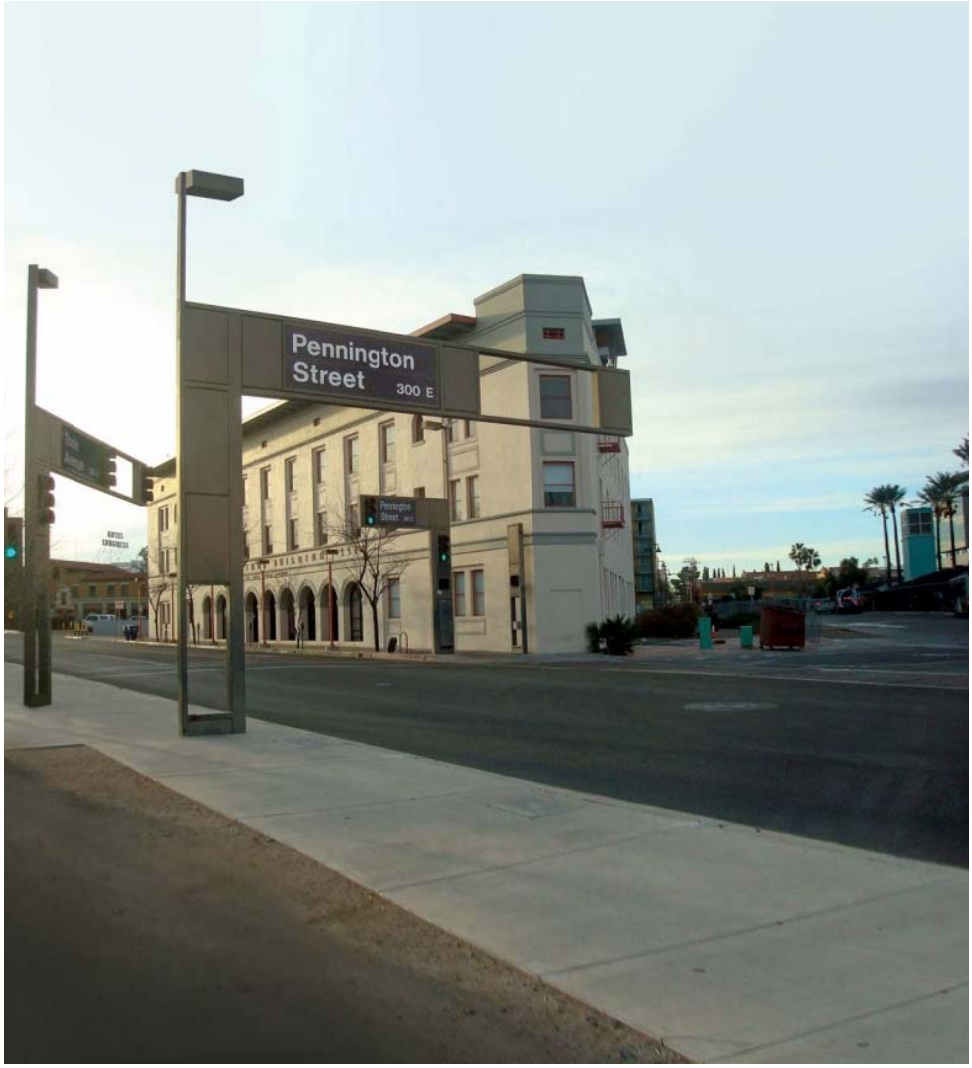
DOWNTOWN INTERMODAL CENTER (DIMC) PEDESTRIAN SAFETY AND BUS ACCESS IMPROVEMENTS



Plan No. I-2012-009

Final Design Concept Report April 2013
APPENDIX B – Drainage Memorandum

Submitted to

Submitted by

APPENDIX B - DRAINAGE MEMORANDUM

Downtown Intermodal Center (DIMC)

Pedestrian Safety and Bus Access Improvements

PLAN NO. I-2012-009

DRAINAGE MEMORANDUM

Prepared for:

CITY OF TUCSON DEPARTMENT OF TRANSPORTATION

Prepared by:

PARSONS BRINCKERHOFF
177 North Church Avenue, Suite 610
Tucson, Arizona 85701
(520) 882-6424

April 2013

INTRODUCTION

This memorandum is provided to recommend the extent of the drainage design for the Design Concept Report (DCR) for the Downtown Intermodal Center Pedestrian Safety and Bus Access Improvement (DIMC) project. The DIMC DCR project consists of evaluating options to realign Pennington Street between Sixth Avenue and Toole Avenue, project location has been identified in Figure 1. Two alternatives are being considered; a roundabout and a "T" intersection. In addition to the DCR portion of the project, PB was contracted by City of Tucson to design 6th Avenue from 7th Street to Broadway Boulevard converting the existing one-way traffic to a permanent two-way traffic operation.

Improvements to the roadway itself are only being considered south and east from the 6th Avenue/ Toole Avenue/ Alameda Street intersection. Within this scope, the extent of the existing drainage system consists of three catch basins located at the 6th Avenue/ Toole Avenue/ Alameda Street intersection. PB has evaluated impacts to these catch basins from the options being considered for the DIMC project; as well as, reviewed the potential changes to this system as a result of the new roadway configuration.

Figure 1 shows the three existing catch basins (CB1, CB2 and CB3) at the intersection of 6th Avenue and Toole Avenue. One catch basin is located on the east side of 6th Avenue (CB1). The other two catch basins are located south, and north of Toole Avenue (CB2 and CB3). A photo log has been created to show the existing condition of the catch basins and is included in Appendix B-1. As seen on the photo log, the two catch basins, CB2 and CB 3, on Toole Avenue have been impacted by multiple overlays. These overlays have reduced the operational efficiency of these two catch basins. The opening heights of these catch basins have been reduced significantly compared to the original design as shown in the as-built plans located in Appendix B-2.

The preferred alternative was the "T" intersection. Therefore, this memo studies the hydrology and hydraulics for this option. Based on this cursory investigation, improvements to the roadways are not anticipated to negatively impact the existing flood condition, nor, will the improvements change the hydrologic conditions of the catch basins. However, recent overlays have reduced the efficiency of the two catch basins on Toole Avenue. It is recommended that these catch basins be replaced in-kind to restore historic efficiency of each catch basin.

The permanent two-way conversion of 6th Avenue with its associated pavement markings, signing, and traffic signal upgrades has been accelerated by TDOT ahead of the Pennington Street realignment. Therefore, no analysis was conducted for the two way conversion on 6th Avenue. The Pennington Street and Toole Avenue intersection was analyzed based on the DCR and is described below.

ANALYSES

DCR HYDROLOGY (Toole and Pennington)

A preliminary hydrologic analysis was conducted in order to identify approximate discharges impacting the Toole Avenue and Pennington Street Intersection. Upstream of the project, there are several curb inlets that capture a portion of runoff on the street. Figure 1 provides a general overview of flow paths and watersheds that drain into the project site. The City of Tucson Hydrology method (Simons, Li & Associates, 1989) (City Drainage Manual) was used to evaluate the concept hydrology. The 10-Year Event was analyzed to determine the effect of the runoff on the curb inlets, and the 100-Year Event was analyzed to evaluate the existing flood conditions within Toole Avenue. The hydrology does not change as a result of the preferred alternative. Neither intersection option will impact the hydrologic condition of the project site.

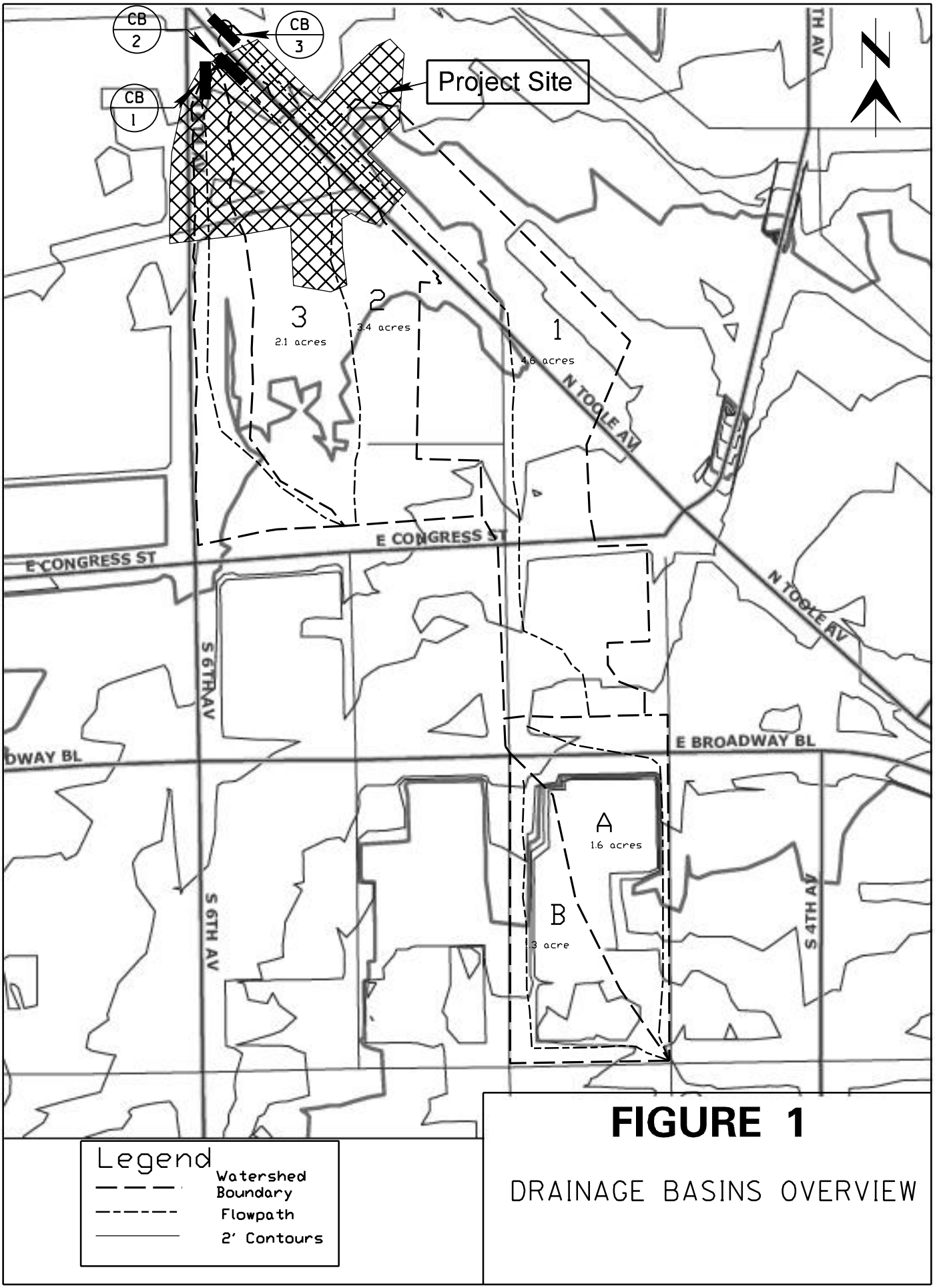


FIGURE 1

DRAINAGE BASINS OVERVIEW

DCR HYDRAULIC (Toole and Pennington)

The hydraulic programs, Flowmaster and Visual Urban, were used to analyze several cross sections throughout the project site and areas upstream of the project site to establish approximate flooding levels to establish a base flood condition in order to evaluate impacts to the flood level resulting from changes in roadway configuration. The City Drainage Manual was used to evaluate the amount of runoff that the Toole Avenue curb inlets, CB2 and CB3 capture. A combination of inlet capacity of the curb inlet and normal depth calculations were used to evaluate the discharge bypassing the curb inlets. There were no impacts to the existing flood levels from the "T" intersection option.

The roundabout option warrants further calculations, however, it is anticipated that the roundabout would create a longer flow path, reducing the longitudinal slope resulting in an increase of the water surface through the roundabout. This increase would potentially impact nearby buildings in the intersection vicinity. No analyses were conducted to evaluate the roundabout due to it not being selected as the preferred alternative.

RESULTS

The 100-Year event analysis shows that the flood level overtops the curbed section by about 2.5 inches. No impact is expected to the flood level as the "T" alternative will not change the Toole Avenue roadway configuration.

Under existing conditions, there is a significant amount of bypass from the project site. There are approximately 24-cfs in the 10- Year Event that bypasses the perimeter of the proposed project, where as in the 100-Year Event, there are approximately 60-cfs bypassing into the underpass, located north of the 6th Avenue and Toole Avenue Intersection. The catch basins will continue to operate as they currently do as long as project improvements do not alter the catch basin openings. The proposed conditions match the same results as existing conditions.

