Computational Forensics

October 2019

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Licensed Geoscientist, TX;
Licensed Geologist, Ark;
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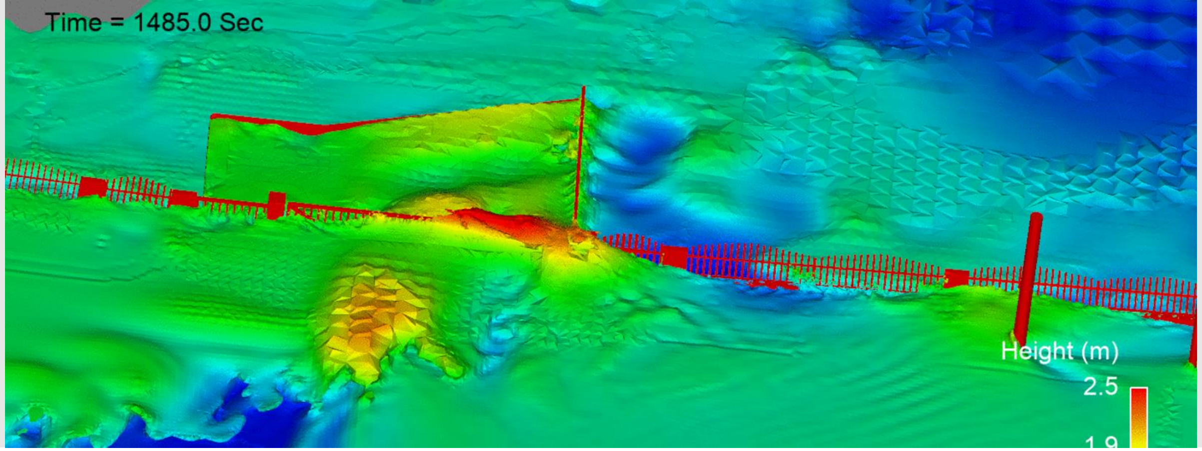
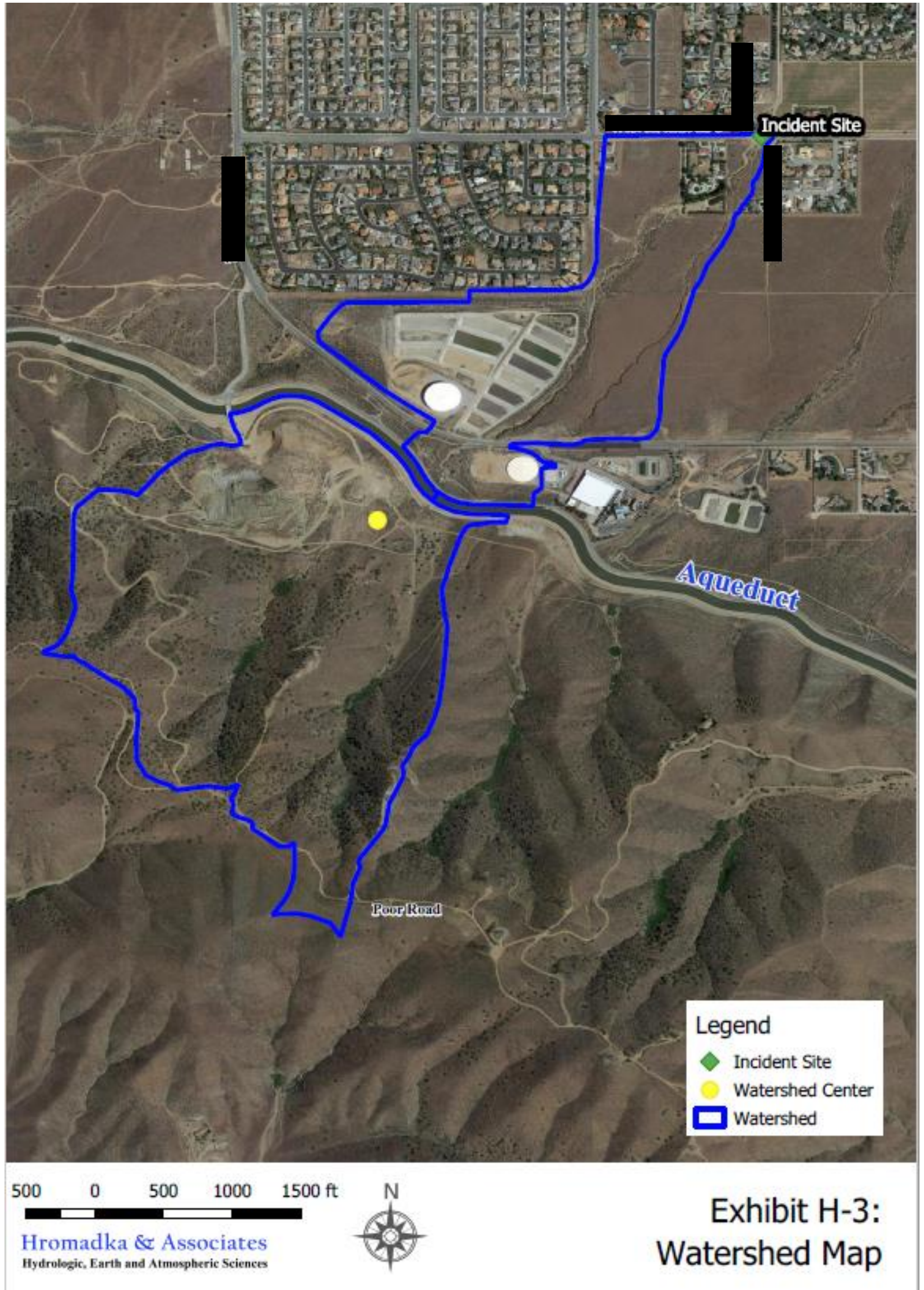
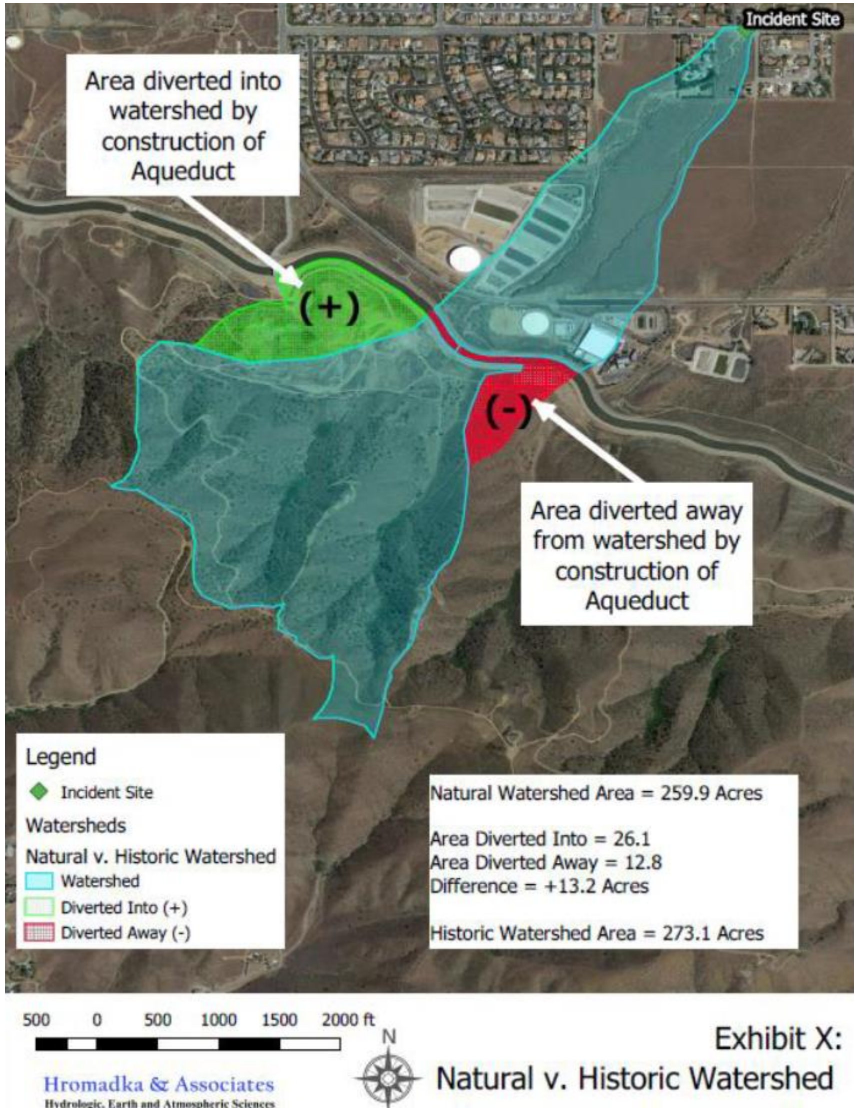


