Manitoba Floodway Authority

Red River Floodway Expansion Project
2013 Post-Construction Monitoring Program Activity Report
Memo Reference: .9999-92.06 HM98

FINAL – Rev 0

File No. 05-1100-01.19.12.06
March 2014

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March 31, 2014 File No: 05-1100-01.19.12.06

Manitoba Floodway Authority
200 – 155 Carlton Street
Winnipeg, Manitoba
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ATTENTION: Ms. Leanne Shewchuk
Manager Special Projects and Environmental Services

RE: Red River Floodway Expansion Project
2013 Post Construction Monitoring Program Activity Report
Memo Reference: .9999-92.06 HM98
Final Report – March 2014

Dear Ms. Shewchuk:

Please find enclosed twenty (20) copies of the Final 2013 Post-Construction Monitoring Program Activity Report. The report satisfies requirements for annual monitoring in Environmental Licence 2691 for the 2013 period, and was conducted according to the Post Construction and Long Term Monitoring Plan HM72 Rev 1 issued April 2013.

We appreciate the opportunity to provide ongoing services to the Manitoba Floodway Authority.

Sincerely,

J. Bert Smith, P.Eng.
Channel Design Manager

JBS/MFH/mlb
Enclosure

cc: Dave MacMillan – KGS Group
Marci Friedman Hamm – KGS Group

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LIST OF FIGURES

1.0 INTRODUCTION AND AQUIFER CHARACTERIZATION

This 2013 Groundwater Monitoring Activity report is submitted in response to the requirements for annual monitoring in accordance with Clause 27 and Clause 30 of Environmental Licence No. 2691 dated July 8, 2005 and described in memorandum HM72 Rev 1 Post-Construction and Long-Term Monitoring Program issued April 2013. Groundwater activities for 2005 and 2006 were summarized in the 2006 Groundwater Monitoring Activity Report issued March 2007, which should be used as a reference to this report. Activities for 2007 to 2011 are summarized in the annual 2007 to 2011 Groundwater Monitoring Activity Reports, respectively, issued in March or April after the respective year ends. There was no monitoring program in 2012.

The groundwater monitoring results in 2013 represent post-construction monitoring. The only construction activities carried out in 2013 were the Inlet Structure Modifications, which did not have potential to affect groundwater.

During the 2013 spring flood event, the Red River water began naturally flowing into the Floodway Channel on April 29, 2013. The Floodway gates were in operation for 41 days from April 29 to June 8, 2013. The Red River crested on May 4, 2013 at the Floodway Inlet with a peak flow of 444 m^3/s diverted into the Floodway Channel, and a total combined flow of approximately 1500 m^3/s. The spring 2013 flood was similar in size to the spring 2005 flood diverted into the channel (433 m^3/s), with a duration slightly less than the 2011 flood (41 vs. 47 days).

The objective of the Post-Construction monitoring program is to verify the effects predicted in the Project Environmental Impact Assessment and confirm the findings of the groundwater monitoring program during construction, relative to long-term analysis of the groundwater regime.

The requirements for Post-Construction Monitoring Program A were initially anticipated for 2013 based on flood forecasts in March 2013. Program A is used with spring floodway operation with flows less than, or equal to the largest flood monitored to that date and a duration of 8 weeks or less. As of 2012, the largest flood monitored was the 2009 flood (1220 m^3/s) diverted to the channel. Program B pre-melt monitoring was initiated in late April 2013, when Provincial flood forecasts predicted peak flows greater than the largest flood monitored to this date (2009 flood). The flood forecast was subsequently downgraded prior to floodway operation, and the Program B pre-melt monitoring was discontinued. The remainder of the program was conducted in accordance with Program A.

Two events were monitored in 2013:

- March 2013 – pre-spring run-off (no Floodway Operation) (selected monitoring wells).
- April to June 2013 – Floodway Operation (monitoring wells and surface water monitoring).

