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South Davis Sewer District Pump Station Hydraulic Capacity Evaluation

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SOUTH DAVIS SEWER DISTRICT PUMP STATION HYDRAULIC CAPACITY

EVALUATION.

by

James Dixon

A project submitted in partial
fulfillment of the requirements for the
degree

of

MASTER OF SCIENCE

in

Civil Engineering

Approved:

Dr. Gilberto Urroz Major Professor	Dr. William Rahmeyer Committee Member
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ABSTRACT

South Davis Sewer District Pump Station Hydraulic Capacity Evaluation

by

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Utah State University, 2011

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In 2010, South Davis Sewer District (SDSD) determined that possible hydraulic problems existed in their various pump stations operating within their treatment plants. A hydraulic analysis was conducted for the pump stations to diagnose the problems and provide possible alternative solutions. This analysis was conducted by using hydraulic minor loss equations to determine the amount of flow that the pumps were capable of producing and then comparing those results to the required demands in the plants. In cases where the flows were lower than needed, alternatives were designed to provide the required flows.

In the south plant the pumps were capable of meeting the hydraulic needs of the plant. However, in the north plant, the pump stations were far under capacity and alternative designs were provided. It was recommended that the first pump station add a fifth pump in order to generate the extra capacity needed while the second station would have their pumps replaced with new pumps capable of providing a slightly larger flow capacity. It was also recommended that SDSD review other areas of treatments and hydraulics that may have been causing additional problems.

(165 pages)

DISCLAIMER

The designs proposed in this report were produced by James Dixon while working for the South Davis Sewer District during the Summer of 2010 and are his and the South Davis Sewer District own intellectual property. Utah State University does not endorse any of the designs detailed herein nor any of the brand-name equipment shown in this report. Utah State University is not responsible for any liability that may result from the implementation of the designs presented in this report.

PREFACE

This report was produced by James Dixon, while working for the South Davis Sewer District (SDSD) during the Summer of 2010. The study reported herein was aimed at improving the performance of the sewage pumping stations located in the south and north plants of SDSD. All work found herein, unless otherwise stated, was conducted personally by James Dixon under the direct supervision of the district's licensed engineer, Matthew Myers.

James Dixon

South Davis Sewer District Pump Station Hydraulic Capacity Evaluation:

North Plant

Pump Stations 1 & 2

&

South Plant

Main, Intermediate & Secondary Pump Stations

South Davis Sewer District
James Dixon
May 26, 2011

Executive Summary

The South Davis Sewer District (SDSD) North Treatment Plant has been experiencing capacity challenges in its influent pump station during sustained wet weather events. As a result, SDSD decided to initiate a system analysis of this pump station as well as its four other treatment plant pumping stations. All systems analyzed are listed below.

- North Plant Pump Station 1 (NP-PS1)
- North Plant Pump Station 2 (NP-PS2)
- South Plant Primary Pump Station (SP-PS1)
- South Plant Intermediate Pump Station (SP-PS2)
- South Plant Secondary Pump Station (SP-PS3)

To determine the existing system analyses and to look at possible alternatives for increasing the pump station capacities, models were created using head loss equations. These models, when compared to the pump curves of the existing pumps, helped to show which systems were not capable of pumping the design flows.

North Plant

In order to determine any necessary upgrades in the north plant to meet the influent design flow of 24 mgd (16666.7 gpm) plus recirculated flows, five alternatives (not including the existing system) were modeled in NP-PS1. The first three were designed to meet the design criteria while the last two were chosen as possible smaller upgrades. While these upgrades do not meet the design capacities, they would raise the capacity of the plant without requiring the higher costs that seem to be requisite with the other alternatives. However, Alternative 4 would be preferred because less labor may be required in the upgrade and would provide an increased pumping capacity of 28 mgd (19444 gpm) which meets the design criteria.

In NP-PS2, five alternatives (not including the existing system) were chosen and, again, the first three were selected to meet capacity while the last two were chosen as a less costly alternative. Alternative 5 would be preferred due to the smaller amount of labor that may be required to complete the upgrade as well as using smaller sized pumps that would be less costly to run and would provide a pumping capacity of 27.75 mgd (19270 gpm). While this does not reach the required 31.5 mgd, it would be a large increase from what is currently in place and may be sufficient for the needs of SDSD.

It was also noted that upgrades at each process of the north plant may be needed in order to rectify all hydraulic issues limiting the capacity of the existing system. Should the elevation at any of the treatment processes or distribution boxes be raised, a review of the pump stations will be required in order to ensure its continued operation.

Should all the abovementioned upgrades be performed in the North Plant, it is believed that the capacity of the South Davis Sewer District north plant could be substantially increased while still maintaining the recirculated flows.

South Plant

At the south plant, a much smaller amount of flow must be treated and the design flow only calls for an influent of 6 mgd (4166.7 gpm). Analysis was much simpler because the required capacity was already being met and there was no need for upgrades. Because of this, only the existing systems were considered as alternatives and any upgrades were dismissed.

SP-PS1, was found to have a capacity of 7.22 mgd (5013.9 gpm) and requires no replacements or improvements.

The capacity of the Intermediate Pump Station, SP-PS2, was found to be 11 mgd (7638.9 gpm). Again, no improvements are needed.

At the secondary pump station, SP-PS3, the capacity was found to be 7.2 mgd (5000 gpm) and, as with the other stations, was well within the needed hydraulic capacity. No change is needed to meet capacity.

It has been recommended that no improvements or changes be made to the south plant pump stations because they are fully capable of hydraulically handling the influent flows. The south plant should be reviewed however to determine if any bottlenecks in the treatment components exist in the system that could pose a problem not located in the pump stations.

Conclusions

It has been determined that while larger upgrades are needed in NP-PS1 and NP-PS2, the south plant pump stations are capable of handling the required design flows in their current setup. If the upgrades recommended above are performed, it has also been determined that the capacity could be raised substantially in the north plant although design flows would not be reached.

In the case of both plants, it must be noted, however, that treatment in the south plant and internal plant hydraulics in the north plant, are both bottlenecks that could cause the system to fail even though the hydraulic capacity of the pump stations has been increased to handle higher flows. These problems should be reviewed prior to the implementation of any upgrades in the system.

Table 1.1: Summary of Alternatives for each pump station discussed in this report

Summary of Alternatives							
	Hp	Inlet / Outlet (in.)	Number of New Pumps Required	Capacity w/o Standby (mgd)	Capital Costs	O&M Costs	Total Costs
NP-PS1 Alternative 1: Existing System	50 / 60	10 / 10 14 / 14	-	20.25	$0.00	$606,394.99	$606,394.99
NP-PS1 Alternative 2: Four that Fit	140	16 / 14	4	30.75	$332,325.00	$1,196,005.51	$1,528,330.51
NP-PS1 Alternative 3: Four that Squeeze	90	20 / 16	4	30.25	$515,655.00	$1,079,298.42	$1,594,953.42
NP-PS1 Alternative 4: Five Pump System	60 / 85	14 / 14 16 / 14	2	28	$144,112.50	$920,394.03	$1,064,506.53
NP-PS1 Alternative 5: Lower Cost Four that Fit	70	16 / 14	4	24.75	$281,295.00	$919,288.67	$1,200,583.67
NP-PS1 Alternative 6: Lower Cost Four that Squeeze	60	20 / 16	4	23.5	$493,605.00	$794,067.14	$1,287,672.14
NP-PS2 Alternative 1: Existing System	50 / 60	10 / 10 14 / 14	-	21	$0.00	$612,521.72	$612,521.72
NP-PS2 Alternative 2: Four that Fit	170	24 / 20	4	36	$556,290.00	$1,348,873.12	$1,905,163.12
NP-PS2 Alternative 3: Four that Squeeze	185	24 / 20	4	39.75	$656,460.00	$1,674,157.61	$2,330,617.61
NP-PS2 Alternative 4: Three Big Pumps	250	24 / 20	3	34.5	$519,277.50	$1,710,209.67	$2,229,487.17
NP-PS2 Alternative 5: Lower Cost Four that Fit	85	16 / 14	4	27.75	$274,995.00	$1,189,441.51	$1,464,436.51
NP-PS2 Alternative 6: Lower Cost Four that Squeeze	60	20 / 16	4	24	$477,855.00	$736,812.34	$1,214,667.34
SP-PS1: Existing System	40	6 / 6	-	7.18	NA	NA	NA
SP-PS2: Existing System	NA	10 / 8	-	10.7	NA	NA	NA
SP-PS3: Existing System	30	8 / 8	-	7.2	NA	NA	NA

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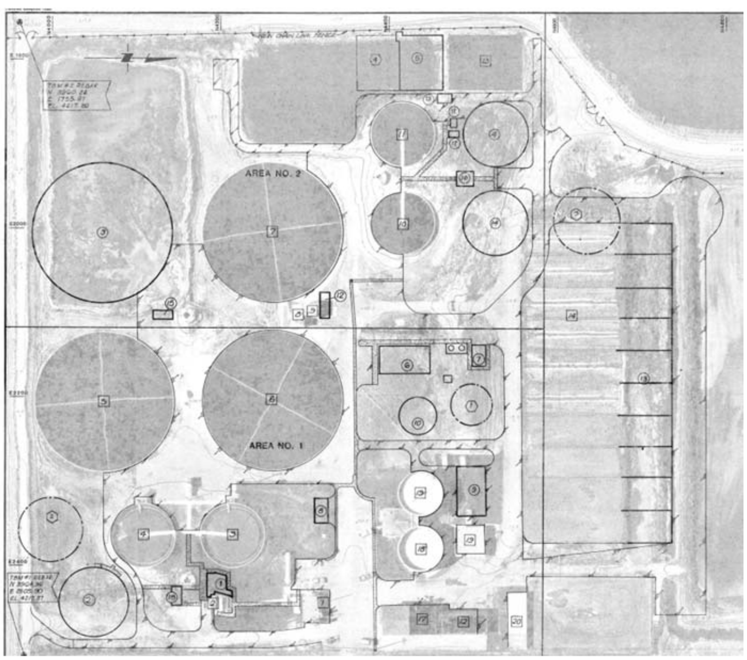
1.0 Introduction

This report was created in order to analyze the existing hydraulic flow capacity of all five operating pump stations of the South Davis Sewer District (SDSD). These stations include: Pump Station 1 (NP-PS1) and Pump Station 2 (NP-PS2) at the North Plant as well as the Main Pump Station (SP-PS1), Intermediate Pump Station (SP-PS2), and Secondary Pump Station (SP-PS3) at the South Plant. Because a pump analysis has never been conducted by SDSD before, this report will also serve as a guide and template for future studies as well.

1.1 Historical Background

In 1959, the South Davis Sewer District was established to provide wastewater treatment for five local cities: Bountiful, Centerville, North Salt Lake, West Bountiful and Woods Cross. Two plants were established to handle the flows with the northern plant being the larger of the two.

At the north plant, which serves the northern drainage basin, two pump stations were built to carry the flows up to the various treatment systems. These stations were creatively named Pump Stations 1 and 2. NP-PS1 was designed to carry all incoming flows up to the primary clarifiers while NP-PS2 was to be an intermediate pump system and lift the flows up to the final clarifiers. Each station was built with two 50 hp pumps and an additional smaller pump to handle lower flows. Space was also left with the intention of adding an additional pump in the future as the need arose.



It was not until 1988 that a plant expansion would take place at the north plant. In this expansion, an additional pump was added and some of the old pumps removed to accommodate the growing demand from the cities. At the time, the smaller pump was removed and two 60 hp pumps were added to increase the pumping capacity of the plant. These pumps were to work along with the two existing 50 hp pumps so that the four pumps could handle a peak design flow of 24 mgd of influent. Only a few years later, one of the 50 hp pumps was removed to accommodate a third 60 hp pump at each of the stations.

At the South Plant, three pump stations were created to serve the southern drainage basin. The stations consist of a primary pump station which pumps the initial influent up to the primary clarifiers, an intermediate pump station where water is pumped up to the intermediate clarifier and the secondary pump station where water is lifted to the final clarifiers.

Similar to the situation at the north plant, the south plant did not receive any upgrades until 1992, where some of the pumps were replaced to compensate for increasing flows. Currently, SP-PS1 continues to use the original 40 hp pumps that were placed there, SP-PS3 has had all its pumps replaced with 30 hp pumps and SP-PS2 has more recently had its pumps replaced with different pumps.

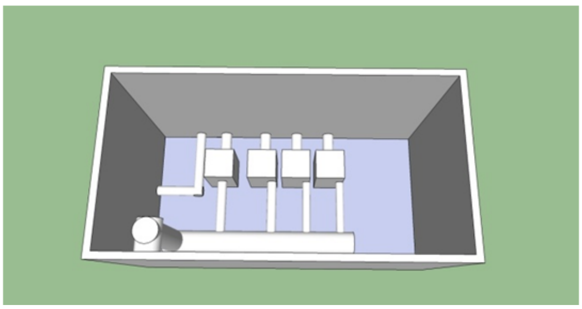
1.2 Problem Description:

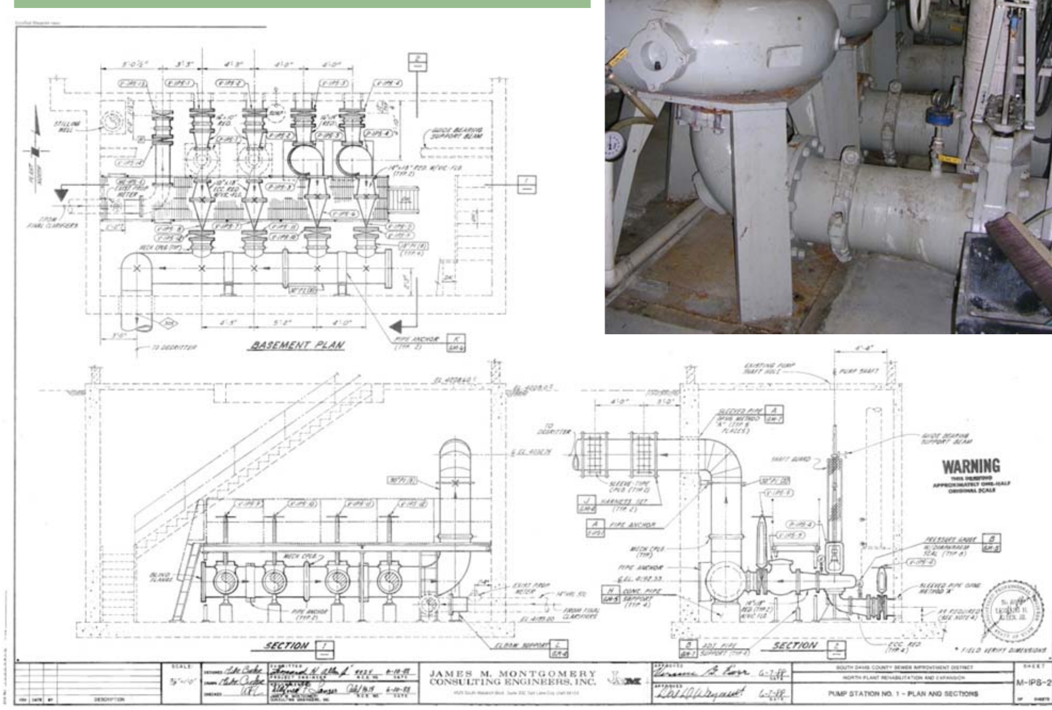
South Davis Sewer District houses two plants in order to handle the local wastewater. At the north plant, all incoming flows meet at Pump Station 1 (NP-PS1), where they are lifted over 20 ft. to the clarifiers. A small wet well exists, but does not allow for much storage which forces the pumps to operate near incoming flows. In order to meet the flow demand, four pumps are operated. However, periodically, the District receives large flows into their north plant due to a heavy spring runoff. On one occasion, 18 mgd (12500 gpm) of influent flow was observed and areas near the tail-end of the plant began to flood. The plant was originally designed to handle a 24 mgd (16666.7 gpm) peak flow yet even at 18 mgd the operators still experience difficulty in keeping up with the incoming flow. Due to this fact, it was determined that a hydraulic analysis of the two pump stations should be conducted in order to determine whether the stations were in need of an upgrade or whether the problem came from some other source. It was also decided that an analysis of the south plant pump stations be conducted as well to determine the possibility of similar problems.

2.0 System Description

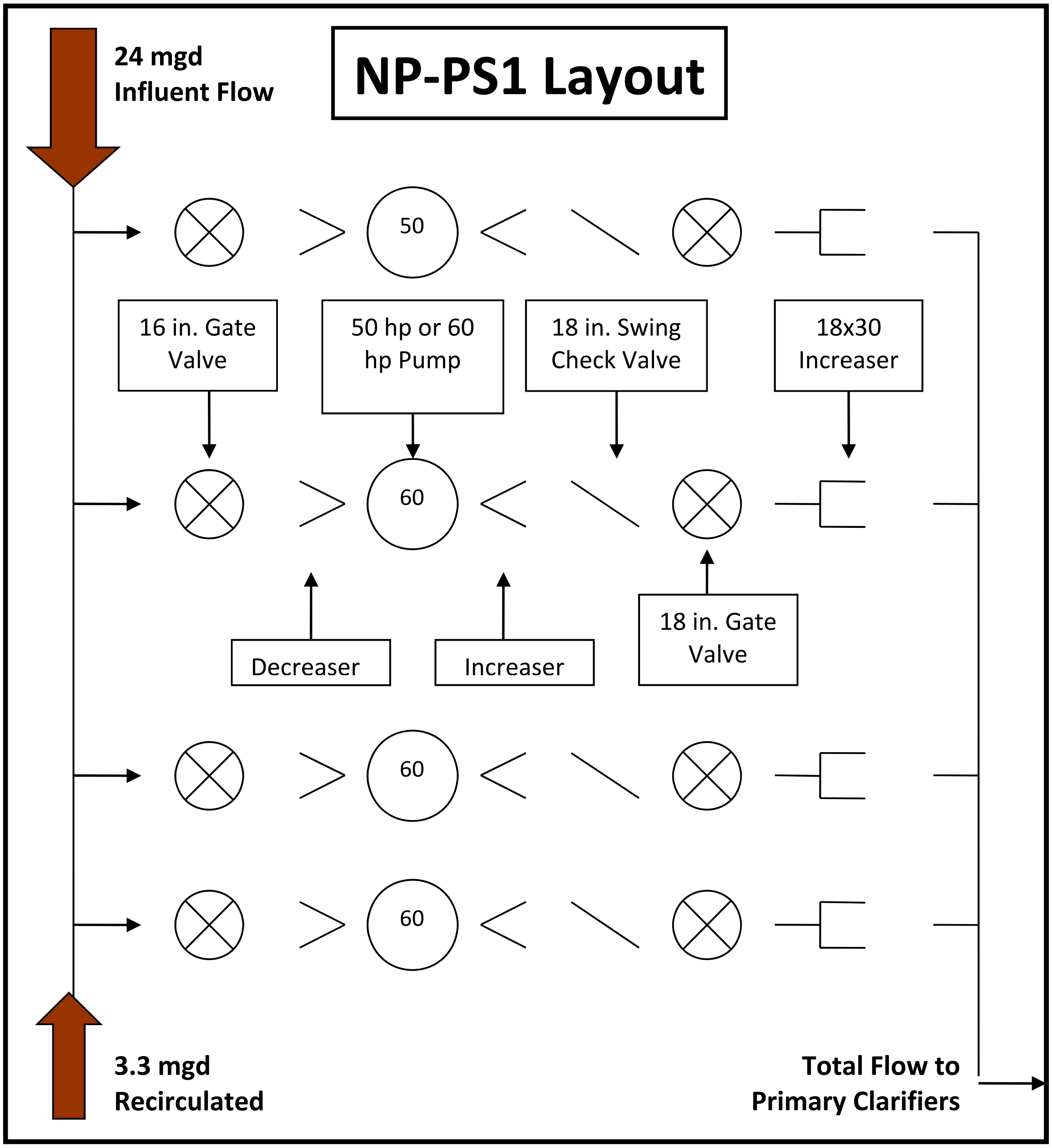
2.1 Pump Station 1 Layout

Wastewater enters NP-PS1 by way of a Parshall flume before entering the wet well. The flow then passes through one of four rounded 16 in. pipes, before being reduced to the correct pump size, and enters one of four pumps. Three of the pumps are identical 60 hp pumps and the fourth is a single 50 hp pump to handle lower flows. A variable frequency drive (VFD) is set up so that any one of the pumps can be operated at lower speeds and thus, lower flows. Following the pumps, the pipe is then expanded to 18 in. in order to accommodate the existing valves and then expanded again in order to connect to the 30 in. manifold. Finally, the 30 in. pipe then travels roughly 90 ft. and rises nearly 25 ft. before entering the clarifiers.



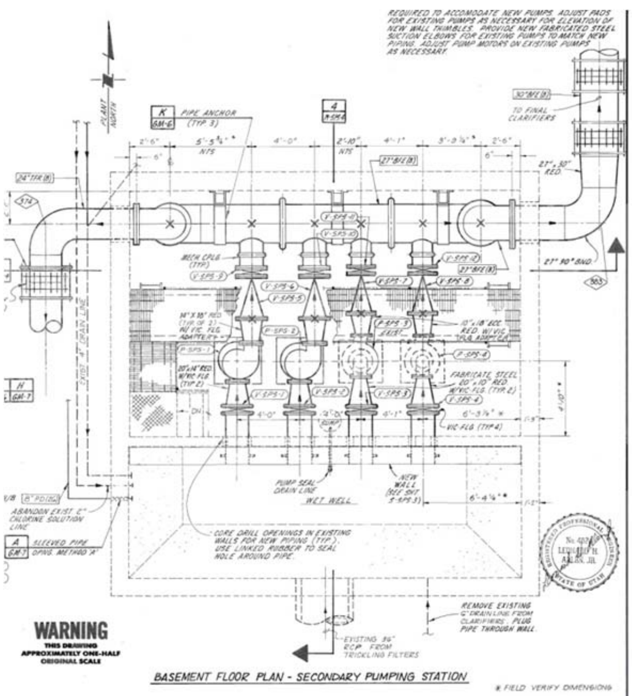


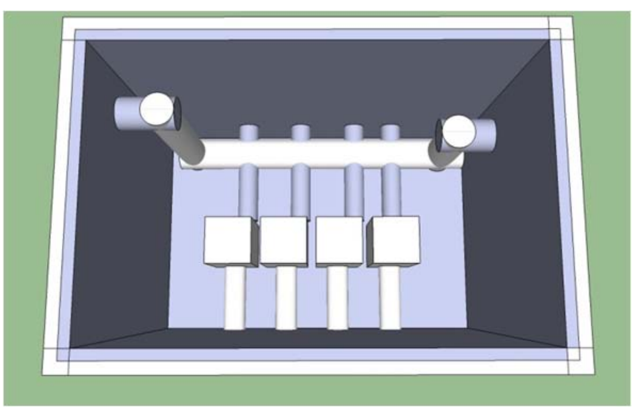
Design peak flows in NP-PS1 were reported to be 24 mgd although an additional 3.3 mgd come from recirculated flows that are unaccounted for otherwise. This brings the total amount that must be pumped to about 27.3 mgd.


NP-PS1 Layout
24 mgd
Influent Flow
50
60
60
60
16 in. Gate Valve
50 hp or 60 hp Pump
18 in. Swing Check Valve
18x30 Increaser
Decreaser
Increaser
18 in. Gate Valve
3.3 mgd
Recirculated
Total Flow to
Primary Clarifiers

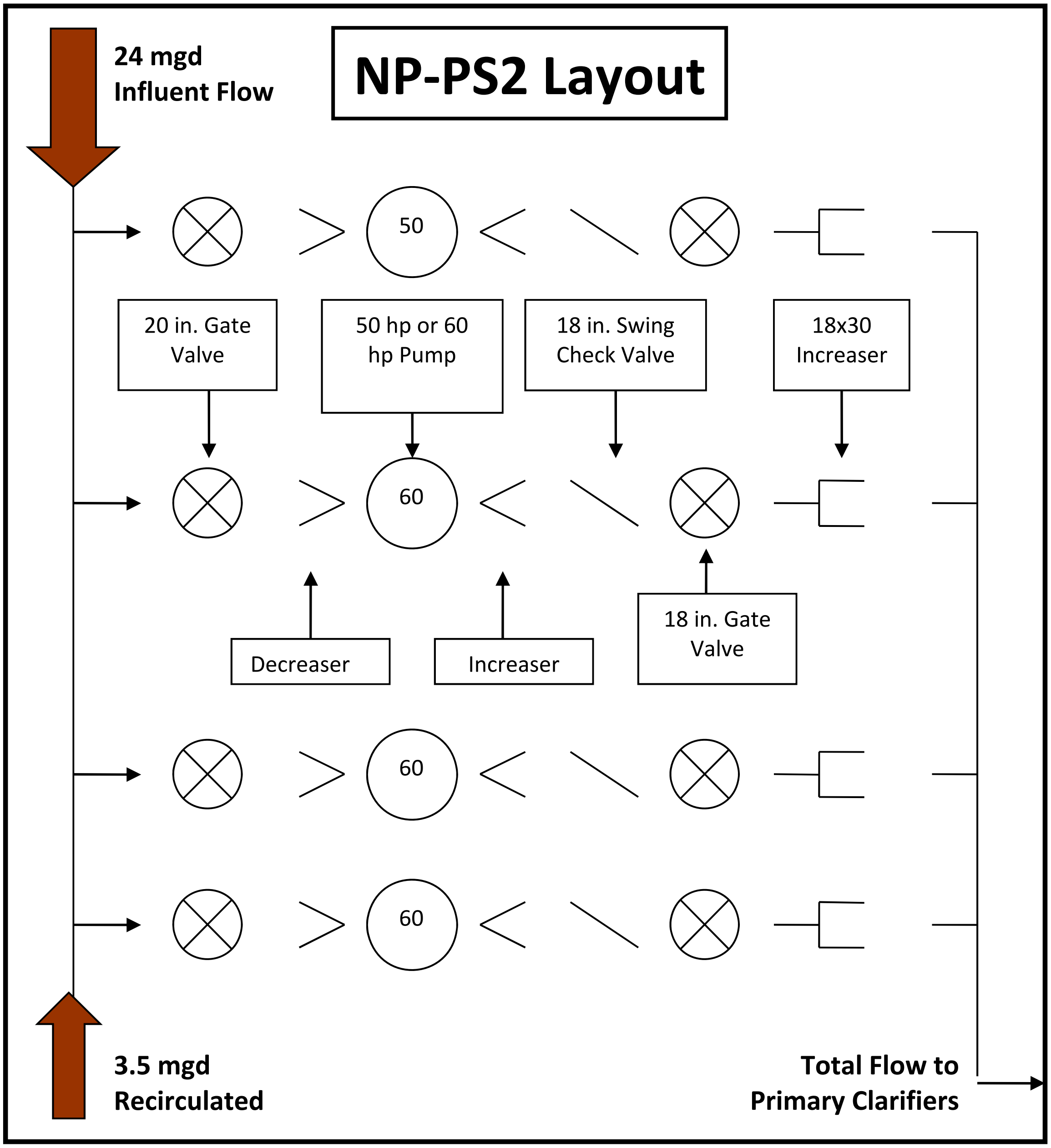
2.2 Pump Station 2 Layout

While NP-PS1 and NP-PS2 are very similar in setup, there are a few intrinsic differences in NP-PS2 that must be noted before an analysis can be done. NP-PS2 is an intermediate station and lies between the trickling filters and the final clarifiers of the north plant. Flows enter NP-PS2 through one of four rounded 20 in. pipes and are then reduced down to the respective pump size. As in NP-PS1, three identical 60 hp pumps exist with a single 50 hp pump to handle lower flows. Again, the pumps are identical in sizing to the pumps in NP-PS1 and a VFD allows any one of the pumps to operate at lower speeds. After the pumps, the pipe expands into a manifold and is later increased into a 30 in. pipe. This pipe travels a little over 300 ft. before entering the final clarifiers.





The design peak flow in NP-PS2 remains at 24 mgd (16666.7 gpm) with the additional 3.3 mgd of recirculated flows from the system. However, another additional 3.5 mgd (2430.6 gpm) is also recirculated from the trickling filters leaving the total pumped amount at 30.8 mgd (21388.9 gpm). One of the benefits at NP-PS2 is that the amount of head that must be pumped is slightly less which helps to alleviate some of the head that the pumps must produce.


24 mgd
Influent Flow
NP-PS2 Layout
50
20 in. Gate Valve
50 hp or 60 hp Pump
18 in. Swing Check Valve
18x30 Increaser
60
Decreaser
Increaser
18 in. Gate Valve
60
60
3.5 mgd
Recirculated
Total Flow to
Primary Clarifiers

2.6 Summary of North Plant General Design

The table below divides the plant data into two sections, the actual design and the observed data. In comparing these two sets of data, it is possible to see whether the observed flows are reaching the amounts for which the plant was designed.

Table 2.1: North Plant Design and Observed Data

North Plant Design Data	
Design Parameters	**North Plant General**
Avg. Daily Flow (mgd/gpm)	12 / 8300
Peak Hour Flow (mgd/gpm)	24 / 16700
Inplant Return Flow (mgd/gpm)	12 / 8300

	NP-PS1	**NP-PS2**
#60 hp Pumps/gpm	2 / 6000	2 / 6000
#50 hp Pumps/gpm	2 / 3300	2 / 3300
Combined Pumping Capacity (mgd/gpm)	26.8 / 18600	26.8 / 18600

North Plant Observed Data				
Item	**NP Data 2007**	**NP Data 2008**	**NP Data 2009**	Description
Avg. Dry Weather Flow (mgd/gpm) (based only on effluent and not on influent flows to the pump stations) (Oct. – Mar.)	7.1 / 4900	7.3 / 5100	7.5 / 5200	The average of the daily flows sustained during dry-weather periods with limited infiltration
Avg. Wet Weather Flow (mgd/gpm) (based only on effluent and not on influent flows to the pump stations) (Apr. – Sept.)	7.4 / 5100	7.5 / 5200	8.5 / 5900	The average of the daily flows sustained during wet-weather periods when infiltration is a factor
Peak Hour (mgd/gpm) (based on effluent and not on influent flows to the pump stations)	15 / 10400	15 / 10400	15 / 10400	The average of the peak flows sustained for a period of 1 hour in the record examined

3.0 Existing System Analysis

In order to complete an analysis of the existing system and to verify the current capacity that may be handled, a spreadsheet model was created by using hydraulic methods and equations outlined in greater detail in Appendix A.

3.1 Data Gathering

Data was collected by using various methods in order to create the most accurate model possible. The original 1960 construction plans were compared against the later 1988 expansion plans to determine materials used as well as accurate hydraulic dimensions. Pump curves for the existing pumps from the same time periods were also located and evaluated.

After locating the details of the plant and its design, flow values were taken from recorded data using the existing Parshall flume and totalizer for the plant. These values were then checked against several archived pen charts from 2004 to 2010 to determine the accuracy of the recorded influent values.

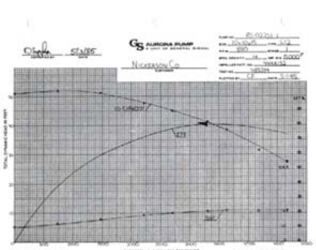
Because the automated valve system to control the recirculated flow is no longer operable, the valves are left open and only operated manually. As a result, the recirculated flows for the plant are dictated solely by the amount of head available to push flows through them. Pen charts showed these values to peak at an average of about 3.3 mgd for recirculated flows from the final clarifiers and the flows from the trickling filters are maintained at 3.5 mgd. Because these flows are not accounted for in the Parshall flume, they were manually accounted for in the model.

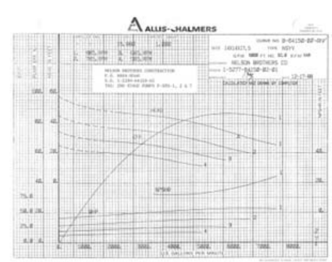
Several hydraulic design references, such as Pumping Station Design (Sanks, 1989) and Advanced Water Distribution Modeling and Management (Haestad, 2003), were used and various coefficients and common values were taken from them to help maintain accuracy in the calculations

3.2 Pump Curve

Before attempting to model the existing system, it was necessary to recreate the pump curves in order to calculate the curve equation. By finding this equation, values could be found on the curve without the use of interpolation or excessive amounts of manually located points.

After the curves were put into the spreadsheet and the curves calculated, they were added in various parallel combinations. This simplification allowed for the ability to quickly view the results of running various specific pumps.



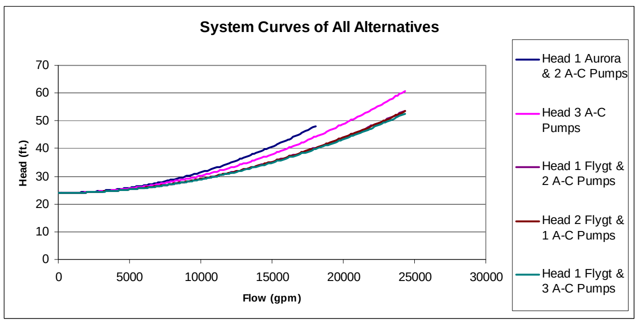


3.3 System Curve Modeling

In modeling the system curve, a minor loss equation was used to find the needed head values at a given flow where *h* is the head produced (total head), *ΔEl* is the distance that the water must rise by the end of the pipe (static head), and the last term accounts for the minor losses that will occur throughout the system (dynamic head):

$$h = \Delta El + \sum k \frac{Q^2}{2gA^2} + h_f$$

This is not to say that the calculated head would be produced at the end of the pipe, but that the pump would produce the calculated head immediately upon discharge. Then, as the flows pass through the various valves and other fittings, the heads drop until reaching the needed head at the end of the pipe. It is also important to note that as the flows become greater, the amount of head that must be produced will also become greater.



Values for minor losses were taken from the given ranges of Pumping Station Design (Sanks, 1989) and, for lack of better information, the most conservative values were used. Using the minor loss equation, curves were calculated for each system which show the various heads that would be needed in order to provide the desired flows.

3.3.1 Difficulties Encountered in Comparing the Pump and System Curve: Because the existing system uses a variable frequency drive, pump curves will change at different speeds. Also, because intermediate curves were not available, only the 885 rpm speed pump curves were compared to the system curves.

3.3.2 Difficulties Encountered in Modeling the System Curve: Two problems arose when modeling the system curve for which no solid solution was found. The first arose when modeling flows through the manifold after the pumps in each station. The second dealt with simply determining how to divide the flows through each pump.

When modeling the system curve through the manifold, no information on standard practice for designing manifolds was found and no text could be located that provided such information. Without further guidance, it was decided that the manifold could be broken into various tees and elbows. In this way, the flows could be modeled as they passed through each of the intersections instead of using the manifold as a whole. As a result, it was also decided that less conservative values should be used when considering losses through the manifold so that it would not be weighted as heavily while other values were left more conservative.

3.3.3 Difficulties Encountered in Calibrating the System Curve: Several of the data points taken from the pen charts showed that the maximum flows into the plant were all 15 mgd (10416.7 gpm). The charts that were compared to these values are only capable of reaching 15 mgd, which caused some difficulty because no reliable maximum flows could be used to calibrate the model. In recreating the system curve, maximum flows were assumed to be higher than 15 mgd and the model was calibrated based on this information. Fortunately, due to a storm event, a value of 18 mgd (12500 gpm) influent was observed with the flume and this value was checked against the system curve with positive results.

A large problem was found in the initial design of the treatment plant. In the plant design, a head was stated for the pump station of 32 ft regardless of which pump was being used. Because this number does not match the static head, it was determined that it must refer to the total head. It is also assumed that this head was for the design flow, but when compared with the model, the values were found to be very different.

The design called for the flows at a specific head, but the flow at this head, when compared to the pump curves, did not match the design flow. Also, the heads from the design points marked on the pump curves did not always match what was called for in the design and, in the table below, both have been noted. Not only do they not match, but the pump curves for the 60 hp and 50 hp pumps have different design point heads. This would indicate that, even though they run in parallel, the pumps operate at vastly different heads.

Due to the confusion caused by the discrepancies in the design values, it was determined that the model should not be calibrated based on the design data. The design points were still compared to the curve, but did not provide sufficient reason for adjusting the curve to fit them.

Table 3.1: Design and Modeled Heads

Head at NP-PS1 for 26.78 mgd Pumped Flow (design capacity)		
	Design / 60 hp Pump Curve / 50 hp Pump Curve (ft.)	**Modeled (ft.)**
Static Head	24 / 24 / 24	24
Dynamic Head	8 / 8 / 17	16
Total Head	32 / 32 / 41	40
Head at NP-PS2 for 26.78 mgd Pumped Flow (design capacity)		
	Design / 60 hp Pump Curve / 50 hp Pump Curve (ft.)	**Modeled (ft.)**
Static Head	21.17 / 21.17 / 21.17	21.17
Dynamic Head	10.83 / 10.83 / 19.83	19.75
Total Head	32 / 32 / 41	40.92

3.4 System Analysis

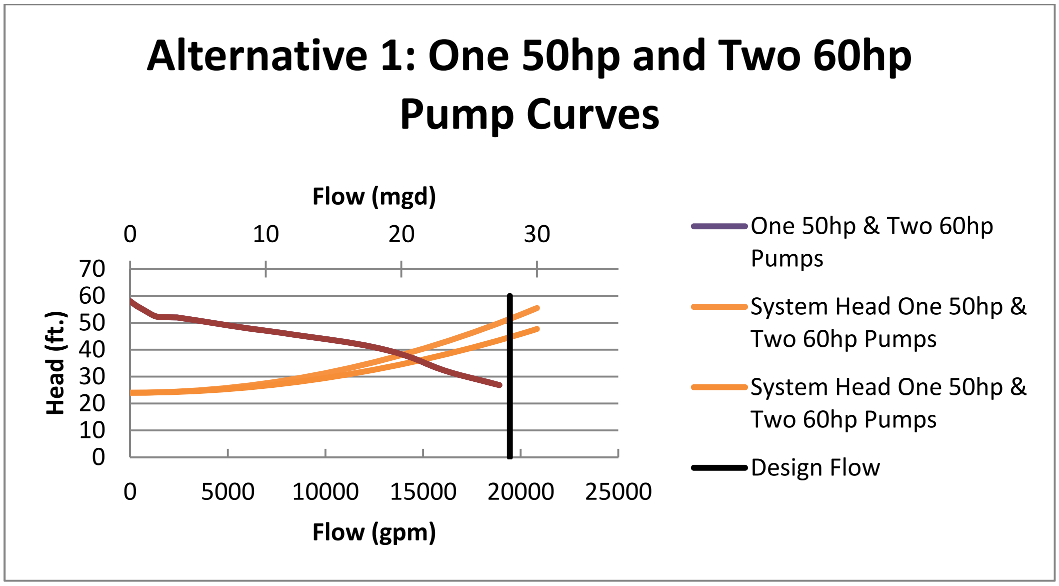
Whereas the pump curves help to detail the amount of head that can be produced at a given flow, the system curve shows the amount of head required for a given flow. Once completed, the system curves were compared against the pump curves to determine the points of intersection. Each pump curve corresponds to a specific system curve and the intersection of the two shows the amount of flow that will be produced when running the corresponding pumps while still providing the needed head in the line.

It is also important to note that even though multiple pumps may be available, one of these pumps must be considered a “standby” pump in case any pump should fail. In creating a system design, it is considered that one pump is acting as the standby and that the largest available pump should no longer be considered as contributing in the design.

Below are graphs of the pump curves with the calculated system curves. Although the most conservative values were used, a second system curve was drawn using the least conservative values to illustrate the range of values that could be calculated if different values were chosen. In this way, it can be seen whether the conservative assumptions are too strict.

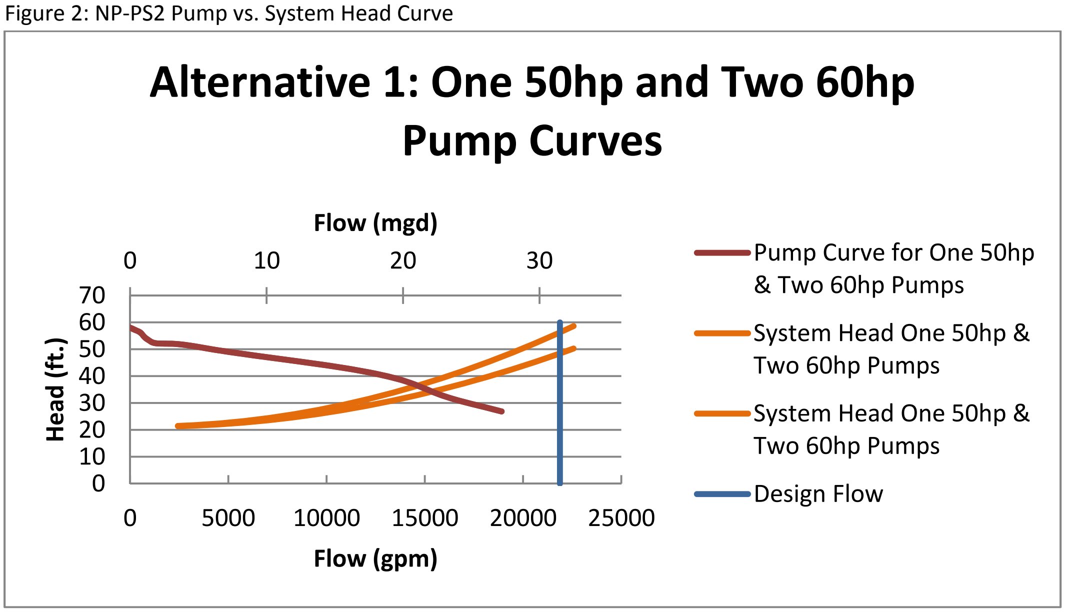
3.4.1 Pump Station 1: In comparing the points of crossing, it was determined that the highest amount that could possibly be pumped from NP-PS1 would be approximately between 20 to 21 mgd (13888.9 and 14583.3 gpm) when a pump is left on standby. As was stated previously, the plant was designed for a maximum of 24 mgd (16666.7 gpm) influent, but there should be an additional 3.3 mgd (2292 gpm) that is constantly being recirculated to aid in the treatment of the influent. Because of this, 27.3 mgd (18958 gpm) might need to be pumped at any given time while somewhere between 20 to 21 mgd could be pumped. Under these circumstances, the system is entirely unable to pump the required flows!

Figure 1: NP-PS1 Pump vs. System Head Curves



3.4.2 Pump Station 2: While similar to NP-PS1, the point of crossing for NP-PS2 resulted in a larger value between 21 and 21.8 mgd (14583.3 and 15138.9 gpm) being pumped when one pump is left on standby. After applying recirculated flows, the required flow came to 30.8 mgd (21388.9 gpm) flow through the pumps. This results in an even bigger problem than was seen in NP-PS1 being about 9 mgd under-capacity!

Figure 2: NP-PS2 Pump vs. System Head Curve



Without an upgrade, the only solution under these conditions would be to shut off the recirculated flow so that only the influent would be pumped. While it is possible that this might provide a hydraulic solution, treatment may be inhibited which could result in fines for those treatment levels that are not met.

3.5 Summary of Hydraulic Findings

In the table below, observed flow data from over the last couple years show a steady increase each year. In reviewing the data of SDSD, it was noted that flows have actually been increasing recently in part because some of the flow has been bypassed from the south plant. Also, even though the peak flows are only able to be read up to about 15 mgd, higher flows have been pumped through the system. 18 mgd flows were observed at one point, so it is very possible that even higher flows may have occurred than 18 mgd. Basically, the 15 mgd value has been listed as the maximum flow for years, but it is neither accurate nor does it reflect the actual peak flow.

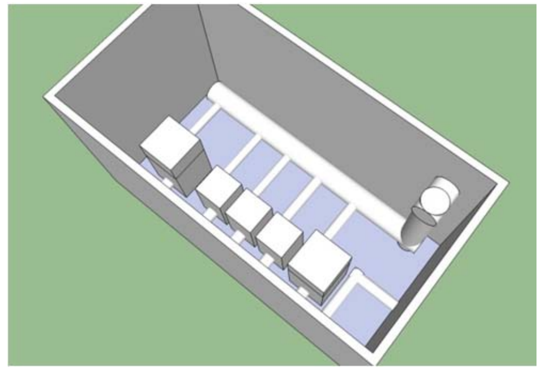
Similarly, minimal flows could be attributed to situations when flows may have been shut off or diverted past the measurement devices. To account for this, an annual average was taken and considered to be a much more accurate minimum flow.

Table 3.2: Observed North Plant Flows

	2007	**2008**	**2009**
Avg. Daily Flow (mgd/gpm)	7.3 / 5100	7.4 / 5100	8.0 / 5600
Peak Hourly Flow (mgd/gpm) (based on final effluent and not on influent to the pumps)	15 / 10400	15 / 10400	15 / 10400
Minimum Flows (mgd/gpm)	4.13 / 2900	4.25 / 3000	4.43 / 3100

3.6 3D Analysis

In looking at the pump sizes, a larger pump means a bigger footprint. In NP-PS1 and NP-PS2, space is very limited and any alterations must be made with that in mind. In order to better understand the effect that a larger pump might have on the available space, simple 3-D models were created using SketchUp where pumps could be placed in order to determine whether certain alternatives could be considered feasible. These models are not considered to be mechanical or structural drawings, but they provide a rough estimate at what type of space might be needed. Each pump was added as a block and all fittings were neglected in the models because only a rough idea was needed in considering possible alternatives.



Dimensions for the model were taken from the original 1960 structural and mechanical plans as well as the 1988 expansion plans. As further investigation was conducted, it was noted that the true dimensions of the manifold were not available and are different from the drawings and plans mentioned above. Alterations to the model were made as accurately as possible, however, before an upgrade is implemented, correct dimensions should be measured.

When looking at the various alternatives, no in-depth analysis was completed regarding the sizing of fittings or valves that might have to be changed in addition to the pumps. Only pipe sizes and pump sizes were altered and a more thorough investigation into the possibility of replacing or reusing fittings should be done if an upgrade is considered.

While simple, the 3-D model created for this analysis proved to be a powerful tool and it was only after its use that the recommended alternatives were considered to be feasible.

3.7 Cost Analysis

Although a hydraulic analysis showed which alternative could achieve the highest flow, often the most controlling factor is the amount that each alternative costs. An ideal hydraulic solution may be found, but if the cost is too high, it becomes impractical and a less expensive solution must be implemented.

To calculate the cost of each alternative, power rates were taken from the current electric bills. Because the rates vary throughout the year, a weighted average was taken for both the rate and demand charges.

Efficiencies were used to find the amount of power that would have to be utilized by the pumps. Although it is known that the demand charges are not controlled by any single process of the plants, it was determined that the portion that the pumps contribute to the whole could be found. For this calculation, it was assumed that, every month, all pumps (with the exclusion of the one on standby), would activate at some point in the month and it would be this amount that would be charged.

To determine the number of kwh that would be required for each alternative, average flows were found for 2009 and a day containing these flows was reviewed. With this “average day”, a simplified diurnal pattern was created. By determining the flows at each segment of time in this pattern, the number of pumps needed to maintain those flows was found. The required kwh were taken from this pattern and costs were then calculated from this new data. Because the power costs of using a VFD were unavailable, it was assumed that the pumps would be left running with a full load during each segment of time. Although this caused the power costs to appear higher than they actually are, it was decided that it would be close enough for the comparison of alternatives that this difference would be insignificant.

A more detailed explanation of the cost calculations is included in Appendix A

4.0 Alternatives

Because the model that was used to review the various alternatives could not be calibrated to any great extent, it must be noted that all values chosen for coefficients were selected at the most conservative level. In doing this, operating flows could prove to be much higher than stated in the alternatives and therefore the numbers produced by the model were regarded as the worst-case scenario. It is also for this reason that recommended alternatives were often chosen even after having fallen slightly below design flows.

In all alternatives that have been considered, one brand of pumps have been used in order to better compare the differences in alternatives without adding other variables. In addition to working well in a dry-pit situation, alternative pumps are all of submersible design which means that the motor is connected directly to the pump and long drive shafts are not needed. Because the pumps are connected to the pumps in such a way, pump sizes listed in the alternatives include the hp required by the motors. It is possible that a non-submersible pump would be able to use a variety of motors and energy could be saved by selecting a lower hp-rating motor. However, the possibility of lower energy motors was not considered for this study and all power costs were found under the assumption that the motor listed for each pump model is the motor that would be used to operate the pumps.

Table 4.1: Pump models that were reviewed in this study

Pumps Models Reviewed	Inlet / Discharge (in)	hp	Operating Range (mgd/gpm)
50 hp	10 / 10	50	NA
60 hp	14 / 14	60	NA
NP-PS1 Alternative 2	16 / 14	140	≈ 2.8 to Duty Point (1944 to Duty Point)
NP-PS1 Alternative 3	20 / 16	90	NA
NP-PS1 Alternative 4 & NP-PS2 Alternative 5	16 / 14	85	≈ 2.5 to Duty Point (1736 to Duty Point)
NP-PS1 Alternative 5	16 / 14	70	≈ 2.9 to Duty Point (2000 to Duty Point)
NP-PS1 Alternative 6 & NP-PS2 Alternative 6	20 / 16	60	NA
NP-PS2 Alternative 2	24 / 20	170	≈ 5.0 to Duty Point (3472 to Duty Point)
NP-PS2 Alternative 3	24 / 20	185	≈ 5.4 to Duty Point (3750 to Duty Point)
NP-PS2 Alternative 4	24 / 20	250	≈ 4.6 to Duty Point (3194 to Duty Point)

4.1 NP-PS1 Alternatives

In looking at the various alternatives, it was important that the amount of recirculated flow be increased from the observed amount to provide a greater safety factor. Because of this, the total recirculated rate was raised to 4 mgd (2777.8 gpm) while the trickling filter recirculation was left at 3.5 mgd (2430.6 gpm). This increase in recirculated flow brought the total design flow at NP-PS1 to 28 mgd (19444.4 gpm).

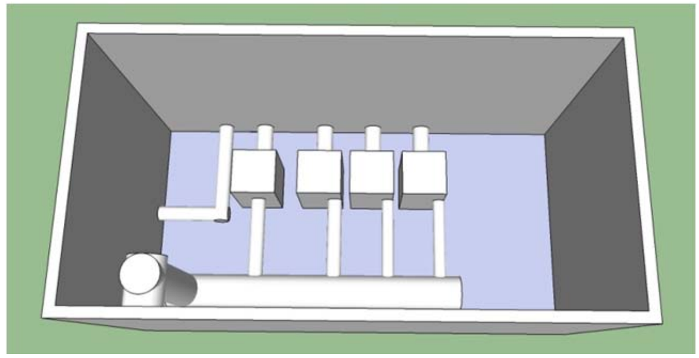
Another special consideration that was taken into account was the amount of space available in the current NP-PS1 building. Inside, all the pumps are located close together and would create some difficulty should they need to be moved or replaced.

To account for the possible need for an increased capacity, five alternatives were considered with regard to the hydraulic capacity of NP-PS1:

- Leaving the system as it is currently designed
- Four That Fit
- Four That Squeeze
- Replacing the 50 hp with two larger pumps to create a five pump system
- Four That Fit (70 hp)
- Four That Squeeze (60 hp)

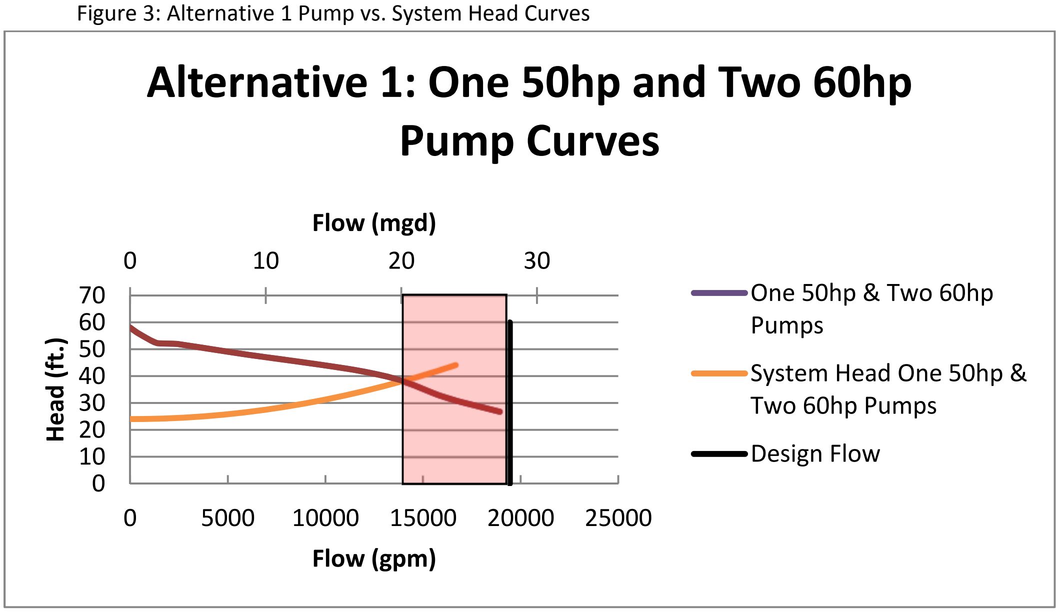
4.1.1 Alternative 1 - Existing System:

After modeling the existing system, the capacity was determined to be only 20.25 mgd (14062 gpm) when a pump is left to act as a standby. Because this is so far below the desired 28 mgd (18055 gpm), it is considered a very inadequate alternative.



Because of the possible error in the model used to determine the current capacity of NP-PS2, one option would be to allow the system to continue as it is currently designed even though the design is far below the desired capacity. This method would cost nothing to implement and more accurate data could be gathered for a later date.

Figure 3: Alternative 1 Pump vs. System Head Curves



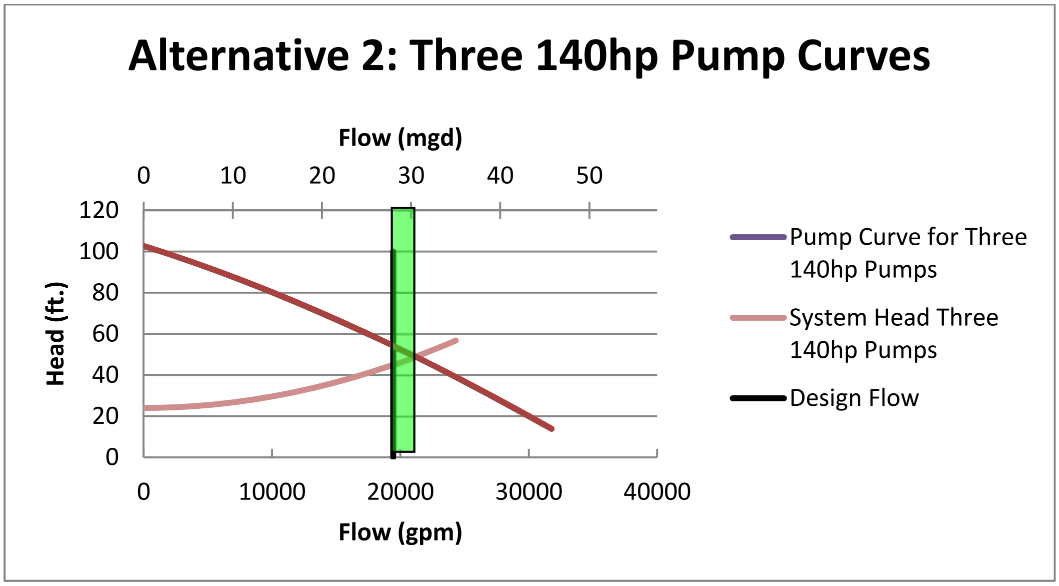
4.1.2 Alternative 2: Four That Fit

Other than leaving the existing system in operation, the most cost-effective means of increasing capacity would be to replace the existing pumps without having to replace anything else. To accomplish this, it was decided that one alternative would be to find pumps of the same size but with more capacity.

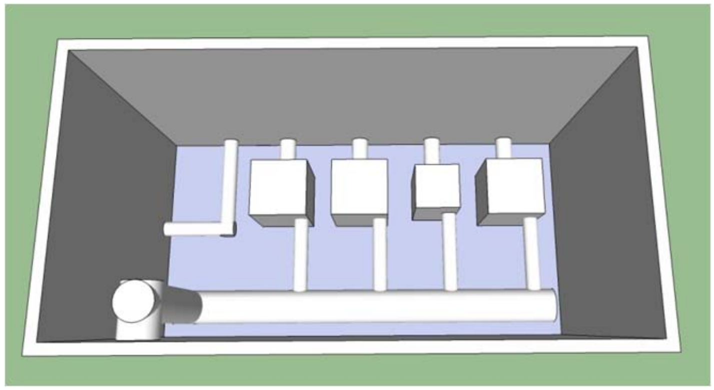
For the model, a 140 hp pump (1185 rpm) was selected that had nearly the same entrance and exit sizes as the 60 hp pumps already in use. An identical size could not be selected because the amount of flow that is needed requires that the inlet be larger than the discharge of the pump. The 140 hp uses a 16 inch inlet and 14 inch discharge which would allow for similar fittings to be used in the new installation which cuts down on costs. However, the 140 hp pump was found to be slightly larger than the 60 hp pumps and quite a bit taller due to the motor located above the pump. Even with this larger footprint, it was decided that the pump would likely still fit into the current pump location.

After modeling this change in pump, it was found that the three 140 hp pumps running together could achieve up to 30.75 mgd (21354 gpm). Alternative 2 is considered to be adequate because it meets the required demand while requiring little more than replacing the old pumps with newer models.

Figure 4: Alternative 2 Pump vs. System Head Curves



4.1.3 Alternative 3: Four That Squeeze

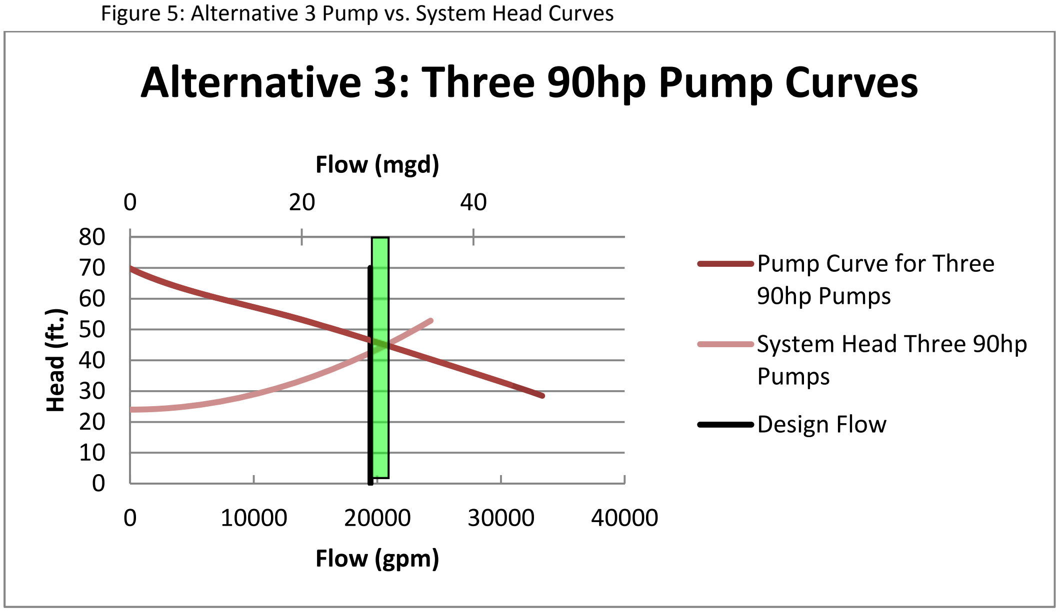


As a slightly different approach to Alternative 4, it was decided that a possibly more efficient pump might be found if a larger size pump than the existing pumps were selected. While the installation of such a system might be more costly, a more efficient pump could save on energy costs and thus be less expensive in the long term.

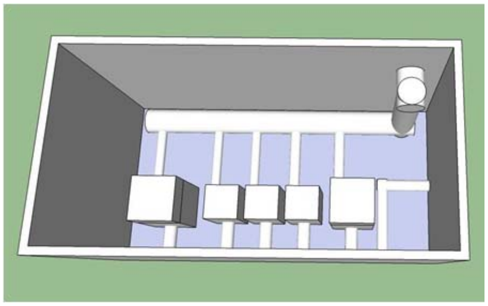
A 90 hp pump (705 rpm) was selected, however, instead of using the previously used fittings, the pumps would have an entrance of 20 in. and a discharge of 16 in. This would require that the entrance to the wet well be increased and many of the fittings replaced. It was also determined that if the inlet were increased in size, minor losses could be reduced and the system could be made more efficient. The difference in pump size was a benefit as well because the increased size of fittings would eliminate the need for the reducers currently in place.

The model for Alternative 3 showed a small increase from the previous alternatives and resulted in 30.25 mgd (21006 gpm). Although the capacity was reached, Alternative 3 is considered to be an inadequate solution since it would cost so much more to install than Alternative 2 while still using the same amount of power.

Figure 5: Alternative 3 Pump vs. System Head Curves



4.1.4 Alternative 4: Five Pump System

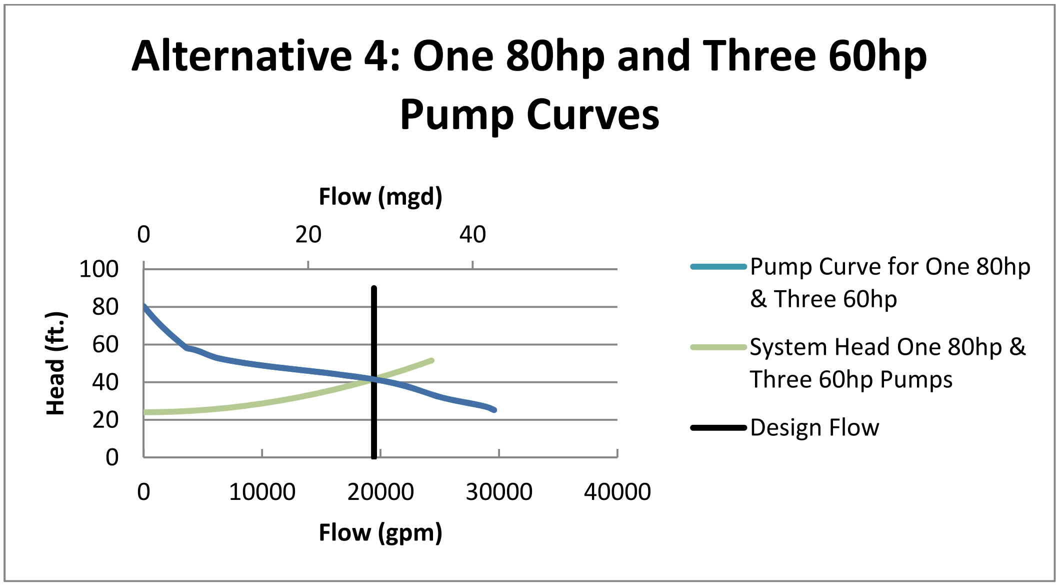


In Alternative 4, the staircase would be removed to allow a greater useable space for the pumps. In reviewing this possibility, it was noted that enough space might be left that a fifth pump could be added. In nearly every alternative, four pumps were able to handle the design flows and it was only after one was left as a standby that they became unable to meet the capacity required by the design. By adding a fifth pump, all four pumps could be used and greater capacity more easily achieved.

Although the smallest replacement, a 85 hp pump (880 rpm) was selected to replace the existing 50 hp and one of the 60 hp pumps. It would use the same fittings and only increase the footprint by about 4 in. on each side although it would only be 2-3 ft. taller than the existing 60 hp pumps. The benefit to this would be that all the pumps could be left when they are currently in use and their same fittings used without the need for replacement. Also, the manifold would not need replacement as it could simply be expanded and a single hole punched into the wet well to serve as an inlet to the pump.

This model proved to be very successful in all regards. The three 60 hp pumps and single 85 hp pump could produce 28 mgd (19444 gpm). This alternative would create the needed capacity of the plant as well as requiring less construction to be done. One disadvantage to this alternative is that the existing pumps are already so worn that they may not be capable of continuing for long at the current demands being placed on them. It is recommended that Alternative 4 be implemented in order to increase plant capacity in NP-PS1 in spite of the fact that the pumps may need to be replaced.

Figure 6: Alternative 4 Pump vs. System Head Curves

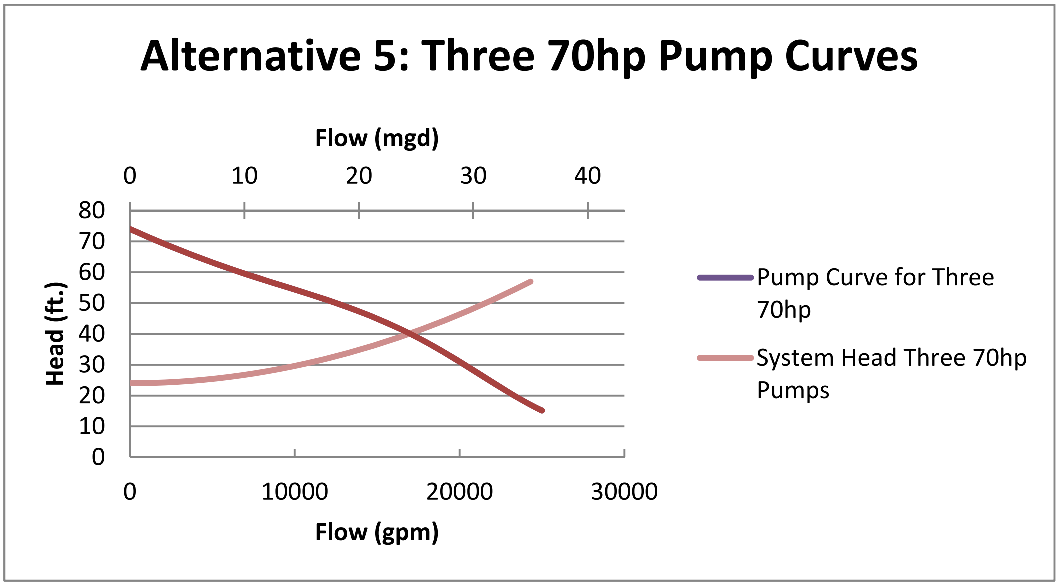


4.1.5 Alternative 5: Four That Fit (70 hp)

The idea behind Alternative 5 is very similar to that of Alternative 2. However, it was decided that to reach the design point might be asking too much. Therefore, in this alternative, a 70 hp pump (880 rpm) was selected that could use nearly the same fittings and location as the existing pumps. The inlet for the pumps would be increased to 16 inches while the discharge would remain at 14 inches. This would allow for the elimination of the reducer before the pump.

This model proved to be fairly successful in all regards. The three 70 hp pumps could produce 24.75 mgd (17187 gpm). This alternative would create much of the needed capacity of the plant as well as requiring less construction to be done.

Figure 7: Alternative 5 Pump vs. System Head Curves

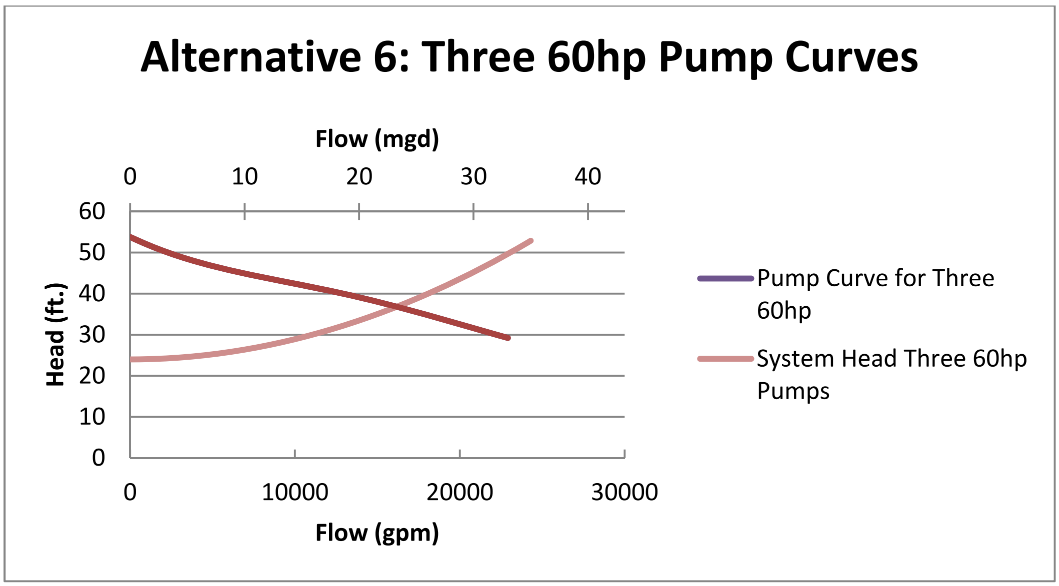


4.1.6 Alternative 6: Four That Squeeze (60 hp)

Again, the idea of Alternative 6 is similar to that of Alternative 3, but using a smaller pump and determining how close that would come to the design point. A 60 hp pump (590 rpm) was selected to replace the existing pumps. This pump has a 20 inch inlet and a 16 inch outlet which would require that a new opening be made into the wet well, but would help to lower the amount of head lost to minor losses. Not only would new fittings be required, but also a new gate valve would be required before the pump as well.

This model proved to be fairly successful in all regards. The three 60 hp pumps and single replacement 60 hp pump could produce 23. 5 mgd (16319 gpm).

