PRELIMINARY DRAINAGE ANALYSIS
FOR THE
4TH STREET EAST AND BRAZIL STREET NEIGHBORHOOD

Chad S. Moll, RCE 79721

My license expires 9/30/2018

Date: December 27, 2017

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BEAR FLAG ENGINEERING, INC.
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Project management – LAND DEVELOPMENT – FORENSIC ENGINEERING
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DRAINAGE SUMMARY

1. <u>Summary</u>

On November 2nd 2017, a meeting was held with Colleen Ferguson (Sonoma City Engineer), Bill Jasper (Applicant), and Chad Moll (Project Engineer) to review existing drainage issues associated with failing swales and blocked or undersized culverts near the intersection of 4th Street East and Brazil Street as well as the best approach for addressing these concerns. This report has been prepared to review those existing drainage concerns, perform hydrologic calculations to determine preliminary runoff amounts, determine if existing culverts and swales have capacity for either a 10 or 100-year storm event, and provide recommendations for upgrades if infrastructure does not provide sufficient capacity.

2. <u>Existing Property</u>

The existing watershed for the roadside swale along 4th Street East and Brazil Street consists of hillside terrain with slopes between 5 and 25-percent. Soils on all three properties consist of loam with high rock content, which are well drained. Existing drainage patterns consist of sub-surface flow and sheet flow on the surface through the watershed. There are no creeks or any significant concentrations of runoff. Drainage eventually is collected by a roadside swale along Brazil Street and then 4th Street East. Site coverage for the almost 24.9-acre watershed consists of woodland hillside terrain, existing driveways and residences.

3. <u>Capacity Analysis</u>

Capacity analysis is required to determine the 10 and 100-year depth of flow for existing storm drains and swales. Hydrology calculations have been calculated using the Modified Rational Method in accordance with the Sonoma County Flood Control Design Manual. Sub-sheds have been separated and points of concentration selected at existing culverts along 4th Street East and Brazil Street. A drainage feature in AutoCAD LDD was used to perform capacity calculations for swales and pipes. The hydrology map shows locations of the analyzed culverts and swale locations.

Here is a summary of the culverts:

Ex SD-1: This culvert is an 8-inch diameter steel pipe approximately 50-feet from the high point in Brazil Street. The culvert has dirt and debris in it, which removes approximately 50-percent of

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the capacity. Recommendation is to remove debris from the culvert to enhance capacity and performance.

Ex SWL-1: This swale exists between points of concentration 1 and 2 on Brazil Street. The swale has a depth of 6-8-inches with a 2-foot bottom width and provides sufficient capacity to convey both the 10 and 100-year storm event.

Ex SD-2: This culvert is a 12-inch storm drain under the driveway serving 434 Brazil Street. I estimate the culvert is approximately 75-percent blocked with debris. Recommendation: The culvert is calculated to pass the 100-year storm event if it is cleaned out.

Ex SWL-2: This swale exists between points of concentration 2 and 4 on Brazil Street. The swale has an approximate depth of 18-inches and a 2-foot bottom width and provides sufficient capacity to convey both the 10 and 100-year storm event.

Ex SD-3: This culvert is a 12-inch storm drain and is estimated at 50-percent blocked with debris. The culvert is undersized for both the 10 and 100-year storm event even if it was cleaned out. Recommendation: Replace this culvert with an 18-inch storm drain

Ex SD-4: This culvert is an 18-inch concrete storm drain located on the uphill side of the driveway serving 95 Brazil Street. This culvert provides sufficient capacity for the 10 and 100-year storm events.

Ex SD-5: This culvert is a 24-inch concrete culvert on the downhill side of the driveway serving 95 Brazil Street. This culvert provides sufficient capacity for the 10 and 100-year storm events.

Ex SWL-3: This swale is located between the driveway serving 95 Brazil Street and the upper driveway serving 131 4th Street East. It has an approximate 12-inch depth and a 2-foot bottom width at the most conservative point. The swale does not provide sufficient capacity for the 10 and 100-year storm event. Recommendation: Clean out debris and regrade swale to an 18-inch depth.

Ex SD-6: This culvert consists of an 18-inch culvert under the upper driveway entrance serving 131 4th Street East. This culvert does not provide sufficient capacity for the 10 or 100-year storm event. Recommendation: Replace this culvert with a 24-inch storm drain.

Ex SWL-4: This swale is an 18-inch depth with almost 2-foot bottom width and provides sufficient capacity for the 10 and 100-year storm event.

Ex SD-7: This culvert consists of an 18-inch culvert under a pathway serving 131 4th Street East. The culvert does not provide sufficient capacity for the 10 and 100-year storm event. Recommendation: Replace this culvert with a 24-inch storm drain. Note: There are two additional culverts between Ex SD-6 and Ex SD-7 that shall also be replaced with 24-inch storm drain.

4. <u>Conclusion</u>

The existing culverts along 4th Street East and Brazil Street have created a restriction and the drainage issues the neighbors are concerned with. Some culverts can provide sufficient capacity by simply cleaning out the debris and regrading the swales to avoid backup of storm flows. Some existing culverts are too small to provide sufficient capacity and should be replaced. Note that these recommendations pertain to existing conditions before the proposed home projects and the drainage plans for the proposed development of three homes in the watershed will not exacerbate the issues. We recommend that these mitigations shall be addressed by the city and neighbors located within the watershed to prevent public runoff discharging onto private property and causing issues.

Untitled Map

Write a description for your map.

