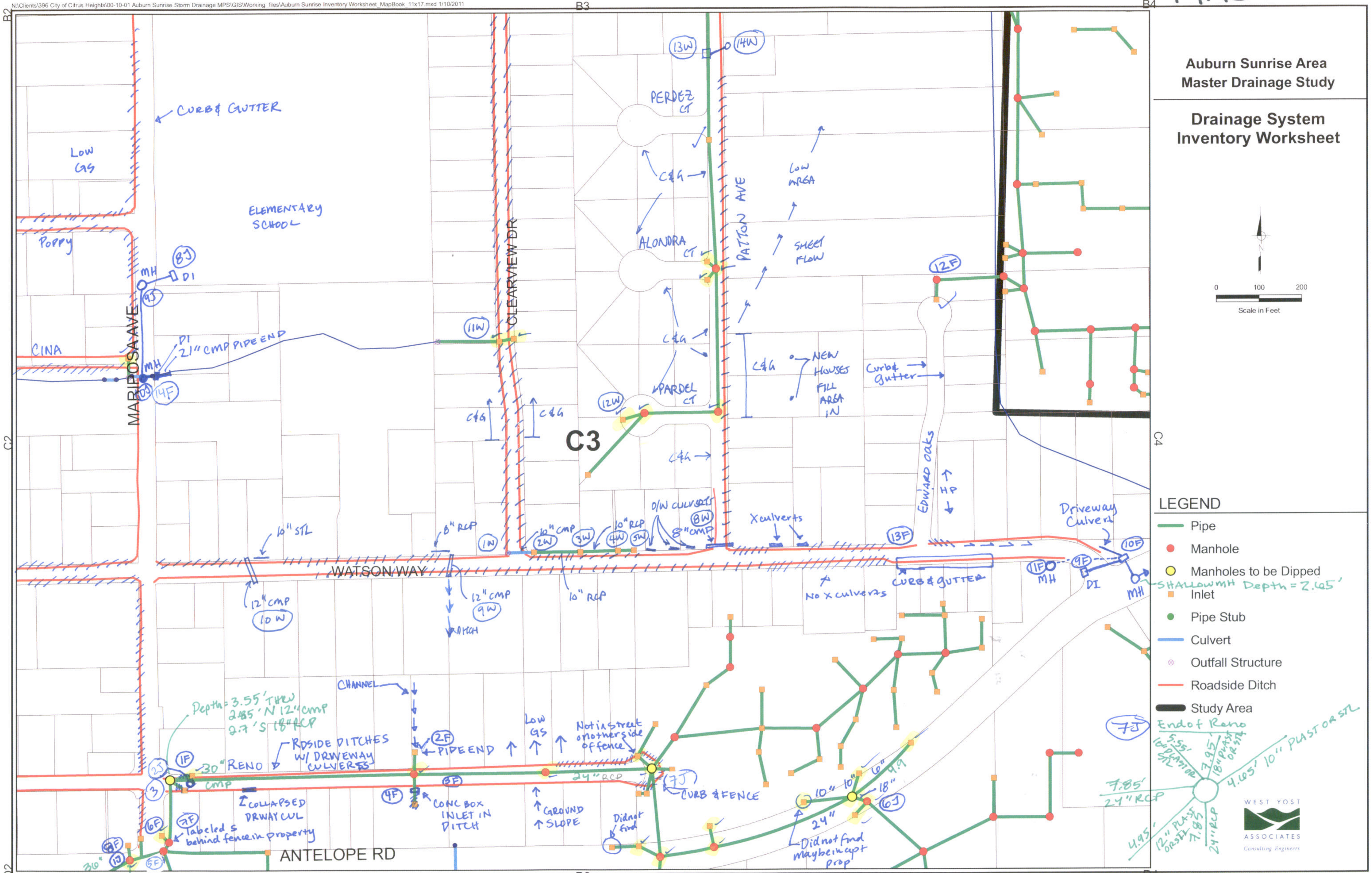
MASTER



Auburn Sunrise Area
Master Drainage Study
Drainage System
Inventory Worksheet
0
100
200
Scale in Feet
LEGEND
Pipe
Manhole
Manholes to be Dipped
Inlet
Pipe Stub
Culvert
Outfall Structure
Roadside Ditch
Study Area
WEST YOST ASSOCIATES
Consulting Engineers
C3
B3
B4
C2
C4
D2
D3
D4
MARIPOSA AVE
CLEARVIEW DR
WATSON WAY
ANTELOPE RD
PATTON AVE
PERDEZ CT
ALONDRA CT
PARDEL CT
Edward Oaks
CURB & GUTTER
Low GS
ELEMENTARY SCHOOL
POPPY
CINA
MH
DI
8J
9J
14F
21" CMP PIPE END
11W
13W
14W
C&G
Low AREA
SHEET FLOW
NEW HOUSES FILL AREA IN
Curb & gutter
12F
12W
HP
Driveway Culvert
10F
13F
Xculverts
D/W CULVERTS
8W
8" CMP
10" RCP
10" CMP
1W
2W
3W
4W
5W
8" RCP
10" STL
12" CMP
10W
9W
DITCH
No X culverts
CURB & GUTTER
11F
9F
SHALLOW MH Depth = 2.65'
CHANNEL
Depth = 3.55' THEN 2.85' N 12" CMP 2.7' S 18" RCP
RDSIDE DITCHES W/ DRIVEWAY CULVERTS
30" RENO
CMP
2F
PIPE END
Low GS
Not in street on other side of fence
24" RCP
7J
CURB & FENCE
3F
4F
CONC BOX INLET IN DITCH
GROUND SLOPE
COLLAPSED DRWAY CUL
7F
labeled & behind fence in property
6F
8F
5F
Didn't find
Did not find maybe in apt prop
10"
6"
4.9
18"
6J
24"
7J
End of Reno
5.55' 30" PLAST STL
7.95' 18" PLAST OR STL
4.65' 10" PLAST OR STL
7.85' 24" RCP
4.95' 12" PLAST OR STL
7.85' 24" RCP
3.65' NE 12" STL
5.95 W 36 CMP
6.0 E 36 RCP

10/16

MASTER

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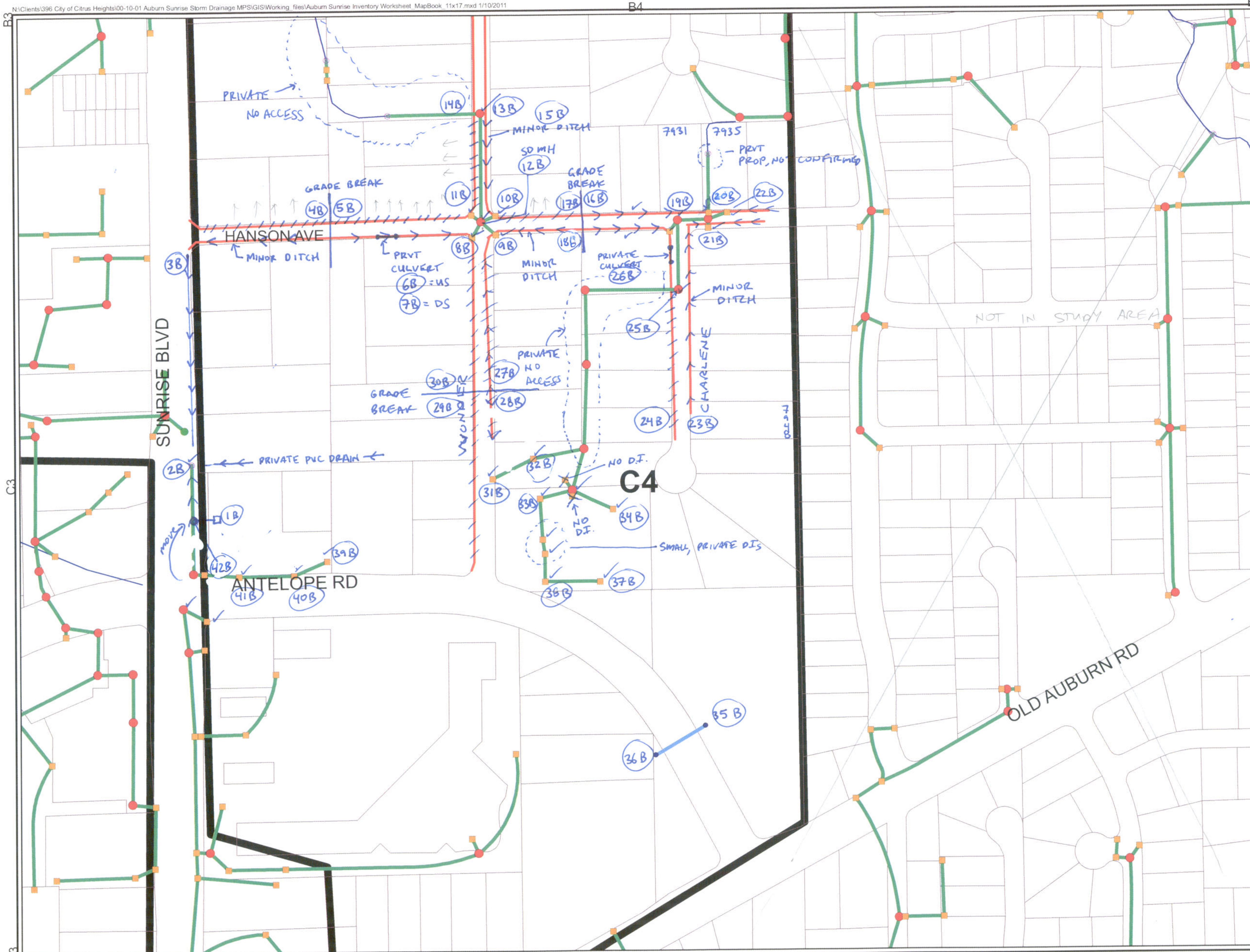

Auburn Sunrise Area Master Drainage Study

Drainage System Inventory Worksheet

0 100 200

Scale in Feet

LEGEND

- Pipe
- Manhole
- Manholes to be Dipped
- Inlet
- Pipe Stub
- Culvert
- Outfall Structure
- Roadside Ditch
- Study Area

WEST YOST ASSOCIATES

Consulting Engineers

11/16

MASTER

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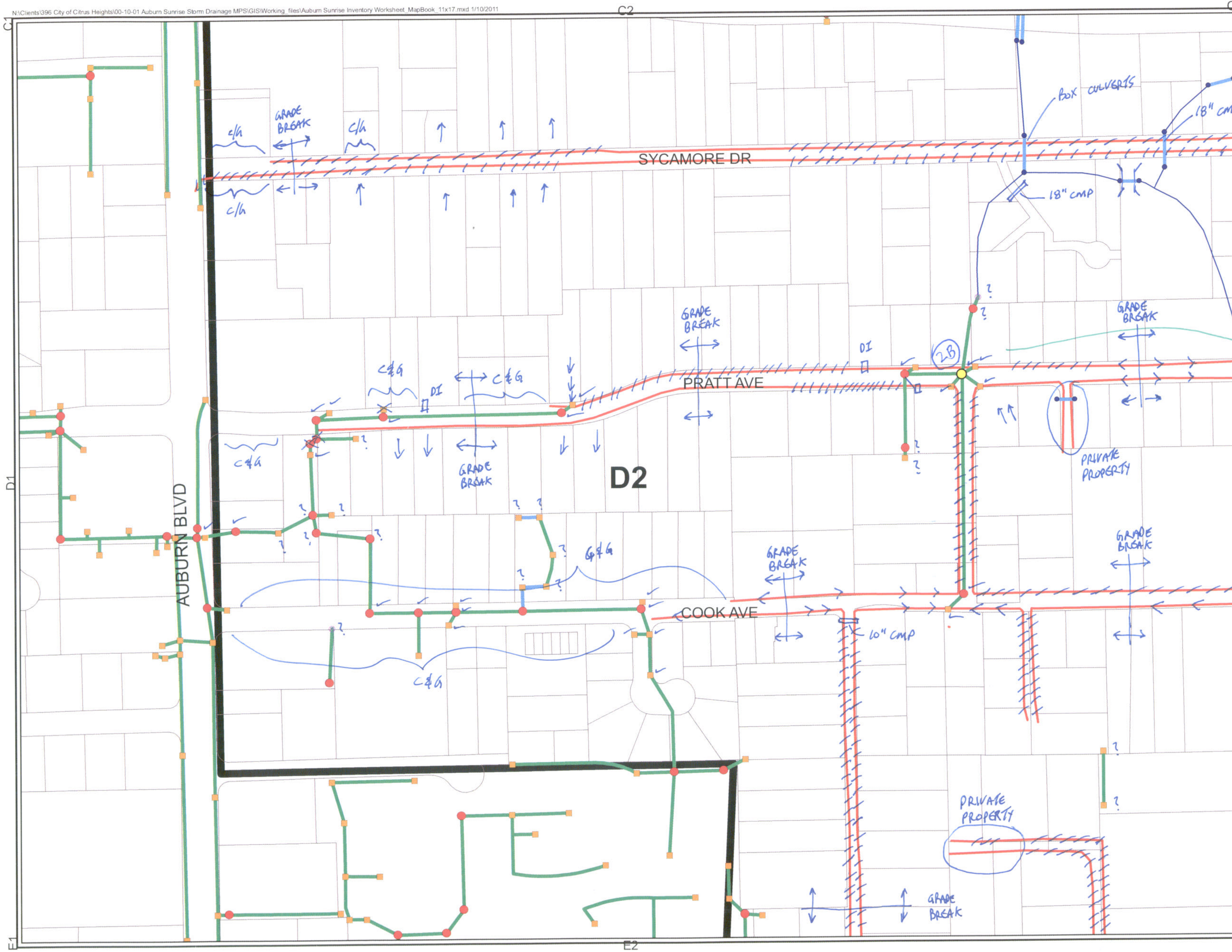


Auburn Sunrise Area Master Drainage Study

Drainage System Inventory Worksheet

0 100 200

Scale in Feet

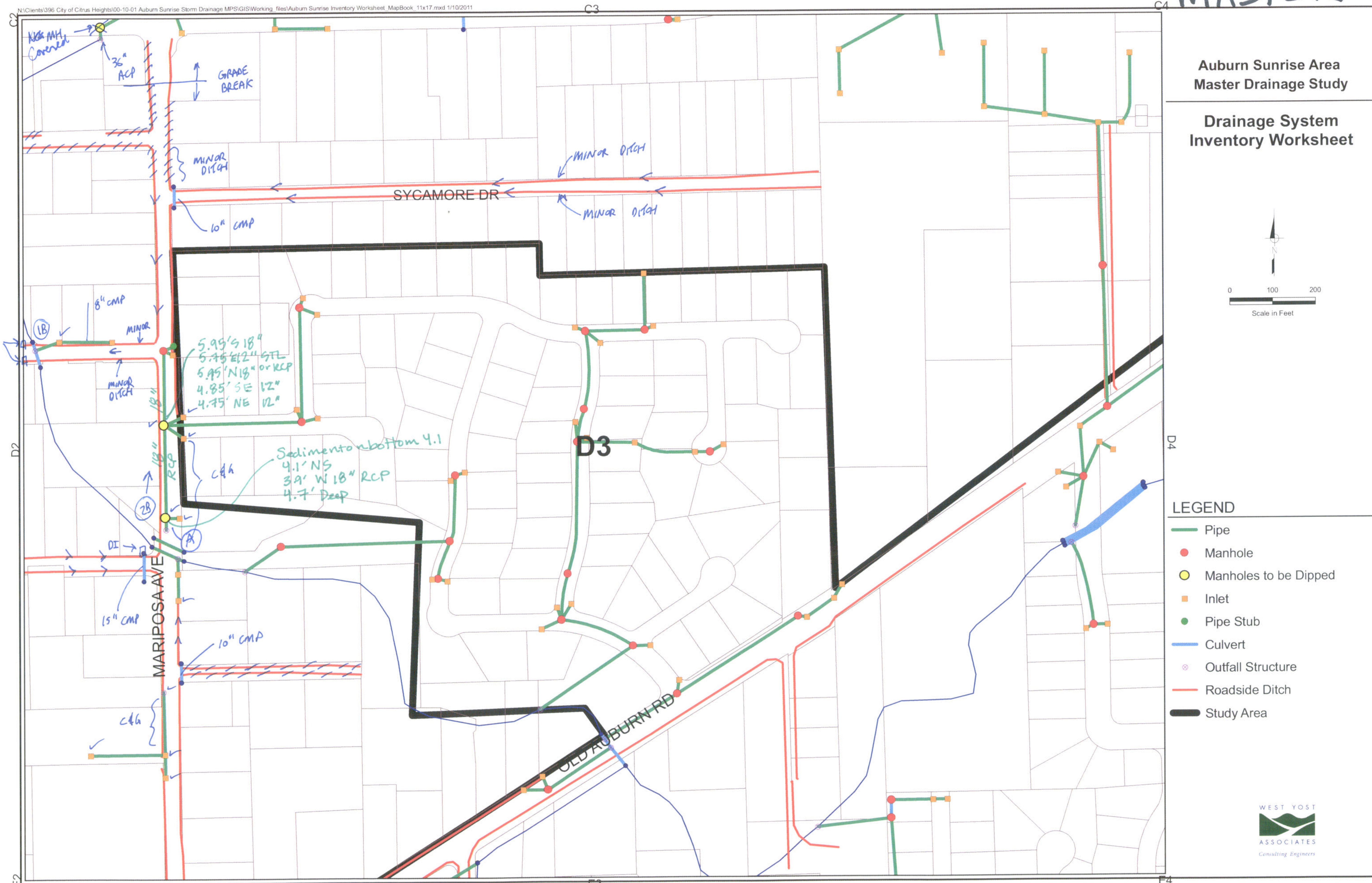
LEGEND

- Pipe
- Manhole
- Manholes to be Dipped
- Inlet
- Pipe Stub
- Culvert
- Outfall Structure
- Roadside Ditch
- Study Area

WEST YOST ASSOCIATES
Consulting Engineers

12/16

MASTER



Auburn Sunrise Area
Master Drainage Study
Drainage System Inventory Worksheet
0
100
200
Scale in Feet
LEGEND
Pipe
Manhole
Manholes to be Dipped
Inlet
Pipe Stub
Culvert
Outfall Structure
Roadside Ditch
Study Area
WEST YOST ASSOCIATES
Consulting Engineers
C2
C3
C4
D2
D4
E2
E3
E4
SYCAMORE DR
MARIPOSA AVE
OLD AUBURN RD
D3
MINOR DITCH
MINOR DITCH
MINOR DITCH
MINOR DITCH
MINOR DITCH
GRADE BREAK
36" ACP
10" CMP
8" CMP
15" CMP
10" CMP
1B
2B
A
2 DI
DI
C&G
C&G
5.95' S 18"
5.15' E 12" STL
5.95' N 18" or RCP
4.85' SE 12"
4.75' NE 12"
18"
18" RCP
Sediment on bottom 4.1
4.1' NS
3.9' W 18" RCP
4.7' Deep

