11.0 City of Winnipeg Flood Protection Infrastructure

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11.1 CITY OF WINNIPEG FLOOD IMPROVEMENTS

The Floodway Expansion Project contemplates that to achieve the overall 1 in 700 year flood protection for the City of Winnipeg will require raising the primary dykes within the City of Winnipeg. Until permanent upgrades to the primary dyking system are completed, the City can be protected against the 1 in 700 year flood with temporary raises of the primary dykes.

The primary dykes in the City of Winnipeg date back to 1950. Following the disastrous 1950 flood, the federal and provincial governments agreed to a cost sharing agreement that resulted in building the primary dykes and associated flood pumping stations. These works were constructed in the fall of 1950. The primary dyking system was considered as an interim flood protection measure, before other flood works could be built. When the Floodway was completed in 1968, the primary dyking system had already proved to be effective in fighting the 1956 and 1966 floods.

The primary dykes follow for the most part, the road network that parallels the Red, Assiniboine and Seine rivers. The minimum elevation for the primary dykes was set at 26.5 feet at James Avenue or approximately 4 feet below the 1950 peak of 30.3 feet JAPSD. All elevations within the City reference James Avenue and are referred to as James Avenue Pumping Station Datum (JAPSD). Since the primary dykes follow the City road network there are numerous locations where they are above 26.5 feet. Assuming a nominal 2 feet of freeboard, the City is protected for floods up to 24.5 feet JAPSD. The primary dykes are designed to allow for temporary raises as was done during the 1966 flood. The flood of 1997, with James Avenue reaching 24.5 feet highlighted some deficiencies in the 68 miles (110 kilometres) of primary dykes. In the south end of the City (i.e., upstream end) a higher percentage of the total flow coming from the Red during the 1997 flood (than what occurred in the 1950 and other floods) reduced the available freeboard on the primary dykes in this area. In the north end of the City, the backwater effect of the Floodway also reduced freeboard levels on the primary dykes.

In providing flood protection for a 1 in 700 year flood, the primary dykes are required to be raised to meet a higher water level than experienced in 1997. This is required to accommodate a backwater effect along the Red River from the Floodway outlet structure south through Winnipeg when the expanded Floodway is flowing at its design capacity of 140,000 cubic feet per second (see Preliminary Engineering Report Appendix L). The City has suggested that a two-phased approach could be considered:

- The first phase could involve addressing deficiencies in the primary dykes noted from the 1997 flood (i.e. dykes below 26.5 feet JAPSD), as well as raising the primary dykes in the north end of the City to accommodate the increased backwater effect from the design flood with the expanded Floodway. In this phase, all primary dykes below 26.5 feet JAPSD would be raised. If feasible, all primary dykes that are raised in this phase of the work would be built to the higher backwater elevation as discussed next.

- The second phase could involve raising the primary dykes that currently exceed 26.5 feet JAPSD but are lower than the 1 in 700 year flood level. In the 1 in 700 year flood event, water levels in the City are projected to rise to 26.5 feet JAPSD. With a two foot freeboard allowance, all primary dykes below 28.5 feet would be at risk.

The City estimates that the cost of raising the primary dykes to the 1 in 700 year flood would be $149 million (including interest and escalation). This estimate also includes raising the primary dyke within the University of Manitoba, which is the responsibility of the University. The costs are relatively high due to the need to replace roadway pavement since over 95% of the primary dykes follow City streets. Additional investigation still needs to be done to determine if there are opportunities to coordinate raising of the primary dykes coincident with street reconstruction. Depending on whether the primary dykes are 6, 12, 18 or 24 inches below the 28.5 foot level, different strategies could be considered that vary between temporary to permanent raising of the primary dykes.

A first step in evaluating the first phase of the work is determining what needs to be done in each specific area below 26.5 feet JAPSD and determining if it is practical to raise levels to 28.5 feet JAPSD. For areas that already have significant primary dykes it may be too difficult to raise levels to the 1 in 700 year level due to the steep side slopes of intersection streets and sidewalks. Aesthetics and local issues may also be a factor in limiting how high the primary dykes may be raised. As well, it may not make sense to reconstruct otherwise adequate pavement for the sake of raising a dyke six inches to two feet simply to provide 2 feet freeboard, until the street needs to be reconstructed. Until the primary dykes are raised or if it proves too difficult to do a permanent raise, temporary dykes would be constructed.

A final decision and a timetable for undertaking permanent raising of the primary dykes will be dependent on available funding.

A conceptual review of the primary dyke system has been undertaken to determine where it is required to be raised to two feet above the 1 in 700 year backwater water level. The overall length of the primary dyking system is approximately 68 miles (110 kilometres) and based on the results of the conceptual review, approximately 16 miles (27 kilometres) requires raising less than two feet (0.6 metres) and approximately 5 miles (9 kilometres) requires raising over two feet (0.6 metres). Using sandbags for heights of two feet (0.6 metres) or less and clay for heights over two feet (0.6 metres), it is estimated that less equipment and materials would be required than that utilized for emergency construction of the secondary dykes in the 1997 flood.

The City has embarked on a capital program to upgrade other portions of its flood infrastructure. This includes upgrades to the City's flood pumping stations that were constructed in 1950. The City is also doing upgrades to components of its land drainage system that are at risk during high river levels. Upgrades include installation of gate chambers versus the use of inflatable dams as was used in 1997 as well as allowance for temporary pumping facilities. Since the 1997 flood, the City has expended approximately $11.9 Million (1997 to 2003) and has budgeted approximately $22.5 Million in the current five year capital program (2004 to 2009) for on-going improvements to their permanent flood protection works.

11.2 DESCRIPTION OF SEWER AND FLOOD CONTROL SYSTEMS

Flood protection works in the City of Winnipeg consist of components of the sewer systems and more typical structural and non-structural flood control systems such as primary dykes and flood proofing legislation, respectively.

11.2.1 The Sewer System

11.2.1.1 History

The City of Winnipeg was incorporated in 1873 with a population of 2000. There was no drainage system, and sewage collection and removal was primitive. The first drainage sewers were constructed in 1876, which led to the beginnings of the combined sewer system in 1882 when sewage was also directed to the land drainage sewers. Even at that time there was a concern about both basement and Red River flooding.

By 1915 most of the sewers in the former City of Winnipeg were complete. This was also the beginning of the era of combined sewers (1915 to 1960) in the adjacent municipalities. The year 1960 signified the beginning of the era of separate sewers, which are the systems still built today. The construction of relief sewers, to improve the capacity of the older combined sewers, also began in the 1960's. In 1972, the City of Winnipeg and the adjacent 12 municipalities amalgamated.

