60% Report

486 CAPSTONE PROJECT:

RYAN'S TRAIL ROAD REDESIGN IN COCONINO COUNTY, FLAGSTAFF, ARIZONA

NORTHERN ARIZONA UNIVERSITY®

College of Engineering, Forestry, and Natural Sciences

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Yufei Cheng
McKenzie Moten
Parker Schrandt
Trevor Snipes

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Acknowledgements

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We would also like to thank Dr. Brendan Russo for his professional technical expertise on the preliminary and design phases of our road redesign project.

Lastly, we would like to thank the residents of Lockett Ranches for allowing us to design their improved access road and perform the necessary fieldwork in their development.

Without the assistance of these individuals, the road redesign would not have been possible.

1.0 Project Introduction

1.1 Project Purpose

The residents of Lockett Ranches have requested improvements for an existing private road. The Ryan's Trail Capstone team will be evaluating potential design options by completing the project "Ryan's Trail Road Redesign". The clients would like to enhance many elements of the road including: the ease of snow removal, the suitability for all vehicle types, the durability for regular use, insurance of proper drainage, and the cost effectiveness of road maintenance. The team will be expected to recommend designs that best satisfy all the said requests within the means of the clients. These designs will be dependent upon the team's thorough analysis both in the field and in the office. A renovation may include a change of material and a change in the road's structure.

1.2 Project Background

1.2.1 Road Location and Dimensions

Located in Coconino County, which is northeast of Flagstaff city limits, is a residential development "Lockett Ranches" (Figure 1). Within the community it is east off of Hattie Greene Road. Some of the utilities lie on N. Wildcat Trail, which is the road west of Ryan's Trail (Figure 2). The road itself is classified as a private road, and is a quarter-mile long and approximately 12 feet wide (Figure 3).

