SECTION 2.0
FACILITY PLANNING FRAMEWORK

2.1 INTRODUCTION

2.1.1 General

This section of the report sets out the framework used in the development of alternatives for upgrades to the City of Winnipeg's Water Pollution Control Centres (WPCCs) to reduce the level of un-ionized ammonia discharged to the Red and Assiniboine Rivers.

2.1.2 Planning Horizons

The implementation of nitrification upgrades at any of the City's WPCCs will be a major undertaking, requiring a substantial investment and providing potentially long lasting benefits. Therefore, the development and evaluation of alternatives must be based on a long term perspective. For this purpose, the planning horizon has been selected to be the year 2041, which provides for approximately 40 years from the time that this study is expected to be completed. The 40 year period is consistent with the long term horizon assumed by the City in previous conceptual planning studies for the three plants.

It is often appropriate to also consider a shorter term horizon for when planning facility development. The shorter term horizon is applicable when considering the implementation of works, particularly the staging of construction. Staging can be used to mitigate the risk of overbuilding facilities, which may occur if only the longer term horizon is considered. Typically, shorter term horizons can be considered in increments of 10 years.

As noted in the following Section 2.2, the increase in wastewater flows and loads over the long term planning horizon will be minimal for the NEWPCC and the WEWPCC. Therefore, it is likely not practicable nor advantageous to the City to consider staging of the implementation of nitrification at these two facilities to accommodate increases in flows and loads over the long term planning horizon. (Staging to achieve increasingly more stringent effluent standards could be sensible and is to be considered in the Conceptual Design Report).

For the SEWPCC, the increase in flows and loads over the long term planning horizon is more significant and it may make sense to consider staged implementation to match expenditures more closely to growth.

2.1.3 Allowances for Future Conditions

As a general rule, it is appropriate to make some allowance for possible future needs. With respect to this study, various levels of ammonia control will be considered and some consideration will be given to nutrient control requirements. In setting out alternatives for a given level of control, due consideration will be given the highest anticipated level of control, and wherever practicable, allowances to readily facilitate upgrading to higher levels of control will be incorporated in the preliminary and conceptual designs. Alternatives that are easily adapted to meet future requirements will have an inherent advantage.

2.2 FLOW AND LOAD PROJECTIONS

2.2.1 General

This section develops wastewater flow and load predictions appropriate for planning future wastewater treatment capacity requirements for the three City of Winnipeg Water Pollution Control Centres. First, in Section 2.2.2, population and flow and load projections that have been prepared by the City are reviewed. In Section 2.2.3, historic flows and loads are reviewed for each of the three plants. These flows and loads are compared to recent City projections. Unit flow projections are presented in Section 2.2.4 that reflect the findings of the data review. Similar rationale is developed in Section 2.2.5 to provide a basis for unit loads that can be used for future projections. Diurnal flow variations are discussed in Section 2.2.6. Section 2.2.7 presents future flow and load projections based on the populations and unit flows and loads derived in previous subsections. In Section 2.2.7, a synthetic flow and load projection is developed for use in modeling plant processes.

2.2.2 City of Winnipeg Projections

The City of Winnipeg recently prepared a series of population projections for their wastewater utility [City of Winnipeg (1999). *Population and Land Development Projections for the NEWPCC, SEWPCC, and WEWPCC Service Areas*, Water and Waste Department, City of Winnipeg]. The population projections are based on the totals predicted for the Winnipeg Water Conservation Project [TetrES Consultants Inc. (1998). *Water Demand Evaluation and Projections Report*, Water and Waste Department, City of Winnipeg]. Population growth derived for this report was based on moderate projections developed in 1994 by the City Planning Department. In the 1999 report, the population was segregated into the three wastewater catchments by reviewing neighbourhood populations and allotting the tributary populations to each catchment in accordance with the location of the neighbourhood. Recent growth in each catchment was assessed to determine a growth rate specific to each. Potential growth areas and the development plans for each were considered to modify the recent growth rates so that they could be extrapolated into the future. Based on this work, predicted catchment populations for the three plants are as shown in Table 2.1.

Table 2.1: Population Projections[1]

Year	NEWPCC	SEWPCC	WEWPCC	City Total
1996	373,355	159,530	85,635	618,520
1997[2]	374,920	163,849	86,011	624,780
1998[2]	376,485	168,168	86,386	631,039
1999[2]	378,050	172,487	86,762	637,299
2001	381,179	181,124	87,513	649,816
2006	384,741	190,955	88,368	664,064
2011	387,872	199,956	89,119	676,947
2016	391,277	208,993	89,936	690,206
2021	394,970	219,187	90,823	704,980
2026	398,452	228,798	91,658	718,908
2031	401,048	235,961	92,281	729,290
2036	402,542	240,085	92,640	735,267
2041	403,295	242,164	92,821	738,280
2046	403,968	244,021	92,982	740,971

NOTES: 1. Data taken from "City of Winnipeg (1999). *Population and Land Development Projections for the NEWPCC, SEWPCC, and WEWPCC Service Areas*, Water and Waste Department, City of Winnipeg.

2. Values shown for 1997 to 1999 were derived from linear interpolation between the actual 1996 and the predicted 2001 populations.

In another recent report prepared by the City [City of Winnipeg (1999). *Wastewater Flow and Load Projections for the NEWPCC, SEWPCC, and WEWPCC*, Water and Waste Department, City of Winnipeg.], the flows were predicted for each of the three catchments. The total flows were based on the application of unit flow rates to the tributary population. The unit flows were assumed to decrease with time. The rationale for this decrease was based on the approach developed for the Winnipeg Water Treatment Plant Conceptual Design, as reported in a 1998 TetrES report [TetrES Consultants Inc. (1998). *Water Demand Evaluation and Projections Report*, City of Winnipeg, Water and Waste Department.] Numerous reasons were presented for the trends indicated, the more important of which are summarized in the following:

- Increasing public awareness of the environmental need to conserve water.
- Avoidance of costs through reduced water consumption.

- The introduction of water conserving appliances; especially low volume flush toilets and low water use showers.
- Changing demographics.

The recent trend to lower water consumption, and thus, less wastewater generation, is contrary to historic trends toward greater consumption. Until the 1980s, water and wastewater utilities generally planned future expansions on the basis of ever increasing rates of water consumption. The increased use of water using appliances and increased affluence justified this approach.

Since the 1980s, cultural changes, lower government funding levels, and an increased public appreciation of the limited nature of water resources has stimulated water conservation. Subsequently, water use fell, either through voluntary reductions in consumption or through stipulated or price driven programs.

Per capita commercial and industrial water use allocations were assumed to remain constant (50 L/c/d and 75 L/c/d, respectively). Based on the derived unit water consumption rates, it was estimated that Winnipeg's average water consumption would remain relatively constant at between 300 and 315 ML/d until after 2040.

A sensitivity analysis of the basic assumptions used in the water consumption evaluation provided estimates of high and low boundaries for the projections, summarized for 2046 as follows:

2046	–	Median Water Consumption Estimate	307 ML/d
	–	Low Water Consumption Estimate	286 ML/d
	–	High Water Consumption Estimate	351 ML/d

The 1998 TetrES report suggested that technology change would account for approximately 45 L/c/d in reduced indoor residential water consumption (from 221 L/c/d to 176 L/c/d) in the same period. A further 4 L/c/d reduction in water consumption was suggested to occur as a result of public education programs aimed at water conservation. Offsetting these decreases was the trend toward lower housing densities. At lower housing densities, per capita water consumption increases.

Given these current trends, the predicted wastewater unit flows (Litres per capita per day, L/c/d) for Winnipeg are presented in Table 2.2.

