GRANDE PRAIRIE
RICHMOND INDUSTRIAL PARK
STORM BASIN STUDY

Project number 060200141

Prepared by:

Focus Corporation
10127 – 120 Avenue
Grande Prairie, AB
T8V 8H8

Submitted to:

The City of Grande Prairie
Engineering Services
9505 – 112 Street
Grande Prairie, AB
T8V 6V3

Draft December, 2012
Draft July, 2013
Final December, 2013

FOCUS

9.5. Community Safety Committee – February 4, 2014

MOVED by Councillor McLean that Council receive the minutes of the Community Safety Committee meeting held February 4, 2014.

CARRIED.

9.5.1 Storm Drainage Master Plan

MOVED by Councillor McLean that Council adopt the Storm Drainage Master Plan and supplemental Richmond Industrial Park Storm Basin Study.

CARRIED.

9.5.2 SPCA Agreement

Councillor Clayton declared conflict of interest as she sits on the SPCA Board and vacated Council Chambers.

MOVED by Councillor McLean that Council enter into a contract with the Grande Prairie and District SPCA for the operation of the Regional Animal Pound for 2014, in the amount of $267,836.00, plus GST.

CARRIED.

Councillor Clayton re-entered Council Chambers.

9.6. Municipal Government Day Committee – February 4, 2014

MOVED by Councillor Thiessen that Council receive the minutes of the Municipal Government Day Committee meeting held February 4, 2014.

CARRIED.

9.6.1 2014 Municipal Government Day - Date and Location

MOVED by Councillor Thiessen that Council approve the 2014 Municipal Government Day event be held at Muskoseepi Park on June 11, 2014.

CARRIED.

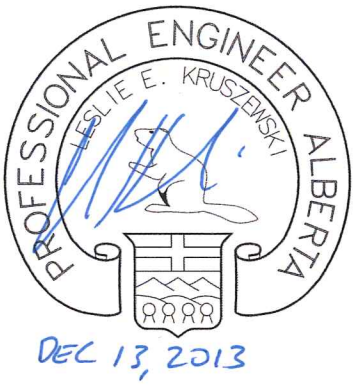
9.6.2 2014 Municipal Government Day Program

MOVED by Councillor Thiessen that Council approve the 2014 Municipal Government Day Program, as presented.

CARRIED.

CORPORATE AUTHORIZATION

This report, "Grande Prairie, Richmond Industrial Park Basin Storm Water Study - 2012", was prepared by Focus Corporation for the account of the City of Grande Prairie, Engineering Services. The material in it reflects the judgement of Focus Corporation, in light of the information available at the time of preparation. Any use of the information by a third party, or any reliance on or decisions made on it are the responsibility of such third parties. Focus Corporation accepts no responsibility for damages, if any, suffered by a third party as a result of decisions made or actions taken, based upon information contained in the report.



PROFESSIONAL SEAL

PERMIT TO PRACTICE
FOCUS CORPORATION
Signature Blair Raymond
Date Dec. 13, 2013
PERMIT NUMBER: P 6386
The Association of Professional Engineers and Geoscientists of Alberta

PERMIT TO PRACTICE

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1.0 INTRODUCTION

The City of Grande Prairie has retained Focus Corporation to analyse the Richmond Industrial Park drainage basin and provide recommendations on possible solutions to reduce flooding in the low laying areas.

The scope of the work includes update their 2004 XPSWMM model of the storm sewer system of the area, analyse the drainage basin for flooding locations and make recommendations on additions or changes to the system to help mitigate flooding problems in the area.

1.1 Objectives

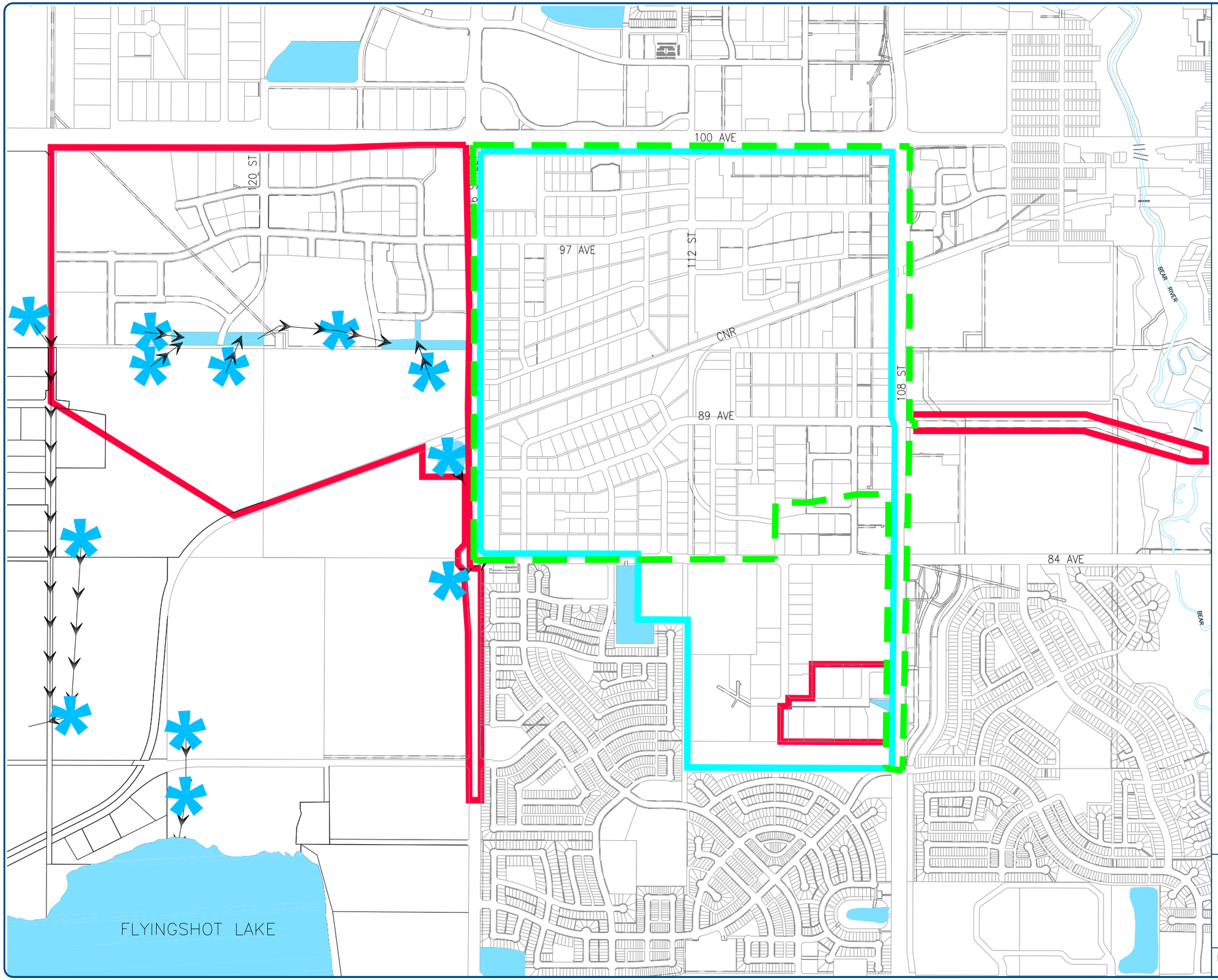
The objectives of this study are the following:

- Update the 2004 storm water model for the Richmond Industrial Park basin
- Use the updated storm water model for the Richmond Industrial Park area and offsite catchment areas as a tool to find possible solutions to the storm water issues in the area.
- Provide the city with an updated storm water model of the area.
- Provide the city with recommendations for mitigation of storm water issues currently being experienced in the study area.

1.2 Richmond Industrial Background

The area of study is described as the industrial - commercial development generally bounded by 116th Street, Wapiti Road (108th Street) 84th Avenue and 100th Avenue. The Richmond drainage basin study area differs from the Richmond Industrial Park boundary both of which are shown in Figure 1.2.1. The majority of the drainage basin has been developed as industrial business use with commercial use on the edges. Historical development was done with a rural cross-section roadway with ditches on both sides for storm water drainage. Past development did not provide storm water management facilities but the ditches of Richmond served as storm water storage. In the early 2000's the City changed the roadway system to an urban style with curb and gutter on the road edges and storm sewer piping and inlets for storm water drainage. The conversion of the road system to the urban style currently used created an increase in the hard surfacing within Richmond Industrial Park (Richmond) and a reduction of the built in storage the ditches provided.

The current road grading in Richmond brings over land flow from south of the CNR tracks to the low point just west of the intersection of 89th Avenue and Wapiti Road. The current grade of Wapiti Road does not provide an adequate over-land flow path during large storms. At this point the storm sewer piping is the only conveyance that crosses Wapiti Road. The flow then continues through the Canfor site piping and ditches and ultimately empties into the Bear River. The ditches in the Canfor site were cleaned of sediment and aquatic plants in the fall of 2011 as maintenance work.



RICHMOND INDUSTRIAL STORM DRAINAGE BASIN STUDY GRANDE PRAIRIE

LEGEND:

- RICHMOND INDUSTRIAL PARK BOUNDARY
- 2012 MODEL ADDITION
- 2004 MODEL BOUNDARY
- FLOW DIRECTION
- FUTURE SWMF

FIGURE 1.2.1
MODEL BOUNDARIES

Project No.	Date.	Scale
060200141	JULY, 2013	1:15000

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DATE PLOTTED: July 23, 2013

1.3 Existing Reports Supporting Recent Development

Continued development in the basin has added storm water flow through Richmond. These offsite flows include drainage from 116th Street, the Vision West subdivision and the Centre West Subdivision. These subdivision areas were designed based on modeling of the whole basin and controls were placed to limit the flow of storm water into the Richmond area as per the West Annexation Lands Storm and Sanitary Study (WALSSS), (Stewart, Weir and Co. Ltd, 2004). This report noted that introducing more storm water into the Richmond storm system would not increase flooding volumes or durations within Richmond due to the timing of the release into the existing storm sewer system. This design report was not intended to address any flooding concerns within Richmond other than to show no increased flooding in the operation of the existing system.

The West Annexation Lands Study also showed the airport lands and part of S ½ 21-71-6-W6 south of the Centre West and Vision West Subdivisions draining to Richmond. These areas represent the top end of the drainage basin that eventually drains through Richmond. The Study indicated that the airport lands and nearby Brochu Industrial Park originally drained south and then east through Richmond. The current drainage pattern caused by the construction of Highway 43 drains these two areas to the east on the north side of Highway 43 past Westgate West and East and through Gateway commercial. This storm water flow creates overcapacity conditions in the storm sewer in and downstream from the Gateway development. The Study recommended directing the flow from the airport lands and Brochu Industrial Park back to its original flow path across the highway to the south through Centre West and into Richmond.

Additional flow was introduced in the Richmond storm system when the Alberta Transportation (AT) yard in the south east corner of the Richmond was redeveloped. The AT yard drainage was split with some flowing north into the Richmond system and the balance south through the Mission Heights storm sewer system

1.4 XPSWMM Storm Water Management Model

The XPSWMM model from the city, referred to as the 2004 model in this study, was last updated for the Grande Prairie Storm Drainage Master Plan 2004 (SDMP, Associated Engineering, 2004). The model had detailed coverage of the Richmond Industrial area. There has been significant land development in areas previously undeveloped when the 2004 SDMP model was prepared and the drainage from the undeveloped upstream catchment areas was not accounted for in the 2004 model. The catchment boundary for the 2004 model is shown in Figure 1.2.1.

The 2004 model drained to a free outfall located just east of Wapiti Road (108 Street) as if no restrictions in the ditches on the Canfor site present at that time. This means that the 2004 model did not account for the gentle channel slope of the Canfor ditches and the resulting backwater effect on the Richmond drainage system. This backwater effect is a significant factor in the flooding of areas on 89th Avenue east of Wapiti Road.

The SDMP 2004 indicated that calibration of the 2004 model had been done. The rainfall events and flow data provided in the report were mostly of smaller events but the largest event with correlating flow data was deemed acceptable for calibration. This was used to set the various parameters of the 20004 model to best replicate the flows experienced with the corresponding rainfall event.

