Technical Memorandum

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Project: Coastal Branch Supplemental Modeling Scenarios

SUBJECT: **EVALUATION OF THE CAPACITY RELATIONSHIP BETWEEN THE LOPEZ AND THE SANTA BARBARA COUNTY TURNOUTS OF THE COASTAL BRANCH PIPELINE - FINAL**

Purpose

The San Luis Obispo County Flood Control & Water Conservation District (District) hired Water Systems Consulting, Inc. (WSC) to investigate the capacity relationship between the Lopez turnout and the Santa Barbara County turnouts of the Coastal Branch pipeline. The goal was to understand the impact of increasing flow rates to the Lopez turnout on the Santa Barbara County turnouts. This memorandum summarizes the results of the supplemental modeling, and describes the relationship between flow rates at the Lopez turnout and the Santa Barbara County turnouts.

This memorandum includes the following sections: Purpose; Background; Methodology; Modeling Results; and Conclusions.

Background

In 2011, the District and the Central Coast Water Authority (CCWA) hired WSC, HDR Engineering Inc. and GEI, Inc. to assess the hydraulic capacity of the Coastal Branch, Chorro Valley and Lopez pipelines through the development of a GIS based hydraulic model (hereafter referred to as "Coastal Branch Capacity Assessment"). During the course of the Coastal Branch Capacity Assessment, it was determined that pressure restrictions within the pipeline were limiting the capacity of the pipeline to deliver increased flows to the turnouts downstream of the Energy Dissipating Valve (EDV) structure. In this analysis, the EDV was modeled with a downstream maximum pressure set-point of 385 psi.

Upon completion of the Coastal Branch Capacity Assessment, CCWA hired WSC to investigate the potential to further increase flows to turnouts downstream of the EDV through the development of a maximum operating HGL, based on pipeline pressure class and elevation (hereafter referred to as "Coastal Branch Pressure Class Evaluation"). The analysis determined that flows downstream of the EDV could be increased further without the pipeline HGL exceeding the maximum operating HGL.

Based on the results of the Coastal Branch Pressure Class Evaluation, the District desired to utilize the maximum operating HGL methodology to further evaluate the ability of the pipeline to increase flows to turnouts

downstream of the EDV, specifically the capacity relationship between the Lopez and the Santa Barbara County turnouts. This supplemental modeling study evaluates this relationship.

Methodology

This analysis utilizes the WaterGEMs® hydraulic model from the Coastal Branch Capacity Assessment and the maximum operating HGL from the Coastal Branch Pressure Class Evaluation to run five (5) supplemental steady state modeling scenarios. Refer to the Coastal Branch Capacity Assessment report (dated December 22, 2011) for a detailed discussion of the WaterGEMs® model development and the Coastal Branch Pressure Class Evaluation Technical Memorandum (dated March 14, 2012) for a detailed discussion of the methodology used to develop the maximum operating HGL.

Scenario Definitions

The five scenarios evaluated in this study were:

- Scenario #10A: Lopez turnout set at 3.60 cfs (contract flow rate); Santa Barbara County turnouts increased to maximum allowable flow rate based on parameters described below
- Scenario #10B: Lopez turnout set at 7.75 cfs (average of contract flow rate and maximum modeled capacity from Coastal Branch Capacity Assessment); Santa Barbara County turnouts increased to maximum allowable flow rate based on parameters described below
- Scenario #10C: Lopez turnout set at 11.90 cfs (maximum modeled capacity from Coastal Branch Capacity Assessment); Santa Barbara County turnouts increased to maximum allowable flow rate based on parameters described below
- Scenario #10D: Lopez turnout set at 15.09 cfs (average of maximum modeled capacity from Coastal Branch Capacity Assessment and maximum modeled flow rate from Scenario #10E); Santa Barbara County turnouts increased to maximum allowable flow rate based on parameters described below
- Scenario #10E: Santa Barbara County turnouts set at contract flow rates; Lopez turnout increased to maximum allowable flow rate based on parameters described below

The contract flow rates for each of the turnouts are shown in Table 1 below. Consistent with the methodology in the Coastal Branch Capacity Assessment, the contract flow rate for each turnout represents the annual SWP allocation for each agency receiving water through the turnout divided over an 11 month period.

Table 1. Coastal Branch pipeline contract flow rates

	Subcontractors	Contract Flow Rate (cfs)
Shandon		0.15
CVTO[1]	Morro Bay	1.98
	CMC Contractors	1.54
LPTO[2]		3.60
	Subtotal San Luis Obispo County	*7.28*
SBTO[3]	Guadalupe	0.91
	Santa Maria	26.85
	So. Ca. Water Co.	0.83
	Tank 5	36.18
	Subtotal SBTO	*64.77*
	Total	**72.05**

[1] Chorro Valley Turnout; [2] Lopez Turnout; [3] Santa Barbara Turnouts

Modeling Parameters

To estimate pipeline capacity for each scenario, WSC incrementally increased the flow rate through the respective turnout(s) until the scenario reached the operational criteria established during the Coastal Branch Capacity Assessment and this study. These parameters are listed below:

- **Maximum HGL:** The pipeline HGL was maintained below the maximum operating HGL for Reach 5A2, 5B and 6. Pipeline HGL decreases at higher flow rates along all other sections of the pipeline.
- **Minimum Pressure:** Pipeline pressure was maintained above 15 psi, except at locations in close proximity to the storage facilities.
- **Maximum Velocity:** Due to the cement mortar lining, the velocity within the Coastal Branch pipeline was maintained below 20 ft/s, except through the 24-inch flow control sleeve valves at Tank 2 and the EDV, which are epoxy lined and has a higher velocity rating.

