2015-05

Manitoba
Floodway Authority

2015 Groundwater Monitoring Program
2015 Long-term Monitoring Program Activity Report
Memo Reference: HM102
FINAL – Rev 0

KGS Group 15-1100-001
June 2015

Prepared By

Marci Friedman Hamm
Marci Friedman Hamm P. Geo
Senior Hydrogeologist

Approved By

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

KGS Group
Winnipeg, Manitoba

|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

June 29, 2015

File No: 15-1100-001

Manitoba Floodway Authority
200 – 155 Carlton Street
Winnipeg, Manitoba
R3C 3H8

ATTENTION: Ms. Leanne Shewchuk
Manager Special Projects and Environmental Services

RE: 2015 Groundwater Monitoring Program
2015 Long-term Monitoring Program Activity Report
Memo Reference: HM102
Final – Rev 0, June 2015

Dear Ms. Shewchuk:

Please find enclosed twenty (20) paper copies including a CD of the 2015 Long-term Monitoring Program Activity Report HM102 – Rev 0, June 2015. The report satisfies requirements for annual monitoring in Environmental Licence 2691 for the 2015 period, through the end of June 2015. Monitoring was conducted according to the Post-construction and Long-term Monitoring Plan HM72 Rev 1 issued April 2013.

We appreciate the opportunity to provide on-going services to the Manitoba Floodway Authority.

Sincerely,

J. Bert Smith, P.Eng.
Principal

JBS/MFH/mlb
Enclosure

Cc: Al Zaporzan – MIT
Dave MacMillan – KGS Group
Marci Friedman Hamm – KGS Group

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1.0 INTRODUCTION AND AQUIFER CHARACTERIZATION

This 2015 Groundwater Monitoring Activity report for monitoring to May 31, 2015 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. Revisions to the Long-term Monitoring Program were given in HM99, the 2013 to 2014 Post-construction Monitoring Program Comprehensive Annual Report February 2015. Subsequent 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 were summarized in the annual 2007 to 2014 Groundwater Monitoring Activity Reports, issued in March or April after the respective year ends. There was no monitoring program in 2012.

The objective of the Long-term monitoring program (as stated in HM72) is to observe monitoring data for long-term trend analysis to confirm the characterization of the groundwater regime. The groundwater monitoring results to the end of May 2015 represent the first year of long-term monitoring. No construction activities were carried out in 2015.

The Red River Floodway was not operated in the spring of 2015, nor was there any Red River flow into the Floodway Channel. The requirements for Long-term Monitoring Program A-1 (as described in HM99 Table I-1-1) were initiated in spring 2015. This included sampling of 5 instrumented wells for inorganic parameters and bacteria three times: at pre-melt; at the peak flow of the Red River at the Inlet Control Structure; and post-melt (several weeks after peak flow). Sampling of surface water is required once at two locations during the peak flow in the Red River; however an additional sample was taken because of the unique conditions encountered in the spring of 2015.

The three events monitored in the spring of 2015 included:

- Pre-melt monitoring conducted on March 12, 2015;

- Spring melt monitoring on April 6, 2015 since the peak flow in the Red River (approximately 670 cms at St. Agathe) occurred on March 21, 2015, significantly before the on-set of warmer weather; and
- Post-melt monitoring on May 4, 2015.

The previous year monitored with similar conditions was in 2008 when there was no floodway operation, however, none of the monitoring wells used in this program were installed at that time.

The carbonate aquifer found along the Floodway Channel is part of a regional groundwater 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). Conductivity is a measure of dissolved solids, such as calcium, magnesium, chloride, sodium and sulphate. 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.

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 into the groundwater aquifer is to monitor an indicator parameter such as conductivity, which along with other parameters, can be used to evaluate this contrast. In the vicinity of the Bird's Hill sand and gravel surficial aquifer, recharge from precipitation results in groundwater in the carbonate aquifer with lower conductivity (500 μS/cm to 1,000 μS/cm) than is found in other areas of the carbonate aquifer.

