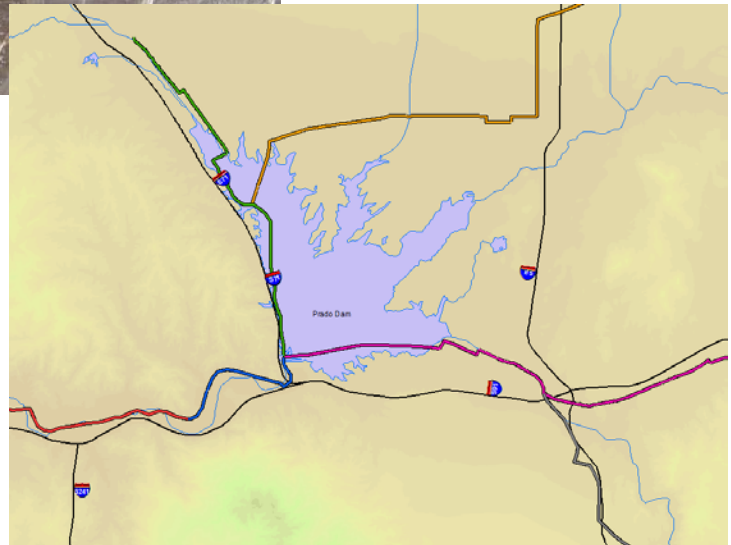


Santa Ana Regional Interceptor Hydraulic Model and Capacity Assessment



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Santa Ana Regional Interceptor

Hydraulic Model and Capacity

Assessment

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Executive Summary

In its entirety, the Santa Ana Regional Interceptor (SARI) comprises approximately 92 miles of pipeline running through Orange, Riverside, and San Bernardino Counties. The interceptor was initially constructed to provide for disposal of highly saline brine discharges by conveying these discharges out of the Upper Santa Ana River Watershed and to treatment and outfall facilities.

Two developments in the Upper SARI system have required SAWPA to develop more detailed information on the capacity and predicted future flows in the Upper SARI system. The first of these developments is the possible high-volume flushing of Reach V for improved operations and maintenance. The second development is the future capacity needs of the Upper SARI system member agencies.

A hydraulic model was developed to determine flows and capacity in the Upper SARI system under a variety of scenarios. These scenarios are described in further detail in Section 5. The results and implications of these scenarios are presented and discussed in detail in Section 6 – Section 9.

The hydraulic model's accuracy is constrained by the following factors:

- The inflow and infiltration factors (I&I) applied to the model represent the best information known by SAWPA staff, but they are untested and uncalibrated by field values.
- The diurnal peak factors developed for the model do not represent the maximum values allowed by contract with the dischargers.
- The diurnal peak factors developed for the model are based upon best available monitored data, but they underestimate the true peak discharges seen in the Upper SARI system.
- Horizontal and vertical curves in the Upper SARI system's pipelines are not captured in the model data, but these curves will affect hydraulic performance.

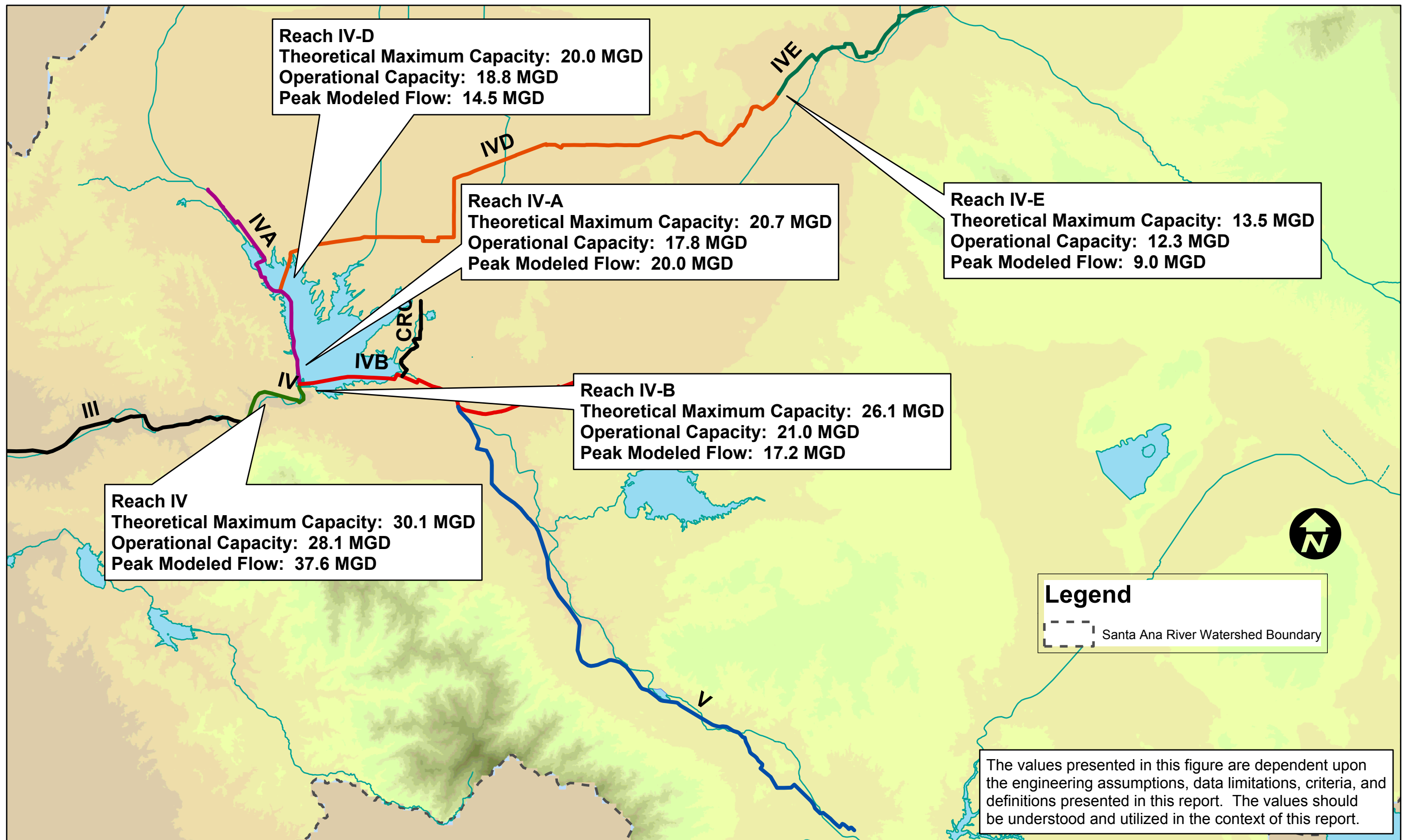
- Lateral lines jutting into a pipe and other such imperfections affect system performance in ways that cannot be captured by the hydraulic model.
- Hydrodynamic phenomena, such as air bubbles trapped due to poor blow-off valve performance, affect system performance in ways that cannot be captured by the hydraulic model.
- Average condition values relating to Manning's n values were used.
- Unknown defects may exist and cannot be captured by the hydraulic model.
- Unknown maintenance issues may exist and cannot be captured by the model.

The model results, subject to the above-described constraints, are given in detail in Section 6. The results from three scenarios given by reach are summarized in Figure 1. The theoretical maximum capacity listed in the figure is the full-pipe capacity of the capacity-constraining pipe for each reach. The operational capacity listed for each reach is the capacity of the constraining pipe for each at a depth-to-diameter (d/D) ration of 0.75. Finally, the maximum modeled flow is the maximum flow passing through the constraining pipe for each reach under the "30 MGD Peaked + 3 MGD" scenario (see Chapter 5). These results, in conjunction with SAWPA staff discussions, led to the development of the following recommendations about the future study and management of the Upper SARI system:

- Inflow and infiltration (I&I) should be quantified.
- Video analysis of the pipes and visual inspection of the manhole structures should focus on identifying areas of deterioration that would lead to exfiltration. Areas of the Upper SARI system that demonstrate high I&I values should be subjected to pipe joint inspection to identify ways to prevent both I&I and exfiltration.
- As the system nears capacity, flow equalization basins should be placed on each private lateral from an industrial user or municipal corporation sewer collection system to trim peaking of discharge to a rate of flow that is as near to constant as possible.
- Flow characteristics of desalters should be confirmed.
- Flow meters with data loggers should be installed on private service laterals that enter the SARI. These meters will establish flow patterns and provide the data necessary for

SAWPA to work proactively with industrial users and municipalities to maintain acceptable flow levels and reduce peaking.

- The installation of flow control devices (principally weirs) should be considered on private service laterals to help ensure a consistent flow rate. These devices are normally installed as detention basin outlet structures. If such a device is placed on a desalter line that has a reasonably constant flow rate, then some capacity to store flow above the flow control point would be needed. This minor amount of detention could mitigate the effects of unusual operational circumstances that could create limited-duration flow spikes.
- The various reaches of the Upper SARI system should be evaluated for low points and points of diversion and bypass.



Section 2: Model of Reach V Flushing Flow Rate

The operational environment of Reach V may require flushing to reduce deposition in the siphons of this reach. For this project, Kennedy/Jenks Consultants initially built a steady-state model to analyze the required flushing flow rate. Section 2 describes this initial model.

2.1 Background on Reach V

As shown in Figure 1, Reach V runs from southern Riverside County to a connection with Reach IV-B in the City of Corona. Recently, developers within the Alberhill area of Elsinore Valley Municipal Water District have requested an interim connection to the SARI line in order to dispose of domestic wastewater until the Alberhill Water Reclamation Facility is constructed and becomes operational.

Because of the nature of the terrain it traverses, Reach V contains many pipes with negative slopes. In these pipes, a siphon situation is created, resulting in pressurized flow. Currently, the flow in Reach V is small in comparison with the capacity of this reach and those downstream. As a result, the velocity of the flow, especially in the pressurized pipes, is low. Because of the proposed discharge of domestic wastewater into Reach V, SAWPA staff is concerned about possible low velocities that would increase the amount of solids deposition and scaling in the reach, reducing the reach's hydraulic performance.

Previously, the feasibility of pigging Reach V was considered. In fact, SAWPA included pig launching stations along Reach V to allow such cleaning. In light of the considerable expense and risk involved in pigging Reach V, however, it is necessary to evaluate alternative methods for cleaning the siphons to help prevent solids deposition.

One such method involves increasing the amount of flow in the siphons until flushing velocities are achieved. The flushing flow would remove materials deposited during routine flow, and, if performed regularly, it would help maintain unobstructed flow throughout the SARI line. Because SAWPA maintains gates at several points in the SARI line, it was originally thought that flushing velocities could be created by closing one or more gates, allowing fluid to pond behind the gate, and then rapidly opening the gate to release the fluid. Subsequent calculations

indicate that sufficient water volume for flushing would not be achieved under this method. SAWPA has access to other sources of water for flushing; therefore, SAWPA staff desires evaluation of the flow rate required for flushing within Reach V.

2.2 Construction of Reach V Steady-State Flushing Model

SAWPA staff provided data on the attributes of approximately 325 pipes that are part of the SARI line in Reach V, extending from Elsinore Valley Municipal Water District into the City of Corona. These attribute data were used to create a steady-state hydraulic model to evaluate the steady-state flow rate needed to create flushing flows within the siphons. The steady-state hydraulic model was constructed in H2OMap Sewer from the electronic file (cleaningflowcalcs20050407_REV.xls). This file indicated stationing for the reach, with each station delineating a segment of pipe. For each pipe segment, physical data, including pipe material, diameter and invert elevations, were available in the electronic file. The invert elevations and pipe lengths were imported from Excel to AutoCAD and then exported to the H2OMap Sewer model. Information on the pipe material and diameters were then added through database exchange from the Excel file to the H2OMap Sewer model. A Manning's 'n' value of .010 was used for all PVC and HDPE pipe. Assumptions were required to create a running model. These assumptions included manhole diameters of 4 feet each and a rim elevation of 7 feet higher than the invert elevation for each manhole. (Because Reach V is sealed for pressure, rim elevation is not an essential attribute.) In several cases, representations of manholes and short segments of pipe were inserted into the model to create logical connections between segments in the input data. These insertions were noted in the input data for verification. The input data can be found in Appendix B, Reach V-Table 1, The notations for inserted sections are highlighted in red.

Discussion with SAWPA staff indicated that the typical flow observed in Reach V is 400 gallons per minute (gpm). This flow rate was used as the baseline flow rate in the model. The flow was assigned as a point load at the furthest upstream manhole in the model.

2.3 Criteria and Constraints for Reach V Model

A velocity of 2.0 feet per second (fps) is generally prescribed as a “self-cleansing velocity” within a wastewater system. At this velocity, particles will not fall out of the liquid stream to deposit in the pipe. After discussion with SAWPA staff, it was decided that 3.0 fps would be designated as the flushing velocity for this study. At this higher velocity, existing deposits in the pipe would be lifted back into the liquid stream, cleaning areas that have not experienced flushing flows for some time.

During creation of flushing flow conditions in the siphons, one must be careful not to exceed the design constraints of the pipes. Discussion with SAWPA staff indicated that the pipes and joints of Reach V have a maximum design pressure of 80 pounds per square inch (psi); therefore, no action taken to clean the siphons should result in pressures greater than 80 psi anywhere in Reach V.

2.4 Results from Reach V Model

Reach V-Table 2 (Appendix B) presents model outputs for the baseline scenario of 400 gpm. As in Reach V-Table 1, the results are presented in order of stations, from the downstream to the upstream section of the modeled reach; the three large siphons are called out in gray. As expected, the velocities in the siphons resulting from the baseline flow scenario are much lower than velocities that would be necessary to achieve flushing. In the largest-diameter siphons (30 inches diameter), the baseline flow results in pressurized velocities of only 0.18 fps.

The steady-state model indicates that a flow of 6,600 gpm would be required to achieve flushing velocities in the siphon sections throughout the modeled reach of the SARI line. This flow is the lowest at which all siphon sections of the modeled reach achieve flushing.

Reach V-Table 3 (Appendix B) presents model outputs for this steady-state flow rate. The siphons are called out in yellow in the results. As indicated, the pressurized velocity in the siphon sections ranges from 3.0 fps for the 30-inch-diameter lines to 4.6 fps in the 24-inch-diameter lines.

Information in Table 3 that is of concern is the velocities produced in some of the open-channel gravity pipes located between siphons; these velocities are greater than 10 fps in several sections, under 6,600 gpm flows. Velocities greater than 10 fps are cause for concern because of the scouring damage they can cause to the pipe material.

2.5 Flushing Effects on the Upper SARI System

As noted in Section 2.4, the steady-state model indicates that a flow of 6,600 gpm would be required to achieve flushing velocities in the siphon sections throughout the modeled reach of the SARI line. The model also indicates that this flow rate could produce high velocities in some of the gravity pipes of the modeled reach.

Of more importance is the potential impact of these Reach V flushing flows on the rest of the Upper SARI system. This potential impact is explored with the development of a full Upper SARI system model, described in the following sections.

Section 3: Upper SARI Hydraulic Model Creation

A hydraulic model is a mathematical representation of the physical infrastructure, fluid flows, and control mechanisms of a hydraulic system. Section 3 describes the process, for this project, by which an appropriate modeling software was selected, refined, and populated with data on the Upper SARI system. The end result is a powerful, flexible tool for the hydraulic analysis of the entire Upper SARI system.

3.1 Model Selection

The goal in creating any hydraulic model is to construct a tool that accurately represents the existing hydraulics of the modeled system so that questions about existing and future operations can be analyzed with confidence. The analytic capabilities of the software and the model's degree of accuracy depend upon the detail and complexity of the questions to be analyzed. In successful hydraulic modeling efforts, software appropriately matches the system and the required analysis.

The Upper SARI system requires a very robust model. The majority of the system consists of open-channel flow, but numerous siphons and areas of reverse slope also yield many pipes with pressurized flow. The non-steady-state discharges into the system necessitate dynamic flow analysis. Finally, the fact that the Upper SARI system is expected to run at a very high percentage of total capacity in the future necessitates a model that can maintain accuracy in near-surge conditions.

For this project, Kennedy/Jenks Consultants utilized the H2OMapSWMM hydraulic model, which meets the above-described criteria. Based upon the EPA-SWMM hydraulic engine, this model solves the fully dynamic St. Venant's equations for open-channel flow. It also allows for real-time control of weir and orifice conditions in the model. More details concerning the history and capability of this model can be found at <http://www.epa.gov/ednrmrl/swmm>. The H2OMapSWMM program incorporates the EPA-SWMM engine into a user interface that surpasses the original EPA interface.

3.2 Model Schematization

Figure 1, shown above, displays the actual physical layout of the SARI line. The detailed information available for creating a hydraulic model of the SARI line did not include the accurate spatial location of the line's entities, however. Thus, the decision was made to create a schematic model of the Upper SARI line. The schematic model is hydraulically accurate in relation to SARI line lengths, inverts, slopes, diameters, and material, but it is not spatially representative. Figure 2 shows the schematic representation of the Upper SARI model, divided by reach. While this model looks different from the system presented in Figure 1, it is hydraulically identical. Should the spatial attributes of the Upper SARI system become available, they can be easily incorporated into the hydraulic model.

The model is as hydraulically accurate as the information provided to build the model. The model schematic was populated with data that had been assembled by SAWPA staff as part of an earlier modeling effort. These data were assembled according to reach and contract from record drawings of the Upper SARI line. Model node identification was assigned by SAWPA staff. The data were "cleaned" to correspond with H20MapSWMM data import conventions. During the cleaning process, data order may have been re-arranged, and "placeholder" nodes were inserted as noted below, requiring a re-calculation of stationing; however no data values were deleted or changed.

The following are key aspects of the model schematization:

- The H20MapSWMM program uses nodes to calculate the invert elevations of the pipes. Since a node is needed to decipher any change in alignment, "placeholder" nodes were assigned at siphon locations and throughout Reach V. They have been identified by "KJ" in the node ID; they do not reflect the actual presence of manholes.
- Manning's numbers, reflecting the pipe condition, were applied to each segment of pipe. The following values were assumed based upon pipe material following commonly used average values. (Sections of pipe lined with PVC were given the Manning's number corresponding to PVC).
 - RCP: 0.013
 - VCP: 0.013

- HDPE: 0.010
- PVC: 0.010

- The outfall of the Upper SARI system was assumed to be a free outfall with no backwater effects. This assumes that the current meter at the county line will be replaced with a free-flowing apparatus. Should it become necessary to model the effects of the current meter, an orifice will be placed at the model outfall and an orifice co-efficient will be developed based upon the geometry of the current meter.

For locations that appeared anomalous, the information imported into the model was checked against the record drawings. Any conflicts were resolved by using the record drawing information, along with confirmation by SAWPA staff. Vertical datum shifts were originally thought to be a concern, but work done in the previous modeling effort to reconcile vertical data among reaches eliminated nearly all problems in this regard.

Future scenarios that were analyzed using the model incorporate hydraulic changes according to plans prepared by CDM and Krieger and Stewart. These plans describe changes to be made to Reach IV of the SARI line as it passes through the Prado Dam area. Because this construction is not currently complete, it was not reflected in existing modeling scenarios. In general, the new designs flatten the slope of the line in the Prado Dam area.

3.3 Existing Flows in Upper SARI System

Existing flows (discharges) were identified by SAWPA staff. Monthly discharge information was provided for the years 2001-2005. At the direction of SAWPA staff, flows from July 2005 were chosen as representative of existing conditions within the Upper SARI line. SAWPA staff provided the manhole location of each discharger. Because some the manholes listed were not included in the hydraulic schematic model, the nearest manhole upstream of the given manhole was used as the loading manhole in the model. The list of the existing dischargers, the load discharged by each, and the loading manhole are listed in Table 1. It should be noted that more recent data has called the Table 1 flows into question for being too low. These flows should be re-examined and perhaps remodeled. Figure 2 shows the locations of the dischargers in the model.

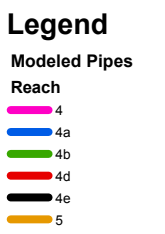
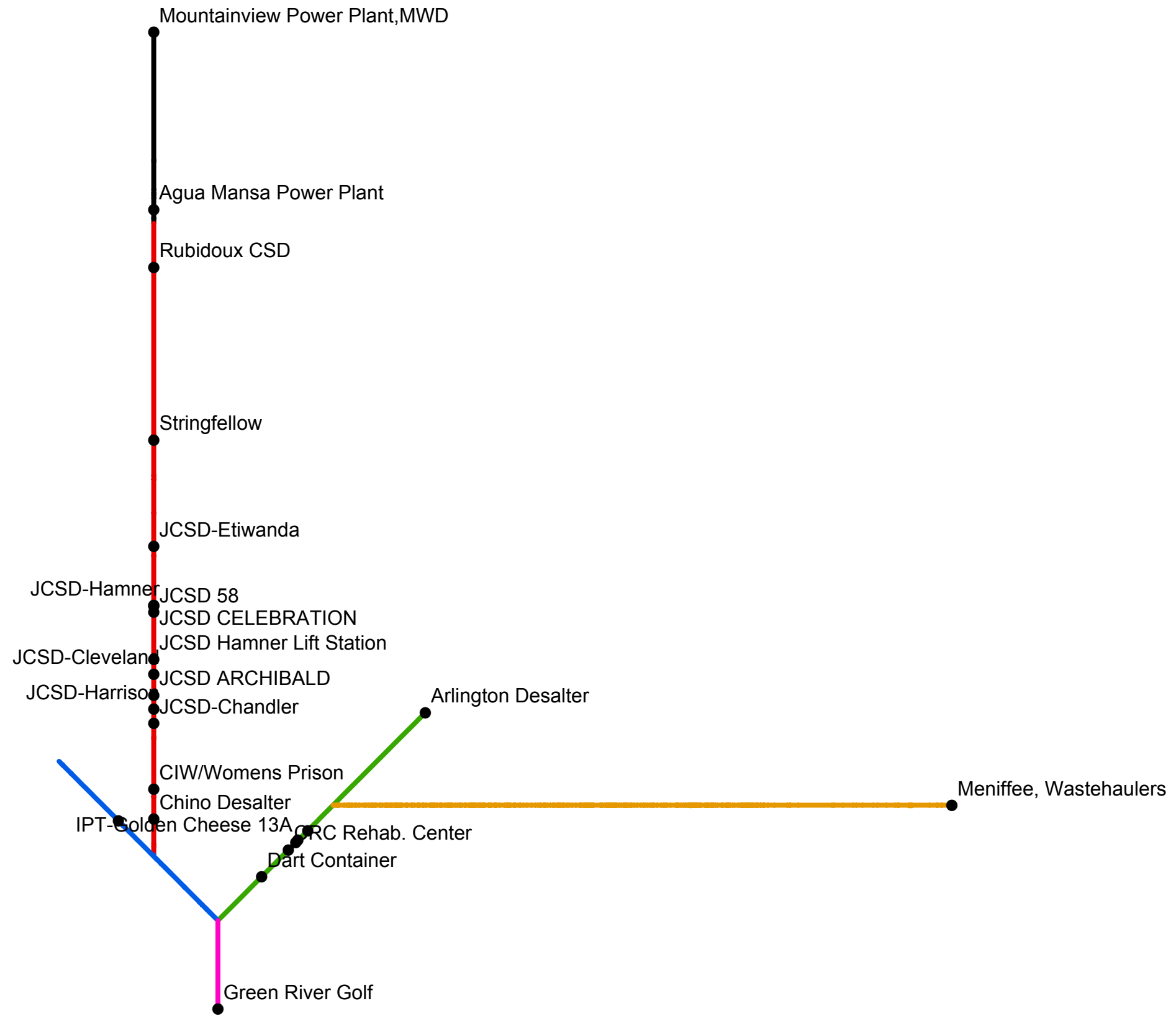


Table 1: Existing Discharge Amounts into Upper SARI System (July 2005)

| Permit No | Discharger | Discharge Manhole | Model Manhole | Discharge Amount (mgd) |
|--------------|--------------------------|-------------------|---------------|------------------------|
| 5 | IEUA | 4A-0389 | 4A-0390 | 0.55 |
| 11 | Wastehaulers | | 4A-0390 | 0.12 |
| 13A | IPT-Golden Cheese | 4B-0262 | 4B-0270 | 1.09 |
| 13B | IPT-Golden Cheese | 4B-0252 | 4B-0260 | 0.08 |
| 19 | CRC Rehab. Center | 4B-0215 | 4B-0220 | 0.75 |
| 20 | Corona Energy Part. | 4B-0258 | 4B-0260 | 0.09 |
| 21 | JCSD-Cleveland | 4D-0458 | 4D-0460 | 0.35 |
| 22 | Arlington Desalter | 4B-0888 | 4B-0890 | 1.49 |
| 24 | JCSD-Hamner | 4D-0588 | 4D-0590 | 0.02 |
| 25 | Green River Golf | 4-0008 | 4-0010 | 0.01 |
| 26 | CIW/Women's Prison | 4D-0218 | 4D-0220 | 0.29 |
| 28 | JCSD-Etiwanda | 4D-0748 | 4D-0750 | 0.49 |
| 29 | Rubidoux CSD | 4D-1458 | 4D-1460 | 0.01 |
| 32 | Temescal Desalter | 4B-0328 | 4B-0330 | 1.22 |
| 34 | Chino Desalter | 4D-0118 | 4D-0120 | 1.39 |
| 35 | Mountainview Power | 4E-0385 | 4E-0390 | 0.14 |
| 36 | JCSD-Chandler | 4D-0378 | 4D-0380 | 0.35 |
| 40 | JCSD 58th Street | 4D-0562 | 4D-0570 | 0.06 |
| 41 | Menifee Desalter | REACH V | J1 | 0.44 |
| 42 | MWD | 4E-0385 | 4E-0390 | 0.04 |
| 46 | Unilever | REACH V | J1 | 0.01 |
| 48 | JCSD-Harrison | 4D-0398 | 4D-0400 | 0.15 |
| 49 | JCSD Hamner Lift Station | 4D-0488 | 4D-0490 | 0.29 |
| 50 | Dart Container | 4B-0102 | 4B-0110 | 0.03 |
| 53 | Agua Mansa Power Plant | 4E-0018 | 4E-0020 | 0.02 |
| 54 | JCSD CELEBRATION | 4D-0572 | 4D-0580 | 0.04 |
| 55 | JCSD ARCHIBALD | | 4D-0420 | 0.06 |
| 97 | IEUA Pond | 4A-0389 | 4A-0390 | 0.00 |
| 101 | Stringfellow | 4D-1068 | 4D-1070 | 0.13 |
| 220 | Bonview | | 4A-0390 | 0.00 |
| Total | | | | 9.70 |

3.4 Diurnal Flow Peak Factors

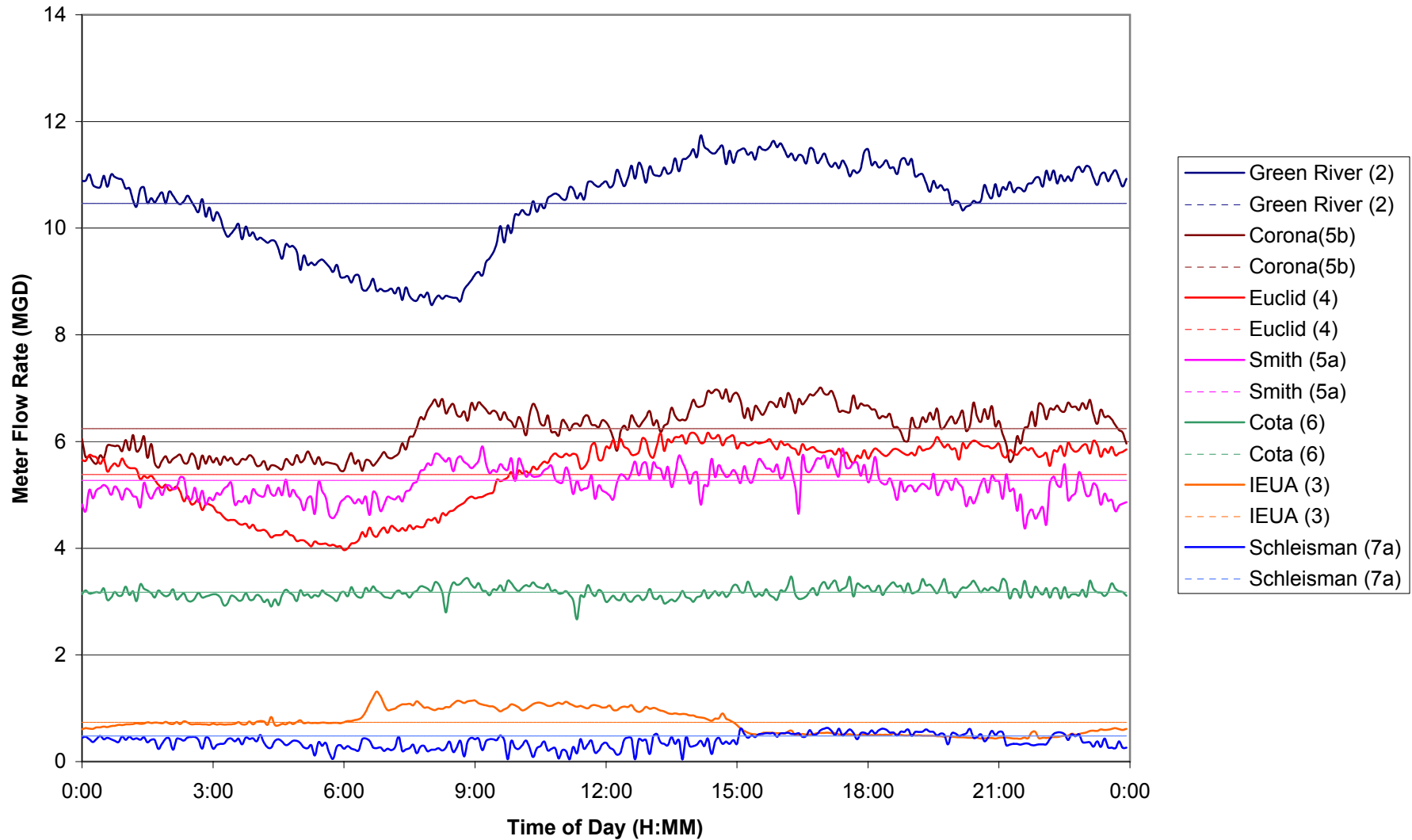
The flow data listed in Table 1 were gathered on the basis of a monthly total; the data give no indication of peak discharge values during that month. Flow monitoring data collected by SAWPA, however, do give an indication of peak values for specific reaches of the Upper SARI system.

