WEST YOST
ASSOCIATES
Consulting Engineers

REGISTERED PROFESSIONAL ENGINEER
POLLY L. BOISSEVAIN
No. C36164
Exp. 6-30-20
CIVIL
STATE OF CALIFORNIA

TECHNICAL MEMORANDUM

DATE:	August 1, 2018	Project No.: 693-20-16-01 SENT VIA: EMAIL
TO:	SRWA Technical Advisory Committee	
FROM:	Polly Boissevain, R.C.E. #36164 Dakari Barksdale, R.C.E. #87542	
REVIEWED BY:	Gerry Nakano, R.C.E #29524	
SUBJECT:	Regional Surface Water Supply Project - Raw Water System Surge Analysis	

The purpose of this Technical Memorandum (TM) is to detail the hydraulic water system model setup and report the results of the Regional Surface Water Supply Project (Project) raw water system transient analysis. The raw water system conveys water from the Raw Water Pump Station, located adjacent to the Stanislaus River, to the Regional Water Treatment Plant (WTP) and the Ceres Main Canal, as shown on Figure 1. The raw water pipeline includes a total of approximately 4,500 linear feet (LF) of welded steel pipe, with 2,500 LF of 60-inch diameter pipeline from the Raw Water Pump Station to the flow split vault, where flow can either be directed to the Regional WTP or the Ceres Main Canal. From the flow split vault there is approximately 500 LF of 48-inch diameter pipeline to the WTP, and approximately 430 LF of 60-inch pipeline from to the Ceres Main Canal. Upstream of the pump header, the pipelines for each individual pump are 20 inches in diameter.

Hydraulic transients are generated in a water distribution system any time changes in flow and corresponding changes in velocity occur within the system. Hydraulic transients are generated under normal operating conditions due to operational changes, such as pump starts and stops, valve opening or closing, or hydrant operations, or due to unanticipated operations, such as pump station power failure or a water main break. Transients propagate through the water system at the speed of sound, about 3,600 feet/second. The pressure changes associated with transients can be quite large compared with normal operating pressures. For normal system operations, transients can be controlled by making slower changes in operations. For uncontrolled operational conditions, mitigation must be incorporated into facility design.

West Yost evaluated the Project raw water system using a model specifically developed for this transient analysis. The transient analysis uses the InfoSurge® software module, which runs within the InfoWater® modeling software package. InfoSurge® is a software analysis tool that uses the University of Kentucky surge analysis code, which has been used widely for many years for hydraulic transient analysis. The InfoSurge® software uses hydraulic information defined within the InfoWater® model, along with additional information needed for the hydraulic transient analysis to evaluate hydraulic transient scenarios. For the Project raw water system, the primary concerns would

1777 Botelho Drive, Suite 240 Walnut Creek, CA 94596 Phone 925.949.5800 Fax 925.949.5845 westyost.com

be a low-pressure event and water column separation following an abrupt power failure at the raw water pump station, and the subsequent high-pressure surge that would occur when the water column rejoins within the pipeline.

This TM covers the following information:

- Modeling Assumptions
- Analysis Criteria
- Model Scenarios and Results
- Recommended Mitigation

MODELING ASSUMPTIONS

The Project raw water pipeline varies in diameter (depending on segment location) between either a 48-inch or 60-inch welded steel pipeline. Figure 1 shows the approximate location of the new pump station, pipeline and flow split vault and connections to the WTP and Ceres Main Canal. The following information was used to define facilities associated with Project:

- Elevations – estimated based on pre-design drawings
- Raw Water Pump Station Wet Well – assumed hydraulic grade line of 58.9 feet (the mid-level point of the wet well) based on minimum level (49.5 feet) and maximum level (68.3 feet) shown on the pre-design drawings
- Raw Water Pump Station – modeled with multiple point curve from quote provided by pump manufacturer The Weir Group. The design flow rate and total dynamic head are 9,028 gpm and 125 feet, respectively. Two pumps will be initially installed as part of the Project, one duty and one standby, and an additional four pumps will be installed in the future to meet buildout of the Project (five duty pumps, one standby)
- Wave speeds – calculated based on steel pipe wall thicknesses, with wave speeds ranging from 3,600 ft/second to 4,300 feet/second, depending on pipeline diameter and wall thickness
- Hazen-Williams C-values ranging from 140 to 145, depending on diameter, based on AWWA M-11 Steel Pipe – A Guide for Design and Installation
- Flow control valves in the flow split vault – valve characteristic curves based on APCO Willamette List 26 ball valves
- Water Treatment Plant – assumed hydraulic grade line of 133 feet based on the water surface elevation in the flocculation and sedimentation tank shown on the HGL profile figure provided in the pre-design TM prepared by Trussell Technologies, Inc.
- Ceres Main Canal Outfall Weir – assumed to be a 25-foot-long weir with a ground elevation of 137.2 and a high level HGL of 138.09 based on preliminary design drawings

ANALYSIS CRITERIA

Vacuum conditions and high-pressure surge are the risks associated with a power failure at the Raw Water Pump Station. The Raw Water System was evaluated to assess the potential for sub-atmospheric pressure conditions to occur, which could require incorporating surge protection into the pipeline design. Since this is a raw water transmission system, Title 22 of the California Code of Regulation; Section 64602 of Chapter 16, the California Waterworks Standards, which requires that a distribution system be operated to maintain a minimum pressure of at least 20 psi does not apply. Although steel pipe can withstand full vacuum conditions, the minimum pressure criteria used for this analysis is -5 psi, based on standard practice, to prevent the potential for vapor cavity formation and subsequent cavitation associated with vapor cavity collapse. The SRWA Raw Water System was also evaluated for high pressures. Welded steel pipeline has a surge allowance of 150 percent of design pressure.

MODEL SCENARIOS AND RESULTS

A pre-design transient analysis was performed to assist in determining the required mitigation required to reduce the damaging effects of pressure surges. Two different scenarios were developed and evaluated:

- Phase 1 design flow condition of 15 million gallons per day (mgd) flowing to the WTP. No deliveries to Ceres Main Canal are planned in Phase 1
- Buildout design flow condition of 45 mgd flowing to the WTP and 20 mgd flowing to the Ceres Main Canal[1]

Each scenario was evaluated assuming a power failure at the Raw Water Pump Station, initially without mitigation, and then with mitigation.

Results for each of the scenarios are summarized below.

Scenario 1 – Phase 1 Raw Water Pump Station Power Failure

Without the implementation of surge protection devices, a power failure would cause a pressure drop to full vacuum conditions along nearly the entire length of the pipeline, and subsequent vapor cavity collapse and cavitation, with a maximum pressure rise of 110 psi at the pump station discharge header. Mitigation required for Phase 1 includes 2-inch air vacuum valves on the discharge pipeline for each pump, immediately downstream of each flow control valve in the flow split vault, just upstream of the Ceres Main Canal Outfall and along the pipeline at Station 12+09 and 18+40.

Figure 2 shows pressure results without and with mitigation at the pump discharge header, with the gray pressure trace showing results without mitigation and the blue pressure trace showing results with mitigation. Figure 3 shows hydraulic grade line (HGL) and pressure plots along the pipeline under a power failure scenario with no mitigation, showing results at the pump station on

[1] Total raw water pump station diversion capacity is 100 cubic feet per second (cfs), or 65 mgd, with 70 cfs to the WTP (45 mgd) and 30 cfs to the Ceres Main Canal (20 mgd).

the left and at the WTP on the right. Figure 4 shows the HGL and pressure plots along the pipeline with the proposed mitigation.

Scenario 2 – Buildout Raw Water Pump Station Power Failure

Without the implementation of surge protection devices, a power failure would cause a pressure drop to full vacuum conditions along nearly the entire length of the pipeline, and subsequent vapor cavity collapse and cavitation, with a maximum pressure rise of 110 psi at the pump station discharge header. Mitigation required for Buildout includes 2-inch air vacuum valves on the discharge pipeline for each pump, immediately downstream of each flow control valve in the flow split vault, just upstream of the Ceres Main Canal Outfall and along the pipeline at Station 12+09 and 18+40.

