West Street Wash Redesign/Rehabilitation - Final Presentation

Northern Arizona University-
Department of Engineering, CENE 486C

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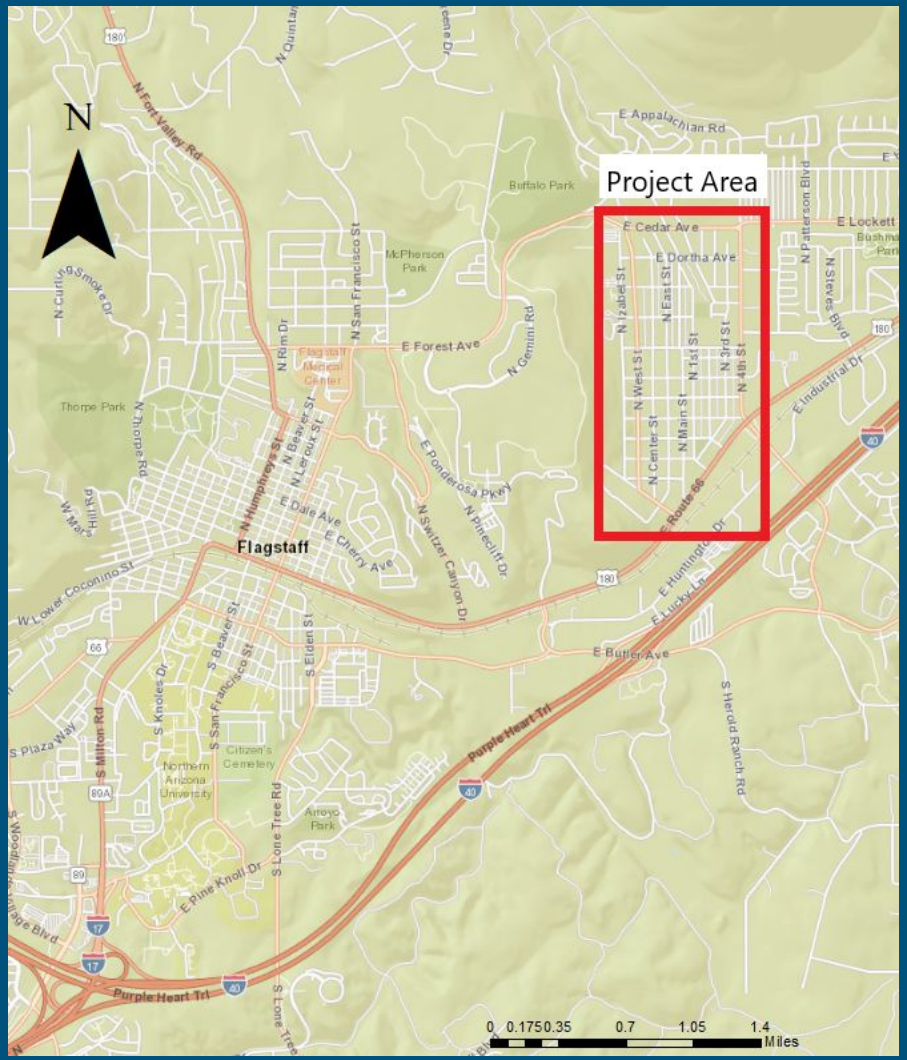
Client/TA: Edward Schenk
GI: Dr. Heiderscheidt.

4/28/2023

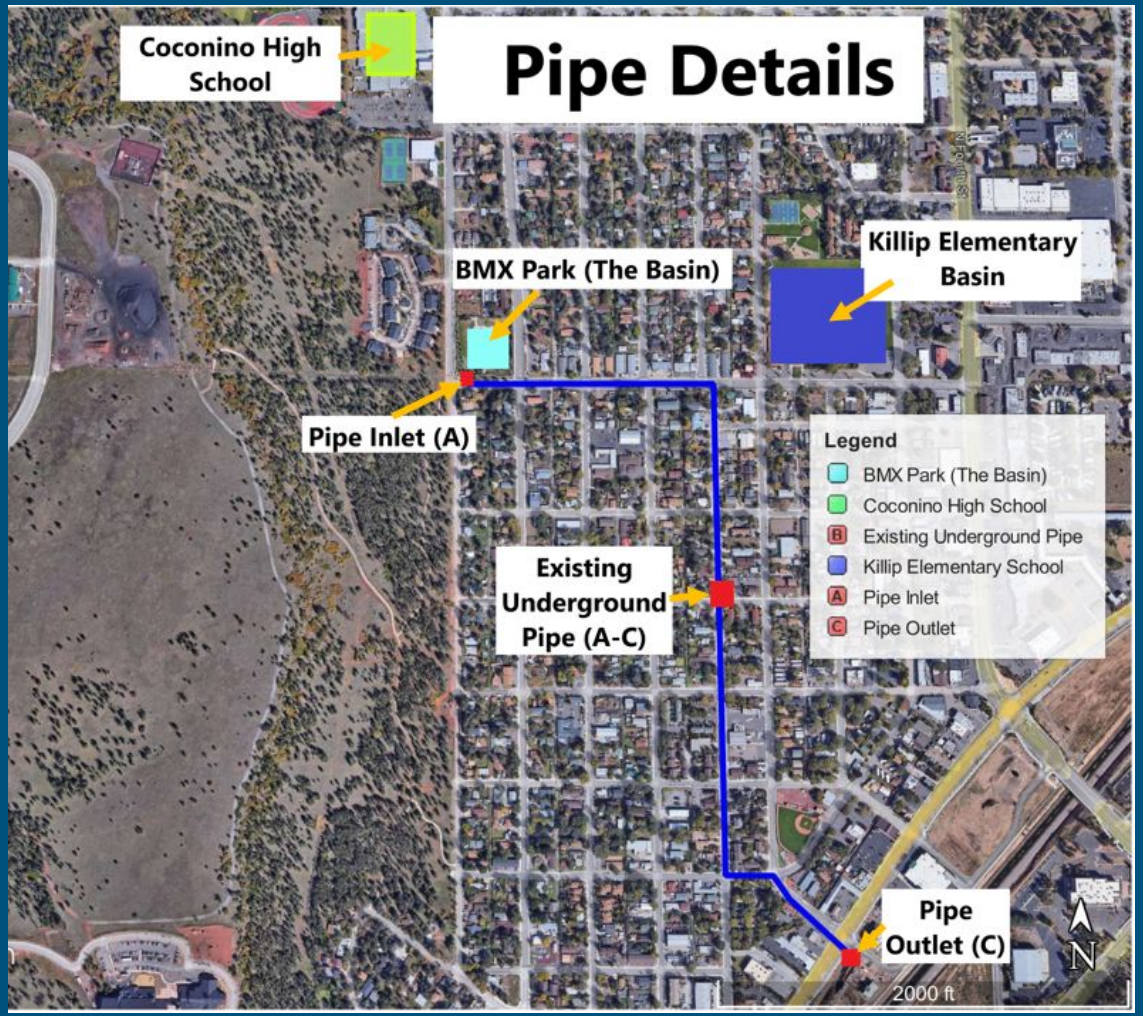


Project Location: Flagstaff, AZ

- Current infrastructure is not capable of handling 25 year recurrence flows.
- Emergency 100 year storm events cause intense flooding in the area.

Project Goal: Increase stormwater capacity and rehabilitate West St Wash drainage system.

