, careful planning would be required to ensure that the necessary machines are available as soon as drilling approval has been obtained and heavy equipment is ready to transport for lease construction.

5.0 HELICOPTER DRILLING SUPPORT SERVICES

Conventional drilling programs rely on vehicle transport to deliver drilling mud, additional drill pipe and drilling tools, haul fresh water and waste water, to ferry crews to and from road accessed staging areas and for emergency evacuation/medical emergencies.

A heliportable drilling program would involve use of helicopters for these same functions. A key aspect of efficiently managing a heliportable drilling operation is ensuring sufficient stockpiles of all essential supplies, fuel and equipment, including that for contingencies are onsite as part of the initial rig mobilization. Once heavy-lift helicopter requirements have been met, practical needs for crew moves, mud, drill pipe (etc.) and other supplies can be met with smaller helicopters. The Bell 212 and Sikorsky S-61 has been identified as good intermediate helicopters for this purpose and could be supplemented with an A-Star or Bell Jet Ranger for backup. Daily fuel consumption for drilling operations can be in the range of 11,356 litres to 18,927 litres (3,000 to 5,000 gallons) per day and as such potentially require multiple trips with a medium lift helicopter or one single lift with a Chinook 234 (Crowson pers. comm.). In discussions with Columbia Helicopters, it appears that most heliportable drill sites are serviced by a single helicopter (Peterson pers. comm.). In addition to ensuring service helicopters are properly equipped to maximize their operating window, adequate stockpiling of equipment, supplies and consumables at the drilling site is required to minimize any problems associated with no-fly conditions caused by weather and/or mechanical problems. Most large commercial helicopter companies have expertise (loadmasters) to manage and organize loads to make the process more efficient.

5.1 Conclusion

Routine drilling support services can be effectively provided by medium-sized helicopters. Considerations in respect of emergency response capabilities are discussed further in Sections 7.0 and 8.0.

6.0 WELL SITE CONSTRUCTION AND RECLAMATION

6.1 Conventional

Well site construction requires the transport of heavy equipment and fuel to the well site. For conventional lease construction, the same equipment used for access construction is also used for lease construction and reclamation and typically includes large bulldozers (*e.g.,* D8's) and track hoes. With this equipment, lease construction can take anywhere from one week to one month or more, depending on difficulties associated with the site. During reclamation, equipment is brought in as required. Somewhat smaller equipment may be used for this purpose. The time required for reclamation is roughly similar to that required for construction, depending on needs for special soil handling or cleanup and restoration.

6.2 Heliportable

Plate 2 Part of disassembled hoe to be transported via helicopter (photo courtesy of W. Sawchuck).

The mainframe components of typical heavy equipment (*e.g.,* D7 and larger bulldozers) used for lease construction substantially exceeds the lift capacity of heavy-lift helicopters. Typical heliportable drilling operations rely on smaller earth moving equipment such as D5 or D6 caterpillar tractors and smaller back hoes (*e.g.,* CAT 229 or equivalent). Transporting a D6 caterpillar tractor via helicopter typically requires removal of the track prior to transport. Use of this smaller equipment can be expected to somewhat lengthen the time for lease construction depending on site conditions. Relatively large conventional hoes (*e.g.,* CAT 330) can also be disassembled into heliportable loads (Plate 2). Heliportable 30 to 40 ton cranes are among the first pieces of equipment transported in order to facilitate the assembly of heavy equipment and the heliportable drilling rig. Lease construction time will be extended to the extent a larger lease is required at a heliportable site to accommodate heliportable operations, a potential camp and extra stockpiles of drilling supplies.

Fuel bladders are often used for onsite fuel storage at heliportable sites. From a practical perspective the heavy-lift helicopter deploying the lease construction equipment could make the initial fuel supply. In this regard, a Chinook 234 can transport approximately 3,000 gallons of fuel. Given that lease construction could take up to a month, it may be more practical to release the heavy-lift helicopter until the site is ready for the rig move and carry out any refueling or other service needs using a medium lift capacity helicopter. A Bell 212 can transport approximately 450 gallons of fuel and may be a reasonable choice for both the construction and drilling phase. Fuel consumption in the range of 3,000 to 5,000 gallons/day is not uncommon on a typical drilling program. Chinook helicopters are also used for fuel supply on many international heliportable drilling programs (Crowson pers. com.).

Once the site is prepared, heliportable 30 to 40 ton cranes are the next pieces of equipment transported in order to facilitate the assembly of the drilling rig, camp and other heavy equipment. A decision needs to be made as to whether some of the original lease construction equipment is stored onsite for the drilling period, or is removed and brought back once the site is ready to be reclaimed. Maintaining some equipment (*e.g.,* a bulldozer, track hoe and crane) would provide some contingency in the event of a spill or blow-out and also avoid the additional charges for heavy-lift helicopter moves for redeployment during reclamation. This would be partially offset by standby charges for that equipment during the 3 to 4 month anticipated drilling cycle.

6.3 Conclusion

Well site construction and reclamation is technically feasible using helicopter support though can be expected to take additional time for completion due to limitations on equipment size and potential requirement for a larger lease area. In a helicopter supported operation, there is a greater practicality in retaining some heavy equipment (*e.g.,* one small bulldozer and at least one crane) onsite to provide for immediate contingency response.

7.0 PLANNING AND TIMING CONSIDERATIONS

7.1 Planning and Approvals

Conventional drilling programs in more environmentally sensitive areas typically have long planning and approval times associated with them due to the requirement for more intensive site selection, design and consultation. Much of this effort is associated with the access route. Long roads, involving new cut, particularly where these traverse watercourses and other sensitive habitats or landscapes typically require much longer pre-planning time frames. Site-specific studies are often required to address engineering and geo-technical constraints, critical fish and wildlife habitat protection, archaeological resource potential, and First Nations concerns. This necessary pre-planning can frequently take up to six months or more depending on the site sensitivity and level of public and First Nations concern and consultation. Concern over local environmental sensitivities in the MK have typically required companies to schedule drilling programs during the winter period in order to facilitate low impact construction in some areas. In mountainous areas, road construction may take up to one week per kilometer of access.