The carbonate aquifer found along the Floodway Channel is part of a regional flow system from eastern Manitoba. The confined carbonate bedrock aquifer has natural variations in water quality, with the conductivity ranging from moderate to high (1,000 to 2,000 µS/cm). Near the Floodway Inlet, local mixing with saline groundwater found west of the Red River results in higher conductivity groundwater (greater than 3,000 µS/cm) with increased chloride and sodium. Conductivity is a measure of dissolved solids, such as calcium, magnesium, chloride, sodium and sulphate.

Lower conductivity values are found in the bedrock aquifer where it is influenced by the Birds Hill surficial granular aquifer, from CPR Keewatin Bridge to Church Road. The Birds Hill sand and gravel surficial aquifer is a local unconfined aquifer near PTH 59N Bridge. The bedrock aquifer beneath and surrounding the Birds Hill deposit has lower groundwater conductivity due to the freshwater recharge through the sand and gravel.

Natural variations in groundwater quality by location and with the seasons must be considered when the baseline and ongoing water quality results are evaluated during construction activities and Floodway Operation events. One way to detect whether there is surface water intrusion is to monitor an indicator parameter such as conductivity. In the vicinity of the Bird's Hill sand and gravel surficial aquifer, recharge from precipitation results in groundwater with lower conductivity (500 µS/cm to 1,000 µS/cm) than is found in other areas of the carbonate aquifer.

The intrusion of any surface water into the groundwater is most readily detected when there is a contrast between the chemistry of the samples. Conductivity (along with other parameters) can be used to evaluate this contrast. Most groundwater conductivity values were found to be greater than surface water conductivity values measured during annual spring Floodway Operation. Red River conductivity values are historically lowest during spring flood events, such as in the spring of 2005, 2006, 2007, 2009, 2010 and 2011. In this situation, groundwater conductivity would be expected to decrease, if surface water intruded. During summer Floodway Operation in 2005, summer Floodway use in 2007, and summer Floodway Operation in 2010 and 2011 conductivity values of water from the Red River diverted in the Floodway were slightly higher than in the spring, and higher than the natural groundwater in some areas near the CPR Keewatin Bridge, PTH 59N Bridge and Church Road. These areas have naturally low conductivity. Floodway Channel surface water conductivity was also higher during the summer precipitation events in June 2008 than during the spring melt with no Floodway Operation in April 2008. An increase in groundwater conductivity might occur in summer if surface water intrudes into the groundwater at this time.

In the spring 2013 flood, weekly sampling in the Floodway Channel during the 6-week Floodway Operation showed that the conductivity of the surface water increased, with the lowest conductivity found at the beginning of the monitoring. Interpreting changes in groundwater water quality required consideration of the pre-flood conductivity and the changing chemistry of the potential surface water infiltration source.

2.0 POST-CONSTRUCTION MONITORING

Groundwater monitoring in 2010 was considered the first year of the 5-year post-construction monitoring since most channel excavation had been completed. Groundwater depressurization activities in 2010 were completed prior to the spring flood. The 2013 program represents the fourth year of the 5-year post-construction period. No further monitoring is required for construction effects, as all channel excavation and groundwater depressurization activities are complete. Post-construction monitoring will continue in 2014, with long-term monitoring to follow focusing on key flood events in future years.

In 2013 surface water monitoring of the Floodway Channel during Floodway Operation was carried out at locations near the PTH 44 Bridge and PTH 59N Bridge.

The 2013 post-construction monitoring program used wells designated in the monitoring program for Program A with limited sampling of some Program B wells as shown on Figure HM98-1. In the spring 2013 Floodway Operation, additional samples were collected within the Floodway Channel Right-of-Way from 14 bedrock monitoring wells, and one domestic well at the Floodway Inlet structure. Monitoring wells are not used for water supply. Samples for bacteria analysis were taken in five of these monitoring wells in 2013. A monitoring well disinfection program was conducted in late winter 2013, prior to sampling in these wells.