Figure 8: Alternative 6 Pump vs. System Head Curves



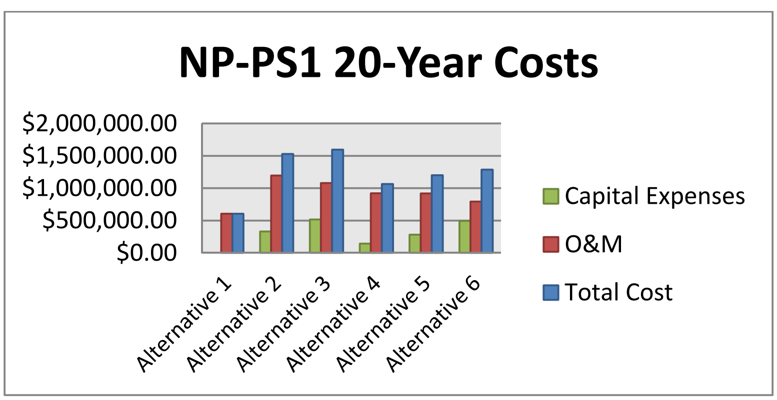
4.1.7 Summary of NP-PS1 Alternatives

NP-PS1 was unable to reach its needed capacity. Due to this deficiency, several alternatives were reviewed and compared. Below is a table of the various alternatives reviewed and what capacities they can achieve. In comparing these values, Alternative 4 proves to be the most adequate for the needs of SDSD.

Since all alternative pumps are submersible, a budgetary quote was taken for a similar pump to that of Alternative 2. This pump would be require 150 hp motor and would cost nearly $150,000 for each set of pumps and motors. While this price could probably be negotiated, the motor would be larger and would require a larger energy cost.

Table 4.2: Pump Station 1 Alternatives Summary

Summary of NP-PS1 Alternatives				
	Capacity without Standby Pump (mgd/gpm)	Capacity using Standby Pump (mgd/gpm)	Work Required	Total 20-Year Cost
Alternative 1: Existing System	20.25 / 14100	26 / 18100	None	$606,394.99
Alternative 2: Four That Fit (140 hp)	30.75 / 21400	40 / 27800	Replacement of existing pumps and removal of some fittings	$1,528,330.51
Alternative 3: Four That Squeeze (90 hp)	30.25 / 21000	36 / 25000	Replacement of existing pumps, change of fittings, replacement of upstream valves, and new inlets	$1,594,953.42
Alternative 4: Five Pump System (85 hp)	28 / 19400	33/ 22900	Expand the manifold, add another pump and its required fittings and valves, and create additional inlet	$1,064,506.53
Alternative 5: Four That Fit (70 hp)	24.75 / 17200	32 / 22200	Replacement of existing pumps and removal of some fittings	$1,200,583.67
Alternative 6: Four That Squeeze (60 hp)	23.5 / 16300	28 / 19400	Replacement of existing pumps, change of fittings, replacement of upstream valves, and new inlets	$1,287,672.14



4.2 NP-PS2 Alternatives

Similar to NP-PS1, it was important that the amount of recirculated flow be increased from the observed amount to provide a greater safety factor. Because of this, the total recirculated rate was raised to 4 mgd (2777.8 gpm) while the trickling filter recirculation was left at 3.5 mgd (2430.6 gpm). This increase in recirculated flow brought the total design flow at NP-PS2 to 31.5 mgd (21875 gpm).

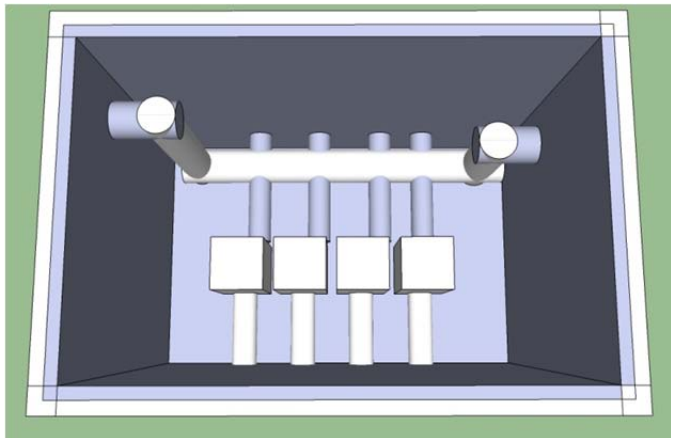
Another special consideration that was taken into account was the amount of space available in the current NP-PS2 building. Inside, all the pumps are located close together and would create some difficulty should they need to be moved or replaced. However, unlike NP-PS1, the manifold cannot be adjusted to allow for more space between the pumps. It is assumed that some adjustments can be made through the use of eccentric fittings.

To account for the possible need for an increased capacity, five alternatives were considered with regard to the hydraulic capacity of NP-PS2:

- Leaving the system as it is currently designed
- Four That Fit
- Four That Squeeze
- Three Large Pumps
- Four That Fit (70 hp)
- Four That Squeeze (60 hp)

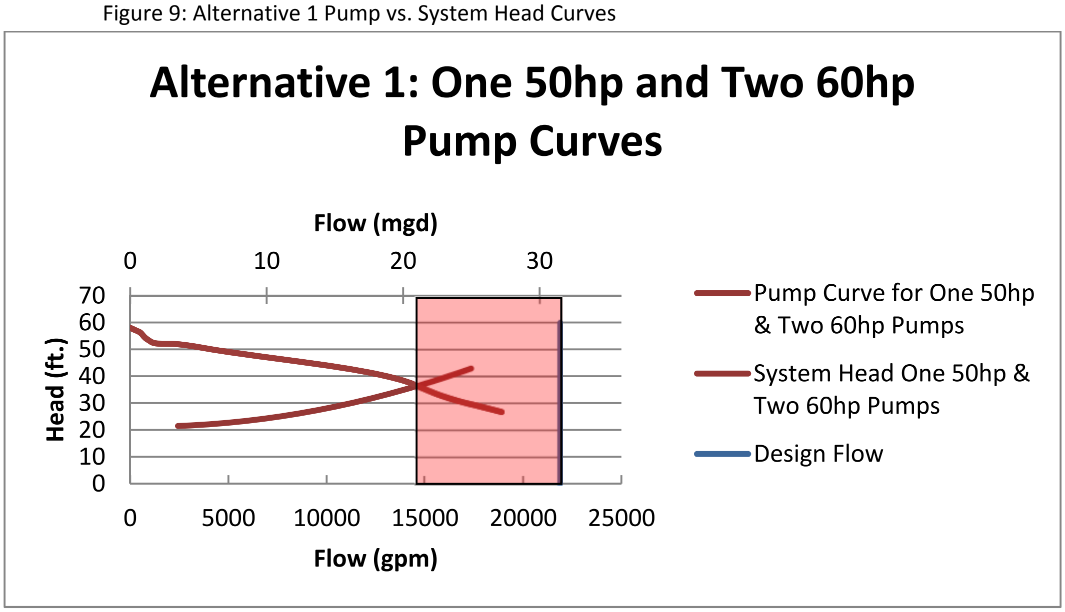
4.2.1 Alternative 1: Existing System:

After modeling the existing system, the capacity was determined to be only 21 mgd (14756.9 gpm) when a single pump is left as a standby. This a little better than was seen at NP-PS1, but the desired amount of flow to be pumped is 31.5 mgd (21875 gpm). This means that the pump station can pump less than 70% of the desired capacity. Because it is so far insufficient, leaving the existing system is considered to be an inadequate alternative.



Due to the possible error in the model used to determine the current capacity of NP-PS2, one possible solution would be to allow the system to continue as it is currently designed even though the design is far below the desired capacity. This method would cost nothing to execute and a more accurate study could be performed at a later date when the current capacity is reached.

Figure 9: Alternative 1 Pump vs. System Head Curves

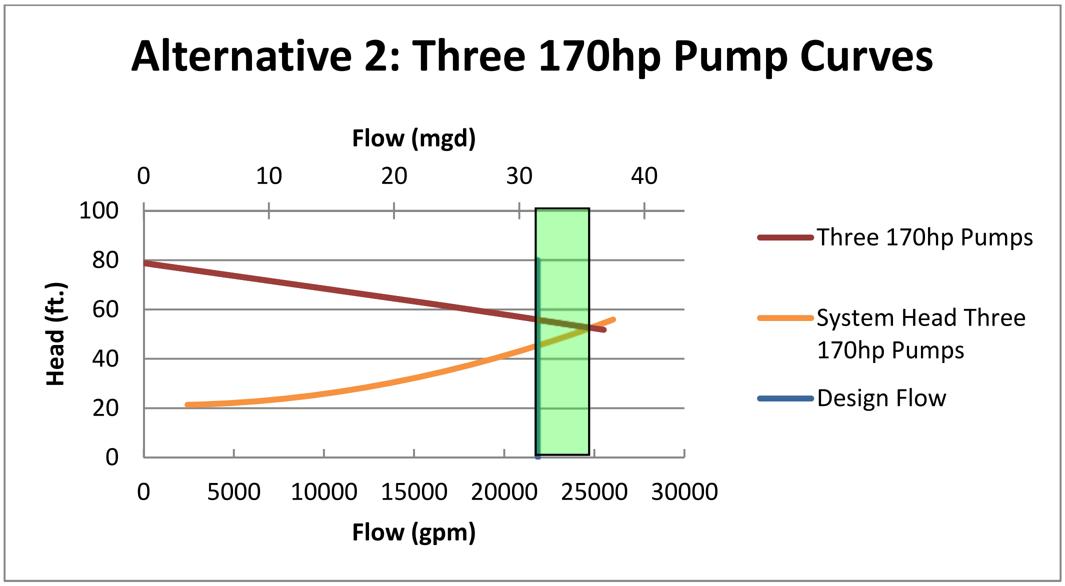


4.2.2 Alternative 2: Four That Squeeze

Although the space available for a replacement pump does not exist in NP-PS2, it was considered possible that by using specialized fittings and making other small adjustments, a larger pump could possibly replace the existing pumps.

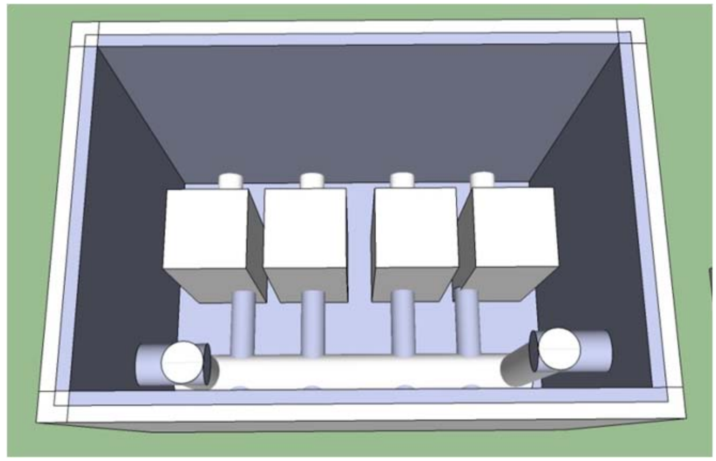
In this alternative, a 170 hp pump (1185 rpm) was selected that would require a large upgrade to the existing fittings and manifold. The existing pumps have a 14 inch inlet and 14 inch discharge while the new 170 hp pumps would be 24 inches in and 20 inches out. Because of the larger inlet size, it was hoped that some of the minor losses might be decreased to the point that a greater efficiency might be achieved. The capacity of the three pumps was capable of reaching 36 mgd (25000 gpm).

Figure 10: Alternative 2 Pump vs. System Head Curves



Alternative 2 is considered inadequate because it achieves desired flows but requires a lot in the way of construction since the same locations and fittings cannot be used.

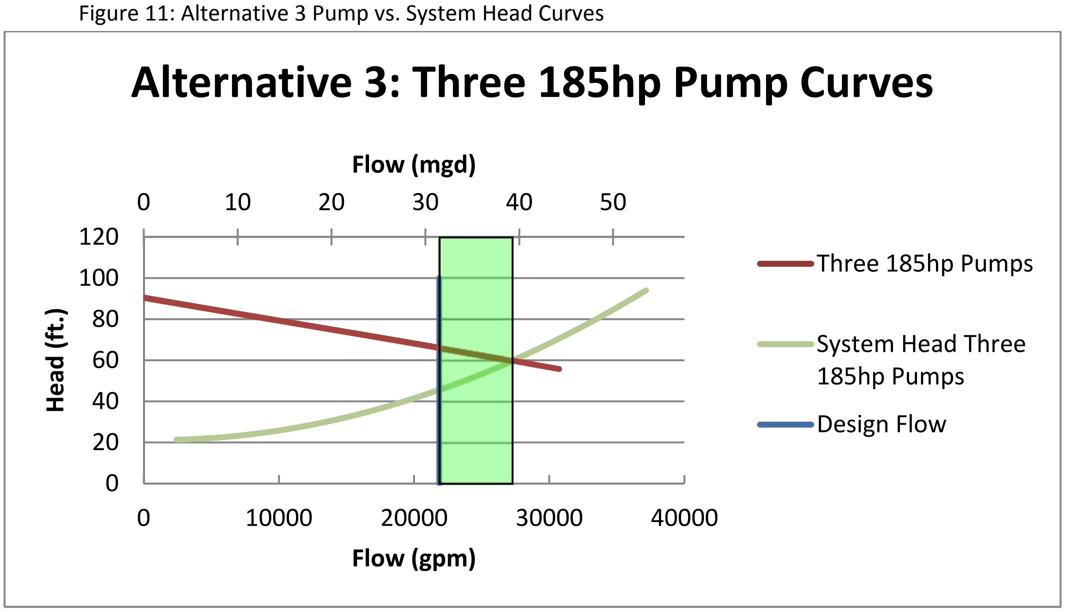
4.2.3 Alternative 3: Four That Squeeze



While space is still lacking in NP-PS2, it was decided that a similar setup could exist as that used in Alternative 2, where specialized fittings might be used to allow for the spacing along the length of the manifold. A 185 hp pump (710 rpm) was selected that would require a larger set of fittings since it has a 24 inch inlet and a 20 inch discharge. No reducer would be needed upstream of the pumps. The downstream reducer would thus be the only fitting that could be used to place the pumps where they might fit.

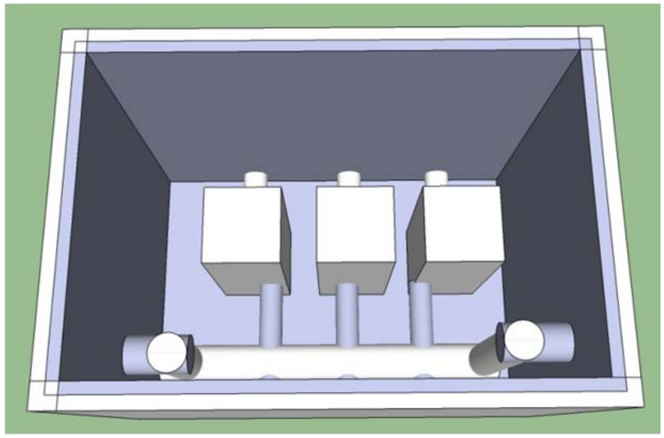
With the four larger pumps, the capacity was attained but, because of the size of the pump, was also far surpassed. It was found that 39.75 mgd (27604 gpm) could be reached even while one pump acted as a standby.

Figure 11: Alternative 3 Pump vs. System Head Curves



Alternative 3 is considered to be inadequate in spite of having reached the needed capacity. This was because the capacity was far surpassed even though it was unnecessary.

4.2.4 Alternative 4: Three Large Pumps

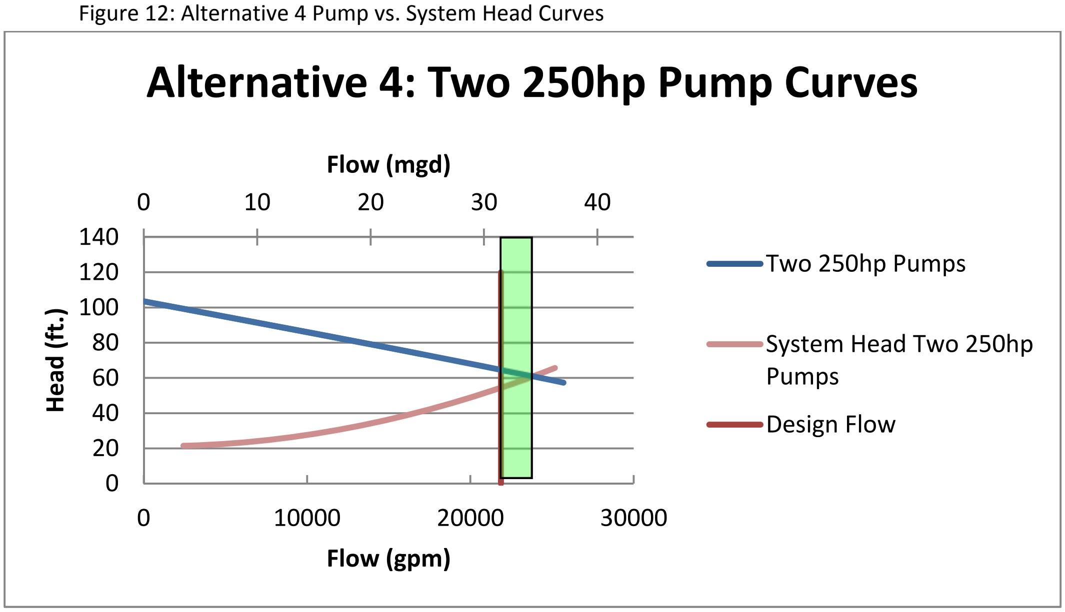


In reviewing the NP-PS2 building, it was determined that since space was so limited, it might be beneficial to replace the existing pumps with three much larger pumps. This would allow for more space between them, but with a pump acting as standby, it would also require a very large increase in size of the pumps.

A 250 hp pump (885 rpm) was selected to achieve the desired flows. Again, the inlet to the pump is 24 in. and the outlet is 20 in. which is larger than the existing pumps. However, the inlet from the wet well is currently 20 in. and it is assumed that the same holes could be used to provide water to the larger pumps. The outlet would require the same number of fittings due to the fact that the discharge would still need to be reduced to the existing 18 in. valves.

If the abovementioned changes were implemented, it was found that 34.5 mgd (23958 gpm) could be pumped from just two 250 hp pumps. This value is well over the needed capacity therefore Alternative 4 is suitable for the needs of SDSD. However, because of the large amount of installation that would be needed and the large power requirement of the pumps, it is probable that this alternative could prove to be the most costly in the long run even when using the existing variable frequency drive.

Figure 12: Alternative 4 Pump vs. System Head Curves

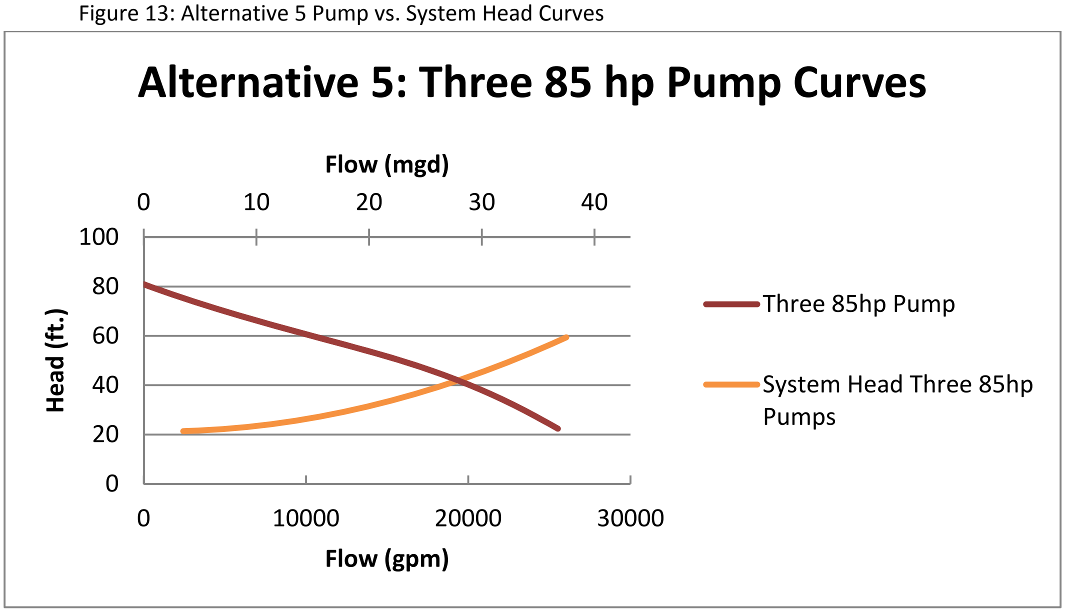


4.2.5 Alternative 5: Four That Fit (85 hp)

One concern that arose during the analysis was that the alternatives would be too expensive. To compensate for this, it was determined that some of the alternatives should include smaller pumps that were not expected to achieve the design flows. While all the previous alternatives were able to meet the design criteria, it was decided that smaller pumps could be used to increase capacity even if it is not the design capacity. A 85 hp pump (880 rpm) was selected to raise the flow capacity. The inlet of the pump is 16 inches and the outlet is 14 inches which allows the pumps to replace the existing pumps without any changes to the valves or manifold.

If the abovementioned changes were implemented, it was found that 27.75 mgd (19270 gpm) could be pumped with three 85 hp pumps. While the design capacity is not met by this alternative, the increase in capacity may be considered adequate for the needs of SDSD.

Figure 13: Alternative 5 Pump vs. System Head Curves

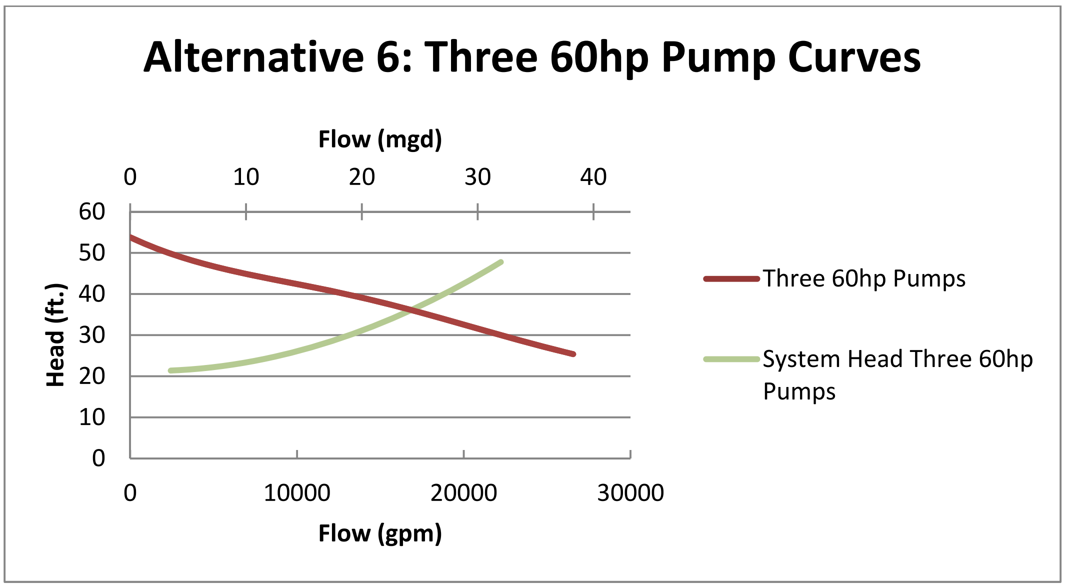


4.2.6 Alternative 6: Four That Squeeze (60 hp)

While most of the previous alternatives were able to meet the design criteria, it was decided that smaller pumps could be used to increase capacity even if it is not the design capacity. A 60 hp pump (590 rpm) was selected to raise the flow capacity. The inlet of the pump is 20 inches and the outlet is 16 inches which requires that not only the pumps be replaced, but new inlets be made into the wet well, the upstream valves be replaced and many of the fittings be changed as well.

If the abovementioned changes were implemented, it was found that 24 mgd (16667 gpm) could be pumped with three 60 hp pumps. While the design capacity is not met by this alternative, the increase in capacity may be considered adequate for the needs of SDSD.

Figure 14: Alternative 6 Pump vs. System Head Curves



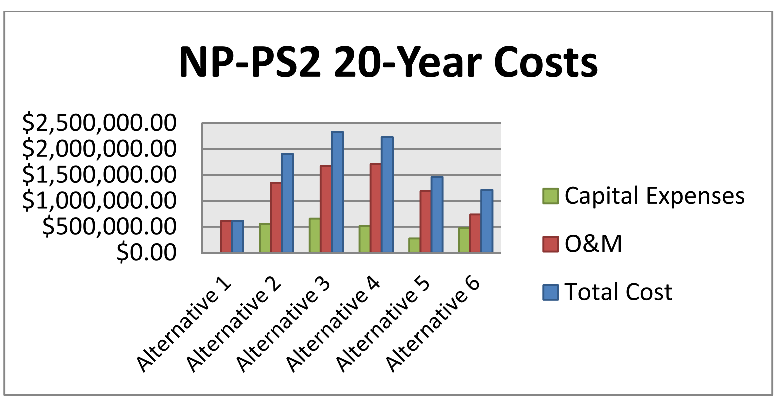
4.3 Summary of NP-PS2 Alternatives

Similar to NP-PS1, NP-PS2 was unable to reach its needed capacity. Due to this deficiency, six alternatives were reviewed and compared. Below is a table of the various alternatives reviewed and what capacities they can each achieve. In comparing these values, Alternative 5 proves to be the most adequate to the needs of SDSD. Likewise, it proves to be the least costly as well.

Since all alternative pumps are submersible, a budgetary quote was taken for a similar pump to that of Alternative 2. However, this pump would be able to fit into the existing pump locations. This pump would be require 150 hp motor and would cost nearly $150,000 for each set of pumps and motors. This would be a much cheaper alternative than trying to put in larger pumps.

Table 4.3: Pump Station 2 Alternatives Summary

Summary of NP-PS2 Alternatives				
	Capacity without Standby Pump (mgd/gpm)	Capacity using Standby Pump (mgd/gpm)	Work Required	Cost
Alternative 1: Existing System	21 / 14600	26 / 18100	None	$612,521.72
Alternative 2: Four That Fit (170 hp)	36 / 25000	44 / 30600	Replacement of existing pumps and replacement of some fittings	$1,905,163.12
Alternative 3: Four That Squeeze (185 hp)	39.75 / 27600	46 / 31900	Replacement of existing pumps and removal of some fittings	$2,330,617.61
Alternative 4: Three Large Pumps (250 hp)	34.5 / 24000	43.5 / 30200	Expand the manifold, add another pump and its required fittings and valves, and create additional inlet	$2,229,487.17
Alternative 5: Four That Fit (85 hp)	27.75 / 19300	36 / 25000	Replacement of existing pumps and replacement of some fittings	$1,464,436.51
Alternative 6: Four That Squeeze (60 hp)	24 / 16700	29 / 20100	Replacement of existing pumps and removal of some fittings	$1,214,667.34



5.0 Additional Recommendations

5.1 VFD

The existing VFD's that are used to slow the speed of a pump in order to handle lower flows are currently capable of operating a single pump. Because of this, as the water level fluctuates between needing more than one pump or less than one, a single pump will be activated and shut off continuously as the water level changes. The reason for this is explained in Pumping Station Design (Sanks, 1989) which states that, "The minimum discharge should be at least 30% of the maximum [bep]." It also mentions that many manufacturers even list their minimum values to be much higher percentage. As a result, if flows are slightly beyond the capacity of a single pump, another must activate to handle the flows. Because the second pump cannot run at lower than 30% of its maximum capacity, it will draw down the wet well. Due to the small size of the existing wet wells, this happens very quickly and the second pump will see cyclic activation until flows either increase or decrease to a more stable level.

To avoid these problems, a second VFD could be operated so that, as the second pump activates, they would both reduce their output so that they each operate at 50% of the flow and then ramp up together. This allows for the cyclic activation to be eliminated even though the VFD's may cause the pumps to operate a lower efficiency. Although energy costs might increase slightly, the life of the pumps should increase as well. Even more preferable would be to have a VFD for each pump. Then as flows increase, any active pumps will be discharging at the same flows. It is recommended that additional VFD's be considered in the event of any upgrades.

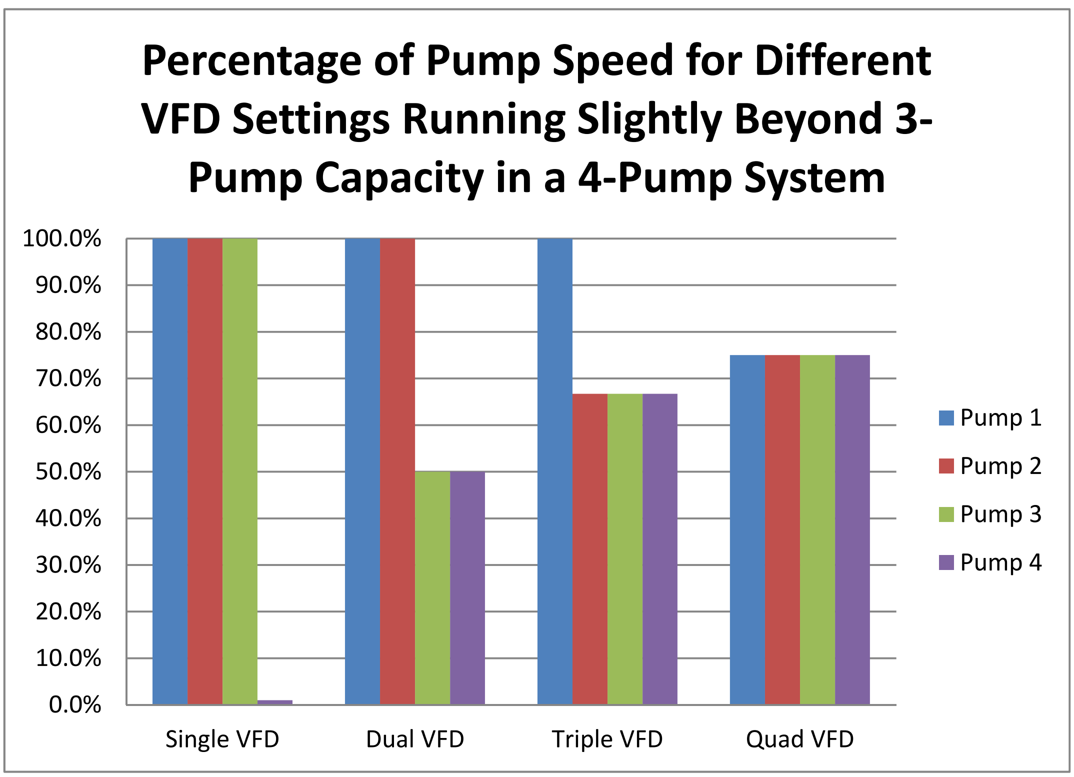


Table 5.1: Rough Estimated Costs of VFD Units

Estimated VFD Costs				
	Full Load Current (A)	**Amp Rating** (A)	**Unit Cost**	**Total Cost**
Alternative 2: Four That Fit (140 hp)	179	202	$14,600.00	**$43,800.00**
Alternative 3: Four That Squeeze (90 hp)	129	138	$10,600.00	**$31,800.00**
Alternative 4: Five Pump System (85 hp)	93	104	$23,150.00	**$69,450.00**
Alternative 5: Four That Fit (70 hp)	93	104	$7,800.00	**$31,200.00**
Alternative 6: Four That Squeeze (60 hp)	103	104	$7,800.00	**$23,400.00**
Alternative 2: Four That Fit (170 hp)	231	236	$14,600.00	**$43,800.00**
Alternative 3: Four That Squeeze (185 hp)	253	290	$10,600.00	**$31,800.00**
Alternative 4: Three Large Pumps (250 hp)	355	390	$23,150.00	**$69,450.00**
Alternative 5: Four That Fit (70 hp)	112	138	$7,800.00	**$31,200.00**
Alternative 6: Four That Squeeze (60 hp)	112	138	$7,800.00	**$23,400.00**

5.2 In-Plant Hydraulic Capacity

Although the hydraulic capacity of the pump stations could be increased, it may not be the controlling factor in the plant. Operators have stated that, under a stress test of 18 mgd (22500 gpm) that was maintained for a little over two hours, the plant began to fail at every section. The grit chambers begin to overflow, the trickling filters cannot discharge quickly enough and all the distribution boxes begin to spill water. At this point, no treatment is being done except to "remove the rags".

Because of this handicap of 18 mgd, the pumps can never truly reach their maximum capacity because so many other things will fail first. Before any upgrades can be implemented, these problems should be analyzed thoroughly so that the upgraded capacity is not simply wasted.

5.3 Tail-End Discharge

While the hydraulic capacity of the pump stations is important, its importance is situational. It has been observed that if the water levels in the discharge channel are high at the same time high flows are being discharged, the water will back up into the contact basin causing it to flood and operate under submerged conditions. Under the abovementioned conditions, it has also been observed that the final clarifiers will flood and operate under submerged conditions.

The current head at the contact basins is maintained at an elevation of about 4209 ft. and then travels down to the discharge canal by way of a submerged pipe. However, the high river flow for the state canal is actually about 4213 ft. As the flows rise, it is very easy for the water to begin backing up and flooding the plant facilities. The water leaves the contact basin by way of a 42 in. pipe and travels nearly 1500 ft. before being discharged into the state canal. By placing these values into the energy equation used to solve for the system curves and using the Hazen-Williams equation to solve for the friction, the required upstream elevation in order to continue discharging the needed 24 mgd of flow was found to be about 4217 ft. To achieve this would require raising the contact basin and final clarifiers as well as their respective distribution boxes by about 8 feet!

Because 8 ft. was determined to be unreasonable, it was decided that, instead of using the high water surface elevation, the elevation of the road out to the discharge pipe could be used as a more reasonable high water elevation. Through the use of GPS surveying equipment, this elevation was found to be about 4208.5 ft. which would require that the contact basin walls be located at an elevation of about 4213 ft. It was also found that the maximum elevation of the walls in the existing contact basin was about 4211 ft. even though a lower water surface elevation is maintained. This would mean that the walls would only need to be raised 2 ft. to allow for the higher flows to continue discharging even when the canal has flooded its banks.

As the head would be raised at the final clarifiers, NP-PS2 would be required to pump to a higher head as well. It was found that when the head was raised by 2 ft. under the Alternative 5 conditions, that the capacity would decrease from 31.5 mgd (21875 gpm) to 30.5 mgd (20833.3 gpm). While short of the required design flows, it is possible that the increase in the tail-end capacity would be more effective than pumping higher flows while the tail-end of the plant is backed up.

It is recommended that the walls of the contact basins, final clarifiers, and all their distribution boxes be raised by at least 2 ft. in order to produce the necessary head to discharge at higher flows. It must be noted that, with such an upgrade, the required head at NP-PS2 will increase and the amount of water that can be discharged from the pumps will be reduced. As a result, if an upgrade is considered on the tail end of the plant, the second pump station will also require review.

5.4 Grit Chamber Distribution

It has also been stated by the operators that they are unable to even operate at the current capacity of NP-PS1 because of the distribution system used at the grit chambers. After flowing from NP-PS1, flows are divided down two channels where they enter two separate grit chambers. The dividing mechanism used is a concrete wall at the end of a tee. Flows slam into the head of the tee before being able to travel laterally. Operators have said that if they run the system near capacity, the influent begins to “shoot” out the top of this open-air splitter. Because of this, some other sort of distribution system may need to be considered along with any upgrades in NP-PS1 since the increased capacity will not be a benefit until this problem in distribution is fixed. At a minimum, it may be necessary to lay sheet metal or some wood sheeting on top of the grating so that access is not limited, but water can be maintained inside the distribution box.

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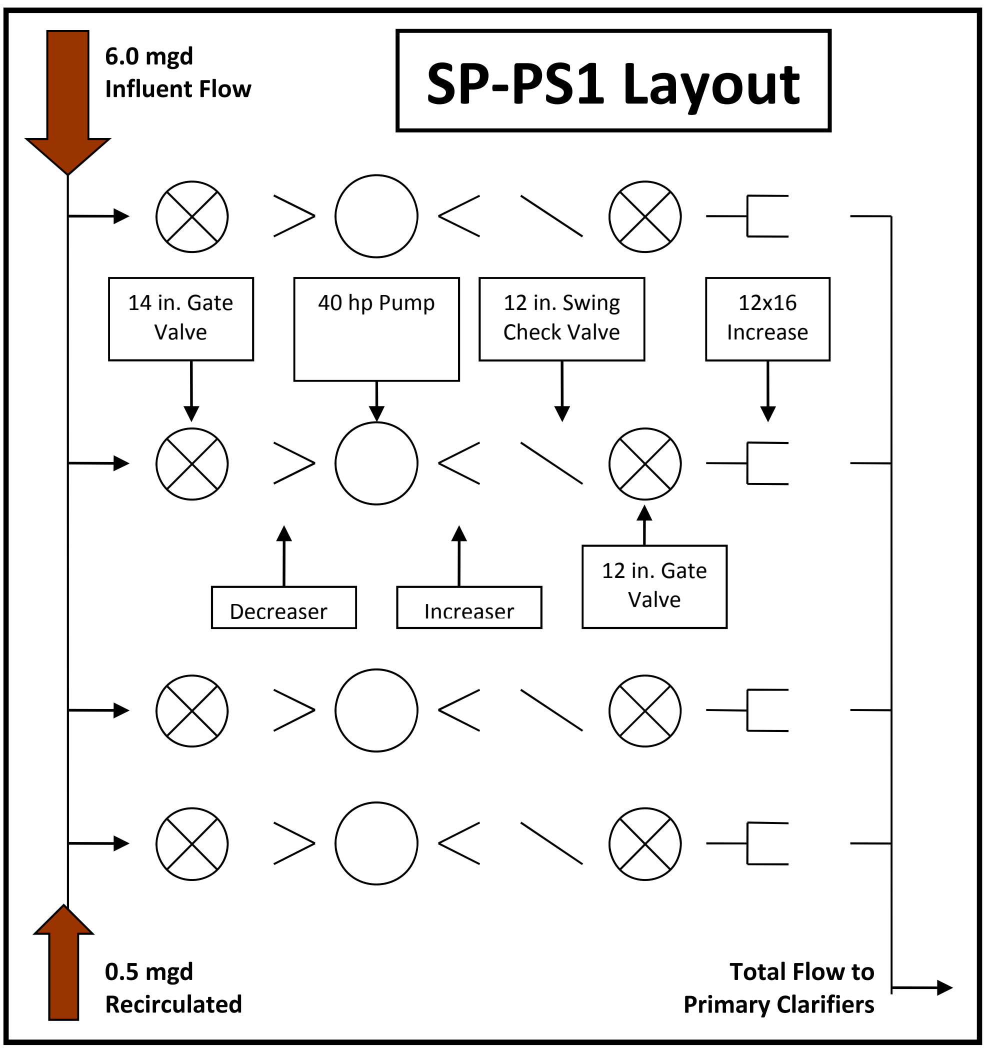
2.0 System Description

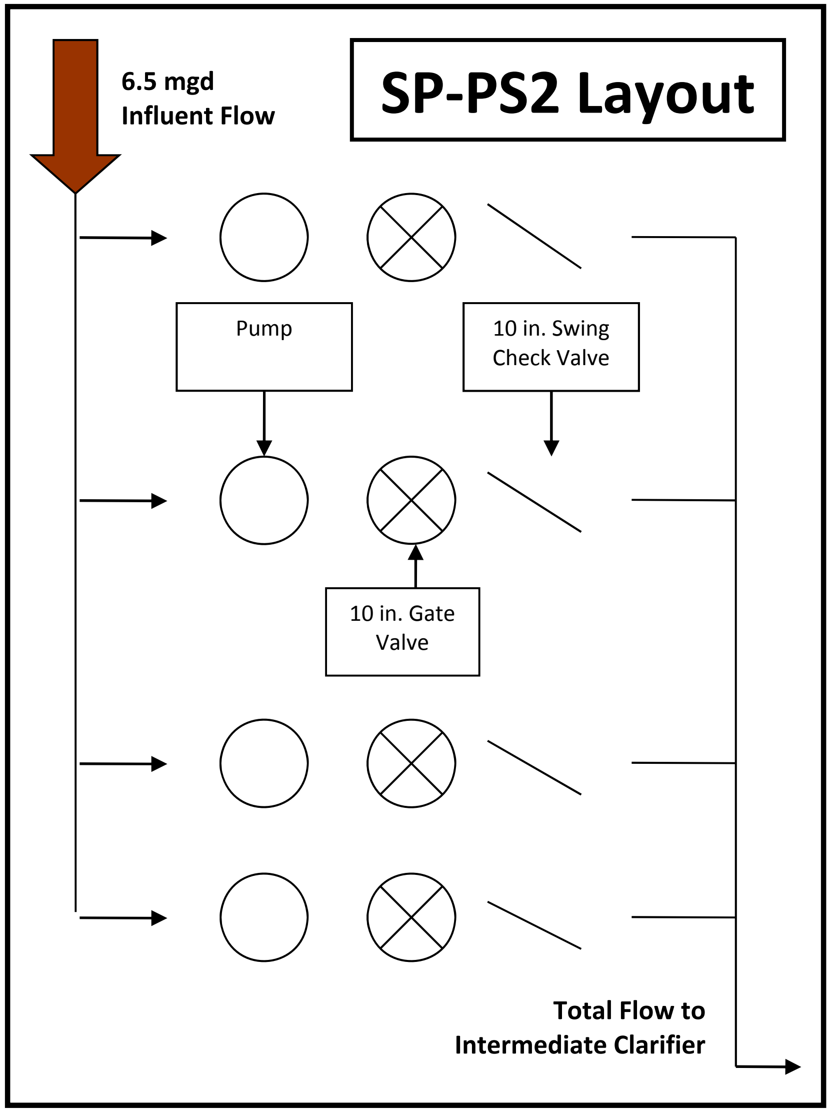
2.1 Primary Pump Station Layout

Wastewater enters SP-PS1 by way of a Parshall flume before entering the wet well. The flow then passes through one of four rounded 14 in. pipes, before being reduced to the correct pump size, and enters one of four pumps. All four pumps are identical 40 hp pumps. A variable speed drive is set up so that any one of the pumps can be operated by it. Following the pumps, the pipe is then expanded to 12 in. in order to accommodate the existing valves and then expanded again in order to connect to the 16 in. manifold. Finally, the 16 in. pipe travels roughly 90 ft. and rises nearly 37 ft. before entering the clarifiers.

Design peak flows in SP-PS1 were reported to be 6.0 mgd although an additional 0.5 mgd (347.2 gpm) comes from recirculated flows that are otherwise unaccounted for. This brings the total amount that must be pumped to about 6.5 mgd.



2.2 Intermediate Pump Station Layout



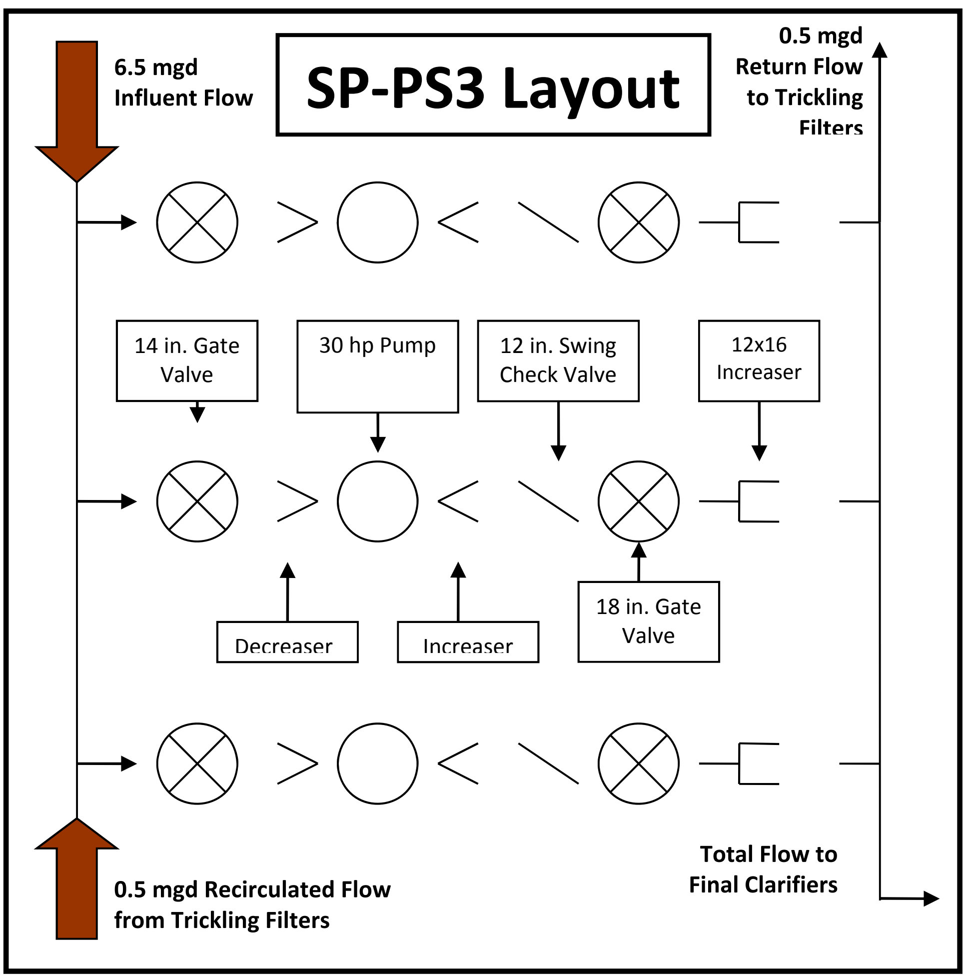
Unlike what exists in the North Plant, SP-PS1 and SP-PS2 are vastly different in their setup. SP-PS2 is an intermediate station and lifts flows up to the intermediate clarifiers and trickling filter. Because the clarifiers are located immediately downstream of SP-PS2, there is little chance at any backflow which results in a much smaller number of fittings. Flows enter SP-PS2 through one of four bell-mouthed 6 in. pipes and are then piped directly up to the pumps above. Since the pumps are not at water level, no isolation valves are needed on the upstream side of the valve. Here, four identical pumps are used. Again, a VFD allows any one of the pumps to operate at lower speeds. After the pumps, flows discharge directly into a wet well that feeds into the intermediate clarifier. Friction is negligible as a result and only the few fittings that exist provide any losses.

As in SP-PS1, the design peak flow in SP-PS2 remains at 6.5 mgd with the additional recirculated flows from the system.

2.3 Secondary Pump Station Layout

After passing through the intermediate trickling filter, flows are then routed back to the main pump station building where the secondary pumps are maintained. The secondary pumps are fed from a wet well through 14 in. inlets which are then reduced down to the size of the pumps. Three identical 30 hp pumps are used with a variable speed drive to allow for the lower flows to be met. Following the pumps, the pipe is then expanded to 12 in. to accommodate the valves and fittings and then expanded to a 16 in. manifold. Farther down the pipe, it expands again into an 18 in. pipeline. Flows travel about 30 ft. and are lifted about 15 ft. before reaching the distribution box for the final clarifiers.

The design peak flow in SP-PS3 remains at 6.5 mgd with the additional recirculated flows from the system. However, an additional 0.5 mgd is also recirculated from the trickling filters leaving the total pumped amount at 7.0 mgd.



2.3 Summary of South Plant General Design

The table below divides the design of the plant into two sections, the actual design and the observed data. In comparing these two sets of data, it is possible to see whether the observed flows are reaching the amounts that were designed for.

Table 2.2: South Plant Design and Observed Data

South Plant Design Data			
Design Parameters	**South Plant General**		
Avg. Daily Flow (mgd/gpm)	4 / 2800		
Peak Hour Flow (mgd/gpm)	6 / 4200		
Inplant Return Flow (mgd/gpm)	3 / 2100		
	SP-PS1	**SP-PS2**	**SP-PS3**
#40 hp Pumps/gpm	4 / 2000	NA	NA
# Pumps/gpm	NA	4 / 1500	NA
#30 hp Pumps/gpm	NA	NA	3 / 2500
Combined Pumping Capacity (mgd/gpm)	11.5 / 8000	8.6 / 6000	10.8 / 7500

South Plant Observed Data				
Item	**SP Data 2007**	**SP Data 2008**	**SP Data 2009**	Description (M&E, pg 179)
Avg. Dry Weather Flow (influent mgd/gpm) (effluent mgd/gpm) (Oct. – Mar.)	3.37 / 2340 2.85 / 1980	2.74 / 1900 2.50 / 1740	2.44 / 1720 2.37 / 1650	The average of the daily flows sustained during dry-weather periods with limited infiltration
Avg. Wet Weather Flow (influent mgd/gpm) (effluent mgd/gpm) (Apr. – Sept.)	3.80 / 2640 3.20 / 2220	3.40 / 2360 3.10 / 2150	2.90 / 2010 3.00 / 2080	The average of the daily flows sustained during wet-weather periods when infiltration is a factor
Peak Hour (mgd/gpm)	10.10 / 7010	10.0 / 6940	7.30 / 5070	The average of the peak flows sustained for a period of 1 hour in the record examined (usually based on 10-min increments)

3.0 Existing System Analysis

In order to complete an analysis of the existing system and to verify the current capacity that may be handled, a spreadsheet model was created by using hydraulic methods and equations outlined in greater detail in Appendix A.

3.1 Data Gathering

Data was collected by using various methods in order to create the most accurate model possible. The original 1960 construction plans were compared against the later 1990 expansion plans to determine materials used as well as accurate hydraulic sizing. Pump curves for the existing pumps from the same time periods were also located and evaluated.

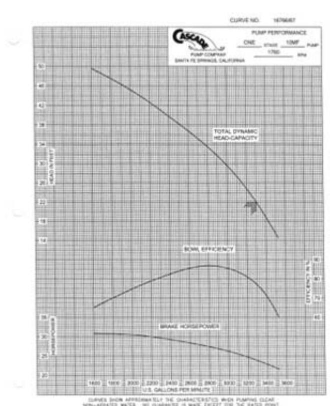
After locating the details of the plant and its design, flow values were taken from recorded data using the existing Parshall flume and totalizer for the plant. These values were then checked against several archived pen charts from 2004 to 2010 to determine the accuracy of the recorded influent values.

No recirculation data is kept at the south plant which means that there is no way to define what the recirculation amounts actually are. Since there was no data to review, recirculation flows were estimated.

Several hydraulic design references, such as <u>Pumping Station Design</u> and <u>Advanced Water Distribution Modeling and Management</u> (Haestad, 2003), were used and various coefficients and common values were taken from them to help maintain accuracy in the calculations

3.2 Pump Curve

Before attempting to model the existing system, it was necessary to recreate the pump curves in order to calculate the curve equation. By finding this equation, values could be found on the curve without the use of interpolation or excessive amounts of manually located points.



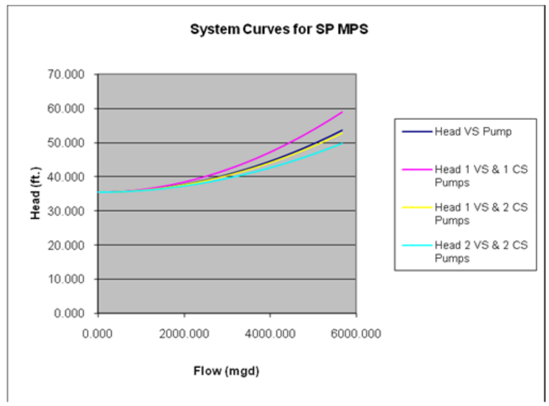
After the curves were put into the spreadsheet and the curves calculated, they were added in various parallel combinations. This simplification allowed for the ability to quickly view the results of running various specific pumps.

3.3 System Curve Modeling

In modeling the system curve, a minor loss equation was used to find the needed head values at a given flow where *h* is the total head produced, *ΔEl* is the distance that the water must rise by the end of the pipe (static head), and the last term accounts for the minor losses that will occur throughout the system (dynamic head):

$$h = \Delta El + \sum k \frac{Q^2}{2gA^2} + h_f$$

This is not to say that the calculated head would be produced at the end of the pipe, but that the pump would produce the calculated head immediately upon discharge. Then, as the flows pass through the various valves and fittings, they would drop until reaching the needed head at the end of the pipe. It is also important to note that as the flows become greater, the amount of head that must be produced will also become greater.



Values for minor losses were taken from the given ranges of Pumping Station Design (Sanks, 1989) and, for lack of better information, conservative values were used. Using the minor loss equation, curves were calculated for each system and show the various heads that would be needed in order to provide the desired flows.

3.3.1 Difficulties Encountered in Comparing the Pump Curve to the System Curve: Because the existing systems use a variable frequency drive, pump curves will change at different speeds. Also, because the intermediate curves were not available, only the maximum speed pump curves were compared to the system curves.

3.3.2 Difficulties Encountered in Modeling the System Curve: Two problems arose when modeling the system curve for which no solid solution was found. The first came up when modeling flows through the manifold after the pumps in each station. The second dealt with simply determining how to divide the flows through each pump.

When modeling the system curve through the manifold, no information on standard practice for designing manifolds was found and no text could be located that provides such information. Without further guidance, it was decided that the manifold could be broken into various tees and elbows. In this way, the flows could be modeled as they passed through each of the intersections instead of using the manifold as a whole. As a result, it was also decided that less conservative values should be used when considering losses through the manifold so that it would not be weighted as heavily while other values were left more conservative.

3.3.1 Difficulties Encountered in Calibrating the System Curve: Several of the data points taken from the totalizer showed that the maximum flows into the plant were up to 10 mgd. The pen charts that were compared to these values are capable of reaching 15mgd, but these high points don't usually follow flow patterns for the day and are most likely due to periods of flushing or cleaning of the system. This theory conforms to the typical routine that is followed for flushing the system. In recreating the system curve, maximum flows were assumed to be no higher than 6 mgd and the model was calibrated based on this information (the model was left alone because it could not reach 10 mgd and would have to be calibrated to do so).

3.3.1 Difficulties Encountered in Initial Design: Another difficulty that came up was a problem in the initial design of the treatment plant. In the plant design, a single head was called out for the pump station regardless of which pump was being used. Because this number does not match the static head, it was determined to be the total head. It is also assumed that this head was for the design flow, but when compared with the model, the values were found to be very different. Also, the design called for the flows at a specific head, but the flow at this head from the pump curves did not match the design flow. Often the design points marked on the pump curves did not match what was called for in design and both have been noted in the table below.

Specifically in the case of SP-PS2, an upgrade was done after the design listed in the plans; however, no record of the updated design was available. The design point, taken from the pump curve, has been listed for the pump curve while the design portion of the plans shall be left as the original 1990 design.

On the pump curve for SP-PS3, no point was listed for design and therefore the table has been left null for the pump curve design. It should be noted however, that at the head mentioned in design, the curve does not extend far enough down to reach the specified head and it appears that the lowest head on the curve was simply used as a "best guess" because it is not considered good practice to extrapolate data beyond the given curve.

Due to the discrepancies in the design values, it was determined that the model should not be calibrated to the design data. The design points were still compared to the curve, but did not provide sufficient reason for adjusting the curve to fit them.

Table 3.3: Design and Model Heads

Heads for SP-PS1 at 11.5 mgd (design capacity)		
	Design/Pump Curve (ft.)	**Modeled (ft.)**
Static Head	35.5/35.5	35.5
Dynamic Head	-0.5/9.5	28.5
Total Head	35/45	64
Heads for SP-PS2 at 8.6 mgd (design capacity)		
	Design/Pump Curve (ft.)	**Modeled (ft.)**
Static Head	11/11	11
Dynamic Head	9/11	13
Total Head	20/22	24
Heads for SP-PS3 at 10.8 mgd (design capacity)		
	Design/Pump Curve (ft.)	**Modeled (ft.)**
Static Head	19/NA	19
Dynamic Head	11/NA	17.4
Total Head	30/NA	36.4

3.4 System Analysis

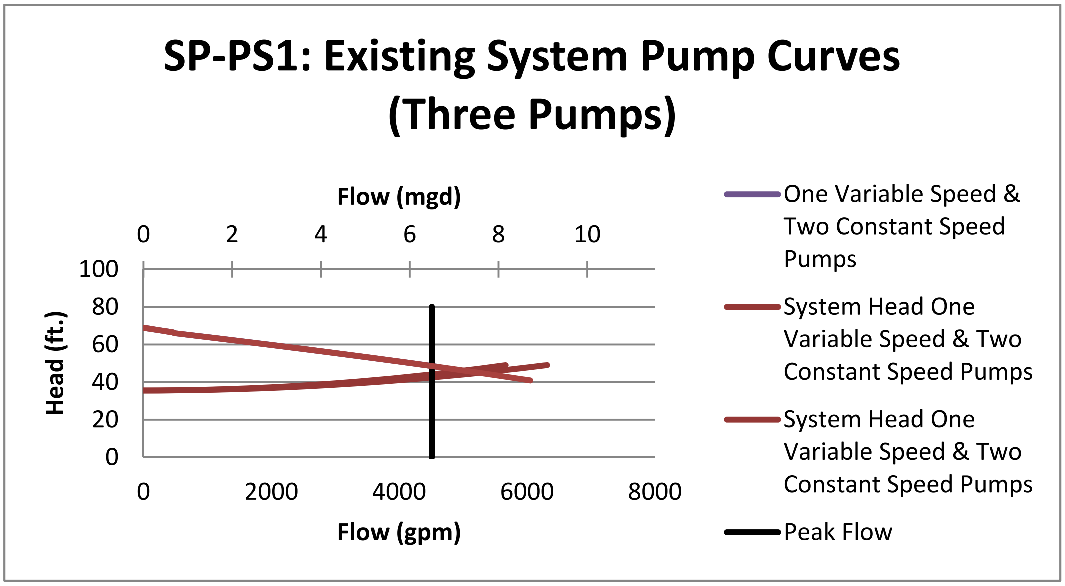
Whereas the pump curves help to detail the amount of head that can be produced at a given flow, the system curve shows the amount of head required for a given flow. Once completed, the system curves were compared against the pump curves to determine the points of intersection. Each pump curve corresponds to a specific system curve and where they intersect shows the amount of flow that will be produced when running the corresponding pumps while still providing the needed head in the line.

It is also important to note that even though four pumps may be available, one of these pumps must be considered a “standby” pump in case any pump should fail. In creating a system design, it is considered that one pump will act as the standby and thus the largest available pump should no longer be considered in the design.

Below are graphs of the pump curves with the calculated system curves. Although the most conservative values were used, a second system curve was drawn using the least conservative values to illustrate the range of values that could be calculated if different values were chosen. In this way, it can be seen whether the conservative assumptions were too strict.

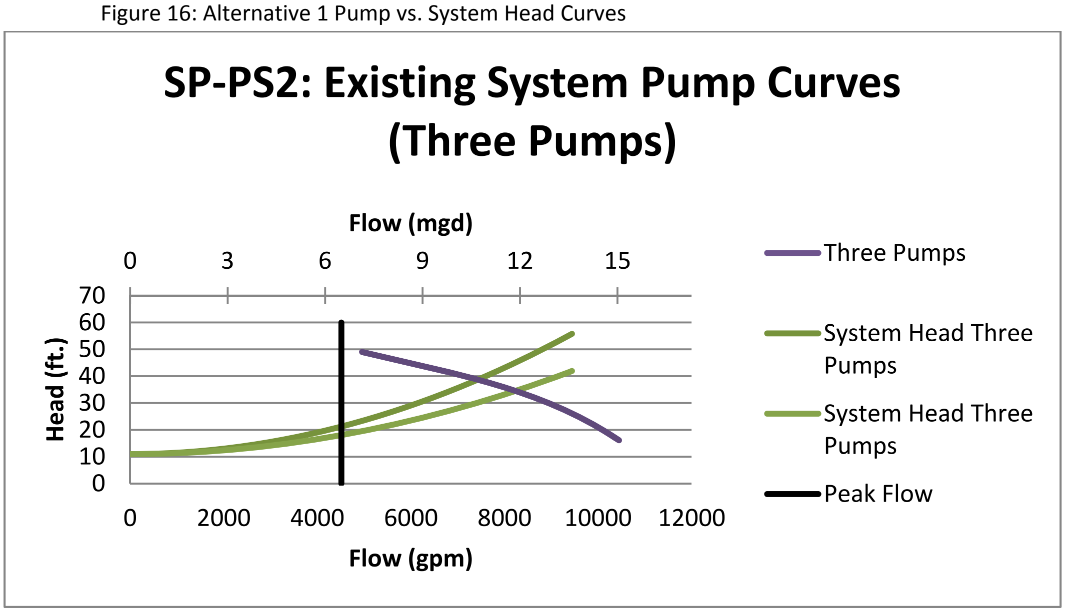
3.4.1 SP-PS1: In comparing the points of crossing, it was determined that the highest amount that could possibly be pumped from SP-PS1 would be between 6.68 and 7.95 mgd (4639 and 5521 gpm) when one pump is left on standby. As was stated previously, the plant was designed for a maximum of 6 mgd (4166.7 gpm) influent, but there should be an additional 0.5 mgd (347.2 gpm) that is constantly being recirculated to aid in the treatment of the influent. This amount is adequate to handle the expected design flows.

Figure 15: Alternative 1 Pump vs. System Head Curves



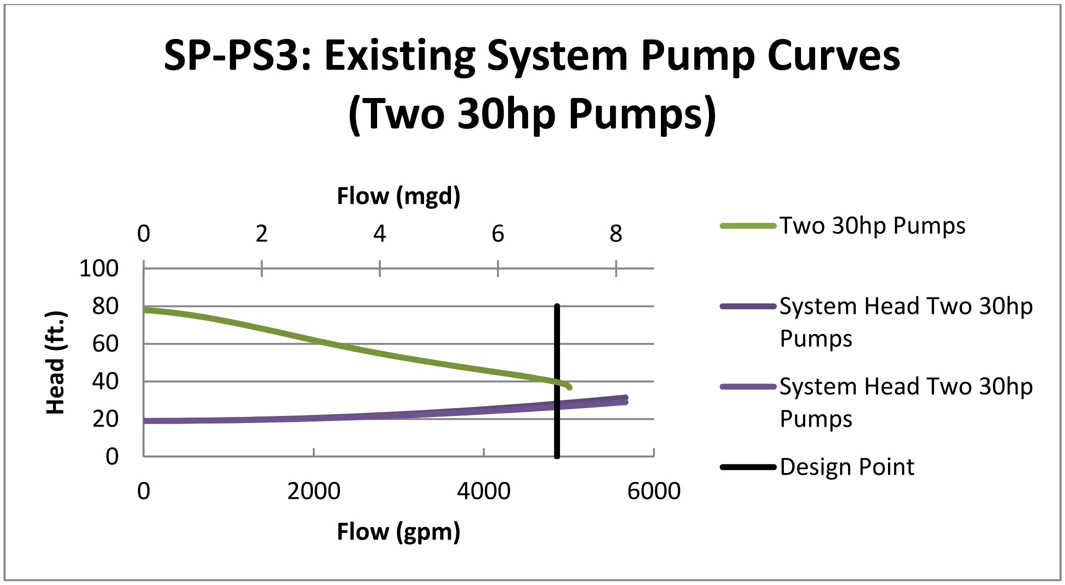
3.4.2 SP-PS2: The point of crossing for SP-PS2 resulted in a much larger value of between 11 and 12 mgd (7638.9 and 8333 gpm) can be pumped with a pump left on standby! This is well beyond any needed capacity at the South Plant.

Figure 16: Alternative 1 Pump vs. System Head Curves



3.4.3 SP-PS3: While similar in design to SP-PS1, no point of crossing for SP-PS3 resulted due to the much lower head losses. Because it is bad practice to extrapolate pump curves, the highest flow on the curve was used for each pump. This resulted in 7.2 mgd (5000gpm) when a single pump is left on standby. Even after applying recirculated flows, enough capacity exists in the system. It is also assumed that higher flows are actually reached even though they cannot be quantified.

Figure 17: Alternative 1 Pump vs. System Head Curves



3.5 Summary of Hydraulic Findings

In the table below, observed flow data from over the last couple years show a steady decrease each year. It was noted that flows have actually been decreasing recently in large part because some of the flow has been bypassed to the north plant. Operators have said that the peak flows shown below are due to flushing the system and are neither accurate nor reflective of the actual peak flows. This is especially notable because the peak flows usually occur during the winter months when runoff is not a contributing factor and infiltration is much lower. It is unlikely that the flows would reach such peaks when infiltration is minimal. Unlike the north plant, the peak flows seen at the south plant should be much lower.

Similarly, the minimum flows often occurred when the system was shut off or had other contributing factors. To compensate for this, an annual average was taken and attributed to being nearly the lowest flow that would be seen each year.

Table 3.4: South Plant Observed Flows

	2007	2008	2009
Avg. Daily Flow (Influent mgd/gpm) (effluent mgd/gpm)	3.6 / 2500 3.0 / 2100	3.1 / 2200 2.8 / 1900	2.7 / 1900 2.7 / 1900

Peak Hourly Flow (mgd/gpm)	10.1 / 7000	10.0 / 6900	7.3 / 5100
Minimum Flow (mgd/gpm)	2.16 / 1500	1.71 / 1200	1.56 / 1100

3.6 3D Analysis

Because the existing system was determined to be adequate for the design flows, creating a 3-D model was not done for any of the south plant pump stations.

3.7 Cost Analysis

Because no alternatives were reviewed at the south plant, costs were also disregarded since they were irrelevant.

4.0 Alternatives

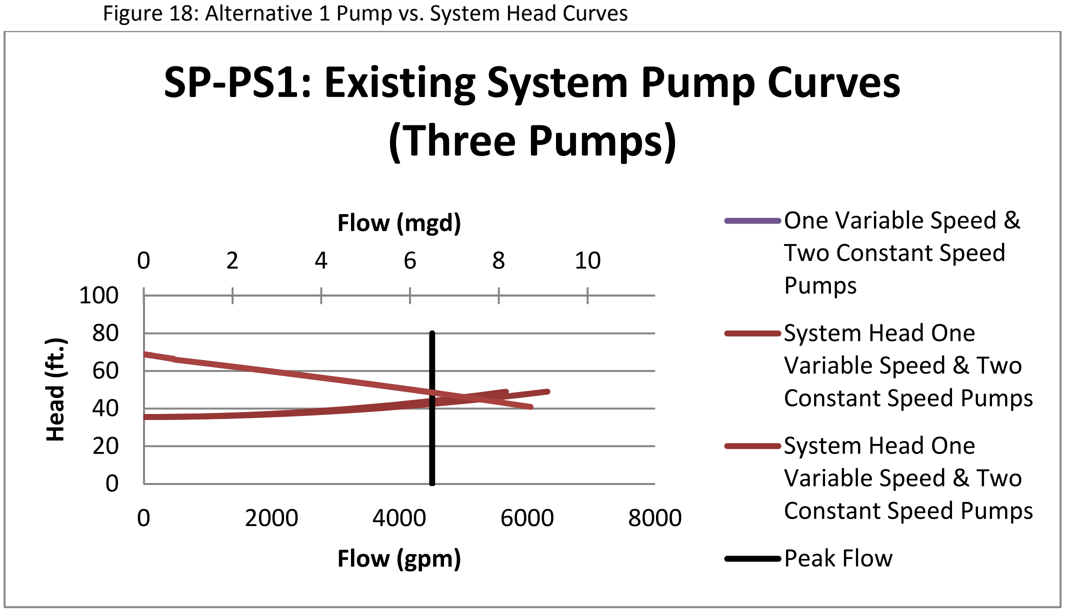
Because the model that was used to review the various alternatives was not able to be calibrated to any great extent, it must be noted that all values chosen for coefficients were selected at the most conservative level. In doing this, all values the operating flows could prove to be much higher than stated in the alternatives and should therefore be regarded as the worst-case scenario. It is also for this reason that recommended alternatives were often chosen in spite of having fallen slightly below design flows.

It should also be noted that, while some pump stations were incapable of reaching their needed capacity, the treatment capacity of the south plant is so much less that the hydraulic capacity could be considered irrelevant. Usually, if the south plant receives more than about 4 mgd, excess is piped to the north plant in order to avoid overloading the south plant.

4.1 SP-PS1 Alternatives

After modeling the existing system, the capacity was found to be 7.18 mgd (4986 gpm) when a pump is left on standby. This value is sufficient to handle the design flows and the existing system is considered adequate. As such, no other alternatives required review.

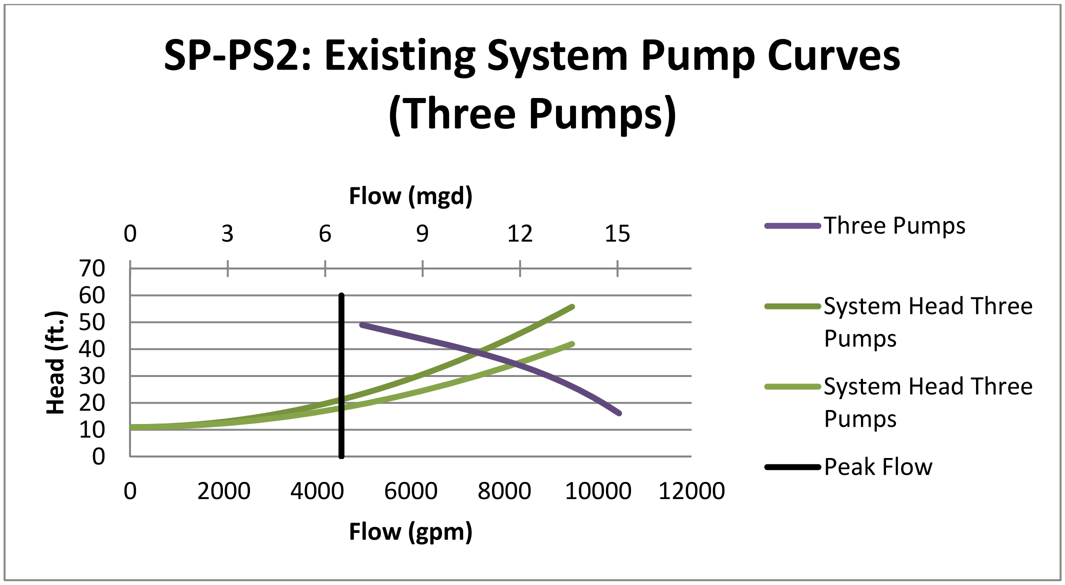
Figure 18: Alternative 1 Pump vs. System Head Curves



4.2 SP-PS2 Alternatives

Because the capacity of three pumps running in SP-PS2 was found to be 10.7 mgd (7431 gpm), it was determined that no alternatives need be reviewed and that the existing system at SP-PS2 is more than adequate to serve any incoming flows.