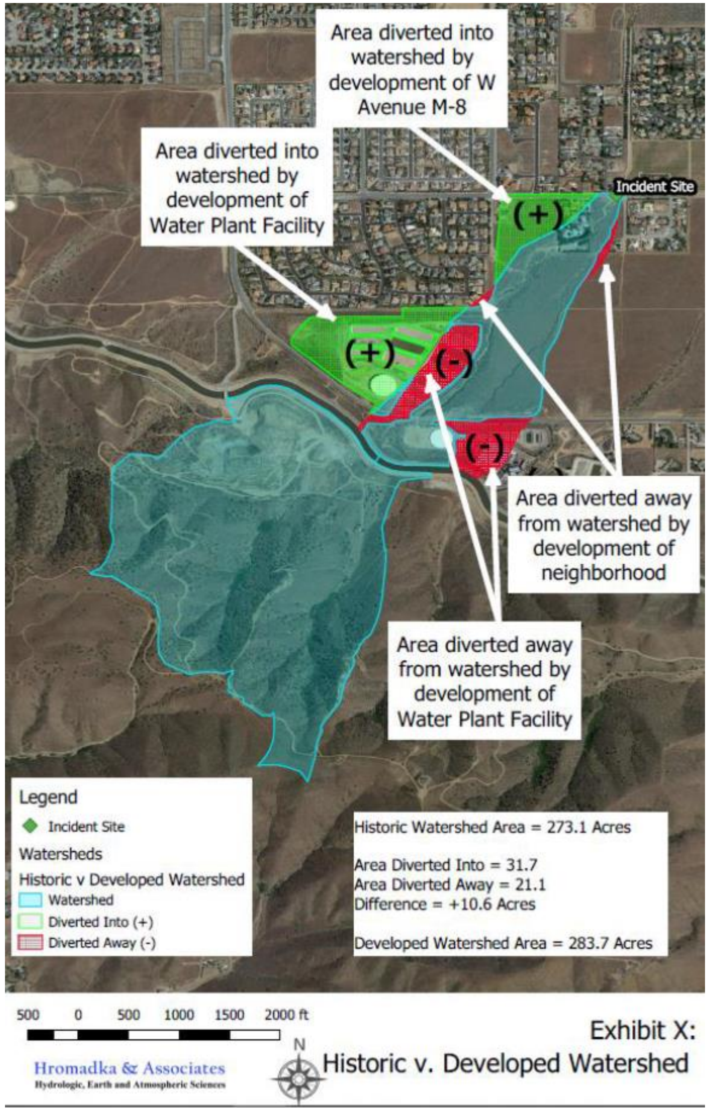
Hydrology and Runoff Modelling

Step 1a: Delineate Watershed to Location of Interest



Step 1b: Evaluate the Historical Development of the Watershed





Step 2: Identify, Characterize, and Map All Nearby Rain Gages

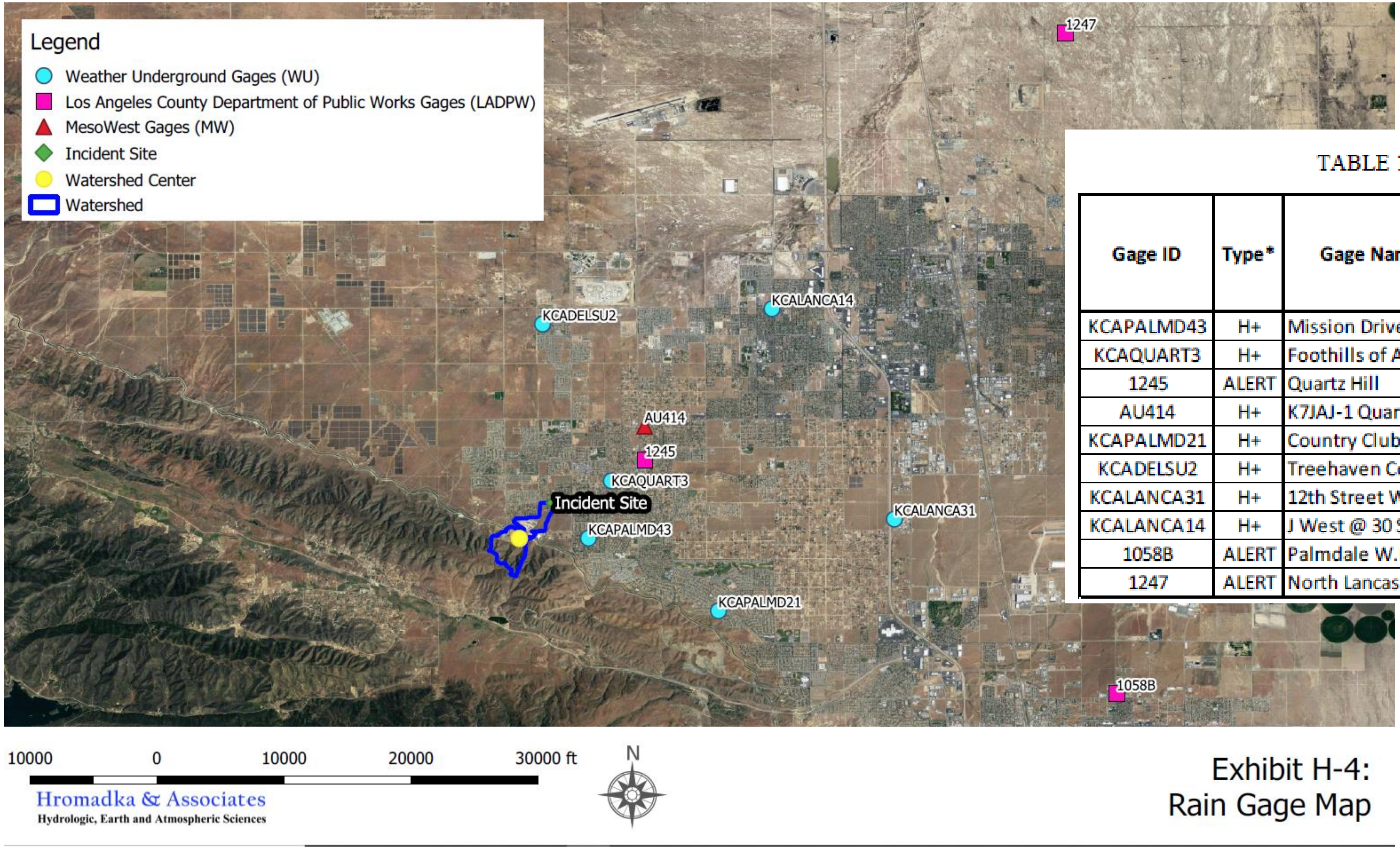


Exhibit H-4:
Rain Gage Map

TABLE 1: RAIN GAGE CHARACTERISTICS

Gage ID	Type*	Gage Name	Source**	Elevation (feet)	Data From	Data To	Data Years	Approximate Distance From Watershed Center (miles)
KCAPALMD43	H+	Mission Drive	WU	2752	2015	2017	2	1
KCAQUART3	H+	Foothills of AV	WU	2500	2008	2017	9	1.8
1245	ALERT	Quartz Hill	LADPW	2395	1998	2017	19	2.4
AU414	H+	K7JAJ-1 Quartz Hill	MW	2448	2012	2017	5	2.8
KCAPALMD21	H+	Country Club Ridge	WU	2736	2012	2017	5	3.3
KCADELSU2	H+	Treehaven Court	WU	2372	2015	2017	2	3.9
KCALANCA31	H+	12th Street West	WU	2588	2015	2017	2	5.6
KCALANCA14	H+	J West @ 30 St	WU	2343	2008	2017	9	5.7
1058B	ALERT	Palmdale W.D.	LADPW	2595	2006	2017	11	9.4
1247	ALERT	North Lancaster	LADPW	2310	2002	2017	15	11.6

Step 3: Calculate Precipitation for Durations of Interest and find the Return Frequency

TABLE 2: RAIN GAGE PEAK RAINFALLS (inches)

Gage ID	Approximate Distance From Watershed Center (miles)	Peak 15-min Precipitation (inches)	Peak 30-min Precipiation (inches)	Peak 60-min Precipitation (inches)
KCAPALMD43	1	0.78	1.53	2.41
KCAQUART3	1.8	0.68	1.03	1.29
1245	2.4	0.63	1.05	1.44
AU414	2.8	0.35	0.61	1.04
KCAPALMD21	3.3	0.44	0.73	0.88
KCADELSU2	3.9	0.22	0.43	0.69
KCALANCA31	5.6	0.21	0.42	0.56
KCALANCA14	5.7	0.36	0.54	0.74
1058B	9.4	0.37	0.54	0.73
1247	11.6	0.23	0.27	0.33

TABLE 6: NOAA 14 RETURN FREQUENCIES

Gage	Approximate Distance From Watershed Center	Peak 15-min RF (NOAA 14)	Peak 30-min RF (NOAA 14)	Peak 60-min RF (NOAA 14)
KCAPALMD43	1	548	1000+	1000+
KCAQUART3	1.8	640	1000	465
1245	2.4	579	1000+	1000+
AU414	2.8	24	72	220
KCAPALMD21	3.3	38	86	40
KCADELSU2	3.9	5	17	30
KCALANCA31	5.6	4	13	10
KCALANCA14	5.7	38	50	45
1058B	9.4	22	25	22
1247	11.6	6	4	2

Step 4: Identify Nearby Radar Stations

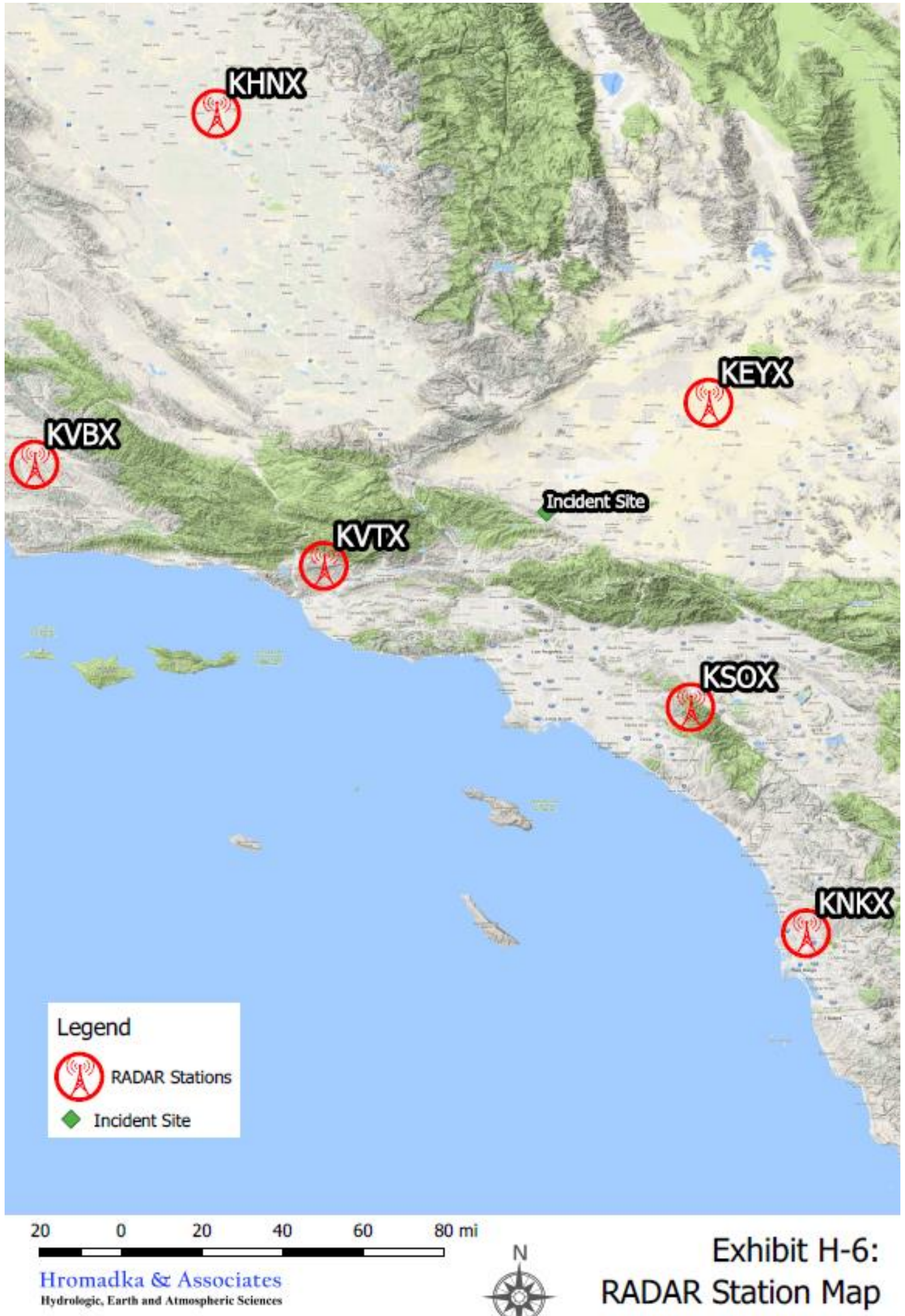


Exhibit H-6:
RADAR Station Map

Step 5: Qualitatively Analyze Radar Data

Note that, in this case, the radar measured precipitation is more intense over the watershed than at any of the rain gages.

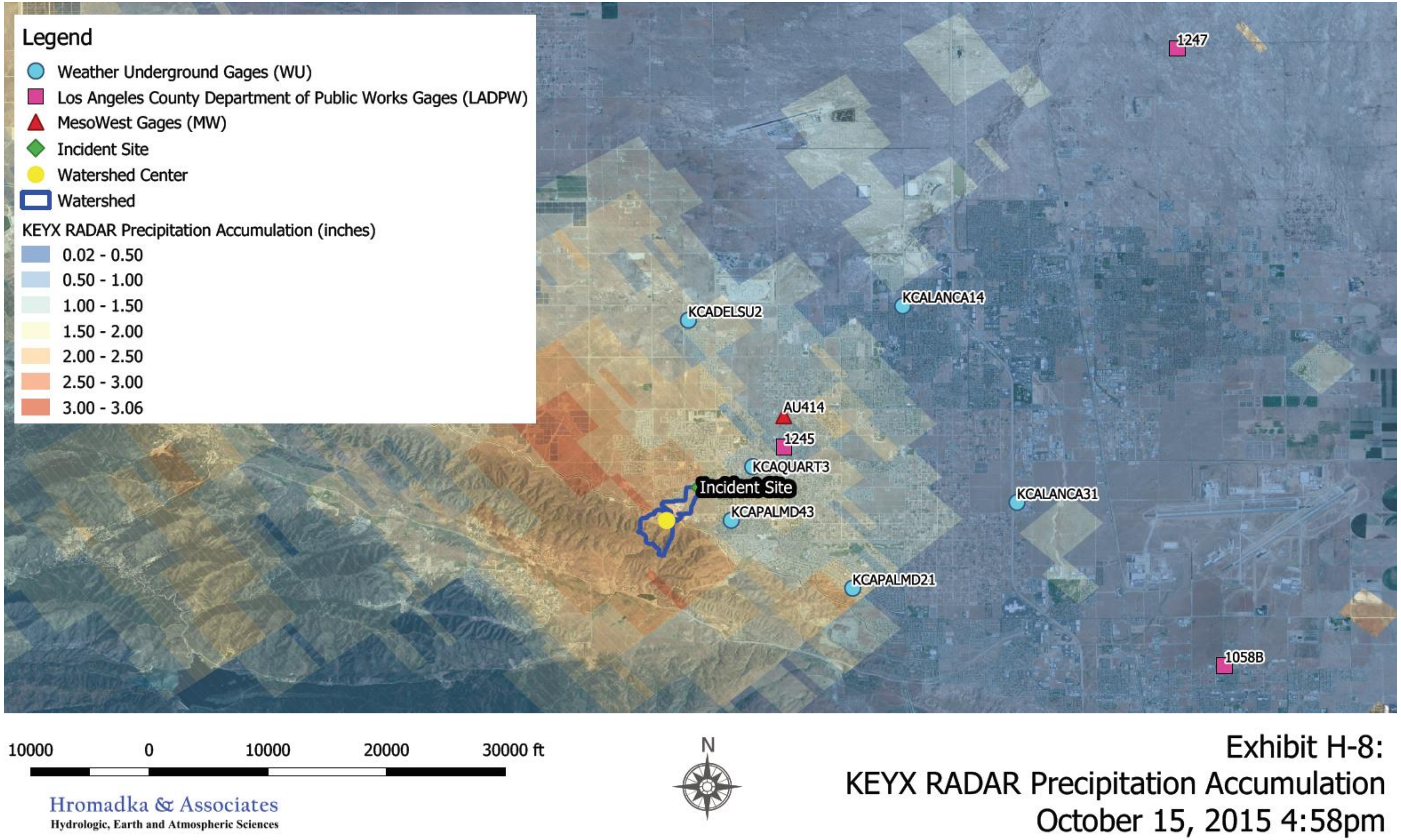


Exhibit H-8:
KEYX RADAR Precipitation Accumulation
October 15, 2015 4:58pm

Step 6: Ground-truth the Radar Data

TABLE 3: RADAR COMPARISONS

	c-value	residual*	shift (minutes)	distance from radar to Watershed Center (miles)	radar station elevation* (feet, MSL)	max interference height^^ (feet, MSL)	relative interference ^	Reasoning
KEYX	1.3	103.2	+10	50	2757	3088	331	Second Best Choice- higher residual than KSOX - closest to site - lowest relative interference
KVTX	1.1	89.5	+15	55	2726	4758	2032	Third Best Choice- residual and relative interference invetween KSOX and KEYX
KSOX	0.9	21	+10	70	3027	6986	3959	Best Choice - lowest residual - lowest c-value - better relative interference
KVBX	1.1	44.8	+15	125	1233	6000	4767	Low residual - highest timing shift - high relative interference - 55 miles further from site than KSOX
KHNX	1.1	61.2	+10	140	243	6600	6357	Site is located at maximum radar range - high residual - high relative interference
KNKX	1.1	114	+10	140	955	6660	5705	Site is located at maximum radar range - highest residual - high relative interference

* residual calculated as sum differences sqaured on intervals with rain gage data greater than zero

^relative interference is the difference between radar station elevation and the maximum interference height

^^max interference height is the height of the tallest object between the radar and watershed center

