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3.0 PROJECT DESCRIPTION

3.1 INTRODUCTION

Manitoba Hydro's requirement for Bipole III, a third +/- 500 kV HVdc (high voltage direct current) transmission line, was identified during the course of system planning reliability studies. At present, two HVdc lines (Bipoles I and II), which share a common right-of-way for the majority of their length, deliver power from generating stations on the Nelson River to Dorsey Converter Station, in the RM of Rosser, northwest of the City of Winnipeg. There, the direct current (dc) from the Bipole lines is inverted to alternating current (ac) and injected into the southern transmission system. Dorsey Converter Station feeds a network of 230 kV (kilovolt) transmission lines serving Winnipeg and southern Manitoba. It also feeds export interconnections, principally the 500 kV international D602F transmission line[1] between Dorsey and Forbes, Minnesota. Figure 3.1-1 illustrates Manitoba Hydro's current transmission system.

Approximately 70% of Manitoba's hydroelectric generating capacity is delivered to Dorsey Converter Station in southern Manitoba via the Interlake corridor shared by the Bipoles I and II HVdc transmission lines. The HVdc transmission system is vulnerable to the risk of catastrophic outage, particularly through the length of the shared corridor and at Dorsey Station, due to severe weather events, fire, sabotage, or similar contingencies. System reliability studies conducted by Manitoba Hydro, and guided by North American Electric Reliability Council (NERC) and Midwest Reliability Organization (MRO) recommendations respecting system reliability (see Appendix 3A)[2], have concluded that the risk of such events, when combined with the potentially catastrophic consequences of prolonged major outages, warrants mitigation measures to reduce dependence on Dorsey Station and the existing Bipoles I and II transmission lines.

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[1] The designation D602F applies to the existing international line between Dorsey and Forbes. Following completion of the Riel Sectionalization Project, the two resultant lines will be renamed. The section between Dorsey and Riel stations will become D603M; the section between Riel and Dorsey will become M602F.

[2] International system planning criteria and related standards are developed by the North American Electric Reliability Council (NERC). As at 01 January 2006, Manitoba Hydro is part of the Midwest Reliability Organization (MRO), one of several reliability regions within the NERC umbrella. MRO replaced the former Mid Continent Area Power Pool (MAPP). Transmission issues are within the purview of several regional transmission organizations. Manitoba Hydro is part of the Midwest Independent System Operator (MISO).

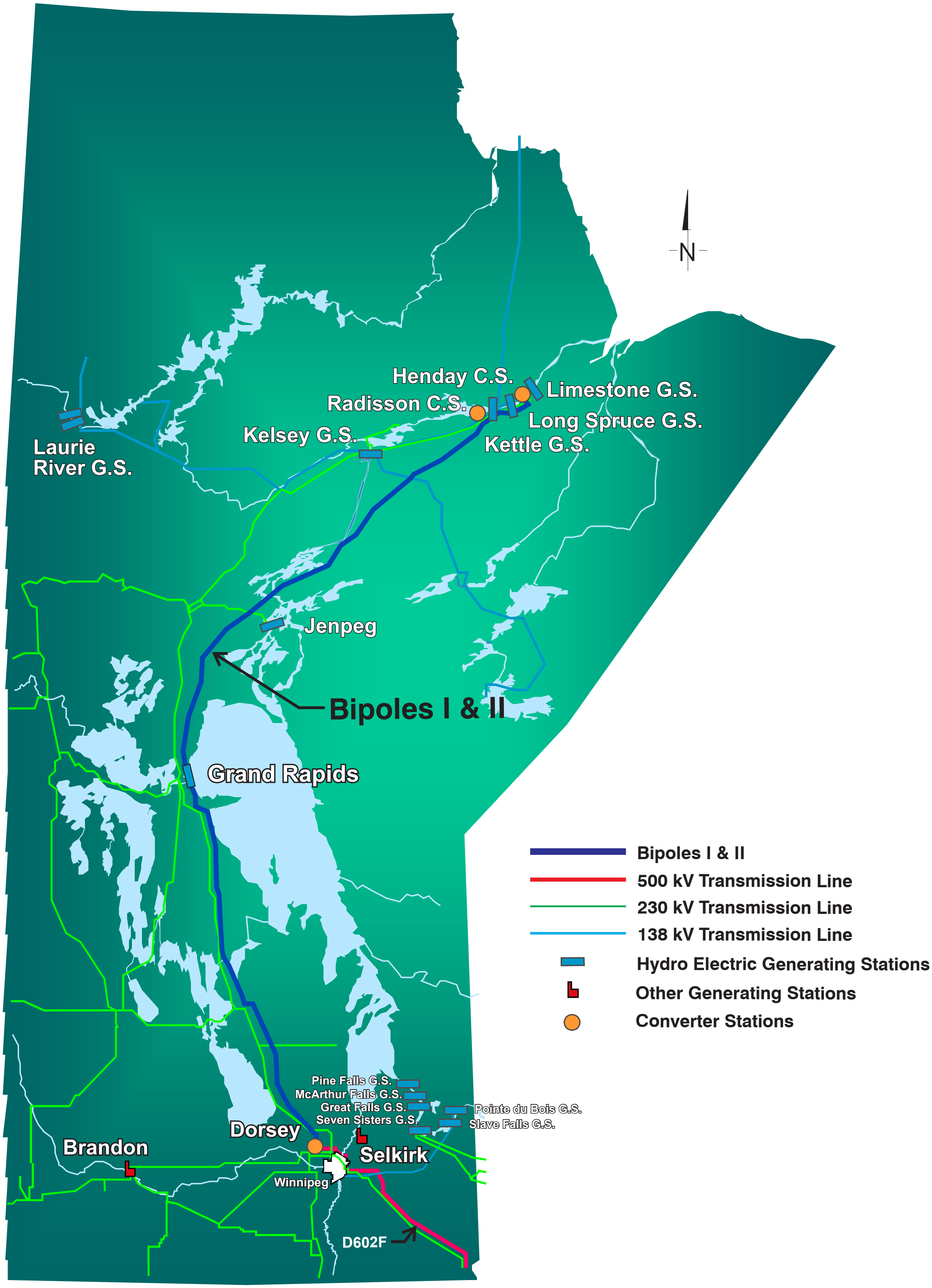

Figure 3.1-1:
Major Components of Manitoba Hydro's Existing Transmission System

In 1996, the existing Bipoles I and II experienced simultaneous and major damage as a result of an extreme wind event in the vicinity of Grosse Isle, north of Dorsey Station. The existing 500 kV international transmission line (D602F) was temporarily used to import power to support the Winnipeg area transmission system while the damage was being repaired. Had the wind event occurred a few kilometres further south, D602F might have been simultaneously damaged—severely limiting the ability of the system to supply power to Manitobans. The consequences of an event like this, or of a similar major outage of Dorsey Converter Station, could include severe supply restrictions and rotating blackouts.

These system reliability concerns led to the recommendation of two major mitigation measures: sectionalization of the international transmission line D602F and development of Bipole III.

Sectionalization of D602F, at the Riel site east of Winnipeg, will relieve dependence on Bipoles I and II by enabling power from the international transmission line to be injected into the Manitoba Hydro transmission system at either Dorsey or Riel stations. The Riel Reliability Improvement Initiative (Riel Sectionalization) has recently been licensed and is currently under construction. Once completed, Riel Sectionalization will provide an alternative terminal for the existing D602F international interconnection, enabling the import of power to the southern transmission system in the event of a major HVdc outage involving Dorsey Converter Station and/or Bipoles I and II.

While the Riel Reliability Improvement Initiative will improve system reliability, it will not directly affect the possibility of outages affecting Dorsey Station, the Bipole I and II HVdc facilities, and other major transmission corridors in the Winnipeg area. The existing geographic concentration of these facilities is vulnerable to outages that could affect:

- The Bipole I and II HVdc facilities at Dorsey Station;
- The 500 kV switchyard at Dorsey Station;
- The existing Bipole I and II transmission lines;
- The shared transmission corridor immediately north of Dorsey Station containing D602F, Bipoles I and II, and a major 230 kV line to Brandon; and
- The shared transmission corridor immediately north and east of Winnipeg between Dorsey Station and the Riel Station site.

Even with the Riel Sectionalization project, the consequences of such outages would be severe. Development of the Bipole III Project, which is the subject of this document, will further improve system reliability by establishing another major point of injection of power from generating stations in northern Manitoba into the southern transmission system, and reducing dependence on the existing Bipoles I and II and the existing concentration of transmission facilities in and around Dorsey Station.

Apart from its direct benefits to system security, the addition of Bipole III will improve the existing Bipoles I and II line losses under current system conditions, and provide additional transmission capacity to transmit new northern hydroelectric generation to southern markets.[3]

3.2 BASIC BIPOLE III TRANSMISSION CONCEPT

The primary function of Bipole III, based on system reliability requirements, is to provide contingent transmission capacity to counter the risk of outages to the existing HVdc transmission system. Under normal operating circumstances, the power flow from northern Manitoba will be distributed between Bipoles I, II and III.

The basic Bipole III transmission concept is illustrated in Map 3-1. The Bipole III Project will consist of an HVdc transmission line, originating at a new converter station to be located near the proposed site of the Conawapa Generating Station and terminating at a second new converter station located at the Riel site immediately east of the Red River Floodway in the Rural Municipality of Springfield. Based on recommendations from Fox Lake Cree Nation, the new northern converter station will be named the Keewatinoow Converter Station. The southern converter station will be named the Riel Converter Station.

Apart from the HVdc transmission line and the new converter stations, the project will include new 230 kV transmission lines linking the Keewatinoow Converter Station to the northern collector system at the existing 230 kV switchyards at Henday Converter Station and the Long Spruce Switching Station. It will also include sectionalization of the existing Ridgeway-Richer 230 kV transmission line R49R at Riel and expansion of the 230 kv switchyard currently being developed as part of the Riel Reliability Initiative.

[3] The addition of Bipole III will reduce line losses for the present system configuration, due to the resultant reduction in loading (amperes) arising from its distribution over three Bipole lines as opposed to the two existing lines. Loading and line losses, for the three Bipoles, will increase as and when additional generating stations (e.g., Keeyask and Conawapa) are added to the HVdc system.

Each of the new converter stations will also require development of a separate ground electrode, connected to the station by a low voltage[4] overhead line.

Keewatinoow Converter Station will allow power to be exchanged between the northern high voltage ac transmission collector system, characterized by an oscillating voltage and current waveform, and the Bipole III high voltage dc transmission system, characterized by a constant value voltage and current waveform. The dc system is divided into two poles, a positive pole operating at +500 kV, and a negative pole operating at -500 kV with respect to earth (or ground) potential. Both poles will be transmitted on a single transmission line, referred to as the Bipole III HVdc transmission line. Riel Converter Station will allow dc power from the HVdc line to be exchanged with the high voltage southern transmission receiver system.

3.3 OVERVIEW OF PROJECT COMPONENTS AND ACTIVITIES

3.3.1 Bipole III HVdc Transmission Line

From a land use and environmental planning perspective, the HVdc transmission line is the most significant component of the Bipole III Project. The preferred route, as illustrated in Map 3-2, has been selected on the basis of environmental, socio-economic and technical criteria and an extensive program of public and community consultation (see Chapter 5). To minimize the risk of common outage (e.g., outage involving both the existing Bipoles and Bipole III due to a single extreme weather event), the routing process has avoided the Interlake area, in order to provide substantial physical separation from the existing Bipole I and II transmission lines. For reasons of provincial policy, the routing process has also avoided the area east of Lake Winnipeg.

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[4] Ground electrodes for both the Keewatinoow and Riel converter stations will be used for ground return of minor dc current flows during normal bipolar operation (typically less than 50 amperes and arising from minor differences in equipment characteristics within the station equipment). Occasionally, outages resulting from routine equipment maintenance, repair, or malfunction will require monopolar operation with current being conducted through the low voltage electrode line and ground electrode equal to the current on the Bipole III HVdc transmission line. Ground electrode current during monopolar operation is dependent on the dc power being transmitted; at full load, the current will be approximately 2,000 amperes (with design provision for up to 2,200 amperes).

The Bipole III HVdc transmission line will originate from the new Keewatinoow Converter Station to be located near the proposed site of the future Conawapa Generating Station, on the Nelson River in northern Manitoba, approximately 90 km downstream from the community of Gillam. It will terminate at a new southern converter station to be constructed on the Riel site, where the Riel Reliability Improvement Initiative for sectionalization of D602F is currently under construction.

3.3.2 Connections to the Northern Collector System

The power transmitted by Bipole III will originate at generating stations on the Nelson River in northern Manitoba. Existing generating stations are linked to the existing Bipoles I and II by a collector system of high voltage three phase ac transmission lines and switchyards. The collector system carries power from the generating stations on the lower Nelson River (Kettle, Long Spruce, and Limestone generating stations) to the existing Radisson and Henday converter stations in northern Manitoba, where it is converted (or rectified)[5] to dc power for transmission on to Dorsey Converter Station in southern Manitoba via the Bipole I and II HVdc transmission lines. The northern collector system comprises a network of transmission lines and switchyards that offers some flexibility in routing the flow of power from the lower Nelson River generating stations to southern Manitoba, via Bipoles I and II, in the event of outages. To enhance that flexibility and reliability further, the new Bipole III Keewatinoow Converter Station will require additional transmission lines and switchyard connections to the existing collector system, both to ensure that Bipole III is accessible from the various northern generating stations, and to enable its full capacity to be utilized to transmit power in a wide variety of potential outage conditions.

The proposed connections include five high voltage three phase ac lines. One 230 kV transmission line will extend from the existing 230 kV switchyard at Long Spruce Switching Station to a new 230 kV switchyard to be developed at the site of the new Keewatinoow Converter Station. In addition, four 230 kV transmission lines will be constructed from the existing 230 kV switchyard at Henday Converter Station to the

[5] Where power flows from the ac transmission system to the dc transmission system, the converter station is called a rectifier. Where the flow is from the dc system to the ac system, the converter station is called an inverter. In the case of Bipole III, Keewatinoow Converter Station will be operated in rectifier mode; Riel Converter Station will be operated in inverter mode.

new 230 kV switchyard at the new Keewatinoow Converter Station.[6] These lines and their proposed routes are schematically illustrated in Figure 3.3-1 (Preferred routes are subsequently illustrated in Map Series 3-500). Related modifications to the Henday and Long Spruce switching stations are described in Section 3.4.2.4.

The design concept for the 230 kV switchyard at the new Keewatinoow Converter Station will also make provision for possible future termination of 230 kV transmission lines in the event of new northern generation developments (e.g., Conawapa).

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[6] Two of the four Henday collector lines (K63H and K64H extending from Henday Switching Station to the 230 kV switchyard at Keewatinoow Converter Station) would no longer be required for HVdc system reliability in the event that development of the Conawapa Generating Station proceeds and, in that event, would be decommissioned and salvaged.

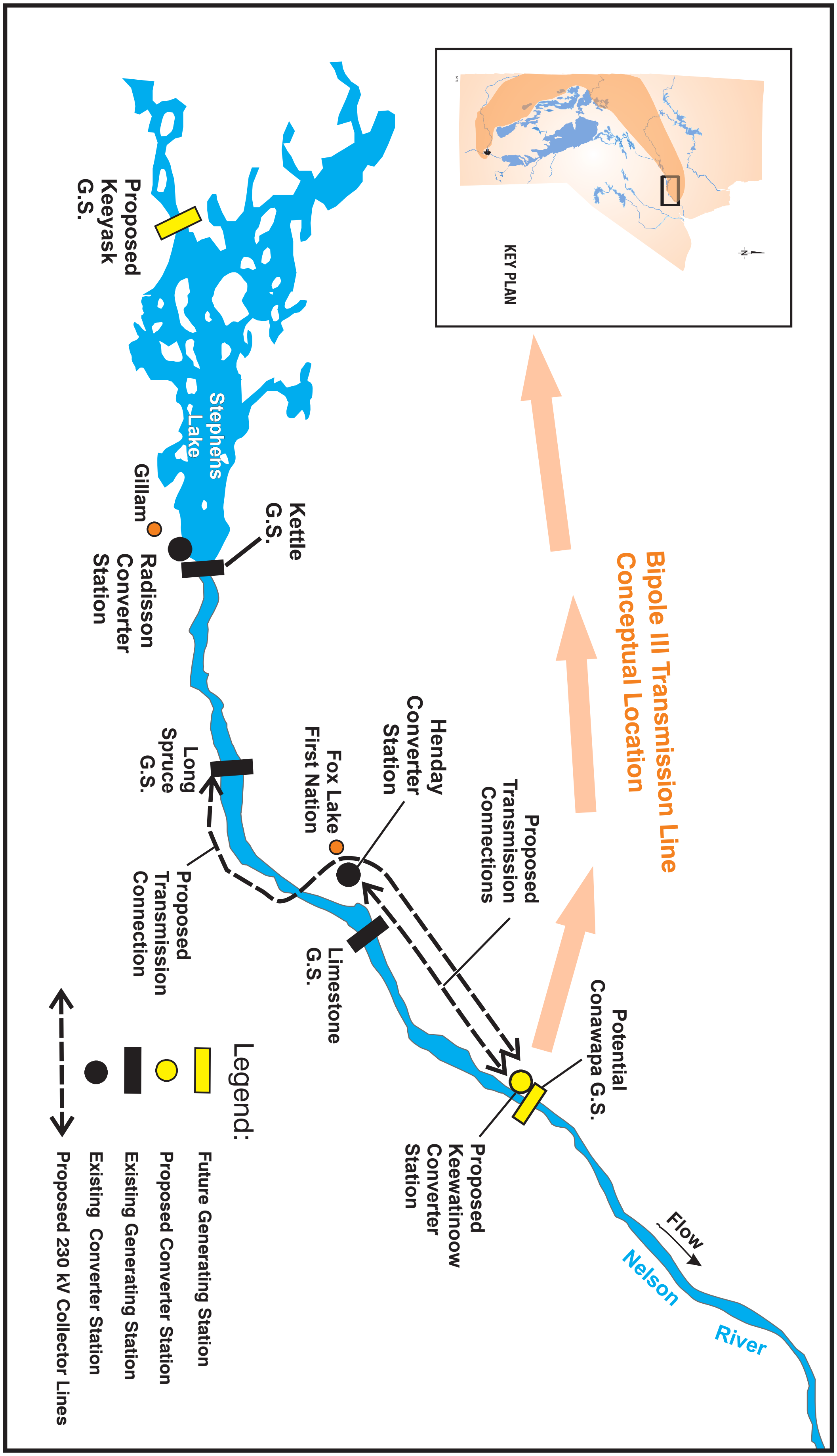

Figure 3.3-1:
Proposed Keewatinoow Converter Station and Northern Collector System Connections

3.3.3 Keewatinoow Converter Station and Ground Electrode

The new Keewatinoow Converter Station will include the converters and associated equipment and ancillary facilities, together required to terminate the 230 kV transmission line connections to the northern collector system, to convert the ac power from the collector system to dc power at the +/- 500 kV level, and to provide the HVdc switching facilities necessary for termination of the new HVdc Bipole III transmission line. The general concept of siting the Keewatinoow Converter Station near the potential Conawapa Generating Station site was established on the basis of system planning requirements. The choice of the Keewatinoow site primarily reflects technical considerations: the location is physically separated from existing Bipole I and II converter facilities at Radisson and Henday; the site is accessible via the existing Conawapa access road; the site is reasonably located for connection to the existing northern collector system; and the site is well located relative to possible future generating station development at Keeyask and Conawapa.

Details of the site selection and development concept, including the 230 kV ac switchyard and HVdc switchyard, are being adjusted to ensure compatibility with the potential future development of the Conawapa Generating Station, including related construction camp, construction power, marshalling, and access requirements.

The HVdc switchyard will provide the connection between the converter station and the positive and negative pole conductors which will be carried on the steel towers comprising the Bipole III HVdc transmission line. It will also terminate the connection between the centre point of the station (also called the neutral bus) to earth potential at the ground electrode.

The ground electrode required for the Keewatinoow Converter Station has been the subject of technical site feasibility studies to identify a suitable location within a maximum distance of approximately 50 km (31 mi.) from the station. See Section 3.5.1.2 for details.

The preferred converter station site, together with the preferred ground electrode site and connecting line route, are schematically illustrated in Map 3-3. Figure 3.3-2 is a photo of the existing Henday Converter Station and provides a sense of the general scale and appearance of a converter station. Precise details and layout of the Bipole III converter stations (Keewatinoow and Riel) are subject to ongoing design studies.

The sites chosen for the Keewatinoow project components and the associated construction camps were reviewed and discussed with representatives of Fox Lake Cree Nation in a number of meetings. Discussions continue with a view to identifying and addressing the effects on members of Fox Lake Cree Nation of the Bipole III Project.

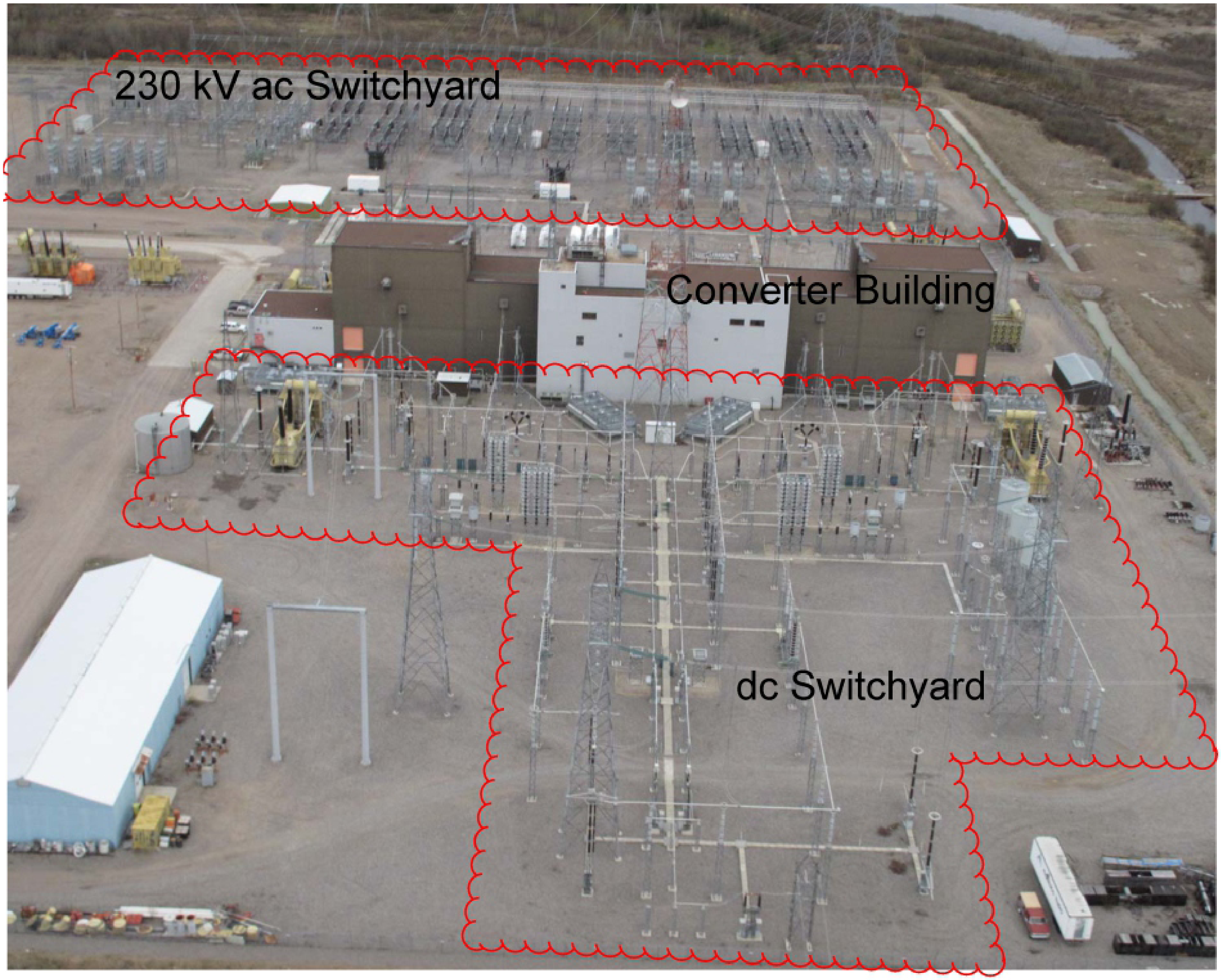

Figure 3.3-2:
Existing Henday Converter Station

3.3.4 Riel Converter Station and Ground Electrode

The new southern converter station will include the HVdc switchyard facilities necessary to terminate the new HVdc transmission line, together with the converters and the ancillary facilities required to convert the dc power from the Bipole III transmission line to ac power at the 230 kV level necessary for injection into the southern receiving system. Although otherwise similar in concept to the Keewatinoow Converter Station, the Riel converter facilities may include synchronous compensators for strengthening of the system, supporting the Bipole III converters, controlling voltage, and adding system inertia for stability.

The southern converter station will be developed at the Riel Station site, in the RM of Springfield immediately east of the Winnipeg Floodway and north of the City of Winnipeg Deacon Water Supply Reservoir. The site is currently under development for the Riel Reliability Improvement Initiative (Riel Sectionalization). Its joint use as the southern converter station for Bipole III was identified in the licensing submission for the Riel Sectionalization project and has been the subject of numerous prior system planning studies and related siting and environmental assessment initiatives.

The Riel Sectionalization project includes development of 500 kV and 230 kV ac switchyards, and 230 kV connections to the southern receiver system serving Winnipeg and southern Manitoba. Site preparation and infrastructure development for the sectionalization project extends, in part, to that required for the Bipole III HVdc and ancillary facilities. As in the case of Keewatinoow, Figure 3.3-2 provides a general sense of the scale and appearance of a typical converter station and the corresponding components at Riel. The Riel location is schematically illustrated in Figure 3.3-3. The Bipole III concept provides essentially for new development of dc/ac conversion facilities, a dc switchyard, and ancillary equipment and connections within the existing Riel footprint. It provides as well for sectionalization of the existing 230 kV transmission line R49R at Riel (to increase output to the 230 kV southern receiver system) and for additions to the Riel 230 kV switchyard.

As in the case of Keewatinoow, the ground electrode required for Riel converter station has been the subject of ongoing technical site feasibility studies to identify a suitable location, within a maximum distance of approximately 50 km (about 31 mi.) from the station. The final choice of the proposed site, and the route of its low voltage overhead line connection to the converter station, is being made through a site selection and environmental assessment (SSEA) process conducted in consultation with potentially affected community and public interests. See Section 3.6.1.2 for details.

The proposed converter station site, together with the proposed ground electrode site and the study area for routing of the low voltage line between the station and the ground electrode, is illustrated in Map 3-4.

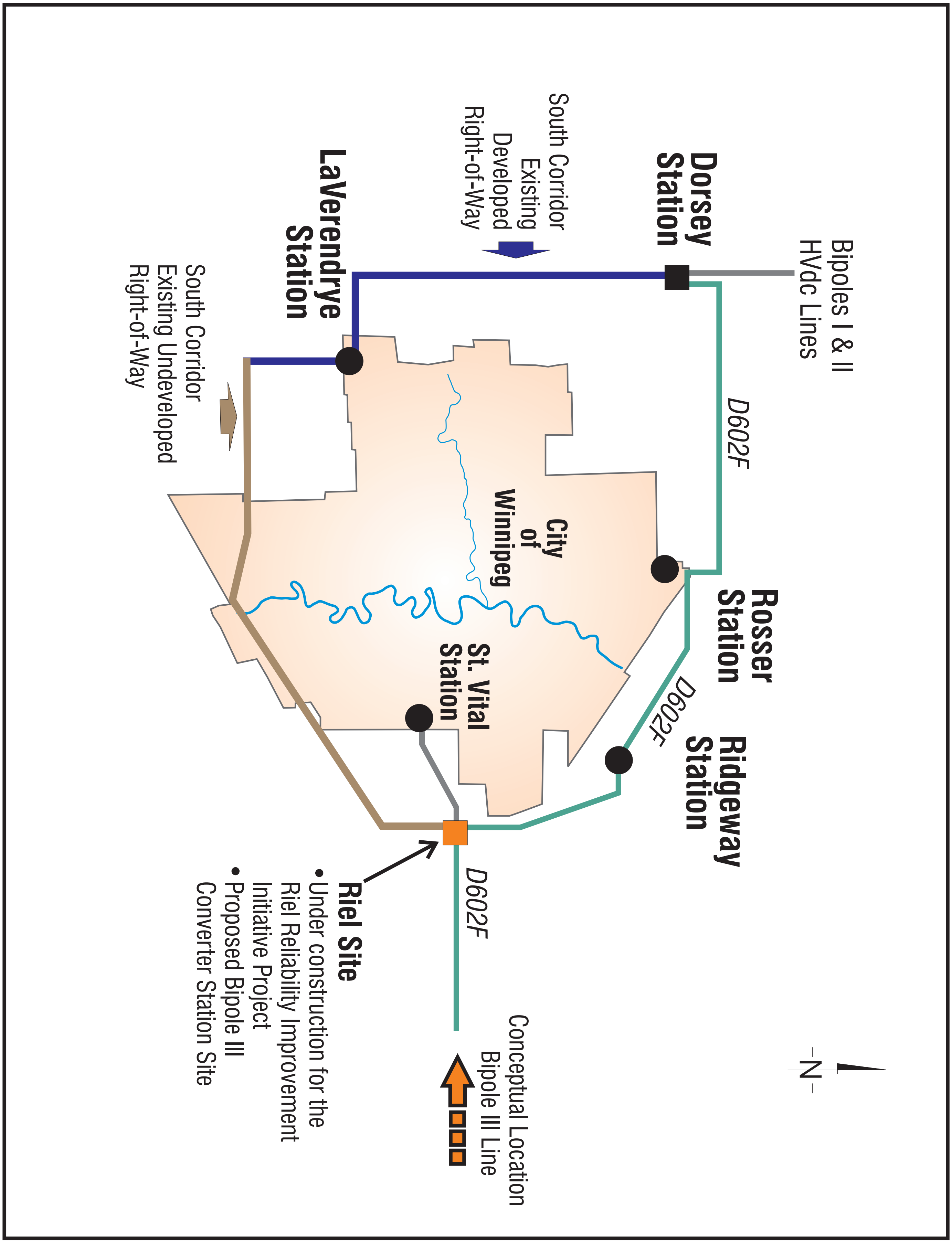

Figure 3.3-3:
Riel Station Site and Connections to Dorsey Station and Southern Receiver System

3.3.5 Connections to the Southern Receiver System

The southern receiver system, serving Winnipeg and southern Manitoba, is fed from a network of 230 kV transmission lines originating at Dorsey Station and at a number of existing substations in the Winnipeg area. The Riel Sectionalization project includes sectionalization of several of these existing transmission lines, in order to enable injection of power from the sectionalized D602F line at Riel. Although the resultant capacity of the 230 kV connections at Riel facilitates injection of power from Bipole III, additional transmission capacity will be required.

The additional transmission capacity will be provided by sectionalization of the existing Ridgeway-Richer 230 kV transmission line R49R at Riel. The implications of sectionalizing R49R are described in Section 3.6.2.2, which details Bipole III requirements in the Riel 230 kV switchyard.

3.4 TRANSMISSION AND COLLECTOR LINES – TECHNICAL DESCRIPTION

The following subsections provide a more detailed life cycle description of the transmission line components included in the Bipole III Project (e.g., +/- 500 kV HVdc transmission line, 230 kV ac connections to the northern collector system, and a 238 kV construction power line). The description includes the construction, operation and maintenance phases of each component, as well as prospective decommissioning.

As written, the project description information is based on preliminary design and on Manitoba Hydro policy with respect to design and construction, operation and maintenance, and decommissioning. Project development will also adhere to applicable North American Reliability Council/Midwest Reliability Organization/Midwest Independent System Operator (NERC/MRO/MISO) criteria and Canadian Standard Association (CSA) standards (see Appendix 3A). Subject to approval requirements, details of final design may vary from the preliminary design on the basis of field conditions and contract requirements.

3.4.1 Bipole III +/- 500 kV HVdc Transmission Line

Design of the HVdc transmission line will be subject to two general design standards. The C22.3 No. 1-10 "Overhead Systems" standard[7] will be applied to determine all electrical and safety clearances, and the CAN/CSA-C22.3 No. 60826-10 "Design criteria of overhead transmission lines" standard[8] will be used for structural and mechanical design, applying design loads based on a 150 year return period, in accordance with the Reliability Based Design (RBD) method. The 150 year return standard is consistent with CSA standards for transmission lines over 230 kV in the Reliability Level II category, which, in turn, reflect recommendations of International Electrotechnical Commission (IEC).[9]

3.4.1.1 Structure Design and Location

Two basic tangent structure types will be used for the straight line sections of the Bipole III HVdc transmission line, as outlined below. In northern Manitoba, the line conductors will be suspended from guyed lattice steel structures (i.e., assemblies of steel structural members with bolted connections). Guyed structures, the main shafts of which have pin type foundations, are most suitable for terrain conditions subject to shifting as a result of seasonal changes in soil conditions (e.g., conditions found especially in permafrost areas). These structures allow for adjustment of the anchor guys to maintain desired guy loads and forces in the main tower shaft, as well as straightness of the entire structure. In the more intensively developed agricultural areas of southern Manitoba, self-supporting lattice steel structures will be used to minimize the potential impact on farming practice (i.e., to reduce the tower footprint). A mix of self-supporting and guyed structures will be used in the central portion of the line, based on the land use in the area of the right-of-way.

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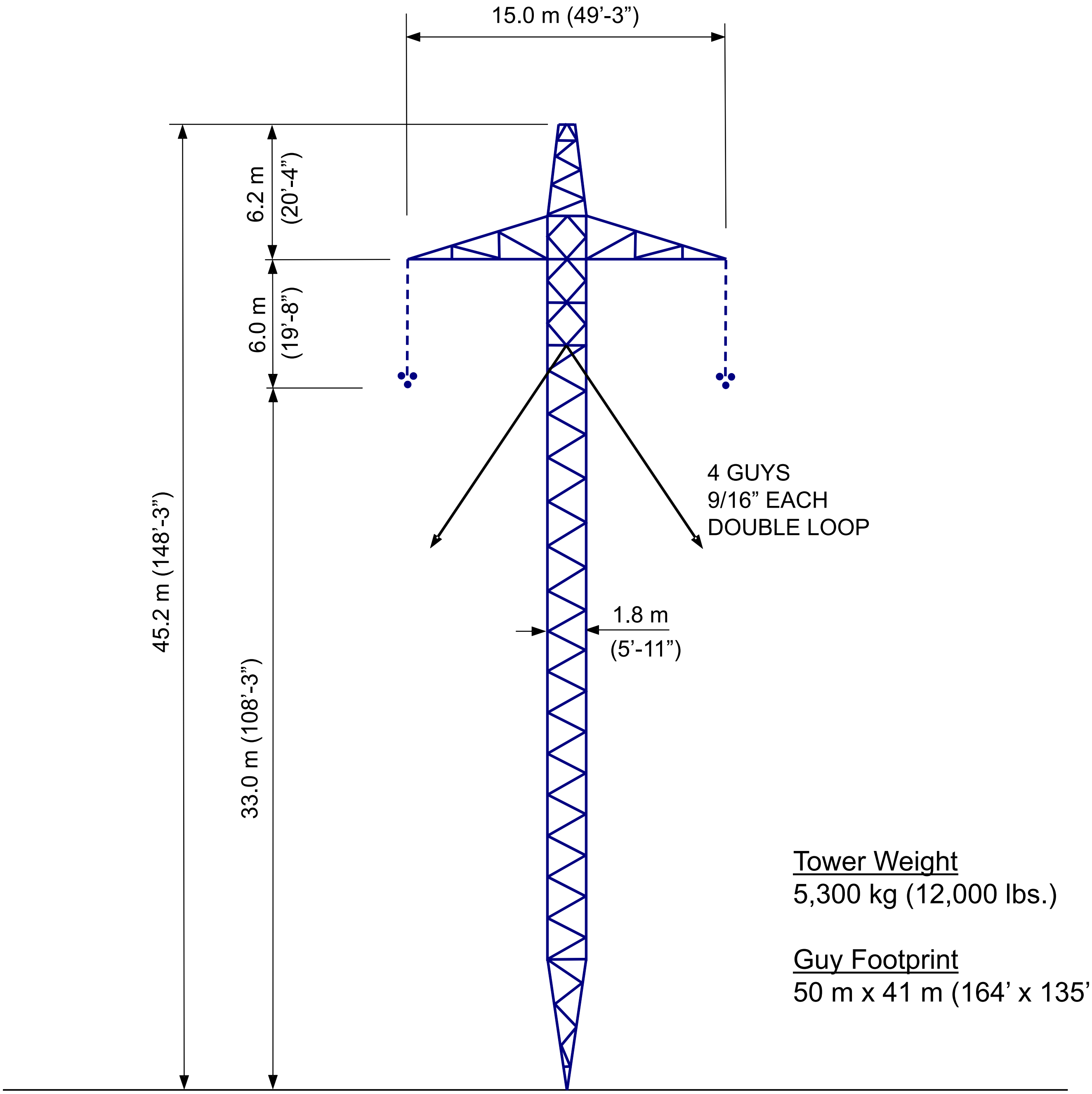
[7] C22.3 No. 1-10, Canadian Standards Association (CSA), 2010.
[8] C22.3 No. 60826-2010, Canadian Standards Association (CAN/CSA), 2010.
[9] Applicable reliability level categories relate to the nature of the transmission line. Level III (for which design weather loads are based on a 500 year return period) is recommended for lines above 230 kV which "constitute the principal or perhaps the only source of supply to a particular electric load". The Bipole III transmission line, as a project intended to improve system reliability by providing an alternative source of supply (and not itself a sole or critical source) is considered to fall under Level II (for which design weather loads are based on a 150 year return period). Full details respecting selection of reliability level can be found in Report BP3-TR-03, Optimization of Reliability (Selection of Optimum Return Period of Design Loads), Manitoba Hydro).

- Preliminary design for a typical guyed suspension tangent lattice steel structure is illustrated in Figure 3.4-1. These structures are based on a single foundation at their centre point and are stabilized by four guy wires, arranged diagonally to the route of the line with a typical overall rectangular footprint of 50 x 41 m (approximately 164 x 135 ft.). Guy wires will be 14 mm (9/16") diameter galvanized steel, and configured in a double loop (two wires per guy). The typical structure's overall height is 45.2 m (148' 3"). Taller structures, with larger guy footprints, will be used where warranted by land use or terrain conditions (e.g., highway crossings, water crossings, uneven terrain, etc.).
- Preliminary design for a typical self-supporting suspension tangent lattice steel structure is illustrated in Figure 3.4-2. The structure is supported on four separately founded legs. The structure footprint is approximately 7.85 m (25.75 ft.) square. The structure's overall height is approximately 47 m (154 ft.). Taller structures with larger footprints will be used where warranted by land use or terrain conditions.
- The guyed and self-supporting suspension structures include horizontal lattice steel cross-arms, from which the conductors are suspended. Cross-arm width for guyed tangent structures will be approximately 15 m (49.3 ft.), and approximately 15.5 m (50.8 ft.) for self-supporting structures. The height of the cross-arm will be approximately 39 m (128 ft.) above-ground level in the case of guyed structures (40 m or about 131 ft. in the case of self-supporting structures), but may be higher depending on the particular circumstances of the tower location. The actual dimension will depend on the height required to ensure adequate ground to conductor clearance at mid-span between the towers.

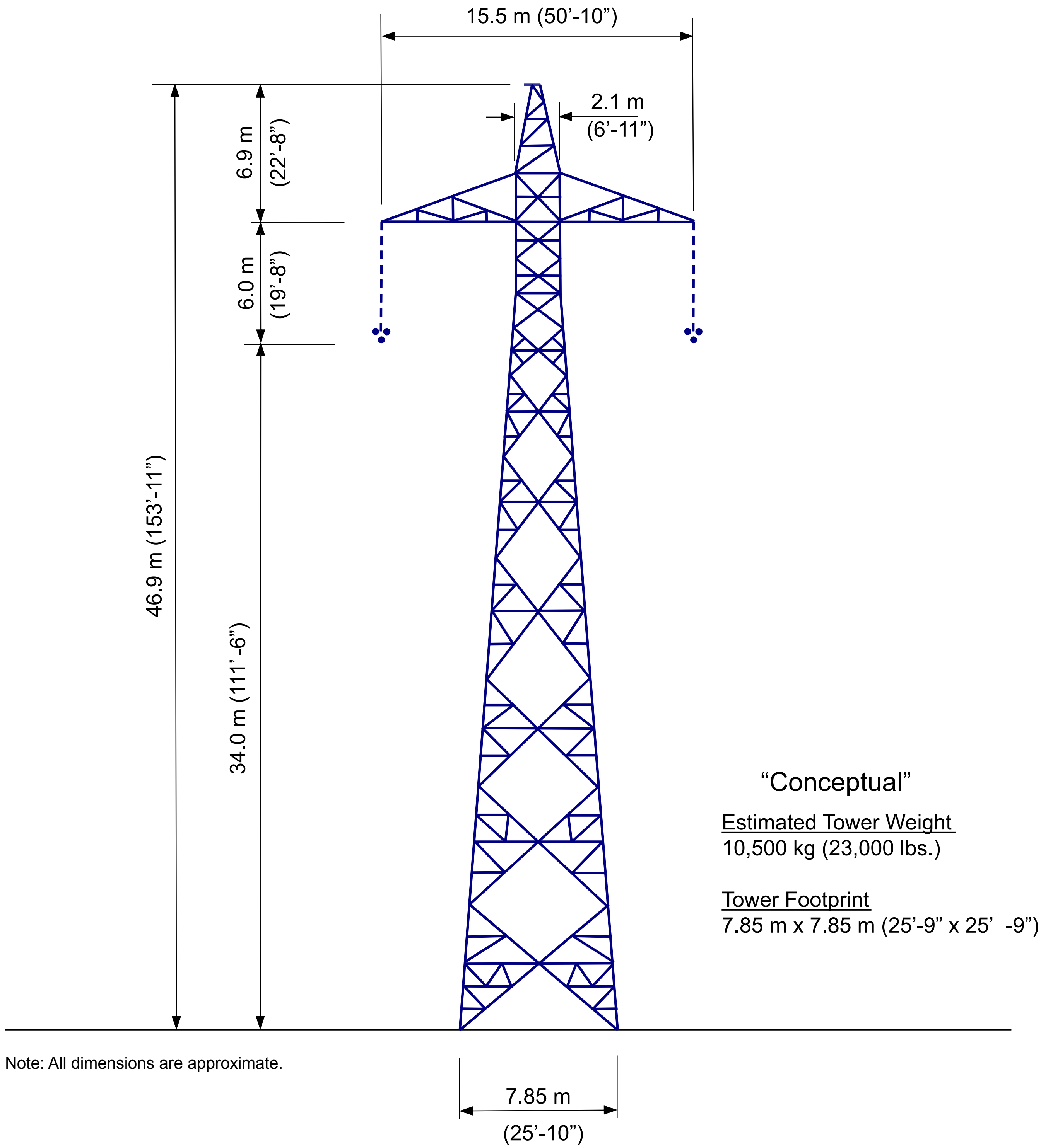
Apart from the weather loads, which are created by wind and ice conditions, the principal force affecting design of tangent suspension structures is the weight of the conductors. Unlike tangent structures, towers located at corners where there is a change in the route direction (i.e., angle structures) are subject to additional longitudinal loads arising from the tension of the conductors. Similarly, towers at terminations of the line (i.e., dead-end structures) are subject to loads arising from the unbalanced effect of conductor tension on one side of the structure. Design for these more complex loading conditions typically requires greater structural strength and heavier construction, as outlined below.

- Preliminary design for a typical triple-shaft guyed angle or dead-end structure is shown in Figure 3.4-3. This structure is supported by three guyed and separately-founded vertical lattice members. The central and tallest shaft is approximately 46.2 m (152 ft.) in height. The combined guy footprint is approximately 52 x 66 m (171 ft. x 217 ft.) Guy wires will be approximately 32 mm (1 ¼") diameter, configured as four single wires per shaft.



Note: All dimensions are approximate.

Figure 3.4-1:
Bipole III HVdc Line, Typical Guyed Suspension Tower Configuration



Note: All dimensions are approximate.