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MASTER

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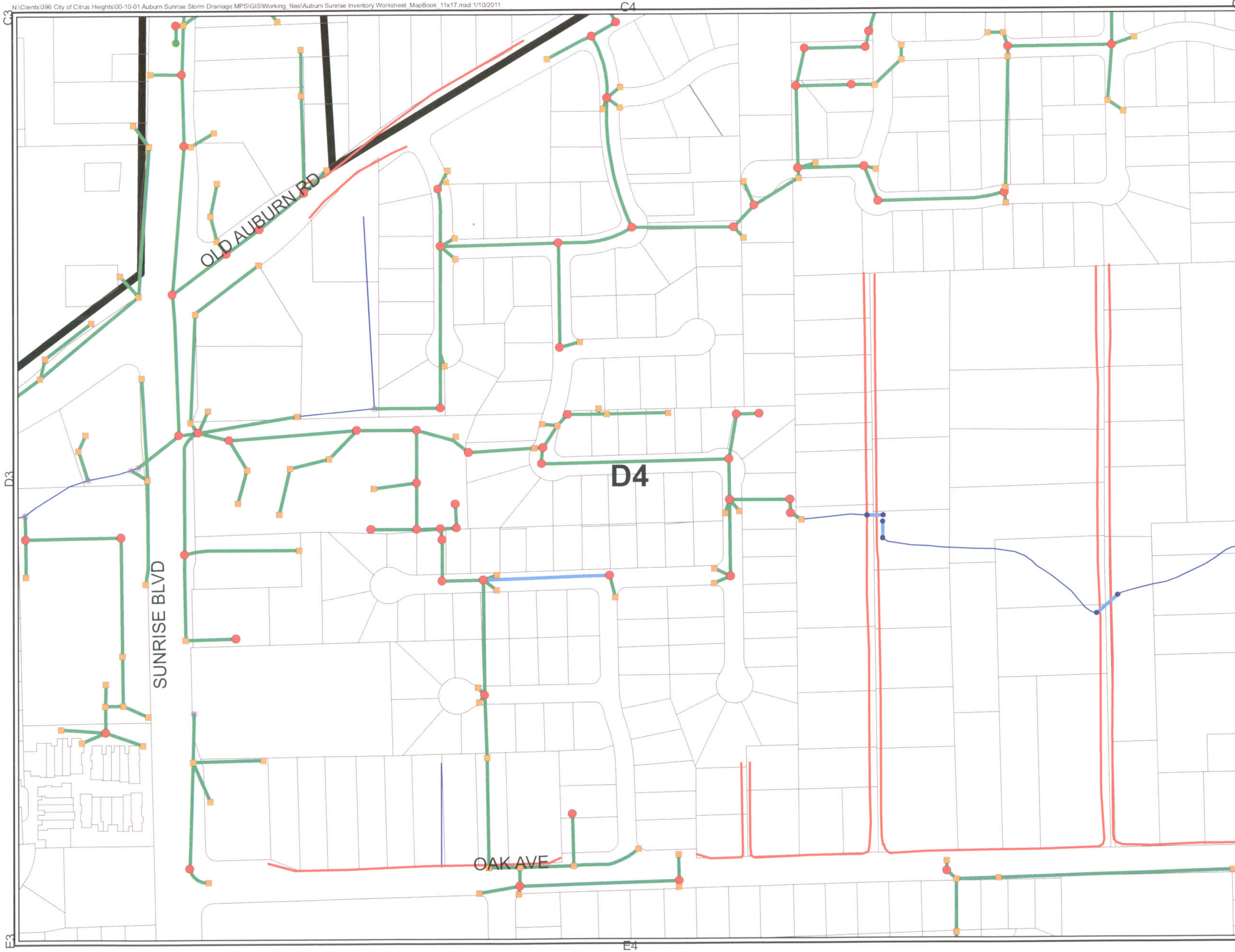


Auburn Sunrise Area Master Drainage Study

Drainage System Inventory Worksheet

0 100 200
Scale in Feet

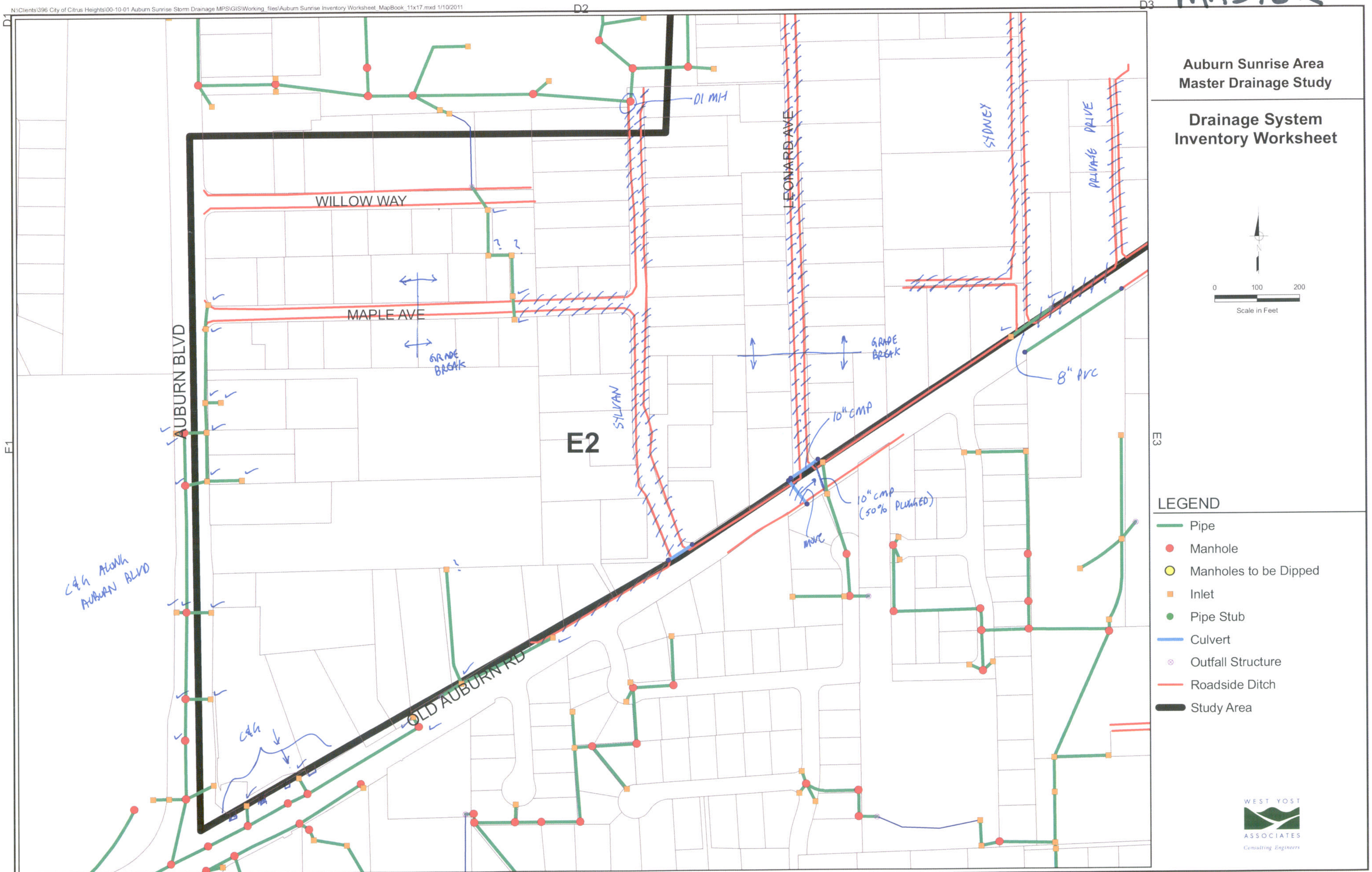
LEGEND

- Pipe
- Manhole
- Manholes to be Dipped
- Inlet
- Pipe Stub
- Culvert
- Outfall Structure
- Roadside Ditch
- Study Area

WEST YOST ASSOCIATES
Consulting Engineers

14/16

MASTER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D1
D2
D3
E1
E2
E3
Auburn Sunrise Area
Master Drainage Study
Drainage System
Inventory Worksheet
0
100
200
Scale in Feet
LEGEND
Pipe
Manhole
Manholes to be Dipped
Inlet
Pipe Stub
Culvert
Outfall Structure
Roadside Ditch
Study Area
WEST YOST
ASSOCIATES
Consulting Engineers
WILLOW WAY
MAPLE AVE
AUBURN BLVD
LEONARD AVE
OLD AUBURN RD
SYLVAN
SYDNEY
PRIVATE DRIVE
01 MH
GRADE BREAK
GRADE BREAK
8" PVC
10" CMP
10" CMP (50% PLUGGED)
MOVE
C&G ALONG AUBURN BLVD
C&G

15/16

MASTER

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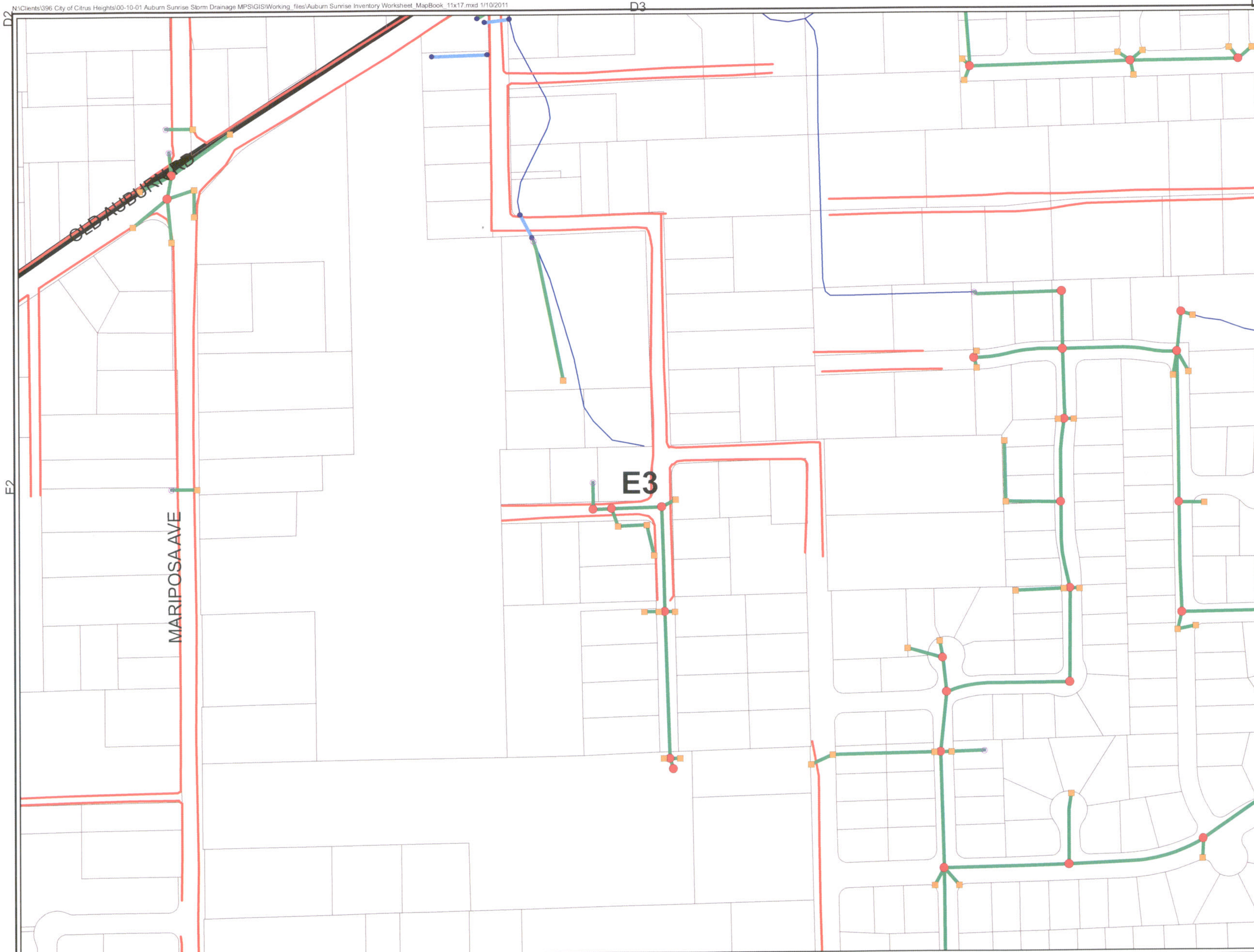


Auburn Sunrise Area Master Drainage Study

Drainage System Inventory Worksheet

0 100 200
Scale in Feet

LEGEND
- Pipe
- Manhole
- Manholes to be Dipped
- Inlet
- Pipe Stub
- Culvert
- Outfall Structure
- Roadside Ditch
- Study Area

WEST YOST ASSOCIATES
Consulting Engineers

16/16

ATTACHMENT 3B

Photos on CD

CHAPTER 4
GIS Database Development

The City maintains a GIS database that includes data representing the existing drainage facilities in the City. For this study, West Yost obtained two shapefiles from the City: one that represents the point drainage facilities such as inlets, manholes, and outfalls; and one that represents line drainage facilities such as pipes, culverts, ditches, and creeks. These shapefiles were updated during this study to include corrected information related to the existing data or to include new information generated during the study.

4.1 GIS REVISIONS DEVELOPED FROM THE FIELD

West Yost performed a field inventory of the existing drainage facilities in the study area as described in Chapter 3. This task included verifying the existence and location of drainage facilities included in the City's GIS system. For some facilities, additional information was collected such as the facility condition, size, depth, etc. The findings from the drainage system inventory were used to update the City's GIS database. The approach to making these updates is described below.

1. Roadside Ditches and Curb and Gutter: The existing GIS mapping shows roadside ditches wherever curb and gutter do not exist. However, many roads do not have curb and gutter or clearly defined drainage ditches. Rather, runoff sheet flows across the adjacent property to nearby creeks or storm drain systems. To better represent this situation, a new roadside drainage shapefile was created that shows ditches only in locations where they actually exist. The City's shapefile was updated to include an attribute field to allow the three potential conditions to be categorized. The attribute field was populated with one of the following values:

    - Ditch – to represent locations where ditches exist
    - Curb and Gutter – to represent those locations where curb and gutter exists
    - None – to represent those locations where neither curb and gutter nor ditches exist

    An attribute field labeled "DATE_UPDAT" was also added and was populated with the date of the field work (populated with mmyyyy).

2. Missing Facilities: Some drainage facilities were located during the field investigations that are not included in the City's original GIS database. The locations of these facilities were established in the field based on adjacent property lines or with a GPS unit. These facilities were added to the appropriate layer of the City's GIS database. Fields such as the X and Y coordinates and depth in the existing GIS database were filled in, as appropriate. The following additional fields were added to track the changes:

    - DATE_UPDAT – populated with mmyyyy (e.g., 022011)
    - UPDATE_BY – filled in with WEST YOST
    - LOC_Meth – includes a notation of either APPROX or GPS

- NOTES – in the shapefile representing the point data, this field includes miscellaneous notes from the field and also an ID No. that corresponds to the ID No. on Table 3-1. For the shapefile representing the line data, this field may also include information on pipe size and condition.

3. Verified or Unverified Facilities: Facilities that were located in the field and found to be generally consistent with the existing mapping were tracked in the City's GIS database. New X and Y coordinates were provided for facilities that appeared to be located incorrectly in the original GIS database. Facilities that were accessible from the public right-of-way but could not be found were identified. Also, facilities that could not be assessed due to access limitations (e.g. private property) were identified. The verification status was included with "Verified – Found" (the facility was found), "Not Found" (the facility was not found), or "Not Verified – Private Property or Inaccessible" (the facility is on private property and its existence could not be verified). The date of verification corresponds to "DATE_UPDAT" field previously described.

   The updated GIS shapefiles were renamed as follows:

   - CH_RoadsideDrainage_update2011.shp
   - CH_DrainageLinesMerge_update2011.shp
   - CH_DrainagePointsMerge_update2011.shp

4.2 OTHER GIS DATA DEVELOPED DURING THE STUDY

In addition to the revisions described above, new drainage data was developed during the study and new shapefiles were created. The following data was developed during the study:

1. Watershed Boundaries for Trunk Pipes – As described in Chapter 6, hydrologic and hydraulic analyses were performed for the major trunk pipe systems within the study area. This included delineation of the watersheds draining to the pipe system. The watershed boundaries are represented in a new shapefile (trunk_pipe_sheds.shp).
2. Recommended Improvements – As described in Chapter 7, improvements were recommended to solve the flooding and drainage problems in the study area. The proposed improvements are schematically represented in the following shapefiles:
   - A shapefile representing proposed point facilities (Proposed Drain Point Solutions.shp)
   - A shapefile representing proposed pipe facilities (Proposed Pipeline Solutions.shp)
   - A shapefile representing proposed improvements to existing ditches (Proposed Ditch Solutions.shp)

CHAPTER 5
Hydrologic and Hydraulic Model Development

West Yost performed hydrologic and hydraulic analyses of major storm drainage systems within the study area to assess their capacities, to determine deficiencies, and to define recommended new facilities. Descriptions of the types of facilities that were evaluated, the approach for the hydrologic and hydraulic analyses, and the criteria used to evaluate the performance of the facilities are provided below.

5.1 FACILITIES EVALUATED DURING STUDY

Within the detailed study area (see Figure 1-2), hydrologic and hydraulic analyses were performed to assess the performance of existing trunk drainage pipes that are 18-inches in diameter and larger. Significant flooding problems are less likely to occur in areas served by smaller pipe sizes because the small tributary watersheds typically served by these pipes tend to produce limited volumes of water. Even during large storms, the excess runoff from small watersheds can usually be conveyed or stored on the ground surface without causing property damage. Therefore, limiting the evaluation to the larger pipes was considered appropriate and allowed the level of effort for the study to be kept to a reasonable level. Descriptions of the specific trunk pipes analyzed during this study and the results of the analyses are provided in Chapter 6.

In addition to the trunk pipe systems, modeling was also performed for other areas that are known to have drainage or flooding problems. These areas were identified based on input from area residents, review of service calls compiled by the City and Sacramento County, and input from City staff. These known problem areas are served by a variety of drainage system types including pipes, roadside ditches, and channels. Descriptions of the specific problem areas and the results of the analyses are provided in Chapter 7. For most of the problem areas, hydrologic and hydraulic analyses were performed to size recommended facilities to eliminate or reduce the problems. Relatively complex problems were assessed using hydrologic and hydraulic modeling. Less complex problems were evaluated with spreadsheet calculations or normal depth analyses. For the simplest problems with relatively straightforward solutions, City staff directed that only qualitative analyses be performed. For those problems, general solutions were recommended without having engineering calculations performed.

As discussed previously, modeling was not performed for the major creeks in the area including Cripple Creek and Mariposa Creek. Although there are known flooding problems along these creeks, these problems represent regional flooding issues that need to be resolved in coordination with Sacramento County.

5.2 HYDROLOGIC ANALYSES

Peak flood flows were determined based on the methods in the County of Sacramento Municipal Services Agency Improvement Standards (County Standards) dated October 1, 2006. In accordance with these standards, peak flows for evaluating pipe systems were based on the Nolte Method. This method has been used in Sacramento County since the 1960’s and produces peak flows that have a recurrence interval from 2- to 5-years. Nolte Method flood peaks were calculated for the major storm drainage facilities using Sacramento County’s SacCalc software. SacCalc is a program that was developed for Sacramento County to assist local engineers in preparing hydrologic models based on the County Standards.

