Hillside Mine

Bureau of Land Management

CENE 486 Section 1

Final Report

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1.0 Project Understanding

1.1 Project Purpose

The purpose of this project is to identify and map the potential damage to the Hillside Mine waste repository cap in the event of a catastrophic flood. Due to recent changes in yearly weather patterns the possibility of a 500 year event is greater.

Arizona has been in a state of drought for fifteen years. The potential for wildfires is greatly increased versus years with average precipitation. Given that the Boulder Creek watershed extends into higher forested elevations, the possibility for fire damage on Bozarth mesa may also be a concern. Flash flooding is much more likely in areas affected by devastating fires.

Another concern is from higher than average precipitation. Arizona is expected to have one of the strongest El Nino weather patterns on record towards the end of the 2015 winter [1]. Additional precipitation could create oversaturation of soils, increasing the chance for localized flooding in the area. There is a direct relationship between rainfall and erosion on the cap. The goal of this project is to identify the potential and probability of an event causing damage to the Hillside mine cap. If the current containment design is found inadequate, the project may lead to future designs.

The main objective is to keep contaminants, such as heavy metals and acids, out of Boulder Creek. The problem to solve is erosion. The hydraulic study contained within the scope of this project will identify the capacity of erosion to the waste repository cap.

1.2 Project Background

The Hillside Mine is located in the Eureka Mining District in Yavapai County, Arizona. It is located in a mountainous region in the mid-western portion of Arizona. The mine site is five miles north of Bagdad, Arizona, which makes it in close proximity of a small town.

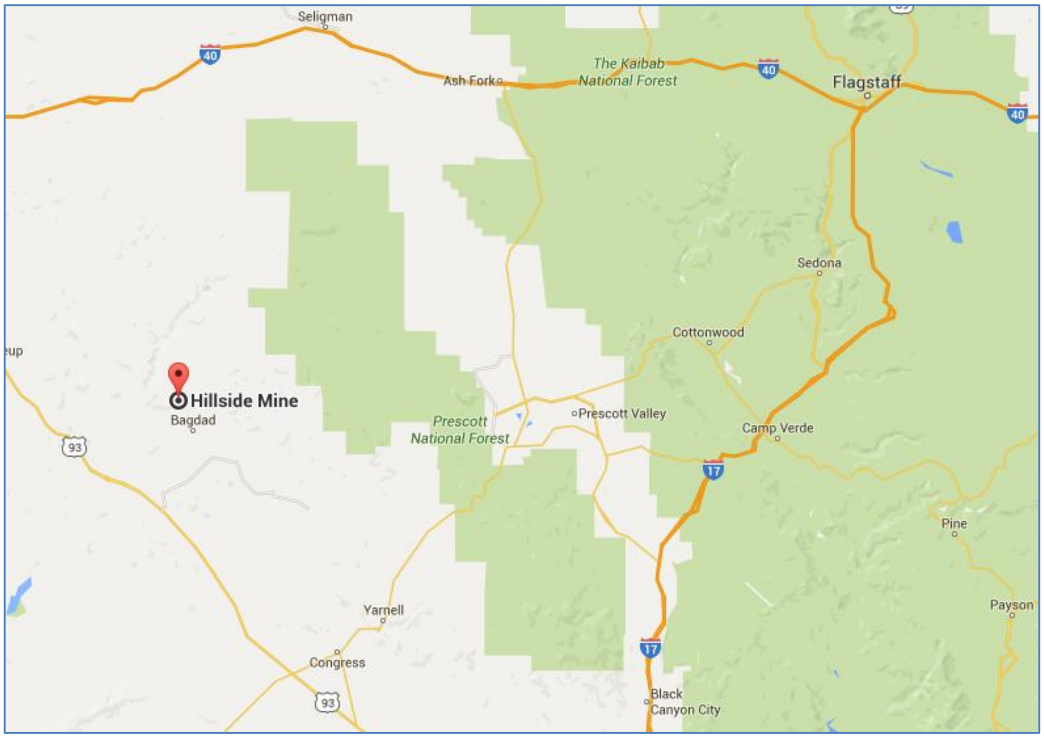


Figure 1.1: Site Location

Boulder Creek is an intermittent stream starting at Camp Wood Mount and extending approximately 37 miles southeast. As seen in figure 1.2, the location of the site is found in the Bill Williams Watershed (#4 on map).

Figure 1.2: Arizona’s Watersheds. [9]

A closer look at the sub-watershed can be seen in figure 1.3. Before the cap was placed on the Upper Tailings pile, Boulder Creek was in danger of contamination issues due to erosion of the tailings. The current cap safely controls the erosion issues around the creek. The location of this particular site makes it difficult for vehicles to reach area which acts as a benefit considering recreational activity around the site may cause damage and decrease the lifespan of the engineered cap.

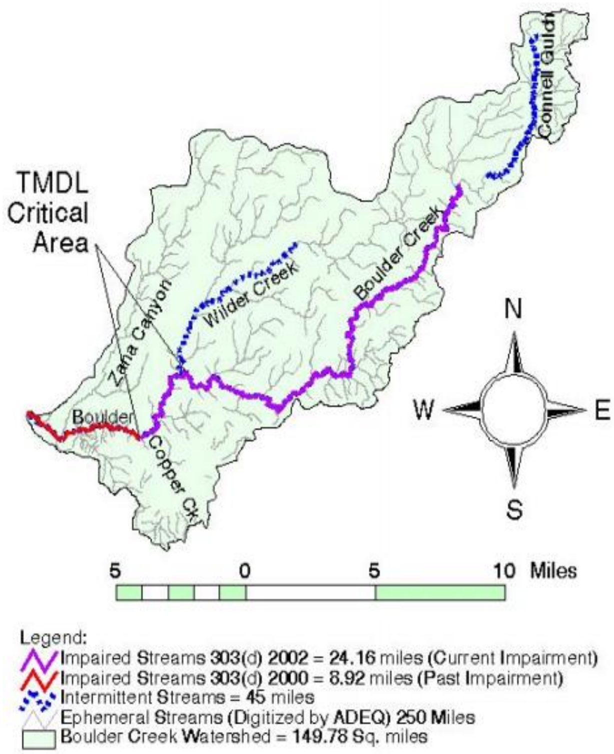


Figure 1.3: Boulder Creek Watershed. [9]

1.3 Technical Description

The project is heavily based in the hydrology field of engineering. Considering that the Boulder Creek watershed is approximately 138 square miles and the flow depends heavily on winter storms and spring snowmelt, hydraulic modeling systems are required. [6] The US Army Corps of Engineers developed a program called HEC-RAS (Hydrologic Engineering Centers River Analysis System) which allows one to perform one-dimensional steady flow, unsteady flow, sediment transport, and water temperature modeling. This modeling system will provide the information needed to anticipate how the stream will act under a catastrophic storm event.

Along with hydrology, the project also includes a geotechnical aspect. Knowing the land and the soil around the stream will lead to more precise erosion results. Since the stream will be analyzed under a 500 year storm, erosion is cause for concern. Too much erosion around the stream could possibly cause failure of the cap, which would release containments into Boulder Creek.

1.4 Potential Challenges

In order to establish the erosion potential of the mine surveying must be performed over a large area. Many hours will be spent gathering the necessary data to map the area. The elevation of the mine is around 3000 feet above mean sea level [6]. In Arizona this elevation can reach temperatures well above 90 degrees Fahrenheit for summer months. Day and night temperatures can vary by 40 degrees. Winter temperatures can drop well below freezing. Crews must be prepared for this environment.

Other potential challenges when conducting this hydraulic study include steep terrain, weather, general access, and contact with plant and animal life. Rain and snow are considerations for access to the mine. The roads are primitive and subject to washouts, and could become too muddy for travel.

The elevation of the mine is around 3000 feet above mean sea level. In Arizona this region contains a range of potential risks. Local wildlife includes venomous snakes, poisonous spiders and scorpions. Cactus and chaparral can create difficulty when traversing rough canyon country. In addition the terrain is steep and rocky which adds difficulty when conducting a survey.

1.5 Stakeholders

The stakeholders consist of the Bureau of Land management, taxpayers, and local populations of the nearby mine, which in this case is the City of Bagdad. Additionally, any living organism within the watershed may be affected.

The BLM is a stakeholder because they are the organization that is trying to manage land on which the mine is located. The living organisms within the watershed have a stake in this project because their livelihood will be affected if the stream overflows and the cap's integrity on the mine becomes compromised.

The contamination by mining is directly hazardous to people that participate in recreational activities at the Hillside Mine or Boulder Creek. Secondly, local ranching operations may also be affected by these contaminants. For example, cattle may use the Boulder and Burro Creek as a primary water source. Therefore, it can be said that the contamination released from mining has adverse impacts on almost all direct and indirect stakeholders.

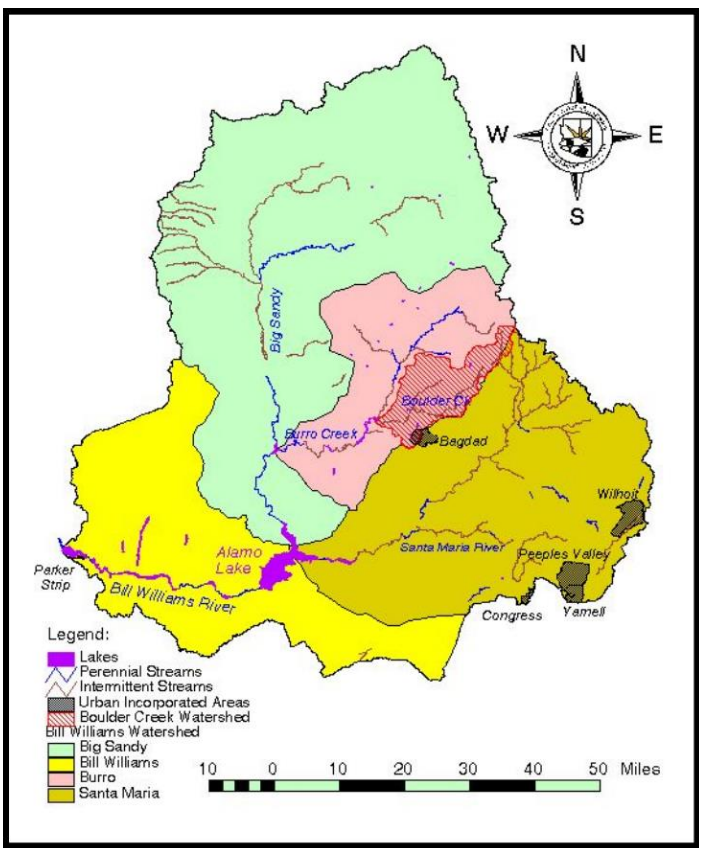
2.0 Technical Sections

2.1 Task 1: Data Collection

Data gathered included: USGS stream data for Boulder Creek, precipitation data, Site Observations, and Survey data from the critical stream section.