RECOMMENDATION

The preferred "T" Intersection will not significantly change the existing configuration of either roadway; therefore, no further analysis is necessary.

Related to the interaction of the project improvements with the existing catch basins, the pavement at the catch basins will be saw cut to prevent any disturbance. In order to reduce any potential negative impact to the effectiveness of the catch basins, the pavement should be taper milled to restore opening heights. Since the inlet efficiencies are not impacted, Design Team discussions have concluded that none of the three (3) existing catch basins will be reconstructed with this project.

APPENDIX B-1 - PHOTO LOG

PHOTO NO. 1 – CATCH BASIN EAST SIDE OF 6TH AVE. SOUTH OF TOOLE AVE

PHOTO NO. 2 – CATCH BASIN EAST SIDE OF 6TH AVE LOOKING SOUTH

PHOTO NO. 3 – CATCH BASIN EAST SIDE OF 6TH AVE LOOKING NORTH

PHOTO NO. 4 – CATCH BASIN SOUTH SIDE OF TOOLE AVE EAST OF 6TH AVE. LOOKING WEST

PHOTO NO. 5 – CATCH BASIN SOUTH SIDE OF TOOLE AVE LOOKING EAST

PHOTO NO. 6 – CATCH BASIN SOUTH SIDE OF TOOLE AVE . PAVEMENT OVERLAID CONCRETE APRON/GUTTER TO EXTENT OF RESTRICTING OPENING HEIGHT

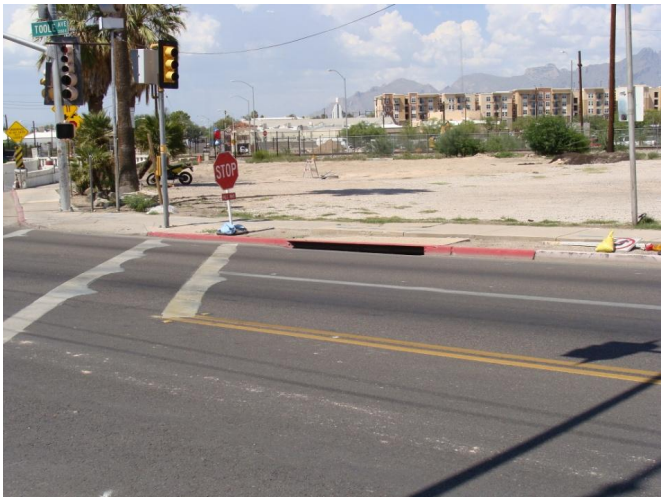
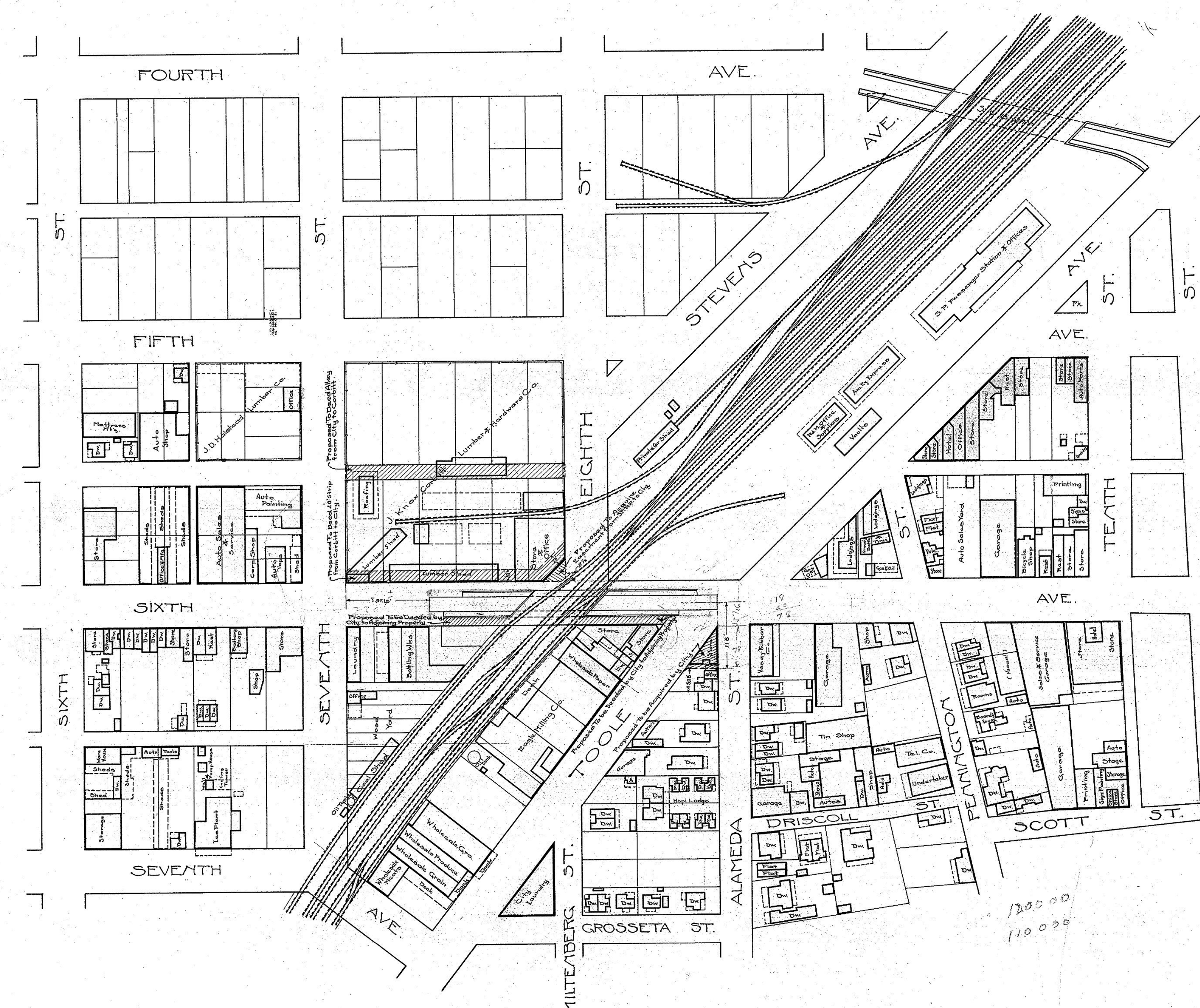


PHOTO NO. 7 – CATCH BASIN NORTH SIDE OF TOOLE AVE EAST OF 6TH AVE

PHOTO NO. 8 – CATCH BASIN NORTH EAST CORNER OF TOOLE AVE AND 6TH AVE (LOOKING WEST)

APPENDIX B-2 – AS-BUILTS

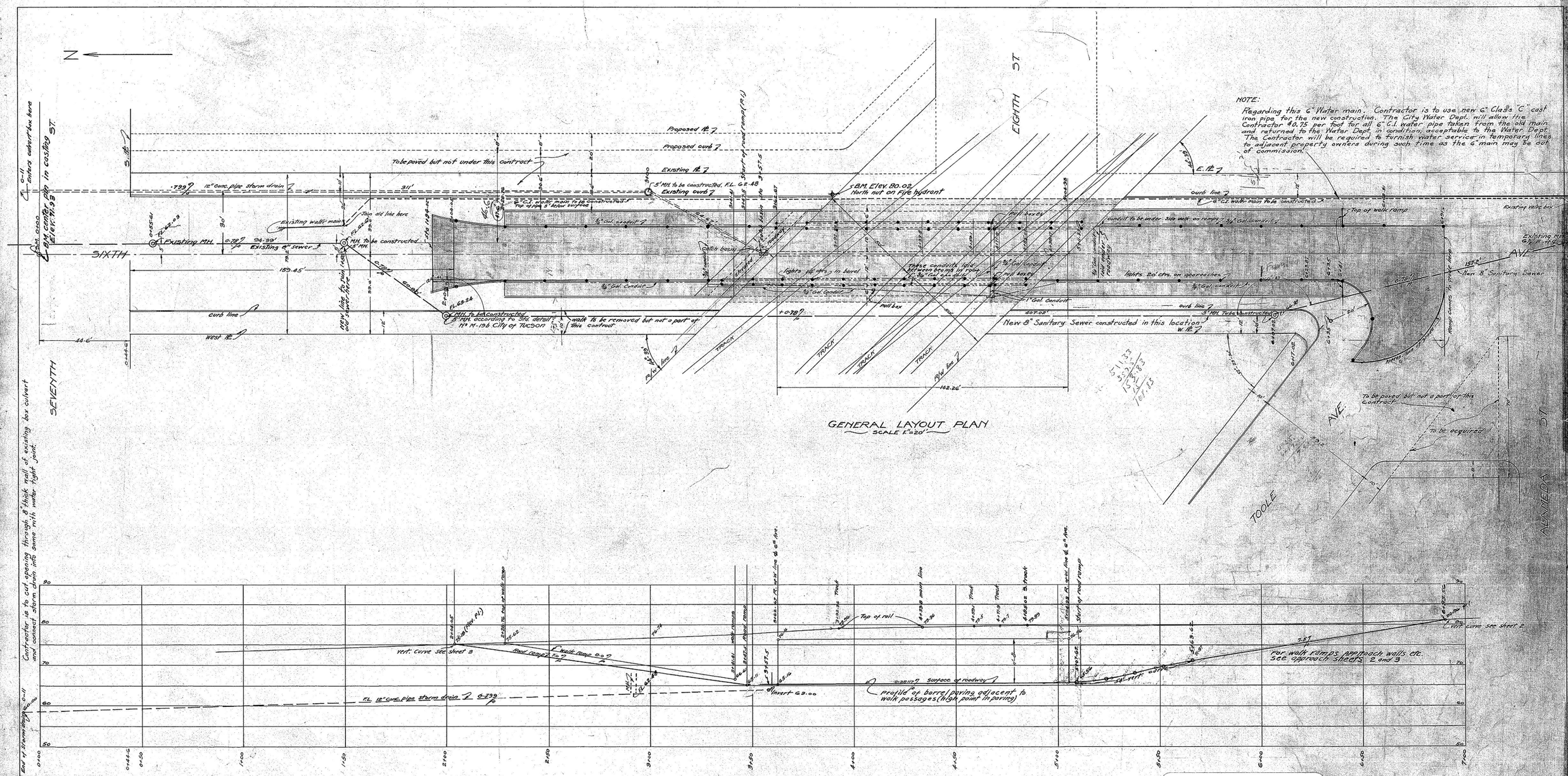


INCHES
0 1 2 3

PLAN NO. I-336
SHT. NO. 1 of 9
SCALE 1" = 100'

000077

CITY OF TUCSON
ENGINEERING DEPARTMENT
PLAN No. I-336
LOCATION OF
SIXTH AVENUE SUBWAY
SCALE: 1" = 100' — APRIL, 1926
GEO. T. GROVE, CITY ENGINEER
REGISTERED PROFESSIONAL ENGINEER



GENERAL LAYOUT PLAN
SCALE 1" = 20'