Figure 5 shows pressure results without and with mitigation at pump discharge header. Figures 6 and 7 shows hydraulic grade line (HGL) and pressure plots along the pipeline with no mitigation. Figure 8 and 9 shows the HGL and pressure plots along the pipeline with the proposed mitigation.

RECOMMENDED MITIGATION

Proposed mitigation is the addition of two-stage air vacuum valves along the pipeline. Two-stage air vacuum valves allow air to quickly enter the pipeline through a large-diameter orifice to reduce the chance of causing full vacuum conditions in the pipeline. As the system re-pressurizes, air is slowly vented to atmosphere through the small-diameter orifice, reducing the risk of rapid closure of the air vacuum valve that could also cause a hydraulic transient. It is recommended that 5 air vacuum valves be installed along the pipeline and 1 air vacuum valve be installed at each pump for a total of 11 air vacuum valves. The recommended valve diameters are 2 inches for the inlet and 0.5 inches for the outlet. The recommended placement of the air vacuum valves can be seen in Figure 10. Based on the pre-design drawings, the recommended air vacuum valve stations are 12+09, 18+40, immediately downstream of each flow control valves in the vault, and just upstream of the Ceres Main Canal. Air vacuum valves should also be installed just downstream of each pump.

Last Saved: 7/9/2018 7:29:58 PM N:\Clients\693 SRWA\20-16-01 PM WTP\GIS\MXD\10_Hydraulics\Transient\Fig01Transient.mxd : dbarksdale

PS Raw Water Pump Station

Ceres Canal Weir

VAULT Flow Split Vault

Raw Water Pipeline

Flocculation and Sedimentation Basin

Water Treatment Plant Site

0 200 400

Scale in Feet

SRWA STANISLAUS REGIONAL WATER AUTHORITY

WEST YOST ASSOCIATES

Figure 1

Raw Water Facilities Locations

Stanislaus Regional Water Authority
Surface Water Supply Project

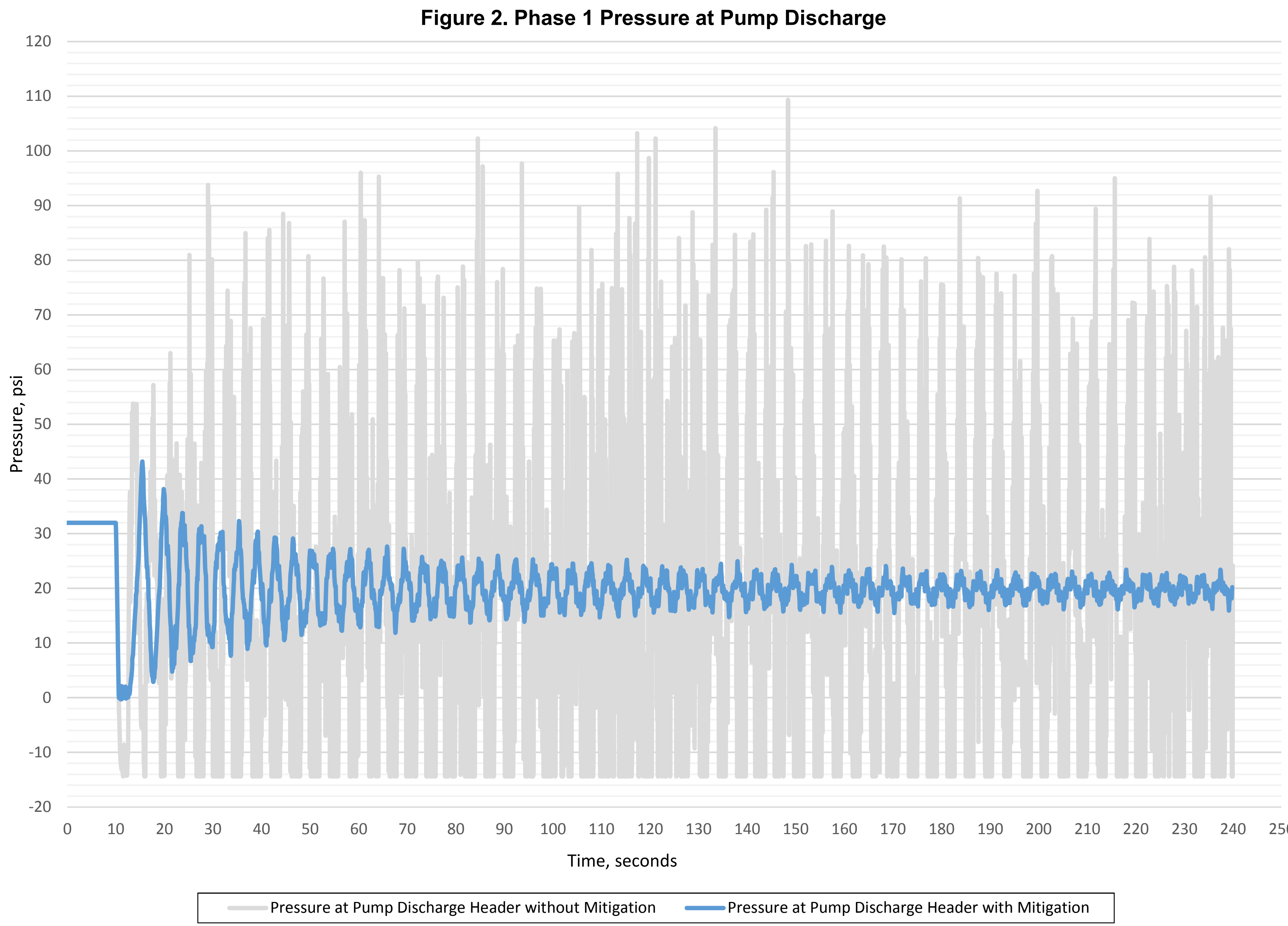
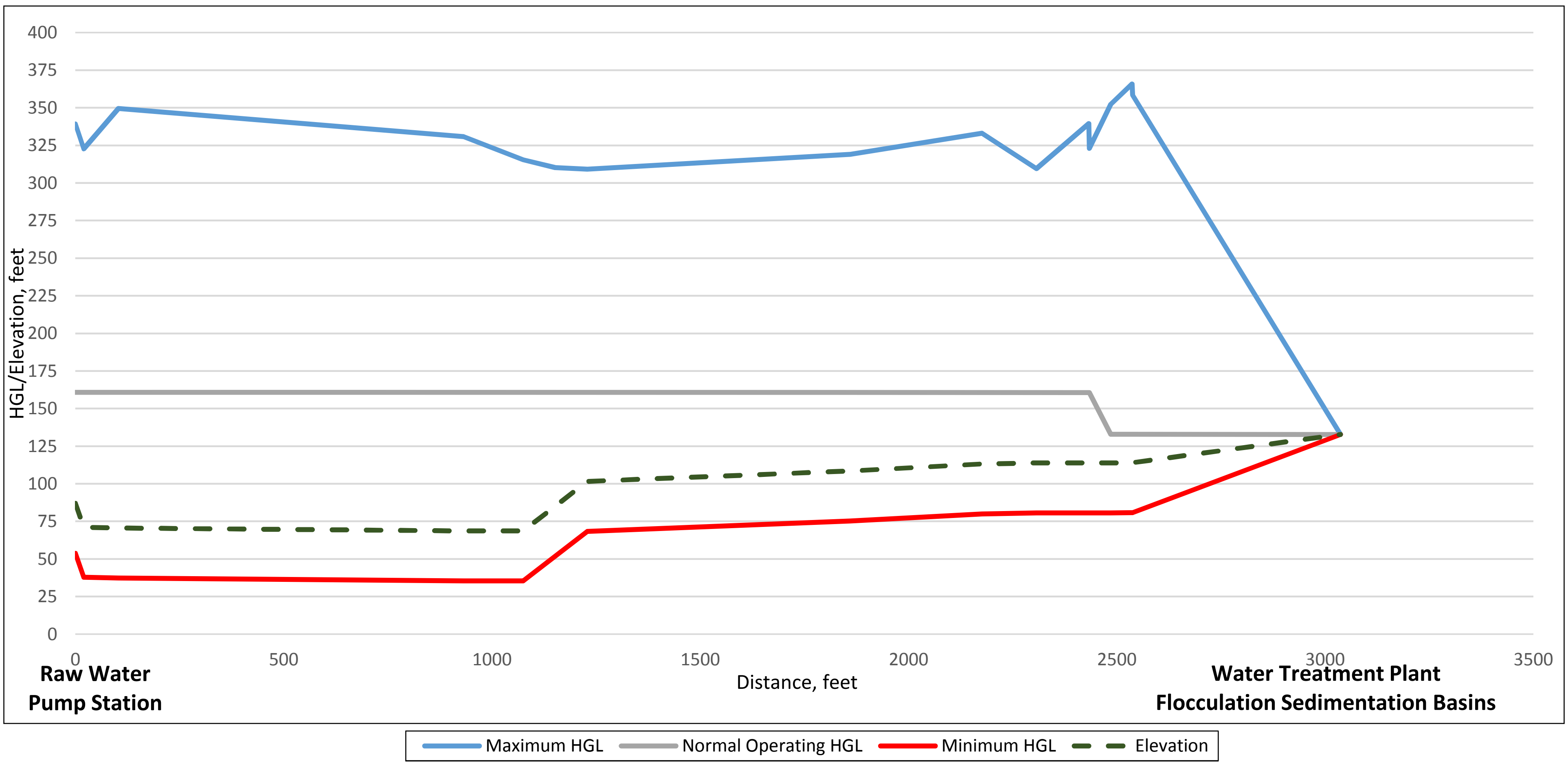


