|Kontzamanis|Graumann|Smith|MacMillan|Inc.|

KGS GROUP
CONSULTING ENGINEERS

3rd Floor
865 Waverley Street
Winnipeg,
Manitoba
R3T 5P4
204.896.1209
fax: 204.896.0754
www.kgsgroup.com

September 8, 2017 File No. 16-0300-006

Manitoba Infrastructure
Water Management and Structures
600 - 215 Garry Street
Winnipeg, Manitoba
R3C 3P3

ATTENTION: Mr. Mark Allard, P.Eng.
Project Director

RE: Groundwater and Surface Water and Geotechnical Investigations & Preliminary Engineering for Lake Manitoba Outlet Channels Option C & D – Route G Letter Report – Final

Dear Mr. Allard:

KGS Group is pleased to submit our final Route G Letter Report as per your request.

1.0 INTRODUCTION AND BACKGROUND

During meetings held between Manitoba Infrastructure (MI) and local landowners affected by the Route D Lake Manitoba outlet channel (Moosehorn, May 29, 2017), members of the community raised the question of the feasibility of a an alternate route (herein referred to as Route "G"). Route G is in general located several kilometres south of Route C within relatively sparsely populated lands, and enters the Lake St. Martin area in the vicinity of Hilbre, Manitoba (Figure 1). Similar routes from Lake Manitoba to Lake St. Martin were previously considered but they were dismissed at the screening level of study and therefore not examined in detail. As such, MI took this suggestion from the public under advisement and requested that KGS Group build upon previously compiled knowledge of the potential outlet channel routes between Lake Manitoba and Lake St. Martin (i.e. Routes B, C, and D), and re-examine the feasibility of this new Route G alignment, using the same criteria as previously applied to the possible Lake Manitoba outlet channel alignments.

As detailed within the recent "Investigations and Preliminary Engineering for Lake Manitoba Outlet Channels Options C & D Summary Report " (KGS Group, 2017), the Interlake area between Lake Manitoba and Lake St. Martin/Lake Winnipeg is a prime groundwater recharge area for the regional carbonate bedrock aquifer system. Recharge from precipitation and snowmelt enters the bedrock aquifer in areas of relatively high bedrock elevation, where there is thin (to no) overburden soil cover. Groundwater flows are in general eastward and westward from these high elevation bedrock recharge areas, to Lake Winnipeg (and Lake St. Martin) and Lake Manitoba, and to other low-lying creeks, rivers, and bog areas, at the local scale.

There are many well-documented areas within the project region where this bedrock aquifer recharge condition occurs. One example of this is along the Route C outlet channel alignment, where recent studies (KGS Group, 2017) not only verified the combination of high bedrock topography and thin overburden cover typical of aquifer recharge areas, but also measured and documented downward recharge vertical groundwater gradients between the upper and lower bedrock aquifer system.

As such, the excavation of the Route C outlet channel option directly into the bedrock aquifer, within a groundwater recharge area, was determined to be a high risk option, from the perspective of long-term aquifer water quality, and GUDI (Groundwater Under Direct Influence of Surface Water) concerns for nearby well users. Many private and public groundwater wells are located within the vicinity of Route C, including on the adjacent Pinaymootang First Nation. To assure long-term water supplies in the region, a district water treatment and distribution system was assessed as necessary to mitigate this risk to long-term regional water quality.

Route D is the preferred option for the Lake Manitoba outlet channel, based on the ranking, weighting, and evaluation of a broad set of criteria, as detailed in the recent preliminary engineering report for Routes C and D (KGS Group, 2017). An advantage of Route D is that it is located within a localized and structurally controlled low elevation bedrock area between Lake Manitoba and Lake St. Martin (Figure 1). Along Route D, provided the underlying confined bedrock aquifer groundwater pressures are controlled during construction and in the long-term, the Route D outlet channel will be constructed within the in-situ, low permeability and intact dense till. This is a significant advantage in isolating the outlet channel surface waters from the aquifer system. In addition, upward pressure gradients from the underlying bedrock aquifer may be maintained, thus resulting in a discharge or exfiltration groundwater gradient to the outlet channel surface water system along Route D, and therefore a second method to help mitigate the potential for any long-term bedrock aquifer groundwater quality impacts.

Among other criteria (KGS Group, 2017), and particularly in consideration of the hydrogeological setting described above, the routing of any Lake Manitoba outlet channel in this region, including and not limited to Route G, is best routed to avoid incising of the channel directly into the bedrock aquifer, and in particular within high elevation, bedrock aquifer recharge areas.

2.0 DETAILED RE-ASSESSMENT OF BEDROCK SURFACE IN THE REGION OF THE ROUTE C AND ROUTE D CHANNELS

To evaluate potential additional routes (such as Route G) as requested in the region of the Lake Manitoba outlet channel, the available geological dataset was re-visited, updated, expanded, and re-analyzed from that completed during the recent investigations and preliminary engineering work that focused on Options C and D (KGS Group, 2017). The goal was to assemble a mapping product, for the purposes of evaluating the new Route G option, or other possible options that could be considered in the Lake Manitoba outlet channel project area south of Route C. Data assembled included the following (see representation of the available data distribution on Figure 1):

- The 2016 provincial GWDRILL water well database (checked and verified against the 2013 database version for consistency);
- Geotechnical/environmental engineering explorations advanced during preliminary engineering studies at routes B, C, and D;
- Regional geological/hydrogeological mapping studies compiled by Betcher (1987);

- Regional geological mapping compiled by Groom (2006); and
- Other regional reports outlined within the references within the recent KGS Group preliminary Engineering study (KGS Group, 2017).

A review of the data sources outlined above identified 1,510 independent datapoints defining the surface of the bedrock in the region of the Lake Manitoba outlet channels (Figure 1). Because of the widely varying descriptions typically contained within the GWDRILL database, each record was independently checked and verified prior to input to the final dataset used to model the bedrock surface. Establishment of ground surface elevation, used to calculate the elevation of the bedrock surface, was completed as follows:

- Where the GWDRILL database contained an exact measurement of the ground surface elevation, this elevation was applied;
- Where the GWDRILL database contained no ground surface elevation, the available project LIDAR (Light Detection and Ranging) ground elevation data was applied; and
- Where neither GWDRILL nor LIDAR data was available, the CGIAR Consortium for Spatial Information SRTM (Shuttle Radar Topography Mission) 90 m digital elevation database was applied.