Legend
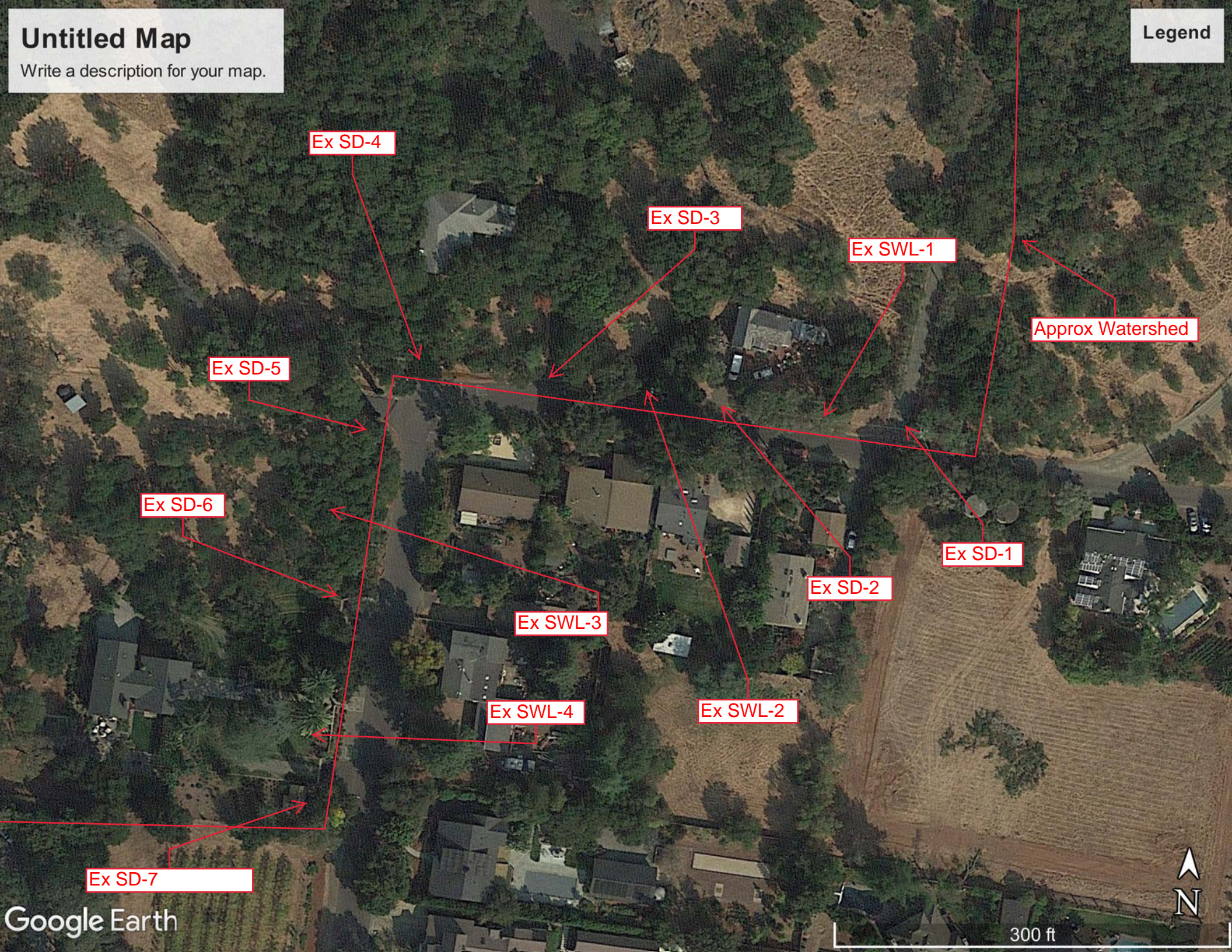
Ex SD-4

Ex SD-3

Ex SWL-1

Approx Watershed

Ex SD-5

Ex SD-6

Ex SD-1

Ex SD-2

Ex SWL-3

Ex SWL-4

Ex SWL-2

Ex SD-7

Google Earth

300 ft

N

PRE-CONSTRUCTION
OVERALL HYDROLOGY MAP
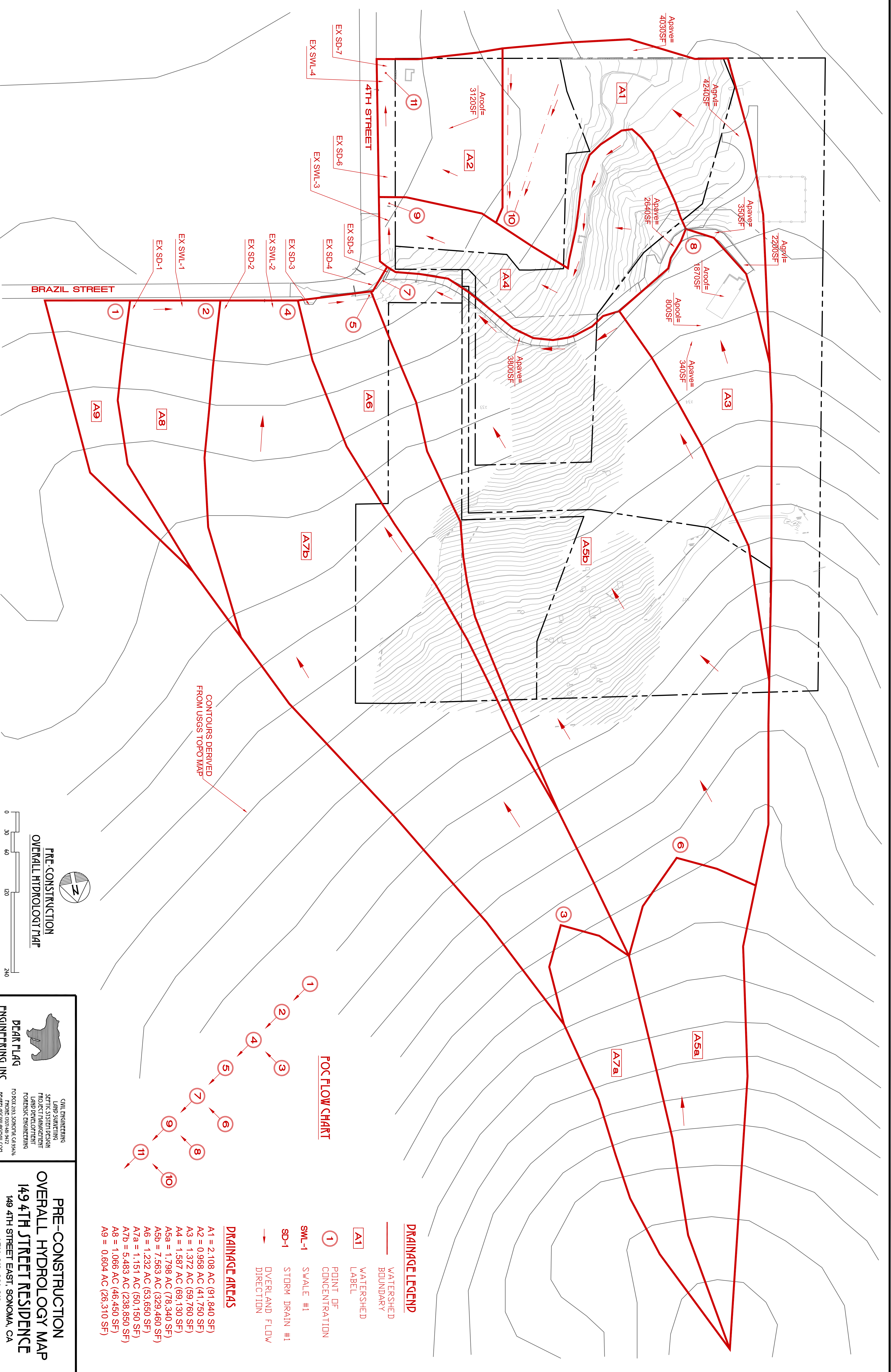
CONTOURS DERIVED FROM USGS TOPO MAP

4TH STREET

BRAZIL STREET

EX SD-7
EX SWL-4
EX SD-6
EX SWL-3
EX SD-5
EX SD-4
EX SWL-2
EX SD-3
EX SWL-1
EX SD-2
EX SD-1

Apave=4030SF
Aroof=3120SF
Aroof=4240SF
Apave=2640SF
Apave=350SF
Aroof=1870SF
Apool=800SF
Apave=2200SF
Apave=3800SF
Apave=340SF

A1
A2
A3
A4
A5a
A5b
A6
A7a
A7b
A8
A9

PRE-CONSTRUCTION
OVERALL HYDROLOGY MAP
SCALE 1"=60'
0 30 60 120 240

POC FLOW CHART

DRAINAGE LEGEND

— WATERSHED BOUNDARY

A1 — WATERSHED LABEL

(1) — POINT OF CONCENTRATION

SWL-1 — SWALE #1

SD-1 — STORM DRAIN #1

→ OVERLAND FLOW DIRECTION
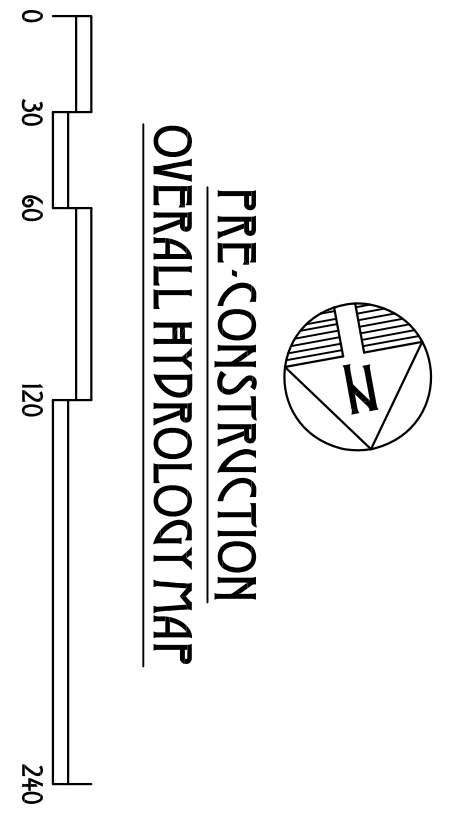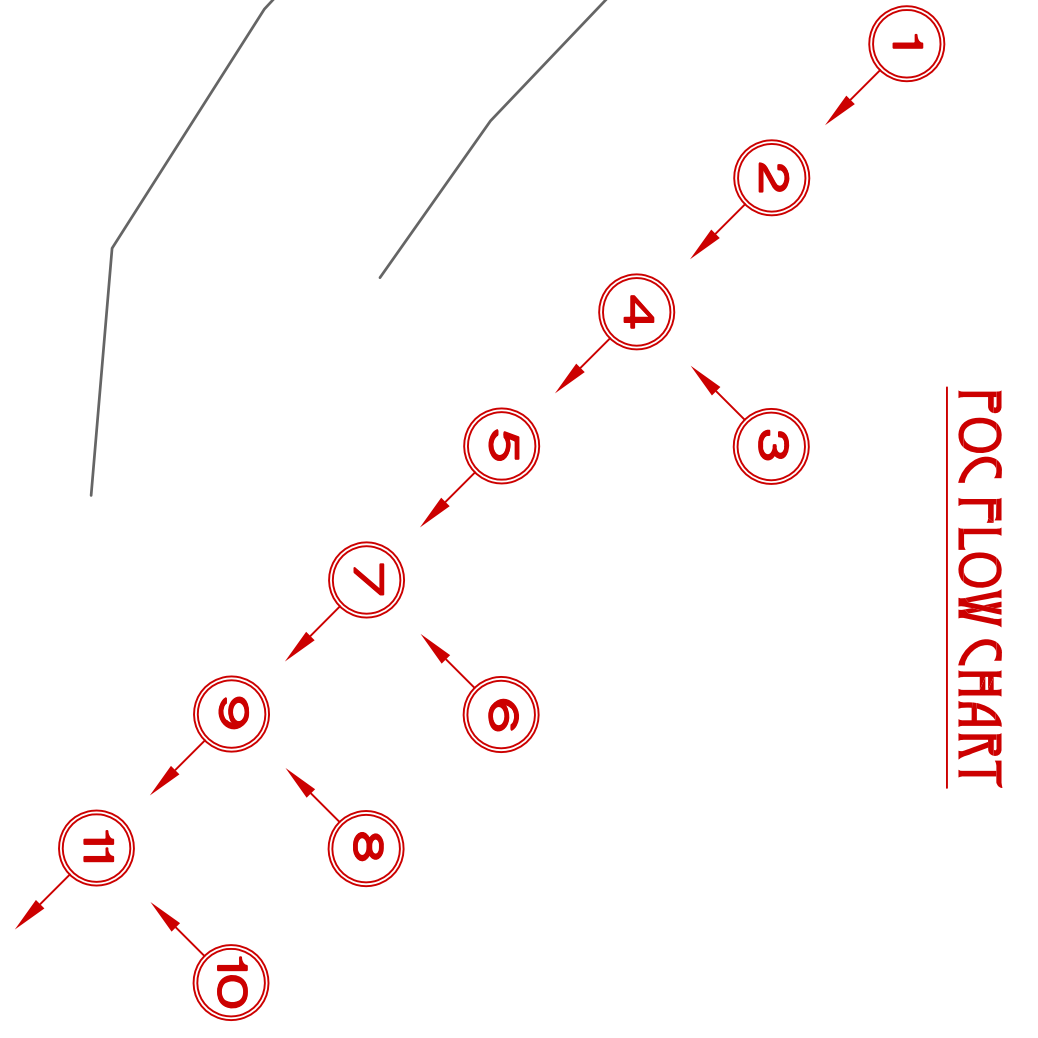
DRAINAGE AREAS