In a heliportable application, it is assumed that less time would be associated with pre-planning site investigations, consultation and approvals once some initial local experience in this drilling technique has been gained. Scheduling a heliportable drill during the summer helps maximize the available daytime flying hours and improving potential emergency response.

7.2 Scheduling

The logistical organization and scheduling of a heliportable drill affects the overall time for execution, cost and safety of the drilling program. The steps involve survey and preparation of the road accessible staging area, construction of the lease and camp area and any interconnecting roads, establishment of the camp, rig mobilization and set up, drilling, rig and camp demobilization, reclamation, or production facilities construction. These steps are summarized in Table 1.

TABLE 1

TASKS ASSOCIATED WITH A HELIPORTABLE DRILLING PROGRAM

Task No.	Task
1	Schedule/reserve drilling rig.
2	Contract and schedule heavy-lift helicopter services.
3	Prepare road accessible staging areas for heavy equipment, rig components and supplies.
4	Prepare nearby dust free staging area for heavy-lift helicopter (approximately 70 m x 45 m).
5	Hand clear landing area, heavy equipment drop off site and refueling area at proposed campsite (assumes camp and well site are both heliportable locations in relatively close proximity (*e.g.,* within 1 to 2 km)).
6	Prepare helipad and heavy equipment refueling area at campsite.
7	Transport lease and camp construction equipment (*e.g.,* D5, D6, CAT 229 hoe) and fuel to site via heavy-lift helicopter.
8	Release heavy-lift helicopter until the drilling rig move. Service construction site with medium or light lift helicopter (*e.g.,* 212, A Star).
9	Prepare the campsite first followed by the lease site or bring in additional equipment to work on both concurrently.
10	Reposition heavy-lift helicopter once camp and lease site prepared.
11	Transport 1 or 2, 30 ton to 40 ton cranes to the lease site and assemble.
12	Heli-transport camp, rig and supplies to site.
13	Remove most/all lease construction equipment on return trips (back hauls). (may want to leave one crane and two pieces of heavy equipment onsite for emergency response)
14	Release heavy-lift helicopter.
15	Complete drilling program with medium-lift helicopter.
16	Disassemble drilling rig and campsite for heli-transport.
17	Reposition heavy-lift helicopter and return drilling rig, camp and non-essential equipment to road accessible staging area.
18	Use heavy-lift helicopter to transport reclamation equipment back to lease site for reclamation if equipment not kept on site through drilling program.
19	Reclaim the lease site.
20	Use heavy-lift helicopter to return reclamation equipment to staging area.

The helicopter company must supply experienced loadmasters at both staging area and drill site (Taylor pers. com.). All personnel must have good radio communication (including being able to contact the helicopters en route). All loads must be weighed and marked before being transported by helicopter. There should be a designated drop site at the staging area and the drill site unless a load has to be placed in a specific spot. It is recommended that all personnel involved must discuss the day's work in a morning meeting to ensure that it will progress safely and efficiently. It is everyone's responsibility to make sure that the take-off and approach paths are kept clear. External loads must not be flown over people, vehicles or buildings (Taylor pers. comm.).

7.3 Heliportable Lease and Staging Area Preparation

The time frame for preparation of a heliportable lease can be expected to be somewhat longer than a conventional road accessed lease due to limitations on heavy equipment size and the larger required lease size to accommodate additional drilling supplies storage, helicopter loading area, and helipads (including alternate landing area). Some additional time may be required for preparation of a staging area. This additional time will likely still be considerably less than the time required to construct a conventional lease and its associated access road. While this will vary from site to site it is estimated that a heliportable lease would take perhaps two to four months less than a conventional well site and access road, again primarily related to the elimination of a need to construct and later reclaim the access road.

7.4 Drilling Rig Mobilization and Demobilization

A heliportable rig move may require mobilizing between 50 to 200 loads depending on the rig and helicopter for the rig and tubulars and up to an additional 150 to 200 loads of mud, cement and other supplies (Pare, Crowson pers. comm.). Assuming 10 hour flying days and one load per hour this translates into 5 to 20 days for rig mobilization and up to 15 to 20 days for supplies unless more than one helicopter is used. Another 5 to 20, 10 hour days would be required for demobilization. It should be noted that daylight hours in the north are extended in the summer. Between April and September daylight hours can be expected to range from 12 to 20 hours (see Environmental Report, Section 2.4).

The total time to assemble a 3,400 m rated heliportable rig onsite has been estimated at about five days (Pare pers. comm.). This assembly can be occurring concurrently with movement of drill rig components and supplies, provided they are properly coordinated. It is recommended that one or two 30 to 40 ton cranes be used onsite for rig assembly. Cranes with this capacity can be readily broken down into about three loads for transport by helicopter.

Based on these figures, a total of 250 to 600 hours of heavy-lift helicopter flying time or 25 to 60 days could be required for mobilization and demobilization of the rig and necessary supplies. Time required for conventional road access rig mobilization and demobilization is in the range of 10 days.

Total flying time and thus time for mobilization and demobilization, is directly affected by the distance between the staging area and the heliportable drill site. For example to move 200 loads it was roughly estimated to take approximately 25 to 30 hours of flying time to a hypothetical heliportable lease site located 5 km from a given road accessed staging area, and 65 to 70 hours for a lease site located 20 km from the staging area (McDermid, Peterson pers. comm.). For comparison, conventional truck transported rigs with 3,000 m to 5,000 m capability can take between about 25 to 50 loads and typically be delivered to a typical site within four or five days and assembled in an additional five days.