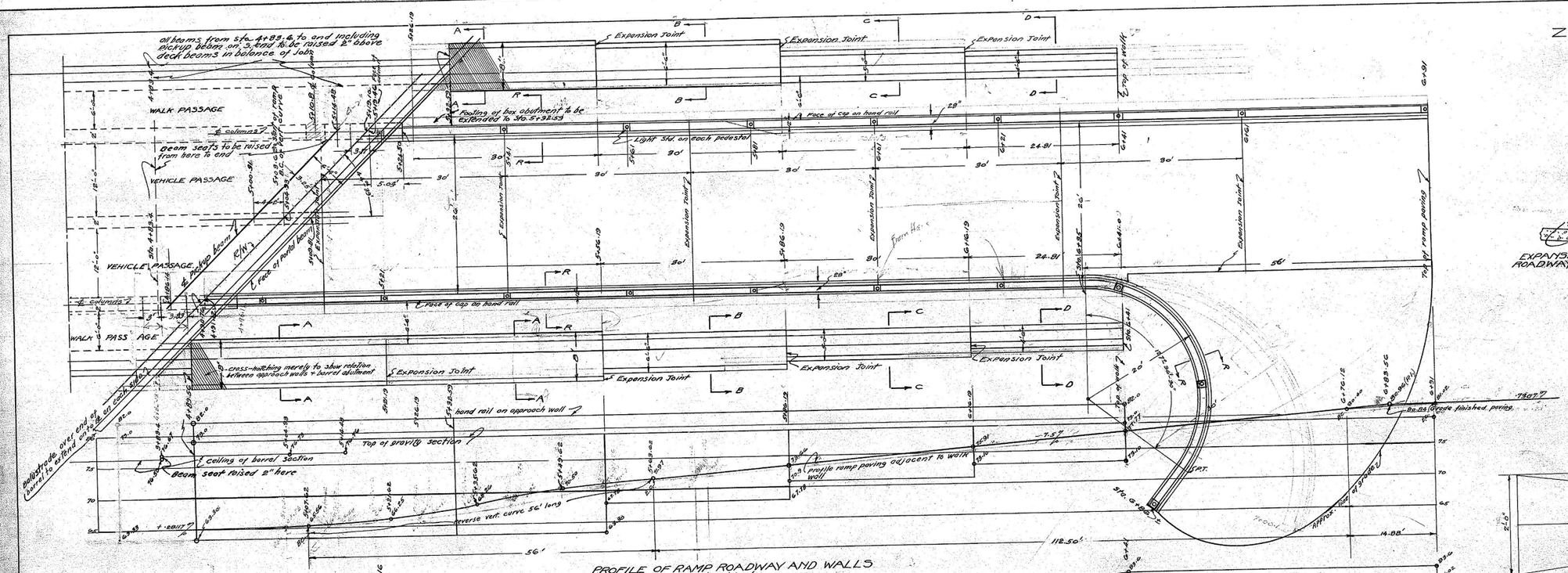
PROFILE
BARREL AND RAMPS

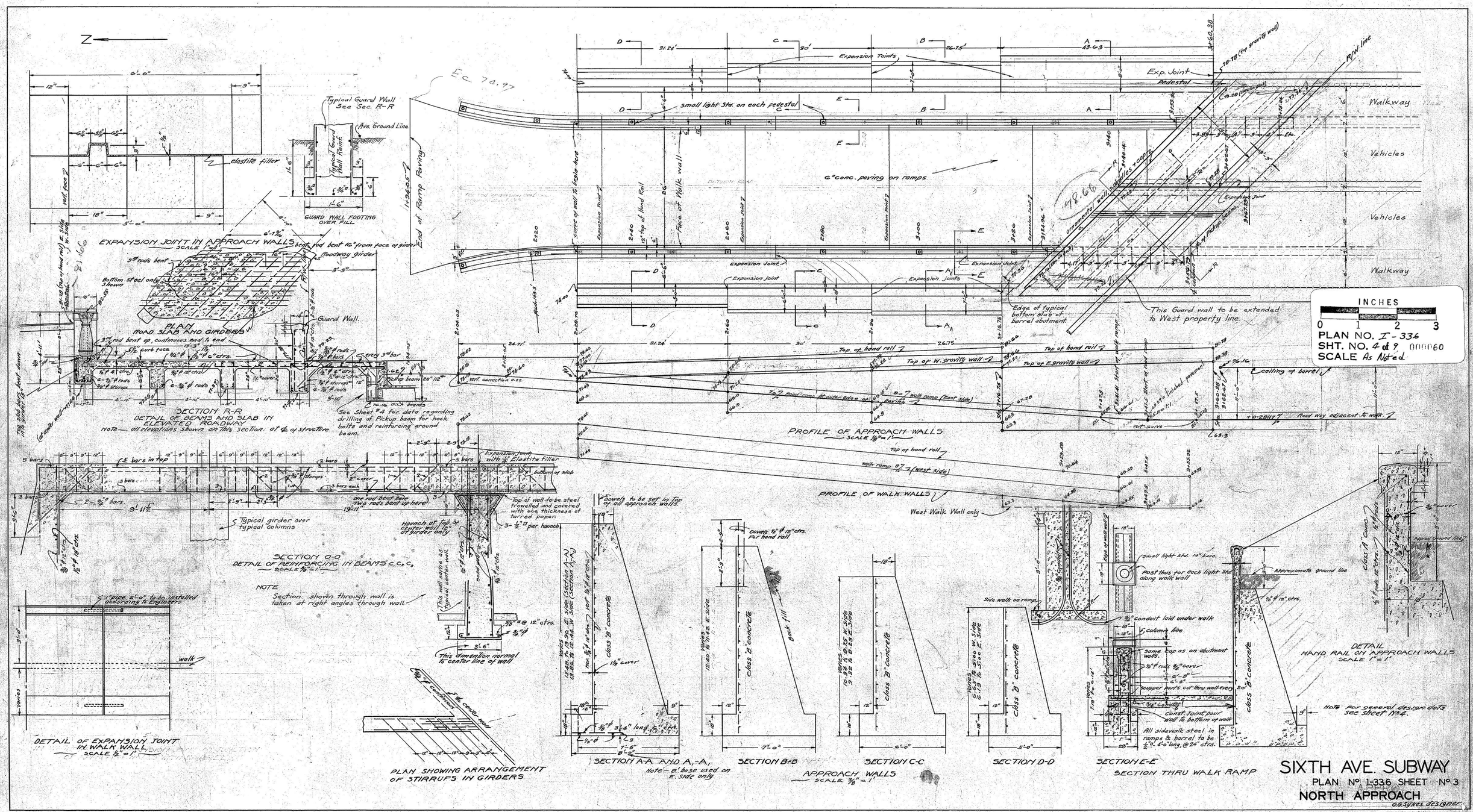
NOTE:
Regarding this 6" Water main. Contractor is to use new 6" Class "C" cast iron pipe for the new construction. The City Water Dept. will allow the Contractor $0.75 per foot for all 6" C.I. water pipe taken from the old main and returned to the Water Dept. in condition, acceptable to the Water Dept. The Contractor will be required to furnish water service in temporary lines to adjacent property owners during such time as the 6" main may be off of commission.

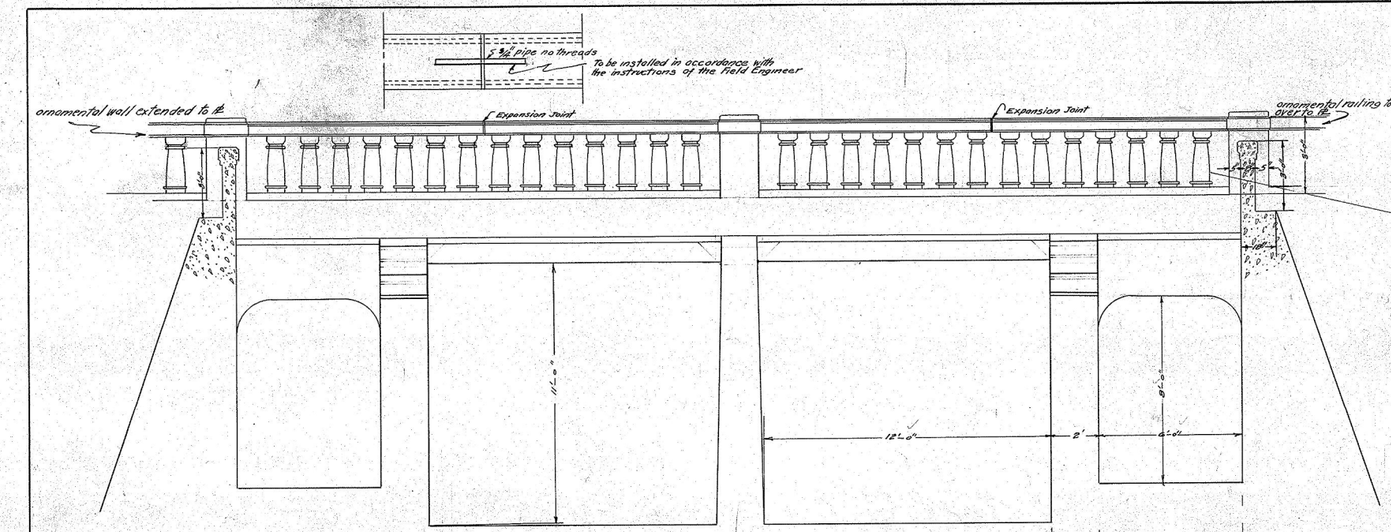
INCHES
0 1 2 3

PLAN NO. I-336
SHT. NO. 2 of 9
SCALE As Noted

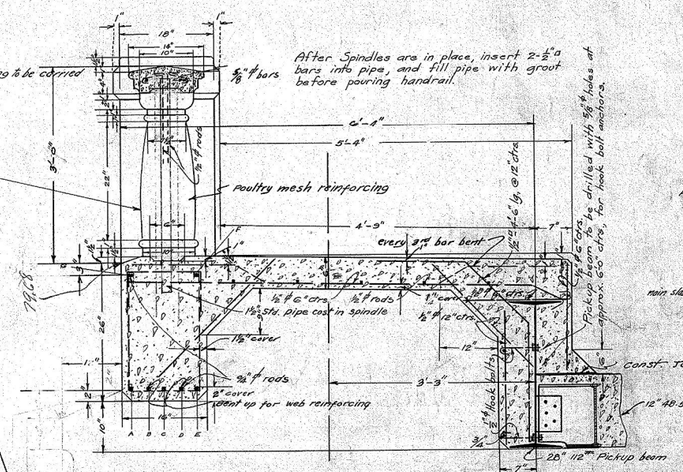
CITY OF TUCSON
ENGINEERING DEPARTMENT
SIXTH AVE. SUBWAY
PLAN No. I-336
GEO. T. GROVE CITY ENGINEER
LAYOUT PLAN
SHEET No. 1
G.G. Sykes designer


WALK PASSAGE
VEHICLE PASSAGE
VEHICLE PASSAGE
WALK PASSAGE
Expansion Joint
Top of walk
Footing of box abutment to be extended to Sta. 5+92.59
Face of cap on hand rail
Light std. on each pedestal
Beam seats to be raised from here to end
Face of cap on hand rail
cross-hatching merely to show relation between approach walls & barrel abutment
hand rail on approach walls
Top of gravity section
Ceiling of barrel section
Beam seat raised 2" here
reverse vert. curve 56' long
profile ramp paving adjacent to walk wall
Top of ramp paving
Grade finished paving
Approx. line of grade
Top of ramp paving
PROFILE OF RAMP ROADWAY AND WALLS
SCALE 1/8"=1'
hand rail on walk wall
surface of walk
at low side
profile on walk surface at low side adjacent to walk wall
base of footing of walk wall
base of footing walk wall
PROFILE OF WALK AND WALK WALLS
hand rail on walk wall
base of footing walk wall
PROFILE OF CURVED PORTION OF WALK WALL
EXPANSION JOINT IN ROADWAY PAVING 30' CTRS.
DETAIL OF PAVING ANCHOR TO BE INSTALLED ON RAMPS
SCALE 1/2"=1'
PLAN
6'-0"
ELEVATION
Detail of Wheel Guard. Construct one at each end of center Wall.
Fin. Pavement
Section 6-6
Reinforcing same as here shown in all gravity approach walls
SECTION "A-A"
SECTION B-B
DETAIL OF APPROACH WALL
SECTION C-C
SECTION D-D
SECTION R-R
SECTION THRU WALK RAMP
curb
headers.
steel not shown
TYPICAL SECTION THRU RAMP
SCALE 1/8"=1'
For general design data see sheet #4
INCHES
0 1 2 3
PLAN NO. I-336
SHT. NO. 3 of 9
SCALE As Noted
SIXTH AVE. SUBWAY
PLAN Nº 1-336 SHEET Nº 2
SOUTH APPROACH
A.G. Sykes designer

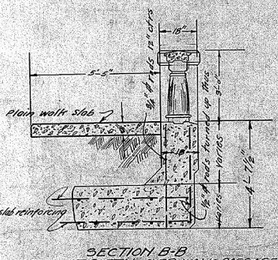

Z
Elastite filler
Typical Guard Wall See Sec. R-R
Ave. Ground Line
GUARD WALL FOOTING OVER FILL
EXPANSION JOINT IN APPROACH WALLS
SCALE 1"=1'
floodway girder
Bottom steel only shown
PLAN ROAD SLAB AND GIRDERS
Guard Wall.
SECTION R-R
DETAIL OF BEAMS AND SLAB IN ELEVATED ROADWAY
Note— all elevations shown on this section at ℄ of structure
See Sheet #4 for data regarding drilling of Pickup beam for hook bolts and reinforcing around beam.
Expansion joint with ½" Elastite filler
Typical girder over typical columns
SECTION O-O
DETAIL OF REINFORCING IN BEAMS C, C₂ C₃
SCALE ⅜"=1'
NOTE
Section shown through wall is taken at right angles through wall.
This dimension normal to center line of wall
DETAIL OF EXPANSION JOINT IN WALK WALL
SCALE ½"=1'
PLAN SHOWING ARRANGEMENT OF STIRRUPS IN GIRDERS
End of Ramp Paving
Small light std. on each pedestal
6" conc. paving on ramps
Expansion Joints
Face of Walk wall
Top of Hand Rail
Top of W. gravity wall
Top of E. gravity wall
Road way adjacent to wall
Ceiling of barrel
Edge of typical bottom slab of barrel abutment.
This Guard wall to be extended to West property line.
Walkway
Vehicles
Vehicles
Walkway
INCHES
0 1 2 3
PLAN NO. I-336
SHT. NO. 4 of 9
SCALE As Noted
PROFILE OF APPROACH WALLS
SCALE ⅛"=1'
PROFILE OF WALK WALLS
West Walk Wall only
Dowels to be set in top of all approach walls.
Dowels ½" ϕ 12" ctrs. for hand rail
Back fill
class B concrete
SECTION A-A AND A₁-A₁
Note— 8' base used on E. side only
SECTION B-B
SECTION C-C
APPROACH WALLS
SCALE ⅜"=1'
Side walk on ramp
SECTION D-D
Post thus for each light std. along walk wall
¾" conduit laid under walk
Column line
Same cap as on abutment walls.
Scupper ports cut thru wall every
¾" conduit
Const. joint, pour wall to bottom of walk
All sidewalk steel in ramps & barrel to be ½" ϕ, 4'-6" long, @ 24" ctrs.
SECTION E-E
SECTION THRU WALK RAMP
Approximate ground line
DETAIL HAND RAIL ON APPROACH WALLS
SCALE 1"=1'
Note for general design data see Sheet No 4.
SIXTH AVE. SUBWAY
PLAN No. I-336 SHEET No 3
NORTH APPROACH
G.G. Sykes designer



