

Appendix E

Supporting Information

Concept Design Drawings (Preferred Alternative)

Ecosystem Services Tradeoff Analysis Evaluation

PR&G Preliminary Alternative Analysis Report

Biological Assessment

Aquatic Resources Report

Cultural Resource Assessment (redacted)

Saratoga Springs Watershed Plan-EA Technical Memorandum – 01

Geologic Units

Soil Types

Concept Design Drawings (Preferred Alternative)

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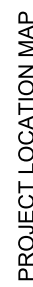
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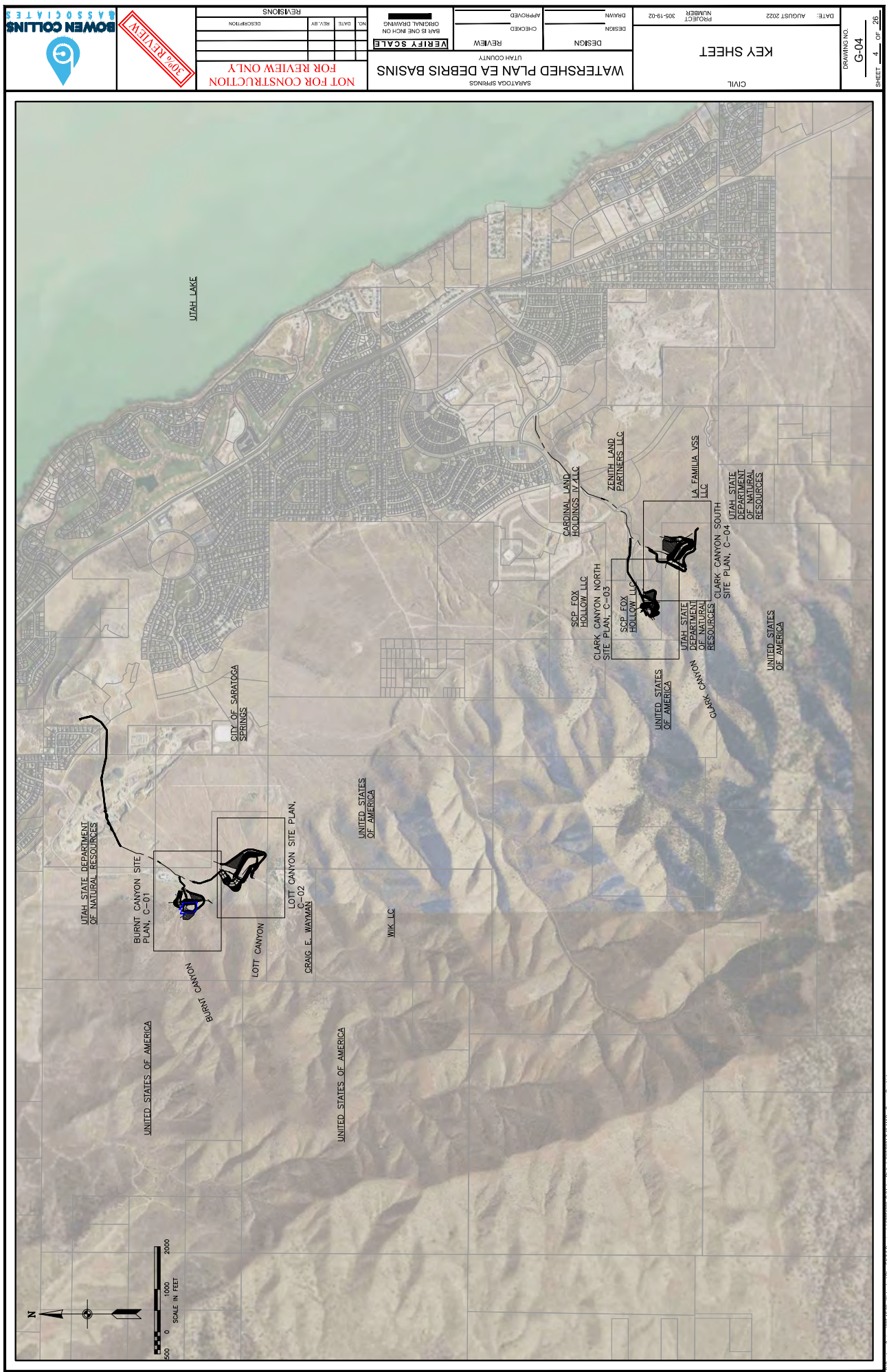
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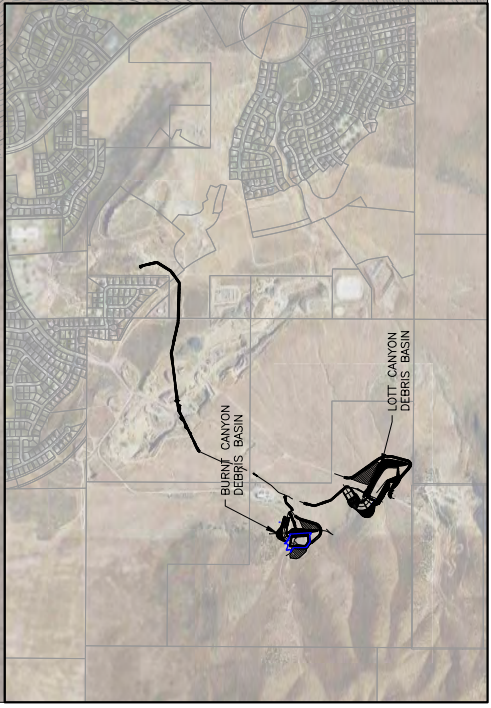
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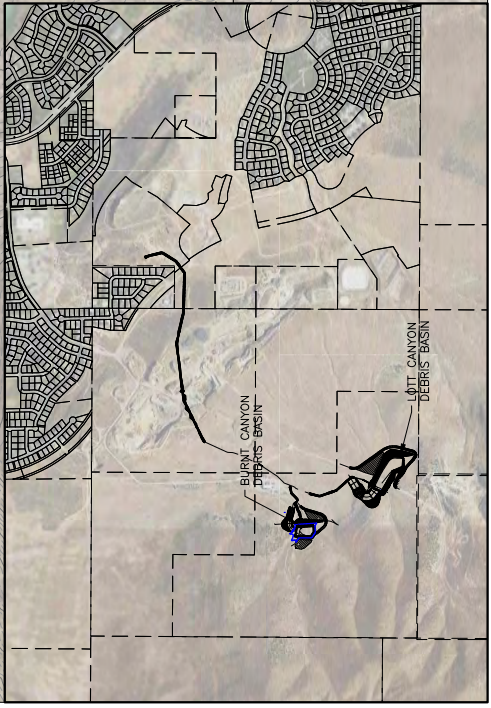
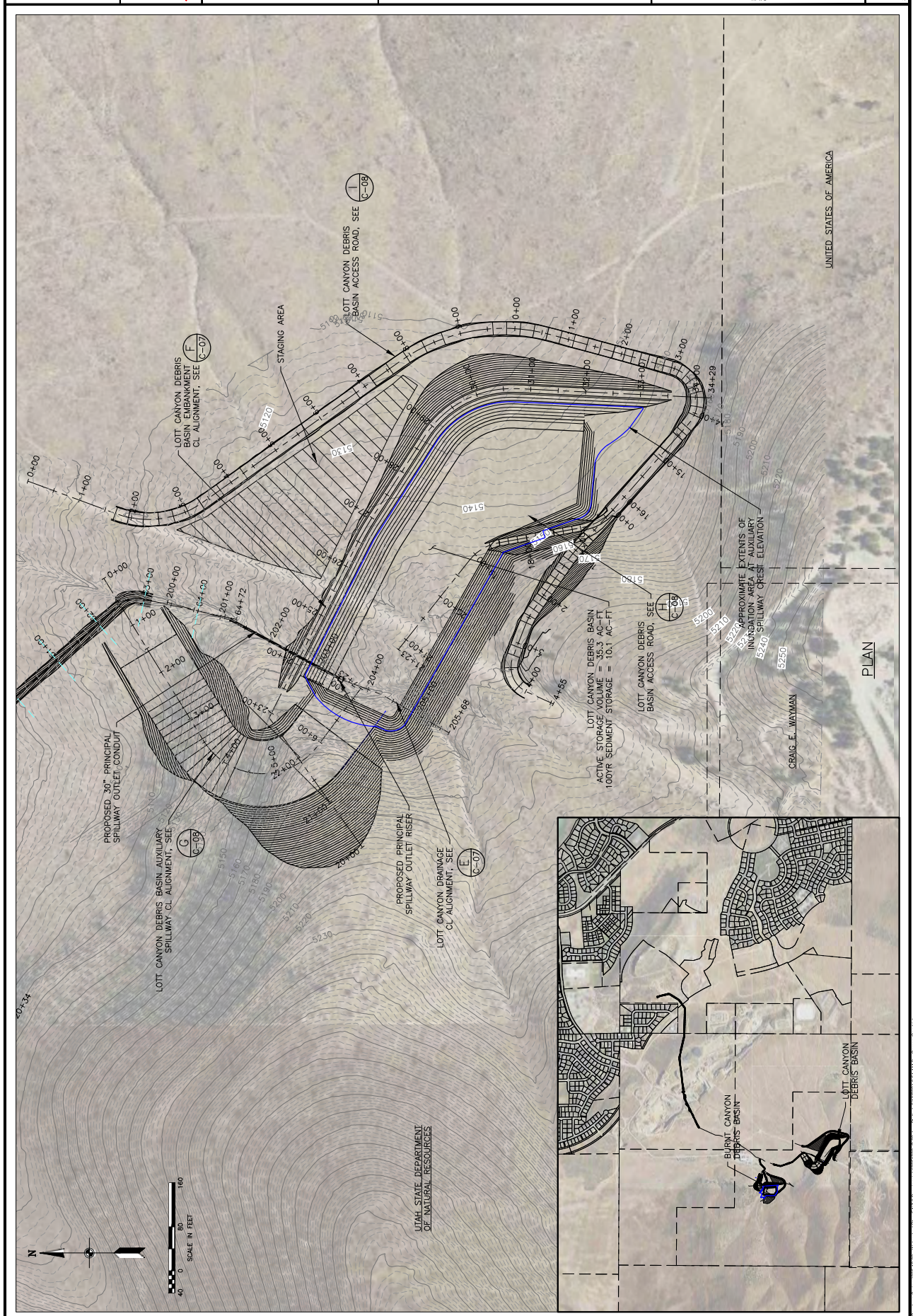
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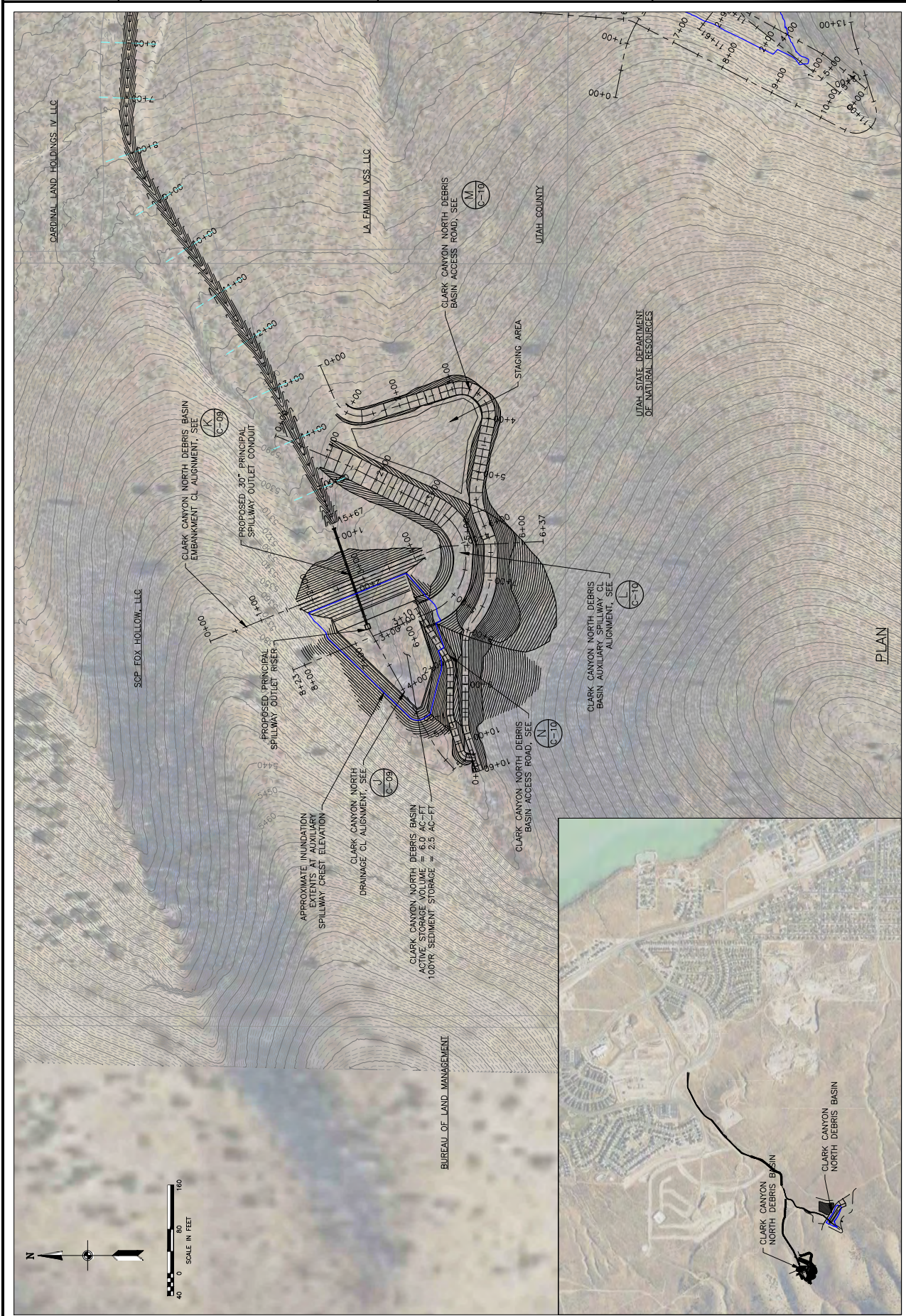
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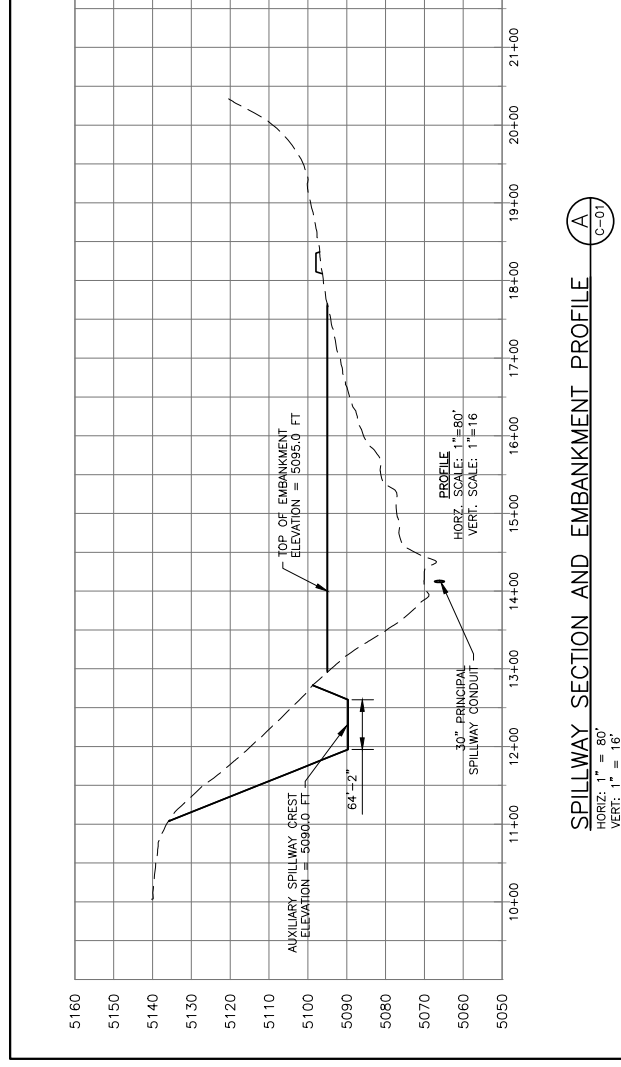
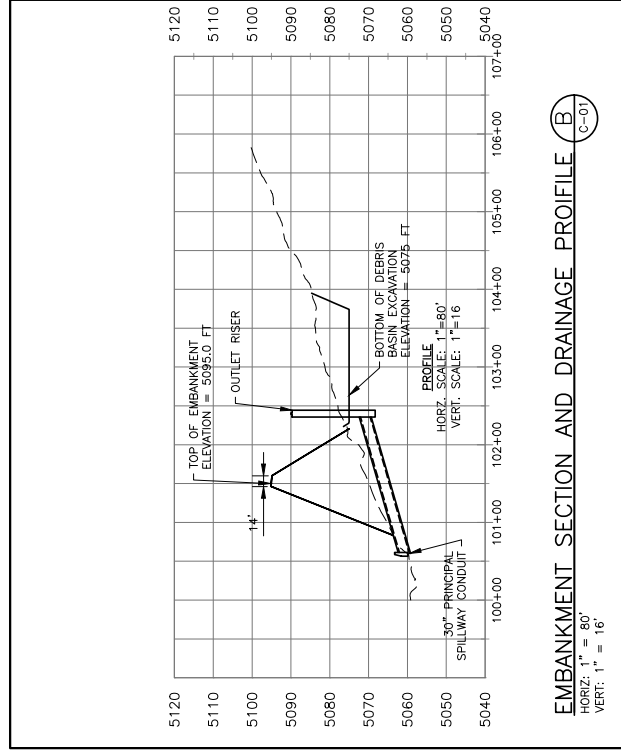
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**BURNT CANYON
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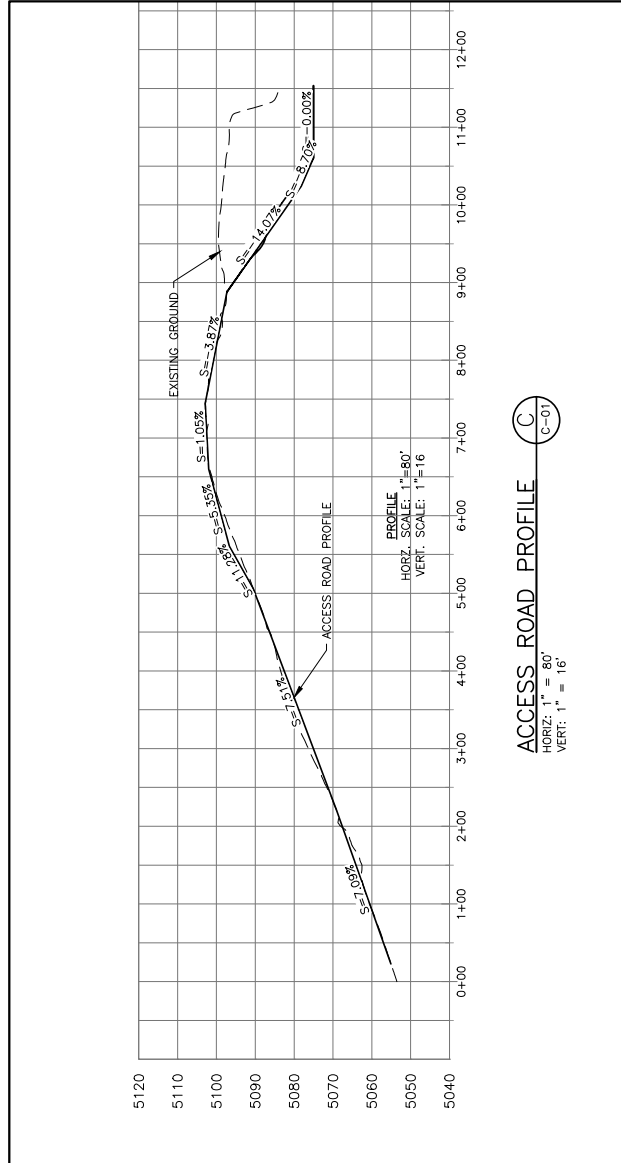
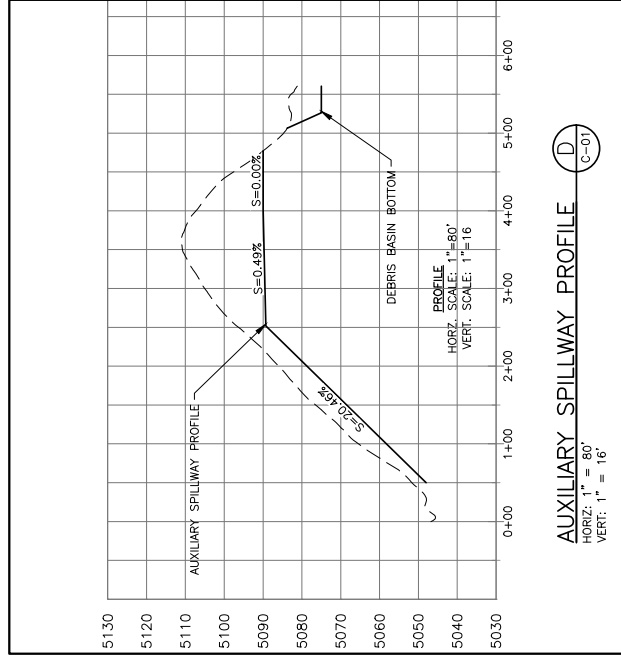
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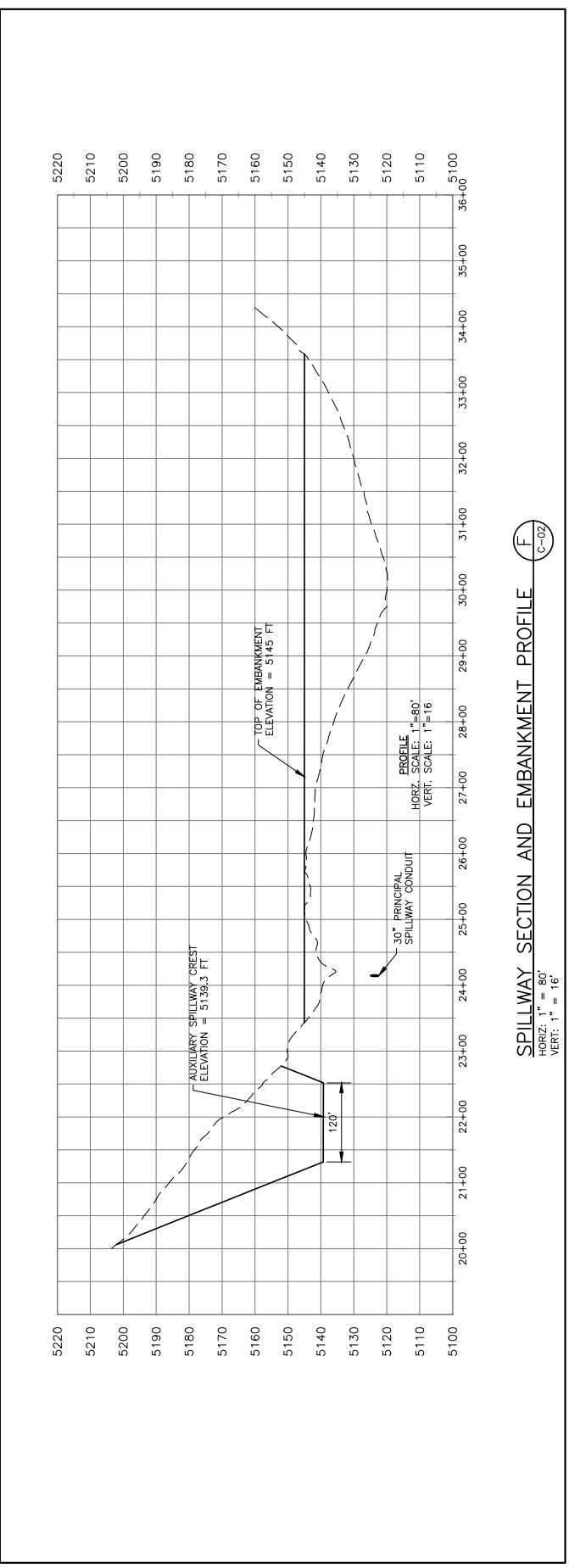
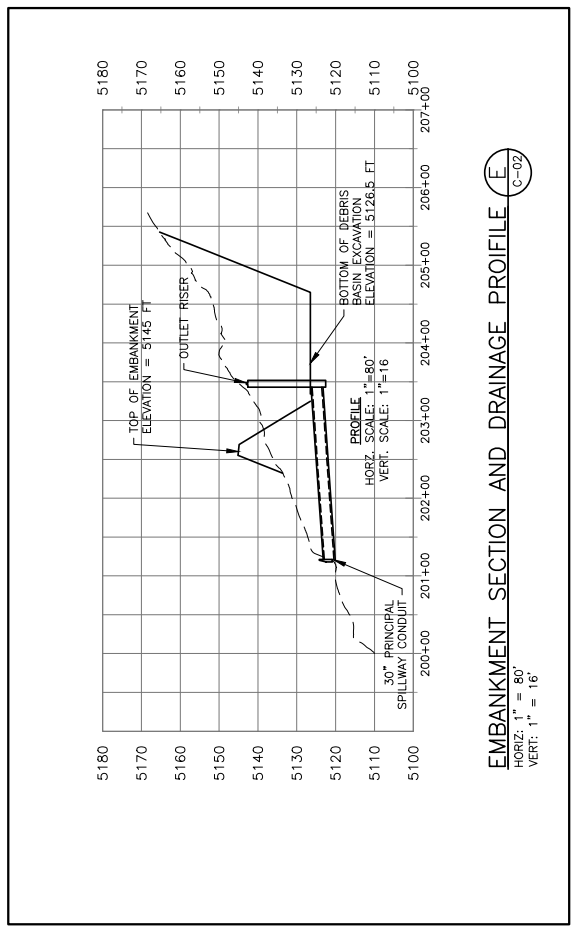
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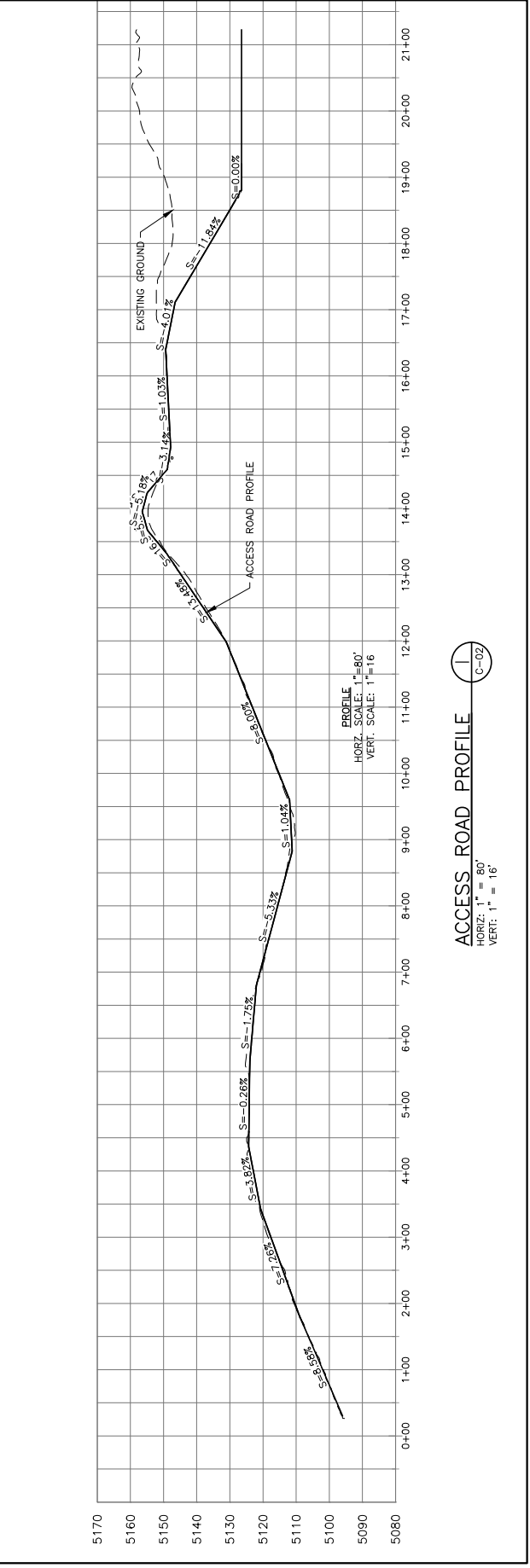
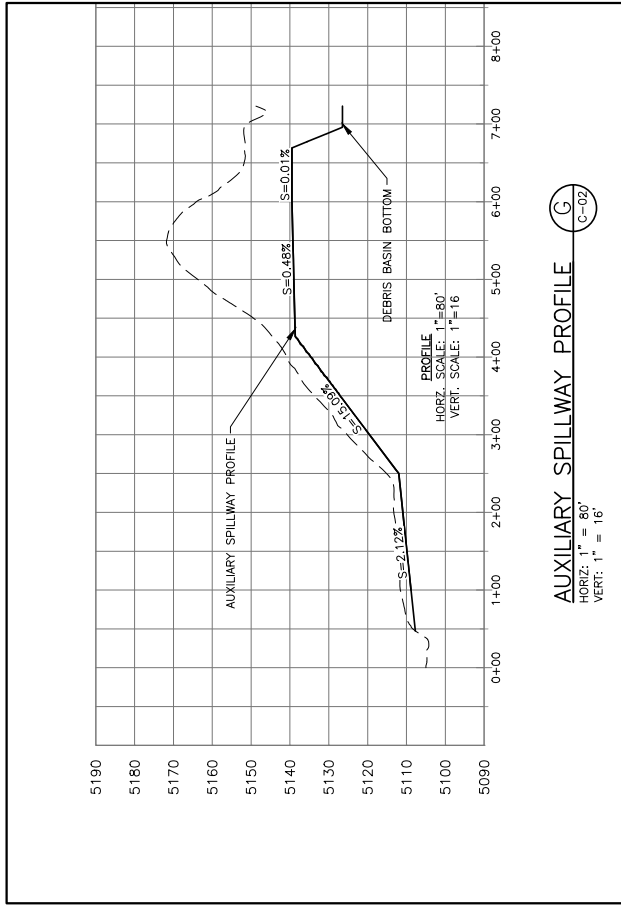
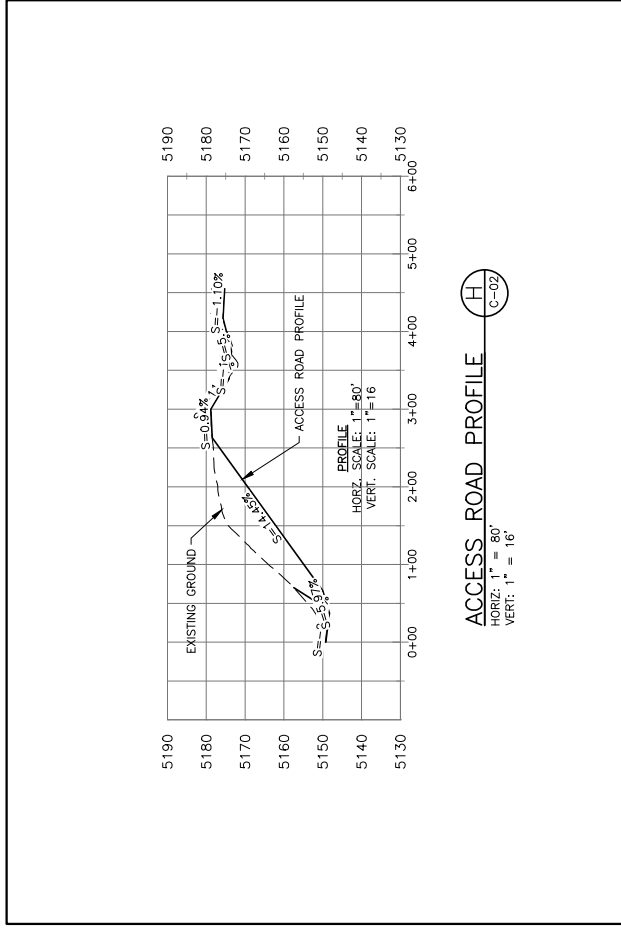
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LOT CANYON DEBRIS BASIN PROFILES AND SECTIONS - 1

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CLARK CANYON NORTH DEBRIS BASIN

