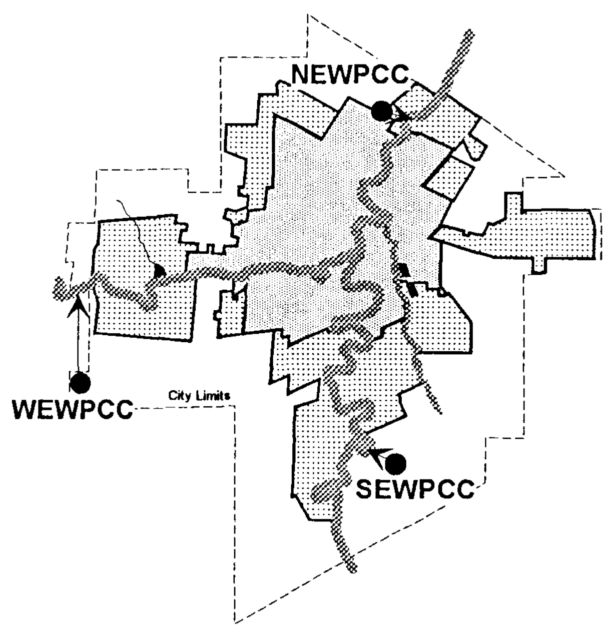
City of Winnipeg
Waterwork, Waste
and Disposal Department

Phase 1 Technical Memorandum for

Combined Sewer Overflow Management Study

TREATMENT

Technical Memorandum No. 3



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1.0 INTRODUCTION

Winnipeg has three water pollution control centres (WPCC), which are the North End Water Pollution Control Centre (NEWPCC), South End Water Pollution Control Centre (SEWPCC), and West End Water Pollution Control Centre (WEWPCC).

As the names imply, each of these WPCC's treat the waste from a section of the City.

The capacities of the WPCC are expressed in ML/d for the following:

- Average Dry Weather Flow (ADWF)
- Peak Dry Weather Flow (PDWF)
- Peak Wet Weather Flow (PWWF)

Typically the primary treatment facilities are sized to handle PWWF, while the secondary treatment facilities are sized to treat PDWF conditions. Discussions of capacities and characteristics of each WPCC are included in the following sections of this document.

2.0 NORTH END WATER POLLUTION CONTROL CENTRE (NEWPCC)

The NEWPCC has been constructed in stages since 1937. The most recent expansion was completed in 1989, to provide secondary treatment for an ADWF of 302 ML/d.

The following table summarizes the capacity of the primary and secondary portions of the NEWPCC and references the capacity as a factor of the ADWF:

Treatment	ADWF ML/d	PDWF ML/d	Factor x ADWF	PWWF ML/d	Factor x ADWF
Primary	302	600	2.0	827	2.75
Secondary	302	600	2.0	600	2.0

A flow schematic of the NEWPCC showing the major components is shown on Figure 2.1. A description of the major plant components follows.

2.1 PRIMARY TREATMENT COMPONENTS

2.1.1 Raw Sewage Pumping

Raw sewage arrives to the NEWPCC via three interceptors that combine just before the surge well.

