Manitoba Floodway Authority

Red River Floodway Expansion Project
2010 Groundwater Monitoring Activity Report
.999923 HM70

FINAL REV 0

March 2011

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March 31, 2011

File No: 05-1100-01.19.12.06

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

ATTENTION: Ms. Leanne Shewchuk
Manager, Environmental Services

RE: Red River Floodway Expansion Project
2010 Groundwater Monitoring Activity Report
Memo Reference: 999923 HM70
Final Report – March 2011

Dear Ms. Shewchuk:

Please find enclosed twenty (20) copies of the Final 2011 Groundwater Monitoring Activity Report. The report combines requirements for baseline monitoring and annual monitoring in Environmental Licence 2691 (including construction monitoring) for the 2010 period. Because of privacy issues and the volume of data, detailed information is not presented here, but will be made available to the Manitoba Floodway Authority if required.

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

Sincerely,

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

JBS/mfh/mlb
Enclosure

cc: Mr. Dave MacMillan, Project Manager – KGS Group

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1.0 INTRODUCTION AND AQUIFER CHARACTERIZATION

This report is submitted in response to the requirements for annual (construction) monitoring in accordance with Clause 27 and Clause 30 of Environmental Licence No. 2691 dated July 8, 2005. 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 are summarized in the 2007 Groundwater Monitoring Activity Report issued March 2008, activities for 2008 are summarized in the 2008 Groundwater Monitoring Activity report issued March 2009 and activities for 2009 are summarized in the 2009 Groundwater Monitoring Activity report issued April, 2010.

During the 2010 spring flood event, the Red River water began naturally flowing into the Floodway Channel on March 24, 2010 when the water levels rose above an elevation of 750 feet (228.6 m). The floodway gates were in operation from March 28, 2010 to April 22, 2010 with a channel crest on April 7, 2010 at an elevation of 231.46 m (759.39 ft) and a flow of 1903 m^3/s (67,200 cfs) in the Red River and 449 m^3/sec (15,850 cfs) diverted into the Floodway Channel.

A summer flood event occurred in 2010 from May 30, 2010 to June 16, 2010, with a channel crest on June 4, 2010 at an elevation of 231.1 m (758.24 ft) and a flow of 1230 m^3/s (43,450 cfs) in the Red River and 345 m^3/sec (12,200 cfs) diverted into the Floodway Channel.

The purpose of the groundwater monitoring program is to monitor the effects of construction during Floodway expansion and to determine whether Floodway expansion has resulted in potential effects on local groundwater. Another objective of the program is to identify the potential for water quality changes and characterize the nature of any water quality changes found in the groundwater. This includes evaluating if Floodway Operation is a source of the water quality change, or if other sources and factors are more likely. Both groundwater and surface water data are collected as part of the monitoring program. Data gathered during the monitoring program has been analyzed and interpreted in relation to environmental considerations.

Two events were monitored in 2010:

- March 2010 – Pre-Spring Runoff (no Floodway Operation)
- March/April 2010 – Floodway Operation

Domestic wells and monitoring wells were not sampled during the summer Floodway Operation event, however, groundwater data from transducers is available for this event. Surface water samples were taken during the summer flood event as part of the program to monitor for potential construction effects. Surface water quality samples collected to monitor for potential effects from construction activities provide comparative data for the groundwater monitoring program. Groundwater and surface water quality samples were collected during the spring Floodway Operation event. Additional surface water samples were collected during the summer event.

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 from southwest Manitoba results in higher conductivity (greater than 3,000 µS/cm) groundwater 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. Bedrock 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 monitor 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 forms groundwater with lower conductivity (500 µS/cm to 1,000 µS/cm) than other areas of the carbonate aquifer.

The intrusion of any surface water into the groundwater is most readily detected when the chemical contrast (i.e. conductivity) between the two is greatest. Most groundwater conductivity values were found to be greater than surface water conductivity values measured during annual spring Floodway Operation. River conductivity values are historically lowest during spring flood events, such as in 2005, 2006, 2007, 2009 and 2010. In this situation, groundwater conductivity would be expected to decrease, if surface water intruded. During summer Floodway Operation in 2005, floodway use in 2007, and summer Floodway Operation in 2010 river conductivity values 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.

2.0 CONSTRUCTION MONITORING

2.1 BACKGROUND

Potential groundwater effects from construction activities were identified in the pre-construction Environmental Impact Assessment; the groundwater monitoring program was developed to assess and characterize the potential effect and adjust mitigation measures accordingly. Possible groundwater effects, namely the drawdown of local wells, were identified for those construction activities that required groundwater depressurization (i.e. construction of certain bridge piers in areas of high piezometric groundwater levels). Channel excavation was complete in all areas of the floodway by the end of 2010. Construction of the PTH 44 and PTH 15 Bridges continued into 2010. The groundwater construction monitoring program locations were selected to provide coverage along the channel and in areas of construction for bridges, Oasis Road, the Outlet Structure, and the Kildare Land Drainage Pumping Station. Additional monitoring locations were adjusted or added to increase coverage in certain areas as construction proceeded.