11.2.1.2 Components of the Sewer System

Winnipeg’s sewer system includes combined and separate sewers. Combined sewers transport land drainage runoff and wastewater (residential, commercial and industrial) together. Approximately 27% of the City, primarily the central older area, is served by combined sewers. Separate sewers include two pipes: a land drainage sewer and a wastewater sewer. There are 42 combined sewer districts and 30 separate sewer districts. A sewer district is the geographical area served by the trunk sewer and is usually named after the street beneath which the trunk sewer runs. For example, the trunk sewer in the Bannatyne Combined Sewer District runs beneath Bannatyne Avenue to the Red River.

The sewer systems consist of several elements: the building service or service connection, local or lateral sewer, collector sewer, trunk sewer, interceptor sewer, relief sewer, lift station, flood pumping station, gate chamber or gate structure (with flap and/or positive gates) and outfalls to the rivers. An outfall is the end of the pipe that protrudes through the riverbank into the river and is usually submerged below the normal summer river level.

Sewage or wastewater is first discharged from buildings through the service connections to local sewers that run down most streets. These sewers discharge to collector sewers and then to trunk sewers. Prior to the construction of the first treatment plant in the north end of Winnipeg in 1935, trunk sewers discharged directly to the rivers through outfalls.

The interceptor sewer “intercepts” the wastewater or combined wastewater and land drainage before it discharges through the outfall to the river. The interceptor sewer carries wastewater and land drainage runoff to one of the three sewage treatment plants (in the north end, south end and west end). The diversion to the interceptor sewer is achieved by a weir (or dam) in the trunk sewer positioned just before the outfall. When wastewater flow hits the weir, it is then redirected and flows to and through another pipe in the side of the trunk sewer. If the interceptor sewer is lower than the trunk sewer, then the wastewater flows by gravity to the interceptor sewer. If the interceptor sewer is higher than the trunk sewer, then the wastewater flows to a pump and is lifted to the interceptor sewer. The pumps are housed in a sanitary lift station adjacent to the trunk sewer. Sanitary lift stations are also utilized anytime a sewer is too deep to discharge by gravity into the next downstream sewer. This can occur when servicing a relatively low area or extending a sewer district beyond its original boundaries.

Generally, the combined sewer system can handle wet weather flows (combined wastewater and land drainage) up to 2.75 times average dry weather flow (wastewater flow only). When rainfall runoff in the trunk sewer exceeds the capacity of the diversion to the interceptor sewer, the excess flow spills over the weir and discharges directly to the river through the outfall. This occurs for every major rainstorm.

Separate sewer systems include two pipes: 1) a wastewater sewer for carrying sanitary or wastewater flow to one of the three sewage treatment plants, and; 2) a land drainage or storm sewer to transport land drainage runoff (from snowmelt or rainstorms) directly to the rivers. Some land drainage sewer systems include stormwater retention basins (SRBs). These SRBs are utilized for retaining land drainage flows during and following a runoff event. By directing the drainage to a SRB, the piping between the SRB and the river can be much smaller than would be without the SRB. The SRB water level rises as water is directed to it and then recedes slowly to its normal water level as the water is discharged through the downstream pipe.

Storm relief sewers are installed to “relieve” existing sewers of some of the extraneous flow from land drainage runoff. Typically, storm relief sewers parallel existing sewers, are installed slightly lower to receive the overflow, and discharge directly to the rivers. Storm relief sewers are required in those sewer districts that do not meet minimum design standards. The minimum design standard is a five-year return frequency rainstorm for combined sewers and up to a ten-year event for separate land drainage sewers. These design criteria are deemed to be cost effective and therefore are typical for most jurisdictions for the reduction of incidence of basement flooding.

Since the mid-1970’s, the City has invested more than $200 million to increase basement flooding protection to the current standard. The program has relieved both combined and separate sewer systems throughout the City, but a majority of the funding has been spent on combined sewer systems. Homeowners are encouraged to take additional preventive measures such as improving drainage around the house, installing backwater valves and installing sump pits and pumps, to increase their protection against sewer backup.

Gate chambers or gate structures and flood pumping stations were constructed on the existing combined sewer systems when the primary dyking system was constructed in 1950/1951. Gate chambers contain flap and/or sluice gates which, when closed, prevent river water (especially high river levels) from backing up into the sewer system. A flap gate is hinged at the top and opens towards the river when there is combined wastewater/land drainage flow against it. It automatically closes when the river level rises and when the pressure of the river water is greater than the combined wastewater and land drainage in the sewer. Typically, a sluice gate is manually operated and slides up and down in a guide. The gate is attached to a threaded rod which extends to the top of the chamber and is turned by a hand wheel or by an electric driven device similar to a power drill or screw gun.

The flood pumping stations are operated when river levels are too high for the sewers to flow by gravity and when the combined wastewater/land drainage flow exceeds the capacity to divert to the interceptor sewer. They pump combined wastewater and land drainage (snowmelt and/or rainfall runoff) accumulated behind the closed gates up and over the primary dykes. Without the flood pumps, the combined flow could surcharge and "backup" into basements. There is still a risk of this occurring if rainstorm runoff exceeds the design capacity of the pump station.

Since the completion of the primary dyking system in 1951, all new sewer systems (combined, separate, and storm relief) with outfalls (holes through the dyke) have been protected as necessary to the design level in effect at the time. If the land behind the dyke served by the sewer system is below the flood protection level (design water level plus two feet freeboard), then gates are installed and the gate chamber is designed with provision for a temporary pumping operation. Conversely, if the land behind the dyke served by the sewer system is above the flood protection level, no gate chamber is installed. Since 1980, the City has had a policy that if the land behind the dyke served by the sewer system is below the 50-year return frequency spring flood event, then a permanent pumping station is also installed.

11.2.1.3 Effect of High River Levels

The City of Winnipeg's combined sewers and separate land drainage sewers are dependent upon gravity flow to the City's rivers and streams during periods of significant rainfall. When the rivers are in flood stage, the gravity flow capacities of these sewers are significantly reduced or even eliminated and the water in the sewers must be pumped. Similarly, water in major drains or ditches, including drainage received from outside the City (for example Lot 16 Drain through the Rural Municipality of Macdonald and Fort Garry) must be pumped when the rivers are in flood stage.

The section below titled "1997 Flood Experience" discusses the effect of high river levels on the sewer systems in more detail.

11.2.2 The Flood Protection System

The City of Winnipeg's flood protection system consists of non-structural and structural components. The non-structural components include items and activities such as legislation, policies, studies, and regular reporting. The structural components are the physical structures that divert or hold back water.