3.0 SURFACE WATER RESULTS AND ASSESSMENT

The cold temperature of the Red River at the beginning of the spring melt is generally useful as an indicator of surface water infiltration when the river temperature is a few degrees above freezing and the groundwater temperature is higher. During the 2013 spring flood; however, temperature was of limited use because the river had already risen to 3 to 4°C four days after the Floodway Operation started on April 29, 2013. Temperatures continued to increase to 9°C by May 8, 2013, overlapping with the typical range of groundwater temperatures. Temperature became more useful during the peak and later portions of the flood when surface water was at 19 to 20°C, higher than the groundwater temperatures. A similar pattern was found previously in 2011.

Total Coliform and *E. coli* are present in the surface water. In the 2013 spring flood, Total Coliform bacteria in surface water were present in the 100 to 570 MPN/100 mL range during most of the flood. Values of *E. coli* ranged from <6 to 260 MPN/100 mL, with the higher values recorded in the 2 weeks after the flood peak.

The maximum concentration of nitrate plus nitrite as nitrogen (N) measured was approximately 0.8 mg/L near the beginning of the flood on May 1, 2013. Nitrate plus nitrite (as N) decreased for each successive week of the flood, reaching 0.24 mg/L on June 5, 2013. The maximum concentration measured in the river water was below the CCME criteria for nitrate plus nitrite (as N) in drinking water (10 mg/L); however, background groundwater concentrations are generally below 0.1 mg/L in many areas of the Floodway. Ammonia, phosphorous and total suspended solids also followed a decreasing trend as the flood progressed.

Surface water conductivity increased during the flood, from 382 µS/cm on May 1, 2013 to 698 µS/cm on June 5, 2013, reflecting the increase in dissolved solids. There was a generally stable water type with a minor change due to an increase in sulphate concentration. Conductivity and major ions increased as nitrate plus nitrite (as N) and bacteria decreased during the Floodway Operation period.

4.0 GROUNDWATER RESULTS

4.1 FLOODWAY OUTLET AND PTH 44 BRIDGE

At the Floodway Outlet, monitoring wells located 65 m, 160 m and 350 m north of the expanded channel within the Right-of-Way, showed evidence of surface water intrusion in 2013. Changes in conductivity at the Outlet wells corresponded to changes in major ion concentrations in 2013, consistent with previous years. Changes in bacteria (Total Coliform) at the closest monitoring well correlated with inorganic groundwater quality changes in that well. These changes included a decrease in nitrate plus nitrite (as N) concentrations from locally elevated background values. This well closest to the Floodway, has the strongest evidence for surface water infiltration, with the intermediate distance well also having similar evidence.

The monitoring well on Rockhaven Road installed in 2013 shows slight evidence of surface water intrusion including decreases in conductivity and major ions, decreases in nitrates from locally elevated background values, and bacteria detection during the flood peak in 2013. These changes may be influenced by the floodway with contributions from other sources including recharge to the aquifer, septic influences and the Red River.

Surface water infiltration from the Floodway is likely on the west side of the PTH 44 Bridge, based on the inorganic water quality decreases in a monitoring well located inside the floodway Right-of-Way during the 2013 flood. The water quality change is similar to the changes during the 2011 flood, although the parameters experiencing change differ.

4.2 HAY ROAD TO DUNNING ROAD

Water quality changes were not seen at Hay Road in 2013. There was a small shift in parameters seen at Church Road in spring 2013 that did not correlate with any increase in nitrate plus nitrite (as N) or increase in dissolved oxygen. Water quality was stable at Ludwick Road, Dunning Road and Bray Road during and after the flood.

4.3 OASIS ROAD

Bedrock monitoring at Oasis Road (southeast of the cut-off wall and close to the channel) showed no evidence of surface water intrusion during the 2013 monitoring based on stable conductivity values measured with a transducer that are consistent with previous years.