Table 2.2: Predicted Wastewater Unit Flows (L/c/d, Average Annual)[1]

Year	NEWPCC[2]	SEWPCC	WEWPCC
1996	704	397	412
1997	701	392	409
1998	699	388	406
1999[2]	691	390	406
2001	688	387	402
2006	691	387	403
2011	686	381	396
2016	681	376	390
2021	677	372	386
2026	672	374	384
2031	669	374	381
2036	668	370	378
2041	667	364	375

NOTES:
1. Data taken from "City of Winnipeg (1999). *Wastewater Flow and Load Projections for the NEWPCC, SEWPCC, and WEWPCC*, Water and Waste Department, City of Winnipeg.
2. Values indicated for 2006 and beyond were modified to adjust for the possible contribution from the City of Winnipeg Water Treatment Plant.

The projected unit wastewater flows decrease between 8 and 9 percent between 1999 and 2041. In the NEWPCC catchment, this reduction totals 34 L/c/d; in the SEWPCC catchment, 26 L/c/d; and in the WEWPCC, the reduction is 31 L/c/d.

The derivation of wastewater flows for each of the three catchments, through the period of 1996 to 2046, was based on several steps, as follows:

1. Determine projected total water use in the City.
2. Allocate the water consumption per catchment based on present populations.
3. Adjust water consumption in the catchments on the basis of the anticipated growth in that catchment.
4. Using historic average annual flow (AAF) to water consumption ratios, determine the AAF for each catchment.
5. Apply other historic ratios to obtain the average dry weather flow (ADWF) and peak dry weather flow (PDWF).

The PDWF derived in the City's report was actually the maximum day dry weather flow, termed MDWF for the remainder of this report. It did not include any allowance for diurnal variations during the day such as the peak hourly flow, which is the normal definition of PDWF.

2.2.3 Historic Flows and Loads

Records for the 1995 to 1998 period, for each plant, were obtained and assessed to determine several flow characteristics, as follows:

- Average annual flow (AAF): Average flow for the entire calendar year
- Maximum month flow (MMF): Maximum 30 day running average during any calendar year
- Maximum week flow (MWF): Maximum 7 day running average during any calendar year
- Maximum day flow (MDF): Maximum single day flow during any calendar year
- Average dry weather flow (ADWF): Average flow during January, February, and December of any calendar year. During years when warmer temperatures occurred earlier than the end of February of any year, the latter half of February was truncated from the averaging period.
- Maximum dry weather flow (MDWF): Maximum single day flow during the dry weather period.

These flow characteristics are tabulated for each plant in Table 2.3.

Table 2.3: Flow Characteristics - 1995 to 1998

Description	1995	1996	1997	1998
NEWPCC				
Tributary Population	371,790	373,355	374,920	376,485
Year-round				
AAF, ML/d	225	263	265	226
MMF, ML/d	381	524	552	318
MWF, ML/d	479	627	694	410
MDF, ML/d	735	742	753	711
Winter				
ADWF, ML/d[1]	179	184	183	172
MDWF, ML/d[1]	216	222	213	229

Table 2.3: Flow Characteristics - 1995 to 1998 *(Cont'd)*

Description	1995	1996	1997	1998
SEWPCC				
Tributary Population	155,211	159,530	163,849	168,168
Year-round				
AAF, ML/d	57.4	62.8	60.5	59.7
MMF, ML/d	75.2	105.3	111.0	80.4
MWF, ML/d	98.8	136.8	155.3	108.8
MDF, ML/d	190.0	177.6	171.7	173.2
Winter				
ADWF, ML/d	49.1	48.5	49.5	48.2
MDWF, ML/d	52.9	52.3	54.9	54.2
WEWPCC				
Tributary Population	85,259	85,635	86,011	86,386
Year-round				
AAF, ML/d	29.4	31.7	32.5	30.0
MMF, ML/d	41.5	55.5	58.6	37.9
MWF, ML/d	55.5	72.1	78.8	47.3
MDF, ML/d	83.8	103.9	96.0	72.6
Winter				
ADWF, ML/d	25.9	24.0	25.9	25.8
MDWF, ML/d	28.9	27.3	28.7	29.4

NOTES: 1. Winter data taken from January to February and December of any calendar year, except for 1998 when last half of February was not included in dry weather flows.

The flows in each catchment vary significantly through the year. To illustrate this phenomenon, the average and maximum day flows for the four seasons are summarized in Table 2.4. The seasons were apportioned into three month segments as follows:

Winter	December to February
Spring	March to May
Summer	June to August
Autumn	September to November

Table 2.4: Seasonal Flows - 1995 to 1998

Description	1995	1996	1997	1998
NEWPCC				
Winter[1]				
ADWF, ML/d[1]	179	184	184	172
MDWF, ML/d[1]	216	222	213	229
Spring[1]				
Average, ML/d	291	373	384	281
Maximum Day, ML/d	735	742	753	711

Table 2.4: Seasonal Flows - 1995 to 1998 *(Cont'd)*

Description	1995	1996	1997	1998
NEWPCC *(Cont'd)*				
Summer[1]				
Average, ML/d	226	282	249	234
Maximum Day, ML/d	532	694	633	429
Fall[1]				
Average, ML/d	202	212	242	197
Maximum Day, ML/d	463	366	548	421
SEWPCC				
Winter				
ADWF, ML/d	49.1	48.5	49.5	48.2
MDWF, ML/d	52.9	52.3	54.9	54.2
Spring[1]				
Average, ML/d	62.8	79.5	77.0	73.8
Maximum Day, ML/d	105.3	177.6	171.7	173.2
Summer[1]				
Average, ML/d	60.6	65.9	58.0	60.8
Maximum Day, ML/d	190.0	141.3	119.5	91.1
Fall[1]				
Average, ML/d	55.4	55.6	57.2	51.7
Maximum Day, ML/d	102.7	68.1	119.5	80.6
WEWPCC				
Winter				
ADWF, ML/d	25.9	24.0	25.9	25.8
MDWF, ML/d	28.9	27.3	28.7	29.4
Spring[1]				
Average, ML/d	33.6	40.5	41.5	34.5
Maximum Day, ML/d	83.8	98.5	96.0	72.6
Summer[1]				
Average, ML/d	30.4	34.8	32.9	31.2
Maximum Day, ML/d	64.8	103.9	73.4	46.6
Fall[1]				
Average, ML/d	27.7	27.9	29.6	27.0
Maximum Day, ML/d	53.6	34.6	57.1	44.2

NOTES: 1. Winter data taken from January to February and December of any calendar year.

Plant loads also were reviewed for the four years from 1995 to 1998. Table 2.5 summarizes the average annual loads (AAL) and maximum month loads (MML) for influent total suspended solids (TSS), 5-day biochemical oxygen demand (BOD), total Kjeldahl nitrogen (TKN), and total phosphorus (TP).

