



ARIZONA WATER COMPANY

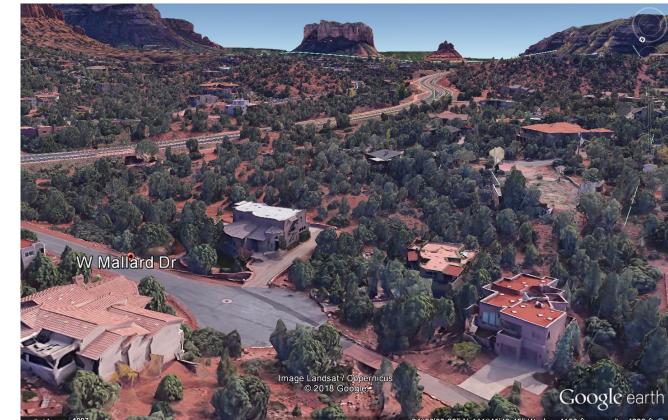
East Sedona Water Storage Facility

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?

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



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 $Q=C \times I \times A$

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.

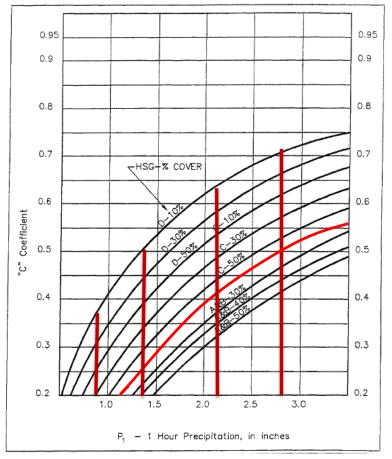
Arizona Water Company Site Analysis $Q = C \times I \times A$

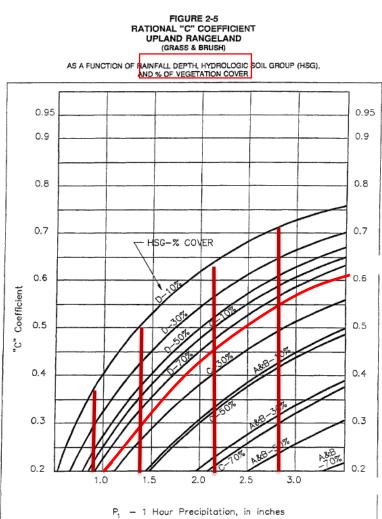
<i>Ninyo</i> « Moore		SAMPLES		CE)	N	DATE EXCAVATED TEST PIT NO	•			-0		ŝ				
TEST PIT LOG	E E	SAM	2E (%	_ L	SATIC	GROUND ELEVATION LOGGED BYM	. 6	° N	مم ا	e	E	APLE	9	, <mark>6</mark>	S	DATE EXCAVATED <u>11/13/12</u> TEST PIT NO. <u>TP-3</u>
CHAPEL HILLS WATER CAMPUS MALLARD DRIVE AND STATE ROUTE 179	Ē	Bulk Driven SAMPI	nd Cone MOISTURE (%)	DRY DENSITY (PCF)	CLASSIFICATION U.S.C.S.	METHOD OF EXCAVATION JD 310 SG Backhoe, 14" Bucket	1		OG		Ē	SAMPLES	d Cone MOISTURE (%)	DRY DENSITY (PCF)	CLASSIFICATION U.S.C.S.	GROUND ELEVATION LOGGED BY
SEDONA, ARIZONA	B	Bulk		J Z Z	TAS	LOCATION Sedona, Arizona	ē	LS WATE	R CAMP		 Ĕ		an line	ISN	SIFIC	METHOD OF EXCAVATION JD 310 SG Backhoe, 14" Bucket
PROJECT NO. DATE 603971001 10/16			San	Ľ۵		DESCRIPTION		AND ST VA, ARIZ	ATE ROU ONA	TE 179	Ъ.	iven		۳ ۲		LOCATION Sedona, Arizona
	-				SM	<u>COLLUVIUM</u> : Red, dry to damp, medium dense, silty SAND; few fine to coarse gravel.	- -	-		ATE 0/16	 -	Bulk Driven SAMPL	Sano	Ř	ō	DESCRIPTION
	-		1			Backhoe refusal on bedrock.					-				GM	COLLUVIUM: Red, dry to damp, very dense, fine to coarse silty GRAVEL.
	-2					Total Depth = 2 feet. (Refusal) Groundwater not encountered during excavation. Backfilled on 11/13/12 promptly after completion of excavating.	.				-2		2.7	7 112.1	ı	
	- 4					<u>Note:</u> Groundwater, though not encountered at the time of excavating, may rise to a higher level due to seasonal variations in precipitation and several other factor		_			-					Backhoe refusal on bedrock.
	-					as discussed in the report.					-4			+		Backhoe refusal on bedrock. Total Depth = 3.5 feet. (Refusal) Groundwater not encountered during excavation.
	-6		_													Backfilled on 11/13/12 promptly after completion of excavating. Note:
	-		_								-					Groundwater, though not encountered at the time of excavating, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report.
	- 8		-								-					as discussed in the report.
	-		_				-				-					
	- 10		-				-				- 8					
							-				-		-			
											- 10					
SCALE = 1 in./2 ft.											10					
								+			-		_			
						SCALE = 1 in./2 ft.										

