1.0 Introduction

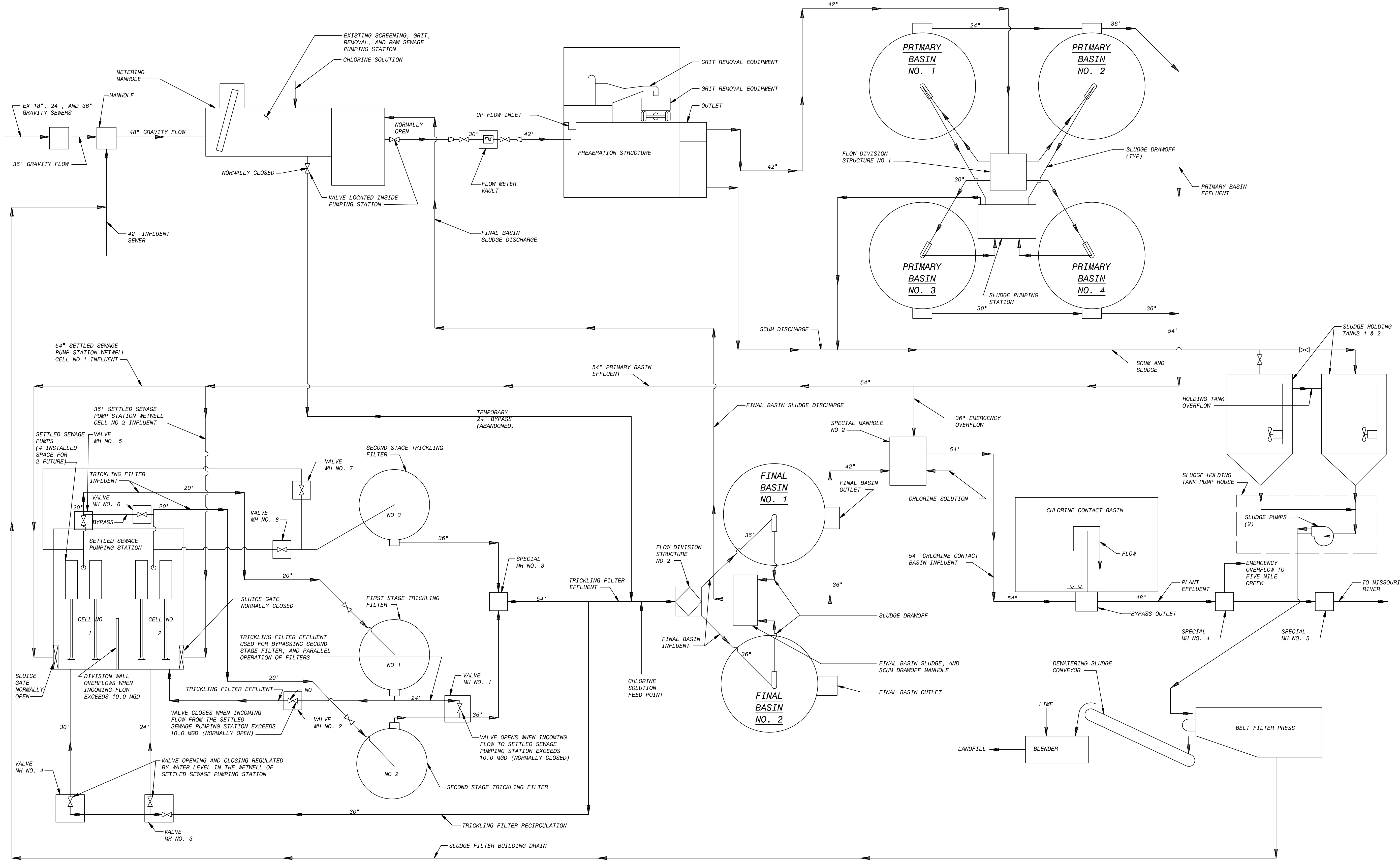
1.1 Background and Purpose

In 2002, Black & Veatch (B&V) completed a comprehensive Wastewater Master Plan for the City of Leavenworth to identify the most efficient, cost-effective, and appropriate collection system and facility improvements to accommodate existing and future wastewater flows through the year 2020. The plan included flow and rainfall monitoring in the collection system, hydraulic modeling of the collection system interceptors, identification of needed rehabilitation and repair of existing facilities and equipment at the wastewater treatment plant (WWTP), and an analysis of expansion alternatives at the WWTP.