The intrusion of surface water into the groundwater is most readily detected when there is a contrast between the chemistry of the samples. Most groundwater conductivity values were found to be greater than surface water conductivity values measured during annual spring floodway operation. Red River surface water conductivity values are historically lowest during spring flood events reflecting snow melt, such as in the spring of 2005, 2006, 2007, 2009, 2010, 2011, 2013 and 2014. 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 surface water from the Red River diverted in the floodway were slightly higher than in the spring, and higher than the natural groundwater conductivity levels in some areas near the CPR Keewatin Bridge, PTH 59N Bridge and Church Road. These areas have naturally low groundwater conductivity in the bedrock aquifer. 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 2015 flood, one time sampling in the Floodway Channel during the spring melt on April 6, 2015 (no floodway flow or floodway operation) showed that the conductivity of the local surface water in the Floodway Channel was low in April, and increased in May as the surface water input decreased and the groundwater baseflow became a greater percentage of the flow system.

LONG-TERM MONITORING

The spring 2015 program represents the first year of the Long-term Monitoring Program. In 2015 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 2015 long-term spring monitoring program used wells designated in the monitoring program for Program A-1 as shown on Figure HM101-1. In the spring 2015 (no floodway flow or floodway operation) samples were collected within the Floodway Channel Right-of-Way from 5 bedrock monitoring wells. Monitoring wells are not used for water supply. Samples for bacteria analysis were taken in these five monitoring wells in 2015. A monitoring well disinfection program was conducted in fall 2014, prior to sampling in these wells.

2.0 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 2015 spring flood, Red River water did not enter the floodway; however local surface water sources and spring melt entered the channel. The surface water temperature was measured at 2 to 5.6° C on April 6, 2015 and 13.6 to 14° C on May 4, 2015 versus groundwater temperatures of approximately 6.5 to 7.5°C

Total Coliform and *E. coli* are present in the surface water. In the 2015 spring melt, Total Coliform bacteria in surface water were present at 43 to 140 MPN/100 mL. Values of *E. coli* ranged from <3 to 9 CFU/100 mL. This low range reflects the dilute nature of the early spring runoff

The maximum concentration of nitrate plus nitrite as nitrogen (N) measured in the Floodway Channel was approximately 0.18 mg/L on April 6, 2015, below the CCME criteria for nitrate plus nitrite (as N) in drinking water (10 mg/L); and close to, background groundwater concentrations which are generally below 0.1 mg/L in many areas of the floodway. Ammonia values during the spring melt were 0.042 to 0.045 mg/L, while TKN values were 0.94 to 1.2 mg/L.

Surface water conductivity of the channel flow was lower during the spring melt on April 6, 2015 (395 to 435 µS/cm), than after the melt on May 4, 2015 (857 to 962 µS/cm). The increase in conductivity reflects the increasing percentage of groundwater baseflow contribution.

The return to surface water reflecting the baseflow groundwater quality is indicated by the May 4, 2015 samples with increases in alkalinity, hardness, chloride, sulphate, and sodium. Concentrations of nitrate plus nitrite (as N), TKN and ammonia (PTH 59N only) decreased during the May 2015 sampling. Bacteria concentrations reflected surface water influence however, and were higher in May, from 1990 to 727 MPN/100 mL for total coliform, and from 4 to 186 MPN/100 mL for *E. coli*. Groundwater discharge mixes with residual surface water and is exposed to sources of total coliform bacteria and *E. coli* in the open waters of the channel. The lower flow and warmer temperatures in May can also increase bacterial counts.