Recent development of “casing drilling” whereby the hole is drilled with casing instead of drill pipe and then cemented in, has the potential to reduce the need for hauling additional loads of drill pipe (Pare pers. comm.). Casing drilling also increases the depth capacity of 3,400 m rigs to 4,500 m because the rig does not have to pull the drill pipe back out of the well.

7.5 Other Timing Considerations

A number of other activities are required to be incorporated into the planning sequence for a heliportable drilling program, though these can be undertaken concurrently and do not affect the total time required for site preparation or drilling. These items potentially include preparation of detailed drilling, transportation and safety plan (2 months), water well packaging (1 week), helicopter pad licensing (3 to 6 months), preparation of heli-lift cementing equipment (90-days) and preparation of open hole logging equipment (90-days). Additional significant lead time would be required in cases where a heliportable rig was being specifically designed and constructed (8 to 10 months) (Luft pers. comm.).

Time required for road construction and reclamation would also be avoided. At the present time, drilling activities in the MK are often restricted to the winter season in order to allow low impact construction techniques. It has been suggested that this restriction could be lifted such that summer heliportable drilling would be allowed. This could be argued to expand the potential operating season for drilling. However, it must also be recognized that while a winter heliportable drill could be carried out, it is a less optimal time for helicopter operation due to the reduced amount of daylight hours.

The use of “casing drilling” mentioned in Section 7.4 above, which avoids the need to use drill pipe, has also been suggested to have potential to reduce drilling time by perhaps 30% (Pare pers. comm.).

Where rigs have to be brought in from international locations on relatively short notice this can be achieved using large C-130 or Hercules transport aircraft (Crowson pers. comm.). This capability could in theory be used to transport a rig to a remote well site where an airstrip had been constructed.

7.6 Conclusion

Heliportable drilling entails it’s own unique set of planning and scheduling requirements. The primary advantages in this regard over conventional drilling programs relate to the potentially reduced time for project approval in sensitive areas (particularly if some initial experience has been gained) and elimination of time required for access road construction and reclamation. Heliportable operations do require additional time for rig mobilization, set up and demobilization due to the need to break the rig up into small packages. Heliportable drilling may allow year round drilling within the MK, though this could be reduced where there are particular concerns regarding wildlife, hunting activities and reduced winter day length for Visual Flight Rules (VFR) flying.

8.0 WELL CONTROL AND SOUR GAS BLOW-OUTS

8.1 Probability of Occurrence

Among the more significant concerns that have been raised in regard to the feasibility and practicality of heliportable drilling, are its potential implications when there is a loss of well control and potential uncontrolled release of sour gas and/or liquids (*e.g.,* saltwater, condensate).

Drilling technology and experience have advanced significantly such that the probability of an uncontrolled release or blow-out is low provided current and appropriate professional standards and practice are followed. In BC, blow-out records over the ten year period from 1992 to 2001 indicate there were three “major incidents” (a blow-out occurred and was uncontrolled) (Table 1). For the 5,030 wells drilled in BC over this same period this represents approximately 0.6 blow-outs/1000 wells drilled. Of the “major incidents”, the drilling rig was destroyed in two cases, and a relief well was used in one case to intercept and kill the well. In Alberta, between 1991 and 2001, there were approximately 26 blow-outs where there was a release of gas or liquids during the drilling of approximately 89,463 wells (Table 2). This represents approximately 0.3 blow-outs/1,000 wells drilled. The most frequent cause of blow-outs is human error. Columbia Helicopters reports that there have never been blow-outs at any of the 150+ heliportable wells they have worked on (Peterson pers. comm.).

TABLE 2

DRILLING BLOW-OUTS IN ALBERTA AND BRITISH COLUMBIA 1992-2001

	Alberta			British Columbia		
Year	Wells Drilled[1]	Blow-outs[2]	Blow-outs/1000 wells	Wells Drilled[1]	Blow-outs[3]	Blow-outs/1000 wells[4]
1992	3,704	1	0.3	158		
1993	6,807	2	0.3	280	1s	
1994	8,845	3	0.3	490	1m,1s	2.0
1995	8,379	2	0.2	405		
1996	9,489	1	0.1	404		
1997	11,848	1	0.1	460		
1998	7,280	5	0.7	589		
1999	7,698	3	0.4	579	2m,1s	3.4
2000	11,990	6	0.5	593	1	
2001	13,423	2	0.1	834		
Total	**89,463**	**26**	**0.3**	**5,030**	**3m**	**0.6**

1. Canadian Association of Oil Well Drilling Contractors 2002. Does not include servicing rigs activity but does include dry holes.
2. Alberta Energy and Utilities Board 2002. Table enumerates blow-outs during drilling only and does not include blow-outs for active or suspended wells.
3. Krezanoski pers. comm., BC Oil and Gas Commission, 2002. m = major incident involving uncontrolled blow-out, s= significant incident but well brought under control.
4. Based on “major” incidents only.

8.2 Blow-out Prevention and Risk Minimization

Reducing the probability of a blow-out requires proper planning, equipment, mud specification, monitoring and supervision. Ongoing efforts to further reduce the probability and consequence of blow-outs are being pursued on both a company and industry wide basis. The Canadian Petroleum Safety Council (CPSC) has for example recently released its *Industry Recommended Practice* for critical sour drilling (CPSC 2002) to address all aspects of sour drilling in order to ensure worker safety and minimize potential for blow-outs.