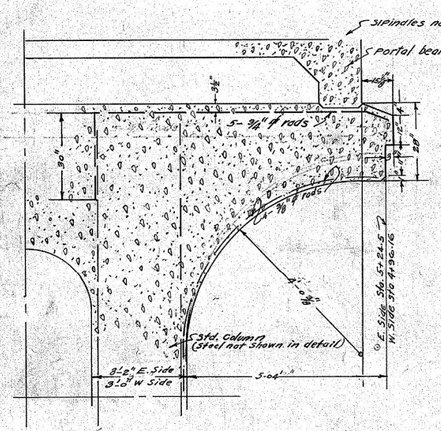
ELEVATION OF SOUTH PORTAL
SCALE 3/8"=1'



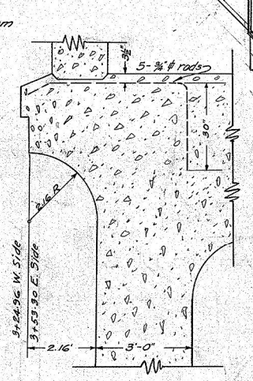
SECTION A-A
DETAIL OF PORTAL BEAM AND REINFORCED WALK
SCALE 1"=1'



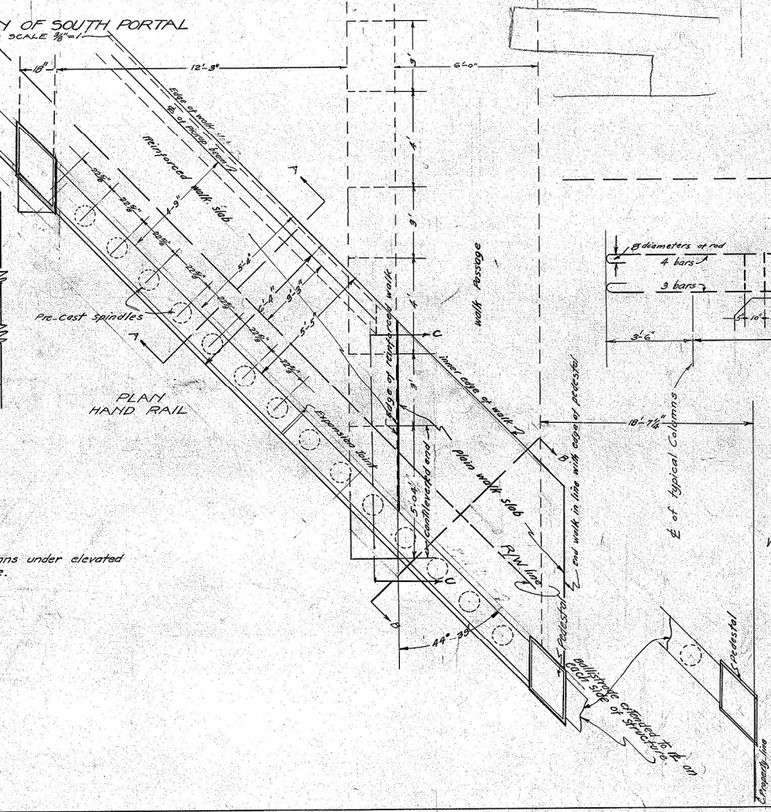
SECTION B-B
DETAIL AT PORTAL OVER WALK PASSAGE
SCALE 3/8"=1'



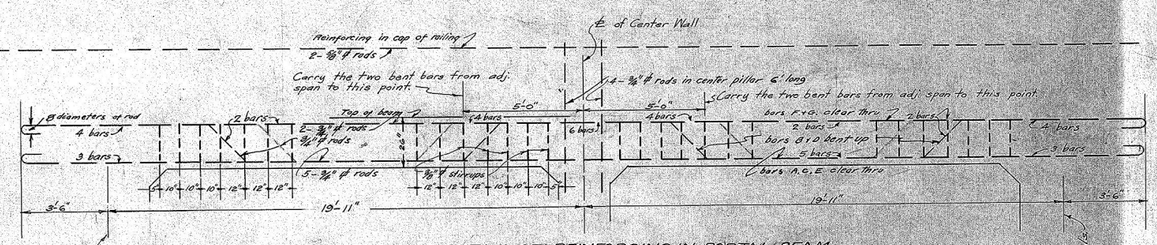
SECTION "CC"
END COLUMNS CANTILEVERED TO CARRY BALUSTRADE
SCALE 1/2"=1'



SECTION X-X
Detail of Cantilever at end columns under elevated roadway at N. end of structure.



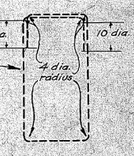
PLAN
HAND RAIL



DETAIL OF REINFORCING IN PORTAL BEAM
SCALE 3/8"=1'

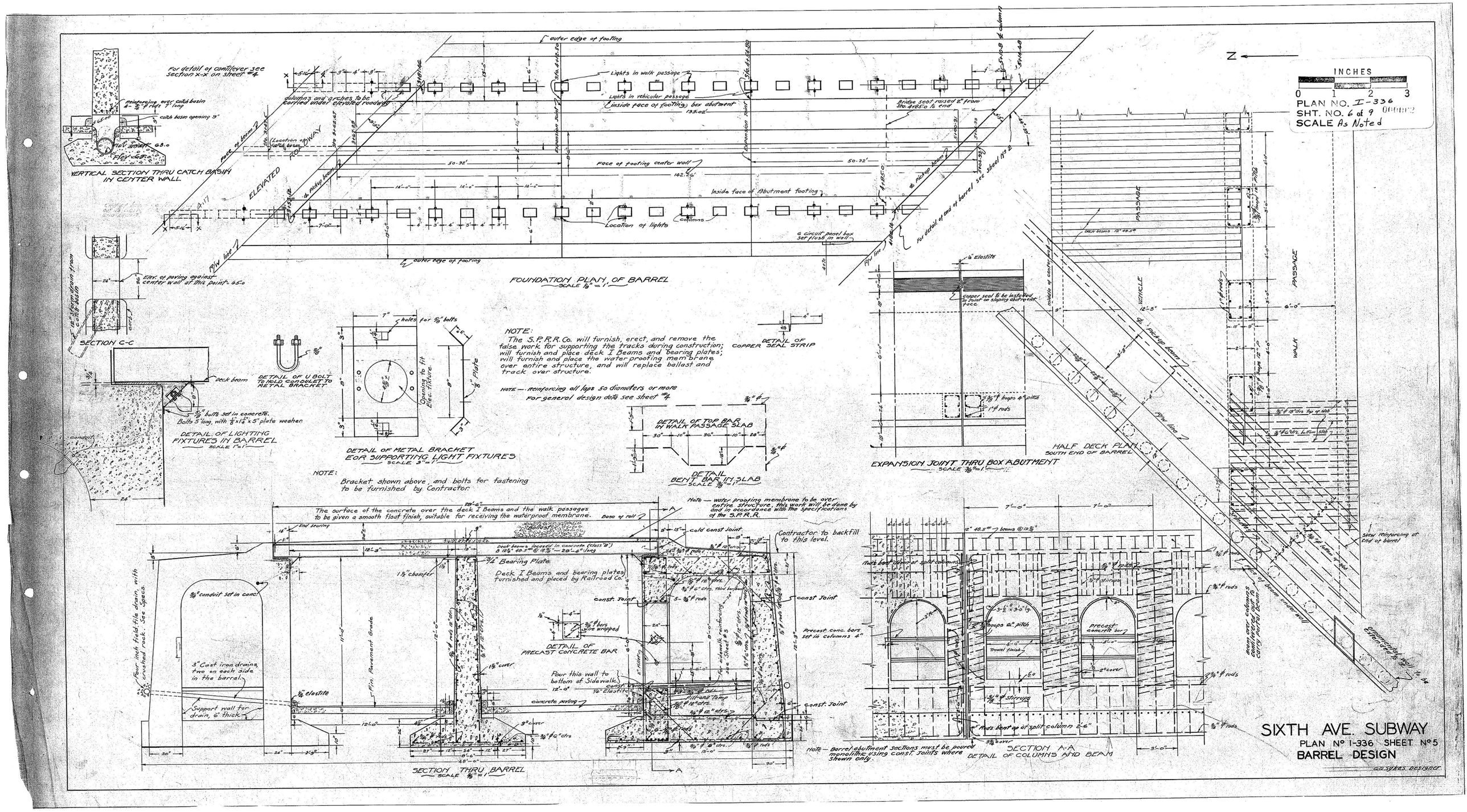
GENERAL NOTES ON DESIGN & DETAIL

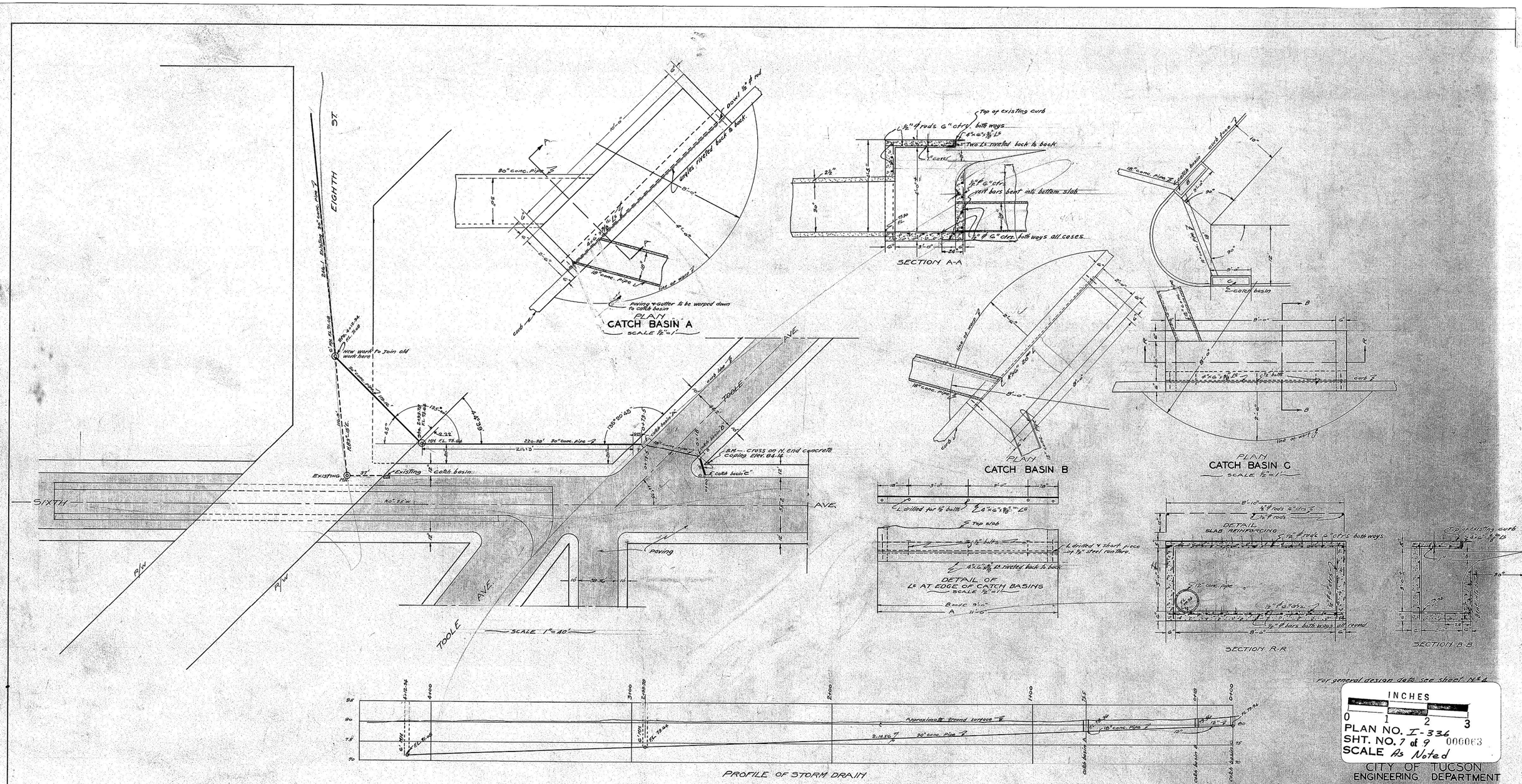
Structure designed for a safe bearing value of soil of 4300# per sq. ft. throughout.
All class "A" concrete designed for 2000#/□" ultimate compressive stress.
" " "B" " " 1500#/□" " "
Reinforcing steel intermediate grade, deformed throughout.
Wherever bars are spliced in field same shall lap each other not less than 50 diameters.
Dimensions shown from face of concrete to reinforcing bars are in all cases to center of bar.
Wherever bars are shown or called for to be bent the radius of each bend shall be not less than 4 diameters.
All hooks shall return at least 10 diameters beyond end of bend.
All concrete is class "A" except as noted.
All stirrups throughout the job shall be bent as shown with a coverage of concrete of 2 diameters on all sides.
If backfill behind retaining walls is placed by flooding, same shall be flooded in layers not to exceed one-third the height of the wall, and each layer allowed to dry and pack before flooding successive layer.

