

APPENDIX F

Summary of Hydraulic Model Calibration Process and Results



This appendix provides a detailed summary of the City's hydraulic model calibration completed for the Citywide Water System Master Plan. The City's current hydraulic model was first updated with facilities that have been constructed or replaced since the last model update in 2007 and then calibrated to confirm that the computer simulation model can accurately represent the operation of the existing potable water distribution system under varying conditions. Calibration of the hydraulic model used data gathered through hydrant tests, hydrant pressure recorders, and the City's SCADA system as described in the following sections.

DEVELOPMENT OF HYDRANT (C-FACTOR) TESTS

After updating the hydraulic model with new facilities, 13 locations were selected for possible hydrant flow testing (see Figure 7-4). Since pipeline age information was not available on all the water system pipelines, selection of these hydrant test sites was predominantly based on specific pipeline size and material type. These hydrant tests were used to (1) evaluate pipeline friction factors (C-factors) currently assigned in the hydraulic model and (2) to calibrate the model to ensure that the hydraulic model closely represented actual observed flow and pressure conditions in the field.

Hydrant flow testing was scheduled and performed on April 20, 2010. However, one hydrant test (Test 7) was not completed that day due to the inability to flow the test hydrant because of an unidentified closed valve. The closed valve was subsequently located by City staff, and Test 7 was completed on May 6, 2010. Table 1 provides the field status of each proposed hydrant test. Of the original 13 scheduled hydrant tests, 11 were performed in the field as shown in Table 1. One hydrant test was canceled due to constraints identified by City staff related to the ability to isolate the hydrants for testing. The remaining test was considered an alternate test, and was not required.

Each hydrant test involved flowing water through pipelines of a specific size and material type¹, and then measuring the pressure drops along the pipelines to determine friction losses. The hydrant test procedure consisted of monitoring discharge flow and pressure at the key (flowing) hydrant, and pressures at other hydrants along the supply routes to that key hydrant. Static pressures were measured while the key hydrant was closed, and residual pressures were measured while the key hydrant was flowing.

Each completed hydrant flow test was then simulated using the updated hydraulic model of the City's existing potable water system. Results from the hydraulic model were compared to the collected field data to determine the accuracy of the hydraulic model. The differences between observed static and residual pressures for the field hydrant test, compared to readings predicted by the model, were calculated. The goal of the calibration effort was to achieve no greater than a 5 psi differential between the field hydrant test data and model-simulated results. Results from the hydrant tests are discussed in more detail in the following section.

¹ For each hydrant test, system valves were closed as necessary to isolate pipelines of a specific size and material type.



Table 1. Hydrant Test Locations^(a)

Test #	Material	Diameter, inches	Location	Field Status
1 ^(b)	AC ^(c)	10	Along Tenth St., West of East St.	Completed
2	CI ^(d)	8	Along Parker Ave., North of Twelfth St.	Completed
3	AC	8	Along Buthmann Ave., North of Grant Line Rd.	Completed
4	DI	12	Along Kavanagh Ave., West of Reyes Ln.	Completed
5	DI	8	Along Rugby Ct., West of Hampshire Ln.	Completed
6	DI	10	Along Gentry Ln., South of Anthony Dr.	Completed
7	DI	12	Along Schulte Rd., approx. 3,700 feet East of Lammers Rd.	Completed ^(e)
8	AC	8	Along Hickory Ave., South of Tennis Ln.	Completed
9	AC	12	Along South St., West of A St.	Canceled
10 ^(b)	DI	8	Along Earl Way, North of Silkwood Ln.	Completed
A1	DI	8	Along Misty Meadow Dr., North of Meadow Ln.	Completed
A2	AC	6	Along Alvarado Way, West of Cabrillo Dr.	Completed
A3	CI	6	Along Lowell Ave., West of Wall St.	--

^(a) 10 Test Locations (#1-10), 3 Alternate Test Locations (#A1-A3).
^(b) Test location was slightly revised on April 20, 2010.
^(c) Some of the pipelines in this test have been replaced with DI pipe.
^(d) All the pipelines in this test have been replaced with DI pipe.
^(e) Test was completed on May 6, 2010.

HYDRANT (C-FACTOR) TEST RESULTS

The results of the simulated hydrant flow tests generally validated the system pipeline configuration and confirmed the C-factors currently assigned in the hydraulic model. However, based on the comparison of the collected hydrant flow test data and initial model-simulated results, three of the hydrant flow tests (Tests 5, 8, and 10) required further evaluation and adjustments because they did not initially meet the ± 5 psi tolerance limit established for model calibration. Additional discussion regarding adjustments to Tests 5, 8, and 10 is provided below.

Hydrant Test 5: 8-inch DI Pipelines

The difference between field-observed and model-simulated pressures for all hydrants included in Test 5 was up to 7 psi. Since the C-factor required for the model to simulate within the ± 5 psi pressure differential for Test 5 is unreasonable for this pipeline diameter and material, the results from the hydraulic model simulation indicate that there may be system configuration issues (e.g., partially closed valve(s), inaccurate representation of pipeline connectivity, etc.) within the area of Test 5.

On May 11, 2010, City staff confirmed that there was a closed valve located on Banbury Court, southeast of Blandford Lane.² Test 5 simulates within a 5 psi differential from the field hydrant

² This closed valve has subsequently been opened by City staff.



test data after the closed valve was accurately simulated within the hydraulic model. This result indicates that the current C-factor assigned to 8-inch DI pipelines is appropriate.

Hydrant Test 8: 8-inch AC Pipelines

The difference between field-observed and model-simulated pressures for Hydrant 8C was 12 psi. However, model simulation results from observed Hydrants 8A and 8B were well within the ± 5 psi tolerance limit. In addition, the C-factor for 8-inch AC pipelines was previously validated in Test 3. Therefore, the results from the hydraulic model simulation indicate that for Test 8 there may have been an error with the residual pressure reading at Hydrant 8C. It is recommended that the data from observed Hydrant 8C not be used.

Test 8 simulates within a 5 psi differential from the field hydrant test data after the pressure comparison at Hydrant 8C was removed. This result indicates that the current C-factor assigned to 8-inch AC pipelines is appropriate.

Hydrant Test 10: 8-inch DI Pipelines

The difference between field-observed and model-simulated pressures for Hydrant 10C was 10 psi. However, model simulation results from observed Hydrants 10A, 10B, and 10D were within the ± 5 psi tolerance limit. In addition, the C-factor for 8-inch DI pipelines was validated in Tests 2 and A1. Therefore, the results from the hydraulic model simulation indicate that for Test 10 there may have been an error with the residual pressure reading at Hydrant 10C. It is recommended that the data from observed Hydrant 10C not be used.

Test 10 simulates within a 5 psi differential from the field hydrant test data after the pressure comparison at Hydrant 10C was removed. This result indicates that the current C-factor assigned to 8-inch DI pipelines is appropriate.

Summary of Hydrant Test Results

Because Tests 5, 8, and 10 were able to meet the ± 5 psi tolerance limit established for calibration after the removal of erroneous data and slight adjustments, and the remaining (8) hydrant tests were able to closely replicate field-observed pressures, these results indicate that the C-factors currently assigned in the hydraulic model are appropriate for use to represent the City's existing potable water distribution system. The following pages (F-5 through F-32) contain complete detailed results of each individual hydrant test that was performed in the field. Discussions regarding the development of the extended period simulation and the associated model verification results begin on Page F-33.



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Hydrant Test No. 1

Hydrant Test No. 1 was performed on Tenth Street, west of East Street.³ This test was conducted to confirm the C-factor (initially assumed to equal 125) of a 10-inch diameter, AC pipeline. However, based on discussions with City staff during the test, it was found that pipelines located on Tenth Street may have been replaced in 2005. Subsequent review of pipeline replacement drawings (CIP No. 7966) indicated that the pipelines between Hydrants 1B and 1D have been replaced with 10-inch diameter DI pipes. Consequently, the hydraulic model was updated to reflect this information. The C-factor assumed for the new 10-inch diameter DI pipe was 130.

A comparison of the differential pressure readings predicted by the hydraulic model, compared to pressures actually measured in the field, demonstrates that the pressures predicted by the model are within ±5 psi of the measured field value. The calibrated model results and the field data are shown in Table F-1 and indicate that the use of a C-factor equal to 125 for 10-inch diameter AC pipelines and a C-factor equal to 130 for 10-inch diameter DI pipelines is valid.

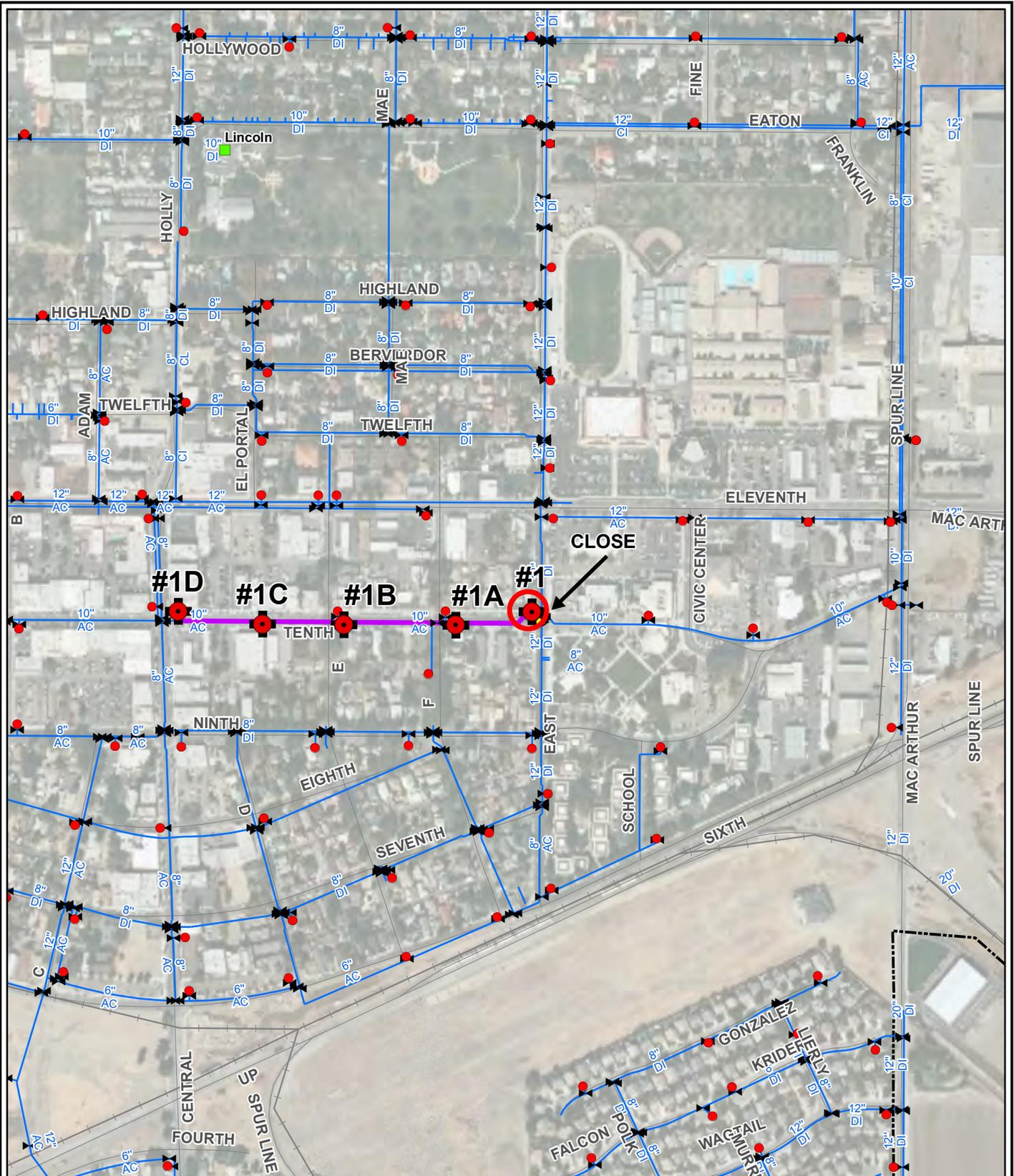
Table F-1. Hydrant Test No. 1

Hydrant ⁽¹⁾	Field Data			Modeled Data			Comparison of Differential Pressures (psi) (g = c-f)
	Static Pressure (psi) (a)	Residual Pressure (psi) (b)	Differential Pressure (psi) (c = a-b)	Static Pressure (psi) (d)	Residual Pressure (psi) (e)	Differential Pressure (psi) (f = d-e)	
Flowing ⁽²⁾	61	36	NA	61	NA	NA	NA
1A ⁽³⁾	62	50	12	61	47	14	-2
1B ⁽⁴⁾	64	54	10	60	51	9	1
1C ⁽⁵⁾	60	52	8	60	55	5	3
1D ⁽⁶⁾	60	54	6	60	58	2	4

(1) Location of fire hydrants can be found on Figure F-1.
 (2) The "Flowing Hydrant" is located on Tenth Street, west of East Street.
 (3) Hydrant 1A is located on Tenth Street, east of F Street.
 (4) Hydrant 1B is located on Tenth Street, east of E Street.
 (5) Hydrant 1C is located on Tenth Street, west of Hydrant 1B.
 (6) Hydrant 1D is located on Tenth Street, east of Central Avenue.
 NA = Not Applicable

³ The original location was revised on April 20, 2010 due to a broken valve located at the proposed flowing hydrant.

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LEGEND:

- Test Hydrant
- Hydrant
- Close Valve
- Valve
- Test Pipeline
- Pipeline



FIGURE F-1

**City of Tracy
Citywide Water Master Plan**

**TEST #1 (10" AC)
(Revised on 04/20/10)**





Hydrant Test No. 2

Hydrant Test No. 2 was performed on Parker Avenue, north of Twelfth Street. Based on discussions with City staff during the test, it was found that the 8-inch diameter CI pipelines located on Parker Avenue may have been replaced. Subsequent review of pipeline replacement drawings (Parker Avenue Rehabilitation Project) indicated that the pipelines on Parker Avenue between Eleventh Street and Grant Line Road have been replaced with 8-inch diameter DI pipes. Consequently, the hydraulic model was updated to reflect this information. The C-factor assumed for the new 8-inch diameter DI pipe was 130.

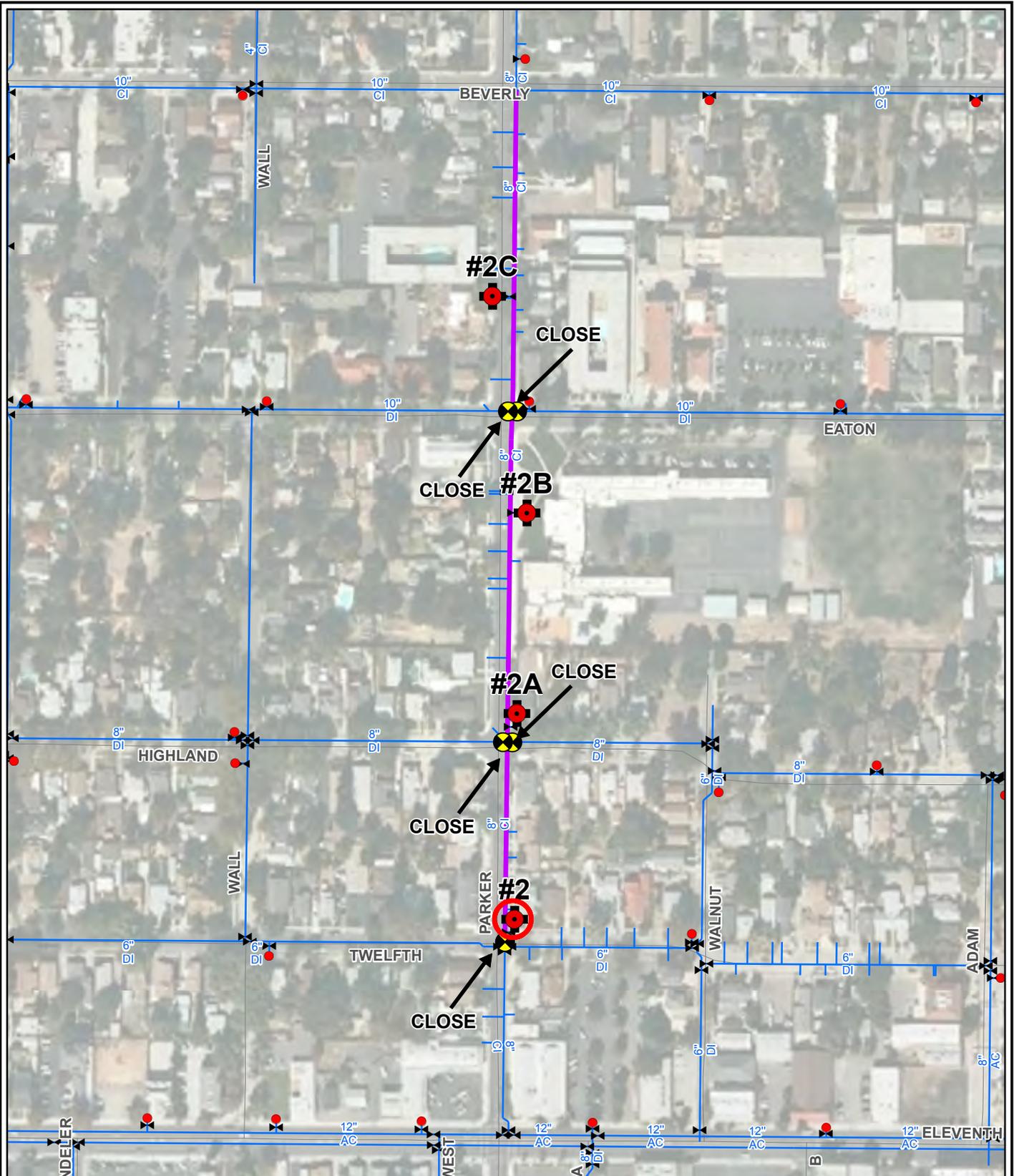
A comparison of the differential pressure readings predicted by the hydraulic model, compared to pressures actually measured in the field, demonstrates that the pressures predicted by the model are within ± 5 psi of the measured field value. The calibrated model results and the field data are shown in Table F-2 and indicate that the use of a C-factor equal to 130 for 8-inch diameter DI pipelines is valid.

Table F-2. Hydrant Test No. 2

Hydrant ⁽¹⁾	Field Data			Modeled Data			Comparison of Differential Pressures (psi) (g = c-f)
	Static Pressure (psi) (a)	Residual Pressure (psi) (b)	Differential Pressure (psi) (c = a-b)	Static Pressure (psi) (d)	Residual Pressure (psi) (e)	Differential Pressure (psi) (f = d-e)	
Flowing ⁽²⁾	60	14	NA	60	NA	NA	NA
2A ⁽³⁾	62	27	35	62	32	30	5
2B ⁽⁴⁾	65	42	23	62	41	21	2
2C ⁽⁵⁾	61	46	15	64	51	13	2

(1) Location of fire hydrants can be found on Figure F-2.
 (2) The "Flowing Hydrant" is located on Parker Avenue, north of Twelfth Street.
 (3) Hydrant 2A is located on Parker Avenue, north of W Highland Avenue.
 (4) Hydrant 2B is located on Parker Avenue, south of Eaton Avenue.
 (5) Hydrant 2C is located on Parker Avenue, north of Eaton Avenue.
 NA = Not Applicable

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LEGEND:

-  Test Hydrant
-  Hydrant
-  Close Valve
-  Valve
-  Test Pipeline
-  Pipeline



FIGURE F-2

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Citywide Water Master Plan**

TEST #2 (8" CI)





Hydrant Test No. 3

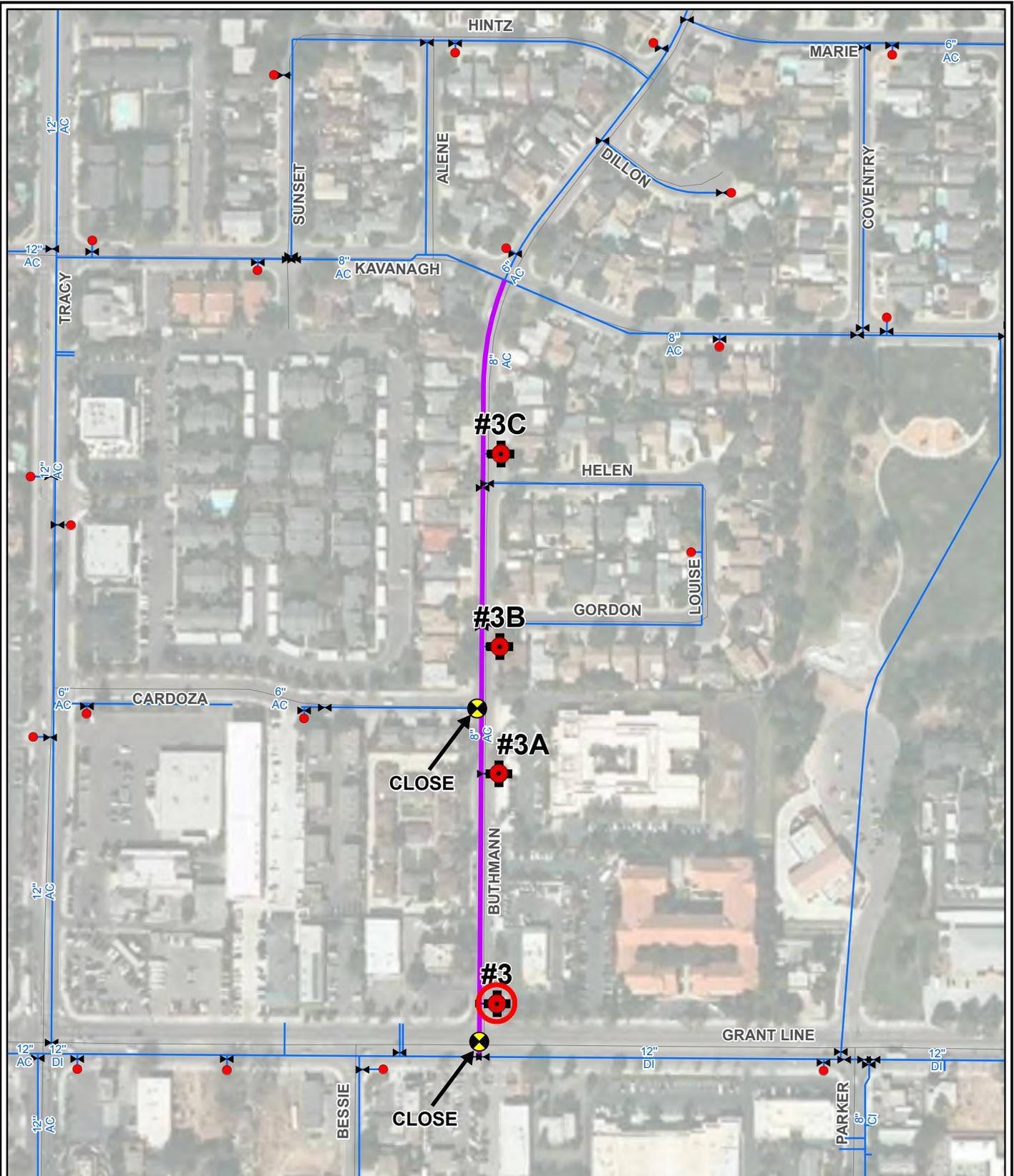
Hydrant Test No. 3 was performed on Buthmann Avenue, north of Grant Line Road. This test was conducted to confirm the C-factor (initially assumed to equal 125) of an 8-inch diameter, AC pipeline. A comparison of the differential pressure readings predicted by the hydraulic model, compared to pressures actually measured in the field, demonstrates that the pressures predicted by the model are within ± 5 psi of the measured field value. The calibrated model results and the field data are shown in Table F-3 and indicate that the use of a C-factor equal to 125 for this size and type of pipeline is valid.