11.2.2.1 Legislative Framework

In early 1980, legislation came into effect which established the floodway and floodway fringe areas along the rivers in the City, a design flood protection level (level to which all development shall be protected to), and flood proofing criteria. The specific legislation is within the City of Winnipeg Act and the associated Designated Floodway Fringe Area Regulation (MB Regulation 266/91). The floodway and floodway fringe are delineated on the Interim Flood Risk Maps. The Flood Protection Level (FPL) is defined as the maximum static water level that occurs with a 160-year return frequency spring runoff event plus two feet freeboard. The FPL is equivalent to 27.8 feet at the City's James Avenue Station (City datum of zero feet is 727.57 feet above sea level). The post-1997 flood recalculated unofficial return frequency event equivalent to a water level of 25.8 feet at James Avenue is now approximately 130 years.

All development in Winnipeg since 1980 has adhered to the requirements of the legislation. After the 1950 flood but prior to the 1980 legislation, the unofficial flood protection level was equivalent to the constructed top elevation of the primary dykes (equivalent to approximately 26.5 feet at James Avenue datum). This equates to a water level of 24.5 feet at James Avenue when a two foot freeboard is assumed. Therefore, flood protection systems and sewer systems were designed in that 30 year period based on a water level of 24.5 feet at James Avenue. There is more discussion on this point in the following section.

A summary of the legislation related to flood protection follows.

- The Dyking Authority Act (1952) – legislation providing for the maintenance of the primary dykes and flood pumping stations in Winnipeg.
- The Dyking Commissioner – the Dyking Authority Act establishes this position within the Provincial Water Resources Branch for the administration of the Act, and annual reporting to the Provincial Minister of Natural Resources on the condition of the system. For example the report identifies any improvements to flood pumping stations or gate chambers or extensions to the primary dyking system.
- Canada – Manitoba Flood Damage Reduction Agreements – provided for the study and preparation of the Interim Flood Risk Maps, which outline the Floodway Areas, the Floodway Fringe Areas, and the Primary Line of Defence (primary dykes). The maps also indicate the Flood Protection Level along regular intervals of the rivers. The information on these maps is referenced in the City of Winnipeg Act.
- The City of Winnipeg Act – establishes the Floodway Area and Floodway Fringe Area development regulations (Designated Floodway Fringe Area Regulation – current version is Manitoba Regulation 266/91), and zoning and development approvals process.
- The Emergency Measures Act – permits City Council to declare a local state of emergency.

11.2.2.2 Other Non-structural Components

There are several other non-structural flood protection items that help to protect the City of Winnipeg against flooding. These are:

- Floodway Operating Rules – discussed in a separate section in this report.
- City of Winnipeg Flood Activity/Emergency Manual - In 2002 the City completed a project to convert paper manuals to a detailed and comprehensive operations manual in electronic

format describing all flood activities required such as gate monitoring, gate closures, activation of pump facilities, raising primary dykes, erecting secondary dykes, etc., at various flood stages. This will ensure proper and prompt action by staff to protect properties from overland and basement flooding. The preparation of a comprehensive manual was also recommended by the IJC.

- The Manitoba River Forecast Centre – provides the long range and daily river level forecasts. This information is fundamental to the City's flood protection operations. The forecasts are critical as they form the basis for all planning, preparations and operations before and during a high river level event.
- Weather and radar reports - forecasts assist in preparing for inclement weather, such as rainstorm events.
- River ice monitoring through Winnipeg – this is during river ice break-up and in recent years this major role has been played by the Amateur Radio Operators Association of Manitoba.
- The City's Emergency Operations Centre – is activated for all major flood events to assist in the coordination of the resources needed for flood protection operations.
- Manitoba Disaster Assistance Board – Provides the guidelines for eligible and non-eligible items for flood fighting and damage costs.
- Manitoba Emergency Measures Organization – Assists the City as necessary in the provision of resources, such as Canadian Armed Forces personnel.
- Public Education – Primarily an activity during a flood event, but is critical for public understanding of the facts surrounding any emergency situation.
- On-going studies/projects – the City of Winnipeg has, at any time, several flood related studies and capital improvement projects underway. These may involve sewer relief programs, flood pumping station upgrades, gate chamber upgrades, permanent secondary dykes, and more.

11.2.2.3 Structural Components

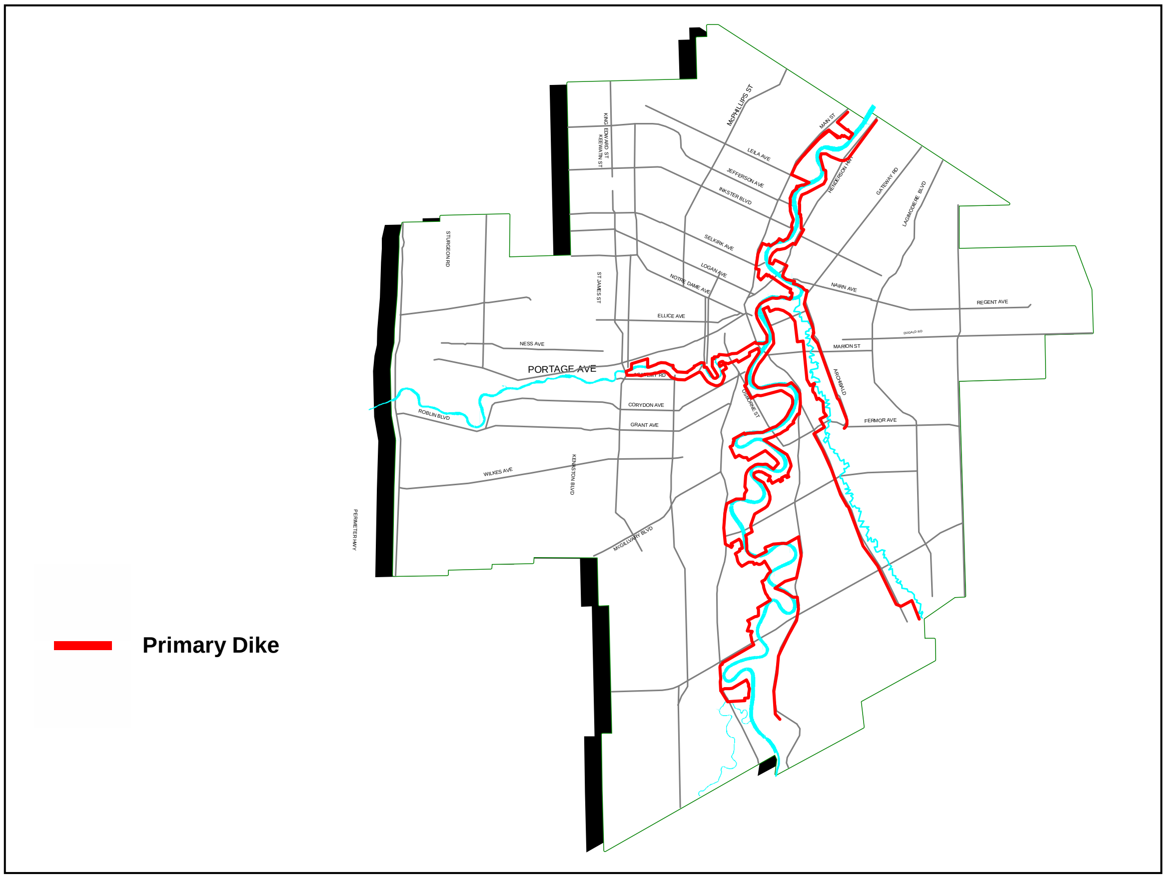
The structural components include the major flood control works (Shellmouth Dam and Reservoir, Assiniboine River Diversion and the Red River Floodway), as well as all the structures associated with the City's primary dyking system and other miscellaneous controls. The major flood control works are discussed in more detail in another section.