During the original calibration of the Coastal Branch pipeline model, a minor loss was added immediately downstream of the EDV to allow the model to mimic the observed pressure losses between the EDV and Lopez turnouts. For the original analysis of the Coastal Branch pipeline capacity, it did not matter where the minor loss was placed between the EDV and the Lopez turnout since there are no turnouts between those locations. However, for the Coastal Branch Pressure Class Evaluation and this supplemental modeling study, the placement of the minor loss along the segment is important since maximum operating HGL is being compared with modeled HGL at multiple locations along the segment. Due to limited monitoring data available from CCWA, it is unknown where these minor losses actually occur along this stretch of pipeline. Given the uncertainty of where the minor losses were located, the hydraulic model was modified to distribute the minor losses evenly along this entire pipeline section. This provides a more conservative estimate of pipeline capacity, since the original placement of the minor loss decreased the pipeline HGL for this entire section of pipeline.

Modeling Results

Utilizing the updated Coastal Branch pipeline hydraulic model, the maximum operating HGL of the pipeline, and the operating restrictions described above, WSC determined the flow rates and limiting factors for each of the five scenarios; the results are shown in Table 2.

For Scenario #10A and #10B, flow could not be increased beyond that shown in Table 2 without exceeding the maximum operating HGL at Station 3375+00. For Scenario #10C, #10D, and #10E, flow could not by increased beyond that shown in Table 2 without exceeding the capacity of the Tank 2 sleeve valve.

Although the Tank 2 sleeve valve is the limiting factor for Scenario #10C, #10D, and #10E, additional analysis showed that making modifications to the valves and/or piping at Tank 2 will not yield significant opportunities for capacity increase because the hydraulic capacity of the Coastal Branch pipeline quickly becomes the limiting factor.

Table 2. Summary of Scenario #10 Modeling Results (Instantaneous Flow Rate)

Scenario	Lopez Turnout		All Santa Barbara Turnouts		Total Flow Through EDV (cfs)	Limiting Factor
	Flow (cfs)	Flow Above Contract Rates (Δcfs)	Flow (cfs)	Flow Above Contract Rates (Δcfs)		
#10A	3.60	0.00	74.49	9.72	78.09	Maximum Operating HGL at Station 3375+00
#10B	7.75	4.15	73.19	8.42	80.94	Maximum Operating HGL at Station 3375+00
#10C	11.90	8.30	70.60	5.83	82.50	Tank 2 Sleeve Valve
#10D	15.09	11.49	67.36	2.59	82.45	Tank 2 Sleeve Valve
#10E	18.27	14.67	64.77	0.00	83.05	Tank 2 Sleeve Valve

Based on the instantaneous flow rate results shown in Table 2, WSC calculated the annual capacity for each scenario assuming continuous delivery at the scenario specific flow rates for 11 months. The calculated annual capacity is shown in Table 3.

Table 3. Summary of Scenario #10 Modeling Results (Annual Capacity)[1]

Scenario	Lopez Turnout		All Santa Barbara Turnouts		Total Annual Capacity Through EDV (AFY)
	Annual Capacity (AFY)	Annual Capacity Above Contract Rates (ΔAFY)	Annual Capacity (AFY)	Annual Capacity Above Contract Rates (ΔAFY)	
#10A	2,392	0	49,434	6,448	51,826
#10B	5,143	2,751	48,574	5,588	53,717
#10C	7,897	5,505	46,855	3,869	54,752
#10D	10,014	7,622	44,705	1,719	54,720
#10E	12,127	9,735	42,986	0	55,113

Figure 1 and Figure 2 show the modeling results for each scenario graphically and display the capacity relationship between flow to the Lopez turnout and flow to the Santa Barbara turnouts.