Table F-3. Hydrant Test No. 3

Hydrant ⁽¹⁾	Field Data			Modeled Data			Comparison of Differential Pressures (psi) (g = c-f)
	Static Pressure (psi) (a)	Residual Pressure (psi) (b)	Differential Pressure (psi) (c = a-b)	Static Pressure (psi) (d)	Residual Pressure (psi) (e)	Differential Pressure (psi) (f = d-e)	
Flowing ⁽²⁾	69	18	NA	71	NA	NA	NA
3A ⁽³⁾	72	48	24	72	45	27	-3
3B ⁽⁴⁾	73	51	22	72	52	20	2
3C ⁽⁵⁾	71	53	18	73	59	14	4

(1) Location of fire hydrants can be found on Figure F-3.
 (2) The "Flowing Hydrant" is located on Buthmann Avenue, north of Grant Line Road.
 (3) Hydrant 3A is located on Buthmann Avenue, south of Cordoza Road.
 (4) Hydrant 3B is located on Buthmann Avenue, south of Gordon Avenue.
 (5) Hydrant 3C is located on Buthmann Avenue, north of Helen Avenue.
 NA = Not Applicable

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LEGEND:

-  Test Hydrant
-  Hydrant
-  Close Valve
-  Valve
-  Test Pipeline
-  Pipeline

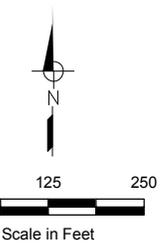


FIGURE F-3

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TEST #3 (8" AC)





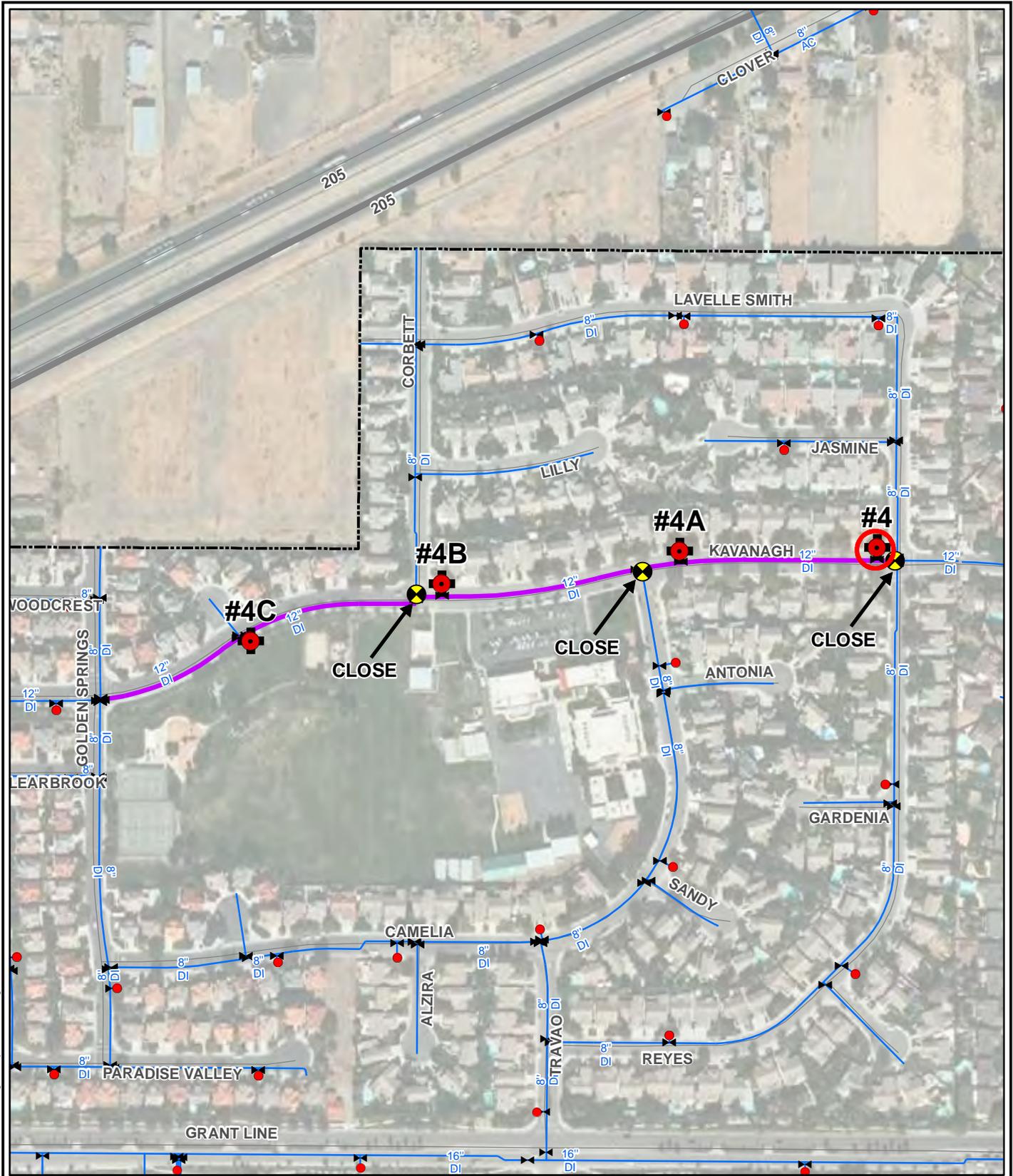
Hydrant Test No. 4

Hydrant Test No. 4 was performed on W. Kavanagh Avenue, west of Reyes Lane. This test was conducted to confirm the C-factor (initially assumed to equal 130) of a 12-inch diameter, DI pipeline. A comparison of the differential pressure readings predicted by the hydraulic model, compared to pressures actually measured in the field, demonstrates that the pressures predicted by the model are within ± 5 psi of the measured field value. The calibrated model results and the field data are shown in Table F-4 and indicate that the use of a C-factor equal to 130 for this size and type of pipeline is valid.

Table F-4. Hydrant Test No. 4

Hydrant ⁽¹⁾	Field Data			Modeled Data			Comparison of Differential Pressures (psi) (g = c-f)
	Static Pressure (psi) (a)	Residual Pressure (psi) (b)	Differential Pressure (psi) (c = a-b)	Static Pressure (psi) (d)	Residual Pressure (psi) (e)	Differential Pressure (psi) (f = d-e)	
Flowing ⁽²⁾	71	34	NA	72	NA	NA	NA
4A ⁽³⁾	74	55	19	72	55	17	2
4B ⁽⁴⁾	75	59	16	73	60	13	3
4C ⁽⁵⁾	72	59	13	72	63	9	4

(1) Location of fire hydrants can be found on Figure F-4.
 (2) The "Flowing Hydrant" is located on W Kavanagh Avenue, west of Reyes Lane.
 (3) Hydrant 4A is located on W Kavanagh Avenue, east of Camellia Drive.
 (4) Hydrant 4B is located on W Kavanagh Avenue, east of Corbett Lane.
 (5) Hydrant 4C is located on W Kavanagh Avenue, northeast of Golden Springs Drive.
 NA = Not Applicable



LEGEND:

-  Test Hydrant
-  Hydrant
-  Close Valve
-  Valve
-  Test Pipeline
-  Pipeline

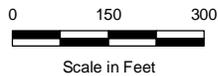


FIGURE F-4

**City of Tracy
Citywide Water Master Plan**

TEST #4 (12" DI)





Hydrant Test No. 5

Hydrant Test No. 5 was performed at the west end of Rugby Court. This test was conducted to confirm the C-factor (initially assumed to equal 135) of an 8-inch diameter, DI pipeline. A comparison of the differential pressure readings predicted by the hydraulic model, compared to pressures actually measured in the field, demonstrates that the pressures predicted by the model are not within ± 5 psi of the measured field value. The initial model-simulated results and field-observed data are shown in Table F-5A.

Since the C-factor required for the model to simulate within the ± 5 psi pressure differential for Test 5 is unreasonable for this pipeline diameter and material, the results from the hydraulic model simulation indicate that there may be system configuration issues (e.g., partially closed valve(s), inaccurate representation of pipeline connectivity, etc.) within the area of Test 5.

On May 11, 2010, City staff confirmed that there was a closed valve located on Banbury Court, southeast of Blandford Lane.⁴ As shown in Table F-5B, Test 5 simulates within a 5 psi differential from the field hydrant test data after the closed valve was accurately simulated within the hydraulic model. This result indicates that the use of a C-factor equal to 135 for this size and type of pipeline is valid.

Table F-5A. Hydrant Test No. 5

Hydrant ⁽¹⁾	Field Data			Modeled Data			Comparison of Differential Pressures (psi) (g = c-f)
	Static Pressure (psi) (a)	Residual Pressure (psi) (b)	Differential Pressure psi (c = a-b)	Static Pressure (psi) (d)	Residual Pressure (psi) (e)	Differential Pressure (psi) (f = d-e)	
Flowing ⁽²⁾	66	13	NA	67	NA	NA	NA
5A ⁽³⁾	68	30	38	67	36	31	7
5B ⁽⁴⁾	69	38	31	67	42	25	6
5C ⁽⁵⁾							
5D ⁽⁶⁾	67	42	25	68	50	18	7

(1) Location of fire hydrants can be found on Figure F-5.
 (2) The "Flowing Hydrant" is located at west end of Rugby Court.
 (3) Hydrant 5A is located on Hampshire Lane, southwest of Rugby Court.
 (4) Hydrant 5B is located on Ferndown Lane, west of Hampshire Lane.
 (5) Hydrant 5C does not exist.
 (6) Hydrant 5D is located on Ferndown Lane, southeast of Blandford Lane.
 NA = Not Applicable

⁴ This closed valve has subsequently been opened by City staff.

Appendix F

Summary of Hydraulic Model Calibration Process and Results

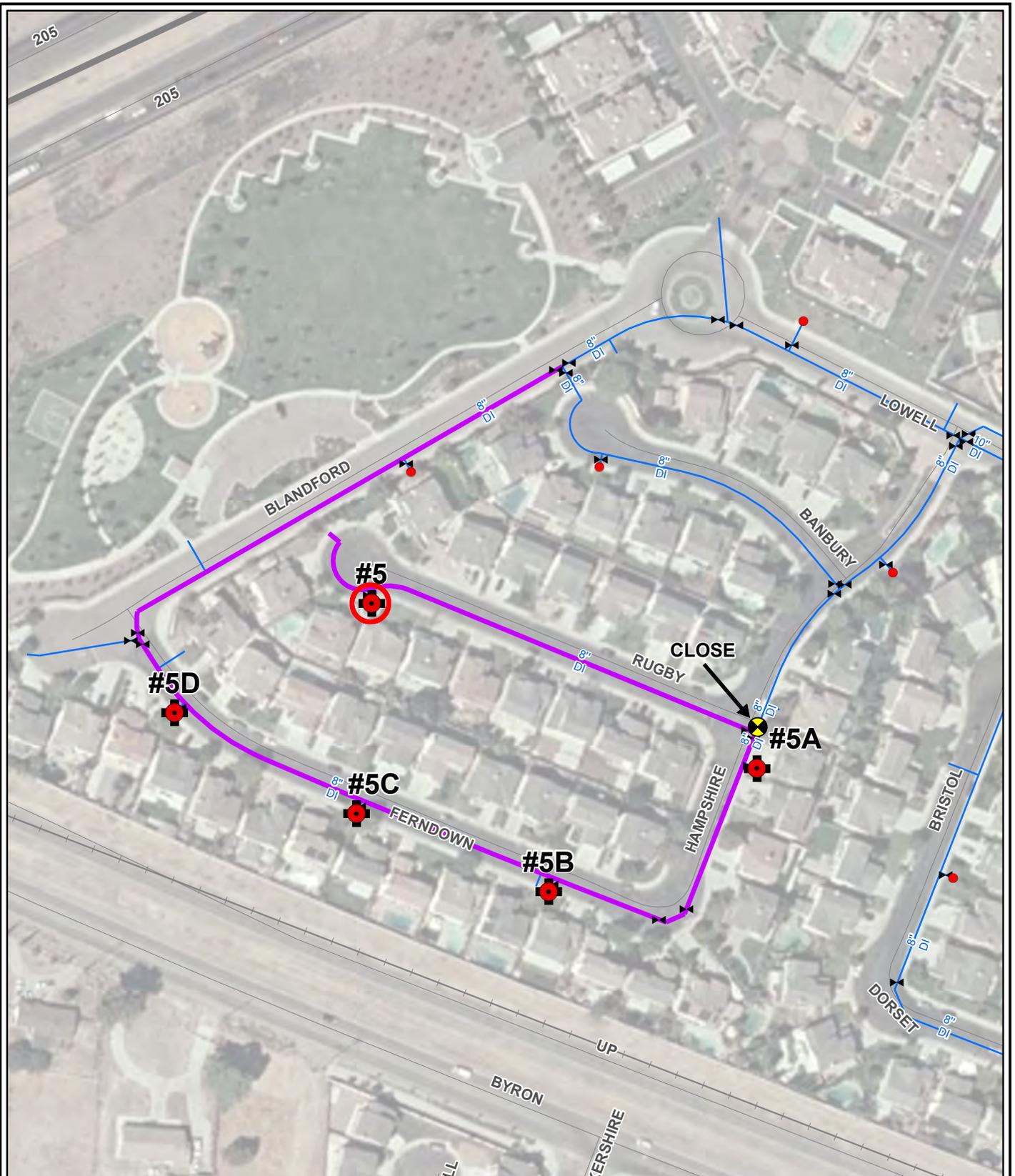


Table F-5B. Hydrant Test No. 5 (Revised)

Hydrant ⁽¹⁾	Field Data			Modeled Data			Comparison of Differential Pressures (psi) (g = c-f)
	Static Pressure (psi) (a)	Residual Pressure (psi) (b)	Differential Pressure psi (c = a-b)	Static Pressure (psi) (d)	Residual Pressure (psi) (e)	Differential Pressure (psi) (f = d-e)	
Flowing ⁽²⁾	66	13	NA	67	NA	NA	NA
5A ⁽³⁾	68	30	38	67	31	36	2
5B ⁽⁴⁾	69	38	31	67	36	31	0
5C ⁽⁵⁾							
5D ⁽⁶⁾	67	42	25	68	44	24	1

(1) Location of fire hydrants can be found on Figure F-5.
 (2) The "Flowing Hydrant" is located at west end of Rugby Court.
 (3) Hydrant 5A is located on Hampshire Lane, southwest of Rugby Court.
 (4) Hydrant 5B is located on Ferndown Lane, west of Hampshire Lane.
 (5) Hydrant 5C does not exist.
 (6) Hydrant 5D is located on Ferndown Lane, southeast of Blandford Lane.
 NA = Not Applicable

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LEGEND:

-  Test Hydrant
-  Hydrant
-  Close Valve
-  Valve
-  Test Pipeline
-  Pipeline

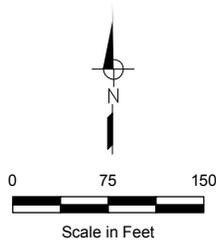


FIGURE F-5

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Citywide Water Master Plan**

TEST #5 (8" DI)





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Hydrant Test No. 6

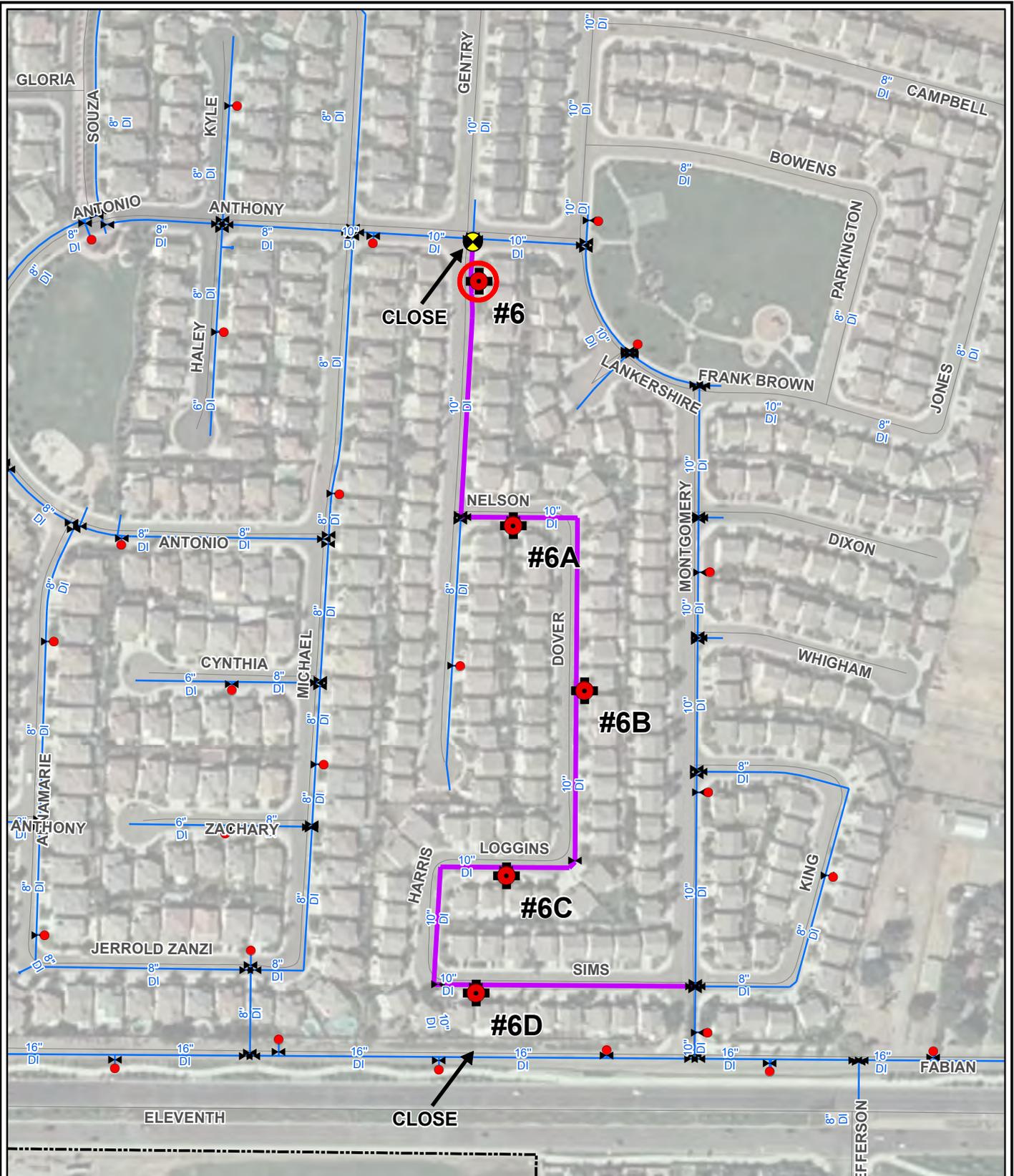
Hydrant Test No. 6 was performed on Gentry Lane, south of Anthony Drive. This test was conducted to confirm the C-factor (initially assumed to equal 135) of a 10-inch diameter, DI pipeline. A comparison of the differential pressure readings predicted by the hydraulic model, compared to pressures actually measured in the field, demonstrates that the pressures predicted by the model are within ± 5 psi of the measured field value. The calibrated model results and the field data are shown in Table F-6 and indicate that the use of a C-factor equal to 135 for this size and type of pipeline is valid.

Table F-6. Hydrant Test No. 6

Hydrant ⁽⁶⁾	Field Data			Modeled Data			Comparison of Differential Pressures (psi) (g = c-f)
	Static Pressure (psi) (a)	Residual Pressure (psi) (b)	Differential Pressure (psi) (c = a-b)	Static Pressure (psi) (d)	Residual Pressure (psi) (e)	Differential Pressure (psi) (f = d-e)	
Flowing ⁽²⁾	61	29	NA	64	NA	NA	NA
6A ⁽³⁾	64	42	22	63	39	24	-2
6B ⁽⁴⁾	64	48	16	63	44	19	-3
6C ⁽⁵⁾	62	47	15	61	48	13	2
6D ⁽⁶⁾	62	50	12	61	53	8	4

(1) Location of fire hydrants can be found on Figure F-6.
 (2) The "Flowing Hydrant" is located on Gentry Lane, south of Anthony Drive.
 (3) Hydrant 6A is located on Nelson Lane, east of Gentry Court.
 (4) Hydrant 6B is located on Dover Lane, north of Loggins Lane.
 (5) Hydrant 6C is located on Loggins Lane, west of Dover Lane.
 (6) Hydrant 6D is located on Simms Lane, east of Harris Lane.
 NA = Not Applicable

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LEGEND:

-  Test Hydrant
-  Hydrant
-  Close Valve
-  Valve
-  Test Pipeline
-  Pipeline



FIGURE F-6

**City of Tracy
Citywide Water Master Plan**

TEST #6 (10" DI)





Hydrant Test No. 7

Hydrant Test No. 7 was performed on Schulte Road, across from Cottage Grove Court.⁵ This test was conducted to confirm the C-factor (initially assumed to equal 135) of a 12-inch diameter, DI pipeline. A comparison of the differential pressure readings predicted by the hydraulic model, compared to pressures actually measured in the field, demonstrates that the pressures predicted by the model are within ± 5 psi of the measured field value. The calibrated model results and the field data are shown in Table F-7 and indicate that the use of a C-factor equal to 135 for this size and type of pipeline is valid.

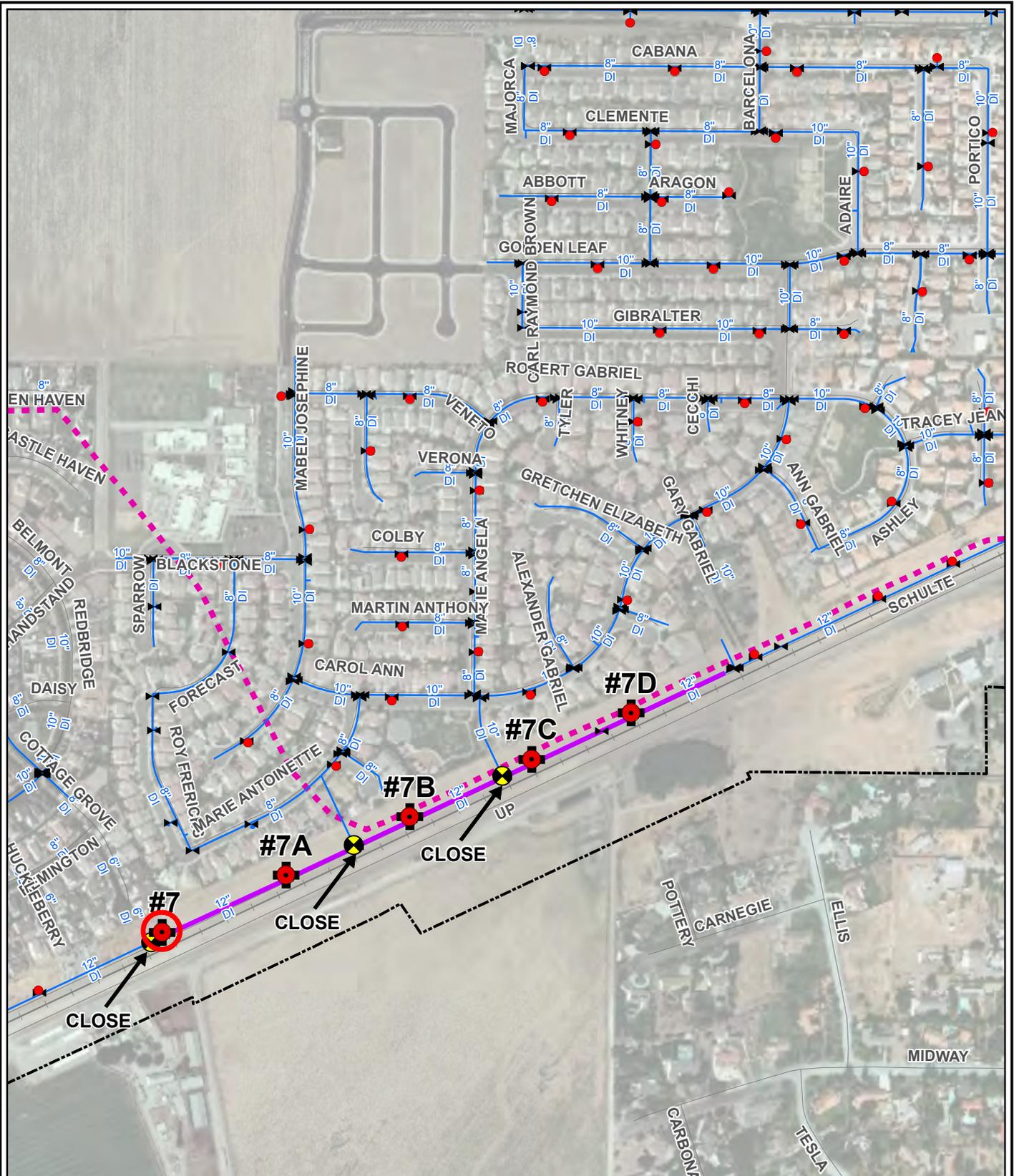
Table F-7. Hydrant Test No. 7

Hydrant ⁽¹⁾	Field Data			Modeled Data			Comparison of Differential Pressures (psi) (g = c-f)
	Static Pressure (psi) (a)	Residual Pressure (psi) (b)	Differential Pressure (psi) (c = a-b)	Static Pressure (psi) (d)	Residual Pressure (psi) (e)	Differential Pressure (psi) (f = d-e)	
Flowing ⁽²⁾	78	65	NA	73	NA	NA	NA
7A ⁽³⁾	82	72	10	78	68	10	0
7B ⁽⁴⁾	85	75	10	79	71	8	2
7C ⁽⁵⁾	82	72	10	82	75	7	3
7D ⁽⁶⁾	84	77	7	82	76	6	1

(1) Location of fire hydrants can be found on Figure F-7.
 (2) The "Flowing Hydrant" is located on Schulte Road, across from Cottage Grove Court.
 (3) Hydrant 7A is located on Schulte Road, northeast of flowing hydrant.
 (4) Hydrant 7B is located on Schulte Road, northeast of Hydrant 7A.
 (5) Hydrant 7C is located on Schulte Road, northeast of Hydrant 7B.
 (6) Hydrant 7D is located on Schulte Road, northeast of Hydrant 7C.
 NA = Not Applicable

⁵ Test 7 was not completed as scheduled on April 20, 2010 due to the inability to flow the test hydrant because of an unidentified closed valve. The closed valve was subsequently located by City staff, and Test 7 was completed on May 6, 2010.

