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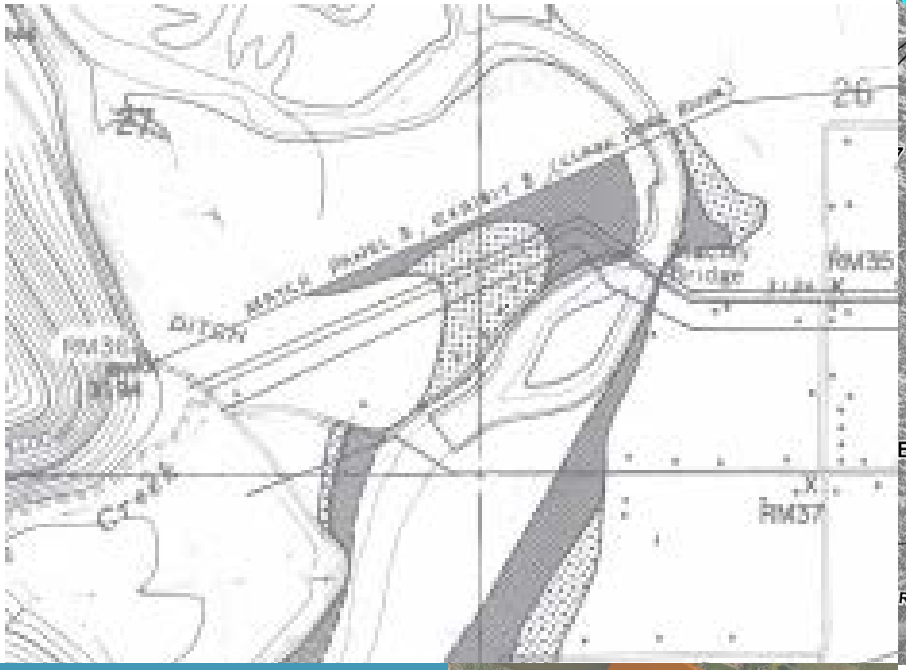

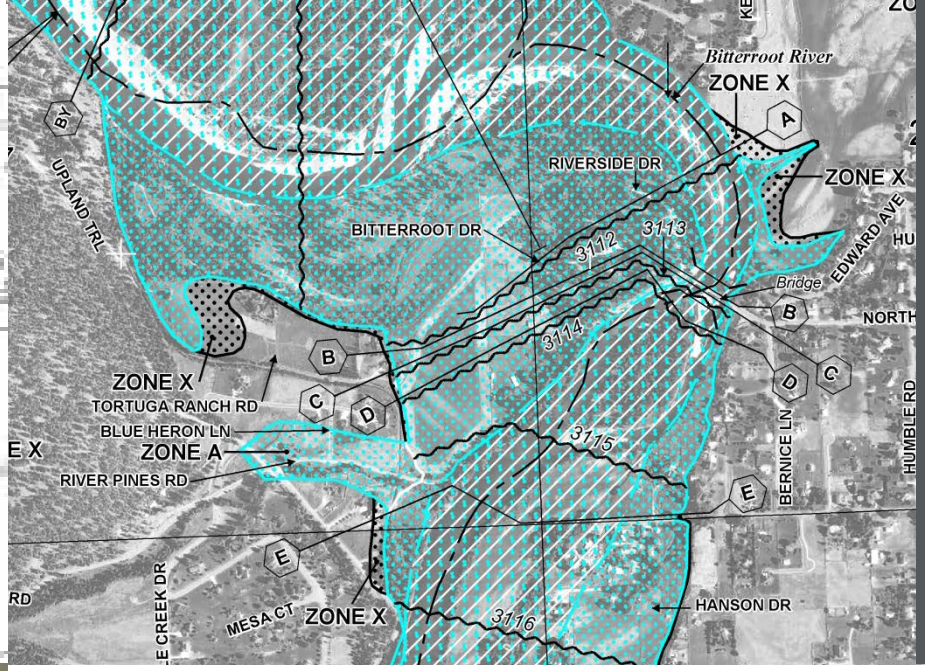

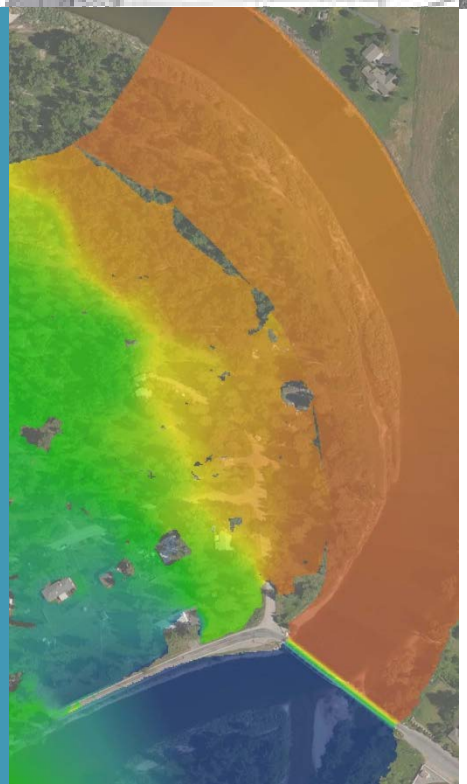

THE PROGRESSION OF MAP DECAY

A Product of Technological Advancement

Ben Fennelly, PE, CFM

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01 WHAT IS MAP DECAY?

02 WHY DOES IT MATTER?

03 EXAMPLES

04 Q&A

WHAT IS MAP DECAY?

- Association of State Floodplain Managers (ASFPM) defines map decay as the change in accuracy of flood insurance rate maps over time (Flood Mapping for the Nation, 2013)

FLOODPLAIN STUDIES ARE …

- Performed using best data <u>at that time</u>
- Analyzed with the best methods <u>at that time</u>
- Mapped to the highest accuracy <u>at that time</u>
- Conducted according to the highest standards <u>at that time</u>

WHY DOES MAP DECAY MATTER?

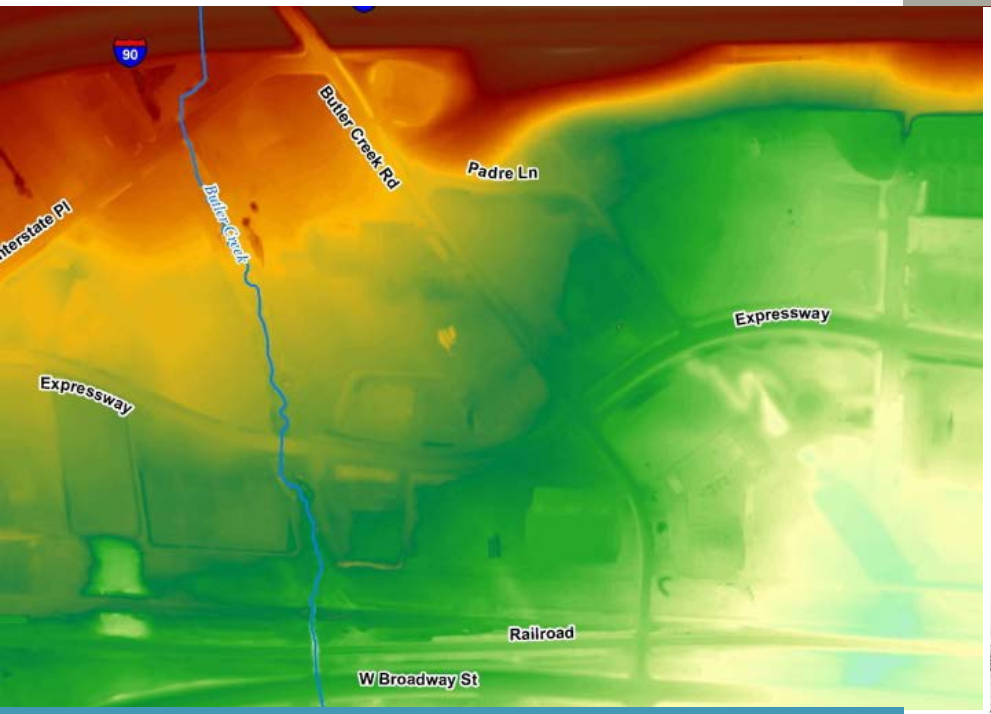
- Inaccurate Risk Assessment
- Ever Increasing Growth and Encroachment
- Battle of Costs
  - Maintenance
    - National: $116M - $275M (ASFPM, 2013)
  - Recovery
    - 2011 in MT:
      - » MDT infrastructure estimated at $36.8M (Missoulian, 2011)
      - » FEMA estimated > $53.4M (Missoulian, 2011)
- Highlight Mitigation Possibilities

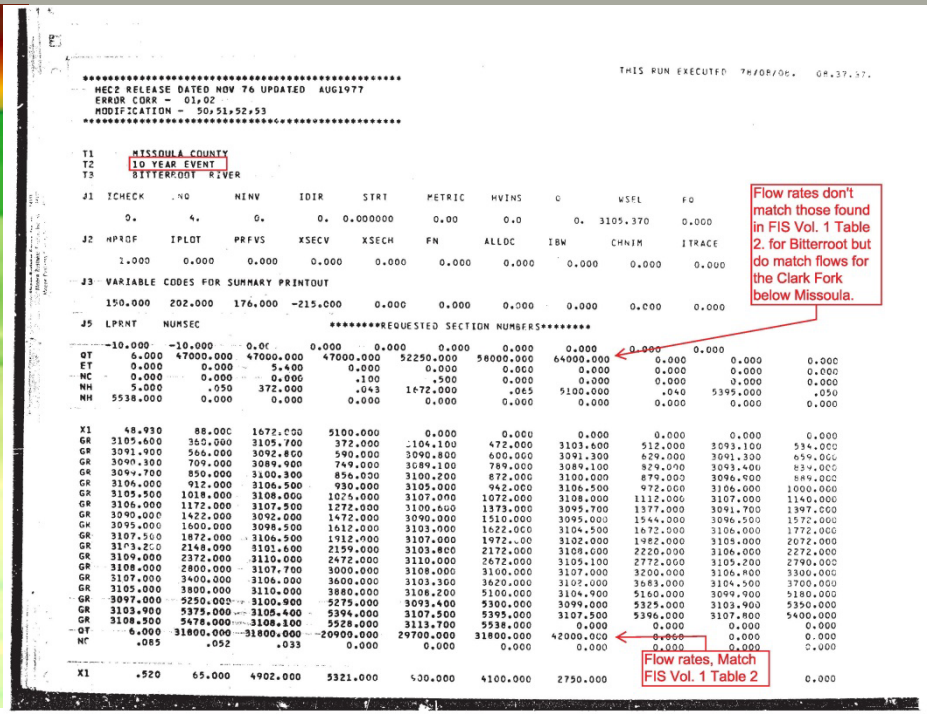
CAUSES OF MAP DECAY

- Age
  - Additional length to gage records
    - For example, events of 2011
  - Improvements to regression methods and estimates
- Changes in Growth and Development
  - Urbanization
  - Change To Controls

CAUSES OF MAP DECAY

- Improvements in Technology
  - Data collection
    - Survey (GPS)
    - Topographic survey





THIS RUN EXECUTED 7M/08/06. 08.37.57.

****
HEC2 RELEASE DATED NOV 76 UPDATED AUG1977
ERROR CORR - 01,02
MODIFICATION - 50,51,52,53
****

T1 MISSOULA COUNTY
T2 10 YEAR EVENT
T3 BITTERROOT RIVER

J1	ICHECK	NQ	NINV	IDIR	STRT	METRIC	HVINS	Q	WSEL	FQ
	0.	4.	0.	0.	0.000000	0.00	0.0	0.	3105.370	0.000

J2	NPROF	IPLOT	PRFVS	XSECV	XSECH	FN	ALLOC	IBW	CHNIM	ITRACE
	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

J3 VARIABLE CODES FOR SUMMARY PRINTOUT

150.000	202.000	176.000	-215.000	0.000	0.000	0.000	0.000	0.000	0.000

J5 LPRNT NUMSEC ********REQUESTED SECTION NUMBERS********

-10.000	-10.000	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
QT 6.000	47000.000	47000.000	47000.000	52250.000	58000.000	64000.000	0.000	0.000	0.000	
ET 0.000	0.000	5.400	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
NC 0.000	0.000	0.000	.100	.500	0.000	0.000	0.000	0.000	0.000	
NH 5.000	.050	372.000	.043	1672.000	.065	5100.000	.040	5395.000	.050	
NH 5538.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	

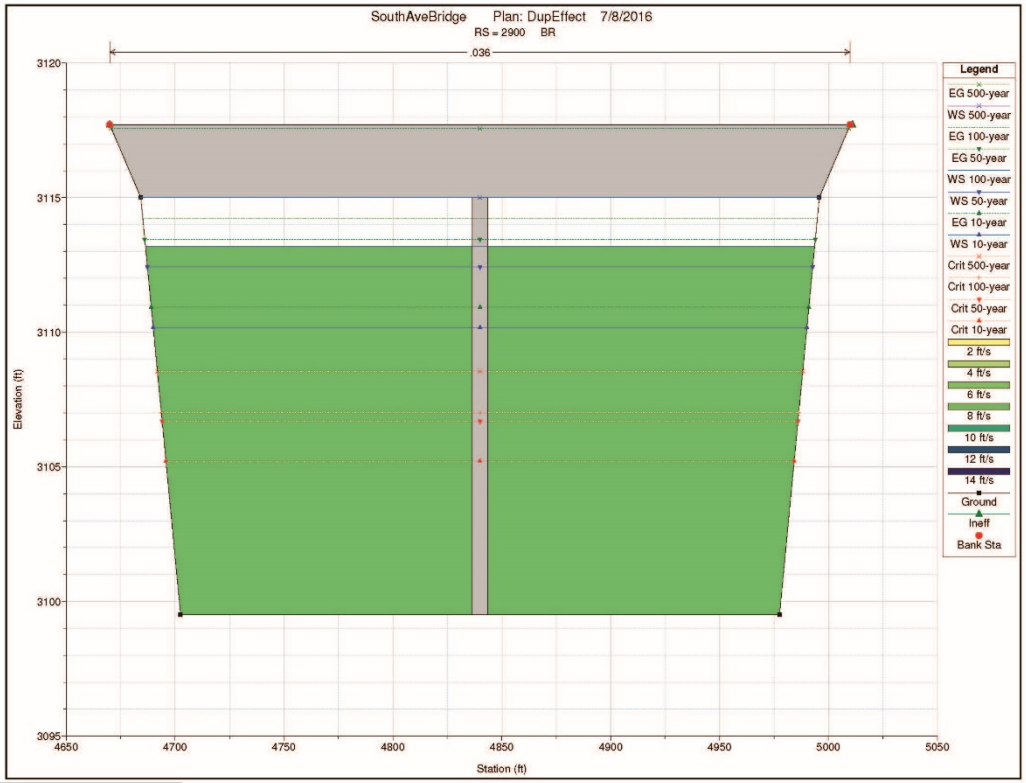
X1	48.930	88.000	1672.000	5100.000	0.000	0.000	0.000	0.000	0.000	0.000
GR	3105.600	360.000	3105.700	372.000	3104.100	472.000	3103.600	512.000	3093.100	534.000
GR	3091.900	566.000	3092.800	590.000	3090.800	600.000	3091.300	629.000	3091.300	659.000
GR	3090.300	709.000	3089.900	749.000	3089.100	789.000	3089.100	829.000	3093.400	839.000
GR	3094.700	850.000	3100.300	856.000	3100.200	872.000	3100.000	879.000	3096.900	889.000
GR	3106.000	912.000	3106.500	930.000	3105.000	942.000	3106.500	972.000	3106.000	1000.000
GR	3105.500	1018.000	3108.000	1025.000	3107.000	1072.000	3108.000	1112.000	3107.000	1140.000
GR	3106.000	1172.000	3107.500	1272.000	3100.600	1373.000	3095.700	1377.000	3091.700	1397.000
GR	3090.000	1422.000	3092.000	1472.000	3090.000	1510.000	3095.000	1544.000	3096.500	1572.000
GR	3095.000	1600.000	3098.500	1612.000	3103.000	1622.000	3104.500	1672.000	3106.000	1772.000
GR	3107.500	1872.000	3106.500	1912.000	3107.000	1972.00	3102.000	1982.000	3105.000	2072.000
GR	3103.200	2148.000	3101.600	2159.000	3103.800	2172.000	3108.000	2220.000	3106.000	2272.000
GR	3109.000	2372.000	3110.000	2472.000	3110.000	2672.000	3105.100	2772.000	3105.200	2790.000
GR	3108.000	2800.000	3107.700	3000.000	3108.000	3100.000	3107.000	3200.000	3106.800	3300.000
GR	3107.000	3400.000	3106.000	3600.000	3103.300	3620.000	3102.000	3683.000	3104.500	3700.000
GR	3105.000	3800.000	3110.000	3880.000	3108.200	5100.000	3104.900	5160.000	3099.900	5180.000
GR	3097.000	5250.000	3100.900	5275.000	3093.400	5300.000	3099.000	5325.000	3103.900	5350.000
GR	3103.900	5375.000	3105.400	5394.000	3107.500	5395.000	3107.500	5396.000	3107.800	5400.000
GR	3108.500	5478.000	3108.100	5528.000	3113.700	5538.000	0.000	0.000	0.000	0.000
QT	6.000	31800.000	31800.000	20900.000	29700.000	31800.000	42000.000	0.000	0.000	0.000
NC	.085	.052	.033	0.000	0.000	0.000	0.000	0.000	0.000	0.000
X1	.520	65.000	4902.000	5321.000	500.000	4100.000	2750.000			0.000

Flow rates don't match those found in FIS Vol. 1 Table 2. for Bitterroot but do match flows for the Clark Fork below Missoula.

