2012P049

eps group, Inc.
Engineers, Planners & Surveyors

Final Drainage Report

For

Desert Place at Morrison Ranch - Phase I

Mesa, Arizona

Owner/Developer
Morrison Ranch, Inc.
3180 E. Elliot Rd
Gilbert, Arizona 85234
Phone: (480) 813-8234
Fax: (480) 813-8235
Contact: Scott Morrison

Registered Professional Engineer (Civil)
CERTIFICATE NO.
44744
ERIC D.
WINTERS
Date Signed 09-17-12
ARIZONA, U.S.A.
EXPIRES 6/30/201

Project No. 06-016

Prepared: July 2012
Revised: September 2012

2045 S. Vineyard Avenue, Suite 101
Mesa, AZ 85210
o: 480.503.2250
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Appendices

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List of Figures

1.0 Introduction

Desert Place at Morrison Ranch is located on the southwest corner of Guadalupe Road and Sossaman Road in Mesa, Arizona. Phase 1 of Desert Place at Morrison Ranch is comprised of 317 single family lots and is approximately 109 gross acres. Phases 2 & 3 will be designed and constructed at a later date in the future. See Figure 1 Vicinity Map.

Construction documents for Desert Place at Morrison Ranch – Phase 1 are separated into seven separate plan sets, however this drainage report will cover the entirety of Phase 1. All retention and storm drain outlets will be constructed in the first Phase of plan sets (Phase 1A).

This report has been prepared based on standards set forth in the City of Mesa's Drainage Standards and by the Flood Control District of Maricopa County.

2.0 Flood Insurance Rate Zone

This site is located within FEMA Flood Zone X (Shaded) as shown on FEMA Flood Insurance Rate Map number 04013C2685H dated September 30, 2005. See Figure 2: FIRM Map.

Flood Zone X (Shaded) is defined as:

> Areas of 0.2% annual chance flood; areas of 1% annual chance flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; area areas protected by levees from 1% annual chance flood.

3.0 Existing Site Conditions

The project area is currently an active agricultural field that slopes to the southwest at approximately 0.5%.

Desert Place is bounded on the north and east by Guadalupe Road and Sossaman Road, respectively. Both arterial roadways have developed half streets from adjacent developments. The arterial roadways, adjacent to the project's first phase, will be constructed with the subdivision improvements.

Desert Place – Phase 1 is bounded to the west by the future second phase of Desert Place. The Desert Place – Phase 2 project area is and will remain an active agricultural field. It slopes southwest at approximately 0.5%.

Desert Place – Phase I is also bounded to the south by an active agricultural field that slopes southwest at approximately 0.5%. This property is part of the future Desert Place at Morrison Ranch industrial project.

4.0 Offsite Drainage

The ground naturally slopes southwest in the general vicinity of the project at a slope of approximately 0.5%. Any offsite runoff generated north or south of the project will flow to the west and not affect the project area.

Desert Place is protected from regional drainage generated north and northeast of the project by a concrete lined drainage channel that commences at the northeast corner of the Guadalupe Road/Sossaman Road intersection and flows west along the north side of Guadalupe Road until it reaches the East Maricopa Floodway approximately a third of a mile west of Desert Place – Phase 3.

The area between Desert Place at Morrison Ranch and the East Maricopa Floodway are downstream of the proposed Desert Place project and therefore will not cause any runoff to backup into the project limits.

5.0 Onsite Drainage

The drainage scheme of this project is to allow all onsite storm water to drain into the roadways and be conveyed to low points. The runoff will then be conveyed into surface retention basins by catch basins, storm drains, and bubble-up catch basins which are connected to a bleed off system that eventually discharges into the East Maricopa Floodway.

5.1 Rainfall Depth

For the purposes of sizing retention basins, the rainfall depth for this project corresponding to the 100-year, 2-hour storm event, as stated in the City of Mesa Engineering & Design Standards, Chapter 8, Section 806.4, is 2.7 inches.

For the purposes of hydrologic and hydraulic analysis, the rainfall depths for this project were derived from the NOAA ATLAS 14 ("Precipitation-Frequency Atlas of the United States" NOAA ATLAS 14, Volume 1, Version 4). The data taken represents the approximate project location as estimated using Google Earth. Results from the Upper Bound of the 90% confidence interval have been used to compute the site specific runoff values and the site specific I-D-F curve (Intensity-Duration-Frequency Curve). See Appendix C for NOAA ATLAS 14 data.

5.2 Calculation Methodology – Weighted "C" values

The weighted runoff coefficients, C, were computed based on criteria outlined in City of Mesa Engineering & Design Standards, Chapter 8, Section 806.7. The following C values were weighted to compute composite runoff coefficients for specific areas:

City of Mesa

Runoff Coefficients

Description	C
Roofs and Concrete	0.95
Asphalt	0.85
Desert Landscaping	0.50
Green Landscaping	0.15

The runoff coefficient for the lot area was found by applying the above C values to minimum sized lots with typical expected rooftop and driveway areas. Weighted C values for the lots were calculated for all lot sizes. See Appendix B for detailed lot weighted C value calculations.

Six weighted C values were computed for the project. See the tabular summary below of the weighted C values:

Summary of Composite Runoff Coefficient

Area Description	C Value
Guadalupe Road	0.78
Sossaman Road	0.73
N-S Road	0.73
70x130 lot on Standard Local Roads	0.60
60x120 lot on Standard Local Roads	0.60
50x115 lot on Standard Local Roads	0.65

These weighted C values were calculated based on a conservative cross section cut through the roadway or through the lot and adjacent half street.

See Appendix B for detailed weighted C value calculations.

5.3 Calculation Methodology – Peak Flow and Time of Concentration

The Rational Method was used to calculate peak flows at critical locations in the development. The Rational Method was applied as outlined in the Drainage Design Manual for Maricopa County Drainage, Hydrology. Peak flows were calculated as follows:

$$Q = C * i * A$$

Where Q is the Peak Discharge in cubic feet per second, C is the weighted "c" value of the area, *i* is the rainfall intensity (as defined by the local time of concentration and the site specific IDF curve) in inches per hour, and A is the area in acres.

The time of concentration calculations for the street drainage were performed using the Papadakis and Kazan equation as follows:

$$T_c = 11.4 L^{0.5} K_b^{0.52} S^{-0.31} i^{-0.38}$$

Where T_c is the time of concentration (in minutes), L is the length of the longest flow path (in miles), K_b is the watershed resistance coefficient, S is the watercourse slope (in feet per mile), and *i* is the rainfall intensity (in inches per hour).

Intensity was estimated by linearly interpolating the site specific I-D-F curve that was derived from the NOAA ATLAS 14 data (described in section 5.1 of this report) at a specific time of concentration.

As is seen, the time of concentration is a function of the intensity and the intensity is a function of the time of concentration. Therefore, the equations were iterated until both equations were satisfied. When both equations are satisfied for each sub basin area, the resulting values were applied to that sub basin area and the peak flow at the concentration point was calculated.

The time of concentration was calculated in one of two ways. First, for drainage areas with only streets the time of concentration was calculated from the street high point to the street low point. In this circumstance, the drainage length "L" was measured from the street high point to the street low point along the flow line. The slope of the watercourse "S" was calculated by dividing the difference in the street gutter elevation at the high point and at the low point of the drainage area by the drainage length "L".

Second, for drainage areas with lots, the time of concentration was calculated from the street on the low side of the most remote lot to the drainage area low point plus 15 minutes for initial lot time of concentration. In this circumstance the drainage length "L" was measured from the flow line in the street adjacent to the low side of the most remote lot to the street low point along the flow line. The slope of the watercourse "S" was calculated by dividing the difference in the street gutter elevation adjacent to the low side of the most remote lot and at the lot point of the drainage area by the drainage length "L". An initial lot time of concentration of 15 minutes was added to the derived time of concentration as described above.

See Appendix D for Hydrology calculations.

5.4 Onsite Retention

Retention calculations were performed as outlined in the City of Mesa Engineering & Design Standards, Chapter 8, Section 806.13. Retention basins were designed to retain 100% of the 100-year 2-hour storm event (2.7 inches). See Appendix C for retention calculations. See Figure 3: Drainage Map – Retention for locations of calculations.

Basin B1 was designed to receive runoff from Guadalupe Road and Sossaman Road.

Basins B2-B4 were designed to receive runoff from Sossaman Road and Desert Place – Phase 1.

Basin B5 was designed to receive runoff from Guadalupe Road and Desert Place – Phase 1.

Basins B6-B7 were designed to receive runoff from Desert Place – Phase 1.

Basins B5 through B7 were planned to receive runoff from Desert Place – Phase 2. A Final Drainage Report for Phase 2 will substantiate the capacity the basins with the addition of the additional volume required from Phase 2.

Basin B16 is a shallow retention basin located within the existing 250-ft wide SRP transmission easement and was designed to receive runoff from within the easement only. This basin will have a ponding depth of less than one foot.

Basin B17 is a shallow retention basin located within the existing 250-ft wide SRP transmission easement and was designed to receive runoff from within the easement and from a small portion of Sossaman Road. This basin will have a ponding depth of less than one foot.

See Appendix C for detailed retention calculations.

5.5 Storm Water Disposal (Bleed-off)

Retention basins were designed to dispose of their storm water via gravity bleed-off as outlined in Section 806.21.3 of the City of Mesa Engineering & Design Standards, Chapter 8. All bubbler boxes in the basins have been connected into the bleedoff system to dispose of the storm water within the basins. The bleed-off system was designed to connect the series of storm drain pipes that eventually discharge to the East Maricopa Floodway (EMF).

The minimum pipe size has been set at 8-inches however the pipe diameters were hydraulically sized to drain the required volume within the stipulated 36-hours.

The bleed-off pipe network was designed such that it is capable of conveying a flow rate sufficient to drain all retention basins in Phase 1, 2, and 3 of Desert Place at Morrison Ranch within 36 hours. This required average flow rate was estimated to be 10.1 cfs.

The bleed-off system is restricted by an existing 15 inch pipe (dry line) that is located downstream of all basins. This pipe is located within an easement across the Gilbert Unified School District's property. Hydraulic calculations show that this 15 inch pipe can only flow at 11.6 cfs before the HGL in the pipe rises higher than the rim of the manhole MH2. Manhole MH2 is located on the upstream side of the existing 15 inch pipe. Since these manholes will not be pressure manholes, runoff would bubble out of the downstream most manhole and not allow more than 11.6 cfs to enter the EMF. Calculations showing the maximum flow rate of 11.6 have been included in Appendix. These calculations show that a flow rate of 11.6 cfs will push the HGL higher than the rim of manhole MH2. Flap gates will not be installed in this manhole. See improvement plans for exact location of MH2.

Due to the restriction being located at the downstream end of the system, flap gates will be installed to allow the head in the basin to regulate the order in which the basins will drain through the bleed-off system. The flap gates will allow basins of higher head to drain while the basins of lower head are protected from receiving runoff from the bleed-off pipe system. Flap gates will be installed in manholes where bleedoff lines from multiple lines connect. Flap gates will be installed on the end of the inlet pipes of the selected manholes.

See Appendix F for detailed storm water disposal (bleed-off) calculations.

An advanced vortex separator was added to the bleed-off system just prior to discharging into the East Maricopa Floodway to remove sediments, petroleum byproducts and floatables from the storm water runoff. The Downstream Defender, manufactured by Hydro International, was selected to be installed based on its effective sediment capture, its low headloss and its ability to prevent washout. The Downstream Defender has specially designed internal components to maximized removal of sediment and prevent washout of previously captured pollutants during intense stormwater runoff surges.

See Appendix G for Downstream Defender product literature and technical abstracts.

5.6 Street Hydraulics

Arterial streets were designed to convey the 10-year peak flow such that the runoff does not encroach more than one travel lane from either side. The 50-year peak flow will be conveyed within the right-of-way at a depth no greater than 3" above the centerline.

Local streets were designed to convey the 10-year peak flow below the top of curb, and to convey the 50-year peak flow within the right-of-way. The 100-year peak flow will pass through the streets between finished floors.

Where 4" roll curb is not able to convey its runoff as described above, 6" vertical curb will be installed. Where 6" vertical curb is not able to convey its runoff as described above, the drainage will be captured by storm drains so that the 6" vertical curb capacity is not exceeded.

Manning's equation was used to compute the street capacity to determine if the requirements for street capacity were met. A Manning's "n" value of 0.015 was used for all street calculations.

See Appendix D for detailed street hydraulics calculations. See Figure 3: Drainage Map – Hydrology for locations of calculations.

5.7 Inlet and Storm Drain Calculations

Catch basins were designed to capture the 10-year peak event. Catch basins were designed according to the criteria set forth in the Maricopa County Drainage Manuals.

In the 100-year event, the peak flow will cause ponding in the street at the inlet. This ponded depth will overtop the sidewalk and flow into the retention basin. It will be the responsibility of the HOA to maintain tracts affected by the overtopping of 10-year sized inlets in larger storm events.

Detailed hydraulic grade line (HGL) calculations for each storm drain were calculated for the 10-year storm event. The HGL will be maintained at least 6 inches below the rim of manholes, catch basins, or grates.

See Appendix E for detailed inlet and storm drain calculations. See Figure 3: Drainage Map – Hydrology for locations of calculations.

6.0 Basin Low Outfall and Minimum Finished Floor

Basins B1 will outfall by surcharging the grate of Catch Basin 19 (200-feet south of the Guadalupe Road/Sossaman Road intersection) at an elevation of 1356.56 and will flow into Sossaman Road south towards basin B2.

Basins B2 will outfall by surcharging the grate of Catch Basin 23 and 24 (at the east side of Lot 278) at an elevation of 1352.40, will pond in the street until overtopping at a high point within E. Plata Avenue at an elevation of 1352.72, and will then flow west down E. Plata Avenue towards basin B6. All finished floor elevations within this sub basin area shall be a minimum of 18" (1354.22) above this specific outfall elevation.

Basins B3 will outfall by surcharging the proposed sidewalk at the east side of Lot 233 at an elevation of 1352.13, will overtop the top of curb to the southwest, and will then flow south down S. Annanea towards basin B4. All finished floor elevations within this sub basin area shall be a minimum of 18" (1353.63) above this specific outfall elevation.

Basins B4 will outfall by overtopping the sidewalk at the east side of Lot 191 at an elevation of 1350.32 and will flow west down E. Peralta Avenue towards basin B7. All finished floor elevations within this sub basin area shall be a minimum of 18" (1351.82) above this specific outfall elevation.

Basin B5 will outfall to the southwest over the proposed sidewalk into the existing adjacent farm field at an elevation of 1344.39. All finished floor elevations within this sub basin area shall be a minimum of 18" (1345.89) above this specific outfall elevation.

Basin B6 will outfall to the southwest over the proposed sidewalk into the existing adjacent farm field at an elevation of 1341.68. All finished floor elevations within this sub basin area shall be a minimum of 18" (1343.18) above this specific outfall elevation.

Basin B7 will outfall to the west over the proposed sidewalk into the existing adjacent farm field at an elevation of 1341.22. All finished floor elevations within this sub basin area shall be a minimum of 18" (1342.72) above this specific outfall elevation.

Basin B16 will outfall to the southwest at existing grade into the existing adjacent farm field at an elevation of 1346.19.

Basin B17 will outfall to the southwest at existing grade into the existing adjacent farm field at an elevation of 1348.70.

7.0 Conclusions

This report concluded that:

- This site has been designed in accordance with the City of Mesa's standards.
- No offsite flow adversely impacts the site.
- This site will create no adverse impacts on any downstream property.
- The finished floor for all homes will be a minimum of 18 inches above the highest adjacent water surface elevation.
- Retention requirements for onsite storm water and offsite storm water have been met by onsite surface retention basins.
- A series of hydraulically sized storm drain pipes will bleed-off retention basins within the required time period.
- Inlets and Storm Drain Pipes have been designed to convey the 10-year storm event.

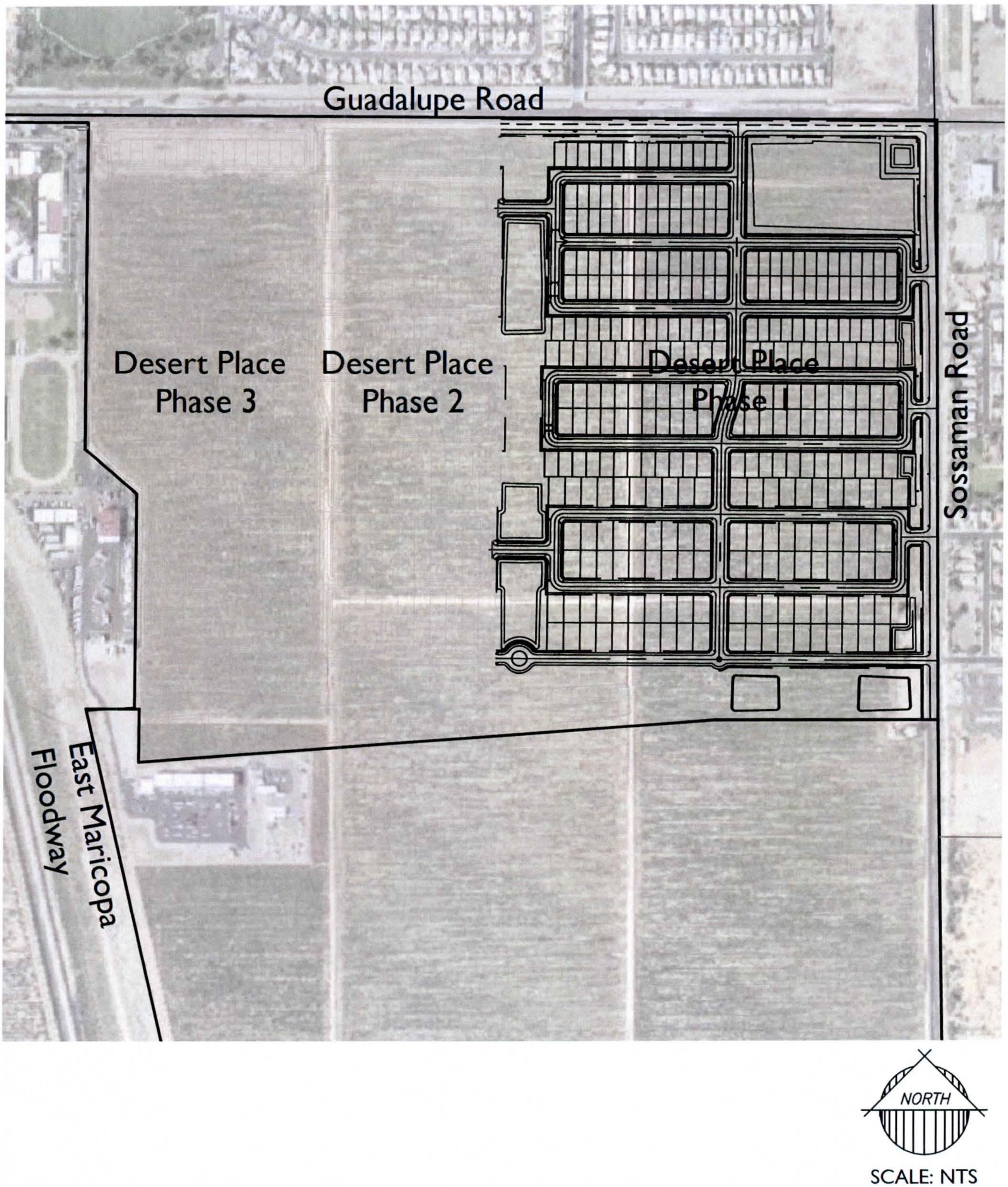
8.0 References

City of Mesa
City of Mesa Engineering & Design Standards, Chapter 8

Flood Control District of Maricopa County, 1995
Drainage Design Manual for Maricopa County, AZ. Volume 1, Hydrology

Flood Control District of Maricopa County, 2009 (Draft)
Drainage Design Manual for Maricopa County, AZ. Volume 2, Hydraulics