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LEGEND:

-  Test Hydrant
-  Hydrant
-  Close Valve
-  Valve
-  Test Pipeline
-  Pipeline



FIGURE F-7

**City of Tracy
Citywide Water Master Plan**

TEST #7 (12" DI)





Hydrant Test No. 8

Hydrant Test No. 8 was performed on S Hickory Avenue, south of Tennis Lane. This test was conducted to confirm the C-factor (initially assumed to equal 125) of an 8-inch diameter, AC pipeline. A comparison of the differential pressure readings predicted by the hydraulic model, compared to pressures actually measured in the field, demonstrates that the pressures predicted by the model are within ± 5 psi of the measured field value, except for the result at Hydrant 8C. Hydrant 8C shows a difference between measured and modeled pressures of 12 psi, which is not within the ± 5 psi tolerance limit. The model-simulated results and the field-observed data are shown in Table F-8.

Since the C-factor for 8-inch AC pipelines was previously validated in Test 3 and model simulation results from observed Hydrants 8A and 8B were well within the ± 5 psi tolerance limit, the results from the hydraulic model simulation indicate that for Test 8 there may have been an error with the residual pressure reading at Hydrant 8C. Therefore, it is recommended that the data from observed Hydrant 8C not be used.

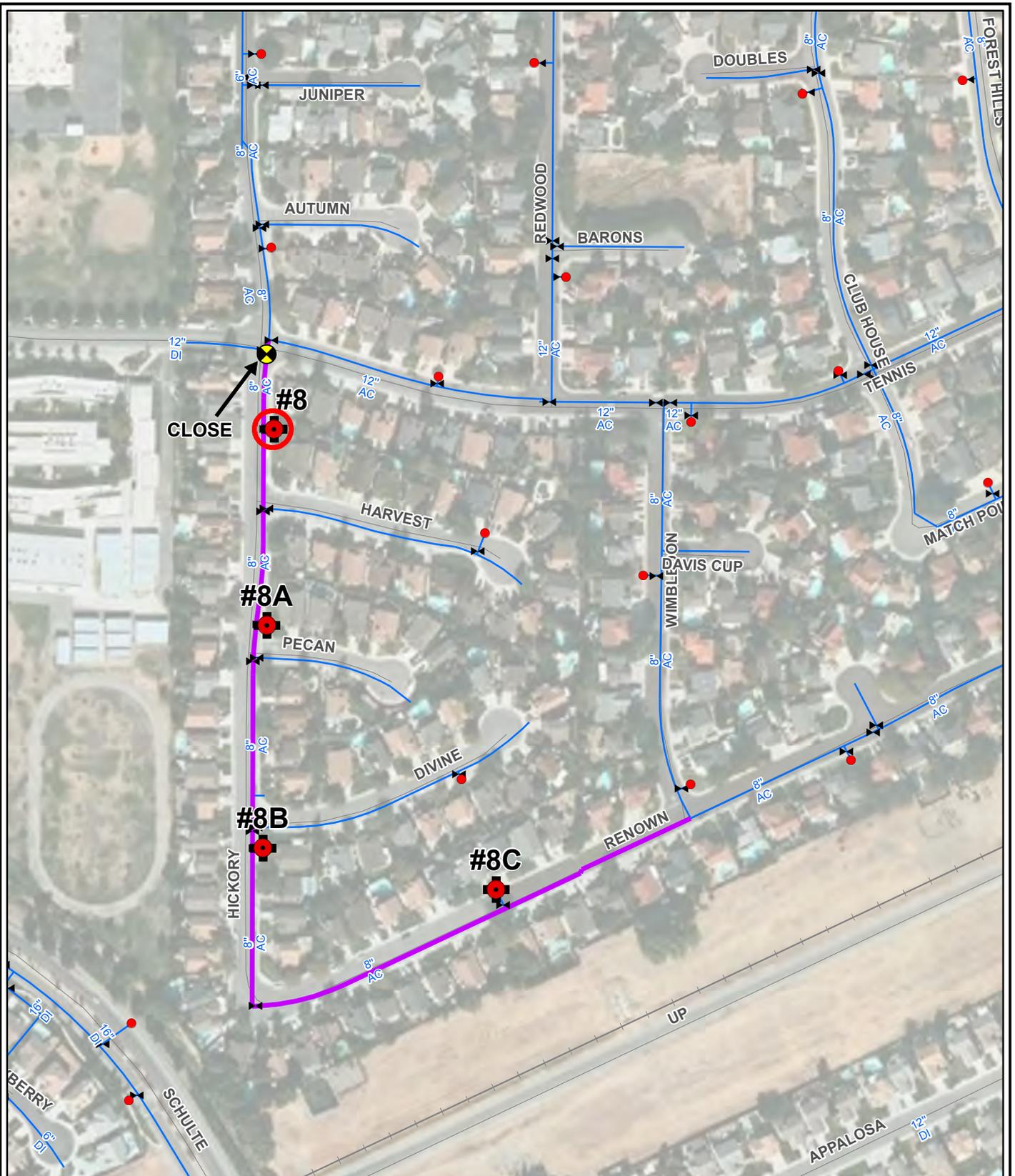
Test 8 simulates within a 5 psi differential from the field hydrant test data after the pressure comparison at Hydrant 8C was removed. This result indicates that the current C-factor assigned to 8-inch AC pipelines is appropriate.

Table F-8. Hydrant Test No. 8

Hydrant ⁽¹⁾	Field Data			Modeled Data			Comparison of Differential Pressures (psi) (g = c-f)
	Static Pressure (psi) (a)	Residual Pressure (psi) (b)	Differential Pressure (psi) (c = a-b)	Static Pressure (psi) (d)	Residual Pressure (psi) (e)	Differential Pressure (psi) (f = d-e)	
Flowing ⁽²⁾	58	8	NA	54	NA	NA	NA
8A ⁽³⁾	60	20	40	54	14	40	0
8B ⁽⁴⁾	60	28	32	54	22	32	0
8C ⁽⁵⁾	56	29	27	53	38	15	12

(1) Location of fire hydrants can be found on Figure F-8.
 (2) The "Flowing Hydrant" is located on S Hickory Avenue, south of Tennis Lane.
 (3) Hydrant 8A is located on S Hickory Avenue, north of Pecan Lane.
 (4) Hydrant 8B is located on S Hickory Avenue, south of Divine Lane.
 (5) Hydrant 8C is located on Renown Drive, northeast of S Hickory Avenue.
 NA = Not Applicable

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LEGEND:

-  Test Hydrant
-  Hydrant
-  Close Valve
-  Valve
-  Test Pipeline
-  Pipeline



FIGURE F-8

**City of Tracy
Citywide Water Master Plan**

TEST #8 (8" AC)





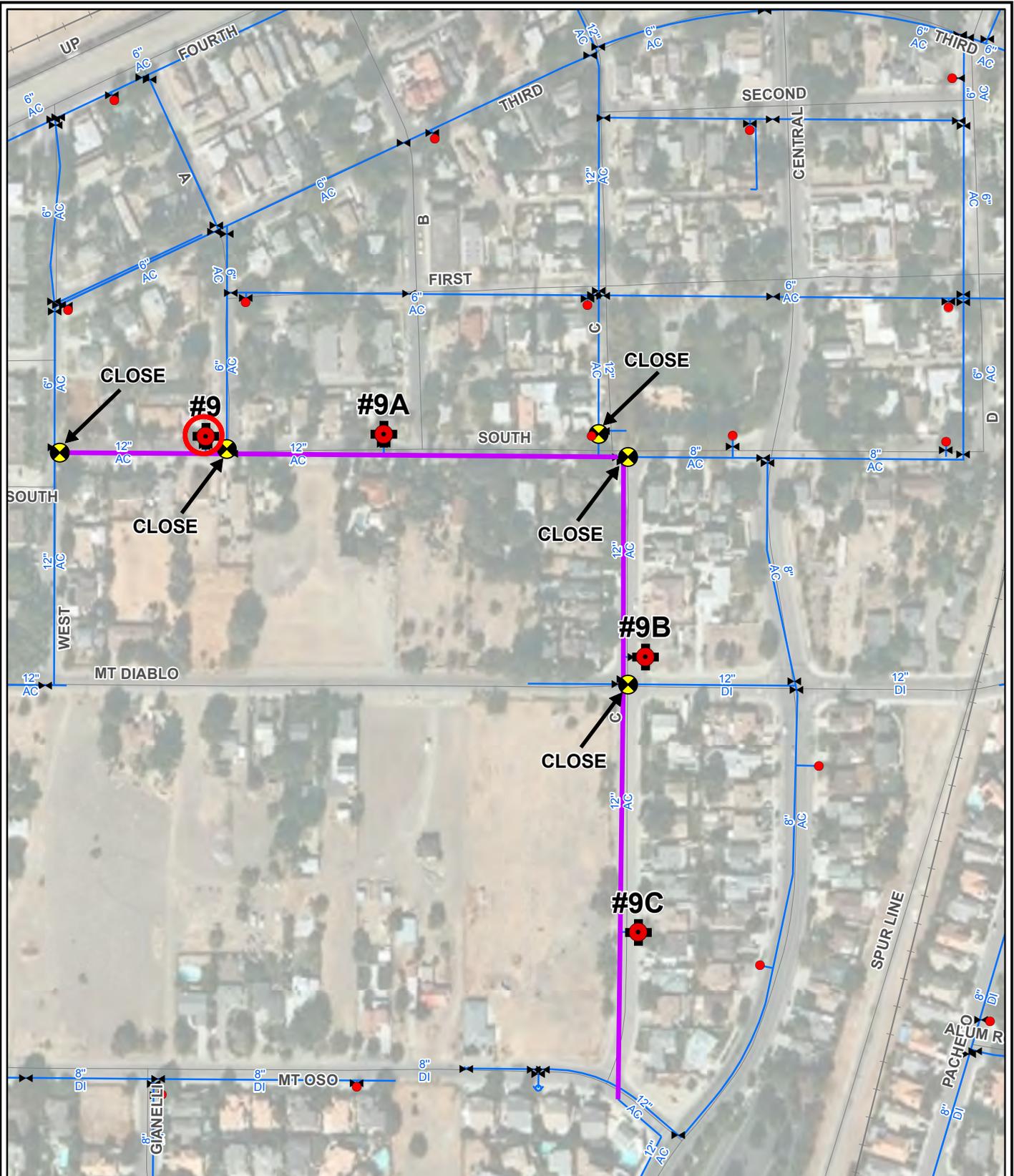
Hydrant Test No. 9

Hydrant Test No. 9 is located on W South Street, west of A Street. This test was intended to confirm the C-factor (initially assumed to equal 125) of a 12-inch diameter, AC pipeline. This test was canceled due to constraints identified by City staff related to the ability to isolate the hydrants for testing.

Table F-9. Hydrant Test No. 9

Hydrant ⁽¹⁾	Field Data			Modeled Data			Comparison
	Static Pressure (psi) (a)	Residual Pressure (psi) (b)	Differential Pressure (psi) (c = a-b)	Static Pressure (psi) (d)	Residual Pressure (psi) (e)	Differential Pressure (psi) (f = d-e)	of Differential Pressures (psi) (g = c-f)
Flowing ⁽²⁾	CANCELED						
9A ⁽³⁾							
9B ⁽⁴⁾							
9C ⁽⁵⁾							
(1) Location of fire hydrants can be found on Figure F-9. (2) The "Flowing Hydrant" is located on W South Street, west of A Street. (3) Hydrant 9A is located on W South Street, east of A Street. (4) Hydrant 9B is located on C Street, north of W Mt. Diablo Avenue. (5) Hydrant 9C is located on C Street, south of W Mt. Diablo Avenue. NA = Not Applicable							

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LEGEND:

-  Test Hydrant
-  Hydrant
-  Close Valve
-  Valve
-  Test Pipeline
-  Pipeline



FIGURE F-9

**City of Tracy
Citywide Water Master Plan**

TEST #9 (12" AC)





Hydrant Test No. 10

Hydrant Test No. 10 was performed on Earl Way, north of Silkwood Lane.⁶ This test was conducted to confirm the C-factor (initially assumed to equal 130) of an 8-inch diameter, DI pipeline. A comparison of the differential pressure readings predicted by the hydraulic model, compared to pressures actually measured in the field, demonstrates that the pressures predicted by the model are within ±5 psi of the measured field value, except for the result at Hydrant 10C. Hydrant 10C shows a difference between measured and modeled pressures of 10 psi, which is not within the ±5 psi tolerance limit. The model-simulated results and the field-observed data are shown in Table F-10.

Since the C-factor for 8-inch DI pipelines was validated in Tests 2 and A1, and model simulation results from observed Hydrants 10A, 10B and 10D were within the ±5 psi tolerance limit, the results from the hydraulic model simulation indicate that for Test 10 there may have been an error with the residual pressure reading at Hydrant 10C. Therefore, it is recommended that the data from observed Hydrant 10C not be used.

Test 10 simulates within a 5 psi differential from the field hydrant test data after the pressure comparison at Hydrant 10C was removed. This result indicates that the current C-factor assigned to 8-inch DI pipelines is appropriate.

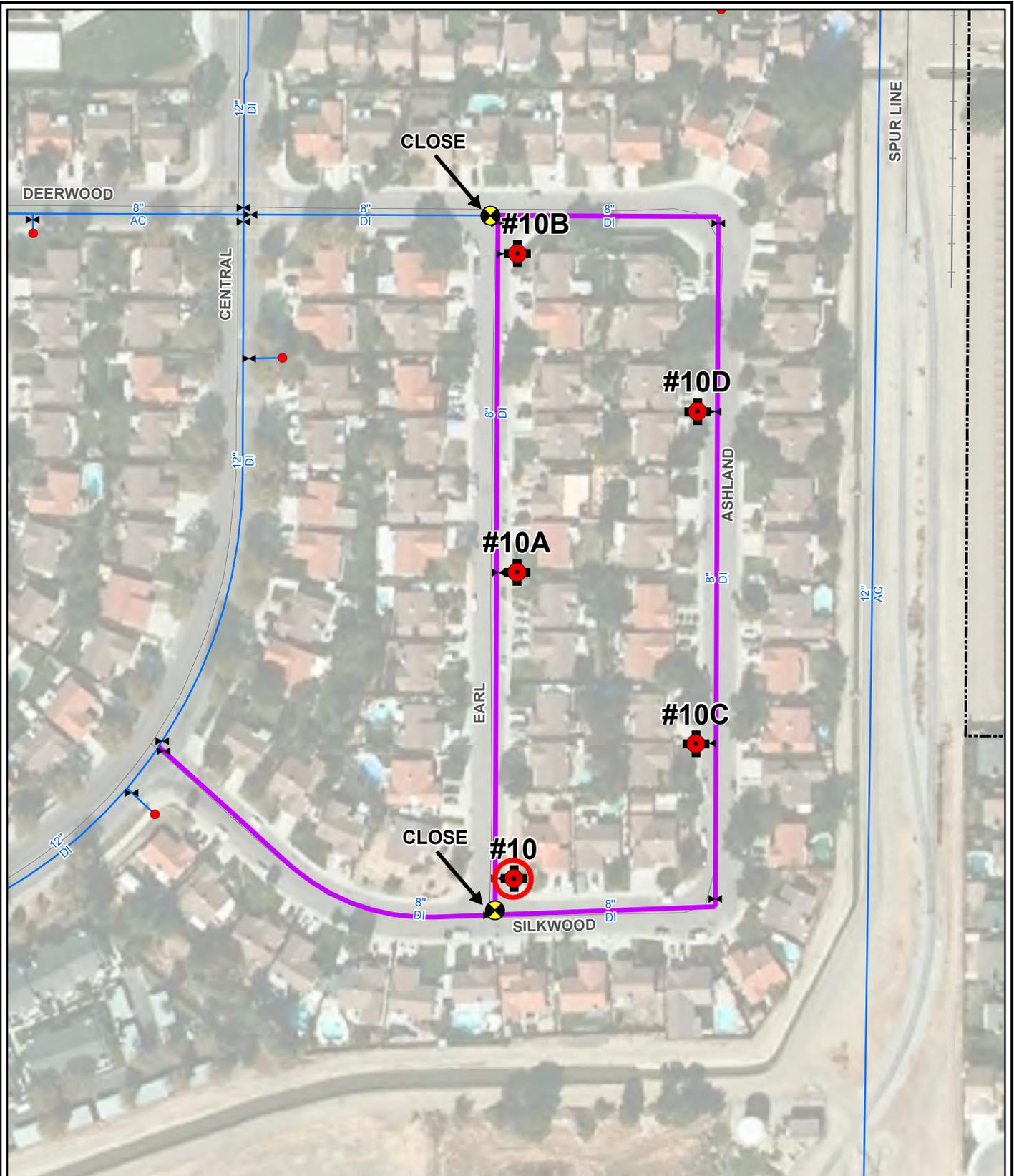
Table F-10. Hydrant Test No. 10

Hydrant ⁽¹⁾	Field Data			Modeled Data			Comparison of Differential Pressures (psi) (g = c-f)
	Static Pressure (psi) (a)	Residual Pressure (psi) (b)	Differential Pressure (psi) (c = a-b)	Static Pressure (psi) (d)	Residual Pressure (psi) (e)	Differential Pressure (psi) (f = d-e)	
Flowing ⁽²⁾	75	17	NA	73	NA	NA	NA
10A ⁽³⁾	79	34	45	75	28	47	-2
10B ⁽⁴⁾	80	41	39	76	36	40	-1
10C ⁽⁵⁾	75	42	33	75	52	23	10
10D ⁽⁶⁾	77	42	33	75	45	30	5

(1) Location of fire hydrants can be found on Figure F-10.
 (2) The "Flowing Hydrant" is located on Earl Way, north of Silkwood Lane.
 (3) Hydrant 10A is located on Earl Way, north of flowing hydrant.
 (4) Hydrant 10B is located on Earl Way, south of Deerwood Lane.
 (5) Hydrant 10C is located on Ashland Drive, north of Silkwood Lane.
 (6) Hydrant 10D is located on Ashland Drive, south of Deerwood Lane.
 NA = Not Applicable

⁶ The original location was revised on April 20, 2010 due to a broken valve located at the proposed flowing hydrant.

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LEGEND:

-  Test Hydrant
-  Hydrant
-  Close Valve
-  Valve
-  Test Pipeline
-  Pipeline

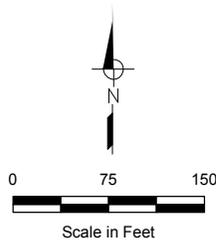


FIGURE F-10

**City of Tracy
Citywide Water Master Plan**

**TEST #10 (8" DI)
(Revised on 04/20/10)**





Hydrant Test No. A1

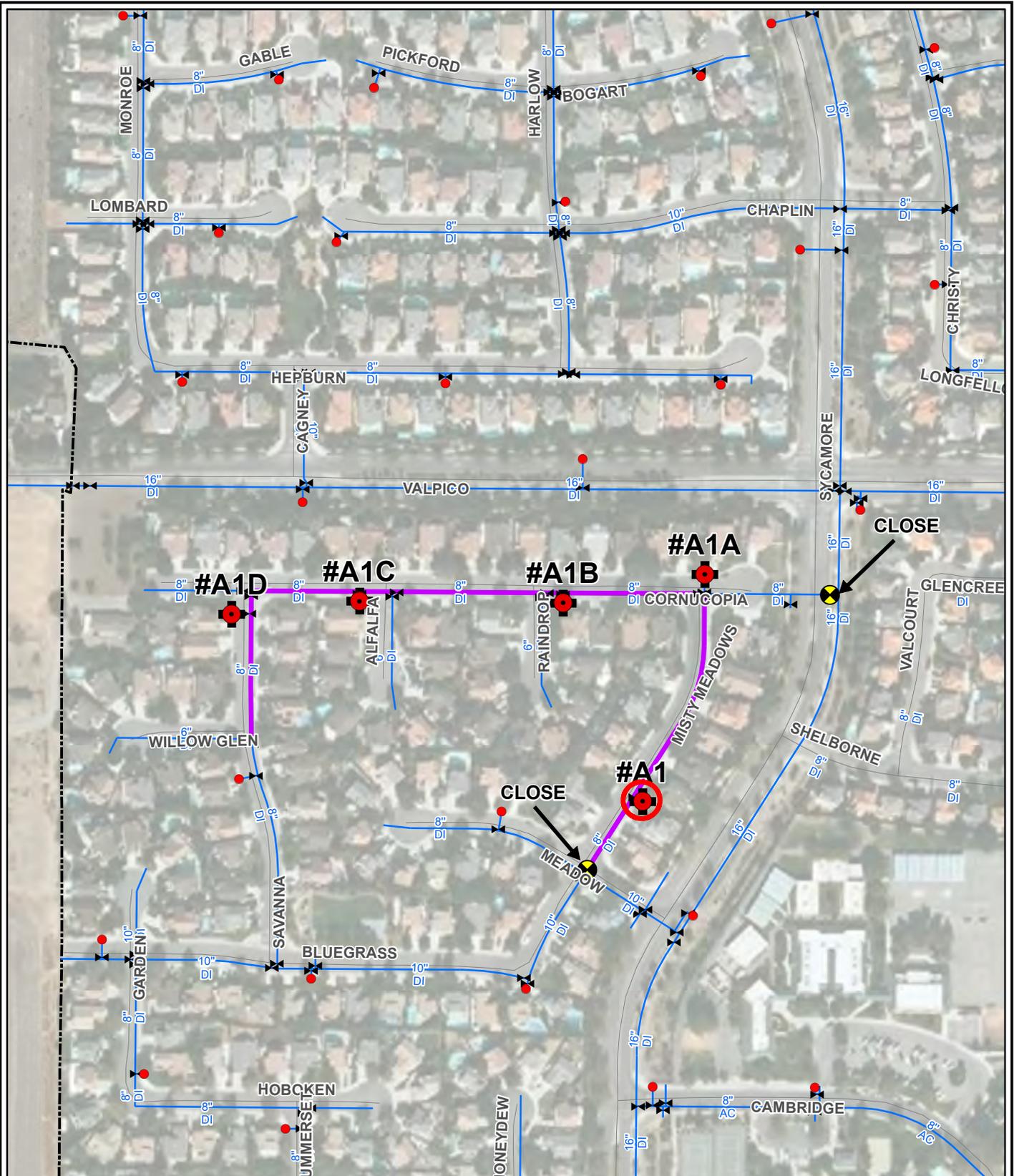
Hydrant Test No. A1 was performed on Misty Meadow Drive, northeast of Meadow Lane. This test was conducted to confirm the C-factor (initially assumed to equal 130) of an 8-inch diameter, DI pipeline. A comparison of the differential pressure readings predicted by the hydraulic model, compared to pressures actually measured in the field, demonstrates that the pressures predicted by the model are within ± 5 psi of the measured field value. The calibrated model results and the field data are shown in Table F-A1 and indicate that the use of a C-factor equal to 130 for this size and type of pipeline is valid.