A broad sweep of the available bedrock surface datapoints was examined in a simple scatterplot, to identify whether there is any area within the study region that consistently falls below the proposed range in Lake Manitoba outlet channel inverts (Figure 2). Data local to the Route C and D outlet channel options examined previously (KGS Group, 2017) are separated in the Figure 2 plots by color (green = data in the vicinity of Route C; blue=vicinity of Route D). The plots are organized by UTM coordinates, showing the bedrock surface data in a sweep of the region from west to east, and from south to north. These scatterplots illustrate the following:

- There are wide ranges in bedrock surface elevations, with bedrock surfaces in places occurring well above to well below the typical invert ranges for any Lake Manitoba outlet channel;
- The bedrock surface elevation may vary drastically over relatively short distance, which is typical of karstic bedrock conditions in the project area, and with sinkholes/infills that are present as part of the typical geological conditions;
- The bedrock surface elevation is highly irregular and does not display a particularly consistent trend in any one direction or area, though in general, the bedrock surface trends to the highest regional elevations toward the south and east (i.e. south- southeast); and
- Importantly, there does not appear to be a significant area or quadrant within the study area (i.e. south-north-east-west) that has a bedrock surface consistently below the proposed range in outlet channel inverts, which could simplify route selection.

A much closer look at the bedrock surface topography is necessary to determine whether there is a Lake Manitoba outlet channel routing option which avoids interconnecting the outlet channel surface water regime to the bedrock aquifer groundwater system, in this critical Interlake groundwater recharge area. The representation of the regional bedrock surface is shown on Figure 3. Information on Figure 3 includes the following:

- A bedrock topography plot (Figure A), illustrating areas where the bedrock surface is above the anticipated range in Lake Manitoba outlet channel inverts. These areas are denoted with bedrock topography contours that are red in color;
- Bedrock topography areas (Figure A) below the invert range of a Lake Manitoba outlet channel are shown shaded in grey, with bedrock topography contours that are black in color;
- A second plot (Figure B) illustrates the estimate of cut or excavation into the bedrock aquifer, assuming a channel invert of El. 242 m (typical channel invert ranges are anticipated to be between El. 240 m and El. 243 m);
- Figure B shows regional areas of aquifer excavation in red-colored contours;
- Figure B shows areas of no aquifer excavation shaded in grey, with black colored contours; and
- The line of “0 m” excavation in bedrock is shown in blue on Figure B.

Based on the data available to date, Routes B, C, and G traverse bedrock areas in the order of El. 250 m and greater, necessitating between approximately 5 m and 10 m of bedrock excavation, into the recharge zone of the regional bedrock aquifer, and over large expanses of these channel routes. Route D is located within a structurally controlled, low elevation bedrock zone that is oriented north-south between Lake Manitoba and Lake St. Martin (Figure 3). Based on preliminary engineering completed to date, the Route D channel option has the opportunity to be constructed entirely within the intact, in-situ dense till, provided groundwater piezometric pressure of the underlying confined bedrock aquifer in the vicinity of the channel is controlled during construction, and in the long term. The Route D channel option provides the opportunity to isolate the outlet channel surface water system from the groundwater system, in combination with an outlet channel location in a groundwater bedrock aquifer discharge area, where vertical groundwater gradients are strongly upward, to flowing artesian (KGS Group, 2017).

The Route D outlet channel option is the preferred option to mitigate the concern of interconnecting the surface water outlet channel regime to the bedrock aquifer system. Based on the mapping completed, using data available to date, there is not another potential route in the Route B, C, or G areas that would mitigate this risk to the extent that is provided by the Route D option.

3.0 QUALITATIVE EVALUATION OF AQUIFER RISK

The recent preliminary engineering study (KGS Group, 2017) discussed, weighted, and ranked the outlet channel route Options C and D against a comprehensive list of criteria, including the risk to the aquifer and groundwater supplies/well users in the region. The Route C option, incised into the bedrock aquifer in a groundwater recharge zone, and in close proximity to many well users (including on the adjacent Pinaymootang First Nation) carried a very high risk to the groundwater supplies and well users. A water treatment and distribution system would accompany the Route C option to mitigate the concern with groundwater supplies in the long term. While the proposed Route G outlet channel option relocates the outlet channel route into an area of generally lesser population and well users, the Route G option has similar concerns as Route C, for long-term water supplies because it (like Route C)would be excavated into the bedrock aquifer in a groundwater recharge area.

The physical relocation of the Route G option further away from a large group of groundwater well users reduces the immediate risk to groundwater supplies in the shorter term. However, it still poses a risk to the aquifer and regional well users, including at Pinaymootang First Nation, in the long term. Additionally, the Route G option shifts more risk towards new clusters of groundwater well users, more specifically those in the vicinity of Hilbre, Manitoba.

An assessment of groundwater use was conducted near Hilbre Manitoba in conjunction with the evaluation of Route G. Information provided by Manitoba Sustainable Development GWDRILL database (2016) was used. Non-domestic water supplies were previously identified in the KGS Group (2017) study (Deliverable D4, Table D4-6). These include the Hilbre Gospel Chapel, Hilbre School, CNR, and the Hilbre Community Hall owned by the LGD Grahamdale.

Relative to Route G, wells in the following legal locations (Section-Township-Range) near Hilbre were evaluated: 30-29-08W, 25-29-09W, 26-29-09W, 27-29-09W, 19-29-08W, 24-29-09W (Hilbre), 23-29-09W, and 22-29-09W. A total of 41 wells were located in the database. Two of these are very old, noted as being drilled between 1903 and 1921, and may not be currently serving as water supplies. Municipal use was noted for the Hilbre Community Hall; however the well had a pumping rate of 10 gpm when tested and likely serves the only that building. Six wells were designated for livestock use, and 1 well for both livestock and domestic use. The current status and water use at these locations has not been confirmed. Other water supplies not listed on the GWDRILL database may also be present in the area.