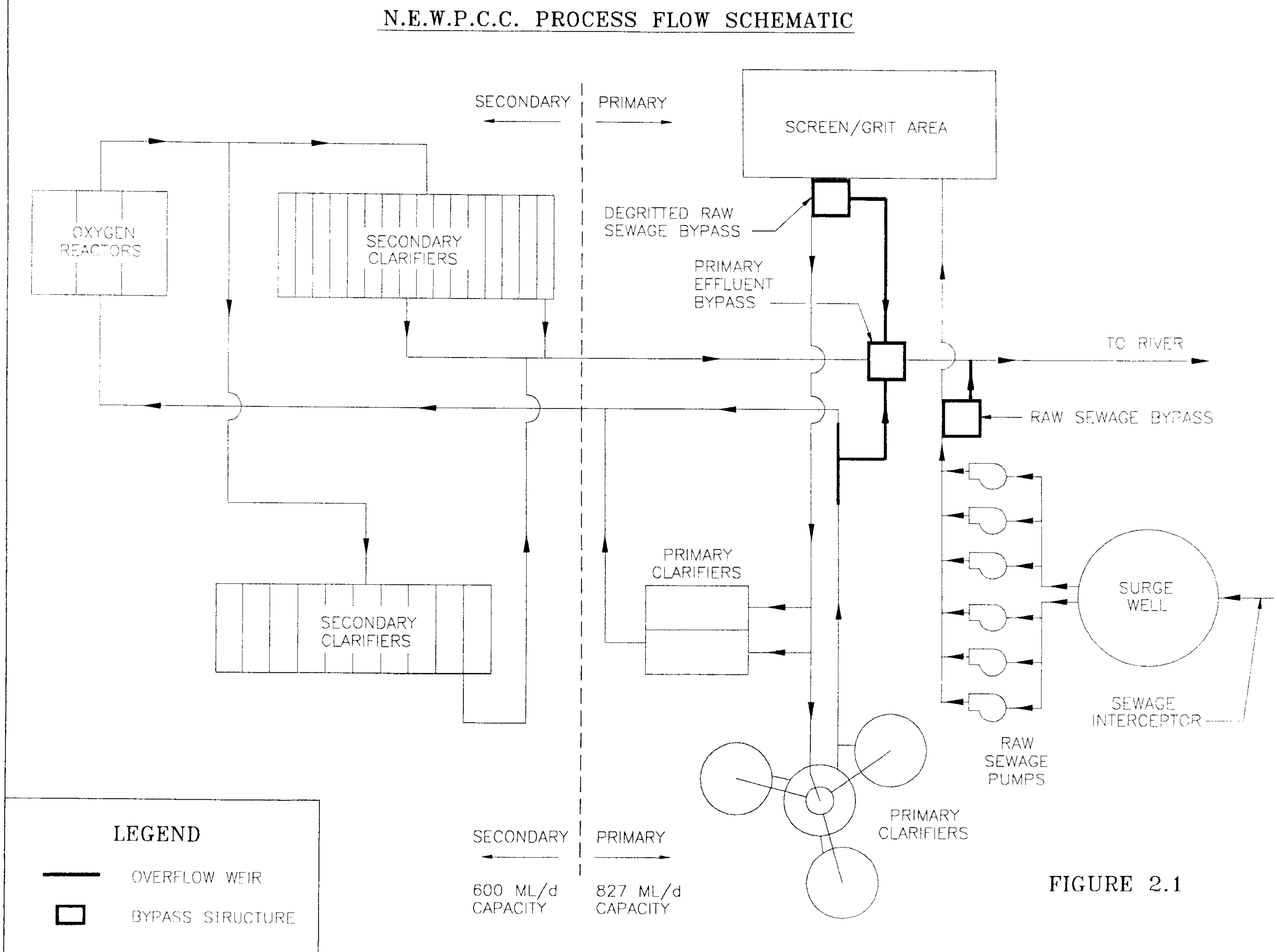

N.E.W.P.C.C. PROCESS FLOW SCHEMATIC
SECONDARY
PRIMARY
SCREEN/GRIT AREA
OXYGEN REACTORS
SECONDARY CLARIFIERS
DEGRITTED RAW SEWAGE BYPASS
PRIMARY EFFLUENT BYPASS
TO RIVER
RAW SEWAGE BYPASS
PRIMARY CLARIFIERS
SURGE WELL
SECONDARY CLARIFIERS
SEWAGE INTERCEPTOR
RAW SEWAGE PUMPS
PRIMARY CLARIFIERS
LEGEND
OVERFLOW WEIR
BYPASS STRUCTURE
SECONDARY
PRIMARY
600 ML/d CAPACITY
827 ML/d CAPACITY

FIGURE 2.1

There are six raw sewage pumps with the following capacities:

Number	Speed	ML/d
2	Variable	77/180
2	Constant	180
1	Constant	107
1	2-Speed	140/180
Total Installed Capacity		**1007**
Total Firm Capacity		**827**

Pumps have a nominally increased capacity at high surge well levels.

The pump cycling and speed variations are computer controlled to maintain a particular set point elevation in the surge well. The set point is adjustable and is normally set low during the wet-weather season to permit maximum storage within the surge well and interceptor sewer.

The raw sewage pumps discharge to a pump discharge chamber from which sewage flows by gravity through the plant. There is a possibility of bypassing from this location, as discussed later.

2.2 Screen and Grit Area

There are four screens and four grit/aeration tanks.

The screens and grit tanks have a hydraulic capacity of 827 ML/d, and can thus handle all of the pumped sewage.

2.3 PRIMARY CLARIFIERS

There are five primary clarifiers, three circular and two rectangular.

The design overflow rate at PWWF is 120 $m^3/m^2/d$. The combined capacity of the primary clarifiers is 827 ML/d, consequently all the sewage pumped can receive primary treatment.