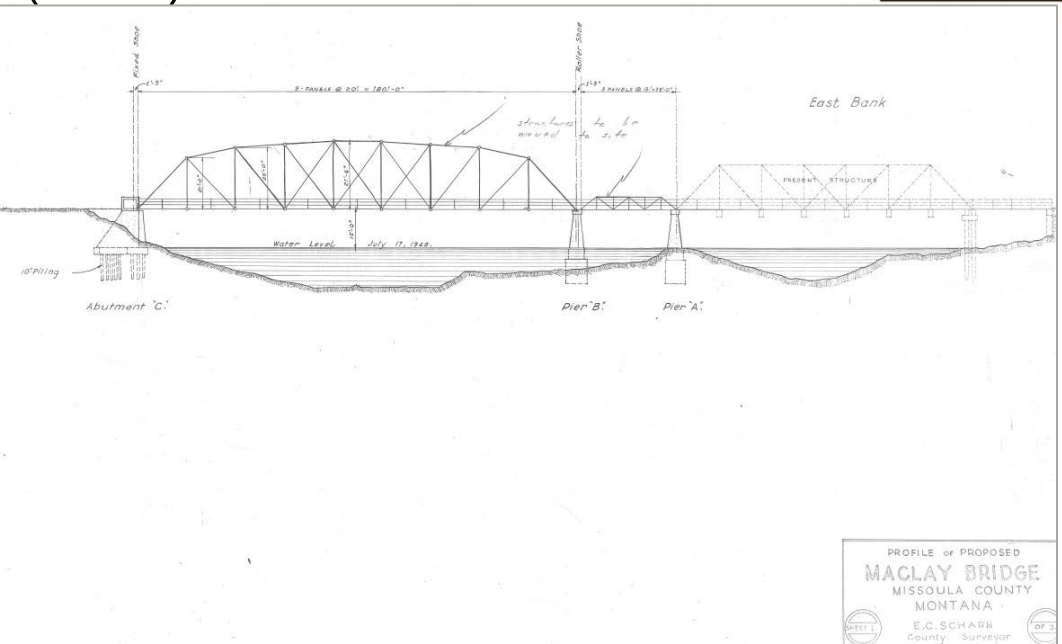
Flow rates, Match FIS Vol. 1 Table 2

CAUSES OF MAP DECAY

- Improvements in Technology
  - Calculation methods
    - Improvements in efficiency
    - Multi-dimensional analysis



Example: Maclay Bridge (HEC-2)



CAUSES OF MAP DECAY

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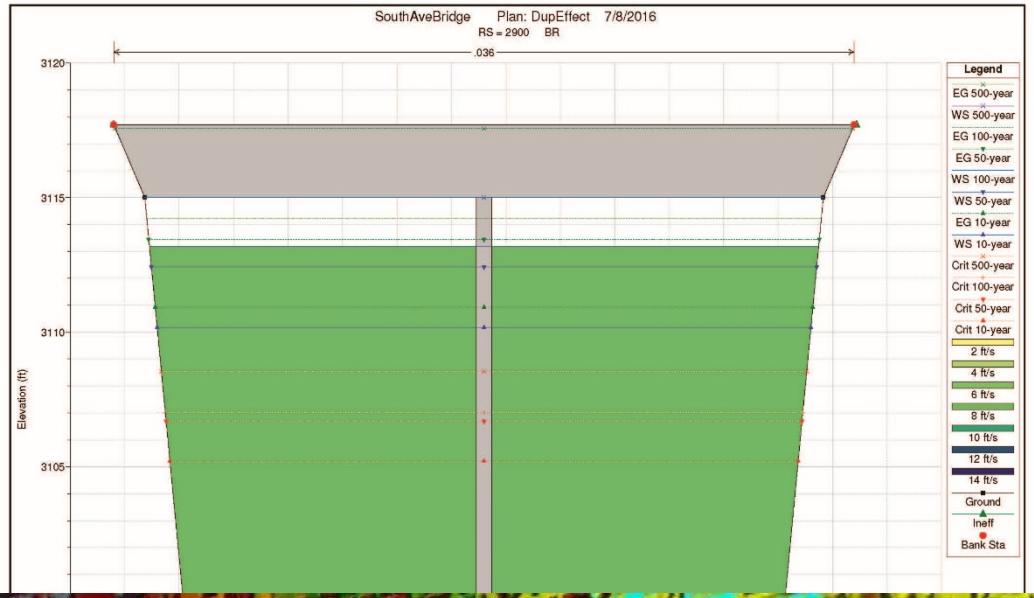
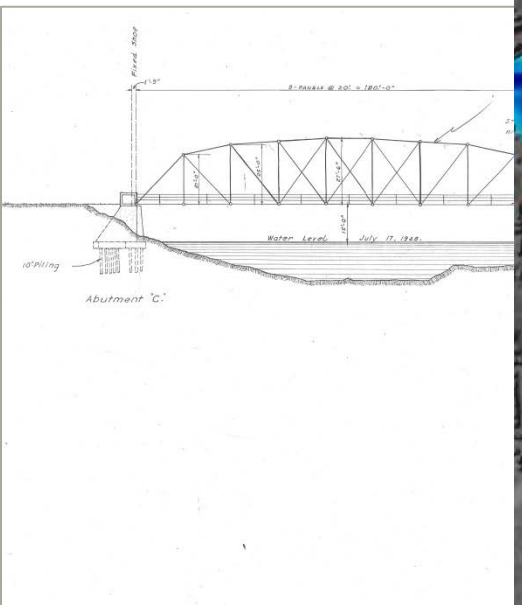
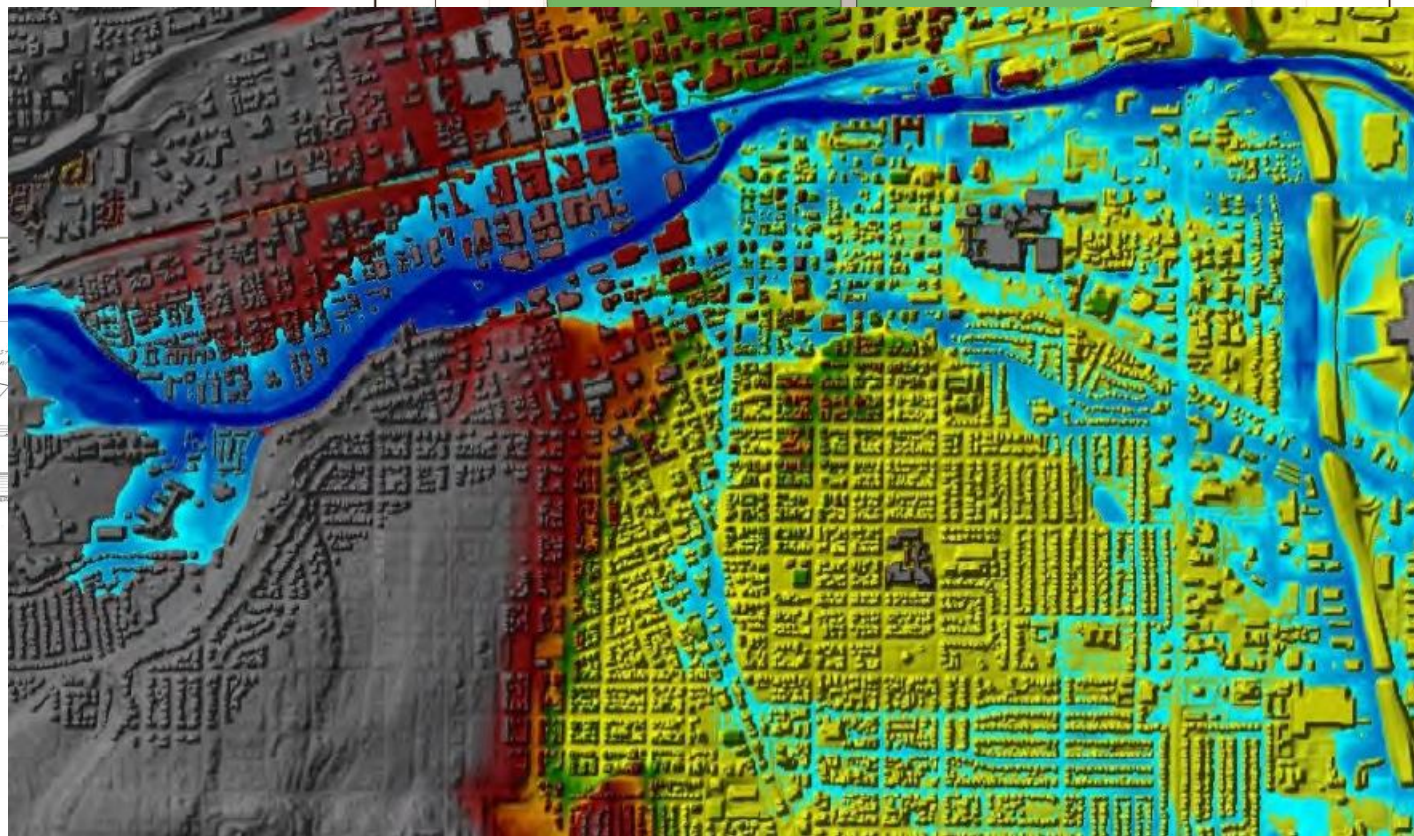
    - Multi-dimensional analysis

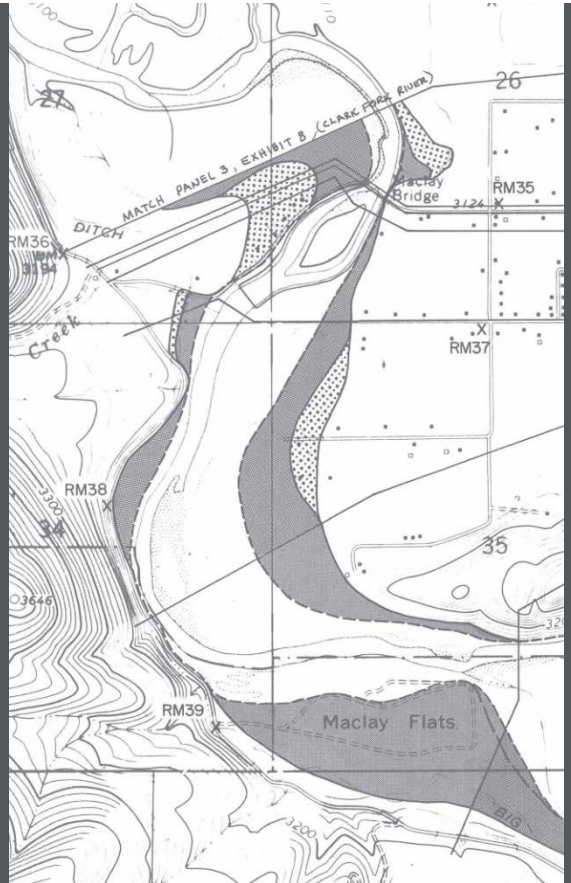


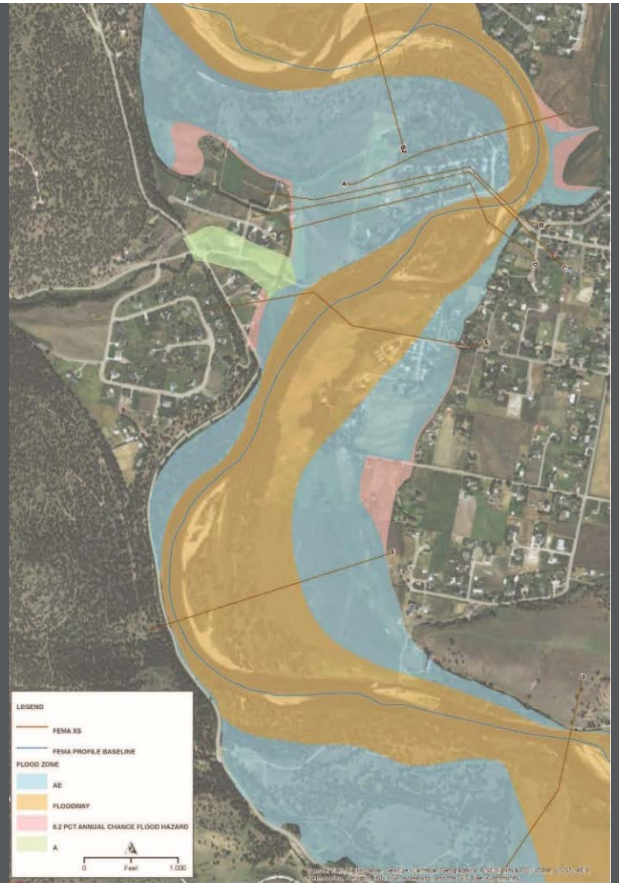




CAUSES OF MAP DECAY

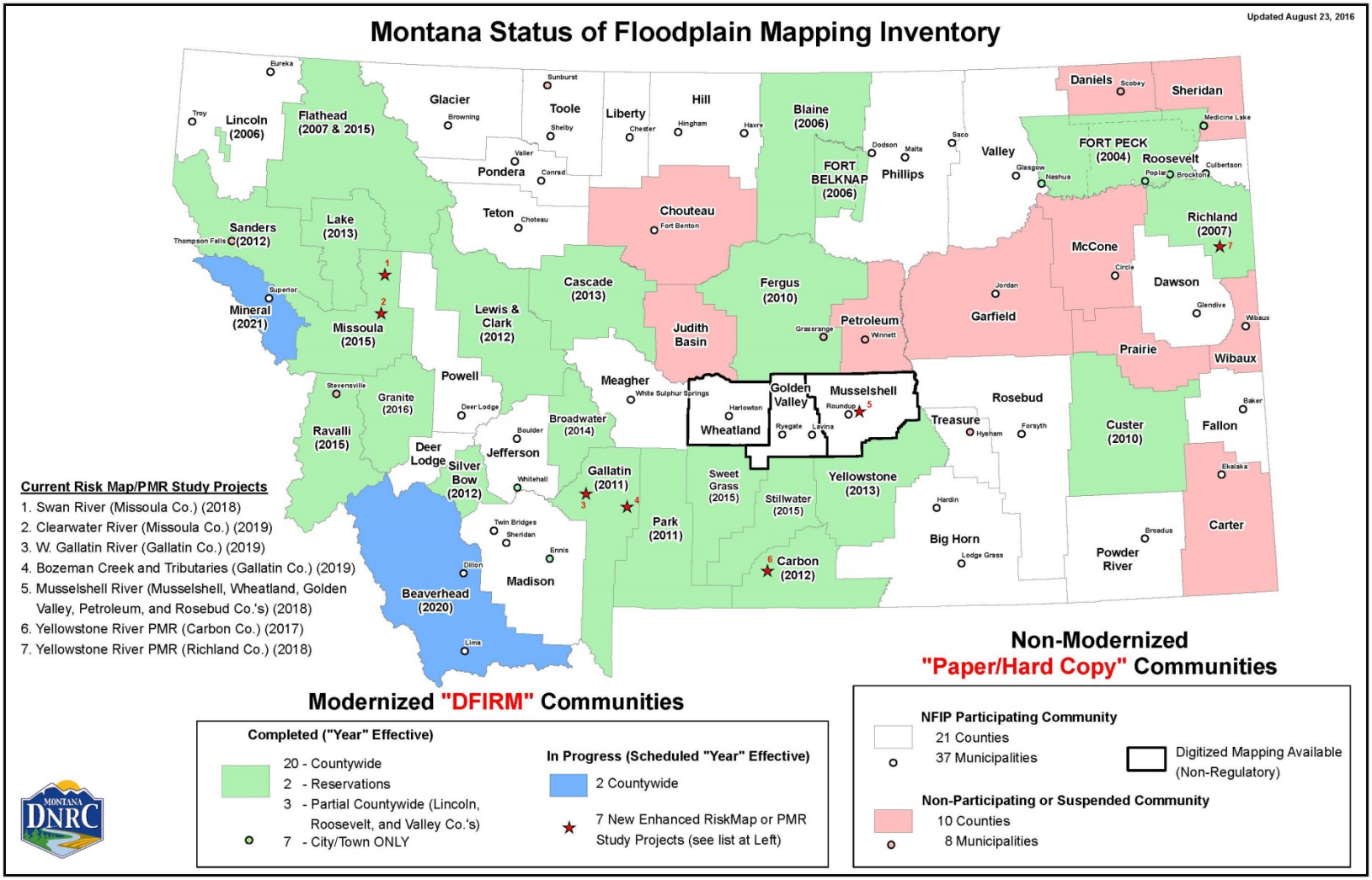
- Improvements in Technology
  - Mapping efficiencies
    - » Automatic delineation
    - » Topographic survey
  - Regulations





STATE OF THE STATE'S MAPS

- Majority of the initial studies were completed in the 1970's and 1980's



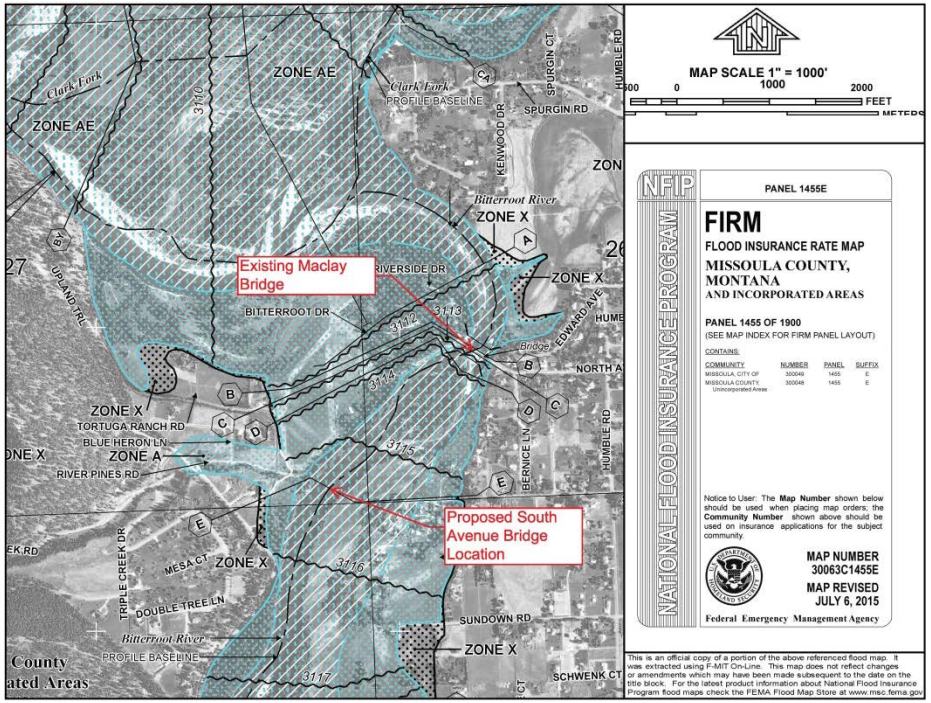
Credit: MT DNRC, http://dnrc.mt.gov/divisions/water/operations/floodplain-management/mapping-and-technical-resources