The primary dyking system falls under the jurisdiction of the City of Winnipeg but is monitored by the Provincial Dyking Commissioner. The system consists of primary dykes, gate chambers and flood pumping stations. The secondary dykes in the City are also integral to protecting the properties on the river side of the primary dyking system. These structures are not recognized in the legislation for flood protection and have been mostly temporarily constructed for each flood event. However, many permanent secondary dykes were constructed between 1999 and 2004 at locations throughout the City under the Canada – Manitoba – City of Winnipeg Secondary Dyking Enhancement Program.

The primary dykes were constructed in 1950 by the Greater Winnipeg Dyking Board. They were constructed to a uniform elevation of 26.5 feet equivalent at James Avenue and are generally located along street rights-of-way. They parallel the Red River (from the north limit to the south limit of the

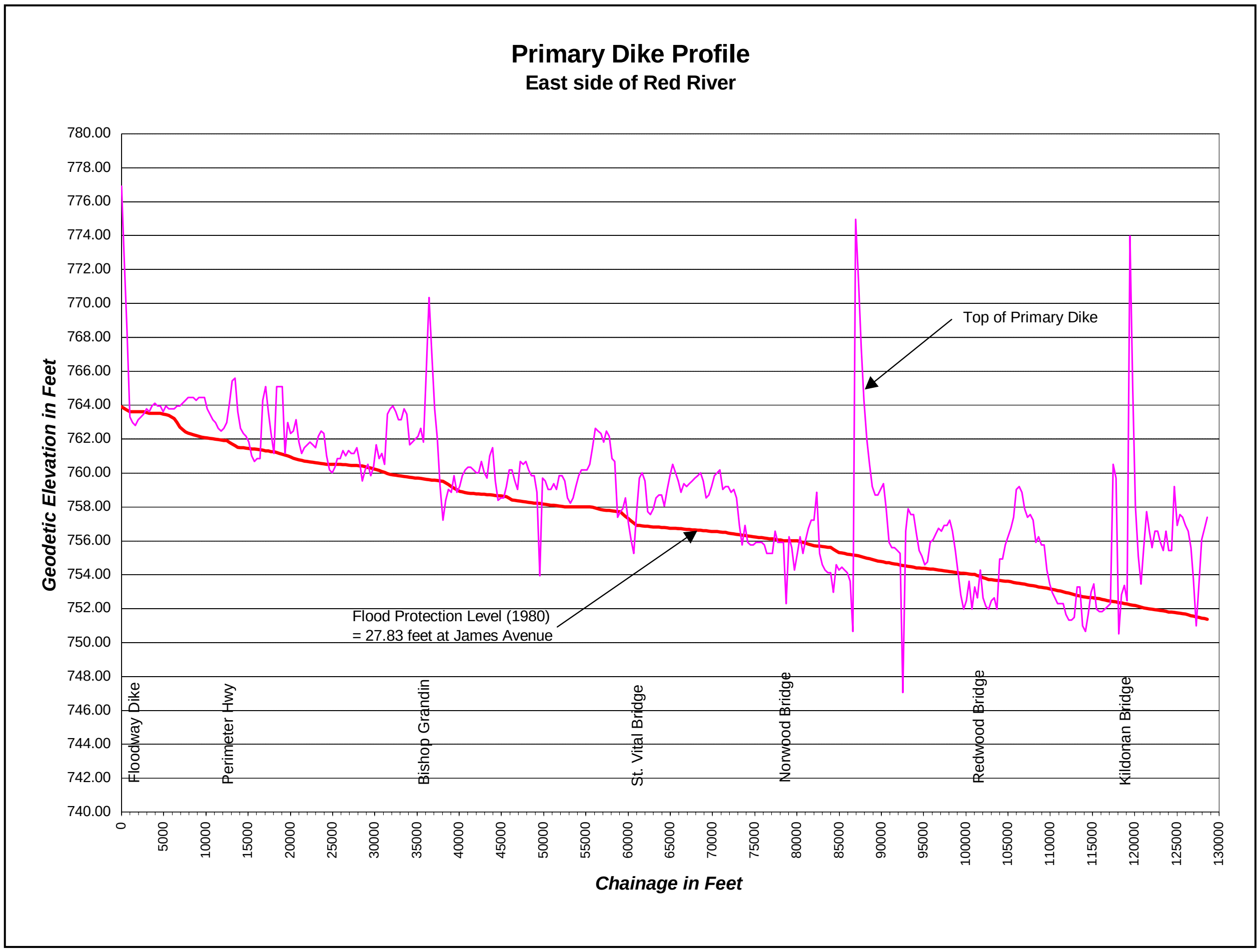
City), the Assiniboine River (from the confluence with the Red River to St. James Street) and a portion of the Seine River, as shown in the Figure 11.2-1.

Figure 11.2-1
Primary Dyking System in Winnipeg



Today there are 68 miles (110 kilometres) of primary dyke and the top elevation varies considerably. This is illustrated in Figures 11.2-2 and 11.2-3, which include the primary dyke along the east and west sides of the Red River, respectively. It is presumed that the dyke top elevation has been modified over the years due to temporary raising (1966 flood) and due to modifications required for street renewals. As well, any additions or extensions to the primary dyking system since 1980 have included a minimum top elevation of 27.8 feet equivalent at James Avenue (to meet the Flood Protection Level), in accordance with Manitoba Regulation 266/91 of the City of Winnipeg Act. In some cases, an extension to the primary dyke has been constructed even higher, up to the “Primary Dyke Level” which is equivalent to 31.8 feet at James Avenue (which has sometimes been referred to as the 300-year flood water level). An example of such an extension is the primary dyke through the Riverpointe residential subdivision just south of Bishop Grandin Boulevard off River Road, which is at a minimum of 29.8 feet equivalent to James Avenue.