Step 7: Quantitatively Assess Radar Data and Determine the Return Frequency

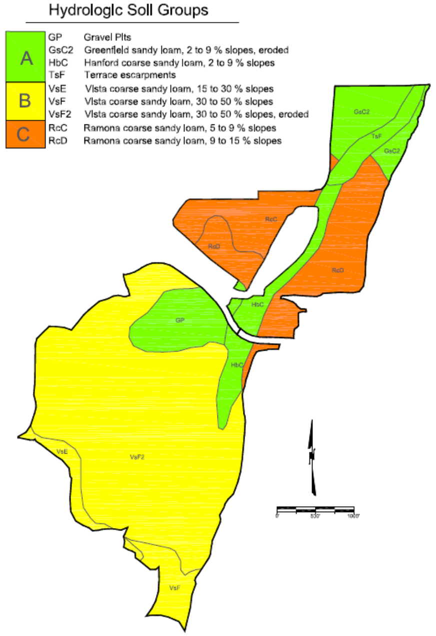
TABLE 4: RADAR PEAK RAINFALLS (INCHES)

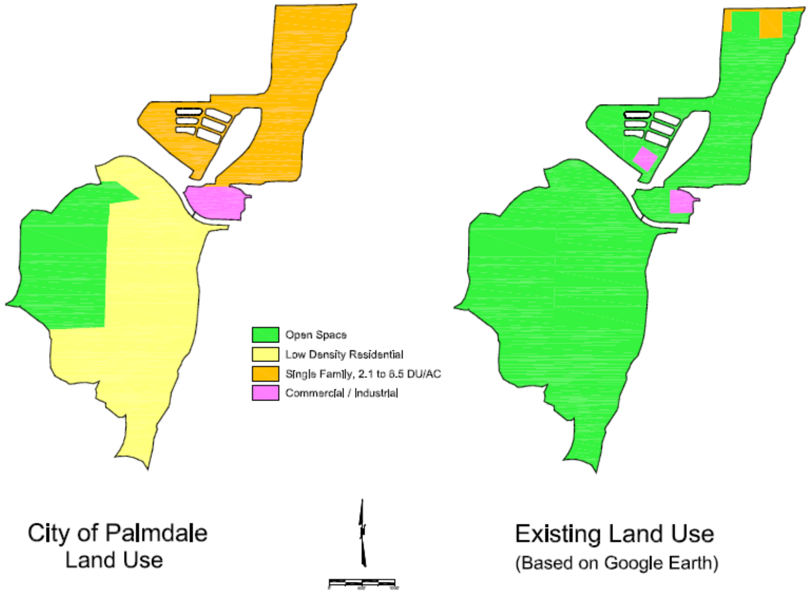
Gage ID	Peak 15-min Precipitation (inches)	Peak 30-min Precipitation (inches)	Peak 60-min Precipitation (inches)
KSOX (watershed)	1.04	1.75	2.51
KEYX (watershed)	1.11	1.98	2.59
KVTX (watershed)	1.09	1.77	2.60

TABLE 7: RADAR RETURN FREQUENCIES (NOAA 14)

Gage ID	Peak 15-min RF (NOAA 14)	Peak 30-min RF (NOAA 14)	Peak 60-min RF (NOAA 14)
KSOX (watershed)	1000+	1000+	1000+
KEYX (watershed)	1000+	1000+	1000+
KVTX (watershed)	1000+	1000+	1000+

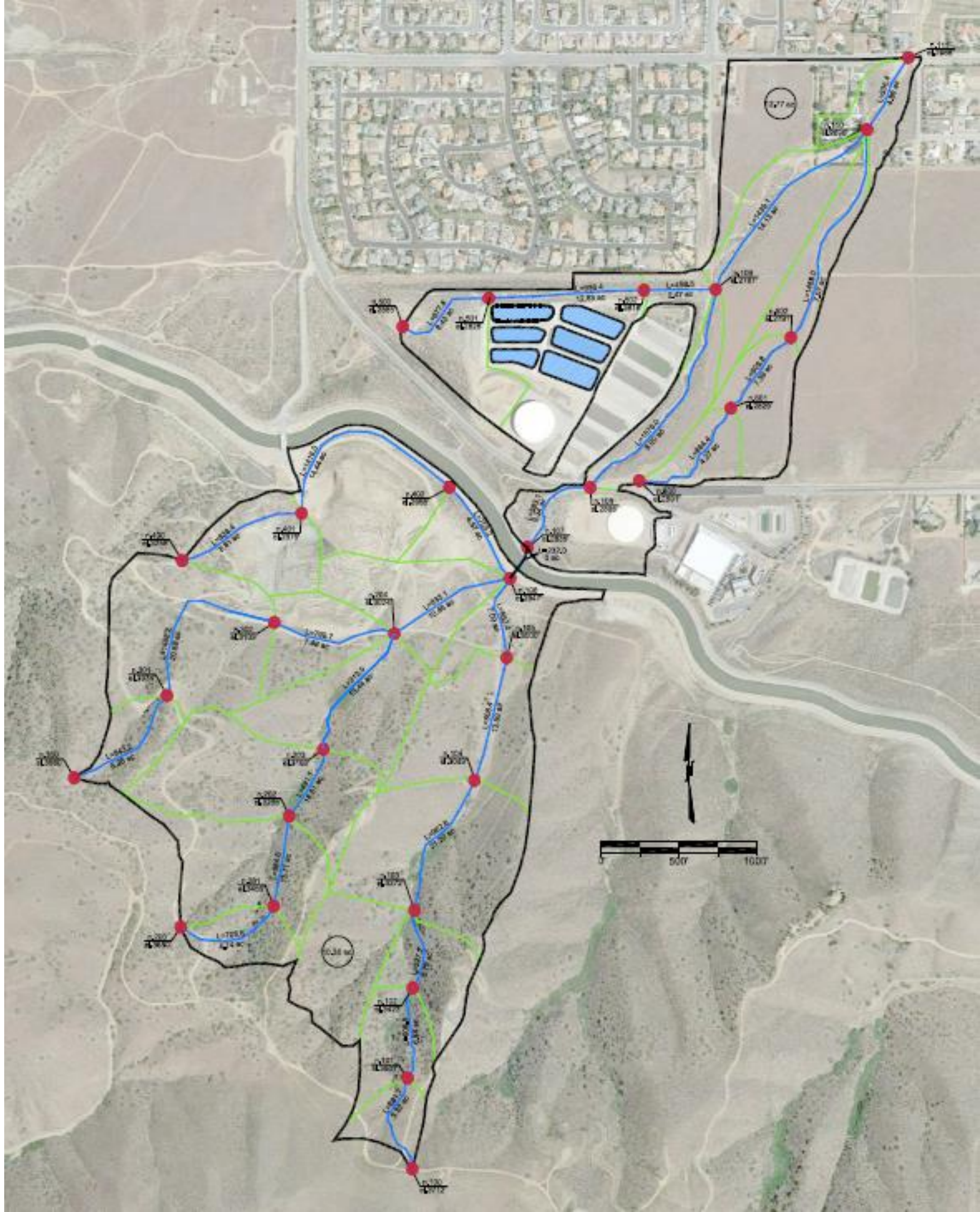
Step 8: Build a Rational Method Model



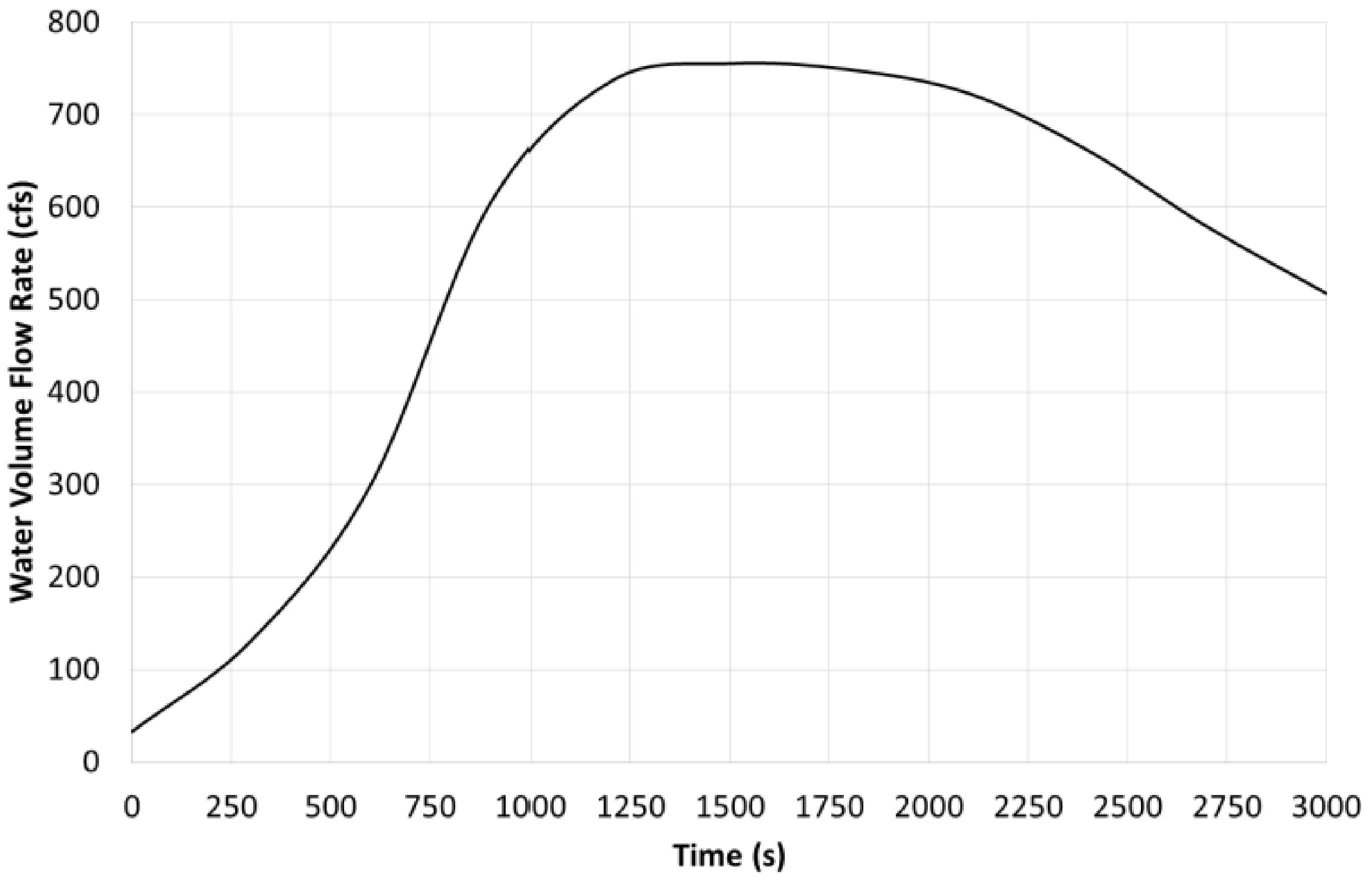


City of Palmdale Land Use

Existing Land Use (Based on Google Earth)

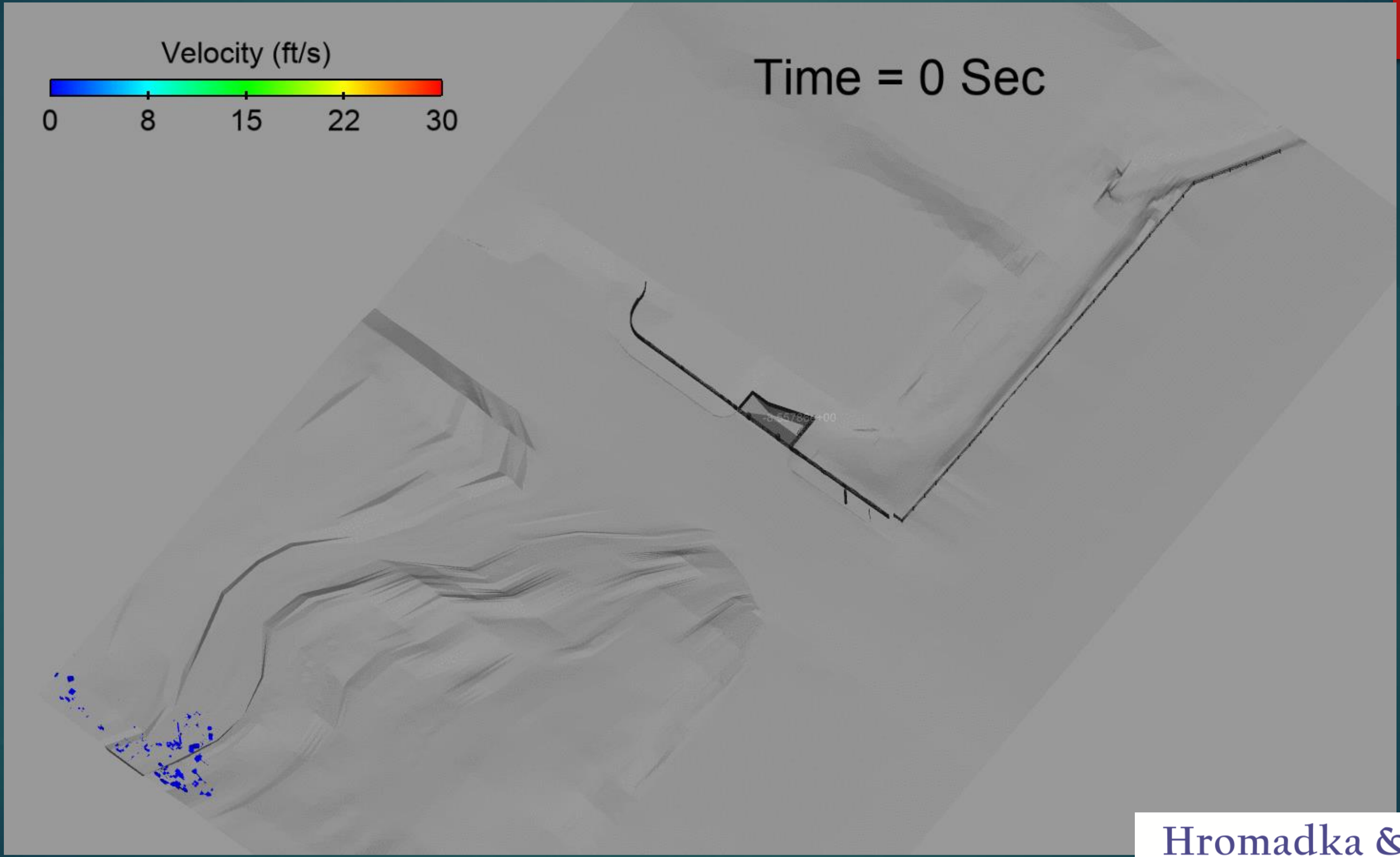


Step 9: Using the Results of the Rational Method, Build and Calibrate a Unit Hydrograph Model. The Output of the Unit Hydrograph Model is a Flow Hydrograph of Volume Flow Rate over Time. This is the Input to the CFD Analysis Described in the Next Presentation