The Leavenworth WWTPs current National Pollutant Discharge Elimination System (NPDES) permit issued by the Kansas Department of Health and Environment (KDHE) under the Schedule of Compliance requires the permittee to complete and submit an updated Wastewater Master Plan by December 1, 2010. The permit requires the updated master plan to include an implementation plan for disinfection of plant effluent as well as an assessment of the feasibility of incorporating nutrient removal facilities and processes into the plant. This Master Plan Update will provide an evaluation of facility improvements to meet the proposed nutrient goal levels, a recommendation for the implementation of disinfection facilities, and a collection system update. The contents of this report fulfill the requirements outlined in the current NPDES permit.

1.2 Facilities Description

The Leavenworth WWTP is located at 1800 South 2nd Street in Leavenworth, Kansas and consists of the following facilities: influent screening and pumping, aerated grit removal, primary clarification, intermediate pumping (settled sewage), trickling filters, final clarification, and sludge dewatering (belt filter press). *Figure 1-1* shows the existing plant process schematic.



NOTE:

NOT ALL PIPING AND VALVES ARE SHOWN IN THIS SCHEMATIC.

EXISTING PROCESS SCHEMATIC

NO SCALE

PRELIMINARY - NOT FOR CONSTRUCTION

NO.	BY	CK	APP	DATE

REVISIONS AND RECORD OF ISSUE

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SW: PW FIL: Process Schematic.DWG

BLACK & VEATCH Corporation
Kansas City, Missouri

LEAVENWORTH, KANSAS
MASTER PLAN &
COLLECTION SYSTEM UPDATE

EXISTING PROCESS SCHEMATIC

DESIGNED:
DETAILED:
CHECKED:
APPROVED:
DATE:

PROJECT NO.

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FIG 1-1

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1.3 Population Projections and Industrial Growth

The City provided population projections out to 2020 and a basis for projecting to 2030. Population has declined somewhat from the 2000 Census figures, and City growth is anticipated to be slower than previously projected in the 2002 Master Plan for the next 10 years. However, Fort Leavenworth, the Veterans Administration, and the penitentiary are expected to add facilities for additional residents and employees. The growth of these industries and population segments will result in some overall population growth. Previous reports used a more optimistic growth projection which resulted in a higher population for 2020 and future buildout. It has also been anticipated that a new development in the Salt Creek Valley could fuel population growth. That development has not yet begun however. For planning purposes, this Master Plan Update will consider the higher projections for ultimate sizing of facilities and space allocations but will provide phasing options to allow intermittent improvements. This will allow the City of Leavenworth some flexibility to meet their needs based on actual population growth.

Table 1-1
Population Data and Projections

Year	Population
2010	34,000
2020	36,380
2030	46,000

1.4 Influent Wastewater Flow

1.4.1 Historical Flow Data

Plant staff records both the influent and effluent flow readings. The influent flow meter was replaced in the Phase 1 Improvements. A magnetic flowmeter was installed in a new vault between the influent pumping station and the preaeration facility. There is recirculation flow from the final clarifiers as well as potable water which is included in this influent meter reading. The recirculation flow from the final clarifiers is metered which allows staff to subtract this for a more accurate influent reading. The return potable water is not metered separately however; so there is not an easy way to accurately determine what portion of the influent flow is from return potable water.

The effluent flow reading is measured by an ultrasonic level sensor over a weir in Special Manhole No. 2 which combines the flow from the two final clarifiers. This reading does not include any flow from the emergency overflow line.

The influent and effluent flow readings do not correlate well. The effluent reading is used for reporting purposes. It is recommended that an additional investigation be conducted to accurately determine flows.

Data provided by the City from 2008 through the present was analyzed. This data indicated an average daily flow of 4.38 mgd, maximum month flow of 7.63 mgd, and a peak day flow of 12.39 mgd. Dividing these flows over the current population results in a flow of 129 gallons per capita per day (gpcd). This is a fairly high value, however, the WWTP was originally designed for a similar average daily per capita flow of 125 mgd.

1.4.2 Flow Projections

Table 1-2 presents flow projections for 2020 and 2030 by carrying the calculated 129 gpcd forward with the population projections. It also indicates flows based on an optimistic population projection that might be reached if additional land is annexed.