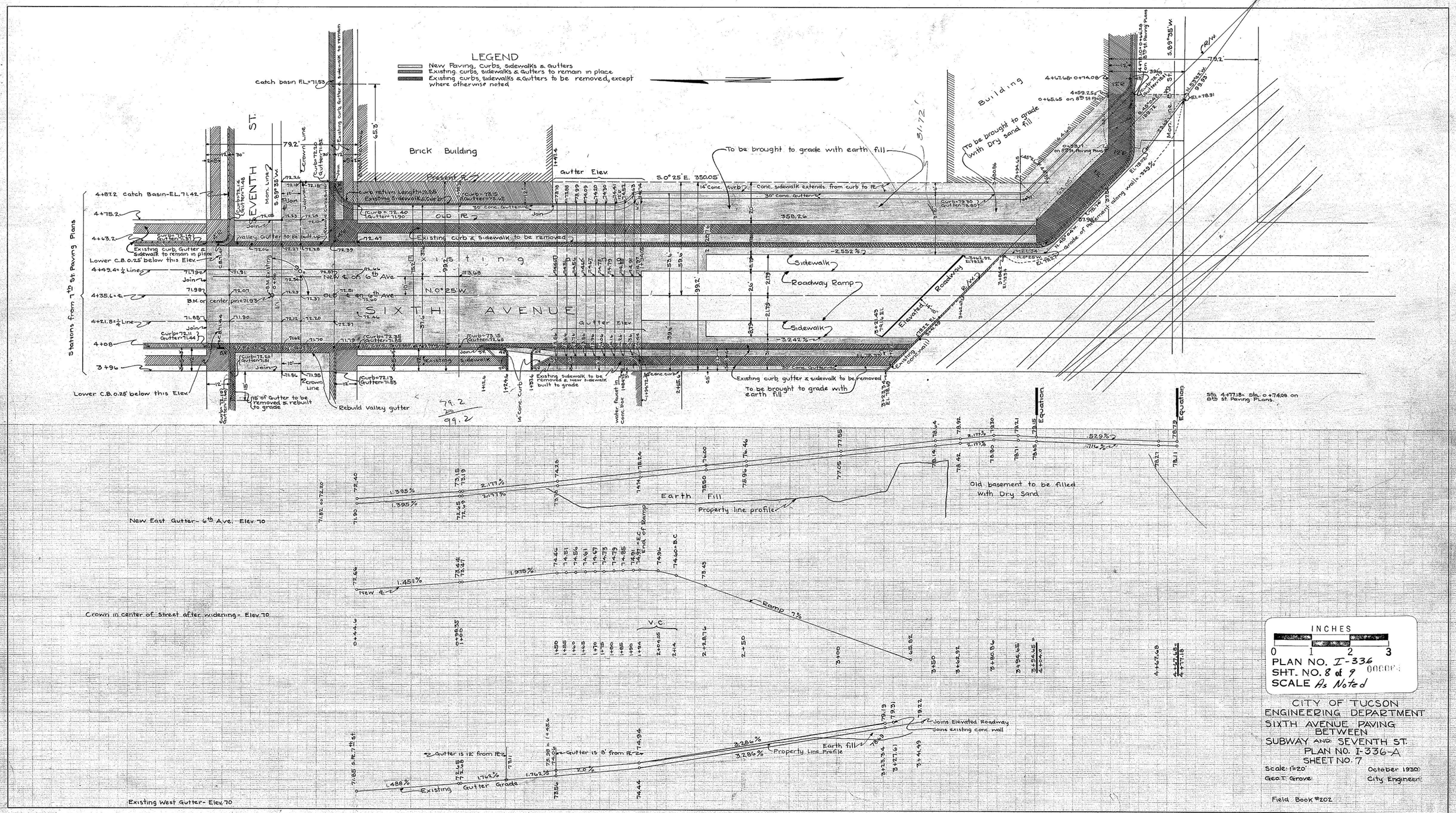


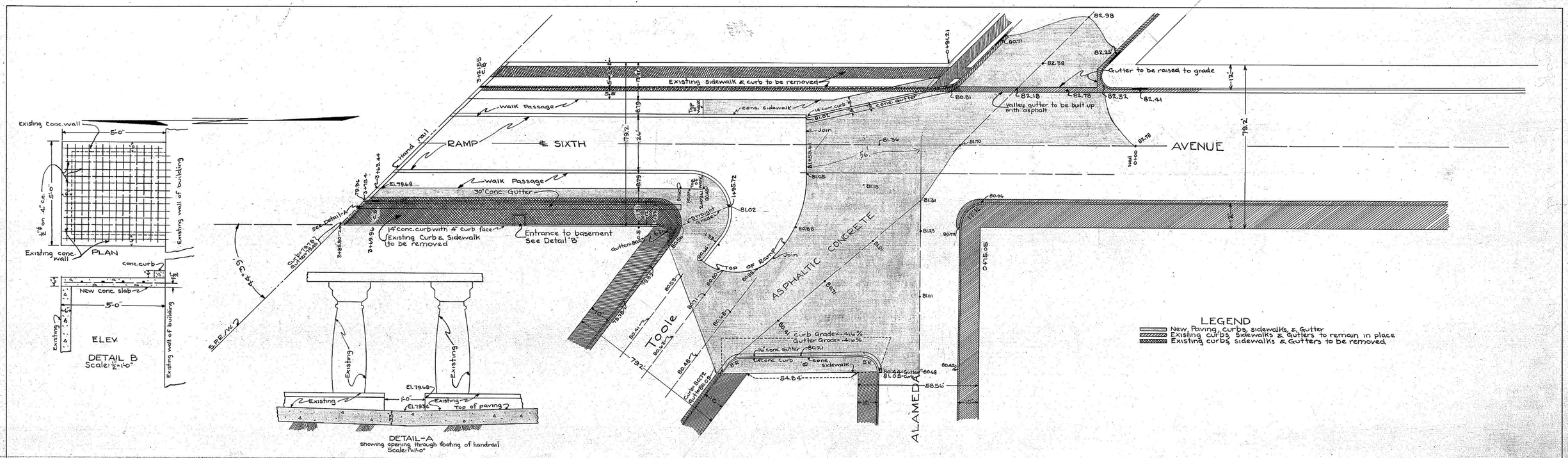
INCHES
0 1 2 3
PLAN NO. I-336
SHT. NO. 5 of 9
SCALE As Noted

SIXTH AVE. SUBWAY
PLAN N° I-336 SHEET N° 4
SOUTH PORTAL ELEVATION
G.C. Sykes Designer


INCHES
0 1 2 3
PLAN NO. I-336
SHT. NO. 6 of 9
SCALE As Noted
N
VERTICAL SECTION THRU CATCH BASIN IN CENTER WALL
For detail at cantilever see section x-x on sheet #4
FOUNDATION PLAN OF BARREL
SCALE 1/8" = 1'
ELEVATED
ROADWAY
Lights in walk passage
Lights in vehicular passage
Inside face of footing, box abutment
Face of footing center wall
Inside face of abutment footing
Location of lights
Columns
Bridge seat raised 2" from Sta. 4+85.0 to end
For detail of end of barrel see sheet 17
outer edge of footing
PASSAGE
VEHICLE
WALK
SECTION C-C
DETAIL OF LIGHTING FIXTURES IN BARREL
DETAIL OF U BOLT TO HOLD CONDUIT TO METAL BRACKET
DETAIL OF METAL BRACKET FOR SUPPORTING LIGHT FIXTURES
SCALE 3"=1'
NOTE:
Bracket shown above and bolts for fastening to be furnished by Contractor.
NOTE:
The S.P.R.R.Co. will furnish, erect, and remove the false work for supporting the tracks during construction; will furnish and place deck I Beams and bearing plates; will furnish and place the waterproofing membrane over entire structure, and will replace ballast and track over structure.
NOTE — reinforcing all laps 50 diameters or more
For general design data see sheet #4
DETAIL OF COPPER SEAL STRIP
DETAIL OF TOP BAR IN WALK PASSAGE SLAB
DETAIL BENT BAR IN SLAB
SCALE 3/8"=1'
EXPANSION JOINT THRU BOX ABUTMENT
SCALE 3/8"=1'
HALF DECK PLAN SOUTH END OF BARREL
The surface of the concrete over the deck I Beams and the walk passages to be given a smooth float finish, suitable for receiving the waterproof membrane.
Note — waterproofing membrane to be over entire structure, this work will be done by and in accordance with the specifications of the S.P.R.R.
Contractor to backfill to this level.
Deck I Beams and bearing plates furnished and placed by Railroad Co.
DETAIL OF PRECAST CONCRETE BAR
Pour this wall to bottom of Sidewalk.
Support wall for drain, 6" thick
3" Cast iron drains, two on each side in the barrel.
Four inch field tile drain, with 3/4" crushed rock. See Specs.
SECTION THRU BARREL
SCALE 3/8"=1'
Note — Barrel abutment sections must be poured monolithic using const. joints where shown only.
SECTION A-A
DETAIL OF COLUMNS AND BEAM
SIXTH AVE. SUBWAY
PLAN No 1-336 SHEET No 5
BARREL DESIGN
G.A. Sykes Designer


EIGHTH ST.
SIXTH AVE.
TOOLE AVE.
R/W
R/W
New work to join old work here
Existing catch basin
Paving
SCALE 1" = 40'
PLAN
CATCH BASIN A
SCALE 1/2" = 1'
SECTION A-A
PLAN
CATCH BASIN B
PLAN
CATCH BASIN C
SCALE 1/2" = 1'
DETAIL OF
L's AT EDGE OF CATCH BASINS
SCALE 1/2" = 1'
DETAIL
SLAB REINFORCING
SECTION R-R
SECTION B-B
PROFILE OF STORM DRAIN
Approximate ground surface
30" conc. Pipe
18" conc. Pipe
For general design data see sheet No. 4
INCHES
0 1 2 3
PLAN NO. I-336
SHT. NO. 7 of 9
SCALE As Noted
CITY OF TUCSON
ENGINEERING DEPARTMENT
CATCH BASINS
AND STORM DRAIN
INTERSECTION OF SIXTH AVE. & TOOLE AVE.
PLAN No I-336
SHEET No 6


LEGEND
New Paving, curbs, sidewalks & gutters
Existing curbs, sidewalks & gutters to remain in place
Existing curbs, sidewalks & gutters to be removed, except where otherwise noted
SEVENTH ST.
SIXTH AVENUE
Brick Building
Building
Catch basin EL.=71.53
4+87.2 catch Basin-EL.71.42
Stations from 7th St. Paving Plans
Lower C.B. 0.25' below this Elev.
Existing curb, Gutter & Sidewalk to remain in place
Valley Gutter to be built up
Existing curb & sidewalk to be removed
To be brought to grade with earth fill
To be brought to grade with dry sand fill
Sidewalk
Roadway Ramp
Elevated Roadway
Rebuild valley gutter
18" of Gutter to be removed & rebuilt to grade
Existing sidewalk to be removed & new sidewalk built to grade
Existing curb gutter & sidewalk to be removed
To be brought to grade with earth fill
Old basement to be filled with Dry Sand
Earth Fill
Property line profile
New East Gutter- 6th Ave. Elev. 70
Crown in center of Street after widening- Elev. 70
Existing West Gutter- Elev. 70
Existing Gutter Grade
Joins Elevated Roadway
Joins existing conc. wall
Equation
Ramp 7%
INCHES
0 1 2 3
PLAN NO. I-336
SHT. NO. 8 of 9
SCALE As Noted
CITY OF TUCSON
ENGINEERING DEPARTMENT
SIXTH AVENUE PAVING
BETWEEN
SUBWAY AND SEVENTH ST.
PLAN NO. I-336-A
SHEET NO. 7
Scale: 1"=20'
October 1930
Geo. T. Grove
City Engineer
Field Book #202