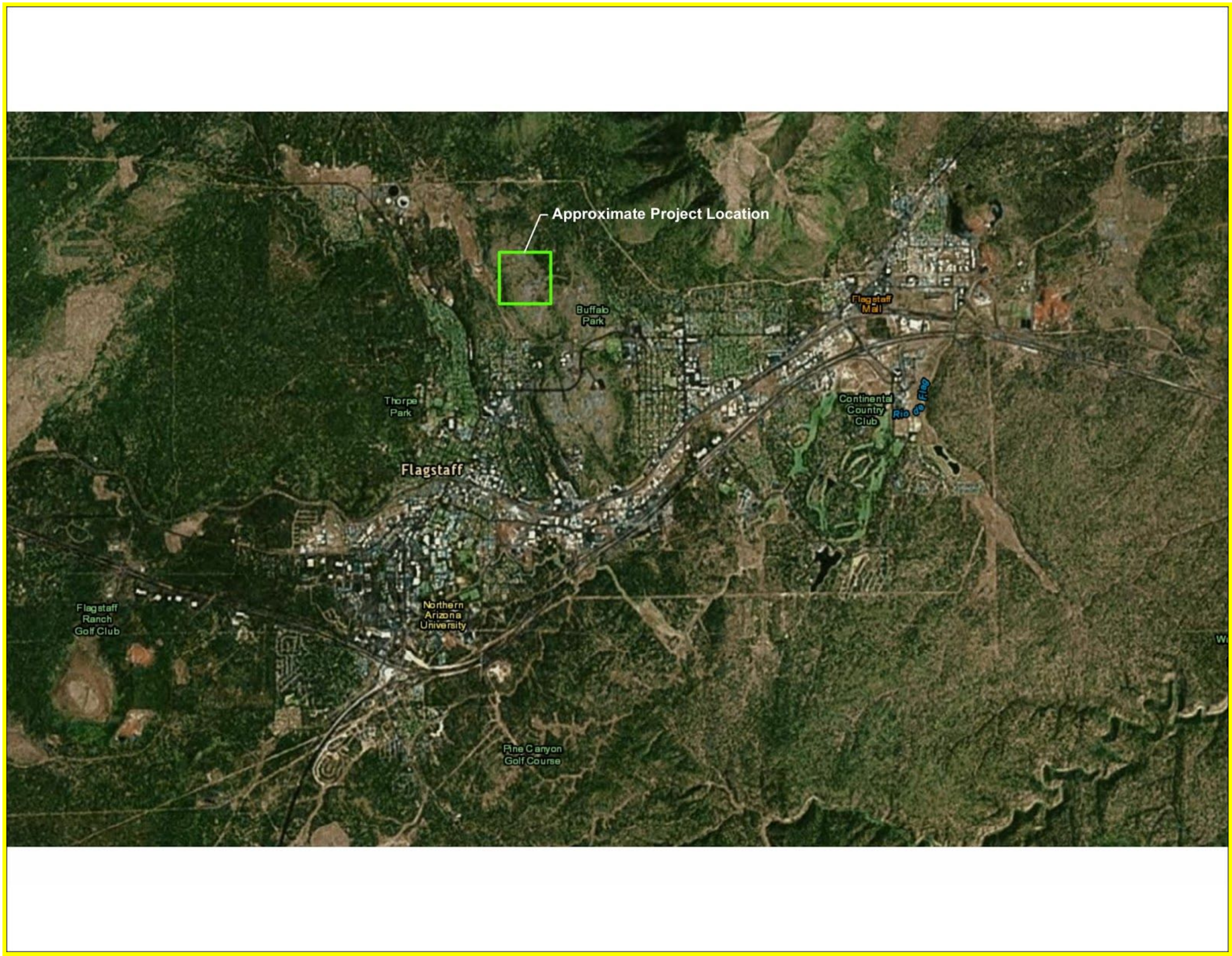

Figure 1: Location of Coconino County in Arizona [1]