Figure 19: Alternative 1 Pump vs. System Head Curves

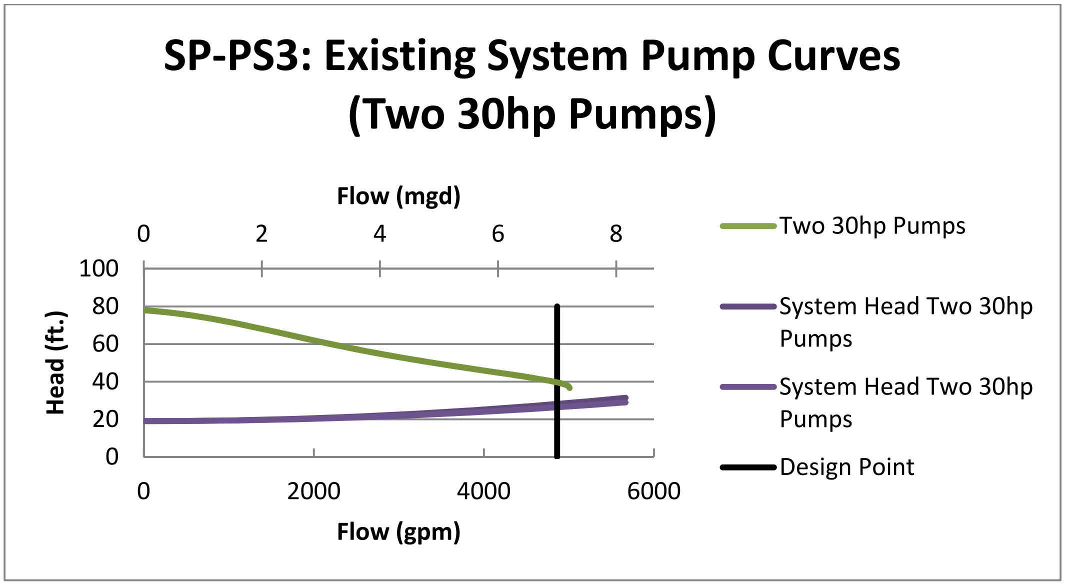


4.3 SP-PS3 Alternatives

There was some difficulty in modeling the existing system for SP-PS3 because the total head used for the system curve never intersects with the pump curve provided by the manufacturer. Even the head used for the original design does not intersect. Therefore it was decided that in order to have a value, that the lowest point on the pump curve would be used as the pump flow value. Because the pumps are currently working in this setup, it is assumed that they must be acting on the far right end of the curve.

In using the lowest point on the pump curve, a total flow of 7.2 mgd (5000 gpm) could be achieved while providing a backup. In reality, the actual capacity of the pumps may be far beyond this point, but since extrapolating a pump curve is not considered good practice, it was not attempted. Since the pumping capacity is so far beyond the needed values, it was determined that no other alternatives need be reviewed because the existing system is adequate for any required flows.

Figure 20: Alternative 1 Pump vs. System Head Curves



4.4 Summary of South Plant Alternatives

At the south plant, all three pump stations were found to be adequate for the projected design flows. Because they were all adequate, no other alternatives were reviewed. Below are listed the results of the various pump stations.

Table 4.4: South Plant Alternatives Summary

Summary of SP-PS1 Alternatives			
	Capacity without Standby Pump (mgd/gpm)	Capacity using Standby Pump (mgd/gpm)	Cost
Alternative 1: Existing System	7.18 / 4990	8.66 / 6010	NA

Summary of SP-PS2 Alternatives			
	Capacity without Standby Pump (mgd/gpm)	Capacity using Standby Pump (mgd/gpm)	Cost
Alternative 1: Existing System	10.7 / 7430	12.9 / 8960	NA

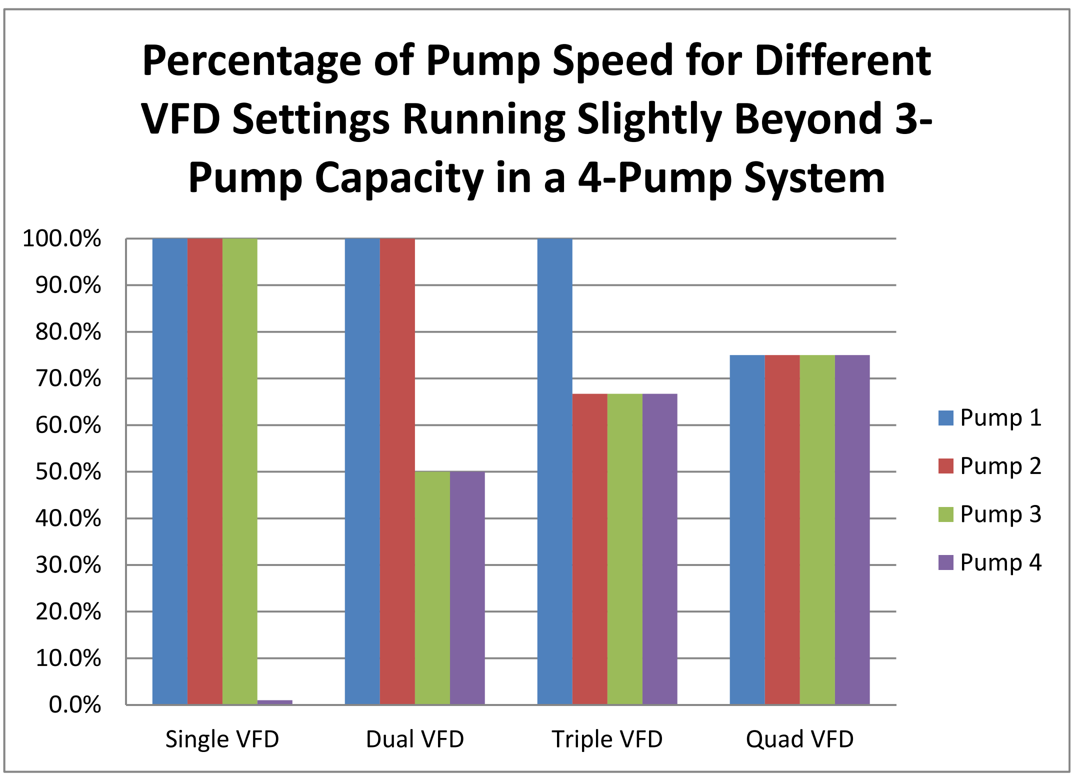
Summary of SP-PS3 Alternatives			
	Capacity without Standby Pump (mgd/gpm) (based on the farthest point on the pump curve)	Capacity using Standby Pump (mgd/gpm) (based on the farthest point on the pump curve)	Cost
Alternative 1: Existing System	7.2 / 5000	10.8 / 7500	NA

5.0 Additional Recommendations

5.1 VFD

The existing VFD's that are used to slow the speed of a pump in order to handle lower flows are currently capable of operating a single pump. Because of this, as the water level fluctuates between needing more than one pump or less than one, a single pump will be activated and shut off continuously as the water level changes. The reason for this is explained in Pumping Station Design (Sanks, 1989) which states that, "The minimum discharge should be at least 30% of the maximum [bep]." It also mentions that many manufacturers even list their minimum values to be much higher percentage. As a result, if flows are slightly beyond the capacity of a single pump, another must activate to handle the flows. Because the second pump cannot run at lower than 30% of its maximum capacity, it will draw down the wet well. Due to the small size of the existing wet wells, this happens very quickly and the second pump will see cyclic activation until flows either increase or decrease to a more stable level.

To avoid these problems, a second VFD could be operated so that, as the second pump activates, they would both reduce their output so that they each operate at 50% of the flow and then ramp up together. This allows for the cyclic activation to be eliminated even though the VFD's may cause the pumps to operate a lower efficiency. Although energy costs might increase slightly, the life of the pumps should increase as well. Even more preferable would be to have a VFD for each pump. Then as flows increase, any active pumps will be discharging at the same flows. It is recommended that additional VFD's be considered in the event of any upgrades.



5.2 Tail-End Discharge

While the hydraulic capacity of the pump stations is important, its importance may be situational. It has been observed that if the water levels in the discharge channel are high when high flows are being discharged, that the water could back up into the contact basin causing it to flood and operate under submerged conditions. Because of this possibility, it is important to verify the capacity of the plant to discharge at higher discharge elevations.

5.3 Treatment Capacity

Although the hydraulic capacity is important, it should also be noted that the treatment capacity is much less and often part of the flow is diverted to the north plant in order to allow the south plant to effectively treat its waste. Because of this, before any hydraulic upgrades are made, it is recommended that a treatment analysis be done to determine how best to increase the capacity of the plant.

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6.0 Conclusions

Through modeling the existing systems, it appears that the original designs did not account for the recirculated flows of the plants and also did not provide any redundancy by leaving a pump to act as a backup. Because of this, in order to reach the design capacity, some type of upgrade will be required.

6.1 North Plant

In the north plant, both pump stations had to be upgraded to increase their capacity to the needed amount. It is recommended that Alternative 4 be followed for NP-PS1 because it may require the minimal work without any large building additions, and thus cost less, to implement. It will also provide the design capacity for the station. Although the existing pumps may not last the full 20-year period, it may be possible to replace the three 60 hp pumps with two 85 hp pumps as they begin to fail. In this way, the old system could be phased out while allowing the newer 85 hp pumps to replace them a few at a time.

Alternative 5 is recommended for use in the case of NP-PS2 because, although it does not meet the flow requirements, it could increase the capacity substantially enough to help against the immediate demands that may be seen. It is also possible to shut off the recirculated flows if necessary which would nearly allow NP-PS2 to pump the same amount of flow that can be pumped in NP-PS1.

While both of these alternatives are very beneficial, it is also important to note that they would each require the same pump to be put in place although the impellers would be different sizes. This would mean that instead of the existing two different pump models in the north plant, there would be three that would have to be maintained and have spare parts. Fortunately, since the two new pumps would be so similar in size, it is possible that they would use many of the same parts, thus requiring fewer parts be kept on hand.

By following these recommendations, the capacity of the north plant could be raised to a much higher influent flow while still accounting for recirculated flows. Also, by using the existing VFD system, low flows could be handled in a similar way to that of the existing system. If the other recommendations stated in section 5.0 are followed, the hydraulic capacity of the north plant could be increased to handle far more than the existing pumps are capable of doing.

6.2 South Plant

In the south plant, none of the three pump stations required an upgrade to meet the design flows in the system. It is recommended that, in the case of SP-PS1, SP-PS2 and SP-PS3, no change be implemented and that the existing system be left alone.

In following the above recommendations, the south plant will remain capable of handling the needed 6 mgd of influent flow. Also, the existing VFD's can be used to handle lower flows. However, since the true bottleneck lies in the treatment at the south plant, any increase in hydraulic capacity will be crippled. It is only by reviewing and increasing the treatment capacity that the needed flow capacity be reached.

SDSD has not undergone any major expansions since the one mentioned in 1988. For over twenty years no major work has had to be done to increase capacity, but it appears that perhaps the limit is near being reached. Also, the existing pumps are getting older and beginning to wear thin. By following the listed recommendations, the capacity of the pump stations could be raised to be able to handle any further increase that may occur in the future. Also, the district is nearly grown out which means that this raise in capacity should be more than sufficient for future demand as well. This would leave the district in a very good position and should act as a long term solution to some of the current problems that have been observed.

In addition to providing solutions to the observed problems, this study will benefit SDSD in the future as well. Because of the observed problems, a study had to be done in order to determine any possible solutions. A study of the pump stations has never been done at SDSD in the past. With this new information, other alternatives can be reviewed and the existing model can be modified to allow for future capacity studies. Through this study possible solutions have been recommended and a powerful tool has been created for future use.

7.0 References

Sanks, Robert L. Pumping Station Design. Butterworth-Heinemann. 1998.

Haestad, Walski, Chase, Savic, Grayman, Beckwith, Koelle . Advanced Water Distribution Modeling and Management. Haestad Methods. 2003-2004.

Flygt Product Catalogue. (July, 2010). https://catalog.flygtus.com/login.aspx?ReturnUrl=%2fcatalog%2f38919.html

Hutchison, David. UMS Central. (July, 2010). Personal Communication.

Pump Manufacturers Information Binder – (Kept at South Davis Sewer District Administration Building)

Construction of North Plant Wastewater Treatment Plant Rehabilitation and Expansion. 1988.

Construction of South Plant Wastewater Treatment Plant Rehabilitation and Expansion. 1992.

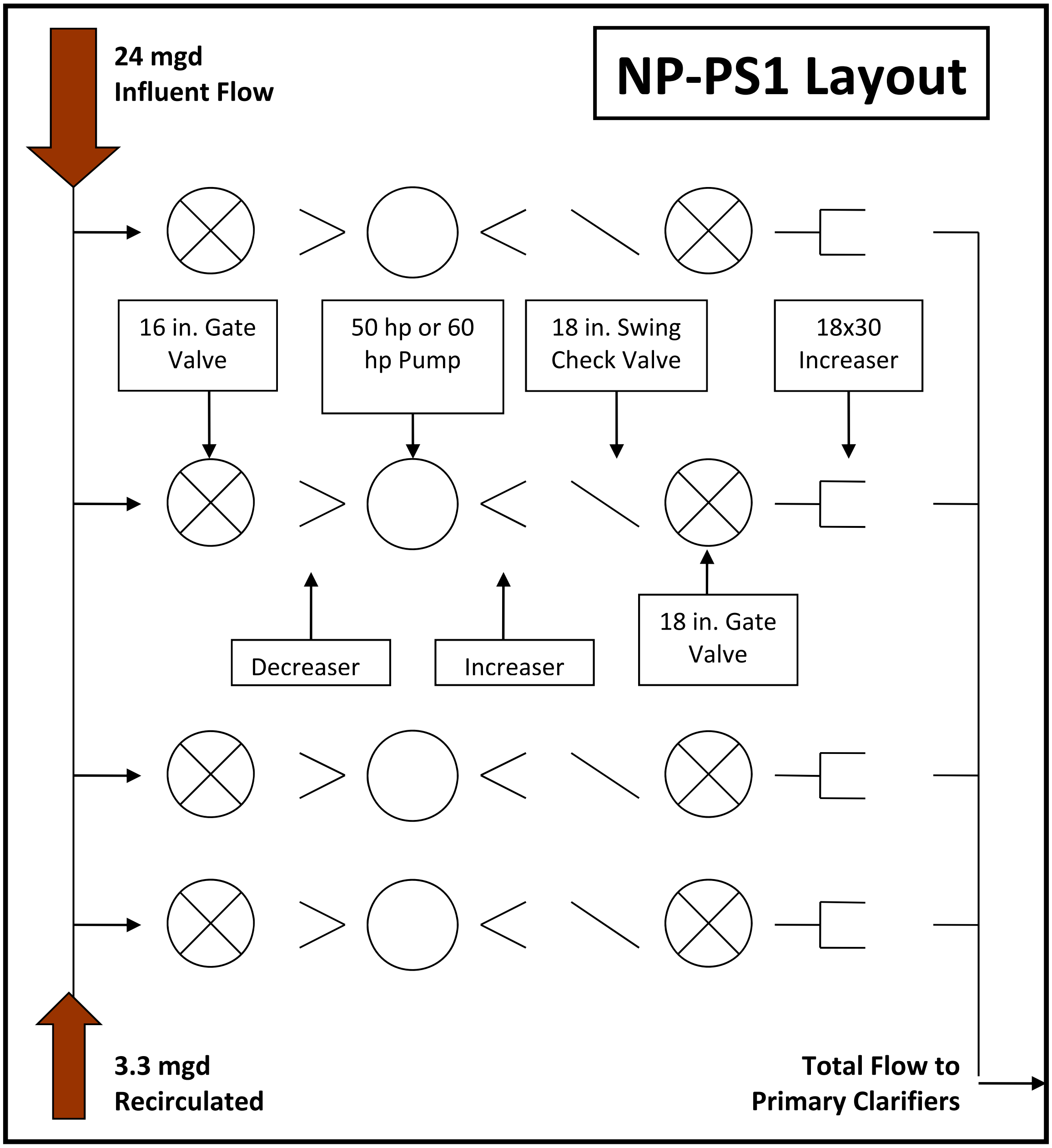
Appendices

Appendix A: Existing System Descriptions

NP-PS1

The primary pumping system of the SDSD north plant consists of four pumps that tie into a single force main by way of a manifold. A wet well, located beneath the Parshall flume, supplies water to the pumps. Three of the pumps are identical, 14 inch, 60 hp pumps (885 rpm) and the last pump is a 10 inch, 50 hp pump (880 rpm) which is used to handle lower flows. In addition to the smaller pump, a variable frequency drive (VFD) is connected to the system so that any one of the pumps can be operated by it.

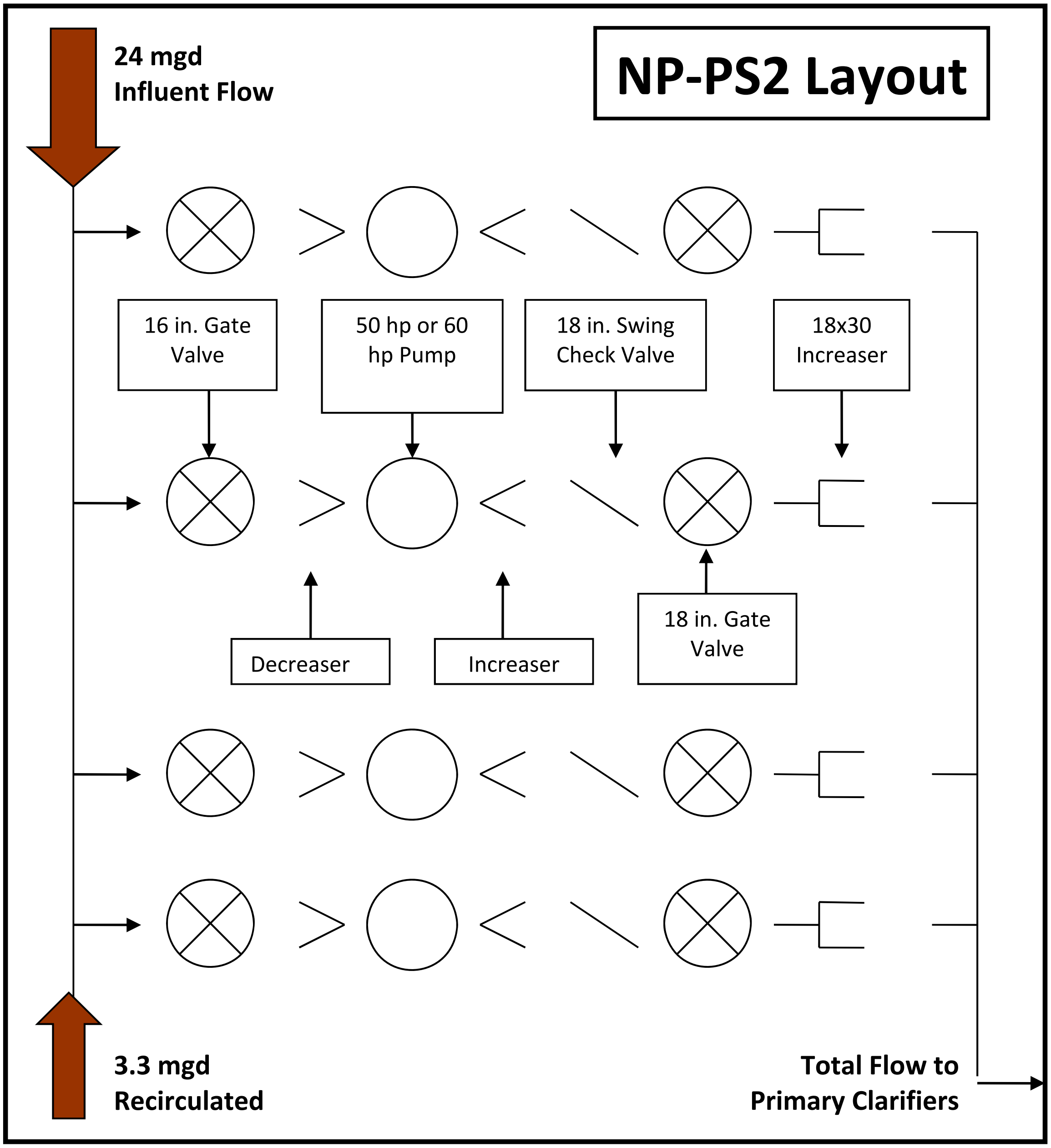
Raw wastewater enters NP-PS1 by way of a Parshall flume before entering the wet well. The flow then passes into one of four rounded 16 in. pipes and through a 16 in. knife gate valve before being reduced to the correct pump size, and enters one of the pumps. Following the pumps, the pipe is then expanded to 18 in. in order to accommodate an 18 in. swing check valve and an 18 in. knife gate valve. After passing through the valves, the pipe is expanded suddenly in order to connect to the 30 in. manifold. After exiting the manifold, the flow then passes through two elbows and a bend where it travels roughly 90 ft. and rises 24 ft. before entering the grit chamber distribution box.



NP-PS1 Layout
24 mgd
Influent Flow
16 in. Gate Valve
50 hp or 60 hp Pump
18 in. Swing Check Valve
18x30 Increaser
Decreaser
Increaser
18 in. Gate Valve
3.3 mgd
Recirculated
Total Flow to
Primary Clarifiers

NP-PS2
Between the trickling filters and the final clarifiers lies NP-PS2. Secondary pumping for the north plant houses an identical set of pumps as those in NP-PS1 (Three 60 hp and one 50 hp pump). Again, a VFD is used to regulate the flows through the pumps. The four pumps also take their flows from a single wet well and are each connected to the force main by way of a manifold.

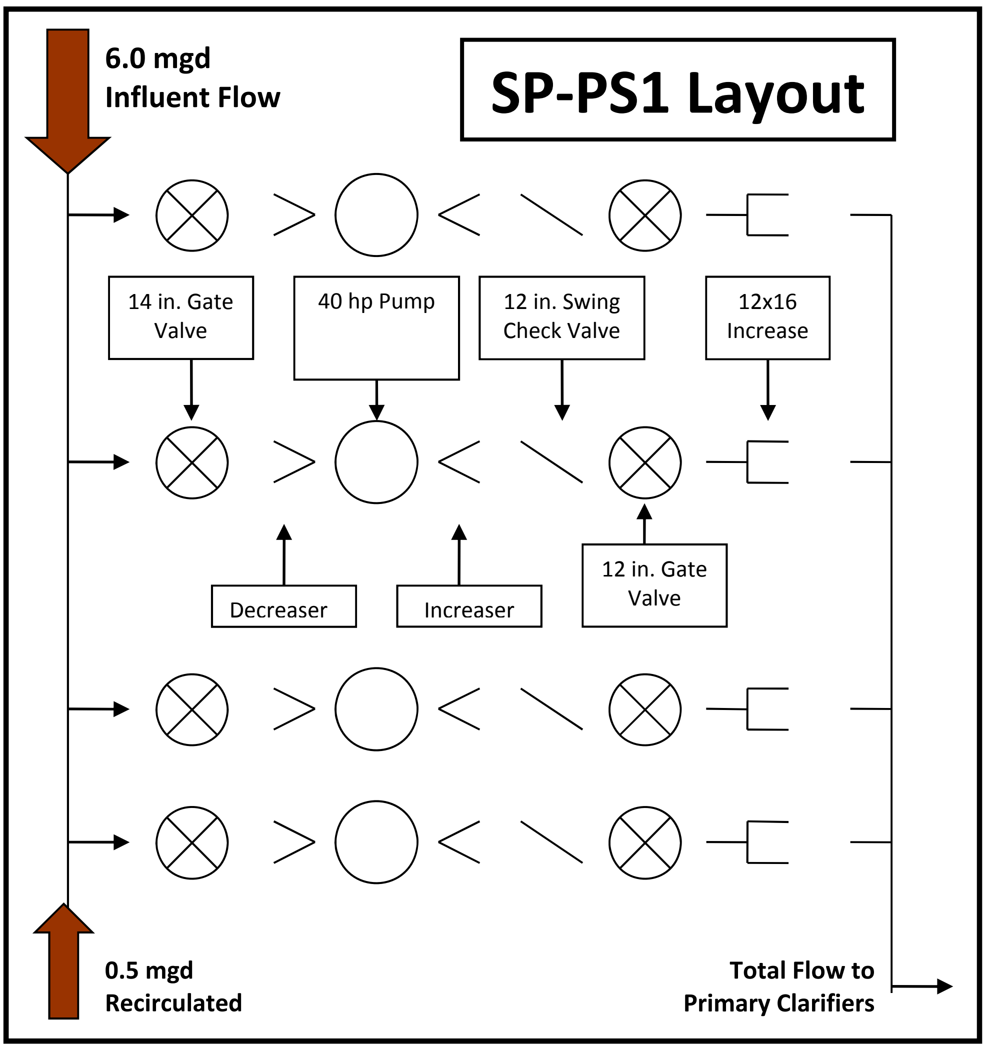
Flows enter NP-PS2 through one of four rounded 20 in. pipes and through a 20 in. knife gate valve which are then reduced down to their respective pump size. After the pumps, the pipe expands to 18 in. to accommodate an 18 in. swing check valve and an 18 in. knife gate valve. After passing through the valves, the pipe expands suddenly to 27 in and enters the 27 in. manifold. At the end of the manifold, the pipe is increased into a 30 in. pipe which travels a little over 300 ft. before entering the final clarifiers. The water is raised by 21.17 ft. before entering the final clarifiers.


NP-PS2 Layout
24 mgd
Influent Flow
16 in. Gate Valve
50 hp or 60 hp Pump
18 in. Swing Check Valve
18x30 Increaser
Decreaser
Increaser
18 in. Gate Valve
3.3 mgd
Recirculated
Total Flow to
Primary Clarifiers

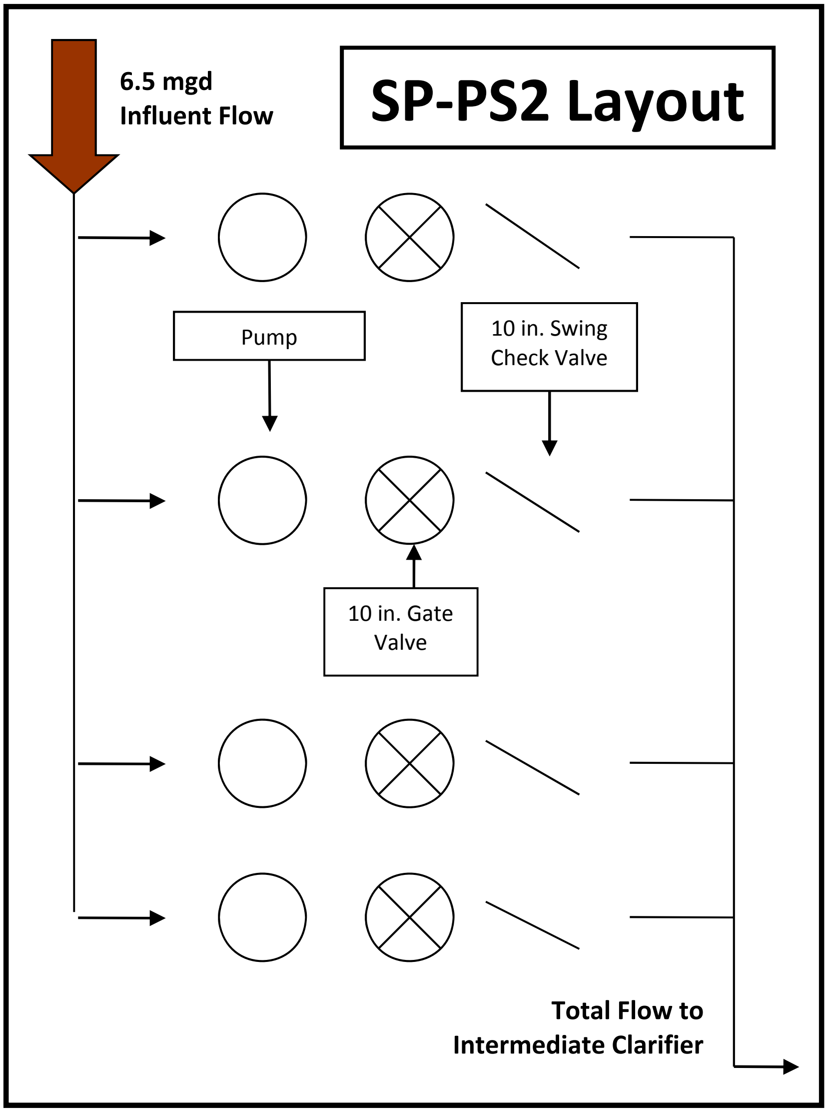
SP-PS1

In the south plant, primary influent is pumped by the original four identical 40 hp pumps that were installed in 1960. A VFD has since been installed to handle lower flows. These pumps are all 40 hp, 14 in. pumps and are supplied by a wet well. The four pumps are then tied to the force main via a manifold.

Wastewater enters SP-PS1 by way of a Parshall flume before entering the wet well. The flow then passes through one of four rounded 14 in. pipes and through a 14 in. knife gate valve before being reduced to the pump size. Following the pumps, the pipe is then expanded to 12 in. in order to accommodate an existing 12 in. knife gate valve and 12 in. swing check valve. The pipe is then expanded again in order to connect to the 16 in. manifold. Finally, the 16 in. pipe travels roughly 90 ft. and rises nearly 37 ft. before entering the clarifiers.



SP-PS2



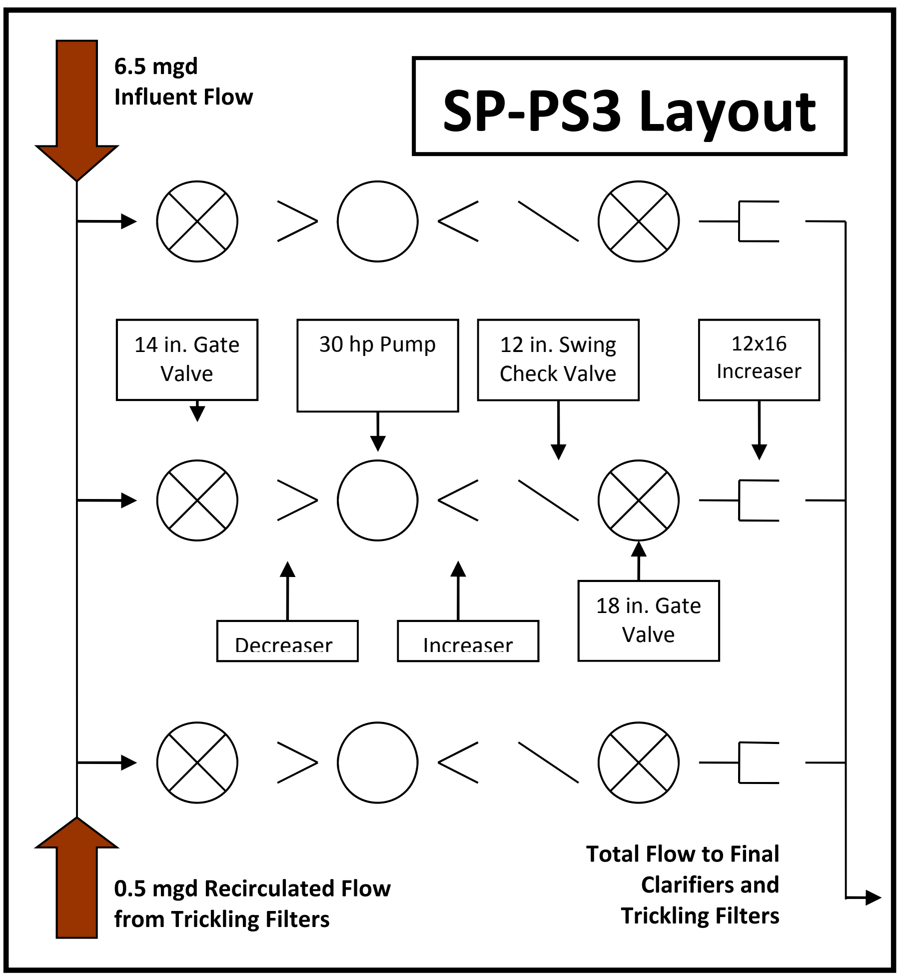
Unlike what exists in the North Plant, SP-PS1 and SP-PS2 are vastly different in their setup. SP-PS2 is an intermediate station and lifts flows up to the intermediate clarifiers and trickling filter. Because the clarifiers are located immediately downstream of SP-PS2, there is little chance at any backflow which results in a much smaller number of fittings. Four identical 6 in. pumps are used to lift the flows to the distributions box. Again, a VFD allows for the pumps to handle lower flows. There is no force main in this case since the flows are delivered directly to the distribution box.

Flows enter SP-PS2 through one of four bell-mouthed 6 in. pipes and are then piped directly up to the pumps above. Since the pumps are not located at water level, no isolation valves are needed on the upstream side of the valve. Following the pumps flows pass through a 10 in. knife gate valve and 10 in. swing check valve before discharging directly into a distribution box that feeds into the intermediate clarifier. Friction is negligible as a result and only the few fittings that exist provide any losses.

SP-PS3

The secondary pumping system is housed in the same building as the primary system. However, only three pumps existing at SP-PS3. They are identical 8 in. 30 hp pumps and tie into the force main through a manifold. As with the other pump stations, a VFD helps the pumps to handle lower flows.

After passing through the intermediate trickling filter, flows are routed back to the main pump station building where the secondary pumps are maintained. The secondary pumps are fed from a wet well through 14 in. inlets and through a 14 in. knife gate valve which are then reduced down to the size of the pumps. Following the pumps, the pipe is then expanded to 12 in. to accommodate a 12 in. swing check valve and 12 in. knife gate valve. The pipe is then expanded to a 16 in. manifold. Farther down the pipe, it expands again into an 18 in. pipeline. Flows travel about 30 ft. and are lifted about 15 ft. before reaching the distribution box for the final clarifiers.



Appendix B: System Head Curve Method

A spreadsheet was created in Excel using various sheets to find the intersection point of the system head curve and the given pump curves. First, several points were taken from the given pump curves and input into the spreadsheet where they could be graphed. A trendline was then added to the graph with its corresponding equation. This equation was then used to determine the head along the curve at any given flow.

It was also important, since the pumps run in parallel, that the pump curves be added together in various combinations. The flows were added together at arbitrarily chosen heads to create the necessary points for the pump curve.

After recreating the pump curves, the system curve was created using by collecting information about the existing system materials and setup. With this information, the Hazen-Williams equation, as well as various loss approximation equations, was used to determine the needed loss coefficients. These coefficients were then plugged into the head loss equation to find the total dynamic head required by the system. When added to the static head, a total head for the system could be found.

The flows and areas used in the minor loss equation were taken from the existing system. Areas were taken from the existing valves and fittings and then flows were chosen at small intervals so that the various heads found with the equation could be graphed into a curve. Different curves were also created by assuming various combinations of pumps as well. This could be done because the total flow would not travel through any single pump when multiple pumps were running, therefore flows could be divided among the pumps to create unique system head curves.

When the various pump and system head curves were completed, they were plotted against each other to determine where their points of intersection occurred. The intersection points are referred to as "duty points" and help to illustrate at what flow and pressure a pump will operate. The duty points for the systems which allow a pump to act as a standby pump are referred to as the capacity of the pump station and these points were found for each pump station and each alternative.

Hazen-Williams Equation (ft. of head per 1000 ft. of length):

$$h_f = \left(\frac{149Q}{CD^{2.63}} \right)^{1.85}$$

Head Loss Equation (ft.):

$$h = \Delta El. + \sum k \frac{Q^2}{2gA^2} + h_f$$

Head losses were calculated using the loss coefficient (k) associated with its respective area.

Head Loss (ft.): Conical Increaser (Sanks, pg. 898)

$$h = 0.25\frac{\left(\frac{Q^2}{A_1^{\,2}} - \frac{Q^2}{A_2^{\,2}}\right)}{2g}$$

Head Loss (ft.): Sudden Increaser (Sanks, pg. 898)

$$h = \left[\left(\frac{A_2}{A_1}\right)^2 - 1\right]\frac{Q^2}{2gA_2^{\,2}}$$

Increaser heads were calculated using an approximate method since the lengths of the increasers were not available and use custom, non-standard fittings.

Variables Used:

US El.	Upstream Elevation
DS El.	Downstream Elevation
ΔEl.	Change in Elevation
g	Acceleration of Gravity
Q	Flow
D	Diameter
A	Area
k	Minor Loss Coefficient
h	Head
hf	Head Loss per 1000 ft. Due to Friction
C	Hazen-Williams Loss Coefficient

Minor Losses were calculated using the following assumptions and equations:

Losses	Symbol	Non-Conservative Value	Conservative Value	Description
Hazen-Williams Loss Coefficient	C =	125		Ductile Iron with Cement Mortar Lining 24” Troweled in place (Sanks, pg. 896)
Minor Loss Coefficients				

Entrance Loss	k_{ent} =	0.25		Rounded entrance (Sanks, pg. 898)
Loss from Reducer	$k_{reducer}$ =	0.02	0.03	Conical before pumps (Sanks, pg. 898)
Loss from Increaser	$k_{increaser}$ =	in formula		Conical and sudden after pumps (Sanks, pg. 898)
Loss from Gate Valve	k_{gv} =	0.1	0.3	Gate, resilient seat (conservative guess) (Sanks, pg. 899)
Loss from Swing Check Valve	k_{cv} =	0.6	2.2	Swing check valve (Sanks, pg. 899)
Loss from Elbow	k_{elbow} =	0.3		Elbow between the manifold and clarifiers (Sanks, pg. 898)
Loss from Bend in Force Main	k_{bend} =	0.15		Bend in force main after the manifold and appears to be about 20 degrees (Extrapolated value from 90 and 45 degree bends) (Sanks, pg. 898)
Misc. Minor Losses	k =	0.5		Misc. losses
Exit Loss	k_{exit} =	1.0		

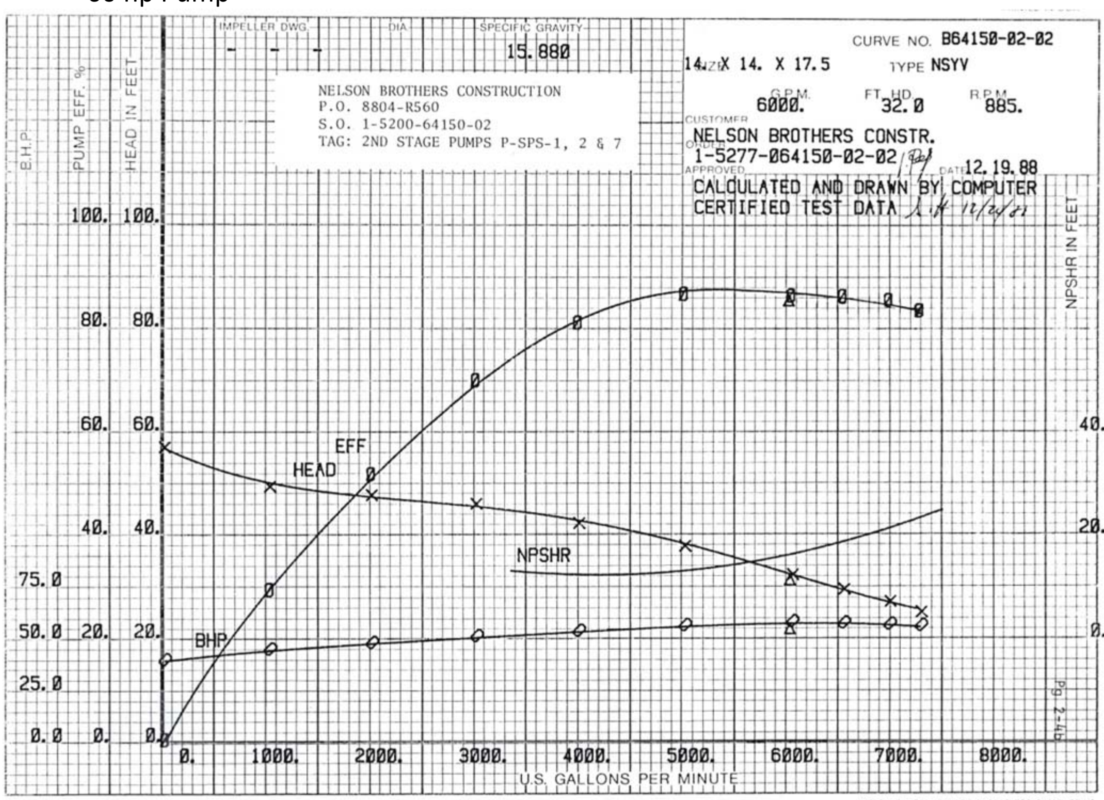
Appendix C: Pump Information:

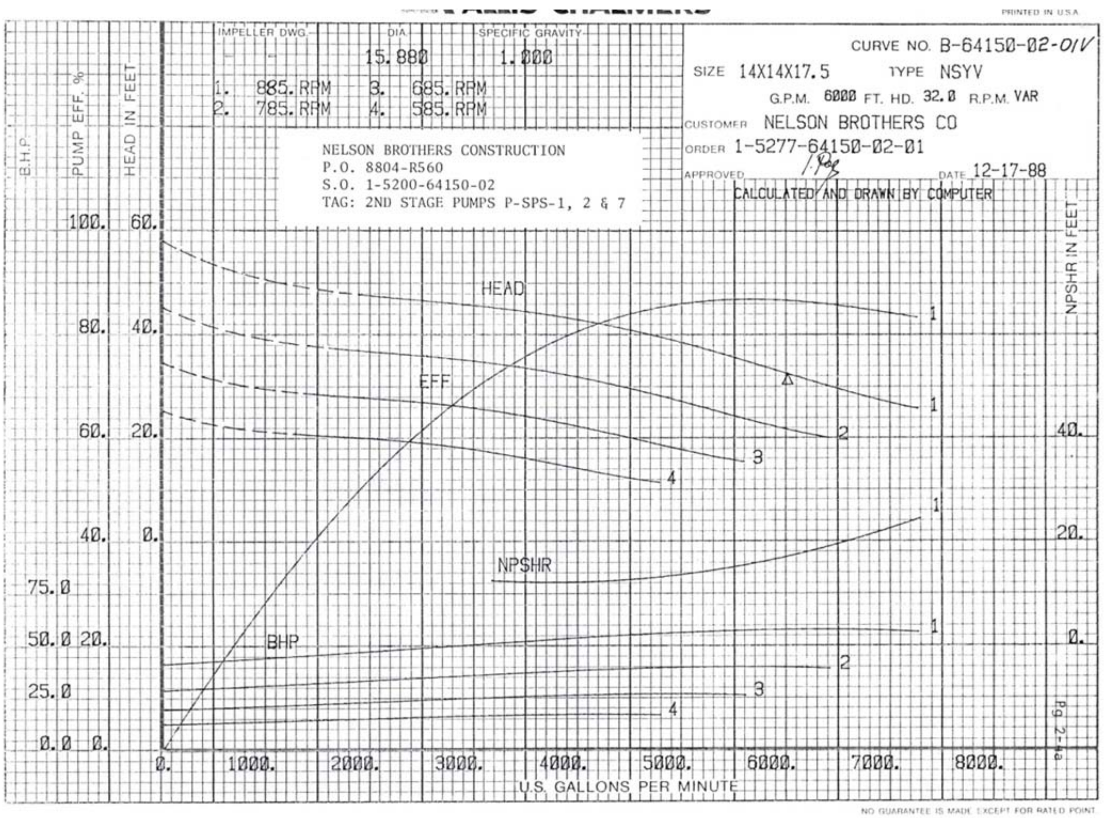
In this study, five different pumps were reviewed from the existing system, but an additional eight pumps were also reviewed to determine the feasibility of the different alternatives.

Existing Pump Information

Currently, there are five different models of pumps running at the SDSD north and south plants. At the south plant, a single model is used in each pump station while at the north plant, two different pumps are located at each pump station. In order to create the necessary pump comparisons, information on all the existing pumps had to be located and organized.

60 hp Pump

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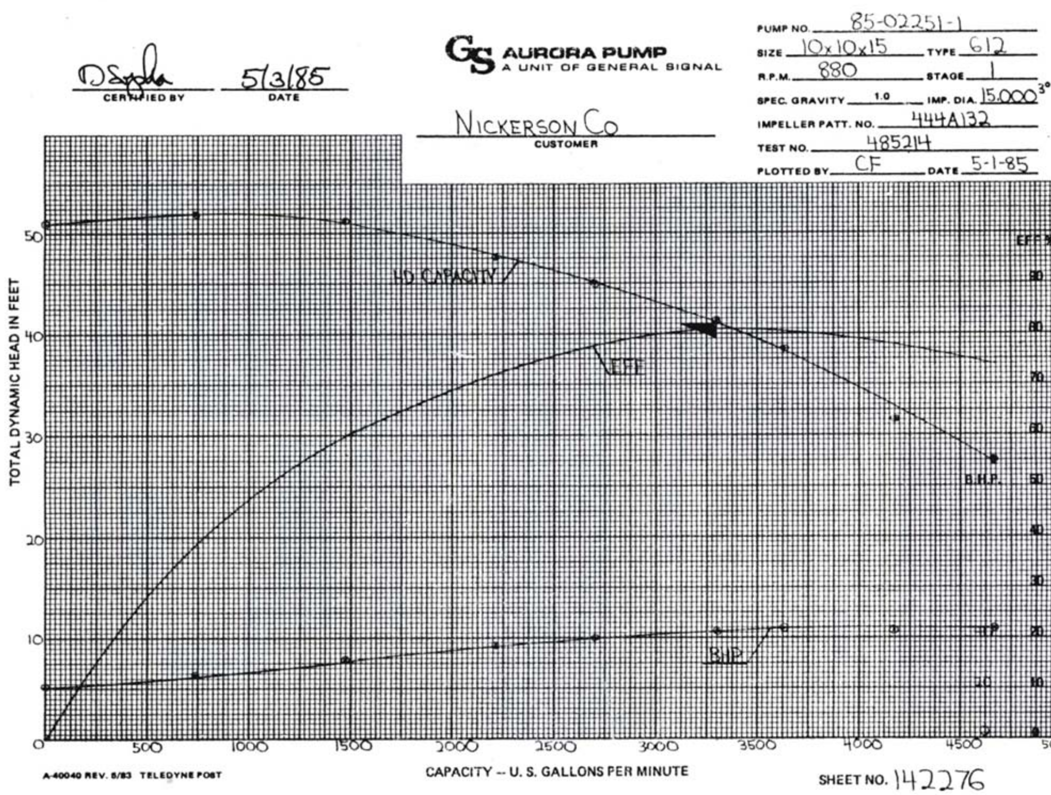
15.880 1.000
1. 885. RPM 3. 685. RPM
2. 785. RPM 4. 585. RPM
NELSON BROTHERS CONSTRUCTION
P.O. 8804-R560
S.O. 1-5200-64150-02
TAG: 2ND STAGE PUMPS P-SPS-1, 2 & 7
CURVE NO. B-64150-02-01V
SIZE 14X14X17.5 TYPE NSYV
G.P.M. 6000 FT. HD. 32.0 R.P.M. VAR
CUSTOMER NELSON BROTHERS CO
ORDER 1-5277-64150-02-01
DATE 12-17-88
CALCULATED AND DRAWN BY COMPUTER
B.H.P.
PUMP EFF. %
HEAD IN FEET
NPSHR IN FEET
HEAD
EFF
NPSHR
BHP
U.S. GALLONS PER MINUTE
NO GUARANTEE IS MADE EXCEPT FOR RATED POINT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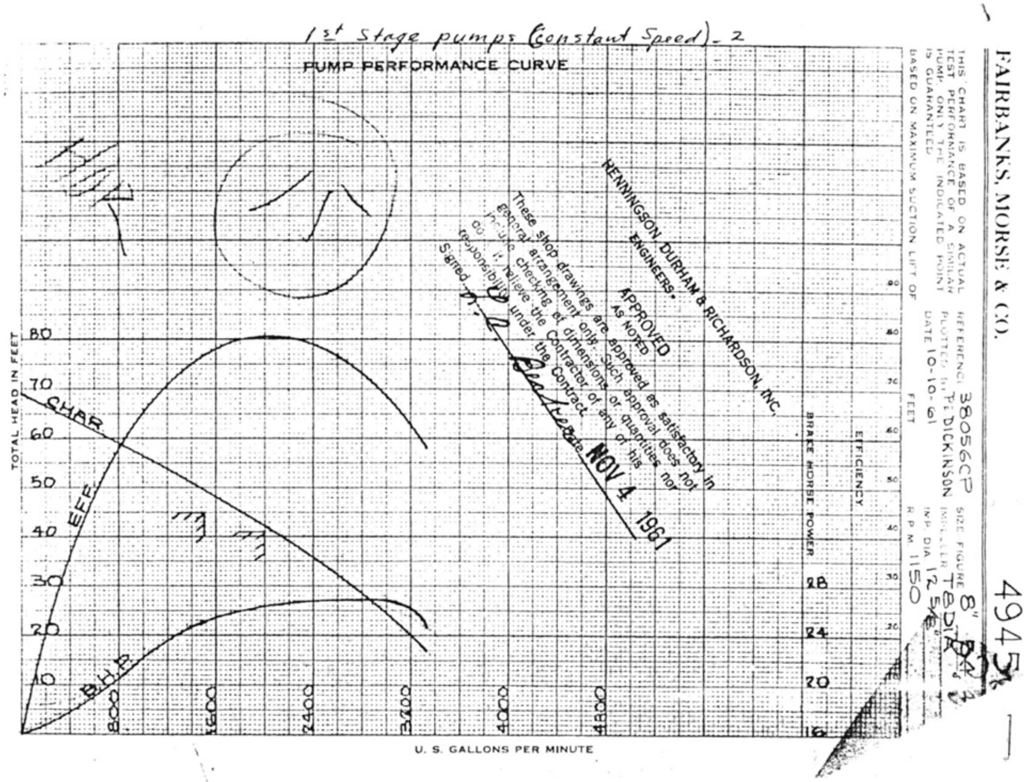
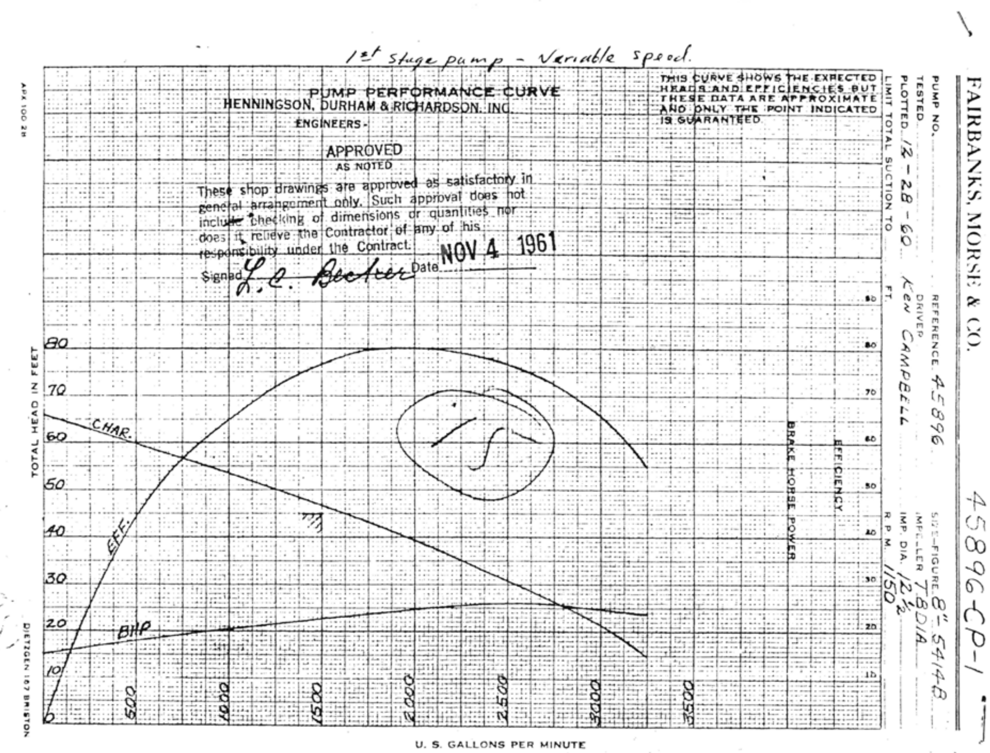
SIZE 10x10x15 TYPE 612
R.P.M. 880 STAGE 1
SPEC. GRAVITY 1.0 IMP. DIA. 15.000
IMPELLER PATT. NO. 444A132
TEST NO. 485214
PLOTTED BY CF DATE 5-1-85
AURORA PUMP
A UNIT OF GENERAL SIGNAL
CERTIFIED BY
5/3/85
DATE
NICKERSON CO
CUSTOMER
TOTAL DYNAMIC HEAD IN FEET
HD CAPACITY
EFF
BHP
EFF %
B.H.P.
CAPACITY -- U. S. GALLONS PER MINUTE
A-40040 REV. 5/83 TELEDYNE POST
SHEET NO. 142276


1st Stage pumps (Constant Speed) - 2
PUMP PERFORMANCE CURVE
FAIRBANKS, MORSE & CO.
THIS CHART IS BASED ON ACTUAL TEST PERFORMANCE OF A SIMILAR PUMP. ONLY THE INDICATED POINT IS GUARANTEED
BASED ON MAXIMUM SUCTION LIFT OF FEET
REFERENCE 38056CP
PLOTTED BY T. DICKINSON
DATE 10-10-61
HENNINGSON, DURHAM & RICHARDSON, INC.
ENGINEERS
APPROVED
AS NOTED
These shop drawings are approved as satisfactory in general arrangement only. Such approval does not include checking of dimensions or quantities nor does it relieve the Contractor of any of his responsibility under the Contract.
Signed
Date NOV 4 1961
TOTAL HEAD IN FEET
CHAR
EFF
B.H.P.
BRAKE HORSE POWER
EFFICIENCY
U. S. GALLONS PER MINUTE
800
1600
2400
3200
4000
4800
80
70
60
50
40
30
20
10
28
24
20
16
R.P.M. 1150
494


1st Stage pump - Variable Speed.
PUMP PERFORMANCE CURVE
FAIRBANKS, MORSE & CO.
HENNINGSON, DURHAM & RICHARDSON, INC.
ENGINEERS
APPROVED
AS NOTED
These shop drawings are approved as satisfactory in general arrangement only. Such approval does not include checking of dimensions or quantities nor does it relieve the Contractor of any of his responsibility under the Contract.
Signed L.C. Becker
Date NOV 4 1961
THIS CURVE SHOWS THE EXPECTED HEADS AND EFFICIENCIES BUT THESE DATA ARE APPROXIMATE AND ONLY THE POINT INDICATED IS GUARANTEED
PUMP NO.
TESTED
PLOTTED 12-28-60
LIMIT TOTAL SUCTION TO FT.
REFERENCE 45896
DRIVER
KEN CAMPBELL
SIZE-FIGURE 8" 5414-B
IMPELLER T.B. DIA
IMP. DIA. 12 1/2
R.P.M. 1150
45896-CP-1
TOTAL HEAD IN FEET
CHAR.
EFF.
BHP
BRAKE HORSE POWER
EFFICIENCY
U. S. GALLONS PER MINUTE
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1000
1500
2000
2500
3000
3500
80
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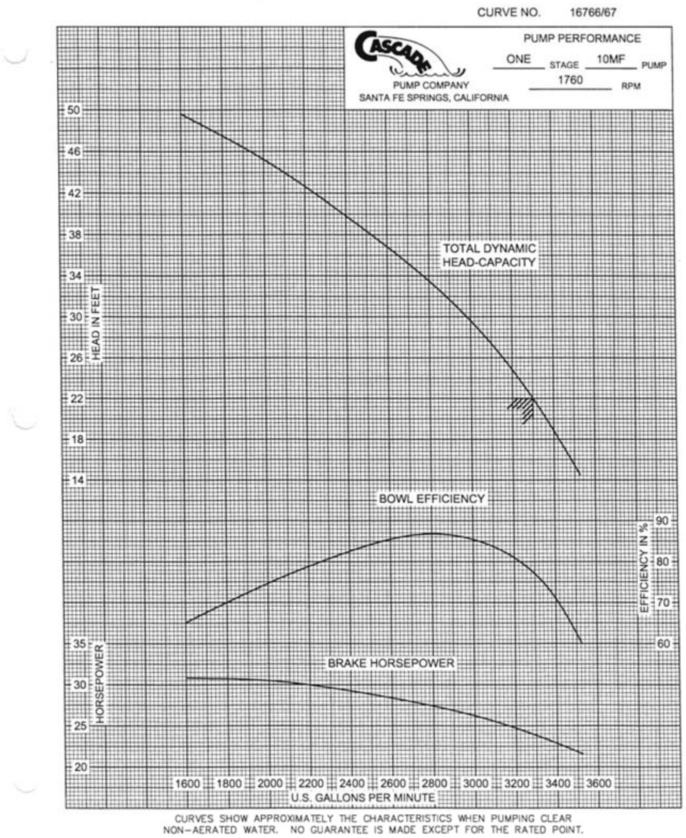
50
40
30
20
10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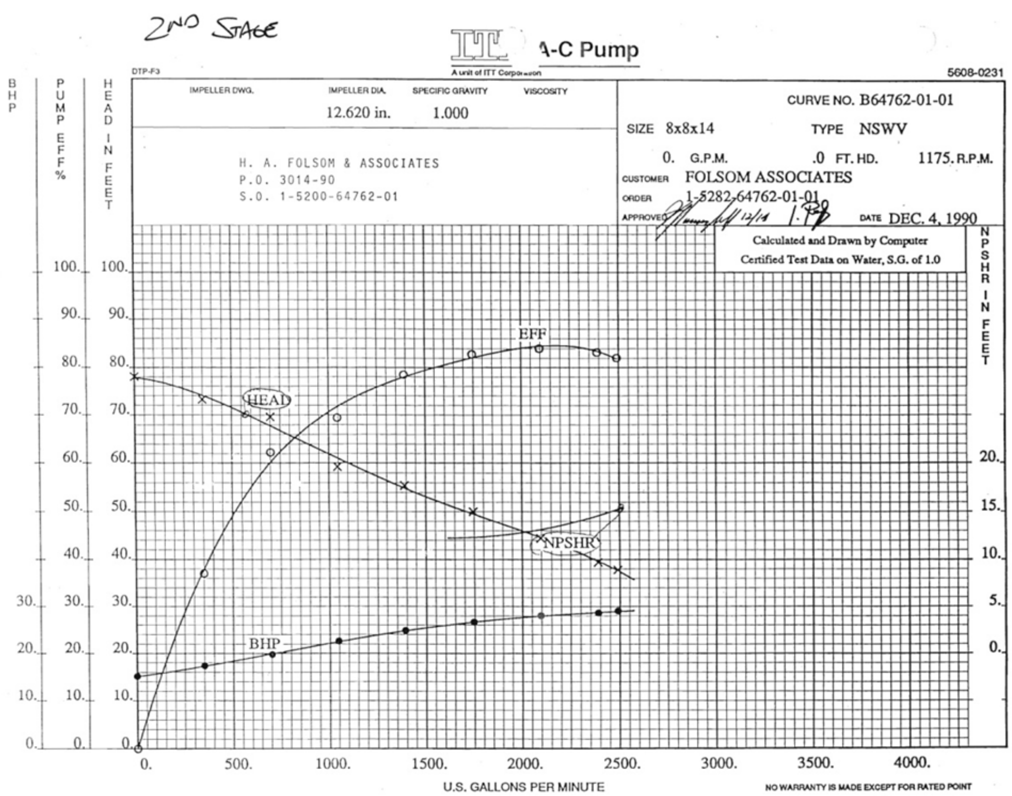
CASCADE
PUMP COMPANY
SANTA FE SPRINGS, CALIFORNIA
PUMP PERFORMANCE
ONE STAGE 10MF PUMP
1760 RPM
TOTAL DYNAMIC HEAD-CAPACITY
BOWL EFFICIENCY
BRAKE HORSEPOWER
HEAD IN FEET
EFFICIENCY IN %
HORSEPOWER
U.S. GALLONS PER MINUTE
CURVES SHOW APPROXIMATELY THE CHARACTERISTICS WHEN PUMPING CLEAR NON-AERATED WATER. NO GUARANTEE IS MADE EXCEPT FOR THE RATED POINT.


2ND STAGE
ITT A-C Pump
A unit of ITT Corporation
5608-0231
IMPELLER DWG.
IMPELLER DIA. 12.620 in.
SPECIFIC GRAVITY 1.000
VISCOSITY
CURVE NO. B64762-01-01
SIZE 8x8x14
TYPE NSWV
0. G.P.M.
.0 FT. HD.
1175. R.P.M.
CUSTOMER FOLSOM ASSOCIATES
ORDER 1-5282-64762-01-01
DATE DEC. 4, 1990
H. A. FOLSOM & ASSOCIATES
P.O. 3014-90
S.O. 1-5200-64762-01
Calculated and Drawn by Computer
Certified Test Data on Water, S.G. of 1.0
EFF
HEAD
NPSHR
BHP
BHP
PUMP EFF %
HEAD IN FEET
NPSHR IN FEET
U.S. GALLONS PER MINUTE
NO WARRANTY IS MADE EXCEPT FOR RATED POINT

Alternative Pump Information

Eight different pumps were modeled to determine whether they could improve flow capacities sufficiently or not. Information for these pumps is listed below. However, due to manufacturer request, much of the pump detail cannot be provided here. In order to obtain the needed pump information, a stipulation was given by the manufacturer that the released information would not be made available to anyone else. As a result, much of the information was made available to SDSD, but this information could only be provided in the report if certain details were left out such as the models of the pumps. For this same reason, the pump curves could not be included in this report. All pump curve information is included in the Pump Curve binder at SDSD.

Appendix D: Reviewed Alternatives

Although only a few of the alternatives were listed in the report, other scenarios were modeled and dozens of pumps were tried. Below are all the descriptions for each attempted alternative.

NP-PS1

- Alternative 1: Existing System
- Alternative 2: Four that Fit
- Alternative 3: Four that Squeeze
- Alternative 4: Five Pump System
- Alternative 5: Four that Fit (70 hp)
- Alternative 6: Four that Squeeze (60 hp)
- Discarded Alternatives:
    - Alternative 7: Replace 50 hp Pump
    - Alternative 8: Replace Two Pumps
    - Alternative 9: Replace Three Pumps
    - Alternative 10: Three Large Pumps

NP-PS2

- Alternative 1: Existing System
- Alternative 2: Four that Fit
- Alternative 3: Four that Squeeze
- Alternative 4: Three Large Pumps
- Alternative 5: Four that Fit (70 hp)
- Alternative 6: Four that Squeeze (60 hp)
- Discarded Alternatives:
    - Alternative 7: Replace 50 hp Pump
    - Alternative 8: Replace Two Pumps
    - Alternative 9: Replace Three Pumps

SP-PS1

- Alternative 1: Existing System

SP-PS2

- Alternative 1: Existing System

SP-PS3

- Alternative 1: Existing System

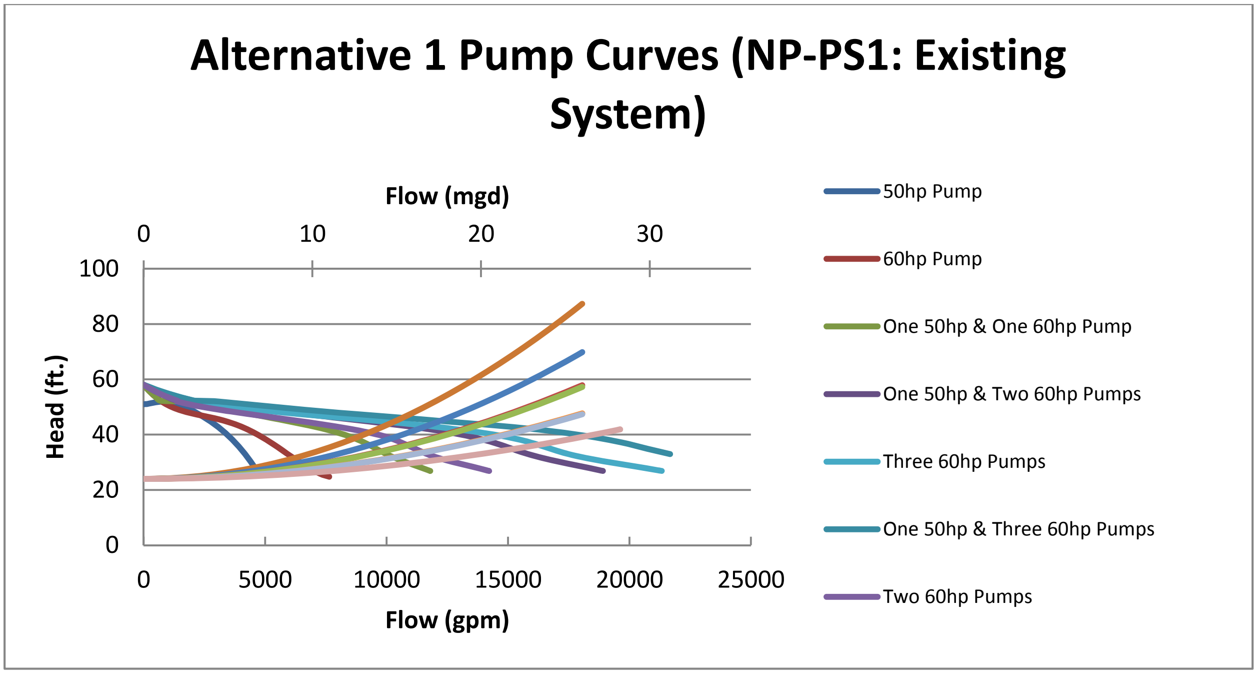
NP-PS1 Alternative 1: Existing System

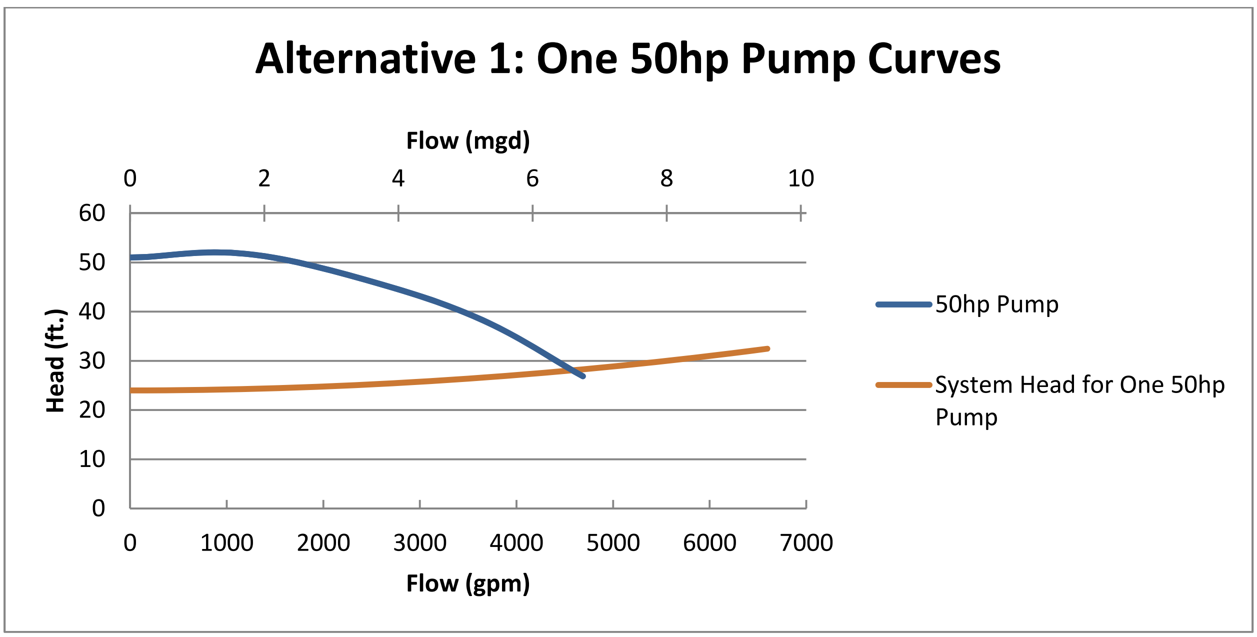
Existing system assumptions were as follows:

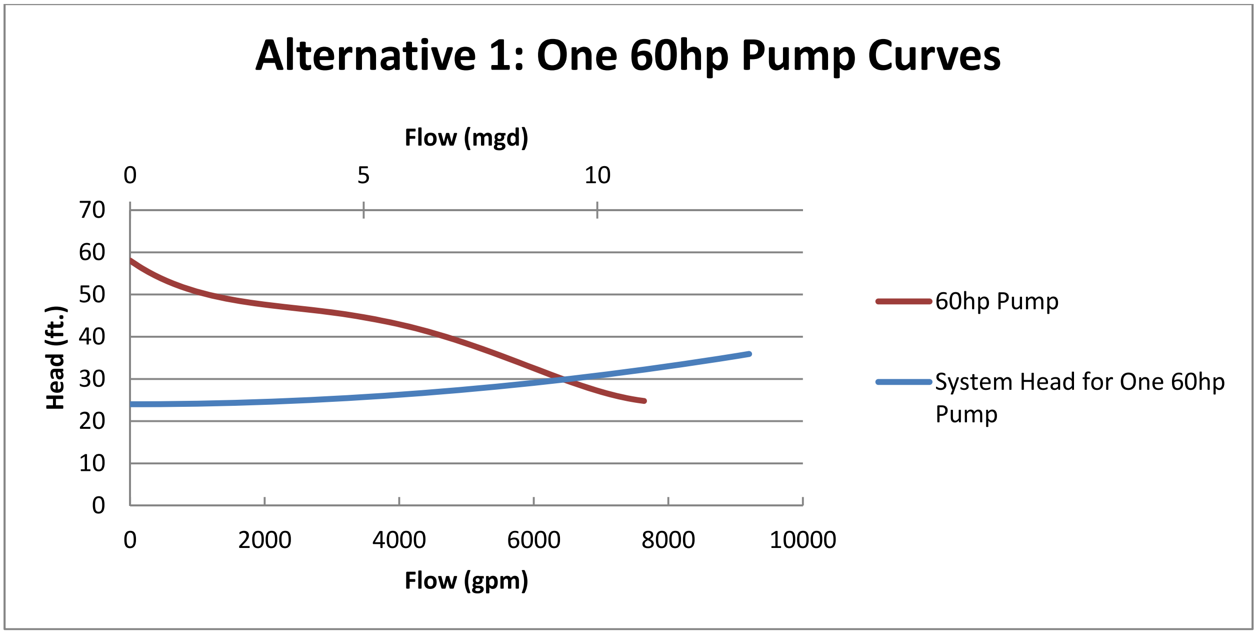
- Activated pumps were assumed to be those creating the greatest amount of loss (i.e., those farthest from the exit). This was done to create the most conservative model.
- The amount of flow handled by each individual pump is proportional to its horsepower rating. While a more accurate model would have been iterative in this respect, it was determined that an iterative model would take too long to create and would only be of minimal use.
- All pumps flowed at 885 rpm's for the 60 hp pumps and 880 rpm's for the 50 hp pumps. These values were not varied.
- Areas were calculated assuming that the pipes are always flowing full.