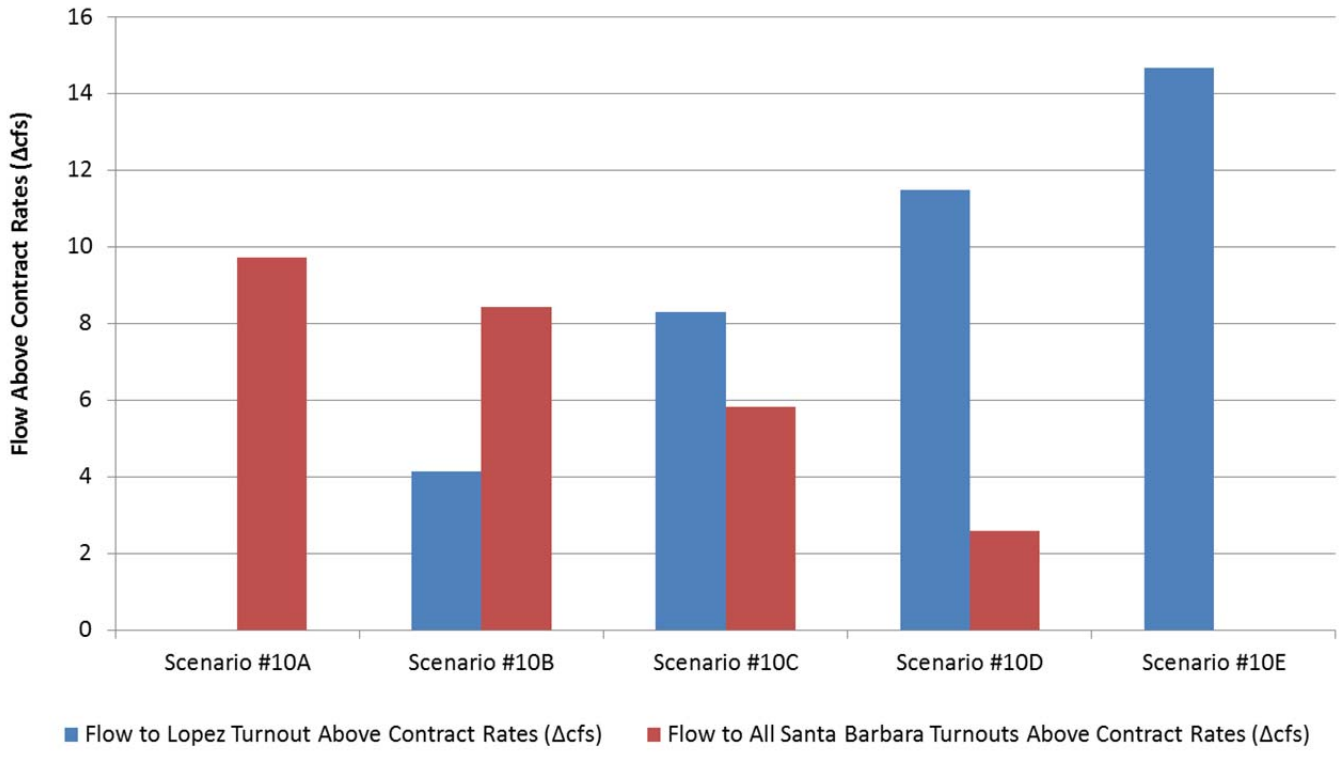

Figure 1. Scenario #10 Modeling Results

[1] Annual capacity results assume continuous delivery at the scenario specific flow rates for 11 months and that there is sufficient sub-contractor demand to receive these flow rates.

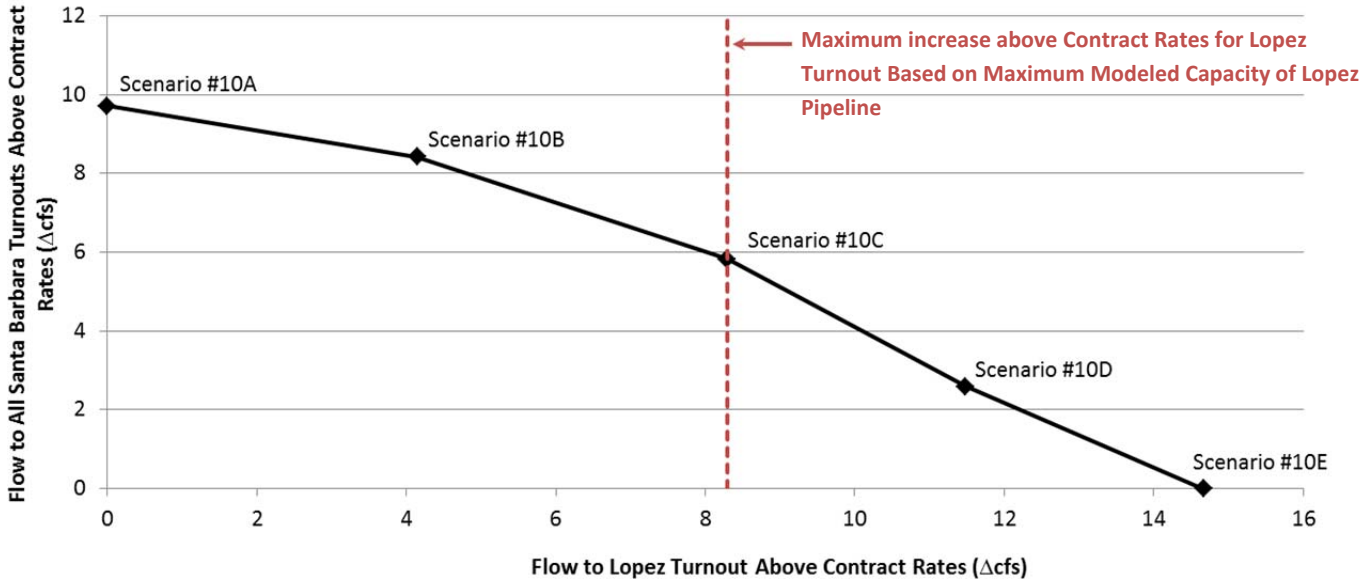

Figure 2. Capacity Relationship between Flow to Lopez Turnout and Flow to Santa Barbara County Turnouts

The modeling results by turnout for each scenario are shown in Table 4. The annual capacity by turnout based on the modeling results is shown in Table 5 and the increase in annual capacity above contract rates by turnout is shown in Table 6.

Table 4. Scenario #10 Modeling Results by Turnout (Instantaneous Flow Rate)

		Baseline Contract flow rates (cfs)	Scenario #10A LPTO set at contract; then max flow to SBTO (cfs)	Scenario #10B LPTO set at average of contract and max capacity; then max flow to SBTO (cfs)	Scenario #10C LPTO set at max capacity; then max flow to SBTO (cfs)	Scenario #10D LPTO set higher than max capacity; then max flow to SBTO (cfs)	Scenario #10E SBTO set at contract; then max flow to LPTO (cfs)
Shandon		0.15	0.15	0.15	0.15	0.15	0.15
CVTO	Morro Bay	1.98	1.98	1.98	1.98	1.98	1.98
	CMC Contractors	1.54	1.54	1.54	1.54	1.54	1.54
LPTO		3.60	3.60	7.75	11.90	15.09	18.27
Subtotal San Luis Obispo County		7.28	7.28	11.42	15.57	18.76	21.95
SBTO	Guadalupe	0.91	1.05	1.03	0.99	0.95	0.91
	Santa Maria	26.85	30.88	30.34	29.27	27.93	26.85
	So. Ca. Water Co.	0.83	0.95	0.94	0.90	0.86	0.83
	Tank 5	36.18	41.61	40.88	39.44	37.63	36.18
	Subtotal SBTO	64.77	74.49	73.19	70.60	67.36	64.77
Total		**72.05**	**81.77**	**84.62**	**86.18**	**86.13**	**86.72**

Table 5. Scenario #10 Modeling Results by Turnout (Annual Capacity)[2]