2.1 FLOODWAY OUTLET AND PTH 44 BRIDGE

At the Floodway Outlet, monitoring wells located 65 m, and 350 m north of the expanded channel within the Right-of-Way, did not show evidence of surface water intrusion from the floodway in 2015. The well closest to the channel had stable water quality, while the well close to Rockhaven Road showed a small decrease in concentration in many parameters in April 2015 in comparison to readings in March 2015 (conductivity, alkalinity, bicarbonate, hardness, chloride and sulphate). Nitrate plus nitrite (as N) also decreased from locally elevated values. The decrease remained in May 2015 after the spring melt. This points to local recharge north of the floodway or influence of the Red River as a source of the small water quality change seen in this well. Changes in parameters at the Outlet well near Rockhaven Road were less than seen during years of floodway operation. Total Coliform and *E. coli* bacteria were below detection (<1 MPN/100 mL) at both wells at these locations on all three dates.

2.2 HAY ROAD TO DUNNING ROAD

At the bedrock well within the Right-of-Way at Church Road, there was a small increase in several parameters between the pre-melt March 2015 and spring melt April 2015 samples, including alkalinity, hardness and sulphate. Nitrate plus nitrite (as N) remained below detection. Total Coliform and *E. coli* bacteria were below detection (<1 MPN/100 mL) at these locations on all three dates. Dissolved oxygen values were low (below 0.5 mg/L) on all dates. Previous small *decreases* in parameters were seen at this well during floodway operations in some years. The water quality concentrations in the March, April and May 2015 sampling are similar to previous water quality from pre-melt or post-flood samples, and do not indicate surface water intrusion.

Water quality was not monitored at Hay Road, Ludwick Road, Dunning Road or Bray Road in 2015

2.3 PTH 59N BRIDGE AREA

At the bedrock well located upstream of the PTH 59N Bridge and 250 m west of the expanded channel at the west Right-of-Way boundary, pre-melt concentrations in 2015 were similar to 2011, but lower than pre-melt conditions in other years monitored. Concentrations remained stable through the spring melt and post-melt monitoring except for a small increase in nitrate plus nitrite (as N) in May 2015. Dissolved oxygen was low (<0.5 mg/L) during all dates. There was no indication of surface water intrusion in this well.

At the bedrock well located U/S of the PTH 59N bridge and 60 m west of the west channel slope within the Right-of-Way, a small decrease in parameters (hardness, sulphate and sodium) was seen between the pre-melt March and spring melt April samples. Samples returned to pre-melt conditions in May 2015. There was no increase in nitrate associated with the decrease in other parameters, as was typically seen during years of floodway operation. Dissolved oxygen was low (<0.5 mg/L) during the spring melt and post-melt sampling. The change in water quality is attributed to either local recharge or limited short-term local surface water infiltration from the channel.

Total Coliform and *E. coli* bacteria were below detection (<1 MPN/100 mL) at both these locations on all three dates.

The response at the well closest to the channel was consistent with monitoring in previous years, but much less pronounced, and without the presence of total coliform and *E. coli* bacteria. Even local spring melt flow in the channel can 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.

Spring melt sampling occurred in the monitoring well after the peak water levels in the Red River. The groundwater quality returned to a typical pre-melt groundwater composition by the time the spring melt flow in the Floodway Channel had discharged from the channel, and flow was back to the Low Flow Channel (LFC) water level.

The monitoring well at McGregor Farm Road was not sampled in 2015.

2.4 KEEWATIN BRIDGE AND AREA TO THE SOUTH

The well at the Floodway Inlet was not sampled in 2015.

3.0 GROUNDWATER RESULTS AND ASSESSMENT

3.1 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. Groundwater 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 2015, 5 monitoring wells were sampled in three events, for water chemistry and bacteria. During the spring melt monitoring in 2015, no obvious change in groundwater quality was seen in 60% (3) of the 5 wells sampled.

Changes found in the other wells during the spring melt were classified as follows:

- Type C (10 to 25% change) for 2 wells (40% of the total) located inside of the Right-of-Way at the Outlet and PTH 59N west side.
- Type D (5 to 10% change) for 1 well (20%) located inside of the Right-of-Way at the PTH 59N Bridge west side at west Right-of-Way.