A1 = 2.108 AC (91,840 SF)
A2 = 0.958 AC (41,750 SF)
A3 = 1.372 AC (59,760 SF)
A4 = 1.587 AC (69,130 SF)
A5a = 1.798 AC (78,340 SF)
A5b = 7.563 AC (329,460 SF)
A6 = 1.232 AC (53,650 SF)
A7a = 1.151 AC (50,150 SF)
A7b = 5.483 AC (238,850 SF)
A8 = 1.066 AC (46,450 SF)
A9 = 0.604 AC (26,310 SF)

PRE-CONSTRUCTION
OVERALL HYDROLOGY MAP
149 4TH STREET RESIDENCE
149 4TH STREET EAST, SONOMA, CA
APN: 018-091-08

RATIONAL METHOD DRAINAGE STUDY

Date: 12/20/2017   Project: 4th Street and Brazil Analysis   Sheet: 1 of 2
              Storm: **10-Year (Pre-Construction)**   By: CM

10-Year Storm Event

POC	Area	Elev (ft)	Dist (ft)	Slope (ft/ft)	V (ft/s)	Tc (min)	Time (min)	I (in/hr)	K	C	A (acres)	A_total (acres)	KAC	Sum KAC	Q (ft³/s)	Description
1	A9					15.00	15.00	1.70376	1.0	0.500	0.604	0.604	0.302	0.302	0.51	(EX SD-1)
2	A8	3.2	130	0.025	1.47	1.47	16.47	1.62201	1.0	0.500	1.066	1.670	0.533	0.835	1.35	8"SD (EX SD-2) (EX SWL-1)
3	A7a					15.00	15.00	1.70376	1.0	0.500	1.151	1.151	0.576	0.576	0.98	Overland Flow
POC 4 Combines Flows from POCs 2 and 3							15.00					2.821		1.411	2.33	Overland Flow
4	A7b	300	1070	0.280	6.69	2.67	17.67	1.56328	1.0	0.527	5.483	8.304	2.890	4.300	6.72	8"SD (EX SD-3) (EX SWL-2)
5	A6	2.5	110	0.023	3.80	0.48	18.15	1.54131	1.0	0.549	1.232	9.536	0.676	4.976	7.67	18"SD (EX SD-4)
6	A5a					15.00	15.00	1.70376	1.0	0.500	1.798	1.798	0.899	0.899	1.53	Overland Flow
POC 7 Combines Flows from POCs 5 and 6							18.15					11.334		5.875	9.20	Overland Flow
7	A5b	3	40	0.075	5.21	0.13	18.28	1.53562	1.0	0.505	7.563	18.897	3.819	9.695	14.89	18"SD (EX SD-5) (EX SWL-3)
8	A3					15.00	15.00	1.70376	1.0	0.525	1.372	1.372	0.720	0.720	1.23	Overland Flow
POC 9 Combines Flows from POCs 7 and 8							18.28					20.269		10.415	16.11	Overland Flow
9	A4	7	100	0.070	5.13	0.32	18.60	1.52145	1.0	0.515	1.587	21.856	0.817	11.232	17.09	24"SD (EX SD-6)
10	A1					15.00	15.00	1.70376	1.0	0.547	2.108	2.108	1.153	1.153	1.96	Overland Flow
POC 11 Combines Flows from POCs 9 and 10							18.60					23.964		12.385	19.05	Overland Flow
11	A2	4.5	204	0.022	6.07	0.56	19.16	1.49787	1.0	0.581	0.958	24.922	0.557	12.942	19.39	24"SD (EX SD-7) (EX SWL-4)

RATIONAL METHOD DRAINAGE STUDY

Date: 12/20/2017   Project: 4th Street and Brazil Analysis   Sheet: 2 of 2
                                Storm: **100-Year (Pre-Construction)**   By: CM

100-Year Storm Event

POC	Area	Elev (ft)	Dist (ft)	Slope (ft/ft)	V (ft/s)	Tc (min)	Time (min)	I (in/hr)	K	C	A (acres)	A$_{total}$ (acres)	KAC	Sum KAC	Q (ft^3/s)	Description
1	A9					15.00	15.00	2.42278	1.0	0.500	0.604	0.604	0.302	0.302	0.73	(EX SD-1)
2	A8	3.2	130	0.025	2.10	1.03	16.03	2.33886	1.0	0.500	1.066	1.670	0.533	0.835	1.95	8 "SD (EX SD-2) (EX SWL-1)
3	A7a					15.00	15.00	2.42278	1.0	0.500	1.151	1.151	0.576	0.576	1.39	Overland Flow
POC 4 Combines Flows from POCs 2 and 3							15.00					2.821		1.411	3.35	Overland Flow
4	A7b	300	1070	0.280	4.26	4.18	19.18	2.12709	1.0	0.527	5.483	8.304	2.890	4.300	9.15	12 "SD (EX SD-3) (EX SWL-2)
5	A6	2.5	110	0.023	3.80	0.48	19.67	2.09935	1.0	0.549	1.232	9.536	0.676	4.976	10.45	21 "SD (EX SD-4)
6	A5a					15.00	15.00	2.42278	1.0	0.500	1.798	1.798	0.899	0.899	2.18	Overland Flow
POC 7 Combines Flows from POCs 5 and 6							19.67					11.334		5.875	12.63	Overland Flow
7	A5b	3	40	0.075	5.25	0.13	19.79	2.09221	1.0	0.505	7.563	18.897	3.819	9.695	20.28	21 "SD (EX SD-5) (EX SWL-3)
8	A3					15.00	15.00	2.42278	1.0	0.525	1.372	1.372	0.720	0.720	1.75	Overland Flow
POC 9 Combines Flows from POCs 7 and 8							19.79					20.269		10.415	22.03	Overland Flow
9	A4	7	100	0.070	5.54	0.30	20.09	2.07558	1.0	0.515	1.587	21.856	0.817	11.232	23.31	27 "SD (EX SD-6)
10	A1					15.00	15.00	2.42278	1.0	0.547	2.108	2.108	1.153	1.153	2.79	Overland Flow
POC 11 Combines Flows from POCs 9 and 10							20.09					23.964		12.385	26.11	Overland Flow
11	A2	4.5	204	0.022	6.57	0.52	20.61	2.04783	1.0	0.581	0.958	24.922	0.557	12.942	26.50	27 "SD (EX SD-7) (EX SWL-4)