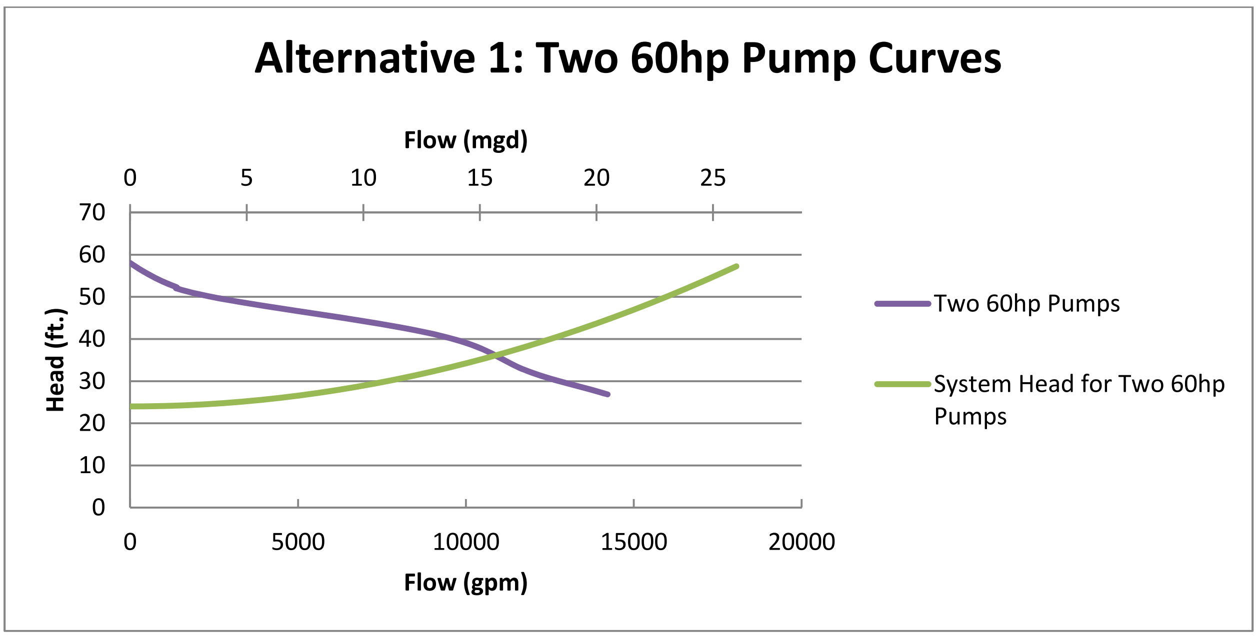
Other initial assumptions were made as follows:

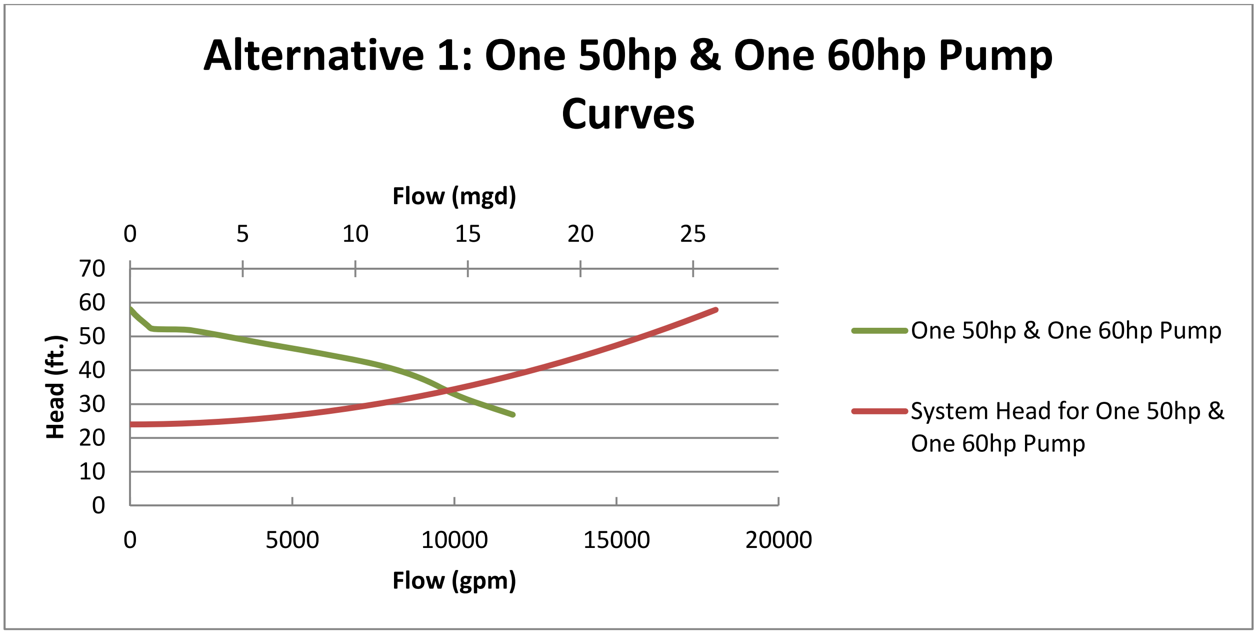
US El. =	4194	ft.
DS El. =	4218	ft.
ΔEl. =	24	ft.
g =	32.2	ft/s^2
D_{in} =	16	in
D_{50} =	10	in
D_{60} =	14	in
D_{valve} =	18	in
D_{pipe} =	30	in
Peak Influent		
Flow =	24	mgd
	16666.7	gpm

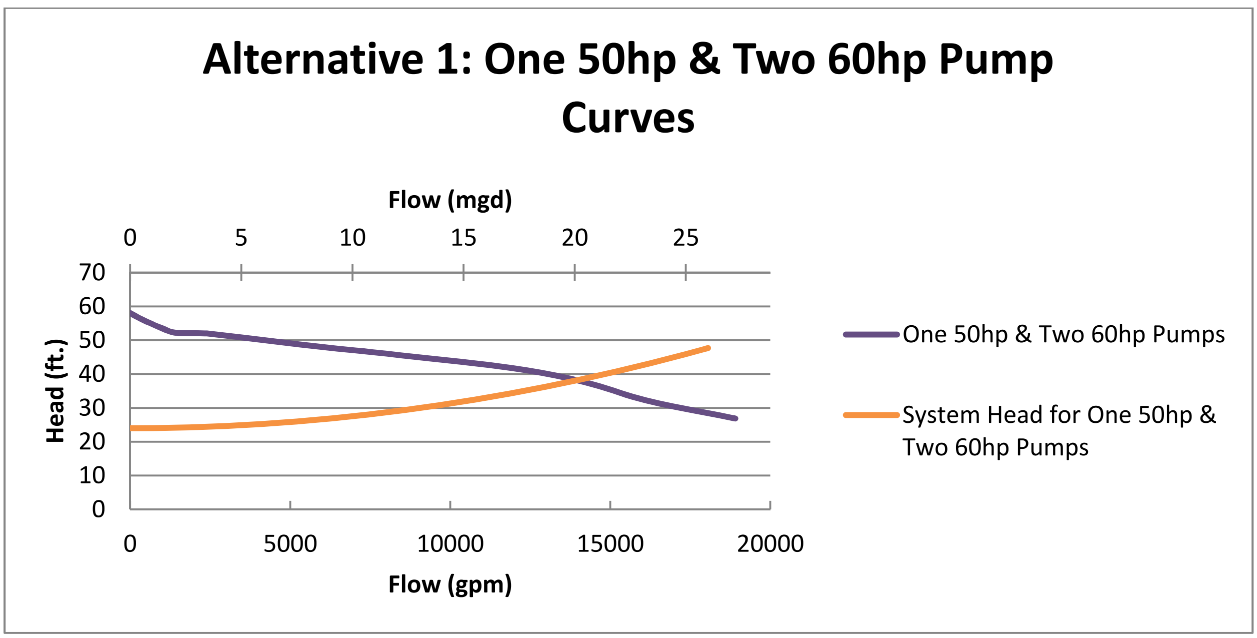

Alternative 1 Pump Curves (NP-PS1: Existing System)
Flow (mgd)
0
10
20
30
100
80
60
40
20
0
Head (ft.)
0
5000
10000
15000
20000
25000
Flow (gpm)
50hp Pump
60hp Pump
One 50hp & One 60hp Pump
One 50hp & Two 60hp Pumps
Three 60hp Pumps
One 50hp & Three 60hp Pumps
Two 60hp Pumps

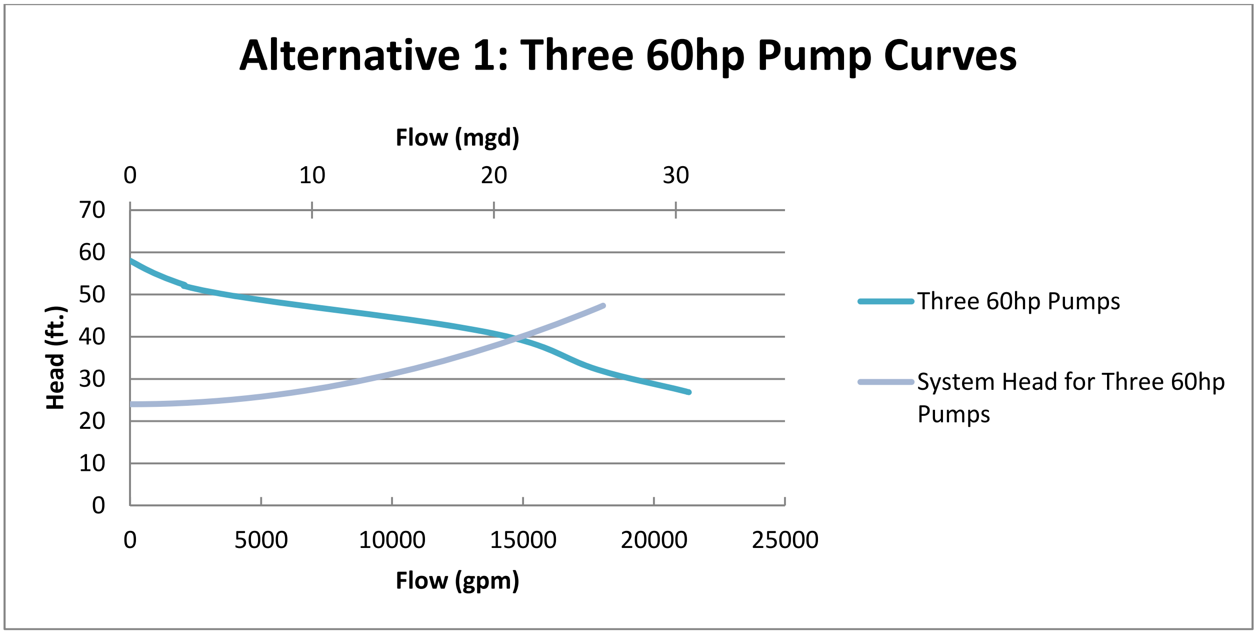

Alternative 1: One 50hp Pump Curves
Flow (mgd)
0
2
4
6
8
10
60
50
40
30
20
10
0
Head (ft.)
0
1000
2000
3000
4000
5000
6000
7000
Flow (gpm)
50hp Pump
System Head for One 50hp Pump

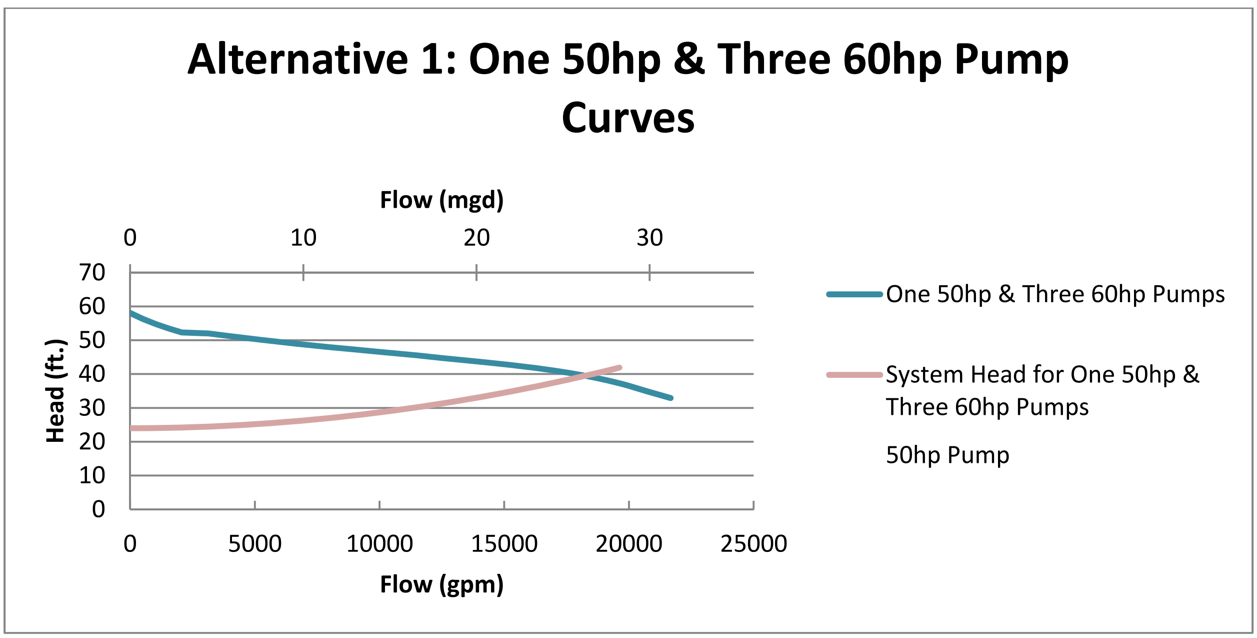

Alternative 1: One 60hp Pump Curves
Flow (mgd)
0
5
10
70
60
50
40
30
20
10
0
Head (ft.)
0
2000
4000
6000
8000
10000
Flow (gpm)
60hp Pump
System Head for One 60hp Pump


Alternative 1: Two 60hp Pump Curves
Flow (mgd)
0
5
10
15
20
25
70
60
50
40
30
20
10
0
Head (ft.)
0
5000
10000
15000
20000
Flow (gpm)
Two 60hp Pumps
System Head for Two 60hp Pumps


Alternative 1: One 50hp & One 60hp Pump Curves
Flow (mgd)
0 5 10 15 20 25
Head (ft.)
70 60 50 40 30 20 10 0
0 5000 10000 15000 20000
Flow (gpm)
One 50hp & One 60hp Pump
System Head for One 50hp & One 60hp Pump


Alternative 1: One 50hp & Two 60hp Pump Curves
Flow (mgd)
0 5 10 15 20 25
Head (ft.)
70 60 50 40 30 20 10 0
0 5000 10000 15000 20000
Flow (gpm)
One 50hp & Two 60hp Pumps
System Head for One 50hp & Two 60hp Pumps


Alternative 1: Three 60hp Pump Curves
Flow (mgd)
0
10
20
30
70
60
50
40
30
20
10
0
Head (ft.)
0
5000
10000
15000
20000
25000
Flow (gpm)
Three 60hp Pumps
System Head for Three 60hp Pumps


Alternative 1: One 50hp & Three 60hp Pump Curves
Flow (mgd)
0
10
20
30
70
60
50
40
30
20
10
0
Head (ft.)
0
5000
10000
15000
20000
25000
Flow (gpm)
One 50hp & Three 60hp Pumps
System Head for One 50hp & Three 60hp Pumps
50hp Pump

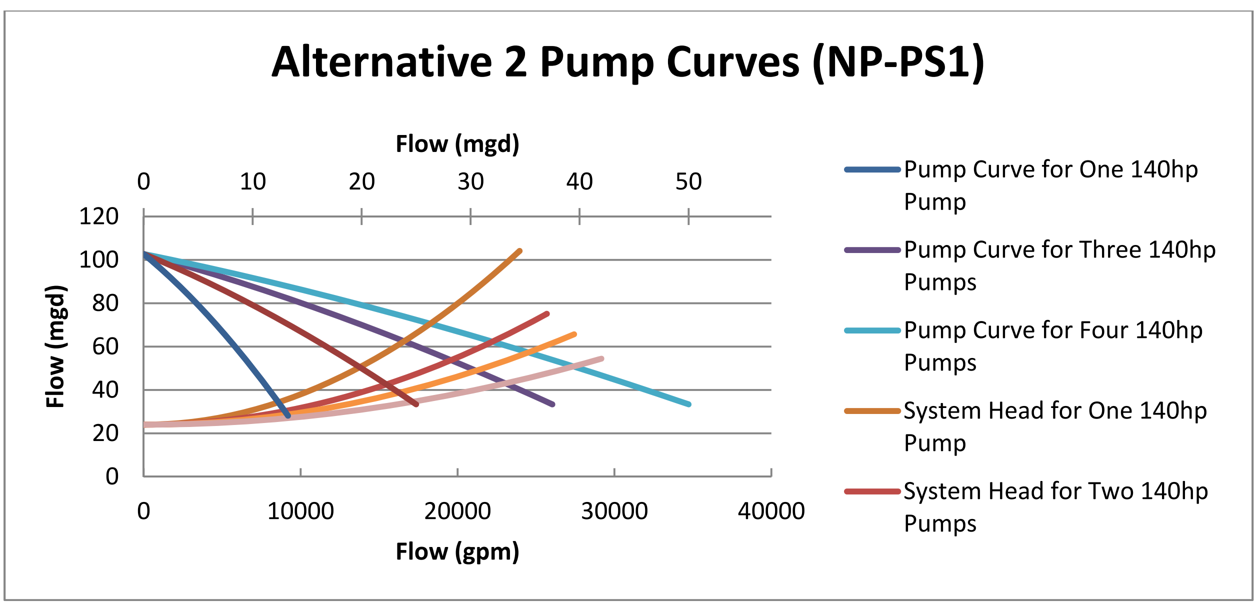
NP-PS1 Alternative 2: Four That Fit

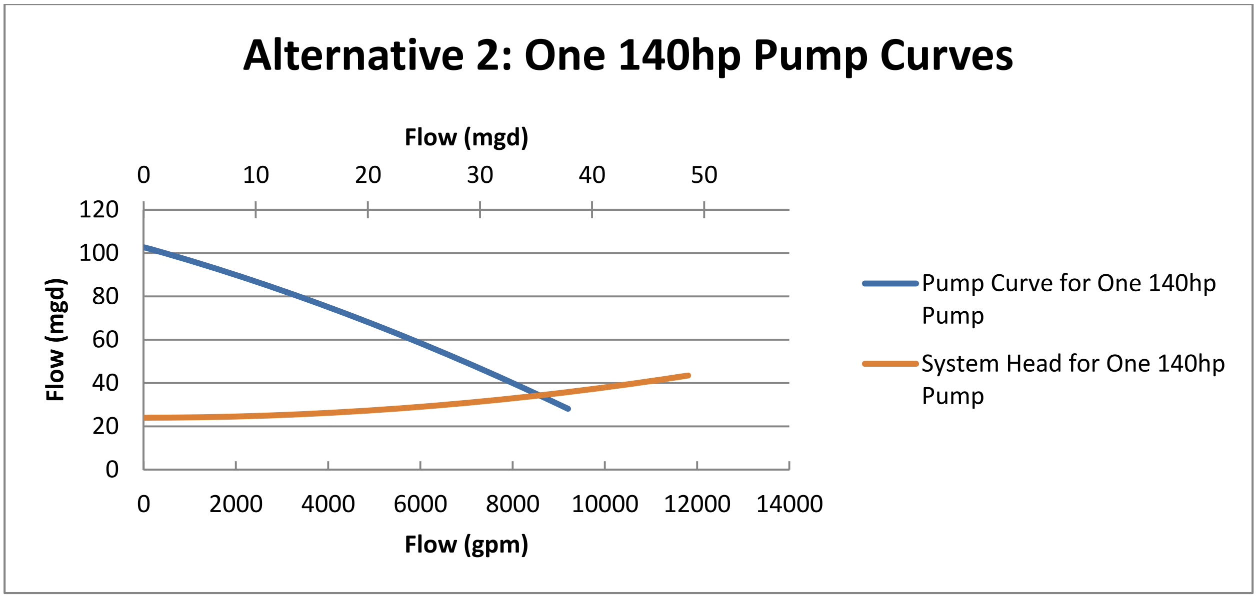
Alternative system assumptions were as follows:

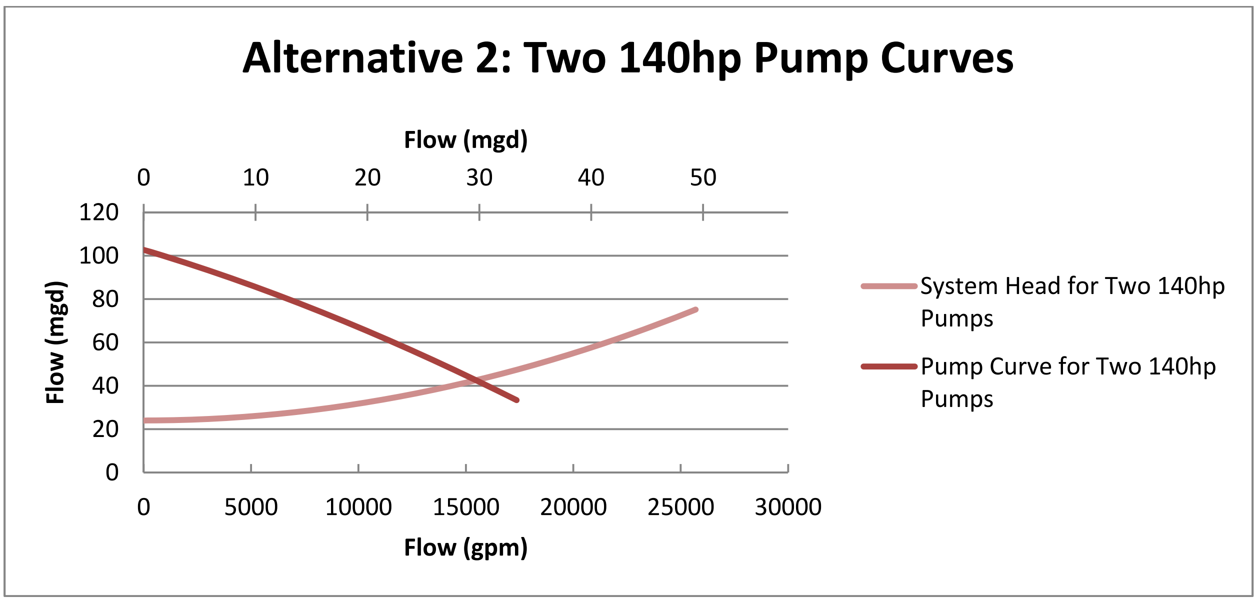
- Activated pumps were assumed to be those creating the greatest amount of loss (i.e., those farthest from the exit). This was done to create the most conservative model.
- Areas were calculated assuming that the pipes are always flowing full.

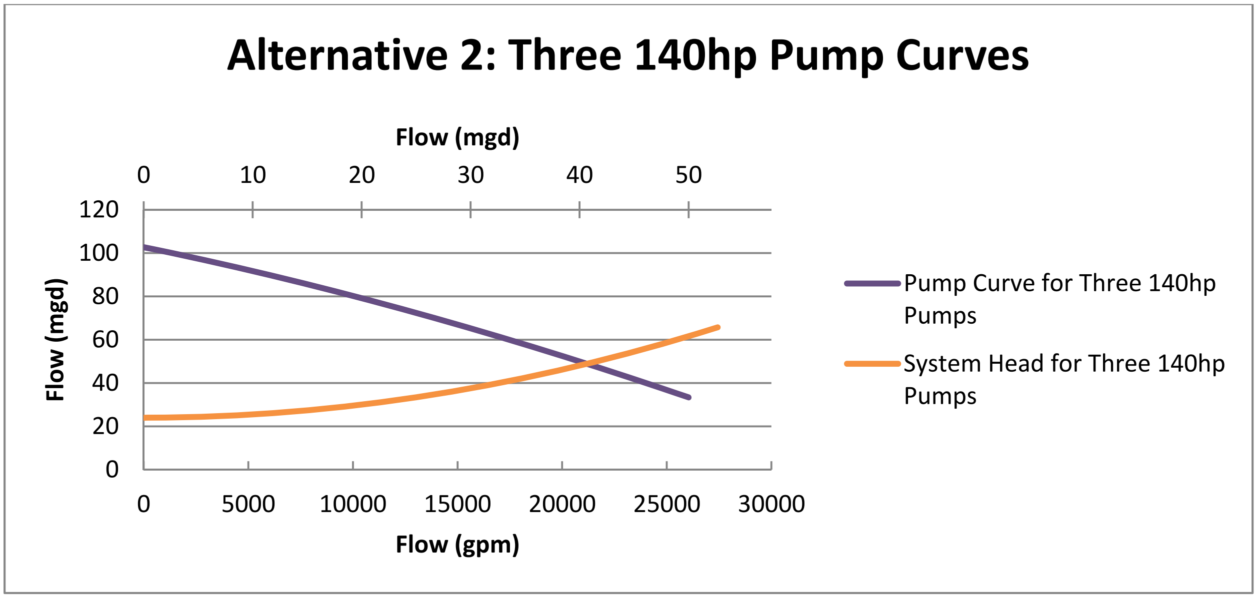
Other assumptions were made as follows:

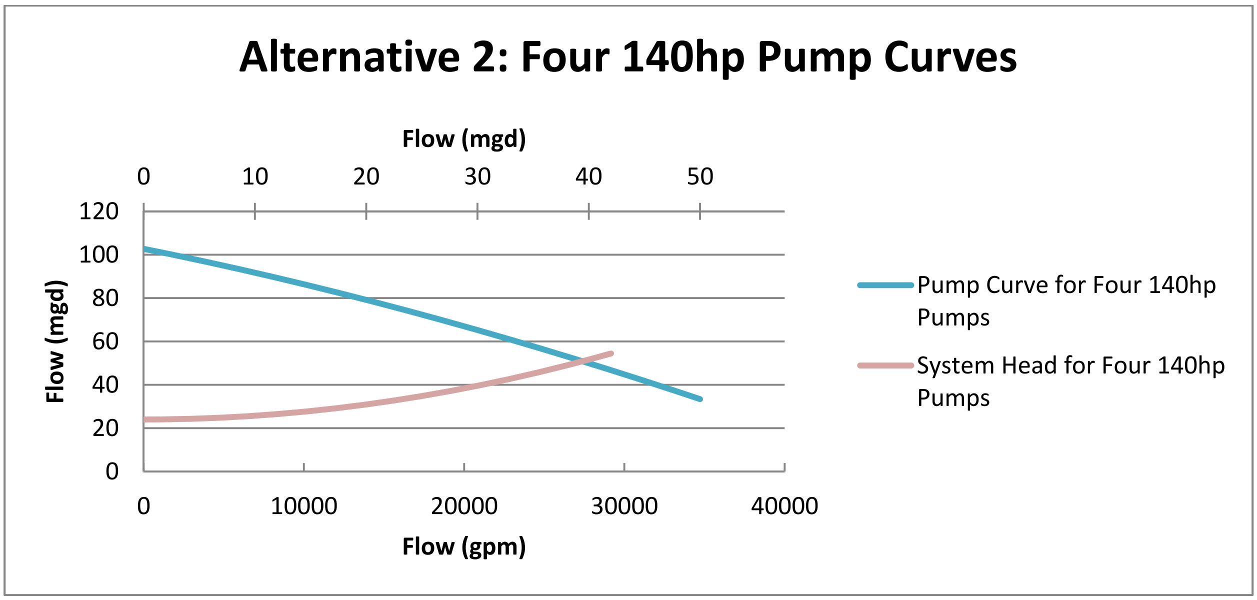
US El. =	4194	ft.
DS El. =	4218	ft.
ΔEl. =	24	
g =	32.2	ft/s^2
D_{in} =	16	in
D_1 =	16	in
D_2 =	14	in
D_{out} =	18	in
D_{pipe} =	30	in
Peak Flow =	28	mgd
	19444.44	gpm




Alternative 2: One 140hp Pump Curves
Flow (mgd)
0
10
20
30
40
50
120
100
80
60
40
20
0
Flow (mgd)
0
2000
4000
6000
8000
10000
12000
14000
Flow (gpm)
Pump Curve for One 140hp Pump
System Head for One 140hp Pump


Alternative 2: Two 140hp Pump Curves
Flow (mgd)
0
10
20
30
40
50
120
100
80
60
40
20
0
Flow (mgd)
0
5000
10000
15000
20000
25000
30000
Flow (gpm)
System Head for Two 140hp Pumps
Pump Curve for Two 140hp Pumps


Alternative 2: Three 140hp Pump Curves
Flow (mgd)
0
10
20
30
40
50
120
100
80
60
40
20
0
Flow (mgd)
0
5000
10000
15000
20000
25000
30000
Flow (gpm)
Pump Curve for Three 140hp Pumps
System Head for Three 140hp Pumps


Alternative 2: Four 140hp Pump Curves
Flow (mgd)
0
10
20
30
40
50
120
100
80
60
40
20
0
Flow (mgd)
0
10000
20000
30000
40000
Flow (gpm)
Pump Curve for Four 140hp Pumps
System Head for Four 140hp Pumps

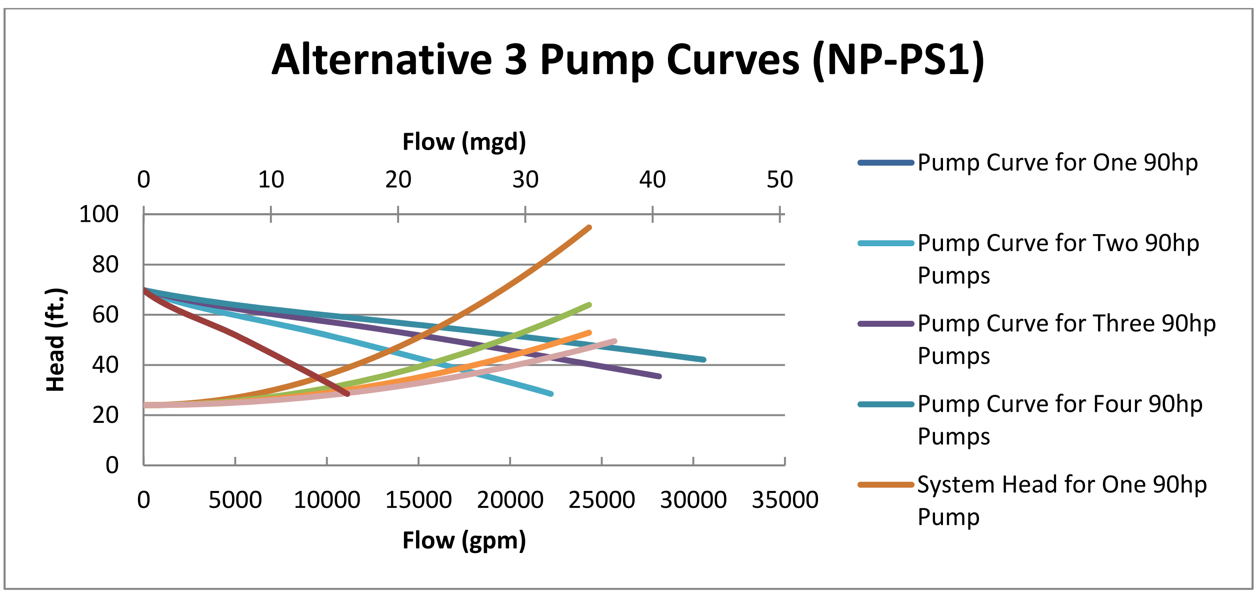
NP-PS1 Alternative 3: Four That Squeeze

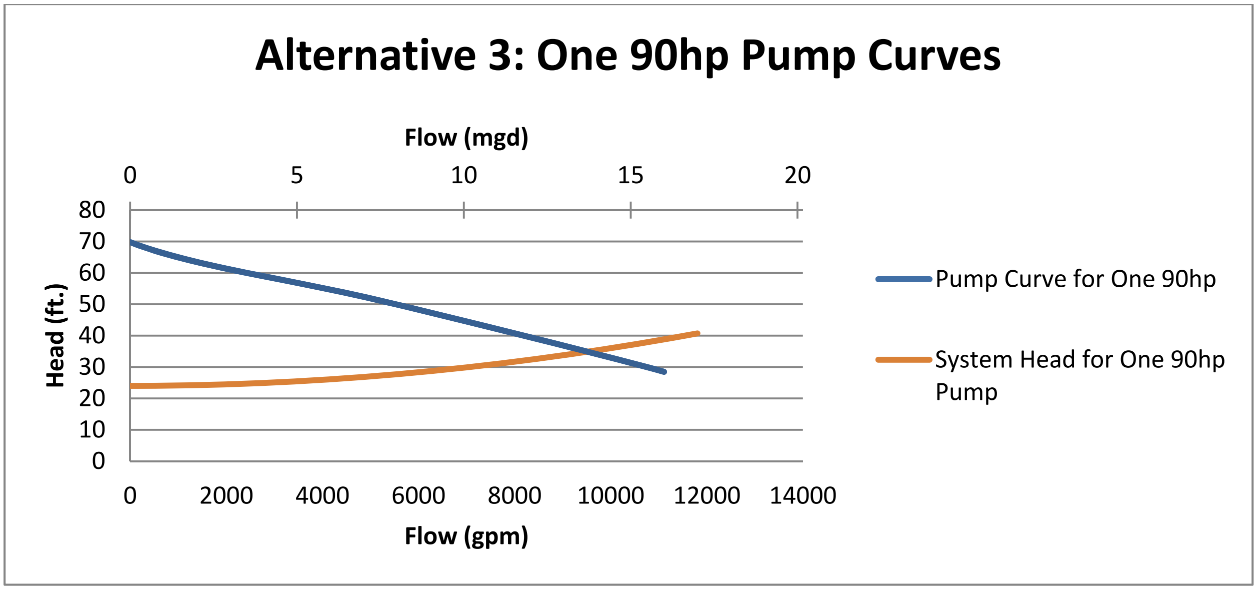
Alternative system assumptions were as follows:

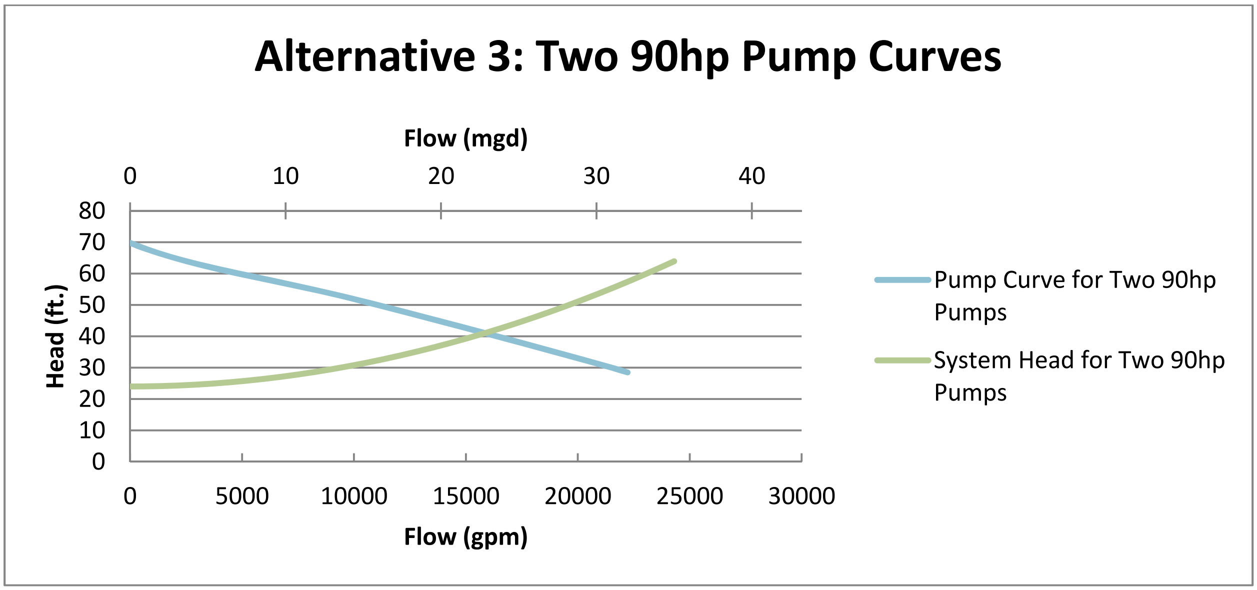
- Activated pumps were assumed to be those creating the greatest amount of loss (i.e., those farthest from the exit). This was done to create the most conservative model.
- Areas were calculated assuming that the pipes are always flowing full.

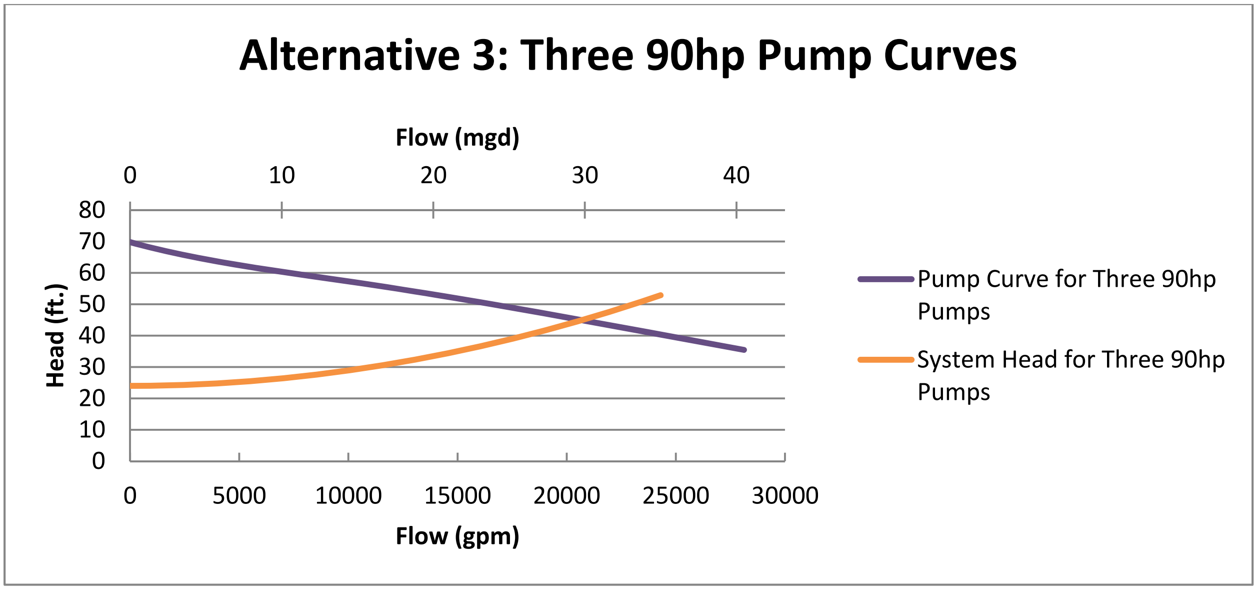
Other assumptions were made as follows:

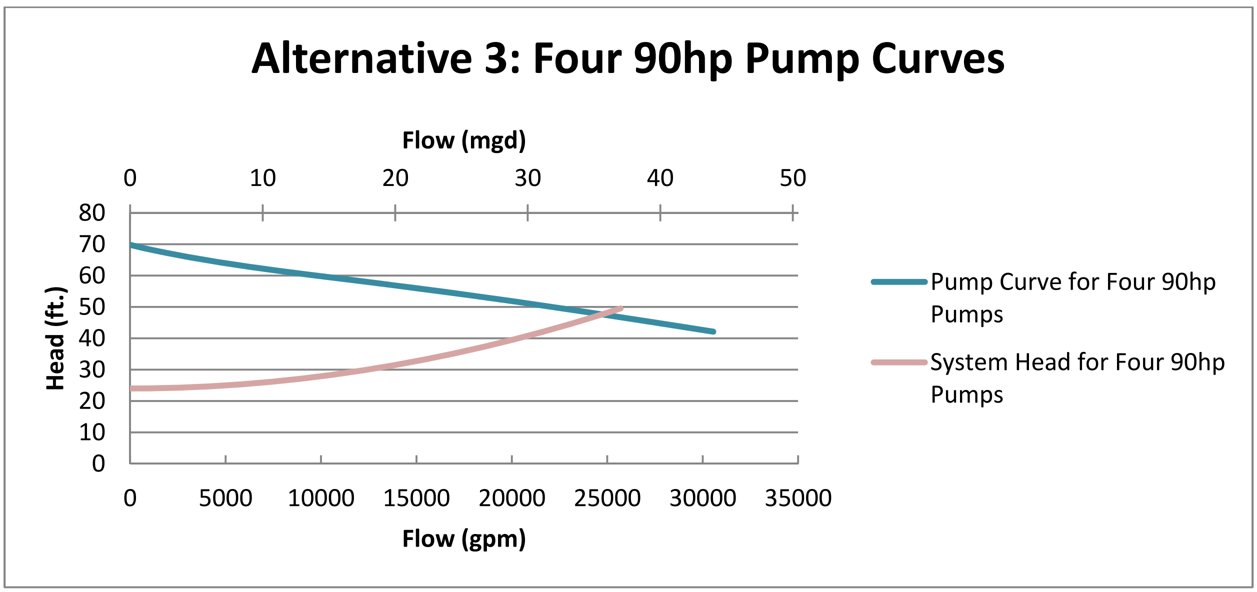
US El. =	4194	ft.
DS El. =	4218	ft.
ΔEl. =	24	
g =	32.2	ft/s^2
D_{in} =	20	in
D_{1in} =	20	in
D_1 =	16	in
D_2 =	16	in
D_{out} =	18	in
D_{pipe} =	30	in
Peak Flow =	28	mgd
	19444.44	gpm




Alternative 3: One 90hp Pump Curves
Flow (mgd)
0
5
10
15
20
80
70
60
50
40
30
20
10
0
Head (ft.)
0
2000
4000
6000
8000
10000
12000
14000
Flow (gpm)
Pump Curve for One 90hp
System Head for One 90hp Pump


Alternative 3: Two 90hp Pump Curves
Flow (mgd)
0
10
20
30
40
80
70
60
50
40
30
20
10
0
Head (ft.)
0
5000
10000
15000
20000
25000
30000
Flow (gpm)
Pump Curve for Two 90hp Pumps
System Head for Two 90hp Pumps


Alternative 3: Three 90hp Pump Curves
Flow (mgd)
0
10
20
30
40
Head (ft.)
80
70
60
50
40
30
20
10
0
0
5000
10000
15000
20000
25000
30000
Flow (gpm)
Pump Curve for Three 90hp Pumps
System Head for Three 90hp Pumps

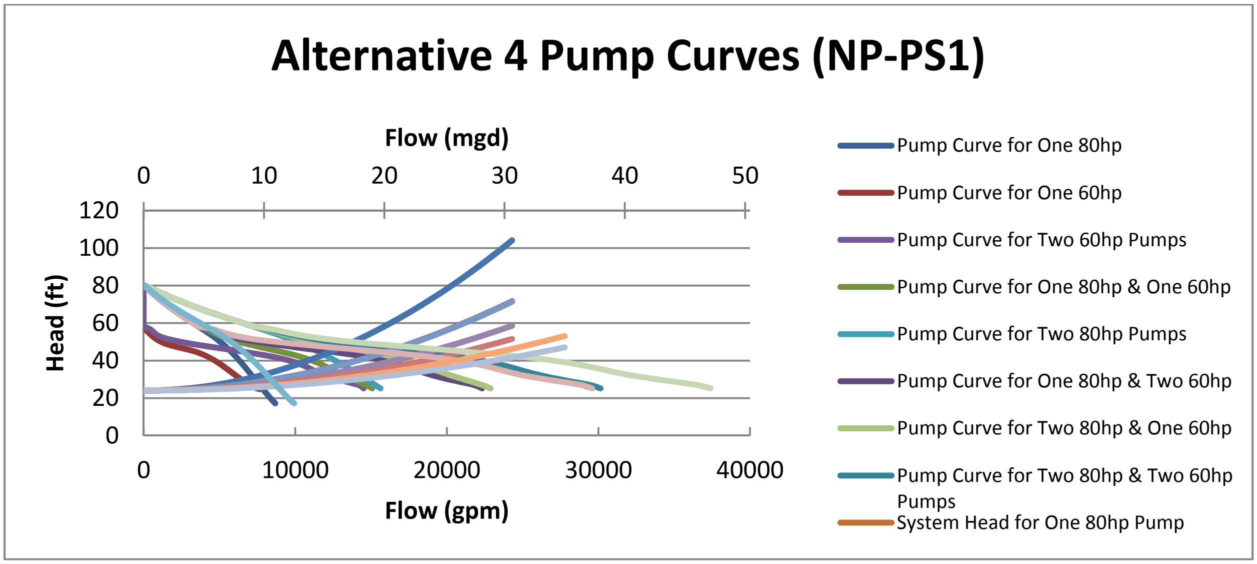

Alternative 3: Four 90hp Pump Curves
Flow (mgd)
0
10
20
30
40
50
Head (ft.)
80
70
60
50
40
30
20
10
0
0
5000
10000
15000
20000
25000
30000
35000
Flow (gpm)
Pump Curve for Four 90hp Pumps
System Head for Four 90hp Pumps

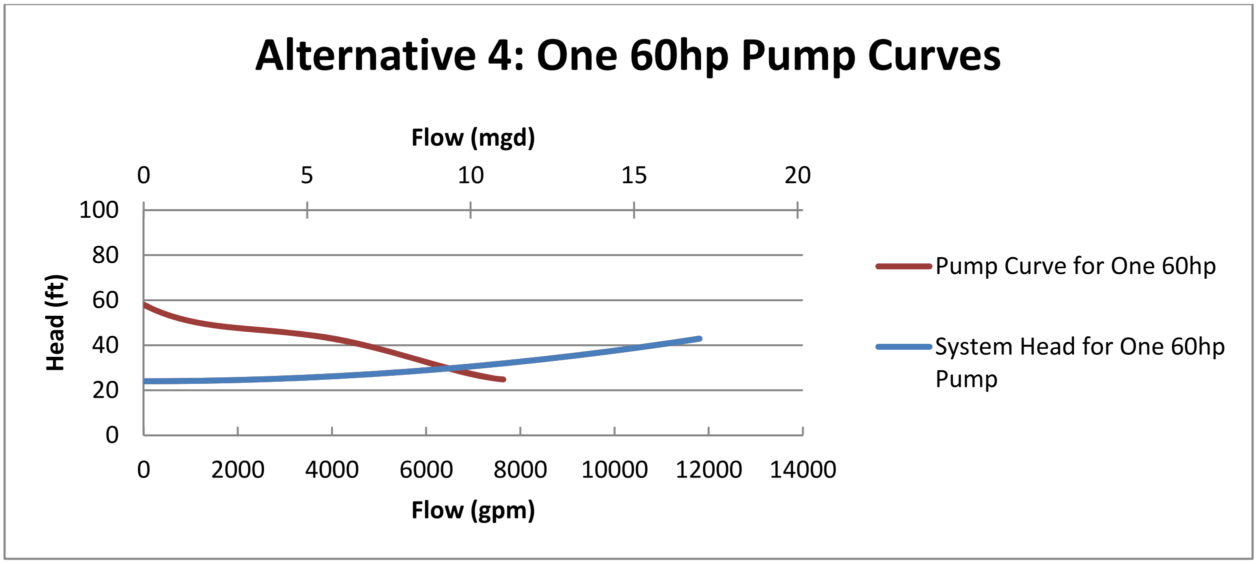
NP-PS1 Alternative 4: Five Pump System
Alternative system assumptions were as follows:

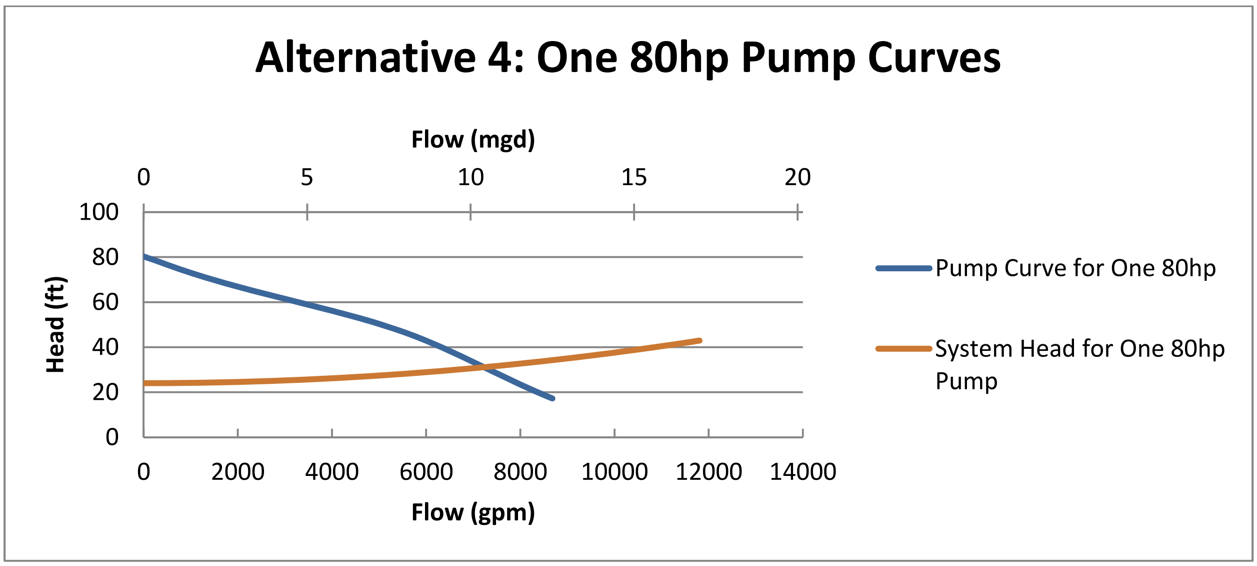
- Activated pumps were assumed to be those creating the greatest amount of loss (i.e., those farthest from the exit). This was done to create the most conservative model.
- Areas were calculated assuming that the pipes are always flowing full.

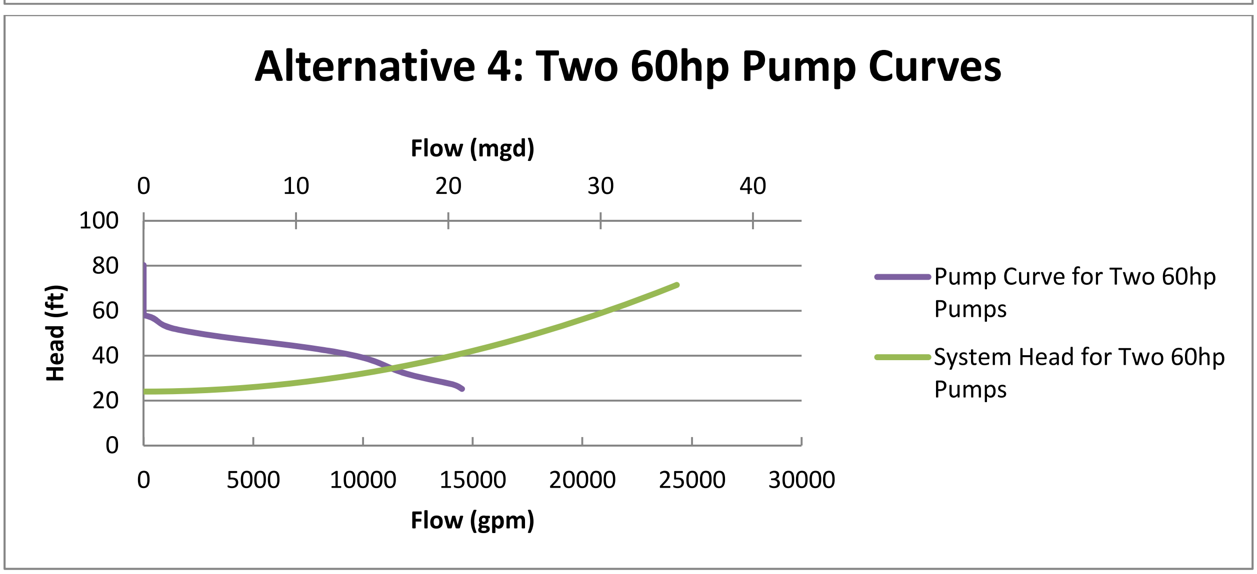
Other assumptions were made as follows:

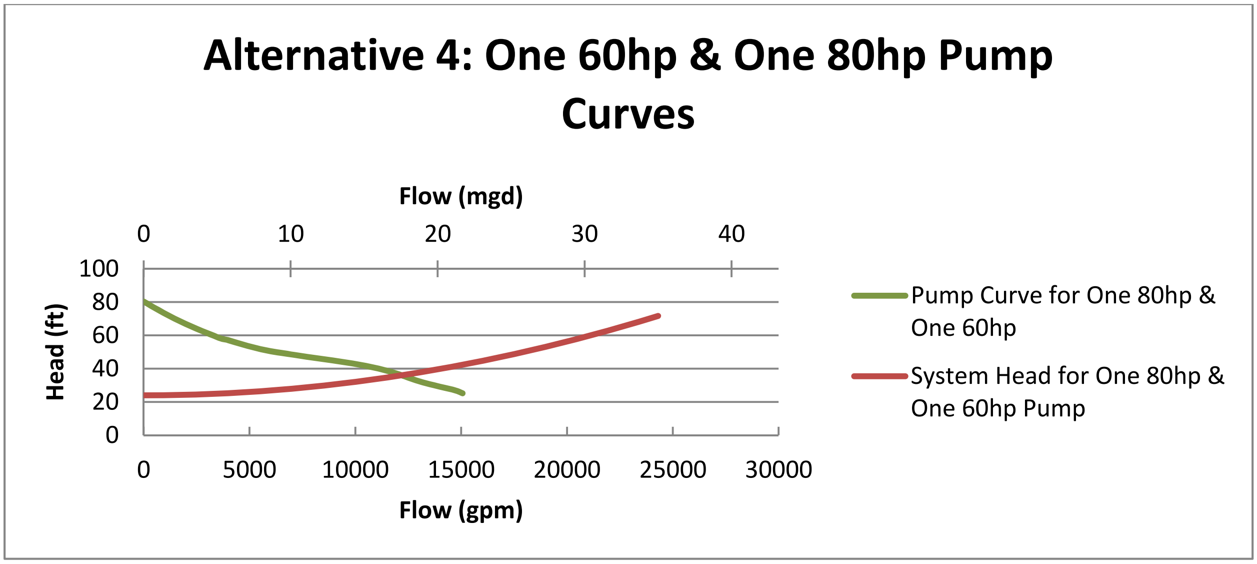
US El. =	4194	ft.
DS El. =	4218	ft.
ΔEl. =	24	
g =	32.2	ft/s^2
D_{in} =	16	in
D_{1in} =	16	in
D_1 =	14	in
D_2 =	14	in
D_{out} =	18	in
D_{pipe} =	30	in
Peak Flow =	28	mgd
	19444.44	gpm

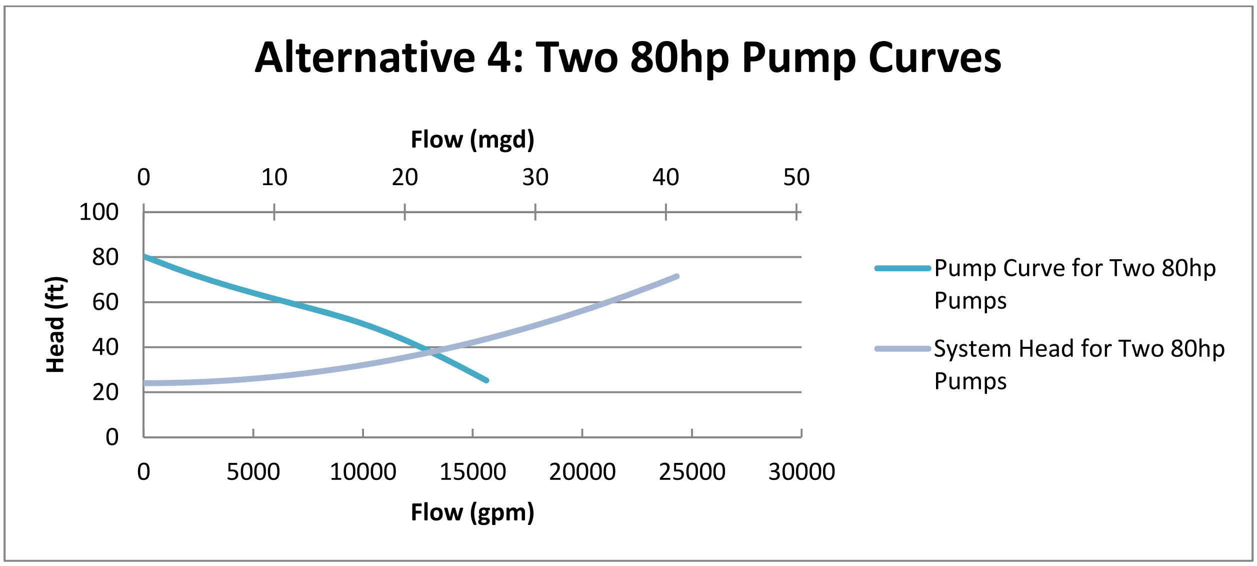


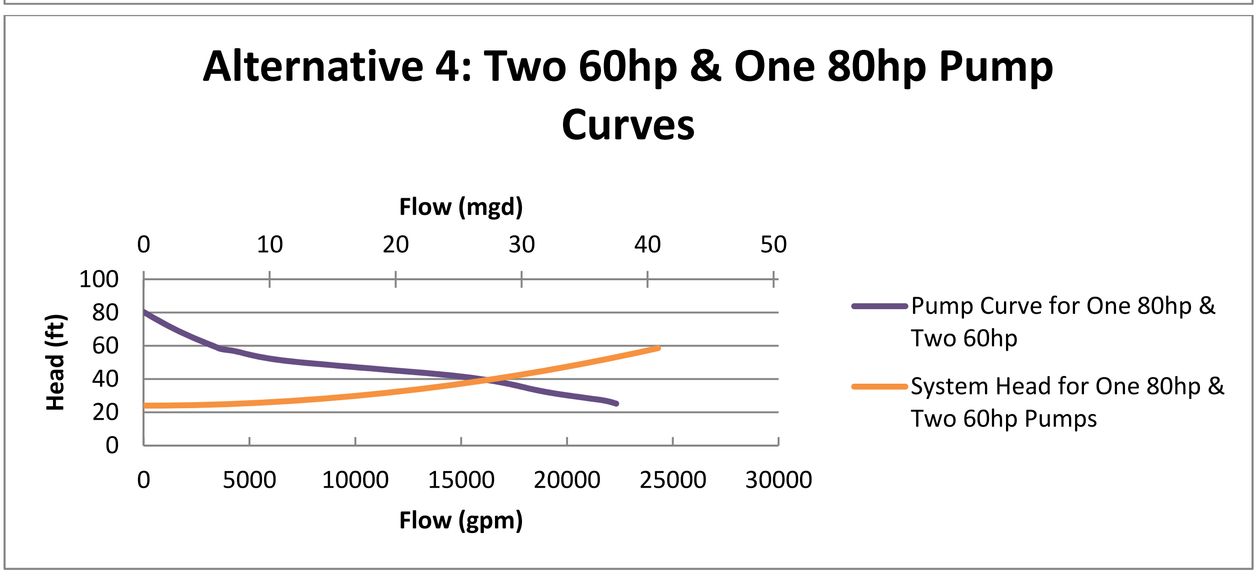

Alternative 4: One 60hp Pump Curves
Flow (mgd)
0
5
10
15
20
100
80
60
40
20
0
Head (ft)
0
2000
4000
6000
8000
10000
12000
14000
Flow (gpm)
Pump Curve for One 60hp
System Head for One 60hp Pump

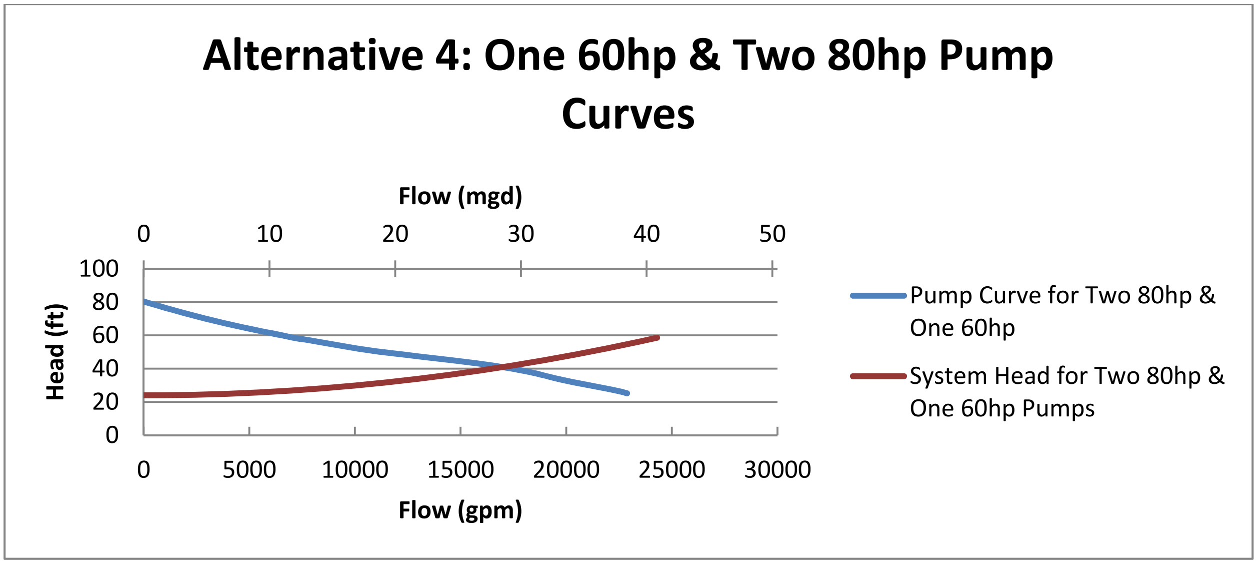

Alternative 4: One 80hp Pump Curves
Flow (mgd)
0
5
10
15
20
100
80
60
40
20
0
Head (ft)
0
2000
4000
6000
8000
10000
12000
14000
Flow (gpm)
Pump Curve for One 80hp
System Head for One 80hp Pump

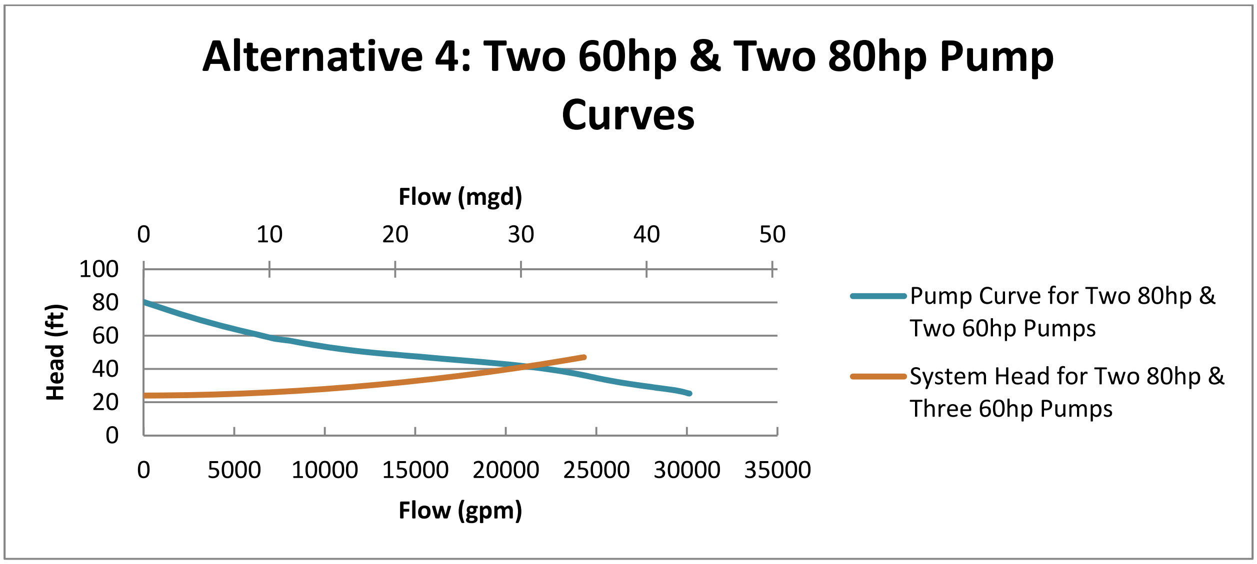

Alternative 4: Two 60hp Pump Curves
Flow (mgd)
0
10
20
30
40
100
80
60
40
20
0
Head (ft)
0
5000
10000
15000
20000
25000
30000
Flow (gpm)
Pump Curve for Two 60hp Pumps
System Head for Two 60hp Pumps

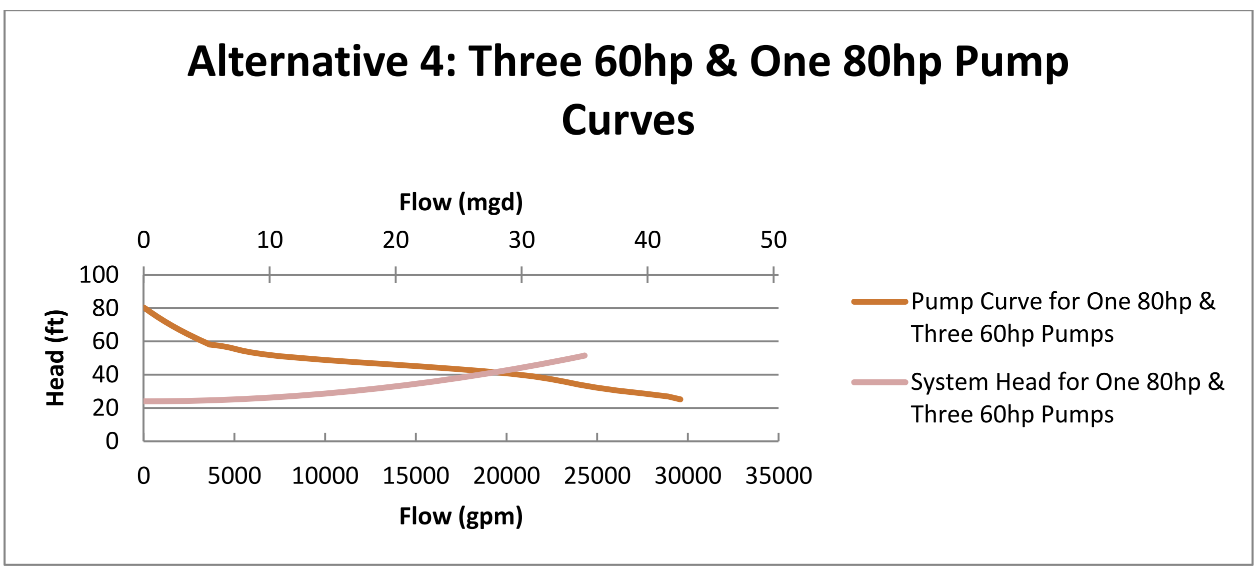

Alternative 4: One 60hp & One 80hp Pump Curves
Flow (mgd)
0
10
20
30
40
100
80
60
40
20
0
Head (ft)
0
5000
10000
15000
20000
25000
30000
Flow (gpm)
Pump Curve for One 80hp & One 60hp
System Head for One 80hp & One 60hp Pump