Table F-A1. Hydrant Test No. A1

Hydrant ⁽¹⁾	Field Data			Modeled Data			Comparison of Differential Pressures (psi) (g = c-f)
	Static Pressure (psi) (a)	Residual Pressure (psi) (b)	Differential Pressure (psi) (c = a-b)	Static Pressure (psi) (d)	Residual Pressure (psi) (e)	Differential Pressure (psi) (f = d-e)	
Flowing ⁽²⁾	69	19	NA	72	NA	NA	NA
A1A ⁽³⁾	72	42	30	73	40	33	-3
A1B ⁽⁴⁾	74	45	29	74	46	28	1
A1C ⁽⁵⁾	70	48	22	73	52	21	1
A1D ⁽⁶⁾	69	54	15	73	56	17	-2

(1) Location of fire hydrants can be found on Figure F-A1.
 (2) The “Flowing Hydrant” is located on Misty Meadow Drive, northeast of Meadow Lane.
 (3) Hydrant A1A is located at the intersection of Cornucopia Place and Misty Meadow Drive.
 (4) Hydrant A1B is located on Cornucopia Place, east of Raindrop Court.
 (5) Hydrant A1C is located on Cornucopia Place, west of Alfalfa Court.
 (6) Hydrant A1D is located on Savanna Drive, south of Cornucopia Place.
 NA = Not Applicable

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- LEGEND:**
- Test Hydrant
 - Hydrant
 - Close Valve
 - Valve
 - Test Pipeline
 - Pipeline

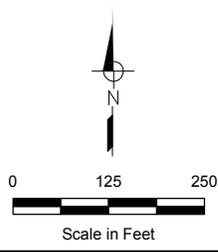


FIGURE F-A1

**City of Tracy
Citywide Water Master Plan**

TEST #A1 (8" DI)





Hydrant Test No. A2

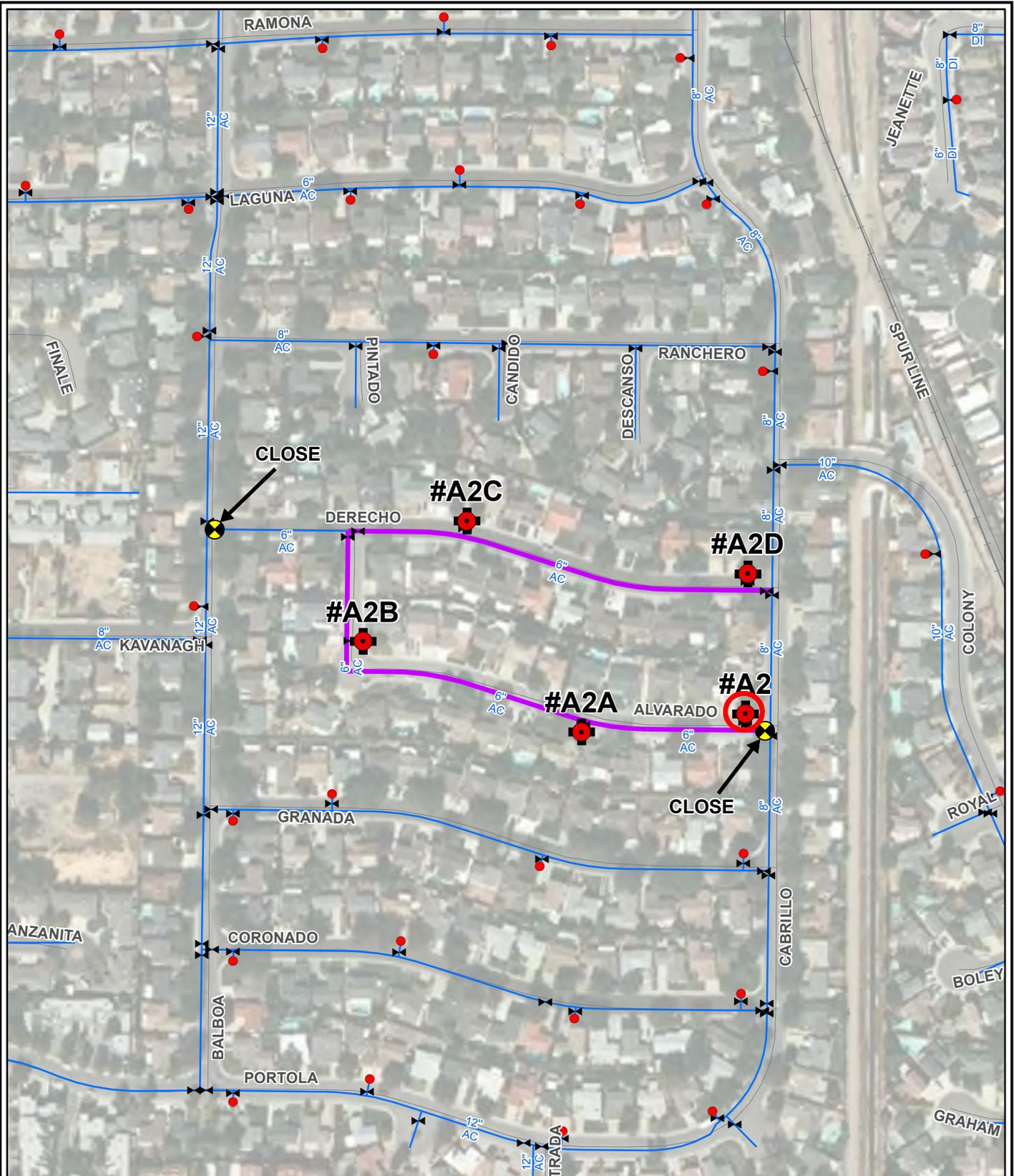
Hydrant Test No. A2 was performed on Alvarado Way, west of Cabrillo Drive. This test was conducted to confirm the C-factor (initially assumed to equal 125) of a 6-inch diameter, AC pipeline. A comparison of the differential pressure readings predicted by the hydraulic model, compared to pressures actually measured in the field, demonstrates that the pressures predicted by the model are within ± 5 psi of the measured field value. The calibrated model results and the field data are shown in Table F-A2 and indicate that the use of a C-factor equal to 125 for this size and type of pipeline is valid.

Table F-A2. Hydrant Test No. A2

Hydrant ⁽¹⁾	Field Data			Modeled Data			Comparison of Differential Pressures (psi) (g = c-f)
	Static Pressure (psi) (a)	Residual Pressure (psi) (b)	Differential Pressure (psi) (c = a-b)	Static Pressure (psi) (d)	Residual Pressure (psi) (e)	Differential Pressure (psi) (f = d-e)	
Flowing ⁽²⁾	70	<10	NA	71	NA	NA	NA
A2A ⁽³⁾	72	22	50	71	22	49	1
A2B ⁽⁴⁾	72	42	30	71	38	33	-3
A2C ⁽⁵⁾	71	52	19	71	50	21	-2
A2D ⁽⁶⁾	71	64	7	71	68	3	4

(1) Location of fire hydrants can be found on Figure F-A2.
 (2) The "Flowing Hydrant" is located on Alvarado Way, west of Cabrillo Drive.
 (3) Hydrant A2A is located on Alvarado Way, west of flowing hydrant.
 (4) Hydrant A2B is located on Alvarado Way, south of Derecho Way.
 (5) Hydrant A2C is located on Derecho Way, east of Alvarado Way.
 (6) Hydrant A2D is located on Derecho Way, west of Cabrillo Drive.
 NA = Not Applicable

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LEGEND:

-  Test Hydrant
-  Hydrant
-  Close Valve
-  Valve
-  Test Pipeline
-  Pipeline



FIGURE F-A2

**City of Tracy
Citywide Water Master Plan**

TEST #A2 (6" AC)





Hydrant Test No. A3

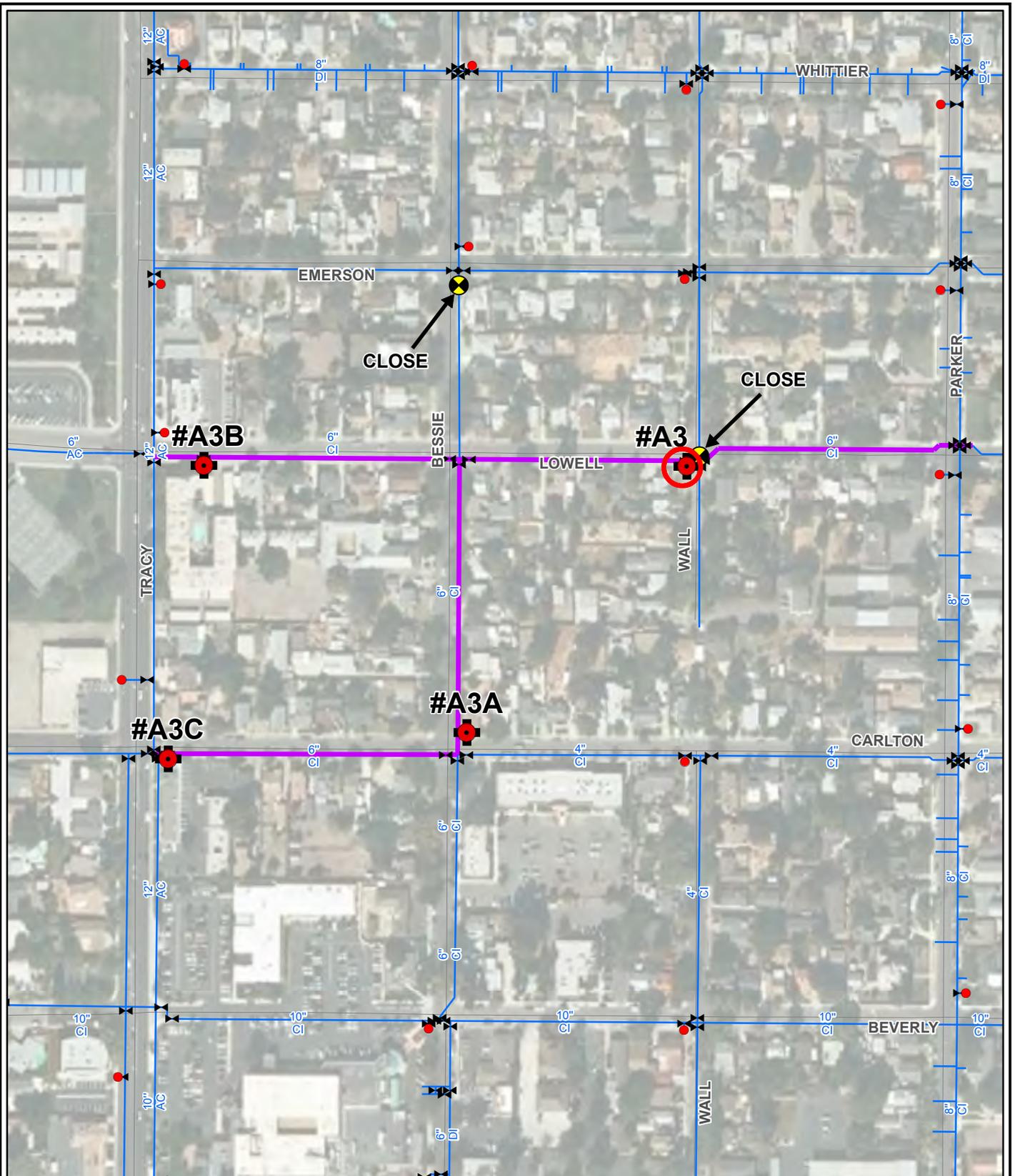
Hydrant Test No. A3 is located on W Lowell Avenue, west of Wall Street. This test was intended to confirm the C-factor (initially assumed to equal 80) of a 6-inch diameter, CI pipeline. This alternate hydrant test was not performed.

Table F-A3. Hydrant Test No. A3

Hydrant ⁽¹⁾	Field Data			Modeled Data			Comparison of Differential Pressures (psi) (g = c-f)
	Static Pressure (psi) (a)	Residual Pressure (psi) (b)	Differential Pressure (psi) (c = a-b)	Static Pressure (psi) (d)	Residual Pressure (psi) (e)	Differential Pressure (psi) (f = d-e)	
Flowing ⁽²⁾	NA	NA	NA	NA	NA	NA	NA
A3A ⁽³⁾	NA	NA	NA	NA	NA	NA	NA
A3B ⁽⁴⁾	NA	NA	NA	NA	NA	NA	NA
A3C ⁽⁵⁾	NA	NA	NA	NA	NA	NA	NA

(1) Location of fire hydrants can be found on Figure F-A3.
 (2) The "Flowing Hydrant" is located on W Lowell Avenue, west of Wall Street.
 (3) Hydrant A3A is located on Bessie Avenue, north of Carlton Way.
 (4) Hydrant A3B is located on W Lowell Avenue, east of Tracy Boulevard.
 (5) Hydrant A3C is located on Carlton Way, east of Tracy Boulevard.
 NA = Not Applicable

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LEGEND:

-  Test Hydrant
-  Hydrant
-  Close Valve
-  Valve
-  Test Pipeline
-  Pipeline



FIGURE F-A3

**City of Tracy
Citywide Water Master Plan**

TEST #A3 (6" CI)





DEVELOPMENT OF THE VERIFICATION PROCESS

Verifying that a hydraulic model replicates field conditions requires thorough knowledge of how the water system performs over a wide range of operating conditions. To ensure that the hydraulic model was correctly configured and capable of producing results that are consistent with those observed in the field, a verification process was conducted for Zone 1.⁷ Hydrant pressure recorders (HPRs) were first set-up at selected fire hydrants located in Zone 1 and used to record pressures in the field. The field-collected data was then compared with model-simulated pressures at the same system locations. Other pressure points monitored by the City were also used in the verification process. A brief description of the verification process is discussed below.

Twenty-two (22) hydrant pressure recorders were placed in different locations within Zone 1 of the City's existing potable water distribution system. Each HPR collected field-pressure data for approximately two weeks (from April 21, 2010 to May 6, 2010). The locations were selected based on their proximity to the transmission mains and to extreme elevations (low and high) in the water distribution system. Figure 7-5 shows the location of each HPR placed within the City's potable water system. As shown on Figure 7-5, HPRs 9 and 10 were missing data; this most likely occurred due to defective HPRs. However, the absence of data from HPRs 9 and 10 does not compromise the verification process because data from HPRs 5 and 11, which are in the vicinity of these HPRs, can be used.

Following the integration of the 24-hour diurnal water demand patterns into the hydraulic model, an extended period simulation (EPS) was then performed in the hydraulic model. The model-simulated pressures from each HPR, the flows and pressures from each pump, and the tank levels were plotted. To verify whether the City's hydraulic model was accurately predicting actual water system tank levels, flows, and pressures, model-simulated tank levels, flows, and pressures were compared to the field-observed data. Results from the verification process are discussed below.

VERIFICATION RESULTS

Graphs of representative comparisons between model-simulated and field-observed tank levels, flows, and pressures are provided in Figures F-11 through F-21. As shown on Figures F-11 through F-21, the model-simulated levels, flows, and pressures for most of the City's facilities trend closely to the field-recorded levels, flows, and pressures during the extended period simulation.

Verification results for the City's existing water system indicate that the model-simulated tank levels and booster pump station discharge pressures from NEI and Linne Road stations trend well with collected SCADA system data as shown on Figures F-11 through F-13. Model-simulated booster pump station flows from NEI and Linne Road stations generally trend well with SCADA system data; however, model-simulated booster pump station flows from Linne were higher than

⁷ Zone 2 was last verified in 2007 as part of the City's Pressure Zone 2 Evaluation. Consequently, the hydraulic model verification effort for this Citywide Water System Master Plan focused on Zone 1.



SCADA system recorded flows between the hours of 8 a.m. and 1 p.m. as shown on Figure F-13. A review of the data from the Zone 1 36-inch diameter transmission main (see Figure F-15) indicates that the model-simulated flows from this station were lower than SCADA system recorded flows between the hours of 8 a.m. and 1 p.m. These results suggest that water demands within Zone 1 during the hours of 8 a.m. and 1 p.m. were supplied from Zone 2 through the pressure regulating stations instead of the Zone 1 36-inch diameter transmission main. Some possible reasons for this discrepancy in the model-simulated results are discussed below:

- Set point controls for each pressure regulating station were input based on data provided by City staff. However, actual set points in the field may vary from the data received. This will affect how much flow is supplied to Zone 1 through each pressure regulating station during the hydraulic model simulation.
- There may be limitations with the modeling software in accurately simulating the City's pressure regulating stations. This will also affect how much flow is supplied to Zone 1 through each pressure regulating station during the hydraulic model simulation.
- The assumptions made during the development of the diurnal water demand pattern of the main distribution system due to inaccurate SCADA system data (*e.g.*, Zone 2 booster pump station flow) may cause the model-simulated results to not match the recorded SCADA system data.

Without actual field data collected from each pressure regulating station, it is not possible to confirm the exact reason for the discrepancy between the model-simulated and SCADA system recorded flows from the Zone 1 36-inch diameter transmission main. As discussed in Chapter 7, the addition of SCADA system monitoring to each pressure regulating station is recommended for additional understanding of water demand patterns and supply within each zone.

Verification results from the remaining facilities in the City's existing water system (*i.e.*, Patterson Pass booster pump station, Zone 2 booster pump station, and groundwater wells) indicate that the model-simulated pump flow and pressure comparisons are similar to the collected SCADA system data as shown on Figure F-14, and Figures F-16 through F-20. Overall, the comparisons between model-simulated and field-observed data from the City's water supply facilities indicate that the model was able to generally replicate field conditions.

Graphs of representative comparisons between model-simulated and field-observed pressures at each HPR location are provided in Figures F-22 through F-32. As shown on Figures F-22 through F-32, the model-simulated pressures for most of the pressure recorders trend closely to the field-recorded pressure readings during the extended period simulation.

As discussed above, HPRs 9 and 10 were missing data as shown on Figure F-26, and were subsequently not used for data comparison. However, data from HPRs 5 and 11, which are located in the vicinity of HPRs 9 and 10, indicate that the model-simulated pressures closely matched the field-recorded pressure readings.

Only HPRs 11, 12, and 16 showed a few pressure comparisons above the ± 5 psi tolerance limit. The location of HPRs 11, 12, and 16 (*i.e.*, farthest away from the NEI and groundwater well supply sources) indicate that this may be due to the fact that a *specific* diurnal water demand

Appendix F

Summary of Hydraulic Model Calibration Process and Results



pattern was not developed for each pressure zone. If a diurnal water demand pattern specific to Zone 1 was available, it may produce more accurate results from the model. As discussed in Chapter 7, the addition of SCADA system monitoring to each pressure regulating station will provide the ability to create diurnal curves that are specific to each zone, which will help provide a better understanding of water demand patterns by zone.

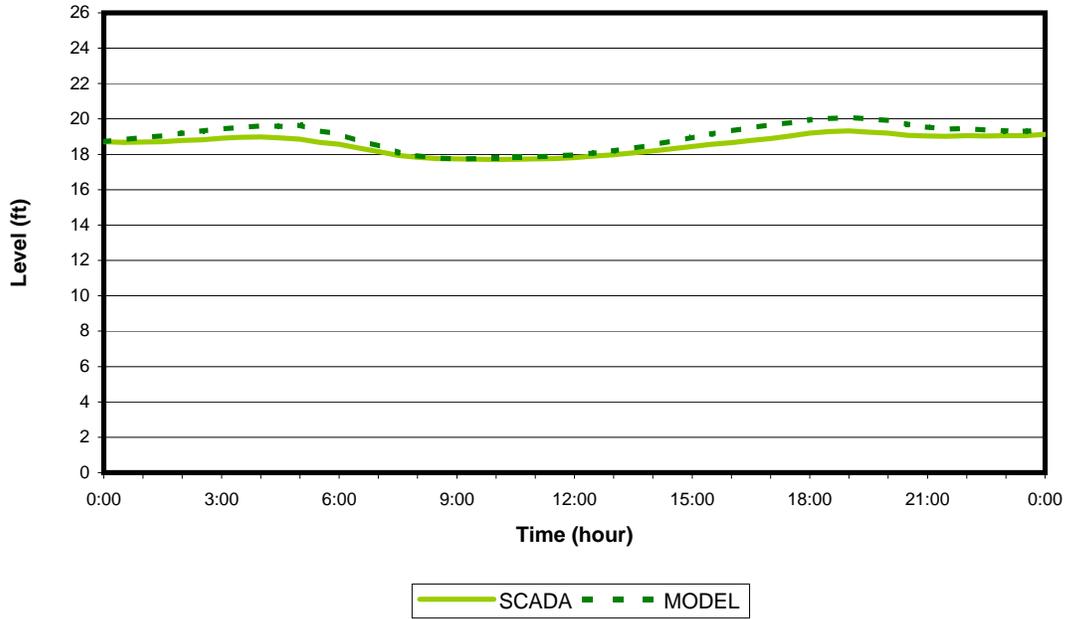
In general, the extended period simulation results from the hydraulic model indicate that water demands are properly allocated in the model and that the modeled pipeline network is accurately configured. Therefore, it can be concluded that the hydraulic model provides an accurate operational representation of the City's existing potable water distribution system, and is more than adequate for use as a planning and operational tool.



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Figure F-11. Tank Levels

**City of Tracy - NEI Tank Level
May 3, 2010**



**City of Tracy - Linne Road Tank Level
May 3, 2010**

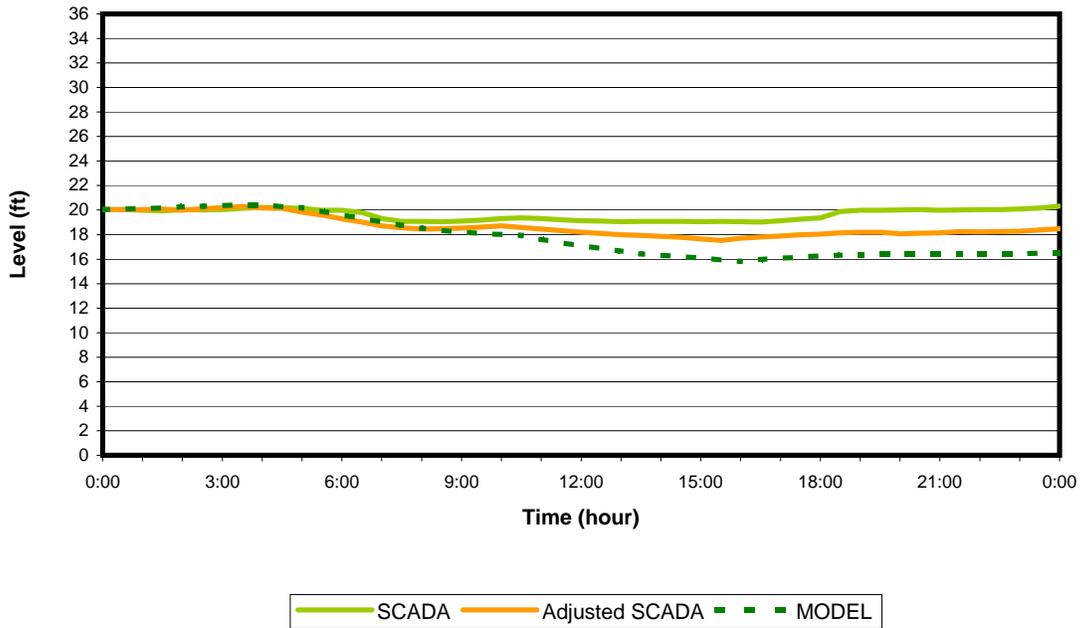
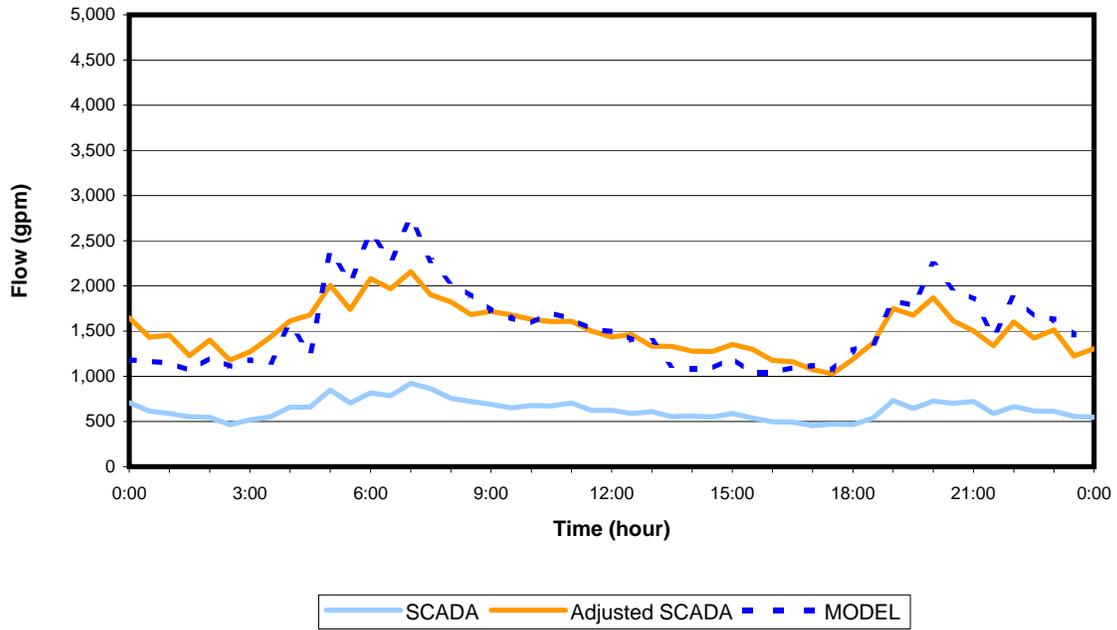