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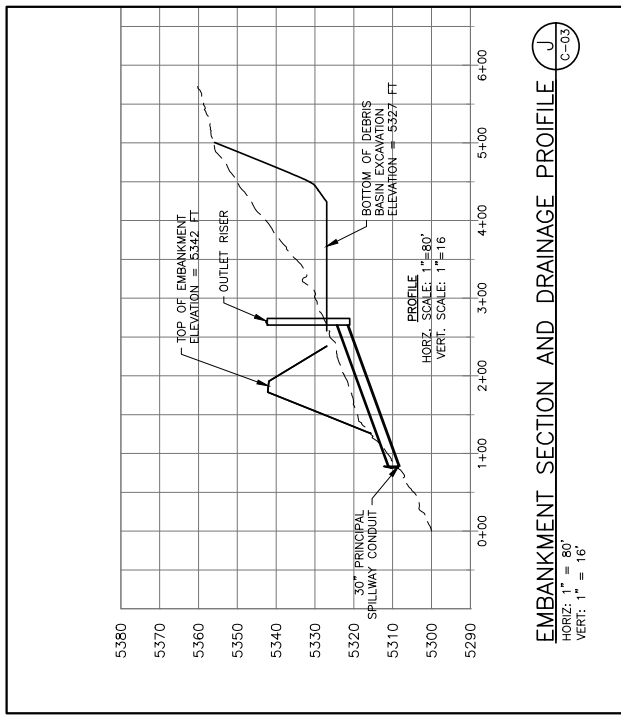
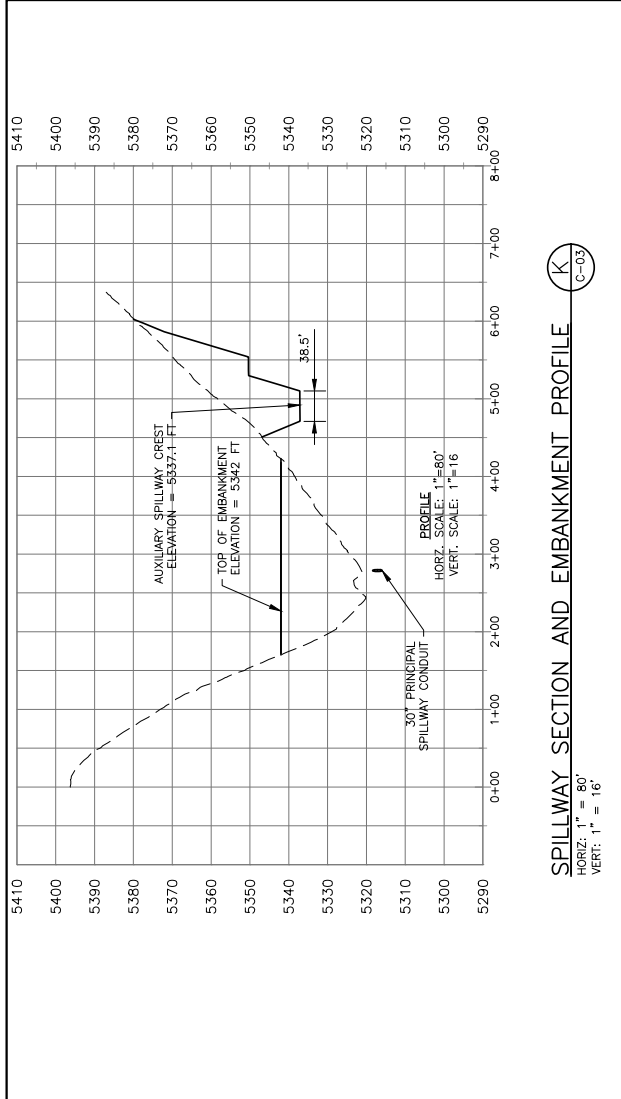
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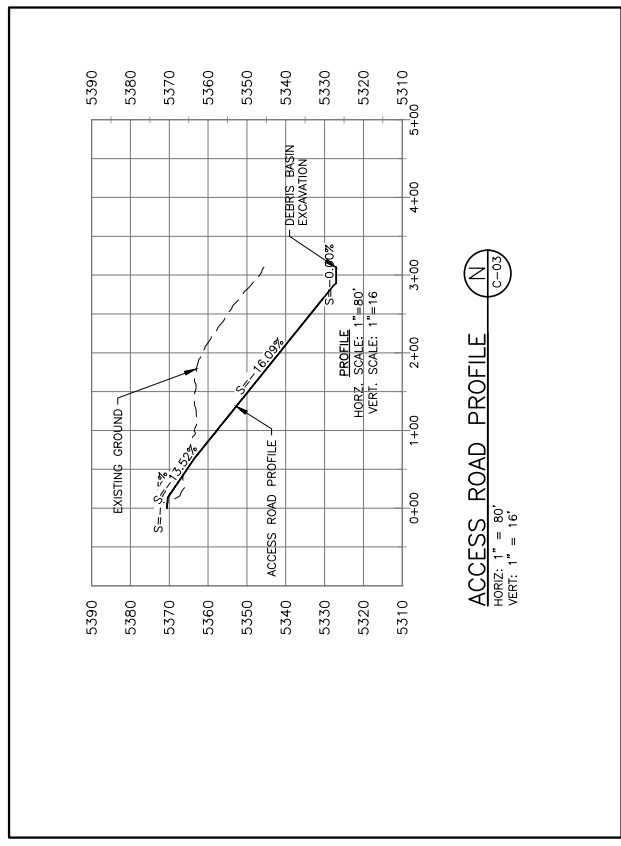
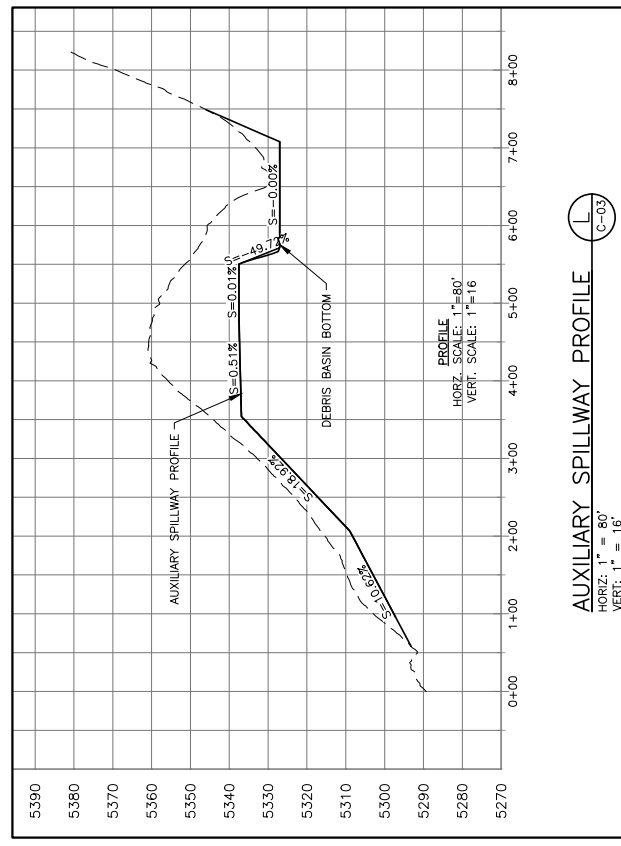
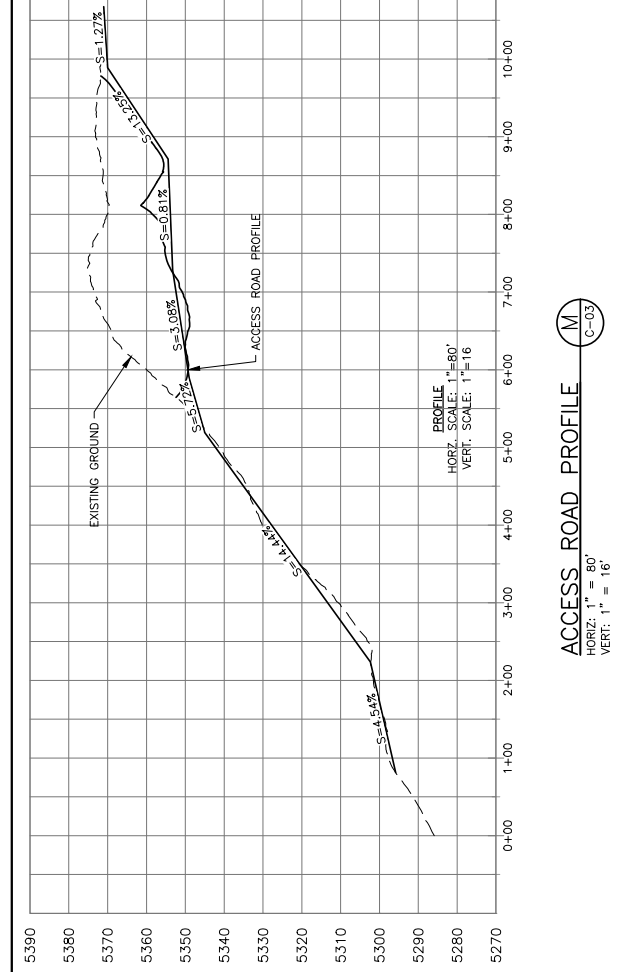
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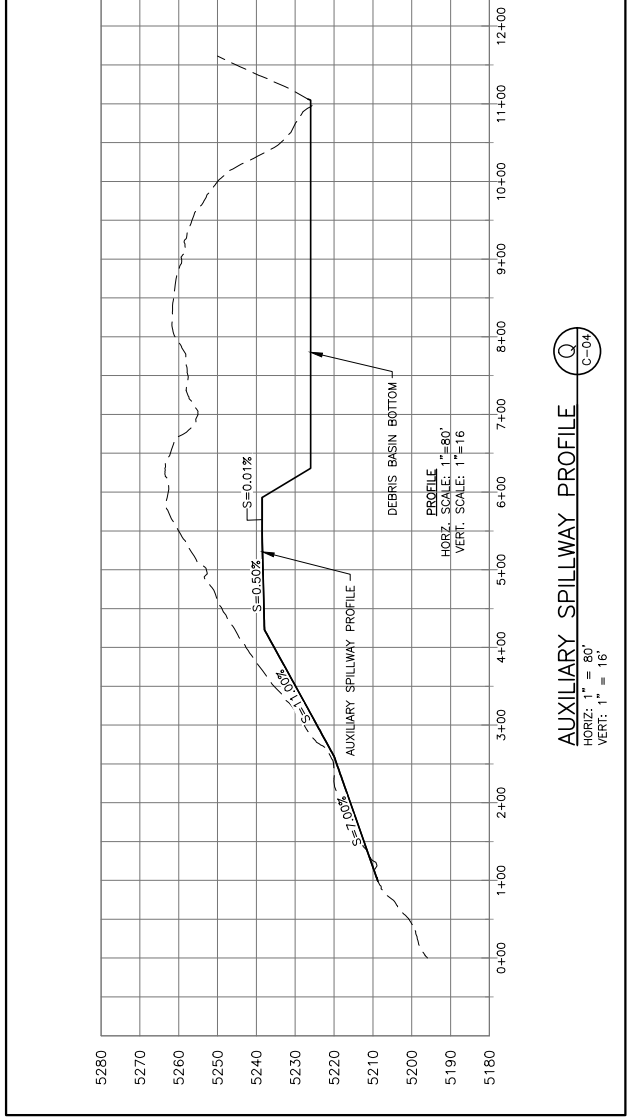
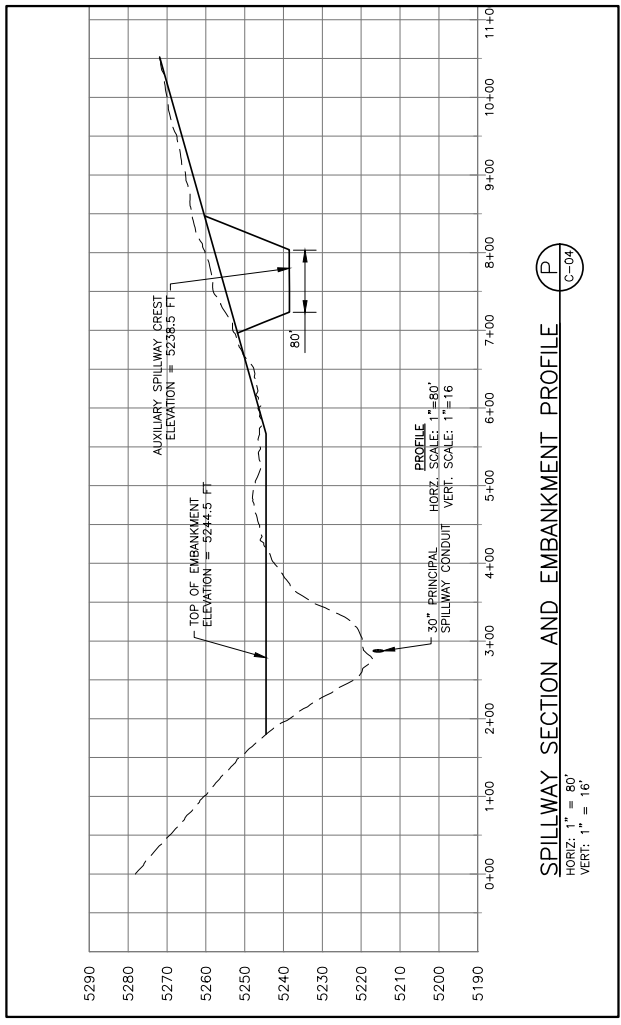
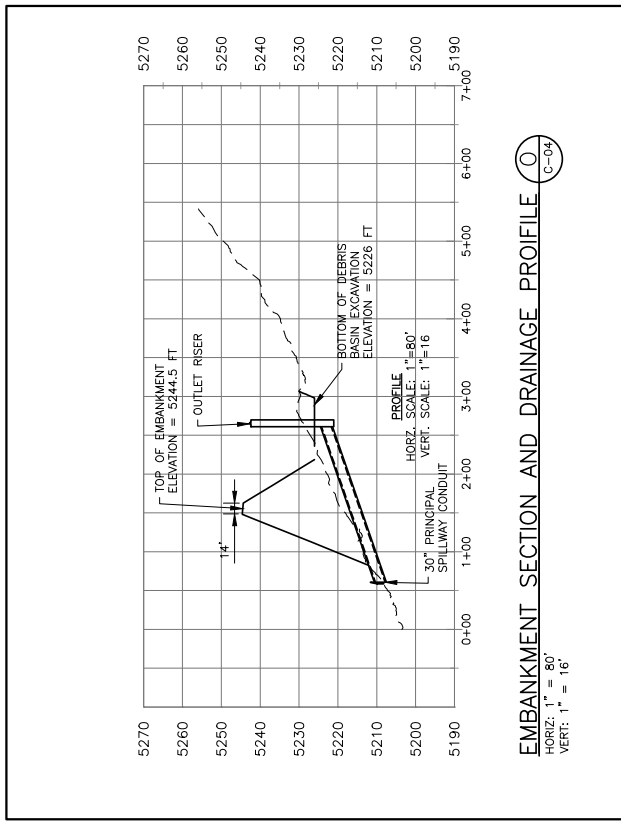
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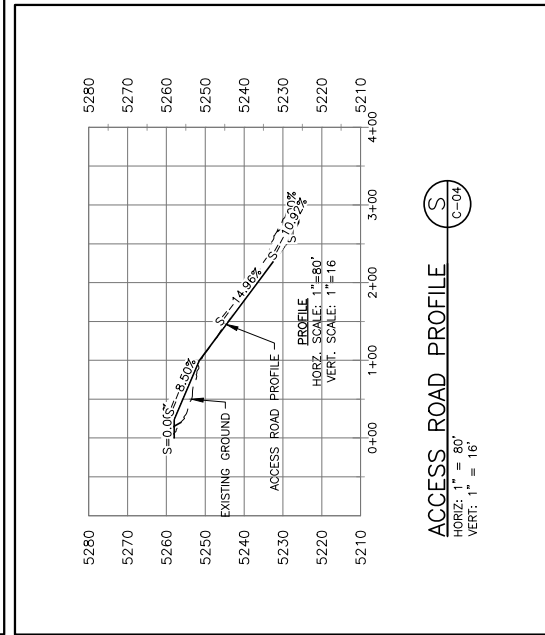
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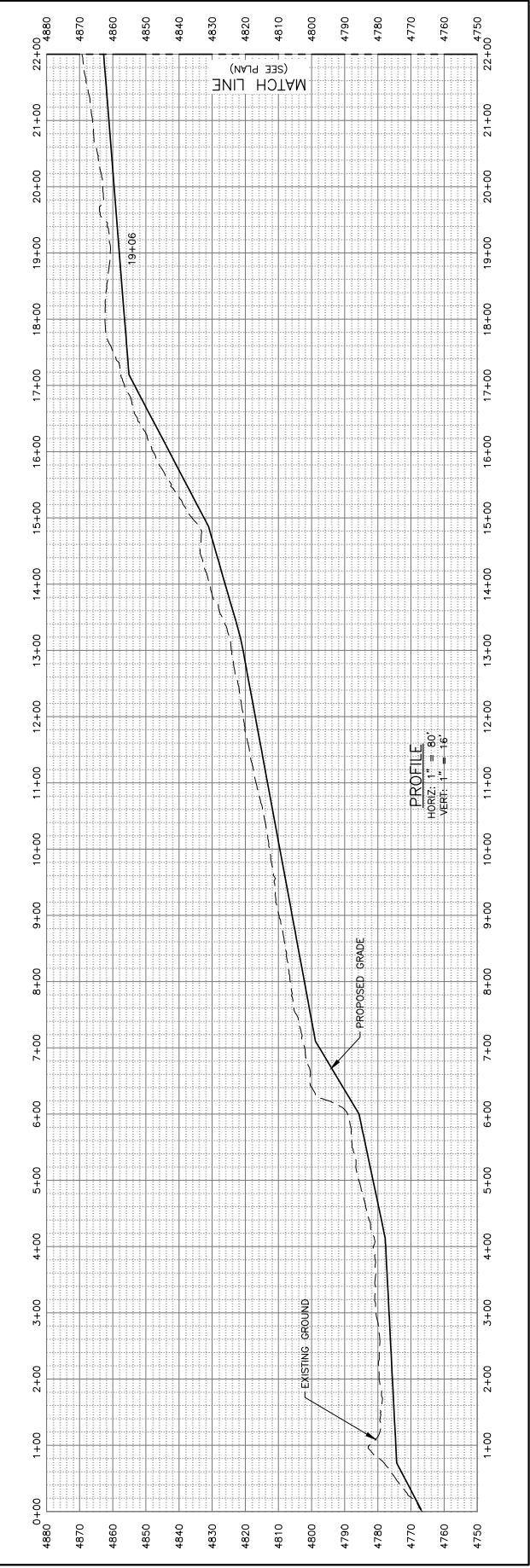
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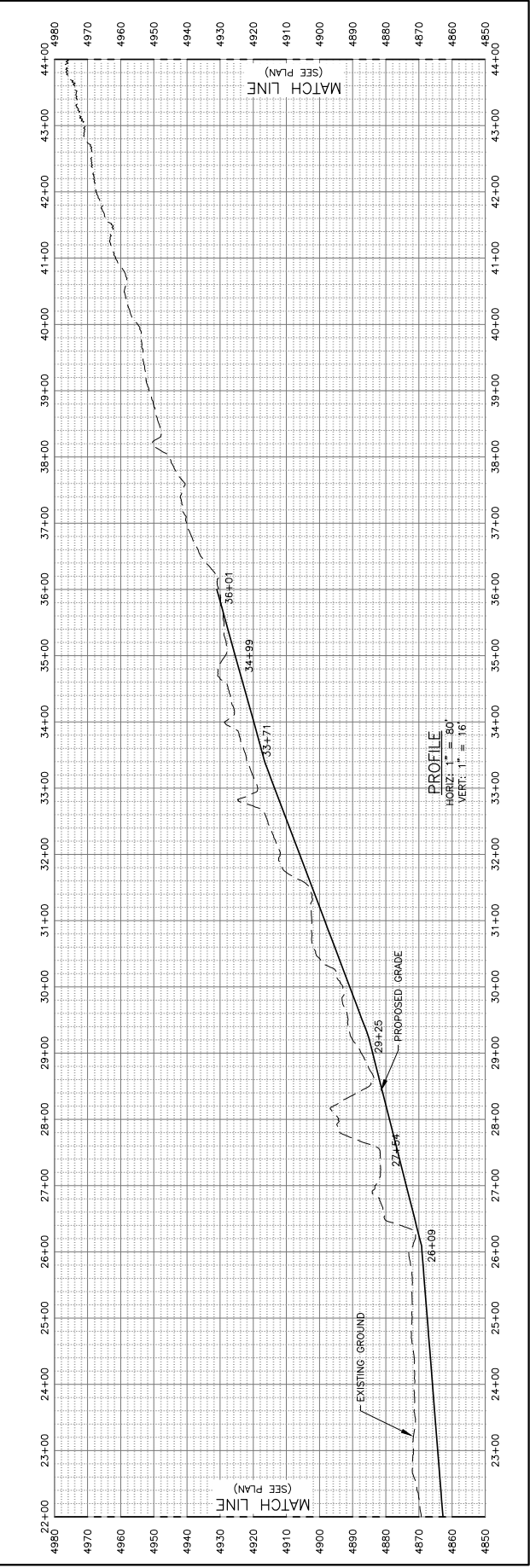
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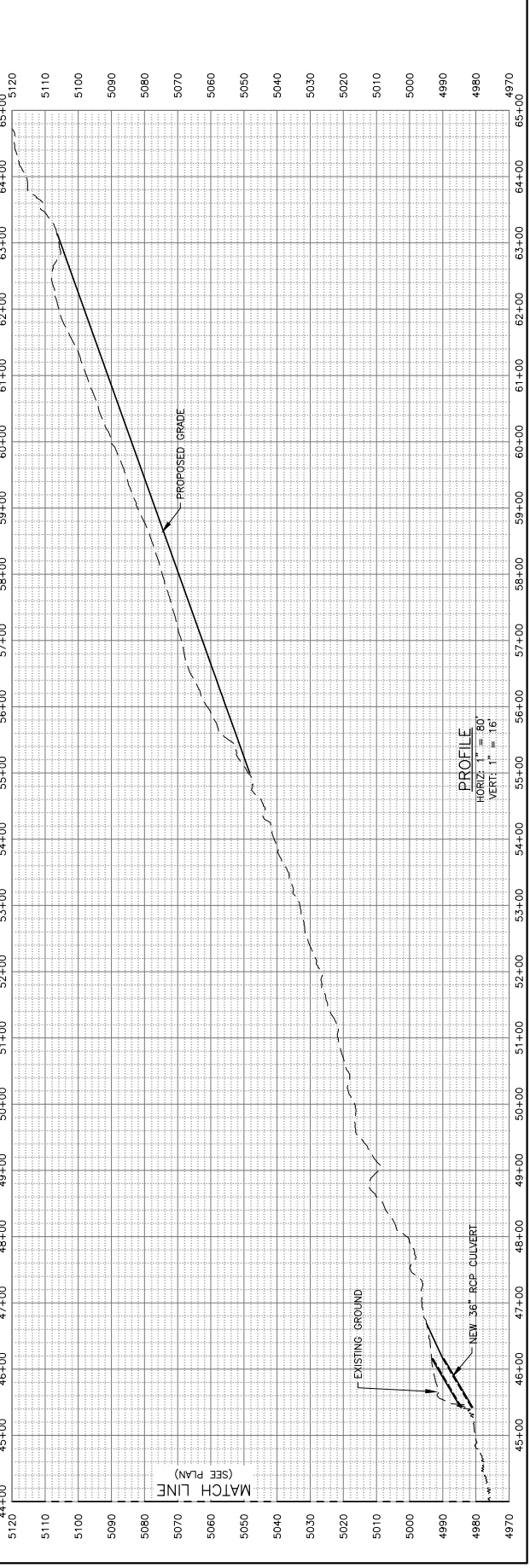
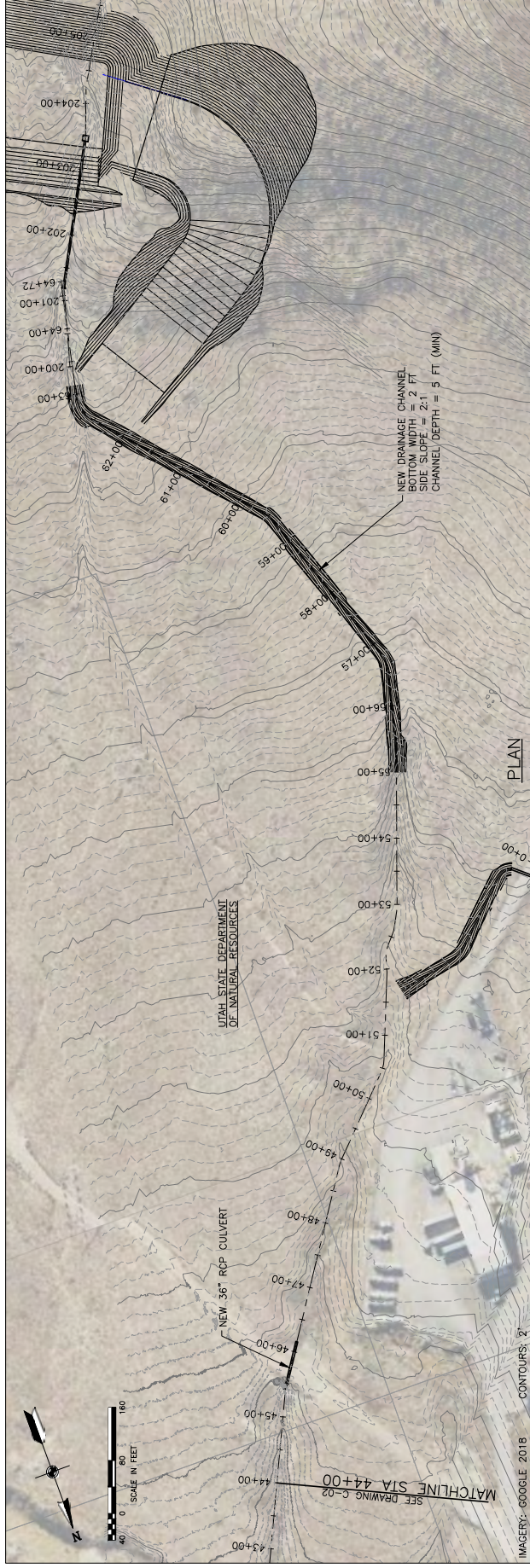
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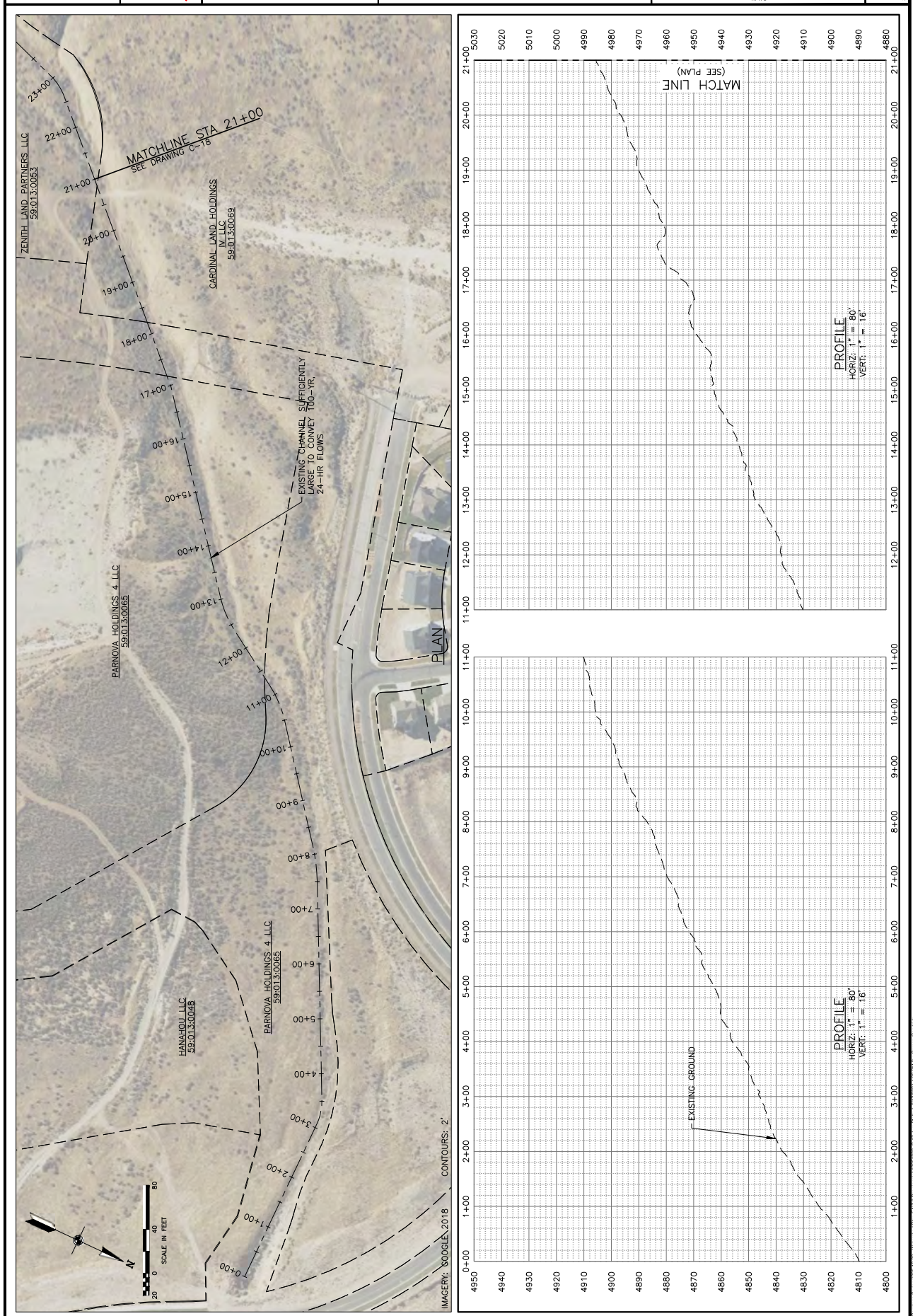
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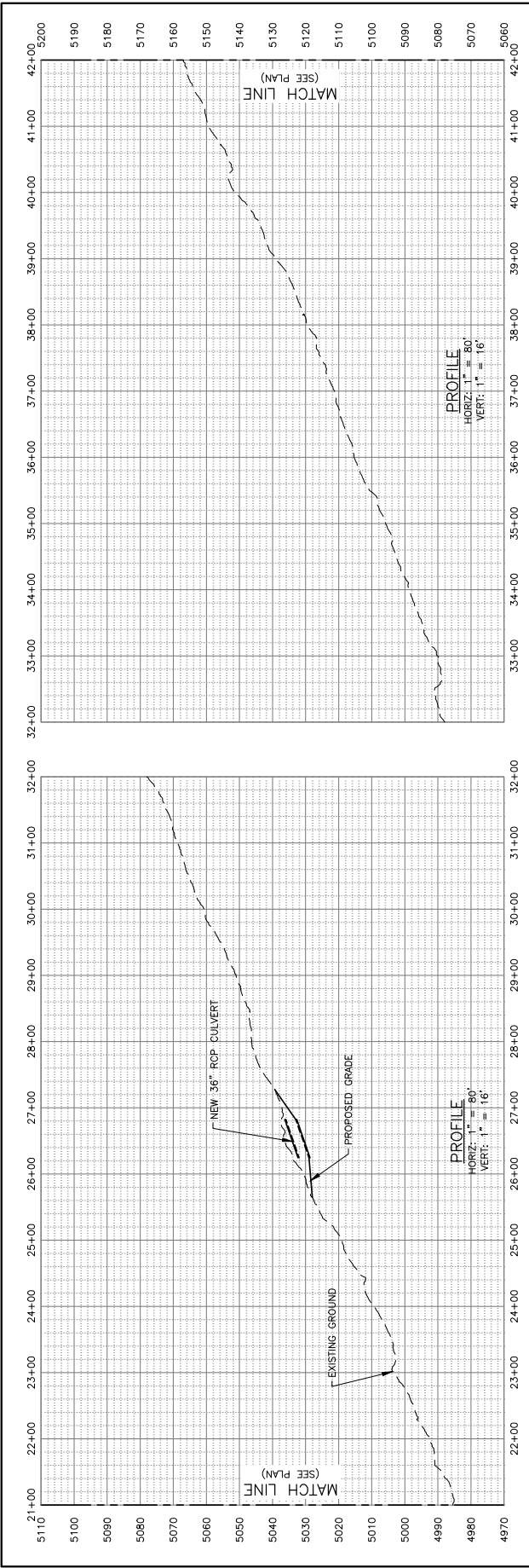
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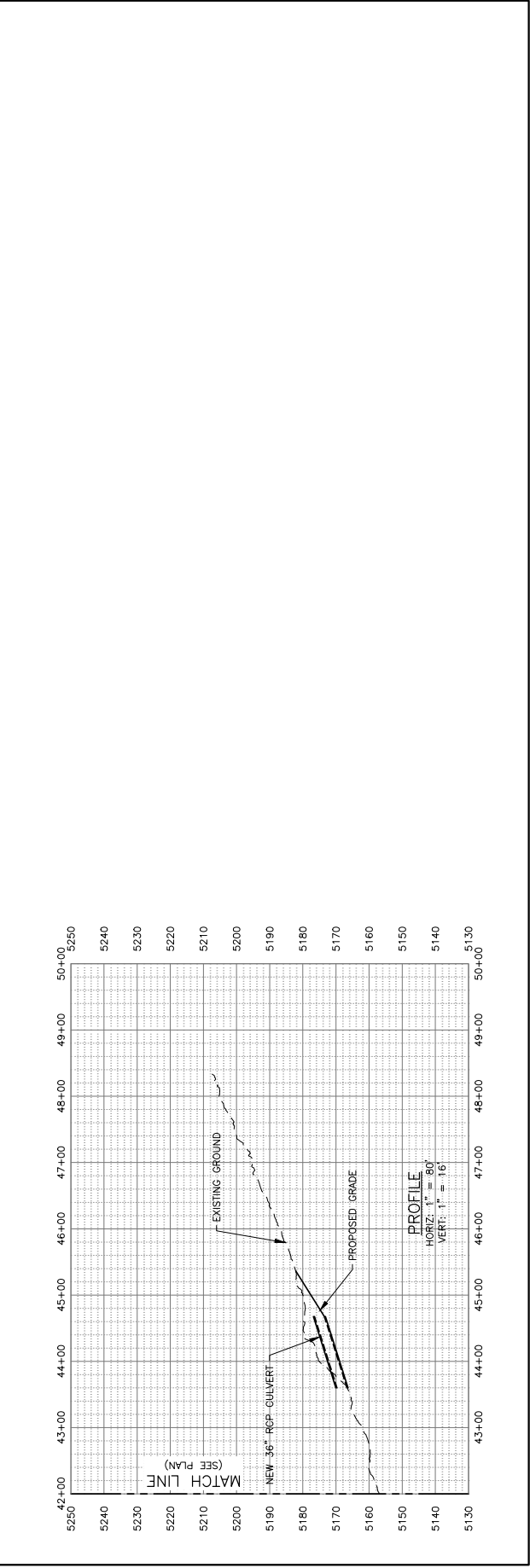
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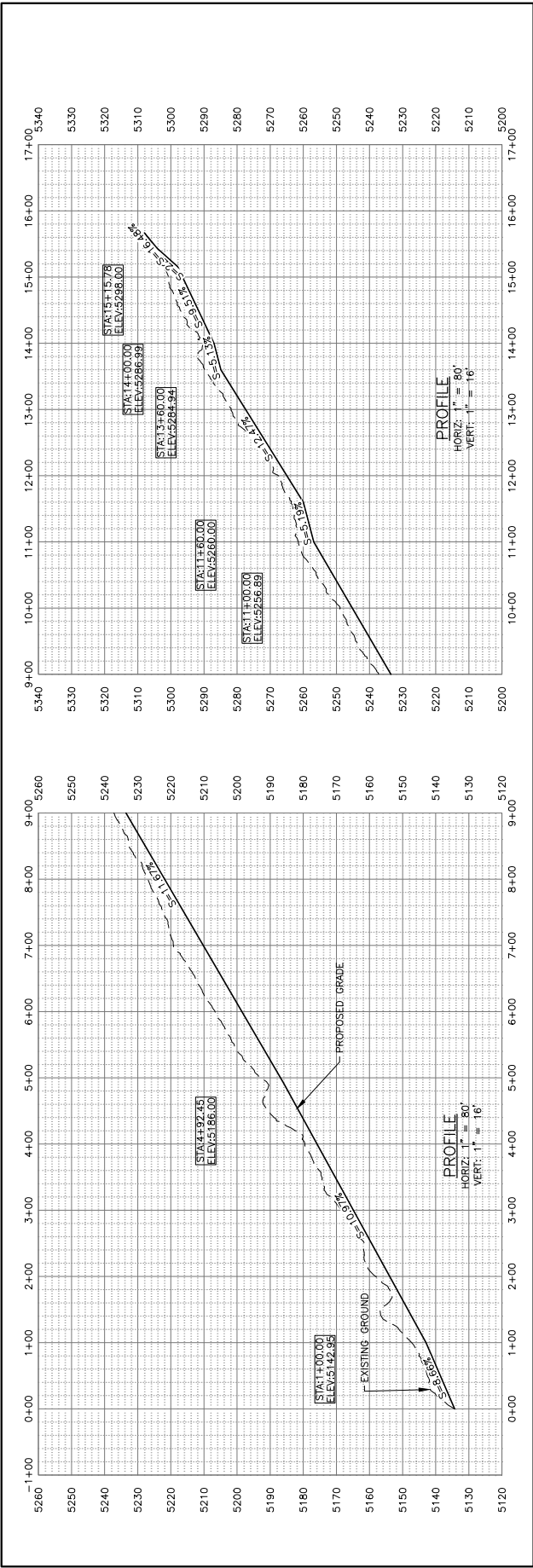
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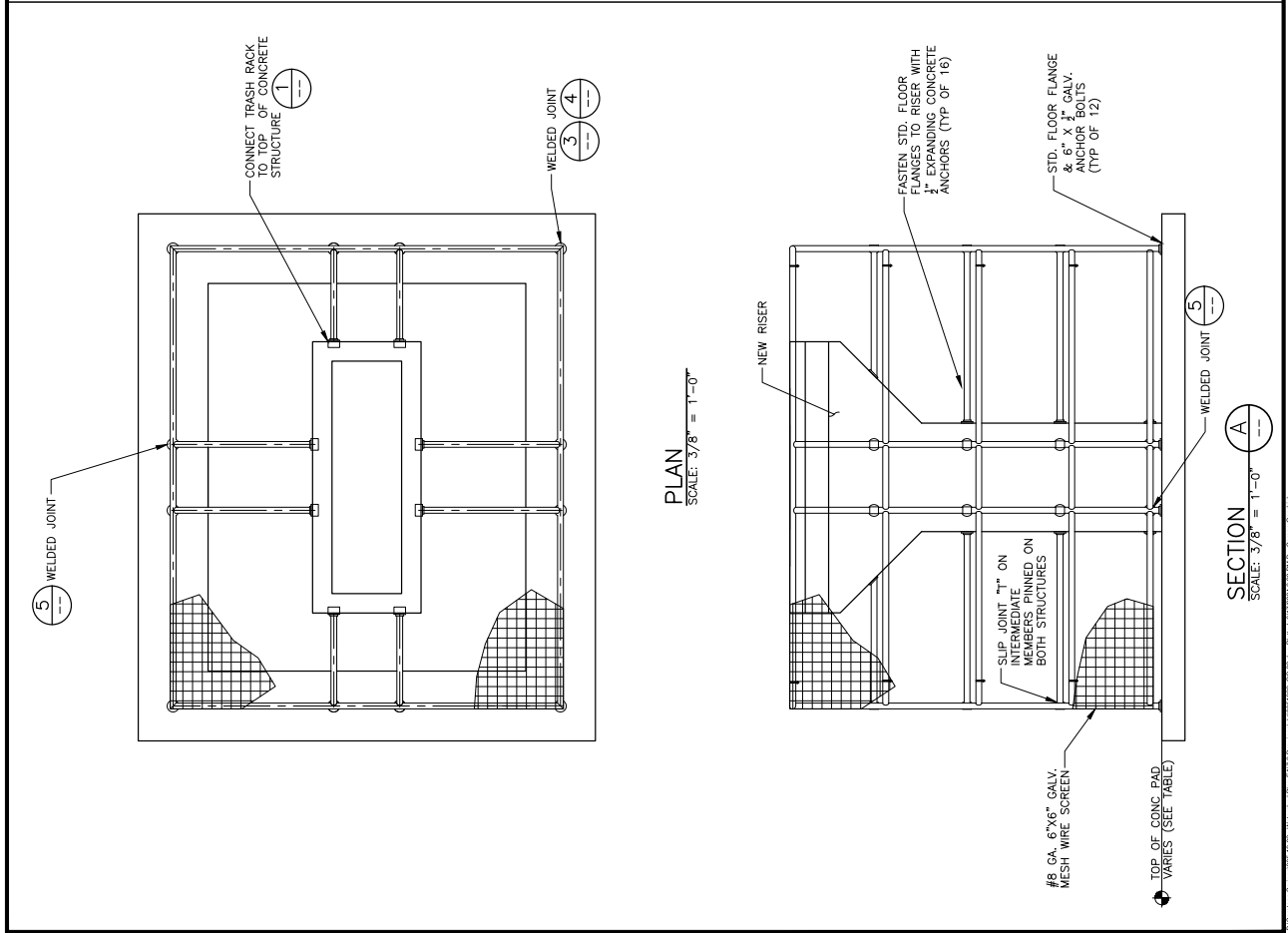
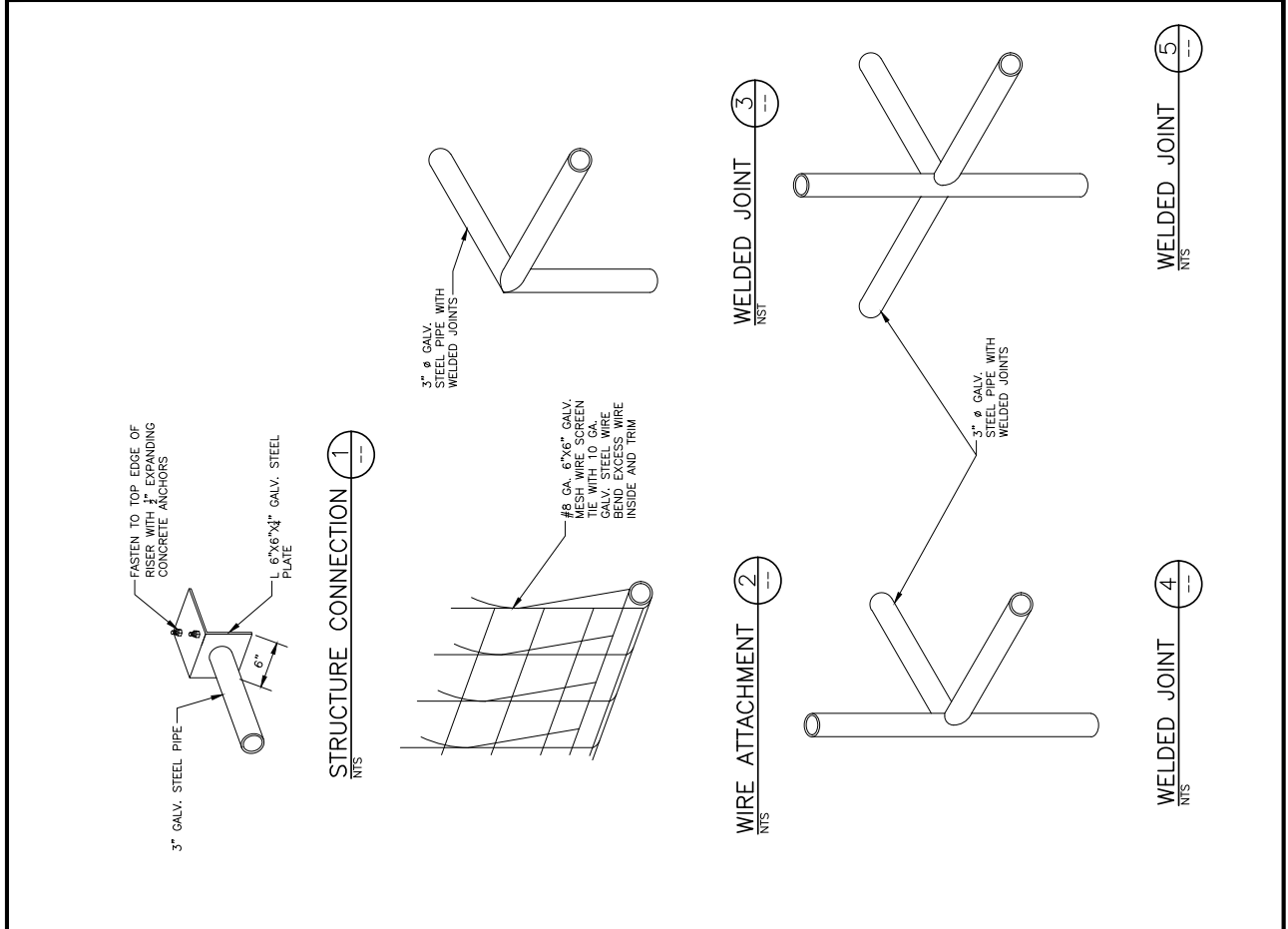








