75th STREET WASTEWATER TREATMENT PLANT UPGRADES PROJECT

Basis of Design Memorandum

Design Memo No.:	**DM-1**	Date:	**August 26, 2004**
		Project/Task:	**24487.410**
Subject:	**Design Flows and Loads**		
Prepared by:	**John Bratby, Ph.D., P.E., Brown and Caldwell**		
Reviewed by:	**Boyd Hanzon, P.E., Brown and Caldwell** **Denny Parker, Ph.D., P.E., Brown and Caldwell**		

SCOPE OF DESIGN

This design memorandum (DM) presents the basis for the selection of influent flow and load parameters that will be applied to the design of the City of Boulder 75th Street Wastewater Treatment Plant (WWTP) upgrades.

Previous analyses reported in Chapter 4 of *The City of Boulder Wastewater Utility Plan*, indicated that the maximum month flow projected for 2025 is 25 million gallons per day (mgd), and the corresponding maximum month 5-day biochemical oxygen demand (BOD) load is projected to be 36,000 pounds per day (lb/d). These projections are accepted and form the basis for determining influent flow and load parameters for design.

HISTORICAL DATA

Historical data in the form of daily average flows are presented in Figure 1. As seen in this figure, the maximum daily flow recorded in the 75th Street facility since 1994 was recorded in May 1995, at 46.6 mgd. From Figure 1 it can be seen that May 1995 exhibited unusual influent flow peaks, not seen in the subsequent seven years. One change which occurred as a result of this event is the improvements in infiltration/inflow (I/I) control which have been ongoing since 1992. However, another significant factor leading to the high flows observed in 1995 is that collection system manhole covers were popped off during the storm event in May, particularly in wetland/swamp areas upstream of the wastewater treatment plant. Because of this, after passage of the storm, high flows continued to the plant because of unrestricted inflow via the submerged, open manholes.

Figure 1. Historical Daily Average Flows

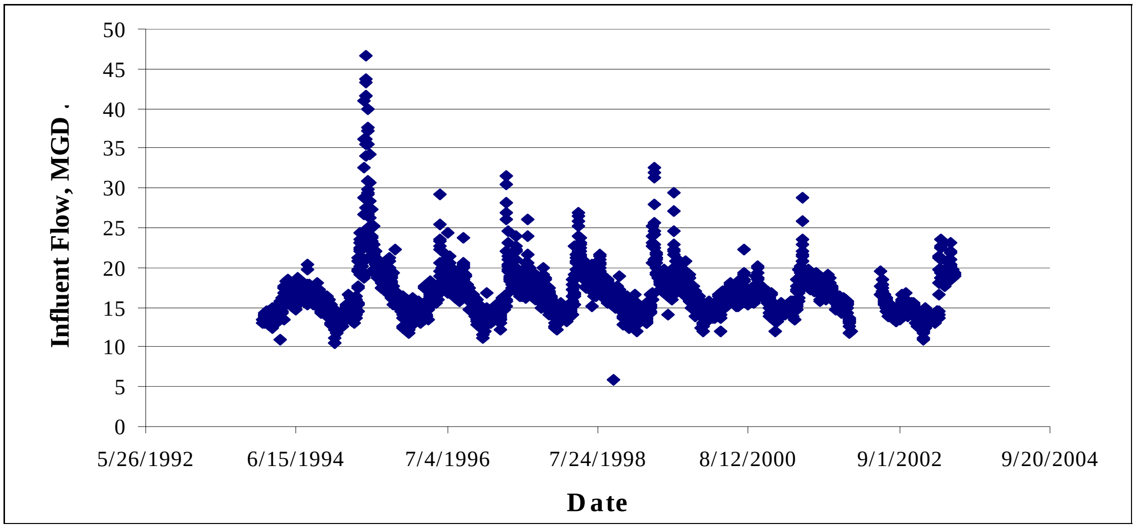


Table 1 presents rainfall data for the peak daily flow periods identified in Figure 1. It is seen that higher rainfall volumes occurred in 1996 and 1997, when compared with 1995. Therefore, as explained previously the high flows can likely be attributed to unrestricted inflow through open manholes. The City has since anchored the manhole covers so it is unlikely that this inflow would occur in the future. Therefore, the peak flows which occurred in 1995 are not considered in this analysis.