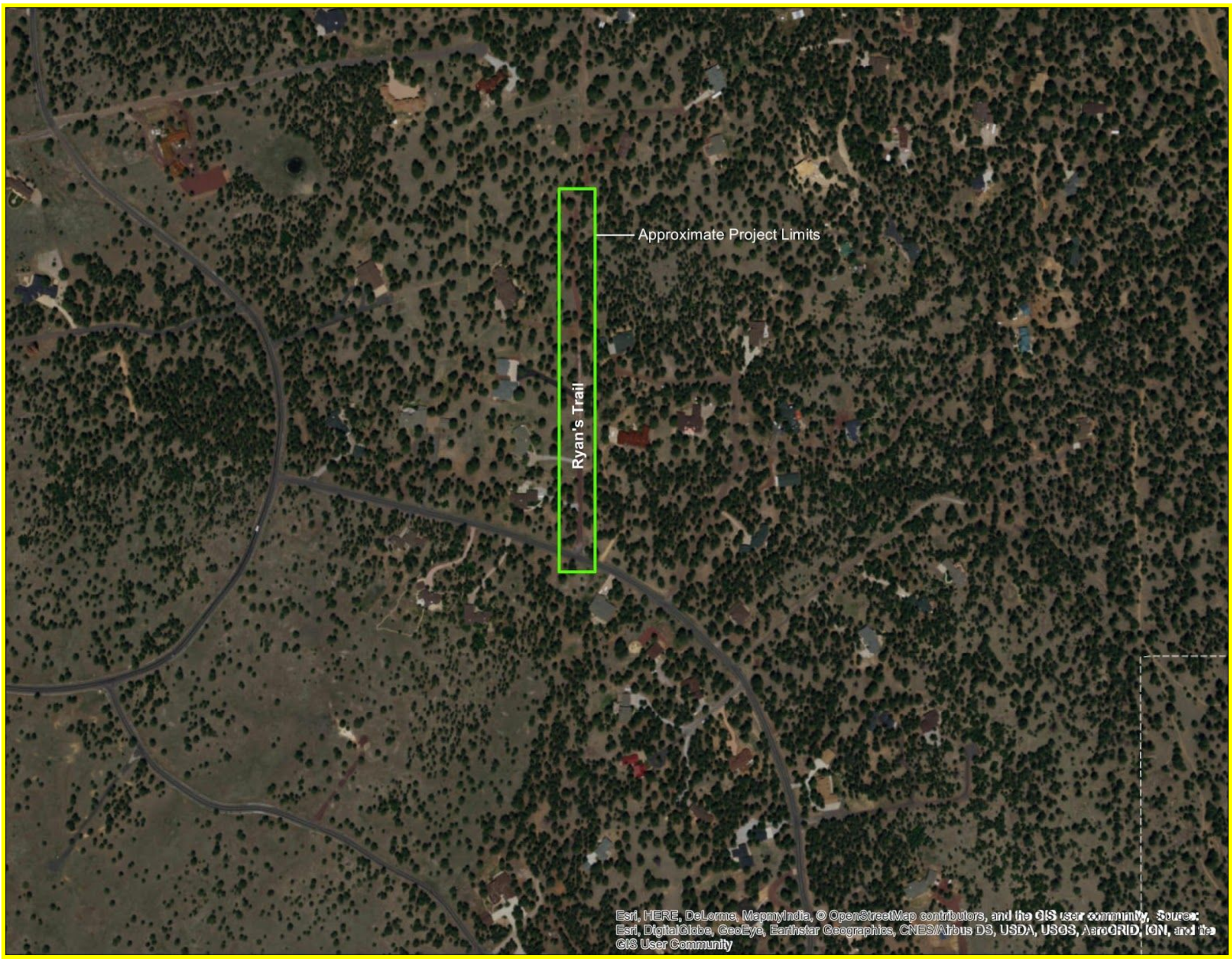

Figure 2: Lockett Ranches Site Map [1]

Photo By: McKenzie Moten

Figure 3:Private Road "Ryan's Trail" located in Lockett Ranches, AZ

1.2.2 Existing Material Conditions

The road currently consists of mostly dirt with a combination of crushed cinders and gravel on top. The maximum amount of gravel, cinders, or a combination of the two at any point on the trail is no more than six inches. There are five residential homes accessed by the use of Ryan's Trail paired with their individual driveways. The material of these driveways is necessary to consider because the newly designed road will need to mesh into the driveway material without complications. There are currently two gravel driveways, a dirt driveway, an asphalt driveway, and a driveway composed of cinders.

1.2.3 Existing Watershed Analysis

The team will perform an analysis using "GIS" (Geographic Information Systems) to determine the specific hydrological patterns of Ryan's Trail. The results can be found under the "Technical Considerations" section. The current research conducted regarding the hydrology of the area concluded that the runoff from the San Francisco Peaks drains primarily around our given site (Figure 4).

WANTS FORMAL WATER SHED MAP

Figure 4: Watershed behavior in Coconino County [3]

1.2.4 Existing Utilities

The existing utilities (gas, water, electric, and cable) that are located under Ryan's Trail were to be identified to prevent damage during the road redesign. Blue Stake (a service used to mark existing utilities) was contracted to help prevent incidents such as gas leaks or the leakage of electricity during construction. The Blue Stake results can be seen in Figure 5.