1.5 Existing Flooding Records

Limited data was available regarding flooding in the Richmond area. The city records available for 2011 Runoff Service Requests show various locations that were investigated for either runoff or storm sewer issues. The locations and descriptions of these events are shown in Appendix 2. The dates and locations were noted and the historic weather was checked during and preceding each event. There was no correlation with rainfall events and therefore the incidents were deemed non-rainfall related events. Most of the events were in March and April and could have been due to snow melt as weather records showed freezing at night and above freezing temperatures during the day. Only 2.2mm of rain was noted in the days before the March event and no precipitation before the April event. The events in May and July were preceded by little or no rain.

Flooding events observed by city personnel during rainfall events were most useful in determining areas of concern. These observations were used to change the model to better reflect the actual observed events through adjustment of manhole rim elevations in the model. The main location with observed flooding is on 89th Avenue between 109th Street and Wapiti Road. A second location is north of the CNR tracks on the service road west of Wapiti Road. Both these locations are low lying relative to the rest of the immediate basin area.

1.6 Pre-development Storm Water Runoff

Storm water pre-development runoff rates for the Grande Prairie area have been studied at length in a number of documents and the results of these studies has varied significantly. These different results were evaluated in the 2004 Storm Water Drainage Master Plan with the conclusion that a rate of 5.0 l/s/ha should be adopted as the pre-development base runoff rate for the 1:100 year storm event for the City of Grande Prairie. This rate was chosen so that a pond could drain within a 96 hour time frame to have the available storage available for a subsequent storm.

Development or re-development of a property within the Richmond Industrial Park should provide flow controls and storage on the property. The storage should be based on the City's current standards of 5.0 l/s/ha and should be achieved with an orifice of 50mm diameter or greater. The discharge rate will be larger than 5.0 l/s/ha in cases where the lot size is less than 1.5 ha since the minimum orifice size would apply in these cases. The on lot storage should be calculated based on the change in usage of the lot, gravel to paved etc and as per the current standards should be based on the ultimate surfacing of the lot area being developed.

2.0 STORM WATER MANAGEMENT MODEL UPDATES AND RESULTS

The updates to the 2004 model included additions and modifications of the existing system. The boundaries of the 2004 Model and the Updated Model are shown in Figure 1.2.1. The additions included the Centre West and Vision West subdivisions, the undeveloped land south of these subdivisions, piping and ditches from Wapiti Road through the Canfor site to Bear River, new storm pond and area at Wapiti Road and 79th Avenue and new piping and storm pond on 116th Street. Modifications included checking model parameters, adjusting sub-catchment areas near 116th Street and around the old Alberta Transportation yard and updating rim elevations to better reflect the current grades and flooding conditions.

2.1 Model Parameters

The model parameters shown in Table 2.1.1 that are used in the Richmond study were based on the 2004 SDMP in which calibration to flow / rainfall events was undertaken. Since yard improvements and additional development in the basin has taken place since 2004, an analysis of imperviousness was done. The analysis was based on a 9 ha area taken on the north half of the industrial park. Buildings and roads were 100% impervious, yards (mostly rough gravel) were 50% impervious and grass or trees were taken as 20% impervious. A weighted average was taken of the various areas and their percentage imperviousness to arrive at 58% average imperviousness. Based on this rating the 60% used in the 2004 model has been kept for the 2012 Models. Sub-catchment area slope remained the same in the Richmond area and was entered into the parameters for the new areas based on record drawings at approximately 1%. Calibration of the 2004 SDMP models was based on other parameters with the percent imperviousness adjusted for land use only and therefore checked here.

Table 2.1.1 – Model Parameters – 100 Year 4 Hour Design Storm Simulation

MODEL PARAMETER – 100YR	2004 SDMP	2012 RICHMOND
Initial Abstraction	0 mm	0 mm
Initial Infiltration Rate	15 mm/hour	15 mm/hour
Saturated Infiltration Rate	3 mm/hour	3 mm/hour
Imperviousness	60%	60%
Mannings ‘n’ Impervious	0.014	0.014
Mannings ‘n’ Pervious	0.24	0.24
Depression Storage, Impervious	0 mm	0 mm
Depression Storage, Pervious	0 mm	0 mm

2.2 2012 Model Additions

The 2004 SDMP provided good coverage of the Richmond Industrial Park storm system existing in 2002. Since that time development within the Richmond limits and to the west has increased the amount of runoff flowing through the Richmond storm sewer system. The 2004 SDMP model was limited to only the Richmond area and did not include any offsite drainage from the undeveloped land to the west that would eventually come into the Richmond area. The 2004 WALSSS indicated flows from the Brochu and airport lands north of Highway 43 should be directed through Richmond via the Centre West development. The 2012 model does not have this connection since additional storage was provided by the Westgate west

storm pond east of Brochu to attenuate Brochu and possibly the airport storm flows. These changes allow the runoff from Brochu and airport lands to stay on the north side of Highway 43. The storm water runoff path from the airport lands was unclear from the data provided but in any case should not be transferred to the south side of Highway 43.

Storm water runoff from the Centre West and Vision West areas were added to the 2012 Model. Inverts and rim elevations for these additions were made based on record drawings of the areas and design reports. Undeveloped land south of these subdivisions was captured in the 2012 Model via a connection to the Centre West and Vision West ponds as recommended in the 2004 WALSSS. These undeveloped areas were modeled as undeveloped land and therefore must be changed to developed land in the model at a later time when development proceeds at a discharge rate and control to not adversely affect the Richmond system. Storm sewer connections for Centre West and Vision West to Richmond Industrial Park storm sewers were added to 116th Street manholes 57290 at 97th Avenue and 57294 at 96th Avenue. A Hydro-Brake ™ was used at manhole 57294 to limit the flow at this connection point and the existing 675mm diameter pipe downstream of manhole 57290 was the restriction at the northern connection point.

Other additions to the Richmond system included the 116th Street storm sewers and pond (west of 116th Street and south of the railway), development in the old Alberta Transportation yard site in the southeast corner of Richmond, addition of the 78th Avenue/Wapiti Road storm pond with catchment and the outfall piping and ditch through the Canfor site. These additions were made based on record drawings, LIDAR survey data, and a Focus survey of the Canfor ditch. In the AT yard area the sub-catchment areas were adjusted to match the final developed configuration. Changes on the Canfor site included adding 1050mm and 1800mm pipes, and then extending these with twin 2000mm culverts as well as adding four culvert crossings. Two areas of storm sewer were updated on 116th Street including a storm pond near the CNR-116th Street intersection, piping from 75th Avenue to 91st Avenue and north of the CNR to approximately 96th Avenue.

It is noted that in the fall of 2011 the drainage ditch sections through the Canfor site were cleaned of vegetation and sediment. This work improved the hydraulic characteristics of the ditch significantly. When the work was completed water was observed flowing from the drainage pipes that was held back by the build-up of sediment in the ditch. Additional sediment removal was required after the backed up water was released and deposited more material in the ditch. This restriction is noted as a significant concern and indicates monitoring and maintenance are needed on a regular basis to keep the stormwater pipes and channels functioning as intended. In one scenario the 2012 Model was modified to include sediment in the pipes of the Canfor site to investigate the effect flooding at node 57099-A, the low point on 89th Avenue. The sediment depth used in the 2012 Model of 600 mm was estimated based on photographs from the 2004 SDMP and observations taken when the cleaning was done in 2011.

2.3 Model Changes

The 2004 model with additions noted above was run to determine if observed flooding by City staff was reflected in the model. Based on the model results, rim elevations were adjusted in the lower reaches of the drainage basin, near possible storm ponds and along Wapiti Road. It was noted that no flooding occurred in the intersection of 89th Avenue and 109th Street at manhole 57099 of the preliminary updated model. The rim elevation of manhole 57099 at this location did not represent the actual physical elevation

and therefore was adjusted to reflect LIDAR elevations. Also the sag point between 109th Street and Wapiti Road on 89th Avenue was not present in the model. This sag location was added as manhole 57099-A with an elevation from LIDAR data and exhibited flooding as observed in actual storms.

2.4 Model Calibration

Flow monitoring data was available for manhole 57299 located on 114th Street between 97th and 98th Avenues and manhole 57028 located on 109th Street north of 89th Avenue. For manhole 57299, data included flows from the summers of 2008, 2009 and 2011 although only flows in 2011 were large enough to be considered in a calibration exercise. For manhole 57028 data was available for rainfall (service centre rain gauge) and flows but the events were very small (below 1:2 year storms) and flow data was estimated with depth due to a velocity probe failure. The 2011 available rainfall data was reviewed and rainfall for the Aquatera monitored gauges was available for storms matching larger events of 2011. The largest event of 2011 was less than a 1:2 year return period storm as recorded by the nearest rain gauges at Pump House 2 (PH2) and Pump House 3 (PH3). The closest rain gauge was at the Service Centre but the records at this location stopped on September 22, 2008.

A comparison of the recorded flow data and 2012 Model flow data at manhole 57299 for the rainfall during the period of July 6-14, 2011 was performed. The rain storms from the two closest rain gauges at PH2 and PH3 were used and the flow results at manhole 57299 were compared to the modeled flows. Gauge PH3 provided a flow pattern that matched quite well to the recorded flow data in shape but was significantly less than the actual flow magnitude as shown in Figures 2.4.1 and 2.4.2. To investigate the difference between the model and actual flow rates daily total data available from the Environment Canada gauge at the airport was useful for a general comparison of rainfall. The comparison of the daily totals at gauge PH3 and the airport gauge showed that the airport location generally received more rainfall in the selected period than gauge PH3. This generally matched the lower modeled flow rates using the PH3 gauge value. Other dates in 2011 did not match up rainfall and flow data patterns and were discarded prior to modeling.

Although there is a general trend of modeled flows for gauge PH3 following a pattern similar to the recorded flows, the flow magnitude difference is significant for manhole 57299. The Environment Canada gauge being closest to the monitoring site indicates heavier rainfall at the flow monitoring site than gauge PH3 would show. Based on these discrepancies in the available data, the model could not be calibrated any further than the 2004 model.

Future flow monitoring data should be collected starting early spring with a corresponding rain gauge at a nearby location to allow for model calibration. No changes to the model parameters were made.