Example Projects

SOUTH AVENUE BRIDGE

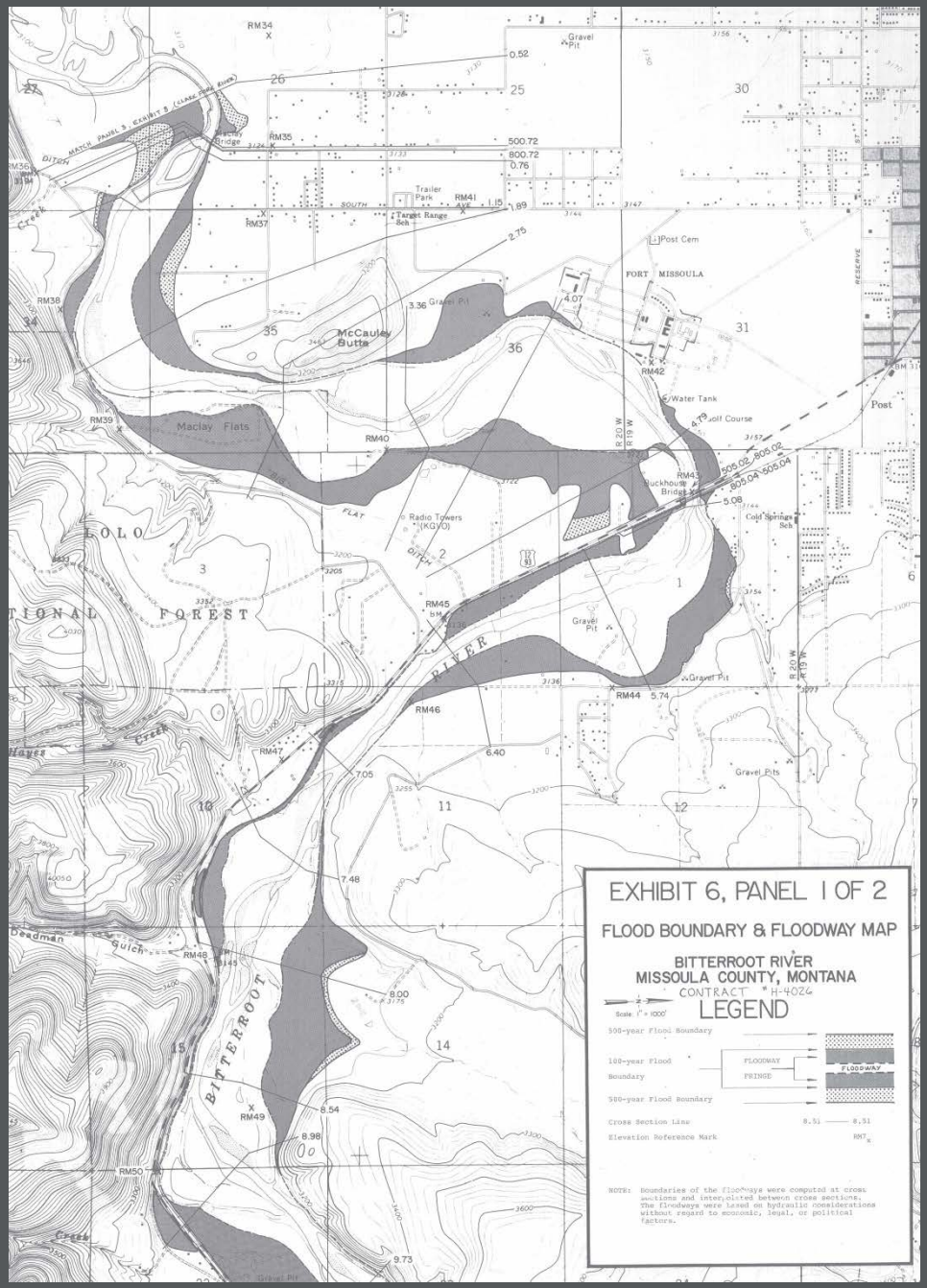
Project Overview

- New bridge at western terminus of South Avenue
- Remove existing Maclay Bridge
  - 0.4 mi downstream of South Avenue



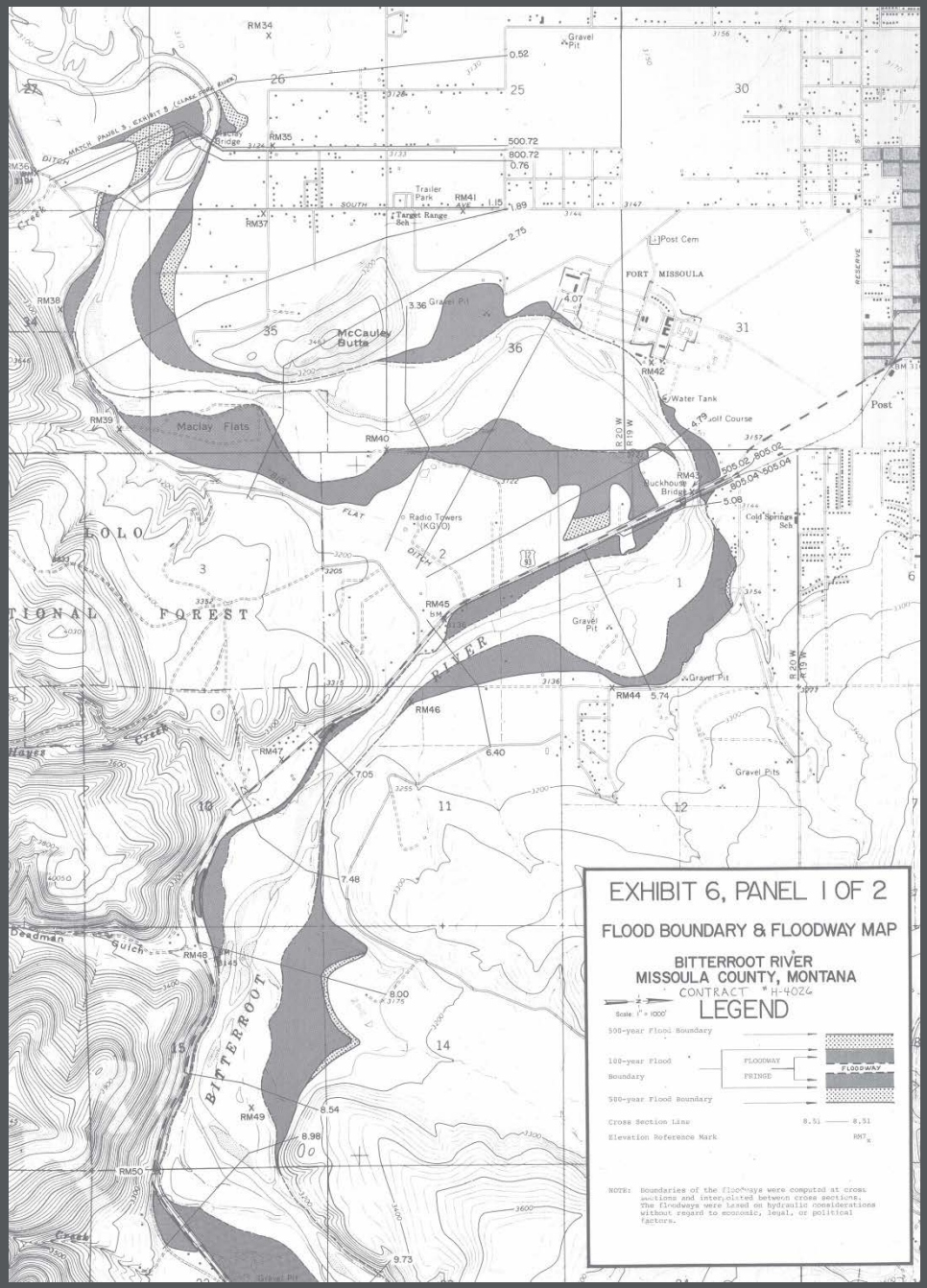
SOUTH AVENUE BRIDGE

- History of project's floodplain
  - USACE 1974
    - Hydrologic Analysis
      - » Gage analysis
    - Hydraulic analysis
      - » HEC-2
    - Mapping

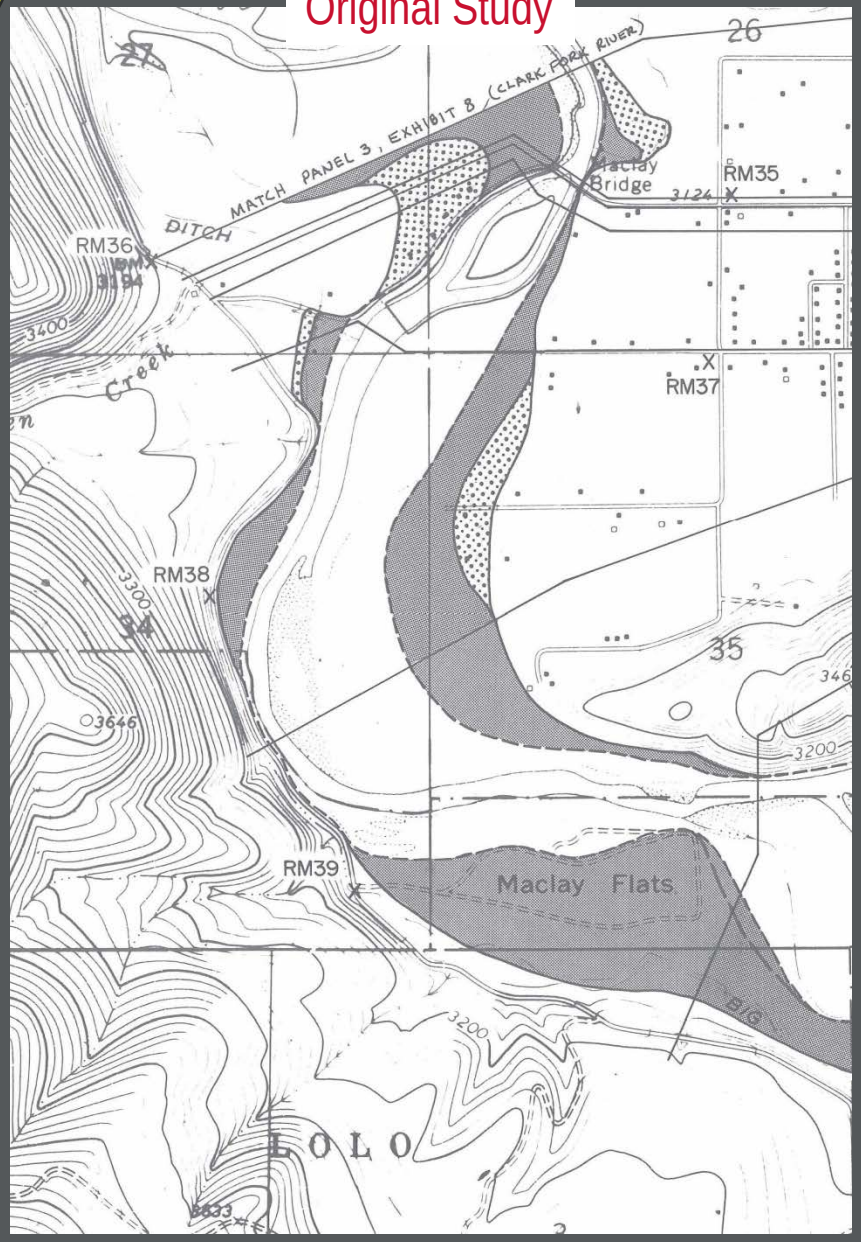


SOUTH AVENUE BRIDGE

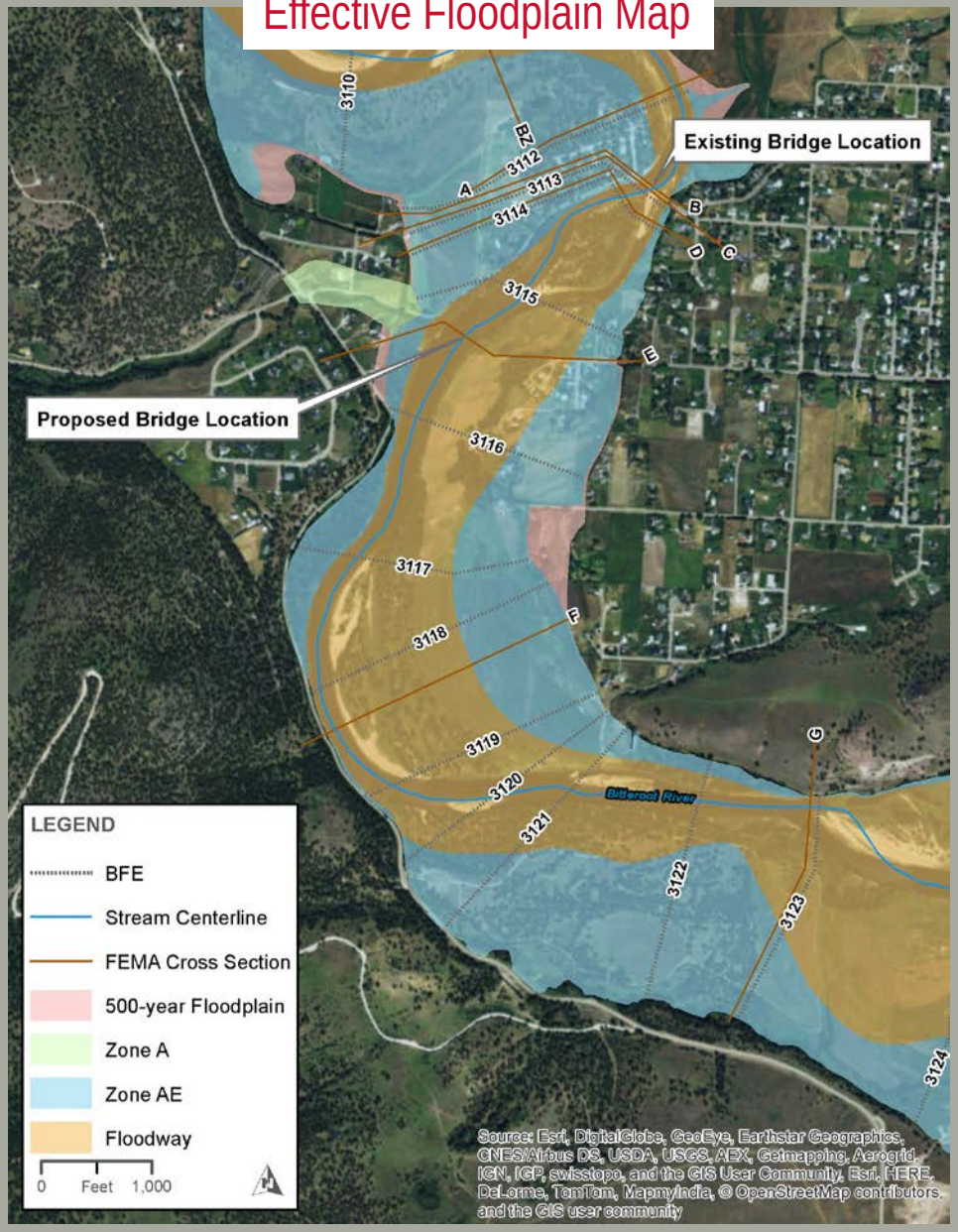
- History of project's floodplain
  - USACE 1974
    - Hydrologic Analysis
      - » Gage analysis
    - Hydraulic analysis
      - » HEC-2
    - Mapping
  - Missoula County MapMod
    - Redelination of Bitterroot River
      - » New topographic data (LiDAR)