Information on water supplies in the Hilbre area was summarized in the KGS Group (2017) study, within Deliverable D4 (Plates D4-7.1 and D4-7.2 and Plates D4-8.1 and D-4-8.2). Reference drawings within the KGS Group (2017) Deliverable D4 (Plates D4-3.1 and D4-3.2; D4-4.1 and D4- 4.2) detail the areas to the west of Route G. Casing depths are generally shallow (0 to 10 m depth), consistent with the higher elevation bedrock surface in this area.
Well logs show depths to water below ground surface (i.e. non-artesian conditions) at all locations, typical of groundwater recharge areas. Groundwater pressures were above the bedrock surface (i.e. confined conditions) in approximately half the wells examined, and below the bedrock surface (i.e. unconfined conditions) in approximately half the wells. This data is recorded at the time of drilling and may vary seasonally. Many of the wells showing confined conditions, have very thin overburden cover above the carbonate bedrock aquifer.

In the previous study (KGS Group, 2017; Deliverable D6 Plate D6-1), regional groundwater flow from the Route G channel in the vicinity of Hilbre is estimated to be north, northeast and east, ultimately discharging towards Lake St. Martin. No investigations were conducted in this area for any formal evaluation of a Route G option. A Route G option would provide a direct interconnection between the Lake Manitoba/Lake St. Martin surface water and the surrounding bedrock groundwater aquifer, in relatively close proximity to existing well users. Wells under confined and unconfined conditions would have a potential risk of experiencing GUDI (Groundwater under Direct Influence of Surface Water) conditions.

The risk to the individual water supplies will vary with proximity to the channel, though the interconnections and permeability of individual karstic fracture systems within the bedrock aquifer also exert an influence. The population centre in the town of Hilbre is approximately 1.5 to 2 km south of the Route G centreline. Hilbre is also downgradient of an area of potential surface water/groundwater infiltration and flow dispersion, from upstream portions of the Route G channel, along the regional groundwater flow system, ultimately discharging at Lake St. Martin. This, along with the combined pumping influence of the existing area wells or future water supply development, could also alter groundwater flow directions, inducing surface water/groundwater flows from the Route G channel area toward the community.

Similar to the Route C option, groundwater aquifer mitigation measures (and associated mitigation costs) for Route G are estimated to be comparable and would require a regional drinking water supply and distribution system for long term protection of the regional bedrock aquifer.

4.0 HYDRAULIC DESIGN OF ROUTE G

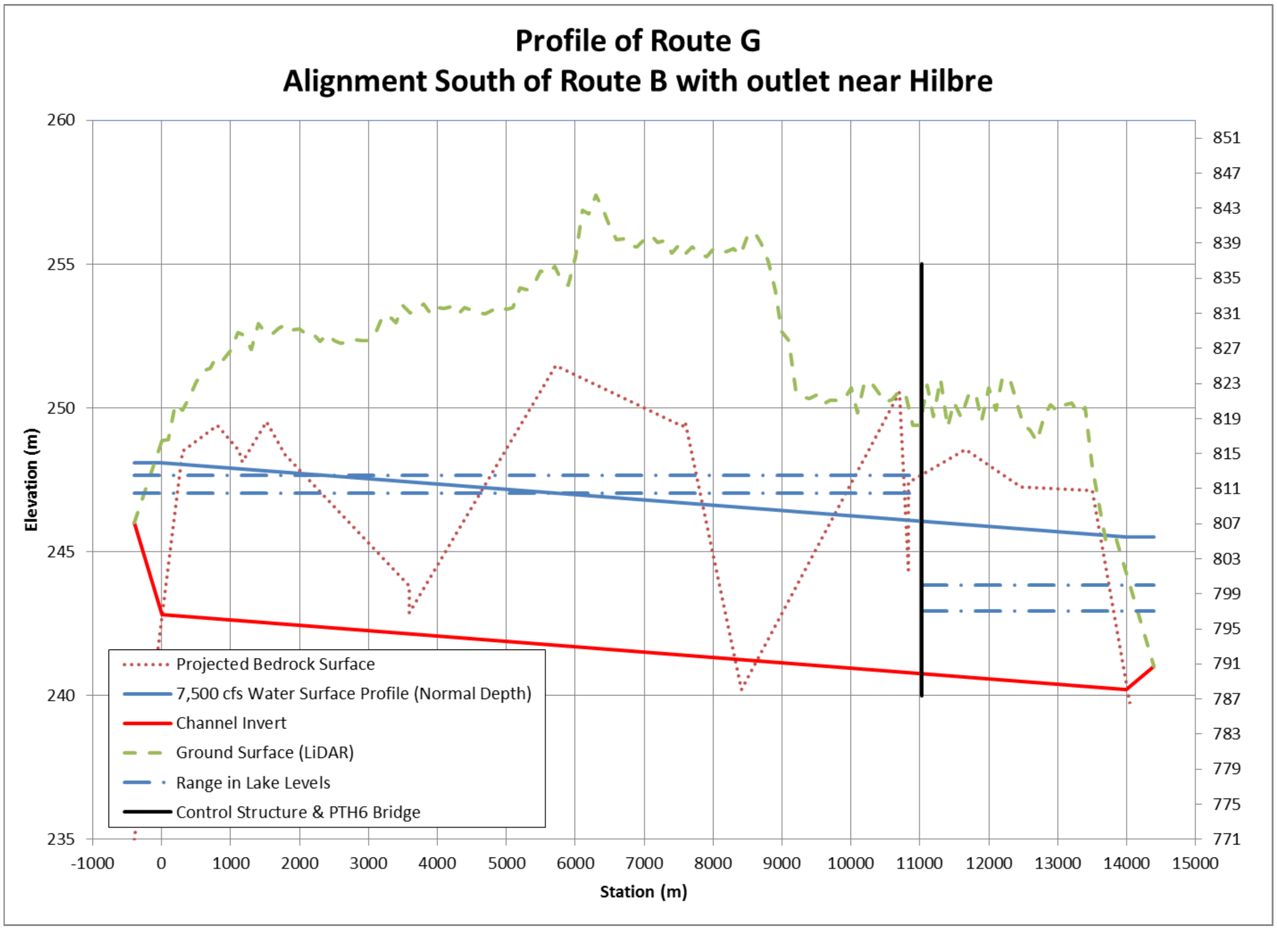
The hydraulic design of the Route G channel was based on Manning's equation to compute the base width using the channel design parameters listed in Table 1, and a design discharge of 212 m^3/s (7,500 cfs). The parameters selected for design are consistent with those that were previously adopted for other Lake Manitoba Outlet Channel concepts identified as part of the Stage 2 conceptual design study (KGS Group, 2016).