Figure 3.4-2:
Bipole III HVdc Line, Typical Self-Supporting Suspension Tower Configuration

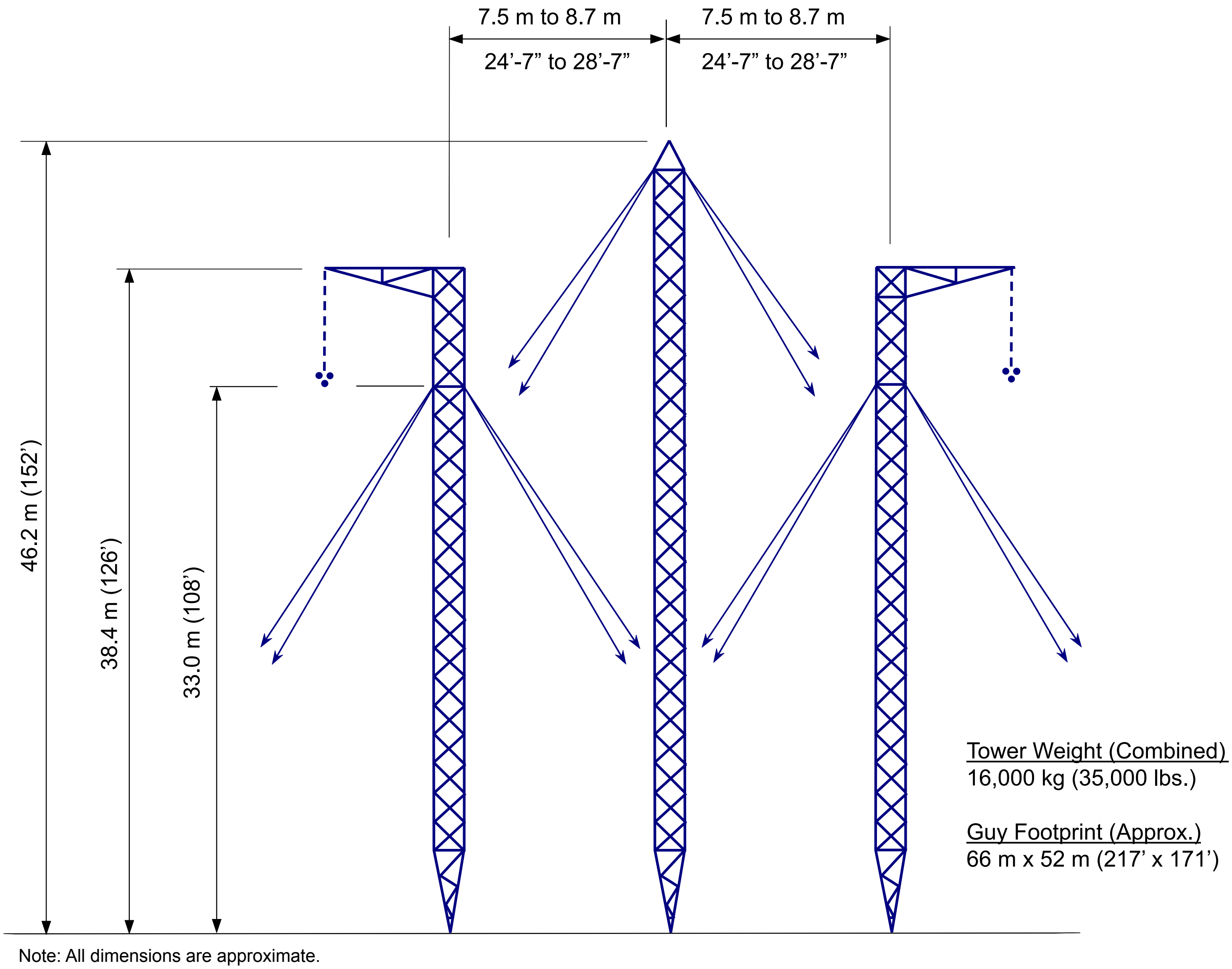


Figure 3.4-3:
Bipole III HVdc Line, Typical Three-Shafted Guyed Dead-End Tower Configuration

- Preliminary design for a typical self-supporting lattice steel angle or dead-end structure is illustrated in Figure 3.4-4. This structure is supported by four legs requiring individual foundations. The tower footprint is approximately 15 x 15 m (49 x 49 ft.). The structure's overall height is approximately 44.6 m (146 ft.).
- As in the case of the conventional guyed and self-supporting structures, both angle and dead-end structures also include a horizontal lattice steel cross-arm, as previously described, from which the conductors are suspended.

The structures will generally be centred in a right-of-way 66 m (216.5 ft.) in width. This will accommodate conductor "swing-out" under wind conditions equivalent to 90% of the extreme wind speed design parameter for the affected weather zones, using the 150 year return period.

Although the tower design will provide for span lengths of up to 550 m (about 1,804 ft.), the average span between structures will be approximately 488 m (about 1,600 ft.) resulting in approximately two structures per kilometre (about 3.3 structures per mile). Additional detail respecting span length and tower placement is provided in Section 3.4.5.1. Based on a preferred route line length of 1,376 km (855 mi.) for the HVdc line[10], it is estimated that a total of approximately 1,859 guyed suspension structures, 64 guyed dead-end structures, 864 self-supporting suspension structures, and 67 self-supporting dead-end structures will be required to support the line. The totals include 1,498 guyed towers (1441 suspension and 57 dead-end) for the 745 km (463 mi.) northern portion of the line; 425 guyed (418 suspension and 7 dead-end) and 304 self-supporting structures (288 suspension and 16 dead-end) for the 331 km (206 mi.) central portion; and 627 self-supporting towers (576 suspension and 51 dead-end) for the 300 km (186 mi.) southern portion.

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[10] The preferred route length of 1,376 km (855 mi.) was the basis for all of the tower quantities and related statistics presented in this section. Subsequent route adjustments have modestly altered the length to 1,384 km (860 mi.).

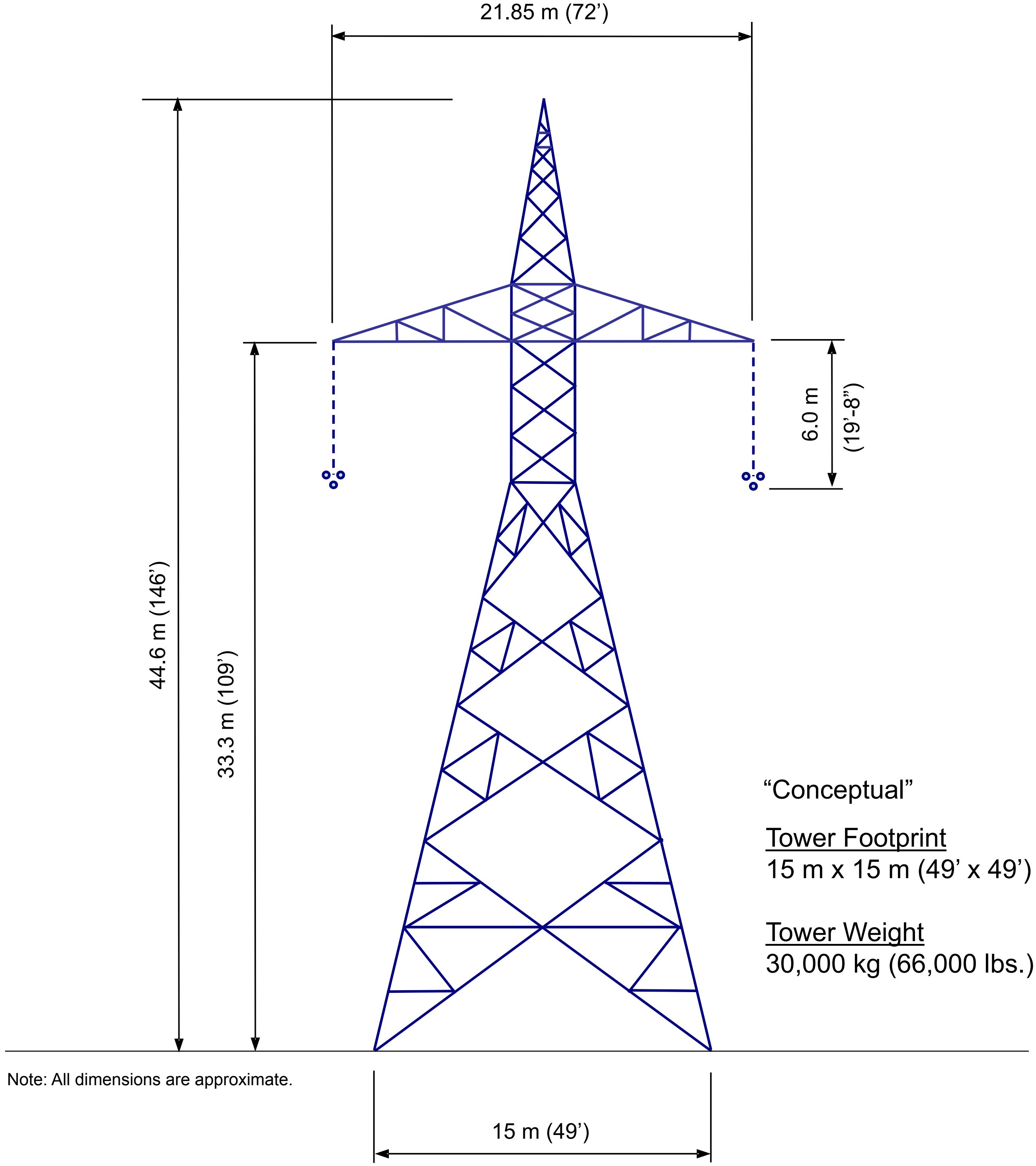


Figure 3.4-4:
Bipole III Hvdc Line, Typical Self-Supporting Dead-End Tower Configuration

3.4.1.2 Conductors and Insulators

Like other HVdc bipole transmission lines, the Bipole III structures will support two separate pole conductors. Each pole conductor will comprise a bundle of three sub-conductors. Under normal operating circumstances, the positive pole will be energized at +500 kV and the negative pole at -500 kV. In the event of a conductor outage, or a partial outage of the converter facilities, the line may be operated in monopolar mode, with one conductor energized at up to +/-500 kV and the current flow maintained by ground or earth return via the converter station ground electrodes. As well, for circumstances involving an electrode outage and a partial converter outage, Bipole III may be designed to accommodate its operation in metallic return mode with one pole conductor energized at up to 500 kV and the return current flow maintained through the second conductor.

The preliminary conductor design has been selected to satisfy electromagnetic performance requirements, and provides for two conductor bundles (one per pole), each comprising three separate metallic sub-conductors, or phase conductors, arranged in a triangular cross-section (see Figure 3.4-1 to Figure 3.4-4 for tower schematics). The sub-conductors will be 806-A4-61 AAAC (All Aluminium Alloy Conductor), equivalent to 1,590 MCM (thousand circular mils) ACSR (Aluminium Conductor Steel Reinforced). Each will have a diameter of 38.01 mm (1.50 in.) and will be separated from the two others by 457 mm (18 in). At each structure, each conductor bundle will be attached to one end of the structure cross arm using a string of porcelain or toughened glass insulator discs and associated hardware. Insulator strings on the tangent suspension towers in northern Manitoba will comprise 28 discs. Each insulator string will have a diameter of about 340 mm (13 in.) and a weight of approximately 10.5 kg (23 lb.) per disc. In central and southern Manitoba, each tangent suspension insulator string will comprise 25 discs with a diameter of 380 mm (15 in.) and a weight of 15.4 kg (34 lb.) per disc. Dead-end insulator assemblies, throughout the length of the line, will comprise 30 discs. The precise type (porcelain or toughened glass ball and socket) and number of insulator discs for the various structures will be subject to detailed engineering design.

At the structures, the clearance between ground level and the bottom of the conductor bundles will typically be approximately 33 m (108’ 3”) in the case of guyed tangent structures, 34 m (111’ 6“) in the case of self-supporting structures. Similar clearances will be maintained at angle and dead-end towers. Because of conductor sag, minimum ground to conductor clearance will generally occur at mid-span between structures. Actual clearance requirements vary with respect to land use circumstances and are further detailed in Section 3.4.5.2.

3.4.1.3 Optical Protection Overhead Ground Wire

Apart from the two conductor bundles, the towers will also support an optical ground wire (OPGW), strung between and attached to the peaks of the towers. The OPGW will serve both to provide grounding and lightning protection, as well as to transmit communications for Bipole III control and protection.

The fibre optic cable will be subject to splicing at intervals of approximately five km (3.1 mi.), in splice boxes mounted high on the transmission tower. Four repeater stations will be required at intervals of approximately 300 km (186 mi.) for regeneration of communications signals. Two repeater stations will be housed at the sites of existing transmission stations in the vicinity of the right-of-way (The Pas – Ralls Island and Portage la Prairie South), in order to take advantage of the existing communications facilities. The remaining two repeater stations will be housed in yet to be developed or new stand-alone sites located within the HVdc line right-of-way, and within 100 m of a transmission tower. One of these will be located in the southwest quarter of Section 3, Township 76, Range 1 west of the prime meridian, between Keewatinoow (about 290 km distant along the right-of-way from the proposed repeater station location) and The Pas-Ralls Island (about 336 km distant from the repeater station). The site is near Partridge Crop Lake, roughly 30 km southeast of Thompson. The second site will be located in the southwest quarter of Section 31, Township 30, Range 18 west of the prime meridian, between The Pas-Ralls Island (about 290 km distant along the right-of-way from the proposed repeater station location) and Portage South transmission station (about 271 km distant from the repeater station). This second stand-alone site is about five km southwest of the community of Winnipegosis.

Due to the different mechanical loading conditions, the OPGW conductor size will vary for different portions of the HVdc line. The overall diameter of the OPGW conductor will be approximately 13 mm (0.5 in.) in the northern portion of the line, versus 18 mm (0.7 in.) in the central and southern portions.

Repeater station sites will require an all-weather access road or a helicopter pad, an ac electric service pole line, and a property sufficiently large to develop a graded and gravel-surfaced area, approximately 33 m x 40 m in dimension, to accommodate parking and building areas. The building area will require a chain link perimeter fence and will house two structures, a back-up diesel generator (genset) building and a communications building. The generator structure, approximately 2.6 m x 3.5 m in size, will house a diesel motor, fuel tank and ac generator. The communications building, approximately 4.3 m x 11.0 m in area, will house communications equipment, lead acid standby batteries, and an electric toilet. A typical site layout is illustrated in Figure 3.4-5.

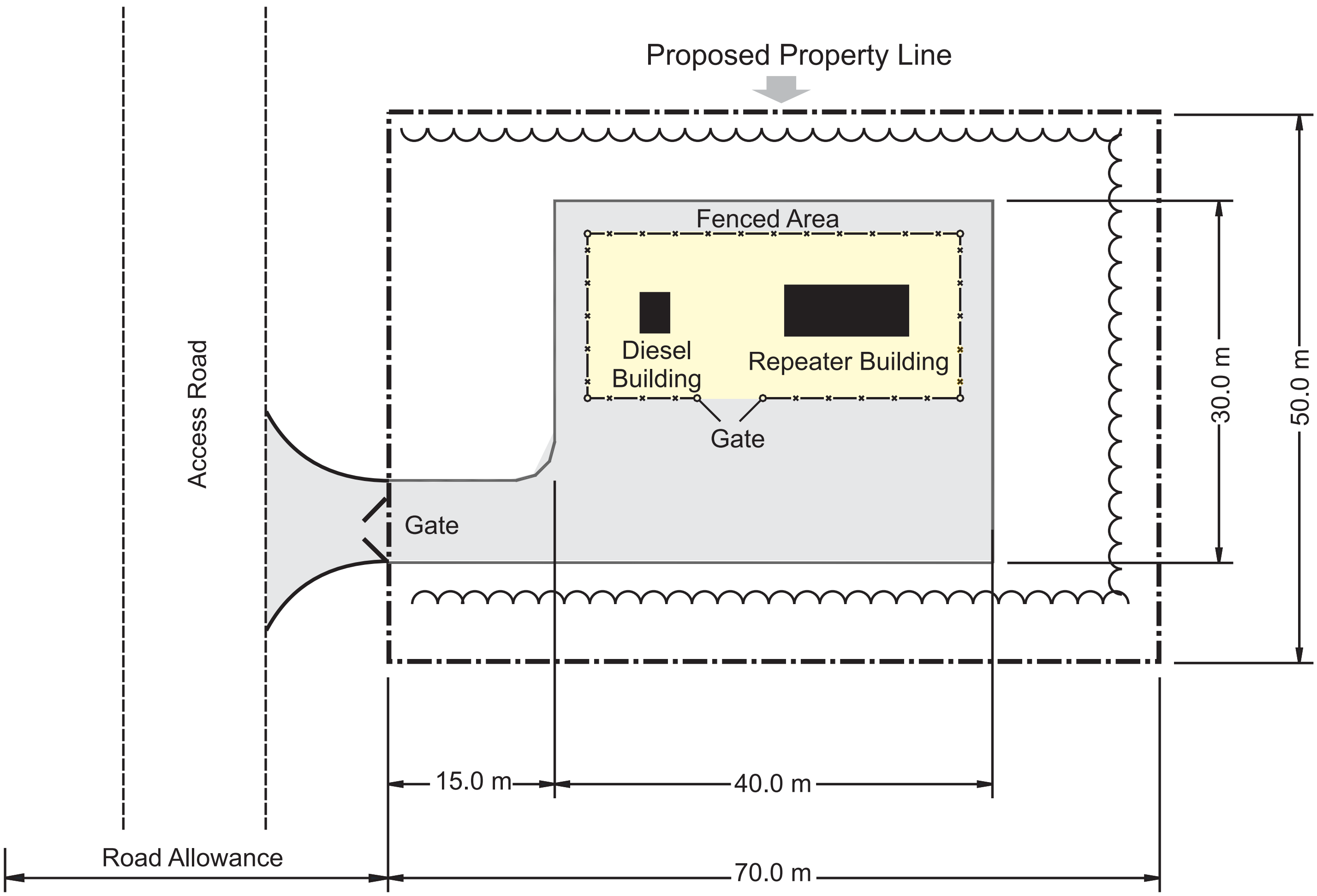


Figure 3.4-5:
Bipole III HVdc Line, Typical Relay Station Layout

3.4.2 230 kV Connections to the Northern Collector System

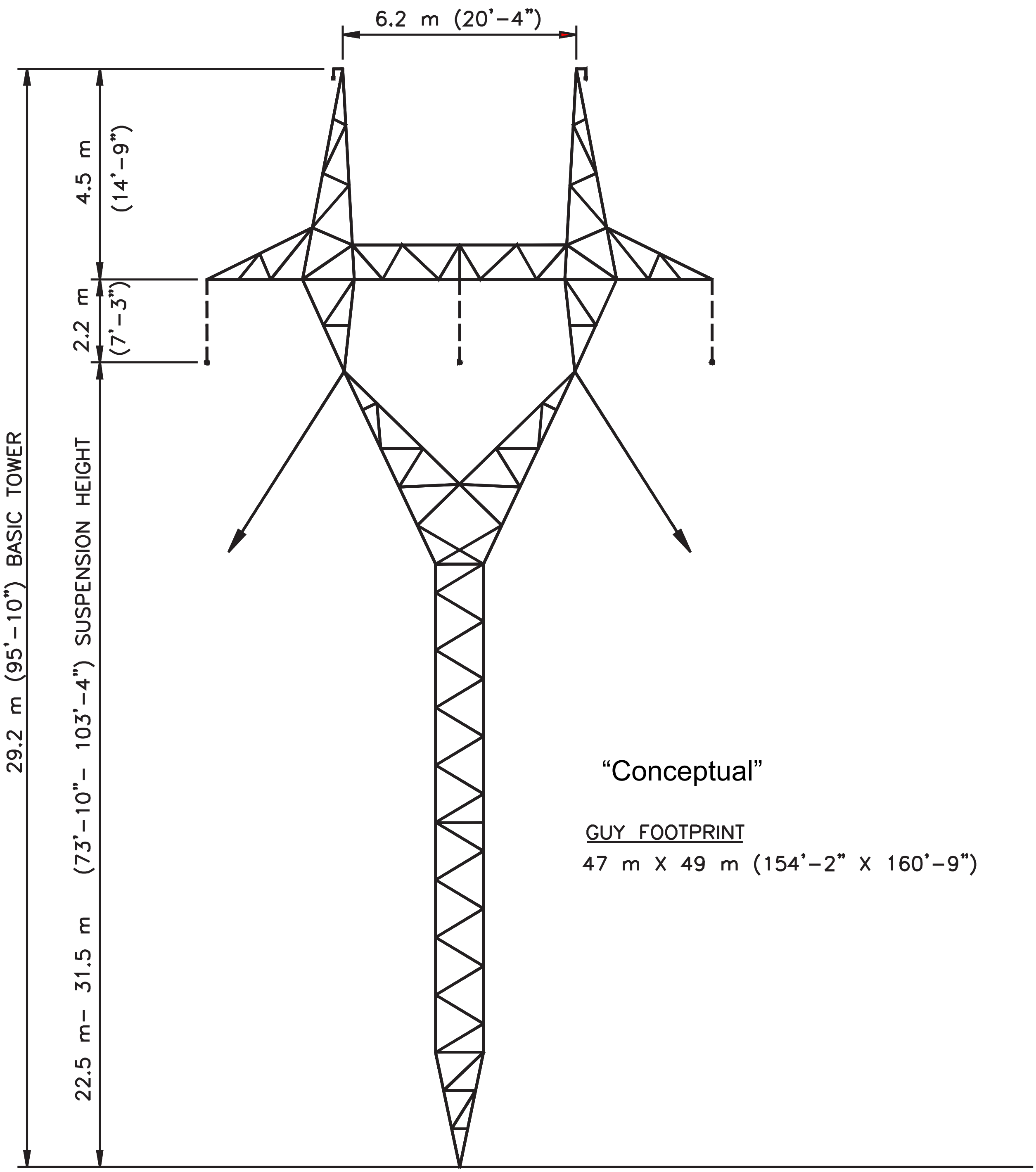
3.4.2.1 Structure Design and Location

Based on prior design experience in northern Manitoba, guyed lattice steel structures have been identified as the preliminary design standard for straight (tangent) sections of the 230 kV northern collector transmission lines. As for the northern portion of the Bipole III HVdc line, guyed structures provide flexibility for tower construction and maintenance in difficult foundation and terrain conditions. Self-supporting lattice steel structures will be used for all angle or dead-end tower locations.

Conceptual design for a typical guyed tangent structure is illustrated in Figure 3.4-6. The structure is based on a single point foundation, stabilized by four guy wires, placed diagonally to the route of the line, and with an overall rectangular footprint of 47 x 49 m (approximately 154 x 161 ft.). The tangent structures will be approximately 29.2 m (95' 10") in height. Taller structures with larger footprints will be used where warranted by land use or conditions.

Conceptual design for a typical angle structure is illustrated in Figure 3.4-7. The structure has four legs requiring individual foundations and a footprint approximately 13.7 m (45' 3") square. The typical structure height is approximately 30 m (98' 5").

The average span between structures will be approximately 420 m (1,380 ft.) resulting in approximately 2.4 structures per kilometre (about 3.8 structures per mile). Additional detail respecting span length and tower placement is provided in Section 3.4.5.1.



Note: All dimensions are approximate.

Figure 3.4-6:
Keewatinoow 230 kV Collector Lines, Tangent Tower Configuration

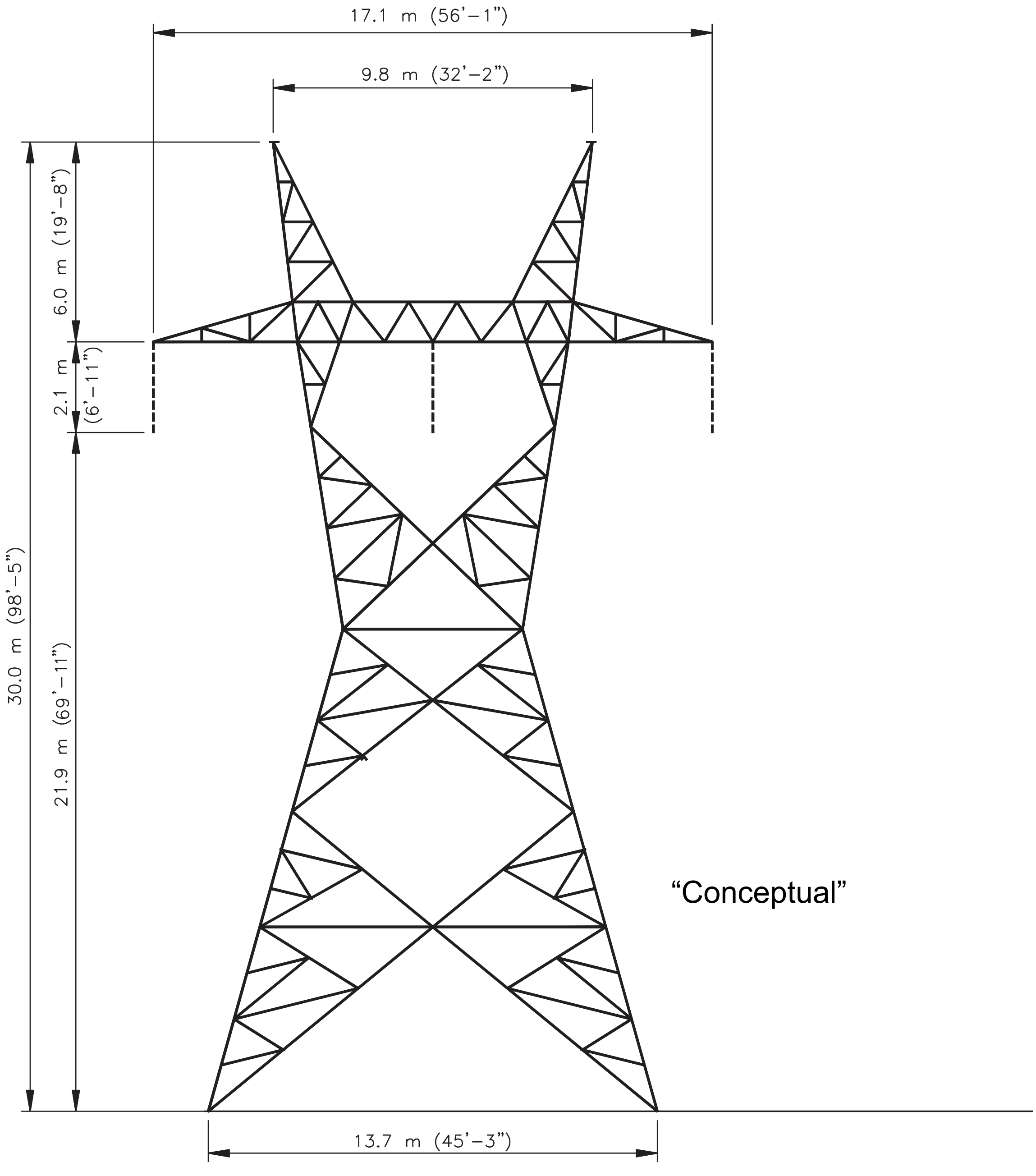


Figure 3.4-7:
Keewatinoow 230 kV Collector Lines, Dead-End Tower Configuration

3.4.2.2 Conductors and Insulators

The structures for the northern collector lines will carry a three-phase 230 kV ac circuit consisting of three ACSR (Aluminium Conductor Steel Reinforced) phase conductors. In the case of the Long Spruce-Keewatinoow line, the specified phase conductors are a twin bundle comprising two 795 MCM ACSR subconductors, each 28.1 mm (1.1 in.) in diameter. In the case of the Henday-Keewatinoow lines, the specified phase conductor is a single 1,590 MCM ACSR conductor, 39.3 mm (1.55 in.) in diameter.

The conductors will be insulated from the structures by insulator strings consisting of 12 ceramic insulator bells attached to the crossarms of the structures using suspension insulator string assemblies (see Figure 3.4-6 and Figure 3.4-7). Conductor clearances are discussed in Section 3.4.5.2.

3.4.2.3 Overhead Ground Wires

Two galvanized steel strand ground conductors having an overall diameter of nine mm (approx. 0.34 in.) will be strung between the two peaks of the structures to provide lightning protection.

One of the Henday-Keewatinoow 230 kV collector lines will have an optical ground wire (OPGW) strung between and attached to the peaks of the towers. The OPGW will serve both to provide grounding and lightning protection, and to transmit communications for line control and protection.

3.4.2.4 Switchyard Terminations

Details respecting termination of the new northern collector lines at the Keewatinoow Converter Station are provided in Section 3.5.2.2.

The Long Spruce-Keewatinoow 230 kV line will require the retrofit of one existing bay at the Long Spruce switching station. Termination of the four new 230 kV lines from Henday to Keewatinoow will necessitate expansion of an existing bay and development of one additional bay within the present fenced area of the Henday 230 kV switchyard. The related installations are similar and incremental to the existing development and operation of these facilities. No significant new or additional environmental effects are anticipated.

3.4.3 Henday-Keewatinoow Construction Power Line

Construction power requirements for the Keewatinoow Converter Station will require the extension of the existing 138 kV line KN36, which presently runs from Kelsey Generating Station to the Limestone Generating Station construction power station, to the proposed Keewatinoow construction power station (see Section 3.5.4.3).

3.4.3.1 Structure Design and Location

Guyed lattice steel structures will be used for straight (tangent) sections. Self-supporting lattice steel structures will be used for angle or dead-end towers. Structure geometry will be similar to that of the structures proposed for the 230 kV collector lines (see Figure 3.4-6 and Figure 3.4-7).

The average span between structures will be approximately 420 m (1,380 ft.) resulting in approximately 2.4 structures per kilometre (about 3.8 structures per mile). Additional detail respecting span length and tower placement is provided in Section 3.4.5.1.

3.4.3.2 Conductors and Insulators

The structures for the construction power line will carry a three-phase 138 kV ac circuit consisting of three 336 MCM ACSR (Aluminium Conductor Steel Reinforced) phase conductors, each 18.3 mm (0.7") in diameter.

Conductors will be insulated from the structures by an insulator string consisting of 8 ceramic insulator bells.

3.4.3.3 Overhead Ground Wires

Two galvanized steel strand ground conductors having an overall diameter of nine mm (approx. 0.34 in.) will be strung between the two peaks of the structures to provide lightning protection.

3.4.3.4 Station and Switchyard Terminations

Termination of the line at the Keewatinoow construction power station is described in Section 3.5.4.3.

3.4.4 230 kV Connections to the Southern Receiver System

As indicated in Section 3.3.5, injection of Bipole III power at Riel will require additional 230 kV connections to the southern receiver system. These will be provided by sectionalization of the existing R49R 230 kV transmission line at Riel. Related 230 kV switchyard implications at Riel are discussed in Section 3.6.2.2.

3.4.5 General Transmission Line Design Considerations

Detailed engineering design for transmission facilities will be undertaken after receipt of project environmental approvals, and following right-of-way acquisition and detailed field survey. Precise tower locations and required conductor-to-ground clearances will be established at that time.

3.4.5.1 Tower Spacing and Span Length

Special crossing structures will be necessary in specific circumstances (e.g., long span crossings of major rivers or roadways, or crossings of other transmission lines). Such structures will typically require greater height, greater strength and heavier construction, but will otherwise be similar to other suspension structures on the line.

Final structure locations will be determined on the basis of field surveys, including input from affected landowners/stakeholders, and will reflect detailed engineering and economic analysis with respect to span length, local soil conditions, topographic and geological features, and proximity to existing infrastructure.

Subject to detailed engineering analysis, tower location (tower "spotting") has been identified as a potential mitigative measure to reduce adverse environmental and aesthetic impacts. Location preferences identified in the course of the SSEA process (including more detailed pre-construction evaluation of the selected rights-of-way) will be included in the engineering analysis and, where technically and economically feasible, incorporated in the final structure placement decision during the pre-construction phase of the project.

3.4.5.2 Conductor Clearance

The new HVdc transmission line, the 230 kV collector lines, and the 138 kV construction power line will be designed to the following minimum conductor-to-ground clearances, which will meet or exceed C22.3 No. 1"Overhead Systems" values (shown in brackets in the table and elaborated in the points following the table).

Table 3.4-1: Minimum Conductor to Ground Clearances

Condition	500 kV HVdc Line	230 kV ac line	138 kV ac line
Farmland	13.2 m / 43 ft. (CSA 7.7 m / 25 ft.)	7.6 m / 25 ft. (CSA 6.1 m / 20 ft.)	7.3 m / 24 ft. (CSA 5.5 m / 18 ft.)
Roads, Highways and Street Crossings	13.7 m / 45 ft. (CSA 7.7 m / 25 ft.)	12.2 m / 40 ft. (CSA 6.1 m / 20 ft.)	10.7 m / 35 ft. (CSA 5.5 m / 18 ft.)
Railway Crossings	13.7 m / 45 ft. (CSA 10.7 m / 35 ft.)	12.2 m / 40 ft. (CSA 9.0 m / 30 ft.)	10.7 m / 35 ft. (CSA 8.4 m / 28 ft.)
Underground Pipeline Crossings	13.2 m / 43 ft. (CSA 7.7 m / 25 ft.)	7.3 m / 24 ft. (CSA 6.1 m / 20 ft.)	7.3 m / 24 ft. (CSA 5.5 m / 18 ft.)

- In circumstances involving land that is likely to be traversed by vehicles, the proposed HVdc line clearance of 13.2 m (43 ft.) or 13.7 m (45 ft.) is substantially more than the required minimum clearance for the HVdc conductors of 7.65 m (approximately 25.1 ft.) and 6.45 m (approximately 21.16 ft.) for pedestrians. In the case of the 230 kV lines, the proposed clearance of 7.6 m (25 ft.) or 12.2 m (40 ft.) exceeds the corresponding minimum of 6.1 m (approximately 20.0 ft.) for vehicles and 4.6 m (approximately 15.1 ft.) for pedestrians. Proposed clearances for the construction power line also exceed the specified minimum.

- For gas pipeline crossings, the proposed HVdc clearance of 13.2 m (43 ft.) exceeds the required minimum clearance of 7.65 m (approximately 25.1 ft.). In the case of the 230 kV lines and the construction power line, the proposed 7.3 m clearance exceeds the corresponding minimums of 6.1 m (approximately 20.0 ft.) and 5.5 m (approximately 18 ft.) respectively. In all cases, approvals will be obtained from the affected pipeline companies.

- For railway crossings, the proposed HVdc line clearance of 13.7 m (45 ft.) exceeds the required minimum clearance of 10.65 m (approximately 34.94 ft.). In the case of the 230 kV lines, the proposed clearance of 12.2 m (40 ft.) exceeds the corresponding minimum of 9.0 m (approximately 29.5 ft.). In all cases, approvals will be obtained from the affected railway companies.

Design parameters for provision of the necessary clearances are applied at the point of maximum conductor sag under heavy line loading conditions or at the maximum conductor operating temperature[11], whichever results in the least clearance.

HVdc line conductor clearances at water crossings will be in accordance with C22.3 No.1 standard and will range from 9.6 m (32 ft.) to 20.8 m (68 ft.) depending on the water body class. These crossings will also be subject to federal fisheries review, and to approval in the case of water bodies deemed to be navigable.[12]

In the case of crossings of other Manitoba Hydro transmission lines, necessary clearances will be determined internally. Vertical clearances between energized Bipole III conductors and the conductors of the line being crossed will be the same as those established for the existing Bipole I and II lines, and will exceed the minimum values specified in the CSA standard.

In the case of the HVdc line, the minimum ground clearance will be 13.2 m, based on the 2000 MW normal maximum line load and a calculated conductor summer operating temperature of 60 degrees Celsius. The same 13.2 m clearance will be specified over navigable Class 0, 1, and 2 waterways (respectively described as minor non-navigable; shallow or fast moving, canoes and paddle boats only; and shallow or fast moving, motorboats, no masted vessels) and will exceed the clearances specified by the CSA standard. Greater clearances over Class 3-6 waterways will meet those specified by the CSA standard. Clearances over highways and railways will be 13.7 m (45 ft.).

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[11] Manitoba Hydro uses a maximum conductor design temperature of 100 degrees C for all new ac transmission lines. However, the conductors on the Bipole III HVdc transmission line are expected to have an operating temperature of 60 C under normal 2000 MW load, and up to 90 C under extreme load conditions.

[12] CSA C22.3 No. 1 provides minimum requirements for vertical design clearances of transmission line conductors over navigable waterways for both ac and dc lines. Clearances for 230 kV lines range upwards from 7.3 m and depend on the category of waterway. Although the standard makes no specific provision for clearances over lands prone to flooding (e.g., the Red River flood plain in the Winnipeg area), it does refer to clearance requirements over farm land and over waters which are not navigable. In the case of 500 kV dc transmission lines, the required clearances are 7.65 m over farmland and 9.6 m over non-navigable waters. Manitoba Hydro has increased design clearances for Bipole III to 13.2 m (43.3 ft.) over land (i.e. exceeding the 10.65 m stipulated by CSA C22.3 No. 1 for clearances over highways and gas pipelines). This improves clearance (e.g., for large farm equipment) and will provide additional protection in the case of overland flooding.

3.4.6 Right-of-Way Requirements and Acquisition Policy

The proposed transmission line routes and related right-of-way requirements and lengths have been determined through a site selection and environmental assessment (SSEA) process, involving extensive community and public consultation (see Map 3-2 and Map Series 3-500, and chapters five and seven). Choice of the proposed routes reflects a careful balance between the general technical (engineering), economic and environmental implications of increased line length and the reduction of adverse effects through the avoidance of sensitive environmental features and land use conflicts.

Proposed right-of-way widths are based on operating considerations and related safety requirements and can vary for different line operating voltages and structure types. To allow for the effects of wind on the conductors (conductor swing-out), the right-of-way width must be sufficient, under severe wind conditions, to provide lateral separation between the conductors and any object located at the right-of-way edge. Right-of-way widths are also designed to avoid damage to adjacent property in the event of a structure failure and to reduce electric and magnetic field (EMF) effects, like radio interference and audible noise, which decrease with increasing distance from the lines. Related design parameters are based both on CSA standards, NERC/MRO/MISO reliability criteria, and internal Manitoba Hydro policy.

Right-of-way widths also reflect access requirements for line construction and maintenance. Access is typically by surface vehicles and equipment but may also involve helicopters, particularly in the case of northern lines. Access is generally made on or along the right-of-way (i.e., "down-line") from intersecting roadways. In cases of remote location or difficult terrain, however, it may be necessary to provide for secondary surface access to, or along, segments of the right-of-way.

3.4.6.1 HVdc Transmission Line

As illustrated in Map 3-2, the proposed Bipole III HVdc transmission line route is 1,384 km (860 mi.) in length.[13] The proposed right-of-way will be 66 m (216.5 ft.) in width along the entire length from the new Keewatinoow Converter Station to the Riel Station site (see Figure 3.4-8). The general character of the various portions of the line is described in the following table.

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[13] See footnote 10.

Table 3.4-2: HVdc Transmission Line Sections

Line Section	Northern (Keewatinoow to Mafeking)	Central (Mafeking to Langruth)	Southern (Langruth to Riel)
General Description and Tenure	Wilderness (generally Crown land)	Mix of woodland, wetland, pastures and cultivated farm land (Crown and private land)	Predominantly cultivated farm land (generally private land)
Structure Type	All Guyed	Mix of Guyed and Self-Supporting	All Self-Supporting
Approximate Length	745 km[14]	331 km	300 km

Some sections of the line, particularly in northern Manitoba, may require supplementary right-of-way area for marshalling or supply of construction materials (e.g., aggregate for tower foundations), or for construction and maintenance access. Such requirements, typically involving provincial Crown lands, cannot be identified until post-approval field surveys, detailed design, and construction contract arrangements are finalized. Any related right-of-way adjustments will involve application for and extension of the Crown Land Reservation required for the basic 66 m (216.5 ft.) right-of-way.

[14] See footnote 10.

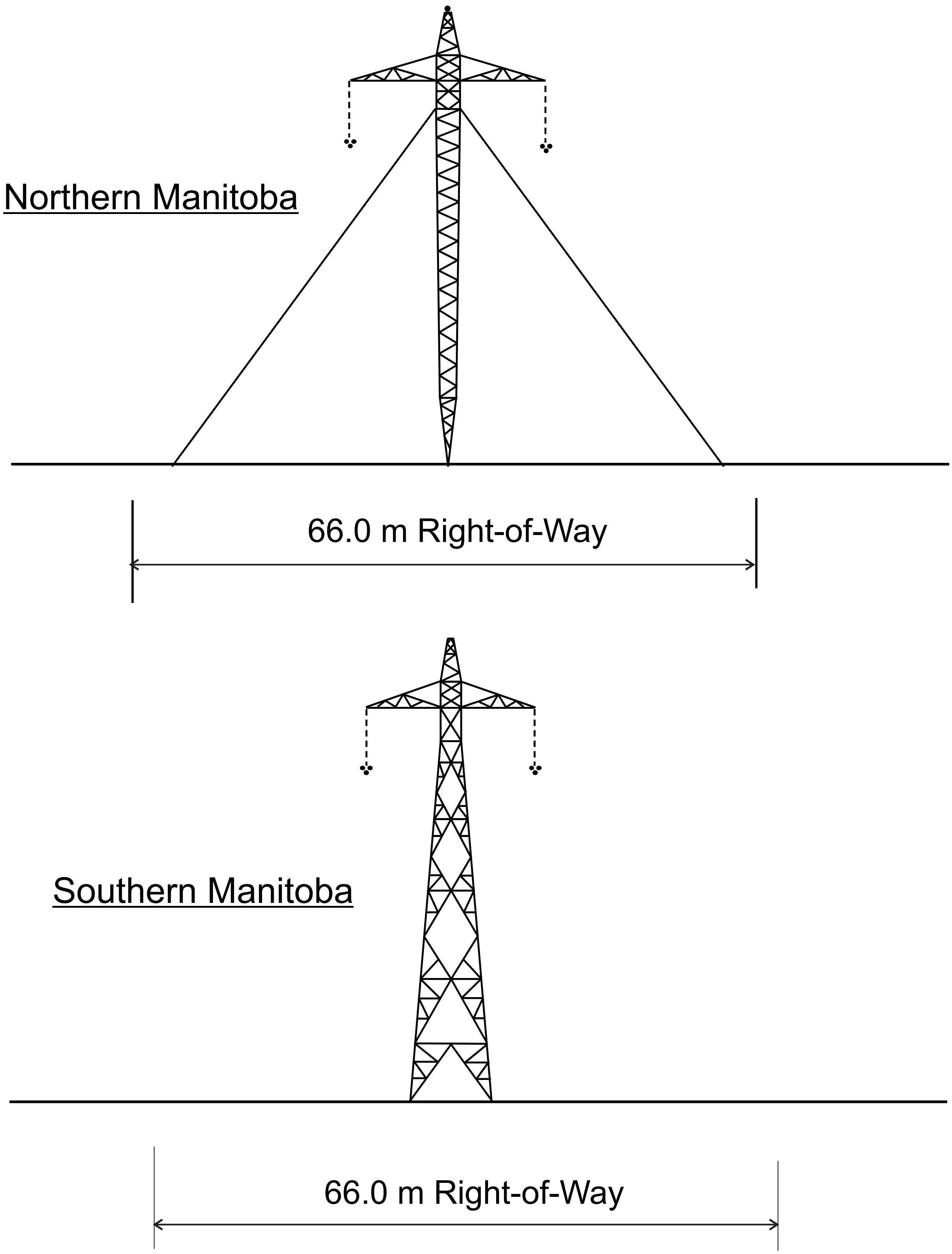

Figure 3.4-8:
Bipole III HVdc Line, Right-of-Way Cross-Sections

3.4.6.2 230 kV Connections to the Northern Collector System and 138 kV Construction Power Line

As indicated in Section 3.3.2 and illustrated in Map Series 3-500 and Figure 3.4-9, the new 230 kV connections to the northern collector system will include one line, approximately 55 km in length, between the 230 kV switchyards at the existing Long Spruce Generating Station and the new Keewatinoow Converter Station; four lines, each approximately 27 km in length, between the 230 kV switchyards at the existing Henday Converter Station and the new Keewatinoow Station; and extension of the 138 kV line KN36 from Limestone Generating Station to the proposed Keewatinoow construction power station (an extension similar in length to the four proposed 27 km Henday-Keewatinoow 230 kV collector lines). For most of the sections of these lines northwest of the Nelson River, between Henday and Keewatinoow, all six are proposed to share a common right-of-way, 310 m in width. The lines will be aligned 50 m apart, centre line to centre line, and 30 m from the right-of-way edge. In the shorter section immediately north from Henday, the five collector lines are proposed to share a common 280 m right-of-way (with line assignments as described previously) from their terminations in the Henday 230 kV switchyard, with the construction power line centred in a separate 60 m right-of-way to the east (extending from its termination in the Limestone construction power station).

As illustrated in Figure 3.4-9, the right-of-way for the Long Spruce line L61K, between Long Spruce and Limestone, will vary in width and configuration. In the section immediately south of Long Spruce, the line will be centrally located in an existing transmission corridor shared with six other lines (L41R, L42R, L43R, L48H, L47H and L46H). It will then be redirected easterly and north-easterly, running to the south of lines L48H, L47H and L46H in a right-of-way of varying width running parallel to the Henday-Radisson section of Bipole II. This configuration will continue across the Nelson River and on to the Henday Converter Station.

The rights-of-way for the six lines will variously traverse lands within the Town of Gillam and portions of the Split Lake and Fox Lake RMAs.