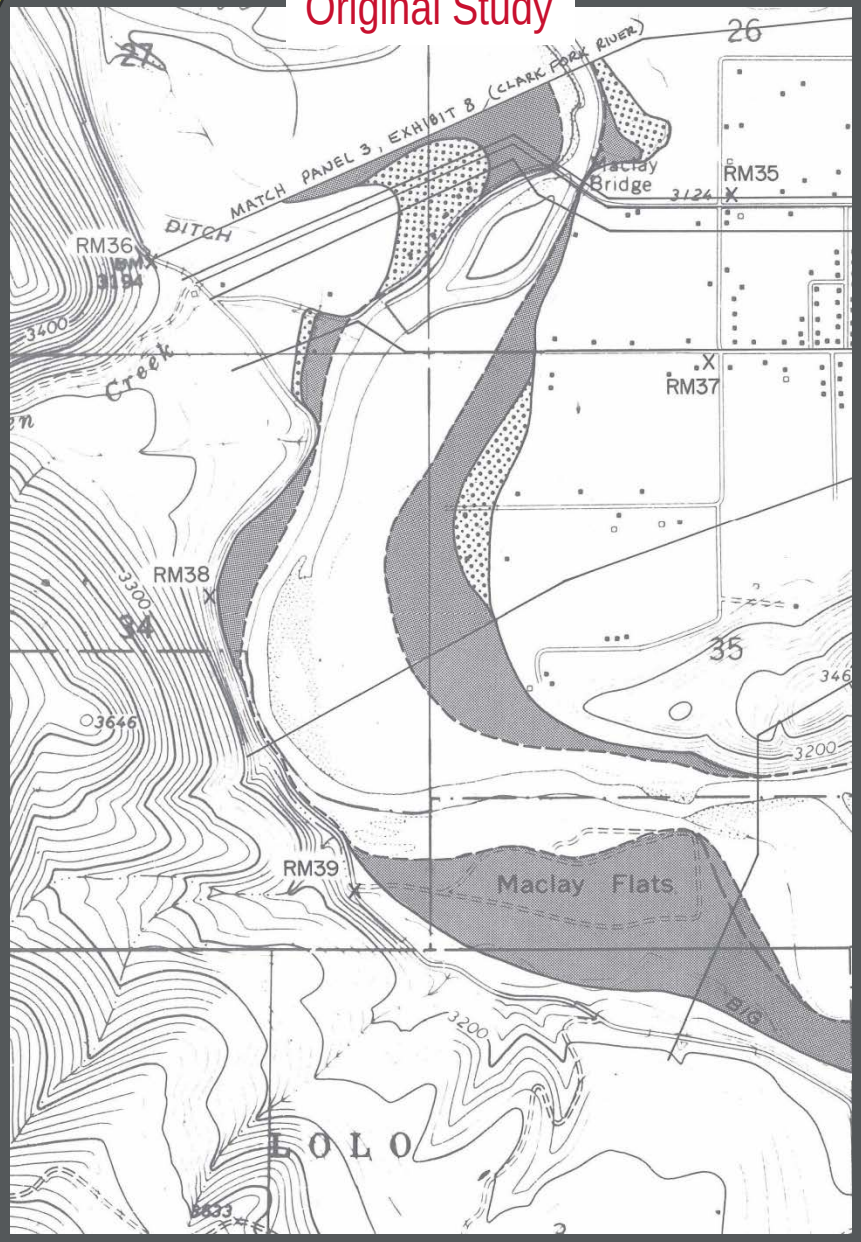
Original Study



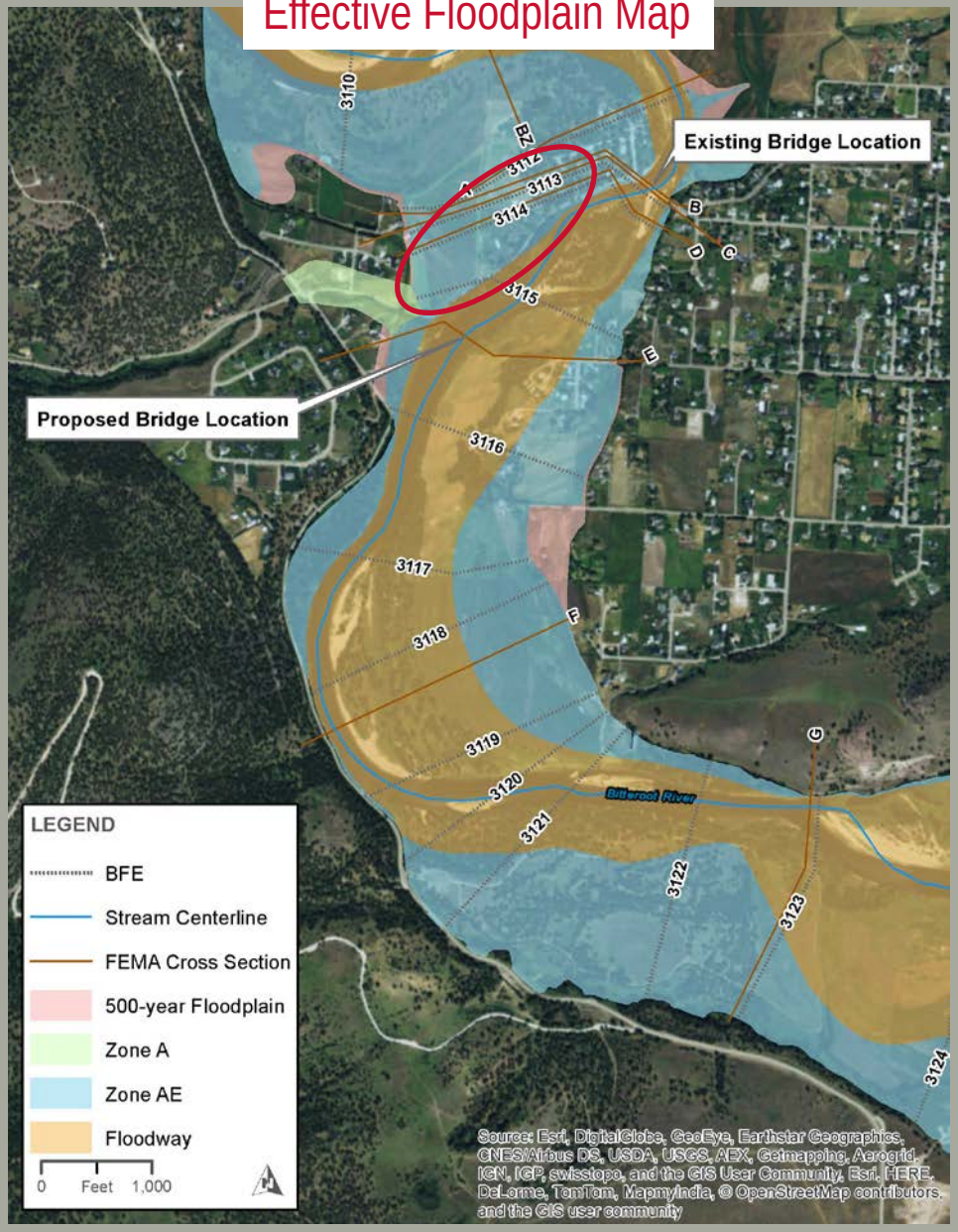
Effective Floodplain Map



Original Study

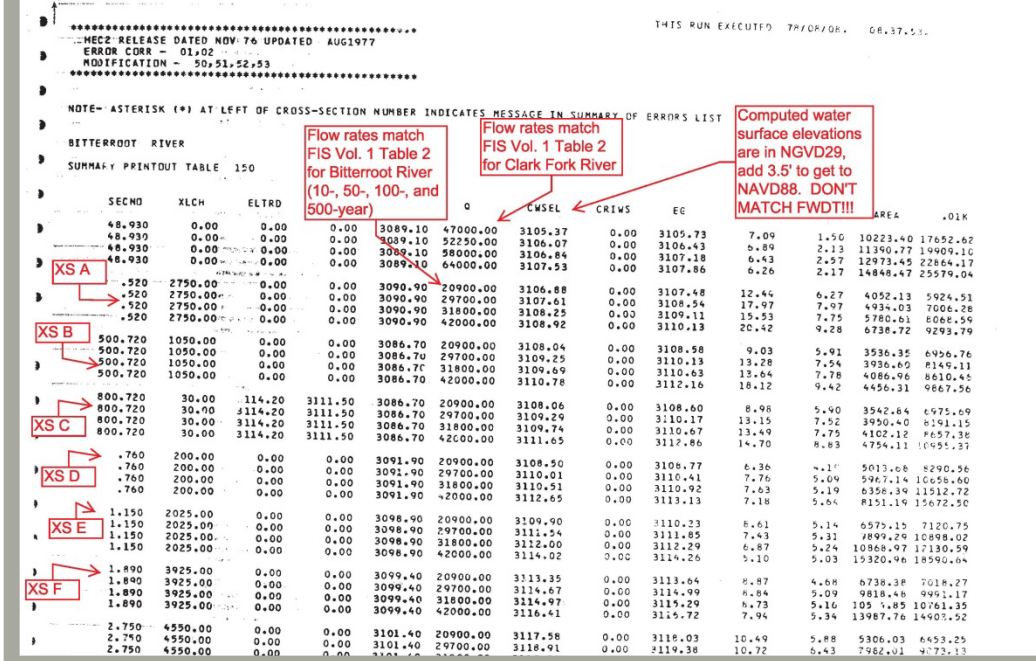


Effective Floodplain Map



SOUTH AVENUE BRIDGE

- Development of:
  - o Duplicated Effective Model
  - o Corrected Effective Model
  - o Existing Conditions Model
  - o Proposed Model
- River Pines Road = Non-Levee Embankment
  - o Effective Study assumed road contained discharge
    - • Used <u>two</u> cross sections along road
  - o Existing conditions analysis showed overtopping



HEC2 RELEASE DATED NOV 76 UPDATED AUG1977
ERROR CORR - 01,02
MODIFICATION - 50,51,52,53

NOTE- ASTERISK (*) AT LEFT OF CROSS-SECTION NUMBER INDICATES MESSAGE IN SUMMARY OF ERRORS LIST

BITTERROOT RIVER

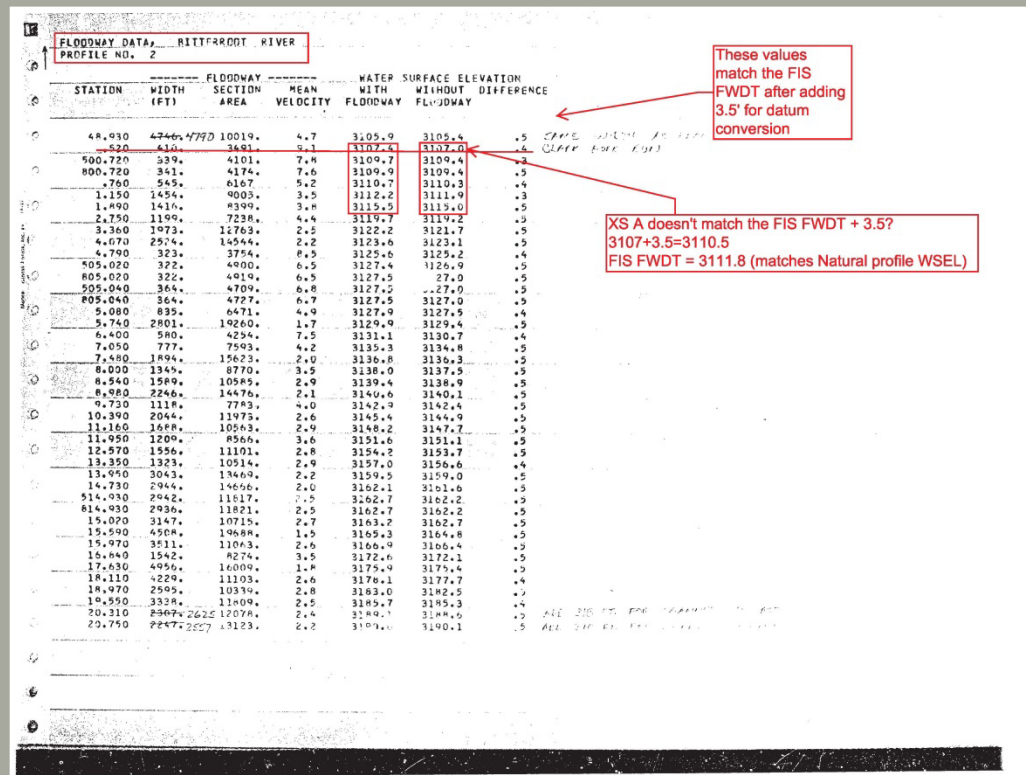
SUMMARY PRINTOUT TABLE 150

Flow rates match FIS Vol. 1 Table 2 for Bitterroot River (10-, 50-, 100-, and 500-year)

Flow rates match FIS Vol. 1 Table 2 for Clark Fork River

Computed water surface elevations are in NGVD29, add 3.5' to get to NAVD88. DON'T MATCH FWDT!!!

	SECNO	XLCH	ELTRD		Q	CWSEL	CRIWS	EG			AREA	.01K
	48.930	0.00	0.00	0.00	3089.10	47000.00	3105.37	0.00	3105.73	7.09	1.50	10223.40	17652.62
	48.930	0.00	0.00	0.00	3089.10	52250.00	3106.07	0.00	3106.43	6.89	2.13	11390.77	19909.10
	48.930	0.00	0.00	0.00	3089.10	58000.00	3106.84	0.00	3107.18	6.43	2.57	12973.45	22864.17
	48.930	0.00	0.00	0.00	3089.10	64000.00	3107.53	0.00	3107.86	6.26	2.17	14848.47	25579.04
XS A	.520	2750.00	0.00	0.00	3090.90	20900.00	3106.88	0.00	3107.48	12.44	6.27	4052.13	5924.51
	.520	2750.00	0.00	0.00	3090.90	29700.00	3107.61	0.00	3108.54	17.97	7.97	4934.03	7006.28
	.520	2750.00	0.00	0.00	3090.90	31800.00	3108.25	0.00	3109.11	15.53	7.75	5780.61	8066.59
	.520	2750.00	0.00	0.00	3090.90	42000.00	3108.92	0.00	3110.13	20.42	9.28	6738.72	9293.79
XS B	500.720	1050.00	0.00	0.00	3086.70	20900.00	3108.04	0.00	3108.58	9.03	5.91	3536.35	6956.76
	500.720	1050.00	0.00	0.00	3086.70	29700.00	3109.25	0.00	3110.13	13.28	7.54	3936.60	8149.11
	500.720	1050.00	0.00	0.00	3086.70	31800.00	3109.69	0.00	3110.63	13.64	7.78	4086.96	8610.45
	500.720	1050.00	0.00	0.00	3086.70	42000.00	3110.78	0.00	3112.16	18.12	9.42	4456.31	9867.56
XS C	800.720	30.00	114.20	3111.50	3086.70	20900.00	3108.06	0.00	3108.60	8.98	5.90	3542.84	6975.69
	800.720	30.00	3114.20	3111.50	3086.70	29700.00	3109.29	0.00	3110.17	13.15	7.52	3950.40	8191.15
	800.720	30.00	3114.20	3111.50	3086.70	31800.00	3109.74	0.00	3110.67	13.49	7.75	4102.12	8657.38
	800.720	30.00	3114.20	3111.50	3086.70	42000.00	3111.65	0.00	3112.86	14.70	8.83	4754.11	10695.37
XS D	.760	200.00	0.00	0.00	3091.90	20900.00	3108.50	0.00	3108.77	6.36	[illegible]	5013.68	8290.56
	.760	200.00	0.00	0.00	3091.90	29700.00	3110.01	0.00	3110.41	7.76	5.09	5967.14	10658.60
	.760	200.00	0.00	0.00	3091.90	31800.00	3110.51	0.00	3110.92	7.63	5.19	6358.39	11512.72
	.760	200.00	0.00	0.00	3091.90	42000.00	3112.65	0.00	3113.13	7.18	5.64	8151.19	15672.50
XS E	1.150	2025.00	0.00	0.00	3098.90	20900.00	3109.90	0.00	3110.23	8.61	5.14	6575.15	7120.75
	1.150	2025.00	0.00	0.00	3098.90	29700.00	3111.54	0.00	3111.85	7.43	5.31	7899.29	10898.02
	1.150	2025.00	0.00	0.00	3098.90	31800.00	3112.00	0.00	3112.29	6.87	5.24	10868.97	17130.59
	1.150	2025.00	0.00	0.00	3098.90	42000.00	3114.02	0.00	3114.26	5.10	5.03	15320.96	18590.64
XS F	1.890	3925.00	0.00	0.00	3099.40	20900.00	3113.35	0.00	3113.64	8.87	4.68	6738.38	7018.27
	1.890	3925.00	0.00	0.00	3099.40	29700.00	3114.67	0.00	3114.99	8.84	5.09	9818.48	9991.17
	1.890	3925.00	0.00	0.00	3099.40	31800.00	3114.97	0.00	3115.29	8.73	5.16	105[illegible].85	10761.35
	1.890	3925.00	0.00	0.00	3099.40	42000.00	3116.41	0.00	3116.72	7.94	5.34	13987.76	14903.52
	2.750	4550.00	0.00	0.00	3101.40	20900.00	3117.58	0.00	3118.03	10.49	5.88	5306.03	6453.25
	2.750	4550.00	0.00	0.00	3101.40	29700.00	3118.91	0.00	3119.38	10.72	6.43	7982.01	9073.13