Table 2.5: Plant Loads - 1995 to 1998

Description	1995	1996	1997	1998
NEWPCC				
TSS Loads				
AAL, kg TSS/d	58,500	60,400	63,100	59,400
MML, kg TSS/d	112,300	127,700	105,400	118,300
BOD Loads				
AAL, kg BOD/d	51,800	57,400	45,500	44,600
MML, kg BOD/d	63,300	71,500	78,900	53,100
TKN Loads				
AAL, kg N/d	8,700	9,550	9,560	8,380
MML, kg N/d	9,900	12,350	11,570	10,860
Total Phosphorus Loads				
AAL, kg TP/d	1,270	1,270	1,290	1,320
MML, kg TP/d	1,490	1,900	2,030	1,760
SEWPCC				
TSS Loads				
AAL, kg TSS/d	20,600	19,600	19,500	19,700
MML, kg TSS/d	32,000	52,500	40,700	29,200
BOD Loads				
AAL, kg BOD/d	15,500	18,900	14,500	16,500
MML, kg BOD/d	20,200	59,500	21,300	21,600
TKN Loads				
AAL, kg N/d	1,860	2,420	2,320	1,920
MML, kg N/d	2,080	4,090	3,110	2,480
Total Phosphorus Loads				
AAL, kg TP/d	320	420	345	405
MML, kg TP/d	385	860	510	550
WEWPCC				
TSS Loads				
AAL, kg TSS/d	6,980	7,620	7,250	6,370
MML, kg TSS/d	7,740	11,500	13,950	10,020
BOD Loads				
AAL, kg BOD/d	5,570	6,150	5,050	5,630
MML, kg BOD/d	6,950	8,460	6,310	7,480
TKN Loads				
AAL, kg N/d	940	1,025	1,050	960
MML, kg N/d	1,010	1,170	1,160	1,250
Total Phosphorus Loads				
AAL, kg TP/d	160	160	170	185
MML, kg TP/d	180	190	190	245

NOTES:
- AAL – Average annual load; MML – maximum month load (from any 30 day running average through the year with at least 5 values).
- Values for NEWPCC include the impact of centrate return upstream of the headworks of the plant.

The records were not continuous – samples were not always obtained or analyzed each day. The maximum month loads were derived as the running averages for any 30 days when samples were taken. The number of samples might vary from 5 to 30. Any running average that represented less than 5 samples was deleted from the database.

Loads vary seasonally at the three plants. Table 2.6 lists the loads during the three month periods representing the four seasons.

Table 2.6: Seasonal Plant Loads - 1995 to 1998

Description	1995	1996	1997	1998
NEWPCC				
TSS Loads				
Winter, kg TSS/d	47,484	53,488	59,120	58,316
Spring, kg TSS/d	81,631	84,738	81,425	65,975
Summer, kg TSS/d	59,863	65,802	63,865	74,685
Autumn, kg TSS/d	44,786	49,387	44,914	51,150
BOD Loads				
Winter, kg BOD/d	43,283	45,990	62,794	50,923
Spring, kg BOD/d	45,438	56,558	63,137	46,159
Summer, kg BOD/d	45,622	40,248	58,253	45,718
Autumn, kg BOD/d	43,613	41,439	49,044	57,633
SEWPCC				
TSS Loads				
Winter, kg TSS/d	20,469	16,845	9,388	15,325
Spring, kg TSS/d	24,797	27,509	16,829	21,684
Summer, kg TSS/d	19,052	18,508	22,839	23,171
Autumn, kg TSS/d	14,629	17,280	14,944	18,201
BOD Loads				
Winter, kg BOD/d	15,534	15,225	10,088	14,513
Spring, kg BOD/d	18,113	17,529	18,854	15,493
Summer, kg BOD/d	16,479	12,791	18,955	14,470
Autumn, kg BOD/d	15,587	13,310	13,829	16,675
WEWPCC				
TSS Loads				
Winter, kg TSS/d	6,181	5,936	7,694	6,403
Spring, kg TSS/d	7,370	8,885	8,424	7,985
Summer, kg TSS/d	5,841	7,222	7,181	6,890
Autumn, kg TSS/d	6,004	6,784	7,036	6,632
BOD Loads				
Winter, kg BOD/d	5,748	5,407	7,359	5,940
Spring, kg BOD/d	5,956	5,102	4,960	5,375
Summer, kg BOD/d	5,129	4,634	6,092	4,866
Autumn, kg BOD/d	5,700	5,129	6,523	6,113

NOTES:
- AAL – Average annual load; MML – maximum month load (from any 30 day running average through the year with at least 5 values).
- Values for the NEWPCC include the impact of centrate return upstream of the headworks of the plant.

Table 2.7 lists the ratio of the average load during the season to the annual average load, for the four plants. The values listed in this table are based on the data from all four years of record at each plant.

Table 2.7: Ratio of Seasonal Plant Loads to Average Plant Loads

Season	NEWPCC		SEWPCC		WEWPCC	
	TSS Load	BOD Load	TSS Load	BOD Load	TSS Load	BOD Load
Winter	0.90	1.02	0.83	0.90	0.96	1.08
Spring	1.30	1.06	1.21	1.13	1.20	0.96
Summer	1.09	0.95	1.12	1.01	0.99	0.92
Autumn	0.79	0.97	0.88	0.96	0.97	1.04

At each plant, TSS loads are higher during the spring (30 percent higher than the norm at the NEWPCC and about 20 percent at the other two plants). The maximum always occurred during the spring at all three plants. This phenomenon is due to the flushing of the sewers that accompanies snowmelt flows. In addition, the NEWPCC is a combined sewer system and experiences a large inert solids load due to road debris entering the sewer system. Summer TSS loads are higher than those experienced in the autumn and winter; although below spring levels. Intermittent flushing due to rainfall events is the likely cause.

Seasonal BOD load fluctuations are not as pronounced. At the NEWPCC and SEWPCC, spring BOD loads are slightly higher than those measured during the remainder of the year. Natural sewer flushing likely causes the elevated BOD loads, similar to the higher TSS loads during this period. The recorded winter BOD loads at the WEWPCC are higher than the BOD loads measured during the remainder of the year. The difference is not substantial and it would be justified to assume that the BOD load remained relatively constant through the year at the WEWPCC.

TKN and TP loads are not shown in the table, but exhibit seasonal characteristics similar to BOD loads. As with the BOD, a portion of the TKN and TP are soluble and the remainder is associated with the particulate material in the wastewater.

2.2.4 Unit Flows

Unit flows for the last four years are calculated by dividing the measured flow by the estimated tributary population. The unit flows for each plant, through the 1995 to 1998 period, are listed in Table 2.8.

Table 2.8: Unit Flows - 1995 to 1998

Description	1995	1996	1997	1998	Average
NEWPCC					
Year-round					
AAF, L/c/d	604	704	707	599	654
MMF, L/c/d	1026	1404	1473	846	1187
MWF, L/c/d	1287	1681	1852	1088	1477
MDF, L/c/d	1977	1987	2008	1889	1965
Winter					
ADWF, L/c/d [1]	482	493	491	457	481
MDWF, L/c/d [1]	581	595	568	608	588
SEWPCC					
Year-round					
AAF, L/c/d	370	393	370	355	372
MMF, L/c/d	485	660	677	478	575
MWF, L/c/d	636	858	948	647	772
MDF, L/c/d	1224	1113	1048	1030	1104
Winter					
ADWF, L/c/d [2]	316	304	302	287	302
MDWF, L/c/d [2]	341	328	335	322	331
WEWPCC					
Year-round					
AAF, L/c/d	345	371	378	348	360
MMF, L/c/d	486	648	681	439	564
MWF, L/c/d	651	842	916	548	739
MDF, L/c/d	983	1213	1116	840	1038
Winter					
ADWF, L/c/d [2]	304	280	301	299	296
MDWF, L/c/d [2]	339	319	334	340	333

NOTES: 1. Winter data taken from January to February and December of any calendar year.
2. Winter data for SEWPCC and WEWPCC does not include last half of February.

Unit flows during dry weather are relatively consistent at all three plants. Due to the influence of extraneous wastewater flows during wetter periods and spring thaw, the annual maximums vary substantially, due to changing meteorological and groundwater conditions. For analysis and design, it is prudent to base the predicted maximums on a biased average resulting in conservative unit flows. The average of the three highest values measured during the four years is used for further assessments, as summarized in Table 2.9.