Figure F-12. NEI Booster Pump Station Flow and Discharge Pressure

**City of Tracy - NEI BPS Flow
May 3, 2010**



**City of Tracy - NEI BPS Discharge Pressure
May 3, 2010**

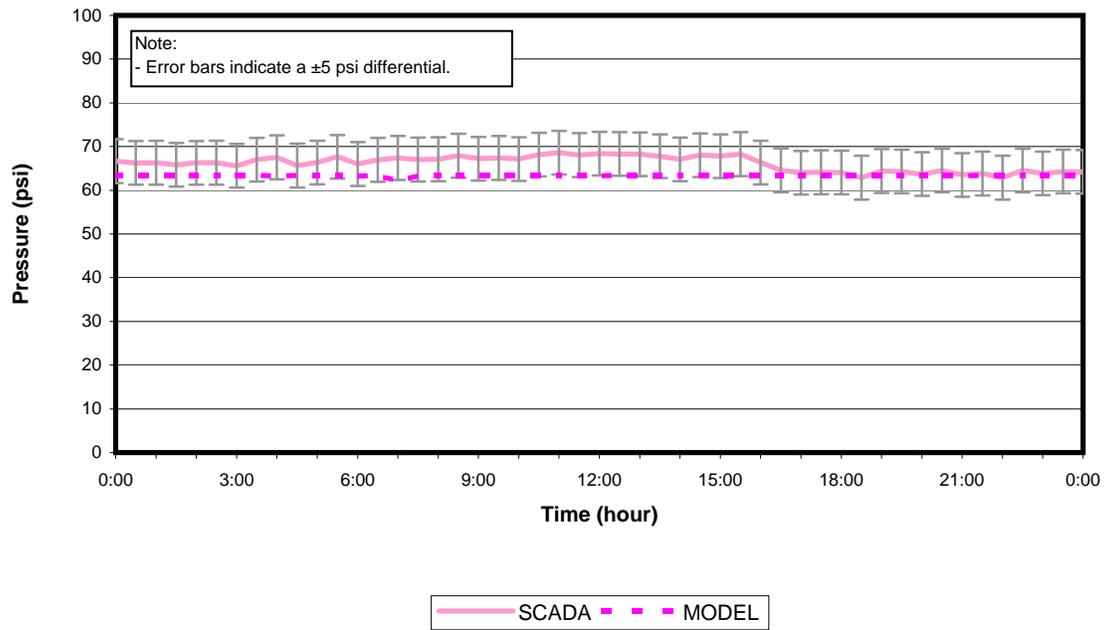


Figure F-13. Linne Road Booster Pump Station Flow and Discharge Pressure

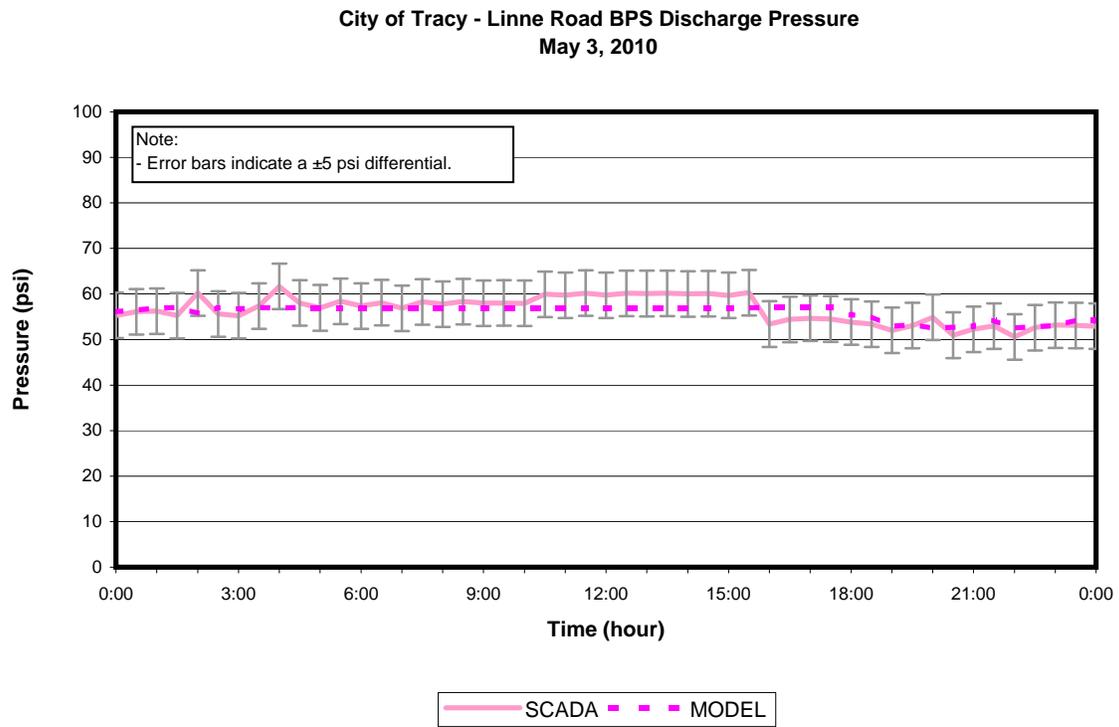
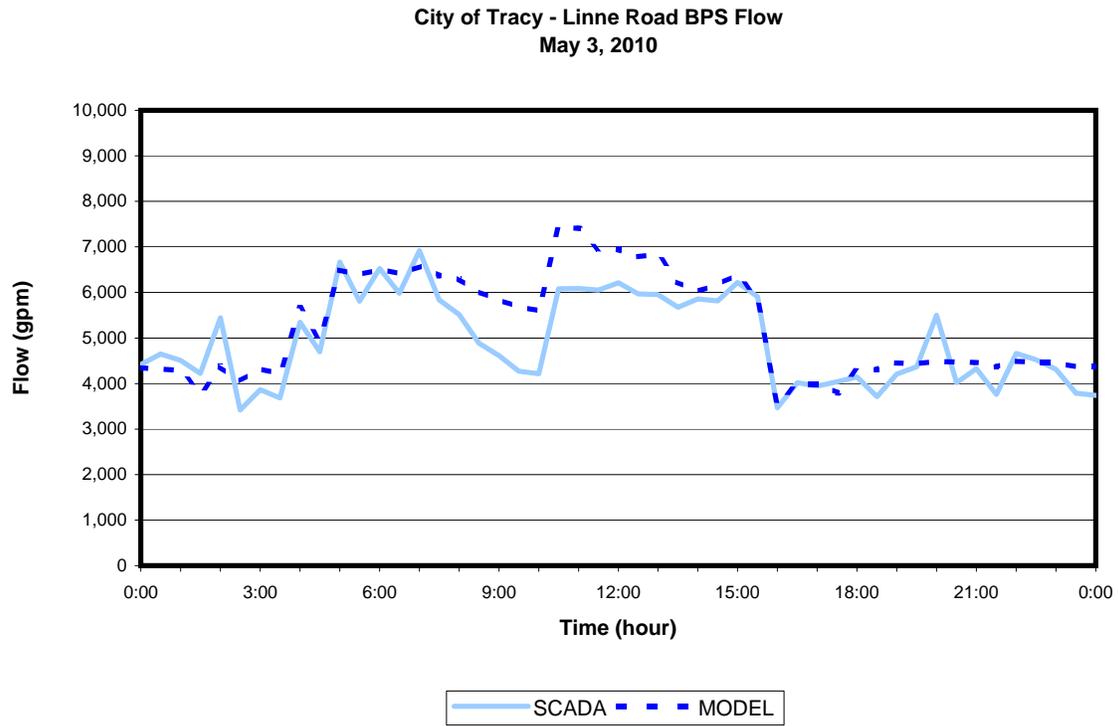
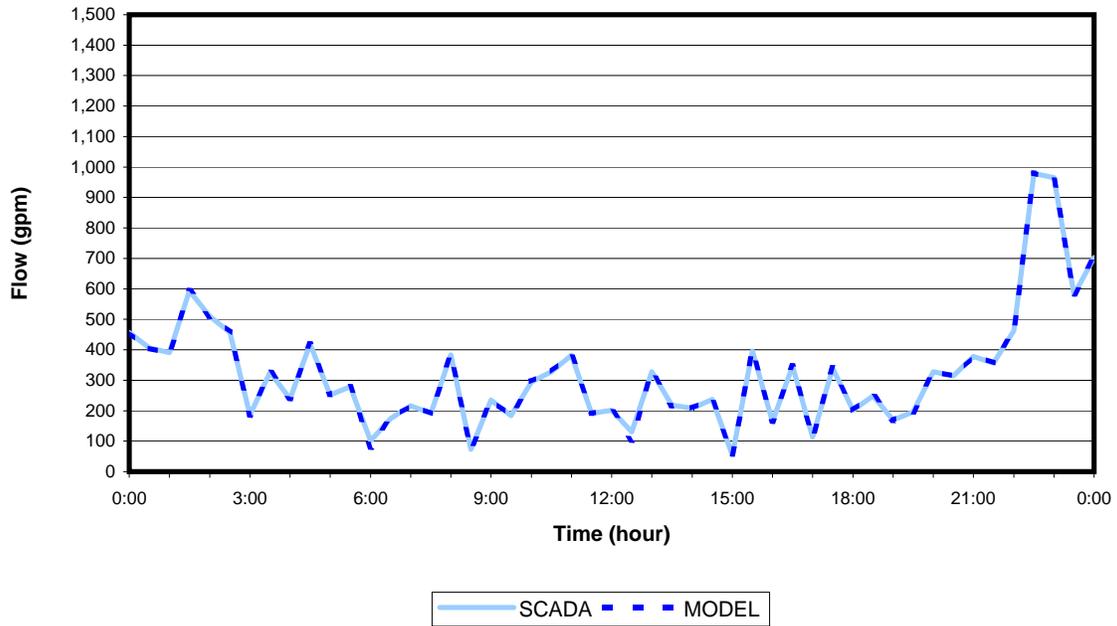


Figure F-14. Patterson Pass BPS Flow and Pressure

**City of Tracy - Patterson Pass BPS Flow
May 3, 2010**



**City of Tracy - Patterson Pass BPS Pressure
May 3, 2010**

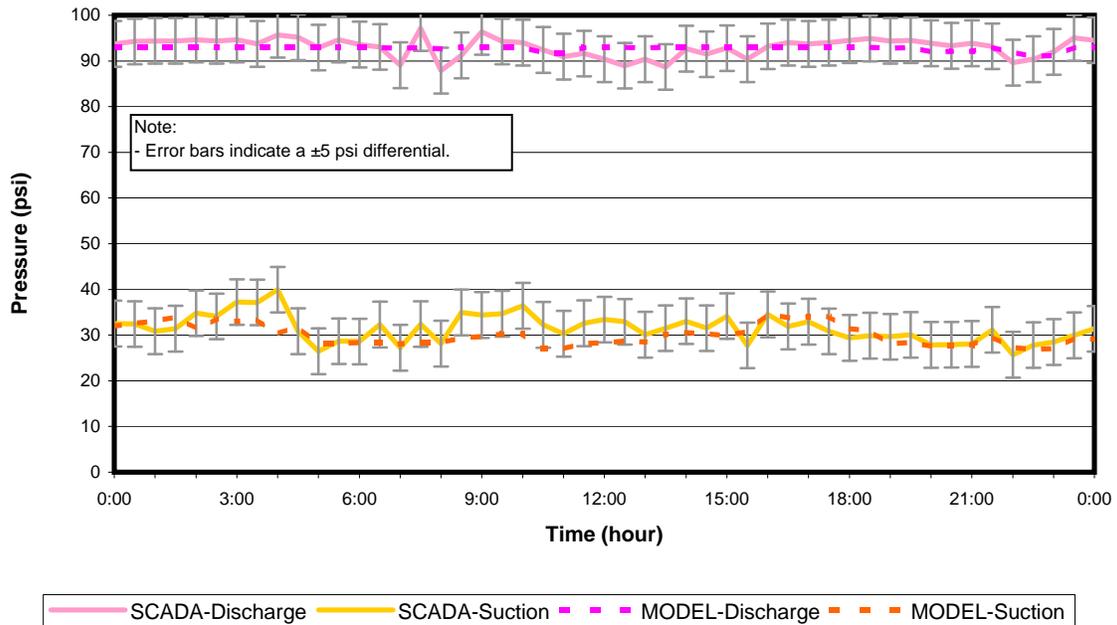


Figure F-15. Zone 1 (36-inch) Transmission Main Flow and Discharge Pressure

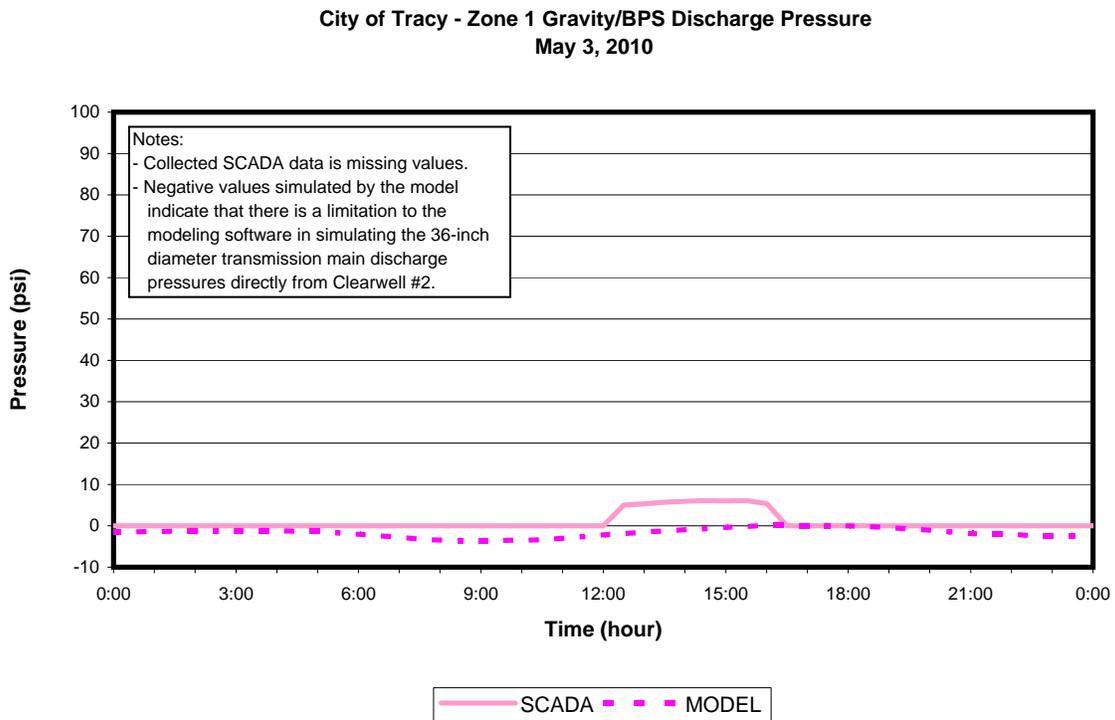
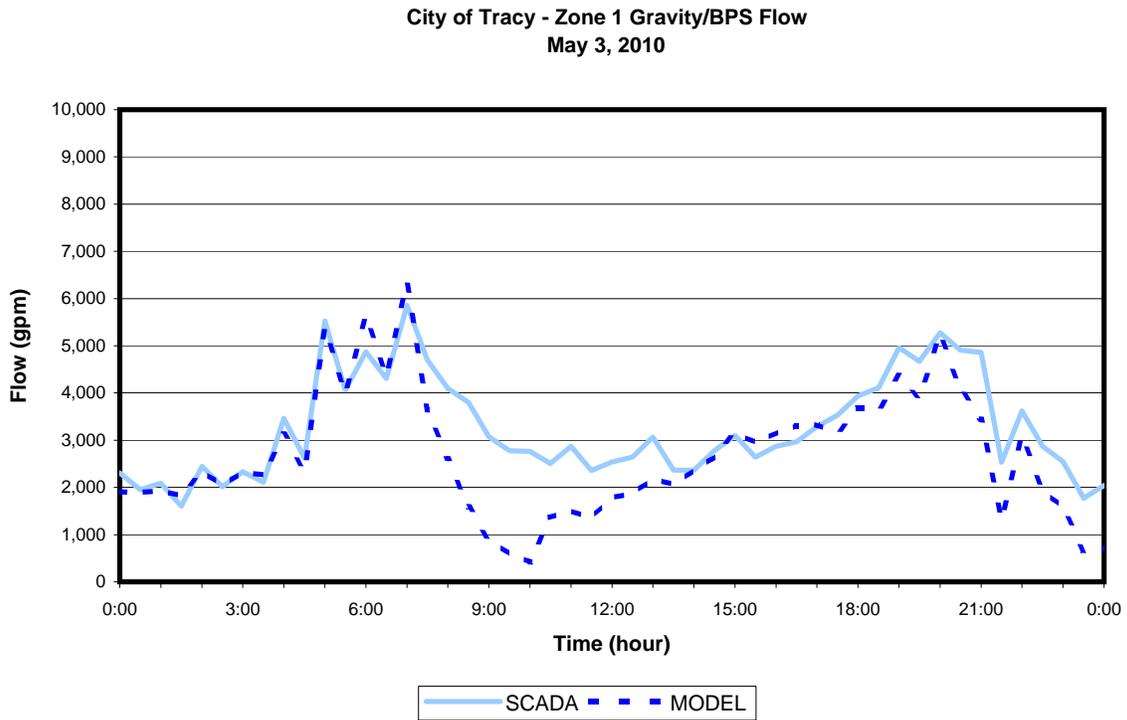


Figure F-16. Zone 2 BPS Flow and Discharge Pressure

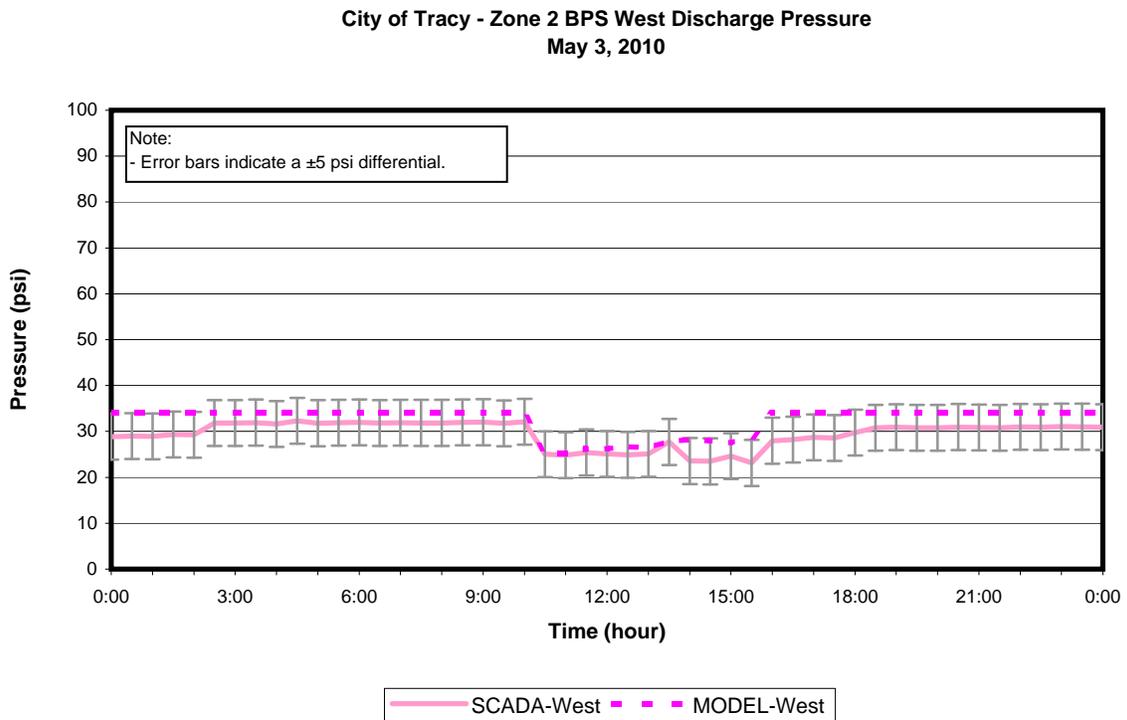
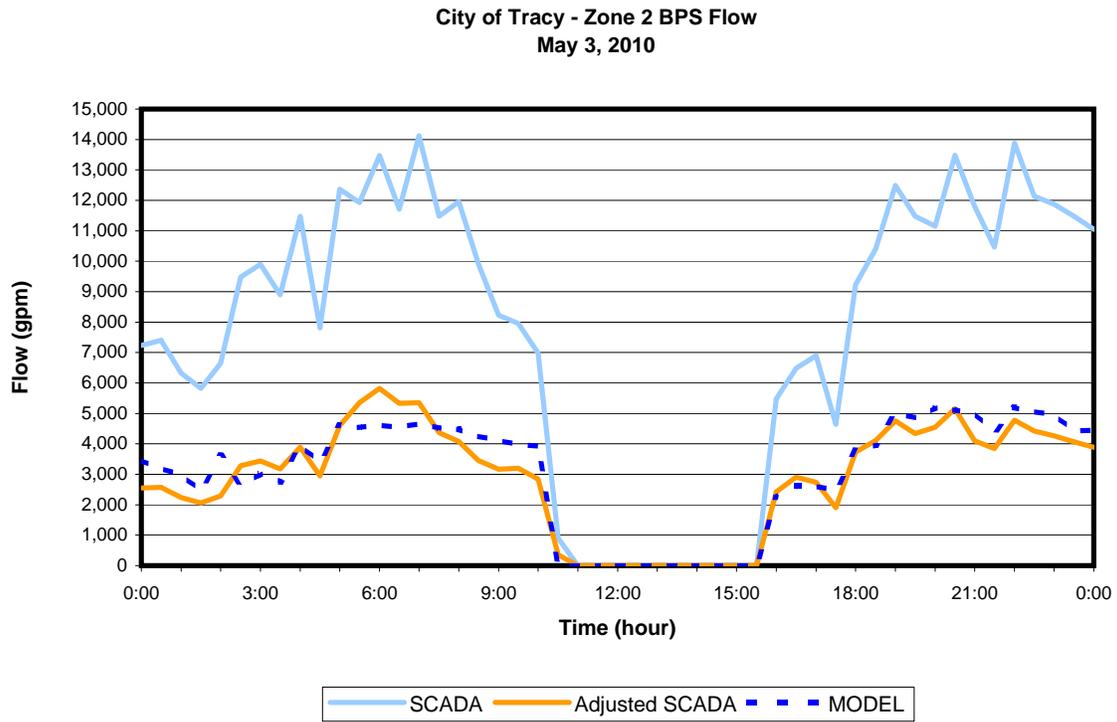