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Ecosystem Services Tradeoff Analysis Evaluation

Summary and Comparison of Alternatives in Detailed Study

Ecosystem Services Tradeoff Analysis Evaluation

Item	Alternatives		
	No Action	Site 1 and Site 2 Debris Basin Improvements	Site 1 Debris Basin and Site 2 Channel Improvements
Locally Preferred		✓	
Environmentally Preferred		✓	
Maximum Net Monetized Benefits Plan			✓
Socially Preferred		✓	
Preferred Alternative/NEE Alternative		✓	
Guiding Principles			
Healthy and Resilient Ecosystems	Flooding of developed areas could contaminate floodwater that flows into Utah Lake impacting the lake ecosystem.	✓ Reduces potential for floodwater contamination benefiting Utah Lake to help maintain the lake ecosystem.	Reduces potential for floodwater contamination benefiting Utah Lake to help maintain the lake ecosystem. However, it removes the floodplain without replacing its beneficial functions.
Sustainable Economic Development	Flooding could adversely impact local economic growth from reduced hours worked, losses in gross domestic product, and losses in productivity.	✓ Flood protection measures support long-term economic growth and avoid long-term adverse environmental, social, and economic impacts.	Flood protection measures support long-term economic growth but there is an increased risk to social, environmental, and economic impacts compared to the other action alternative from channel conveyance failures/ flow path changes and associated flooding.
Floodplains	The alluvial fan floodplain is heavily developed and no longer provides natural floodplain functions.	✓ Transfers floodplain functions of slowing water and trapping sediment through construction of a detention basin and removes flooding to developed areas that no longer provide appropriate floodplain function.	Removes flooding to developed areas that no longer provide appropriate floodplain function, but also removes the floodplain without supplementing sediment trapping and water slowing functions.
Public Safety	The safety of the people who live and work within the floodplain in the City of Saratoga Springs would continue to be threatened from risk of flooding. There is risk of loss of life and injury during flood events.	✓ Provides flood prevention and removes the risk to loss of life for up to and including a 100-year flood improving public safety. Decreases the flood flows and sediment in the alluvial fan channels through the city. This decreases the risk of flow path changes over the alluvial fan to maintain safe flood conveyance.	Provides flood prevention for up to and including a 100-year flood improving public safety. However, increased flood flows and sediment in the alluvial fan channels would result. This increases risk to public safety compared to the other action alternative. The channels are susceptible to flow path changes based on alluvial fan topography and channel sedimentation which could cause unexpected channel failure and flooding to residences threatening public safety.
Environmental Justice	No subject populations have been identified in the Watershed but the adverse flooding condition to the community would remain.	✓ No subject populations have been identified in the Watershed and the Project is intended to benefit all residents of the community.	✓ No subject populations have been identified in the Watershed and the Project is intended to benefit all residents of the community.

Item		Alternatives		
		No Action	Site 1 and Site 2 Debris Basin Improvements	Site 1 Debris Basin and Site 2 Channel Improvements
Watershed Approach		The adverse flooding condition to the developed community in the Watershed would remain. The potential for contaminated floodwater reaching Utah Lake downstream of the Watershed could adversely impact water quality and aquatic species/habitat. Flood corridors would continue to be adversely impacted by development.	✓ This alternative protects the developed community in the Watershed from damaging floods while also: preserving the flood conveyance corridors; maintaining the important floodplain functions of slowing water and trapping sediment; decreasing sediment into Utah Lake; improving Utah Lake water quality which also benefits aquatic species/habitat (including sensitive species).	This alternative protects the developed community from damaging floods while also preserving the flood conveyance corridors. However, it removes important floodplain functions without replacing them.
Ecosystem Services Benefits				
Regulating Services				
Climate	Monetized	Not Calculated ¹	Not Calculated ¹	Not Calculated ¹
	Non-monetized	Climate change would continue to cause more intense flooding as projected with adverse effects to the unprotected community.	Climate change would continue to cause more intense floods, but the alternative protects the community from flooding to better adapt and increase resilience to the climate stressors.	Climate change would continue to cause more intense floods, but the alternative protects the community from flooding to better adapt and increase resilience to the climate stressors.
Water Regulation (quality)	Monetized	Not Calculated ¹	Not Calculated ¹	Not Calculated ¹
	Non-monetized	Flooding to the City of Saratoga Springs could adversely impact Utah Lake water quality from introduction of contaminants picked up by water flowing over developed areas that drain to the lake.	Benefits to water quality from reduced contaminant and sediment input into Utah Lake would be achieved from a decrease in flooding.	Benefits to water quality from reduced contaminant input into Utah Lake would be achieved from a decrease in flooding.
Flood Moderation	Monetized	Annual flood damages are estimated at \$2,180,200 for Site 1 and \$4,649,500 for Site 2.	Annual flood damage reduction benefits are estimated at \$2,144,200 for Site 1 and \$4,631,900 for Site 2.	Annual flood damage reduction benefits are estimated at \$2,144,200 for Site 1 and \$4,639,500 for Site 2
	Non-monetized	Developed areas of the City of Saratoga Springs would continue to be at risk of flooding. Flood damage and insurance requirements for structures in the floodplain may be required in the future. Public health and safety would continue to be threatened.	The risk of flooding would be removed for up to and including the 100-year flood. Public safety would be improved.	The risk of flooding would be removed for up to and including the 100-year flood. Public safety would be improved. However, there is an increased risk of sediment induced channel conveyance failure that could result in unexpected flood damage to homes, roads, and culverts for Site 2 Clark Canyon. This risk and associated damages were not considered in the monetized benefits due to high uncertainties in assumptions.

Item		Alternatives		
		No Action	Site 1 and Site 2 Debris Basin Improvements	Site 1 Debris Basin and Site 2 Channel Improvements
Cultural Services				
Peace and Sustainability	Monetized	Not Calculated ¹	Not Calculated ¹	Not Calculated ¹
	Non-monetized	The people inhabiting the floodplain would continue to be threatened from risk of flooding which could adversely impact their daily lives, source of income, and peace of mind.	The threat of flooding would be reduced benefiting the daily lives, source of income, and peace of mind of the community.	The benefits would be similar to the other action alternative, but the increased risk of channel conveyance failure at Site 2 could have unexpected adverse consequences to peace and sustainability.
Well-being and Safety	Monetized	Not Calculated ¹	Not Calculated ¹	Not Calculated ¹
	Non-monetized	The flood risk would remain. Flooding could result in mental and physical health impacts from injury, potential loss of life, destruction of property, business closures, financial stressors, etc.	Flood protection would be provided for up to and including a 100-year flood. This would improve the mental/ physical well-being and safety for all people who inhabit the floodplain that are currently at risk.	The benefits would be similar to the other action alternative, but the increased risk of channel conveyance failure could have unexpected adverse consequences to the well-being and safety of the community.
Economic Analysis				
Monetized Costs				
Installation Cost		\$0	\$22,222,000	\$21,228,000
Annual Installation Cost ²		\$0	\$672,900	\$642,800
Annual O&M Cost ²		\$17,000	\$58,400	\$65,900
Annual Monetized Benefits for Ecosystem Services				
Regulating ²		\$0	\$6,767,700	\$6,775,200
Cultural		\$0	Not Calculated ¹	Not Calculated ¹
Total Annual Monetized Benefits		\$0	\$6,776,100	\$6,783,700
Total Annual Monetized Costs		\$17,000	\$731,300	\$708,700
Cost-Benefit Ratio		-	9.3	9.6
Annual Monetized Net Benefit		(\$17,000)	\$6,036,400	\$6,066,500

1 – Monetary benefits could not be calculated because monetary value could not be placed on the benefit or due to high uncertainty in assumptions.

2 - Calculated using FY 2025 Water Resources Discount Rate (3.0 percent), annualized over 100-year evaluation period, and using 102-year period of analysis (period of analysis = 100-year project life plus 2 years for installation).

PR&G Preliminary Alternatives Analysis Report

Saratoga Springs Flood Protection Project

Saratoga Springs Watershed

Utah County, Utah

PR&G Preliminary Alternative Analysis Report

Final

June 11, 2024



Prepared for:



Prepared by:



**Long Watershed Planning
Economics, LLC**

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Table of Contents

1.0	Introduction	1
2.0	RP&G Evaluation Process Overview.....	1
3.0	PR&G Eight-Step Evaluation Process.....	2
3.1	Identify Problems and Opportunities.....	2
3.2	Inventory Existing Resource Conditions	2
3.3	Forecast Future Conditions.....	3
3.4	Develop Array of Alternatives	3
3.5	Evaluate Effects of Individual Alternatives	7
3.5.1	Economic Analysis	8
3.5.1	PR&G Framework Table Analysis and Advancement of Alternative for the Plan-EA	16
3.5.2	Environmental Evaluation.....	16
3.6	Compare Alternatives	17
3.7	Identify Recommended Alternative	17
3.8	Implement and Evaluate	17
4.0	References.....	18

List of Tables

Table 1. Site 1 - Burnt/Lott Canyon Action Alternatives Screening Criteria	4
Table 2. Site 2 - Clark Canyon Action Alternatives Screening Criteria	5
Table 3. Site 1 Burnt/Lott Canyons FWOFI Flooding to Buildings	10
Table 4. Site 2 Clark Canyon FWOFI Flooding to Buildings	10
Table 5. Site 1 Alternative 1A and 1B FWFI Flooding to Buildings.....	11
Table 6. Site 2 Alternative 2 FWFI Flooding to Buildings.....	11
Table 7. Site 2 Alternative 3A and 3B FWFI Flooding to Buildings.....	11
Table 8. Site 2 Alternative 4 FWFI Flooding to Buildings.....	11
Table 9. Site 1 Alternative 1A and 1B Average Annual Flood Damage to Buildings	12
Table 10. Site 2 Alternatives Average Annual Flood Damage to Buildings	12
Table 11. FWOFI Road Linear Footage Inundated by Storm Event	13

Table 12. FWFI Road Linear Footage Inundated by Storm Event.....	13
Table 13. Average Annual Flood Damage Reduction to Roads	14
Table 14. FWFI Alternative Economic Benefits	14
Table 15. Installation and O&M Costs	15
Table 16. Alternative Benefit Cost Ratio and Net Benefits	15

Appendices

Appendix A	PR&G Framework Tables
Appendix B	Site 1 Burnt/Lott Canyon Cost Estimates
Appendix C	Site 2 Clark Canyon Cost Estimates

1.0 Introduction

A Natural Resources Conservation Service (NRCS) Supplemental Watershed Plan and Environmental Assessment (Plan-EA) is being prepared for the Saratoga Springs Flood Protection Project (Project) located within the Saratoga Springs Watershed in Utah County, Utah. The Project is authorized under the NRCS Watershed and Flood Prevention Operations Program and funded through the Watershed Protection and Flood Prevention Act of 1954 (PL 83-566). Saratoga Springs City is participating in the Project as the Sponsoring Local Organizations (SLO). The Project consists of flood prevention improvements to reduce flooding to Saratoga Springs City from Burnt, Lott, and Clark Canyons.

The intent of this report is to document Project decision-making and compliance with Principles, Requirements, and Guidelines for Federal Investments in Water Resources (PR&G) per the *Principles and Requirements for Federal Investments in Water Resources* (Council on Environmental Quality [CEQ] 2013), the *Final Interagency Guidelines* (CEQ 2014), USDA Department Manual 9500-013 (USDA 2017), and *NRCS Decision Memorandum for the Acting Chief on PR&G for NRCS Watershed Programs* (NRCS 2018).

2.0 RP&G Evaluation Process Overview

The PR&G evaluation process is based on an eight-step watershed planning process and was completed for the Project as described in this section. The NRCS nine-step planning process was also followed in conjunction with the PR&G evaluation process. The PR&G eight-step evaluation process includes consideration of the federal objective, PL 83-566 general purposes, guiding principles, and ecosystem services. Guiding principles were used to assist in decision making and weighing tradeoffs of Project alternatives, and the use of an ecosystem services framework to describe the comprehensive set of benefits that people receive from nature characterized as ecological goods and services provided by a healthy, functioning environment. The guiding principles are outlined in the PR&G documents and include:

- 1) Healthy and Resilient Ecosystems
- 2) Sustainable Economic Development
- 3) Floodplains (avoiding unwise use of floodplains)
- 4) Public Safety (reducing public health and safety risks)
- 5) Environmental Justice
- 6) Watershed Approach

Ecosystem services benefits have been organized into four service categories that are reflected in the Department of Agriculture Departmental Manual (DM9500-13) and include:

- 1) Provisioning services are tangible goods provided for direct human use and consumption, such as food, fiber, water, timber, or biomass.
- 2) Regulating services maintain a world in which it is possible for people to live, providing critical benefits that buffer against environmental catastrophe – examples include flood and disease control, water filtrations, climate stabilization or crop pollination.

- 3) Supporting services refer to the underlying processes maintaining conditions for life on earth, including nutrient cycling, soil formation, and primary production.
- 4) Culture services make the world a place in which people want to live – recreational use, spiritual, aesthetic viewsheds, or tribal values.

The guiding principles and service categories were evaluated for those that were critical to the decision maker, the analysis, and the stakeholders. A measurement of change in services was determined, where applicable, between the Future without Federal Investment (FWOFI) Alternative, also referred to as the No Action Alternative, and the Future with Federal Investment (FWFI) Alternatives, also referred to as Action Alternatives. An evaluation framework was developed to compare the FWOFI and FWFI Alternatives and is attached in Appendix A. This framework was used to select the “best” alternative that maximized public benefits (environmental, economic, and social goals) with appropriate consideration of costs, and included consideration of the guiding principles and ecosystem services.

3.0 PR&G Eight-Step Evaluation Process

The PR&G eight step evaluation process was used in decision making as outlined in Sections 3.1 through 3.8 below.

3.1 Identify Problems and Opportunities

Problems and opportunities were identified during the Project scoping process. Input from the Sponsors, agencies, the public, organizations, and tribes were solicited as described in Sections 3.0 and Section 7.3.2 of the Plan-EA. A copy of the Scoping Report is provided in Appendix E of the Plan-EA. Engineering analysis was completed to further identify and evaluate problems as documented in the engineering TM attached in Appendix E of the Plan-EA. The purpose and need of the project was formulated with the problems and opportunities in consideration. Where the “purpose” identifies the fundamental reason why the action is being proposed and the “need” describes the problem/s that the proposed action is intended to address and explains the underlying causes of the problem/s. The purpose and need of the Project is included in Section 2.1 of the Plan-EA with information supporting the purpose and need and watershed problems in Sections 2.2 of the Plan-EA. The purpose and need of the Project, as stated in the Plan-EA for reference, is included below. The purpose and need was formulated in conjunction with buyoff from the SLO.

“The purpose of the Project is to prevent flooding to the developed community in the City of Saratoga Springs. There is a need to protect people, structures, roads, utilities, and property within the floodplain.”

3.2 Inventory Existing Resource Conditions

Resources relevant to the proposed action were determined during the scoping process as described in Section 3.0 of the Plan-EA. The existing conditions of resources determined to be relevant are documented in Section 4.0 (Affected Environment) of the Plan-EA. The Affected Environment section of the Plan-EA provides the environmental baseline conditions for resources to be evaluated against alternative actions. The best available data and science was used to inventory the existing resource conditions at the level and scale of analysis determined reasonable for evaluating alternatives and impacts.

3.3 Forecast Future Conditions

A forecast of future conditions was made for resources, where reasonable to address, in the Affected Environment section (Section 4.0) of the Plan-EA. Additional future conditions forecasting was made for each alternative and associated implementation and O&M costs. Future forecasting of alternative impacts is described in Section 6.0 (Environmental Consequences) of the Plan-EA. The installation and O&M costs for future conditions of each alternative are provided in Section 5.3 of the Plan-EA and in Appendix B and C of this Report.

3.4 Develop Array of Alternatives

Project alternatives were formulated following procedures outlined in the National Watershed Program Manual, National Watershed Program Handbook, and PR&G. Alternatives required in the initial consideration per PR&G include the FWOFI Alternative and the FWFI Alternatives consisting of a nonstructural alternative, locally preferred alternative, environmentally preferable alternative, and additional alternatives.

There are two alternative sites proposed for improvements consisting of the Burnt/Lott Canyon Site (Site 1), and the Clark Canyon Site (Site 2). Action Alternatives were developed for improvements to resolve the problems identified and to provide opportunities in the Saratoga Springs Watershed for the PL 83-566 flood prevention (flood damage reduction) authorized purpose. Twenty one (21) Action Alternatives were developed, ten (10) for Site 1 and eleven (11) for Site 2. A list of the alternatives developed for Site 1 is included in Table 1 and for Site 2 is included in Table 2. Descriptions of alternative measures are provided in Section 5.0 of the Plan-EA.

Alternatives were removed from further consideration and analysis during the PR&G evaluation if they were determined infeasible, did not meet the purpose and need, conflicted with the federal objective or guiding principles, had exorbitant costs, or determined to be inferior due to other critical factors. Table 1 below provides a list of Action Alternatives developed and the screening criteria applied. A detailed description of all Action Alternatives is documented in Section 5.0 of the Plan-EA.

Table 1. Site 1 - Burnt/Lott Canyon Action Alternatives Screening Criteria

Alternative	Meets Purpose & Need	Installation Cost / Annual O&M Cost	Availability: Available for Acquisition	Logistics	Removes Risk of Loss of Life	Costs: Reasonable Acquisition Costs (non-exorbitant)	Advance for PR&G Analysis
Alternative 1A (50-YR Sediment Storage) Debris Basin Improvements (100-year flood protection)	Yes	\$12,331,000 / \$30,270	Yes ¹	Yes	Yes	Yes \$137,000	YES
Alternative 1B (100-YR Sediment Storage) Debris Basin Improvements (100-year flood protection)	Yes	\$13,268,000 / \$27,500	Yes ¹	Yes	Yes	Yes \$137,000	YES
Alternative 2 Channel Improvements (100-year flood protection)	Yes	\$18,086,000 / Not Evaluated ²	Yes ¹	Yes	Yes	No \$7,020,000	NO: Land acquisition costs are exorbitant, and installation costs are much greater than other feasible alternatives with no added benefit.
Alternative 3 Debris Basin Improvements (50-year flood protection)	No	Not Evaluated ²	Yes ¹	Yes	No	Not Evaluated ²	NO: This alternative would result in a loss of life during routing of the 100-year flood and was eliminated from further study because it did not meet the purpose and need.
Alternative 4 Channel Improvements (50-year flood protection)	No	Not Evaluated ²	Not Evaluated ²	Yes	No	Not Evaluated ²	NO: This alternative would result in a loss of life during routing of the 100-year flood and was eliminated from further study because it did not meet the purpose and need.
Alternative 5 (Nonstructural) Land Acquisition for Existing 100-Year Floodplain	Yes	Not Evaluated ²	No	Not Evaluated ²	Yes	No >\$100,000,000	NO: The cost of land acquisition alone would be exorbitant and permission to acquire land would not be feasible.
Alternative 6 Land Terracing	No	Not Evaluated ²	No	Not Evaluated ²	Not Evaluated ²	Not Evaluated ²	NO: Disturbance to hundreds of acres of undeveloped land would occur adversely impacting water, plants, animals, and habitat. Additionally, obtaining easements and landowner approval to install these measures is not feasible.
Alternative 7 Seeding	No	Not Evaluated ²	Not Evaluated ²	Not Evaluated ²	No	Not Evaluated ²	NO: There would be negligible changes to flooding conditions for this alternative which does not meet the purpose and need of the project.
Alternative 8 500-Year Flood Protection for Sensitive Facilities	N/A	N/A	N/A	N/A	N/A	N/A	NO: No damaging flooding would occur to sensitive facilities during the 500-year flood after implementation of the feasible alternatives. Therefore, this alternative is not applicable.
Alternative 9 Combined Dam	Yes	Not Evaluated ²	No	Not Evaluated ²	Not Evaluated ²	Not Evaluated ²	NO: The combined dam location would have to be constructed on existing private lands that are already approved for development and not available for acquisition.

1 – Applicant does not own parcels but has the power of eminent domain and ability to purchase property.

2 – The alternative was eliminated from further study due to other more easily identified elimination criteria and was not evaluated further for this criterion.

Table 2. Site 2 - Clark Canyon Action Alternatives Screening Criteria

Alternative	Meets Purpose & Need	Installation Cost / Annual O&M Cost	Availability: Available for Acquisition	Logistics	Removes Risk of Loss of Life	Costs: Reasonable Acquisition Costs (non-exorbitant)	Advance for PR&G Analysis
Alternative 1A Debris Basin Improvements A ³ (100-year flood Protection)	Yes	11,251,000 / \$30,000	Yes ¹	Yes	Yes	Yes \$563,000	NO: Higher cost than other alternatives with no additional benefit.
Alternative 1B Debris Basin Improvements B ⁴ (100-year flood Protection)	Yes	Greater cost than Alternative 1A, 3A or 3B / \$30,000	Yes ¹	Yes	Yes	Yes \$563,000	NO: Higher cost than other alternatives with no additional benefit.
Alternative 2 Channel Improvements (100-year flood Protection)	Yes	\$8,897,000 / \$39,900	Yes ¹	Yes	Yes	Yes \$415,000	YES
Alternative 3A (50-YR Sediment Storage) Debris Basin Improvements (50-year flood Protection)	Yes	\$9,891,000 / \$33,600	Yes ¹	Yes	Yes	Yes \$563,000	YES
Alternative 3B (100-YR Sediment Storage) Debris Basin Improvements (50-year flood Protection)	Yes	\$10,407,000 / 30,000	Yes ¹	Yes	Yes	Yes \$563,000	YES
Alternative 4 Channel Improvements (50-year flood Protection)	Yes	\$8,384,000 / 22,800	Yes ¹	Yes	Yes	Yes \$415,000	YES
Alternative 5 (Nonstructural) Land Acquisition for Existing 100-Year Floodplain	Yes	Not Evaluated ²	No	Not Evaluated ²	Yes	No >\$200,000,000	NO: The cost of land acquisition alone would be exorbitant and permission to acquire land would not be feasible.
Alternative 6 Land Terracing	No	Not Evaluated ²	No	Not Evaluated ²	Not Evaluated ²	Not Evaluated ²	NO: Disturbance to hundreds of acres of undeveloped land would occur adversely impacting water, plants, animals, and habitat. Additionally, obtaining easements and landowner approval to install these measures is not feasible.
Alternative 7 Seeding	No	Not Evaluated ²	Not Evaluated ²	Not Evaluated ²	No	Not Evaluated ²	NO: There would be negligible changes to flooding conditions for this alternative which does not meet the purpose and need of the project.
Alternative 8 500-Year Flood Protection for Sensitive Facilities	N/A	N/A	N/A	N/A	N/A	N/A	NO: No damaging flooding would occur to sensitive facilities during the 500-year flood after implementation of the feasible alternatives. Therefore, this alternative is not applicable.
Alternative 9 Combined Dam	Yes	Not Evaluated ²	No	Not Evaluated ²	Not Evaluated ²	Not Evaluated ²	NO: The combined dam location would have to be constructed on existing private lands that are already approved for development and not available for acquisition.

1 – Applicant does not own parcels but has the power of eminent domain and ability to purchase property.

2 – The alternative was eliminated from further study due to other more easily identified elimination criteria and was not evaluated further for this criterion.

3 – "A" Option is an alternative to construct a dam that provides flood attenuation for the 100-year flood and improves the channel downstream to convey the outflow from the dam at a 100-year flood.

4 – "B" Option is an alternative to construct a dam that provides flood attenuation for the 50-year flood and improves the channel downstream to convey the outflow from the dam at a 100-year flood.

A nonstructural alternative was formulated for each site to meet the Project purpose and need. This included Site 1 Alternative 5 and Site 2 Alternative 6. The nonstructural measures consist of purchasing all lands and structures within the 100-year floodplain, demolishing all structures/infrastructure, and restoring the natural floodplain. The nonstructural alternative was determined to be infeasible due to exorbitant costs and infeasibility of land acquisition, and it was eliminated from further study. Therefore, the nonstructural alternative was not carried through the PR&G or Plan-EA analysis.

Two Action Alternatives for Site 1 at Burnt/Lott Canyons (Alternatives 1A and 1B) were found to meet the screening criteria and were advanced for economic analysis. All other alternatives were eliminated from further study due to infeasibility, not meeting the purpose of the project, or due to higher project costs with no added environmental, social, or economic benefit.

Four Action Alternatives for Site 2 at Clark Canyon (Alternatives 2, 3A, 3B, and 4) were found to meet the screening criteria and were advanced for economic analysis. All other alternatives were eliminated from detailed study due to infeasibility, not meeting the purpose of the project, or due to higher project costs with no added environmental, social, or economic benefit.

The FWOFI Alternative (No Action Alternative) was also evaluated to provide a benchmark for comparison. The FWOFI is the most likely future condition in the absence of federal action or federal funding which provides the baseline for comparison to the FWFI. The FWOFI Alternative consists of continued O&M to maintain the current channel capacities of the Burnt, Lott, and Clark Canyon drainages through the city.

3.5 Evaluate Effects of Individual Alternatives

The guiding principles listed in Section 2.0 above and ecosystem services for provisioning, regulating, cultural, and supporting, as applicable, were assessed for the selected FWFI Alternatives and the FWOFI Alternative. The ecosystem services determined to be applicable to Project measures for evaluation are listed below. Because short-term construction impacts would be avoided, minimized, and/or mitigated, only measurable long-term effects to ecosystem services are considered for the PR&G framework table and determination of applicability.

Regulating Services

- Climate
- Water Regulation (quality and quantity)
- Biological Regulation (plants and animals)
- Natural Hazards Moderation (flood)

Cultural Services

- Peace and Sustainability
- Well-being and Safety

An economic analysis was also completed for the FWOFI and FWFI alternatives evaluated in the framework tables for each site as described in Section 3.5.1 below.

3.5.1 Economic Analysis

The economic analysis was completed by Long Watershed Planning Economics, LLC. Two FWFI Alternatives for Site 1 (Alternatives 1A and 1B), four FWFI Alternatives for Site 2 (Alternatives 2, 3A, 3B, and 4), and one FWOFI Alternative for each site were included in the detailed economic analysis in this section. These were the alternatives selected for economic evaluation as part of the alternative screening process described in 3.4 above.

3.5.1.1 *Benefit Calculations*

The basis of the economic evaluation is the quantification and valuation of flood damages with and without the project measures, by flooding depth for each modeled storm event. A brief physical description of this damage by depth follows.

Flood water depths

Flood depth has a large impact on what is affected in a building by a flood (riskfactor.com N.D.). A few inches of water may cause serious damage and necessitate expensive repairs and/or replacement of items. The risk of mold will be increased.

Outside of the buildings, flooding can cause large damage to transportation and public infrastructure. Six inches of flowing water can knock down an adult, while twelve inches may carry away a small automobile. Roads can be made impassable. Driving should not be attempted if flood depths reach the middle of vehicles wheels. Roads can be closed due to high sediment deposition, impeding critical emergency services and economic activity.

Typical Impacts of Urban Flooding

Half a foot to a foot of floodwater:

- Yards (rotted roots, attraction of insects)
- Drywall, exposed insulation, wallpaper (rotting, mold, loss of insulation, requiring replacement)
- Carpeted, laminate, and wood flooring (carpet and padding difficult cleaning, laminate peeling apart, wood warping and rotting, requiring replacement)
- Operating an automobile (stalling, loss of traction)
- Insulated appliances (more than six inches can require replacement due to electrical parts and insulation)

One to three feet of floodwater (all of the above plus below)

- HVAC, furnaces (contaminated or corroded systems may need replacement)
- Electrical outlets (will need replacement if touched by water)
- Automobiles (can float in one foot of water, and engines can be severely damaged)
- Large appliances (dishwashers, washers and dryers may need repair with greater than 2 feet of water)

3 feet+ of floodwater (all of the above plus below)

- Buildings foundation and framework (damage may occur too severe to repair)
- Utilities (water supply, sewage, plumbing may have lasting damage)

3.5.1.2 *Benefit Calculations*

Monetary economic benefits due to project action identified for the analysis include flood prevention to buildings and roads. Flooding can also result in mental health issues with associated costs, and forgone income. Floods can destroy livelihoods, cause massive debt, threaten life, damage or destroy homes and prized possessions, and negatively impact lives and disrupt communities. Increases in depression, post-traumatic stress disorder, and substance abuse are well documented in the aftermath of floods and can persist for years afterward (MarshMcLennan 2021). Costs associated with these impacts were not estimated due to uncertainties in calculation methods, but they are important to note as they influence impacted individuals financially.

Flood damage reduction benefits were assessed based on the equivalent annual damage reduction expected through implementation of the FWFI Alternatives as compared with the FWOFI baseline. The period of analysis for all alternatives is 102 years. All costs and benefits over the evaluation period were discounted to a net present value, then annualized over the period of analysis using the 2023 Federal Water Resources Discount Rate of 2.5% (NRCS 2023).

Average annual flood damages were calculated using the cumulative probability method as specified in the URB1 manual (SCS 1990). The 5-, 10-, 25-, 50-, 100-, and 500-year storm events for each alternative were modeled using HEC-RAS. Mapping of the flood extents, inundation to structures, roads and agricultural lands was calculated through GIS analysis. Historical flood data from local personnel was used when available.

Inundated structures, roads, and lands were classified into one of three categories: inundated less than 1 foot, inundated 1 to 3 feet, or inundated greater than 3 feet, for each storm event. Depth-damage functions were collected from the USACE to use for each type of structure (USACE 2004). These functions relate the expected depth of flooding to the percent of damage that will occur.

Impacted structures were also classified by general types, including permanent homes, commercial buildings, schools, and churches. Most of the structures damaged in the model were two story homes with a basement, so this depth to damage function was used for homes. For the other types of structures, the appropriate depth-damage function was used.

Depth-damage functions require replacement values (values representing repair costs, not new construction costs) for inundated structures. These were estimated from property tax records and realtor data. For structures with no property tax records (schools and churches), the construction cost was collected from RS Means estimates (RS Means 2023), then adjusted to arrive at a replacement value suitable for flood damage analysis.

Buildings Flood Damage Reduction

Extensive flooding to Saratoga Springs City would occur under the No Action Alternative conditions (FWOFI). The results of modeling showing the types of buildings flooded, the storm event, and the depth of flooding for Site 1 and Site 2 FWOFI conditions are provided in Table 3 and Table 4 below. Depth columns were removed from the tables where no flooding to structures for the depth occurred.

Table 3. Site 1 Burnt/Lott Canyons FWOFI Flooding to Buildings

Event	Homes			Church		School	Comm./ Office
	< 1 ft	1-3 ft	> 3 ft	< 1 ft	1-3 ft	< 1 ft	< 1 ft
2-Year	53	0	0	1	0	1	0
5-Year	181	9	0	2	0	1	2 ^A
10-Year	219	20	0	2	0	1	2 ^A
25-Year	258	35	0	2	0	1	2 ^A
50-Year	281	48	0	1	1	1	2 ^A
100-Year	277	71	0	1	2	1	2 ^A
500-Year	271	116	2	1	2	1	2 ^A

A= Office buildings on LDS Temple property

Table 4. Site 2 Clark Canyon FWOFI Flooding to Buildings

Event	Homes			Church		School	Comm./ Office	Other	
	< 1 ft	1-3 ft	> 3 ft	< 1 ft	1-3 ft	< 1 ft	< 1 ft	< 1 ft	1-3 ft
2-Year	304	40	0	1	0	0	0	0	1 ^B
5-Year	430	84	0	2	0	1	0	0	1 ^B
10-Year	520	127	1	2	0	1	1	0	1 ^B
25-Year	594	167	1	2	0	1	1	0	1 ^B
50-Year	613	211	1	2	0	1	1	0	1 ^B
100-Year	631	250	1	1	1	1	1	0	1 ^B
500-Year	630	327	2	0	2	1	1	1 ^A	1 ^B

A = Pump House

B = El Nautica Boat Club with RV lots

The Site 1 FWFI Alternatives (Alternative 1A and 2A) and Site 2 FWFI Alternatives (Alternatives 2, 3A, and 3B), by contrast, provide for safe conveyance of flood flows for up to and including a 100-year flood, and no flood damages would occur for those events. The Site 2 FWFI Alternative 4 provides for safe conveyance of flood flows for up to and including a 50-year flood. The buildings inundated during the 500-year flood for Site 1 Alternatives 1A and 1B, and Site 2 Alternatives 2, 3A, and 3B, are shown in Table 5, Table 6, and Table 7 below. The buildings inundated during

the 100-year and 500-year flood for Site 2 Alternative 4 is shown in Table 8 below. Depth columns were removed from the tables where no flooding to structures for the depth occurred.

Table 5. Site 1 Alternative 1A and 1B FWFI Flooding to Buildings

Event	Homes			Church		Comm./ Office
	<1 ft	1-3 ft	>3 ft	<1 ft	1-3 ft	>1 ft
500-Year	221	62	-	1	1	1

Note: No flooding would occur outside of the channel through Saratoga Springs City for all floods up to and including the 100-year flood.

Table 6. Site 2 Alternative 2 FWFI Flooding to Buildings

Event	Homes			Commercial	
	<1 ft	1-3 ft	>3 ft	<1 ft	1-3 ft
500-Year	83	27	1	-	1

Note: No flooding would occur outside of the channel through Saratoga Springs City for all floods up to and including the 100-year flood.