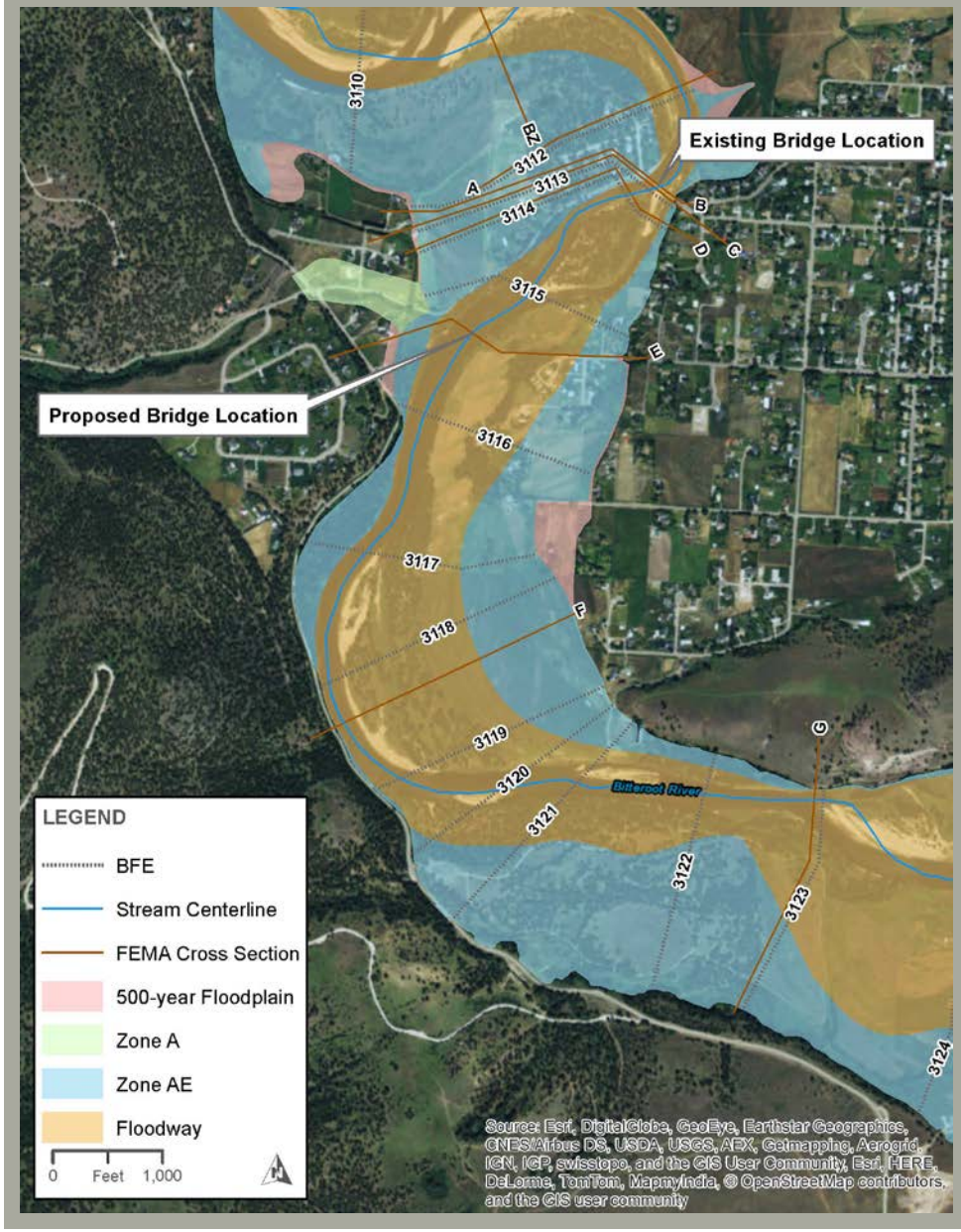
FLOODWAY DATA, BITTERROOT RIVER
PROFILE NO. 2

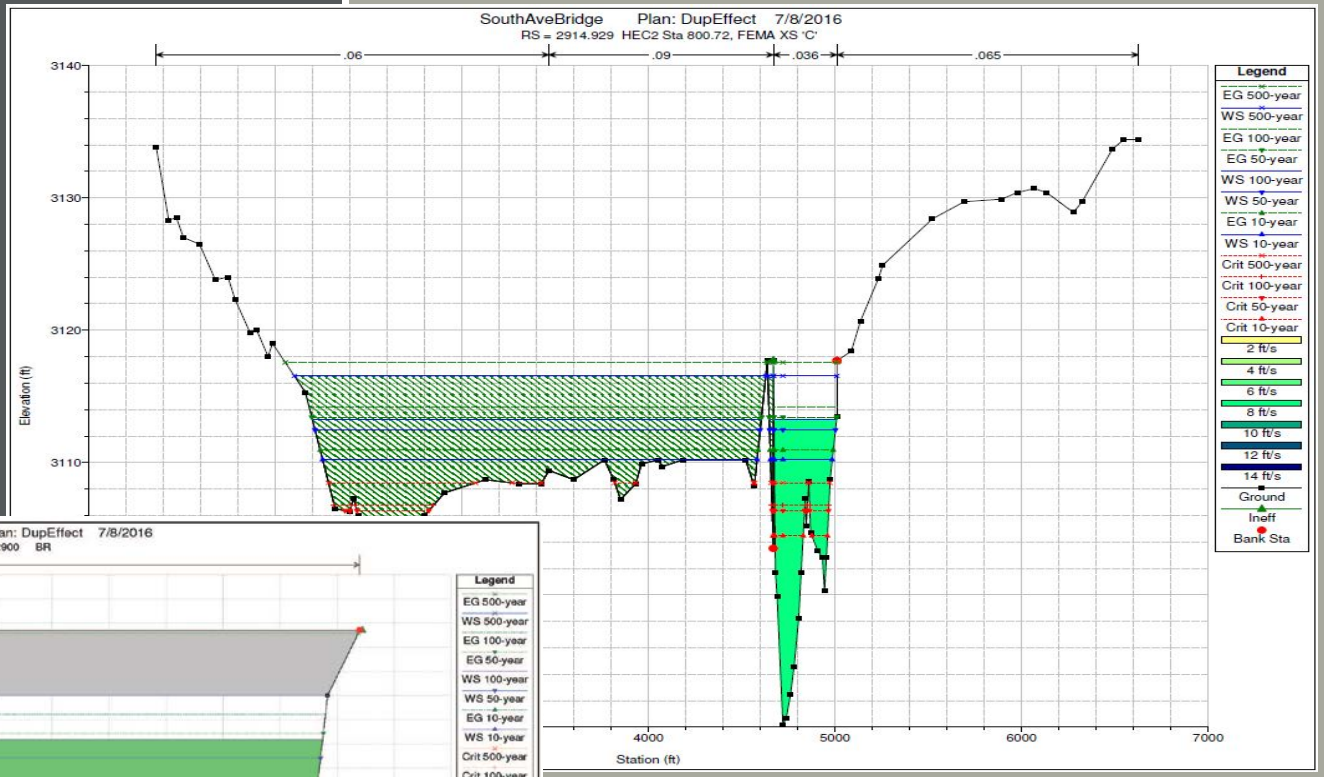
These values match the FIS FWDT after adding 3.5' for datum conversion

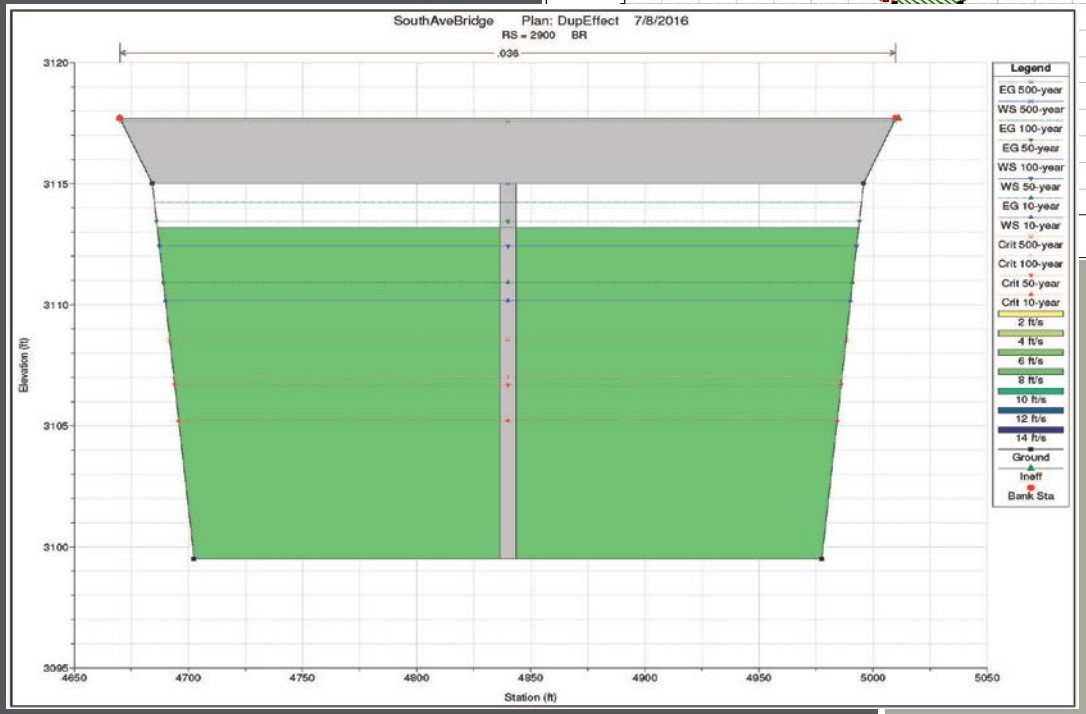
XS A doesn't match the FIS FWDT + 3.5?
3107+3.5=3110.5
FIS FWDT = 3111.8 (matches Natural profile WSEL)

STATION	FLOODWAY WIDTH (FT)	FLOODWAY SECTION AREA	MEAN VELOCITY	WATER SURFACE ELEVATION WITH FLOODWAY	WITHOUT FLOODWAY	DIFFERENCE
48.930	~~4746.~~ 4790	10019.	4.7	3105.9	3105.4	.5
-.520	410.	3491.	9.1	3107.4	3107.0	.4
500.720	339.	4101.	7.8	3109.7	3109.4	.3
800.720	341.	4174.	7.6	3109.9	3109.4	.5
.760	545.	6167	5.2	3110.7	3110.3	.4
1.150	1454.	9003.	3.5	3112.2	3111.9	.3
1.890	1416.	8399.	3.8	3115.5	3115.0	.5
2.750	1199.	7238.	4.4	3119.7	3119.2	.5
3.360	1073.	12763.	2.5	3122.2	3121.7	.5
4.070	2574.	14544.	2.2	3123.6	3123.1	.5
4.790	323.	3754.	8.5	3125.6	3125.2	.4
505.020	322.	4900.	6.5	3127.4	3126.9	.5
805.020	322.	4919.	6.5	3127.5	27.0	.5
505.040	364.	4709.	6.8	3127.5	27.0	.5
805.040	364.	4727.	6.7	3127.5	3127.0	.5
5.080	835.	6471.	4.9	3127.9	3127.5	.4
5.740	2801.	19260.	1.7	3129.9	3129.4	.5
6.400	580.	4254.	7.5	3131.1	3130.7	.4
7.050	777.	7593.	4.2	3135.3	3134.8	.5
7.680	1894.	15623.	2.0	3136.8	3136.3	.5
8.000	1345.	8770.	3.5	3138.0	3137.5	.5
8.540	1589.	10585.	2.9	3139.4	3138.9	.5
8.980	2246.	14476.	2.1	3140.6	3140.1	.5
9.730	1118.	7783.	4.0	3142.9	3142.4	.5
10.390	2044.	11973.	2.6	3145.4	3144.9	.5
11.160	1668.	10563.	2.9	3148.2	3147.7	.5
11.950	1209.	8566.	3.6	3151.6	3151.1	.5
12.570	1556.	11101.	2.8	3154.2	3153.7	.5
13.350	1323.	10514.	2.9	3157.0	3156.6	.4
13.950	3043.	13469.	2.2	3159.5	3159.0	.5
14.730	2944.	14666.	2.0	3162.1	3161.6	.5
514.930	2942.	11617.	[illegible]	3162.7	3162.2	.5
814.930	2936.	11821.	2.5	3162.7	3162.2	.5
15.020	3147.	10715.	2.7	3163.2	3162.7	.5
15.590	4508.	19688.	1.5	3165.3	3164.8	.5
15.970	3511.	11063.	2.6	3166.9	3166.4	.5
16.640	1542.	8274.	3.5	3172.6	3172.1	.5
17.630	4956.	16009.	1.8	3175.9	3175.4	.5
18.110	4229.	11103.	2.6	3178.1	3177.7	.4
18.970	2595.	10339.	2.8	3183.0	3182.5	.5
19.550	3338.	11809.	2.5	3185.7	3185.3	.4
20.310	~~2307.~~ 2625	12078.	2.4	3188.[illegible]	3188.6	.5
20.750	~~2247.~~ 2557	13123.	2.2	3190.[illegible]	3190.1	.5

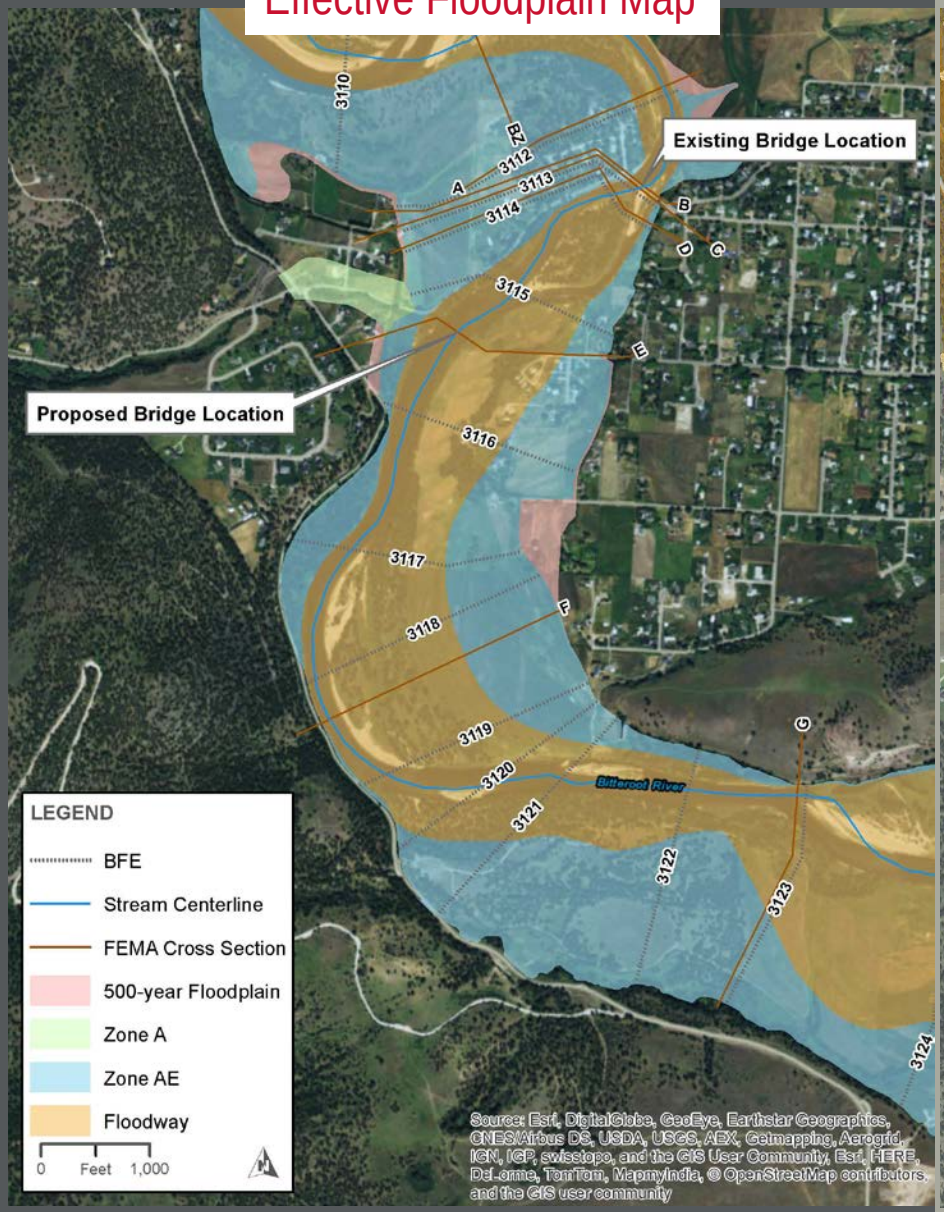
Cross Section	100-Year WSEL		Difference (ft)
	Existing Conditions	Existing Conditions, Floodway Only	
A	3110.18	3112.37	2.19
B	3111.65	3114.03	2.38
	Existing Maclay Bridge		
C	3112.90	3115.17	2.27
D	3113.58	3115.90	2.32
E	3115.56	3117.66	2.10
F	3118.12	3119.59	1.47



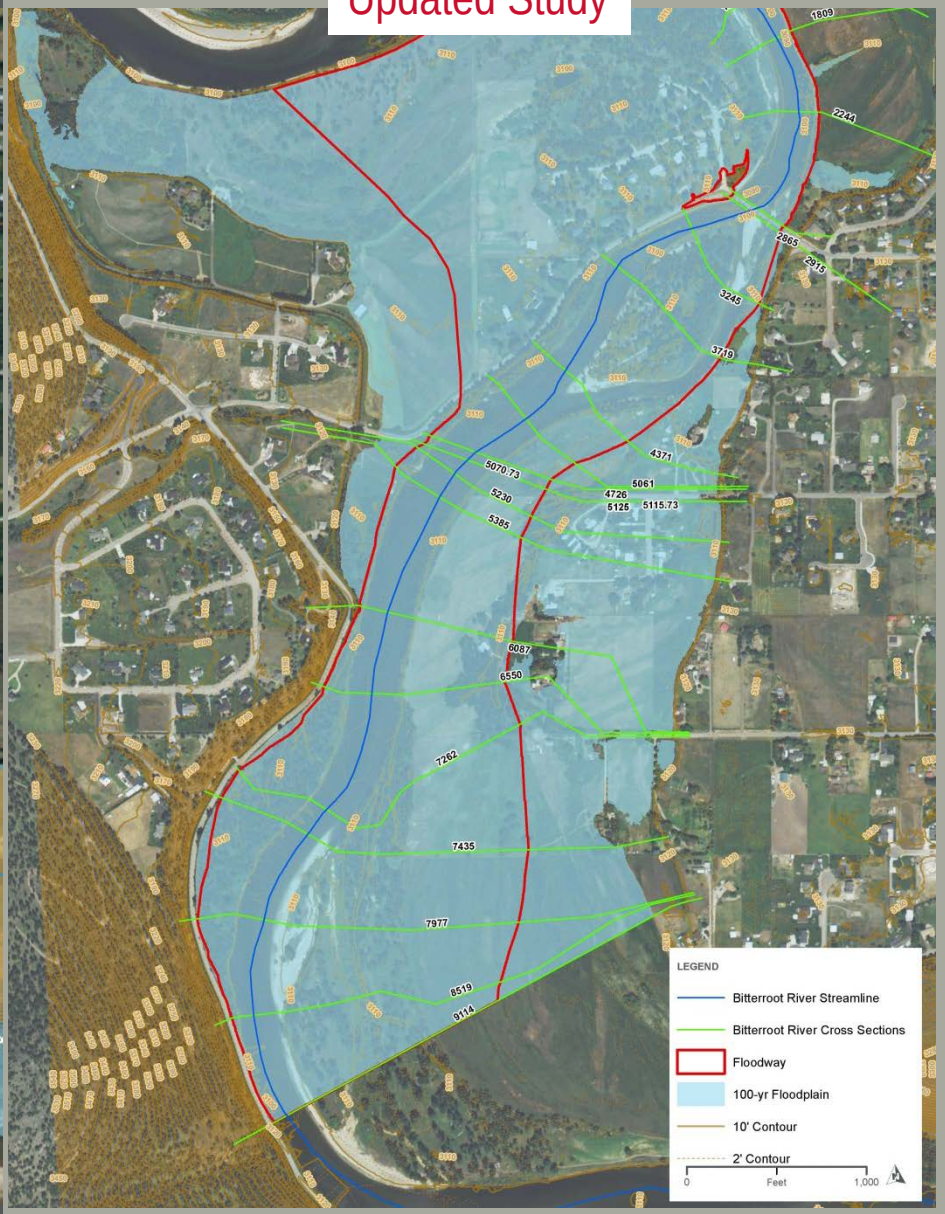

SouthAveBridge Plan: DupEffect 7/8/2016
RS = 2914.929 HEC2 Sta 800.72, FEMA XS 'C'
.06
.09
.036
.065
Elevation (ft)
Station (ft)
Legend
EG 500-year
WS 500-year
EG 100-year
EG 50-year
WS 100-year
WS 50-year
EG 10-year
WS 10-year
Crit 500-year
Crit 100-year
Crit 50-year
Crit 10-year
2 ft/s
4 ft/s
6 ft/s
8 ft/s
10 ft/s
12 ft/s
14 ft/s
Ground
Ineff
Bank Sta


SouthAveBridge Plan: DupEffect 7/8/2016
RS = 2900 BR
.036
Elevation (ft)
Station (ft)
Legend
EG 500-year
WS 500-year
EG 100-year
EG 50-year
WS 100-year
WS 50-year
EG 10-year
WS 10-year
Crit 500-year
Crit 100-year
Crit 50-year
Crit 10-year
2 ft/s
4 ft/s
6 ft/s
8 ft/s
10 ft/s
12 ft/s
14 ft/s
Ground
Ineff
Bank Sta