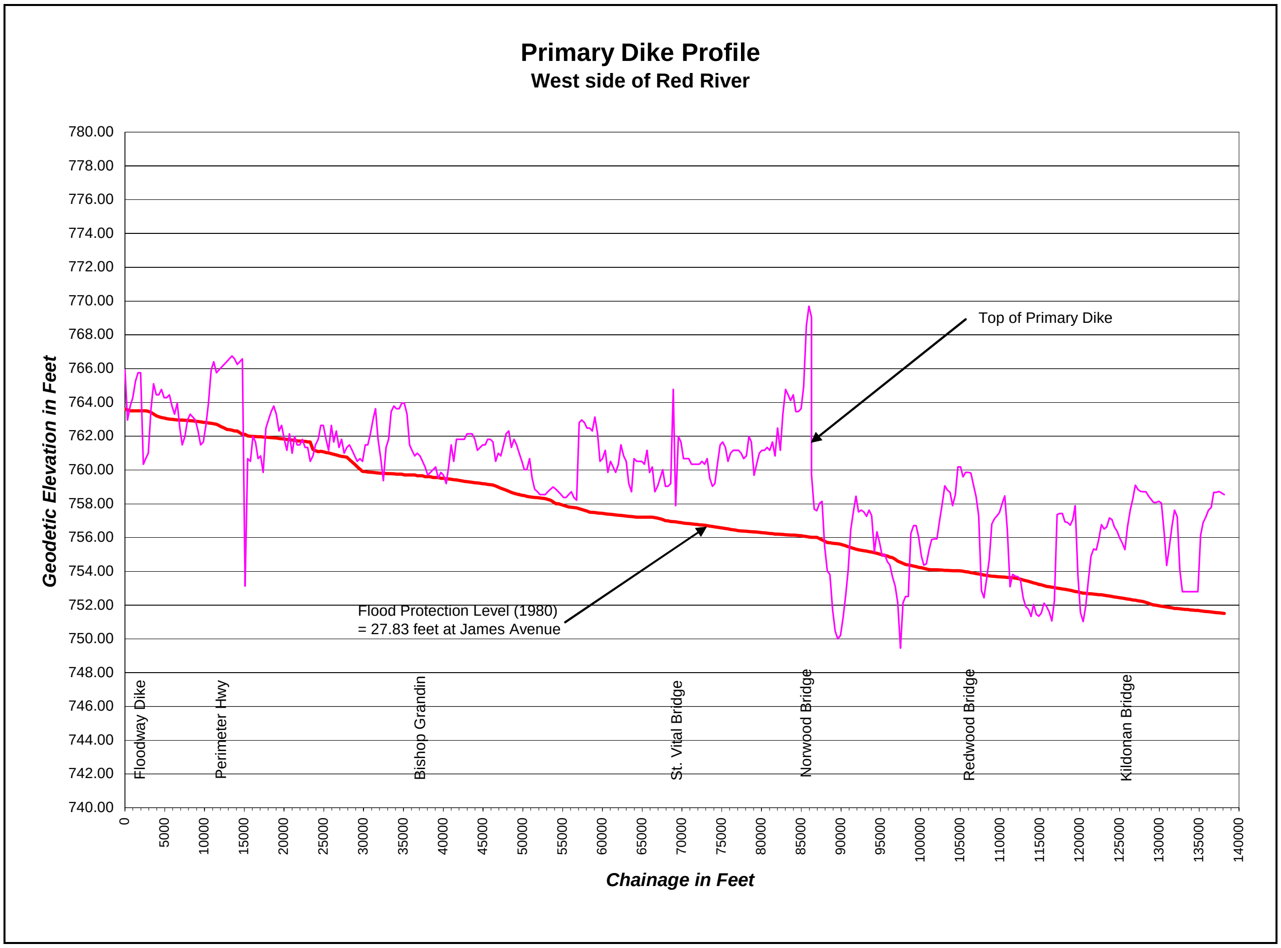
Figure 11.2-2
Profile of the Primary Dyke along the East Side or the Red River



There are other works within and outside of Winnipeg which provide flood control, some of which were discussed in the section titled "Components of the Sewer System". These are:

- The sewage treatment plant main pumps – utilized to "dewater" the sewer system faster to reduce the incidences of basement flooding.
- Stormwater retention basins – these can be utilized to store greater runoff than under normal operating conditions.

Figure 11.2-3
Profile of the Primary Dyke along the West Side or the Red River



- Pipe storage/overflows – components of the sewer systems can be “manipulated” to help reduce the incidence of basement flooding. Under-utilized pipes can be temporarily blocked to store more water thereby reducing discharges downstream where there are significant flows. Some components of the sewer system have overflows to the river to “relieve” the sewer and reduce the incident of basement flooding.
- Seine River Diversion – reduces peak flows on the Seine River.
- St. Andrews Lock and Dam – utilized to control the level of the Red River in Winnipeg. This structure is “wide open” during Spring runoff and typically “closed” during summer, except for river flows in excess of approximately 12,000 cfs. It can be opened for summer high river level events thereby increasing the gravity capacity of the sewer systems and reducing the risk of basement flooding.

11.2.3 1997 FLOOD EXPERIENCE

During the flood of 1997, the City of Winnipeg was vulnerable to basement flooding due to several different types of possible failure modes. These include a primary dyke breach, a secondary dyke breach, wastewater or combined sewer system breaches, land drainage sewer or ditch breaches, and pump failures.

For most part, the flood protection and sewer systems in Winnipeg are protected to a water level corresponding to 24.5 feet at James Avenue. This is because the primary dyking system was originally constructed to 26.5 feet at James Avenue, allowing for a freeboard of 2.0 feet, and many of the systems were constructed prior to the 1980 legislation wherein the Flood Protection Level (27.8 feet at James Avenue) was established. There is evidence that prior to 1980, planners and engineers were aware of the impending Flood Protection Level legislation, and attempted to introduce this standard in developments. However, without the enactment of the legislation there was no method to legally enforce the standards and the flood protection conditions were not met. Therefore, most of the flood protection and sewer systems constructed prior to 1980, are vulnerable to water levels above 24.5 feet equivalent at James Avenue.