Table 2.9: Comparison Between Actual and Conservative Unit Flows[1]

Description	Actual, 1995 to 1998	Unit Flows- Basis for Analysis[1]	Ratio to ADWF
NEWPCC			
AAF, L/c/d	654	655	1.35
MMF, L/c/d	1187	1300	2.68
MWF, L/c/d	1477	1605	3.31
MDF, L/c/d	1965	1990	4.10
ADWF, L/c/d	481	485	-
MDWF, L/c/d	588	595	1.23
SEWPCC			
Year-round			
AAF, L/c/d	372	375	1.23
MMF, L/c/d	575	610	2.00
MWF, L/c/d	772	820	2.69
MDF, L/c/d	1104	1130	3.70
ADWF, L/c/d	302	305	-
MDWF, L/c/d	331	335	1.10
WEWPCC			
Year-round			
AAF, L/c/d	360	360	1.20
MMF, L/c/d	564	605	2.02
MWF, L/c/d	739	805	2.68
MDF, L/c/d	1038	1105	3.68
ADWF, L/c/d	296	300	-
MDWF, L/c/d	333	340	1.13

NOTES: [1] Conservative unit flows are based on the average of the highest three years during the four year period from 1995 and 1998.

The average unit flows measured over the last four years are lower than the City's projected values for 1999. In the case of the NEWPCC and WEWPCC, even the projected unit flows for 2041 are higher than the actual 1995 to 1998 flows, as shown in the following:

	1995 to 1998 Actual	City Projection 1999	2041
NEWPCC, AAF, L/c/d	654	695	669
SEWPCC, AAF, L/c/d	372	408	364
WEWPCC, AAF, L/c/d	360	396	375

The ratio used by the City in the calculation of the average annual flow differs slightly from the values derived from the last four years of data. At the NEWPCC, the 4-year average AAF:ADWF ratio is 1.35 while the City's projections incorporate a value of 1.275. At the SEWPCC, the 4-year average AAF:ADWF ratio is 1.23 and the City's projection is 1.16. The 4-year average AAF:ADWF ratio at the WEWPCC is 1.20

while the City used 1.175. These small differences are related to the different data sets for which the ratios were calculated.

To maintain similarity with the City's projections, its AAF:ADWF ratios are used for future projections. For other flows (MMF, MWF, etc.), the City did not project values and the ratios used to derive future projections are based on the last four years of data.

The use of ratios to determine the maximum flows from the ADWF implicitly assumes that the characteristics of the catchment will remain unchanged. Technology changes, variations in the industrial and commercial components, changes in wet weather flow management techniques, and other factors will influence future maximum flows. However, determination of the impact of these future effects is likely not significant within the context of the accuracy of the projections. For this reason, the ratio of maximum flows to ADWF is assumed to remain constant through the study period.

There is one exception. Peak wet weather flows (PWWF) are related more to collection and conveyance system capacity. These characteristics are not likely to change substantially in the foreseeable future unless modified to suit changes in CSO management policy. Generally, PWWFs will be consistent with the pumping capacity at the three plants. The maximum and firm capacity of the three plants is as follows:

	Maximum Pumping Capacity (ML/d)	Firm Pumping Capacity (ML/d)
NEWPCC	1,060	865
SEWPCC	364	250
WEWPCC	112	100

During the spring of 1997, each plant ran at full capacity. Although this operation was coincident with an unprecedented flood situation, anecdotal data suggest that the plants must handle flows of this magnitude frequently. Thus, for the purpose of this report, PWWF values have been assumed to equal the maximum pumping capacity at each plant.

2.2.5 Unit Loads

Unit loads for the last four years are based on the measured load (flow times the concentration) divided by the estimated tributary population and are listed in Table 2.10.

Table 2.10: Unit Loads - 1995 to 1998

Description	1995	1996	1997	1998	Averages
NEWPCC					
TSS Loads					
AAL, kg TSS/c/d	0.157	0.162	0.168	0.158	0.161
MML, kg TSS/c/d	0.302	0.342	0.281	0.314	0.310
BOD Loads					
AAL, kg BOD/c/d	0.139	0.154	0.121	0.118	0.133
MML, kg BOD/c/d	0.170	0.192	0.210	0.141	0.178
TKN Loads					
AAL, kg N/c/d	0.023	0.026	0.025	0.022	0.024
MML, kg N/c/d	0.027	0.033	0.031	0.029	0.030
Total Phosphorus Loads					
AAL, kg TP/c/d	0.0034	0.0034	0.0035	0.0035	0.0034
MML, kg TP/c/d	0.0040	0.0051	0.0054	0.0047	0.0048
SEWPCC					
TSS Loads					
AAL, kg TSS/c/d	0.133	0.123	0.119	0.117	0.123
MML, kg TSS/c/d	0.206	0.329	0.248	0.174	0.239
BOD Loads					
AAL, kg BOD/c/d	0.100	0.119	0.088	0.098	0.101
MML, kg BOD/c/d	0.130	0.373	0.130	0.129	0.190
TKN Loads					
AAL, kg N/c/d	0.012	0.015	0.014	0.011	0.013
MML, kg N/c/d	0.013	0.026	0.019	0.015	0.018
Total Phosphorus Loads					
AAL, kg TP/c/d	0.0021	0.0026	0.0021	0.0024	0.0023
MML, kg TP/c/d	0.0025	0.0054	0.0031	0.0033	0.0036
WEWPCC					
TSS Loads					
AAL, kg TSS/c/d	0.082	0.089	0.084	0.074	0.082
MML, kg TSS/c/d	0.114	0.134	0.162	0.116	0.132
BOD Loads					
AAL, kg BOD/c/d	0.065	0.072	0.059	0.065	0.065
MML, kg BOD/c/d	0.081	0.099	0.073	0.087	0.085
TKN Loads					
AAL, kg N/c/d	0.011	0.012	0.012	0.011	0.012
MML, kg N/c/d	0.012	0.014	0.014	0.014	0.013
Total Phosphorus Loads					
AAL, kg TP/c/d	0.0019	0.0019	0.0020	0.0021	0.0020
MML, kg TP/c/d	0.0021	0.0022	0.0022	0.0029	0.0023

NOTES:
- AAL – Average annual load; MML – maximum month load (from any 30 day running average through the year with at least 5 values).
- Values for NEWPCC include the impact of centrate return upstream of the headworks for the plant.

Unit loads at the NEWPCC are substantially higher than the unit loads measured at the other two plants. Some of this difference will be due to the fact that at the NEWPCC, centrate is returned to the mainstream flow at a point upstream of the headworks. Thus, the raw wastewater samples at the NEWPCC include the impact of centrate return. This difference is likely to be greatest for TKN. At the NEWPCC, the centrate stream contributes about 20 percent of the TKN load. This difference is due also in part to the commercial and industrial contributors to the NEWPCC. Furthermore, additional TSS load is due in part to the combined sewer system and the debris that is discharged to the sewer with the stormwater (street sand, leaves, etc).

Generally, the unit loads for NEWPCC and SEWPCC are higher than measured in many other western Canadian cities. Generally, unit TSS and BOD loads range from 0.07 kg/c/d to 0.11 kg/c/d. The unit loads derived for several other cities in comparison to the three Winnipeg plants are as follows:

	TSS Load (kg/c/d)	BOD Load (kg/c/d)	TKN Load (kg/c/d)	TP Load (kg/c/d)
Prince Albert, Saskatchewan	0.110	0.100	0.012	0.004
Regina, Saskatchewan	0.108	0.770	-	-
Calgary, Alberta	0.105	0.110	-	-
Grande Prairie, Alberta	0.118	0.074	-	-
Banff, Alberta	0.093	0.080	-	-
Kelowna, B.C.	0.075	0.075	0.014	0.003
Vancouver, B.C.				
Annacis Island Catchment	0.092	0.102	-	-
Lulu Island Catchment	0.092	0.094	-	-
Winnipeg				
NEWPCC	0.161	0.133	0.024	0.0034
SEWPCC	0.123	0.101	0.013	0.0023
WEWPCC	0.082	0.065	0.012	0.0030

Regina and Annacis Island have significant industrial contributors and large combined sewer areas within the catchment. Nonetheless, unit TSS and BOD loads are much higher in the NEWPCC catchment than in these two examples. This anomaly should be investigated by the City.