2.2 Task 2: Establishing Flows for Analysis

The greatest difficulty in analysis of flows in Boulder Creek is a lack of data. Stream gauges are not established in this particular drainage. The best source of comparable stream gauge data in the area is Burro Creek. The contributing drainage, which includes Boulder Creeks, is 601 square miles. Elevations are similar when comparing the two watersheds so a relationship can be assumed when comparing flows. The drainage area for Boulder creek is approximately 4 times smaller than the Burro Creek area so adjustments for flow data were made. Figure 2.2 shows the watersheds in relation to each other. Boulder Creek watershed is in pink while the Burro Creek watershed is hatched in red. Table 2.1 contains the peak flows recorded from 1980 to 2014 for the Burro Creek USGS gauging station. Ten years are not recorded due to damage to the gauging stations. Twenty four years of peak flows are recorded in table 2.2



Figue 2.1 Burro and Boulder creek watersheds [9]

Table 2.1: Mohave County, Arizona
Hydrologic Unit Code 15030202
Latitude 34°32'30", Longitude 113°26'40" NAD27
Drainage area 611 square miles
Contributing drainage area 601 square miles
Gage datum 1,880 feet above NGVD29

Year	Date	Gauge Height	CFS
1980	Feb. 14, 1980	15.60	47,400
1981	Sep. 05, 1981	5.00	728
1982	Feb. 11, 1982	8.37	5,400
1983	Mar. 03, 1983	13.70	30,600
1984	Aug. 24, 1984	7.73	3,950
1985	Dec. 27, 1984	10.24	12,400
1986	Nov. 30, 1985	8.63	6,210
1987	Mar. 05, 1987	5.14	565
1988	Aug. 27, 1988	8.70	6,410
1989	Jan. 05, 1989	5.52	798
1990	Sep. 18, 1990	6.13	1,410
1991	Mar. 01, 1991	13.71	29,900
1992	Feb. 13, 1992	10.87	12,300
1993	Feb. 08, 1993	16.30	55,300
2004	Sep. 19, 2004	13.15	21,200
2005	Feb. 11, 2005	16.48	44,600
2006	Sep. 09, 2006	6.63	1,510
2007	Sep. 22, 2007	9.04	5,700
2009	Dec. 26, 2008	12.86	21,800
2010	Jan. 21, 2010	17.32	50,900
2011	Mar. 02, 2011	7.07	1,650
2012	Aug. 21, 2012	6.97	5,890
2013	Sep. 11, 2013	7.80	2,000
2014	Aug. 26, 2014	9.82	7,910

Using the peak flows a scatterplot was formed to graphically analyze the data. Frequencies ranging from two to twenty five years were estimated vs. flows. This established grouping of data points to indicate the average flows at 2,5,10 and 25 years.

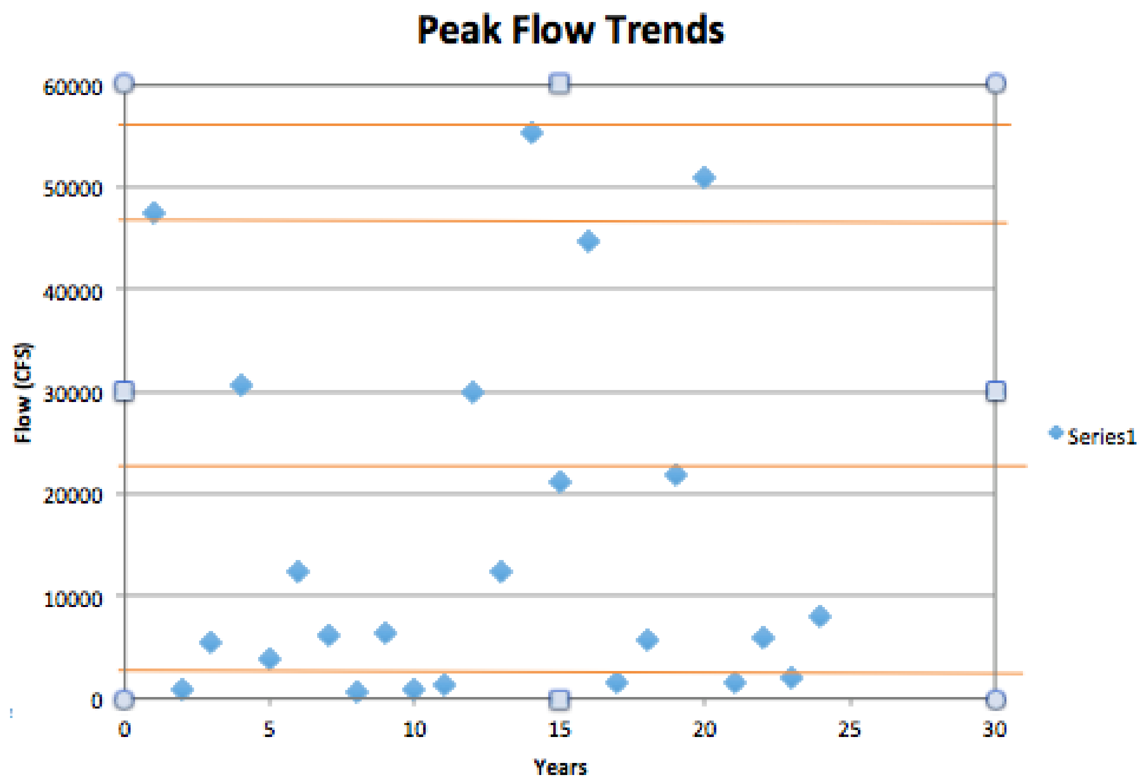


Figure 2.2: graphical analysis

After establishing the flood frequencies up to 25 years a plot was made to show peak flows for events of 2, 5, 20, and 25 years. A best fit line and equations for that line indicates a logarithmic function is best model for flows. Using the line equation, 500 and 1000 year flows can be estimated. The graph of Burro creek peak storm events can be seen in fig. 2.3. Table 2.2 shows the extrapolated flows up to 500 years.

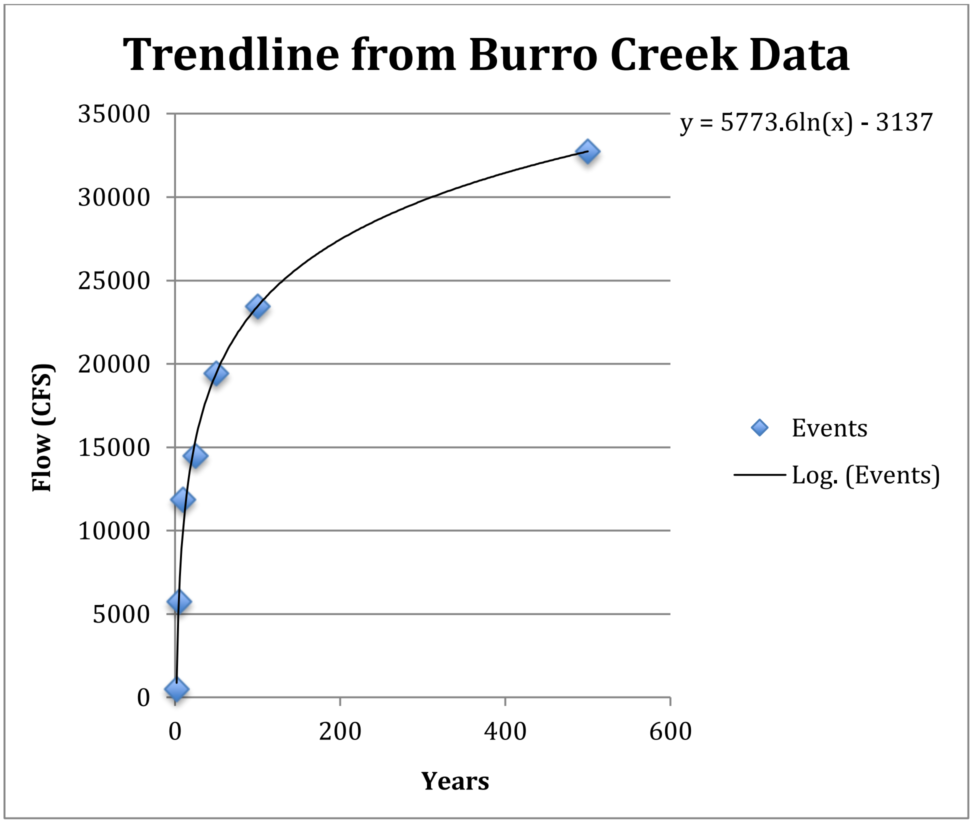


Figure 2.3 Graph of flood events

Storm Event	Flow (CFS)
2	500
5	5750
10	11875
25	14500
50	19449
100	23451
500	32744

Table 2.2 flows using Burro Creek gage station data

Another method of analysis requires using National Flood Frequency equations. These equations were developed for the United States Geological Survey in 1999. Regression equations are used for regions based on topogropy, geology and vegetation types. These equations only require an area in square miles and an average elevation. The average elevation was established at 5000 feet in elevation and the area was calculated at 137 square miles.

$$Q_{25} = 942(AREA)^{0.630}\left(\frac{ELEV}{1000}\right)^{-0.383}$$

Equation 1: sample regression equation.

Once flows were calculated for 2, 5, 10, 25, and 100 years they were graphed vs. time. A best fit line and equations were then used to evaluate flows up to 1000 years. Figure 2.4 shows this graph. Table 2.3 shows the extrapolated flows using the line equation.

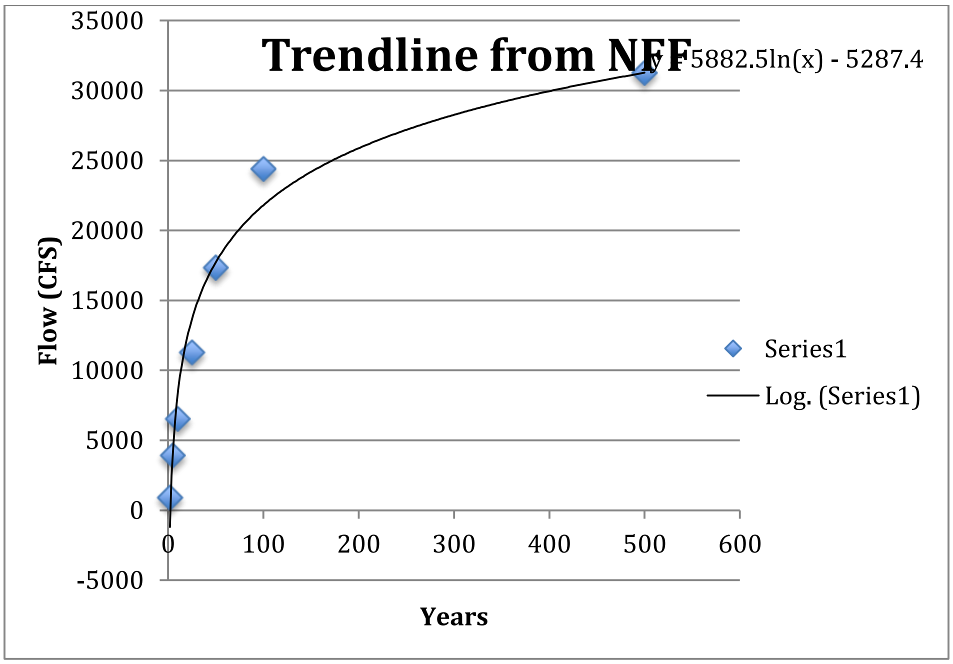


Figure 2.4: Graph of flood events using NFF equations

Storm Event	Flow (CFS)
2	907
5	3929
10	6524
25	11284
50	17349
100	24410
500	31270
1000	35347

Table 2.3: estimated flows from NFF equations

Both methods of analysis showed similar flows. The estimations using the NFF equations were comparable to the actual peak flows in the area giving a high level of confidence in the estimated flows for Boulder Creek. Averaging the two methods gives a 500 year flow estimate of 32,000 CFS for analysis HEC-RAS

2.3 Task 3: Survey

Surveying was conducted north of the Hillside Mine inside of Boulder Creek. There is only a 120 yard span of Boulder Creek that has the potential of compromising the mine cap’s integrity. The total station was setup along the thalweg of Boulder Creek just 45 feet north of the mine cap and towards the western part of the 120 yard span. The second total station setup was towards the eastern part, which allowed hidden sections of the creek to be captured. Survey data was collected throughout Boulder Creek, which included the banks, thalweg, and other critical points that can contribute to the development of the topographic map of the project site. Prisms and prism rods where used to collect the survey points. The survey points were stored into a data collector which connects to the total station and allows the input data to be matched between the two devices. The data was extracted from the data collector onto a PC where AutoCAD Civil 3D can process the data.