Equipment which can be employed to reduce the probability and consequence of a blow-out include: using Class C blow-out prevention equipment (BC Ministry of Energy, Mines and Petroleum Resources 1995) and testing procedures, providing extra high volume mixing tanks (*e.g.,* 400 bbl); using extra high capacity separator and mud weighting capability, using and maintaining high quality tubulars, maintaining a backup companion flange and BOP (single or multiple gate) on site and possibly an additional centrifical separator. All of these equipment items are transportable by helicopter.

In addition to having properly trained and experienced crews, following good basic drilling practices in conjunction with sound contingency plans can further reduce the risk of blow-out. Key examples of these practices include the following:

1. Two drilling foreman should be on location at all times. These supervisors will be scheduled on a 12-hour basis.
2. Pressure integrity testing should be conducted after drilling out the surface casing shoe.
3. The formation should be tested to Leak–Off Pressure or to MACP (Maximum Allowable Casing Pressure).
4. BOP stack should be pressure tested after nipple up on surface casing and again at regular intervals during the drilling.
5. A test plug should be run on bit trips and the well head and BOP stack pressure tested at intervals not exceeding seven days apart.
6. Each crew under the supervision of the Drilling Foreman and the Tower Push should hold daily BOP drills.

Among the concerns raised by the BC Oil and Gas Commission in its rejection of a recent heliportable drilling application was the concern that “the store of loss circulation materials is depleted before the well is brought fully under control” or that the re-supply of other “equipment and materials” could not be guaranteed due the potential for weather conditions to delay flying. This factor was seen to increase the relative risk of heliportable drilling over conventional road accessed drilling. Based on interviews with helicopter operators in the area, no-fly conditions as may occur in the MK would be expected to be short term, and limit transportation capability for portions of any given day as opposed to prolonged, multi-day suspension (Environmental Report, Section 2.3). Given this circumstance it appears that restocking or resupply of equipment could still occur on a daily basis. Helicopters are already relied on to some extent for resupply of equipment where particularly fast turn around is required. The risks mentioned can be further significantly reduced by ensuring a reserve of critical materials are initially stockpiled at the well site (*e.g.,* 50% reserve).

Consulting with a blow-out control company to ensure the site is optimally selected and designed for blow-out control would also help ensure that in the event of a blow-out the well can be efficiently brought under control and collateral environmental damage minimized (Miller pers. comm.). Additional measures include ensuring the last casing set before entering the critical zone is pressure rated to exceed anticipated pressure within the critical zone (Cole pers. comm.). The well site should also be selected such that it can be readily expanded to perhaps twice it's size to provide greater operational flexibility should a blow-out occur.

Where sour gas is potentially present, the drilling camp should be located in a favorable wind and air drainage position such that any H_2S release is less likely to reach the camp. As a general guide, having the camp at least 1 to 1.6 km away from the drilling site could be considered good practice (Pare, Miller pers. com.). Greater or lesser setbacks may be appropriate depending on the site-specific location (Miller pers. comm.). Consideration should also be given to having one or two alternate air equipped shelters and helicopter pads at each emergency escape route. Emergency flight route alternatives should also be included in pre-planning for helicopter drilling.

Under-balanced drilling (using mud pressures below anticipated reservoir pressure), currently practiced on conventional gas wells (including sour wells) to enhance formation gas delivery would require additional heliportable equipment (*e.g.,* high pressure vessels) and require a further degree of supervision and monitoring. Underbalanced drilling has become common and been argued by some to actually safer than overbalanced drilling (Hennegan and Divine 2002) in part due to the higher levels of supervision associated with this activity. Consideration should be given to the relative risk imposed by this drilling technique on any heliportable application.

8.3 Blow-out Response

Where measures to control the release of sour gas (or sweet gas) from an exploration well have failed and there is an uncontrolled blow-out, the operator immediately implements a site-specific Emergency Response Plan and begins procedures for bringing the well under control. These procedures typically involve the following:

- immediate evacuation of personnel on foot via a designated escape route out of the immediate hazard zone;

- potential rig ignition depending on circumstance (*e.g.,* source and type of released product, risk to life);
- contract blow-out control service;
- immediately construct any required additional site drainage and containment to handle released liquids;
- remove equipment and rig from hole (can take two or more days);
- expose and cut off casing and any pipe with magnesium lance or water jet;
- slide new companion flange and valve over well;
- shut-off gas/liquids flow;
- clean-up and/or treat any released liquids contamination; and
- bring in new rig (in most cases sour gas well blow-outs result in rig loss).

In cases where there is good access to the ground around the well site (*i.e.,* not in a muskeg or other very high water area) blow-outs are most typically and effectively controlled by the methods described above rather than bringing in a relief rig (Miller pers. comm.). Relief rigs are now primarily used for rare situations where the casing cannot be accessed reasonably by excavation, in the offshore environment or other situations where heavy equipment access to the well head cannot be achieved (*e.g.,* in cases where the site is underwater *e.g.*, offshore drilling. The time to bring a well under control varies depending on many factors with time ranging from hours to a week or more (most within three weeks), though in virtually all cases, well control is achieved before any relief wells are ever completed.

In cases where a substantial release of gas is involved, it is generally easier and safer to work on a rig which has been ignited (Miller pers. comm.). However, in cases of small releases, well control can often be achieved in an hour or two using air equipment (H_2S protective breathing equipment) without igniting the rig and without exposure of rig crews to unnecessary risk.

Once the valve has been installed and the well capped or partial control gained (*e.g.,* where flow can be directed), there is an opportunity and time to either bring in another heliportable rig or build an access road to deliver a conventional rig. At this point, it may be feasible to use a smaller rig than used on the initial drill assuming the intermediate casing had been set prior to the blow-out. This option may increase the pool of heliportable rigs available to complete the well.