		Baseline Contract flow rates (AFY)	Scenario #10A LPTO set at contract; then max flow to SBTO (AFY)	Scenario #10B LPTO set at average of contract and max capacity; then max flow to SBTO (AFY)	Scenario #10C LPTO set at max capacity; then max flow to SBTO (AFY)	Scenario #10D LPTO set higher than max capacity; then max flow to SBTO (AFY)	Scenario #10E SBTO set at contract; then max flow to LPTO (AFY)
Shandon		100	100	100	100	100	100
CVTO	Morro Bay	1,313	1,313	1,313	1,313	1,313	1,313
	CMC Contractors	1,025	1,025	1,025	1,025	1,025	1,025
LPTO		2,392	2,392	5,143	7,897	10,014	12,127
Subtotal San Luis Obispo County		4,830	4,830	7,581	10,335	12,452	14,565
SBTO	Guadalupe	605	696	684	659	629	605
	Santa Maria	17,820	20,493	20,137	19,424	18,533	17,820
	So. Ca. Water Co.	550	633	622	600	572	550
	Tank 5	24,011	27,613	27,132	26,172	24,971	24,011
	Subtotal SBTO	42,986	49,434	48,574	46,855	44,705	42,986
Total		**47,816**	**54,264**	**56,155**	**57,190**	**57,158**	**57,551**

Table 6. Annual Capacity Increase from Contract Rates, by Turnout

		Scenario #10A LPTO set at contract; then max flow to SBTO (AFY)	Scenario #10B LPTO set at average of contract and max capacity; then max flow to SBTO (AFY)	Scenario #10C LPTO set at max capacity; then max flow to SBTO (AFY)	Scenario #10D LPTO set higher than max capacity; then max flow to SBTO (AFY)	Scenario #10E SBTO set at contract; then max flow to LPTO (AFY)
Shandon		0	0	0	0	0
CVTO	Morro Bay	0	0	0	0	0
	CMC Contractors	0	0	0	0	0
LPTO		0	2,751	5,505	7,622	9,735
Subtotal San Luis Obispo County		0	2,751	5,505	7,622	9,735
SBTO	Guadalupe	91	79	54	24	0
	Santa Maria	2,673	2,317	1,604	713	0
	So. Ca. Water Co.	83	72	50	22	0
	Tank 5	3,602	3,121	2,161	960	0
	Subtotal SBTO	6,448	5,588	3,869	1,719	0
Total		**6,448**	**8,339**	**9,374**	**9,342**	**9,735**

[2] Annual capacity results assume continuous delivery at the scenario specific flow rates for 11 months and that there is sufficient sub-contractor demand to receive these flow rates.

The pipeline HGL and maximum operating HGL plot, along with detailed results for each scenario, are included in Appendix A.

Based on the data and methodologies described herein, WSC estimates that flows to the Lopez turnout could be increased to 18.27 cfs, or 14.67 cfs above contract rates, without considering the capacity of the Lopez pipeline (Scenario #10E). However, as stated in the Coastal Branch Capacity Assessment, the maximum modeled capacity of the Lopez pipeline is limited to 11.90 cfs. The identified capacity of 11.90 cfs for the Lopez pipeline represents the total capacity for the pipeline. A significant portion of this capacity is required to deliver water from the Lopez Project and existing SWP Table A allocations. Delivering the Lopez and SWP contract flow rates for the existing Lopez pipeline customers requires 9.77 cfs of capacity. Therefore, the remaining capacity within the Lopez pipeline to deliver additional SWP is limited to 2.13 cfs.

The District plans to pig the 33 inch and 30 inch diameter sections of the Lopez pipeline, and based upon observed performance improvements following a recent pigging project on a separate reach of the Lopez pipeline, expects to yield an additional increase in the pipeline capacity. Additionally, there is the potential that the theoretical capacity of 11.90 cfs could be increased if further hydraulic analysis was performed on each of the turnouts along the Lopez pipeline to better understand the relationship between pipeline HGL and turnout capacities; this would require developing system curves for the individual agency distribution systems. Finally, SWP water could be delivered through the Lopez pipeline in-lieu of Lopez water, thus allowing Lopez water to be banked in Lopez Lake.

As shown in Table 2 above, the limiting factors for the scenarios change as the flow to the Lopez turnout is increased and the flow to the Santa Barbara County turnouts is decreased. When the flow to the Lopez turnout is near its contract rate, flows to the Santa Barbara County turnouts are limited by the maximum operating HGL of the pipeline from station 3375+00 to 3392+50. As flows to the Lopez turnout increase, the limiting factor becomes the hydraulic capacity of the sleeve valve at Tank 2. The limiting factor changes from the maximum operating HGL to the Tank 2 sleeve valve when the flow to the Lopez turnout is between 7.75 cfs and 11.90 cfs and the flow to the Santa Barbara County turnouts is between 70.60 cfs and 67.36, respectively.

Model Limitations

There are several aspects of the model that limit the model's ability to represent real world conditions. These limitations include:

- **Calibration Error** - Absolute and relative HGL error related to the model calibration (see Coastal Branch Capacity Assessment) limit the ability of the model to represent real world conditions (+/- 3.6% accuracy).
- **Instrument Accuracy** - Errors in the flow test data, related to the accuracy of the pressure gages and flow meters, limit the accuracy of the model calibration (+/- 0.5% accuracy).
- **Simplified Turnout Assumptions** - Variable conditions within the distribution systems downstream of each turnout can affect turnout capacity for a given HGL in the Coastal Branch pipeline.
- **Steady State Model** - Dynamic conditions within the pipeline that are not captured within a steady state model and may impact the maximum capacity of the pipeline.

This analysis calculates the maximum operating HGL at discrete locations along the pipeline alignment corresponding to appurtenance locations and changes in pipe material or diameter. It does not include an

evaluation of the maximum operating HGL for every location along Reaches 5A2, 5B and 6 of the Coastal Branch pipeline. Before any operational decisions are made to increase flow, the maximum operating HGL should be updated to include pipeline slope information. By including slope information a continuous plot of the maximum operating HGL could be developed to provide a comprehensive maximum operating HGL for Reaches 5A2, 5B and 6.