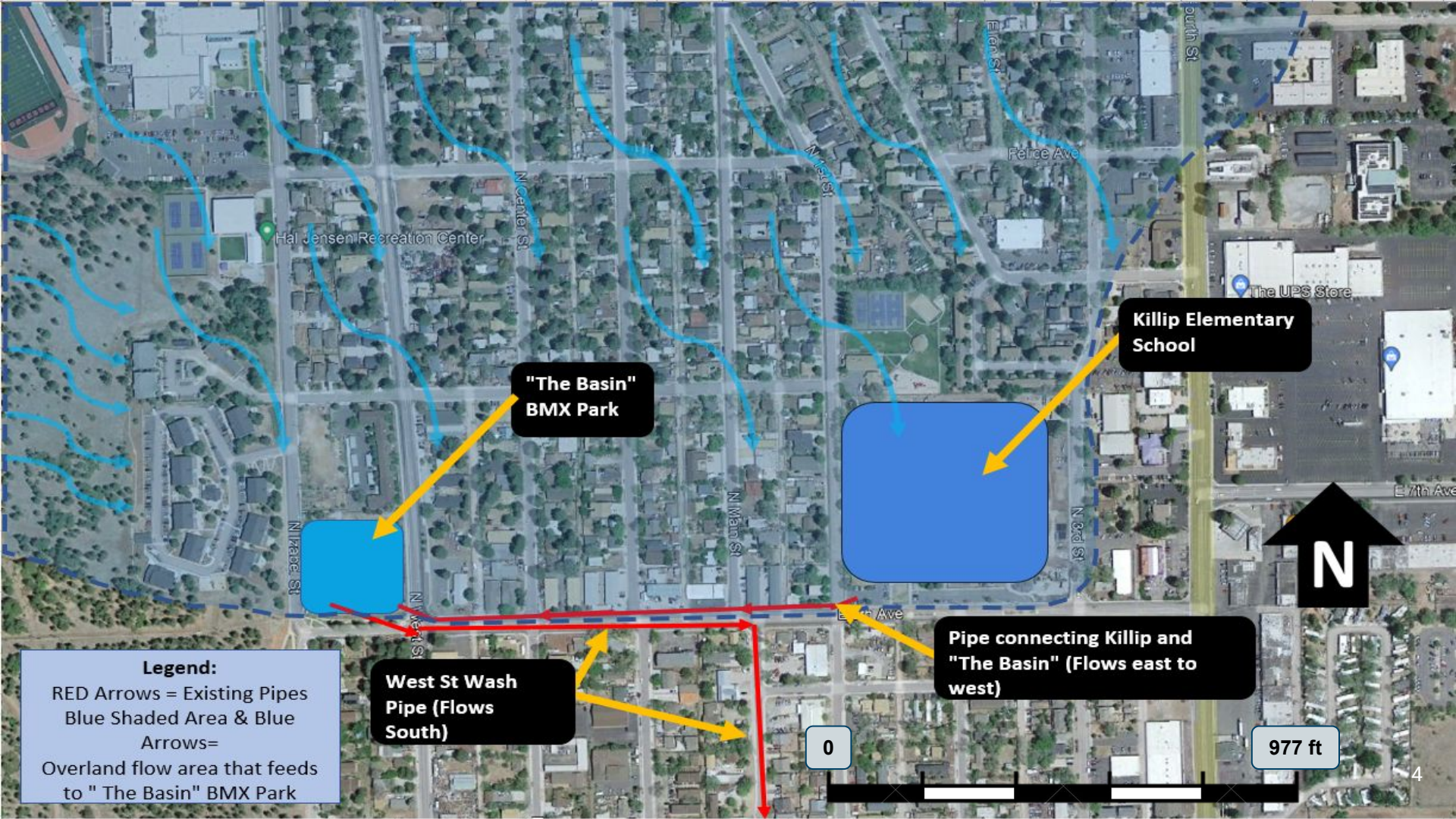
Figure 1: Project Area location



Current stormwater system is underground from “The Basin” BMX park to Route 66 beneath West St.

Each neighborhood block is occupied by business and homes.
Resulting in Very little space to work with for a solution

Figure 2: Stormwater drainage system


"The Basin" BMX Park
Killip Elementary School
Pipe connecting Killip and "The Basin" (Flows east to west)
West St Wash Pipe (Flows South)
Legend:
RED Arrows = Existing Pipes
Blue Shaded Area & Blue Arrows=
Overland flow area that feeds to " The Basin" BMX Park
0
977 ft
N
Hal Jensen Recreation Center
N Center St
N Main St
N 3rd St
Fellce Ave
The UPS Store
N Pace St
N West St