TABLE 1
HYDRAULIC DESIGN SUMMARY FOR LAKE MANITOBA OUTLET CHANNEL ROUTE G

Parameter	Rock	Overburden / Till
Design discharge	212 m^3/s (7,500 cfs)	
Lake Manitoba water level	248.1 m (814 ft)	
Channel Invert at Lake Manitoba	242.8 m	
Channel Invert at Lake St. Martin	240.2 m	
Channel Length	14 km	
Channel Longitudinal Slope	0.0186%	
Typical Channel Bottom Width	49 m	16 m
Side slopes	1H:8V	4H:1V
Manning's Roughness, "*n*"	0.032	0.028
Normal Depth of Flow	5.3 m	5.3 m
Average Velocity	0.8 m/s	1.1 m/s

The channel and hydraulic profile at the design flow of 212 m^3/s (7,500 cfs) is shown on Figure 4. As shown on the profile, the water control structure is located at PTH 6. This location allows minimizing the structure size and cost, and is consistent with other outlet channel concepts. When the channel is not in operation, the water level in the channel upstream of the control structure would equal Lake Manitoba levels, while the water level in the channel downstream of the control structure would equal Lake St. Martin levels.

FIGURE 4
PROFILE OF LAKE MANITOBA OUTLET CHANNEL ROUTE G



As shown on Figure 4, the majority of the channel has the invert located in bedrock, with only the inlet, outlet and a very short reach between Station 8+000 and 9+000 located in till. Where the design water surface profile is located in till, but the channel invert remains located in rock, the channel base width was estimated by interpolating between the values shown on Table 1. A 4m bench was also incorporated into the design at the top of the rock cut, or approximately mid-height within the till, for slope stability, similar to the other Lake Manitoba Outlet Channel options identified as part of the Stage 1 and 2 conceptual design studies.

5.0 COST COMPARISON

A cost estimate was developed for Route G based on the same methodology and assumptions developed as part of the Stage 2 Study for Options C and D. Earth and rock excavation quantities were estimated based on the proposed channel cross section defined in the hydraulic design, the ground surface obtained from LiDAR, and the projected rock surface was estimated from nearby borehole data points. The estimated excavation quantities for Route G, compared to the quantities for Options C and D are summarized in Table 2. Excavation quantities for Route G are significantly greater than Route C due to its longer length (approximately 2km longer), and increased depth of cut (approximately 1-2m deeper on average), due to generally higher topography in the vicinity of Route G.

TABLE 2
ROUTE C AND ROUTE G EXCAVATION QUANTITIES (m3)

Excavation	Route G	Route C	Route D
Till / Overburden	5,510,000	3,890,000	10,840,000
Rock	3,770,000	1,940,000	0

At this concept level of analysis, revegetation quantities and land acquisition for Route G were assumed to be the same as those of Route C. It is likely that under a more detailed analysis, these quantities for Route G would be more due to the additional 2 km length of channel. Inlet and outlet costs for Route G were also assumed to be the same as Route C due to the relatively close proximity of the two channel routes. However, based on a preliminary inspection of bathymetric data at the two inlets, the Route G inlet is located in a cove and the lake depth is shallower than at Route C. This could lead to additional excavation quantities at the inlet of Route G; however this has not been included in the estimate at this conceptual stage.

Two bridges would be required for Route G and would likely be of similar size and width as the two bridges proposed for Route C. The costs of the two Route G bridges were therefore assumed to be the same as those of Route C. Similarly the Water Control Structure / Bridge at PTH 6 would be similar in size, and based on the same concepts previously assumed as part of the Stage 2 study. The Water Control Structure / Bridge cost was therefore assumed to be the same as those previously developed for Route C and D. Other project components, including electrical power supply and fish passage were not updated at this stage of design and were assumed to be the same as Route C and D.

An assessment of mitigation cost and residual risk cost was not conducted at this conceptual level of design for Route G. However, based on the qualitative evaluation of aquifer risk described in Section 3.0, it was assumed that Route G would carry similar cost for risk and mitigation as Route C. Table 3 summarizes the estimated cost for Route G, compared to the estimates of Route C and D based on the Risk Assessment (KGS Group, 2017 Deliverable D11). The estimate includes a 20% allowance for engineering, contract administration and approvals.

TABLE 3
ESTIMATED PROJECT COST CONSIDERING RISK

	Route G	Route C	Route D
Base Cost	$207,774,000	$142,755,000	$173,771,000
Mitigation Cost	$11,492,000	$11,492,000	$10,400,000
Engineering, Contract Admin, Approvals (20%)	$41,555,000	$28,551,000	$34,754,200
Residual Risk Cost	$113,649,000	$113,649,000	$50,795,000
TOTAL	$374,470,000	$296,447,000	$269,720,200

In summary, the estimated cost for Route G, including residual risk and mitigation, has been estimated at $374,470,000. In comparison, Route G is estimated to cost approximately $80 million more than Route C, and $100 million more than Route D.

6.0 SUMMARY

KGS Group conducted a review of a potential “Route G” option, brought forward to MI by the public, during affected landowner meetings for the Lake Manitoba Outlet Channel (May, 2017). The evaluation of the route G option, as described herein, is not a preferred route as a replacement for Route D, for the following reasons:

- Like Route C, Route G would be incised into the bedrock aquifer within a groundwater recharge area, presenting a risk to short and long term aquifer water quality, including presenting GUDI concerns to local well users, wells in the Hilbre area, and those on Pinaymootang First Nation.

- Risk mitigation for the aquifer water quality and GUDI issues involves installation of regional groundwater treatment and distribution infrastructure, whether for Route C or for Route G.

- Moving the Route G channel into less populated areas of the region somewhat reduces immediate aquifer risks to the local well users (including at Pinaymootang First Nation), but does not mitigate long-term risks to the same groundwater and well users. In addition, with a change to Route G (from Route C), some of the risk is increased to other well users, namely those in the Hilbre area.

- Only Route D provides the opportunity for construction of a Lake Manitoba outlet channel that is isolated from the bedrock aquifer by the in-situ dense silt tills, and is located in a groundwater discharge area, where upward vertical gradients and flowing artesian conditions from the bedrock aquifer occur.

- Using mapping and data available to date, there is not another potential route in the Route B, C, or G areas which would mitigate the risk to the aquifer system to the extent that is provided by the preferred, Route D option.

- Excavation quantities for Route G are significantly greater than Route C due to its longer length (approximately 2km longer), and increased depth of cut (approximately 1-2m deeper on average, due to higher topography of the ground surface in the region of Route G).

