San Simon Barrier Dam Undergraduate Symposium Presentation

CENE 486C

UGRADS

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Project Introduction

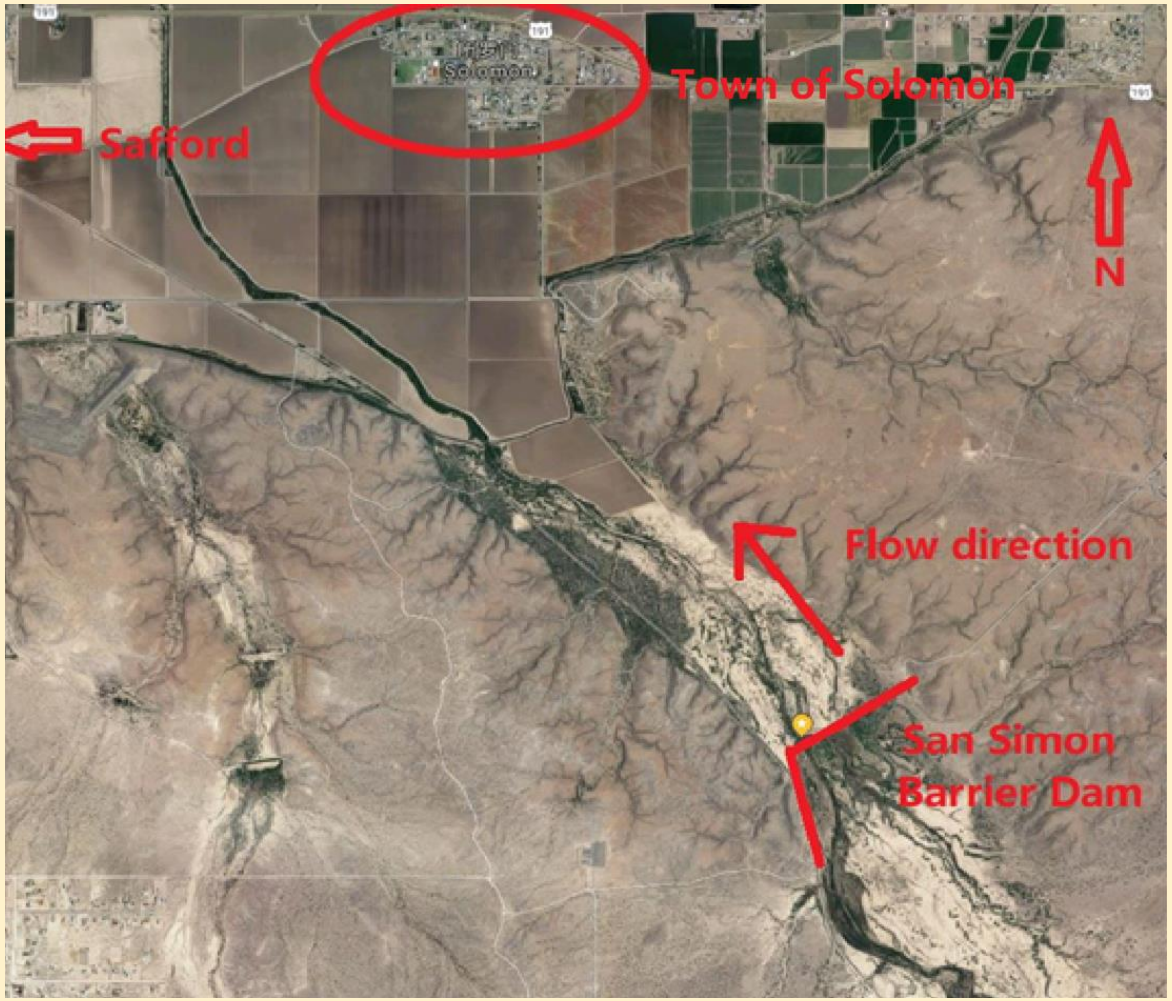


Figure 1. Map of Solomon and Safford Arizona in reference to the San Simon Barrier Dam. [1]

- Location: San Simon Barrier Dam Located near Safford in Southeastern Arizona
- Client: Bureau of Land Management (BLM)
- Flow analysis of unmaintained sediment structure
- Determine dam safety rating using FEMA rating tables
- Perform an economic analysis based on flood analysis results

Stakeholders

- Bureau of Land Management
- Town of Solomon, AZ
- Northern Arizona University
- The engineering team

Figure 2-3. Northern Arizona University logo and Bureau of Land Management logo. [2-3]

Reason for Project

- Evaluate the San Simon Barrier Dams FEMA safety rating
- FEMA rating is determined as a result of catastrophic dam failure
- Recommend a change in FEMA hazard rating to protect against possible flood damage

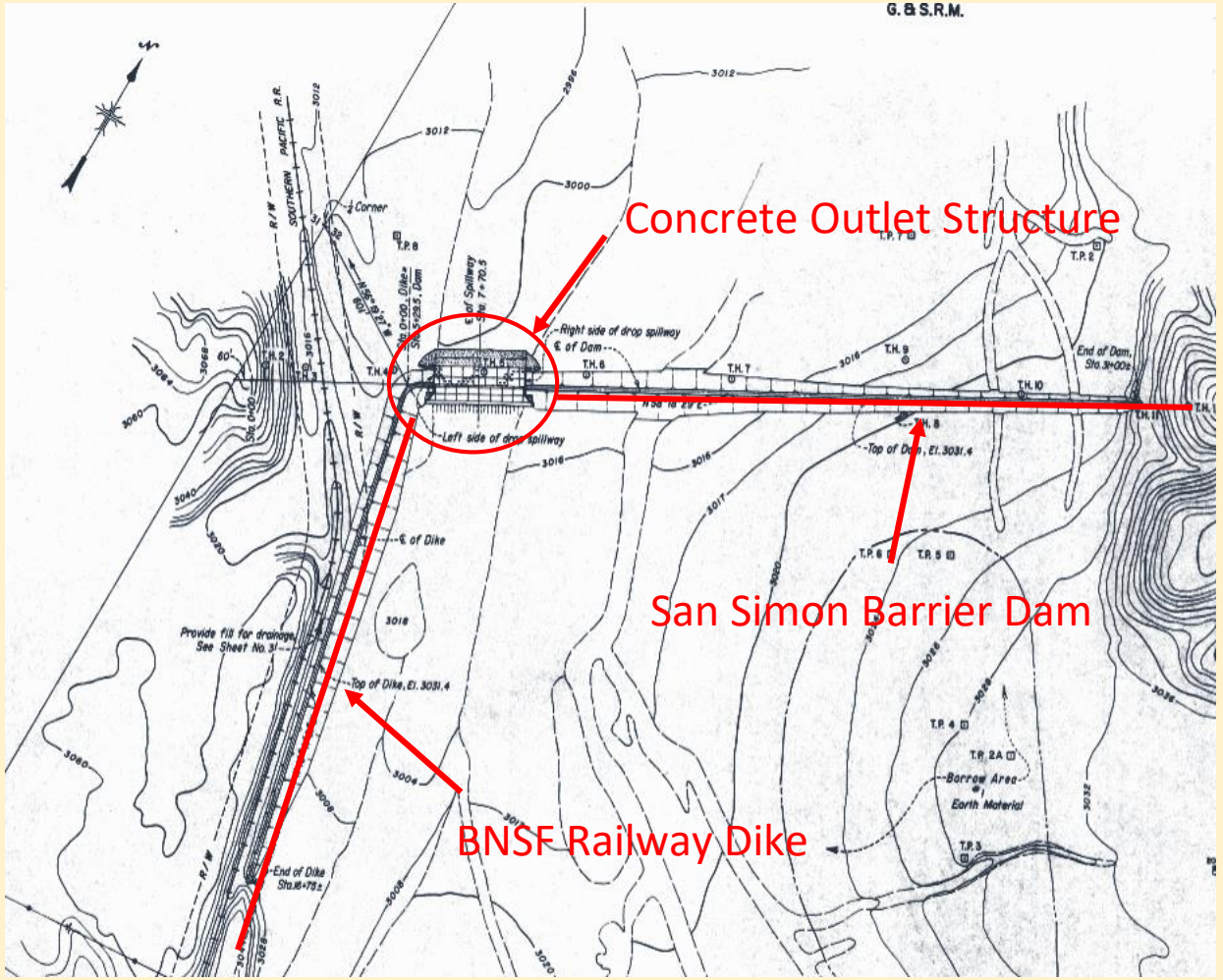


Figure 4. Original construction document from 1979 showing San Simon Barrier Dam from birds-eye view.

