ARIZONA WATER COMPANY

East Sedona Water Storage Facility

February 21, 2018 Community Meeting

STORMWATER RUNOFF

Issue: Runoff sometimes flows out of the wash at bottlenecks in front of several homes on W. Mallard

Questions:

How will Arizona Water's project affect runoff?

How is stormwater runoff calculated?

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Arizona Water Company's Existing Site

- 1.05 Acres (45,738 sq. ft.) – Two lots
- Topsoil is 2 to 3.5 ft. +/- deep
- Sloped
- Site drains to North and Southwest

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Sedona Routinely Handles Drainage Issues

City's Land Development Code includes a well-defined formula for calculating runoff and managing flood risk.

Rational Drainage Equation: Q (cfs) = C x I x A

Q   Quantity of stormwater runoff, in cubic feet per second (cfs)

C   Runoff Coefficient determines the amount of rainfall that
          is NOT absorbed by the ground

I   Precipitation. Drainage Design – Table 8.1 – Applicable Sections

A   Area

Determining the Coefficient: Start with Type of Soil
Q=C x I x A

Four factors as defined by the U. S. Department of Agriculture, Hydrologic Soils Group

A - Soils having high infiltration rates even when thoroughly wetted and consisting chiefly of deep and well to excessively drained sands and gravels. These soils have a high rate of water transmission.
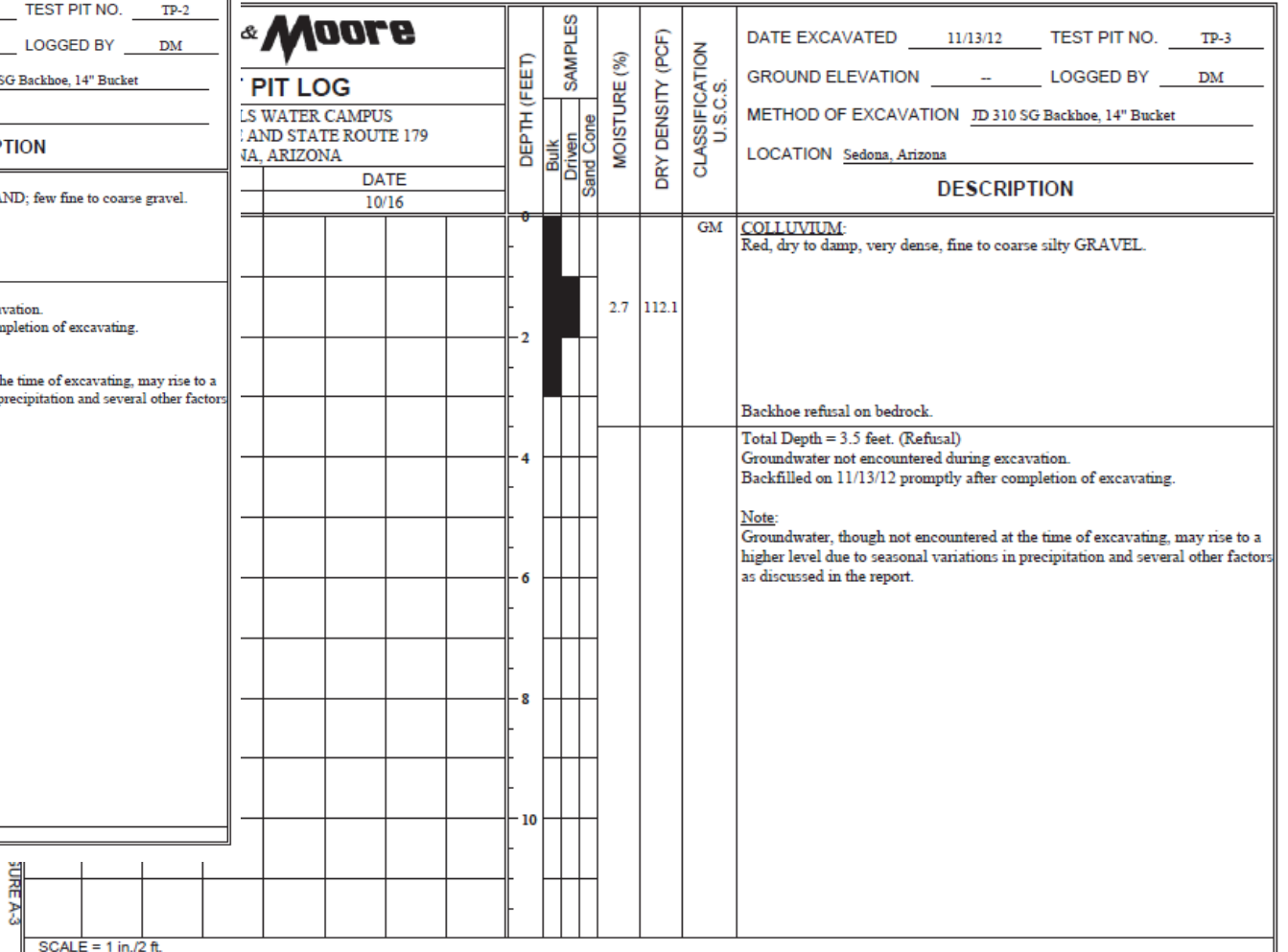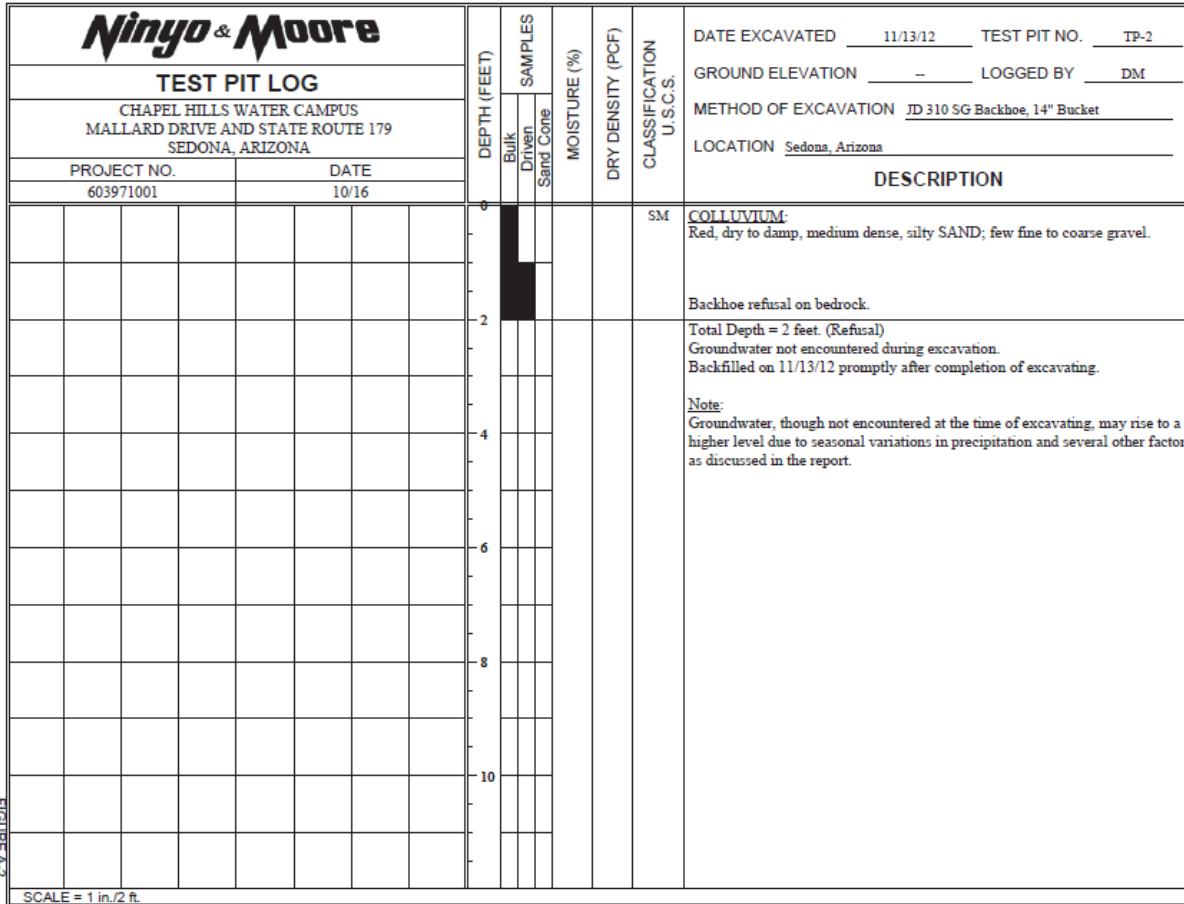
B - Soils having moderate infiltration rates when thoroughly wetted and consisting chiefly of moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission.