- The cost for Route G has been estimated at $374,470,000 and is approximately $80 million more than Route C, and $100 million more than Route D, including potential residual risk costs.

7.0 REFERENCES

- Betcher, R.N. (1987). Groundwater Availability Map Series. Dauphin Lake (62O). Manitoba Natural Resources, Water Resources.

- Groom, H.D. (2006). Aggregate resources in the Rural Municipality of Grahamdale, Manitoba; Manitoba Industry, Economic Development and Mines, Manitoba Geological Survey, Geoscientific Map, Map 2006-1, scale 1:100 000.

- KGS Group (2017). Investigations and Preliminary Engineering for Lake Manitoba Outlet Channels Options C & D Summary Report, Final Rev. 0, May 18, 2017.
- KGS Group (2016). Assiniboine River & Lake Manitoba Basins Flood Mitigation Study, LMB & LSM Outlet Channels, Conceptual Design – Stage 2, Final Report.

8.0 STATEMENT OF LIMITATIONS AND CONDITIONS

8.1 THIRD PARTY USE OF REPORT

This report has been prepared for Manitoba Infrastructure and any use a third party makes of this report or any reliance on or decisions made based on it, are the responsibility of such third parties. KGS Group accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions undertaken based on this report.

Prepared by:

<Original signed by>

Patrice Leclercq, P. Eng.
Water Resources Engineer

Prepared by:

<Original signed by>

Jason Mann, P.Geo.
Senior Geologist/Hydrogeologist

Approved by:

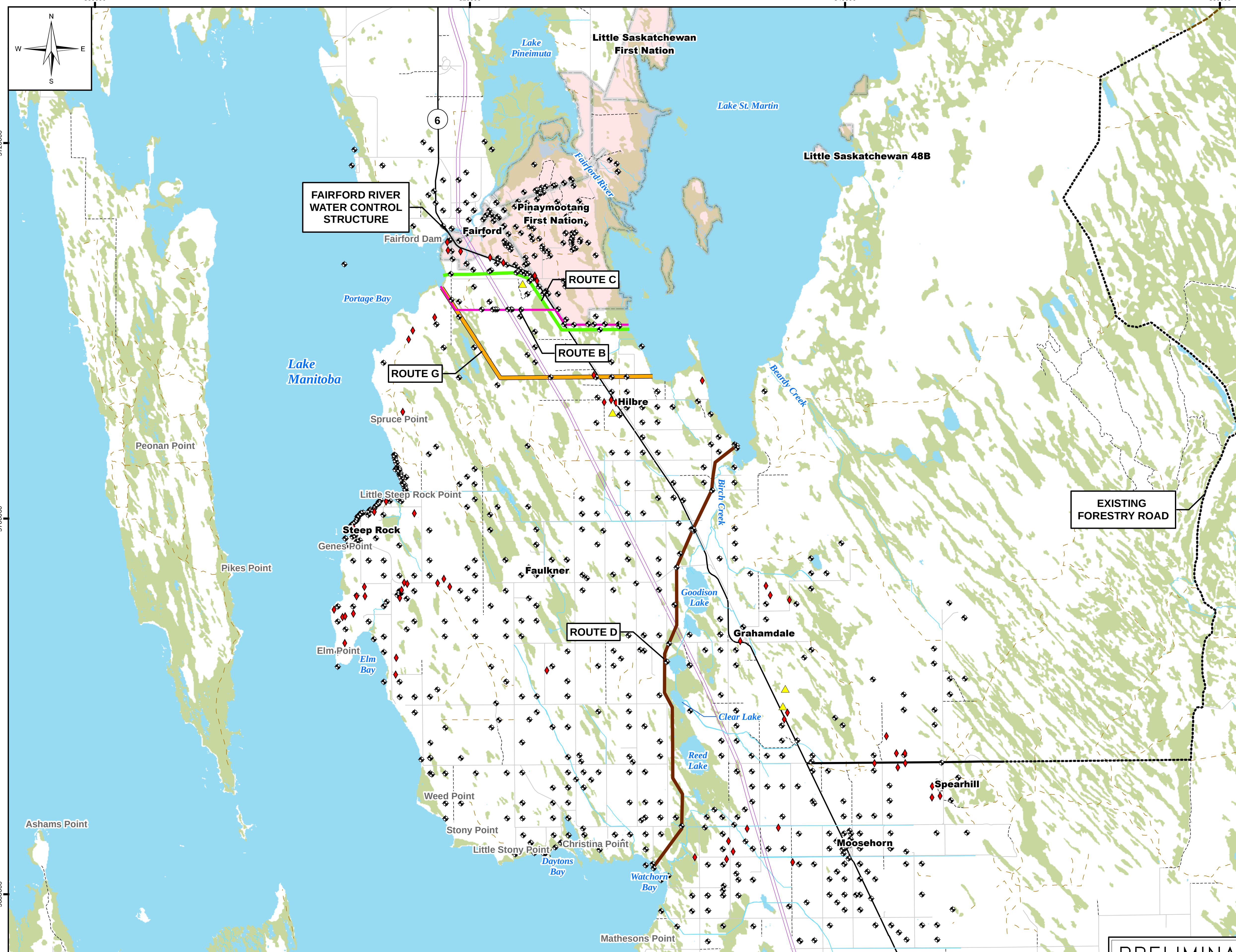
<Original signed by>

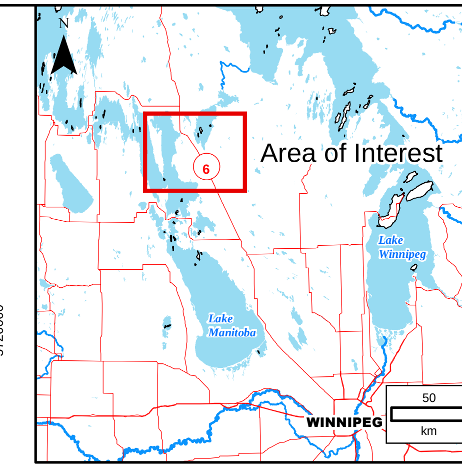
Colin Siepman, P.Eng.
Senior Infrastructure / Project Engineer

PL/JM/ama
Enclosure

Cc: Jared Baldwin, Manitoba Infrastructure
Coenraad Fourie, Manitoba Infrastructure
Bert Smith, KGS Group
Dave MacMillan, KGS Group

FIGURES





LEGEND:

- Borehole (GW Drill 2016; 2011 – 2016 Engineering Investigation)
- Bedrock (Betcher, 1987; Groom, 2006)
- Quarry (Groom, 2006)
- LMB Channel Option B
- LMB Channel Option C
- LMB Channel Option D
- LMB Channel Option G
- Existing Transmission Line
- Forestry Road
- Access Road
- Municipal Road
- Highway
- Limited Use Road
- Trail
- Watercourse
- Wetlands
- Waterbody
- First Nation

NOTES:
1. Individual borehole symbol may represent multiple GW drill database records.
2. All units are metric and in metres unless otherwise specified. Transverse Mercator Projection, NAD 1983, Zone 14. Elevations are in metres above sea level (MSL).