Baseline Results

Animation: Water interface colored by Velocity



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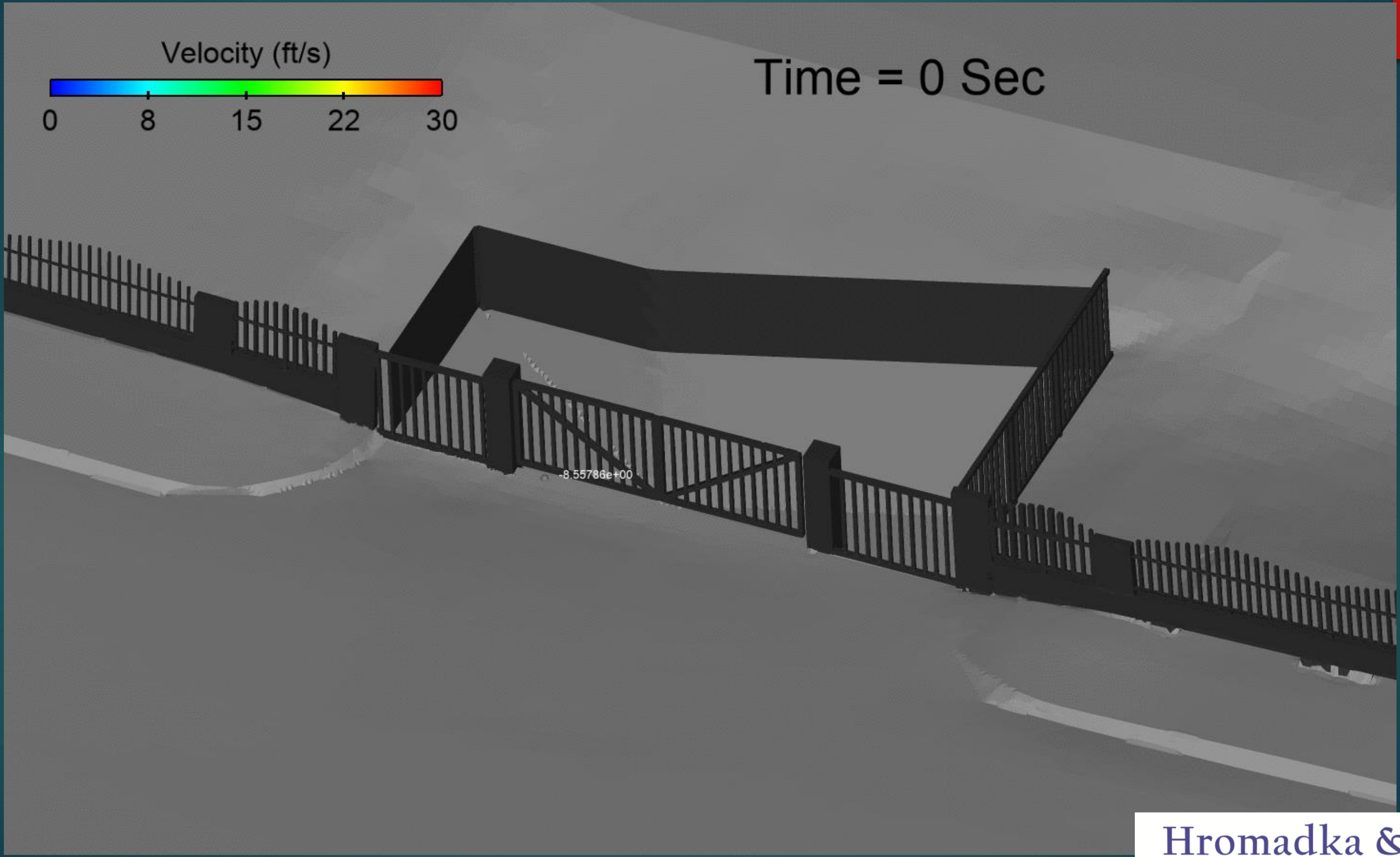
Baseline Results

Animation: Water interface colored by Velocity



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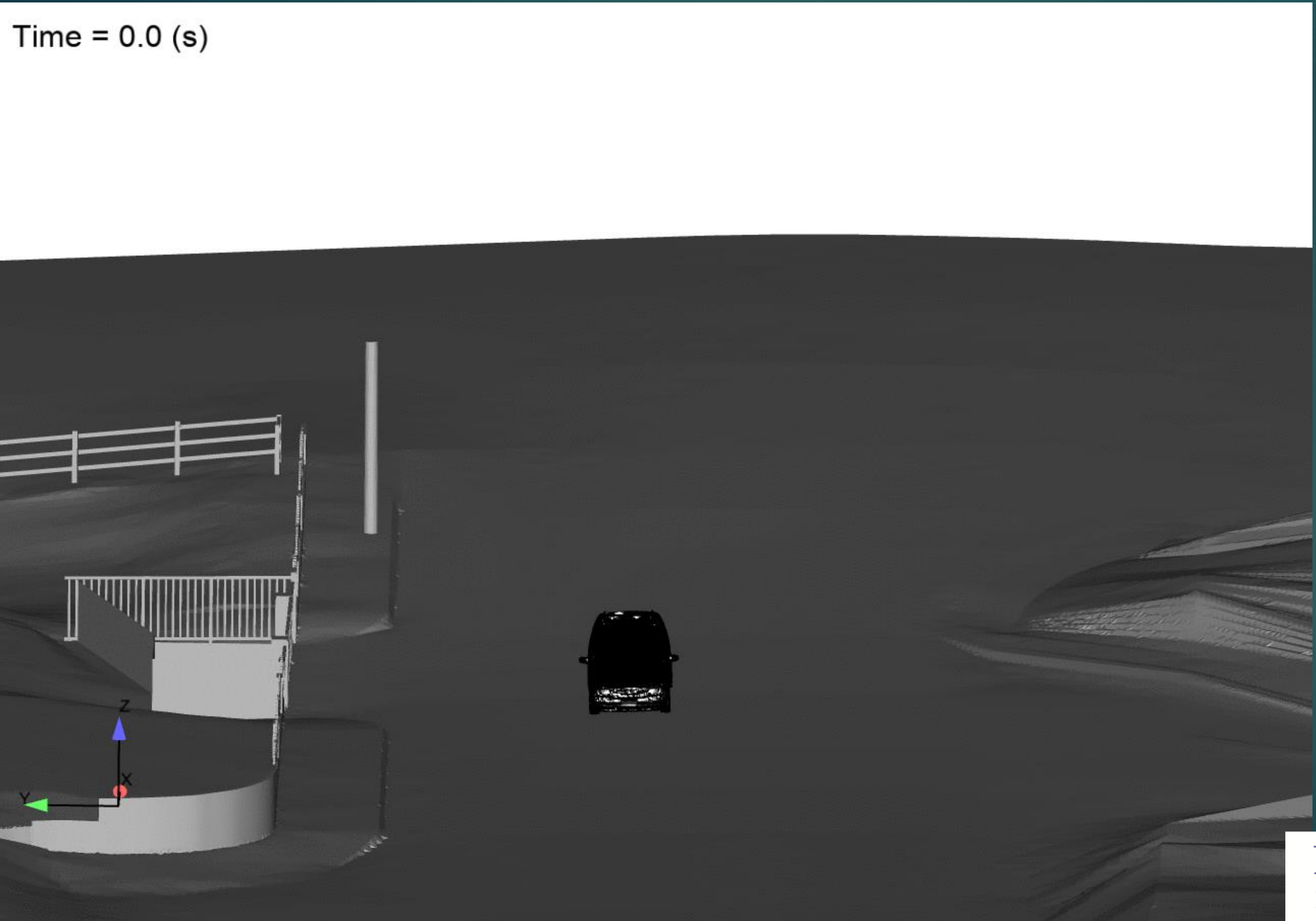
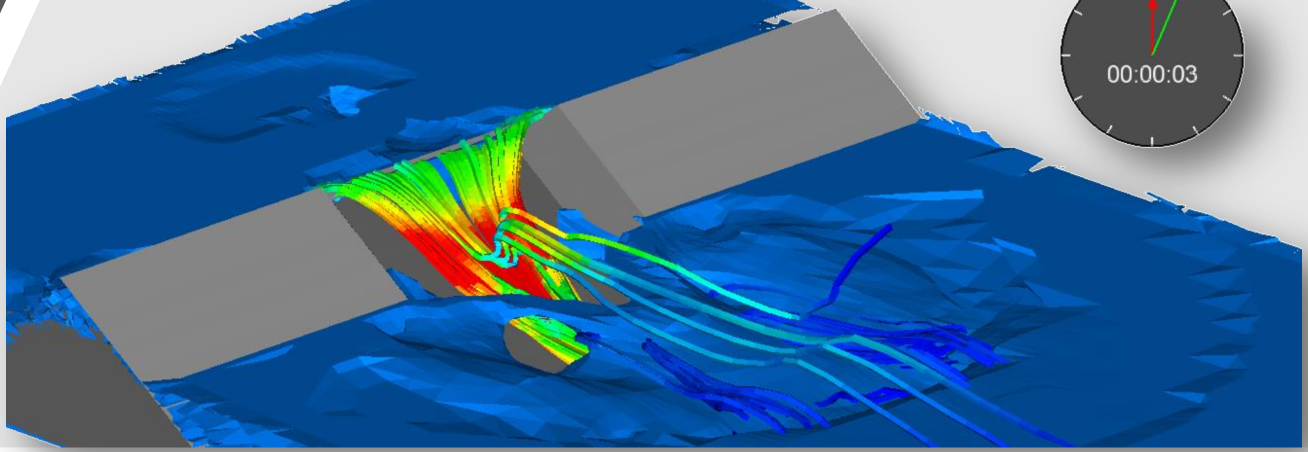
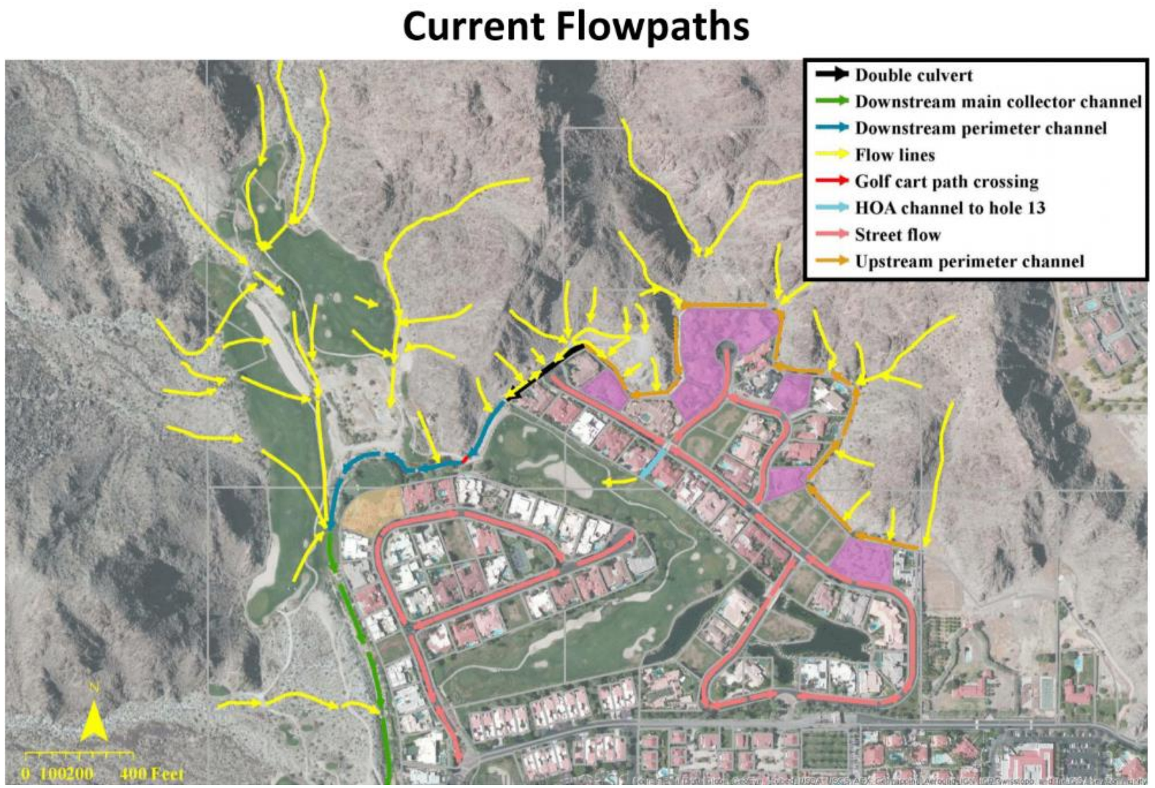
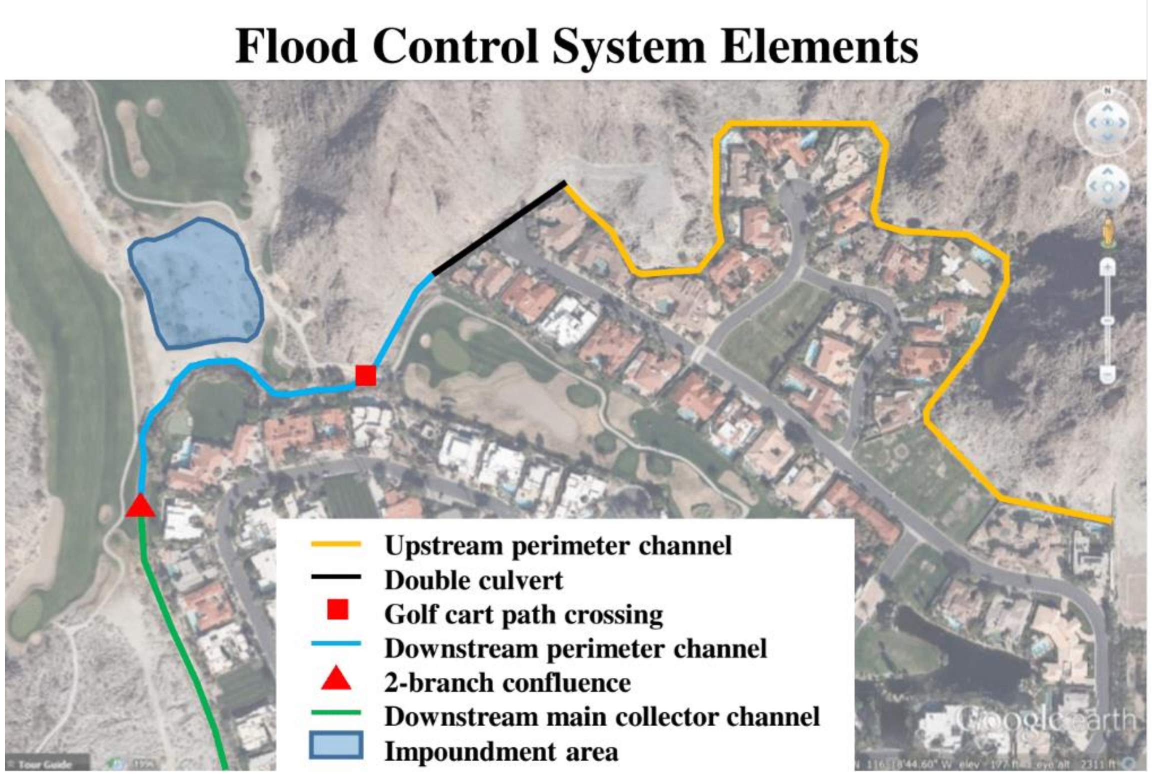
Baseline with Vehicle
Animation: Water interface