At the direction of SAWPA staff, diurnal peak curves for the reaches were used as representative diurnal patterns for the dischargers to that reach. Although this tactic is not entirely precise in representing conditions in the line, it offers the best representation of the data available. It should be noted that these peak factors likely underestimate the true peaks at the individual dischargers, because of travel time and dynamic flow dampening.

Figure 3 shows the diurnal patterns developed from the raw data recorded by the flow monitors. The information in Figure 3 corresponds with what is known about the Upper SARI system and the dischargers. For example, the IEUA curve corresponds with a 12-hour industrial cycle. The Euclid curve shows evidence of both the industrial dischargers and the domestic dischargers represented by the JCSD connections. Figure shows the locations of the flow monitors in the Upper SARI system.

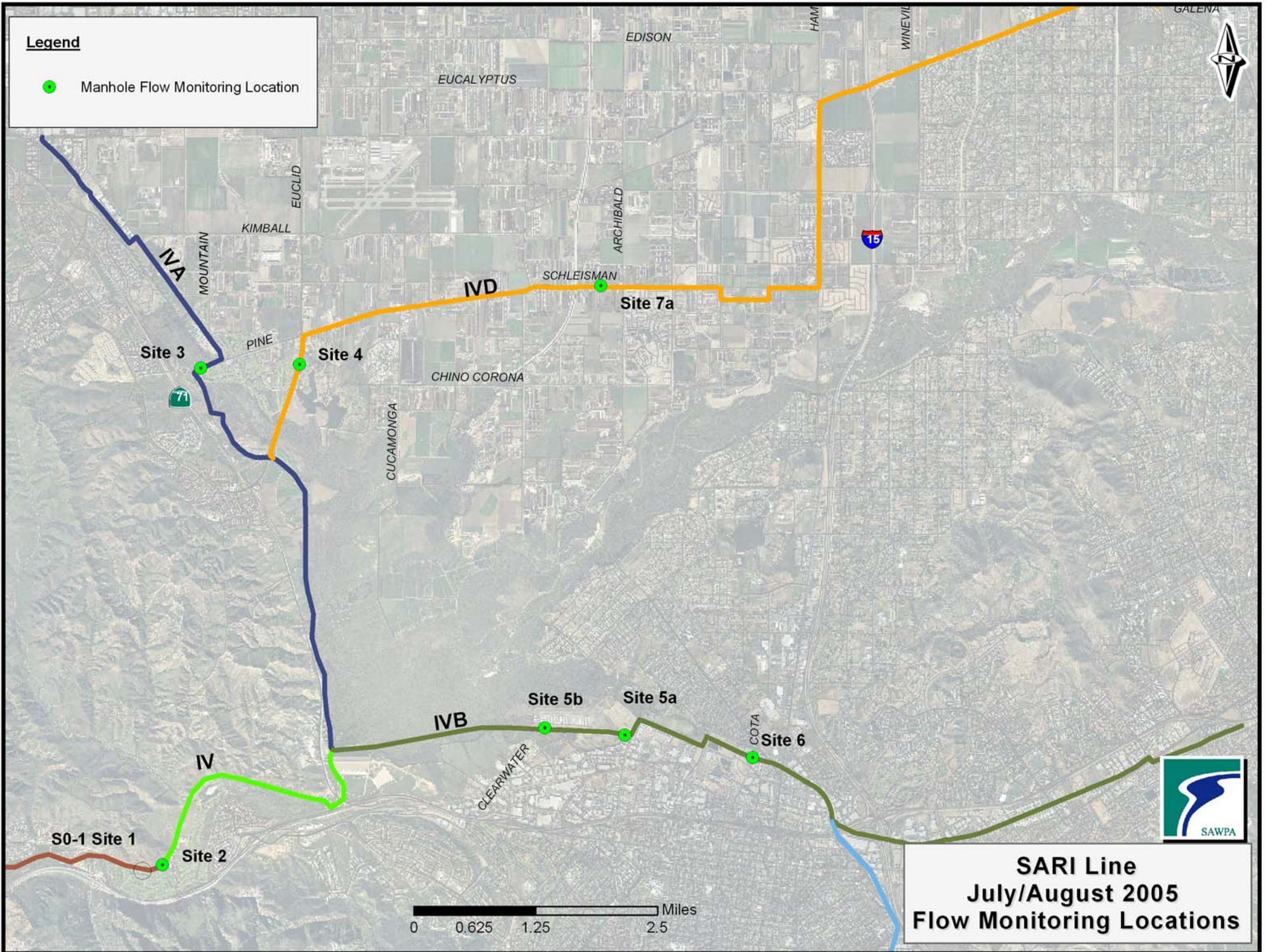
Table 2 lists the diurnal peak curves developed from the flow monitoring data and applied to the average flows listed in Table 1. As noted in Figure 3, each value in Table 2 represents the weekday flow at a given hour of the day divided by the average flow for the meter for that week. It should be noted that desalters and other dischargers known to have steady diurnal flows were not given a peak curve.

Representative Average Diurnal Flows
(Solid Lines are Weekday Diurnal Patterns; Dashes are Weekly Averages)



Legend

- Manhole Flow Monitoring Location



**SARI Line
July/August 2005
Flow Monitoring Locations**

Table 2: Diurnal Peak Curve Values

| | Corona | Cota | Euclid | Green River | IEUA | Schleishman | Smith |
|----------|-------------|-------------|-------------|----------------|-------------|-------------|-------------|
| 12:00 AM | 0.97 | 1.02 | 1.07 | 1.05 | 0.94 | 1.06 | 0.98 |
| 1:00 AM | 0.98 | 1.05 | 1.03 | 1.03 | 1.01 | 0.99 | 0.99 |
| 2:00 AM | 0.92 | 1.02 | 0.96 | 1.02 | 1.02 | 1.06 | 1.01 |
| 3:00 AM | 0.92 | 0.99 | 0.89 | 0.98 | 1.02 | 1.03 | 0.99 |
| 4:00 AM | 0.92 | 1.02 | 0.81 | 0.94 | 1.13 | 1.03 | 1 |
| 5:00 AM | 0.93 | 1.01 | 0.77 | 0.91 | 1.05 | 1.15 | 0.99 |
| 6:00 AM | 0.93 | 1.04 | 0.82 | 0.87 | 1.78 | 1.03 | 0.96 |
| 7:00 AM | 1.06 | 1.03 | 0.84 | 0.85 | 1.53 | 1.09 | 1.06 |
| 8:00 AM | 1.08 | 1.08 | 0.99 | 0.96 | 1.55 | 1.03 | 1.12 |
| 9:00 AM | 1.07 | 1.06 | 1.06 | 1.01 | 1.49 | 0.99 | 1.08 |
| 10:00 AM | 1.04 | 1.04 | 1.11 | 1.04 | 1.52 | 0.99 | 1.05 |
| 11:00 AM | 1.04 | 1.01 | 1.12 | 1.07 | 1.43 | 1.03 | 1.07 |
| 12:00 PM | 1.06 | 1.02 | 1.14 | 1.08 | 1.39 | 1.1 | 1.09 |
| 1:00 PM | 1.12 | 1.01 | 1.15 | 1.12 | 1.22 | 1.01 | 1.08 |
| 2:00 PM | 1.11 | 1.06 | 1.14 | 1.1 | 1.05 | 1.27 | 1.08 |
| 3:00 PM | 1.11 | 1.09 | 1.12 | 1.11 | 0.78 | 1.33 | 1.09 |
| 4:00 PM | 1.12 | 1.09 | 1.09 | 1.09 | 0.73 | 1.31 | 1.11 |
| 5:00 PM | 1.08 | 1.06 | 1.09 | 1.1 | 0.71 | 1.27 | 1.08 |
| 6:00 PM | 1.06 | 1.08 | 1.13 | 1.08 | 0.68 | 1.27 | 1.02 |
| 7:00 PM | 1.08 | 1.07 | 1.12 | 1.03 | 0.64 | 1.27 | 1.01 |
| 8:00 PM | 1.07 | 1.08 | 1.11 | 1.04 | 0.74 | 1.31 | 1.02 |
| 9:00 PM | 1.08 | 1.03 | 1.11 | 1.06 | 0.75 | 1.19 | 1.06 |
| 10:00 PM | 1.09 | 1.07 | 1.12 | 1.07 | 0.85 | 1.1 | 1.03 |
| 11:00 PM | 0.99 | 1 | 1.09 | 1.04 | 0.83 | 0.95 | 0.92 |

Section 4: Hydraulic Model Calibration

Hydraulic model calibration is the process by which modeled results are compared to observed hydraulic data on the modeled system. Calibration is used to confirm that the model accurately represents known conditions in the system, making it more likely that the model can accurately predict unknown conditions.

4.1 Selection of Calibration Points

Hydraulic model calibration is performed using points in the hydraulic system at which data can be observed and compared to modeled data. Because the July 2005 flows into the Upper SARI system were chosen to represent existing conditions in the system, measured data for calibration must have been collected at this time in order for an accurate comparison to be made.

While flow monitoring data was collected by SAWPA staff at several locations throughout July 2005, several of the monitors had recently been moved and a couple of others showed unreliable data, as pointed out by SAWPA staff upon review of the preliminary data; therefore, reliable calibration points within the system were limited.

The Green River flow monitor provided reliable data for the majority of the month, and it had a known location throughout the month. Also, the Green River flow monitor measures all flows passing through the Upper SARI system, because it is at the far downstream end of the system. For these reasons, the Green River flow monitor was chosen as the current calibration point for the Upper SARI system hydraulic model.

4.2 Calibration Data

Model data for calibration was generated from Pipe P-40040 (upstream of Manhole 4-0040) in the hydraulic model. Hourly flow information was downloaded from the model for a 24-hour diurnal pattern. These data were taken from the calibration scenario (see Section 5 for definitions and descriptions of various model scenarios) for a 24-hour period after all transient

effects of model startup had been dissipated. The downloaded data included data on both depth of flow in the pipe and velocity of flow in the pipe.

Observed data for calibration were taken from raw 15-minute flow monitoring data provided by SAWPA staff. The data for each 15-minute interval throughout the day were averaged across the available data to produce an average diurnal curve. As with the modeled data, the process took place for both depth and velocity of flow through the flow monitor.

As can be seen in Figure 5, the modeled depth at the calibration point consistently is slightly lower than the observed depth, but never by more than 7 percent. This fact is consistent with the fact that the peak factors applied to the average flows probably underestimate the true peaks at the discharge points (as discussed in Section 3). Also, the modeled velocity is consistently lower than the observed velocity, but less noticeably so, as can be seen in Figure 6. The observed velocity pattern shows the oscillations typical in ultrasonic velocity sensors used to measure open channel flow velocities. Figure 7 shows the flow profile through Reach IV with maximum values of calibration flows.

Figure 5: Depth Calibration at Green River Monitor

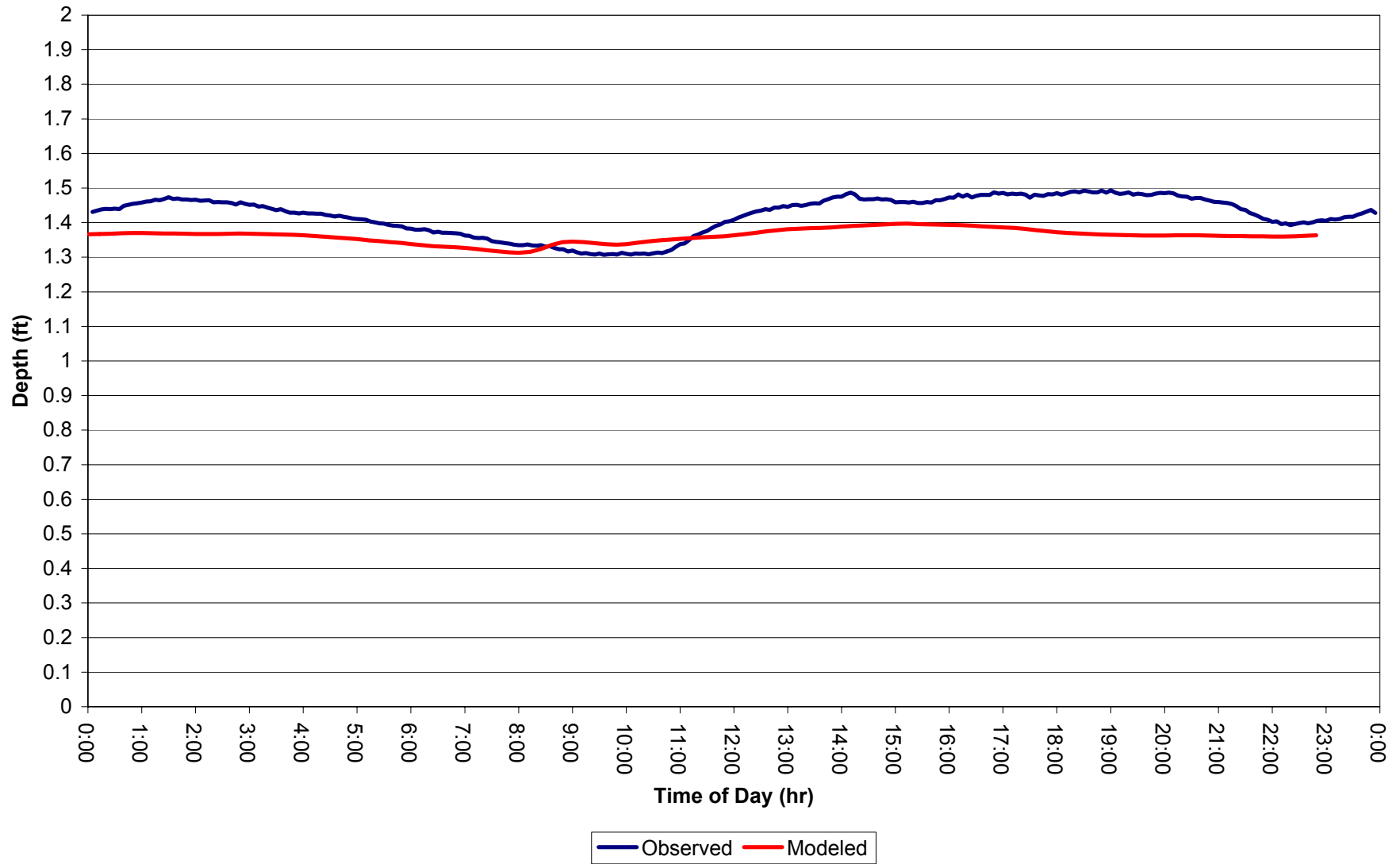
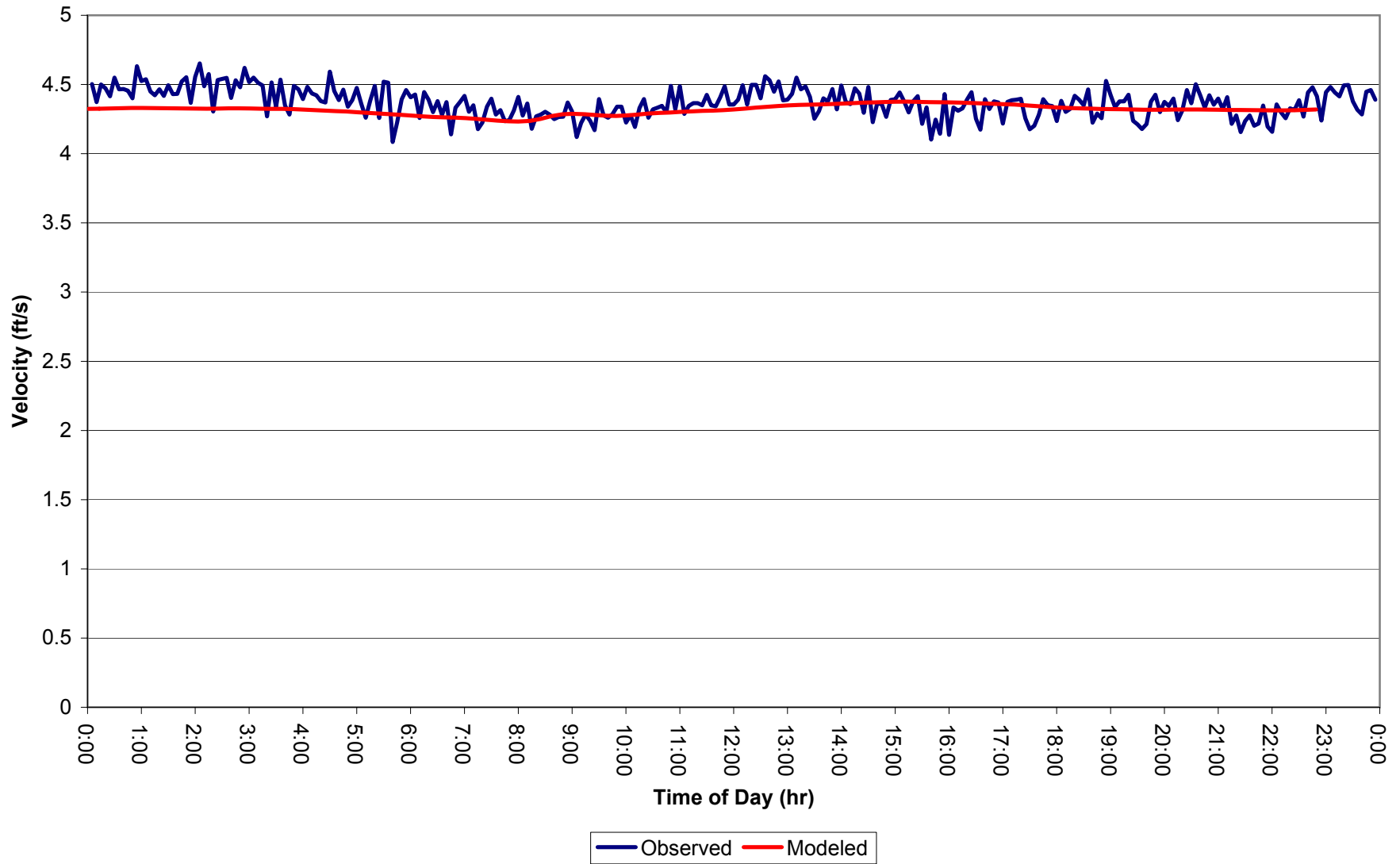
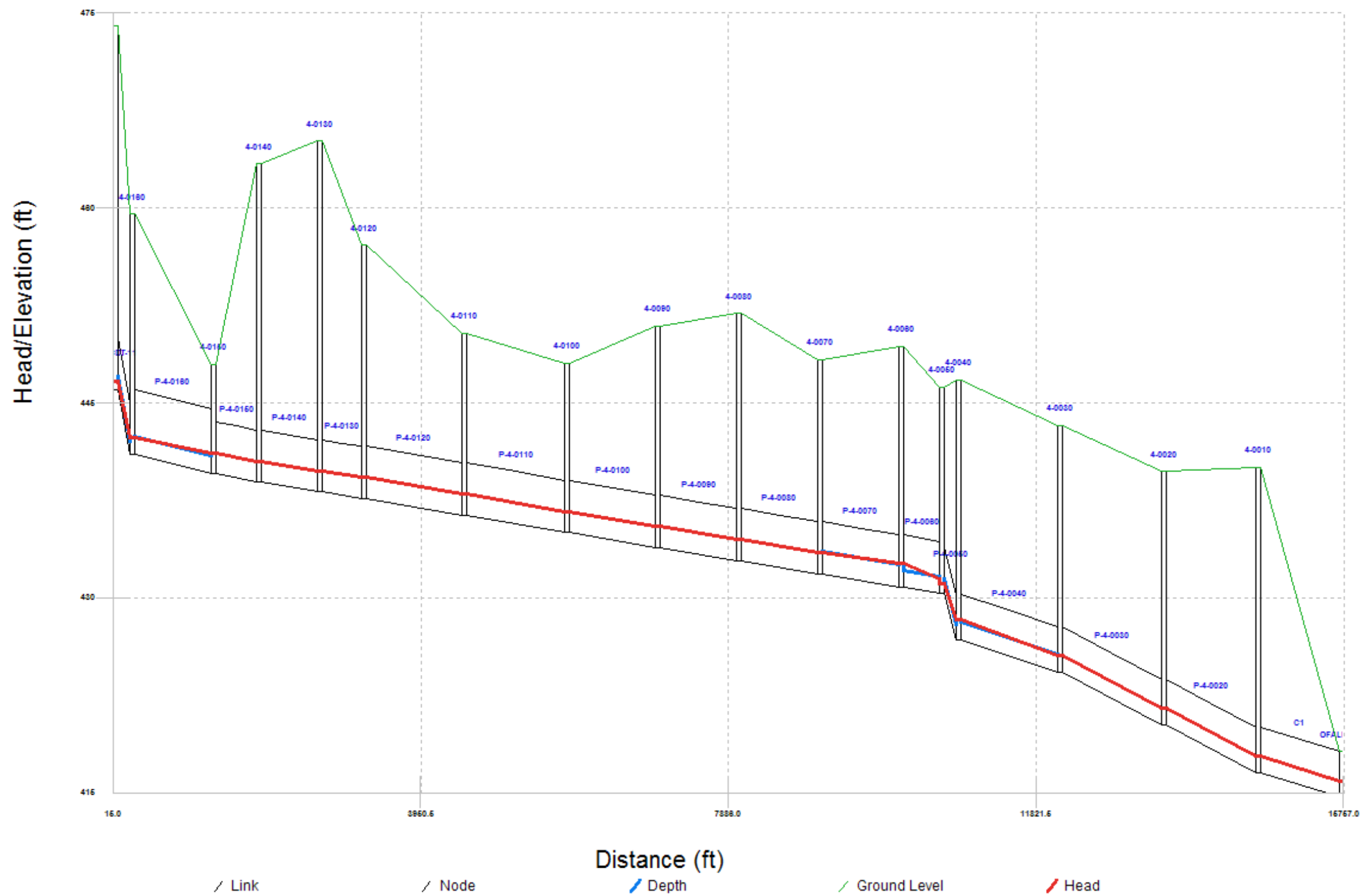


Figure 6: Velocity Calibration at Green River Monitor



Reach IV Peak Calibration Flows



Section 5: Hydraulic Model Scenario Creation

As described previously in this report, a hydraulic model is a mathematical representation of the infrastructure, fluid flows, and hydraulic control features in a hydraulic system. A scenario in such a model is a particular combination of infrastructure, flows, and controls chosen for analysis. Such a combination may consist of existing elements for which the model results can be compared with measured values (e.g., a calibration scenario, as developed for Section 4), or it may be a combination of hypothetical elements chosen to reflect anticipated future conditions of a system.

5.1 Upper SARI System Scenario

The purpose of creating future scenarios is to anticipate changes to the infrastructure and flow loading of the Upper SARI system so that the model can be used to calculate the performance of the system under these predicted conditions. As described in Section 1, the two primary set of conditions to be modeled in the Upper SARI system concern the effects of flushing Reach V and the effects of continued discharge increases inside the system. The following scenarios were created to simulate these conditions of concern. As described below, these scenarios incorporate not only anticipated flow changes, but also anticipated infrastructure changes concerning the alignment of the SARI line through the Prado Dam Area (the confluence of Reaches IVA and IVB into Reach IV).

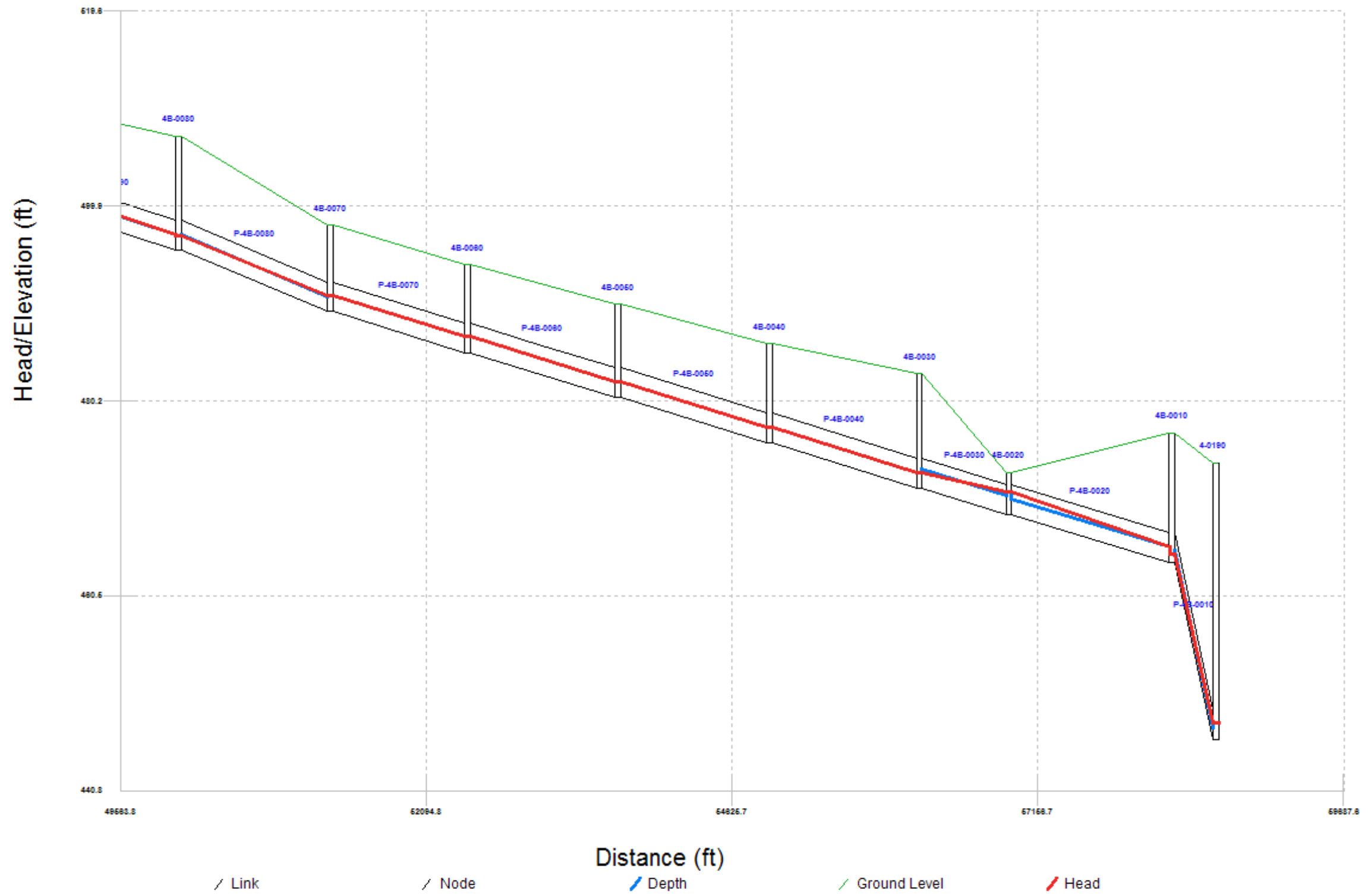
5.2 Reach V Flushing Scenario

As described in Section 1, the steady-state hydraulic model developed for Reach V indicated that a flow of 6,600 gpm would achieve flushing flows in the largest siphons. This flow equates to approximately 9.5 mgd. For the Reach V flushing scenario, 9.5 mgd was added to the upstream end of Reach V, supplementing the existing average flow of 9.7 mgd.

The results of this scenario indicate that the critical area created by the flushing flows is the lower stretch of Reach IV-B. As shown in Figure 8, a depth-to-diameter (d/D) ratio of 0.68 in

this area has been identified . Reach V reaches pressure conditions by design and therefore shows now critical areas.

Flushing Scenario - Peak Flows Reach IV-B



5.3 30-mgd Future Flows

The future scenario of 30-mgd flows was modeled. For this scenario, SAWPA provided data on the projected discharges into the Upper SARI line for the year 2025. Table 3 lists the dischargers, discharge location, and projected flow amounts for this scenario.