Existing Conc. wall
5'-0"
PLAN
Existing wall of building
New Conc. slab
ELEV.
DETAIL B
Scale: ½"=1'-0"
Hand rail
RAMP
℄ SIXTH
Walk Passage
30" Conc. Gutter
14" Conc. curb with 4" curb face
Existing Curb & Sidewalk to be removed
Entrance to basement See Detail "B"
Existing Sidewalk & curb to be removed
Gutter to be raised to grade
Valley gutter to be built up with asphalt
AVENUE
ASPHALTIC CONCRETE
TOOLE
ALAMEDA
Top of Ramp
Join
Curb Grade = .416%
Gutter Grade = .416%
14" Conc. Gutter
14" Conc. Curb
6" Conc. Sidewalk
54.84'
58.56'
79.2'
12'
LEGEND
New Paving, curbs, sidewalks & Gutter
Existing curbs, sidewalks & Gutters to remain in place
Existing curbs, sidewalks & Gutters to be removed
DETAIL-A
showing opening through footing of handrail
Scale: 1"=1'-0"
Top of paving
Existing
East Side - Elev. 80.0
.630%
Gutter ℄ Elev. 80.0
.606%
West Side - Elev. 80.0
.744%
.615%
Top of walk
Edge of Ramp wall
INCHES
0 1 2 3
PLAN NO. I-336
SHT. NO. 9 of 9
SCALE As Noted
CITY OF TUCSON
ENGINEERING DEPARTMENT
SIXTH AVENUE PAVING
AT INTERSECTION
OF
TOOLE AVE. & ALAMEDA ST.
PLAN NO. I-336-A
SHEET NO. 8
Scale: 1"=20'
October 1930
Geo. T. Grove
City Engineer
Field Book #202

APPENDIX B-3 – HYDROLOGY

CITY OF TUCSON
HYDROLOGIC DATA SHEET FOR COMPUTING 100-YEAR PEAK DISCHARGE (Qp100)

PB Project No.:	**11536C**	
Project Name:	**DCIM**	
CP Desc:	**A**	
	EXISTING CONDITION, Upstream of CP-1	
DA:	1.60	-Acres
Lc:	699.0	-Feet
Lca:	367.0	-Feet

Calc'd:	Ruvalcaba	Date:	
Chk'd:		Date:	

Slope Computation --

CPi	*Dli*	*Dhi*	*Si*
	699.0	8.0	0.0114
Lc:	**699.0**	**Sc:**	**0.0114**

Land Use --

Description	*Channel Type*	*Basin Factor*	*Area Factor*
Commercial/Indus	DF	0.048	0.90
	n_{bw100}:	**0.048**	**F_{ACW}:** **0.90**

P_{1-100}: 3.00 Inches

F_{ACW} OVERRIDE: **1.00**

Soils--

CPi	*Description*	*Sub-area (acres)*	*B (%)*	*C_B (-)*	*C (%)*	*C_C (-)*	*D (%)*	*C_D (-)*	*I (%)*	*C_I (-)*	*C (-)*
	Commercial/Industr	1.60					100	0.77	98	0.96	0.96
										Cw:	**0.96**

	Calc'd	Used
T_{C100}=	**6.27**	**6.27**

$$T_{C-100} = \left(\frac{0.23 n_{bw100} \left(LcLca \right)^{0.3}}{\left(ScP_{1,100} C_{W100} \right)^{0.4}} + 1.31 \right)$$

i_{100}=	**9.14**

$$i_{100} = \frac{4 \times P_{1,100}}{\left(1 + 0.05\, T_{C\,100} \right)}$$

Aerial Weight Computation --

Description	*Area (Ac)*	*2-Yr Ratio*	*5-Yr Ratio*	*10-Yr Ratio*	*25-Yr Ratio*	*50-Yr Ratio*	F_{ACW}
Commercial/Indus	1.60	0.22	0.35	0.50	0.70	0.90	0.90
Weighted Average:		**0.22**	**0.35**	**0.50**	**0.70**	**0.90**	**0.90**

Q_{100}=	**14.0**
Q_{50}=	**12.6**
Q_{25}=	**9.8**
Q_{10}=	**7.0**
Q_5=	**4.9**
Q_2=	**3.1**

CITY OF TUCSON
HYDROLOGIC DATA SHEET FOR COMPUTING 100-YEAR PEAK DISCHARGE (Qp100)

PB Project No.:	**11536C**	
Project Name:	**DCIM**	
CP Desc:	**2**	
	EXISTING CONDITION, Upstream of CP-1	
DA:	1.30	-Acres
Lc:	636.0	-Feet
Lca:	270.0	-Feet

Calc'd:	Ruvalcaba	Date:	
Chk'd:		Date:	

Slope Computation --

CPi	*Dli*	*Dhi*	*Si*
	636.0	8.0	0.0126
Lc:	**636.0**	**Sc:**	**0.0126**

Land Use --

Description	*Channel Type*	*Basin Factor*	*Area Factor*
Commercial/Indus	DF	0.048	0.90
	n_{bw100}:	**0.048**	**F_{ACW}:** **0.90**

P_{1-100}: 3.00 Inches

F_{ACW} OVERRIDE: **1.00**

Soils--

CPi	*Description*	*Sub-area (acres)*	*B (%)*	*C_B (-)*	*C (%)*	*C_C (-)*	*D (%)*	*C_D (-)*	*I (%)*	*C_I (-)*	*C (-)*
	Commercial/Industr	1.30					100	0.77	98	0.96	0.96
										Cw:	**0.96**

	Calc'd	Used
T_{C100}=	**5.43**	**5.43**

$$T_{C-100} = \left(\frac{0.23 n_{bw100} \left(LcLca \right)^{0.3}}{\left(ScP_{1,100} C_{W100} \right)^{0.4}} + 1.31 \right)$$

i_{100}=	**9.44**

$$i_{100} = \frac{4 \times P_{1,100}}{\left(1 + 0.05\, T_{C\,100} \right)}$$

Aerial Weight Computation --

Description	*Area (Ac)*	*2-Yr Ratio*	*5-Yr Ratio*	*10-Yr Ratio*	*25-Yr Ratio*	*50-Yr Ratio*	F_{ACW}
Commercial/Indus	1.30	0.22	0.35	0.50	0.70	0.90	0.90
Weighted Average:		**0.22**	**0.35**	**0.50**	**0.70**	**0.90**	**0.90**

Q_{100}=	**11.7**
Q_{50}=	**10.6**
Q_{25}=	**8.2**
Q_{10}=	**5.9**
Q_5=	**4.1**
Q_2=	**2.6**

CITY OF TUCSON
HYDROLOGIC DATA SHEET FOR COMPUTING 100-YEAR PEAK DISCHARGE (Qp100)

PB Project No.:	**11536C**	
Project Name:	**DCIM**	
CP Desc:	**1**	
	EXISTING CONDITION, Toole Ave.	
DA:	4.60	-Acres
Lc:	1354.0	-Feet
Lca:	705.0	-Feet

Calc'd:	David Ruvalcaba	Date:	
Chk'd:		Date:	

Slope Computation --

CPi	Dli	Dhi	Si
	1354.0	13.0	0.0096
Lc:	**1354.0**	**Sc:**	**0.0096**

Land Use --

Description	Channel Type	Basin Factor		Area Factor
Commercial/Indus	DF	0.048		0.90
		n_{bw100}:	**F_{ACW}:**	**0.90**

P_{1-100}: 3.00 Inches

F_{ACW} OVERRIDE: **1.00**

Soils--

CPi	Description	Sub-area (acres)	B (%)	C_B (-)	C (%)	C_C (-)	D (%)	C_D (-)	I (%)	C_I (-)	C (-)
	Commercial/Industr	4.60					100	0.77	90	0.96	0.94
										Cw:	**0.94**

	Calc'd	Used
T_{C100}=	**10.15**	**10.15**

$$T_{C-100} = \left(\frac{0.23 n_{bw100} (LcLca)^{0.3}}{(ScP_{1,100} C_{W100})^{0.4}} + 1.31 \right)$$

i_{100}=	**7.96**

$$i_{100} = \frac{4 \times P_{1,100}}{(1 + 0.05\, T_{C\,100})}$$

Aerial Weight Computation --

Description	Area (Ac)	2-Yr Ratio	5-Yr Ratio	10-Yr Ratio	25-Yr Ratio	50-Yr Ratio	F_{ACW}
Commercial/Indus	4.60	0.22	0.35	0.50	0.70	0.90	0.90
Weighted Average:		**0.22**	**0.35**	**0.50**	**0.70**	**0.90**	**0.90**

Q_{100}=	**34.5**
Q_{50}=	**31.0**
Q_{25}=	**24.1**
Q_{10}=	**17.2**
Q_5=	**12.1**
Q_2=	**7.6**

CITY OF TUCSON
HYDROLOGIC DATA SHEET FOR COMPUTING 100-YEAR PEAK DISCHARGE (Qp100)

PB Project No.:	**11536C**	
Project Name:	**DCIM**	
CP Desc:	**1a**	
	EXISTING CONDITION, Toole Ave., South East of Toole and Pennington Intersection	
DA:	3.80	-Acres
Lc:	983.0	-Feet
Lca:	446.0	-Feet

Calc'd:	David Ruvalcaba	Date:	
Chk'd:		Date:	

Slope Computation --

CPi	Dli	Dhi	Si
	983.0	9.0	0.0092
Lc:	**983.0**	**Sc:**	**0.0092**

Land Use --

Description	Channel Type	Basin Factor		Area Factor
Commercial/Indus	DF	0.048		0.90
		n_{bw100}:	**F_{ACW}:**	**0.90**

P_{1-100}: 3.00 Inches

F_{ACW} OVERRIDE: **1.00**

Soils--

CPi	Description	Sub-area (acres)	B (%)	C_B (-)	C (%)	C_C (-)	D (%)	C_D (-)	I (%)	C_I (-)	C (-)
	Commercial/Industr	4.60					100	0.77	90	0.96	0.94
										Cw:	**0.94**

	Calc'd	Used
T_{C100}=	**8.07**	**8.07**

$$T_{C-100} = \left(\frac{0.23 n_{bw100} (LcLca)^{0.3}}{(ScP_{1,100} C_{W100})^{0.4}} + 1.31 \right)$$

i_{100}=	**8.55**

$$i_{100} = \frac{4 \times P_{1,100}}{(1 + 0.05\, T_{C\,100})}$$

Aerial Weight Computation --

Description	Area (Ac)	2-Yr Ratio	5-Yr Ratio	10-Yr Ratio	25-Yr Ratio	50-Yr Ratio	F_{ACW}
Commercial/Indus	4.60	0.22	0.35	0.50	0.70	0.90	0.90
Weighted Average:		**0.22**	**0.35**	**0.50**	**0.70**	**0.90**	**0.90**

Q_{100}=	**30.6**
Q_{50}=	**27.5**
Q_{25}=	**21.4**
Q_{10}=	**15.3**
Q_5=	**10.7**
Q_2=	**6.7**

CITY OF TUCSON
HYDROLOGIC DATA SHEET FOR COMPUTING 100-YEAR PEAK DISCHARGE (Qp100)

PB Project No.:	**11536C**	
Project Name:	**DCIM**	
CP Desc:	**2**	
	EXISTING CONDITION, Area between Toole and 6th Ave.	
DA:	3.40	-Acres
Lc:	899.0	-Feet
Lca:	490.0	-Feet

Calc'd:	David Ruvalcaba	Date:	
Chk'd:		Date:	

Slope Computation --

CPi	Dli	Dhi	Si
	899.0	9.0	0.0100
Lc:	**899.0**	**Sc:**	**0.0100**

Land Use --

Description	Channel Type	Basin Factor	Area Factor
Commercial/Indus	DF	0.048	0.90
	n_{bw100}:	**0.048**	**F_{ACW}:** **0.90**

P_{1-100}: 3.00 Inches

F_{ACW} OVERRIDE: **1.00**

Soils--

CPi	Description	Sub-area (acres)	B (%)	C_B (-)	C (%)	C_C (-)	D (%)	C_D (-)	I (%)	C_I (-)	C (-)
	Commercial/Industr	3.40					100	0.77	98	0.96	0.96
										Cw:	**0.96**