2.4 SECONDARY TREATMENT COMPONENTS

The secondary treatment facility consists of an oxygen activated sludge treatment system. Its capacity is 302 ML/d ADWF, but can handle PDWF of 600 ML/d.

2.4.1 Oxygen Reactor Tanks

There are 6 oxygen reactor tanks which operate in 3 trains of 2 tanks each.

The capacity of each train is 100 ML/d ADWF and PDWF of 200 ML/d.

2.4.2 Oxygen Production Facility

Oxygen for the reactor tanks is supplied from an on-site cryogenic oxygen production facility which is owned and operated by a private company. In addition a liquid oxygen storage facility is provided on-site to provide oxygen in the event of oxygen equipment breakdown. Sufficient oxygen is supplied to treat ADWFs of 300 ML/d and PDWF of 600 ML/d.

2.4.3 Final Clarifiers

There are 26 final clarifier tanks, 16 of rectangular and 10 square.

Each of the three reactor trains are matched to a set of final clarifiers, eg., two groups of eight rectangular tanks are matched to two of the reactor trains while the third one is matched with the ten square clarifiers.

The final clarifiers have an ADWF capacity of 302 ML/d and PDWF capacity of 600 ML/d.

2.5 POTENTIAL BYPASS POSSIBILITIES

2.5.1 Bypass Descriptions

There are three locations in the plant where it is possible to bypass sewage at varying degrees of treatment. These locations are shown in Figure 2.1 and are described below:

- The first location is from the raw sewage discharge chamber from which raw sewage may overflow a weir if the sewage pumped is greater than the downstream screen/grit facilities can handle. This might occur in the event of a tank out of service.

  In our discussions with operating staff, we understand this very rarely happens because the pumping capacity would be reduced to avoid this occurrence. The reduction in pumping rate, in turn may cause the interceptor to back-up and cause a spill to occur ahead of the plant from the interceptor system.

- A second location where bypass can physically occur is immediately downstream of the grit tanks; where flow can be directed to the outfall conduit. Our discussions with operating staff indicate that this bypass never gets used.

- A third location, where most of the bypassing occurs, is downstream of the primary clarifiers. The secondary treatment components are designed to handle only 600 ML/d (2 x ADWF), whereas the primary treatment facilities can treat 827 ML/d (2.75 x ADWF).

  A weir overflow has been designed to bypass all primary effluent (PE) flows in excess of 600 ML/d. This is effected by valves working in conjunction with magnetic flow meters to control the flow to the reactors and cause the PE to back-up, thus overflowing the weir.

  Bypass of PE typically occurs only during spring run-off and following heavy rains.

2.5.2 Assessment of Bypassing

Scheduled maintenance of plant components are always carried out during the winter low flow periods, during which time no bypassing is necessary. As a result bypassing of sewage either ahead of screen/grit facilities or before the primary clarifiers virtually never occurs. The only planned bypassing occurs after primary treatment when flows exceed secondary treatment plant capacity.

The characteristics of the PE bypass are somewhat represented by the sample for PE.

This sample provides an approximation only as the PE sample is a 24-hour composite, while the bypass may occur only for a portion of that time, and may have different characteristics.

2.6 SAMPLING AND FLOW MONITORING

The NEWPCC is equipped with a state of the art instrumentation and control system which enables extensive flow monitoring and sample collection.

Flow monitoring is carried out continuously by means of magnetic flow meters at various locations, and records are tabulated as noted below.

Flow proportional composite samples are collected daily, except weekends, at several locations as tabulated below:

NEWPCC
METERING AND SAMPLING LOCATIONS

Location	Flow Monitoring	Sampling
Raw Sewage	daily flow per pump daily total flow monthly maximum daily flow monthly minimum daily flow monthly average daily flow	collected from pump discharge chamber
Surge Well Level	daily maximum level daily minimum level daily average	no sampling
PE (Feed to Reactors)	daily flow to each reactor train daily total flow to reactors monthly maximum flow monthly minimum flow monthly average flow	collected from PE channel
Final Clarifier	no monitoring of flows	collected from each group of clarifiers on one train
Final Effluent		collected from final effluent conduit

The City has commenced recording pumped raw sewage flows and surge well levels at 10 minute intervals since June 1, 1994. This is important for analyzing interceptor hydraulics.

3.0 SOUTH END WATER POLLUTION CONTROL CENTRE (SEWPCC)

The SEWPCC was originally commissioned in 1974 and has recently been expanded to provide complete secondary treatment for an ADWF of 59 ML/d.