Runoff Coefficient Worksheet (Pre-Construction)							
A1				A2			
Surface	RC	Area (sq.ft)	RC x A	Surface	RC	Area (sq.ft)	RC x A
Pervious	0.50	81020	40510	Pervious	0.50	34384	17192
Gravel	0.90	6440	5796	Gravel	0.90	0	0
Pavement	0.90	4380	3942	Pavement	0.90	3000	2700
Pool	1.00	0	0	Pool	1.00	0	0
Roof	1.00	0	0	Roof	1.00	4366	4366
	Subtotal	91840	50248		Subtotal	41750	24258
	0.547	Weighted RC			0.581	Weighted RC	
A3				A4			
Surface	RC	Area (sq.ft)	RC x A	Surface	RC	Area (sq.ft)	RC x A
Pervious	0.50	56750	28375	Pervious	0.50	66490	33245
Gravel	0.90	0	0	Gravel	0.90	0	0
Pavement	0.90	340	306	Pavement	0.90	2640	2376
Pool	1.00	800	800	Pool	1.00	0	0
Roof	1.00	1870	1870	Roof	1.00	0	0
	Subtotal	59760	31351		Subtotal	69130	35621
	0.525	Weighted RC			0.515	Weighted RC	
A5a				A5b			
Surface	RC	Area (sq.ft)	RC x A	Surface	RC	Area (sq.ft)	RC x A
Pervious	0.50	78340	39170	Pervious	0.50	325660	162830
Gravel	0.90	0	0	Gravel	0.90	0	0
Pavement	0.90	0	0	Pavement	0.90	3800	3420
Pool	1.00	0	0	Pool	1.00	0	0
Roof	1.00	0	0	Roof	1.00	0	0
	Subtotal	78340	39170		Subtotal	329460	166250
	0.500	Weighted RC			0.505	Weighted RC	
A6				A7a			
Surface	RC	Area (sq.ft)	RC x A	Surface	RC	Area (sq.ft)	RC x A
Pervious	0.50	47950	23975	Pervious	0.50	50150	25075
Gravel	0.90	0	0	Gravel	0.90	0	0
Pavement	0.90	2300	2070	Pavement	0.90	0	0
Pool	1.00	0	0	Pool	1.00	0	0
Roof	1.00	3400	3400	Roof	1.00	0	0
	Subtotal	53650	29445		Subtotal	50150	25075
	0.549	Weighted RC			0.500	Weighted RC	

A7b			
Surface	RC	Area (sq.ft)	RC x A
Pervious	0.50	224300	112150
Gravel	0.90	0	0
Pavement	0.90	9400	8460
Pool	1.00	0	0
Roof	1.00	5150	5150
	Subtotal	238850	125760
	0.527	Weighted RC	

A8			
Surface	RC	Area (sq.ft)	RC x A
Pervious	0.50	46450	23225
Gravel	0.90	0	0
Pavement	0.90	0	0
Pool	1.00	0	0
Roof	1.00	0	0
	Subtotal	46450	23225
	0.500	Weighted RC	

A9			
Surface	RC	Area (sq.ft)	RC x A
Pervious	0.50	26310	13155
Gravel	0.90	0	0
Pavement	0.90	0	0
Pool	1.00	0	0
Roof	1.00	0	0
	Subtotal	26310	13155
	0.500	Weighted RC	

EX SD-1 (100-Year Storm Event)
Manning Pipe Calculator

Given Input Data:
    Shape .... Circular
    Solving for .... Depth of Flow
    Diameter .... 0.6700 ft
    Flowrate .... 0.5100 cfs
    Slope .... 0.0500 ft/ft
    Manning's n 0.0140

Computed Results:
    Depth .... 0.2035 ft
    Area 0.3526 ft2
    Wetted Area 0.0905 ft2
    Wetted Perimeter .... 0.7822 ft
    Perimeter .... 2.1049 ft
    Velocity .... 5.6355 fps
    Hydraulic Radius .... 0.1157 ft
    Percent Full .... 30.3736 %
    Full flow Flowrate .... 2.5427 cfs
    Full flow velocity .... 7.2119 fps

EX SD-1 (100-Year Storm Event)
         Manning Pipe Calculator

Given Input Data:
    Shape .... Circular
    Solving for .... Depth of Flow
    Diameter .... 0.6700 ft
    Flowrate .... 0.7300 cfs
    Slope .... 0.0500 ft/ft
    Manning's n 0.0140

Computed Results:
    Depth .... 0.2457 ft
    Area 0.3526 ft2
    Wetted Area 0.1172 ft2
    Wetted Perimeter .... 0.8717 ft
    Perimeter .... 2.1049 ft
    Velocity .... 6.2287 fps
    Hydraulic Radius .... 0.1344 ft
    Percent Full .... 36.6789 %
    Full flow Flowrate .... 2.5427 cfs
    Full flow velocity .... 7.2119 fps

EX SD-2 (10-Year Storm Event)
          Manning Pipe Calculator

Given Input Data:
    Shape .... Circular
    Solving for .... Depth of Flow
    Diameter .... 1.0000 ft
    Flowrate .... 1.3500 cfs
    Slope .... 0.0200 ft/ft
    Manning's n 0.0140

Computed Results:
    Depth .... 0.3678 ft
    Area 0.7854 ft2
    Wetted Area 0.2620 ft2
    Wetted Perimeter .... 1.3032 ft
    Perimeter .... 3.1416 ft
    Velocity .... 5.1520 fps
    Hydraulic Radius .... 0.2011 ft
    Percent Full .... 36.7777 %
    Full flow Flowrate .... 4.6787 cfs
    Full flow velocity .... 5.9571 fps

EX SD-2 (100-Year Storm Event)
        Manning Pipe Calculator

Given Input Data:
    Shape .... Circular
    Solving for .... Depth of Flow
    Diameter .... 1.0000 ft
    Flowrate .... 1.9500 cfs
    Slope .... 0.0200 ft/ft
    Manning's n 0.0140

Computed Results:
    Depth .... 0.4502 ft
    Area 0.7854 ft2
    Wetted Area 0.3429 ft2
    Wetted Perimeter .... 1.4709 ft
    Perimeter .... 3.1416 ft
    Velocity .... 5.6862 fps
    Hydraulic Radius .... 0.2331 ft
    Percent Full .... 45.0156 %
    Full flow Flowrate .... 4.6787 cfs
    Full flow velocity .... 5.9571 fps

EX SD-3 Max Flow
Manning Pipe Calculator

Given Input Data:
    Shape .... Circular
    Solving for .... Flowrate
    Diameter .... 1.0000 ft
    Depth .... 0.9400 ft
    Slope .... 0.0200 ft/ft
    Manning's n 0.0140

Computed Results:
    Flowrate .... 5.0327 cfs
    Area 0.7854 ft2
    Wetted Area 0.7662 ft2
    Wetted Perimeter .... 2.6467 ft
    Perimeter .... 3.1416 ft
    Velocity .... 6.5688 fps
    Hydraulic Radius .... 0.2895 ft
    Percent Full .... 94.0000 %
    Full flow Flowrate .... 4.6787 cfs
    Full flow velocity .... 5.9571 fps

EX SD-3 Upgrade (10-Year Storm Event)
Manning Pipe Calculator

Given Input Data:
    Shape .... Circular
    Solving for .... Depth of Flow
    Diameter .... 1.2500 ft
    Flowrate .... 6.7300 cfs
    Slope .... 0.0200 ft/ft
    Manning's n 0.0140

Computed Results:
    Depth .... 0.8406 ft
    Area 1.2272 ft2
    Wetted Area 0.8776 ft2
    Wetted Perimeter .... 2.4037 ft
    Perimeter .... 3.9270 ft
    Velocity .... 7.6682 fps
    Hydraulic Radius .... 0.3651 ft
    Percent Full .... 67.2481 %
    Full flow Flowrate .... 8.4830 cfs
    Full flow velocity .... 6.9126 fps

EX SD-3 Upgrade (100-Year Storm Event)
Manning Pipe Calculator

Given Input Data:
    Shape .... Circular
    Solving for .... Depth of Flow
    Diameter .... 1.5000 ft
    Flowrate .... 9.1500 cfs
    Slope .... 0.0200 ft/ft
    Manning's n 0.0140