Like the flows, the maximum values selected for input into further analysis are based on the average of the highest three years, as summarized in Table 2.11.

Table 2.11: Comparison Between Actual and Conservative Unit Loads

Description	Actual, 1995 to 1998	Unit Flows- Basis for Analysis
NEWPCC		
TSS Loads		
AAL, kg TSS/c/d	0.161	0.161
MML, kg TSS/c/d	0.310	0.320
BOD Loads		
AAL, kg BOD/c/d	0.133	0.133
MML, kg BOD/c/d	0.178	0.190
TKN Loads		
AAL, kg N/c/d	0.024	0.024
MML, kg N/c/d	0.030	0.031
Total Phosphorus Loads		
AAL, kg TP/c/d	0.0034	0.0034
MML, kg TP/c/d	0.0048	0.0051
SEWPCC		
TSS Loads		
AAL, kg TSS/c/d	0.123	0.123
MML, kg TSS/c/d	0.239	0.260
BOD Loads		
AAL, kg BOD/c/d	0.101	0.101
MML, kg BOD/c/d	0.190	0.210
TKN Loads		
AAL, kg N/c/d	0.013	0.013
MML, kg N/c/d	0.018	0.020
Total Phosphorus Loads		
AAL, kg TP/c/d	0.0023	0.0023
MML, kg TP/c/d	0.0036	0.0039
WEWPCC		
TSS Loads		
AAL, kg TSS/c/d	0.082	0.082
MML, kg TSS/c/d	0.132	0.137
BOD Loads		
AAL, kg BOD/c/d	0.065	0.065
MML, kg BOD/c/d	0.085	0.090
TKN Loads		
AAL, kg N/c/d	0.012	0.012
MML, kg N/c/d	0.013	0.014
Total Phosphorus Loads		
AAL, kg TP/c/d	0.0020	0.0020
MML, kg TP/c/d	0.0023	0.0024

NOTES:
- AAL – Average annual load; MML – maximum month load (from any 30 day running average through the year with at least 5 values).
- Values for NEWPCC include the impact of centrate return upstream of the headworks for the plant.

2.2.6 Diurnal Flow Variations

Peak flows are generally considered the maximum flow during any one hour period. There are two peak flows of interest – peak dry weather flow (PDWF) and peak wet weather flow (PWWF). Generally the peak flow to any Winnipeg plant is a result of rain storm or spring runoff events. These peaks have been identified in the previous sections – maximum month flow, maximum week flow, and maximum day flow.

Wastewater treatment planning must also account for the diurnal peaks that occur in a plant. To analyze these peaks, flow data measured at short intervals - 6 minutes intervals at NEWPCC through 1999 and 10 minute intervals for 1996 were reviewed. At the other plants, flow data recorded in 10 minute intervals were obtained for 1996 and 1999. In addition, previous data from the SEWPCC for the summer of 1998 were obtained.

Figure 2.1 illustrates the flow pattern measured for several days in January 1996 (10 minute intervals). The flow records on several days in January 1999 are shown in Figure 2.2.