Figure 2. Phase 1 Pressure at Pump Discharge
Pressure, psi
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
-20
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
250
Time, seconds
Pressure at Pump Discharge Header without Mitigation
Pressure at Pump Discharge Header with Mitigation

Phase 1 Hydraulic Grade Line Profile Pump Station to Water Treatment Plant



Phase 1 Pressure Profile Pump Station to Water Treatment Plant

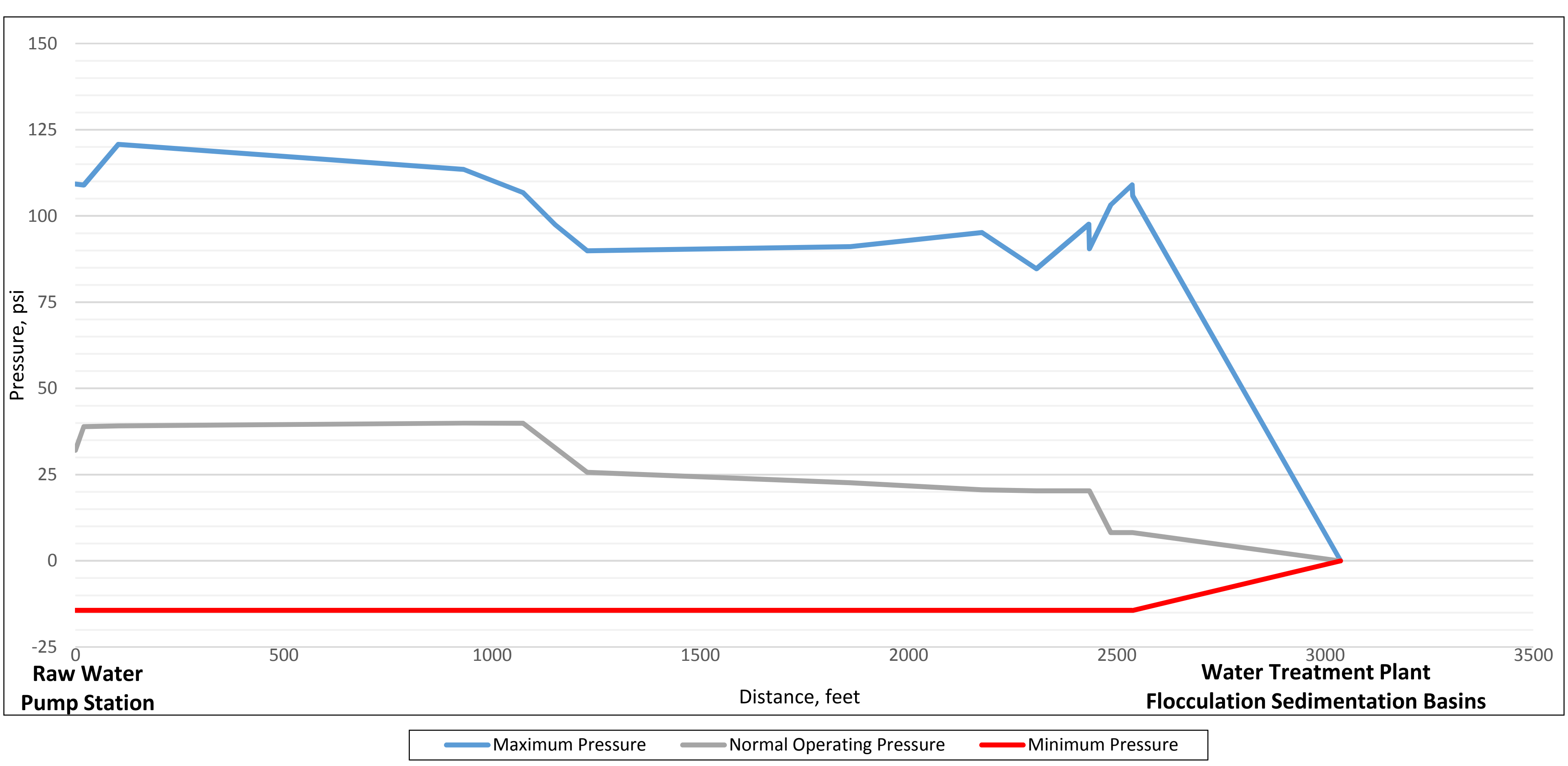
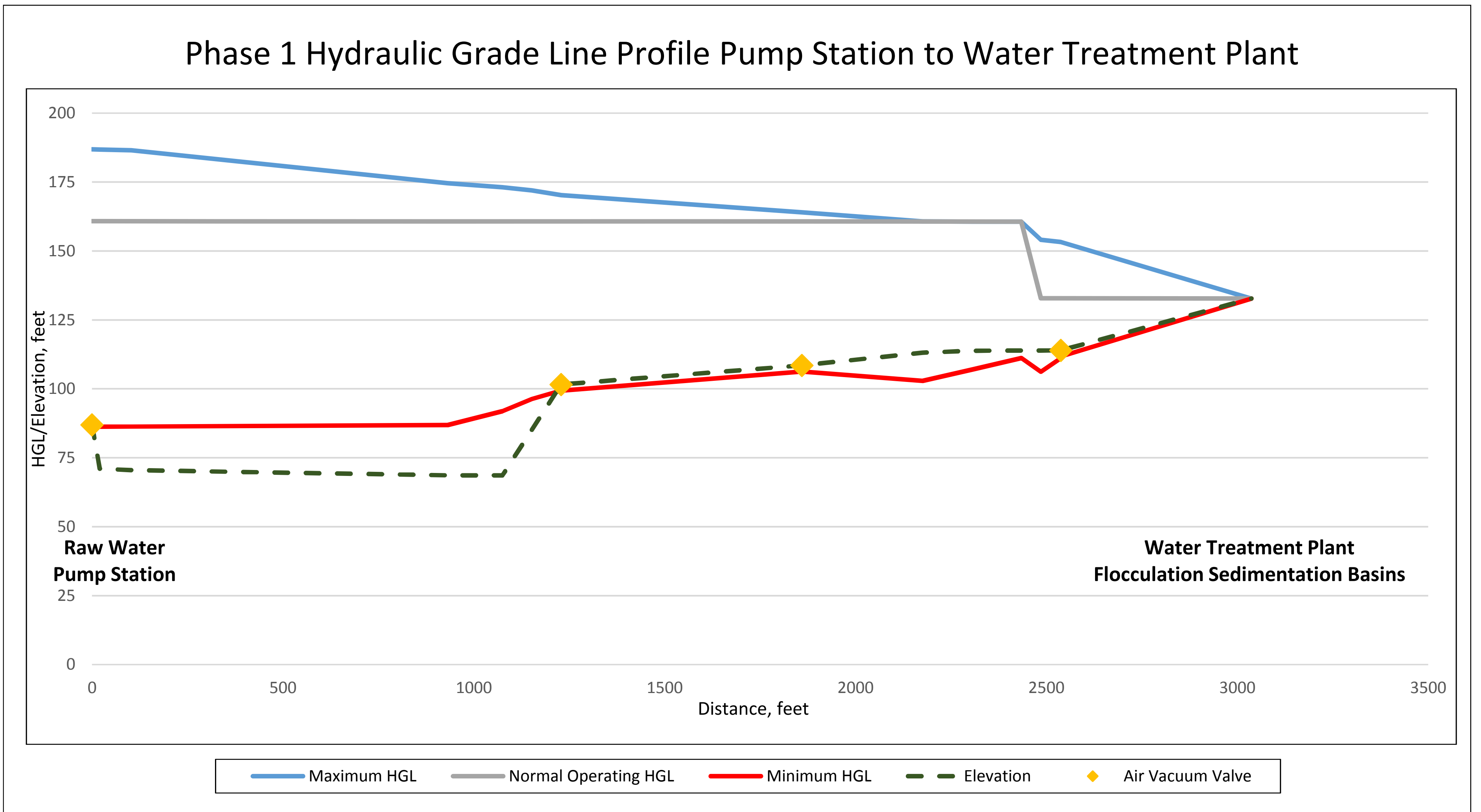