2.4 Task 4: AutoCAD Drawings

The surface created by the survey data is shown in the Appendix. With an area of 230,000 sq ft. and a length of approximately 700 yards along the thalweg, this surface shows the most critical section along the tailing pile. An elevation model of surface was also created as another visual where one can see the elevation difference as shown in the appendix. A profile drawing of the thalweg can be seen in the Appendix. The alignment shows that the thalweg has an approximate 1.5% slope. The three cross sections shown in the Appendix correspond to their labels. The cross sections represent upstream, center, and downstream. As seen in the drawings, the side slopes reach a vertical height of approximately 60 ft. from the stream bed. This is a good sign considering the stream channel needs to hold a 500-year flood event.

2.5 Task 5: HEC-RAS

The geometric data from AutoCAD as well as the flow data were inputted into the HEC-RAS program. Along with using the cross sections from our AutoCAD surface, and average slope and manning's roughness coefficient were implemented. An average slope of 1.5% was used and a manning's coefficient of 0.035. HEC-RAS used all the data provided and created the models, as seen in the Appendix. The main objective of these models is to make sure that the calculated flow does not exceed the cap boundary line. The 100-year flow of 24,000 cfs did not come close to the cap line with approximately 40 vertical feet to spare. The 500-year flow event as requested by the client resulted in a flow of 30,000 cfs. This flow did not cause any overtopping and had approximately 30 vertical feet to spare before hitting the cap line. Overtopping will not be an issue with any of these storm events. Each model can be seen in the Appendix. KASH Engineering has determined that the site is not in danger of overtopping. Although the storm events do not reach the cap line, the high amounts of energy of a stream flowing at this rate could cause undercutting and possible erosion issues.

2.5 Task 6: Project Management

2.5.1 Subtask 5.1: Client Interaction

Kash Engineering will work closely with the client and notify the client of progress throughout the span of the project. Kash Engineering will also communicate with the client to ensure the project tasks that have been stated are completed.

2.5.2 Subtask 5.2: Team Management

The project workload will be divided throughout the Kash Engineering staff. Based on personal qualifications, workload, and available time, individual tasks will be completed in the most efficient manner possible. The team will peer review all aspects of this project to ensure quality and consistency throughout the process.

3.0 Schedule

The project schedule is displayed below in figure 3.1

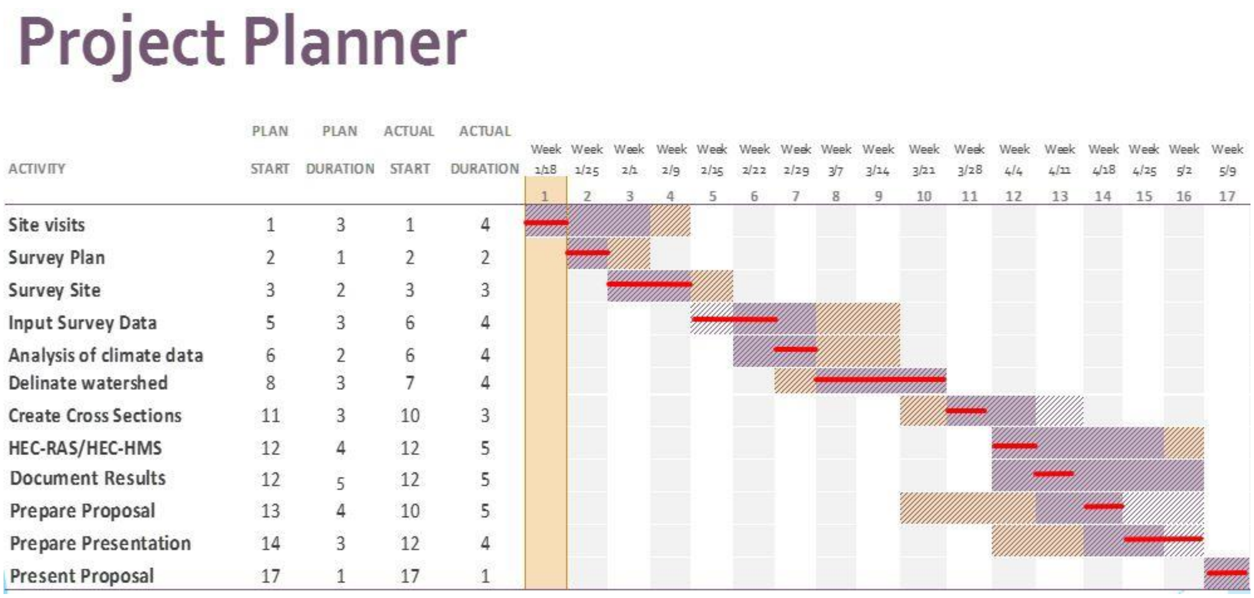


Figure 3.1: Project Schedule

The project will begin on the Jan 19th and be completed by May 16th. These tasks are essential to the completion of the project but are not entirely dependent on each other. The red line indicates the critical path of the project.

4.0 Staffing Plan/Cost of Engineering Services

This section includes an explanation of the positions required and the cost of service to complete the project

4.1 Staffing

Surveyor: The project surveyor is responsible for recording exact measurements of Boulder Creek.

Project Engineer: The Project Engineer is responsible for reviewing all project work and will determine that all client requirements are met. The Engineer will maintain a safe working environment by enforcing proper procedures and regulations.

Hydrology Analyst: The Hydrology Analyst will perform all hydraulic and hydrologic modeling.

Project Manager: The project manager will oversee the project from beginning to the end. The project manager will ensure the project is moving along according to plan and all tasks are being completed.

4.2 Cost of Engineering Services

Figure 4.1 shows the cost breakdown for the project. The estimated personnel costs for each position is shown along with number of hours per task each position will be working. Overhead is included in these billable rates. Additional expenses include travel costs and lodging. Figure 4.1 displays the cost analysis in detail.

Figure 4.1: Cost Breakdown for Project

1.0 Personal		Tasks													
		1		2		3		4		5					
Title	Rate (dollar/hr)	Data Collection (hr)		Site Inspection (hr)		Surveying (hr)		Hydraulic Modeling (hr)		Project Mangement (hr)		Total Hours		Cost	
		Proj.	Actual	Proj.	Actual	Proj.	Actual	Proj.	Actual	Proj.	Actual	Projected	Actual	Projected	Actual
Senior engineer	145			60	10					100	50	160	60	$23,200.00	$8,700.00
Project engineer	108	30	30	60	10	50	10	30	30		20	170	100	$18,360.00	$10,800.00
Surveyor	78	20	25	40	10	70	30					130	65	$10,140.00	$5,070.00
Hydrology analyst	56		40	10	10	30	10	100	40			140	100	$7,840.00	$5,600.00
											Total:	600	325	$59,540.00	$30,170.00
2.0 Reimbursed expenses		Projected		Actual											
Travel	$0.55/mile	1280 miles		400 miles										$704.00	$220.00
Hotel	$90/room	3 nights		0										$540.00	$0.00
Per-diem	$60/person	3 days		0										$720.00	$0.00
Rental vehicle	$55/day	3 days		1 day										$165.00	$55.00
													Total:	$61,669.00	$30,445.00

5.0 Conclusion

The main objective of this project was to check if Boulder Creek would cause any damages to the engineered cap located in the Hillside Mine. The Hillside Mine is located in the Eureka Mining district in Yavapai County, Arizona. The Mine is covered with an engineered cap to prevent contaminates such as zinc, manganese, copper, and acid from getting into Boulder Creek. The engineered cap was placed in December/2014, and the cap appears to be in good condition since it was placed recently. However, the results from clime change as lack of rain and bad environment could lead to breaking the cap or even erosion within the cap. The consider area from Auto Cad drawing is 230,000 sq. ft., with a length of 700 yards along the thalweg. In this navigation, the three cross sections were used to depict affected areas due to contamination.

The steam bed consideration was decent to derive the information regarding 500-years storm event. The result conducted by KASH Engineering shows the 500-years storm event will not overbank into the cap. However, if there is high precipitation within Boulder Creek the cap could be undercut from the energy of high flow. Also, the ups stream center, and downstream have been navigated in this phase of examination. In addition, the interaction with client Eric Zielske was effective, as the client was involved by KASH Engineering with lucrative communication to complete the project with the expected results on the due date.

6.0 References

[1] D. D. Gillham, “Winter Preview: El NiÃ±o contributes to a tale of two seasons,” *The Weather Network*, Feb-2015.

[2] “USGS TNM 2.0 Viewer,” *USGS TNM 2.0 Viewer*.

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[4] D. Feldman, *Hydrologic Modeling System: HEC-HMS:* US Army Corps of Engineers, Institute for Water Resources, Hydrologic Engineering Center, 2001.

[5] G. W. Brunner, *HEC-RAS River Analysis System: User's Manual*. US Army Corps of Engineers, Institute for Water Resources, Hydrologic Engineering Center, 2001.

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[7] USGS Surface Water for Arizona: Peak Streamflow,” USGS Surface Water for Arizona: Peak Streamflow. [Online]. Available at: http://nwis.waterdata.usgs.gov/az/nwis/peak?site_no=09424447. [Accessed: 08-Mar-2016].

[8] “Climate Data Online: Dataset Discovery,” Datasets. [Online]. Available at: https://www.ncdc.noaa.gov/cdo-web/datasets. [Accessed: 08-Mar-2016].