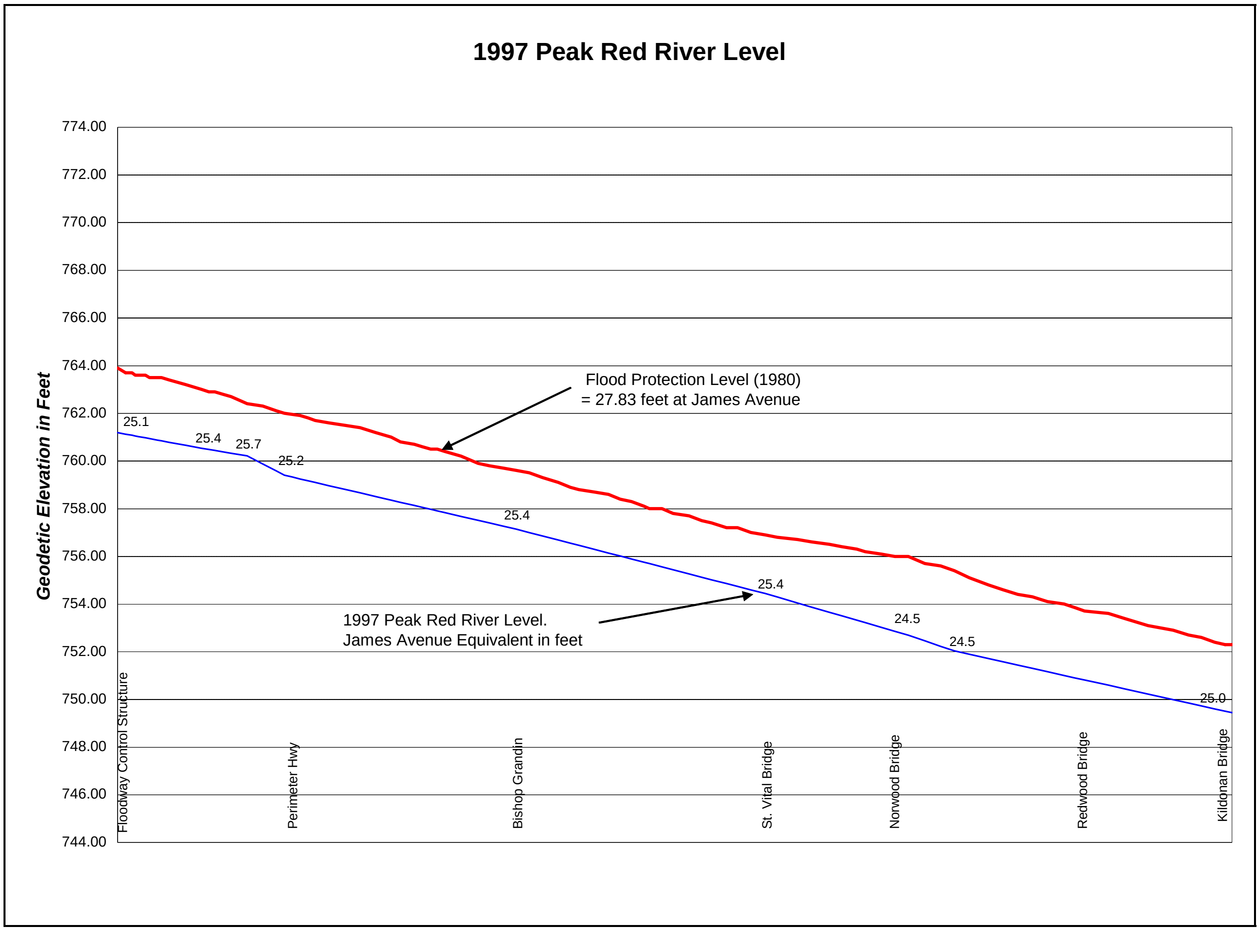
11.2.3.1 1997 Peak Red River Level

During the flood of 1997, the peak level reached at the James Avenue Station was 24.5 feet above City datum (datum is 727.57 feet above sea level). North of James Avenue to the north limit of the City, the peak level gradually rose to a level equivalent to 25.0 feet at James Avenue. However, in the south end of the City, peak levels were higher, as shown in Figure 11.2-4. Between the Floodway and the St. Vital Bridge, the peak level varied from 25.4 feet to 25.7 feet equivalent at James Avenue. The actual slope of the river was not uniform and had the level been raised above 24.5 feet at James Avenue, the flood protection and sewer systems would have been compromised to a greater degree than experienced in 1997, as discussed below.

11.2.3.2 Potential Primary Dyke Breaches

In 1997, specific locations of the primary dyking system throughout Winnipeg, but primarily in the south end of the City, were raised in preparation for the potential Z-dike failure scenario. Approximately three miles of the total 68 miles of primary dyke had to be raised approximately three feet to 27.5 feet equivalent at James Avenue. This was undertaken in one week and fortunately frost and frozen material, which would have hampered production seriously, was not much of an issue during the 1997 flood. Had these locations along the primary dyke not been raised for the potential event, many of them would have been overtopped for the actual 1997 peak Red River level.

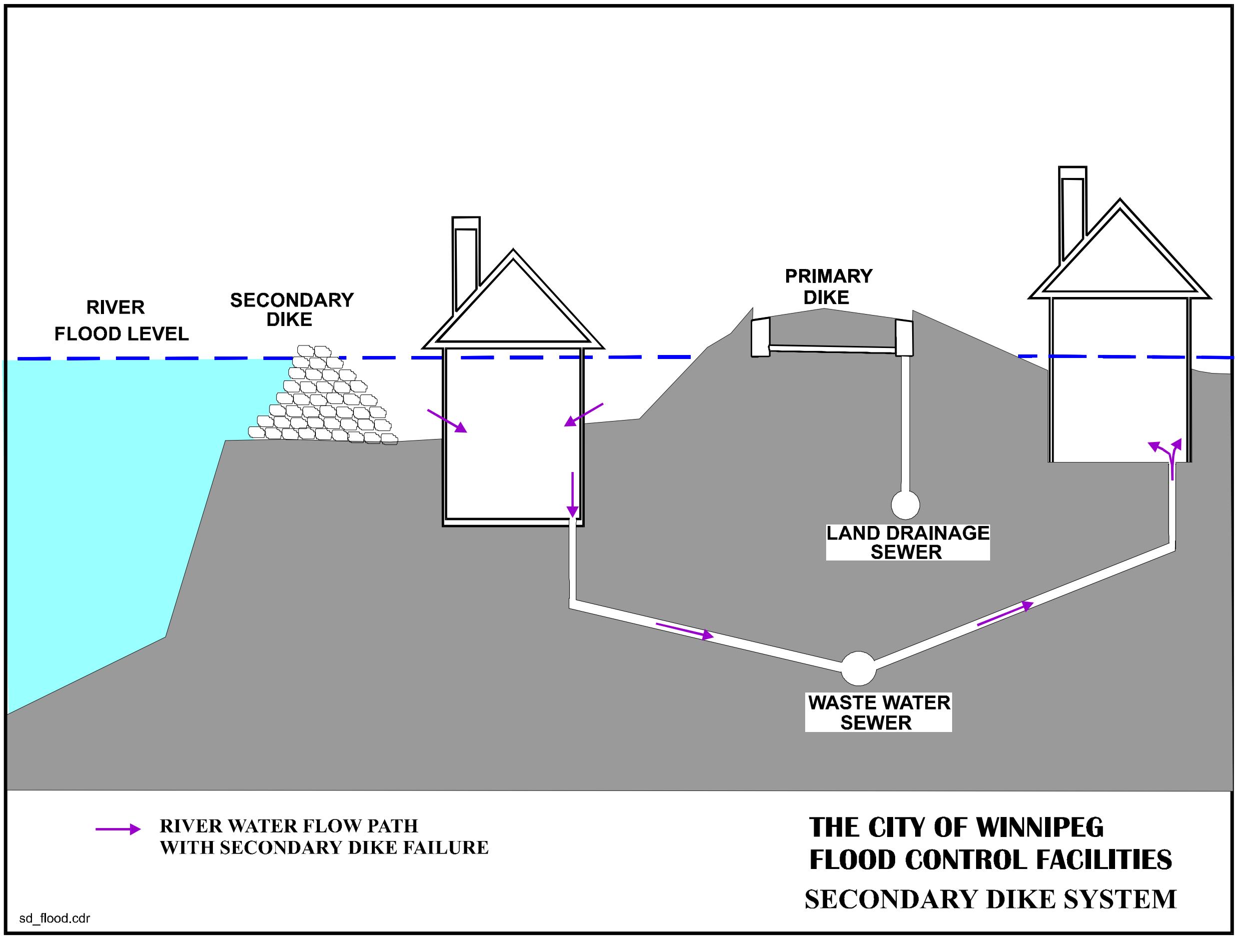
Figure 11.2-4
Profile of the Red River at 1997 Peak Level