C - Soils having slow infiltration rates when thoroughly wetted and consisting chiefly of soils with a layer that impedes downward movement of water, or soils with moderately fine to fine texture. These soils have a slow rate of water transmission.

D - Soils having very slow infiltration rates when thoroughly wetted and consisting chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan at or near the surface, and shallow soils over nearly impervious material. These soils have a very slow rate of water transmission.

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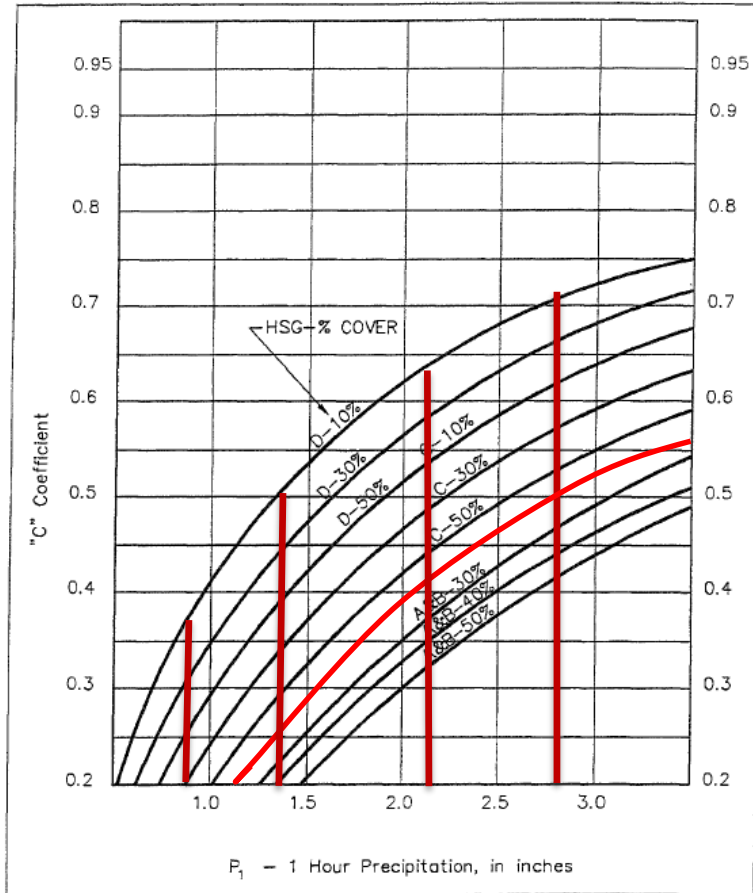
Arizona Water Company Site Analysis
Q = C x I x A
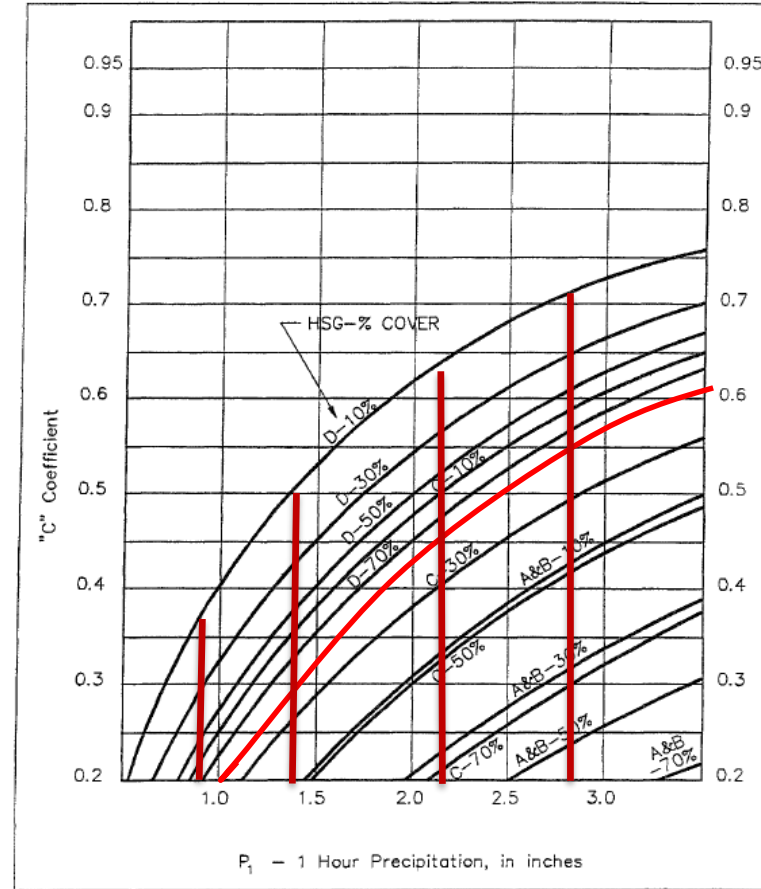

FIGURE 2-4
RATIONAL "C" COEFFICIENT
DESERT
(CACTUS, GRASS & BRUSH)

AS A FUNCTION OF RAINFALL DEPTH, HYDROLOGIC SOIL GROUP (HSG),
AND % OF VEGETATION COVER.

FIGURE 2-5
RATIONAL "C" COEFFICIENT
UPLAND RANGELAND
(GRASS & BRUSH)

AS A FUNCTION OF RAINFALL DEPTH, HYDROLOGIC SOIL GROUP (HSG),
AND % OF VEGETATION COVER.