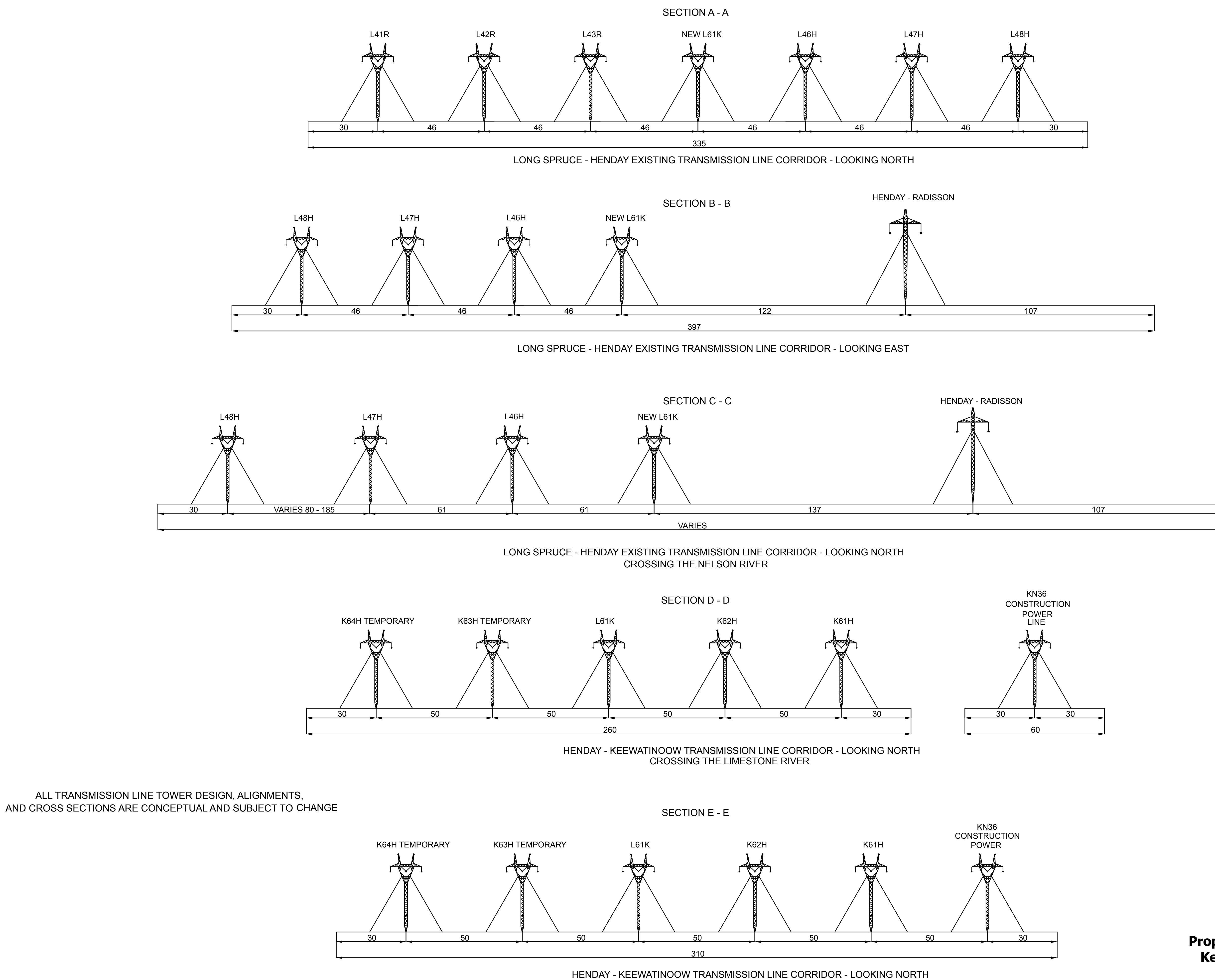

Figure 3.4-9:
Proposed Rights-of-Way Cross-Sections for Keewatinoow 138 kV Construction Power and 230 kV Collector Lines

3.4.6.3 Henday-Keewatinoow 138 kV Construction Power Line

In the area north of Limestone and Henday (as illustrated in Map Series 3-500 [map tile 3]), the 138 kV construction power line KN36 is proposed to be centred in a separate 60 m right-of-way located east of the combined Henday-Keewatinoow 230 kV line right-of-way.

The 60 m right-of-way is proposed to extend north to join the combined 230 kV right-of-way, at the point where the latter turns towards Keewatinoow Converter Station. Through this portion of the right-of-way, the KN36 centre-line will be located 30 m inside the eastern edge of the combined 310 m right-of-way width.

At the point where the 230 kV lines turn again to extend east into the 230 kV switchyard at Keewatinoow Converter Station, the construction power line will continue in a 60 m right-of-way to the proposed Keewatinoow construction power station.

3.4.6.4 Easement Procurement Procedures and Compensation

For those portions of the transmission lines where Manitoba Hydro does not presently own the right-of-way, easements will be acquired from the landowners who have legal entitlement to the land. In the case of privately-owned lands, easements are normally secured through negotiation of an agreement with the property owner. In the event that an agreement with private landowners is not negotiable, Manitoba Hydro has the right of expropriation. In the case of provincial Crown lands, Manitoba Hydro typically secures the necessary transmission line right-of-way through Crown Land Reservations, easement agreements or similar arrangements. In all cases, easement arrangements (whether on private or Crown land) are followed up by registration of an easement plan in the appropriate provincial land titles office.

The conventional terms of the right-of-way easement agreement provide that:

- Manitoba Hydro acquires the right to construct, operate, maintain and repair the transmission line within the right-of-way, while the landowner retains title to the land and, where applicable, continues to use the land in a fashion compatible with the transmission line right-of-way requirements.
- The private landowner can continue to use the land (i.e., for farming, grazing or other compatible uses) as long as the activity will not compromise safety requirements or hamper line operation. Landowners cannot plant trees, construct buildings, or place other structures within the easement area without prior approval from Manitoba Hydro.

- Manitoba Hydro personnel are permitted to enter and use the right-of-way for construction, inspection, maintenance or repair of the transmission line facilities.

In agricultural areas, compensation for use of private property is provided for in the terms of the easement agreement. Manitoba Hydro adopted an enhanced Landowners' Compensation Policy in August 2011 for transmission lines of 500 kV or greater to reflect the importance of very high voltage lines to Manitoba Hydro's system, and to recognize the landowners who provide the property rights for these facilities. Under this policy, landowners whose property is being intersected by the 66 m right-of-way for the Bipole III HVdc transmission line will receive up to three types of payment:

- A one-time payment equivalent to 150% of fair market value for the land area within the required right-of-way (easement or land payment).
- A lump sum payment for having to work around structures, if the land is being farmed (structure impact payment). Payments are made for each structure on a land parcel.
- Additional payment, up to 60% of fair market value depending on the specifics of each property, for ancillary impacts such as disturbance, injurious affection, or any other special value considerations (disturbance payment).

The structure payment, determined with the assistance of Manitoba Agriculture, Food and Rural Initiatives, takes into account the potential cost to the landowner of:

- Crop losses on land permanently removed from production.
- Reduced productivity in the area of overlap around each structure with respect to its effect on normal cropping practice (added machinery costs).
- The additional time required to manoeuvre farm machinery around each structure (added labour costs).
- Double application of seed, fertilizer and chemicals in the area of overlap around each structure (added fertilizer, seed, and herbicide costs).
- Weed control around each structure.

Structure payments to private landowners are made on a one-time basis as a lump sum payment. Actual payment amounts are in accordance with calculations which are updated and adjusted semi-annually. The payment calculations take into account the effect of the specific structure (e.g., structure type and location with respect to property lines) and the nature of the affected land use (e.g., row crop activity is subject to greater compensation than cereal crop, seeded hay land, or unimproved pasture or hay land).

If the landowner suffers crop loss or property damage during the construction period, or as a result of subsequent maintenance or repair work, a Manitoba Hydro property agent will investigate the damage claim and, where appropriate, arrange for repair by Manitoba Hydro or for settlement. This provision includes damage to crops (including hay crops), drains, culverts, fences and access roads, as well as damage caused by soil compaction and rutting.

3.4.7 Community Development Initiative

In association with the Bipole III Transmission Project, Manitoba Hydro has developed the Community Development Initiative (CDI).

In the past, Manitoba Hydro has heard from communities that transmission projects do not provide any benefits to them. The CDI will provide real and direct benefits to communities in the vicinity of the Bipole III Project. It is anticipated that approximately 60 communities will be eligible for the CDI, including First Nations, community councils, rural municipalities, and incorporated towns and villages.

The CDI funds are to be used to support community development projects that benefit a broad segment of the community. Manitoba Hydro envisions that this would include projects in the areas of environmental sustainability; resource rehabilitation and development; cultural and social support and development; training, employment and economic development; and community infrastructure development.

Annual payments to eligible communities will begin upon receipt of regulatory approvals for the Bipole III Project and will continue for 10 years, with the potential for renewal. The benefits provided by the CDI program will total approximately four to five million dollars annually over the 10 year period.

3.4.7.1 Community Development Initiative Eligibility Criteria

Those eligible to receive funds from the Community Development Initiative are as follows:

Aboriginal and Northern Communities

First Nations, incorporated northern towns, and communities recognized under the Northern Affairs Act (Northern Affairs Community Councils) will be eligible for CDI payments when:

- The Resource Management Area (RMA) or Registered Trapline Area (RTL) associated with the community is traversed by the Bipole III facilities; or

- The community is located within 25 km of the Bipole III facilities, for communities without a specifically associated RMA or RTL.

Municipal Act Communities

Rural municipalities which are traversed by the Bipole III facilities will be eligible for the CDI, as well as incorporated towns and villages within these traversed municipalities that are located within 25 km of either side of Bipole III facilities.

3.4.8 Right-of-Way Clearing and Transmission Line Construction

In total, clearing and construction of the Bipole III HVdc transmission line will require five years to complete. The shorter 230 kV connections to the northern collector system will require less time to construct individually but, with the several lines involved, it is expected that their overall construction will involve the four winter seasons of 2012-2013 through 2015-2016. Clearing and construction activity for these lines and for the northern portion of the HVdc line will be confined to winter months. Construction in southern Manitoba can occur at any time during the year, subject to avoidance of conflict with agricultural use or to payment of compensation for crop damage if conflict is unavoidable due to schedule constraints.

3.4.8.1 Right-of-Way Clearing

Prior to construction, the right-of-way and required easements will first be surveyed and flagged to establish the line alignment. Clearing and disposal of trees on the proposed right-of-way will be undertaken in advance to facilitate construction activities. Right-of-way clearing will be subject to standard environmental protection measures which have been established in association with Manitoba Hydro transmission line construction practices, as well as the project-specific Environmental Protection Plan.

With the exception of environmentally sensitive areas, the cleared right-of-way width for the guyed structures used in the northern portion of the lines will be 62 m (203 ft.) within the total 66 m (217 ft.) right-of-way. For the southern portion of the HVdc transmission line (involving use of self-supporting towers) the cleared width will generally be 45 m (148 ft.) (see Figure 3.4-10). Clearing will be modified in environmentally sensitive areas (e.g., river and stream crossings) and will be subject to a variety of pre-determined but adaptable environmental protection measures.

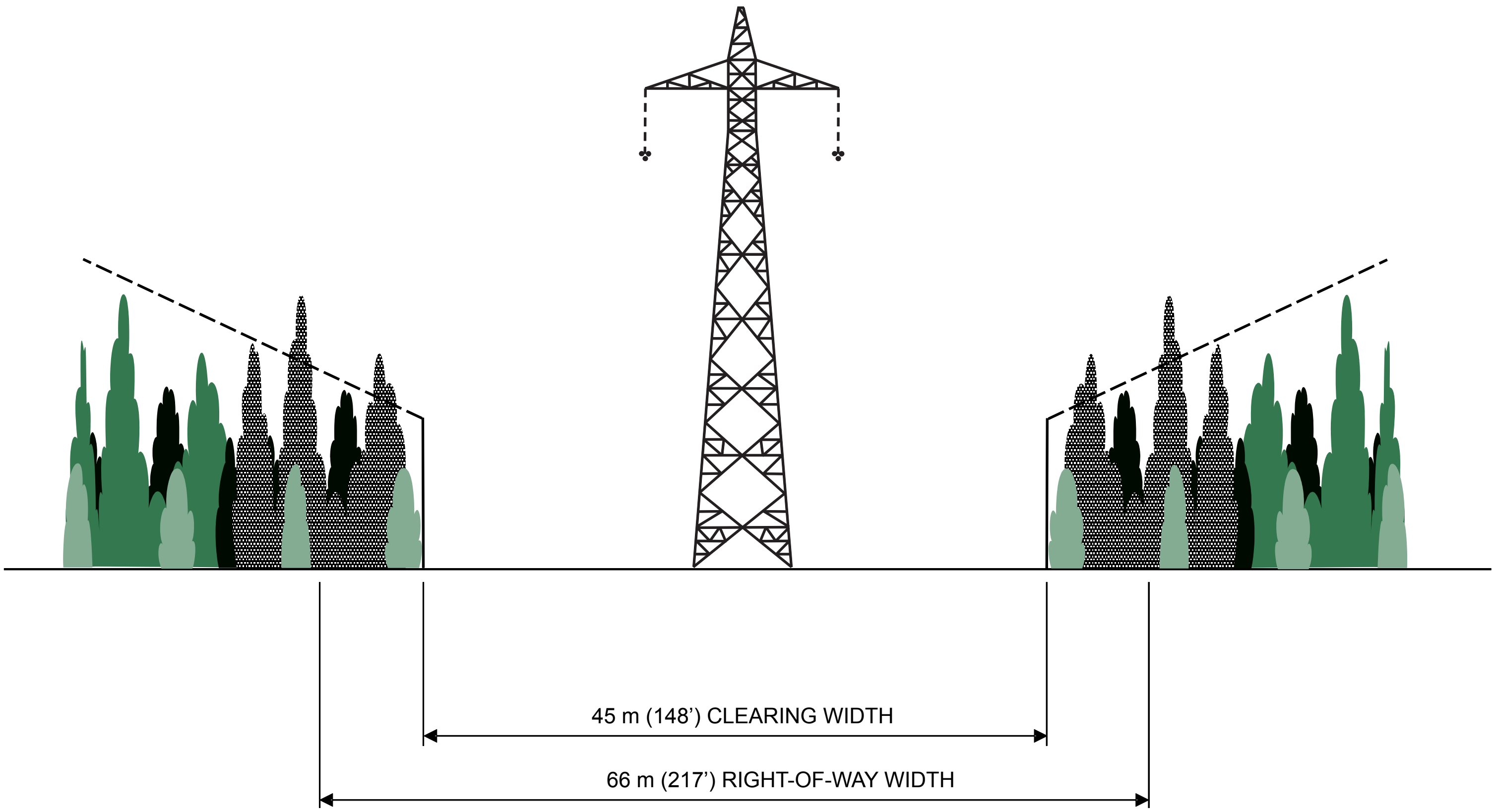

Figure 3.4-10:
Bipole III HVdc Line, Right-of-Way Clearing Requirements for Self-Supporting Suspension Structures

For the northern collector lines, the single Long Spruce 230 kV transmission line will involve approximately 58 m of clearing within the 60 m (about 197 ft.) wide right-of-way. For the shared right-of-way corridors to be occupied by the 230 kV collector lines and the 138 kV construction power line (e.g., the 310 m right-of-way Henday and Keewatinoow) the entire right-of-way will be cleared.

Clearing requirements for the new transmission line rights-of-way will also require selective clearing of "danger trees" beyond the right-of-way. Such trees could potentially affect the function of the transmission line or result in safety concerns, and are normally identified during initial right-of-way clearing activities and removed.

A variety of methods are available for right-of-way clearing. Typically, these include conventional clearing done by "V" and KG" blades on tracked bulldozers, mulching by rotary drums, selective tree removal by feller bunchers (e.g. for removal of danger trees with minimal adverse effect to adjacent vegetation and trees) and hand clearing with chain saws in environmentally sensitive sites. Final clearing methods will be determined on the basis of detailed survey of the transmission line routes, and site-specific identification of environmentally sensitive features. Trees within the right-of-way will be cleared to a maximum height of approximately 10 cm (four in.) above the ground. Ground vegetation will not be "grubbed" except at tower sites, where the foundation area will typically be scraped to allow unencumbered access for equipment and safe walking areas for workers.

Disposal of cleared vegetation typically involves a variety of options including piling and burning, mulching, collection and secondary use by local communities (e.g. firewood), or salvage and marketing of merchantable timber resources if feasible. The final decision for disposal of vegetation will be determined by the method of clearing used and the environmental license conditions applied to the project.

Apart from removal of danger trees along the right-of-way edges, clearing procedures are normally confined to the right-of-way. Where access outside the right-of-way is necessary (e.g. by-pass trails) and has not been identified in advance[15], supplementary approvals will be obtained from Manitoba Conversation (e.g., work permits and timber permits relating to activity on provincial Crown lands) or from individual land owners.

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[15] Manitoba Hydro is attempting to reduce supplementary approval requirements by identifying access requirements outside the line right-of-way in advance of construction. This will entail use of LiDAR/DEM remote sensing technology (Light Detection and Ranging/Digital Elevation Model), as well as establishment of an initial access road inventory, so as to minimize clearing requirements by taking advantage of existing cut lines or trails.

To facilitate such supplementary arrangements and avoid construction delays, every effort will be made to identify related access requirements as soon as possible during the clearing process.

3.4.8.2 Transmission Line Construction

Transmission line construction involves several stages: installing tower foundations and anchors, assembling and erecting structures, and stringing of the conductor and overhead ground wires. The different stages entail the use of various types of vehicles and heavy equipment, and involve a range of skills and trades.

Although both structure and conductor designs and dimensions are subject to final detailed design, and will differ between those for the HVdc line and those for the 230 kV lines and the 138 kV construction power line, the basic concepts and construction procedures will be similar for comparable terrain and soil conditions. The principal distinctions will be between construction in the north, where difficult soil and terrain conditions are more prevalent, and in the south where construction conditions are generally less constrained. Unless otherwise specified, the following descriptions are based on preliminary design analysis for the HVdc line and on prior experience with similar projects and conditions. The dimensions provided for the various structure and foundation types are subject to revision in the course of final design and confirmation of field construction conditions.

- For the guyed suspension structures to be used in northern and central non-agricultural areas, design and construction of the central foundations will vary based on soil and terrain conditions. In surface or shallow bedrock conditions, the lattice structure will be founded on a steel column fixed directly to the rock by four steel dowels drilled and grouted into the rock. In more conventional soil, or in swamp conditions, the structures will be founded on timber or concrete mats, sized to provide adequate bearing support (typically in the order of 1.8 m [six ft.] square) and buried to a depth of approximately three m (10 ft.). Depending on soil conditions, deep foundations (i.e., piles) are also an option. Each of the four guy wires for these structures will be secured at ground level either by drilled and grouted anchors, in the case of rock conditions or, in the case of soil foundation conditions, by overburden grouted anchors, mat anchors, or other deep anchors (e.g., screw anchors).
- The self-supporting suspension lattice steel structures, to be used in central and southern Manitoba, will involve either mat or pile foundations. Mat foundations will typically be three m (9.8 ft.) square by three m (9.8 ft.) deep. Pile foundations will involve four individual piles or pile groups, one for each leg of the structure. Piles

may be cast-in-place concrete, generally 900 mm (36 in.) in diameter and approximately 10 m (33 ft.) in length, or steel pile groups with a welded cap (similar in footprint to concrete piles).

- Guyed triple-shaft dead-end structures, for use in northern and central sections of the line, will be founded similarly to guyed suspension structures but will require a separate foundation for each of the three vertical members. In the case of mat footings, their dimension will be in the order of 1.8 x 3.6 m (six x 12 ft.).
- Self-supporting angle and dead-end structures will also have individual foundations for each of their four legs. For bedrock foundation conditions in northern Manitoba, reinforced concrete or steel pedestal foundations will be used. These will be approximately 1.1 x 1.5 m (about 3.5 x five ft.) in horizontal dimension up to a depth of 1.5 m (six ft.), and fixed directly to the rock with steel dowels. Conventional soil or swamp conditions in the north will typically involve mat foundations, sized to provide adequate bearing area and approximately three m (10 ft.) below ground surface. In central and southern Manitoba, either mat or pile foundations will be used. Mat foundations will typically be four m (13.1 ft.) square by three m (9.8 ft.) deep, for each leg of the structure. Pile foundations will typically consist of four 1200 mm (48 in.) diameter concrete piles approximately 11 m (36 ft.) in depth, or steel pile groups with a welded cap (of similar footprint to concrete piles). Dimensions will be subject to detailed design and will vary for specific foundation conditions.
- Where necessary (e.g., in the case of organic soils), foundation excavations will be backfilled with approved soil or granular material and the excavated organic material mounded to provide additional cover over the foundations. Where wet or unstable soil conditions are encountered, the raft foundations may be installed inside a large diameter steel culvert section to provide additional stability. Such requirements may be limited to guyed tangent or suspension structures.

Different contractors may have different preferences as to structure assembly. Some may choose to assemble structures at each tower site and then erect them by crane. Others may choose to assemble the structures at a central marshalling yard and then either truck the structures to the site and erect them by crane, or use a helicopter to fly the towers to the site and erect them.

Insulator strings are attached to the structure cross arms prior to tower erection. The insulators will separate the conductors from the structures. Conductors are transported to the site in reels, then suspended from the insulator strings, and tensioned by machine to provide the ground-to-conductor design clearances specified at the midspan points of maximum sag. Each reel holds about 3,200 m (10,500 ft.) of conductor. The conductor ends are spliced by use of implosive sleeves.

Access for construction (and subsequent line maintenance) activities will generally occur along the right-of-way using existing public access roads or trails wherever possible. This enables maximum use of existing road access and minimizes the requirement for the development of new temporary trail access, and the associated environmental effects. Minor deviations from the right-of-way may be necessary in severe terrain conditions. Unless required for on-going maintenance, the right-of-way access trails will not be regularly maintained post construction.

Construction activity and access requirements will be subject to standard environmental protection measures[16] associated with Manitoba Hydro's transmission line construction practices. These will be identified and cross-referenced in site-specific Environmental Protection Plans (to be submitted with the Environmental Impact Statement for review and approval), and adherence to them will be stipulated in related contract specifications.

At waterway crossings, structures will be located as far back from the water's edge as possible, to maximize stability and prevent bank erosion. Construction procedures used at each required crossing will be based on site-specific considerations, such as existing soil and subsurface conditions, biophysical sensitivities, and operational requirements. Site-specific construction techniques will be developed where necessary for difficult terrain or steep slope conditions. Contractors will be required to develop site-specific sediment and erosion control plans.

Equipment access and construction activities will be carried out in a manner that will minimize disturbance to shorelines. Vegetative buffer zones will be retained along the shorelines wherever possible. The precise character and extent of buffer zones will be determined on a site-specific basis. In general, existing (and potential future) tree heights will govern the amount of clearing that must be done in buffer zones to ensure the safe operation of the line.

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[16] Environmental Protection; Guidelines Construction, Operation and Decommissioning; Manitoba Hydro Work Sites and Facilities; Manitoba Hydro, November 2007.
The reference is one of several Manitoba Hydro documents which identify standards and protocols cited and/or included in previous license applications for transmission projects. Related procedures are also described in the corporation's Hazardous Material Management Handbook (Manitoba Hydro, 2003), In the case of Bipole III, related concerns are being addressed in the Environmental Protection Plan, a draft of which is being submitted as part of the license application.

Apart from a yard proposed to be developed at the Riel Station site for marshalling of tower steel requirements for the Project (see section 3.6.4.4), marshalling yards will typically be established near the transmission line route for the storage of construction materials and equipment, and for further deployment to the construction site. The exact number and location of marshalling yards will be determined during the course of developing detailed construction specifications and contract arrangements. Granular materials required for line construction (e.g., concrete and granular fill) will generally be purchased from local suppliers. Disposal of solid waste materials and refuse will generally be transported off-site and will rely on local available services and infrastructure. Accordingly, existing and appropriately licensed operations will be utilized. Material supply and waste handling activities will be subject to standard environmental protection measures associated with Manitoba Hydro transmission line construction practices and to the Environmental Protection Plan requirements.[17]

Aggregates required for use in foundation construction will generally be transported from established and appropriately licensed sources off-site. Suitable material for backfill of excavated organic soils may be hauled from newly developed borrow areas along the right-of-way. Potential borrow locations have not been specifically identified at this time. Typically, borrow pit locations will be located along the right-of-way to minimize environmental disruption, haul distances and cost. Where suitable sources are not available along or close to the right-of-way, nearby deposits may have to be identified and the surrounding brush cleared to gain access to the line. Normally, rubber-tired dump trucks are used to transport gravel and fill materials. Selection, development and reclamation of new borrow sites will be undertaken in accordance with provincial regulations and with the approval of the local Natural Resources Officer and local government authorities. Where borrow pits are required, exposed soils will be reclaimed by promoting re-growth of native vegetation and other mitigation measures in accordance with The Mines Act.

Any use of explosives during transmission line construction (e.g., in borrow pit operations, foundation installation, conductor splicing, etc.) will be made in accordance with all applicable legislation and regulations, including acquisition of permits and compliance with all conditions set by Manitoba Conservation.

Transmission line construction activity will extend to implementation of site-specific mitigation measures, identified in the course of final survey and design. Such measures

[17] Ibid. see footnote 16.

can include construction safety measures at infrastructure or waterway crossings, and provision for control of induced voltage and current effects within CSA and industry standards (e.g. in the case of railways, communications facilities, pipelines, metallic fences, etc.). Such measures will be coordinated with the appropriate government and corporate authorities, and with individual landowners.

3.4.8.3 Accommodations and Construction Camps

Clearing and construction workers on the HVdc transmission line may be housed in mobile construction camps, or where feasible and practical, in suitable accommodations available in local communities. Where mobile construction camps are required, these will typically include sleeper units, a wash car, cooking and eating trailers, offices and a machine/parts shop. Mobile construction camps are generally relocated along the right-of-way as the various construction activities proceed. Camp size will be in the range of 10 to as many as 200 workers, but will vary according to the activity, contract size and labour force requirements. Clearing camps are generally smaller and may be moved more frequently than construction camps.

Mobile Camps are generally located in well-drained areas within the right-of-way. Additional clearing may be required, however, to facilitate vehicular traffic, transportation and distribution of construction materials, installation of temporary maintenance shops, kitchens, sleeping quarters, offices, etc. Specific field camp locations will be determined after final project planning and design are completed. As construction moves down the line, the camps will be relocated at intervals of approximately 60 to 80 km (about 35 to 50 mi.) to minimize travel time for workers.

Potable water will generally be transported to the camps. Subject to suitable soil conditions and drainage, and to approval of the Natural Resources Officer, wastewater will typically be disposed of in pits constructed for that purpose and sited to minimize the potential for surface or groundwater contamination. All work camp sites will be restored to pre-project condition with the exception of vegetation, which will be allowed to regenerate naturally on the sites.

For the 138 kV construction power line and the 230 kV northern collector lines, suitable workforce accommodations are expected to be available initially at the start-up construction camp that will be required for the construction of the Keewatinoow Converter Station. At minimum, this will facilitate contractor development of the mobile camp facilities which will otherwise be required for accommodation of the transmission line workers, as previously described for construction of the HVdc line.

3.4.8.4 Contract Procedures and Workforce Requirements

Precise workforce numbers will be dictated by contract negotiations, the methods of clearing and construction to be undertaken, and the sequencing of project components to be completed.

Based on experience with previous transmission line projects in northern Manitoba, the workforce for clearing and construction will be cyclical and seasonal in nature. Northern clearing and construction activities will occur during winter months from November to April. It is expected that construction of the northern portion of the HVdc line will be divided into four line segments. Clearing and construction of the first three segments will proceed more or less concurrently over the period 2012-2015. The fourth will be cleared and constructed in the period 2014-2017. The remainder of the line will also be divided into four segments, two in the central Manitoba zone (likely to be predominantly winter construction) and two in the southern zone. The central and southern sections are planned to be concurrently cleared and constructed in the period 2014-2016.

Clearing activities for the HVdc line will involve a range of skills, generally less specialized than for the construction phase. Although the number of positions will fluctuate, job positions for clearing might be in the range of 15 to 40 per transmission line segment. Clearing for the first three segments is expected to take place in the winter seasons of 2012-2013 and 2013-2014. Clearing for the fourth is planned for the winters of 2014-2015 and 2015-2016. Clearing requirements for the southern portion of the line are expected to be confined to the two segments in central Manitoba and to involve smaller crews of approximately 20 workers each, working in the winters of 2013-2014 and 2014-2015.

Transmission line construction activities will variously involve the construction of winter access trails, materials transportation, structure surveying, installation of anchors and foundations, assembly and erection of structures, stringing and clean-up. Various skill sets will be required for each activity.

Although the numbers of positions will fluctuate throughout the construction period, total positions per segment, for the northern portion of HVdc line, are expected to range from 10 to as many as many as 200 workers at peak periods. Construction of the first three northern segments is expected to take place in the winter seasons during the period 2013-2015. Construction of the fourth northern segment is planned for the period 2015-2017.

Construction of the southern portions of the line is expected to involve smaller crews, peaking at 150 workers per segment. The central Manitoba segments are expected to be constructed separately in 2014-2015 and 2015-2016. The two southernmost segments will be constructed separately in 2014 and 2015.

The 2016-2017 construction seasons will be reserved for risk management, and may be used for catch-up and clean-up of any line portions (north, central or south) not completed in the 2013-2016 time frame. The HVdc line must be available by April 2017 for commissioning of the poles.

Clearing and construction of the 138 kV construction power line is planned for the winter of 2012-2013 and is expected to require a crew of between 50 to 150 workers.

Clearing and construction of the five 230 kV connections from Keewatinoow to Long Spruce and Henday is planned for the winters 2012-2013, 2014-2015 and 2015-2016. Workforce requirements are expected to range from 20 to 150 workers over the construction period.

Construction of the transmission line components of the Project will be subject to a collective bargaining agreement.[18] Where applicable, individual transmission line construction contracts will specify allocation of employment opportunities and hiring preferences.

Total transmission line employment (project-direct in Manitoba), including both the HVdc line and the northern collector and construction power lines, has been estimated to total 1990 person-years during the construction phase.

3.4.9 Transmission Line Operations and Maintenance

Transmission lines are designed to operate 24 hours per day, year round. Actual transmission of electricity will vary with demand and electrical load conditions.

3.4.9.1 Electric and Magnetic Fields and Corona

Operation of any transmission line involves the production of electric and magnetic fields (EMF) and corona discharges. Corona discharges, in turn, may result in audible noise and low frequency electrical interference. The level of these will vary with time, subject to variations in the operating mode and loading conditions of the line and, as

[18] Transmission line contractors will generally be required to enter into the Manitoba Hydro Contracted Transmission Line Collective Agreement, the content of which has been worked out between Manitoba Hydro, Local Union 2023 of the International Brotherhood of Electrical Workers, and Local Union 987 of the International Union of Operating Engineers. Individual contracts may also contain specific provisions respecting allocation of employment opportunities and hiring preferences.

well, to final line design, conductor condition, and such external considerations as meteorological conditions.

Estimated levels of these emissions and related effects have been based on mathematical modeling and on comparison to corresponding levels associated with other existing lines in the Manitoba Hydro system. The studies included both the HVdc line and the 230 kV ac lines required for connection to the northern collector system.[19]

In the case of the HVdc line, modelling included dc EMF, audible noise (AN) and radio interference (RI) levels associated with a representative range of right-of-way configurations, operating scenarios, and loading conditions. In the case of the ac transmission lines, modelling included ac EMF, AN, and RI levels for the right-of-way configuration planned in the shared transmission corridor between Henday and Keewatinoow. In addition, background measurements were made of dc and ac EMF, air ions, and charged aerosols, both in everyday Manitoba environments and in the vicinity of the existing Bipole I and Bipole II HVdc transmission lines.

In the case of the calculated levels for the proposed HVdc transmission line, the studies found that "the levels of magnetic fields, electric fields, AN, RN, and small air ions outside the right-of-way of Bipole III are all below limits recommended by provincial, national and international agencies. "No guidance for the ion current density was identified, but compliance of Bipole III with both electric field and small air ion recommended limits indicates that this parameter, computed as the product of the electric field and small ion concentration, is not of (additional) consequence".[20]

With respect to the various ac transmission lines included in the project, the studies further concluded that "The levels of EMF, AN, and RN of the proposed 230-kV and 138 kV transmission lines, that will provide power to Keewatinoow Converter Station and Bipole III from existing generation sources are all below provincial, national, and international guidelines".[21]

Concerns respecting the potential for environmental effects (e.g., health effects, electrostatic and electromagnetic induction effects, and communications interference arising from EMF and corona emissions) were raised in the course of the public

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[19] E^x^ponent, Modelling of the Electrical Environment for Proposed DC and AC Components of the Bipole III Project, prepared for Manitoba Hydro, March 31, 2011; E^x^ponent, Draft Modeling of the Electrical Environment for Proposed DC Components of the Bipole III Project, prepared for Manitoba Hydro, May 25, 2011.
[20] Ibid. E^x^ponent March 31, 2011, p. 36, and May 25, 2011, p. 62.
[21] Ibid. E^x^ponent March 31, 2011, p. 37.

consultation program for the project. These concerns, together with assessment of any potential effects and related mitigation measures, are discussed in chapters five and eight of this Environmental Impact Statement.

3.4.9.2 Line Maintenance Procedures

Manitoba Hydro conducts inspection of all its transmission lines and electric transmission corridors on an annual basis. The inspection encompasses both facilities (right-of-way, right-of-way access, structures and wires) and vegetation conditions. Following the inspection, all pertinent information and findings are entered into a transmission line management database program. From this central database, annual maintenance activities are identified and tracked. The annual patrol is conducted either by ground or by air, and is completed once per fiscal year on every span in the transmission system. Non-scheduled patrols, by ground or air, may be conducted should unexpected information requirements be identified. Patrols are normally undertaken by snow machine, all-terrain vehicles, light trucks or helicopter, depending on the geographical location and ease of access. In winter, equipment operations may include a soft track groomer to facilitate access where snow conditions otherwise restrict travel on the right-of-way.

Where maintenance tasks involve heavy equipment (such as brushing), winter roads must be built for access in remote areas. Where mobile work camps are required for line maintenance activities, these will typically include a collection of trailers on tank-like tracks consisting of a few bunk trailers (each sleeping three or four people), a shower trailer, a kitchen trailer and a generator trailer. Mobile work camps generally consist of approximately 12 workers and must be set up in a spot where there is a water source for the shower and kitchen. The camp is moved about every two weeks when enough progress is made in each direction along the line.

Maintenance procedures are well established and are the subject of continuously updated corporate guidelines for maintenance and construction activities.[22] Maintenance activities include instances where crews are required to obtain access to specific areas to repair deficiencies on the transmission system. In northern regions, maintenance repairs are typically done in the winter months, after frost has entered the ground, using heavier soft track equipment to gain access. When summer access is required in agricultural

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[22] See footnote 16.

areas, related maintenance activities are planned, wherever possible, to avoid conflict with farm activity.

In circumstances where maintenance activity requires the use of access trails off the right-of-way (e.g., difficult terrain), approval is first obtained from Manitoba Conservation, when on provincial Crown land, and through formal easement or Crown land reservations where necessary. In areas where access to or across private lands is required, or if working on an easement on private lands, the landowners are contacted in advance. In the case of herbicide application, Manitoba Hydro also contacts landowners adjacent to the right-of-way.

3.4.9.3 Work Force Requirements

Work force requirements associated with the operations and maintenance of a particular transmission line generally involve deployment of established regional operations and maintenance personnel, and contractor staff as required. Line inspections could involve concurrent inspections of various lines in the region. Maintenance would include repairs as required.

For the operations and maintenance activity associated with the HVdc line and the 230 kV northern collector lines, the average annual workforce requirement (average over the life expectancy of the project) is estimated to be 11.5 persons. It is anticipated that initial workforce requirements up to the first major maintenance event (i.e., between the in-service-date and year eight of operations) will increase gradually to this level.

Of the total average of 11.5 persons, two to three would be internal Manitoba Hydro staff and the remainder would be contractor staff. The breakdown of the total average would be roughly two patrollers, two linemen, 0.5 helicopter pilots, and seven heavy equipment operators (e.g., caterpillar, backhoe, crane, etc.).

3.4.9.4 Vegetation Management

Vegetation management is required on an ongoing basis to ensure that re-growth in the cleared rights-of-way does not interfere with transmission line operations. Related management procedures extend to periodic review and removal of danger trees in the immediate vicinity of the right-of-way. Manitoba Hydro is also subject to NERC requirements that stipulate vegetation control be conducted along its rights-of-way to prevent situations from arising where trees can cause an outage on transmission lines 230 kV or higher.

Vegetation management involves a variety of methods, including hand cutting (e.g., utilizing chainsaws, brush saws, axes, or brush hooks), mechanical shear blading (using

“V” or “KG” blades), brush mowing with rotary and drum cutters (typically rubber-tired equipment), and herbicide treatment. These are typically conducted on foot, or by all terrain or flex-tracked vehicles. Due to access constraints, regular brushing in northern areas is normally done during the winter months using the shear blading method. In agricultural areas, vegetation management schedules are adjusted to accommodate farming schedules. The vegetation maintenance brushing cycle for transmission line rights-of-way typically ranges between 8 and 10 years.

An integrated vegetation management and weed control approach is used within the right-of-way to control and reduce potential tree and weed problems. Weed control by Manitoba Hydro is generally limited to rights-of-way in urban areas. Herbicide treatments are formulated to target only broad-leafed plants (trees and weeds) leaving grasses unaffected. Foliar applications of herbicides are made in the summer months only; dormant stem applications are done when the plants are dormant, usually in the fall and winter. Permits for pesticide use are obtained on an annual basis. The process involves public notification as part of the formal permit application to Manitoba Conservation Pesticide Approvals Branch. All herbicide applications are completed and supervised by licensed applicators and in accordance with conditions specified in the Pesticide Use Permit. Herbicide application rates are established by Manitoba Hydro’s Chief Forester in accordance with product label instructions. Only herbicides which have been approved in the Pesticide Use Permit are used. Manitoba Hydro maintains a typical list of herbicide foliage treatments and has developed application guidelines that it adheres to for its activities. Manitoba Hydro’s vegetation management procedures are well established with respect to herbicide and pesticide application requirements and obtaining the Pesticide Use Permits.

Several methods of herbicide application are available. High volume broadcast stem/foliar application equipment, used for tree heights of 2.5 m (8 ft.) or less, includes droplet applicators (such as Radiarc and Vecta-Spray sprayers), boom busters, and hose and handgun sprayers. Aerial foliar spraying has also been used as an application technique and could be used in the future. Selective stem/foliar applications (both high and low volume) are the preferred method for tree heights of 2.5 m (8 feet) of less, and are made with hose and handgun sprayers, or backpack sprayers.

Individual stem treatment includes thin line or similar basal treatment applications made with hand-held equipment to direct a low pressure stream to the lower tree stem, or tree injection techniques. These can be done at any time of year and on trees over 2.5 m (8 ft.) in height, and are used in circumstances where selective treatment is necessary for environmental or aesthetic reasons. Wherever practical, stump treatment is used following hand-cutting to provide selective control of suckering for deciduous species and to minimize effects on desirable vegetation.

Weed control on the rights-of-way is required for regulatory (i.e., The Noxious Weed Act), operational and safety reasons. In agricultural areas, continued cultivation will reduce the need for weed control. Alternative techniques for the uncultivated portions of the right-of-way include mowing (which is reasonably effective when conducted two to three times per growing season and prior to seed set), and herbicide spraying, which is the most effective method to control weed growth. Spraying equipment includes backpack sprayers, truck-mounted power sprayers equipped with a broadcast applicator system, hose and handgun, and ATV (all-terrain vehicle) mounted power sprayers.

Weed control in cultivated and uncultivated areas of the right-of-way involves activity by both landowners and Manitoba Hydro. Prior to any vegetation management work on private land, permission will be requested from the appropriate landowner or authority. On provincial Crown lands, a work permit issued under The Forest Act (Manitoba) is required and owners adjacent to the ROW are typically notified in advance. Manitoba Hydro's Chief Forester coordinates the necessary approvals and is responsible for obtaining the necessary Pesticide Use Permits and submitting Post Seasonal Control Reports as per Manitoba Regulation 94-88R under The Environment Act.

3.4.10 Transmission Line Decommissioning

Should transmission lines be decommissioned at some future date, Manitoba Hydro has tentatively identified acceptable means for environmentally restoring project sites and rights-of-way. Established procedures are available for the decommissioning of temporary infrastructure or facilities (e.g., borrow pits, access trails, marshalling areas, mobile construction camps, etc.).

Current methods of transmission line decommissioning entail the dismantling of the structures and salvage or disposal of all steel structure components, as well as removal and salvage of insulators, conductors and ground wires.

Decommissioning of rights-of-way currently involves clean-up and/or remediation to a standard commensurate with local environmental conditions, including the existing land use and policy with respect to future development.

Decommissioning of marshalling yards currently involves the removal of all new and used equipment and materials, dismantling of any ancillary equipment or structures, and the remediation of the yard property.

Based on the longevity of the existing Bipole I and II transmission lines, the Bipole III HVdc transmission line is expected to be in service for at least fifty years. Other identified transmission facilities (i.e., northern collector lines) are also expected to have a service life of at least fifty years. In the event that transmission lines are taken out of service, the specific methods and procedures for decommissioning and salvage will be adjusted to meet the regulatory and legislative requirements in place at the time.

3.5 KEEWATINOOW CONVERTER STATION – TECHNICAL DESCRIPTION

As outlined in Section 3.3.3, the northern terminus of the Bipole III HVdc transmission line will be at the new Keewatinoow Converter Station, located near the site of the potential Conawapa Generating Station. The converter station site will include a 230 kV ac switchyard, converter transformers, converter building and solid state electronic valve groups, and a dc switchyard. The required ground electrode will be developed at a separate site, connected to the station site by a low voltage overhead line. The photograph of the existing Henday Converter Station in Figure 3.3-2 provides a sense of the scale and appearance of a converter station facility.

The 230 kV ac switchyard at Keewatinoow will provide the terminations of the incoming ac transmission lines from the northern collector system. Apart from the related overhead connections and buswork, other major elements in the ac switchyard will include circuit breakers, station service transformers, and filters. The switchyard will be connected to the converter facilities through converter transformers.

Within the converter facilities, the conversion process from ac to dc will be accomplished using solid state power electronics. Generally, the solid state electronics are arranged in building block elements called valve groups. The valve groups (one or more per pole) are configured to achieve the required voltage, current and power ratings of the converter station. Each valve group is enclosed in a separate environmentally controlled room called a valve hall. The valve halls are contained in an HVdc converter building that also contains rooms for control, protection, communication, operation and maintenance, and other related ancillary equipment.

The valve groups will be connected to the dc switchyard through high voltage bushings in the wall of the converter building. The major dc switchyard components will include dc smoothing reactors, dc filters, switching equipment and the terminations for the outgoing HVdc transmission line and the low voltage overhead ground electrode line (the other end of which will be terminated at the Keewatinoow ground electrode site).

As in the case of the project transmission lines, the converter station and its ancillary facilities will be subject to CSA design standards. Planning and design will also be subject to National Building Code requirements, and will be guided by NERC/MRO/MISO reliability criteria (see Appendix 3A).

3.5.1 Keewatinoow Site Selection Process

The Keewatinoow Converter Station and ground electrode sites, as well as the right-of-way for the ground electrode line, will involve provincial Crown lands. The necessary property rights will be secured through Crown Land reservations, and followed up with registration of an easement plan in the appropriate provincial land titles office. Map Series 3-500 (Map Tiles 3 and 4) and Map 3-9 illustrate the general Keewatinoow area, proposed development sites and associated borrow areas, construction facilities and supporting infrastructure.

3.5.1.1 Converter Station Site Selection

The Keewatinoow Converter Station is proposed to be sited in proximity to the proposed site of the potential Conawapa Generating Station and has been planned to reflect related preliminary Conawapa development concepts. Other considerations included site-specific criteria such as topography, hydrology, geology, and proximity to suitable quarry and granular material sources.

Ten candidate converter station sites were identified for evaluation (see Map 3-6). Of the ten, only five met the minimum criteria and were selected for further consideration (see Map 3-7).

The five potential site locations were comparatively evaluated on the basis of their technical merits: distance to potential Conawapa generating station; site size; topography; constructability; feasibility of ac transmission line and HVdc line connections and ease of line entry; flexibility; availability of suitable staging and laydown areas; avoidance of potential land use conflicts; access to construction material sources; availability of raw water source; feasibility of water treatment and wastewater disposal; feasibility of oil spill containment; related geotechnical characteristics; and general feasibility of operations. All five potential sites were considered to be acceptable for development. In rank order of technical preference, the five are NCS4a, NCS4b, NCS3, NCS1a and NCS1b. The technically preferred site has been established as NCS4, an optimized combination of sites NCS4a and NCS4b, located within the Fox Lake Resource Management Area. The basis for the technical preference is summarized in the following points:

- Within 5.5 km of the site of the potential Conawapa Generating Station in order to minimize potential reactive power losses;
- Meets and provides flexibility for ac transmission and HVdc transmission line entry requirements;
- Sufficient space for potential future generation requirements;

- Flat site (less than 0.5% slope across site) with minor topographical variation allows for all foundations to have the same top elevation without excessive projection from the ground;
- Lowest estimated civil site improvement costs;
- Proximity to preferred granular source material deposits;
- Proximity to Goose Creek offers drainage advantages;
- Proximity to potential staging and laydown areas across the Conawapa access road; and
- No significant land use conflicts with preliminary development concepts for the potential Conawapa Generating Station.

The Keewatinoow Converter Station site is estimated to require a footprint of approximately 640 m x 640 m in dimension for a total area of approximately 410,000 m^2 (41 ha), including allowances for items such as road and transmission line approaches. The fenced area at the station is estimated to require a footprint of approximately 310,000 (31 ha).

The chosen station site was reviewed and discussed with representatives of Fox Lake Cree Nation in a number of meetings. Discussions continue with a view to identifying and addressing the effects on members of Fox Lake Cree Nation of the Bipole III Project.

3.5.1.2 Ground Electrode Site Selection

The proposed siting of the Keewatinoow ground electrode is based on: criteria respecting separation from the Keewatinoow Converter Station siting area and other existing facilities and infrastructure; site-specific criteria with respect to ground resistivity; geology; topology; near surface stratigraphy; hydrology; geospatial separation; and on environmental considerations, land ownership and related land interests.

The Keewatinoow ground electrode site selection process was a three phase program. Phase one identified 23 candidate sites. Measurements and desktop studies of these sites were undertaken in phase two; twenty of the 23 sites did not satisfy the desired technical requirements. During phase 3 of the selection process, the three remaining potential sites were comparatively evaluated on the basis of their technical merits: topography, ground resistivity, water supply, ground potential rise, soil moisture, soil thermal conductivity and heat capacity, land use, step potential (safety), proximity to existing infrastructure and facilities, and proximity to Keewatinoow Converter Station siting area. Two potential sites were considered acceptable for development. In rank order of technical preference, these are NES6 and NES7 (see Map 3-8).