Table 3: Future Upper SARI System Dischargers

| Site Name | SARI Reach | Model Node ID | 2025 Projected Flow (mgd) |
|---|------------------|---------------|---------------------------|
| Menifee Desalter | Beg. Reach V | J275 | 1.2 |
| Perris Desalter | Beg. Reach V | J275 | 1.6 |
| Perris Desalter II | Beg. Reach V | J275 | 1.6 |
| Chino Desalter I | Reach IV-D, S-34 | 4D-0120 | 2.05 |
| Chino Desalter II | Reach IV-D, S-28 | 4D-0750 | 1.62 |
| Chino Desalter III | Reach IVD, S-28 | 4D-0750 | 1.5 |
| California Institution for Men | Reach IV-A, S-05 | 4A-0390 | 0.19 |
| City of Chino Hills | Reach IV-A, S-05 | 4A-0390 | 0.04 |
| RCSD, Anita Smith Ion Exchange | Reach IV-D, S-29 | 4D-1460 | 0.03 |
| Temescal Desalter | Reach IV-B, S-32 | 4B-0330 | 1.5 |
| Elsinore Desalter | Beg. Reach V | J275 | 1 |
| JCSD Ion Exchange | Reach IV-D, S-28 | 4D-0750 | 0.59 |
| JCSD Industrial | Reach IV-D | 4D-0750 | 1.1 |
| Arlington Desalter Facility (Transition to WMWD) | Reach IV-B, S-22 | 4B-0890 | 1.7 |
| Hexfet | Beg. Reach V | J275 | 0.01 |
| Inland Empire Energy Center (2007) | Beg. Reach V | J275 | 1.2 |
| Industrial (EMWD) | Beg. Reach V | J275 | 1.5 |
| Mission Uniform and Linen Service | Reach IV-A, S-05 | 4A-0390 | 0.71 |
| Future Uniform and Linen Service (Aramark) | Reach IV-A, S-05 | 4A-0390 | 0.2 |
| OLS Energy | Reach IV-A, S-05 | 4A-0390 | 0.13 |
| Paradise Textile Corp. | Reach IV-A, S-05 | 4A-0390 | 0.67 |
| RP-5 Renewable Energy | Reach IV-A, S-05 | 4A-0390 | 0.1 |
| Mountainview Power Company, LLC (Operational 2006) | Beg. Reach IV-E | 4E-0390 | 0.432 |
| SBVMWD (formely SCE Highgrove PP) - No Current Permit | Beg. Reach IV-E | 4E-0390 | 0.08 |
| SBVMWD (YVWD or Future Industrial) | Beg. Reach IV-E | 4E-0390 | 0.568 |
| City of San Bernardino - No Current Permit | Beg. Reach IV-E | 4E-0390 | 2.5 |
| City of Colton - No Current Permit | Reach IV-E, S-31 | 4B-0120 | 2 |

| | | | |
|--|---------------------|---------|--------------|
| City of Realto - No Current Permit | Reach IV-E, S-53 | 4E-0020 | 1.5 |
| YVWD, includes Future Ion Exchange - No Current Permit | Beg. Reach IV-E | 4E-0390 | 1.432 |
| Corona Energy Partners | Reach IV-B, S-20 | 4B-0260 | 0.1 |
| Metropolitan Water District | Reach IV-E, SP42 | 4E-0390 | 0.05 |
| Unilever Food Solutions | Reach V, S-46 | J1 | 0.02 |
| Stingfellow Pretreatment Facility | Reach IV-D, S-101 | 4D-1070 | 0.26 |
| El Colton (formerly Agua Mansa PP) | Reach IV-E, S-53 | 4E-0020 | 0.04 |
| Golden Cheese | Reach IV-B, S-13A/B | 4A-0320 | 1.2 |
| Alcoa | Reach IV-B, S-52 | 4D-0120 | 0.01 |
| Dart container | Reach IV-B, S-50 | 4B-0110 | 0.03 |
| Wastehaulers (S-11 = total of all wastehaulers) | Reach IV-A, S-05 | 4A-0390 | 0.1 |
| | Total | | 30.56 |

5.4 30-mgd Peaked Scenario

Also modeled was the 30-mgd peaked scenario, which is based upon the 30-mgd scenario with the following additions:

- Peak curves were added to data on relevant discharges. This increases the total modeled flow in the Upper SARI system to approximately 33 mgd.
- Five percent of the base flow in the future scenario was added as an approximation of I&I. The I&I flows accounted for 1.5 mgd and raised the total flow in the scenario to 34.5 mgd. The infiltration flows were loaded on manholes at the far upstream of Reach IV-A, IV-B, and IV-E.

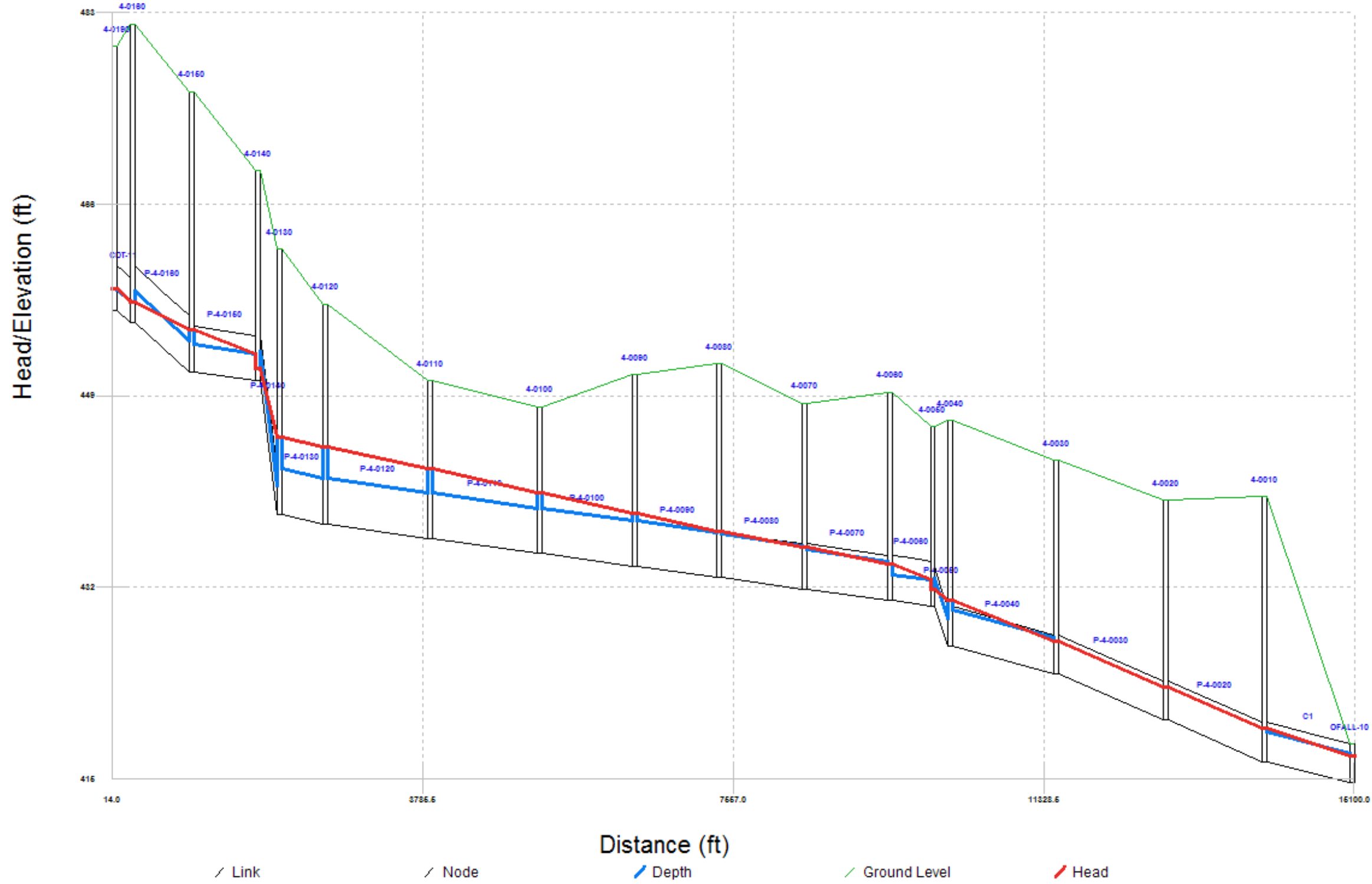
5.5 30-mgd Peaked + 3-mgd Scenario

This scenario is based upon the 30-mgd peaked scenario with the following addition:

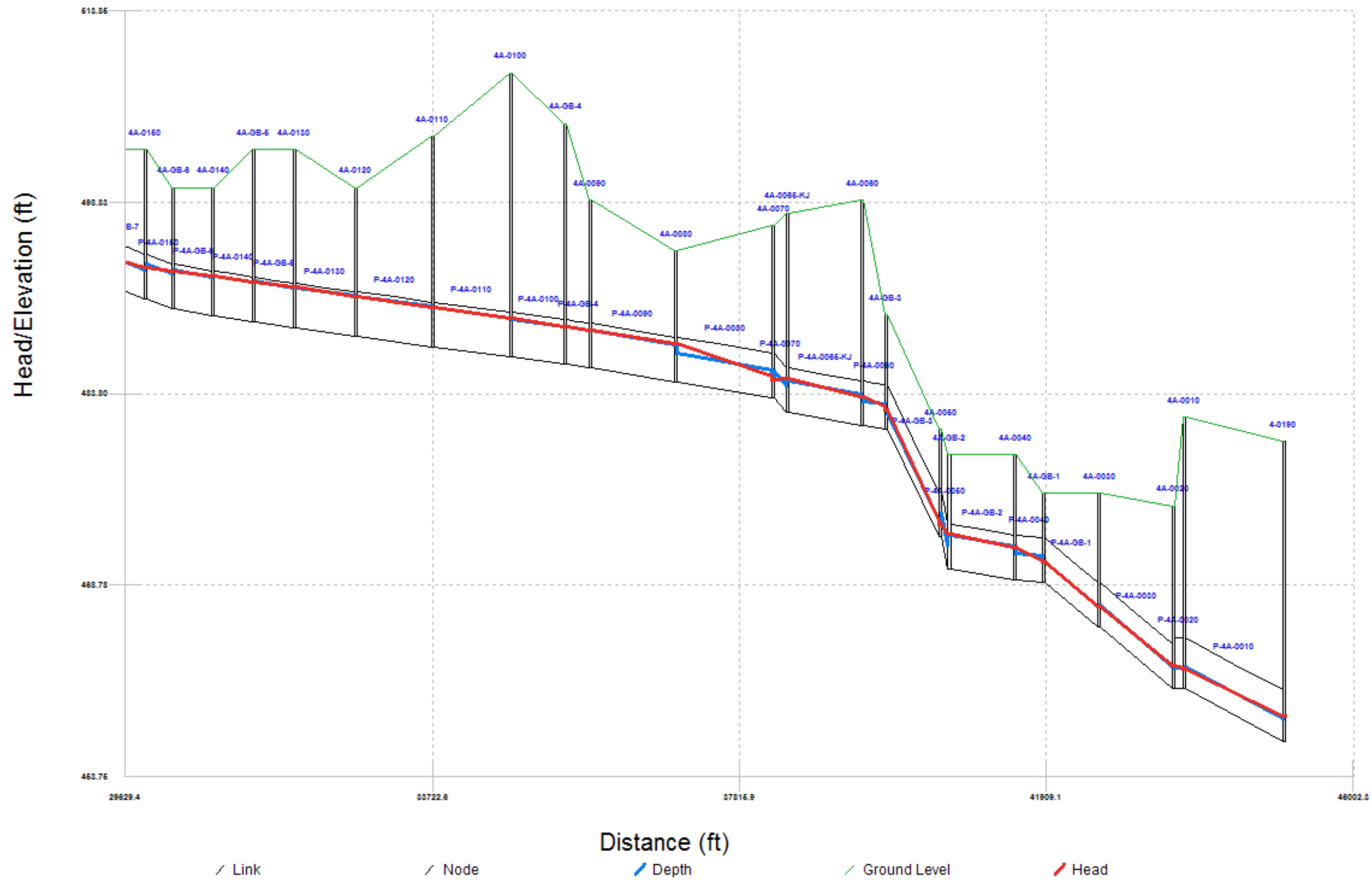
- 3 mgd was added at the end of Reach V to account for requested flow by a member agency at this point. This raised the total peak flow of the scenario to approximately 37.5 mgd.

The 30-mgd peaked + 3-mgd scenario takes the Upper SARI system right up to, and in some cases beyond, its maximum theoretical capacity. The following figures show the profile results of this scenario in the most critical areas of each reach of the Upper SARI system. As can be seen in Figure 9, Reach IV achieves surcharge conditions under peak flows in this scenario. Figure 10 shows that Reach IV-A nearly surcharges as well. Figure 11 shows the critical elements of Reach IV-B, where flow reaches the maximum theoretical capacity of the pipe. Figure 12 shows the critical elements of the Reach IV-E. Figure 13 shows the critical elements of Reach IV-D. Figure 14 is a summary of critical flow elements.

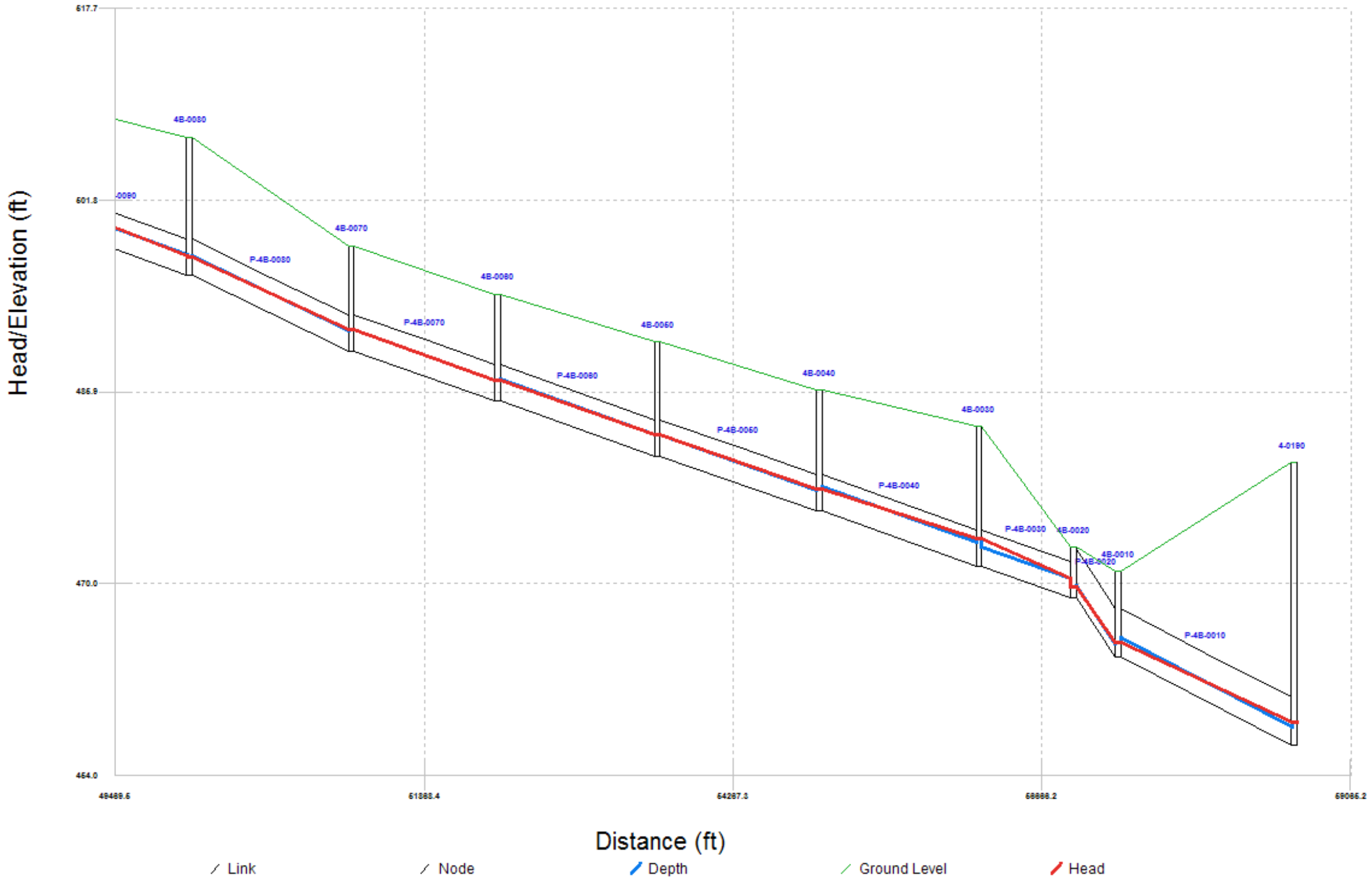
Reach IV 30 MGD Peaked + 3 MGD Peak Flows



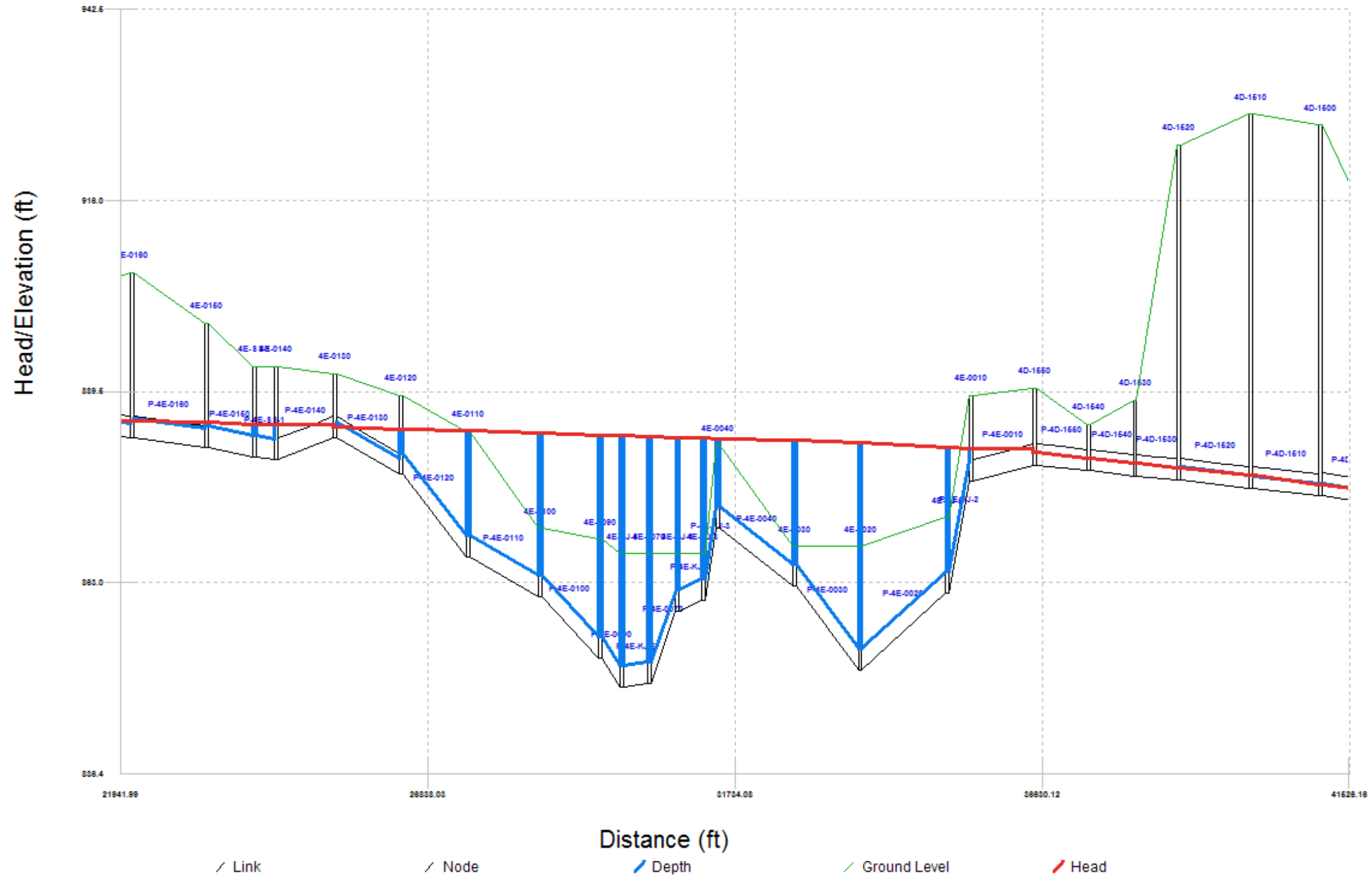
Reach IV-A 30 MGD Peaked + 3 MGD Critical Element Peak Flows

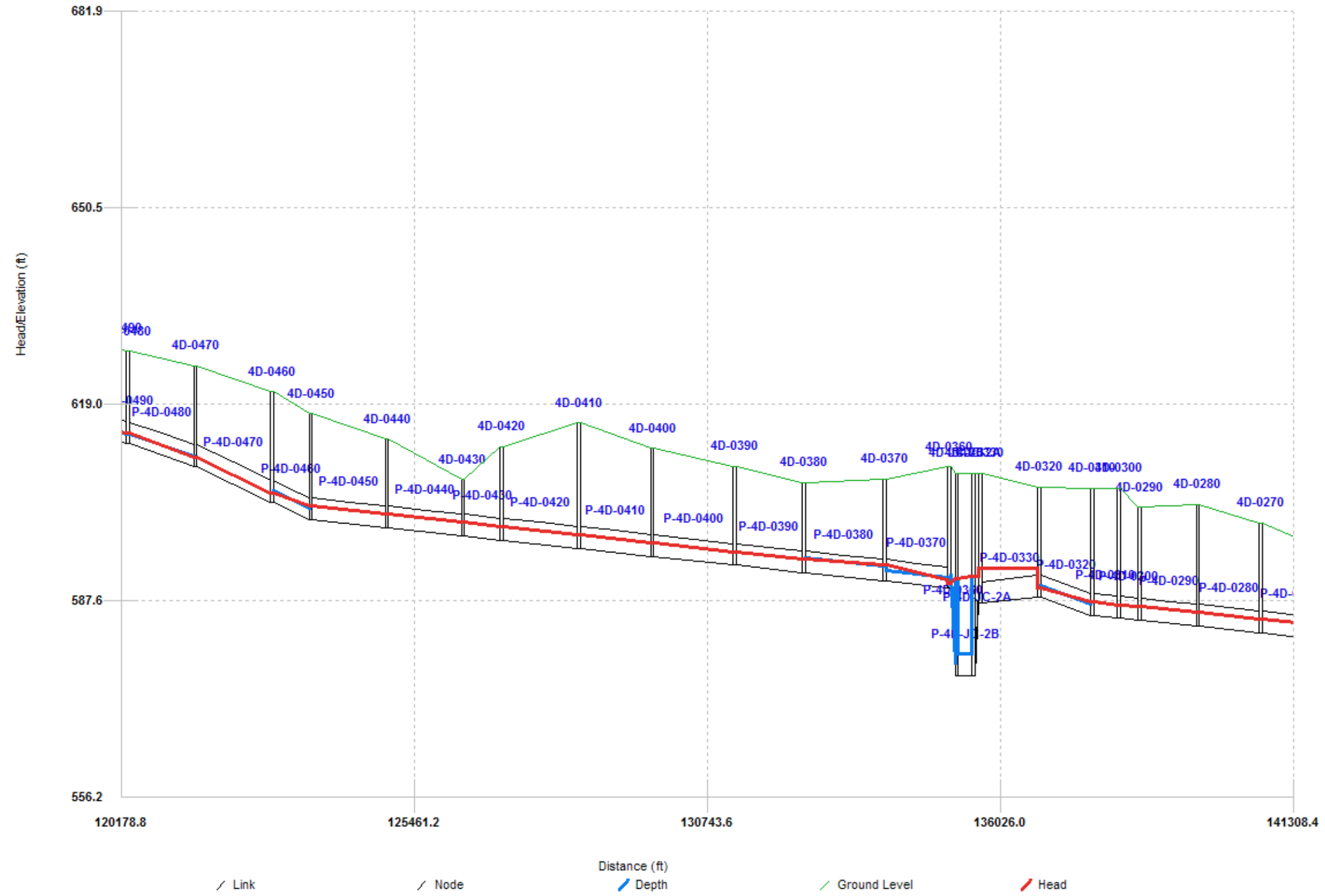


Reach IV-B 30 MGD Peaked + 3 MGD Critical Element Peak Flows



Reach IV-E 30 MGD Peaked + 3 MGD Critical Element Peak Flows





Section 6: Implications of Model Results

6.1 Identification of Critical Infrastructure in the Upper SARI Line

The flow profiles shown in Section 5 help identify the critical infrastructure in the Upper SARI system: the specific infrastructure that is being used at or close to capacity under the maximum-flow scenario. Inspection of the profiles helps us identify four distinct areas where capacity is of concern:

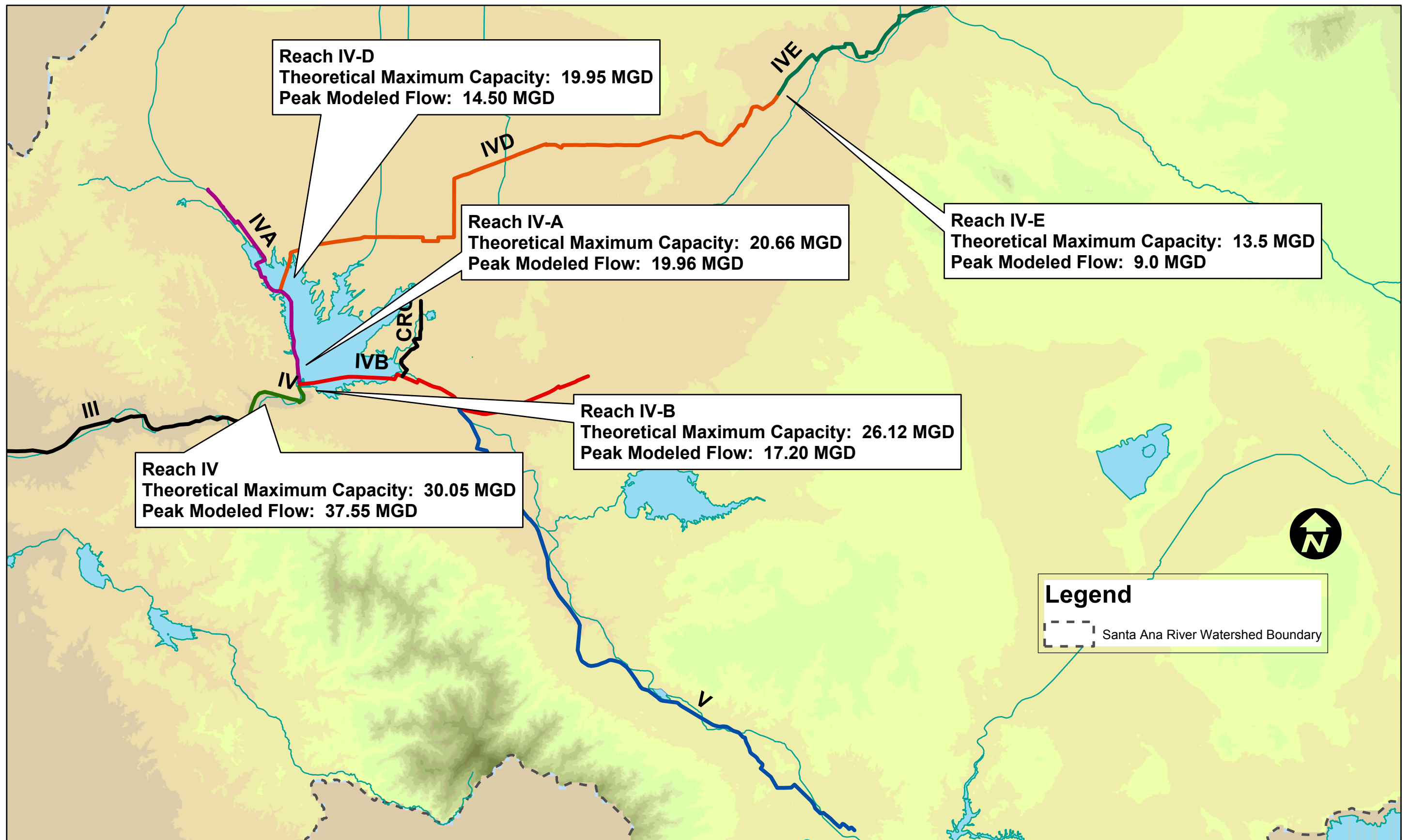
- Siphon over the La Sierra Channel at the upper end of Reach IV-B (IVB-0830 to IVB-079)
- Lower section of Reach IV-B as it enters Reach IV (IVB-0070 to IV-0180)
- Siphon section at the lower end of Reach IV-E (IVE-0110 to IVE-0010)
- Lower section of Reach IV-D
- Area of low slope at the lower end of Reach IV-A (IVA-0100)
- Upper end of Reach IV (IV-0130 to IV-0060)

These critical elements of infrastructure are summarized in Figure 14, which shows maximum modeled flow in comparison to maximum theoretical flow through the line at the critical areas in each reach. Maximum theoretical flow is defined as flow at full pipe subject to the modeling limitations discussed below.

6.2 Maximum Theoretical Flow and Limitations of Current Hydraulic Model

The maximum theoretical flow in the hydraulic model is limited by the following conditions:

- Horizontal and vertical curves in the Upper SARI system's pipelines are not captured in the model data, but these curves will affect hydraulic performance.
- Lateral lines jutting into a pipe are not represented.
- Hydrodynamic phenomena, such as air bubbles trapped due to poor blow-off valve performance, are not represented.



6.3 Discussion of Critical Infrastructure

The critical areas identified in the model and listed above were discussed with SAWPA staff. Through these discussions, possible methods of alleviating capacity constriction of critical infrastructure were developed, which can be categorized into the following types of solutions:

- Policy and management solutions (discussed in Section 7)
- Operation and maintenance solutions (discussed in Section 7)
- Establishment of firm operational criteria for capacity (discussed in Section 8)
- Possible capital improvements (discussed in Section 9)

Section 7: Policy and Management Solutions

7.1 Flow Peaking and Equalization

As an example of how Upper SARI system capacity can be quickly utilized or over-utilized, consider a scenario in which all major users have peak hourly flow rates of double the average daily flow rate. If these flows were to be added together in a short time period, the available average capacity would be reduced to approximately one-half the maximum theoretical capacity.

Because of the current excess in the Upper SARI system's capacity, the relationship of peak flow from a discharger to average flow is of little concern, but as the flow contributions to the SARI pipeline increase, this relationship will need to be considered.

To address the impact of discharges from users at peak levels on the pipeline capacity, SAWPA might construct detention basins between the user (whether industry or municipal) and the SARI. Where desalters can demonstrate only a slight difference between peak flow and average flow, detention basins may not be required. In these cases, small storage areas in the pipeline flow path, which include installation of a weir to control flow rate, are often used.

SAWPA might consider requiring placement of detention basins with outlet flow controls (weirs) for all new users. (This type of flow equalization is most effective when installed on private service laterals between the user and the SARI line.) The same requirement could be considered for existing users, as part of a discharge permit/agreement renewal. While requiring both may represent a challenge to SAWPA, the implementation of individual flow equalization for each discharger will make a significant difference.

The detention basins can be sized to discharge flow collected over an operating time-frame at a constant rate throughout the entire day. Basins also can be sized to discharge at the maximum allowable continuous rate noted in the agreement between SAWPA and industry or a municipal entity.

7.2 Flow Monitoring

If SAWPA implements flow controls on industrial users, it should also consider a continuous flow monitoring program. The benefits of flow monitoring on private laterals entering the SARI could be considerable. For example, improved data on discharge frequency and flow from dischargers could be obtained and used to refine the understanding of system capacity. The greater the understanding of discharges and their timing, the greater the confidence in developing a maximum operational flow in relation to the maximum theoretical flow of 38 mgd.

7.3 Partnering with Industrial and Municipal Users

Industrial users and municipal entities discharging non-desalter flows should be a particular focus, as they exhibit the greatest variability in flow rate. SAWPA may be able to identify opportunities for industry to operate swing and/or graveyard shifts, or to store flow and discharge it during daily low flow periods. Rate structures to encourage the off-peak discharge could be considered.