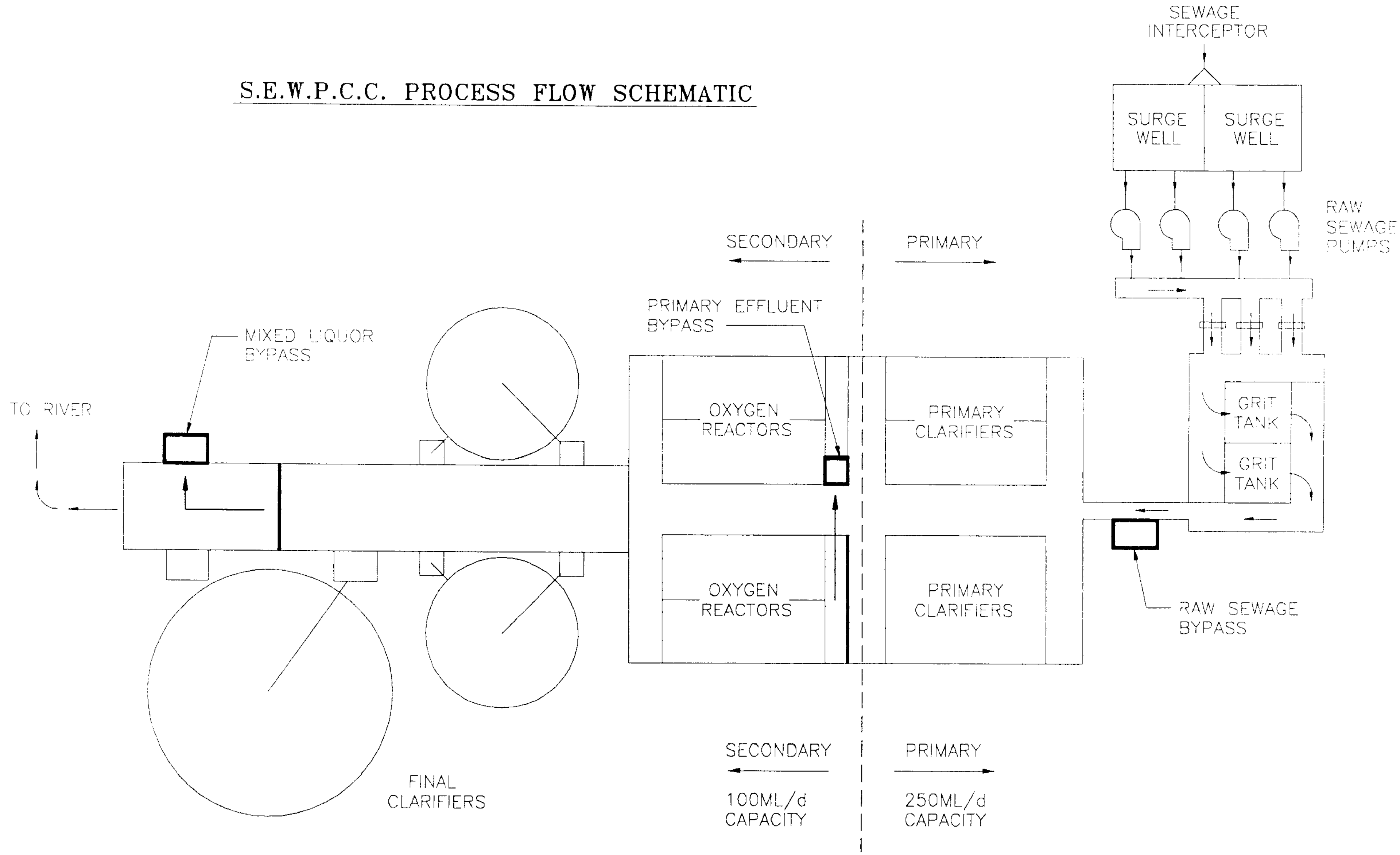
The following table summarizes the capacity of the primary and secondary portions of the SEWPCC and references the capacity as a factor of the ADWF.

Treatment	ADWF ML/d	PDWF ML/d	Factor x ADWF	PWWF	Factor x ADWF
Primary	59	100	1.7	176	3.0
Secondary	59	100	1.7	100	1.7

The WPCC consists of primary treatment and oxygen activated sludge secondary treatment facilities. All sludge from the SEWPCC is hauled to the North End Water Pollution Control Centre (NEWPCC) for digestion and ultimate disposal. The process flow schematic is shown on Figure 3.1.