Field Work and Surveying

- Surveyed the dimensions of the San Simon Barrier Dam
- Investigated the local population distribution
- Investigated the local cropland distribution
- Recorded aerial video of the terrain and surrounding area

Figure 5. Picture of baffle blocks located in the San Simon Barrier Dam outlet structure.

Surrounding Area Video

Youtube link: https://youtu.be/DI5OZPxsAVo

Research and Construction Documents

- Hydraulic Analysis
  - Peak Flow determined to be 27,400 cfs
- Dam Geometry
  - Checked field surveyed geometry of the San Simon Barrier Dam with original construction documents

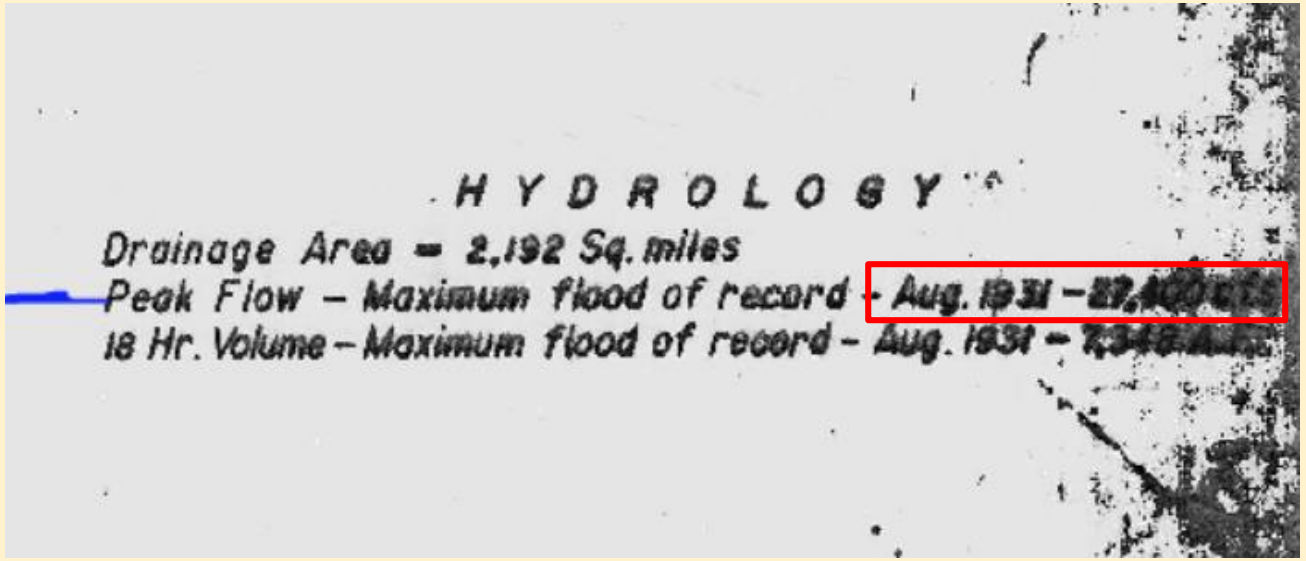


Figure 6. Original 1979 construction document from BLM containing the peak flow used for the hydraulic analysis.

Model Set Up in ArcMap

- ArcMap was used to convert NRCS 10 meter DEM files into usable HEC-RAS geometry files

- The HEC-geoRAS extension was used in ArcMap to establish:
  - River reach
  - Banklines
  - Flowpath
  - Cross sections

- Data was imported into HEC-RAS to run an initial dynamic flow event of 27,400 cfs

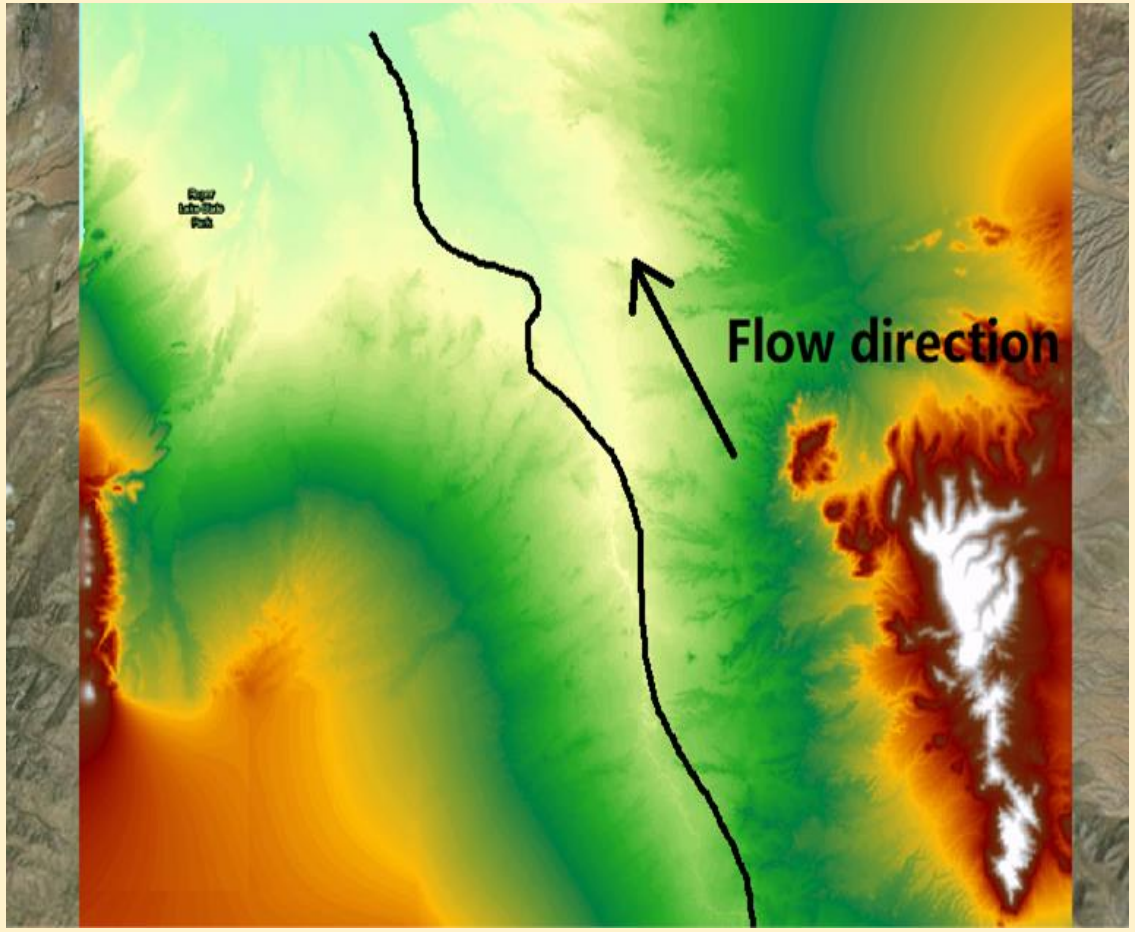


Figure 7. ArcGIS elevation map of San Simon Basin created using HEC-geoRAS extension as a raster image.