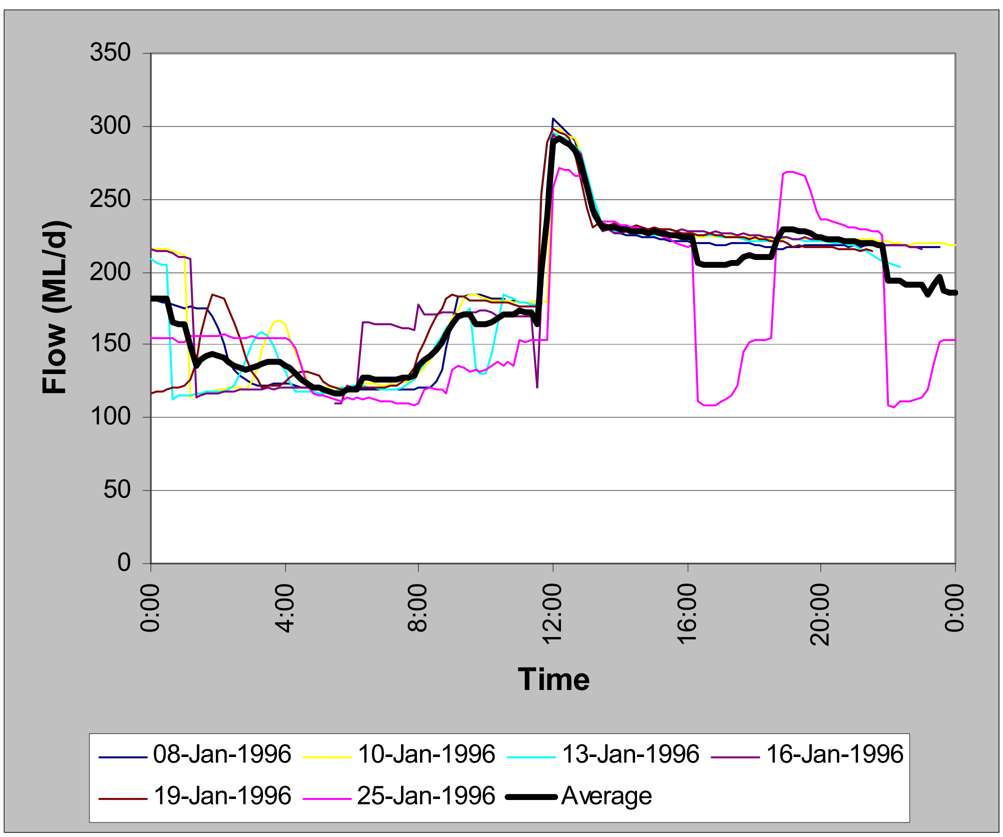

Figure 2.1: Diurnal Flow at NEWPCC, Dry Weather Periods, 1996

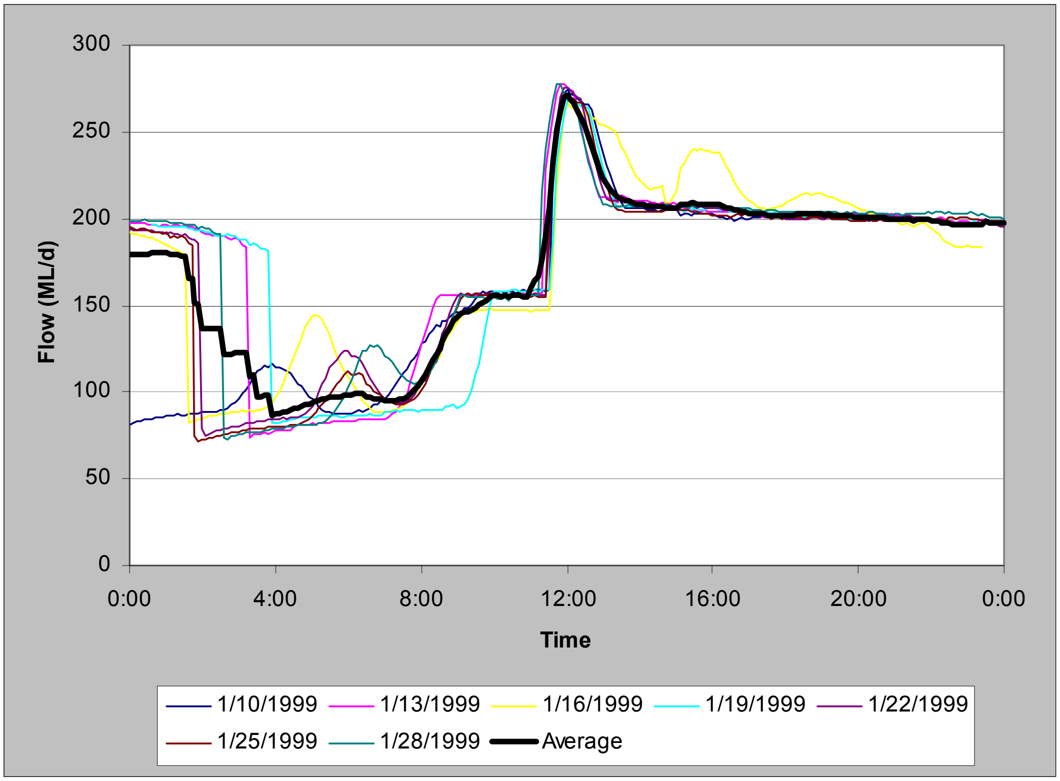

Figure 2.2: Diurnal Flow at NEWPCC, Dry Weather Periods, 1999

The pattern is very similar for the selected dates during 1996 and 1999. For both years, the data have been shifted to superimpose the peaks that generally happen at approximately 12:00 p.m. The peaks actually occurred between 11:30 am and 2:00 p.m. During 1996, the average flow for the dates that are shown in the graph is 184 ML/d and the peak to average ratio is about 1.59. For 1999, the average flow for the dates shown is 171 ML/d and the peak to average ratio, about 1.61.

The peak hour dry weather flow for the NEWPCC is estimated as the maximum day dry weather flow plus the diurnal peak, as follows:

	PDWF	=	MDWF + Diurnal Peak
Where:	PDWF	=	Peak dry weather flow, ML/d
	MDWF	=	Maximum day dry weather flow, ML/d
	Diurnal Peak	=	65 percent of ADWF, ML/d

The maximum dry weather flow equals 1.23 times the ADWF; thus for the NEWPCC, the peak dry weather flow is equal to 1.88 times the ADWF. This ratio is greater than the value currently used by the City in their planning – 1.70. However, it appears reasonable given the results assessed in this work.

Figure 2.3 illustrates flows to the NEWPCC during two high flow days during May 1999. On May 18, 1999, the total flow was about 265 ML; on May 23, 1999, the total flow was 455 ML. Superimposed on the graph is a line ("Projected") indicating the diurnal pattern with an increased base flow equal to the differential between the average May 18 flow and the 1999 dry weather flow (170 ML/d). It is apparent from the above graph that wet weather flows up to approximately 1.50 times the ADWF have characteristics that are similar to the dry weather flow. However, at higher flows, the interactions of the sewage collection system, the pumping systems, and the storms are much more important than normal variations in residential, commercial, and industrial wastewater generation.

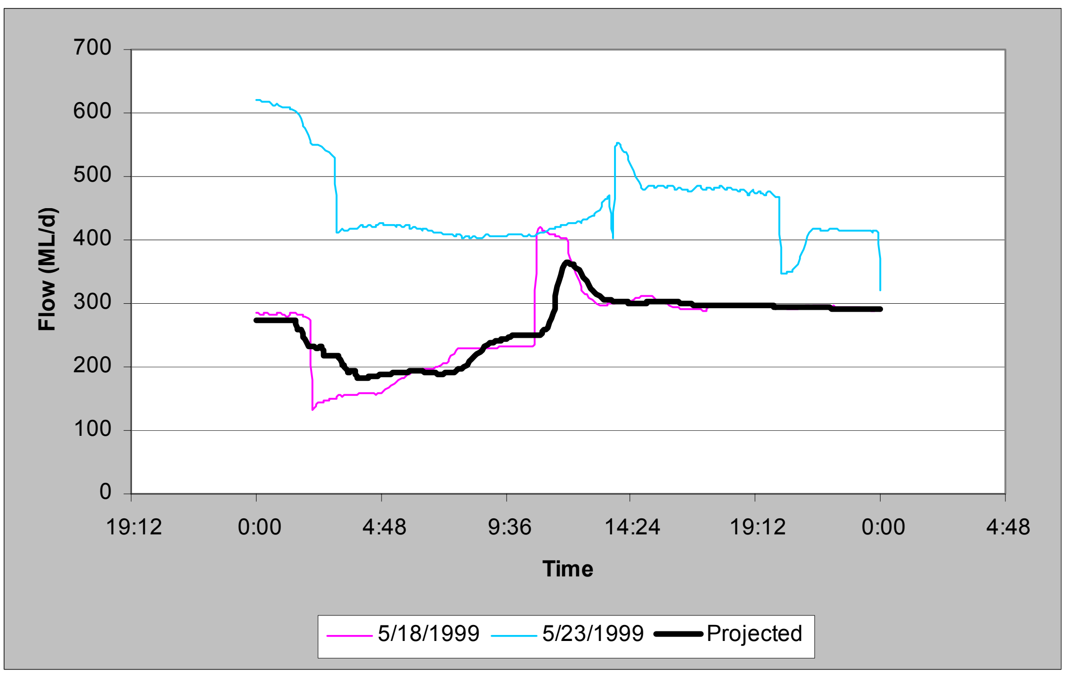

Figure 2.3: Diurnal Flow at NEWPCC, High Flow Periods, May, 1999

Figure 2.4 illustrates the flow entering the SEWPCC during the latter part of September 1998. During this period, the average flow was about 49.5 ML/d; just slightly above the ADWF for the year of 48.2 ML/d. The peak flow during this three day period consistently occurred at about 12:00 am and was about 1.38 times the average flow.

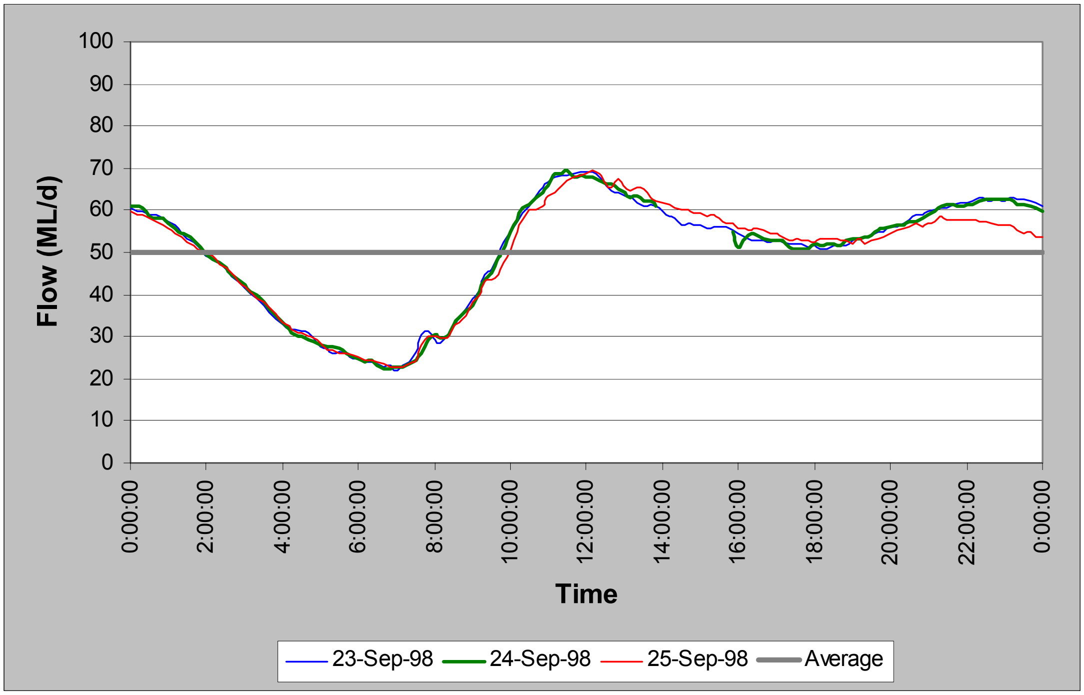

Figure 2.4: Diurnal Flow Pattern at SEWPCC, Dry Period

From this analysis, it is concluded that the peak diurnal flow is approximately equal to the average flow plus 40 percent of the ADWF. Verification of this approach is illustrated through the analysis of the flows during wetter periods. Figure 2.5 illustrates the flow measured on May 13 and May 19, 1998. On each day, the average flow was substantially above the ADWF due to rainfall in the catchment. On May 13, the average flow was about 64 ML/d and on May 19, approximately 81 ML/d. The curves in Figure 2.4 show the diurnal curve (from September 23 to 25 1998) raised by the difference between the average flow and the flow on that day.