Construction monitoring programs included field measurements in domestic wells to evaluate if remedial work was required prior to depressurization programs. Measurement of water levels in regional monitoring wells enabled construction managers to adjust the timing and amount of groundwater pumping to minimize domestic well drawdown, while ensuring adequate protection for construction foundations. Post-construction monitoring successfully documented full aquifer recovery.

2.2 2010 PROGRAM

Groundwater monitoring of temporary construction depressurization programs was conducted in 2010 at the active bridge project sites; PTH 44 and PTH15 Bridge locations. These programs were designed to minimize groundwater seepage into the excavations required for the bridge piers. Monitoring for these programs included the following activities:

- monitoring well water quality sampling,
- continuous water level measurements,

- domestic well sampling,
- additional domestic, commercial and industrial well inventories, and
- field water level measurement programs at selected domestic, commercial and industrial wells.

A second brief groundwater depressurization program at PTH 15 was conducted in October 2010 to install clay fill and a reverse filter around the piers. At sites requiring construction depressurization of the bedrock aquifer, groundwater levels returned to normal after pumping programs stopped. Most of the recovery took place within hours and full recovery took place within a week. Some wells installed for the PTH15 and PTH44 Bridge program have been retained for future use. Wells located within the channel have been protected from flooding by installation of waterproof seals.

The Groundwater Action Response Plan has been used effectively during construction. There were no public complaints during groundwater depressurization projects in 2010 and complaints in prior years were minimal.

Thirty complaints were received pertaining to construction projects throughout from 2005-2010. All were resolved as detailed in past groundwater activity reports.

No further monitoring is required for construction effects, as all groundwater depressurization activities are complete.

3.0 DOMESTIC WELLS

3.1 INTRODUCTION

Domestic well monitoring was conducted to provide an initial baseline prior to Floodway expansion. Subsequent annual programs were conducted to monitor for construction effects and for potential effects during periods of Floodway Operation. The domestic well monitoring augmented the original pre-expansion water chemistry from provincial wells and the data collected from new monitoring wells installed for the Floodway Expansion Project.

Approximately 200 wells were sampled in 2010 during each of the March pre-flood, and March/April post flood sampling events. A core list of wells was targeted, with other wells added for construction monitoring as needed. The location of wells sampled varies between flood events depending on the location of construction, access provided by well owners, and results of programs from prior years. As a result of the analysis of prior years, the well sampling locations shifts away from areas where there is no construction or where there has been no evidence of effects from Floodway / groundwater interactions, based on hydrogeologic conditions supported by sample data. In 2010, wells at 230 residences were sampled at least once. The distribution of these wells is shown on Figure HM70-1. Individual well owners received copies of their laboratory analysis after each sampling event.

The electronic well inventory database was updated in 2010. It contains homeowner interview information, field sampling results and links to water chemistry results. The inventory is being used with the Floodway GIS database on an on-going basis and has been a resource when investigating public inquiries and during temporary groundwater depressurization activities at construction sites such as bridges, the Aqueduct, Kildare Flood Pumping Station, Oasis Road cut-off wall and the Outlet Control Structure. Since 2005, domestic well inventories have been conducted at approximately 747 locations, with 107 other domestic locations identified and georeferenced.

A variety of factors can contribute to changes in domestic well water quality. This can make detection of possible surface water intrusion from the floodway difficult to interpret. Infiltration from septic fields or unsanitary conditions in the well, or local surface water infiltration may

introduce bacteria or nitrates, unrelated to Floodway Operation. Location near gravel pits, ponds or creeks may also cause bacteria and nitrates to enter the well. If local surface water sources infiltrate and move to the well, the resulting water quality changes are often similar to those potentially caused by Red River water infiltrating via the Floodway.

Since the Floodway receives surface water from the Seine River and various municipal drains and outfalls, the channel can carry a substantial flow, even when the gates are not operated to allow the Red River to enter. Periods of high rainfall in the summer can also fill the base of the Floodway such as occurred in early July and early August 2009. These events were correlated to groundwater elevation changes. In some cases, water quality changes were monitored in areas where recharge or infiltration occurred.

Monitoring of the domestic wells will be phased out now that channel expansion construction has been completed. Monitoring wells installed under controlled conditions along the channel right-of-way are preferred for on-going sampling programs, to avoid potential limitations due to access as well as varying age, construction, and maintenance of the domestic wells.