Additionally, further analysis should be conducted to investigate the minor losses that the model predicts along the segment of pipe from the EDV to the Lopez turnout. Determining the location of these minor losses will provide a more accurate pipeline HGL and improve the maximum operating HGL methodology.

Conclusions

The results of the supplemental modeling scenarios provide a capacity relationship between flow to the Lopez turnout and flows to the Santa Barbara County turnouts. The maximum operating HGL limits the flow to the Santa Barbara County turnouts when the Lopez turnout is set at the contract rate. The hydraulic capacity of the Tank 2 sleeve valve limits the flow to the Lopez turnout when the Santa Barbara County turnouts are set at the contract rates. The limiting factor changes when the flow to the Lopez turnout is between 7.75 cfs and 11.90 cfs and the flow to the Santa Barbara County turnouts is between 70.60 cfs and 67.36 cfs, respectively.

The maximum flow rate to the Lopez turnout is 18.27 cfs, which is greater than the capacity of the pipeline determined through the Coastal Branch Capacity Assessment (11.90 cfs). Therefore, the currently achievable maximum flow to the Lopez turnout is limited by the capacity of the Lopez pipeline not the operating HGL of the Coastal Branch pipeline or flow control valves on the Coastal Branch pipeline. If the capacity of the Lopez pipeline is increased, flows of up to 18.27 cfs to the Lopez turnout may be possible.

Appendix A

Table A-1. Scenario #10A Results

	Subcontractors	Contract Rate (cfs)	Scenario Flow Rate (cfs)	Flow Rate Increase (cfs)	HGL (ft)
Shandon		0.15	0.15	0.00	1868
CVTO	Morro Bay	1.98	1.98	0.00	
	CMC Contractors	1.54	1.54	0.00	
	Subtotal	3.52	3.52	0.00	1485
LPTO		3.60	3.60	0.00	1112
SBTO	Guadalupe	0.91	1.05	0.14	872
	Santa Maria	26.85	30.88	4.03	807
	So. Ca. Water Co.	0.83	0.95	0.12	798
	Tank 5	36.18	41.61	5.43	
	Subtotal	64.77	74.49	9.72	
Total		**72.05**	**81.77**	**9.72**	

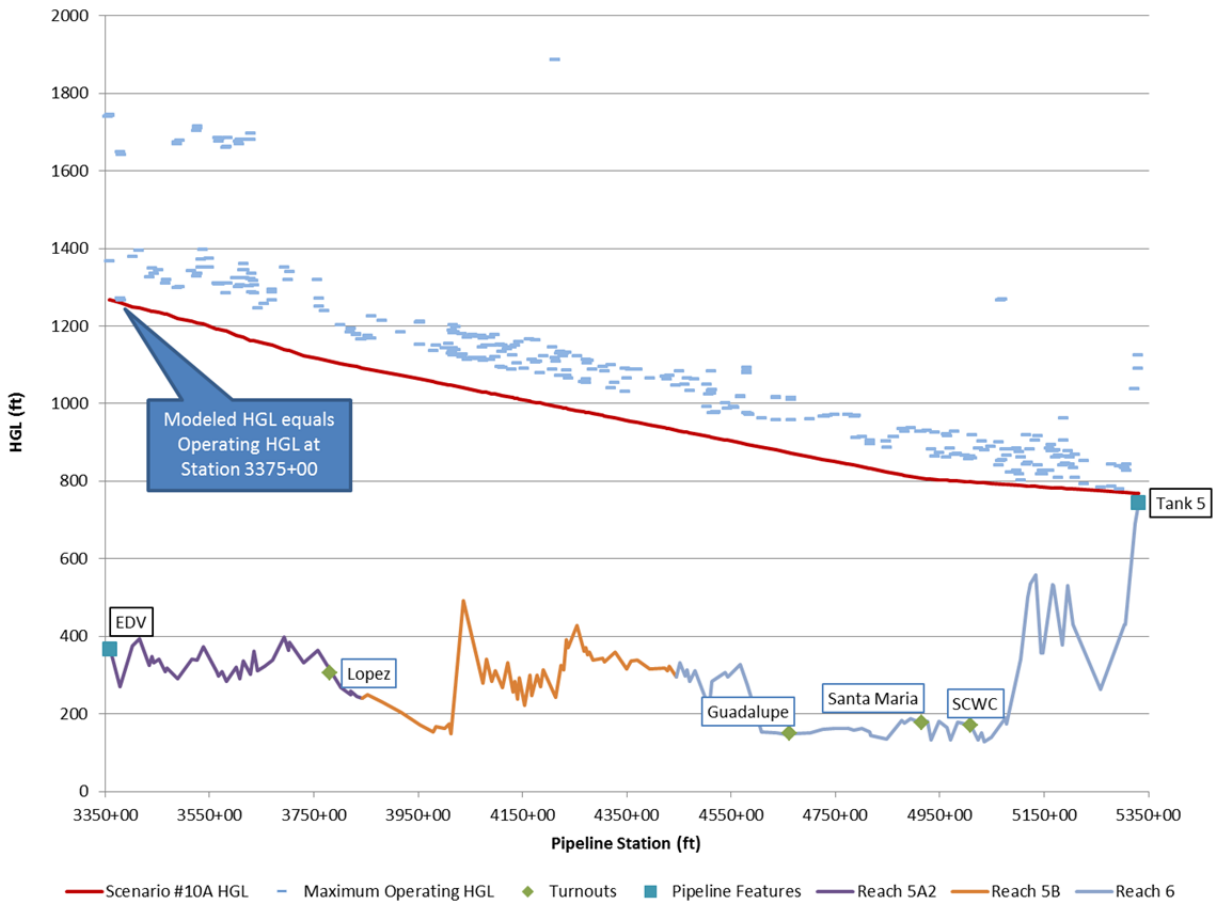

Figure A-1. Scenario #10A HGL Plot

Table A-2. Scenario #10B Results

	Subcontractors	Contract Rate (cfs)	Scenario Flow Rate (cfs)	Flow Rate Increase (cfs)	HGL (ft)
Shandon		0.15	0.15	0.00	1860
CVTO	Morro Bay	1.98	1.98	0.00	
	CMC Contractors	1.54	1.54	0.00	
	Subtotal	3.52	3.52	0.00	1477
LPTO		3.60	7.75	4.15	1101
SBTO	Guadalupe	0.91	1.03	0.12	869
	Santa Maria	26.85	30.34	3.49	805
	So. Ca. Water Co.	0.83	0.94	0.11	797
	Tank 5	36.18	40.88	4.70	
	Subtotal	64.77	73.19	8.42	
Total		**72.05**	**84.62**	**12.57**	