Figure 3

Raw Water Pump Station to Water Treatment Plant Hydraulic Grade Line and Pressure Profiles for Phase 1 without Mitigation

Stanislaus Regional Water Authority
Raw Water Transient Analysis



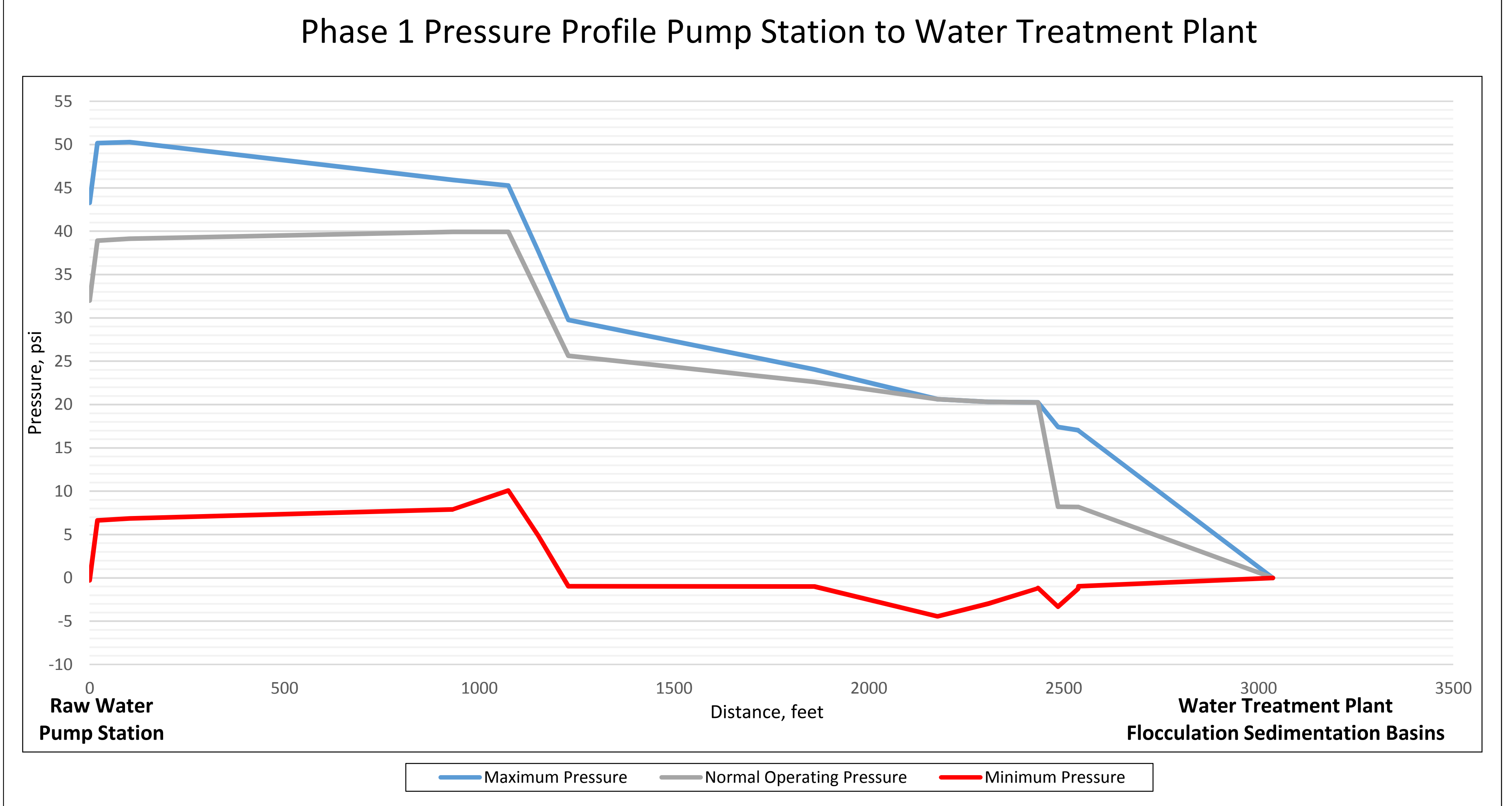
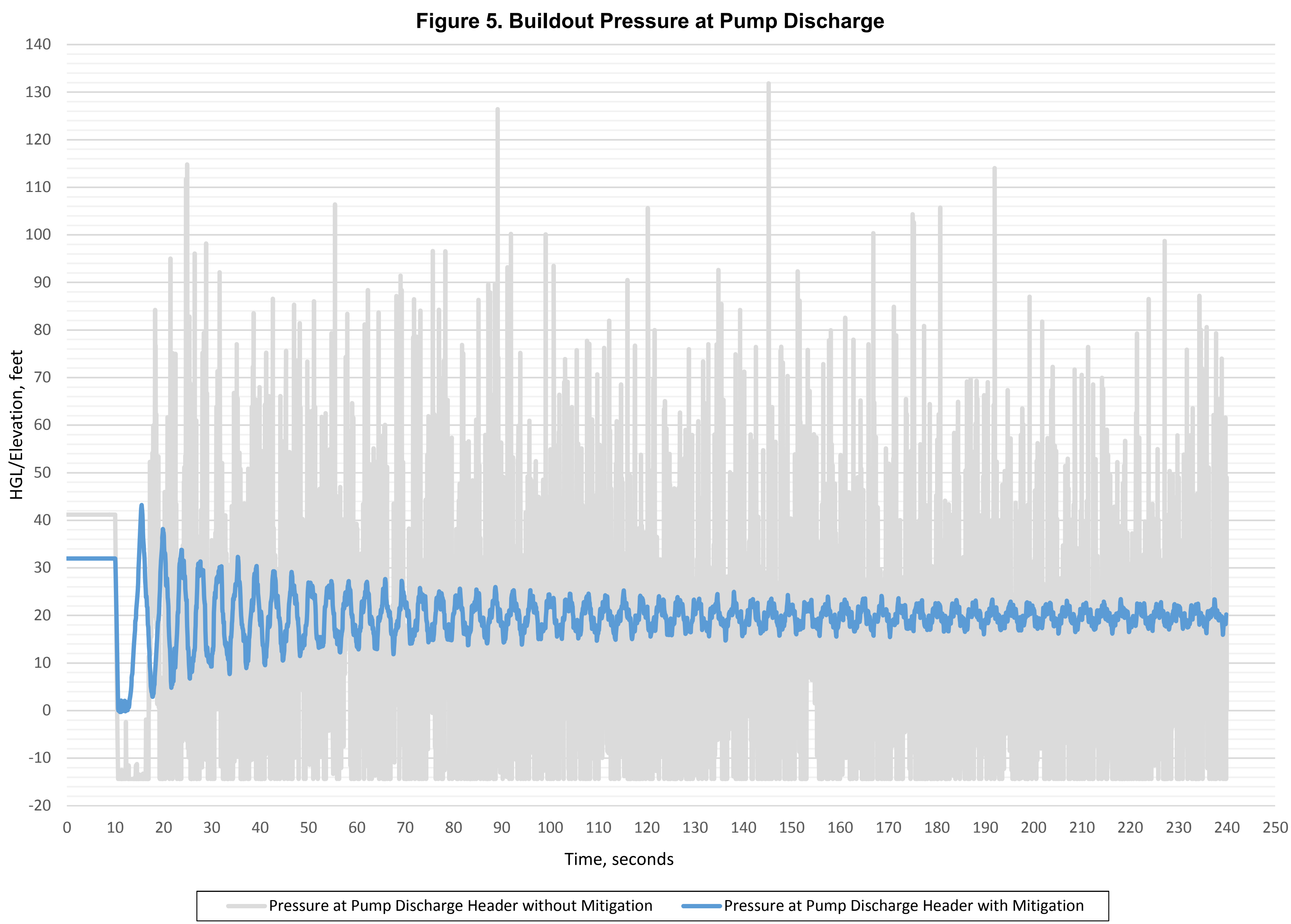