Table 1. Rainfall During Storm Events

Date	**5/25/1995**	**5/26/1995**	**5/27/1995**	**5/28/1995**	**5/29/1995**	**Totals**
Rain, Inches	**0.73**	**0.02**	**0.91**	**0.47**	**0.82**	**2.95**
Date	**5/22/1996**	**5/23/1996**	**5/24/1996**	**5/25/1996**	**5/26/1996**	**-**
Rain, inches	**0**	**0.3**	**0.34**	**1.91**	**1.45**	**4.00**
Date	**4/22/1997**	**4/23/1997**	**4/24/1997**	**4/25/1997**	**4/26/1997**	**-**
Rain, inches	**0**	**0.16**	**3.2**	**0.35**	**0.16**	**3.87**
Date	**4/28/1999**	**4/29/1999**	**4/30/1999**	**5/1/1999**	**5/2/1999**	**-**
Rain, inches	**Not available**			**0.5**	**0.07**	**0.57**
Date	**5/1/2001**	**5/2/2001**	**5/3/2001**	**5/4/2001**	**5/5/2001**	**-**
Rain, inches	**0**	**0.52**	**0.63**	**0.46**	**0.99**	**2.60**

Figure 2 shows the maximum daily and maximum month flows observed at the treatment plant since 1994. From this figure it is seen that in only four out of the eight years analyzed, the maximum daily flow occurs in the same month as the maximum month flow. Figure 2 also shows that the maximum month flow typically occurs between April and September. For the period of 1994 through 2002, the maximum month average flow was approximately 28 mgd, recorded in May 1995. If 1995 data are eliminated, as explained above, the maximum month flow reduces to approximately 22 mgd, in 1998.

Figure 2. Maximum Daily (MDF) and Maximum Month Flows (MMF) – 1994 through 2001

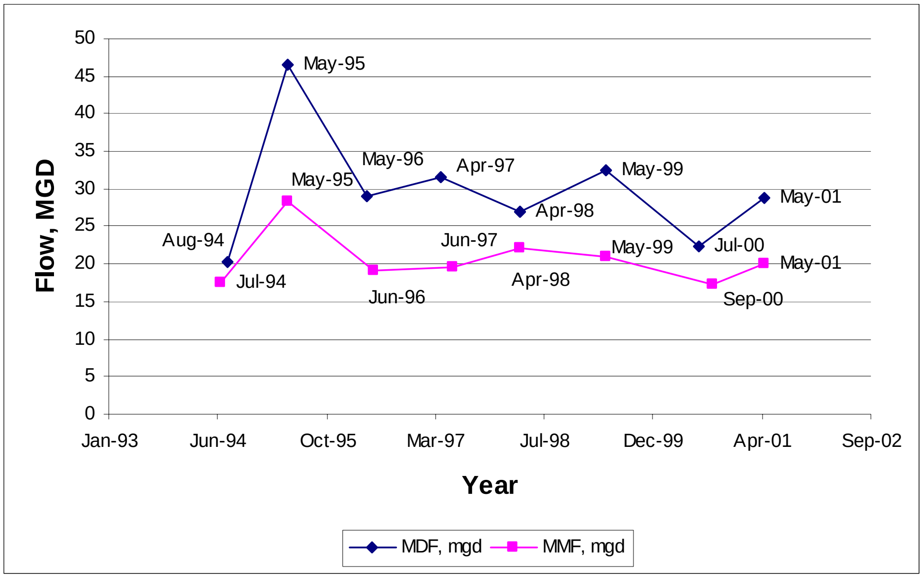


Figure 3 shows hourly flows for high flow days selected from Figure 1.