Figure F-17. Ball Park Well Flow and Discharge Pressure

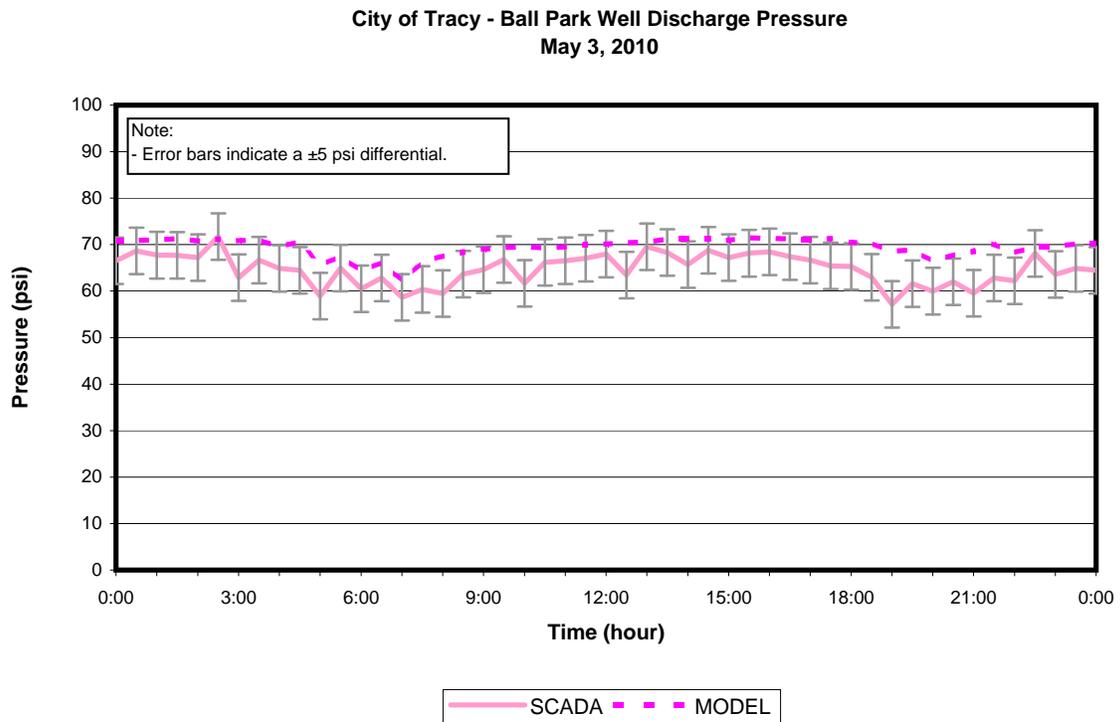
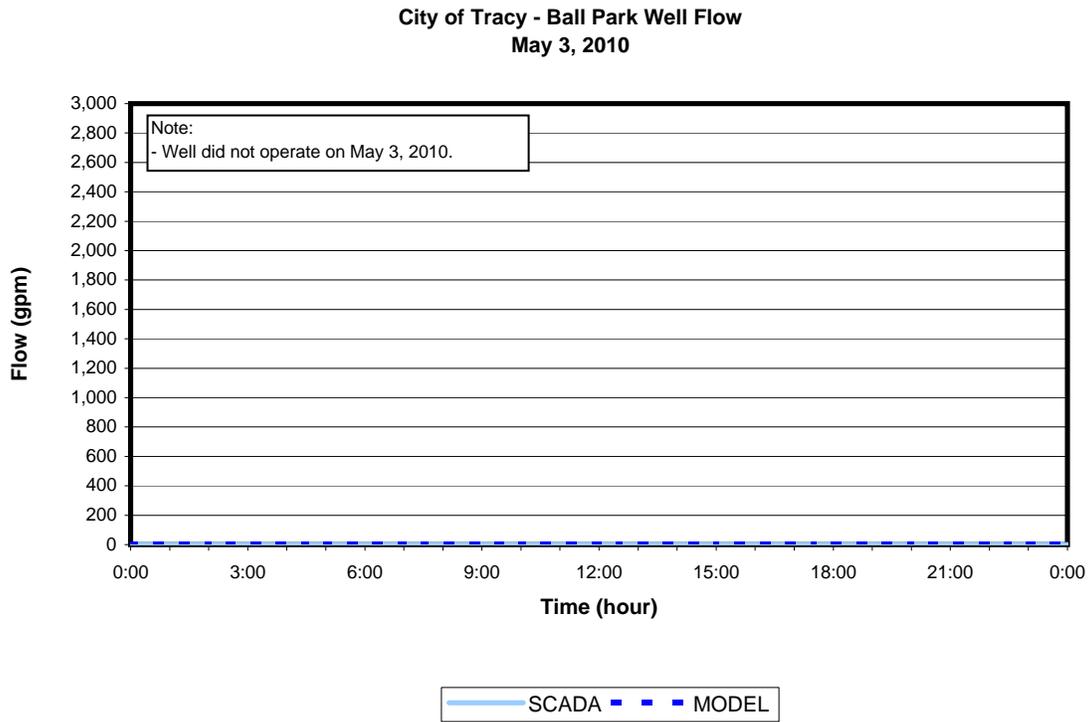
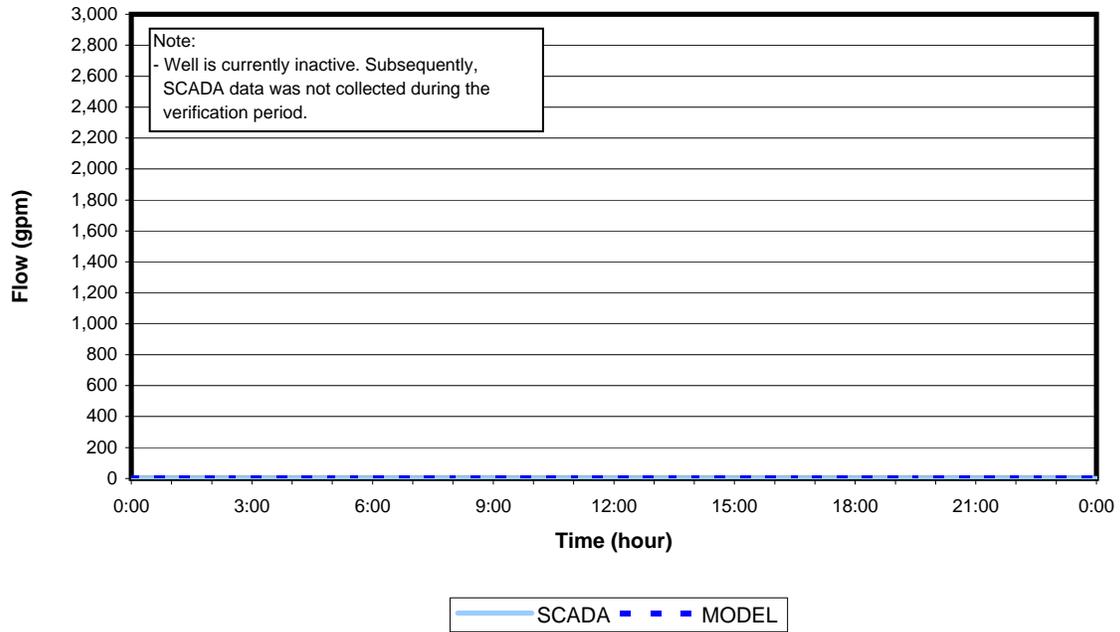


Figure F-18. Lincoln Well Flow and Discharge Pressure

**City of Tracy - Lincoln Well Flow
May 3, 2010**



**City of Tracy - Lincoln Well Discharge Pressure
May 3, 2010**

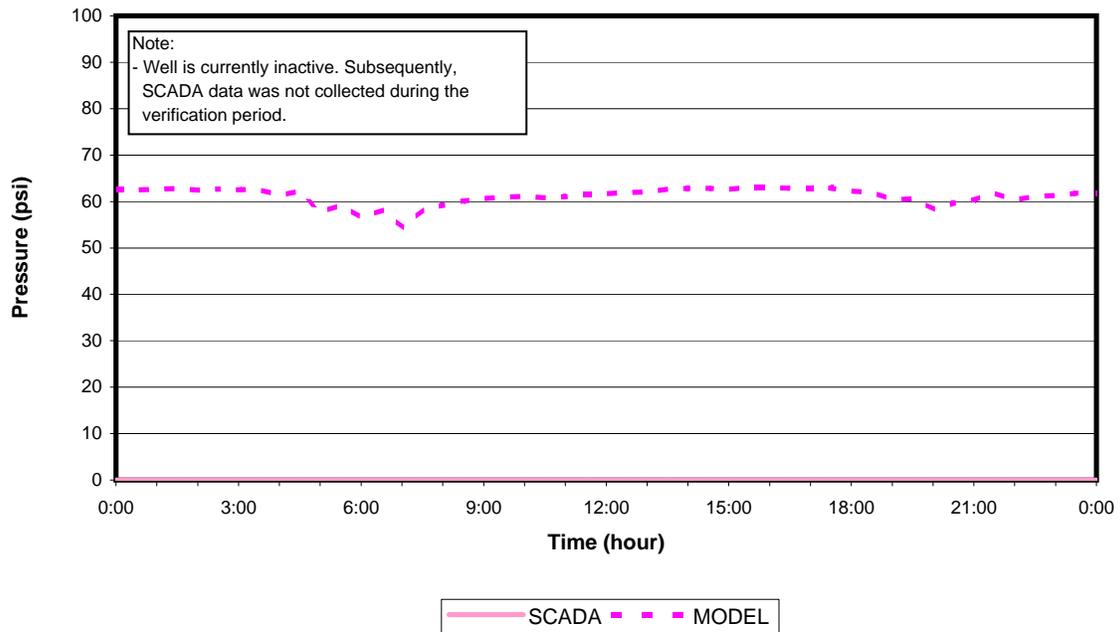


Figure F-19. Lewis Manor Well Flow and Discharge Pressure

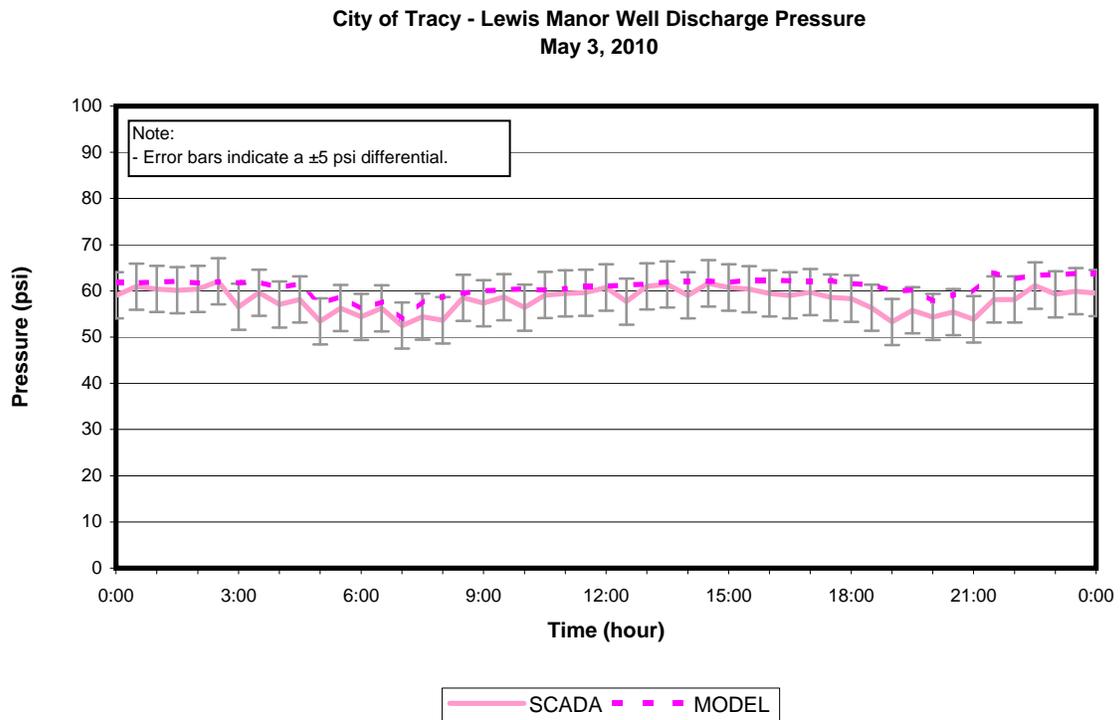
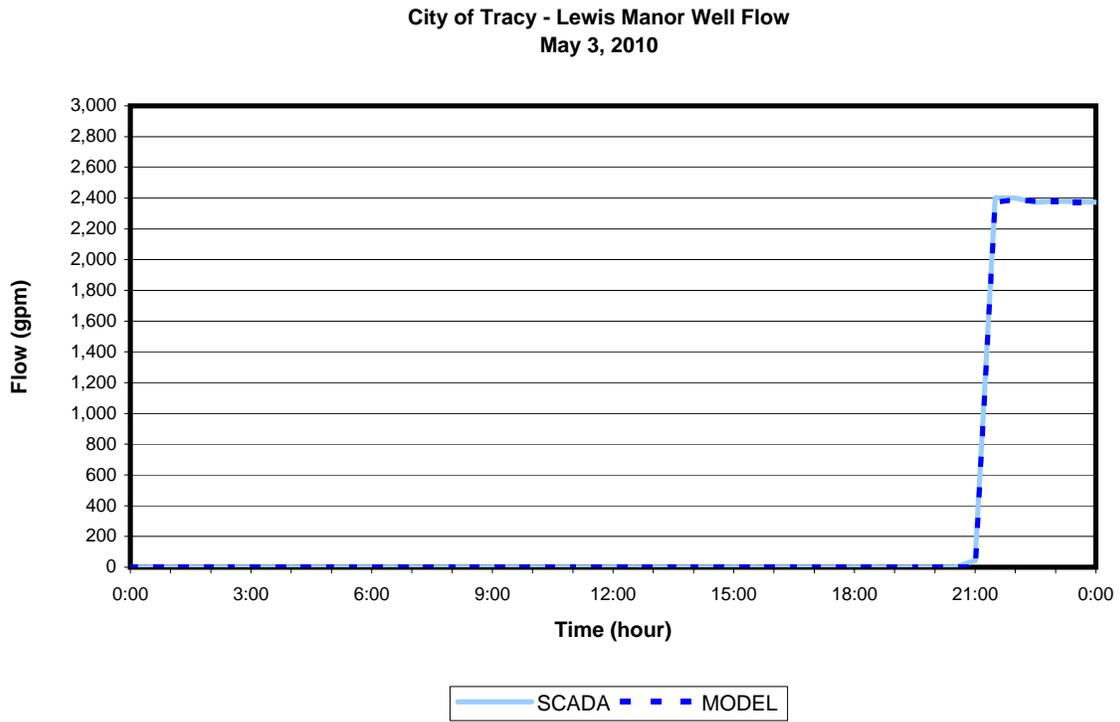
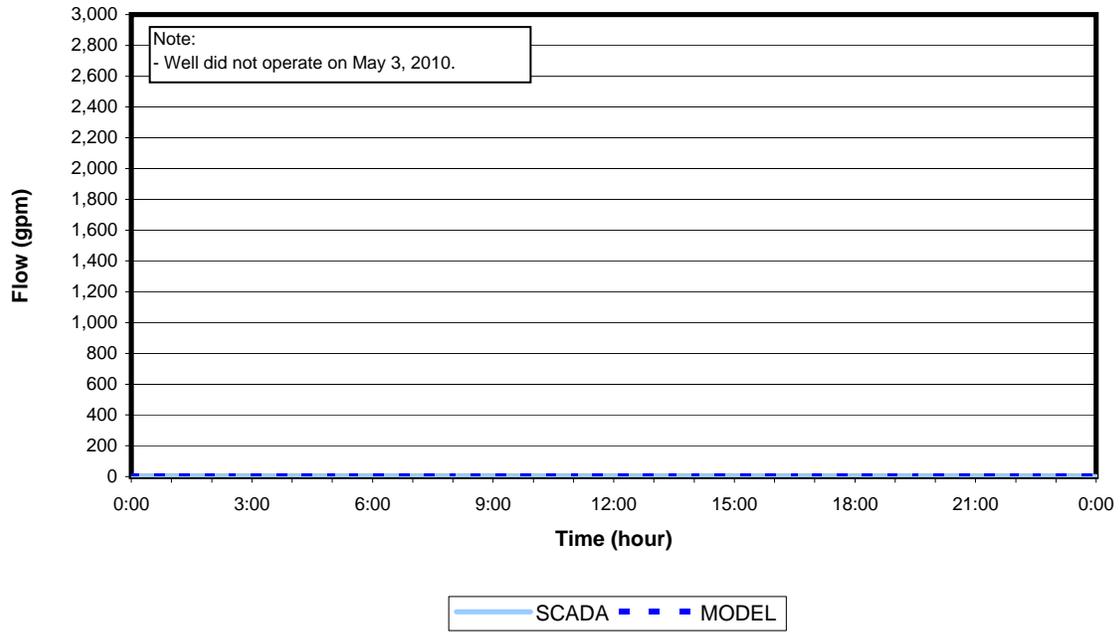


Figure F-20. Park and Ride Well Flow and Discharge Pressure

**City of Tracy - Park and Ride Well Flow
May 3, 2010**



**City of Tracy - Park and Ride Well Discharge Pressure
May 3, 2010**

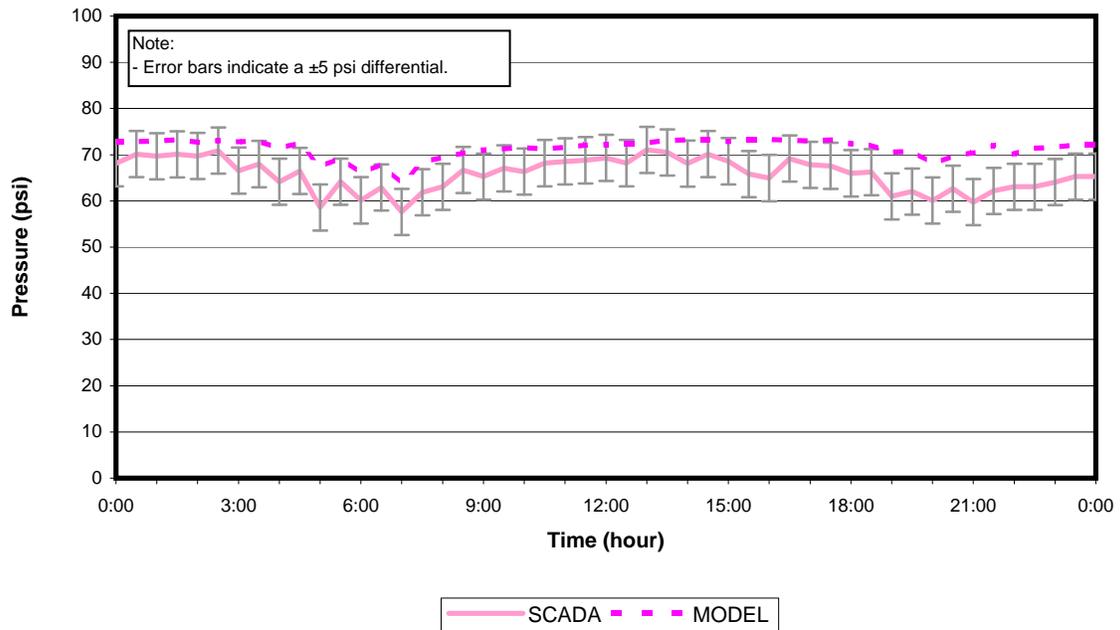


Figure F-21. Mossdale Booster Pump Station Flow

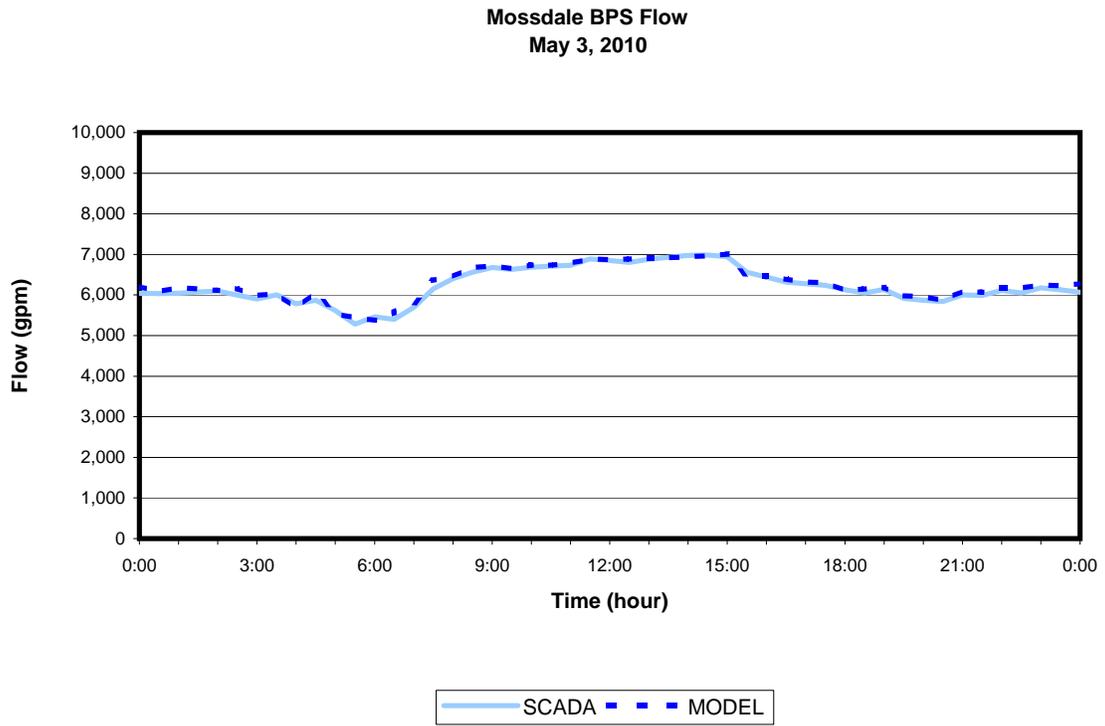
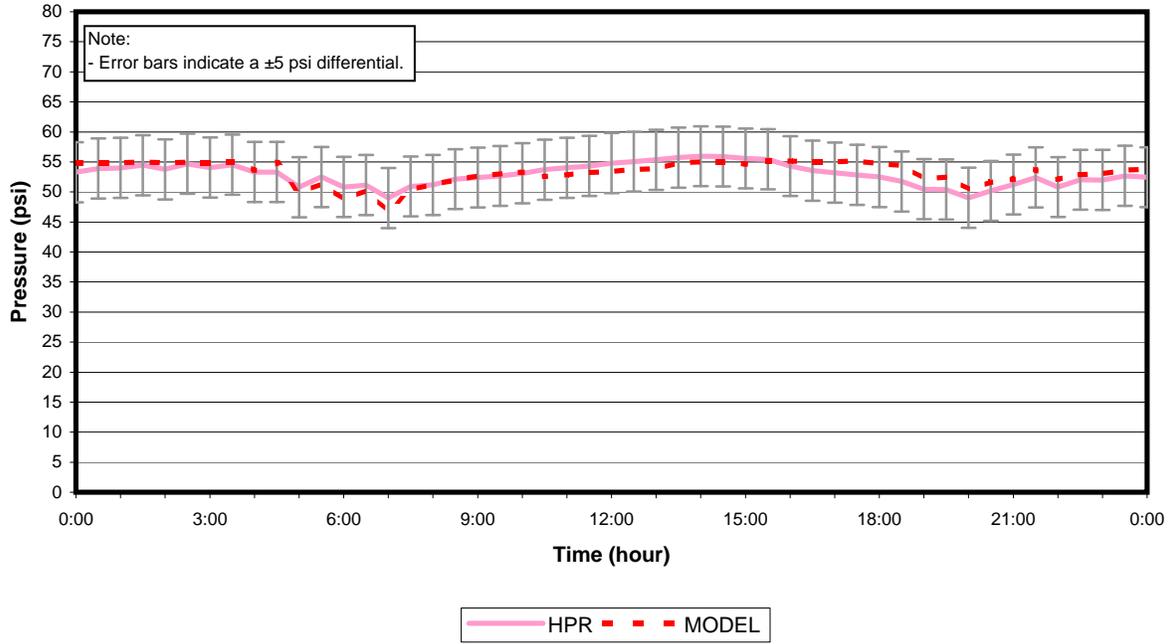