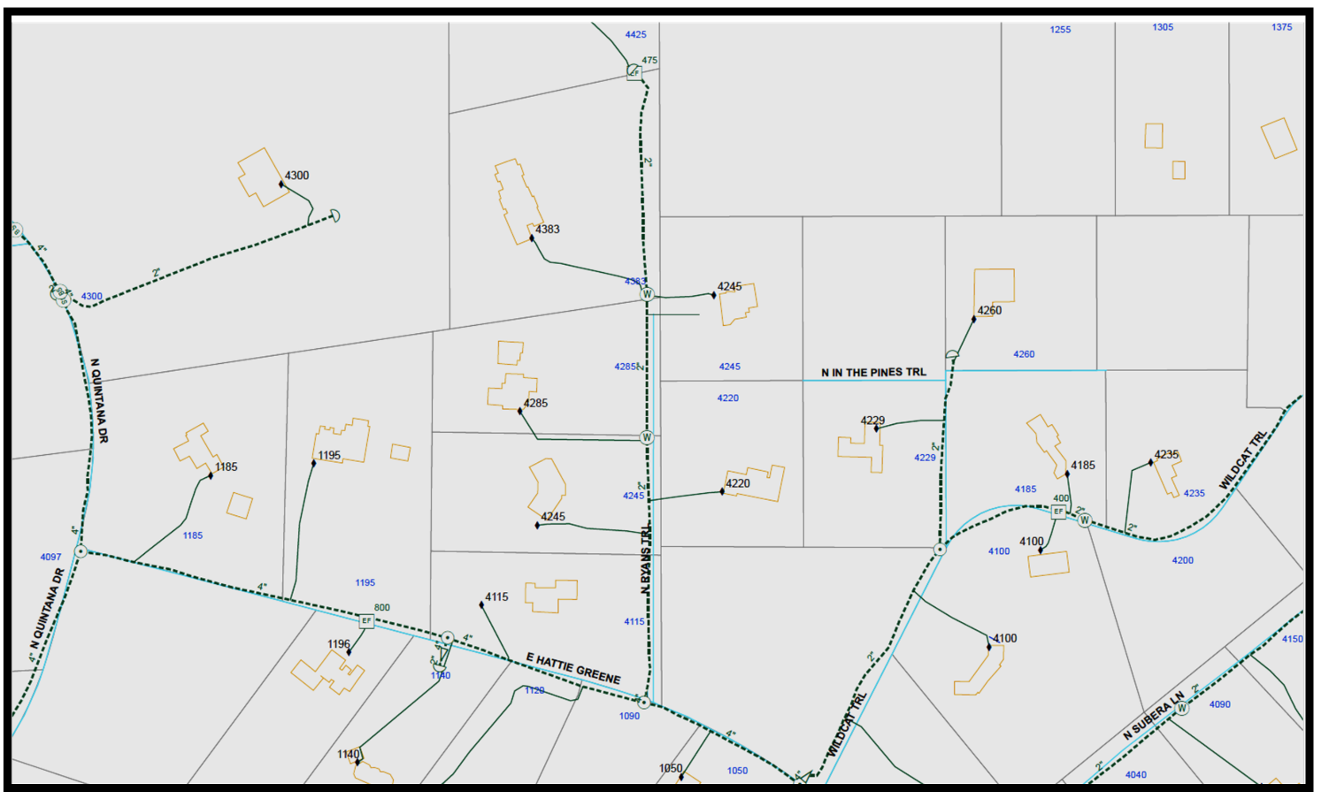

Figure 5: Utilities Located in Lockett Ranches Indicated by Blue Stake Services

1.2.5 Constraints and Limitations

The potential challenges the team predicts they will have to overcome in the preliminary design phases include financial constraints and locating affordable materials. During the construction phase the access, utilities, codes, and weather are all of concern to the team. Lastly, evaluating the maintenance and success of the project will be difficult to measure with benefits such as "comfortability" or "aesthetics".

1.2.6 Scope of Project

While there are many components of this project the tasks that the team is responsible for are to be specified clearly and systematically. The engineering team is accountable for administering background research, performing a site investigation, developing a topographic map, analyzing the current design and it's hydrology, suggesting alternatives, and performing a life cycle cost analysis on the final designs. A detailed description of each of these tasks, and the subtasks that they include can be found in section 2.0 "Technical Considerations".

2.0 Technical Considerations

2.1 Site Investigation

2.1.1 Site Visit

The site investigation included multiple forms of documentation. The photographic observations and notes taken assisted the team in the beginning part of the analysis. The initial notes concluded that the road was not properly designed for snow removal, drainage, and everyday residential use. The team also spoke with the secondary clients and evaluated their interest in financing the project.

2.1.2 Blue Stake

Underneath Ryan's Trail are a number of existing utility lines. These lines have a few existing boxes and hand holes that will require adjusting to grade if the road elevation is changed. The boxes that need to be adjusted will be called out on the plan set as such.

2.1.3 Field Surveying

A Topographic Map will require survey of the existing site conditions. A theodolite total station will be used to collect data. This includes existing road grades, nearby tree locations, utility boxes, and drainage structures.

2.2 Site Map

To provide a topographic map, the survey will also need to be drafted. AutoCAD will be used to provide the topographic map. This can be seen in the attached construction plans.

2.3 Conceptual Design

2.3.1 Existing Design Analysis

This report was purely to inform the client that the team had a complete understanding of the objectives and task at hand. This allowed the team to develop general ideas about what they thought could serve as possible solutions and began to do research and calculations to support these hypothesis.

2.3.2 30% Report

The 30% Report included the complete analysis of the existing conditions.

2.3.3 Material Concepts

WANTS FORMAL AUTOCAD CROSS SECTIONS

2.4 Hydrology

2.4.1 Watershed Analysis

The area of Ryan's Trail is higher in elevation, and between two analysed watershed drainage basins. Based on the relative data of the basins, Ryan's Trail is not in a floodpath. Though the road is not prone to flooding, potholes and deterioration of the road is plausible. With the addition of another material to the road, such as asphalt or gravel, the percolation and surface runoff will need to be analyzed to ensure that the culverts and drainage routes beside the road will meet the necessary capacity.

