Pipeline System Modeling

Tank 1 to Santa Ynez Pump Facility
Definition of Available Extra Capacity

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Central Coast Water Authority

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Summary

This model development and calibration effort is in response to the desire of CCWA to have a high level of confidence regarding available additional capacity in the State Water pipeline from Tank 1 to its Santa Ynez Pump Facility.

The CCWA pipeline from Tank 1 to the Santa Ynez Pump Facility forebay (approximately 124 miles) was modeled using a series of Excel spreadsheets. The model was calibrated using data from the peak flows that occurred during July and September 2004 (flow out of Tank 1 over 70 cfs).

The model is based on the Hazen Williams formula which is used in all water system models. The C-factors used in the Hazen Williams formula generally range from 135 to 153 for mortar lined pipe. The C factors associated with the CCWA pipeline are shown in Table 1 below.

Table 1: Summary of C Factors

CCWA and DWR Design:	**135 throughout**
Model Calibration:	**150-156 upstream of Tank 5** **135 downstream of Tank 5**
Recommended:	**150 upstream of Tank 5** **135 downstream of Tank 5**

The difference in the C factors in the two portions of the pipeline appears to be a function of the alignment and valves along the pipeline and not the surface lining. For example, the DWR section of the pipeline is generally much straighter with fewer valves than the CCWA section of pipeline. The CCWA pipeline has numerous mitered turns and a series of isolation valves associated with avoiding large spills on chloraminated water into endangered species habitat. These miter turns and valves increase losses in the pipeline resulting in the relatively lower C factor. The entire pipeline with a couple of minor exceptions is mortar lined steel pipe.

One area of concern regarding the calibration effort is that the calibration relies heavily on pressure readings along the pipeline. During the calibration process we used five sets of pressure data from the following points:

Upstream of the Energy Dissipation Valve (EDV)
Downstream of the Energy Dissipation Valve (EDV)
At the SYID#1 Turnout

To confirm the accuracy of the model we used the calibrated model to calculate the pressures at the various turnouts. The results are shown below.

Table 2: Confirmation of Model Accuracy

Turnout	Pressure Reading Actual psi	Pressure Calculated by Model psi	Difference psi
Chorro	418	425	-7
Lopez	313	307	+6
Guadalupe	297	296	+1
Santa Maria	261	266	-5
SoCAL	265	268	-3
VAFB	17	17	0
Buellton	120	98	+22
Solvang	69	68	-1
SYID#1	40	40	0
**			
Date	7-12-04		
Flow Tank 2	68.7	68.7	
Flow to Cachuma	18.8	18.8	
C Factor		150,150,135	

The model accurately estimated the pressure at the turnouts to within 1 to 2 percent except for the Buellton turnout. CCWA staff are investigating the data associated with the Buellton turnout pressure.

To further confirm the model calibration and accuracy we put the collected data into a WaterCad model. The WaterCad model was based on the modeling work done by Montgomery Watson in the 1990's. The WaterCad model duplicated the results obtained from the spreadsheet model. The simplicity and accuracy of the spreadsheet model for this single pipeline system, make it the best model to accurately and quickly run a variety of flow scenarios.

During the design of the pipeline during the early 1990s there was some concern that the C factor would degrade over time as the flow of water inside of the pipe caused the lining to become rougher. Our research has determined that the mortar lined pipe industry has now concluded that unless water velocities exceed approximately 14 feet per second, the mortar on the inside of the pipe will not become rougher over time. Based on the highest flows possible through the smallest portions of the pipeline, the worst case scenario involves 81 cfs through a short 42" diameter section of pipe with a water velocity of approximately 8.5 feet per second. Since the velocity of water in the pipeline is generally less than

6 feet per second, no roughening of the inside of the pipe is anticipated. Therefore the C factors estimated at this point in time should be good for the life of the pipe.

Based on our calibration work, our familiarity with the pipeline, our research, standard C-factors for pipes with the same lining and these test results we have a high level of confidence that the model reasonably calculates the friction losses along the pipeline and can be used to estimate maximum flows and pressures in the water line.

Results

The calibrated spreadsheet model was used to calculate maximum flows through the pipeline based on several criteria.

First flow data associated with CCWA entitlements and drought buffer were put into the model using a conservative C factor of 135 throughout the pipeline. This flow data is summarized in **Table 3: CCWA Turnout Demand Flows for Modeling Purposes**. The model confirmed that the CCWA water system can deliver to the turnouts all entitlements plus the drought buffer associated with each turnout. The flow rates assume that the CCWA pipeline will only be available 11 months each year due to downtime for maintenance.

The next model run used the C factor of 135 throughout to estimate additional capacity in the pipeline. This model run estimated that an additional 1.5 cfs of water could be added to the pipeline between Tank 1 and the Lopez Turnout. Additional capacity was not available below Tank 5. The 1.5 cfs is equivalent to 1,000 acre feet per year with one month of downtime for maintenance.