When the Phase I expansion is completed, the PWWF treatment capacities for secondary and primary will be increased to 150 and 264 ML/d respectively.

S.E.W.P.C.C. PROCESS FLOW SCHEMATIC



LEGEND

- OVERFLOW WEIR
- BYPASS STRUCTURE

FIGURE 3.1

3.1 Primary Treatment Components

The primary treatment components have a PWWF capacity of 176 ML/d (3 x ADWF) and can handle hydraulic loads up to 250 ML/d (4 x ADWF). The various unit process are described below.

3.1.1 Raw Sewage Pumps

There are four raw sewage pumps, all with variable speed drives:

- Two pumps each with capacity of 68 ML/d.
- Two pumps each with capacity of 114 ML/d.
- Installed capacity is 364 ML/d.
- Firm capacity is 250 ML/d, but can handle up to 265 ML/d at high surge well levels.

The raw sewage pumps are cycled automatically and speed varied to maintain wet-well set point elevations. The set point is adjustable according to wet-weather or dry-weather seasons. During the wet-weather season the set point is kept low to enable maximum storage within the interceptor.

3.1.2 Screens

There are three self-cleaning screens, each 1.83 m wide. These have the capacity to handle all pumped flows, i.e., up to 364 ML/d.

3.1.3 Grit Tanks

There are two aerated grit tasks, that can hydraulically handle the full capacity of the raw sewage pumps. At flows exceeding 225 ML/d the effectiveness of the grit tanks reduces, but does not cause any bypassing.

3.1.4 Primary Clarifiers

There are three primary clarifiers:

- two with a design capacity of 44 ML/d each; and
- one with a capacity of 88 ML/d.

The design overflow rate at PWWF is 90 $m^3/m^2/d$ and the detention time is 1.1 hours. The total combined capacity is 176 ML/d. The three primary clarifiers, however, are capable of handling hydraulic flows up to 250 ML/d (4.2 x ADWF).

3.2 SECONDARY TREATMENT COMPONENTS

The secondary treatment plant components have a total ADWF capacity of 50 ML/d and a PDWF capacity of 100 ML/d (1.7 x ADWF). The various components are described in the following sections.

3.2.1 Reactors

There are four oxygen reactor tanks each with a capacity to handle PWWF of 25 ML/d for a total 100 ML/d capacity.

3.2.2 Oxygen Production Facility

The oxygen production facility consists of two pressure swing absorption (PSA) units, each with a rated capacity of 9.0 tonnes/day and a liquid oxygen tank and oxygen supply system to provide treatment for flows up to 88 ML/d ADWF and 150 ML/d PDWF.

3.2.3 Secondary Clarifiers

There are three secondary clarifiers with the following characteristics and capacities:

- two at 33.5 m diameter each with PDWF capacity of 25 ML/d; and
- one at 45.7 m diameter each with PDWF capacity of 50 ML/d.

Total PDWF capacity is 100 ML/d and total ADWF capacity is 59 ML/d.

3.3 POTENTIAL BYPASS POSSIBILITIES

3.3.1 Bypass Descriptions

The SEWPCC has three potential bypass possibilities, as shown in Figure 3.1. The first one is between the grit tanks and primary clarifiers. This consists of an overflow weir in the channel that bypasses raw sewage flows in excess of the primary clarifier hydraulic capacity. Operating staff have advised that, little if any bypass occurs here unless one or more primary clarifiers are out of service, in which case, the channel backs-up causing an overflow.

The second bypass location is downstream of the primary clarifiers, where PE flows in excess of 100 ML/d (1.7 x ADWF) are bypassed. This bypass of settled sewage occurs during spring run-off periods and following heavy rains. This bypass is required since secondary facilities can only handle 100 ML/d (1.7 x ADWF) whereas the primary facilities are rated at 176 ML/d (3.0 x ADWF) but can hydraulically handle 250 ML/d (4.2 x ADWF).

The third potential bypass location is from the mixed liquor channel. In the event of flow restriction to the final clarifiers, due to servicing, the mixed liquor can overflow a weir to a bypass manhole. This feature provides a protection against overflowing the mixed liquor channels and causing flood damage within the facility. This is estimated to occur very rarely.

3.3.2 Assessment of Bypass

Scheduled maintenance of plant components are always carried out during the winter low flow periods, during this time, no bypassing is necessary.