Precipitation and Drainage Design – Tables 8.2, 8.3
$Q = C \times I \times A$

Table 8.2

Mean Precipitation Frequency Estimates

Freq (yr)	5-min	10-min	15-min	30-min	60-min	120-min	3-hr	6-hr	12-hr	24-hr	2-day	4-day
1	0.21	0.33	0.40	0.54	0.67	0.80	0.86	1.05	1.34	1.72	2.02	2.33
2	0.28	0.42	0.52	0.70	0.86	1.01	1.08	1.30	1.66	2.14	2.52	2.91
5	0.37	0.56	0.70	0.94	1.16	1.33	1.39	1.61	2.03	2.66	3.14	3.65
10	0.45	0.68	0.85	1.14	1.41	1.60	1.65	1.89	2.33	3.08	3.64	4.25
25	0.56	0.85	1.06	1.43	1.77	1.99	2.03	2.28	2.75	3.67	4.33	5.10
50	0.66	1.00	1.24	1.67	2.06	2.31	2.35	2.60	3.07	4.13	4.87	5.78
100	0.76	1.15	1.43	1.93	2.38	2.67	2.71	2.96	3.41	4.61	5.44	6.50
200	0.87	1.32	1.64	2.20	2.73	3.06	3.10	3.32	3.75	5.10	6.03	7.25
500	1.03	1.56	1.94	2.61	3.23	3.63	3.66	3.87	4.22	5.76	6.83	8.30
1,000	1.16	1.77	2.19	2.95	3.65	4.10	4.13	4.31	4.60	6.30	7.46	9.13

Tables copied from Sedona Land Development Code

Table 8.3

Upper Limit Precipitation Frequency Estimates

Freq (yr)	5-min	10-min	15-min	30-min	60-min	120-min	3-hr	6-hr	12-hr	24-hr	2-day	4-day	7-day	10-day	20 da
1	0.26	0.39	0.48	0.65	0.80	0.93	0.99	1.16	1.49	1.88	2.23	2.57	3.00	3.43	4.4
2	0.33	0.50	0.62	0.83	1.03	1.18	1.26	1.44	1.84	2.36	2.79	3.21	3.75	4.27	5.5
5	0.44	0.67	0.83	1.12	1.39	1.55	1.60	1.79	2.24	2.94	3.47	4.02	4.64	5.26	6.6
10	0.54	0.82	1.01	1.36	1.69	1.87	1.91	2.10	2.57	3.41	4.01	4.68	5.39	6.05	7.5
25	0.67	1.02	1.26	1.70	2.10	2.31	2.34	2.54	3.03	4.05	4.77	5.60	6.43	7.10	8.7
50	0.78	1.19	1.47	1.98	2.46	2.69	2.71	2.89	3.38	4.55	5.36	6.34	7.27	7.94	9.5
100	0.90	1.37	1.70	2.29	2.84	3.12	3.14	3.29	3.76	5.08	5.99	7.14	8.16	8.80	10.4
200	1.03	1.57	1.95	2.63	3.25	3.57	3.59	3.72	4.14	5.63	6.66	7.97	9.06	9.66	11.2
500	1.23	1.88	2.33	3.12	3.88	4.24	4.27	4.37	4.70	6.40	7.56	9.18	10.37	10.84	12.2
1,000	1.40	2.13	2.65	3.56	4.41	4.79	4.85								

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Sedona Routinely Handles Runoff and Flooding Issues

$$Q = C \times I \times A$$

Table Copied from Sedona Land Development Code

4.0	Open Channels	Storm Frequency:	25-yr. 100-yr. (check)
		Froude No.:	FN ≤ 0.86; 1.13 ≤ FN ≤ 2.0
		Freeboard (Minimum):	
		Subcritical Flow	FB = 0.25*[y+(v²/2g)] (1-ft. min.)
		Supercritical Flow	FB = 0.25*[y+(v²/2g)] (2-ft. min.)
		Maintenance Road:	12 ft. wide, 1 side of channel
		Maximum Velocity:	per channel lining material
		Maximum Side Slope:	(ss = from slope stability analysis)
		Vegetal/Earth	3:1 or ss
		Loose Riprap	3:1 or ss
		Rigid Lining	ss
		Shotcrete	1:1
		Soil Cement	1:1
		Building Setback from Channel Bank and Floodway:	1.5 x the channel depth, unless otherwise approved by the City Engineer for engineering reasons. However, in any case, the more restrictive requirements within this article shall apply.
5.0	Stormwater Storage	Storm Frequency:	2-, 10-, 25-, and 100-yr. storms
		Criteria:	post-proj. Q ≤ pre-proj. Q
		When Required:	1 acre or larger development or when post-development flow will exceed pre-development flow by ≥ 1 cfs.
		Maintenance Road:	12-ft. access road
		Maximum Depth:	
		Parking Areas	
		Emergency Spillway:	pass post-developed 100-yr. Q
		Maximum Drain Time:	12 hrs. upstream watershed areas ≤ 10 ac. and 24 hrs. for an upstream watershed area > 10 ac.
		Freeboard (Minimum):	1 ft. (post developed 100-yr. event)
		Min. Principal Outlet:	12 inch
		Maximum Side Slopes:	
		Depth < 3 ft.	2:1, protected; 3:1, unprotected
		Depth ≥ 3 ft.	4:1

Runoff Calculations

Yavapai County Drainage Policies & Standards	$V=C(P/12)A$	
100 Yr- 1 Hr Storm Rainfall Depth, inch	2.84	City of Sedona Precipitation Frequency Estimates

- $Q = C \times I \times A$

				Existing		
Description – Existing	**Area, sqft**	**Area, acres**	**C - Value**	**Peak Discharge, cfs**	**Runoff Volume, acre-ft**	**Runoff Volume, cft**
Grass and Brush - Area 1	4,400	0.10	0.55	0.16	0.01	573
Grass and Brush - Area 2	41,338	0.95	0.55	1.48	0.12	5,381
Pavement & Rooftops						
Roadway/Concrete Pads	0	0.00		0.00	0.000	0
Reservoir	0	0.00		0.00	0.000	0
Reservoir 10 ft backfill ring						
Total	**45,738**	**1.05**	**0.55**	**1.64**	**0.1**	**5,954**

				Future		
Description - Proposed	**Area, sqft**	**Area, acres**	**C - Value**	**Peak Discharge, cfs**	**Runoff Volume, acre-ft**	**Runoff Volume, cft**
Grass and Brush - Area 1	4,400	0.10	0.55	0.16	0.01	573
Grass and Brush - Area 2	20,357	0.47	0.55	0.73	0.06	2,650
Hillslope Sonoran Desert - Landscaped area above reservoir	2,838	0.07	0.55	0.10	0.01	369
Pavement & Rooftops						
Roadway/Concrete Pads	360	0.01	0.88	0.02	0.002	75
Reservoir	7,186	0.16	1.00	0.47	0.039	1,701
Reservoir 10 ft backfill ring	10,598	0.24	0.50	0.35	0.03	1,254
Total	**45,738**	**1.05**	**0.61**	**1.82**	**0.15**	**6,622**
Excess Runoff - Area 1 (Retention Volume Required, cft)						**0**
Excess Runoff - Area 2 (Retention Volume Required, cft)						**668**
Excess Runoff (Retention Volume Required, cft)						**668**

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Runoff Coefficient Sensitivity Analysis
Runoff increase still < 1 cfs of existing conditions

Left side:

Yavapai County Drainage Policies & Standards	V=C(P/12)A	
100 Yr- 1 Hr Storm Rainfall Depth, inch	2.84	Sedona Precipitation Frequency Estimates

Existing						
Description - Existing	Area, sqft	Area, acres	C - Value	Peak Discharge, cfs	Runoff Volume, acre-ft	Runoff Volume, cft
Grass and Brush - Area 1	4,400	0.10	0.70	0.20	0.02	729
Grass and Brush - Area 2	41,338	0.95	0.70	1.89	0.16	6,848
Pavement & Rooftopes						
Roadway/Concrete Pads	0	0.00		0.00	0.000	0
Reservoir	0	0.00		0.00	0.000	0
Reservoir 10 ft backfill ring						
Total	**45,738**	**1.05**	**0.70**	**2.09**	**0.2**	**7,577**