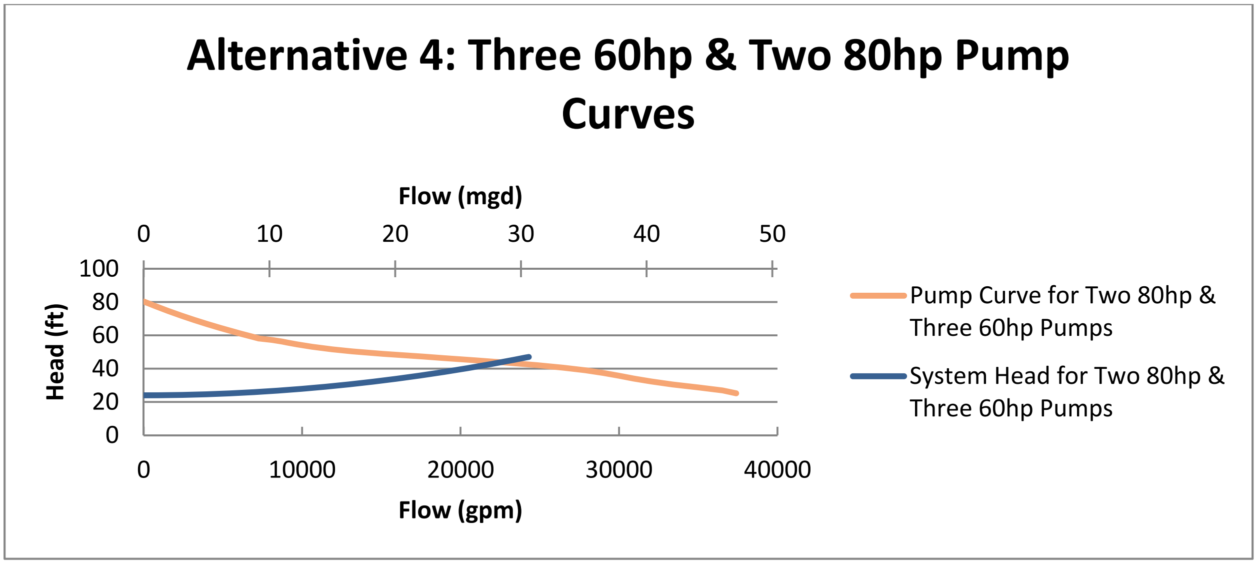

Alternative 4: Two 80hp Pump Curves
Flow (mgd)
0
10
20
30
40
50
100
80
60
40
20
0
Head (ft)
0
5000
10000
15000
20000
25000
30000
Flow (gpm)
Pump Curve for Two 80hp Pumps
System Head for Two 80hp Pumps


Alternative 4: Two 60hp & One 80hp Pump Curves
Flow (mgd)
0
10
20
30
40
50
100
80
60
40
20
0
Head (ft)
0
5000
10000
15000
20000
25000
30000
Flow (gpm)
Pump Curve for One 80hp & Two 60hp
System Head for One 80hp & Two 60hp Pumps


Alternative 4: One 60hp & Two 80hp Pump Curves
Flow (mgd)
0
10
20
30
40
50
Head (ft)
100
80
60
40
20
0
0
5000
10000
15000
20000
25000
30000
Flow (gpm)
Pump Curve for Two 80hp & One 60hp
System Head for Two 80hp & One 60hp Pumps


Alternative 4: Two 60hp & Two 80hp Pump Curves
Flow (mgd)
0
10
20
30
40
50
Head (ft)
100
80
60
40
20
0
0
5000
10000
15000
20000
25000
30000
35000
Flow (gpm)
Pump Curve for Two 80hp & Two 60hp Pumps
System Head for Two 80hp & Three 60hp Pumps


Alternative 4: Three 60hp & One 80hp Pump Curves
Flow (mgd)
0
10
20
30
40
50
Head (ft)
100
80
60
40
20
0
0
5000
10000
15000
20000
25000
30000
35000
Flow (gpm)
Pump Curve for One 80hp & Three 60hp Pumps
System Head for One 80hp & Three 60hp Pumps


Alternative 4: Three 60hp & Two 80hp Pump Curves
Flow (mgd)
0
10
20
30
40
50
100
80
60
40
20
0
Head (ft)
0
10000
20000
30000
40000
Flow (gpm)
Pump Curve for Two 80hp & Three 60hp Pumps
System Head for Two 80hp & Three 60hp Pumps

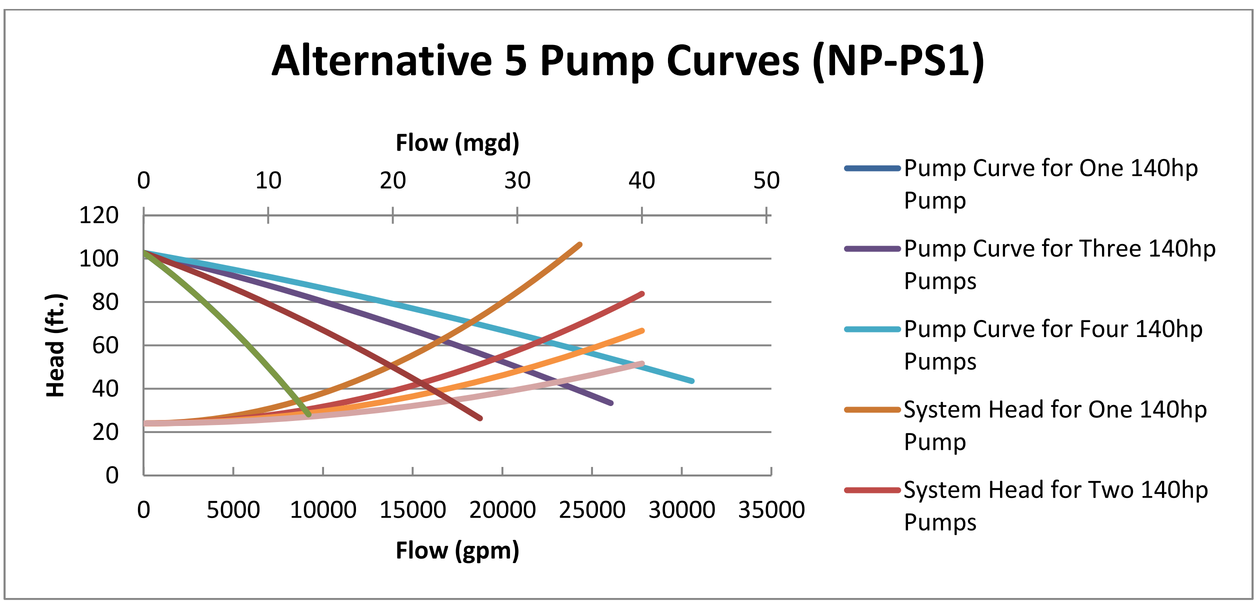
NP-PS1 Alternative 5: Four That Fit (70hp)

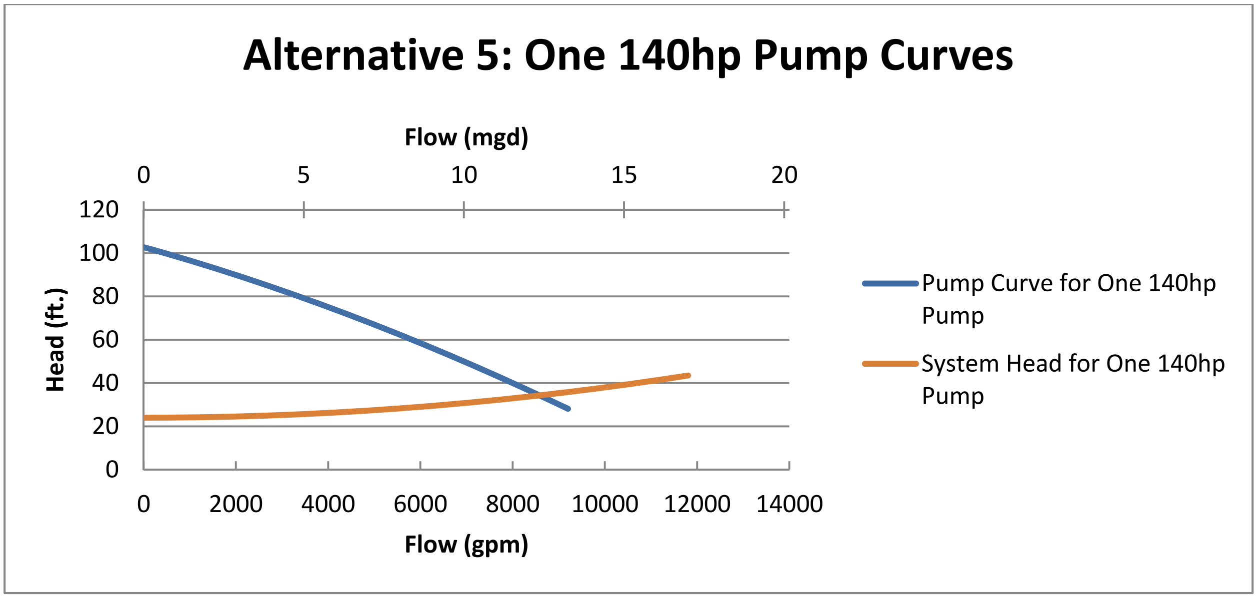
Alternative system assumptions were as follows:

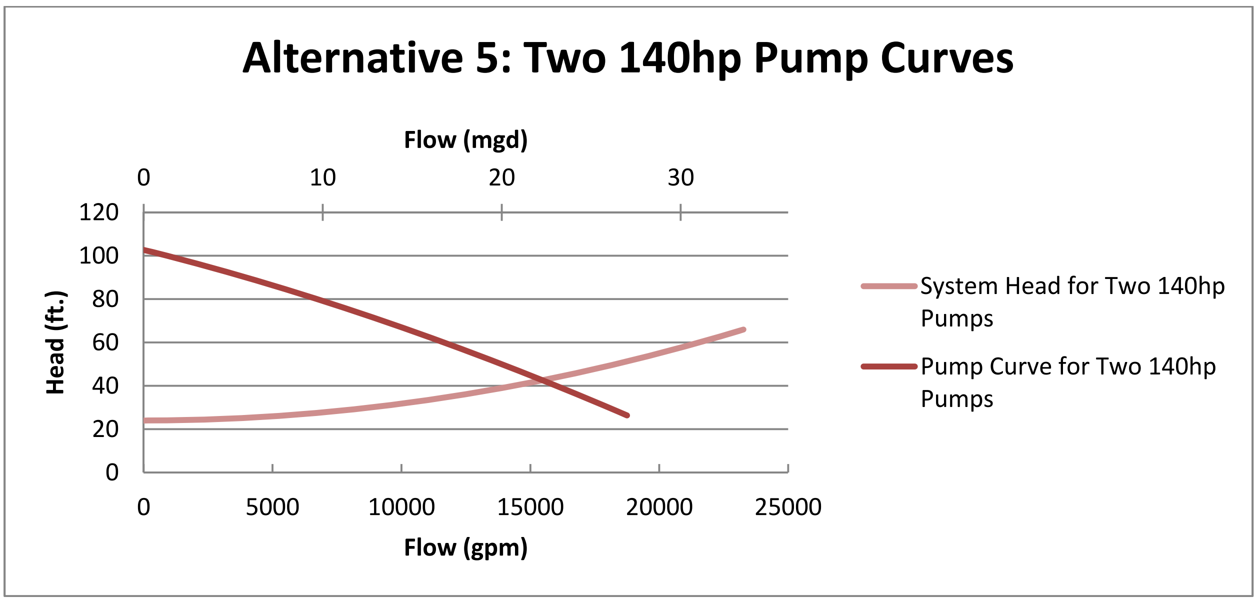
- Activated pumps were assumed to be those creating the greatest amount of loss (i.e., those farthest from the exit). This was done to create the most conservative model.
- Areas were calculated assuming that the pipes are always flowing full.

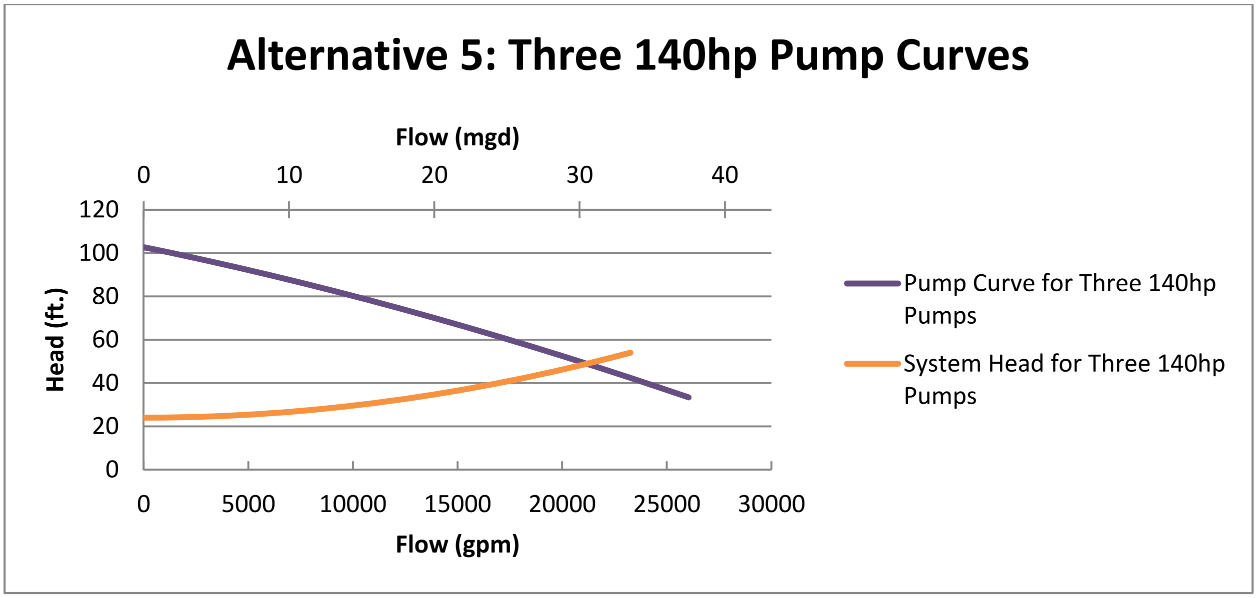
Other assumptions were made as follows:

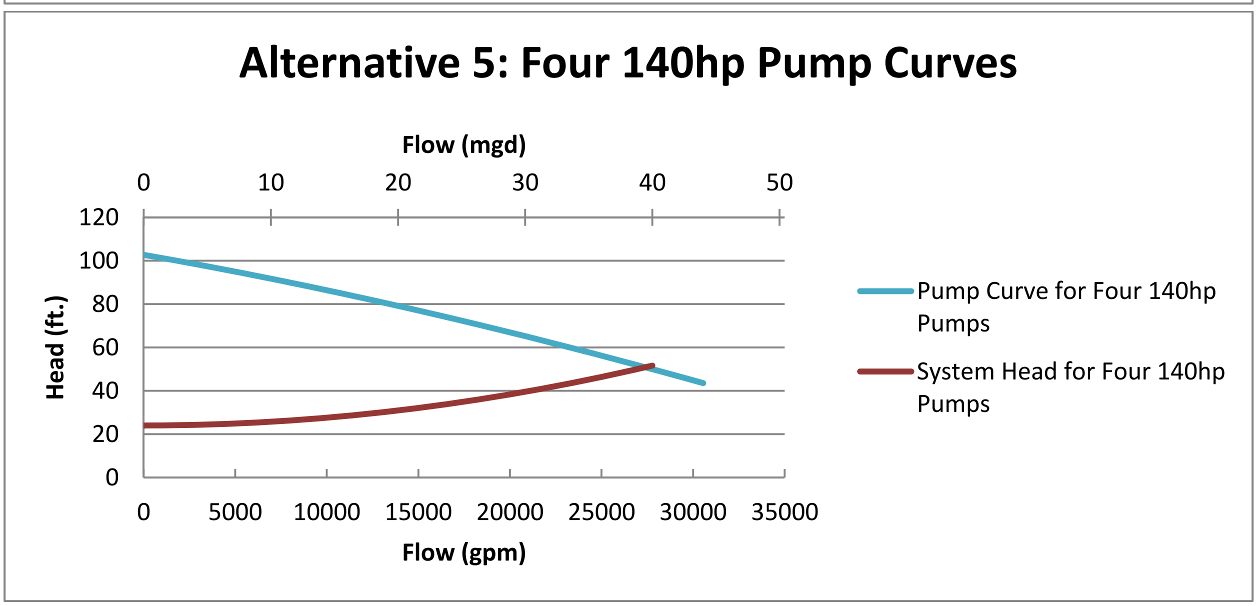
US El. =	4194	ft.
DS El. =	4218	ft.
ΔEl. =	24	
g =	32.2	ft/s^2
D_{in} =	16	in
D_1 =	14	in
D_2 =	14	in
D_{out} =	18	in
D_{pipe} =	30	in
Peak Flow =	28	mgd
	19444.44	gpm




Alternative 5: One 140hp Pump Curves
Flow (mgd)
0
5
10
15
20
120
100
80
60
40
20
0
Head (ft.)
0
2000
4000
6000
8000
10000
12000
14000
Flow (gpm)
Pump Curve for One 140hp Pump
System Head for One 140hp Pump


Alternative 5: Two 140hp Pump Curves
Flow (mgd)
0
10
20
30
120
100
80
60
40
20
0
Head (ft.)
0
5000
10000
15000
20000
25000
Flow (gpm)
System Head for Two 140hp Pumps
Pump Curve for Two 140hp Pumps


Alternative 5: Three 140hp Pump Curves
Flow (mgd)
0
10
20
30
40
120
100
80
60
40
20
0
Head (ft.)
0
5000
10000
15000
20000
25000
30000
Flow (gpm)
Pump Curve for Three 140hp Pumps
System Head for Three 140hp Pumps


Alternative 5: Four 140hp Pump Curves
Flow (mgd)
0
10
20
30
40
50
120
100
80
60
40
20
0
Head (ft.)
0
5000
10000
15000
20000
25000
30000
35000
Flow (gpm)
Pump Curve for Four 140hp Pumps
System Head for Four 140hp Pumps

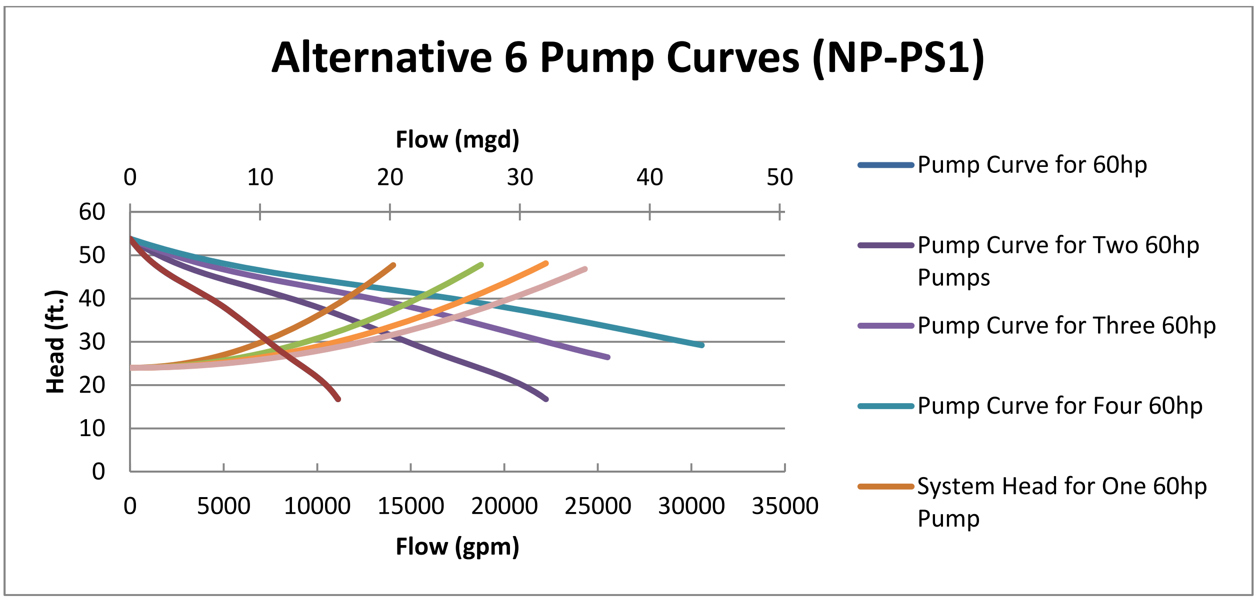
NP-PS1 Alternative 6: Four That Squeeze (60hp)

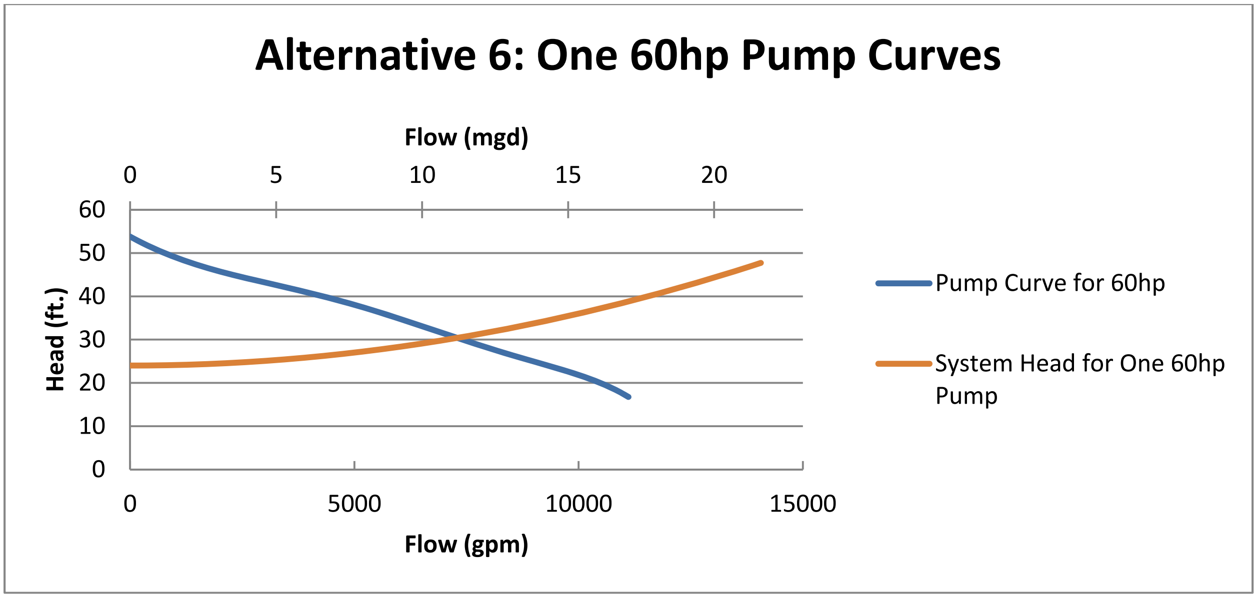
Alternative system assumptions were as follows:

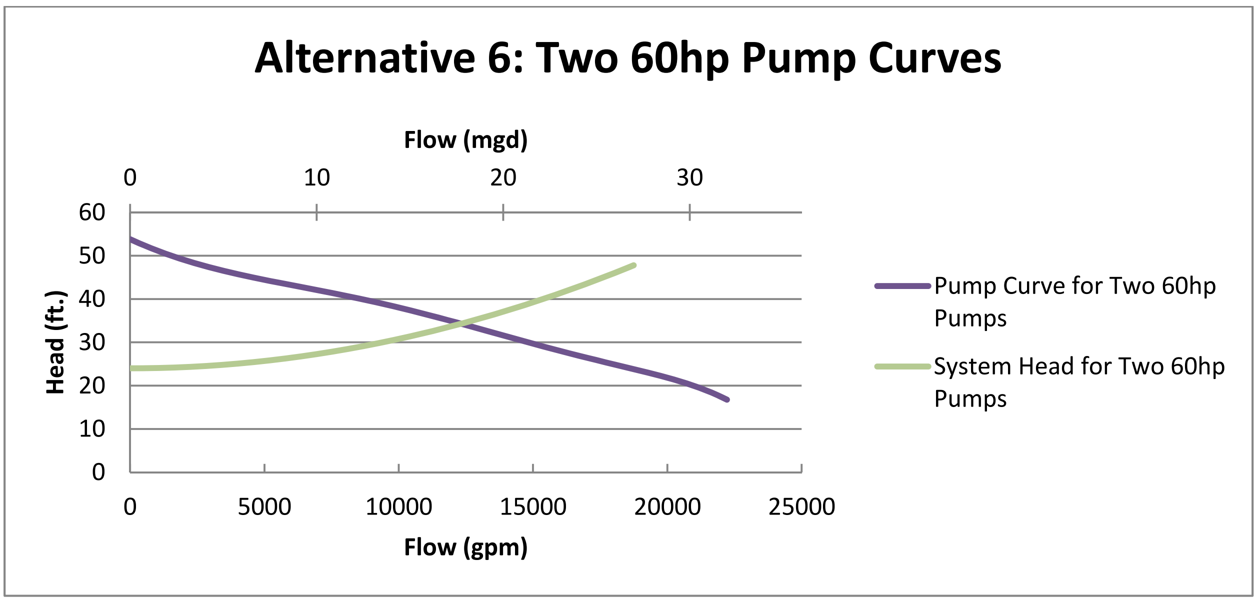
- Activated pumps were assumed to be those creating the greatest amount of loss (i.e., those farthest from the exit). This was done to create the most conservative model.
- Areas were calculated assuming that the pipes are always flowing full.

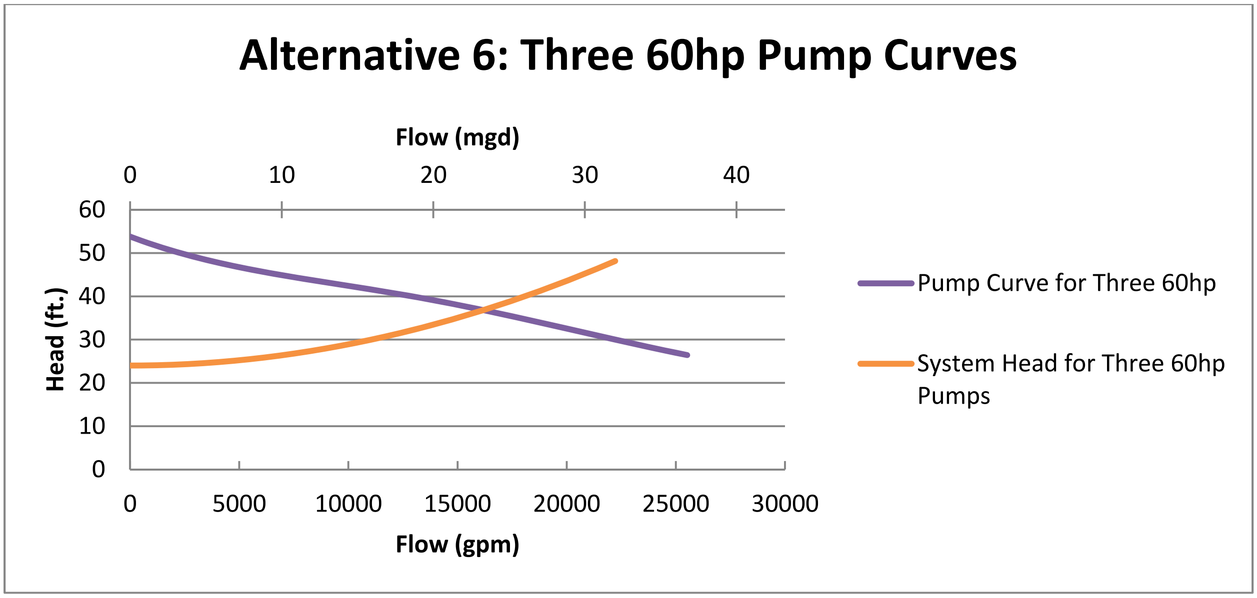
Other assumptions were made as follows:

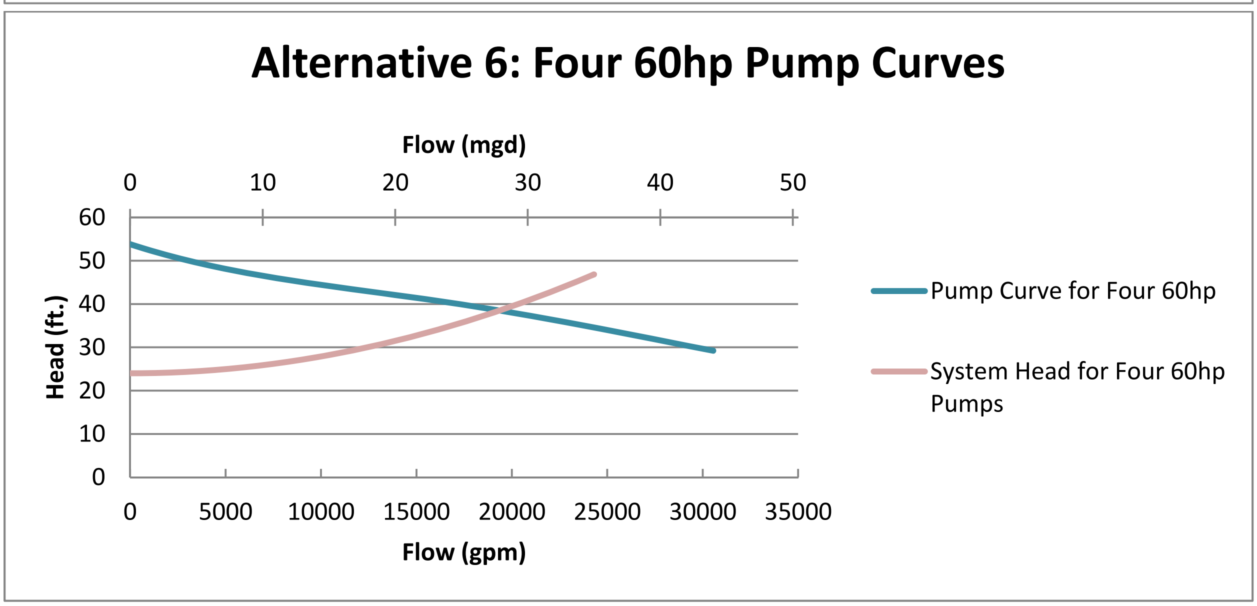
US El. =	4194	ft.
DS El. =	4218	ft.
ΔEl. =	24	
g =	32.2	ft/s^2
D_{in} =	20	in
D_{1in} =	20	in
D_1 =	16	in
D_2 =	16	in
D_{out} =	18	in
D_{pipe} =	30	in
Peak Flow =	28	mgd
	19444.44	gpm




Alternative 6: One 60hp Pump Curves
Flow (mgd)
0
5
10
15
20
60
50
40
30
20
10
0
Head (ft.)
0
5000
10000
15000
Flow (gpm)
Pump Curve for 60hp
System Head for One 60hp Pump


Alternative 6: Two 60hp Pump Curves
Flow (mgd)
0
10
20
30
60
50
40
30
20
10
0
Head (ft.)
0
5000
10000
15000
20000
25000
Flow (gpm)
Pump Curve for Two 60hp Pumps
System Head for Two 60hp Pumps


Alternative 6: Three 60hp Pump Curves
Flow (mgd)
0
10
20
30
40
60
50
40
30
20
10
0
Head (ft.)
0
5000
10000
15000
20000
25000
30000
Flow (gpm)
Pump Curve for Three 60hp
System Head for Three 60hp Pumps


Alternative 6: Four 60hp Pump Curves
Flow (mgd)
0
10
20
30
40
50
60
50
40
30
20
10
0
Head (ft.)
0
5000
10000
15000
20000
25000
30000
35000
Flow (gpm)
Pump Curve for Four 60hp
System Head for Four 60hp Pumps

NP-PS1 Alternative 7: Replace 50 hp Pump

One method to increase flows was to simply replace the existing 50 hp pump and see whether the three existing 60 hp pumps could handle the capacity while the new pump would remain as a standby pump. The capacity achieved by this alternative was far below the required value. This alternative was discarded in an attempt to create a set of alternatives that could all meet the required flows and this alternative did not.

NP-PS1 Alternative 8: Replace Two Pumps

Since a single pump could not increase flow enough, it was hoped that perhaps two could pump the remaining amount. The capacity achieved by this alternative was below the required value as well. This alternative was discarded in an attempt to create a set of alternatives that could all meet the required flows and this alternative did not.

NP-PS1 Alternative 9: Replace Three Pumps

The existing system uses three larger pumps and a smaller pump to handle lower flows. To create a similar situation, three pumps would be replaced and a single 60 hp pump would be left for the lower flows. The capacity achieved by this alternative was below the required value since one of the larger pumps would need to be left on standby. This alternative was discarded in an attempt to create a set of alternatives that could all meet the required flows and this alternative did not.

NP-PS1 Alternative 10: Three Large Pumps

After reviewing the building setup, it was determined that perhaps the staircase leading into NP-PS1 could be moved in order to create more space. With this added space, it was felt that perhaps the four existing pumps might be replaced with three much larger pumps. In this way, the new pumps would be farther spaced than the existing pumps. When modeled, this method proved to be sufficient, however, a pump vendor representative stated that he was unable to determine the effects of two of these pumps together, so it was decided that this alternative should be discarded.

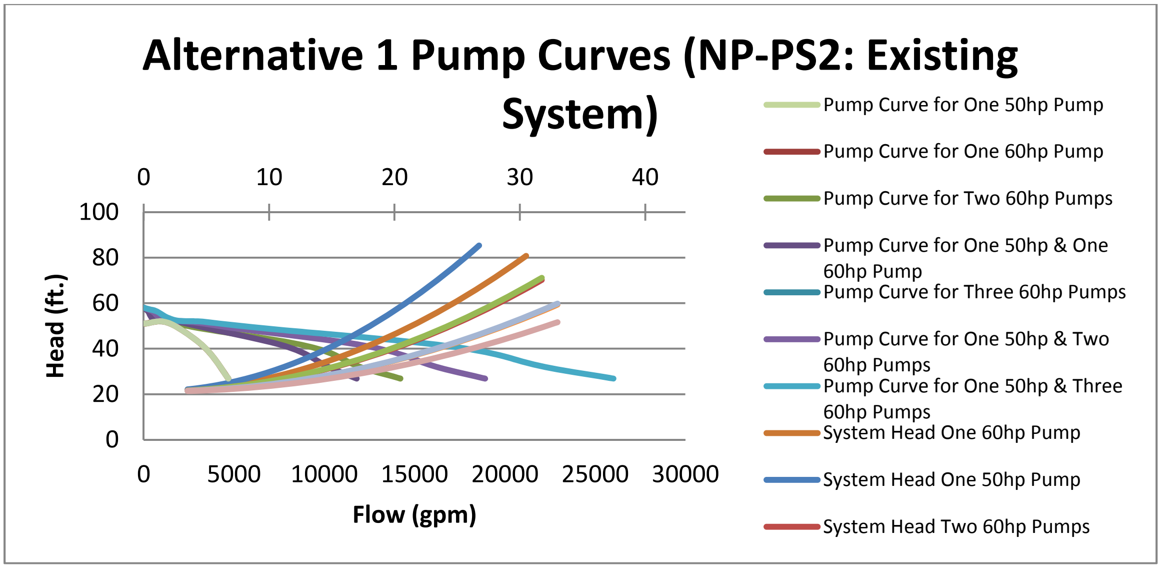
NP-PS2 Alternative 1: Existing System

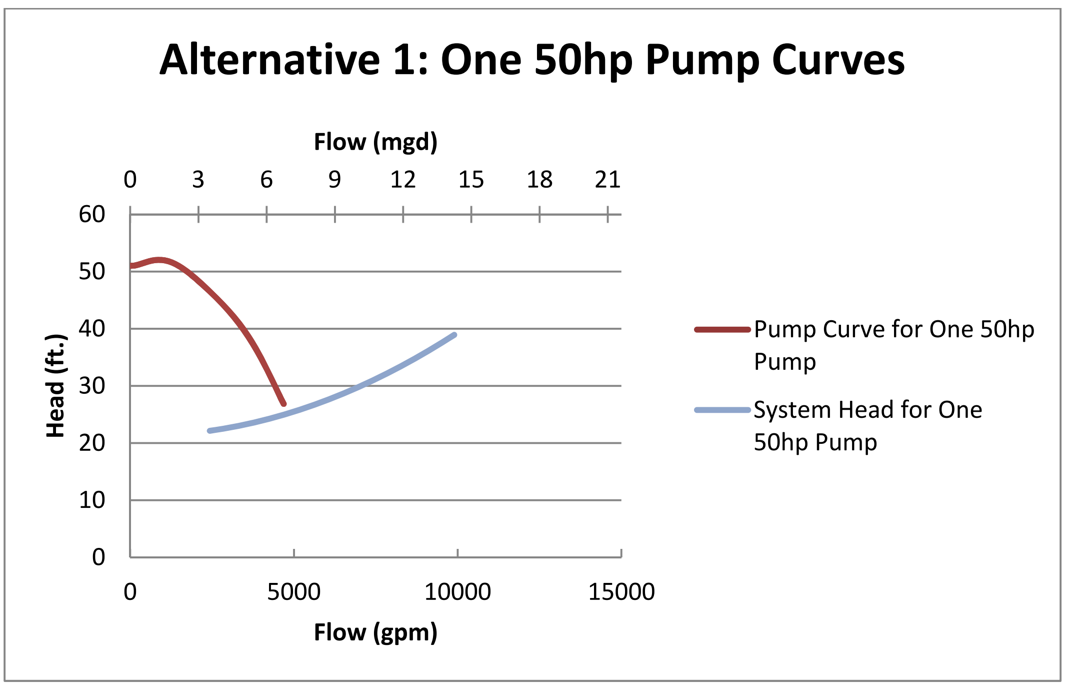
Existing system assumptions were as follows:

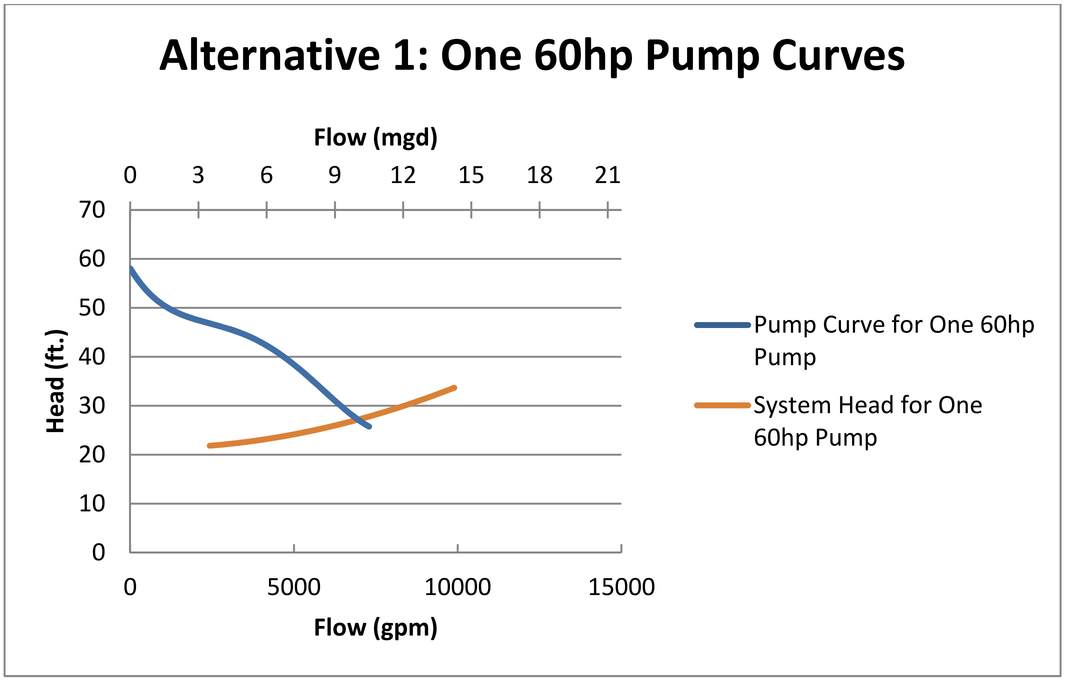
- Activated pumps were assumed to be those creating the greatest amount of loss (i.e., those farthest from the exit). This was done to create the most conservative model.
- The amount of flow handled by each individual pump is proportional to its horsepower rating. While a more accurate model would have been iterative in this respect, it was determined that an iterative model would take too long to create and would only be of minimal use.
- All pumps flowed at 885 rpm's for the 60 hp pumps and 880 rpm's for the 50 hp pumps. These values were not varied.
- Areas were calculated assuming that the pipes are always flowing full.

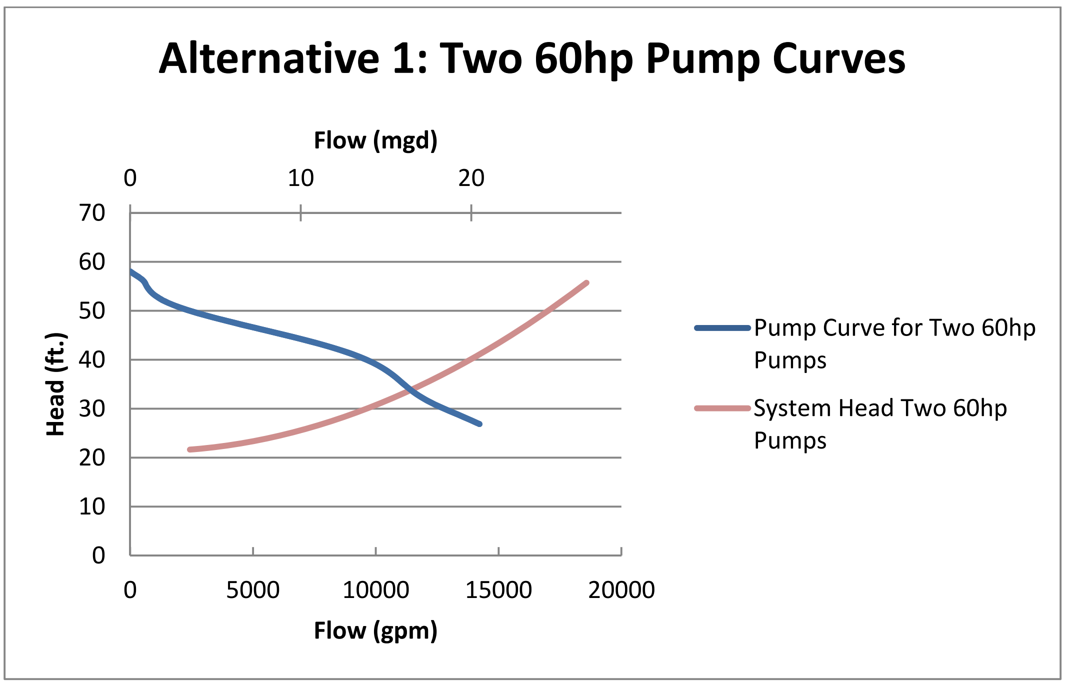
Other initial assumptions were made as follows:

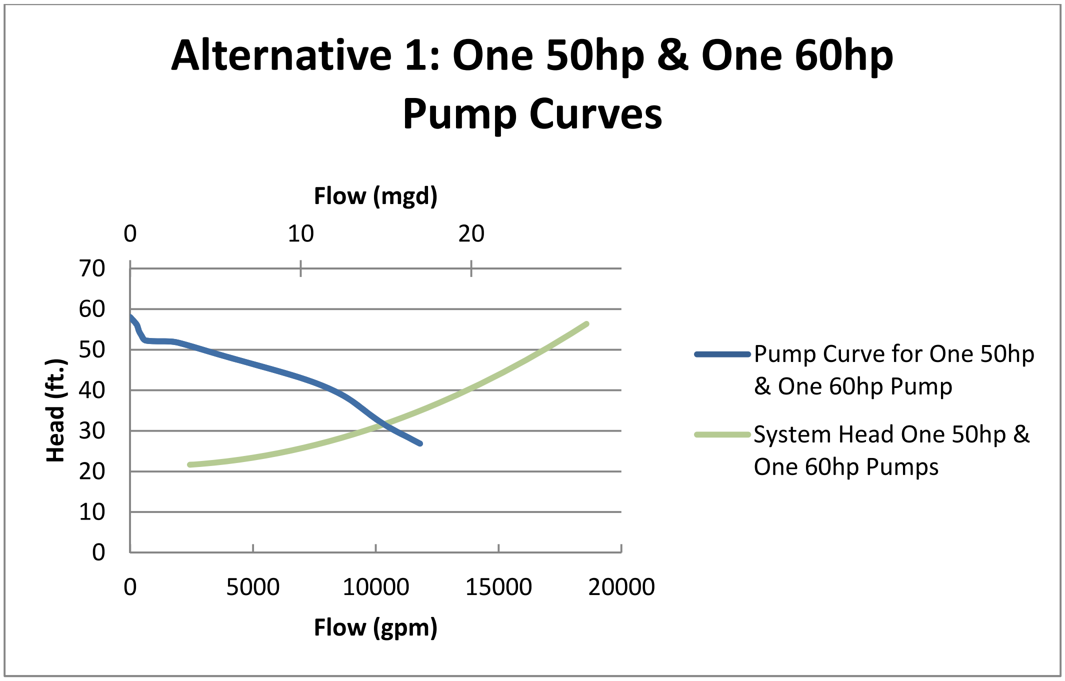
US El. =	4194	ft.
DS El. =	4218	ft.
ΔEl. =	24	ft.
g =	32.2	ft/s^2
D_{in} =	16	in
D_{50} =	10	in
D_{60} =	14	in
D_{valve} =	18	in
D_{pipe} =	30	in
Peak Influent		
Flow =	24	mgd
	16666.7	gpm

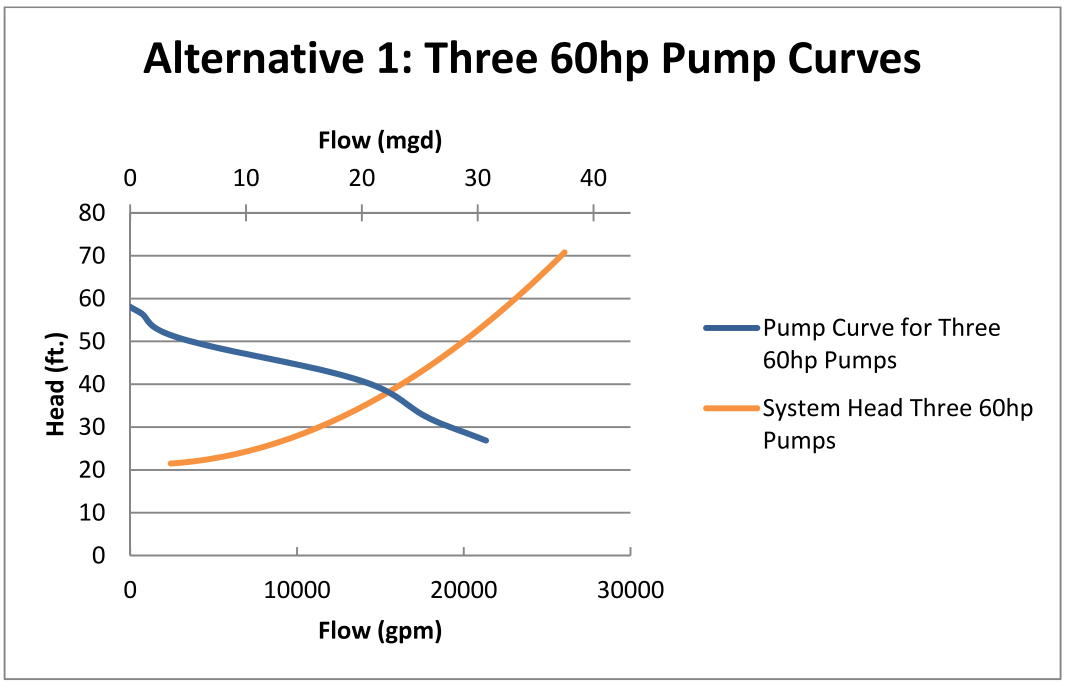

Alternative 1 Pump Curves (NP-PS2: Existing System)
Head (ft.)
Flow (gpm)
0
10
20
30
40
100
80
60
40
20
0
5000
10000
15000
20000
25000
30000
Pump Curve for One 50hp Pump
Pump Curve for One 60hp Pump
Pump Curve for Two 60hp Pumps
Pump Curve for One 50hp & One 60hp Pump
Pump Curve for Three 60hp Pumps
Pump Curve for One 50hp & Two 60hp Pumps
Pump Curve for One 50hp & Three 60hp Pumps
System Head One 60hp Pump
System Head One 50hp Pump
System Head Two 60hp Pumps

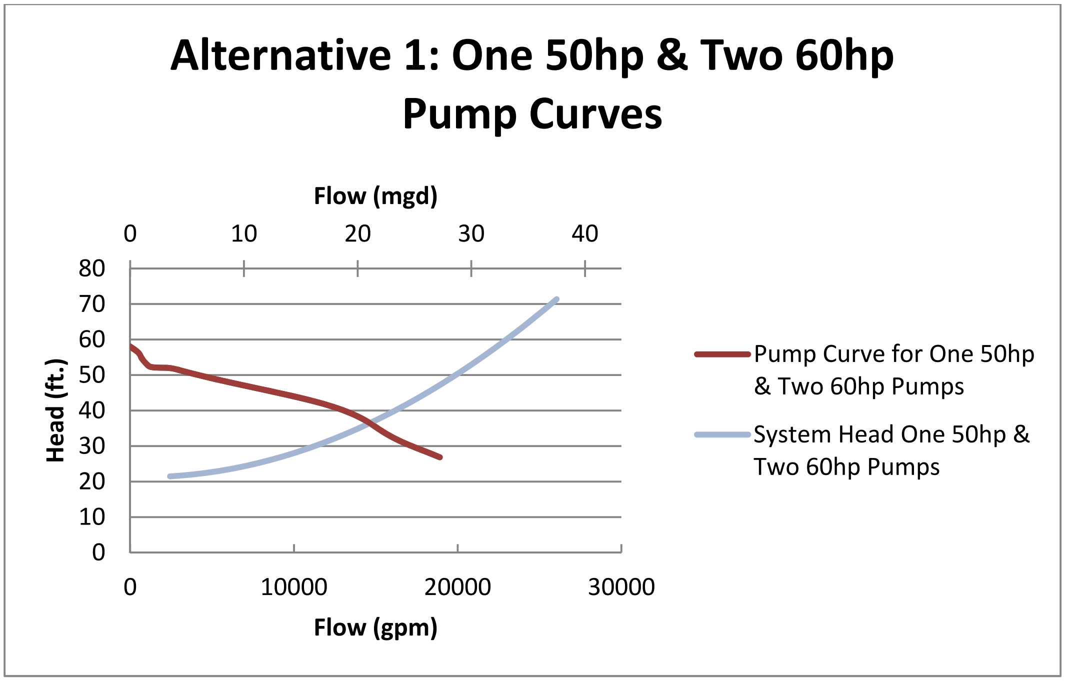

Alternative 1: One 50hp Pump Curves
Flow (mgd)
0
3
6
9
12
15
18
21
Head (ft.)
60
50
40
30
20
10
0
5000
10000
15000
Flow (gpm)
Pump Curve for One 50hp Pump
System Head for One 50hp Pump

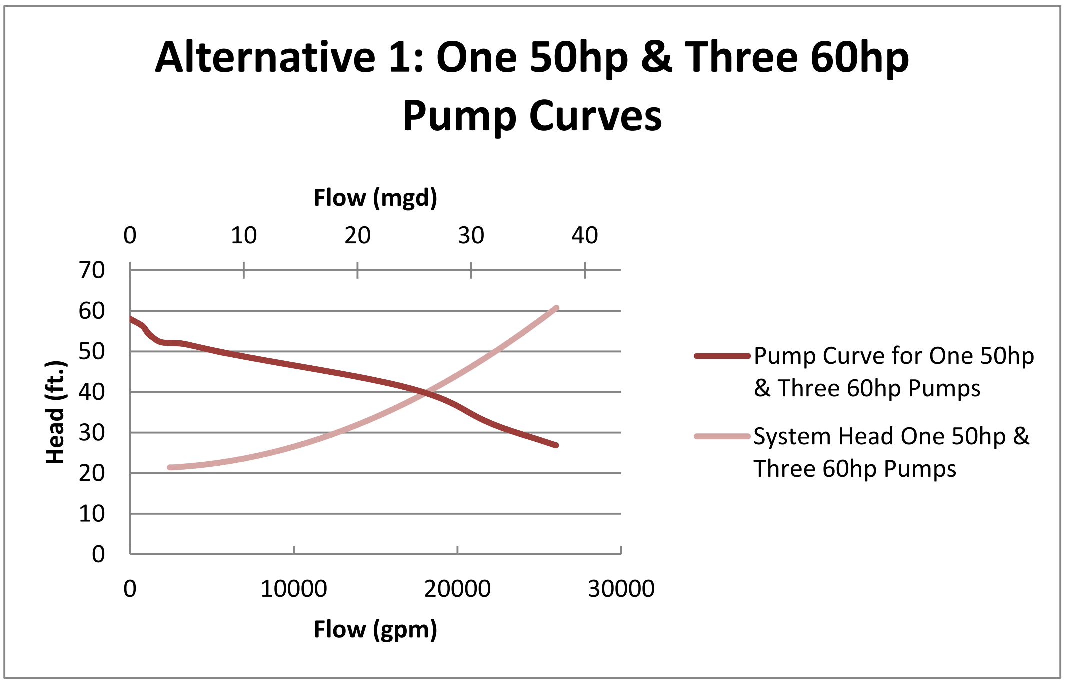

Alternative 1: One 60hp Pump Curves
Flow (mgd)
0
3
6
9
12
15
18
21
70
60
50
40
30
20
10
0
Head (ft.)
0
5000
10000
15000
Flow (gpm)
Pump Curve for One 60hp Pump
System Head for One 60hp Pump


Alternative 1: Two 60hp Pump Curves
Flow (mgd)
0
10
20
70
60
50
40
30
20
10
0
Head (ft.)
0
5000
10000
15000
20000
Flow (gpm)
Pump Curve for Two 60hp Pumps
System Head Two 60hp Pumps


Alternative 1: One 50hp & One 60hp Pump Curves
Flow (mgd)
0
10
20
Head (ft.)
70
60
50
40
30
20
10
0
0
5000
10000
15000
20000
Flow (gpm)
Pump Curve for One 50hp & One 60hp Pump
System Head One 50hp & One 60hp Pumps


Alternative 1: Three 60hp Pump Curves
Flow (mgd)
0
10
20
30
40
Head (ft.)
80
70
60
50
40
30
20
10
0
0
10000
20000
30000
Flow (gpm)
Pump Curve for Three 60hp Pumps
System Head Three 60hp Pumps


Alternative 1: One 50hp & Two 60hp
Pump Curves
Flow (mgd)
0
10
20
30
40
80
70
60
50
40
30
20
10
0
Head (ft.)
0
10000
20000
30000
Flow (gpm)
Pump Curve for One 50hp & Two 60hp Pumps
System Head One 50hp & Two 60hp Pumps


Alternative 1: One 50hp & Three 60hp
Pump Curves
Flow (mgd)
0
10
20
30
40
70
60
50
40
30
20
10
0
Head (ft.)
0
10000
20000
30000
Flow (gpm)
Pump Curve for One 50hp & Three 60hp Pumps
System Head One 50hp & Three 60hp Pumps

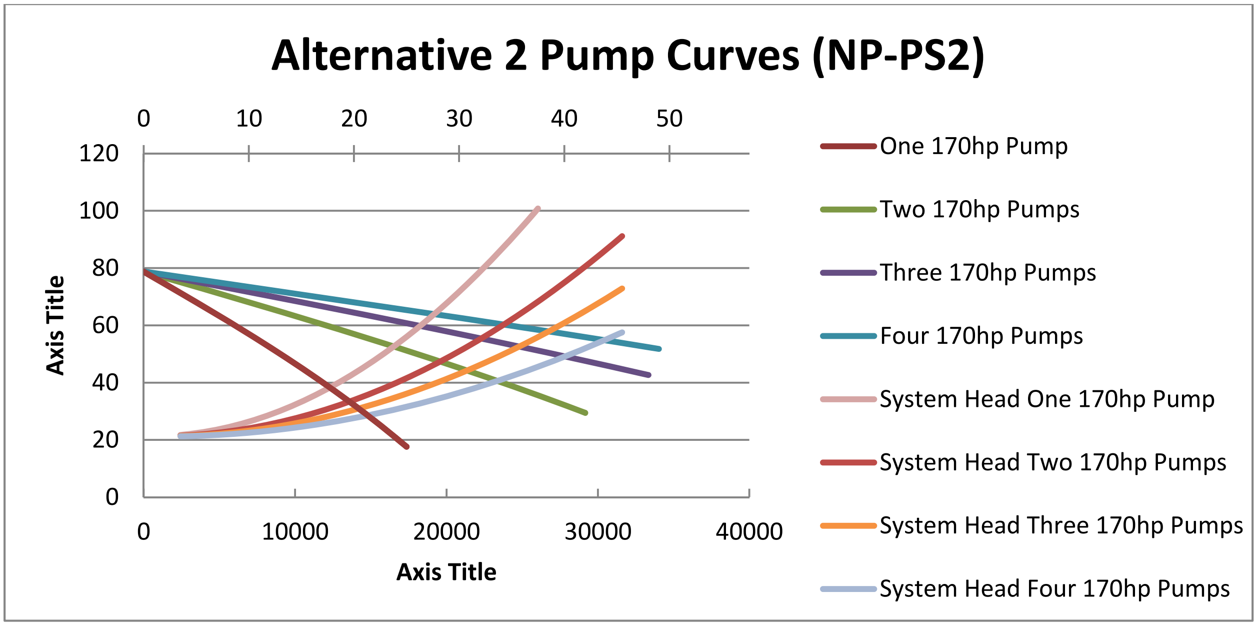
NP-PS2 Alternative 2: Four That squeeze

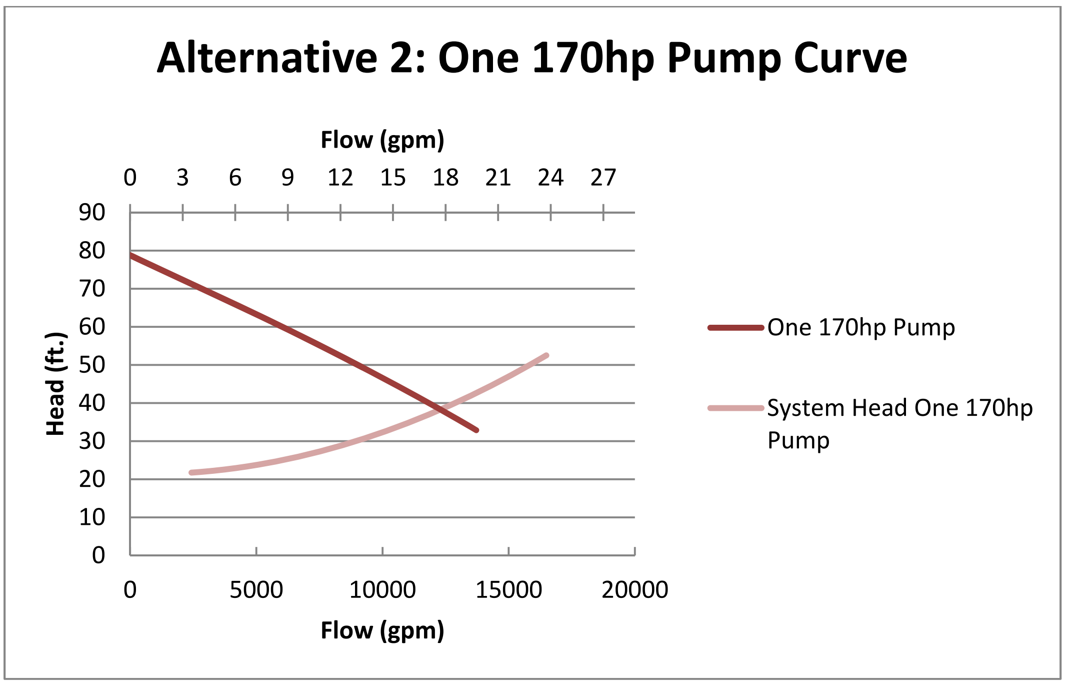
Alternative system assumptions were as follows:

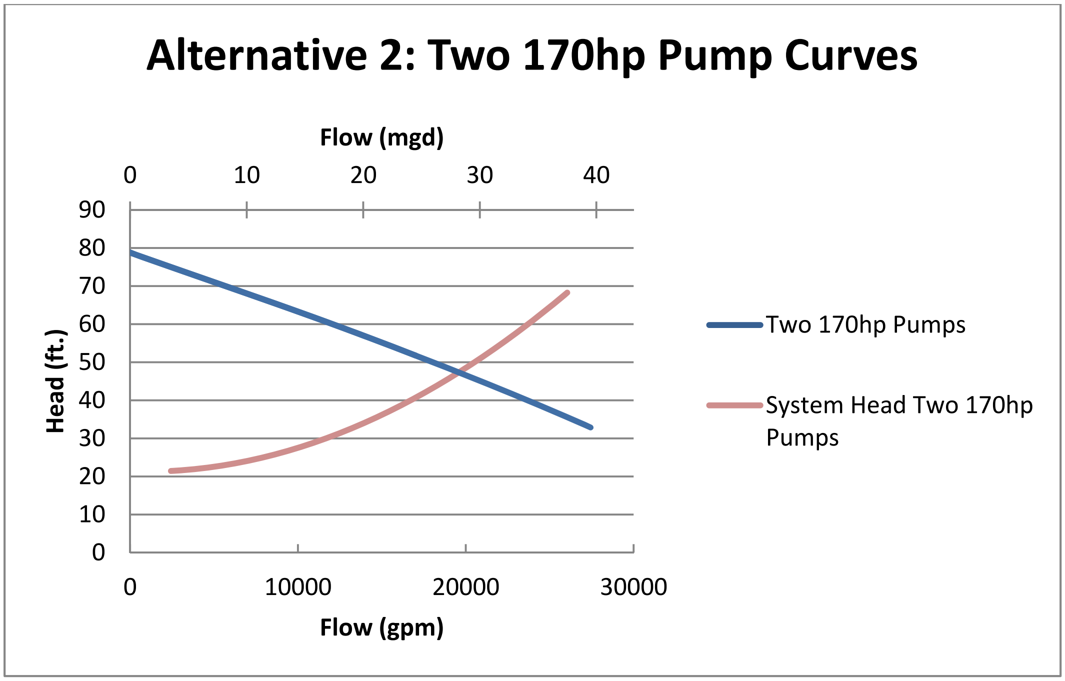
- Activated pumps were assumed to be those creating the greatest amount of loss (i.e., those farthest from the exit). This was done to create the most conservative model.
- Areas were calculated assuming that the pipes are always flowing full.

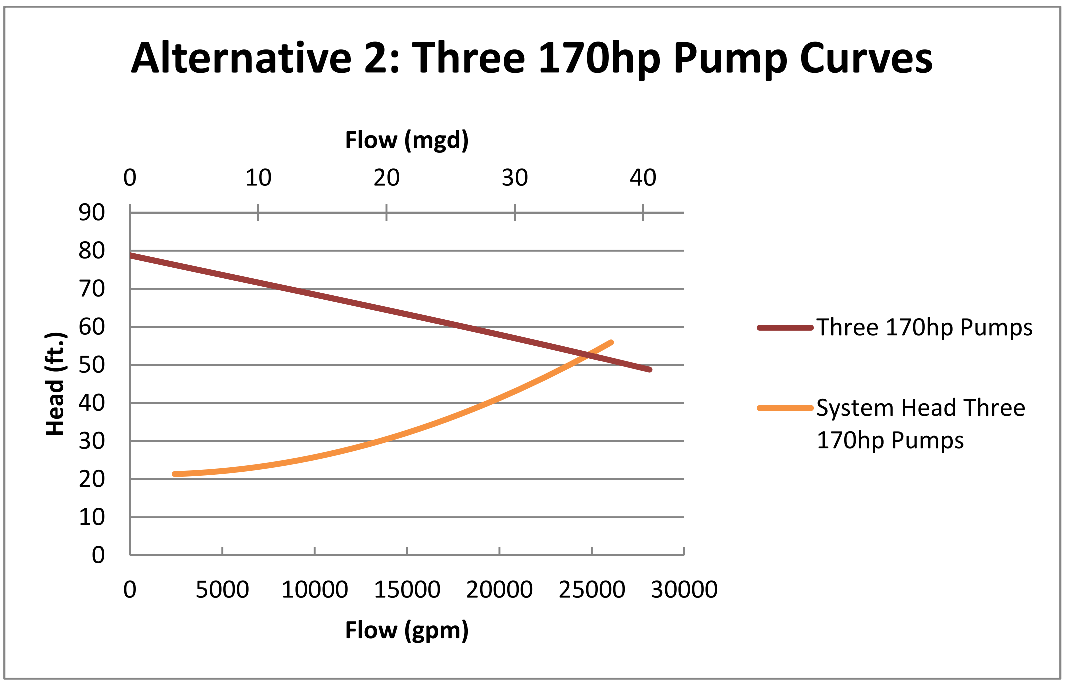
Other initial assumptions were made as follows:

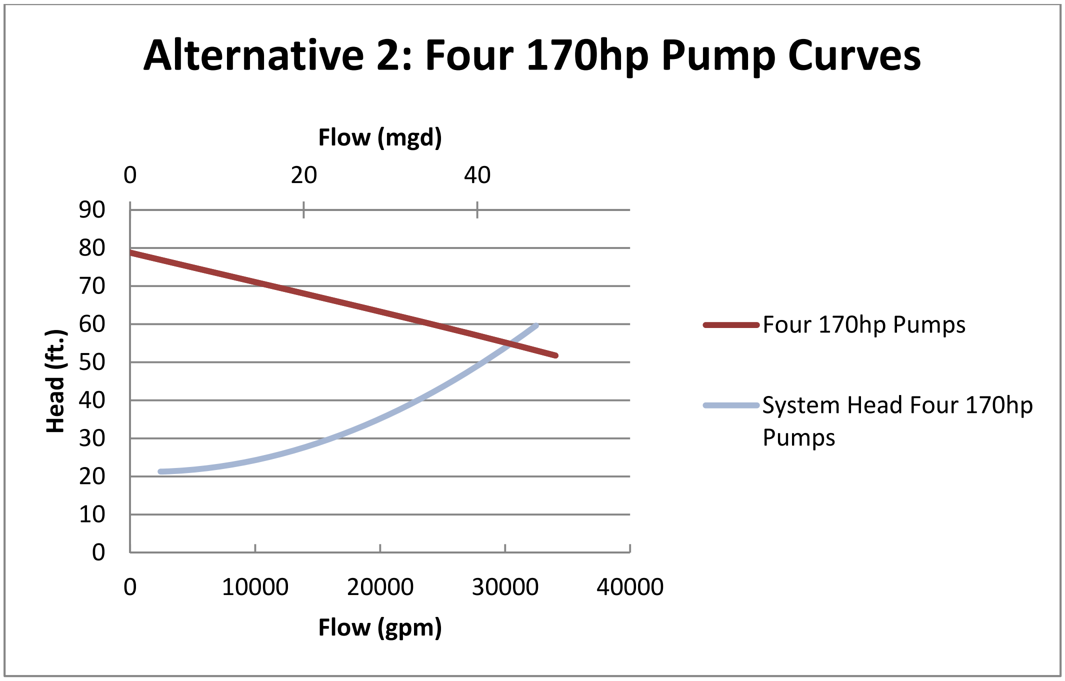
US El. =	4193	ft.
DS El. =	4214.17	ft.
ΔEl. =	21.17	ft.
g =	32.2	ft/s^2
D_{in} =	24	in
D_1 =	24	in
D_2 =	20	in
D_{out} =	18	in
$D_{manifold}$ =	27	in
D_{pipe} =	30	in
Peak Influent Flow =	31.5	mgd
	21875.00	gpm


Alternative 2 Pump Curves (NP-PS2)
0 10 20 30 40 50
120 100 80 60 40 20 0
Axis Title
0 10000 20000 30000 40000
Axis Title
One 170hp Pump
Two 170hp Pumps
Three 170hp Pumps
Four 170hp Pumps
System Head One 170hp Pump
System Head Two 170hp Pumps
System Head Three 170hp Pumps
System Head Four 170hp Pumps


Alternative 2: One 170hp Pump Curve
Flow (gpm)
0 3 6 9 12 15 18 21 24 27
90 80 70 60 50 40 30 20 10 0
Head (ft.)
0 5000 10000 15000 20000
Flow (gpm)
One 170hp Pump
System Head One 170hp Pump


Alternative 2: Two 170hp Pump Curves
Flow (mgd)
0
10
20
30
40
90
80
70
60
50
40
30
20
10
0
Head (ft.)
0
10000
20000
30000
Flow (gpm)
Two 170hp Pumps
System Head Two 170hp Pumps


Alternative 2: Three 170hp Pump Curves
Flow (mgd)
0
10
20
30
40
90
80
70
60
50
40
30
20
10
0
Head (ft.)
0
5000
10000
15000
20000
25000
30000
Flow (gpm)
Three 170hp Pumps
System Head Three 170hp Pumps


Alternative 2: Four 170hp Pump Curves
Flow (mgd)
0
20
40
Head (ft.)
90
80
70
60
50
40
30
20
10
0
0
10000
20000
30000
40000
Flow (gpm)
Four 170hp Pumps
System Head Four 170hp Pumps

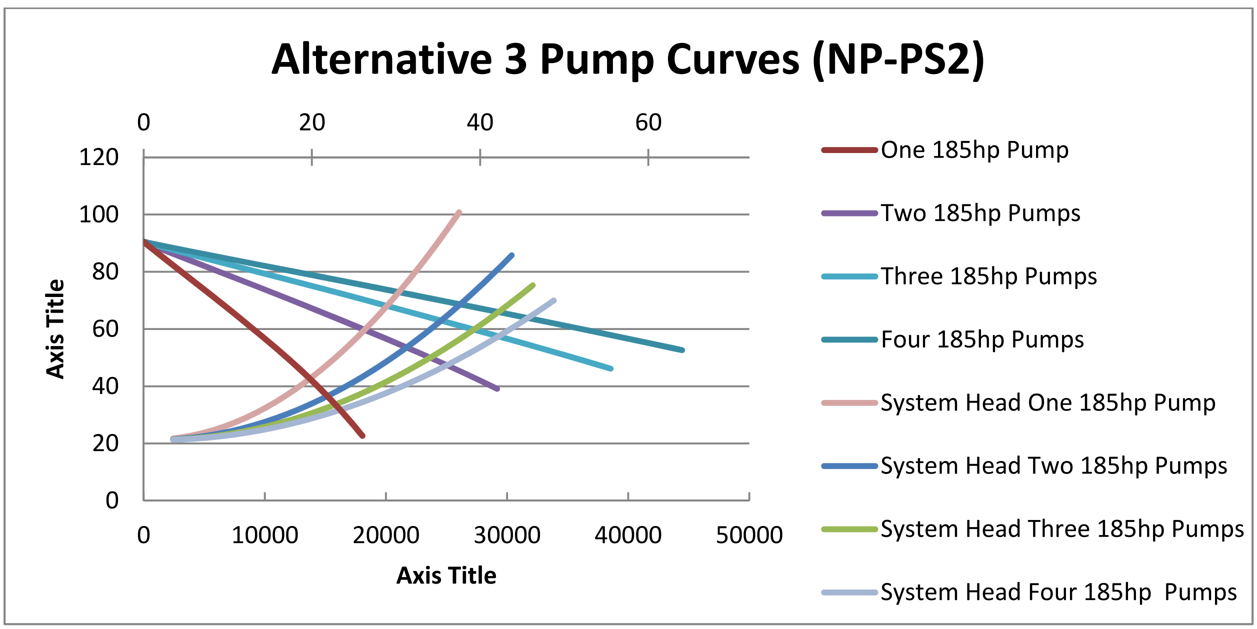
NP-PS2 Alternative 3: Four That Squeeze

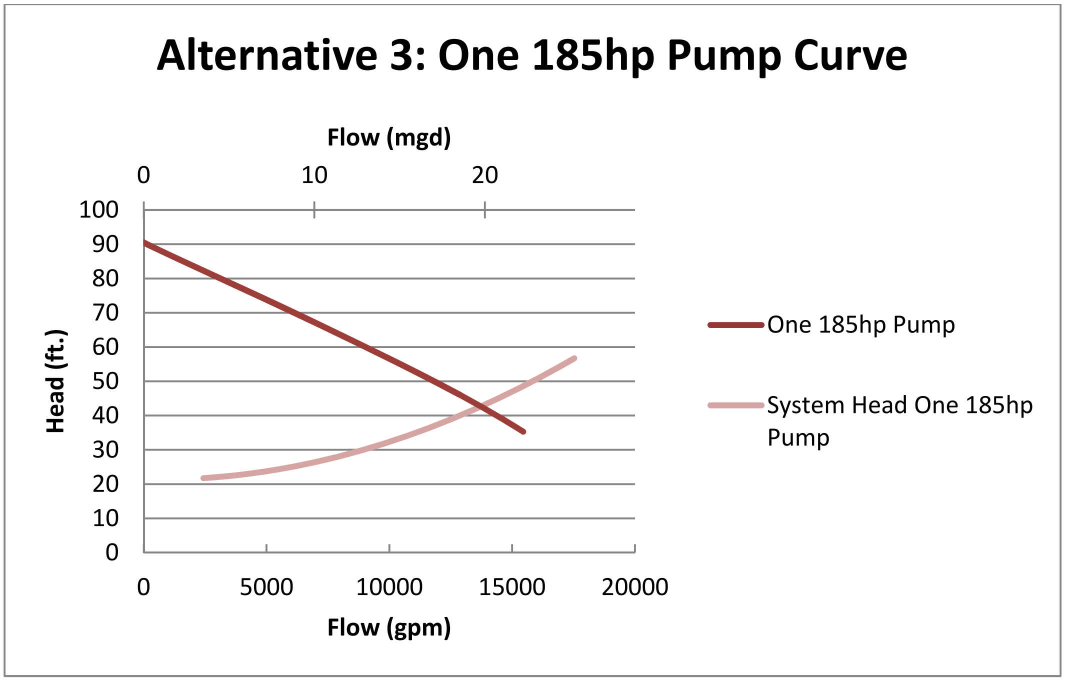
Alternative system assumptions were as follows:

- Activated pumps were assumed to be those creating the greatest amount of loss (i.e., those farthest from the exit). This was done to create the most conservative model.
- Areas were calculated assuming that the pipes are always flowing full.