2.4.2 Culvert Design

Utilizing the FlowMaster and CulvertMaster programs, USGS rainfall and runoff data, and Coconino County Records the team determined the peak discharge for the drainage over Ryan's Trail. The team analyzed the seven existing culverts to verify and determine whether they were sufficient for the existing parameters. The team found that the flow in the first culvert was classified as supercritical, while the following downstream were subcritical. Below is a table that represents the analyzed data for the seven culverts.

Culvert	Discharge (cfs)	Slope (ft/ft)	Velocity (ft/s)	H.W. Elevation (ft)
1	0.06	0.03700	1.65	100.09
2	0.02	0.00350	1.05	95.17
3	0.03	0.00998	1.17	94.57
4	0.02	0.00388	1.05	95.24
5	0.02	0.00300	1.05	95.04
6	0.03	0.00993	1.17	96.27
7	0.02	0.00372	1.05	96.84

Figure(): Culvert Analysis

2.4.3 Improved Road Design Alternatives

Based on the analysis performed for the existing culverts, it was determined that two more culverts would be required to prevent puddling and pooling near the road. Based on the elevations of the individual culverts, and the flow velocities for each, the team would suggest a culvert be installed between numbers three and four and would run perpendicular to the road. A second culvert would also be installed perpendicular to the road, between culverts five and six. This would ensure that the runoff would have another route downhill, and would prevent pooling at the inlets. To address the supercritical flow in the first culvert, the slope would need to be decreased to ensure that a subcritical flow is achieved. The length of the culvert is respective to the width of the road around the cul-de-sac, therefore the slope would be the simplest adjustment for the drainage of the road.

2.5 Life Cycle Cost Analysis

As seen in the “Technical Considerations,” the life cycle cost analysis is a component that is included in the team’s scope. This shows the life cycle of the different materials in their entirety for the client to compare.

2.5.1 Feasibility Report

The feasibility report as well as the cash flow diagrams will be completed with the

- Service Life
- Construction Cost
- Annual O and M Cost
- Annual Safety and Operational Benefits
- Salvage Value or Cost

When these specific values/ bids are received from local companies (in response to the formal alternative drawings that will be sent off to them by Sunday).

WANTS FORMAL LCCA

2.6 Final Design Recommendations

Section not expected to be completed at this time

2.8 Summary of Engineering Work

Section not expected to be completed at this time

2.9 Summary of Engineering Costs

Section not expected to be completed at this time

2.9.1 Staff

2.9.2 Qualifications

2.9.3 Budget

2.9.4 Justification

3.0 Conclusion

Section not expected to be completed at this time

4.0 References

[1] Google LLC, "Google Maps," Google LLC, 2017. [Online]. Available:

https://www.google.com/maps. [Accessed November 2017].

[2] U.S. Geological Survey, G. W. Hill, and B. N. Aldridge, *Flood Hydrology Near Flagstaff, Arizona*. Tucson, AZ, 1988.

Appendix A

Culvert Summary					
Computed Headwater Elevation	100.09	ft	Discharge	0.06	cfs
Inlet Control HW Elev.	100.09	ft	Tailwater Elevation	0.00	ft
Outlet Control HW Elev.	100.07	ft	Control Type	Inlet Control	
Headwater Depth/Height	0.11				

Grades					
Upstream Invert	99.93	ft	Downstream Invert	99.26	ft
Length	18.18	ft	Constructed Slope	0.036854	ft/ft

Hydraulic Profile					
Profile	S2		Depth, Downstream	0.08	ft
Slope Type	Steep		Normal Depth	0.08	ft
Flow Regime	Supercritical		Critical Depth	0.09	ft
Velocity Downstream	1.65	ft/s	Critical Slope	0.022583	ft/ft

Section					
Section Shape	Circular		Mannings Coefficient	0.024	
Section Material	Aluminum		Span	1.50	ft
Section Size	18 inch		Rise	1.50	ft
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	100.07	ft	Upstream Velocity Head	0.03	ft
Ke	0.70		Entrance Loss	0.02	ft

Inlet Control Properties					
Inlet Control HW Elev.	100.09	ft	Flow Control	Unsubmerged	
Inlet Type	Mitered to slope		Area Full	1.8	ft²
K	0.02100		HDS 5 Chart	2	
M	1.33000		HDS 5 Scale	2	
C	0.04630		Equation Form	1	
Y	0.75000				