Future						
Description - Proposed	Area, sqft	Area, acres	C - Value	Peak Discharge, cfs	Runoff Volume, acre-ft	Runoff Volume, cft
Grass and Brush - Area 1	4,400	0.10	0.70	0.20	0.02	729
Grass and Brush - Area 2	20,357	0.47	0.70	0.93	0.08	3,372
Hillslope Sonoran Desert - Landscaped area above reservoir	2,838	0.07	0.70	0.13	0.01	470
Pavement & Rooftopes						
Roadway/Concrete Pads	360	0.01	0.88	0.02	0.002	75
Reservoir	7,186	0.16	1.00	0.47	0.039	1,701
Reservoir 10 ft backfill ring	10,598	0.24	0.50	0.35	0.03	1,254
Total	**45,738**	**1.05**	**0.70**	**2.09**	**0.17**	**7,601**
Excess Runoff - Area 1 (Retention Volume Required, cft)						0
Excess Runoff - Area 2 (Retention Volume Required, cft)						24
Excess Runoff (Retention Volume Required, cft)						24

Right side:

Yavapai County Drainage Policies & Standards	V=C(P/12)A	
100 Yr- 1 Hr Storm Rainfall Depth, inch	2.84	Sedona Precipitation Frequency Estimates

Existing						
Description - Existing	Area, sqft	Area, acres	C - Value	Peak Discharge, cfs	Runoff Volume, acre-ft	Runoff Volume, cft
Grass and Brush - Area 1	4,400	0.10	0.25	0.07	0.01	260
Grass and Brush - Area 2	41,338	0.95	0.25	0.67	0.06	2,446
Pavement & Rooftopes						
Roadway/Concrete Pads	0	0.00		0.00	0.000	0
Reservoir	0	0.00		0.00	0.000	0
Reservoir 10 ft backfill ring						
Total	**45,738**	**1.05**	**0.25**	**0.75**	**0.1**	**2,706**

Future						
Description - Proposed	Area, sqft	Area, acres	C - Value	Peak Discharge, cfs	Runoff Volume, acre-ft	Runoff Volume, cft
Grass and Brush - Area 1	4,400	0.10	0.25	0.07	0.01	260
Grass and Brush - Area 2	20,357	0.47	0.25	0.33	0.03	1,204
Hillslope Sonoran Desert - Landscaped area above reservoir	2,838	0.07	0.25	0.05	0.00	168
Pavement & Rooftopes						
Roadway/Concrete Pads	360	0.01	0.88	0.02	0.002	75
Reservoir	7,186	0.16	1.00	0.47	0.039	1,701
Reservoir 10 ft backfill ring	10,598	0.24	0.50	0.35	0.03	1,254
Total	**45,738**	**1.05**	**0.43**	**1.28**	**0.11**	**4,662**
Excess Runoff - Area 1 (Retention Volume Required, cft)						0
Excess Runoff - Area 2 (Retention Volume Required, cft)						1,956
Excess Runoff (Retention Volume Required, cft)						1,956

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Project Conditions
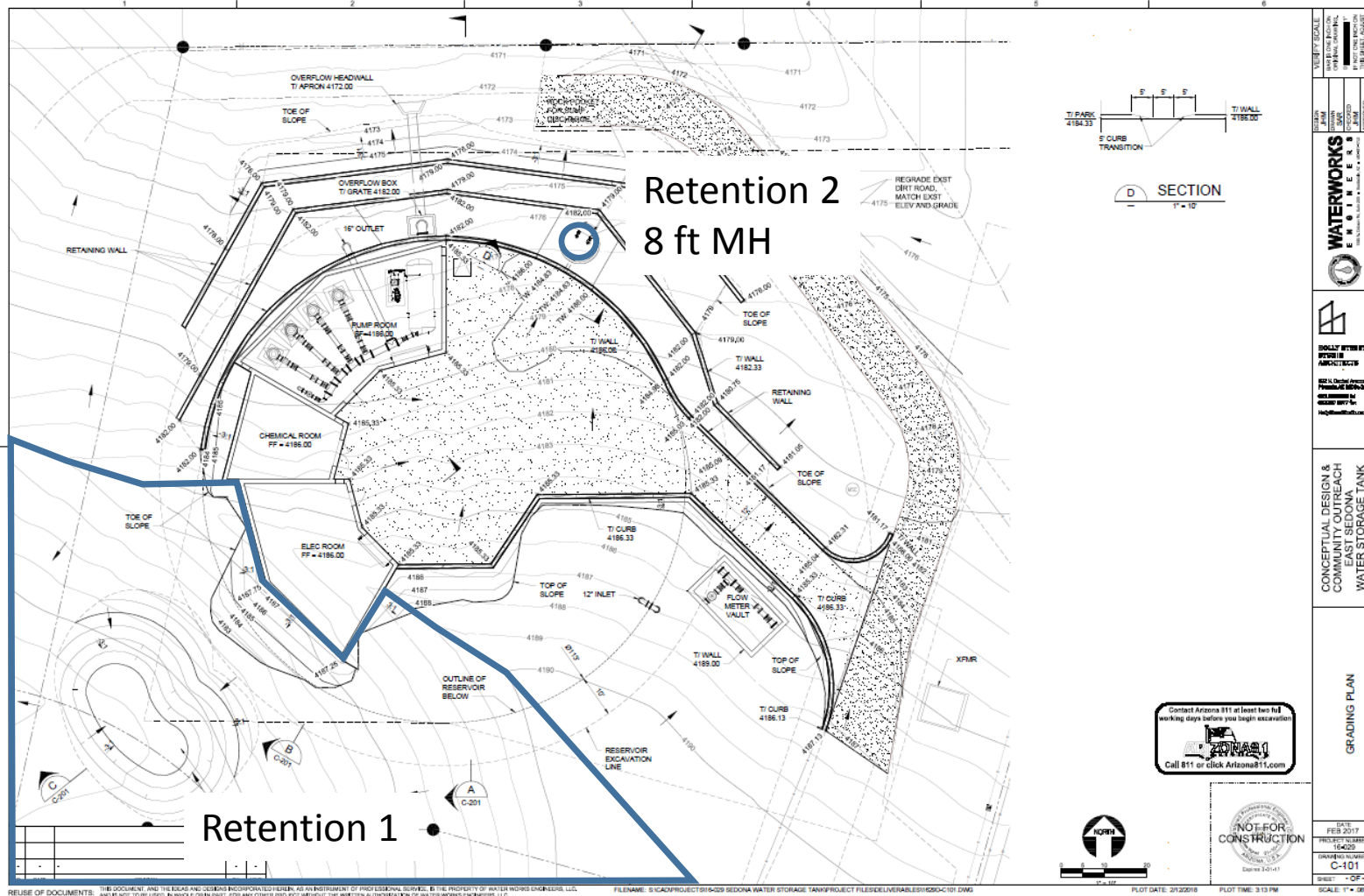
Existing Site
- 1.05 acres
- 113 ft. diameter tank
- 10 ft. ring around tank – sand
- Building above tank
- 2,840 sq.ft. soil cover over tank
- Impermeable area – 7,200 sq.ft.