Table 1-2
Projection of Flows

Year	2010	2020	2030	2030[1]
Population	34,000	36,380	46,000	53,000
Avg Day Flow, mgd	4.36	4.67	5.90	8.10
Max Month Flow, mgd	7.63	8.15	10.30	14.11
Peak Day Flow, mgd	12.39	13.26	16.76	23.0
Peak Hour Flow, mgd	27.5	29.43	37.24	42.91

Notes:
1. Includes flow from the annexation of Salt Creek Valley.

Discrepancies between influent and effluent flow readings raise the question of which peak hourly flow to use for design. Peak hourly flow is significant for disinfection as well as hydraulics. A peak hourly flow rate of 34 mgd has been used in past reports. This was based on a typical peaking factor of 7.57 suggested by a hydraulic model of the collection system for one subbasin. The flow meters at the Leavenworth WWTP have not confirmed that a peak flow of 34 mgd actually reaches the treatment facility. The highest recorded flow from the data provided was 27.5 mgd. The existing collection system trunk sewers likely do not have enough capacity to convey higher flows into the plant. It is also likely that the 7.57 peaking factor is only applicable to that particular subbasin. It is recommended that increased logging and monitoring of plant flows be performed as well as possible flow monitoring of the collection system upstream of the treatment plant. This 27.5 mgd will be used for current peak hourly flow for this report. This results in a peaking factor of 6.28 which could be maintained or possibly improved by an I&I reduction program.

1.5 Influent Wastewater Loads

1.5.1 Recent Data

Three and a half years of historical data (2007 - June 2010) were evaluated to develop influent wastewater characteristics. Within the data set there were two very high influent biochemical oxygen demand (BOD) concentrations that were removed from the evaluation. These data points had extremely high influent BOD concentrations at days when the influent flow was also high. Given the higher influent flow rates, the influent BOD concentration should have been more dilute. The two days in question were:

- May 1, 2007 – Flow 7.54 mgd and 346 mg/L BOD = 21,763 ppd BOD
- April 1, 2008 – Flow 5.26 mgd and 424 mg/L BOD = 18,590 ppd BOD

City laboratory staff were contacted to determine if these two days were associated with some unusual activity. There were no anomalies that were noted in the laboratory records. The daily influent BOD mass load data is shown in *Figure 1-2*. It is evident from this figure that the two high influent BOD mass loads were not typical and should be dropped from the data set.