7.4 Modifying Existing Agreements at Renewal

It has been indicated by SAWPA staff that a number of existing agreements allow peaking factors of 1.5 times the average flow rate. SAWPA could develop a policy to encourage the removal of peaking factors at the renewal of discharge permits/agreements. Additionally, SAWPA could work to help shift discharges to off-peak periods.

7.5 Infiltration/Inflow Forecasting

The flow model just completed for the Upper SARI system includes a reservation of 5 percent of the total average projected flow of 30 mgd, or 1.50 mgd, for flows entering the system from I&I, which, in the SAWPA service area, results from high groundwater and surface runoff in the Prado basin. It is of concern that the 5 percent estimation of flow is likely too low for a 73-mile-long interceptor along with private service laterals, industrial sites, and municipal sewer collection systems. Further, as the piping system ages, inflow will increase.

More accurate forecasting is important to predict the reduction in available capacity from I&I within the Upper SARI system. An in-depth approach to forecasting I&I contributions should be developed as capacity for the future is being allocated.

Inflow is defined as water entering the piping system from surface-water sources, including parking lots, roofs, foundation drains, catch basins, and holes in pipe open to the surface. Infiltration is the movement of water from saturated soil through cracks and leaky joints in the pipe.

For the SAWPA service area, a very preliminary discussion with SAWPA staff of I&I indicates that water contributions from infiltration are currently limited because the groundwater table is below the elevation of the pipe in most locations. A notable exception is the areas located in Reaches IV, IV-A, and IV-B behind the Prado Dam. Since this dam is used for flood control, completely saturated soil above the pipe, with a varying amount of head due to changing water depth, should be expected.

Other locations of potential infiltration could exist in low-lying areas through which private laterals run and within municipal sewer collection systems traversing wet areas (e.g., JCSD).

Inflow is known to provide some contribution of flow to the upper SARI system during and immediately after rainfall events. This can be verified by comparing the near-term flow rates at the metering stations with longer-interval “before and after” flows from the same meter. It is currently unknown what range of percentage of increase is actually being experienced.

7.6 Overflows

Within the SAWPA basin today, concern about overflows of the Upper SARI system is minimal. This is due in large part to the relative newness of the system. The other contributing factor is the low current ratio of flow to capacity. SAWPA, however should prepare for the eventuality of an emergency overflow condition.

As the flows entering the SARI increase and the piping system ages, the system will be less able to absorb and attenuate high peak flows. Normally, operating a gravity piping system in a

full pipe-flow configuration with an expectation of no overflows or bypasses is difficult as the system ages and flow reaches peak levels.

A number of clients faced with increasing age and flow in a gravity system prepare for the eventuality of an emergency overflow condition by establishing where an overflow will occur in each topographic reach of piping. Other utilities have prevented overflows by developing bypass locations to other piping systems located in the area. The RIX system is an example of a piping system in the basin that could be used as a bypass. There is a concrete box where both the SARI and RIX pipeline lie in parallel. An overflow pathway could be created to the RIX line at this location. Other opportunities for bypass facilities may also exist where wastewater outfalls cross the SARI pipeline and right-of-way. When bypass locations are developed, an event counter is typically installed and a method of estimating the duration of bypass and level of flow is established.

Planning for the eventuality of an emergency overflow in a particular reach of piping could include a piped transport of high flow from the SARI to an area of least impact, where the overflow can be accommodated. One option to consider is to develop a piping system from the overflow point to a lined detention basin off site. If an overflow occurs, an alarm sounds and operations and maintenance staff are summoned to the overflow to determine the issue and implement a timely repair. The captured flows are reintroduced to the SARI system at a controlled rate once the overflow condition is satisfied. In this case, an overflow never reaches beyond the facilities of the utility. In planning, SAWPA may wish to consider development of a system of bypasses and overflow points to detention basins that could be acceptable and may want to develop a capital improvement plan (CIP) to implement them over time. Developing a backup system of bypasses and off-line detention basins greatly reduces the potential for a high-profile overflow, with its substantial expense and heightened public awareness. Developing the agreements for bypass to area pipelines and acquiring land for off-line detention facilities is usually easier in the earlier stages of the basin's development.

7.7 Regulatory Interaction

As the Upper SARI system increases its flow, healthy interaction between SAWPA and the Regional Board should continue. This relationship can help develop a common level of understanding of the constraints and concerns of each body. When such a relationship has

been maintained in other locations, each agency has been able to move toward increasingly common ground.

A sound relationship between SAWPA and the Regional Board is particularly helpful should the unexpected happen. If it does, and it involves a possible regulatory violation, the first response from regulators usually is more positive in the case of existing cordial communications.

One of the ways to continue fostering a strong relationship with the Regional Board is to invite its representatives to periodic site visits. For example, the Prado Dam project, currently nearing completion, will change the head of water above the pipeline and that area of the SARI system that will be under water in the winter months. The Dam reconstruction requires a relocation of piping through the dam and immediately downstream in an area along the contractor's temporary bypass channel. Increased opportunity for infiltration behind the dam during the construction and initial startup phase exists. Developing an expectation by the Regional Board of the challenges faced in the raising of the Dam crest could be positive, especially should an unexpected event affecting the SARI occur during startup.

7.8 Loss of Staff institutional Knowledge

During our recent work with the Management, Engineering and Maintenance staff of SAWPA, Kennedy/Jenks came to understand that a substantial amount of knowledge is maintained by the SAWPA staff. As time passes, staff will retire, and with them will go a wealth of knowledge about the physical properties, operational characteristics, and users of the SARI system. It is recommended that SAWPA begin to develop additions to its database to capture the institutional knowledge of its long-term and valued staff.

7.9 Funding for the Future

SAWPA should consider the creation of a capital improvement plan (CIP) and development of funding for the future.

The reasons for identifying funding methods and sources are many. The SARI system is extensive in its geographic coverage. The expansive nature of the area that could be served suggests that capacity beyond the firm fixed capacity of the existing pipeline may be needed. Often a CIP is developed to create new capacity for the future.

Additional funding may be required to upgrade the levels and location of treatment and discharge. Further, funding may be needed for improvements intended to increase the reliability of the SARI to carry peak flows without overflow beyond the SARI system as it develops in the future.

Capital for new improvements can be gained by a number of funding vehicles, including connection fees, use fees, system development charges, and state and federal grants, including earmarking of funding at the national level.

7.10 Operations and Maintenance

Changes in the Upper SARI system operations and maintenance (O&M) will be driven by at least three factors: 1) implementation of new policies and management systems enacted by the Board, 2) the need to meet increasingly stringent regulatory requirements, and 3) increased maintenance activities as flow increases toward the allowable pipeline capacity. These changes will be enacted by O&M staff in response to requests from management and in reaction to encountering changing conditions in the piping system that require increased maintenance and oversight to prevent problems, especially overflows.

O&M should be considered to include the cataloging, in permanent form, of unwritten knowledge held in the minds of District staff.

Section 8: Establishing a Maximum Operating Capacity Within the Upper SARI Line

8.1 General Approach to Establishing Maximum Operating Capacity

For any piping system, a maximum hydraulic capacity can be established by modeling that is normally considered to be its theoretical or ideal capacity. The actual pipeline capacity often is less than the ideal capacity, because of unknowns inherent in the actual construction of the pipeline. Factors that could reduce the capacity of the piping system include high spots in vertical alignment from poor installation of the pipeline. Where this occurs, a series of high pockets that retain air is developed. Air pockets in full-flowing pipelines tend to reduce capacity. Other construction issues that can reduce ideal capacity include laterals that protrude into the pipeline, pipelines installed at flatter grade than designed, entrance losses at manholes from incoming flow at laterals, pipe with greater roughness than shown on the plans (concrete vs. PVC lined), and sanding-in of gently sloping pipelines. Sanding-in of pipelines occurs in areas where sandy soil migrates into the piping systems or in beach communities where it enters the domestic sewer system from clothes washing and bathing.

In addition to the physical factors of the pipeline construction that can limit the capacity, the maximum operating capacity for approved users can be reduced. The calculated reductions should include at least an estimate of the contribution of flow during wet weather from I&I, a reduction for the flow increase due to peaking of discharges, and a reduction that provides an appropriate safety factor to help insure that overflows do not occur.

The decision to establish a maximum operating capacity is a combination of the science of flow estimation and the art of evaluating risk. One method of establishing the maximum operating capacity (or maximum allowable flow) in the SARI is for the Board to determine an acceptable balance of maximum flow and risk of overflow.

Methods to raise the maximum allowable flow while maintaining an acceptable factor of safety include developing bypasses and off-site detention facilities for overflow protection.

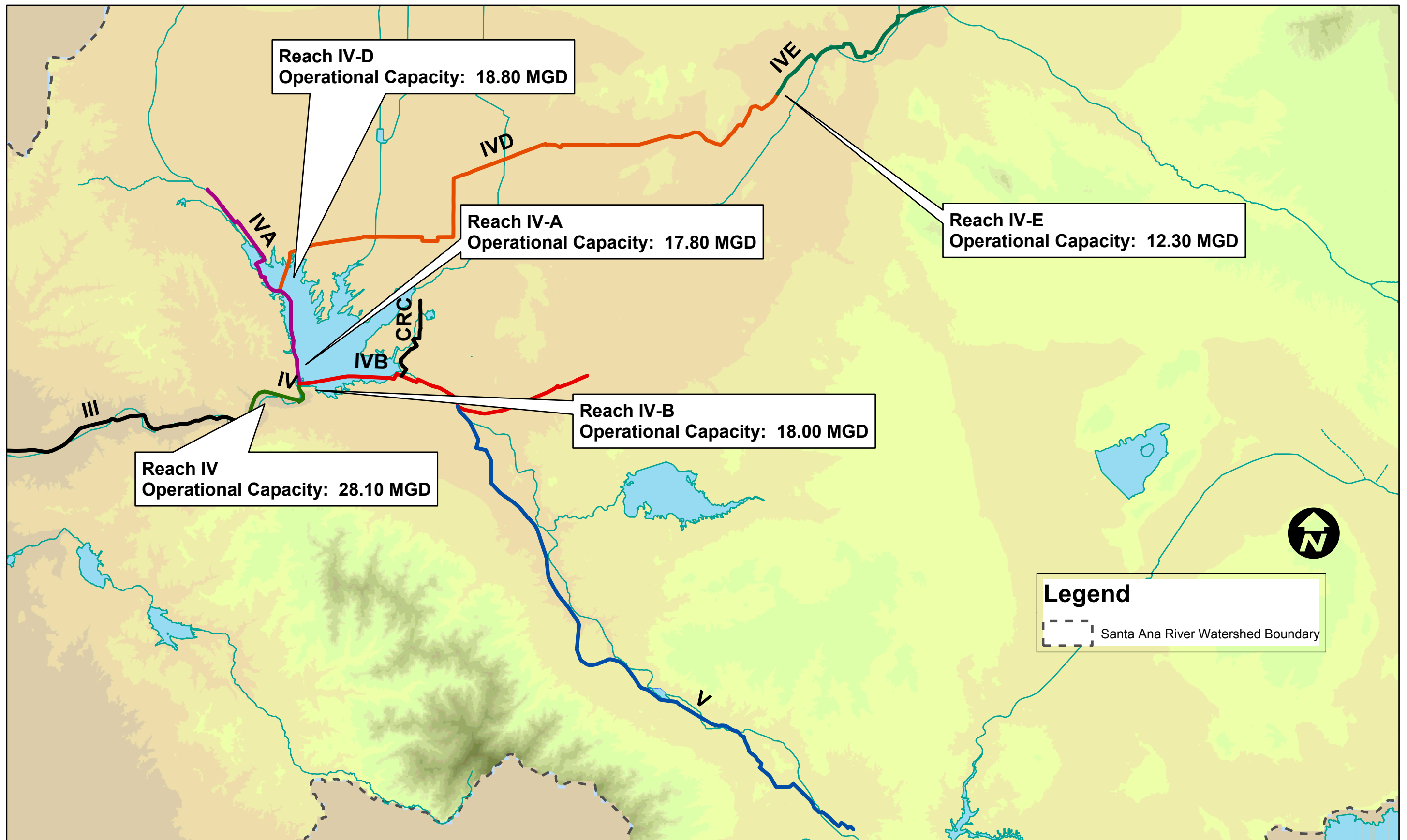
8.2 Determination of Maximum Operating Flow Criteria

Development of the maximum operating flow in any system requires establishment of system criteria that can be applied to all of the elements in that system. Commonly, these criteria are based upon a maximum depth, flow rate, or velocity to be allowed in the system.

In pressurized flow systems, maximum amounts of head loss are also used as operational criteria.

Typical open-channel flow system operational criteria are based upon depth-to-diameter (d/D) ratios. Criteria of d/D ratios can be consistently applied across a system of varying diameter. Maximum flow in an open circular conduit occurs at $d/D = 0.82$. A typical operational maximum for wastewater systems is $d/D = 0.75$. This value is often seen as an acceptable balance between maximizing the capacity used in infrastructure and reserving some capacity for flow contingencies.

After discussion with SAWPA staff, Kennedy/Jenks chose a value of $d/D = 0.75$ as the operational criteria for the Upper SARI system. Using this criterion, the hydraulic model was run to determine flow values in the various reaches. Figure 13 displays the values developed in the hydraulic model. This analysis is not applicable to Reach V, as it is designed for pressure flow.



Section 9: Capital Improvement Projects

9.1 High-Flow Impact on the SARI Piping System

A program of manhole inspection in areas where future surcharging is expected to occur is recommended. This inspection could be performed as a portion of the annual O&M program.

The need for the manhole inspection program is driven by the fact that, as discussed above, the theoretical capacity of the Upper SARI system has been estimated by modeling to approach maximum theoretical capacity. To come close to this level of flow requires operation at full or near-full pipe flow in most reaches of the alignment. Where steeply sloping pipeline alignments exist, the depth of flow is reduced. Because the depth of flow is lower, the resulting velocity is necessarily higher to transport the same volume of water. In reaches of the pipeline where the topography is gently sloping or flat, the flow backs up into the manhole barrels in a surcharge condition.

These areas were examined to determine if the added level of surcharging of manholes could create a chance of an overflow as the allowable capacity of the pipe is approached. A number of manholes were identified with rim (ground surface elevation) elevations below the hydraulic grade line (expected water surface).

SAWPA staff was queried about these locations, and staff members indicated that the manholes are already constructed in a pressure-rated watertight configuration. This configuration tends to consist of a manhole with the SARI pipeline running continuously through it. At the approximate center of the manhole, a vertical standing tee with a flanged outlet has been installed in the pipeline. A blind flange has been bolted to the flanged outlet to make a watertight connection. Access to the pipeline can be obtained only by removing the blind flange. The only purpose of the manhole in this location is to provide an access point to the vertical tee and blind flange assembly.

Manholes have been identified where the surcharge conditions in the pipeline will cause flow to back up vertically into the open barrels of manholes to a height of a few feet or more. Most of

the manholes that will be surcharged were installed with a PVC or similar lining system to prevent corrosion. It is expected that the manholes were water tested at the time of installation; however, this is not certain.

Since the nature of the waste is considered to be industrial and hazardous, the release of effluent through joints between the manhole barrel and the base and between manhole rings should be prevented.

Effluent surcharging in the manholes that are not configured to be internally pressure-tight should not be allowed to rise to the level above which cast-in-place or manhole barrel construction ends. Between this location and the manhole lid and casting, pre-cast grade rings are typically used to match the top of the manhole with the ground surface. Seldom are these grade rings installed to prevent infiltration or exfiltration as the pipeline ages. Problems with the cement grout seal used to connect one to the other typically allow them to leak. It is not unusual to see up to 3 feet of grade rings stacked vertically on top of precast or cast-in-place manhole barrels in many systems.

During annual general maintenance activities a log book of manhole problems could be developed, which would include the depth of grade rings and other areas of potential concern.

It should also be noted that a number of manholes have been constructed to prevent outside flow from entering the SARI system during rainfall or flood conditions. The most notable of these manholes exist above the Prado Dam, which is currently being raised. These manholes are at the branch of Reaches IV and IV-B and include manholes upstream on each reach. Because the manholes are in the main portion of the water pool behind the dam, they will be exposed to substantial head and the potential for leakage. The same condition exists in the pipelines that traverse the area underneath the pool. The head on the external joints between the pipe barrels will be significantly greater than has been applied previously. During filling of the dam, monitoring of outflows from the SARI pipeline to insure that they stay at normal levels may be appropriate.

It should also be noted that a siphon over the La Sierra Drainage canal in the upper area of Reach IV-B will restrict the future allowable flow contribution above this location. Maintenance and engineering personnel indicate that this area carries the flow of a single desalter facility

(Arlington Desalter) and that the SARI would be improved only in response to siting of a new discharger upstream of this location. Accordingly, there has been no development of a plan and an associated cost estimate to remedy this area of flow restriction.

9.2 Recommended Capital Improvements to Undertake Now

The work discussed in this report indicates that there are no specific added improvements be undertaken currently to increase the capacity of the SARI pipeline. Areas that were identified as being susceptible to overflow as a peak flow rate is approached are already being modified (Prado Dam impoundment and immediate downstream reach) or have internal pressure-rated watertight manholes in existence. The siphon in the upper part of Reach IV-B will not require capacity-increasing improvements until an additional user is sited above the area of restriction.

We suggest that a series of steps be taken as a part of the annual O&M program to identify and replace corroded or defective valves (principally air and vacuum relief valves). We also suggest a comprehensive inspection of manhole integrity and watertightness, especially in areas where surcharging is likely. A database of issues to correct should be developed, followed by a plan of maintenance to undertake the repairs.

9.3 Recommended Capital Improvements to Consider for the Future

When the flow rate of 30 mgd is approached in the Upper SARI system, the ability of the piping network to store flows from peaking discharges, and to attenuate these flows over the long run of piping, will be effectively removed. The factor of safety available today within the piping system to prevent overflows will be lost.

It is seldom recommended that a pipeline be operated while approaching its maximum capacity with an absolute expectation that overflows from the system will never occur. The operating histories of other gravity systems operated at or above full pipe capacity, and with overflow points at low-lying manholes similar to the SARI system, indicates that SAWPA should consider the potential for overflow.

Appendix A: Scope of Work

Task 1 – Build and Load Model

A hydraulic model comprises two basic sets of data: the physical system to be modeled (gravity pipes, force mains, outfalls, pumps, manholes, etc) and the flows to be modeled. Task 1 encompasses the steps necessary to accurately build the physical model and to load the correct flows at the correct places in the system. The following subtasks are part of this task:

Subtask 1.1 Build Physical Schematic

The SARI line physical data currently exists in excel spreadsheet format, broken down by reach and contract. Each pipe listed in the spreadsheet will be drawn in AutoCAD format to the length specified by the spreadsheet. The pipes will be connected as indicated by the data. The pipes will be drawn so that each reach is identifiable, but the pipes will not be truly spatially referenced. Points will be drawn at the intersection of the lines to represent manholes. The points will be labeled with unique identifiers according to the convention specified by SAWPA. When all pipes and manholes have been thus digitized, they will be imported into the model as separate layers. Physical connectivity will be established so that each pipe becomes linked with its upstream and downstream manholes. At this point, attribute data will be imported from the spreadsheet using the unique identifier to populate the model. Pipes will be populated with upstream and downstream invert elevations, slope, diameter, and material attributes. Manholes will be populated with manhole diameter and rim elevation information. Manhole sump elevation will be calculated from the lowest invert in the manhole according to a convention established by SAWPA.

Subtask 1.2 Verify Physical Schematic

The physical connectivity and attribute data will be verified to the extent allowed by the data. Test flows will be placed at the upstream end of each reach so that the hydraulic grade line (HGL) can be tracked and examined for inconsistencies that would indicate inaccurate data. Critical flow areas will be identified and the data for these areas will be checked according to record drawings for accuracy. Manholes that serve to tie multiple reaches together will receive particular attention because of their importance to the hydraulics. Inconsistent data that cannot be reconciled will be referred to SAWPA.

Subtask 1.3 Identify, Calculate, and Attach Flow Loads

In order to be a useful tool in the assessment of the capacity of the SARI system, the model must be able to represent both average and peak flow conditions within the system. To this end, a list of dischargers to the SARI system will be established. The list will include the unique identifier of the manhole to which the discharger's flows enter the system. For each discharger, the last 12 months of available data will be plotted. By examining the patterns in these flows, K/J will develop an Existing Average Day (EAD) flow for each discharger. For those dischargers for whom "strip" data showing diurnal patterns is available, an Existing Peak Day (EPD) flow will be developed. These loads will be attached to the correct model manhole using a table import and the unique identifiers of the model manholes.

Subtask 1.4 Verify Loads

The list of dischargers and discharge location will be provided to SAWPA for review. Model output at the downstream end of the SARI system will be checked versus historical field flows to verify that the model flows are reasonable and “in the ballpark” for pre-calibrated values.

Task 1 Deliverable

A plan view model schematic annotated with reach information, discharger location, uncalibrated flow at junctions, and uncalibrated flow through key areas of the system will be delivered. Profiles of key system areas will be delivered as well.

Task 2 – Calibrate Model

Calibration is the process by which modeled flows through the system are compared with known field values to verify that the model accurately represents field conditions. Calibration includes the following subtasks:

Subtask 2.1 Identify Calibration Points

By definition, calibration points must be chosen to correspond to areas of known flow in the system. SAWPA is currently collecting flow data at several points within the system. KJ will work with SAWPA to identify the unique identifiers of the manholes currently being monitored. These manholes will be calibration points. The outlet of the upper SARI system into the lower SARI system is monitored and will be a calibration point as well. Any other points of known flow will be identified and located according manhole to serve as calibration points.

Subtask 2.2 Develop Calibration Field Values

Once the calibration points throughout the system are known, flow data will be collected for each of the points. Because the model will be run for EAD and EPD flows, values representative of these conditions must be calculated at each point. In order to accomplish this, time series flows at each calibration point will be plotted. Typical days will be identified and values for these days will be averaged to develop EAD field flows. Peak daily values will be identified from the plots and will be developed into EPD field flows.

Subtask 2.3 Compare Model and Field Values

Tables will be developed showing each calibration point, the EAD and EPD field values, and the modeled values for these flows. The field and modeled values will also be shown on the schematic for spatial comparison. Percent difference values will be calculated at each calibration point.

Subtask 2.4 Assess Flows, Peaks, and I&I for Calibration

For those calibration points at which modeled and field flows differ significantly, possible relevant discharges upstream will be re-evaluated to determine possible reasons for the modeled and field flows not matching. For those dischargers that did not initially have diurnal data available, diurnal patterns may be assumed in order to calibrate EPF flows. Inflow and infiltration (I&I) will be investigated for those areas that consistently show modeled flows beneath field flows.

Task 2 Deliverable

The model schematic will be delivered showing calibration points, field values, and model values. A supplementary table will be delivered with the schematic detailing all assumptions and calibration adjustments made to discharges, peaks, and I&I in order to create a calibrated model.

Task 3 – Create and Run Model Scenarios

Model scenarios are the means by which we organize the future discharges and infrastructure changes whose effects we want to test on the calibrated model. The task of creating and running the model scenarios is composed of the following subtasks:

Subtask 3.1 Identify and Create Required Model Scenarios

In collaboration with SAWPA staff, K/J and SAWPA will identify scenarios to be modeled. This scope of work assumes that the number of modeled scenarios will be less than seven.

Subtask 3.2 Run Scenarios

Once the scenarios have been input in the model, each scenario will be run separately. Preliminary analysis of the results will be done after each model run to ensure that model behavior is as expected.

Subtask 3.3 Extract and Present Scenario Results

Results from each scenario will be extracted from the model and placed in tools such as spreadsheets and GIS shapefiles so that the results can be presented in easily understood visual format. Results will be displayed in the plan view schematic and in hydraulic profiles of key results.

Task 3 Deliverable

A table will be delivered detailing the composition and significance of each scenario. Schematics and profiles of key results will be delivered for SAWPA review.

Task 4 – CIP Development

The ultimate goal of this project is the development of a capital improvement program that recommends facilities to meet the ultimate projected flows of the SARI system. The hydraulic model scenarios run above will be used as tools in the development of the CIP. The following subtasks will be required:

Subtask 4.1 Identify Critical Infrastructure

The model results will be used in conjunction with discussion with SAWPA staff in order to determine the critical infrastructure in the SAWPA system. Critical infrastructure includes those entities that are existing capacity chokepoints.

Subtask 4.2 Assess Critical Infrastructure

Working in collaboration with SAWPA staff, K/J will evaluate existing SARI facilities to identify additional improvements required to support project wastewater flows within the SARI system. This effort will be performed with SAWPA staff through two (2) eight hour meetings held at SAWPA's offices.

Subtask 4.3 Develop CIP Based Upon Assessment

Where hydraulic deficiencies are found based upon the results of Task 3, capital improvements will be identified to alleviate the deficiencies. Alternative improvements will be delineated where available, and the focus will be on improvements that are integrated across the entire system. Capital costs will be identified for each proposed improvement. Recommended improvements will be remodeled, if relevant, to verify that they have the desired effect.

Task 4 Deliverable

A technical memorandum will be delivered listing the proposed capital improvements in tabular form, with description of each improvement. Schematics will be attached showing locations of improvements and their relationships to the overall system.

Task 5 – Project Communication

As discussed in the schedule section below, the deadlines required by this project require a very aggressive schedule. Tasks 1-4 will have to be completed under best case scenarios if the deadlines are to be met. To facilitate this schedule, project communication and cooperation between K/J and SAWPA will be of utmost importance. Project communication will consist of weekly conference calls or meetings between the project teams, as laid out in the schedule. In addition project communication will consist of K/J support for meetings and presentations so that the results of all of the above efforts can be communicated to decision makers.

Appendix B: Reach V Steady State Model Tables

Table 1 : Model Input Data

| Pipe ID | Revised Downstream Station | From Invert (ft) | To Invert (ft) | Revised Length (ft) | Material | Diameter (in) | Comments |
|---------|----------------------------|------------------|----------------|---------------------|----------|---------------|--------------------|
| 1 | 66.1 | 602.33 | 598.50 | 66.1 | HDPE | 26 | |
| 2 | 558.1 | 603.32 | 602.33 | 492 | HDPE | 26 | Gate per Lee Slate |
| 3 | 891.1 | 609.00 | 603.32 | 333 | HDPE | 26 | |
| 4 | 1097.1 | 609.50 | 609.00 | 206 | HDPE | 26 | |
| 5 | 2097.1 | 614.40 | 609.50 | 1000 | HDPE | 26 | |
| 6 | 2597.1 | 616.40 | 614.40 | 500 | HDPE | 26 | |
| 7 | 2897.1 | 618.00 | 616.40 | 300 | HDPE | 26 | |
| 8 | 3162.1 | 620.40 | 618.00 | 265 | HDPE | 26 | |
| 9 | 3475.1 | 611.36 | 620.40 | 313 | HDPE | 26 | |
| 10 | 3544.1 | 621.90 | 611.36 | 69 | HDPE | 26 | |
| 11 | 4067.1 | 621.90 | 621.90 | 523 | HDPE | 26 | |
| 12 | 4332.1 | 625.20 | 621.90 | 265 | HDPE | 26 | |
| 13 | 4870.1 | 626.78 | 625.20 | 538 | HDPE | 26 | |
| 14 | 5797.1 | 628.73 | 626.78 | 927 | HDPE | 26 | |
| 15 | 6137.1 | 633.90 | 628.73 | 340 | HDPE | 26 | |
| 16 | 6651.1 | 651.48 | 633.90 | 514 | HDPE | 26 | |
| 17 | 7047.1 | 672.93 | 651.48 | 396 | HDPE | 26 | |
| 328 | 7161.1 | 674.05 | 672.93 | 114 | HDPE | 26 | |
| 18 | 7177.1 | 697.04 | 674.05 | 16 | PVC | 24 | |
| 19 | 7516.1 | 705.10 | 697.04 | 339 | PVC | 24 | |
| 20 | 7817.46 | 714.41 | 705.10 | 301.36 | PVC | 24 | |
| 21 | 7997.1 | 732.50 | 714.41 | 179.64 | PVC | 24 | |
| 22 | 8722.1 | 728.00 | 732.50 | 725 | PVC | 24 | |
| 23 | 8744.59 | 727.20 | 728.00 | 22.49 | PVC | 24 | |
| 24 | 9149.1 | 719.00 | 727.20 | 404.51 | PVC | 24 | |
| 25 | 9687.1 | 708.43 | 719.00 | 538 | PVC | 24 | |
| 26 | 9927.1 | 708.10 | 708.43 | 240 | PVC | 24 | |
| 27 | 10147.1 | 713.99 | 708.10 | 220 | PVC | 24 | |
| 28 | 10507.1 | 715.85 | 713.99 | 360 | PVC | 24 | |
| 29 | 10797.1 | 718.63 | 715.85 | 290 | PVC | 24 | |
| 30 | 11022.1 | 742.25 | 718.63 | 225 | PVC | 24 | |
| 31 | 11427.1 | 745.91 | 742.25 | 405 | PVC | 24 | |
| 32 | 11582.1 | 746.27 | 745.91 | 155 | PVC | 24 | |
| 33 | 11762.1 | 748.63 | 746.27 | 180 | PVC | 24 | |
| 34 | 11902.1 | 749.43 | 748.63 | 140 | PVC | 24 | |
| 35 | 12162.1 | 756.45 | 749.43 | 260 | PVC | 24 | |
| 36 | 12412.1 | 758.56 | 756.45 | 250 | PVC | 24 | |
| 37 | 12667.1 | 765.51 | 758.56 | 255 | PVC | 24 | |
| 38 | 12827.1 | 786.54 | 765.51 | 160 | PVC | 24 | |
| 39 | 13587.1 | 792.00 | 786.54 | 760 | PVC | 24 | |
| 40 | 13687.1 | 792.40 | 792.00 | 100 | PVC | 24 | |
| 41 | 13747.1 | 791.00 | 792.40 | 60 | PVC | 24 | |
| 42 | 13787.1 | 817.00 | 791.00 | 40 | PVC | 24 | |
| 43 | 14587.1 | 818.48 | 817.00 | 800 | PVC | 24 | |
| 44 | 14707.1 | 832.91 | 818.48 | 120 | PVC | 24 | |
| 45 | 15097.1 | 848.00 | 832.91 | 390 | PVC | 24 | |
| 46 | 15697.1 | 850.20 | 848.00 | 600 | PVC | 24 | |
| 47 | 15867.1 | 862.49 | 850.20 | 170 | PVC | 24 | |
| 48 | 16097.1 | 882.20 | 862.49 | 230 | PVC | 24 | |
| 49 | 16657.1 | 882.39 | 882.20 | 560 | PVC | 24 | |
| 50 | 16717.1 | 891.06 | 882.39 | 60 | PVC | 24 | |
| 51 | 16847.1 | 894.89 | 891.06 | 130 | PVC | 24 | |
| 52 | 17297.1 | 897.30 | 894.89 | 450 | PVC | 30 | |
| 53 | 18047.1 | 900.00 | 897.30 | 750 | PVC | 30 | |
| 54 | 18162.1 | 900.07 | 900.00 | 115 | PVC | 30 | |
| 55 | 18232.1 | 896.00 | 900.07 | 70 | PVC | 30 | |
| 56 | 18347.1 | 900.28 | 896.00 | 115 | PVC | 30 | |
| 57 | 18597.1 | 898.50 | 900.28 | 250 | PVC | 30 | |
| 58 | 18707.1 | 900.57 | 898.50 | 110 | PVC | 30 | |
| 59 | 18907.1 | 900.84 | 900.57 | 200 | PVC | 30 | |
| 60 | 19152.1 | 890.40 | 900.84 | 245 | PVC | 30 | |
| 61 | 19397.1 | 889.89 | 890.40 | 245 | PVC | 30 | |
| 62 | 19862.1 | 886.99 | 889.89 | 465 | PVC | 30 | |
| 63 | 19997.1 | 885.31 | 886.99 | 135 | PVC | 30 | |
| 64 | 20237.1 | 868.50 | 885.31 | 240 | PVC | 30 | |
| 65 | 20797.1 | 866.98 | 868.50 | 560 | PVC | 30 | |
| 66 | 21197.1 | 865.09 | 866.98 | 400 | PVC | 30 | |
| 67 | 21497.1 | 862.24 | 865.09 | 300 | PVC | 30 | |
| 68 | 21667.1 | 854.90 | 862.24 | 170 | PVC | 30 | |