3.2 BACTERIA

Positive detection of Total Coliform bacteria in domestic wells in 2010 was low and was not strongly correlated with the Floodway Operation period in April or with construction activities, although there were increases in some wells during the spring floodway period. In 2010, most of the samples analyzed had no Total Coliform bacteria. In March 2010 prior to the spring flood, 24 of 192 samples (13%) tested positive for Total Coliform. Subsequently, Total Coliform detections increased slightly to 37 of 210 samples (18%) in late March/April 2010 during Floodway Operation. These detection percentage variations between sampling periods and between years reflect that the specific wells sampled change each time, not necessarily that there is any increasing trend. The program is refined each year, to target wells in areas deemed to be most vulnerable, maintaining wells in the monitoring program that demonstrate varying water quality, eliminating those that do not and focusing sampling in more sensitive groundwater areas in order to optimize the information gained within a practical budget.

Most positive detections of Total Coliform bacteria in 2010 have occurred north of the CN Keewatin Bridge. No sampling was conducted south of the TCH Bridge in 2010, since in previous years Total Coliform bacteria were rarely detected in those wells. There was a slight increase in detection of Total Coliform bacteria for the spring flood event in late March/April 2010, versus the pre-flood monitoring. There are, however, a variety of sources of bacteria potentially influencing the groundwater quality such as, Floodway Operation, but also other sources including spring melt conditions or in-well effects. Clusters of wells with positive Total Coliform bacteria were monitored in higher density developments including Rockhaven Road, north of Ludwick Road, Bray Road and near CPR Keewatin. All wells are assumed to be developed in the bedrock aquifer based on drilling records examined in selected areas.

E. Coli bacteria were detected in three wells of 192 domestic wells tested in March 2010, prior to the spring melt and Floodway Operation. *E. Coli* was not detected in any of the 21 domestic wells sampled in April 2010 during Floodway Operation. All homeowners were notified if they had positive bacteria results.

Homeowners participating in the program have received provincial fact sheets on well maintenance and well disinfection. Where bacteria results are positive, homeowners are contacted by phone and directed to the Office of Drinking Water for any further well-related questions.

3.3 NITRATE+NITRITE (AS NITROGEN)

Most nitrate + nitrite (as N) values throughout the study area are historically well below the Canadian Drinking Water Quality Guideline (CDWQG) value of 10 mg/L nitrate + nitrite (as N). In March and late March /April 2010, 78 to 80% of samples were less than detection (0.05 mg/L) and 95% of the values were less than 1 mg/L. Values from 1 to 5 mg/L were present in 5% to 6% of wells. A value from 5 to 10 mg/L was found only at 1 well, near the Outlet Structure, in March 2010. In 2010, nitrate values were not strongly correlated with Floodway Operation as explained in Section 3.6. This is consistent with monitoring in prior years, which also showed little relation between nitrate values and Floodway Operation.

3.4 PESTICIDES

Pesticides/Herbicides selected for testing in prior years were representative of those used in local agricultural practice. No pesticides were used on the channel contracts. None of the pesticides/herbicides analyzed were detected in the six domestic wells sampled in 2009. None of the herbicides were detected during the 2009 Spring flood in the surface water samples at VEG U/S (11+000) and VEG D/S (50+900). Since pesticides and herbicides had not been detected in domestic wells, they were not sampled in domestic wells in 2010. In surface water sampling in 2010, only AMPA was detected (1.02 to 1.07 ug/L at both CON u/S (5+500) and CON D/S (50 +900).

Pesticides and herbicides have not been detected in domestic well groundwater samples since the start of Groundwater monitoring in 2005.

3.5 CONDUCTIVITY

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 other parameters 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. Conversely, increases in groundwater conductivity would be seen in areas where baseline groundwater conductivity is less than that of surface waters.

In the study area, potential surface water infiltration sources are ponds and open sand and gravel quarries, and creeks, as well as the Floodway and Red River primarily near the Floodway Outlet.

During spring monitoring, no obvious change in groundwater quality was seen in 69% (146) of the 210 domestic wells sampled. There were 64 wells (30% of the total wells) showing possible

slight to moderate decreases in conductivity. The decreases were rated as slight (<10% change) for 30 wells (14% of the total) and minor (10 to 25% change) for 30 wells (14% of the total), with the slight to minor water quality changes interspersed along the channel from Hwy 59 Bridge to the Outlet. Moderate (25 to 50% change) decreases were noted for 4 wells (2%) which were located in the Floodway Outlet area. There were 13 wells (20%) that had both water quality changes and Total Coliform. The wells currently selected for the sampling programs are in areas with higher potential for surface water intrusion due to hydrogeologic conditions or location near other surface water sources. In 2010, well sampling occurred north of TCH 1. All of the domestic wells with conductivity decreases are located from north of PTH 15 Bridge to the Floodway Outlet.