Retention Basin Calculations – 1 hr. Rain Duration

					Retention					Storm Water Flow w Proposed Retention	
Storm Frequency	Inch in 1 hr	Exist Cndts	Project Cndts	Increase	Required	Match Existing Cndts	Proposed Retention 1	Proposed Retention 2	Total		% Reduction
(yr)		(cfs)	(cfs)	(cfs)	(cft)	(cft)	(cft)	(cft)	(cft)	(cfs)	%
2	0.86	0.18	0.36	0.18	0	657	450	1005	1455	0.00	100.0%
10	1.41	0.44	0.68	0.24	0	865	450	1005	1455	0.28	59.2%
25	2.1	0.99	1.22	0.22	0	811	450	1005	1455	0.81	33.2%
100	2.84	1.64	1.82	0.18	0	668	450	1005	1455	1.42	22.2%

- Retention 1 – located along the southwest corner of the site
- Retention 2 – 8 ft. manhole located north of the proposed tank

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Retention Basin Calculations – 2 hr. Rain Duration

Storm Frequency	Inch in 2 hrs	Exist Cndts	Project Cndts	Increase	Retention Required	Match Existing Cdts	Proposed Retention 1	Proposed Retention 2	Total Retention	Storm Water Flow w Proposed Retention	% Reduction
(yr)		(cfs)	(cfs)	(cfs)	(cft)	(cft)	(cft)	(cft)	(cft)	(cfs)	%
2	1.01	0.58	0.65	0.07	0	238	450	1005	1455	0.24	62.3%
10	1.6	0.92	1.03	0.10	0	376	450	1005	1455	0.62	39.3%
25	2.31	1.33	1.48	0.15	0	543	450	1005	1455	1.08	27.2%
100	3.12	1.80	2.00	0.20	0	734	450	1005	1455	1.60	20.2%

- Retention 1 – located along the southwest corner of the site
- Retention 2 – 8 ft. manhole located north of the proposed tank

WATERSHED DISCUSSSION

Sedona Watersheds
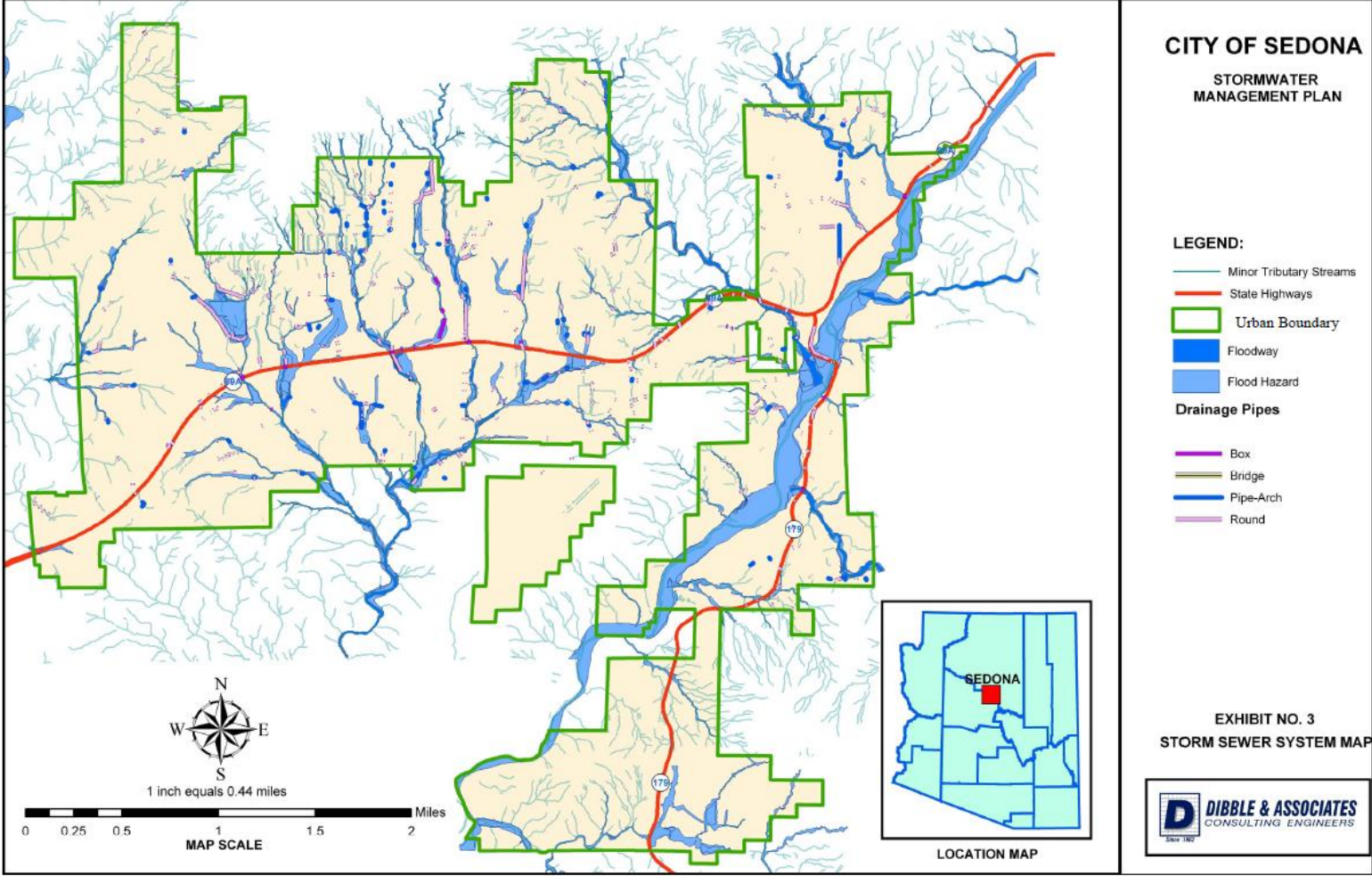
City of Sedona – Stormwater Management Program

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Sedona Watersheds

Water Company
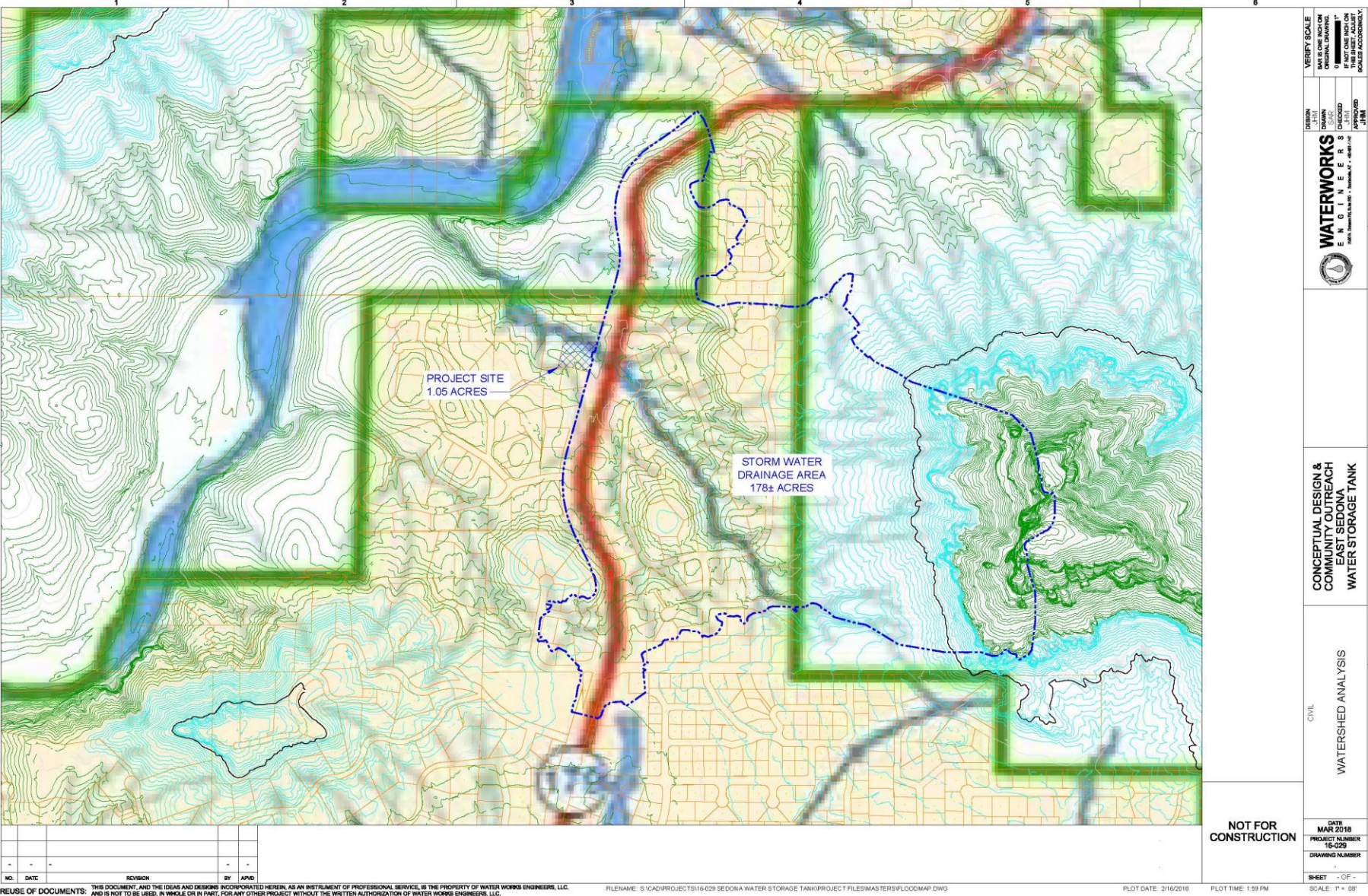
# On Site Runoff Compared to Wash Flows