Overland Flow entering “The Basin” BMX Park

"The Basin" BMX Park

Colanthe Ave

N

0

388 ft

5

Flow Paths at “The Basin” BMX Park

"The Basin" BMX Park

West St Wash Pipe Outlet

West St Wash Pipe

Pipe between Killip & BMX Park

N Isabel St

N West St

N

0

209 ft

West St Wash Pipe Outlet

West St Wash Pipe

N

0

371 ft

Analysis of existing infrastructure

CMP = Corrugated Metal Pipe

RCP = Reinforced Concrete Pipe

RGRCP = Rubber Gasket Reinforced Concrete Pipe

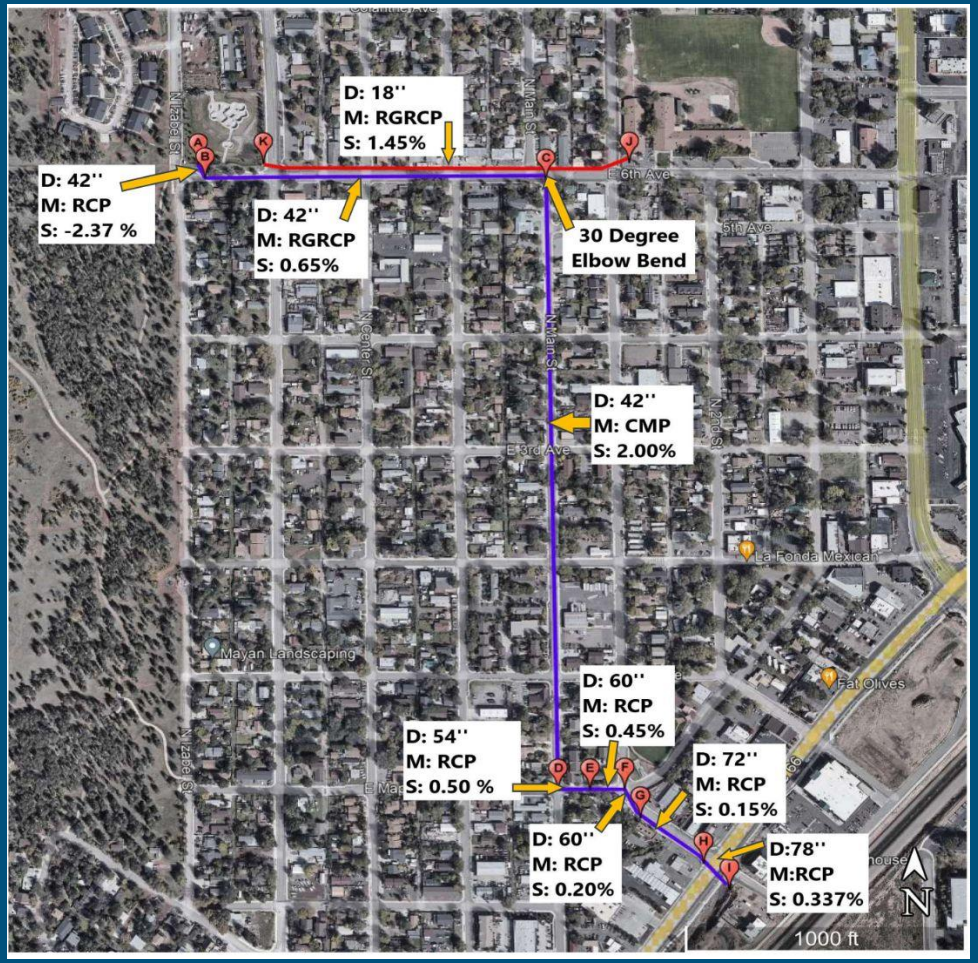


Figure 5: Pipe Flow Map

Time of Concentration

Time of concentration by hand= 36 minutes

Rational Method: TOC = 36.5 min

COF Stormwater Management (2009):
Used to determine rainfall intensities

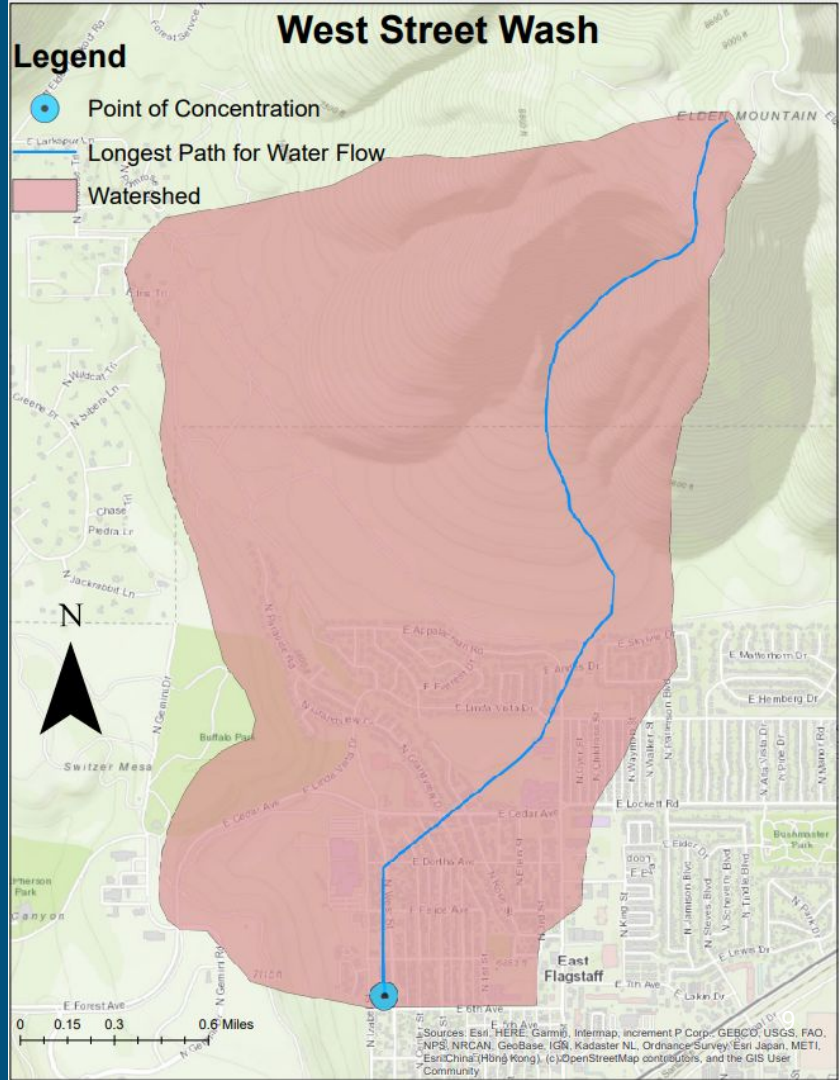


Figure 4: Watershed, Point of Concentration & Longest Flow Path

Hydrologic Analysis

Utilized Google Earth Pro to:

- Calculate watershed area = 1678.85 Acres.
- Measure longest flow path = 13471 ft
- Parce out watershed to use rational method.

Table 1: ADOT Rational Method Tool Results		
Parameter	25 - year	100 - year
Discharge Q (cfs)	1222.4	2073.7
Runoff Coefficient C	0.31	0.36
Rainfall intensity I, (in/hr)	2.35	3.43
Subbasin Total Area A (acres)	1678.85	
Computed TOC Tc, (min)	42.2	36.5
Applied TOC Tc, (min)	42.2	36.5

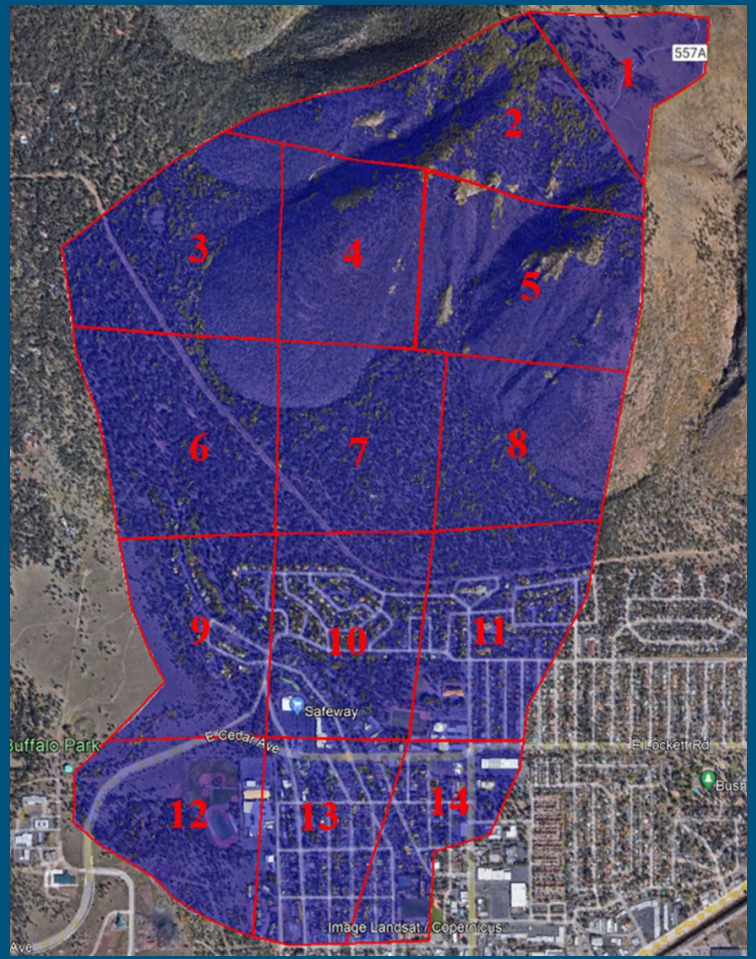
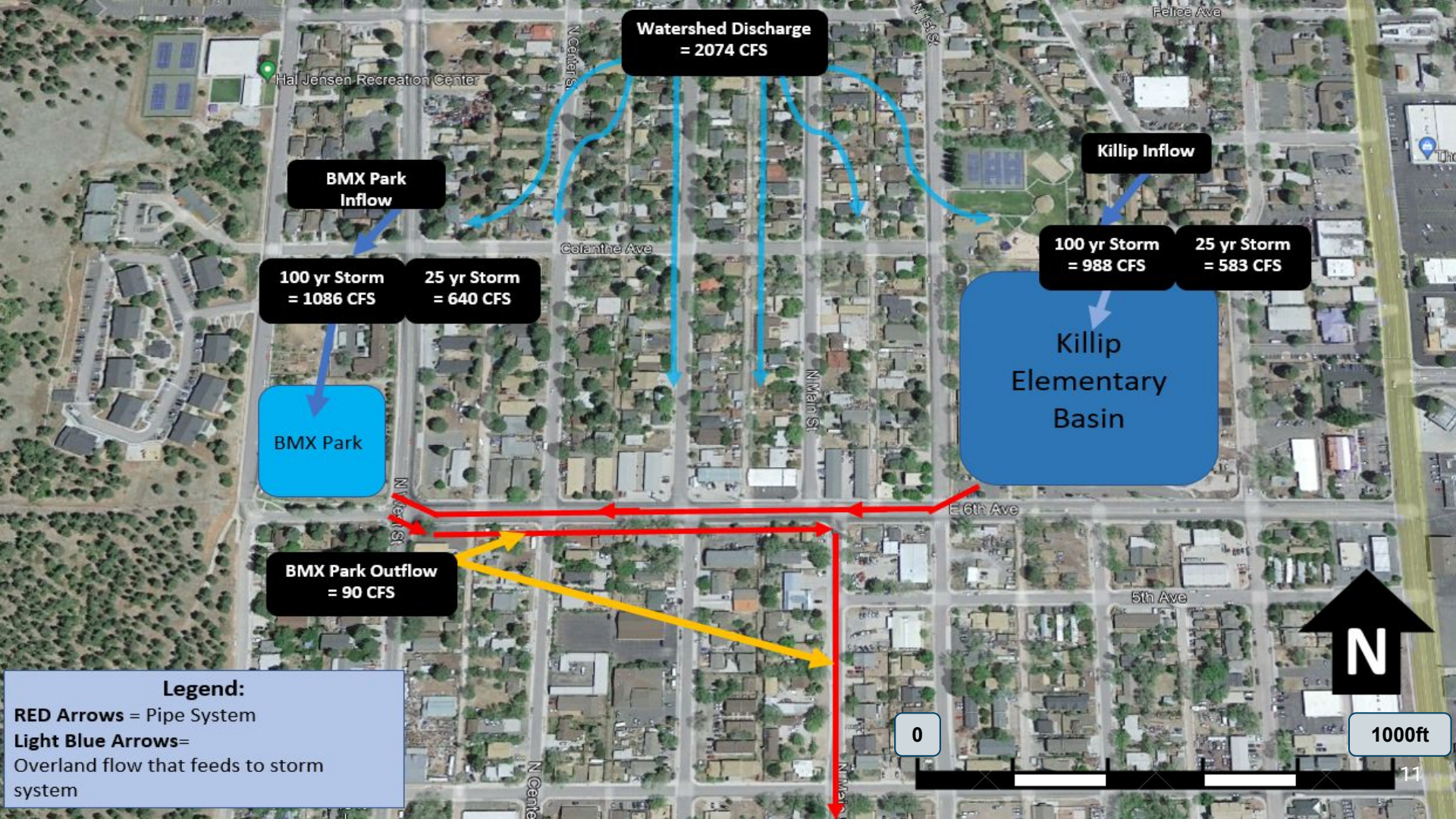