Appendix A:
Figures



06-016

Project:
Desert Place at Morrison Ranch - Phase 1
Mesa, Arizona

Figure 1: Vicinity Map

eps group, Inc.
Engineers, Planners & Surveyors
2045 S. Vineyard, Ste. 101, Mesa, Arizona 85210
Phone (480) 503-2250 Fax (480) 503-2258

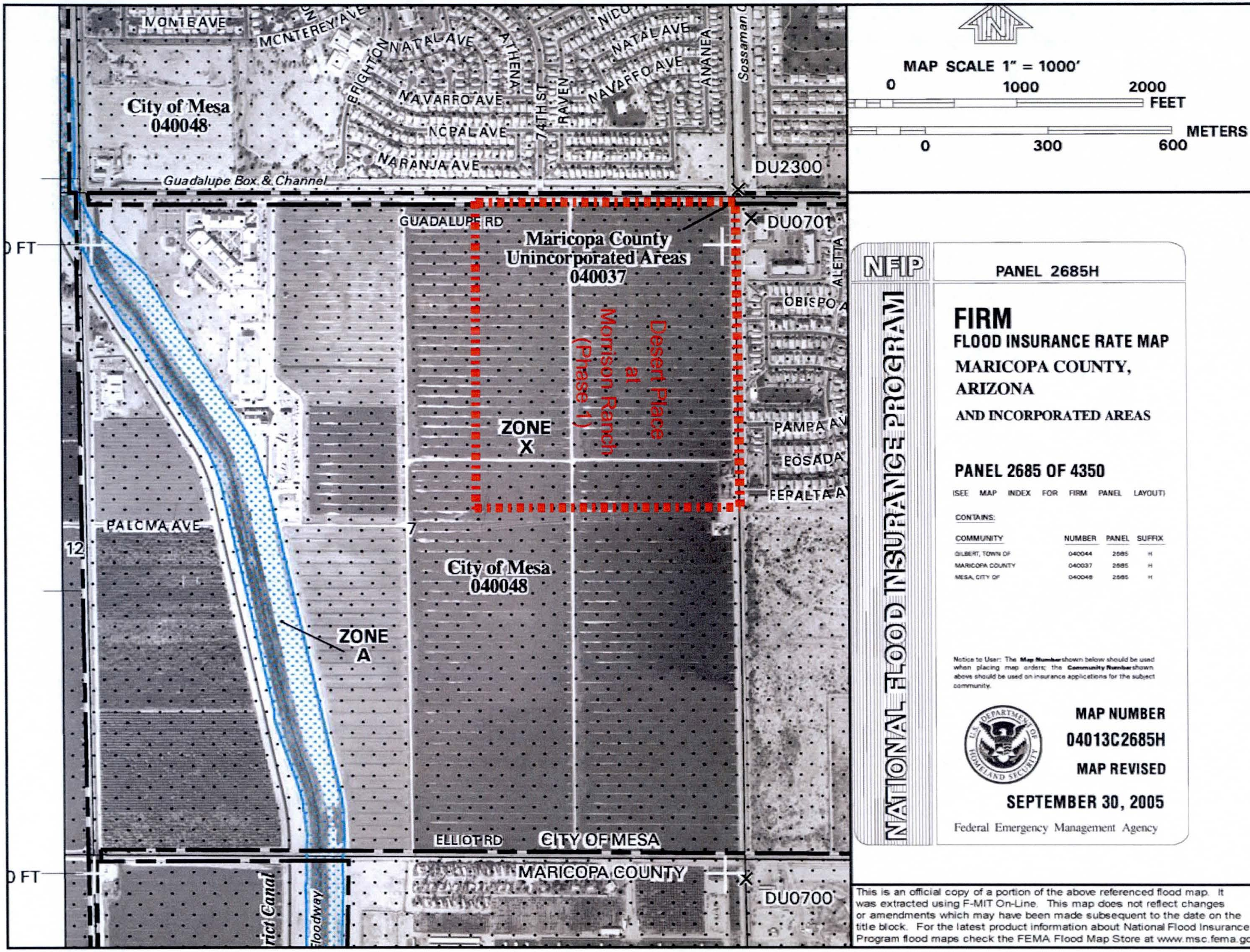


Figure 2: FIRM Map


06-016 - Desert Place at Morrison Ranch - Phase 1
Jul 17, 2012 10:38am S:\Projects\2006\06-016\Civil\CAD\Design\Drainage\Phase 1 Drainage Exhibit\06-016 — PH1 — FIG03-DE01.dwg
iwallace
E. Guadalupe Rd.
E. Olla Ave.
E. Osaga Ave.
E. Onza Ave.
E. Plata Ave.
E. Portobello Ave.
E. Pampa Ave.
E. Posada Ave.
E. Peralta Ave.
S. Avoca
S. Raven
S. Annanea
S. Sossaman Rd.
Desert Place
Phase 3
(Not A Part)
Desert Place
Phase 2
(Not A Part)
LEGEND:
Basin Drainage Area
Sub-Basin Drainage Area
Flow Arrow
Basin ID
BX
Sub-Basin ID
BX-AX
120 0 120 240
scale feet
DOWNSTREAM DEFENDER (DD)
EMF
MH1
MH2
MH3
MH4
MH5
MH6
MH7
MH8
MH9
MH10
MH11
MH12
MH13
MH14
MH21
J5
J6
J7
J16
J18
B1
B2
B3
B4
B5
B6
B7
B16
B17
B1-A1
B1-A2
B1-A3
B2-A1
B2-A2
B2-A3
B2-A4
B3-A1
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B4-A1
B4-A2
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B5-A1
B5-A3
B5-A4
B5-A5
B5-A7
B5-A8
B5-A9
B6-A1
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B6-A5
B6-A6
B6-A7
B7-A1
B7-A3
B7-A4
B7-A5
B16-A1
B17-A1
B17-A2
eps group, Inc.
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Phone (480) 503-2250 Fax (480) 503-2258
Project:
Desert Place at Morrison Ranch - Phase 1
City of Mesa, Arizona
FIGURE 3: DRAINAGE MAP - RETENTION
Revisions:
ARIZONA 811
Designer: BN
Drawn by: DBA
Preliminary
Not For
Construction
Or
Recording
Job No.
06-016
DE01
Sheet No.
1
of 1

06-016 - Desert Place at Morrison Ranch - Phase 1

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Phone (480) 503-2250 Fax (480) 503-2258

Project: Desert Place at Morrison Ranch - Phase I
City of Mesa, Arizona

FIGURE 3: DRAINAGE MAP - HYDROLOGY

Revisions:

Call at least two full working days before you begin excavation.
ARIZONA 811

Designer: BN
Drawn by: DBA

Preliminary
Not For
Construction
Or
Recording

Job No.
06-016

DE02

Sheet No.
1
of 1

Jul 17, 2012 10:37am S:\Projects\2006\06-016\Civil\CAD\Design\Drainage\Phase 1 Drainage\Exhibit 06-016 – PH1 – FIG04-DE01.dwg

bnicholls

Appendix B:
Weighted C Value Calculations

Summary of Weighted Runoff Coefficient

Project: Desert Place at Morrison Ranch - Phase 1

Description: Summary

Prepared by: Brian Nicholls **Date:** 7/17/2012

Summary of Weighted Runoff Coefficient

Area Description	C Value
Guadalupe Road	0.78
Sossaman Road	0.73
N-S Road	0.73
70x130 lot on Standard Local Roads	0.60
60x120 lot on Standard Local Roads	0.60
50x115 lot on Standard Local Roads	0.65

Summary of City of Mesa Runoff Coefficients

Area Description	C Value
Roofs and Concrete	0.95
Asphalt	0.85
Desert Landscaping	0.50
Green Landscaping	0.15

Typical Weighted Runoff Coefficient

Project: Desert Place at Morrison Ranch - Phase I

Description: Guadalupe Road

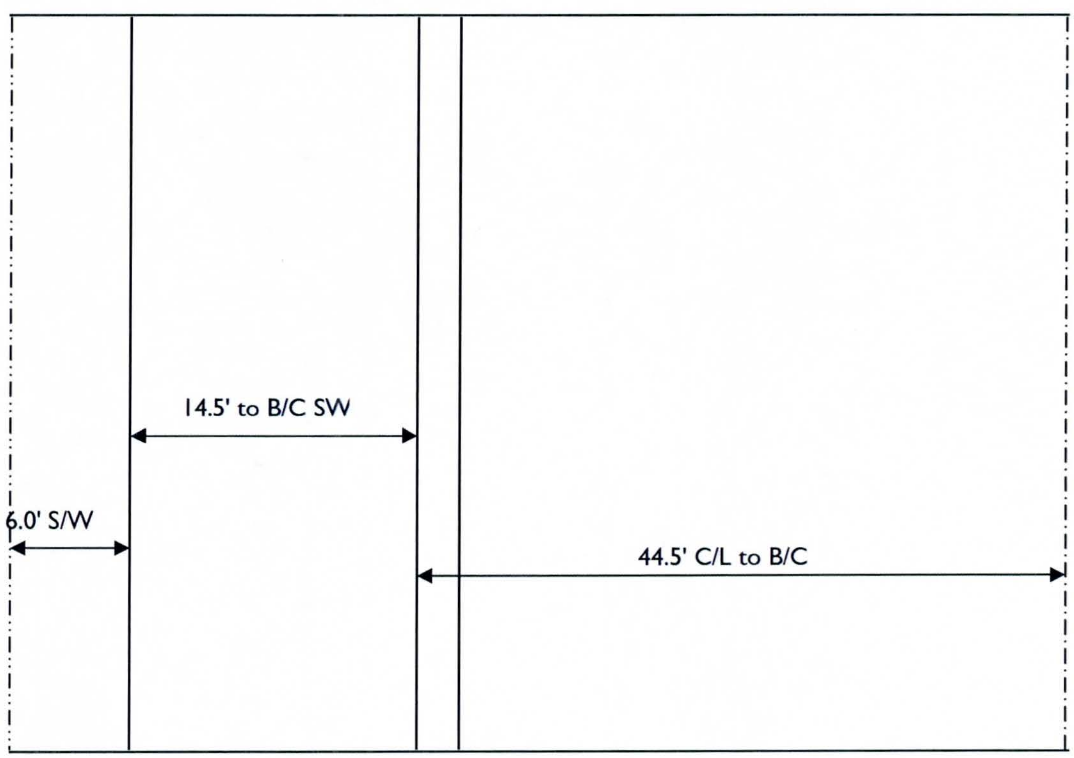
Prepared by: Brian Nicholls **Date:** 7/17/2012

	Depth (LF)	Type	Runoff Coef (1)	Length x Runoff Coef
C/L to Lip	42.50	Asphalt	0.85	36.13
Lip to B/C	2.00	Concrete	0.95	1.90
B/C to S/W	14.50	Desert	0.50	7.25
Sidewalk	6.00	Concrete	0.95	5.70

C	**0.78**

(1) Runoff Coefficients from City of Mesa Standards

Typical Street Section



Typical Weighted Runoff Coefficient

Project: Desert Place at Morrison Ranch - Phase I

Description: Sossaman Road

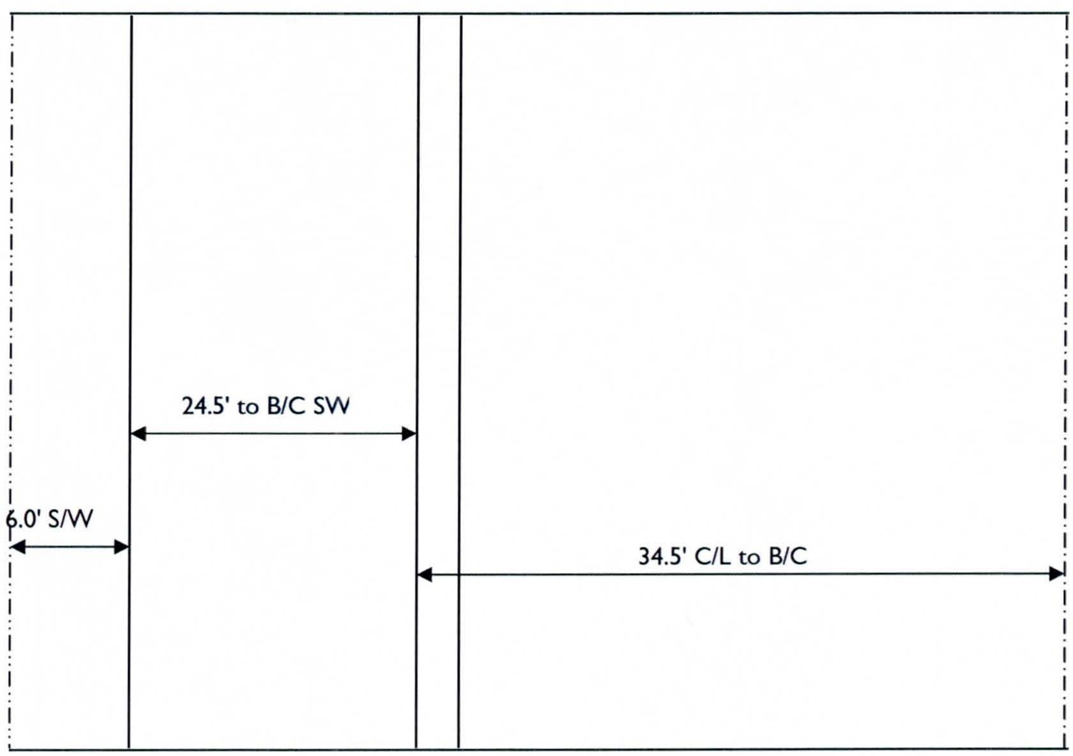
Prepared by: Brian Nicholls **Date:** 7/17/2012

	Depth (LF)	Type	Runoff Coef [1]	Length x Runoff Coef
C/L to Lip	32.50	Asphalt	0.85	27.63
Lip to B/C	2.00	Concrete	0.95	1.90
B/C to S/W	24.50	Desert	0.50	12.25
Sidewalk	6.00	Concrete	0.95	5.70

C	**0.73**

(1) Runoff Coefficients from City of Mesa Standards

Typical Street Section



Typical Weighted Runoff Coefficient

Project: Desert Place at Morrison Ranch - Phase I

Description: N-S Road

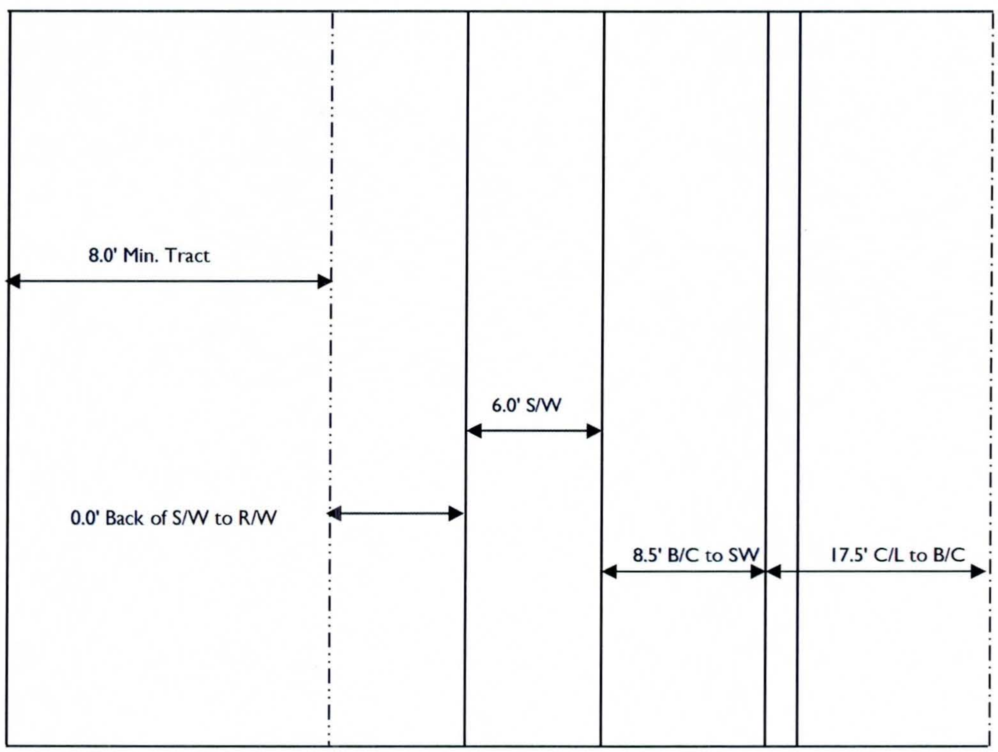
Prepared by: Brian Nicholls **Date:** 7/17/2012

	Depth (LF)	Type	Runoff Coef (1)	Length x Runoff Coef
CL to Lip	15.50	Asphalt	0.85	13.18
Lip to B/C	2.00	Concrete	0.95	1.90
B/C to SW	8.50	Desert	0.50	4.25
Sidewalk Width	6.00	Concrete	0.95	5.70
Back of Sidewalk to R/W	0.00	Desert	0.50	0.00
Min. Tract	8.00	Desert	0.50	4.00

C	**0.73**

(1) Runoff Coefficients from City of Mesa Standards

Typical N-S Roadway Street Section



Typical Weighted Runoff Coefficient

Project: Desert Place at Morrison Ranch - Phase 1

Description: 70x130 lot on Standard Local Roads

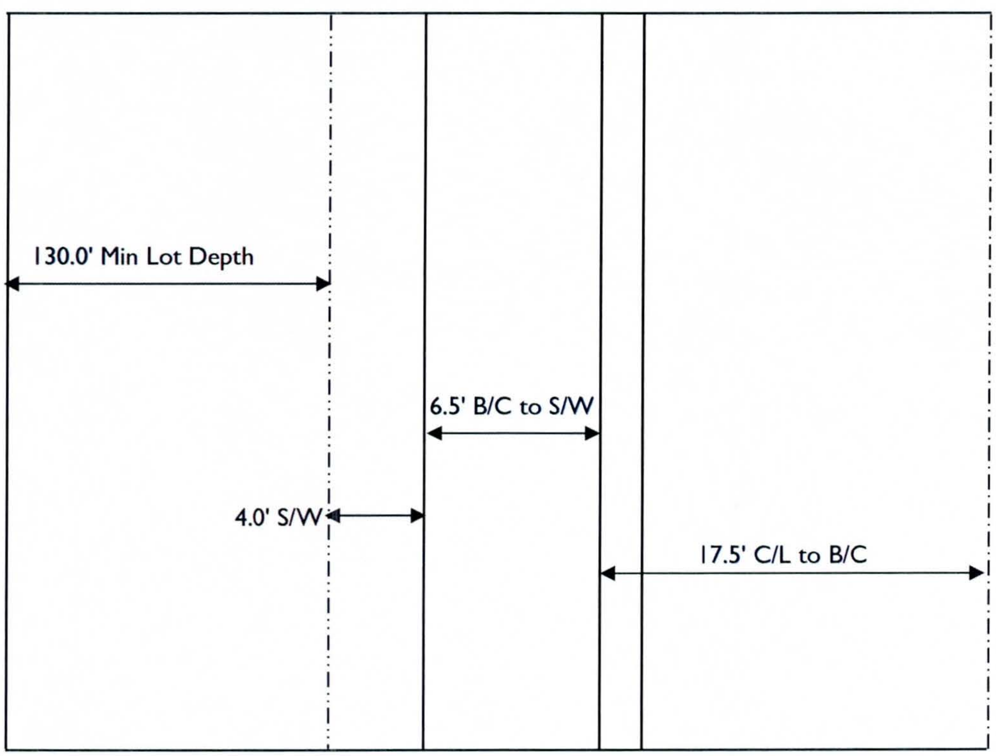
Prepared by: Brian Nicholls **Date:** 7/17/2012