Model Setup in HEC-RAS

- The model used a Manning's coefficient of 0.06 as directed by the Flood Insurance Study in Graham County, AZ
- Model slope was determined by ArcMap for HEC-RAS
- Unsteady peak flow was set as one event flow hydrograph in order to set the initial dam flow

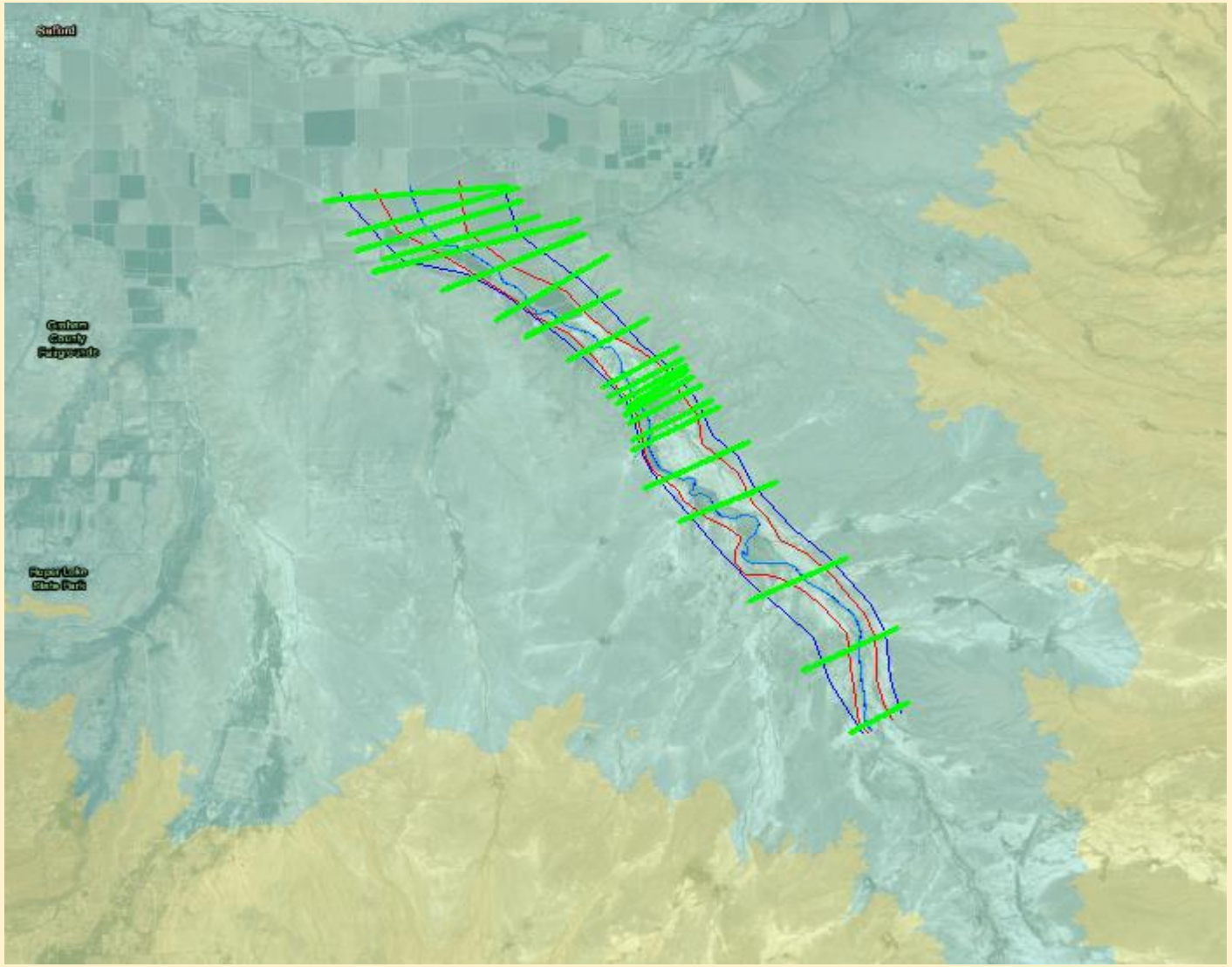


Figure 8. HEC-geoRAS input from ArcMap to HEC-RAS including river teach, bank lines, flowpath, and cross sections.

Flow Hydrograph for Dam Breach

- Initial flow was determined to be 365 cfs as the dams outlet structure capacity
- Dam breach hydrograph was determined by using the NRCS TR-60 & TR-66 calculator [9]
- The dam was removed from the model to simulate the effect of a catastrophic dam failure

