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Avery Drive Area Drainage Improvement

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Avery Drive Area Drainage Improvement

by

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Thesis

Presented to the Faculty of the Graduate School of

The University of Texas at Austin

in Partial Fulfillment

of the Requirements

for the Degree of

Master of Science in Engineering

The University of Texas at Austin

August 2011

Abstract

Avery Drive Area Drainage Improvement

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The University of Texas at Austin, 2011

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The area of study is the Avery Drive drainage area. The objective of these projects is to alleviate frequent flooding at the Avery Drive neighborhoods. RC&A designed two options for improving the Avery Drive drainage area. Option one increases the capacity of the existing sewer system, and option two constructs a new storm drain system along Simon Street while keeping the existing system in place. Although both options offer preliminary solutions for alleviating flooding, the designs are unviable due to the lack of data that was available for the study. The following research will prove that RC&A fulfilled its contractual obligation of practicing due diligence by recommending further investigation to obtain valuable data for a complete and successful final design, rather than providing a solid recommendation based on existing data.

Table of Contents

List of Tables

List of Figures

Chapter 1 Introduction

In 1996, a devastating storm hit the small town of Taylor, Texas, causing massive flooding that resulted in damages estimated in the millions. Ruth Mantor described to the Taylor Statesman the harrowing effect fast-rising water can have. "Another normally quiet stream, Mustang Creek, rose with such force that several steel rails of the International and Great Northern Railroad (I&GN) were curled around a large cottonwood tree. The force of the water was unbelievable. Every bridge coming into Taylor was washed away" **(**Komandosky, 2008). Even more than two decades later, the area surrounding Mustang Creek, the Avery Drive neighborhood, is still inundated with flooding during powerful storms. Of course, there's no way to prevent inclement weather, however there is one simple, proactive improvement that can be taken to address this issue. The Raymond Chan & Associates (RC&A) has undertaken a preliminary evaluation and investigation of a drainage improvement project that is part of the Taylor General Obligation Bond Project. The area of study is the Avery Drive drainage area. The objective of these projects is to alleviate frequent flooding at the Avery Drive neighborhoods. RC&A designed two options for improving the Avery Drive drainage area. Option one increases the capacity of the existing sewer system, and option two constructs a new storm drain system along Simon Street while keeping the existing system in place. Although both options offer preliminary solutions for alleviating flooding, the designs are unviable due to the lack of data that was available for the study. The following research will prove that RC&A fulfilled its contractual obligation of practicing due diligence by recommending further investigation to obtain valuable data for a complete and successful final design, rather than providing a solid recommendation based on existing data.

Chapter 2 Existing Conditions at Avery Drive

In the Avery Drive area, a neighborhood has a history of localized flooding because of its construction along an old tributary of Mustang Creek. From Raymond Chan & Associates (RC&A) analysis, the Avery Drive neighborhood’s existing drainage system is extremely undersized, and cannot capture runoff of water collecting near the depressed areas of the old tributary of Mustang Creek. The existing drainage system consists of three 5’ curb inlets, three 5’ X 5’ grate inlets, and 32” diameter storm drain pipe line. The surface runoff of water not captured by the existing drainage system, flows overland southward toward Avery Drive through low lying areas (Chan & Partners Engineering, LLC. 2000). Thus, the Avery Drive neighborhood experiences frequent and extensive flooding because it is located at the downstream end of the area.

From field investigation and topography from USGS mapping, the Avery Drive drainage area for surface runoff is generally bounded by Highway 95 on the west, the railroad tracks to the north and east, and Mustang street on the South.

As indicated by the elevation lines on Figure 1, the majority of the Avery drive neighborhood was constructed along an old tributary of Mustang Creek. In general, surface storm-water runoff draining from the east and west sides of East Walnut street, East Pecan Street, Rio Grande Street, Avery Drive and Mustang Street collects at the depressed areas of the streets. Although there are grate and curb inlets located near the depressed areas, hydraulic calculations indicate that the storm drain systems along these streets are significantly under-sized (Chan & Partners Engineering, LLC. 2000).