Computed Results:
    Depth .... 0.8925 ft
    Area 1.7671 ft2
    Wetted Area 1.0961 ft2
    Wetted Perimeter .... 2.6430 ft
    Perimeter .... 4.7124 ft
    Velocity .... 8.3478 fps
    Hydraulic Radius .... 0.4147 ft
    Percent Full .... 59.5032 %
    Full flow Flowrate .... 13.7943 cfs
    Full flow velocity .... 7.8060 fps

EX SD-4 (10-Year Storm Event)
        Manning Pipe Calculator

Given Input Data:
    Shape .... Circular
    Solving for .... Depth of Flow
    Diameter .... 1.5000 ft
    Flowrate .... 7.6400 cfs
    Slope .... 0.0500 ft/ft
    Manning's n 0.0140

Computed Results:
    Depth .... 0.6129 ft
    Area 1.7671 ft2
    Wetted Area 0.6790 ft2
    Wetted Perimeter .... 2.0804 ft
    Perimeter .... 4.7124 ft
    Velocity .... 11.2514 fps
    Hydraulic Radius .... 0.3264 ft
    Percent Full .... 40.8579 %
    Full flow Flowrate .... 21.8107 cfs
    Full flow velocity .... 12.3423 fps

EX SD-4 (100-Year Storm Event)
               Manning Pipe Calculator

Given Input Data:
    Shape .... Circular
    Solving for .... Depth of Flow
    Diameter .... 1.5000 ft
    Flowrate .... 10.4100 cfs
    Slope .... 0.0500 ft/ft
    Manning's n 0.0140

Computed Results:
    Depth .... 0.7299 ft
    Area 1.7671 ft2
    Wetted Area 0.8534 ft2
    Wetted Perimeter .... 2.3159 ft
    Perimeter .... 4.7124 ft
    Velocity .... 12.1988 fps
    Hydraulic Radius .... 0.3685 ft
    Percent Full .... 48.6571 %
    Full flow Flowrate .... 21.8107 cfs
    Full flow velocity .... 12.3423 fps

EX SD-5 (10-Year Storm Event)
        Manning Pipe Calculator

Given Input Data:
    Shape .... Circular
    Solving for .... Depth of Flow
    Diameter .... 2.0000 ft
    Flowrate .... 14.8600 cfs
    Slope .... 0.0500 ft/ft
    Manning's n 0.0140

Computed Results:
    Depth .... 0.7730 ft
    Area 3.1416 ft2
    Wetted Area 1.1206 ft2
    Wetted Perimeter .... 2.6835 ft
    Perimeter .... 6.2832 ft
    Velocity .... 13.2602 fps
    Hydraulic Radius .... 0.4176 ft
    Percent Full .... 38.6479 %
    Full flow Flowrate .... 46.9720 cfs
    Full flow velocity .... 14.9516 fps

EX SD-5 (100-Year Storm Event)
        Manning Pipe Calculator

Given Input Data:
    Shape .... Circular
    Solving for .... Depth of Flow
    Diameter .... 2.0000 ft
    Flowrate .... 20.2400 cfs
    Slope .... 0.0500 ft/ft
    Manning's n 0.0140

Computed Results:
    Depth .... 0.9175 ft
    Area 3.1416 ft2
    Wetted Area 1.4060 ft2
    Wetted Perimeter .... 2.9764 ft
    Perimeter .... 6.2832 ft
    Velocity .... 14.3957 fps
    Hydraulic Radius .... 0.4724 ft
    Percent Full .... 45.8747 %
    Full flow Flowrate .... 46.9720 cfs
    Full flow velocity .... 14.9516 fps

EX SD-6 Max Flow
Manning Pipe Calculator

Given Input Data:
    Shape .... Circular
    Solving for .... Flowrate
    Diameter .... 1.5000 ft
    Depth .... 0.9984 ft
    Slope .... 0.0200 ft/ft
    Manning's n 0.0140

Computed Results:
    Flowrate .... 10.7897 cfs
    Area 1.7671 ft2
    Wetted Area 1.2493 ft2
    Wetted Perimeter .... 2.8627 ft
    Perimeter .... 4.7124 ft
    Velocity .... 8.6365 fps
    Hydraulic Radius .... 0.4364 ft
    Percent Full .... 66.5630 %
    Full flow Flowrate .... 13.7943 cfs
    Full flow velocity .... 7.8060 fps

EX SD-6 (100-Year Storm Event)
Manning Pipe Calculator

Given Input Data:
    Shape .... Circular
    Solving for .... Depth of Flow
    Diameter .... 2.0000 ft
    Flowrate .... 23.2700 cfs
    Slope .... 0.0200 ft/ft
    Manning's n 0.0140

Computed Results:
    Depth .... 1.3326 ft
    Area 3.1416 ft2
    Wetted Area 2.2236 ft2
    Wetted Perimeter .... 3.8198 ft
    Perimeter .... 6.2832 ft
    Velocity .... 10.4652 fps
    Hydraulic Radius .... 0.5821 ft
    Percent Full .... 66.6310 %
    Full flow Flowrate .... 29.7077 cfs
    Full flow velocity .... 9.4563 fps

EX SD-7 Max Flow
Manning Pipe Calculator

Given Input Data:
    Shape .... Circular
    Solving for .... Flowrate
    Diameter .... 1.5000 ft
    Depth .... 0.9984 ft
    Slope .... 0.0300 ft/ft
    Manning's n 0.0140

Computed Results:
    Flowrate .... 13.2146 cfs
    Area 1.7671 ft2
    Wetted Area 1.2493 ft2
    Wetted Perimeter .... 2.8627 ft
    Perimeter .... 4.7124 ft
    Velocity .... 10.5776 fps
    Hydraulic Radius .... 0.4364 ft
    Percent Full .... 66.5630 %
    Full flow Flowrate .... 16.8945 cfs
    Full flow velocity .... 9.5603 fps

EX SD-7 Upgrade (100-Year Storm Event)
Manning Pipe Calculator

Given Input Data:
    Shape .... Circular
    Solving for .... Depth of Flow
    Diameter .... 2.0000 ft
    Flowrate .... 26.4600 cfs
    Slope .... 0.0300 ft/ft
    Manning's n 0.0140

Computed Results:
    Depth .... 1.2651 ft
    Area 3.1416 ft2
    Wetted Area 2.0948 ft2
    Wetted Perimeter .... 3.6783 ft
    Perimeter .... 6.2832 ft
    Velocity .... 12.6313 fps
    Hydraulic Radius .... 0.5695 ft
    Percent Full .... 63.2570 %
    Full flow Flowrate .... 36.3843 cfs
    Full flow velocity .... 11.5815 fps

EX SWL-1 (10-Year Storm Event)
Channel Calculator

Given Input Data:
    Shape .... Trapezoidal
    Solving for .... Depth of Flow
    Flowrate .... 1.3500 cfs
    Slope .... 0.0200 ft/ft
    Manning's n 0.0350
    Height .... 0.5000 ft
    Bottom width .... 2.0000 ft
    Left slope .... 0.5000 ft/ft (V/H)
    Right slope .... 0.5000 ft/ft (V/H)

Computed Results:
    Depth .... 0.2571 ft
    Velocity .... 2.0889 fps
    Full Flowrate .... 4.5079 cfs
    Flow area 0.6463 ft2
    Flow perimeter .... 3.1496 ft
    Hydraulic radius .... 0.2052 ft
    Top width .... 3.0282 ft
    Area 1.5000 ft2
    Perimeter .... 4.2361 ft
    Percent full .... 51.4123 %

EX SWL-1 (100-Year Storm Event)
Channel Calculator

Given Input Data:
    Shape .... Trapezoidal
    Solving for .... Depth of Flow
    Flowrate .... 1.9500 cfs
    Slope .... 0.0200 ft/ft
    Manning's n 0.0350
    Height .... 0.5000 ft
    Bottom width .... 2.0000 ft
    Left slope .... 0.5000 ft/ft (V/H)
    Right slope .... 0.5000 ft/ft (V/H)

Computed Results:
    Depth .... 0.3162 ft
    Velocity .... 2.3431 fps
    Full Flowrate .... 4.5079 cfs
    Flow area 0.8322 ft2
    Flow perimeter .... 3.4139 ft
    Hydraulic radius .... 0.2438 ft
    Top width .... 3.2646 ft
    Area 1.5000 ft2
    Perimeter .... 4.2361 ft
    Percent full .... 63.2315 %