Figure 3: Watershed Subarea Map


Watershed Discharge
= 2074 CFS
Killip Inflow
BMX Park
Inflow
100 yr Storm
= 1086 CFS
25 yr Storm
= 640 CFS
100 yr Storm
= 988 CFS
25 yr Storm
= 583 CFS
Killip
Elementary
Basin
BMX Park
BMX Park Outflow
= 90 CFS
Hal Jensen Recreation Center
N Center St
N 1st St
Felice Ave
Columbine Ave
N Main St
E 6th Ave
5th Ave
N
0
1000ft
Legend:
RED Arrows = Pipe System
Light Blue Arrows=
Overland flow that feeds to storm system

Alternative Designs

Designs considered:

- Surface Retention or Detention basin
- Underground Retention system
- New pipe exiting Killip Elementary basin
- Combining Underground retention with a new pipe at Killip Elementary

Drivers of Design:

- **2,074 CFS = 4,542,060 CF**/(36.5 min Storm)
- Monumental volume of water.
- Minimal space to work with.
- Keeping future improvements in mind.

Surface Detention Basin

Design Concerns:

- Mass excavation
- All water arriving at Killip basin needs to be piped to the BMX park, then to surface detention
- Proposed area for surface basin is at higher elevation than the BMX park

Footprint: 280,000 SF
Depth: 16 FT
Approximate cost: **$6.9 million**

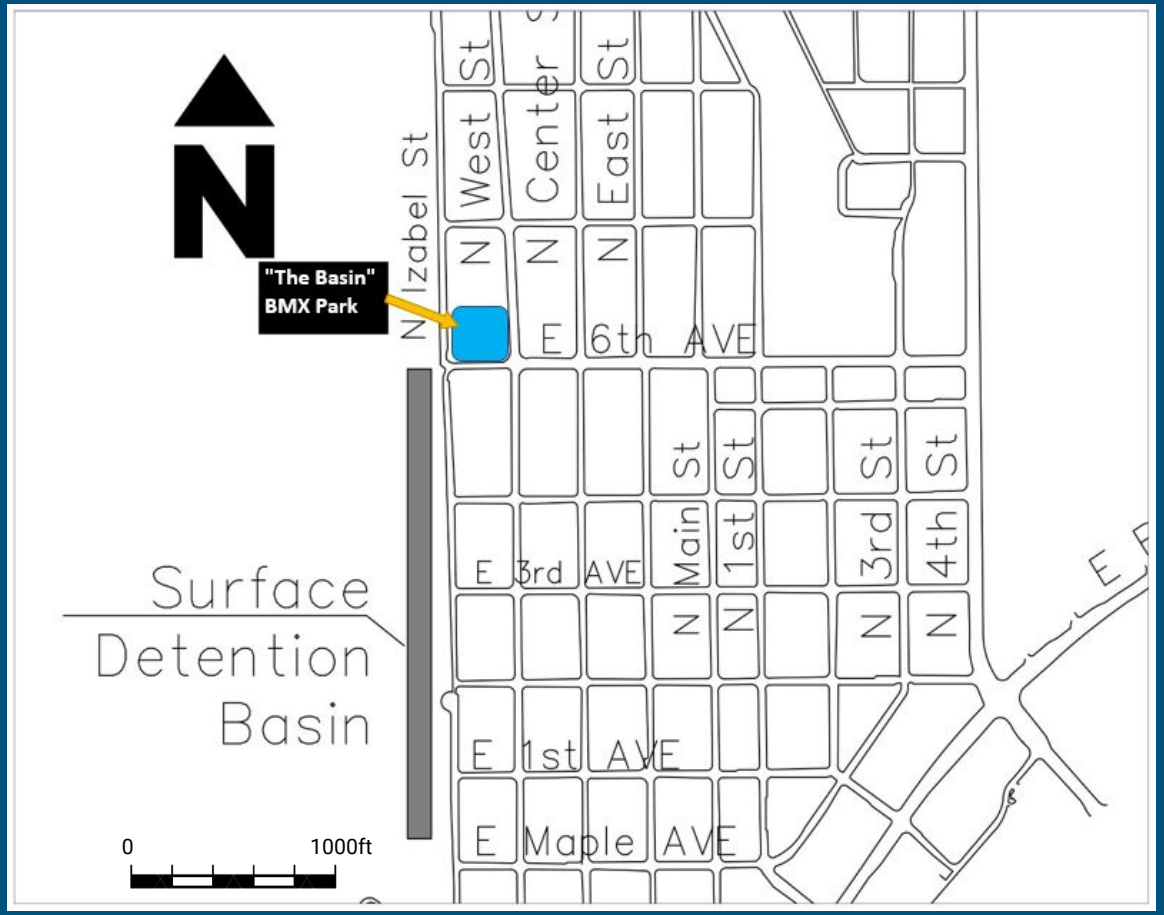


Figure 6: Design Alternative 1

Underground Retention Tank Beneath BMX Park

Design Concerns:

- Custom concrete vault system is expensive
- All water at the Killip Elementary basin needs to be piped into the BMX Park
- Roadways of relatively high traffic would need to be demolished and replaced

Figure 7: Design Alternative 2 Footprint

Footprint: 140,000 SF
Depth: 37 FT
Approximate cost: **$33 million**

New Storm Pipe from BMX to Killip Basin & New Pipe Exiting Basin

Design Concerns:

- All water arriving at BMX Park needs to be piped to Killip
- Equipment access
- Overhead power lines

Pipe would overwhelm current storm system downstream.
Diameter: **144”**(CulvertMaster)
Flow Capacity: 1895 CFS
Approximate Cost: **$3.1 Million**

Figure 8 and Figure 9:
Design Alternative 3

New Pipe and Underground Tank

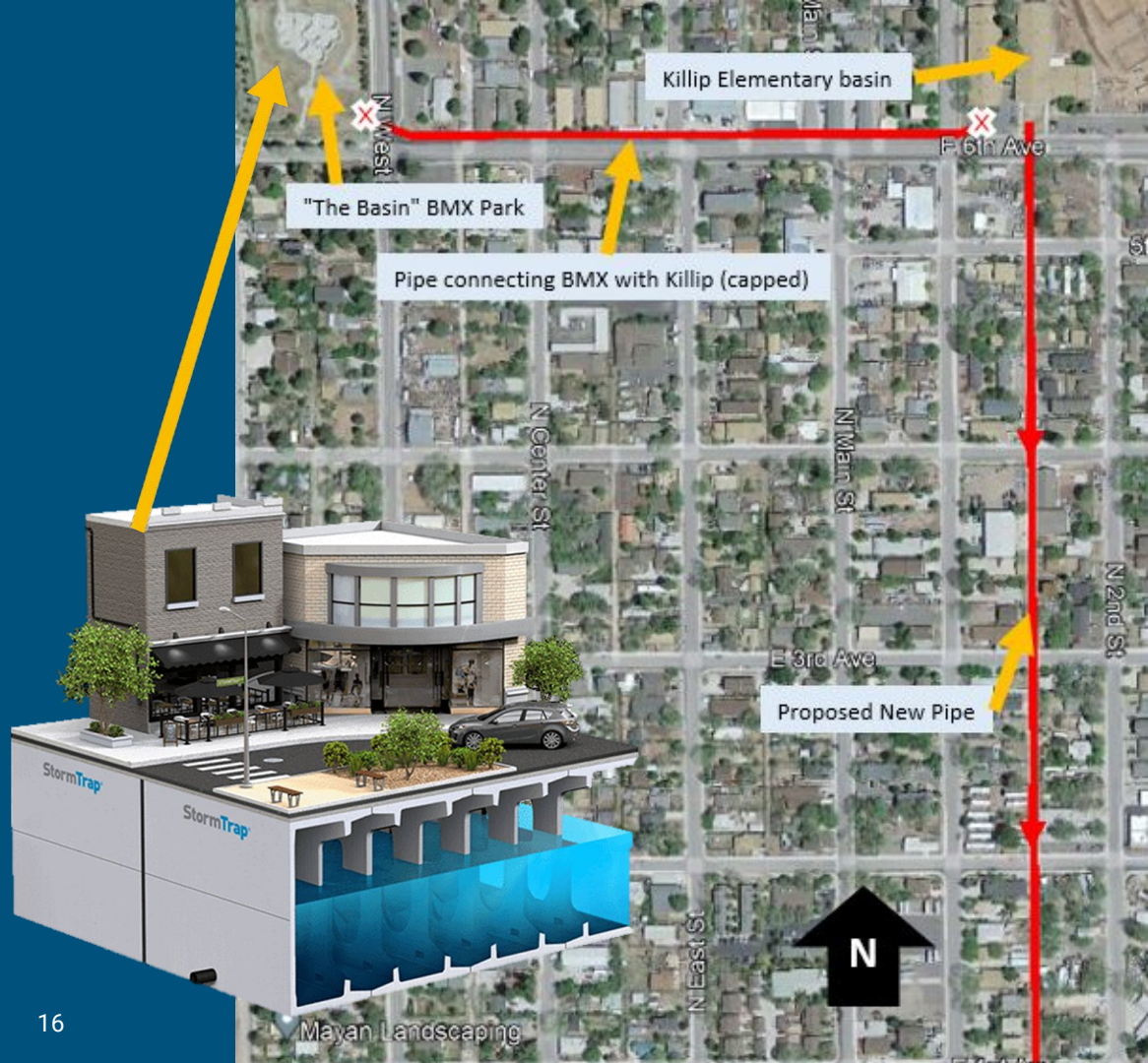
Design Concerns:

- Pipe between Killip and BMX park needs to be capped
- Tank footprint maximizes BMX park
- Overhead power lines over new pipe
- Equipment access

Underground Retention:
Footprint: 90,000 SF
Depth: 15 FT

Proposed New Pipe:
Diameter: 54” CMP
Flow Capacity: 250 CFS (CulvertMaster)

Approximate cost: **$10.5 million**



Design Analysis

Criteria determined by project constraints

Table 4: Criteria

Criteria		Consideration
Feasibility	35%	Difficulty of design implementation.
Environmental Impacts	15%	Weighing positive and negative environmental impacts.
Social Impacts	15%	Public approval during and after construction.
Construction Cost	20%	Cost of design implementation.
Operation & Maintenance	15%	Cost of operation and maintenance (O & M)

Criteria Scoring

Table 5: Scoring for Decision Matrix

SCORE	Feasibility	Environmental Impacts	Social Impacts	Construction Cost	Operation & Maintenance
3	**Easy to build**	**Positive environmental impacts**	**Positive social impacts**	**Design < $7.5 million**	**O & M cost should be minimal**
2	**Reasonable to build**	**Positive and negative environmental impacts**	**Positive and negative social impacts**	**$7.5 million < Design < $15 million**	**O & M cost is reasonable**
1	**Very difficult to build**	**Negative environmental impacts**	**Negative social impacts**	**$15 million < Design**	**O & M cost is high**

Selection of Best Alternative

Design alternatives were assigned scores based on the criteria scoring system outlined on slide 17.

New Pipe + Underground Tank design scored highest.