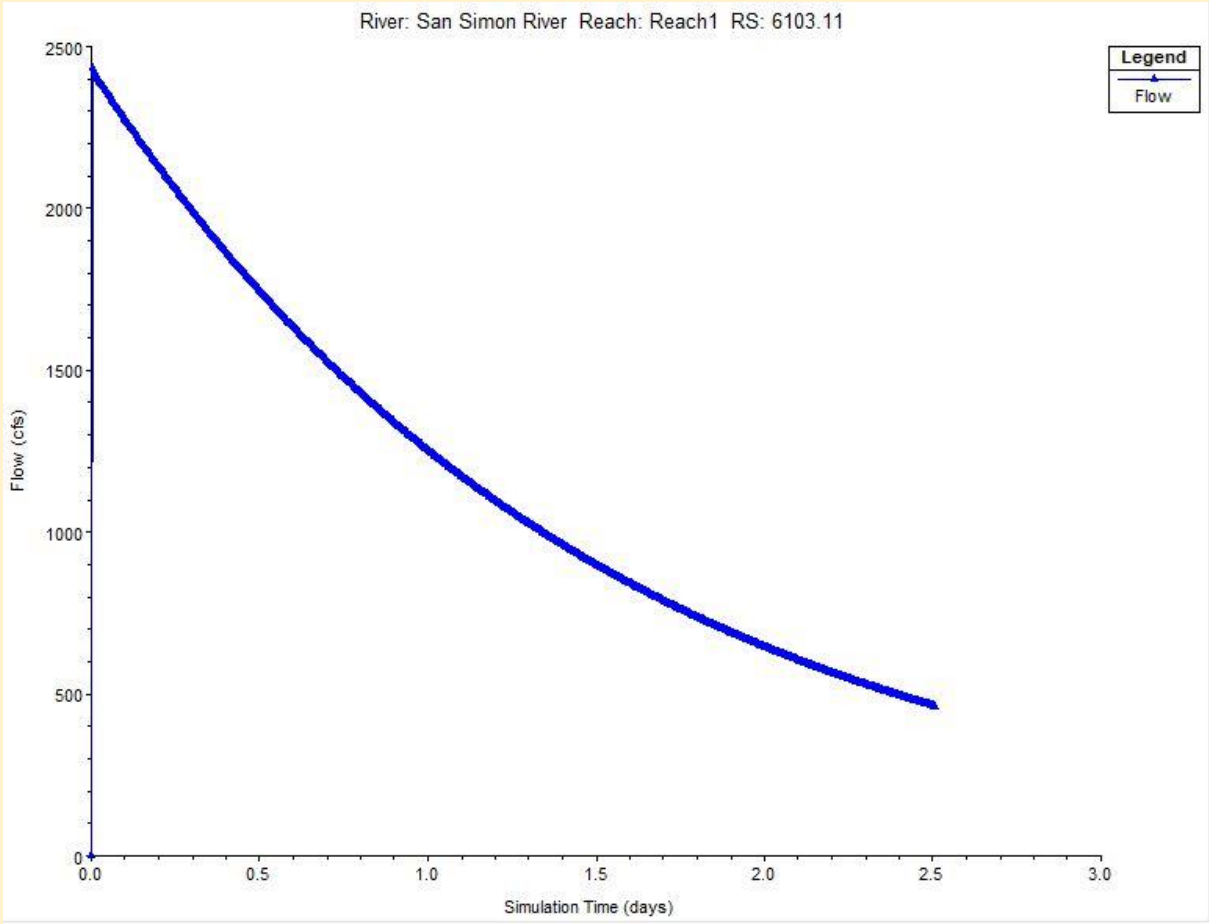


Figure 9. San Simon River dam breach hydrograph.

Dambreach Hydrographs via TRs 60 & 66 NRCS guidance

version 2, Mar 2017

Input data required:

data	variable	explanation
3023	crestEL	dam crest elevation
3020.2	wsEL	w.s. elev at time of breach
3100	TW	dam top width (feet)
3	SSup	dam side slope (upstream, SSup:1)
2	SSdn	dam side slope (downstream, SSdn:1)
3006	floorEL	valley floor elev
7267	Vs	resv vol at time of breach (acre-feet)
2460.63	L	valley width at dam axis & w.s. elev (feet)
3020.2	ELwave	top of wave berm elevation
2460.63	Wwave	width of top of wave berm feet
3	SSwave	wave berm side slope (SSwave:1)
3017	ELstab	top of stability berm elevation
2460.63	Wstab	width of top of stability berm (feet)
2	SSstab	stability berm side slope (SSstab:1)
6	ts	timestep (minutes) for breach hydrograph

output		breach hydrograph	
variable	results	time (min)	Q (cfs)
T	395	0	0
(L < T)?	N	6	2431
H_w	14.2	12	2418
Q_1	8803	18	2411
(H_w < 103)?	Y	24	2405
Awave	34940.946	30	2398

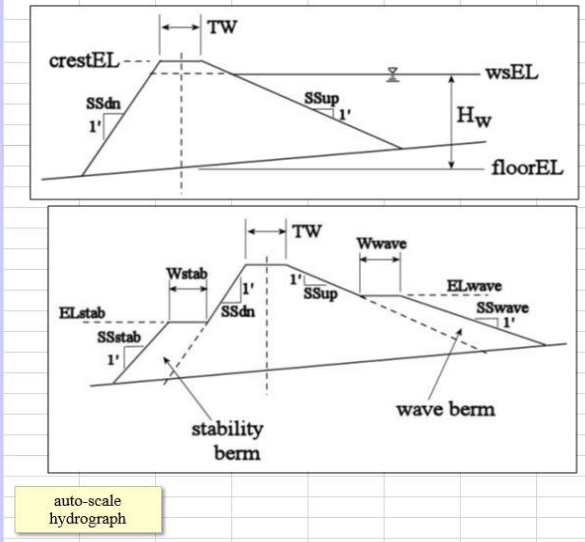
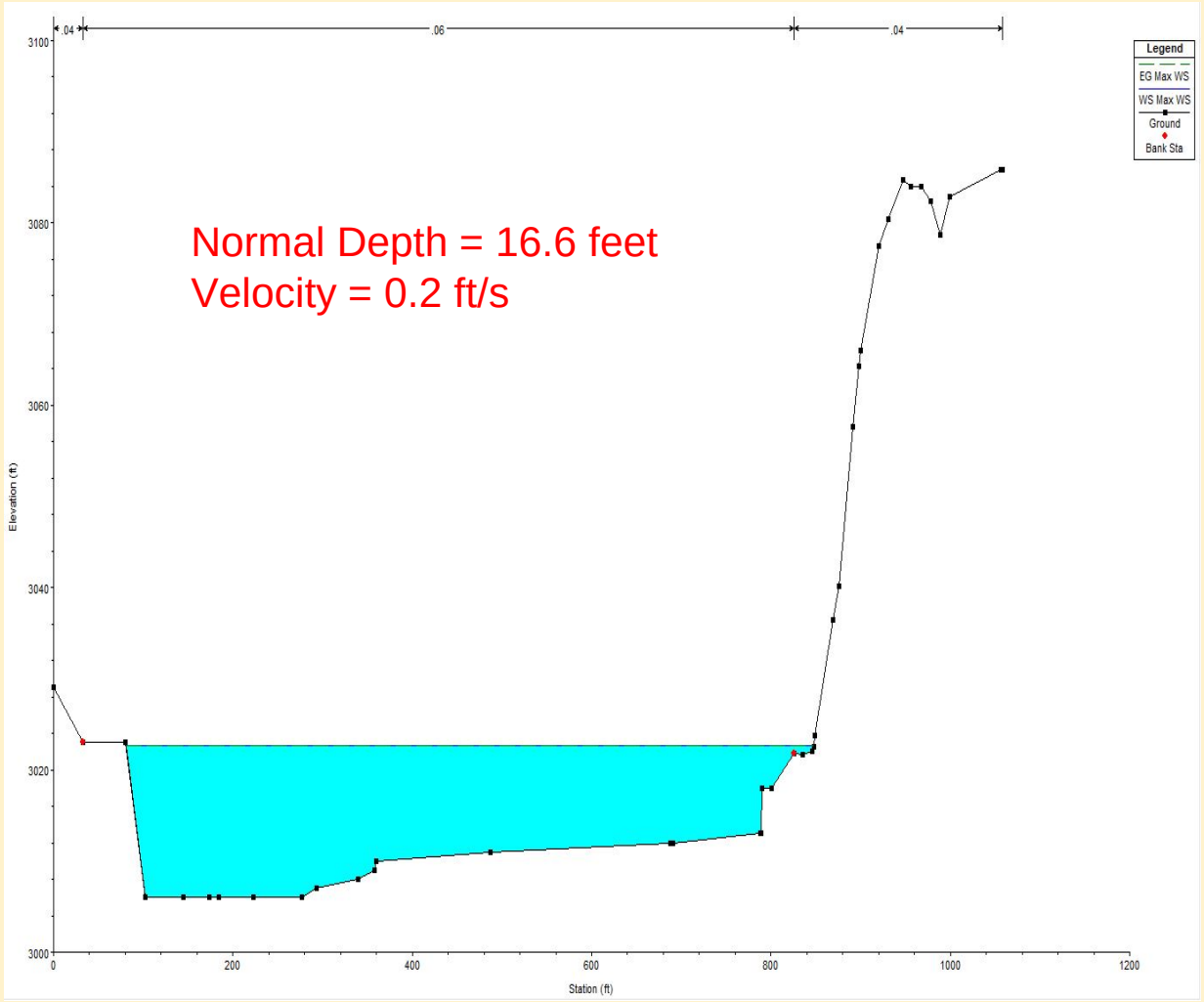