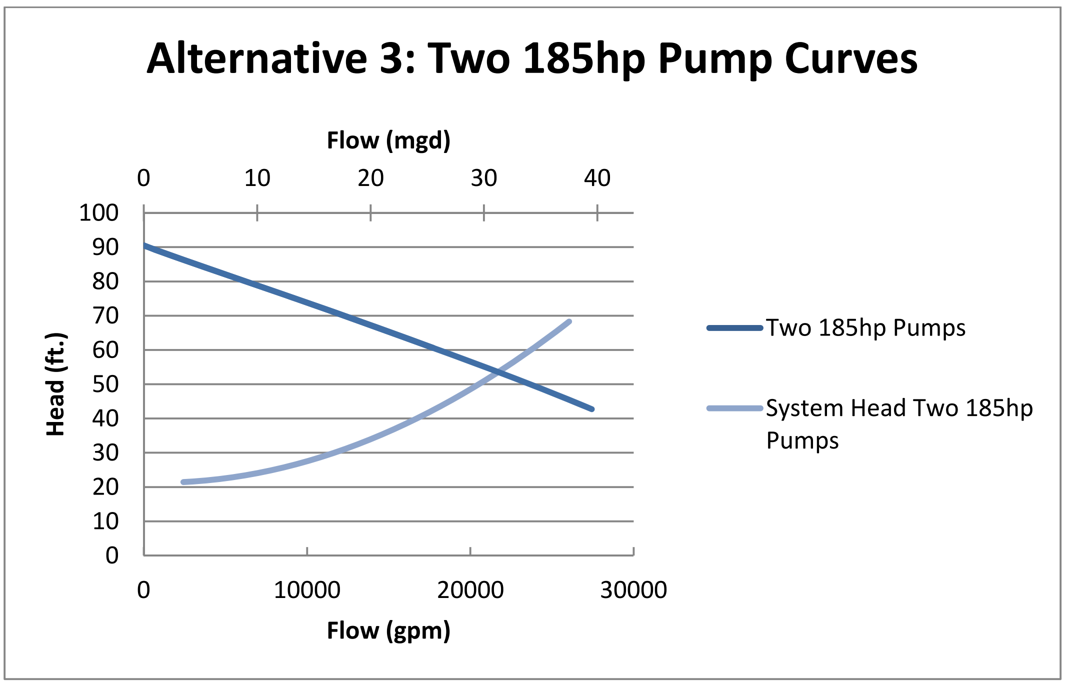
Other initial assumptions were made as follows:

US El. =	4193	ft.
DS El. =	4214.17	ft.
ΔEl. =	21.17	ft.
g =	32.2	ft/s^2
D_{in} =	24	in
D_1 =	24	in
D_{1out} =	20	in
D_{out} =	18	in
$D_{manifold}$ =	27	in
D_{pipe} =	30	in
Peak Influent Flow =	31.5	mgd
	21875.00	gpm

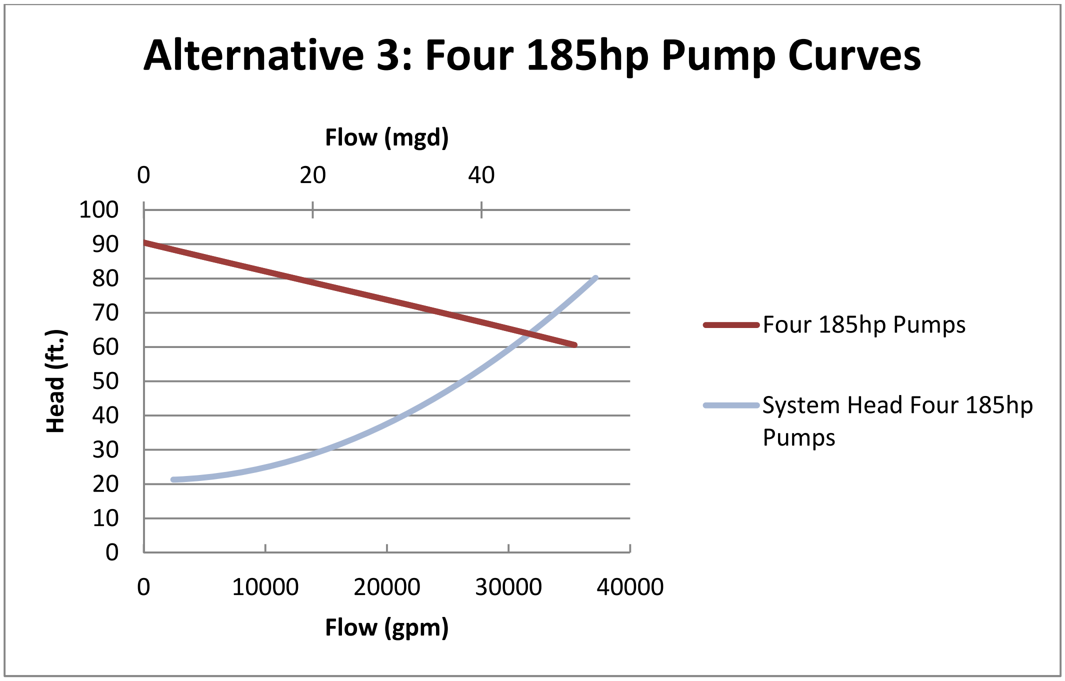


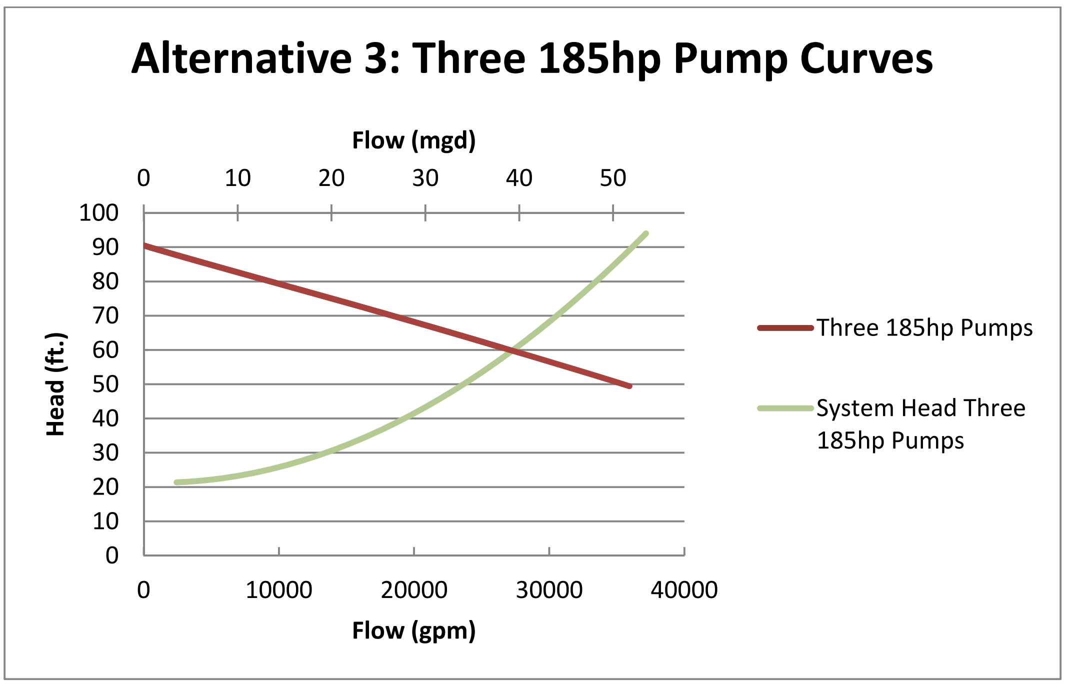


Alternative 3: One 185hp Pump Curve
Flow (mgd)
0
10
20
Head (ft.)
100
90
80
70
60
50
40
30
20
10
0
0
5000
10000
15000
20000
Flow (gpm)
One 185hp Pump
System Head One 185hp Pump



Alternative 3: Two 185hp Pump Curves
Flow (mgd)
0
10
20
30
40
Head (ft.)
100
90
80
70
60
50
40
30
20
10
0
0
10000
20000
30000
Flow (gpm)
Two 185hp Pumps
System Head Two 185hp Pumps


Alternative 3: Four 185hp Pump Curves
Flow (mgd)
0
20
40
100
90
80
70
60
50
40
30
20
10
0
Head (ft.)
0
10000
20000
30000
40000
Flow (gpm)
Four 185hp Pumps
System Head Four 185hp Pumps


Alternative 3: Three 185hp Pump Curves
Flow (mgd)
0
10
20
30
40
50
100
90
80
70
60
50
40
30
20
10
0
Head (ft.)
0
10000
20000
30000
40000
Flow (gpm)
Three 185hp Pumps
System Head Three 185hp Pumps

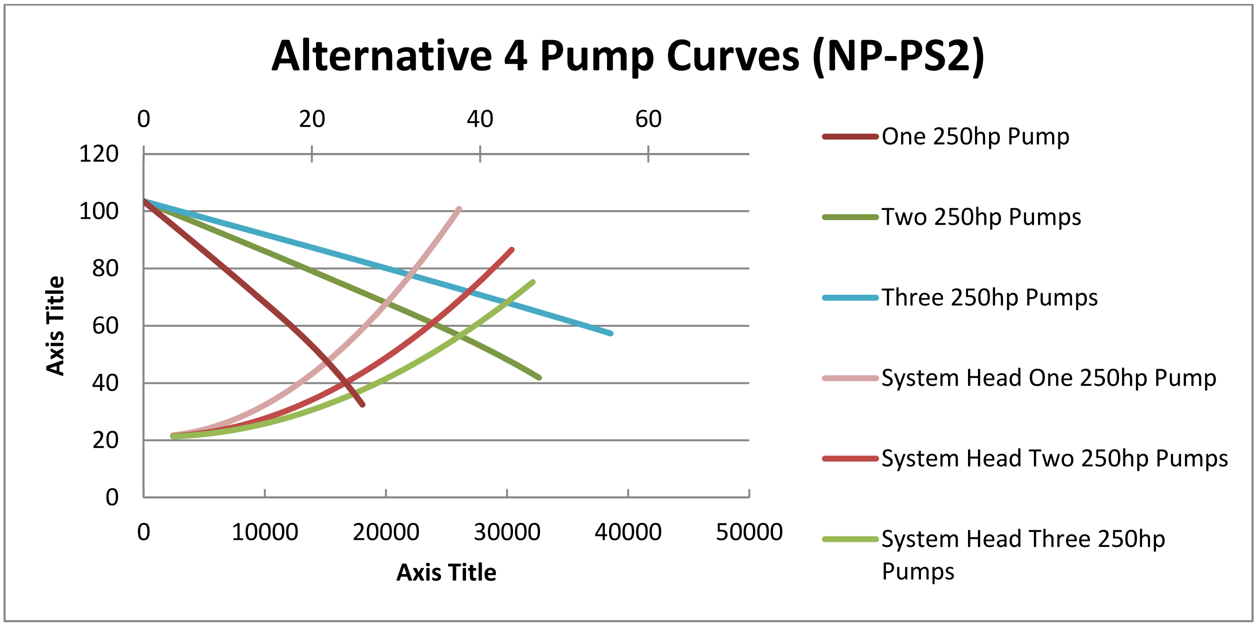
NP-PS2 Alternative 4: Three Large Pumps System

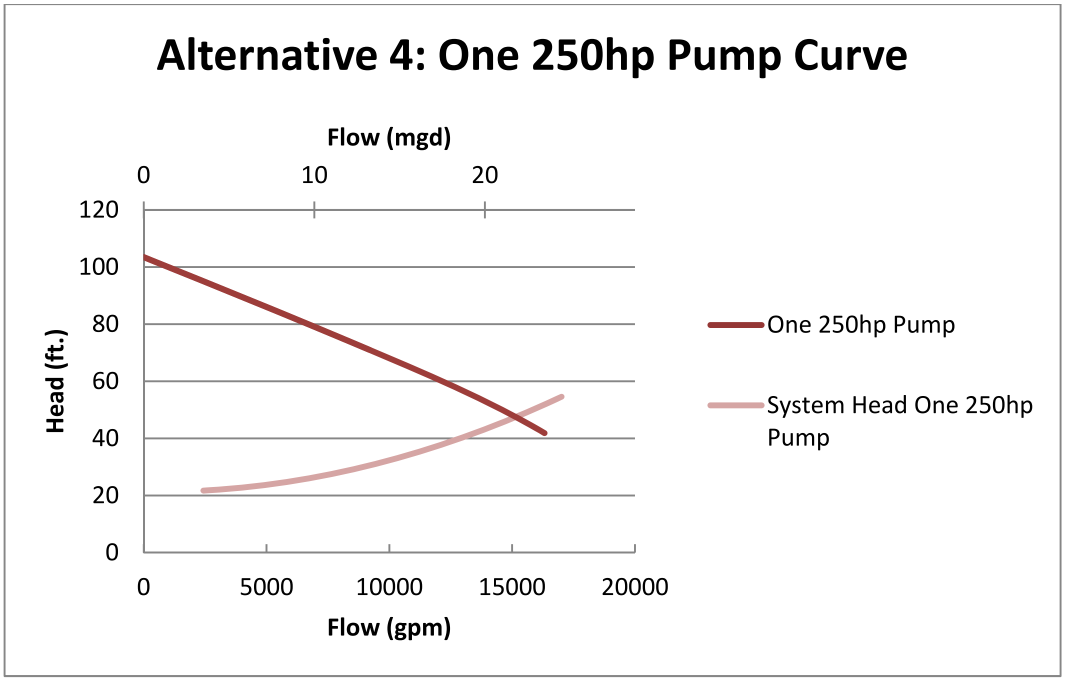
Alternative system assumptions were as follows:

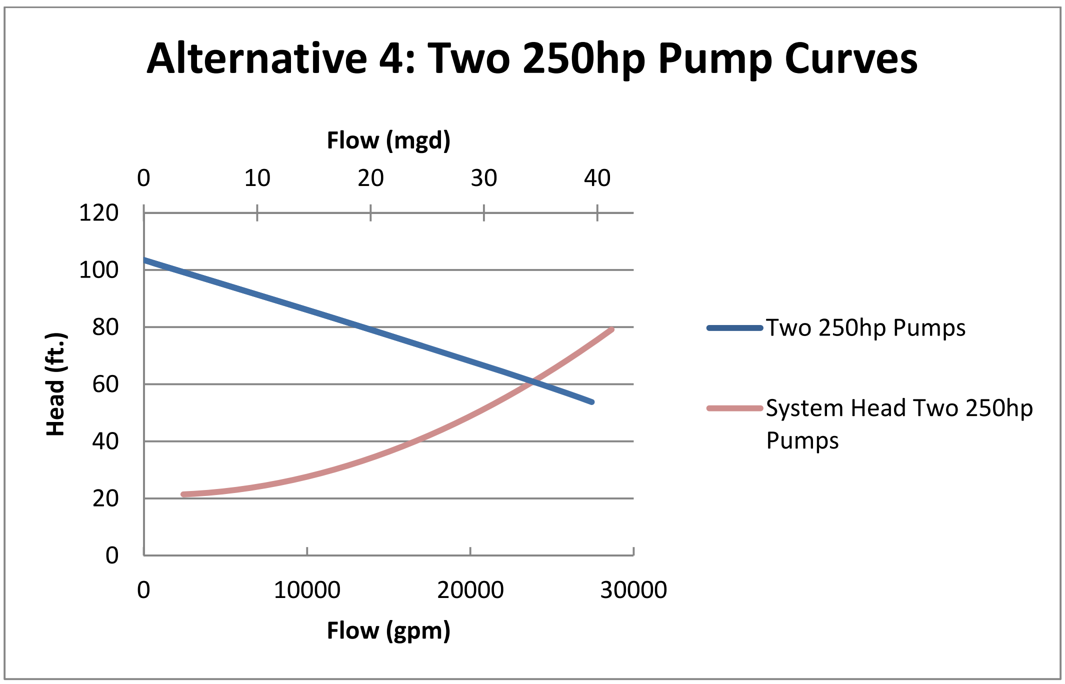
- Activated pumps were assumed to be those creating the greatest amount of loss (i.e., those farthest from the exit). This was done to create the most conservative model.
- Areas were calculated assuming that the pipes are always flowing full.

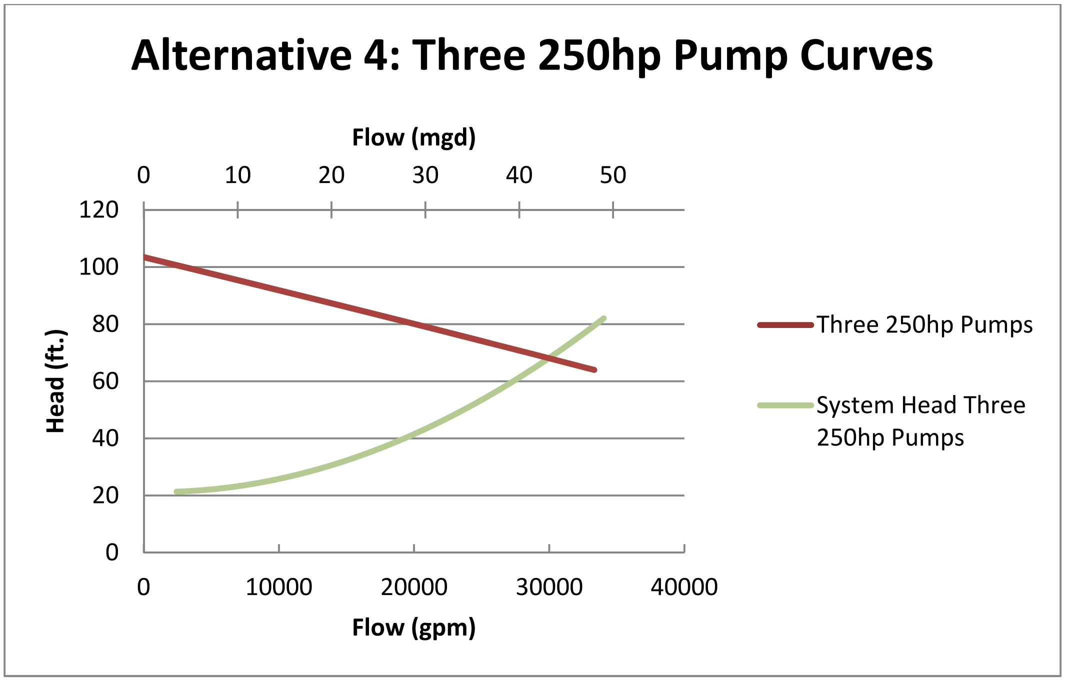
Other initial assumptions were made as follows:

US El. =	4193	ft.
DS El. =	4214.17	ft.
ΔEl. =	21.17	ft.
g =	32.2	ft/s^2
D_{in} =	24	in
D_1 =	24	in
D_2 =	20	in
D_{out} =	18	in
$D_{manifold}$ =	27	in
D_{pipe} =	30	in
Peak Influent Flow =	31.5	mgd
	21875.00	gpm




Alternative 4: One 250hp Pump Curve
Flow (mgd)
0
10
20
Head (ft.)
120
100
80
60
40
20
0
0
5000
10000
15000
20000
Flow (gpm)
One 250hp Pump
System Head One 250hp Pump


Alternative 4: Two 250hp Pump Curves
Flow (mgd)
0
10
20
30
40
Head (ft.)
120
100
80
60
40
20
0
0
10000
20000
30000
Flow (gpm)
Two 250hp Pumps
System Head Two 250hp Pumps

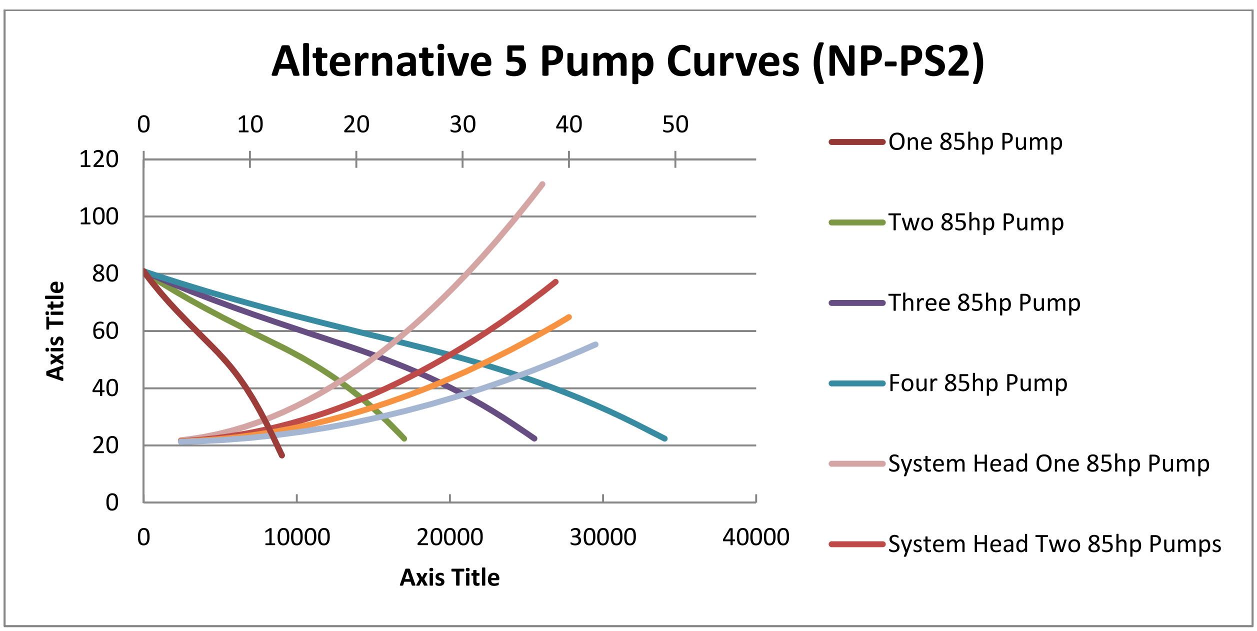

Alternative 4: Three 250hp Pump Curves
Flow (mgd)
0
10
20
30
40
50
120
100
80
60
40
20
0
Head (ft.)
0
10000
20000
30000
40000
Flow (gpm)
Three 250hp Pumps
System Head Three 250hp Pumps

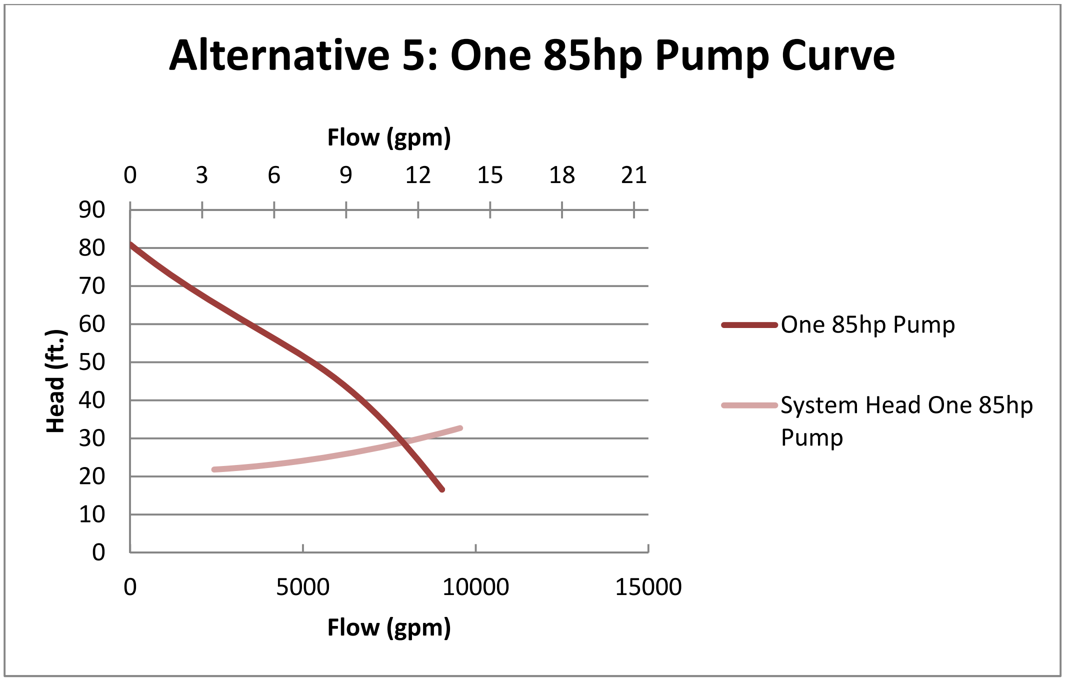
NP-PS2 Alternative 5: Four That Fit (70hp)
Alternative system assumptions were as follows:

- Activated pumps were assumed to be those creating the greatest amount of loss (i.e., those farthest from the exit). This was done to create the most conservative model.
- Areas were calculated assuming that the pipes are always flowing full.

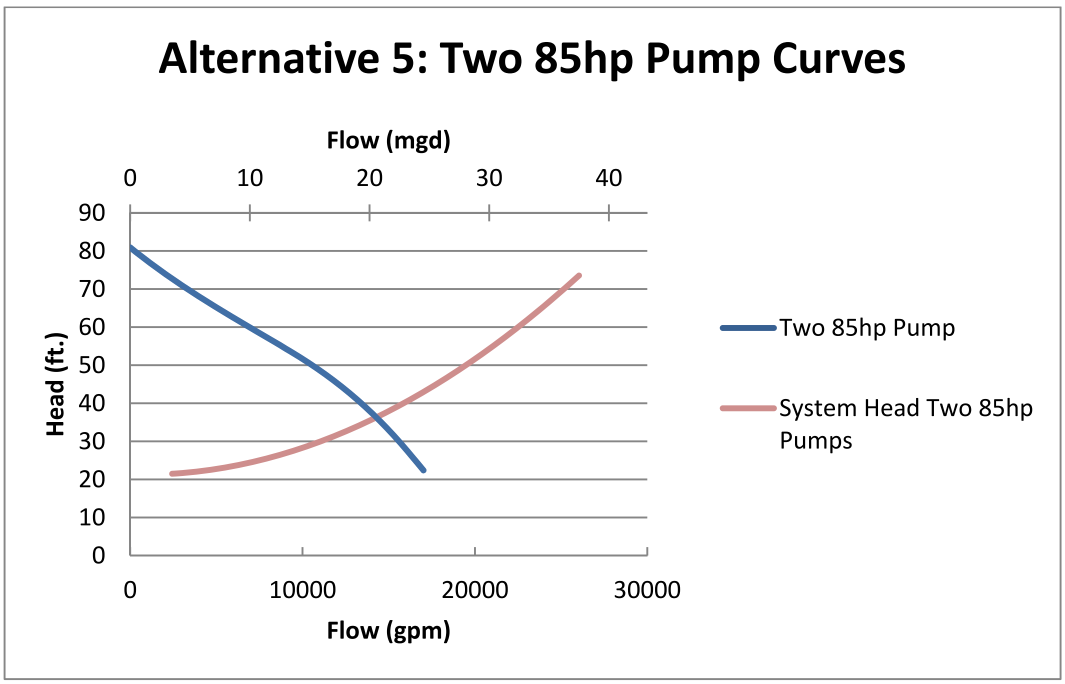
Other initial assumptions were made as follows:

US El. =	4193	ft.
DS El. =	4214.17	ft.
ΔEl. =	21.17	ft.
g =	32.2	ft/s^2
D_{in} =	20	in
D_1 =	16	in
D_2 =	14	in
D_{out} =	18	in
$D_{manifold}$ =	27	in
D_{pipe} =	30	in
Peak Influent		
Flow =	31.5	mgd
	21875.00	gpm

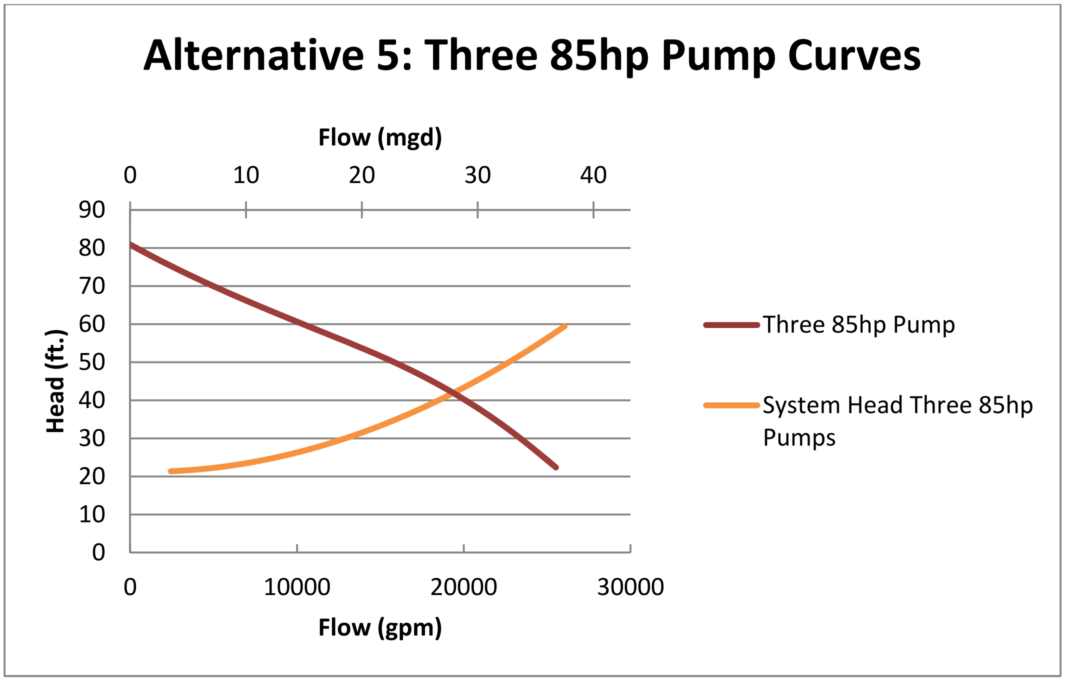


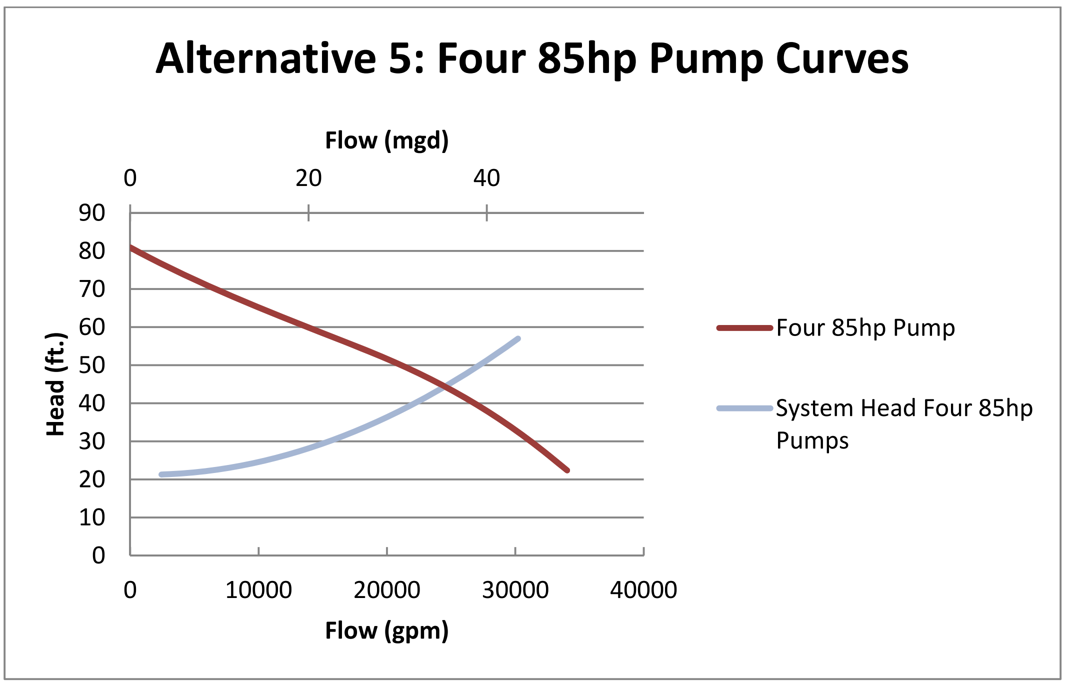


Alternative 5: One 85hp Pump Curve
Flow (gpm)
0
3
6
9
12
15
18
21
90
80
70
60
50
40
30
20
10
0
Head (ft.)
0
5000
10000
15000
Flow (gpm)
One 85hp Pump
System Head One 85hp Pump



Alternative 5: Two 85hp Pump Curves
Flow (mgd)
0
10
20
30
40
90
80
70
60
50
40
30
20
10
0
Head (ft.)
0
10000
20000
30000
Flow (gpm)
Two 85hp Pump
System Head Two 85hp Pumps


Alternative 5: Three 85hp Pump Curves
Flow (mgd)
0
10
20
30
40
90
80
70
60
50
40
30
20
10
0
Head (ft.)
0
10000
20000
30000
Flow (gpm)
Three 85hp Pump
System Head Three 85hp Pumps

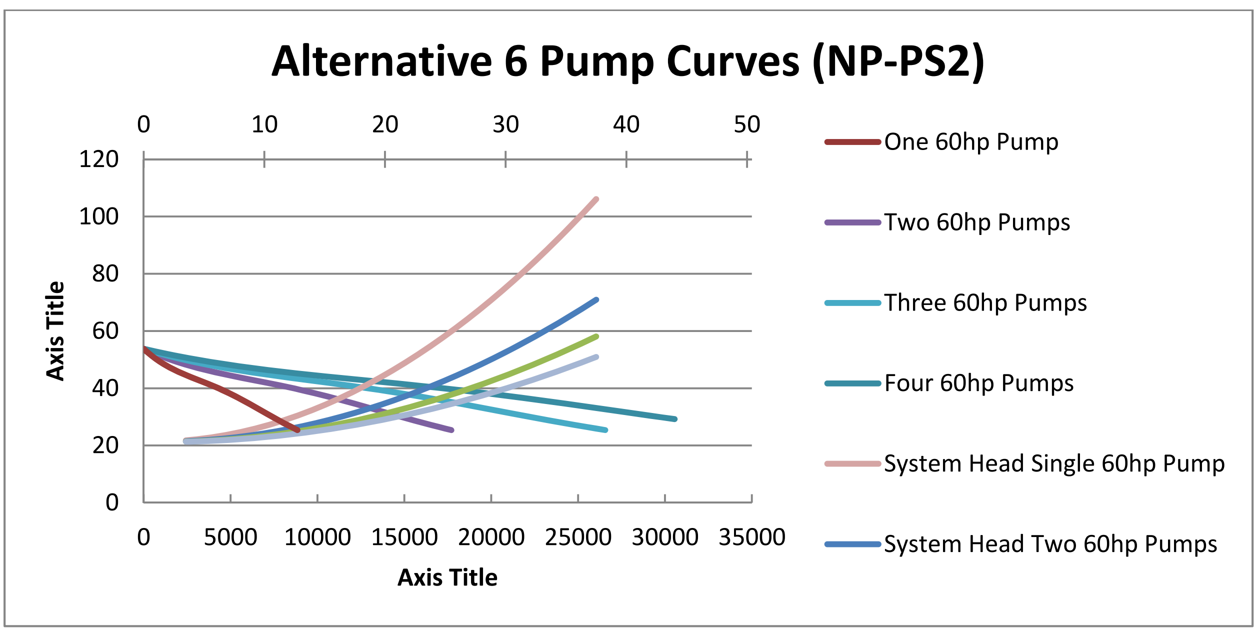

Alternative 5: Four 85hp Pump Curves
Flow (mgd)
0
20
40
90
80
70
60
50
40
30
20
10
0
Head (ft.)
0
10000
20000
30000
40000
Flow (gpm)
Four 85hp Pump
System Head Four 85hp Pumps

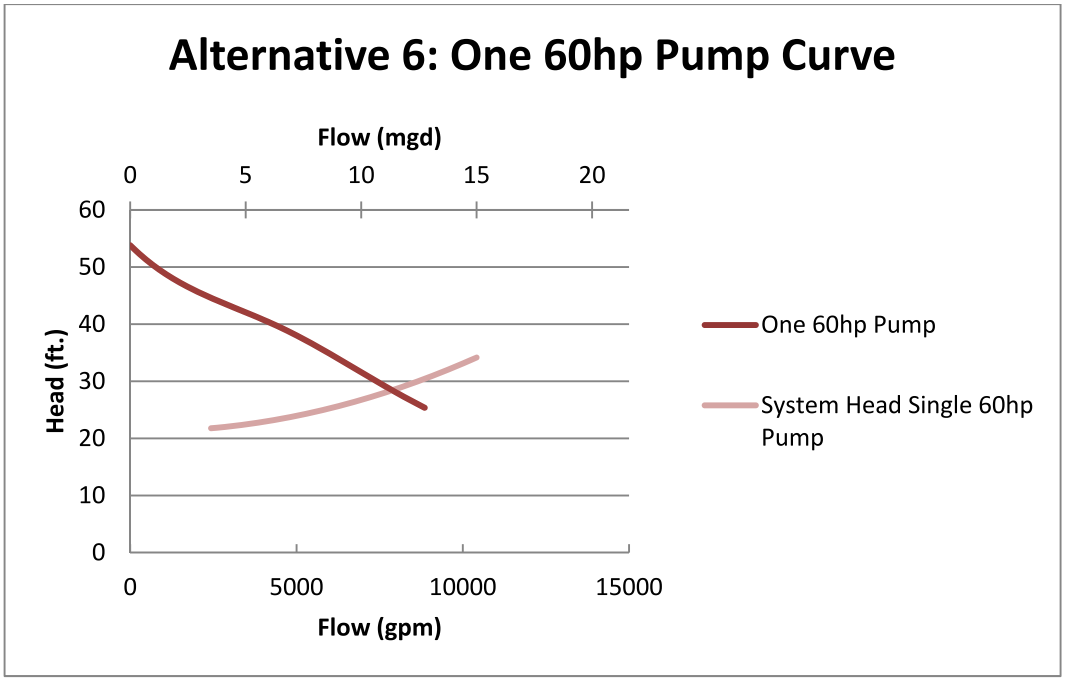
NP-PS2 Alternative 6: Four That Squeeze (60hp)
Alternative system assumptions were as follows:

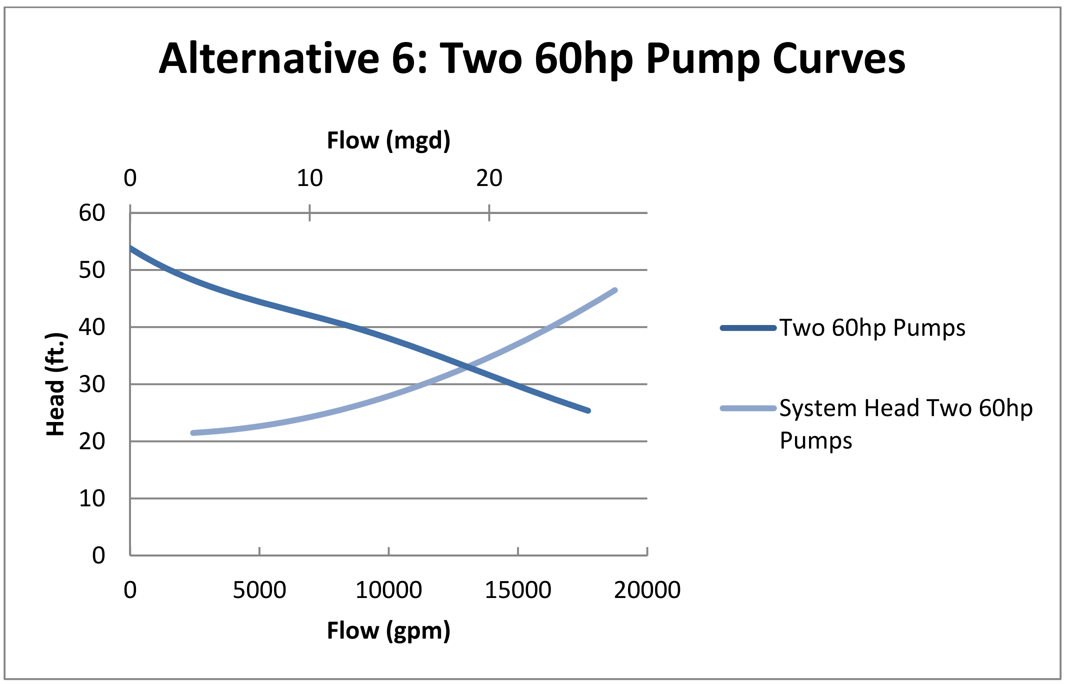
- Activated pumps were assumed to be those creating the greatest amount of loss (i.e., those farthest from the exit). This was done to create the most conservative model.
- Areas were calculated assuming that the pipes are always flowing full.

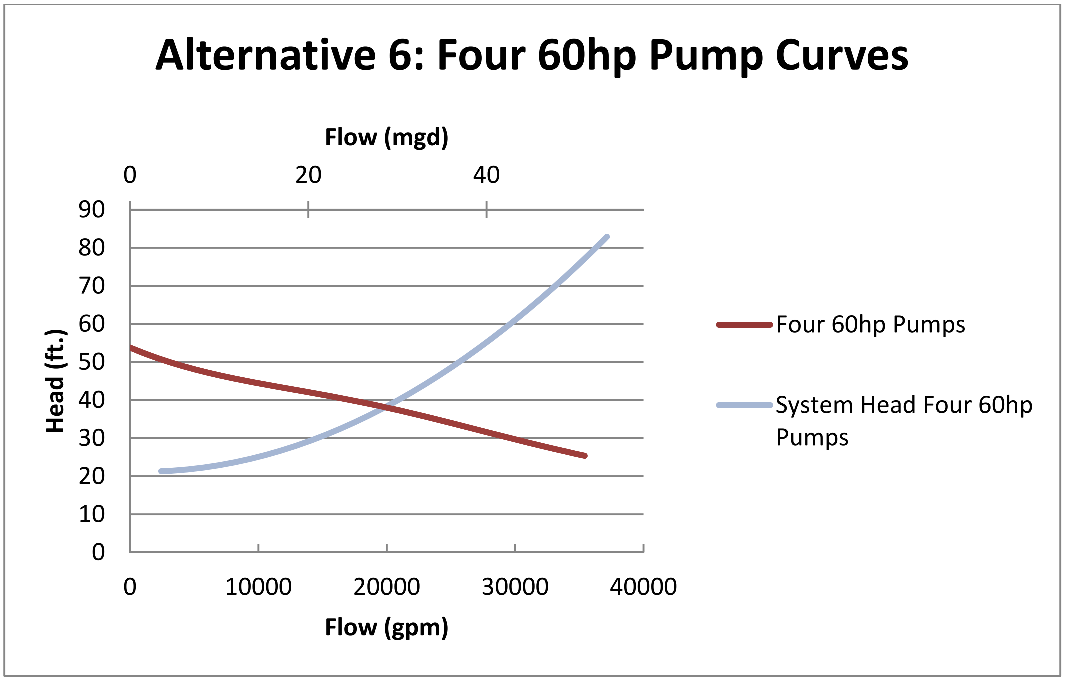
Other initial assumptions were made as follows:

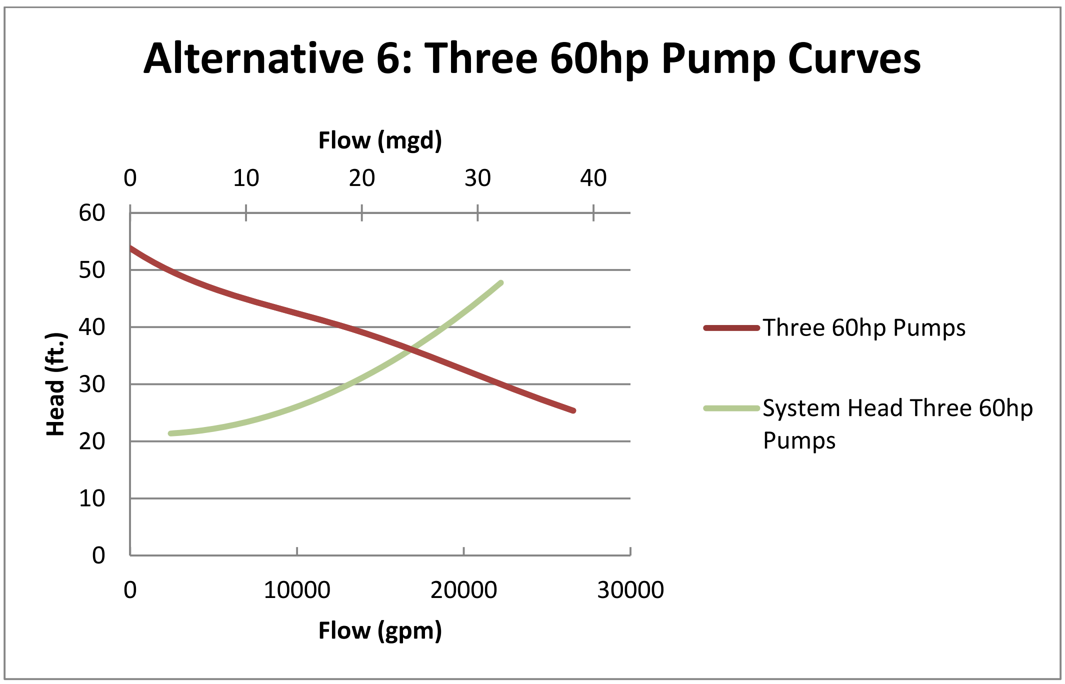
US El. =	4193	ft.
DS El. =	4214.17	ft.
ΔEl. =	21.17	ft.
g =	32.2	ft/s^2
D_{in} =	20	in
D_1 =	20	in
D_{1out} =	16	in
D_{out} =	18	in
$D_{manifold}$ =	27	in
D_{pipe} =	30	in
Peak Influent Flow =	31.5	mgd
	21875.00	gpm




Alternative 6: One 60hp Pump Curve
Flow (mgd)
0
5
10
15
20
60
50
40
30
20
10
0
Head (ft.)
0
5000
10000
15000
Flow (gpm)
One 60hp Pump
System Head Single 60hp Pump


Alternative 6: Two 60hp Pump Curves
Flow (mgd)
0
10
20
60
50
40
30
20
10
0
Head (ft.)
0
5000
10000
15000
20000
Flow (gpm)
Two 60hp Pumps
System Head Two 60hp Pumps


Alternative 6: Four 60hp Pump Curves
Flow (mgd)
0
20
40
90
80
70
60
50
40
30
20
10
0
Head (ft.)
0
10000
20000
30000
40000
Flow (gpm)
Four 60hp Pumps
System Head Four 60hp Pumps


Alternative 6: Three 60hp Pump Curves
Flow (mgd)
0
10
20
30
40
60
50
40
30
20
10
0
Head (ft.)
0
10000
20000
30000
Flow (gpm)
Three 60hp Pumps
System Head Three 60hp Pumps

NP-PS2 Alternative 7: Replace 50 hp Pump

One method to increase flows was to simply replace the existing 50 hp pump and see whether the three existing 60 hp pumps could handle the capacity while the new pump would remain as a standby pump. The capacity achieved by this alternative was far below the required value. This alternative was discarded in an attempt to create a set of alternatives that could all meet the required flows and this alternative did not.

NP-PS2 Alternative 8: Replace Two Pumps

Since a single pump could not increase flow enough, it was hoped that perhaps two could pump the remaining amount. The capacity achieved by this alternative was below the required value as well. This alternative was discarded in an attempt to create a set of alternatives that could all meet the required flows and this alternative did not.

NP-PS2 Alternative 9: Replace Three Pumps

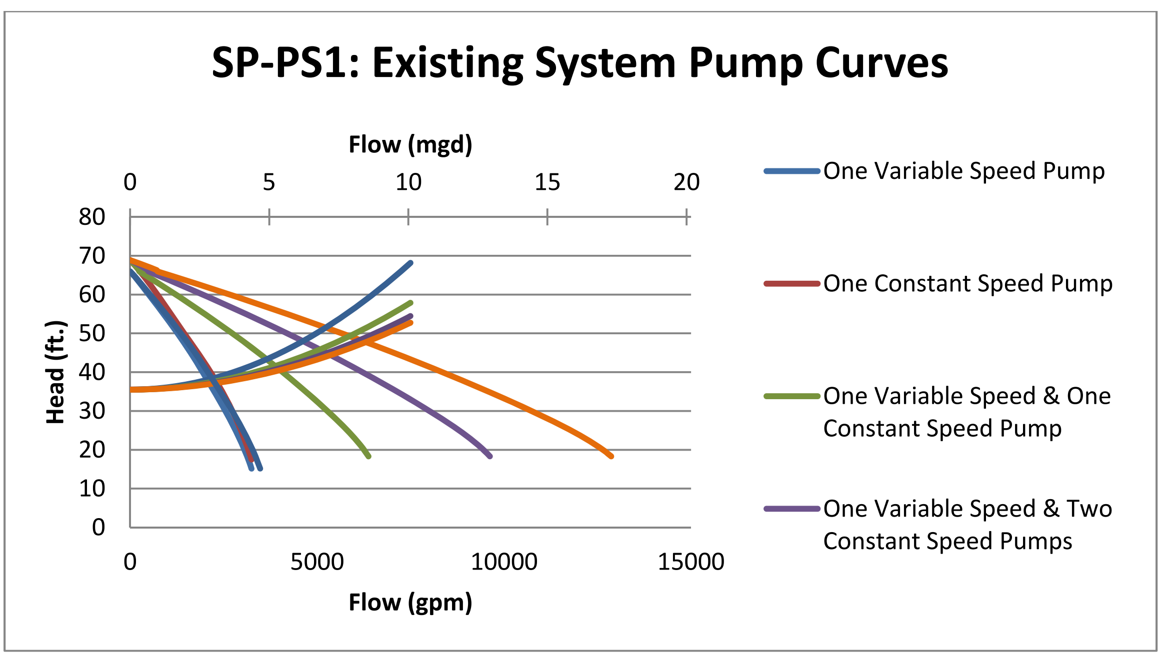
The existing system uses three larger pumps and a smaller pump to handle lower flows. To create a similar situation, three pumps would be replaced and a single 60 hp pump would be left for the lower flows. The capacity achieved by this alternative was below the required value since one of the larger pumps would need to be left on standby. This alternative was discarded in an attempt to create a set of alternatives that could all meet the required flows and this alternative did not.

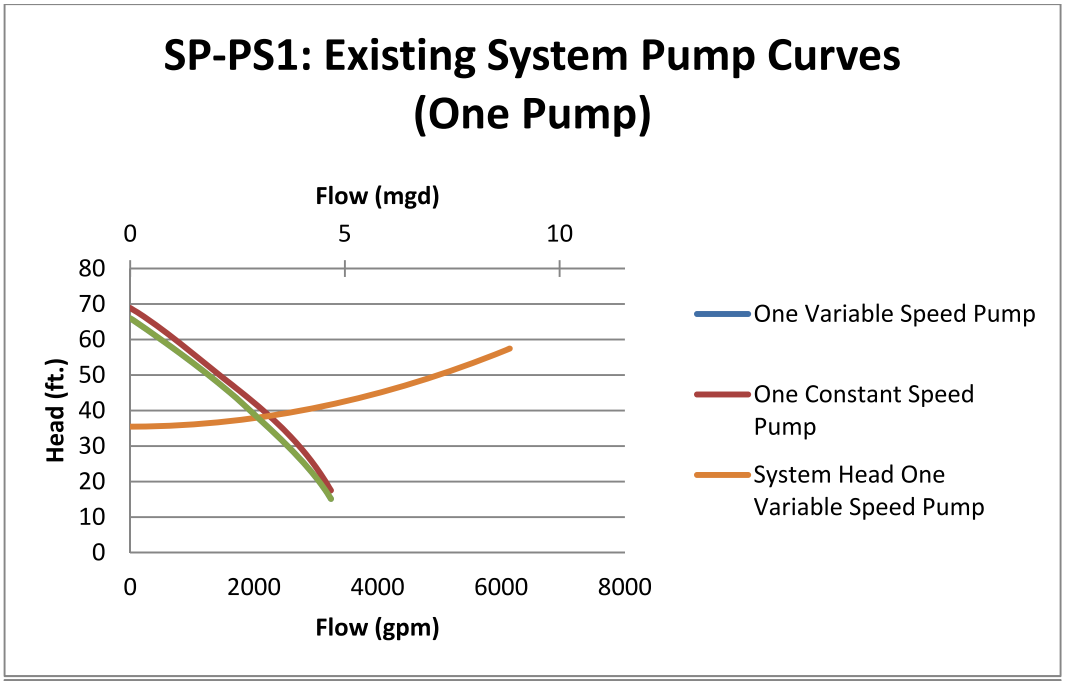
SP-PS1 Alternative 1: Existing System
Initial assumptions were as follows:

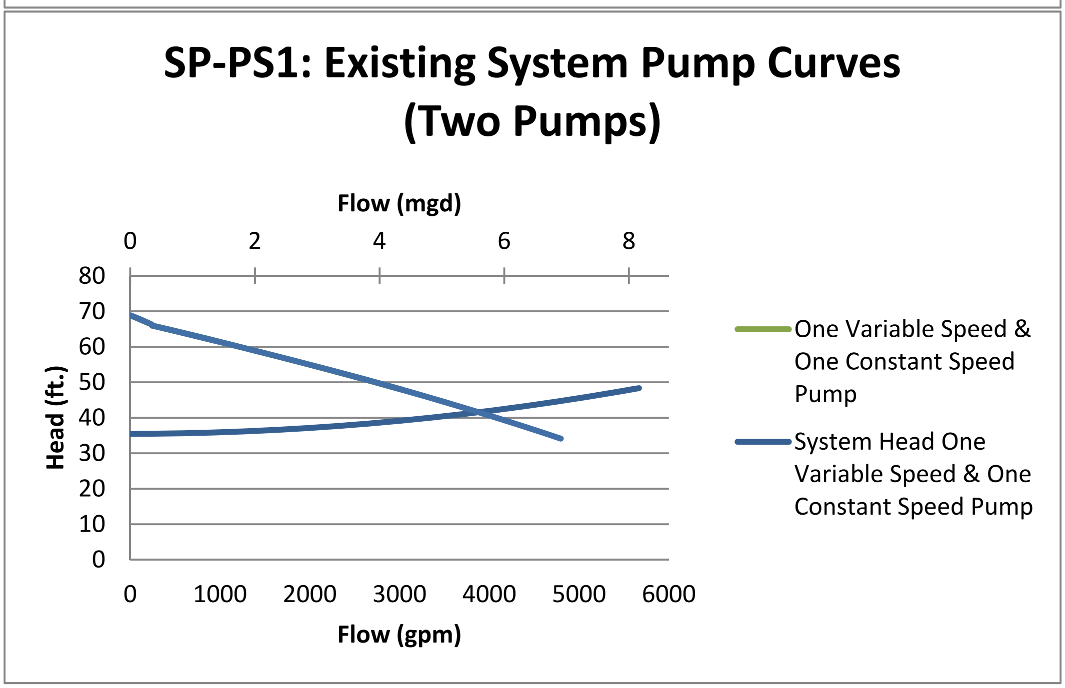
- Activated pumps were assumed to be those creating the greatest amount of loss (i.e., those farthest from the exit). This was done to create the most conservative model.
- All pumps flowed at 1150 rpm's and were not varied.
- Areas were calculated assuming that the pipes are always flowing full.

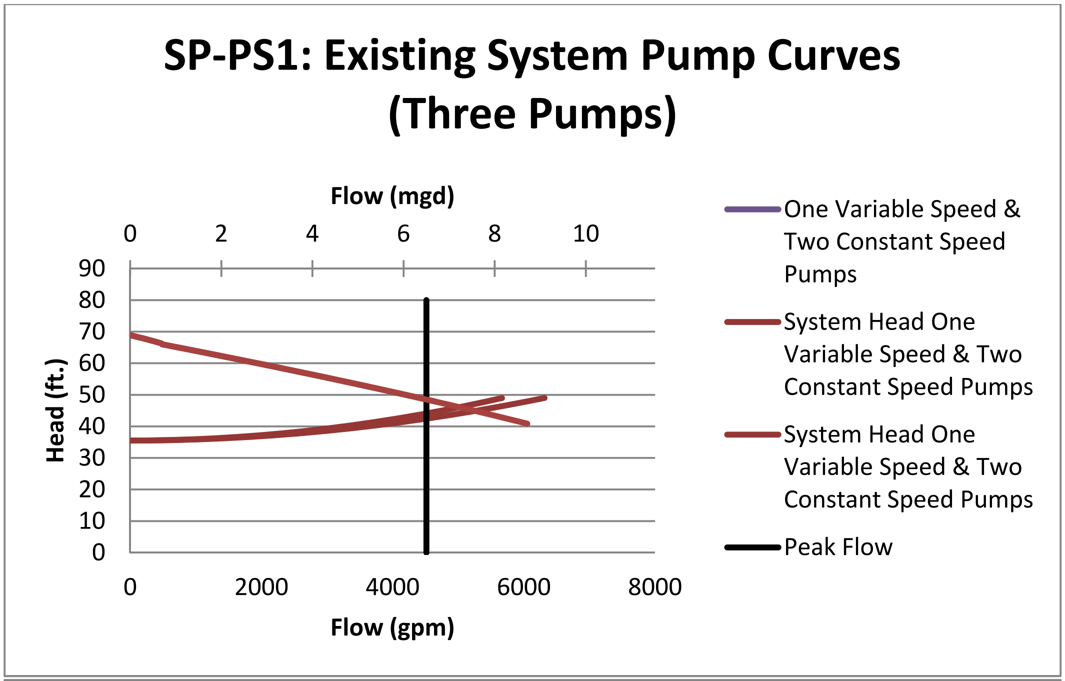
Other initial assumptions were made as follows:

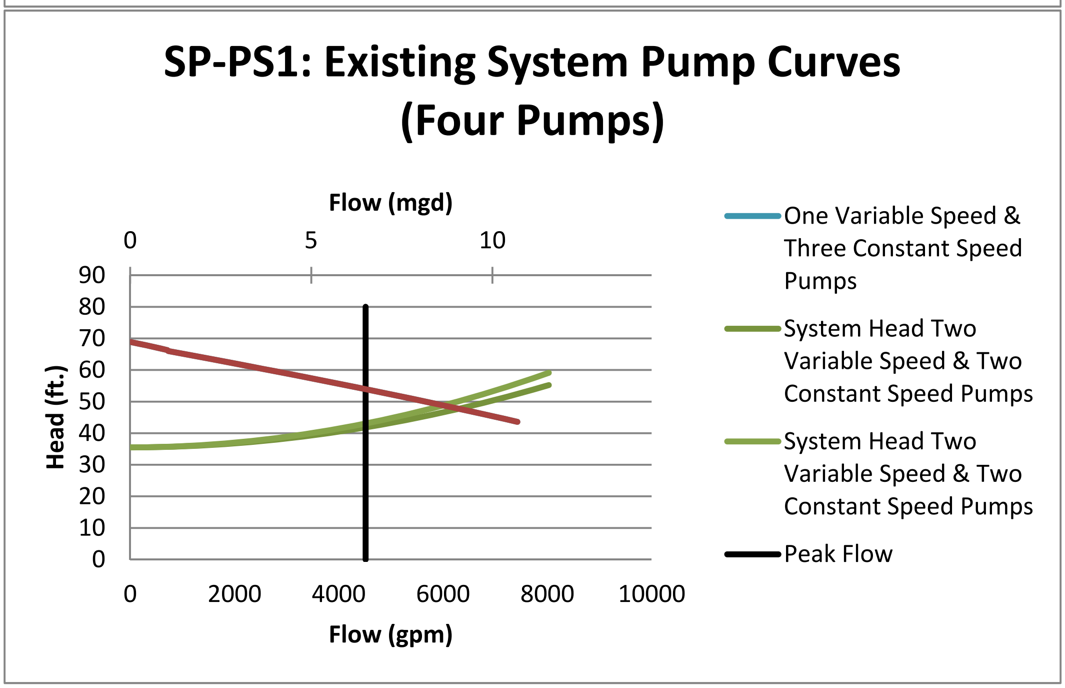
US El. =	97	ft.
DS El. =	132.5	ft.
ΔEl. =	35.5	ft.
g =	32.2	ft/s^2
$D_{initial}$ =	14	in
D_{in} =	10	in
D_{out} =	8	in
D_{branch} =	12	in
D_{pipe} =	16	in
$D_{pipe\ end}$ =	24	in
Peak Flow =	6.5	mgd
	4513.89	gpm




SP-PS1: Existing System Pump Curves
(One Pump)
Flow (mgd)
0
5
10
Head (ft.)
80
70
60
50
40
30
20
10
0
0
2000
4000
6000
8000
Flow (gpm)
One Variable Speed Pump
One Constant Speed Pump
System Head One Variable Speed Pump


SP-PS1: Existing System Pump Curves
(Two Pumps)
Flow (mgd)
0
2
4
6
8
Head (ft.)
80
70
60
50
40
30
20
10
0
0
1000
2000
3000
4000
5000
6000
Flow (gpm)
One Variable Speed & One Constant Speed Pump
System Head One Variable Speed & One Constant Speed Pump


SP-PS1: Existing System Pump Curves
(Three Pumps)
Flow (mgd)
0
2
4
6
8
10
Head (ft.)
90
80
70
60
50
40
30
20
10
0
0
2000
4000
6000
8000
Flow (gpm)
One Variable Speed & Two Constant Speed Pumps
System Head One Variable Speed & Two Constant Speed Pumps
System Head One Variable Speed & Two Constant Speed Pumps
Peak Flow

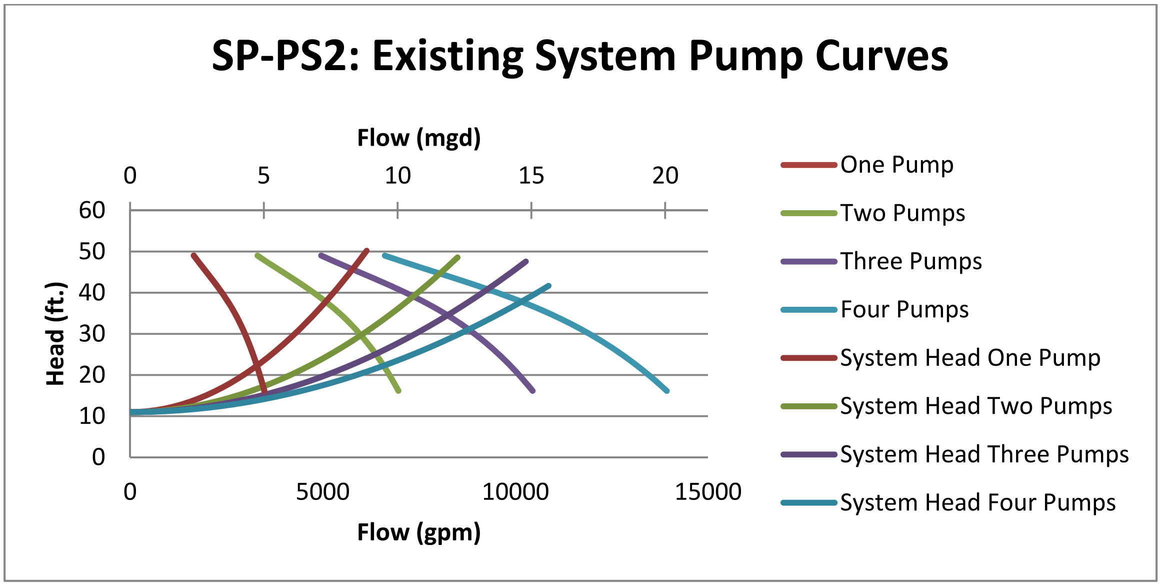

SP-PS1: Existing System Pump Curves
(Four Pumps)
Flow (mgd)
0
5
10
Head (ft.)
90
80
70
60
50
40
30
20
10
0
0
2000
4000
6000
8000
10000
Flow (gpm)
One Variable Speed & Three Constant Speed Pumps
System Head Two Variable Speed & Two Constant Speed Pumps
System Head Two Variable Speed & Two Constant Speed Pumps
Peak Flow

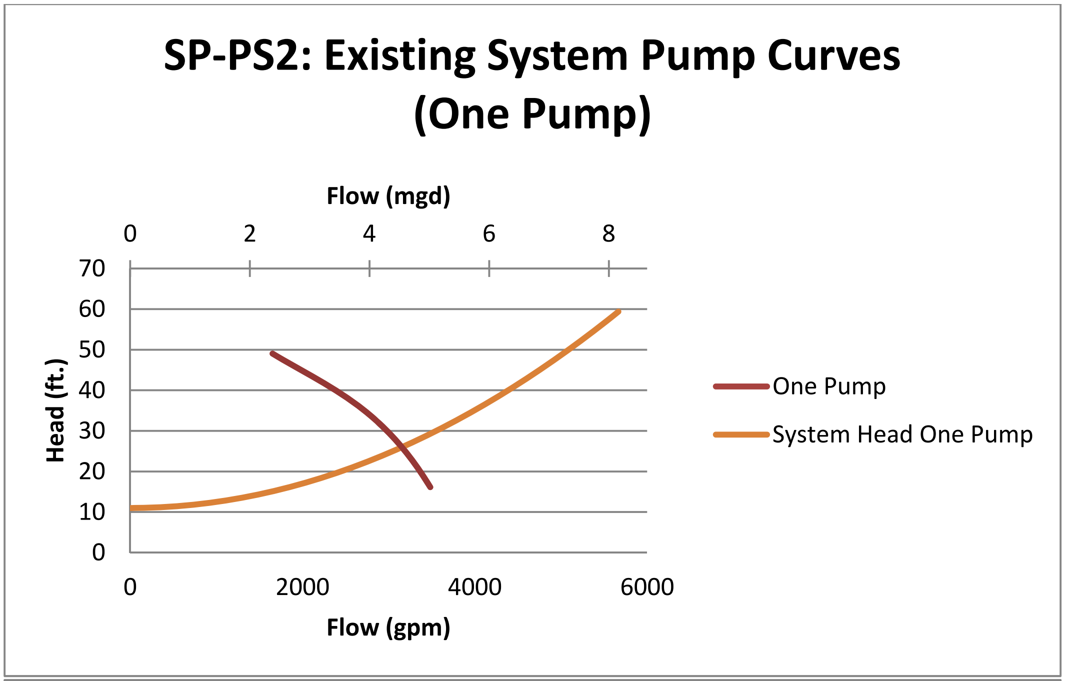
SP-PS2 Alternative 1: Existing System
Initial assumptions were as follows:

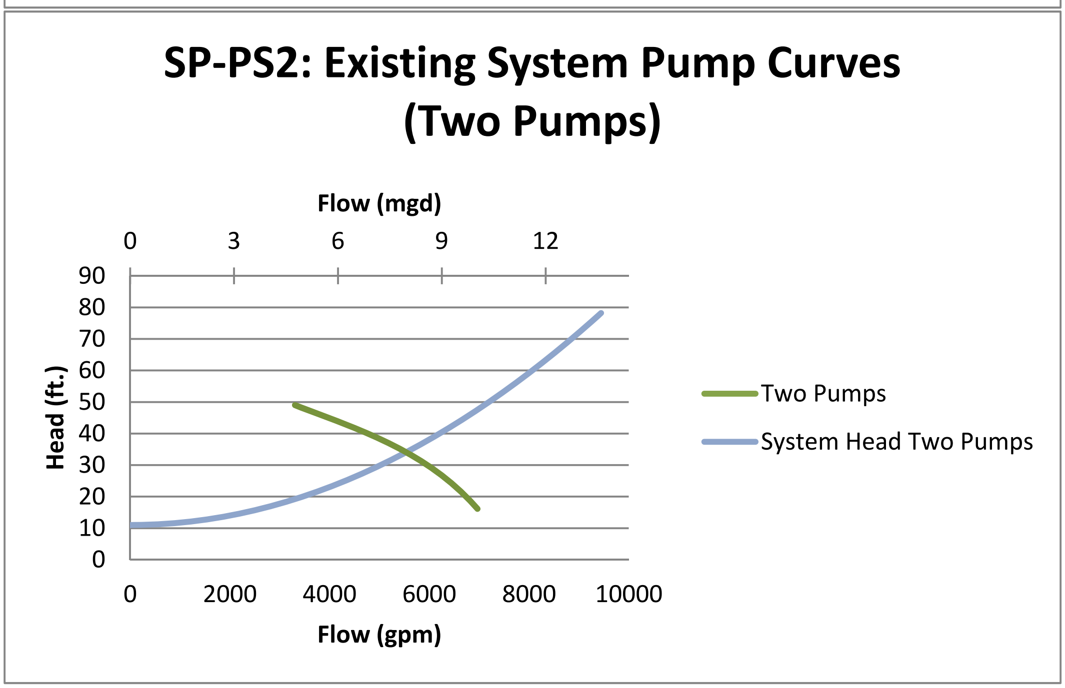
- Activated pumps were assumed to be those creating the greatest amount of loss (i.e., those farthest from the exit). This was done to create the most conservative model.
- All pumps flowed at 1760 rpm's and were not varied.
- Areas were calculated assuming that the pipes are always flowing full.