The only location where bypassing occurs fairly frequently is downstream of the primary clarifiers. Bypasses are not monitored or sampled. Extent of bypass of PE can be obtained by the difference between raw-sewage flows and feed to secondary providing no bypass has occurred ahead of the primaries.

The characteristics of the PE bypass are somewhat represented by the sample for PE. This sample provides an approximation only as the PE sample is a 24-hour composite, while the bypass may occur only for a portion of that time, and may have different characteristics.

3.4 SAMPLING AND FLOW MONITORING

Flow monitoring is carried out continuously by means of magnetic flow meters at various locations. Flow proportional composite samples are collected daily, except weekends, at several locations as tabulated on the following page.

SEWPCC
MONITORING AND SAMPLING LOCATIONS

Location	Flow Monitoring	Sampling
Raw Sewage	daily flow per pump daily totalized flow daily maximum flow daily minimum flow daily average flow	collected from pump discharge channel
Surge Well	daily minimum level daily maximum level daily average level	no sampling
PE (Feed to Reactors)	daily flow to each reactor daily total flow to reactors daily maximum flow daily minimum flow daily average flow	sampling from each reactor feed is optional, usually one only is sampled
Final Clarifier	daily ML flow to each clarifier	from each final clarifier effluent
Final Effluent		from final effluent conduit

4.0 WEST END WATER POLLUTION CONTROL CENTRE (WEWPCC)

The WEWPCC is a new facility completed in 1993, and can provide secondary treatment for an ADWF of 32 ML/d

The following table summarizes the capacity of the primary and secondary portion of the WEWPCC and references the capacity as a factor of the ADWF:

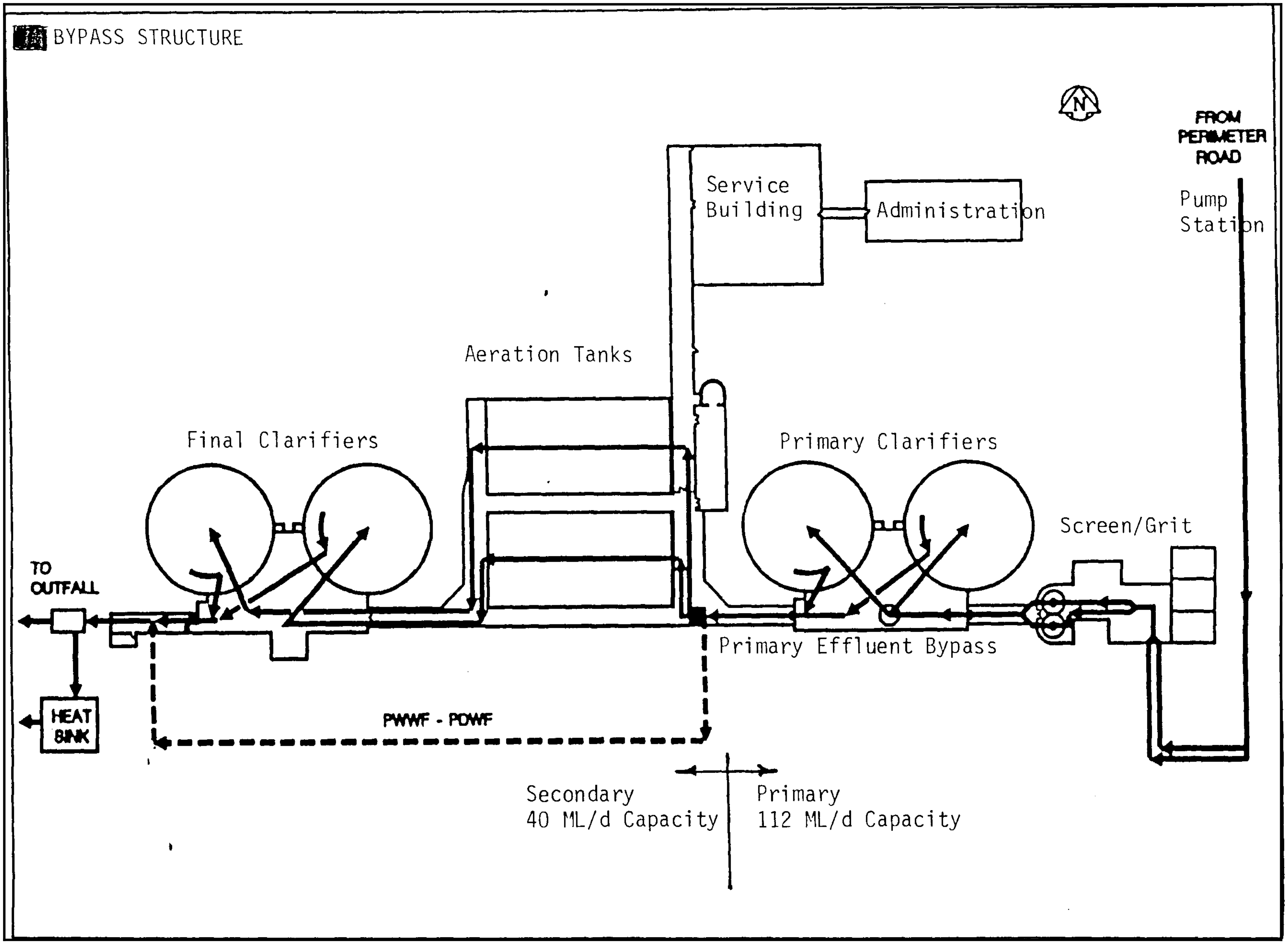
Treatment	ADWF ML/d	PDWF ML/d	Factor x ADWF	PWWF ML/d	Factor x ADWF
Primary	32	[1]40	1.25	112	3.5
Secondary	32	[1]40	1.25	[1]40	1.25