Table 1 : Model Input Data

| Pipe ID | Revised Downstream Station | From Invert (ft) | To Invert (ft) | Revised Length (ft) | Material | Diameter (in) | Comments |
|---------|----------------------------|------------------|----------------|---------------------|----------|---------------|----------|
| 69 | 21717.1 | 854.57 | 854.90 | 50 | PVC | 30 | |
| 70 | 22017.1 | 853.57 | 854.57 | 300 | PVC | 30 | |
| 71 | 22097.1 | 849.20 | 853.57 | 80 | PVC | 30 | |
| 72 | 22161.85 | 848.01 | 849.20 | 64.75 | PVC | 30 | |
| 73 | 22682.1 | 856.99 | 848.01 | 520.25 | PVC | 30 | |
| 74 | 23117.1 | 858.38 | 856.99 | 435 | PVC | 30 | |
| 75 | 23527.1 | 852.83 | 858.38 | 410 | PVC | 30 | |
| 76 | 23627.1 | 847.88 | 852.83 | 100 | PVC | 30 | |
| 77 | 23938.33 | 838.90 | 847.88 | 311.23 | PVC | 30 | |
| 78 | 24472.1 | 836.22 | 838.90 | 533.77 | PVC | 30 | |
| 79 | 24597.1 | 829.50 | 836.22 | 125 | PVC | 30 | |
| 80 | 24661.78 | 828.96 | 829.50 | 64.68 | PVC | 30 | |
| 81 | 25197.1 | 825.00 | 828.96 | 535.32 | PVC | 30 | |
| 82 | 25482.1 | 822.64 | 825.00 | 285 | PVC | 30 | |
| 83 | 25671.1 | 816.00 | 822.64 | 189 | PVC | 30 | |
| 84 | 25697.1 | 816.20 | 816.00 | 26 | PVC | 30 | |
| 85 | 25727.1 | 822.00 | 816.20 | 30 | PVC | 30 | |
| 86 | 25757.1 | 822.03 | 822.00 | 30 | PVC | 30 | |
| 87 | 25797.1 | 823.25 | 822.03 | 40 | PVC | 30 | |
| 88 | 25839.16 | 816.98 | 823.25 | 42.06 | PVC | 24 | |
| 89 | 25894.16 | 821.70 | 816.98 | 55 | PVC | 24 | |
| 90 | 25934.16 | 821.40 | 821.70 | 40 | PVC | 24 | |
| 91 | 26042.16 | 804.60 | 821.40 | 108 | PVC | 24 | |
| 92 | 26304.16 | 801.40 | 804.60 | 262 | PVC | 24 | |
| 93 | 26534.16 | 794.60 | 801.40 | 230 | PVC | 24 | |
| 94 | 26889.16 | 790.50 | 794.60 | 355 | PVC | 24 | |
| 95 | 27204.16 | 791.00 | 790.50 | 315 | PVC | 24 | |
| 96 | 27299.16 | 799.30 | 791.00 | 95 | PVC | 24 | |
| 97 | 27584.16 | 798.20 | 799.30 | 285 | PVC | 24 | |
| 98 | 27834.16 | 790.00 | 798.20 | 250 | PVC | 24 | |
| 99 | 27934.16 | 791.00 | 790.00 | 100 | PVC | 24 | |
| 100 | 28034.16 | 799.80 | 791.00 | 100 | PVC | 24 | |
| 101 | 28170.16 | 801.71 | 799.80 | 136 | PVC | 24 | |
| 102 | 28934.16 | 796.00 | 801.71 | 764 | PVC | 24 | |
| 103 | 29004.16 | 796.50 | 796.00 | 70 | PVC | 24 | |
| 104 | 29054.16 | 802.10 | 796.50 | 50 | PVC | 24 | |
| 105 | 29094.16 | 802.90 | 802.10 | 40 | PVC | 24 | |
| 106 | 29414.16 | 805.00 | 802.90 | 320 | PVC | 24 | |
| 107 | 29964.16 | 809.00 | 805.00 | 550 | PVC | 24 | |
| 108 | 30154.16 | 810.40 | 809.00 | 190 | PVC | 24 | |
| 109 | 30284.16 | 813.60 | 810.40 | 130 | PVC | 24 | |
| 110 | 30384.16 | 823.50 | 813.60 | 100 | PVC | 24 | |
| 111 | 30963.16 | 845.70 | 823.50 | 579 | PVC | 24 | |
| 112 | 31854.16 | 857.90 | 845.70 | 891 | PVC | 24 | |
| 113 | 32204.16 | 857.00 | 857.90 | 350 | PVC | 24 | |
| 114 | 32318.16 | 844.00 | 857.00 | 114 | PVC | 24 | |
| 115 | 32395.16 | 843.00 | 844.00 | 77 | PVC | 24 | |
| 116 | 32458.16 | 853.80 | 843.00 | 63 | PVC | 24 | |
| 117 | 32549.16 | 861.40 | 853.80 | 91 | PVC | 24 | |
| 118 | 32728.16 | 857.70 | 861.40 | 179 | PVC | 24 | |
| 119 | 33008.16 | 858.85 | 857.70 | 280 | PVC | 24 | |
| 120 | 33584.16 | 853.00 | 858.85 | 576 | PVC | 24 | |
| 121 | 33634.16 | 853.60 | 853.00 | 50 | PVC | 24 | |
| 122 | 33774.16 | 857.60 | 853.60 | 140 | PVC | 24 | |
| 123 | 33824.16 | 855.00 | 857.60 | 50 | PVC | 24 | |
| 124 | 34354.16 | 858.00 | 855.00 | 530 | PVC | 24 | |
| 125 | 34718.16 | 864.80 | 858.00 | 364 | PVC | 24 | |
| 126 | 34796.16 | 875.00 | 864.80 | 78 | PVC | 24 | |
| 127 | 35369.16 | 881.70 | 875.00 | 573 | PVC | 24 | |
| 128 | 36001.16 | 903.80 | 881.70 | 632 | PVC | 24 | |
| 129 | 36889.16 | 901.00 | 903.80 | 888 | PVC | 24 | |
| 130 | 37594.16 | 911.00 | 901.00 | 705 | PVC | 24 | |
| 131 | 38122.16 | 915.50 | 911.00 | 528 | PVC | 24 | |
| 132 | 38482.16 | 918.30 | 915.50 | 360 | PVC | 24 | |
| 133 | 38634.16 | 923.60 | 918.30 | 152 | PVC | 24 | |
| 134 | 39124.16 | 924.00 | 923.60 | 490 | PVC | 24 | |
| 135 | 39234.16 | 916.00 | 924.00 | 110 | PVC | 24 | |
| 136 | 39280.16 | 916.00 | 916.00 | 46 | PVC | 24 | |
| 137 | 39341.16 | 922.30 | 916.00 | 61 | PVC | 24 | |

Table 1 : Model Input Data

| Pipe ID | Revised Downstream Station | From Invert (ft) | To Invert (ft) | Revised Length (ft) | Material | Diameter (in) | Comments |
|---------|----------------------------|------------------|----------------|---------------------|----------|---------------|----------|
| 138 | 39372.76 | 923.60 | 922.30 | 31.6 | PVC | 24 | |
| 139 | 39814.16 | 926.10 | 923.60 | 441.4 | PVC | 24 | |
| 140 | 40740.26 | 921.70 | 926.10 | 549 | PVC | 24 | |
| 141 | 40884.16 | 924.10 | 921.70 | 521 | PVC | 24 | |
| 142 | 40912.16 | 922.30 | 924.10 | 28 | PVC | 24 | |
| 143 | 41154.16 | 917.45 | 922.30 | 242 | PVC | 24 | |
| 144 | 41594.16 | 908.00 | 917.45 | 440 | PVC | 24 | |
| 145 | 41794.16 | 900.00 | 908.00 | 260 | PVC | 24 | |
| 146 | 42104.16 | 900.00 | 900.00 | 190 | PVC | 24 | |
| 147 | 42154.16 | 901.80 | 900.00 | 68 | PVC | 24 | |
| 148 | 42214.16 | 917.40 | 901.80 | 102 | PVC | 24 | |
| 149 | 42664.16 | 918.45 | 917.40 | 370 | PVC | 24 | |
| 150 | 42834.16 | 914.25 | 918.45 | 130 | PVC | 24 | |
| 151 | 43013.16 | 910.50 | 914.25 | 156 | PVC | 24 | |
| 329 | 43013.16 | 911.00 | 910.50 | 143 | PVC | 24 | |
| 152 | 43486.16 | 919.49 | 911.00 | 473 | PVC | 24 | |
| 153 | 43864.16 | 920.40 | 919.49 | 378 | PVC | 24 | |
| 154 | 44434.16 | 922.60 | 920.40 | 570 | PVC | 24 | |
| 155 | 45119.66 | 943.60 | 922.60 | 685.5 | PVC | 24 | |
| 156 | 45855.16 | 934.50 | 943.60 | 735.5 | PVC | 24 | |
| 157 | 45984.16 | 935.00 | 934.50 | 129 | PVC | 24 | |
| 158 | 46014.16 | 944.90 | 935.00 | 30 | PVC | 24 | |
| 159 | 46120.16 | 948.20 | 944.90 | 106 | PVC | 24 | |
| 160 | 46234.16 | 956.00 | 948.20 | 114 | PVC | 24 | |
| 161 | 46624.16 | 948.00 | 956.00 | 390 | PVC | 24 | |
| 162 | 46704.16 | 949.00 | 948.00 | 80 | PVC | 24 | |
| 163 | 46794.16 | 956.80 | 949.00 | 90 | PVC | 24 | |
| 164 | 46874.16 | 960.40 | 956.80 | 80 | PVC | 24 | |
| 165 | 47004.16 | 966.00 | 960.40 | 130 | PVC | 24 | |
| 166 | 47144.16 | 969.50 | 966.00 | 140 | PVC | 24 | |
| 167 | 47174.16 | 976.00 | 969.50 | 30 | PVC | 24 | |
| 168 | 47364.16 | 981.50 | 976.00 | 190 | PVC | 24 | |
| 169 | 47447.16 | 984.64 | 981.50 | 83 | PVC | 24 | |
| 170 | 47754.16 | 989.80 | 984.64 | 307 | PVC | 24 | |
| 171 | 47884.16 | 994.50 | 989.80 | 130 | PVC | 24 | |
| 172 | 47934.16 | 1002.50 | 994.50 | 50 | PVC | 24 | |
| 173 | 48154.16 | 1006.78 | 1002.50 | 220 | PVC | 24 | |
| 174 | 48364.16 | 1013.00 | 1006.78 | 210 | PVC | 24 | |
| 175 | 48414.16 | 1045.10 | 1013.00 | 50 | PVC | 24 | |
| 176 | 49664.16 | 1047.00 | 1045.10 | 1250 | PVC | 24 | |
| 177 | 49909.16 | 1051.00 | 1047.00 | 245 | PVC | 24 | |
| 178 | 50034.16 | 1062.10 | 1051.00 | 125 | PVC | 24 | |
| 179 | 50474.16 | 1065.30 | 1062.10 | 440 | PVC | 24 | |
| 180 | 50794.16 | 1050.00 | 1065.30 | 320 | PVC | 24 | |
| 181 | 50894.16 | 1050.80 | 1050.00 | 100 | PVC | 24 | |
| 182 | 50964.16 | 1069.00 | 1050.80 | 70 | PVC | 24 | |
| 183 | 51166.16 | 1070.10 | 1069.00 | 202 | PVC | 24 | |
| 184 | 51339.16 | 1074.80 | 1070.10 | 173 | PVC | 24 | |
| 185 | 51514.16 | 1077.00 | 1074.80 | 175 | PVC | 24 | |
| 186 | 51729.16 | 1075.00 | 1077.00 | 215 | PVC | 24 | |
| 187 | 51834.16 | 1079.00 | 1075.00 | 105 | PVC | 24 | |
| 188 | 52034.16 | 1073.00 | 1079.00 | 200 | PVC | 24 | |
| 189 | 52134.16 | 1075.00 | 1073.00 | 100 | PVC | 24 | |
| 190 | 52334.16 | 1083.25 | 1075.00 | 200 | PVC | 24 | |
| 191 | 52412.06 | 1082.93 | 1083.25 | 77.9 | PVC | 24 | |
| 192 | 52465.06 | 1080.32 | 1082.93 | 53 | HDPE | 26 | |
| 193 | 52522.06 | 1080.34 | 1080.32 | 57 | HDPE | 26 | |
| 194 | 52542.06 | 1086.05 | 1080.34 | 20 | HDPE | 26 | |
| 195 | 52662.06 | 1088.30 | 1086.05 | 120 | HDPE | 26 | |
| 196 | 52902.06 | 1097.80 | 1088.30 | 240 | HDPE | 26 | |
| 197 | 53182.06 | 1099.20 | 1097.80 | 280 | HDPE | 26 | |
| 198 | 53582.06 | 1092.05 | 1099.20 | 400 | HDPE | 26 | |
| 199 | 53962.06 | 1086.11 | 1092.05 | 380 | HDPE | 26 | |
| 200 | 54129.06 | 1083.50 | 1086.11 | 167 | HDPE | 26 | |
| 201 | 54169.06 | 1080.19 | 1083.50 | 40 | HDPE | 26 | |
| 202 | 54357.06 | 1078.35 | 1080.19 | 188 | HDPE | 26 | |
| 203 | 54439.06 | 1076.25 | 1078.35 | 82 | HDPE | 26 | |
| 204 | 54642.06 | 1076.14 | 1076.25 | 203 | HDPE | 26 | |
| 205 | 54991.06 | 1070.40 | 1076.14 | 349 | HDPE | 26 | |

Table 1 : Model Input Data

| Pipe ID | Revised Downstream Station | From Invert (ft) | To Invert (ft) | Revised Length (ft) | Material | Diameter (in) | Comments |
|---------|----------------------------|------------------|----------------|---------------------|----------|---------------|----------------------|
| 206 | 55332.06 | 1067.00 | 1070.40 | 341 | HDPE | 26 | |
| 207 | 55492.06 | 1060.40 | 1067.00 | 160 | HDPE | 26 | |
| 208 | 55962.06 | 1055.20 | 1060.40 | 470 | HDPE | 26 | |
| 209 | 56472.06 | 1036.60 | 1055.20 | 510 | HDPE | 26 | |
| 210 | 57202.06 | 1021.40 | 1036.60 | 730 | HDPE | 26 | |
| 211 | 57662.06 | 1020.07 | 1021.40 | 460 | HDPE | 26 | |
| 212 | 57962.06 | 1009.50 | 1020.07 | 300 | HDPE | 26 | |
| 213 | 58462.06 | 1002.40 | 1009.50 | 500 | HDPE | 26 | |
| 214 | 58932.06 | 999.40 | 1002.40 | 470 | HDPE | 26 | |
| 215 | 59312.06 | 1000.76 | 999.40 | 380 | HDPE | 26 | |
| 216 | 59512.06 | 1003.00 | 1000.76 | 200 | HDPE | 26 | |
| 217 | 59562.06 | 1003.56 | 1003.00 | 50 | HDPE | 26 | |
| 218 | 60212.06 | 1010.68 | 1003.56 | 650 | HDPE | 26 | |
| 219 | 61012.06 | 1014.61 | 1010.68 | 800 | HDPE | 26 | |
| 220 | 61422.06 | 1019.92 | 1014.61 | 410 | HDPE | 26 | |
| 221 | 61712.06 | 1027.22 | 1019.92 | 290 | HDPE | 26 | |
| 222 | 62032.56 | 1050.96 | 1027.22 | 320.5 | HDPE | 26 | |
| 223 | 62712.06 | 1089.00 | 1050.96 | 679.5 | HDPE | 26 | |
| 224 | 63672.06 | 1091.50 | 1089.00 | 960 | HDPE | 26 | |
| 225 | 63772.06 | 1098.00 | 1091.50 | 100 | HDPE | 26 | |
| 226 | 63922.06 | 1103.00 | 1098.00 | 150 | HDPE | 26 | |
| 227 | 64022.06 | 1104.80 | 1103.00 | 100 | HDPE | 26 | |
| 228 | 64122.06 | 1111.40 | 1104.80 | 100 | HDPE | 26 | Gate per spreadsheet |
| 229 | 64222.06 | 1131.80 | 1111.40 | 100 | HDPE | 26 | |
| 230 | 64652.06 | 1147.82 | 1131.80 | 430 | HDPE | 26 | |
| 231 | 65052.06 | 1148.31 | 1147.82 | 400 | HDPE | 26 | |
| 232 | 65417.64 | 1147.07 | 1148.31 | 365.58 | HDPE | 26 | |
| 233 | 65532.06 | 1132.92 | 1147.07 | 114.42 | HDPE | 26 | |
| 234 | 65942.06 | 1130.53 | 1132.92 | 410 | HDPE | 26 | |
| 235 | 66092.06 | 1130.30 | 1130.53 | 150 | HDPE | 26 | |
| 236 | 66132.06 | 1118.80 | 1130.30 | 40 | HDPE | 26 | |
| 237 | 66362.06 | 1119.00 | 1118.80 | 230 | HDPE | 26 | |
| 238 | 66412.06 | 1128.00 | 1119.00 | 50 | HDPE | 26 | |
| 239 | 66422.06 | 1129.36 | 1128.00 | 10 | HDPE | 26 | |
| 240 | 66652.06 | 1132.60 | 1129.36 | 230 | HDPE | 26 | |
| 241 | 66800.21 | 1134.68 | 1132.60 | 148.15 | HDPE | 26 | |
| 242 | 66952.06 | 1134.58 | 1134.68 | 189 | HDPE | 26 | |
| 330 | | 1134.53 | 1134.58 | 95.59 | HDPE | 26 | |
| 243 | 67047.65 | 1126.00 | 1134.53 | 19.17 | HDPE | 26 | |
| 244 | 67080.06 | 1116.12 | 1126.00 | 18 | HDPE | 26 | |
| 331 | | 1116.60 | 1116.12 | 64 | HDPE | 26 | |
| 245 | 67176.06 | 1137.00 | 1116.60 | 96 | HDPE | 26 | |
| 246 | 67412.06 | 1138.10 | 1137.00 | 236 | HDPE | 26 | |
| 247 | 67572.06 | 1149.80 | 1138.10 | 160 | HDPE | 26 | |
| 248 | 67862.06 | 1151.02 | 1149.80 | 290 | HDPE | 26 | |
| 249 | 68042.06 | 1159.50 | 1151.02 | 180 | HDPE | 26 | |
| 250 | 68262.06 | 1163.90 | 1159.50 | 220 | HDPE | 26 | |
| 251 | 68952.06 | 1163.40 | 1163.90 | 690 | HDPE | 26 | |
| 252 | 69232.06 | 1159.00 | 1163.40 | 280 | HDPE | 26 | |
| 253 | 69432.06 | 1159.00 | 1159.00 | 200 | HDPE | 26 | |
| 254 | 69562.06 | 1159.00 | 1159.00 | 130 | HDPE | 26 | |
| 255 | 69712.06 | 1157.32 | 1159.00 | 150 | HDPE | 26 | |
| 256 | 70067.06 | 1146.06 | 1157.32 | 355 | HDPE | 26 | |
| 257 | 70292.06 | 1142.26 | 1146.06 | 225 | HDPE | 26 | |
| 258 | 70462.06 | 1143.80 | 1142.26 | 170 | HDPE | 26 | |
| 259 | 70532.06 | 1148.45 | 1143.80 | 70 | HDPE | 26 | |
| 260 | 70642.06 | 1165.75 | 1148.45 | 110 | HDPE | 26 | |
| 261 | 70962.06 | 1172.97 | 1165.75 | 320 | HDPE | 26 | |
| 262 | 71342.06 | 1173.84 | 1172.97 | 380 | HDPE | 26 | |
| 263 | 72062.06 | 1174.06 | 1173.84 | 720 | HDPE | 26 | |
| 264 | 72242.06 | 1178.00 | 1174.06 | 180 | HDPE | 26 | |
| 265 | 72351.99 | 1178.67 | 1178.00 | 109.93 | HDPE | 26 | |
| 266 | 72885.56 | 1182.67 | 1178.67 | 533.57 | HDPE | 26 | |
| 267 | 73045.56 | 1185.47 | 1182.67 | 160 | HDPE | 26 | |
| 268 | 73138.06 | 1191.00 | 1185.47 | 92.5 | HDPE | 26 | |
| 269 | 73321.01 | 1192.00 | 1191.00 | 182.95 | HDPE | 26 | |
| 270 | 73431.01 | 1198.40 | 1192.00 | 110 | HDPE | 26 | |
| 271 | 73651.01 | 1201.68 | 1198.40 | 220 | HDPE | 26 | |
| 272 | 74111.56 | 1203.20 | 1201.68 | 460.55 | HDPE | 26 | |

Table 1 : Model Input Data

| Pipe ID | Revised Downstream Station | From Invert (ft) | To Invert (ft) | Revised Length (ft) | Material | Diameter (in) | Comments |
|---------|----------------------------|------------------|----------------|---------------------|----------|---------------|----------------------|
| 273 | 74474.01 | 1184.07 | 1203.20 | 362.45 | HDPE | 26 | |
| 274 | 75121.09 | 1171.46 | 1184.07 | 647.08 | HDPE | 26 | |
| 275 | 75515.96 | 1168.00 | 1171.46 | 394.87 | HDPE | 26 | |
| 276 | 75803.37 | 1167.70 | 1168.00 | 287.41 | HDPE | 26 | |
| 277 | 75907.37 | 1170.00 | 1167.70 | 104 | HDPE | 26 | |
| 278 | 75993.37 | 1174.00 | 1170.00 | 86 | HDPE | 26 | |
| 279 | 76243.37 | 1174.50 | 1174.00 | 250 | HDPE | 26 | |
| 280 | 76488.37 | 1167.00 | 1174.50 | 245 | HDPE | 26 | |
| 281 | 76693.37 | 1166.75 | 1167.00 | 205 | HDPE | 26 | |
| 282 | 76843.37 | 1162.25 | 1166.75 | 150 | HDPE | 26 | |
| 283 | 77043.37 | 1162.20 | 1162.25 | 200 | HDPE | 26 | |
| 284 | 77182.69 | 1161.25 | 1162.20 | 139.32 | HDPE | 26 | |
| 285 | 77243.37 | 1166.30 | 1161.25 | 60.68 | HDPE | 26 | |
| 286 | 77443.37 | 1167.00 | 1166.30 | 200 | HDPE | 26 | |
| 287 | 77728.37 | 1172.00 | 1167.00 | 285 | HDPE | 26 | |
| 288 | 77923.37 | 1177.00 | 1172.00 | 195 | HDPE | 26 | |
| 289 | 78293.37 | 1178.00 | 1177.00 | 370 | HDPE | 26 | |
| 290 | 78573.37 | 1178.63 | 1178.00 | 280 | HDPE | 26 | |
| 291 | 78643.37 | 1179.05 | 1178.63 | 70 | HDPE | 26 | |
| 292 | 78736.37 | 1180.29 | 1179.05 | 93 | HDPE | 26 | |
| 293 | 78803.37 | 1187.00 | 1180.29 | 67 | HDPE | 26 | |
| 294 | 79293.37 | 1187.80 | 1187.00 | 490 | HDPE | 26 | |
| 295 | 79343.37 | 1188.22 | 1187.80 | 50 | HDPE | 26 | |
| 296 | 79763.37 | 1185.35 | 1188.22 | 420 | HDPE | 26 | |
| 297 | 79968.37 | 1191.20 | 1185.35 | 205 | HDPE | 26 | |
| 298 | 80002.41 | 1212.67 | 1191.20 | 34.04 | HDPE | 26 | |
| 299 | 80702.41 | 1197.10 | 1212.67 | 700 | HDPE | 26 | |
| 300 | 81852.41 | 1211.00 | 1197.10 | 1150 | HDPE | 26 | |
| 301 | 84302.41 | 1205.60 | 1211.00 | 2450 | HDPE | 26 | |
| 302 | 84713.41 | 1205.20 | 1205.60 | 411 | HDPE | 26 | |
| 303 | 84811.41 | 1225.29 | 1205.20 | 98 | HDPE | 26 | |
| 304 | 87402.41 | 1356.10 | 1225.29 | 1524.1 | HDPE | 26 | Gate per spreadsheet |
| 305 | 94202.41 | 1343.58 | 1356.10 | 6275.68 | HDPE | 26 | |
| 306 | 94602.41 | 1374.04 | 1343.58 | 400 | HDPE | 26 | |
| 307 | 96202.41 | 1317.00 | 1374.04 | 1600 | HDPE | 26 | |
| 308 | 98102.41 | 1329.94 | 1317.00 | 1900 | PVC | 30 | |
| 309 | 98702.41 | 1305.75 | 1329.94 | 600 | PVC | 30 | |
| 310 | 99852.41 | 1262.60 | 1305.75 | 1150 | PVC | 30 | |
| 311 | 101829.41 | 1253.50 | 1262.60 | 1977.71 | PVC | 30 | |
| 312 | 102629.41 | 1251.20 | 1253.50 | 782.35 | PVC | 30 | |
| 313 | 104329.41 | 1305.85 | 1251.20 | 1700 | PVC | 30 | |
| 314 | 105879.41 | 1290.50 | 1305.85 | 1550 | PVC | 30 | |
| 315 | 106379.41 | 1312.00 | 1290.50 | 500 | PVC | 30 | |
| 316 | 106629.41 | 1247.50 | 1312.00 | 250 | PVC | 30 | |
| 317 | 108557.41 | 1239.40 | 1247.50 | 1928 | PVC | 30 | |
| 318 | 108565.41 | 1240.00 | 1239.40 | 8 | PVC | 30 | |
| 319 | 108979.41 | 1251.96 | 1240.00 | 414 | HDPE | 26 | |
| 320 | 108991.41 | 1252.00 | 1251.96 | 12 | PVC | 30 | |
| 321 | 112329.41 | 1259.93 | 1252.00 | 3338 | PVC | 30 | |
| 322 | 113729.41 | 1255.00 | 1259.93 | 1400 | PVC | 30 | |
| 323 | 113748.41 | 1258.36 | 1255.00 | 19 | PVC | 30 | |
| 324 | 113929.41 | 1259.00 | 1258.36 | 181 | PVC | 30 | |
| 325 | 114569.41 | 1262.00 | 1259.00 | 640 | PVC | 30 | |
| 326 | 114589.41 | 1278.65 | 1262.00 | 20 | PVC | 30 | |
| 327 | 116494.41 | 1279 | 1278.65 | 1905 | PVC | 30 | |