4.4 PTH 59N BRIDGE AREA

Short-term infiltration of Floodway surface water into the bedrock aquifer was documented in 2013 at the PTH 59N Bridge (west side) within the Floodway Right-of-Way. This occurred at a bedrock well located 60 m west of the west channel slope, and a bedrock well 250 m west of the expanded channel at the west Right-of-Way boundary. These responses were consistent with monitoring in previous years (such as the 2011 flood) and included changes in conductivity, increasing nitrate plus nitrite as (N) and the presence of *E. coli*. Any size or duration operation is likely to cause a short-term response at this location due to the potential for surface water to infiltrate through the sand and gravel in the channel, to the bedrock.

Groundwater quality changes occurred concurrently with water level changes at this location with little time lag. The groundwater quality returned to a typical pre-melt groundwater composition by the time the spring run-off flow in the Floodway Channel had discharged from the channel, and flow was back to the Low Flow Channel (LFC) water level.

The response in this area may represent an initial local recharge through the sand and gravel overburden, followed by infiltration of Floodway surface water.

At a monitoring well installed in 2013 at McGregor Farm Road, the conductivity and major ion results did not correlate well with stable dissolved oxygen and nitrate plus nitrite (as N) values, which may indicate that sources other than the Floodway may be contributing to changes at this well. Since this was the first year of monitoring at this well the changes cannot be compared to previous years.

4.5 KEEWATIN BRIDGE AND AREA TO THE SOUTH

There was no evidence of surface water infiltration within the Floodway Right-of-Way at the west bridge abutment at the CPR Keewatin Bridge in 2013.

At the Floodway inlet, the water quality change seen in 2013 appears to be due to surface water infiltration, but was less pronounced in 2013 in comparison to previous years. The lack of change in nitrate plus nitrite (as N) suggests movement of fresher groundwater into the well due to the movement of the saline groundwater boundary to the west during the flood.

5.0 GROUNDWATER RESULTS AND ASSESSMENT

5.1 CONDUCTIVITY CHANGES

Conductivity changes are being used as an indicator of surface water influence on groundwater quality, as conductivity is a parameter that is readily measured. Conductivity changes reflect the changes in major ions contributing to the dissolved solids.

If surface water intrudes into the aquifer, the mixing would result in changes observed in groundwater conductivity. Conductivity decreases with the addition of surface waters in most areas. Changes are most readily observed in areas where groundwater is more mineralized and thus has higher conductivity than surface water, which is typically the case during the spring. Conversely, increases in groundwater conductivity would be seen in areas where baseline groundwater conductivity is less than that of surface waters.

In addition to the Floodway, potential surface water infiltration sources in the area include ponds and open sand and gravel quarries, creeks, and the Red River (primarily near the Floodway Outlet).

The magnitude of the water quality change is described by a range in the percentage change in conductivity as follows: Type A (>50% change); Type B (25 to 50% change); Type C (10 to 25% change); Type D (5 to 10% change).

In 2013, 14 monitoring wells and one domestic well (Inlet Control) were sampled for water chemistry. Five of these wells were sampled for bacteria. During spring monitoring in 2013, no obvious change in groundwater quality was seen in 40% (6) of the 15 wells sampled.

Changes found in the other wells were classified as follows:

- Type D (5 to 10% change) for 1 well (6% of the total) located inside of the Right-of-Way at Church Road.
- Type C (10 to 25% change) for 4 wells (27% of the total) located inside of the Right-of-Way at McGregor Farm Road, the Inlet, the PTH 59N Bridge and the Outlet.

- Type B (25 to 50% change) for 4 wells (27%) which were located inside of the Right-of-Way at the PTH 44 Bridge, the Outlet and the PTH 59N Bridge.