During an actual sour gas blow-out or uncontrolled release on a conventional drilling project, the access roads primary purpose is for delivery of additional well control supplies (*e.g.,* flanges, valves and heavy equipment such as large excavators and bulldozers) and to bring in heavy equipment. This heavy equipment is used to pull key equipment away from the hazard area, to pull the rig off well, to excavate around the well bore to expose the casing, and other earthwork (*e.g.,* ditching and diking to manage liquids release). Concern over potential weather-related unreliability of helicopters for delivery of emergency equipment and supplies once a blow out occurs was among the reasons the OGC rejected the one application for heliportable drilling it has dealt with. As discussed above, the potential for weather delays for heliportable transport are by and large limited to portions of a given day such that such equipment could still be mobilized on any given day. Longer delays (*e.g.,* 2-3+ days) could occur where heavy equipment must be mobilized using heavy-lift helicopter which had to be positioned from a remote location unless this equipment was already stocked on site. In a heliportable application, the most precautionary approach would be to ensure necessary blow-out control equipment (*e.g.,* companion flange and valve assemblies) and basic heavy equipment (*e.g.,* one or two 30 to 40 ton cranes, one D6 or equivalent bulldozer and possibly a larger backhoe such as a CAT 330) are onsite or at least available and transportable on very short notice. Proper site design would also be a risk reducing factor (see 8.3.2 below)

8.3.1 Site Evacuation

Emergency Response Plans usually identify primary and alternate escape routes from the site to a predetermined upwind station. While the access road for a conventional well may also be used for emergency evacuation, this is dependent on the direction of the prevailing wind at the time of the evacuation and is not relied on for initial site evacuation. Alternate routes are seldom cleared or prepared but do provide for a temporary foot access away from the hazard zone. In a heliportable situation, initial evacuation would also be via foot similar to a conventional drilling site. During a blow-out, the use of vehicles in close proximity to the well is unadvisable due to the risk of accidental ignition of released hydrocarbons. Final site evacuation would be via helicopter and require that the helicopter pad be located beyond the zone at which the helicopter could be damaged by heat or flying debris and which could be safely accessed without risk of exposure to sour gas. Consideration should be given to providing some form of temporary shelter, possibly combined with air equipment and a small helipad at the end point of one or more emergency holding areas unless the camp is clearly away from the potential hazard area.

8.3.2 Management of Released Sour Gas and Liquids

In many cases it may be hours or days after an initial kick before there is an actual release or blow-out of gas or liquids to the surface. In the case of a controlled release of gas to surface via the well bore, liquids (frequently salt water and at times some natural gas liquids) would be diverted to a containment tank and gas directed to a flare stack until the well is brought back under control. In this scenario, there are no special transportation requirements assuming there has been adequate onsite storage of emergency drilling supplies. These would be normally kept onsite as part of routine contingency planning in both a conventional and heliportable drilling program. Well control in such cases is normally achieved through increasing mud weights.

In the event of an uncontrolled release of sour gas where there is a perceived hazard to human life, the rig is ignited to eliminate the sour gas hazard. Igniting the well also facilitates follow-up work on the well to bring it under control. In such cases the well site may eventually be doubled in size to facilitate rig and equipment storage and operations. In cases where there is an uncontrolled release of sour water which cannot be ignited at the well bore, the sour hazard can be controlled by diverting the liquid stream to a centrifical separator and then igniting the gas stream (Miller pers. comm.)

Uncontrolled release of liquids at a heliportable well may or may not result in substantial release of sweet or sour gas, salt water or condensate. During a 1999 UPRI blow-out at Klua Lake located 48.5 km southeast of Fort Nelson, BC, the well produced up to 1,200 to 1,500 m^3/day of water which was trucked off-site for disposal into a water injection well (BC Oil and Gas Commission 1999). While this is an extreme case, it provides an indication of the problems a heliportable drilling program could be required to manage. Up to approximately 20 pieces of heavy equipment were onsite at the Klua blow-out to contain water volumes (ditching and diking) and to move the rig and ancillary equipment off-site. This equipment included D8 sized bulldozers and large excavators/hoes (*e.g.,* CAT 245). Concern over the inability to rapidly mobilize necessary heavy equipment to clean up, contain and ultimately remove any blow out associated spilled liquids was also among the reasons for the OGC's rejection of a recent heliportable drilling application.

A heliportable drill site is handicapped by the size of equipment that can be flown in for the purpose of spill containment, cleanup and recovery. As previously discussed, maximum heliportable bulldozer size is a CAT D6 or equivalent. Relatively large hoes can still be transported in pieces for re-assembly on site. For example, a CAT 330 hoe with a 2.8 cubic yard bucket could be transported in about six loads (car body minus track group 10,000 kg (22,000 lb), track group 2,272 kg (5,000 lb), house 10,000 kg (22,000 lb), counter weight 6,636 kg (14,600 lb), boom 3,636 kg (8,000 lb) and stick 1,091 kg (2,400 lb) (Devries pers. comm.). Contingency planning for a potential massive liquids release at a heliportable well site would likely be best served by ensuring the site is properly laid out and drained, identifying a containment area, keeping a reserve of heavy equipment onsite (*e.g.*, one to two D6 bulldozers and one track hoe) and on call, as required.

An alternate to heliportable access for well control involves construction of an emergency road to the well site, an activity that would entail its own additional environmental costs. However, for relatively remote or difficult sites it is likely that the well would be brought under control prior to a road being constructed and that adequate heavy equipment could be heli-transported to the site. A road still may need to be developed depending on the volumes and fate of any released liquids. The Klua Lake blow-out produced approximately 1.2 million kg and 1.5 million kg per day of water requiring storage or disposal. A Chinook 234 would be capable of hauling approximately 13.6 m^3 of produced water per trip (assuming 1,000 kg/m^3) and would require approximately 137 flights per day to move this volume of fluid. Options for treating such fluids onsite would likely be a first course action.