Arizona Water Company Site Analysis $Q = C \times I \times A$

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

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





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

Table 8.2

		Mean Precipitation Frequency Estimates										Land Development Code																
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	Table 8.3															
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	Upper Limit Precipitation Frequency Estimates															
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	Freq	5-	10-	15-	30-	60-	120-	3-hr	6-hr	12-hr	24-hr	2-	4-	7-	10-	20
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	(yr)	min	min	min	min	min	min					day		-	day	da
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	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
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	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.
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	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.
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	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.
500	1.03	1.56	1.94	2.61	3.23	3.63		3.87		5.76	6.83	8.30	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
1,000	1.16	1.77	2.19	2.95	3.65	4.10		4.31		6.30	7.46	9.13	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.
1,000	1.10	1.,,	2.15	2.55	5.05	1.10	113		1.00	0.50	/110	5.15	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.
													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.
													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.
													1,000	1.40	2.13	2.65	3.56	4.41	4.79	4.85		Ariz	zon	a M	late	ar C	Com	

Tables conied from Sedona

		Storm Frequency:	25-yr. 100 yr. (chock)						
			100-yr. (check)						
		Froude No.:	$FN \le 0.86; 1.13 \le FN \le 2.0$						
		Freeboard (Minimum):							
		Subcritical Flow	$FB = 0.25*[y+(v^2/2g)] (1-ft. min.)$						
		Supercritical Flow	$FB = 0.25*[y+(v^2/2g)]$ (2-ft. min.)						
		Maintenance Road:	12 ft. wide, 1 side of channel						
		Maximum Velocity:	per channel lining material						
	Open	Maximum Side Slope:	(ss = from slope stability analysis)						
4.0	Channels	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 restric requirements within this article shall apply.	tive					
		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 \geq 1 cfs.						
		Maintenance Road:	12-ft. access road						
		Maximum Depth:							
5.0	Stormwater	Parking Areas							
	Storage	Emergency Spillway:	pass post-developed 100-yr. Q						
		Maximum Drain Time:	12 hrs. upstream watershed areas \leq 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 \geq 3 ft.	4:1						