Impoundment Breach and Flooding: Physical and Computational Modelling

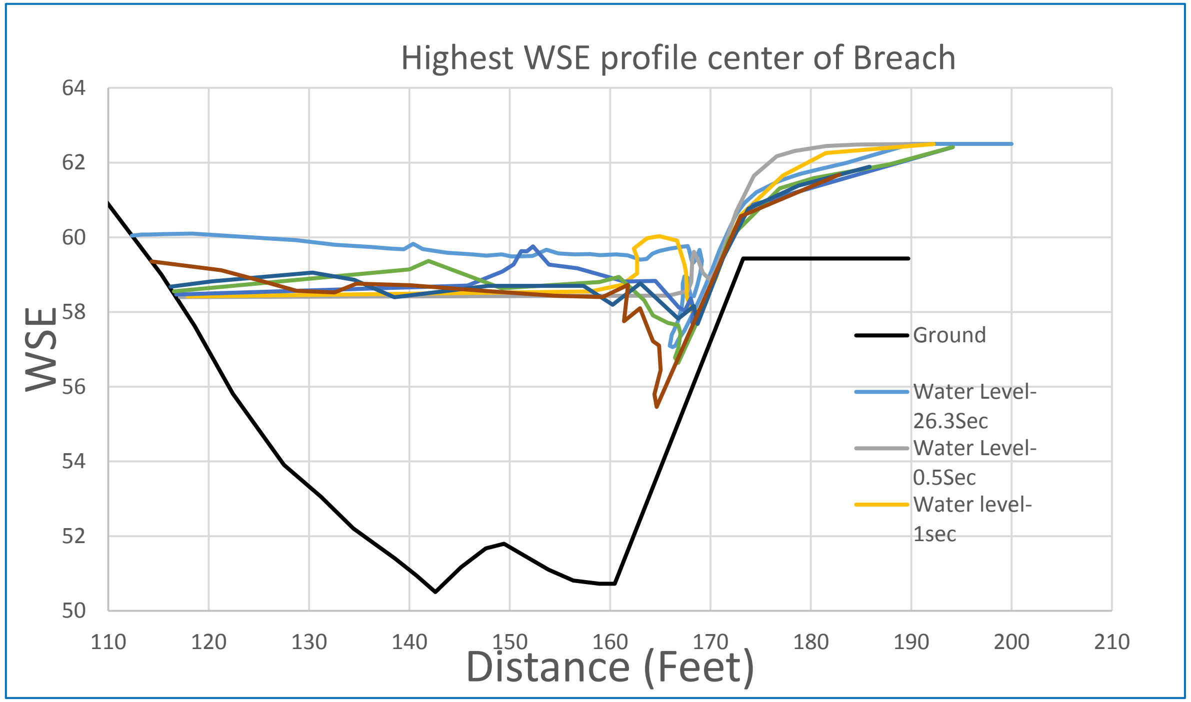


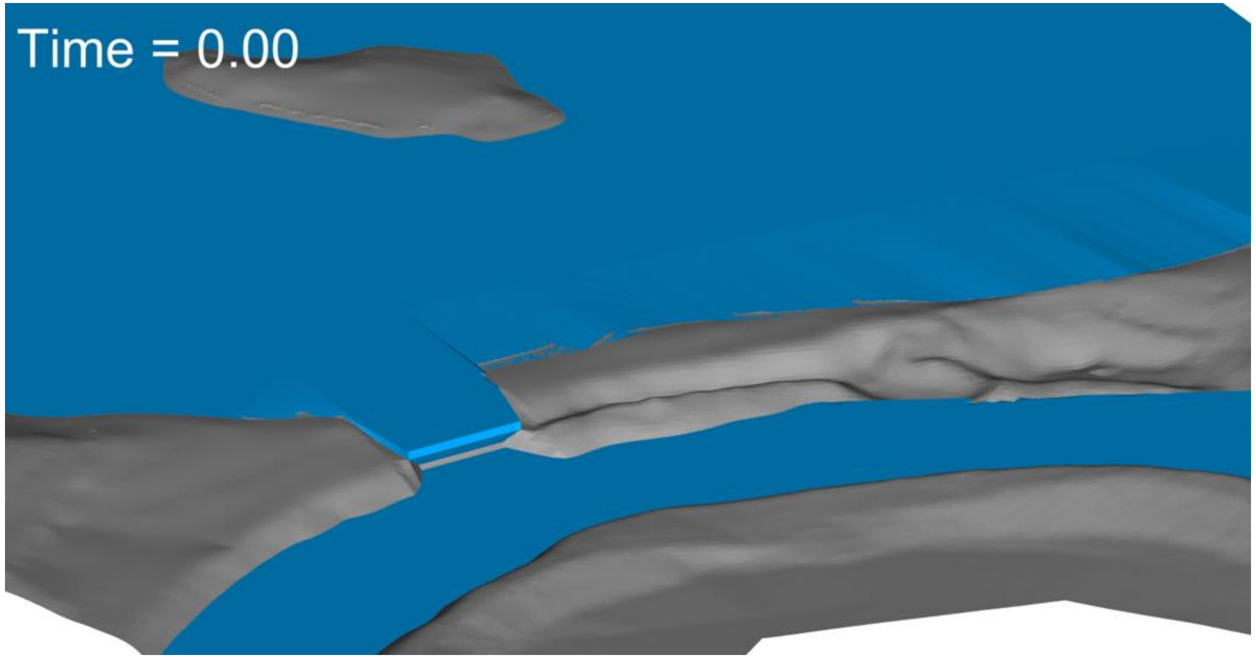


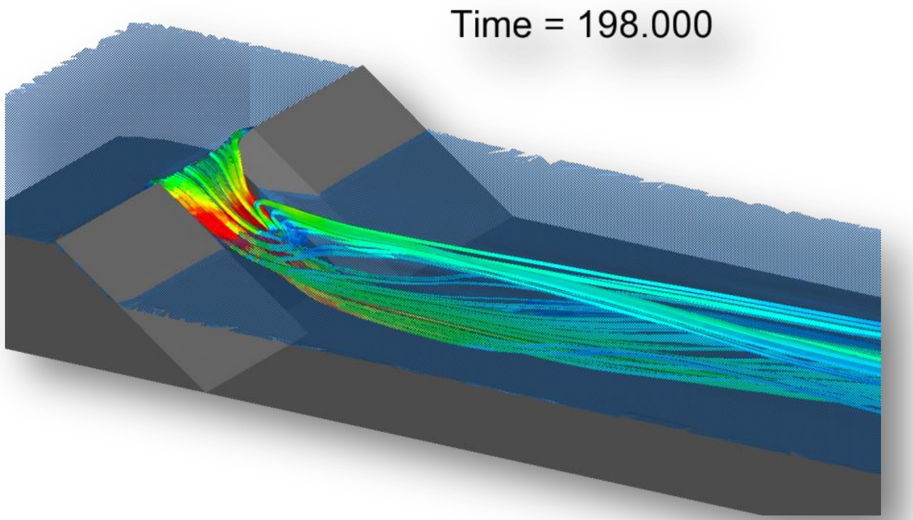
Impoundment Breach and Flooding: Overview