[9] Enterline, Max, Watershed Coordinator Watershed Management Unit Arizona Department of Environmental Quality, *Part I of the Boulder Creek Implementation Plan*, 2003

APPENDIX

APPENDIX A

U.S. Department of Commerce
National Oceanic & Atmospheric Administration
National Environmental Satellite, Data, and Information Service

Record of Climatological Observations
These data are quality controlled and may not be identical to the original observations.
Generated on 04/09/2015

National Centers for Environmental Informatio
151 Patton Avenu
Asheville, North Carolina 2880

Elev: 38 ft. Lat: 38.333° N Lon: 76.417° W
Station: **PATUXENT RIVER, MD US GHCND:USC00186915**

Observation Time Temperature: Unknown Observation Time Precipitation: Unknow

Preliminary	Year	Month	Day	Temperature (F) 24 hrs. ending at observation time Max.	Temperature (F) 24 hrs. ending at observation time Min.	Temperature (F) at Observation	Precipitation(see **) 24 Hour Amounts ending at observation time Rain, melted snow, etc. (in)	Flag	Snow, ice pellets, hail (in)	Flag	At Obs Time Snow, ice pellets, hail, ice on ground (in)	Evaporation 24 Hour Wind Movement (mi)	Evaporation Amount of Evap. (in)	Soil Temperature (F) 4 in depth Ground Cover (see *)	4 in depth Max.	4 in depth Min.	8 in depth Ground Cover (see *)	8 in depth Max.	8 in depth Min.
	1989	4	1	52	41		0.00		0.0		0								
	1989	4	2	51	33		0.00		0.0		0								
	1989	4	3	71	47		0.21		0.0		0								
	1989	4	4	81	57		0.00		0.0		0								
	1989	4	5	71	50		0.84		0.0		0								
	1989	4	6	58	44		0.22		0.0		0								
	1989	4	7	50	36		1.29		T		0								
	1989	4	8	52	37		0.02		0.0		0								
	1989	4	9	60	43		0.00		0.0		0								
	1989	4	10	54	41		0.00		0.0		0								
	1989	4	11	49	35		0.00		0.0		0								
	1989	4	12	55	33		0.00		0.0		0								
	1989	4	13	58	36		0.00		0.0		0								
	1989	4	14	58	44		0.00		0.0		0								
	1989	4	15	53	50		1.08		0.0		0								
	1989	4	16	63	44		0.00		0.0		0								
	1989	4	17	70	44		0.00		0.0		0								
	1989	4	18	77	58		0.29		0.0		0								
	1989	4	19	60	44		0.03		0.0		0								

[8]

APPENDIX B

USGS
science for a changing world

The National Flood-Frequency Program—Methods for Estimating Flood Magnitude and Frequency in Rural Areas in Arizona

Introduction

Estimates of the magnitude and frequency of flood-peak discharges and flood hydrographs are used for a variety of purposes, such as for the design of bridges, culverts, and flood-control structures; and for the management and regulation of flood plains. To provide simple methods of estimating flood-peak discharges, the U.S. Geological Survey (USGS) has developed and published equations for every State, the Commonwealth of Puerto Rico, and a number of metropolitan areas in the United States. In 1993, the USGS, in cooperation with the Federal Emergency Management Agency and the Federal Highway Administration, compiled all current USGS statewide and metropolitan area equations into a computer program, titled “The National Flood-Frequency (NFF) Program” (Jennings and others, 1994).

Since 1993, new or updated equations have been developed by the USGS for various areas of the Nation. These new equations have been incorporated into an updated version of the NFF Program.

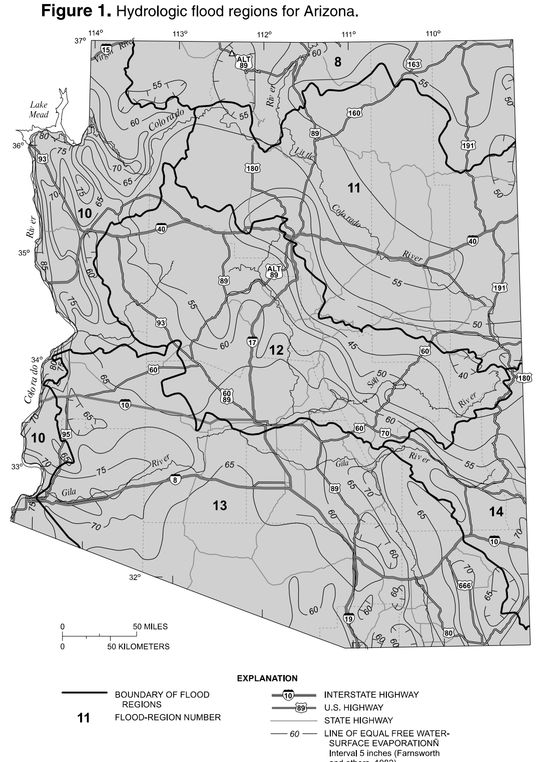
Fact sheets that describe application of the updated NFF Program to various areas of the Nation are available. This fact sheet describes the application of the updated NFF Program to streams that drain rural areas in Arizona.

Overview

The State of Arizona is wholly located within a regional flood study area that encompasses the arid lands of the southwestern United States (Thomas and others, 1997). The study area is divided into 16 hydrologic flood regions, of which 7 include portions of Arizona (fig. 1). These regions were delineated on the basis of regional flood sources (snowmelt, summer thunderstorms, or cyclonic rainfall), elevation, and analysis of flood yields and residuals of preliminary regional flood-frequency relations. Within Arizona, sites greater in elevation than 7,500 feet above sea level [National Geodetic Vertical Datum of 1929 (NGVD of 1929)] are considered to be in region 1. Sites located at elevations of 7,500 feet or less may belong to regions 8, 10, 11, 12, 13, or 14 on the basis of geographic location (fig. 1).

Thomas and others (1997) developed regression equations for estimating peak discharges (Q_T), in cubic feet per second, that have recurrence intervals that range from 2 to 100 years for ungaged, unregulated rural streams. The NFF Program provides estimates of the 500-year discharge on the basis of extrapolation. Although some sites with drainages greater than 200 square miles were used to develop the equations, applications are best limited to 200 square miles or less.

Figure 1. Hydrologic flood regions for Arizona.



APPENDIX C

NOAA Atlas 14, Volume 1, Version 5
Location name: Prescott, Arizona, US*
Latitude: 34.7288°, Longitude: -113.1434°
Elevation: 4905 ft*
* source: Google Maps

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Sarah Dietz, Sarah Heim, Lillian Hiner, Kazungu Maitaria, Deborah Martin, Sandra Pavlovic, Ishani Roy, Carl Trypaluk, Dale Unruh, Fenglin Yan, Michael Yekta, Tan Zhao, Geoffrey Bonnin, Daniel Brewer, Li-Chuan Chen, Tye Parzybok, John Yarchoan

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	**0.250** (0.211-0.298)	**0.328** (0.278-0.392)	**0.448** (0.378-0.534)	**0.538** (0.452-0.640)	**0.659** (0.547-0.782)	**0.751** (0.618-0.891)	**0.845** (0.687-1.01)	**0.940** (0.755-1.13)	**1.07** (0.843-1.29)	**1.18** (0.909-1.43)
10-min	**0.380** (0.322-0.454)	**0.500** (0.423-0.597)	**0.682** (0.575-0.813)	**0.819** (0.687-0.973)	**1.00** (0.832-1.19)	**1.14** (0.940-1.36)	**1.29** (1.05-1.53)	**1.43** (1.15-1.71)	**1.63** (1.28-1.97)	**1.79** (1.38-2.17)
15-min	**0.472** (0.399-0.563)	**0.619** (0.524-0.739)	**0.846** (0.713-1.01)	**1.02** (0.852-1.21)	**1.24** (1.03-1.48)	**1.42** (1.17-1.68)	**1.59** (1.30-1.90)	**1.77** (1.42-2.12)	**2.02** (1.59-2.44)	**2.22** (1.72-2.70)
30-min	**0.635** (0.537-0.758)	**0.834** (0.705-0.996)	**1.14** (0.960-1.36)	**1.37** (1.15-1.63)	**1.67** (1.39-1.99)	**1.91** (1.57-2.26)	**2.15** (1.75-2.56)	**2.39** (1.92-2.86)	**2.72** (2.14-3.28)	**2.98** (2.31-3.63)
60-min	**0.786** (0.664-0.938)	**1.03** (0.873-1.23)	**1.41** (1.19-1.68)	**1.69** (1.42-2.01)	**2.07** (1.72-2.46)	**2.36** (1.94-2.80)	**2.66** (2.16-3.16)	**2.96** (2.37-3.54)	**3.37** (2.65-4.06)	**3.69** (2.86-4.49)
2-hr	**0.926** (0.780-1.10)	**1.20** (1.01-1.43)	**1.62** (1.36-1.93)	**1.96** (1.63-2.32)	**2.42** (1.99-2.86)	**2.79** (2.27-3.30)	**3.17** (2.56-3.77)	**3.58** (2.85-4.28)	**4.15** (3.22-5.00)	**4.62** (3.50-5.62)
3-hr	**1.00** (0.853-1.20)	**1.28** (1.09-1.54)	**1.71** (1.44-2.05)	**2.05** (1.72-2.46)	**2.54** (2.10-3.05)	**2.95** (2.40-3.53)	**3.38** (2.71-4.06)	**3.85** (3.04-4.64)	**4.52** (3.47-5.49)	**5.07** (3.79-6.21)
6-hr	**1.22** (1.04-1.47)	**1.55** (1.31-1.87)	**2.01** (1.69-2.43)	**2.38** (1.99-2.88)	**2.92** (2.40-3.53)	**3.36** (2.72-4.06)	**3.82** (3.05-4.63)	**4.31** (3.38-5.25)	**5.01** (3.82-6.15)	**5.58** (4.15-6.91)
12-hr	**1.49** (1.25-1.81)	**1.88** (1.58-2.30)	**2.42** (2.03-2.96)	**2.86** (2.38-3.49)	**3.46** (2.84-4.23)	**3.94** (3.20-4.82)	**4.43** (3.56-5.44)	**4.95** (3.91-6.10)	**5.67** (4.37-7.07)	**6.26** (4.72-7.87)
24-hr	**1.85** (1.65-2.09)	**2.33** (2.08-2.63)	**2.95** (2.63-3.33)	**3.45** (3.06-3.88)	**4.12** (3.65-4.63)	**4.64** (4.09-5.22)	**5.19** (4.55-5.83)	**5.74** (5.01-6.45)	**6.50** (5.62-7.30)	**7.09** (6.09-7.98)
2-day	**2.10** (1.87-2.36)	**2.65** (2.35-2.98)	**3.36** (2.98-3.78)	**3.94** (3.48-4.42)	**4.72** (4.16-5.29)	**5.34** (4.68-5.98)	**5.99** (5.22-6.71)	**6.65** (5.76-7.47)	**7.56** (6.49-8.52)	**8.28** (7.04-9.35)
3-day	**2.25** (2.00-2.52)	**2.83** (2.52-3.18)	**3.61** (3.20-4.04)	**4.22** (3.73-4.73)	**5.06** (4.46-5.66)	**5.71** (5.02-6.40)	**6.40** (5.59-7.16)	**7.10** (6.17-7.96)	**8.05** (6.94-9.05)	**8.80** (7.53-9.92)
4-day	**2.39** (2.13-2.68)	**3.02** (2.68-3.38)	**3.85** (3.41-4.31)	**4.50** (3.98-5.04)	**5.39** (4.75-6.03)	**6.09** (5.35-6.81)	**6.81** (5.96-7.61)	**7.55** (6.58-8.44)	**8.55** (7.39-9.59)	**9.32** (8.01-10.5)
7-day	**2.78** (2.49-3.11)	**3.52** (3.15-3.93)	**4.47** (3.99-5.00)	**5.22** (4.65-5.83)	**6.24** (5.52-6.95)	**7.02** (6.19-7.82)	**7.82** (6.86-8.72)	**8.64** (7.54-9.64)	**9.74** (8.42-10.9)	**10.6** (9.08-11.9)
10-day	**3.09** (2.76-3.46)	**3.91** (3.48-4.37)	**4.96** (4.42-5.55)	**5.78** (5.14-6.46)	**6.88** (6.09-7.68)	**7.72** (6.80-8.62)	**8.58** (7.53-9.59)	**9.44** (8.24-10.6)	**10.6** (9.17-11.9)	**11.5** (9.87-12.9)
20-day	**3.98** (3.58-4.40)	**5.03** (4.54-5.57)	**6.33** (5.69-7.00)	**7.27** (6.53-8.03)	**8.46** (7.57-9.35)	**9.33** (8.34-10.3)	**10.2** (9.06-11.3)	**11.0** (9.75-12.2)	**12.0** (10.6-13.4)	**12.8** (11.2-14.3)
30-day	**4.63** (4.18-5.11)	**5.88** (5.31-6.49)	**7.44** (6.71-8.19)	**8.59** (7.74-9.46)	**10.1** (9.04-11.1)	**11.1** (9.99-12.3)	**12.2** (10.9-13.5)	**13.3** (11.8-14.6)	**14.6** (12.9-16.2)	**15.6** (13.7-17.3)
45-day	**5.58** (5.04-6.16)	**7.08** (6.39-7.83)	**9.01** (8.13-9.96)	**10.4** (9.42-11.5)	**12.3** (11.1-13.6)	**13.7** (12.3-15.1)	**15.1** (13.5-16.7)	**16.5** (14.7-18.3)	**18.3** (16.2-20.3)	**19.6** (17.3-21.9)
60-day	**6.18** (5.58-6.81)	**7.86** (7.11-8.66)	**9.98** (9.03-11.0)	**11.5** (10.4-12.7)	**13.5** (12.2-14.9)	**15.0** (13.5-16.6)	**16.5** (14.7-18.2)	**17.9** (15.9-19.8)	**19.7** (17.4-21.8)	**21.0** (18.5-23.4)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