3.6 RELATIONSHIP AMONG PARAMETERS

Total Coliform was found in 37 of the 210 wells (18%) sampled during the spring flood in 2010. Conductivity changes occurred in 64 of the 210 wells (30%). Total Coliform presence, however, was not strongly correlated with decreases in conductivity attributed to surface water intrusion in the 2010 spring flood. At times Total Coliform occurred without conductivity changes, while in other cases the two occurred together, typical of the pattern found in other years. In 2010, Total Coliform was found in 24 wells that had no conductivity changes and in 13 wells which had conductivity changes. Total Coliform was not detected in the remaining 51 of the 64 wells (80%) which had conductivity changes.

Increases in nitrate + nitrite (as N) were also not strongly correlated with the decreases in conductivity. Increases in nitrate + nitrite (as N) were found in 7 of the 64 wells that showed decreases in conductivity. The increases found in nitrate + nitrite (as N) were slight and ranged from 0.1 to 0.5 mg/L in 5 of the wells, and up to 1.7 mg/ in the 2 other wells, which had a history of increased nitrates.

Nitrates in surface water during Floodway Operation were a maximum of 1.7 mg/L in 2010. The total nitrate concentration in groundwater from the domestic wells was generally less than 1 mg/L, far below the Canadian Drinking Water Quality Objective of 10 mg/L for total nitrate (as N).

A conductivity decrease associated with both a Total Coliform presence and a nitrate + nitrite (as N) increase was seen in 3 of the 64 wells that showed water quality changes: one with a moderate (25 to 50%) conductivity change; and two with minor (10 to 25%) conductivity changes. However, one of these wells also had bacteria during non-flood events, which suggests that well water quality is being influenced by sources other than Floodway Operation (e.g. a bacteria source from within the well).

E. Coli bacteria were not detected in any samples during the spring 2010 Floodway Operation. The historical record for the 37 domestic wells with Total Coliform bacteria in 2010 shows that there are some wells (22) where Total Coliform bacteria is only found during flood events, and not at other times of the year. The remainder of the wells (15) contained Total Coliform bacteria both during flood events and at other times of the year. Many of these wells were sampled for the first time during a flood event in 2010. All wells with Total Coliform bacteria were located north of PTH 59 on the west side of the floodway, except for one well which was on the east side of PTH 59.

3.7 LOCATION OF GROUNDWATER QUALITY CHANGES

In summary, 146 or 69% of the 210 domestic wells showed no measureable change in groundwater quality in 2010. Groundwater quality changes were found in 64 or 31% of the wells. These wells are located from PTH 15 north to the Floodway Outlet, with concentrations at PTH 59N Bridge and north of Ludwick Road.

The 13 wells with Total Coliform and other water quality changes (e.g.. conductivity) are located primarily north of Hay Road to the Floodway Outlet.

The 7 wells showing nitrate increases associated with conductivity decreases are located near the CEMR Bridge and the PTH 59N Bridge.

The 3 wells showing a conductivity decrease with both a nitrate increase and a Total Coliform presence are located at the Floodway Outlet and PTH 59N Bridge.

4.0 MONITORING WELLS

4.1 INTRODUCTION

In 2010 monitoring well samples were collected primarily within the Floodway Channel Right-of-Way from approximately 45 bedrock wells, 10 till wells adjacent to the floodway, plus 5 sand and gravel wells (Oasis Road area only). Monitoring wells are not used for water supply and are not domestic wells. During the spring Floodway Operation, 45 wells were sampled including 43 monitoring wells and 2 sand and gravel wells. Monitoring well locations are shown in Figure HM70-2. Conductivity in the monitoring wells generally shows the same distribution along the Floodway as for the domestic wells. Bacteria were not sampled in monitoring wells in 2010. It is not feasible to disinfect the 2-inch standpipes sufficiently to eliminate sediment, which can naturally carry Total Coliform bacteria. Larger diameter provincial wells do not have the sanitary protection needed for reliable bacteria monitoring.

4.2 NITRATE-NITRITE (AS NITROGEN)

In the monitoring well samples most nitrate + nitrite (as Nitrogen) concentrations were low in 2010 and lower than surface water levels during Floodway Operation (a maximum of 1.7 mg/L). About half of the 211 values are less than 0.05 mg/L, 20% are between 0.05 and 0.3 mg/L, 8% are between 0.3 and 1 mg/l (at Hay Rd. Kildare LDS, CPR Keewatin Bridge, and PTH 59N), 6 % between 1 mg/L and 2 mg/L, and 14% are between 2 and 2.5 mg/L (at PTH 44 Bridge and the Floodway Outlet). All values were below the Canadian Drinking Water Quality Guidelines for nitrate + nitrite (as N), 10 mg/L.