Breach and Flooding: Physical Mock-Up

Breach and Flooding: Physical Mock-Up Videos

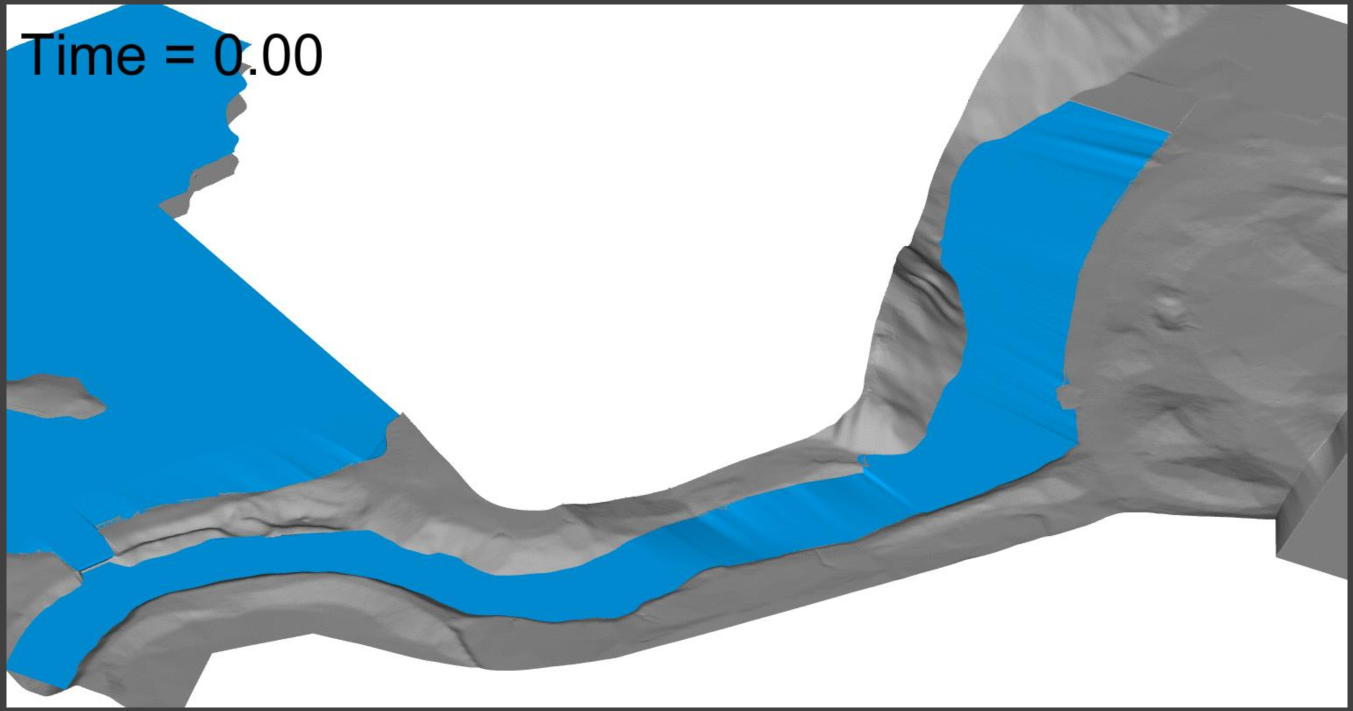






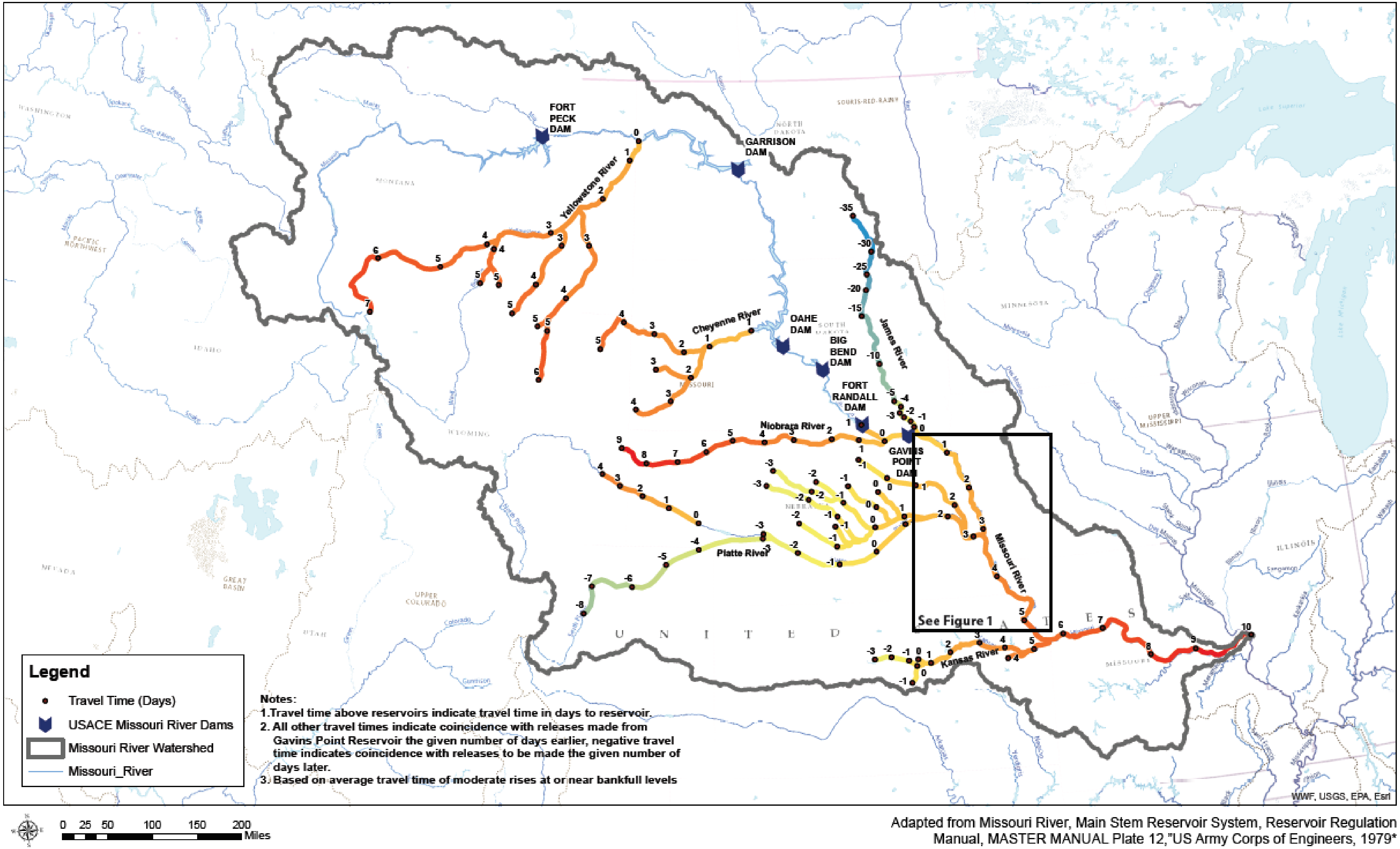
Breach and Flooding: Computational Fluid Dynamics

Breach and Flooding: Computational Fluid Dynamics



Case Example: Missouri River

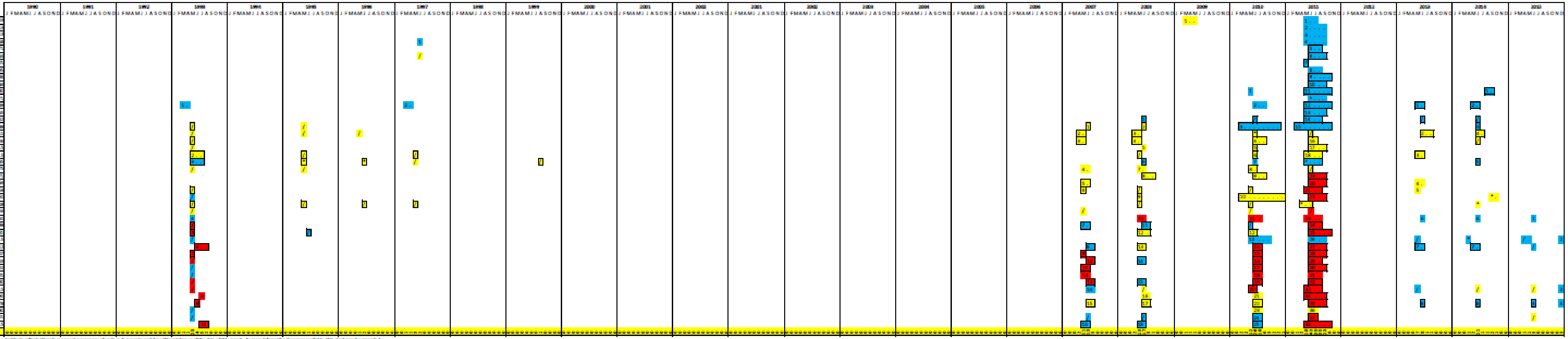
Missouri River Flooding



Adapted from Missouri River, Main Stem Reservoir System, Reservoir Regulation Manual, MASTER MANUAL Plate 12,"US Army Corps of Engineers, 1979*

INCIDENT CHART

ID	Region	Plaintiff Name	RM
187	1	Hogue	1020
203	1	Masset	1018
225-226	1	Moritz	1018
87	1	Kelley	1008
48	1	Andersen	771
81	1	Dailey	758
4A	2	Andersen	725
287	2	Omaha Tribe	695
89	2	Tobin (Tob-Isle)	690
7	2	Archer	690
213	2	Olson	690
82	2	Brainard	671
150	2	Jackson/Blodgett	669
50	2	Conneely	660
290-295	2	Salter	662
409	2	Shaner/Neale	638
28	2	Adkins	611
1488	2	Huss	608
2808	2	Roth	598.5
409	2	Sieck	597.5
265	3	Sargent	585
281	3	Roth	575
78	3	Kittleman	571
159	3	Johnson/KMJ Farms	566
255	3	Payne	558
870	3	Wollenrath	550
289	3	Schemmel	548
11	3	Barnes	548
186	4	Larson	540
94-95	4	Bardt	539
118	4	Griffin	530
85	4	Fossil	529.5
166	4	Kleiber	513
71-74	4	Drewes	507
58-59	4	Cunningham	508
22	4	Binder	502
267	4	Saunders	505
57	4	Cunningham Farms	500
111	5	Green	490.5
183	5	Luce	490
804-805	5	Schneider	479
283	5	Rouse	480
89	5	Frakes	425
131	5	Hildebrandt	408.5
TOTALS			Total



Incidents reflected herein represent a summary of various documents and depositions taken as of the date of this report. As more information becomes available, this chart may be amended.

Overland flooding without levee breach
Levee Breach flooding
Seepage/Blocked Drainage
Insurance Claim

- * no duration given
- * no timing given
- / no duration or timing

DOWNSTREAM OF GAVINS POINT DAM

total # of cells (# of months * all)	13440
# of filled cells	391
% of time with damage	2.9%

1993

	TIMING & DURATION	Reference	DEPTH	Reference
1	one week in late Mar/early Apr	Depo 87:9, 87:20	6-6 ft	Depo 87:16
2	2-6 weeks; most of the summer was wet	Depo 162:9, 162:11		
3	May through July, 6-7 weeks	Depo 75:14		
4	few days; no timing; flooded from Honey Creek	Depo 52:4		
5	1-2 weeks; no timing	Depo 91:15	5-6 ft	Depo 90:7
6	60-90 days; began in June; due to 2 levee breaches	Depo 61:11, 64:12		
7	~3 weeks; no timing	Interrogatories		
8	one month later in the year; no timing	Depo 158:11		
9	mid-July; no duration	Depo 148:8		
10	private and federal levees breached; no duration	Depo 25:10		

1997

	TIMING & DURATION	Reference	DEPTH	Reference
1	couple weeks - no timing	Depo 181:22		
2	one week in late march/early april	Depo 87:10, 89:11	6-6 ft	Depo 89:12-18

2007

	TIMING & DURATION	Reference	DEPTH	Reference
1	1-2 Weeks mid-June	Depo 86:2, 87:3		
2	seep water came up in Apr or May	Depo 73:4, 77:5		
3	2 weeks in early spring, May or June	Depo 57:19,22 58:16		
4	4-6 weeks; similar to 2008	Interrogatories		
5	Couple weeks May-June	Interrogatories		
6	2 weeks; no timing	Depo 80:11		
7	May 8 - June; blocked drainage	Depo 78:9, 78:7, 79:9	1 foot	Depo 80:10
8	June 30-60 days	Depo 68: 1-4, 69:4		
9	2-6 weeks; two levee breaches	Depo 82:7, 85:18	1 in - 5 ft	Depo 84:5
10	8 weeks in June; two levee breaches - one north, one south	Interrogatories	1 foot	Interrogatories
11	one week in May	Depo 65:11	6-6 ft	Depo 74:1
12	couple of weeks; out of house May 5-18	Depo 58:18	5 ft	Depo 59:16
13	one month	Interrogatories	1.5 ft	Interrogatories
14	one week to one month starting in June	Depo 85:15, 86:6		
15	2-6 weeks starting in June	Depo 64:24, 75:15	6-6 ft	Depo 79:25
16	one week to one month starting in May	Depo 44:8,50:16	6 or 5 ft	Depo 44:18

2008

	TIMING & DURATION	Reference	DEPTH	Reference
1	2-6 weeks probably in June	Depo 89:10, 91:10		
2	1-2 weeks mid-June	Depo 62:10, 63:20		
3	seep water came up in Apr or May	Depo 88:10		
4	2+ weeks in spring, May and June	Depo 65:12		
5	2-6 weeks mid-June	Depo 71:18		
6	couple weeks starting June 12	Depo 87:8, 87:12		
7	mid-late May through mid-late June	Depo 71:7	8 ft	Depo 73:18
8	mid-June to early Aug	Depo 94:18	6-12 in	Depo 97:11
9	one month; no timing	Depo 83:8		
10	couple weeks; May	Depo 108:8		
11	started early June; blocked drainage; overtopping from river	Depo 99:18, 99:25, 100:3		
12	two months - May to July	Interrogatories		
13	30-45 days; no timing	Depo 75:14		
14	one month beginning latter part of June	Interrogatories		
15	topping or breaches of levee	Interrogatories	2.5 ft	Interrogatories
16	2-6 weeks starting June	Depo 71:1, 78:20		
17	4-6 weeks starting in June	Depo 80:24,81:4		
18	one week to one month starting in May	Depo 56:18,57:7	5-6 ft	Depo 57:14

2009

	TIMING & DURATION	Reference	DEPTH	Reference
1	caused by ice jams	Depo 128:1		

2010

	TIMING & DURATION	Reference	DEPTH	Reference
1	1-2 weeks; no timing	Depo 68:15		
2	2-8 months starting end of June or first of July	Depo 93:3, 97:21	6-5 ft	Depo 93:12
3	property inundated 5-6 times Mar-Nov; 1-2 wks each time	Depo 44:14, 45:4, 48:23		
4	river high for 8 months starting June or July; not draining	Depo 70:22, 71:1	1 in - 8ft	Depo 77:8
5	2-8 weeks mid-June	Depo 80:18, 81:8		
6	8 weeks; peaked in June	Depo 150:20	2-8 ft	Depo 150:25
7	began around June 18; 1-8 weeks	Depo 87:8, 88:12		
8	late May or early June; less than 30 days	Depo 60:22		
9	mid-June to end of Aug	Depo 108:8	8-18 in	Depo 106:7
10	Mar 10 - May 29; June 3 - Dec 13	Depo 88:21-23, 88:24-25		
11	8 months May - July	Depo 112:3, 112:10	5-8 ft	Depo 121:18
12	one month - May to June	Interrogatories		
13	late May to early June; 20-30 days (Peeler)	Depo 28:11		
14	levee breach ~June 19 ; 8 months	Depo 187:7, 188:9	8-10 ft	Depo 148:10
15	Mid to late June; two levee breaches	Depo 111:8, 111:18, 112	1-2 ft	Depo 107:2
16	8 wks June to mid-July; multiple levee breaches	Depo 105:26	2 ft	Depo 105:26
17	couple of weeks in June	Depo 81:23, 84:23	6-8 ft	Depo 82:2
18	out of house June 13 - July 31	Depo 70:8	6-6 ft	Depo 69:25, 71:8
19	8 weeks from June to mid-July	Depo 105:26	2 ft	Depo 105:26
20	May 8th; 2-8 months	Depo 98:1, 101:8	17 ft	Depo 100:21
21	June and July; one month	Depo 87:23, 88:15		
22	4-6 weeks starting in June	Depo 88:1, 88:12	6-5 ft	Depo 87:1
23	60 days; dried out by July 6	Depo 64:8, 68:11		
24	60 days starting June	Depo 160:17,166:16		
25	private & federal levees overtopped; federal levee breached	Depo 68:4, 69:14, 70:8		