Effective Floodplain Map



Updated Study

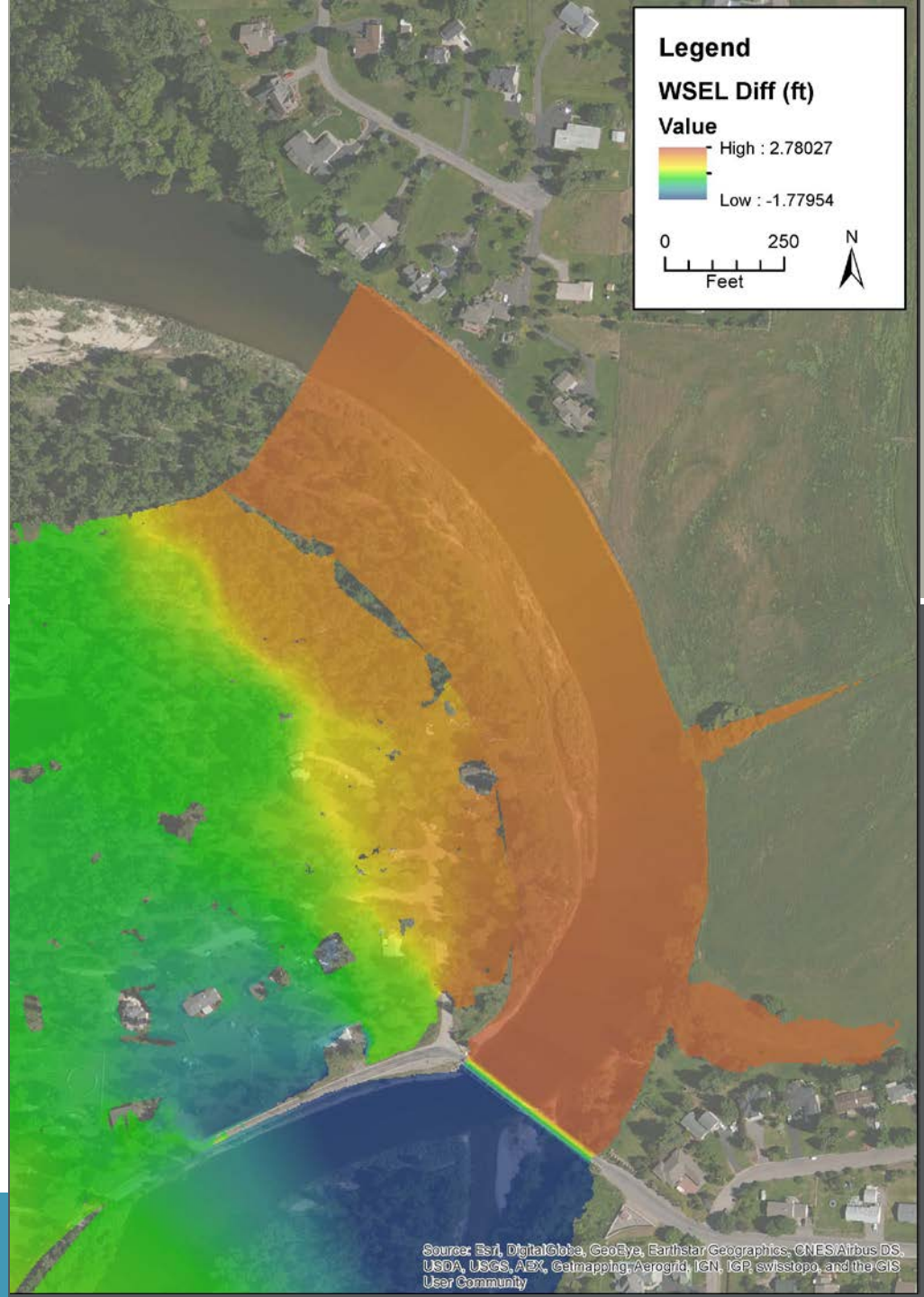


LESSONS LEARNED:
SOUTH AVENUE BRIDGE

Challenge: Thorough review of project's history prior to scoping

Solution: Constant communication with project team and community. Helps when stakeholders are knowledgeable.

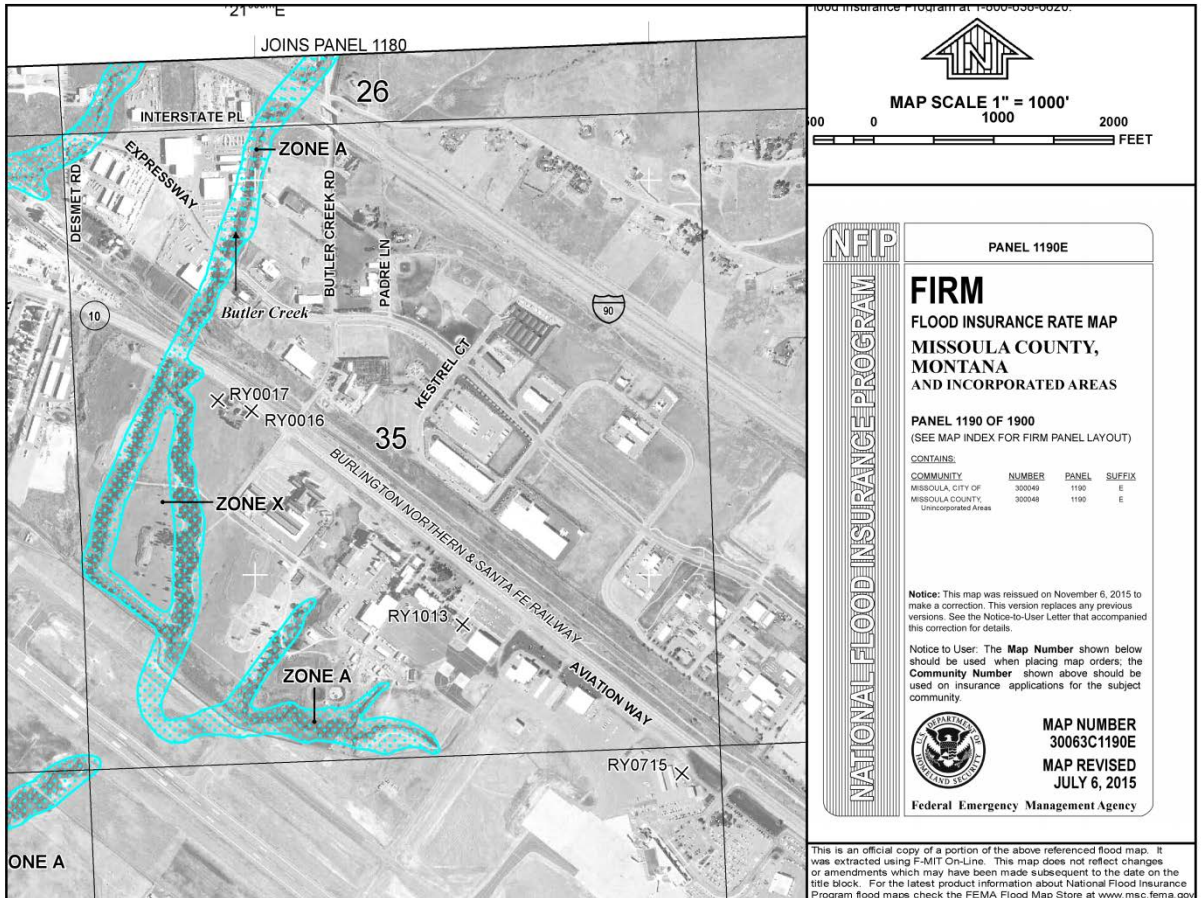
Get FEMA and DNRC involved early



BUTLER CREEK

Project Overview

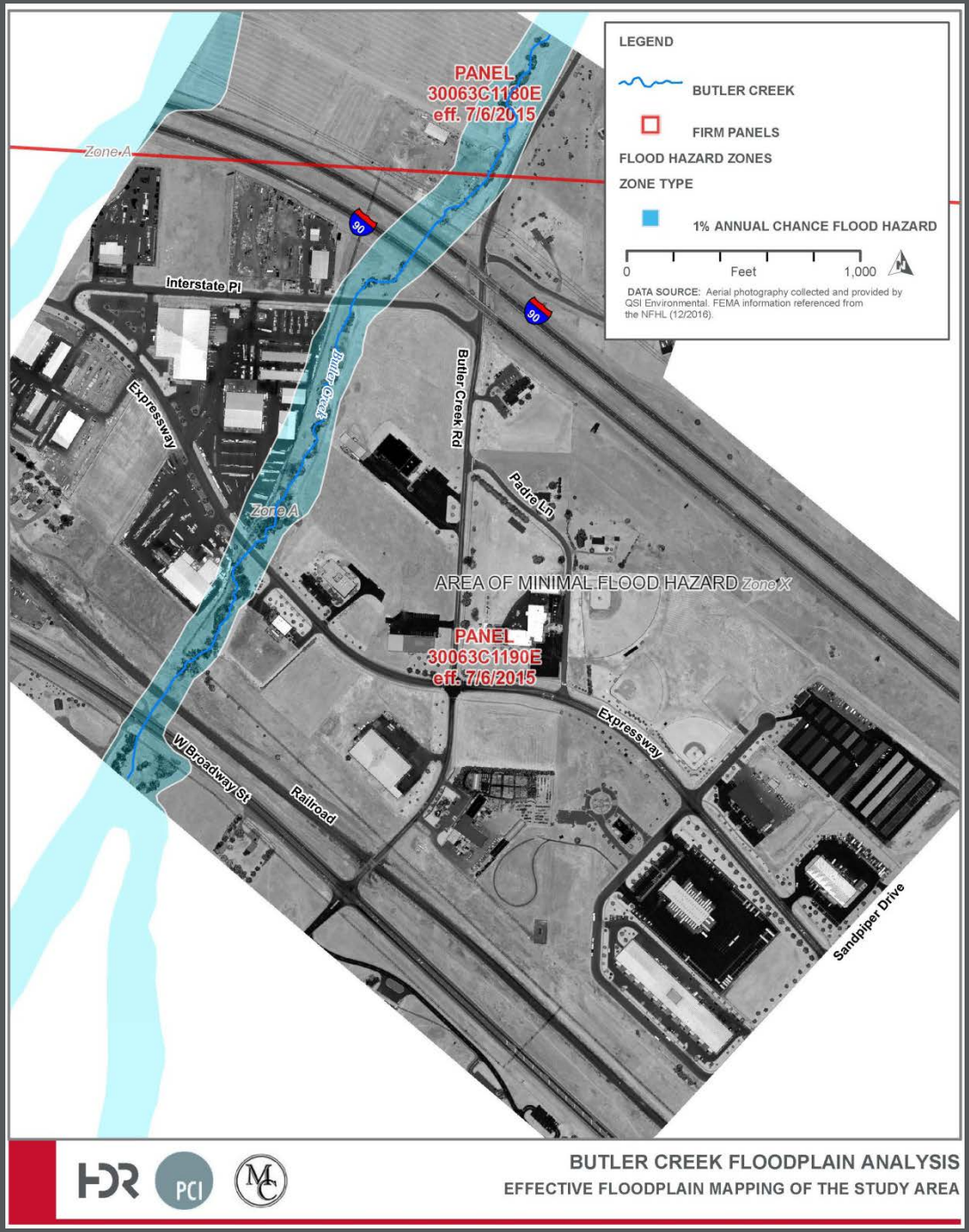
- Development pressure
- History of project's floodplain
  - Zone A
  - MapMod redelineation



BUTLER CREEK

Project Overview

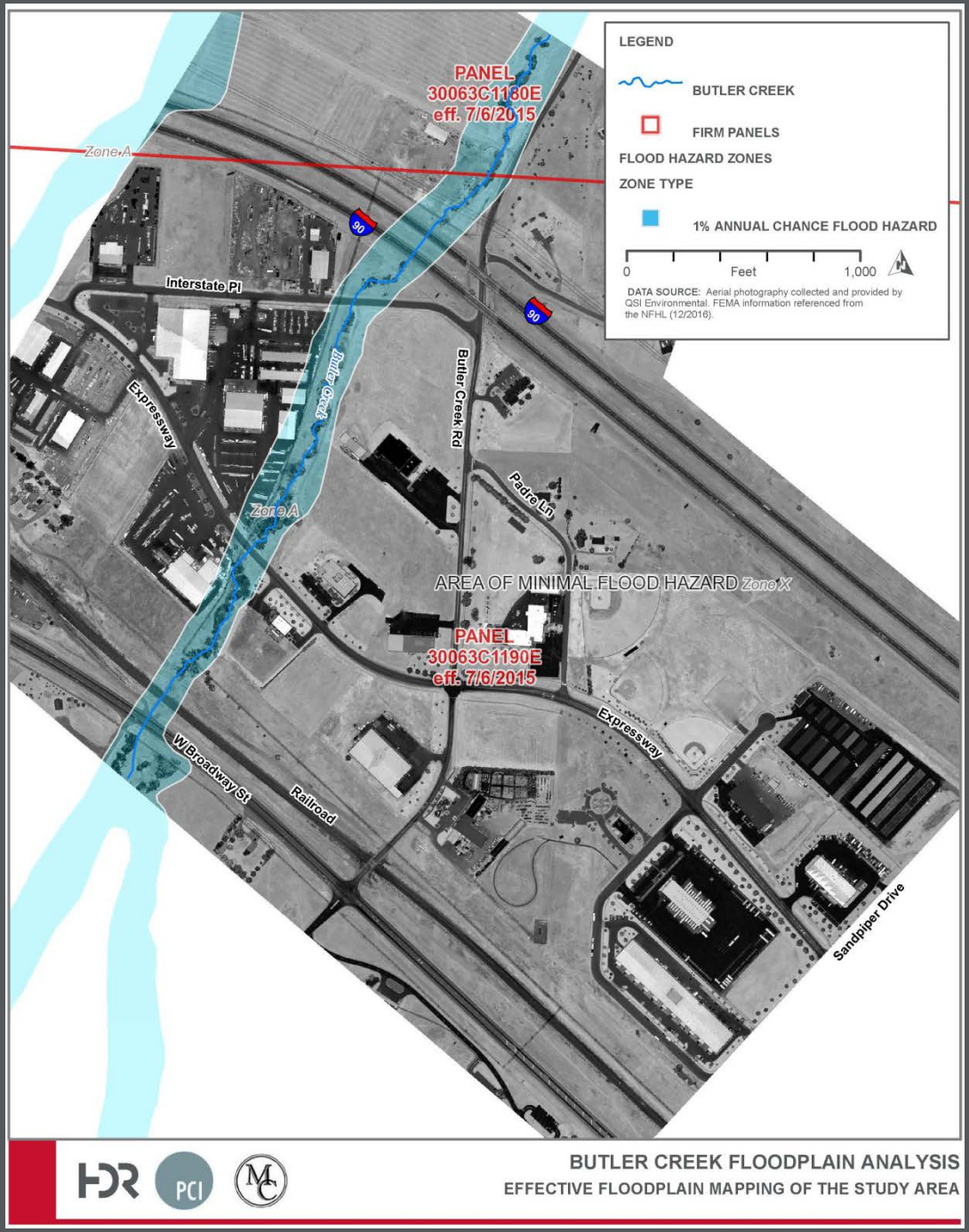
- Public accounts of flooding
  - School
- Questionable mapping accuracy