Culvert 1

Culvert Summary					
Computed Headwater Elevation	95.17	ft	Discharge	0.02	cfs
Inlet Control HW Elev.	95.07	ft	Tailwater Elevation	N/A	ft
Outlet Control HW Elev.	95.17	ft	Control Type	Outlet Control	
Headwater Depth/Height	0.11				

Grades					
Upstream Invert	95.00	ft	Downstream Invert	94.93	ft
Length	20.00	ft	Constructed Slope	0.000000	ft/ft

Hydraulic Profile					
Profile	H2		Depth, Downstream	0.05	ft
Slope Type	Horizontal		Normal Depth	N/A	ft
Flow Regime	Subcritical		Critical Depth	0.05	ft
Velocity Downstream	1.05	ft/s	Critical Slope	0.026421	ft/ft

Section					
Section Shape	Circular		Mannings Coefficient	0.024	
Section Material	Aluminum		Span	1.50	ft
Section Size	18 inch		Rise	1.50	ft
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	95.17	ft	Upstream Velocity Head	0.00	ft
Ke	0.90		Entrance Loss	0.00	ft

Inlet Control Properties					
Inlet Control HW Elev.	95.07	ft	Flow Control	Unsubmerged	
Inlet Type	Projecting		Area Full	1.8	ft²
K	0.03400		HDS 5 Chart	2	
M	1.50000		HDS 5 Scale	3	
C	0.05530		Equation Form	1	
Y	0.54000				

Culvert 2

Culvert Summary					
Computed Headwater Elevation	94.57	ft	Discharge	0.03	cfs
Inlet Control HW Elev.	94.55	ft	Tailwater Elevation	N/A	ft
Outlet Control HW Elev.	94.57	ft	Control Type	Outlet Control	
Headwater Depth/Height	0.07				

Grades					
Upstream Invert	94.47	ft	Downstream Invert	94.27	ft
Length	20.05	ft	Constructed Slope	0.009975	ft/ft

Hydraulic Profile					
Profile	M2		Depth, Downstream	0.06	ft
Slope Type	Mild		Normal Depth	0.08	ft
Flow Regime	Subcritical		Critical Depth	0.06	ft
Velocity Downstream	1.17	ft/s	Critical Slope	0.025239	ft/ft

Section					
Section Shape	Circular		Mannings Coefficient	0.024	
Section Material	Aluminum		Span	1.50	ft
Section Size	18 inch		Rise	1.50	ft
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	94.57	ft	Upstream Velocity Head	0.01	ft
Ke	0.90		Entrance Loss	0.01	ft

Inlet Control Properties					
Inlet Control HW Elev.	94.55	ft	Flow Control	Unsubmerged	
Inlet Type	Projecting		Area Full	1.8	ft²
K	0.03400		HDS 5 Chart	2	
M	1.50000		HDS 5 Scale	3	
C	0.05530		Equation Form	1	
Y	0.54000				

Culvert 3

Culvert Summary					
Computed Headwater Elevation	95.24	ft	Discharge	0.02	cfs
Inlet Control HW Elev.	95.22	ft	Tailwater Elevation	N/A	ft
Outlet Control HW Elev.	95.24	ft	Control Type	Outlet Control	
Headwater Depth/Height	0.06				

Grades					
Upstream Invert	95.15	ft	Downstream Invert	94.92	ft
Length	59.30	ft	Constructed Slope	0.003879	ft/ft

Hydraulic Profile					
Profile	M2		Depth, Downstream	0.05	ft
Slope Type	Mild		Normal Depth	0.08	ft
Flow Regime	Subcritical		Critical Depth	0.05	ft
Velocity Downstream	1.05	ft/s	Critical Slope	0.026421	ft/ft

Section					
Section Shape	Circular		Mannings Coefficient	0.024	
Section Material	Aluminum		Span	1.50	ft
Section Size	18 inch		Rise	1.50	ft
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	95.24	ft	Upstream Velocity Head	0.00	ft
Ke	0.70		Entrance Loss	0.00	ft

Inlet Control Properties					
Inlet Control HW Elev.	95.22	ft	Flow Control	Unsubmerged	
Inlet Type	Mitered to slope		Area Full	1.8	ft²
K	0.02100		HDS 5 Chart	2	
M	1.33000		HDS 5 Scale	2	
C	0.04630		Equation Form	1	
Y	0.75000				