Figure F-22. HPR 1 & HPR 2

HPR 1: Along Mt. Diablo Ave., East of Third St.
May 3, 2010



HPR 2: Along Schulte Rd., West of Edenvale Cir.
May 3, 2010

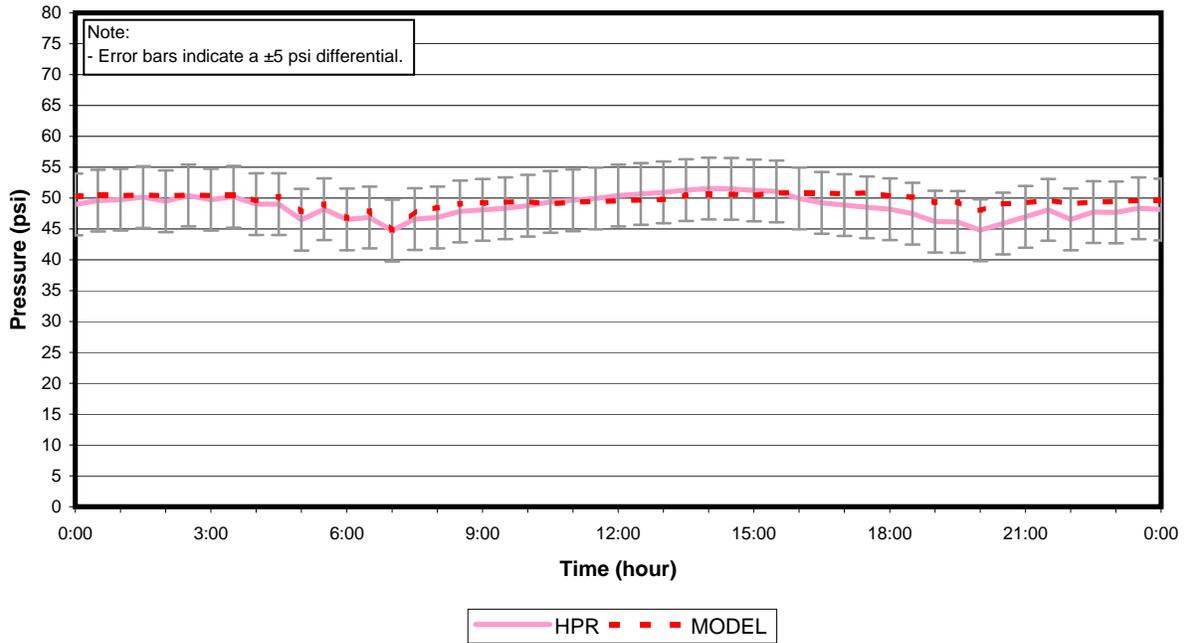
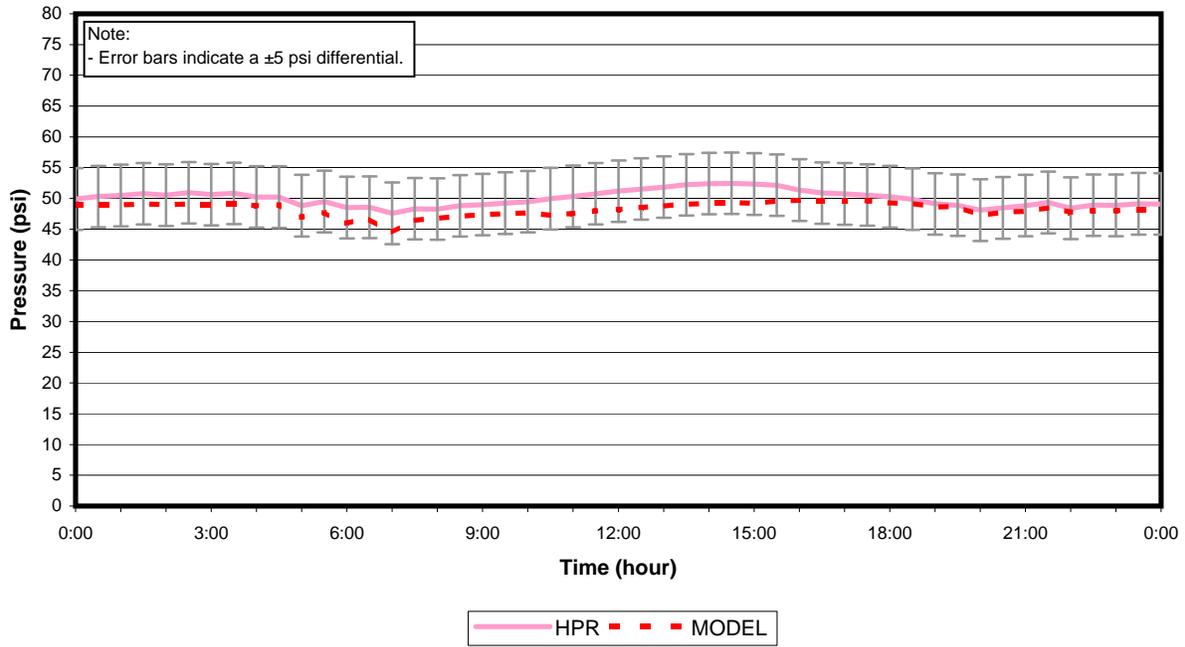


Figure F-23. HPR 3 & HPR 4

**HPR 3: Along Schulte Rd., West of Margarite St.
May 3, 2010**



**HPR 4: Along Schulte Rd., approx. 2,500 feet East of Corral Hollow Rd.
May 3, 2010**

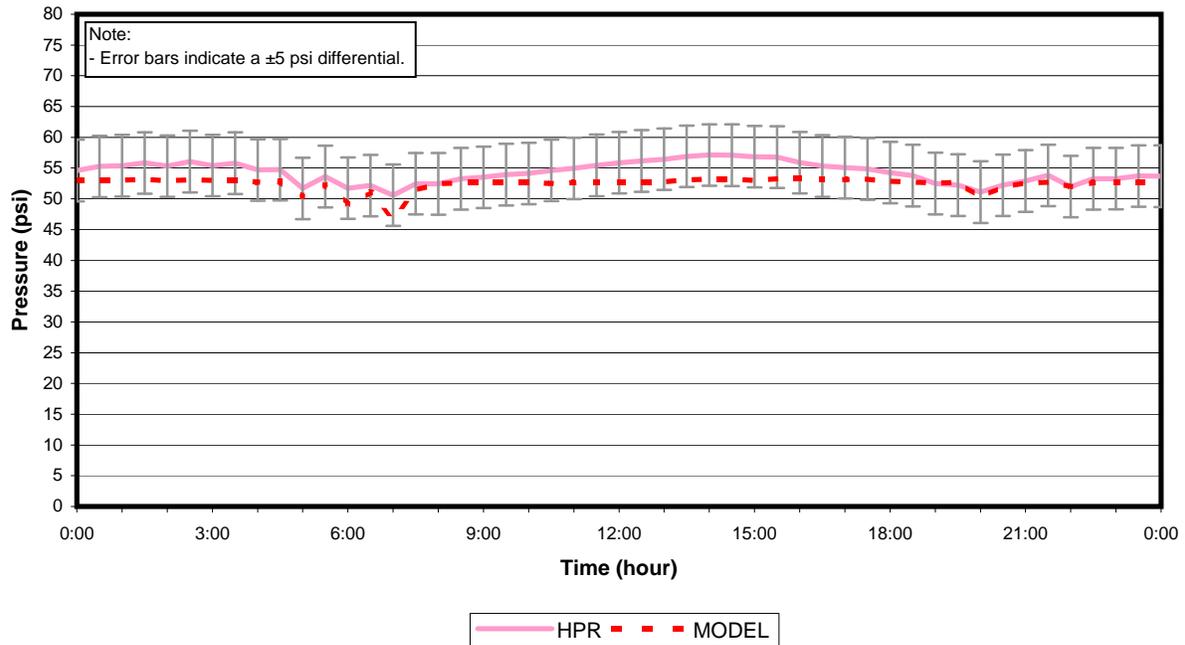
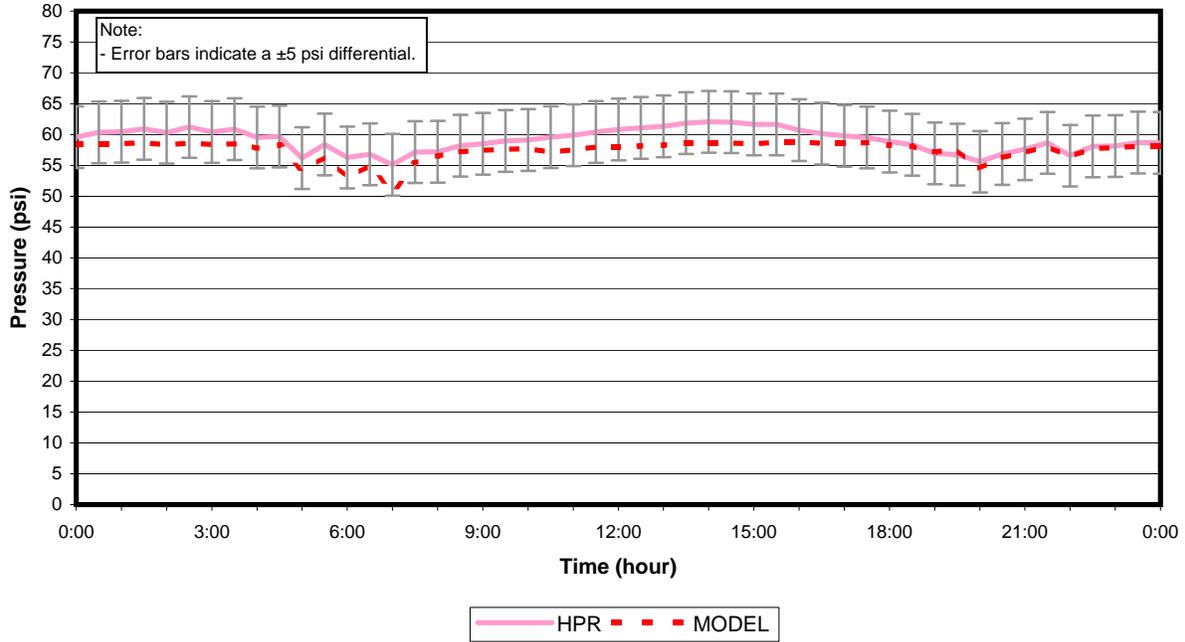


Figure F-24. HPR 5 & HPR 6

HPR 5: Along Corral Hollow Rd., North of Schulte Rd.
May 3, 2010



HPR 6: Along Tracy Blvd., North of Fourth St.
May 3, 2010

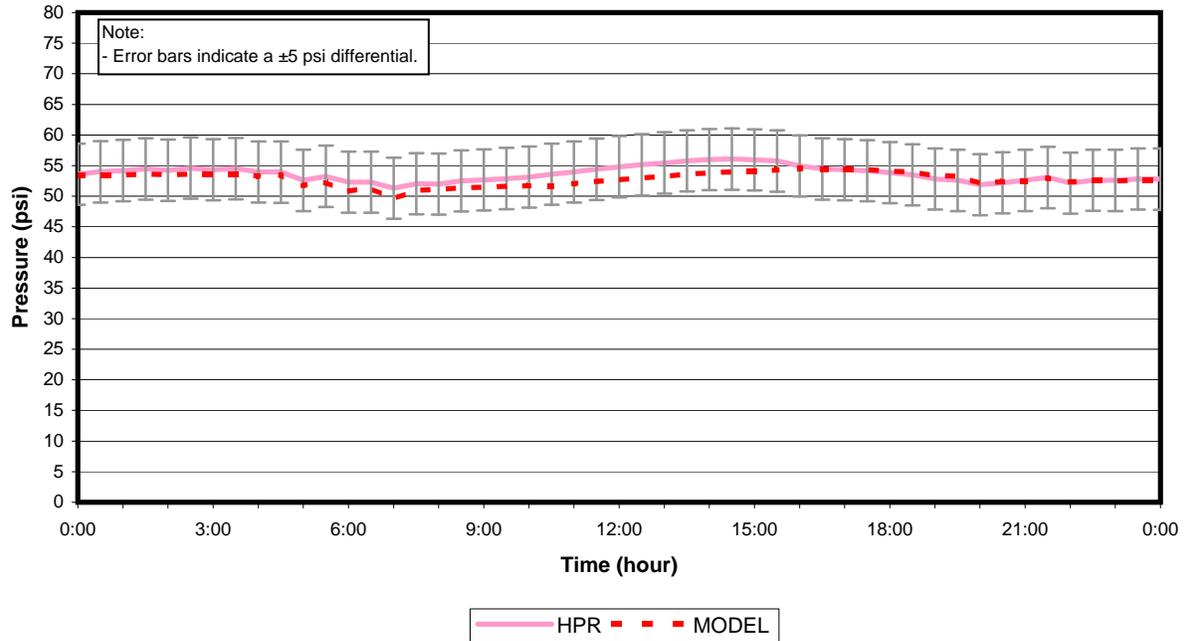
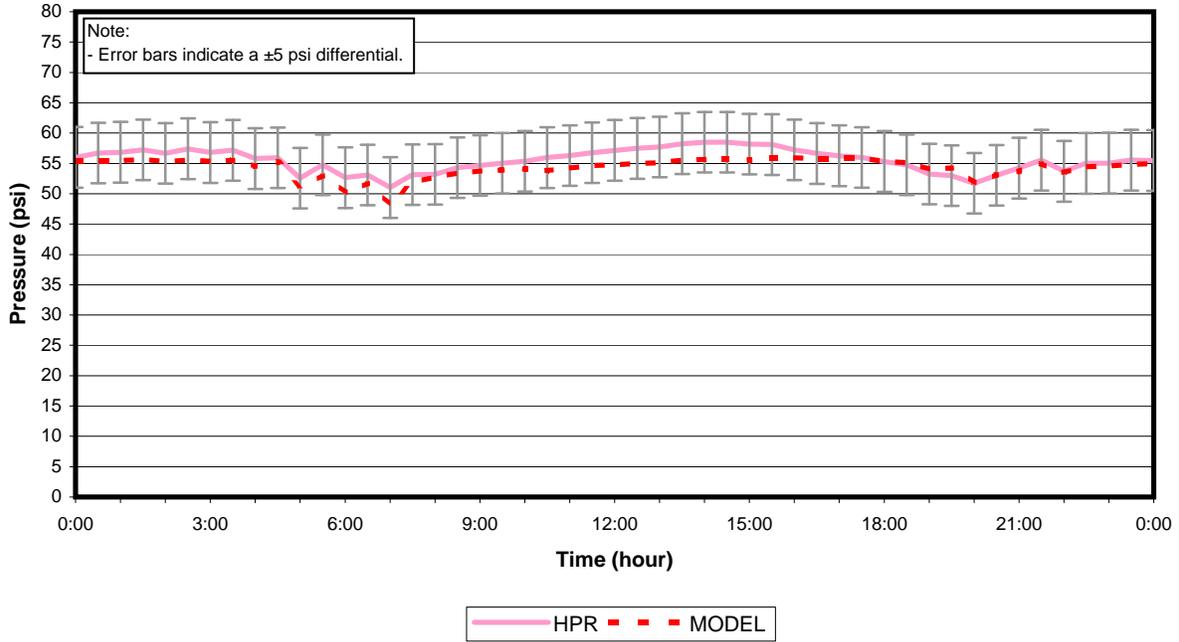


Figure F-25. HPR 7 & HPR 8

HPR 7: Along Redwood Dr., South of Cypress Dr.
May 3, 2010



HPR 8: Along East St., North of Seventh St.
May 3, 2010

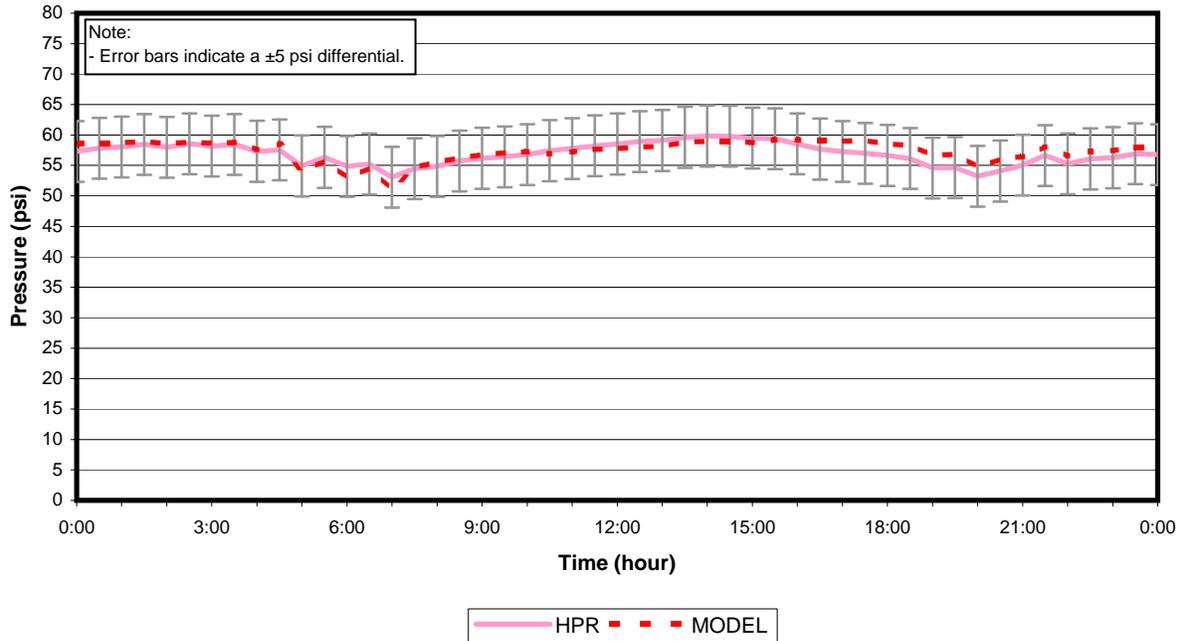
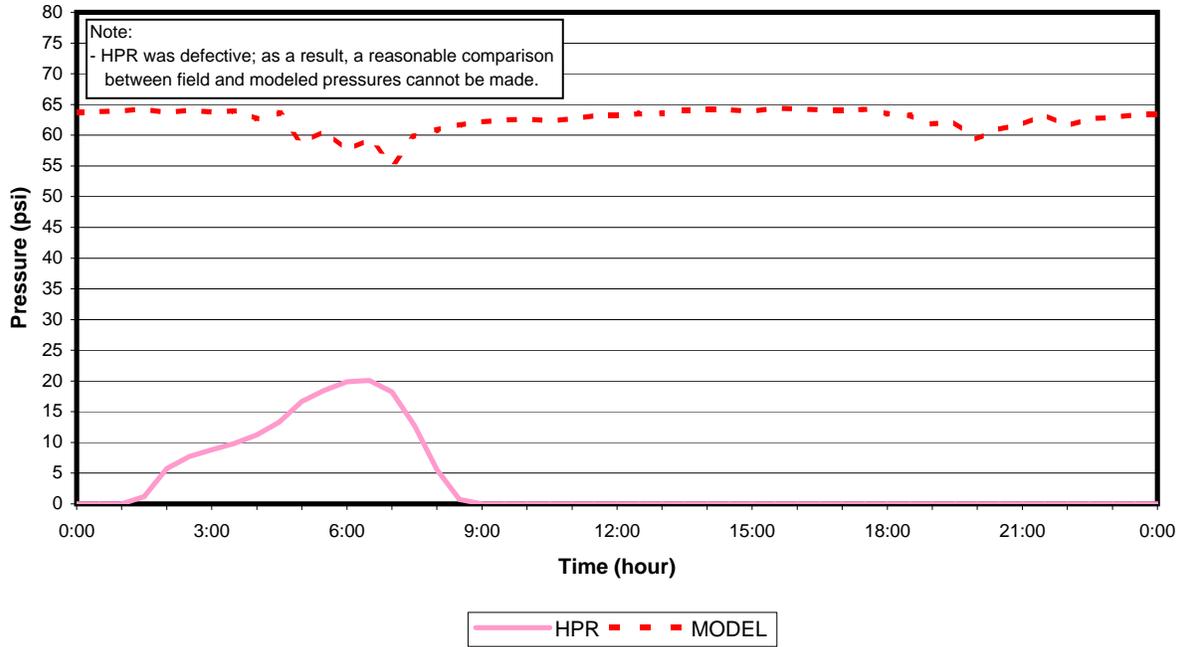


Figure F-26. HPR 9 & HPR 10

**HPR 9: Along Eleventh St., West of Corral Hollow Rd.
May 3, 2010**



**HPR 10: Along Barcelona Dr., South of Tennis Ln.
May 3, 2010**

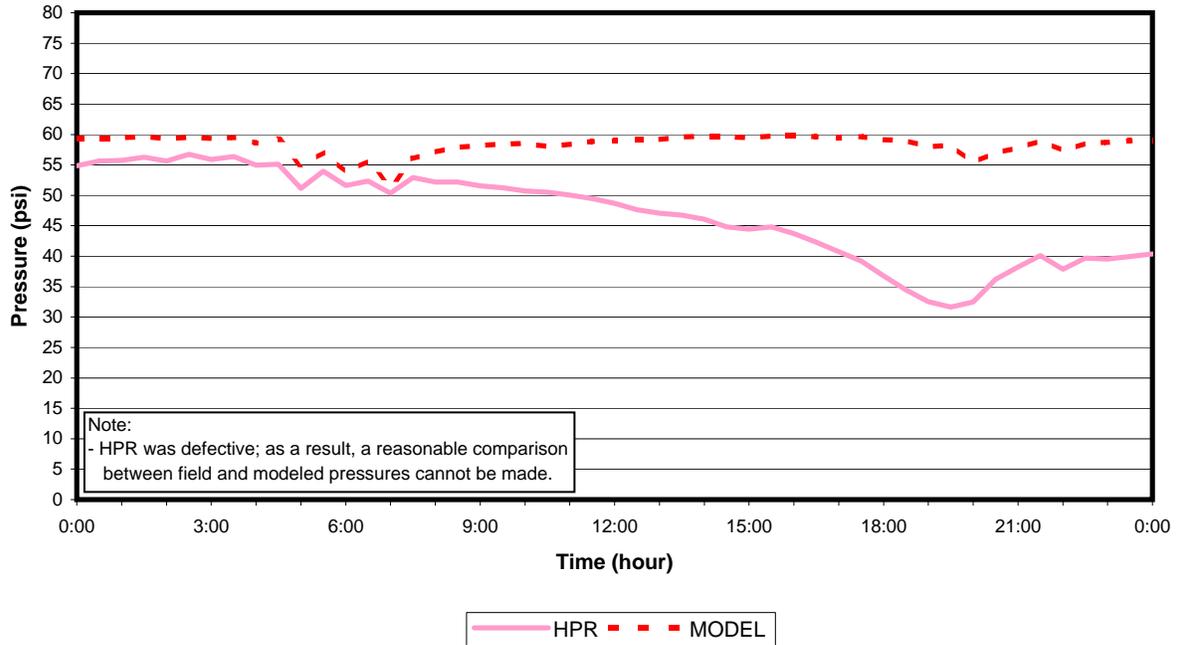
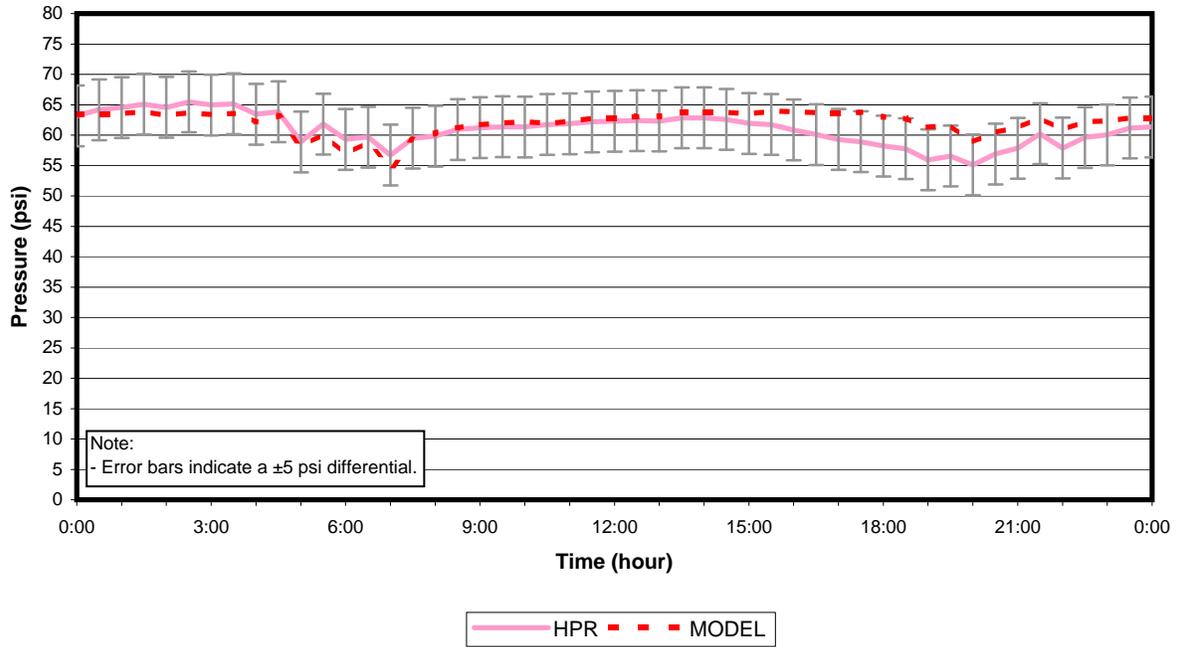