Sedona Routinely Handles Runoff and Flooding Issues

 $Q = C \times I \times A$

Table Copied from Sedona Land Development Code

Yavapai County Drainage Policies & V=C(P/12)A Standards

100 Yr- 1 Hr Storm Rainfall Depth, inch

City of Sedona Precipitation Frequency Estimates

Runoff Calculations

• $\mathbf{Q} = \mathbf{C} \times | \times \mathbf{A}$

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

2.84

	F	uture				
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

Arizona Water Company

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

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								

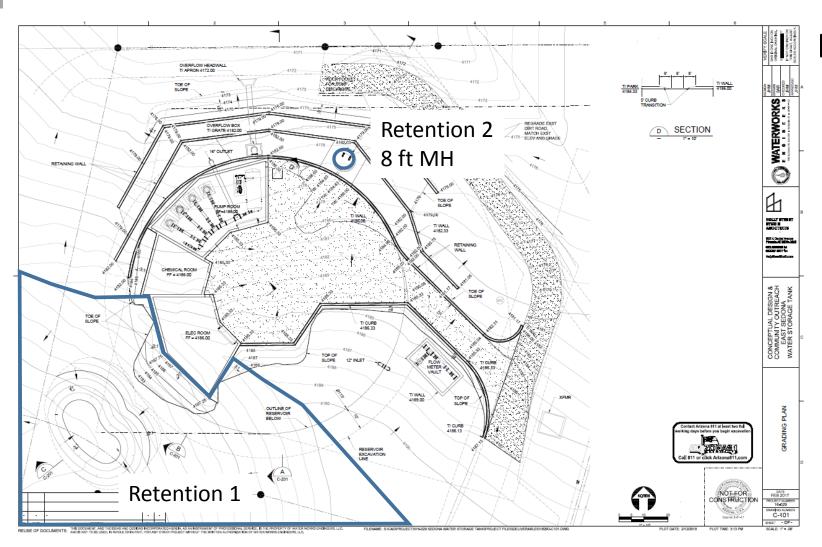
	<u>Fut</u>	ure				
Description - Proposed	Area, sqft	Area, acres	C - Value	Peak Discharge, cfs	Runoff Volume, acre-ft	Runoff Volume, cft
Grass and Brush - Area 1	4,400	0.10	0.70	0.20	0.02	729
Grass and Brush - Area 2	20,357	0.47	0.70	0.93	0.08	3,372
Hillslope Sonoran Desert - Landscaped area above reservoir	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

	V=C(P/12)	
Yavapai County Drainage Policies & Standards	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	1	0.00	0.000	0						
Reservoir 10 ft backfill ring												
Total	45,738	1.05	0.25	0.75	0.1	2,706						

<u>Future</u>												
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						

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	
						Match	Proposed	Proposed		Flow w	
Storm	Inch E	xist	Project			Existing	Retention	Retention		Proposed	%
Frequency	in 1 hr Cı	ndts	Cndts	Increase	Required	Cndts	1	2	Total	Retention	Reduction
(yr)	(0	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

Retention Basin Calculations – 2 hr. Rain Duration

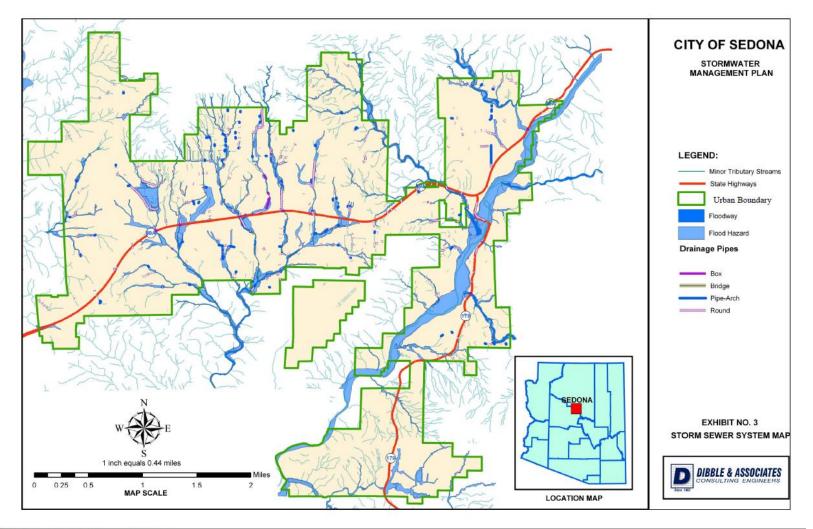
							Retention				
										Storm Water	
						Match	Proposed	Proposed		Flow w	
Storm	Inch in	Exist	Project			Existing	Retention	Retention	Total	Proposed	%
Frequency	2 hrs	Cndts	Cndts	Increase	Required	Cdts	1	2	Retention	Retention	Reduction
(yr)		(cfs)	(cfs)	(cfs)	(cft)	(cft)	(cft)	(cft)	(cft)	(cfs)	%
2	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