8.4 Blow-out Control Using Relief Rigs

As discussed in Section 8.3 above, most well blow-outs are more immediately controlled by capping rather than bringing in a relief rig. The primary need for a relief well arises when the well head cannot be accessed by heavy equipment and/or potentially where the blow out originates at significant depth below ground. With a conventional road accessed well site a relief rig with sufficient depth capability can be relatively easily obtained from the large pool of conventional rigs in western Canada. The probability of a blow-out is low enough and the availability of conventional rigs is such that the industry typically does not reserve relief rigs during conventional drilling programs, but instead rely on assumed availability.

In the case of a heliportable drilling program, the requirement for a relief rig can be achieved either by mobilizing any available heliportable rigs with sufficient depth capability or by constructing a new access road into the site and mobilizing a conventional rig. In the case of mobilizing a second heliportable rig, a company could choose to either reserve a second rig and incur associated standby charges or rely on assumed availability. As is apparent from Section 2.1, the number of available heliportable rigs in North America is very limited. Partially offsetting this is the fact that relief well capability potentially can be provided by a shallower depth rated heliportable rig.

Where a decision was made to pioneer a new access road into the heliportable site to bring in a conventional rig, delays, environmental impacts, planning/permitting, consultation requirements and costs would be commensurate with the nature of the location.

8.5 Underbalanced Drilling

Underbalanced drilling involves using mud weights below anticipated reservoir pressure in order to reduce the invasion of particulates into the reservoir, as well as avoid several other problems associated with overbalanced drilling such as adverse clay reactions, phase trapping and precipitation and emulsification all of which can greatly reduce the productivity of oil and gas reservoirs. Underbalanced drilling can reduce drilling time (and thus drilling costs), provide greater rates of penetration, increase bit life, provide rapid indication of productive reservoir zones and the option for dynamic flow testing (Hycal Energy Research Laboratories Ltd. 2002). Underbalanced drilling relies on surface equipment rather than mud weight to achieve well control and has been suggested by some to make well control more easily managed and predictable in part owing to the higher level of supervision associated with these operations (Hannegan and Divine 2002). This drilling approach has been in use for over thirty years and has currently evolved to the point where it is being used on sour gas wells. The realization of its benefits and minimization of potential risks demands a relatively high level of planning and communication (Murphy and Thompson 2002). A more exhaustive consideration of its implications for cumulative risk management in regard to underbalanced heliportable exploration drilling should be considered.

8.6 Conclusion

Based on a relatively coarse review of the available statistics, the risk of a blow-out in BC and Alberta ranges from 0.6 to 0.3 blow-outs/1,000 wells drilled and is most often attributed to human error. The high level of supervision and management routinely associated with sour gas drilling suggests that the probability of this occurrence at sour gas wells is likely much lower. The probability of a blow-out at a heliportable well site in the MK is likely very small given the anticipated high level of planning, staffing, supervision and training of the drilling crew which would be selected for this operation.

The drilling program would of necessity still require a blow-out contingency plan which would include provision for well capping or drilling a relief well and management of a liquids release. In most cases, well control will be achieved by capping and a relief rig is not required. Options for relief well capability for a heliportable operation involve either retaining a second heliportable rig on standby or pre-planning for construction of a conventional road access. A relief rig need not necessarily be rated as the original well, as its primary function is to bring the well under control. In the event a heliportable rig is not available for relief well drilling, an emergency haul road would have to be constructed and require an expedited approvals and planning process.

Conventional road access provides no greater ability to provide for initial short-term emergency site evacuation than a heliportable drilling program, but does provide a somewhat greater ability to provide for movement of crews on and off the site following initial evacuation and drilling rig ignition. The availability of a relief rig will be significantly greater with a conventional accessed drilling rig than a heliportable drilling rig due to the number of conventional rigs available.

As with a conventional drilling program, an essential component to managing the risk and consequences of a blow-out in a heliportable operation is the need for a good safety plan with evacuation procedures and training for onsite personnel.

9.0 24-HOUR EMERGENCY MEDICAL RESPONSE

Concern over the ability to adequately manage worker safety and emergency medical response has been raised in regard to the feasibility of heliportable drilling. The access road to a conventional drilling rig provides 24-hour all-weather access to the site for emergency medical evacuations. In a conventional road access scenario, a seriously injured worker in a remote location still relies primarily on helicopter transport for the most efficient evacuation. In conditions locally unfavorable for helicopter evacuation, the injured worker is either held until such transport is available or transported by vehicle until such time as they can be intercepted by helicopter. It would be very unlikely that a seriously injured worker would be driven the full distance to either Fort St. John or Fort Nelson before being transferred to a helicopter.

During consultations with Columbia Helicopters, 24-hour air service capability had not been a component of any of the over 150 heliportable wells they had been involved with (Peterson pers. comm.). Also of interest in this regard, are reports that Columbia Helicopters has never had a helicopter-related injury in any of their heliportable drilling programs. While accidents can and do happen, risks associated with helicopter operation are minimized through provision of adequately trained personnel, ensuring the helipads and staging areas are of adequate size and dust free, thorough planning and supervision prior to and during equipment mobilization, and by working out defined flight paths and contingency routes in advance. Further reduction of the likelihood of a serious accident during the actual drilling program can be achieved through ensuring that only properly trained and experienced crews are used on any heliportable program. Lack of rig worker experience combined with poorly handled supervision of rig crews has been identified as a significant source of most injury related accidents during drilling programs (Calgary Herald, December 26, 2001).