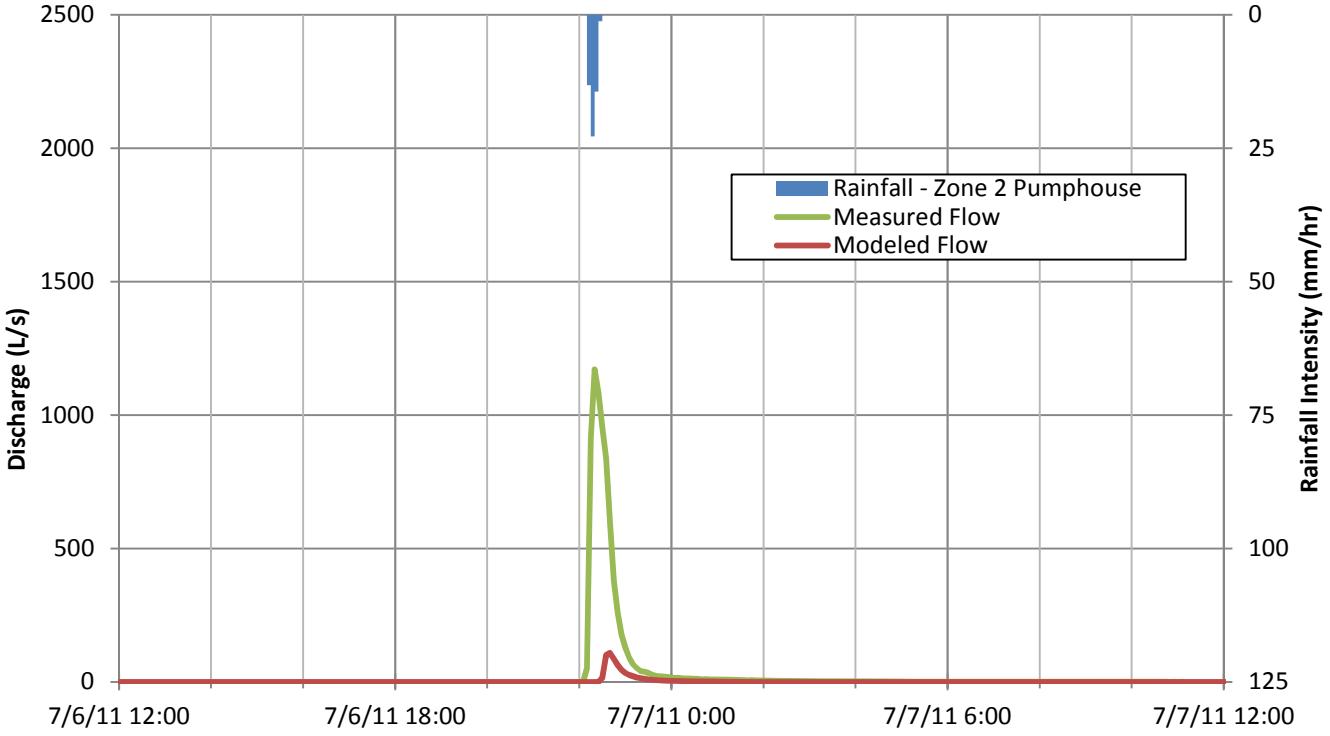


Figure 2.4.1
Manhole 57299 - July 6, 2011

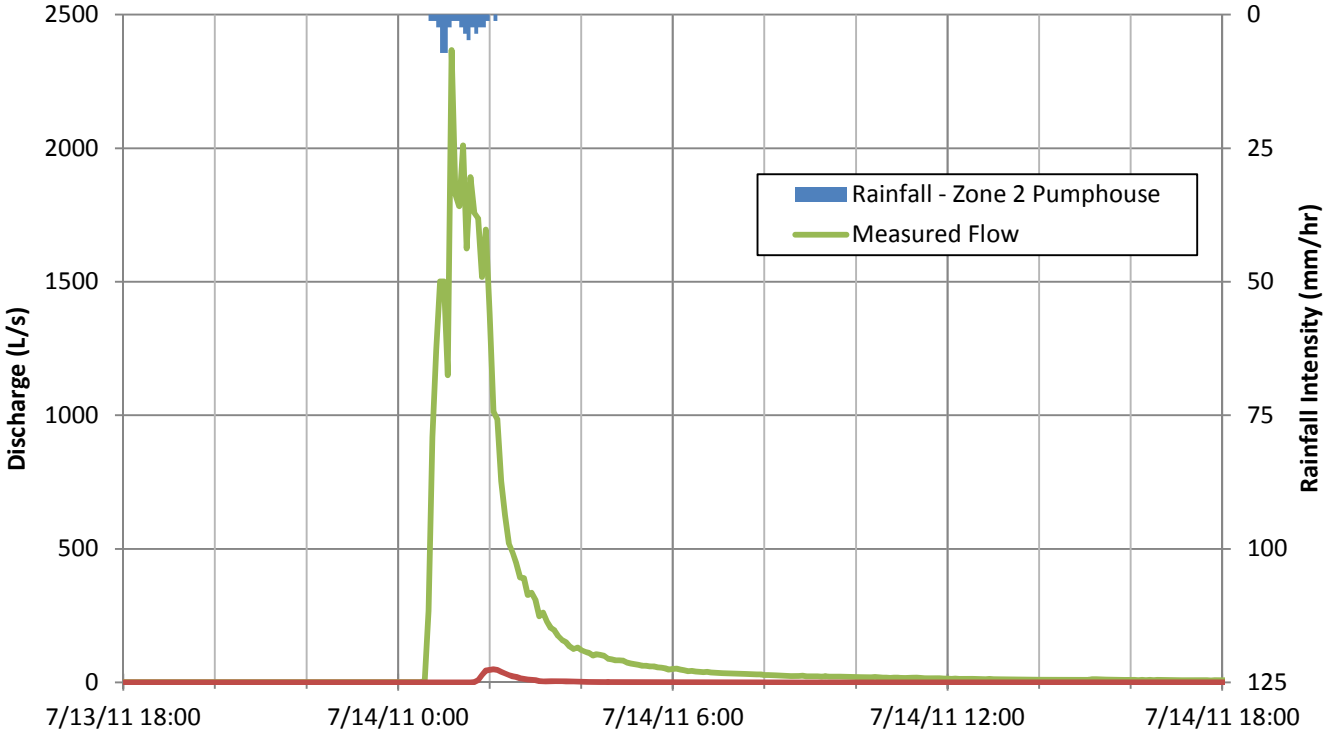


Figure 2.4.2
Manhole 57299 - July 14, 2011

2.5 Flood Mitigation Measures - Infrastructure

Focus investigated the addition of storage, increased lower basin pipe conveyance and control of water flowing into the Richmond storm sewers. The potential storage locations included the rail spur right-of-way on 112th Street, the area near Wapiti Road / CNR railway and sag storage. Piping improvements across Wapiti Road to the Canfor site and additional controls or changes in piping for sewers on or crossing 116th Street were also investigated.

Two types of storage were investigated during the process of finding effective solutions to reduce flooding in Richmond. The first type was storage in storm ponds where a large volume of water could pool temporarily and drain back into the system once capacity was available. The second type of storage reviewed was distributed storage at catch basins in sag location created by limiting the flow of water into the connection to the storm system from the catch basin. The storm runoff would be forced to pool on the surface in smaller amounts than the ponds and then drain into the system slowly as the capacity of the pipes returned.

Using LIDAR survey data, profiles along the roads through Richmond were prepared to examine road slope as well as identify sag locations. Richmond roads have few sag locations typical of the rural road cross-section present when the subdivision was first developed. The use of sag locations alone to provide storm runoff storage would not provide enough storage to significantly reduce flooding in Richmond. Typical commercial – industrial subdivisions require in the order of 600 m^3/ha of storage or 153,000 m^3 for the area in the Richmond model. As a comparison the WALSS Study recommended approximately 620 m^3/ha.

Adding storage at the approximately 60 sag locations would provide a very small amount of storage with an average of approximately 70 m^3 per location. Additionally, surcharge of sewers to surface is already causing ponding at many of the sag locations in the basin. A model was created that simulated storage at all catch basins in the Richmond area by allowing ponding at each manhole in the model. This was done to see what the net effect of distributed storage would have on the flows in the basin. There were 83 manhole locations that had shown a storage of over 20 m^3. The storage per manhole location ranged from 30 to 1,100 m^3 with an average of 380 m^3. Storing this amount of water at each of these manholes would help the situation in the lower reaches of the basin but would require significant installations of road side swales to accomplish the modeled storage volumes essentially reverting back to a system similar to ditches. Space to construct this road side storage is limited at best.. Based on this analysis our focus was on larger storage locations and additional piping that are centred in a couple of areas to hopefully simplify the mitigation process. Where possible localized ponding should be implemented since the dynamics of the storm sewer system will function better with additional storage wherever it can be obtained and operated where there is little chance of hazard to the public and property.

The location of the storm pond storage areas were selected from vacant city land where possible and privately owned undeveloped land in the basin that was located upstream of the low area of the basin on 89th Avenue. The city currently owns the old railway spur line parcels of land in the middle of Richmond that meet these requirements specifically Lot U8, Plan 1289TR; Lot 11U, Block 4, Plan 7822458 and Lot 15U, Block 6, Plan 7822458. In the land directly south of 89th Avenue (Lot U8) there is already a drainage ditch along the west edge of the lot which would be expanded to the full lot width and deepened to create storage. Additionally there is some undeveloped land that could be used for a storm water storage facility

construction located near Wapiti Road south of the railway. In each of these sites the land contours from the LIDAR survey data were used to create a preliminary design for the individual storage facilities so that more accurate facilities could be added to the model. Detailed surveys of these areas will have to be performed for final design purposes.

A model was also run with proposed storage in the Canfor site to simulate an end of pipe/ditch storage option. In this option the proposed storage sites in Richmond were removed and a large 2000mm diameter pipe was placed between 109th Street and the end of the twin 2000mm diameter Canfor culverts to move as much water out of the lower end of Richmond into the proposed Canfor storage. This reduced the flooding in the low area on 89th Avenue; left flooding in other areas of Richmond relatively unchanged and increased the flow in the Canfor ditch. The storage provided on the Canfor ditch was not used efficiently because water could not get through the piping in the Richmond system in a timely manner even with the addition of the 2000mm diameter pipe across Wapiti Road. In addition to the low storage utilization of a potential pond on the Canfor site, the proposed pipe across Wapiti Road would be a large engineering and construction challenge.

2.6 Flood Mitigation Measures – Maintenance

Based on comments from city personnel and observations taken during the cleaning of the Canfor ditch ongoing monitoring and maintenance of the storm sewer system should be done. The significant backwater caused by sediment build up in the Canfor ditch restricts flow from the system and increases the chances of a flood event occurring. It is recommended that storm sewers in the Richmond area be monitored and cleaned as necessary and the date, location and type of maintenance recorded. The results of this monitoring and record keeping will provide the information to develop a scheduled cleaning program. A condition score program can also be developed so that the sewers can be monitored on a regular basis to keep them in the best operating condition possible.

2.7 Model Scenarios

Based on the city design standards, the models were evaluated using the city's 4 hour design storms with return periods of 5 years and 100 years. These storms will be referred to as 5 year and 100 year storms in this report. The 5 year storm was used to calculate a pipe utilization percentage as well as investigate the flooding that occurs in the smaller storm events and is shown in Figure 2.7.1. The majority of modeling used the 100 year storm and determined what affect the added storage facilities and infrastructure changes would have on the overall system flooding response.

The location of the modeled flood mitigation options are shown on Figure 2.7.2. The details of the individual options are shown in Table 2.7.1 below.