Figure F-27. HPR 11 & HPR 12

**HPR 11: Along Summer Ln., South of Paul Poole Dr.
May 3, 2010**



**HPR 12: Along Lammers Rd., South of Feteira Way
May 3, 2010**

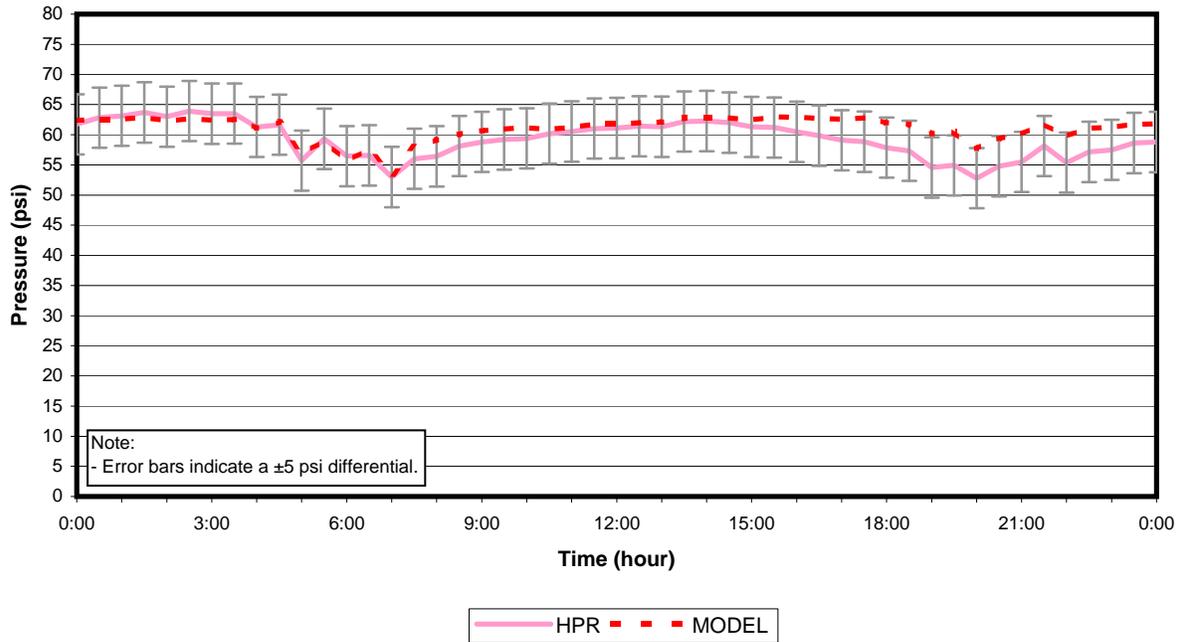
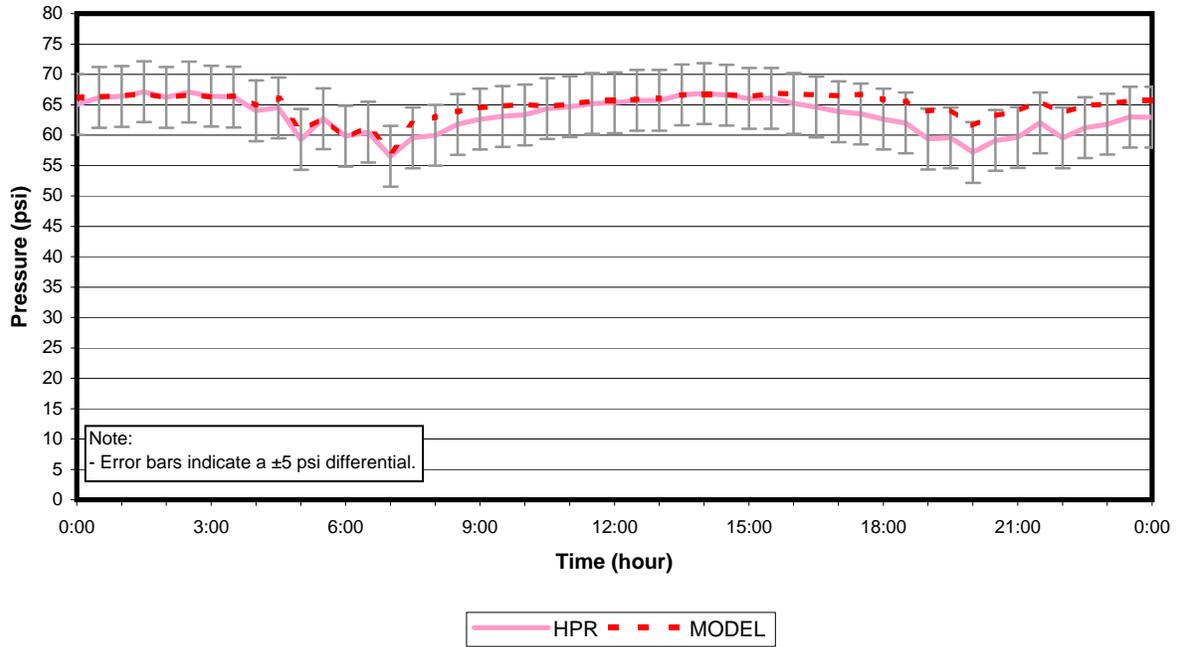


Figure F-28. HPR 13 & HPR 14

HPR 13: Along Lowell Ave., West of Bridle Creek Cir.
May 3, 2010



HPR 14: Along Lincoln Blvd., North of Lowell Ave.
May 3, 2010

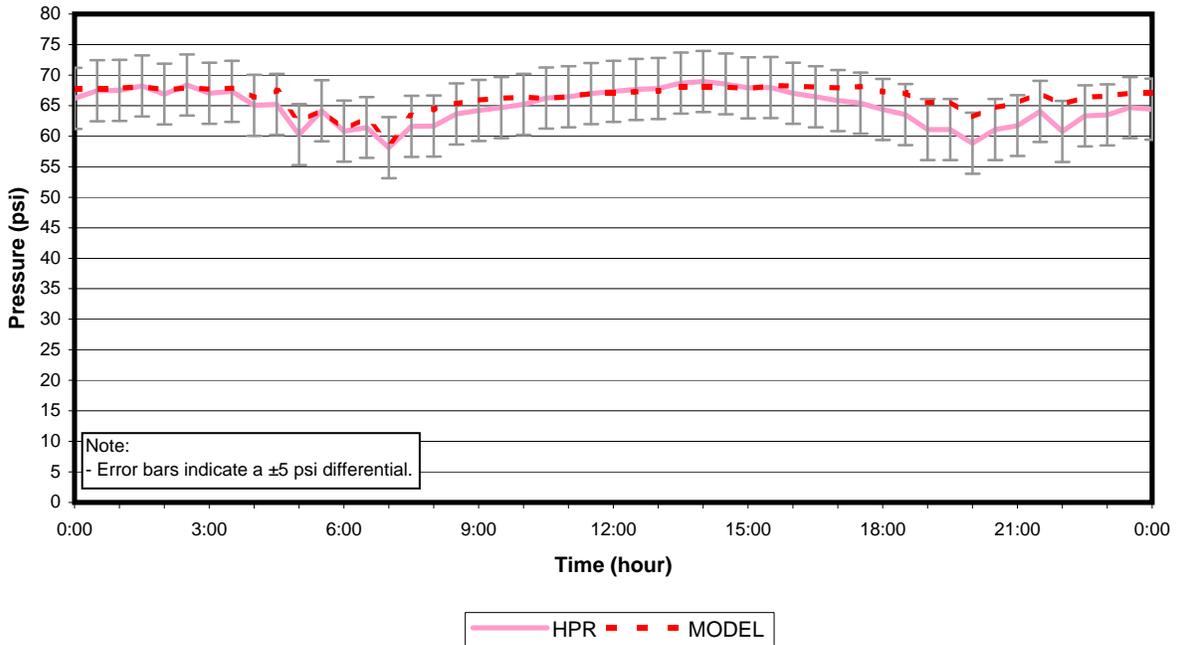
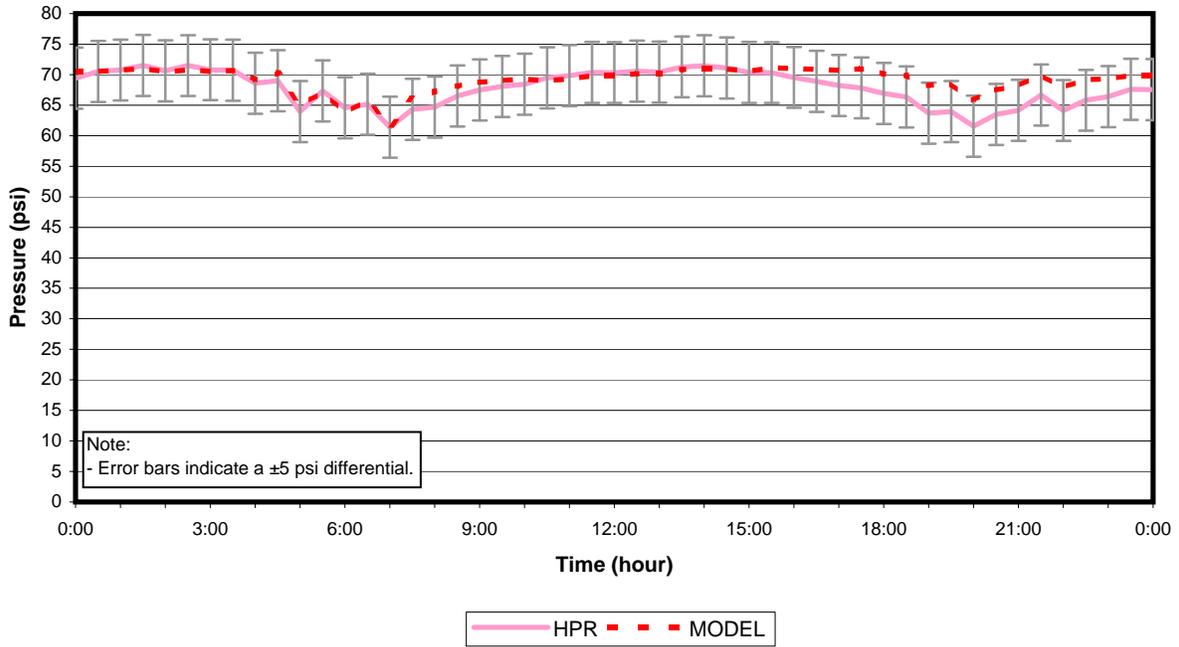


Figure F-29. HPR 15 & HPR 16

HPR 15: Along Grant Line Rd., East of Corral Hollow Rd.
May 3, 2010



HPR 16: Along Larch Rd., East of Corral Hollow Rd.
May 3, 2010

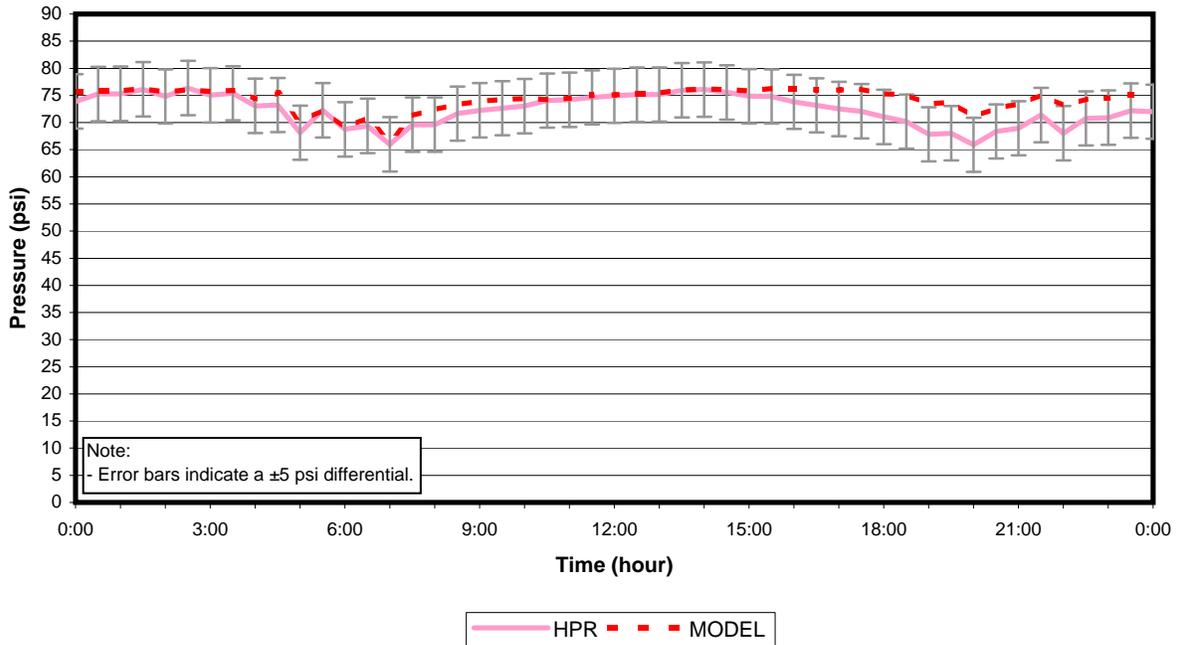
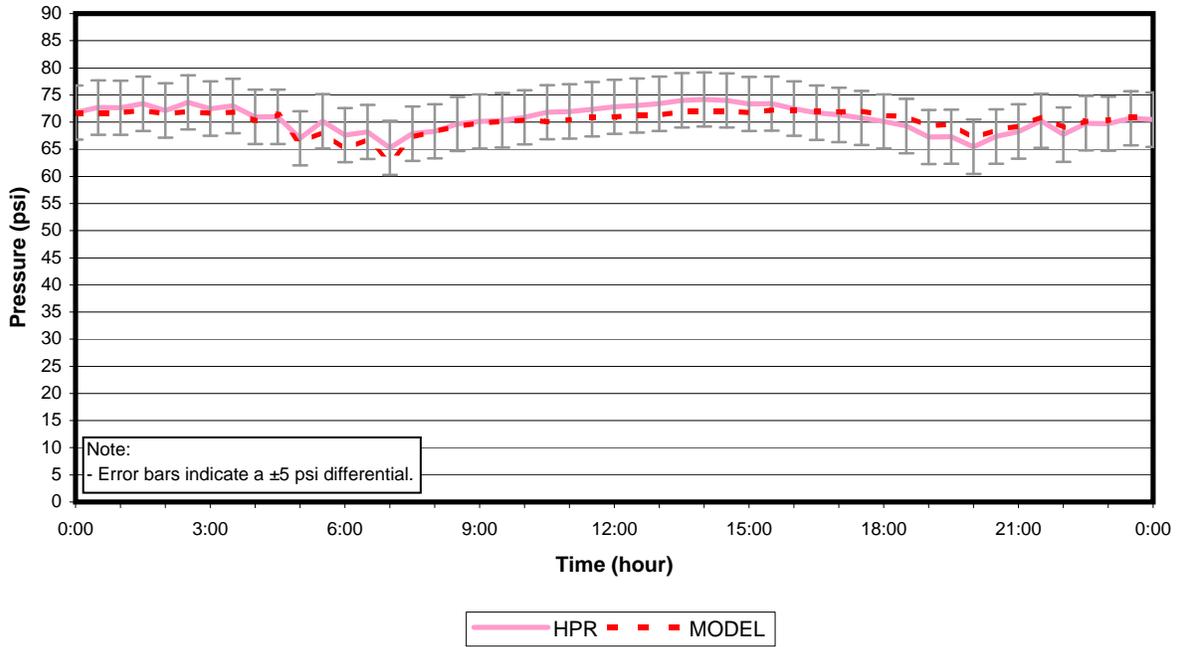


Figure F-30. HPR 17 & HPR 18

HPR 17: Along Tracy Blvd., North of Clover Rd.
May 3, 2010



HPR 18: Along Holly Dr., North of Twentieth St.
May 3, 2010

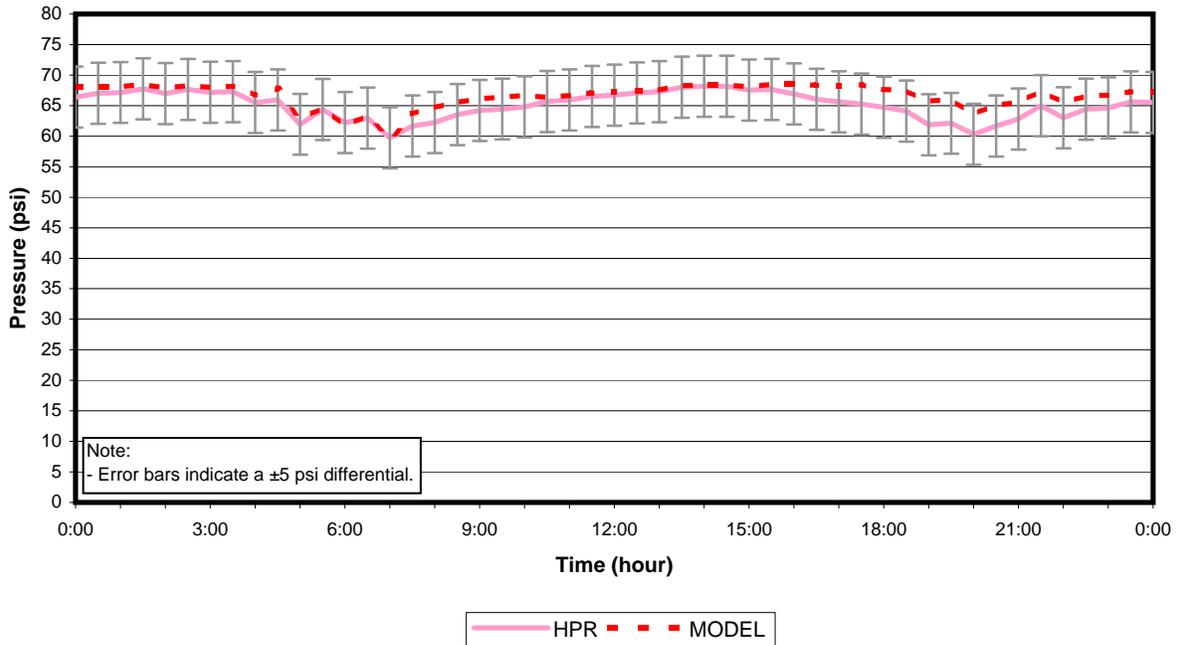
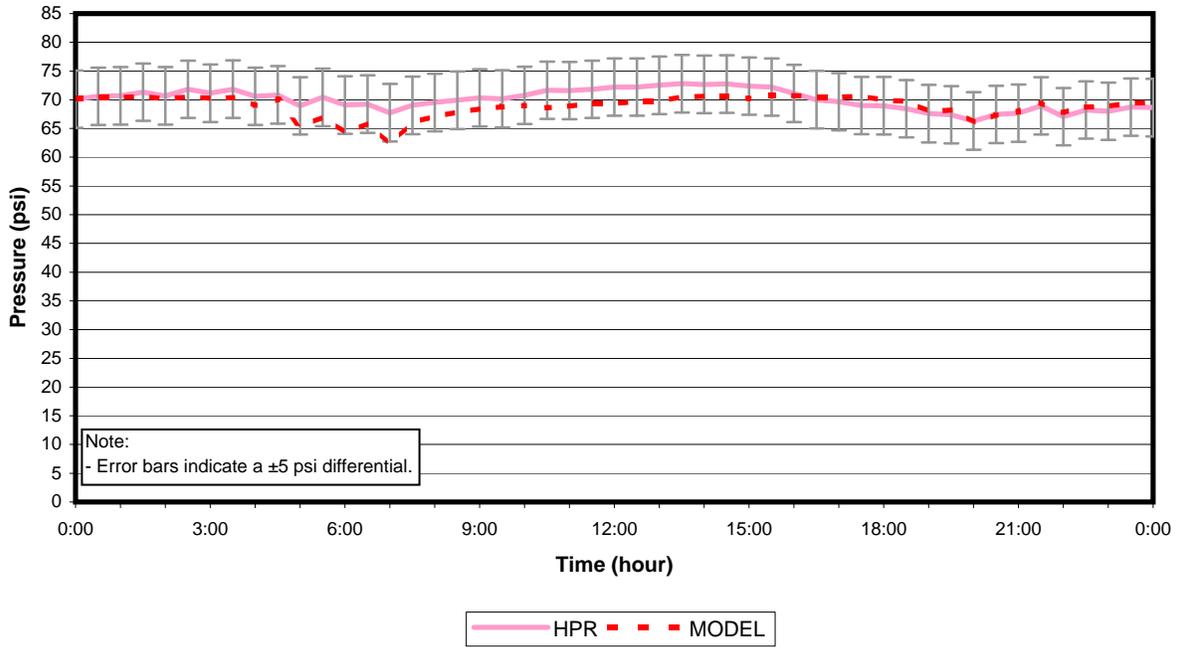


Figure F-31. HPR 19 & HPR 20

**HPR 19: Along Mac Arthur Dr., South of Pombo Square Dr.
May 3, 2010**



**HPR 20: Along Mac Arthur Dr., North of Eleventh St.
May 3, 2010**

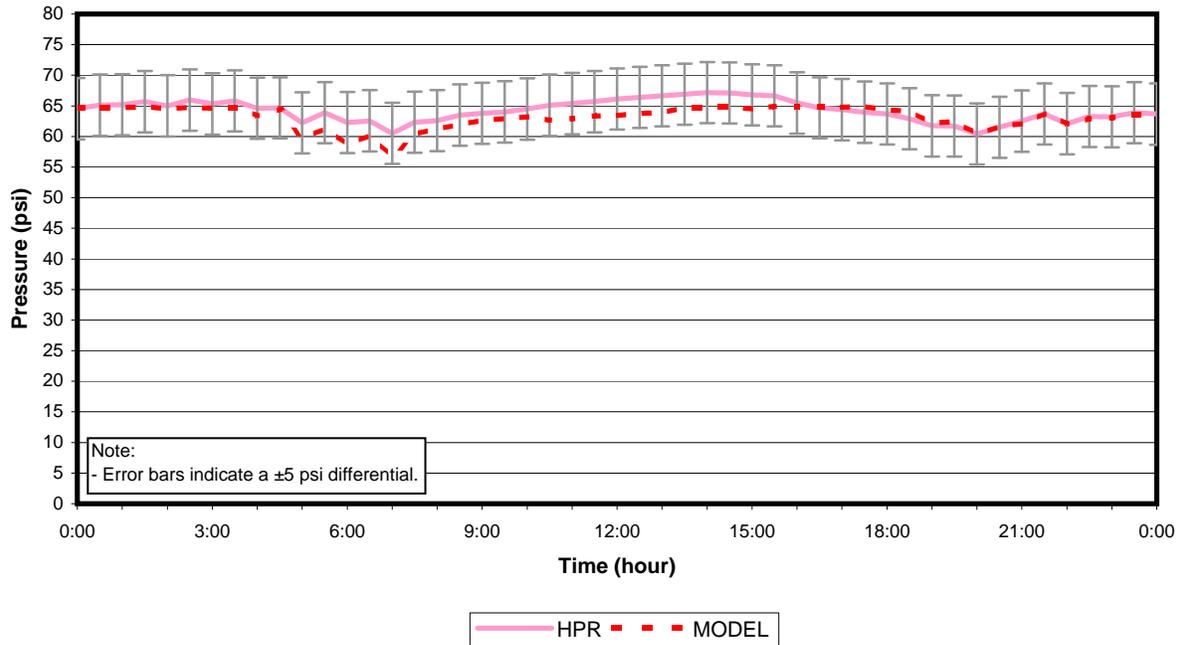
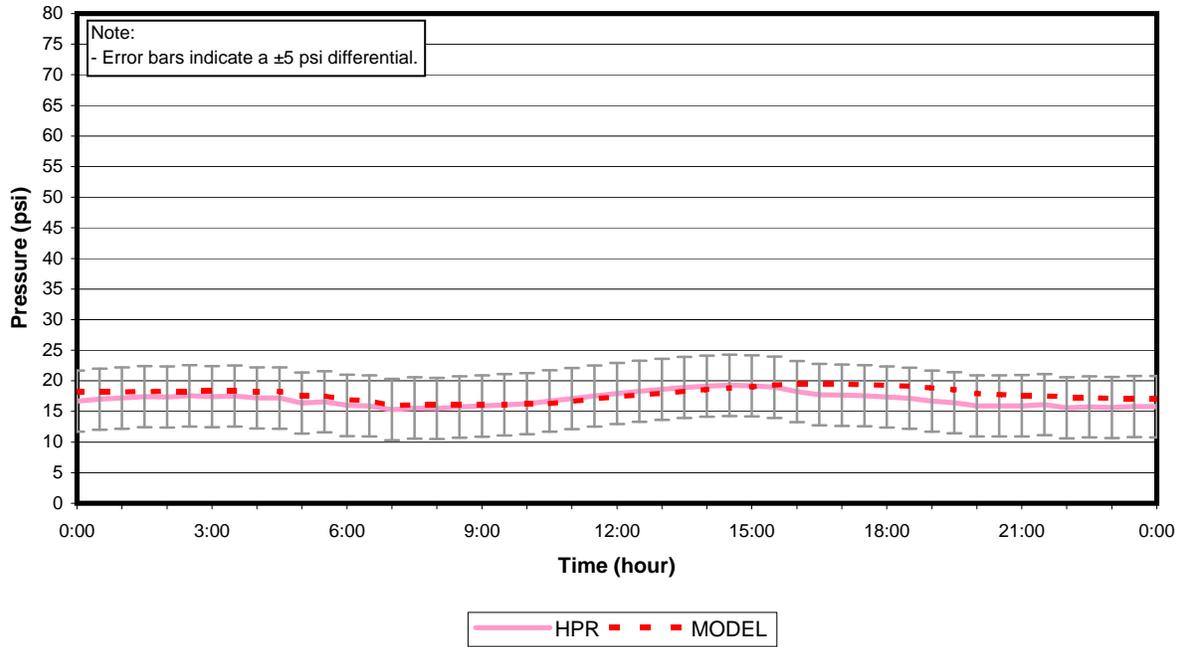


Figure F-32. HPR 21 & HPR 22

HPR 21: Along Tracy Blvd., North of Linne Rd.
May 3, 2010



HPR 22: Along Sixth St., East of Tracy Blvd.
May 3, 2010