Peak flows for evaluating overland flow paths were based on the 100-year storm. The 100-year peak flows were determined using the Sacramento Method charts in the County Standards.

Watershed boundaries were determined primarily from 2-foot contour LIDAR topographic mapping. In some cases as-built plans, previous studies, aerial photographs, and field visits were also used to assist with the watershed boundary definitions.

The land use within each watershed was determined from high resolution aerial photographs that were produced in 2008 for the California Department of Water Resources Central Valley Flood Plain Evaluation and Delineation project. Because the study area is nearly built out, land-use densities are not expected to change significantly in the future. Therefore, flood flows were only calculated for existing land-use conditions.

5.3 HYDRAULIC ANALYSES

Hydraulic analyses were performed to evaluate the performance of major drainage facilities and to size recommended improvements to solve problems. Hydraulic calculations were performed in accordance with the County Standards. The hydraulic calculations for pipe systems were based on the Friction Loss Method 1, which neglects minor losses but uses a larger Manning's n value to compensate. Typical Manning's n values used for the study are presented in Table 5-1.

Table 5-1. Typical Manning's n Values

Item	Manning's n Value
Concrete Pipe	0.015
Corrugated Metal Pipe	0.024 - 0.028
Open Channel	0.04 - 0.06

For all trunk pipelines, and for many of the drainage systems at the known problem areas, hydraulic models were prepared using the XPSWMM modeling software. The XPSWMM models were configured to perform steady-state calculations using peak flows for the pipe design event (Nolte Method) and also for the 100-year storm event.

Pipe sizes, invert elevations, and materials were determined from as-built drawings when available (see Table 2-2). For pipes without as-built plans, pipe data was estimated from field measurements. Invert elevations were estimated at key locations by measuring the depth to the invert from the surface, and subtracting this value from the nearest spot elevation from the LiDAR topographic data. Typically, this was done at two or three key points along a pipe system and that information was used to estimate the invert elevations at other locations along the pipeline. Channel and ditch sizes, depths, and inverts were also estimated using field measurements, LiDAR topographic data, and photographs. Because no field surveying was performed, the elevations used in the models are considered approximate.

The method used to establish the starting water surface elevations at the downstream ends of the hydraulic models was dependent on the specific situation. For drainage systems that discharge directly to Cripple Creek or Mariposa Creek, the water surface profiles published by FEMA were used. For the Nolte pipe design event, the starting water surface elevation was set to the 10-year water surface elevation in the creek. For the 100-year event, it was set to the 100-year water surface elevation in the creek. In most other cases, the starting water surface elevations were typically set at normal depth.

5.4 PERFORMANCE CRITERIA

The performance of the drainage systems was evaluated using the following criteria:

- For pipe systems, Sacramento County Standards require that the hydraulic grade line be a minimum of 0.5 foot below inlet grates. This criterion was used for proposed new pipe systems. However, for existing pipe systems, it was considered acceptable for the hydraulic grade line to rise up to the elevation of the inlet grates.
- For open ditches and channels, the capacity should be adequate to contain the peak flows based on the Nolte Method, at a minimum.
- Ideally, structures should be protected from the 100-year storm by limiting the hydraulic grade line during the 100-year storm to no greater than nearby building pad elevations. Pad elevations were estimated using LiDAR topographic data. The economic feasibility of providing this level of protection was considered when recommending proposed drainage facilities.

For proposed new drainage systems, the primary objective was eliminating or reducing flooding problems. However, consideration was also given to incorporating features into the improvements that would improve stormwater quality or promote infiltration of runoff.

CHAPTER 6
Analysis of Existing Pipes

6.1 INTRODUCTION

As described in Chapter 5, hydrologic and hydraulic analyses of the existing trunk storm drain pipes were performed to determine whether the major pipe systems in the study area have adequate capacity. The trunk pipes with diameters 18-inches or larger that are within the detailed study area were evaluated and are shown on Figure 6-1. There are some additional trunk pipes that were identified by City staff as having been recently studied or recently constructed and those pipes were not evaluated as a part of this study. As shown on Figure 6-1, 12 distinct trunk pipes or pipe systems were originally identified for evaluation during this study. Each of the systems was given a unique identifier (SD1 through SD12). After reviewing the each of the systems, SD9 was dropped from the evaluation list. This decision was made by City staff after a field review of the pipe system. The pipe system travels through private property and it was difficult to gain the access needed to obtain information on the system. A property owner along the pipe route indicated that he had lived on the property for over 30 years and had never witnessed any problems along the pipe system. Therefore, the City decided it was unnecessary to evaluate SD9 and it was dropped from the evaluation list.

6.2 HYDROLOGIC ANALYSIS OF EXISTING PIPES

For each of the 11 trunk pipe systems that were evaluated, SacCalc models were prepared to calculate peak design flows based on the Nolte Method (see additional discussion in Chapter 5). The Nolte Method flow rates were used to assess the capacities of the pipe systems. Peak flows for the 100-year storm were determined using the Sacramento Method charts. The 100-year flows were used to assess the adequacy of overland flow paths.

The watershed boundaries for each of the trunk pipe systems are shown on Figures 6-2 through 6-6. The calculated flood flows are presented in Table 6-1.

6.3 HYDRAULIC ANALYSIS OF EXISTING PIPES

For each of the eleven trunk pipe systems that were evaluated, XP-SWMM models were prepared to perform hydraulic calculations. Chapter 5 provides additional discussion on the approach used to perform these calculations. The results from the XP-SWMM models were used to determine whether each pipe system had adequate capacity to convey the pipe design flows based on the City’s drainage standards. In addition, the models were used to assess the adequacy of the overland release path for the 100-year storm.

The pipe layouts for each of the trunk systems are presented on Figures 6-2 through 6-6. The input data for each pipe system are presented in Table 6-2. It should be reiterated that field surveying was not performed for this study. The pipe data listed in Table 6-2 was based on as-built plans or approximate field measurements and is considered approximate.

Table 6-1. Peak Flows for Existing Trunk Storm Drains

		Contributing Area (acres) by Land-Use Type and Percent Impervious								Subshed Total		Cumulative Total at Node			
		Comm./ Office	Apts./ RD-20	RD-10	RD-5	RD-4	RD-3	RD-2	RD-1					Pipe Flow, cfs	100-year Flow, cfs
Upstream Node	Downstream Node	90%	80%	70%	50%	40%	30%	25%	20%	Area, acres	% Imp.	Area, acres	% Imp.	Nolte Zone 1	Sac. Method Zone 3
Trunk Storm Drain SD1															
SD1-A1	SD1-A	-	-	-	-	-	56.3	-	-	56.3	30.0	56.3	30.0	20.7	80.0
SD1-A	SD1-B	-	-	-	-	-	1.6	-	-	1.6	30.0	57.9	30.0	21.5	82.0
SD1-B	SD1-C	-	-	-	-	-	21.1	-	-	21.1	30.0	79.0	30.0	32.0	104.0
Trunk Storm Drain SD2															
SD2-A	SD2-B	-	-	-	-	-	9.7	-	-	9.7	30.0	9.7	30.0	2.7	18.0
SD2-B	SD2-C	-	-	-	-	-	5.5	-	-	5.5	30.0	15.2	30.0	4.4	26.0
Trunk Storm Drain SD3															
SD3-A	SD3-B	-	-	-	-	-	-	12.1	5.0	17.1	23.5	17.1	23.5	4.9	30.0
SD3-C	SD3-D	-	-	-	-	-	-	1.7	-	1.7	25.0	18.8	24.3	5.4	32.0
SD3-C	SD3-D	-	-	-	-	-	4.9	-	-	4.9	30.0	23.7	26.6	7.0	40.0
Trunk Storm Drain SD4															
SD4C	SD4A	-	-	-	-	-	-	5.3	13.0	18.3	21.5	18.3	21.5	5.3	31.0
Trunk Storm Drain SD5															
SD5-A	SD5-B	-	-	-	-	-	-	5.6	7.8	13.4	22.1	13.4	22.1	3.8	26.0
SD5-B	SD5-E	-	-	-	-	-	-	1.8		1.8	25.0	15.2	25.0	4.4	28.0
SD5-E	SD5-C	-	-	-	-	-	-	-	10.4	10.4	20.0	10.4	20.0	2.9	20.0
SD5-C	SD5-D	-	-	-	-	-	-	-	-	0.0	-	25.6	21.4	7.6	48.0
Trunk Storm Drain SD6															
SD6-A	SD-6B	6.4	32.2	-			25.7	-	-	64.3	61.0	64.3	61.0	26.5	104.0
SD-6B	SD-6C	-	-	-	-	-	-	6.6	6.6	13.2	22.5	77.5	54.4	31.9	115.0
SD6-C1	SD6-C3	-	-	-	10.2	-	-	10.2	-	20.3	37.5	20.3	37.5	5.9	25.0
SD6C3	SD6D	-	-	-	-	-	-	-	-	0.0	-	97.8	50.9	43.3	140.0
SD6-D1	SD6-DE	-	-	-	-	-	18.1	-	-	18.1	30.0	115.9	47.7	58.9	150.0
Trunk Storm Drain SD7															
SD7-A	SD7-B	-	7.1	-	-	-	-	-	-	7.1	80.0	7.1	80.0	3.3	18.0
SD7-B	SD7-D	-	-	-	-	4.1	-	-	-	4.1	40.0	11.2	65.4	4.2	26.0
SD7-C	SD7-D	-	1.4	-	0.4	-	-	-	-	1.8	74.0	1.8	74.0	0.8	6.0
SD7-D	SD7-E	-	5.8	-	1.5	-	-	-	-	7.3	74.0	20.3	69.2	8.0	43.0
SD7-E	SD7-F	-	-	-	19.7	-	-	-	-	19.7	50.0	40.0	59.8	14.6	72.0
SD7-F	SD7-G	-	-	-	9.7	-	-	-	-	9.7	50.0	49.7	57.9	18.8	84.0
SD7-G	SD7-H	-	-	-	4.2	-	-	-	-	4.2	50.0	53.9	57.2	20.8	92.0
Trunk Storm Drain SD8															
SD8-A	SD8-C	-	-	-	-	-	6.3	-	-	6.3	30.0	6.3	30.0	1.8	15.0
SD8-B	SD8-C	-	-	-	-	-	18.3	-	-	18.3	30.0	18.3	30.0	5.3	33.0
SD8-C	SD8-D	-	-	-	-	-	-	-	-	0.0	-	24.6	30.0	7.3	44.0
Trunk Storm Drain SD10															
SD10-A	SD10-B	-	-	-	-	-	-	10.5	-	10.5	25.0	10.5	25.0	3.0	21.5
SD10-B	SD10-D	-	-	-	-	-	-	7.8	-	7.8	25.0	18.3	25.0	5.3	32.0
Trunk Storm Drain SD11															
SD11-A	SD11-B	-	-	-	-	-	-	15.2	19.3	34.5	22.2	34.5	22.2	10.6	52.0
SD11-B	SD11-B	-	-	-	-	-	-	-	1.9	1.9	20.0	36.4	21.1	11.4	54.0
Trunk Storm Drain SD12															
SD12-A	SD12-B	-	-	18.2	78.6	-	9.1	-	8.0	113.9	49.5	113.9	49.5	56.9	160.0
SD12-B	SD12-C	-	-	-	-	3.2	-	-	3.7	6.9	29.4	120.8	48.4	63.8	164.0
SD12-C	SD12-C1	-	-	-	-	1.4	-	3.0	-	4.4	29.8	125.2	47.7	68.3	168.0
SD12-D	SD12-E1	-	-	-	-	1.2	-	-	2.0	3.2	27.4	3.2	27.4	0.9	8.0
SD12-E1	SD12-E2	0.6	-	-	-	-	-	-	1.0	1.6	48.0	130.0	47.2	73.2	176.0