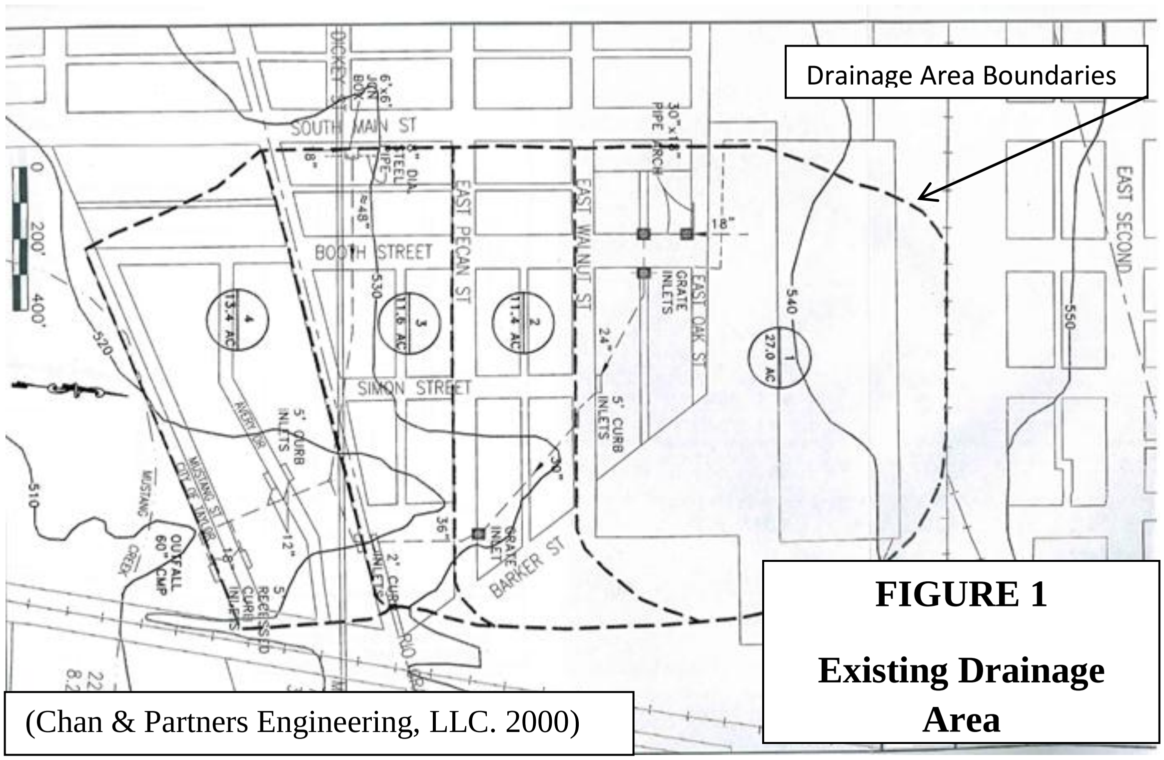


FIGURE 1

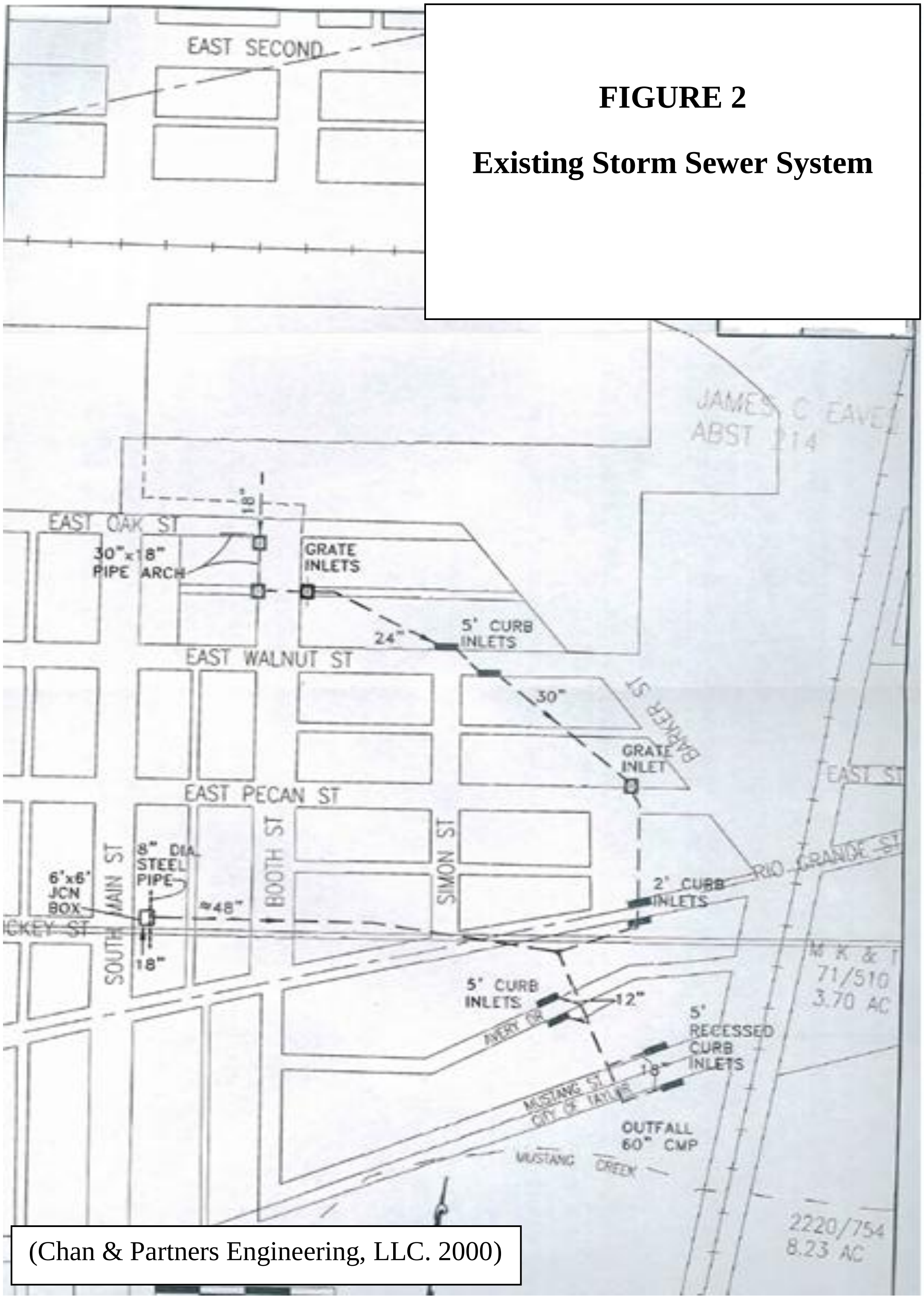
Existing Drainage Area

(Chan & Partners Engineering, LLC. 2000)

Due to the lack of record information, field investigation was performed to attempt to locate the alignments and sizes of existing storm sewer pipe lines. A storm sewer system that is believed to drain the downtown business district appears to run roughly east and west, crossing Highway 95 near Dickey Street, running east and crossing Rio Grande Street, and then turning south in the center of the Avery Drive Housing Project and out-falling south of Mustang Street. At the outfall of this 60” line, extensive scouring and erosion are occurring. Another existing storm sewer system in the area appears to run roughly north and south from East Oak Street to Rio Grande Street and is believed to tie into the downtown business district line near the Avery Drive Housing Project (Chan & Partners Engineering, LLC. 2000). The estimated existing storm sewer systems, as determined by field investigation, are shown in Figure 2.

FIGURE 2

Existing Storm Sewer System



(Chan & Partners Engineering, LLC. 2000)

Chapter 3 Hydrology

The peak flow calculations of the existing drainage area was based on the following assumptions: the drainage boundary for surface water runoff presented by RC&A in figure 1 is correct; the project area drainage system begins on East Oak Street, and it does not extend beyond the drainage boundaries, and east-west streets Walnut, Pecan, Rio Grande, and Mustang intercept flows and divert them to the local drainage system (Chan & Partners Engineering, LLC. 2000).

With the above assumptions, the drainage area was broken into four sub-areas, with divisions at the east-west streets listed above. The Rational Method was used to calculate peak flow rates from the sub-areas, using "C" runoff coefficients from the City of Austin Drainage Criteria Manual [10], and intensity, duration, frequency coefficients for Williamson County from the TxDOT Hydraulic Manual. Land uses were taken from the City's comprehensive plan and were determined to be approximately 30% impervious cover and 70% fair grass cover for each sub-area (City of Austin, Drainage Criteria Manual 1996). Times of concentration were calculated with TR-55 methodology (Chan & Partners Engineering, LLC. 2000). A summary of the hydrologic results are presented in Tables 2-0.

TABLE 2-0

Existing Drainage Area Peak Flow Calculations

Summary Table

Drainage Area	2 year Peak Flow (cfs)	5 year Peak Flow (cfs)	10 year Peak Flow (cfs)	25 year Peak Flow (cfs)	50 year Peak Flow (cfs)	100 year Peak Flow (cfs)
1	42	55.8	72.1	90.5	106.4	130.9
2	20.8	27.4	35.3	44.3	51.9	64.1
3	20.4	27	34.8	43.7	51.2	63.2
4	23.6	31.2	40.2	50.4	59.2	73

Combined Flows

1, 2	58.1	77.2	99.9	125.3	147.5	181.4
1, 2, 3	73.7	97.9	126.8	159.1	187.3	230.2
1, 2, 3, 4	91	121	156.8	196.8	231.8	284.8

Composite C Values for all subareas (City of Austin Drainage Criteria Manual 1996)
Approximately 30% impervious cover, 70% fair grass on flat slope (0-2%)

	2 year	5 year	10 year	25 year	50 year	100 year
Impervious	0.74	0.785	0.82	0.87	0.91	0.96
Pervious	0.25	0.28	0.3	0.34	0.37	0.41
Composite C	0.397	0.4315	0.456	0.499	0.532	0.575

Rainfall Intensity (Coefficients for Williamson County) (TxDOT 1985)

	Return Period					
	2 year	5 year	10 year	25 year	50 year	100 year
b	56	68	77	88	92	103
d	8	8.5	8.5	8.5	8.5	8
e	0.798	0.792	0.769	0.768	0.752	0.751

2 Year Peak Flow Rates

Drainage Area	Acreage (Ac.)	Time of Concentration (min)	Intensity (in/hr)	C Value	Peak Flow (cfs)
1	27	20	3.92	0.397	42
2	11.4	15	4.59	0.397	20.8
3	11.6	16	4.43	0.397	20.4
4	13.4	16	4.43	0.397	23.6