4.3 PESTICIDES

The pesticides analyzed represented products used in the area for agriculture plus those that had been intended for floodway construction use (although pesticides were not ultimately used). Glyphosate was found at monitoring well K03-12006C on April 6, 2010 at a concentration of 0.56 µg/L. The CCME Canadian Drinking Water Guideline for glyphosate is 280 µg/L. Glyphosate found in surface water was at twice the levels in the groundwater, but still at a low concentration of 1.1 µg/L upstream of construction (CON U/S) and 1.25 µg/l downstream of

Construction. None of the other pesticides / herbicides that were analyzed were found in the four monitoring wells sampled.

4.4 CONDUCTIVITY

No conductivity change was seen in 28 (63%) of the 44 monitoring wells sampled during the spring Floodway Operation in 2010. There were 16 wells (37%) which showed possible decreases in conductivity and other parameter concentrations compared to the pre-flood (March 2010) monitoring. For 9 (21%) of these monitoring wells, the conductivity decreases were rated as slight (less than 10% change) to minor (10% to 25% change). The conductivity decreases were moderate (25 to 50% change) for another 7 (16%) of the wells.

Wells with moderate changes were found as follows:

- One bedrock sand and gravel monitoring well at the west side of PTH 59N Bridge in overburden and one bedrock well (where the Floodway Channel is in sand and gravel over bedrock)
- Two bedrock monitoring wells at the Floodway outlet where bedrock is close to the channel bottom
- One bedrock monitoring well at the PTH 44 Bridge where there is a high bedrock transmissivity in an upper fractured zone
- One bedrock monitoring well at the Floodway Inlet Control Structure where there is a direct connection between the Red River and the aquifer
- One bedrock monitoring well near CNR Redditt and Kildare in an area where the channel base is in till

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. Travel times to the wells vary depending on Floodway Channel water elevations, and piezometric water elevations and the hydraulic conductivity of the bedrock, which varies from highly fractured to very tight. 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. The water quality changes related to these gradients and travel times should correspondingly decrease with distance away from the channel.

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 after the peak flow dropped and reached pre-melt conditions soon after Floodway Operation ended.

4.5 RELATIONSHIP AMONG PARAMETERS

Nitrate values increased in 5 of the 16 wells where decreases in conductivity occurred in spring 2010. The nitrate values measured at these wells were below levels measured in surface waters (a maximum of 1.7 m/L) during Floodway Operation. The increases in nitrate ranged from 0.22 to 0.85 mg/L with total nitrate plus nitrite (as nitrogen) of 0.85 mg/L or less. Nitrate concentrations in these wells were below the Canadian Drinking Water Guideline of 10 mg/L nitrate (as N).

4.6 WATER LEVELS

In 2010, water level measurements were taken during the pre-melt and spring flood groundwater monitoring periods and during work at sites of temporary construction dewatering. Water level measurements from 10 provincial monitors with chart recorders also were examined. These show water levels within the range of historic data. Those wells close to temporary construction depressurization programs show the groundwater drawdown and recovery associated with changes in the depressurization programs.

4.7 CONTINUOUS MEASUREMENTS

Transducers were installed at 23 monitoring wells in 2010. Data from the transducers taking continuous conductivity, temperature and elevation measurements at monitoring wells did not identify significant potential surface water intrusion into the vast majority of wells during the Floodway Operation in 2010. The two main exceptions to these findings were noted at PTH 59N Bridge west side, and at the Floodway Outlet and PTH 44 Bridge area. Minor changes were also seen at Church Road.

Infiltration of Floodway surface water into the bedrock aquifer was documented at PTH 59N Bridge west side at a bedrock well located within 40 m of the west channel slope within the Floodway Right-of-Way. A short-term minor decrease in conductivity was measured during Floodway Operation in 2010 in this bedrock well. The sand and gravel well at this location also shows a short term moderate decrease in conductivity. The sand and gravel well is west of the cut-off wall (e.g. away from channel side), installed to bedrock on the west side of the channel. There is potential for surface water to infiltrate through the channel to the bedrock, and influence the sand and gravel well, which is installed close to the bedrock surface. This response is consistent with previous years. 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.

Infiltration of surface water from the Red River and subsequent Floodway Operation was also seen in April 2010 at the Floodway Outlet, in six monitoring wells located between 200 and 350 m north of the Outlet Structure and cut-off wall, on-site and at Henderson Highway and Rockhaven Road. Conductivity measurements in the wells were low in March/April 2010 during the Floodway Operation. Conductivity measurements increased rapidly after the peak of the melt, correlating with the groundwater elevation decline. Conductivity returned to typical background bedrock groundwater quality as the floodway flow levels approached the LFC level.