	Depth (LF)	Type	Runoff Coef (1)	Length x Runoff Coef
Min. Lot Depth	130.00	Lot	0.56	72.80
CL to Lip	15.50	Asphalt	0.85	13.18
Lip to B/C	2.00	Concrete	0.95	1.90
B/C to S/W	6.50	Desert	0.50	3.25
Sidewalk	4.00	Concrete	0.95	3.80

C	**0.60**

(1) Runoff Coefficients from City of Mesa Standards

Typical Residential Street and Lot Section



Typical Weighted Runoff Coefficient

Project: Desert Place at Morrison Ranch - Phase 1

Description: 60x120 lot on Standard Local Roads

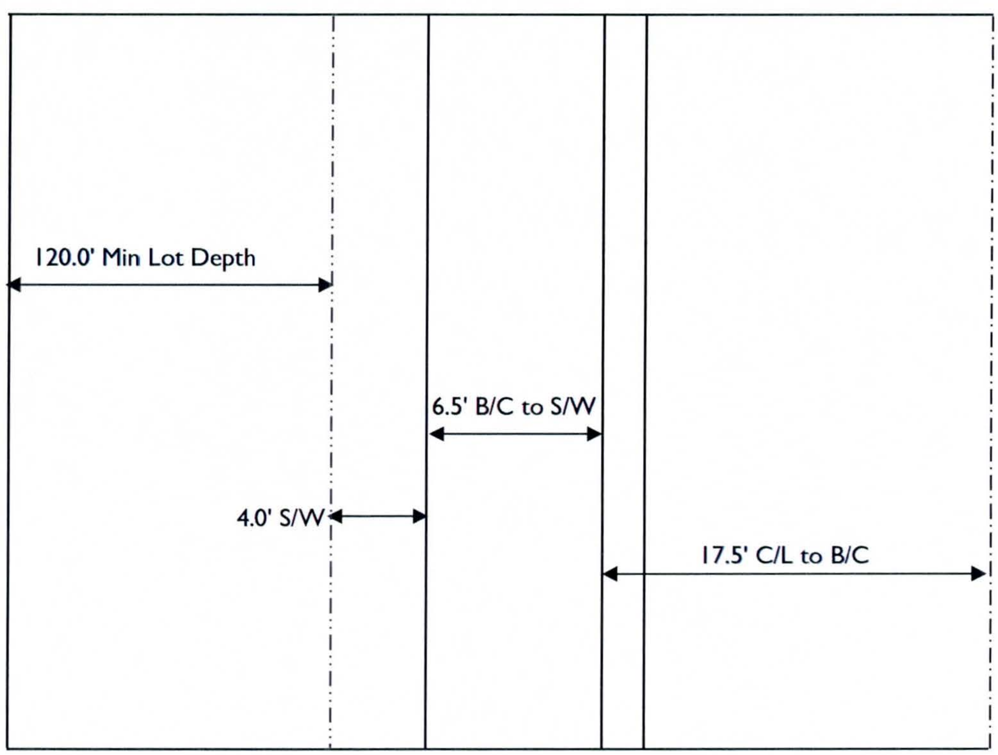
Prepared by: Brian Nicholls **Date:** 7/17/2012

	Depth (LF)	Type	Runoff Coef [(1)]	Length x Runoff Coef
Min. Lot Depth	120.00	Lot	0.56	67.20
CL to Lip	15.50	Asphalt	0.85	13.18
Lip to B/C	2.00	Concrete	0.95	1.90
B/C to S/W	6.50	Desert	0.50	3.25
Sidewalk	4.00	Concrete	0.95	3.80

C	**0.60**

(1) Runoff Coefficients from City of Mesa Standards

Typical Residential Street and Lot Section



Typical Weighted Runoff Coefficient

Project: Desert Place at Morrison Ranch - Phase 1

Description: 50x115 lot on Standard Local Roads

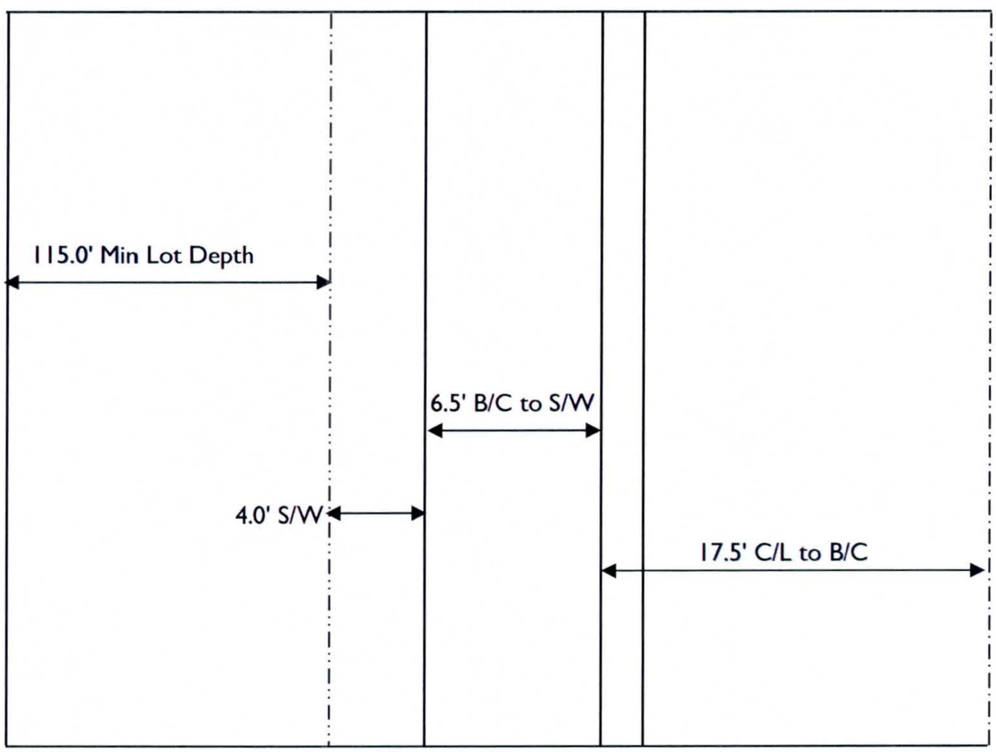
Prepared by: Brian Nicholls **Date:** 7/17/2012

	Depth (LF)	Type	Runoff Coef [1]	Length x Runoff Coef
Min. Lot Depth	115.00	Lot	0.62	71.30
CL to Lip	15.50	Asphalt	0.85	13.18
Lip to B/C	2.00	Concrete	0.95	1.90
B/C to S/W	6.50	Desert	0.50	3.25
Sidewalk	4.00	Concrete	0.95	3.80

C	**0.65**

(1) Runoff Coefficients from City of Mesa Standards

Typical Residential Street and Lot Section



Weighted Runoff Coefficient by Area - Lot Analysis

Project: Desert Place at Morrison Ranch - Phase I

Prepared By: Brian Nicholls **Date:** 7/17/2012

Sub Basin Area: 50x115 Lot

Area Description	"C"	Area
Roofs and Concrete	0.95	2,674
Asphalt	0.85	0
Desert Landscaping	0.50	1,538
Green Landscaping	0.15	1,538
Total Area	---	5,750
	Weighted "C"	**0.62**

Sub Basin Area: 60x120 Lot

Area Description	"C"	Area
Roofs and Concrete	0.95	2,736
Asphalt	0.85	0
Desert Landscaping	0.50	2,232
Green Landscaping	0.15	2,232
Total Area	---	7,200
	Weighted "C"	**0.56**

Sub Basin Area: 70x130 Lot

Area Description	"C"	Area
Roofs and Concrete	0.95	3,458
Asphalt	0.85	0
Desert Landscaping	0.50	2,821
Green Landscaping	0.15	2,821
Total Area	---	9,100
	Weighted "C"	**0.56**

Appendix C:
Retention Calculations

Retention Calculations

Project: Desert Place at Morrison Ranch - Phase I
Storm Event: 100-year, 2-hour
Prepared by: Brian Nicholls **Date:** 9/15/2012

V = C * A * P / 12
Where:
V = Runoff Volume
C = Runoff Coefficient
A = Drainage Area
P = 2.70 in

Surface Retention Basin Volume Calculations

Basin ID	*Elevation*	*Area (ft^2)*	*Incremental Volume (ft^3)*	*Volume Provided, V_p (ft^3)*	*Volume Provided, V_p (ac-ft)*
B1	1352.50	5,328			
	1356.00	10,166	27,115	27,115	0.62
B2	1349.10	7,178			
	1352.10	13,137	30,472	30,472	0.70
B3	1348.20	2,691			
	1351.70	9,299	20,981	20,981	0.48
B4	1347.00	6,824			
	1350.00	14,205	31,544	31,544	0.72
B5	1340.80	71,999			
	1344.30	89,992	283,484	283,484	6.51
B6	1337.40	35,803			
	1340.90	47,508	145,793	145,793	3.35
B7	1336.60	50,905			
	1340.10	66,701	205,812	205,812	4.72
B16	1345.10	28,263			
	1345.70	30,893	17,747	17,747	0.41
B17	1347.50	30,423			
	1348.10	33,289	19,114	19,114	0.44

Retention Calculations

Project: Desert Place at Morrison Ranch - Phase I

Storm Event: 100-year, 2-hour

Prepared by: Brian Nicholls **Date:** 9/15/2012

Volume Required and Summary

Basin ID	Sub-Basin ID	Sub Basin Area Description	Contributing Area (ft^2)	C =	Volume Required, V_R (ac-ft)	Flow passed into next basin (ac-ft)	Adjusted Volume Required (ac-ft)	Volume Provided, V_p (ac-ft)	Estimated Water Depth (ft)
B1	B1-A1	Desert	26,348	0.50	0.07				
	B1-A2	Sossaman Road	9,958	0.73	0.04				
	B1-A3	Guadalupe Road	9,578	0.78	0.04				
		Total	45,884	0.61	0.14	0.00	0.14	0.62	0.81
B2	B2-A1	Desert	36,719	0.50	0.09				
	B2-A2	Sossaman Road	47,890	0.73	0.18				
	B2-A3	50' Parcel	55,191	0.67	0.19				
	B2-A4	60' Parcel	45,247	0.62	0.14				
		Total	185,048	0.64	0.61	0.00	0.61	0.70	2.62
B3	B3-A1	Desert	32,722	0.50	0.08				
	B3-A2	Sossaman Road	38,883	0.73	0.15				
	B3-A3	60' Parcel	54,094	0.62	0.17				
		Total	125,699	0.62	0.40	0.00	0.40	0.48	2.94
B4	B4-A1	Desert	42,189	0.50	0.11				
	B4-A2	Sossaman Road	47,484	0.73	0.18				
	B4-A3	70' Parcel	93,542	0.62	0.30				
		Total	183,215	0.62	0.59	0.00	0.59	0.72	2.43
B5	B5-A1	Green	61,680	0.15	0.05				
	B5-A2	Desert	2,415	0.50	0.01				
	B5-A3	Desert	30,531	0.50	0.08				
	B5-A4	Guadalupe Road	86,092	0.78	0.35				
	B5-A5	Green	118,450	0.15	0.09				
	B5-A6	50' Parcel	196,022	0.67	0.68				
	B5-A7	50' Parcel	662,094	0.67	2.29				
	B5-A8	N-S Street	58,672	0.73	0.22				
	B5-A9	50' Parcel	275,913	0.67	0.95				
	B5-A10	50' Parcel*	88,399	0.67	0.31				
	B5-A11	50' Parcel*	219,489	0.67	0.76				
		Total	1,799,758	0.58	5.78	0.00	5.78	6.51	3.11
B6	B6-A1	Green	172,092	0.15	0.13				
	B6-A2	60' Parcel	110,432	0.62	0.35				
	B6-A3	60' Parcel	443,803	0.62	1.42				
	B6-A4	N-S Street	43,011	0.73	0.16				
	B6-A5	Green	8,911	0.15	0.01				
	B6-A6	Green	8,911	0.15	0.01				
	B6-A7	60' Parcel	333,556	0.62	1.07				
		Total	1,120,716	0.54	3.15	0.00	3.15	3.35	3.29
B7	B7-A1	Green	92,788	0.15	0.07				
	B7-A2	70' Parcel	139,800	0.62	0.45				
	B7-A3	70' Parcel	601,640	0.62	1.92				
	B7-A4	N-S Street	75,008	0.73	0.28				
	B7-A5	70' Parcel	540,576	0.62	1.72				
		Total	1,449,812	0.56	4.44	0.00	4.44	4.72	3.29

Retention Calculations

Project: Desert Place at Morrison Ranch - Phase I

Storm Event: 100-year, 2-hour

Prepared by: Brian Nicholls **Date:** 9/15/2012

B16	B16-A1	Desert	127,428	0.50	0.33				
					0.00				
		Total	127,428	0.50	0.33	0.00	0.33	0.41	0.48

B17	B17-A1	Desert	68,907	0.50	0.18				
	B17-A2	Sossaman Road	19,470	0.73	0.07				
		Total	88,378	0.55	0.25	0.00	0.25	0.44	0.34

Bleedoff Flow Calculations

Basin	*Adjusted Volume Required (ac-ft)*	*Discharge (cfs)*
B1	0.62	0.21
B2	0.70	0.24
B3	0.48	0.16
B4	0.72	0.24
B5	6.51	2.19
B6	3.35	1.12
B7	4.72	1.59

Notes:

Point Precipitation Frequency Estimates (inches)

NOAA Atlas 14 Volume 1 Version 5

Data type: Precipitation depth

Time series type: Partial duration

Project area: Southwest

Latitude (decimal degrees): 33.3620

Longitude (decimal degrees): -111.6750

PRECIPITATION FREQUENCY ESTIMATES

by duration for ARI:	1	2	5	10	25	50	100	200	500	1000 years
5-min:	0.19	0.24	0.33	0.4	0.49	0.56	0.63	0.7	0.8	0.88
10-min:	0.28	0.37	0.5	0.6	0.74	0.85	0.96	1.07	1.22	1.33
15-min:	0.35	0.46	0.62	0.75	0.92	1.05	1.19	1.32	1.51	1.65
30-min:	0.47	0.62	0.84	1	1.24	1.41	1.6	1.78	2.04	2.22
60-min:	0.59	0.77	1.04	1.24	1.53	1.75	1.98	2.21	2.52	2.75
2-hr:	0.67	0.87	1.16	1.38	1.68	1.92	2.16	2.41	2.74	3
3-hr:	0.71	0.91	1.2	1.42	1.74	1.99	2.26	2.54	2.92	3.23
6-hr:	0.86	1.08	1.39	1.63	1.96	2.22	2.49	2.77	3.16	3.47
12-hr:	0.96	1.22	1.54	1.79	2.13	2.39	2.66	2.93	3.3	3.59
24-hr:	1.18	1.49	1.91	2.24	2.71	3.07	3.45	3.84	4.39	4.81
2-day:	1.24	1.58	2.05	2.42	2.93	3.34	3.76	4.2	4.8	5.28
3-day:	1.33	1.69	2.2	2.61	3.19	3.65	4.13	4.64	5.35	5.92
4-day:	1.41	1.8	2.35	2.8	3.44	3.95	4.5	5.08	5.9	6.56
7-day:	1.55	1.98	2.59	3.09	3.8	4.37	4.97	5.62	6.52	7.26
10-day:	1.7	2.16	2.83	3.37	4.13	4.74	5.38	6.06	7.01	7.77
20-day:	2.1	2.69	3.53	4.17	5.03	5.69	6.36	7.04	7.96	8.66
30-day:	2.45	3.14	4.11	4.84	5.83	6.59	7.37	8.16	9.23	10.04
45-day:	2.85	3.66	4.79	5.62	6.72	7.54	8.37	9.19	10.26	11.06
60-day:	3.17	4.07	5.3	6.2	7.38	8.24	9.1	9.94	11.02	11.82

PRECIPITATION FREQUENCY ESTIMATES AT UPPER BOUND OF 90% CONFIDENCE INTERVAL

by duration for ARI:	1	2	5	10	25	50	100	200	500	1000 years
5-min:	0.23	0.3	0.41	0.48	0.59	0.67	0.76	0.85	0.96	1.06
10-min:	0.35	0.46	0.62	0.74	0.9	1.03	1.16	1.29	1.47	1.61
15-min:	0.43	0.57	0.76	0.91	1.11	1.27	1.43	1.6	1.82	2
30-min:	0.58	0.76	1.03	1.23	1.5	1.71	1.93	2.15	2.45	2.69
60-min:	0.72	0.94	1.27	1.52	1.86	2.12	2.39	2.66	3.04	3.33
2-hr:	0.81	1.05	1.39	1.66	2.01	2.29	2.58	2.86	3.26	3.59
3-hr:	0.87	1.12	1.46	1.73	2.1	2.4	2.71	3.04	3.5	3.88
6-hr:	1.01	1.28	1.64	1.91	2.29	2.58	2.9	3.22	3.68	4.05
12-hr:	1.11	1.4	1.77	2.05	2.43	2.72	3.04	3.35	3.79	4.15
24-hr:	1.31	1.66	2.13	2.5	3.01	3.41	3.83	4.28	4.89	5.39
2-day:	1.39	1.77	2.29	2.71	3.27	3.72	4.2	4.69	5.38	5.94
3-day:	1.48	1.88	2.45	2.9	3.53	4.03	4.58	5.15	5.95	6.62
4-day:	1.56	1.99	2.6	3.09	3.79	4.35	4.96	5.61	6.53	7.29
7-day:	1.72	2.19	2.87	3.41	4.18	4.81	5.48	6.2	7.22	8.07
10-day:	1.87	2.39	3.12	3.71	4.54	5.2	5.91	6.66	7.73	8.59
20-day:	2.32	2.98	3.9	4.6	5.54	6.27	7.02	7.78	8.83	9.64
30-day:	2.69	3.45	4.5	5.31	6.39	7.23	8.09	8.97	10.18	11.12
45-day:	3.14	4.03	5.27	6.19	7.39	8.3	9.22	10.13	11.35	12.27
60-day:	3.48	4.47	5.83	6.81	8.09	9.05	10.01	10.94	12.17	13.08

Point Precipitation Frequency Estimates (inches)

NOAA Atlas 14 Volume 1 Version 5
Data type: Precipitation depth
Time series type: Partial duration
Project area: Southwest
Latitude (decimal degrees): 33.3620
Longitude (decimal degrees): -111.6750

PRECIPITATION FREQUENCY ESTIMATES AT LOWER BOUND OF 90% CONFIDENCE INTERVAL

by duration for ARI:	1	2	5	10	25	50	100	200	500	1000 years
5-min:	0.16	0.2	0.28	0.33	0.4	0.45	0.5	0.55	0.6	0.65
10-min:	0.24	0.31	0.42	0.5	0.6	0.68	0.76	0.83	0.92	0.99
15-min:	0.29	0.39	0.52	0.62	0.75	0.84	0.94	1.03	1.14	1.22
30-min:	0.4	0.52	0.7	0.83	1.01	1.14	1.26	1.39	1.54	1.65
60-min:	0.49	0.64	0.86	1.03	1.25	1.41	1.56	1.71	1.9	2.04
2-hr:	0.56	0.73	0.97	1.15	1.38	1.56	1.72	1.89	2.09	2.24
3-hr:	0.6	0.77	1.01	1.19	1.43	1.61	1.79	1.98	2.21	2.38
6-hr:	0.74	0.94	1.2	1.39	1.65	1.84	2.03	2.22	2.46	2.63
12-hr:	0.85	1.07	1.34	1.55	1.83	2.03	2.23	2.42	2.65	2.83
24-hr:	1.06	1.34	1.71	2	2.4	2.7	3.01	3.32	3.72	4.04
2-day:	1.12	1.42	1.84	2.16	2.6	2.94	3.28	3.62	4.07	4.42
3-day:	1.2	1.53	1.99	2.34	2.85	3.23	3.63	4.04	4.58	5.01
4-day:	1.28	1.63	2.13	2.53	3.09	3.53	3.98	4.45	5.09	5.61
7-day:	1.41	1.8	2.35	2.79	3.41	3.9	4.4	4.93	5.64	6.21
10-day:	1.54	1.97	2.57	3.05	3.72	4.24	4.78	5.34	6.09	6.69
20-day:	1.9	2.44	3.19	3.76	4.52	5.09	5.66	6.23	6.98	7.54
30-day:	2.23	2.85	3.73	4.39	5.27	5.93	6.6	7.26	8.13	8.78
45-day:	2.59	3.33	4.34	5.09	6.07	6.78	7.5	8.18	9.06	9.71
60-day:	2.89	3.7	4.82	5.63	6.67	7.43	8.17	8.88	9.79	10.44