Figure 10. NRCS TR-60 & TR-66 dam breach hydrograph calculator. [9]

HEC-RAS Model Cross Sections Part 1



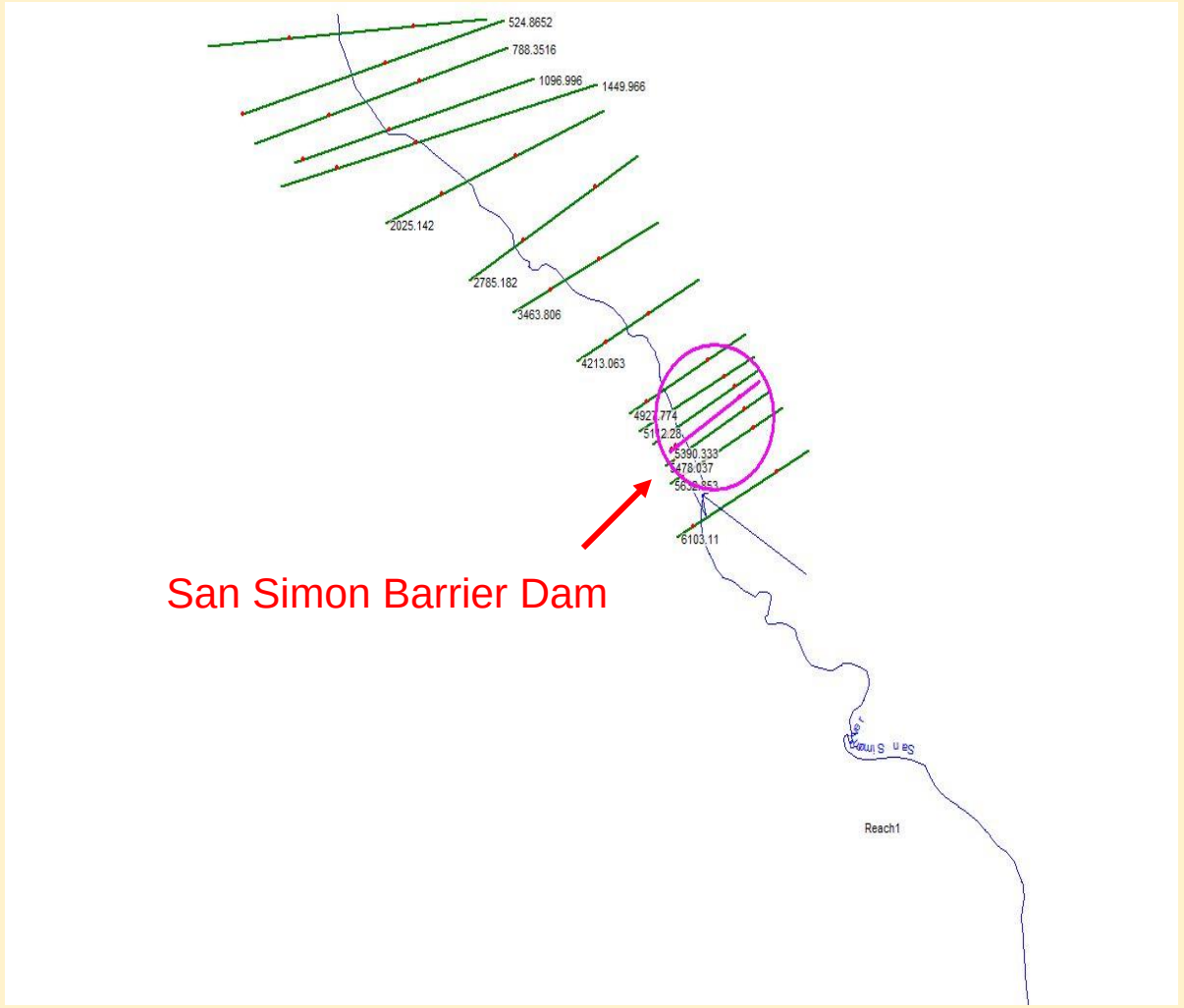
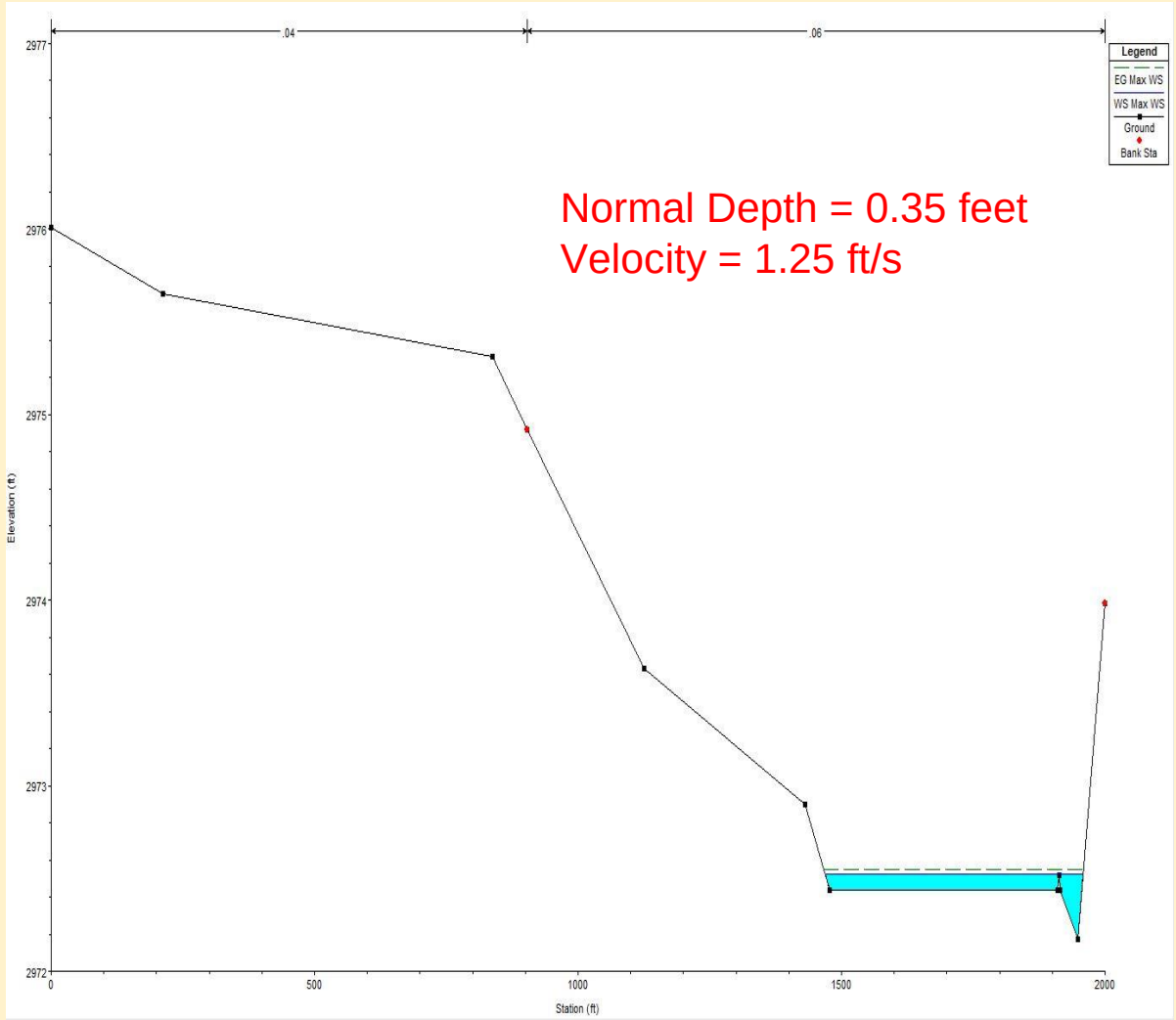


Figure 11-12. HEC-RAS cross section for STA. 5390 after the simulated San Simon Barrier Dam catastrophic breach and its location on the reach.