2011

	TIMING & DURATION	Reference	DEPTH	Reference
1	140+ days beginning late May or early June	Depo 80:23		
2	2-2.5 months; started to recede in Aug; wasn't gone until Sept	Depo 68:18	1-2 ft	Depo 67:3
3	Memorial Day through approximately Labor Day	Depo 52:1	5 ft	Depo 54:18
4	100 days from Memorial Day until after Labor Day	Depo 118:38		
5	approximatey three months - June through August	Depo 107:12		
6	June through Sept	Depo 66:24	5-8 ft	Depo 72:8
7	approximatey three months - June through August	Depo 107:12		
8	90 days beginning early June	Depo 50:25	12-18 in	Depo 67:19
9	110 days from June 7 through Oct	Depo 97:14	5 ft	Depo 105:9
10	100+ days mid-June through mid-Sept	Depo 109:9-14		
11	started late-May or June 1st through late Sept or early Oct	Depo 77:8-15	2 ft	Depo 69:14
12	mid-May through Oct 1	Depo 113:14, 118:18, 1		
13	100 days; Memorial Day until Sept 2	Depo 98:1, 98:8, 99:18	81 inches	Depo 100:8
14	100+ days starting late May	Depo 97:24	12-15 ft	Depo 98:19
15	Mar through Oct	Depo 83:14, 84:19		
16	river ran high 90+ days; ok until early June rains	Depo 79:11, 79:17, 80:23		
17	100+ days, during June and July	Depo 67:20, 108:5	8+ ft, 10-12 ft	Depo 67:24, 68:8
18	110 days all summer	Depo 109:10		
19	seep began June 10; levee breach June 28; receded late Sept	Depo 107:8, 114:8	6 ft	Depo 118:17
20	100 days; June-Sept	Depo 78:13-15, 78:1,8		
21	early May for 100+ days	Depo 97:1-4		
22	8 levee breaches; June 3, 6, & 18	Depo 58, 95:11-12, 104		
23	most of the summer; approximatly 3 months, June-August	Depo 188:16	8-10 ft	Depo 198:8
24	blocked drainage June 8th; levee breach mid-June; 90 days	Depo 186:25, 185:8, 187		
25	levee breach June 28; to Sept or Oct	Depo 91:11-13, 87:15	5 ft	Depo 90:7
26	100+ days	Interrogatories	2-8 ft	Depo 67:2
27	100+ days June - Sept	Depo 81:5-10		
28	100+ days; 2 levee breaches; mid/late June to mid/late Sept	Depo 117 : 22, 118 : 20,	2-8 ft	Depo 119 : 16
29	8+ months	Interrogatories	8 ft	Interrogatories
30	8+ months starting in June	Depo 99 : 19	6-8 ft	Depo 98 : 15
31	June 1 - Aug 1	Depo 82 : 6	7 ft 8 in	Depo 93 : 10
32	flooding	Interrogatories	8.5 ft	Interrogatories
33	May 6 until Aug	Depo 108:15		
34	seepage in late May or early June; levee breached ~June 20	Depo 99 :1, 99 : 8		
35	levee overtop June 27 to Sept; 8 breaches (7/1, 7/13-15, Aug)	Depo 95 :18, 95:18, 96:2		
36	90-100 days; through end of Aug or Sept; ~8 months	Depo 78:23, 79:2,6,19-22	8ft	Depo 91:23
37	8 breaches; lasted 100+ days	Depo 178:19, 183:1	6-10ft	Depo 18:21
38	late May through late Sept or Oct	Depo 80:22		

2013

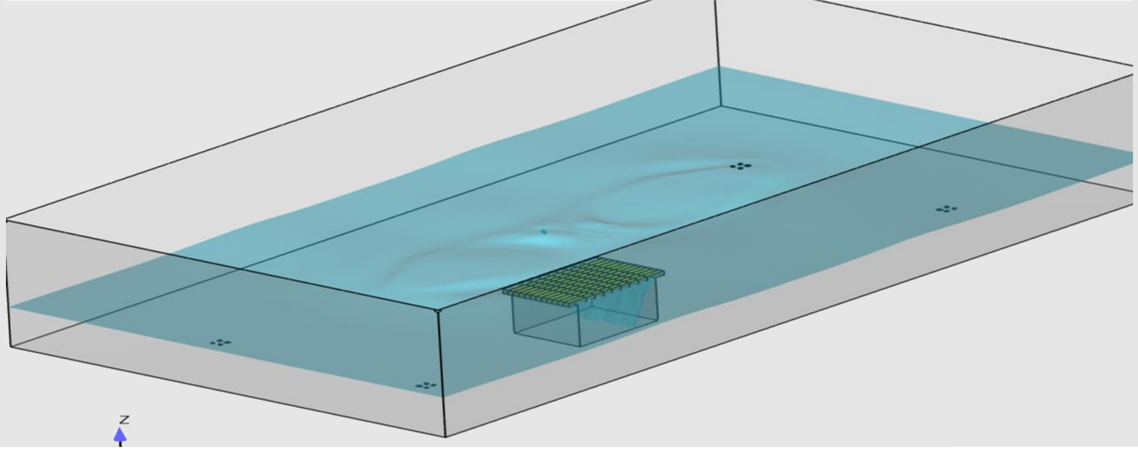
	TIMING & DURATION	Reference	DEPTH	Reference
1	couple weeks; May or June	Depo 141:14, 142:18	2 ft	Depo 143:17
2	ran high all year; seepage stayed through Aug; no duration	Depo 116:8		
3	8 weeks beginning in May	Depo 151: 20	2-8 ft	Depo 151:19
4	couple weeks May-June	Depo 121:6		
5	less than 2 weeks; no timing	Depo 120:19		
6	from Honey Creek; couple weeks in June	Depo 158:20, 156:11	5 ft	Depo 155:17
7	30-45 days in May or June	Depo 82:3-7, 85:9		
8	early June; 1-2 weeks	Depo 112:11		

2014

	TIMING & DURATION	Reference	DEPTH	Reference
1	4-6 weeks; Aug or early Sept	Depo 79:2-4, 80:2		
2	couple weeks; May or June	Depo 151:8, 151:7		
3	occurred 2-8 weeks after June 3rd	Depo 92:17, 98:12		
4	quick river rise in June or early July	Depo 116:22, 117:4		
5	1-2 weeks; Late June	Depo 92:26		
6	from Honey Creek; couple weeks in June	Depo 159:22, 160:11	5 ft	Depo 160:8
7	30-45 days in May or June	Depo 82:3, 85:9, 86:8-8		
8	early June; one week	Depo 112:11-20		

2014

	TIMING & DURATION	Reference	DEPTH	Reference
1	from Honey Creek; couple weeks in June	Depo 160:9-16, 161:1	5 ft	Depo 160:8
2	Dec; no duration	Depo 88:10		
3	December; no duration; rainfall	Depo 119:8		
4	mid-June for 7-10 days; Dec - no duration	Depo 120:20, 120:8	10 ft	Depo 118:1



Case Study: Small Scale Flow Modelling of Grate Inlet

Goal: Determine if the inlet grate capacity was the limiting factor in a storm drainage system, and thus the cause of flooding downstream onto plaintiff's property. CFD was used to measure Grate Capacity (cfs) as a function of water height

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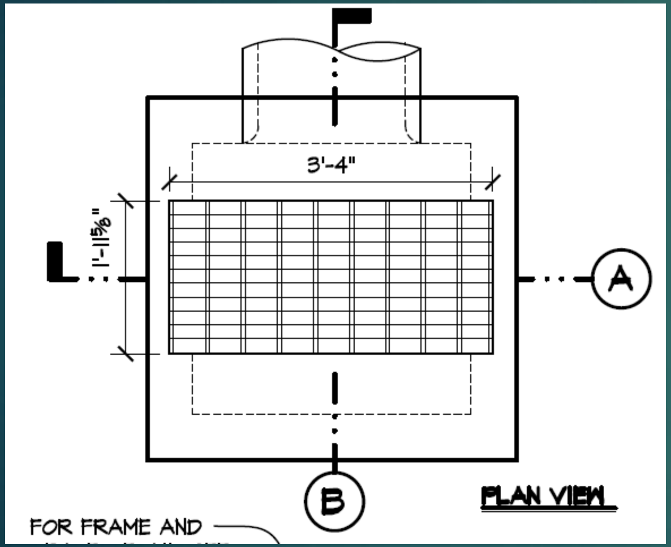
Geometry construction

- The CAD geometry was constructed based on:
  - Schematic drawing (grate Type)
  - Actual grate pictures from the site

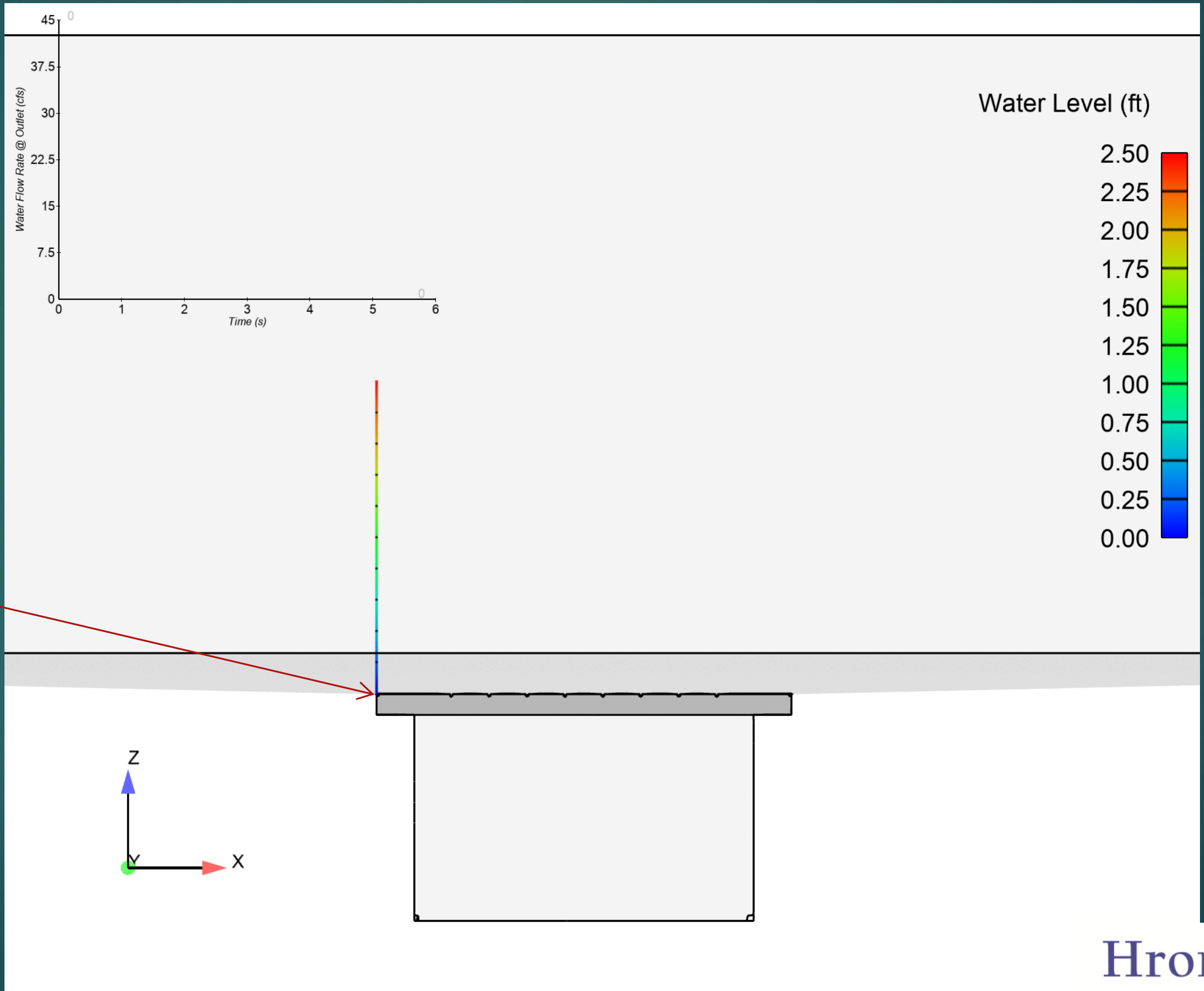


~2"

Results: Water interface colored by water level

Water flow rate through the Grate plot

0,0,0 reference point @ top surface of grate



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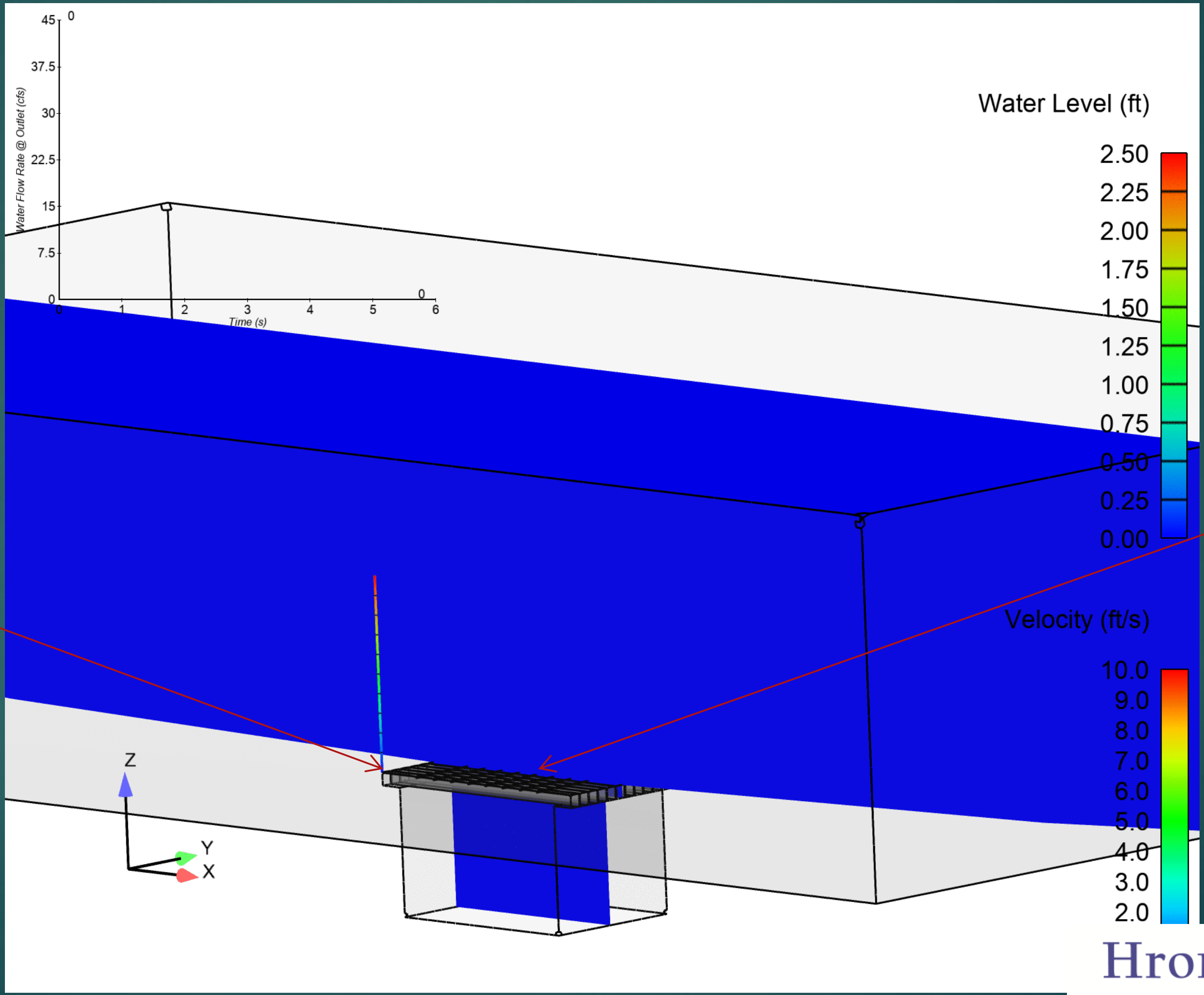
Results: Cut plane colored by water velocity