(Chan & Partners Engineering, LLC. 2000)

TABLE 2-0
Existing Drainage Area Peak Flow Calculations

5 Year Peak Flow Rates

Drainage Area	Acreage (Ac.)	Time of Concentration (min)	Intensity (in/hr)	C Value	Peak Flow (cfs)
1	27	20	4.79	0.4315	55.8
2	11.4	15	5.58	0.4315	27.4
3	11.6	16	5.4	0.4315	27
4	13.4	16	5.4	0.4315	31.2

10 Year Peak Flow Rates

Drainage Area	Acreage (Ac.)	Time of Concentration (min)	Intensity (in/hr)	C Value	Peak Flow (cfs)
1	27	20	5.86	0.456	72.1
2	11.4	15	6.79	0.456	35.3
3	11.6	16	6.58	0.456	34.8
4	13.4	16	6.58	0.456	40.2

25 Year Peak Flow Rates

Drainage Area	Acreage (Ac.)	Time of Concentration (min)	Intensity (in/hr)	C Value	Peak Flow (cfs)
1	27	20	6.72	0.499	90.5
2	11.4	15	7.79	0.499	44.3
3	11.6	16	7.54	0.499	43.7
4	13.4	16	7.54	0.499	50.4

50 Year Peak Flow Rates

Drainage Area	Acreage (Ac.)	Time of Concentration (min)	Intensity (in/hr)	C Value	Peak Flow (cfs)
1	27	20	7.41	0.532	106.4
2	11.4	15	8.57	0.532	51.9
3	11.6	16	8.3	0.532	51.2
4	13.4	16	8.3	0.532	59.2

100 Year Peak Flow Rates

Drainage Area	Acreage (Ac.)	Time of Concentration (min)	Intensity (in/hr)	C Value	Peak Flow (cfs)
1	27	20	8.43	0.575	130.9
2	11.4	15	9.78	0.575	64.1
3	11.6	16	9.47	0.575	63.2
4	13.4	16	9.47	0.575	73

(Chan & Partners Engineering, LLC. 2000)

Table 2.0

Existing Drainage Area Peak Flow Calculations

Drainage Area	Acreage (Ac.)	Time of Concentration (min)	Intensity (in/hr)	C Value	Peak Flow (cfs)
2 year Combined Area Peak Flows					
1, 2	38.4	21	3.81	0.397	58.1
1, 2, 3	50	22	3.71	0.397	73.7
1, 2, 3, 4	63.4	23	3.61	0.397	91
5 year Combined Area Peak Flows					
Drainage Area	Acreage (Ac.)	Time of Concentration (min)	Intensity (in/hr)	C Value	Peak Flow (cfs)
1, 2	38.4	21	4.66	0.4315	77.2
1, 2, 3	50	22	4.54	0.4315	97.9
1, 2, 3, 4	63.4	23	4.42	0.4315	121
10 year Combined Area Peak Flows					
Drainage Area	Acreage (Ac.)	Time of Concentration (min)	Intensity (in/hr)	C Value	Peak Flow (cfs)
1, 2	38.4	21	5.7	0.456	99.9
1, 2, 3	50	22	5.56	0.456	126.8
1, 2, 3, 4	63.4	23	5.42	0.456	156.8
25 year Combined Area Peak Flows					
Drainage Area	Acreage (Ac.)	Time of Concentration (min)	Intensity (in/hr)	C Value	Peak Flow (cfs)
1, 2	38.4	21	6.54	0.499	125.3
1, 2, 3	50	22	6.38	0.499	159.1
1, 2, 3, 4	63.4	23	6.22	0.499	196.8
50 year Combined Area Peak Flows					
Drainage Area	Acreage (Ac.)	Time of Concentration (min)	Intensity (in/hr)	C Value	Peak Flow (cfs)
1, 2	38.4	21	7.22	0.532	147.5
1, 2, 3	50	22	7.04	0.532	187.3
1, 2, 3, 4	63.4	23	6.87	0.532	231.8
100 year Combined Area Peak Flows					
Drainage Area	Acreage (Ac.)	Time of Concentration (min)	Intensity (in/hr)	C Value	Peak Flow (cfs)
1, 2	38.4	21	8.21	0.575	181.4
1, 2, 3	50	22	8.01	0.575	230.2
1, 2, 3, 4	63.4	23	7.81	0.575	284.8

(Chan & Partners Engineering, LLC. 2000)

Chapter 4 Hydraulics, Storm Sewer Capacities

The estimated existing storm sewer systems in the project area are shown in Figure 2. No inlets were found on the central business district line between Highway 95 and Rio Grande Street. The major storm sewer for the project area is the system starting at East Oak Street and running south to Rio Grande Street. Below Rio Grande, it is believed that the systems converge, and capture runoff from inlets on Avery Drive and Mustang Street (Chan & Partners Engineering, LLC. 2000). Table 2-1 presents calculations used to determine the capacity of the existing system from Oak Street to Rio Grande Street.

The existing storm sewer capacity calculations was based on the following assumptions: the system was in average working condition; grate inlets and curb inlets are acting as sum inlets and have a clogging factor of 20% and 10% respectively; and the maximum depth of water at inlet locations was one foot. With these assumptions, the analysis shows that the existing system is severely undersized. As indicated in Table 2-1, substantial water bypasses the system at the two-year frequency storm (Chan & Partners Engineering, LLC. 2000). When the system capacity is exceeded, surface runoff begins to flow overland, which creates localized surface flooding in low-lying areas.

TABLE 2-1
Existing Conditions
Storm Sewer Capacities

Assumptions:

Drainage boundary for area is roughly bounded by Hwy 95 on west, along railroad tracks on north and east, and along Mustang Street on south.

No other flows enter this area either as overland, channel, or storm sewer (with the exception of the business district storm sewer.

East / west streets (Walnut, Pecan, Rio Grande, and Mustang) intercept runoff moving south and divert them to the system inlets.

System is in average working condition.

Storm sewer line grades are roughly those of existing ground slope above.

Grate Inlet Capacity
Assumptions:

All grates are similar in size, approximately 2 ft x 2 ft.

Open area available for flow is 1.8 ft^2

Clogging factor of 20% applied.

Maximum depth of water over the grate inlet is 1 ft.

Grate Inlets are acting in sump locations.

Grate Inlet sump Equation:

Q = 4.82 * A * H^0.5 * F

where Q is the flow rate in cfs.

A is open area in ft^2.

H is the height of water above ithe inlet opening.

F is the coefficent for clogging.

Using above assumptions,

Q = 4.82 * 1.80 * 1^0.5 * 0.8 = 6.9 cfs / inlet

(Chan & Partners Engineering, LLC)

Table 2-1

Curb Inlet Capacity

Assumptions:

All curb inlets are acting in sump locations.

Maximum height of water above throat opening is 1 ft.

Clogging factor of 10% applied.