	Calc'd	Used
T_{C100}=	**7.74**	**7.74**

$$T_{C-100} = \left(\frac{0.23 n_{bw100} (LcLca)^{0.3}}{(ScP_{1,100} C_{W100})^{0.4}} + 1.31 \right)$$

i_{100}=	**8.65**

$$i_{100} = \frac{4 \times P_{1,100}}{(1 + 0.05\, T_{C\,100})}$$

Aerial Weight Computation --

Description	Area (Ac)	2-Yr Ratio	5-Yr Ratio	10-Yr Ratio	25-Yr Ratio	50-Yr Ratio	F_{ACW}
Commercial/Indus	3.40	0.22	0.35	0.50	0.70	0.90	0.90
Weighted Average:		**0.22**	**0.35**	**0.50**	**0.70**	**0.90**	**0.90**

Q_{100}=	**28.1**
Q_{50}=	**25.3**
Q_{25}=	**19.7**
Q_{10}=	**14.1**
Q_5=	**9.8**
Q_2=	**6.2**

CITY OF TUCSON
HYDROLOGIC DATA SHEET FOR COMPUTING 100-YEAR PEAK DISCHARGE (Qp100)

PB Project No.:	**11536C**	
Project Name:	**DCIM**	
CP Desc:	**2a**	
	EXISTING CONDITION, Area between Toole and 6th Ave. South West of Intersection of Pennington and T	
DA:	2.90	-Acres
Lc:	646.0	-Feet
Lca:	290.0	-Feet

Calc'd:	David Ruvalcaba	Date:	
Chk'd:		Date:	

Slope Computation --

CPi	Dli	Dhi	Si
	646.0	9.0	0.0139
Lc:	**646.0**	**Sc:**	**0.0139**

Land Use --

Description	Channel Type	Basin Factor		Area Factor
Commercial/Indus	DF	0.048		0.90
	n_{bw100}:	**0.048**	**F_{ACW}:**	**0.90**

P_{1-100}: 3.00 Inches

F_{ACW} OVERRIDE: **1.00**

Soils--

CPi	Description	Sub-area (acres)	B (%)	C_B (-)	C (%)	C_C (-)	D (%)	C_D (-)	I (%)	C_I (-)	C (-)
	Commercial/Industr	2.90					100	0.77	98	0.96	0.96
										Cw:	**0.96**

	Calc'd	Used
T_{C100}=	**5.36**	**5.36**

$$T_{C-100} = \left(\frac{0.23 n_{bw100} (LcLca)^{0.3}}{(ScP_{1,100} C_{W100})^{0.4}} + 1.31 \right)$$

i_{100}=	**9.46**

$$i_{100} = \frac{4 \times P_{1,100}}{(1 + 0.05\, T_{C\,100})}$$

Aerial Weight Computation --

Description	Area (Ac)	2-Yr Ratio	5-Yr Ratio	10-Yr Ratio	25-Yr Ratio	50-Yr Ratio	F_{ACW}
Commercial/Indus	2.90	0.22	0.35	0.50	0.70	0.90	0.90
Weighted Average:		**0.22**	**0.35**	**0.50**	**0.70**	**0.90**	**0.90**

Q_{100}=	**26.2**
Q_{50}=	**23.6**
Q_{25}=	**18.4**
Q_{10}=	**13.1**
Q_5=	**9.2**
Q_2=	**5.8**

CITY OF TUCSON
HYDROLOGIC DATA SHEET FOR COMPUTING 100-YEAR PEAK DISCHARGE (Qp100)

PB Project No.:	**11536C**	
Project Name:	**DCIM**	
CP Desc:	**3**	
	EXISTING CONDITION, 6th Ave	
DA:	2.10	-Acres
Lc:	817.0	-Feet
Lca:	461.0	-Feet

Calc'd:	David Ruvalcaba	Date:	
Chk'd:		Date:	

Slope Computation --

CPi	Dli	Dhi	Si
	817.0	6.0	0.0073
Lc:	**817.0**	**Sc:**	**0.0073**

Land Use --

Description	Channel Type	Basin Factor		Area Factor
Commercial/Indus	DF	0.048		0.90
		n_{bw100}:	**F_{ACW}:**	**0.90**

P_{1-100}: 3.00 Inches

F_{ACW} OVERRIDE: **1.00**

Soils--

CPi	Description	Sub-area (acres)	B (%)	C_B (-)	C (%)	C_C (-)	D (%)	C_D (-)	I (%)	C_I (-)	C (-)
	Commercial/Industr	2.10					60	0.77	60	0.96	0.76
										Cw:	**0.76**

	Calc'd	Used
T_{C100}=	**9.23**	**9.23**

$$T_{C-100} = \left(\frac{0.23 n_{bw100} (LcLca)^{0.3}}{(ScP_{1,100} C_{W100})^{0.4}} + 1.31 \right)$$

i_{100}=	**8.21**

$$i_{100} = \frac{4 \times P_{1,100}}{(1 + 0.05\, T_{C\,100})}$$

Aerial Weight Computation --

Description	Area (Ac)	2-Yr Ratio	5-Yr Ratio	10-Yr Ratio	25-Yr Ratio	50-Yr Ratio	F_{ACW}
Commercial/Indus	2.10	0.22	0.35	0.50	0.70	0.90	0.90
Weighted Average:		**0.22**	**0.35**	**0.50**	**0.70**	**0.90**	**0.90**

Q_{100}=	**13.1**
Q_{50}=	**11.8**
Q_{25}=	**9.2**
Q_{10}=	**6.6**
Q_5=	**4.6**
Q_2=	**2.9**

APPENDIX B-4 - HYDRAULICS

PARSONS BRINCKERHOFF Computation Sheet

made by D. Ruvalcaba

date 11/30/12

checked by

date

subject 11536C Downtown Intermodal Center Pedestrian Safety and Bus Access Improvement Bypass Calculations

From the EXCEL SHEET UTILIZING THE City of Tucson Method

CP-A	CP-B	CP-1	CP-2	CP-3
$Q_{100} = 14.0$ cfs	$Q_{100} = 11.7$ cfs	$Q_{100} = 34.5$	$Q_{100} = 28.1$ cfs	$Q_{100} = 13.1$ cfs
$Q_{10} = 7.0$ cfs	$Q_{10} = 5.9$ cfs	$Q_{10} = 17.2$	$Q_{10} = 17.2$ cfs	$Q_{10} = 6.6$ cfs

Sumary From Visual Urban

AT CP-A

10-Yr; Bypass flow to CP-1 is 2(1.5) = 3.0 cfs

100-Yr: bypass to CP-1 is 2(3.8) = 7.6 cfs

AT CP-B

10-Yr: Bypass to CP-1 is 3.7 cfs

100-Yr: Bypass to CP-1 is 8.4 cfs

Total Flowrate at:

CP-1a (Upstream of Project site)

10-Year

3.0 (CP-A Bypass) + 3.7 (CP-B Bypass) + 15.3 (CP 1a) = 22.0 cfs

100-Year

7.6 (CP-A Bypass) + 8.4 (CP-B Bypass) + 34.5 (CP-1a) = 50.5 cfs

CP-1a (Downstream of Project intersection)

10-Year

22.0 (CP-1a) + 13.1 (CP-2a) = 35.1 cfs

100-Year

50.5 (CP-1a) + 26.2 (CP-2a) = 76.7 cfs

PARSONS BRINCKERHOFF Computation Sheet

made by D Ruwaba

date 1/15/13

checked by

date

subject 115 36C Downtown Intermodal Center Pedestrian Safety and Bus Access Improvement Curb Inlet Procedure

1. Use Flowmaster to calculate the depth at the gutters of the existing crossection.

2. To find the capture of each catch basin, the depth will used to find the spread in a gutter section. Therefore, divide the depth found by the road xslope.

3. This spread, channel slope, gutter width, gutter slope, road x slope, and roughness coefficient are coded into a gutter cross section to obtain the flowrate in the gutter.

4. The flowrate is then used to find the efficiency of the grate, using equation 10.22 from the Standards Manual for Drainage Design in Tucson, AZ.

5. This efficiency is used to calculate the flowrate captured.

PARSONS BRINCKERHOFF Computation Sheet

page 3 of 4

made by D. Ruwalcaba

date 11/30/12

checked by

date

subject 115366 Downtown Intermodal Center Pedestrian Safety and Bus Access Improvement Curb Inlet Calculation

Section North of Tuole

$Q_{10} = 38$ cfs

w/ a Lslope of 0.0079 '/ft

Xslope of 0.032 '/ft

Spread of = 19.38'

$n = 0.018$

$\therefore$ depth = 0.62

Required $Q = 24.17 \approx 24$

From Eqn 10.22 $L_t = 0.6\left(Q_T^{0.42} S_o^{0.3}\right)\left(\frac{1}{n\, S_x}\right)^{0.6}$

$L_t = 0.6\left(24^{0.42} (0.0079)^{0.3}\right) * \left(\frac{1}{(0.018)(0.03)}\right)^{0.6}$

$L_t = 49$

$L_i = 8$

$E_i = 1 - \left(1 - \frac{L_i}{L_t}\right)^{1.8} = 1 - \left(1 - \frac{8}{49}\right)^{1.8} = 27\%$

$0.27 * 24 = 6.5$ captured in 10 year

$Q_{100} = 78.6$

same section

depth = 0.71 and T = 22.2

Resulting $Q = 34.7 \approx 35$

$L_t = (0.6)(35^{0.42} * 0.23)(91.3) = 57$

$E_i = 1 - \left(1 - \frac{8}{57}\right)^{1.8} = 24\%$

$0.24 * 35 = 8.4$ captured in 100 year

PARSONS BRINCKERHOFF Computation Sheet

made by D. Ruvalcaba

date

checked by

date

subject 11536C DIMC

Curb Inlet Calculation

At second CB

$Q_{100} = 38 - 6.5 = 31.5$

with a $L_{slope} = 0.0079$ '/ft

$X_{slope} = 0.0338$ '/ft

$n = 0.018$

$\therefore$ depth = 0.60 and T = 18.75

Resulting Q = 22.13 ≈ 22

From Eqn 10.22 $L_t = 0.6\left(Q_r^{0.42} S_0^{0.3}\right)\left(\frac{1}{n S_x}\right)^{0.6}$

$L_t = 0.6\left(22^{0.42} * 0.23\right)(91.3)$

$L_t = 0.6(3.7 * 0.28)(91.3)$

$L_t = 47'$

$L_i = 10$

$E_i = 1-\left(1-\frac{L_i}{L_t}\right)^{1.8} = 1-\left(1-\frac{10}{47}\right)^{1.8} = 35\%$

$0.35 * 22 = 7.7$ cfs

$Q_{100} = 78.6 - 8.4 = 70.2$

depth = 0.70 and T = 21.88

Resulting in Q = 33.4 ≈ 33 cfs

From Eqn 10.22 $L_t = 0.6\left(Q_r^{0.42} S_0^{0.3}\right)\left(\frac{1}{n S_x}\right)^{0.6}$

$L_t = 0.6\left(33^{0.42} * 0.23\right)(91.3)$

$L_t = 54.7 \approx 55$

$L_i = 10$

$E_i = 1-\left(1-\frac{L_i}{L_t}\right)^{1.8} = 1-\left(1-\frac{10}{55}\right)^{1.8} = 30\%$

$0.30 * 33 = 9.9$ cfs

FHWA Urban Drainage Design Program, HY-22
Drainage of Highway Pavements

Inlets on Grade
Date: 01/14/2013

Project No. :11536C
Project Name.:DCIM
Computed by :D. Ruvalcaba

Project Description
Existing Condition CP-A
Q100=7.0cfs
Lslope=0.0046, Xslope=0.0088

Inlets on Grade: Curb Opening Inlet

Roadway and Discharge Data

	Cross Slope	Uniform
S	Longitudinal Slope (ft/ft)	0.0046
Sx	Pavement Cross Slope (ft/ft)	0.0088
Sw	Gutter Cross Slope (ft/ft)	0.0088
n	Manning's Coefficient	0.018
W	Gutter Width (ft)	0.00
a	Gutter Depression (inch)	0.00
Q	Discharge (cfs)	7.000
T	Width of Spread (ft)	30.20

Gutter Flow

Eo	Gutter Flow Ratio	0.000
d	Depth of Flow (ft)	0.27
V	Average Velocity (ft/sec)	1.74

Inlet Interception

	Inlet Type	Curb-Opening
LT	Length for 100% Inteception (ft)	51.53
L	Curb-Opening Length (ft)	14.40
e	Inlet Efficiency	0.446
Qi	Intercepted Flow (cfs)	3.119
Qb	By-pass Flow (cfs)	3.881