Water flow rate through the Grate plot

0,0,0 reference point @ top surface of grate



Water depth changes from : weir flow, through mixing flow to orifice flow

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Case Study: La Conchita Landslide

La Conchita Landslide

La Conchita Landslide

- January 10, 2005
- Prior 15-days had low intensity rainfall
- ~250-year return frequency at closest gage
- Previous slides at site examined
- Developed Rainfall Threshold

January 10, 2005 @ ~12:30 pm (click to play video)

Additional Case Examples: Dam and Levee Failures

Ka Loko Dam Failure

Fernley flood victims win $18.1M settlement from 2008 canal break

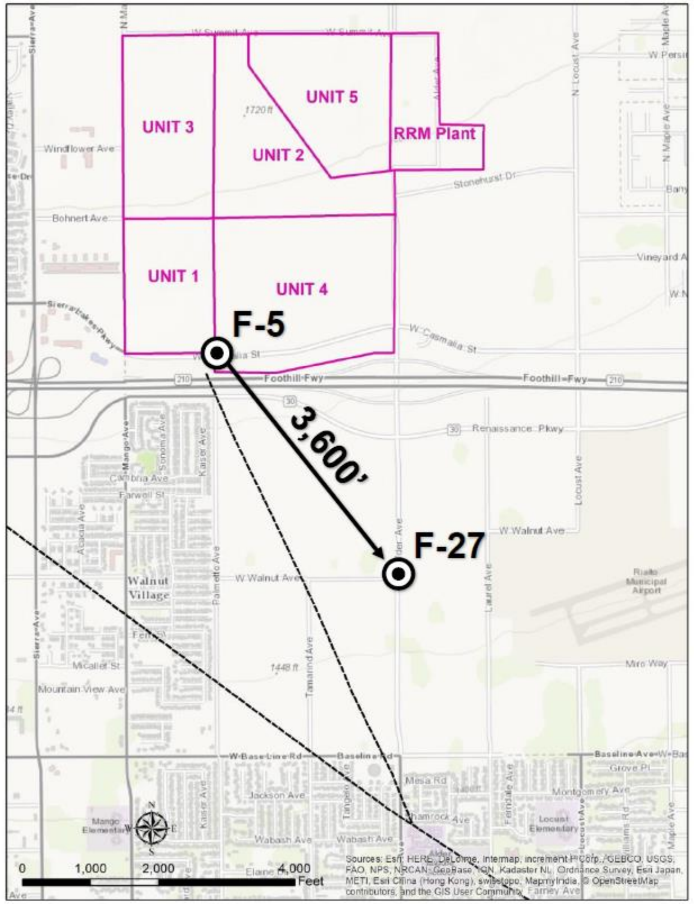
Levee Failure in Nevada

Mid-Valley Sanitary Landfill: Contaminant Transport in Groundwater

Groundwater Contamination

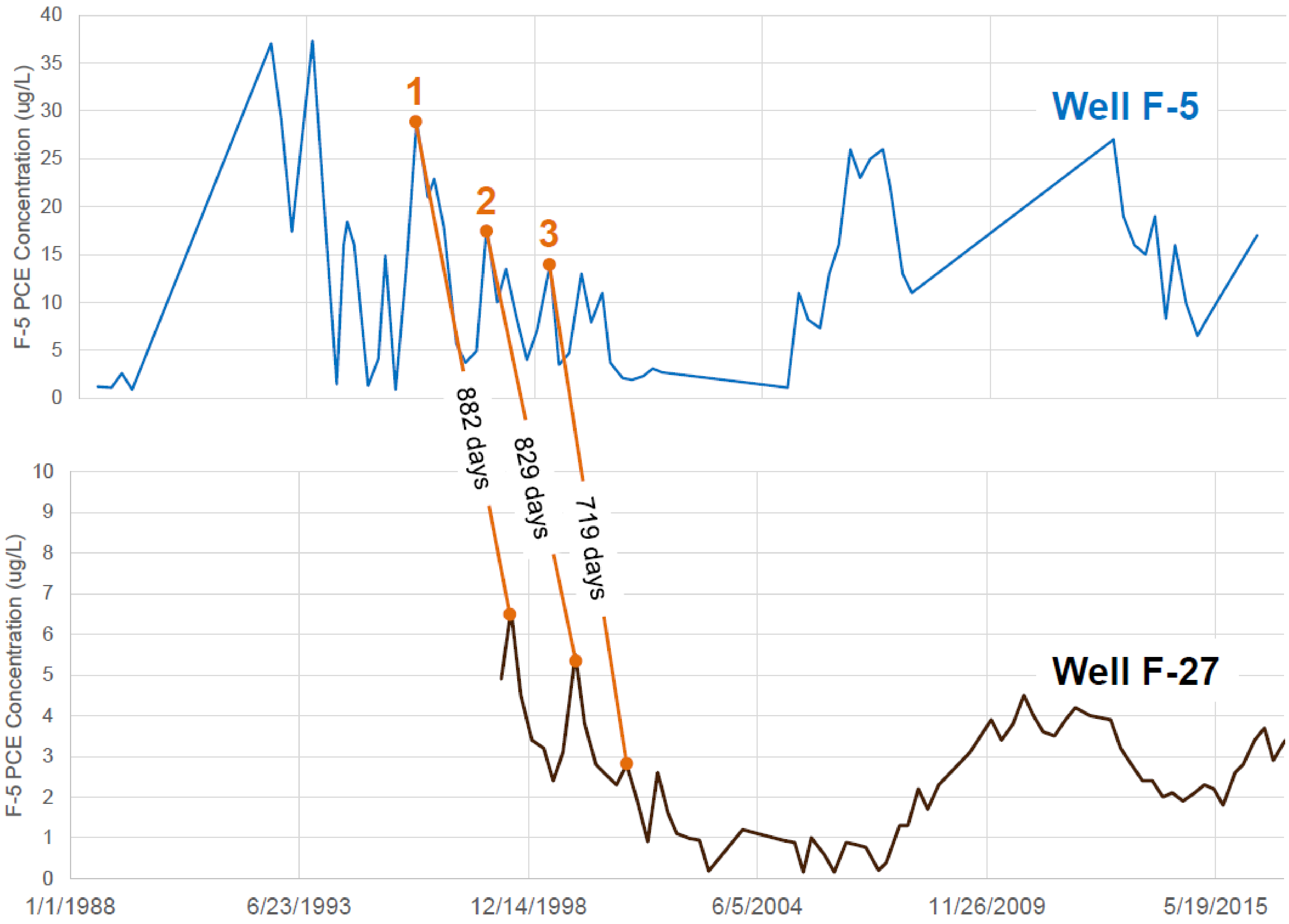
- At Issue:
  - How to determine the timing of a groundwater contamination event based on chemical readings at spatially separated wells
  - Convincing a jury that peak concentrations, even when shifted in time, represent the same underlying data

Calculating Travel Time Through the Saturated Zone



- Calculate travel time of PCE peaks between well pairs
- Back calculate PCE velocity given the known well distance between well pairs
- Distance between wells F-5 and F-27 is approximately 3,600 feet
- PCE travel time between F-5 and F-27 is between 719 and 882 days

Calculating Travel Time Through the Saturated Zone



PEPCON Explosion

Henderson, NV

Henderson, NV: PEPCON Explosion

- May 4, 1988
- Conflagration and several explosions occurred at the Pacific Engineering and Production Company of Nevada (PEPCON)
- Two (2) fatalities and 372 injuries, over $100 million in damages
- Damage radius of 10 miles

Henderson, NV: PEPCON Explosion

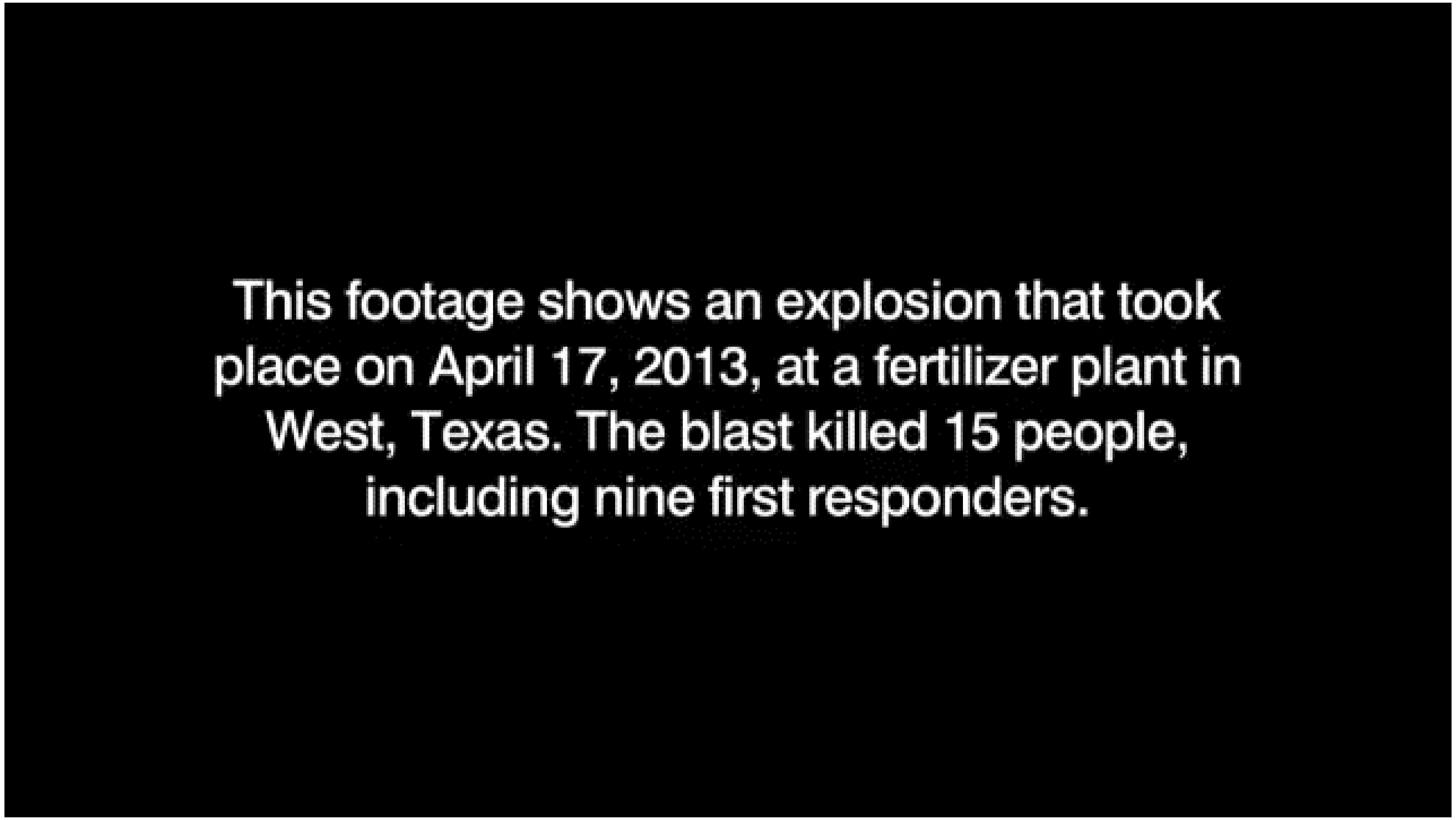
West, Texas Fertilizer Plant Explosion

City of West, Texas

City of West, Texas: Fertilizer Plant Explosion

- April 17, 2013
- Ammonium Nitrate explosion occurred at the West Fertilizer Company storage and distribution facility
- 15 fatalities, 160+ injuries, 150 buildings damaged or destroyed

West, Texas Fertilizer Plant Explosion



Case Study: Other Events

Amtrak Train Derailment (1997)– Kingman, AZ

Cedar Rapids Bridge Collapse and Flooding (2008)

Gillespie Dam Failure (1993)