EX SWL-2 (10-Year Storm Event)
          Channel Calculator

Given Input Data:
    Shape .... Trapezoidal
    Solving for .... Depth of Flow
    Flowrate .... 6.7200 cfs
    Slope .... 0.0200 ft/ft
    Manning's n 0.0350
    Height .... 1.5000 ft
    Bottom width .... 2.0000 ft
    Left slope .... 0.5000 ft/ft (V/H)
    Right slope .... 0.5000 ft/ft (V/H)

Computed Results:
    Depth .... 0.6174 ft
    Velocity .... 3.3647 fps
    Full Flowrate .... 40.7645 cfs
    Flow area 1.9972 ft2
    Flow perimeter .... 4.7612 ft
    Hydraulic radius .... 0.4195 ft
    Top width .... 4.4697 ft
    Area 7.5000 ft2
    Perimeter .... 8.7082 ft
    Percent full .... 41.1609 %

EX SWL-2 (100-Year Storm EVent)
            Channel Calculator

Given Input Data:
    Shape .... Trapezoidal
    Solving for .... Depth of Flow
    Flowrate .... 9.1500 cfs
    Slope .... 0.0200 ft/ft
    Manning's n 0.0350
    Height .... 1.5000 ft
    Bottom width .... 2.0000 ft
    Left slope .... 0.5000 ft/ft (V/H)
    Right slope .... 0.5000 ft/ft (V/H)

Computed Results:
    Depth .... 0.7242 ft
    Velocity .... 3.6640 fps
    Full Flowrate .... 40.7645 cfs
    Flow area 2.4972 ft2
    Flow perimeter .... 5.2386 ft
    Hydraulic radius .... 0.4767 ft
    Top width .... 4.8967 ft
    Area 7.5000 ft2
    Perimeter .... 8.7082 ft
    Percent full .... 48.2788 %

EX SWL-3 (10-Year Storm Event)
Channel Calculator

Given Input Data:
    Shape .... Trapezoidal
    Solving for .... Depth of Flow
    Flowrate .... 14.8600 cfs
    Slope .... 0.0300 ft/ft
    Manning's n 0.0350
    Height .... 1.5000 ft
    Bottom width .... 2.0000 ft
    Left slope .... 0.5000 ft/ft (V/H)
    Right slope .... 0.5000 ft/ft (V/H)

Computed Results:
    Depth .... 0.8356 ft
    Velocity .... 4.8445 fps
    Full Flowrate .... 49.9261 cfs
    Flow area 3.0674 ft2
    Flow perimeter .... 5.7367 ft
    Hydraulic radius .... 0.5347 ft
    Top width .... 5.3422 ft
    Area 7.5000 ft2
    Perimeter .... 8.7082 ft
    Percent full .... 55.7034 %

EX SWL-3 (100-Year Storm Event)
Channel Calculator

Given Input Data:
    Shape .... Trapezoidal
    Solving for .... Flowrate
    Slope .... 0.0200 ft/ft
    Manning's n 0.0350
    Depth .... 0.9000 ft
    Height .... 1.0000 ft
    Bottom width .... 2.0000 ft
    Left slope .... 0.5000 ft/ft (V/H)
    Right slope .... 0.5000 ft/ft (V/H)

Computed Results:
    Flowrate .... 14.0780 cfs
    Velocity .... 4.1164 fps
    Full Flowrate .... 17.4261 cfs
    Flow area 3.4200 ft2
    Flow perimeter .... 6.0249 ft
    Hydraulic radius .... 0.5676 ft
    Top width .... 5.6000 ft
    Area 4.0000 ft2
    Perimeter .... 6.4721 ft
    Percent full .... 90.0000 %

EX SWL-3 Upgrade (100-Year Storm Event)
Channel Calculator

Given Input Data:
    Shape .... Trapezoidal
    Solving for .... Depth of Flow
    Flowrate .... 20.2400 cfs
    Slope .... 0.0200 ft/ft
    Manning's n 0.0350
    Height .... 1.5000 ft
    Bottom width .... 2.0000 ft
    Left slope .... 0.5000 ft/ft (V/H)
    Right slope .... 0.5000 ft/ft (V/H)

Computed Results:
    Depth .... 1.0758 ft
    Velocity .... 4.5319 fps
    Full Flowrate .... 40.7645 cfs
    Flow area 4.4661 ft2
    Flow perimeter .... 6.8110 ft
    Hydraulic radius .... 0.6557 ft
    Top width .... 6.3031 ft
    Area 7.5000 ft2
    Perimeter .... 8.7082 ft
    Percent full .... 71.7183 %

EX SWL-4 (10-Year Storm Event)
Channel Calculator

Given Input Data:
    Shape .... Trapezoidal
    Solving for .... Depth of Flow
    Flowrate .... 19.3500 cfs
    Slope .... 0.0300 ft/ft
    Manning's n 0.0350
    Height .... 1.5000 ft
    Bottom width .... 2.0000 ft
    Left slope .... 0.5000 ft/ft (V/H)
    Right slope .... 0.5000 ft/ft (V/H)

Computed Results:
    Depth .... 0.9529 ft
    Velocity .... 5.1988 fps
    Full Flowrate .... 49.9261 cfs
    Flow area 3.7220 ft2
    Flow perimeter .... 6.2616 ft
    Hydraulic radius .... 0.5944 ft
    Top width .... 5.8117 ft
    Area 7.5000 ft2
    Perimeter .... 8.7082 ft
    Percent full .... 63.5286 %

EX SWL-4 (100-Year Storm Event)
Channel Calculator

Given Input Data:
    Shape .... Trapezoidal
    Solving for .... Depth of Flow
    Flowrate .... 26.4600 cfs
    Slope .... 0.0300 ft/ft
    Manning's n 0.0350
    Height .... 1.5000 ft
    Bottom width .... 2.0000 ft
    Left slope .... 0.5000 ft/ft (V/H)
    Right slope .... 0.5000 ft/ft (V/H)

Computed Results:
    Depth .... 1.1103 ft
    Velocity .... 5.6463 fps
    Full Flowrate .... 49.9261 cfs
    Flow area 4.6863 ft2
    Flow perimeter .... 6.9655 ft
    Hydraulic radius .... 0.6728 ft
    Top width .... 6.4413 ft
    Area 7.5000 ft2
    Perimeter .... 8.7082 ft
    Percent full .... 74.0215 %

APPENDIX

PROJECT SITE
P=30 in/yr
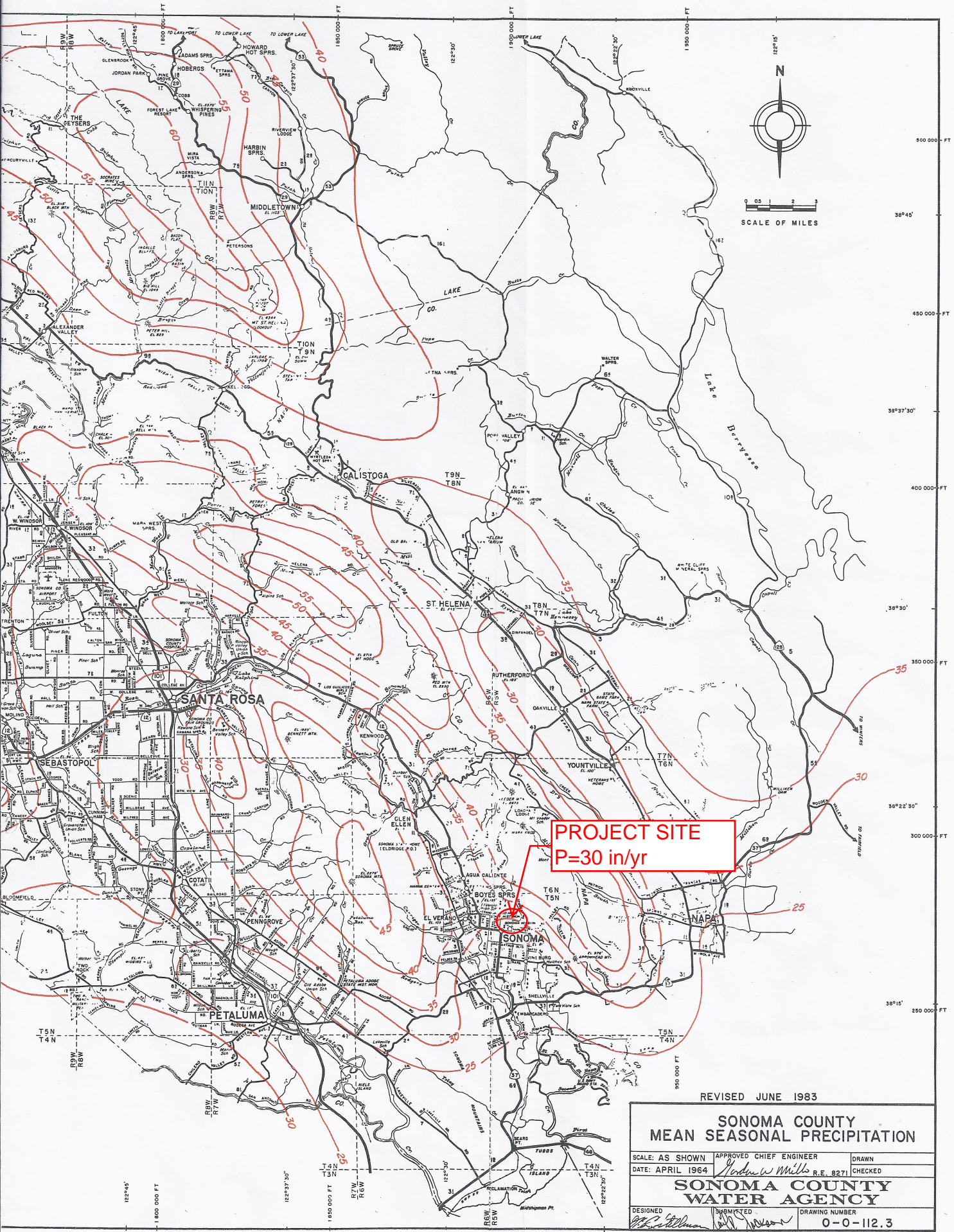
REVISED JUNE 1983