The next model run used a C factor of 150 above Tank 5 and 135 below Tank 5 as estimated during the calibration process. This model run estimated an additional 13.7 cfs of water could be added to the pipeline between Tank 1 and the Lopez Turnout (above entitlements plus drought buffer). Additional capacity was not available below Tank 5. The 13.7 cfs is equivalent to 9,100 acre feet per year with one month of downtime for maintenance.

The next model run was used to estimate the additional amount of water that could be removed from the pipeline in the Santa Maria Valley with 1.5 cfs removed from the pipeline at the Lopez turnout. This model run also used a C factor of 150 above Tank 5 and 135 below Tank 5 as estimated during the calibration process. The model estimated that an additional 7.5 cfs could be added to the pipeline between Tank 1 and Santa Maria Valley (in addition to the 1.5 cfs for Lopez). Additional capacity was not available below Tank 5. The 7.5 cfs to the Santa Maria Valley is equivalent to approximately 5,000 acre feet per year with one month of downtime for maintenance.

Table 3: CCWA Turnout Demand Flows For Modeling Purposes

PROJECT TURNOUT	Entitlment AFY	Drought Buffer AFY	Entitlement Plus Drought Buffer AFY	Turnout Raw cfs* cfs	**Peak Turnout Demand ** cfs**	**Peak Turnout Demand gpm**
PPWTP - Tank 1						
Tank 2						
Chorro	2,438		2,438	3.37	**3.67**	**1,649**
Energy Dissipation Valve						
Lopez	2,392		2,392	3.30	**3.60**	**1,618**
City of Guadalupe	550	55	605	0.84	**0.91**	**409**
City of Santa Maria	16,200	1,620	17,820	24.61	**26.85**	**12,052**
SCWC	500	50	550	0.76	**0.83**	**372**
Tank 5						
Vandenberg AFB	5,500	550	6,050	8.36	**9.12**	**4,092**
Tank 7						
City of Buellton	578	58	636	0.88	**0.96**	**430**
Santa Ynez ID#1 (Solvang)	1,500		1,500	2.07	**2.26**	**1,014**
Santa Ynez ID#1 ***	500	200	700	0.97	**1.05**	**473**
Pump Facility						
Lake Cachuma	13,750	1,375	15,125	20.89	**22.79**	**10,229**
Goleta WD	4,500					
Morehart Land Company	200					
La Cumbre Mutual WC	1,000					
Raytheon Systems Co.	50					
City of Santa Barbara	3,000					
Montecito WD	3,000					
Carpinteria Valley WD	2,000					
CCWA Subtotal	39,078					
SLOCFC&WCD Subtotal	4,830					
TOTAL	43,908	3,908	47,816	66	**72.1**	**32,339**

* AFY/724=cfs
**Raw cfs /11 months * 12 months (one month downtime)=Demand cfs
1 cfs for 1 year = 724 acre-feet per year
1 cfs for 11 months = 664 acre-feet per year
1 cfs = 448.83 gpm
***The Exchange Agreement allows SYID#1 to divert flow that would go to Lake Cachuma to its turnout during the summer months. This modeling effort assumes that the extra amount going to SYID#1 will not exceed the amount that would otherwise go to Lake Cachuma. Therefore the net result is that to upstream users there is no change in the demand downstream of SYID#1.

The last two columns of the table show the flow rates needed to deliver the base entitlement and drought buffer in 11 months leaving one month for maintenance downtime.

Note that the friction losses between Lopez turnout and the Santa Maria Valley (approximately 22 miles) means that more additional water can be taken out of the pipeline at Lopez Turnout than at the Santa Maria turnout.

A separate model run was made to estimate the additional amount of water that could be removed from the pipeline in the Santa Maria Valley with 2.3 cfs removed from the pipeline at the Lopez turnout (1,500 AFY). The model estimated that an additional 7.1 cfs could be added to the pipeline between Tank 1 and Santa Maria Valley (in addition to the 2.3 cfs for Lopez). Additional capacity was not available below Tank 5. The 7.1 cfs to the Santa Maria Valley is equivalent to approximately 4,700 acre feet per year with one month of downtime for maintenance.

Finally a model run was made to estimate the additional amount of water that could be removed from the pipeline in the Santa Maria Valley with no water removed from the pipeline at the Lopez turnout. The model estimated that an additional 8.4 cfs could be added to the pipeline between Tank 1 and Santa Maria Valley. Additional capacity was not available below Tank 5. The 8.4 cfs to the Santa Maria Valley is equivalent to approximately 5,600 acre feet per year with one month of downtime for maintenance.

Table 4: Model Run Results Additional Capacity Available

C Factor of 135 Throughout 124 Mile Pipeline
Entitlement with Drought Buffer &
Additional 1.5 cfs (1,000 AFY) to Lopez

C Factor of 150 Upstream of Tank 5
Additional 13.7 cfs (9,100 AFY) to Lopez
or
Additional 1.5 cfs (1,000 AFY) to Lopez &
7.5 cfs (5,000 AFY) to Santa Maria Valley
or
Additional 2.3 cfs (1,500 AFY) to Lopez &
7.1 cfs (4,700 AFY) to Santa Maria Valley
or
Additional 8.4 cfs (5,600 AFY) to Santa Maria Valley

Additional capacity not available below Tank 5