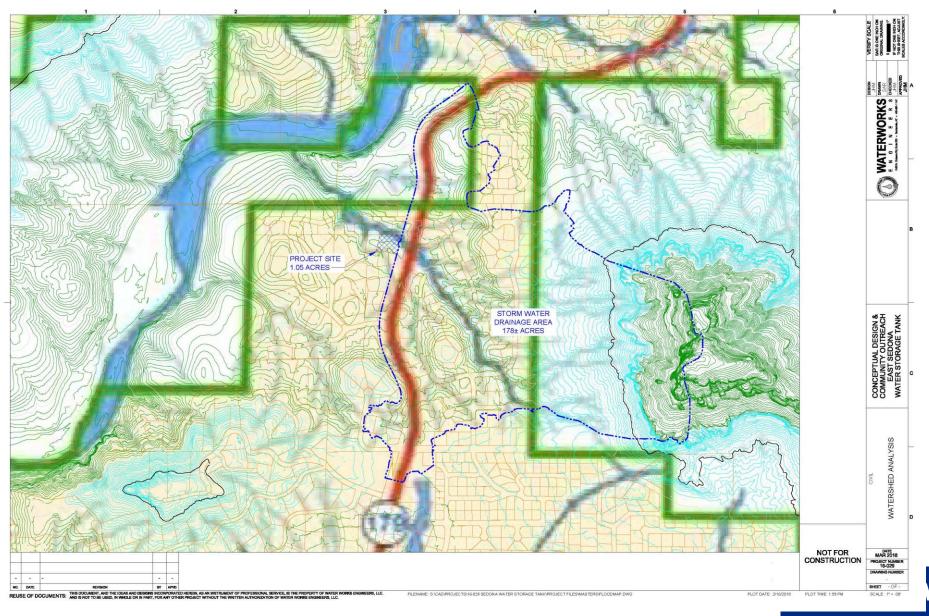
WATERSHED DISCUSSSION

Sedona Watersheds

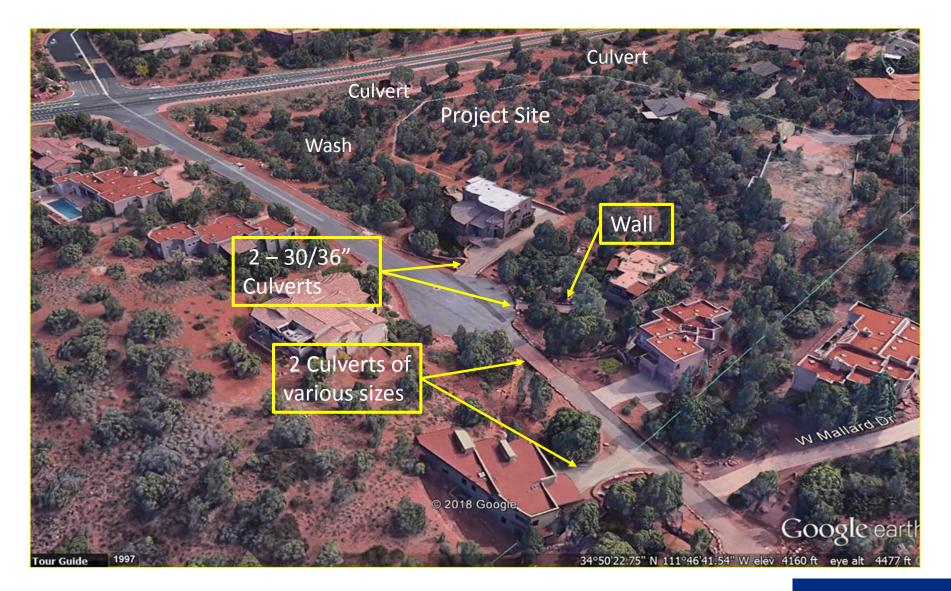


City of Sedona - Stormwater Management Program

Sedona Watersheds

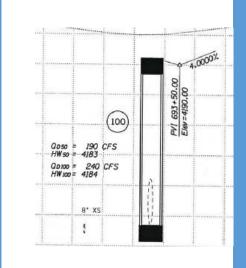


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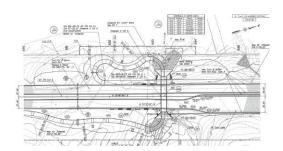
On Site Runoff Compared to Wash Flows

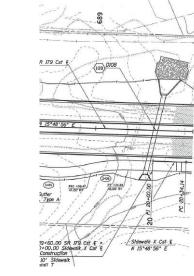
- Two culverts convey storm water runoff from east to west of SR 179