[1]Capacity currently restricted to 40 ML/d. Rated capacity is 54 ML/d (1.7 x ADWF).

The WEWPCC consists of primary treatment and air activated sludge secondary treatment facilities. All sludge from the WEWPCC is hauled to the NEWPCC for digestion and ultimate disposal. The process flow schematic is shown on Figure 4.1.

4.1 PRIMARY TREATMENT COMPONENTS

The primary treatment components have a PWWF capacity of 112 ML/d (3.5 x ADWF). The various components are described in the following sections.



WEST END WATER POLLUTION CONTROL CENTER PROCESS FLOW SCHEMATIC

FIGURE 4.1

4.1.1 Raw Sewage Pumps

The Perimeter Road Pumping Station which is located remote from the WEWPCC consists of four pumps with the following capacities:

Pump	ML/d
One Variable Speed Electric	39 to 60
One Variable Speed Diesel	26 to 59
One Single Speed Electric	40
One is Small and is Not Normally Used	
Installed Capacity	**160**
Firm Capacity	**112**

The raw sewage pumps are cycled automatically and speed varied over a certain range depending on wet-well elevations.

4.1.2 Screens

There are two self-cleaning screens each with a capacity of 86 ML/d. These can handle all flows pumped to the WPCC.

4.1.3 Grit Removal

The two vortex type grit removal chambers each have a capacity of 86 ML/d, and can thus treat all pumped flows.

4.1.4 Primary Clarifiers

There are two 30 m diameter circular primary clarifiers each with a capacity of 86 ML/d. Thus all pumped flows can be provided with primary treatment.

4.2 SECONDARY TREATMENT COMPONENTS

The secondary treatment plant components are rated to provide secondary treatment for ADWFs of 32 ML/d. The PWWF capacities are rated at 54 ML/d but are currently limited to 40 ML/d. A bypass weir ahead of the secondary plant enables bypass of all PE flows in excess of 40 ML/d.

4.2.1 Aeration Tanks

There are two aeration tanks. These are fitted with coarse bubble diffused air diffusers. Their PWWF capacity is currently limited to a combined total flow of 40 ML/d.

4.2.2 Secondary Clarifiers

There are two 30 m diameter circular secondary clarifiers, their combined capacity is currently limited to 40 ML/d.

4.3 POTENTIAL BYPASS POSSIBILITIES

4.3.1 Bypass Descriptions

There is only one location within the WEWPCC where bypass of flows can occur. This location is downstream of the primary clarifiers, just ahead of the aeration tanks. Since the secondary treatment components can only handle flows of 40 ML/d, all PE flows in excess of 40 ML/d bypass the secondary facilities and are directed to the outfall.

The outfall from the plant is directed to one of the original facultative lagoon secondary cells, which in turn, discharges to the Assiniboine River.

4.3.2 Assessment of Bypass

Scheduled maintenance of plant components are always carried out during the winter low flow period, during this period no bypassing is necessary. The bypassing of PE occurs only during run-off and following heavy rains. Bypasses are not monitored or sampled. Extent of bypass can be obtained by the difference between the raw sewage pumped and the flows to the secondary facilities. The quality of the bypass is represented by the PE sample. This would be an approximation only as the PE sample is a 24-hour composite, while the bypass may occur only over a short time.