The technically preferred site has been established as NES6, located within the Fox Lake Resource Management Area. Site NES6 ranked highest in technical review of the three alternatives. The basis for the technical preference is summarized in the following points:

- Relatively flat site with minor topographical variation;
- Acceptable surface ground resistivity for a shallow ring ground electrode, and located above a conductive body with good (i.e., low) deep resistivity;
- Ground water availability;
- Lowest effects on Henday Converter Station when both Bipoles II and III are in operation;
- Predominantly wet site with a good back-up water supply;
- Promising thermal conductivity and heat capacity soil characteristics;
- No significant land use conflicts with proposed transmission lines or potential Conawapa Generating Station development;
- Low step potential; safe for humans and animals to walk across the site during operation;
- Acceptable proximity to major planned and existing facilities;
- Located within the 50 km siting distance from the Keewatinoow Converter Station siting area (approximately 10 km distant) and in an operationally preferred location along the Conawapa access road; and
- No known shallow permafrost affects.

The chosen station site was reviewed and discussed with representatives of Fox Lake Cree Nation. Discussions continue with a view to identifying and addressing the effects on members of Fox Lake Cree Nation of the Bipole III Project.

The Keewatinoow ground electrode site area requirement is estimated to be approximately 2,000 m x 2,000 m or 4,000,000 m^2 (400 ha), only a portion of which will be cleared and affected by the electrode installation. This includes allowances for items such as access road and electrode line approaches. The Keewatinoow ground electrode will likely be a shallow ring electrode, estimated to be approximately 800 m in diameter, and situated within the specified site area identified.

3.5.2 Keewatinoow Converter Station Facilities and Infrastructure

The Keewatinoow Converter Station development will consist of infrastructure and buildings to support its operation: a 230 kV ac switchyard, converter transformers, a converter building and conversion equipment, and a dc switchyard. Related details are further described in the following Sections 3.5.2.1 to 3.5.2.5. The proposed station layout is schematically illustrated in Figure 3.5-1.

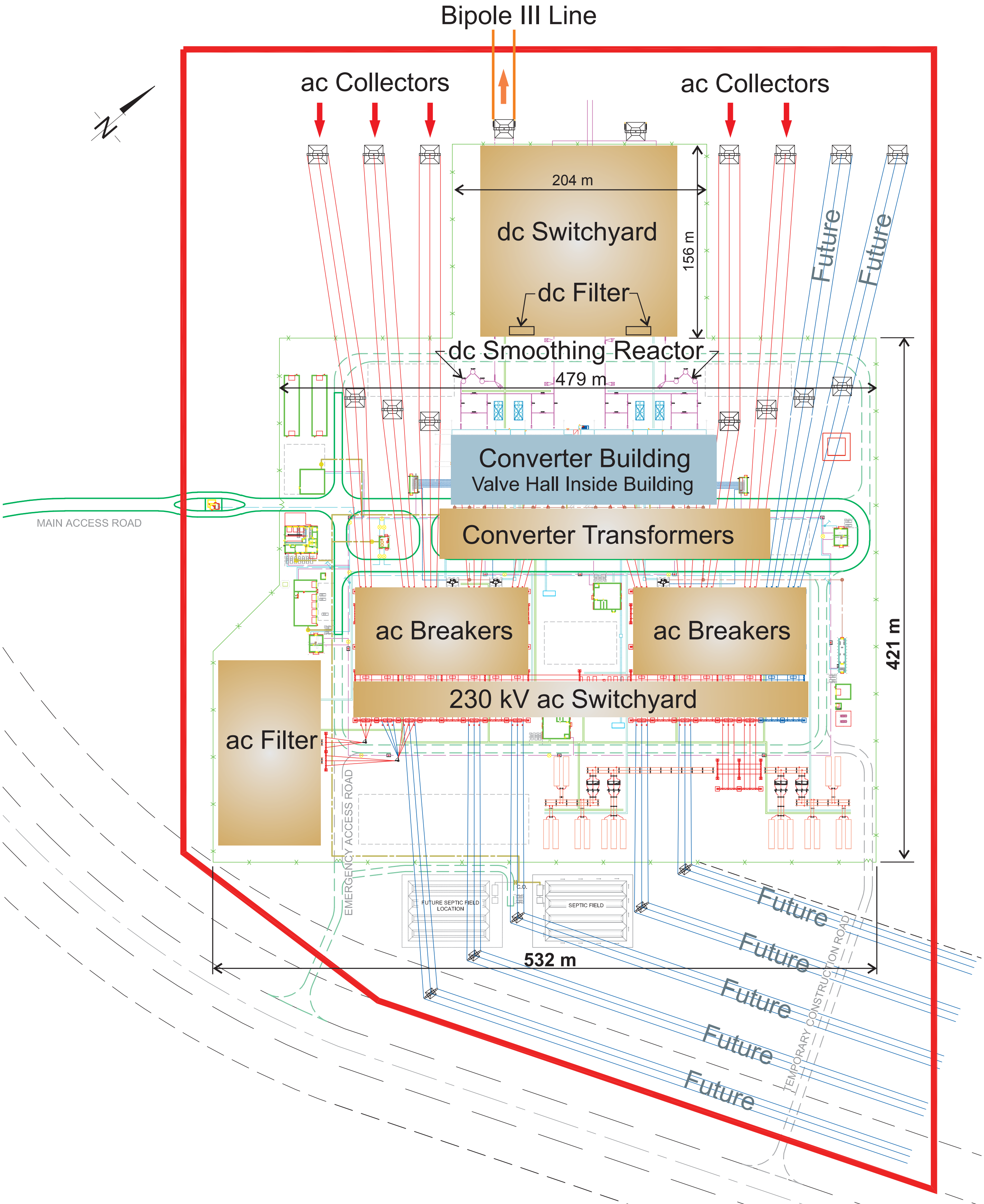

Figure 3.5-1:
Schematic Layout of Proposed Keewatinoow Converter Station

3.5.2.1 Converter Station Site Infrastructure

The Keewatinoow Converter Station site preparation and infrastructure will include site grading and drainage, internal roadways, site security, station lighting, oil storage, oil containment, domestic water and wastewater systems, fire suppression systems, the station grounding system, communication facilities, and ancillary buildings and equipment.

Site Grading and Drainage

The Keewatinoow Converter Station site will be constructed above the existing ground surface, taking into account both existing drainage patterns surrounding the site and the need to protect the converter station from overland flooding during spring runoff or an extreme rainfall event. Subject to final design, land drainage within the site will be managed by a combination of surface and underground drainage systems, with minimum ground surface slopes of approximately one percent. Proper site drainage is required to ensure that there is no surface ponding around the electrical equipment.

Based on preliminary design, the entire Keewatinoow Converter Station site will be covered with an insulation stone course, approximately 150 mm in thickness and typically consisting of 20-40 mm diameter clean stone aggregate. The composition of the underlying sub-base and sub-grade will vary, depending on the intended utilization of specific site areas. Materials and material quantities are further described in Section 3.5.4.5.

Rainfall and snowmelt will infiltrate directly into the pervious insulating stone course. The clean, free-draining rock will not impede the draining of storm water into an internal site ditch system and/or a buried pipe and catch basin drainage system. The details of the drainage system will be determined pending further site investigation studies and detailed design.

Surface drainage and storm water flows from the internal drainage system will be directed to the existing drainage ditch running parallel to the Conawapa access road. This ditch flows north for approximately 900 m until it discharges into Goose Creek.

The surface drainage system design will ensure that potential oil contaminants from large oil containing equipment will be contained within the on-site oil containment system, described in later in this section, and will not be discharged through storm water flows.

Internal Roadways

Keewatinoow Converter Station access will consist of an internal roadway network (no rail access is planned) extending from the existing Conawapa access road. The majority of the internal roadway network will be gravel surfaced. Portions may be paved with asphalt to minimize dust production in the vicinity of key electrical components and the converter building. The details of the internal roadways will be determined pending further site investigation studies and detailed design.

The roadway network will permit on-site tractor-trailer access for site development and equipment installation and maintenance, as well as access for employees and smaller service vehicles.

Gravel surfaced areas will be provided throughout the site for employees and for contractor use as staging and parking. Concrete pads may also be provided for the loading and unloading of equipment.

Site Security

The Keewatinoow Converter Station site will be enclosed within a single continuous perimeter fence, consisting of heavy chain link fabric extending to an approximate height of 2.1 m, with a top guard of at least three strands of barbed wire extending to an overall height of approximately 2.4 m.

A remote controlled gate, operated by the site security staff, will provide primary access from the Conawapa access road. Additional manually-operated secondary access gates may be provided to facilitate major equipment delivery in event that the primary access is not usable. The secondary gates may also be used for emergency egress.

A security building will be located at the primary access gate for security personnel, and will house closed circuit television monitoring equipment, computer equipment, and other systems needed to support site security operations. The security building will be constructed above grade and will include electric heating and air conditioning systems. See later "ancillary buildings and equipment" heading in this section for more information relating to these and other ancillary buildings at Keewatinoow Converter Station.

Station Lighting

Keewatinoow Converter Station will have a site lighting system for safety, security and maintenance purposes. The site lighting system will be designed to provide lighting along the internal roadway network and along the perimeter fence. The lighting system will be designed to achieve an average maintained lighting level of approximately 10 lux (10 lumen per square metre).

Oil Storage

Keewatinoow Converter Station will include provision for storage of the insulating oil used in the operation and maintenance of high voltage apparatus and equipment, such as the converter transformers. The tanks will provide for storage of up to a maximum of 300,000 litres.

Oil Containment

An oil containment system will be provided to contain any oil spills within the station site. A typical oil containment system consists of point source containment, non-point source containment , a fast drain system and oil-water separator facilities. The Keewatinoow Converter Station will conform to all applicable oil containment standards.

Primary containment, at the location of equipment containing large oil volumes, will involve the use of either a concrete, clay, or a membrane barrier, extending a minimum of 1.5 m beyond the edge of any such equipment. At a minimum, the design will provide primary containment for equipment containing over 5,000 litres of oil, and groups (or zones) of equipment individually containing less than 5,000 litres and greater than 1,895 litres, as per applicable standards.

Wherever feasible, oil from the oil containment system will be carried through a system of pipes called the fast drain system, to the oil-water separator facility.

The oil containment system will also collect rain, snow melt and water from the fire suppression systems. Water collected in the oil containment system will undergo a treatment process of separating the oil from the water. The oil-water separator facility may include the use of an oil-water separator building using gravity separation and oil skimming techniques or, alternatively, large above-ground containment ponds with an oil interceptor.

In the case of an enclosed oil-water separator facility, a building will be provided on the station site to house the necessary mechanical and electrical oil-water separation equipment. The building would include a pit constructed below grade, and a mechanical area constructed above grade, and would include electric heating for freeze protection. See Section 3.5.2.1 for more information relating to the ancillary buildings at Keewatinoow Converter Station.

In the case of oil containment ponds, one or more ponds would be located on the Keewatinoow converter site and equipped with oil interceptors The oil ponds would consist of cells constructed at or below grade, and an oil interceptor below grade. Such ponds would be approximately 12,000 m^2 (1.2 ha) in size.

Water captured from the oil-water separator facilities will be discharged into the local land drainage system, which will drain into the existing drainage ditch along the Conawapa access Road, and discharge into Goose Creek and ultimately into the Nelson River. Water effluent will be monitored to ensure that it meets environmental requirements. Oil recovered from the separator facilities will be collected in a storage tank and removed from the site by a licensed carrier.

The details of the oil containment system will be determined pending further site investigation studies and detailed design.

Water and Wastewater Systems

Water Supply and Treatment

The Keewatinoow Converter Station will require a raw water supply, a water treatment/disinfection system, and potable water distribution throughout the site. Additionally, wastewater collection, treatment and disposal will be required.

Preliminary studies indicate that a groundwater source is feasible. Groundwater will be drawn from wells at or near the station site. The raw water will require a water treatment system in order to meet provincial regulations under The Drinking Water Safety Act (Manitoba). Selection of the treatment system will be subject to analysis of a number of treatment options.

Water treatment will likely involve a factory-built, modular, packaged water treatment plant. Subject to final decision based on more detailed water analysis, the treatment process will likely entail conventional chemical coagulation, clarification and membrane filtration to reduce turbidity and colour. Testing equipment to monitor chlorine and turbidity levels will be provided on-site. Potable water will be treated to meet provincial standards for drinking water quality and aesthetics.

Water storage at the treatment plant will involve use of underground reservoirs or above-ground tanks. The maximum consumption of treated water is estimated to be less than 10,000 litres per day.

Waste water from the water treatment plant will consist mainly of process filter backwash and settling chamber sludge, and will be discharged to the sewage collection system for further treatment. Subsequent discharge to the Nelson River will be made in accordance with Manitoba Conservation guidelines. The wastewater effluent is expected to meet the allowable concentrations under the Wastewater Systems Effluent Regulation, but currently this is not formally required as the volume of wastewater generated will be less than 10,000 L/day.

Water Distribution System

Treated water at Keewatinoow Converter Station will be supplied via a piped distribution system, the main function of which is to deliver domestic water requirements.

The outdoor distribution piping will be buried below the frost line to prevent freezing. Any shallow buried piping will be insulated and heat traced for freeze protection.

The raw and treated water distribution piping system will be designed in accordance with ANSI/ASME (American National Standards Institute/American Society of Mechanical Engineers) process and pressure piping standards.

Potable Water Design Flows

It is anticipated that up to 30 Manitoba Hydro employees will be present at the Keewatinoow Converter Station site during normal operation. Additionally, up to 30 contractor employees may be present at the site during maintenance activities. The water consumption, based on the total number of employees at the site, is estimated to be 10,000 litres per day.

Potable water flows are considered to be equivalent to the wastewater flows generated. Industry design information is based on wastewater flows, which are detailed in a subsequent subsection.

Wastewater Flows and Quality

The waste water flows at Keewatinoow Converter Station will not exceed 10,000 litres per day. The influent quality of wastewater from the Keewatinoow Converter Station to the wastewater treatment facility is expected to be similar to that of medium strength domestic wastewater (i.e., wastewater containing average amounts of fats, oils and greases, or other organic components; and an average quantity of suspended solids or such chemicals as disinfectants which can interfere with normal biological processes). The wastewater will be treated to ensure that the effluent quality will meet the limits established under the Environment Act (Manitoba).

Wastewater Collection

There are no existing municipal wastewater systems operating in the area of the proposed Keewatinoow Converter Station. Manitoba Hydro's preference for the required station wastewater treatment is for a pressurized sewer system flowing to a sewage treatment facility.

Wastewater Treatment and Disposal

Wastewater treatment options include a conventional lagoon, pressurized sand mound, modified above-ground leaching bed system, sand filter, or packaged mechanical treatment facility. The above-ground leaching bed system is the preferred option. A secondary option is to tie into the main construction camp lagoon (described in Section 3.5.4.8) via a low pressure system. The selected option will be designed to meet provincial standards.

Each serviced building will be equipped with a grinder pump station. At each pump station, wastewater will be ground into a macerated liquid and pumped to a septic tank. The septic tank will consist of two chambers, a solids settling chamber, where the solid content of the macerated liquid will settle out and an effluent discharge chamber, where the liquid from the solid settling chamber will pass through a filter prior to discharge to an attached pumping chamber. Once the accumulated treated effluent reaches a predetermined volume, the effluent will be pumped to an above-ground leaching bed. The above-ground leaching bed will be constructed of a layer of sand, an infiltration chamber system to distribute the treated effluent, loam material, and topsoil which will be seeded with grass to provide a vegetative cover.

Additional geotechnical investigations in the area of the proposed converter station are required to determine a suitable location for the above-ground leaching bed.

Fire Suppression Systems

The Keewatinoow Converter Station will be designed with a fire suppression system conforming to applicable standards and codes.

Water for fire suppression activities at the converter station will be drawn from a groundwater source and stored on-site in tanks. Total tank storage will be a minimum of approximately 200,000 imperial gallons (approximately 909,000 litres), in order to meet the code requirements for a two-hour water supply. The tanks may be fabricated of steel above grade, or constructed of concrete below grade. Each tank will require an adjacent above grade fire pumphouse building, containing the pumps, valves, electric power, and electronic controls needed to maintain water pressure and to provide flow control. Electrically powered pumps will provide water circulation under normal operation, with a diesel powered pump providing backup capability in the event that the electric pumps are not available or cannot provide adequate water pressure and flow. Diesel fuel will be stored outside the fire pumphouse building in two 500 gallon tanks (approximately 2,300 litre tanks). Electric heat and ventilation equipment will be installed within each pumphouse. See subsequent heading in this section respecting ancillary buildings and equipment.

Water for fire suppression will be distributed throughout the converter station site through underground pipe buried below the frost line. Piping is typically polyvinyl chloride (PVC) or high density polyethylene (HDPE).

Water for the suppression of transformer fires is controlled via deluge buildings. The deluge buildings will have a pit area constructed below grade, with an area for electrical equipment located above grade. The deluge buildings will include electric heat for freeze protection. See Section 3.5.2.1 for more information relating to the ancillary buildings.

The details of the fire suppression system will be determined pending further site investigation studies and detailed design.

Station Grounding System

The Keewatinoow Converter Station site will include a subsurface ground grid for personnel and equipment safety, conforming to Manitoba Hydro best practices for station design.

The station ground grid will be placed under the insulating stone surface and will extend just beyond the perimeter fence in accordance with the standard. The subsurface ground grid at the site will consist of numerous copper clad steel ground rods (approximately three metres in length) driven into the ground and connected together below the surface with bare copper wire. The ground grid will also connect to metallic objects within the converter station site such as the perimeter fence, steel structures, equipment structures and foundations, transformers, buildings, pipes, cables, etc.

Communications Facilities

The Keewatinoow Converter Station will require multiple communications paths to facilitate reliable integration into the existing Manitoba Hydro power system. These communication pathways will generally be comprised of fibre optic networks. Optical ground wire (OPGW), as described in Sections 3.4.1.3 and 3.4.2.3, will provide communication pathways for HVdc system control and operation. An additional fibre optic cable connecting the converter station to the existing Manitoba Hydro fibre optic network at Henday Converter Station will also be required for station data and telephone services. The cable is planned to be placed in the ditch adjacent to the Conawapa access road.

The converter station will also require a communications antenna as a backup to transfer critical signals along Manitoba Hydro's existing microwave system. The antenna will also provide service to the Keewatinoow station site and construction camp during the construction period. It will be located within the fenced area of the Keewatinoow construction power station.

Ancillary Buildings and Equipment

Apart from the converter building, the Keewatinoow station site will include a number of ancillary buildings. The equipment and facilities contained in these buildings will support a variety of functions relating to station operation and maintenance.

The approximate size and anticipated number of each type of ancillary building is identified in the following table, together with a cross-reference to the project description section in which the building function is described. Actual building requirements are subject to final design and will vary depending on the selected system concept.

Table 3.5-1: Keewatinoow Converter Station; Ancillary Buildings

Building Type	Number	Approximate Size (m2)	Function Description (section cross-reference)
230 kV Control	2-4	600	3.5.2.2
Switchgear	2	400	3.5.2.2
Fire Deluge	3	150	3.5.2.1
Fire Pumphouse	2	150	3.5.2.1
Oil-Water Separator	1	150	3.5.2.1
Water Treatment Plant	1	100	3.5.2.1.
Emergency Response	1	600	n.a.
Security	1	200	3.5.2.1
Cold Storage	2	100	n.a.
Heated Storage	2	600	n.a.
	1	150	n.a.
Engineering Construction Office	1	500	n.a.

The design of the converter station ancillary buildings will conform to CSA design standards and National Building Code requirements.

All buildings are expected to be supported on piles due to the potential for permafrost melt and frost heave. Based on geotechnical investigations performed on the Keewatinoow site, pile foundations are estimated to be approximately 15 m in depth.

Pre-engineered metal building systems will likely be the most cost-effective building wall system and will meet the design requirements of the project. A panelized metal roofing system, sloped to provide adequate drainage and prevent ponding of water on the roof, is consistent with a pre-engineered steel building system and will be adequate.

Ancillary building aesthetics at Keewatinoow will be limited by the industrial nature of the facility. The ancillary buildings will conform to applicable Manitoba Hydro standards, to create an aesthetic that is uniform between the station structures and existing buildings at other Manitoba Hydro stations.

In addition to the ancillary buildings, there will be a requirement during operations and maintenance for temporary equipment, which may include bucket trucks, lift platforms, oil processing equipment, trailers, tanks, carts for handling of SF_6 gas, and high voltage testing equipment.

3.5.2.2 230 kV ac Switchyard

The Keewatinoow Converter Station 230 kV ac switchyard is required to provide flexible and reliable control and distribution of ac power from the northern generation system to the converter transformers and valve groups located within the converter building.

Components within the 230 kV ac switchyard will include all the necessary concrete foundations, steel structures and equipment supports, and station service transformers. Equipment foundations will range from concrete slab-on-grade to deep-piled foundations, depending on equipment weight and geotechnical conditions. Steel structures will be placed on the foundations and will support electrical apparatus and electrical conductors, and hardware associated with the switchyard and transformer functions. Station service transformers and other equipment structures will also be placed on concrete foundations.

The switchyard will be air-insulated. Electrical apparatus is presently planned for possible future development of up to nine bays. The nine bays, seven of which will be developed for the Bipole III Project, will provide connections to the ac filter banks and the converter transformers, and terminations for the five proposed 230 kV line connections to the northern collector system.

The proposed ac switchyard will require an area of approximately 90,000 m^2 (9.0 ha) within the converter station fenced area.

Detailed numbers and ratings of the switchyard electrical apparatus to be located within the ac switchyard will not be known until final design is complete. Principal electrical components are described in the following subsections.

230 kV ac Circuit Breakers and Disconnect Switches

High voltage circuit breakers (see photo of existing high voltage ac circuit breakers at Dorsey Converter Station in Figure 3.5-2) are required to carry load current, to switch equipment and lines in and out of service as operating conditions dictate, and to isolate faulty equipment connected to, or within, the switchyard. Modern high voltage ac circuit breakers contain a hermetically sealed mixture of sulphur hexafluoride (SF_6) and carbon tetraflouride (CF4) or nitrogen (N2) gases as the insulating medium inside the breaker. Approximately 24 three-phase 230 kV circuit breakers will be required for the Keewatinoow ac switchyard. Each breaker will contain approximately 75 kg of insulating gas, comprised of approximately 50% SF_6 and 50% CF_4 or N_2.

Figure 3.5-2:
High Voltage ac Circuit Breakers at Dorsey Converter Station

Station Service Transformers

Station service transformers are required to serve the auxiliary power requirements of the converter station including the ac switchyard, converter building, dc switchyard, and ancillary buildings and equipment. Auxiliary power requirements include electrical loads such as building heating and cooling, process cooling systems, lighting, and various other support systems needed for station operation. Three three-phase, two-winding, 230 kV-12.47 kV MVA (mega volt-amperes) station service transformers will be required, each containing approximately 35,000 litres of insulating oil.

Instrument Transformers

Instrument transformers measure currents (current transformers) and voltages (voltage transformers) on apparatus within the 230 kV ac switchyard. Signals from the instrument transformers are used for control, protection and monitoring purposes.

The Keewatinoow ac switchyard will require approximately 70 single phase voltage transformers, each containing approximately 100 litres of insulating oil. The switchyard will also require approximately 126 single phase current transformers, each containing approximately 200 litres of insulating oil.

ac Harmonic Filters

Harmonic filters (see photo of existing ac harmonic filters at Dorsey Converter Station in Figure 3.5-3) are typically required due to the ac current harmonics generated in the process of converting ac power to dc power. These harmonics could be harmful to equipment connected to the ac system, including generators, if allowed to flow out of the converter station.

Figure 3.5-3:
ac Harmonic Filters at Dorsey Converter Station

Depending upon the conversion technology selected for Bipole III[23], as well as the outcome of final design studies, Keewatinoow Station may require four three-phase ac harmonic filter banks, each of which may be comprised of up to three sub-banks. Operation of the sub-banks would be controlled using dedicated ac circuit breakers similar to those described in this section. Eight such ac circuit breakers would be required.

The ac harmonic filter banks and sub-banks are typically comprised of a combination of capacitors, reactors, and resistors. Filter capacitors are generally filled with an insulating oil fluid. Approximately 1,100 capacitors, each containing approximately 16 litres of insulating fluid, will be required for each ac harmonic filter bank.

Surge Arrestors

Surge arrestors provide protection to ac switchyard components from abnormally high voltages induced from lightning. Surge arrestors are comprised of porcelain or composite materials, and are similar in appearance to insulators.

Insulators

Insulators are non-conducting posts (porcelain or composite) used to support energized equipment and hardware in the switchyard. Insulators are typically placed on the top of steel equipment support structures, but may also be placed directly on the equipment foundations.

Control Buildings

Two to four control buildings will be required for the Keewatinoow 230 kV ac switchyard to house the control, protection, and communications equipment necessary for its operation. Cables will connect the control buildings to the ac switchyard apparatus and to the remainder of the converter station. The control buildings typically contain battery banks to meet the power requirements for the electrical equipment installed within the building. Approximately 1,300 litres of battery acid will be contained

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[23] Line-commutated converter (LCC) technology utilizes thyristor based power electronic conversion equipment similar to that in the Manitoba Hydro Bipole I and Bipole II converter stations. Voltage-source converter (VSC) technology utilizes insulated gate bipolar transistor (IGBT) based power electronic conversion equipment. In addition to the valve group power electronic components, the different conversion technologies under consideration for Bipole III have different requirements for ac harmonic filters, the converter building, dc switchyard equipment, and synchronous condensers.

within the batteries in each control building. The control buildings will also require heating and air handling equipment to control the building ambient temperature.

Switchgear Buildings and Auxiliary Power Distribution

Two switchgear buildings will be required within the ac switchyard. The buildings will house equipment for control of the 12.47 kV auxiliary power from the station service transformers to the converter station electric power loads. Each building will include approximately 15 circuit breakers and the control and protection electronics necessary for their proper operation. The buildings will require electric heat and air handling equipment.

Power from the switchgear buildings to the converter station electric power loads will be distributed throughout the station by power cables to indoor and outdoor power centres. Each power centre will require two transformers approximately 2,500 kVA in size. Outdoor power centres may utilize oil-filled transformers, each containing approximately 2,200 litres of insulating oil. Indoor power centres, located within the converter building, typically utilize dry-type transformers which do not contain insulating oil. It is anticipated that four outdoor and four indoor power centres will be required for Keewatinoow Converter Station.

3.5.2.3 Converter Transformers

The 230 kV ac switchyard will be electrically connected to converter transformers, through which power is passed from the ac switchyard to the solid state power electronic valve groups within the converter building. The converter transformers provide an interface between the ac voltages in the ac switchyard and the dc voltages in the valve groups.

Keewatinoow Converter Station will require up to fourteen converter transformers for the conversion of ac to dc power - three for each of the four valve groups, and two spares (for use during maintenance or outage).

The final layout design of the converter transformers will depend on such factors as the HVdc system configuration, converter building size and layout, ac filtering and reactive power compensation requirements.

In order to obtain a more compact station design and reduce the number of insulated high voltage wall bushings, converter transformers may be situated adjacent to the converter building with the valve group side connections protruding into the valve hall. This configuration reduces buswork requirements and improves protection of the valve group from lightning strikes. Alternatively, if the converter transformers are not situated adjacent to the converter building, approximately 48 wall bushings will be required in the converter building wall between the converter transformers and the valve halls.

The principal components of individual converter transformers are the tank which includes the transformer core and copper windings, transformer bushings, and oil cooling radiators and fans.

The converter transformers are filled with insulating oil for electrical insulation and heat transfer purposes. Insulating oil is circulated between the tank and the cooling radiators, where excess heat is transferred to the air. Each converter transformer (see photo of existing converter transformer at Dorsey Converter Station in Figure 3.5-4) will contain approximately 115,000 litres of insulating oil. Due to the volume of insulating oil in each transformer, the design will incorporate primary oil containment (see Section 3.5.2.1).

Figure 3.5-4:
Converter Transformer at Dorsey Converter Station

3.5.2.4 Converter Building

The Keewatinoow Converter Station will include a converter building which is typically centrally located on the station site, between the converter transformers and the dc switchyard. The primary function of the converter building is to house the solid state power electronics and ancillary systems used to support the conversion of ac power to dc power.

The layout of the converter building at the Keewatinoow site will be modelled after the existing converter building at Henday Converter Station (see photo of existing converter building at Henday Converter Station in Figure 3.5-5). Similar to Henday, the converter building at Keewatinoow will consist of four valve halls, two for each pole of the converter station. The valve halls associated with each pole are typically situated adjacent to one another, with the ac switchyard on one side of the valve halls and the dc switchyard on the other side. Each valve hall will house the solid state power electronics associated with one valve group. Each valve hall will be approximately 20 m high and, depending on the conversion technology[24] selected, between approximately 1,200 and 5,000 m^2 in area.

The valve hall environment is closely monitored and controlled for air quality, operating temperatures, and fire detection. The valve halls are electrically shielded to prevent electrically generated high frequency signals (also called noise) from either entering or leaving the room.

In addition to the valve halls, the converter building will also include one or more service and auxiliary equipment areas. Service areas within the converter building will include the control room, maintenance and storage areas, and administrative offices. Auxiliary equipment areas within the converter building will include valve group cooling, HVdc control and protection, communications, building mechanical services, and auxiliary power.

[24] See footnote 23.

Figure 3.5-5:
Converter Building at Henday Converter Station

Valve Groups

Bipole III will consist of two poles, one energized at +500 kV dc, and the other at -500 kV dc. Each pole will be energized by two valve groups, connected in configurations designed to achieve the required current and voltage ratings of the converter station. The valve groups convert ac power from the converter transformers into dc power through high speed coordinated electronic switching of solid state power electronic devices.

Two conversion technologies are presently being considered for Bipole III: conventional line-commutated conversion (LCC) technology, and newer voltage-source converter (VSC) technology.[25] Selection of the conversion technology is expected in late 2011.

Each of the four valve halls within the converter building (see photo of existing valve hall at Dorsey Converter Station in Figure 3.5-6) will house a valve group. Each valve group typically consists of three tower assemblies, which are either suspended from the roof of the valve hall or supported from the floor by insulators. Each tower assembly is comprised of multiple valves, and each valve consists of multiple solid state power electronic devices as well as resistors, capacitors, control electronics, and fibre optics. The specific selection and arrangement of these components is subject to ongoing studies to establish final design criteria, and will be determined in the course of detailed design. These studies will establish whether supplemental design criteria are necessary or appropriate (e.g., design hardening to protect against extreme weather events).

The power electronics components are liquid-cooled using a closed-loop cooling system located outside the valve hall. Heat generated within the valve groups is transferred by the cooling liquid to the outside air. Cooling liquid is circulated through the valves and cooling equipment by electric pumps. The cooling systems typically use an ethylene glycol/water mixture as the cooling medium. Each of the four valve group cooling systems will typically contain 14,000 litres of the coolant mixture.

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[25] Ibid. See footnote 23.

Figure 3.5-6:
Valve Hall at Dorsey Converter Station

Control Room and Ancillary Converter Building Facilities

Operation of the electrical apparatus within the converter station will be monitored and controlled from a control room, the principal features of which will include a control desk and supporting equipment. Various operating conditions of the station apparatus will be monitored and controlled from the desk, including status of the various components and systems, alarms, voltages, currents, temperatures, pressures, flows and levels. Other control room equipment and electronics will include computers, printers, closed circuit television monitoring systems, and communication devices. Service and auxiliary equipment areas may be centrally located within the converter building, or distributed throughout the converter building and grouped in functional areas. Specific sizes and locations of each area within the converter building will not be determined until final design is complete.

3.5.2.5 dc Switchyard

The dc switchyard is vital to the transmission of HVdc power out of the converter station and provides a controlled path for dc power to pass from the valve groups in the converter building to the Bipole III HVdc transmission line (see photo of existing dc switchyard at Henday Converter Station in Figure 3.5-7).

The Keewatinoow dc switchyard will be separated into two poles, referred to as Pole 5 and Pole 6. The high voltage side of Pole 5 will operate at -500 kV dc, while the high voltage side of Pole 6 will operate at +500 kV dc. The high voltage sides of Poles 5 and 6 will connect the dc switchyard to the Bipole III HVdc transmission line conductors for transmission of power out of Keewatinoow.

The low voltage sides of Poles 5 and Pole 6 will operate at near zero voltage, and will be connected together to form the portion of the dc switchyard that is generally referred to as the neutral bus. The neutral bus serves as the connection from the dc switchyard to the low voltage electrode line leading to the Keewatinoow ground electrode.

Poles 5 and 6 will require a variety of electrical apparatus within the dc switchyard. The major components are described in the following subsections. Other dc switchyard components will include concrete foundations, steel structures, and equipment supports for the electrical apparatus. Equipment foundations will range from concrete slab-on-grade to deep-piled foundations, depending on equipment weight and geotechnical conditions. Steel structures will be placed on the foundations and will support electrical apparatus and electrical conductors, and other hardware associated with the switchyard.

Figure 3.5-7:
dc Switchyard at Henday Converter Station

Specific quantities and ratings of the electrical apparatus located within the dc switchyard are subject to the selected Bipole III conversion technology[26], and will be finalized during the course of detailed design studies.

dc Wall Bushings

The dc wall bushings provide a transition between the converter building valve halls and the dc switchyard area. Approximately eight dc solid composite wall bushings will be required.

Switchgear

Switchgear is needed to control the flow of dc power within the dc switchyard. Modern high speed dc switches, similar in operation and appearance to ac circuit breakers (see Section 3.5.2.2), use a hermetically sealed mixture of sulphur hexafluoride (SF_6) and carbon tetraflouride (CF4) or nitrogen (N2) gases as the insulating medium inside the switch. Approximately 13 high speed switches will be required for the dc switchyard. Combined, these switches will contain approximately 400 kg of SF_6 and 120 kg of CF_4 or N_2 gas.

dc Filter Banks

Filter banks (see photo of existing dc filter bank at Henday Converter Station in Figure 3.5-8) are comprised primarily of capacitors and reactors, and provide attenuation of voltage harmonics generated by the valve groups prior to transmission on the Bipole III HVdc transmission line. A total of six dc filter banks are anticipated for the dc switchyard. Each bank will contain approximately 2,800 litres of insulating fluid.

dc Voltage and Current Measuring Devices

Monitoring and control of the Bipole III HVdc system will require dc current and voltage measurement devices to be installed within the dc switchyard. Approximately 19 dc current transducers and eight dc voltage dividers will be required. Each voltage divider will contain approximately 66 kg of SF_6 insulating gas.

dc Smoothing Reactors

Smoothing reactors (see photo of existing dc smoothing reactor at Henday Converter Station in Figure 3.5-9) are comprised of one or more air insulated copper coils. The reactors are required for attenuating dc voltage and current harmonics on the Bipole III HVdc transmission line.

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[26] See footnote 23.

Figure 3.5-8:
dc Filter Bank at Henday Converter Station

Figure 3.5-9:
dc Smoothing Reactor at Henday Converter Station

Surge Arrestors

Surge arrestors provide protection to ac switchyard components from abnormally high voltages induced from lightning. Surge arrestors are comprised of porcelain or composite materials, and are similar in appearance to insulators.

Insulators

Insulators are non-conducting posts used to support energized equipment and hardware in the switchyard. Insulators are typically placed on the top of steel equipment support structures, but may also be placed directly on equipment foundations.

3.5.3 Keewatinoow Ground Electrode

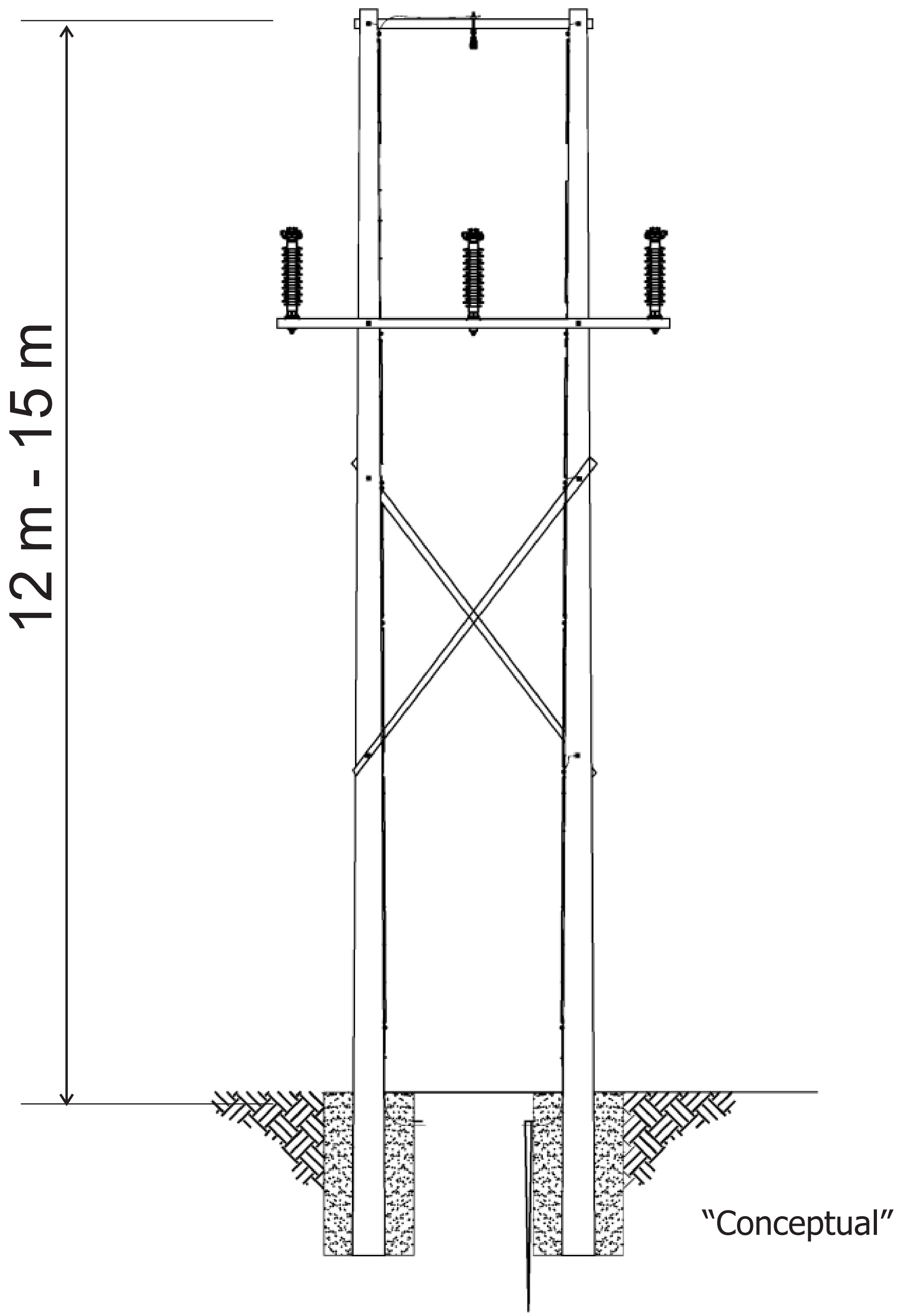
As outlined in previous sections, the neutral bus in the Keewatinoow Converter Station dc switchyard will be connected to the station ground electrode site by a low voltage overhead line.

3.5.3.1 Low Voltage Electrode Line

The function of the low voltage electrode line is to provide a low resistance connection between the neutral bus in the Keewatinoow dc switchyard and the ground electrode site. During normal operation (bipolar operation) of the converter station, the electrode line will carry very low levels of current between the station and the ground electrode. However, during some maintenance activities or emergency outages, the electrode line will carry current equal to the amount of current on the HVdc transmission line (monopolar operation).

The low voltage electrode line will be an overhead line supported either on guyed wood structures in a compressed H-frame configuration (see Figure 3.5-10), or on guyed steel lattice structures the same as those to be used for the 138 kV Keeewatinoow construction power line (similar to the tower illustrated in Figure 3.4-10). The structures will support three conductors, similar in current-carrying capacity to the pole conductors of the Bipole III HVdc transmission line.

Based on the location of the preferred Keewatinoow ground electrode site, the most direct and preferred routing for the electrode line is along an existing cleared right-of-way 30 m in width, shown in Map Series 3-500 (Map Tiles 3 and 4). Alternatively, the electrode line could be routed along the right-of-way of the Conawapa access road. However, this could necessitate use of additional guy wires for the poles in order for the line to follow the curvature of the road alignment. As well, the larger footprint required for placement of the guy wires might necessitate realignment of the line and corresponding road crossings.



THE ABOVE STRUCTURE WOULD REQUIRE
GUYING FOR NORTHERN MANITOBA
APPLICATIONS

Figure 3.5-10:
Alternative H-Frame Wood Pole Structure for Keewatinoow Ground Electrode Line

3.5.3.2 Ground Electrode

The function of the ground electrode is to provide a return path for current between the Riel and Keewatinoow converter stations. During normal operation (bipolar operation) of the Keewatinoow Converter Station, the ground electrode will conduct very low levels of current. However, during some maintenance or emergency outages at either converter station, the ground electrode will conduct current equal to the amount of current on the HVdc transmission line (monopolar operation).

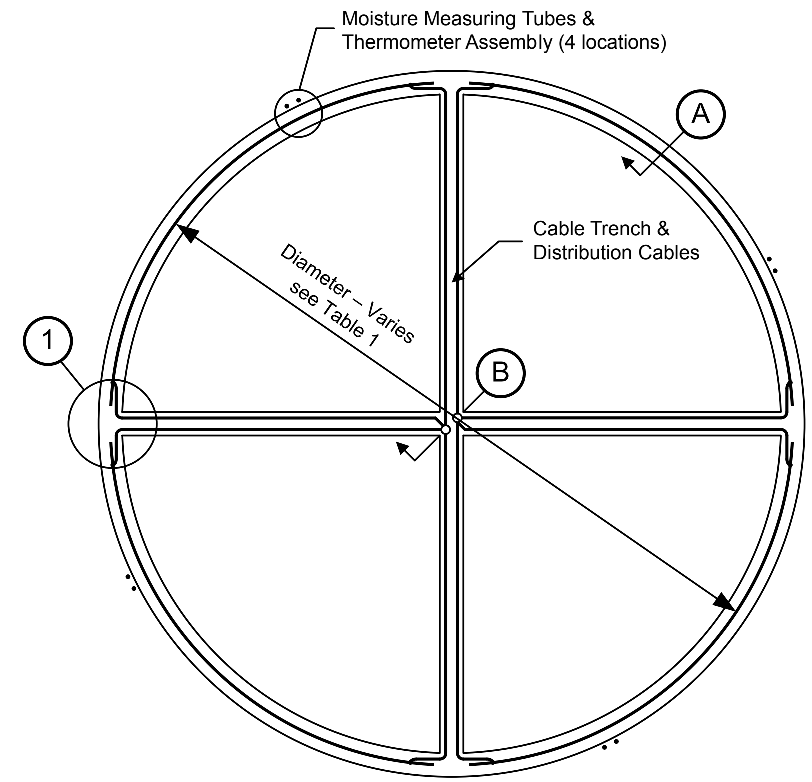
Pending confirmation of detailed design criteria, the ground electrode will be a shallow ring electrode—comprised of a four rod segments in a ring configuration, similar to the ground electrodes employed in support of Henday and Radisson converter stations. Shallow ring electrodes are typically buried below the frost line with the electrode ring embedded in a highly conductive coke bed (see Figure 3.5-11). Underground cables will connect the electrode ring to a dead-end pole structure located centrally on the electrode site. The dead-end structure provides termination for the electrode line and transition to the underground cables.

The ground electrode will require adequate soil moisture to function properly. Although the preferred site has promising soil moisture attributes, the electrode will be equipped with an underground irrigation system to provide for significant changes in soil moisture, or drought events. The irrigation system will be installed in or above the coke bed and fed from wells located on site.

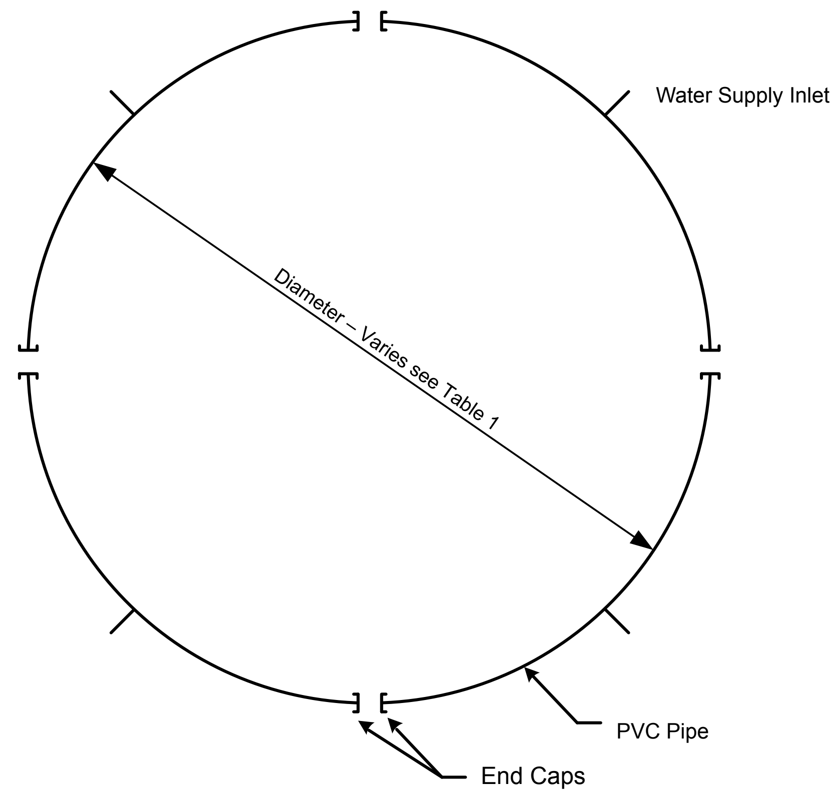
Within the preferred electrode site, a shallow ring electrode will be approximately 800 m in diameter. An access road for construction and ongoing maintenance will be constructed from the Conawapa access road to the site.