APPENDIX D

NOAA Atlas 14, Volume 1, Version 5
Location name: Prescott, Arizona, US*
Latitude: 34.7288°, Longitude: -113.1434°
Elevation: 4905 ft*
* source: Google Maps

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Sarah Dietz, Sarah Heim, Lillian Hiner, Kazungu Maitaria, Deborah Martin, Sandra Pavlovic, Ishani Roy, Carl Trypaluk, Dale Unruh, Fenglin Yan, Michael Yekta, Tan Zhao, Geoffrey Bonnin, Daniel Brewer, Li-Chuan Chen, Tye Parzybok, John Yarchoan

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	**0.250** (0.211-0.298)	**0.328** (0.278-0.392)	**0.448** (0.378-0.534)	**0.538** (0.452-0.640)	**0.659** (0.547-0.782)	**0.751** (0.618-0.891)	**0.845** (0.687-1.01)	**0.940** (0.755-1.13)	**1.07** (0.843-1.29)	**1.18** (0.909-1.43)
10-min	**0.380** (0.322-0.454)	**0.500** (0.423-0.597)	**0.682** (0.575-0.813)	**0.819** (0.687-0.973)	**1.00** (0.832-1.19)	**1.14** (0.940-1.36)	**1.29** (1.05-1.53)	**1.43** (1.15-1.71)	**1.63** (1.28-1.97)	**1.79** (1.38-2.17)
15-min	**0.472** (0.399-0.563)	**0.619** (0.524-0.739)	**0.846** (0.713-1.01)	**1.02** (0.852-1.21)	**1.24** (1.03-1.48)	**1.42** (1.17-1.68)	**1.59** (1.30-1.90)	**1.77** (1.42-2.12)	**2.02** (1.59-2.44)	**2.22** (1.72-2.70)
30-min	**0.635** (0.537-0.758)	**0.834** (0.705-0.996)	**1.14** (0.960-1.36)	**1.37** (1.15-1.63)	**1.67** (1.39-1.99)	**1.91** (1.57-2.26)	**2.15** (1.75-2.56)	**2.39** (1.92-2.86)	**2.72** (2.14-3.28)	**2.98** (2.31-3.63)
60-min	**0.786** (0.664-0.938)	**1.03** (0.873-1.23)	**1.41** (1.19-1.68)	**1.69** (1.42-2.01)	**2.07** (1.72-2.46)	**2.36** (1.94-2.80)	**2.66** (2.16-3.16)	**2.96** (2.37-3.54)	**3.37** (2.65-4.06)	**3.69** (2.86-4.49)
2-hr	**0.926** (0.780-1.10)	**1.20** (1.01-1.43)	**1.62** (1.36-1.93)	**1.96** (1.63-2.32)	**2.42** (1.99-2.86)	**2.79** (2.27-3.30)	**3.17** (2.56-3.77)	**3.58** (2.85-4.28)	**4.15** (3.22-5.00)	**4.62** (3.50-5.62)
3-hr	**1.00** (0.853-1.20)	**1.28** (1.09-1.54)	**1.71** (1.44-2.05)	**2.05** (1.72-2.46)	**2.54** (2.10-3.05)	**2.95** (2.40-3.53)	**3.38** (2.71-4.06)	**3.85** (3.04-4.64)	**4.52** (3.47-5.49)	**5.07** (3.79-6.21)
6-hr	**1.22** (1.04-1.47)	**1.55** (1.31-1.87)	**2.01** (1.69-2.43)	**2.38** (1.99-2.88)	**2.92** (2.40-3.53)	**3.36** (2.72-4.06)	**3.82** (3.05-4.63)	**4.31** (3.38-5.25)	**5.01** (3.82-6.15)	**5.58** (4.15-6.91)
12-hr	**1.49** (1.25-1.81)	**1.88** (1.58-2.30)	**2.42** (2.03-2.96)	**2.86** (2.38-3.49)	**3.46** (2.84-4.23)	**3.94** (3.20-4.82)	**4.43** (3.56-5.44)	**4.95** (3.91-6.10)	**5.67** (4.37-7.07)	**6.26** (4.72-7.87)
24-hr	**1.85** (1.65-2.09)	**2.33** (2.08-2.63)	**2.95** (2.63-3.33)	**3.45** (3.06-3.88)	**4.12** (3.65-4.63)	**4.64** (4.09-5.22)	**5.19** (4.55-5.83)	**5.74** (5.01-6.45)	**6.50** (5.62-7.30)	**7.09** (6.09-7.98)
2-day	**2.10** (1.87-2.36)	**2.65** (2.35-2.98)	**3.36** (2.98-3.78)	**3.94** (3.48-4.42)	**4.72** (4.16-5.29)	**5.34** (4.68-5.98)	**5.99** (5.22-6.71)	**6.65** (5.76-7.47)	**7.56** (6.49-8.52)	**8.28** (7.04-9.35)
3-day	**2.25** (2.00-2.52)	**2.83** (2.52-3.18)	**3.61** (3.20-4.04)	**4.22** (3.73-4.73)	**5.06** (4.46-5.66)	**5.71** (5.02-6.40)	**6.40** (5.59-7.16)	**7.10** (6.17-7.96)	**8.05** (6.94-9.05)	**8.80** (7.53-9.92)
4-day	**2.39** (2.13-2.68)	**3.02** (2.68-3.38)	**3.85** (3.41-4.31)	**4.50** (3.98-5.04)	**5.39** (4.75-6.03)	**6.09** (5.35-6.81)	**6.81** (5.96-7.61)	**7.55** (6.58-8.44)	**8.55** (7.39-9.59)	**9.32** (8.01-10.5)
7-day	**2.78** (2.49-3.11)	**3.52** (3.15-3.93)	**4.47** (3.99-5.00)	**5.22** (4.65-5.83)	**6.24** (5.52-6.95)	**7.02** (6.19-7.82)	**7.82** (6.86-8.72)	**8.64** (7.54-9.64)	**9.74** (8.42-10.9)	**10.6** (9.08-11.9)
10-day	**3.09** (2.76-3.46)	**3.91** (3.48-4.37)	**4.96** (4.42-5.55)	**5.78** (5.14-6.46)	**6.88** (6.09-7.68)	**7.72** (6.80-8.62)	**8.58** (7.53-9.59)	**9.44** (8.24-10.6)	**10.6** (9.17-11.9)	**11.5** (9.87-12.9)
20-day	**3.98** (3.58-4.40)	**5.03** (4.54-5.57)	**6.33** (5.69-7.00)	**7.27** (6.53-8.03)	**8.46** (7.57-9.35)	**9.33** (8.34-10.3)	**10.2** (9.06-11.3)	**11.0** (9.75-12.2)	**12.0** (10.6-13.4)	**12.8** (11.2-14.3)
30-day	**4.63** (4.18-5.11)	**5.88** (5.31-6.49)	**7.44** (6.71-8.19)	**8.59** (7.74-9.46)	**10.1** (9.04-11.1)	**11.1** (9.99-12.3)	**12.2** (10.9-13.5)	**13.3** (11.8-14.6)	**14.6** (12.9-16.2)	**15.6** (13.7-17.3)
45-day	**5.58** (5.04-6.16)	**7.08** (6.39-7.83)	**9.01** (8.13-9.96)	**10.4** (9.42-11.5)	**12.3** (11.1-13.6)	**13.7** (12.3-15.1)	**15.1** (13.5-16.7)	**16.5** (14.7-18.3)	**18.3** (16.2-20.3)	**19.6** (17.3-21.9)
60-day	**6.18** (5.58-6.81)	**7.86** (7.11-8.66)	**9.98** (9.03-11.0)	**11.5** (10.4-12.7)	**13.5** (12.2-14.9)	**15.0** (13.5-16.6)	**16.5** (14.7-18.2)	**17.9** (15.9-19.8)	**19.7** (17.4-21.8)	**21.0** (18.5-23.4)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

APPENDIX E

Procedure

The equations are based on the inch-pound system of units, but the NFF Program will accept and report either the inch-pound or metric system of units. The explanatory watershed variables used in the regression equations are as follows:

Drainage area (AREA), in square miles, is the total area that contributes runoff upstream of the location of the stream site of interest.

Mean annual precipitation (PREC), in inches, is the average mean annual precipitation for the basin as determined from isohyetal maps developed by the U.S. Weather Bureau (1963). The average is best determined by use of grid sampling techniques. Lines of equal precipitation from the Weather Bureau map are intersected with (drawn on to) a map of the drainage basin, a grid with equal-size cells is overlaid on the map, the mean annual precipitation is determined at each grid intersection, and the values are averaged.

Mean basin elevation (ELEV), in feet above sea level, is also determined by grid sampling techniques. The elevations of a minimum of 20 equally spaced points are determined, and the average of the points is taken. As many as 100 points may be needed for large basins.

Mean annual evaporation (EVAP), in inches, is the mean annual free water-surface evaporation at the study site. This variable should be estimated for the stream site of interest by linear interpolation between the lines of free surface-water evaporation shown in figure 1.

The regression equations, the average standard errors of prediction, and the equivalent years of record for regions 1, 8, 12, 13, and 14 are given in table 1. The average standard errors of prediction are an average measure of the accuracy of the regression equations when estimating peak-discharge values for ungaged watersheds similar to those that were used to derive the regression equations. The equivalent years of record is the number of years of streamflow record needed to achieve the same accuracy as the regression equation.