Table 7. Site 2 Alternative 3A and 3B FWFI Flooding to Buildings

Event	Homes			Commercial	
	<1 ft	1-3 ft	>3 ft	<1 ft	1-3 ft
500-Year	132	64	-	-	1

Note: No flooding would occur outside of the channel through Saratoga Springs City for all floods up to and including the 100-year flood.

Table 8. Site 2 Alternative 4 FWFI Flooding to Buildings

Event	Homes			Commercial	
	<1 ft	1-3 ft	>3 ft	<1 ft	1-3 ft
100-Year	108	30	-	1	-
500-Year	165	86	1	-	1

Note: No flooding would occur outside of the channel through Saratoga Springs City for all floods up to and including the 50-year flood.

Table 9 shows the average annual damages estimated for Site 1 Burnt/Lott Canyons Alternatives 1A and 1B for each type of building and their contents, based on the results above.

Table 9. Site 1 Alternative 1A and 1B Average Annual Flood Damage to Buildings

Type	FWOFI Flood Damage (\$)	FWFI Flood Damage (\$)	Annual Flood Damage Reduction (\$)
Other	830,300	9,700	820,600
Residential	1,280,200	24,400	1,255,800
Commercial	10,100	200	9,900
Total	2,120,600	34,300	2,086,300

Table 10 shows the average annual damages estimated for Site 2 Clark Canyon Alternatives 2, 3A, 3B, and 4 for each type of building and their contents, based on the results above.

Table 10. Site 2 Alternatives Average Annual Flood Damage to Buildings

Type	FWOFI Flood Damage (\$)	FWFI Flood Damage (\$)			Annual Flood Damage Reduction (\$)
		Other	Residential	Commercial	
Site 2 Alternative 2	4,587,000	0	9,600	100	4,577,300
Site 2 Alternatives 3A and 3B	4,587,000	0	17,100	100	4,569,800
Site 2 Alternative 4	4,587,000	0	39,700	200	4,547,100

Roads Flood Damage Reduction

Several floods have damaged and/or closed roads and bridges in Utah County over the years, as well as throughout the entire state. To account for these impacts, the modeled storms were intersected with roads in GIS to calculate the linear footage inundated.

As with agricultural land and urban structures, affected roads were classified into one of three categories for each storm event: inundated less than 1 foot, inundated 1 to 3 feet, or inundated greater than 3 feet. The linear footage of roads inundated by event for each depth category for the FWOFI Alternative at each site is included in Table 11.

Table 11. FWOFI Road Linear Footage Inundated by Storm Event

Event	Burnt/Lott Canyons (Site 1)			Clark Canyon (Site 2)		
	< 1 ft depth	1 to 3 ft depth	> 3 ft depth	< 1 ft depth	1 to 3 ft depth	> 3 ft depth
2-Year	290	80	30	2,760	470	-
5-Year	5,380	300	40	7,310	630	-
10-Year	9,620	450	40	8,110	540	-
25-Year	14,300	1,040	40	9,270	760	-
50-Year	17,750	3,550	70	11,030	1,900	-
100-Year	19,700	6,010	130	12,700	3,730	-
500-Year	19,200	13,100	400	17,820	6,990	40

The FWFI Alternatives provide for safe conveyance of flood flows for up to and including a 100-year storm for Site 1 Alternatives 1A and 1B, and for Site 2 Alternatives 2, 3A, and 3B. Site 2 Alternative 4 provides for safe conveyance of flood flows for up to and including the 50-year flood. No flood damage to roads would occur for those events. Linear footage of roads inundated at the 500-year flood for Site 1 Alternatives 1A, and 1B, and Site 2 Alternatives 2, 3A, and 3B were calculated, and the 100-year and 500-year floods for Site 2 Alternative 4 were calculated. The results are included in Table 12.

Table 12. FWFI Road Linear Footage Inundated by Storm Event

Site and Alternative	Event	< 1 ft depth	1 to 3 ft depth	> 3 ft depth
Site 1 Alternative 1A and 1B	500-Year	17,100	1,680	70
Site 2 Alternative 2	500-Year	930	210	40
Site 2 Alternative 3A and 3B	500-Year	2,500	325	10
Site 2 Alternative 4	100-Year	1,080	140	10
	500-Year	3,260	840	20

Damages were estimated through resulting costs for cleanup of sediment and debris left by storms, and for resurfacing arterial flat rural roads. Typical street sweeping costs per curb mile to remove deposited debris and sediment from flooding were collected and updated to current costs. Street sweeping costs range from \$16 to \$31 per curb mile, depending on the type of road, the number of intersections and exits, local regulations regarding debris disposal, etc. (Kidwell-Ross 2023 and Micheal Baker International N.D.). The average curb mile cost (\$22) was applied to the linear footage inundated less than 3 feet, while the high cost (\$31) was applied to the linear footage inundated greater than 3 feet.

Resurfacing of flat rural roads was estimated by the U.S. Department of Transportation (USDOT)

at \$427,700 (2023 dollars) per lane mile (USDOT 2019). This figure was used as an estimate to account for road damage for both lanes. Flooding does wash out sections of road, even destroying some portions, requiring complete replacement. This damage along with minor debris clean-up (street sweeping) was incorporated into the storm event probability analysis to arrive at average annual damage figures.

The average annual damages for the FWOFI and FWFI Alternatives, and the associated flood damage reduction from implementation of the FWFI Alternatives, is provided in Table 13.

Table 13. Average Annual Flood Damage Reduction to Roads

Alternative	FWOFI Average Annual Flood Damage (\$)	FWFI Average Annual Flood Damage (\$)	Annual Flood Damage Reduction (\$)
Site 1 Alternatives 1A and 1B	59,600	1,700	57,900
Site 2 Alternative 2	62,400	200	62,200
Site 2 Alternatives 3A and 3B	62,400	300	62,100
Site 2 Alternative 4	62,400	1,000	61,400

Table 14 Summarizes the FWFI Alternatives average annual benefits to each type of flood damage.

Table 14. FWFI Alternative Economic Benefits

Alternative	Buildings (\$)	Roads (\$)	Total (\$)
Site 1 Alternatives 1A and 1B	2,086,300	57,900	2,144,200
Site 2 Alternative 2	4,577,300	62,200	4,639,500
Site 2 Alternatives 3A and 3B	4,569,800	62,100	4,631,900
Site 2 Alternative 4	4,547,100	61,400	4,608,500

3.5.1.3 *Alternative Costs*

Alternative installation and O&M costs were provided by Bowen Collins & Associates (BC&A). The FWOFI alternative does not incur installation costs, but does have O&M costs to maintain the existing channel capacities. The FWFI Alternative costs include installation cost for construction, engineering, administrative time, permitting, and real property rights, as applicable. The FWFI Alternative costs also include the O&M costs after installation of alternative measures. The detailed costs estimated by BC&A are included in Appendix B and C for reference.

The annualized installation and O&M costs were calculated for the FWOFI and FWFI Alternatives using the FY 2023 Water Resources Discount Rate (2.5%), annualized over a 100-year evaluation period. Calculated annual costs are provided in Table 15.

Table 15. Installation and O&M Costs

Improvements	Installation Cost (\$) ¹	Average Annual Installation Cost (\$/year)	Average Annual O&M Cost (\$/year)	Total Average Annual Cost (\$/year)
FWOFI Alternative	-	-	17,000	17,000
Site 1 Alternative 1A	12,331,000	324,600	28,800	353,400
Site 1 Alternative 1B	13,268,000	349,200	26,200	375,400
Site 2 Alternative 2	8,897,000	234,200	38,000	272,200
Site 2 Alternative 3A	9,891,000	260,300	30,500	290,800
Site 2 Alternative 3B	10,407,000	273,900	28,600	302,500
Site 2 Alternative 4	8,384,000	220,700	21,700	242,400

1 – Installation costs have been rounded to the nearest thousand

3.5.1.4 Cost Benefit Comparison

The FWOFI and FWFI alternatives costs and benefits were compared to determine a benefit cost ratio and total average annual economic benefits (Table 16). The results of the cost benefit comparison were incorporated into the evaluation framework tables included in Appendix A. Total annual costs were taken from Table 15 and the total annual benefits were taken from Table 14.

Table 16. Alternative Benefit Cost Ratio and Net Benefits

Alternative	Total Annual Costs	Total Annual Benefits	Benefit Cost Ratio	Net Annual Economic Benefit
FWOFI Alternative	17,000	-	-	-17,000
Site 1 Alternative 1A	353,400	2,144,200	6.1	1,790,800
Site 1 Alternative 1B	375,400	2,144,200	5.7	1,768,800
Site 2 Alternative 2	272,200	4,639,500	17.0	4,367,300
Site 2 Alternative 3A	290,800	4,631,900	15.9	4,341,100
Site 2 Alternative 3B	302,500	4,631,900	15.3	4,329,400
Site 2 Alternative 4	242,400	4,608,500	19.0	4,366,100

As with all projections of future costs and benefits, there is a degree of uncertainty assumed. Installation costs, O&M costs, crop yields, housing markets, labor markets, and commodity and input prices will all fluctuate. Flood frequencies and magnitudes used in the analysis always carry a degree of uncertainty. Another uncertainty is whether climate change is changing longer-term precipitation patterns. If longer-term trends are occurring, the value of past records may be

suspect in predicting future flooding. For all these reasons, economic estimates of flood control measures are not precise; the intention is that they are reasonably accurate and can assist in making good decisions.

3.5.1 PR&G Framework Table Analysis and Advancement of Alternative for the Plan-EA

The Site 1 Alternatives (Alternatives 1A and 1B) and Site 2 Alternatives (Alternatives 2, 3A, 3B, and 4) were included in the PR&G Framework Table comparison (Appendix A) based on meeting the screening criteria outlined in Table 1 of Section 3.4. Economic and PR&G analysis results were used to narrow down alternatives to advance for detailed study in the Plan-EA.

For Site 1, Alternatives 1A and 1B have similar installation measures and footprints with different sediment storage capacities and provide the same level of flood protection. This is also the case for Alternatives 3A and 3B at Site 2. Therefore, there would be no measurable change in effects to resources between the two alternatives at either site, resulting in only cost differences. At both sites, the detention dam providing a 100-year sediment storage capacity was found to cost more compared to the cost for the sponsor to excavate sediment from the basins at year 50 to meet a 100-year sediment life. This resulted in a lower cost benefit ratio for the dams constructed with a 100-year sediment storage capacity consisting of Site 1 Alternative 1B and Site 2 Alternative 3B. For this reason, the alternatives with the lower cost-benefit ratio between the two (Site 1 Alternative 1B and Site 2 Alternative 3B) were eliminated from detailed analysis in the Plan-EA.

Alternative 2 and Alternative 4 at Site 2 consist of channel modifications along the same lengths of channel. Alternative 2 is designed to safely convey a 100-year flood and Alternative 4 has a lesser level of flood protection for a safe conveyance of a 50-year flood. Based on the economic analysis, Alternative 4 provides a \$1,200 more net annual benefit than Alternative 2. However, this was determined to be negligible to the overall benefits at less than 0.03% of the total benefit provided. Alternative 4 leaves peace/sustainability/well-being/safety concerns to populations remaining in the 100-year floodplain. Additionally, future development should be taken into consideration for decision making. Assuming residential development within the next 10 years would occur on approximately 75 acres of undeveloped land that currently adjoin the channel, Alternative 2 could surpass the 0.03% difference in net annual benefits of Alternative 4. Therefore, Alternative 4 was eliminated from further advancement in the Plan-EA as it was determined an unwise decision based on the providing least amount of public benefits of the channel improvement alternatives.

The alternatives chosen for advancement for detailed analysis in the Plan-EA include Site 1 Alternative 1A (Debris Basin Improvements), Site 2 Alternative 2 (Channel Improvements) and Site 2 Alternative 3A (Debris Basin Improvements).

3.5.2 Environmental Evaluation

An environmental evaluation was completed for the alternative included in detailed study in the Plan-EA. These include the FWOFI Alternative (No Action Alternative) and the FWFI Alternatives (Action Alternatives) identified above. The potential effects of each alternative were determined for relevant resource categories and are documented in Section 5.0 (Environmental Consequences) of the Plan-EA.

3.6 Compare Alternatives

A measurement of change in services was determined, where applicable, between the FWOFI Alternative FWFI Alternative/s for each site. The alternatives for each site meeting the guiding principles were noted in the framework table for side-by-side alternative comparison. The ecosystem services were also compared in the framework table. The PR&G evaluation comparison tables for decision making are included in Appendix A.

Alternatives were evaluated to determine the locally, environmentally, and socially preferred alternative plans. The locally preferred alternative was coordinated with the those having local interests and oversight for implementation authorities and responsibilities. The local entities included Saratoga Springs City. The environmentally preferred alternative was selected based on evaluations and decision making performed during the NEPA process, and from the determination of environmental consequences as documented in Section 5.0 of the Plan-EA. Determination of the socially preferred alternative compared impacts or benefits for each alternative related to the social wellbeing of the community.

3.7 Identify Recommended Alternative

NRCS must identify the federally assisted alternative that “best” maximizes public benefits (environmental, economic, and social goals) with appropriate consideration of costs, guiding principles, and ecosystem services. This alternative is known as the NRCS National Economic Efficiency (NEE) Alternative. The Plan-EA analysis identifies the NEE alternative based on the results of environmental consequences to resources (environmental, economic, and social) and ecosystem services tradeoffs. The Plan-EA incorporates a description of the decision-making process for selection of the NEE alternative in 6.1 (Rationale for Preferred Alternative Selection).

3.8 Implement and Evaluate

Alternatives were evaluated in the Plan-EA and environmental consequences of the alternatives are included in Section 5.0 of the Plan-EA. The No Action alternative was also evaluated in the Plan-EA to provide a baseline comparison. The effects of alternatives were determined for each resource relevant to the proposed action. The evaluation assessed the proposed alternatives against the baseline data presented in Section 3.0 (Affected Environment) of the Plan-EA.

An additional evaluation of the NEE alternative was completed that included information on implementing the proposed measures. This included recommended measures to be installed, avoidance/minimization measures, required permits and compliance, installation/financing, O&M, costs, cost share, and economic benefits. This is included in Section 6.0 (Preferred Alternative) of the Plan-EA. After the Plan-EA is approved, the next phase would consist of final design followed by installation of preferred alternative measures. NRCS and the Sponsors would evaluate the effectiveness of the plan in solving the resource concerns then adjustments to the plan would be made as needed.

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Appendix A

PR&G Framework Tables

Preliminary PR&G Framework and Tradeoff Table
Site 1 Burnt/Lott Canyons
Saratoga Springs Flood Prevention Project
Saratoga Springs Watershed

Alternatives Considered				
Future Without Federal Investment (FWOFI): No Action Alternative The SLO's most likely course of action would be to continue O&M along the existing conveyance channel through Saratoga Springs City on an as needed basis to maintain the existing conveyance capacity.				
Future With Federal Investment (FWFI): Action Alternatives Alternative 1A:Debris Basin and Channel Improvements (100-year level of flood protection and 50 years of sediment storage) Alternative 1B: Debris Basin and Channel Improvements (100-year level of flood protection and 100 years of sediment storage)				
Eight additional FWFI Alternatives were formulated during the alternative formulation process but eliminated from further consideration in this table because they did not meet the purpose and need, were infeasible, had additional costs or adverse impacts without providing additional benefits, or had exorbitant costs. A nonstructural alternative was developed, but it was determined to be infeasible based on exorbitant cost and logistics, and the alternative was eliminated from further study.				
Please refer to Section 4.0 of the Plan-EA for further description of alternatives developed and justification for elimination.				
Summary and Comparison				
Item	FWOFI	FWFI		Comments
		Alternative 1A	Alternative 1B	
Alternative Plans				
Locally Preferred			✓	Alternative 1B is preferred by Saratoga City because it decreases the Sponsor O&M responsibilities and Sponsor O&M costs for the dams.
Nonstructural				There are no feasible nonstructural alternatives that would meet the purpose and need of the project.
Environmentally Preferred		✓		Alternative 1A constructs a smaller dam that has less population at risk downstream of the dam than the dam constructed for Alternative 1B.
Socially Preferred		✓		Both FWFI Alternatives provides the same amount of flood prevention benefit for the local community. Alternative 1A constructs a smaller dam that has less population at risk downstream of the dam than the dam constructed for Alternative 1B.
Guiding Principles				Comments
Healthy and Resilient Ecosystems		✓	✓	Neither FWFI alternatives are anticipated to have a measureable adverse impact on healthy and resilient ecosystems.
Sustainable Economic Development		✓	✓	Both FWFI Alternatives provide an equal amount of positive economic benefits to support sustainable economic development of Saratoga Springs City.
Floodplains		✓	✓	No FEMA floodplains have been mapped within the impacted areas. However, flooding has been documented and modeling has also shown flooding could occur. The floodplains of the impacted areas are almost entirely developed or planned for development with residential subdivisions, which has adversely impacted the floodplain ecological function. Both FWFI Alternatives seek to avoid flooding to the developed areas while protecting the flood conveyance corridors and supplementing the lost ecological function by trapping sediment an slowing water velocities.
Public Safety		✓		Both FWFI Alternatives improve public safety through reduction of flooding to Saratoga Springs City at the same level of protection. However, Alternative 1A constructs a smaller dam that has less population at risk downstream of the dam than the larger dam constructed for Alternative 1B.
Environmental Justice		✓	✓	All FWFI alternatives would benefit subject populations and no adverse impacts to subject populations would occur.
Watershed Approach		✓	✓	The floodplain has been adversely impacted from development with residential subdivisions. Both alternatives seek to protect the developed community from damaging floods while also protecting the flood conveyance corridors and their remaining ecological function.

Preliminary Evaluation Framework and Tradeoffs			
Item	FWOFI	FWFI	
		Alternative 1A	Alternative 1B
Regulating Services			
Climate	Climate change would continue to cause more intense flooding as projected.	Climate change would continue to cause more intense floods, but alternative measures provide flood prevention measures to better adapt and increase resilience to climate change stressors.	Same as Alternative 1.
Water Regulation (quality and quantity)	Water quality and quantity would be unchanged during small storm events. Storm events large enough to cause flooding to Saratoga Springs City would adversely impact water quality of Utah Lake from introduction of contaminants picked up by water flowing over lawns, gardens, parking lots, streets, other developed areas, ect. and reentering the ephemeral stream system that drains to Utah Lake.	Water quality and quantity would be unchanged during small storm events. Large storm events would be confined to the modified channel reducing contaminant input from removal of overland flooding through developed areas and associated contaminiant introduction to waters. The basin is designed to trap sediment which mimics the floodplain function of the existing floodplain, and similarly decres sediment loads in surface waters.	Same as Alternative 1.
Flood Moderation	This alternative does not change existing flood conditions and developed areas of Saratoga Springs City would continue to be at risk of flooding.	This alternative provides for safe flood conveyance for all storms up to and including a 100-year flood. This would reduce flood damages by an estimated \$2,144,200 annually.	Same as Alternative 1.
Cultural Services			
Peace and Sustainability	The people who live and work within the floodplain in Saratoga Springs City would continue to be threatened from risk of flooding adversely impacting their daily lives, source of income, and peace of mind.	The threat of flooding would be reduced benefiting the daily lives, source of income, and peace of mind of the community.	Same as Alternative 1.
Well-being and safety	The people who live and work within the floodplain in Saratoga Springs City would continue to be threatened from risk of flooding, adversely impacting their mental/physical well-being and threatening their safety. If a large flood were to occur, the community would suffer from substantial mental and physical health impacts from injury, potential loss of life, destruction of property, business closures, financial stressors, etc. that would be present in the wake of the flood.	The threat of flooding to homes, businesses, and other community infrastructure would be reduced. This would improve the mental/ physical well-being and safety for all people who live, work, or are present within the floodplain that are currently at risk.	Same as Alternative 1.
Economic Analysis			
Item	FWOFI	FWFI	
		Alternative 1A	Alternative 1B
Costs			
Installation Federal PL 83-566	-	\$11,688,000	\$12,590,000
Installation Sponsor	-	\$643,000	\$678,000
Total Installation Cost	-	\$12,331,000	\$13,268,000
Annual Installation Costs	-	\$324,600	\$349,200
Annual O&M Costs	\$5,700	\$28,800	\$26,200
Total Annual Costs	\$5,700	\$353,400	\$375,400
Annual Benefits			
Flood Damage Reduction	-	\$2,144,200	\$2,144,200
Cost Benefit Ratio and Net Benefits			
Cost-Benefit Ratio	-	6.1	5.7
Net Benefit	(\$5,700)	\$1,790,800	\$1,768,800
Decision-Making Conclusion	The FWOFI alternative is required to be included in detailed study in the Plan-EA.	Selected for Detailed Study in Plan-EA: Alternative1A has the greatest benefit to ecosystem services, the greatest economic benefit, and is the socially and environmentally preferred alternative that meets the purpose and need of the Project.	Alternative 1B has the same flood prevention benefits as Alternative 1A but costs more resulting in a lower cost-benefit ratio. This alternative is the locally preferred alternative by the Sponsor because it decreases the Sponsor O&M costs by \$362,000, but in turn it increases the installation costs by \$937,000. Therefore, this alternative is not selected for detailed study in the Plan-EA.

Preliminary PR&G Framework and Tradeoff Table - Site 2 Clark Canyon

Saratoga Springs Flood Prevention Project Saratoga Springs Watershed

Alternatives Considered						
Future Without Federal Investment (FWOFI): No Action Alternative The SLO's most likely course of action would be to continue O&M along the existing conveyance channel through Saratoga Springs City on an as needed basis to maintain the existing conveyance capacity.						
Future With Federal Investment (FWFI): Action Alternatives Alternative 2: Channel Improvements (100-year level of flood protection) Alternative 3A: Debris Basin and Channel Improvements (100-year level of flood protection and 50 years of sediment storage) Alternative 3B: Debris Basin and Channel Improvements (100-year level of flood protection and 100 years of sediment storage) Alternative 4: Channel Improvements (50-year level of flood protection)						
Seven additional FWFI Alternatives were formulated during the alternative formulation process but eliminated from further consideration in this table because they did not meet the purpose and need, were infeasible, had additional costs or adverse impacts without providing additional benefits, or had exorbitant costs. A nonstructural alternative was developed, but it was determined to be infeasible based on exorbitant cost and logistics, and the alternative was eliminated from further study.						
Please refer to Section 5.0 of the Plan-EA for further description of alternatives developed and justification for elimination.						
Summary and Comparison						
Item	FWOFI	FWFI				Comments
		Alternative 2	Alternative 3A	Alternative 3B	Alternative 4	
Alternative Plans						
Locally Preferred				✓		Alternative 3B is preferred by Saratoga City because it decreases water velocities along the conveyance channel that pass through residential areas. Additionally, it decreases the Sponsor O&M responsibilities and Sponsor O&M costs for the Project compared to Alternative 3A.
Nonstructural						There are no feasible nonstructural alternatives that would meet the purpose and need of the project.
Environmentally Preferred			✓			Alternatives 2 and 4 remove the floodplain and convey flood flows through the channel. This removes the floodplain function that slows water velocities and captures sediment, resulting in increased sediment loads into Utah Lake. Alternatives 3A and 3B construct detention dams that supplement the floodplain function to decrease water velocities and trap sediment. However, Alternative 3A constructs a smaller dam that has less population at risk downstream of the dam than the dam constructed for Alternative 3B. Therefore, Alternative 3A is the environmentally preferred alternative.
Socially Preferred		✓	✓			Alternative 4 is not socially preferred because it provides flood protection for only a 50-year flood and damage would occur to the community at a 100-year flood. Alternatives 2, 3A, and 3B all provide flood protection for up to and including a 100-year flood. However, Alternative 3B would have a greater population at risk downstream of the dam than Alternative 3A and it was not selected as the socially preferred alternative. Therefore, Alternatives 3A and 4 were selected as socially preferred.
Guiding Principles						Comments
Healthy and Resilient Ecosystems			✓	✓		Alternatives 2 and 4 remove the floodplain function and Alternatives 3A and 3B construct detention dams to transfer the floodplain functions. Alternatives 2 and 4 would result in increased water velocities and sediment loads into Utah Lake, while Alternatives 3A and 3B would slow water and trap sediment, mimicking the existing floodplain functions.
Sustainable Economic Development		✓	✓	✓		Alternatives 2, 3A, and 3B provide an equal amount of flood protection to support sustainable economic development of Saratoga Springs City.
Floodplains			✓	✓		No FEMA floodplains have been mapped within the impacted areas. However, flooding has been documented and modeling has also shown flooding could occur. The floodplains of the impacted areas are almost entirely developed or planned for development with residential subdivisions, which has adversely impacted the floodplain ecological function. The FWFI Alternatives seek to avoid flooding to the developed areas while protecting the flood conveyance corridors. Alternatives 3A and 3B supplement the lost ecological floodplain functions by constructing detention dams to decrease water velocities and trap sediment, while Alternatives 2 and 4 removes the floodplain function resulting in increased water velocities and sediment into Utah Lake.
Public Safety		✓	✓			Alternatives 2, 3A, and 3B provide an equal amount of flood protection to Saratoga Springs City. However, Alternative 3B would have a greater population at risk downstream of the dam than Alternative 3A.
Environmental Justice		✓			✓	All FWFI alternatives would benefit subject populations and no adverse impacts to subject populations would occur.
Watershed Approach			✓	✓		The floodplain has been adversely impacted from development with residential subdivisions. All alternatives seek to protect the developed community from damaging floods while also protecting the flood conveyance corridors and their remaining ecological function. Alternatives 3A and 3B supplement the lost ecological floodplain functions by constructing detention dams to decrease water velocities and trap sediment, while Alternatives 2 and 4 removes the floodplain function resulting in increased water velocities and sediment into Utah Lake.

Preliminary Evaluation Framework and Tradeoffs					
Item	FWOFI	FWFI			
		Alternative 2	Alternative 3A	Alternative 3B	Alternative 4
Regulating Services					
Climate	Climate change would continue to cause more intense flooding as projected.	Climate change would continue to cause more intense floods, but alternative measures provide flood prevention measures to better adapt and increase resilience to climate stressors.	Same as Alternative 2.	Same as Alternative 2.	Similar to Alternative 2, with a decreased level of resilience when compared to the other alternatives.
Water Regulation (quality and quantity)	Water quality and quantity would be unchanged during small storm events. Storm events large enough to cause flooding to Saratoga Springs City would adversely impact water quality of Utah Lake from introduction of contaminants picked up by water flowing over lawns, gardens, parking lots, streets, other developed areas, ect. and reentering the ephemeral stream system that drains to Utah Lake.	Water quality and quantity would be unchanged during small storm events. Large storm events would be confined to the modified channel reducing contaminant input into Utah Lake from removal of overland flooding through developed areas. However, removing the floodplain would increase water velocities and remove sediment capture floodplain function. This would result in increased sediment loads into Utah Lake.	Similar to Alternative 2, this alternative reduces contaminant input into Utah Lake. Additionally, it traps sediment and slows water velocities to supplement the lost floodplain functions.	Same as Alternative 3A.	Same as Alternative 2.
Flood Moderation	This alternative does not change existing flood conditions and developed areas of Saratoga Springs City would continue to be at risk of flooding.	This alternative provides for safe flood conveyance for all storms up to and including a 100-year flood. This would reduce flood damages by \$4,639,500 annually.	This alternative provides for safe flood conveyance for all storms up to and including a 100-year flood. This would reduce flood damages by \$4,631,900 annually.	Same as Alternative 3A.	This alternative provides for safe flood conveyance for all storms up to and including a 50-year flood. This would reduce flood damages by \$4,608,500 annually.
Cultural Services					
Peace and Sustainability	The people who live and work within the floodplain in Saratoga Springs City would continue to be threatened from risk of flooding adversely impacting their daily lives, source of income, and peace of mind.	The threat of flooding would be reduced benefiting the daily lives, source of income, and peace of mind of the community.	Same as Alternative 2.	Same as Alternative 2.	Same as Alternative 2, but provides a decreased level of flood protection. Peace and sustainability would still be improved, but not to the same extent as for the alternatives that protect for up to and including a 100-year flood.
Well-being and safety	The people who live and work within the floodplain in Saratoga Springs City would continue to be threatened from risk of flooding, adversely impacting their mental/physical well-being and threatening their safety. If a large flood were to occur, the community would suffer from substantial mental and physical health impacts from injury, potential loss of life, destruction of property, business closures, financial stressors, etc. that would be present in the wake of the flood.	The threat of flooding to homes, businesses, and other community infrastructure would be reduced. This would improve the mental/ physical well-being and safety for all people who live, work, or are present within the floodplain that are currently at risk.	Same as Alternative 2.	Same as Alternative 2.	Same as Alternative 2, but provides a decreased level of flood protection. Well-being and safety would still be improved, but not to the same extent as for the alternatives that protect up to a 100-year flood..

Economic Analysis					
Item	FWOFI	FWFI			
		Alternative 2	Alternative 3A	Alternative 3B	Alternative 4
Costs					
Installation Federal PL 83-566	-	\$6,005,000	\$8,905,000	\$9,402,000	\$5,511,000
Installation Sponsor	-	\$2,892,000	\$986,000	\$1,005,000	\$2,873,000
Total Installation Cost	-	\$8,897,000	\$9,891,000	\$10,407,000	\$8,384,000
Annual Installation Costs	-	\$234,200	\$260,300	\$273,900	\$220,700
Annual O&M Costs	\$11,300	\$38,000	\$30,500	\$28,600	\$21,700
Total Annual Costs	\$11,300	\$272,200	\$290,800	\$302,500	\$242,400
Annual Benefits					
Flood Damage Reduction	-	\$4,639,500	\$4,631,900	\$4,631,900	\$4,608,500
Cost Benefit Ratio and Net Benefits					
Cost-Benefit Ratio	-	17.0	15.9	15.3	19.0
Net Annual Benefit	(\$11,300)	\$4,367,300	\$4,341,100	\$4,329,400	\$4,366,100
Decision-Making Conclusion	The FWOFI alternative is required to be included in detailed study of the Plan-EA.	Selected for Detailed Study in the Plan-EA: This was selected as the channel improvement alternative that best met ecosystem service benefits. While Alternative 4 has a better cost-benefit ratio, future development and associated uncalculated damages were considered in decision making. It was determined that the difference in annual benefit between Alternative 4 of \$1,200 is negligible considering it accounts for less than 0.03% of the annual benefits, and the other ecosystem service benefits were determined to outweigh the negligible difference from Alternative 4. Further detailed evaluation is needed to weigh tradeoffs between this alterantive and Alternative 3A.	Selected for Detailed Study in the Plan-EA: Alternative 3A supplements the existing lost floodplain functions by constructing a detention basin that slows water and captures sediment. It provides benefits to ecosystem services, and is the socially and environmentally preferred alternative that meets the purpose and need of the Project.	Alternative 3B has the same flood prevention benefits as Alternative 3A but costs more resulting in a lower cost-benefit ratio and net benefits. This alternative is the locally preferred alternative by the Sponsor because it decreases the Sponsor O&M costs by \$277,000, but in turn it increases the installation costs by \$516,000. Therefore, it was not selected for detailed study in the Plan-EA.	Although this alternative has the greatest net benefit of all alternatives, it leaves peace/sustainability/well-being/and safety concens to populations remaining in the 100-year floodplain. Therefore, it was not selected for detailed study in the Plan-EA.

Appendix B

Site 1 Burnt/Lott Canyons Cost Estimates

Site 1 Burnt/Lott Canyons

Summary of Alternative Installation and O&M Costs Used in Economic Analysis

Alternative Installation Cost Summary¹

Item	No Action	Alternative 1A Debris Basin and Channel Improvements (50 years sediment storage)	Alternative 1B Debris Basin and Channel Improvements (100 years sediment storage)
Construction	-	\$10,119,000	\$10,896,000
Engineering/Technical Assistance <i>10% of Construction</i>	-	\$1,012,000	\$1,090,000
Permitting <i>0.5% of Construction</i>	-	\$51,000	\$55,000
Real Property Rights	-	\$137,000	\$137,000
Sponsor Administrative <i>4% of Construction</i>	-	\$405,000	\$436,000
NRCS Administrative <i>6% of Construction</i>	-	\$607,000	\$654,000
TOTAL INSTALLATION	-	\$12,331,000	\$13,268,000
Installation Period	-	2 Years	2 Years

1 - All estimates are rounded to the nearest thousand

Alternative O&M Cost Summary

Item	No Action	Alternative 1A Debris Basin and Channel Improvements (50 years sediment storage)	Alternative 1B Debris Basin and Channel Improvements (100 years sediment storage)
Annual O&M	\$5,700	\$27,500	\$27,500
Sediment Removal from Debris Basin (remove from 2 dams at year 50)	-	\$362,000	-

Detailed engineering cost estimates provided by Bowen Collins & Associates are included below

Site 1 Burnt/Lott Canyon

Alternative 1A - Debris Basin and Channel Improvements

50-Year Sediment Storage Capacity and 100-Year Flood Attenuation in Basin

Preliminary Opinion of Project Cost



Project: Saratoga Springs Plan EA Projects			Date:	8/28/2023	
Owner: Saratoga Springs City, NRCS			Prepared by:	CM	
Item No.	Classification of Unit Price Work	Quantity	Unit	Unit Price	Amount
Construction Costs:					
1	Burnt Canyon Debris Basin	1	LS	\$ 2,381,100	\$ 2,381,100
2	Lott Canyon Debris Basin	1	LS	\$ 5,631,600	\$ 5,631,600
3	Burnt/Lott Canyon Discharge Pipeline Drainage Channels	1	LS	\$ 419,700	\$ 419,700
SUBTOTAL:					\$ 8,432,400
Contingency				20%	\$ 1,686,500
CONSTRUCTION SUBTOTAL:					\$ 10,118,900
Other Installation Costs:					
Engineering				10%	\$ 1,011,900
Real Property Rights				1%	\$ 137,000
Natural Resources Rights				0%	\$ -
Permitting				0.50%	\$ 50,600
Relocation Payments				0%	\$ -
Administration				10%	\$ 1,011,900
OTHER INSTALLATION COSTS SUBTOTAL:					\$ 2,211,400
TOTAL COST:					\$ 12,330,300

This opinion of probable construction is based on experience with past projects of similar construction. It is understood that Bowen Collins & Associates has no control over economical factors or unknown conditions that may have a significant impact on actual project costs. Bowen Collins & Associates does not guarantee its cost estimates and accepts no liability for problems created by the difference in actual costs and this opinion of probable construction cost.

Preliminary Opinion of Probable Construction Cost



Project: Burnt Canyon Debris Basin (100-yr Storm, 50-yr Sed)			Date:	8/28/2023	
Owner: Saratoga Springs City, NRCS			Prepared by:	CM	
Item No.	Classification of Unit Price Work	Quantity	Unit	Unit Price	Amount
1	Mobilization (5% of Subtotal)	1	LS	\$ 113,385	\$ 113,400
2	Site Prep / survey / misc	1	LS	\$ 95,000	\$ 95,000
3	Debris Basin Excavation	25,600	CY	\$ 12	\$ 307,200
4	Foundation Excavation	16,400	CY	\$ 12	\$ 196,800
5	Embankment Fill	22,500	CY	\$ 12	\$ 270,000
6	Auxiliary Spillway Excavation	17,100	CY	\$ 12	\$ 205,200
7	Excess Material Haul Off	59,100	CY	\$ 5	\$ 295,500
8	Access Road	1,000	LF	\$ 20	\$ 20,000
9	Install Type 'G' Cap on Dam Embankment Crest	500	LF	\$ 50	\$ 25,000
10	Type 'R' Drain Gravel	3,300	CY	\$ 80	\$ 264,000
11	Type 'Q' Filter Sand	3,300	CY	\$ 80	\$ 264,000
12	Rock Mulch (On Upstream Slope of Dam)	500	CY	\$ 40	\$ 20,000
13	6-inch Toe Drain Pipe (Perforated)	1,000	LF	\$ 40	\$ 40,000
14	Outlet Riser w/ Trash Rack	1	LS	\$ 60,000	\$ 60,000
15	30" Concrete Encased Steel Discharge Conduit	175	LF	\$ 1,000	\$ 175,000
16	Restoration	1	LS	\$ 30,000	\$ 30,000
SUBTOTAL:					\$ 2,381,100
			Contingency	0%	\$ -
TOTAL COST:					\$ 2,381,100
This opinion of probable construction is based on experience with past projects of similar construction. It is understood that Bowen Collins & Associates has no control over economical factors or unknown conditions that may have a significant impact on actual project costs. Bowen Collins & Associates does not guarantee its cost estimates and accepts no liability for problems created by the difference in actual costs and this opinion of probable construction cost.					