The wells selected for the sampling in 2013 programs were in areas with higher potential for surface water intrusion due to hydrogeologic conditions, or locations near other surface water sources (such as the Floodway outlet). In 2013, well sampling occurred north of TCH-1, except for the Floodway Inlet. All of the monitoring wells with water quality changes are located within the Floodway Right-of -Way from north of PTH15 to the Floodway Outlet, except at the Floodway Inlet.

5.2 BACTERIA

Total coliform bacteria were detected in four of the five wells sampled for bacteria at the peak of the flood. The fifth well had total coliform bacteria before, during and after the flood. *E. coli* was detected in three of the five wells at the peak of the flood.

5.3 NITRATE PLUS NITRITE AS (NITROGEN)

Nitrate plus nitrite (as N) concentrations were below the Canadian Drinking Water Quality Guidelines (CDWQG) of 10 mg/L. Seven of the 14 samples, (50%) were below detection (<0.0005 to <0.07 mg/L) both pre-melt and during the flood. Two samples showed increases in nitrate plus nitrite (as N), where surface water concentrations were greater than groundwater concentrations. Three samples showed decreases in nitrate plus nitrite (as N), where surface water concentrations were less than groundwater.

5.4 RELATIONSHIP BETWEEN PARAMETERS

Four of five monitoring wells (80%) sampled for bacteria showed changes in both conductivity and Total Coliform at the peak of the flood. These wells were located inside of the Right-of-Way at PTH 59N Bridge at the west Right-of-Way and inside of the Right-of-Way at two wells at the Floodway Outlet.

Three of five (60%) monitoring wells sampled for bacteria also had changes in *E. coli* as well as conductivity and total coliform. These wells were located inside of the Right-of-Way at the

PTH 59N Bridge west Right-of-Way and channel. Bacteria were sampled in areas where changes were expected and locations do not represent a random sample.

Changes in nitrate plus nitrite (as N) correlated with changes in water quality at 33% (5) of 15 wells sampled. Since the maximum nitrate plus nitrite (as N) values in surface water were 0.9 mg/L in 2013, any higher values would be unrelated to Floodway Operation.

Changes in nitrate plus nitrite (as N) correlate with changes in water quality at PTH 59N Bridge west side (2 wells increasing concentration), PTH44 Bridge (decreasing concentration) and the Floodway Outlet (2 wells decreasing concentration). Nitrate plus nitrite (as N) values changed in 5 of the 9 wells where decreases in conductivity (greater than 5%) occurred in spring 2013. The increases in nitrate plus nitrite (as N) were less than 1 mg/L with total nitrate plus nitrite (as N) of 2.0 mg/L or less. Nitrate plus nitrite (as N) concentrations in these wells were below the Canadian Drinking Water Quality Guideline of 10 mg/L nitrate plus nitrite (as N).

Many of the monitoring wells are located on the shoulder of the Floodway Channel, or in the spoil pile, and would be expected to experience any water quality changes more quickly than domestic wells located further away, beyond the Floodway Right-of Way. Domestic wells (with the exception of the Floodway Inlet well) are not monitored in the Post-Construction program. Travel times from the floodway surface water to the monitoring wells vary depending on Floodway Channel water elevations, piezometric water elevations and the hydraulic conductivity of the bedrock, which ranges from highly fractured to massive. In general; however, groundwater gradients will be greater and their travel times will be shorter closer to the Floodway. Gradients will decrease and travel times will lengthen further from the Floodway.

In cases where conductivity changes appeared to be correlated to Floodway use in the spring, the maximum change correlated with conditions of peak flow and surface water elevation during the Floodway Operation period. Water quality started returning to typical pre-spring melt groundwater concentrations as soon as the peak flow started to drop. Water quality returned to pre-melt conditions soon after Floodway Operation ended.

5.5 SUMMARY ASSESSMENT OF CHANGES

The 2013 flood represented a moderate flood with moderate duration. Groundwater quality changes in 2013 were similar to previous years with moderate to large floods. All wells which showed groundwater quality changes in 2013 also showed changes in previous floods. Inorganic groundwater quality changes seen in monitoring wells in 2013 did not exceed the Canadian Water Quality Guidelines for Drinking Water.