The regression equations for regions 10 and 11 were developed using an iterative regression method (Hjalmarson and Thomas, 1992) and a modified form of the station year statistical analysis method (Fuller, 1914). The regression equations, the estimated average standard errors of regression, and the equivalent years of record for regions 10 and 11 are given in table 2. The average standard error of regression is an estimate of the predictive accuracy of these regression equations and is determined by a direct sampling method.

The approximate ranges of the explanatory watershed variables over which the equations are applicable are shown in table 3. Thomas and others (1997) presented the actual ranges of applicability as two-dimensional clusters

Table 1. Flood-peak discharge regression equations and associated statistics for regions 1, 8, 12, 13, and 14 in Arizona (modified from Thomas and others, 1997)

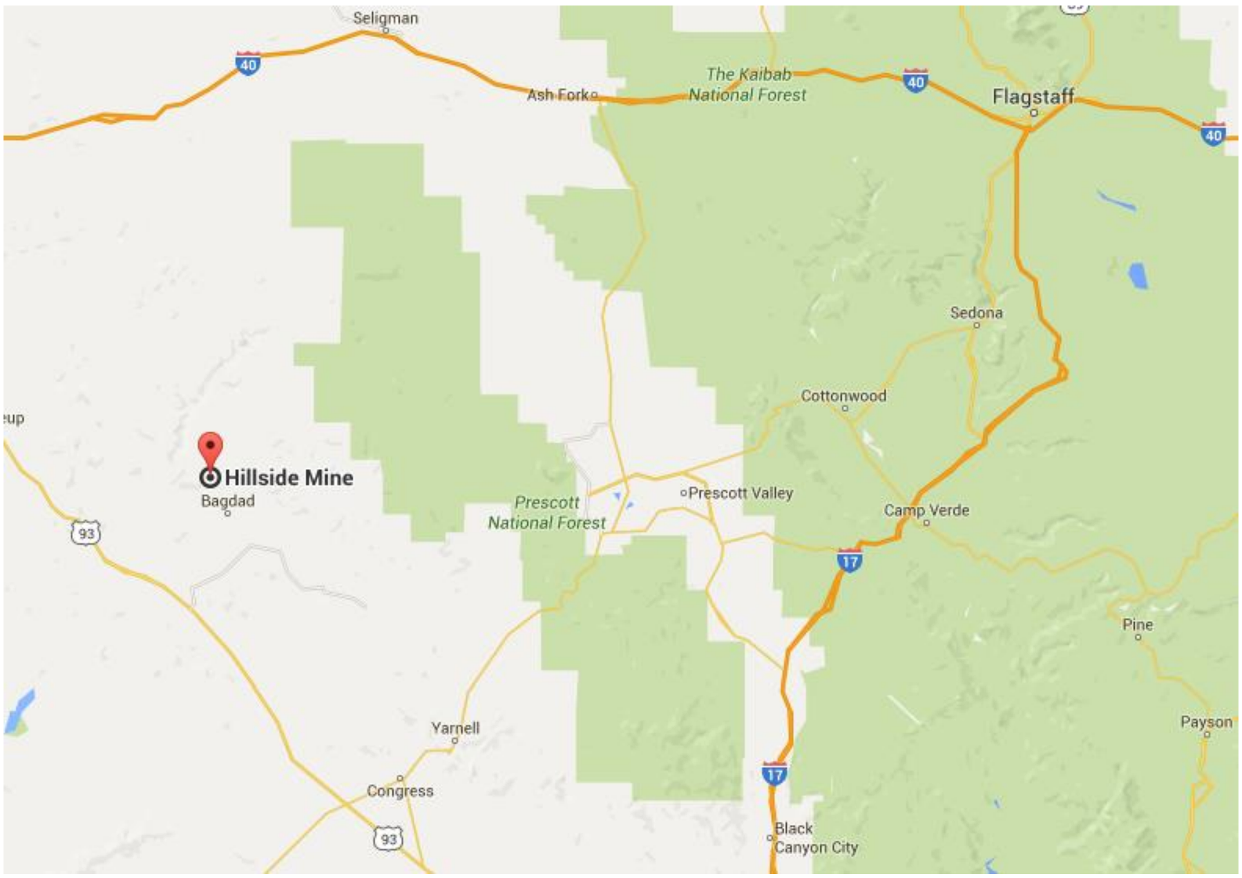
[Q_T, peak discharge, in cubic feet per second for recurrence interval *T*, 2 to 100 years; AREA, drainage area, in square miles; PREC, precipitation, in inches; ELEV, mean basin elevation, in feet above sea level (NGVD of 1929)]

Regression equation	Average standard error of prediction, in percent	Equivalent years of record
Region 1 (For sites located at elevations greater than 7,500 feet above sea level[1]) -165 stations		
$Q_2 = 0.124AREA^{0.845}PREC^{1.44}$	59	0.16
$Q_5 = 0.629AREA^{0.807}PREC^{1.12}$	52	.62
$Q_{10} = 1.43AREA^{0.786}PREC^{0.958}$	48	1.34
$Q_{25} = 3.08AREA^{0.768}PREC^{0.811}$	46	2.50
$Q_{50} = 4.75AREA^{0.758}PREC^{0.732}$	46	3.37
$Q_{100} = 6.78AREA^{0.750}PREC^{0.668}$	46	4.19
Region 8 -108 stations		
$Q_2 = 598AREA^{0.501}(ELEV/1{,}000)^{-1.02}$	72	0.37
$Q_5 = 2{,}620AREA^{0.449}(ELEV/1{,}000)^{-1.28}$	62	1.35
$Q_{10} = 5{,}310AREA^{0.425}(ELEV/1{,}000)^{-1.40}$	57	2.88
$Q_{25} = 10{,}500AREA^{0.403}(ELEV/1{,}000)^{-1.49}$	54	5.45
$Q_{50} = 16{,}000AREA^{0.390}(ELEV/1{,}000)^{-1.54}$	53	7.45
$Q_{100} = 23{,}300AREA^{0.377}(ELEV/1{,}000)^{-1.59}$	53	9.28
Region 12 -68 stations		
$Q_2 = 41.1AREA^{0.629}$	105	0.23
$Q_5 = 238AREA^{0.687}(ELEV/1{,}000)^{-0.358}$	68	1.90
$Q_{10} = 479AREA^{0.661}(ELEV/1{,}000)^{-0.398}$	52	6.24
$Q_{25} = 942AREA^{0.630}(ELEV/1{,}000)^{-0.383}$	40	17.8
$Q_{50} = 10^{(7.36 - 4.17AREA^{-0.08})}(ELEV/1{,}000)^{-0.440}$	37	27.5
$Q_{100} = 10^{(6.55 - 3.17AREA^{-0.11})}(ELEV/1{,}000)^{-0.454}$	39	32.1
Region 13 - 73 stations		
$Q_2 = 10^{(6.38 - 4.29AREA^{-0.06})}$	57	2.0
$Q_5 = 10^{(5.78 - 3.31AREA^{-0.08})}$	40	6.25
$Q_{10} = 10^{(5.68 - 3.02AREA^{-0.09})}$	37	11.1
$Q_{25} = 10^{(5.64 - 2.78AREA^{-0.10})}$	39	15.0
$Q_{50} = 10^{(5.57 - 2.59AREA^{-0.11})}$	43	15.9
$Q_{100} = 10^{(5.52 - 2.42AREA^{-0.12})}$	48	16.1
Region 14- 22 stations		
$Q_2 = 583AREA^{0.588}(ELEV/1{,}000)^{-1.3}$	74	1.69
$Q_5 = 618AREA^{0.524}(ELEV/1{,}000)^{-0.70}$	63	3.54
$Q_{10} = 361AREA^{0.464}$	65	4.95
$Q_{25} = 581AREA^{0.462}$	63	7.75
$Q_{50} = 779AREA^{0.462}$	64	9.65
$Q_{100} = 1{,}010AREA^{0.463}$	66	11.2

[1]NGVD of 1929

APPENDIX F

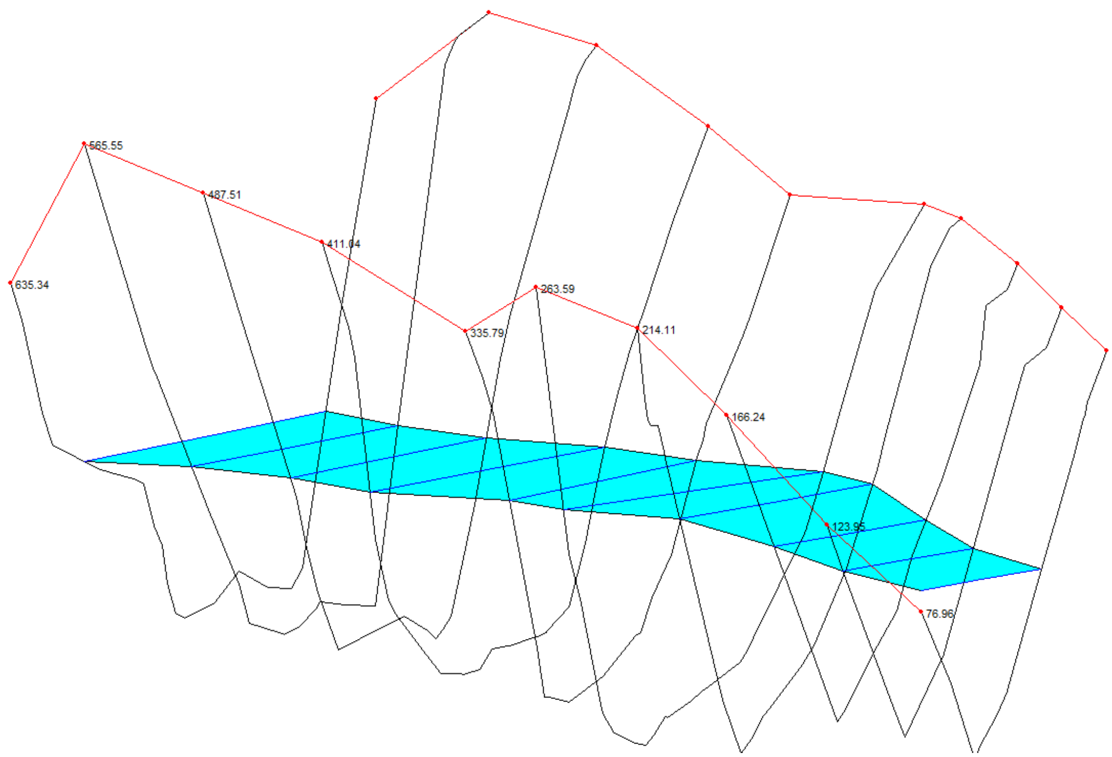
LOCATION INFORMATION:
Name: Bagdad, Arizona, US*
Latitude: 34.5834°
Longitude: -113.1749°
Elevation: 4050 ft*