Preliminary Opinion of Probable Construction Cost



Project: Lott Canyon Debris Basin (100-yr Storm, 50yr Sed)			Date:	8/28/2023	
Owner: Saratoga Springs City, NRCS			Prepared by:	CM	
Item No.	Classification of Unit Price Work	Quantity	Unit	Unit Price	Amount
1	Mobilization (5% of Subtotal)	1	LS	\$ 268,170	\$ 268,200
2	Site Prep / survey / misc	1	LS	\$ 95,000	\$ 95,000
3	Debris Basin Excavation	102,600	CY	\$ 12	\$ 1,231,200
4	Foundation Excavation	35,300	CY	\$ 12	\$ 423,600
5	Embankment Fill	42,000	CY	\$ 12	\$ 504,000
6	Auxiliary Spillway Excavation	45,500	CY	\$ 12	\$ 546,000
7	Excess Material Haul Off	183,400	CY	\$ 5	\$ 917,000
8	Access Road	1,900	LF	\$ 20	\$ 38,000
9	Install Type 'G' Cap on Dam Embankment Crest	1,020	LF	\$ 50	\$ 51,000
10	Type 'R' Drain Gravel	7,100	CY	\$ 80	\$ 568,000
11	Type 'Q' Filter Sand	7,100	CY	\$ 80	\$ 568,000
12	Rock Mulch (On Upstream Slope of Dam)	500	CY	\$ 40	\$ 20,000
13	6-inch Toe Drain Pipe (Perforated)	2,040	LF	\$ 40	\$ 81,600
14	Outlet Riser w/ Trash Rack	1	LS	\$ 60,000	\$ 60,000
15	30" Concrete Encased Steel Discharge Conduit	230	LF	\$ 1,000	\$ 230,000
16	Restoration	1	LS	\$ 30,000	\$ 30,000
SUBTOTAL:					\$ 5,631,600
			Contingency	0%	\$ -
TOTAL COST:					\$ 5,631,600

This opinion of probable construction is based on experience with past projects of similar construction. It is understood that Bowen Collins & Associates has no control over economical factors or unknown conditions that may have a significant impact on actual project costs. Bowen Collins & Associates does not guarantee its cost estimates and accepts no liability for problems created by the difference in actual costs and this opinion of probable construction cost.

Preliminary Opinion of Probable Construction Cost



Project: Drainage Channels Burnt/Lott			Date:	8/28/2023	
Owner: Saratoga Springs City, NRCS			Prepared by:	CM	
Item No.	Classification of Unit Price Work	Quantity	Unit	Unit Price	Amount
1	Mobilization (5% of Subtotal)	1	LS	\$ 19,985	\$ 20,000
2	Site Prep / survey / misc	1	LS	\$ 20,000	\$ 20,000
3	New Drainage Channel	4,800	LF	\$ 30	\$ 144,000
4	Toe Protection, 12-inch Riprap	1,430	CY	\$ 130	\$ 185,900
5	36" Culvert Installation	190	LF	\$ 220	\$ 41,800
6	18" Culvert Installation	50	LF	\$ 160	\$ 8,000
SUBTOTAL:					\$ 419,700
			Contingency	0%	\$ -
TOTAL COST:					\$ 419,700
This opinion of probable construction is based on experience with past projects of similar construction. It is understood that Bowen Collins & Associates has no control over economical factors or unknown conditions that may have a significant impact on actual project costs. Bowen Collins & Associates does not guarantee its cost estimates and accepts no liability for problems created by the difference in actual costs and this opinion of probable construction cost.					

Site 1 Burnt/Lott Canyon

Alternative 1B - Debris Basin and Channel Improvements

100-Year Sediment Storage Capacity and 100-Year Flood Attenuation in Basin

Preliminary Opinion of Project Cost



Project: Saratoga Springs Plan EA Projects			Date:	8/28/2023	
Owner: Saratoga Springs City, NRCS			Prepared by:	CM	
Item No.	Classification of Unit Price Work	Quantity	Unit	Unit Price	Amount
Construction Costs:					
1	Burnt Canyon Debris Basin	1	LS	\$ 2,527,100	\$ 2,527,100
2	Lott Canyon Debris Basin	1	LS	\$ 6,132,800	\$ 6,132,800
3	Burnt/Lott Canyon Discharge Pipeline Drainage Channels	1	LS	\$ 419,700	\$ 419,700
SUBTOTAL:					\$ 9,079,600
Contingency				20%	\$ 1,815,900
CONSTRUCTION SUBTOTAL:					\$ 10,895,500
Other Installation Costs:					
Engineering				10%	\$ 1,089,600
Real Property Rights				1%	\$ 137,000
Natural Resources Rights				0%	\$ -
Permitting				0.50%	\$ 54,500
Relocation Payments				0%	\$ -
Administration				10%	\$ 1,089,600
OTHER INSTALLATION COSTS SUBTOTAL:					\$ 2,370,700
TOTAL COST:					\$ 13,266,200

This opinion of probable construction is based on experience with past projects of similar construction. It is understood that Bowen Collins & Associates has no control over economical factors or unknown conditions that may have a significant impact on actual project costs. Bowen Collins & Associates does not guarantee its cost estimates and accepts no liability for problems created by the difference in actual costs and this opinion of probable construction cost.

Preliminary Opinion of Probable Construction Cost



Project: Burnt Canyon Debris Basin (100-yr Storm, 100-yr Sed)			Date:	8/28/2023	
Owner: Saratoga Springs City, NRCS			Prepared by:	CM	
Item No.	Classification of Unit Price Work	Quantity	Unit	Unit Price	Amount
1	Mobilization (5% of Subtotal)	1	LS	\$ 120,340	\$ 120,300
2	Site Prep / survey / misc	1	LS	\$ 95,000	\$ 95,000
3	Debris Basin Excavation	25,600	CY	\$ 12	\$ 307,200
4	Foundation Excavation	18,200	CY	\$ 12	\$ 218,400
5	Embankment Fill	26,100	CY	\$ 12	\$ 313,200
6	Auxiliary Spillway Excavation	17,100	CY	\$ 12	\$ 205,200
7	Excess Material Haul Off	60,900	CY	\$ 5	\$ 304,500
8	Access Road	1,000	LF	\$ 20	\$ 20,000
9	Install Type 'G' Cap on Dam Embankment Crest	510	LF	\$ 50	\$ 25,500
10	Type 'R' Drain Gravel	3,700	CY	\$ 80	\$ 296,000
11	Type 'Q' Filter Sand	3,700	CY	\$ 80	\$ 296,000
12	Rock Mulch (On Upstream Slope of Dam)	500	CY	\$ 40	\$ 20,000
13	6-inch Toe Drain Pipe (Perforated)	1,020	LF	\$ 40	\$ 40,800
14	Outlet Riser w/ Trash Rack	1	LS	\$ 60,000	\$ 60,000
15	30" Concrete Encased Steel Discharge Conduit	175	LF	\$ 1,000	\$ 175,000
16	Restoration	1	LS	\$ 30,000	\$ 30,000
SUBTOTAL:					\$ 2,527,100
			Contingency	0%	\$ -
TOTAL COST:					\$ 2,527,100
This opinion of probable construction is based on experience with past projects of similar construction. It is understood that Bowen Collins & Associates has no control over economical factors or unknown conditions that may have a significant impact on actual project costs. Bowen Collins & Associates does not guarantee its cost estimates and accepts no liability for problems created by the difference in actual costs and this opinion of probable construction cost.					

Preliminary Opinion of Probable Construction Cost



Project: Lott Canyon Debris Basin (100-yr Storm, 100-yr Sed)			Date:	8/28/2023	
Owner: Saratoga Springs City, NRCS			Prepared by:	CM	
Item No.	Classification of Unit Price Work	Quantity	Unit	Unit Price	Amount
1	Mobilization (5% of Subtotal)	1	LS	\$ 292,040	\$ 292,000
2	Site Prep / survey / misc	1	LS	\$ 95,000	\$ 95,000
3	Debris Basin Excavation	102,600	CY	\$ 12	\$ 1,231,200
4	Foundation Excavation	41,600	CY	\$ 12	\$ 499,200
5	Embankment Fill	53,200	CY	\$ 12	\$ 638,400
6	Auxiliary Spillway Excavation	45,500	CY	\$ 12	\$ 546,000
7	Excess Material Haul Off	189,700	CY	\$ 5	\$ 948,500
8	Access Road	1,900	LF	\$ 20	\$ 38,000
9	Install Type 'G' Cap on Dam Embankment Crest	1,050	LF	\$ 50	\$ 52,500
10	Type 'R' Drain Gravel	8,400	CY	\$ 80	\$ 672,000
11	Type 'Q' Filter Sand	8,400	CY	\$ 80	\$ 672,000
12	Rock Mulch (On Upstream Slope of Dam)	1,100	CY	\$ 40	\$ 44,000
13	6-inch Toe Drain Pipe (Perforated)	2,100	LF	\$ 40	\$ 84,000
14	Outlet Riser w/ Trash Rack	1	LS	\$ 60,000	\$ 60,000
15	30" Concrete Encased Steel Discharge Conduit	230	LF	\$ 1,000	\$ 230,000
16	Restoration	1	LS	\$ 30,000	\$ 30,000
SUBTOTAL:					\$ 6,132,800
			Contingency	0%	\$ -
TOTAL COST:					\$ 6,132,800

This opinion of probable construction is based on experience with past projects of similar construction. It is understood that Bowen Collins & Associates has no control over economical factors or unknown conditions that may have a significant impact on actual project costs. Bowen Collins & Associates does not guarantee its cost estimates and accepts no liability for problems created by the difference in actual costs and this opinion of probable construction cost.

Preliminary Opinion of Probable Construction Cost



Project: Drainage Channels Burnt/Lott			Date:	8/28/2023	
Owner: Saratoga Springs City, NRCS			Prepared by:	CM	
Item No.	Classification of Unit Price Work	Quantity	Unit	Unit Price	Amount
1	Mobilization (5% of Subtotal)	1	LS	\$ 19,985	\$ 20,000
2	Site Prep / survey / misc	1	LS	\$ 20,000	\$ 20,000
3	New Drainage Channel	4,800	LF	\$ 30	\$ 144,000
4	Toe Protection, 12-inch Riprap	1,430	CY	\$ 130	\$ 185,900
5	36" Culvert Installation	190	LF	\$ 220	\$ 41,800
6	18" Culvert Installation	50	LF	\$ 160	\$ 8,000
SUBTOTAL:					\$ 419,700
			Contingency	0%	\$ -
TOTAL COST:					\$ 419,700
This opinion of probable construction is based on experience with past projects of similar construction. It is understood that Bowen Collins & Associates has no control over economical factors or unknown conditions that may have a significant impact on actual project costs. Bowen Collins & Associates does not guarantee its cost estimates and accepts no liability for problems created by the difference in actual costs and this opinion of probable construction cost.					

Appendix C

Site 1 Clark Canyon Cost Estimates

Site 2 Clark Canyon

Summary of Alternative Installation and O&M Costs Used in Economic Analysis

Alternative Installation Cost Summary¹

Item	No Action	Alternative 2 Channel Improvements (100yr flood protection)	Alternative 3A Debris Basin and Channel Improvements (50 years sediment storage)	Alternative 3B Debris Basin and Channel Improvements (100 years sediment storage)	Alternative 4 Channel Improvements (50yr flood protection)
Construction	-	\$7,039,000	\$7,741,000	\$8,169,000	\$6,613,000
Engineering/Technical Assistance <i>10% of Construction</i>	-	\$704,000	\$774,000	\$817,000	\$661,000
Permitting <i>0.5% of Construction</i>	-	\$35,000	\$39,000	\$41,000	\$33,000
Real Property Rights	-	\$415,000	\$563,000	\$563,000	\$415,000
Sponsor Administrative <i>4% of Construction</i>	-	\$282,000	\$310,000	\$327,000	\$265,000
NRCS Administrative <i>6% of Construction</i>	-	\$422,000	\$464,000	\$490,000	\$397,000
TOTAL INSTALLATION	-	\$8,897,000	\$9,891,000	\$10,407,000	\$8,384,000
Installation Period	-	1-Year	2 Years	2 Years	1-Year

1 - All estimates are rounded to the nearest thousand

Alternative O&M Cost Summary

Item	No Action	Alternative 2 Channel Improvements (100yr flood protection)	Alternative 3A Debris Basin and Channel Improvements (50 years sediment storage)	Alternative 3B Debris Basin and Channel Improvements (100 years sediment storage)	Alternative 4 Channel Improvements (50yr flood protection)
Annual O&M	\$11,300	\$39,900	\$30,000	\$30,000	\$22,800
Sediment Removal from Debris Basin (remove sediment from 2 dams at year 50)	-	-	\$277,000	-	-

Detailed engineering cost estimates provided by Bowen Collins & Associates are included below

Site 2 Clark Canyon

Alternative 2 - Channel Improvements (100-Year Flood Protection)

Opinion of Probable Construction Cost



Project: CC Channel Alternative Cost - 100-yr Design Storm			Date:	8/28/2023	
Owner: Saratoga Springs			Prepared by:	CM	
Item No.	Classification of Unit Price Work	Quantity	Unit	Unit Price	Amount
1	Mobilization (5% of Subtotal)	1	LS	\$280,000	\$280,000
2	Field Survey and Staking	1	LS	\$20,000	\$20,000
3	Dewater and River Management	1	LS	\$30,000	\$30,000
4	Construction Access	1	LS	\$20,000	\$20,000
5	Sediment & Debris Removal, and Disposal	42,410	CY	\$30	\$1,272,300
6	Riprap D ₅₀ = 12-inch (reduced due to drop structures)	1,680	CY	\$130	\$218,400
7	Restore Disturbed Areas (seed, coir logs, erosion control blanket). 3:1 slopes.	226,000.0	SF	\$5	\$1,017,000
8	6" Aggregate Base Course	2,519	CY	\$60	\$151,100
9	Seed Restoration (disturbed areas for construction)	226,000	SF	\$1	\$113,000
10	Drop Structures	295	EA	\$3,200	\$944,000
11	Box Culverts	3	EA	\$600,000	\$1,800,000
				SUBTOTAL:	\$ 5,865,800
				Contingency	20% \$ 1,173,200
				CONSTRUCTION SUBTOTAL:	\$ 7,039,000
				Engineering	10% \$ 703,900
				Real Property Rights	6% \$ 415,000
				Natural Resources Rights	0% \$ -
				Permitting	0.50% \$ 35,195
				Relocation Payments	0% \$ -
				Administration	10% \$ 703,900
				OTHER INSTALLATION COSTS SUBTOTAL:	\$ 1,857,995
				TOTAL COST:	\$ 8,896,995
This opinion of probable construction is based on experience with past projects of similar construction. It is understood that Bowen Collins & Associates has no control over economical factors or unknown conditions that may have a significant impact on actual project costs. Bowen Collins & Associates does not guarantee its cost estimates and accepts no liability for problems created by the difference in actual costs and this opinion of probable construction cost.					

Site 2 Clark Canyon

Alternative 3A - Debris Basin and Channel Improvements

50-Year Sediment Storage Capacity and 50-Year Flood Attenuation in Basin

Preliminary Opinion of Project Cost



Project: Clark Canyon - 50-yr Storm, 50-yr Sediment			Date:	8/30/2023	
Owner: Saratoga Springs City, NRCS			Prepared by:	CM	
Item No.	Classification of Unit Price Work	Quantity	Unit	Unit Price	Amount
Construction Costs:					
1	Clark Canyon North Debris Basin	1	LS	\$ 1,739,500	\$ 1,739,500
2	Clark Canyon South Debris Basin	1	LS	\$ 4,516,500	\$ 4,516,500
3	Clark Canyon Discharge Pipeline Drainage Channels	1	LS	\$ 194,400	\$ 194,400
SUBTOTAL:					\$ 6,450,400
Contingency				20%	\$ 1,290,100
CONSTRUCTION SUBTOTAL:					\$ 7,740,500
Other Installation Costs:					
Engineering				10%	\$ 774,100
Real Property Rights				7%	\$ 563,000
Natural Resources Rights				0%	\$ -
Permitting				0.50%	\$ 38,700
Relocation Payments				0%	\$ -
Administration				10%	\$ 774,100
OTHER INSTALLATION COSTS SUBTOTAL:					\$ 2,149,900
TOTAL COST:					\$ 9,890,400
This opinion of probable construction is based on experience with past projects of similar construction. It is understood that Bowen Collins & Associates has no control over economical factors or unknown conditions that may have a significant impact on actual project costs. Bowen Collins & Associates does not guarantee its cost estimates and accepts no liability for problems created by the difference in actual costs and this opinion of probable construction cost.					

Preliminary Opinion of Probable Construction Cost



Project: Clark Canyon North Debris Basin (50-yr Storm, 50-yr Sed)			Date:	8/28/2023	
Owner: Saratoga Springs City, NRCS			Prepared by:	CM	
Item No.	Classification of Unit Price Work	Quantity	Unit	Unit Price	Amount
1	Mobilization (5% of Subtotal)	1	LS	\$ 82,835	\$ 82,800
2	Site Prep / survey / misc	1	LS	\$ 95,000	\$ 95,000
3	Debris Basin Excavation	22,700	CY	\$ 12	\$ 272,400
4	Foundation Excavation	8,500	CY	\$ 12	\$ 102,000
5	Embankment Fill	10,800	CY	\$ 12	\$ 129,600
6	Auxiliary Spillway Excavation	16,700	CY	\$ 12	\$ 200,400
7	Excess Material Haul Off	47,900	CY	\$ 5	\$ 239,500
8	Access Road	1,000	LF	\$ 20	\$ 20,000
9	Install Type 'G' Cap on Dam Embankment Crest	260	LF	\$ 50	\$ 13,000
10	Type 'R' Drain Gravel	1,700	CY	\$ 80	\$ 136,000
11	Type 'Q' Filter Sand	1,700	CY	\$ 80	\$ 136,000
12	Rock Mulch (On Upstream Slope of Dam)	300	CY	\$ 40	\$ 12,000
13	6-inch Toe Drain Pipe (Perforated)	520	LF	\$ 40	\$ 20,800
14	Outlet Riser w/ Trash Rack	1	LS	\$ 60,000	\$ 60,000
15	30" Concrete Encased Steel Discharge Conduit	190	LF	\$ 1,000	\$ 190,000
16	Restoration	1	LS	\$ 30,000	\$ 30,000
SUBTOTAL:					\$ 1,739,500
			Contingency	0%	\$ -
TOTAL COST:					\$ 1,739,500
This opinion of probable construction is based on experience with past projects of similar construction. It is understood that Bowen Collins & Associates has no control over economical factors or unknown conditions that may have a significant impact on actual project costs. Bowen Collins & Associates does not guarantee its cost estimates and accepts no liability for problems created by the difference in actual costs and this opinion of probable construction cost.					

Preliminary Opinion of Probable Construction Cost



Project: Clark Canyon South Debris Basin (50-yr Storm, 50-yr Sed)			Date:	8/28/2023	
Owner: Saratoga Springs City, NRCS			Prepared by:	CM	
Item No.	Classification of Unit Price Work	Quantity	Unit	Unit Price	Amount
1	Mobilization (5% of Subtotal)	1	LS	\$ 215,070	\$ 215,100
2	Site Prep / survey / misc	1	LS	\$ 95,000	\$ 95,000
3	Debris Basin Excavation	101,300	CY	\$ 12	\$ 1,215,600
4	Foundation Excavation	23,800	CY	\$ 12	\$ 285,600
5	Embankment Fill	20,800	CY	\$ 12	\$ 249,600
6	Auxiliary Spillway Excavation	10,400	CY	\$ 12	\$ 124,800
7	Non-woven Geotextile Fabric	5,400	SY	\$ 6	\$ 32,400
8	Auxiliary Spillway Riprap Armoring (D50 = 24 in)	7,200	CY	\$ 60	\$ 432,000
9	Excess Material Haul Off	135,500	CY	\$ 5	\$ 677,500
10	Access Road	2,300	LF	\$ 20	\$ 46,000
11	Install Type 'G' Cap on Dam Embankment Crest	430	LF	\$ 50	\$ 21,500
12	Type 'R' Drain Gravel	4,800	CY	\$ 80	\$ 384,000
13	Type 'Q' Filter Sand	4,800	CY	\$ 80	\$ 384,000
14	Rock Mulch (On Upstream Slope of Dam)	600	CY	\$ 40	\$ 24,000
15	6-inch Toe Drain Pipe (Perforated)	860	LF	\$ 40	\$ 34,400
16	Outlet Riser w/ Trash Rack	1	LS	\$ 60,000	\$ 60,000
17	30" Concrete Encased Steel Discharge Conduit	205	LF	\$ 1,000	\$ 205,000
18	Restoration	1	LS	\$ 30,000	\$ 30,000
SUBTOTAL:					\$ 4,516,500
			Contingency	0%	\$ -
TOTAL COST:					\$ 4,516,500

This opinion of probable construction is based on experience with past projects of similar construction. It is understood that Bowen Collins & Associates has no control over economical factors or unknown conditions that may have a significant impact on actual project costs. Bowen Collins & Associates does not guarantee its cost estimates and accepts no liability for problems created by the difference in actual costs and this opinion of probable construction cost.

Preliminary Opinion of Probable Construction Cost



Project: Drainage Channels Clark Canyon			Date:	5/13/2022	
Owner: Saratoga Springs City, NRCS			Prepared by:	CM	
Item No.	Classification of Unit Price Work	Quantity	Unit	Unit Price	Amount
1	Mobilization (5% of Subtotal)	1	LS	\$ 9,255	\$ 9,300
2	Site Prep / survey / misc	1	LS	\$ 20,000	\$ 20,000
3	New Drainage Channel	1,500	LF	\$ 30	\$ 45,000
4	Toe Protection, 12-inch Riprap	450	CY	\$ 130	\$ 58,500
5	36" Culvert Installation	280	LF	\$ 220	\$ 61,600
6	18" Culvert Installation	0	LF	\$ 160	\$ -
SUBTOTAL:					\$ 194,400
Contingency					0% \$ -
TOTAL COST:					\$ 194,400
This opinion of probable construction is based on experience with past projects of similar construction. It is understood that Bowen Collins & Associates has no control over economical factors or unknown conditions that may have a significant impact on actual project costs. Bowen Collins & Associates does not guarantee its cost estimates and accepts no liability for problems created by the difference in actual costs and this opinion of probable construction cost.					

Site 2 Clark Canyon

Alternative 3B - Debris Basin and Channel Improvements

100-Year Sediment Storage Capacity and 50-Year Flood Attenuation in Basin

Preliminary Opinion of Project Cost



Project: Clark Canyon - 50-yr Storm, 100-yr Sediment			Date:	8/30/2023	
Owner: Saratoga Springs City, NRCS			Prepared by:	CM	
Item No.	Classification of Unit Price Work	Quantity	Unit	Unit Price	Amount
Construction Costs:					
1	Clark Canyon North Debris Basin	1	LS	\$ 1,862,300	\$ 1,862,300
2	Clark Canyon South Debris Basin	1	LS	\$ 4,750,500	\$ 4,750,500
3	Clark Canyon Discharge Pipeline Drainage Channels	1	LS	\$ 194,400	\$ 194,400
SUBTOTAL:					\$ 6,807,200
Contingency				20%	\$ 1,361,400
CONSTRUCTION SUBTOTAL:					\$ 8,168,600
Other Installation Costs:					
Engineering				10%	\$ 816,900
Real Property Rights				7%	\$ 563,000
Natural Resources Rights				0%	\$ -
Permitting				0.50%	\$ 40,800
Relocation Payments				0%	\$ -
Administration				10%	\$ 816,900
OTHER INSTALLATION COSTS SUBTOTAL:					\$ 2,237,600
TOTAL COST:					\$ 10,406,200
This opinion of probable construction is based on experience with past projects of similar construction. It is understood that Bowen Collins & Associates has no control over economical factors or unknown conditions that may have a significant impact on actual project costs. Bowen Collins & Associates does not guarantee its cost estimates and accepts no liability for problems created by the difference in actual costs and this opinion of probable construction cost.					

Preliminary Opinion of Probable Construction Cost



Project: Clark Canyon North Debris Basin (50-yr Storm, 100-yr Sed)			Date:	8/28/2023	
Owner: Saratoga Springs City, NRCS			Prepared by:	CM	
Item No.	Classification of Unit Price Work	Quantity	Unit	Unit Price	Amount
1	Mobilization (5% of Subtotal)	1	LS	\$ 88,680	\$ 88,700
2	Site Prep / survey / misc	1	LS	\$ 95,000	\$ 95,000
3	Debris Basin Excavation	22,700	CY	\$ 12	\$ 272,400
4	Foundation Excavation	10,000	CY	\$ 12	\$ 120,000
5	Embankment Fill	14,200	CY	\$ 12	\$ 170,400
6	Auxiliary Spillway Excavation	16,700	CY	\$ 12	\$ 200,400
7	Excess Material Haul Off	49,400	CY	\$ 5	\$ 247,000
8	Access Road	1,000	LF	\$ 20	\$ 20,000
9	Install Type 'G' Cap on Dam Embankment Crest	280	LF	\$ 50	\$ 14,000
10	Type 'R' Drain Gravel	2,000	CY	\$ 80	\$ 160,000
11	Type 'Q' Filter Sand	2,000	CY	\$ 80	\$ 160,000
12	Rock Mulch (On Upstream Slope of Dam)	300	CY	\$ 40	\$ 12,000
13	6-inch Toe Drain Pipe (Perforated)	560	LF	\$ 40	\$ 22,400
14	Outlet Riser w/ Trash Rack	1	LS	\$ 60,000	\$ 60,000
15	30" Concrete Encased Steel Discharge Conduit	190	LF	\$ 1,000	\$ 190,000
16	Restoration	1	LS	\$ 30,000	\$ 30,000
SUBTOTAL:					\$ 1,862,300
			Contingency	0%	\$ -
TOTAL COST:					\$ 1,862,300
This opinion of probable construction is based on experience with past projects of similar construction. It is understood that Bowen Collins & Associates has no control over economical factors or unknown conditions that may have a significant impact on actual project costs. Bowen Collins & Associates does not guarantee its cost estimates and accepts no liability for problems created by the difference in actual costs and this opinion of probable construction cost.					

Preliminary Opinion of Probable Construction Cost



Project: Clark Canyon South Debris Basin (50-yr Storm, 100-yr Sed)			Date:	8/28/2023	
Owner: Saratoga Springs City, NRCS			Prepared by:	CM	
Item No.	Classification of Unit Price Work	Quantity	Unit	Unit Price	Amount
1	Mobilization (5% of Subtotal)	1	LS	\$ 226,215	\$ 226,200
2	Site Prep / survey / misc	1	LS	\$ 95,000	\$ 95,000
3	Debris Basin Excavation	101,300	CY	\$ 12	\$ 1,215,600
4	Foundation Excavation	26,900	CY	\$ 12	\$ 322,800
5	Embankment Fill	26,000	CY	\$ 12	\$ 312,000
6	Auxiliary Spillway Excavation	10,400	CY	\$ 12	\$ 124,800
7	Non-woven Geotextile Fabric	5,400	SY	\$ 6	\$ 32,400
8	Auxiliary Spillway Riprap Armoring (D50 = 24 in)	7,200	CY	\$ 60	\$ 432,000
9	Excess Material Haul Off	138,600	CY	\$ 5	\$ 693,000
10	Access Road	2,300	LF	\$ 20	\$ 46,000
11	Install Type 'G' Cap on Dam Embankment Crest	490	LF	\$ 50	\$ 24,500
12	Type 'R' Drain Gravel	5,400	CY	\$ 80	\$ 432,000
13	Type 'Q' Filter Sand	5,400	CY	\$ 80	\$ 432,000
14	Rock Mulch (On Upstream Slope of Dam)	700	CY	\$ 40	\$ 28,000
15	6-inch Toe Drain Pipe (Perforated)	980	LF	\$ 40	\$ 39,200
16	Outlet Riser w/ Trash Rack	1	LS	\$ 60,000	\$ 60,000
17	30" Concrete Encased Steel Discharge Conduit	205	LF	\$ 1,000	\$ 205,000
18	Restoration	1	LS	\$ 30,000	\$ 30,000
				SUBTOTAL:	\$ 4,750,500
				Contingency	0% \$ -
				TOTAL COST:	\$ 4,750,500

This opinion of probable construction is based on experience with past projects of similar construction. It is understood that Bowen Collins & Associates has no control over economical factors or unknown conditions that may have a significant impact on actual project costs. Bowen Collins & Associates does not guarantee its cost estimates and accepts no liability for problems created by the difference in actual costs and this opinion of probable construction cost.

Preliminary Opinion of Probable Construction Cost



Project: Drainage Channels Clark Canyon			Date:	5/13/2022	
Owner: Saratoga Springs City, NRCS			Prepared by:	CM	
Item No.	Classification of Unit Price Work	Quantity	Unit	Unit Price	Amount
1	Mobilization (5% of Subtotal)	1	LS	\$ 9,255	\$ 9,300
2	Site Prep / survey / misc	1	LS	\$ 20,000	\$ 20,000
3	New Drainage Channel	1,500	LF	\$ 30	\$ 45,000
4	Toe Protection, 12-inch Riprap	450	CY	\$ 130	\$ 58,500
5	36" Culvert Installation	280	LF	\$ 220	\$ 61,600
6	18" Culvert Installation	0	LF	\$ 160	\$ -
SUBTOTAL:					\$ 194,400
Contingency					0% \$ -
TOTAL COST:					\$ 194,400
This opinion of probable construction is based on experience with past projects of similar construction. It is understood that Bowen Collins & Associates has no control over economical factors or unknown conditions that may have a significant impact on actual project costs. Bowen Collins & Associates does not guarantee its cost estimates and accepts no liability for problems created by the difference in actual costs and this opinion of probable construction cost.					

Site 2 Clark Canyon

Alternative 4 - Channel Improvements (50-Year Flood Protection)

Opinion of Probable Construction Cost



Project: CC Channel Alternative Cost - 50-yr Design Storm			Date:	8/28/2023	
Owner: Saratoga Springs			Prepared by:	CM	
Item No.	Classification of Unit Price Work	Quantity	Unit	Unit Price	Amount
1	Mobilization (5% of Subtotal)	1	LS	\$270,000	\$270,000
2	Field Survey and Staking	1	LS	\$20,000	\$20,000
3	Dewater and River Management	1	LS	\$30,000	\$30,000
4	Construction Access	1	LS	\$20,000	\$20,000
5	Sediment & Debris Removal, and Disposal	34,850	CY	\$30	\$1,045,500
6	Riprap D ₅₀ = 12-inch (reduced due to drop structures)	1,680	CY	\$130	\$218,400
7	Restore Disturbed Areas (seed, coir logs, erosion control blanket). 3:1 slopes.	226,000.0	SF	\$5	\$1,017,000
8	6" Aggregate Base Course	2,519	CY	\$60	\$151,100
9	Seed Restoration (disturbed areas for construction)	226,000	SF	\$1	\$113,000
10	Drop Structures	295	EA	\$2,800	\$826,000
11	Box Culverts	3	EA	\$600,000	\$1,800,000
				SUBTOTAL:	\$ 5,511,000
				Contingency	20% \$ 1,102,200
				CONSTRUCTION SUBTOTAL:	\$ 6,613,200
				Engineering	10% \$ 661,320
				Real Property Rights	6% \$ 415,000
				Natural Resources Rights	0% \$ -
				Permitting	0.50% \$ 33,066
				Relocation Payments	0% \$ -
				Administration	10% \$ 661,320
				OTHER INSTALLATION COSTS SUBTOTAL:	\$ 1,770,706
				TOTAL COST:	\$ 8,383,906

This opinion of probable construction is based on experience with past projects of similar construction. It is understood that Bowen Collins & Associates has no control over economical factors or unknown conditions that may have a significant impact on actual project costs. Bowen Collins & Associates does not guarantee its cost estimates and accepts no liability for problems created by the difference in actual costs and this opinion of probable construction cost.

Biological Assessment

BIOLOGICAL ASSESSMENT OF THE SARATOGA SPRINGS WATERSHED EA SARATOGA SPRINGS, UTAH

Prepared for:



**SARATOGA
SPRINGS**
Life's just better here



Attn: Jeremy Lapin, Public Works
Director
1307 N. Commerce Dr. #200
Saratoga Springs, UT 84045
(801) 766-7506

NRCS
125 State St # 4010
Salt Lake City, UT 84138

Prepared by:



BOWEN COLLINS
& A S S O C I A T E S

154 East 14075 South
Draper, UT 84020
801-495-2224

December 2024

TABLE OF CONTENTS

	Page
TABLE OF CONTENTS	i
1.0 INTRODUCTION	1
1.1 Purpose	1
1.2 Project Responsibility	1
1.3 Federal Consultation to Date	2
2.0 PROJECT DESCRIPTION	2
2.1 Background	2
2.2 Action.....	2
2.3 Operation & Maintenance	3
2.4 Schedule.....	3
2.5 Conservation Commitments.....	3
3.0 ACTION AREA	4
3.1 Baseline Conditions	4
4.0 LISTED SPECIES & CRITICAL HABITAT IN THE ACTION AREA.....	5
4.1 Species.....	6
4.1.1 June Sucker	6
5.0 EFFECT ANALYSIS	6
5.1 Species Effects.....	6
5.1.1 June Sucker	6
5.2 Interrelated and Interdependent Actions.....	6
5.3 Cumulative Effects.....	7
5.3.1 Past.....	7
5.3.2 Present and Foreseeable Activities	7
6.0 CONCLUSIONS & DETERMINATION OF EFFECTS.....	7
7.0 LITERATURE CITED	8

LIST OF APPENDICES

APPENDIX A	Site Location Maps
APPENDIX B	Official USFWS TES Species Lists
APPENDIX C	Utah Natural Heritage Program Species Reports
APPENDIX D	Plan Figures
APPENDIX E	Habitat Assessment
APPENDIX F	Site Photos

LIST OF TABLES

Table 1	ESA-Listed Species & Critical Habitat
Table 2	Potential TES Species & Habitat in the Action Area
Table 3	Determinations for ESA-Listed Species Potentially Occurring in the Action Area

TABLE OF CONTENTS (continued)

ACRONYMS & ABBREVIATIONS

BC&A – Bowen Collins & Associates
NRCS – National Resource Conservation Service
UDWR – Utah Division of Wildlife Resources
UNHP – Utah Natural Heritage Program
USFWS/Service – U. S. Fish & Wildlife Service
YBCU – Yellow-billed Cuckoo

1.0 INTRODUCTION

This Biological Assessment has been prepared by Bowen Collins & Associates (BC&A), on behalf of the City of Saratoga Springs (City) and the National Resource Conservation Service (NRCS) for the Saratoga Springs Watershed Plan Environmental Assessment (EA) in Utah County, Utah (See Site Location Maps, Appendix A). The City is evaluating four debris basins and channel improvements for floodplain management in this area to protect the City residents and associated infrastructure downstream.

1.1 Purpose

The purpose of this biological assessment (BA) is to assess the potential environmental impacts of the proposed project on federally-listed plant and animal species in accordance with the requirements of Section 7 of the Endangered Species Act (ESA; 16 U.S.C. 460 et seq., as amended) (See official species list in Appendix B). The federal action agency is the NRCS who is providing funding for the proposed project.

The objective of the proposed action is to provide flood management for the Saratoga Springs residents and infrastructure in response to flood hazards. Additional details about the proposed action are included below but in general the project includes the construction of four debris basins and associated channel improvements. Based on the U.S. Fish & Wildlife Service (Service) Information for Planning and Consultation (IPAC) online tool this project has potential to affect the ESA-listed species listed in Table 1 below that may occur in this area.

Table 1
ESA-Listed Species & Critical Habitat

Common Name	Scientific Name	Critical Habitat
Yellow-billed Cuckoo	<i>Coccyzus americanus</i>	Not Present
June Sucker	<i>Chasmistes liorus</i>	Not Present
Monarch Butterfly	<i>Danaus plexippus</i>	Not Designated

This BA, prepared by BC&A, addresses the proposed action in compliance with Section 7 of the ESA. Section 7 assures that, through consultation (or conferencing for proposed species) with the Service, federal actions do not jeopardize the continued existence of any threatened, endangered or proposed species, or result in the destruction or adverse modification of critical habitat.

1.2 Project Responsibility

Project implementation responsibilities are as follows.

Lead Federal Agency:

NRCS – Derek Hamilton (Water Resources Coordinator)
125 South State Street, Room 4010
Salt Lake City, UT 84138

Project Sponsor:

City of Saratoga Springs – Jeremy Lapin (Public Works Director)
1307 North Commerce Drive #200
Saratoga Springs, UT 84045

Design Engineer:

Bowen Collins & Associates – Cody Moultrie (P.E.)
154 East 1407 South
Draper, UT 84020

1.3 Federal Consultation to Date

Early coordination and pre-consultation with the Service was not conducted due to lack of suitable habitat or the level of anticipated effects.

2.0 PROJECT DESCRIPTION

2.1 Background

The purpose of the Project is to provide flood prevention measures to reduce flooding in the City of Saratoga Springs. There is a need to protect people, structures, roads, utilities, and property within the floodplain.

Areas downstream of Lott Canyon, Burnt Canyon, and Clark Canyon are at risk of flooding and debris flows. Fires that have affected the area in the past 15 years have also increased the risk of flood hazards of these drainages and others in the vicinity. A previous flood event from September 2012 also severely damaged the Saratoga Springs Jacob's Ranch neighborhood located between the drainage basins previously mentioned (see Figure 2, Appendix A). Most of the drainage basins in the Lake Mountains on the western side of the City are very similar and susceptible to similar flooding events, especially in the wildfire damaged areas, and the City is in need of flood mitigation to prevent injury and destruction for its residents and their properties.