Figure 3. Wet Weather Hourly Flow Data

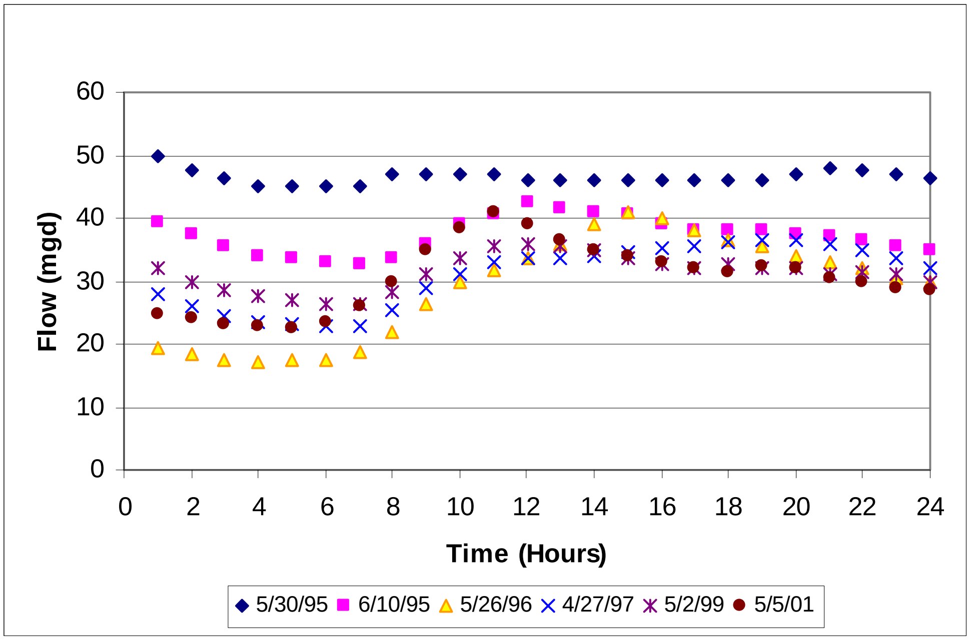


Table 2 presents a summary of flow data for the eight year period 1994 through 2001. If 1995 data are eliminated, as explained above, the maximum day flow, as a factor of the maximum month flow ranges from 1.17 to 1.62. The peak hour flow, as a factor of the maximum month flow ranges from 1.71 to 2.14.