A vertical well electrode could also be selected for the electrode design if, during the detailed resistivity surveys phase, lower resistivity soil is found at deeper depths. Existing vertical well electrodes in other HVdc systems around the world are most frequently built at depths of 40 m or more. A vertical electrode would consist of an array of approximately 80-90 wells equally spaced and arranged in a circle, and would require a site similar in size to that identified for a shallow ring electrode.

Plan View

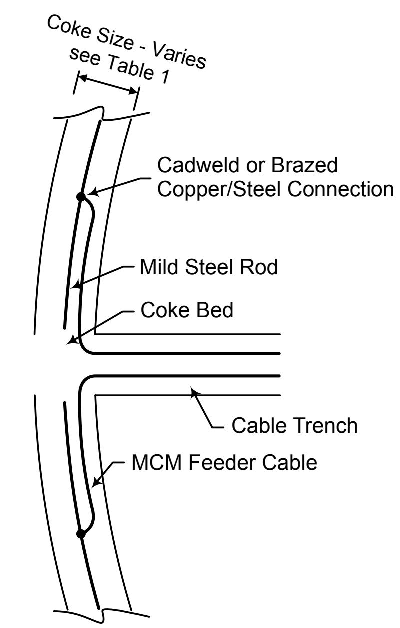


Water Distribution System



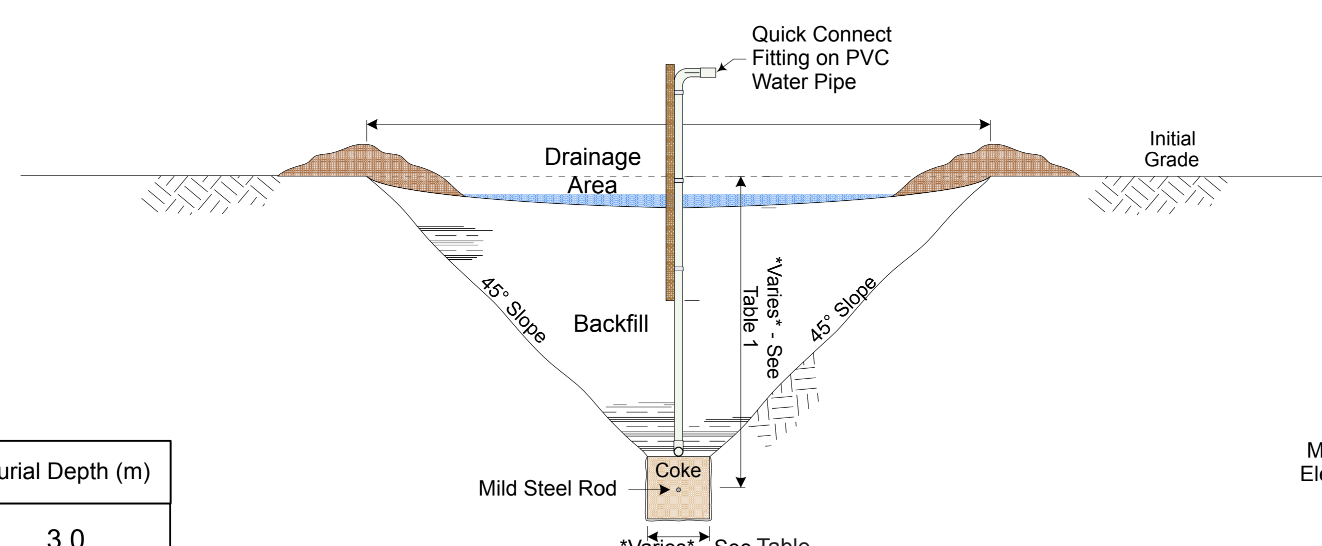
DETAIL 1

Distribution Cable Connections to Mild Steel Rods



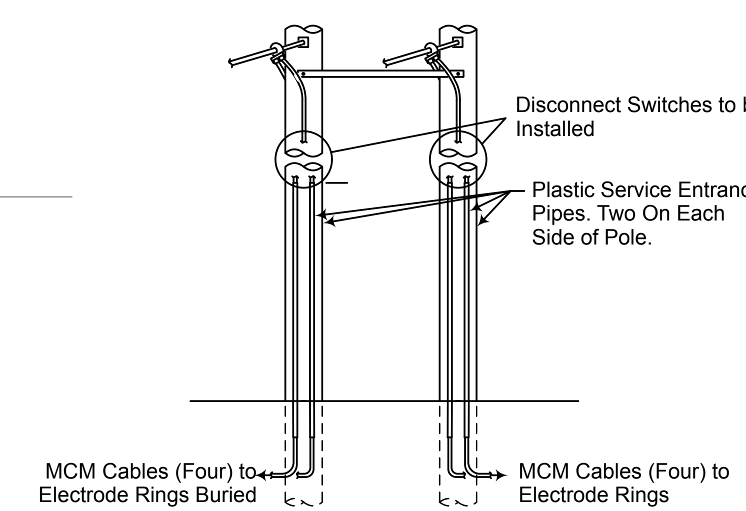
SECTION A

Electrode Trench



SECTION B

Electrode Line Terminal



Preliminary Ring Diameter and Coke Bed Size

Site #	Operating Current (amp)	Ring Electrode Diameter (m)	Coke Bed Size (m)	Burial Depth (m)
SES 1c	2200	400	0.6	3.0
NES6	2200	800	0.9	4.0

Figure 3.5-11:
Preliminary Design Concept for Keewatinoow and Riel Shallow Ring Ground Electrodes

3.5.4 Keewatinoow Construction Activities and Materials

The scope of the Keewatinoow Converter Station component of the Bipole III Project includes design, procurement and installation of a construction power station and construction facilities, including a camp to support a workforce of up to 500 people. Depending on internal Manitoba Hydro resources and the overall project delivery strategy, conventional construction contract and management procedures may apply to construction of the ground electrode, site preparation and infrastructure development, and development of the construction power station. The major equipment and electrical components to be installed in the station, such as the converter transformers, valve groups and ancillary facilities, and 230 kV switchyard equipment, are highly specialized devices which will be designed and manufactured off-site and delivered for installation and/or final assembly by highly specialized workers.

Clean-up will occur throughout all phases of construction. Disposal of non-toxic materials produced as a result of construction activities will be made at existing, appropriately licensed local facilities. Material supply and waste handling will be subject to conventional Manitoba Hydro codes of practice and relevant provincial legislation.

3.5.4.1 Converter Station Construction Activities

Construction of the Keewatinoow Converter Station will generally involve site preparation, such as: removing existing vegetation and organic topsoil; adding fill material; and placing granular materials for foundations, roadways, and site surfacing. Site development will include: drilling for wells and piles; driving pre-cast piles; placing concrete for cast-in-place piles, foundations, pads and structures; trenching for the placement of in-ground piping and cabling; placement of granular materials for surfacing; and erection and construction of ancillary buildings.

Construction of the 230 kV ac switchyard will include: drilling and driving of piles; placing concrete for piles, foundations, pads and structures; erecting steel structures for electrical hardware and equipment; erecting the control and switchgear buildings; delivery, placement and construction of switchyard equipment such as breakers and transformers; and the stringing, splicing and termination of overhead conductors for the switchyard.

Installation of the converter transformers will require drilling/placement or driving of piles; placing concrete for piles and transformer foundations and pads; and the delivery, placement, and construction/assembly of the transformers.

Construction of the converter building will involve the drilling and placing of piles; placing concrete for the building foundation; erecting the building using masonry, concrete and steel materials; installing and fitting of building mechanical and electrical support systems; and finishing the interior with materials to suit the different requirements such as offices, work areas, valve halls, storage and battery rooms.

Valve groups will be constructed within the valve halls of the converter building. Construction of the valve groups will involve erection of the valve towers within the valve halls; installation of electronic valve group controls; and placement of outdoor evaporative coolers and installation of indoor cooling systems.

Construction of the dc switchyard will include drilling and driving of piles; placing concrete for piles, foundations, pads and structures; erecting steel structures for electrical hardware and equipment; delivery, placement and construction of dc switchyard equipment such as switches, reactors and filters; and the stringing, splicing and termination of overhead conductors for the switchyard.

All construction activities conclude with the filling of insulating oils, insulating gases, battery acids, refrigerants, and other cooling mediums prior to system commissioning.

3.5.4.2 Electrode Construction Activities

Major activities for construction of a shallow ring ground electrode will include land clearing (only of that portion of the site to be occupied by the ring electrode and associated infrastructure); excavation of the electrode trench to a depth of approximately three to four metres; placement of coke bedding material; assembly of steel electrode rods; compaction of the coke bed; installation of irrigation pipes; backfilling of electrode trench; installing feeder cables; constructing of the line termination structure; and the termination of the feeder cables and electrode line to the termination structure.

Pending analysis of detailed resistivity surveys, which will be ongoing into the construction phase, a shallow ring electrode may not prove feasible. An alternative design would be a vertical well ground electrode. In that case, major construction activities would include land clearing; drilling of electrode wells to a depth of approximately 40 metres; assembly of piping and steel rods and cables; placement of the rods into the wellbores; pumping of water/coke slurry into the wellbore; and installing concrete covers over the wellbores.

3.5.4.3 Construction Power Station

The total construction power load is expected to be approximately 10-15 mega volt-amperes (MVA) inclusive of the Keewatinoow construction camp and converter station requirements, and a contingency allowance. The existing feeder line LC9 (a 12.47 kV distribution line from the Limestone construction power station) to the Conawapa site is rated for 1.5 MVA.

The additional construction power requirement will be provided by extending the existing 138 kV transmission line KN36 (which runs from Kelsey Generating Station to the Limestone construction power station) to a newly developed construction power station located near the Keewatinoow Converter Station site, a distance of approximately 31 km. On the basis that it may be used in the future for the potential Conawapa Generating Station, the station location is consistent with Manitoba Hydro's preliminary Conawapa development concept. The existing 12 kV feeder line LC9 will be re-terminated in the station for backup purposes. The station will remain in place following completion of the Bipole III Project to service the possible future Conawapa development.

The preliminary Conawapa development concept originally provided for siting of the construction power station on the northwest edge of the Conawapa access road allowance, approximately two km southwest of the future generating site. The proposed site has since been relocated approximately 80 m further southwest, enabling the fenced area to be located on a former construction site used during development of the Conawapa access road. Both the original and the revised sites are illustrated in Figure 3.5-12.

The overall Keewatinoow construction power station site area will be approximately 150 m square. The graded and fenced area occupied by the station equipment will be approximately 90 m x 65 m in dimension, with the long dimension oriented parallel to the Conawapa access road. Two site access roads will be provided between the fenced area and the Conawapa road.

The new station will supply the necessary power for construction of the Keewatinoow Converter Station, but will be designed to enable future expansion to support the power requirements for potential future Conawapa construction. The station site will be designed to accommodate three transformer banks, two of which (rated at 138 kV on the high voltage side) will be developed for the Bipole III Project requirements, and will terminate the 138 kV line KN36 from Limestone construction power station. A future third bank, rated at 230 kV on the high voltage side, will terminate the 230 kV line K61H from Henday and will serve the potential construction power requirements for Conawapa.

Wood pole structures will be installed for the 12.47 kV equipment. Steel structures will be used for the 138/230 kV equipment.

Figure 3.5-12:
Proposed Keewatinoow Construction Power Station

The two transformers will provide a loading capacity of 15 MVA with one unit operating, or 24 MVA with two units connected.

The 12.47 kV wood pole structure will terminate the overhead distribution pole lines for service of the Keewatinoow construction power requirements, and will be designed to accommodate a total of eight feeders including three potential future feeders and two 1,500 kVAR capacitor banks. The line egress for the five 12 kV feeders will be built overhead. One 12 kV feeder will terminate line LC9 from the Limestone construction power station. The existing Conawapa exploration camp is presently fed by line LC9.

The construction power station site will also house communications equipment. A microwave tower will be installed inside the station fence to provide construction communication needs (including station, camp, and construction activities) in the Keewatinoow area. The tower will be a self-supporting lattice steel structure, approximately 46 m tall, with a footprint of less than 25 m^2.

A shared modular building will house radio communications equipment and standby power (provided by batteries) for the Microwave tower and may also house some station control and protection equipment.

3.5.4.4 Site Preparation

Construction activity at the various Keewatinoow construction sites will generally involve advance site preparation and access development activities.

Clearing and Stripping

Initial site preparation will generally consist of clearing, grubbing and disposal of vegetation; stripping and removal of organic soils; and grading and drainage for control of surface or near-surface water.

Clearing procedures will be subject to detailed requirements identified in the Environmental Protection Plan. Suitable buffer zones will be provided and maintained to the satisfaction of Manitoba Conservation. Applicable fire, roadway and electrical (hydro pole) clearances will be maintained.

Cleared trees and brush will be stockpiled and burned, or otherwise disposed of in a manner approved by Manitoba Conservation. There is no merchantable timber in the immediate vicinity of the Keewatinoow site.

Organic soils suitable for landscaping and site reclamation will be stockpiled for later use during decommissioning of the various construction support facilities, to be undertaken once construction is complete.

Site Access Roads

Primary access to the Keewatinoow construction sites will be via an existing all-weather gravel road that was completed in 1992. Commonly referred to as the Conawapa access road, it was initially developed for the planned Conawapa Generating Station project, development of which was subsequently deferred.

The access road extends approximately 22 km from the provincial highway system (the termination of PR290) at Limestone Generating Station. As extension of rail access is not considered feasible, the road will provide the sole means of conventional vehicular overland access to Keewatinoow.

The access road will be used by heavy construction equipment for the duration of Keewatinoow construction. Some road rehabilitation and maintenance activities will be undertaken as soon as authorization for the Bipole III Project is received. The extent of the required access road upgrading is under ongoing assessment. It is anticipated that the work will be confined between the shoulders of the existing road surface, which should not affect existing ditches, drainage culverts or stream crossings.

All-weather gravel-surfaced internal access and haul roads for the individual construction sites within the Keewatinoow site will be extended from the Conawapa access road, and designed to serve the needs of the various sites during both the construction and operation phases of the project.

Roadways will generally be constructed on a compacted sub-grade, clear of any vegetation and organic soil, except in permafrost affected areas. Removal of vegetation will be carried out to the extent necessary for fire and utility clearances. The sub-grade will be excavated or backfilled as required to suit the final road elevation.

Localized soft spots will be excavated an additional 0.30 m below the sub-grade elevation and replaced with compacted granular material. Alternatively, geotextile may be placed on the sub-grade to support and separate it from the overlying granular road fill materials.

Roadway shoulders will generally be cross-graded at four percent down from the crown towards both shoulders. The maximum vertical grade of the roadways will be 6%. Horizontal and vertical curves will be in designed in accordance with Road and Transportation Association of Canada (RTAC) standards.

In permafrost affected areas, the roadways will be designed with an allowance for settlement. Road settlement will be kept within acceptable limits through maintenance procedures. Special construction procedures such as placement of a "corduroy" of timbers, or a geotextile at the foundation surface, may be required to ensure stability and provide greater strength of the sub-grade materials.

In areas where sub-grade disturbance is required for installation of culverts, or other underground infrastructure, excavated materials will be replaced with well compacted granular fill. Natural drainage will be maintained wherever possible. Any stream crossings required for access roads will be installed in accordance with stream crossing guidelines and Canada Fisheries and Oceans operation statements (see Aquatics Technical Report for stream crossing review).

Precise layout and design requirements for the access and haul roads will be determined on the basis of the contractors' proposed construction methodology and subject to Manitoba Hydro approval.

Site Grading and Drainage

Sub-grade preparation at the construction sites will remove unsuitable material prior to fill placement.

Depressions resulting from removal of stumps, logs and roots in the course of grubbing, or from removal of organic material and rocks, will be backfilled with suitable compacted material. Areas with any extent of permafrost concern will be excavated. Soft areas of the sub-grade surface will be broken up by disking or ploughing, and then compacted to acceptable density.

Suitable fill will be placed and compacted in accordance with site grading plans. Grading will be based on roadway and structure development requirements, adjusted for local topography and drainage requirements, and designed to minimize the volume of excavated material and fill.

Site drainage will be achieved by use of swales, culverts and ditches within and around the roadways and structures.

Ditch capacities will be sized to accommodate the extreme daily rainfall event. Flow volumes and velocities will be kept low enough to minimize erosion and scouring of drainage areas. Energy dissipating methods, such as use of riprap and ditch lining, will be applied in areas where velocities are deemed to be otherwise excessive. Silt fences will be installed where necessary to prevent sediment from reaching natural waterways.

Disposal of Excavated Materials

In the course of borrow area development and site preparation for the various Keewatinoow components, a considerable amount of earth and rock materials will be excavated. Some of these (e.g., soil and organic materials) will be stored and used in site construction and borrow area rehabilitation. The remainder will be placed in an excavated material placement area (see Map 3-9). Materials will be placed to a height of up to eight metres. The central portion will be largely composed of impervious silts and clays and will have very shallow outer slopes. Rock filled berms will be used at the toe of the disposal area to prevent erosion. The majority of drainage water will be reabsorbed within the immediate area and runoff will naturally flow towards the Nelson River. At the close of the construction phase, the placement area will be covered with salvaged organics and soils to provide an erosion resistant surficial layer and to promote the re-growth of natural vegetation. The area will settle gradually at non-uniform rates, resulting in some containment of run-off that will further assist in re-growth of natural vegetation.

3.5.4.5 Construction Material Requirements

Construction materials will be required to support site development for the converter station, the ground electrode, the station access road, the construction camp and other supporting infrastructure. The required materials will include concrete aggregates, random fill, sub base material, insulation stone, road-topping material, erosion control material, oil containment material, and pipe bedding. The following table lists the related requirements, including estimated volumes.

Table 3.5-2: Keewatinoow Granular Material Requirements for Construction

Granular Material Type	Estimated Material Volume Required by Development Site (m3)			
	Converter Station	Electrode and Access Road	Construction Facilities	Total Estimated Volume
Concrete Aggregate - Fine Aggregate - Coarse Aggregate	35,000 46,000	2,000 2,000		37,000 48,000
Random Fill	500,000	120,000	35,000	655,000
Sub-base Material	120,000	140,000	5,000	265,000
Insulation Stone	52,000	2,000		54,000
Road Topping Material	10,000	80,000	5,000	95,000
Erosion Control Material	5,000	5,000		10,000
Oil Containment Material	10,000			10,000
Pipe Bedding	15,000	15,000		30,000
Total Granular Material Requirement	793,000	366,000	45,000	1,204,000

Site investigations, conducted over the years by Manitoba Hydro and others, have identified a number of nearby natural sources of impervious (e.g., clay) and granular (e.g., sand and gravel) materials which could be used in the construction of the camp and supporting infrastructure for the Keewatinoow development.

Suitable impervious materials are available at or near the various construction sites. Off-site borrow sources will be required primarily for supply of granular materials. Materials such as concrete aggregates and granular fill will generally be obtained from borrow pits in close proximity to the construction sites (see Map 3-9) or from quarry stockpiles in the vicinity of Limestone Generating Station. Additionally, some materials may also be purchased from local suppliers.

Testing of borrow pit and stockpile materials is currently in progress to ensure that all materials are suitable for use in both the temporary and permanent structures. Both sand borrow and rock samples have been chemically tested for their suitability for placement in an aquatic environment. Preliminary results indicate a relatively low potential for metal leachate generation and, on that basis, no related environmental concerns are anticipated.

In general, the selection and utilization of borrow areas will remain the responsibility of the contractors. However, borrow pit siting and development will only be undertaken with the prior review and approval of Manitoba Conservation and Manitoba Hydro. The Environmental Protection Plans within the contract documents will clearly stipulate requirements for the protection of streams, ground water, wildlife habitat and adjacent vegetation during exploitation of material source deposits by the contractor. Contract documents will also clearly state the nature of and methods for rehabilitation of the areas after usage.

3.5.4.6 Supporting Construction Infrastructure and Activities

Construction support activities are described in the following sections. These will include aggregate processing and concrete batch plant operation, development and operation of equipment storage and work areas, and development and administration of an access management plan.

Aggregate Processing

Processing of aggregates for Keewatinoow construction requirements will involve crushing, screening, washing and stockpiling of granular materials from the borrow areas. Related operations will involve crushing machines and conveyor belt systems, similar to those pictured in Figure 3.5-13, a photo of aggregate processing operations at the Wuskwatim Generation Project.

Concrete Batch Plant

Construction activities at Keewatinoow Converter Station and supporting sites will require the production of approximately 15,000 to 45,000 m^3 of concrete that will be manufactured in an on-site batch plant (see Figure 3.5-14 – a photo of the concrete batch plant at Wuskwatim), the function of which is to mix water, cement, aggregates, and additives to produce concrete.

Figure 3.5-13:
Aggregate Processing Operations for Construction of Wuskwatim Generating Station

Figure 3.5-14:
Concrete Batch Plant for Construction of Wuskwatim Generating Station

The total quantity of concrete to be cast in place will be a function of the detail design and the use of precast concrete materials. The contractor will be responsible for determining the layout and installation of the Keewatinoow batch plant within the confines of the converter station site as shown in Map Series 3-500 (Map Tile 4) or associated contractor's work area.

Studies are currently underway to confirm the feasibility of drawing on ground water for the supply of water for concrete production. Cement will be supplied to the site throughout the duration of project construction and will be held in temporary storage silos adjacent to the batch plant. Finished aggregate will also be stored adjacent to the batch plant. Concrete additives will be sourced and supplied based on technical and economic considerations, as proposed by the contractor.

The production of concrete during the winter months may require a heating system to maintain the concrete at a suitable temperature. Concrete production during summer months may require a cooling system employing an ice plant to maintain the concrete at a suitable temperature. Heated water will not be discharged directly to natural water courses.

Aggregate wash water will flow into an appropriately sized settling pond with a minimum of two cells. The larger particles will settle out in the primary cell and the finer particles in the secondary cell; some filtering may also be provided. Total levels of suspended solids will be monitored to ensure conformance to provincial and federal regulations and the Environmental Protection Plans. The pond will be intermittently discharged through the local land drainage system to the existing drainage ditch along the Conawapa access road, which leads to Goose Creek and ultimately to the Nelson River

Concrete wash water (the relatively smaller amounts of water used to wash out concrete trucks and the concrete batch mixer) will be contained on-site and treated to meet turbidity and pH requirements prior to discharge. Turbidity will be treated by settlement or filtration; pH will be treated by use of acid, dry ice, or carbon dioxide gas. The contractor may elect to use a washout treatment unit, which typically uses carbon dioxide for treatment. Following treatment, in accordance with provincial and federal regulation and the Environmental Protection Plans, the effluent will be intermittently discharged through the local land drainage system into the existing drainage ditch along the Conawapa access road, which flows to Goose Creek with an ultimate discharge into the Nelson River.

Manitoba Hydro Work Area

Work areas will be provided both for Manitoba Hydro and the contractors involved in the construction of converter station on or adjacent to the principal construction sites.

Additionally, it is anticipated that small storage and field office facilities will located at the various construction sites within the station area.

The Manitoba Hydro work area will contain an engineering office, a warehouse storage building and yard, a fuel storage and vehicle refuelling facility, field offices, a soils and concrete laboratory, and a maintenance building. A helicopter landing area will be located close to the access road near the Manitoba Hydro work area. The landing area will be available for all emergency medical evacuations and other authorized traffic, as required. Work area water and sewer services will utilize the construction camp water and sewer systems. Water and wastewater will either be handled through direct connection to the camp systems, or will be transported between the camp facilities and holding tanks at the work area.

Contractors' Work Areas

The contractors' work area will generally contain portable modular buildings, storage facilities, maintenance shops, a fuel storage and vehicle refuelling facility, toilet facilities, a concrete batch plant, an aggregate processing area, a carpenters' shop, and a precast concrete yard.

In the event that the use of explosives is necessary (e.g., for excavation of rock or large boulders or for splicing and terminating electrical conductors), a magazine for storage of explosives will be located away from the work and camp areas, in accordance with provincial blasting regulations. The contractor will be responsible for obtaining any required licensing. Location of the magazine will be subject to all applicable legislation and regulation, and to Manitoba Hydro approval.

The contractor will provide temporary portable toilet facilities, with holding tanks, at the various station construction sites. The waste will be regularly pumped out and transported for disposal via the construction camp wastewater system.

The Environmental Protection Plans will identify special precautions to be taken within the work areas. Provincial and federal regulations, guidelines and special conditions related to the storage of fuels and explosives, and to the handling and storage of other hazardous or dangerous goods, will be strictly enforced.

The design and development of the construction access routes, water crossings, drainage facilities, and erosion and sediment control methods will be developed by the contractor, subject to Manitoba Hydro approval, and in accordance with the project Environment Act license and the Environmental Protection Plans.

Construction Access Management

It is anticipated that major equipment and materials required for Keewatinoow development will be transported via rail to the existing Henday Converter Station siding, and then transferred to truck for road delivery to Keewatinoow. Alternatively, equipment and materials may be transported directly from point of origin to the Keewatinoow site by truck, or by a combination of air, rail and road. No direct rail access or airport/runway development is proposed at the site.

Highway weight and size restrictions will require some major equipment deliveries to be made by CN rail services from Winnipeg, via the existing Hudson Bay (HB) rail facilities, to Gillam, Henday or the Limestone Generating Station stores yard. Such deliveries will be trans-shipped by truck to the Keewatinoow site.

Construction access to the station site and the electrode site will require development of local access extending from the Conawapa access road, a private road owned and operated by Manitoba Hydro. During construction of the converter station and associated infrastructure, the Conawapa access road will be closed to the general public for safety reasons. A 24-hour supervised security gate located near the beginning of the existing access road will control access to the road.

The security gate area will include a small, self-contained security office or "gatehouse", which will contain a potable water supply and public washroom with holding tank. Other features will include radio communications, electric heat, overhead exterior lighting, parking stalls and a turnout/parking lane for large trucks. Electricity will be provided by tapping into Manitoba Hydro's existing electrical distribution lines.

A shuttle van service will be established to transfer workers and mail to and from Gillam and the main camp during the Keewatinoow construction phase. This service will be coordinated with the current commercial bus service operating between Thompson and Gillam and with scheduled airline services. The shuttle service will not be provided for the purpose of worker recreation.

Henday/Limestone Rail Access

The existing rail spur at Limestone/Henday connects to the (Winnipeg-Churchill) Hudson Bay Railway. This rail spur is currently used intermittently for Henday Converter Station operational requirements, and was used during construction of the Limestone Generating Station.

Rail transportation provides an alternative to trucking, especially for oversized or overweight shipments. Rail shipments of project material/equipment would be offloaded at Limestone or Henday and subsequently trans-shipped by truck to the Keewatinoow site.

The rail spur will require some upgrading and maintenance, the extent of which is under ongoing review. It is anticipated the work will consist of new track ballast, ties and possibly replacement of some defective rail. Work will be confined to the railroad bed and will not affect existing ditches, drainage culverts or stream crossings.

Henday/Limestone Marshalling and Storage Areas

The contractors working on the Keewatinoow Project will require areas to off-load, store and stage project material and equipment prior to its requirement for construction, installation or decommissioning. Manitoba Hydro has also considered the feasibility of using off-site yards to promote more extensive use of rail shipments (e.g., for bulk materials like cement, reinforcing steel, etc.), as well as the prospect of using the yards in support of potential future Conawapa development.

Two areas have been identified for this purpose: the existing Henday Converter Station storage yard, and the existing Limestone Generating Station yard. Both areas are serviced by the previously described HB rail spur. Both provide large areas for storage and lay-down, and their use will reduce the corresponding requirement for marshalling and storage at the Keewatinoow site.

Both yards will require some upgrading, the extent of which is under study. It is anticipated that the work will include grading and levelling of the existing granular base, and the provision of additional loading docks and new grid markers.

Depending on how the project stores operation is organized, it may be necessary to install a temporary modular office building, as well as new heated and un-heated storage buildings. These would likely be retained for operational use after completion of the Keewatinoow development.

Potable water supply will be supplied by either an extension of the existing Limestone and Henday systems, or by transport from Henday, Limestone or Gillam and storage in approved potable water containers located at the yards. All solid and liquid sewage wastes will be collected in holding tanks and removed from the site to licensed disposal/treatment facilities.

Construction Traffic

Construction traffic on the Conawapa access road will include heavy truck traffic from Henday/Limestone and from borrow areas, as well as lighter vehicle traffic for transport of workers to and from the Keewatinoow construction camp and the various construction sites. Vehicular construction traffic at, and in the vicinity of, the various Keewatinoow construction sites will likely involve both rubber tired and track-mounted vehicles.

Traffic studies[27] have included estimates of project shipping and workforce travel requirements, by rail and road, for the Keewatinoow and Riel converter stations, as well as the HVdc transmission line. Estimates have been compared to current and historical traffic flows on existing area transportation infrastructure. In the case of Keewatinoow (independent of all other project components), estimated daily workforce trips during the construction period are estimated to range up to 130 trips (AADT [average annual daily trips]) in year 3 on the Conawapa access road between the construction camp and the work site, and up to 116 trips in year 3 on PR 290 near Sundance. Corresponding estimates for daily truck trips (AADTT), for transport of materials and equipment, range up to 405 trips (in 2013) on the Conawapa access road, and up to 10 trips (in 2015) between Winnipeg and the access road. The studies extended to analysis of potential impacts of construction traffic on road, rail and air infrastructure. Related findings are further discussed in subsequent sections of the Environmental Impact Statement.

Any traffic noise generated during the construction phase will be temporary in nature and will be subject to all relevant policies and regulations, including limits to construction working hours. All pertinent laws and regulations respecting such use of public roads, including any road restrictions, will be observed. Construction activity and access requirements will be subject to established environmental protection measures associated with conventional Manitoba Hydro station construction practices.

Construction staff will be housed in a nearby construction camp (see Section 3.5.4.8). The primary means of worker transportation to the camp will be by road direct, or by air to Gillam and road to the camp.

Details respecting construction staging and marshalling of construction materials (as between the Limestone and Henday yards and the Keewatinoow site) will be provided as studies are completed.

3.5.4.7 Construction Contract Procedures and Workforce Requirements

Over the duration of its construction, employment associated with development of the Keewatinoow Converter Station is expected to total 922 person-years, inclusive of all specialized trades, construction management, general assembly and installation, maintenance, catering, labour, etc. (see Figure 3.5-15 and Figure 3.5-16).

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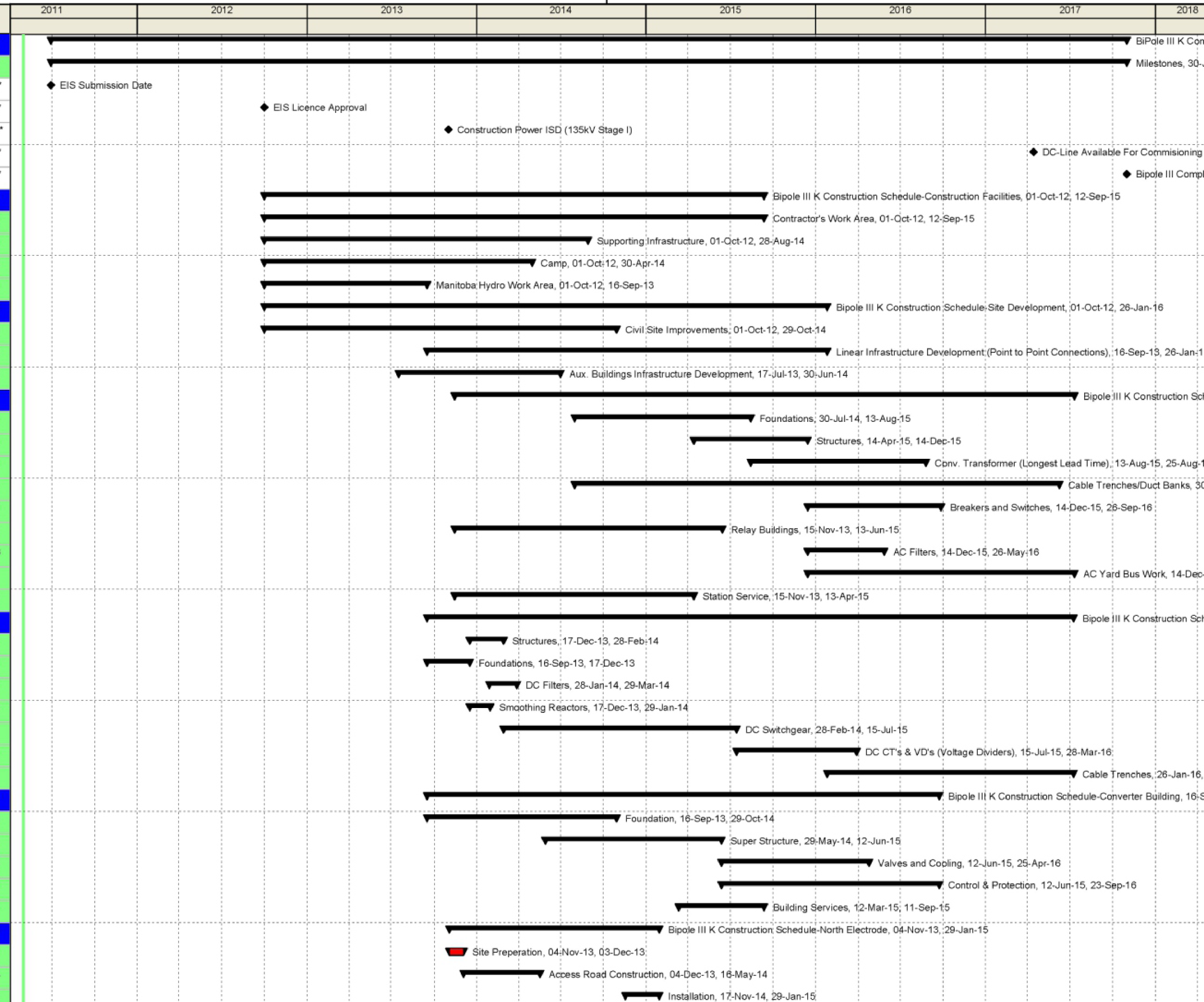
[27] MMM Group Limited, Bipole III Transmission Project, Transportation Study, Draft 3, prepared for Manitoba Hydro, June 2011.

Environmental approval and licensing of the Project is expected to be completed by the Fall of 2012. Pre-licensing activities and related job opportunities will include environmental assessment and consultation activity, and on-site engineering field investigations (including soil sampling, resistivity and magneto-telluric testing, and installation of thermal monitoring wells). Related activities (e.g., clearing of sampling sites and access trails, drilling of sampling holes, etc.) are being reviewed with First Nations in the vicinity of the site in advance of application for and receipt of the necessary government work permits.

BPIII - Keewatinoow Pre-Construction Plan Schedule Draft	Preliminary Draft Schedule	Draft Schedule Printed 2011/01/27

Activity ID	Activity Name	Original Duration	Start	Finish
	BiPole III K Construction Schedule-Milestone Dates	1873	30-Jun-11	31-Oct-17
	Milestones	1873	30-Jun-11	31-Oct-17
MS1000	EIS Submission Date	0		30-Jun-11*
MS1010	EIS Licence Approval	0		01-Oct-12*
MS1020	Construction Power ISD (135kV Stage I)	0		01-Nov-13*
MS1040	DC-Line Available For Commisioning	0		13-Apr-17*
MS1050	Bipole III Complex ISD	0		31-Oct-17*
	Bipole III K Construction Schedule-Construction Facilities	890	01-Oct-12	12-Sep-15
	Contractor's Work Area	890	01-Oct-12	12-Sep-15
	Supporting Infrastructure	576	01-Oct-12	28-Aug-14
	Camp	472	01-Oct-12	30-Apr-14
	Manitoba Hydro Work Area	290	01-Oct-12	16-Sep-13
	Bipole III K Construction Schedule-Site Development	994	01-Oct-12	26-Jan-16
	Civil Site Improvements	628	01-Oct-12	29-Oct-14
	Linear Infrastructure Development (Point to Point Connections)	705	16-Sep-13	26-Jan-16
	Aux. Buildings Infrastructure Development	287	17-Jul-13	30-Jun-14
	Bipole III K Construction Schedule-AC Yard	1097	15-Nov-13	10-Jul-17
	Foundations	313	30-Jul-14	13-Aug-15
	Structures	209	14-Apr-15	14-Dec-15
	Conv. Transformer (Longest Lead Time)	313	13-Aug-15	25-Aug-16
	Cable Trenches/Duct Banks	861	30-Jul-14	08-Jun-17
	Breakers and Switches	235	14-Dec-15	26-Sep-16
	Relay Buildings	470	15-Nov-13	13-Jun-15
	AC Filters	130	14-Dec-15	26-May-16
	AC Yard Bus Work	470	14-Dec-15	10-Jul-17
	Station Service	417	15-Nov-13	13-Apr-15
	Bipole III K Construction Schedule-DC Yard	1148	16-Sep-13	08-Jul-17
	Structures	52	17-Dec-13	28-Feb-14
	Foundations	78	16-Sep-13	17-Dec-13
	DC Filters	52	28-Jan-14	29-Mar-14
	Smoothing Reactors	26	17-Dec-13	29-Jan-14
	DC Switchgear	418	28-Feb-14	15-Jul-15
	DC CT's & VD's (Voltage Dividers)	209	15-Jul-15	28-Mar-16
	Cable Trenches	443	26-Jan-16	08-Jul-17
	Bipole III K Construction Schedule-Converter Building	912	16-Sep-13	23-Sep-16
	Foundation	339	16-Sep-13	29-Oct-14
	Super Structure	313	29-May-14	12-Jun-15
	Valves and Cooling	261	12-Jun-15	25-Apr-16
	Control & Protection	391	12-Jun-15	23-Sep-16
	Building Services	157	12-Mar-15	11-Sep-15
	Bipole III K Construction Schedule-North Electrode	365	04-Nov-13	29-Jan-15
	Site Preperation	26	04-Nov-13	03-Dec-13
	Access Road Construction	130	04-Dec-13	16-May-14
	Installation	52	17-Nov-14	29-Jan-15



Actual Work | Critical Remaining Work | Milestone | Remaining Work | Start Constraint | Summary

Figure 3.5-15:
Preliminary Keewatinoow Construction Schedule

Contract Procedures

Initial construction and related contracts are anticipated to follow conventional design and construction practice. This will involve direct participation by Manitoba Hydro staff and consultant personnel in the conduct of on-site investigations, and preparation of design documents and construction specifications. Some construction activity will also be undertaken directly by Manitoba Hydro personnel.

Some components will involve letting of construction contracts and on-going supervision by Manitoba Hydro. Corresponding arrangements will apply to site preparation work and related infrastructure for the construction power station, the construction camp, and the converter station and electrode site. Similar arrangements are likely to apply to construction of the ground electrode and connecting line.

The more technically complex aspects of the project, including the converter transformers, the valve groups and ancillary facilities, and 230 kV ac switchyard equipment, are expected to be designed and manufactured off-site. Assembly and installation of such equipment will generally be performed by highly specialized workers.

All contracts and tender calls will include environmental information and stipulate adherence to related environmental protection requirements.

Employment Opportunities

The conventional contract arrangements will include a substantial component of general labour and construction trades, and will offer a variety of employment opportunities. Contracts related to the assembly and installation of the HVdc and 230 kV ac switchyard equipment will substantially involve highly specialized workers, many of whom will be involved in both the off-site manufacture of equipment and its on-site assembly and installation. Local employment opportunities will be less significant for these contracts.

Keewatinoow Converter Station employment opportunities will include construction and service jobs in areas such as:

- Catering for the camps and security (for both the camp and construction sites), extending for the duration of the construction schedule;
- Site and camp development (labourers, operators and teamsters for clearing, grubbing, excavation and earthmoving), extending for a period of approximately four months;
- Foundation preparation (labourers, carpenters, and steelworkers for construction of building, structure and equipment foundations), extending for a period of approximately four months; and

- Buildings and services development (labourers, carpenters, electricians and pipefitters for construction of camp).

The allocation of employment opportunities will generally be based on the hiring preferences defined in the Burntwood Nelson Agreement (BNA)[28]. Manitoba Hydro may also directly negotiate certain contracts or work packages with in-vicinity First Nations, who would then have ability to hire their members directly for such work.

The Keewatinoow project work will be tightly scheduled. The work week is expected to include six nine-hour work days, typically on a Monday to Saturday schedule. Workers will be eligible for an unpaid leave of up to six days after 45 days on the job. Overtime will be paid after 40 to 45 hours per week depending on the trade. Employees will be able to live at no cost to them in the construction camp. Those who choose to live in a nearby community and commute to the job site will be responsible for their own transportation costs, but existing local residents may be provided with a modest housing allowance.

Work Force Requirements and Schedule

Figure 3.5-16 illustrates the estimated workforce requirements for Keewatinoow construction (i.e., exclusive of transmission line requirements), by quarter, over the course of the construction period. The estimates are for the peak employment during the quarter; not all of these positions would last for the entire duration of the quarter. The estimates include contractor positions that would be within the scope of the collective bargaining agreement, but exclude senior contractor supervisory and management staff, Manitoba Hydro staff, camp operation staff, and positions related to transmission line construction. Manitoba Hydro and contractor supervisory staff requirements are expected to be in the order of 20% of the illustrated estimates.

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[28] Work at the Keewatinoow site will be covered by a collective bargaining agreement known as the Burntwood-Nelson Agreement (BNA), which is intended to ensure labour stability (i.e. no strikes or lock-outs during construction) and provide cost-competitive wages and benefits. All jobs filled through the job order process will be covered by this agreement which, among other things, sets out wages, employee benefits, work hours, overtime pay and specifies the job referral process, hiring preferences, trainee/apprenticeship ratios, the lay-off process and the grievance process. The BNA is negotiated by the Hydro Project Management Association, which represents Manitoba Hydro and contractors, and the Allied Hydro Council, which represents the construction unions. Parties to the negotiation process have to agree on and approve the conditions of employment (e.g., the hiring preference, referral and hiring system, and on-the-job training provisions) for the project. All contractor employees covered under the CBA will be required to become a union member once they are hired to work on the Project, if they are not already union members.

Keewatinoow Converter Station - DRAFT
Quarterly Construction Site Workforce Forecast
Contractor Site Craft Personnel
February 28, 2011

Labor Group	Total (person-years)	Y-6				Y-5				Y-4				Y-3				Y-2				Y-1				Y				Y+1			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
CONSTRUCTION SUPPORT AND SERVICE TRADES	219	0	0	0	0	0	0	1	39	41	44	53	50	52	46	37	39	35	41	52	52	43	44	42	35	32	32	31	19	11	8	6	2
NON-DESIGNATED TRADES	252	0	0	0	0	0	0	0	55	72	64	85	114	118	92	57	62	51	46	64	53	18	19	19	14	7	7	7	5	3	0	0	0
DESIGNATED TRADES	451	0	0	0	0	0	0	0	32	73	105	115	145	198	174	96	106	84	86	121	136	94	96	83	28	23	25	23	11	3	0	0	0
TOTAL CONTRACTOR CRAFT PERSONNEL	**922**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**126**	**186**	**213**	**253**	**309**	**368**	**312**	**190**	**207**	**170**	**173**	**237**	**241**	**155**	**159**	**144**	**77**	**62**	**64**	**61**	**35**	**17**	**8**	**6**	**2**

Notes:

1) The above forecasts are based on Manitoba Hydro's forecast of workforce and a construction schedule based on a October 2017 in-service date of the Bipole III Complex.

2) The above information represents a forecast only, based on current regulations, present project plans, and experience with similar projects. Contractors will determine specific job requirements when the project is being built. Actual employment requirements will vary from the forecast presented above.

3) "TOTAL CONTRACTOR CRAFT PERSONNEL" refers to the average number of people on site within the quarter specified based on a monthly estimate, rounded to the nearest whole number.

4) The above information indicates contractor craft site personnel (not including supervisory and management positions). The above forecasts also do not include Manitoba Hydro staff, or workforce for the construction of Substations and Transmission Lines.

5) **Designated Trades** are those trades which apprenticeship training and certification requirements are regulated by the Government of Manitoba in accordance with the Apprenticeship and Trades Qualification Act.

6) Total (person-years) are calculated based on the estimate of person-months, where one person year is equivalent to 12 person-months.

7) Estimate represents projected number of workers needed on site during the specified time period and does not account for turnarounds.