Two groundwater discharge areas (springs) located in the Floodway Channel that were treated with a reverse filter in 2009, were monitored to document water quality changes. The results confirmed that floodway surface water can reverse the gradient and flow direction temporarily, infiltrating or recharging into the bedrock locally, in these normal groundwater discharge areas. Water quality monitored after surface water passed through the sand filters showed a significant drop in Total Coliform and suspended sediments. In addition, the groundwater quality discharging from these reverse filter springs returned to bedrock groundwater quality as soon as the floodway flow reverted back to the LFC level. Eleven additional discharge areas were treated with reverse granular filters in early winter 2010.

5.0 2011 MONITORING

Groundwater monitoring will continue in 2011. The purpose of the 2011 monitoring program is to gain further information on floodway response primarily during larger flood events which is predicted for 2011. The program will focus on monitoring wells. A small number of domestic wells will be used in 2011 to provide correlation during this transition. A targeted surface water monitoring program will be included to aid the groundwater data interpretation and to characterize the changes in water quality in the incoming surface water during the event. Monitoring beyond 2011 will be outlined in a post-construction and long-term on-going monitoring plan to be submitted to Manitoba Conservation.

FIGURES

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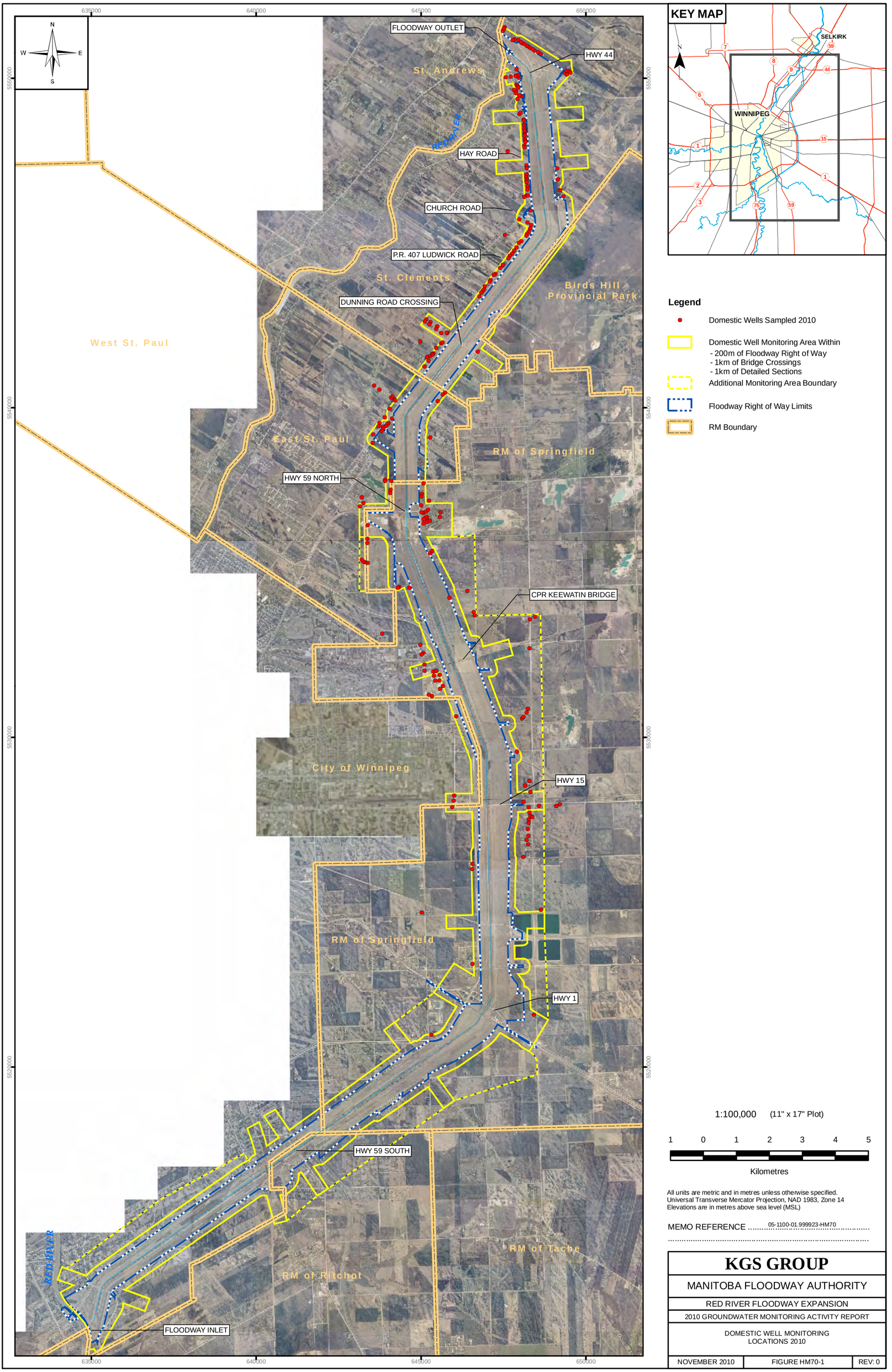