**SONOMA COUNTY
MEAN SEASONAL PRECIPITATION**

| SCALE: AS SHOWN | APPROVED CHIEF ENGINEER | DRAWN |
| DATE: APRIL 1964 | _Gordon W Mills_ R.E. 8271 | CHECKED |

**SONOMA COUNTY
WATER AGENCY**

| DESIGNED | SUBMITTED | DRAWING NUMBER |
| | | 0-0-112.3 |

PLATE No. B-3
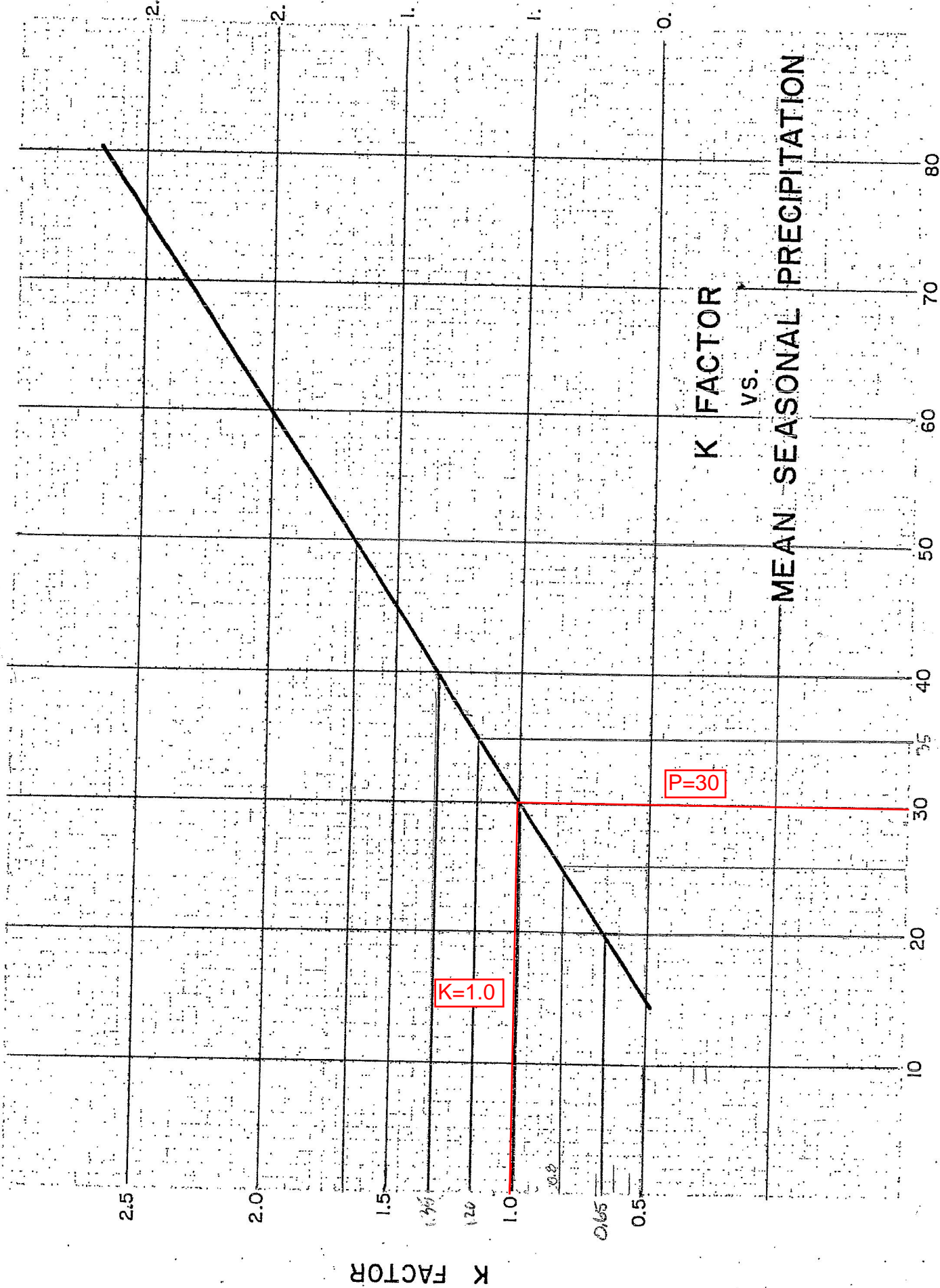
K FACTOR
vs.
MEAN SEASONAL PRECIPITATION

MEAN SEASONAL PRECIPITATION – INCHES

K FACTOR

P=30

K=1.0

2-66

PLATE No. B-4
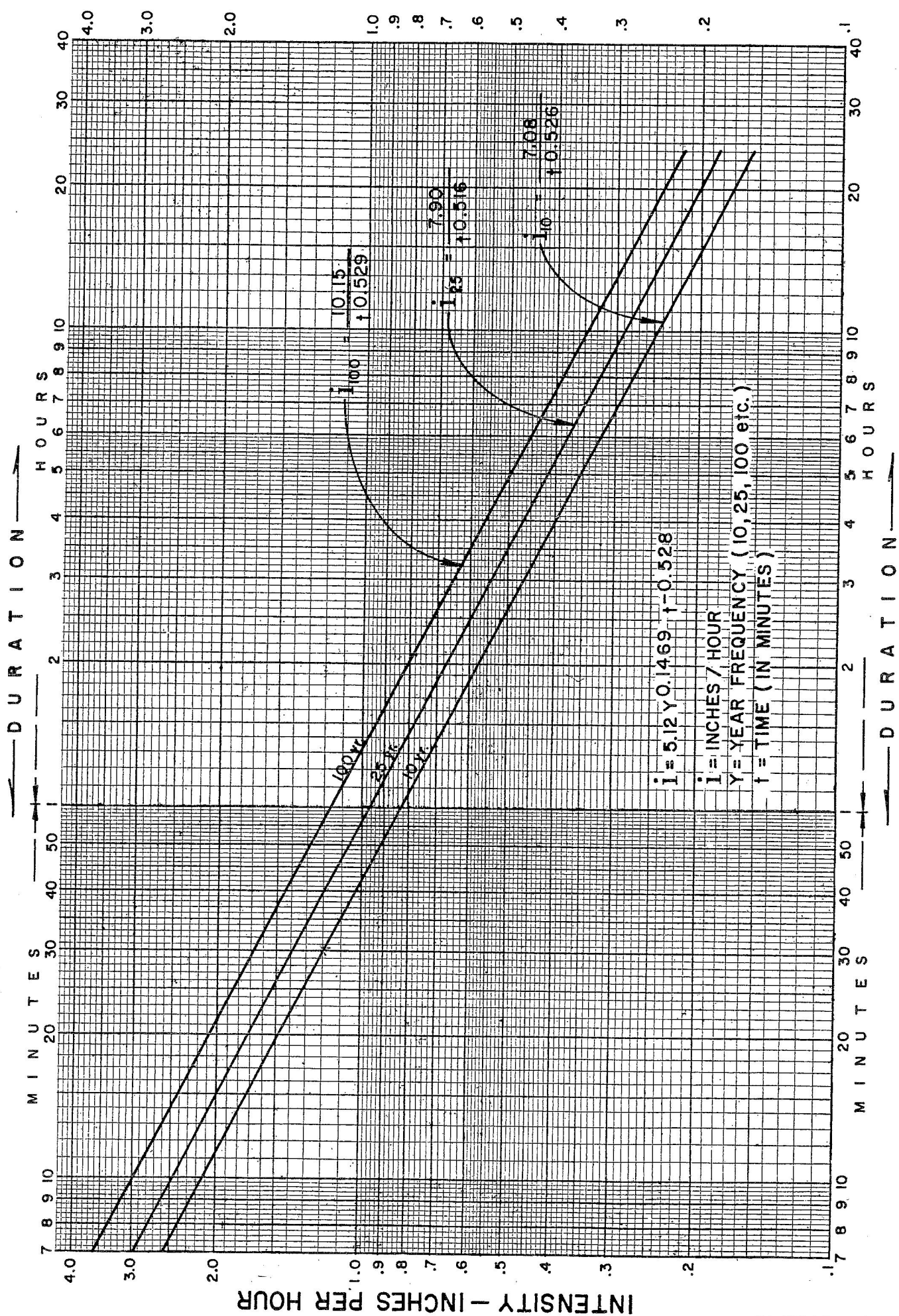
RAINFALL
INTENSITY vs DURATION