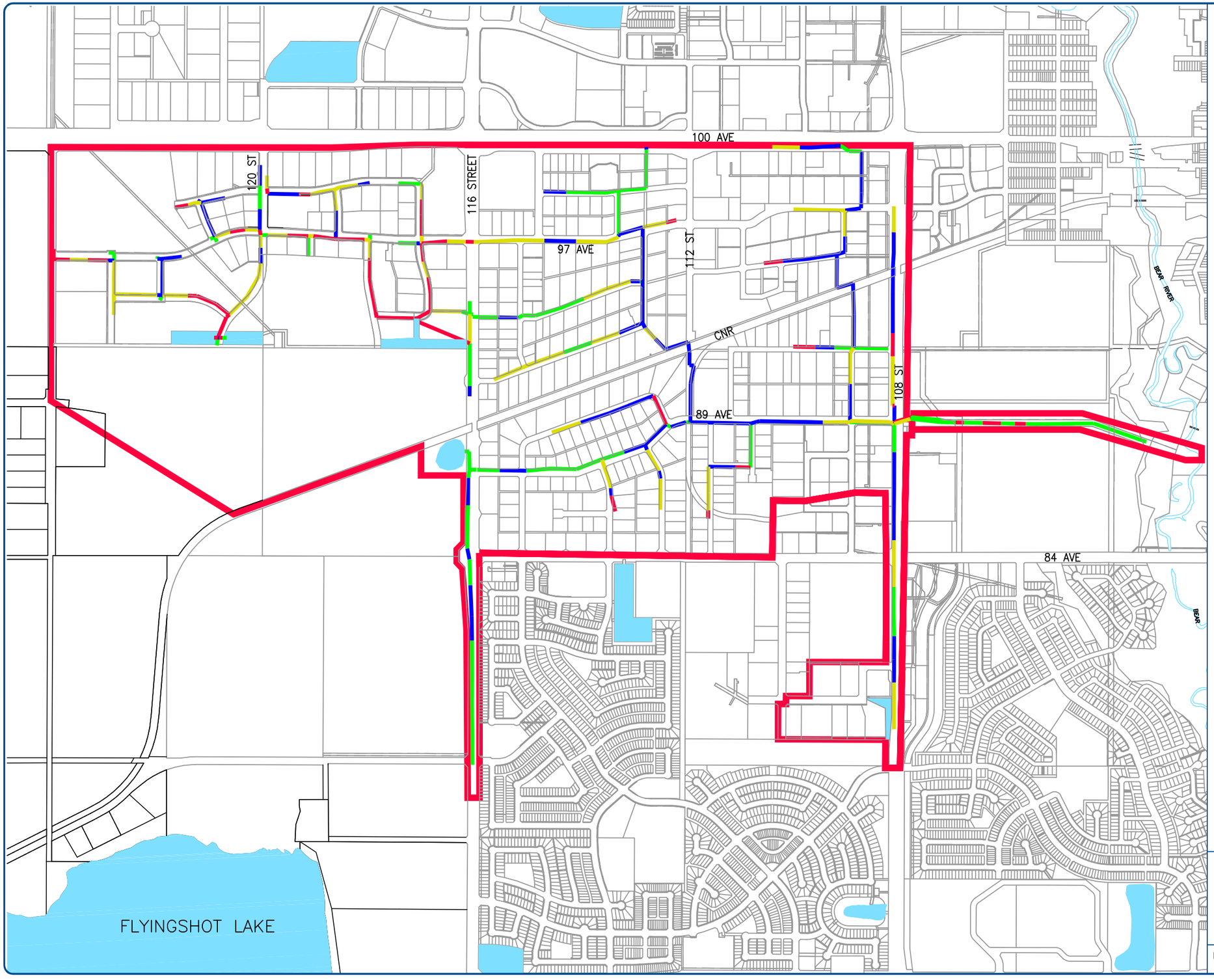
Table 2.7.1 – Flood Mitigation Options

MITIGATION MEASURE	LOCATION	DESCRIPTION
1. North Lot U8 Storage	On the extension of 112th Street, South of the CNR ROW in existing PUL.	1,800 m^3 provided
2A. South Lots U8 & 11U Storage	Old rail spur ROW south of 89th Avenue to 111A Street	10,400 m^3 provided 900 mm dia orifice
2B. South Lot 15U Storage	Old rail spur ROW east of 111A Street	3,050 m^3 provided
3. Wapiti Road Conveyance	Piping from the low point on 89th Avenue across Wapiti Road to the Canfor site.	Size varies depending upon other measures implemented. Due to significant existing buried utilities in the area space for piping is an issue.
4. Wapiti Road /CNR Area Storage	1.5 hectare near the CNR, and Wapiti Road	26,700 m^3 provided in the model
5. Flow control from Centre West	Manhole 577819, 97th Avenue connection point from Centre West	500 mm dia orifice control to force water to Centre West pond & reduce 116th St flooding
6. Flow control from Centre West	Manhole 577831, 96th Avenue connection point from Centre West	400 mm dia orifice control to force water to Centre West pond & reduce 116th St flooding
7. Dedicated storage – 116th Street	Near Centre West pond, west of 116th Street	10,500 m^3 provided

The model scenarios are shown in Table 2.7.2 below. Models A to D vary the options applied to the model in the Richmond area with orifices and storage added to 116th Street. Models A-1 to D-1 are the same as A to D but without the additional infrastructure on 116th Street. Models E-1 to E-4 have the additional infrastructure in Richmond and varying infrastructure on 116th Street. A model with distributed storage, Model F1, not shown in Table 2.7.2 was created to simulate storage at catch basins in Richmond to investigate the possible storage volumes and locations as noted in section 2.5.

Table 2.7.2 – Model Scenarios Matrix

LOCATION DESCRIPTION TYPE	1 N LOT 8U STORAGE	2 S LOT 8U STORAGE & ORIFICE	3 WAPITI RD PIPE	4 WAPITI RD STORAGE	5 97 AVE ORIFICE	6 96 AVE ORIFICE	7 116 ST STORAGE
MODEL A	***Y***	***Y***	***N***	***Y***	***Y***	***Y***	***Y***
MODEL B	***Y***	***Y***	***N***	***N***	***Y***	***Y***	***Y***
MODEL C	***N***	***N***	***N***	***Y***	***Y***	***Y***	***Y***
MODEL D	***N***	***N***	***Y***	***N***	***Y***	***Y***	***Y***
MODEL A1	***Y***	***Y***	***N***	***Y***	***N***	***N***	***N***
MODEL B1	***Y***	***Y***	***N***	***N***	***N***	***N***	***N***
MODEL C1	***N***	***N***	***N***	***Y***	***N***	***N***	***N***
MODEL D1	***N***	***N***	***Y***	***N***	***N***	***N***	***N***
MODEL E1	***Y***	***Y***	***N***	***Y***	***Y***	***Y***	***N***
MODEL E2	***Y***	***Y***	***N***	***Y***	***N***	***N***	***Y***
MODEL E3	***Y***	***Y***	***N***	***Y***	***N***	***Y***	***Y***
MODEL E4	***Y***	***Y***	***N***	***Y***	***Y***	***N***	***Y***
2012 Model	***N***	***N***	***N***	***N***	***N***	***N***	***N***



RICHMOND INDUSTRIAL STORM DRAINAGE BASIN STUDY GRANDE PRAIRIE

LEGEND:

2012 MODEL BOUNDARY

PIPE UTILIZATION = $\frac{\text{PEAK FLOW}}{\text{PIPE CAPACITY}}$

- < 0.80
- 0.80 - 1.20
- 1.20 - 2.00
- > 2.00

FIGURE 2.7.1
1:5 YEAR EXISTING PIPE UTILIZATION

Project No.	Date.	Scale
060200141	JULY, 2013	1:15000

DATE PLOTTED: July 23, 2013
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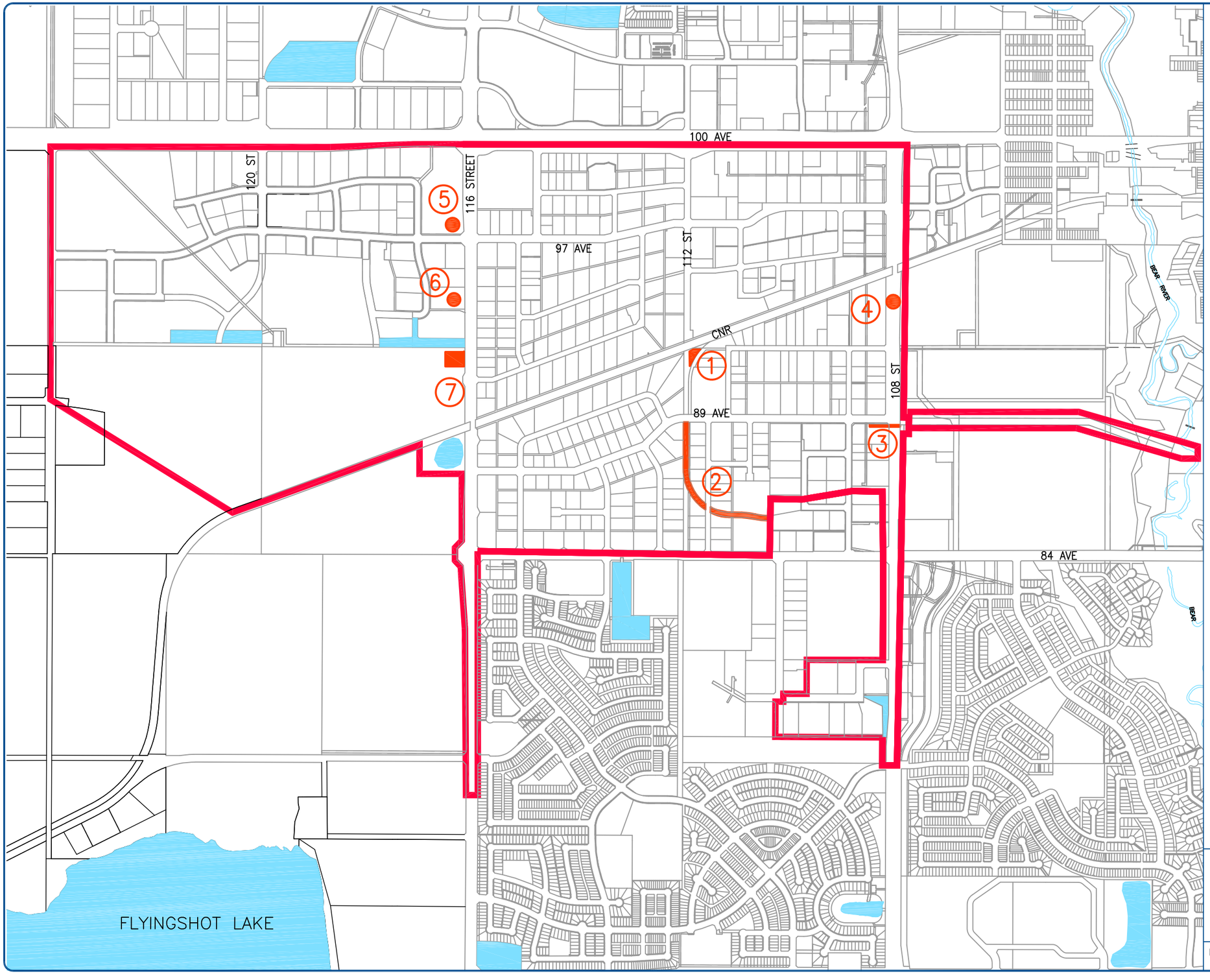


RICHMOND INDUSTRIAL STORM DRAINAGE BASIN STUDY GRANDE PRAIRIE

LEGEND:

- 2012 MODEL BOUNDARY
- ① NORTH LOT 8U STORAGE
- ② SOUTH LOT 8U STORAGE
- ③ WAPITI ROAD CONVEYANCE
- ④ WAPITI RD / CNR STORAGE
- ⑤ 97 AVE FLOW CONTROL
- ⑥ 96 AVE FLOW CONTROL
- ⑦ 116 STREET STORAGE

FIGURE 2.7.2

PROPOSED 2012 STORM DRAINAGE MITIGATION LOCATIONS

Project No.	Date.	Scale
060200141	JULY, 2013	1:15000

CAD FILE NAME: N:\060200141 - City of GP Stormwater Master Plan\Engineering\060200141\Reports\Richmond Industrial\CAD files\Report Figures\060200141 - RICHMOND FIGURES.dwg
DATE PLOTTED: July 24, 2013

2.8 Model Results

The 2012 Model was used as a baseline to judge the effectiveness of changes to the Richmond storm system. Manhole flooding was observed in the 2012 Model in the low areas on 89th Avenue near 109th Street as well as flooding on 116th Street near 97th Avenue. These and other areas showing flooding are plotted on Figure 2.8.1 which is based on a 2012 Model without any additional storage. The extent of manhole flooding is represented by coloured dots at the location of each manhole. The majority of manholes showed flooding of less than 2,000 m^3 of water. The most significant locations were chosen based on flooding observed in the 2012 Model with the 100 year storm. The top 15 manholes with the highest volume of flooding were chosen to evaluate the mitigation measures. The locations, manhole numbers and model flood volumes in cubic metres for the top seven manholes are shown in Table 2.8.1. The following analysis uses the flood volume as a gauge of effectiveness of the various scenarios presented. The flood volume at a manhole in the PCSWMM software represents the volume of water that exits the model at the manhole and is lost to the model. Water will exit a manhole when the surcharge condition in the pipe exceeds the rim elevation entered in the model for a manhole and therefore flood volume was chosen as it represents the system's ability to contain and convey storm runoff.

Table 2.8.1 – Significant Model Flooding Locations – Existing System

LOCATION	MANHOLE NUMBER	FLOOD VOLUME
On 116th Street at 96th Avenue extension	577832	11,000
N of CNR, at the southerly extension of 109th Street	57033	4,100
Sag location on 89th Avenue between Wapiti Road & 109th Street	57099-A	3,700
Sag location on 110A Street between 88th & 89th Avenues	57111	3,500
109th Street & 92nd Avenue	57030	2,500
96th Avenue between 110th & 111th Street	57059	2,100
89th Avenue & 110A Street	57110	1,800

The added storage was evaluated based on the flooding volume within the models with specific observation of the effect on manhole 57099-A, the low point on 89th Avenue. Depending upon the various modifications that were made to the model, the amount of flood volume reported at the manholes of interest changed. An attempt was made to balance the effect on the system as eliminating the surface flooding in one location often shifted it to another as was observed at location 2 when running trials to size the orifice used here. Locations of the modifications are shown on Figure 2.7.2.

The general trend was that the changes in the model along 116th Street did not affect the flooding in Richmond and vice versa. The farther away from the location of a change in the system, the less of an

impact that change had on the flow at a selected manhole. Since the flows from the West Annexation lands are controlled, changes to storm sewers on or near 116th Street had only a small effect on Richmond storm sewers except those that are adjacent to the connection points on 96th and 97th Avenues. Figures 2.8.2 to 2.8.6 present manhole flood volume data for the top fifteen manholes that showed the most flooding in the 2012 Model. These manholes include those in Table 2.8.1 plus an additional eight chosen in decreasing order of manhole flooding observed in the 2012 Model. The title of each graph is the manhole number in the model plus a one word descriptor 116St, West or Richmond representing the general location of the manhole as along 116th Street, in Vision West or Centre West and in Richmond Industrial respectively. As a before and after comparison, Figure 2.8.1 shows the 2012 Model and Figure 2.8.7 shows the flooding volumes with all mitigation measures used in Model A. Model A included all measures except the pipe across Wapiti Road.