2 0 2 4 6 8
Kilometres
SCALE: 1:200,000 METRIC 11"x17"

NO.	YY/MM/DD	DESCRIPTION	ISSUED BY	CHECK BY
0	17/09/08	ISSUED WITH LETTER REPORT	JDM	CS

REVISIONS / ISSUE

KGS GROUP CONSULTING ENGINEERS

Manitoba Infrastructure

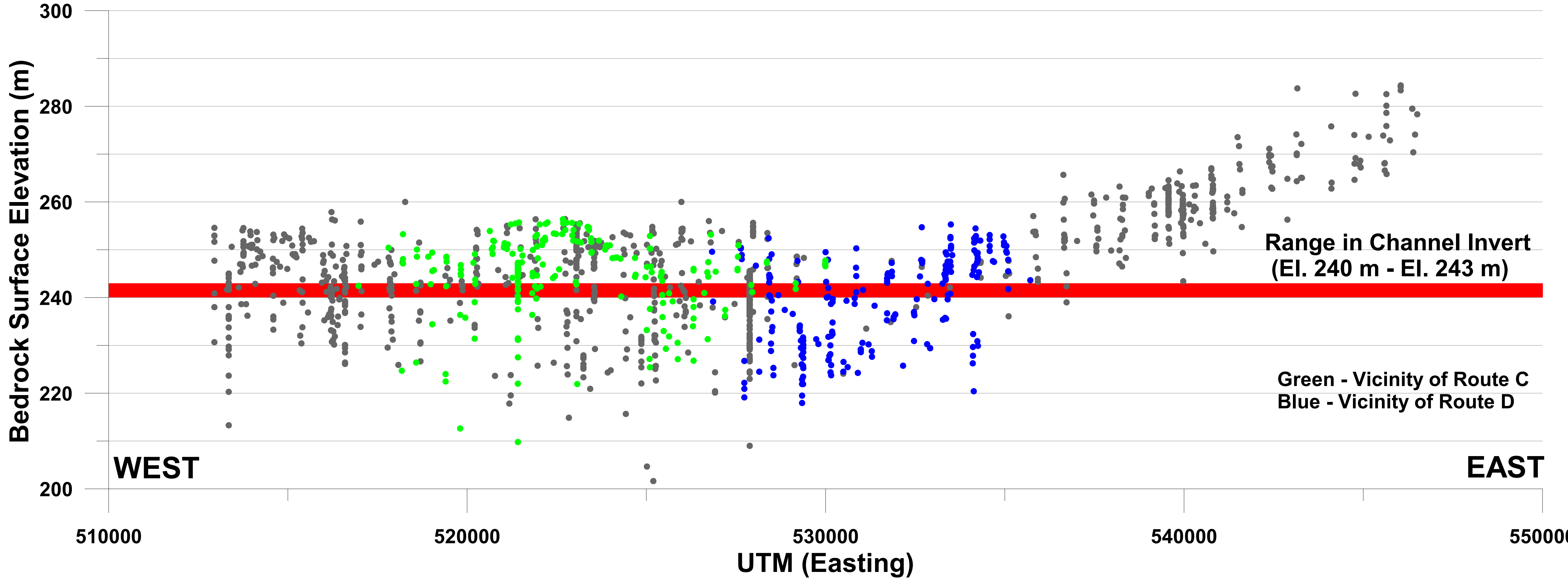
INVESTIGATIONS & PRELIMINARY ENGINEERING FOR LMB OUTLET CHANNELS OPTIONS C&D

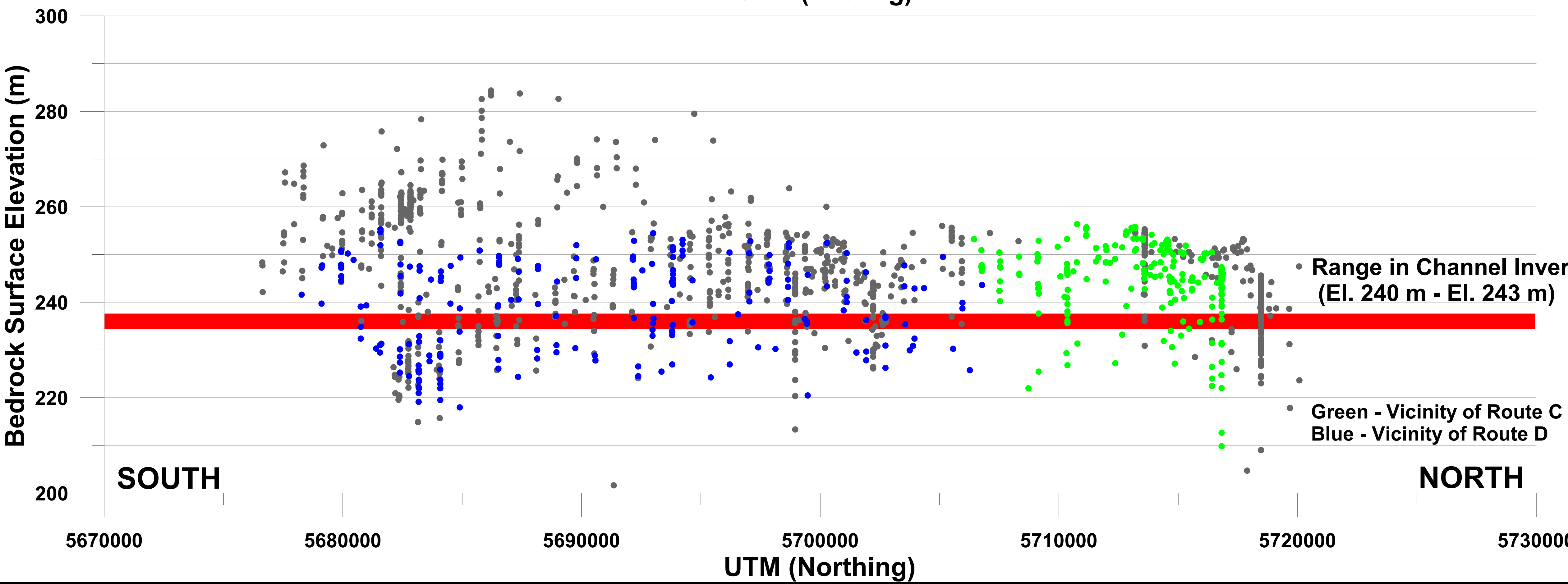
GENERAL SITE PLAN
ROUTES B, C, D AND G

PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION

SEPTEMBER 2017 | FIGURE 1 | REV: 0

FileName: P:\Projects\2016\16-0300-006\Dwg\GIS\MXD\Rev0\RouteG\16-0300-006_Fig1_Rev0.mxd
11"x17" PLOT SCALE 1:1