Figure 4

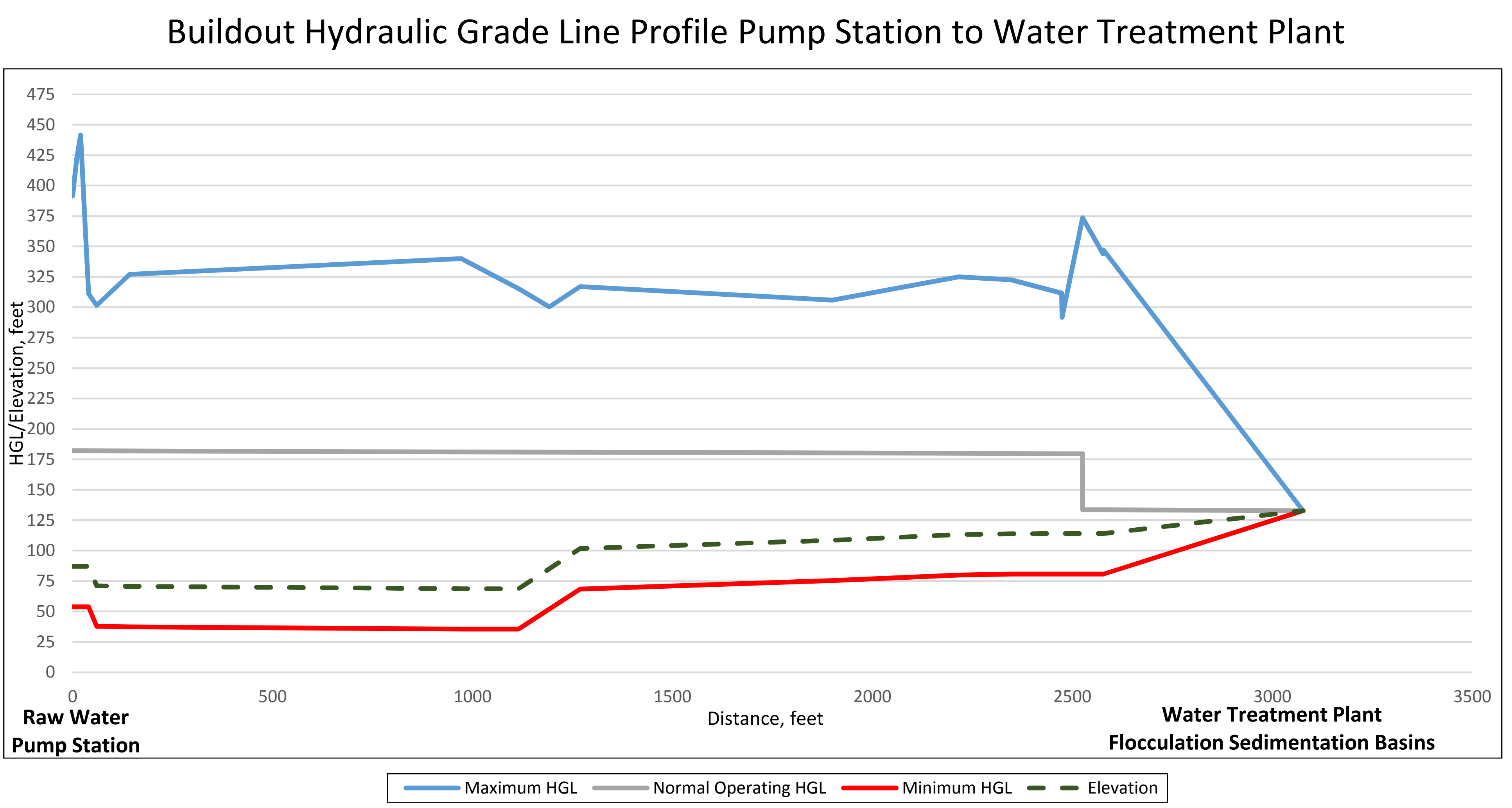
Raw Water Pump Station to Water Treatment Plant Hydraulic Grade Line and Pressure Profiles for Phase 1 with Mitigation

Stanislaus Regional Water Authority
Raw Water Transient Analysis



WEST YOST ASSOCIATES
w\c\693\20-16-01\mod\transient\modelingnotes.xlsx
Last Revised: 06-08-2018