Date/time (GMT): Thu Dec 1 22:02:49 2011
pyRunTime: 0.0782630443573

Appendix D:
Hydrology and Street Capacity Calculations

Peak Flow and Street Capacity Calculations using the Rational Method

Project: Desert Place - Phase I

Prepared By: Brian Nicholls

Date: 9/15/2012

Time of Concentration calculated using the Papadakis and Kazan Equation

"C" Value Adjustment	
100-yr	1.00
50-yr	1.00
25-yr	1.00
10-yr	1.00

Street Code	Description	10 yr "K"	50 yr "K"
1	Local Road - 4" Roll	71.57	220.60
2	Local Road - 6" Vert	227.20	395.24
3	Arterials - 6" Vert	105.16	1105.70

		Sub Basin Area Description											Peak Flow Calculations (Storm Event: 10 yr)					Peak Flow Calculations (Storm Event: 50 yr)					Street Capacity Calculations			10 yr Street Capacity		50 yr Street Capacity	
Concentration Point ID	Local Contributing Areas	Drainage Area (acres)	Drainage Length (ft)	High Point Elevation	Low Point Elevation	Watercourse slope	Initial Lot Tc (min)	Kb	Type	Roughness Description	m	b	Weighted C	Local Time of Concentration (min)	Local Intensity (in/hr)	Additional Flow (cfs)	Peak Flow (cfs)	Weighted C	Local Time of Concentration (min)	Local Intensity (in/hr)	Additional Flow (cfs)	Peak Flow (cfs)	Street Code	Half/Full Street	Critical Slope	Capacity	Check	Capacity	Check
CP1	CP1	5.53	961	1356.10	1351.26	0.0050	15	0.0354	A	Minimal	-0.0063	0.040	0.65	29.11	2.06		**7.4**	0.65	27.09	3.09		**11.1**	1	F	0.0034	8.3	OK	25.7	OK
CP2	CP2	6.48	980	1354.38	1349.54	0.0049	15	0.0349	A	Minimal	-0.0063	0.040	0.65	29.28	2.05		**8.6**	0.65	27.23	3.07		**12.9**	1	F	0.0037	8.7	OK	26.8	OK
CP3	CP2-CP3 +FB	10.18	1671	1354.38	1345.40	0.0054	15	0.0337	A	Minimal	-0.0063	0.040	0.65	33.27	1.92	3.00	**15.7**	0.65	30.84	2.79	4.80	**23.3**	2	F	0.0110	47.7	OK	82.9	OK
CP4	CP4	6.15	940	1353.53	1347.27	0.0067	15	0.0351	A	Minimal	-0.0063	0.040	0.65	27.51	2.16		**8.6**	0.65	25.76	3.21		**12.8**	1	F	0.0037	8.7	OK	26.8	OK
CP5	CP4-CP5	9.10	1441	1353.53	1345.41	0.0056	15	0.0340	A	Minimal	-0.0063	0.040	0.65	31.66	1.96		**11.6**	0.65	29.40	2.88		**17.0**	2	F	0.0037	27.6	OK	48.1	OK
CP6	CP6	1.18	100	1353.53	1353.33	0.0020	15	0.0396	A	Minimal	-0.0063	0.040	0.65	20.89	2.58		**2.0**	0.65	20.13	3.73		**2.9**	1	F	0.0020	6.4	OK	19.7	OK
CP7	CP7	7.79	1170	1352.72	1344.76	0.0068	15	0.0344	A	Minimal	-0.0063	0.040	0.60	28.97	2.07		**9.7**	0.60	26.97	3.10		**14.5**	1	F	0.0047	9.8	OK	30.2	OK
CP8	CP7-CP8	9.62	1599	1352.72	1342.13	0.0066	15	0.0339	A	Minimal	-0.0063	0.040	0.60	31.66	1.96		**11.3**	0.60	29.40	2.88		**16.6**	2	F	0.0047	31.2	OK	54.2	OK
CP9	CP9	8.92	1290	1352.34	1342.79	0.0074	15	0.0341	A	Minimal	-0.0063	0.040	0.60	29.26	2.05		**11.0**	0.60	27.21	3.08		**16.5**	1	F	0.0061	11.2	OK	34.5	OK
CP10	CP9-CP10+FB	9.63	1451	1352.34	1342.13	0.0070	15	0.0339	A	Minimal	-0.0063	0.040	0.60	30.48	1.99	5.00	**16.5**	0.60	28.28	2.98	8.00	**25.2**	2	F	0.0026	23.2	OK	40.3	OK
CP11	CP11	1.04	120	1352.72	1352.48	0.0020	15	0.0399	A	Minimal	-0.0063	0.040	0.60	21.52	2.54		**1.6**	0.60	20.67	3.68		**2.3**	1	F	0.0020	6.4	OK	19.7	OK
CP12	CP12	1.25	120	1352.34	1352.10	0.0020	15	0.0394	A	Minimal	-0.0063	0.040	0.60	21.48	2.55		**1.9**	0.60	20.63	3.68		**2.8**	1	F	0.0020	6.4	OK	19.7	OK
CP13	CP13	8.76	1210	1351.88	1342.82	0.0075	15	0.0341	A	Minimal	-0.0063	0.040	0.60	28.67	2.08		**11.0**	0.60	26.73	3.12		**16.4**	1	F	0.0059	11.0	OK	33.9	OK
CP14	CP13-CP14	10.59	1611	1351.88	1340.65	0.0070	15	0.0336	A	Minimal	-0.0063	0.040	0.60	31.37	1.97		**12.5**	0.60	29.12	2.90		**18.4**	2	F	0.0036	27.3	OK	47.4	OK
CP15	CP15	8.20	1070	1350.85	1342.70	0.0076	15	0.0343	A	Minimal	-0.0063	0.040	0.60	27.68	2.15		**10.6**	0.60	25.90	3.20		**15.7**	1	F	0.0059	11.0	OK	33.9	OK
CP16	CP16	10.60	1459	1350.85	1340.65	0.0070	15	0.0336	A	Minimal	-0.0063	0.040	0.60	30.49	1.99	5.20	**17.8**	0.60	28.29	2.98	8.20	**27.1**	2	F	0.0035	26.9	OK	46.8	OK
CP18	CP18	6.34	1644	1351.39	1342.17	0.0056	15	0.0350	A	Minimal	-0.0063	0.040	0.60	33.24	1.92		**7.3**	0.60	30.82	2.79		**10.6**	1	F	0.0050	10.1	OK	31.2	OK
CP19	CP18-CP19	6.74	1844	1351.39	1341.42	0.0054	15	0.0348	A	Minimal	-0.0063	0.040	0.60	34.62	1.88		**7.6**	0.60	31.99	2.75		**11.1**	2	F	0.0027	23.6	OK	41.1	OK
CP49	CP49	2.14	169	1350.85	1350.50	0.0021	15	0.0379	A	Minimal	-0.0063	0.040	0.60	22.52	2.48		**3.2**	0.60	21.53	3.60		**4.6**	1	F	0.0021	6.5	OK	20.1	OK
CP50	CP50	0.23	136	1358.16	1357.53	0.0046	0	0.0440	A	Minimal	-0.0063	0.040	0.78	4.43	4.80		**0.8**	0.78	3.90	6.72		**1.2**	1	H	0.0046	4.9	OK	15.0	OK
CP51	CP51+FB	2.09	901	1357.53	1353.09	0.0049	0	0.0380	A	Minimal	-0.0063	0.040	0.78	11.85	3.36	0.20	**5.7**	0.78	10.13	5.08	0.40	**8.7**	3	H	0.0049	7.4	OK	77.6	OK
CP52	CP52	1.00	740	0.65	0.00	0.0009	0	0.0400	A	Minimal	-0.0063	0.040	0.50	20.79	2.59		**1.3**	0.50	17.71	3.95		**2.0**	Inlet*			N/A	N/A	N/A	N/A
CP53	CP53	0.27	166	1358.08	1356.64	0.0087	0	0.0436	A	Minimal	-0.0063	0.040	0.73	4.00	4.80		**0.9**	0.73	3.52	6.72		**1.3**	3	H	0.0087	9.8	OK	103.0	OK
CP54	CP54+FB	1.11	757	1356.64	1353.96	0.0035	0	0.0397	A	Minimal	-0.0063	0.040	0.73	12.42	3.29	0.30	**3.0**	0.73	10.60	4.99	0.40	**4.4**	3	H	0.0035	6.3	OK	65.8	OK
CP55	CP55+FB	0.85	491	1353.96	1352.53	0.0029	0	0.0404	A	Minimal	-0.0063	0.040	0.73	10.42	3.55	1.10	**3.3**	0.73	8.84	5.48	1.70	**5.1**	3	H	0.0029	5.7	OK	59.7	OK
CP56	CP56	1.07	825	1352.53	1351.20	0.0016	0	0.0398	A	Minimal	-0.0063	0.040	0.73	17.63	2.79		**2.2**	0.73	15.11	4.19		**3.3**	3	H	0.0016	4.2	OK	44.4	OK
CP57	CP57+FB	0.42	293	1351.20	1350.59	0.0021	0	0.0424	A	Minimal	-0.0063	0.040	0.73	8.85	3.88	0.70	**1.9**	0.73	7.55	5.89	1.10	**2.9**	3	H	0.0021	4.8	OK	50.5	OK
CP58	CP58	0.65	390	1354.66	1350.85	0.0098	0	0.0412	A	Minimal	-0.0063	0.040	0.65	5.84	4.60		**1.9**	0.65	5.06	6.70		**2.8**	3	H	0.0058	8.0	OK	84.2	OK

Note:

* "Inlet" in the street code column signifies the the concentration point is a combination of two other contributing areas at an inlet and therefore does not represent a flow rate in the street, rather it is the peak flow in the inlet. Therefore, the street capacity calculations are not applicable

On Grade Grate Inlet Calculations

Project: Desert Place - Phase I
Storm Event: 10-yr
Prepared By: Brian Nicholls **Date:** 7/13/2012

Source: Drainage Design Manual for Maricopa County, Arizona: Hydraulics (March 2009, Draft)

Equations Used in Inlet Calculations:

$$T = \left(\frac{Q}{\left(\frac{0.56}{n}\right) S_X^{1.67} S^{0.50}} \right)^{\left(\frac{1}{2.67}\right)}$$

From Equation 3.2

$$E_0 = 1 - \left(1 - \left(\frac{W}{T}\right)\right)^{2.67}$$

Equation 3.15

$$R_S = \frac{1}{1 + \frac{0.15V^{1.8}}{S_S L^{2.3}}}$$

Equation 3.18

$$Q_i = Q * \left[R_f E_O + R_S (1 - E_O) \right]$$

Equation 3.20

Definition of Variables:

Q = Total Peak Flow
T = Top Width of Flow in street
W = Width of Gutter
n = Manning's "n" for street
S_X = Street Cross Slope
R_S = Ratio of Side Flow Intercepted to Total Flow
S = Longitudinal Street Slope
E_O = Ratio of flow in depressed gutter section to total gutter flow
L = Total Length of grate
V = Velocity of Flow

Inlet Calculations:

Grate Clogging Factor: 25% (Percent Clogged)

Catch Basin ID	Total Peak Flow (cfs)	Gutter Depression (ft)	W (ft)	S_X	S	n	L (ft)	R_f	T (ft)	E_O	V (fps)	R_s	Q_i	Unadjusted % Intercepted	Flow Captured (cfs)	Bypass Flow (cfs)
CB 1	3.80	0.17	1.833	2.00%	0.36%	0.015	6.84	1.0	14.08	0.311	1.92	0.77	3.21	84.5%	2.4	1.4
CB 2	3.80	0.17	1.833	2.00%	0.36%	0.015	6.84	1.0	14.08	0.311	1.92	0.77	3.21	84.5%	2.4	1.4
CB 5	6.25	0.17	1.833	2.00%	0.36%	0.015	6.84	1.0	16.97	0.263	2.17	0.73	5.02	80.4%	3.8	2.5
CB 6	6.25	0.17	1.833	2.00%	0.36%	0.015	6.84	1.0	16.97	0.263	2.17	0.73	5.02	80.4%	3.8	2.5
CB 9	5.65	0.17	1.833	2.00%	0.66%	0.015	6.84	1.0	14.58	0.301	2.66	0.66	4.29	76.0%	3.2	2.4
CB 10	5.65	0.17	1.833	2.00%	0.66%	0.015	6.84	1.0	14.58	0.301	2.66	0.66	4.29	76.0%	3.2	2.4
CB 15	3.70	0.17	1.833	2.00%	0.74%	0.015	6.84	1.0	12.18	0.353	2.49	0.68	2.94	79.4%	2.2	1.5
CB 16	3.70	0.17	1.833	2.00%	0.74%	0.015	6.84	1.0	12.18	0.353	2.49	0.68	2.94	79.4%	2.2	1.5
CB 18	0.80	0.17	1.833	2.00%	0.53%	0.015	6.84	1.0	7.31	0.538	1.50	0.84	0.74	92.7%	0.6	0.2
CB 19	0.90	0.17	1.833	2.00%	0.80%	0.015	6.84	1.0	7.07	0.551	1.80	0.79	0.82	90.8%	0.6	0.3
CB 22	3.00	0.17	1.833	2.00%	0.35%	0.015	6.84	1.0	12.96	0.335	1.79	0.80	2.59	86.4%	1.9	1.1
CB 30	2.20	0.17	1.833	2.00%	0.20%	0.015	6.84	1.0	12.81	0.338	1.34	0.87	2.01	91.2%	1.5	0.7
CB 31	1.90	0.17	1.833	2.00%	0.21%	0.015	6.84	1.0	12.01	0.357	1.32	0.87	1.74	91.7%	1.3	0.6

On Grade Grate Inlet Calculations

Project: Desert Place - Phase I

Storm Event: 50-yr

Prepared By: Brian Nicholls **Date:** 7/13/2012

Source: Drainage Design Manual for Maricopa County, Arizona: Hydraulics (March 2009, Draft)

Equations Used in Inlet Calculations:

$$T = \left(\frac{Q}{\left(\frac{0.56}{n}\right) S_X^{1.67} S^{0.50}} \right)^{\left(\frac{1}{2.67}\right)}$$ From Equation 3.2

$$E_0 = 1 - \left(1 - \left(\frac{W}{T}\right)\right)^{2.67}$$ Equation 3.15

$$R_S = \frac{1}{1 + \frac{0.15V^{1.8}}{S_S L^{2.3}}}$$ Equation 3.18

$$Q_i = Q * \left[R_f E_O + R_S (1 - E_O)\right]$$ Equation 3.20

Definition of Variables:

Q = Total Peak Flow
T = Top Width of Flow in street
W = Width of Gutter
n = Manning's "n" for street
S_X = Street Cross Slope
R_S = Ratio of Side Flow Intercepted to Total Flow
S = Longitudinal Street Slope
E_O = Ratio of flow in depressed gutter section to total gutter flow
L = Total Length of grate
V = Velocity of Flow

Inlet Calculations:

Grate Clogging Factor: 25% (Percent Clogged)

Catch Basin ID	Total Peak Flow (cfs)	Gutter Depression (ft)	W (ft)	S_X	S	n	L (ft)	R_f	T (ft)	E_O	V (fps)	R_s	Q_i	Unadjusted % Intercepted	Flow Captured (cfs)	Bypass Flow (cfs)
CB 1	5.55	0.17	1.833	2.00%	0.36%	0.015	6.84	1.0	16.23	0.274	2.11	0.74	4.52	81.4%	3.4	2.2
CB 2	5.55	0.17	1.833	2.00%	0.36%	0.015	6.84	1.0	16.23	0.274	2.11	0.74	4.52	81.4%	3.4	2.2
CB 5	9.20	0.17	1.833	2.00%	0.36%	0.015	6.84	1.0	19.61	0.231	2.39	0.70	7.06	76.8%	5.3	3.9
CB 6	9.20	0.17	1.833	2.00%	0.36%	0.015	6.84	1.0	19.61	0.231	2.39	0.70	7.06	76.8%	5.3	3.9
CB 9	8.30	0.17	1.833	2.00%	0.66%	0.015	6.84	1.0	16.84	0.265	2.93	0.62	5.96	71.8%	4.5	3.8
CB 10	8.30	0.17	1.833	2.00%	0.66%	0.015	6.84	1.0	16.84	0.265	2.93	0.62	5.96	71.8%	4.5	3.8
CB 15	5.55	0.17	1.833	2.00%	0.74%	0.015	6.84	1.0	14.18	0.309	2.76	0.64	4.17	75.2%	3.1	2.4
CB 16	5.55	0.17	1.833	2.00%	0.74%	0.015	6.84	1.0	14.18	0.309	2.76	0.64	4.17	75.2%	3.1	2.4
CB 18	1.20	0.17	1.833	2.00%	0.53%	0.015	6.84	1.0	8.50	0.477	1.66	0.82	1.09	90.4%	0.8	0.4
CB 19	1.30	0.17	1.833	2.00%	0.80%	0.015	6.84	1.0	8.11	0.495	1.97	0.77	1.15	88.2%	0.9	0.4
CB 22	4.50	0.17	1.833	2.00%	0.35%	0.015	6.84	1.0	15.08	0.293	1.98	0.76	3.75	83.4%	2.8	1.7
CB 30	3.30	0.17	1.833	2.00%	0.20%	0.015	6.84	1.0	14.91	0.295	1.48	0.85	2.94	89.1%	2.2	1.1
CB 31	2.90	0.17	1.833	2.00%	0.21%	0.015	6.84	1.0	14.08	0.311	1.46	0.85	2.60	89.6%	1.9	1.0

Inlet Capacity (Combination Inlets in Sump, Curb Opening & Grate)

Project: Desert Place at Morrison Ranch - Phase I
Storm Event: 100-year, 2-hour
Prepared By: Brian Nicholls **Date:** 7/13/2012

Design Capacity for Grate:

Design Capacity as a Weir:

$$Q = C_W P (1 - F_{CL}) d^{1.5}$$

Design Capacity as an Orifice:

$$Q = C_O A_g (1 - F_{CL})(2gd)^{0.5}$$

Where:
- Cw = 3.0
- Co = 0.67
- P = Perimeter Length of Grate
- Ag = Open Area of Grate
- Fcl = 0.0% (Percent Clogged)
- d = 0.67 ft
- g = 32.2 (ft/sec2)

Design Capacity for Curb Opening:

Design Capacity as a Weir:

$$Q = C_W ((L + 1.8W) * (1 - F_{CL})) d^{1.5}$$

Design Capacity as an Orifice:

$$Q = C_O hL (1 - F_{CL})(2gd)^{0.5}$$

Where:
- Cw = 2.3
- Co = 0.67
- h = d*1.4 (minimum)
- L= Total Curb Opening Length
- Fcl = 20.0% (Percent Clogged)
- W = Width of grate or depressed gutter
- g = 32.2 (ft/sec2)
- d = 0.67 ft