Curb Inlet Sump Equation:

Q = 3.0 * H^1.5 * L * F

where L is the length of the curb inlet opening

Using above assumptions,

Q = 3.0 * 1^1.5 * L * 0.9 = 2.7 * L

Existing System Capacity Calculations

Drainage Area One at Walnut Street (Refer to Figure 1)

	3 - Grate inlets at 6.9 cfs	20.7 cfs
	2 - 5' curb inlets at 13.5 cfs	27.0 cfs
Maximum inlet capacity for Area One		47.7 cfs
capacity of 30" CMP line at 1.4%		26.3 cfs
Maximum flow in system at Walnut St.		26.3 cfs
	(lesser of inlet capacity and pipe capacity)	

Drainage Area Two at Pecan Street

	1 - Grate inlet at 6.9 cfs	6.9 cfs
Maximum inlet capacity for Area Two		6.9 cfs
capacity of 30" line at 2.8%		37.2 cfs
Maximum flow in system at Pecan St.		26.3 + 6.9 cfs = 33.2 cfs
	(lesser of Walnut St. flows and inlet capacity for Area Two or pipe capacity for Area Two)	

(Chan & Partners Engineering, LLC. 2000)

Chapter 5 Option One

Option one proposes to replace the majority of the existing north-south storm sewer system pipes, maintaining to a large extent the current alignment. The drainage areas for Option One are also the same as for existing conditions. To facilitate the capturing of surface runoff, new curb inlets are also proposed at the low points of East Walnut Street, East Pecan Street, Rio Grande Street, and Avery Drive. The new storm sewer system will parallel the existing line though the Avery Drive Projects, out-falling to Mustang Creek adjacent to the existing 60" CMP. Erosion Protection and energy dissipaters will be constructed at the outfall of the two (one existing and one proposed) storm sewer pipes (Chan & Partners Engineering, LLC. 2000). The proposed storm drain sewer system should have adequate conveyance for the 25 -year frequency storm, which is the city's minimum requirement. Option One's storm sewer system layout is in Figure 3, and its capacity analysis is in Table 2-2.

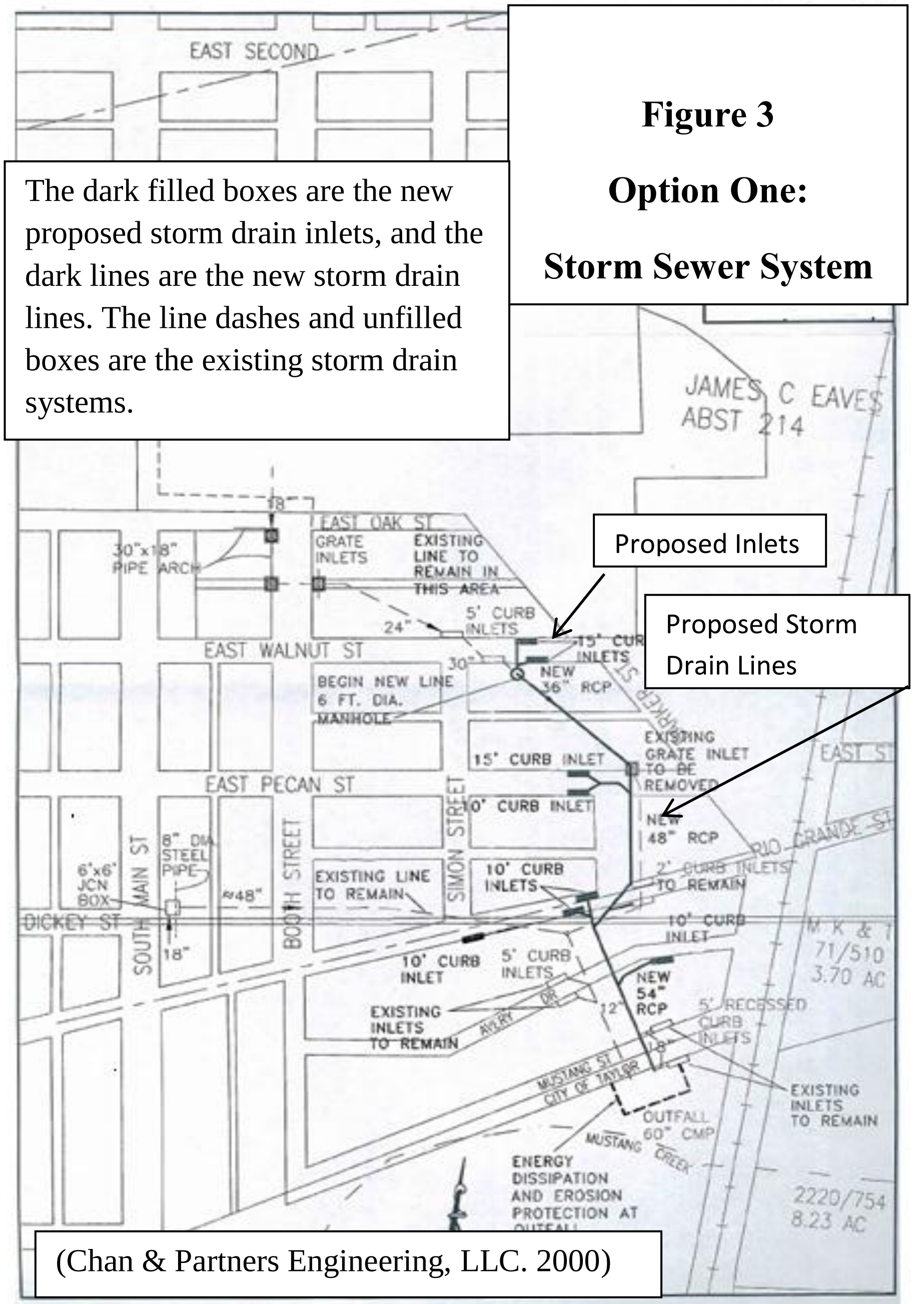


Figure 3

Option One:

Storm Sewer System

The dark filled boxes are the new proposed storm drain inlets, and the dark lines are the new storm drain lines. The line dashes and unfilled boxes are the existing storm drain systems.

(Chan & Partners Engineering, LLC. 2000)

Table 2-2

Option One, Proposed Storm Sewer Capacities

(Chan & Partners Engineering, LLC. 2000)

Assumptions:

- Drainage boundary for area is roughly bounded by Hwy. 95 on west, along railroad tracks on north and east, and along Mustang Street on south.
- No other flows enter this area either as overland, channel, or storm sewer (with the exception of the business district storm sewer).
- East / west (Walnut, Pecan, rio Grande, and Mustang) intercept runoff moving south and divert them to the system inlets.
- Clogging factor of 20% applied to all grate inlets in sump locations.
- Clogging factor of 10% applied to all curb inlets in sump locations.
- Maximum depth of water above opening of inlets is 10 inches (.833 ft).