Stanislaus Regional Water Authority
Raw Water Transient Analysis



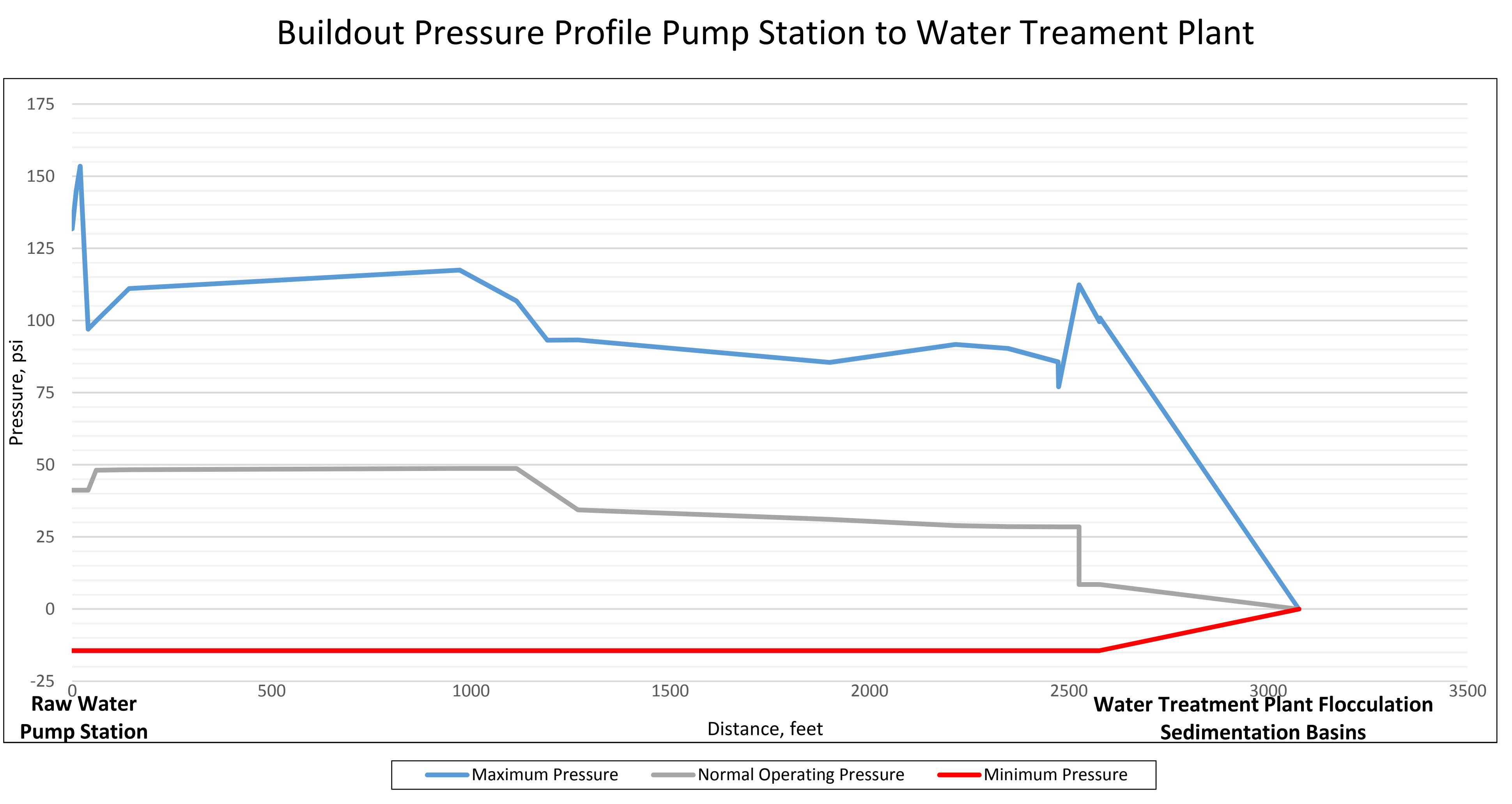
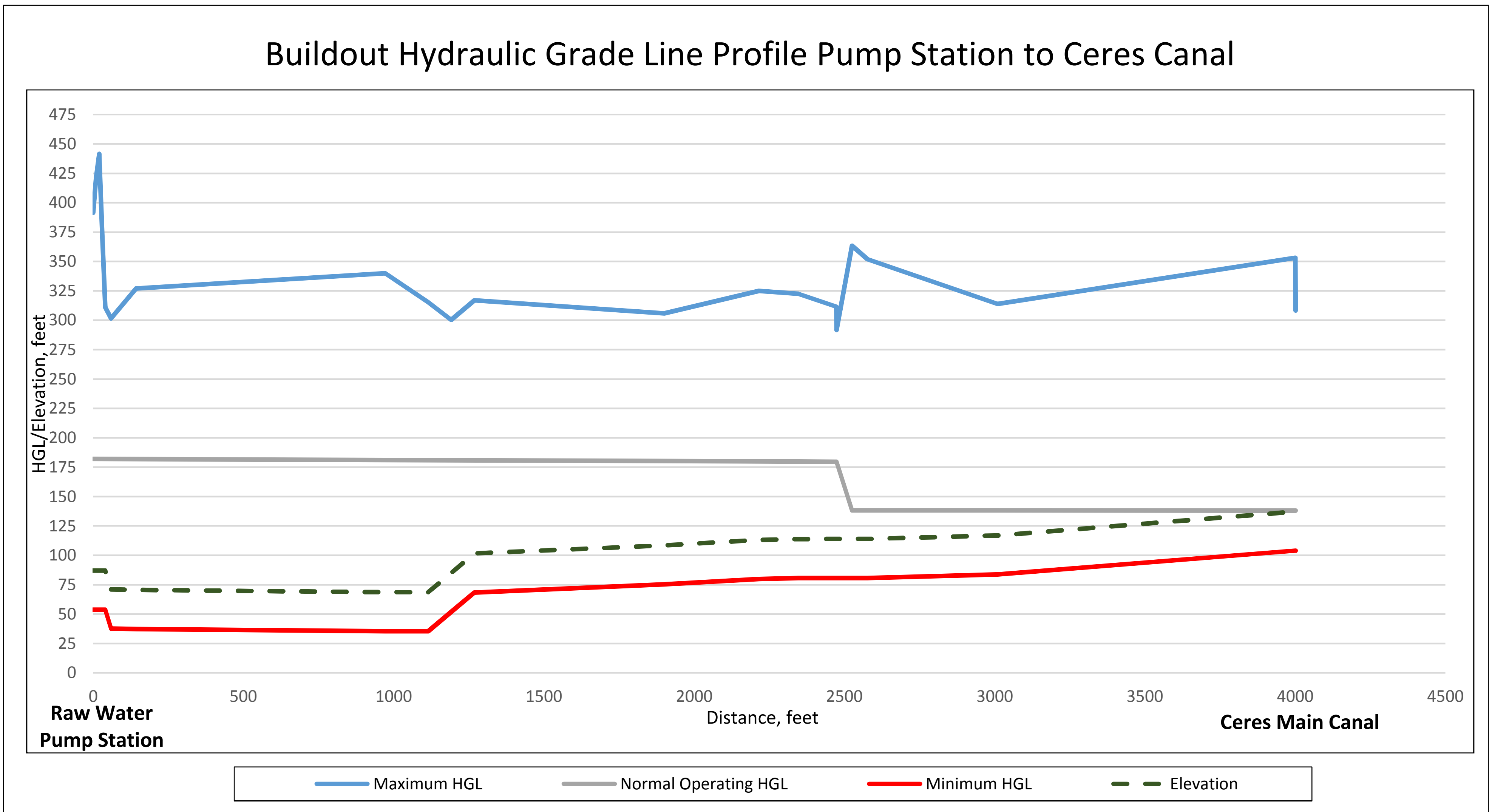


Figure 6

Raw Water Pump Station to Water Treatment Plant Hydraulic Grade Line and Pressure Profiles at Buildout without Mitigation