2.2 Action

The proposed actions are to construct two to four new debris basins at the mouths of Burnt Canyon, Lott Canyon, and Clark Canyon to capture sediment and detain and attenuate expected flood flows. Various alternatives have been discussed as a part of the EA as seen in Table 2 below:

Table 2
Options for Alternative Hydraulic Modeling

Drainage Basin	Option for Alternative Modeling	Description
Burnt/Lott Canyon	Debris Basin Improvements	Constructs a debris basin to attenuate all flows up to and including a 100-year flood before activation of auxiliary spillway.
	Channel Improvements	Increase channel capacity to convey 100-year flood flow from drainage areas to Utah Lake.
Clark Canyon	Debris Basin Improvements	Constructs a debris basin to attenuate all flows up to and including a 100-year flood before activation of auxiliary spillway.
	Debris Basin Improvements	Constructs a debris basin to attenuate all flows up to and including a 50-year flood before activation of auxiliary spillway.
	Channel Improvements	Increase channel capacity to convey 100-year flood flow from drainage areas to Utah Lake.
	Channel Improvements	Increase channel capacity to convey 50-year flood flow from drainage areas to Utah Lake.

Anticipated work includes the following:

- Construct a new 18.4 ac-ft debris basin at the mouth of Burnt Canyon
- Construct a new 35.3 ac-ft debris basin at the mouth of Lott Canyon
- Potentially construct a new 6.0 ac-ft debris basin at the mouth of Clark Canyon (North)
- Potentially construct a new 18.3 ac-ft debris basin at the mouth of Clark Canyon (South)
- Construction of each of the four basins will include:
 - Installation of a new dam embankment
 - Debris basin excavation
 - Principal and auxiliary spillway installation
 - Access road installation
- Construct new drainage channels downstream of the Burnt Canyon, Lott Canyon, and Clark Canyon North Debris Basins to connect to existing drainages and/or storm infrastructure
- Install five new 36" culverts
- Equipment staging, borrow for earthen embankments, and disposal of organic materials from clearing and grubbing
- Restoration of temporary impact areas

2.3 Operation & Maintenance

The City will have the responsibility to operate and maintain the debris basins, access roads, and drainage channels and ensure they are in good repair.

2.4 Schedule

Construction of these will take place during standard construction hours per the County standards. It is anticipated work will take place between 2027 and 2029.

2.5 Conservation Commitments

To minimize impacts and maximize conservation measures the City anticipates coordinating with the USFWS and NRCS on the planning and development of the project. Specific measures and plans known at this time include the following:

1. If any trees are expected to be removed as part of the project construction during nesting and breeding season (April – August) a qualified biologist will conduct surveys no more than five days prior to the commencement of work. If active nests are found during surveys, tree removal will be postponed until the young have fledged or the nest is no longer active as determined by the biologist.
2. Equipment will be cleaned to remove noxious weeds/seeds and petroleum products prior to moving on site. Additionally, any chemical pollutants produced during the construction activities shall be safely disposed of.
3. Fueling machinery will occur off site or in a confined, designated area to prevent spillage into waterways and wetlands.

4. Materials will not be stockpiled in the riparian areas or other sensitive areas such as wetlands.
5. Fill materials will be free of fines, waste, pollutants, and noxious weeds/seeds.
6. Excavated soils will be sorted into mineral soil and topsoil. When backfilling a disturbed site, topsoil will be placed on top to provide a seed bed for native plants.
7. Excavated material and construction debris may not be wasted in any stream channel or placed in flowing waters or adjacent wetlands; this will include material such as grease, oil, joint coating, or any other possible pollutants. Excess material must be wasted at an upland site away from any channel or habitat of a federally-listed or sensitive species.
8. The applicant will complete the project in as short of a timeframe as possible (taking into account the terms and conditions above) to minimize the potential for damage to the altered channel during high flows caused by storm events and to reduce the potential for birds to abandon use of the area.

3.0 ACTION AREA

The action area totals 120 acres and is located just west of Utah Lake in the Lake Mountain foothills above Saratoga Springs, an area known for arid deserts and low mountain ranges in the Great Basin Ecosystem. Three canyons make up the west border including Burnt Canyon, Lott Canyon, and Clark Canyon, which connect to the Lake Mountain Range. The west border of the action area meets Saratoga Springs housing developments. The action area falls in a combination of private lands and State Lands as shown on Figure 2A, Appendix A. The four proposed basins and their associated spillways make up the bulk of the action area, but additional channel improvements, channels that have flow paths from the proposed basin areas and all potential access roads have also been included in the action area for evaluation of impacts.

The habitat review area consists of approximately 3,912 acres for analysis which includes a half-mile buffer for species analysis (See Site Location Figures, Appendix A, and half-mile buffer on Habitat Figure, Appendix E). The USFWS required half-mile buffer for yellow-billed cuckoo habitat analysis was analyzed to account for potential indirect effects such as construction disturbance, noise, and light or short-term sedimentation and turbidity downstream during the construction activities. Access roads and staging areas are also shown on the project plans in Appendix D.

3.1 Baseline Conditions

Most of the action area is undeveloped open space with sparse juniper and scrub oak forests in the higher elevations or desert shrub/grasslands including a dominance of cheatgrass as you get closer to Utah Lake. Eight unnamed drainage channels flow from west to east within or through the action area as they make their way to the lake, however, these channels are typically dry except during storm events. Due to the consistently dry habitat conditions, wildfire risk is typically high in this area, and the 2020 Knolls wildfire mentioned previously has greatly increased the potential for flooding and debris flow damage to the City down below.

City neighborhoods provide access points out to the proposed basin sites, however, in general the proposed basins are over a half-mile from any homes and none of the action area contains any residences. Although occasional hikers can access the action area from these neighborhoods, there is not a developed trail system beyond existing two track dirt roads and pedestrian use is not common.

Two businesses operate within or near the action area plus one private quarry. Peck Rock Products and Landfill operates a gravel and rock quarry in addition to a county landfill at the west side of the Lott and Burnt Canyon action area via a lease from the State of Utah. In January of 2021 the landfill caught fire but was contained and managed within a couple of days. What appears to be an additional rock or gravel quarry is located on the west side of the Clark Canyon action area. This site is owned by SPC Fox Hollow LLC, but it does not seem to be used for commercial purposes. Finally, Southwest Energy, which provides explosive products and services for mining, quarry and construction companies currently leases land from the State and has a small facility at the mouth of Burnt Canyon. Heavy equipment regularly accesses the Peck Rock and Southwest Energy sites, but equipment was not observed during either site visit at the SPC Fox Hollow quarry.

Wildlife likely frequent the abundance of open space in the action area and may include deer, birds, and other small terrestrial animals. According to State GIS data, the east side of the action area is considered substantial year-long mule deer and chukar habitat and the west side includes substantial year-long ring-necked pheasant habitat although much of the pheasant habitat has been reduced by the presence of the new neighborhoods developed in recent years (See Figures 2B & 2C, Appendix E). Habitat photos taken at the site on May 28, 2021, and August 23, 2021, are included in Appendix F.

4.0 LISTED SPECIES & CRITICAL HABITAT IN THE ACTION AREA

The purpose of this section is to identify and describe protected species and critical habitat that may be present within the action area. Table 2 on the next page includes all potential species and designated critical habitat as listed on the official Service list of TES (retrieved October 1, 2024) that may occur in or be affected by the proposed project (See Official Species List, Appendix B), with habitat or species presence determined within various boundaries from the site according to species (See Figure 2, Appendix E).

Table 2
Potential TES Species & Habitat in the Action Area

Species	Status	Habitat Requirements	Habitat in Action Area	Critical Habitat in Action Area
Birds				
Yellow-billed Cuckoo <i>Coccyzus americanus</i>	Threatened	Prefer nesting habitat within 100 meters of riparian habitat with a dense sub-canopy or shrub layer	No	No
Fish				
June Sucker <i>Chasmistes liorus</i>	Threatened	Native to Utah Lake and its tributaries, not naturally found outside of this native habitat.	No*	No
Insects				
Monarch Butterfly <i>Danaus plexippus</i>	Candidate	Open areas with flowering plants and milkweed for breeding.	No	Not Designated

*The Action Area does not overlap with June sucker habitat, but the new drainage channel will flow into the lake and have an impact on June sucker habitat.

A site visit was conducted to assess habitat suitability and/or presence/absence of species by BC&A biologist, Merissa Davis, on June 28, 2021 and August 23, 2021. Based on these site visits, it was

determined that habitat was not present for any of the species and there would be *no effect* to them as described below:

- **Yellow-billed Cuckoo:** Yellow-billed Cuckoo are found in riparian habitat with a mix of multi-layered trees and shrubs. There is no riparian habitat present in the action area, nor any multistoried vegetation. There are no State records of this species within two miles of the action area (UNHP, 2024) and this species is not expected to be present therefore no further analysis of effects will be made. Due to lack of habitat, the proposed project should have *no effect* on yellow-billed cuckoo or its habitat.
- **Monarch Butterfly:** Milkweed is necessary for monarch butterfly reproduction. As no milkweed was found within the project area, there will be *no effect* on monarch butterfly.

These species will not be reviewed further in this BA because it has been determined that the proposed action will have *no effect* on them. This is due to lack of suitable habitat in the action area, and as such, they are not expected to be present. As June sucker is present in the Lake where water from the proposed project will flow, this species will be further reviewed in the remainder of this report.

4.1 Species

4.1.1 June Sucker. The June sucker (*Chasmistes liorus*) was listed as an endangered species of fish in April 1986, and it was downlisted to threatened in January 2021 after several successful conservation projects and activities (Endangered and Threatened, 2016). This fish species is usually about 5 pounds and reaches lengths between 17 and 24 inches (JSRIP, 2020). It is endemic to Utah Lake and acts as an indicator species for the health of the lake. June sucker usually spawn in the lake's tributaries on the east side of the lake between May and June. Eggs usually hatch after a week, and the fry are carried downstream by the current of the river. They find cover in aquatic vegetation near the mouths of these rivers until they are large enough to move out toward the larger lake. They reach sexual maturity after five to ten years. Adult June suckers generally congregate on the west shore of the lake in fall, the east shore of the lake in winter, and exhibit lake-wide distribution for the rest of the year (Endangered and Threatened, 2016).

5.0 EFFECT ANALYSIS

5.1 Species Effects

5.1.1 June Sucker. This species is present in Utah Lake, however, the action area is planned well above lake levels and the lake itself will not be disturbed by construction activities. The project *may affect but is not likely to adversely affect* the species as its effects are expected to be beneficial. Flows from aquatic resources in the action area that currently reach the lake will continue contributing to the overall lake volume as usual. The presence of the detention basin will have the ability to settle sediments and stop debris that might have otherwise reached the lake during storm events so the net water quality of contributing waters should be improved. Due to a lack of lake disturbance and expected water quality improvements from tributary waters to Utah Lake, the project should have a *beneficial effect* without any adverse effects on June sucker or its habitat.

5.2 Interrelated and Interdependent Actions

There are no interrelated or interdependent actions associated with the proposed action.

5.3 Cumulative Effects

Cumulative effects are impacts from state, tribal, local, or private activities, not involving the proposed action, that have previously occurred or are reasonably certain to occur within the action area.

5.3.1 Past. This area is a sloped hillside with various ephemeral drainages which span towards a residential community below. Dirt roads along this hillside are utilized for recreation and commercial access. Primarily, the project area is open land with sparse vegetation without any previous land uses.

5.3.2 Present and Foreseeable Activities. Future development surrounding the project area in residential and commercial capacities may occur, but no expanded development within the project areas are anticipated. In summary, impacts associated with future activities in the action area are not expected to result in cumulative adverse impacts to federally-listed ESA species because the anticipated impacts are insignificant (based on severity and/or size) or beneficial.

6.0 CONCLUSIONS & DETERMINATION OF EFFECTS

The construction of the proposed basins, channel improvements and culvert installation above Saratoga Springs are expected to take place between 2027 and 2029 pending environmental clearances, permitting, contracts and agreements. Three potential species were identified to possibly exist in the action area as threatened or endangered by the USFWS IPAC system. No suitable habitat exists for these three species within the project area, and no suitable cuckoo habitat exists within the USFWS required yellow-billed cuckoo habitat analysis buffer. There will be *no effect* to critical habitat as there is no critical habitat present within the action area. While it is expected there will be *no effect* to yellow-billed cuckoo and monarch butterfly, channel improvements are anticipated to have a *beneficial effect* on water quality that impacts June sucker habitat downstream. Therefore, the project *may affect, but is not likely to adversely affect*, June sucker. Effect determinations for all species are shown in Table 3 below.

Table 3
Determinations for ESA-Listed Species Potentially Occurring in the Action Area

Species	Determination
Yellow-billed Cuckoo <i>Coccyzus americanus</i>	No Effect
June Sucker <i>Chasmistes liorus</i>	May Affect, Not Likely to Adversely Affect (Beneficial Effect)
Monarch Butterfly <i>Danaus plexippus</i>	No Effect

7.0 LITERATURE CITED

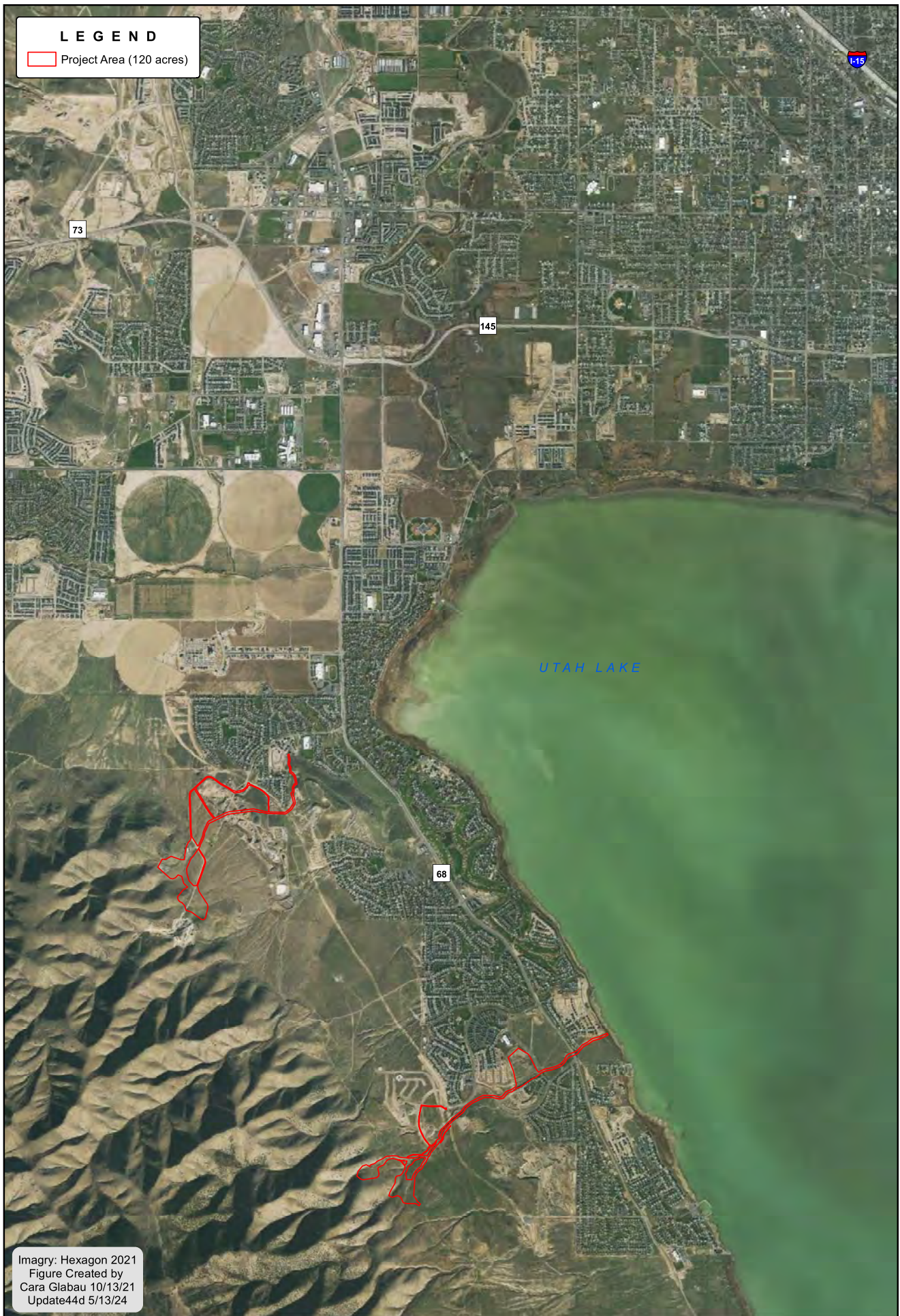
- Endangered and Threatened Species: Reclassification of the Endangered June Sucker to Threatened, 86 F.R. 192 (proposed Jan 3, 2021) (to be codified at 50 C.F.R. § 17).
<https://www.regulations.gov/document/FWS-R6-ES-2019-0026-0023ulations.gov>
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- Utah Division of Wildlife Resources (UDWR). 2024. *Utah Conservation Data Center*.
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- Utah Natural Heritage Program (UNHP). 2024. *Online Species Search Report # 15532*. May 9, 2024.

APPENDIX A

Site Location Maps

LEGEND

 Project Area (120 acres)



Imagry: Hexagon 2021
Figure Created by
Cara Glabau 10/13/21
Update44d 5/13/24



CITY OF SARATOGA SPRINGS
SARATOGA SPRINGS
WATERSHED EA

SITE LOCATION



SCALE:
0 1,500 3,000
Feet

FIGURE NO.
1A



CITY OF SARATOGA SPRINGS
**SARATOGA SPRINGS
WATERSHED EA**

SITE LOCATION



SCALE:
0 1,000 2,000
Feet

FIGURE NO.
1B

APPENDIX B

Official USFWS TES Species Lists



United States Department of the Interior

FISH AND WILDLIFE SERVICE

Utah Ecological Services Field Office

2369 West Orton Circle, Suite 50

West Valley City, UT 84119-7603

Phone: (801) 975-3330 Fax: (801) 975-3331



In Reply Refer To:

10/01/2024 19:18:36 UTC

Project Code: 2024-0088255

Project Name: Saratoga Springs Plan EA

Subject: List of threatened and endangered species that may occur in your proposed project location or may be affected by your proposed project

To Whom It May Concern:

The enclosed species list identifies threatened, endangered, proposed, and candidate species, as well as proposed and final designated critical habitat, that may occur within the boundary of your proposed project and/or may be affected by your proposed project. The species list fulfills the requirements of the U.S. Fish and Wildlife Service (Service) under section 7(c) of the Endangered Species Act (Act) of 1973, as amended (16 U.S.C. 1531 *et seq.*).

New information based on updated surveys, changes in the abundance and distribution of species, changed habitat conditions, or other factors could change this list. Please feel free to contact us if you need more current information or assistance regarding the potential impacts to federally proposed, listed, and candidate species and federally designated and proposed critical habitat. Please note that under 50 CFR 402.12(e) of the regulations implementing section 7 of the Act, the accuracy of this species list should be verified after 90 days. This verification can be completed formally or informally as desired. The Service recommends that verification be completed by visiting the IPaC website at regular intervals during project planning and implementation for updates to species lists and information. An updated list may be requested through the IPaC system by completing the same process used to receive the enclosed list.

The purpose of the Act is to provide a means whereby threatened and endangered species and the ecosystems upon which they depend may be conserved. Under sections 7(a)(1) and 7(a)(2) of the Act and its implementing regulations (50 CFR 402 *et seq.*), Federal agencies are required to utilize their authorities to carry out programs for the conservation of threatened and endangered species and to determine whether projects may affect threatened and endangered species and/or designated critical habitat.

A Biological Assessment is required for construction projects (or other undertakings having similar physical impacts) that are major Federal actions significantly affecting the quality of the human environment as defined in the National Environmental Policy Act (42 U.S.C. 4332(2) (c)). For projects other than major construction activities, the Service suggests that a biological

evaluation similar to a Biological Assessment be prepared to determine whether the project may affect listed or proposed species and/or designated or proposed critical habitat. Recommended contents of a Biological Assessment are described at 50 CFR 402.12.

If a Federal agency determines, based on the Biological Assessment or biological evaluation, that listed species and/or designated critical habitat may be affected by the proposed project, the agency is required to consult with the Service pursuant to 50 CFR 402. In addition, the Service recommends that candidate species, proposed species and proposed critical habitat be addressed within the consultation. More information on the regulations and procedures for section 7 consultation, including the role of permit or license applicants, can be found in the "Endangered Species Consultation Handbook" at:

<https://www.fws.gov/sites/default/files/documents/endangered-species-consultation-handbook.pdf>

Migratory Birds: In addition to responsibilities to protect threatened and endangered species under the Endangered Species Act (ESA), there are additional responsibilities under the Migratory Bird Treaty Act (MBTA) and the Bald and Golden Eagle Protection Act (BGEPA) to protect native birds from project-related impacts. Any activity, intentional or unintentional, resulting in take of migratory birds, including eagles, is prohibited unless otherwise permitted by the U.S. Fish and Wildlife Service (50 C.F.R. Sec. 10.12 and 16 U.S.C. Sec. 668(a)). For more information regarding these Acts, see <https://www.fws.gov/program/migratory-bird-permit/what-we-do>.

The MBTA has no provision for allowing take of migratory birds that may be unintentionally killed or injured by otherwise lawful activities. It is the responsibility of the project proponent to comply with these Acts by identifying potential impacts to migratory birds and eagles within applicable NEPA documents (when there is a federal nexus) or a Bird/Eagle Conservation Plan (when there is no federal nexus). Proponents should implement conservation measures to avoid or minimize the production of project-related stressors or minimize the exposure of birds and their resources to the project-related stressors. For more information on avian stressors and recommended conservation measures, see <https://www.fws.gov/library/collections/threats-birds>.

In addition to MBTA and BGEPA, Executive Order 13186: *Responsibilities of Federal Agencies to Protect Migratory Birds*, obligates all Federal agencies that engage in or authorize activities that might affect migratory birds, to minimize those effects and encourage conservation measures that will improve bird populations. Executive Order 13186 provides for the protection of both migratory birds and migratory bird habitat. For information regarding the implementation of Executive Order 13186, please visit <https://www.fws.gov/partner/council-conservation-migratory-birds>.

We appreciate your concern for threatened and endangered species. The Service encourages Federal agencies to include conservation of threatened and endangered species into their project planning to further the purposes of the Act. Please include the Consultation Code in the header of this letter with any request for consultation or correspondence about your project that you submit to our office.

Attachment(s):

- Official Species List

OFFICIAL SPECIES LIST

This list is provided pursuant to Section 7 of the Endangered Species Act, and fulfills the requirement for Federal agencies to "request of the Secretary of the Interior information whether any species which is listed or proposed to be listed may be present in the area of a proposed action".

This species list is provided by:

Utah Ecological Services Field Office

2369 West Orton Circle, Suite 50
West Valley City, UT 84119-7603
(801) 975-3330

PROJECT SUMMARY

Project Code: 2024-0088255

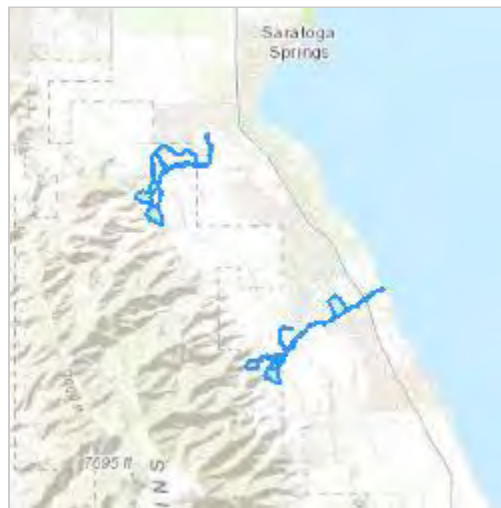
Project Name: Saratoga Springs Plan EA

Project Type: Flooding

Project Description: Saratoga Springs City is evaluating four debris basins and channel improvements for floodplain management in this area to protect the City residents and associated infrastructure downstream.

Project Location:

The approximate location of the project can be viewed in Google Maps: <https://www.google.com/maps/@40.29907765,-111.90188679361765,14z>



Counties: Utah County, Utah

ENDANGERED SPECIES ACT SPECIES

There is a total of 3 threatened, endangered, or candidate species on this species list.

Species on this list should be considered in an effects analysis for your project and could include species that exist in another geographic area. For example, certain fish may appear on the species list because a project could affect downstream species.

IPaC does not display listed species or critical habitats under the sole jurisdiction of NOAA Fisheries¹, as USFWS does not have the authority to speak on behalf of NOAA and the Department of Commerce.

See the "Critical habitats" section below for those critical habitats that lie wholly or partially within your project area under this office's jurisdiction. Please contact the designated FWS office if you have questions.

-
1. [NOAA Fisheries](#), also known as the National Marine Fisheries Service (NMFS), is an office of the National Oceanic and Atmospheric Administration within the Department of Commerce.

BIRDS

NAME	STATUS
Yellow-billed Cuckoo <i>Coccyzus americanus</i> Population: Western U.S. DPS There is final critical habitat for this species. Your location does not overlap the critical habitat. Species profile: https://ecos.fws.gov/ecp/species/3911	Threatened

FISHES

NAME	STATUS
June Sucker <i>Chasmistes liorus</i> There is final critical habitat for this species. Your location does not overlap the critical habitat. Species profile: https://ecos.fws.gov/ecp/species/4133	Threatened

INSECTS

NAME	STATUS
Monarch Butterfly <i>Danaus plexippus</i> No critical habitat has been designated for this species. Species profile: https://ecos.fws.gov/ecp/species/9743	Candidate

CRITICAL HABITATS

THERE ARE NO CRITICAL HABITATS WITHIN YOUR PROJECT AREA UNDER THIS OFFICE'S JURISDICTION.

YOU ARE STILL REQUIRED TO DETERMINE IF YOUR PROJECT(S) MAY HAVE EFFECTS ON ALL ABOVE LISTED SPECIES.

IPAC USER CONTACT INFORMATION

Agency: Bowen Collins & Associates

Name: Merissa Davis

Address: 154 East 14075 South

City: Draper

State: UT

Zip: 84020

Email: mdavis@bowencollins.com

Phone: 8014952224

LEAD AGENCY CONTACT INFORMATION

Lead Agency: Natural Resources Conservation Service

APPENDIX C

Utah Natural Heritage Program Species Reports



Utah Division of Wildlife Resources
Utah Natural Heritage Program
1594 W. North Temple
PO Box 146301
Salt Lake City, UT 84116

Report Number: 15532
May 9, 2024

Utah Natural Heritage Program Online Species Search Report

Project Information

Project Name

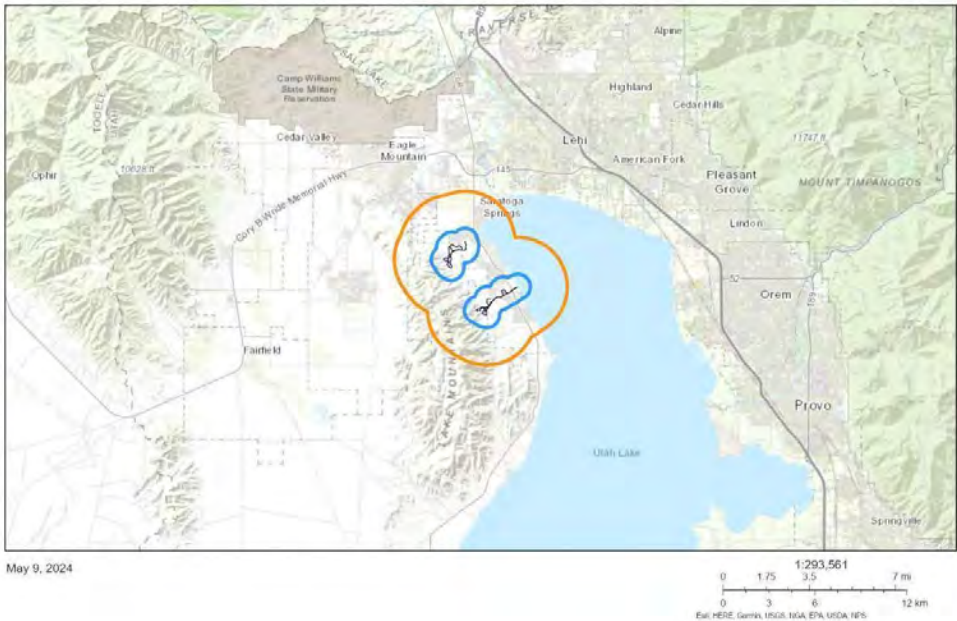
Saratoga Springs Plan EA

Project Description

The City is evaluating four debris basins and channel improvements for floodplain management in this area to protect the City residents and associated infrastructure downstream.

Location Description

Foothills of Saratoga Springs (See Map)



Animals within a 1/2 mile radius

Common Name	Scientific Name	State Status	U.S. ESA Status	Last Observation Year
American Bittern	Botaurus lentiginosus	SGCN		1942
Bald Eagle	Haliaeetus leucocephalus	SGCN		2006
June Sucker	Chasmistes liorus	SGCN	LT	2006
Least Chub	Iotichthys phlegethontis	SGCN		1931
Northern Leopard Frog	Lithobates pipiens	SGCN		1992
Peregrine Falcon	Falco peregrinus	SGCN		1940

Plants within a 1/2 mile radius

Common Name	Scientific Name	State Status	U.S. ESA Status	Last Observation Year
No Species Found				

Animals within a 2 mile radius

Common Name	Scientific Name	State Status	U.S. ESA Status	Last Observation Year
American Bittern	<i>Botaurus lentiginosus</i>	SGCN		1942
Bald Eagle	<i>Haliaeetus leucocephalus</i>	SGCN		2006
Coarse Rams-horn	<i>Planorbella binneyi</i>	SGCN		1937
Desert Tryonia	<i>Tryonia porrecta</i>	SGCN		1939
Ferruginous Hawk	<i>Buteo regalis</i>	SGCN		1939
Golden Eagle	<i>Aquila chrysaetos</i>	SGCN		2013
Green River Pebblesnail	<i>Fluminicola coloradoensis</i>	SGCN		1942
June Sucker	<i>Chasmistes liorus</i>	SGCN	LT	2006
Least Chub	<i>Lotichthys phlegethontis</i>	SGCN		1931
Northern Leopard Frog	<i>Lithobates pipiens</i>	SGCN		1992
Peregrine Falcon	<i>Falco peregrinus</i>	SGCN		1940
Utah Physa	<i>Physa gyrina utahensis</i>	SGCN		1942
Winged Floater	<i>Anodonta nuttalliana</i>	SGCN		1942

Plants within a 2 mile radius

Common Name	Scientific Name	State Status	U.S. ESA Status	Last Observation Year
No Species Found				

Definitions

State Status

SGCN	Species of greatest conservation need listed in the Utah Wildlife Action Plan
------	---

U.S. Endangered Species Act

LE	A taxon that is listed by the U.S. Fish and Wildlife Service as "endangered" with the probability of worldwide extinction
LT	A taxon that is listed by the U.S. Fish and Wildlife Service as "threatened" with becoming endangered
LE;XN	An "endangered" taxon that is considered by the U.S. Fish and Wildlife Service to be "experimental and nonessential" in its designated use areas in Utah
C	A taxon for which the U.S. Fish and Wildlife Service has on file sufficient information on biological vulnerability and threats to justify it being a "candidate" for listing as endangered or threatened
PT/PE	A taxon "proposed" to be listed as "endangered" or "threatened" by the U.S. Fish and Wildlife Service

Disclaimer

The information provided in this report is based on data existing in the Utah Division of Wildlife Resources' central database at the time of the request. It should not be regarded as a final statement on the occurrence of any species on or near the designated site, nor should it be considered a substitute for on-the-ground biological surveys. Moreover, because the Utah Division of Wildlife Resources' central database is continually updated, any given response is only appropriate for its respective request.

The UDWR provides no warranty, nor accepts any liability, occurring from any incorrect, incomplete, or misleading data, or from any incorrect, incomplete, or misleading use of these data.

The results are a query of species tracked by the Utah Natural Heritage Program, which includes all species listed under the U.S. Endangered Species Act and species on the Utah Wildlife Action Plan. Other significant wildlife values might also be present on the designated site. Please [contact](#) UDWR's regional habitat manager if you have any questions.

For additional information about species listed under the Endangered Species Act and their Critical Habitats that may be affected by activities in this area or for information about Section 7 consultation under the Endangered Species Act, please visit <https://ecos.fws.gov/ipac/> or contact the [U.S. Fish and Wildlife Service Utah Ecological Services Field Office](#) at (801) 975-3330 or utahfieldoffice_esa@fws.gov.

Please contact our office at (801) 538-4759 or habitat@utah.gov if you require further assistance.