1279.00

Table 2 : 400 gpm Steady-State Results

| Pipe ID | Diameter (in) | Length (ft) | Slope | Flow Type | Velocity (fps) | d/D | q/Q | Water Depth (ft) | Full Flow (gpm) |
|---------|---------------|-------------|--------|--------------|----------------|-------|-------|------------------|-----------------|
| 1 | 26 | 66.1 | 0.058 | Free Surface | 7.685 | 0.071 | 0.01 | 0.154 | 39,438.50 |
| 2 | 26 | 492 | 0.002 | Free Surface | 2.374 | 0.158 | 0.054 | 0.343 | 7,349.48 |
| 3 | 26 | 333 | 0.017 | Free Surface | 5.019 | 0.095 | 0.019 | 0.206 | 21,398.03 |
| 4 | 26 | 206 | 0.002 | Free Surface | 2.536 | 0.151 | 0.05 | 0.328 | 8,071.85 |
| 5 | 26 | 1,000.00 | 0.005 | Free Surface | 3.243 | 0.128 | 0.035 | 0.277 | 11,468.85 |
| 6 | 26 | 500 | 0.004 | Free Surface | 3.022 | 0.134 | 0.039 | 0.291 | 10,362.19 |
| 7 | 26 | 300 | 0.005 | Free Surface | 3.341 | 0.125 | 0.033 | 0.271 | 11,965.23 |
| 8 | 26 | 265 | 0.009 | Free Surface | 4.02 | 0.11 | 0.026 | 0.239 | 15,592.09 |
| 9 | 26 | 313 | -0.029 | Pressurized | 0.242 | 1 | 1 | 2.167 | 400 |
| 10 | 26 | 69 | 0.153 | Free Surface | 10.764 | 0.057 | 0.006 | 0.123 | 64,035.01 |
| 11 | 26 | 523 | 0 | Pressurized | 0.242 | 1 | 1 | 2.167 | 400 |
| 12 | 26 | 265 | 0.012 | Free Surface | 4.492 | 0.102 | 0.022 | 0.222 | 18,283.35 |
| 13 | 26 | 538 | 0.003 | Free Surface | 2.712 | 0.145 | 0.045 | 0.313 | 8,878.90 |
| 14 | 26 | 927 | 0.002 | Free Surface | 2.411 | 0.157 | 0.053 | 0.34 | 7,514.48 |
| 15 | 26 | 340 | 0.015 | Free Surface | 4.818 | 0.098 | 0.02 | 0.211 | 20,203.54 |
| 16 | 26 | 514 | 0.034 | Free Surface | 6.397 | 0.08 | 0.013 | 0.174 | 30,300.49 |
| 17 | 26 | 396 | 0.054 | Free Surface | 7.503 | 0.072 | 0.01 | 0.156 | 38,131.84 |
| 328 | 26 | 114 | 0.01 | Free Surface | 4.14 | 0.108 | 0.025 | 0.234 | 16,239.71 |
| 18 | 24 | 16 | 1.437 | Free Surface | 23.755 | 0.037 | 0.003 | 0.074 | 158,646.72 |
| 19 | 24 | 339 | 0.024 | Free Surface | 5.696 | 0.097 | 0.02 | 0.194 | 20,407.48 |
| 20 | 24 | 301.36 | 0.031 | Free Surface | 6.242 | 0.091 | 0.017 | 0.182 | 23,262.35 |
| 21 | 24 | 179.64 | 0.101 | Free Surface | 9.423 | 0.069 | 0.01 | 0.138 | 41,999.04 |
| 22 | 24 | 725 | -0.006 | Pressurized | 0.284 | 1 | 1 | 2 | 400 |
| 23 | 24 | 22.49 | -0.036 | Pressurized | 0.284 | 1 | 1 | 2 | 400 |
| 24 | 24 | 404.51 | -0.02 | Pressurized | 0.284 | 1 | 1 | 2 | 400 |
| 25 | 24 | 538 | -0.02 | Pressurized | 0.284 | 1 | 1 | 2 | 400 |
| 26 | 24 | 240 | -0.001 | Pressurized | 0.284 | 1 | 1 | 2 | 400 |
| 27 | 24 | 220 | 0.027 | Free Surface | 5.936 | 0.094 | 0.018 | 0.189 | 21,655.49 |
| 28 | 24 | 360 | 0.005 | Free Surface | 3.337 | 0.14 | 0.042 | 0.28 | 9,513.21 |
| 29 | 24 | 290 | 0.01 | Free Surface | 4.149 | 0.12 | 0.031 | 0.241 | 12,958.21 |
| 30 | 24 | 225 | 0.105 | Free Surface | 9.56 | 0.068 | 0.009 | 0.137 | 42,881.53 |
| 31 | 24 | 405 | 0.009 | Free Surface | 4.064 | 0.122 | 0.032 | 0.244 | 12,581.56 |
| 32 | 24 | 155 | 0.002 | Free Surface | 2.521 | 0.17 | 0.063 | 0.34 | 6,378.33 |
| 33 | 24 | 180 | 0.013 | Free Surface | 4.627 | 0.112 | 0.026 | 0.224 | 15,154.49 |
| 34 | 24 | 140 | 0.006 | Free Surface | 3.46 | 0.136 | 0.04 | 0.273 | 10,004.67 |
| 35 | 24 | 260 | 0.027 | Free Surface | 5.958 | 0.094 | 0.018 | 0.188 | 21,747.21 |
| 36 | 24 | 250 | 0.008 | Free Surface | 3.966 | 0.124 | 0.033 | 0.249 | 12,158.86 |
| 37 | 24 | 255 | 0.027 | Free Surface | 5.975 | 0.094 | 0.018 | 0.188 | 21,849.62 |
| 38 | 24 | 160 | 0.131 | Free Surface | 10.343 | 0.065 | 0.008 | 0.13 | 47,982.32 |
| 39 | 24 | 760 | 0.007 | Free Surface | 3.749 | 0.129 | 0.036 | 0.258 | 11,217.89 |
| 40 | 24 | 100 | 0.004 | Free Surface | 3.051 | 0.149 | 0.048 | 0.298 | 8,370.50 |
| 41 | 24 | 60 | -0.023 | Pressurized | 0.284 | 1 | 1 | 2 | 400 |
| 42 | 24 | 40 | 0.65 | Free Surface | 18.028 | 0.045 | 0.004 | 0.089 | 106,703.41 |
| 43 | 24 | 800 | 0.002 | Free Surface | 2.328 | 0.179 | 0.07 | 0.359 | 5,692.56 |
| 44 | 24 | 120 | 0.12 | Free Surface | 10.02 | 0.066 | 0.009 | 0.132 | 45,894.87 |
| 45 | 24 | 390 | 0.039 | Free Surface | 6.754 | 0.086 | 0.015 | 0.173 | 26,033.58 |
| 46 | 24 | 600 | 0.004 | Free Surface | 2.959 | 0.152 | 0.05 | 0.304 | 8,014.15 |
| 47 | 24 | 170 | 0.072 | Free Surface | 8.394 | 0.075 | 0.011 | 0.149 | 35,585.50 |
| 48 | 24 | 230 | 0.086 | Free Surface | 8.905 | 0.072 | 0.01 | 0.143 | 38,743.69 |
| 49 | 24 | 560 | 0 | Free Surface | 1.276 | 0.274 | 0.164 | 0.548 | 2,437.84 |
| 50 | 24 | 60 | 0.144 | Free Surface | 10.684 | 0.063 | 0.008 | 0.127 | 50,310.14 |
| 51 | 24 | 130 | 0.029 | Free Surface | 6.139 | 0.092 | 0.018 | 0.184 | 22,716.91 |
| 52 | 30 | 450 | 0.005 | Free Surface | 3.282 | 0.104 | 0.023 | 0.261 | 17,561.19 |
| 53 | 30 | 750 | 0.004 | Free Surface | 2.856 | 0.115 | 0.028 | 0.287 | 14,398.02 |
| 54 | 30 | 115 | 0.001 | Free Surface | 1.532 | 0.176 | 0.068 | 0.44 | 5,920.41 |
| 55 | 30 | 70 | -0.058 | Pressurized | 0.182 | 1 | 1 | 2.5 | 400 |
| 56 | 30 | 115 | 0.037 | Free Surface | 6.457 | 0.066 | 0.009 | 0.165 | 46,293.98 |
| 57 | 30 | 250 | -0.007 | Pressurized | 0.182 | 1 | 1 | 2.5 | 400 |
| 58 | 30 | 110 | 0.019 | Free Surface | 5.087 | 0.077 | 0.012 | 0.193 | 32,918.53 |
| 59 | 30 | 200 | 0.001 | Free Surface | 2.027 | 0.145 | 0.045 | 0.363 | 8,816.95 |
| 60 | 30 | 245 | -0.043 | Pressurized | 0.182 | 1 | 1 | 2.5 | 400 |
| 61 | 30 | 245 | -0.002 | Pressurized | 0.182 | 1 | 1 | 2.5 | 400 |
| 62 | 30 | 465 | -0.006 | Pressurized | 0.182 | 1 | 1 | 2.5 | 400 |
| 63 | 30 | 135 | -0.012 | Pressurized | 0.182 | 1 | 1 | 2.5 | 400 |
| 64 | 30 | 240 | -0.07 | Pressurized | 0.182 | 1 | 1 | 2.5 | 400 |
| 65 | 30 | 560 | -0.003 | Pressurized | 0.182 | 1 | 1 | 2.5 | 400 |
| 66 | 30 | 400 | -0.005 | Pressurized | 0.182 | 1 | 1 | 2.5 | 400 |

Table 2 : 400 gpm Steady-State Results

| Pipe ID | Diameter (in) | Length (ft) | Slope | Flow Type | Velocity (fps) | d/D | q/Q | Water Depth (ft) | Full Flow (gpm) |
|---------|---------------|-------------|--------|--------------|----------------|-------|-------|------------------|-----------------|
| 67 | 30 | 300 | -0.009 | Pressurized | 0.182 | 1 | 1 | 2.5 | 400 |
| 68 | 30 | 170 | -0.043 | Pressurized | 0.182 | 1 | 1 | 2.5 | 400 |
| 69 | 30 | 50 | -0.007 | Pressurized | 0.182 | 1 | 1 | 2.5 | 400 |
| 70 | 30 | 300 | -0.003 | Pressurized | 0.182 | 1 | 1 | 2.5 | 400 |
| 71 | 30 | 80 | -0.055 | Pressurized | 0.182 | 1 | 1 | 2.5 | 400 |
| 72 | 30 | 64.75 | -0.018 | Pressurized | 0.182 | 1 | 1 | 2.5 | 400 |
| 73 | 30 | 520.25 | 0.017 | Free Surface | 4.937 | 0.079 | 0.013 | 0.197 | 31,527.07 |
| 74 | 30 | 435 | 0.003 | Free Surface | 2.74 | 0.118 | 0.029 | 0.295 | 13,564.83 |
| 75 | 30 | 410 | -0.014 | Pressurized | 0.182 | 1 | 1 | 2.5 | 400 |
| 76 | 30 | 100 | -0.05 | Pressurized | 0.182 | 1 | 1 | 2.5 | 400 |
| 77 | 30 | 311.23 | -0.029 | Pressurized | 0.182 | 1 | 1 | 2.5 | 400 |
| 78 | 30 | 533.77 | -0.005 | Pressurized | 0.182 | 1 | 1 | 2.5 | 400 |
| 79 | 30 | 125 | -0.054 | Pressurized | 0.182 | 1 | 1 | 2.5 | 400 |
| 80 | 30 | 64.68 | -0.008 | Pressurized | 0.182 | 1 | 1 | 2.5 | 400 |
| 81 | 30 | 535.32 | -0.007 | Pressurized | 0.182 | 1 | 1 | 2.5 | 400 |
| 82 | 30 | 285 | -0.008 | Pressurized | 0.182 | 1 | 1 | 2.5 | 400 |
| 83 | 30 | 189 | -0.035 | Pressurized | 0.182 | 1 | 1 | 2.5 | 400 |
| 84 | 30 | 26 | 0.008 | Pressurized | 3.724 | 0.096 | 0.019 | 0.239 | 21,046.50 |
| 85 | 30 | 30 | 0.193 | Free Surface | 11.444 | 0.045 | 0.004 | 0.112 | 105,512.74 |
| 86 | 30 | 30 | 0.001 | Free Surface | 1.823 | 0.156 | 0.053 | 0.39 | 7,588.42 |
| 87 | 30 | 40 | 0.03 | Free Surface | 6.023 | 0.069 | 0.01 | 0.173 | 41,908.44 |
| 88 | 24 | 42.06 | -0.149 | Pressurized | 0.284 | 1 | 1 | 2 | 400 |
| 89 | 24 | 55 | 0.086 | Pressurized | 8.917 | 0.072 | 0.01 | 0.143 | 38,771.38 |
| 90 | 24 | 40 | -0.007 | Pressurized | 0.284 | 1 | 1 | 2 | 400 |
| 91 | 24 | 108 | -0.156 | Pressurized | 0.284 | 1 | 1 | 2 | 400 |
| 92 | 24 | 262 | -0.012 | Pressurized | 0.284 | 1 | 1 | 2 | 400 |
| 93 | 24 | 230 | -0.03 | Pressurized | 0.284 | 1 | 1 | 2 | 400 |
| 94 | 24 | 355 | -0.012 | Pressurized | 0.284 | 1 | 1 | 2 | 400 |
| 95 | 24 | 315 | 0.002 | Pressurized | 2.206 | 0.186 | 0.076 | 0.373 | 5,272.92 |
| 96 | 24 | 95 | 0.087 | Free Surface | 8.973 | 0.071 | 0.01 | 0.143 | 39,120.00 |
| 97 | 24 | 285 | -0.004 | Pressurized | 0.284 | 1 | 1 | 2 | 400 |
| 98 | 24 | 250 | -0.033 | Pressurized | 0.284 | 1 | 1 | 2 | 400 |
| 99 | 24 | 100 | 0.01 | Pressurized | 4.211 | 0.119 | 0.03 | 0.239 | 13,234.93 |
| 100 | 24 | 100 | 0.088 | Free Surface | 8.996 | 0.071 | 0.01 | 0.142 | 39,261.14 |
| 101 | 24 | 136 | 0.014 | Free Surface | 4.741 | 0.11 | 0.026 | 0.22 | 15,684.43 |
| 102 | 24 | 764 | -0.007 | Pressurized | 0.284 | 1 | 1 | 2 | 400 |
| 103 | 24 | 70 | 0.007 | Pressurized | 3.739 | 0.129 | 0.036 | 0.259 | 11,185.56 |
| 104 | 24 | 50 | 0.112 | Free Surface | 9.779 | 0.067 | 0.009 | 0.135 | 44,292.54 |
| 105 | 24 | 40 | 0.02 | Free Surface | 5.366 | 0.101 | 0.021 | 0.202 | 18,717.02 |
| 106 | 24 | 320 | 0.007 | Free Surface | 3.633 | 0.132 | 0.037 | 0.264 | 10,721.52 |
| 107 | 24 | 550 | 0.007 | Free Surface | 3.765 | 0.129 | 0.035 | 0.258 | 11,286.79 |
| 108 | 24 | 190 | 0.007 | Free Surface | 3.78 | 0.128 | 0.035 | 0.257 | 11,360.80 |
| 109 | 24 | 130 | 0.025 | Free Surface | 5.765 | 0.096 | 0.019 | 0.193 | 20,764.67 |
| 110 | 24 | 100 | 0.099 | Free Surface | 9.373 | 0.069 | 0.01 | 0.138 | 41,642.73 |
| 111 | 24 | 579 | 0.038 | Free Surface | 6.726 | 0.087 | 0.015 | 0.173 | 25,915.45 |
| 112 | 24 | 891 | 0.014 | Free Surface | 4.695 | 0.111 | 0.026 | 0.221 | 15,486.84 |
| 113 | 24 | 350 | -0.003 | Pressurized | 0.284 | 1 | 1 | 2 | 400 |
| 114 | 24 | 114 | -0.114 | Pressurized | 0.284 | 1 | 1 | 2 | 400 |
| 115 | 24 | 77 | -0.013 | Pressurized | 0.284 | 1 | 1 | 2 | 400 |
| 116 | 24 | 63 | 0.171 | Free Surface | 11.341 | 0.061 | 0.007 | 0.122 | 54,797.81 |
| 117 | 24 | 91 | 0.084 | Free Surface | 8.828 | 0.072 | 0.01 | 0.144 | 38,247.91 |
| 118 | 24 | 179 | -0.021 | Pressurized | 0.284 | 1 | 1 | 2 | 400 |
| 119 | 24 | 280 | 0.004 | Pressurized | 3.08 | 0.148 | 0.047 | 0.296 | 8,481.87 |
| 120 | 24 | 576 | -0.01 | Pressurized | 0.284 | 1 | 1 | 2 | 400 |
| 121 | 24 | 50 | 0.012 | Pressurized | 4.483 | 0.114 | 0.028 | 0.229 | 14,498.14 |
| 122 | 24 | 140 | 0.029 | Pressurized | 6.074 | 0.093 | 0.018 | 0.186 | 22,371.11 |
| 123 | 24 | 50 | -0.052 | Pressurized | 0.284 | 1 | 1 | 2 | 400 |
| 124 | 24 | 530 | 0.006 | Pressurized | 3.446 | 0.137 | 0.04 | 0.274 | 9,957.36 |
| 125 | 24 | 364 | 0.019 | Free Surface | 5.235 | 0.103 | 0.022 | 0.206 | 18,089.45 |
| 126 | 24 | 78 | 0.131 | Free Surface | 10.314 | 0.065 | 0.008 | 0.13 | 47,860.19 |
| 127 | 24 | 573 | 0.012 | Free Surface | 4.445 | 0.115 | 0.028 | 0.23 | 14,311.39 |
| 128 | 24 | 632 | 0.035 | Free Surface | 6.516 | 0.089 | 0.016 | 0.177 | 24,749.09 |
| 129 | 24 | 888 | -0.003 | Pressurized | 0.284 | 1 | 1 | 2 | 400 |
| 130 | 24 | 705 | 0.014 | Free Surface | 4.756 | 0.11 | 0.025 | 0.219 | 15,762.57 |
| 131 | 24 | 528 | 0.009 | Free Surface | 3.977 | 0.124 | 0.033 | 0.248 | 12,218.30 |
| 132 | 24 | 360 | 0.008 | Free Surface | 3.855 | 0.127 | 0.034 | 0.253 | 11,672.11 |
| 133 | 24 | 152 | 0.035 | Free Surface | 6.509 | 0.089 | 0.016 | 0.177 | 24,713.70 |

Table 2 : 400 gpm Steady-State Results

| Pipe ID | Diameter (in) | Length (ft) | Slope | Flow Type | Velocity (fps) | d/D | q/Q | Water Depth (ft) | Full Flow (gpm) |
|---------|---------------|-------------|--------|--------------|----------------|-------|-------|------------------|-----------------|
| 134 | 24 | 490 | 0.001 | Free Surface | 1.742 | 0.22 | 0.106 | 0.439 | 3,781.41 |
| 135 | 24 | 110 | -0.073 | Pressurized | 0.284 | 1 | 1 | 2 | 400 |
| 136 | 24 | 46 | 0 | Pressurized | 0.284 | 1 | 1 | 2 | 400 |
| 137 | 24 | 61 | 0.103 | Free Surface | 9.51 | 0.069 | 0.009 | 0.137 | 42,533.09 |
| 138 | 24 | 31.6 | 0.041 | Free Surface | 6.897 | 0.085 | 0.015 | 0.17 | 26,844.16 |
| 139 | 24 | 441.4 | 0.006 | Free Surface | 3.451 | 0.137 | 0.04 | 0.273 | 9,960.37 |
| 140 | 24 | 549 | -0.008 | Pressurized | 0.284 | 1 | 1 | 2 | 400 |
| 141 | 24 | 521 | 0.005 | Pressurized | 3.206 | 0.144 | 0.045 | 0.288 | 8,982.73 |
| 142 | 24 | 28 | -0.064 | Pressurized | 0.284 | 1 | 1 | 2 | 400 |
| 143 | 24 | 242 | -0.02 | Pressurized | 0.284 | 1 | 1 | 2 | 400 |
| 144 | 24 | 440 | -0.021 | Pressurized | 0.284 | 1 | 1 | 2 | 400 |
| 145 | 24 | 260 | -0.031 | Pressurized | 0.284 | 1 | 1 | 2 | 400 |
| 146 | 24 | 190 | 0 | Pressurized | 0.284 | 1 | 1 | 2 | 400 |
| 147 | 24 | 68 | 0.026 | Pressurized | 5.913 | 0.095 | 0.019 | 0.189 | 21,532.94 |
| 148 | 24 | 102 | 0.153 | Free Surface | 10.901 | 0.063 | 0.008 | 0.125 | 51,758.76 |
| 149 | 24 | 370 | 0.003 | Free Surface | 2.707 | 0.162 | 0.057 | 0.323 | 7,050.43 |
| 150 | 24 | 130 | -0.032 | Pressurized | 0.284 | 1 | 1 | 2 | 400 |
| 151 | 24 | 156 | -0.024 | Pressurized | 0.284 | 1 | 1 | 2 | 400 |
| 329 | 24 | 143 | 0.003 | Pressurized | 2.912 | 0.154 | 0.051 | 0.307 | 7,825.98 |
| 152 | 24 | 473 | 0.018 | Free Surface | 5.163 | 0.104 | 0.023 | 0.208 | 17,731.48 |
| 153 | 24 | 378 | 0.002 | Free Surface | 2.555 | 0.168 | 0.062 | 0.336 | 6,493.76 |
| 154 | 24 | 570 | 0.004 | Free Surface | 3.015 | 0.15 | 0.049 | 0.3 | 8,222.34 |
| 155 | 24 | 685.5 | 0.031 | Free Surface | 6.224 | 0.091 | 0.017 | 0.183 | 23,164.75 |
| 156 | 24 | 735.5 | -0.012 | Pressurized | 0.284 | 1 | 1 | 2 | 400 |
| 157 | 24 | 129 | 0.004 | Pressurized | 3.019 | 0.15 | 0.049 | 0.3 | 8,239.71 |
| 158 | 24 | 30 | 0.33 | Free Surface | 14.242 | 0.052 | 0.005 | 0.104 | 76,028.88 |
| 159 | 24 | 106 | 0.031 | Free Surface | 6.254 | 0.091 | 0.017 | 0.182 | 23,352.08 |
| 160 | 24 | 114 | 0.068 | Free Surface | 8.234 | 0.076 | 0.012 | 0.151 | 34,619.16 |
| 161 | 24 | 390 | -0.021 | Pressurized | 0.284 | 1 | 1 | 2 | 400 |
| 162 | 24 | 80 | 0.013 | Pressurized | 4.547 | 0.113 | 0.027 | 0.226 | 14,797.10 |
| 163 | 24 | 90 | 0.087 | Free Surface | 8.939 | 0.071 | 0.01 | 0.143 | 38,962.58 |
| 164 | 24 | 80 | 0.045 | Free Surface | 7.114 | 0.083 | 0.014 | 0.167 | 28,075.52 |
| 165 | 24 | 130 | 0.043 | Free Surface | 7.008 | 0.084 | 0.015 | 0.169 | 27,469.07 |
| 166 | 24 | 140 | 0.025 | Free Surface | 5.797 | 0.096 | 0.019 | 0.192 | 20,926.26 |
| 167 | 24 | 30 | 0.217 | Free Surface | 12.297 | 0.058 | 0.006 | 0.115 | 61,605.24 |
| 168 | 24 | 190 | 0.029 | Free Surface | 6.097 | 0.093 | 0.018 | 0.185 | 22,517.81 |
| 169 | 24 | 83 | 0.038 | Free Surface | 6.699 | 0.087 | 0.016 | 0.174 | 25,742.30 |
| 170 | 24 | 307 | 0.017 | Free Surface | 5.05 | 0.105 | 0.023 | 0.211 | 17,158.42 |
| 171 | 24 | 130 | 0.036 | Free Surface | 6.589 | 0.088 | 0.016 | 0.176 | 25,165.11 |
| 172 | 24 | 50 | 0.16 | Free Surface | 11.076 | 0.062 | 0.008 | 0.124 | 52,939.72 |
| 173 | 24 | 220 | 0.019 | Free Surface | 5.309 | 0.102 | 0.022 | 0.204 | 18,460.02 |
| 174 | 24 | 210 | 0.03 | Free Surface | 6.151 | 0.092 | 0.018 | 0.184 | 22,777.56 |
| 175 | 24 | 50 | 0.642 | Free Surface | 17.936 | 0.045 | 0.004 | 0.089 | 106,044.74 |
| 176 | 24 | 1,250.00 | 0.002 | Free Surface | 2.171 | 0.188 | 0.078 | 0.377 | 5,159.93 |
| 177 | 24 | 245 | 0.016 | Free Surface | 4.999 | 0.106 | 0.024 | 0.212 | 16,910.97 |
| 178 | 24 | 125 | 0.089 | Free Surface | 9.019 | 0.071 | 0.01 | 0.142 | 39,439.20 |
| 179 | 24 | 440 | 0.007 | Free Surface | 3.765 | 0.129 | 0.035 | 0.258 | 11,286.79 |
| 180 | 24 | 320 | -0.048 | Pressurized | 0.284 | 1 | 1 | 2 | 400 |
| 181 | 24 | 100 | 0.008 | Pressurized | 3.893 | 0.126 | 0.034 | 0.252 | 11,837.68 |
| 182 | 24 | 70 | 0.26 | Free Surface | 13.112 | 0.055 | 0.006 | 0.11 | 67,485.16 |
| 183 | 24 | 202 | 0.005 | Free Surface | 3.402 | 0.138 | 0.041 | 0.276 | 9,766.58 |
| 184 | 24 | 173 | 0.027 | Free Surface | 5.97 | 0.094 | 0.018 | 0.188 | 21,814.61 |
| 185 | 24 | 175 | 0.013 | Free Surface | 4.562 | 0.113 | 0.027 | 0.226 | 14,839.32 |
| 186 | 24 | 215 | -0.009 | Pressurized | 0.284 | 1 | 1 | 2 | 400 |
| 187 | 24 | 105 | 0.038 | Free Surface | 6.713 | 0.087 | 0.015 | 0.174 | 25,831.94 |
| 188 | 24 | 200 | -0.03 | Pressurized | 0.284 | 1 | 1 | 2 | 400 |
| 189 | 24 | 100 | 0.02 | Pressurized | 5.366 | 0.101 | 0.021 | 0.202 | 18,717.02 |
| 190 | 24 | 200 | 0.041 | Free Surface | 6.905 | 0.085 | 0.015 | 0.17 | 26,880.27 |
| 191 | 24 | 77.9 | -0.004 | Pressurized | 0.284 | 1 | 1 | 2 | 400 |
| 192 | 26 | 53 | -0.049 | Pressurized | 0.242 | 1 | 1 | 2.167 | 400 |
| 193 | 26 | 57 | 0 | Pressurized | 1.28 | 0.244 | 0.13 | 0.528 | 3,069.02 |
| 194 | 26 | 20 | 0.285 | Free Surface | 13.394 | 0.049 | 0.005 | 0.106 | 87,543.68 |
| 195 | 26 | 120 | 0.019 | Free Surface | 5.185 | 0.093 | 0.018 | 0.201 | 22,434.81 |
| 196 | 26 | 240 | 0.04 | Free Surface | 6.725 | 0.078 | 0.012 | 0.168 | 32,597.02 |
| 197 | 26 | 280 | 0.005 | Free Surface | 3.266 | 0.127 | 0.035 | 0.276 | 11,585.29 |
| 198 | 26 | 400 | -0.018 | Pressurized | 0.242 | 1 | 1 | 2.167 | 400 |
| 199 | 26 | 380 | -0.016 | Pressurized | 0.242 | 1 | 1 | 2.167 | 400 |