Grate Inlet Sump Equation:

Q = 4.82 * A * H^0.5 * F

for existing grate inlets with above assumptions:

Q = 4.82 * 1.8 * .833^0.5 * .80 = 6.3 cfs

Curb Inlet Sump Equation:

Q = 3.0 * H^1.5 * L * F

Q = 3.0 * .833^1.5 * L * 0.9 = 2.0 * L

Proposed system capacity compared to 25 -year peak flows

At Walnut Street (refer to Figure 3)

3 - existing grate inlets at 6.3 cfs	18.9 cfs
2 - existing 5 foot curb inlets at 10 cfs	20.0 cfs
1 - 15 foot curb inlet on north side of Walnut	30.0 cfs
1 - 15 foot curb inlet on south side of Walnut	30.0 cfs
Intercepted flow	98.9 cfs
25 -year peak flow	90.5 cfs

TABLE 2-2

(Option One, Proposed Storm Sewer Capacities)

From Walnut to Pecan	
Capacity of 36" RCP @ 2.5%	105 cfs
25 -year peak flow	90.5 cfs
At Pecan Street	
1 - 15 foot curb inlet on north side of Pecan	30.0 cfs
1 - 10 foot curb inlet on south side of Pecan	20.0 cfs
Intercepted Flow	50.0 cfs
25 -year peak flow from area Two	44.3 cfs
From Pecan to Rio Grande	
Capacity of 48" RCP @ 1.0%	143.0 cfs
Combined Areas One and Two 25 -year peak flow	125.0 cfs
At Rio Grande Street	
1 - 10 foot curb inlet on north side of Rio Grande	20.0 cfs
1 - 10 foot curb inlet on south side of Rio Grande	20.0 cfs
1 - 10 foot curb inlet on grade east of Booth Street	8.0 cfs (drains to existing 60")
Intercepted Flow	48.0 cfs
25 -year peak flow from Area Three	43.7 cfs
In Avery Drive Projects	
1 -10 foot curb inlet on Avery Drive in east parking lot	20.0 cfs
2 - 5 foot existing curb inlets on Mustang St. at 10.0 cfs	20.0 cfs
2 - 10 foot existing curb inlets on Avery Drive	20.0 cfs (drains to existing 60")
Intercepted Flow	60.0 cfs
25 -year peak flow from Area Four	50.4 cfs
From Rio Grande to outfall	
Capacity of 54" RCP @ 1.0%	196.0 cfs
Combined Areas One through Four 25 -year peak flow	168.8 cfs (28.0 cfs drains to CBD line)

(Chan & Partners Engineering, LLC. 2000)

Chapter 6 Option Two

Option Two proposes a new storm sewer system to be installed in Simon Street from East Walnut Street to Rio Grande Street, and from Rio Grande Street to Mustang Creek though the Avery Drive Projects. This option creates east (existing) and west (proposed) storm sewer systems that join together below Rio Grande Street. The new storm sewer line (west) will tie into the existing storm sewer line at East Walnut Street and divert all upstream flows into the new system. New storm sewer pipes will be added in Simon Street and curb inlets will be installed at East Walnut Street, East Pecan Street, and Rio Grande Street. With the new storm sewer line intercepting the runoff from Drainage Areas 1W and 2W, the existing storm sewer line (east) can maintain the current storm sewer pipes. Additional curb inlets at East Walnut Street and East Pecan Street are needed to capture the 25 -year storm runoff from the remaining drainage areas. Below the confluence of the two storm sewer systems, the Option Two storm sewer is identical to Option One (Chan & Partners Engineering, LLC. 2000). The new storm sewer line creates additional drainage areas, and the drainage area map for this option is shown in Figure 4. A conceptual layout of the Option Two storm sewer systems is shown in Figure 5.

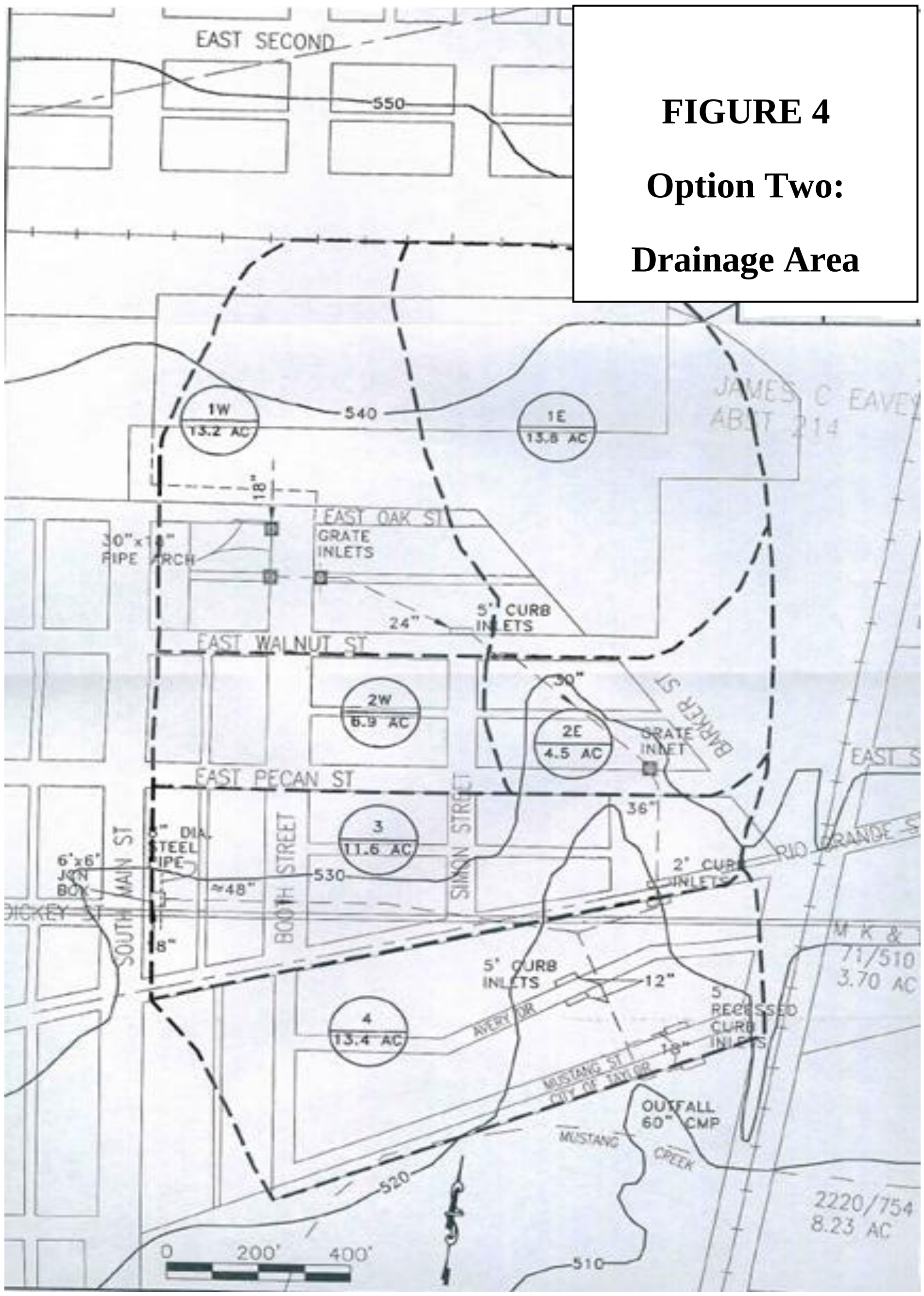


FIGURE 4

Option Two:

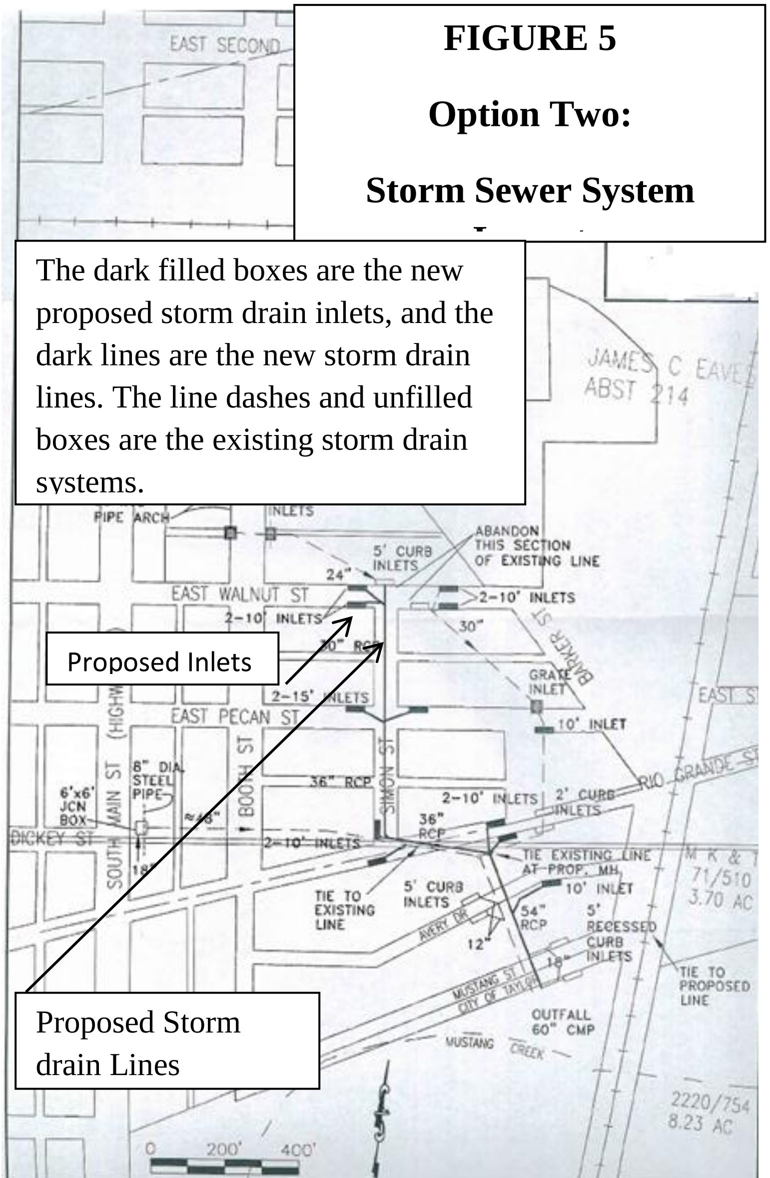
Drainage Area

FIGURE 5

Option Two:

Storm Sewer System

The dark filled boxes are the new proposed storm drain inlets, and the dark lines are the new storm drain lines. The line dashes and unfilled boxes are the existing storm drain systems.



(Chan & Partners Engineering, LLC. 2000)

Chapter 7 RC&A's Due Diligence

With current information available, RC&A has provided accurate calculations of the current drainage system. They determined that the current drainage system is extremely undersized, and it cannot handle the existing peak flows in Table 2-0. To solve this issue, RC&A has developed two new drainage system options in Tables 2-3 and Tables 2-4. Not only do the proposed drainage systems solve the flooding issues, but options were given to the client, which are to avoid: excavations on private property, conflicts with existing lines, and roadway closure that are a major inconvenience for public drivers. This section will discuss how RC&A has used due diligence in their drainage design for the client and their recommendations to make their proposed options more accurate.

RC&A's Option One design replaces an existing storm sewer line, and it keeps the current alignment of the drainage system. This will reduce possible conflicts with existing underground utilities and overhead utilities. Also, no new storm sewer pipe lines are added to the drainage areas. With Option One's drainage system, trenching within roadways is reduced; however, road crossings and associated repairs will be needed. Most of the construction would be across private properties, and this will create an inconvenience for residents. Also, the existence of drainage easements for the existing storm sewer system has not all been confirmed. To maximize water runoff capture, new inlets can be positioned at the low points within the drainage areas.

The alternative to construction across private properties would be Option Two for design. The majority of work of Option Two's drainage system would be in Simon Street and Rio Grande Street. However, there may be possible conflicts with existing underground utilities and overhead utilities within Simon Street and Rio Grande Street. Also, periodic closure of the roadways may occur because of construction. Some of Option Two's central business district (CBD) storm sewer line may cross private property at the northeast corner of Simon Street and Rio Grande Street without any public easements. Without public easements, the new 36" line (indicated on Figure 5) would not be able to parallel the CBD storm line. Thus, this option is totally dependent on the location of the CBD storm line. Additionally, Simon and Rio Grande Street are in deteriorated condition, so patching of these streets are not recommended. Therefore, the only alternative is to re-pave the construction parts of Simon and Rio Grande Street. The re-paving of these streets will also improve the capture of water runoff within the construction area. Current inlets on Simon Street would not be able to capture a 25 –year storm water runoff, so additional inlets are required to prevent flooding (Chan & Partners Engineering, LLC. 2000).

Table 2-3
Option Two
Drainage Area Peak Flow Calculations

SUMMARY TABLE

Drainage Area	2 year Peak Flow (cfs)	5 year Peak Flow (cfs)	10 year Peak Flow (cfs)	25 year Peak Flow (cfs)	50 year Peak Flow (cfs)	100 year Peak Flow (cfs)
1W	20.5	27.3	35.3	44.2	52.0	64.0
1E	21.5	28.5	36.9	46.3	54.4	66.9
2W	12.6	16.6	21.4	26.8	31.4	38.8
2E	8.2	10.8	13.9	17.5	20.5	25.3
3	20.4	27.0	34.8	43.7	51.2	63.2
4	23.6	31.2	40.2	50.4	59.2	73.0

COMBINED FLOWS

1W,2W	30.4	40.4	52.3	65.6	77.2	94.9
1E,2E	27.7	36.8	47.6	59.7	70.3	86.4
1,2,3	73.7	97.9	126.8	159.1	187.3	230.2
1,2,3,4	91.0	121.0	156.8	196.8	231.8	284.8

Composite C values for all subareas (COA Drainage Criteria Manual)
Approximately 30% impervious cover, 70% fair grass on flat slope (0-2%)

	2year	5year	10year	25year	50year	100year
Impervious	0.74	0.785	0.82	0.87	0.91	0.96
Pervious	0.25	0.28	0.3	0.34	0.37	0.41
Composite C	0.397	0.4315	0.456	0.499	0.532	0.575

Rainfall Intensity (TxDOT idf coefficients for Williamson County)

	Return Period					
	2 year	5 year	10 year	25 year	50 year	100 year
b	56.0	68.0	77.0	88.0	92.0	103.0
d	8.0	8.5	8.5	8.5	8.5	8.0
e	0.798	0.792	0.769	0.768	0.752	0.751

(Chan & Partners Engineering, LLC. 2000)

TABLE 2-3

(Option Two, Drainage Area Peak Flow Calculations)

2 Year Peak Flow Rates					
Drainage Area	**Acreage (Ac.)**	**Time of Concentration (min)**	**Intensity (in/hr)**	**C value**	**Peak Flow (cfs)**
1W	13.2	20	3.92	0.397	20.5
1E	13.8	20	3.92	0.397	21.5
2W	6.9	15	4.59	0.397	12.6
2E	4.5	15	4.59	0.397	8.2
3	11.6	16	4.43	0.397	20.4
4	13.4	16	4.43	0.397	23.6