The wells selected for the sampling in 2015 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 2015, well sampling occurred north of TCH-1. The two wells with water quality changes are located within the Floodway Right-of-Way from north of PTH15 to the Floodway Outlet.

3.2 BACTERIA

Total coliform bacteria and *E. coli* were not detected (<1 MPN/100 mL) in any of the five wells sampled within the Right-of-Way during the three sampling events: pre-melt, spring melt and post-melt samples.

3.3 NITRATE PLUS NITRITE AS (NITROGEN)

Nitrate plus nitrite (as N) concentrations were below the Canadian Drinking Water Quality Guidelines (CDWQG) of 10 mg/L. One of the 5 samples, (20%) was below detection (<0.001 to <0.005 mg/L) both pre-melt, during spring melt and during post-melt sampling. One sample within the Right-of-Way at the west right of way at PTH 59N Bridge showed increases in nitrate plus nitrite (as N). One sample at the Outlet showed decreases in nitrate plus nitrite (as N), where local nitrate plus nitrite (as N), levels are elevated.

3.4 RELATIONSHIP BETWEEN PARAMETERS

Changes in conductivity during the spring melt at one well at the Floodway Outlet (Rockhaven Rd) and one well at the PTH 59 N west side channel (all within the Floodway Right-of-Way) did not correlate with detection of total coliform or *E. coli* bacteria, as no bacteria were detected. Bacteria were sampled in areas where changes were expected and locations do not represent a random sample.

Changes in nitrate plus nitrite (as N) during the spring melt correlated with changes in water quality at 20% (1) of 5 wells sampled within the Right-of-Way (at Rockhaven Road). Since the maximum nitrate plus nitrite (as N) values in surface water were 0.18 mg/L in 2015, any higher values would be unrelated to local surface water in the channel.

Changes in nitrate plus nitrite (as N) (increases) did not correlate with changes in water quality (at PTH 59N Bridge west side west Right-of-Way during the spring melt. Nitrate plus nitrite (as N) concentrations in all wells tested 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 long-term monitoring 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 groundwater gradients will be greater and travel rates will be faster closer to the floodway. Gradients will decrease and travel times will lengthen further from the floodway. In years like 2015, with dry conditions and without floodway operation and limited channel flow, groundwater gradients, typically remain towards the channel south of PTH 59N, with groundwater discharging to contribute to the base flow.

In cases where conductivity changes may be correlated to spring melt water levels in the Floodway Channel with no operation, the change was still seen 2 days after the last peak flow in the channel (April 4, 2015 based on the piezometric hydrograph). Water quality returned to typical pre-spring melt groundwater concentrations by the time the post-melt sample was taken in May 2015, and likely sooner.

3.5 SUMMARY ASSESSMENT OF CHANGES

The 2015 monitoring event flood represented a year with a dry early spring with no floodway operation. Flow levels at the time of monitoring, with local contributions from streams and ditches, were within the Low Flow Channel. Groundwater quality changes observed from monitoring wells located within the Floodway Right-of-Way in 2015 were less than during periods of floodway operation in prior years. The only other non-operation date monitored was 2008; however none of these monitoring wells were installed at that time, so a comparison cannot be made. Bacteria were not detected in 2015, in contrast to other recent years with floodway operation where bacteria were detected at the Outlet and PTH 59N Bridge west side. The 2015 bacteria results support the conclusion that past bacteria in these wells is related to floodway operation and/ or heavy precipitation events combined with floodway operation.

All wells which showed groundwater quality changes in 2015 also showed changes in previous floods. Inorganic groundwater quality changes seen in monitoring wells in 2015 did not exceed the Canadian Water Quality Guidelines for Drinking Water.