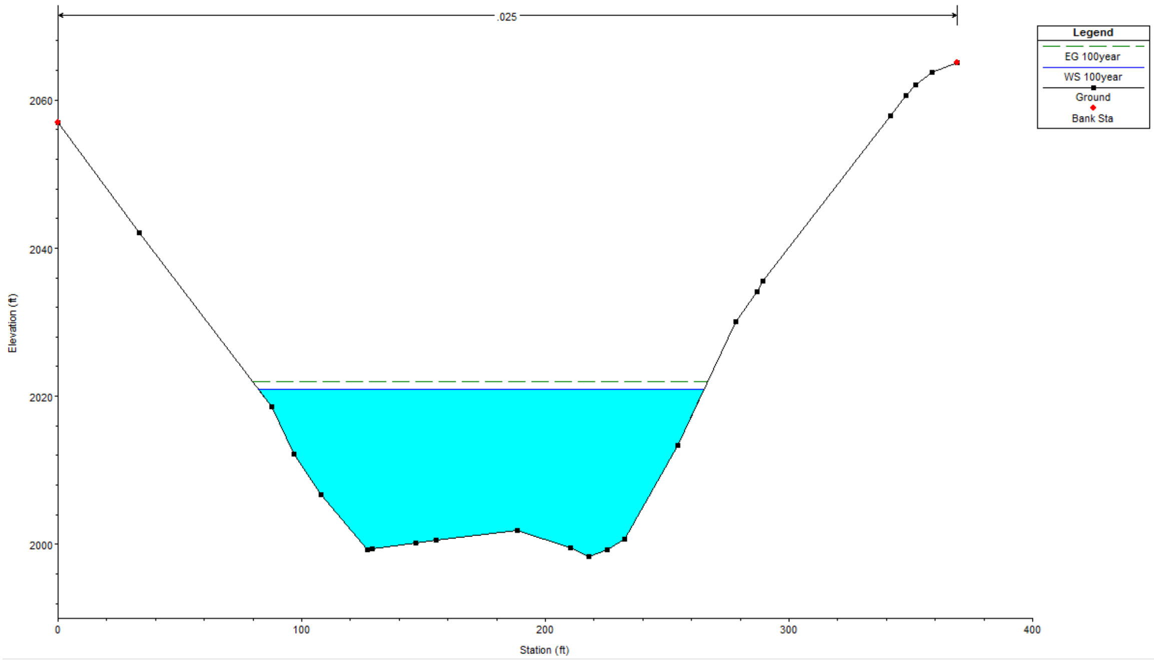


APPENDIX G

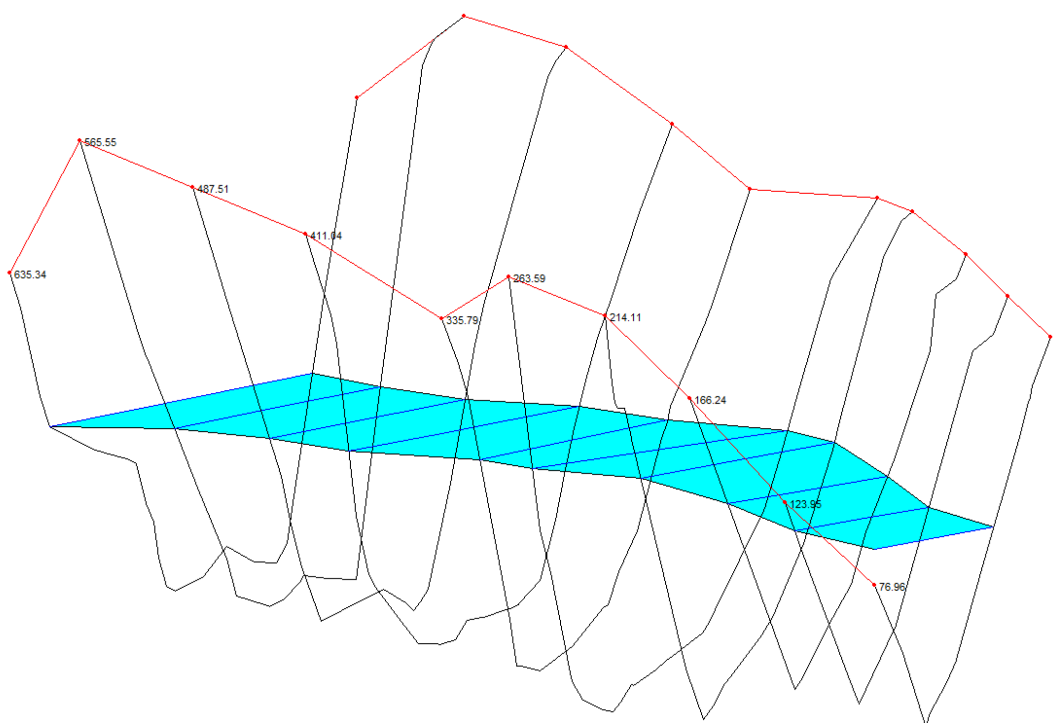
PDS-based precipitation frequency estimates with 90% confidence intervals (in inches)[1]										
Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.236 (0.200-0.281)	0.310 (0.263-0.371)	0.425 (0.359-0.506)	0.511 (0.429-0.607)	0.624 (0.519-0.742)	0.710 (0.586-0.845)	0.798 (0.651-0.953)	0.887 (0.713-1.06)	1.01 (0.793-1.22)	1.10 (0.853-1.34)
10-min	0.360 (0.304-0.428)	0.472 (0.401-0.564)	0.647 (0.547-0.770)	0.777 (0.653-0.924)	0.950 (0.790-1.13)	1.08 (0.892-1.29)	1.22 (0.990-1.45)	1.35 (1.08-1.62)	1.53 (1.21-1.85)	1.68 (1.30-2.04)
15-min	0.446 (0.377-0.531)	0.585 (0.497-0.699)	0.802 (0.678-0.955)	0.964 (0.810-1.15)	1.18 (0.979-1.40)	1.34 (1.10-1.59)	1.51 (1.23-1.80)	1.67 (1.34-2.01)	1.90 (1.50-2.30)	2.08 (1.61-2.54)
30-min	0.600 (0.508-0.715)	0.788 (0.669-0.942)	1.08 (0.913-1.29)	1.30 (1.09-1.54)	1.59 (1.32-1.89)	1.80 (1.49-2.15)	2.03 (1.65-2.42)	2.25 (1.81-2.71)	2.56 (2.02-3.10)	2.80 (2.17-3.42)
60-min	0.743 (0.629-0.885)	0.976 (0.828-1.17)	1.34 (1.13-1.59)	1.61 (1.35-1.91)	1.96 (1.63-2.33)	2.23 (1.84-2.66)	2.51 (2.05-3.00)	2.79 (2.24-3.35)	3.17 (2.49-3.83)	3.46 (2.68-4.23)
2-hr	0.878 (0.741-1.04)	1.14 (0.964-1.36)	1.55 (1.30-1.85)	1.87 (1.56-2.22)	2.31 (1.91-2.75)	2.67 (2.17-3.17)	3.04 (2.44-3.62)	3.43 (2.71-4.11)	3.96 (3.06-4.80)	4.40 (3.33-5.39)
3-hr	0.955 (0.811-1.15)	1.23 (1.04-1.48)	1.64 (1.38-1.97)	1.97 (1.65-2.37)	2.45 (2.02-2.94)	2.84 (2.30-3.42)	3.26 (2.60-3.93)	3.72 (2.92-4.50)	4.37 (3.33-5.33)	4.90 (3.64-6.04)
6-hr	1.16 (0.982-1.40)	1.47 (1.25-1.79)	1.93 (1.61-2.33)	2.29 (1.91-2.78)	2.82 (2.31-3.41)	3.24 (2.62-3.93)	3.69 (2.93-4.49)	4.17 (3.25-5.10)	4.86 (3.67-5.98)	5.41 (3.99-6.74)
12-hr	1.40 (1.17-1.71)	1.78 (1.49-2.18)	2.30 (1.92-2.83)	2.73 (2.26-3.34)	3.31 (2.70-4.06)	3.77 (3.05-4.64)	4.26 (3.39-5.25)	4.76 (3.73-5.89)	5.47 (4.18-6.85)	6.05 (4.52-7.64)
24-hr	1.70 (1.51-1.91)	2.13 (1.91-2.41)	2.72 (2.42-3.07)	3.18 (2.83-3.58)	3.81 (3.37-4.29)	4.30 (3.79-4.84)	4.81 (4.21-5.41)	5.33 (4.63-6.00)	6.04 (5.20-6.92)	6.59 (5.62-7.72)
2-day	1.89 (1.69-2.13)	2.39 (2.13-2.69)	3.04 (2.71-3.41)	3.56 (3.17-3.99)	4.27 (3.77-4.78)	4.83 (4.24-5.40)	5.40 (4.72-6.05)	5.99 (5.20-6.73)	6.79 (5.84-7.66)	7.42 (6.32-8.39)
3-day	2.02 (1.81-2.26)	2.55 (2.28-2.85)	3.25 (2.89-3.62)	3.79 (3.38-4.23)	4.54 (4.02-5.06)	5.12 (4.52-5.71)	5.72 (5.03-6.39)	6.34 (5.54-7.08)	7.18 (6.21-8.04)	7.83 (6.72-8.79)
4-day	2.15 (1.92-2.40)	2.71 (2.42-3.02)	3.45 (3.08-3.84)	4.03 (3.59-4.47)	4.81 (4.27-5.34)	5.42 (4.80-6.02)	6.05 (5.34-6.72)	6.69 (5.88-7.44)	7.56 (6.59-8.42)	8.23 (7.13-9.19)
7-day	2.50 (2.25-2.78)	3.16 (2.84-3.51)	4.01 (3.60-4.45)	4.67 (4.18-5.18)	5.57 (4.96-6.16)	6.25 (5.55-6.92)	6.95 (6.14-7.70)	7.66 (6.73-8.49)	8.60 (7.50-9.56)	9.33 (8.07-10.4)
10-day	2.77 (2.49-3.08)	3.50 (3.14-3.89)	4.44 (3.98-4.93)	5.17 (4.62-5.74)	6.14 (5.46-6.80)	6.88 (6.10-7.62)	7.63 (6.74-8.46)	8.38 (7.37-9.30)	9.38 (8.18-10.4)	10.1 (8.80-11.3)
20-day	3.51 (3.18-3.86)	4.44 (4.02-4.89)	5.58 (5.04-6.13)	6.41 (5.79-7.04)	7.46 (6.71-8.18)	8.22 (7.38-9.02)	8.96 (8.02-9.84)	9.67 (8.62-10.6)	10.6 (9.38-11.7)	11.2 (9.92-12.4)
30-day	4.10 (3.71-4.49)	5.20 (4.71-5.70)	6.57 (5.95-7.20)	7.58 (6.86-8.30)	8.87 (8.01-9.72)	9.81 (8.85-10.8)	10.7 (9.66-11.8)	11.6 (10.4-12.8)	12.8 (11.4-14.1)	13.6 (12.1-15.1)
45-day	4.87 (4.41-5.37)	6.19 (5.60-6.82)	7.87 (7.12-8.67)	9.12 (8.24-10.0)	10.7 (9.68-11.8)	11.9 (10.7-13.1)	13.1 (11.8-14.4)	14.3 (12.7-15.7)	15.8 (14.0-17.4)	16.9 (14.9-18.7)
60-day	5.42 (4.90-5.96)	6.89 (6.24-7.58)	8.75 (7.92-9.62)	10.1 (9.15-11.1)	11.9 (10.7-13.0)	13.1 (11.8-14.4)	14.4 (12.9-15.8)	15.6 (13.9-17.2)	17.1 (15.2-18.9)	18.2 (16.1-20.2)