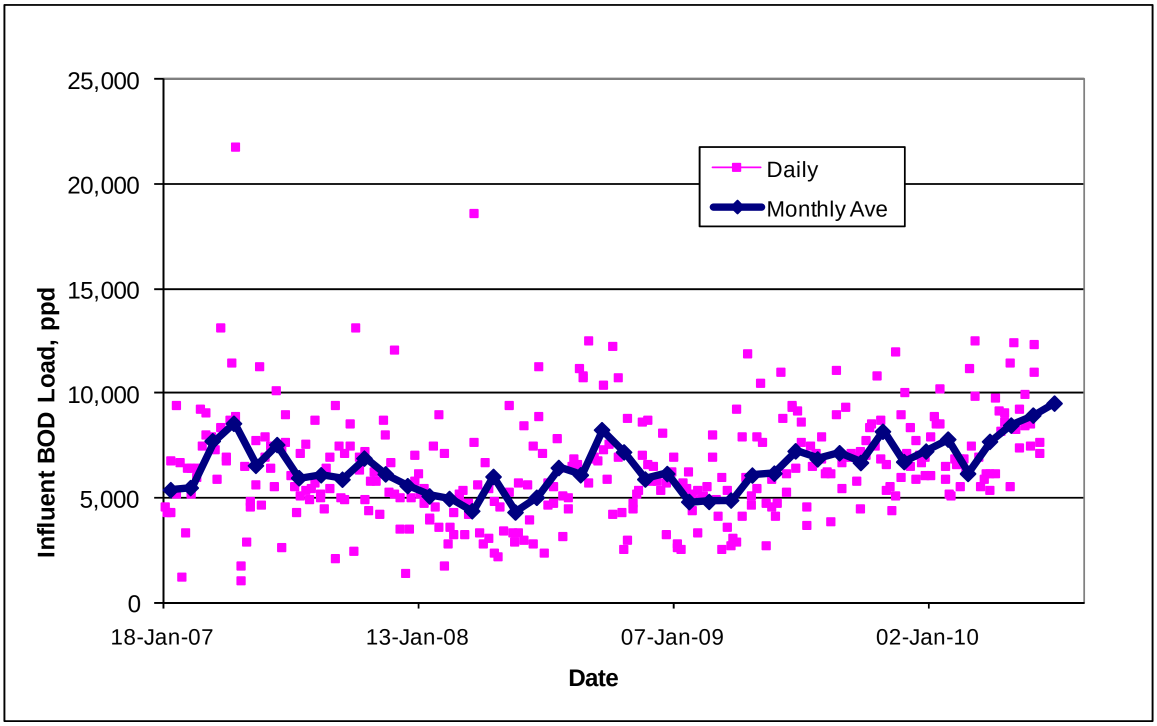


Figure 1-2 Daily Influent Mass Load of BOD

The influent TSS data was also evaluated and several high days with very high TSS mass loads were identified. The daily influent TSS data is shown in *Figure 1-3*. The very high load days are identified on the graph. City laboratory staff were contacted about these data points. City staff felt that these data were valid. American Water at Fort Leavenworth does discharge their sludge to the sewer for removal in the City's primary clarifier. It was felt that these high influent TSS load days corresponded to sludge wasting from the water plant. If the high solids loading is always due to the discharge of water plant sludge, then the solids removal performance at the primary clarifier should not be impacted as these solids will be easily removed. It is anticipated that primary clarifier effluent quality will remain consistent, but primary sludge production will spike on those days. The only design consideration is primary sludge pumping and solids storage. Since the long term plan is to continue to store, dewater and haul to a landfill, no further investigation into the high solids loads was warranted. The high BOD loading days were not thought to be related to the water plant sludge. Water plant sludge is non-biodegradable inert material.

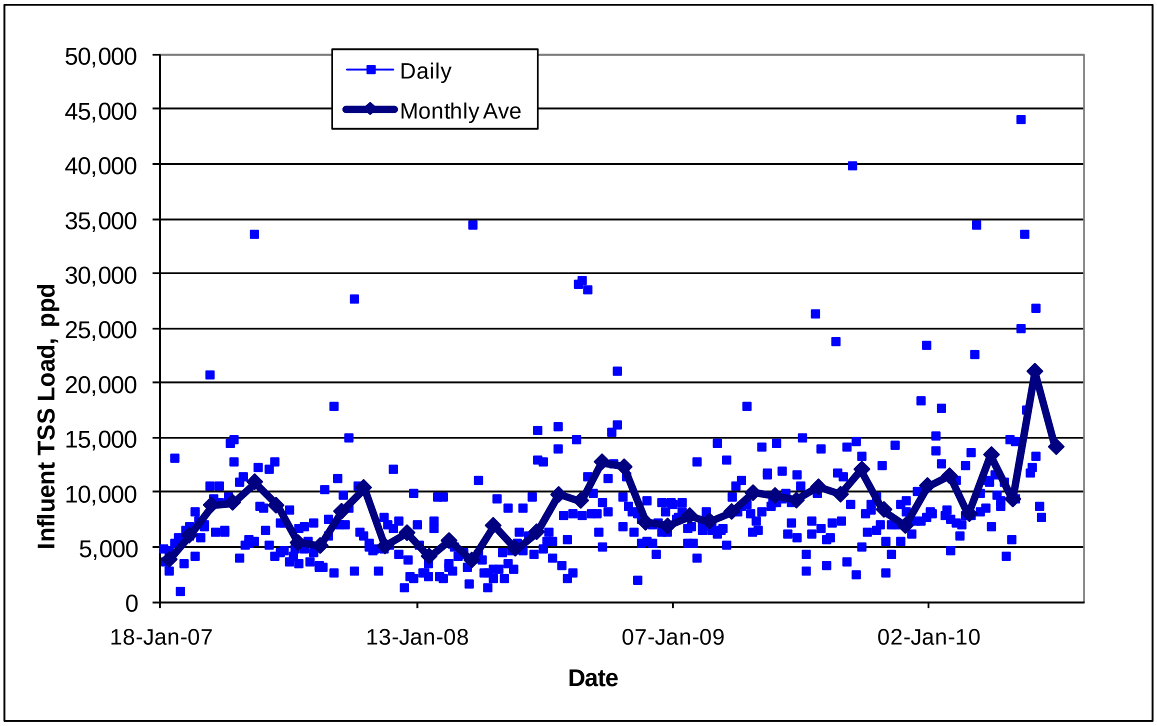


Figure 1-3 Daily Influent Mass Load of TSS

The truncated data set (with removal of the two high BOD data points) is summarized in *Table 1-3*. The Minimum Month condition has been defined for future detailed design to define blower turndown conditions.