$i = 5.12 \ Y 0.1469 \ t^{-0.528}$

$i = $ INCHES / HOUR
$Y = $ YEAR FREQUENCY (10, 25, 100 etc.)
$t = $ TIME (IN MINUTES)

$i_{100} = \dfrac{10.15}{t^{+0.529}}$

$i_{25} = \dfrac{7.90}{t^{+0.516}}$

$i_{10} = \dfrac{7.08}{t^{+0.526}}$

INTENSITY — INCHES PER HOUR

DURATION

HOURS

MINUTES

NOTE: THE INFORMATION SHOWN IS SUBJECT TO
ANNUAL REVISION AS ADDITIONAL RAINFALL
DATA BECOMES AVAILABLE

PLATE No. B-2

RUNOFF COEFFICIENTS
FOR
RATIONAL FORMULA

Cv=0.50

S=20%

Under 1/4 Acre Lots

Single and Two Family Residential

1/4 to 1/2 Acre Lots

Residential

Over 1/2 Acre Lots

Residential

Parks - Vegetated Areas - C_v

RUNOFF COEFFICIENT - C

AVERAGE GROUND SLOPE %
(NOT SLOPE OF CHANNEL OR STORM DRAIN)
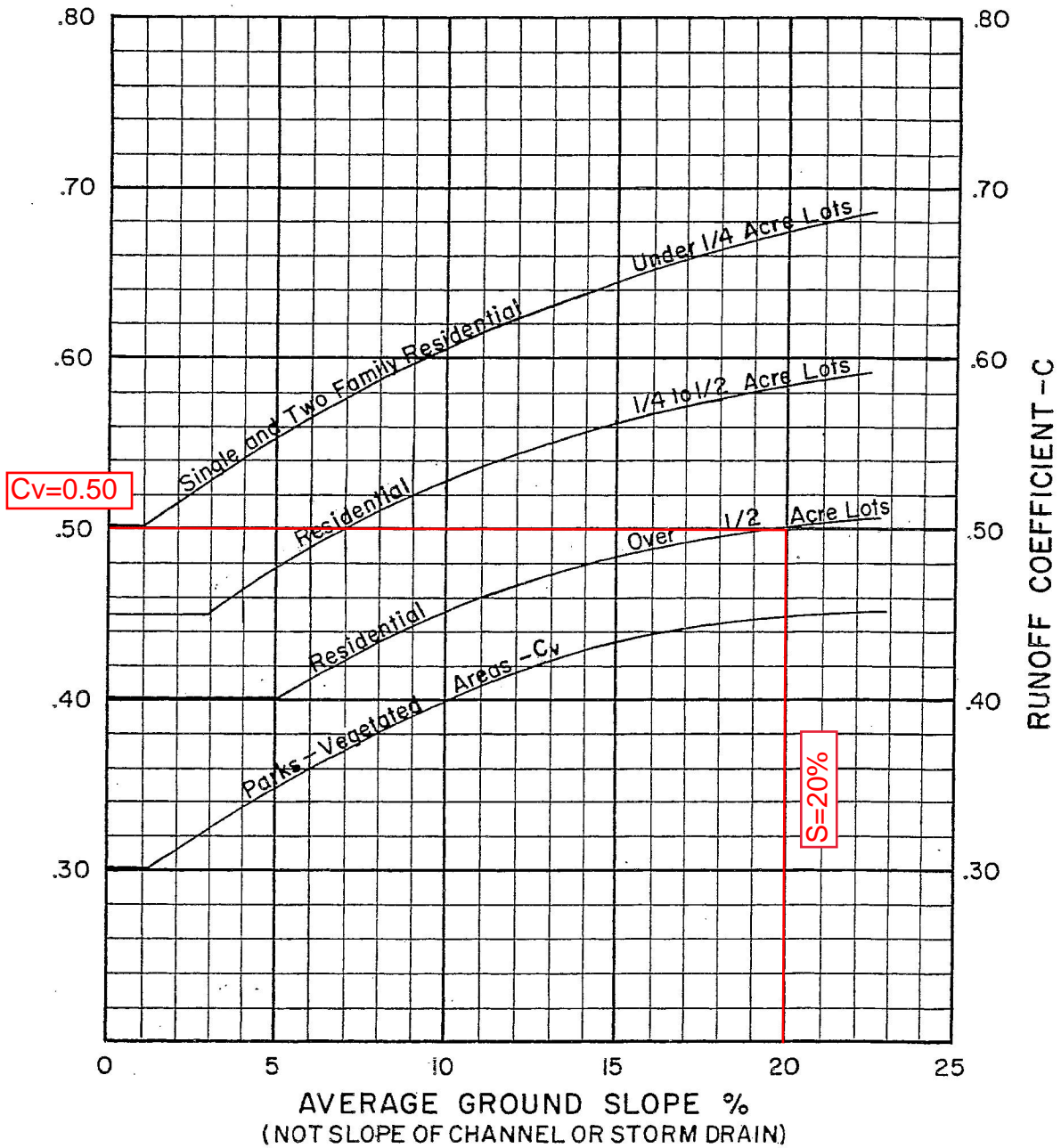
NOTE: Commercial, Industrial & Multiple Residential Areas
$C_P = 0.9$ (Based on paving, roofs, etc.)
When vegetated area exceeds 20% of total,
C_v from vegetated curve may be used to reduce
above C_P as follows:

$$C_T = C_V \frac{A_V}{A_T} + C_P \frac{A_P}{A_T}$$

SONOMA COUNTY WATER AGENCY

118-2
7/64

PLATE No. B-1

USGS
science for a changing world

U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

The National Map
US Topo

SONOMA QUADRANGLE
CALIFORNIA
7.5-MINUTE SERIES

Lokoya

Drainage
Watershed

Mission Highlands

Fetters Hot
Springs

Boyes Hot Springs

El Verano

Verano

Valley of
the Moon

SONOMA

Nathanson Creek
Bridge

Saint Francis Solano
Catholic Cemetery

Buena
Vista

Batto

Bonilla

Four
Corners

Vineburg

Temelec

Sonoma Skypark

SCALE 1:24 000

UTM GRID AND 2015 MAGNETIC NORTH
DECLINATION AT CENTER OF SHEET

U.S. National Grid

CONTOUR INTERVAL 20 FEET
NORTH AMERICAN VERTICAL DATUM OF 1988

This map was produced to conform with the
National Geospatial Program US Topo Product Standard, 2011.
A metadata file associated with this product is draft version 0.6.18

ROAD CLASSIFICATION

Expressway	Local Connector
Secondary Hwy	Local Road
Ramp	4WD

Interstate Route   US Route   State Route

QUADRANGLE LOCATION

ADJOINING QUADRANGLES

1 Kenwood
2 Rutherford
3 Yountville
4 Glen Ellen
5 Napa
6 Petaluma River
7 Sears Point
8 Cuttings Wharf

SONOMA, CA
2015