Table 6-2. Results from Hydraulic Analysis for Trunk Storm Drains

Conduit	Conduit Type	Upstream Node	Downstream Node	Length, ft	Upstream Invert Elevation, ft[1]	Downstream Invert Elevation, ft[1]	Slope, ft/ft	Manning's n Value	Pipe Diameter, in	Avg. Ditch Bottom Width, ft	Avg. Ditch Depth, ft	Avg. Ditch Side Slope, (H:V)	Est. Inlet or Top of Channel Elev., ft[1]	Est. Low Pad Elev., ft[1]	Upstream Pipe Design hgl, ft[1,2]	Upstream 100-Year hgl, ft[1,2]
Trunk Storm Drain SD1																
SD1-A1Pi	Pipe	SD1-A1	SD1-A	92	153.9	153.8	0.0003	0.024	36	-	-	-	160.5	161.0	158.3	160.1
SD1-ALPi	Pipe	SD1-A	SD1-B	216	153.8	153.8	0.0003	0.024	36	-	-	-	159.7	160.5	158.0	159.9
SD1-BLPi	Pipe	SD1-B	SD1-C	125	153.8	153.4	0.0032	0.024	36	-	-	-	158.3	159.8	157.3	159.1
SD1-A1Rd	Street Surface	SD1-A1	SD1-A	98	159.3	159.4	-0.0015	0.025	-	30	0.5	20:1	160.5	161.0	-	160.1
SD1-ALRd	Street Surface	SD1-A	SD1-B	224	159.4	158.0	0.0063	0.025	-	30	0.5	20:1	159.7	160.5	-	159.9
SD1-BLRd	Street Surface	SD1-B	SD1-C	100	158.0	157.5	0.0050	0.025	-	30	0.5	20:1	158.3	159.8	-	159.1
Trunk Storm Drain SD2																
SD2-Api	Pipe	SD2-A	SD2-B	218	157.9	157.7	0.0012	0.015	18	-	-	-	162.4	162.5	159.0	162.2
SD2-Bpi	Pipe	SD2-B	SD2-C	186	157.7	157.1	0.0028	0.015	18	-	-	-	161.5	162.5	158.7	161.8
SD2-CL	Pipe	SD2-C	SD2-D	219	156.7	156.2	0.0024	0.015	18	-	-	-	161.0	161.5	157.8	160.7
SD2-EL	Ditch	SD2-D	SD2-E	236	156.2	152.0	0.0178	0.030	-	10	2.0	20:1	158.2	158.8	156.4	156.5
SD2-Aolr	Overland	SD2-A	SD2-B	218	158.0	158.8	-0.0037	0.035	-	200	1.0	20:1	n/a	162.5	-	162.2
SD2-Bolr	Street Surface	SD2-B	SD2-C	186	161.1	160.4	0.0035	0.025	-	0	0.5	20:1	n/a	165.5	-	161.8
SD2-CO2	Street Surface	SD2-C	SD2-F	346	160.4	156.7	0.0107	0.025	-	30	0.5	20:1	n/a	161.5	-	160.7
Trunk Storm Drain SD3																
PAB1	Pipe	SD3-A	SD3-B	134	153.2	153.0	0.0017	0.015	18	-	-	-	157.7	157.7	154.5	**158.2**
PBC1	Pipe	SD3-B	SD3-C	167	153.0	152.4	0.0036	0.015	18	-	-	-	155.5	157.4	154.1	157.2
PCD1	Pipe	SD3-C	SD3-D	507	150.5	146.4	0.0081	0.024	24	-	-	-	154.5	154.9	151.6	154.5
PDE1	Pipe	SD3-D	SD3-E	360	146.2	143.3	0.0081	0.024	24	-	-	-	151.5	151.6	147.5	**151.8**
CCD1	Ditch	SD3-C	SD3-D	507	153.0	149.5	0.0069	0.030	-	1.5	2.0	1.7	n/a	154.9	n/a	154.5
CAB1	Overland	SD3-A	SD3-B	134	157.7	156.8	0.0067	0.040	-	25.0	1.0	0.002	n/a	157.7	n/a	**158.2**
CBC1	Overland	SD3-B	SD3-C	157	156.8	155.5	0.0083	0.040	-	25.0	1.0	0.002	n/a	157.4	n/a	157.2
CDE1	Overland	SD3-D	SD3-E	360	151.5	149.0	0.0069	0.040	-	25.0	1.0	0.002	n/a	151.6	n/a	**151.8**
Trunk Storm Drain SD4																
PCA1	Pipe	SD4C	SD4-A	250	148.1	141.3	0.0274	0.015	18	-	-	-	150.5	150.5	148.7	150.5
PAB1	Pipe	SD4-A	SD4-B	168	141.3	140.7	0.0033	0.015	18	-	-	-	147.2	147.2	143.9	147.2
CCA1	Ditch	SD4C	SD4-A	250	149.5	145.5	0.0160	0.035	-	2.0	1.0	3.0	150.5	150.5	n/a	150.5
CAB1	Overland	SD4-A	SD4-B	168	146.9	144.0	0.0173	0.020	-	20.0	-	-	147.2	147.2	n/a	147.2
Trunk Storm Drain SD5																
PAB1	Pipe	SD5-A	SD5-B	365	140.6	136.8	0.0103	0.015	18	-	-	-	146.0	149.3	141.2	147.3
PBC1	Pipe	SD5-B	SD5-C	160	136.6	135.6	0.0065	0.015	24	-	-	-	138.8	139.5	137.4	139.2
PEC1	Pipe	SD5-E	SD5-C	176	136.9	135.6	0.0077	0.028	18	-	-	-	139.6	140.3	138.0	139.8
PCD1	Pipe	SD5-C	SD5-D	73	135.6	135.0	0.0077	0.028	18	-	-	-	139.3	140.3	137.4	139.2
PFG1	Pipe	SD5-F	SD5-G	120	142.2	140.3	0.0158	0.015	12	-	-	-	145.6	145.6	-	**146.0**
CGI1	Ditch	SD5-G	SD5-I	207	140.3	136.1	0.0203	0.040	-	1.5	2.0	1.7:1	139.0	144.9	-	140.7
CID1	Ditch	SD5-I	SD5-D	233	136.1	139.5	-0.0146	0.040	-	1.5	2.0	1.7:1	138.8	139.5	137.0	139.2
PIJ1	Pipe	SD5-I	SD5-J	95	136.1	135.9	0.0020	0.028	24	-	-	-	138.8	139.5	137.0	139.2
PBI1	Pipe	SD5-B	SD5-I	30	136.5	136.1	0.0133	0.015	0.833	-	-	-	138.8	139.5	137.4	139.2
PAF1	Street Flow	SD5-A	SD5-F	50	147.0	145.5	0.0295	0.020	-	0.0	1.0	50:1	146.0	149.3	141.2	147.3
CBC1	Street Flow	SD5-B	SD5-C	160	138.8	137.5	0.0081	0.020	-	0.0	1.0	20:1	138.8	139.5	137.4	139.2
CBI1	Street Flow	SD5-B	SD5-I	35	138.8	138.5	0.0086	0.020	-	10.0	0.5	50:1	138.8	139.5	137.4	139.2
CCD1	Street Flow	SD5-C	SD5-D	73	139.5	138.0	0.0205	0.020	-	0.0	1.0	20:1	139.3	140.3	137.4	139.2
CFH1	Overland	SD5-F	SD5-H	300	145.5	145.3	0.0008	0.020	-	20.0	2.0	-	145.3	145.6	-	**146.0**
OEC1	Street Flow	SD5-E	SD5-C	176	139.3	139	0.0017	0.02	-	0	0.5	50	145.3	145.6	138.0	139.8
Trunk Storm Drain SD6																
SD6-AL	Pipe	SD6-A	SD6-A1	235	160.5	157.5	0.0127	0.015	30	-	-	-	165.8	167.0	162.0	166.6
SD6-A1L	Pipe	SD6-A1	SD-6B	186	157.5	157.0	0.0027	0.015	36	-	-	-	162.6	164.3	159.6	164.1
SD6-BL1	Pipe	SD-6B	SD6C3	472	157.0	154.8	0.0046	0.015	36	-	-	-	163.4	164.3	159.1	164.0
SD6-C1L	Pipe	SD6-C1	SD6-C2	65	157.7	157.5	0.0040	0.015	18	-	-	-	162.2	163.0	158.8	163.0
SD6-C2L.1	Pipe	SD6-C2	SD6C3	127	157.2	156.6	0.0050	0.015	21	-	-	-	162.6	162.9	158.2	162.8
SD6-CL1	Pipe	SD6C3	SD6-D	487	154.8	151.5	0.0069	0.015	42	-	-	-	162.7	162.9	156.8	162.6
SD6-CL.1	Pipe	SD6-D	SD6-D1	384	151.5	149.0	0.0064	0.015	48	-	-	-	156.5	157.2	153.7	155.7
SD6-DL.1	Pipe	SD6-D1	SD6-E	143	149.0	148.1	0.0064	0.015	48	-	-	-	157.3	158.6	151.5	152.7
SD6-EL.1	Pipe	SD6-E	SD6-F	31	148.1	147.9	0.0066	0.015	48	-	-	-	152.2	152.2	150.5	151.5
SD6-OL	Overland	SD6-A	SD6-A1	235	166.2	162.6	0.0153	0.060	-	100.0	0.5	50	165.8	167.0	-	166.6
SD6-A1O	Street Flow	SD6-A1	SD-6B	186	162.6	162.8	-0.0011	0.025	-	0.0	0.5	50	163.0	164.3	-	164.1
SD6-BO.1	Street Flow	SD-6B	SD6C3	472	162.8	162.7	0.0002	0.025	-	0.0	0.5	50	163.4	164.3	-	164.0
SD6-C1O1	Street Flow	SD6-C1	SD6-C2	65	162.5	162.1	0.0055	0.025	-	0.0	0.5	50	162.2	163.0	-	163.0
SD6-C2O	Street Flow	SD6-C2	SD6C3	127	162.0	162.2	-0.0016	0.025	-	0.0	0.5	50	162.6	162.9	-	162.8
SD6-CO1	Street Flow	SD6C3	SD6-D	487	162.3	157.6	0.0097	0.025	-	0.0	0.5	50	162.7	162.9	-	162.6
SD6-DO	Street Flow	SD6-D	SD6-D1	384	157.6	157.9	-0.0008	0.025	-	0.0	0.5	50	156.5	157.2	-	-
SD6-DO.1	Street Flow	SD6-D1	SD6-E	143	157.9	152.2	0.0399	0.035	-	20.0	0.2	10	157.3	158.6	-	-
SD6-BO.2	Overland	SD6C3	OL1	635	162.2	156.7	0.0087	0.060	-	50.0	0.5	38	162.7	162.9	-	162.6
SD6-CO.2	Street Flow	SD6-D	OL1	375	157.6	156.7	0.0024	0.025	-	0.0	0.5	50	156.5	157.2	-	-
OL1-O	Street Flow	OL1	Out_OL	910	156.7	146.2	0.0115	0.025	-	0.0	0.5	50	156.5	157.5	-	157.2
Trunk Storm Drain SD7																
SD7-AL	Pipe	SD7-A	SD7-B	472	167.7	163.3	0.0093	0.015	24	-	-	-	175.2	176.2	168.3	175.6
SD7-BL	Pipe	SD7-B	SD7-D	209	163.3	161.7	0.0075	0.015	24	-	-	-	172.8	174.2	164.0	172.4
SD7-CL	Pipe	SD7-C	SD7-D	425	165.4	161.7	0.0085	0.015	18	-	-	-	174.3	174.3	165.7	170.6
SD7-DL	Pipe	SD7-D	SD7-E	557	161.7	154.4	0.0131	0.015	24	-	-	-	167.8	168.8	162.9	168.8
SD7-EL	Pipe	SD7-E	SD7-F	573	154.4	153.7	0.0014	0.015	30	-	-	-	161.0	162.4	156.7	162.2
SD7-FL	Pipe	SD7-F	SD7-G	251	153.7	151.2	0.0098	0.024	30	-	-	-	156.5	158.4	155.9	158.3
SD7-GL	Pipe	SD7-G	SD7-H	96	151.2	151.1	0.0010	0.015	36	-	-	-	156.4	157.4	154.2	157.2
SD7-HL	Pipe	SD7-H	SD7-I	14	151.1	151.1	0.0010	0.015	36	-	-	-	156.5	157.5	154.1	154.8
SD7-AO.1	Street Flow	SD7-A	SD7-B	472	175.4	174.0	0.0030	0.025	-	0.0	0.5	50:1	175.2	176.2	-	175.6
SD7-DO.1	Street Flow	SD7-D	SD7-E	557	168.5	162.3	0.0111	0.025	-	0.0	0.5	50:1	167.8	168.8	-	168.8
SD7-DO.2	Ditch	SD7-D	SD7-E	557	168.0	161.7	0.0113	0.040	-	1.0	0.5	2:1	167.8	168.8	-	168.8
SD7-DO.3	Ditch	SD7-D	SD7-E	557	168.0	161.7	0.0113	0.040	-	1.0	0.5	2:1	167.8	168.8	-	168.8
SD7-EO.1	Street Flow	SD7-E	SD7-F	573	161.6	157.2	0.0077	0.025	-	0.0	0.5	50:1	161.0	162.4	-	162.2
SD7-FO.1	Street Flow	SD7-F	SD7-G	241	157.3	157.2	0.0004	0.025	-	0.0	1.0	50:1	156.5	158.4	-	158.3
Trunk Storm Drain SD8																
PAC1	Pipe	SD8-A	SD8-C	134	150.4	148.3	0.0154	0.015	12	-	-	-	154.0	154.0	150.9	153.8
PBC1	Pipe	SD8-B	SD8-C	428	148.2	147.8	0.0008	0.015	15	-	-	-	154.7	155.6	152.5	155.0
PCD1	Pipe	SD8-C	SD8-D	83	147.2	146.5	0.0088	0.015	24	-	-	-	152.5	152.5	148.1	148.5
PDE1	Pipe	SD8-D	SD8-E	110	146.5	146.1	0.0035	0.015	24	-	-	-	150.1	150.1	147.6	148.1
PEF1	Pipe	SD8-E	SD8-F	55	145.9	145.7	0.0035	0.015	27	-	-	-	149.4	149.5	147.2	147.6
Trunk Storm Drain SD10																
PAB1	Pipe	SD10-A	SD10-B	163.0	149.5	147.8	0.0100	0.015	18	-	-	-	155.1	155.5	151.6	154.7
PBC1	Pipe	SD10-B	SD10-C	212.0	147.8	147.1	0.0035	0.015	18	-	-	-	153.2	154.2	151.4	153.4
PCD1	Pipe	SD10-C	SD10-D	40.0	147.1	147.0	0.0030	0.015	18	-	-	-	151.1	151.2	150.7	**151.9[3]**
CAB1	Street Flow	SD10-A	SD10-B	163.0	154.5	153.0	0.0092	0.020	-	0.0	1.0	50:1	155.1	155.5	-	154.7
CBC1	Street Flow	SD10-B	SD10-C	212.0	153.0	151.0	0.0094	0.020	-	0.0	1.0	50:1	153.2	154.2	-	153.4
CCD1	Street Flow	SD10-C	SD10-D	40.0	151.0	150.0	0.0250	0.020	-	0.0	1.0	50:1	151.1	151.2	-	**151.9[3]**
CAE1	Street Flow	SD10-A	SD10-E	310.0	154.5	149.1	0.0174	0.020	-	0.0	1.0	50:1	155.1	155.5	-	154.7
Trunk Storm Drain SD11																
PAB1	Pipe	SD11-A	SD11-B	139	153.9	153.3	0.0043	0.015	18	-	-	-	158.2	160.0	157.3	158.5
CBC1	Ditch	SD11-B	SD11-C	114	153.3	152.8	0.0044	0.040	-	1.5	1.0	0.333	157.3	157.7	155.4	156.3
CAB1	Street Flow	SD11-A	SD11-B	139	158.0	156.0	0.0144	0.040	-	0.0	0.5	50	158.2	160.0	-	158.5
CBC2	Street Flow	SD11-B	SD11-C	114	155.8	154.7	0.0096	0.020	-	0.0	1.0	50	157.3	157.7	-	156.3
Trunk Storm Drain SD12																
SD12-AL	Pipe	SD12-A	SD12-B	276	150.8	149.7	0.0040	0.015	54	-	-	-	162.3	162.3	154.5	161.1
SD12-BL	Pipe	SD12-B	SD12-C	278	149.7	149.1	0.0020	0.015	54	-	-	-	157.3	160.0	154.3	158.7
SD12-CL	Pipe	SD12-C	SD12-C1	114	149.1	148.5	0.0056	0.015	54	-	-	-	157.4	159.8	153.9	157.2
SD12-C1L	Pipe	SD12-C1	SD12-C2	26	148.5	146.5	0.0788	0.015	48	-	-	-	155.4	159.8	153.7	156.1
SD12-C2L	Pipe	SD12-C2	SD12-E1	318	148.2	147.3	0.0028	0.015	48	-	-	-	155.4	162.2	153.7	156.0
SD12-EL	Pipe	SD12-D	SD12-E1	40	147.6	147.3	0.0075	0.015	48	-	-	-	154.5	155.0	152.7	**155.5[3]**
SD12-E1L	Pipe	SD12-E1	SD12-E2	210	147.3	146.7	0.0030	0.015	60	-	-	-	154.5	155.0	152.7	**155.5[3]**
SD12-BO	Street Flow	SD12-B	SD12-C	278	157.3	157.4	-0.0004	0.02	-	0	0.5	50:1	157.3	160.0	-	158.7
SD12-CO	Street Flow	SD12-C	SD12-C1	114	157.4	155.1	0.0202	0.02	-	0	0.5	50:1	157.4	159.8	-	157.2
SD12-C1O	Street Flow	SD12-C1	SD12-C2	26	155.2	155.1	0.0038	0.02	-	0	0.5	50:1	155.4	159.8	-	156.1
SD12-C2O	Street Flow	SD12-C2	SD12-E1	318	155.1	153.7	0.0044	0.02	-	0	0.5	50:1	155.4	162.2	-	156.0
SD12-E1O	Street Flow	SD12-E1	SD12-E2	210	154.8	153.5	0.0062	0.02	-	0	0.5	50:1	154.5	155.0	-	**155.5[3]**

1. All elevations are based on the North American Vertical Datum 1988.
2. Hgl values with red and bold text indicate that the performance criteria is not met at that location.
3. The problem indicated at this location is the result of high water in the creek at the downstream end of the pipe system rather than a lack of pipe or overland flow capacity.

6.4 RESULTS FROM THE ANALYSIS OF EXISTING PIPES

Calculated water surface elevations along the pipe systems are presented in Table 6-2. These water surface elevations were used to determine whether the pipe systems have adequate capacity based on the following criteria:

- The pipe design hydraulic grade line (hgl) should be below the inlet grate elevation
- The 100-year hgl should be below the lowest adjacent pad elevation

At those locations where the calculated water surface (i.e., the hgl) does not meet the capacity criteria above, the water surface elevation is highlighted in Table 6-2 with a bold red font. As Table 6-2 shows, each of the pipe systems meets the criterion for the pipe system design flow. However, there are four pipe systems (SD3, SD5, SD10, and SD12) where the 100-year overland release criterion is not met. At two of these locations, SD10 and SD12, the problems are caused by high water in Mariposa Creek and Cripple Creek at the downstream end of the pipes rather than a lack of pipe system capacity or overland flow capacity. Therefore, these two potential flooding problems cannot be solved without developing a solution to reduce the water surface elevations in the creeks, which is beyond the scope of this study.

The other two pipe systems, SD3 and SD5, appear to have potential 100-year flooding issues due to insufficient overland flow capacity along the systems. For trunk pipe SD3, one potential flooding problem is located near the upstream end of the trunk pipe where it travels through the side yards of some residential lots between Colony Way and Baird Way. The pipe follows low ground and during a large storm that exceeds the capacity of the pipe system, excess flow will travel through the lots. At least one building pad located along this overland flow path appears to be at-risk of flooding during a 100-year storm event. In addition, along Baird Way, many of the lots along the south side of the road are lower than the road itself. During a large storm event that exceeds the capacity of the pipe system and the existing ditch on the north side of the road, some of these lots are at risk of flooding.

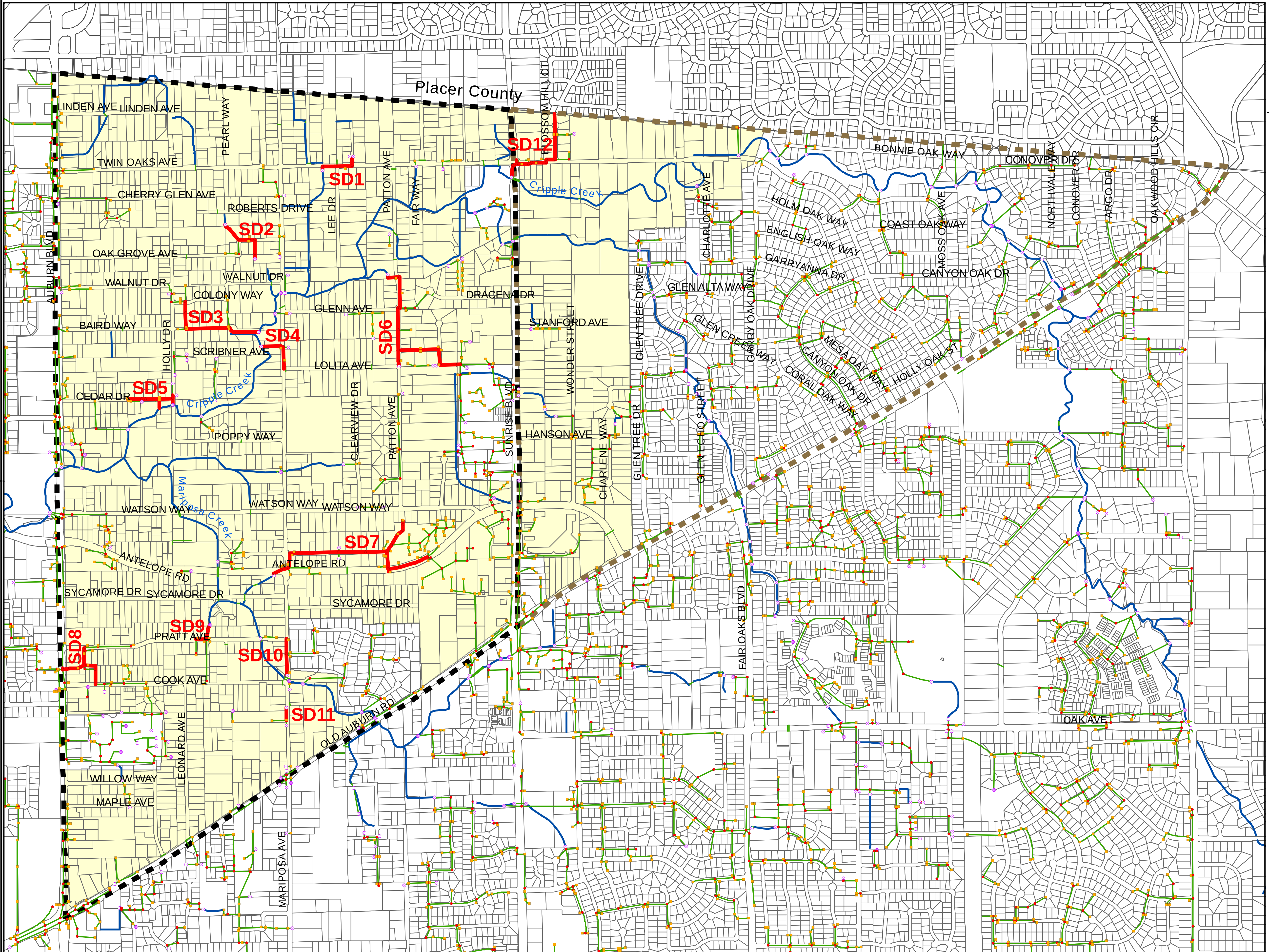
Trunk pipe SD5 is located on Cedar Drive. Near the upstream end of this pipe, the lots on the south side of the road are lower than the road itself. During a large storm event that exceeds the capacity of the pipe system, excess flow will spill across the road from north to south resulting in potential flooding of some lots on the south side of the road. A supplemental drainage system has been constructed on the south side of the road consisting of additional inlets, an 8-inch culvert, and a ditch. This supplemental system provides some level of protection against flooding during some storm events that exceed the capacity of the pipe SD5, but it does not eliminate the risk of flooding during a 100-year storm event.

Based on the results of the trunk pipe modeling, the potential flooding problems identified along pipes SD3 and SD5 were added to the list of problems that were evaluated as a part of this study. The evaluations of potential solutions to solve these problems are described in Chapter 7. In that chapter, the problems along trunk systems SD3 and SD5 are included as Problems 20 and 21, respectively.