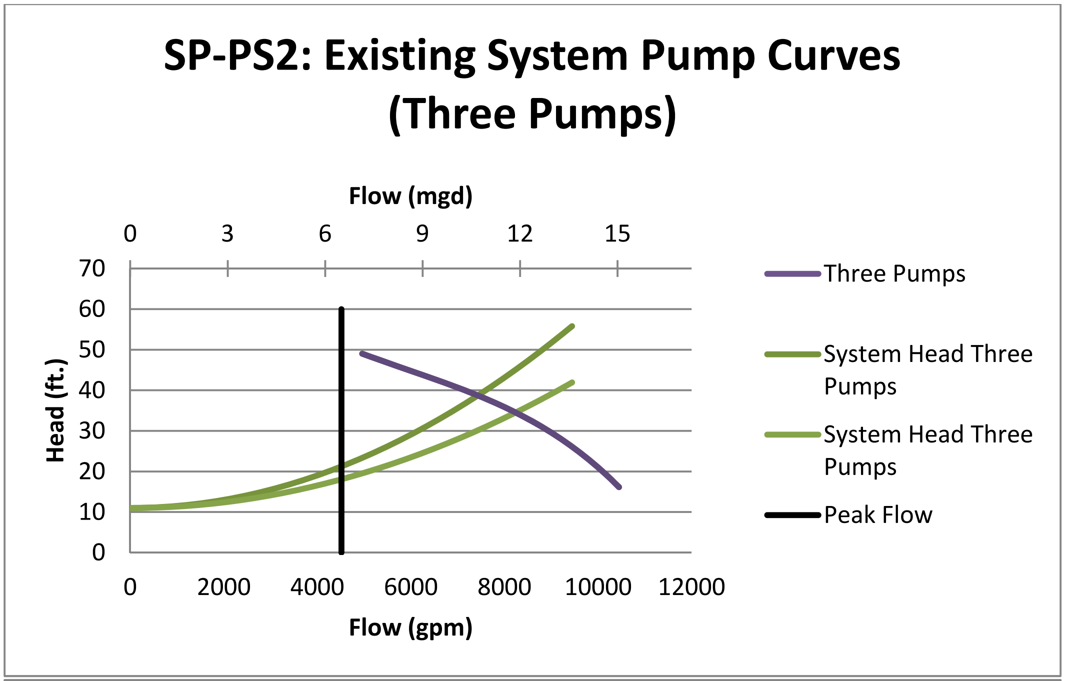
Other initial assumptions were made as follows:

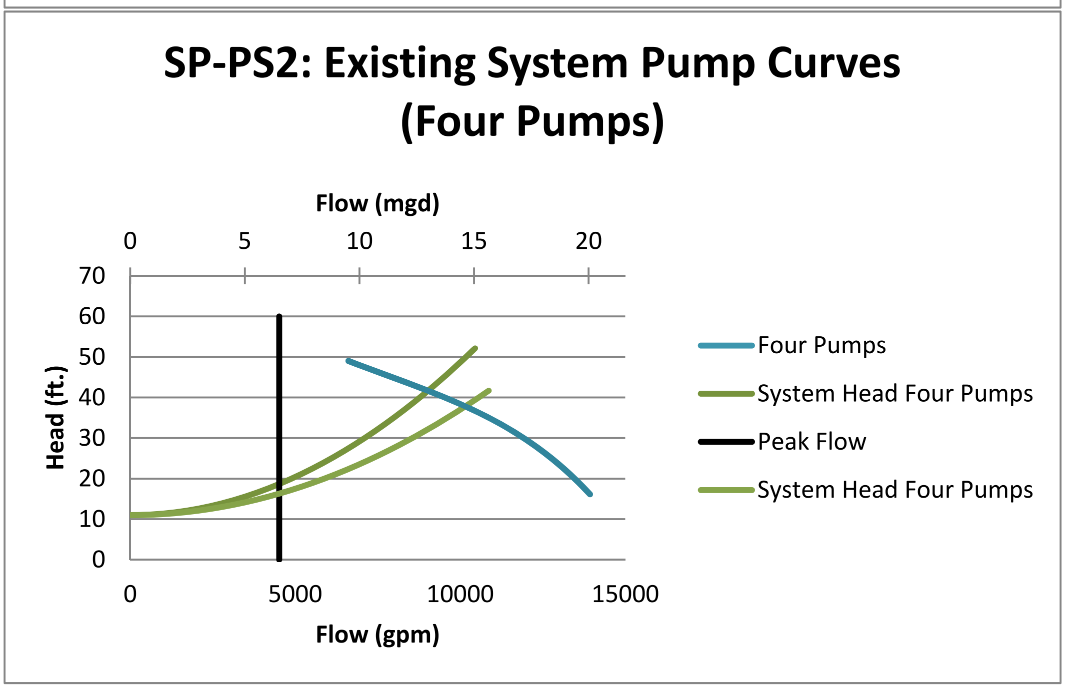
US El. =	6	ft.
DS El. =	17	ft.
ΔEl. =	11	ft.
g =	32.2	ft/s^2
D_{in} =	6	in
D_{out} =	10	in
Peak Flow =	6.5	mgd
	4513.89	gpm




SP-PS2: Existing System Pump Curves
(One Pump)
Flow (mgd)
0
2
4
6
8
70
60
50
40
30
20
10
0
Head (ft.)
0
2000
4000
6000
Flow (gpm)
One Pump
System Head One Pump


SP-PS2: Existing System Pump Curves
(Two Pumps)
Flow (mgd)
0
3
6
9
12
90
80
70
60
50
40
30
20
10
0
Head (ft.)
0
2000
4000
6000
8000
10000
Flow (gpm)
Two Pumps
System Head Two Pumps


SP-PS2: Existing System Pump Curves
(Three Pumps)
Flow (mgd)
0
3
6
9
12
15
70
60
50
40
30
20
10
0
Head (ft.)
0
2000
4000
6000
8000
10000
12000
Flow (gpm)
Three Pumps
System Head Three Pumps
System Head Three Pumps
Peak Flow

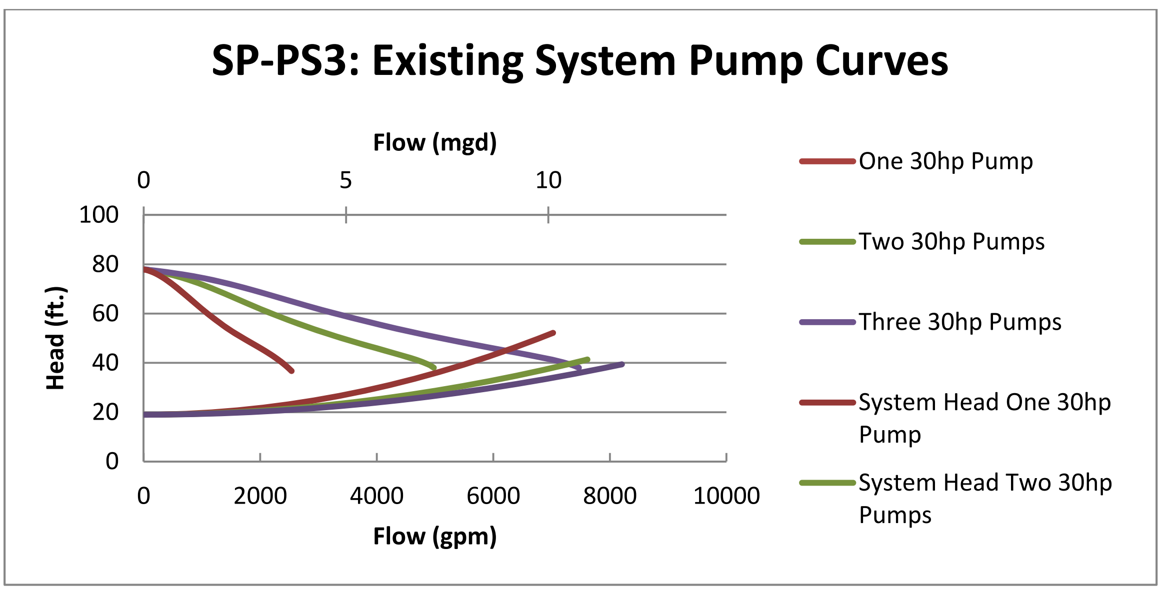

SP-PS2: Existing System Pump Curves
(Four Pumps)
Flow (mgd)
0
5
10
15
20
70
60
50
40
30
20
10
0
Head (ft.)
0
5000
10000
15000
Flow (gpm)
Four Pumps
System Head Four Pumps
Peak Flow
System Head Four Pumps

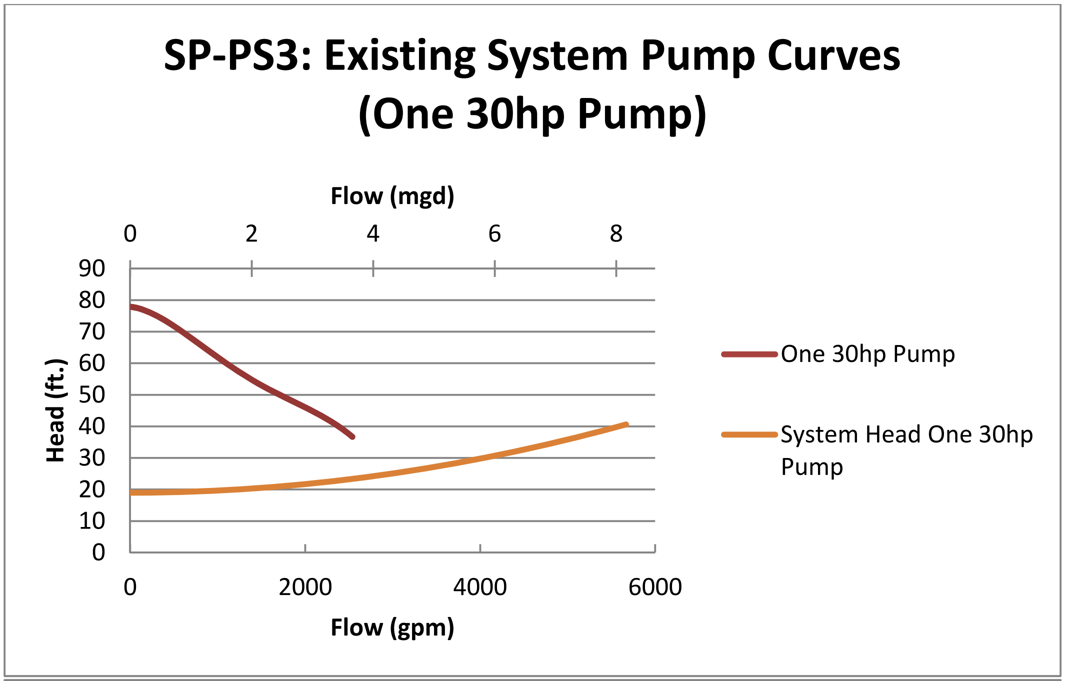
SP-PS3 Alternative 1: Existing System
Initial assumptions were as follows:

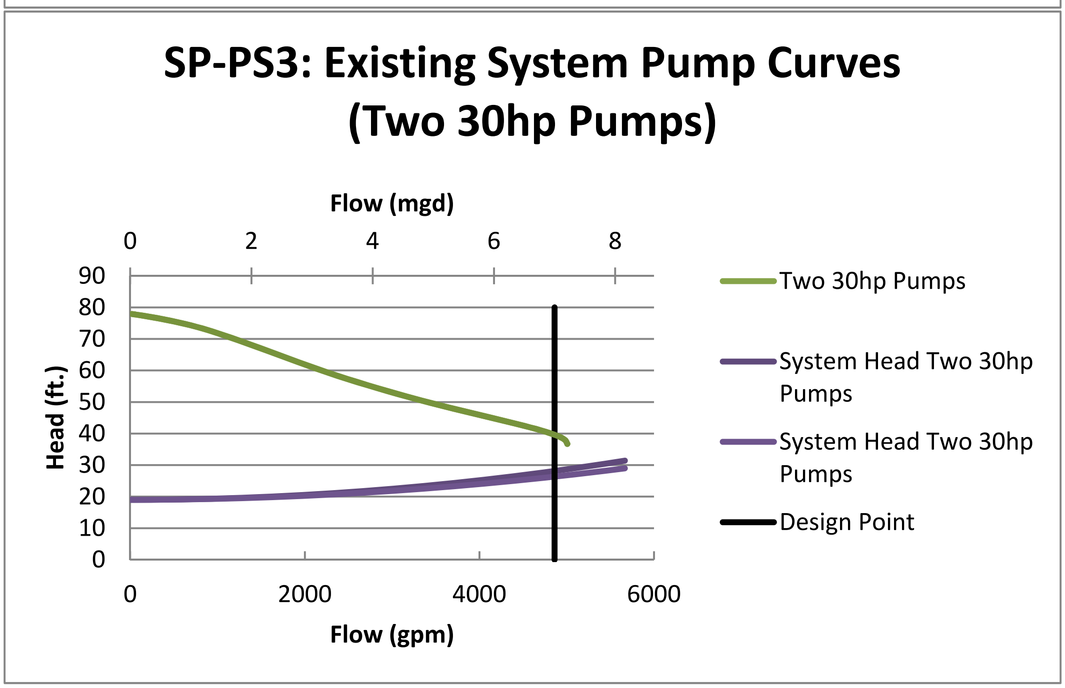
- Activated pumps were assumed to be those creating the greatest amount of loss (i.e., those farthest from the exit). This was done to create the most conservative model.
- All pumps flowed at 1175 rpm's and were not varied.
- Areas were calculated assuming that the pipes are always flowing full.

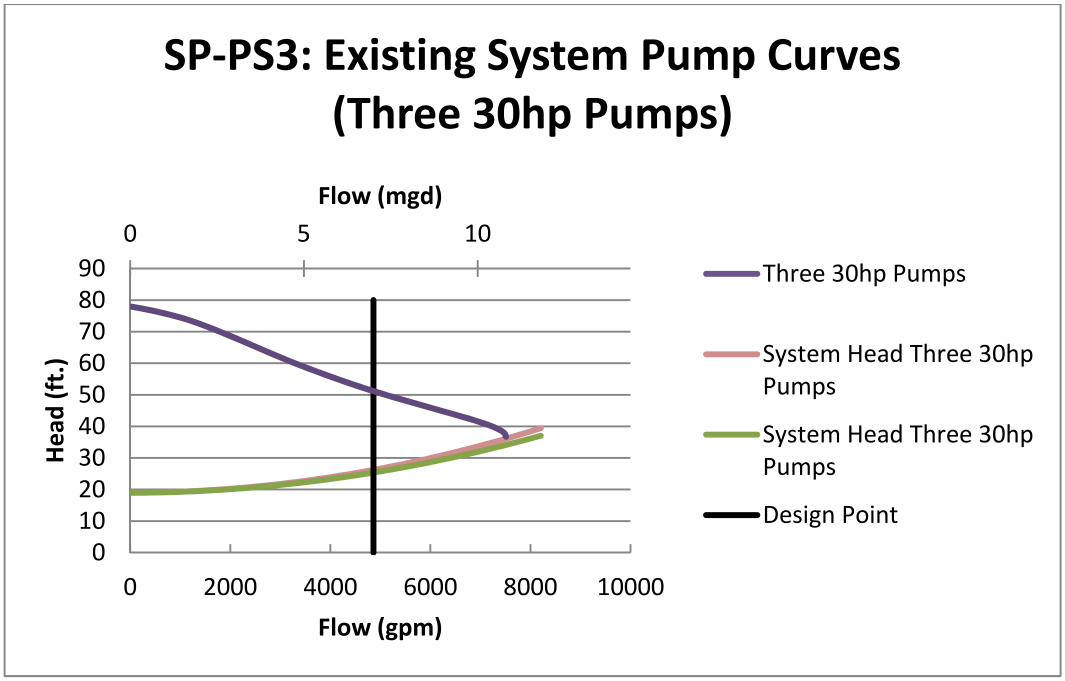
Other initial assumptions were made as follows:

US El. =	11	ft.
DS El. =	30	ft.
ΔEl. =	19	ft.
g =	32.2	ft/s^2
$D_{initial}$ =	14	in
D_{in} =	8	in
D_{out} =	8	in
D_{valves} =	12	in
D_{branch} =	16	in
D_{pipe} =	16	in
$D_{pipe\ end}$ =	18	in
Peak Flow =	7	mgd
	4861.11	gpm




SP-PS3: Existing System Pump Curves
(One 30hp Pump)
Flow (mgd)
0
2
4
6
8
90
80
70
60
50
40
30
20
10
0
Head (ft.)
0
2000
4000
6000
Flow (gpm)
One 30hp Pump
System Head One 30hp Pump


SP-PS3: Existing System Pump Curves
(Two 30hp Pumps)
Flow (mgd)
0
2
4
6
8
90
80
70
60
50
40
30
20
10
0
Head (ft.)
0
2000
4000
6000
Flow (gpm)
Two 30hp Pumps
System Head Two 30hp Pumps
System Head Two 30hp Pumps
Design Point


SP-PS3: Existing System Pump Curves
(Three 30hp Pumps)
Flow (mgd)
0
5
10
90
80
70
60
50
40
30
20
10
0
Head (ft.)
0
2000
4000
6000
8000
10000
Flow (gpm)
Three 30hp Pumps
System Head Three 30hp Pumps
System Head Three 30hp Pumps
Design Point

Appendix E: Cost Calculations

Although a hydraulic analysis showed which alternative could achieve the highest flow, the factor that often controls the most is the amount that each alternative costs. An ideal hydraulic solution may be found, but if the cost is too high, it becomes impractical and a less expensive solution must be implemented.

Operating costs only include those costs which are associated with energy consumption. All other O&M costs were covered in the maintenance costs and are bundled into a lump sum.

The operating costs were modeled three different ways so that a good comparison could be made between them. First, a model was created to show what it would cost to run different alternatives for an entire year. This would show what will cost more per minute to run. The second method was to show the costs to pump an entire year's volume of water. This would help to show that, even though a pumping system might cost more per minute, they can do the work quickly enough to make the time difference enough that the costs would become smaller as well. Finally, the last method was to create a very basic diurnal pattern of flows with only four flow values used over the time of day. The number of pumps was to operate at these values was decided to be the smallest number of pumps capable of handling the entire flow, even if that meant that the pumps would be far oversized. Although the VFD could not be incorporated into this method, it would help to show a more realistic cost to run a variable number of pumps for a year instead of running a set number of pumps. It was this method that was used when calculating the 20-year costs.

To calculate the cost of each alternative, power rates were taken from the current electric bills. Because the rates vary throughout the year, a weighted average was taken for both the rate and demand charges.

Efficiencies were used to find the amount of power that would have to be utilized by the pumps. Although it is known that the demand charges are not controlled by any single process of the plants, it was determined that the portion that the pumps contribute to the whole could be found. For this calculation, it was assumed that, every month, all pumps (with the exclusion of the one on standby), would activate at some point in the month and it would be this amount that would be charged.

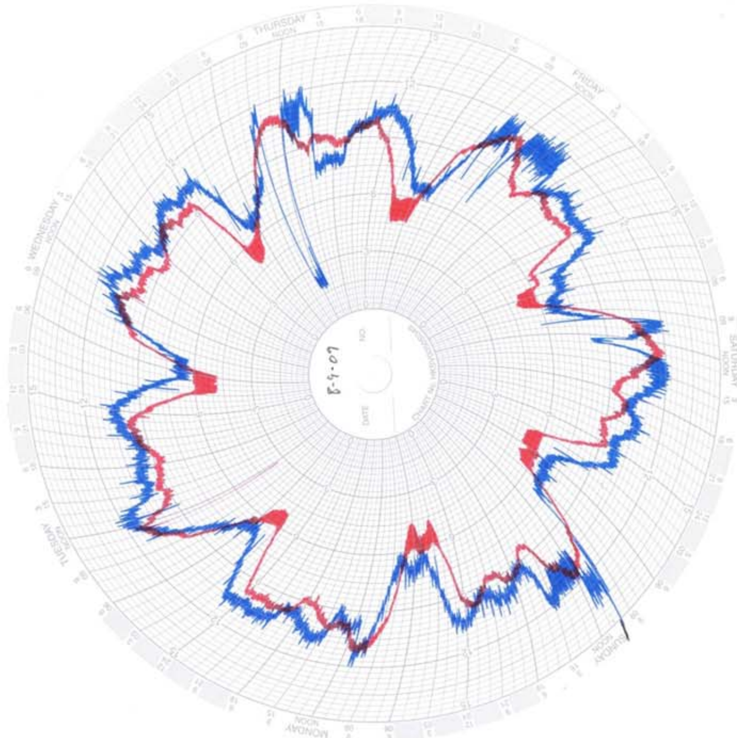
To determine the number of kwh that would be required for each alternative, average flows were found for 2009 and a day containing these flows was reviewed. With this "average day", a simplified diurnal pattern was created. By determining the flows at each segment of time in this pattern, the number of pumps needed to maintain those flows was found. The required kwh were taken from this pattern and costs were then calculated from this new data. Because the power costs of using a VFD were unavailable, it was assumed that the pumps would be left running with a full load during each segment of time. Although this caused the power costs to appear higher than they actually are, it was decided that it would be close enough for the comparison of alternatives that this difference would be insignificant.

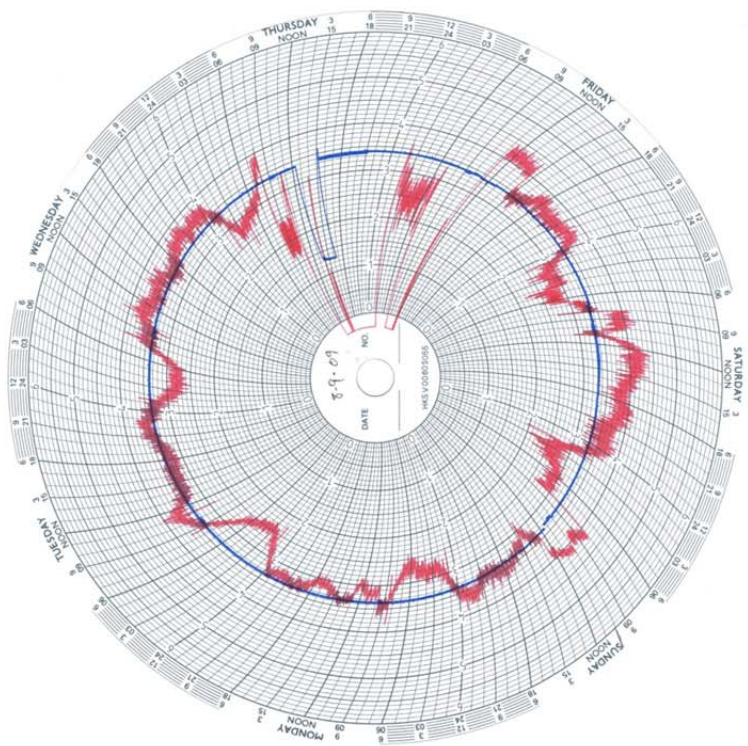
Summary of Costs: North Plant				
NP-PS1				
	Installation	**Operating** (Annual / 20-Yr.)	**Maintenance** (Annual / 20-Yr.)	**Total Costs**
Alternative 1: Existing System	NA	$38,841.62 $577,865.25	$7,500.00 $111,581.06	$689,446.31
Alternative 2: Four That Fit	$316,502.00	$68,372.24 $1,017,206.34	$8,190.00 $121,846.52	$1,455,554.86
Alternative 3: Four That Squeeze	$476,100.00	$60,901.24 $906,056.74	$8,190.00 $121,846.52	$1,504,003.26
Alternative 4: Five Pump System	$137,139.00	$49,198.99 $731,956.68	$10,237.50 $152,308.15	$1,021,403.83
Alternative 5: Four That Fit (70 hp)	$267,720.00	$50,658.23 $753,666.50	$8,190.00 $121,846.52	$1,143,233.02
Alternative 6: Four That Squeeze (60 hp)	$454,986.00	$42,642.18 $634,407.90	$8,190.00 $121,846.52	$1,211,240.42

NP-PS2				
	Installation	**Operating** (Annual / 20-Yr.)	**Maintenance** (Annual / 20-Yr.)	**Total Costs**
Alternative 1: Existing System	NA	$31,940.93 $475,200.32	$7,500.00 $111,581.06	$586,781.38
Alternative 2: Four That Fit	$529,574.00	$41,921.12 $623,680.44	$8,190.00 $121,846.52	$1,275,100.96
Alternative 3: Four That Squeeze	$625,070.00	$60,132.76 $894,623.59	$8,190.00 $121,846.52	$1,641,540.11
Alternative 4: Three Large Pumps	$494,523.00	$76,213.97 $1,133,871.49	$6,142.50 $91,384.89	$1,719,779.38
Alternative 5: Four That Fit (70 hp)	$261,716.00	$50,839.80 $756,367.91	$8,190.00 $121,846.52	$1,139,930.43
Alternative 6: Four That Squeeze (60 hp)	$454,986.00	$26,428.32 $393,186.66	$8,190.00 $121,846.52	$970,019.18

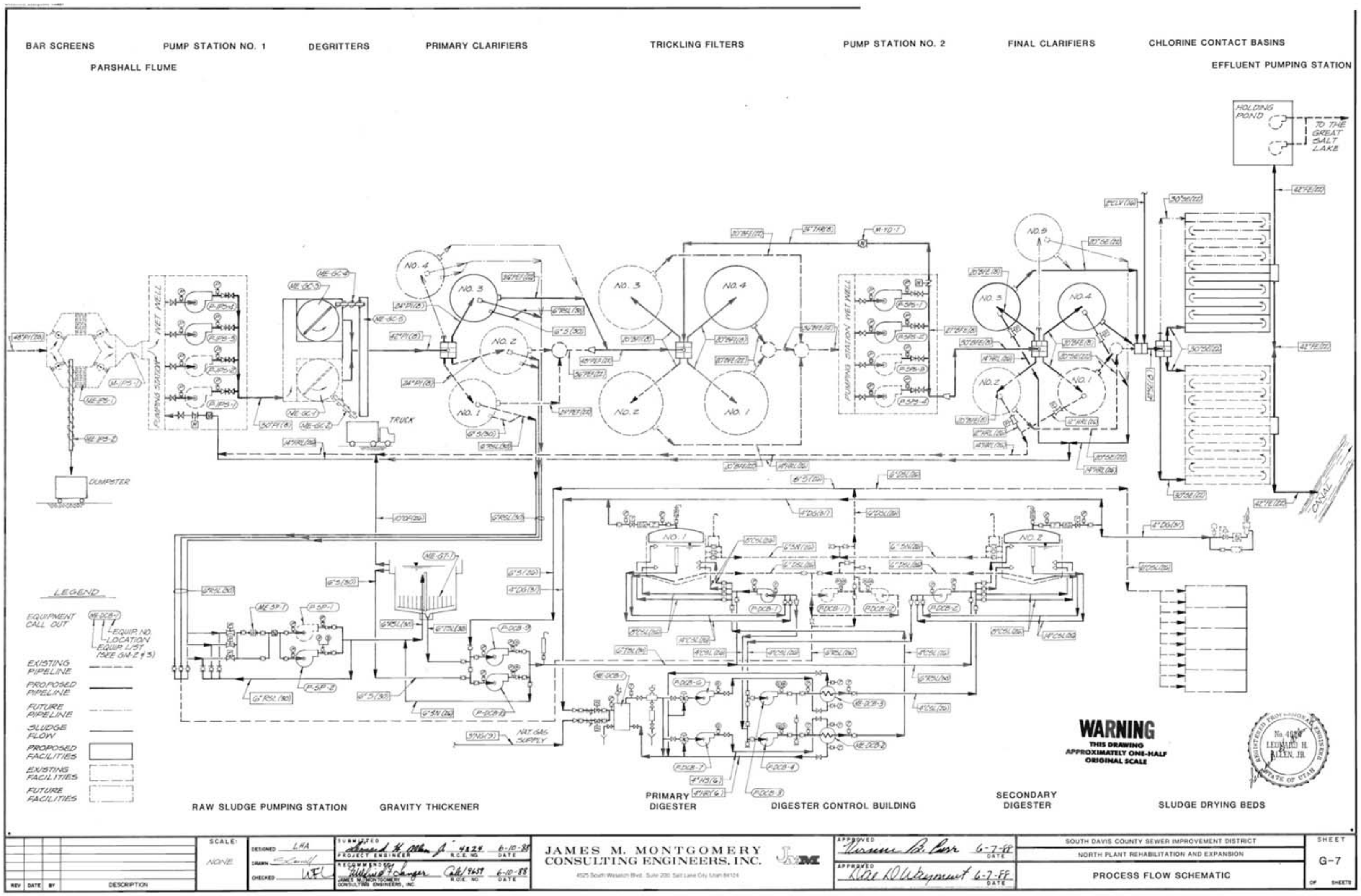
Appendix F: Miscellaneous

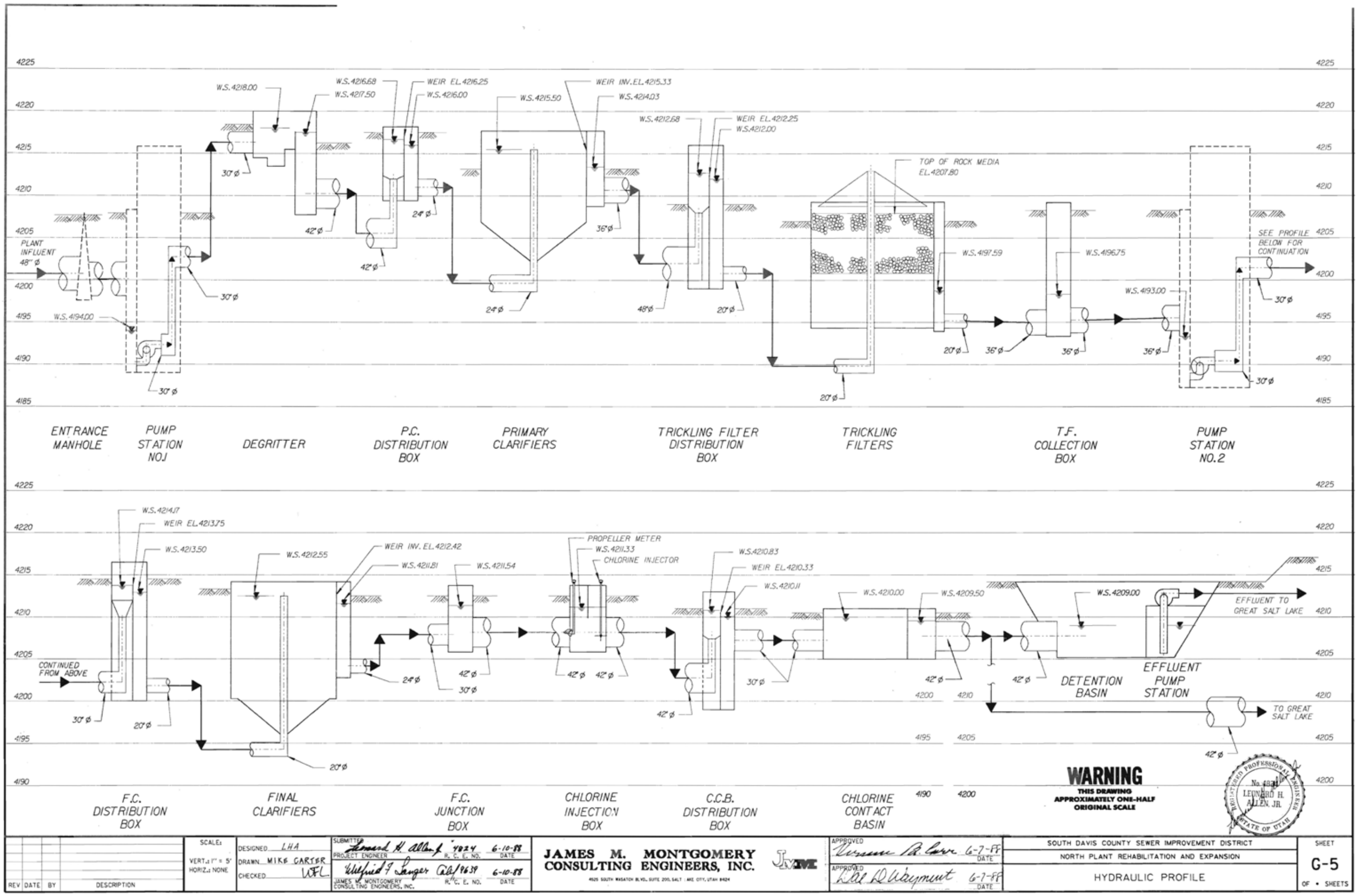
Pen charts for the north plant showing influent and effluent flows (top) and recirculated flow (bottom). These charts are typical of the data that was reviewed.

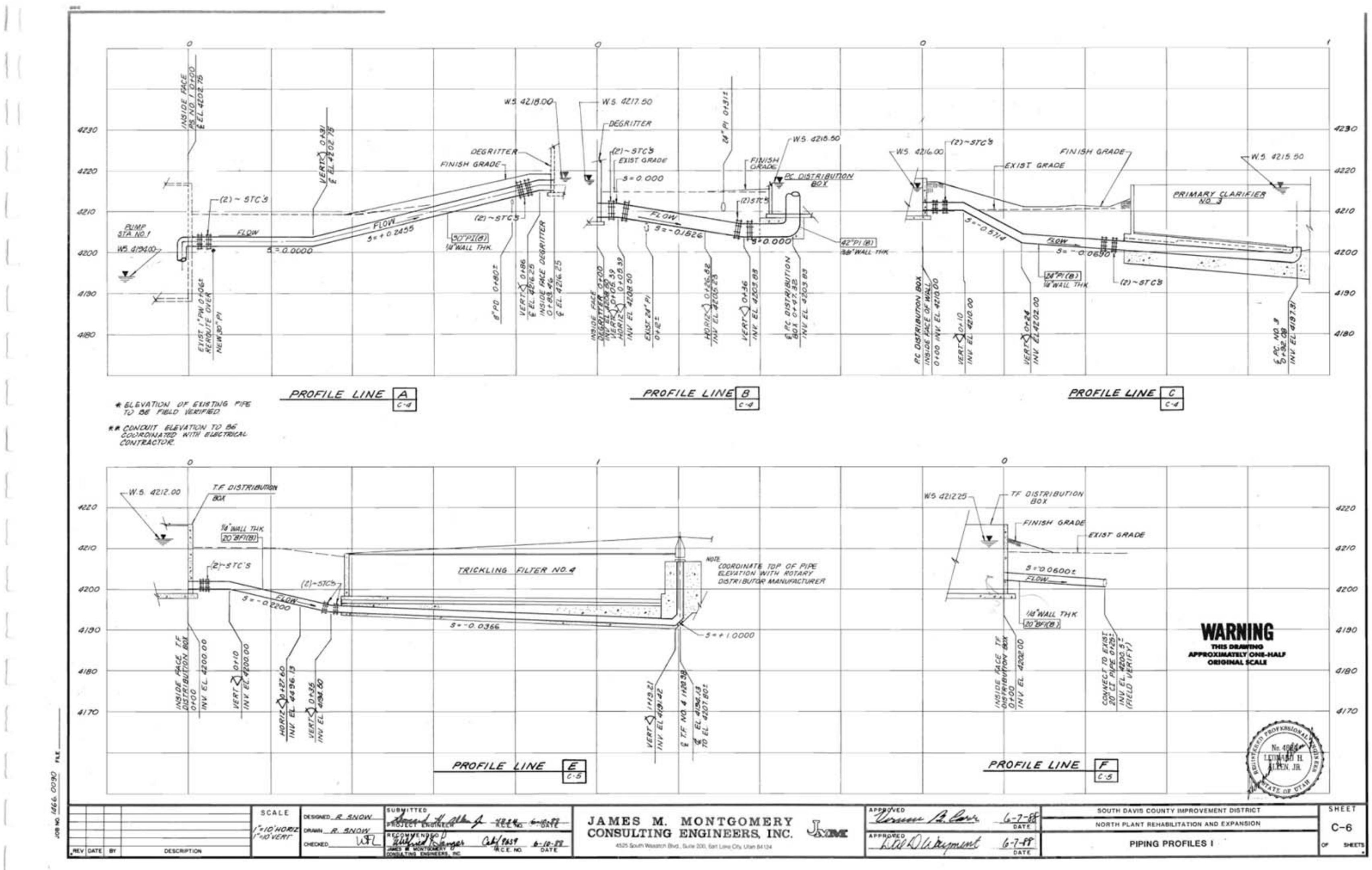


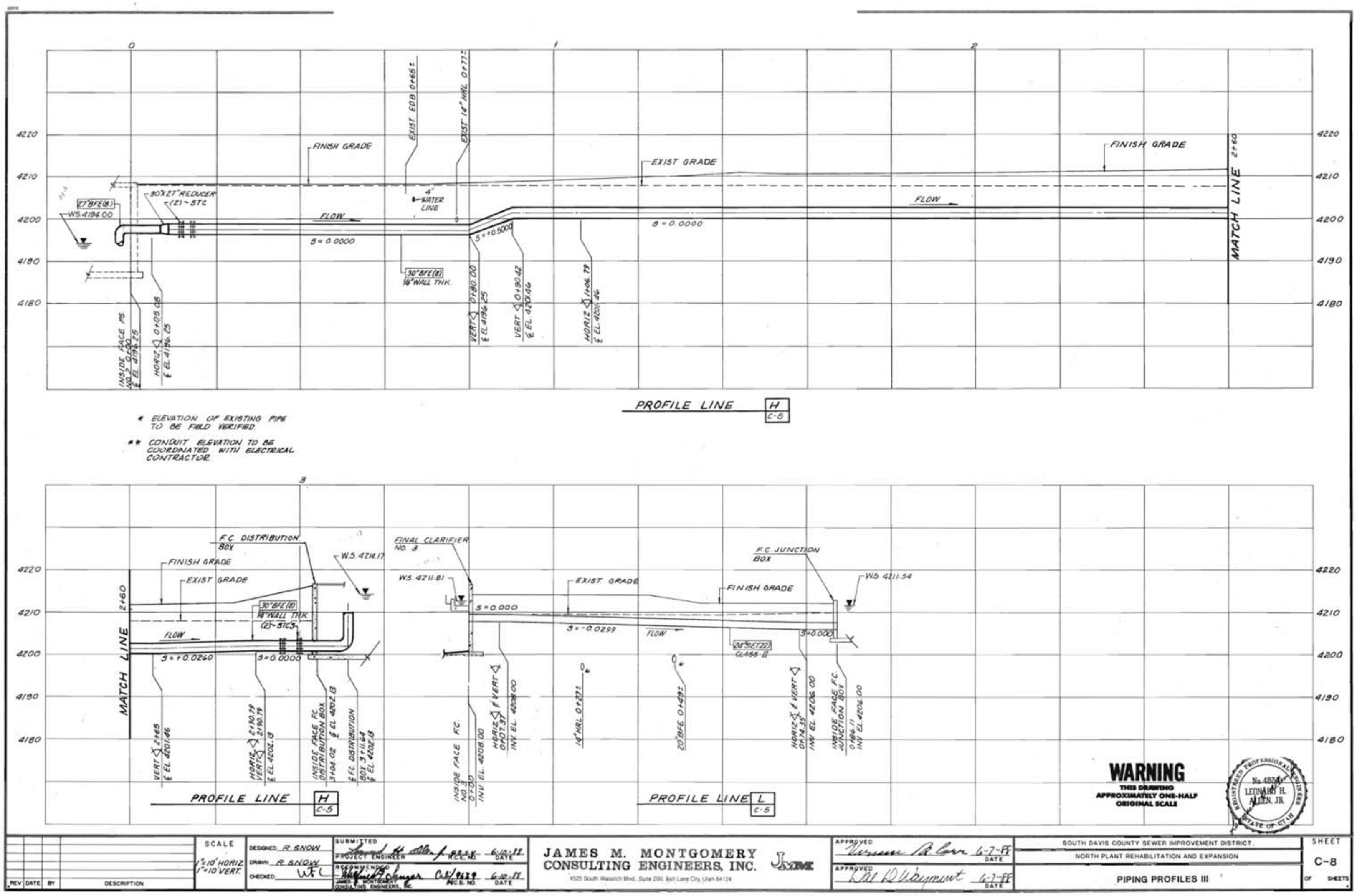


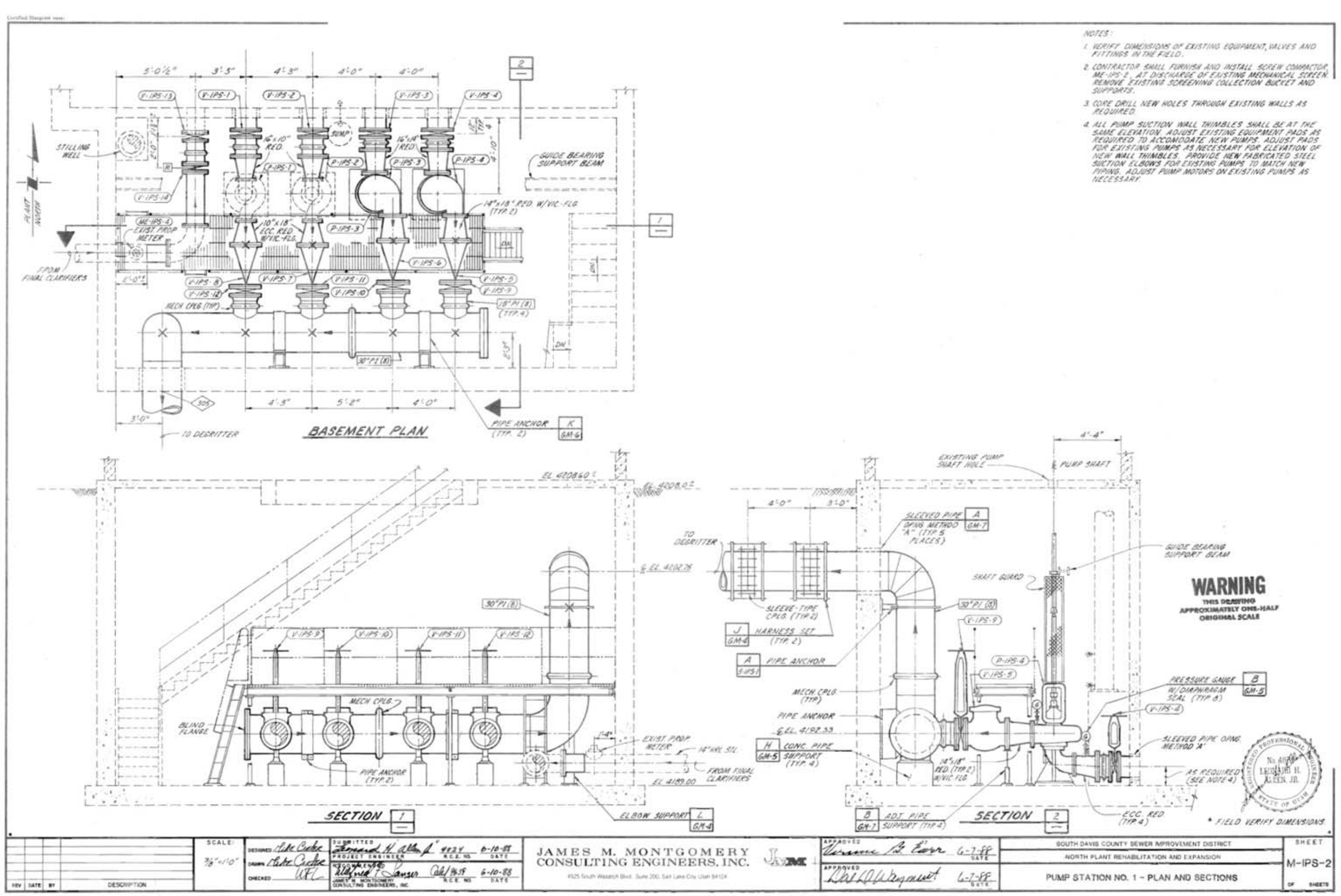
The following pages contain the various drawings and plans that were used to create the model and define the layout of the existing stations.

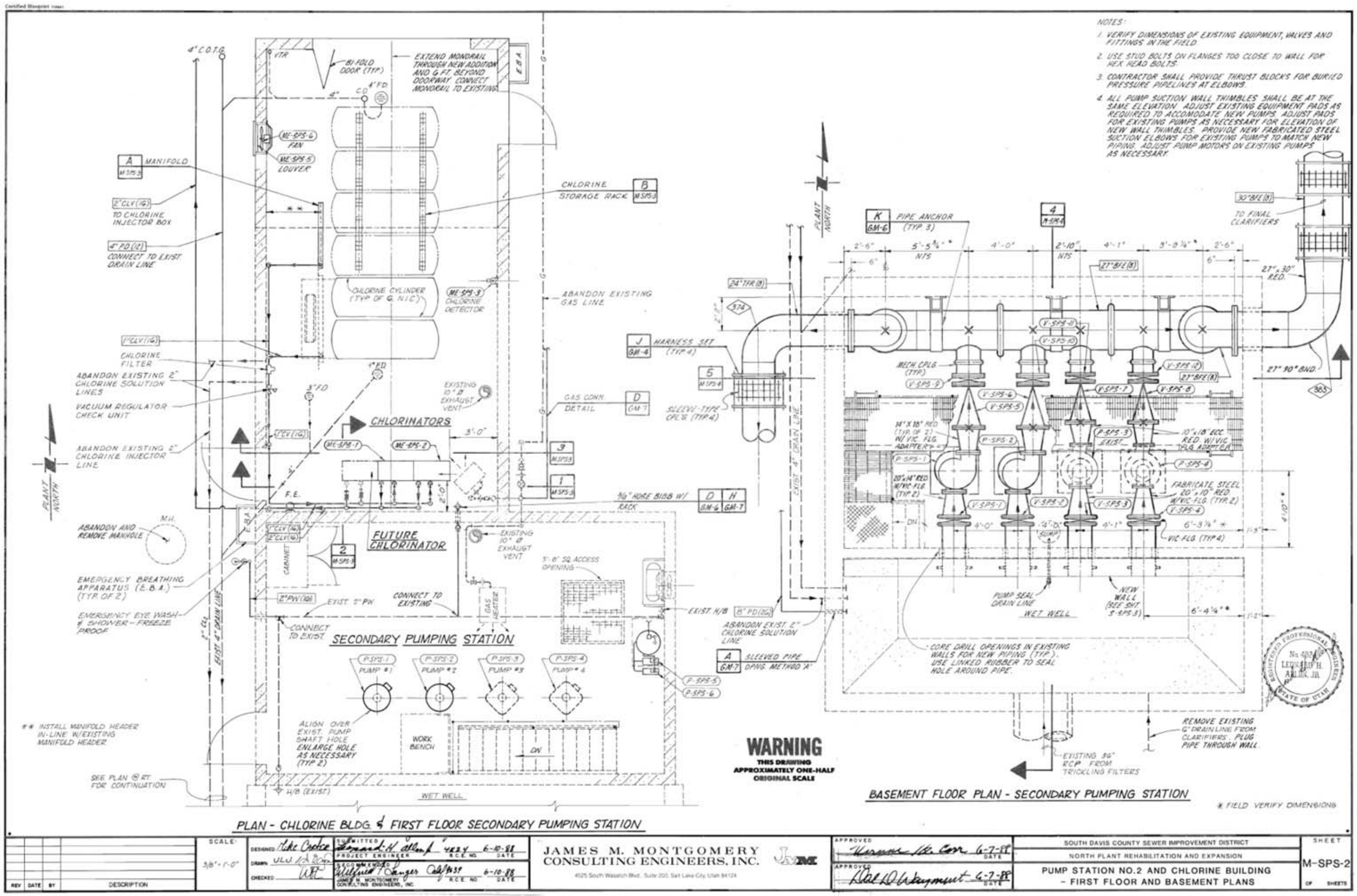

BAR SCREENS
PARSHALL FLUME
PUMP STATION NO. 1
DEGRITTERS
PRIMARY CLARIFIERS
TRICKLING FILTERS
PUMP STATION NO. 2
FINAL CLARIFIERS
CHLORINE CONTACT BASINS
EFFLUENT PUMPING STATION
HOLDING POND
TO THE GREAT SALT LAKE
DUMPSTER
TRUCK
CANAL
LEGEND
EQUIPMENT CALL OUT
EQUIP. NO.
LOCATION
EQUIP. LIST (SEE GN-2 & 3)
EXISTING PIPELINE
PROPOSED PIPELINE
FUTURE PIPELINE
SLUDGE FLOW
PROPOSED FACILITIES
EXISTING FACILITIES
FUTURE FACILITIES
NAT. GAS SUPPLY
WARNING
THIS DRAWING APPROXIMATELY ONE-HALF ORIGINAL SCALE
RAW SLUDGE PUMPING STATION
GRAVITY THICKENER
PRIMARY DIGESTER
DIGESTER CONTROL BUILDING
SECONDARY DIGESTER
SLUDGE DRYING BEDS
JAMES M. MONTGOMERY CONSULTING ENGINEERS, INC.
SOUTH DAVIS COUNTY SEWER IMPROVEMENT DISTRICT
NORTH PLANT REHABILITATION AND EXPANSION
PROCESS FLOW SCHEMATIC
G-7
SCALE: NONE

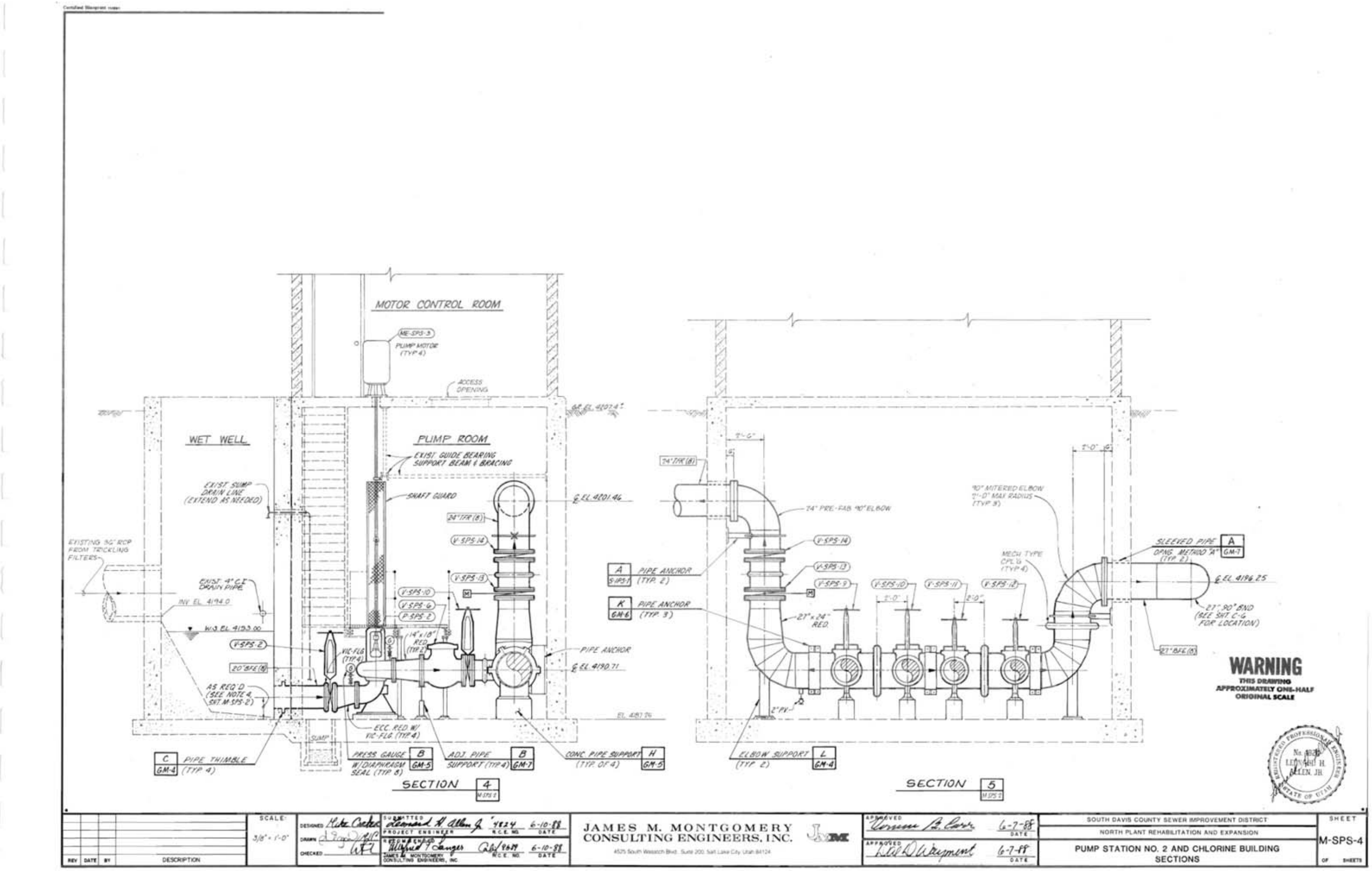

ENTRANCE MANHOLE
PUMP STATION NO.1
DEGRITTER
P.C. DISTRIBUTION BOX
PRIMARY CLARIFIERS
TRICKLING FILTER DISTRIBUTION BOX
TRICKLING FILTERS
T.F. COLLECTION BOX
PUMP STATION NO.2
PLANT INFLUENT 48" Ø
TOP OF ROCK MEDIA EL.4207.80
SEE PROFILE BELOW FOR CONTINUATION
F.C. DISTRIBUTION BOX
FINAL CLARIFIERS
F.C. JUNCTION BOX
CHLORINE INJECTION BOX
C.C.B. DISTRIBUTION BOX
CHLORINE CONTACT BASIN
DETENTION BASIN
EFFLUENT PUMP STATION
CONTINUED FROM ABOVE
PROPELLER METER
CHLORINE INJECTOR
EFFLUENT TO GREAT SALT LAKE
TO GREAT SALT LAKE
WARNING
THIS DRAWING APPROXIMATELY ONE-HALF ORIGINAL SCALE
JAMES M. MONTGOMERY CONSULTING ENGINEERS, INC.
SOUTH DAVIS COUNTY SEWER IMPROVEMENT DISTRICT
NORTH PLANT REHABILITATION AND EXPANSION
HYDRAULIC PROFILE
G-5
DESIGNED LHA
DRAWN MIKE CARTER
REV DATE BY DESCRIPTION

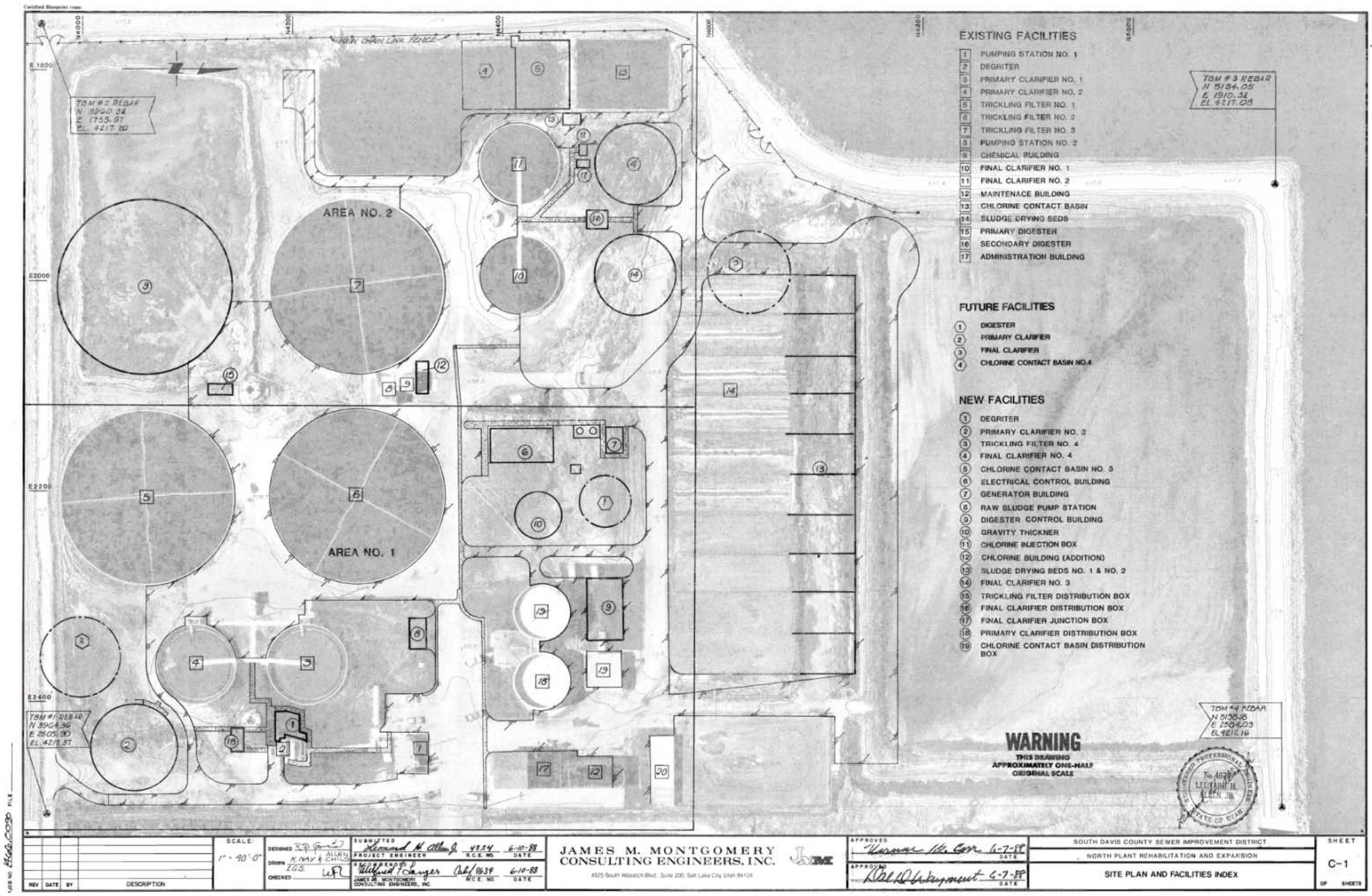

PROFILE LINE A C-4
PROFILE LINE B C-4
PROFILE LINE C C-4
PROFILE LINE E C-5
PROFILE LINE F C-5
PRIMARY CLARIFIER NO. 3
TRICKLING FILTER NO. 4
* ELEVATION OF EXISTING PIPE TO BE FIELD VERIFIED
** CONDUIT ELEVATION TO BE COORDINATED WITH ELECTRICAL CONTRACTOR
NOTE: COORDINATE TOP OF PIPE ELEVATION WITH ROTARY DISTRIBUTOR MANUFACTURER
WARNING
THIS DRAWING APPROXIMATELY ONE-HALF ORIGINAL SCALE
JAMES M. MONTGOMERY CONSULTING ENGINEERS, INC.
SOUTH DAVIS COUNTY IMPROVEMENT DISTRICT
NORTH PLANT REHABILITATION AND EXPANSION
PIPING PROFILES I
C-6

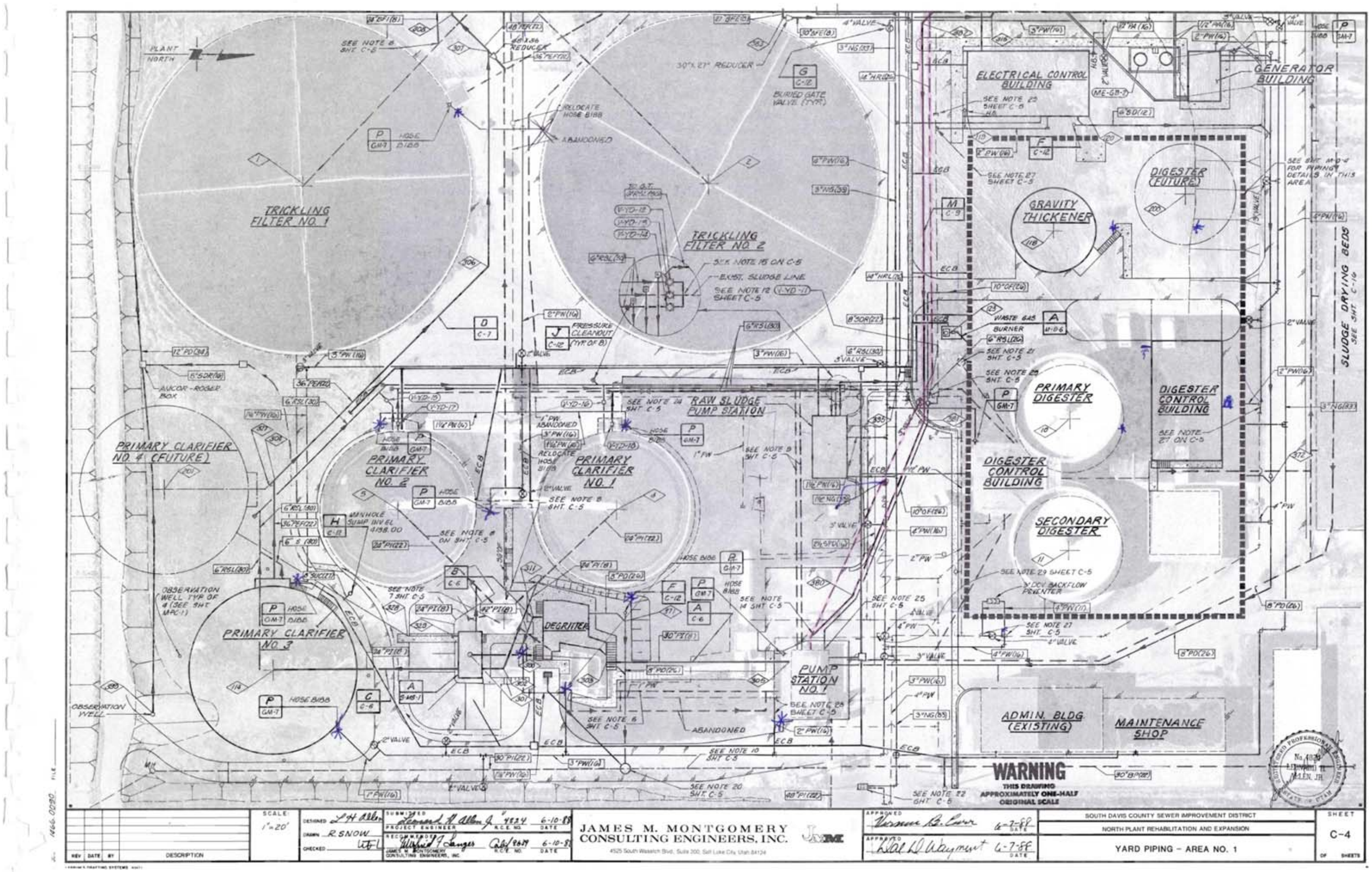

PROFILE LINE H C-5
FINISH GRADE
EXIST GRADE
FLOW
MATCH LINE 2+60
* ELEVATION OF EXISTING PIPE TO BE FIELD VERIFIED.
** CONDUIT ELEVATION TO BE COORDINATED WITH ELECTRICAL CONTRACTOR.
F.C. DISTRIBUTION BOX
FINAL CLARIFIER NO. 3
F.C. JUNCTION BOX
PROFILE LINE L C-5
WARNING
THIS DRAWING APPROXIMATELY ONE-HALF ORIGINAL SCALE
JAMES M. MONTGOMERY CONSULTING ENGINEERS, INC.
SOUTH DAVIS COUNTY SEWER IMPROVEMENT DISTRICT
NORTH PLANT REHABILITATION AND EXPANSION
PIPING PROFILES III
C-8


NOTES:
1. VERIFY DIMENSIONS OF EXISTING EQUIPMENT, VALVES AND FITTINGS IN THE FIELD.
BASEMENT PLAN
SECTION 1
SECTION 2
WARNING
JAMES M. MONTGOMERY CONSULTING ENGINEERS, INC.
SOUTH DAVIS COUNTY SEWER IMPROVEMENT DISTRICT
NORTH PLANT REHABILITATION AND EXPANSION
PUMP STATION NO. 1 - PLAN AND SECTIONS
M-IPS-2