Compute Grates as: **Weir**

Compute Curb Openings as: **None**

Catch Basin ID	Concentration Point	Estimated Peak Flow (cfs)	Catch Basin Type	Capacity of Grate (CFS)	Capacity of Curb Opening (CFS)	Total Inlet Capacity (CFS)
CB3	CP16	9.2	MAG 534 (Double)	11.7	0.0	11.7
CB4	CP16	9.2	MAG 534 (Double)	11.7	0.0	11.7
CB7	CP10	8.5	MAG 534 (Double)	11.7	0.0	11.7
CB8	CP10	8.5	MAG 534 (Double)	11.7	0.0	11.7
CB11	CP5	6.0	MAG 534 (Double)	11.7	0.0	11.7
CB12	CP5	6.0	MAG 534 (Double)	11.7	0.0	11.7
CB13	CP3	8.2	MAG 534 (Double)	11.7	0.0	11.7
CB14	CP3	8.2	MAG 534 (Double)	11.7	0.0	11.7
CB17	CP51	5.7	MAG 534 (Double)	11.7	0.0	11.7
	CP21	13.1	MAG 534 (Triple)	15.6	0.0	15.6
CB20	CP6	1.0	MAG 534 (Single)	7.7	0.0	7.7
CB21	CP6	1.0	MAG 534 (Single)	7.7	0.0	7.7

Notes:

Inlet Capacity (Combination Inlets in Sump, Curb Opening & Grate)

Project: Desert Place at Morrison Ranch - Phase I

Storm Event: 100-year, 2-hour

Prepared By: Brian Nicholls **Date:** 7/16/2012

Design Capacity for Grate:

Design Capacity as a Weir:

$$Q = C_W P(1 - F_{CL})d^{1.5}$$

Design Capacity as an Orifice:

$$Q = C_O A_g (1 - F_{CL})(2gd)^{0.5}$$

Where:

Cw = 3.0
Co = 0.67
P = Perimeter Length of Grate
Ag = Open Area of Grate
Fcl = 0.0% (Percent Clogged)
d = 0.67 ft
g = 32.2 (ft/sec2)

Design Capacity for Curb Opening:

Design Capacity as a Weir:

$$Q = C_W((L + 1.8W) * (1 - F_{CL}))d^{1.5}$$

Design Capacity as an Orifice:

$$Q = C_O hL(1 - F_{CL})(2gd)^{0.5}$$

Where:

Cw = 2.3
Co = 0.67
h = d*1.4 (minimum)
L= Total Curb Opening Length
Fcl = 20.0% (Percent Clogged)
W = Width of grate or depressed gutter
g = 32.2 (ft/sec2)
d = 0.67 ft

Compute Grates as: **Weir**

Compute Curb Openings as: **None**

Catch Basin ID	Concentration Point	Estimated Peak Flow (cfs)	Catch Basin Type	Capacity of Grate (CFS)	Capacity of Curb Opening (CFS)	Total Inlet Capacity (CFS)
CB23	CP11	0.8	MAG 534 (Single)	7.7	0.0	7.7
CB24	CP11	0.8	MAG 534 (Single)	7.7	0.0	7.7
CB25	CP12	1.0	MAG 534 (Single)	7.7	0.0	7.7
CB26	CP12	1.0	MAG 534 (Single)	7.7	0.0	7.7
CB27	CP55	3.3	MAG 534 (Single)	7.7	0.0	7.7
CB28	CP49	1.7	MAG 534 (Single)	7.7	0.0	7.7
CB29	CP49	1.7	MAG 534 (Single)	7.7	0.0	7.7
CB31	CP57	1.9	MAG 534 (Double)	11.7	0.0	11.7

Notes:

Appendix E:
Hydraulic Calculations

Pipe Hydraulics Using Manning's Equation

Project: Desert Place @ Morrison Ranch
Storm Event: 10 yr
Prepared By: Brian Nicholls
Date: 9/15/2012

		Storm Drain Pipe Design								Full Flow Check		Beginning HGL			
From Pt.	To Pt.	Length (ft)	Discharge (cfs)	Pipe Diameter (in)	Downstream Invert Elevation	Upstream Invert Elevation	Slope (ft/ft)	Upstream Grate/Rim Elevation	Manning's Roughness	Full Flow Capacity (cfs)	Pressurized Flow?	Downstream Pipe HGL (ft)	K (Junction)	Headless (Junction) (ft)	Begin HGL (ft)
BB1	**CB1**	69	4.8	15	31.85	33.70	0.0268	41.35	0.012	11.49	YES	---			38.35
CB1	**CB2**	34	2.4	15	33.70	33.89	0.0056	41.35	0.012	5.25	YES	38.91	1.0	0.06	38.97
BB2	**CB3**	45	18.3	24	31.85	35.96	0.0913	40.57	0.012	74.26	YES	---			38.35
CB3	**CB4**	34	9.2	18	35.96	36.15	0.0056	40.57	0.012	8.53	YES	39.13	1.0	0.42	39.54
BB3	**CB5**	45	7.6	15	31.85	36.07	0.0938	40.68	0.012	21.49	YES	---			38.35
CB5	**CB6**	34	3.8	15	36.07	36.26	0.0056	40.68	0.012	5.25	YES	39.48	1.0	0.15	39.63
BB5	**MH1**	252	22.9	30	32.65	36.60	0.0157	42.76	0.012	55.78	YES	---			39.15
MH1	**CB7**	33	16.5	24	36.60	36.94	0.0103	42.05	0.012	24.94	YES	40.16	1.0	0.43	40.59
CB7	**CB8**	33	8.3	18	36.94	37.13	0.0058	42.05	0.012	8.66	YES	40.73	1.0	0.34	41.07
MH1	**MH2**	24	6.4	18	36.73	37.67	0.0392	42.92	0.012	22.58	YES				40.56
MH2	**CB9**	33	6.4	18	37.67	37.88	0.0064	42.24	0.012	9.10	YES	40.56	1.0	0.20	40.76
CB9	**CB10**	34	3.2	15	37.88	38.07	0.0056	42.24	0.012	5.25	YES	40.87	1.0	0.11	40.97
BB7	**CB11**	45	11.6	18	37.05	40.95	0.0867	45.31	0.012	33.59	YES				42.55
CB11	**CB12**	34	5.8	15	40.95	41.14	0.0056	45.31	0.012	5.25	YES	43.69	1.0	0.35	44.03
BB8	**CB13**	45	15.7	24	37.05	40.50	0.0767	45.32	0.012	68.04	YES				42.55
CB13	**CB14**	34	7.9	18	40.50	40.69	0.0056	45.32	0.012	8.53	YES	43.12	1.0	0.31	43.43
BB10	**CB15**	54	4.8	15	37.05	41.25	0.0778	47.52	0.012	19.57	YES				42.55
CB15	**CB16**	34	2.4	15	41.25	41.44	0.0056	47.52	0.012	5.25	YES	43.04	1.0	0.06	43.10
BB10	**MH4**	384	8.9	15	37.05	44.73	0.0200	49.96	0.012	9.92	NO				42.55
MH4	**ADS**	204	1.9	15	44.73	46.09	0.0067	50.85	0.012	5.73	NO	45.98	1.0	0.04	46.01
MH4	**BB11**	73	7.0	15	44.73	46.56	0.0251	50.30	0.012	11.11	NO				46.59
BB11	**MH5**	39	5.7	15	46.56	47.34	0.0200	54.43	0.012	9.92	NO	47.28	1.0	0.33	47.61
MH5	**MH6**	545	5.7	15	47.34	48.57	0.0023	53.55	0.012	3.33	YES	48.02	1.0	0.33	48.35
MH6	**CB17**	13	5.7	15	48.57	48.64	0.0054	53.01	0.012	5.15	YES	51.97	1.0	0.33	52.30
BB12	**CB18**	76	0.6	15	48.75	53.09	0.0571	57.45	0.012	16.77	NO				54.25
BB13	**CB 19**	88	0.6	15	48.75	52.18	0.0390	56.56	0.012	13.85	YES				54.25
BB14	**CB20**	67	2.0	15	45.35	46.81	0.0218	53.25	0.012	10.36	YES				50.60
CB20	**CB21**	34	1.0	15	46.81	47.00	0.0056	53.25	0.012	5.25	YES	50.70	1.0	0.01	50.71
BB15	**CB22**	86	3.0	15	45.35	49.51	0.0484	53.89	0.012	15.43	NO				50.60
BB16	**CB23**	55	1.6	15	45.35	46.15	0.0145	52.40	0.012	8.46	YES				50.60
CB23	**CB24**	34	0.8	15	46.15	46.34	0.0056	52.40	0.012	5.25	YES	50.66	1.0	0.01	50.66

		Pressurized Flow Calculations									Non-Pressurized Flow Calculations								Design Validation		
From Pt.	To Pt.	Area (ft^2)	Full Velocity (fps)	Velocity Head (ft)	Friction Headloss (ft)	K (other)	Headloss (other) (ft)	Total Headloss (ft)	End HGL (ft)	End EGL (ft)	Theta of flow (rad)	Depth of Flow (ft)	Percent Full (d/D)	Area of Flow (ft^2)	Wetted Perimeter of flow (ft)	Velocity of Flow (fps)	End HGL (ft)	End EGL (ft)	End HGL (ft)	Freeboard (FB) (ft)	FB > 0.50 (ft)
BB1	**CB1**	1.23	3.91	0.238	0.32	1.0	0.24	0.56	**38.91**	39.15	6.28	1.25	100%	1.227	3.93	3.91	**38.35**	38.59	**38.91**	2.44	OK
CB1	**CB2**	1.23	1.96	0.059	0.04		0.00	0.04	**39.01**	39.07	6.28	1.25	100%	1.227	3.93	1.96	**38.97**	39.03	**39.01**	2.34	OK
BB2	**CB3**	3.14	5.83	0.527	0.25	1.0	0.53	0.78	**39.13**	39.65	6.28	2.00	100%	3.142	6.28	5.83	**38.35**	38.88	**39.13**	1.44	OK
CB3	**CB4**	1.77	5.18	0.416	0.22		0.00	0.22	**39.76**	40.18	6.28	1.50	100%	1.767	4.71	5.18	**39.54**	39.96	**39.76**	0.81	OK
BB3	**CB5**	1.23	6.19	0.596	0.53	1.0	0.60	1.13	**39.48**	40.07	6.28	1.25	100%	1.227	3.93	6.19	**38.35**	38.95	**39.48**	1.20	OK
CB5	**CB6**	1.23	3.10	0.149	0.10		0.00	0.10	**39.73**	39.87	6.28	1.25	100%	1.227	3.93	3.10	**39.63**	39.77	**39.73**	0.95	OK
BB5	**MH1**	4.91	4.67	0.338	0.67	1.0	0.34	1.01	**40.16**	40.49	6.28	2.50	100%	4.909	7.85	4.67	**39.15**	39.49	**40.16**	2.60	OK
MH1	**CB7**	3.14	5.25	0.428	0.15		0.00	0.15	**40.73**	41.16	6.28	2.00	100%	3.142	6.28	5.25	**40.59**	41.01	**40.73**	1.32	OK
CB7	**CB8**	1.77	4.67	0.338	0.17		0.00	0.17	**41.25**	41.59	6.28	1.50	100%	1.767	4.71	4.67	**41.07**	41.41	**41.25**	0.80	OK
MH1	**MH2**	1.77	3.62	0.204	0.08	1.0	0.20	0.28	**40.84**	41.04	6.28	1.50	100%	1.767	4.71	3.62	**40.56**	40.76	**40.84**	2.08	OK
MH2	**CB9**	1.77	3.62	0.204	0.10		0.00	0.10	**40.87**	41.07	6.28	1.50	100%	1.767	4.71	3.62	**40.76**	40.97	**40.87**	1.37	OK
CB9	**CB10**	1.23	2.61	0.106	0.07		0.00	0.07	**41.04**	41.15	6.28	1.25	100%	1.227	3.93	2.61	**40.97**	41.08	**41.04**	1.20	OK
BB7	**CB11**	1.77	6.56	0.669	0.47	1.0	0.67	1.14	**43.69**	44.36	6.28	1.50	100%	1.767	4.71	6.56	**42.55**	43.22	**43.69**	1.62	OK
CB11	**CB12**	1.23	4.73	0.347	0.23		0.00	0.23	**44.27**	44.61	6.28	1.25	100%	1.227	3.93	4.73	**44.03**	44.38	**44.27**	1.04	OK
BB8	**CB13**	3.14	5.00	0.388	0.18	1.0	0.39	0.57	**43.12**	43.51	6.28	2.00	100%	3.142	6.28	5.00	**42.55**	42.94	**43.12**	2.20	OK
CB13	**CB14**	1.77	4.44	0.306	0.16		0.00	0.16	**43.59**	43.90	6.28	1.50	100%	1.767	4.71	4.44	**43.43**	43.74	**43.59**	1.73	OK
BB10	**CB15**	1.23	3.91	0.238	0.25	1.0	0.24	0.49	**43.04**	43.28	6.28	1.25	100%	1.227	3.93	3.91	**42.55**	42.79	**43.04**	4.48	OK
CB15	**CB16**	1.23	1.96	0.059	0.04		0.00	0.04	**43.14**	43.20	6.28	1.25	100%	1.227	3.93	1.96	**43.10**	43.16	**43.14**	4.38	OK
BB10	**MH4**	1.23	7.25	0.817	6.21	1.0	0.82	7.03	**49.58**	50.39	6.51	1.25	100%	1.228	4.07	7.25	**45.98**	46.79	**45.98**	3.98	OK
MH4	**ADS**	1.23	1.55	0.037	0.15		0.00	0.15	**46.16**	46.20	2.72	0.50	40%	0.453	1.70	4.19	**46.59**	46.86	**46.59**	4.26	OK
MH4	**BB11**	1.23	5.70	0.505	0.73	1.0	0.51	1.24	**47.82**	48.33	3.45	0.72	58%	0.731	2.15	9.57	**47.28**	48.70	**47.28**	3.02	OK
BB11	**MH5**	1.23	4.64	0.335	0.26		0.00	0.26	**47.87**	48.21	3.32	0.68	54%	0.681	2.07	8.37	**48.02**	49.11	**48.02**	6.41	OK
MH5	**MH6**	1.23	4.64	0.335	3.61		0.00	3.61	**51.97**	52.30	6.28	1.25	100%	1.227	3.93	4.64	**49.82**	50.15	**51.97**	1.58	OK
MH6	**CB17**	1.23	4.64	0.335	0.09		0.00	0.09	**52.39**	52.72	6.28	1.25	100%	1.227	3.93	4.64	**52.30**	52.64	**52.39**	0.62	OK
BB12	**CB18**	1.23	0.49	0.004	0.01	1.0	0.00	0.01	**54.26**	54.26	1.48	0.16	13%	0.094	0.92	6.35	**54.25**	54.88	**54.25**	3.20	OK
BB13	**CB 19**	1.23	0.49	0.004	0.01	1.0	0.00	0.01	**54.26**	54.26	6.28	1.25	100%	1.227	3.93	0.49	**54.25**	54.25	**54.26**	2.30	OK
BB14	**CB20**	1.23	1.63	0.041	0.05	1.0	0.04	0.10	**50.70**	50.74	6.28	1.25	100%	1.227	3.93	1.63	**50.60**	50.64	**50.70**	2.55	OK
CB20	**CB21**	1.23	0.81	0.010	0.01		0.00	0.01	**50.71**	50.72	6.28	1.25	100%	1.227	3.93	0.81	**50.71**	50.72	**50.71**	2.54	OK
BB15	**CB22**	1.23	2.44	0.093	0.16	1.0	0.09	0.25	**50.85**	50.94	2.31	0.37	30%	0.308	1.45	9.74	**50.60**	52.07	**50.60**	3.29	OK
BB16	**CB23**	1.23	1.30	0.026	0.03	1.0	0.03	0.06	**50.66**	50.68	6.28	1.25	100%	1.227	3.93	1.30	**50.60**	50.63	**50.66**	1.74	OK
CB23	**CB24**	1.23	0.65	0.007	0.00		0.00	0.00	**50.67**	50.67	6.28	1.25	100%	1.227	3.93	0.65	**50.66**	50.67	**50.67**	1.73	OK

Notes:

Pipe Hydraulics Using Manning's Equation

Project: Project Title
Storm Event: 100 yr
Prepared By: Designer
Date: 9/15/2012

		Storm Drain Pipe Design								Full Flow Check		Beginning HGL			
From Pt.	To Pt.	Length (ft)	Discharge (cfs)	Pipe Diameter (in)	Downstream Invert Elevation	Upstream Invert Elevation	Slope (ft/ft)	Upstream Grate/Rim Elevation	Manning's Roughness	Full Flow Capacity (cfs)	Pressurized Flow?	Downstream Pipe HGL (ft)	K (Junction)	Headless (Junction) (ft)	Begin HGL (ft)
BB17	**CB25**	57	2.0	15	44.45	45.58	0.0198	52.02	0.012	9.88	YES	---			49.95
CB25	**CB26**	34	1.0	15	45.58	45.77	0.0056	52.02	0.012	5.25	YES	50.04	1.0	0.01	50.05
BB17	**CB27**	107	3.3	15	44.45	48.08	0.0339	52.45	0.012	12.92	NO	---			
BB18	**MH7**	104	3.3	15	43.75	45.84	0.0201	51.95	0.012	9.95	YES	---			48.50
MH7	**CB28**	36	3.3	15	45.84	46.06	0.0061	50.42	0.012	5.49	YES	48.84	1.0	0.11	48.96
CB28	**CB29**	34	1.7	15	46.06	46.25	0.0056	50.42	0.012	5.25	YES	49.04	1.0	0.03	49.06
BB19	**CB30**	88	1.5	15	42.00	42.95	0.0108	51.12	0.012	7.29	YES	---			48.50
BB20	**CB31**	106	2.0	15	38.00	44.00	0.0566	50.50	0.012	16.69	YES	---			47.80

		Pressurized Flow Calculations									Non-Pressurized Flow Calculations								Design Validation		
From Pt.	To Pt.	Area (ft^2)	Full Velocity (fps)	Velocity Head (ft)	Friction Headloss (ft)	K (other)	Headloss (other) (ft)	Total Headloss (ft)	End HGL (ft)	End EGL (ft)	Theta of flow (rad)	Depth of Flow (ft)	Percent Full (d/D)	Area of Flow (ft^2)	Wetted Perimeter of flow (ft)	Velocity of Flow (fps)	End HGL (ft)	End EGL (ft)	End HGL (ft)	Freeboard (FB) (ft)	FB > 0.50 (ft)
BB17	**CB25**	1.23	1.63	0.041	0.05	1.0	0.04	0.09	**50.04**	50.08	6.28	1.25	100%	1.227	3.93	1.63	**49.95**	49.99	**50.04**	1.98	OK
CB25	**CB26**	1.23	0.81	0.010	0.01		0.00	0.01	**50.06**	50.07	6.28	1.25	100%	1.227	3.93	0.81	**50.05**	50.06	**50.06**	1.96	OK
BB17	**CB27**	1.23	2.69	0.112	0.24	1.0	0.11	0.35	**0.35**	0.46	2.51	0.43	34%	0.375	1.57	8.81	**48.51**	49.71	**48.51**	3.94	OK
BB18	**MH7**	1.23	2.69	0.112	0.23	1.0	0.11	0.34	**48.84**	48.96	6.28	1.25	100%	1.227	3.93	2.69	**48.50**	48.61	**48.84**	3.11	OK
MH7	**CB28**	1.23	2.69	0.112	0.08		0.00	0.08	**49.04**	49.15	6.28	1.25	100%	1.227	3.93	2.69	**48.96**	49.07	**49.04**	1.38	OK
CB28	**CB29**	1.23	1.34	0.028	0.02		0.00	0.02	**49.08**	49.11	6.28	1.25	100%	1.227	3.93	1.34	**49.06**	49.09	**49.08**	1.34	OK
BB19	**CB30**	1.23	1.22	0.023	0.04	1.0	0.02	0.06	**48.56**	48.59	6.28	1.25	100%	1.227	3.93	1.22	**48.50**	48.52	**48.56**	2.56	OK
BB20	**CB31**	1.23	1.63	0.041	0.09	1.0	0.04	0.13	**47.93**	47.97	6.28	1.25	100%	1.227	3.93	1.63	**47.80**	47.84	**47.93**	2.57	OK