Total coliform and *E.coli* bacteria were not present (less than detection limit of 1 MPN/100 mL) in any of the five monitoring wells within the Floodway Right-of-Way either before, during or after the spring melt. Because of this, no interim reporting to Conservation and Water Stewardship was required in accordance with the Long-term monitoring program.

4.0 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 during recharge into the aquifer, 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, 2011 and 2013, with more limited change seen in 2014.

In 2015 one spring discharge location was monitored with a transducer. The results from 2015 showed no infiltration and no drop in conductivity or temperature during the spring melt. Prior years monitoring showed that a sufficient floodway flow water depth will temporarily reverse the discharge groundwater gradient to a surface water recharge with flow direction from the channel into the bedrock beneath the spring. There is a return to groundwater quality as the floodway begins to drain and groundwater is again discharged into the channel. Since there was no Red

River flow into the channel these conditions did not occur in 2015. Also the total flow and water depth in channel was insufficient to a reverse gradient at the spring.

A summer inspection of 23 spring locations treated with reverse sand filters was conducted in June 2014. This work documents conditions in the long-term monitoring period and can be compared with surveys completed in 2013 and 2014 and continue to confirm that filters are operating as designed with no new discharge areas noted during the survey.

5.0 GROUNDWATER ACTION RESPONSE PLAN AND LONG-TERM MONITORING

The Groundwater Action Response Plan has been continued to June of 2015. No complaints were received to June of 2015.

The 2015 program is an example of baseline conditions during a very dry spring melt with no floodway operation and provides comparison for future monitoring years with floodway operation.

5.0 STATEMENT OF LIMITATIONS AND CONDITIONS

5.1 THIRD PARTY USE OF REPORT

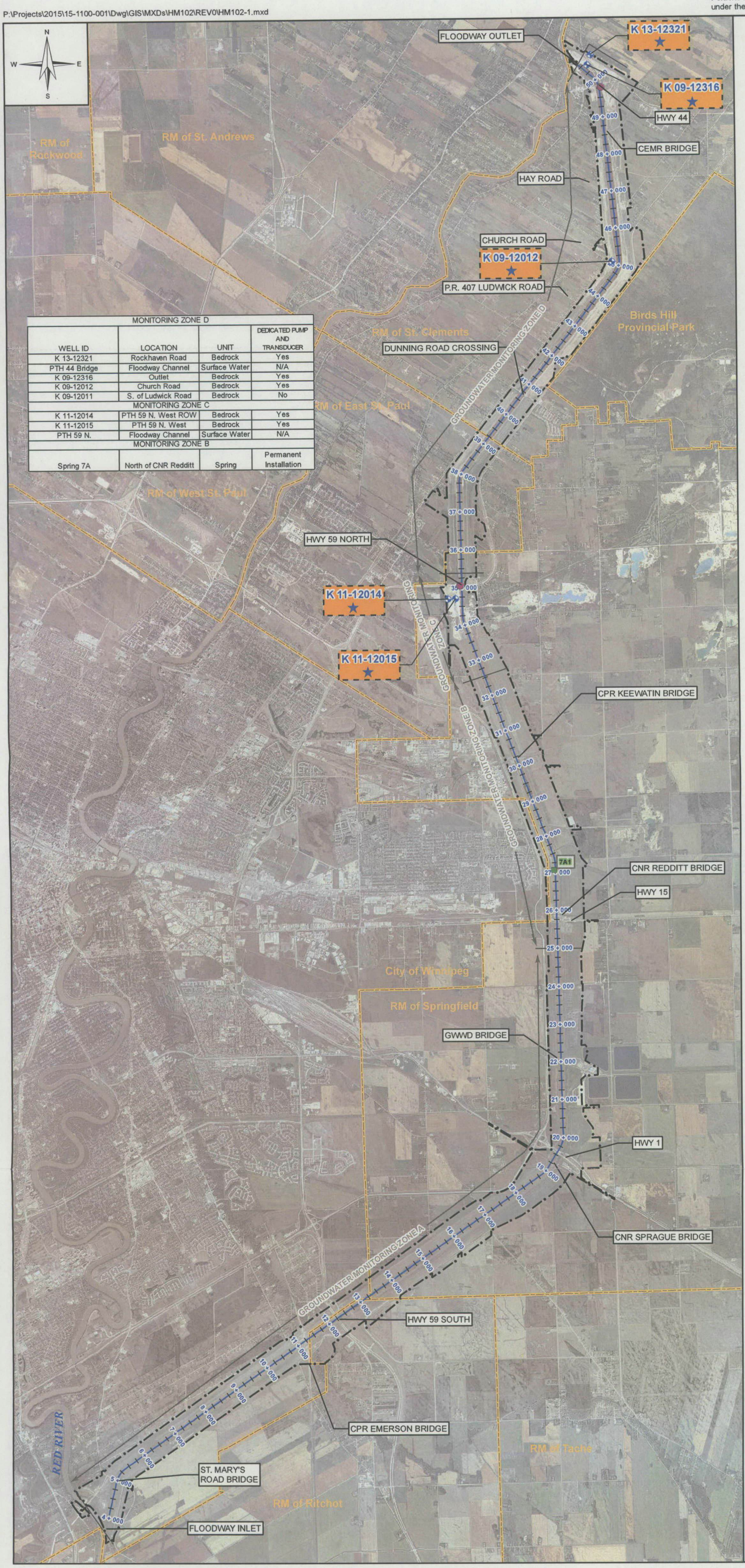
This report has been prepared for the Manitoba Floodway Authority to whom this report has been addressed and any use a third party makes of this report, or any reliance on or decisions made based on it, are the responsibility of such third parties. KGS Group accepts no responsibility for damages, if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