Legend

- Domestic Wells Sampled 2010
- Domestic Well Monitoring Area Within
  - 200m of Floodway Right of Way
  - 1km of Bridge Crossings
  - 1km of Detailed Sections
- Additional Monitoring Area Boundary
- Floodway Right of Way Limits
- RM Boundary

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 05-1100-01.999923-HM70

KGS GROUP

MANITOBA FLOODWAY AUTHORITY

RED RIVER FLOODWAY EXPANSION

2010 GROUNDWATER MONITORING ACTIVITY REPORT

DOMESTIC WELL MONITORING LOCATIONS 2010

NOVEMBER 2010	FIGURE HM70-1	REV: 0

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640000 660000

5560000 5540000

N W E S

RM of St. Andrews

RM of West St. Paul

CITY OF WINNIPEG

RM of East St. Paul

RM of Brokenhead

RM of St. Clements

Birds Hill Provincial Park

RM of Springfield

CEMR

CPR KEEWATIN

LISTER RAPIDS

RED RIVER FLOODWAY

OAKBANK

LOCKPORT

ST. ANDREWS LOCK AND DAM

OUTLET STRUCTURE

Hay Road

Bray Road

Oasis Road

STUDY AREA BOUNDARY

8 9 12 44 59 101

K 07-8810
K 09-12319
K 09-12318
K 09-12317
K 07-8809
K 09-12316
K 03-12005-B
G05OJ005

K 08-9262
RRF023 (Decom)
W 03-11030
W 03-11032
K 03-12003-B
K 03-12003-C
W 03-11031
W 03-11033

K 09-12012
G05OJ001 (Decom)

K 09-12011
RRF072 (Decom)

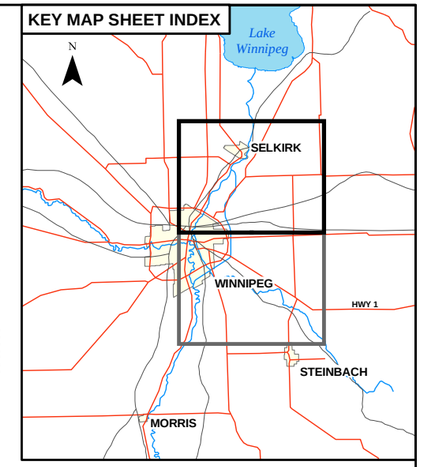
W 03-11036
W 03-11038
W 03-11040
W 03-11037
W 03-11039
K 03-12004-B
G05OJ002

K 03-12008-B
G05OJ077

TRUCK TRAINING WELL
W 03-11025-L
W 03-11025-U
W 03-11026
K 03-12006-B
K 03-12006-C
K 04-12102-B
K 04-12101 (BR)
K 04-12101 (S+G)
K 04-12104
U 06-9236
K 03-12009-B
G05OJ079
G05OJ148
G05OJ006
K 04-12103
K 06-12108 (Decom)
K 06-12109
K 06-8721 (Decom)
K 07-12124
K 07-12126
K 07-12136
W 03-11018
W 03-11019

W 03-9200
W 03-11017
U 06-13542
G05OJ014

KEY MAP SHEET INDEX



Monitoring Wells
- Bedrock Well
- Till Well
- Sand and Gravel Well

Topographic Features
- Primary Highways
- Railway
- Major Rivers
- RM Boundaries
- Study Area Boundary

Notes:
1. (Decom) - Decomissioned Well
2. Wells K 09-12316 through K 09-12319 were formerly named K 09-9616 through K 09-9619.