Notes:

Appendix F:
Bleed-off Calculations

Pipe Hydraulics Using Manning's Equation

Project: Desert Place at Morrison Ranch - Phase I

Storm Event: 100-year, 2-hour

Prepared By: Brian Nicholls

Date: 9/15/2012

		Storm Drain Pipe Design								Full Flow Check		Beginning HGL				Pressurized Flow Calculations									Non-Pressurized Flow Calculations								Design Validation		
From Pt.	To Pt.	Length (ft)	Discharge (cfs)	Pipe Diameter (in)	Downstream Invert Elevation	Upstream Invert Elevation	Slope (ft/ft)	Upstream Grate/Rim Elevation	Manning's Roughness	Full Flow Capacity (cfs)	Pressurized Flow?	Downstream Pipe HGL (ft)	K (Junction)	Headless (Junction) (ft)	Begin HGL (ft)	Area (ft^2)	Full Velocity (fps)	Velocity Head (ft)	Friction Headloss (ft)	K (other)	Headloss (other) (ft)	Total Headloss (ft)	End HGL (ft)	End EGL (ft)	Theta of flow (rad)	Depth of Flow (ft)	Percent Full (d/D)	Area of Flow (ft^2)	Wetted Perimeter of flow (ft)	Velocity of Flow (fps)	End HGL (ft)	End EGL (ft)	End HGL (ft)	Freeboard (FB) (ft)	FB > 0.50 (ft)
EMF	MH1	170	10.1	24	25.10	25.75	0.0038	32.58	0.012	15.19	NO				27.10	3.14	3.21	0.160	0.29	1.0	0.16	0.45	**27.55**	27.71	3.53	1.19	60%	1.952	3.53	5.17	**27.10**	27.52	**27.55**	5.03	OK
MH1	MH2	199	10.1	15	25.75	26.00	0.0013	34.56	0.012	2.49	YES	27.55	1.0	1.05	28.60	1.23	8.24	1.054	4.15		0.00	4.15	**32.75**	33.81	6.28	1.25	100%	1.227	3.93	8.24	**28.60**	29.66	**32.75**	1.81	OK
MH2	DD	154	10.1	30	26.00	26.62	0.0040	29.30	0.012	28.27	YES	32.75	1.0	0.07	32.82	4.91	2.06	0.066	0.08		0.00	0.08	**32.90**	32.97	6.28	2.50	100%	4.909	7.85	2.06	**32.82**	32.89	**32.90**	-3.60	NOT OK
DD	MH3	16	10.1	24	24.62	24.68	0.0037	35.50	0.012	15.05	YES	32.90	1.0	0.16	33.06	3.14	3.21	0.160	0.03		0.00	0.03	**33.09**	33.25	6.28	2.00	100%	3.142	6.28	3.21	**33.06**	33.22	**33.09**	2.41	OK
MH3	MH4	580	5.8	24	24.62	28.53	0.0067	35.50	0.012	20.18	YES	33.09	1.0	0.05	33.14	3.14	1.85	0.053	0.32		0.00	0.32	**33.47**	33.52	6.28	2.00	100%	3.142	6.28	1.85	**33.14**	33.19	**33.47**	2.03	OK
MH4	MH5	507	5.8	24	28.53	29.41	0.0017	36.60	0.012	10.24	YES	33.47	1.0	0.05	33.52	3.14	1.85	0.053	0.28		0.00	0.28	**33.80**	33.86	6.28	2.00	100%	3.142	6.28	1.85	**33.52**	33.57	**33.80**	2.80	OK
MH5	MH6	507	5.8	24	29.41	30.28	0.0017	36.60	0.012	10.18	YES	33.80	1.0	0.05	33.86	3.14	1.85	0.053	0.28		0.00	0.28	**34.14**	34.19	6.28	2.00	100%	3.142	6.28	1.85	**33.86**	33.91	**34.14**	2.46	OK
MH6	MH7	606	0.9	8	31.61	38.86	0.0120	47.00	0.012	1.44	NO	34.14	1.0	0.10	34.24	0.35	2.58	0.103	2.86		0.00	2.86	**37.11**	37.21	3.44	0.38	57%	0.207	1.15	4.34	**39.24**	39.54	**39.24**	7.76	OK
MH7	MH8	40	0.9	8	38.86	38.94	0.0020	47.00	0.012	0.59	YES	39.24	1.0	0.10	39.35	0.35	2.58	0.103	0.19		0.00	0.19	**39.53**	39.64	6.28	0.67	100%	0.349	2.09	2.58	**39.61**	39.71	**39.53**	7.47	OK
MH8	MH9	507	0.9	8	38.94	39.97	0.0020	47.00	0.012	0.59	YES	39.53	1.0	0.10	39.64	0.35	2.58	0.103	2.40		0.00	2.40	**42.03**	42.14	6.28	0.67	100%	0.349	2.09	2.58	**40.64**	40.74	**42.03**	4.97	OK
MH9	MH10	507	0.9	8	39.97	41.00	0.0020	47.00	0.012	0.59	YES	42.03	1.0	0.10	42.14	0.35	2.58	0.103	2.40		0.00	2.40	**44.53**	44.64	6.28	0.67	100%	0.349	2.09	2.58	**42.14**	42.24	**44.53**	2.47	OK
MH10	J3	58	0.9	8	41.00	41.11	0.0019	47.00	0.012	0.57	YES	44.53	1.0	0.09	44.62	0.35	2.44	0.092	0.24		0.00	0.24	**44.87**	44.96	6.28	0.67	100%	0.349	2.09	2.44	**44.62**	44.72	**44.87**	2.13	OK
J3	J4	213	0.6	8	41.11	41.54	0.0020	48.20	0.012	0.59	YES	44.87	1.0	0.05	44.91	0.35	1.72	0.046	0.45		0.00	0.45	**45.36**	45.41	6.28	0.67	100%	0.349	2.09	1.72	**44.91**	44.96	**45.36**	2.84	OK
J4	MH11	223	0.6	8	41.54	41.99	0.0020	48.20	0.012	0.59	YES	45.36	1.0	0.05	45.41	0.35	1.75	0.047	0.48		0.00	0.48	**45.89**	45.94	6.28	0.67	100%	0.349	2.09	1.75	**45.41**	45.46	**45.89**	2.31	OK
MH11	J5	223	0.6	8	41.99	42.73	0.0033	49.10	0.012	0.76	YES	45.89	1.0	0.05	45.94	0.35	1.75	0.047	0.48		0.00	0.48	**46.42**	46.47	6.28	0.67	100%	0.349	2.09	1.75	**45.94**	45.99	**46.42**	2.68	OK
J5	MH12	179	0.5	8	42.73	43.09	0.0020	49.10	0.012	0.59	YES	46.42	1.0	0.03	46.46	0.35	1.43	0.032	0.26		0.00	0.26	**46.72**	46.75	6.28	0.67	100%	0.349	2.09	1.43	**46.46**	46.49	**46.72**	2.38	OK
MH12	J6	261	0.5	8	43.09	43.61	0.0020	49.10	0.012	0.59	YES	46.72	1.0	0.03	46.74	0.35	1.29	0.026	0.31		0.00	0.31	**47.05**	47.08	6.28	0.67	100%	0.349	2.09	1.29	**46.74**	46.77	**47.05**	2.05	OK
J6	J7	168	0.2	8	43.61	43.95	0.0020	52.50	0.012	0.59	YES	47.05	1.0	0.01	47.06	0.35	0.57	0.005	0.04		0.00	0.04	**47.10**	47.10	6.28	0.67	100%	0.349	2.09	0.57	**47.06**	47.06	**47.10**	5.40	OK
J7	MH13	148	0.2	8	43.95	45.43	0.0100	52.50	0.012	1.31	YES	47.10	1.0	0.01	47.10	0.35	0.57	0.005	0.03		0.00	0.03	**47.14**	47.14	6.28	0.67	100%	0.349	2.09	0.57	**47.10**	47.11	**47.14**	5.36	OK
MH13	J21	235	0.2	8	45.43	46.77	0.0057	52.50	0.012	0.99	NO	47.14	1.0	0.01	47.14	0.35	0.60	0.006	0.06		0.00	0.06	**47.20**	47.21	2.37	0.21	31%	0.093	0.79	2.25	**47.14**	47.22	**47.20**	5.30	OK
J21	MH14	9	0.2	8	46.77	46.83	0.0067	52.50	0.012	1.07	NO	47.20	1.0	0.01	47.21	0.35	0.57	0.005	0.00		0.00	0.00	**47.21**	47.21	2.29	0.20	29%	0.085	0.76	2.35	**47.21**	47.29	**47.21**	5.29	OK
MH14	MH15	271	0.2	8	46.83	48.41	0.0058	52.50	0.012	1.00	NO	47.21	1.0	0.01	47.21	0.35	0.57	0.005	0.06		0.00	0.06	**47.28**	47.28	2.33	0.20	30%	0.089	0.78	2.24	**48.61**	48.69	**48.61**	3.89	OK
MH15	J8	26	0.2	8	48.41	48.51	0.0038	52.50	0.012	0.81	NO	48.61	1.0	0.01	48.62	0.35	0.57	0.005	0.01		0.00	0.01	**48.62**	48.63	2.48	0.23	34%	0.104	0.83	1.93	**48.74**	48.79	**48.74**	3.76	OK
J8	J9	57	0.1	8	48.51	48.59	0.0014	52.50	0.012	0.49	NO	48.74	1.0	0.00	48.74	0.35	0.29	0.001	0.00		0.00	0.00	**48.74**	48.74	2.34	0.20	31%	0.090	0.78	1.11	**48.79**	48.81	**48.79**	3.71	OK
MH6	J12	182	4.9	18	30.78	30.97	0.0010	36.60	0.012	3.68	YES				34.14	1.77	2.77	0.119	0.34	1.0	0.12	0.46	**34.60**	34.72	6.28	1.50	100%	1.767	4.71	2.77	**34.14**	34.26	**34.60**	2.00	OK
J12	MH16	149	4.9	18	30.97	31.12	0.0010	36.60	0.012	3.62	YES	34.60	1.0	0.12	34.72	1.77	2.77	0.119	0.28		0.00	0.28	**34.99**	35.11	6.28	1.50	100%	1.767	4.71	2.77	**34.72**	34.84	**34.99**	1.61	OK
MH16	J13	130	4.9	18	31.12	31.25	0.0010	36.60	0.012	3.61	YES	34.99	1.0	0.12	35.11	1.77	2.77	0.119	0.24		0.00	0.24	**35.35**	35.47	6.28	1.50	100%	1.767	4.71	2.77	**35.11**	35.23	**35.35**	1.25	OK
J13	J14	34	4.9	18	31.25	31.35	0.0029	36.60	0.012	6.18	YES	35.35	1.0	0.12	35.47	1.77	2.77	0.119	0.06		0.00	0.06	**35.54**	35.66	6.28	1.50	100%	1.767	4.71	2.77	**35.47**	35.59	**35.54**	1.06	OK
J14	J15	332	3.3	15	31.48	32.31	0.0025	37.40	0.012	3.51	YES	35.54	1.0	0.11	35.65	1.23	2.70	0.113	0.74		0.00	0.74	**36.39**	36.50	6.28	1.25	100%	1.227	3.93	2.70	**35.65**	35.76	**36.39**	1.01	OK
J15	MH17	44	3.3	15	32.31	33.74	0.0327	37.40	0.012	12.68	YES	36.39	1.0	0.11	36.50	1.23	2.69	0.112	0.10		0.00	0.10	**36.60**	36.71	6.28	1.25	100%	1.227	3.93	2.69	**36.50**	36.62	**36.60**	0.80	OK
MH17	MH18	540	2.2	12	33.99	36.17	0.0040	40.80	0.012	2.46	NO	36.60	1.0	0.12	36.72	0.79	2.79	0.121	1.74		0.00	1.74	**38.46**	38.58	6.35	1.00	100%	0.785	3.17	2.79	**37.17**	37.29	**37.17**	3.63	OK
MH18	J16	255	2.2	12	36.17	36.42	0.0010	40.80	0.012	1.21	YES	37.17	1.0	0.12	37.29	0.79	2.79	0.121	0.82		0.00	0.82	**38.11**	38.23	6.28	1.00	100%	0.785	3.14	2.79	**37.42**	37.54	**38.11**	2.69	OK
J16	J17	58	2.2	12	36.42	36.48	0.0010	40.80	0.012	1.24	YES	38.11	1.0	0.12	38.23	0.79	2.79	0.121	0.19		0.00	0.19	**38.42**	38.54	6.28	1.00	100%	0.785	3.14	2.79	**38.23**	38.35	**38.42**	2.38	OK
J17	MH19	228	2.2	12	36.48	36.71	0.0010	40.80	0.012	1.23	YES	38.42	1.0	0.12	38.54	0.79	2.79	0.121	0.73		0.00	0.73	**39.27**	39.39	6.28	1.00	100%	0.785	3.14	2.79	**38.54**	38.66	**39.27**	1.53	OK
MH19	BB10	12	2.2	12	37.04	37.05	0.0008	40.80	0.012	1.10	YES	39.27	1.0	0.12	39.39	0.79	2.79	0.121	0.04		0.00	0.04	**39.43**	39.55	6.28	1.00	100%	0.785	3.14	2.79	**39.39**	39.51	**39.43**	1.37	OK

Notes:

Pipe Hydraulics Using Manning's Equation

Project: Desert Place at Morrison Ranch - Phase I

Storm Event: Maximum Flow Rate

Prepared By: Brian Nicholls

Date: 9/15/2012

		Storm Drain Pipe Design								Full Flow Check	
From Pt.	To Pt.	Length (ft)	Discharge (cfs)	Pipe Diameter (in)	Downstream Invert Elevation	Upstream Invert Elevation	Slope (ft/ft)	Upstream Grate/Rim Elevation	Manning's Roughness	Full Flow Capacity (cfs)	Pressurized Flow?
EMF	MH1	170 ✓	11.6	24 ✓	25.10 ✓	25.75 ✓	0.0038	32.58	0.012	15.19	NO
MH1	MH2	199 ✓	11.6	15 ✓	25.75 ✓	26.00 ✓	0.0013	34.56	0.012	2.49	YES
MH2	DD	154	11.6	30	26.00	26.62	0.0040	29.30	0.012	28.27	YES
DD	MH3	16	11.6	24	24.62	24.68	0.0037	35.50	0.012	15.05	YES
MH3	MH4	580	6.7	24	24.62	28.53	0.0067	35.50	0.012	20.18	YES
MH4	MH5	507	6.7	24	28.53	29.41	0.0017	36.60	0.012	10.24	YES
MH5	MH6	507	6.7	24	29.41	30.28	0.0017	36.60	0.012	10.18	YES
MH6	MH7	606	1.0	8	31.61	38.86	0.0120	47.00	0.012	1.44	NO
MH7	MH8	40	1.0	8	38.86	38.94	0.0020	47.00	0.012	0.59	YES
MH8	MH9	507	1.0	8	38.94	39.97	0.0020	47.00	0.012	0.59	YES
MH9	MH10	507	1.0	8	39.97	41.00	0.0020	47.00	0.012	0.59	YES
MH10	J3	58	1.0	8	41.00	41.11	0.0019	47.00	0.012	0.57	YES
J3	J4	213	0.7	8	41.11	41.54	0.0020	48.20	0.012	0.59	YES
J4	MH11	223	0.7	8	41.54	41.99	0.0020	48.20	0.012	0.59	YES
MH11	J5	223	0.7	8	41.99	42.73	0.0033	49.10	0.012	0.76	YES
J5	MH12	179	0.6	8	42.73	43.09	0.0020	49.10	0.012	0.59	YES
MH12	J6	261	0.5	8	43.09	43.61	0.0020	49.10	0.012	0.59	YES
J6	J7	168	0.2	8	43.61	43.95	0.0020	52.50	0.012	0.59	YES
J7	MH13	148	0.2	8	43.95	45.43	0.0100	52.50	0.012	1.31	YES
MH13	J21	235	0.2	8	45.43	46.77	0.0057	52.50	0.012	0.99	YES
J21	MH14	9	0.2	8	46.77	46.83	0.0067	52.50	0.012	1.07	YES
MH14	MH15	271	0.2	8	46.83	48.41	0.0058	52.50	0.012	1.00	YES
MH15	J8	26	0.2	8	48.41	48.51	0.0038	52.50	0.012	0.81	YES
J8	J9	57	0.1	8	48.51	48.59	0.0014	52.50	0.012	0.49	YES
MH6	J12	182	5.6	18	30.78	30.97	0.0010	36.60	0.012	3.68	YES
J12	MH16	149	5.6	18	30.97	31.12	0.0010	36.60	0.012	3.62	YES
MH16	J13	130	5.6	18	31.12	31.25	0.0010	36.60	0.012	3.61	YES
J13	J14	34	5.6	18	31.25	31.35	0.0029	36.60	0.012	6.18	YES
J14	J15	332	3.8	15	31.48	32.31	0.0025	37.40	0.012	3.51	YES
J15	MH17	44	3.8	15	32.31	33.74	0.0327	37.40	0.012	12.68	YES
MH17	MH18	540	2.5	12	33.99	36.17	0.0040	40.80	0.012	2.46	YES
MH18	J16	255	2.5	12	36.17	36.42	0.0010	40.80	0.012	1.21	YES
J16	J17	58	2.5	12	36.42	36.48	0.0010	40.80	0.012	1.24	YES
J17	MH19	228	2.5	12	36.48	36.71	0.0010	40.80	0.012	1.23	YES
MH19	BB10	12	2.5	12	37.04	37.05	0.0008	40.80	0.012	1.10	YES