5.2 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.

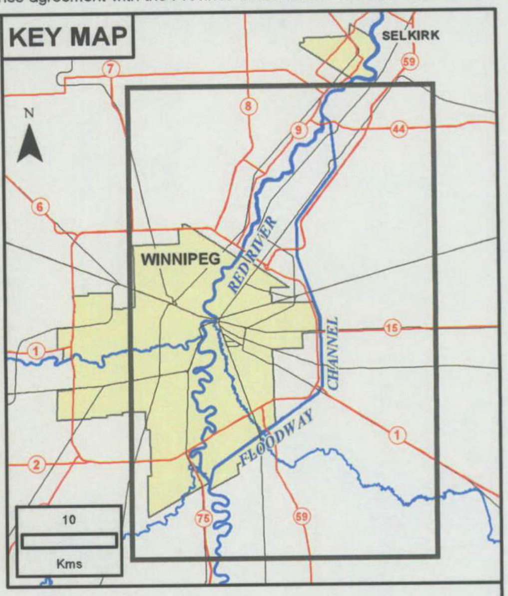
FIGURES

P:\Projects\2015\15-1100-001\Dwg\GIS\MXDs\HM102\REV0\HM102-1.mxd



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
K 09-12012	Church Road	Bedrock	Yes
K 09-12011	S. of Ludwick 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
MONITORING ZONE B			
Spring 7A	North of CNR Redditt	Spring	Permanent Installation

KEY MAP



Legend

- Spring Treatment Site
- Monitoring Wells
- Core 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
Instrumented Monitoring Wells	5	2	1 transducer download only	5

Notes:
1. Program A-1 conducted in 2015.
2. Instrumented monitoring well locations includes well disinfection, dedicated pumps and trandsducers, and analysis of dissolved oxygen and bacteria.
3. 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 .... 05-1100-001 HM102 ....

KGS GROUP

MANITOBA FLOODWAY AUTHORITY

RED RIVER FLOODWAY EXPANSION

2015 LONG-TERM MONITORING PROGRAM ACTIVITY REPORT

2015 MONITORING PROGRAM

JUNE 2015	FIGURE HM102-1	REV: 0