FIGURE 6-1

City of Citrus Heights
Neighborhoods 6 and 7
Drainage Master Plan Study

TRUNK PIPES



N

0 550 1,100
Scale in Feet

LEGEND

- Inlet
- Outfall
- Manhole
- Trunk Pipe with ID
- Drainage Pipe
- Stream or Channel
- Neighborhood 6
- Neighborhood 7
- Detailed Study Area

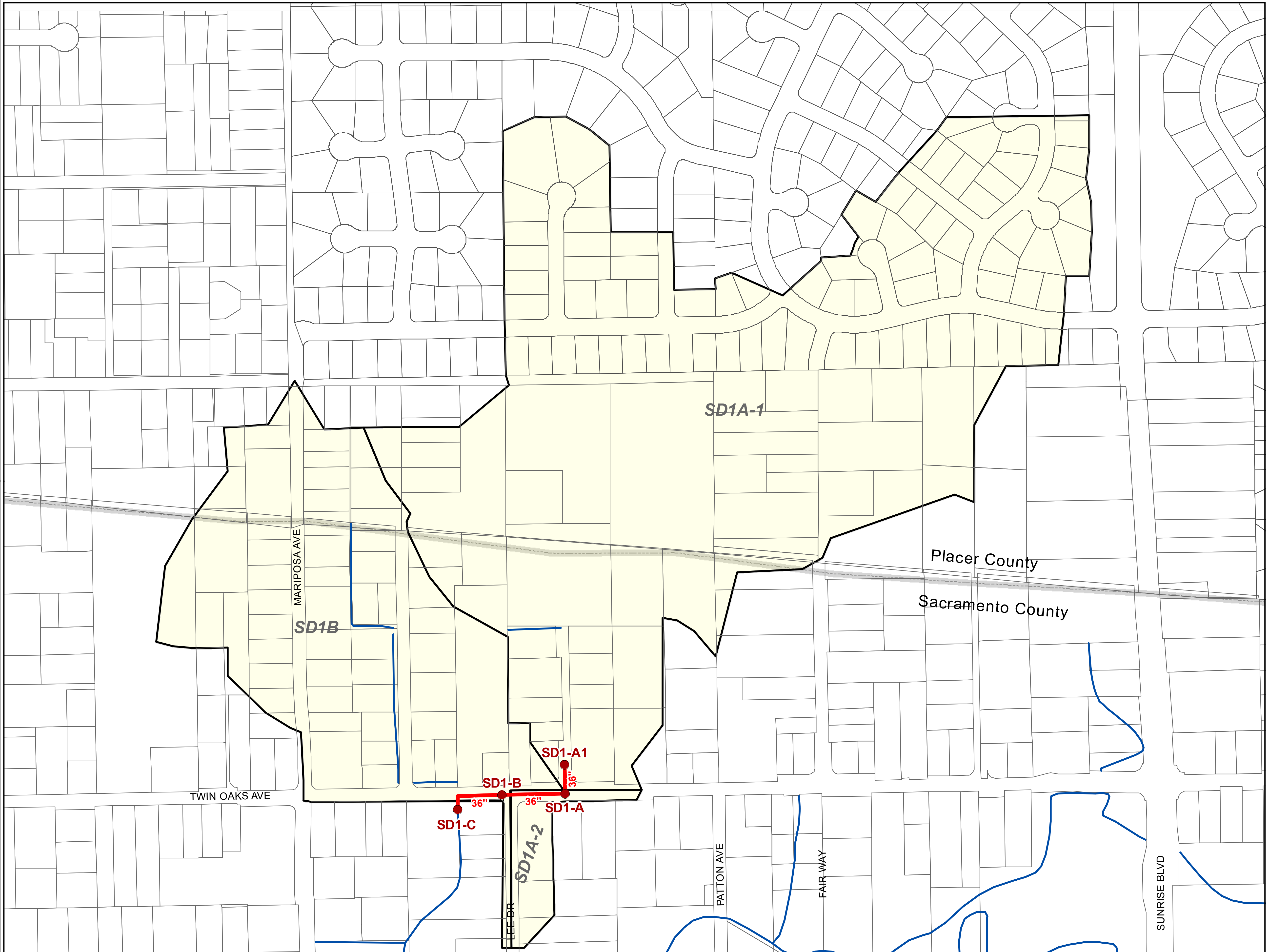
CITY OF CITRUS HEIGHTS JANUARY 1, 1997

WEST YOST ASSOCIATES
Consulting Engineers

FIGURE 6-2

City of Citrus Heights
Neighborhoods 6 and 7
Drainage Master Plan Study

TRUNK PIPE SD1 SUBSHEDS AND MODELED FACILITIES



LEGEND

- Modeled Node
- Modeled Trunk Pipe
- Stream or Channel
- Trunk Pipe SD1 Subshed
- County Boundary

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N:\Clients\396 City of Citrus Heights\00-10-01 Auburn Sunrise Storm Drainage MPS\GIS\Figures\Fig6-3_Modeled_Trunk_Pipes_SD2_3_4_5.mxd 8/29/2011

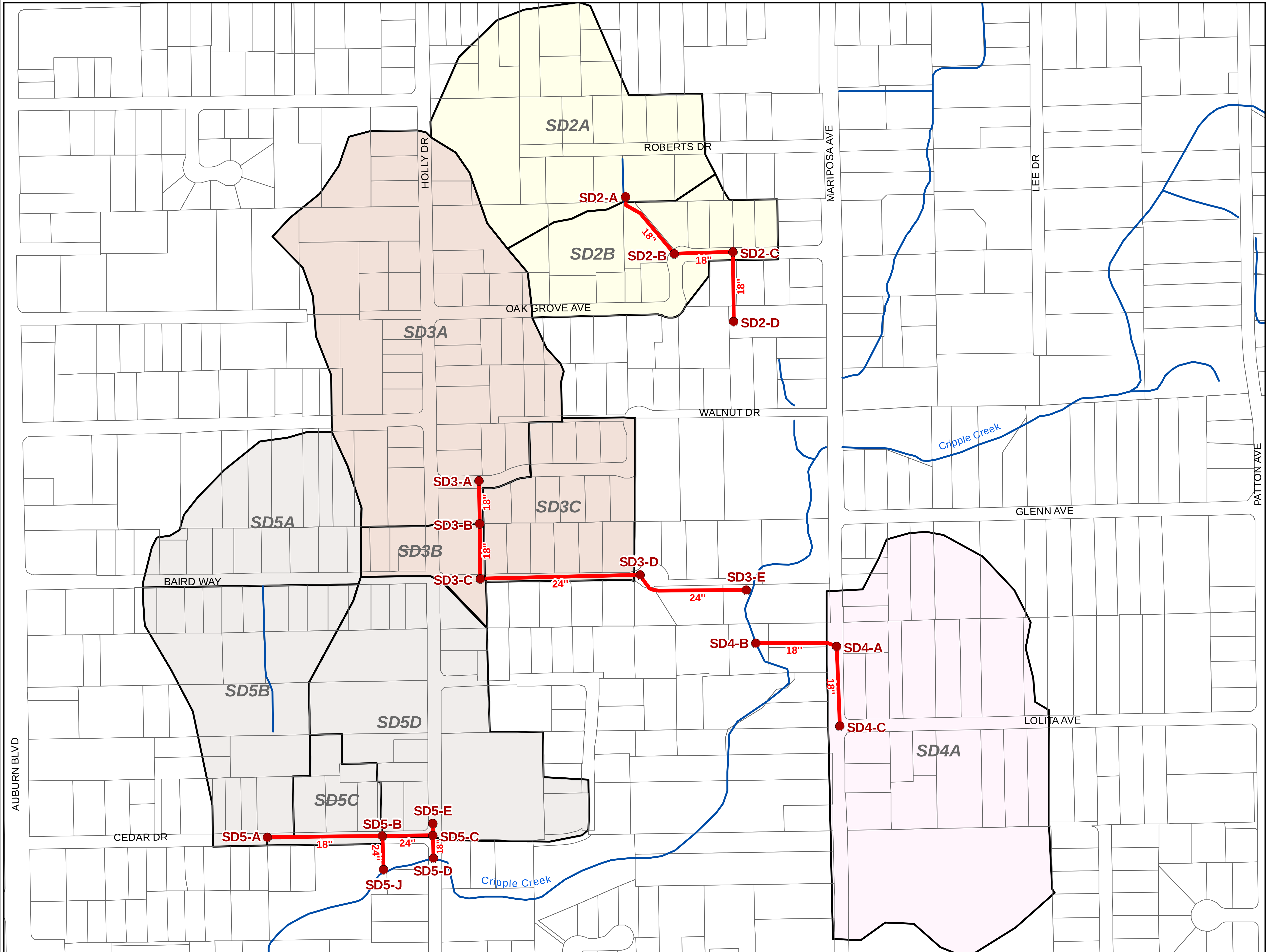


FIGURE 6-3

City of Citrus Heights
Neighborhoods 6 and 7
Drainage Master Plan Study

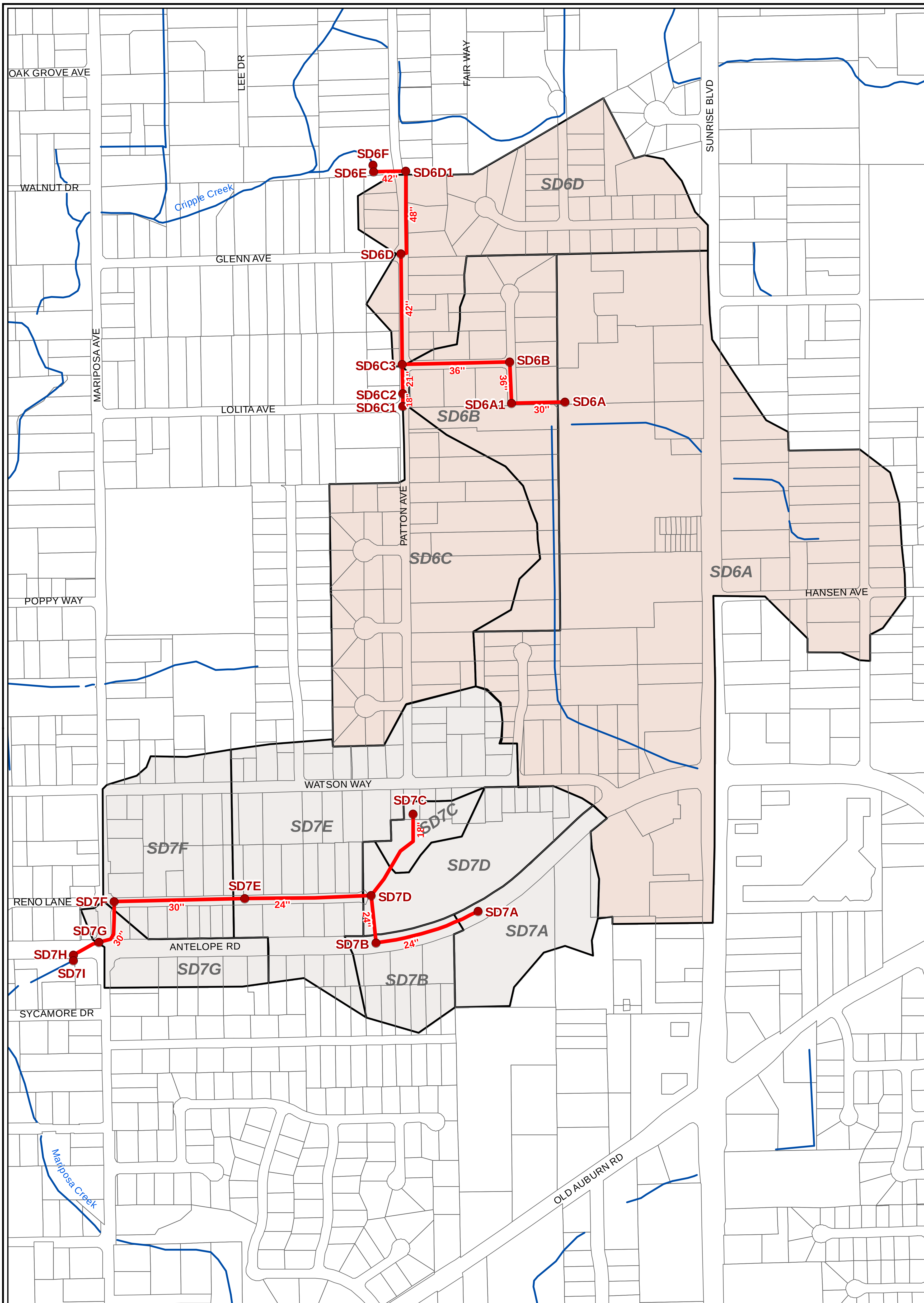
TRUNK PIPE SD2, SD3, SD4, and SD5 SUBSHEDS AND MODELED FACILITIES

N

0 150 300
Scale in Feet

LEGEND

- Modeled Node
- Modeled Trunk Pipe
- Stream or Channel
- Trunk Pipe SD2 Subshed
- Trunk Pipe SD3 Subshed
- Trunk Pipe SD4 Subshed
- Trunk Pipe SD5 Subshed



LEGEND

- Modeled Node
- Modeled Trunk Pipe
- Stream or Channel
- Trunk Pipe SD6 Subshed
- Trunk Pipe SD7 Subshed

0 200 400
Scale in Feet

FIGURE 6-4
City of Citrus Heights
Neighborhoods 6 and 7
Drainage Master Plan Study

TRUNK PIPES SD6 and SD7
SUBSHEDS AND MODELED FACILITIES

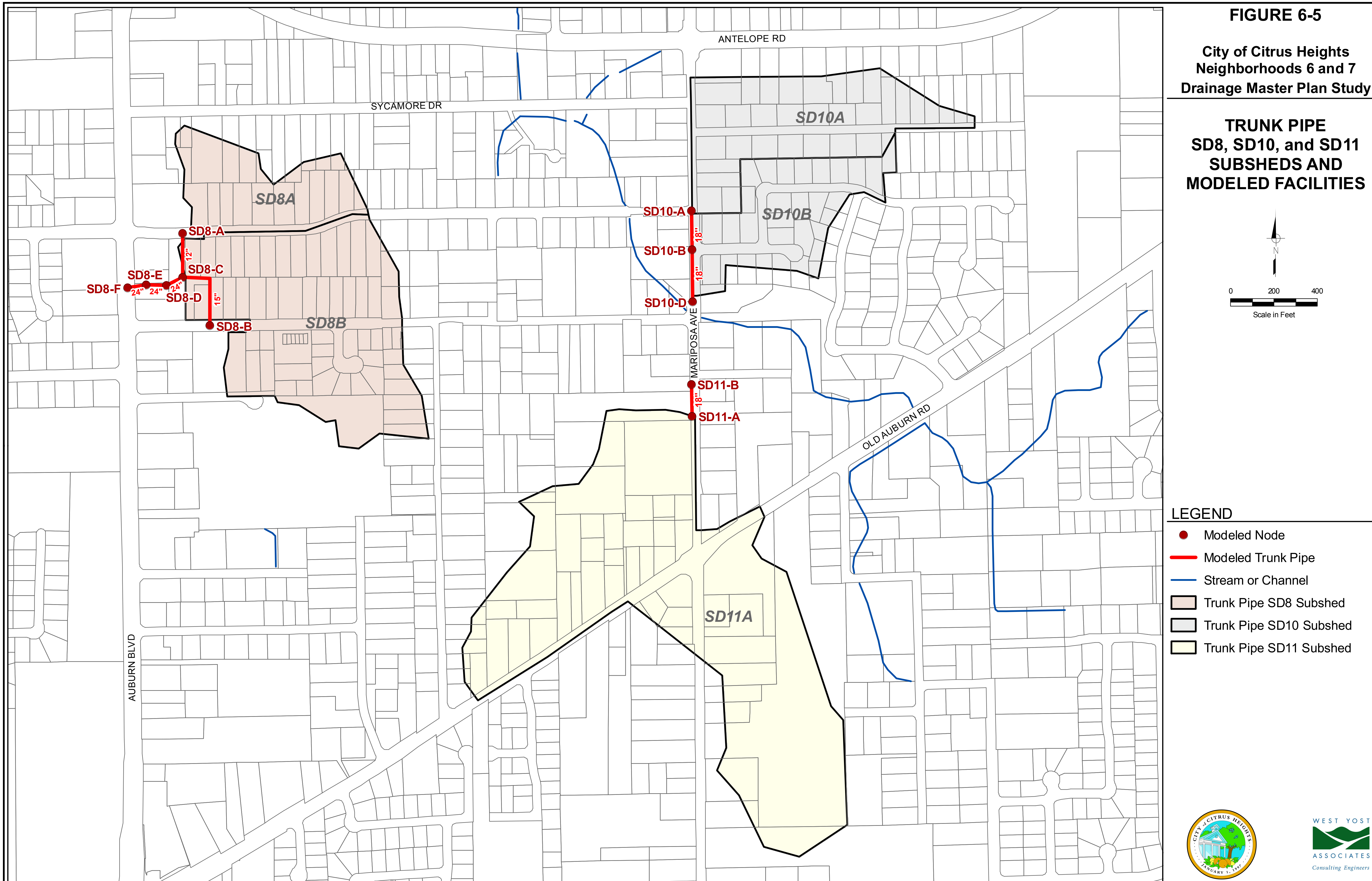
WEST YOST ASSOCIATES
Consulting Engineers

N:\Clients\396 City of Citrus Heights\00-10-01 Auburn Sunrise Storm Drainage MP\GIS\Figures\Fig6-4_Modeled_Trunk_Pipes_SD6_7.mxd 10/18/2011

FIGURE 6-5

City of Citrus Heights
Neighborhoods 6 and 7
Drainage Master Plan Study

TRUNK PIPE SD8, SD10, and SD11 SUBSHEDS AND MODELED FACILITIES



N:\Clients\396 City of Citrus Heights\00-10-01 Auburn Sunrise Storm Drainage MPS\GIS\Figures\Fig6.6_Modeled_Trunk_Pipes_SD12.mxd 7/28/2011

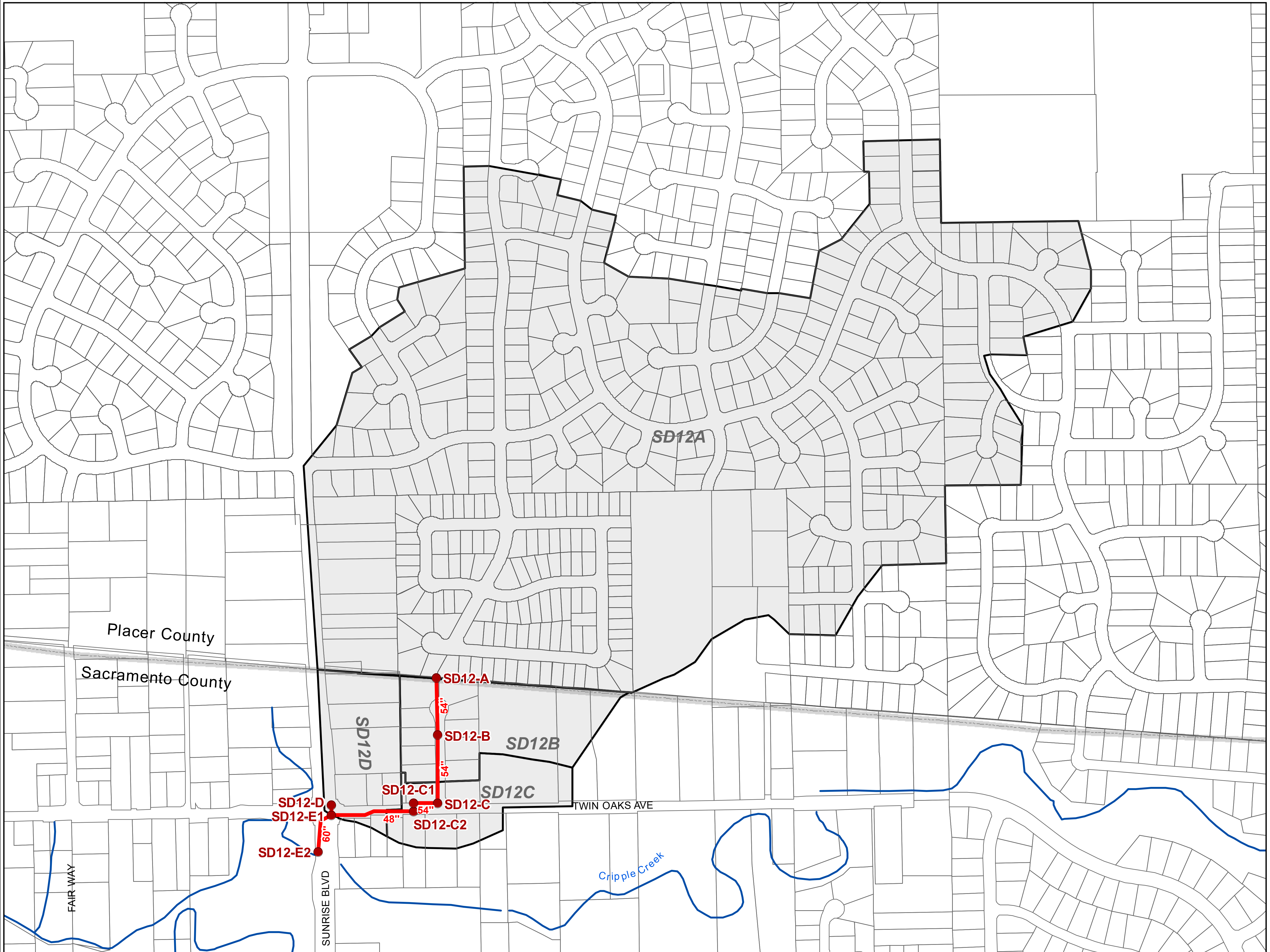


FIGURE 6-6

City of Citrus Heights
Neighborhoods 6 and 7
Drainage Master Plan Study

TRUNK PIPE SD12 SUBSHEDS AND MODELED FACILITIES

N

0 200 400
Scale in Feet

LEGEND

- Modeled Node
- Modeled Trunk Pipe
- Stream or Channel
- Trunk Pipe SD12 Subshed
- County Boundary