11.2.3.3 Secondary Dyke Breaches

There were 800 properties protected by secondary dykes in 1997, most of these by 8,000,000 sandbags and 50 locations by earth fill dikes. At 500 of these locations, modifications were made to the building plumbing system (basement floor drains, toilets, sinks and other plumbing fixtures) to isolate them from the wastewater sewer system on the “dry” side of the primary dyke. In the case of a secondary dyke failing and flooding a basement, river water would otherwise be able to enter the wastewater sewer system via the building service connection. This would overload the wastewater system and would result in basement flooding in areas that were protected by the primary dyking system, as shown in Figure 11.2-5. In the south end of the City, a sandbag secondary dyke did fail and flooded the basements of two houses. The plumbing system modifications had already been completed, thus preventing river water from entering the wastewater sewer system that serves the St. Norbert area.

Figure 11.2-5
Cross-section of Secondary Dyke and Sewer System



11.2.3.4 Sewer System Breaches

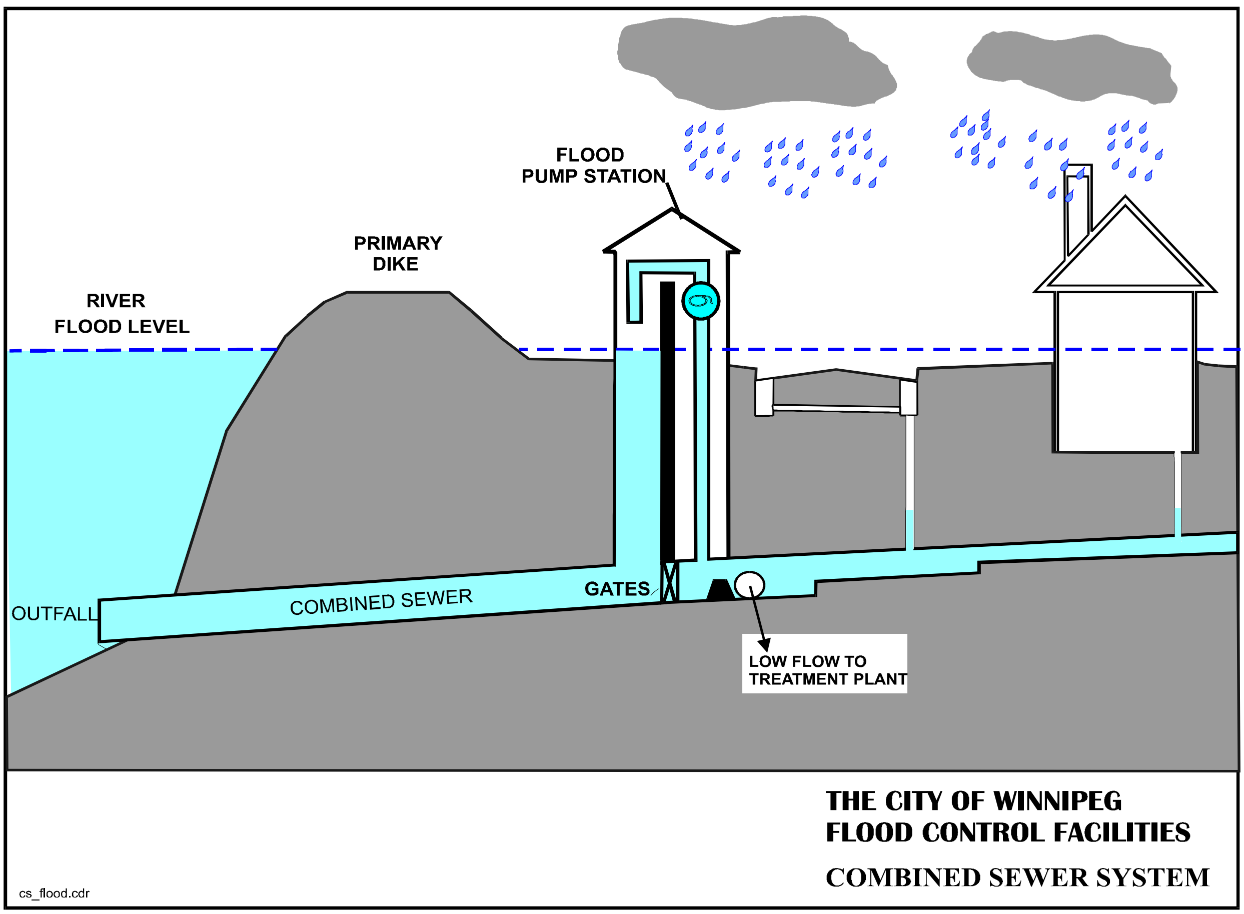
There is little or no hydraulic grade in the combined sewers or land drainage systems (sewers, channels and creeks) above a river water level equivalent to 24.5 feet at James Avenue. Also, there are numerous "holes" in the primary dyking system that had to be plugged in 1997. Many of the holes were the land drainage system outfalls that have no gate protection and/or permanent pumping station.