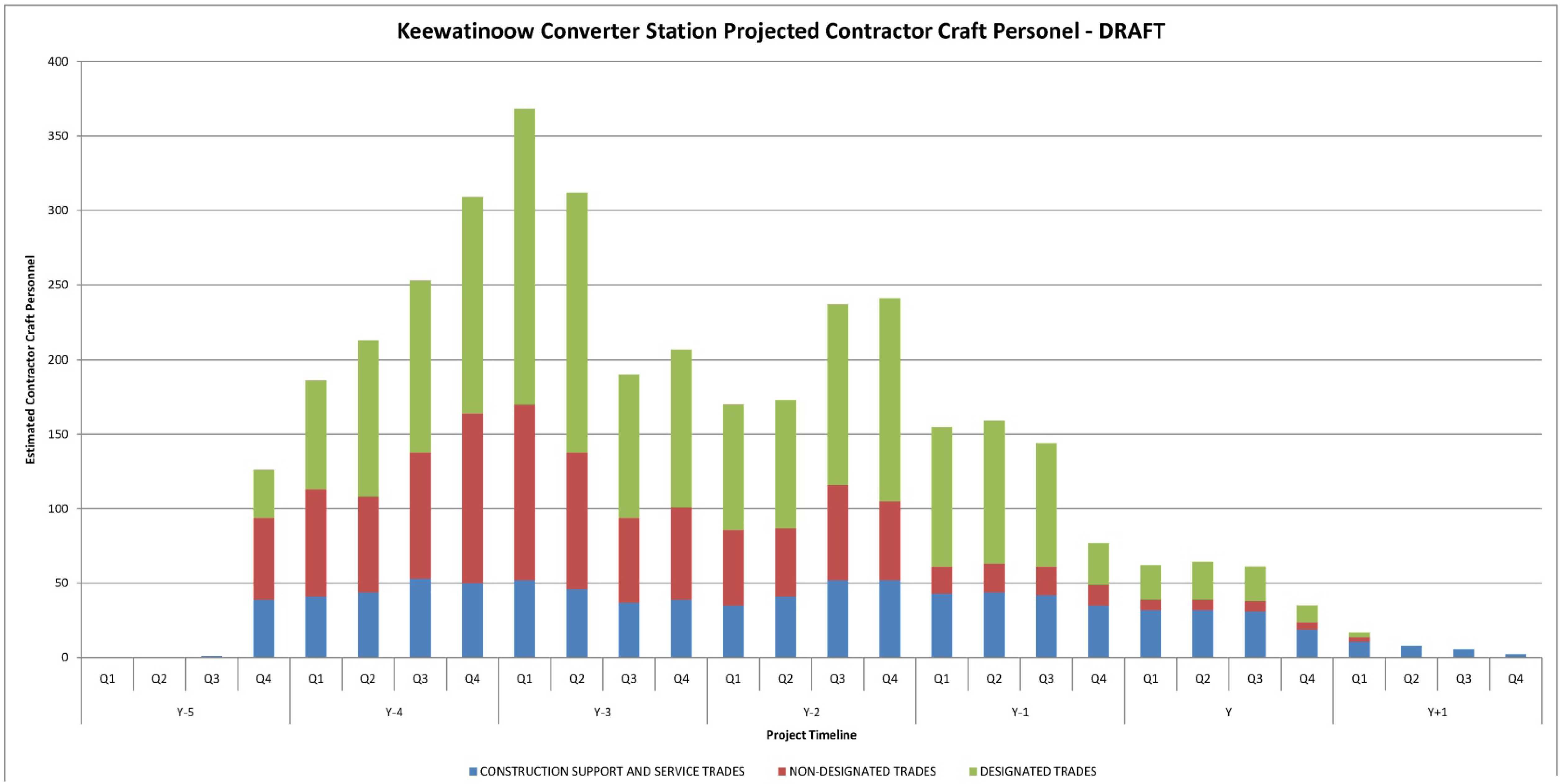

Figure 3.5-16:
Preliminary Keewatinoow Work Force Estimates

The workforce (exclusive of Manitoba Hydro and contractor supervisory staff) will be in the order of 250 through mid-2013, until installation of the construction power station is complete—tentatively scheduled for October 2013. Basic site preparation and infrastructure construction will follow, as will development of the construction camp. The main camp is scheduled to be operational by the end of April 2014.

Major construction is expected to commence in late 2013, continuing through to September 2017. The workforce during this period will peak in excess of 300 in late 2013 and early 2014, and taper gradually down to less than 100 by late 2016. Through to completion of construction in late 2017, the total will decline to about 30, as the emphasis shifts from construction to commissioning. The construction workforce will wind down entirely by mid-2018.

3.5.4.8 Keewatinoow Construction Camp

Work Force Accommodation Alternatives

The experience of past major Manitoba Hydro projects has shown that recruitment and retention of a quality workforce requires provision of clean, comfortable accommodation, good quality nutritious food, and a sense of community.

The Keewatinoow site is remotely located. The nearest existing communities, Gillam (2006 census population of 1,209 [Statistics Canada]) and the Fox Lake Cree Nation community at Bird (estimated January 2011 population of 134 [Indian and Northern Affairs Canada]) are too small to accommodate the expected peak workforce required for Keewatinoow construction comfortably, and too distant (91 km and 35 km respectively) to facilitate effective commuting arrangements.

Given these circumstances, housing the workforce at the Keewatinoow site was determined to be the preferred alternative. Such an approach will reduce concerns about the potential adverse social effects arising from an influx of project workers into neighbouring communities. The approach will also minimize the adverse effects on the workforce arising from a long daily commute, and, to the extent that a full range of accommodation can be feasibly provided at a single location, it avoids the cost of duplicating facilities and infrastructure in multiple locations.

Policies regarding alternative accommodations and eligibility of project employees are under ongoing review. Consideration is being given to the option of providing a limited number of family accommodations in Gillam (expected to be less than five) for use by project employees who would reside at the Keewatinoow site during the workweek. Such an alternative might appeal to project management staff with families and school-age children.

Workforce Accommodation Concepts and Site Selection

Manitoba Hydro's objective is to ensure that camp accommodations support a quality of life that is conducive to attracting and retaining the quantity and quality of workers required to construct a major project successfully. Achievement of this objective requires careful attention to safety, construction and maintenance standards, appearance, comfort, amenities, operations and catering.

The Keewatinoow work force accommodations will include a start-up camp and a main camp, including a management subdivision. Camp layout has not been finalized, but will be similar in concept and appearance to the Wuskwatim camp layout illustrated by the annotated photo in Figure 3.5-17.

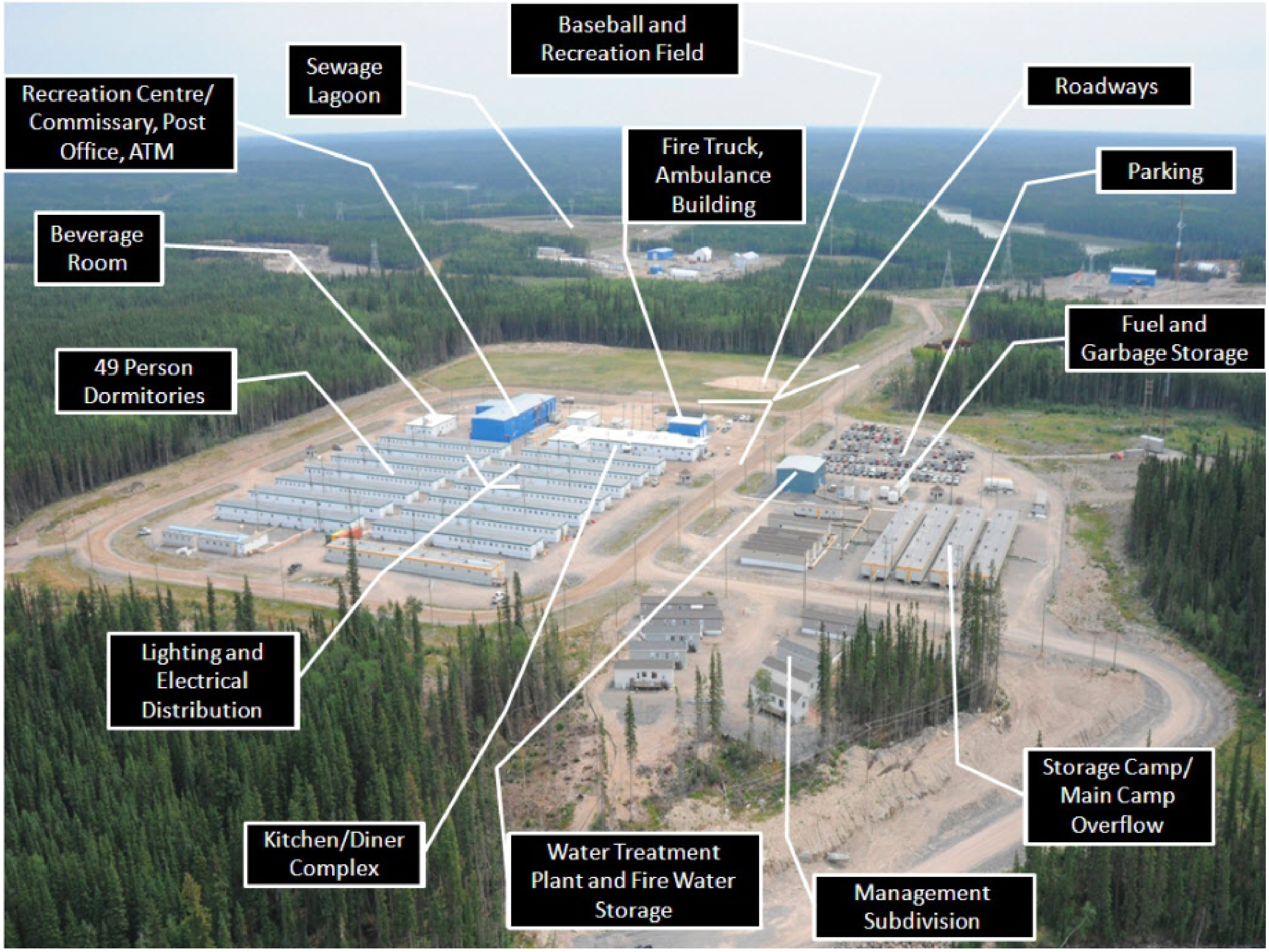

Figure 3.5-17:
Construction Camp for Wuskwatim Generating Station

As previously indicated, the sites chosen for the Keewatinoow construction camp requirements were reviewed and discussed with representatives of Fox Lake Cree Nation in a number of meetings. Discussions continue with a view to identifying and addressing the effects on members of Fox Lake Cree Nation of the Bipole III Project.

Start-up Camp

Site Selection and Location

A temporary start-up camp will house workers constructing the larger main camp and other initial construction activities, including converter station site development (as well as transmission line workers involved in development of the construction power and northern collector lines), upgrade of the access road, and development of construction power. The start-up camp development land parcel will be approximately 250 m x 250 m (6.25 ha) in size. It is proposed to be located at the site of the existing exploration camp, approximately four km north of the Keewatinoow Converter Station site, on the north side of the Nelson River and adjacent to the south side of the access road (known locally as the "Conawapa camp").

The proposed site offers a number of advantages:

- Proximity and good access to work areas (i.e., converter station and proposed main camp site);
- Removed from existing communities (which will minimize worker interaction);
- Existing exploration camp provides an option for initial accommodations during the early stages of the project;
- Minimal clearing and site preparation requirements;
- Existing well provides a good quality and economical water source;
- Existing electric power and communications systems;
- Existing helicopter landing area; and
- Size and proximity provide option to utilize start-up camp as overflow accommodation to supplement capacity at the main camp, if it is required during the peak years of project construction.

The combination of these advantages will minimize adverse environmental effects. As well, the site is reasonably well-removed from on-going Keewatinoow construction activities.

Camp Capacity and Facilities

The proposed site area is currently in use, on an as-needed basis, as a camp site for Manitoba Hydro pre-construction field exploration activities in the region. The camp is owned and operated by Fox Lake Cree Nation, and offers accommodation and basic amenities for a capacity of approximately 75 persons. Development of the start-up camp will expand the capacity of the exploration camp to 350 persons.

The start-up camp will consist largely of relocatable modular buildings: single-status dormitories (a possible mix of existing and newly installed mobile structures), kitchen/diner/recreation complex, camp administration offices, an uncontrolled helicopter landing area, a temporary building to house a fire truck and ambulance (which vehicles will be relocated to the main construction camp once its construction is complete), a communications building, a potable water and fire water storage building, a wastewater storage building, fuel storage and dispensing facilities, and miscellaneous other storage buildings. Maximum use will be made of existing facilities and infrastructure.

The camp will be installed and operated in accordance with all applicable regulations, codes and standards.

Main Camp

Site Selection and Location

The main camp is required to house workers constructing the converter station and ancillary facilities. It is proposed to be sited approximately two km north of the converter station site, adjacent to the south side of the access road. The main camp development land parcel will be approximately 350 m x 700 m (24.5 ha) in size. The site is an old burn site with sparse tree cover and a surface layer of organic material overlying low plastic clays or poorly graded sands and gravel. It is located between two existing streams known as Creeks Fourteen and Fifteen. The site slopes downward approximately 20 m from the main access road towards the Nelson River.

Advantages of the proposed site include:

- Location adjacent to the access road provides good access to the Keewatinoow Converter Station construction areas, but is not so close as to be adversely affected by nuisance effects during construction (e.g., noise);
- Good natural drainage avoids the need for extensive terrain alteration, subject to cut and fill requirements, to provide level sites for the various camp components;
- Good potential source of well water;

- Limited suitability as a borrow area avoids construction material resource conflict;
- Former burn site has limited tree growth and minimizes clearing requirements;
- Proximity to the proposed Keewatinoow construction power station and existing 12 kV power distribution line;
- Basic communications systems in place; and
- Adequate area to accommodate potential future development without having to duplicate existing camp infrastructure features.

Development of the site should involve minimal adverse environmental effects. In addition, the site offers good potential for re-use and scalability in the event that development of the Conawapa Generating Station proceeds.

Camp Capacity and Facilities

The main camp will be developed to house the expected peak of 500 single-status construction workers (converter station and transmission line workers combined). The capacity of the main camp will be approximately 550 rooms, to accommodate worker turn-around.

In general, structures at the Keewatinoow camp will be modular, portable buildings or pre-engineered steel buildings. All buildings will be designed in accordance with the most current edition of the National Building Code of Canada and the latest edition of the Manitoba Building Code.

In addition to the dormitory living quarters, the camp facilities will include a core complex (reception/offices/kitchen/diner/recreation); a chapel/meeting room; a beverage hall/cafeteria; a fire truck garage and training room for the volunteer fire department; a first aid building and ambulance garage; an uncontrolled helicopter landing area; communication systems; potable water and fire water storage buildings; a commissary; miscellaneous maintenance and storage buildings; vehicle parking areas and roadways; and outdoor recreation areas for sports.

The dormitories will be connected to the core complex by heated "arctic corridors", which also provide for routing and placement of services.

Accommodation Standards

Two quality levels are planned for living accommodations within the main camp; one for general labour (craft) accommodations, and a second for supervisory/management staff.

The craft accommodation will be single-status only, and will consist of dormitories with separate rooms for each worker. Additional privacy improvements being considered include individual wash basins with shared shower and toilet facilities between adjacent rooms, expanded room sizes, and improved sleeping amenities. Male and female residents will be housed in separate dormitories.

Single-status supervisory/management dormitory accommodations will be located within the main camp, separate from craft dormitory accommodations. Additional privacy improvements being considered include individual wash basins, showers and toilet facilities; expanded room sizes; and improved sleeping amenities.

Management Subdivision

Development of the main camp is proposed to include a management subdivision on an adjacent site. The management subdivision land parcel will be approximately 225 m x 300 m (6.75 ha) in size. The subdivision will provide serviced individual lots for installation of mobile homes to house senior management staff (married/couple-status) working on the project. Similar accommodation provided at the Wuskwatim Generating Station Project camp proved a viable alternative to a fully-serviced town site to attract and retain long term management employees.

Because the management subdivision may accommodate couples or families with pre-school children, the preference is that it be physically separated from the general workforce population residing in the main camp. The proposed site is immediately south of the main camp site, and physically separated from it by Creek Fourteen.

The management subdivision will consist of approximately 25 serviced lots, surfaced with compacted gravel and capable of accepting "ready-to-move" (RTM) homes or single-wide mobile homes. RTM or mobile homes will be purchased and installed subsequently, on an as-needed basis.

Vehicular access to the subdivision lots will be provided by an internal roadway system linked to the main access road. Pedestrian access to the main camp facilities will be provided by a foot path and bridge over Creek Fourteen.

Camp Infrastructure and Construction Activities

Start-up Camp

Water and Sewage Systems

Water will likely continue to be obtained from an existing on-site well, treated with approved water treatment equipment, and stored in approved potable water containers. Alternatively, potable water may be hauled in from Gillam and stored in approved potable water containers located at the camp.

Sewage will be collected initially in holding tanks and removed from the site to licensed disposal/treatment facilities. Subject to final design studies, holding cells may be developed south of the start-up camp site. Sewage would be collected in these and conveyed subsequently to the main camp lagoon. Subject to environmental approval, grey water (wash water from showers, etc.) may be routed into sullage pits. Final decisions respecting sewage treatment and disposal are being deferred to further study of the sewage treatment alternatives for the main construction camp, and will be the subject of a separate environmental license application.

Waste Collection and Disposal

Solid waste will be hauled to a licensed waste disposal site with adequate capacity, subject to approval by the facility owner and Manitoba Conservation.

Food refuse that is not disposed of through the kitchen garburators and sewage system, as well as other wastes destined for the waste disposal site, will be stored temporarily in approved containers maintained in a secure location to prevent intrusion by wildlife. Requirements for storage and haulage may be minimized through the use of garbage compactors.

A recycling and waste management plan will be developed in relation to camp operations. The plan will: provide for appropriate separation of waste streams; optimize recycling; and ensure proper disposal of all solid wastes.

Main Camp and Management Subdivision

Main camp service systems will generally be shared by the management subdivision, and are planned to include electrical power; water supply and distribution; wastewater collection and disposal; cable TV, internet, telephone and communication systems; and surface drainage management.

Although the main camp will be sized to approximately 550 rooms, design of the camp infrastructure, wherever feasible and practical, will be scalable. This will provide flexibility in the event that workforce requirements are adjusted to match contractors' construction methodology or to reflect changes in schedule. It will also facilitate incorporation of features designed to accommodate possible future redevelopment of the camp to accommodate the estimated 2,500 person workforce potentially required for future construction of the Conawapa Generating Station.

Most above-ground camp infrastructure is easily scalable, provided that appropriate provisions are incorporated in the engineering design of the facility. For example, the camp dormitories, dining facilities, and sewage treatment lagoon could be readily expanded (or contracted) to suit a changing workforce. Facilities in the kitchen/recreation complex may be sized for the larger Conawapa camp requirements.

However, initial development of dining and facilities will be sized for the estimated Keewatinoow construction requirements. Underground water distribution and sewer systems will also be designed for the combined needs of the Keewatinoow camp and the potential future needs of a Conawapa construction camp. However, only infrastructure required to support the Keewatinoow project will be constructed at this time.

Camp Construction Power

The existing 12 kV distribution line, described in Section 3.5.4.3, will provide power for construction and operation of the start-up camp and main camp until such time as power is provided from the Keewatinoow construction power station.

Site Preparation

Site preparation, including development of internal access roads and drainage works for the main camp, will be similar to the Keewatinoow Converter Station works described in Section 3.5.4.4.

The camp layout will take advantage of existing clearings and open areas to minimize clearing activities.

Marshalling and Work Storage Area

A material marshalling and work storage area will be required within the main camp land parcel. This will give the camp services provider a location to store building components, equipment, and material related to the camp development. Following camp development, a portion of the area will be used for camp resident parking.

Water Supply, Treatment and Distribution

Test wells drilled in the Main Camp area (primary well OW7 and secondary well OW6) have been found to be capable of providing an adequate and dependable supply of potable and fire protection water for the camp and associated accommodations.

Water treatment will be provided by a factory-built, modular, packaged water treatment plant. The treatment process will likely entail conventional chemical coagulation, clarification and membrane filtration to reduce turbidity and colour. Final decision on the treatment process will be subject to more detailed water analysis.

The water treatment plant is expected to be built at the site of the primary well OW7. The treatment plant building will house the water treatment equipment, chlorination equipment, and related chemical storage.

Water storage at the water treatment plant will likely involve use of above-ground tanks. This storage alternative provides both for scalability and ease of decommissioning.

Storage capacity requirements will be governed by fire protection requirements and standards. Approximately 340,000 litres of fire water storage will be required. Total water storage, including equalization storage, emergency storage and other safety factors has not been finalized but may be in the same order of magnitude as that of the Wuskwatim water treatment plant which provided three storage chambers with a total capacity of 581,400 litres.

Submersible pumps will be used to deliver the raw well water to the water treatment plant. The distribution pump system will consist of electric pumps and a diesel powered back-up fire pump system. These units will be tied to a common distribution header.

Wastewater from the water treatment plant will consist mainly of process filter backwash and settling chamber sludge, and will be discharged to the sewage collection system for further treatment.

Based on an average consumption of 265 litres/person/day, the main camp requirements, including a design allowance, will be approximately 159,000 litres/day. In addition, an estimated 5,000 litres/day allowance has been made for Manitoba Hydro and contactor activities at the construction site, bringing the total daily consumption of treated water to an estimated 164,000 litres/day.

Testing equipment to monitor chlorine and turbidity levels will be provided on-site. Potable water will be treated to meet provincial standards for drinking water quality and aesthetics.

Water lines will likely consist of shallow buried, insulated and heat-traced high-density polyethylene pipe, installed using a backhoe or trencher. There will be a recirculation system and heating provided at the water treatment plant to prevent freezing. Service connections to modular and pre-engineered buildings will likely be buried, heat traced and insulated.

Water for fire-fighting will be drawn from the same source as the potable water supply and will be pumped through the same system. The camp and work area buildings will contain fire detection sensors, which will be continuously monitored by site security.

The water system will be tested and monitored in accordance with government regulations.

Sewage Collection, Treatment, and Disposal

A sewage lagoon will be constructed for treatment of main camp sewage. A lagoon was selected as the preferred sewage treatment option for the following reasons:

- Manitoba Hydro has had good experience with lagoons on past major project camps;

- Lagoon operation and maintenance requirements are well suited to the availability and qualifications of local labour;
- Requires less energy than most other wastewater treatment methods;
- Relatively low construction cost; and
- Scalability for potential future uses.

There are two potential site areas for the main camp lagoon. Final selection is subject to further geotechnical investigation.

The lagoon will be designed and constructed to meet: the Keewatinoow camp capacity, plus allowances for Manitoba Hydro and contractor activities at the construction site; backwash waste from the water treatment plant; and sewer main infiltration.

In addition, the lagoon will be designed both to enable its expansion to accommodate the anticipated peak camp capacity of a potential Conawapa camp, and to facilitate its eventual downsizing to accommodate permanent facilities following decommissioning of the camp.

Sewage will be conveyed by gravity to a main sewage lift station or a series of lift stations, from where it will be pumped via force main to the lagoon.

The treatment lagoon will be a multi-cell facility, constructed and lined from locally available clays. If local clays are found to be unsuitable for use as a liner, a synthetic liner will be installed. It is estimated that the total size of the lagoon to be built at this time will be approximately 200 m x 500 m. It will be designed to handle the untreated influent typical of construction camps. The lagoon will be operated as a controlled discharge facility, which may be discharged twice per year, once in the spring (June) and once in the fall (October), in accordance with provincial regulations.

Sewage collection systems will be insulated and heat-traced where required. Grease traps will be provided at the kitchen complex to reduce the loading on the treatment system. Water conversation methods under consideration include dual-flush toilets and flow-restricting shower heads. The lagoon will have a perimeter fence and a gated access road.

Operation of the lagoon and effluent water treatment quality objectives will conform to provincial environmental standards and regulations. In the period during main camp construction, prior to commissioning of the lagoon, sewage will be collected, stored and hauled to a licensed treatment facility.

Solid Waste Management

Solid wastes generated in the camp and ancillary facilities will be subject to waste management practices applicable to the Keewatinoow development (see Section 3.5.4.9).

Animal proof garbage containers will be provided throughout the main camp, including the management subdivision.

Food refuse which is not disposed of through the kitchen garburators and sewage system, as well as those other wastes destined for the waste disposal site, will be stored temporarily in approved containers maintained in a secure location to prevent intrusion by wildlife. The requirements for storage and haulage may be minimized through the use of garbage compactors.

As in the case of the start-up camp, a recycling and waste management plan will be developed for camp operation. The plan will provide for appropriate separation of waste streams, optimize recycling, and ensure proper disposal of all solid wastes.

Camp Operations

The main camp, including the management subdivision, will have a fire safety plan. Fire preparedness equipment will be in place to the satisfaction of Manitoba Conservation.

Camp residents and site visitors will be subject to a variety of rules and regulations:

- Smoking will be allowed only in designated areas;
- Although boat access to the Nelson River currently exists at the Conawapa site, there are no plans to make boat/watercraft access available for camp residents' recreation. Existing arrangements for boat access by resource users and for non-recreational purposes such as safety, research or law enforcement will be maintained. These details will be addressed by Manitoba Hydro, prior to construction, through discussions with potentially affected resource users and First Nations, and their respective Resource Management Boards as required;
- For safety reasons, snowmobiles and all-terrain vehicles will not be allowed on the project site or on the access road right-of-way without prior approval; and
- "No Trespassing" - Private Property" and "No firearms/hunting" signage will be posted at key access points along the access road right-of-way (i.e., transmission line corridor crossings, security gatehouse, etc.) Special access arrangements for resource users will be worked out in discussions with potentially affected resource users and First Nations, and their respective Resource Management Boards as required.

All camp resident recreational activities will be required to comply with applicable provincial and federal regulations.

3.5.4.9 Solid Waste and Hazardous Materials Management

Both hazardous and non-hazardous wastes will be generated through the course of construction, both at the camps and at the sites of the various station components and construction support activities. Wastes will be managed, collected and disposed of in accordance with current provincial and/or federal regulations. Management procedures for specific hazardous materials are detailed in the Hazardous Material Management Handbook (Manitoba Hydro 2003). The Environmental Protection Plans will contain general guidelines for non-hazardous and hazardous waste management.

Opportunities to reduce, reuse, and recycle the wastes will be taken whenever possible, and identified in a waste management and recycling plan. Wastes will be stored in designated areas (i.e., transfer stations) and disposed of regularly to reduce potential for unsafe conditions and adverse impacts. It is likely that scrap wood and paper products will be disposed of by burning in a designated area at the construction site, under a permit from Manitoba Conservation. Other waste will be disposed of either by creating a new permanent waste disposal site or by haulage from a transfer station to an existing permitted waste disposal site. The preferred option will be selected on the basis of discussions with the Town of Gillam, Manitoba Conservation, and the in-vicinity First Nation(s) and their respective Resource Management Boards, as required.

3.5.4.10 Keewatinoow Site Area Requirements

The proposed Keewatinoow site is approximately 775 km north-east of Winnipeg and 235 km south of Churchill. The converter station and supporting construction facilities are located within the Fox Lake Resource Management Area. The access road, rail spur, material marshalling areas and granular deposits are located variously within in the Split Lake and Fox Lake Resource Management Areas. All of the required site area is Provincial Crown Land. Most is within Manitoba Hydro's Churchill River Diversion license area and the Province of Manitoba's Water Power Reserve area. Exceptions include portions of the access road, construction power transmission line right-of-way, and granular borrow areas.

The site areas required for construction, operation and maintenance of the Keewatinoow facilities, excluding the transmission lines and associated works, are summarized in the following table. Following construction, the land required for permanent facilities will be retained for ongoing operations and maintenance. The remaining areas used during construction, will be rehabilitated as discussed in Section 3.5.4.11, or maintained pending future requirements associated with the potential Conawapa Generating Station development.

3.5.4.11 Construction Clean-up and Rehabilitation

Construction clean-up will occur throughout all phases of construction. As soon as possible after completion of construction, the permanent converter station sites will be cleaned up and left in standard operating condition. All non-toxic materials will be disposed of using existing, appropriately licensed local facilities. As with construction activity, material supply and waste handling will be subject to conventional Manitoba Hydro codes of practice and relevant provincial legislation.

Decommissioning and clean-up of temporary facilities (i.e., those required only for the Keewatinoow development) will occur after construction is complete and the converter station and associated facilities are in service. As indicated previously, the timing of decommissioning and clean-up of some temporary facilities (e.g., construction camp, construction power station, borrow areas, etc.) may be subject to future development requirements (e.g., potential development of Conawapa Generating Station).

Decommissioning of the temporary facilities will involve removal of supporting infrastructure including specific roads and buildings; collection and disposal of wastes, recyclables and hazardous materials and, in the case of the construction camp, removal of water distribution and sewage collection facilities. If no longer required, the construction power station and the local distribution system will be decommissioned and salvaged. The conductors will be removed from the poles and the poles will be pulled from the ground. All electrical distribution equipment will be salvaged and returned to Manitoba Hydro for re-use.

Reclamation and re-vegetation programs will be initiated for the vacated sites and borrow areas to control/prevent erosion, re-establish wildlife habitat, and/or create buffer zones. Reclamation measures and vegetation species will be selected on the basis of regulatory requirements, site conditions, and management objectives. Manitoba Hydro will monitor site reclamation/re-vegetation programs, in consultation with the appropriate authorities and stakeholders.

All clean-up and rehabilitation activity will be subject to the requirements of the Environmental Protection Plans.

Table 3.5-3: Keewatinoow Converter Station and Related Infrastructure - Land Requirements

Project Component	Required Land Area	Disposition Post-Construction
Permanent Facilities		
Converter Station	40 ha.	Required permanently
Ground Electrode	400 ha	Required permanently
Ground Electrode Line	10 km right-of-way	Required permanently
Construction Power Station	2.25 ha	Required permanently
Construction Support Facilities		
Manitoba Hydro and Contractors Work Area	21 ha	Rehabilitation
Henday/Limestone Marshalling Yards (existing) Henday off-loading facility (at Henday Converter Station)	3.5 ha	Required permanently (existing)
Manitoba Hydro & contractor work area (by Limestone stockpile) Manitoba Hydro & contractor work area (existing Limestone stores yard)	11.2 ha 19.2 ha	Subject to potential Conawapa plans (existing) Required permanently (existing)
Existing Conawapa Access Road	32 km right-of-way (Limestone turnoff to Conawapa)	Required permanently
Borrow Areas (granular and impervious)	258.95 ha	Rehabilitation (pending Conawapa plans)
Excavated Material Disposal Area and General Borrow Areas	143.1 ha	Rehabilitation (pending Conawapa plans)
Construction Camp		
Start-up Camp	6.25 ha	Maintenance (pending Conawapa plans)
Main Camp	24.5 ha	Maintenance (pending Conawapa plans)
Main Camp Management Subdivision	6.75 ha	Maintenance (pending Conawapa plans)
Main Camp Sewage Lagoon	10 ha	Maintenance (pending Conawapa plans)

3.5.4.12 Construction Safety, Security and Emergency Response Plans

Manitoba Hydro's vision is "to be the best utility in North America with respect to safety, rates, reliability, customer satisfaction, and environmental leadership, and to always be considerate of the needs of customers, employees, and stakeholders."[29] The safety and well-being of its employees is of primary importance to the Corporation.

Specific safety requirements will be stipulated in the contract packages for all construction activities. Contractors will be required to comply with current provincial occupational health and safety regulations.

Development of emergency response plans and programs will include procedures to address all foreseeable situations that may occur during construction (and subsequently during station operation and maintenance). A helicopter landing area will be located near the work site to provide a means for emergency evacuation.

Management of environmental issues such as spills will be addressed in the Environmental Protection Plans. Spill response programs and equipment will be in place for spillage or leaks of any oils or contaminants. All materials will be stored and handled in accordance with established policies and regulations. During construction, on-site emergency response teams will receive training with respect to fuel spill containment, clean-up and other emergency measures.

Transportation and handling of dangerous goods will comply with applicable legislation and regulations. Road transportation of dangerous goods will be undertaken only by appropriately licensed carriers.

An on-site Safety Supervisor will be employed during the construction period to ensure that Manitoba Hydro staff receives adequate training and that all Contractors comply with applicable regulations.

During the construction period, security officers will provide roving security and fire watch patrols throughout the work areas, the construction camp, and related facilities. The security personnel will operate access gates for approved personnel and vehicles, and maintain remote surveillance on a 24-hour basis.

No firearms will be allowed in the camp or Project site. All firearms will be declared and checked-in at the camp security gatehouse. For safety reasons, no hunting areas will be

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[29] Manitoba Hydro Corporate Strategic Plan 2011-2012; per Manitoba Hydro website, www.hydro.mb.ca/corporate/csp/index.shtmlwww.hydro.

established within the vicinity of the Keewatinoow sites and the access road right-of-way. Special arrangements will be made for resource users wanting to use the access road to gain access to harvest areas in the region (excluding the no hunting areas defined for construction safety). These arrangements will be developed, prior to construction, in consultation with resource users and First Nations in the vicinity of the project, and applicable Resource Management Boards.

3.5.4.13 Environmental Protection Plans and Monitoring

As in the case of the HVdc and ac collector transmission lines, Keewatinoow construction activity and access requirements will be subject to standard environmental protection measures. These will be identified and cross-referenced in site-specific Environmental Protection Plans (EnvPPs). A general project EnvPP will be submitted with the Environmental Impact Statement for review and approval. Construction phase EnvPPs will be developed following licensing for each major project component. Adherence to the EnvPPs will be stipulated in related contract specifications.

Three separate EnvPPs are being prepared for the Keewatinoow project:

- Keewatinoow Converter Station Access Road Upgrade Environmental Protection Plan & Monitoring Program;
- Keewatinoow Converter Station Construction Camp Environmental Protection Plan & Monitoring Program; and
- Keewatinoow Converter Station Environmental Protection Plan & Monitoring Program.

3.5.5 Station and Electrode Operation and Maintenance

Once completed and fully commissioned, the Keewatinoow Converter Station will be operated 24 hours a day, year round, and will have Manitoba Hydro personnel on-site performing regular operation, maintenance and inspection duties. Qualified operators and maintenance personnel will routinely inspect and maintain the station and electrode sites and, in the case of contingencies, correct any problems or related environmental effects. Total operations and maintenance workforce has been estimated at 42 workers, exclusive of the periodic presence of contractor staff.

3.5.5.1 Station Operations

The Keewatinoow Converter Station control room, located within the converter building, will provide the human/machine interface equipment for the operators to control critical functions in the station and power flow in the system. These critical functions will also be monitored and controlled remotely by Manitoba Hydro's System Control Center.

Routine and emergency maintenance of the converter station equipment and facilities will normally be performed by Manitoba Hydro personnel assigned to the station. Maintenance and repair activities not normally performed by Manitoba Hydro staff may be performed by external companies under contract. Administrative functions and site security will also be performed by Manitoba Hydro staff.

As in the case of construction, maintenance and repair routines are subject to standard Manitoba Hydro procedures.

Environmental Emissions and Discharges during Station Operation

Electric and Magnetic Fields and Corona

As in the case of the connecting transmission lines, operation of the converter station electrical equipment will involve the production of electric and magnetic fields (EMF) and corona discharges. The level of these will vary with time, subject to: operating mode and loading conditions; final station design and equipment selection; and external considerations such as meteorological conditions.

Estimated levels of these emissions are generally based on mathematical modeling and on comparison to corresponding levels associated with other similar facilities in the Manitoba Hydro system. Concerns respecting potential environmental effects (e.g., health effects, electrostatic and electromagnetic induction effects, etc.) arising from EMF and corona emissions were raised in the course of the public consultation program for the project. These concerns, together with assessment of any potential effects and related mitigation measures, are discussed in later sections of the Environmental Impact Statement.

Studies have been conducted to model the electric and magnetic fields associated with operation of the ground electrode and its connecting low voltage line, as well as the prospect of audible or radio/television frequency noise arising from operation of the electrode line. The studies include different operating modes and conditions.

The electric and magnetic fields associated with converter station equipment are not expected to cause field levels outside the station sites to be significantly elevated except where transmission lines traverse the site boundary. The related field levels associated with transmission lines were independently modelled. The studies extended to the prospect of harmonics and radio frequency noise associated with station operations.

Detailed study results are provide in the associated technical reports[30], and are discussed elsewhere in the Environmental Impact Statement in the chapters addressing public consultation and environmental effects.

Other Emissions and Discharges

Apart from EMF and corona-related emissions, station operation will involve a variety of other emissions, discharges and activities. Most have been previously discussed in the descriptions of the station components (e.g., station lighting, discharge of treated wastewater, oil spill containment, etc.). Others are more general in nature and may, in some circumstances, be subject to public concerns respecting potential adverse environmental effects.

Audible Equipment Noise

Audible noise levels arising from station equipment operation will be subject to final design and equipment selection, but will comply with applicable provincial regulations and guidelines.

Solid Waste and Hazardous Materials Management

Station operation will entail the use of several controlled materials, in particular ethylene glycol, refrigerants, and battery acid.

Ethylene Glycol

The valve groups within the valve halls generate heat during operation. This heat must be dissipated quickly and efficiently in order to protect the critical electronic components. The removal of heat is performed by a cooling system which circulates a de-ionized water-glycol solution through a system of manifolds and pipes. Although the probability of leaks in the system is low, the system is closely monitored to ensure proper operation.

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[30] Op. cit., E^x^ponent, May 25, 2011.

Refrigerants

Mechanical cooling, if required, will include a conventional HVAC (heating, ventilation and air conditioning) system with a compressor and refrigerants. All refrigerants will be subject to environmental specifications in accordance with ASHRAE (American Society of Heating, Refrigerating and Air Conditioning Engineers) guidelines.

Battery Acid

Batteries are required to power critical communications, and control and protection systems in the station. The batteries are arranged in groups called battery banks. The banks are housed in separate rooms designed to minimize risks associated with fire and to contain any potential leaks.

Sulphur Hexaflouride (SF_6) and Carbon Tetraflouride (CF_4)

High voltage electrical apparatus such as circuit breakers and bushings typically use Sulphur Hexafluoride (SF_6) as an internal insulating medium between energized and non-energized components. A blend of SF_6 and Carbon Tetraflouride (CF_4) or Nitrogen (N_2) gas is typically utilized to prevent condensation of the SF_6 gas within the apparatus and maintain adequate electrical insulation at ambient temperatures as low as -50 degrees Celsius.

Insulating Oil

Insulating oil is used in power transformers and other high voltage electrical apparatus as an electrical insulator and heat transfer medium. In the case of power transformers, the insulating oil is circulated through a radiator in order to transfer heat generated from the transformer to the atmosphere.

3.5.5.2 Ground Electrode and Ground Electrode Line Operation

The ground electrode site will not normally be staffed. Inspection and maintenance of the electrode and the electrode line will be performed by Manitoba Hydro staff based on frequencies and procedures to be established. Associated inspection and maintenance activities will include site inspection, monitoring of soil moisture, monitoring and operation of electrode irrigation system, and inspection of the electrode ring.

During normal operation (i.e., bipolar mode), the low voltage electrode line and ground electrode will conduct very low levels of dc current. This current flow arises from anticipated minor differences in equipment characteristics within the station converter transformers, valve groups, dc switchyard and the HVdc transmission line. Ground electrode current during bipolar operation will typically be less than 110 amperes.

Occasionally, outages resulting from routine equipment maintenance, repair or malfunction may require that dc current equal to the HVdc transmission line current be conducted through the low voltage electrode line and ground electrode (i.e., monopolar mode). Ground electrode current during monopolar operation is dependent on the dc power being transmitted on the HVdc transmission line. At full load, it would be approximately 2,000 amperes, but the design will provide for up to 2,200 amperes for extra margin during a contingency.

Operation of full load dc current through the ground electrodes can cause stray electric current to flow in the surface layer of the soil which, in turn, will cause a ground potential rise in the soil surrounding the electrodes. Metallic infrastructure such as underground cables, transmission line tower footings, and buried pipelines (gas, water, sewer, etc.) may be affected by the stray current, which can lead to corrosion. In addition, stray current flowing through large substation power transformers can result in excessive heating. Studies using computer models have been used to calculate stray current distribution, to analyze potential interference on buried infrastructure and substation transformers and to guide electrode site selection and design. Related findings are further discussed in later sections of the Environmental Impact Statement.

3.5.5.3 Work Force Requirements

Estimates of the Keewatinoow Converter Station workforce requirements during the operations and maintenance phase have been previously discussed in reference to water supply and wastewater disposal infrastructure. It is currently estimated that 42 Manitoba Hydro staff will be employed at the station with approximately 30 staff on-site on a daily basis. In addition, there may be approximately 30 contractor staff present on-site during station maintenance periods. Typical employment opportunities at Keewatinoow will include staff positions for power supply workers (multi-skilled), operators, electrical and mechanical technicians, and maintenance utility workers. Manitoba Hydro has established initiatives to provide Aboriginal people with the opportunity to enter training programs related to such careers and gain employment with Manitoba Hydro, such as the Keeyask Working Group on Operational Jobs, established with Tataskweyak Cree Nation, War Lake First Nation, Fox Lake Cree Nation and York Factory First Nation, and the Southern and Northern Aboriginal Pre-Placement Programs.

Site traffic generation, during operations, has been estimated on the basis of trip generation statistics from the Institute of Traffic Engineers (ITE) Trip Generation Manual. Expected employee trips were calculated for the morning (AM) and evening (PM) peak hours as well as total weekday trips:

- AM Peak trips = 46 (based on ITE Land Use 170 Utilities rate of 0.76 trips per employee).
- PM Peak trips = 46 (based on ITE Land Use 170 Utilities rate of 0.76 trips per employee).
- Total Weekday trips = 181 (based on ITE Land Use 110 Light Industrial rate of 3.02 trips per employee).

3.5.6 Keewatinoow Decommissioning

The life span of converter station facilities is normally considered to be in the order of 50 years. However, converter station facilities are not sited and designed with a view to decommissioning.

As individual station components fail, replacement will normally be made with equivalent new equipment or facilities. Major station facilities are also subject to continuing maintenance, refurbishing, and expansion to respond to changing system requirements and to upgrade in response to improved technologies. The station facilities, given their role and function, are considered to be effectively permanent.

In the extremely unlikely event that the Keewatinoow Converter Station was to be decommissioned, the process would be subject to development and approval of appropriate procedures which, in turn, would be subject to applicable regulatory requirements in place at the time. The overall objective of any decommissioning plans would be to restore the station site to a condition consistent with the future intended use of that site. Station components and site improvements would be salvaged, removed and disposed of in compliance with all relevant regulations. Depending on the extent of any surface contamination on-site (e.g., petroleum contamination in soils), remediation would occur to correct any residual impact. A careful investigation of containment parameters, future land use, site risks, and remedial technologies would be conducted as part of the development and implementation of a remedial action plan.

3.6 RIEL CONVERTER STATION – TECHNICAL DESCRIPTION

As outlined in Section 3.3.4, the southern terminus of the Bipole III HVdc transmission line will be at a new converter station (Riel Converter Station), located on the Riel Station site, in the RM of Springfield immediately east of the Winnipeg Floodway and north of the City of Winnipeg Deacon Water Supply Reservoir. The site is presently under development for the previously approved and licensed Riel Reliability Improvement Initiative (Riel Sectionalization).

The Riel Converter Station development required for the Bipole III complex will share the site infrastructure and certain other elements being developed for the Riel Reliability Improvement Initiative. The Bipole III development at Riel will include expansion of the 230 kV ac switchyard, as well as new infrastructure including synchronous condensers (subject to final selection of converter technology), converter transformers, a converter building, solid state power electronic valve groups, and a dc switchyard. As at Keewatinoow Converter Station, a new Riel ground electrode will be developed at a separate site and will be connected to the station by a new, low voltage overhead line. A typical converter station has previously been illustrated in Figure 3.3-2.

The 230 kV ac switchyard expansion will include additional incoming ac transmission line re-terminations, buswork and overhead connections. Other major elements will include circuit breakers, a station service transformer, and ac filters. The ac switchyard will be connected to the converter facilities through converter transformers. Similarly, the synchronous condensers will be connected to the 230 kV ac switchyard through unit transformers.

Within the Riel converter facilities, the conversion process from dc back to ac will be accomplished using solid state power electronics. Generally, the solid state power electronics are arranged in building block elements called valve groups. The valve groups (two per pole) are configured to achieve the required voltage, current and power ratings of the converter station. Each valve group is enclosed in a separate environmentally controlled room called a valve hall. The valve halls are contained in an HVdc converter building that also contains rooms for control, protection, communication, operation and maintenance, and other related ancillary equipment.

The valve groups will be connected to the dc switchyard through high voltage bushings in the wall of the converter building. The major dc switchyard equipment will include dc smoothing reactors, dc filters, switching equipment, and the terminations for the incoming HVdc transmission line and the low voltage overhead ground electrode line (the other end of which will be terminated at the Riel ground electrode site).

Similar to the discussion in Section 3.5, planning and design of the converter station and its ancillary facilities will be subject to CSA design standards and National Building Code requirements, and will be guided by NERC/MRO/MISO reliability criteria.

3.6.1 Riel Station Site and Ground Electrode Site Selection Process

The Riel Converter Station will be developed on the existing site of the Riel Reliability Improvement Initiative, and will not require the purchase of any new lands. The Riel ground electrode site will require purchase of privately-held lands. Pending final decisions respecting design and route selection, the low voltage electrode line will occupy existing road allowances or other rights-of-way.

3.6.1.1 Converter Station Site

The Riel Converter Station site will be located at the existing Riel Station, situated immediately west of PR 207 land in the east half of Section 26, Township 10, Range 4 E.P.M. (see Figure 3.6-1).

A portion of the station site (and related transmission rights-of-way) was first purchased by Manitoba Hydro at the time of development of the 500 kV Dorsey-Forbes export transmission line D602F in the late 1970s. The site was later enlarged to reflect earlier plans for Bipole III development and ongoing conceptual planning for development of the Riel station. To avoid conflict with neighbouring land uses, additional properties adjacent to the site were subsequently acquired during the period 2007 to 2009, in the course of planning and development for the Riel Sectionalization project. At the present time, all abutting properties are owned by Manitoba Hydro or are subject to its first right of refusal in the event of sale. Current land ownership status in and around the Riel site is illustrated in Figure 3.6-2. The existing Riel station site occupies a footprint of approximately 110 ha. The station fenced area is nominally 640 m x 1,278 m in dimension, occupying approximately 82 ha of land. The Bipole III facilities at Riel, excluding modifications to the 230 kV switchyard, will generally occupy the northeast portion of the site. The overall Riel site development concept is illustrated schematically in Figure 3.6-3.