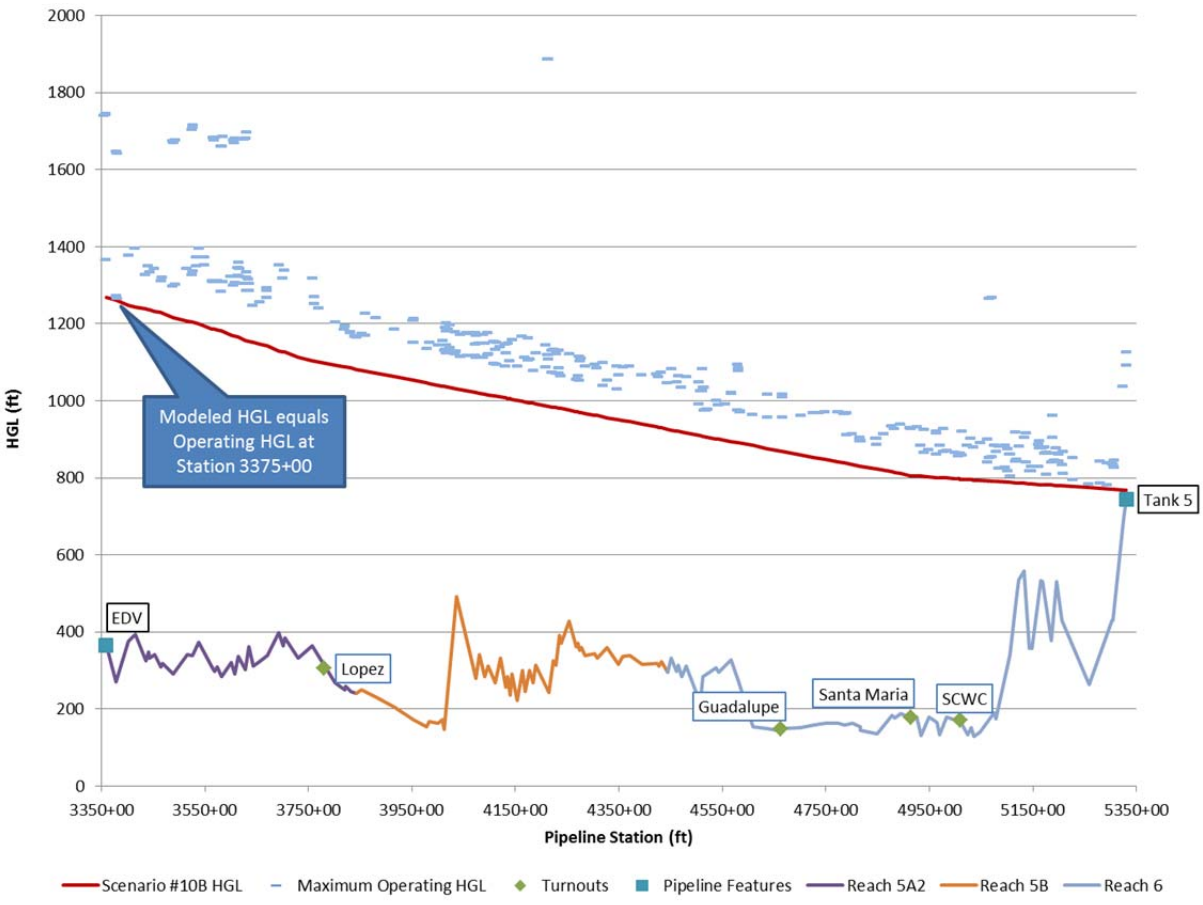

Figure A-2. Scenario #10B HGL Plot

Table A-3. Scenario #10C Results

	Subcontractors	Contract Rate (cfs)	Scenario Flow Rate (cfs)	Flow Rate Increase (cfs)	HGL (ft)
Shandon		0.15	0.15	0.00	1856
CVTO	Morro Bay	1.98	1.98	0.00	
	CMC Contractors	1.54	1.54	0.00	
	Subtotal	3.52	3.52	0.00	1472
LPTO		3.60	11.90	8.30	1079
SBTO	Guadalupe	0.91	0.99	0.08	862
	Santa Maria	26.85	29.27	2.42	803
	So. Ca. Water Co.	0.83	0.90	0.07	795
	Tank 5	36.18	39.44	3.26	
	Subtotal	64.77	70.60	5.83	
Total		**72.05**	**86.18**	**14.13**	