WEST YOST ASSOCIATES
Consulting Engineers

CHAPTER 7
Analysis of Problem Locations

7.1 INTRODUCTION

One of the key objectives of this study was to identify significant drainage and flooding problems in the study area and to develop solutions to reduce or eliminate the problems. The problem locations were identified from the following activities:

- Existing Trunk Pipe Analyses – As discussed in Chapter 6, hydraulic analyses were performed for the existing trunk pipe systems within the detailed study area. Problems were identified along two of the eleven trunk pipe systems that were analyzed.
- Review of Service Call Records – As discussed in Chapter 2, City staff provided service call records that document problems reported by residents during prior storm events. These records were reviewed to determine potential problem locations.
- Input from City Staff – City staff have significant knowledge of the drainage issues in the study area based on prior discussions with residents and visual observations during storm events. West Yost met with City staff at the outset of the project to obtain input on known problem locations.
- Input from Public – A public meeting was held on January 19, 2011 to solicit input from the public on potential flooding and drainage problems in the area. Descriptions of potential problems were provided by the residents both orally and in writing. As discussed in Chapter 2, a summary table was prepared after the meeting that provides descriptions of each problem, the location of the problem, the name and address of the resident that reported the problem, and a problem category (i.e. flooding, drainage system, maintenance). This summary table was provided in Table 2-3. A follow-up meeting was held with the public on July 20, 2011. At this meeting, the public was provided a status report and a description of preliminary solutions that had been developed for the problems. Some new problems were identified at that meeting. In addition, a few problems were identified when residents contacted City staff by phone.

Based on the above activities, a total of 26 flooding and drainage problems were identified for evaluation. The general locations of the problems are shown on Figure 7-1. Relatively complex problems were assessed using hydrologic and hydraulic modeling. Less complex problems were evaluated with spreadsheet calculations or normal depth analyses. For the simplest problems with relatively straightforward solutions, City staff directed that only qualitative analyses be performed. For those problems, general solutions were recommended without engineering calculations being performed.

For all problem areas where modeling or other hydraulic calculations were performed, pipe and channel sizes, depths, and inverts were estimated from limited field measurements, LiDAR topographic data, and photographs. Pad elevations used to determine flooding thresholds were also estimated from LiDAR topographic data. As a result, for the hydraulic calculations are considered approximate. They are considered adequate for planning purposes, but field surveying will be necessary prior to the final planning and design of recommended improvements. The hydraulic calculations for the problem evaluations are provided in Appendix A.

Each flooding and drainage problem area is described in a section below along with descriptions of the evaluation performed and the recommended solution. In some cases, multiple problems were grouped together for evaluation due to their close proximity to one another. Therefore, some of the sections below include discussions of more than one problem.

7.2 PROBLEM LOCATION 1

7.2.1 Description of Problem Location 1

Problem Location 1 is located in the northwest corner of the study area along Linden Avenue (see Figure 7-2). The key drainage feature in this area is a channel that begins on the north side of Twin Oaks Drive east of Holly Drive. This channel conveys runoff generally to the north before entering an underground pipe near Linden Avenue. The pipe conveys runoff north under Linden Avenue and then discharges into a channel near the Placer County line. The channel conveys runoff to the west along the county line for about 700 feet. For this reach of the channel, approximately one third of it is located within Placer County. After following the county line, the channel turns south and continues to Linden Avenue where it crosses the road and generally continues southwest before entering a pipe system in Auburn Boulevard.

The pipe and channel system near the first (eastern) crossing of Linden Avenue does not have sufficient capacity to convey significant storm flows and the flooding of homes and property has been reported along Linden Avenue. In addition, the short reach of the channel that crosses into Placer County has restricted capacity due to blockages along the channel, especially where it crosses under fence lines at property boundaries. These restrictions may exacerbate the flooding upstream.

7.2.2 Proposed Solution for Problem Location 1

Solutions for Problem Location 1 were evaluated with a XP-SWMM hydraulic model. The model was used to evaluate existing conditions for pipe design storm event and the 100-year storm event. Model results confirm that the existing system lacks capacity for large storm events and that significant flooding would occur during the 100-year storm. Based on input from the City and nearby residents, a solution was developed to eliminate the potential flooding.

The proposed solution is shown on Figure 7-3. The solution includes a diversion structure at the eastern crossing of Linden Avenue. The diversion structure will allow flows from small storm events to continue along the existing open channel system downstream. This will allow the infiltration and stormwater quality treatment benefits that occur along the existing channel to be realized during frequent storm events that do not cause flooding problems. In moderate and large storms, excess flows will be diverted over a weir into a new 24-inch pipe that will be constructed along Linden Avenue. The new pipe will convey large flows west along Linden Avenue for approximately 740 feet to the location where the existing open channel crosses Linden Avenue from north to south. At that location, additional runoff will be diverted into the new pipe and the size of the pipe will increase to 42 inches. The new pipe will continue along Linden Avenue for another 715 feet to Auburn Boulevard. At Auburn Boulevard the new 42-inch pipe will turn south and continue for approximately 520 feet, replacing an existing 18-inch pipe in Auburn Boulevard. At the second (western) crossing of Linden Avenue, low flows will be allowed to continue to the south along the existing channel while large flows will be directed into the new pipe along Linden Avenue.

An additional component of the proposed solution is a new, parallel channel that will be constructed along the reach of channel that is located within Placer County. The new reach of channel will be constructed within the City limits and will eliminate reliance on the capacity of the channel within Placer County for which the City has no control. It is assumed that the parallel channel will be the same size as the existing channel, which is approximately 3 feet deep, has a bottom width of 3 feet, and side slopes of 1.5 to 1 (horizontal to vertical). As planning and design of this project moves forward, consideration should be given to creating a more naturalized channel along this alignment to improve the natural functions of the channel. The possibility of extending the natural channel restoration downstream to Linden Avenue should also be considered.

7.3 PROBLEM LOCATIONS 2, 3, AND 11

7.3.1 Description of Problem Location 2

A 36-inch trunk pipe discharges runoff into a drainage ditch that begins on the south side of Twin Oaks Drive just east of Mariposa Avenue. The ditch conveys runoff south along the sides and through the backs of residential lots. The ditch represents a maintenance problem for the City and is also a potential flooding problem (see Figure 7-4).

7.3.2 Description of Problem Location 3

A trunk pipe in Oak Grove Avenue discharges into a ditch that conveys runoff south through residential lots. The ditch has been the source of a number of flooding complaints from residents (see Figure 7-4).

7.3.3 Description of Problem Location 11

At the downstream end of the ditch that is the subject of Problem Location 2, a 24-inch pipe discharges runoff under Jessie Avenue and into another ditch on the south side of the road. The 24-inch pipe is undersized and causes flooding of the property at the upstream end of the pipe (see Figure 7-4).

7.3.4 Proposed Solution for Problem Locations 2, 3, and 11

Solutions for Problem Locations 2, 3, and 11 were evaluated with a XP-SWMM hydraulic model. The proposed solution is shown on Figure 7-5. The solution includes a diversion structure constructed near the outfall of the 36-inch pipe in Twin Oaks Drive. The diversion structure will direct low flows to the existing open channel system downstream. This will allow the infiltration and stormwater quality treatment benefits that occur along the existing channel to be realized during frequent storm events that do not pose a flood risk. In large storms, excess flows will be diverted over a weir at the diversion structure into a new 42-inch pipe that will be constructed along Twin Oaks Drive. The new pipe will convey large flows west along Twin Oaks Drive for approximately 480 feet to Mariposa Avenue. The pipe will continue south along Mariposa Avenue for approximately 1,250 feet where it will tie into an existing 42-inch pipe that continues south to Cripple Creek. This diversion will address Problem Location 2.

Even with the diversion of large flows out of the channel, it will be necessary to enlarge the pipe at the downstream end of the channel at Jessie Avenue to prevent flooding at that location (Problem Location 11). The existing 24-inch pipe will be replaced with a 42-inch pipe that will convey runoff to the new pipe in Mariposa Avenue. The size of this pipe was determined based on the capacity required to prevent pad flooding at the residential lots along Jessie Avenue just upstream of the existing 24-inch pipe.

The new pipe in Mariposa Avenue also provides an opportunity to solve Problem Location 3 by extending an 18-inch pipe in Oak Grove Avenue to the new pipe in Mariposa Avenue. The existing pipe that extends south from Oak Grove Avenue will be plugged.

This solution also includes some additional minor drainage improvements along Mariposa Avenue. A short section of curb and gutter is recommended along the west side of the road, just south of Roberts Drive. In addition, a short section of roadside ditch of the west side of Mariposa Avenue will be replaced with a perforated 8-inch pipe backfilled with aggregate base rock. Local runoff that flows to the ditch location will infiltrate through the aggregate rock and into the perforated pipe, which will convey runoff to an inlet or junction box at the end of the existing ditch. From that point, runoff will be conveyed to the new pipe in Mariposa Avenue. A cross section detail of the proposed ditch replacement concept is presented on Figure 7-25.

7.4 PROBLEM LOCATIONS 4 AND 21

7.4.1 Description of Problem Location 4

A ditch flows from north to south through residential lots on the north side of Cedar Drive. This ditch has been the source of flooding complaints at a residence along Cedar Drive. The location of this problem is shown on Figure 7-6.

7.4.2 Description of Problem Location 21

As discussed in Chapter 6, a trunk pipe conveys runoff along Cedar Drive (Trunk Pipe SD5). This pipe has capacity for the pipe design flows, but during larger storms, overland flow does not have an adequate flow path and flooding may occur at two lots on the south side of Cedar Drive (See Figure 7-6).

7.4.3 Proposed Solution for Problem Locations 4 and 21

Solutions for Problem Locations 4 and 21 were evaluated with a XP-SWMM hydraulic model. For Problem Location 4, one option to solve the problem would be to create a larger ditch along the current alignment, which is along the side yard of a residential lot. However, there is limited space along the side yard that may prevent the ditch from being enlarged enough to achieve the desired capacity. The 100-year peak flow at this location is 26 cfs. To convey this flow would require a trapezoidal ditch with a top width of approximately 6 feet, which may exceed the available space. A pipe could be constructed along the alignment to supplement the capacity of the ditch. Construction of a 15-inch pipe along the side yard would allow the top width of the ditch to be reduced to about 4 feet, which may fit in the available space. For this study, it is recommended that a 15-inch pipe be constructed and the ditch along the side yard be re-graded (See Figure 7-7). However, this recommendation is based on topographic data with limited accuracy. Therefore, at the time the improvements are designed, it is recommended that a detailed survey be performed to better define the ground elevations along the alignment of the pipe/ditch and to define other constraints. If a ditch can be constructed without the pipe, this may be preferable.

For Problem Location 21, it is recommended that the 8-inch drain pipe located along the south side of the road be replaced with a 15-inch pipe (See Figure 7-7). Again, this recommendation should be revisited when the pipe is designed. A more detailed survey should be performed to better define the elevation at which flooding would occur and to define the elevations along the alignment to insure that the proposed pipe can be constructed with adequate cover and that the pipe will provide the appropriate flood protection.

7.5 PROBLEM LOCATIONS 5, 6, 7, 17, 22 AND 24

Problem Locations 5, 6, 7, 17, 22 and 24 are shown on Figure 7-8 and are described below.

7.5.1 Description of Problem Location 5

There is a trunk pipe system in Patton Way (Trunk Pipe SD6). This pipe system has adequate capacity, but it lacks an adequate collection system to deliver runoff into the pipe system. This results in minor road flooding.

7.5.2 Description of Problem Location 6

A number of complaints have been logged from residents on Glenn Avenue related to inadequacies of the existing pipe and roadside ditch system.

7.5.3 Description of Problem Location 7

On Patton Avenue just south of Lolita Avenue, runoff is discharged from a pipe system into a roadside ditch and then back into a pipe system approximately 350 feet downstream. The ditch in this area is deep and is a potential hazard. Erosion along the ditch is also a problem.

7.5.4 Description of Problem Location 17

The storm drain at the west end of Glenn Avenue consists of an 18-inch pipe that connects to a 12-inch outfall to Cripple Creek. The 12-inch pipe has inadequate capacity and needs to be upsized.

7.5.5 Description of Problem Location 22

An inlet located along Patton Avenue has a relatively large side-opening that collects runoff from a road side ditch. The large opening may represent a safety hazard.

7.5.6 Description of Problem Location 24

Frequent ponding occurs in a residential lot on the north side of Loleta Avenue. Runoff also passes through the lot and into another lot to the north causing additional property flooding.

7.5.7 Proposed Solution for Problem Locations 5, 6, 7, 17, 22, and 24

The proposed solution for this set of problems is shown on Figure 7-9. Problem Location 5 will be solved by adding new inlets along Patton Avenue at strategic locations including the intersections with Glenn Avenue, Shareen Way, and Lolita Avenue. South of Lolita Avenue, a new 18-inch pipe is proposed to connect between the existing pipe segments in Patton Avenue. Along this new reach of pipe, the existing ditch of the east side of Patton will be replaced with a perforated 12-inch pipe backfilled with aggregate base rock. Local runoff that flows to the ditch location will infiltrate through the aggregate rock and into the perforated pipe, which will convey runoff to the intersection of Lolita Avenue and into the existing pipe system in Patton Road. A cross section detail of the proposed ditch replacement concept is presented on Figure 7-25. These improvements will solve Problem Locations 5 and 7.

In addition, a 15-inch pipe will be constructed along the side yard of a lot on Lolita Avenue just west of Patton Avenue. This pipe will replace a collapsed reach of pipe along the existing flow path in this area. The pipe will connect to an existing 15-inch pipe at the lot to the north, which continues north to Glenn Avenue. Because the path of this pipe follows low ground, this will also be the path for overland flow during a large storm event that exceeds the capacity of the pipe. If possible, a small ditch should be constructed along this route to convey the overland flows.

Upon reaching Glenn Avenue, the existing 15-inch pipe connects to a 12-inch pipe that conveys runoff to the west and discharges into a ditch. This connection to the 12-inch pipe will be eliminated and a new 15-inch pipe will be constructed along Glenn Avenue. This new pipe will convey runoff to the west for approximately 430 feet where it will turn north and continue for another 270 feet before discharging into Cripple Creek. This new outfall pipe to the creek will require access through private property. If obtaining this access is problematic, an alternative would be to continue the pipe to the west along Glenn Avenue and connecting to the existing pipe system near Mariposa Avenue. This alternative route would require approximately 300 feet of additional 15-inch pipe. In addition, a deep section of roadside ditch along the south side of Glenn Avenue will be replaced with a perforated 12-inch pipe backfilled with aggregate base rock, similar to the ditch replacement on Patton Avenue. These improvements would address Problem Location 6.

Problem Location 17, at the intersection of Glenn Avenue and Mariposa Avenue, will be addressed by replacing the existing 12-inch outfall pipe with a new 18-inch outfall pipe.

Problem Location 22 will be solved by retrofitting the inlet with a rebar grate to limit access to the inlet.

Problem 24 will be solved by construction of a new 12-inch pipe in Loleta Avenue that will convey runoff west to an existing 18-inch trunk pipe in Mariposa Lane. It may be necessary to grade or re-grade roadside ditches to efficiently convey runoff to the new inlets that will collect runoff along Loleta Avenue. The need for ditch grading will be determined when better topographic mapping is available at the time of design.

7.6 PROBLEM LOCATIONS 8, 9, 13, AND 26

Problem Locations 8, 9, 13, and 26 are shown on Figure 7-10 and are described below.

7.6.1 Description of Problem Location 8

Watson Way lacks a defined drainage system in the area just east of Mariposa Avenue. Runoff in this area flows to a low point in Watson Way approximately 400 feet east of Mariposa and then flows overland to the south though residential lots. Flooding complaints have been logged from two residents along the flow path.

7.6.2 Description of Problem Location 9

Runoff from a trunk pipe near the intersection of Antelope Road and Mariposa Avenue (Trunk Pipe SD7) is discharged to a short reach of ditch on the south side of Antelope Road. This ditch conveys runoff to the southwest through residential lots before entering Mariposa Creek. Residents along the ditch have logged complaints of flooding and erosion along the ditch.

7.6.3 Description of Problem Location 13

The drainage system along Watson Way, just west of Patton Avenue, includes a small ditch and pipe system along the north side of the road. This system has sufficient capacity to convey runoff from only small storm events. When the capacity of the existing system is exceeded, excess runoff flows south across Watson Way. Because there is no drainage system on the south side of the road, runoff flows through multiple lots on the south side of the road resulting in property flooding.

7.6.4 Description of Problem Location 26

Problem 26 is located at 7759 Reno Lane where a backyard drainage ditch conveys runoff through the lot and into the adjacent lot to the north. In the neighboring lot to the north, the ditch continues to the north property line then turns south and conveys runoff to Reno Lane where it drains into a trunk drain pipe in the roadway. The drainage ditch at 7759 Reno Lane is lower than the ditch in the property to the north and, as a result, it does not completely drain after storm events, which creates nuisance ponding and a potential mosquito breeding area.

7.6.5 Proposed Solution for Problem Locations 8, 9, and 13

Three options have been identified to solve this set of problems. Each of the proposed solutions includes the construction of new pipes, which were sized using normal depth flow calculations. Option 1 is shown on Figure 7-11A, Option 2 is shown on Figure 7-11B, and Option 3 is shown on Figure 7-11C. Each of the options is described below.