2.8.1 Model Results - Richmond

The addition of storage at locations 1, 2 and 4 was effective in reducing flooding in the low area of 89th Avenue. An additional pipe under Wapiti Road was effective in reducing flooding at manhole 57099-A when no other measures were taken within Richmond. Storage at location 2 was effective only after the addition of an orifice which forced the pipe flow into the location 2 storage. Flow restrictions were not needed at locations 1 and 4 since other restrictions in the system allowed surcharge into these storage locations during runoff events.

For storage in location 2 the orifice sizing was done through multiple runs of PCSWMM with different orifice sizes. The variables used in the sizing of the orifice were amount of water stored, the effect on downstream manholes and the effect on upstream manholes. It was determined that an orifice of approximately 900 mm diameter balanced the amount of water stored, and the flooding both upstream and downstream of the storage area. The most effective combination of mitigation measures was providing storage at locations 1, 2 and 4. Without location 4 there was still a significant reduction of flooding at manhole 57099-A as can be seen in Figure 2.8.2.

The effectiveness of additional piping across Wapiti Road varied based on other mitigation measures used. When storage at locations 1, 2 and 4 were used the effect of additional conveyance under Wapiti Road was negligible. When storage was removed from the system an extra Wapiti pipe operated and reduced flood volumes at manhole 57099-A but caused additional flooding on the east side of Wapiti Road in the Canfor site. The increased flow rates through the Canfor site may cause additional erosion and deposition into Bear River. The optimum solution should reduce both flooding in the Richmond low areas and minimize the flow rate through the Canfor site.

2.8.2 Storage Utilization – Richmond

Storage added to the Richmond system was added to the maximum possible volume attainable in the space available. The amount of storage provided and the amount of storage used is shown in Table 2.8.2. Detailed design of the size and shape of the storage facilities will be required to optimize the size and shape of the storage facilities to ensure the optimum performance. Since this preliminary design is based on a LIDAR surface, a detailed topographical survey would also be required to complete a design suitable for construction.

Table 2.8.2 – Richmond – Mitigation Storage Utilization – Model 'A'

LOCATION NO. & DESCRIPTION	VOLUME PROVIDED (M^3)	VOLUME USED (M^3)
1. North Lot U8 Storage	1,800	1,800
2A. South Lots U8 & 11U Storage	10,400	9,105
2B. South Lot 15U Storage	3,050	2,890
4. Wapiti Road /CNR Area Storage	26,700	11,950

In the model runs, the storm system was allowed to use as much of the provided storage as possible. The invert of the storage was as low as deemed practical for the respective locations. The storage provided at location 2 was connected to manhole 57140 and was envisioned to be similar to the Centre West and Vision West ponds with a very low slow bottom and French drain to maintain the bottom of the storage in as dry a condition as possible. It was modeled with a connection across 111A Street to additional storage at location 2B. Other controls may be used to increase utilization of location 4 but the objective of flood reduction was met with the storage provided.

2.8.3 Model Results 116th Street

The flow from the West Annexation areas was designed to limit the effect on the Richmond system and based on the models this condition is present. The use of the storage facility volumes in Centre West and Vision West was less than expected and may have contributed to observed model flooding on 116th Street based on the analysis of the 2012 Model. In an attempt to increase this storage usage and reduce flooding on 116th Street, additional orifices were modeled on the connection to 97th and 96th Avenue storm sewers. Also a separate storage facility, independent from the Centre West storage facility, was modeled for the runoff from 116th Street.

Manhole 57290-A, on the west side of 116th Street at 97th Avenue, benefited the most from the orifice immediately to the west at location 5 on Figure 2.7.2. This orifice slowed flows to limit flooding at the 97th Avenue intersection.

Manhole 577832 showed the most flooding in the whole drainage basin, that is, across Richmond, Centre West and Vision West. A combination of factors were suspected to be the cause of this flooding including the recent connection of the 116th Street storm sewer directly to the Centre West pond, the elevation drop between the Centre West pond high water level and the rim elevation on 116th Street and the lack of capacity in the Richmond system during initial stages of the design storm events modeled. Stepping through the operation of the 2012 Model storm system on 116th Street shows water flowing from 116th Street through the direct connection to the Centre West pond as expected. As the model run continues, the Centre West pond capacity is used by the Centre West drainage area and the flow through the direct connection to 116th Street is reversed in direction allowing water to flood onto 116th Street from manhole

577832. The outflow of runoff water in the 116th Street pipe system is limited by the Hydro-Brake ™ installed for the west annexation lands development at manhole 577832 on 97th Avenue and 116th Street. Since this restriction of storm water runoff flow to the Richmond system is required to protect the downstream piping, its removal was not an option and other solutions were investigated.

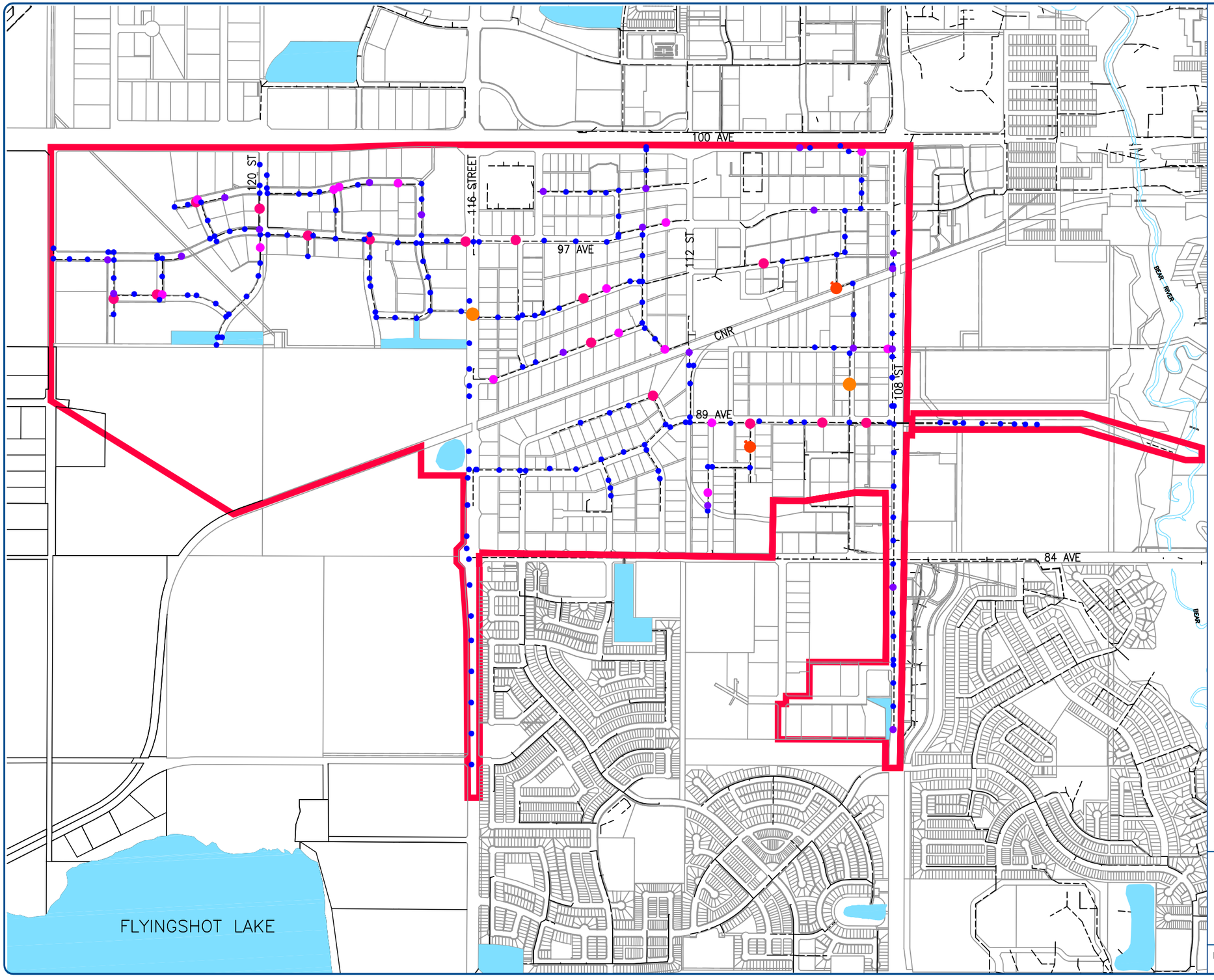
The three solutions looked at for flooding on 116th Street at Manhole 577832 east of the Centre West pond were the use of a flap gate on the 116th Street connection, use of an orifice to restrict flows to 116th Street from the Centre west system and adding exclusive storage facility for the 116th Street drainage. The orifice was placed in the model at location 6 and the storage was added at location 7 as shown in Figure 2.7.2. By using an orifice alone, the pond surcharge onto 116th Street continued and flooding was not significantly changed. Using an orifice with the flap gate was better but there was still significant flooding on 116th Street. Replacing the direct connection from 116th Street to the Centre West pond with a connection to a new exclusive storage and the use of an orifice at location 6 resulted in the best reduction in flooding at manhole 577832.

2.8.4 Storage Utilization – 116th Street

The new storage was sized based on the orifice in use at location 6 and checking various storage sizes. Providing 10,500 m^3 of storage reduced flooding to less than 100 m^3 at manhole 577832 and increased volumes of storage did not provide significant reductions in flooding. The storage volumes modeled are shown in Table 2.8.3.

Table 2.8.3 – 116th Street Storage Sizing

TOP OF PONDING AREA (M^2)	VOLUME PROVIDED (M^3)	VOLUME USED (M^3)	MANHOLE 577832 FLOOD VOLUME (M^3)	FLOODING DECREASE (M^3)
1770	2100	1421	3487	-
3050	4200	2818	2383	1104
4260	6300	4214	1434	949
5440	8400	5613	578	856
6600	10,500	6917	23	555



RICHMOND INDUSTRIAL STORM DRAINAGE BASIN STUDY GRANDE PRAIRIE

LEGEND:

2012 MODEL BOUNDARY

FLOOD VOLUME (M^3)