Total coliform bacteria were present in four monitoring wells during the peak of the flood, in areas with documented groundwater/surface water connections, with concentrations decreasing to zero during the later flood stages and after Floodway operation. *E. coli* was found in three of these monitoring wells on one date during the peak of the flood, decreasing to zero in the next sample taken approximately 2 weeks later.

Very little evidence of adverse effects on groundwater was found even in the sensitive areas that were identified as zones of potential surface water infiltration. The 2013 results showed that these areas were at no greater risk of surface water infiltration than in previous years, therefore no special reporting was required to Manitoba Water Stewardship during or soon after the flood.

6.0 SPRING TREATMENT AREAS

The Spring Treatment Program has mitigated surface water infiltration in the bedrock aquifer by providing sand filtration of any fines migration, by decreasing the amount of flow into the springs at the filter locations for a given flood, by reducing the potential for expansion of spring areas through piping, and by improving the bacterial quality of any infiltrating water. The constructed fine sand filters have a much lower hydraulic conductivity than an open fracture; therefore, the initial flow rate is decreased. As the low permeability silt fraction builds up above the sand filter layer, the infiltration rate is reduced further. The fine sand also meets criteria for slow sand filters designed to reduce bacteria passage through the filter. After the flood, when the flow direction reverses to groundwater discharge, the sand filter protects against upward piping of the foundation material (silt, sand) which otherwise could have increased the size of a fracture/hole.

Sealing the groundwater discharge areas completely is not desirable, as a pressure build-up and uncontrolled discharge in another area would likely develop. The treatments provide pressure relief, but in a controlled fashion and with a flow rate lower than was present before treatment.

Previous sampling in 2009 through 2011 showed that Total Coliform and *E. Coli* bacteria are generally present and at higher levels above the filter. The filter has been effectively reducing Total Coliform concentrations. *E. coli* has not been detected beneath the filter. Soon after the Floodway drains, surface water infiltration is flushed out quickly from the system as shown by a return to groundwater quality and an absence of bacteria. A return to groundwater quality (as shown by conductivity) was seen towards the end of the flood period as shown by the transducer data in 2009 and 2011.

In 2013 one spring was monitored with a transducer. The results from 2013 were similar to 2011 and 2009 showing that Floodway surface water temporarily can reverse the gradient and flow direction from the channel to the bedrock beneath the spring with a return to groundwater quality as the Floodway begins to drain.

A summer inspection of 23 locations treated with reverse sand filters was conducted in 2013 Sketches, photographs and video collected document baseline conditions in the Post-Construction period and can be used in the future to assess if there are changes in conditions.

7.0 GROUNDWATER ACTION RESPONSE PLAN AND POST-CONSTRUCTION AND LONG-TERM MONITORING

The Groundwater Action Response Plan has been continued through the Post-Construction period. No complaints were received in 2013.

Post construction monitoring is planned for 2014 followed by an evaluation that will recommend the scope for a long-term monitoring to begin in 2015.