FHWA Urban Drainage Design Program, HY-22
Drainage of Highway Pavements

Inlets on Grade
Date: 01/14/2013

Project No. :11536C
Project Name.:DCIM
Computed by :D. Ruvalcaba

Project Description
Existing Condition CP-B
Q100=11.7cfs
Lslope=0.0172, Xslope=0.0106

Inlets on Grade: Curb Opening Inlet

Roadway and Discharge Data

	Cross Slope	Uniform
S	Longitudinal Slope (ft/ft)	0.0172
Sx	Pavement Cross Slope (ft/ft)	0.0106
Sw	Gutter Cross Slope (ft/ft)	0.0106
n	Manning's Coefficient	0.018
W	Gutter Width (ft)	0.00
a	Gutter Depression (inch)	0.00
Q	Discharge (cfs)	11.700
T	Width of Spread (ft)	25.45

Gutter Flow

Eo	Gutter Flow Ratio	0.000
d	Depth of Flow (ft)	0.27
V	Average Velocity (ft/sec)	3.41

Inlet Interception

	Inlet Type	Curb-Opening
LT	Length for 100% Inteception (ft)	84.94
L	Curb-Opening Length (ft)	14.40
e	Inlet Efficiency	0.284
Qi	Intercepted Flow (cfs)	3.325
Qb	By-pass Flow (cfs)	8.375

FHWA Urban Drainage Design Program, HY-22
Drainage of Highway Pavements

Inlets on Grade
Date: 01/14/2013

Project No. :11536C
Project Name.:DCIM
Computed by :D. Ruvalcaba

Project Description
Existing Condition CP-B
Q10=5.9cfs
Lslope=0.0172, Xslope=0.0106

Inlets on Grade: Curb Opening Inlet

Roadway and Discharge Data

	Cross Slope	Uniform
S	Longitudinal Slope (ft/ft)	0.0172
Sx	Pavement Cross Slope (ft/ft)	0.0106
Sw	Gutter Cross Slope (ft/ft)	0.0106
n	Manning's Coefficient	0.018
W	Gutter Width (ft)	0.00
a	Gutter Depression (inch)	0.00
Q	Discharge (cfs)	5.900
T	Width of Spread (ft)	19.69

Gutter Flow

Eo	Gutter Flow Ratio	0.000
d	Depth of Flow (ft)	0.21
V	Average Velocity (ft/sec)	2.87

Inlet Interception

	Inlet Type	Curb-Opening
LT	Length for 100% Inteception (ft)	63.71
L	Curb-Opening Length (ft)	14.40
e	Inlet Efficiency	0.369
Qi	Intercepted Flow (cfs)	2.180
Qb	By-pass Flow (cfs)	3.720

FHWA Urban Drainage Design Program, HY-22
Drainage of Highway Pavements

Inlets on Grade
Date: 01/14/2013

Project No. :11536C
Project Name.:DCIM
Computed by :D. Ruvalcaba

Project Description
Existing Condition CP-A
Q10=3.5cfs
Lslope=0.0046, Xslope=0.0088

Inlets on Grade: Curb Opening Inlet

Roadway and Discharge Data

	Cross Slope	Uniform
S	Longitudinal Slope (ft/ft)	0.0046
Sx	Pavement Cross Slope (ft/ft)	0.0088
Sw	Gutter Cross Slope (ft/ft)	0.0088
n	Manning's Coefficient	0.018
W	Gutter Width (ft)	0.00
a	Gutter Depression (inch)	0.00
Q	Discharge (cfs)	3.500
T	Width of Spread (ft)	23.29

Gutter Flow

Eo	Gutter Flow Ratio	0.000
d	Depth of Flow (ft)	0.20
V	Average Velocity (ft/sec)	1.47

Inlet Interception

	Inlet Type	Curb-Opening
LT	Length for 100% Inteception (ft)	38.52
L	Curb-Opening Length (ft)	14.40
e	Inlet Efficiency	0.569
Qi	Intercepted Flow (cfs)	1.993
Qb	By-pass Flow (cfs)	1.507

FHWA Urban Drainage Design Program, HY-22
Drainage of Highway Pavements

Inlets on Grade
Date: 01/14/2013

Project No. :11536C
Project Name.:DCIM
Computed by :D. Ruvalcaba

Project Description
Existing Condition CP-1
Q10=6.3cfs
Lslope=0.0067, Xslope=0.0042

Inlets on Grade: Curb Opening Inlet

Roadway and Discharge Data

	Cross Slope	Uniform
S	Longitudinal Slope (ft/ft)	0.0067
Sx	Pavement Cross Slope (ft/ft)	0.0042
Sw	Gutter Cross Slope (ft/ft)	0.0042
n	Manning's Coefficient	0.018
W	Gutter Width (ft)	0.00
a	Gutter Depression (inch)	0.00
Q	Discharge (cfs)	6.300
T	Width of Spread (ft)	42.95

Gutter Flow

Eo	Gutter Flow Ratio	0.000
d	Depth of Flow (ft)	0.18
V	Average Velocity (ft/sec)	1.63

Inlet Interception

	Inlet Type	Curb-Opening
LT	Length for 100% Inteception (ft)	86.02
L	Curb-Opening Length (ft)	6.40
e	Inlet Efficiency	0.130
Qi	Intercepted Flow (cfs)	0.819
Qb	By-pass Flow (cfs)	5.481

FHWA Urban Drainage Design Program, HY-22
Drainage of Highway Pavements

Inlets on Grade
Date: 01/14/2013

Project No. :11536C
Project Name.:DCIM
Computed by :D. Ruvalcaba

Project Description
Existing Condition CP-1
Q100=12.6cfs
Lslope=0.0067, Xslope=0.0042

Inlets on Grade: Curb Opening Inlet

Roadway and Discharge Data

	Cross Slope	Uniform
S	Longitudinal Slope (ft/ft)	0.0067
Sx	Pavement Cross Slope (ft/ft)	0.0042
Sw	Gutter Cross Slope (ft/ft)	0.0042
n	Manning's Coefficient	0.018
W	Gutter Width (ft)	0.00
a	Gutter Depression (inch)	0.00
Q	Discharge (cfs)	12.600
T	Width of Spread (ft)	55.70

Gutter Flow

Eo	Gutter Flow Ratio	0.000
d	Depth of Flow (ft)	0.23
V	Average Velocity (ft/sec)	1.93

Inlet Interception

	Inlet Type	Curb-Opening
LT	Length for 100% Inteception (ft)	115.08
L	Curb-Opening Length (ft)	6.40
e	Inlet Efficiency	0.098
Qi	Intercepted Flow (cfs)	1.233
Qb	By-pass Flow (cfs)	11.367

Section Upstream of First CB Q10

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.00790	ft/ft
Discharge	38.00	ft³/s

Section Definitions

Station (ft)	Elevation (ft)
0+00	87.34
0+27	86.87
0+27	86.37
0+47	87.01
0+67	86.37
0+67	86.87
0+78	86.86
3+03	87.25

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+00, 87.34)	(3+03, 87.25)	0.018

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Normal Depth	0.62	ft
Elevation Range	86.37 to 87.34 ft	
Flow Area	19.05	ft²
Wetted Perimeter	134.34	ft
Hydraulic Radius	0.14	ft

Section Upstream of First CB Q10

Results

Top Width	133.41	ft
Normal Depth	0.62	ft
Critical Depth	0.61	ft
Critical Slope	0.00917	ft/ft
Velocity	1.99	ft/s
Velocity Head	0.06	ft
Specific Energy	0.68	ft
Froude Number	0.93	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.62	ft
Critical Depth	0.61	ft
Channel Slope	0.00790	ft/ft
Critical Slope	0.00917	ft/ft

Gutter Section of First CB Q10

Project Description

Solve For	Discharge

Input Data

Channel Slope	0.00790	ft/ft
Gutter Width	2.00	ft
Gutter Cross Slope	0.03	ft/ft
Road Cross Slope	0.03	ft/ft
Spread	19.38	ft
Roughness Coefficient	0.018	

Results

Discharge	24.17	ft^3/s
Flow Area	6.01	ft^2
Depth	0.62	ft
Gutter Depression	0.00	ft
Velocity	4.02	ft/s

Section Upstream of First CB Q100

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.00790	ft/ft
Discharge	78.60	ft³/s

Section Definitions

Station (ft)	Elevation (ft)
0+00	87.34
0+27	86.87
0+27	86.37
0+47	87.01
0+67	86.37
0+67	86.87
0+78	86.86
3+03	87.25

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+00, 87.34)	(3+03, 87.25)	0.018

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Normal Depth	0.71	ft
Elevation Range	86.37 to 87.34 ft	
Flow Area	34.13	ft²
Wetted Perimeter	193.77	ft
Hydraulic Radius	0.18	ft

Section Upstream of First CB Q100

Results

Top Width		192.84	ft
Normal Depth		0.71	ft
Critical Depth		0.71	ft
Critical Slope		0.00850	ft/ft
Velocity		2.30	ft/s
Velocity Head		0.08	ft
Specific Energy		0.80	ft
Froude Number		0.97	
Flow Type	Subcritical		

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.71	ft
Critical Depth	0.71	ft
Channel Slope	0.00790	ft/ft
Critical Slope	0.00850	ft/ft

Gutter Section of First CB Q100

Project Description

Solve For	Discharge

Input Data

Channel Slope	0.00790	ft/ft
Gutter Width	2.00	ft
Gutter Cross Slope	0.03	ft/ft
Road Cross Slope	0.03	ft/ft
Spread	22.20	ft
Roughness Coefficient	0.018	

Results

Discharge	34.72	ft^3/s
Flow Area	7.89	ft^2
Depth	0.71	ft
Gutter Depression	0.00	ft
Velocity	4.40	ft/s

Section of Second CB Q10

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.00790	ft/ft
Discharge	31.50	ft³/s

Section Definitions

Station (ft)	Elevation (ft)
0+00	87.34
0+27	86.87
0+27	86.37
0+47	87.01
0+67	86.37
0+67	86.87
0+78	86.86
3+03	87.25

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+00, 87.34)	(3+03, 87.25)	0.018

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Normal Depth	0.60	ft
Elevation Range	86.37 to 87.34 ft	
Flow Area	16.19	ft²
Wetted Perimeter	118.50	ft
Hydraulic Radius	0.14	ft

Section of Second CB Q10

Results

Top Width	117.57	ft
Normal Depth	0.60	ft
Critical Depth	0.59	ft
Critical Slope	0.00928	ft/ft
Velocity	1.95	ft/s
Velocity Head	0.06	ft
Specific Energy	0.66	ft
Froude Number	0.92	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.60	ft
Critical Depth	0.59	ft
Channel Slope	0.00790	ft/ft
Critical Slope	0.00928	ft/ft

Gutter Section of Second CB Q10

Project Description

Solve For	Discharge

Input Data

Channel Slope	0.00790	ft/ft
Gutter Width	2.00	ft
Gutter Cross Slope	0.03	ft/ft
Road Cross Slope	0.03	ft/ft
Spread	18.75	ft
Roughness Coefficient	0.018	

Results

Discharge	22.13	ft^3/s
Flow Area	5.63	ft^2
Depth	0.60	ft
Gutter Depression	0.00	ft
Velocity	3.93	ft/s

Section of Second CB Q100

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.00790	ft/ft
Discharge	70.20	ft³/s

Section Definitions

Station (ft)	Elevation (ft)
0+00	87.34
0+27	86.87
0+27	86.37
0+47	87.01
0+67	86.37
0+67	86.87
0+78	86.86
3+03	87.25

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+00, 87.34)	(3+03, 87.25)	0.018

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Normal Depth	0.70	ft
Elevation Range	86.37 to 87.34 ft	
Flow Area	31.17	ft²
Wetted Perimeter	183.81	ft
Hydraulic Radius	0.17	ft

Section of Second CB Q100

Results

Top Width	182.88	ft
Normal Depth	0.70	ft
Critical Depth	0.69	ft
Critical Slope	0.00861	ft/ft
Velocity	2.25	ft/s
Velocity Head	0.08	ft
Specific Energy	0.78	ft
Froude Number	0.96	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.70	ft
Critical Depth	0.69	ft
Channel Slope	0.00790	ft/ft
Critical Slope	0.00861	ft/ft

Gutter Section of Second CB Q100

Project Description

Solve For	Discharge

Input Data

Channel Slope	0.00790	ft/ft
Gutter Width	2.00	ft
Gutter Cross Slope	0.03	ft/ft
Road Cross Slope	0.03	ft/ft
Spread	21.88	ft
Roughness Coefficient	0.018	

Results

Discharge	33.40	ft^3/s
Flow Area	7.66	ft^2
Depth	0.70	ft
Gutter Depression	0.00	ft
Velocity	4.36	ft/s