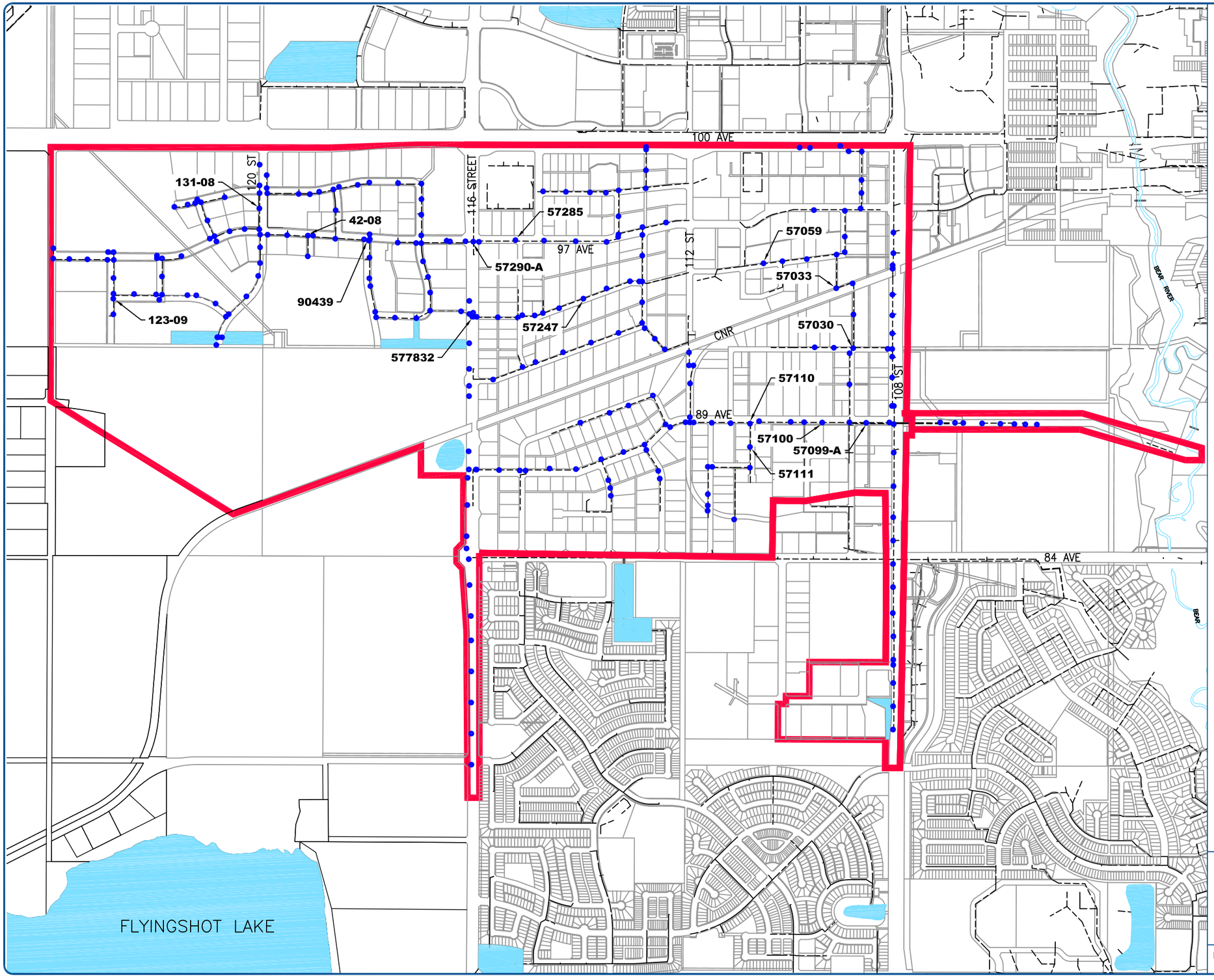
- 0-100
- 100-500
- 500-1000
- 1000-3000
- 3000-6000
- 6000+

FIGURE 2.8.1
2012 MODEL MANHOLE FLOODING VOLUMES

Project No.	Date.	Scale
060200141	MAY, 2013	1:15000

CAD FILE NAME: N:\060200141 - City of GP Stormwater Master Plan\Engineering\060200141\Reports\Richmond Industrial\CAD files\Report Figures\060200141 - RICHMOND FIGURES.dwg

DATE PLOTTED: July 23, 2013



RICHMOND INDUSTRIAL STORM DRAINAGE BASIN STUDY GRANDE PRAIRIE

LEGEND:

- 2012 MODEL BOUNDARY
- MANHOLE
- 57099-A — MANHOLE NUMBER

FIGURE 2.8.2
2012 MODEL SELECTED MANHOLE INDEX PLAN

Project No.	Date.	Scale
060200141	JULY, 2013	1:15000

CAD FILE NAME: N:\060200141 – City of GP Stormwater Master Plan\Engineering\060200141\Reports\Richmond Industrial\CAD files\Report Figures\060200141 – RICHMOND FIGURES.dwg

DATE PLOTTED: July 24, 2013

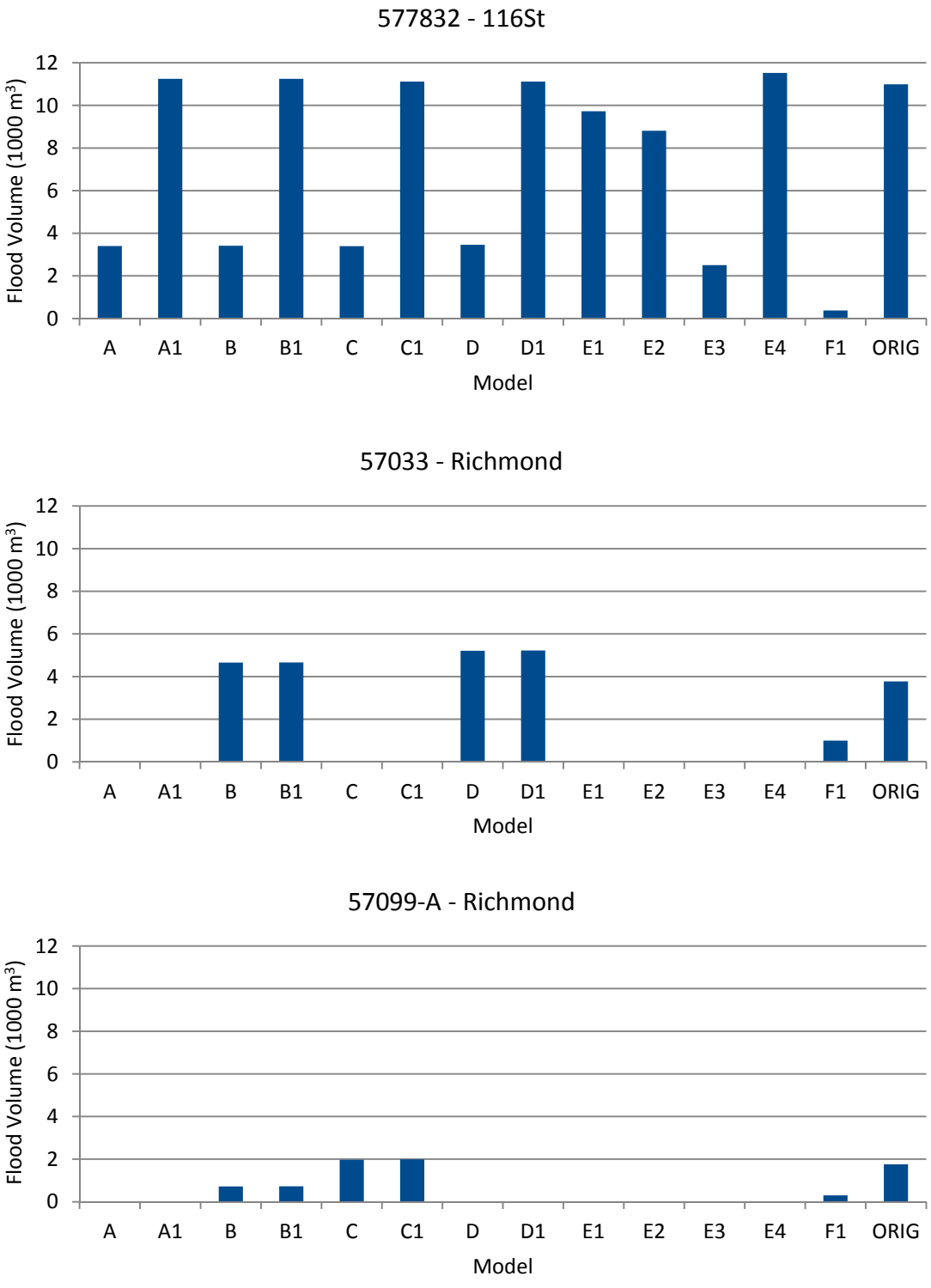


Figure 2.8.3
Flood Volumes - 2012 Modified Models

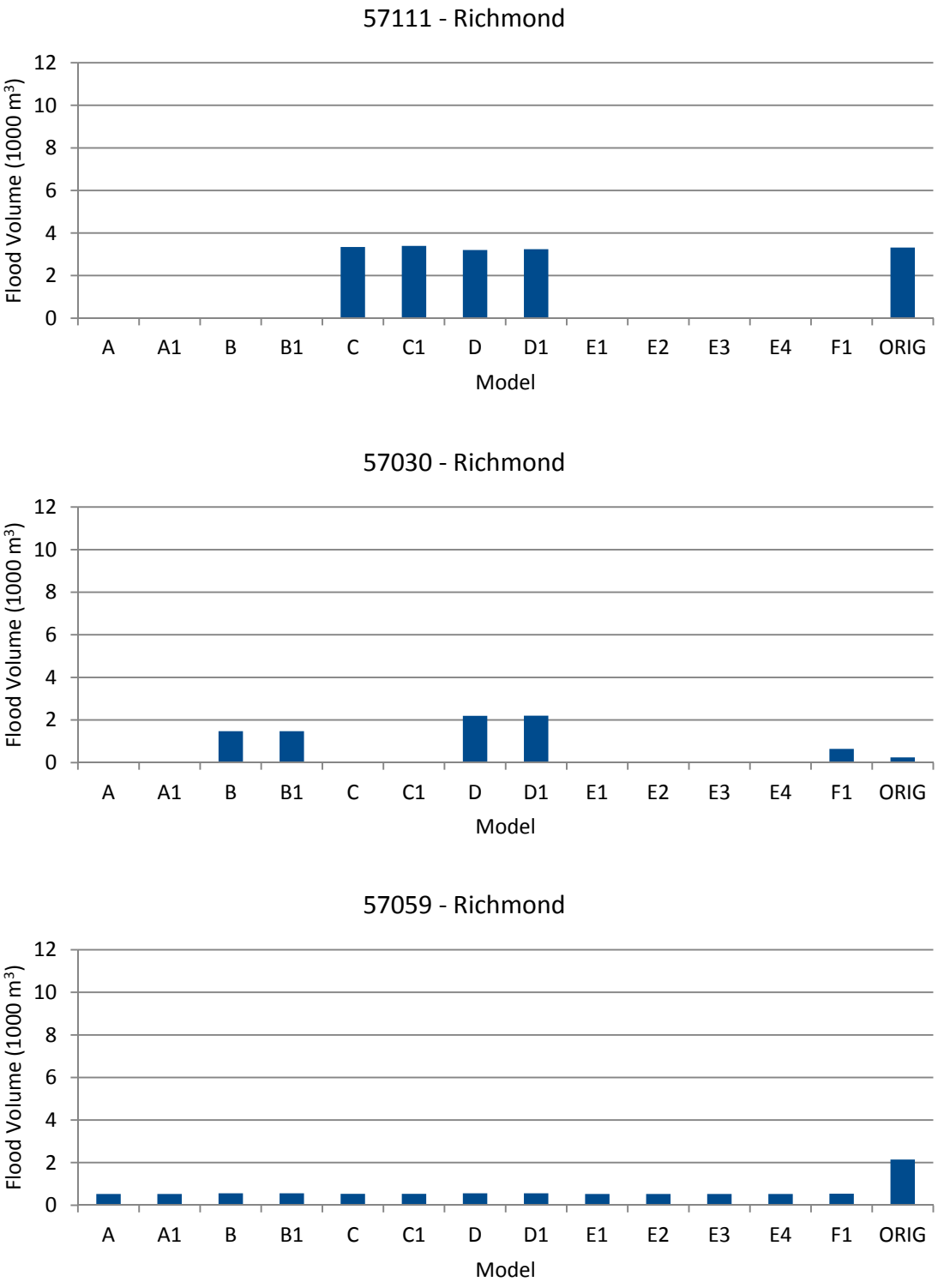
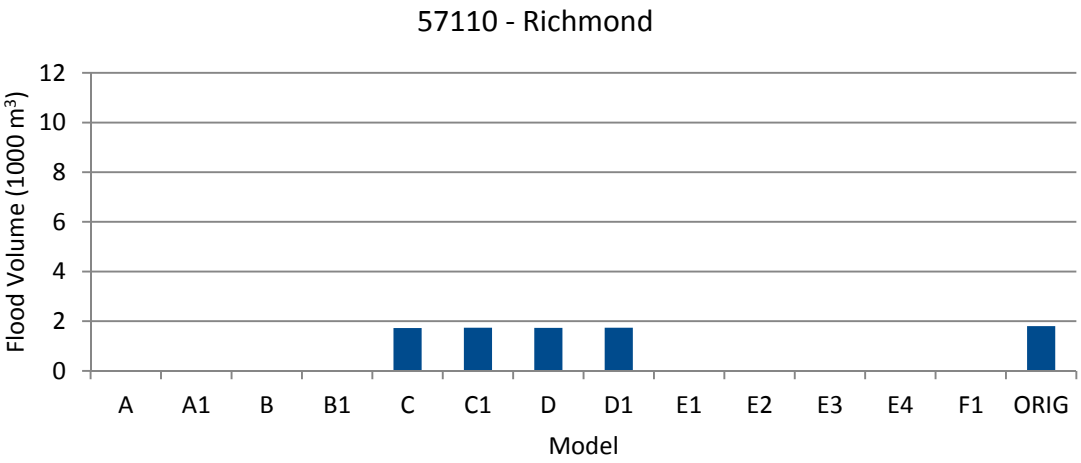
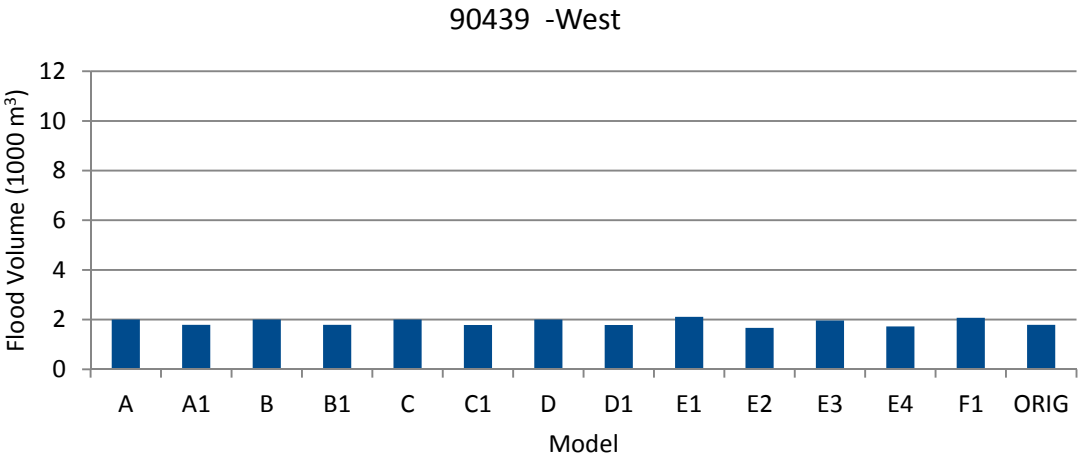