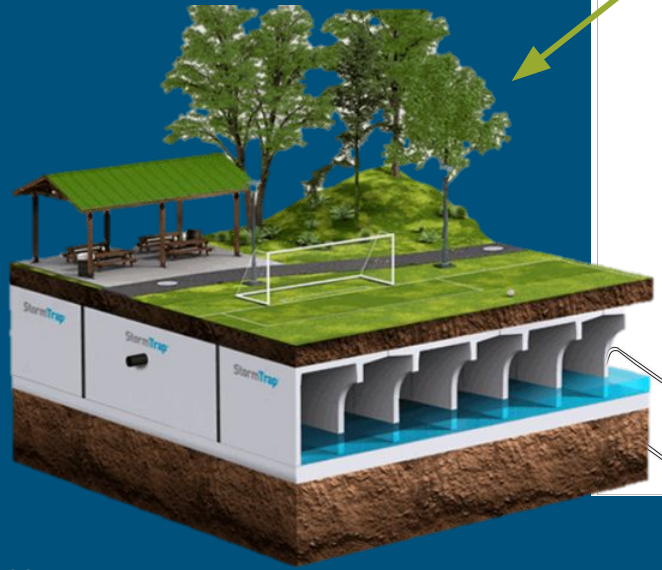
Table 6: Decision Matrix

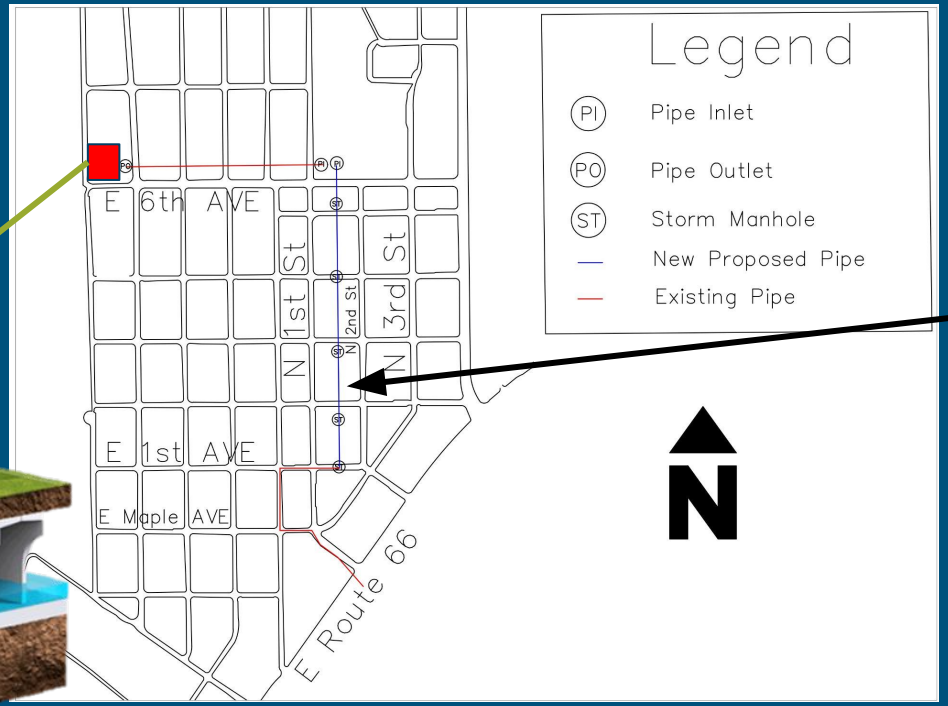
Alternative Design	Weight (%)	Detention Basin		Underground Retention		New pipe @ Killip Elem		New Pipe + Underground Tank	
		SCORE (**X**/3)	Score Weighted	SCORE (**X**/3)	Score Weighted	SCORE (**X**/3)	Score Weighted	SCORE (**X**/3)	Score Weighted
Feasibility	35%	2	0.70	1	0.35	1	0.35	3	1.05
Environmental Impacts	15%	2	0.30	3	0.45	3	0.45	3	0.45
Social Impacts	15%	2	0.30	1	0.15	1	0.15	2	0.30
Construction Cost	20%	3	0.60	1	0.20	3	0.60	2	0.40
Operation & Maintenance	15%	3	0.45	2	0.30	2	0.30	2	0.30
SCORE	100%	12	**2.35**	8	**1.45**	10	**1.85**	12	**2.50**

Final Design

Two parts:
Concrete vault retention system.
New storm pipe exiting the Killip Elementary Retention Basin.

Figure 10:
Proposed Retention System





StormTrap DoubleTrap Patented Concrete Vault Retention System

Figure 11: Acknowledgement: StormTrap Stormwater Solutions

Footprint: **90,037 SF**

Retention Capacity:
1,350,554.32 CF

Pipe inlets/outlets enter the vault system underground through vault walls.

Foundation designed with high void ratio ABC for groundwater infiltration.

Estimated cost of materials and freight: **$9,000,000**

StormTrap DoubleTrap Patented Concrete Vault Retention System

Figure 12 and Figure 13:
Retention Design

Design Aspects:

- Reinforced precast concrete
- 15’ tall vaults
- Groundwater infiltration openings per Flagstaff requirements.

Killip Pipe Addition

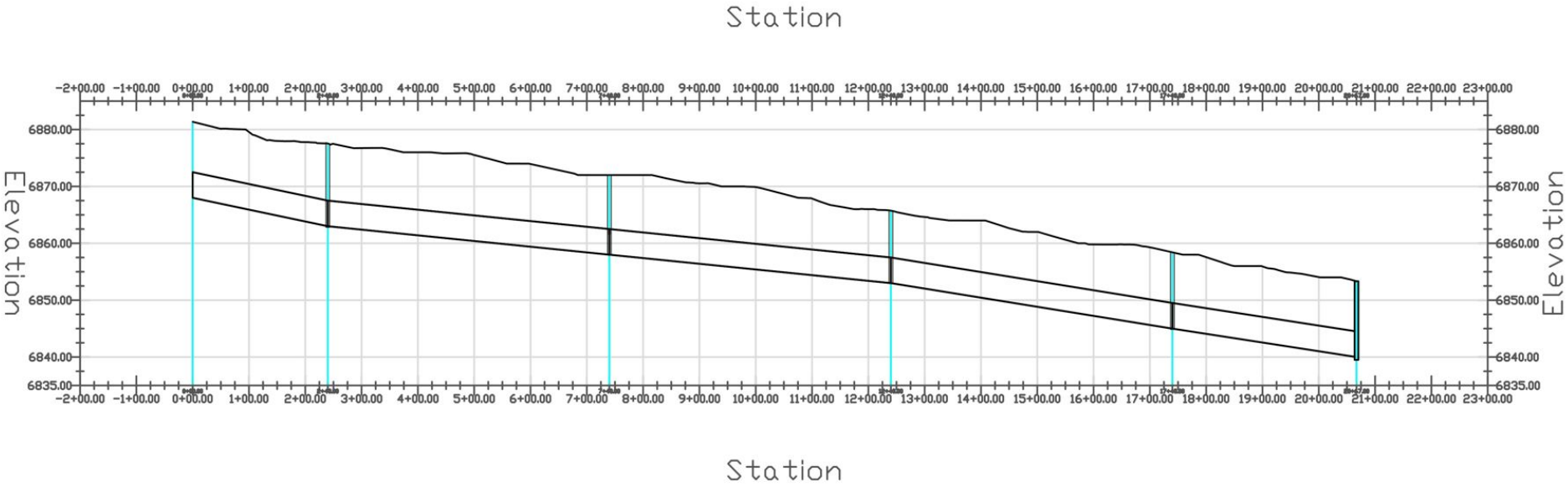
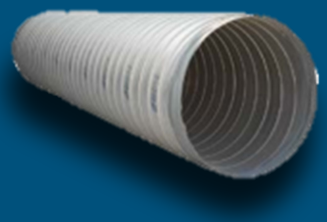
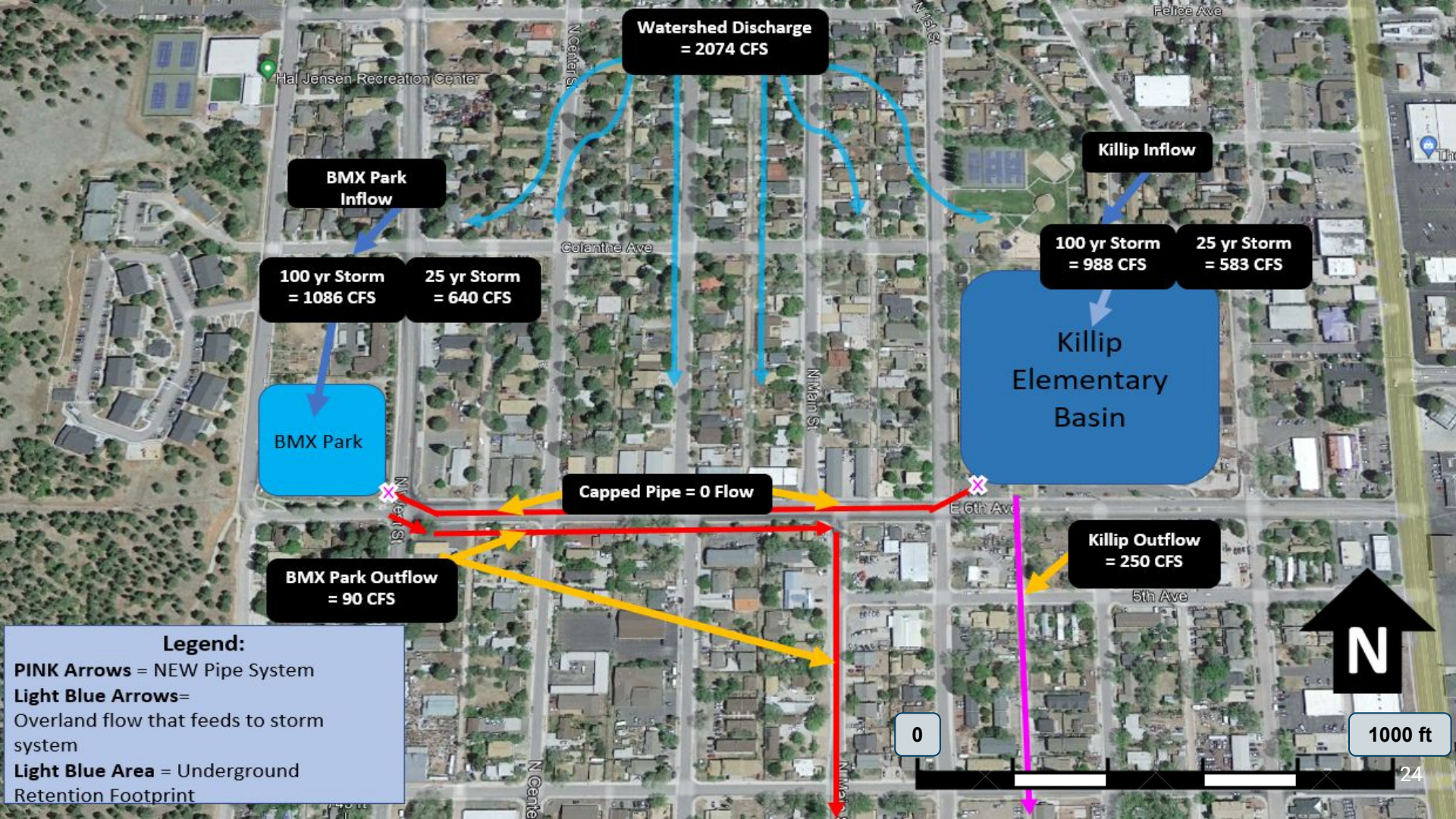