8.0 STATEMENT OF LIMITATIONS AND CONDITIONS

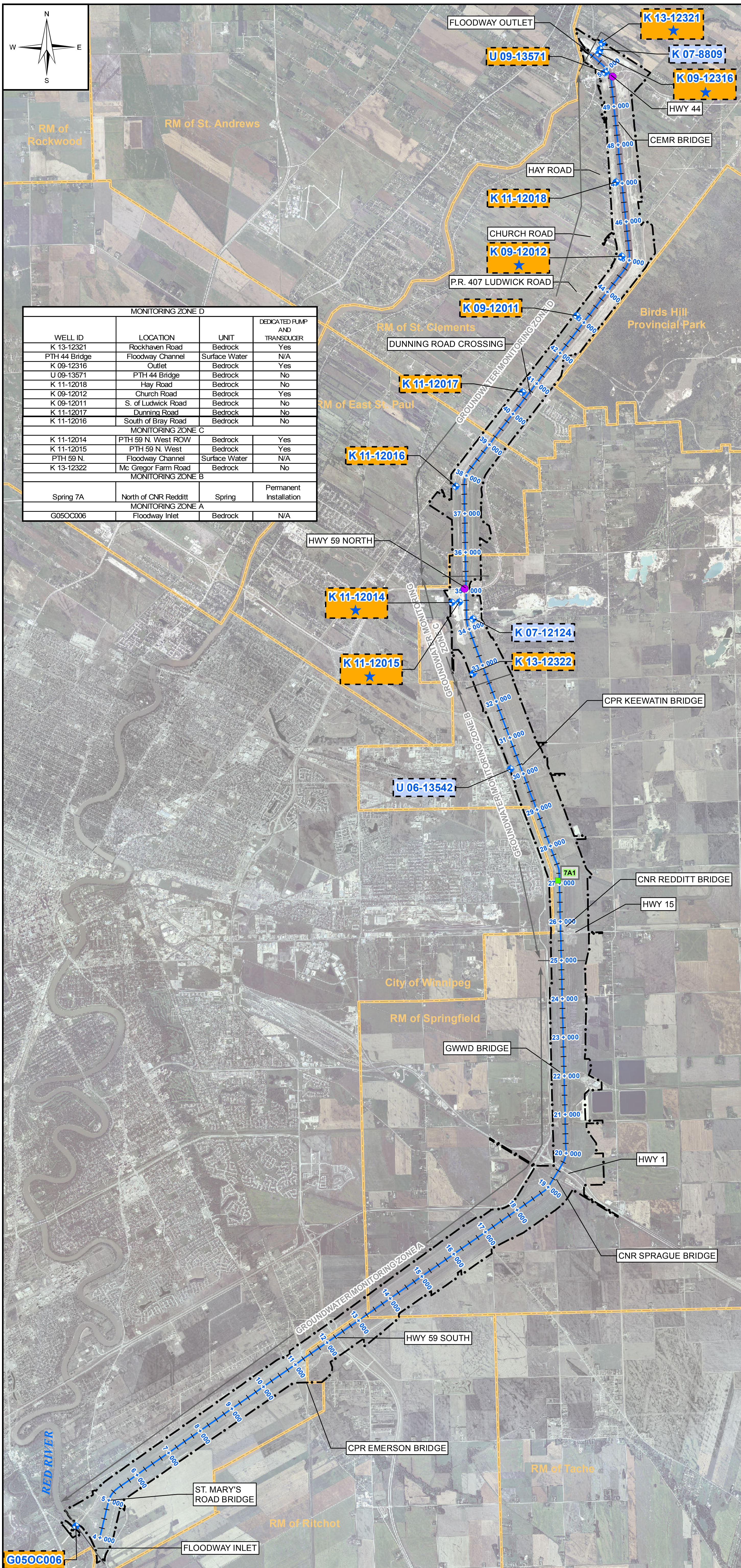
8.1 THIRD PARTY USE OF REPORT

This report has been prepared for the Manitoba Floodway Authority to whom this report has been addressed 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.