Figure 2.8.4
Flood Volumes - 2012 Modified Models





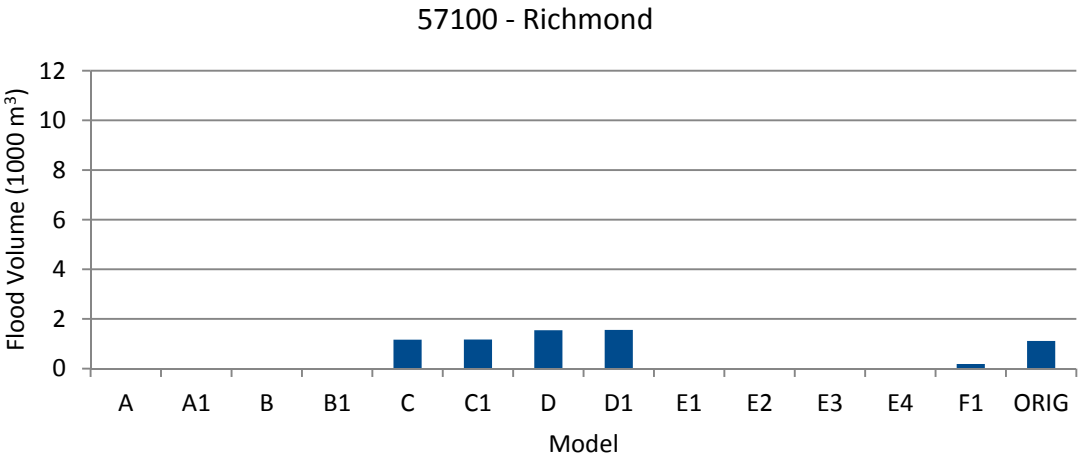


Figure 2.8.5
Flood Volumes - 2012 Modified Models

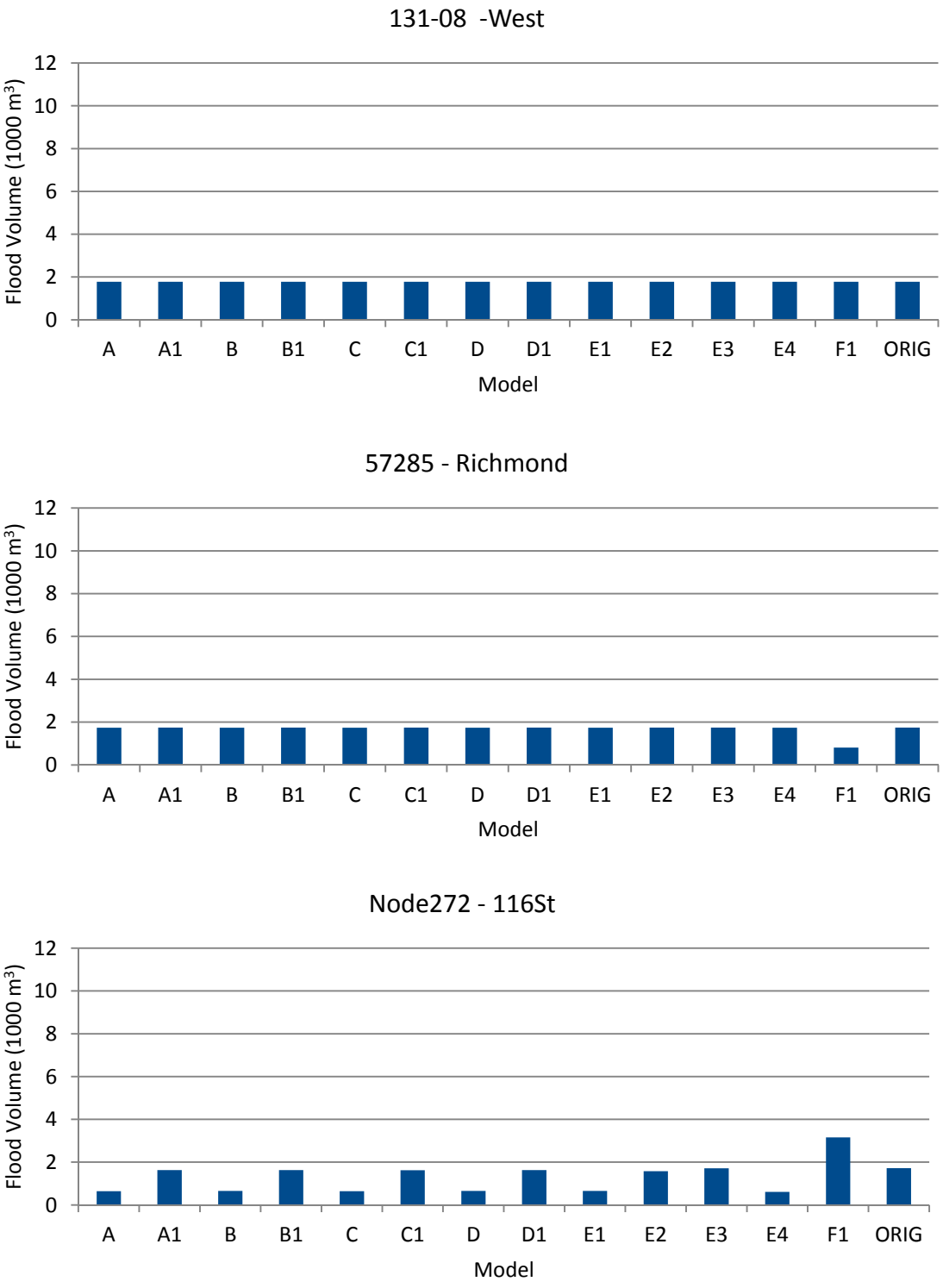
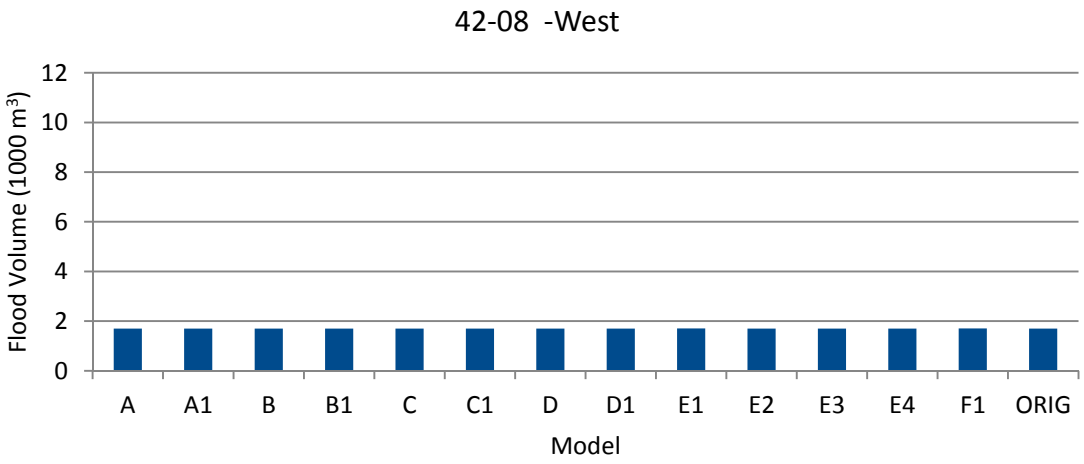
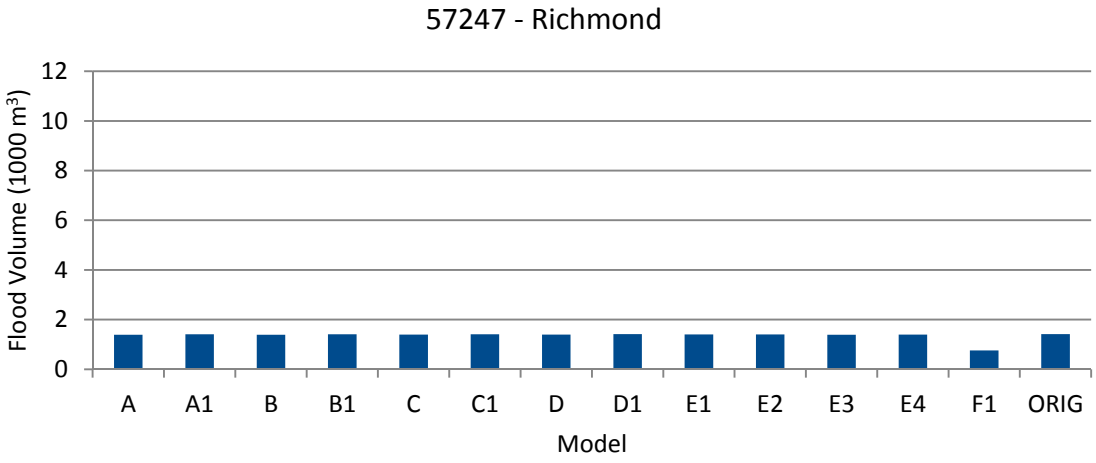