HEC-RAS Model Cross Sections Part 2



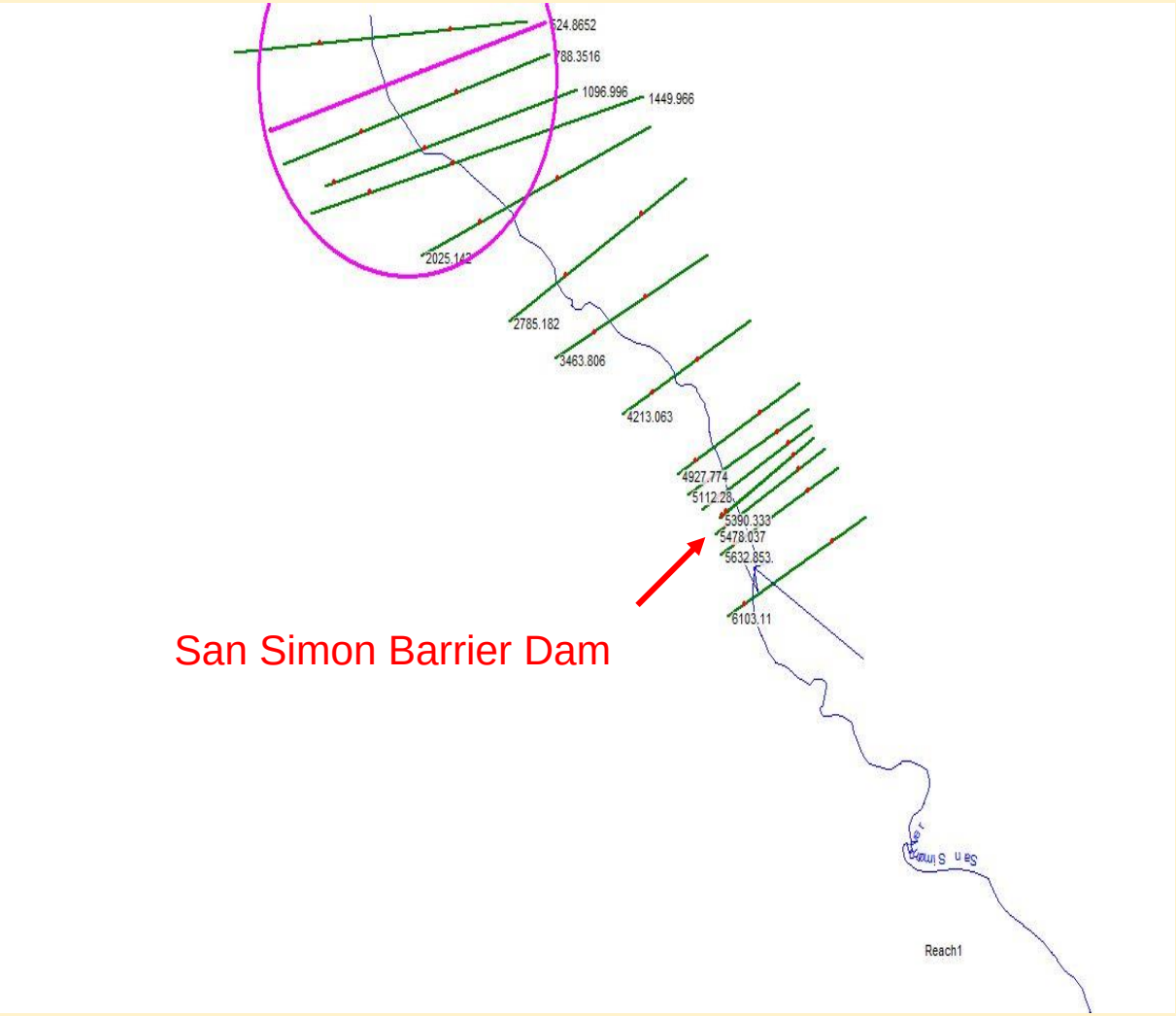


Figure 13-14. HEC-RAS cross section of the end of the reach at STA. 524 with its location on the reach in reference to the San Simon Barrier Dam

HEC-RAS Model Full Reach

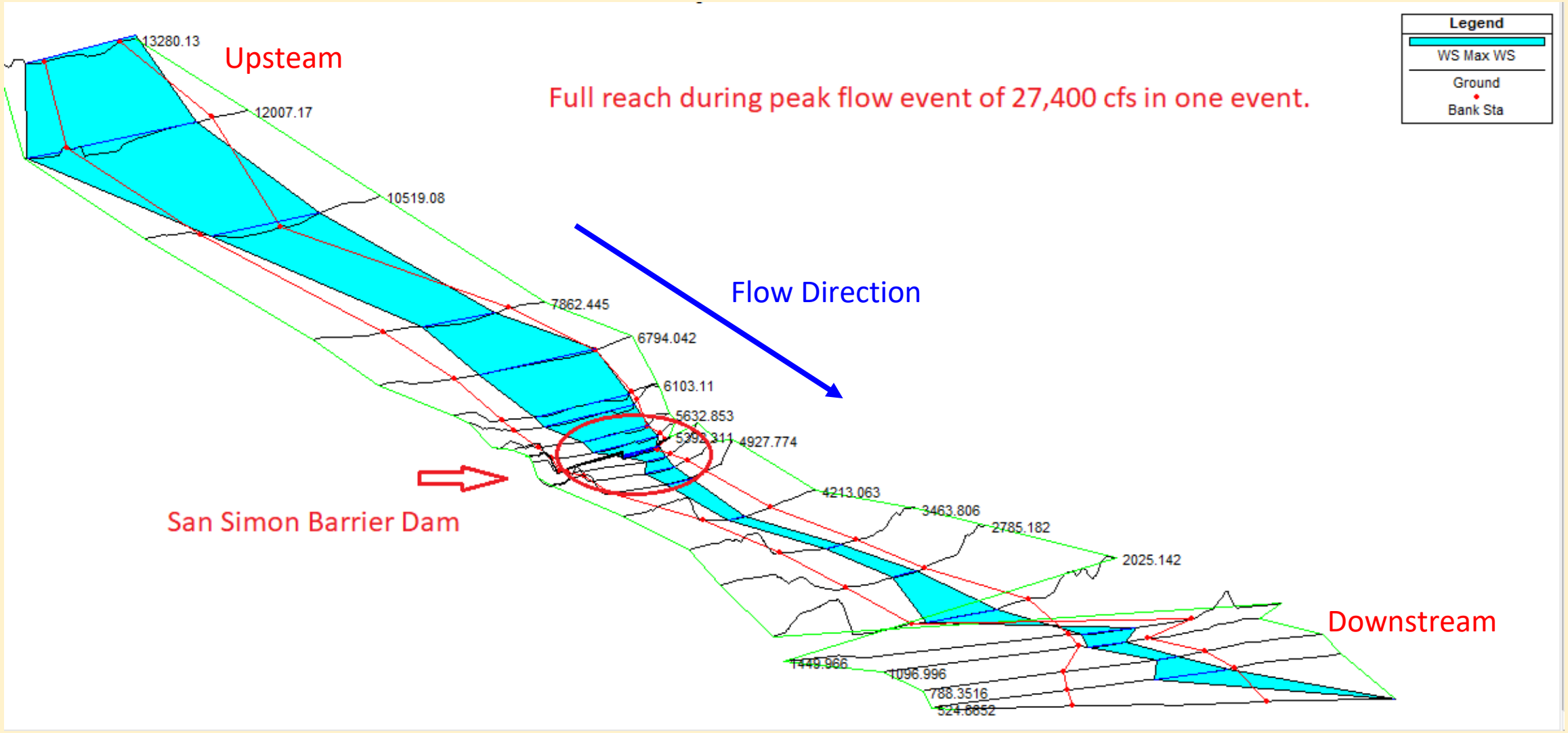


Figure 15. 2D rendition of HEC-RAS 1D unsteady state flow showing max water surface elevation along with banklines and flowpath.