Scheduling a heliportable operation outside of the winter period when longer day length is available, extends the daytime operating window for helicopter flying. In the event company policy or regulator required 24-hour well site access, helicopters, crews and landing areas would have to be set up for Night Visual Flying Rules (Night VFR) and possibly a full Instrument Landing System (ILS). These systems are available. The more sophisticated ILS, while not essential would cost about $1 million and require approximately 6 months for an approval (Adamson pers. comm.). As discussed in the Environmental Report, icing conditions, can temporarily make conditions inoperable for helicopter transportation. Such conditions tend to be seasonal, relatively infrequent and rarely last more than a few hours during any given day (Adamson pers. comm.). In such cases, an injured worker would have to be treated onsite until conditions improved.

While most heliportable drilling operations are serviced by a single helicopter during the drilling phase, consideration could be given to maintaining a smaller back up machine (*e.g.,* A-Star) in order to further increase emergency response capability. Other options to increase emergency response capability would be the identification and hand clearing of an ATV accessible emergency egress route to the nearest all weather access point though functional achievement of this objective may in some instances defeat the purpose of heliportable access in the first instance.

To be technically feasible, heliportable drilling must either provide for such 24-hour all-weather access and/or ensure that all emergency medical needs can be effectively met onsite and in compliance with Workers' Compensation Board of BC (WCB) regulations. The requirements of the WCB are detailed in Section 10.0 of this report. The WCB does not prohibit high risk work sites where activity is only provided by aircraft (Phillips pers. comm.). Numerous remote logging sites, fishing camps and communities are able to operate in compliance with WCB requirements for first aid without 24-hour access.

The WCB would, as with all industrial activities require a risk assessment and written procedures to deal with the site-specific circumstances and hazards of the project (see Section 9.0). By virtue of the well site having both a medical response facility and potentially a helicopter stationed onsite, a heliportable drilling operation in the MK could be argued to provide a greater level of emergency medical response than a conventional drilling rig, which does not typically have a helicopter onsite.

9.1 Conclusion

There are a number of high risk and/or remote work sites in BC that lack guaranteed 24-hour emergency access that provide emergency medical response capability in compliance with WCB regulations. By following similar practice and having a site-specific risk assessment and response plan, a heliportable drilling program would be in compliance with WCB regulations. While not essential for WCB compliance, individual companies could achieve elevated safety contingency by using 24-hour capable helicopter service, minimal ATV egress trails and/or two helicopters onsite. Seasonally scheduling drilling operations during periods of longer day length provides a longer potential window for emergency medical evacuation under VFR conditions. Risk of worker injury could be significantly reduced on a heliportable drilling program by ensuring only experienced drill crews are used. Emergency planning should also consider monitoring and response needs associated with forest fires in order to ensure worker safety.

10.0 WORKERS' COMPENSATION BOARD OF BC

As part of the heliportable feasibility evaluation, an interview was conducted with the Workers' Compensation Board of BC (WCB) (Phillips pers. comm.). The regulations are specified under the Occupational Health and Safety Regulations (OHS) (WCB 2002), and heliportable drilling would require specific attention and compliance with Regulations in Part 4 (General Conditions), Part 33 (Occupational First Aid), Part 29 (Aircraft Operations) and Part 23 (Oil and Gas). The WCB does not prohibit high risk activities, including oil and gas exploration and development, where access is only by aircraft. The following section provides a summary of the WCB requirements on a heliportable well site.

The proponent must conduct a risk assessment. This is required in any workplace in which a need to evacuate or rescue workers may arise (Regulation 4.13), in addition written procedures for transporting injured workers, including who and how to call for transportation and prearranged routes is also required (Regulation 33.28). As per OHS Regulation 33.37 (air transport), in aircraft dependent operations the designated aircraft can substitute for an emergency transport vehicle (ETV) provided that arrangements have been made for an appropriate aircraft to be available, a list of air frequencies is provided in the written procedures, first aid equipment of the type suitable for an aircraft must be available (*e.g.,* aircraft rated spine boards and stretcher) and if weather or other factors could reasonably delay the use of aircraft, alternative transportation options must be provided where practicable (WCB 2002).

According to Schedule 1, Table 1 (OHS Regulation Part 33), a Level 3 Kit, Dressing Station and ETV equipment and a Level 3 attendant are required onsite if the number of workers per shift is between 11 and 30. If the numbers exceed 30 workers per shift, then a Level 3 Kit, First Aid Room, ETV equipment and a Level 3 attendant are required. Regulation 33.10(g) requires that first aid rooms in remote locations are required to provide room and equipment for overnight care for at least two injured workers. The WCB further suggests that the number of workers per shift reflects the maximum number of people that could potentially be onsite at any one time to ensure compliance with the first aid regulations throughout the scope of the operation (*e.g.,* during completions the number of workers onsite may increase substantially and OHS Regulation 33.18 requires that for remote workplaces with lodgings, the number of workers per shift includes all workers at the camp and well site when calculating first aid coverage requirements). Access to the First Aid Room cannot be impeded at anytime, particularly in the event of an "upset" condition such as blow-out or fire. The most preferred location for the First Aid Room is either adjacent to the well site in a designated safe location, or between the well site and the camp along the short 1 km connector road.

WCB evacuation procedures only specify that workers be readily able to safely leave the defined hazard zone by foot, snowmobiles, snow cat or ATV and that there is an identified escape plan and route (Regulation 33.28). These same provisions apply to conventional drilling programs.

10.1 Conclusion

There appears to be no significant obstacle to the operation of heliportable drilling in compliance with WCB rules and regulations.

11.0 PIPELINE AND FACILITY CONSTRUCTION

For conventional pipeline construction in the MK a typical project would involve clearing and installing a buried pipeline usually within a 15 m to 18 m wide right-of-way. Right-of-ways are typically re-contoured to approximate original contours. Roads constructed to allow access for the original exploration or development wells are usually used as pipeline routes although at times, pipeline routing may be shortened to avoid extreme switchbacks and/or to take advantage of another existing linear disturbance. The ability to use the original access road increases the speed at which a pipeline can be constructed as well as reduce costs for this operation.