Figure 14:
Profile View of Killip Pipe

- 54” ULTRA FLO® Pipe
- Pipe cover, manholes and slopes meet Flagstaff requirements
- Pipe can handle 250 cfs

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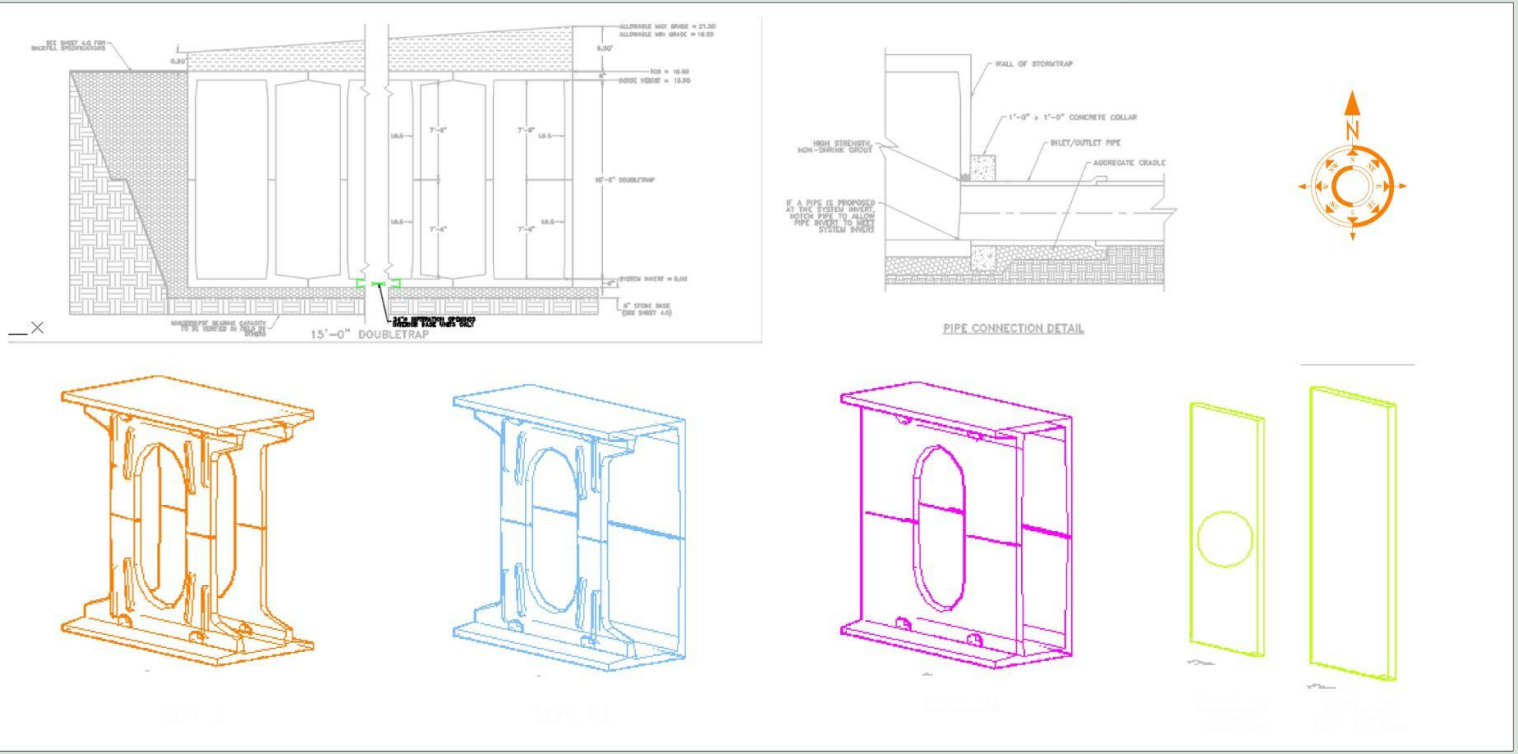
25 yr Storm
= 640 CFS
100 yr Storm
= 988 CFS
25 yr Storm
= 583 CFS
Killip
Elementary
Basin
BMX Park
Capped Pipe = 0 Flow
E 6th Ave
Killip Outflow
= 250 CFS
BMX Park Outflow
= 90 CFS
5th Ave
N
0
1000 ft
Legend:
PINK Arrows = NEW Pipe System
Light Blue Arrows=
Overland flow that feeds to storm system
Light Blue Area = Underground Retention Footprint

Design Analysis

Both new designs are maximized for the area.