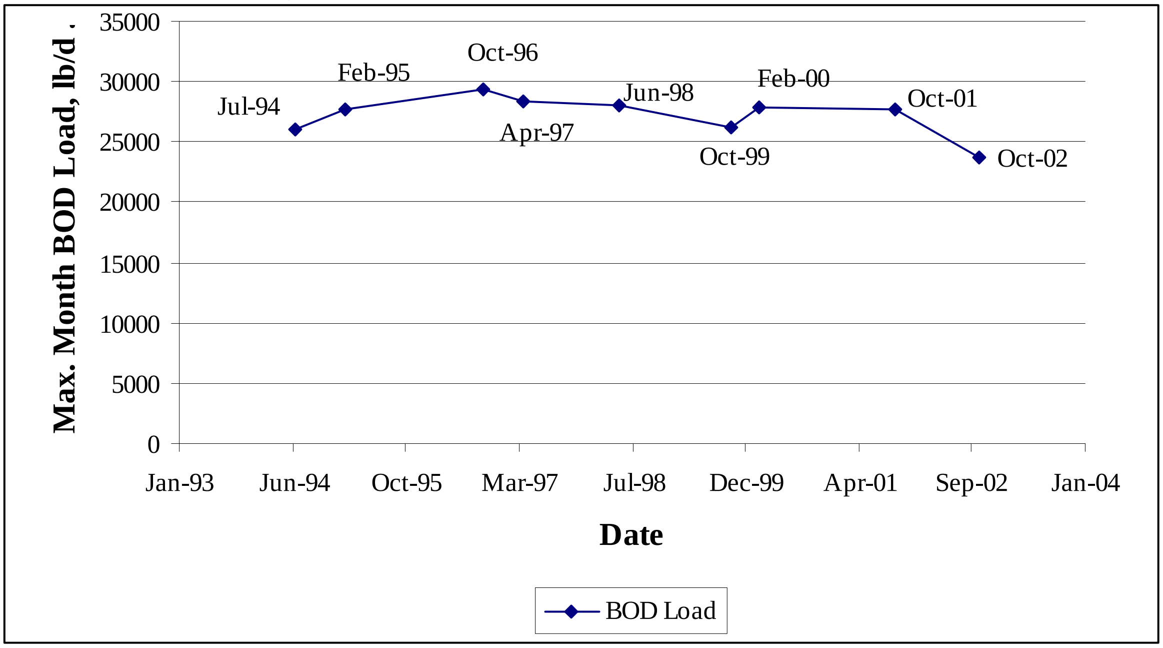
Table 2. Summary of Flow Data

Year	Annual Average Flow, mgd	Maximum Month Flow, mgd	Maximum Day Flow, mgd	Maximum Hour Flow, mgd	Max Day/ Max Mth	Max Hour/ Max Mth
1994	15.5	17.4	20.4		1.17	
1995	18.4	28.3	46.6	50.0	1.65	1.77
1996	16.5	19.2	29.1	41.0	1.52	**2.14**
1997	16.8	19.5	31.5	36.5	**1.62**	1.87
1998	17.1	22.2	26.9		1.21	
1999	17.0	21.1	32.6	36.0	1.55	1.71
2000	15.9	17.3	22.3		1.29	
2001	16.6	20.1	28.9	41.0	1.44	2.04

From Table 2 and for the purposes of design, a Max Day-to-Max Month flow factor of 1.62 is assumed. Similarly, a Peak Hour-to-Max Month flow factor of 2.14 is assumed.

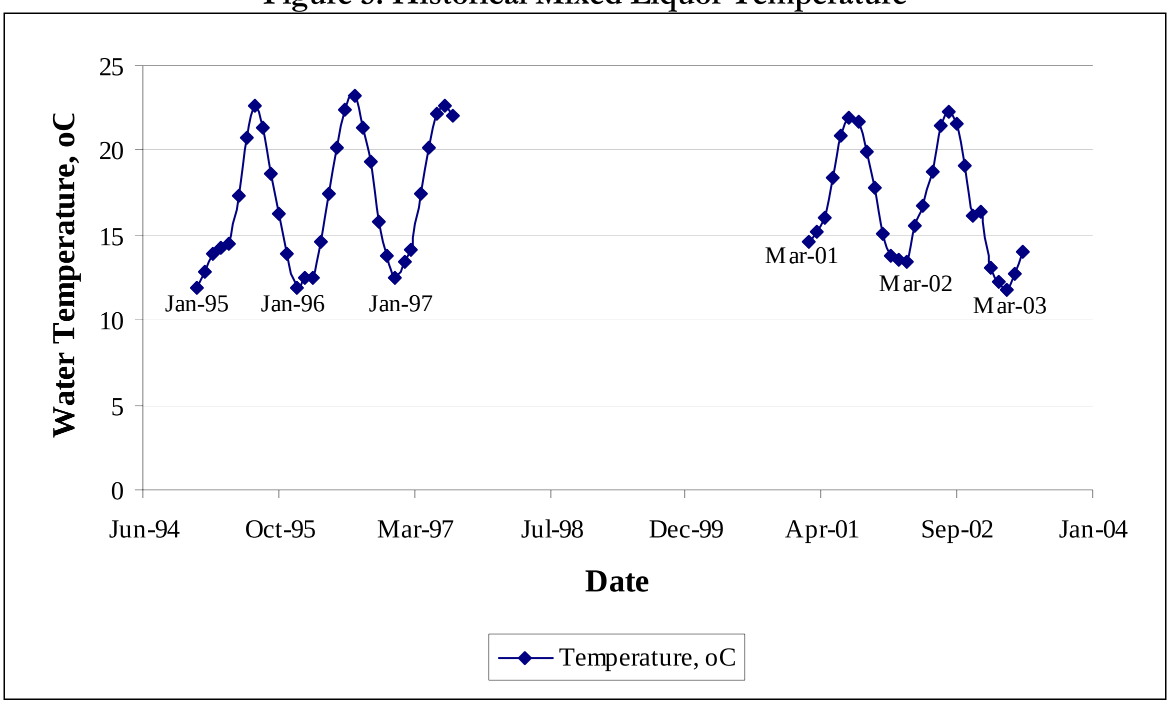
Figure 4 shows the historical maximum month BOD loads from 1994 through 2002. From this figure, it is evident that the maximum month load could occur in any month. Figure 4 shows that the maximum month BOD load reached a maximum value of 29,500 lb/d during the last nine years, and occurred in October 1996.