Your project is located in the following UDWR region(s): Central region

Report generated for:

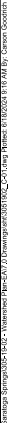
Merissa Davis
Bowen Collins & Associates
154 East 14075 South
Draper, UT 84020
(801) 495-2224
mdavis@bowencollins.com

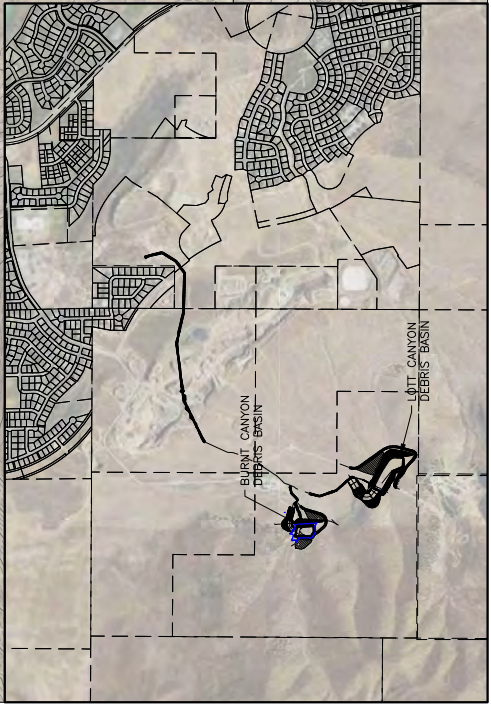
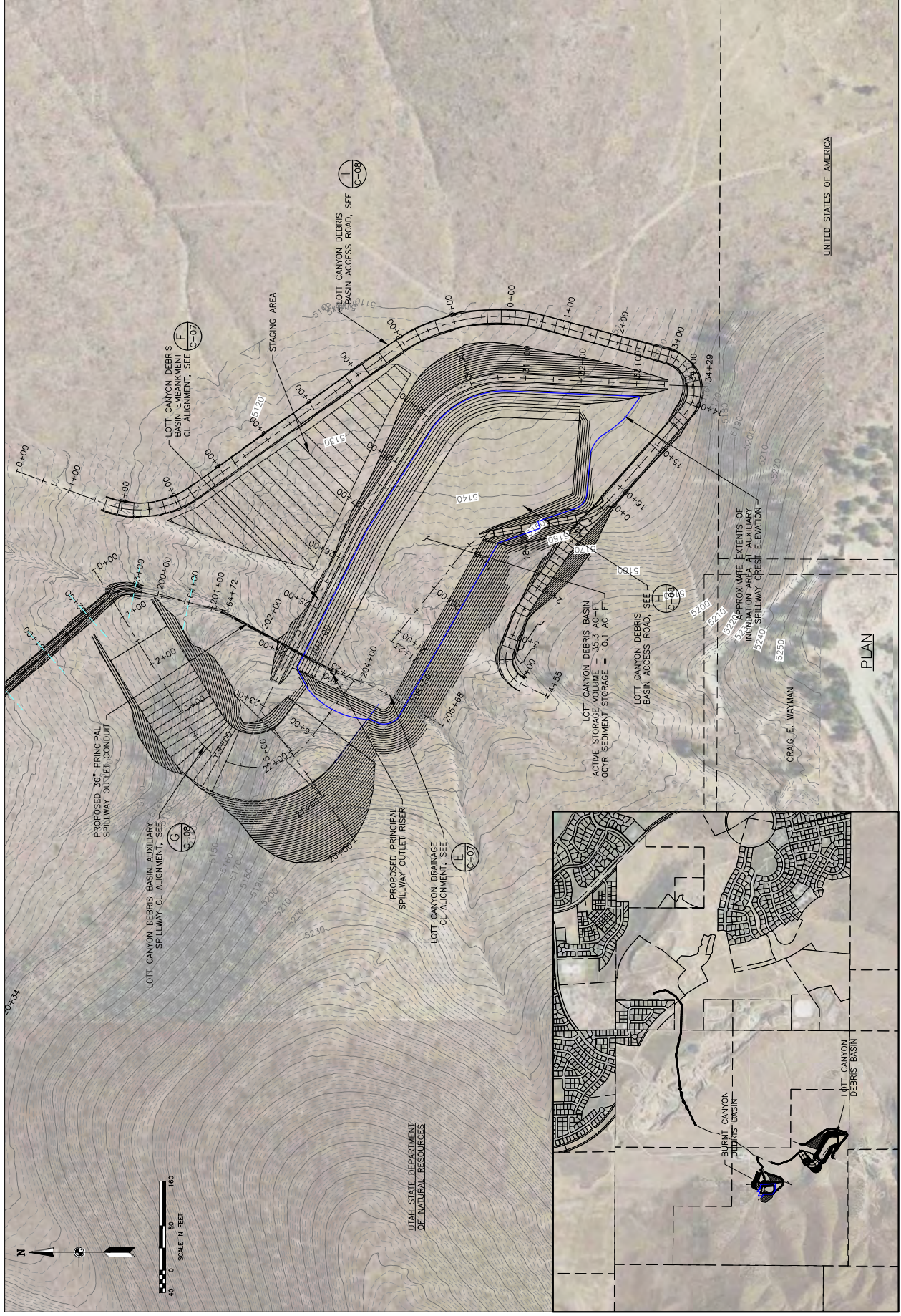


APPENDIX D

Plan Figures

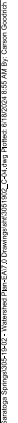






Pathways: Saratoga Springs 19-02 - Watershed Plan C-02.dwg | Pathway: 8/18/2024 1:58 PM | By: Karen Cooper





APPENDIX E

Habitat Assessment



LEGEND

- Project Area (120 acres)
- 1/2-mile Yellow-billed Cuckoo Habitat Analysis Buffer
- Non-Private Landowners:
 - BLM (Federal)
 - DFFSL (State)
 - SITLA (State)

Figure 2B

UTAH LAKE

68

Figure 2C

Imagry: Hexagon 2021
Figure Created by
Merissa Davis 10/21/21
Updated on 5/13/24



CITY OF SARATOGA SPRINGS
SARATOGA SPRINGS
WATERSHED EA

LANDOWNERS &
HABITAT FIGURES INDEX

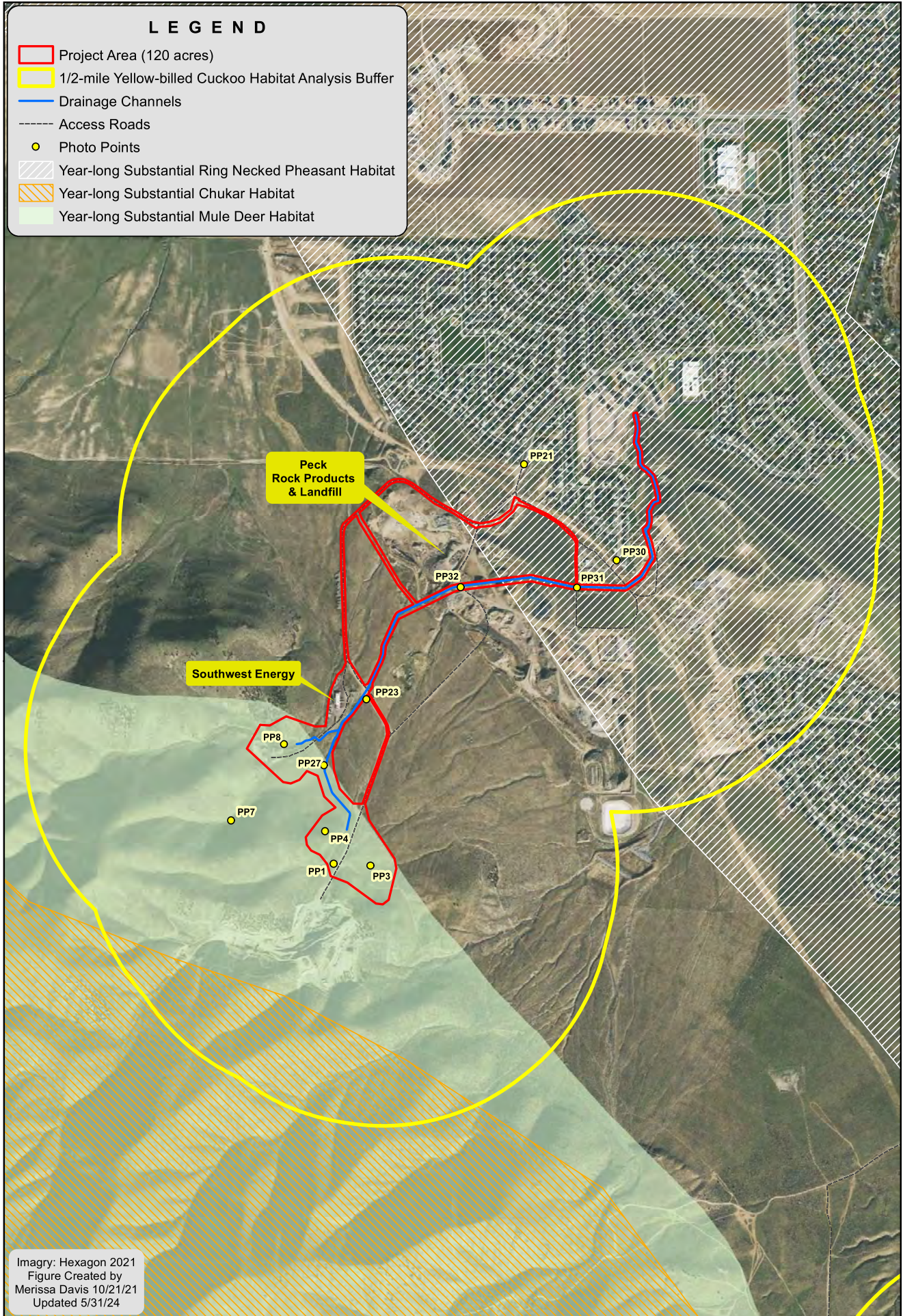


SCALE:
0 1,000 2,000 Feet

FIGURE NO.
2A

LEGEND

- Project Area (120 acres)
- 1/2-mile Yellow-billed Cuckoo Habitat Analysis Buffer
- Drainage Channels
- Access Roads
- Photo Points
- Year-long Substantial Ring Necked Pheasant Habitat
- Year-long Substantial Chukar Habitat
- Year-long Substantial Mule Deer Habitat



Imagry: Hexagon 2021
Figure Created by
Merissa Davis 10/21/21
Updated 5/31/24



CITY OF SARATOGA SPRINGS
SARATOGA SPRINGS
WATERSHED EA

HABITAT ANALYSIS
BURNT CANYON &
LOTT CANYON BASINS

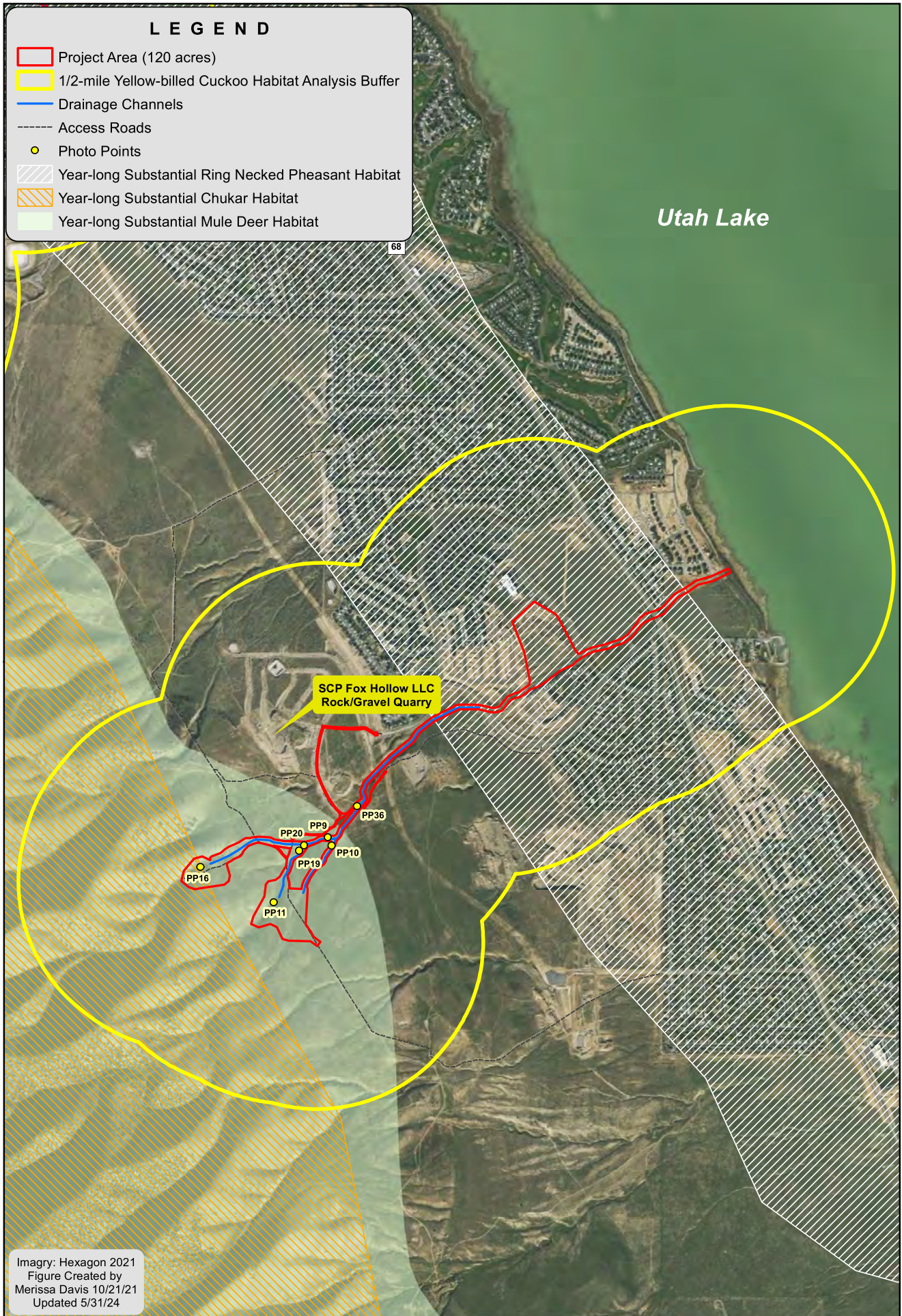


SCALE:
0 500 1,000
Feet

FIGURE NO.
2B

LEGEND

- Project Area (120 acres)
- 1/2-mile Yellow-billed Cuckoo Habitat Analysis Buffer
- Drainage Channels
- Access Roads
- Photo Points
- Year-long Substantial Ring Necked Pheasant Habitat
- Year-long Substantial Chukar Habitat
- Year-long Substantial Mule Deer Habitat



Imagry: Hexagon 2021
Figure Created by
Merissa Davis 10/21/21
Updated 5/31/24



CITY OF SARATOGA SPRINGS
SARATOGA SPRINGS
WATERSHED EA

HABITAT ANALYSIS
CLARK CANYON BASINS



SCALE:
0 500 1,000
Feet

FIGURE NO.
2C

APPENDIX F

Site Photos

Saratoga Springs Watershed Plan Photos



Photo Point 1



Photo Point 3

Saratoga Springs Watershed Plan Photos



Photo Point 4



Photo Point 7

Saratoga Springs Watershed Plan Photos



Photo Point 8



Photo Point 9

Saratoga Springs Watershed Plan Photos



Photo Point 10



Photo Point 10

Saratoga Springs Watershed Plan Photos



Photo Point 11



Photo Point 11

Saratoga Springs Watershed Plan Photos



Photo Point 16



Photo Point 19

Saratoga Springs Watershed Plan Photos



Photo Point 20



Photo Point 21

Saratoga Springs Watershed Plan Photos



Photo Point 23



Photo Point 27

Saratoga Springs Watershed Plan Photos



Photo Point 30

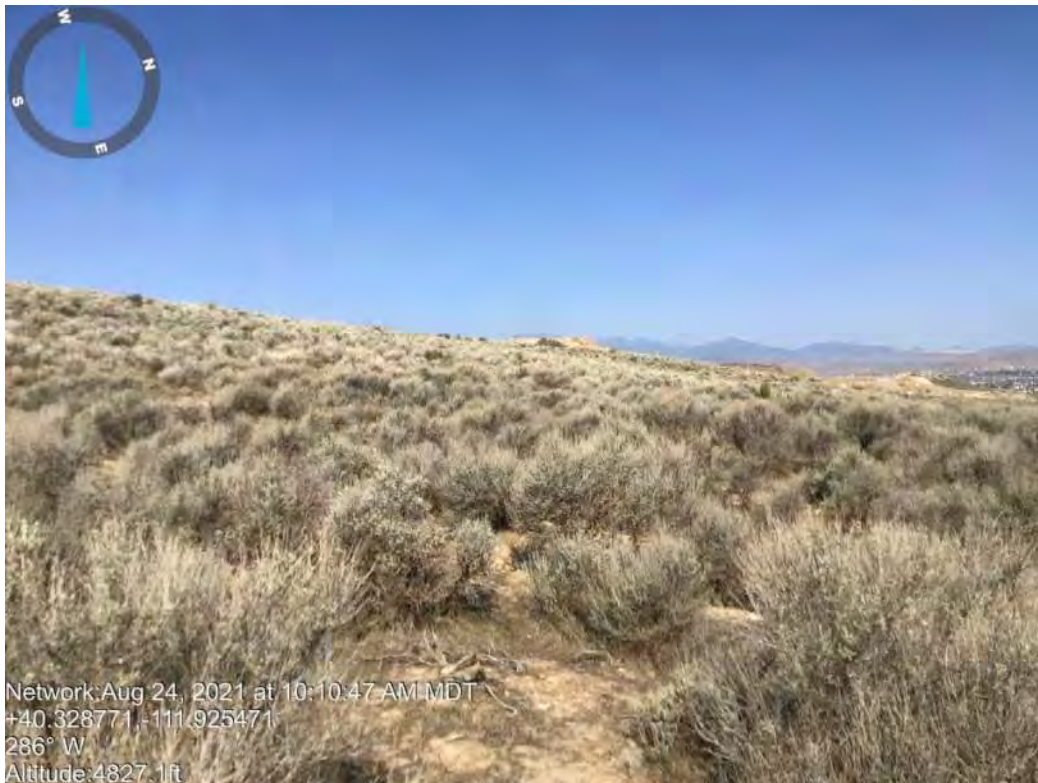


Photo Point 31

Saratoga Springs Watershed Plan Photos



Photo Point 32



Photo Point 36

Aquatic Resources Report

Saratoga Springs Watershed EA Aquatic Resources Report

Prepared for:



Attn: Jeremy Lapin
City of Saratoga Springs
1307 North Commerce Drive, STE 200
Saratoga Springs, UT 84045
801-766-6506

Prepared by:



154 East 14075 South
Draper, UT 84020
801-495-2224

October 2021

Executive Summary

The Saratoga Springs Watershed EA aquatic resource delineation was conducted according to the Corps of Engineers Wetlands Delineation Manual (ACOE 1987) and the Arid West Supplement (ACOE 2008).

A total of 157 acres were surveyed as part of this delineation. Sixteen aquatic resources were identified during the delineation, for a total of 11,262 linear feet of ephemeral stream channels. The aquatic resources identified in the project area are classified as R4SB3P (Riverine Intermittent Streambed Cobble-Gravel Irregularly Flooded). The condition of these resources was typical at the time of the delineation.

TABLE OF CONTENTS

	<u>Page No.</u>
Introduction.....	1
Site Location and Methodology	1
Hydrophytic Vegetation.....	2
Wetland Hydrology.....	2
Hydric Soils	2
Results	2
Vegetation	2
Hydrology	2
Soils.....	3
Sample Points.....	3
Aquatic Resources	3
References.....	5

LIST OF TABLES

Table 1 – Aquatic Resources within the Survey Area	4
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APPENDICES

Appendix A - Site Location Figures
 Appendix B - NWI Figure
 Appendix C - Soil Figure & NRCS Custom Soils Resource Report
 Appendix D - Photos
 Appendix E - Delineation Results Figures
 Appendix F - Aquatic Resources Spreadsheet
 Appendix G - Access Waiver

INTRODUCTION

This document presents results of a delineation of jurisdictional waters of the United States conducted for the City Saratoga Springs (City) by Bowen Collins & Associates (BC&A) at the Debris Basin project site in Saratoga Springs City, Utah. The City is proposing four detention basins to prevent flooding of city neighborhoods in this area where 2012 flooding and debris flows caused significant damage to homes and other infrastructure. Wildfires that occurred in this area in 2020 have further damaged and destabilized these drainage areas further increasing the future flood risks. The purpose of this delineation is to identify channel boundaries and any potential wetlands in preparation for permitting the detention basins project.

SITE LOCATION AND METHODOLOGY

The project area is located directly to the west of Saratoga Springs, Utah County, Utah, Section 3 Township 6S, Range 1W; Section 2 Township 6S, Range 1W; Section 11 Township 6S, Range 1W; Section 14 Township 6S, Range 1W; Section 13 Township 6S, Range 1W; and Section 24 Township 6S, Range 1W. Directions to the site are as follows: Proceed south on I-15 from Bountiful for 24 miles to Exit 282. Head right on the ramp for 2100 North towards Saratoga Springs. Turn right onto 2100 North and continue for 5 miles. Turn left onto Pioneer Crossing and continue for a mile. Bear right toward Redwood Road and continue for 2.6 miles and take a right onto Grandview Boulevard. Approximately 1 mile up this road the neighborhood will end and the project area begins. (See Site Location Figures, Appendix A).

The area delineated is approximately 157 acres of land in the hills above Saratoga Springs, Utah. The project area includes areas for the proposed stormwater detention basins to improve the stormwater runoff conditions from the hills, along with the access roads to the sites. The points of access are existing roadways from residential areas, which are currently being used for recreation and commercial accessibility. The northern portion of the project area is accessed from Grandview Boulevard, and uses roads which are also used for Peck Rock Products and Landfill, and Southwest Energy. To the South, there are multiple points of access to the project area, some roads lead to trailheads and others end at undeveloped recreation sites. The rest of the project area is primarily open land with sparse vegetation.

Ephemeral drainage channels come through the project area down the hillslope towards the residential area below. The delineated area was relatively sloped, gradually towards the east. This project proposes to improve the stormwater detention from the hillslopes to better protect the private property and infrastructure below from flood events. There is no interstate or foreign commerce taking place on or within the delineation area.

Field work for this delineation was conducted on June 28, 2021, and August 23, 2021, by Merissa Davis and Cara Glabau of BC&A. The total area delineated was approximately 157 acres and this entire area was observed during the site visit. Field conditions during the survey were clear and the area had not received precipitation for several weeks prior.

The custom soil report for the Fairfield-Nephi Area, Utah (NRCS 2021) was used to determine soil types for the area. National Wetlands Inventory (NWI) data was also examined to obtain the location of possible jurisdictional wetlands on the site (see NWI figure, Appendix B). The wetland

delineation was conducted according to the Corps of Engineers Wetlands Delineation Manual (ACOE 1987), Arid West Supplement (ACOE 2008), but no observable wetlands were found, thus no sample points were taken. All other points and boundaries were recorded using ArcGIS Collector connected with a Trimble R1 GPS receiver for sub-meter accuracy.

Based on the Manual, jurisdictional wetlands were identified using three criteria:

- Hydrophytic Vegetation
- Wetlands Hydrology
- Hydric Soils

All three criteria must be present for a wetland to be considered jurisdictional. An explanation of these wetland criteria follows.

Hydrophytic Vegetation

Hydrophytic plants are plants that are adapted to wet conditions. The National Wetland Plant List for the Arid West Region (ACOE 2012/2016) was used to determine the wetland indicator status of dominant plant species encountered on sample plots. Sight-identification was used to determine most plant species.

Wetland Hydrology

Wetland hydrology is present when an area is inundated either permanently or periodically at mean water depths of two meters, or the soil is saturated to the surface at some time during the growing season of the prevalent vegetation. Primary hydrologic indicators also include high water tables, oxidized root channels, and sediment and drift deposits. Common secondary hydrologic indicators include watermarks, drainage patterns, and the FAC neutral test.

Hydric Soils

In Field Indicators of Hydric Soils in the U.S. (NRCS 2010) the Natural Resources Conservation Service (NRCS) defines hydric soils as soils that are formed under conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic conditions in the top 12 to 20 inches of soil, depending on soil texture. Hydric properties of soils were assessed using a spade to excavate the soil pit, and Munsell soil color charts to determine soil color.

RESULTS

Vegetation

Vegetation was identified primarily based on flowering parts and structural characteristics. No vegetation was recorded because no sample points were taken, however the dominant vegetation in the area included juniper trees, scrub oak, rabbit brush, sagebrush, tumble mustard, sego lily, toad flax, mullein, Indian paintbrush, common sunflower, globemallow, milkvetch, and native grasses in the uplands. Russian thistle was identified in disturbed areas.

Hydrology

The hydrology of the site comes from stormwater runoff from the surrounding area. The ephemeral streams created from this runoff vary in width and depth and often merge. These channels had no wetland characteristics and during the investigations, had to current hydrology. Erosion and the large amount of debris in the channels indicate large flow events. Water that flows through the project area result in seasonal flooding in residential areas. The ordinary high water mark was identified along the ephemeral streams based on changes in soil types and vegetation as well as drainage patterns and drift deposits.

Soils

The soils at the site are primarily colluvium deposits derived from mixed sources. The Fairfield-Nephi Area, Utah Soil Survey (NRCS 2021) was referenced to determine soil types for the area. In addition to areas with water, the following soil types occur within the delineated area:

- Borvant cobbly loam, 8-25% slopes
- Amtoft, moist-rock outcrop complex, 30-70% slopes
- Calpac-Lundy complex, 30-70% slopes
- Donnardo stony loam, 2-8% slopes
- Donnardo stoney loam, 25-40% slopes
- Dry Creek cobbly loam, 4-15% slopes
- Goldrun loamy fine sand, hummocky, 0-10% slopes
- Juab loam, 2-4% slopes
- Juab loam, 4-8% slopes
- Lodar-Rock outcrop complex, 30-70% slopes
- Pits-Dumps complex
- Saxby, moist-Rock outcrop complex, 30-70% slopes
- Wales loam, 2-4% slopes

Of these soils, none are found on the national and Utah hydric soils lists (NRCS 2015). A custom soil resource report from the NRCS for the site is located in Appendix D.

Sample Points

No sample points were taken within the delineation area because no signs of wetlands were observed.

Aquatic Resources

Although a wide array of ephemeral drainage channels are present, the aquatic resources observed within the project area did not have any wetland characteristics. The hydrology reported for the site is due to stormwater runoff, which is carried through the ephemeral channels and discharged at various locations along the residential area below the project area.

The ephemeral stream channels crossing the project area run from west to east down the hillslope, totaling to 11,262 linear feet (2.83 acres). All of these channels were dry at the time of the field work and are likely dry most of the year except during storm events. Some portions of the channels outside the project area appear to have been modified or reinforced with boulders and rocks, possibly for erosion control efforts. Channels within the project area had clear flow patterns, drift lines, and vegetation/soil changes to identify channel boundaries and the ordinary high water marks as shown on the delineation results figures found in Appendix E. These channels were classified as R4SB3P (Riverine Intermittent Streambed Cobble-Gravel Irregularly Flooded).

The ephemeral channels described above are shown on the Delineation Results Figures found in Appendix E and are listed in the Aquatic Resources spreadsheet in Appendix F and in Table 1 below. No indicators for vegetation, hydrology, and hydric soils were identified for wetlands. The identified waters of the are classified as R4SB3P (Riverine Intermittent Streambed Cobble-Gravel Irregularly Flooded) according to the NWI classification system.

Table 1
Aquatic Resources Within the Survey Area

Aquatic Resource Name	Aquatic Resources Classification		Aquatic Resource Size (acres)	Aquatic Resource Size (feet)
	Cowardin*	Location		
W1A	R4SB3P	40.323137 / -111.935784	(0.23)	1397 LF
W1B	R4SB3P	40.326084 / -111.934089	(0.23)	992 LF
W1C	R4SB3P	40.328022 / -111.932826	(0.14)	420LF
W1D	R4SB3P	40.324141 / -111.935447	(0.02)	85 LF
W1E	R4SB3P	40.324014 / -111.935957	(0.09)	350 LF
W2A	R4SB3P	40.320671 / -111.935501	(0.22)	868 LF
W2B	R4SB3P	40.319348 / -111.935997	(0.14)	636 LF
W2C	R4SB3P	40.324076 / -111.933505	(0.04)	60 LF
W3	R4SB3P	40.323809 / -111.937887	(0.21)	982 LF
W4	R4SB3P	40.302054 / -111.915374	(0.01)	60 LF
W5	R4SB3P	40.300038 / -111.913546	(0.03)	70 LF
W6A	R4SB3P	40.294852 / -111.910018	(0.23)	2322 LF
W6B	R4SB3P	40.293650 / -111.908053	(0.27)	1805 LF
W6C	R4SB3P	40.296936 / -111.903779	(0.04)	142 LF
W7	R4SB3P	40.292113 / -111.907433	(0.91)	1007 LF
W8	R4SB3P	40.289037 / -111.904773	(0.02)	66 LF

*Cowardin Codes:

R4SB3P– Riverine Intermittent Streambed Cobble-Gravel Irregularly Flooded

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Appendix A

Site Location Figures

LEGEND

 APE (157 acres)



Imagery: Hexagon 2018
Figure Created by
Cara Glabau 10/13/21



CITY OF SARATOGA SPRINGS
SARATOGA SPRINGS
WATERSHED EA

SITE LOCATION



SCALE:
0 1,500 3,000
Feet

FIGURE NO.
1A



LEGEND

 APE (157 acres)

UTAH LAKE

SITE A

68

SITE B

Imagry: Hexagon 2018
Figure Created by
Cara Glabau 10/13/21



CITY OF SARATOGA SPRINGS
**SARATOGA SPRINGS
WATERSHED EA**

SITE LOCATION INDEX



SCALE:
0 750 1,500
Feet

FIGURE NO.
1C

Appendix B

NWI Figures

LEGEND

APE (157 acres)

National Wetlands Inventory

Riverine



Imagry: Hexagon 2018
Figure Created by
Cara Glabau 10/13/21

P:\Saratoga Springs\305-19-02 - Watershed Plan-EA\4.0 GIS\4.1 Projects\Environmental\Deineation\Fig2A_NWI_A_SaratogaSpringsEA.mxd cara glabau 10/21/2021

LEGEND

- APE (157 acres)
- National Wetlands Inventory**
 - Lake
 - Riverine



Imagry: Hexagon 2018
Figure Created by
Cara Glabau 10/13/21



CITY OF SARATOGA SPRINGS
**SARATOGA SPRINGS
WATERSHED EA**

NWI



SCALE:
0 400 800 Feet

FIGURE NO.
2B

Appendix C

Soils Figures and NRCS Custom Soils Resource Report

**Appendix not included for distribution.
Information can be provided upon request**

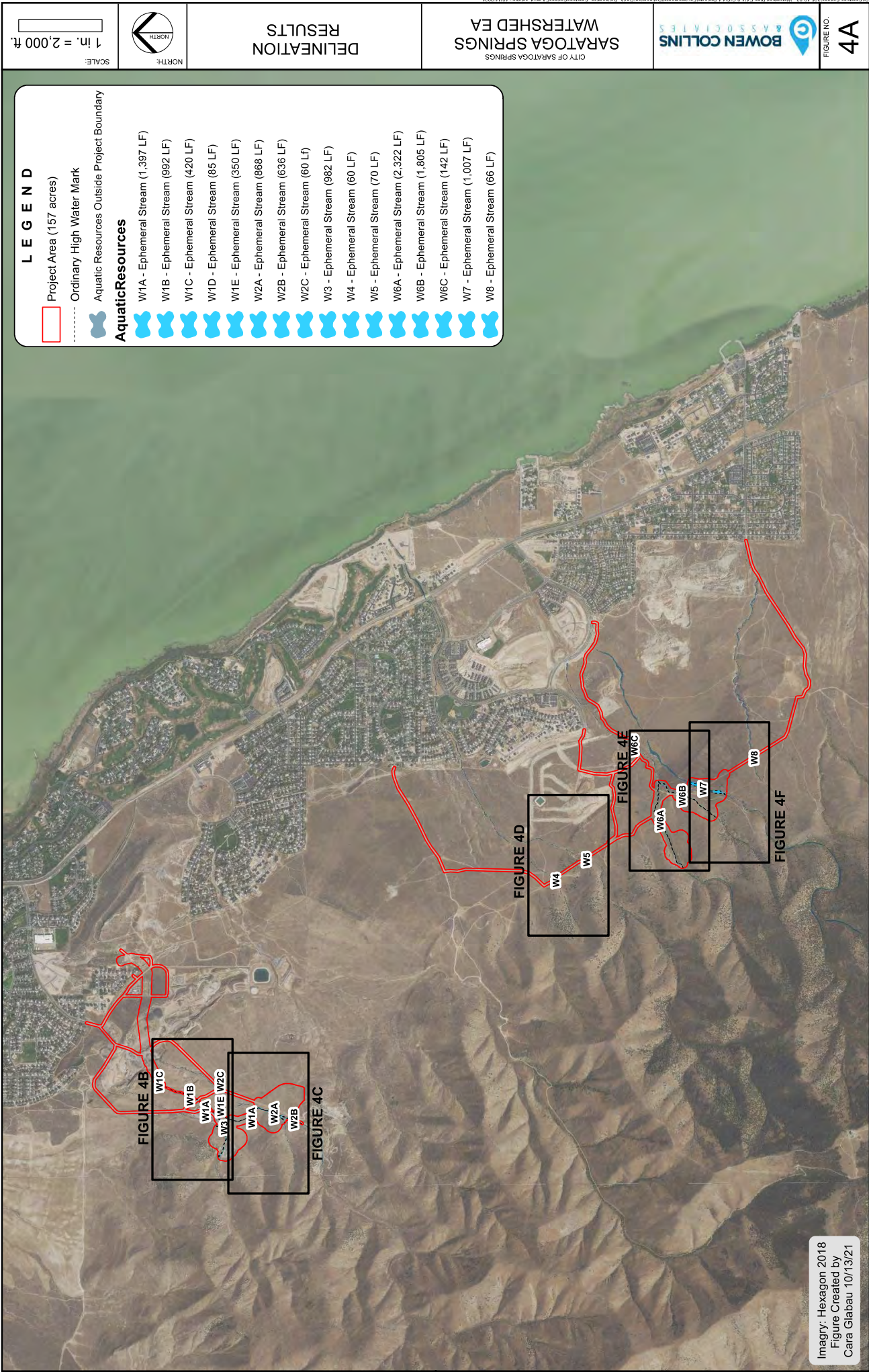
Appendix C

Photos

**Appendix not included for distribution.
Information can be provided upon request**

Appendix E

Wetland Delineation Results



SCALE: 1 in. = 2,000 ft.



DELINEATION RESULTS

SARATOGA SPRINGS
CITY OF SARATOGA SPRINGS
WATERSHED EA

BOWEN COLLINS
ASSOCIATES

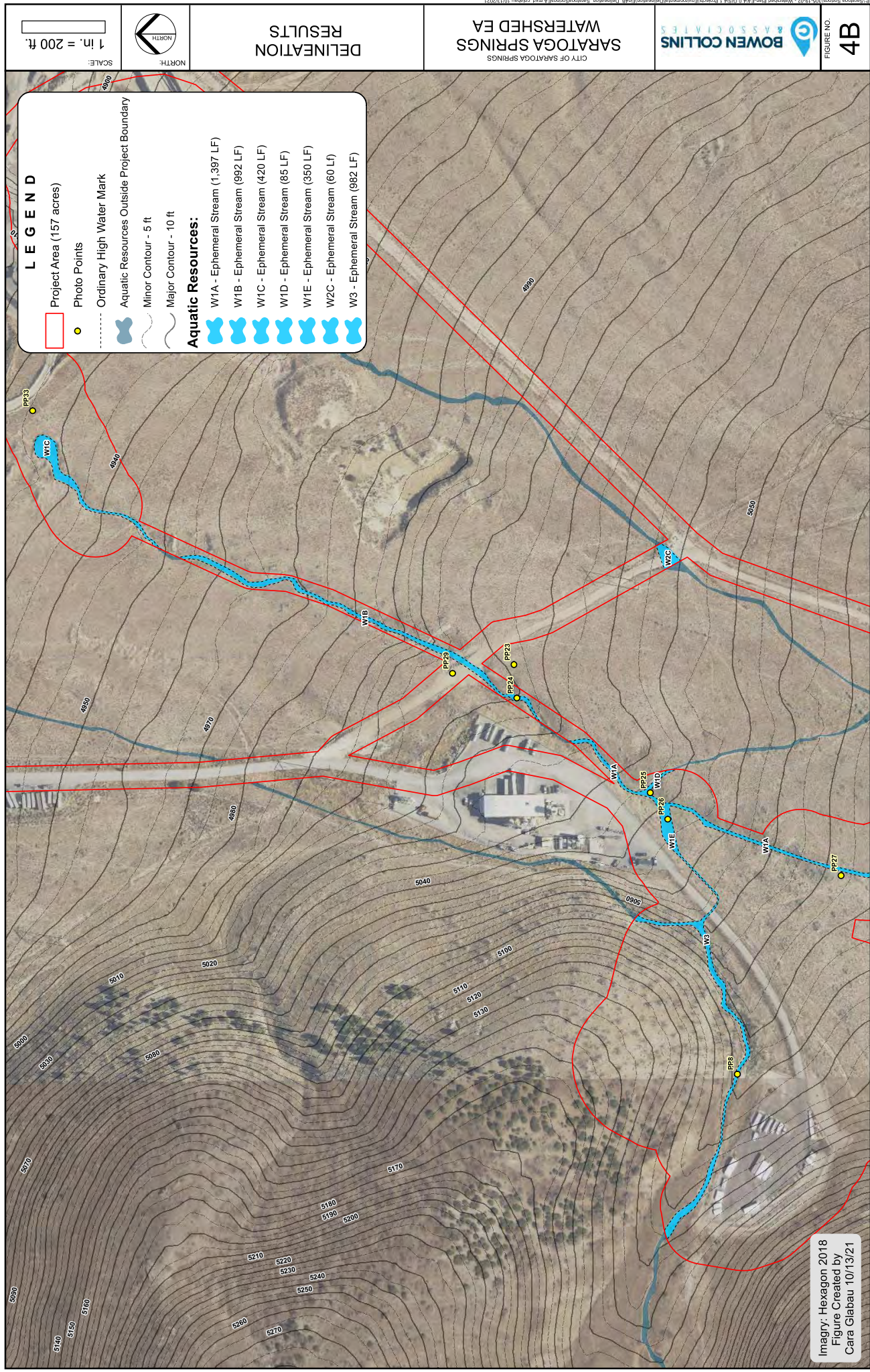
FIGURE NO. **4A**

LEGEND

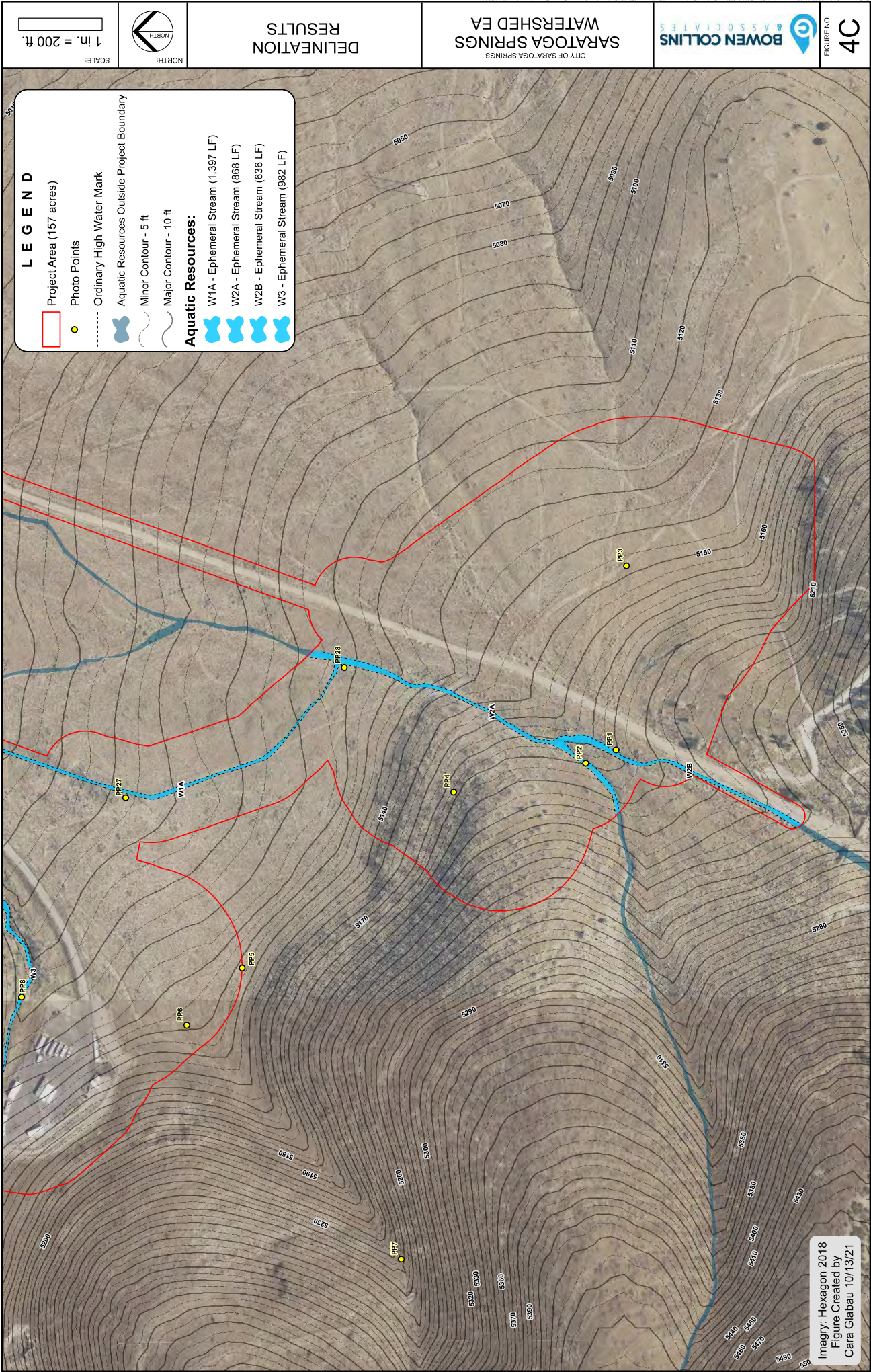
- Project Area (157 acres)
- Ordinary High Water Mark
- Aquatic Resources Outside Project Boundary