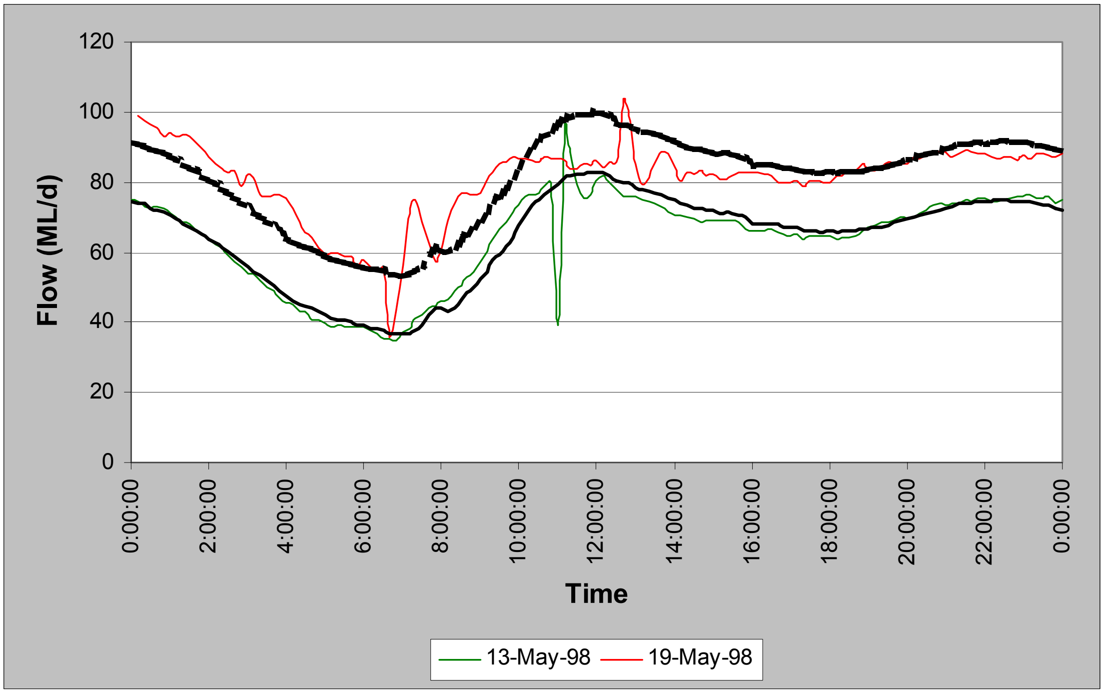

Figure 2.5: Diurnal Flow Pattern at SEWPCC, Wet Period

The thinner, dark line overlaying the May 13, 1998 data represents the diurnal curve with an additional 14 ML/d; while the heavier line overlying the May 19, 1998 data represents the diurnal curve with an additional 31 ML/d. In both cases, the projected curve closely simulates the pattern of the measured data.

Accordingly, the prediction of the peak hour dry weather flow for the SEWPCC is as follows:

PDWF = MDWF + Diurnal Peak

Where:
PDWF = Peak dry weather flow, ML/d
MDWF = Maximum day dry weather flow, ML/d
Diurnal Peak = 40 percent of ADWF, ML/d

The predicted peak wet weather flow is a function of the hydraulic capacity of the plant and influent pumping station. At the SEWPCC, the PWWF is approximately 350 ML/d.

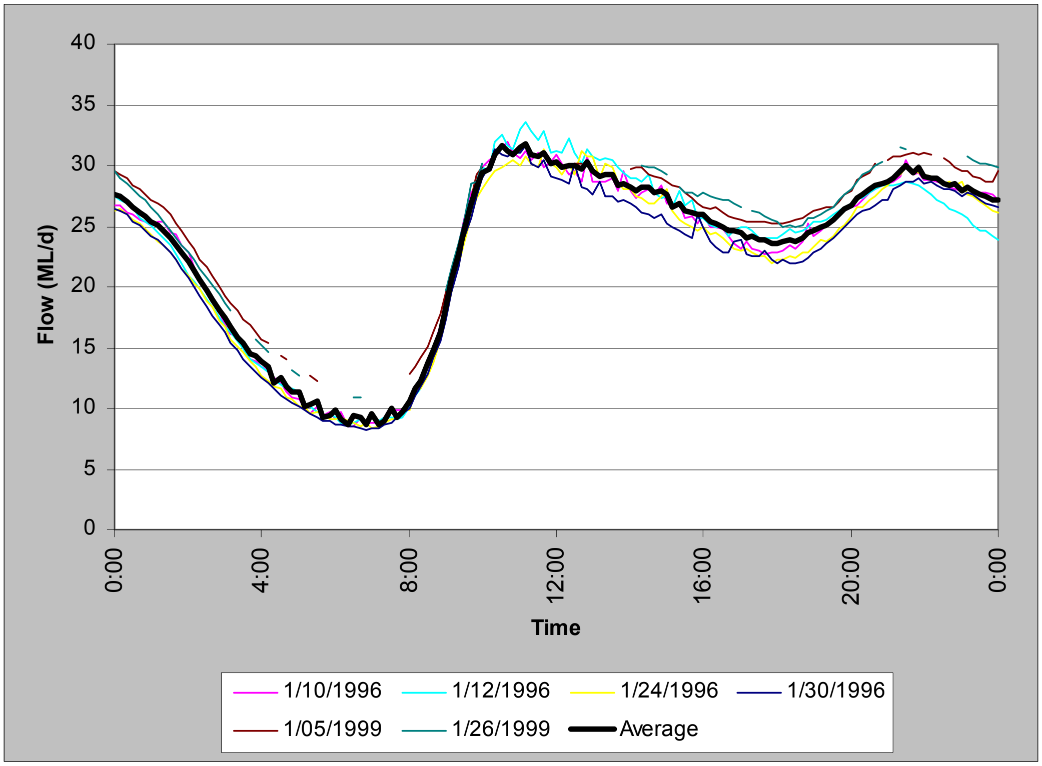

Figure 2.6: Diurnal Flow Pattern at WEWPCC, Dry Period

Figure 2.6 illustrates the diurnal flow pattern at the WEWPCC, from days during January 1996 and January 1999. The patterns in each of these years was very similar although the total flow during January 1999 was slightly higher than in the prior year. The peak to average ratio for each of these days varied from 1.3 to 1.41. A peak to average ratio of 1.45 is used for projections of future PDWF values.