HEC-RAS Peak Flow Event Results

- Max depth in San Simon Barrier Dam outlet structure was 14.2 feet deep which was used to calculate the initial flow of 365 cfs for the dam breach
- Average velocity of water was 1.25 ft/s (will not cause scouring)
- Water overbanks the cross sections downstream of the dam breach

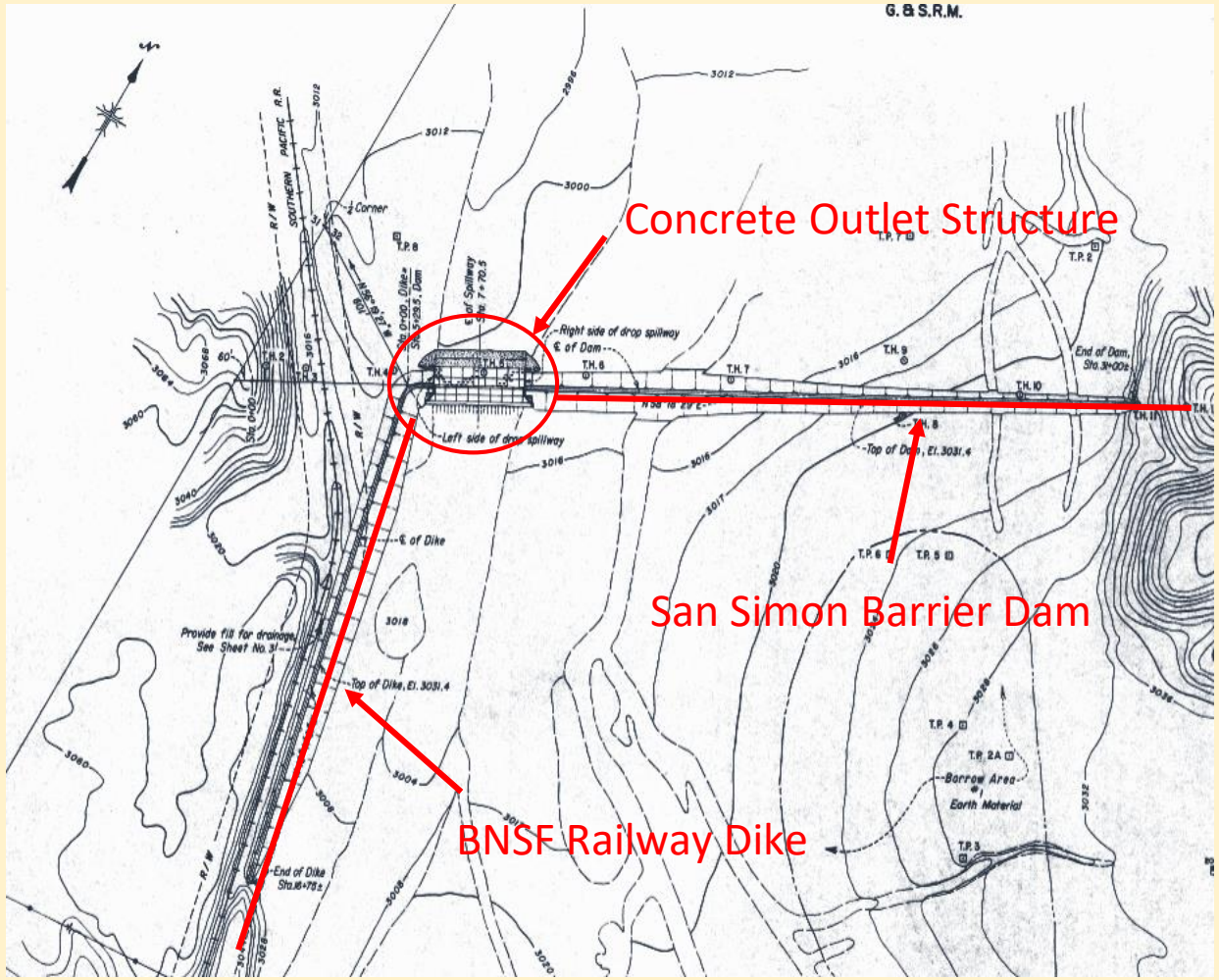


Figure 16. Original construction document from 1979 showing San Simon Barrier Dam from birds-eye view.