Table 2 : 400 gpm Steady-State Results

| Pipe ID | Diameter (in) | Length (ft) | Slope | Flow Type | Velocity (fps) | d/D | q/Q | Water Depth (ft) | Full Flow (gpm) |
|---------|---------------|-------------|--------|--------------|----------------|-------|-------|------------------|-----------------|
| 200 | 26 | 167 | -0.016 | Pressurized | 0.242 | 1 | 1 | 2.167 | 400 |
| 201 | 26 | 40 | -0.083 | Pressurized | 0.242 | 1 | 1 | 2.167 | 400 |
| 202 | 26 | 188 | -0.01 | Pressurized | 0.242 | 1 | 1 | 2.167 | 400 |
| 203 | 26 | 82 | -0.026 | Pressurized | 0.242 | 1 | 1 | 2.167 | 400 |
| 204 | 26 | 203 | -0.001 | Pressurized | 0.242 | 1 | 1 | 2.167 | 400 |
| 205 | 26 | 349 | -0.016 | Pressurized | 0.242 | 1 | 1 | 2.167 | 400 |
| 206 | 26 | 341 | -0.01 | Pressurized | 0.242 | 1 | 1 | 2.167 | 400 |
| 207 | 26 | 160 | -0.041 | Pressurized | 0.242 | 1 | 1 | 2.167 | 400 |
| 208 | 26 | 470 | -0.011 | Pressurized | 0.242 | 1 | 1 | 2.167 | 400 |
| 209 | 26 | 510 | -0.036 | Pressurized | 0.242 | 1 | 1 | 2.167 | 400 |
| 210 | 26 | 730 | -0.021 | Pressurized | 0.242 | 1 | 1 | 2.167 | 400 |
| 211 | 26 | 460 | -0.003 | Pressurized | 0.242 | 1 | 1 | 2.167 | 400 |
| 212 | 26 | 300 | -0.035 | Pressurized | 0.242 | 1 | 1 | 2.167 | 400 |
| 213 | 26 | 500 | -0.014 | Pressurized | 0.242 | 1 | 1 | 2.167 | 400 |
| 214 | 26 | 470 | -0.006 | Pressurized | 0.242 | 1 | 1 | 2.167 | 400 |
| 215 | 26 | 380 | 0.004 | Pressurized | 2.906 | 0.138 | 0.041 | 0.299 | 9,801.65 |
| 216 | 26 | 200 | 0.011 | Pressurized | 4.332 | 0.105 | 0.023 | 0.227 | 17,339.27 |
| 217 | 26 | 50 | 0.011 | Pressurized | 4.332 | 0.105 | 0.023 | 0.227 | 17,339.27 |
| 218 | 26 | 650 | 0.011 | Free Surface | 4.295 | 0.105 | 0.023 | 0.229 | 17,147.67 |
| 219 | 26 | 800 | 0.005 | Free Surface | 3.243 | 0.128 | 0.035 | 0.277 | 11,479.08 |
| 220 | 26 | 410 | 0.013 | Free Surface | 4.556 | 0.101 | 0.021 | 0.22 | 18,650.90 |
| 221 | 26 | 290 | 0.025 | Free Surface | 5.743 | 0.087 | 0.015 | 0.188 | 25,994.66 |
| 222 | 26 | 320.5 | 0.074 | Free Surface | 8.366 | 0.067 | 0.009 | 0.145 | 44,591.09 |
| 223 | 26 | 679.5 | 0.056 | Free Surface | 7.588 | 0.072 | 0.01 | 0.155 | 38,765.67 |
| 224 | 26 | 960 | 0.003 | Free Surface | 2.6 | 0.149 | 0.048 | 0.322 | 8,360.96 |
| 225 | 26 | 100 | 0.065 | Free Surface | 7.997 | 0.069 | 0.01 | 0.15 | 41,771.34 |
| 226 | 26 | 150 | 0.033 | Free Surface | 6.34 | 0.081 | 0.013 | 0.175 | 29,913.08 |
| 227 | 26 | 100 | 0.018 | Free Surface | 5.111 | 0.094 | 0.018 | 0.203 | 21,981.53 |
| 228 | 26 | 100 | 0.066 | Free Surface | 8.039 | 0.069 | 0.01 | 0.149 | 42,091.43 |
| 229 | 26 | 100 | 0.204 | Free Surface | 11.907 | 0.053 | 0.005 | 0.115 | 74,000.87 |
| 230 | 26 | 430 | 0.037 | Free Surface | 6.588 | 0.079 | 0.013 | 0.171 | 31,624.14 |
| 231 | 26 | 400 | 0.001 | Free Surface | 1.993 | 0.179 | 0.07 | 0.387 | 5,734.42 |
| 232 | 26 | 365.58 | -0.003 | Pressurized | 0.242 | 1 | 1 | 2.167 | 400 |
| 233 | 26 | 114.42 | -0.124 | Pressurized | 0.242 | 1 | 1 | 2.167 | 400 |
| 234 | 26 | 410 | -0.006 | Pressurized | 0.242 | 1 | 1 | 2.167 | 400 |
| 235 | 26 | 150 | -0.002 | Pressurized | 0.242 | 1 | 1 | 2.167 | 400 |
| 236 | 26 | 40 | -0.287 | Pressurized | 0.242 | 1 | 1 | 2.167 | 400 |
| 237 | 26 | 230 | 0.001 | Pressurized | 1.766 | 0.195 | 0.083 | 0.422 | 4,831.40 |
| 238 | 26 | 50 | 0.18 | Free Surface | 11.396 | 0.054 | 0.006 | 0.118 | 69,511.71 |
| 239 | 26 | 10 | 0.136 | Free Surface | 10.347 | 0.058 | 0.007 | 0.126 | 60,421.45 |
| 240 | 26 | 230 | 0.014 | Free Surface | 4.688 | 0.099 | 0.021 | 0.215 | 19,433.99 |
| 241 | 26 | 148.15 | 0.014 | Free Surface | 4.688 | 0.099 | 0.021 | 0.215 | 19,432.10 |
| 242 | 26 | 189 | -0.001 | Pressurized | 0.242 | 1 | 1 | 2.167 | 400 |
| 330 | 26 | 95.59 | -0.001 | Pressurized | 0.242 | 1 | 1 | 2.167 | 400 |
| 243 | 26 | 19.17 | -0.445 | Pressurized | 0.242 | 1 | 1 | 2.167 | 400 |
| 244 | 26 | 64 | -0.154 | Pressurized | 0.242 | 1 | 1 | 2.167 | 400 |
| 331 | 26 | 18 | 0.027 | Pressurized | 5.865 | 0.085 | 0.015 | 0.185 | 26,755.07 |
| 245 | 26 | 96 | 0.212 | Free Surface | 12.072 | 0.052 | 0.005 | 0.113 | 75,526.82 |
| 246 | 26 | 236 | 0.005 | Free Surface | 3.186 | 0.129 | 0.036 | 0.28 | 11,185.67 |
| 247 | 26 | 160 | 0.073 | Free Surface | 8.332 | 0.067 | 0.009 | 0.146 | 44,305.20 |
| 248 | 26 | 290 | 0.004 | Free Surface | 3.075 | 0.133 | 0.038 | 0.287 | 10,626.80 |
| 249 | 26 | 180 | 0.047 | Free Surface | 7.152 | 0.075 | 0.011 | 0.162 | 35,561.77 |
| 250 | 26 | 220 | 0.02 | Free Surface | 5.303 | 0.091 | 0.017 | 0.198 | 23,170.57 |
| 251 | 26 | 690 | -0.001 | Pressurized | 0.242 | 1 | 1 | 2.167 | 400 |
| 252 | 26 | 280 | -0.016 | Pressurized | 0.242 | 1 | 1 | 2.167 | 400 |
| 253 | 26 | 200 | 0 | Pressurized | 0.242 | 1 | 1 | 2.167 | 400 |
| 254 | 26 | 130 | 0 | Pressurized | 0.242 | 1 | 1 | 2.167 | 400 |
| 255 | 26 | 150 | -0.011 | Pressurized | 0.242 | 1 | 1 | 2.167 | 400 |
| 256 | 26 | 355 | -0.032 | Pressurized | 0.242 | 1 | 1 | 2.167 | 400 |
| 257 | 26 | 225 | -0.017 | Pressurized | 0.242 | 1 | 1 | 2.167 | 400 |
| 258 | 26 | 170 | 0.009 | Pressurized | 4.02 | 0.11 | 0.026 | 0.239 | 15,594.00 |
| 259 | 26 | 70 | 0.066 | Free Surface | 8.06 | 0.069 | 0.009 | 0.149 | 42,227.87 |
| 260 | 26 | 110 | 0.157 | Free Surface | 10.885 | 0.056 | 0.006 | 0.122 | 64,975.32 |
| 261 | 26 | 320 | 0.023 | Free Surface | 5.535 | 0.089 | 0.016 | 0.192 | 24,610.21 |
| 262 | 26 | 380 | 0.002 | Free Surface | 2.487 | 0.153 | 0.051 | 0.332 | 7,848.53 |
| 263 | 26 | 720 | 0 | Free Surface | 1.216 | 0.253 | 0.14 | 0.548 | 2,850.91 |
| 264 | 26 | 180 | 0.022 | Free Surface | 5.474 | 0.089 | 0.017 | 0.194 | 24,240.05 |

Table 2 : 400 gpm Steady-State Results

| Pipe ID | Diameter (in) | Length (ft) | Slope | Flow Type | Velocity (fps) | d/D | q/Q | Water Depth (ft) | Full Flow (gpm) |
|---------|---------------|-------------|--------|--------------|----------------|-------|-------|------------------|-----------------|
| 265 | 26 | 109.93 | 0.006 | Free Surface | 3.499 | 0.121 | 0.031 | 0.263 | 12,790.90 |
| 266 | 26 | 533.57 | 0.007 | Free Surface | 3.764 | 0.115 | 0.028 | 0.25 | 14,185.87 |
| 267 | 26 | 160 | 0.018 | Free Surface | 5.062 | 0.094 | 0.018 | 0.204 | 21,674.08 |
| 268 | 26 | 92.5 | 0.06 | Free Surface | 7.773 | 0.07 | 0.01 | 0.153 | 40,060.23 |
| 269 | 26 | 182.95 | 0.005 | Free Surface | 3.369 | 0.125 | 0.033 | 0.27 | 12,113.11 |
| 270 | 26 | 110 | 0.058 | Free Surface | 7.694 | 0.071 | 0.01 | 0.154 | 39,519.86 |
| 271 | 26 | 220 | 0.015 | Free Surface | 4.787 | 0.098 | 0.02 | 0.212 | 20,005.40 |
| 272 | 26 | 460.55 | 0.003 | Free Surface | 2.822 | 0.141 | 0.042 | 0.305 | 9,412.50 |
| 273 | 26 | 362.45 | -0.053 | Pressurized | 0.242 | 1 | 1 | 2.167 | 400 |
| 274 | 26 | 647.08 | -0.019 | Pressurized | 0.242 | 1 | 1 | 2.167 | 400 |
| 275 | 26 | 394.87 | -0.009 | Pressurized | 0.242 | 1 | 1 | 2.167 | 400 |
| 276 | 26 | 287.41 | -0.001 | Pressurized | 0.242 | 1 | 1 | 2.167 | 400 |
| 277 | 26 | 104 | 0.022 | Pressurized | 5.491 | 0.089 | 0.016 | 0.193 | 24,365.14 |
| 278 | 26 | 86 | 0.047 | Free Surface | 7.118 | 0.075 | 0.011 | 0.162 | 35,334.79 |
| 279 | 26 | 250 | 0.002 | Free Surface | 2.368 | 0.159 | 0.055 | 0.344 | 7,327.18 |
| 280 | 26 | 245 | -0.031 | Pressurized | 0.242 | 1 | 1 | 2.167 | 400 |
| 281 | 26 | 205 | -0.001 | Pressurized | 0.242 | 1 | 1 | 2.167 | 400 |
| 282 | 26 | 150 | -0.03 | Pressurized | 0.242 | 1 | 1 | 2.167 | 400 |
| 283 | 26 | 200 | 0 | Pressurized | 0.242 | 1 | 1 | 2.167 | 400 |
| 284 | 26 | 139.32 | -0.007 | Pressurized | 0.242 | 1 | 1 | 2.167 | 400 |
| 285 | 26 | 60.68 | 0.083 | Free Surface | 8.715 | 0.065 | 0.008 | 0.141 | 47,265.54 |
| 286 | 26 | 200 | 0.004 | Free Surface | 2.884 | 0.139 | 0.041 | 0.3 | 9,692.95 |
| 287 | 26 | 285 | 0.018 | Free Surface | 5.067 | 0.094 | 0.018 | 0.204 | 21,701.23 |
| 288 | 26 | 195 | 0.026 | Free Surface | 5.785 | 0.086 | 0.015 | 0.187 | 26,235.50 |
| 289 | 26 | 370 | 0.003 | Free Surface | 2.634 | 0.147 | 0.047 | 0.319 | 8,517.67 |
| 290 | 26 | 280 | 0.002 | Free Surface | 2.469 | 0.154 | 0.051 | 0.334 | 7,771.65 |
| 291 | 26 | 70 | 0.006 | Free Surface | 3.483 | 0.122 | 0.032 | 0.264 | 12,691.04 |
| 292 | 26 | 93 | 0.013 | Free Surface | 4.605 | 0.101 | 0.021 | 0.218 | 18,918.69 |
| 293 | 26 | 67 | 0.1 | Free Surface | 9.302 | 0.062 | 0.008 | 0.135 | 51,849.62 |
| 294 | 26 | 490 | 0.002 | Free Surface | 2.205 | 0.167 | 0.06 | 0.361 | 6,620.16 |
| 295 | 26 | 50 | 0.008 | Free Surface | 3.918 | 0.112 | 0.027 | 0.243 | 15,016.25 |
| 296 | 26 | 420 | -0.007 | Pressurized | 0.242 | 1 | 1 | 2.167 | 400 |
| 297 | 26 | 205 | 0.029 | Free Surface | 6.003 | 0.084 | 0.014 | 0.182 | 27,677.24 |
| 298 | 26 | 34.04 | 0.631 | Free Surface | 17.627 | 0.041 | 0.003 | 0.088 | 130,119.67 |
| 299 | 26 | 700 | -0.022 | Pressurized | 0.242 | 1 | 1 | 2.167 | 400 |
| 300 | 26 | 1,150.00 | 0.012 | Free Surface | 4.445 | 0.103 | 0.022 | 0.223 | 18,012.76 |
| 301 | 26 | 2,450.00 | -0.002 | Pressurized | 0.242 | 1 | 1 | 2.167 | 400 |
| 302 | 26 | 411 | -0.001 | Pressurized | 0.242 | 1 | 1 | 2.167 | 400 |
| 303 | 26 | 98 | 0.205 | Free Surface | 11.927 | 0.053 | 0.005 | 0.114 | 74,182.02 |
| 304 | 26 | 1,524.10 | 0.086 | Free Surface | 8.813 | 0.065 | 0.008 | 0.14 | 47,999.36 |
| 305 | 26 | 6,275.68 | -0.002 | Pressurized | 0.242 | 1 | 1 | 2.167 | 400 |
| 306 | 26 | 400 | 0.076 | Free Surface | 8.457 | 0.067 | 0.009 | 0.144 | 45,212.31 |
| 307 | 26 | 1,600.00 | -0.036 | Pressurized | 0.242 | 1 | 1 | 2.167 | 400 |
| 308 | 30 | 1,900.00 | 0.007 | Free Surface | 3.569 | 0.098 | 0.02 | 0.246 | 19,803.50 |
| 309 | 30 | 600 | -0.04 | Pressurized | 0.182 | 1 | 1 | 2.5 | 400 |
| 310 | 30 | 1,150.00 | -0.038 | Pressurized | 0.182 | 1 | 1 | 2.5 | 400 |
| 311 | 30 | 1,977.71 | -0.005 | Pressurized | 0.182 | 1 | 1 | 2.5 | 400 |
| 312 | 30 | 782.35 | -0.003 | Pressurized | 0.182 | 1 | 1 | 2.5 | 400 |
| 313 | 30 | 1,700.00 | 0.032 | Free Surface | 6.134 | 0.068 | 0.009 | 0.17 | 43,025.13 |
| 314 | 30 | 1,550.00 | -0.01 | Pressurized | 0.182 | 1 | 1 | 2.5 | 400 |
| 315 | 30 | 500 | 0.043 | Free Surface | 6.789 | 0.064 | 0.008 | 0.159 | 49,760.62 |
| 316 | 30 | 250 | -0.258 | Pressurized | 0.182 | 1 | 1 | 2.5 | 400 |
| 317 | 30 | 1,928.00 | -0.004 | Pressurized | 0.182 | 1 | 1 | 2.5 | 400 |
| 318 | 30 | 8 | 0.075 | Pressurized | 8.236 | 0.056 | 0.006 | 0.14 | 65,717.67 |
| 319 | 26 | 414 | 0.029 | Free Surface | 6.029 | 0.084 | 0.014 | 0.181 | 27,847.56 |
| 320 | 30 | 12 | 0.003 | Free Surface | 2.782 | 0.117 | 0.029 | 0.292 | 13,854.50 |
| 321 | 30 | 3,338.00 | 0.002 | Free Surface | 2.471 | 0.127 | 0.034 | 0.316 | 11,696.21 |
| 322 | 30 | 1,400.00 | -0.004 | Pressurized | 0.182 | 1 | 1 | 2.5 | 400 |
| 323 | 30 | 19 | 0.177 | Pressurized | 11.094 | 0.046 | 0.004 | 0.114 | 100,912.36 |
| 324 | 30 | 181 | 0.004 | Pressurized | 2.838 | 0.115 | 0.028 | 0.288 | 14,269.29 |
| 325 | 30 | 640 | 0.005 | Free Surface | 3.133 | 0.108 | 0.024 | 0.269 | 16,429.42 |
| 326 | 30 | 20 | 0.833 | Free Surface | 19.014 | 0.032 | 0.002 | 0.08 | 218,949.35 |
| 327 | 30 | 1,905.00 | 0 | Free Surface | 1.003 | 0.237 | 0.123 | 0.592 | 3,252.66 |

Table 3 : 6,600 gpm Steady-State Results

| Pipe ID | Diameter (in) | Length (ft) | Slope | Flow Type | Velocity (fps) | d/D | q/Q | Water Depth (ft) | Full Flow (gpm) |
|---------|---------------|-------------|--------|--------------|----------------|-------|-------|------------------|-----------------|
| 1 | 26 | 66.1 | 0.058 | Free Surface | 17.677 | 0.277 | 0.167 | 0.6 | 39,438.50 |
| 2 | 26 | 492 | 0.002 | Free Surface | 5.025 | 0.74 | 0.898 | 1.604 | 7,349.48 |
| 3 | 26 | 333 | 0.017 | Free Surface | 11.383 | 0.381 | 0.308 | 0.826 | 21,398.03 |
| 4 | 26 | 206 | 0.002 | Free Surface | 5.441 | 0.688 | 0.818 | 1.49 | 8,071.85 |
| 5 | 26 | 1,000.00 | 0.005 | Free Surface | 7.175 | 0.544 | 0.575 | 1.179 | 11,468.85 |
| 6 | 26 | 500 | 0.004 | Free Surface | 6.637 | 0.58 | 0.637 | 1.256 | 10,362.19 |
| 7 | 26 | 300 | 0.005 | Free Surface | 7.406 | 0.53 | 0.552 | 1.149 | 11,965.23 |
| 8 | 26 | 265 | 0.009 | Free Surface | 9.03 | 0.454 | 0.423 | 0.984 | 15,592.09 |
| 9 | 26 | 313 | -0.029 | Pressurized | 3.988 | 1 | 1 | 2.167 | 6,600.00 |
| 10 | 26 | 69 | 0.153 | Free Surface | 24.965 | 0.217 | 0.103 | 0.47 | 64,035.01 |
| 11 | 26 | 523 | 0 | Pressurized | 3.988 | 1 | 1 | 2.167 | 6,600.00 |
| 12 | 26 | 265 | 0.012 | Free Surface | 10.149 | 0.416 | 0.361 | 0.9 | 18,283.35 |
| 13 | 26 | 538 | 0.003 | Free Surface | 5.873 | 0.643 | 0.743 | 1.392 | 8,878.90 |
| 14 | 26 | 927 | 0.002 | Free Surface | 5.125 | 0.727 | 0.878 | 1.574 | 7,514.48 |
| 15 | 26 | 340 | 0.015 | Free Surface | 10.93 | 0.393 | 0.327 | 0.852 | 20,203.54 |
| 16 | 26 | 514 | 0.034 | Free Surface | 14.653 | 0.317 | 0.218 | 0.687 | 30,300.49 |
| 17 | 26 | 396 | 0.054 | Free Surface | 17.271 | 0.281 | 0.173 | 0.61 | 38,131.84 |
| 328 | 26 | 114 | 0.01 | Free Surface | 9.304 | 0.444 | 0.406 | 0.962 | 16,239.71 |
| 18 | 24 | 16 | 1.437 | Free Surface | 55.488 | 0.139 | 0.042 | 0.278 | 158,646.72 |
| 19 | 24 | 339 | 0.024 | Free Surface | 12.913 | 0.391 | 0.323 | 0.782 | 20,407.48 |
| 20 | 24 | 301.36 | 0.031 | Free Surface | 14.2 | 0.365 | 0.284 | 0.729 | 23,262.35 |
| 21 | 24 | 179.64 | 0.101 | Free Surface | 21.704 | 0.268 | 0.157 | 0.536 | 41,999.04 |
| 22 | 24 | 725 | -0.006 | Pressurized | 4.681 | 1 | 1 | 2 | 6,600.00 |
| 23 | 24 | 22.49 | -0.036 | Pressurized | 4.681 | 1 | 1 | 2 | 6,600.00 |
| 24 | 24 | 404.51 | -0.02 | Pressurized | 4.681 | 1 | 1 | 2 | 6,600.00 |
| 25 | 24 | 538 | -0.02 | Pressurized | 4.681 | 1 | 1 | 2 | 6,600.00 |
| 26 | 24 | 240 | -0.001 | Pressurized | 4.681 | 1 | 1 | 2 | 6,600.00 |
| 27 | 24 | 220 | 0.027 | Free Surface | 13.476 | 0.379 | 0.305 | 0.758 | 21,655.49 |
| 28 | 24 | 360 | 0.005 | Free Surface | 7.286 | 0.613 | 0.694 | 1.226 | 9,513.21 |
| 29 | 24 | 290 | 0.01 | Free Surface | 9.235 | 0.505 | 0.509 | 1.011 | 12,958.21 |
| 30 | 24 | 225 | 0.105 | Free Surface | 22.041 | 0.265 | 0.154 | 0.53 | 42,881.53 |
| 31 | 24 | 405 | 0.009 | Free Surface | 9.025 | 0.515 | 0.525 | 1.029 | 12,581.56 |
| 32 | 24 | 155 | 0.002 | Pressurized | 4.681 | 1 | 1.035 | 2 | 6,378.33 |
| 33 | 24 | 180 | 0.013 | Free Surface | 10.38 | 0.461 | 0.436 | 0.923 | 15,154.49 |
| 34 | 24 | 140 | 0.006 | Free Surface | 7.581 | 0.593 | 0.66 | 1.186 | 10,004.67 |
| 35 | 24 | 260 | 0.027 | Free Surface | 13.523 | 0.378 | 0.303 | 0.756 | 21,747.21 |
| 36 | 24 | 250 | 0.008 | Free Surface | 8.803 | 0.525 | 0.543 | 1.05 | 12,158.86 |
| 37 | 24 | 255 | 0.027 | Free Surface | 13.57 | 0.377 | 0.302 | 0.754 | 21,849.62 |
| 38 | 24 | 160 | 0.131 | Free Surface | 23.876 | 0.25 | 0.138 | 0.501 | 47,982.32 |
| 39 | 24 | 760 | 0.007 | Free Surface | 8.273 | 0.552 | 0.588 | 1.104 | 11,217.89 |
| 40 | 24 | 100 | 0.004 | Free Surface | 6.573 | 0.67 | 0.788 | 1.34 | 8,370.50 |
| 41 | 24 | 60 | -0.023 | Pressurized | 4.681 | 1 | 1 | 2 | 6,600.00 |
| 42 | 24 | 40 | 0.65 | Free Surface | 41.983 | 0.169 | 0.062 | 0.337 | 106,703.41 |
| 43 | 24 | 800 | 0.002 | Pressurized | 4.681 | 1 | 1.159 | 2 | 5,692.56 |
| 44 | 24 | 120 | 0.12 | Free Surface | 23.142 | 0.256 | 0.144 | 0.512 | 45,894.87 |
| 45 | 24 | 390 | 0.039 | Free Surface | 15.409 | 0.343 | 0.254 | 0.687 | 26,033.58 |
| 46 | 24 | 600 | 0.004 | Free Surface | 6.346 | 0.691 | 0.824 | 1.383 | 8,014.15 |
| 47 | 24 | 170 | 0.072 | Free Surface | 19.284 | 0.292 | 0.185 | 0.583 | 35,585.50 |
| 48 | 24 | 230 | 0.086 | Free Surface | 20.493 | 0.279 | 0.17 | 0.559 | 38,743.69 |
| 49 | 24 | 560 | 0 | Pressurized | 4.681 | 1 | 2.707 | 2 | 2,437.84 |
| 50 | 24 | 60 | 0.144 | Free Surface | 24.687 | 0.245 | 0.131 | 0.489 | 50,310.14 |
| 51 | 24 | 130 | 0.029 | Free Surface | 13.959 | 0.369 | 0.291 | 0.738 | 22,716.91 |
| 52 | 30 | 450 | 0.005 | Free Surface | 7.404 | 0.425 | 0.376 | 1.062 | 17,561.19 |
| 53 | 30 | 750 | 0.004 | Free Surface | 6.397 | 0.475 | 0.458 | 1.188 | 14,398.02 |
| 54 | 30 | 115 | 0.001 | Pressurized | 2.996 | 1 | 1.115 | 2.5 | 5,920.41 |
| 55 | 30 | 70 | -0.058 | Pressurized | 2.996 | 1 | 1 | 2.5 | 6,600.00 |
| 56 | 30 | 115 | 0.037 | Free Surface | 14.891 | 0.255 | 0.143 | 0.638 | 46,293.98 |
| 57 | 30 | 250 | -0.007 | Pressurized | 2.996 | 1 | 1 | 2.5 | 6,600.00 |
| 58 | 30 | 110 | 0.019 | Free Surface | 11.672 | 0.304 | 0.2 | 0.759 | 32,918.53 |
| 59 | 30 | 200 | 0.001 | Free Surface | 4.388 | 0.646 | 0.749 | 1.614 | 8,816.95 |
| 60 | 30 | 245 | -0.043 | Pressurized | 2.996 | 1 | 1 | 2.5 | 6,600.00 |
| 61 | 30 | 245 | -0.002 | Pressurized | 2.996 | 1 | 1 | 2.5 | 6,600.00 |
| 62 | 30 | 465 | -0.006 | Pressurized | 2.996 | 1 | 1 | 2.5 | 6,600.00 |
| 63 | 30 | 135 | -0.012 | Pressurized | 2.996 | 1 | 1 | 2.5 | 6,600.00 |
| 64 | 30 | 240 | -0.07 | Pressurized | 2.996 | 1 | 1 | 2.5 | 6,600.00 |
| 65 | 30 | 560 | -0.003 | Pressurized | 2.996 | 1 | 1 | 2.5 | 6,600.00 |
| 66 | 30 | 400 | -0.005 | Pressurized | 2.996 | 1 | 1 | 2.5 | 6,600.00 |

Table 3 : 6,600 gpm Steady-State Results

| Pipe ID | Diameter (in) | Length (ft) | Slope | Flow Type | Velocity (fps) | d/D | q/Q | Water Depth (ft) | Full Flow (gpm) |
|---------|---------------|-------------|--------|--------------|----------------|-------|-------|------------------|-----------------|
| 67 | 30 | 300 | -0.009 | Pressurized | 2.996 | 1 | 1 | 2.5 | 6,600.00 |
| 68 | 30 | 170 | -0.043 | Pressurized | 2.996 | 1 | 1 | 2.5 | 6,600.00 |
| 69 | 30 | 50 | -0.007 | Pressurized | 2.996 | 1 | 1 | 2.5 | 6,600.00 |
| 70 | 30 | 300 | -0.003 | Pressurized | 2.996 | 1 | 1 | 2.5 | 6,600.00 |
| 71 | 30 | 80 | -0.055 | Pressurized | 2.996 | 1 | 1 | 2.5 | 6,600.00 |
| 72 | 30 | 64.75 | -0.018 | Pressurized | 2.996 | 1 | 1 | 2.5 | 6,600.00 |
| 73 | 30 | 520.25 | 0.017 | Free Surface | 11.318 | 0.311 | 0.209 | 0.776 | 31,527.07 |
| 74 | 30 | 435 | 0.003 | Free Surface | 6.113 | 0.492 | 0.487 | 1.23 | 13,564.83 |
| 75 | 30 | 410 | -0.014 | Pressurized | 2.996 | 1 | 1 | 2.5 | 6,600.00 |
| 76 | 30 | 100 | -0.05 | Pressurized | 2.996 | 1 | 1 | 2.5 | 6,600.00 |
| 77 | 30 | 311.23 | -0.029 | Pressurized | 2.996 | 1 | 1 | 2.5 | 6,600.00 |
| 78 | 30 | 533.77 | -0.005 | Pressurized | 2.996 | 1 | 1 | 2.5 | 6,600.00 |
| 79 | 30 | 125 | -0.054 | Pressurized | 2.996 | 1 | 1 | 2.5 | 6,600.00 |
| 80 | 30 | 64.68 | -0.008 | Pressurized | 2.996 | 1 | 1 | 2.5 | 6,600.00 |
| 81 | 30 | 535.32 | -0.007 | Pressurized | 2.996 | 1 | 1 | 2.5 | 6,600.00 |
| 82 | 30 | 285 | -0.008 | Pressurized | 2.996 | 1 | 1 | 2.5 | 6,600.00 |
| 83 | 30 | 189 | -0.035 | Pressurized | 2.996 | 1 | 1 | 2.5 | 6,600.00 |
| 84 | 30 | 26 | 0.008 | Pressurized | 8.448 | 0.385 | 0.314 | 0.962 | 21,046.50 |
| 85 | 30 | 30 | 0.193 | Free Surface | 26.674 | 0.17 | 0.063 | 0.424 | 105,512.74 |
| 86 | 30 | 30 | 0.001 | Free Surface | 3.882 | 0.721 | 0.87 | 1.802 | 7,588.42 |
| 87 | 30 | 40 | 0.03 | Free Surface | 13.873 | 0.268 | 0.157 | 0.671 | 41,908.44 |
| 88 | 24 | 42.06 | -0.149 | Pressurized | 4.681 | 1 | 1 | 2 | 6,600.00 |
| 89 | 24 | 55 | 0.086 | Pressurized | 20.493 | 0.279 | 0.17 | 0.559 | 38,771.38 |
| 90 | 24 | 40 | -0.007 | Pressurized | 4.681 | 1 | 1 | 2 | 6,600.00 |
| 91 | 24 | 108 | -0.156 | Pressurized | 4.681 | 1 | 1 | 2 | 6,600.00 |
| 92 | 24 | 262 | -0.012 | Pressurized | 4.681 | 1 | 1 | 2 | 6,600.00 |
| 93 | 24 | 230 | -0.03 | Pressurized | 4.681 | 1 | 1 | 2 | 6,600.00 |
| 94 | 24 | 355 | -0.012 | Pressurized | 4.681 | 1 | 1 | 2 | 6,600.00 |
| 95 | 24 | 315 | 0.002 | Pressurized | 4.681 | 1 | 1.252 | 2 | 5,272.92 |
| 96 | 24 | 95 | 0.087 | Free Surface | 20.644 | 0.278 | 0.169 | 0.556 | 39,120.00 |
| 97 | 24 | 285 | -0.004 | Pressurized | 4.681 | 1 | 1 | 2 | 6,600.00 |
| 98 | 24 | 250 | -0.033 | Pressurized | 4.681 | 1 | 1 | 2 | 6,600.00 |
| 99 | 24 | 100 | 0.01 | Pressurized | 9.385 | 0.499 | 0.499 | 0.998 | 13,234.93 |
| 100 | 24 | 100 | 0.088 | Free Surface | 20.695 | 0.277 | 0.168 | 0.555 | 39,261.14 |
| 101 | 24 | 136 | 0.014 | Free Surface | 10.643 | 0.453 | 0.421 | 0.905 | 15,684.43 |
| 102 | 24 | 764 | -0.007 | Pressurized | 4.681 | 1 | 1 | 2 | 6,600.00 |
| 103 | 24 | 70 | 0.007 | Pressurized | 8.255 | 0.553 | 0.59 | 1.105 | 11,185.56 |
| 104 | 24 | 50 | 0.112 | Free Surface | 22.565 | 0.261 | 0.149 | 0.521 | 44,292.54 |
| 105 | 24 | 40 | 0.02 | Free Surface | 12.119 | 0.41 | 0.353 | 0.82 | 18,717.02 |
| 106 | 24 | 320 | 0.007 | Free Surface | 7.994 | 0.567 | 0.616 | 1.135 | 10,721.52 |
| 107 | 24 | 550 | 0.007 | Free Surface | 8.318 | 0.549 | 0.585 | 1.099 | 11,286.79 |
| 108 | 24 | 190 | 0.007 | Free Surface | 8.355 | 0.547 | 0.581 | 1.095 | 11,360.80 |
| 109 | 24 | 130 | 0.025 | Free Surface | 13.077 | 0.387 | 0.318 | 0.775 | 20,764.67 |
| 110 | 24 | 100 | 0.099 | Free Surface | 21.594 | 0.269 | 0.158 | 0.538 | 41,642.73 |
| 111 | 24 | 579 | 0.038 | Free Surface | 15.35 | 0.344 | 0.255 | 0.688 | 25,915.45 |
| 112 | 24 | 891 | 0.014 | Free Surface | 10.539 | 0.456 | 0.426 | 0.912 | 15,486.84 |
| 113 | 24 | 350 | -0.003 | Pressurized | 4.681 | 1 | 1 | 2 | 6,600.00 |
| 114 | 24 | 114 | -0.114 | Pressurized | 4.681 | 1 | 1 | 2 | 6,600.00 |
| 115 | 24 | 77 | -0.013 | Pressurized | 4.681 | 1 | 1 | 2 | 6,600.00 |
| 116 | 24 | 63 | 0.171 | Free Surface | 26.228 | 0.234 | 0.12 | 0.469 | 54,797.81 |
| 117 | 24 | 91 | 0.084 | Free Surface | 20.294 | 0.281 | 0.173 | 0.563 | 38,247.91 |
| 118 | 24 | 179 | -0.021 | Pressurized | 4.681 | 1 | 1 | 2 | 6,600.00 |
| 119 | 24 | 280 | 0.004 | Pressurized | 6.65 | 0.663 | 0.778 | 1.326 | 8,481.87 |
| 120 | 24 | 576 | -0.01 | Pressurized | 4.681 | 1 | 1 | 2 | 6,600.00 |
| 121 | 24 | 50 | 0.012 | Pressurized | 10.035 | 0.474 | 0.455 | 0.947 | 14,498.14 |
| 122 | 24 | 140 | 0.029 | Pressurized | 13.811 | 0.372 | 0.295 | 0.744 | 22,371.11 |
| 123 | 24 | 50 | -0.052 | Pressurized | 4.681 | 1 | 1 | 2 | 6,600.00 |
| 124 | 24 | 530 | 0.006 | Pressurized | 7.551 | 0.595 | 0.663 | 1.189 | 9,957.36 |
| 125 | 24 | 364 | 0.019 | Free Surface | 11.819 | 0.418 | 0.365 | 0.836 | 18,089.45 |
| 126 | 24 | 78 | 0.131 | Free Surface | 23.843 | 0.251 | 0.138 | 0.501 | 47,860.19 |
| 127 | 24 | 573 | 0.012 | Free Surface | 9.942 | 0.477 | 0.461 | 0.954 | 14,311.39 |
| 128 | 24 | 632 | 0.035 | Free Surface | 14.859 | 0.353 | 0.267 | 0.705 | 24,749.09 |
| 129 | 24 | 888 | -0.003 | Pressurized | 4.681 | 1 | 1 | 2 | 6,600.00 |
| 130 | 24 | 705 | 0.014 | Free Surface | 10.688 | 0.451 | 0.419 | 0.902 | 15,762.57 |
| 131 | 24 | 528 | 0.009 | Free Surface | 8.834 | 0.523 | 0.54 | 1.047 | 12,218.30 |
| 132 | 24 | 360 | 0.008 | Free Surface | 8.534 | 0.538 | 0.565 | 1.076 | 11,672.11 |
| 133 | 24 | 152 | 0.035 | Free Surface | 14.831 | 0.353 | 0.267 | 0.706 | 24,713.70 |