Figure 4. Historical Maximum Month BOD Loads



Historical plant temperature data are shown in Figure 5. As seen in this figure, the lowest temperature reported by plant staff during the period analyzed is 11.8°C. For design purposes, this temperature is selected for critical design conditions.

Figure 5. Historical Mixed Liquor Temperature



BASIS OF DESIGN

The following design conditions were assumed from the above analyses:

Maximum Month Flow	= 25 mgd (taken from Wastewater Utility Plan)
Maximum Month BOD Load	= 36,000 lb/d (taken from Wastewater Utility Plan)
Maximum Daily Flow	= 40.5 mgd (maximum month flow x 1.62)
Peak Hour Flow	= 53.5 mgd (maximum month flow x 2.14)
Minimum Temperature	= 11.8°C.

ASSUMED INFLUENT PARAMETERS FOR PROCESS DESIGN

Historical data in the form of daily averages, together with results from a special sampling campaign carried out in April 2004 were used to determine various parameter ratios, as shown in Table 3. The special sampling results are presented in Appendices 1 through 4.

Table 3. Parameter Ratios from Historical Data

Ratio	Value
COD/CBO D[1]	2.01
COD/TKN[2]	14.75
TP[3]/TKN	0.193
NH4[4]/TKN	0.63

[1] Chemical oxygen demand/Carbonaceous biochemical oxygen demand
[2] Total Kjeldahl nitrogen
[3] Total phosphorus
[4] Ammonia nitrogen

These parameter ratios were used to determine the influent characteristics that were input to the process model used for the activated sludge design. In the case of modeling activated sludge, using the BioWin simulation model, the special sampling data was used to determine key wastewater fractions. Other fractions were assumed to be BioWin default values. Table 4 shows the wastewater fractions adopted for the BioWin simulation model.

Table 4. Wastewater Fractions Adopted for Simulation

Parameter	Influent Value
F_{bs} (fraction of total influent COD which is readily biodegradable)	0.20
F_{ac} (fraction of readily biodegradable COD which is VFAs[1])	0.15
F_{xsp} (fraction of slowly biodegradable influent COD which is particulate)	0.75
F_{us} (fraction of total influent COD which is soluble unbiodegradable)	0.05
F_{up} (fraction of total influent COD which is particulate unbiodegradable)	0.13

Parameter	Influent Value
F_{na} (fraction of influent TKN which is ammonia)	0.63
F_{nox} (fraction of influent organic nitrogen which is particulate)	0.50
F_{nus} (fraction of influent TKN which is soluble unbiodegradable)	0.00
F_{upN} (the N:COD ratio for the influent particulate unbiodegradable COD)	0.035
F_{PO4} (fraction of influent total P which is phosphate)	0.49
F_{upP} (the P:COD ratio for the influent particulate unbiodegradable COD)	0.011

[1] Volatile fatty acids

A key parameter for the simulation model is the rate of nitrification. This parameter governs the required solids retention time (SRT) to achieve nitrification and effluent ammonia objectives. Specialized testing and sampling were carried out during the period June 30 through July 4, 2004. The results of this nitrification rate testing are presented in Appendix 5. Based on the results, it is evident that Biowin default values for nitrification parameters are appropriate for simulating the 75th Street WWTP.