Figure 2.8.6
Flood Volumes - 2012 Modified Models





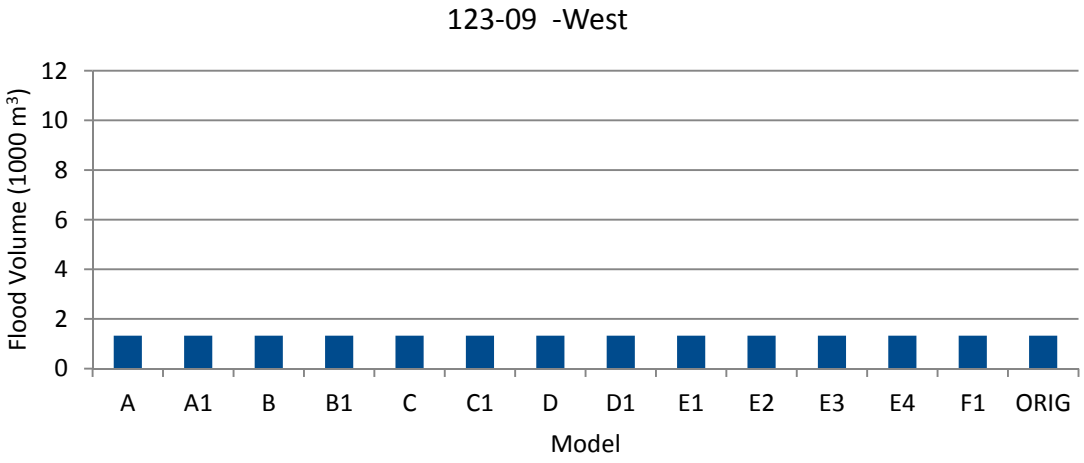
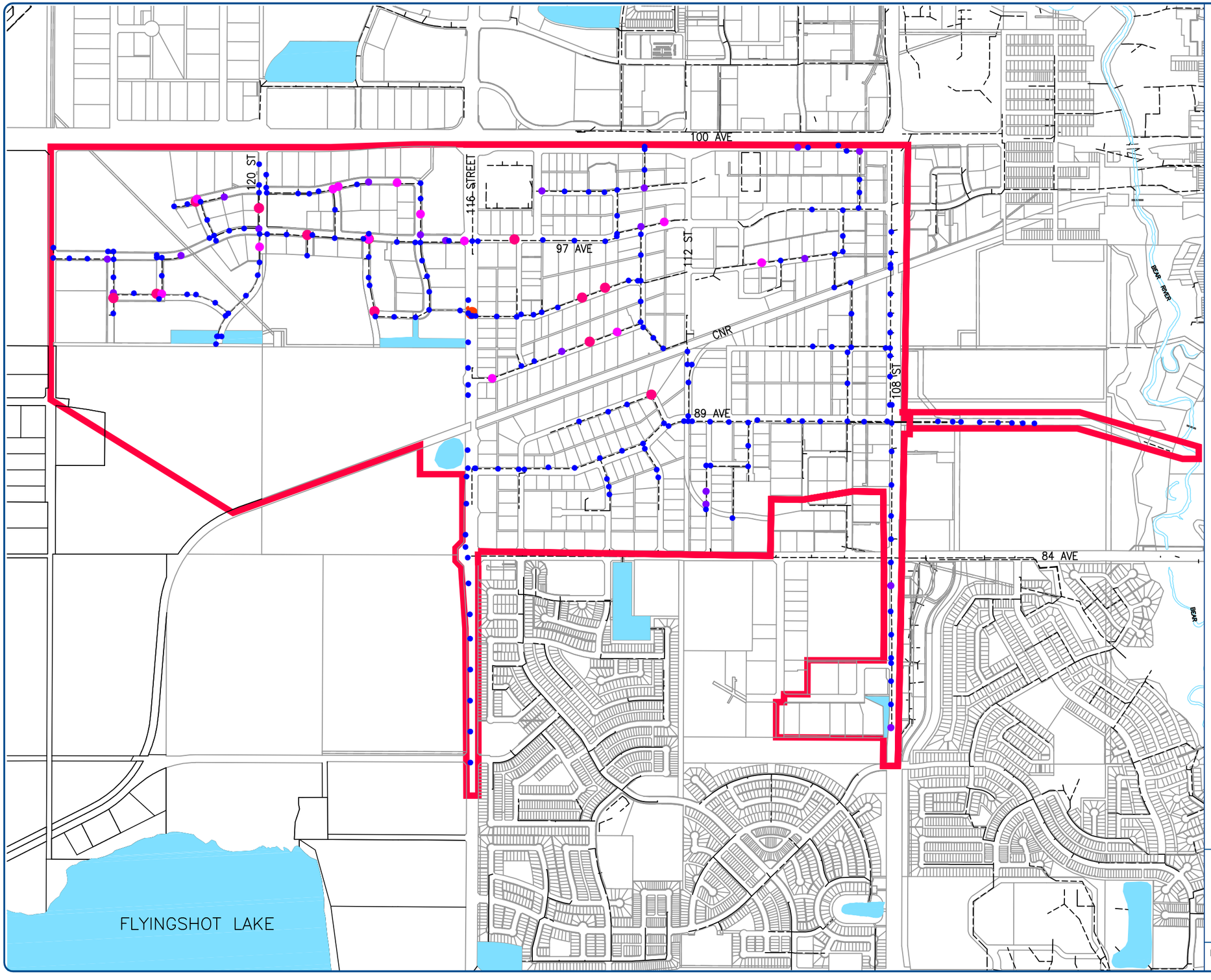


Figure 2.8.7
Flood Volumes - 2012 Modified Models



RICHMOND INDUSTRIAL STORM DRAINAGE BASIN STUDY GRANDE PRAIRIE

LEGEND:

2012 MODEL BOUNDARY

FLOOD VOLUME (M^3)

- 0-100
- 100-500
- 500-1000
- 1000-3000
- 3000-6000

FIGURE 2.8.8
2012 MODEL 'A' MANHOLE FLOODING VOLUMES

Project No.	Date.	Scale
060200141	JULY, 2013	1:15000

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DATE PLOTTED: July 23, 2013

2.9 Option Costs

The cost of each option suggested in the analysis done for this study are presented as budget numbers that includes the cost of design, construction and commissioning as required. Storage planned for locations 1 and 2 will require the removal of private materials currently stored on the city lots. It appears that the nearby businesses have expanded their yards into these areas for storage or driving lanes. This work to coordinate the removal of private materials and fencing as required would be a cost to the city but is not included in these numbers.

Table 2.9.1 – Mitigation Measures – Order of Magnitude Costs

LOCATION / DESCRIPTION	MITIGATION IMPROVEMENT COST
1 – North Lot 8U Storage	$180,000
2 – South Lot 8U Storage	$1,121,000
3 – Wapiti Road Conveyance Pipe	$1,400,000
4 – Wapiti Road / CNR Area Storage	$1,750,000
5 – 97th Avenue Orifice at MH 577819	$15,000
6 – 96th Avenue Orifice at MH 577831	$15,000
7 – 116th Street Storage from MH 103-12	$550,000

The dollar values shown in Table 2.9.1 show our expected order of magnitude costs for the various mitigation measures modeled and presented above. For the storage in Richmond, significant expense is incurred in the connection to the existing system since in the lower reaches of the system the pipe sizes range from 900 mm to 1650mm diameter. For location 2 the replacement of the intersection manhole 57140 would be required to properly connect to the system. Other locations require connection to existing manholes or installation of a perched manhole to make a connection to the existing system. At location 4 the cost of purchasing 1.5 hectares of land is included at $400,000 per hectare. A contingency of 20% has been included in all the costs provided.

3.0 RECOMMENDATIONS

Based on the information in the past studies we reviewed, our modeling and current knowledge of the Richmond drainage basin additional storage and flow restrictions should be implemented. Lands north of the highway should drain east contrary to the WLASS study.

The airport and Brochu areas should drain to the east on the north side of the highway. Additional storage developed within or downstream from these lands and flow controls placed on the outlets will provide relief to the downstream systems. Flow controls for the runoff water should be designed so that water is released at a time when the downstream systems have capacity to handle the flow. It is suggested to limit flow from these areas to 5 l/s/ha to approximate the expected pre-development runoff as per the current city standards. The design of the controls should investigate orifice flow restrictions and if necessary real time controls.

Additional controls and or storage facilities are recommended in the Richmond and Centre West areas. Providing additional storage within Richmond will reduce the risk of flooding on 89th Avenue thereby making additional piping across Wapiti Road unnecessary. The following flood mitigation measures are recommended:

- Provide bulk storage within the Richmond basin upstream of the low area on 89th Avenue specifically in the old railway spur line properties (locations 1 & 2) and the Wapiti Road / CNR area site if possible (location 4)
- Install an orifice at Manhole 57140 to use the location 1 & 2 storage in the old railway spur storage,
- Provide distributed storage where possible throughout Richmond.
- Control flow from Centre West using orifices or other flow control devices at manholes west of 116th Street to help control flooding on 116th Street
- Decouple the storm outfall from Manhole 103-12 and the Centre West storm pond.
- Provide new storage for 116th Street to mitigate flooding at 97th Avenue
- Implement a maintenance program to locate problems in the storm sewer system and clean or repair regularly
- Implement a monitoring program to record problems, maintenance and solutions in detail to be the basis for future studies as well as for the creation of a cost effective maintenance program
- Annual or bi-annual cleaning of sediment in catch basin sumps should be one maintenance program implemented that should reduce other more costly maintenance work
- Any type of development that changes the imperviousness in the Richmond Industrial Park should be require to provide onsite storage for that change and control the release of storm water from the storage at a rate of 5 l/s/ha allowing for a minimum orifice size of 50 mm.

Although these measures are intended to improve the system there will still be some flooding in large storms as the systems are not designed to convey all flow in large storms. Providing storage in the middle to upper areas in the Richmond Park has proven effective in the modeling to reduce the major flooding in the area. The recommendations are not intended to change the manhole flooding in the Centre West and Vision West subdivisions since these areas were designed to surcharge around manholes and provide runoff attenuation in that way.

4.0 REFERENCES

Associated Engineering (2004), City of Grande Prairie Storm Drainage Master Plan, prepared for the City of Grande Prairie.

Beairsto, Lehners, Ketchum Engineering Ltd. (2008), Design Report Westgate West (SE 28-71-6W6M) Stormwater Management Report, prepared for FN Partners Limited Partnership

Focus Corporation (2007), Proposed Vision West Development NW ¼ Section 21-71-6-W6M Overall Stormwater Management Concept, prepared for 272649 Alberta Ltd.

Stewart, Weir & Co. Ltd. (2002), Centre West Business Park Storm Sewer System Design Report, prepared for the City of Grande Prairie on behalf of 838308 Alberta Ltd.

Stewart, Weir & Co. Ltd. (2004), West Annexation Lands Storm and Sanitary Study, 2004, City of Grande Prairie, prepared for the City of Grande Prairie on behalf of 838308 Alberta Ltd.

APPENDIX A

Centre West and Vision West Sub-Catchment Areas

RICHMOND INDUSTRIAL STORM DRAINAGE BASIN STUDY GRANDE PRAIRIE

EXISTING 2012 STORM DRAINAGE CENTRE WEST

Project No.	Date.	Scale
060200141	AUGUST, 2012	N/A

DATE PLOTTED: December 5, 2012
CAD FILE NAME: N:\060200141 - City of GP Stormwater Master Plan\Engineering\060200141\Drawing Files\Preliminary Design\Centre Area.dwg

FIGURE 2

MARK	NATURE OF REVISION	DATE	ENG	DRWN

	Existing	Proposed
Watermain		
Valve		
Hydrant		
Tee		
Reducer		
Plug		
Cap		

	Existing	Proposed
San. Sewer, MH. & Cap.	600 MH 375 MH	600 MH 375 MH
Storm Sewer & MH.		
Catch Basin & Lead		
Curb & Gutter		
Curb & Sidewalk		
Gutter Elevation	562	562
Pavement		

Note: The contractor shall be responsible for the location and protection of all existing utilities.

Drawn By:	GWA
Design By:	DSB
Checked By:	
Date:	DEC 2006
Job No:	124315
Drg. #	124315-A
Scale:	1:1500

VISION WEST
COMMERCIAL SUBDIVISION
STORM CATCHMENT AREAS
GRANDE PRAIRIE, ALBERTA

FOCUS Corporation
10107 - 120 Avenue
Grande Prairie, AB, Canada
T8V 8H8
Main: 780.539.9222
Fax: 780.539.9343
www.focus.ca

APPENDIX B

Service Request Records

Water Drainage / Run off Service Requests
2011 Service Requests from City of Grande Prairie Records

Southern Richmond Industrial Park
Water Drainage / Run off Service Requests

2011 - 2 records to Oct 24, 2011

Location	Number	Date	Time	Type	Priority	Description
11039 78 Ave	22382	31-Mar-11	11:31	RDRAN	H	
8003 110 Street	22548	12-Apr-11	8:39	RDRAN	M	Clean Harbors

Richmond Industrial Park
Water Drainage / Run off Service Requests

2011 - 5 records to Oct 24, 2011

Location	Number	Date	Time	Type	Priority	Description
8525 109 Street	22268	29-Mar-11	15:14	STDMR	M	
8910 108 Street	22269	29-Mar-11	15:29	STDMR	M	
108 Street & Pats Auto	22416	31-Mar-11	15:36	STDMR		
110 Street & 84 Avenue	23353	19-Jul-11	9:12	RDRAN	M	Peace Library
108 Street between Husky and Prairie Truck	22670	4-May-11	14:02	STDMR	N	On service road south side of 100 Ave

Run off Control, Ditches, Road Drainage	RDRAN
Storm Sewer Drainage Problem	STDMR