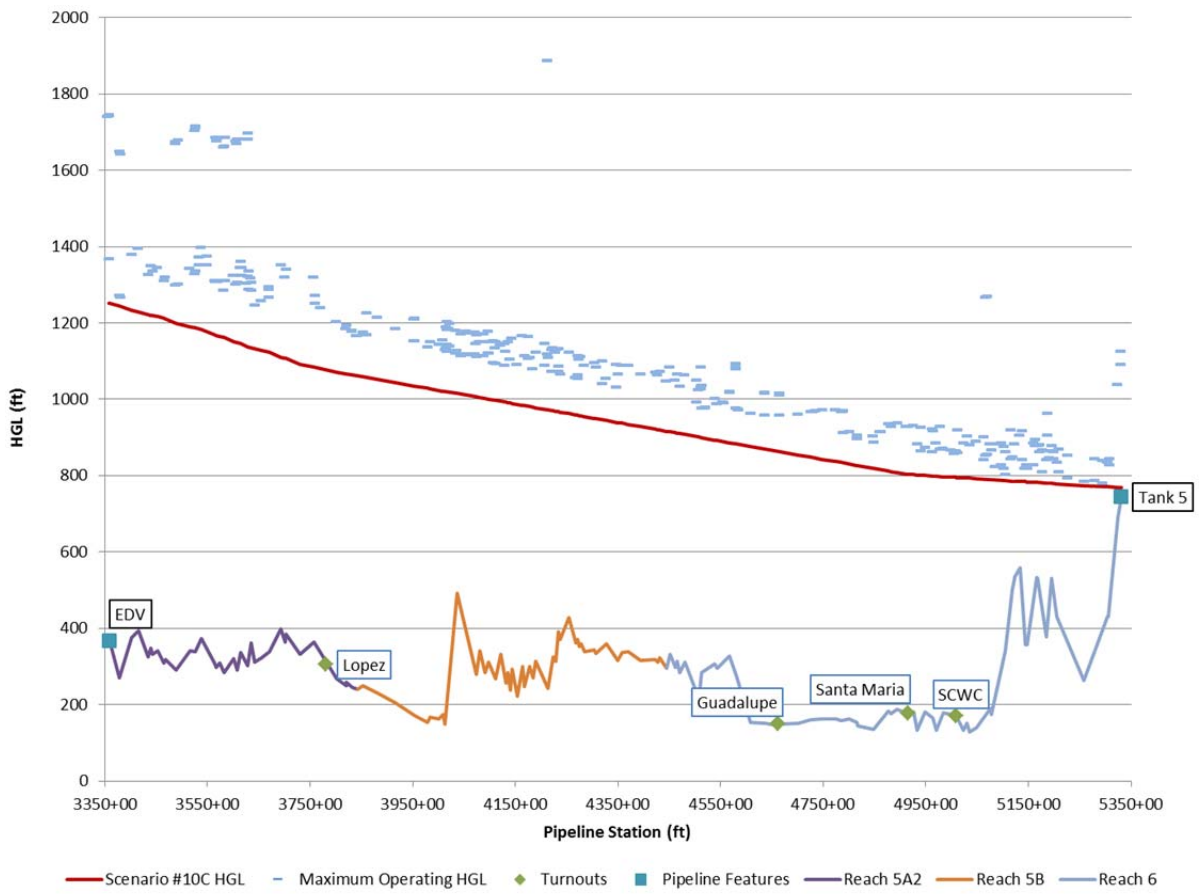

Figure A-3. Scenario #10C HGL Plot

Table A-4. Scenario #10D Results

	Subcontractors	Contract Rate (cfs)	Scenario Flow Rate (cfs)	Flow Rate Increase (cfs)	HGL (ft)
Shandon		0.15	0.15	0.00	1856
CVTO	Morro Bay	1.98	1.98	0.00	
	CMC Contractors	1.54	1.54	0.00	
	Subtotal	3.52	3.52	0.00	1472
LPTO		3.60	15.09	11.49	1053
SBTO	Guadalupe	0.91	0.95	0.04	855
	Santa Maria	26.85	27.93	1.07	800
	So. Ca. Water Co.	0.83	0.86	0.03	793
	Tank 5	36.18	37.63	1.45	
	Subtotal	64.77	67.36	2.59	
Total		**72.05**	**86.13**	**14.08**	