- Two culverts convey storm water runoff from east to west of SR 179

- Culvert information obtained from ADOT drawings:
  - Culvert 100 – box culvert
    - 100 yr. storm flow – 240 cfs
    - 50 yr. storm flow – 190 cfs
  - Culvert 109 – 54" pipe
    - 100 yr. storm flow – 68 cfs
    - 50 yr. storm flow – 55 cfs

- Additional drainage from SR 179

- In comparison, site runoff is less than 1% of flow in wash
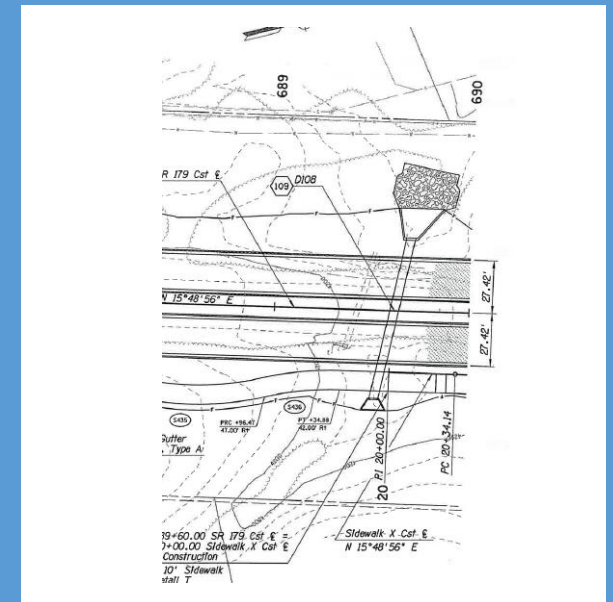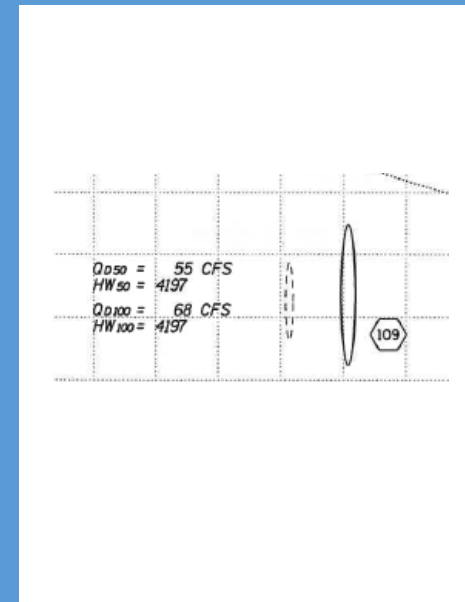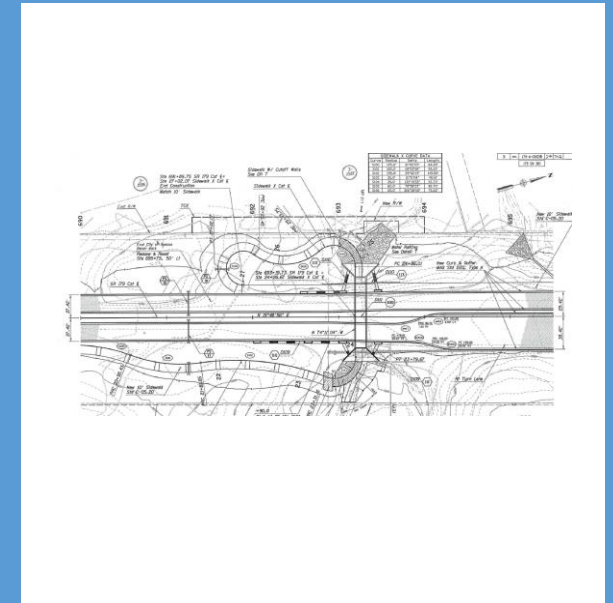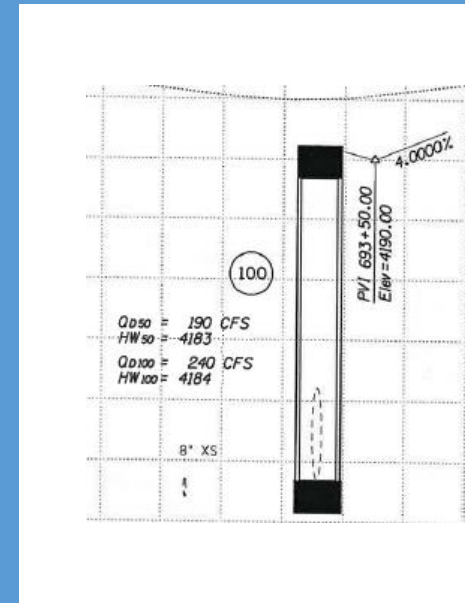
Unnamed Wash Floodplain Analysis