7.6.5.1 Solution for Problem Locations 8, 9, and 13 - Option 1

For this option, a pipe system would be constructed along Watson Way between Patton Avenue and Mariposa Avenue. This pipe system would collect runoff that drains from the north of Watson Avenue and from the road itself and would convey it west to Mariposa Avenue. The pipe system would be sized for the Nolte storm event and the pipe sizes would range from 12 to 15 inches in diameter. The existing ditch on the north side of the road be maintained in place and used to direct runoff into new inlets that would collect and deliver runoff to the new pipe system. During the design of the project, detailed topographic data should be collected to define the size of the existing ditch and determine if it is already adequately sized for this purpose. A ditch may also be necessary on the south side of the road to route the runoff from the road to the new inlets on the south side of the road. Again, the exact requirements will need to be determined after better topographic data is obtained prior to the design of the project. The existing ditch that conveys runoff between Watson Way and Reno Lane should be maintained to convey runoff from the adjacent lots and to convey runoff that exceeds the capacity of the proposed pipe system.

At Mariposa Avenue, the new pipe system would turn south and continue along Mariposa Avenue to Reno Lane where it would connect to an existing pipe system (Trunk Pipe SD7). Because this existing pipe is already sized for the runoff coming from the Watson Way area, it has adequate capacity to accept runoff from the new pipe system.

In addition, a new diversion structure would be constructed near the intersection of Mariposa Avenue and Antelope Road. This diversion structure would be placed along the existing 36-inch pipe at this location. The diversion structure would allow low flows to continue to be discharged into the existing channel that begins just south of Antelope Road. Because of the potential flooding along this ditch during large storms, large flows will be diverted into a new 30-inch pipe that would be constructed in Antelope Road. This pipe would convey large flows west to Mariposa Creek. This diversion would significantly reduce the flooding and erosion problem along the existing ditch south of Antelope Road. Also, although creek flooding is not being specifically addressed by this study, this alternative would also reduce the flow in Mariposa Creek near Sycamore Drive, which is a known problem area along the creek.

The new pipe system along Watson Way and Mariposa Avenue would significantly reduce the flooding from Problems 8 and 13. However, large storm events that exceed the return period of the Nolte design storm (2 years to 5 years), would continue to cause problems on some of the properties south of Watson Way.

7.6.5.2 Solution for Problem Locations 8, 9, and 13 - Option 2

Option 2 would include the same pipe system along Watson Way that is included in Option 1. However, instead turning south on Mariposa Avenue, the pipe system would continue west along Watson Way to Mariposa Creek. This would provide an improved drainage system along Watson Way between Mariposa Avenue and Mariposa Creek and would free up some capacity in the existing Reno Lane/Antelope Road pipe system for larger storms. Option 2 would also include the diversion structure and diversion pipe in Antelope Road that was included in Option 1.

As with Options 1, large storm events that exceed the return period of the Nolte design storm, would continue to cause flooding problems on some of the properties south of Watson Way.

7.6.5.3 Solution for Problem Locations 8, 9, and 13 - Option 3

Option 3 would be similar to Option 2, except the pipe system in Watson Way would be sized for the 10-year storm event. This would result in pipe sizes along Watson Way that would range from 18 inches to 30 inches in diameter. This option would significantly reduce the frequency of flooding along Watson Way. Also, this alternative would significantly reduce the flow discharging to existing channel that begins south of Antelope Road (see Problem 9 description above), therefore, the need for a diversion pipe down Antelope Road to direct flow away from the channel would be eliminated.

7.6.5.4 Recommended Solution for Problem Locations 8, 9, and 13

It is recommended that Option 3 be selected as the preferred alternative. Options 1 and 2 would both significantly improve the flood protection along Watson Way during storms that produce small to moderate peak flows. However, during larger storms, such as the 10-year storm and larger, the pipe system would be overwhelmed and flooding would occur due to the lack of an adequate overland release path. Option 3 would provide protection for much larger storm events and is less costly than Option 2 (see cost discussion later in this chapter). In addition, Option 3 would eliminate the need to construct improvements within Antelope Road, which is a major arterial with high traffic volumes.

7.6.6 Proposed Solution for Problem Location 26

It is recommended that grading be performed to eliminate the low areas in the ditch and to create a positive slope along the entire reach. The property owner indicated that he prefers to have fill placed in the existing ditch to raise the invert to allow positive drainage to the north. This is likely a feasible solution because the tributary watershed that drainage to the ditch is small and therefore the required capacity of the ditch is also small. No detailed calculations were performed for this problem. At the time of project design, it will be necessary to survey the existing ditch to determine the depth and quantity of fill required to achieve positive drainage and whether sufficient capacity will remain in the ditch if it is filled. It may be necessary to deepen the ditch in the neighboring property to the north. The solution for Problem 26 is shown on Figure 7-11C.

7.7 PROBLEM LOCATION 10

7.7.1 Description of Problem Location 10

Figure 7-12 shows the drainage system near Problem Location 10. A pipe system conveys runoff north in Charlene Way to Hansen Avenue. The pipe turns east in Hansen Avenue and continues for a short distance before turning north and continuing through the side yard of a private residential lot. The pipe runs along the side yard and discharges into a small channel that conveys runoff along the rear of the lot. Near the northeast corner of the lot, the channel discharges into a pipe system that continues east and north along the back yards of residential lots. This pipe system does not have adequate capacity to convey moderate to large storms and there are no provisions to safely convey excess flows overland along this path. The lot on Hansen Avenue with the side and back yard drainage system has been subjected to garage and yard flooding.

Problem 10 was evaluated with a XP-SWMM hydraulic model. Options were tested that focused on increasing the capacity of the pipe system through the yard of the at-risk property, but these options were found to be ineffective due to limitations in the pipe capacity downstream. Therefore, two options were developed that divert flows around the property. These two options are discussed below.

7.7.2 Proposed Solution for Problem Location 10

Two options have been identified to solve this problem. Each option was evaluated with a XP-SWMM hydraulic model. Option 1 is shown on Figure 7-13A and Option 2 is shown on Figure 7-13B. Both options are described below.

7.7.2.1 Proposed Solution for Problem Location 10 – Option 1

The existing pipe system through the private lot would be disconnected from the storm drain system in Hansen Avenue. The Hansen Avenue pipe system would be extended east to Glen Tree Drive. The new pipe in Hansen Avenue would be 15 inches in diameter. The existing pipe in Glen Tree Drive would be upsized to 18 inches between Hansen Avenue and Glen Stone Avenue and would connect to the existing 18-inch pipe that continues to Glen Valley Circle. For this option, the new pipes would be sized for the Nolte design storm event. During large storm events that exceed the pipe capacity, excess flow would still follow the low ground along the existing flow path through the residential lot. Although there would be some capacity to convey these flows through and existing storm system that currently travels through the lot, there would still be the potential for flooding during large storms.

7.7.2.2 Proposed Solution for Problem Location 10 – Option 2

For this option, the diversion pipe would be sized for a 10-year storm. This would require a pipe with a diameter of 30 inches to be constructed in Hansen Avenue and in Glen Tree Drive between Hansen Avenue and Glen Valley Circle. A 36-inch diameter pipe would be constructed along Glen Valley Circle to the channel where the existing pipe discharges. This alternative would significantly improve the flood protection over that provided by Option 1. The pipe would convey the peak flows for a 10-year storm without surcharging the pipe. During a 100-year storm, the pipe would surcharge and there would be some road flooding along the pipe route, but the lot on Hanson Avenue would not receive overflow from the pipe system. Although, no other flooding complaints were received from residents in this area, it is likely that the lots along the existing pipe alignment downstream of the reported problem area also experience problems. This option would significantly reduce or eliminate these problems. Flood protection would also be improved along the entire route of the proposed new pipe.

7.7.2.3 Recommended Solution for Problem Location 10

Additional evaluation is necessary before a solution can be recommended for Problem Location 10. Option 1 would improve the flood protection during storms that produce small to moderate peak flows. However, during larger storms, such as the 10-year storm and larger, the pipe system would be overwhelmed and flooding would occur due to the lack of an adequate overland release path along Hansen Avenue. Option 2 would significantly reduce the overland flow through the lot on Hansen Avenue even during large storms. However, the cost for Option 2 is high and may not be justified for improving the flood protection for a single lot. However, it is believed that additional properties to the north of Hansen Avenue are also likely to be affected by the flooding problem and the cost of Option 2 may actually be justified. The City plans to contact additional residents in the area to determine the full extent of the flooding problem. After this outreach effort is completed, the recommended solution for Problem Location 10 will be determined.

7.8 PROBLEM LOCATION 12

Problem Location 12 is located on Poppy Way and is shown on Figure 7-14. Runoff from Poppy Way and the surrounding area is collected in roadside swales to a ditch that conveys runoff from north to south along the side yard of a private residential lot. Near the south end of the lot, the ditch turns west and crosses into the backyard of the adjacent lot. The side yard ditch has restrictions that limit its capacity. At one point, the ditch passes through a low concrete wall that has only a small opening that is a significant restriction to flow. Further downstream, the ditch crosses underneath a fence and the property owner has installed a grate across the opening that appears to be designed to keep pets in the backyard. This fence crossing also appears to be a restriction to flow. These restrictions are at least partially responsible for water backing up in the side yard ditch and flooding into the adjacent lot to the west.

7.8.1 Proposed Solution for Problem Location 12

The proposed solution for Problem Location 12 is shown schematically on Figure 7-15. It is recommended that the existing side yard channel be replaced with an underground pipe. Alternatively, the existing channel could be re-graded and the restrictions removed. The underground pipe may be more desirable because it would eliminate the need to install grates or other measures to limit pet access under the fences. If a pipe is installed, it is recommended that it be sized for a 100-year flow. If the pipe were sized for the Nolte Method flows, then during a larger storm event overland flows would need to be conveyed along the pipe alignment anyway and a channel would be required. Because the watershed area is relatively small, the 100-year flow is only 5 cfs. Based on normal depth calculations, that flow can be conveyed by a 15-inch pipe. There is some uncertainty about whether sufficient cover over the pipe can be achieved along this route. The availability of cover will need to be determined when more detailed topographic data becomes available during the design process. Cover limitations may require that an arch pipe be used rather than a circular pipe. If cover limitations do not allow an underground pipe, then the channel should be re-graded and the obstructions at the wall and fence crossings should be removed and replaced with less restrictive grating.

At the location where the existing channel turns to the west and enters the backyard of the adjacent lot, the existing channel is shallow and there is insufficient cover for an underground pipe. At this location, the channel should be re-graded to a size sufficient to convey the 100-year flow, which is approximately 9 cfs. Based on normal depth calculations, a shallow ditch with a 3 foot bottom and 5:1 side slopes will carry the 100-year flow at a depth of approximately 0.6 feet and a top width of 9 feet. At the time of design, the property owner will need to be consulted to determine the most appropriate location and configuration of the channel. The channel may need to be continued downstream through the property to the south. The exact limits will need to be determined after better topographic data is available.

7.9 PROBLEM LOCATION 14

7.9.1 Description of Problem Location 14

The location of Problem Location 14 is shown on Figure 7-16. According to a nearby resident, water is constantly present on driveways and sidewalks in the area around the existing inlets at a low point on Canyon Oaks Drive. During moderate to heavy rain, the gutters in the street flood approximately 5 feet to 8 feet into the street. The heavy rains of 1995 caused flooding of the resident's garage and left standing water for several days. An obvious problem at this location is the lack of an adequate overland release for flows in excess of the pipe system capacity. From the low point in Canyon Oaks Drive, the pipe system conveys flows north through the side yard of a private residential lot. No overland release path was designed with the subdivision to convey flows in excess of the pipe capacity. Therefore, excess flows at this location will pond at the low point on Canyon Oaks Drive, potentially flooding homes if the storm is large enough.

7.9.2 Proposed Solution for Problem Location 14

A qualitative solution was developed for this problem (see Figure 7-17). To provide an overland release path, the side yard pipe between Canyon Oaks Drive and Blue Oak Way could be enlarged and additional inlets can be provided at each end. This will allow excess flow in Canyon Oaks Drive to be conveyed to Blue Oak Way where it can be conveyed in the street to the north. Another enlarged pipe with additional inlets at each end will be required downstream between Coast Oak Way and Moss Oak Avenue. Prior to design of this project, it should be evaluated in detail with a hydraulic model to size the pipe enlargements and to insure that no flooding would be induced along Blue Oak Way, Coast Oak Way, and Moss Oak Avenue.

7.10 PROBLEM LOCATION 15

7.10.1 Description of Problem Location 15

A ditch flows through private property in the vicinity of Fair Way and Patton Avenue (see Figure 7-18). Over time the ditch has filled with debris that has reduced the ditch capacity and created a potential flooding problem.

7.10.2 Proposed Solution for Problem Location 15

A qualitative solution was developed for this problem (see Figure 7-19). It is recommended that the ditch be cleared of debris and re-graded to restore its capacity.

7.11 PROBLEM LOCATIONS 16 AND 18

7.11.1 Description of Problem Location 16

Problem Location 16 is located along Mariposa Creek at Sycamore Drive (see Figure 7-20). At that location there is a double box culvert under Sycamore Drive that was constructed at right angle bend in the creek. Because the flow velocities are very low along the inside bend of the creek at this location, the box on the inside of the turn fills with sediment, which restricts the culvert capacity and causes a maintenance problem.

7.11.2 Description of Problem Location 18

Sycamore Drive also lacks a roadway drainage system and this has resulted in flooding complaints from residents along the road west of Mariposa Creek.

7.11.3 Proposed Solution for Problem Locations 16 and 18

A qualitative solution was developed for this problem (see Figure 7-21). At the double box culvert under Sycamore Drive, it is recommended that a low stem wall be constructed from the center of the box culvert upstream along the center of the creek through the ninety degree bend. The wall will split flow more evenly between the two barrels of the culvert and keep velocities higher in the inside barrel, which will reduce or eliminate sediment deposition and maintain the flow capacity of the culvert. Along Sycamore Drive, it is recommended that curb and gutter be installed to prevent flooding along the road.

7.12 PROBLEM LOCATION 19

7.12.1 Description of Problem Location 19

A residential lot at the corner of Twin Oaks Drive and Holly Drive has standing water in the yard after storm events (see Figure 7-22).

7.12.2 Proposed Solution for Problem Location 19

A qualitative solution was developed for Problem Location 19 (see Figure 7-22). It is recommended that a ditch be graded from the low area along the side yard to the existing ditch located at the northeast corner of the property.

7.13 PROBLEM LOCATIONS 20 AND 23

7.13.1 Description of Problem Location 20

As discussed in Chapter 6, there is a trunk pipe system that travels through the side yards of some residential lots between Colony Way and Baird Way and then continues east along Baird Way (Trunk Pipe SD3). During a large storm that exceeds the capacity of the pipe system; excess flow will travel overland through the lots between Colony Way and Baird Way. At least two building pads located along this overland flow path appear to be at-risk of flooding during a 100-year storm event. The location of this problem is shown on Figure 7-23.

7.13.2 Description of Problem Location 23

Frequent ponding occurs at the rear of a lot at the west end of Colony Way. The ponding also affects the adjacent lot to the south. Based on descriptions from the property owners, the ponding affects property, but not structures.

7.13.3 Proposed Solution for Problem Locations 20 and 23

Problem Location 20 was evaluated with a XP-SWMM hydraulic model. The model was used to define a solution for providing a release path for peak 100-year flows. To provide an adequate release path, the existing trunk pipe should be enlarged to 30-inches from Colony Way to its outfall at the east end of Baird Way (See Figure 7-24). Additional inlets should be provided at the upstream end of the pipe at Colony Way to allow overland flows to enter into the new pipe.

Problem Location 23 can be solved by constructing a new ditch to drain the area of ponding. There are two optional alignments for the ditch. For Option 1, the ditch would convey runoff west to an existing 12-inch storm drain that conveys runoff from Colony Way to Baird Avenue. For this option the ditch would be sized to convey Nolte flows because the existing downstream system has been sized for that event. It is likely that the existing 12-inch pipe system is deep enough for this alternative to be feasible; however, a field survey will be necessary to confirm this assumption. Larger storms would continue to produce temporary ponding that would drain after the storm recedes. A second option was also considered for solving Problem Location 23. For Option 2, the ditch would convey runoff east to Cripple Creek. The ditch would need to be constructed through two private residential lots east of the lot where the ponding occurs. Because there are two residential structures located south of the proposed ditch alignment, the ditch for Option 2 would be sized for the 100-year storm to prevent induced flooding of the existing structures. It is recommended that Option 1 be implemented because of less private property impacts. With Option 1 some ponding will continue to occur during large storms, but the ponding will be eliminated during frequent storms and the duration of the ponding will be significantly reduced during large storms.

7.14 PROBLEM LOCATION 25

7.14.1 Description of Problem Location 25

The Polaris dealership at 7640 Sunrise Boulevard experiences flooding in their shop on a regular basis.

7.14.2 Proposed Solution for Problem Location 25

This problem is being addressed as a part of the Sunrise Boulevard Phase 1 project that is currently underway. That project will rehabilitate the 18-inch storm drain pipes in front of the property, will install vertical curb and gutter to increase the capacity of the gutter, will install water quality features that will direct roadway runoff into swales, and will re-grade gutter flowlines to such that flows in excess of the pipe system capacity can flow to the south along Sunrise Boulevard prior to causing flooding at the property.

7.15 COST ESTIMATES FOR PROPOSED SOLUTIONS

Implementation cost estimates were prepared for the drainage improvements discussed above. The cost estimates presented in this chapter are master planning level accuracy and are for decision making and budgeting purposes. As projects advance through preliminary design and preparation of plans and specifications, estimates can be made in more detail to greater accuracy. The major assumptions used to estimate costs for drainage improvements are listed below.

- Unit costs are based on current construction costs. (August 2011 ENR 20 Cities CCI of 9088)
- The unit costs used to determine construction costs were based on cost data from recently constructed projects, manufacturer quotes, estimating guides, engineering judgment, and input from City staff.
- For pipelines proposed within existing streets, costs were included for repairing the pavement. For estimating these costs, it was assumed that the width of the trench would be equal to the inside diameter of the pipe plus two feet.
- Land acquisition costs were not included. The proposed improvements will be constructed mostly within the public rights-of-way or within an existing easement. For the few cases where an easement must be obtained, the cost of the easement is not expected to be a significant portion of the total project cost.
- A contractor’s mobilization/demobilization cost of 5 percent was included as part of the construction cost.
- A construction contingency of 20 percent was included to account for the planning level uncertainties (e.g. utility relocations, etc.) and construction cost uncertainties associated with the estimates.
- The following mark-ups were added to the total construction cost to obtain the estimated total project implementation cost or capital cost.
    - Planning & Design @ 10 percent
    - Construction Management @ 10 percent
    - Environmental Permits and Mitigation @ 5 percent
    - Program Management @ 5 percent

  The soft cost percentages above may not be appropriate for small projects. For this study, it is assumed that small projects will be bundled with larger ones during the design and construction phases to achieve better cost efficiency.

A summary of the estimated cost for the proposed solutions for each problem location are presented on Table 7-1. Detailed cost estimates for each of the proposed solutions are provided on Table 7-2.