Stanislaus Regional Water Authority
Raw Water Transient Analysis



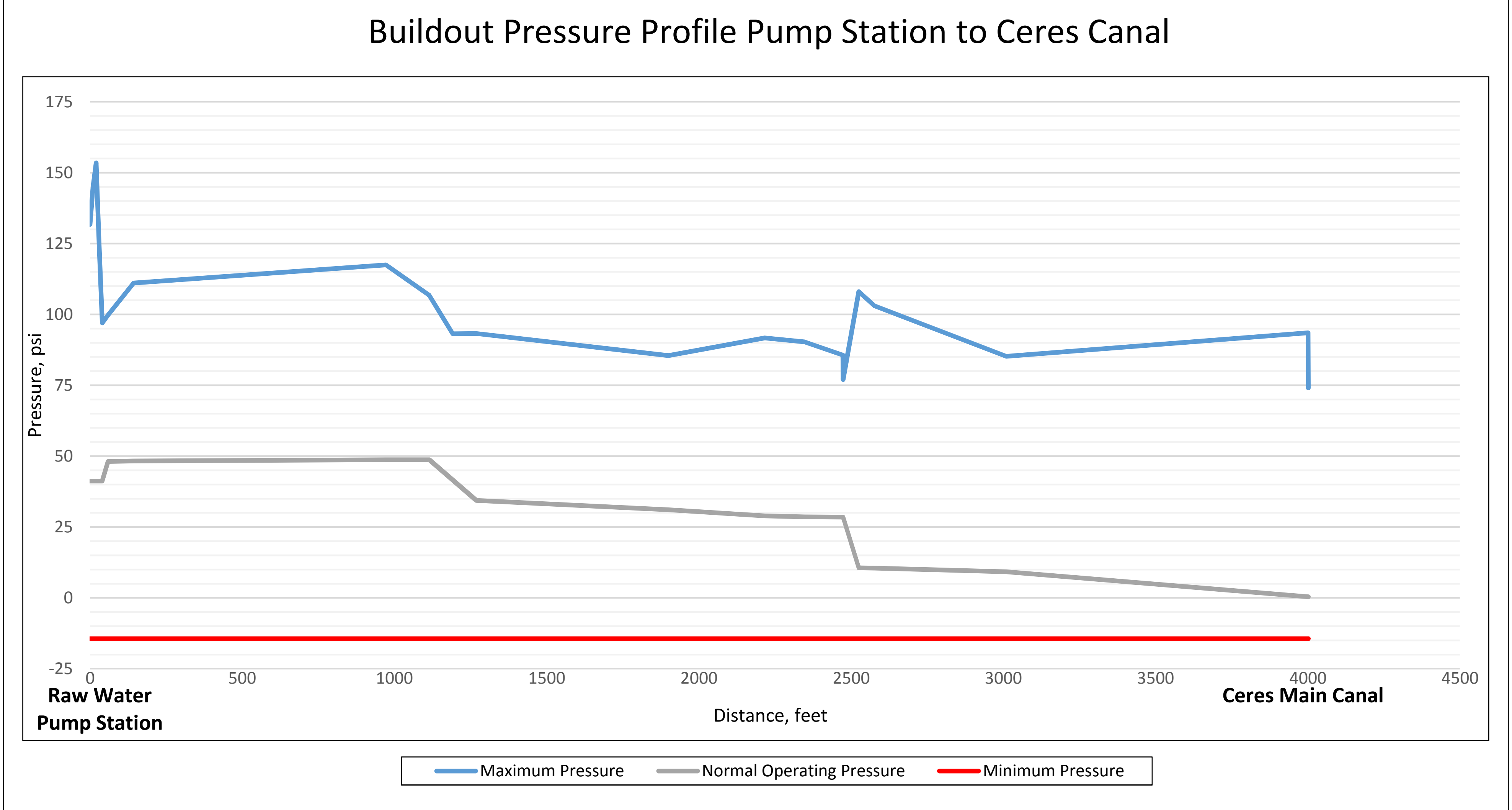


Figure 7

Raw Water Pump Station to Canal Hydraulic Grade Line and Pressure Profiles at Buildout without Mitigation