8.2 GEO-ENVIRONMENTAL STATEMENT OF LIMITATIONS

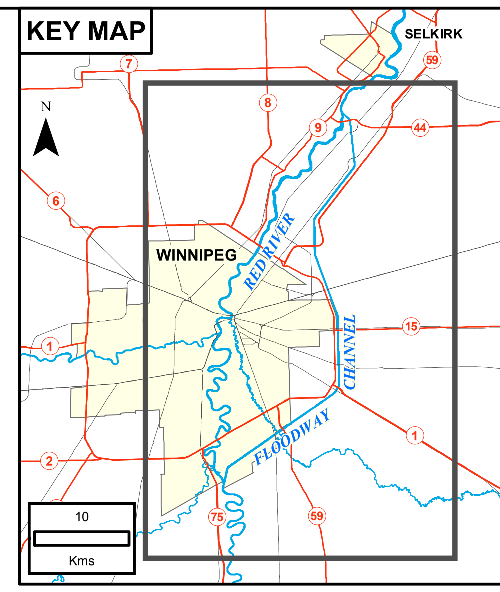
KGS Group prepared the geo-environmental conclusions and recommendations for this report in a professional manner using the degree of skill and care exercised for similar projects under similar conditions by reputable and competent environmental consultants. The information contained in this report is based on the information that was made available to KGS Group during the investigation and upon the services described, which were performed within the time and budgetary requirements of the Manitoba Floodway Authority. As the report is based on the available information, some of its conclusions could be different if the information upon which it is based is determined to be false, inaccurate or contradicted by additional information. KGS Group makes no representation concerning the legal significance of its findings or the value of the property investigated.

FIGURES



MONITORING ZONE D			
WELL ID	LOCATION	UNIT	DEDICATED PUMP AND TRANSDUCER
K 13-12321	Rockhaven Road	Bedrock	Yes
PTH 44 Bridge	Floodway Channel	Surface Water	N/A
K 09-12316	Outlet	Bedrock	Yes
U 09-13571	PTH 44 Bridge	Bedrock	No
K 11-12018	Hay Road	Bedrock	No
K 09-12012	Church Road	Bedrock	Yes
K 09-12011	S. of Ludwick Road	Bedrock	No
K 11-12017	Dunning Road	Bedrock	No
K 11-12016	South of Bray Road	Bedrock	No
MONITORING ZONE C			
K 11-12014	PTH 59 N. West ROW	Bedrock	Yes
K 11-12015	PTH 59 N. West	Bedrock	Yes
PTH 59 N.	Floodway Channel	Surface Water	N/A
K 13-12322	Mc Gregor Farm Road	Bedrock	No
MONITORING ZONE B			
Spring 7A	North of CNR Redditt	Spring	Permanent Installation
MONITORING ZONE A			
G05OC006	Floodway Inlet	Bedrock	N/A

KEY MAP



Legend

- Spring Treatment Site
- Monitoring Wells
- K11-12015 Core Monitoring Well Location
- K07-8809 Additional Monitoring Well Location
- Instrumented Monitoring Well Location (5 Wells)
- Surface Water Sampling Location
- 4 + 000 Floodway Channel Station
- Floodway Right of Way Limits
- RM Boundary

Well Type	Wells Sampled	Surface Water Locations	Spring Treatment Sites	Monitoring Well Transducers
Core Monitoring Wells	12	2	1 transducer download only	5
Additional Monitoring Wells	3	-	-	3

Notes:
1. Program A conducted
2. Pre-melt monitoring for program conducted in most core monitoring well locations plus 3 additional well locations.
3. Transducers installed in instrumented monitoring well locations plus U09-13571, U06-13542, and K07-12124.
4. Instrumented monitoring well locations includes well disinfection, dedicated pumps and transducers, and analysis of dissolved oxygen and bacteria.
5. Imagery from the Manitoba Land Initiative website, and dated 2008-2010.

1:100,000 (11 x 17 Plot)

1 0 1 2 3 4 5
Kilometres

All units are metric and in metres unless otherwise specified.
Universal Transverse Mercator Projection, NAD 1983, Zone 14
Elevations are in metres above sea level (MSL)

MEMO REFERENCE ....05-1100-01.9999-92.06 HM98..........

KGS GROUP

MANITOBA FLOODWAY AUTHORITY

RED RIVER FLOODWAY EXPANSION

2013 POST-CONSTRUCTION MONITORING PROGRAM ACTIVITY REPORT

2013 MONITORING PROGRAM

MARCH 2014	FIGURE HM98-1	REV: A