Basement flooding occurred May 7, 1997 near the flood peak in various areas throughout the City during a rainstorm. In most of these cases the basement flooding was a result of reduced sewer system capacity because the rivers were in flood stage, reducing the gravity capacity of the system. The remainder of the City was protected only to the level of the permanent or temporary pumping capacity installed and available. The rainstorms that occurred in 1997 did not exceed that capacity.

It was fortunate that very little rain was experienced in the City during the peak river elevations in 1997. Had there been a significant spring rainstorm, there would have been extensive basement flooding in both the combined and separate sewer areas.

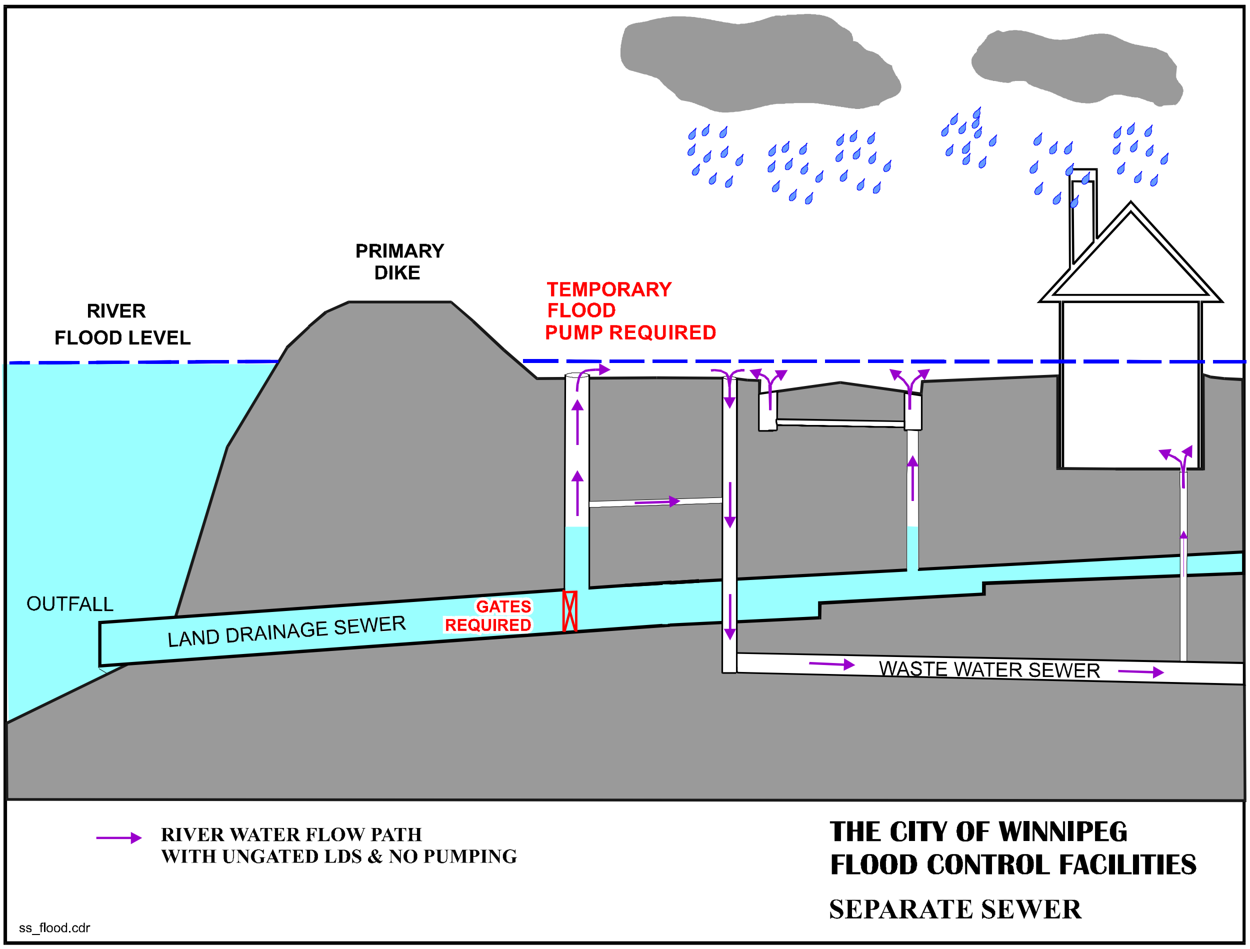
Most of the combined sewer trunk outfalls are equipped with permanent flood pumping stations, as shown in Figure 11.2-6. When the river is in flood stage, the gate will close preventing the river from backing up into the combined sewer system and flooding basements. If it rains during river flood stage, the flood pumping station will activate before the level in the sewer system backs up into basements. Should significant rainfall occur which produces runoff flows that are in excess of the pumping capacity, the sewers will surcharge above basement floor levels. A recent study has also shown that the capacity of each pump station varies.

Figure 11.2-6
Cross-section of a Combined Sewer System at the River



In the south end of the City where water levels exceeded 24.5 feet equivalent at James Avenue, the river water rose to a point that it backed up into the un-gated land drainage sewers, channels and creeks. The river water therefore surcharges to the point that it and land drainage flow (when raining) will pond on the surface of the streets and boulevards and eventually find its way overland into the wastewater sewer system through the manholes, as shown in Figure 11.2-7. The wastewater sewers were not designed to carry this extraneous land drainage water thereby exceeding the sewer capacity, and backing up into the service connections and flooding basements.

Figure 11.2-7
Cross-section of a Separate Sewer System at the River



Many of these un-gated facilities were temporarily plugged, preventing river water from backing up into the system but at the same time eliminating any flow from these systems to the rivers. As a result, snow melt or rainfall could not find its way out of the system. The land drainage works surcharged except where limited temporary pumping was able to lower water levels. Temporary pumping was not able to keep up with the amount of rain that fell. Sealing of wastewater manholes was undertaken as a precautionary measure in some areas and as an emergency measure in others. Further, there was a problem with unidentified cross-connections between the wastewater and land drainage sewer systems.

If the river ever reaches elevations higher than 1997, more of these cross-connections will become evident.

The 1997 flood could have been much worse had more significant rainfall occurred. In 1974, heavy rains preceded and occurred during the weekend of May 18th/19th which was followed by a downpour on May 20th. As this coincided with still high river levels, the gravity and pumping capacity of the system was greatly reduced and resulted in 9,500 flooded basements. Approximately 95% of these were in combined sewer districts.