Stanislaus Regional Water Authority
Raw Water Transient Analysis

Buildout Hydraulic Grade Line Profile Pump Station to Water Treatment Plant

Buildout Pressure Profile Pump Station to Water Treatment Plant

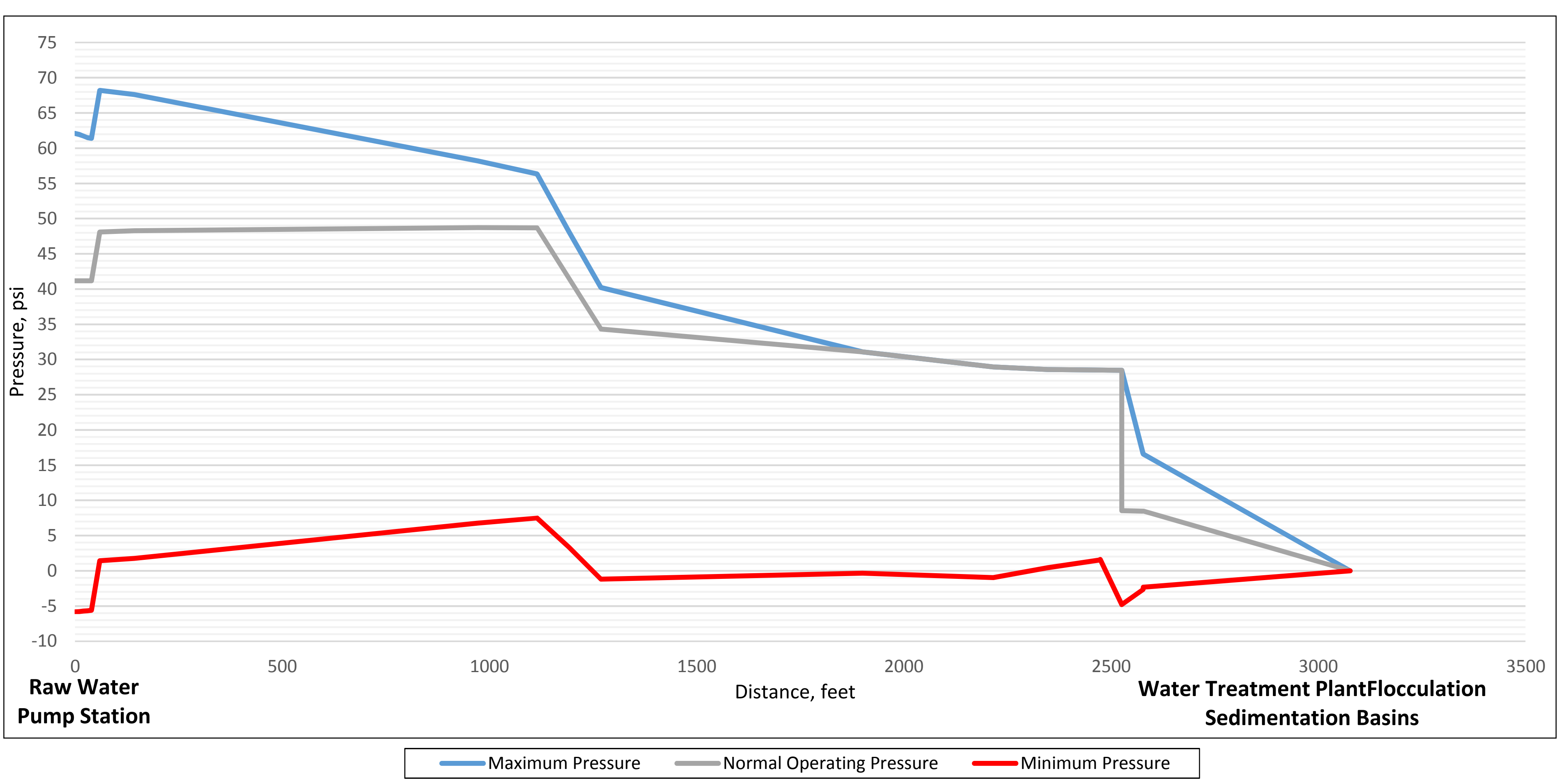


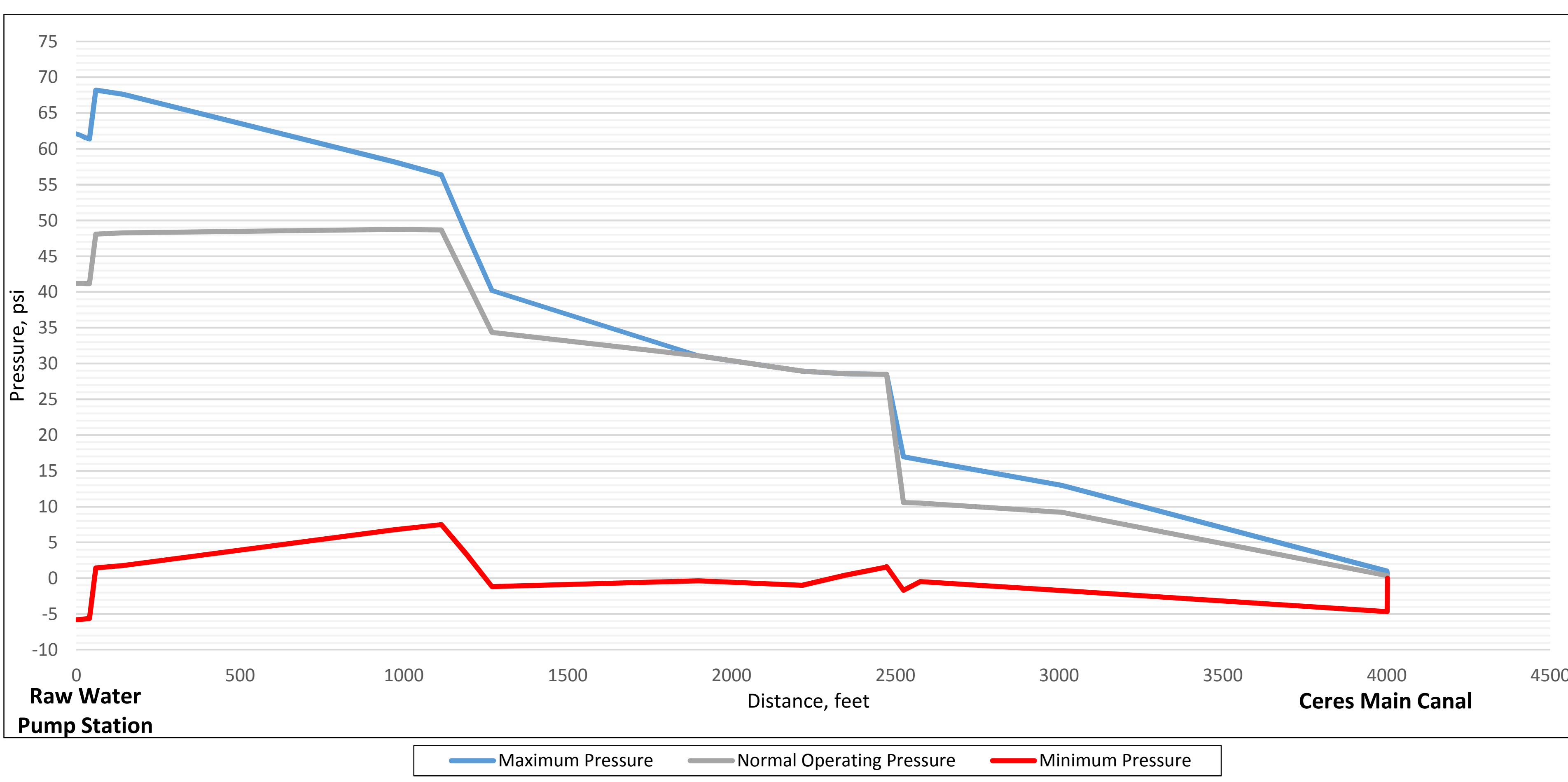
Figure 8

Raw Water Pump Station to Water Treatement Plant Hydraulic Grade Line and Pressure Profiles at Buildout with Mitigation

Stanislaus Regional Water Authority
Raw Water Transient Analysis

Buildout Hydraulic Grade Line Profile Pump Station to Ceres Canal

Buildout Pressure Profile Pump Station to Ceres Canal



SRWA STANISLAUS REGIONAL WATER AUTHORITY

WEST YOST ASSOCIATES

Figure 9

Raw Water Pump Station to Canal Hydraulic Grade Line and Pressure Profiles at Buildout with Mitigation

Stanislaus Regional Water Authority
Raw Water Transient Analysis

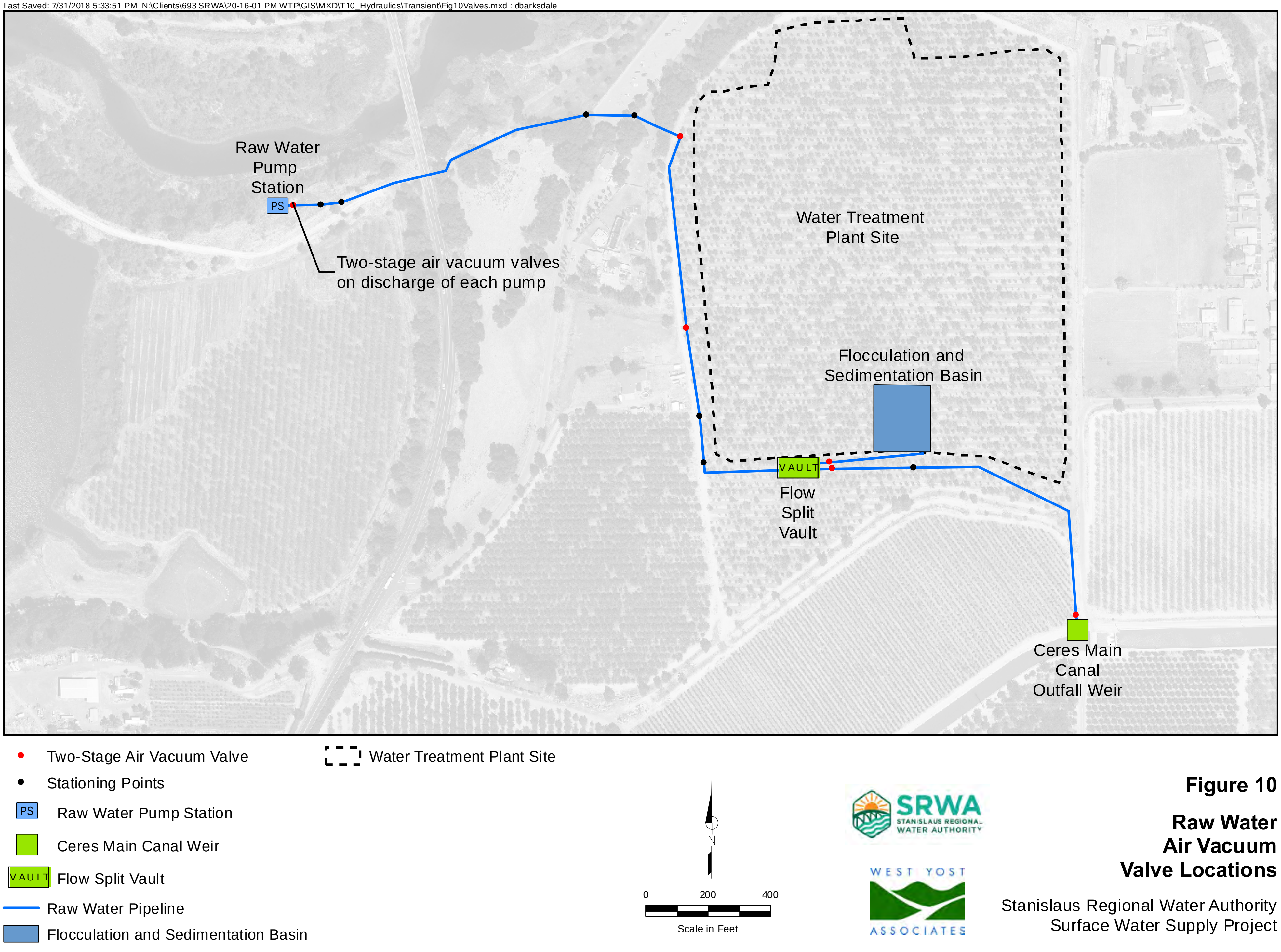


Figure 10

Raw Water Air Vacuum Valve Locations

Stanislaus Regional Water Authority
Surface Water Supply Project