NO.	YY/MM/DD	DESCRIPTION	DESIGN BY	DESIGN CHECK
A	17/09/08	ISSUED WITH LETTER REPORT	JDM	CS

REVISIONS / ISSUE

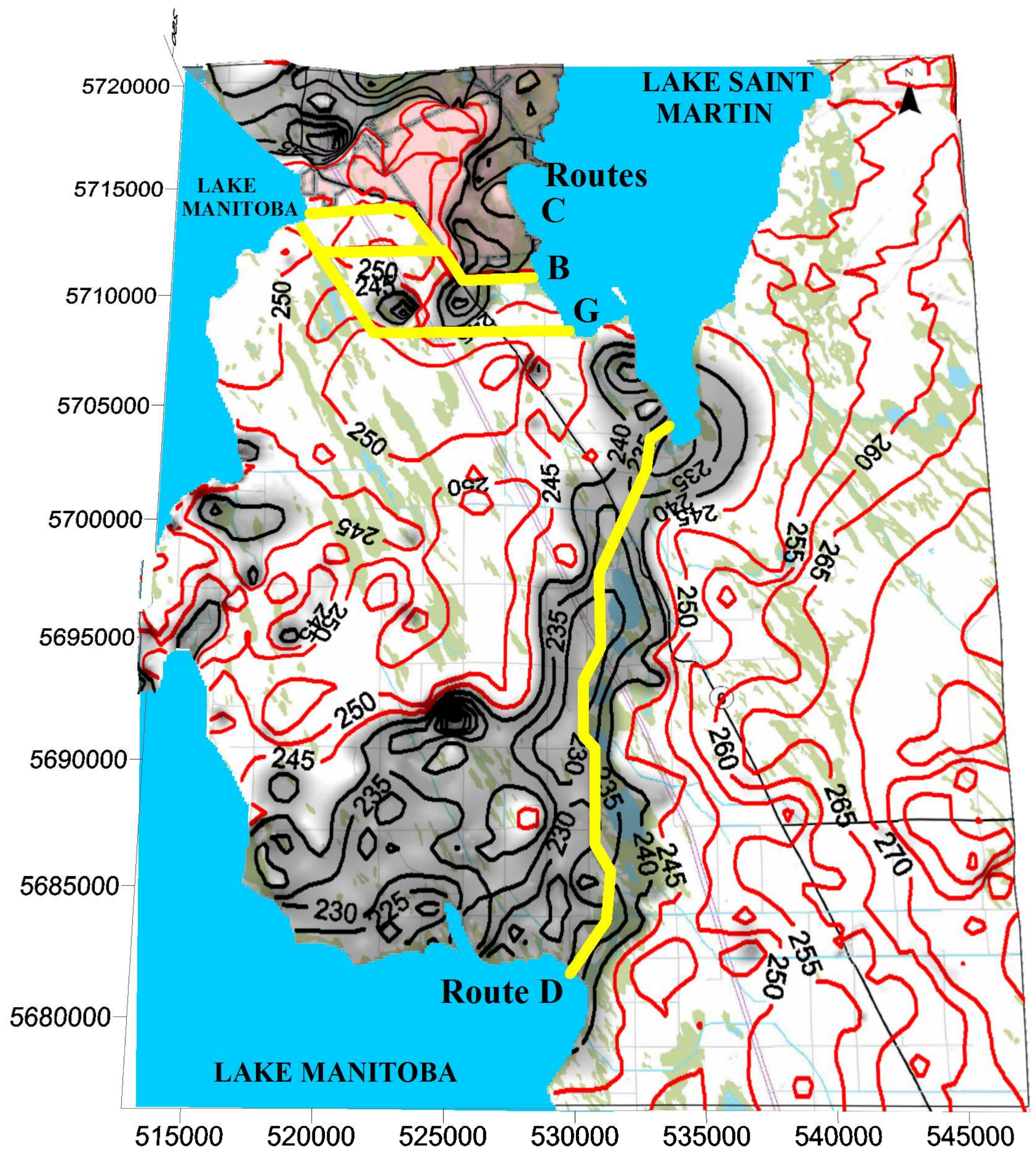
KGS GROUP CONSULTING ENGINEERS

Manitoba Infrastructure

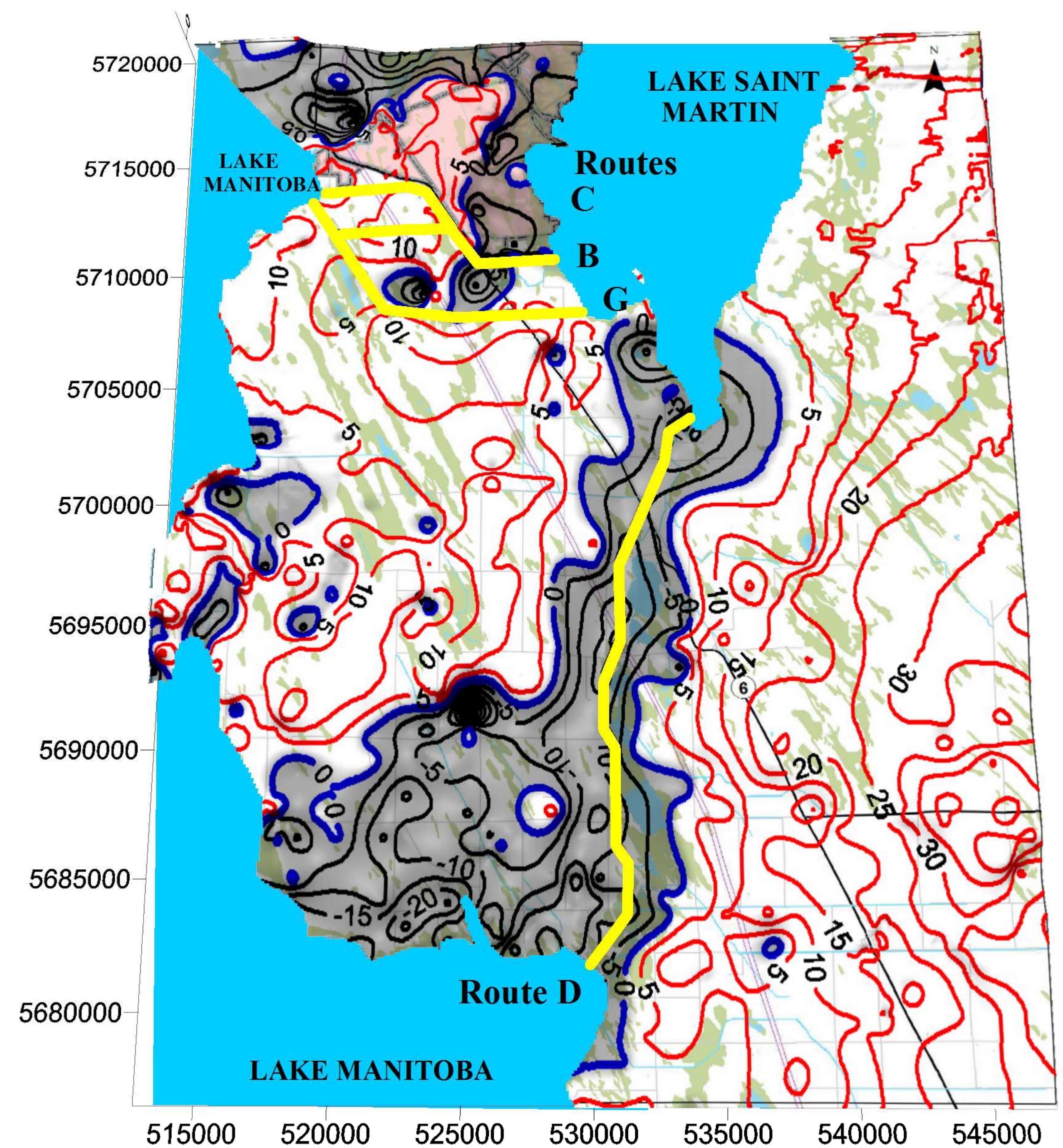
INVESTIGATIONS & PRELIMINARY ENGINEERING FOR LMB OUTLET CHANNELS OPTIONS C & D

SCATTERPLOT OF REGIONAL BEDROCK SURFACE ELEVATION DATA

SEPT 2017 | FIGURE 2 | REV: 0



A: BEDROCK SURFACE ELEVATION (m)



B: DEPTH OF CHANNEL CUT WITHIN BEDROCK (m)

Notes for Figures A and B:

1. All contours in meters.
2. Surfaces shown with 50x vertical exaggeration.
3. Areas in grey = bedrock below channel invert
4. Red contours indicate bedrock above channel invert

Notes:

1. Assumes El. 242 m channel invert.

NO.	YY/MM/DD	DESCRIPTION	DESIGN BY	DESIGN CHECK
A	17/09/08	ISSUED WITH LETTER REPORT	JDM	CS

REVISIONS / ISSUE

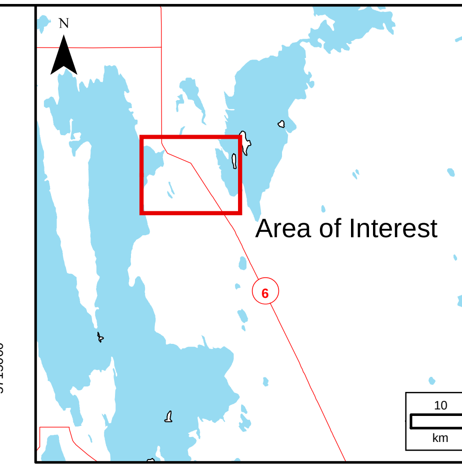
KGS GROUP CONSULTING ENGINEERS

Manitoba Infrastructure

INVESTIGATIONS & PRELIMINARY ENGINEERING FOR LMB OUTLET CHANNELS OPTIONS C & D

REGIONAL BEDROCK TOPOGRAPHY AND ESTIMATED BEDROCK EXCAVATION DEPTHS