- USACE HEC-RAS floodplain modeling software

- Existing and proposed conditions

- 100-year (standard) and 50-year storm events, Discharges from ADOT plans

- No ineffective flow areas, no obstructions, and no structures

- Manning's roughness values
  - 0.040 main channel
  - 0.050 overbanks

- Subcritical flow regime
  - Standard for natural watercourses
  - Downstream boundary condition only
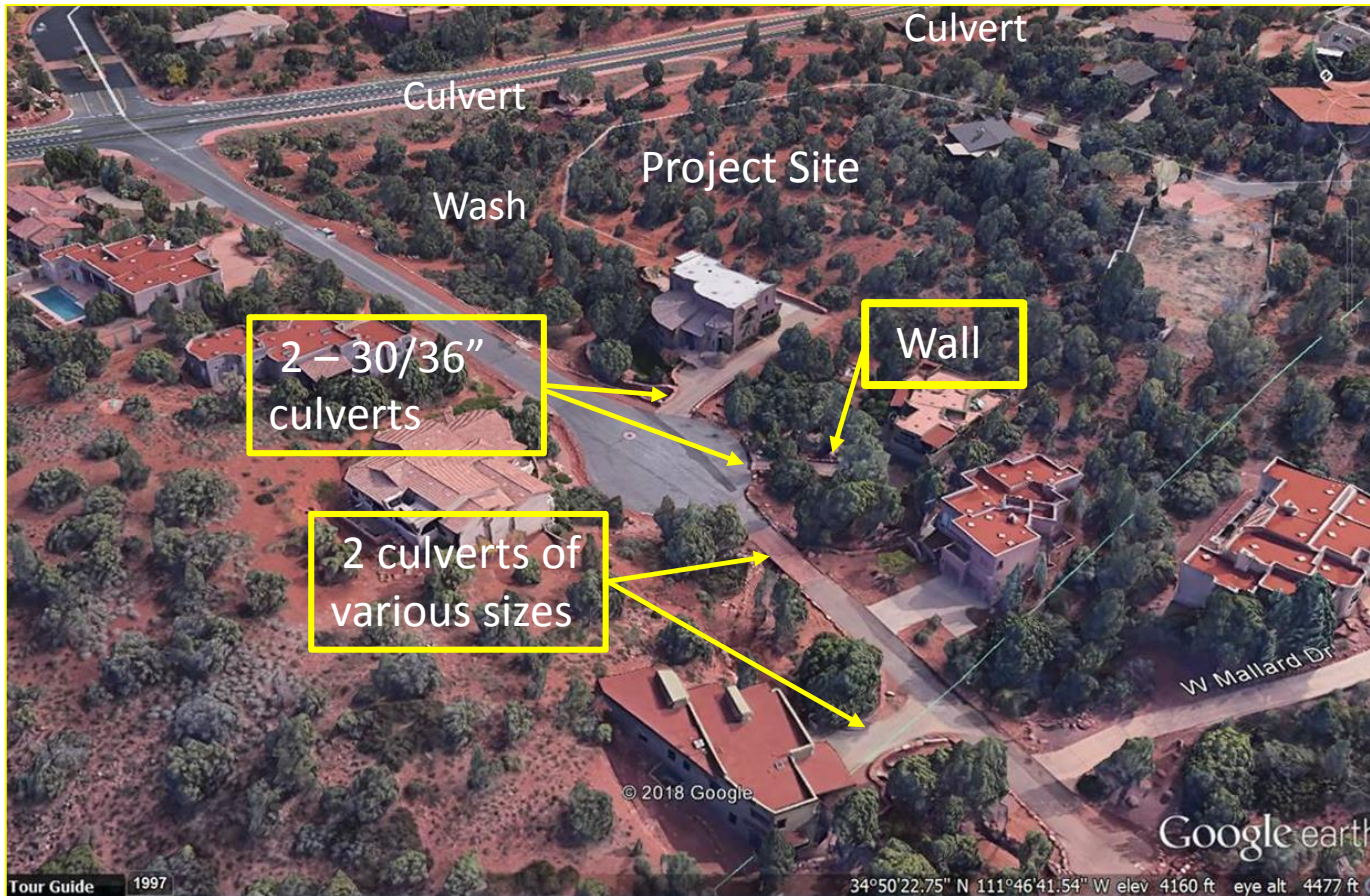
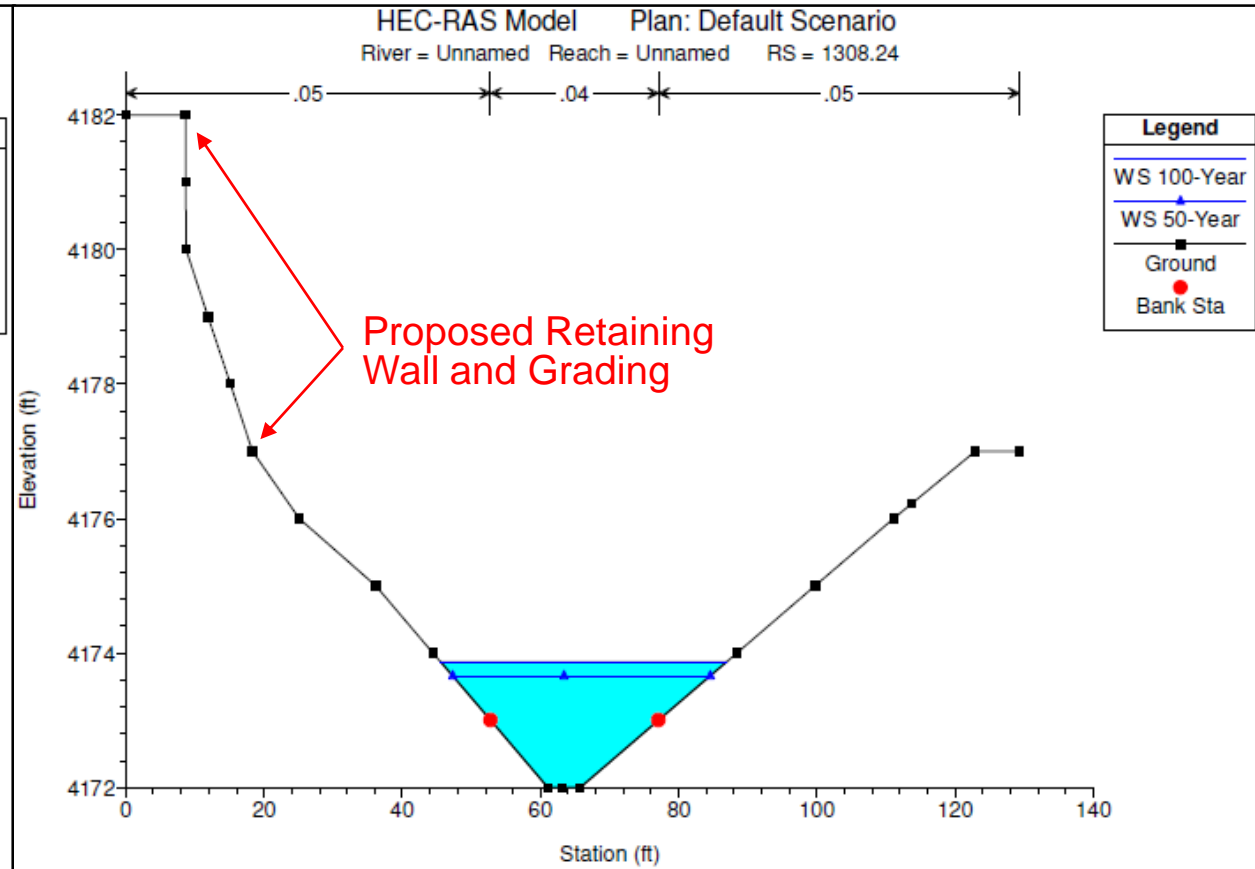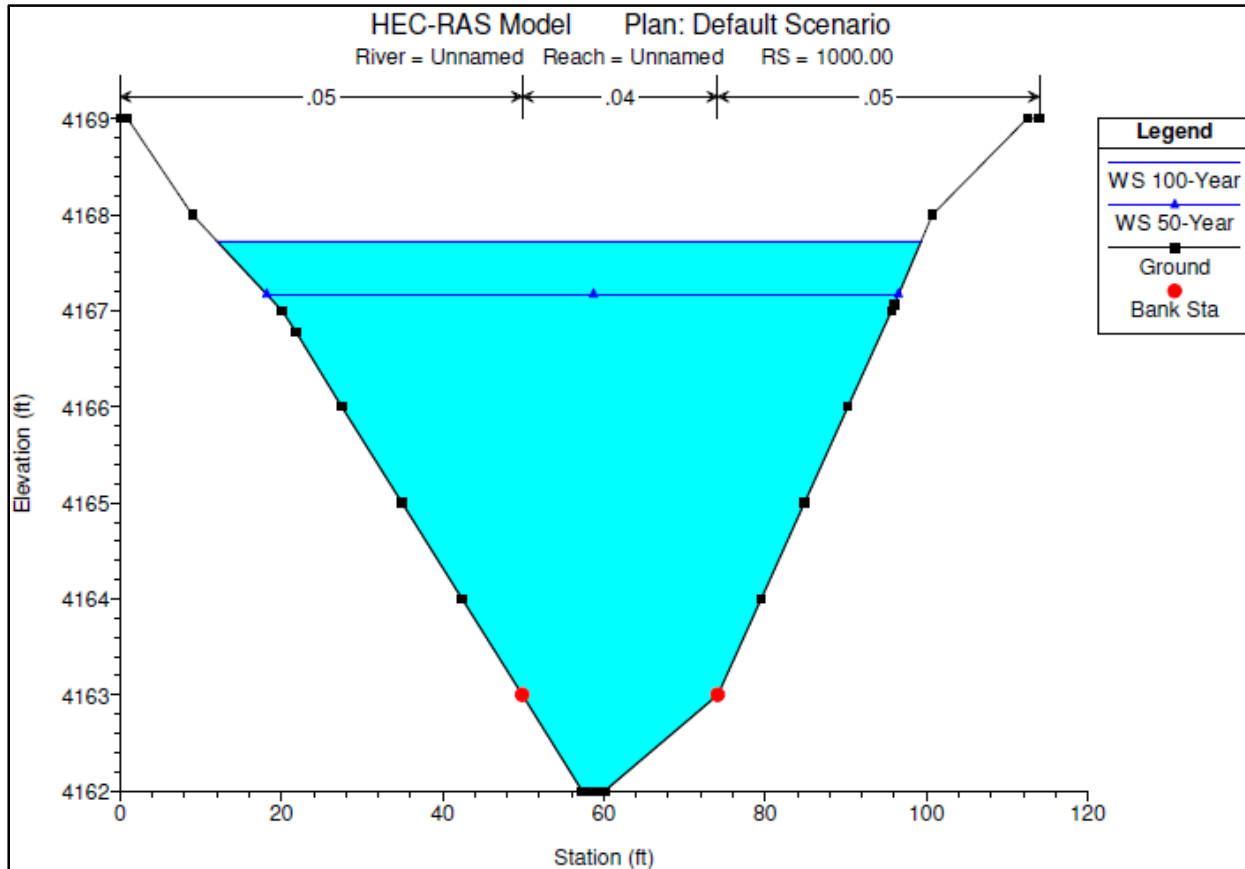# Floodplain Analysis: Boundary Condition