An important note is that there were a series of issues with the special sampling results, particularly with COD, BOD, and total and volatile suspended solids values. Sampling and laboratory QA/QC issues need to be reviewed so that data collected in the future is more reliable. The parameters presented in Tables 3 through 5 represent best estimate values based on historical and special sampling, and experiences elsewhere.

Table 5 shows the maximum month average influent characteristics assumed for process modeling. These values were calculated based on the above wastewater characteristics.

Table 5. Influent Characteristics

Parameter	Value
Flow	25 mgd
COD	347 mg/L
TKN	23.5 mgN/L
Total P	4.5 mgP/L
NO_3-N	0 mgN/L
Alkalinity	182 mg/l $CaCO_3$
ISS[1]	17.8 mg/L

[1] Inert suspended solids (ISS)

Based on the above parameters, plant historical data and the special sampling results, a 90-day influent itinerary was prepared as input to the BioWin simulator. Plant data for the period 1994 through 2001 was used to identify critical periods for design. Based on this analysis three separate 30-day periods were input sequentially into the simulator, as follows:

First 30-Day Period

- Month average influent flow (equivalent to the Maximum Month design flow, MMF) = 25 mgd;
- Month average influent CBOD load (equivalent to the Maximum Month design load, MML) = 36,000 lb/d;
- Month average temperature = 12.8°C. This temperature corresponds with April 2003, which was the earliest (and lowest temperature) peak flow month in the data period of eight years.

Second 30-Day Period

- Month average influent CBOD load (equivalent to the Maximum Month design load) = 36,000 lb/d;
- Month average influent flow = 18.5 mgd. (The flow/MMF ratio for the lowest temperature month averages 0.74 for the data period: 0.74x25 = 18.5 mgd);
- Month average temperature = 11.8°C. This temperature corresponds with the lowest recorded month average temperature in the data period.

Third 30-Day Period

- Month average influent CBOD load (equivalent to the minimum month design load) = 28,800 lb/d (based on the average minimum month/MML for the data period);
- Month average influent flow = 21.25 mgd. (This flow corresponds with an annual average flow, assumed to be 0.85xMMF, based on the data period);
- Month average temperature = 17.2°C. This temperature corresponds with an average temperature from the data period.

Corresponding daily COD load, flow and temperature patterns were taken directly from the corresponding 30-day periods. Hourly parameter variations were then input based on the diurnal sampling results obtained during the sampling campaign.

The above formed the basis for the influent itinerary input into the BioWin simulator. Principal input parameters are shown in Figures 6 through 9.