		Beginning HGL				Pressurized Flow Calculations								
From Pt.	To Pt.	Downstream Pipe HGL (ft)	K (Junction)	Headloss (Junction) (ft)	Begin HGL (ft)	Area (ft^2)	Full Velocity (fps)	Velocity Head (ft)	Friction Headloss (ft)	K (other)	Headloss (other) (ft)	Total Headloss (ft)	End HGL (ft)	End EGL (ft)
EMF	MH1				27.10	3.14	3.71	0.213	0.38	1.0	0.21	0.60	**27.70**	27.91
MH1	MH2	27.70	1.0	1.40	29.09	1.23	9.49	1.397	5.50		0.00	5.50	**34.60**	35.99
MH2	DD	34.60	1.0	0.09	34.68	4.91	2.37	0.087	0.11		0.00	0.11	**34.79**	34.88
DD	MH3	34.79	1.0	0.21	35.00	3.14	3.70	0.213	0.04		0.00	0.04	**35.04**	35.25
MH3	MH4	35.04	1.0	0.07	35.11	3.14	2.13	0.070	0.43		0.00	0.43	**35.54**	35.61
MH4	MH5	35.54	1.0	0.07	35.61	3.14	2.13	0.070	0.38		0.00	0.38	**35.99**	36.06
MH5	MH6	35.99	1.0	0.07	36.06	3.14	2.13	0.070	0.38		0.00	0.38	**36.43**	36.50
MH6	MH7	36.43	1.0	0.14	36.57	0.35	2.97	0.137	3.80		0.00	3.80	**40.36**	40.50
MH7	MH8	39.28	1.0	0.14	39.42	0.35	2.97	0.137	0.25		0.00	0.25	**39.67**	39.80
MH8	MH9	39.67	1.0	0.14	39.80	0.35	2.97	0.137	3.18		0.00	3.18	**42.98**	43.12
MH9	MH10	42.98	1.0	0.14	43.12	0.35	2.97	0.137	3.18		0.00	3.18	**46.29**	46.43
MH10	J3	46.29	1.0	0.12	46.41	0.35	2.80	0.122	0.32		0.00	0.32	**46.74**	46.86
J3	J4	46.74	1.0	0.06	46.80	0.35	1.98	0.061	0.59		0.00	0.59	**47.39**	47.45
J4	MH11	47.39	1.0	0.06	47.45	0.35	2.01	0.063	0.64		0.00	0.64	**48.10**	48.16
MH11	J5	48.10	1.0	0.06	48.16	0.35	2.01	0.063	0.64		0.00	0.64	**48.80**	48.86
J5	MH12	48.80	1.0	0.04	48.84	0.35	1.65	0.042	0.35		0.00	0.35	**49.19**	49.23
MH12	J6	49.19	1.0	0.03	49.22	0.35	1.48	0.034	0.41		0.00	0.41	**49.63**	49.67
J6	J7	49.63	1.0	0.01	49.64	0.35	0.66	0.007	0.05		0.00	0.05	**49.69**	49.70
J7	MH13	49.69	1.0	0.01	49.70	0.35	0.66	0.007	0.05		0.00	0.05	**49.74**	49.75
MH13	J21	49.74	1.0	0.01	49.75	0.35	0.69	0.007	0.08		0.00	0.08	**49.83**	49.84
J21	MH14	49.83	1.0	0.01	49.84	0.35	0.66	0.007	0.00		0.00	0.00	**49.84**	49.85
MH14	MH15	49.84	1.0	0.01	49.85	0.35	0.66	0.007	0.08		0.00	0.08	**49.93**	49.94
MH15	J8	49.93	1.0	0.01	49.94	0.35	0.66	0.007	0.01		0.00	0.01	**49.94**	49.95
J8	J9	49.94	1.0	0.00	49.95	0.35	0.33	0.002	0.00		0.00	0.00	**49.95**	49.95
MH6	J12				36.43	1.77	3.19	0.158	0.45	1.0	0.16	0.61	**37.04**	37.20
J12	MH16	37.04	1.0	0.16	37.20	1.77	3.19	0.158	0.37		0.00	0.37	**37.56**	37.72
MH16	J13	37.56	1.0	0.16	37.72	1.77	3.19	0.158	0.32		0.00	0.32	**38.04**	38.20
J13	J14	38.04	1.0	0.16	38.20	1.77	3.19	0.158	0.08		0.00	0.08	**38.28**	38.44
J14	J15	38.28	1.0	0.15	38.43	1.23	3.11	0.150	0.98		0.00	0.98	**39.42**	39.57
J15	MH17	39.42	1.0	0.15	39.57	1.23	3.10	0.149	0.13		0.00	0.13	**39.70**	39.84
MH17	MH18	39.70	1.0	0.16	39.86	0.79	3.21	0.160	2.30		0.00	2.30	**42.16**	42.32
MH18	J16	42.16	1.0	0.16	42.32	0.79	3.21	0.160	1.09		0.00	1.09	**43.41**	43.57
J16	J17	43.41	1.0	0.16	43.57	0.79	3.21	0.160	0.25		0.00	0.25	**43.82**	43.98
J17	MH19	43.82	1.0	0.16	43.98	0.79	3.21	0.160	0.97		0.00	0.97	**44.95**	45.11
MH19	BB10	44.95	1.0	0.16	45.11	0.79	3.21	0.160	0.05		0.00	0.05	**45.16**	45.32

		Non-Pressurized Flow Calculations								Design Validation		
From Pt.	To Pt.	Theta of flow (rad)	Depth of Flow (ft)	Percent Full (d/D)	Area of Flow (ft^2)	Wetted Perimeter of flow (ft)	Velocity of Flow (fps)	End HGL (ft)	End EGL (ft)	End HGL (ft)	Freeboard (FB) (ft)	FB > 0.50 (ft)
EMF	MH1	3.78	1.31	66%	2.184	3.78	5.33	**27.10**	27.54	**27.70**	4.88	OK
MH1	MH2	6.28	1.25	100%	1.227	3.93	9.49	**29.09**	30.49	**34.60**	-0.04	NOT OK
MH2	DD	6.28	2.50	100%	4.909	7.85	2.37	**34.68**	34.77	**34.79**	-5.49	NOT OK
DD	MH3	6.28	2.00	100%	3.142	6.28	3.70	**35.00**	35.22	**35.04**	0.46	NOT OK
MH3	MH4	6.28	2.00	100%	3.142	6.28	2.13	**35.11**	35.18	**35.54**	-0.04	NOT OK
MH4	MH5	6.28	2.00	100%	3.142	6.28	2.13	**35.61**	35.68	**35.99**	0.61	OK
MH5	MH6	6.28	2.00	100%	3.142	6.28	2.13	**36.06**	36.13	**36.43**	0.17	NOT OK
MH6	MH7	3.66	0.42	63%	0.231	1.22	4.48	**39.28**	39.59	**39.28**	7.72	OK
MH7	MH8	6.28	0.67	100%	0.349	2.09	2.97	**39.61**	39.74	**39.67**	7.33	OK
MH8	MH9	6.28	0.67	100%	0.349	2.09	2.97	**40.64**	40.77	**42.98**	4.02	OK
MH9	MH10	6.28	0.67	100%	0.349	2.09	2.97	**43.12**	43.25	**46.29**	0.71	OK
MH10	J3	6.28	0.67	100%	0.349	2.09	2.80	**46.41**	46.54	**46.74**	0.26	NOT OK
J3	J4	6.28	0.67	100%	0.349	2.09	1.98	**46.80**	46.86	**47.39**	0.81	OK
J4	MH11	6.28	0.67	100%	0.349	2.09	2.01	**47.45**	47.52	**48.10**	0.10	NOT OK
MH11	J5	6.28	0.67	100%	0.349	2.09	2.01	**48.16**	48.22	**48.80**	0.30	NOT OK
J5	MH12	6.28	0.67	100%	0.349	2.09	1.65	**48.84**	48.88	**49.19**	-0.09	NOT OK
MH12	J6	6.28	0.67	100%	0.349	2.09	1.48	**49.22**	49.26	**49.63**	-0.53	NOT OK
J6	J7	6.28	0.67	100%	0.349	2.09	0.66	**49.64**	49.64	**49.69**	2.81	OK
J7	MH13	6.28	0.67	100%	0.349	2.09	0.66	**49.70**	49.70	**49.74**	2.76	OK
MH13	J21	6.28	0.67	100%	0.349	2.09	0.69	**49.75**	49.76	**49.83**	2.67	OK
J21	MH14	6.28	0.67	100%	0.349	2.09	0.66	**49.84**	49.84	**49.84**	2.66	OK
MH14	MH15	6.28	0.67	100%	0.349	2.09	0.66	**49.85**	49.85	**49.93**	2.57	OK
MH15	J8	6.28	0.67	100%	0.349	2.09	0.66	**49.94**	49.94	**49.94**	2.56	OK
J8	J9	6.28	0.67	100%	0.349	2.09	0.33	**49.95**	49.95	**49.95**	2.55	OK
MH6	J12	6.28	1.50	100%	1.767	4.71	3.19	**36.43**	36.59	**37.04**	-0.44	NOT OK
J12	MH16	6.28	1.50	100%	1.767	4.71	3.19	**37.20**	37.36	**37.56**	-0.96	NOT OK
MH16	J13	6.28	1.50	100%	1.767	4.71	3.19	**37.72**	37.88	**38.04**	-1.44	NOT OK
J13	J14	6.28	1.50	100%	1.767	4.71	3.19	**38.20**	38.36	**38.28**	-1.68	NOT OK
J14	J15	6.28	1.25	100%	1.227	3.93	3.11	**38.43**	38.58	**39.42**	-2.02	NOT OK
J15	MH17	6.28	1.25	100%	1.227	3.93	3.10	**39.57**	39.72	**39.70**	-2.30	NOT OK
MH17	MH18	6.28	1.00	100%	0.785	3.14	3.21	**39.86**	40.02	**42.16**	-1.36	NOT OK
MH18	J16	6.28	1.00	100%	0.785	3.14	3.21	**42.32**	42.48	**43.41**	-2.61	NOT OK
J16	J17	6.28	1.00	100%	0.785	3.14	3.21	**43.57**	43.73	**43.82**	-3.02	NOT OK
J17	MH19	6.28	1.00	100%	0.785	3.14	3.21	**43.98**	44.14	**44.95**	-4.15	NOT OK
MH19	BB10	6.28	1.00	100%	0.785	3.14	3.21	**45.11**	45.27	**45.16**	-4.36	NOT OK

Notes:

Appendix G: Downstream Defender Product Literature and Technical Abstracts

Downstream Defender®

Advanced Vortex Separator

Proven to be more efficient for removing pollutants and preventing washout

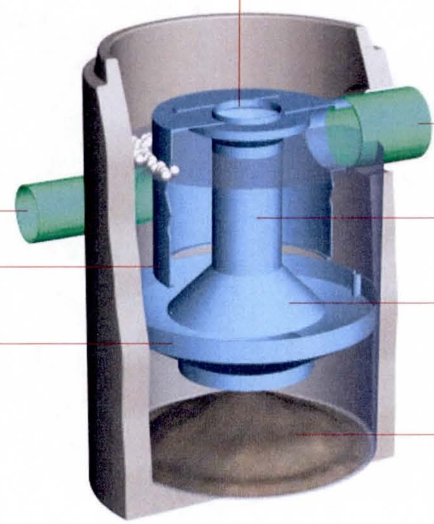
APPLICATIONS

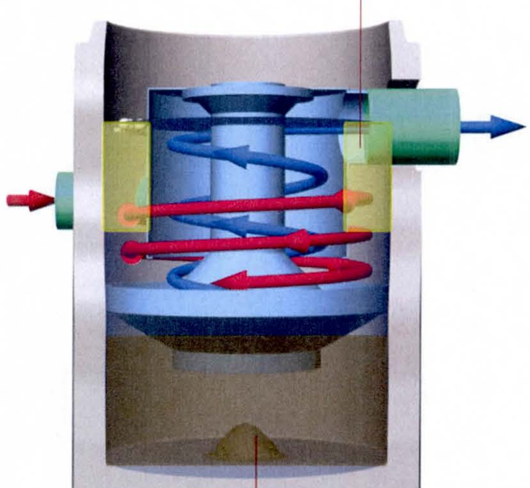
- Control of sediment, floatable trash and petroleum products
- New developments
- Redevelopment projects
- Streets, roadways and parking lots
- Pretreatment for filters, infiltration or storage
- LEED® development projects

ADVANTAGES

- Effective sediment capture across a wide range of flow rates
- Small footprint
- Lower capital cost than many other devices
- Proven to prevent washout
- Verified through nationally recognized programs
- Low system headloss

The **Downstream Defender** is an advanced vortex separator available for the removal of sediment, oil and floatables from stormwater runoff. The **Downstream Defender** is proven to be more efficient than other structural treatment devices in as little as ½ the footprint and features specialized internal components proven to prevent pollutant washout.





HOW IT WORKS

The **Downstream Defender** has internal components designed to advance vortex separation by minimizing turbulence and headloss, increasing efficiency and preventing washout of stored pollutants.

Stormwater is introduced tangentially into the side of the vessel, generating a rotating flow that spirals around the outside of the dip plate (red arrow).

Oils, trash and floatable debris rise to the water surface and are trapped in the oil and floatables storage volume (yellow zone).

As flow continues to spiral down around the dip plate cylinder, low energy vortex motion directs sediment inward along the benching skirt and into the protected sediment storage zone (brown zone).

The benching skirt and center cone redirect the rotating flow up and inward between the center shaft and dip plate cylinder away from the stored sediment. The outlet pipe discharges treated effluent from within the dip plate cylinder ensuring the longest possible residence time (blue arrow).

Advanced vortex separation is provided by extending and stabilizing the flow path while protecting trapped pollutants for a wide range of flow rates.

Hydro International stormwater

Ph: 207.756.6200 • Fax: 207.756.6212 • Email: stormwaterinquiry@hil-tech.com
www.hydro-international.biz

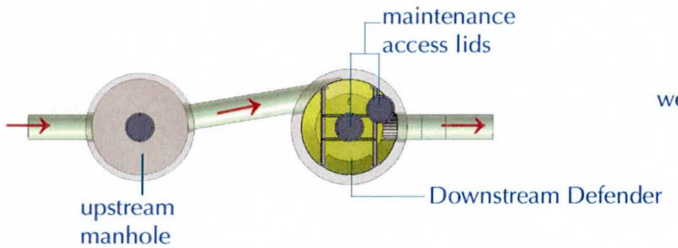
Maintenance

The **Downstream Defender** is easy to maintain using a sump-vac to remove captured sediment and floatables. Cleanout ports are located in the top of the manhole and provide access to pollutant storage areas. Maintenance is generally conducted every 12 to 18 months, although individual maintenance schedules are site specific. Hydro International works with owners and municipalities through networks of certified maintenance contractors to ensure proper maintenance practices.

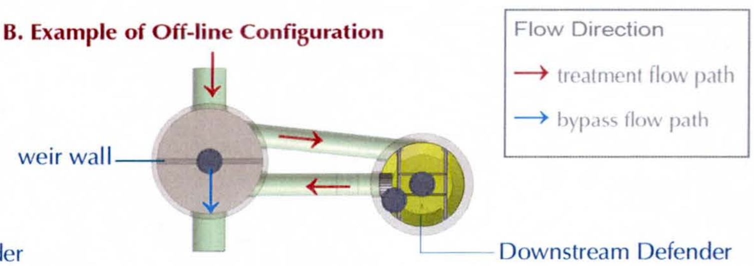
Sizing and Design

The **Downstream Defender** is sized and designed to accommodate site parameters. The device is commonly installed in an on-line configuration (figure A). In an off-line configuration an upstream diversion structure with an integral weir diverts treatment flows to the **Downstream Defender**. Excess storm flows spill over the weir directly to the outlet (figure B).

A. Example of On-line Configuration

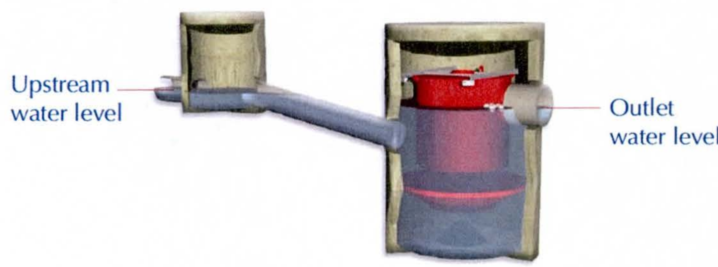


B. Example of Off-line Configuration



Low Headloss

The **Downstream Defender** has clear openings and no internal restrictions in order to minimize hydraulic losses, blockages and the risk of upstream flooding.



Downstream Defender Design Chart

Model Number and Diameter (ft)	Peak Treatment Flow (cfs)	Maximum Pipe Diameter (in)	Oil Storage Capacity (gallons)	Sediment Storage Capacity (cubic yards)	Minimum Distance from Outlet Invert to Top of Rim (ft)	Standard Distance Outlet Invert to Sump Floor (ft)
4	3.0	12	70	0.70	3.2	4.0
6	8.0	18	216	2.10	3.6	5.9
8	15.0	24	540	4.65	4.1	7.7
10	25.0	30	1,050	8.70	4.9	9.4
12	38.0	36	1,770	14.70	5.5	11.2

For more information, and 12' unit availability, please call our office toll free at 800-848-2706 or inquire at www.hydro-international.biz.

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Hydraulic Evaluation - Predicting Headloss of the Downstream Defender®

Technology Description and Hydraulics

The Downstream Defender® is an advanced flow-through vortex separator used in stormwater applications for removing pollutants typically found in urban runoff that are detrimental when released into the environment. It relies on unique flow-modifying internal components to minimize hydraulic losses while preventing scour and washout of captured pollutants. There are no internal weirs or orifices, only large clear openings ensuring relatively low headloss at high loading rates with little risk of surcharging the drainage system.

As shown in Fig.1, the Downstream Defender® is designed with a submerged inlet so that flow entering the vessel is always lower than the water surface elevation (WSE).

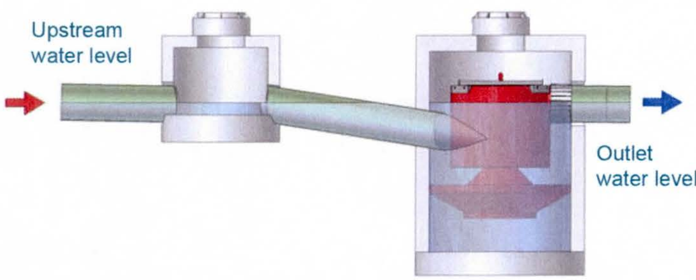

Fig.1 The submerged inlet of the Downstream Defender®.

The submerged inlet is critical for preventing surface turbulence that reduces system pollutant removal and hydraulic efficiency. As runoff enters the Downstream Defender®, entrance, exit and internal frictional losses increase the upstream water elevations. The difference in water elevations upstream and downstream of the Downstream Defender® is defined as the Headloss (H_L).

Downstream Defender® Shown to be a Low Headloss Device

St. Anthony Falls Laboratory (SAFL) at the University of Minnesota completed hydraulics testing of a full-scale 6-ft diameter Downstream Defender® based on ASTM Standard Test Methods C1745 / C1745M – 11: Standard Test Method for Measurement of Hydraulic Characteristics of Hydrodynamic Stormwater Separators and Underground Settling Devices.

The tests were designed to measure the hydrostatic pressure drop across the tested model at different flow rates and determine a headloss curve with head plotted as the dependent variable against flow. Using the velocity head equation (k × $(V_u^2)/2g$) to estimate the headloss curve, a k-value equal to 3 was determined to be appropriate for estimating headlosses for different pipe sizes or inlet velocities, independent of the treatment system's diameter. With $V_u = Q_u/A$, headlosses for the Downstream Defender® are estimated by (Eq.1):

$$H_L = \frac{Q_{inlet}^{\ 2}}{21.5 \times A^2}$$

Eq.1 Estimated headlosses of the Downstream Defender®.

SAFL Hydraulics Facility and Test Procedures

The SAFL test facility is located on Hennepin Island in the Mississippi River and was equipped to divert flows in excess of 9 cfs of river water to a 6-ft diameter Downstream Defender®. Flow was conveyed into the test model's inlet pipe and regulated by a gate valve and small drain valve. After passing through the test model's outlet pipe, the water flowed through an open channel that discharged into a rock crib dissipation chamber and rectangular channel.

The discharged flow rate was measured using a Messa sonic depth sensor and sharp-crested weir wall installed at the downstream end of the rectangular channel. Hydrostatic pressures were measured from three tap locations by running plastic tubing from the taps to manometers (Fig.2).

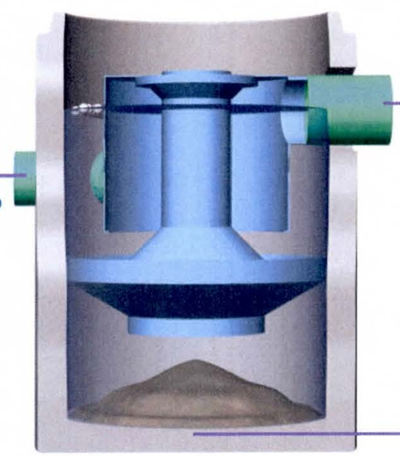

Fig.2 Pressure measurement locations of the test unit.

Downstream Defender®

To accurately measure the pressure at different flow rates, the gate and drain valves were opened and adjusted to obtain the desired flow rate. For each setting, the depth of flow in the rectangular channel was measured to calculate the flow rate discharging over the sharp-crested weir. Once the flow rate had stabilized, pressure readings were recorded from the three manometers. The depth of flow in the outlet pipe was calculated from the difference between the outlet pipe invert and the manometer reading. Velocity in the outlet pipe was estimated from the flow cross-sectional area. The inlet velocity was estimated from the inlet pipe's cross-sectional area and flow rate, or $V_u = Q_{inlet}/A$. Corresponding inlet and outlet velocity heads were added to the pressure head measurements to determine the total head at each tested flow rate. The flow-dependent headloss was then calculated from the difference in total head at the inlet and outlet (Eq.2):

$$H_L = (h_u + \frac{V_u^2}{2g}) - (h_d + \frac{V_d^2}{2g})$$

Eq.2 Flow-dependent headloss of the Downstream Defender®, where:

- H_L = device headloss
- h_u = measured pressure head or water elevation in the inlet or upstream pipe
- h_d = measured pressure head or water elevation in the outlet or downstream pipe
- g = gravitational constant, 32.2 ft/sec^2
- V_u, V_d = calculated average flow velocities in the upstream and downstream pipes, respectively

Hydraulic Test Results

In total, 44 pressure head measurements were taken for flow rates ranging from 0.45 to 8.7 cfs. The total head at the inlet and outlet and the difference (or total headloss) for each flow was calculated and plotted (Fig.3). System headlosses were below 0.25-ft for flows less than 3.4 cfs, and the maximum headloss observed was 1.05 ft at 8.7 cfs.