Table 1-3 Summary of Historical Data				
Condition	**Annual Average**	**Maximum Month**	**Peak day**	**Minimum Month**
Flow, mgd	4.4	7.6	12.4	3.1
BOD, ppd	6,380	9,520	13,125	4,309
BOD, mg/L	175	150	127	
TSS, ppd	8,650	21,000	44,400	3,750
TSS, mg/L	237	330	426	
TKN, ppd	1,320	1,960	2,260	811
TKN, mg/L	36.2	30.9	21.9	
NH_3-N, ppd	990	1,470	1,690	
NH_3-N, mg/L	27.2	23.2	16.4	
TP, ppd	191	286	328	75
TP, mg/L	5.2	4.5	3.2	

1.5.2 Projected Loads

The current connected population equivalent is 34,000. The load data in *Table 1-3* was used to develop the per capita characteristics of the existing wastewater, which is shown in *Table 1-4*.

Table 1-4 Summary of Per Capita Wastewater Characteristics		
	Annual Average	**Maximum Month**
Flow, gpd/ cap	129	224
BOD, ppd/ cap	0.188	0.280
TSS, ppd/ cap	0.255	0.618
TKN ppd/ cap	0.0389	0.0577
NH_3-N, ppd/ cap	0.0292	0.0433
TP, ppd/cap	0.00561	0.00841

Using the population projections from *Table 1-1* and the per capita wastewater characteristics shown in *Table 1-4*, the future loadings conditions can be defined. The future wastewater flows and loads are summarized in *Table 1-5*. Flows and loads are also included for the ultimate buildout of the existing plant site. These values represent the maximum possible usage of the land available.

Table 1-5 Future Wastewater Flow and Load Projections			
2020			
	Annual Average	**Maximum Month**	**Peak Day**
Flow, mgd	4.7	8.2	13.3
BOD, ppd	6,830	10,180	14,040
BOD, mg/L	175	150	127
TSS, ppd	9,260	22,470	47,120
TSS, mg/L	237	330	426
TKN, ppd	1,420	2,100	2,420
TKN, mg/L	36.2	30.9	21.9
NH_3-N, ppd	1,060	1,580	1,810
NH_3-N, mg/L	27.2	23.2	16.4
TP, ppd	204	306	351
TP, mg/L	5.2	4.5	3.2
2030 Conservative Growth			
Flow, mgd	5.9	10.3	16.8
BOD, ppd	8,640	12,880	17,760
BOD, mg/L	175	150	127
TSS, ppd	11,710	28,410	59,950
TSS, mg/L	237	330	426
TKN, ppd	1,790	2,660	3,060
TKN, mg/L	36.2	30.9	21.9
NH_3-N, ppd	1,340	1,990	2,290
NH_3-N, mg/L	27.2	23.2	16.4
TP, ppd	258	387	444
TP, mg/L	5.2	4.5	3.2
Ultimate Buildout of Site			
Flow, mgd	8.1	14.1	23.0
BOD, ppd	11,830	17,630	24,320
BOD, mg/L	175	150	127
TSS, ppd	16,040	38,910	81,610
TSS, mg/L	237	330	426
TKN, ppd	2,450	3,640	4,180
TKN, mg/L	36.2	30.9	21.9
NH_3-N, ppd	1,810	2,730	3,140
NH_3-N, mg/L	27.2	23.2	16.7
TP, ppd	354	530	608
TP, mg/L	5.2	4.5	3.2

1.6 Plant Hydraulics

The hydraulics at the plant is highly influenced by the Missouri River level. The preliminary hydraulic modeling indicates that when the river is at the 100-year flood level, weirs at the chlorine contact basin, Special Manhole No. 2, final clarifiers, and primary clarifiers are submerged during peak hour flows. Some of these weirs are submerged at the 100-year river level regardless of the flow the plant receives. Therefore, there appears to be two issues: backwater from the river during flood stages, and hydraulic bottlenecks within the plant and outfall pipe. The existing hydraulic profile is included as *Figure 1-4*.