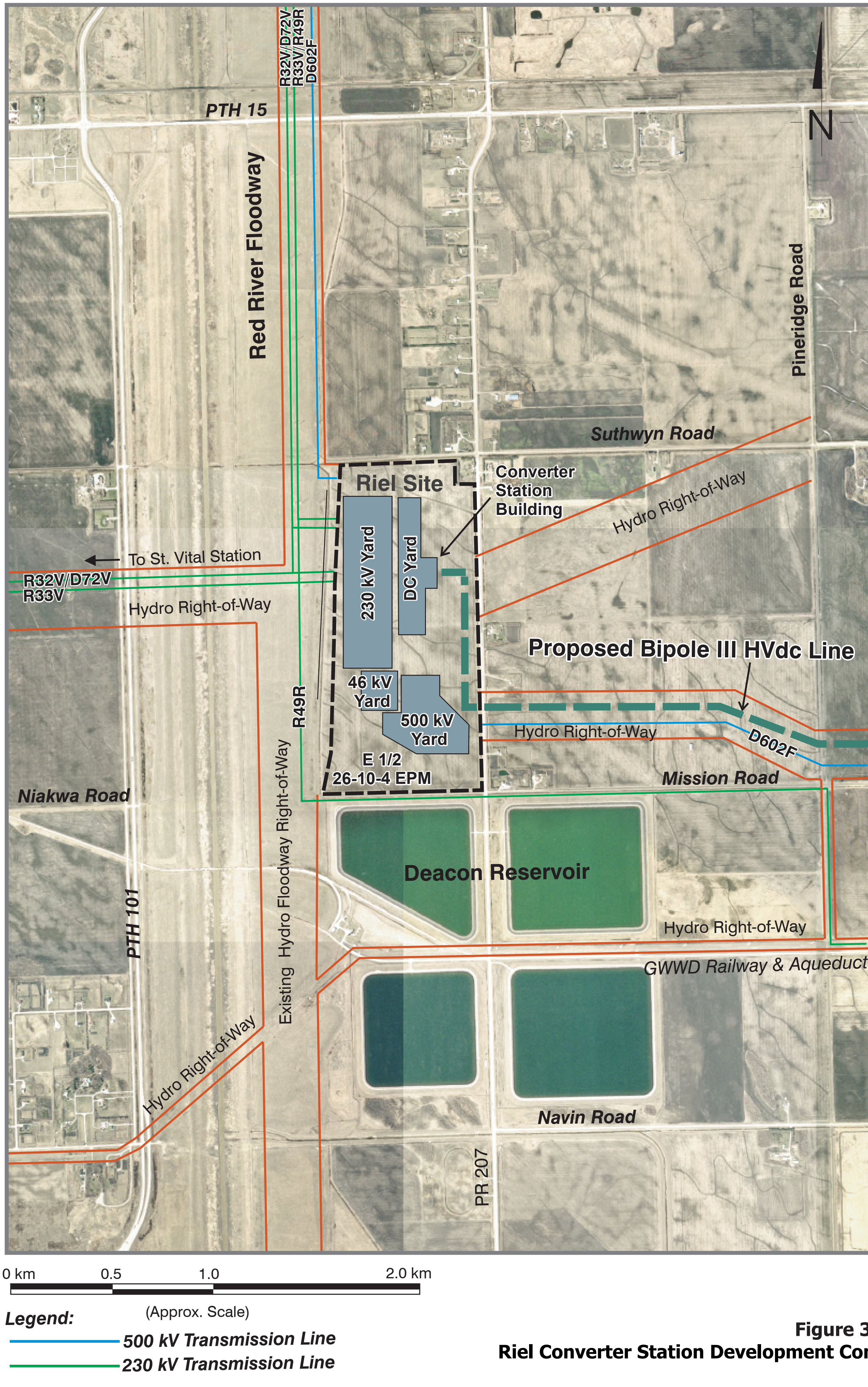

Figure 3.6-1:
Riel Converter Station Development Concept

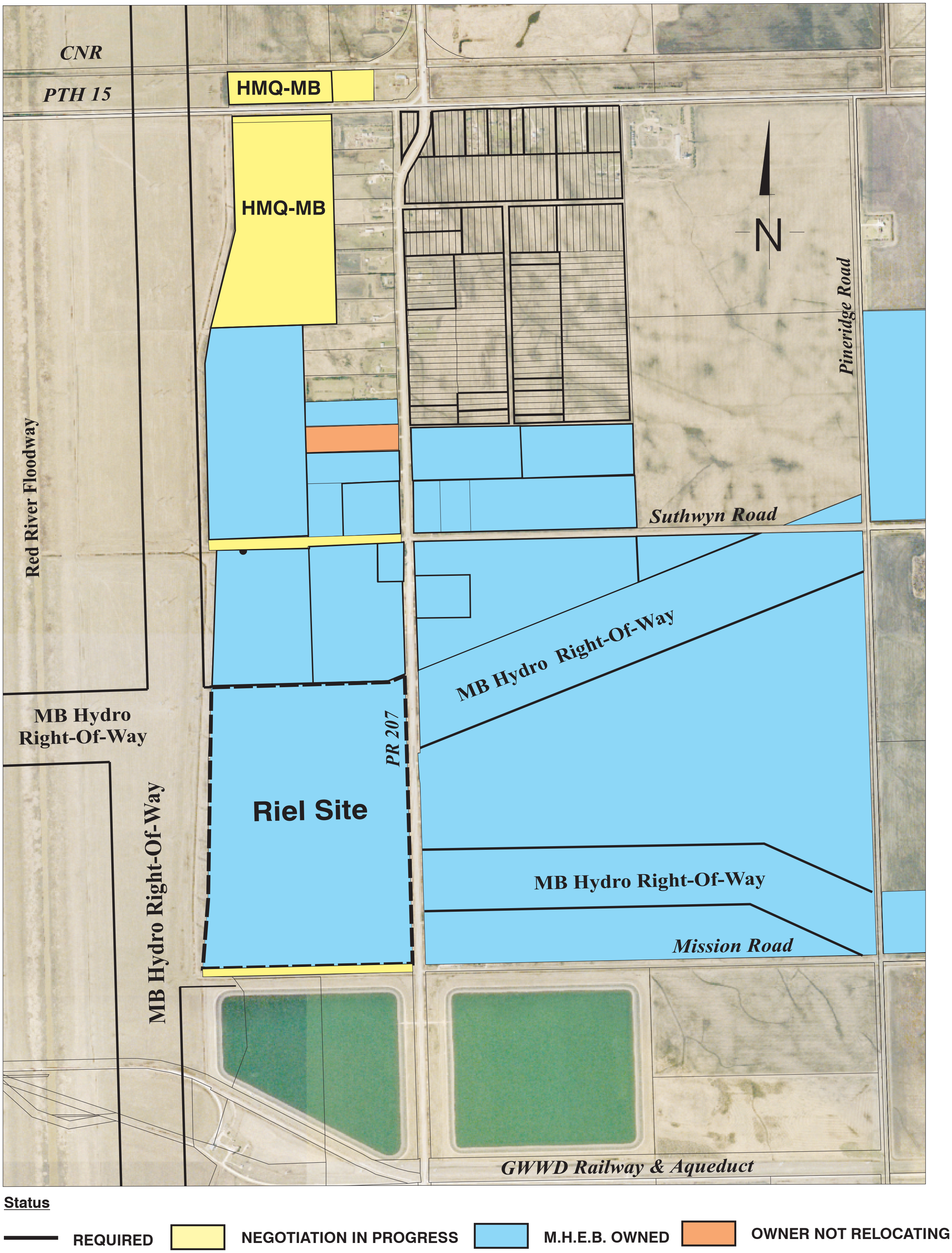

Figure 3.6-2:
Manitoba Hydro Property Ownership in Riel Station Area

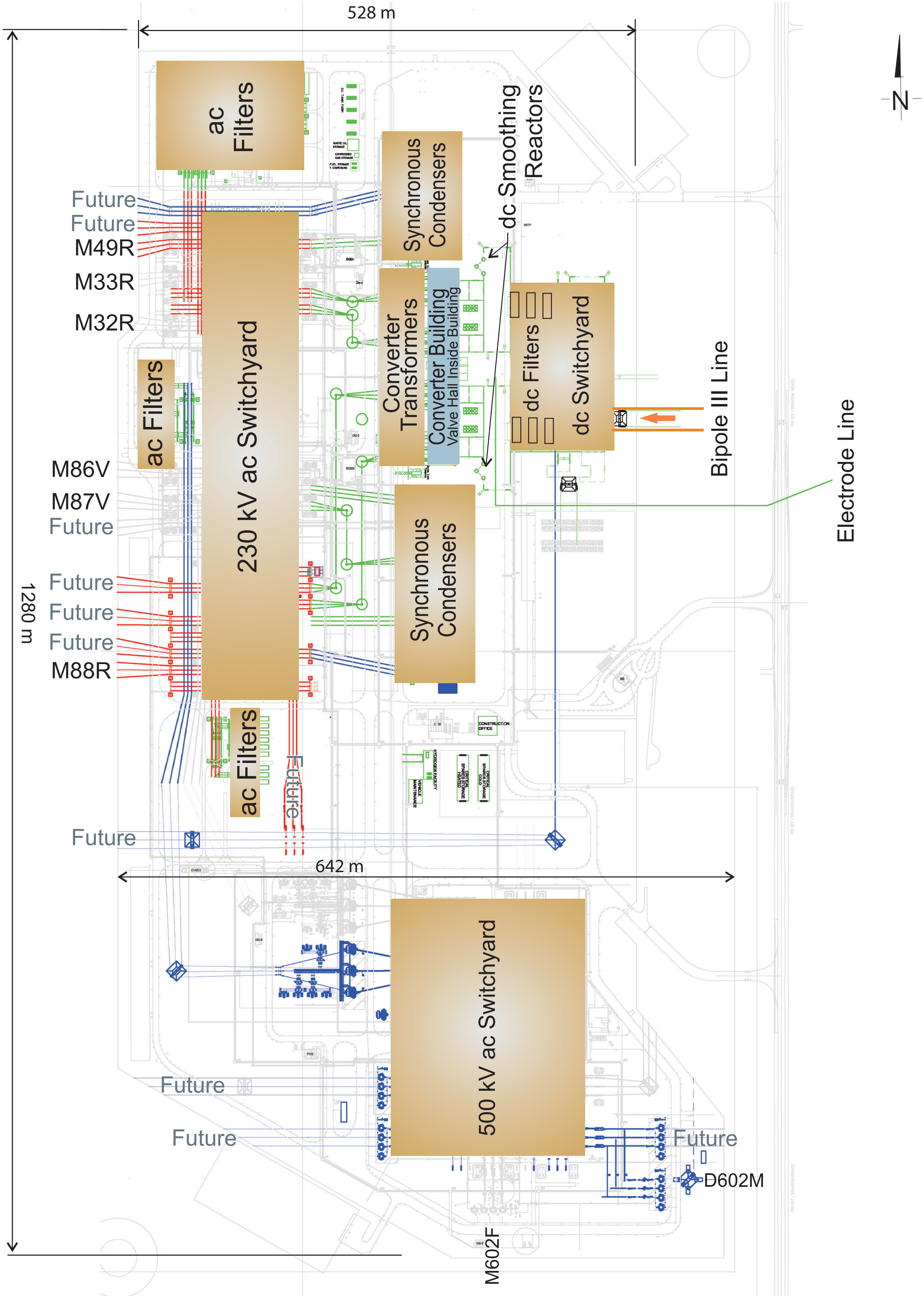

Figure 3.6-3:
Schematic Layout of Proposed Riel Converter Station

3.6.1.2 Ground Electrode Site

Proposed siting of the Riel ground electrode is based on: criteria respecting separation from the Riel Station and other existing facilities and infrastructure: site specific criteria such as ground resistivity, geology, topology, near surface stratigraphy, hydrology, and geospatial separation; and on land ownership and environmental considerations.

The Riel ground electrode site selection process was a three phase program. Phase one of the selection process identified 11 candidate sites. Throughout phase two, measurements and desktop studies were undertaken. Of the 11 sites, seven sites did not satisfy the desired technical requirements. During phase three of the selection process, the four remaining potential sites were comparatively evaluated on the basis of their technical merits: topography, ground resistivity, water supply, ground potential rise, soil moisture, soil thermal conductivity and heat capacity, land use, step potential (safety), proximity to existing infrastructure and facilities, and proximity to Riel converter station. Only one site, SES1c, a variation of SES1, was considered to be acceptable for development (see Map 3-10).

The technically preferred site (established as SES1c) is located in Section 21, Township 11, Range 6 E.P.M. Site SES1c ranked highest in technical review of the four alternatives and has been subject to site selection and environmental assessment (SSEA) review with potentially affected landowners, residents, and affected stakeholders within the RM of Springfield. The basis of the technical preference for this site is summarized in the following points:

- Relatively flat site with minor topographical variation;
- Good surface ground resistivity;
- Ground water availability;
- Predominantly lower ground potential rise (GPR) than other sites evaluated;
- Acceptably wet site with a good back-up water supply;
- Promising thermal conductivity and heat capacity soil characteristics;
- Farmland with no major land use conflicts;
- Low step potential, safe for humans and animals to walk across the site during operation;
- Located in rural area with separation from pipelines, transformers, transmission lines, rail lines, etc; and

- Located within the siting area on the east side of the City of Winnipeg, and requires the shortest electrode line of all sites evaluated.

The electrode site land requirement will include the entire section (i.e., approximately 1,600 m x 1,600 m or 2,560,000 m^2 [256 ha].), and includes a substantial buffer area surrounding the actual site required for installation of the electrode and ancillary facilities. The ground electrode will likely be a shallow ring electrode, estimated to be approximately 400 m in diameter, and situated centrally within the site. The site will be purchased by Manitoba Hydro. The excess land will be leased back to the former owners or others for ongoing non-intensive agricultural use. The surface of the central area of the site (an area of approximately 500 m x 500 m above the ground electrode itself) will be maintained as a grassed area by Manitoba Hydro.

The low voltage connecting line between the electrode site and the converter station will be located either on easements acquired by Manitoba Hydro, predominantly on or adjacent to existing municipal roadway rights-of-way.

The proposed electrode site and electrode line study area has previously been illustrated in Map 3-4.

3.6.2 Riel Converter Station Facilities and Infrastructure

Site infrastructure and facilities being developed for the Riel Reliability Improvement Initiative will be utilized by the Riel Converter Station development for Bipole III.

In addition to the existing infrastructure, the Riel Converter Station will consist of: infrastructure expansion and extension, additional buildings to support the operation of the converter station, a 230 kV ac switchyard expansion, converter transformers, a converter building and conversion equipment, a dc switchyard, and synchronous condenser machines (See Figure 3.6-3). Details on the converter station facilities and infrastructure are further described in Sections 3.6.2.1 to 3.6.2.6.

3.6.2.1 Converter Station Site Infrastructure

General site preparation and the majority of the infrastructure required for the Riel Converter Station has been or is being completed in the course of the Riel Reliability Improvement Initiative.

Site infrastructure for the Reliability Improvement Initiative includes development of overall site grading and drainage, internal roadways, station lighting, station security, oil containment systems, domestic water and wastewater systems, fire suppression systems, station grounding, communication facilities, and some ancillary buildings and equipment.

Necessary expansion of the Riel site infrastructure to accommodate the Bipole III facilities will include: localized site grading, drainage, and grounding; additional oil storage and oil containment facilities; additions and/or extensions to the internal roadway system, station lighting, water and wastewater systems, and fire suppression systems; additional communication facilities; and additional ancillary buildings and equipment.

Site Grading and Drainage

The Riel site, including the converter station site, has already been filled and re-graded above the pre-development ground surface, taking into account both existing drainage patterns surrounding the site and the need to protect the converter station from overland flooding during spring runoff or an extreme rainfall event. Related site preparation activities have extended to grading and placement of sub-base materials within the overall fenced area of the station, construction of a ring dyke and perimeter ditch, installation of land drainage sewers, surfacing with insulation stone, and construction of landscaping berms.

Further development of the Riel station site for the Bipole III Project will include additional localized drainage (including land drainage sewers) in the 230 kV ac switchyard, and in the proposed converter building, dc switchyard and synchronous condenser areas. These areas will be covered with an insulation stone course, approximately 150 mm in thickness, and typically consisting of 20-40 mm diameter clean stone aggregate.

Newly developed localized drainage system additions will direct flows from the internal drainage system required for the Bipole III facilities to the previously developed station drainage network, the design of which includes containment ponds, and oil/water separation facilities. These facilities ensure that potential oil contaminants will be contained on-site and will not be discharged through off-site storm water flows or run-off.

Internal Roadways

The current Riel Reliability Improvement Initiative includes an internal roadway network and rail spur. Additional internal roadways will require development in order to provide on-site access to the Bipole III converter building, synchronous condensers and switchyard areas.

The majority of the additional internal roadway network will be gravel surfaced. Some portions may be paved with asphalt to minimize dust production in the vicinity of key electrical components and the converter building. The details of the internal roadways will be determined during final design.

The roadway network will permit on-site tractor-trailer access for equipment installation and maintenance, as well as access for employees and smaller service vehicles.

The Bipole III facilities will include additional gravel surfaced parking areas for employees, as well as staging and parking areas for contractor use. Concrete pads may also be provided for loading and unloading of equipment.

Site Security

The current Riel Reliability Improvement Initiative includes installation of station security infrastructure. This will include a welded wire perimeter fence and a security building located at the primary entrance to the site. A remote controlled gate and vehicle barriers will be located at the primary station entrance. Video cameras will be used to monitor site activity.

Station Lighting

The current Riel Reliability Improvement Initiative includes all station site perimeter lighting as well as roadway lighting for the associated internal roadway network.

Additional lighting will be required for the roadway extensions required to service the Bipole III facilities. The new lighting will be integrated with the Reliability Improvement Initiative system and will be designed to achieve an average maintained lighting level of approximately 10 lux (10 lumen per square metre).

Oil Storage

The Riel Converter Station will include provision for storage of the insulating oil used in operation and maintenance of high voltage apparatus and equipment, such as the converter transformers. The tanks will provide for storage of up to a maximum of 300,000 litres of insulating oil.

Oil Containment

The current Riel Reliability Improvement Initiative includes all principal components of the station oil containment system. These include a combination of point source containment and non-point source containment for oil filled equipment included in the Reliability Improvement Initiative, as well as a fast drain system for large apparatus, oil-water separator building, and containment ponds, all in conformance with applicable oil containment standards. The containment system has been designed for the entire station site, including the Bipole III facilities in the areas designated for the expanded 230 kV ac switchyard, converter transformers, synchronous condensers, and dc switchyard.

Additional primary containment will be required for large Bipole III Project equipment located within the expanded 230 kV ac switchyard, converter transformer, synchronous condenser, and dc switchyard areas. Primary containment, at the equipment location, will be provided for equipment containing greater than 5,000 litres of oil. This containment will utilize a concrete, clay or synthetic membrane barrier, extending a minimum of 1.5 m beyond the edge of any the equipment. The majority of the primary containment facilities will be connected to the oil-water separator building using fast drain piping. Any exceptions will involve local containment subject to mechanical pump-out, if required.

The extended oil containment facilities will also collect rain, snow melt and water from the fire suppression systems. Water collected in the oil containment system from these sources will undergo oil/water separation in the separator building and containment ponds developed for the Riel Reliability Improvement Initiative.

Water and Wastewater Systems

The current Riel Reliability Improvement Initiative includes on-site water distribution and wastewater collection systems, as well as connections to the City of Winnipeg systems for water supply and waste water disposal. The existing station systems have been designed to accommodate the demands of the entire Riel station site, including those of the Bipole III converter building, synchronous condensers and other ancillary buildings.

New connections to the water distribution and waste water collection systems will be required for the new Bipole III buildings and facilities.

Fire Suppression Systems

The current Riel Reliability Improvement Initiative includes the majority of the fire suppression system required for the site. The system includes 200,000 gallons (approximately 909,000 litres) of water storage, two fire pumphouses, fire deluge facilities, and a fire water distribution system complete with fire hydrants. The fire water storage and distribution system has been designed to accommodate the fire demand for the entire Riel station site, including the Bipole III facilities (i.e., 230 kV ac switchyard expansion, converter transformers, synchronous condensers, converter building, dc switchyard, and other ancillary buildings).

Subject to final design studies, additional fire pumphouses may be required in the dc switchyard and in the 230 kV ac switchyard expansion. Additional deluge buildings may also be required for the Riel Converter Station facilities. Water for the suppression of transformer fires is controlled by facilities housed in the deluge buildings, which include a pit area constructed below grade, and an area for electrical equipment located above grade. The buildings are electrically heated for freeze protection. See Section 3.6.2.1 for more information relating to the Bipole III ancillary buildings at Riel.

The Bipole III deluge facilities will include installation of fire water piping, valves and electronics to connect deluge piping to the converter transformers; unit transformers; and a station service transformer. Fire water connections will also be required to connect the converter building, synchronous condenser buildings, and other ancillary buildings to the fire water distribution system. Water for fire suppression will be distributed throughout the converter station site via underground pipe buried below the frost line. Piping is typically fabricated of polyvinyl chloride (PVC) or high density polyethylene (HDPE).

The details of the fire suppression system, including any additional fire hydrant requirements, will be finalized in the course of detailed design.

Station Grounding

The current Riel Reliability Improvement Initiative includes installation of a station ground grid throughout most of the larger station area, but not extending to the sites of the proposed Bipole III facilities. The grid comprises numerous copper clad steel ground rods (approximately three metres in length) driven into the ground, connected together below the insulating stone surface with bare copper wire, and also connected to metallic objects such as steel structures, equipment structures and foundations, transformers, buildings, pipes, cables, etc.

The Riel Converter Station development will require extension of the ground grid to the 230 kV ac switchyard expansion, converter transformer, converter building, synchronous condenser, and dc switchyard areas. The ground grid is required for personnel and equipment safety, and will conform to Manitoba Hydro best practices for station design. The extension will be integrated with and, where necessary, will supplement the existing ground grid network.

Communications Facilities

The Riel Reliability Improvement Initiative includes installation of communication infrastructure at the site. This infrastructure facilitates reliable integration of the Riel station into the existing Manitoba Hydro power system, and is generally comprised of fibre optic networks.

Optical ground wire (OPGW), as described in Section 3.4.1.3, will provide a communication pathway to Keewatinoow Converter Station for control and operation of the Bipole III HVdc system. The existing communication pathways will also be utilized by the Riel Converter Station for improved communication reliability and to facilitate data and telephone communication to the converter station site.

Ancillary Buildings

The current Riel Reliability Improvement Initiative includes such ancillary buildings as a security building, control buildings, switchgear buildings, an oil-water separator building, fire pumphouses, deluge buildings, and an emergency response building.

The Bipole III facilities at Riel will require additional ancillary buildings to support the new infrastructure for the converter station development. The approximate size and anticipated number of each type of ancillary building is identified in the following table, together with a cross-reference to the project description section in which the building function is described. Actual building requirements are subject to final design and will vary depending on the selected system concept.

The larger converter and synchronous condenser buildings are discussed in Sections 3.6.2.4 and 3.6.2.6.

Design of the ancillary buildings will conform to CSA design standards and National Building Code requirements. All buildings are expected to be supported on piles due to the potential for movement. Based on geotechnical investigations performed on the Riel site, pile foundations are estimated to be approximately 24 m in depth.

A combination of pre-engineered steel buildings and masonry buildings will be utilized to meet the design requirements for the project. Ancillary building aesthetics at Riel will be limited by the industrial nature of the facility. The ancillary buildings will conform to applicable Manitoba Hydro standards to create an aesthetic that is consistent with other Manitoba Hydro converter stations.

Table 3.6-1: Riel Converter Station Ancillary Buildings

Building Type	Number	Approximate Size (m2)	Function Description (section cross-reference)
Fire Deluge and Pumphouse	2-6	150	3.6.2.1
Cold Storage	2	100	n.a.
Heated Storage	2 1	600 150	n.a. n.a.
Engineering Construction Office	1	500	n.a.
Synchronous Condenser Control	4 to 8	600	3.6.2.6
Synchronous Condenser Mechanical	4 to 8	150	3.6.2.6

In addition to the ancillary buildings, there will be a requirement during operations and maintenance for temporary equipment, which may include bucket trucks, lift platforms, oil processing equipment, trailers, tanks, carts for handling of SF_6 gas, and high voltage testing equipment.

3.6.2.2 230 kV ac Switchyard Expansion

The Riel 230 kV ac switchyard will be required to provide flexible and reliable control and distribution of ac power into the southern receiver system from the Bipole III converter transformers and valve groups located within the converter building.

The majority of the infrastructure required for the 230 kV ac switchyard is included in the current Riel Reliability Improvement Initiative. However, expansion of the switchyard will be required as part of the Bipole III Project.

The 230 kV ac switchyard, being developed as part of the Riel Reliability Improvement Initiative, includes a number of ac circuit breakers and switchyard bays; two station service transformers; instrument transformers; four control buildings; two switchgear buildings; an auxiliary power distribution network; and cable ducts and cable trenches.

Consistent with the current 230 kV ac switchyard development, expansion of the switchyard for Bipole III will utilize air-insulated equipment such as high voltage ac circuit breakers, an additional (third) station service transformer, instrument transformers, ac harmonic filters, surge arrestors and insulators. The expansion will also include installation of additional equipment within the control and switchgear buildings, and additions to the auxiliary power distribution system within the station site. The switchyard expansion will provide connection to the Bipole III converter transformers and synchronous condensers, and additional terminations for connection to the 230 kV transmission lines comprising the southern receiver system. These will be provided by sectionalization of the existing Ridgeway-Richer 230 kV transmission line R49R at Riel.

The 230 kV ac switchyard expansion for the Riel Converter Station will supplement the five switchyard bays associated with the Riel Reliability Improvement Initiative with four additional bays. Each additional bay will typically include three ac circuit breakers, instrument transformers for each circuit breaker, multiple switches, and terminations to the electrical equipment. Additional equipment, including ac circuit breakers and instrument transformers, will also be installed in the existing switchyard bays to allow connection of the HVdc converter equipment, ac filters, synchronous condensers, and transmission line terminations.

Switchyard expansion will include concrete foundations, steel structures, equipment supports, cable trenches and cable ducts. Equipment foundations will range from concrete slab-on-grade to deep-piled foundations, depending on equipment weight and geotechnical conditions. Steel structures will be placed on the foundations and will support electrical apparatus and electrical conductors and hardware associated with the switchyard and transformer functions. Station service transformers and other equipment supports will also be located on concrete foundations. A combination of pre-cast and cast in place concrete cable trenches and cable ducts will be required to connect the expanded 230 kV ac switchyard equipment to station infrastructure throughout the site.

Detailed numbers and ratings of the electrical apparatus located within the expanded switchyard are subject to final design. Principal electrical components are described in the following subsections:

230 kV ac Circuit Breakers and Disconnect Switches

High voltage circuit breakers (see Figure 3.5-2) are required to carry load current, to switch equipment and lines in and out of service as operating conditions dictate, and to isolate faulty equipment connected to or within the switchyards. Approximately 22 three-phase 230 kV circuit breakers are required for the ac switchyard expansion. Each breaker will contain approximately 75 kg of insulating gas, comprised of approximately 50% SF_6 and 50% CF_4 or N_2.

Station Service Transformer

Station service transformers are required to serve the auxiliary power requirements of the converter station including the ac switchyard, synchronous condensers, converter building, dc switchyard, and ancillary buildings and equipment. Auxiliary power requirements include electrical loads such as building heating and cooling, process cooling systems, lighting, and various other support systems needed to operate the station. One additional three-phase, two-winding station service transformer will be included in the ac switchyard expansion. The station service transformer will contain approximately 35,000 litres of insulating oil.

Instrument Transformers

Instrument transformers measure currents (current transformers) and voltages (voltage transformers) on apparatus within the 230 kV ac switchyard. Signals from the instrument transformers are used for control, protection and monitoring purposes.

The 230 kV ac switchyard expansion will require approximately 60 single phase voltage transformers, each containing roughly 100 litres of insulating oil, and approximately 114 single phase current transformers, each containing roughly 200 litres of insulating oil.

ac Harmonic Filters

Harmonic filters (see Figure 3.5-3) are required due to the ac current harmonics generated in the process of converting dc power to ac power. These harmonics could be harmful to equipment connected to the ac system if allowed to flow out of the converter station.

Depending upon the conversion technology selected for Bipole III[31], the ac switchyard expansion will require four three-phase ac harmonic filter banks, each of which may be comprised of up to three sub-banks. Operation of the sub-banks within each filter bank will be controlled using dedicated 230kV ac circuit breakers, similar to those described earlier in this section. Eight such ac circuit breakers would be required for the ac harmonic filters.

The ac harmonic filter banks and sub-banks are typically comprised of a combination of capacitors, reactors and resistors. Filter capacitors are generally filled with an insulating oil fluid. Approximately 1100 capacitors, each containing approximately 16 litres of insulating fluid, will be required for each ac harmonic filter bank.

Surge Arrestors

Surge arrestors provide protection to ac switchyard components from abnormally high voltages induced from lightning. Surge arrestors are comprised of porcelain or composite materials, and are similar in appearance to insulators (see Section 3.6.2.2).

Insulators

Insulators are non-conducting posts (porcelain or composite) used to support energized equipment and hardware in the switchyard. Insulators are typically placed on the top of steel equipment support structures, but may also be placed directly on equipment foundations.

Control Buildings

Although no additional control buildings will be required for the Bipole III Project, the four control buildings, developed for the 230 kV ac switchyard as part of the Riel Reliability Improvement Initiative, will require installation of additional control, protection and communications equipment for the operation of the additional switchyard facilities. Additional cabling will also be required from the control buildings to equipment in the expanded ac switchyard and to the converter transformers, synchronous condensers, and converter building.

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[31] See footnote 23.

Switchgear Buildings and Auxiliary Power Distribution

Although no additional switchgear buildings will be required for the Bipole III Project, the two switchgear buildings developed for the Riel Reliability Improvement Initiative will require the installation of additional circuit breakers and control and protection electronics in order to provide auxiliary power from the new station service transformer to the converter station and synchronous condenser electric power loads.

Power from the switchgear buildings will be distributed to the electric power loads via new power cables to indoor and outdoor power centers. Outdoor power centers service the power requirements of the new outdoor devices. Each power center will require two transformers approximately 2,500 kVA in size. The transformers may be oil-filled, each containing approximately 2,200 litres of insulating oil. Indoor power centers, located within the converter building and synchronous condenser buildings, typically utilize dry-type transformers which do not contain insulating oil. It is anticipated that up to four outdoor and eight indoor power centers will be required for Riel Converter Station.

3.6.2.3 Converter Transformers

The 230 kV ac switchyard will be electrically connected to the converter transformers. Power will pass through the transformers from the solid state power electronic valve groups in the converter building to the ac switchyard. The converter transformers provide an interface between the dc voltages in the valve groups and the ac voltages in the 230 kV switchyard.

The Riel Converter Station will require up to 14 new converter transformers for the conversion of dc to ac power, three for each of the four valve groups, and two spares (for use during maintenance outage or emergency).

Similar to the Keewatinoow Converter Station, the final design of the Riel converter transformers will depend on such factors as the HVdc system configuration, converter building size and layout, ac filtering and reactive power compensation requirements.

In order to obtain a more compact station design and reduce the number of insulated high-voltage bushings, converter transformers may be situated adjacent to the converter building with the valve group side connections of each transformer protruding into the valve hall. This configuration reduces buswork requirements and improves the protection of the valve group equipment from lightning strikes. Alternatively, if the converter transformers are not situated adjacent to the converter building, approximately 48 wall bushings will be required to provide the interface between the converter transformers and the converter building valve halls.

The principal components of individual converter transformers are the tank, which includes the transformer core and copper windings, transformer bushings, and oil cooling radiators and fans.

The converter transformers are filled with insulating oil for electrical insulation and heat transfer purposes. Insulating oil is circulated between the tank and the cooling radiators, where excess heat is transferred to the air. Each converter transformer (see Figure 3.5-4) will contain approximately 115,000 litres of insulating oil. Due to the volume of insulating oil in each transformer, the design will incorporate primary oil containment (see Section 3.6.2.1).

3.6.2.4 Converter Building

The Riel Converter Station will include a new converter building centrally located on the converter station site between the converter transformers and the dc switchyard (see Figure 3.5-5 and Figure 3.6-3). The primary function of the converter building is to house the solid state power electronics and ancillary systems used to support the conversion of dc power to ac power.

The layout of the converter building at the Riel site will be consistent with the design of the Keewatinoow converter building. The building will comprise four valve halls; two to serve each of the two poles of the converter station. The valve halls associated with each pole are typically situated adjacent to one another with the ac switchyard on one side of the valve halls and the dc switchyard on the other side. Each valve hall will house the solid state power electronics associated with one valve group. Each valve hall will be approximately 20 metres high and, depending on the conversion technology selected for Bipole III[32], be between approximately 1,200 and 5,000 m^2 in size.

The valve hall environment is closely monitored and controlled for air quality, operating temperatures, and fire detection. The valve halls are electrically shielded to prevent high frequency signals (also called noise) from either entering or leaving the room.

In addition to the valve halls, the converter building will also include one or more service areas and auxiliary equipment areas. Service areas will include the control room, maintenance and storage areas, and administrative offices. Auxiliary equipment areas will house equipment for valve group cooling, HVdc control and protection, communications, building mechanical services, and auxiliary power.

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[32] See footnote 23.

Valve Groups

Bipole III will consist of two poles, one energized at +500 kV dc, and the other at -500kV dc. Each pole will be energized by two valve groups, connected in configurations designed to achieve the required current and voltage ratings of the converter station. The valve groups convert dc power into ac power though high speed coordinated switching of solid state power electronic devices.

Two HVdc conversion technologies are presently being considered for Bipole III; conventional line-commutated (LCC) technology, and newer voltage-source converter (VSC) technology.[33] Selection of the converter technology is expected in late 2011.

Each of the four valve halls within the converter building will house a series of valves called a valve group (see Figure 3.5-6). Each valve group typically consists of three tower assemblies, which are either suspended from the roof of the valve hall or supported from the floor by insulators. Each tower assembly is comprised of multiple valves, and each valve consists of multiple solid state power electronic devices as well as resistors, capacitors, control electronics, and fibre optics. The specific selection and arrangement of these components is subject to ongoing studies and final design.

The power electronics components are liquid cooled using a closed-loop cooling system located outside the valve hall. Heat generated within the valve groups is transferred by the cooling liquid to the outside air. Cooling liquid is circulated through the valves and cooling equipment by electric pumps. The cooling systems typically use an ethylene glycol/water mixture as the cooling medium. Each of the four valve group cooling systems will typically contain 14,000 litres of the coolant mixture.

Control Room and Ancillary Converter Building Facilities

Operation of the electrical apparatus within the converter station will be monitored and controlled from a control room, the principal features of which will include a control desk and supporting equipment. Various operating conditions of the station apparatus will be monitored and controlled from the desk, including status of the various components and systems, alarms, voltages, currents, temperatures, pressures, flows and levels. Other control room equipment and electronics will include computers, printers, closed circuit television monitoring systems, and communication devices. Services and auxiliary equipment areas may be centrally located within the converter building, or

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[33] See footnote 23.

distributed in functional groupings throughout the building. Specific sizes and locations of each area within the building will not be determined until final design is complete.

3.6.2.5 dc Switchyard

The Riel dc switchyard will provide a controlled path for dc power to pass from the Bipole III HVdc transmission line to the valve groups located within the converter building. A typical dc switchyard is illustrated in Figure 3.5-7.

The dc switchyard will be separated into two poles, referred to as Pole 5 and Pole 6. The high voltage side of Pole 5 will operate at -500 kV dc, while the high voltage side of Pole 6 will operate at +500 kV dc. The high voltage sides of Poles 5 and 6 will connect the dc switchyard to the Bipole III HVdc transmission line conductors.

The low voltage sides of Poles 5 and 6 will operate at near zero voltage, and will be connected together to form the portion of the dc switchyard that is generally referred to as the neutral bus. The neutral bus serves as the connection from the dc switchyard to the low voltage electrode line leading to the Riel ground electrode site.

Poles 5 and 6 will require a variety of electrical apparatus within the dc switchyard. The major components are described in the following subsections. Other switchyard components within the Riel dc switchyard include the concrete foundations, steel structures and equipment supports for the electrical apparatus. Equipment foundations will range from concrete slab-on-grade to deep-piled foundations, depending on equipment weight and geotechnical conditions. Steel structures will be placed on the foundations and will support electrical apparatus and electrical conductors, and other hardware associated with the switchyard.

Specific quantities and ratings of the electrical apparatus located within the dc switchyard are dependent upon the selected Bipole III conversion technology[34], and will be finalized during the course of detailed design.

dc Wall Bushings

The dc wall bushings provide a transition between the converter building valve halls and the dc switchyard area. Approximately eight solid composite dc wall bushings will be required.

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[34] See footnote 23.

Switchgear

Switchgear is needed to control the flow of dc power within the dc switchyard. Modern high speed dc switches, similar in operation and appearance to ac circuit breakers (as described in Section 3.6.2.2) use a hermetically sealed mixture of sulphur hexafluoride (SF_6) and carbon tetraflouride (CF_4) or nitrogen (N_2) gases as the insulating medium inside the switch.

Approximately 13 high speed switches will be required for the dc switchyard. Combined, these switches will contain a total of approximately 400 kg of SF_6 and 120 kg of CF_4 or N_2 gas.

dc Filter Banks

Filter banks, as illustrated in Figure 3.5-8, are comprised primarily of capacitors and reactors, and provide attenuation of voltage harmonics generated by the valve groups.

A total of six dc filter banks are anticipated for the dc switchyard. Each filter bank will contain approximately 2,800 litres of insulating fluid within the filter capacitors.

dc Voltage and Current Measuring Devices

Monitoring and control of the Bipole III HVdc system will require dc voltage and current measurement devices to be installed within the dc switchyard. Approximately 19 dc current measuring devices and eight dc voltage measurement devices will be required. Each voltage divider will contain approximately 66 kg of SF_6 insulating gas.

dc Smoothing Reactors

Smoothing reactors, as illustrated in Figure 3.5-9, are comprised of one or more air insulated copper coils. The reactors are required for attenuating voltage and current harmonics on the Bipole III HVdc transmission line.

Surge Arrestors

Surge arrestors provide protection to ac switchyard components from abnormally high voltages induced from lightning. Surge arrestors are comprised of porcelain or composite materials, and are similar in appearance to insulators (see Section 3.6.2.2).

Insulators

Insulators are non-conducting posts (porcelain or composite) used to support energized equipment and hardware in the switchyard. Insulators are typically placed on the top of steel equipment support structures, but may also be placed directly on equipment foundations.

3.6.2.6 Synchronous Condensers

Planning studies have identified that, subject to further study and final selection of the technology for the conversion process[35], four 250 MVAr synchronous condensers may be required for the Riel converter station. If required, the synchronous condensers would serve to provide reactive power compensation, to control the 230 kV ac switchyard bus voltage, and to enhance performance of the Bipole III HVdc system. A typical synchronous condenser machine is shown in Figure 3.6-4.

[35] See footnote 23.

Figure 3.6-4:
Synchronous Condenser at Dorsey Converter Station

Each synchronous condenser machine will comprise a rotating mass within a stationary enclosure, together with the mechanical and electrical systems necessary to support operation of the machine. A unit transformer and high-voltage switchgear will also be required to connect each synchronous condenser to the 230 kV ac switchyard. Each machine will also require a building or buildings (dependent on detailed design) to house the mechanical and electrical support systems. A hydrogen gas storage and distribution system common to all the synchronous condenser machines will be required to support operation and maintenance activities.

Synchronous Machines

Each synchronous machine will be comprised of a stationary body, referred to as the stator, and a rotating body, referred to as the rotor. The stator and rotor assembly is generally situated in a horizontal configuration.

The stator is comprised of a circular steel frame, copper windings and a steel core. The rotor is comprised of a large steel shaft with large copper electric coils mounted to it. The rotor is supported within the stator by two oil lubricated bearings. The stator and rotor assembly is designed to be a gas-tight pressure vessel. Electrical connections to the rotor assembly are facilitated using a slip ring and brush gear arrangement.

The stator and rotor assembly will operate in a pressurized gas environment. Hydrogen gas is utilized as it provides superior cooling capabilities and reduces power losses. A near pure hydrogen gas concentration is maintained during normal operation in order to minimize the risk of explosion. For maintenance, a two stage gas evacuation process is required. Hydrogen is first displaced from within the machine using carbon dioxide; air is then used to displace the carbon dioxide gas. The process is reversed to ready the machine for operation.

Each synchronous machine will require concrete piles and a concrete foundation to support the static and dynamic loading. The machine foundation will likely be integrated with foundation design of the associated buildings. Each synchronous machine will weigh approximately 355 tonnes and be approximately seven metres in height, seven metres in width, and 11 metres in length.

Mechanical Support Systems

Each synchronous condenser will require its own mechanical support system to provide cooling, lubrication, and control of the hydrogen gas. The mechanical support system is typically comprised of a water/ethylene glycol cooling system, a lubricating and jacking oil system, a hydrogen seal oil system, and a hydrogen gas system.

The water-glycol cooling system provides cooling for the synchronous condenser machine and the oil-filled mechanical support systems. The closed-loop system will consist of electric pumps, storage tanks, heat exchangers, piping, valves and fittings. Heat is transferred from the various systems to the water-glycol mixture. The coolant mixture is then circulated to an outdoor heat exchanger, where the heat is transferred to the outdoor air. Each machine will contain approximately 14,000 U.S. gallons of water-glycol mixture (approximately 53,000 litres).

The lubricating and jacking oil system is typically located within a mechanical services building. This system provides oil to the bearings for lubrication and a high pressure oil film to lift the rotor shaft during machine start-up. A typical system comprises electric pumps, a storage tank, piping, valves and fittings. The oil is contained in an oil storage tank, where it is circulated by the electric pumps to the bearings inside the machine. Oil from the bearings is returned to the oil storage tank through the lubricating oil heat exchanger. Each lubricating and jacking oil system will contain approximately 2,500 litres of oil.

The hydrogen seal oil system provides a gas-tight environment within the stator enclosure, by creating a seal consisting of a highly pressurized oil film between the rotor shaft and stator frame. The system consists of high pressure pumps, pressure regulating valves, an accumulator tank, an oil storage tank, valves, piping and fittings. A typical hydrogen seal system will contain 600 litres of oil. Continuous monitoring and control of the hydrogen system will ensure gas purity, leak detection, and containment. Any high gas concentrations detected by the system sensors are used to annunciate alarms and to start the ventilation system.

Electrical Support Systems

Electrical support systems, for operation of the synchronous machines, typically include excitation, auxiliary power supply, starting, and control, protection and monitoring.

The excitation system controls the reactive power output of the condenser and consists of an excitation transformer, isolated phase bus, and control and protection electronics. The excitation transformer will contain approximately 500 litres of insulating oil.

The auxiliary power supply system controls and distributes the ac and dc power needed to support synchronous condenser operation. The ac power is provided from the converter station switchgear building to each machine's medium voltage switchgear through a step-down transformer and on to the various support systems. The dc power is provided from battery banks located within each machine's control building. Approximately 1,300 litres of battery acid will be contained within the battery banks.

The starting system consists of a variable frequency drive, also known as a static frequency converter, that directly feeds power into the machine. Its function is to start the synchronous condenser by supplying the stator winding with dc current to start the rotor and, once it is turning, to alter frequency of the supply current to accelerate or to brake its operation.

The control and protection panels for the electrical support systems will be located in the control building adjacent to the synchronous machines and will include both mechanical and electrical protection relays.

Synchronous Condenser Unit Transformers and Switchgear

Each synchronous condenser will require a unit transformer to connect the synchronous machine to the 230 kV ac switchyard. The unit transformers, together with the associated high voltage switchgear, current and potential transformers will be located adjacent to the synchronous condenser machines.

The unit transformers are filled with insulating oil for electrical insulation and heat transfer. Each will contain approximately 68,000 litres of insulating oil. A point source spill containment system, as described in section 3.6.2.1, will provide protection against leaks and spills.

Synchronous Condenser Buildings

Each synchronous condenser will have a separate single storey building or buildings to house its electrical and mechanical support systems. Buildings will be designed to comply with all local and National Building Code requirements.

Building systems will include fire detection and water based fire suppression, hydrogen detection and ventilation systems, lighting, heating and cooling, security and communications.

Auxiliary Systems

As indicated previously, each synchronous condenser is expected to use hydrogen gas for cooling during normal operation, and carbon dioxide as a purging gas for maintenance requirements. The hydrogen system is also used to inflate the static seal and to control emergency hydrogen scavenging by carbon dioxide.

Hydrogen gas will be stored at a central location in the dc switchyard at the Riel Converter Station. The hydrogen gas will be delivered to the site in a mobile storage tanker. The capacity of the two storage vessels proposed at site the will be approximately 2,400 m^3. The gas will be distributed through a piping system to each synchronous condenser at a pressure of approximately 100 psig. The supply pressure is reduced to approximately 30 psig at each synchronous machine. The hydrogen gas distribution system will be designed to conform to NFPA-55, Compressed Gases and Cryogenic Fluids Code.

The carbon dioxide gas system will be used to purge the synchronous condenser machines during the gassing and de-gassing processes. Carbon dioxide gas will be stored in a vessel approximately 17 m^3 in volume. The carbon dioxide gas is stored in liquid form. The gas storage vessel will be located in the dc switchyard adjacent to the hydrogen gas storage vessels. The distribution of carbon dioxide will be through a piping system. The carbon dioxide will be delivered to site in tanker truck.

3.6.3 Riel Ground Electrode

As outlined in previous sections, the neutral bus in the Riel Converter Station dc switchyard will be connected to the station ground electrode site by a low voltage overhead line.