Table 7-1. Summary of Capital Cost Estimates for Proposed Solutions	
Item	Estimated Total Project Capital Cost, dollars
Problem Location 1 Solution	892,000
Problem Locations 2, 3, and 11 Solution	1,196,000
Problem Locations 4 and 21 Solution	72,000
Problem Locations 5, 6, and 7 Solution	501,000
Problem Location 17 Solution	107,000
Problem Locations 8, 9, and 13 Solution - Option 1	787,000
Problem Locations 8, 9, and 13 Solution - Option 2	1,031,000
Problem Location 8, 9, and 13 Solution - Option 3	980,000
Problem Location 10 Solution - Option 1	199,000
Problem Location 10 Solution - Option 2	TBD
Problem Location 12 Solution	25,400
Problem Location 14 Solution	274,400
Problem Location 15 Solution	8,300
Problem Location 16 Solution	414,800
Problem Location 18 Solution	26,000
Problem Location 19 Solution	1,700
Problem Location 20 Solution	429,400
Problem Location 22 Solution	3,500
Problem Location 23 Solution	12,100
Problem Location 24 Solution	63,000
Problem Location 25 Solution	53,000

Table 7-2. Cost Estimates for Proposed Solutions				
Item	Unit of Measure	Unit Cost, dollars	Quantity	Item Cost, dollars
Problem Location 1 Solution				
24-Inch Storm Drain	ft	144	740	106,560
42-Inch Storm Drain	ft	252	1,190	299,880
Drain Inlets	each	4,000	5	20,000
Maintenance Holes	each	5,000	6	30,000
Diversion Structure	each	10,000	1	10,000
Channel Excavation	cy	140	10	1,400
Existing Pipe Disposal	lf	10	520	5,200
Existing Pavement Repair	sf	8	9,500	76,000
Mobilization/demobilization (at 5 percent)				27,000
Construction Contingency (at 20 percent)				110,000
Estimated Construction Cost				686,000
Engineering, CM/Insp, CEQA, City Admin (Note 1, at 30 percent)				206,000
Estimated Capital Cost				**892,000**
Problem Locations 2, 3, and 11 Solution				
12-Inch Storm Drain	ft	72	80	5,760
18-Inch Storm Drain	ft	108	535	57,780
21-Inch Storm Drain	ft	126	45	5,670
42-Inch Storm Drain	ft	252	1,930	486,360
Curb and Gutter	ft	50	160	8,000
Ditch Replacement with 8-inch Drain	ft	53	150	7,950
Drain Inlets	each	4,000	3	12,000
Maintenance Holes	each	5,000	9	45,000
Diversion Structure	each	10,000	1	10,000
Existing Pavement Repair	sf	8	12,900	103,200
Mobilization/demobilization (at 5 percent)				37,000
Construction Contingency (at 20 percent)				147,000
Estimated Construction Cost				920,000
Engineering, CM/Insp, CEQA, City Admin (Note 1, at 30 percent)				276,000
Estimated Capital Cost				**1,196,000**
Problem Location 4 and 21 Solution				
15-Inch Storm Drain	ft	90	330	29,700
Drain Inlets	each	4,000	2	8,000
Maintenance Holes	each	5,000	1	5,000
Existing Pavement Repair	sf	8	200	1,600
Mobilization/demobilization (at 5 percent)				2,000
Construction Contingency (at 20 percent)				9,000
Estimated Construction Cost				55,000
Engineering, CM/Insp, CEQA, City Admin (Note 1, at 30 percent)				17,000
Estimated Capital Cost				**72,000**
Problem Locations 5, 6, and 7 Solution				
12-Inch Storm Drain	ft	72	255	18,360
15-Inch Storm Drain	ft	90	1,100	99,000
Ditch Replacement with 12-inch Drain	ft	89	1,105	98,345
Drain Inlets	each	4,000	12	48,000
Maintenance Holes	each	5,000	4	20,000
Outfall Structure	each	5,000	1	5,000
Existing Pavement Repair	sf	8	2,400	19,200
Mobilization/demobilization (at 5 percent)				15,000
Construction Contingency (at 20 percent)				62,000
Estimated Construction Cost				385,000
Engineering, CM/Insp, CEQA, City Admin (Note 1, at 30 percent)				116,000
Estimated Capital Cost				**501,000**
Problem Location 17 Solution				
18-Inch Storm Drain	ft	108	460	49,680
Outfall Structure	each	5,000	1	5,000

Table 7-2. Cost Estimates for Proposed Solutions				
Item	Unit of Measure	Unit Cost, dollars	Quantity	Item Cost, dollars
Existing Pipe Disposal	lf	10	108	1,080
Existing Pavement Repair	sf	8	1,300	10,400
Mobilization/demobilization (at 5 percent)				3,000
Construction Contingency (at 20 percent)				13,000
Estimated Construction Cost				82,000
Engineering, CM/Insp, CEQA, City Admin (Note 1, at 30 percent)				25,000
Estimated Capital Cost				**107,000**
Problem Locations 8, 9, and 13 Solution - Option 1				
12-Inch Storm Drain	ft	72	900	64,800
15-Inch Storm Drain	ft	90	1,245	112,050
30-Inch Storm Drain	ft	180	750	135,000
Drain Inlets	each	4,000	9	36,000
Maintenance Holes	each	5,000	8	40,000
Outfall Structure	each	5,000	1	5,000
Diversion Structure	each	10,000	1	10,000
Existing Pavement Repair	sf	8	10,100	80,800
Mobilization/demobilization (at 5 percent)				24,000
Construction Contingency (at 20 percent)				97,000
Estimated Construction Cost				605,000
Land/Easement	acre		0.0	0
Engineering, CM/Insp, CEQA, City Admin (Note 1, at 30 percent)				182,000
Estimated Capital Cost				**787,000**
Problem Locations 8, 9, and 13 Solution - Option 2				
12-Inch Storm Drain	ft	72	1,040	74,880
15-Inch Storm Drain	ft	90	2,085	187,650
30-Inch Storm Drain	ft	180	750	135,000
Drain Inlets	each	4,000	15	60,000
Maintenance Holes	each	5,000	10	50,000
Outfall Structure	each	5,000	2	10,000
Diversion Structure	each	10,000	1	10,000
Existing Pavement Repair	sf	8	13,300	106,400
Mobilization/demobilization (at 5 percent)				32,000
Construction Contingency (at 20 percent)				127,000
Estimated Construction Cost				793,000
Land/Easement	acre		0.0	0
Engineering, CM/Insp, CEQA, City Admin (Note 1, at 30 percent)				238,000
Estimated Capital Cost				**1,031,000**
Problem Locations 8, 9, and 13 Solution - Option 3				
12-Inch Storm Drain	ft	72	390	28,080
18-Inch Storm Drain	ft	108	240	25,920
21-Inch Storm Drain	ft	126	395	49,770
24-Inch Storm Drain	ft	144	2,085	300,240
Drain Inlets	each	4,000	15	60,000
Maintenance Holes	each	5,000	8	40,000
Outfall Structure	each	5,000	1	5,000
Existing Pavement Repair	sf	8	11,800	94,400
Mobilization/demobilization (at 5 percent)				30,000
Construction Contingency (at 20 percent)				121,000
Estimated Construction Cost				754,000
Land/Easement	acre		0.0	0
Engineering, CM/Insp, CEQA, City Admin (Note 1, at 30 percent)				226,000
Estimated Capital Cost				**980,000**
Problem Location 10 Solution - Option 1				
15-Inch Storm Drain	ft	90	350	31,500
18-Inch Storm Drain	ft	108	560	60,480
Existing Pipe Disposal	lf	10	560	5,600

Table 7-2. Cost Estimates for Proposed Solutions				
Item	Unit of Measure	Unit Cost, dollars	Quantity	Item Cost, dollars
Existing Pavement Repair	sf	8	3,100	24,800
Mobilization/demobilization (at 5 percent)				6,119
Construction Contingency (at 20 percent)				24,476
Estimated Construction Cost				152,975
Land/Easement	acre	50,000		0
Engineering, CM/Insp, CEQA, City Admin (Note 1, at 30 percent)				46,000
Estimated Capital Cost				**199,000**
Problem 10 Location Solution - Option 2				
Mobilization/demobilization (at 5 percent)				TBD
Construction Contingency (at 20 percent)				TBD
Estimated Construction Cost				TBD
Land/Easement	acre		0.0	TBD
Engineering, CM/Insp, CEQA, City Admin (Note 1, at 30 percent)				TBD
Estimated Capital Cost				**TBD**
Problem Location 12 Solution				
15-Inch Storm Drain	ft	90	130	11,700
Outfall Structure	each	2,000	1	2,000
Ditch Grading	lump sum	1,500	1	1,500
Fence Removal/Replacement	ft	15	20	300
Mobilization/demobilization (at 5 percent)				775
Construction Contingency (at 20 percent)				3,100
Estimated Construction Cost				19,375
Engineering, CM/Insp, CEQA, City Admin (Note 1, at 30 percent)				6,000
Estimated Capital Cost				**25,400**
Problem Location 14 Solution				
36-Inch Storm Drain	ft	216	580	125,280
Gallery Drain Inlets	each	10,000	4	40,000
Fence Removal/Replacement	ft	15	320	4,800
Mobilization/demobilization (at 5 percent)				8,264
Construction Contingency (at 20 percent)				33,056
Estimated Construction Cost				211,400
Engineering, CM/Insp, CEQA, City Admin (Note 1, at 30 percent)				63,000
Estimated Capital Cost				**274,400**
Problem Location 15 Solution				
Ditch Grading	lump sum	5,000	1	5,000
Mobilization/demobilization (at 5 percent)				250
Construction Contingency (at 20 percent)				1,000
Estimated Construction Cost				6,250
Land/Easement	acre	50,000	0.00	0
Engineering, CM/Insp, CEQA, City Admin (Note 1, at 30 percent)				2,000
Estimated Capital Cost				**8,300**
Problem Location 16 Solution				
Curb and Gutter	lf	50	5,100	255,000
Mobilization/demobilization (at 5 percent)				12,750
Construction Contingency (at 20 percent)				51,000
Estimated Construction Cost				318,750
Land/Easement	acre	50,000	0.00	0
Engineering, CM/Insp, CEQA, City Admin (Note 1, at 30 percent)				96,000
Estimated Capital Cost				**414,800**
Problem Location 18 Solution				
Stem Wall	lf	500	32	16,000
Mobilization/demobilization (at 5 percent)				800
Construction Contingency (at 20 percent)				3,200
Estimated Construction Cost				20,000
Land/Easement	acre	50,000	0.00	0
Engineering, CM/Insp, CEQA, City Admin (Note 1, at 30 percent)				6,000

Table 7-2. Cost Estimates for Proposed Solutions				
Item	Unit of Measure	Unit Cost, dollars	Quantity	Item Cost, dollars
Estimated Capital Cost				**26,000**
Problem Location 19 Solution				
Ditch Grading	lump sum	1,000	1	1,000
Mobilization/demobilization (at 5 percent)				50
Construction Contingency (at 20 percent)				200
Estimated Construction Cost				1,250
Land/Easement	acre	50,000	0.00	0
Engineering, CM/Insp, CEQA, City Admin (Note 1, at 30 percent)				400
Estimated Capital Cost				**1,700**
Problem Location 20 Solution				
30-Inch Storm Drain	lf	180	1,200	216,000
Maintenance Holes	each	5,000	5	25,000
Outfall Structure	each	5,000	1	5,000
Existing Pavement Repair	sf	8	3,800	30,400
Mobilization/demobilization (at 5 percent)				10,800
Construction Contingency (at 20 percent)				43,200
Estimated Construction Cost				330,400
Land/Easement	acre	50,000	0.00	0
Engineering, CM/Insp, CEQA, City Admin (Note 1, at 30 percent)				99,000
Estimated Capital Cost				**429,400**
Problem Location 22 Solution				
Retrofit Grate onto Inlet	lump sum	1	2,000	2,000
Mobilization/demobilization (at 5 percent)				100
Construction Contingency (at 20 percent)				400
Estimated Construction Cost				2,500
Land/Easement	acre	50,000	0.00	0
Engineering, CM/Insp, CEQA, City Admin (Note 1, at 30 percent)				1,000
Estimated Capital Cost				**3,500**
Problem Location 23 Solution - Option 1				
Ditch Grading	lump sum	1	3,000	3,000
12-inch Riser Pipe	each	5,000	1	5,000
Fence Removal/Replacement	ft	15	20	300
Mobilization/demobilization (at 5 percent)				150
Construction Contingency (at 20 percent)				600
Estimated Construction Cost				9,050
Land/Easement	acre	50,000	0.00	0
Engineering, CM/Insp, CEQA, City Admin (Note 1, at 30 percent)				3,000
Estimated Capital Cost				**12,100**
Problem Location 23 Solution - Option 2				
Ditch Grading	lump sum	1	7,000	7,000
Fence Removal/Replacement	ft	15	40	600
Mobilization/demobilization (at 5 percent)				350
Construction Contingency (at 20 percent)				1,400
Estimated Construction Cost				9,350
Land/Easement	acre	50,000	0.00	0
Engineering, CM/Insp, CEQA, City Admin (Note 1, at 30 percent)				3,000
Estimated Capital Cost				**12,400**
Problem Location 24 Solution				
12-Inch Storm Drain	ft	72	500	36,000
Drain Inlets	each	4,000	4	16,000
Maintenance Holes	each	5,000	2	10,000
Ditch Grading	lump sum	1,000	1	1,000
Existing Pavement Repair	sf	8	1,500	12,000
Mobilization/demobilization (at 5 percent)				1,950
Construction Contingency (at 20 percent)				7,800
Estimated Construction Cost				48,750

Table 7-2. Cost Estimates for Proposed Solutions				
Item	Unit of Measure	Unit Cost, dollars	Quantity	Item Cost, dollars
Engineering, CM/Insp, CEQA, City Admin (Note 1, at 30 percent)				14,625
Estimated Capital Cost				**63,000**
Problem Location 25 Solution				
Cost Provided by Bennett Engineering from Sunrise Blvd. Phase 1 Project	lump sum	1	33,800	33,800
Construction Contingency (at 20 percent)				6,760
Estimated Construction Cost				41,000
Engineering, CM/Insp, CEQA, City Admin (Note 1, at 30 percent)				12,300
Estimated Capital Cost				**53,000**
Problem Location 26 Solution				
Ditch Grading	lump sum	1	15,000	15,000
Construction Contingency (at 20 percent)				3,000
Estimated Construction Cost				18,000
Engineering, CM/Insp, CEQA, City Admin (Note 1, at 30 percent)				5,400
Estimated Capital Cost				**23,000**

Notes:

1. Soft costs include and allowance of 30 percent comprised of the following:
   - Planning and design at 10 percent of the construction cost
   - Construction management at 10 percent of the construction cost
   - Environmental permits and mitigation at 5 percent of the construction cost
   - Program management (City administration during design and construction) at 5 percent
2. The unit costs and soft cost percentages are based on the assumption that small projects will be bundled with larger projects to achieve better cost efficiency.
3. Costs are for August 2011 ENRCCI 20 City Average 9,088.

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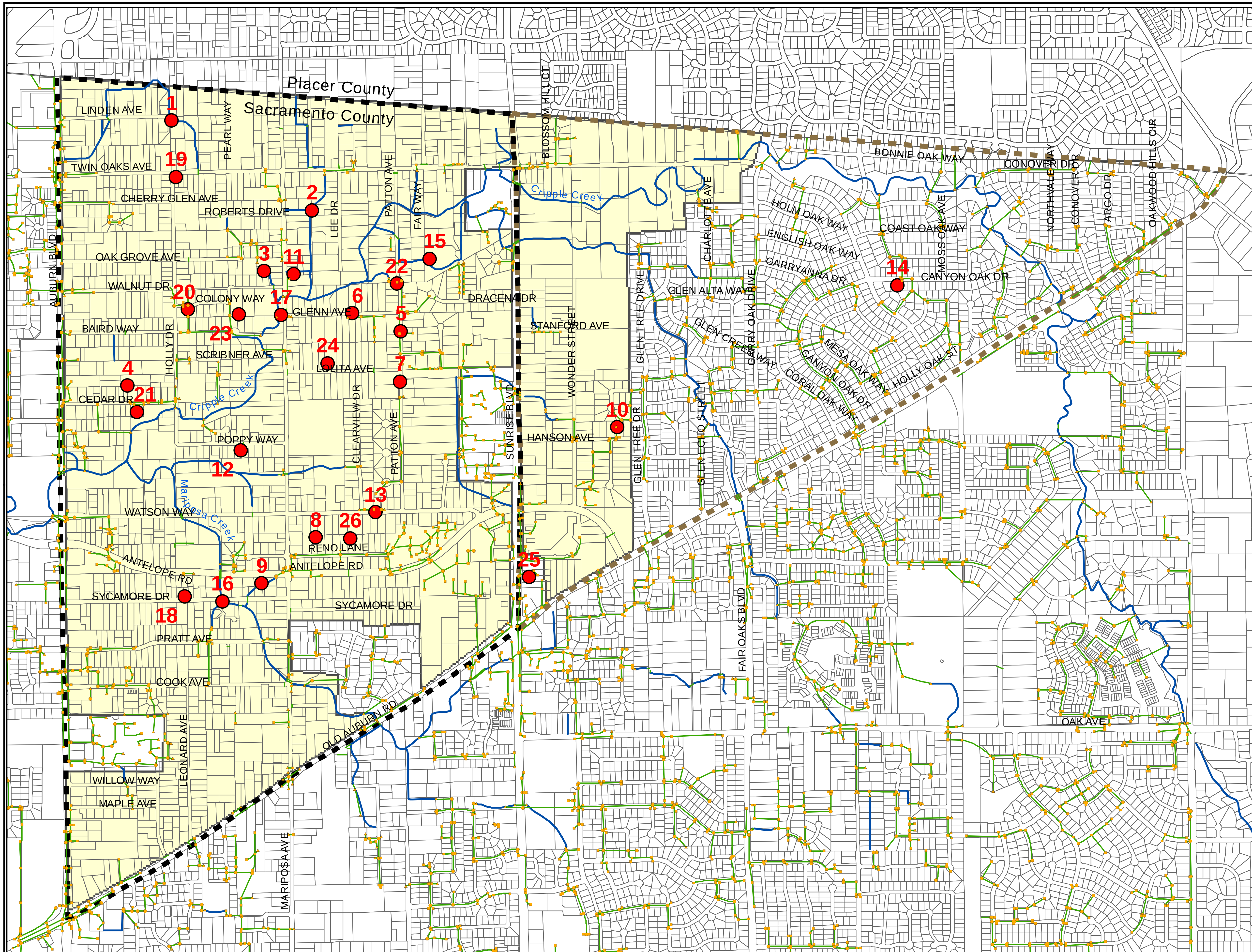

FIGURE 7-1

City of Citrus Heights Neighborhoods 6 and 7 Drainage Master Plan Study

FLOODING/DRAINAGE PROBLEM LOCATIONS

N

0 550 1,100

Scale in Feet

LEGEND

- Existing Inlet
- Existing Outfall
- Existing Manhole
- Problem Location
- Existing Drainage Pipe
- Stream or Channel
- Neighborhood 6
- Neighborhood 7
- Detailed Study Area

WEST YOST ASSOCIATES
Consulting Engineers