- Known water surface elevation

- Existing culverts and driveway impede natural flowpath

- Modeled as a combination of culverts and weir
  - CulvertMaster
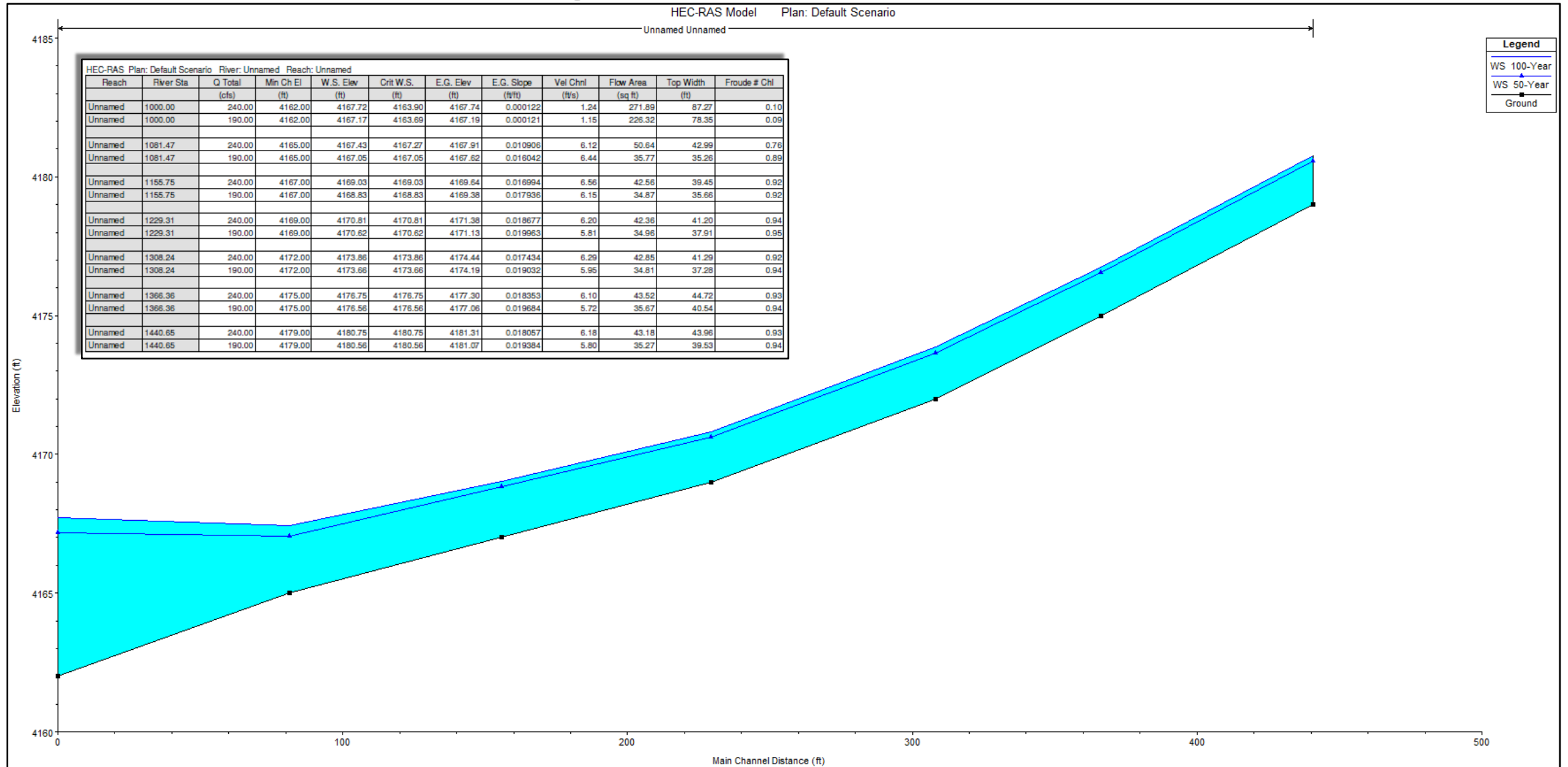 - FlowMaster

- Resulted in ~5.7' of flow depth → WSE

Floodplain Modeling Results: Cross-Sections

Floodplain Modeling Results: Flowline Profile

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Floodplain Modeling Results: WSEs

100-Year Floodplain Results

Cross-Section	Existing WSE	Proposed WSE	Difference (ft)
1000.00	4167.72	4167.72	0.00
1081.47	4167.72	4167.72	0.00
1155.75	4169.03	4169.03	0.00
1229.31	4170.81	4170.81	0.00
1308.24	4173.86	4173.86	0.00
1366.36	4176.75	4176.75	0.00
1440.65	4180.75	4180.75	0.00

50-Year Floodplain Results

Cross-Section	Existing WSE	Proposed WSE	Difference (ft)
1000.00	4167.17	4167.17	0.00
1081.47	4167.17	4167.17	0.00
1155.75	4168.83	4168.83	0.00
1229.31	4170.62	4170.62	0.00
1308.24	4173.66	4173.66	0.00
1366.36	4176.56	4176.56	0.00
1440.65	4180.56	4180.56	0.00

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