1:150,000 (11" x 17" Plot)

2 0 2 4 6
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 05-1100-01.9999023-HM70

KGS GROUP

MANITOBA FLOODWAY AUTHORITY

RED RIVER FLOODWAY EXPANSION

2010 GROUNDWATER MONITORING ACTIVITY REPORT

MONITORING PROGRAM
MONITORING WELL LOCATIONS
(NORTH SHEET)

NOVEMBER 2010	FIGURE HM70-2	REV: 0

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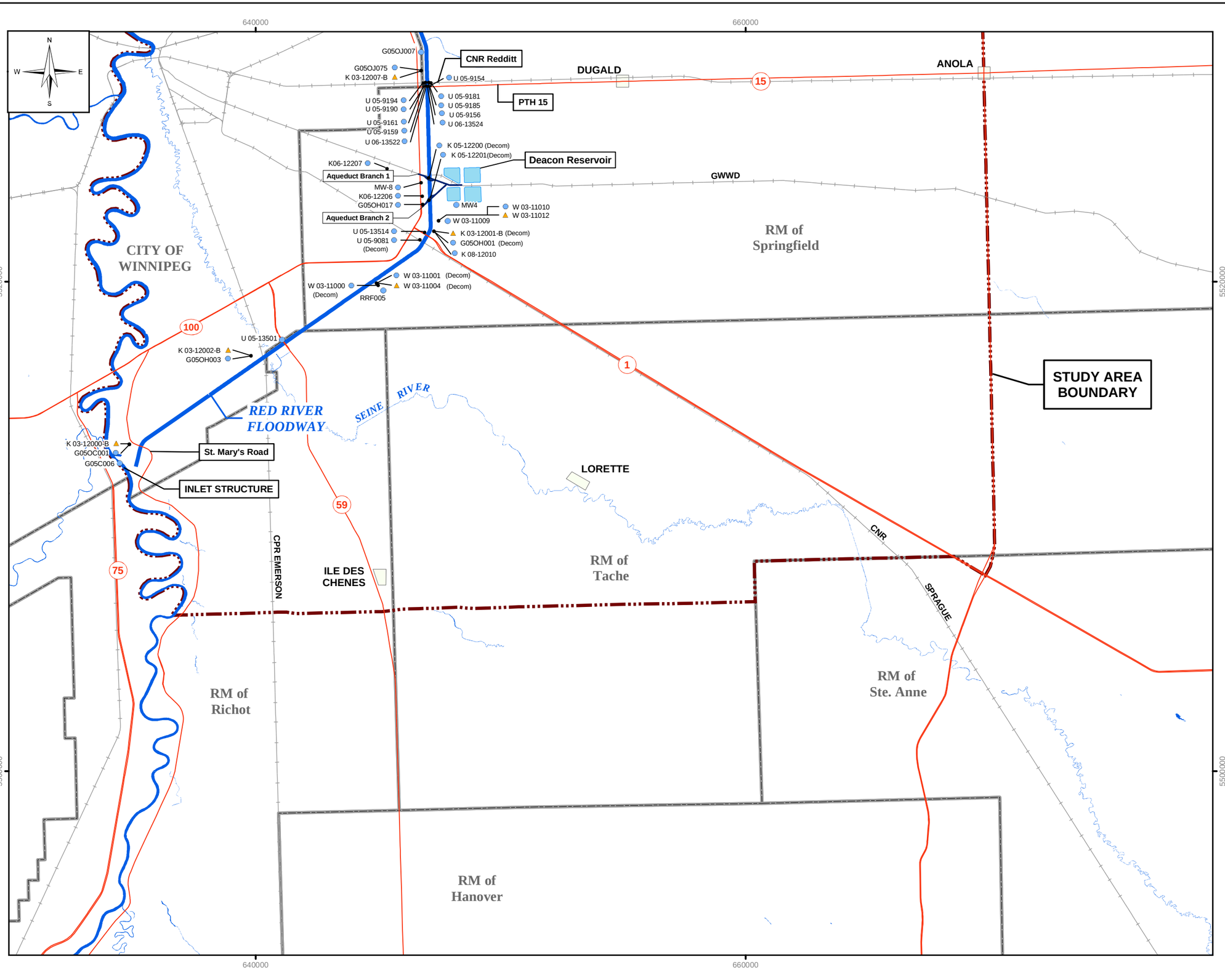

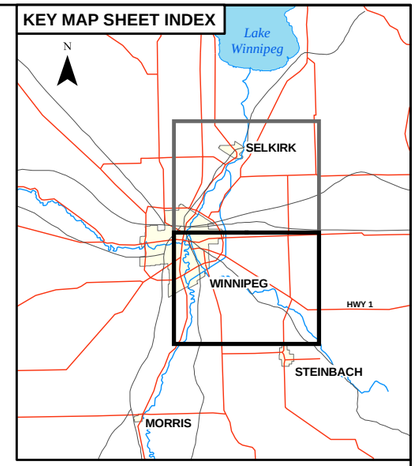

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KGS GROUP

MANITOBA FLOODWAY AUTHORITY

RED RIVER FLOODWAY EXPANSION

2010 GROUNDWATER MONITORING ACTIVITY REPORT

MONITORING PROGRAM
MONITORING WELL LOCATIONS
(SOUTH SHEET)

NOVEMBER 2010	FIGURE HM70-2	REV: 0

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