- Culvert information obtained from ADOT drawings:
 - Culvert 100 box culvert
 - 100 yr. storm flow 240 cfs
 - 50 yr. storm flow 190 cfs
 - Culvert 109 54" pipe
 - 100 yr. storm flow 68 cfs
 - 50 yr. storm flow 55 cfs
- Additional drainage from SR 179
- In comparison, site runoff is less than 1% of flow in wash



Qoso = 55 CFS

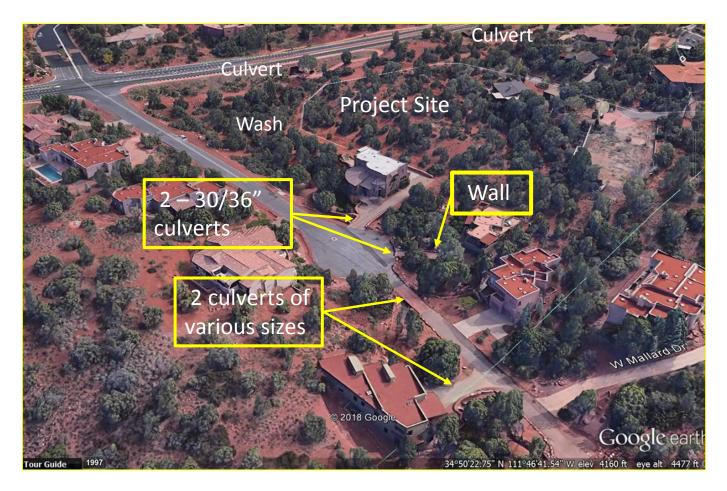
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Unnamed Wash Floodplain Analysis