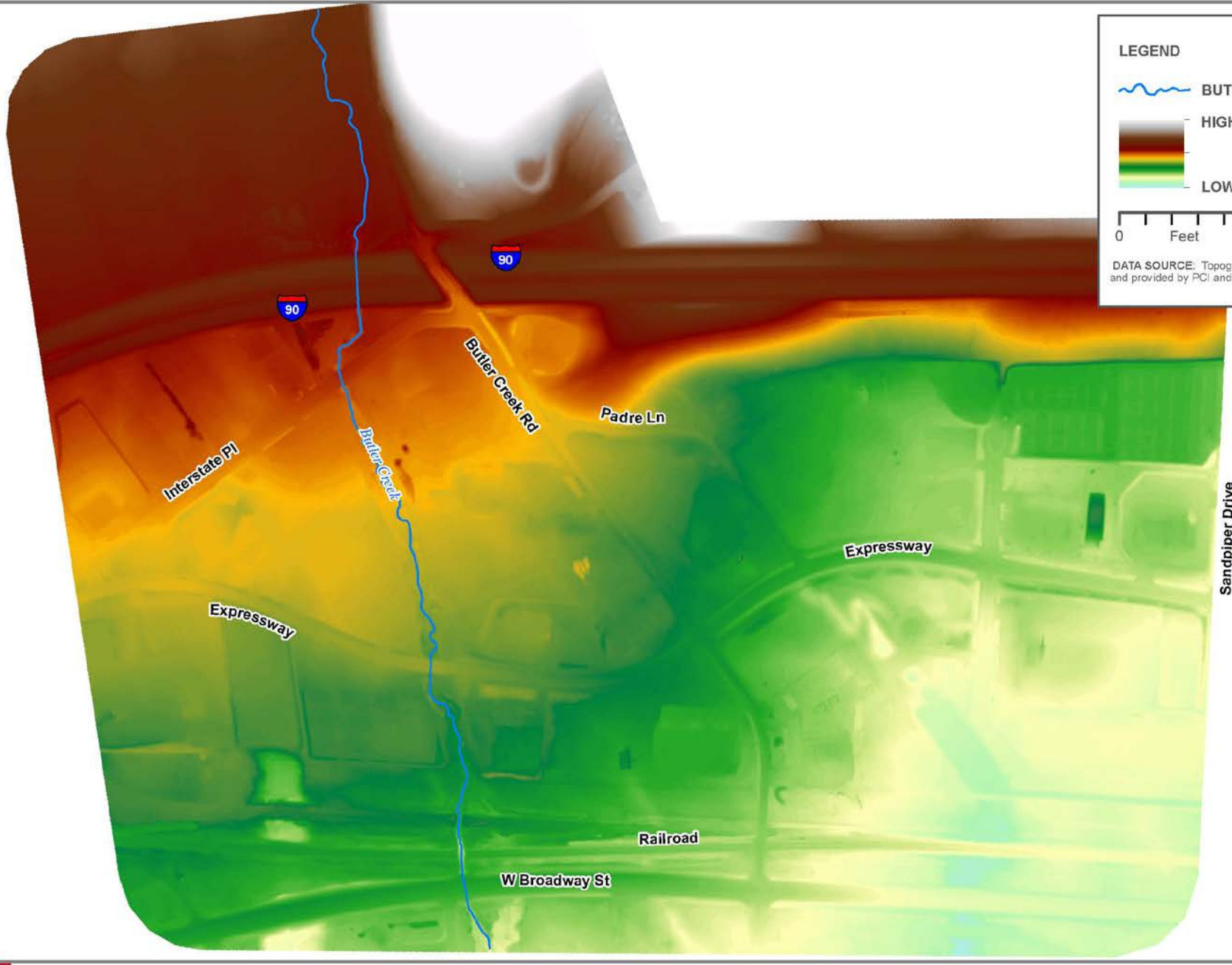


13 6

BUTLER CREEK

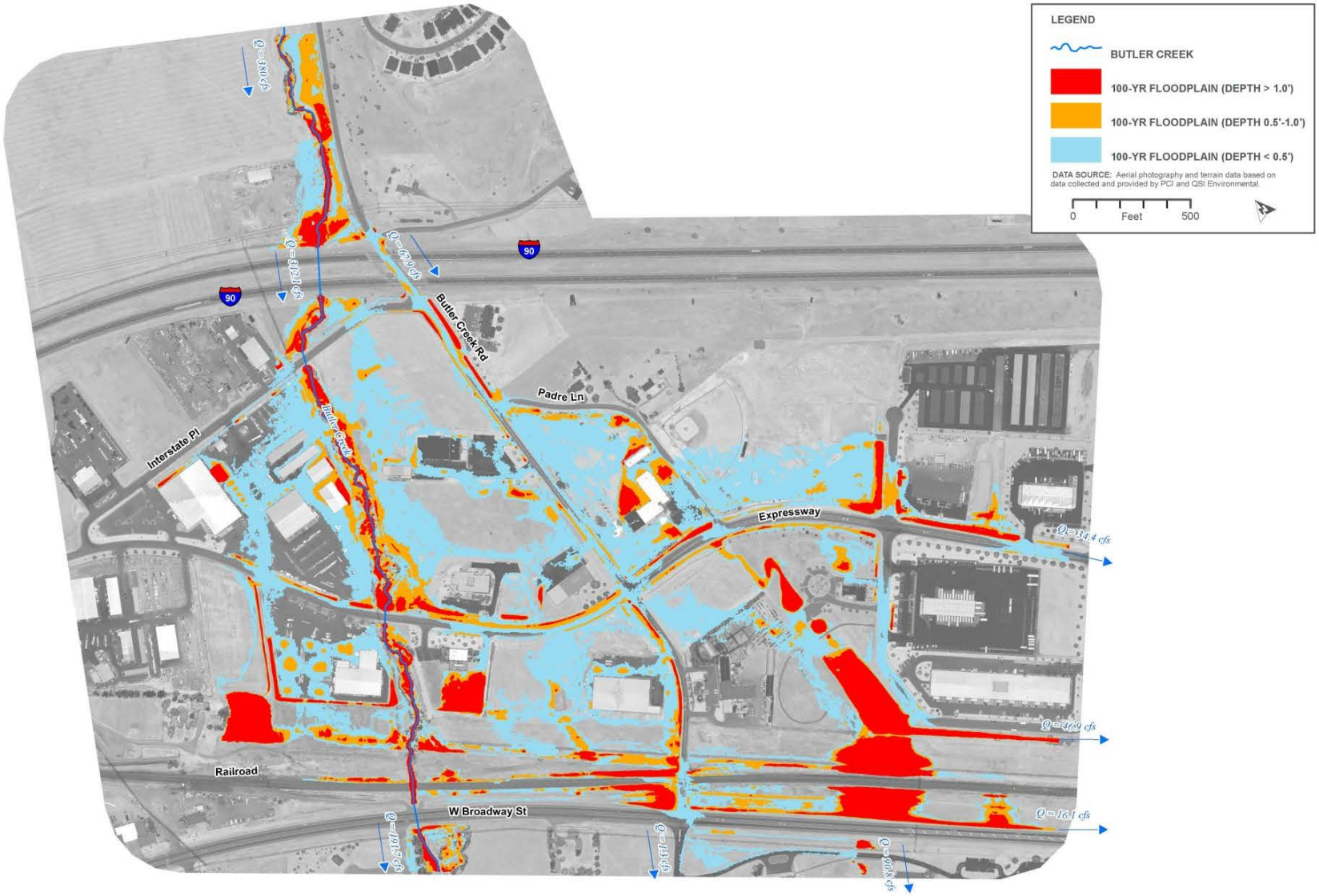
- Project:
  - Topo
    - LiDAR & XS Survey
    - Structure survey
  - Hydrology
    - Local regression (FEMA accepted)
  - Hydraulics
    - 2D hydraulic analysis
      - » HEC-RAS 5.0.3





BUTLER CREEK FLOODPLAIN ANALYSIS

HYDRAULIC MODEL - DIGITAL TERRAIN MODEL



BUTLER CREEK FLOODPLAIN ANALYSIS

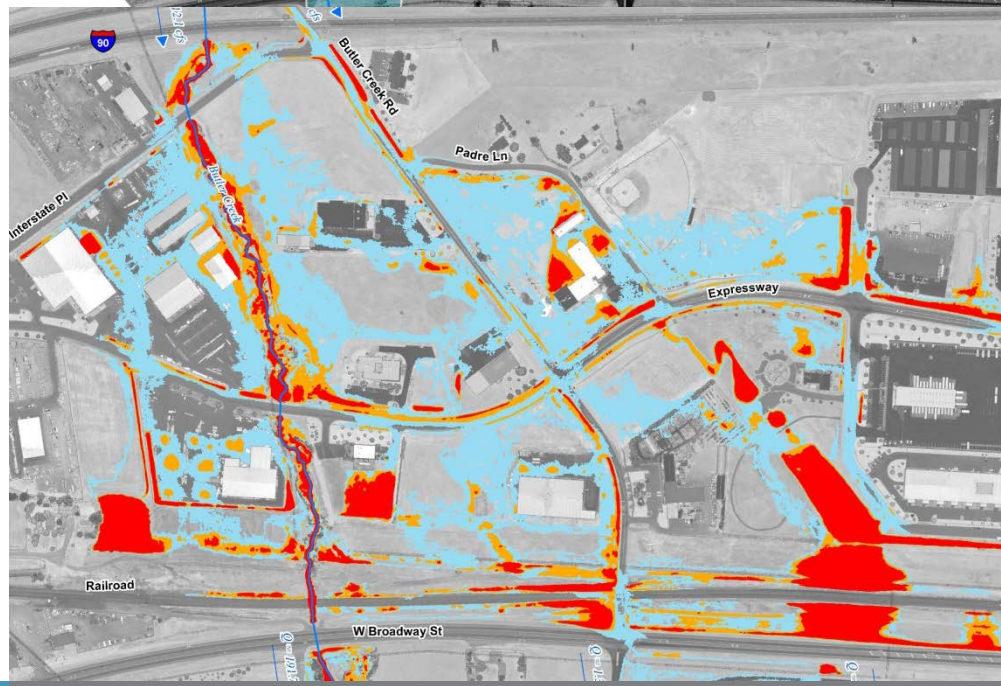
RESULTING INUNDATION LIMITS AND DISCHARGES

LESSONS LEARNED:
BUTLER CREEK

Challenge: Known inaccuracies of effective mapping and bifurcated urban flood flow

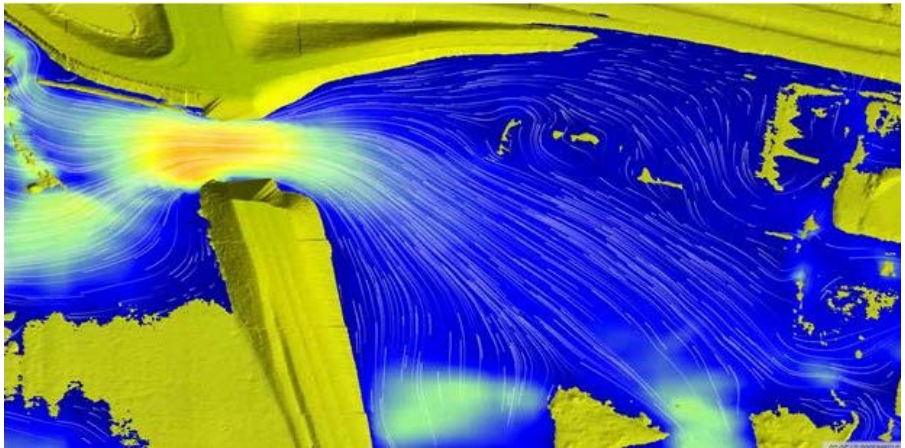
Solution: Proactive FPA and community; not reactive. Multi-dimensional hydraulic analysis.

Embrace new methods and compare risk mapping with historical events



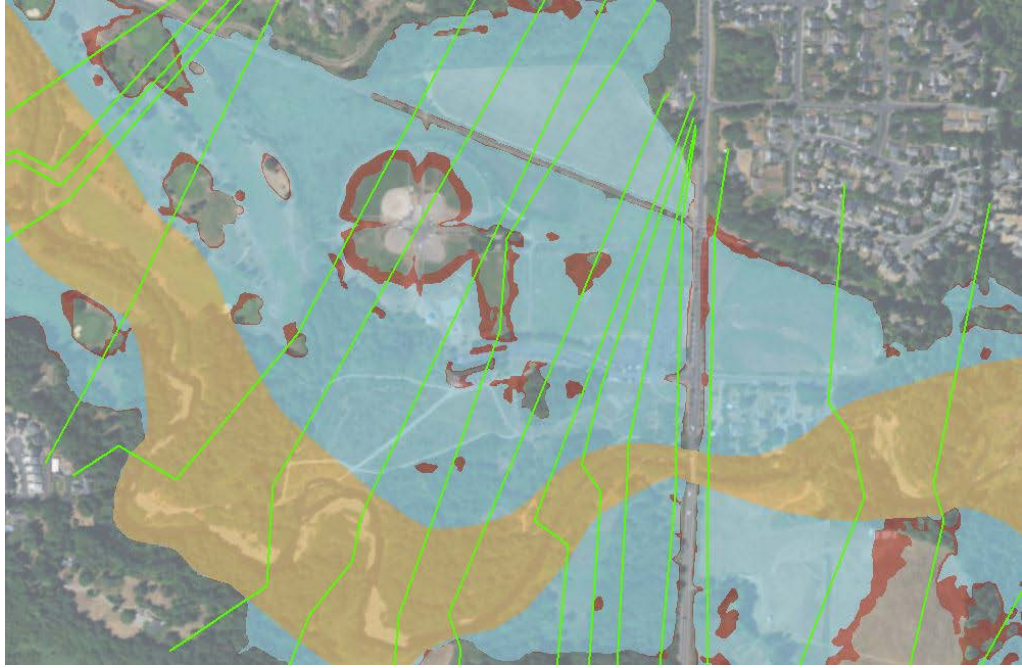
EFFECT OF TECHNOLOGY ON GUIDELINES AND SPECIFICATIONS

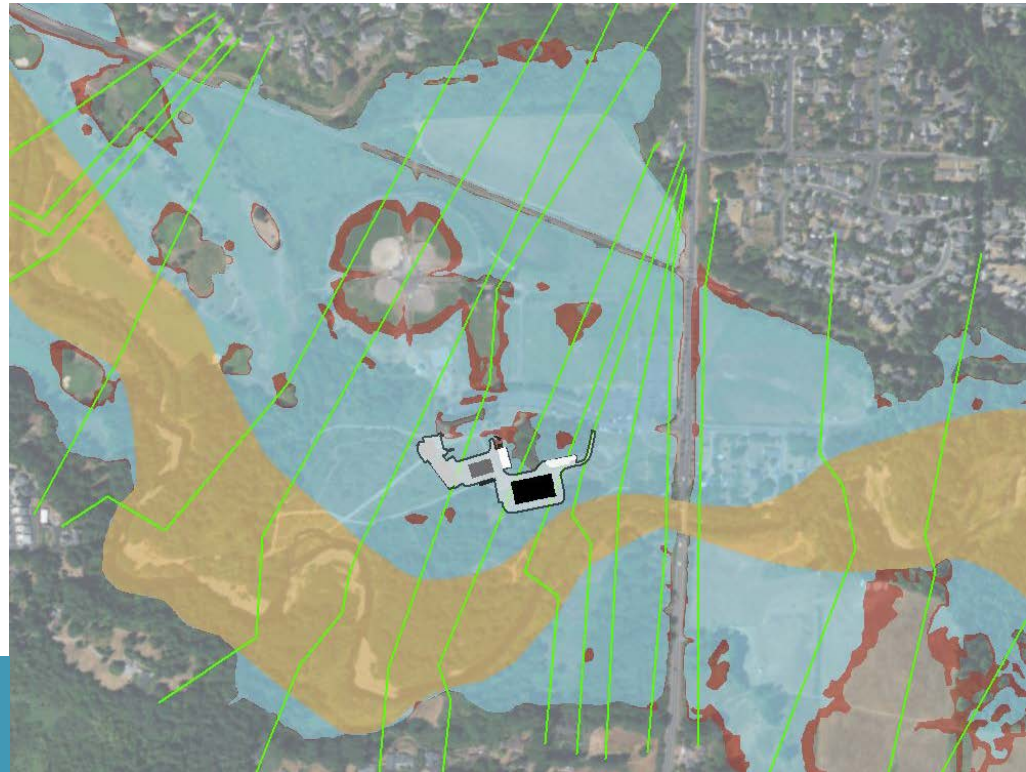
- LiDAR
  - Cross section spacing
  - Mapping accuracy checks
- Multi-dimensional analysis
  - Coming soon???
  - Floodway & No Rise analyses

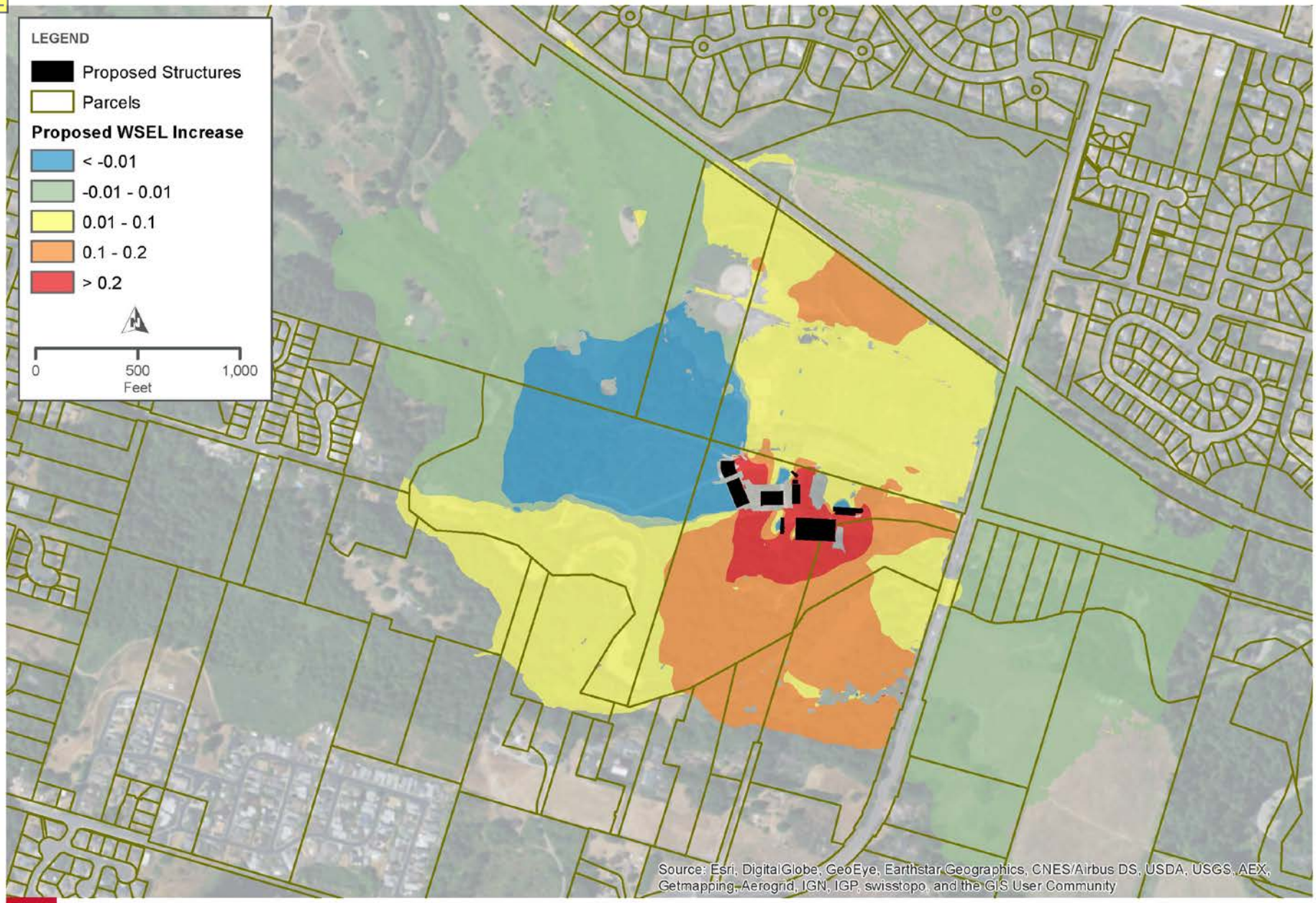


EXAMPLE (WHAT IF?)