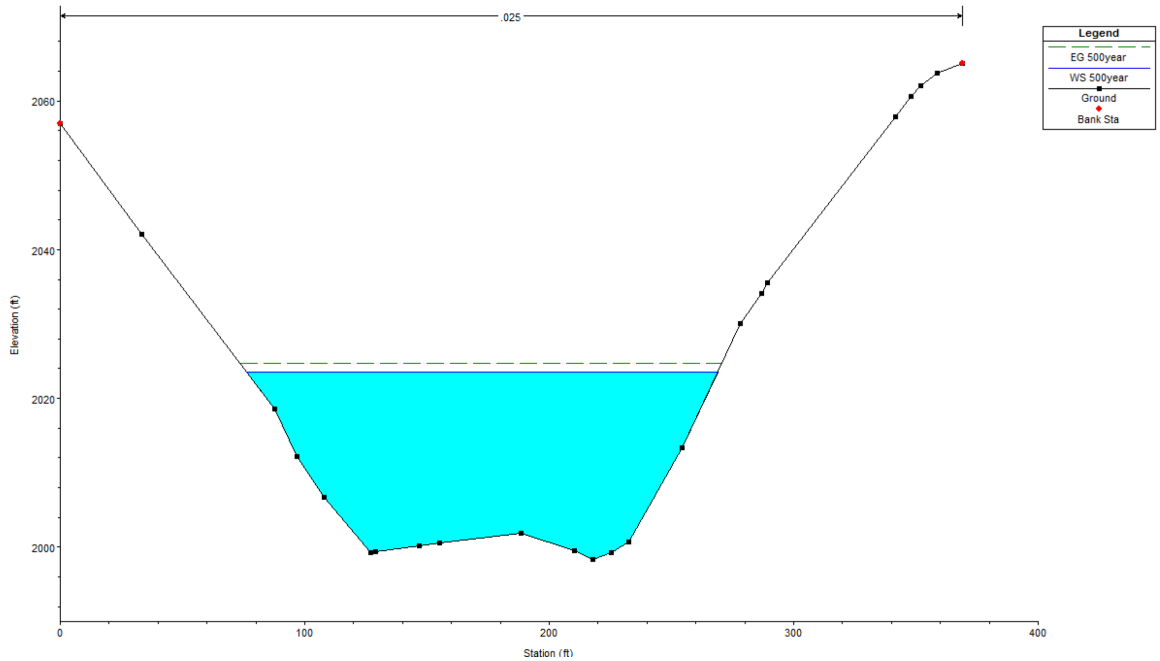
100-year storm



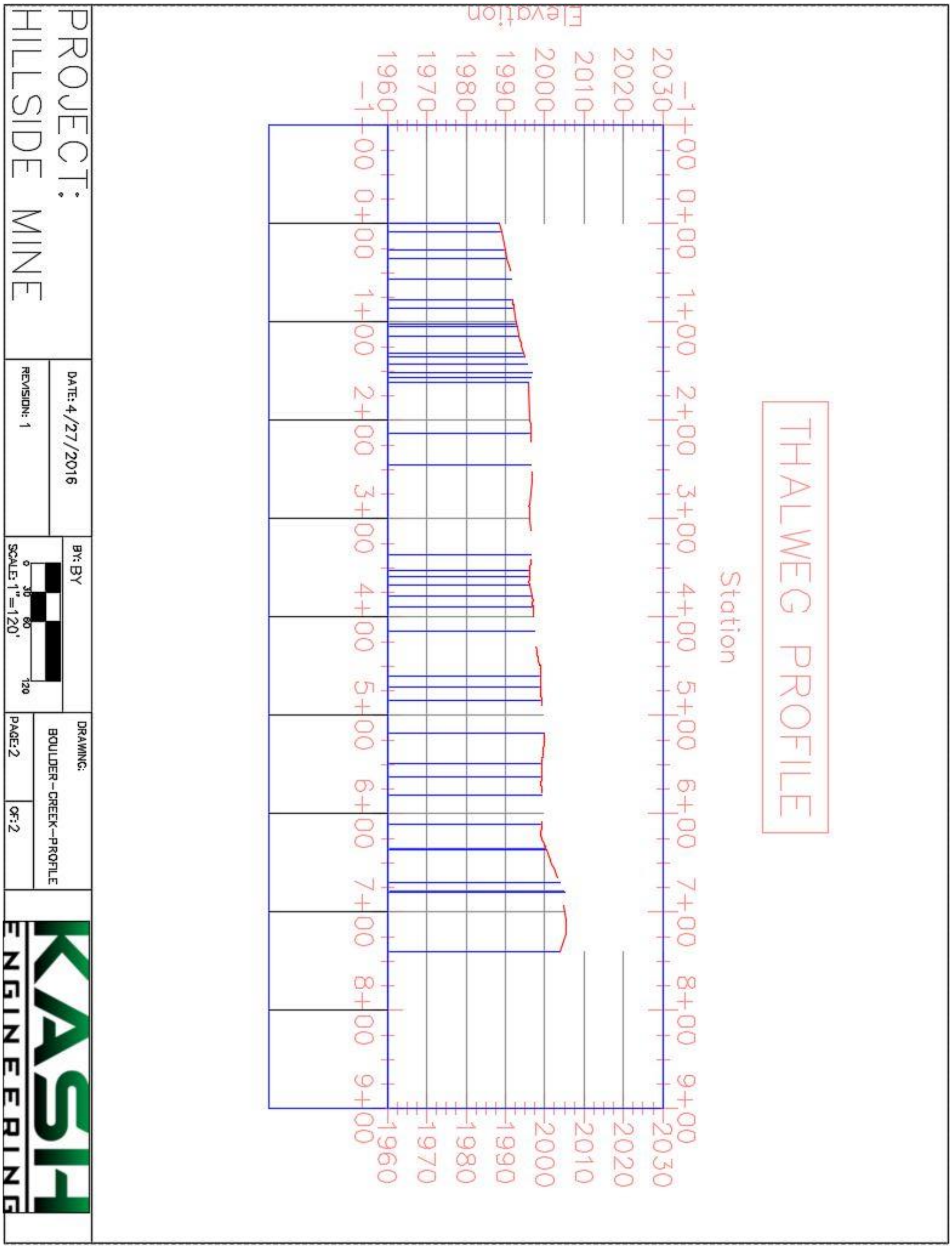


500-year storm




.025
Legend
EG 500year
WS 500year
Ground
Bank Sta
2060
2040
2020
2000
Elevation (ft)
0
100
200
300
400
Station (ft)

APPENDIX H


THALWEG PROFILE
Station
Elevation
PROJECT:
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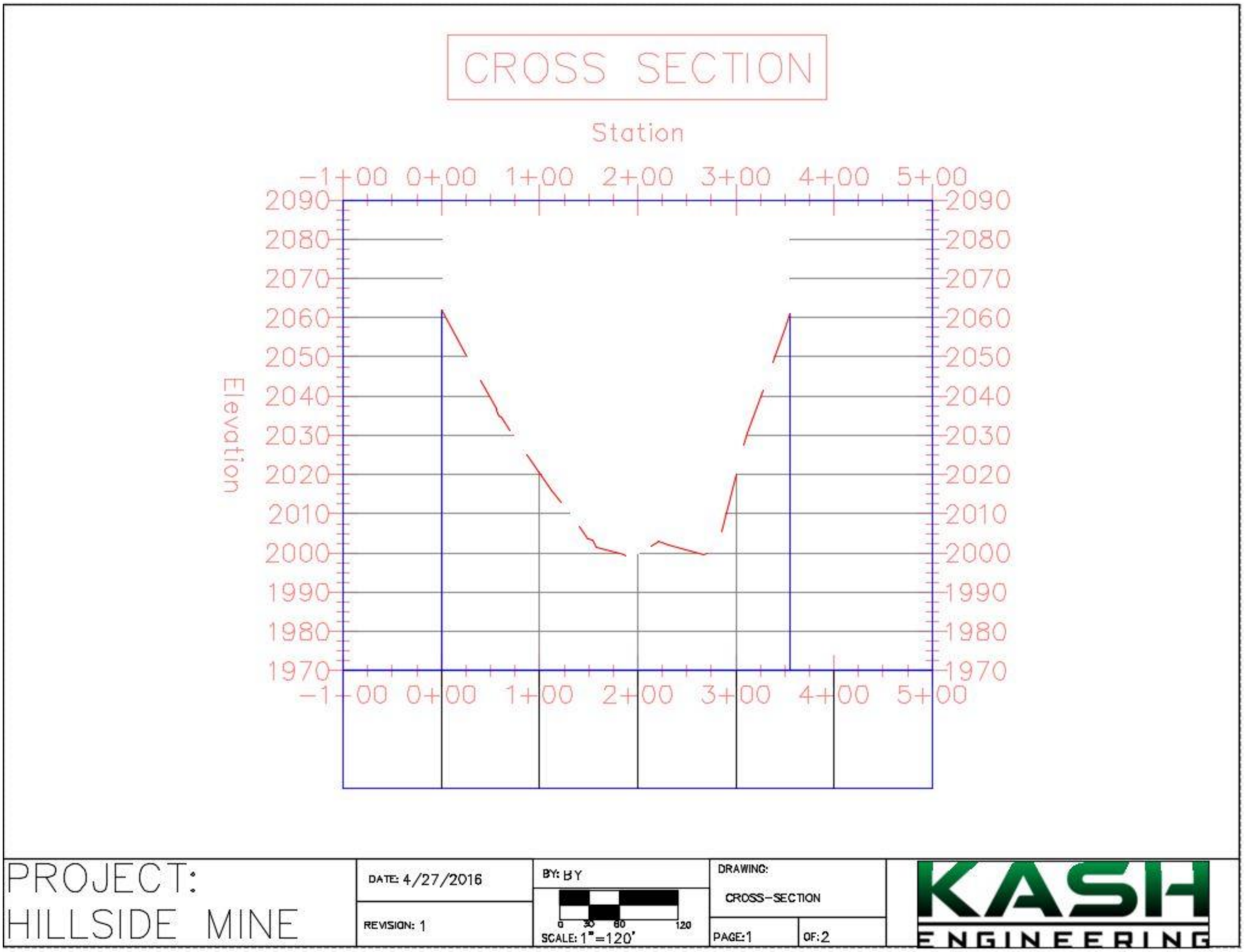
DATE: 4/27/2016
REVISION: 1
BY: BY
SCALE: 1"=120'
DRAWING:
BOULDER-CREEK-PROFILE
PAGE:2
OF:2
KASH
ENGINEERING


CROSS SECTION
Station
−1+00 0+00 1+00 2+00 3+00 4+00 5+00
2090 2080 2070 2060 2050 2040 2030 2020 2010 2000 1990 1980 1970
Elevation
PROJECT:
HILLSIDE MINE
DATE: 4/27/2016
REVISION: 1
BY: BY
0 30 60 120
SCALE: 1"=120'
DRAWING:
CROSS-SECTION
PAGE: 1
OF: 2
KASH
ENGINEERING