- 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

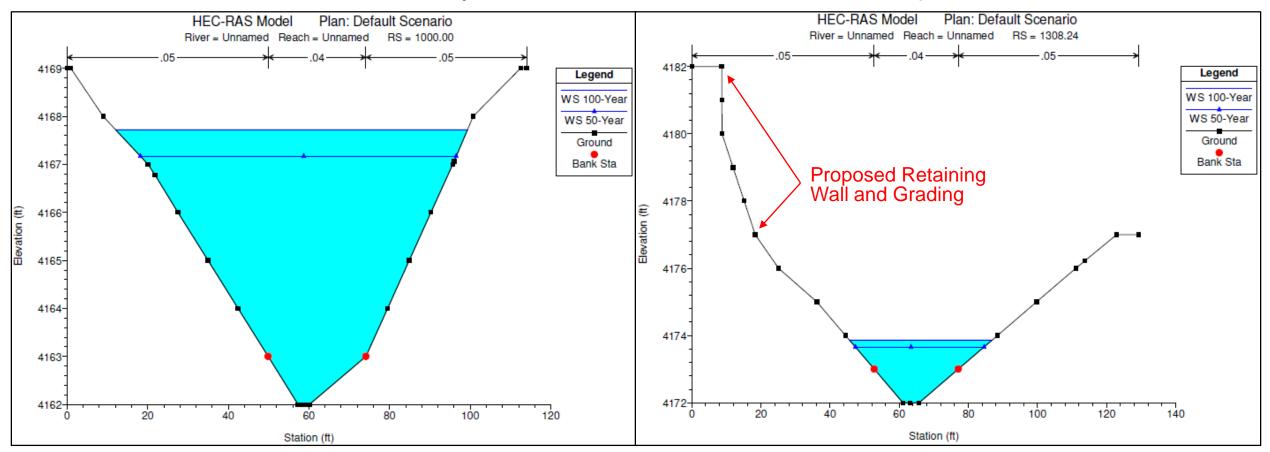
- Known water surface elevation
- Existing culverts and driveway impede natural flowpath
- Modeled as a combination of culverts and weir
 - CulvertMaster
 - FlowMaster
- Resulted in ~5.7' of flow depth \rightarrow WSE



Floodplain Modeling Results: Cross-Sections

@ Downstream Driveway

@ Proposed Tank



Floodplain Modeling Results: Flowline Profile

HEC-RAS Model Plan: Default Scenario Unnamed Unnamed -4185-Legend WS 100-Year EC-RAS Plan: Default Scenario River: Unnamed Reach: Unnamed Reach River Sta Q Total Min Ch El W.S. Elev Crit W.S. E.G. Elev E.G. Slope Vel Chni Flow Area Top Width Froude # Chi WS 50-Year (cfs) (ft) (ft) (ft) (ft) (ft/ft) (ft/s) (sq ft) (ft) Ground 4167.74 0.000122 0.10 nnamed 1000.00 240.00 4162.00 4167.72 4163.9 1.24 271.89 87.27 190.00 4162.00 4167.17 4163.69 4167.19 0.000121 226.32 78.35 0.09 Innamed 1000.00 1.15 Innamed 1081.47 240.00 4165.00 4167.43 4167.27 4167.91 0.010906 6.12 50.64 42.99 0.76 Innamed 1081.47 190.00 4165.00 4167.05 4167.0 4167.62 0.016042 6.44 35.77 35.26 0.89 4180nnamed 1155.75 240.00 4167.00 4169.03 4169.0 4169.64 0.016994 6.56 42.56 39.45 0.92 0.92 nnamed 1155.75 190.00 4167.00 4168.83 4168.83 4169.38 0.017936 6.15 34.87 35.66 4170.8 0.018677 0.94 nnamed 1229.31 240.00 4169.0 4170.81 4171.38 6.20 42.36 41.20 1229.31 190.00 4169.00 4170.62 4170.6 4171.13 0.019963 5.81 34.96 37.91 0.95 nnamed 1308.24 240.00 4172.00 4173.86 4173.8 4174.44 0.017434 42.85 41.29 0.92 Innamed 6.29 0.94 Innamed 1308.24 190.00 4172.00 4173.66 4173.66 4174,19 0.019032 5.95 34.81 37.28 4177.30 0.93 Innamed 1366.36 240.00 4175.00 4176.75 4176.7 0.018353 6.10 43.52 44.72 1366.36 190.00 4175.00 4176.56 4176.56 4177.06 5.72 35.67 40.54 0.94 nnamed 0.019684 4175-0.93 nnamed 1440.65 240.00 4179.00 4180.75 4180.7 4181.31 0.018057 6.18 43.18 43.96 0.94 nnamed 1440.65 190.00 4179.00 4180.56 4180.56 4181.07 0.019384 5.80 35.27 39.53 4170-4165 4160-100 200 300 400 500 Main Channel Distance (ft)

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

Floodplain Modeling Results: Map