- Deschutes River, Tumwater, WA
  - Pioneer Park Fish Hatchery
  - Construction located outside of the floodway
  - Local officials require a 0.0’ rise or less in the <u>floodplain</u>
  - Project will require mitigation of rise
  - What if analysis was performed with multi-dimensional hydraulic analysis







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PIONEER PARK

DIFFERENCE IN WATER SURFACE ELEVATIONS
PROPOSED - EXISTING

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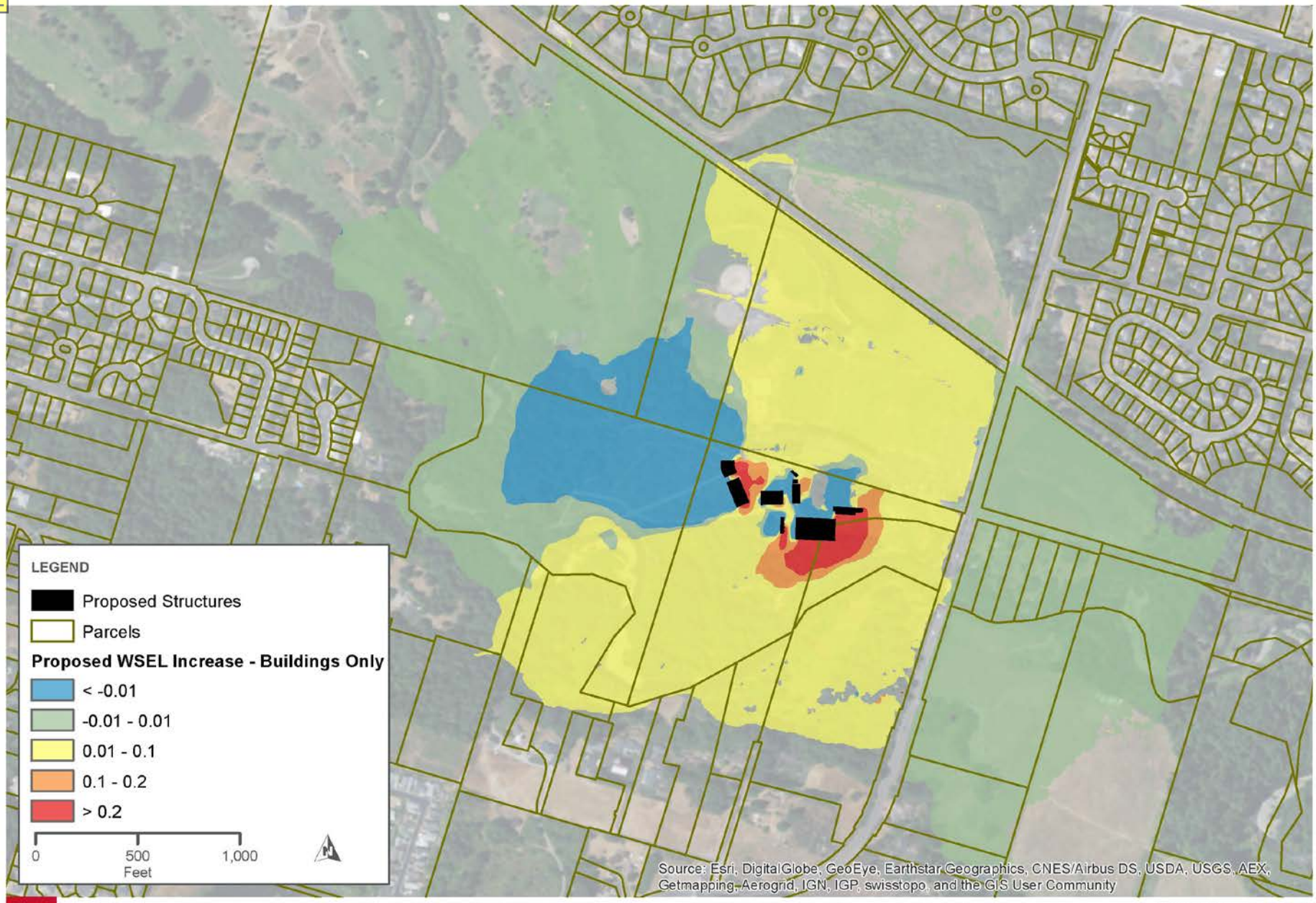

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PIONEER PARK

DIFFERENCE IN WATER SURFACE ELEVATIONS
PROPOSED (BUILDINGS ONLY) - EXISTING

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PIONEER PARK

DIFFERENCE IN WATER SURFACE ELEVATIONS
PROPOSED (NEW GEO BUILDINGS ONLY) - EXISTING

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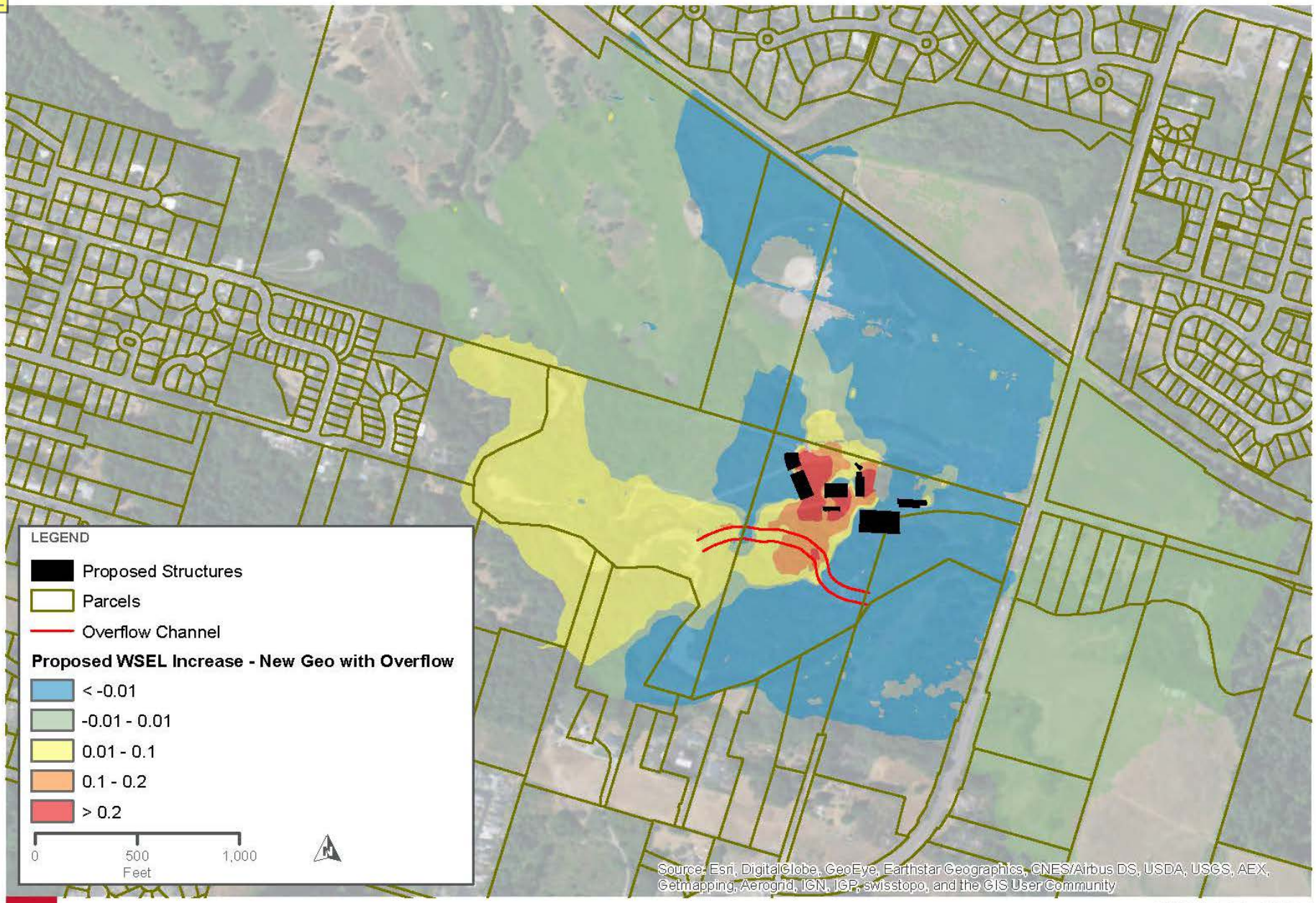

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PIONEER PARK

DIFFERENCE IN WATER SURFACE ELEVATIONS
PROPOSED (NEW GEO & OVERFLOW) - EXISTING

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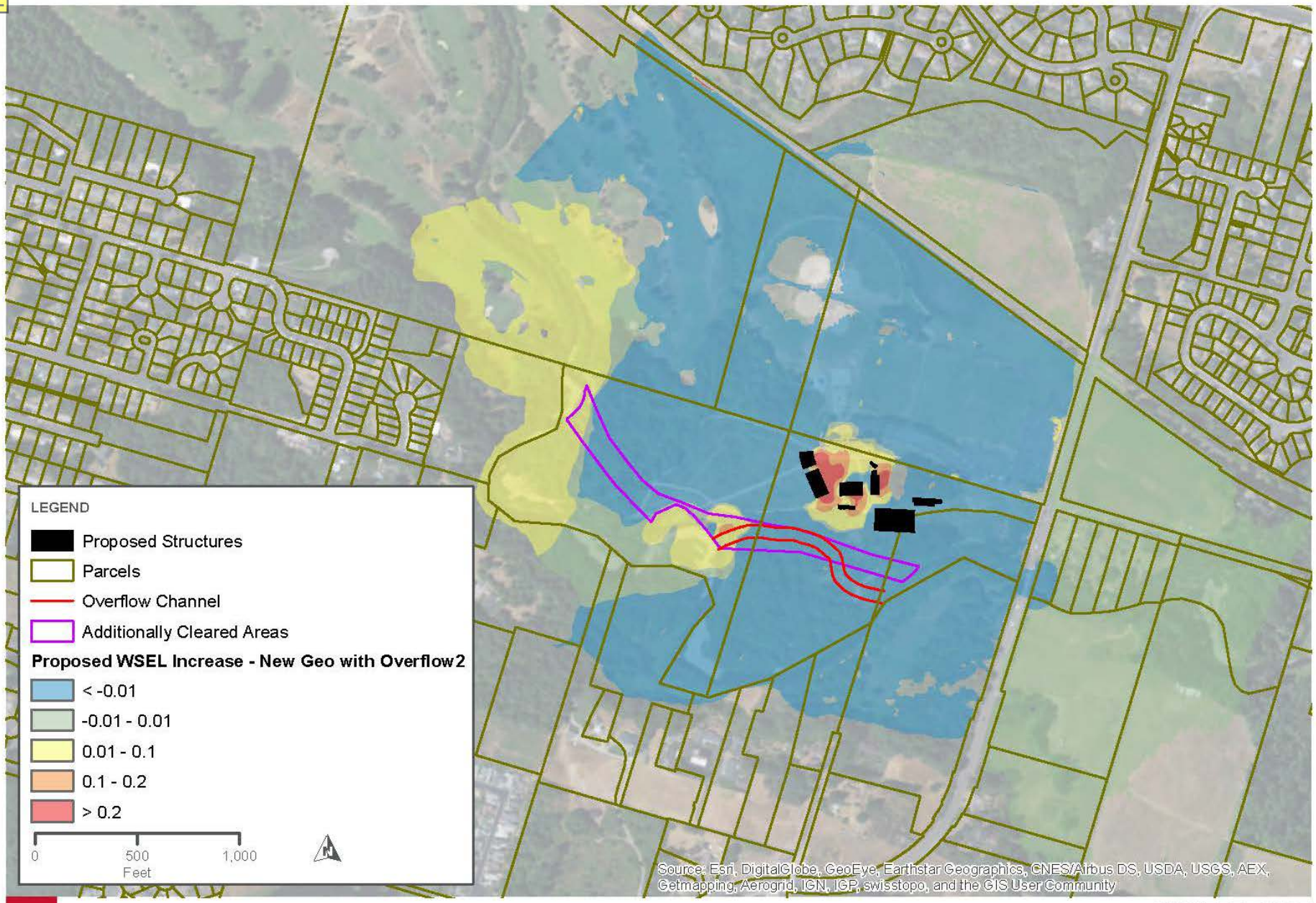

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PIONEER PARK

DIFFERENCE IN WATER SURFACE ELEVATIONS
PROPOSED (NEW GEO & OVERFLOW2) - EXISTING

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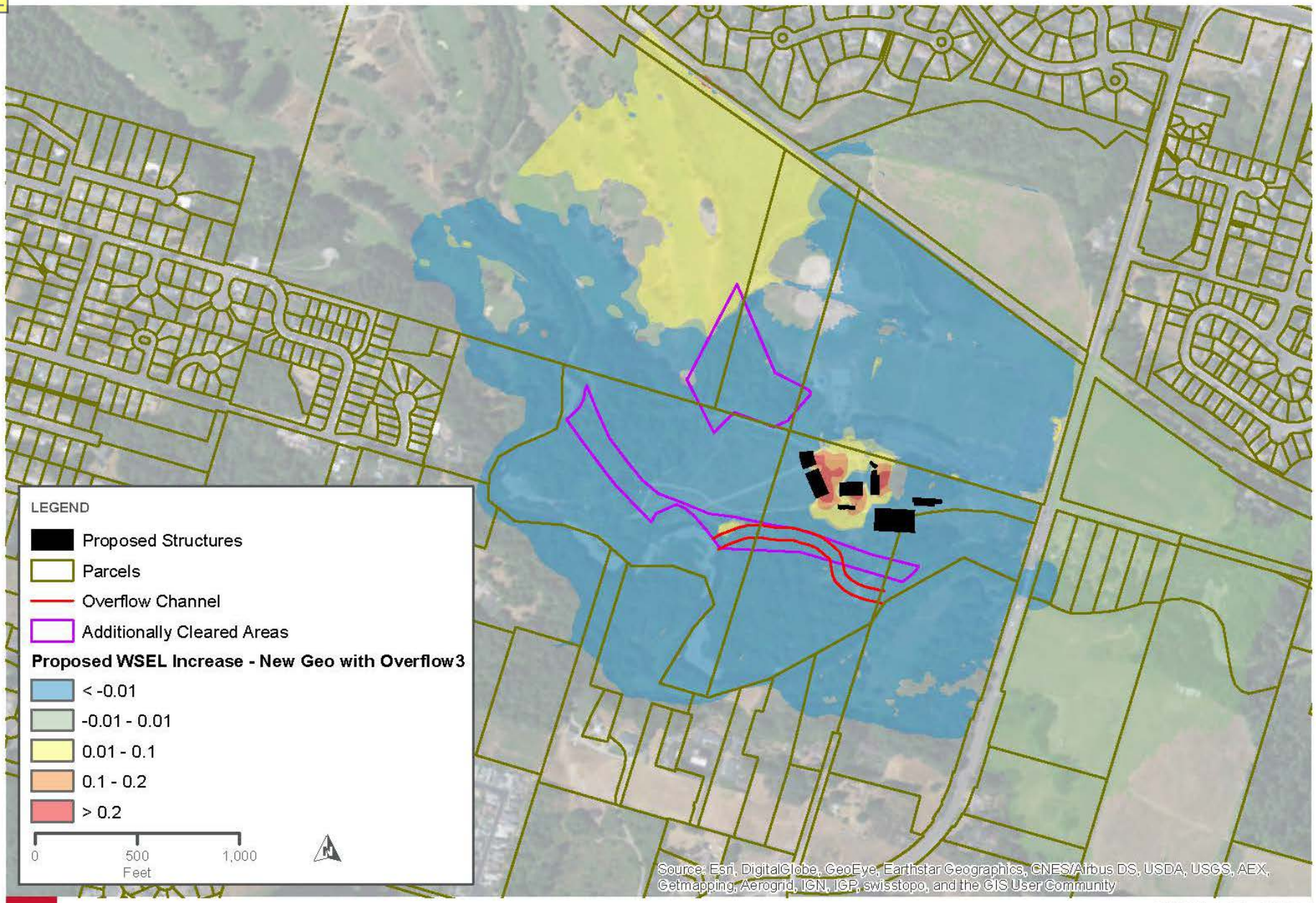

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PIONEER PARK

DIFFERENCE IN WATER SURFACE ELEVATIONS
PROPOSED (NEW GEO & OVERFLOW3) - EXISTING

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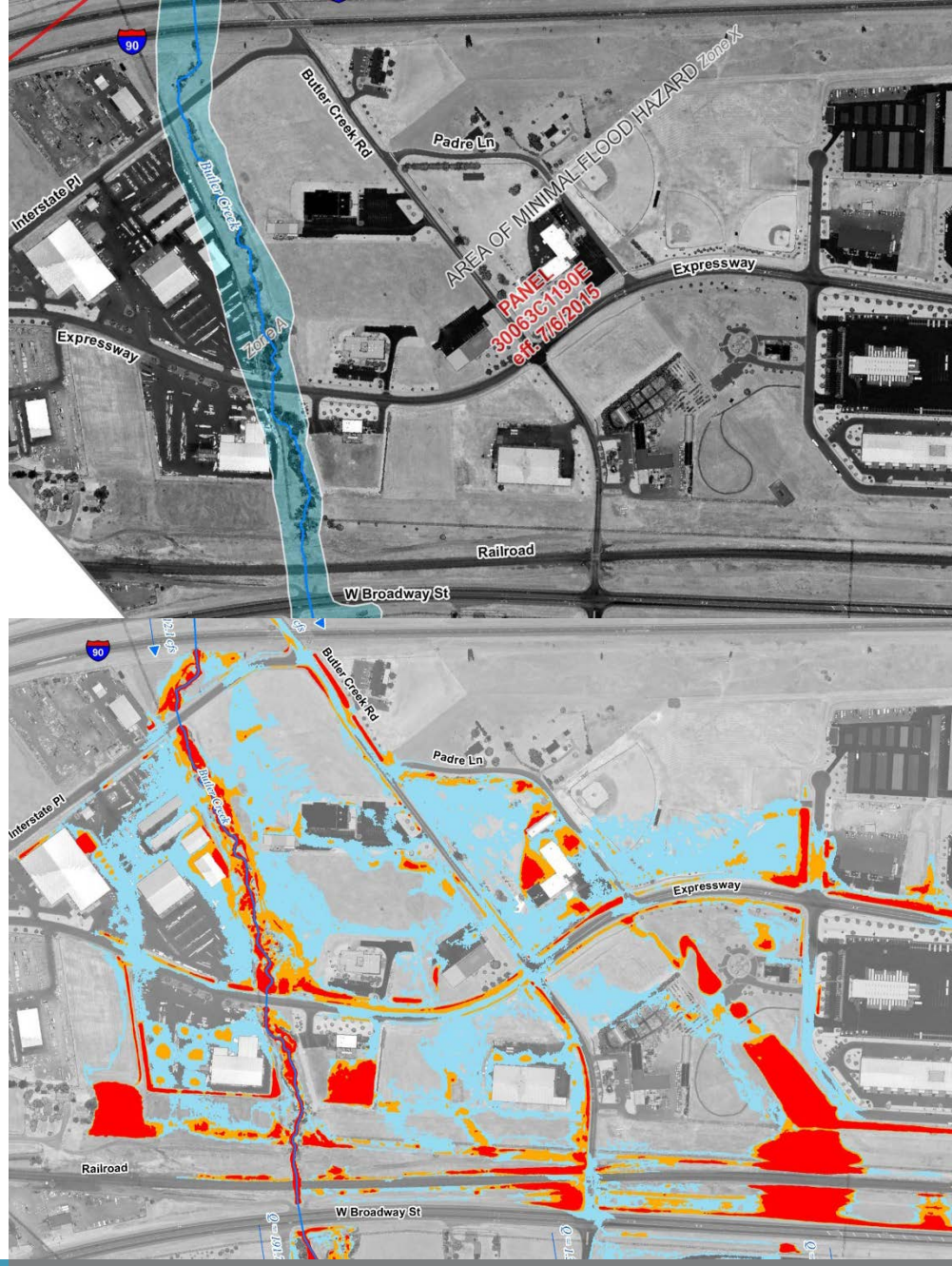
LESSONS LEARNED:
PIONEER PARK

Challenge: Using current standards to regulate multi-dimensional analyses

Solution: ???



Q&A

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