Economic Analysis System

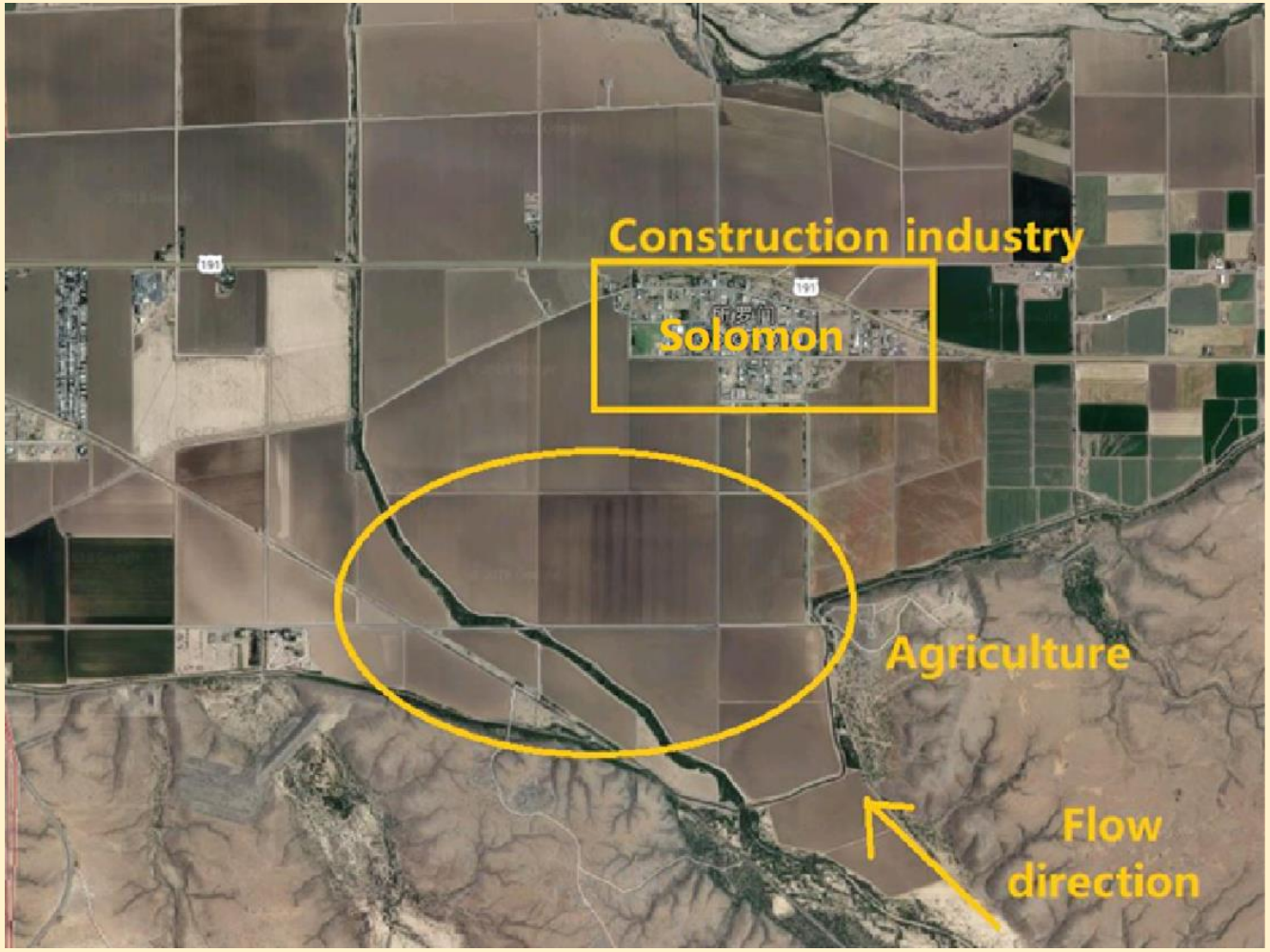


Figure 17. Affected area near Solomon, AZ [1].

- Cotton and Cottonseed: $655.68 / acre [8]
- Arizona average cropland value is $8,400 USD per acre in 2017 [7]
- Transportation structure.

Economic Impact Analysis Method

Table 1. Criteria of zoning and rates of Property Damage of areas inundated by dam-break flood(RESCDAM) [5]

Area category	Zoning Standard			Property loss rate%	Indirect loss factor(λ / %)
	Submerged depth(ft)	Maximum flow rate(cfs)	Flooding duration(h)		
Breakout area	>10	>70.0	>12	100	60
Destruction Area	6.8-10	>70.0	>12	90	57
Severe disaster area	3.4-6.8	35.0-70.0	>24	Calculated with general flood property loss rate	50
Moderate disaster area	1.7-3.4	17.5-35.0	>120		45
Light disaster area	0.34-1.7	3.5-17.5	<48	10	30
Safe area	0-0.34	0-3.5	<0.5	0	10

Dam breach economic loss formula [#]: $S = \alpha W (1 + \lambda)$

- S is the dam economic total loss ($);
- α is the dam flood loss property loss rate;
- W is the property value ($) in the submerged area;
- λ is the indirect economic loss conversion factor of dam break;
- αW is the direct economic loss caused by dam collapse.

Final design

The depth in agriculture field is 0.35 ft. 300 acre cropland is impacted.
Total economic loss: 25576 USD

Table 2: Hazard Ratings and Qualifying Criteria, ADWR Standards [6]

Hazard Potential Classification	Loss of Human Life	Economic, Environmental, Lifeline Losses
Low	**None expected**	**Low and generally limited to owner**
Significant	None expected	Yes
High	Probable. One or more expected	Yes (but not necessary for this classification)

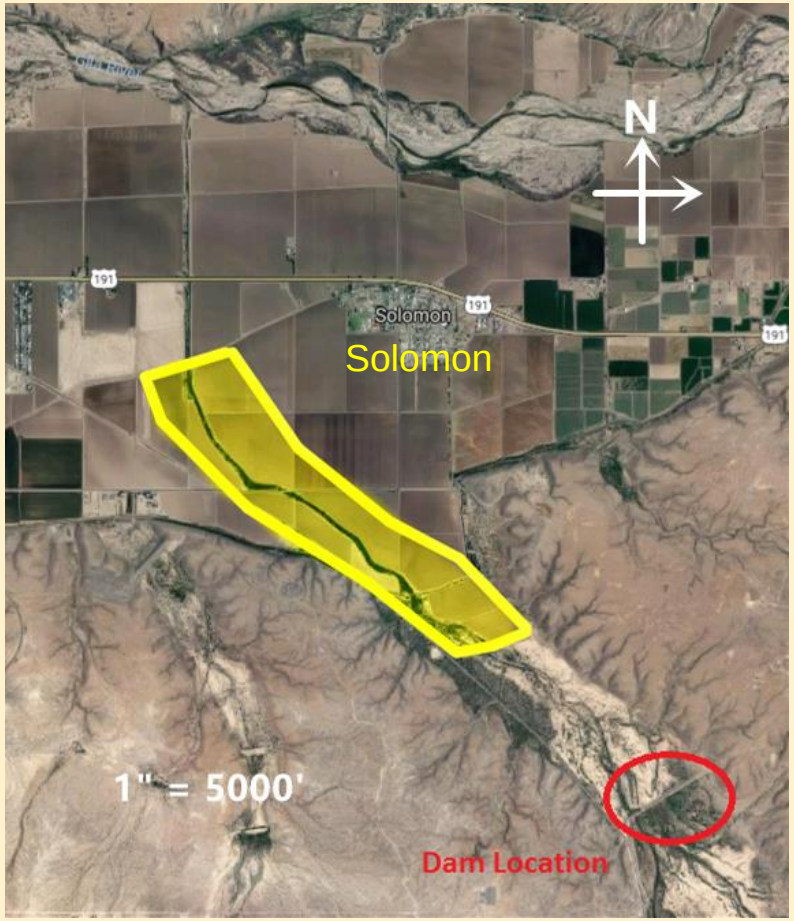


Figure 18. Affected area near Solomon, AZ [1].

Project Staffing Hours And Cost

Table 3: Actual Staffing Costs

	Cost Per Hour	Estimated Time (Hours)	Estimated Cost For Project	Actual Used Time (Hours)	Actual Cost For Project
Principle	$92.75	86	$7,976.50	100	$9,275.00
Manager	$95.50	137	$13,083.50	40	$3,820.00
PE	$30.00	27	$810.00	200	$6,000.00
EIT	$50.50	86	$4,343.00	75	$3,787.50
Drafter	$37.75	62	$2,340.50	10	$377.50
Intern	$22.50	60	$1,350.00	75	$1,687.50
Survey	$41.25	140	$5,775.00	12	$495.00
Admin	$35.50	1	$35.50	5	$177.50
	Total:	599	$35,714.00	517	$25,620.00

Schedule Proposed vs. Actual

Table 4: Schedule of Project

Task #	Task	Original		Actual	
		Start	Finish	Start	Finish
1.0	Field Investigation	1/17/2018	1/21/2018	1/18/2018	1/18/2018
2.0	Hydrology	1/22/2018	1/26/2018	1/19/2018	4/9/2018
3.0	Hydraulic Analysis	1/27/2018	3/30/2018	3/17/2018	3/28/2018
4.0	Eco-Economic Impact	3/20/2018	4/10/2018	4/4/2018	4/22/2018
5.0	Project Deliverables	4/15/2018	4/28/2018	4/15/2018	

:Finished
:Processing

Acknowledgments

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  - Mark Lamer
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  - Dianne McDonnell
  - Bill Mancini
- **Technical Advisor:** Dr. Wilbert Odem
- **Client:** Bureau of Land Management office in Safford, Arizona

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