Figure 6. Influent Flow Itinerary

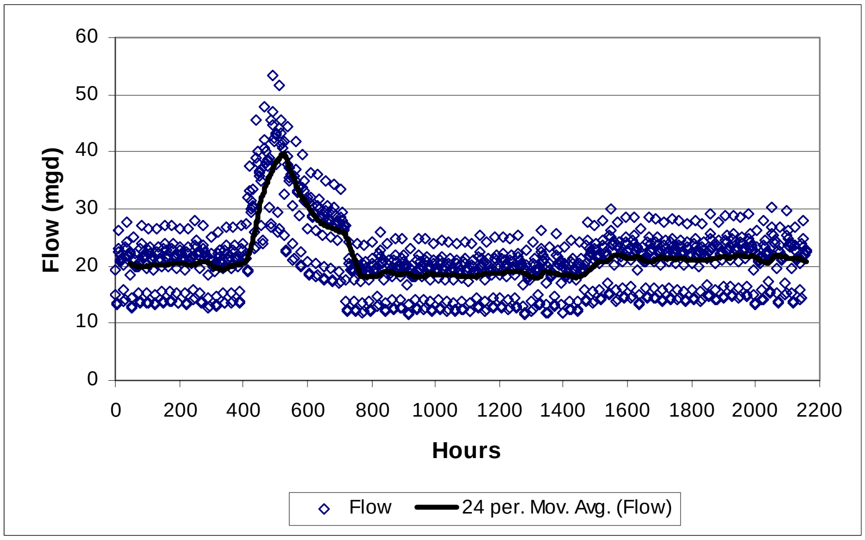


Figure 7. Influent COD Itinerary

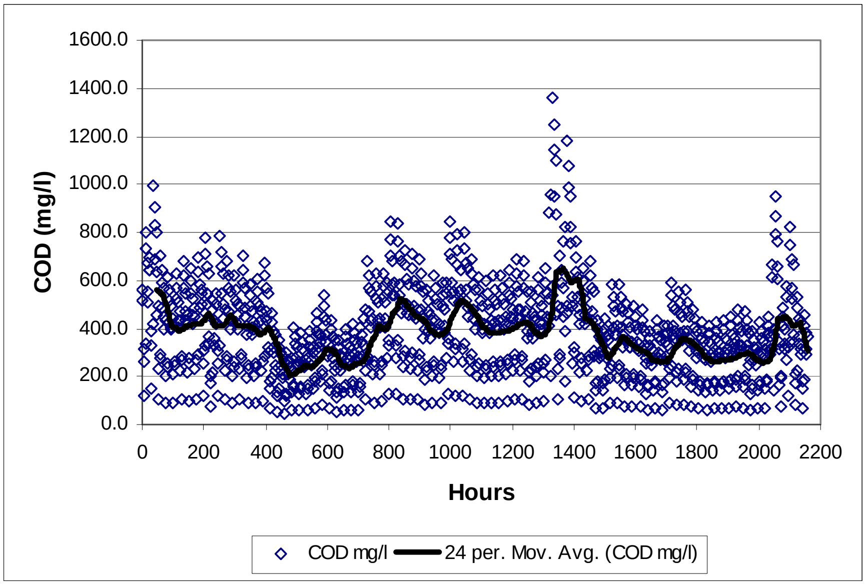


Figure 8. Influent TKN Itinerary

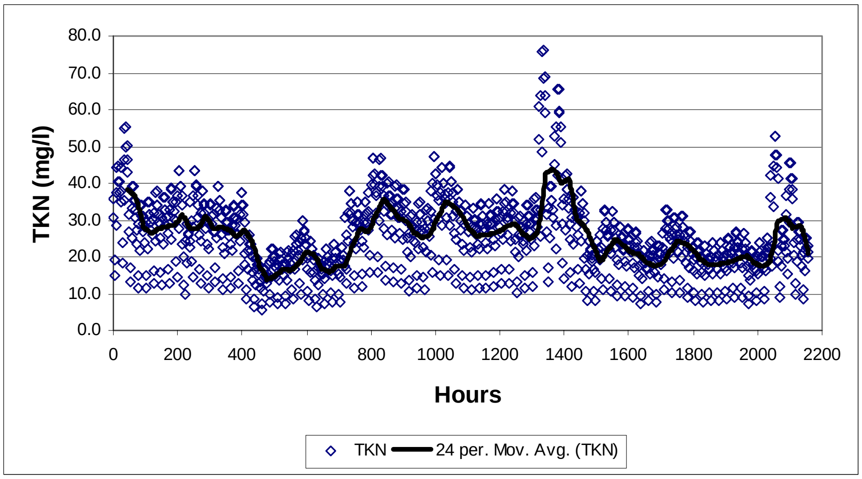


Figure 9. Influent P Itinerary