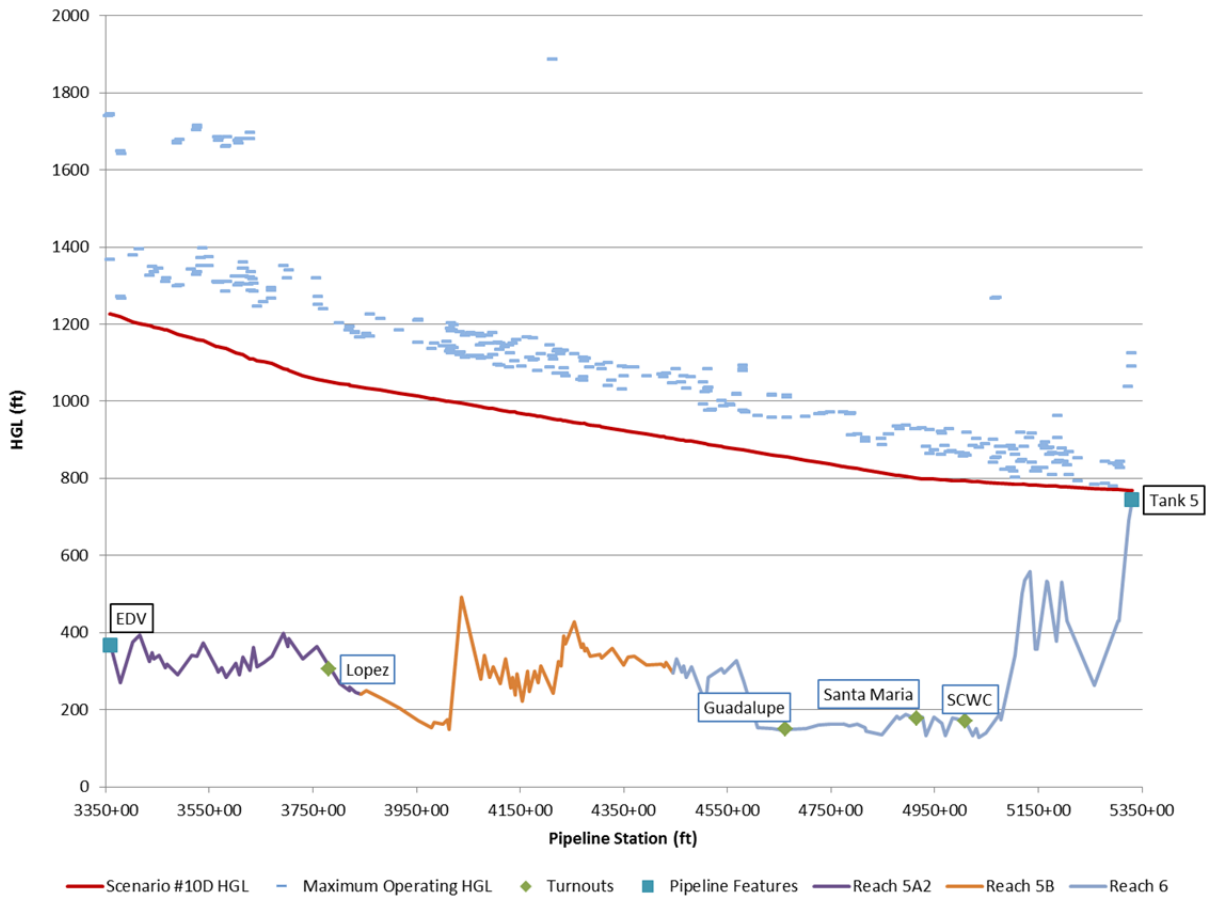

Figure A-4. Scenario #10D HGL Plot

Table A-5. Scenario #10E Results

	Subcontractors	Contract Rate (cfs)	Scenario Flow Rate (cfs)	Flow Rate Increase (cfs)	HGL (ft)
Shandon		0.15	0.15	0.00	1855
CVTO	Morro Bay	1.98	1.98	0.00	
	CMC Contractors	1.54	1.54	0.00	
	Subtotal	3.52	3.52	0.00	1471
LPTO		3.60	18.27	14.67	1033
SBTO	Guadalupe	0.91	0.91	0.00	848
	Santa Maria	26.85	26.85	0.00	798
	So. Ca. Water Co.	0.83	0.83	0.00	791
	Tank 5	36.18	36.18	0.00	
	Subtotal	64.77	64.77	0.00	
Total		**72.05**	**86.72**	**14.67**	

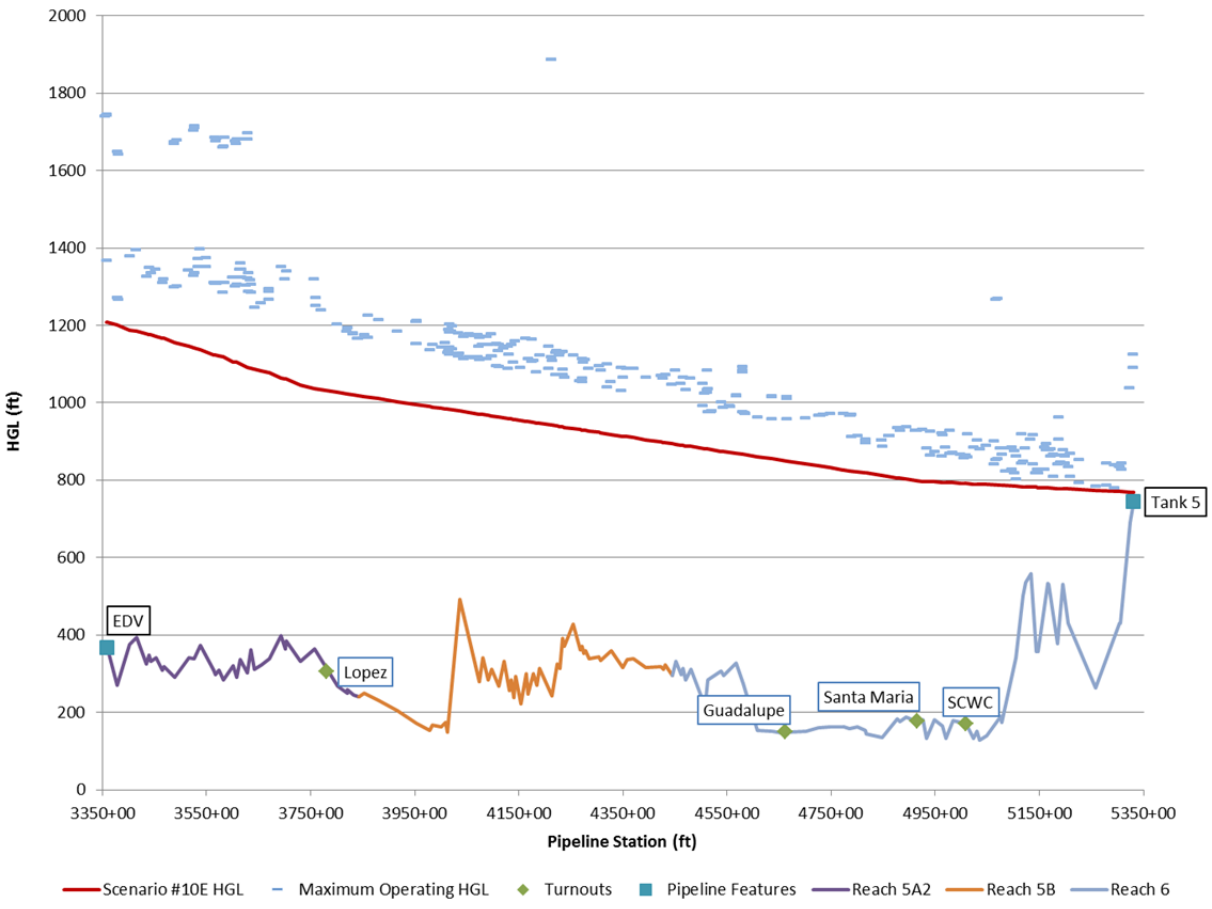

Figure A-5. Scenario #10E HGL Plot