1.6.1 Missouri River Level

Table 1-6 shows the various river levels that were used in the hydraulic modeling. River levels were interpolated from a recent Flood Insurance Survey profile and are at the mouth of 5 Mile Creek.

Table 1-6
Missouri River Flood Elevations

Frequency	Elevation
25-year	770.22
50-year	771.00
100-year	772.00

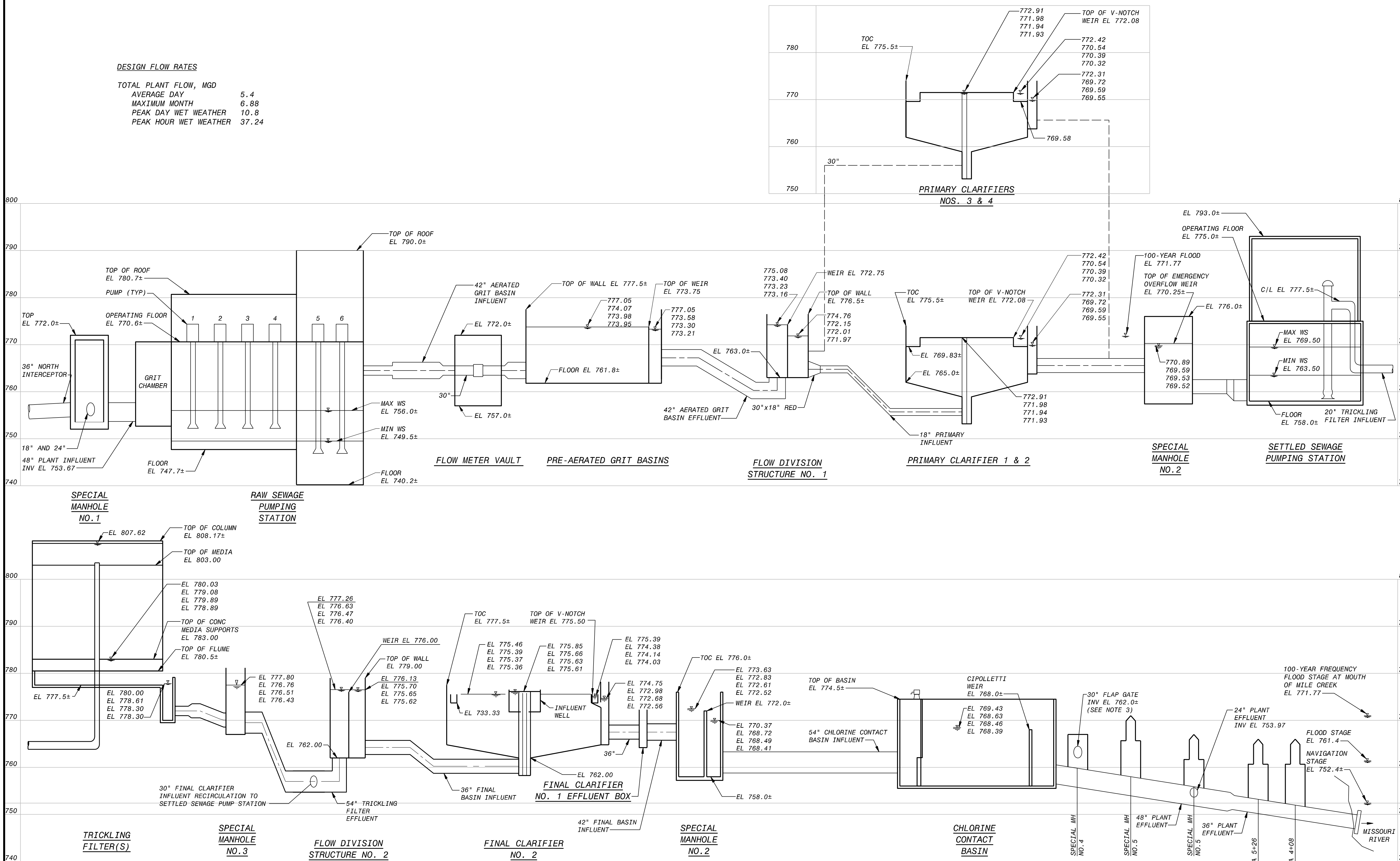
1.6.2 KDHE Requirements

KDHE has requirements for “Emergency Operation” which includes flooding. The following requirements are from KDHE’s “Minimum Standards of Design for Water Pollution Control Facilities”.

a. All units shall remain fully operational during the 25-year flood frequency event.