Culvert 4

Culvert Summary					
Computed Headwater Elevation	95.04	ft	Discharge	0.02	cfs
Inlet Control HW Elev.	95.02	ft	Tailwater Elevation	N/A	ft
Outlet Control HW Elev.	95.04	ft	Control Type	Outlet Control	
Headwater Depth/Height	0.06				

Grades					
Upstream Invert	94.95	ft	Downstream Invert	94.83	ft
Length	40.05	ft	Constructed Slope	0.002996	ft/ft

Hydraulic Profile					
Profile	M2		Depth, Downstream	0.05	ft
Slope Type	Mild		Normal Depth	0.09	ft
Flow Regime	Subcritical		Critical Depth	0.05	ft
Velocity Downstream	1.05	ft/s	Critical Slope	0.026421	ft/ft

Section					
Section Shape	Circular		Mannings Coefficient	0.024	
Section Material	Aluminum		Span	1.50	ft
Section Size	18 inch		Rise	1.50	ft
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	95.04	ft	Upstream Velocity Head	0.00	ft
Ke	0.70		Entrance Loss	0.00	ft

Inlet Control Properties					
Inlet Control HW Elev.	95.02	ft	Flow Control	Unsubmerged	
Inlet Type	Mitered to slope		Area Full	1.8	ft²
K	0.02100		HDS 5 Chart	2	
M	1.33000		HDS 5 Scale	2	
C	0.04630		Equation Form	1	
Y	0.75000				

Culvert 5

Culvert Summary			
Computed Headwater Elevation	96.27 ft	Discharge	0.03 cfs
Inlet Control HW Elev.	96.11 ft	Tailwater Elevation	N/A ft
Outlet Control HW Elev.	96.27 ft	Control Type	Outlet Control
Headwater Depth/Height	0.29		

Grades			
Upstream Invert	95.84 ft	Downstream Invert	96.04 ft
Length	20.15 ft	Constructed Slope	-0.009926 ft/ft

Hydraulic Profile			
Profile	A2	Depth, Downstream	0.06 ft
Slope Type	Adverse	Normal Depth	0.00 ft
Flow Regime	Subcritical	Critical Depth	0.06 ft
Velocity Downstream	1.17 ft/s	Critical Slope	0.025239 ft/ft

Section			
Section Shape	Circular	Mannings Coefficient	0.024
Section Material	Aluminum	Span	1.50 ft
Section Size	18 inch	Rise	1.50 ft
Number Sections	1		

Outlet Control Properties			
Outlet Control HW Elev.	96.27 ft	Upstream Velocity Head	0.00 ft
Ke	0.70	Entrance Loss	0.00 ft

Inlet Control Properties			
Inlet Control HW Elev.	96.11 ft	Flow Control	Unsubmerged
Inlet Type	Mitered to slope	Area Full	1.8 ft²
K	0.02100	HDS 5 Chart	2
M	1.33000	HDS 5 Scale	2
C	0.04630	Equation Form	1
Y	0.75000		

Culvert 6

Culvert Summary					
Computed Headwater Elevation	96.84	ft	Discharge	0.02	cfs
Inlet Control HW Elev.	96.82	ft	Tailwater Elevation	N/A	ft
Outlet Control HW Elev.	96.84	ft	Control Type	Outlet Control	
Headwater Depth/Height	0.06				

Grades					
Upstream Invert	96.75	ft	Downstream Invert	96.54	ft
Length	56.44	ft	Constructed Slope	0.003721	ft/ft

Hydraulic Profile					
Profile	M2		Depth, Downstream	0.05	ft
Slope Type	Mild		Normal Depth	0.08	ft
Flow Regime	Subcritical		Critical Depth	0.05	ft
Velocity Downstream	1.05	ft/s	Critical Slope	0.026421	ft/ft

Section					
Section Shape	Circular		Mannings Coefficient	0.024	
Section Material	Aluminum		Span	1.50	ft
Section Size	18 inch		Rise	1.50	ft
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	96.84	ft	Upstream Velocity Head	0.00	ft
Ke	0.70		Entrance Loss	0.00	ft

Inlet Control Properties					
Inlet Control HW Elev.	96.82	ft	Flow Control	Unsubmerged	
Inlet Type	Mitered to slope		Area Full	1.8	ft²
K	0.02100		HDS 5 Chart	2	
M	1.33000		HDS 5 Scale	2	
C	0.04630		Equation Form	1	
Y	0.75000				

Culvert 7