Table 3 : 6,600 gpm Steady-State Results

| Pipe ID | Diameter (in) | Length (ft) | Slope | Flow Type | Velocity (fps) | d/D | q/Q | Water Depth (ft) | Full Flow (gpm) |
|---------|---------------|-------------|--------|--------------|----------------|-------|-------|------------------|-----------------|
| 134 | 24 | 490 | 0.001 | Pressurized | 4.681 | 1 | 1.745 | 2 | 3,781.41 |
| 135 | 24 | 110 | -0.073 | Pressurized | 4.681 | 1 | 1 | 2 | 6,600.00 |
| 136 | 24 | 46 | 0 | Pressurized | 4.681 | 1 | 1 | 2 | 6,600.00 |
| 137 | 24 | 61 | 0.103 | Free Surface | 21.9 | 0.266 | 0.155 | 0.533 | 42,533.09 |
| 138 | 24 | 31.6 | 0.041 | Free Surface | 15.745 | 0.338 | 0.246 | 0.676 | 26,844.16 |
| 139 | 24 | 441.4 | 0.006 | Free Surface | 7.551 | 0.595 | 0.663 | 1.189 | 9,960.37 |
| 140 | 24 | 549 | -0.008 | Pressurized | 4.681 | 1 | 1 | 2 | 6,600.00 |
| 141 | 24 | 521 | 0.005 | Pressurized | 6.967 | 0.637 | 0.735 | 1.273 | 8,982.73 |
| 142 | 24 | 28 | -0.064 | Pressurized | 4.681 | 1 | 1 | 2 | 6,600.00 |
| 143 | 24 | 242 | -0.02 | Pressurized | 4.681 | 1 | 1 | 2 | 6,600.00 |
| 144 | 24 | 440 | -0.021 | Pressurized | 4.681 | 1 | 1 | 2 | 6,600.00 |
| 145 | 24 | 260 | -0.031 | Pressurized | 4.681 | 1 | 1 | 2 | 6,600.00 |
| 146 | 24 | 190 | 0 | Pressurized | 4.681 | 1 | 1 | 2 | 6,600.00 |
| 147 | 24 | 68 | 0.026 | Pressurized | 13.429 | 0.38 | 0.307 | 0.76 | 21,532.94 |
| 148 | 24 | 102 | 0.153 | Free Surface | 25.183 | 0.241 | 0.128 | 0.482 | 51,758.76 |
| 149 | 24 | 370 | 0.003 | Free Surface | 5.683 | 0.768 | 0.936 | 1.535 | 7,050.43 |
| 150 | 24 | 130 | -0.032 | Pressurized | 4.681 | 1 | 1 | 2 | 6,600.00 |
| 151 | 24 | 156 | -0.024 | Pressurized | 4.681 | 1 | 1 | 2 | 6,600.00 |
| 329 | 24 | 143 | 0.003 | Pressurized | 6.22 | 0.704 | 0.843 | 1.408 | 7,825.98 |
| 152 | 24 | 473 | 0.018 | Free Surface | 11.656 | 0.422 | 0.372 | 0.845 | 17,731.48 |
| 153 | 24 | 378 | 0.002 | Pressurized | 4.681 | 1 | 1.016 | 2 | 6,493.76 |
| 154 | 24 | 570 | 0.004 | Free Surface | 6.478 | 0.679 | 0.803 | 1.357 | 8,222.34 |
| 155 | 24 | 685.5 | 0.031 | Free Surface | 14.162 | 0.365 | 0.285 | 0.73 | 23,164.75 |
| 156 | 24 | 735.5 | -0.012 | Pressurized | 4.681 | 1 | 1 | 2 | 6,600.00 |
| 157 | 24 | 129 | 0.004 | Pressurized | 6.498 | 0.677 | 0.801 | 1.354 | 8,239.71 |
| 158 | 24 | 30 | 0.33 | Free Surface | 33.059 | 0.199 | 0.087 | 0.398 | 76,028.88 |
| 159 | 24 | 106 | 0.031 | Free Surface | 14.239 | 0.364 | 0.283 | 0.728 | 23,352.08 |
| 160 | 24 | 114 | 0.068 | Free Surface | 18.909 | 0.296 | 0.191 | 0.592 | 34,619.16 |
| 161 | 24 | 390 | -0.021 | Pressurized | 4.681 | 1 | 1 | 2 | 6,600.00 |
| 162 | 24 | 80 | 0.013 | Pressurized | 10.198 | 0.468 | 0.446 | 0.936 | 14,797.10 |
| 163 | 24 | 90 | 0.087 | Free Surface | 20.593 | 0.278 | 0.169 | 0.557 | 38,962.58 |
| 164 | 24 | 80 | 0.045 | Free Surface | 16.258 | 0.33 | 0.235 | 0.66 | 28,075.52 |
| 165 | 24 | 130 | 0.043 | Free Surface | 16.014 | 0.334 | 0.24 | 0.667 | 27,469.07 |
| 166 | 24 | 140 | 0.025 | Free Surface | 13.155 | 0.386 | 0.315 | 0.771 | 20,926.26 |
| 167 | 24 | 30 | 0.217 | Free Surface | 28.52 | 0.221 | 0.107 | 0.442 | 61,605.24 |
| 168 | 24 | 190 | 0.029 | Free Surface | 13.872 | 0.371 | 0.293 | 0.742 | 22,517.81 |
| 169 | 24 | 83 | 0.038 | Free Surface | 15.29 | 0.345 | 0.256 | 0.69 | 25,742.30 |
| 170 | 24 | 307 | 0.017 | Free Surface | 11.378 | 0.43 | 0.385 | 0.86 | 17,158.42 |
| 171 | 24 | 130 | 0.036 | Free Surface | 15.029 | 0.35 | 0.262 | 0.699 | 25,165.11 |
| 172 | 24 | 50 | 0.16 | Free Surface | 25.584 | 0.239 | 0.125 | 0.477 | 52,939.72 |
| 173 | 24 | 220 | 0.019 | Free Surface | 12.005 | 0.413 | 0.358 | 0.826 | 18,460.02 |
| 174 | 24 | 210 | 0.03 | Free Surface | 13.984 | 0.369 | 0.29 | 0.737 | 22,777.56 |
| 175 | 24 | 50 | 0.642 | Free Surface | 41.809 | 0.169 | 0.062 | 0.338 | 106,044.74 |
| 176 | 24 | 1,250.00 | 0.002 | Pressurized | 4.681 | 1 | 1.279 | 2 | 5,159.93 |
| 177 | 24 | 245 | 0.016 | Free Surface | 11.26 | 0.434 | 0.39 | 0.867 | 16,910.97 |
| 178 | 24 | 125 | 0.089 | Free Surface | 20.746 | 0.277 | 0.167 | 0.554 | 39,439.20 |
| 179 | 24 | 440 | 0.007 | Free Surface | 8.318 | 0.549 | 0.585 | 1.099 | 11,286.79 |
| 180 | 24 | 320 | -0.048 | Pressurized | 4.681 | 1 | 1 | 2 | 6,600.00 |
| 181 | 24 | 100 | 0.008 | Pressurized | 8.622 | 0.534 | 0.558 | 1.067 | 11,837.68 |
| 182 | 24 | 70 | 0.26 | Free Surface | 30.416 | 0.211 | 0.098 | 0.422 | 67,485.16 |
| 183 | 24 | 202 | 0.005 | Free Surface | 7.434 | 0.603 | 0.676 | 1.205 | 9,766.58 |
| 184 | 24 | 173 | 0.027 | Free Surface | 13.546 | 0.377 | 0.303 | 0.755 | 21,814.61 |
| 185 | 24 | 175 | 0.013 | Free Surface | 10.211 | 0.467 | 0.445 | 0.935 | 14,839.32 |
| 186 | 24 | 215 | -0.009 | Pressurized | 4.681 | 1 | 1 | 2 | 6,600.00 |
| 187 | 24 | 105 | 0.038 | Free Surface | 15.32 | 0.345 | 0.255 | 0.689 | 25,831.94 |
| 188 | 24 | 200 | -0.03 | Pressurized | 4.681 | 1 | 1 | 2 | 6,600.00 |
| 189 | 24 | 100 | 0.02 | Pressurized | 12.119 | 0.41 | 0.353 | 0.82 | 18,717.02 |
| 190 | 24 | 200 | 0.041 | Free Surface | 15.777 | 0.337 | 0.246 | 0.675 | 26,880.27 |
| 191 | 24 | 77.9 | -0.004 | Pressurized | 4.681 | 1 | 1 | 2 | 6,600.00 |
| 192 | 26 | 53 | -0.049 | Pressurized | 3.988 | 1 | 1 | 2.167 | 6,600.00 |
| 193 | 26 | 57 | 0 | Pressurized | 3.988 | 1 | 2.151 | 2.167 | 3,069.02 |
| 194 | 26 | 20 | 0.285 | Free Surface | 31.133 | 0.186 | 0.075 | 0.403 | 87,543.68 |
| 195 | 26 | 120 | 0.019 | Free Surface | 11.789 | 0.372 | 0.294 | 0.805 | 22,434.81 |
| 196 | 26 | 240 | 0.04 | Free Surface | 15.436 | 0.305 | 0.202 | 0.661 | 32,597.02 |
| 197 | 26 | 280 | 0.005 | Free Surface | 7.223 | 0.541 | 0.57 | 1.172 | 11,585.29 |
| 198 | 26 | 400 | -0.018 | Pressurized | 3.988 | 1 | 1 | 2.167 | 6,600.00 |
| 199 | 26 | 380 | -0.016 | Pressurized | 3.988 | 1 | 1 | 2.167 | 6,600.00 |

Table 3 : 6,600 gpm Steady-State Results

| Pipe ID | Diameter (in) | Length (ft) | Slope | Flow Type | Velocity (fps) | d/D | q/Q | Water Depth (ft) | Full Flow (gpm) |
|---------|---------------|-------------|--------|--------------|----------------|-------|-------|------------------|-----------------|
| 200 | 26 | 167 | -0.016 | Pressurized | 3.988 | 1 | 1 | 2.167 | 6,600.00 |
| 201 | 26 | 40 | -0.083 | Pressurized | 3.988 | 1 | 1 | 2.167 | 6,600.00 |
| 202 | 26 | 188 | -0.01 | Pressurized | 3.988 | 1 | 1 | 2.167 | 6,600.00 |
| 203 | 26 | 82 | -0.026 | Pressurized | 3.988 | 1 | 1 | 2.167 | 6,600.00 |
| 204 | 26 | 203 | -0.001 | Pressurized | 3.988 | 1 | 1 | 2.167 | 6,600.00 |
| 205 | 26 | 349 | -0.016 | Pressurized | 3.988 | 1 | 1 | 2.167 | 6,600.00 |
| 206 | 26 | 341 | -0.01 | Pressurized | 3.988 | 1 | 1 | 2.167 | 6,600.00 |
| 207 | 26 | 160 | -0.041 | Pressurized | 3.988 | 1 | 1 | 2.167 | 6,600.00 |
| 208 | 26 | 470 | -0.011 | Pressurized | 3.988 | 1 | 1 | 2.167 | 6,600.00 |
| 209 | 26 | 510 | -0.036 | Pressurized | 3.988 | 1 | 1 | 2.167 | 6,600.00 |
| 210 | 26 | 730 | -0.021 | Pressurized | 3.988 | 1 | 1 | 2.167 | 6,600.00 |
| 211 | 26 | 460 | -0.003 | Pressurized | 3.988 | 1 | 1 | 2.167 | 6,600.00 |
| 212 | 26 | 300 | -0.035 | Pressurized | 3.988 | 1 | 1 | 2.167 | 6,600.00 |
| 213 | 26 | 500 | -0.014 | Pressurized | 3.988 | 1 | 1 | 2.167 | 6,600.00 |
| 214 | 26 | 470 | -0.006 | Pressurized | 3.988 | 1 | 1 | 2.167 | 6,600.00 |
| 215 | 26 | 380 | 0.004 | Pressurized | 6.359 | 0.601 | 0.673 | 1.301 | 9,801.65 |
| 216 | 26 | 200 | 0.011 | Pressurized | 9.768 | 0.428 | 0.381 | 0.927 | 17,339.27 |
| 217 | 26 | 50 | 0.011 | Pressurized | 9.768 | 0.428 | 0.381 | 0.927 | 17,339.27 |
| 218 | 26 | 650 | 0.011 | Free Surface | 9.68 | 0.431 | 0.385 | 0.933 | 17,147.67 |
| 219 | 26 | 800 | 0.005 | Free Surface | 7.175 | 0.544 | 0.575 | 1.179 | 11,479.08 |
| 220 | 26 | 410 | 0.013 | Free Surface | 10.31 | 0.411 | 0.354 | 0.89 | 18,650.90 |
| 221 | 26 | 290 | 0.025 | Free Surface | 13.104 | 0.344 | 0.254 | 0.745 | 25,994.66 |
| 222 | 26 | 320.5 | 0.074 | Free Surface | 19.303 | 0.26 | 0.148 | 0.563 | 44,591.09 |
| 223 | 26 | 679.5 | 0.056 | Free Surface | 17.461 | 0.279 | 0.17 | 0.605 | 38,765.67 |
| 224 | 26 | 960 | 0.003 | Free Surface | 5.601 | 0.67 | 0.789 | 1.451 | 8,360.96 |
| 225 | 26 | 100 | 0.065 | Free Surface | 18.423 | 0.269 | 0.158 | 0.582 | 41,771.34 |
| 226 | 26 | 150 | 0.033 | Free Surface | 14.514 | 0.319 | 0.221 | 0.691 | 29,913.08 |
| 227 | 26 | 100 | 0.018 | Free Surface | 11.613 | 0.376 | 0.3 | 0.814 | 21,981.53 |
| 228 | 26 | 100 | 0.066 | Free Surface | 18.541 | 0.268 | 0.157 | 0.58 | 42,091.43 |
| 229 | 26 | 100 | 0.204 | Free Surface | 27.634 | 0.202 | 0.089 | 0.437 | 74,000.87 |
| 230 | 26 | 430 | 0.037 | Free Surface | 15.101 | 0.31 | 0.209 | 0.672 | 31,624.14 |
| 231 | 26 | 400 | 0.001 | Pressurized | 3.988 | 1 | 1.151 | 2.167 | 5,734.42 |
| 232 | 26 | 365.58 | -0.003 | Pressurized | 3.988 | 1 | 1 | 2.167 | 6,600.00 |
| 233 | 26 | 114.42 | -0.124 | Pressurized | 3.988 | 1 | 1 | 2.167 | 6,600.00 |
| 234 | 26 | 410 | -0.006 | Pressurized | 3.988 | 1 | 1 | 2.167 | 6,600.00 |
| 235 | 26 | 150 | -0.002 | Pressurized | 3.988 | 1 | 1 | 2.167 | 6,600.00 |
| 236 | 26 | 40 | -0.287 | Pressurized | 3.988 | 1 | 1 | 2.167 | 6,600.00 |
| 237 | 26 | 230 | 0.001 | Pressurized | 3.988 | 1 | 1.366 | 2.167 | 4,831.40 |
| 238 | 26 | 50 | 0.18 | Free Surface | 26.439 | 0.208 | 0.095 | 0.451 | 69,511.71 |
| 239 | 26 | 10 | 0.136 | Free Surface | 23.961 | 0.223 | 0.109 | 0.483 | 60,421.45 |
| 240 | 26 | 230 | 0.014 | Free Surface | 10.611 | 0.402 | 0.34 | 0.871 | 19,433.99 |
| 241 | 26 | 148.15 | 0.014 | Free Surface | 10.611 | 0.402 | 0.34 | 0.871 | 19,432.10 |
| 242 | 26 | 189 | -0.001 | Pressurized | 3.988 | 1 | 1 | 2.167 | 6,600.00 |
| 330 | 26 | 95.59 | -0.001 | Pressurized | 3.988 | 1 | 1 | 2.167 | 6,600.00 |
| 243 | 26 | 19.17 | -0.445 | Pressurized | 3.988 | 1 | 1 | 2.167 | 6,600.00 |
| 244 | 26 | 64 | -0.154 | Pressurized | 3.988 | 1 | 1 | 2.167 | 6,600.00 |
| 331 | 26 | 18 | 0.027 | Pressurized | 13.39 | 0.338 | 0.247 | 0.733 | 26,755.07 |
| 245 | 26 | 96 | 0.212 | Free Surface | 28.07 | 0.2 | 0.087 | 0.433 | 75,526.82 |
| 246 | 26 | 236 | 0.005 | Free Surface | 7.034 | 0.553 | 0.59 | 1.198 | 11,185.67 |
| 247 | 26 | 160 | 0.073 | Free Surface | 19.227 | 0.261 | 0.149 | 0.565 | 44,305.20 |
| 248 | 26 | 290 | 0.004 | Free Surface | 6.769 | 0.57 | 0.621 | 1.236 | 10,626.80 |
| 249 | 26 | 180 | 0.047 | Free Surface | 16.431 | 0.292 | 0.186 | 0.632 | 35,561.77 |
| 250 | 26 | 220 | 0.02 | Free Surface | 12.067 | 0.365 | 0.285 | 0.791 | 23,170.57 |
| 251 | 26 | 690 | -0.001 | Pressurized | 3.988 | 1 | 1 | 2.167 | 6,600.00 |
| 252 | 26 | 280 | -0.016 | Pressurized | 3.988 | 1 | 1 | 2.167 | 6,600.00 |
| 253 | 26 | 200 | 0 | Pressurized | 3.988 | 1 | 1 | 2.167 | 6,600.00 |
| 254 | 26 | 130 | 0 | Pressurized | 3.988 | 1 | 1 | 2.167 | 6,600.00 |
| 255 | 26 | 150 | -0.011 | Pressurized | 3.988 | 1 | 1 | 2.167 | 6,600.00 |
| 256 | 26 | 355 | -0.032 | Pressurized | 3.988 | 1 | 1 | 2.167 | 6,600.00 |
| 257 | 26 | 225 | -0.017 | Pressurized | 3.988 | 1 | 1 | 2.167 | 6,600.00 |
| 258 | 26 | 170 | 0.009 | Pressurized | 9.03 | 0.454 | 0.423 | 0.984 | 15,594.00 |
| 259 | 26 | 70 | 0.066 | Free Surface | 18.565 | 0.267 | 0.156 | 0.579 | 42,227.87 |
| 260 | 26 | 110 | 0.157 | Free Surface | 25.208 | 0.215 | 0.102 | 0.467 | 64,975.32 |
| 261 | 26 | 320 | 0.023 | Free Surface | 12.613 | 0.354 | 0.268 | 0.766 | 24,610.21 |
| 262 | 26 | 380 | 0.002 | Free Surface | 5.316 | 0.702 | 0.841 | 1.521 | 7,848.53 |
| 263 | 26 | 720 | 0 | Pressurized | 3.988 | 1 | 2.315 | 2.167 | 2,850.91 |
| 264 | 26 | 180 | 0.022 | Free Surface | 12.472 | 0.356 | 0.272 | 0.772 | 24,240.05 |

Table 3 : 6,600 gpm Steady-State Results

| Pipe ID | Diameter (in) | Length (ft) | Slope | Flow Type | Velocity (fps) | d/D | q/Q | Water Depth (ft) | Full Flow (gpm) |
|---------|---------------|-------------|--------|--------------|----------------|-------|-------|------------------|-----------------|
| 265 | 26 | 109.93 | 0.006 | Free Surface | 7.792 | 0.509 | 0.516 | 1.103 | 12,790.90 |
| 266 | 26 | 533.57 | 0.007 | Free Surface | 8.416 | 0.479 | 0.465 | 1.039 | 14,185.87 |
| 267 | 26 | 160 | 0.018 | Free Surface | 11.502 | 0.378 | 0.305 | 0.82 | 21,674.08 |
| 268 | 26 | 92.5 | 0.06 | Free Surface | 17.897 | 0.274 | 0.165 | 0.595 | 40,060.23 |
| 269 | 26 | 182.95 | 0.005 | Free Surface | 7.475 | 0.526 | 0.545 | 1.14 | 12,113.11 |
| 270 | 26 | 110 | 0.058 | Free Surface | 17.72 | 0.276 | 0.167 | 0.599 | 39,519.86 |
| 271 | 26 | 220 | 0.015 | Free Surface | 10.84 | 0.396 | 0.33 | 0.857 | 20,005.40 |
| 272 | 26 | 460.55 | 0.003 | Free Surface | 6.156 | 0.617 | 0.701 | 1.337 | 9,412.50 |
| 273 | 26 | 362.45 | -0.053 | Pressurized | 3.988 | 1 | 1 | 2.167 | 6,600.00 |
| 274 | 26 | 647.08 | -0.019 | Pressurized | 3.988 | 1 | 1 | 2.167 | 6,600.00 |
| 275 | 26 | 394.87 | -0.009 | Pressurized | 3.988 | 1 | 1 | 2.167 | 6,600.00 |
| 276 | 26 | 287.41 | -0.001 | Pressurized | 3.988 | 1 | 1 | 2.167 | 6,600.00 |
| 277 | 26 | 104 | 0.022 | Pressurized | 12.519 | 0.355 | 0.271 | 0.77 | 24,365.14 |
| 278 | 26 | 86 | 0.047 | Free Surface | 16.355 | 0.293 | 0.187 | 0.634 | 35,334.79 |
| 279 | 26 | 250 | 0.002 | Free Surface | 5.011 | 0.742 | 0.901 | 1.608 | 7,327.18 |
| 280 | 26 | 245 | -0.031 | Pressurized | 3.988 | 1 | 1 | 2.167 | 6,600.00 |
| 281 | 26 | 205 | -0.001 | Pressurized | 3.988 | 1 | 1 | 2.167 | 6,600.00 |
| 282 | 26 | 150 | -0.03 | Pressurized | 3.988 | 1 | 1 | 2.167 | 6,600.00 |
| 283 | 26 | 200 | 0 | Pressurized | 3.988 | 1 | 1 | 2.167 | 6,600.00 |
| 284 | 26 | 139.32 | -0.007 | Pressurized | 3.988 | 1 | 1 | 2.167 | 6,600.00 |
| 285 | 26 | 60.68 | 0.083 | Free Surface | 20.122 | 0.252 | 0.14 | 0.547 | 47,265.54 |
| 286 | 26 | 200 | 0.004 | Free Surface | 6.298 | 0.605 | 0.681 | 1.312 | 9,692.95 |
| 287 | 26 | 285 | 0.018 | Free Surface | 11.502 | 0.378 | 0.304 | 0.82 | 21,701.23 |
| 288 | 26 | 195 | 0.026 | Free Surface | 13.207 | 0.342 | 0.252 | 0.741 | 26,235.50 |
| 289 | 26 | 370 | 0.003 | Free Surface | 5.685 | 0.661 | 0.775 | 1.432 | 8,517.67 |
| 290 | 26 | 280 | 0.002 | Free Surface | 5.269 | 0.708 | 0.849 | 1.534 | 7,771.65 |
| 291 | 26 | 70 | 0.006 | Free Surface | 7.745 | 0.512 | 0.52 | 1.109 | 12,691.04 |
| 292 | 26 | 93 | 0.013 | Free Surface | 10.409 | 0.408 | 0.349 | 0.883 | 18,918.69 |
| 293 | 26 | 67 | 0.1 | Free Surface | 21.488 | 0.241 | 0.127 | 0.522 | 51,849.62 |
| 294 | 26 | 490 | 0.002 | Free Surface | 4.563 | 0.816 | 0.997 | 1.769 | 6,620.16 |
| 295 | 26 | 50 | 0.008 | Free Surface | 8.784 | 0.464 | 0.44 | 1.005 | 15,016.25 |
| 296 | 26 | 420 | -0.007 | Pressurized | 3.988 | 1 | 1 | 2.167 | 6,600.00 |
| 297 | 26 | 205 | 0.029 | Free Surface | 13.714 | 0.333 | 0.238 | 0.72 | 27,677.24 |
| 298 | 26 | 34.04 | 0.631 | Free Surface | 41.171 | 0.153 | 0.051 | 0.332 | 130,119.67 |
| 299 | 26 | 700 | -0.022 | Pressurized | 3.988 | 1 | 1 | 2.167 | 6,600.00 |
| 300 | 26 | 1,150.00 | 0.012 | Free Surface | 10.04 | 0.419 | 0.366 | 0.908 | 18,012.76 |
| 301 | 26 | 2,450.00 | -0.002 | Pressurized | 3.988 | 1 | 1 | 2.167 | 6,600.00 |
| 302 | 26 | 411 | -0.001 | Pressurized | 3.988 | 1 | 1 | 2.167 | 6,600.00 |
| 303 | 26 | 98 | 0.205 | Free Surface | 27.682 | 0.202 | 0.089 | 0.437 | 74,182.02 |
| 304 | 26 | 1,524.10 | 0.086 | Free Surface | 20.344 | 0.25 | 0.138 | 0.543 | 47,999.36 |
| 305 | 26 | 6,275.68 | -0.002 | Pressurized | 3.988 | 1 | 1 | 2.167 | 6,600.00 |
| 306 | 26 | 400 | 0.076 | Free Surface | 19.509 | 0.258 | 0.146 | 0.559 | 45,212.31 |
| 307 | 26 | 1,600.00 | -0.036 | Pressurized | 3.988 | 1 | 1 | 2.167 | 6,600.00 |
| 308 | 30 | 1,900.00 | 0.007 | Free Surface | 8.088 | 0.397 | 0.333 | 0.994 | 19,803.50 |
| 309 | 30 | 600 | -0.04 | Pressurized | 2.996 | 1 | 1 | 2.5 | 6,600.00 |
| 310 | 30 | 1,150.00 | -0.038 | Pressurized | 2.996 | 1 | 1 | 2.5 | 6,600.00 |
| 311 | 30 | 1,977.71 | -0.005 | Pressurized | 2.996 | 1 | 1 | 2.5 | 6,600.00 |
| 312 | 30 | 782.35 | -0.003 | Pressurized | 2.996 | 1 | 1 | 2.5 | 6,600.00 |
| 313 | 30 | 1,700.00 | 0.032 | Free Surface | 14.143 | 0.265 | 0.153 | 0.662 | 43,025.13 |
| 314 | 30 | 1,550.00 | -0.01 | Pressurized | 2.996 | 1 | 1 | 2.5 | 6,600.00 |
| 315 | 30 | 500 | 0.043 | Free Surface | 15.689 | 0.246 | 0.133 | 0.615 | 49,760.62 |
| 316 | 30 | 250 | -0.258 | Pressurized | 2.996 | 1 | 1 | 2.5 | 6,600.00 |
| 317 | 30 | 1,928.00 | -0.004 | Pressurized | 2.996 | 1 | 1 | 2.5 | 6,600.00 |
| 318 | 30 | 8 | 0.075 | Pressurized | 19.088 | 0.214 | 0.1 | 0.535 | 65,717.67 |
| 319 | 26 | 414 | 0.029 | Free Surface | 13.783 | 0.331 | 0.237 | 0.718 | 27,847.56 |
| 320 | 30 | 12 | 0.003 | Free Surface | 6.215 | 0.486 | 0.476 | 1.215 | 13,854.50 |
| 321 | 30 | 3,338.00 | 0.002 | Free Surface | 5.468 | 0.538 | 0.564 | 1.344 | 11,696.21 |
| 322 | 30 | 1,400.00 | -0.004 | Pressurized | 2.996 | 1 | 1 | 2.5 | 6,600.00 |
| 323 | 30 | 19 | 0.177 | Pressurized | 25.839 | 0.173 | 0.065 | 0.433 | 100,912.36 |
| 324 | 30 | 181 | 0.004 | Pressurized | 6.355 | 0.478 | 0.463 | 1.194 | 14,269.29 |
| 325 | 30 | 640 | 0.005 | Free Surface | 7.049 | 0.441 | 0.402 | 1.102 | 16,429.42 |
| 326 | 30 | 20 | 0.833 | Free Surface | 44.535 | 0.119 | 0.03 | 0.298 | 218,949.35 |
| 327 | 30 | 1,905.00 | 0 | Pressurized | 2.996 | 1 | 2.029 | 2.5 | 3,252.66 |