SEPT 2017 | FIGURE 3 | REV: 0



LEGEND:

- Rock Data Points / Well Locations
- Channel Option B
- Existing Transmission Line
- Municipal Road
- Highway
- Limited Use Road
- Trail
- Watercourse
- Waterbody
- First Nation

NOTES:

1. Topographic data was derived from the Lake St. Martin 2011 LiDAR obtained from Manitoba Land Initiative (MLI).
2. All units are metric and in metres unless otherwise specified. Transverse Mercator Projection, NAD 1983, Zone 14. Elevations are in metres above sea level (MSL).

0.5 0 0.5 1 1.5 2

Kilometres

SCALE: 1:50,000 METRIC 11"x17"

NO.	YY/MM/DD	DESCRIPTION	ISSUED BY	CHECK BY
0	17/09/08	ISSUED WITH LETTER REPORT	PAL	CMS

REVISIONS / ISSUE

KGS GROUP CONSULTING ENGINEERS

Manitoba Infrastructure

INVESTIGATIONS & PRELIMINARY ENGINEERING FOR LMB OUTLET CHANNELS OPTIONS C&D

GENERAL SITE PLAN
ROUTE G

SEPTEMBER 2017 | FIGURE 4 | REV: 0

PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION

FileName: P:\Projects\2016\16-0300-006\Dwg\GIS\MXD\Rev0\RouteG\16-0300-006_Fig4_Rev0.mxd
11"x17" PLOT SCALE 1:1