Figure 2.7 shows that during wet weather, a high base flow generally can be superimposed over the dry weather diurnal pattern. The dark line in the graph represents the average dry weather flow shown in Figure 2.6, plus a constant flow of 25 ML/d. This curve generally matches the flows of May 1 and May 23, 1996. However, the flow from April 5, 1996 illustrates a differing pattern. As with all the plants, flow is pumped to the treatment plant and varying storm flows, changes in pumping station operation, and other factors can influence the flow to the plant so that it is not similar to the dry weather diurnal flow pattern.

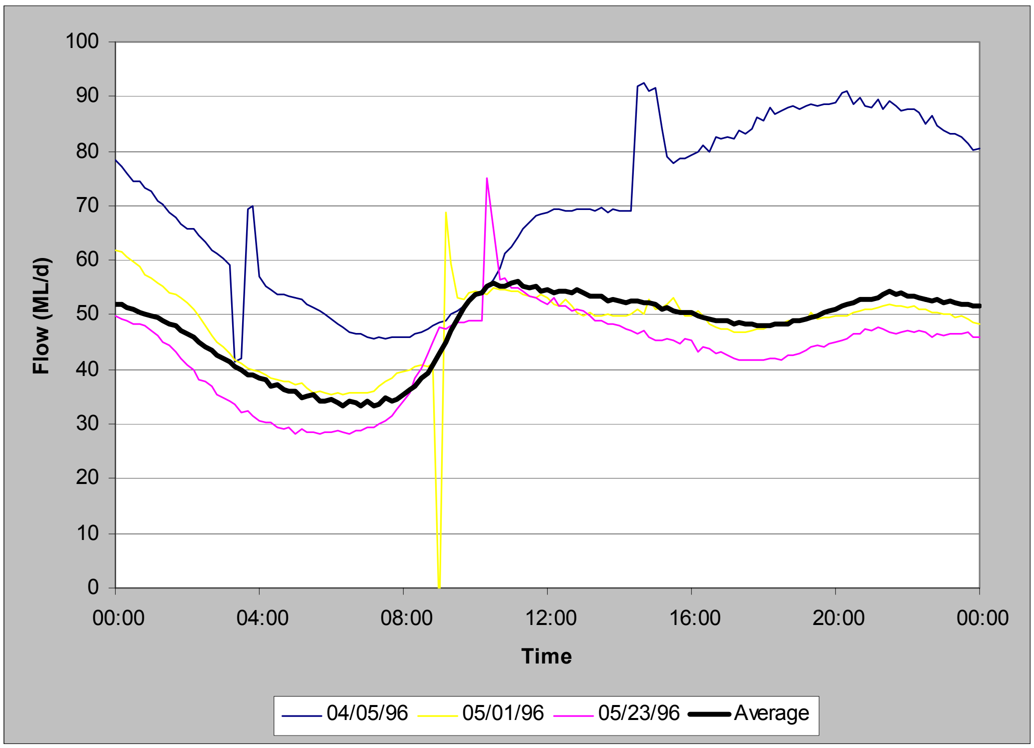

Figure 2.7: Diurnal Flow Pattern at WEWPCC, Wet Period

2.2.7 Projected Flows and Loads

NEWPCC

Based on the above analysis, projected flows and loads are derived for the NEWPCC that represent the likely characteristics of the influent over the next 40 years. These values are summarized in Table 2.12.

Table 2.12: NEWPCC Design Flows and Loads

Description	2001	2011	2021	2031	2041
Tributary Population	381,179	387,872	394,970	401,048	403,295
Design Flows					
AAF, ML/d	262	266	267	268	269
MMF, ML/d	408	413	415	417	418
MWF, ML/d	504	511	514	516	517
MDF, ML/d	636	645	648	651	652
PWWF, ML/d	1,060	1,060	1,060	1,060	1,060
ADWF, ML/d	206	209	210	211	211
MDWF, ML/d	253	257	258	259	259
PDWF, ML/d	387	392	394	396	397
Design Loads					
TSS					
AAL, kg/d	61,370	62,450	63,590	64,570	64,930
MML, kg/d	121,980	124,120	126,390	128,340	129,050
BOD					
AAL, kg/d	50,700	51,590	52,530	53,340	53,640
MML, kg/d	72,420	73,700	75,040	76,200	76,630
TKN					
AAL, kg/d	9,150	9,310	9,480	9,620	9,680
MML, kg/d	11,820	12,024	12,240	12,430	12,500
TP					
AAL, kg/d	1,300	1,320	1,340	1,360	1,370
MML, kg/d	1,940	1,980	2,010	2,040	2,060

NOTE: Load projections for NEWPCC include the impact of centrate return upstream of the headworks of the plant.

SEWPCC

Based on the above analysis, projected flows and loads are derived for the SEWPCC that represent the likely characteristics of the influent over the next 40 years. These values are summarized in Table 2.13.

Table 2.13: SEWPCC Design Flows and Loads

Description	2001	2011	2021	2031	2041
Tributary Population	181,124	199,956	219,187	235,961	242,164
Design Flows					
AAF, ML/d	70	76	82	86	87
MMF, ML/d	121	131	141	148	150
MWF, ML/d	163	177	189	199	202
MDF, ML/d	224	243	260	274	278
PWWF, ML/d	364	364	364	364	364
ADWF, ML/d	60	66	70	74	75
MDWF, ML/d	67	72	77	81	83
PDWF, ML/d	91	99	105	111	113
Design Loads					
TSS					
AAL, kg/d	22,280	24,590	26,960	29,020	29,790
MML, kg/d	47,090	51,990	56,990	61,350	62,960
BOD					
AAL, kg/d	18,290	20,200	22,140	23,830	24,460
MML, kg/d	38,040	41,990	46,030	49,550	50,850
TKN					
AAL, kg/d	2,350	2,600	2,850	3,070	3,150
MML, kg/d	3,620	4,000	4,380	4,720	4,840
TP					
AAL, kg/d	420	460	500	540	560
MML, kg/d	710	780	850	920	940

WEWPCC

Based on the above analysis, projected flows and loads are derived for the WEWPCC that represent the likely characteristics of the influent over the next 40 years. These values are summarized in Table 2.14.

Table 2.14: WEWPCC Design Flows and Loads

Description	2001	2011	2021	2031	2041
Tributary Population	87,513	89,119	90,823	92,281	92,821
Design Flows					
AAF, ML/d	35.4	35.5	35.2	35.0	34.8
MMF, ML/d	60.8	61.0	60.5	60.2	59.8
MWF, ML/d	80.7	81.0	80.3	79.9	79.4
MDF, ML/d	110.8	111.2	110.3	109.7	109.0
PWWF, ML/d	112.0	112.0	112.0	112.0	112.0
ADWF, ML/d	30.1	30.2	30.0	29.8	29.6
MDWF, ML/d	40.3	40.4	40.1	39.9	39.6
PDWF, ML/d	53.8	54.0	53.6	53.3	52.9
Design Loads					
TSS					
AAL, kg/d	7,180	7,310	7,450	7,570	7,610
MML, kg/d	11,990	12,210	12,440	12,640	12,720
BOD					
AAL, kg/d	5,690	5,790	5,900	6,000	6,030
MML, kg/d	7,880	8,020	8,170	8,310	8,350
TKN					
AAL, kg/d	1,050	1,070	1,090	1,110	1,110
MML, kg/d	1,230	1,250	1,270	1,290	1,300
TP					
AAL, kg/d	180	180	180	180	190
MML, kg/d	210	210	220	220	220

2.2.8 Synthetic Flow Distribution

The assessment of various treatment alternatives requires that they be modeled to determine appropriate design parameters. The flows and loads vary significantly through the year and nitrification will likely not be required to the same degree in all seasons due to changing sensitivities in the receiving streams. Thus, synthetic flow patterns will be developed in the Conceptual Design phase for the three plants that reflect typical variations through the year.