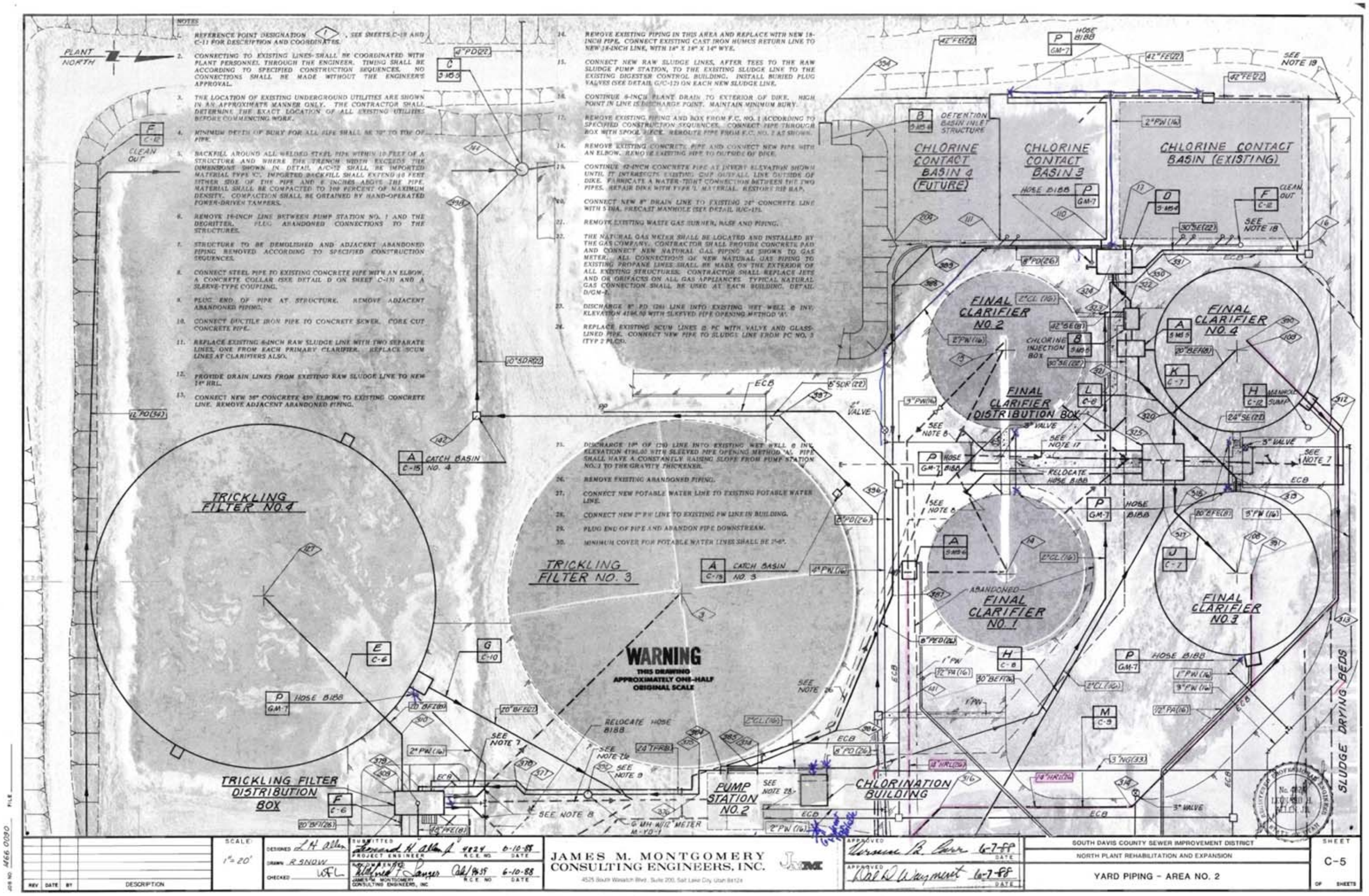

NOTES:
1. VERIFY DIMENSIONS OF EXISTING EQUIPMENT, VALVES AND FITTINGS IN THE FIELD.
2. USE STUD BOLTS ON FLANGES TOO CLOSE TO WALL FOR HEX HEAD BOLTS.
3. CONTRACTOR SHALL PROVIDE THRUST BLOCKS FOR BURIED PRESSURE PIPELINES AT ELBOWS.
4. ALL PUMP SUCTION WALL THIMBLES SHALL BE AT THE SAME ELEVATION. ADJUST EXISTING EQUIPMENT PADS AS REQUIRED TO ACCOMODATE NEW PUMPS. ADJUST PADS FOR EXISTING PUMPS AS NECESSARY FOR ELEVATION OF NEW WALL THIMBLES. PROVIDE NEW FABRICATED STEEL SUCTION ELBOWS FOR EXISTING PUMPS TO MATCH NEW PIPING. ADJUST PUMP MOTORS ON EXISTING PUMPS AS NECESSARY.
CHLORINATORS
FUTURE CHLORINATOR
SECONDARY PUMPING STATION
WARNING
THIS DRAWING APPROXIMATELY ONE-HALF ORIGINAL SCALE
PLAN - CHLORINE BLDG. & FIRST FLOOR SECONDARY PUMPING STATION
BASEMENT FLOOR PLAN - SECONDARY PUMPING STATION
* FIELD VERIFY DIMENSIONS
JAMES M. MONTGOMERY CONSULTING ENGINEERS, INC.
SOUTH DAVIS COUNTY SEWER IMPROVEMENT DISTRICT
NORTH PLANT REHABILITATION AND EXPANSION
PUMP STATION NO.2 AND CHLORINE BUILDING - FIRST FLOOR AND BASEMENT PLANS
SHEET M-SPS-2


MOTOR CONTROL ROOM
WET WELL
PUMP ROOM
PUMP MOTOR (TYP 4)
ACCESS OPENING
EXIST. GUIDE BEARING SUPPORT BEAM & BRACING
SHAFT GUARD
EXIST. SUMP DRAIN LINE (EXTEND AS NEEDED)
EXISTING 36" RCP FROM TRICKLING FILTERS
PIPE ANCHOR
CONC. PIPE SUPPORT (TYP. OF 4)
ADJ. PIPE SUPPORT (TYP 4)
PRESS. GAUGE W/DIAPHRAGM SEAL (TYP 8)
PIPE THIMBLE (TYP 4)
ELBOW SUPPORT (TYP 2)
24" PRE-FAB 90° ELBOW
90° MITERED ELBOW
SLEEVED PIPE
MECH. TYPE CPL'G (TYP 4)
SECTION 4
SECTION 5
WARNING
THIS DRAWING APPROXIMATELY ONE-HALF ORIGINAL SCALE
SCALE: 3/8" = 1'-0"
JAMES M. MONTGOMERY CONSULTING ENGINEERS, INC.
4525 South Wasatch Blvd., Suite 200, Salt Lake City, Utah 84124
SOUTH DAVIS COUNTY SEWER IMPROVEMENT DISTRICT
NORTH PLANT REHABILITATION AND EXPANSION
PUMP STATION NO. 2 AND CHLORINE BUILDING SECTIONS
SHEET M-SPS-4
6-10-88
6-7-88
REV DATE BY DESCRIPTION

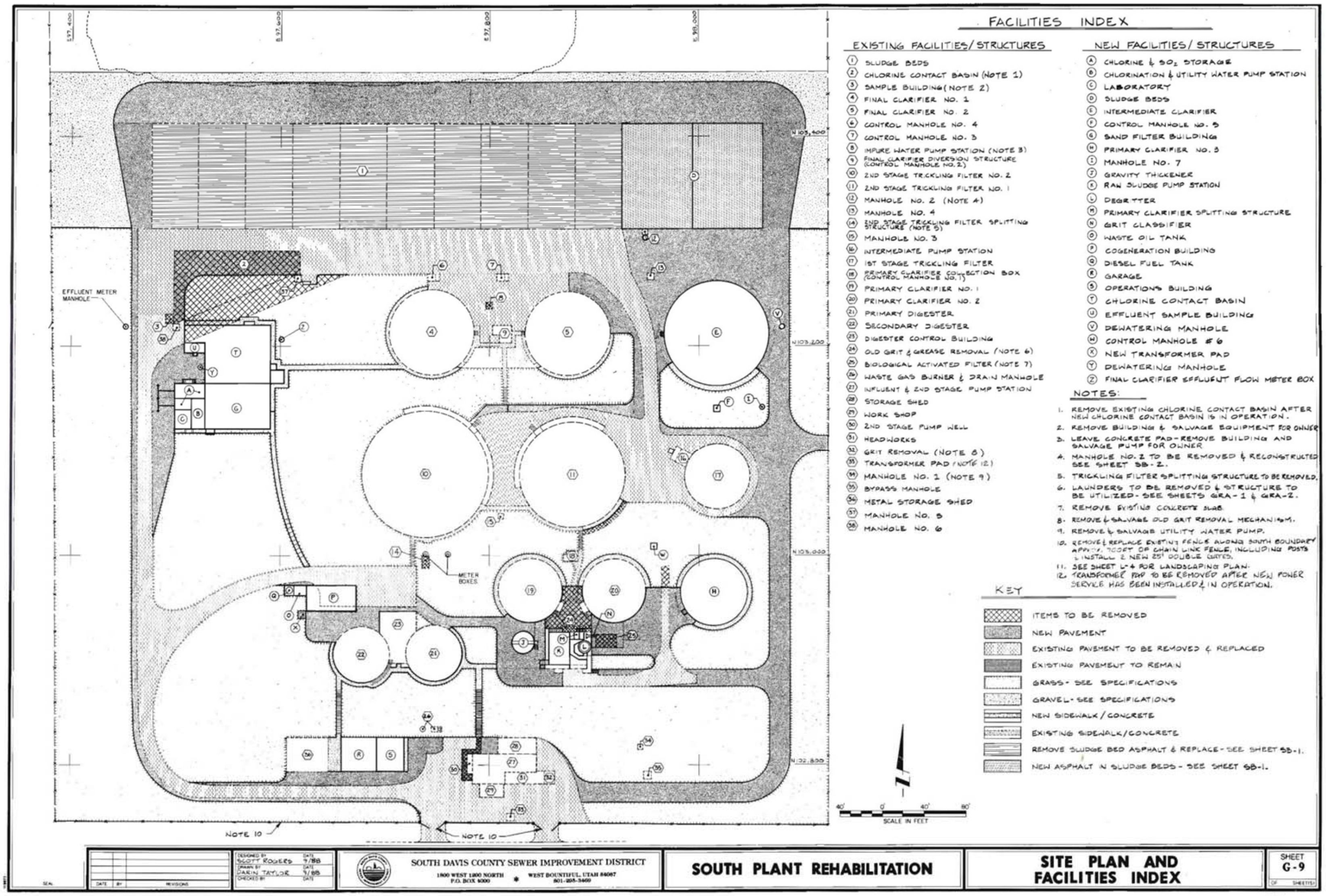

EXISTING FACILITIES
1 PUMPING STATION NO. 1
2 DEGRITER
3 PRIMARY CLARIFIER NO. 1
4 PRIMARY CLARIFIER NO. 2
5 TRICKLING FILTER NO. 1
6 TRICKLING FILTER NO. 2
7 TRICKLING FILTER NO. 3
8 PUMPING STATION NO. 2
9 CHEMICAL BUILDING
10 FINAL CLARIFIER NO. 1
11 FINAL CLARIFIER NO. 2
12 MAINTENACE BUILDING
13 CHLORINE CONTACT BASIN
14 SLUDGE DRYING BEDS
15 PRIMARY DIGESTER
16 SECONDARY DIGESTER
17 ADMINISTRATION BUILDING
FUTURE FACILITIES
1 DIGESTER
2 PRIMARY CLARIFIER
3 FINAL CLARIFIER
4 CHLORINE CONTACT BASIN NO.4
NEW FACILITIES
1 DEGRITER
2 PRIMARY CLARIFIER NO. 3
3 TRICKLING FILTER NO. 4
4 FINAL CLARIFIER NO. 4
5 CHLORINE CONTACT BASIN NO. 3
6 ELECTRICAL CONTROL BUILDING
7 GENERATOR BUILDING
8 RAW SLUDGE PUMP STATION
9 DIGESTER CONTROL BUILDING
10 GRAVITY THICKNER
11 CHLORINE INJECTION BOX
12 CHLORINE BUILDING (ADDITION)
13 SLUDGE DRYING BEDS NO. 1 & NO. 2
14 FINAL CLARIFIER NO. 3
15 TRICKLING FILTER DISTRIBUTION BOX
16 FINAL CLARIFIER DISTRIBUTION BOX
17 FINAL CLARIFIER JUNCTION BOX
18 PRIMARY CLARIFIER DISTRIBUTION BOX
19 CHLORINE CONTACT BASIN DISTRIBUTION BOX
AREA NO. 2
AREA NO. 1
NEW CHAIN LINK FENCE
TBM #2 REBAR N 3960.34 E 1755.87 EL 4217.80
TBM #1 REBAR N 3964.36 E 2605.90 EL 4217.87
TBM #3 REBAR N 5154.05 E 1910.32 EL 4217.08
TBM #4 REBAR N 5158.8 E 2504.03 EL 4216.16
WARNING
THIS DRAWING APPROXIMATELY ONE-HALF ORIGINAL SCALE
SCALE: 1" = 40'-0"
JAMES M. MONTGOMERY CONSULTING ENGINEERS, INC.
4525 South Wasatch Blvd., Suite 200, Salt Lake City, Utah 84124
SOUTH DAVIS COUNTY SEWER IMPROVEMENT DISTRICT
NORTH PLANT REHABILITATION AND EXPANSION
SITE PLAN AND FACILITIES INDEX
SHEET C-1
REV DATE BY DESCRIPTION
DESIGNED
DRAWN
CHECKED
SUBMITTED
PROJECT ENGINEER
R.C.E. NO.
DATE
APPROVED

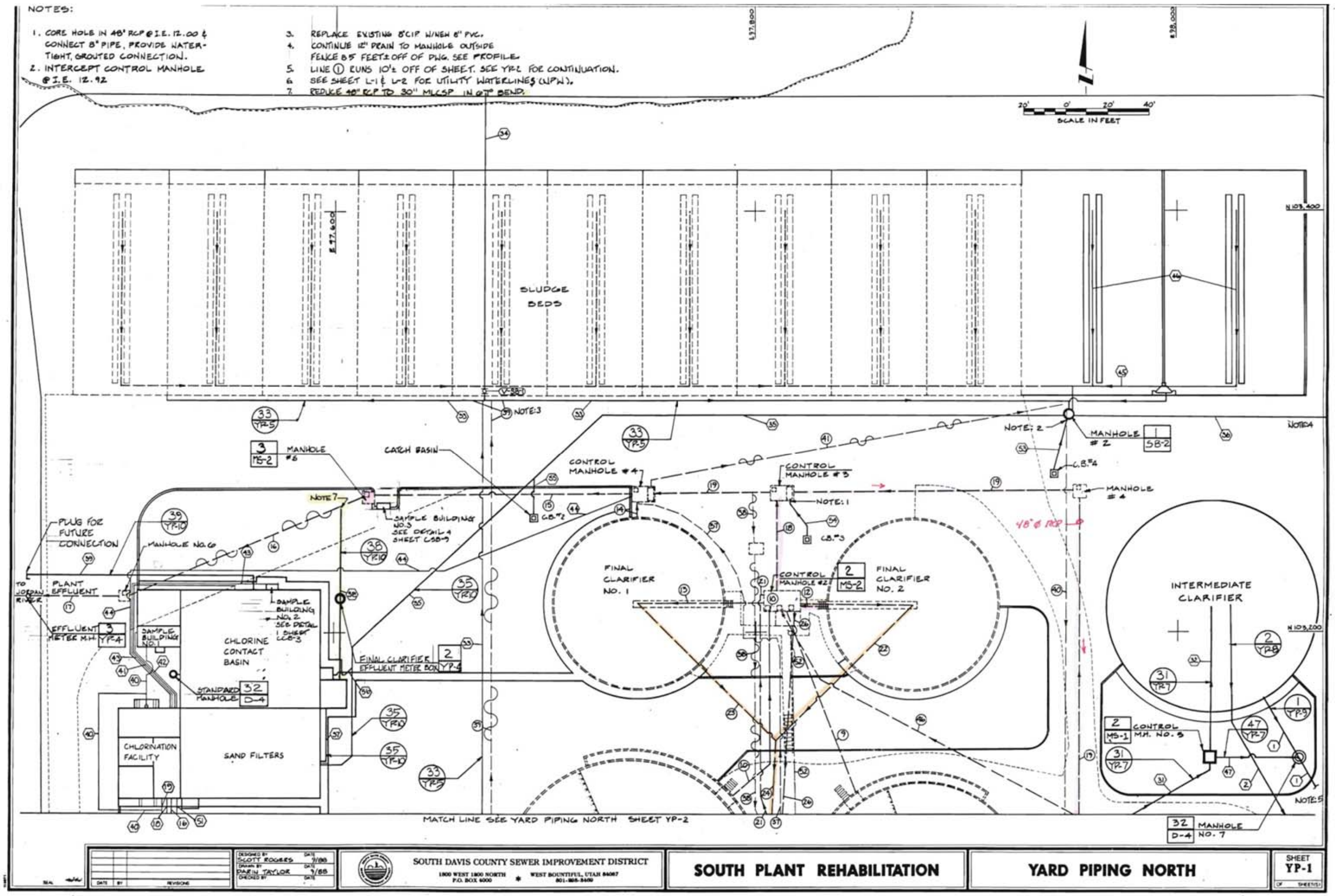


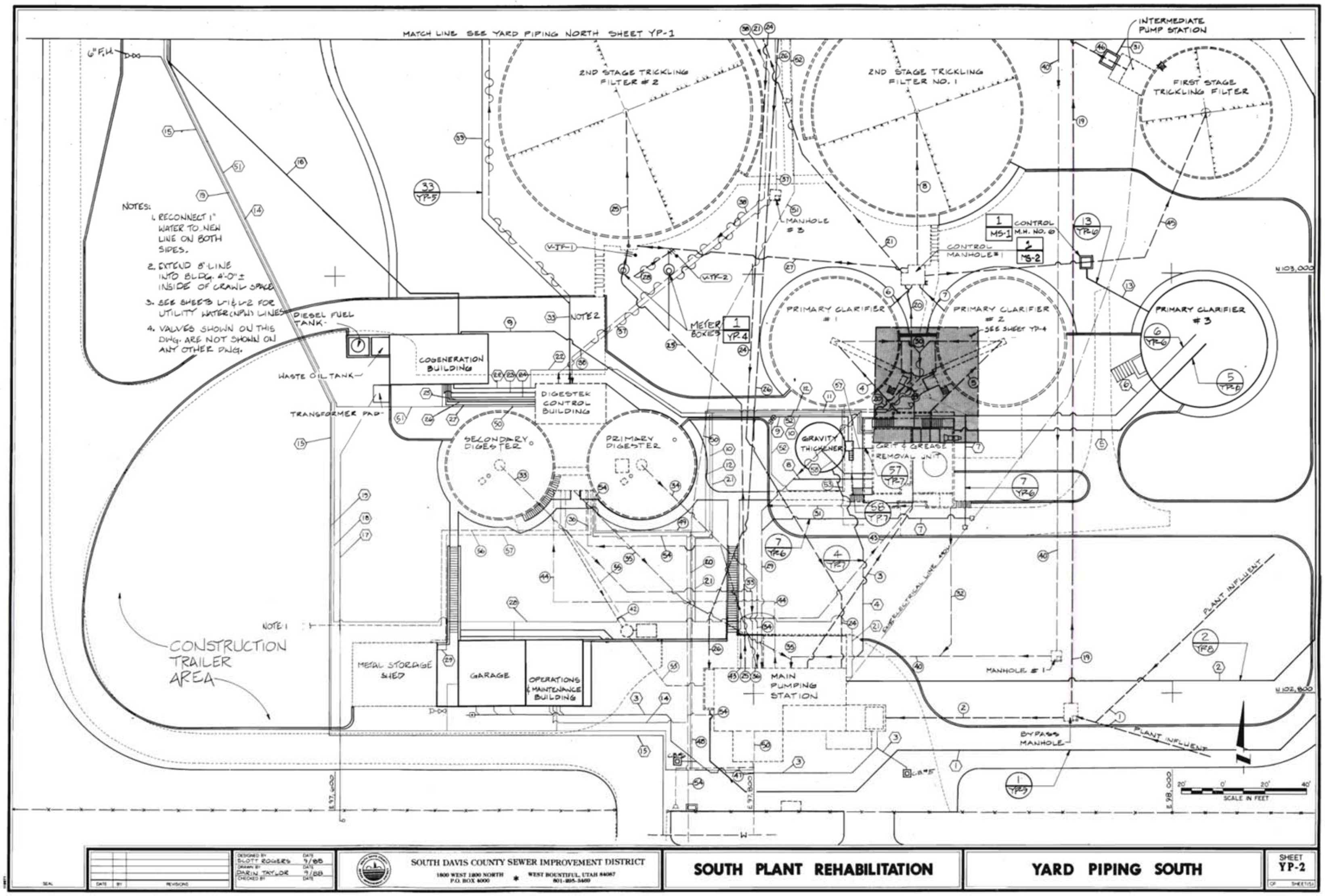
PLANT NORTH
TRICKLING FILTER NO. 1
TRICKLING FILTER NO. 2
30"x 27" REDUCER
BURIED GATE VALVE (TYP.)
RELOCATE HOSE BIBB
ABANDONED
SEE NOTE 15 ON C-5
EXIST. SLUDGE LINE
PRESSURE CLEANOUT (TYP OF 8)
ELECTRICAL CONTROL BUILDING
GENERATOR BUILDING
GRAVITY THICKENER
DIGESTER (FUTURE)
WASTE GAS BURNER
PRIMARY DIGESTER
DIGESTER CONTROL BUILDING
SECONDARY DIGESTER
SLUDGE DRYING BEDS SEE SHT C-16
RAW SLUDGE PUMP STATION
PRIMARY CLARIFIER NO. 4 (FUTURE)
PRIMARY CLARIFIER NO. 2
PRIMARY CLARIFIER NO. 1
PRIMARY CLARIFIER NO. 3
PARSHALL FLUME
MANHOLE SUMP INV. EL. 4198.00
OBSERVATION WELL TYP OF 4 (SEE SHT MPC-1)
OBSERVATION WELL
HOSE BIBB
DEGRITTER
PUMP STATION NO. 1
ADMIN. BLDG (EXISTING)
MAINTENANCE SHOP
ABANDONED
SEE NOTE 29 SHEET C-5
WARNING
THIS DRAWING APPROXIMATELY ONE-HALF ORIGINAL SCALE
SCALE: 1"=20'
DESIGNED L.H. Allen
DRAWN R. SNOW
SUBMITTED Leonard H. Allen Jr. 4824 6-10-88
PROJECT ENGINEER R.C.E. NO. DATE
RECOMMENDED JAMES M. MONTGOMERY CONSULTING ENGINEERS, INC.
JAMES M. MONTGOMERY CONSULTING ENGINEERS, INC.
4525 South Wasatch Blvd., Suite 200, Salt Lake City, Utah 84124
APPROVED 6-7-88
SOUTH DAVIS COUNTY SEWER IMPROVEMENT DISTRICT
NORTH PLANT REHABILITATION AND EXPANSION
YARD PIPING - AREA NO. 1
SHEET C-4
REV DATE BY DESCRIPTION

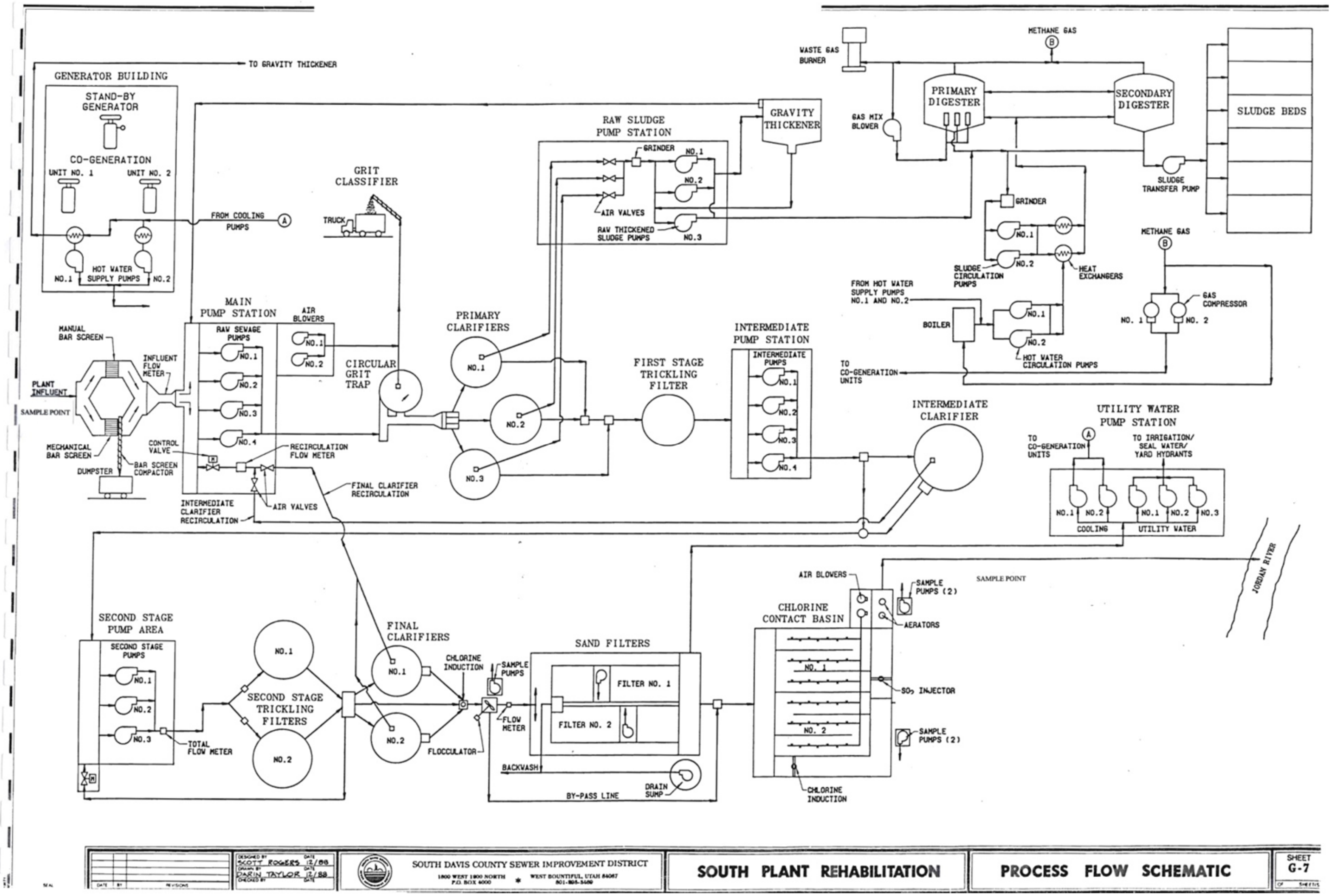

PLANT NORTH
NOTES
CHLORINE CONTACT BASIN 4 (FUTURE)
CHLORINE CONTACT BASIN 3
CHLORINE CONTACT BASIN (EXISTING)
DETENTION BASIN INLET STRUCTURE
FINAL CLARIFIER NO. 2
FINAL CLARIFIER NO. 4
FINAL CLARIFIER DISTRIBUTION BOX
FINAL CLARIFIER NO. 1
FINAL CLARIFIER NO. 3
TRICKLING FILTER NO. 4
TRICKLING FILTER NO. 3
TRICKLING FILTER DISTRIBUTION BOX
CATCH BASIN NO. 4
CATCH BASIN NO. 3
PUMP STATION NO. 2
CHLORINATION BUILDING
SLUDGE DRYING BEDS
WARNING
THIS DRAWING APPROXIMATELY ONE-HALF ORIGINAL SCALE
HOSE BIBB
SEE NOTE 8
SCALE 1" = 20'
JAMES M. MONTGOMERY CONSULTING ENGINEERS, INC.
SOUTH DAVIS COUNTY SEWER IMPROVEMENT DISTRICT
NORTH PLANT REHABILITATION AND EXPANSION
YARD PIPING - AREA NO. 2
SHEET C-5

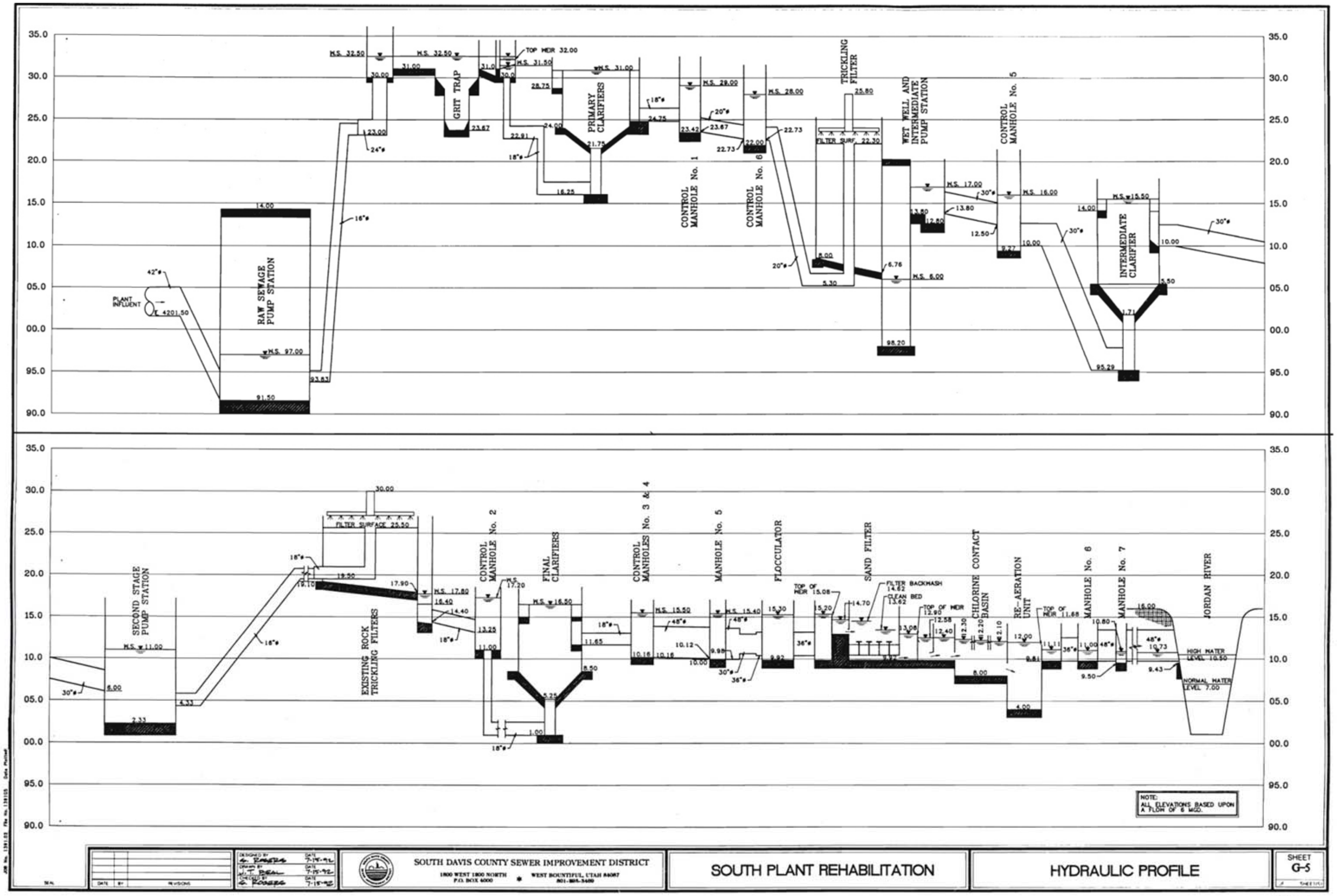
South Plant .pdf Files

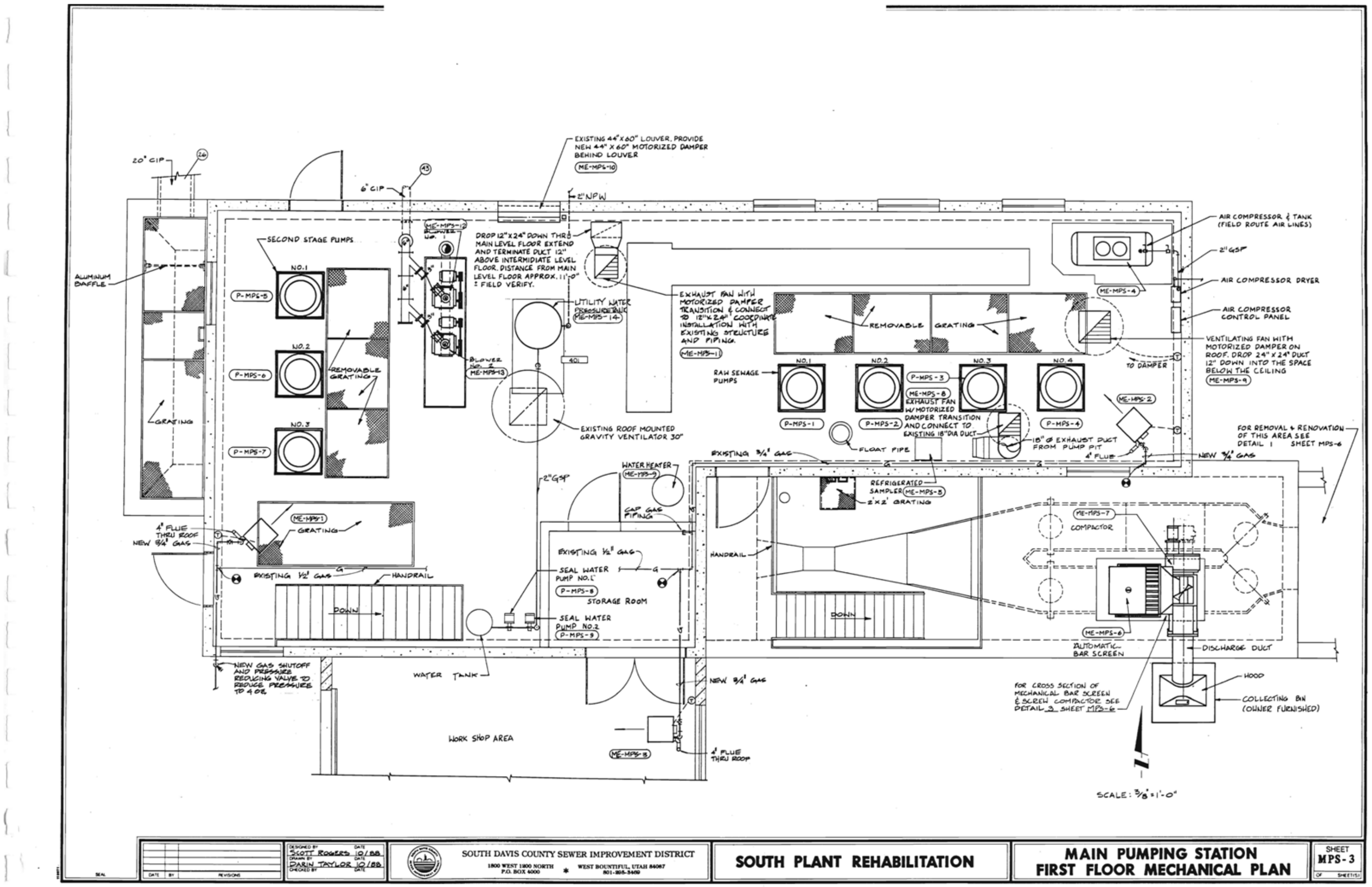

FACILITIES INDEX
EXISTING FACILITIES/ STRUCTURES
1 SLUDGE BEDS
2 CHLORINE CONTACT BASIN (NOTE 1)
3 SAMPLE BUILDING (NOTE 2)
4 FINAL CLARIFIER NO. 1
5 FINAL CLARIFIER NO. 2
6 CONTROL MANHOLE NO. 4
7 CONTROL MANHOLE NO. 3
8 IMPURE WATER PUMP STATION (NOTE 3)
9 FINAL CLARIFIER DIVERSION STRUCTURE (CONTROL MANHOLE NO. 2)
10 2ND STAGE TRICKLING FILTER NO. 2
11 2ND STAGE TRICKLING FILTER NO. 1
12 MANHOLE NO. 2 (NOTE 4)
13 MANHOLE NO. 4
14 2ND STAGE TRICKLING FILTER SPLITTING STRUCTURE (NOTE 5)
15 MANHOLE NO. 3
16 INTERMEDIATE PUMP STATION
17 1ST STAGE TRICKLING FILTER
18 PRIMARY CLARIFIER COLLECTION BOX (CONTROL MANHOLE NO. 1)
19 PRIMARY CLARIFIER NO. 1
20 PRIMARY CLARIFIER NO. 2
21 PRIMARY DIGESTER
22 SECONDARY DIGESTER
23 DIGESTER CONTROL BUILDING
24 OLD GRIT & GREASE REMOVAL (NOTE 6)
25 BIOLOGICAL ACTIVATED FILTER (NOTE 7)
26 WASTE GAS BURNER & DRAIN MANHOLE
27 INFLUENT & 2ND STAGE PUMP STATION
28 STORAGE SHED
29 WORK SHOP
30 2ND STAGE PUMP WELL
31 HEADWORKS
32 GRIT REMOVAL (NOTE 8)
33 TRANSFORMER PAD (NOTE 12)
34 MANHOLE NO. 1 (NOTE 9)
35 BYPASS MANHOLE
36 METAL STORAGE SHED
37 MANHOLE NO. 5
38 MANHOLE NO. 6
NEW FACILITIES/ STRUCTURES
A CHLORINE & SO_2 STORAGE
B CHLORINATION & UTILITY WATER PUMP STATION
C LABORATORY
D SLUDGE BEDS
E INTERMEDIATE CLARIFIER
F CONTROL MANHOLE NO. 5
G SAND FILTER BUILDING
H PRIMARY CLARIFIER NO. 3
I MANHOLE NO. 7
J GRAVITY THICKENER
K RAW SLUDGE PUMP STATION
L DEGRITTER
M PRIMARY CLARIFIER SPLITTING STRUCTURE
N GRIT CLASSIFIER
O WASTE OIL TANK
P COGENERATION BUILDING
Q DIESEL FUEL TANK
R GARAGE
S OPERATIONS BUILDING
T CHLORINE CONTACT BASIN
U EFFLUENT SAMPLE BUILDING
V DEWATERING MANHOLE
W CONTROL MANHOLE # 6
X NEW TRANSFORMER PAD
Y DEWATERING MANHOLE
Z FINAL CLARIFIER EFFLUENT FLOW METER BOX
NOTES:
1. REMOVE EXISTING CHLORINE CONTACT BASIN AFTER NEW CHLORINE CONTACT BASIN IS IN OPERATION.
2. REMOVE BUILDING & SALVAGE EQUIPMENT FOR OWNER
3. LEAVE CONCRETE PAD - REMOVE BUILDING AND SALVAGE PUMP FOR OWNER
4. MANHOLE NO. 2 TO BE REMOVED & RECONSTRUCTED SEE SHEET SB-2.
5. TRICKLING FILTER SPLITTING STRUCTURE TO BE REMOVED.
6. LAUNDERS TO BE REMOVED & STRUCTURE TO BE UTILIZED - SEE SHEETS GRA-1 & GRA-2.
7. REMOVE EXISTING CONCRETE SLAB.
8. REMOVE & SALVAGE OLD GRIT REMOVAL MECHANISM.
9. REMOVE & SALVAGE UTILITY WATER PUMP.
10. REMOVE & REPLACE EXISTING FENCE ALONG SOUTH BOUNDARY APPROX. 700FT OF CHAIN LINK FENCE, INCLUDING POSTS & INSTALL 2 NEW 25' DOUBLE GATES.
11. SEE SHEET L-4 FOR LANDSCAPING PLAN.
12. TRANSFORMER PAD TO BE REMOVED AFTER NEW POWER SERVICE HAS BEEN INSTALLED & IN OPERATION.
KEY
ITEMS TO BE REMOVED
NEW PAVEMENT
EXISTING PAVEMENT TO BE REMOVED & REPLACED
EXISTING PAVEMENT TO REMAIN
GRASS - SEE SPECIFICATIONS
GRAVEL - SEE SPECIFICATIONS
NEW SIDEWALK / CONCRETE
EXISTING SIDEWALK/CONCRETE
REMOVE SLUDGE BED ASPHALT & REPLACE - SEE SHEET SB-1.
NEW ASPHALT IN SLUDGE BEDS - SEE SHEET SB-1.
EFFLUENT METER MANHOLE
METER BOXES
NOTE 10
NOTE 10
40' 0' 40' 80'
SCALE IN FEET
DESIGNED BY SCOTT ROGERS DATE 9/88
DRAWN BY DARIN TAYLOR DATE 9/88
CHECKED BY DATE
SOUTH DAVIS COUNTY SEWER IMPROVEMENT DISTRICT
1800 WEST 1200 NORTH P.O. BOX 4000
WEST BOUNTIFUL, UTAH 84087 801-295-3469
SOUTH PLANT REHABILITATION
SITE PLAN AND FACILITIES INDEX
SHEET G-9

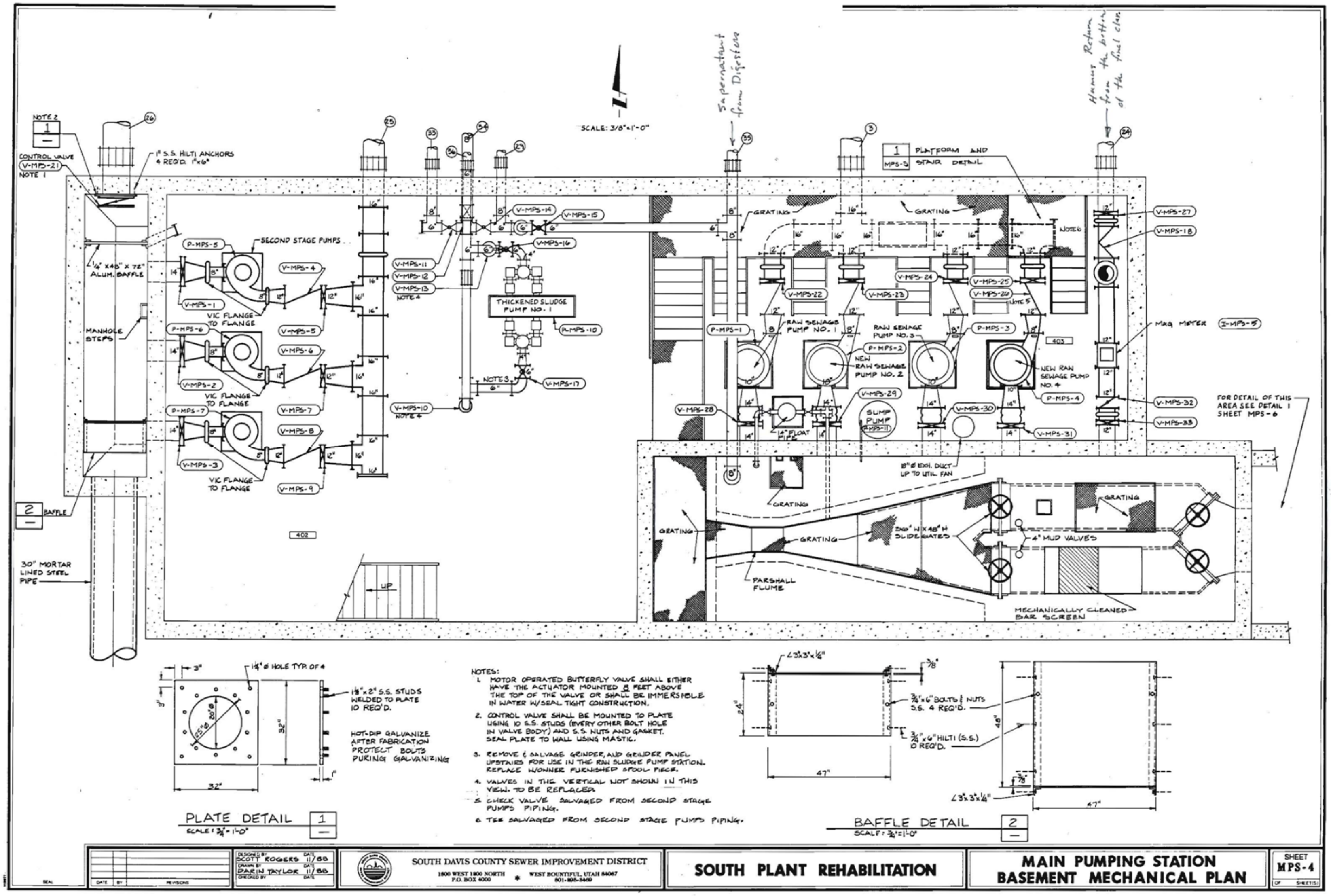

NOTES:
1. CORE HOLE IN 48" RCP @ I.E. 12.00 & CONNECT 8" PIPE, PROVIDE WATER-TIGHT, GROUTED CONNECTION.
2. INTERCEPT CONTROL MANHOLE @ I.E. 12.92
3. REPLACE EXISTING 8"CIP W/NEW 8" PVC.
4. CONTINUE 12" DRAIN TO MANHOLE OUTSIDE FENCE 85 FEET± OFF OF DWG. SEE PROFILE.
5. LINE ① RUNS 10'± OFF OF SHEET. SEE YP-2 FOR CONTINUATION.
6. SEE SHEET L-1 & L-2 FOR UTILITY WATERLINES (NPW).
7. REDUCE 48" RCP TO 30" MLCSP IN 60° BEND.
SCALE IN FEET
SLUDGE BEDS
FINAL CLARIFIER NO. 1
FINAL CLARIFIER NO. 2
INTERMEDIATE CLARIFIER
CHLORINE CONTACT BASIN
SAND FILTERS
CHLORINATION FACILITY
PLUG FOR FUTURE CONNECTION
MANHOLE NO. 6
TO JORDAN RIVER
PLANT EFFLUENT
EFFLUENT METER M.H.
SAMPLE BUILDING NO. 1
SAMPLE BUILDING NO. 2 SEE DETAIL 1 SHEET LCB-3
SAMPLE BUILDING NO. 3 SEE DETAIL 4 SHEET LSB-3
STANDARD MANHOLE
FINAL CLARIFIER EFFLUENT METER BOX
CATCH BASIN
CONTROL MANHOLE #4
CONTROL MANHOLE #3
CONTROL MANHOLE #2
CONTROL M.H. NO. 5
MANHOLE #2
MANHOLE #4
MANHOLE #6
MANHOLE NO. 7
48" Ø RCP
MATCH LINE SEE YARD PIPING NORTH SHEET YP-2
SOUTH DAVIS COUNTY SEWER IMPROVEMENT DISTRICT
1800 WEST 1200 NORTH P.O. BOX 4000 WEST BOUNTIFUL, UTAH 84087
SOUTH PLANT REHABILITATION
YARD PIPING NORTH
SHEET YP-1
SCOTT ROGERS
DARIN TAYLOR

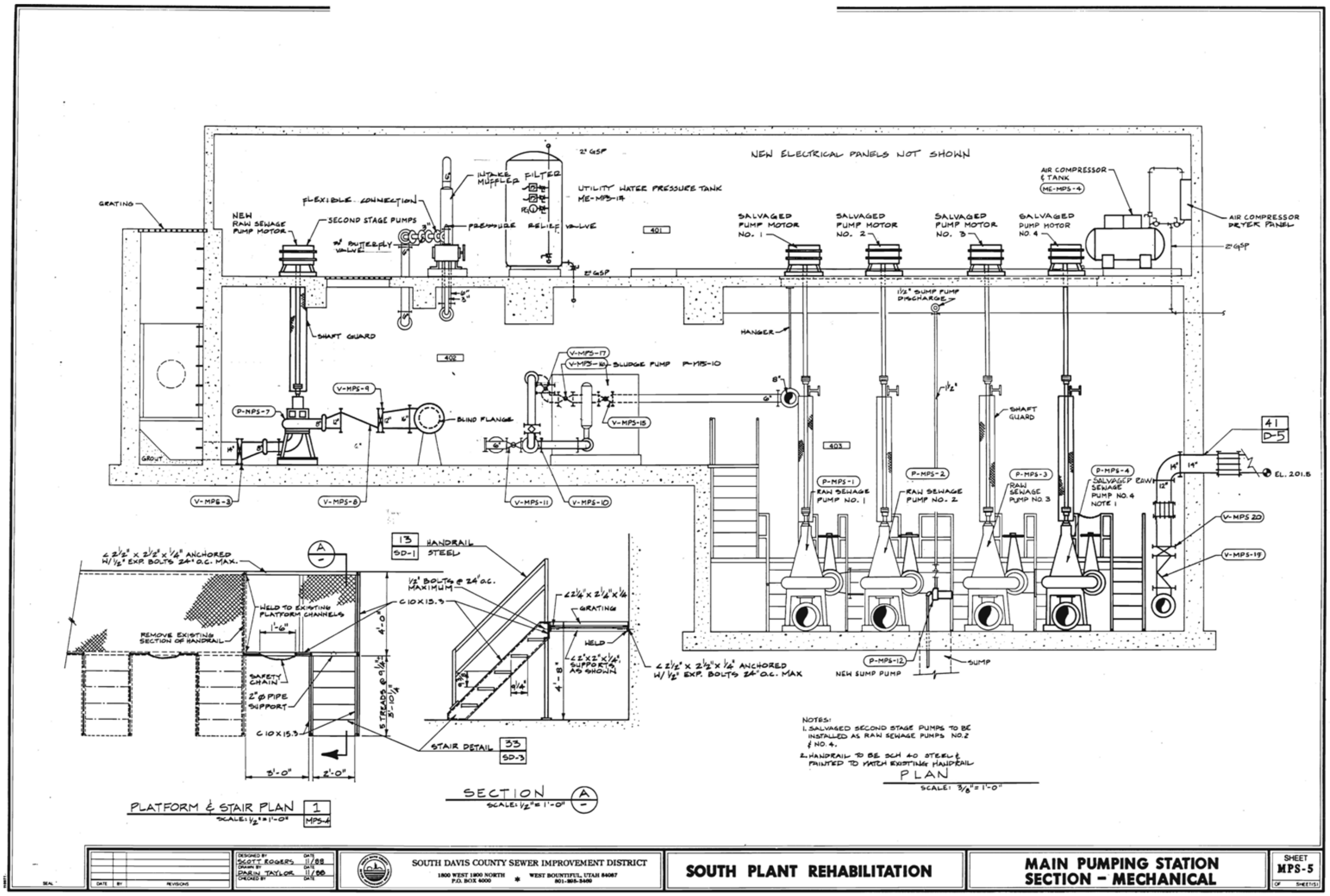

MATCH LINE SEE YARD PIPING NORTH SHEET YP-1
INTERMEDIATE PUMP STATION
2ND STAGE TRICKLING FILTER # 2
2ND STAGE TRICKLING FILTER NO. 1
FIRST STAGE TRICKLING FILTER
NOTES:
1. RECONNECT 1" WATER TO NEW LINE ON BOTH SIDES.
2. EXTEND 8" LINE INTO BLDG. 4'-0" ± INSIDE OF CRAWL SPACE
3. SEE SHEETS U-1 & U-2 FOR UTILITY WATER (NPW) LINES
4. VALVES SHOWN ON THIS DWG. ARE NOT SHOWN ON ANY OTHER DWG.
DIESEL FUEL TANK
WASTE OIL TANK
TRANSFORMER PAD
COGENERATION BUILDING
DIGESTER CONTROL BUILDING
SECONDARY DIGESTER
PRIMARY DIGESTER
MANHOLE # 3
CONTROL M.H. NO. 6
CONTROL MANHOLE # 1
METER BOXES
PRIMARY CLARIFIER # 1
PRIMARY CLARIFIER # 2
SEE SHEET YP-4
PRIMARY CLARIFIER # 3
GRAVITY THICKENER
GRIT & GREASE REMOVAL UNIT
NOTE 2
NOTE 1
CONSTRUCTION TRAILER AREA
METAL STORAGE SHED
GARAGE
OPERATIONS & MAINTENANCE BUILDING
MAIN PUMPING STATION
ELECTRICAL LINE
PLANT INFLUENT
MANHOLE # 1
BYPASS MANHOLE
SCALE IN FEET
SOUTH DAVIS COUNTY SEWER IMPROVEMENT DISTRICT
1800 WEST 1200 NORTH
P.O. BOX 4000
WEST BOUNTIFUL, UTAH 84087
SOUTH PLANT REHABILITATION
YARD PIPING SOUTH
SHEET
YP-2

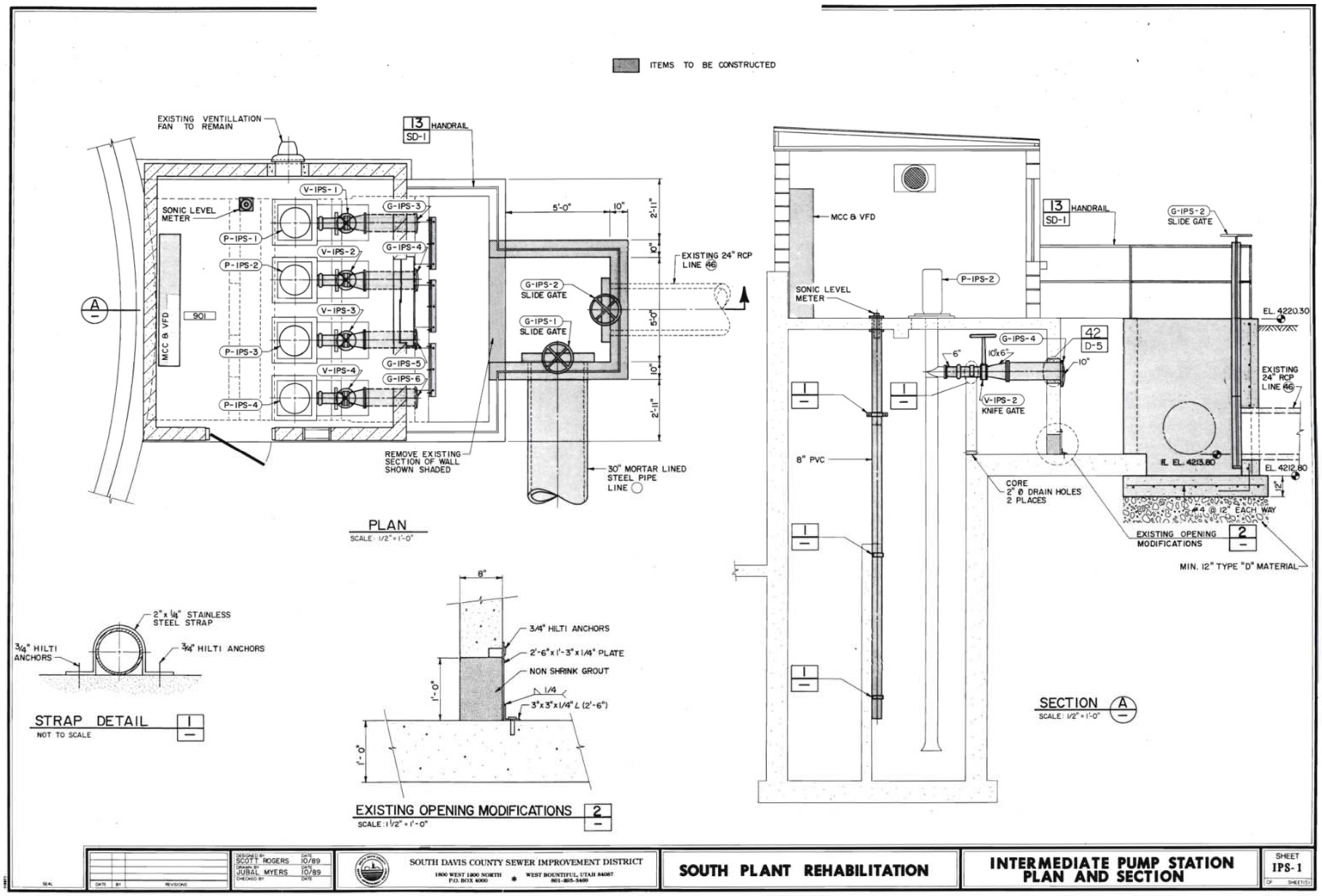

GENERATOR BUILDING
STAND-BY GENERATOR
CO-GENERATION
UNIT NO. 1
UNIT NO. 2
HOT WATER SUPPLY PUMPS
TO GRAVITY THICKENER
FROM COOLING PUMPS
GRIT CLASSIFIER
TRUCK
RAW SLUDGE PUMP STATION
GRINDER
AIR VALVES
RAW THICKENED SLUDGE PUMPS
GRAVITY THICKENER
WASTE GAS BURNER
METHANE GAS
PRIMARY DIGESTER
SECONDARY DIGESTER
SLUDGE BEDS
GAS MIX BLOWER
SLUDGE TRANSFER PUMP
SLUDGE CIRCULATION PUMPS
HEAT EXCHANGERS
FROM HOT WATER SUPPLY PUMPS NO.1 AND NO.2
BOILER
HOT WATER CIRCULATION PUMPS
GAS COMPRESSOR
TO CO-GENERATION UNITS
MANUAL BAR SCREEN
PLANT INFLUENT
SAMPLE POINT
INFLUENT FLOW METER
MECHANICAL BAR SCREEN
DUMPSTER
BAR SCREEN COMPACTOR
MAIN PUMP STATION
RAW SEWAGE PUMPS
AIR BLOWERS
CONTROL VALVE
RECIRCULATION FLOW METER
AIR VALVES
INTERMEDIATE CLARIFIER RECIRCULATION
FINAL CLARIFIER RECIRCULATION
CIRCULAR GRIT TRAP
PRIMARY CLARIFIERS
FIRST STAGE TRICKLING FILTER
INTERMEDIATE PUMP STATION
INTERMEDIATE PUMPS
INTERMEDIATE CLARIFIER
UTILITY WATER PUMP STATION
TO IRRIGATION/ SEAL WATER/ YARD HYDRANTS
COOLING
UTILITY WATER
JORDAN RIVER
SECOND STAGE PUMP AREA
SECOND STAGE PUMPS
TOTAL FLOW METER
SECOND STAGE TRICKLING FILTERS
FINAL CLARIFIERS
CHLORINE INDUCTION
SAMPLE PUMPS
FLOW METER
FLOCCULATOR
SAND FILTERS
FILTER NO. 1
FILTER NO. 2
BACKWASH
DRAIN SUMP
BY-PASS LINE
CHLORINE CONTACT BASIN
AIR BLOWERS
SAMPLE PUMPS (2)
AERATORS
SO_2 INJECTOR
CHLORINE INDUCTION
SOUTH DAVIS COUNTY SEWER IMPROVEMENT DISTRICT
SOUTH PLANT REHABILITATION
PROCESS FLOW SCHEMATIC
SHEET G-7
SCOTT ROGERS 12/88
DARIN TAYLOR 12/88


PLANT INFLUENT
RAW SEWAGE PUMP STATION
GRIT TRAP
PRIMARY CLARIFIERS
CONTROL MANHOLE No. 1
CONTROL MANHOLE No. 6
TRICKLING FILTER
WET WELL AND INTERMEDIATE PUMP STATION
CONTROL MANHOLE No. 5
INTERMEDIATE CLARIFIER
SECOND STAGE PUMP STATION
EXISTING ROCK TRICKLING FILTERS
CONTROL MANHOLE No. 2
FINAL CLARIFIERS
CONTROL MANHOLES No. 3 & 4
MANHOLE No. 5
FLOCCULATOR
SAND FILTER
CHLORINE CONTACT BASIN
RE-AERATION UNIT
MANHOLE No. 6
MANHOLE No. 7
JORDAN RIVER
HIGH WATER LEVEL 10.50
NORMAL WATER LEVEL 7.00
NOTE: ALL ELEVATIONS BASED UPON A FLOW OF 6 MGD.
SOUTH DAVIS COUNTY SEWER IMPROVEMENT DISTRICT
SOUTH PLANT REHABILITATION
HYDRAULIC PROFILE
SHEET G-5


EXISTING 44"X60" LOUVER. PROVIDE NEW 44" X 60" MOTORIZED DAMPER BEHIND LOUVER
ME-MPS-10
20" CIP
6" CIP
2" NPW
SECOND STAGE PUMPS
NO.1
NO.2
NO.3
P-MPS-5
P-MPS-6
P-MPS-7
ALUMINUM BAFFLE
GRATING
REMOVABLE GRATING
DROP 12"X24" DOWN THRU MAIN LEVEL FLOOR EXTEND AND TERMINATE DUCT 12" ABOVE INTERMIDIATE LEVEL FLOOR. DISTANCE FROM MAIN LEVEL FLOOR APPROX. 11'-0" ± FIELD VERIFY.
UTILITY WATER PRESSURE TANK
ME-MPS-14
ME-MPS-13
EXHAUST FAN WITH MOTORIZED DAMPER TRANSITION & CONNECT TO 12"X24" COORDINATE INSTALLATION WITH EXISTING STRUCTURE AND PIPING.
ME-MPS-1
EXISTING ROOF MOUNTED GRAVITY VENTILATOR 30"
AIR COMPRESSOR & TANK (FIELD ROUTE AIR LINES)
2" GSP
AIR COMPRESSOR DRYER
AIR COMPRESSOR CONTROL PANEL
ME-MPS-4
REMOVABLE GRATING
VENTILATING FAN WITH MOTORIZED DAMPER ON ROOF. DROP 24" X 24" DUCT 12" DOWN INTO THE SPACE BELOW THE CEILING
ME-MPS-9
TO DAMPER
RAW SEWAGE PUMPS
NO.4
P-MPS-1
P-MPS-2
P-MPS-3
P-MPS-4
ME-MPS-8
EXHAUST FAN W/ MOTORIZED DAMPER TRANSITION AND CONNECT TO EXISTING 18" DIA DUCT
18" Ø EXHAUST DUCT FROM PUMP PIT
FLOAT PIPE
ME-MPS-2
4" FLUE
NEW 3/4" GAS
FOR REMOVAL & RENOVATION OF THIS AREA SEE DETAIL 1 SHEET MPS-6
EXISTING 3/4" GAS
WATER HEATER
ME-MPS-9
2" GSP
CAP GAS PIPING
REFRIGERATED SAMPLER
ME-MPS-5
2'X2' GRATING
ME-MPS-7
COMPACTOR
4" FLUE THRU ROOF
NEW 3/4" GAS
ME-MPS-11
GRATING
EXISTING 1/2" GAS
HANDRAIL
DOWN
EXISTING 1/2" GAS
SEAL WATER PUMP NO.1
P-MPS-8
STORAGE ROOM
SEAL WATER PUMP NO.2
P-MPS-9
ME-MPS-6
AUTOMATIC BAR SCREEN
DISCHARGE DUCT
HOOD
COLLECTING BIN (OWNER FURNISHED)
NEW GAS SHUTOFF AND PRESSURE REDUCING VALVE TO REDUCE PRESSURE TO 4 OZ.
WATER TANK
NEW 3/4" GAS
FOR CROSS SECTION OF MECHANICAL BAR SCREEN & SCREW COMPACTOR SEE DETAIL 3 SHEET MPS-6
WORK SHOP AREA
ME-MPS-3
4" FLUE THRU ROOF
SCALE: 3/8"=1'-0"
SCOTT ROGERS 10/88
DARIN TAYLOR 10/88
SOUTH DAVIS COUNTY SEWER IMPROVEMENT DISTRICT
SOUTH PLANT REHABILITATION
MAIN PUMPING STATION
FIRST FLOOR MECHANICAL PLAN
SHEET
MPS-3


SCALE: 3/8"=1'-0"
Supernatant from Digesters
Humus Return from the bottom of the final clar.
CONTROL VALVE
V-MPS-21
NOTE 1
1" S.S. HILTI ANCHORS 4 REQ'D. 1"x6"
1/4" x 48" x 72" ALUM. BAFFLE
MANHOLE STEPS
SECOND STAGE PUMPS
VIC FLANGE TO FLANGE
THICKENED SLUDGE PUMP NO. 1
GRATING
PLATFORM AND STAIR DETAIL
RAW SEWAGE PUMP NO. 1
RAW SEWAGE PUMP NO. 3
NEW RAW SEWAGE PUMP NO. 2
NEW RAW SEWAGE PUMP NO. 4
MAG METER
SUMP PUMP
14" FLOAT PIPE
18" Ø EXH. DUCT UP TO UTIL FAN
FOR DETAIL OF THIS AREA SEE DETAIL 1 SHEET MPS-6
30" MORTAR LINED STEEL PIPE
BAFFLE
PARSHALL FLUME
4" MUD VALVES
MECHANICALLY CLEANED BAR SCREEN
UP
NOTES:
1. MOTOR OPERATED BUTTERFLY VALVE SHALL EITHER HAVE THE ACTUATOR MOUNTED 8 FEET ABOVE THE TOP OF THE VALVE OR SHALL BE IMMERSIBLE IN WATER W/SEAL TIGHT CONSTRUCTION.
2. CONTROL VALVE SHALL BE MOUNTED TO PLATE USING 10 S.S. STUDS (EVERY OTHER BOLT HOLE IN VALVE BODY) AND S.S. NUTS AND GASKET. SEAL PLATE TO WALL USING MASTIC.
3. REMOVE & SALVAGE GRINDER, AND GRINDER PANEL UPSTAIRS FOR USE IN THE RAW SLUDGE PUMP STATION. REPLACE W/OWNER FURNISHED SPOOL PIECE.
4. VALVES IN THE VERTICAL NOT SHOWN IN THIS VIEW. TO BE REPLACED.
5. CHECK VALVE SALVAGED FROM SECOND STAGE PUMPS PIPING.
6. TEE SALVAGED FROM SECOND STAGE PUMPS PIPING.
1 3/4" Ø HOLE TYP. OF 4
1 1/2" x 2" S.S. STUDS WELDED TO PLATE 10 REQ'D.
HOT-DIP GALVANIZE AFTER FABRICATION PROTECT BOLTS DURING GALVANIZING
PLATE DETAIL 1
SCALE: 3/4"=1'-0"
BAFFLE DETAIL 2
SCALE: 3/4"=1'-0"
DESIGNED BY SCOTT ROGERS 11/88
DRAWN BY DARIN TAYLOR 11/88
CHECKED BY
SOUTH DAVIS COUNTY SEWER IMPROVEMENT DISTRICT
1800 WEST 1200 NORTH P.O. BOX 4000 WEST BOUNTIFUL, UTAH 84087
SOUTH PLANT REHABILITATION
MAIN PUMPING STATION BASEMENT MECHANICAL PLAN
SHEET MPS-4


NEW ELECTRICAL PANELS NOT SHOWN
UTILITY WATER PRESSURE TANK ME-MPS-14
SALVAGED PUMP MOTOR NO. 1
SALVAGED PUMP MOTOR NO. 2
SALVAGED PUMP MOTOR NO. 3
SALVAGED PUMP MOTOR NO. 4
AIR COMPRESSOR & TANK
AIR COMPRESSOR DRYER PANEL
NEW RAW SEWAGE PUMP MOTOR
SECOND STAGE PUMPS
FLEXIBLE CONNECTION
INTAKE MUFFLER
FILTER
PRESSURE RELIEF VALVE
GRATING
SHAFT GUARD
BLIND FLANGE
SLUDGE PUMP
HANGER
RAW SEWAGE PUMP NO. 1
RAW SEWAGE PUMP NO. 2
NEW SUMP PUMP
SUMP
NOTES:
1. SALVAGED SECOND STAGE PUMPS TO BE INSTALLED AS RAW SEWAGE PUMPS NO. 2 & NO. 4.
2. HANDRAIL TO BE SCH 40 STEEL & PAINTED TO MATCH EXISTING HANDRAIL.
PLAN
SECTION A
PLATFORM & STAIR PLAN 1
STAIR DETAIL
HANDRAIL STEEL
SOUTH DAVIS COUNTY SEWER IMPROVEMENT DISTRICT
SOUTH PLANT REHABILITATION
MAIN PUMPING STATION SECTION - MECHANICAL
SHEET MPS-5


ITEMS TO BE CONSTRUCTED
EXISTING VENTILLATION FAN TO REMAIN
HANDRAIL
SONIC LEVEL METER
MCC & VFD
REMOVE EXISTING SECTION OF WALL SHOWN SHADED
EXISTING 24" RCP LINE
G-IPS-2 SLIDE GATE
G-IPS-1 SLIDE GATE
30" MORTAR LINED STEEL PIPE LINE
PLAN
SCALE: 1/2" = 1'-0"
2" x 1/8" STAINLESS STEEL STRAP
3/4" HILTI ANCHORS
STRAP DETAIL
NOT TO SCALE
3/4" HILTI ANCHORS
2'-6" x 1'-3" x 1/4" PLATE
NON SHRINK GROUT
3" x 3" x 1/4" L (2'-6")
EXISTING OPENING MODIFICATIONS
SCALE: 1 1/2" = 1'-0"
MCC & VFD
P-IPS-2
SONIC LEVEL METER
G-IPS-4
V-IPS-2 KNIFE GATE
8" PVC
CORE 2" Ø DRAIN HOLES 2 PLACES
G-IPS-2 SLIDE GATE
EL. 4220.30
EXISTING 24" RCP LINE
IE. EL. 4213.80
EL. 4212.80
#4 @ 12" EACH WAY
EXISTING OPENING MODIFICATIONS
MIN. 12" TYPE "D" MATERIAL
SECTION
SCALE: 1/2" = 1'-0"
DESIGNED BY SCOTT ROGERS 10/89
DRAWN BY JUBAL MYERS 10/89
CHECKED BY
SOUTH DAVIS COUNTY SEWER IMPROVEMENT DISTRICT
1800 WEST 1800 NORTH P.O. BOX 4000
WEST BOUNTIFUL, UTAH 84087
SOUTH PLANT REHABILITATION
INTERMEDIATE PUMP STATION PLAN AND SECTION
SHEET IPS-1