3.6.3.1 Low Voltage Electrode Line

The function of the low voltage electrode line is to provide a low resistance connection between the neutral bus in the dc switchyard and the ground electrode site. During normal operation (i.e., bipolar operation) of the converter station, the electrode line will carry very low levels of current between the station and the ground electrode. However, during maintenance or emergency outages, the electrode line will carry current equal to the amount of current on the HVdc transmission line (monopolar operation).

The low voltage electrode line between the dc switchyard at the converter station and the Riel electrode site will be an overhead line. The design of the electrode line will closely resemble that of the existing Bipole I and II electrode lines at Dorsey Station. The structures will be similar in size to those on the distribution power lines common along roadsides in rural Manitoba. It is anticipated that it can be routed on existing road or other rights-of-way. The preferred route for this line is currently being determined. Adjacent land owners and the RM of Springfield will be notified of its proposed location prior to route finalization.

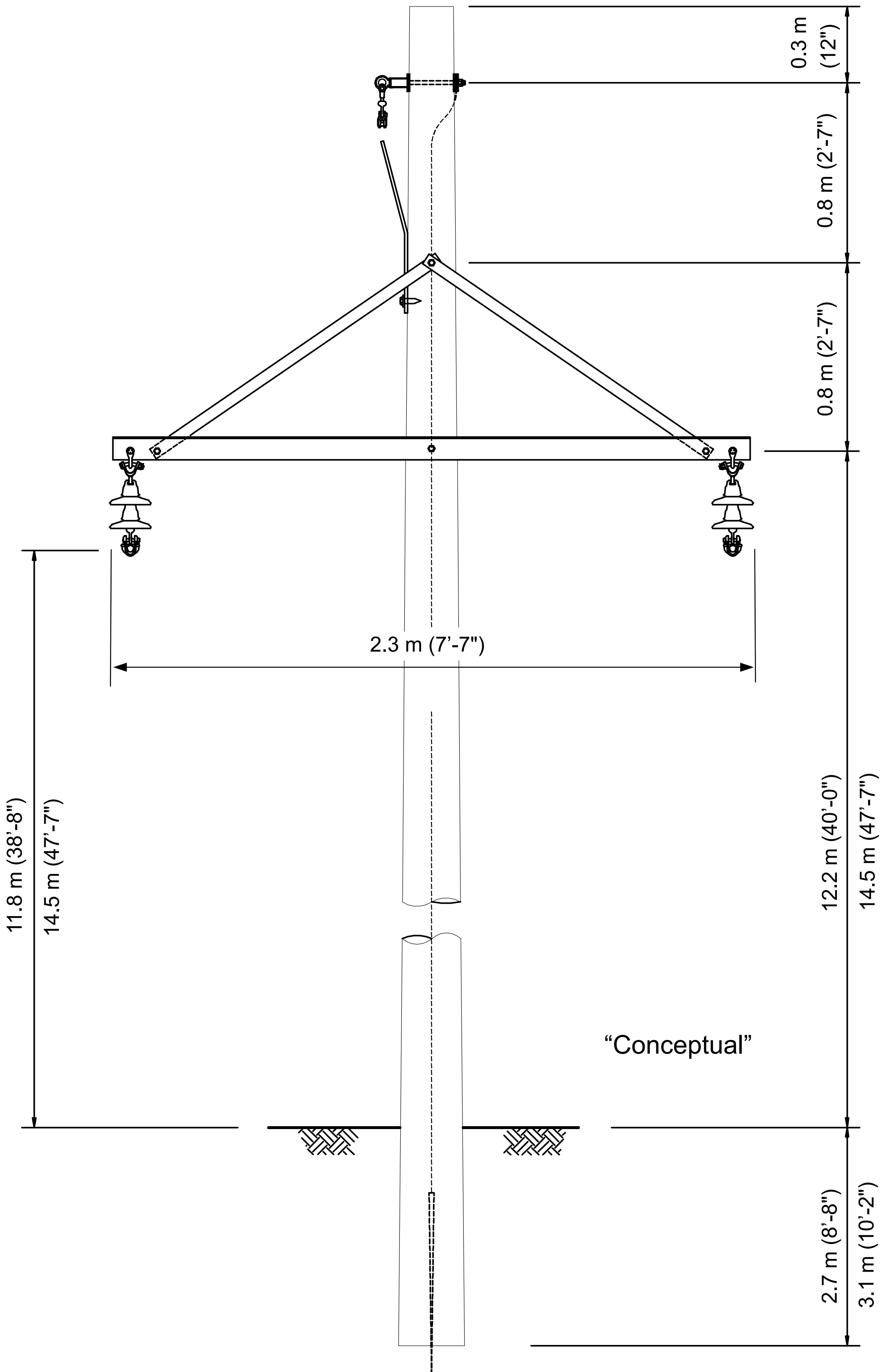

Figure 3.6-5:
Electrode Line Pole Structure (Dorsey Converter Station)

3.6.3.2 Ground Electrode

The function of the ground electrode is to provide a return path for current between the Riel and Keewatinoow converter stations. During normal operation (bipolar operation) of the Riel Converter Station, the ground electrode will conduct very low levels of current. However, during some maintenance or emergency outages at either converter station, the ground electrode will conduct current equal to the amount of current on the HVdc transmission line (monopolar operation).

Pending confirmation of detailed design criteria, the ground electrode will be a shallow electrode—comprised of four rod segments in a ring configuration, similar to the proposed ground electrode for the Keewatinoow Converter Station. Shallow ring electrodes are typically buried below the frost line with the electrode rod segments embedded in a highly conductive coke bed (see Figure 3.5-11). Underground cables will connect the electrode rods to a dead-end pole structure located centrally on the electrode site. The dead-end structure provides termination for the electrode line and transition to the underground cables.

The ground electrode requires adequate soil moisture to function properly. Although the preferred site has promising soil moisture attributes, the electrode will be equipped with an underground irrigation system to provide for significant change in soil moisture or drought events. The underground irrigation system will be installed in or above the coke bed and will be fed from wells located on site.

At the preferred electrode site a shallow ring electrode will be approximately 400 m in diameter. An access road for construction and ongoing maintenance will be constructed from one of the adjacent roadways to the electrode site.

Alternatively, a vertical well electrode could be selected for the electrode design if, during the detailed resistivity surveys phase, it is recognized that lower resistivity soil is found at deeper depths. Existing vertical well electrodes in other HVdc systems around the world are more frequently built at depths of 40 m or more. A vertical electrode would consist of an array of approximately 80-90 wells equally spaced and arranged in a circle, and would require a site similar in size to that identified for a shallow ring electrode.

3.6.4 Riel Converter Station and Ground Electrode Construction

Originally scheduled for completion in spring, 2014, the current Riel Reliability Improvement Initiative is now anticipated to be in service in 2015. With its completion, and prior to licensing and construction of the Bipole III Project, the Riel site will generally have been graded, fenced, aesthetically bermed, and provided with lighting and security systems, and will include extensive electrical apparatus in both the 230 kV and 500 kV ac switchyards. Site infrastructure will include: a network of facilities for access and internal traffic circulation; land drainage; domestic and fire protection water supply and distribution; and wastewater collection and disposal. In addition, the construction power facilities and railway construction access developed for the sectionalization project will be left in place for use in development of the Bipole III facilities at Riel.

As the necessary general station site preparation and infrastructure construction will have been completed in the course of the Riel Reliability Improvement Initiative, construction activities for the Riel Converter Station development will principally involve: final site preparation at the specific sites of the Bipole III facilities; construction of building and equipment foundations; and erection of buildings and structures. Assembly and installation of station apparatus and equipment, including the synchronous condensers, will follow, and will include filling of equipment with insulating oil, construction clean-up and commissioning. Development of the ground electrode and its connecting line will entail more conventional procedures, including site preparation and installation of the electrode and ancillary infrastructure. Construction of the connecting low voltage line will be largely confined to existing roadway rights-of-way.

Material required for station construction (e.g., concrete and granular fill) will generally be obtained from local suppliers (providing specific material specifications can be met) and transported to the site. Construction clean-up will occur throughout all phases of construction. As soon as possible after completion of construction, the converter station and electrode sites will be cleaned up and left in standard operating condition. All non-toxic materials will be disposed of using existing, appropriately licensed local facilities. As with construction activity, material supply and waste handling will be subject to conventional Manitoba Hydro codes of practice and relevant provincial and federal legislation.

Conventional construction contract and management procedures will likely apply to the construction of the ground electrode, site preparation and infrastructure development. The major equipment and electrical components to be installed in the station, such as the converter transformers, valve groups and ancillary facilities, are highly specialized devices which will be designed and manufactured off-site and delivered for installation and/or final assembly by highly specialized workers. Expansion of the 230 kV switchyard is likely to be undertaken by Manitoba Hydro staff or qualified contractors with experience working in an energized yard. Expansion of the 230 kV switchyard is likely to be undertaken by Manitoba Hydro staff or qualified contractors with experience in working in an energized yard.

Bipole III construction activity at Riel will generally be subject to procedures and protocols already established for the Riel Reliability Improvement Initiative and for transmission construction activity generally.

3.6.4.1 Converter Station Construction Activity

To the extent that the specific sites of the Bipole III facilities at Riel will require preparation and extension of station infrastructure systems to service the related buildings and equipment installations, the construction activity will be similar to that currently underway for the Riel Reliability Improvement Initiative.

Site preparation will extend to grading, lining with a geotextile fabric, surfacing with crushed stone, and installation of the subsurface ground grid.

Development of the individual sites will include connection to, and related expansion of, the station infrastructure systems (e.g., drainage and storm water management provisions; installation of point source oil containment and connections to the station fast drain facilities; connections to the internal roadway system; and connections to the station water distribution and wastewater collection systems).

Construction activities for the 230 kV switchyard expansion will include: placement of piles and placement of concrete for foundations, pads and structures; trenching for the placement of in-ground piping and cabling; placement of granular materials for surfacing; erection and construction of ancillary buildings; erection of steel structures for electrical hardware and equipment; delivery, placement and construction of switchyard equipment such as breakers and transformers; and the stringing, splicing and termination of overhead conductors for the switchyard. As in the case of the Riel Reliability Improvement Initiative, the latter activities are likely to include use of implosive sleeves.

Installation of the converter transformers will include placement of piles; placement of concrete for transformer foundations and pads; and the delivery, placement and construction/assembly of the transformers.

Construction of the converter building will involve the placement of piles and placement of concrete for the building foundation; erection of the building using masonry, concrete and steel materials; installation and fitting of building mechanical and electrical support systems; and finishing the interior with materials to suit the different requirements such as offices, work areas, valve halls, storage and battery rooms.

Valve groups will be constructed within the valve halls of the converter building. Construction of the valve groups will involve erection of the valve towers within the valve halls; installation of electronic valve group controls; and installation of cooling systems.

Installation of the synchronous condensers will involve the placement of piles and concrete foundations; on-site assembly of the various machine components; construction of the control buildings; and installation of the support systems, including the necessary unit transformers and related switchyard equipment and facilities.

Construction of the dc switchyard will include placing of piles and placing of concrete for foundations, pads and structures; erecting steel structures for electrical hardware and equipment; delivery, placement and construction of dc switchyard equipment such as switches, reactors and filters; and the stringing, splicing and termination of overhead conductors for the switchyard.

Any noise generated during the construction phase will be temporary in nature and will be subject to all relevant policies and regulations, including limits to construction working hours. Use of implosive sleeves, for example, will be subject to the approvals and protocols in place for the Riel Reliability Improvement Initiative.

All construction activities will conclude with the filling of insulating oils, insulating gases, battery acids, refrigerants, and other cooling mediums prior to system commissioning.

3.6.4.2 Electrode Assembly and Installation

Major activities for construction of a shallow ring ground electrode will include land clearing; excavation of the electrode trench to a depth of approximately three metres; placement of coke bedding material; assembly of steel electrode rods; compaction of the coke bed; installation of irrigation pipes; backfilling of electrode trench; installation of feeder cables; construction of the line termination structure; and the termination of the feeder cables and electrode line to the termination structure.

Pending the results of investigative studies currently underway, a shallow ring electrode may not prove feasible. An alternative design would be a vertical well ground electrode. In that case, major construction activities would include land clearing; drilling of electrode wells to a depth of approximately 40 m; assembly of piping and steel rods and cables; placement of the rods into the wellbores; pumping of water/coke slurry into the wellbore; and installation of concrete covers over the wellbores.

3.6.4.3 Construction Power

Construction power to the Riel site, as developed during the course of the Riel Reliability Improvement Initiative, will be provided via a 5 MVA Distribution Supply Centre, fed from a tap of the existing 66 kV line running along PR207. The Distribution Supply Centre was sized for construction of both the Riel Reliability Improvement Initiative and the Bipole III projects, and is planned to remain in service until Bipole III is in service.

3.6.4.4 Construction Staging and Marshalling

As in the case of construction access and traffic, requirements for station construction staging and marshalling are expected to carry on from corresponding arrangements established for the Riel Reliability Improvement Initiative.

In addition to the marshalling requirements for the station, a marshalling yard for tower steel will be developed on Manitoba Hydro lands in the immediate vicinity of the Riel site for support of transmission line construction requirements. The yard will be located immediately north and east of the station site, in the northeast quadrant of the intersection of PR 207 and Suthwyn Road (see Figure 3.6-2). The yard site will be approximately 300 m (frontage along PR 207) by 700 m in depth (east from PR 207). It will occupy two former private properties acquired by Manitoba Hydro in the course of preparation for the Riel Reliability Improvement Initiative. Highway entrance from PR207 will be provided from an existing access point to the northernmost property. An existing home on that property will be redeveloped as an office; part of an existing quonset storage building will also be retained for yard-related use. Yard development will otherwise involve stripping of the topsoil and replacement with clay fill and a gravel surface. The yard will be fenced and lighted.

Staged development of the marshalling yard will be scheduled initially to meet requirements of the Riel Reliability Improvement Project. A secure storage building for the implosive sleeves being used in construction of that project is being separately permitted and is planned for construction in the Fall of 2011. Initial marshalling yard development is proposed to expand the yard development to receive and store Bipole III transmission line materials for subsequent distribution to HVdc contractors as required.

Temporary storage areas will also be required at the electrode site to ensure that materials are kept secure during the construction period.

3.6.4.5 Construction Access and Traffic

Construction access and traffic arrangements will carry on from the arrangements established for development of the Riel Reliability Improvement Initiative. This will include use of the existing rail spur between the station site and the CN main line north of the site, running adjacent to the north side of PTH 15. PR 207 was upgraded by Manitoba Hydro and Manitoba Infrastructure and Transportation for the Reliability Improvement Initiative to support construction traffic loads and year-round construction.

Traffic studies[36] have included estimates of workforce travel and shipping, by rail and road, for both Keewatinoow and Riel converter stations, as well as the HVdc transmission line. Estimates have been compared to existing and historical traffic flows on existing area transportation infrastructure. In the case of Riel (independent of all other project components), estimated daily workforce trips during the construction period are estimated to range up to a peak during the third year of construction at 287 trips (AADT [average annual daily trips]) on PR 207 north of the site access road, and 123 trips (AADT) south of the station site access road. Corresponding estimates for daily truck trips (AADTT), for transport of materials and equipment, range up to a peak of 32 trips on PR 207 to the Riel site in 2014. The study extended to analysis of potential impacts of construction traffic on road, rail and air infrastructure. Related findings are further discussed in subsequent sections of the Environmental Impact Statement.

Rail deliveries will be subject to the same operating protocols and restrictions applicable to the Riel Reliability Improvement Initiative. Vehicular construction traffic at the converter station site will likely involve both rubber tired and track-mounted vehicles.

Access for transport of materials to and construction operations at the ground electrode site will be designed for maximum load vehicles with trailers.

All pertinent laws and regulations pertaining to such use of public roads, including any road restrictions, will be observed. Construction activity and access requirements will be subject to established environmental protection measures associated with standard Manitoba Hydro station construction practices.

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[36] Op cit., MMM Group Limited, June 2011.

3.6.4.6 Construction Camp

A residential camp will not be required for the converter station project. Workers will travel to and from the site from their residences or normal work places on a daily basis. Storage and marshalling of equipment and materials, together with offices and support facilities for Manitoba Hydro and contractor staff, will continue to be provided using Manitoba Hydro property on and adjacent to the site in arrangements similar to those used in the course of the Riel Sectionalization project.

3.6.4.7 Construction Contract Procedures and Workforce Requirements

Environmental approval and licensing of the Project is expected to be completed by the Fall of 2012. Pre-licensing activities and related job opportunities have included environmental assessment and consultation activity, and on-site engineering field investigations relating primarily to the proposed ground electrode (including soil sampling, resistivity and magneto-telluric testing, and installation of thermal monitoring wells). These were reviewed in advance with the RM of Springfield, and the necessary government work permits were applied for and received.

Contract Procedures

Initial construction and related contracts are expected to follow conventional design and construction practice. This will involve direct participation by Manitoba Hydro staff and consultant personnel in the preparation of design documents and construction specifications. Some construction activity will also be undertaken directly by Manitoba personnel. Some components will involve letting of construction contracts and on-going supervision by Manitoba Hydro.

The more technically complex aspects of the project, including the converter transformers, the valve groups and ancillary facilities, and the synchronous condensers, are expected to be designed and manufactured off-site. Assembly and installation of such equipment will generally be performed by highly specialized workers.

Employment Opportunities

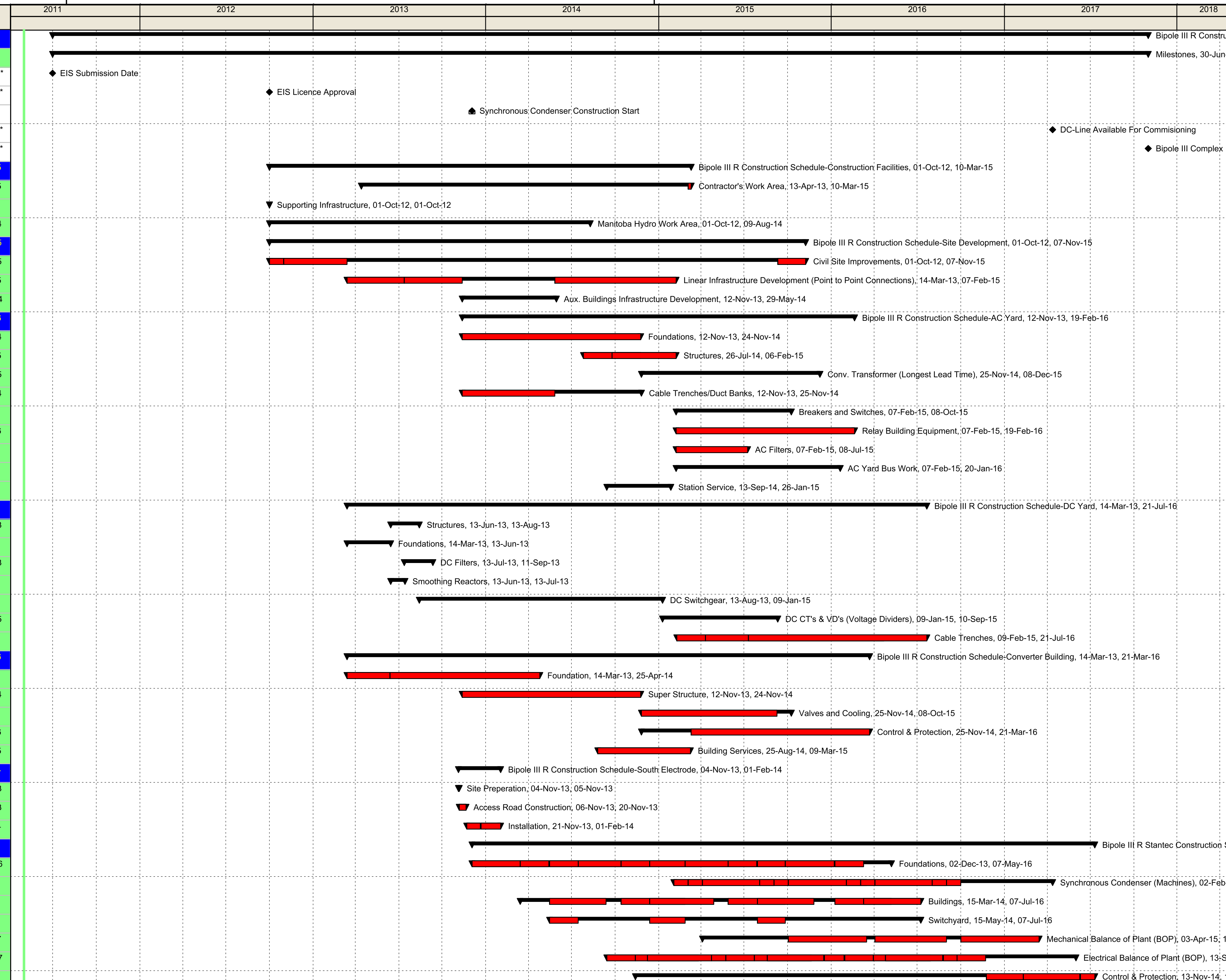
The conventional contract arrangements will generally involve a relatively small component of general labour and construction trades and related employment opportunities. The contracts related to the assembly and installation of the HVdc and synchronous condenser equipment will involve a more substantial component of highly specialized workers, many of whom will be involved in both the off-site manufacture of equipment and its on-site assembly and installation.

Workforce Requirements and Schedule

A preliminary construction schedule and workforce estimates are provided in Figure 3.6-6 and Figure 3.6-7respectively. From project commencement in the Fall of 2012, the Bipole III Riel-related workforce will increase gradually from about 50 people in late 2012, to peak at approximately 260 people in the first quarter of 2014. It will continue at a relatively high level, tapering down to about 150 people by the end of 2015, and to less than 100 by the beginning of 2016. The workforce will continue to decrease gradually, tapering off to approximately 15 people by mid-2017 as the emphasis shifts from construction to commissioning.

BPIII - Riel Pre-Construction Plan Schedule Draft	Preliminary Draft Schedule	Draft Schedule Printed 2011/01/27

Activity ID	Activity Name	Original Duration	Start	Finish
	Bipole III R Construction Schedule-Milestone Dates	1917	30-Jun-11	31-Oct-17
	Milestones	1917	30-Jun-11	31-Oct-17
MS1000	EIS Submission Date	0		30-Jun-11*
MS1010	EIS Licence Approval	0		01-Oct-12*
MS1060	Synchronous Condenser Construction Start	0	02-Dec-13*	
MS1040	DC-Line Available For Commisioning	0		13-Apr-17*
MS1050	Bipole III Complex ISD	0		31-Oct-17*
	Bipole III R Construction Schedule-Construction Facilities	729	01-Oct-12	10-Mar-15
	Contractor's Work Area	573	13-Apr-13	10-Mar-15
	Supporting Infrastructure	1	01-Oct-12	01-Oct-12
	Manitoba Hydro Work Area	560	01-Oct-12	09-Aug-14
	Bipole III R Construction Schedule-Site Development	917	01-Oct-12	07-Nov-15
	Civil Site Improvements	938	01-Oct-12	07-Nov-15
	Linear Infrastructure Development (Point to Point Connections)	574	14-Mar-13	07-Feb-15
	Aux. Buildings Infrastructure Development	157	12-Nov-13	29-May-14
	Bipole III R Construction Schedule-AC Yard	678	12-Nov-13	19-Feb-16
	Foundations	313	12-Nov-13	24-Nov-14
	Structures	156	26-Jul-14	06-Feb-15
	Conv. Transformer (Longest Lead Time)	313	25-Nov-14	08-Dec-15
	Cable Trenches/Duct Banks	314	12-Nov-13	25-Nov-14
	Breakers and Switches	209	07-Feb-15	08-Oct-15
	Relay Building Equipment	313	07-Feb-15	19-Feb-16
	AC Filters	130	07-Feb-15	08-Jul-15
	AC Yard Bus Work	287	07-Feb-15	20-Jan-16
	Station Service	104	13-Sep-14	26-Jan-15
	Bipole III R Construction Schedule-DC Yard	1017	14-Mar-13	21-Jul-16
	Structures	52	13-Jun-13	13-Aug-13
	Foundations	78	14-Mar-13	13-Jun-13
	DC Filters	52	13-Jul-13	11-Sep-13
	Smoothing Reactors	26	13-Jun-13	13-Jul-13
	DC Switchgear	418	13-Aug-13	09-Jan-15
	DC CT's & VD's (Voltage Dividers)	209	09-Jan-15	10-Sep-15
	Cable Trenches	443	09-Feb-15	21-Jul-16
	Bipole III R Construction Schedule-Converter Building	912	14-Mar-13	21-Mar-16
	Foundation	339	14-Mar-13	25-Apr-14
	Super Structure	313	12-Nov-13	24-Nov-14
	Valves and Cooling	261	25-Nov-14	08-Oct-15
	Control & Protection	391	25-Nov-14	21-Mar-16
	Building Services	157	25-Aug-14	09-Mar-15
	Bipole III R Construction Schedule-South Electrode	67	04-Nov-13	01-Feb-14
	Site Preperation	2	04-Nov-13	05-Nov-13
	Access Road Construction	13	06-Nov-13	20-Nov-13
	Installation	52	21-Nov-13	01-Feb-14
	Bipole III R Stantec Construction Schedule-Riel Synchronous ...	1084	02-Dec-13	10-Jul-17
	Foundations	728	02-Dec-13	07-May-16
	Synchronous Condenser (Machines)	665	02-Feb-15	13-Apr-17
	Buildings	702	15-Mar-14	07-Jul-16
	Switchyard	650	15-May-14	07-Jul-16
	Mechanical Balance of Plant (BOP)	587	03-Apr-15	14-Mar-17
	Electrical Balance of Plant (BOP)	816	13-Sep-14	31-May-17
	Control & Protection	798	13-Nov-14	10-Jul-17



Actual Work | Critical Remaining Work | Milestone
Remaining Work | Start Constraint | Summary

Figure 3.6-6:
Preliminary Riel Construction Schedule

Riel Converter Station - DRAFT
Quarterly Construction Site Workforce Forecast
Contractor Site Craft Personnel
February 28, 2011

Labor Group	Total (person-years)	Y-6				Y-5				Y-4				Y-3				Y-2				Y-1				Y				Y+1			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
CONSTRUCTION SUPPORT AND SERVICE TRADES	45	0	0	0	0	0	0	0	5	6	6	6	9	9	9	9	9	9	9	10	9	10	9	10	9	10	9	9	9	2	0	0	0
NON-DESIGNATED TRADES	179	0	0	0	0	0	0	0	31	43	49	34	83	87	76	58	42	40	40	35	31	19	18	12	14	12	6	3	2	0	0	0	0
DESIGNATED TRADES	419	0	0	0	0	0	0	0	18	58	103	83	137	157	127	145	124	152	155	140	111	57	48	37	39	32	10	4	3	0	0	0	0
TOTAL CONTRACTOR CRAFT PERSONNEL	**643**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**54**	**107**	**158**	**123**	**229**	**253**	**212**	**212**	**175**	**201**	**204**	**185**	**151**	**86**	**75**	**59**	**62**	**54**	**25**	**16**	**14**	**2**	**0**	**0**	**0**

Notes:

1) The above forecasts are based on Manitoba Hydro's forecast of workforce and a construction schedule based on a October 2017 in-service date of the Bipole III Complex.

2) The above information represents a forecast only, based on current regulations, present project plans, and experience with similar projects. Contractors will determine specific job requirements when the project is being built. Actual employment requirements will vary from the forecast presented above.

3) "TOTAL CONTRACTOR CRAFT PERSONNEL" refers to the average number of people on site within the quarter specified based on a monthly estimate, rounded to the nearest whole number.

4) The above information indicates contractor craft site personnel (not including supervisory and management positions). The above forecasts also do not include Manitoba Hydro staff, or workforce for the construction of Substations and Transmission Lines.

5) **Designated Trades** are those trades which apprenticeship training and certification requirements are regulated by the Government of Manitoba in accordance with the Apprenticeship and Trades Qualification Act.

6) Total (person-years) are calculated based on the estimate of person-months, where one person year is equivalent to 12 person-months.

7) Estimate represents projected number of workers needed on site during the specified time period and does not account for turnarounds.

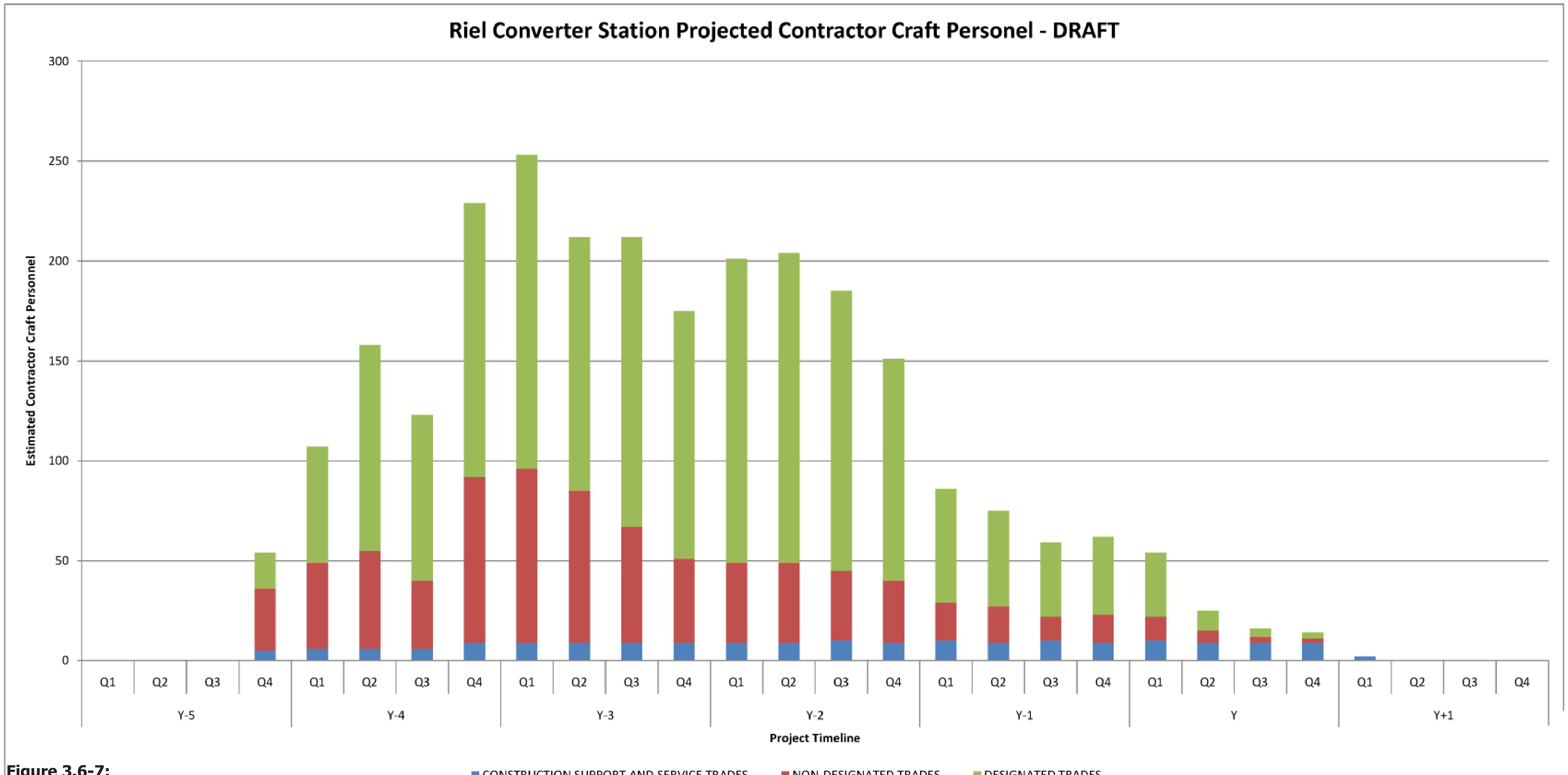


Figure 3.6-7:
Preliminary Riel Work Force Estimates

3.6.4.8 Solid Waste and Hazardous Materials Management

Both hazardous and non-hazardous wastes will be generated through the course of construction both at the sites of the converter station facilities and the ground electrode. Wastes will be managed, collected and disposed of in accordance with current provincial and/or federal regulations. Management procedures for specific hazardous materials are detailed in the Hazardous Material Management Handbook (Manitoba Hydro 2003). The Environmental Protection Plans will contain general guidelines for non-hazardous and hazardous waste management.

Opportunities to reduce, reuse, and recycle the wastes will be taken whenever possible. Wastes will be stored in designated areas (i.e., transfer stations) and disposed of regularly to reduce potential for unsafe conditions and adverse impacts. Waste will be transported to existing permitted waste disposal sites.

3.6.4.9 Riel Site Area Requirements

The proposed Bipole III development at Riel will occupy station lands which are being graded and provided with basic development infrastructure as part of the Riel Reliability Improvement Initiative. Manitoba Hydro lands adjacent to the station, where surplus to the ongoing site requirements, will be cleaned up after completion of construction and generally restored to agricultural use. Exceptions will include ongoing use of the proposed steel marshalling yard, in the northeast quadrant of PR 207 and Suthwyn Road, and retention of the station rail spur for ongoing station maintenance requirements (subject to temporary crossing arrangements at PTH 15).

3.6.4.10 Construction Clean-up and Rehabilitation

Construction clean-up will occur throughout all phases of construction. As soon as possible after completion of construction, the converter station and electrode sites will be cleaned up and left in standard operating condition. All non-toxic materials will be disposed of using existing, appropriately licensed local facilities. As with construction activity, material supply and waste handling will be subject to conventional Manitoba Hydro codes of practice and relevant provincial and federal legislation.

All clean-up and rehabilitation activity will be subject to the requirements of the Environmental Protection Plan.

3.6.4.11 Construction Safety, Security and Emergency Response Plans

Specific safety requirements will be stipulated in the contract packages for all construction activities. Contractors will be required to comply with current provincial occupational health and safety regulations.

Development of emergency response plans and programs will include procedures to address all foreseeable situations that may occur during construction (and subsequently during station operation and maintenance).

Management of environmental issues such as spills will be addressed in the Environmental Protection Plan. Spill response programs and equipment will be in place for spillage or leakage of any oils or contaminants. All materials will be stored and handled in accordance with established policies and regulations. During construction, on-site emergency response teams will receive training with respect to fuel spill containment, clean-up and other emergency measures.

Transportation and handling of dangerous goods will comply with applicable legislation and regulations. Road transportation of dangerous goods will be undertaken only by appropriately licensed carriers.

3.6.4.12 Environmental Protection Plans and Monitoring

As in the case of the Keewatinoow Converter Station and the HVdc and ac collector transmission lines, Riel station and electrode construction activity and operations requirements will be subject to standard environmental protection measures. These will be identified and cross-referenced in an Environmental Protection Plan to be submitted with the Environmental Impact Statement for review and approval. Adherence to the Environmental Protection Plan will be stipulated in related contract specifications.

3.6.5 Station and Electrode Operation and Maintenance

Once completed and fully commissioned, the Riel Converter Station will be operated 24 hours a day, year round, and will have permanent Manitoba Hydro personnel on-site performing regular operation, maintenance and inspection duties. Qualified operators and maintenance personnel will routinely inspect and maintain the sites and, in the case of contingencies, correct any problems or related environmental effects. Total operations and maintenance staff has been estimated at 45 persons.

3.6.5.1 Station Operations

The Riel Converter Station control room, located within the converter building, will provide the human/machine interface equipment for the operators to control critical functions in the station and power flow in the system. These critical functions will also be monitored and controlled remotely by Manitoba Hydro's System Control Center.

Routine and emergency maintenance of the converter station equipment and facilities will normally be performed by Manitoba Hydro personnel assigned to the station. Maintenance and repair activities not normally performed by Manitoba Hydro staff may be performed by external companies under contract. Administrative functions and site security will also be performed by Manitoba Hydro staff.

As in the case of construction, maintenance and repair routines are subject to standard Manitoba Hydro procedures.

Environmental Emissions and Discharges during Station Operation

Electric and Magnetic Fields and Corona

As in the case of the connecting transmission lines, operation of the converter station electrical equipment will involve the production of electric and magnetic fields (EMF) and corona discharges. The level of these will vary with time, subject to operating mode and loading conditions and, as well, to final station design and equipment selection, and such external considerations as meteorological conditions.

Estimated levels of these emissions are generally based on mathematical modeling and on comparison to corresponding levels associated with other similar facilities in the Manitoba Hydro system. Concerns respecting potential environmental effects (e.g., health effects, electrostatic and electromagnetic induction effects, etc.) arising from EMF and corona emissions were raised in the course of the public consultation program for the project. These concerns, together with assessment of any potential effects and related mitigation measures, are discussed in later sections of the Environmental Impact Statement.

Studies have been conducted to model the electric and magnetic fields associated with operation of the ground electrode and its connecting low voltage line, as well as the prospect of audible or radio/television frequency noise arising from operation of the electrode line. The studies include different operating modes and conditions.

The electric and magnetic fields associated with converter station equipment are not expected to cause field levels outside the station sites to be significantly elevated except where transmission lines traverse the site boundary. The related field levels associated with transmission lines were independently modelled. The studies extended to the prospect of harmonics and radio frequency noise associated with station operations.

Detailed study results are provided in the associated technical reports[37], and are discussed elsewhere in the Environmental Impact Statement in the chapters dealing with public consultation and environmental effects.

Other Emissions and Discharges

Apart from EMF and corona-related emissions, station operation will involve a variety of other emissions, discharges and activities. Most have been previously discussed in descriptions of the station components. Others are more general in nature and may, in some circumstances, be subject to public concerns respecting potential adverse environmental effects.

Audible Equipment Noise

Audible noise levels arising from station equipment operation will be subject to final design and equipment selection, but will comply with applicable provincial regulations and guidelines.

Solid Waste and Hazardous Materials Management

Station operation will entail the use of several controlled materials, in particular ethylene glycol, refrigerants, battery acid and, depending on the selected converter technology and the requirement of synchronous condensers, hydrogen.

Ethylene Glycol

The valve groups within the valve halls generate heat during operation. This heat must be dissipated quickly and efficiently in order to protect the critical electronic components. The removal of heat is performed by a cooling system which circulates a de-ionized water-glycol solution through a system of manifolds and pipes. Although the probability of leaks in the system is low, the system is closely monitored to ensure proper operation.

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[37] Op. cit., E[x]ponent, May 25, 2011.

Refrigerants

Mechanical cooling, where required, will involve conventional HVAC design with a compressor and refrigerants. All refrigerants will be subject to environmental specifications in accordance with ASHRAE guidelines.

Battery Acid

Batteries are required to power critical communications, control and protection systems in the station. The batteries are arranged in groups called battery banks. The banks are housed in separate rooms designed to minimize risks associated with fire and to contain any potential leaks.

Sulphur Hexaflouride (SF_6) and Carbon Tetraflouride (CF_4)

High voltage electrical apparatus such as circuit breakers and bushings typically use Sulphur Hexafluoride (SF_6) as an internal insulating medium between energized and non-energized components. A blend of SF_6 and Carbon Tetraflouride (CF_4) or Nitrogen (N_2) gas is typically utilized to prevent condensation of the SF_6 gas within the apparatus and maintain adequate electrical insulation at ambient temperatures as low as -50 degrees Celsius,

Insulating Oil

Insulating oil is used in power transformers and other high voltage electrical apparatus as an electrical insulator and heat transfer medium. In the case of power transformers, the insulating oil is circulated through a radiator in order to transfer heat generated from the transformer to the atmosphere.

Hydrogen

All transportation, handling and storage of hydrogen for use in the synchronous condensers will comply with relevant regulations and guidelines.

Carbon Dioxide

All transportation, handling and storage of carbon dioxide for use in the synchronous condensers will comply with relevant regulations and guidelines.

3.6.5.2 Ground Electrode and Ground Electrode Line Operation

The ground electrode site will not normally be staffed. Inspection and maintenance of the electrode and the electrode line will be performed by Manitoba Hydro staff based on established frequencies and procedures. Associated inspection and maintenance activities will include site inspection, monitoring of soil moisture, monitoring and operation of electrode irrigation system, and inspection of the electrode ring.

During normal operation (i.e., bipolar mode), the low voltage electrode line and ground electrode will conduct very low levels of dc current. This current flow arises from anticipated minor differences in equipment characteristics within the station converter transformers, valve groups, dc switchyard and the HVdc transmission line. Ground electrode current during bipolar operation will typically be less than 110 amperes.

Occasionally, outages resulting from routine equipment maintenance, repair, or malfunction may require dc current equal to the HVdc transmission line current to be conducted through the low voltage electrode line and ground electrode (i.e., monopolar mode). Ground electrode current during monopolar operation is dependent on the dc power being transmitted on the HVdc transmission line. At full load, it would be approximately 2,000 amperes, but the design will provide for up to 2,200 amperes for extra margin during contingency.

Operation of full load dc current through the ground electrodes can cause stray electric current to flow in the surface layer of the soil which, in turn, will cause a ground potential rise in the soil surrounding the electrodes. Metallic infrastructure such as underground cables, transmission line tower footings, and buried pipelines (gas, water, sewer, etc.) may be affected by the stray current, which can lead to corrosion. In addition, stray current flowing through large substation power transformers can result in excessive heating. Studies using computer models have been used to calculate stray current distribution, to analyze potential interference on buried infrastructure and substation transformers and to guide electrode site selection and design. Related findings are further discussed in later sections of the Environmental Impact Statement.

3.6.5.3 Workforce Requirements

It is currently estimated that a total of 45 Manitoba Hydro staff will be employed at the Riel Converter Station. Related employment opportunities will include staff positions for power supply workers (multi-skilled), operators, electrical and mechanical technicians, and maintenance utility workers.

3.6.6 Riel Decommissioning

The life span of converter station facilities is normally considered to be in the order of 50 years. However, converter station facilities are not sited and designed with a view to decommissioning.

As individual station components fail, replacement will normally be made with equivalent new equipment or facilities. Major station facilities are also subject to continuing maintenance, refurbishment, and expansion to respond to changing system requirements, and to upgrade in response to improved technologies. The station facilities, given their role and function, are considered to be effectively permanent.

In the extremely unlikely event that the facility was to be decommissioned, the process would be subject to development and approval of appropriate procedures which, in turn, would be subject to applicable regulatory requirements in place at the time. The overall objective of any decommissioning plans would be to restore the station site to a condition consistent with the future intended use of that site. Station components and site improvements would be salvaged, removed and disposed of in compliance with all relevant regulations. Depending on the extent of any surface contamination on-site (e.g., petroleum contamination in soils), remediation would occur to correct any residual impact. A careful investigation of containment parameters, future land use, site risks, and remedial technologies would be conducted as part of the development and implementation of a remedial action plan.

3.6.6.1 Project Schedule

The Bipole III Reliability Improvement Project (±500 kV HVdc transmission line, northern termination and converter station, and southern termination and converter station) is proposed to be in-service by October 2017. To achieve this, construction will need to commence in the Fall of 2012 at the Keewatinoow site to provide construction power and enable related station work. On the basis of winter construction in the north, construction commencement of the HVdc transmission line will need to occur in December 2012.

The project Environment Act Proposal Form (and environmental assessment scoping document) was filed in December 2009. The period for public comment closed in March 2010. It is anticipated that the Environmental Impact Statement will be filed in the fall of 2011, heard by the Clean Environment Commission in early 2012, and the environmental license received by the target date for construction commencement in the Fall of 2012.

Crown land reservations, easement agreements and any other project-related property arrangements, permits, etc. are targeted to be secured prior to construction commencement in the Fall of 2012, contingent upon license receipt.

Clearing for the HVdc transmission line in the northern portion of the project is proposed to occur generally between November/December and March/April of each of the winters between 2012 and 2016. Line Construction in the north and central line segments would take place in the winter periods of 2013-2014 through 2016-2017. Clearing and construction in the southern portion of the line (central and southern segments) will not be restricted to winter months. Clearing will be undertaken in 2013 through 2016; construction will occur in the period 2014 to 2016. The four years of northern HVdc line construction are expected to involve sections of approximately 200 km in length, more than one of which could be under construction in a given year. Annual central and southern construction programs, during the two to three year period, are each expected to involve a single section approximately 150 km in length (with two such annual segments for each of the southern and central sections).

Clearing and construction for the Northern Collector transmission lines will also be conducted within this schedule, though possibly under separate clearing and construction contracts.

Northern termination construction activity is proposed to commence in December 2015 and to be completed by September 2016. Keewatinoow and Riel converter station construction activity is proposed to be completed by September 2017. Site preparation for the Keewatinoow Converter Station is proposed to commence in April 2014 with completion by December 2015. Site preparation for the Riel Converter Station (i.e., Riel Station) commenced in March 2008, as part of the Riel Reliability Improvement Initiative, and is proposed to be completed by February 2013.

3.7 REFERENCES

Burntwood-Nelson Collective Agreement (BNA), 1989.

Canadian Standards Association. 2010a. Overhead Systems Standard, C22.3 No. 1-10. Standards Council of Canada.

Canadian Standards Association. 2010b. Design Criteria for Overhead Transmission Lines Standard, C22.3 No. 60826-2010. Standards Council of Canada.

Exponent Inc. 2011. Modeling of the Electrical Environment for Proposed DC and AC components of the Bipole III Project. Bowie, MD.

Manitoba Hydro. 2003. Hazardous Material Management Handbook. Winnipeg.

Manitoba Hydro. n.d. Optimization of Reliability (Selection of Optimum Return Period of Design Loads). Report BP3-TR-03. Winnipeg.

National Fire Protection Association. 2011. Codes and Standards. http://www.nfpa.org/categoryList.asp?categoryID=124&URL=Codes%20&%20Standards&cookie%5Ftest=1.

North American Electric Reliability Council and Mid-West Reliability Organization. 2006. System Planning Criteria and Standards.

Statistics Canada. 2006. Census of Canada 2006. Government of Canada. http://www80.statcan.gc.ca/wes-esw/page1-eng.htm.