4.4 Sampling and Flow Monitoring

Flow monitoring is carried out continuously by means of magnetic flow meters at various locations. Proportional flow composite samples are collected daily, except weekends, at several locations, as tabulated below:

WEWPCC FLOW MONITORING AND SAMPLING LOCATIONS		
Location	**Flow Monitoring**	**Sampling**
Raw Sewage	daily total flow monthly maximum daily flow monthly minimum daily flow monthly average daily flow	collected at plant inlet before screens
PE	daily flow to each reactor daily total flow monthly maximum daily flow monthly minimum daily flow monthly average daily flow	collected at PE discharge channel
Final Clarifier	daily flows to each clarifier daily totalized flow monthly maximum daily flow monthly minimum daily flow monthly average daily flow	collected from effluent from one clarifier and from plant effluent
Final Effluent		final effluent leaving lagoon (timed sample rather then flow proportionate)

5.0 DISCUSSION REGARDING AVAILABLE DATA

5.1 GENERAL

The flow monitoring and sampling information collected at all three WPCCs provides detailed data for normal plant operation, and the discharge to the rivers.

The impact of any bypassing which occurs within the WPCC either during emergencies or during run-off and wet-weather flow conditions when some bypassing of PE occurs is not readily available.

5.2 SAMPLING

The characteristics of the PE sample provide only an indication of the characteristics of any PE bypass, the conditions during intermittent bypassing, may not be accurately reflected in the composite PE sample.

The characteristics of the plant effluent sample provide reliable data for dry weather flow periods. When bypassing occurs it may do so for short periods of time which may, depending on the cycles used for the composite sample, not affect the sample quality. For the WEWPCC, the storage heat sink provides some equalization of flows, so the accuracy of the final effluent sample should be quite reliable.

For the most part, analysis of the raw sewage and process effluents comprises TSS and BOD.

5.3 FLOW MEASUREMENTS

The volume of bypass occurring at the WPCCs is not measured, however, it can be calculated from the difference between raw sewage flow and the flow to the secondary reactors or aeration tanks. It may be useful to routinely monitor any flow differences to record this information, when it occurs. This data may initiate different operating procedures.

5.3.1 NEWPCC and WEWPCC

At the NEWPCC and the WEWPCC, virtually the only bypass that occurs is PE ahead of the secondaries, consequently, the difference between raw sewage flow and secondary supply, combined with PE characteristics would provide a measure of the bypass impact. A more accurate approach would be to detect a bypass occurrence and initiate a separate sampler that would take frequent samples of the overflow during the overflow period. This additional sample with the flow differential would provide more reliable data regarding the impact of the PE bypass.

5.3.2 SEWPCC

At the SEWPCC, in addition to the PE bypass, there may be occasional raw sewage bypasses ahead of the primary clarifiers. This may or may not be reflected on the final effluent sample depending on the duration of the bypass.

5.4 FIRST FLUSH ANALYSIS

In order to determine the impact of the first flush and its duration, additional samplers could be installed on the raw sewage feed to each plant. These could be initiated whenever the raw sewage flow metering devices indicate flows with scouring velocities. The samples collected could be stored separately to enable an analysis of relative sewage strength over the high flow period. If the flows were continuously recorded during this period, the data collected would provide useful information in sizing retention facilities to capture solids during the high solids first flush period.

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 CONCLUSIONS

1. The operation of the NEWPCC and SEWPCC with low surge well levels during wet-weather seasons provides potential for storage within the interceptors during a high flow event.

2. The data collected from the WPCC records provides good information on normal plant operation, but it becomes less reliable during high flow events when some bypassing occurs within the WPCCs.

6.2 RECOMMENDATIONS

1. To get better information and to enable corrective measures, the bypassing within the WPCCs should be monitored by automatically detecting and recording the differences between raw sewage flows and secondary flows.

2. Additional noncomposited samples of raw sewage, PE bypass, and final effluent should be collected during the high flow events to develop a better understanding of impact of plant bypasses and on the variations of sewage strength during high flow periods.

3. Flows to and through the plant should be recorded during storm events so that the impact of the first flush can be established in conjunction with additional sampling. This has already been initiated in part at the NEWPCC and should be initiated at the other two WPCCs.

4. Until disinfection is in place, daily final effluent samples for each WPCC should be analyzed for fecal coliform count during a number of storm events. This sampling should continue for some days after each storm event. This information will be used to calibrate the model of fecal coliform concentration in the river.