5 Year Peak Flow Rates					
Drainage Area	**Acreage (Ac.)**	**Time of Concentration (min)**	**Intensity (in/hr)**	**C value**	**Peak Flow (cfs)**
1W	13.2	20	4.79	0.4315	27.3
1E	13.8	20	4.79	0.4315	28.5
2W	6.9	15	5.58	0.4315	16.6
2E	4.5	15	5.58	0.4315	10.8
3	11.6	16	5.40	0.4315	27.0
4	13.4	16	5.40	0.4315	31.2

10 Year Peak Flow Rates					
Drainage Area	**Acreage (Ac.)**	**Time of Concentration (min)**	**Intensity (in/hr)**	**C value**	**Peak Flow (cfs)**
1W	13.2	20	5.86	0.456	35.3
1E	13.8	20	5.86	0.456	36.9
2W	6.9	15	6.79	0.456	21.4
2E	4.5	15	6.79	0.456	13.9
3	11.6	16	6.58	0.456	34.8
4	13.4	16	6.58	0.456	40.2

25 Year Peak Flow Rates					
Drainage Area	**Acreage (Ac.)**	**Time of Concentration (min)**	**Intensity (in/hr)**	**C value**	**Peak Flow (cfs)**
1W	13.2	20	6.72	0.499	44.2
1E	13.8	20	6.72	0.499	46.3
2W	6.9	15	7.79	0.499	26.8
2E	4.5	15	7.79	0.499	17.5
3	11.6	16	7.54	0.499	43.7
4	13.4	16	7.54	0.499	50.4

(Chan & Partners Engineering, LLC. 2000)

TABLE 2-3

(Option Two, Drainage Area Peak Flow Calculations)

50 Year Peak Flow Rates					
Drainage Area	**Acreage (Ac.)**	**Time of Concentration (min)**	**Intensity (in/hr)**	**C value**	**Peak Flow (cfs)**
1W	13.2	20	7.41	0.532	52.0
1E	13.8	20	7.41	0.532	54.4
2W	6.9	15	8.57	0.532	31.4
2E	4.5	15	8.57	0.532	20.5
3	11.6	16	8.30	0.532	51.2
4	13.4	16	8.30	0.532	59.2

100 Year Peak Flow Rates					
Drainage Area	**Acreage (Ac.)**	**Time of Concentration (min)**	**Intensity (in/hr)**	**C value**	**Peak Flow (cfs)**
1W	13.2	20	8.43	0.575	64.0
1E	13.8	20	8.43	0.575	66.9
2W	6.9	15	9.78	0.575	38.8
2E	4.5	15	9.78	0.575	25.3
3	11.6	16	9.47	0.575	63.2
4	13.4	16	9.47	0.575	73.0

2 year Combined Area Peak Flows					
Drainage Area	**Acreage (Ac.)**	**Time of Concentration (min)**	**Intensity (in/hr)**	**C value**	**Peak Flow (cfs)**
1W,2W	20.1	21	3.81	0.397	30.4
1E,2E	18.3	21	3.81	0.397	27.7
1,2,3	50.0	22	3.71	0.397	73.7
1,2,3,4	63.4	23	3.61	0.397	91.0

5 year Combined Area Peak Flows					
Drainage Area	**Acreage (Ac.)**	**Time of Concentration (min)**	**Intensity (in/hr)**	**C value**	**Peak Flow (cfs)**
1W,2W	20.1	21	4.66	0.4315	40.4
1E,2E	18.3	21	4.66	0.4315	36.8
1,2,3	50.0	22	4.54	0.4315	97.9
1,2,3,4	63.4	23	4.42	0.4315	121.0

(Chan & Partners Engineering, LLC. 2000)

TABLE 2-3

(Option Two, Drainage Area Peak Flow Calculations)

10 year Combined Area Peak Flows					
Drainage Area	**Acreage (Ac.)**	**Time of Concentration (min)**	**Intensity (in/hr)**	**C value**	**Peak Flow (cfs)**
1W,2W	20.1	21	5.70	0.456	52.3
1E,2E	18.3	21	5.70	0.456	47.6
1,2,3	50.0	22	5.56	0.456	126.8
1,2,3,4	63.4	23	5.42	0.456	156.8

25 year Combined Area Peak Flows					
Drainage Area	**Acreage (Ac.)**	**Time of Concentration (min)**	**Intensity (in/hr)**	**C value**	**Peak Flow (cfs)**
1W,2W	20.1	21	6.54	0.499	65.6
1E,2E	18.3	21	6.54	0.499	59.7
1,2,3	50.0	22	6.38	0.499	159.1
1,2,3,4	63.4	23	6.22	0.499	196.8

50 year Combined Area Peak Flows					
Drainage Area	**Acreage (Ac.)**	**Time of Concentration (min)**	**Intensity (in/hr)**	**C value**	**Peak Flow (cfs)**
1W,2W	20.1	21	7.22	0.532	77.2
1E,2E	18.3	21	7.22	0.532	70.3
1,2,3	50.0	22	7.04	0.532	187.3
1,2,3,4	63.4	23	6.87	0.532	231.8

100 year Combined Area Peak Flows					
Drainage Area	**Acreage (Ac.)**	**Time of Concentration (min)**	**Intensity (in/hr)**	**C value**	**Peak Flow (cfs)**
1W,2W	20.1	21	8.21	0.575	94.9
1E,2E	18.3	21	8.21	0.575	86.4
1,2,3	50.0	22	8.01	0.575	230.2
1,2,3,4	63.4	23	7.81	0.575	284.8

(Chan & Partners Engineering, LLC. 2000)

Table 2-4
Option Two, Proposed Storm Sewer Capacities

Assumptions:

- Drainage boundary for area is roughly bounded by Hwy. 95 on west, along railroad tracks on north and east, and along Mustang Street on south.
- No other flows enter this area wither as overland, channel, or storm sewer (with the exception of the business district storm sewer).
- East / west streets (Walnut, Pecan, rio Grande, and Mustang) intercept runoff moving south and divert them to the system inlets.
- Clogging factor of 20% applied to all grate inlets in sump locations.
- Clogging factor of 10% applied to all curb inlets in sump locations.
- Maximum depth of water above opening of inlets is 10 inches (.833 ft).

Grate Inlet Sump Equation:

Q = 4.82 * A* H^0.5 * F

for existing grate inlets with above assumptions:

Q = 4.82 * 1.8 * .833^0.5 * .8 = 6.3 cfs

Curb Inlet Sump Equation:

Q = 3.0 * H^1.5 * L * F

Q = 3.0 * .833^1.5 * L * .9 = 2.0 * L

Curb Inlet on grade assumed to capture 1 cfs per foot of opening.

Proposed system capacity compared to 25 -year peak flows.