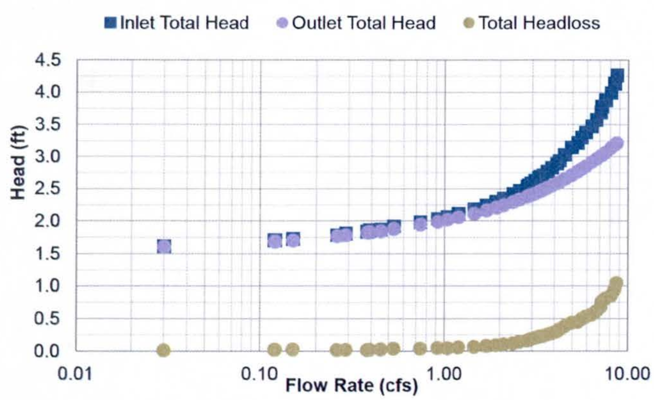

Fig.3 Hydraulic test results showing total system headlosses.

Hydraulic Testing Conclusions

Results of the hydraulic testing were used to determine a formula for calculating headloss across the Downstream Defender®.

It was observed that headloss is primarily dependent on the velocity in the submerged inlet. Accordingly, the curve for measured headloss versus discharge obtained from the hydraulic testing was used to calibrate an inlet velocity head versus discharge curve (Fig.4). This serves as the hydraulic model for calculating headloss for the Downstream Defender®.

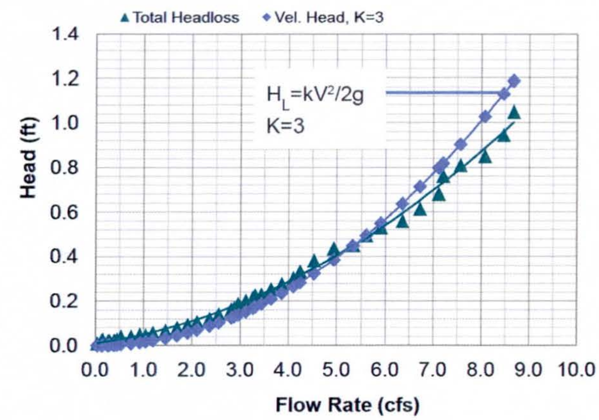

Fig.4 Predicted headloss versus actual measured headloss.

The table below provides estimated headloss for standard Downstream Defender® models operating at Peak Treatment Flow rates and maximum inlet pipe diameters.

Model Unit Diameter	Peak Treatment Flow Rate	Max. Inlet Pipe Diameter	Inlet Pipe Area	Estimated Peak Headloss (H_L)
(ft)	(cfs)	(in)	(ft^2)	(ft)
4	3	12	0.79	0.68
6	8	18	1.77	0.95
8	15	24	3.14	1.1
10	25	30	4.91	1.2
12	38	36	7.07	1.4

Performance Verification of Fine Sediment Removal with US Silica OK-110

The Downstream Defender® is an advanced Hydrodynamic Vortex Separator intended for removing the bulk of the pollutant load from urban stormwater runoff. Flow modifying internal components (Fig.1) differentiate the Downstream Defender® from conventional gravity-based and other vortex separators. These internals are designed to facilitate high-rate separation of pollutants and minimize turbulence. The design also ensures that bypassing is prevented and the entire flow is treated. Compared to devices that have poorly designed internal components and/or an internal bypass that discharges a portion of flow with no treatment, the Downstream Defender® captures and retains more of the annual pollutant load.

Capable of providing high pollutant removals for a wide range of flow rates with minimal headlosses, the Downstream Defender® is an economical solution for constrained sites. Its proven efficiency ensures the longevity and simplifies the maintenance of subsurface storage, infiltration and filtration practices.

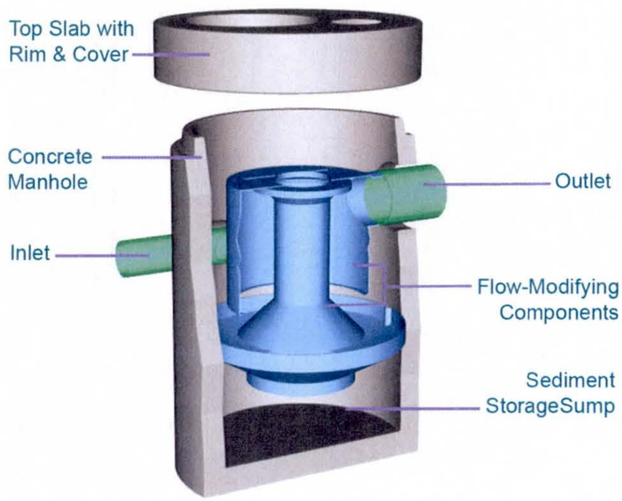

Fig.1 The unique internal components of the Downsream Defender® enhance pollutant removal performance and prevent washout.

Fine Sediment Removal

To quantify the pollutant removal efficacy, a full-scale 4-ft diameter Downstream Defender® was tested under controlled laboratory conditions. Test procedures were based on protocols used for regulatory approval throughout North America.

Commercially available U.S. Silica brand OK-110 (Fig.2) was used to determine the Downstream Defender® treatment loading rate that achieves an 80%-removal efficiency goal. OK-110 has a fine gradation primarily in the 75-150 micron range with a mean of 106-micron. Because about 20% of the particles are between 50-75 micron, use of OK-110 sediment provides a conservative estimate of annual load reductions.

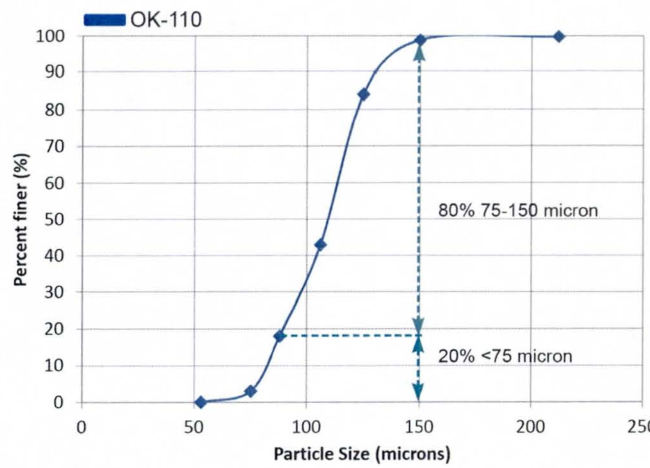

Fig.2 Particle size distribution of the U.S. Silica OK-110 test sediment.

For performance testing, clean water from a 23,000 gal. reservoir was pumped to the Downstream Defender® at flow rates varying from about 0.4 to 2.2 cfs (Fig.3). A concentrated slurry of test sediment was pumped into the inlet pipe at an injection rate that delivered influent concentrations ranging from 200-300 mg/L.

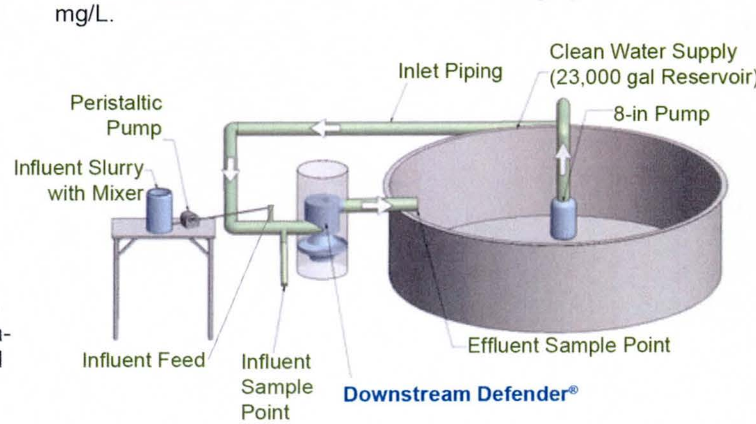

Fig.3 Set-up of the Portland, Maine hydraulic testing facility.

stalling a weir wall in the channel and diverting untreated flows into the unit (Fig.3).

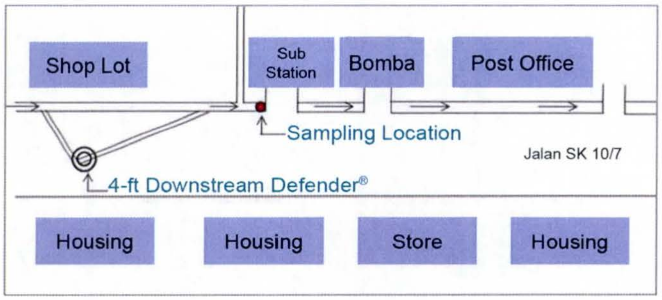

Fig.3 Schematic layout of Downstream Defender® installation showing sampling location.

Samples were collected prior to (Fig.4a) and following (Fig.4b) installation of a 4-ft diameter Downstream Defender® to determine its efficacy in removing and controlling oil and grease (O&G) found in a typical urban "hot spot". The post-installation effluent concentrations were compared with the pre-installation levels to ascertain device efficacy under varying influent concentrations typical of urban hot spots.

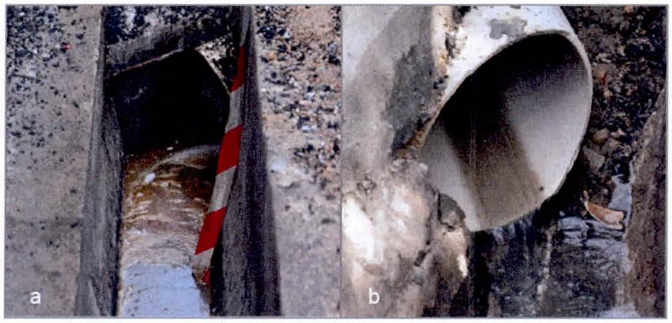

Fig.4(a) Pre-installation and (b) post-installation effluent in a storm trench where the 4-ft diameter Downstream Defender® was installed.

Eighteen "pre-installation and 12 "post-installation" samples were collected over the six-month monitoring period and analyzed for oil and grease by an independent accredited laboratory.

Field Monitoring Results

Post-installation conditions showed a significant drop in oil levels, with net O&G reduction > 89% when compared to pre-installation monitoring levels. More importantly, as shown in Fig.5, the average post-installation O&G effluent concentration was 16.2 mg/L, with a median of 13.0 mg/L. These results demonstrate consistent post-installation effluent O&G concentrations below 20 mg/L over the two-month monitoring period.

Fig.5 Oil & Grease concentrations before and after Downstream Defender® installation.

Downstream Defender® Sizing

There are 5 standard precast model sizes available, as shown in the table below. Treatment flow rates are based on test results using fine sediments. Listed oil storage capacities are the maximum volumes provided during operation. Larger oil storage volumes are possible. Contact Hydro International for more information.

Model Diameter	Oil Storage Volume	Max. Oil Clean Out Depth	Treatment Flow Rate for 80% TSS Removal of 106um Sediment	Peak Treatment Flow Rates
(ft)	(gal)	(in)	(cfs)	(cfs)
4	70	16	1.56	3.0
6	216	23	4.30	8.0
8	540	33	8.82	15.0
10	1,050	42	15.42	25.0
12	1,770	49	24.32	38.0

References

1. Pratt, C. et al. "Laboratory Tests Conducted in the School of The Built Environment, Coventry University, UK, on Downstream Defender for Hydro International plc., Clevedon, BS21 7RD". May - June 2000.

2. Research Centre For River Management, National Hydraulic Research Institute of Malaysia (NAHRIM). "Study On The Effectiveness Of The Downstream Defender, Serial no.: DD 2344". 20 November 2010.

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Technical Abstract

Downstream Defender®

Hydro International®

Performance Verification of Oil and Grease Removal

The Downstream Defender® is a high efficiency advanced vortex separator used to intercept pollutants from urban runoff before they reach sensitive downstream waterways. Although the Downstream Defender® is primarily used to remove sediment from stormwater runoff, independent laboratory and field testing has shown that it is also very effective at capturing oils and grease. Tests conducted under simulated oil spill conditions showed that the Downstream Defender® maintains greater than 80% removal efficiency for a wide range of loading rates. Field testing on an urban mixed-use site showed effective control of oil and grease, limiting the average effluent concentration to 16 mg/L.

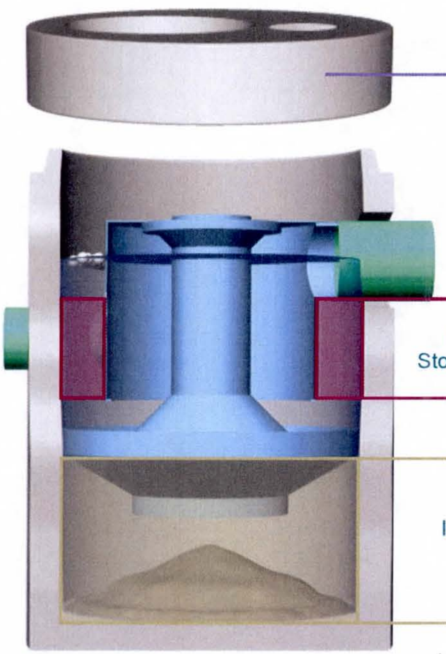

Fig.1 The pollutant storage zones of the Downstream Defender®.

Flow-modifying internal components (Fig.1) are not only critical for promoting separation of pollutants, they also ensure that the sediment and oil storage areas are protected, even at very high flow rates. The internal components keep pollutants such as sediment, oil, floating trash and debris from being washed out during the intense part of a storm. Without this protection, loss of pollutants would occur as they accumulate in the device between clean-outs.

Laboratory Oil Removal Efficiency Testing

An independent third-party laboratory study was conducted in 2000 by Coventry University's School of the Built Environment on a 4-ft Downstream Defender® (Pratt 2000)[1].

The test procedures were designed to simulate a spill event and to determine the efficiency at 6 constant flow rates, each having run durations of 20-27 minutes. The test pollutant was commercially available Shell motor oil. Five effluent samples were collected at each flow rate and analyzed with a Nicolet-250 Fourier Transfer InfraRed Spectrometer based upon ASTM D-3921-81.

Test results demonstrate greater than 80% removal efficiency for all tested flow rates (Fig.2). The results conclude that the Downstream Defender® is an effective device for removing oil in spill-like conditions.

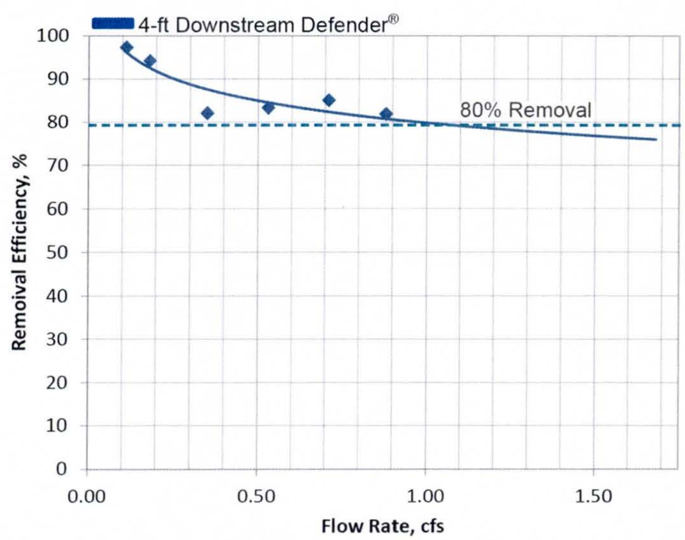

Fig.2 Measured oil removal efficiency of the 4-ft Downstream Defender®.

Effluent Control Field Monitoring

The National Hydraulic Research Institute of Malaysia (NAHRIM) led a field monitoring program in 2010 to evaluate water quality improvements of runoff from an urban, mixed-use site[2]. The field site, located in southern Malaysia, is known for high concentrations of oils, grease, trash and sediment. A variety of point and non-point source pollution is conveyed into a roadside open channel. The Downstream Defender® was retrofitted into the existing drainage network in an off-line configuration by in-

Downstream Defender®

Performance Test Procedures

Five influent and effluent grab samples were taken at 4 different flow rates for a total of 20 samples (Fig.4). All influent and effluent samples were analyzed for Total Suspended Solids (TSS) by APHA SM2540D.

Fig.4 Grab samples were collected from the influent (not pictured) and effluent (above) over a range of hydraulic loading rates.

Performance Results

The resulting test data demonstrates 80% removal of fine sediment for all flows up to 1.56 cfs and 65% efficiency at the highest flow rate tested at 2.2 cfs. As the Downstream Defender® does not incorporate an internal bypass, it will continue to capture sediment at all states of flow up to and including its rated peak treatment flow rate (PTFR). By way of contrast, internally bypassing units will begin to discharge untreated flows as soon as flows exceed their rated treatment flows. For example, tests for the 4-ft Downstream Defender® clearly show continual positive removal efficiencies for flows in excess of its rated treatment flow of 1.56 cfs and positive removals even at its peak rated flow of 3 cfs (Fig.5).

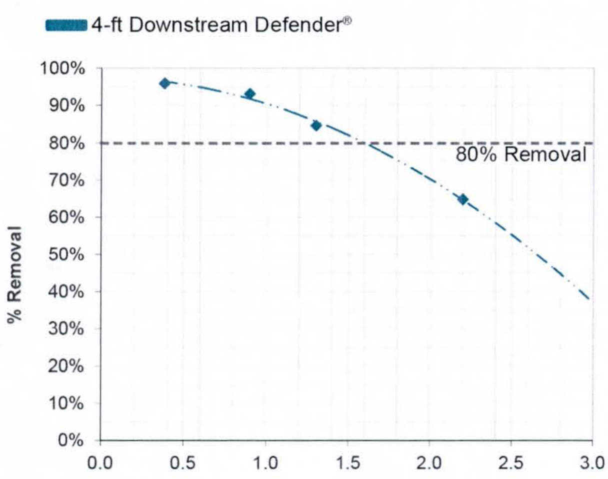

Fig.5 OK-110 silica sand removal efficiency results of the 4-ft Downstream Defender®.

These results confirm the efficacy of the Downstream Defender® for pollutant capture over a wide range of tested flow rates and highlight the benefits of its specially designed internal components that stabilize the flows and prevent bypassing of untreated flow.

Downstream Defender® Sizing

Test results were used to determine the treatment flow rates for larger Downstream Defender® models (see table below). For design purposes, the selected model's Treatment Flow Rate must be greater or equal to the site's Water Quality Flow Rate (WQf).

Model Unit Diameter	Maximum Pipe Diameter	Treatment Flow Rates for 80% TSS Removal	Peak Treatment Flow Rates
(ft)	(in)	(cfs)	(cfs)
4	12	1.56	3.0
6	18	4.25	8.0
8	24	8.82	15.0
10	30	15.42	25.0
12	36	24.32	38.0

The PTFR and maximum pipe size must be considered to determine whether the application of a given Downstream Defender® model is appropriate for the site. An offline configuration or arrangement may be used to overcome constraints presented by the Downstream Defender®'s maximum allowable pipe diameter or PTFR. Contact Hydro International for technical support and design assistance.

Fig.6 Model sizes range from 4-ft to 12-ft in diameter.

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