DESIGN FLOW RATES

TOTAL PLANT FLOW, MGD	
AVERAGE DAY	5.4
MAXIMUM MONTH	6.88
PEAK DAY WET WEATHER	10.8
PEAK HOUR WET WEATHER	37.24



HYDRAULIC PROFILE

HORIZ NO SCALE
VERT 1" = 10'0"

NOTES:

1. WATER SURFACE ELEVATIONS SHOWN ARE BASED ON NAVIGATION STAGE WATER ELEVATION OF MISSOURI RIVER AT EL 752.40.
2. EL XXX.XX (WATER SURFACE @ PEAK HOUR WET WEATHER)
   EL XXX.XX (WATER SURFACE @ PEAK DAY WET WEATHER)
   EL XXX.XX (WATER SURFACE @ MAX MONTH)
   EL XXX.XX (WATER SURFACE @ AVERAGE DAY)
3. OVERFLOW THROUGH 30" FLAP GATE TO 5 MILE CREEK WILL OCCUR AT SPECIAL MANHOLE NO.4 AT ANY FLOW ABOVE 30 MGD WHEN RIVER IS AT NAVIGATION STAGE.

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BLACK & VEATCH Corporation
Kansas City, Missouri

LEAVENWORTH, KANSAS
MASTER PLAN &
COLLECITON SYSTEM UPDATE

EXISTING HYDRAULIC PROFILE

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FIG 1-4

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b. All units required to provide primary treatment (pumping, screening, and removal of settleable solids) shall remain fully operational during the 50-year flood frequency event.

c. All structures, electrical, and mechanical equipment shall be protected from damage due to the 100-year flood frequency event.

The City has indicated that the plant is capable of meeting these requirements, however, a 100-year flood frequency event would require a complete plant shutdown similar to what occurred in the Flood of 1993.

There are also requirements in the KDHE standards for standby power. The plant does not currently have backup power for the existing facilities, but the plant does have dual power feeds. The transfer feed switches are currently manually operated, but the City is planning to add automated power switches to transfer feeds in future improvement projects.

1.6.3 Hydraulic Capacity of Existing Facilities

The preliminary hydraulic calculations showed that there are some hydraulic bottlenecks or constraints at the plant. The key areas of concern are as follows:

Influent Bar Screens: Rated capacity is 26.5 mgd, however more flow can be passed through the screen with reduced screening efficiency.

Settled Sewage Pumping Station: Rated capacity is 30 mgd with all pumps running. If more flow comes to the plant, flow in excess of 30 mgd will pass through the emergency overflow pipe to Special Manhole No. 2.

Outfall Pipe: There are some complexities to the outfall pipe that made it difficult to hydraulically model. Specifically, it appears that there are two outfall pipes extending to the Missouri River from the second Special Manhole No. 5. In Workshop No. 1, the City mentioned that they thought the original outfall pipe had been plugged, which agrees with the way the system was modeled. The results of the model are as follows: when the Missouri River is at navigation stage (el 752.4), plant effluent will discharge directly to 5-Mile Creek through the flap gate in Special Manhole No. 4 when plant flow exceeds 30 mgd. As the Missouri River rises, more flow will discharge directly to 5-Mile Creek.

1.6.4 Potential Hydraulic Modifications

There are modifications that could help alleviate some of the hydraulic concerns. Some could be completed with the initial disinfection project and have been indicated as such below. The modifications are as follows.

- Raise walls of the Chlorine Contact basin to increase freeboard (complete with disinfection improvements)
- Modify Chlorine Contact basin influent piping to reduce headloss (complete with disinfection improvements)
- Add effluent pumping
- Increase Primary Clarifier capacity by replacing the two shallow units
- Increase Settled Sewage Pumping Station capacity and remove emergency bypass
- Add equalization facilities