West System

Area 1W at Walnut Street (Refer to Figure 4)

3 - existing grate inlets at 6.3 cfs	18.9 cfs
1 - existing 5 foot curb inlets at 10 cfs	10.0 cfs
1 - 10 foot curb inlet on north side of Walnut	10.0 cfs
1 - 10 foot curb inlet on south side of Walnut	10.0 cfs
Intercepted Flow	48.9 cfs
25 -year peak flow	44.2 cfs

(Chan & Partners Engineering, LLC. 2000)

TABLE 2-4

(Option Two, Proposed Storm Sewer Capacities)

From Walnut to Pecan	
Capacity of 30" RCP @ 1.5%	50.2 cfs
25 -year peak flow	44.2 cfs
East System	
Area 1E at Walnut Street (Refer to Figure 4)	
1 - existing 5 foot curb inlets at 10 cfs	10.0 cfs
1 - 10 foot curb inlet on north side of Walnut	20.0 cfs
1 - 10 foot curb inlet on south side of Walnut	20.0 cfs
Intercepted Flow	50.0 cfs
25 -year peak flow	46.3 cfs
From Walnut to Pecan	
Capacity of 30" RCP @ 1.5%	50.2 cfs
25 -year peak flow	46.3 cfs
West System	
At Pecan Street	
1 - 15 foot curb inlet west of Simon - north side of Pecan	15.0 cfs
1 - 15 foot curb inlet east of Simon - north side of Pecan	15.0 cfs
Intercepted flow	30.0 cfs
25 -year peak flow from Area 2W	26.3 cfs
From Pecan to Rio Grande	
Capacity of 36" RCP @ 1.5%	81.6 cfs
Combined Areas 1W and 2W 25 -year peak flow	65.6 cfs
East System	
At Pecan Street	
1 - existing grate inlet	6.3 cfs
1 - 10 foot curb south side of Pecan	20.0 cfs
Intercepted Flow	26.3 cfs
25 -year peak flow from Area 2E	17.5 cfs
From Pecan to Rio Grande	
Capacity of 36" RCP @ 1.5%	81.6 cfs
Combined Areas 1E and 2E 25 -year peak flow	59.7 cfs

(Chan & Partners Engineering, LLC. 2000)

TABLE 2-4

(Option Two, Proposed Storm Sewer Capacities)

West System	
At Rio Grande Street	
1 - 10 foot curb inlet on grade - north side of Rio Grande	10.0 cfs
1 - 10 foot curb inlet on grade - south side of Rio Grande	10.0 cfs (drains to existing CBD line)
From Simon St. to junction of East and West systems	
Capacity of 36" at 1.5%	81.6 cfs
Total Flow in West System	75.6 cfs
East System	
at Rio Grande Street	
2 - 2' curb inlets at 2 cfs	4.0 cfs
From Rio Grande St. to junctino of East and West systems	
Capacity of exiting 36" RCP @ 1.5%	81.6 cfs
Total Flow in East system	63.7 cfs
Combined Systems	
At Rio Grande Street	
1 - 10 foot sump inlet - north side of Rio Grande	20.0 cfs
1 - 10 foot sump inlet - south side of Rio Grande	20.0 cfs
Total Intercepted Flow	64.0 cfs
25 -year peak flow from Area Three	43.7 cfs
In Avery Drive Projects	
1 - 10 foot curb inlet on Avery Drive in east parking lot	20.0 cfs
2 - 5 foot existing curb inlets on Mustang St. at 10.0 cfs	20.0 cfs
2 - 5 foot existing curb inlets on Avery Drive at 10.0 cfs	20.0 cfs (drains to existing 60")
Intercepted Flow	60.0 cfs
25 -year peak flow from Area Four	50.4 cfs
From Rio Grande to outfall	
Capacity of 54" RCP @ 1.0%	196.0 cfs
Combined Areas One through Four 25 -year peak flow	166.8 cfs (30.0 cfs to existing CBD line)

(Chan & Partners Engineering, LLC. 2000)

Although the new storm sewer system and local drainage improvements will reduce the localized flooding in the area of Avery Drive, RC&A continues their due diligence by recommending further investigation to obtain certain data for a complete and successful design. The following data is needed:

- Obtain more accurate topographic information for the project area, including a portion of Mustang Creek. This will determine exactly where the water runoff will travel.
- Identify/verify the existing storm sewer systems sizes and locations in the study area, especially the storm sewer system from the Central business district (if not performed by the Public Works Department). Knowing the exact size of the storm sewer system, will also determine exactly how much water is captured.
- Verify that the existing storm sewer line is located within drainage easements. This is crucial in determining if it crosses private property.
- Design / modify the proposed storm sewer system based on new topography. Knowing the exact elevations of the area will determine where the water will flow.
- Determine if additional drainage easement acquisition will be required. This is important because the new drainage system cannot be in private property, so public easements need to be acquired.
- Obtain more accurate information on existing underground utilities and overhead utilities within the project area. During the street excavation, the proposed storm sewer system should not conflict with existing utilities.

- Control erosion problems at the outfall of storm sewer pipes below Mustang Street.

Because of the relatively flat terrain in the Avery Drive drainage area, RC&A's assumptions based on USGS 10 foot contour topography has the potential for serious error. To avoid serious error, two-foot contour topography is needed for the study area, so accurate data of flow paths and drainage areas can be calculated. Also, because of the extent of the project area, RC&A recommends that topography should be created from aerial photos rather than from on-the-ground survey. Additionally, creating aerial photos is also more cost-effective than on-the-ground survey.

Another recommendation from RC&A is the existing storm sewer system needs to be accurately identified to ensure that the system works for the current drainage area calculated. Thus, it does not extend to off-site areas or collect runoff from another drainage system. If off-site flows are currently affecting Avery Drive's drainage system, then Option One and Option Two need to be re-designed to accommodate these additional flows. City of Taylor's surveying crews can locate missing underground storm sewer lines that can contribute to Avery Drive's drainage system.

If existing systems are more accurately identified and new topography is gathered, then the new system layout may need to be modified. When the final layout is determined, further investigation and design will be needed to minimize conflicts with other utility lines.

It may be possible to implement low-cost drainage improvements, consisting primarily of grading, within the Avery Drive projects to protect housing units form nuisance flooding prior to the construction of the proposed storm sewer system. Coordination with the City of Taylor will be required to determine the extent of improvements that can be performed by the City or contractor outside the street right-of-ways.

Serious erosion and scour is occurring at the existing 60” CMP outfall. This situation should be corrected at the time the proposed storm sewer system is installed.

Field investigation of inlets revealed that trash and litter have effectively stopped many inlets from functioning. A maintenance plan should be created establishing routine cleaning of inlets and surrounding areas to ensure that any improvements function as designed. At a minimum, yearly maintenance of the system should be performed (Chan & Partners Engineering, LLC. 2000).

Chapter 8 Conclusion

The study that RC&A was asked to perform was a preliminary investigation and design for solving the drainage issues along Mustang Creek on Avery Drive. In this area, the existing drainage system is extremely undersized, and cannot capture runoff collecting near the depressed areas of the old tributary of Mustang Creek. Surface runoff not captured by the existing drainage system flows overland southward toward Avery Drive though low lying areas, which causes flooding. The study was based on data that was collected and provided by the City of Taylor. The data provided by the City of Taylor was average rainfall occurrence and outdated underground existing utilities. From this limited pool of data, RC&A drew the conclusion that there were two main options for improving the drainage system: Option one increases the capacity of the existing storm sewer system (Figure 3), and Option two constructs a new storm drain system along Simon Street while keeping the existing system in place (Figure 5). Other considerations beyond drainage issues were taken when presenting the two options, such as excavations on private property, conflicts with existing lines, and roadway closure that are a major inconvenience for public drivers. RC&A practiced due diligence by recommending that further data be collected, such as topographic and utility locations, in order to increase the accuracy of the study and further determine which option is the best suited for the client's needs and existing resource base.

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