In the event of a successful well at a heliportable site, a decision would have to be made as to whether a road would be constructed to the site to allow monitoring and servicing of the well, or whether the site would remain helicopter accessed. In the former case, the road and pipeline would be constructed together. In the latter case, the pipeline would be constructed alone, probably via a shorter route than would have occurred via where it followed a potential access road. Heliportable pipeline stringing and welding has been successfully undertaken in some cases to expedite pipeline construction over sensitive ground conditions (*e.g.,* muskeg) (Hunley pers. comm.). Installation of a non-buried pipeline using helicopters, to a heliportable well site may allow further reduction in the amount of surface area disturbance, though this does introduce a unique set of environmental and pipe integrity factors that would need to be considered.

Other facility components such as line heaters, separators and tanks can be transported via helicopter. Compressor loads can weigh up to 113,636 kg (250,000 lb) and would require significant disassembly and reassembly.

11.1 Conclusion

The potential value of helicopters to practically reduce the impacts of pipeline construction in the MK are limited. The primary option would be to use the helicopter to sling pipe either in individual joints or longer pre-welded lengths to the site rather than requiring the additional surface preparation to allow for movement of pipe trucks in certain locations. The cost of this incremental reduction in surface area disturbance would need to be further evaluated.

12.0 OPERATIONS

Numerous remote wells and valves are accessed by helicopter on a seasonal basis. These wells typically have conventional road access during winter to allow for deployment of service rigs for work-overs or other equipment intensive activities. Some companies in western Canada are specializing in heliportable well servicing where the operator is also the pilot (Hunley pers. comm.). These operators may make daily trips to the facility by small helicopters (*e.g.,* Robinson 22's and 44's) depending on requirements and are used to service remote sour and sweet wells. Even where there is potential road access, this approach can be used to reduce the need and cost for road maintenance and potential upgrade.

12.1 Conclusion

Heliportable well site operation is technically feasible, however, in the absence of seasonal road access, equipment such as heliportable service rigs, frac units and other equipment would have to be disassembled and flown via heavy-lift helicopter to the site. No technical limitations would appear to preclude this. The primary factor involved would be related to incremental costs

13.0 ABANDONMENT

Site abandonment typically involves plugging the wellbore, removal of all surface facilities and follow-up work to replace and recontour graded materials and topsoil, installation of any erosion control measures and seeding. For a conventional road accessed well site, road reclamation would typically follow. For a heliportable well site, all surface facilities would have to be transported offsite by helicopter. Heavy equipment for necessary earthwork would have to be remobilized by helicopter.

Conclusion

There are no apparent technical limitations to site abandonment using helicopters.

14.0 RECOMMENDATIONS

1. A set of best practices should be developed which would focus on needs for overall heliportable planning and coordination, training requirements, supervision, environmental protection, blow-out prevention and response.
2. The influence of underbalanced drilling on blow-out risk should be further evaluated.
3. The potential applicability of emerging technology such as "casing drilling" to significantly extend the depth range and possible safety of heliportable rigs should be further monitored and explored.
4. Consideration should be given to collaboratively undertaking these initiatives through the Canadian Petroleum Safety Council or equivalent provincial body.

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APPENDIX A

TYPE AND AVAILABILITY OF HELIPORTABLE RIGS

Company	Heliportable Drilling Rig	Maximum Drilling Depth (m)	Cost/day (CND)	Current Location	Number of Loads
Drillers Technology Corp., Calgary, Alberta	Rig No.4, 5,6, 7	3,400	12,000 - 14,000	Canada	50 (~36 for rig, 14 for tubulars)
Parker Drilling, Houston, Texas	115, 131, 140, 145, 160, 190, 223	5,486	26,000 - 30,000	Peru, New Guinea, Indonesia, Columbia	150 - 200
	146, 206, 225, 226, 250	~6,400	~30,000	Indonesia, Peru	150 - 200
	188	>6,400	33,000	New Zealand	150 - 200
	228, 255	6,705	33,000	Peru, Bolivia	150 - 200
Helmerich and Payne Drilling, Tulsa, Oklahoma	Rig 170	9,144	35,000 (approx.)	South America	180 using a Chinook 234
	Ideco #22	5,486	N/A	South America	
	Ideco #23	5,486	N/A	South America	

APPENDIX B

CAPABILITY AND AVAILABILITY OF HEAVY AND MEDIUM LIFT HELICOPTERS IN NORTH AMERICA

	Name	**Working Weight for Loads**	**Hourly Rate *** (CND, fuel not included)	**Fuel Consumption** (L/hr)
Heavy Lift Helicopter	Boeing Chinook 234	10,886 kg (24,000 lb)	$13,500 -$14,500	1,530
	Boeing Vertol 107 (II)	4,080 kg (9,000 lb)	$4,700 - $5,200	630
	Sikorsky S-64	E Model: 7,700 kg (17,000 lb) F Model: 9,525 kg (21,000)	$10,000 - $12,000	1,985
	Sikorsky S-61A	3,625 kg (8,000 lb)	$4,500 to $5,000	640
	Sikorsky S-61L	3,175 kg (7,000 lb)	$4,500 to $5,000	1.050
	Kamov Ka32A11BC	4,535 kg (10,000 lb)	$5,500	N/A
	Super Puma	8,000 lb	$5,000 to 5,500	1,050
Medium Lift Helicopter	Bell 212	1,270 kg (2,800 lb)	$2,525 (1 pilot) $4,000 (2 pilots for 24-hour operation)	375

* All rates are approximate and vary between operators