Table 7: Design Efficiency		System Capacity (CF)	100 Year storm	50 year storm	25 year storm
			Total Flow (cfs)	Total Flow (cfs)	Total Flow (cfs)
Design	% of Watershed Flow		2074	1586	1223
BMX Park	52.35%	1350000	**61.91%**	**83.27%**	**112.03%**
Killip Basin & Pipe	47.65%	1377540	**63.65%**	**83.24%**	**107.94%**



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FLAGSTAFF, ARIZONA 86011

WEBSITE:
https://www.ceias.nau.edu/capstone/projects/CENE/2023/COF_WestSt/

OKM ENGINEERING LLC.

Basin Plan

4/5/2023

REVISIONS

NO.	BY	DATE	DESCRIPTION

DESIGNED BY:	KFK & MDP & OMS
DRAWN BY:	OMS
CHECKED BY:	JLH

6 of 6

Construction Cost Estimate

Table 8: Underground Detention Basin					
Aspect		Unit	Unit price	Quantity	Cost ($$)
Earthwork:					
	Demo	SF	$4	17,000	$68,000
	Excavation	CY	$10	55,304	$553,042
	Foundation	CY	$18	13,339	$240,099
	Backfill	CY	$10	17,426	$174,258
Retention Tank		LS	$9,000,000	1	$9,000,000
Catch basin drains		# of Units	$2,875	1	$2,875
BMX park rebuild		SF	$55	17,000	$935,000
TOTAL:					**$10,973,274**

Construction Cost Estimate

Table 9: New pipe at killip					
Aspect		Unit	Unit price	Quantity	Cost ($$)
Pipe:					
	Inlet	# of Units	$3,500	1	$3,500
	54" UltraFlo CMP	LF	$210	2,067	$434,070
	Manholes	# of Units	$10,000	5	$50,000
Earthwork:					
	Excavation	CY	$25	9,302	$232,538
	Backfill (native)	CY	$5	7,123	$35,617
	Backfill (ABC)	CY	$30	961	$28,818
TOTAL:					**$784,542**

Construction Cost Estimate

Table 10: Project Cost Analysis	
Earthwork	$1,264,371
Technical work	$10,493,445
Project TOTAL Cost	**$11,757,816**

Project Cost analysis in terms of dirt work vs technical work.

Full project cost analysis.

Table 11: Project Cost Analysis	
Underground Detention Basin	$10,973,274
New Pipe @ Killip Elementary	$784,542
Project TOTAL Cost	**$11,757,816**

Project Impacts

Environmental Impacts

- Prevention of overland flow
- Increased groundwater infiltration
- Absence of overland flow benefits vegetation

- Potential increased erosion downstream
- Construction induced noise and air pollution

Social Impacts

- Less neighborhood flooding
- Community designs new BMX Park

- Demolition of BMX Park
- Access limited in alley by construction
- Potential new flooding patterns downstream

Economical Impacts

- Increased property values
- Reduced flood damage repair costs
- Increased yearly business

- Expensive
- Potential increased flow into Rio De Flag

Thank You For Listening.
Any Questions?

Site Research

Table 12: USDA Soil Data

Area Symbol	Soil Type	Percent Slope (%)
3	Baldy Stoney Loam	2-8
8	Paymaster Family Fine Sandy Loam	0-3
11	Collbran Stoney Clay Loam	5-20

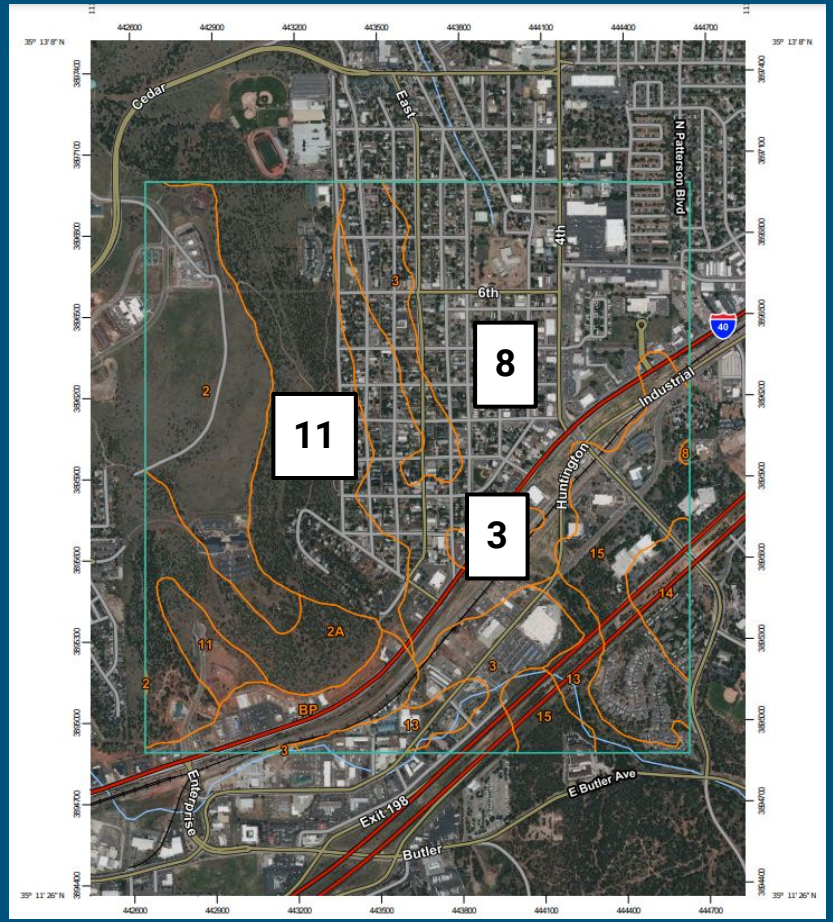

Figure 15: USDA Soil Data

Survey & Survey Data Analysis

Survey data was collected to confirm existing as-builts and GIS data

Figure 16: Omar Preparing to Survey

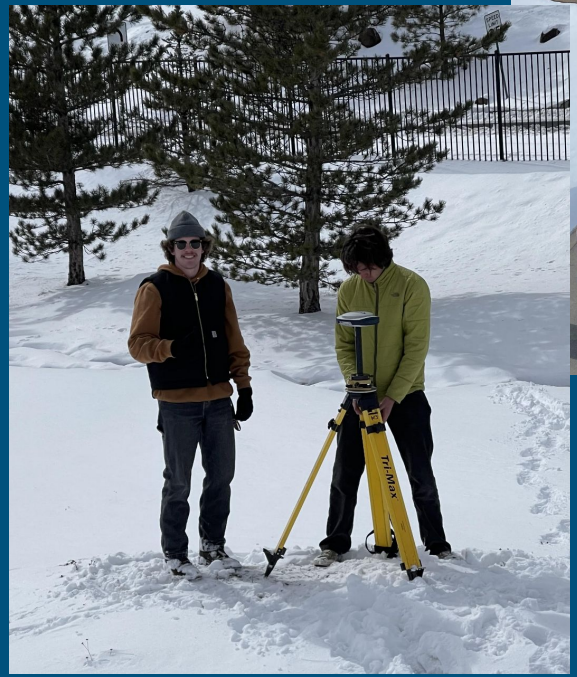

Figure 17: Kolten and Mikael Prepping Base Station

Analysis of Alternatives

Upon further analysis:
- Aquiferous retention design **thrown out** for plausibility.
    - Design **replaced** with s**hallow underground retention**.

- New design alternative in consideration: Combining underground detention with a new pipe at Killip Elementary.
    - Combination will split required capacity between each system.
    - Should be more efficient in the limited space for construction.