Aquatic Resources

- W1A - Ephemeral Stream (1,397 LF)
- W1B - Ephemeral Stream (992 LF)
- W1C - Ephemeral Stream (420 LF)
- W1D - Ephemeral Stream (85 LF)
- W1E - Ephemeral Stream (350 LF)
- W2A - Ephemeral Stream (868 LF)
- W2B - Ephemeral Stream (636 LF)
- W2C - Ephemeral Stream (60 LF)
- W3 - Ephemeral Stream (982 LF)
- W4 - Ephemeral Stream (60 LF)
- W5 - Ephemeral Stream (70 LF)
- W6A - Ephemeral Stream (2,322 LF)
- W6B - Ephemeral Stream (1,805 LF)
- W6C - Ephemeral Stream (142 LF)
- W7 - Ephemeral Stream (1,007 LF)
- W8 - Ephemeral Stream (66 LF)



Imagry: Hexagon 2018
Figure Created by
Cara Glabau 10/13/21

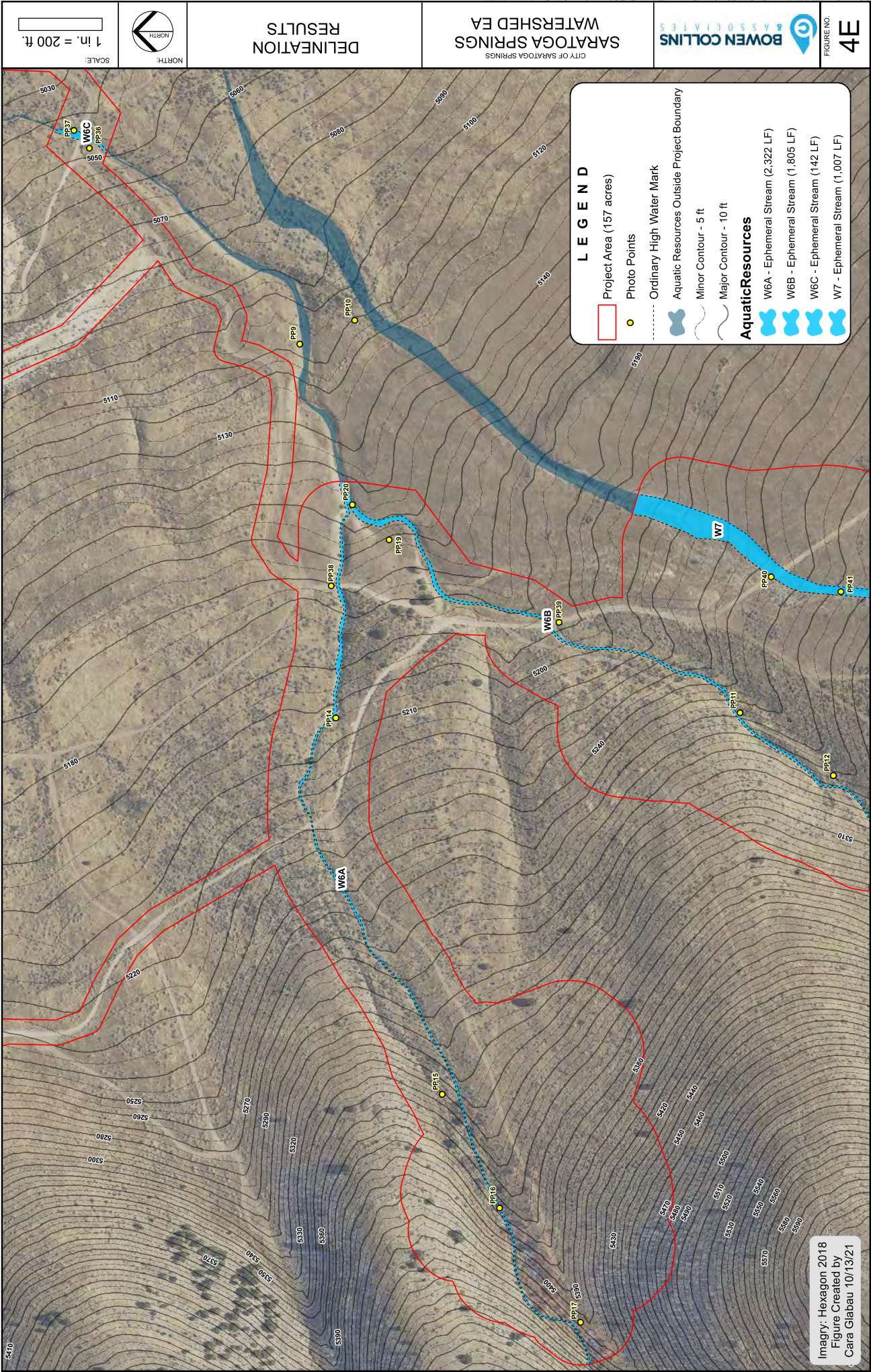


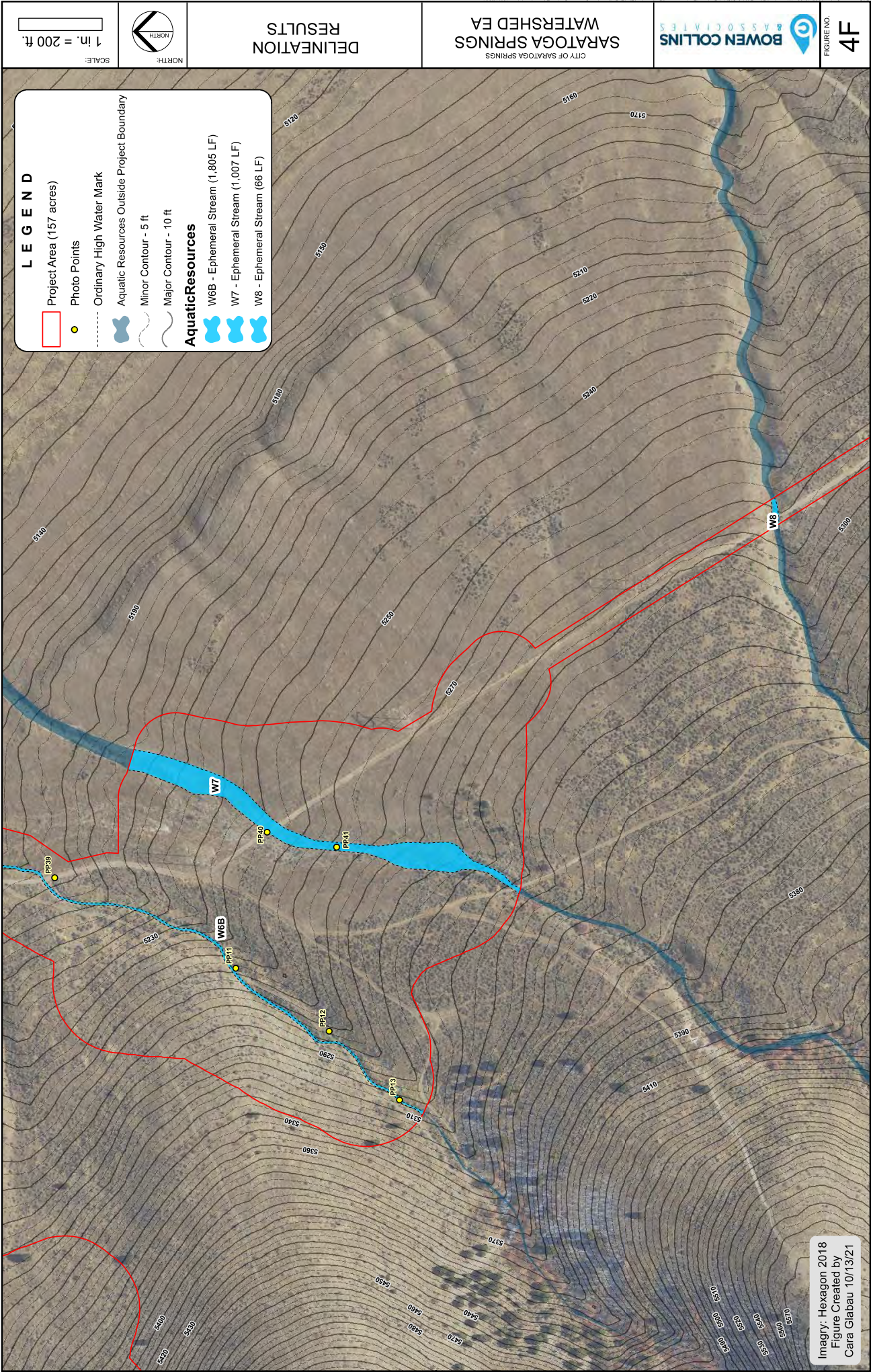
LEGEND

-  Project Area (157 acres)
-  Ordinary High Water Mark
-  Aquatic Resources Outside Project Boundary
-  Minor Contour - 5 ft
-  Major Contour - 10 ft
- Aquatic Resources:**
 -  W4 - Ephemeral Stream (60 LF)
 -  W5 - Ephemeral Stream (70 LF)



Imagry: Hexagon 2018
Figure Created by
Cara Glabau 10/13/21





Imagry: Hexagon 2018
Figure Created by
Cara Glabau 10/13/21

4F

FIGURE NO.



BOWEN COLLINS
ASSOCIATES

SARATOGA SPRINGS
CITY OF SARATOGA SPRINGS
WATERSHED EA

DELINEATION
RESULTS



SCALE:
1 in. = 200 ft.

Appendix F

Aquatic Resources Spreadsheet

Saratoga Springs Watershed EA
Aquatic Resources

Waters Name	State	Cowardin Code	HGM Code	Measurement Type	Amount	Units	Waters Type	Latitude	Longitude	Local Waterway
W1A	Utah	R4SB3P	Riverine	Length	1397	Feet	NRPW	40.323137	-111.935784	Ephemoral Storm Water Drainage
W1B	Utah	R4SB3P	Riverine	Length	992	Feet	NRPW	40.326084	-111.934089	Ephemoral Storm Water Drainage
W1C	Utah	R4SB3P	Riverine	Length	420	Feet	NRPW	40.328022	-111.932826	Ephemoral Storm Water Drainage
W1D	Utah	R4SB3P	Riverine	Length	85	Feet	NRPW	40.324141	-111.935447	Ephemoral Storm Water Drainage
W1E	Utah	R4SB3P	Riverine	Length	350	Feet	NRPW	40.324014	-111.935957	Ephemoral Storm Water Drainage
W2A	Utah	R4SB3P	Riverine	Length	868	Feet	NRPW	40.320671	-111.935501	Ephemoral Storm Water Drainage
W2B	Utah	R4SB3P	Riverine	Length	636	Feet	NRPW	40.319348	-111.935997	Ephemoral Storm Water Drainage
W2C	Utah	R4SB3P	Riverine	Length	60	Feet	NRPW	40.324076	-111.933505	Ephemoral Storm Water Drainage
W3	Utah	R4SB3P	Riverine	Length	982	Feet	NRPW	40.323809	-111.937887	Ephemoral Storm Water Drainage
W4	Utah	R4SB3P	Riverine	Length	60	Feet	NRPW	40.302054	-111.915374	Ephemoral Storm Water Drainage
W5	Utah	R4SB3P	Riverine	Length	70	Feet	NRPW	40.300038	-111.913546	Ephemoral Storm Water Drainage
W6A	Utah	R4SB3P	Riverine	Length	2322	Feet	NRPW	40.294852	-111.910018	Ephemoral Storm Water Drainage
W6B	Utah	R4SB3P	Riverine	Length	1805	Feet	NRPW	40.293650	-111.908053	Ephemoral Storm Water Drainage
W6C	Utah	R4SB3P	Riverine	Length	142	Feet	NRPW	40.296936	-111.903779	Ephemoral Storm Water Drainage
W7	Utah	R4SB3P	Riverine	Length	1007	Feet	NRPW	40.292113	-111.907433	Ephemoral Storm Water Drainage
W8	Utah	R4SB3P	Riverine	Length	66	Feet	NRPW	40.289037	-111.904773	Ephemoral Storm Water Drainage

Appendix G

Signed Access Waiver

**Appendix not included for distribution.
Information can be provided upon request**

Cultural Resource Assessment (redacted)

COVER PAGE

**Must Accompany All Project Reports
Submitted to the Utah SHPO**



Report Title: *A Cultural Resource Assessment for the Saratoga Springs Watershed Plan-EA, Utah County, Utah*

UDSH Project Number: U21HY0758

Report Date: September 12, 2024

Report Author(s): Sheri Murray Ellis

Record Search Date(s): 10/28/21 and 08/27/24

Intensive Acres Surveyed (<15m intervals): 185.8 ac.

USGS 7.5' Series Map Reference(s): Saratoga Springs, UT

Org. Project Number: BCA45

County(ies): Utah

Principal Investigator: Sheri Murray Ellis

Field Supervisor(s): Sheri Murray Ellis

Recon Acres Surveyed (<15m intervals): 12 ac.

Sites Reported	Count	Smithsonian Trinomials
Revisits (no updated site forms)	0	
Updates (updated site forms attached)	3	42UT369 (Destroyed), 42UT2496, 42UT2499
New recordings (site forms attached)	0	
Total Count of Archaeological Sites in APE	2	42UT2496, 42UT2499
Historic Structures (structures forms Attached)	0	
Total National Register Eligible Sites	0	

*Please list all site numbers per category. Number strings are acceptable (e.g. "42TO1-13; 42TO15"). Cells should expand to accommodate extensive lists.

Checklist of Required Items for Submittal to SHPO

- ☒ "Born Digital" Report in a PDF/A format
 - ☒ SHPO Cover Sheet
 - ☒ File Name is the UDSH Project Number with no hyphens or landowner suffixes
- ☒ "Born Digital" Site forms in PDF/A format
 - ☒ UASF with embedded maps and photos
 - ☒ File name is Smithsonian Trinomial without leading zeros (e.g. 42TO13 not 42TO00013)
 - ☒ Photo requirements (including size and quality)
- ☒ Archaeological Site Tabular Data
 - ☒ Single spreadsheet for each project
 - ☒ Follows UTSHPO template (info here: <https://goo.gl/7SLMqi>)
- ☒ GIS data
 - ☒ Zipped polygon shapefile or geodatabase of survey (if different from APE) or other activity area with required field names and variable intensity denoted
 - ☒ Zipped polygon shapefile or geodatabase of site boundaries with a the required field name

A Cultural Resource Assessment for the Saratoga Springs Watershed Plan-EA, Utah County, Utah

Prepared for

Bowen Collins & Associates

Prepared by

Sheri Murray Ellis, MS, RPA
Owner/Consultant



Certus Environmental Solutions, LLC
Salt Lake City, Utah
801.230.7260

**PLPCO Permit No. 176
Utah Antiquities Project No. U21HY0758**

Certus Project Number: BCA45

September 12, 2024

PROJECT ABSTRACT SHEET

Report Title: *A Cultural Resource Assessment for the Saratoga Springs Watershed Plan-EA, Utah County, Utah*

State Project No.: U21HY0758

Project Description: Saratoga Springs City (the City) proposes watershed improvements within their municipal boundaries and is preparing a Watershed Plan and Environmental Assessment (Watershed Plan-EA) to assess and disclose the potential environmental impacts of those improvements. Improvements may include mitigating flooding from three drainage basins—Burnt Canyon, Lott Canyon, and Clark Canyon. Funding for the Plan-EA improvements would be provided through the USDA Natural Resources Conservation Service (NRCS). Issuance of such funding constitutes a federal undertaking per the National Historic Preservation Act and its implementing regulations at 36 CFR §800. As such, impacts to historic properties must be considered and resolved as part of project implementation. The City contracted with Bowen Collins & Associates (BCA) to assist in preparing the Plan-EA and conducting environmental studies as part of that assessment. In turn, BCA contracted with Certus Environmental Solutions (Certus) to prepare a cultural resource assessment pursuant to 36 CFR §800. The results of that assessment are presented herein.

Survey Area: The survey area for cultural resources consists of a series of irregularly shaped polygons connected by narrow linear corridors. Two discontinuous locations are included in the survey area. The survey areas are located on lands owned by the City as well as those owned by private parties and those administered by the Utah Trust Lands Administration (TLA). The NRCS and TLA will determine the final area of potential effects (APE) as part of their funding and permitting actions.

Agencies: Natural Resources Conservation Service; Utah Trust Lands Administration; Saratoga Springs City

Location: Township 5 South, Range 1 West, Section 35; Township 6 South, Range 1 West, Sections 2, 3, 11, 13, 14, and 24

Land Ownership: Private, Municipal, State (TLA)

Date(s) of Fieldwork: November 3 and 4, 2021 and September 1, 2024

Methods: Intensive-level and reconnaissance-level archaeological survey; no buildings are present

Acres Surveyed: 197.8 acres (185.8 intensive; 12 reconnaissance in active gravel/clay mine pit)

Total # of Cultural Resource Sites in Survey Area: 2 (42UT2496 and 42UT2499)*

Resources Recommended Eligible for the NRHP: 0

Resources Recommended Ineligible for the NRHP: 2 (42UT2496 and 42UT2499)

*Site 42UT369 was located in the APE but destroyed

TABLE OF CONTENTS

Project Abstract Sheet	i
Table of Contents.....	ii
List of Figures	ii
Project Purpose and Description of the Undertaking	3
Personnel Qualifications	3
Cultural Resources Survey Area and Area of Potential Effects.....	3
Environmental Setting	7
Field Methods	7
Resource Evaluation Methods	11
File Search and Archival Review.....	11
Findings.....	13
Site 42UT2496, Transmission Line	13
Site 42UT2499, Historical Roads/Israel Canyon Road	16
Benefitted Areas Review.....	17
Summary.....	18
References Cited	19

LIST OF FIGURES

Figure 1. General location of the survey areas	4
Figure 2. Location of cultural resources survey area; Topographic Map 1 of 2.....	5
Figure 3. Location of cultural resources survey area; Topographic Map 2 of 2.....	6
Figure 4. Benefitted Areas	8
Figure 5. Overview of northern survey area; looking northwest	9
Figure 6. Overview of southern survey area; looking west	9
Figure 7. Location of reconnaissance-level cultural resources survey coverage	10
Figure 8. Example of transmission line corridor; looking north	13
Figure 9. Survey results for northern survey area	14
Figure 10. Typical road segment; looking northwest	16

PROJECT PURPOSE AND DESCRIPTION OF THE UNDERTAKING

Saratoga Springs City (the City) proposes watershed improvements within their municipal boundaries and is preparing a Watershed Plan and Environmental Assessment (Watershed Plan-EA) to assess and disclose the potential environmental impacts of those improvements. Improvements may include mitigating flooding from three drainage basins—Burnt Canyon, Lott Canyon, and Clark Canyon (see **Figure 1** for the general project location). Funding for the Plan-EA improvements would be provided through the USDA Natural Resources Conservation Service (NRCS). Issuance of such funding constitutes a federal undertaking per the National Historic Preservation Act and its implementing regulations at 36 CFR §800. As such, impacts to historic properties must be considered and resolved as part of project implementation.

The City contracted with Bowen Collins & Associates (BCA) to assist in preparing the Plan-EA and conducting environmental studies as part of that assessment. In turn, BCA contracted with Certus Environmental Solutions (Certus) to prepare a cultural resource assessment pursuant to 36 CFR 800. The results of that assessment are presented herein.

Fieldwork was carried out on November 3 and 4, 2021 and again on September 1, 2024, after changes were made to the area. The fieldwork was conducted by the author and consisted of intensive-level and reconnaissance-level surveys for archaeological resources. The reconnaissance-level survey was limited to the portion of the survey area extending through an active open pit gravel/clay mine. No buildings are located in the survey area. The work was carried out under Utah State Antiquities Report No. U21HY0758.

PERSONNEL QUALIFICATIONS

Sheri Murray Ellis, holder of State of Utah Public Lands Policy Coordination Office Permit No. 176, conducted fieldwork for the project and served as the principal investigator. Ms. Ellis meets all standards for professional qualifications for both archaeology and architectural history and for both prehistoric and historic period resources. Ms. Ellis holds an M.S. in American Studies (a multi-disciplinary degree that includes archaeology and history). Ms. Ellis has more than 33 years of professional experience in cultural resource assessments in Utah and the western United States.

CULTURAL RESOURCES SURVEY AREA AND AREA OF POTENTIAL EFFECTS

The survey area for cultural resources consists of a series of irregularly shaped polygons connected by narrow linear corridors (see **Figures 2 and 3**). Two discontinuous locations are included in the survey area. The survey areas are located on lands owned by the City as well as those owned by private parties and those administered by the Utah Trust Lands Administration (TLA). The NRCS and TLA will determine the final area of potential effects (APE) as part of their funding and permitting actions.

The survey areas are located in Township 5 South, Range 1 West, Section 35 and Township 6 South, Range 1 West, Sections 2, 3, 11, 13, 14, and 24 of the Salt Lake Base and Meridian. These areas can be found on USGS 7.5' Utah topographic quadrangle Saratoga Springs, Utah (see **Figures 2 and 3**).

The area of potential effects (APE) for direct impacts is smaller than the survey area and fully contained within it, in most cases with substantial buffers between the anticipated edge of disturbance and the edge of the survey area. The APE also includes what is known as the Benefitted Area—those areas/lands that

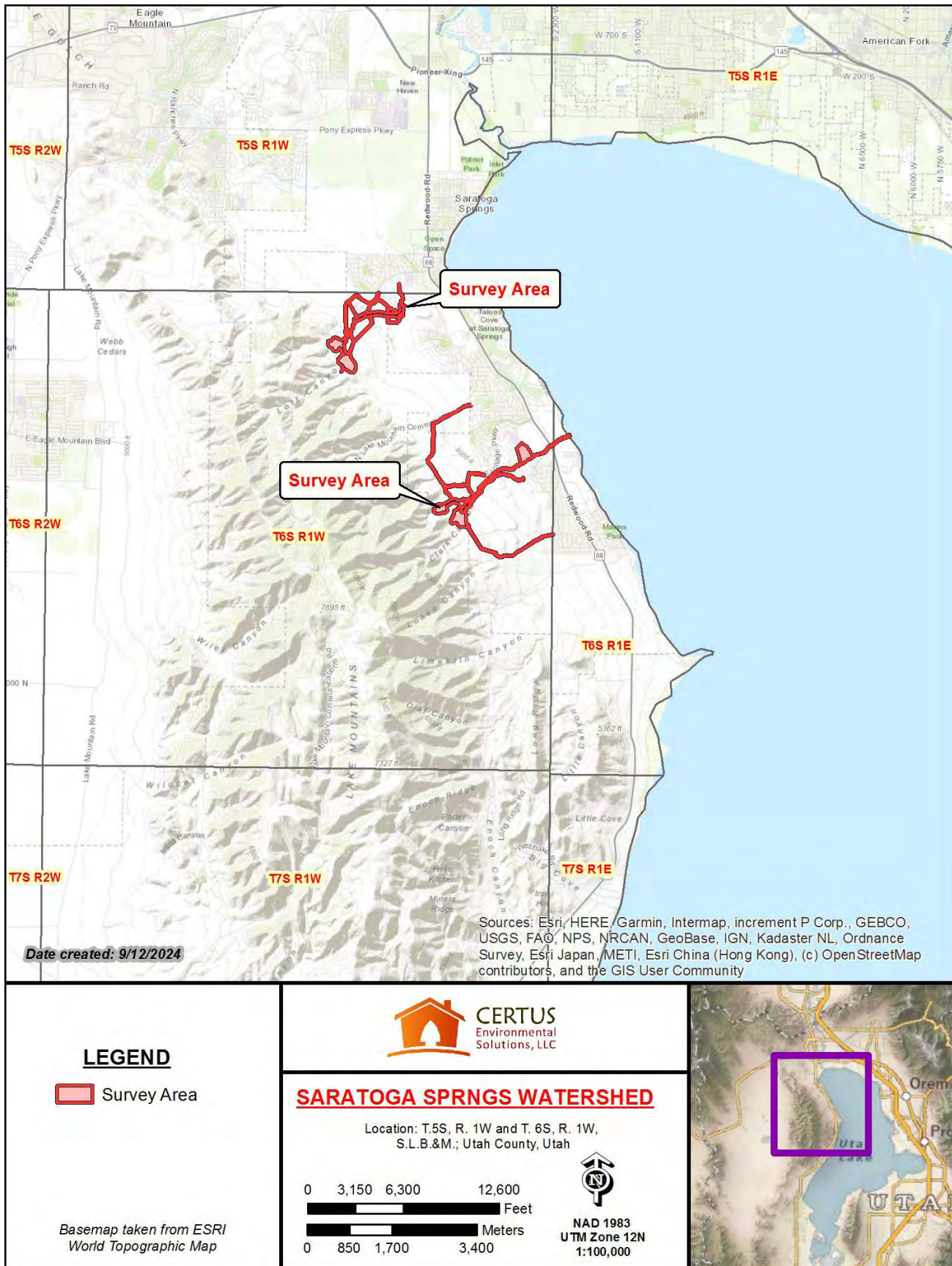


Figure 1. General location of the survey areas

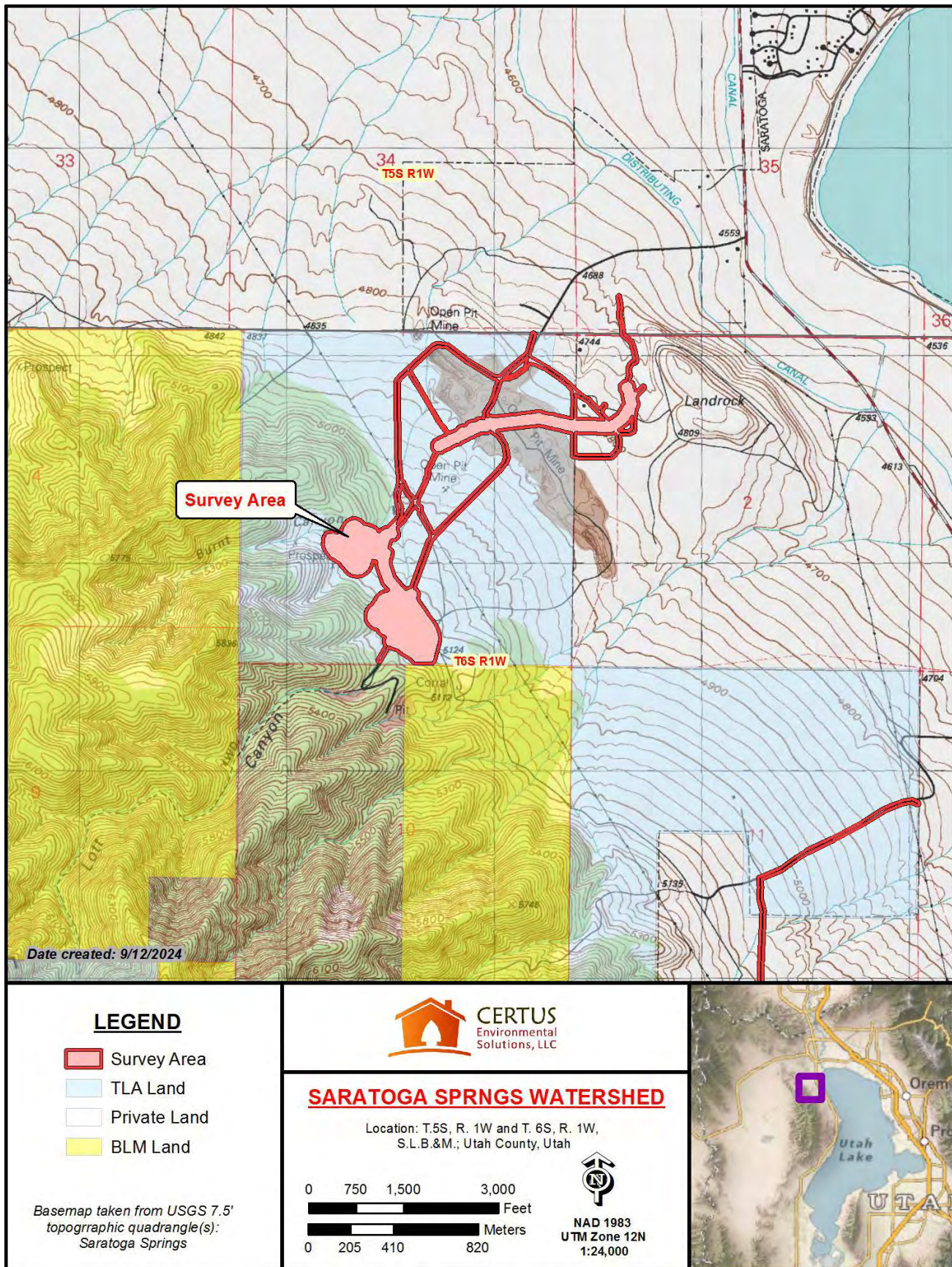


Figure 2. Location of cultural resources survey area; Topographic Map 1 of 2

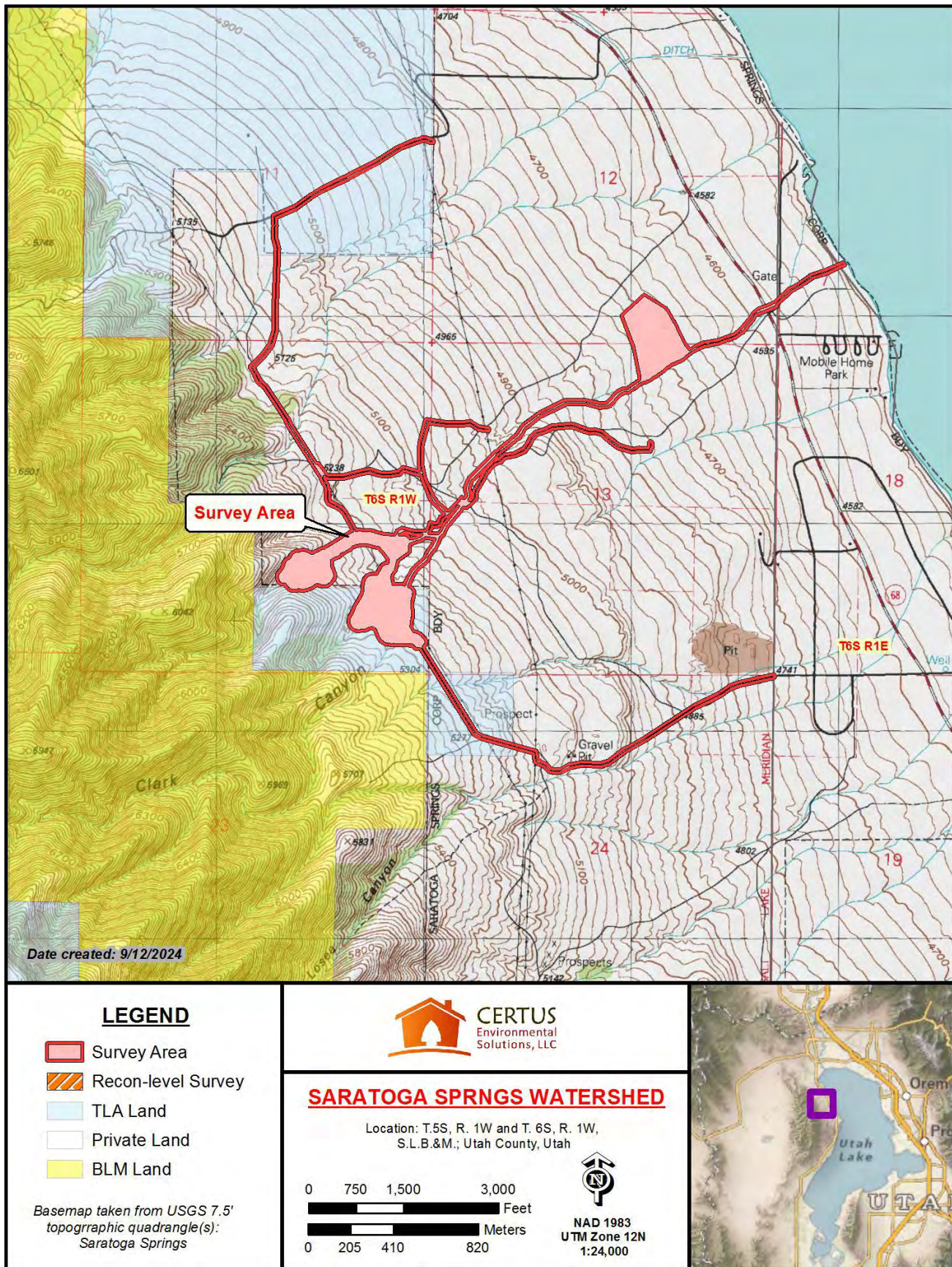


Figure 3. Location of cultural resources survey area; Topographic Map 2 of 2

would see a reduction in or elimination of impacts from unchecked flooding (i.e., current flood conditions) if the proposed action for the project is implemented. This Benefitted Area, which is shown in **Figure 4**, includes two separate large polygons extending downslope in fan-like fashion from the drainages to the west. The northern Benefitted Area (the Burnt/Lott Canyon Benefitted Area) contains approximately 2,005 acres. The southern area (the Clark Canyon Benefitted Area) contains approximately 872 acres. At the direction of the NRCS, these Benefitted Areas were not subject to fieldwork but are addressed via “desktop” review only (i.e., assessment via review of archival records, aerial images, and other data sources).

ENVIRONMENTAL SETTING

The survey areas are located on the west side of Utah Lake in the foothills of the Lake Mountains. More specifically, they are located in the drainages of Burnt Canyon, Lott Canyon, and Clark Canyon. The foothills are characterized by rolling terrain that slopes moderately to steeply downward to the east toward Utah Lake. Lands at the eastern edges of the survey areas were developed during the modern era with residential subdivisions. Lands in the survey areas are largely undeveloped save for a large open pit gravel/clay mine in the middle of the northern survey area. Beyond this, development in the area is primarily limited to unimproved roads used for recreational access and overhead transmission lines. Recreational uses of the area appear to include off-road vehicle travel, hiking, and target shooting in undesignated areas. These activities have led to a scattering of modern trash throughout the area.

Vegetation in the survey areas is a mixture of native plants and invasive weeds. Native plants comprise sagebrush community species and include low sagebrush and occasional juniper. Relatively recent wildfires have denuded much of the survey area, though regrowth of vegetation is occurring and includes low bunch grasses. Invasive plants include cheat grass and thistle. Ground cover was relatively low (e.g., less than 50-percent) across most of the survey areas due to the wildfires, but denser cover was present in the bottoms of the canyon drainages.

The NRCS classifies surface soils in the general survey area as Amtoft moist-rock outcrop, Birdow loam, Donnardo stony loam, Dry Creek cobbly loam, Goldrun loamy fine sand, Juab loam, Lodar-Rock outcrop complex, Pits-Dump complex, Saxby moist-Rock outcrop complex, and Wales loam. Most of the loamy deposits form on alluvial fans and lake terraces.

See **Figures 5 and 6** for photographic overviews of the survey areas.

FIELD METHODS

Certus applied intensive-level and reconnaissance-level survey methods accepted by the Utah State Historic Preservation Office (SHPO) and other agencies in Utah to identify cultural resources that could be affected by the undertaking. For the intensive-level survey, Sheri Murray Ellis of Certus inventoried the designated lands by walking parallel transects spaced no more than 15 meters (50 feet) apart. This equated multiple parallel transects within the polygon portions of the survey areas and a single transect along the proposed access road corridors. The reconnaissance-level survey was limited to the portion of the northern survey area located within an active open pit gravel/clay mine and comprised examination of the area from the nearest safe location outside the facility fence. All lands within this portion of the survey area (see **Figure 7**) have been subjected to several feet of soil removal thereby effectively eliminating the potential for intact cultural resources to be present there. That portion of the project area was also surveyed for cultural resources in 2016 prior to expansion of operations there. Navigation

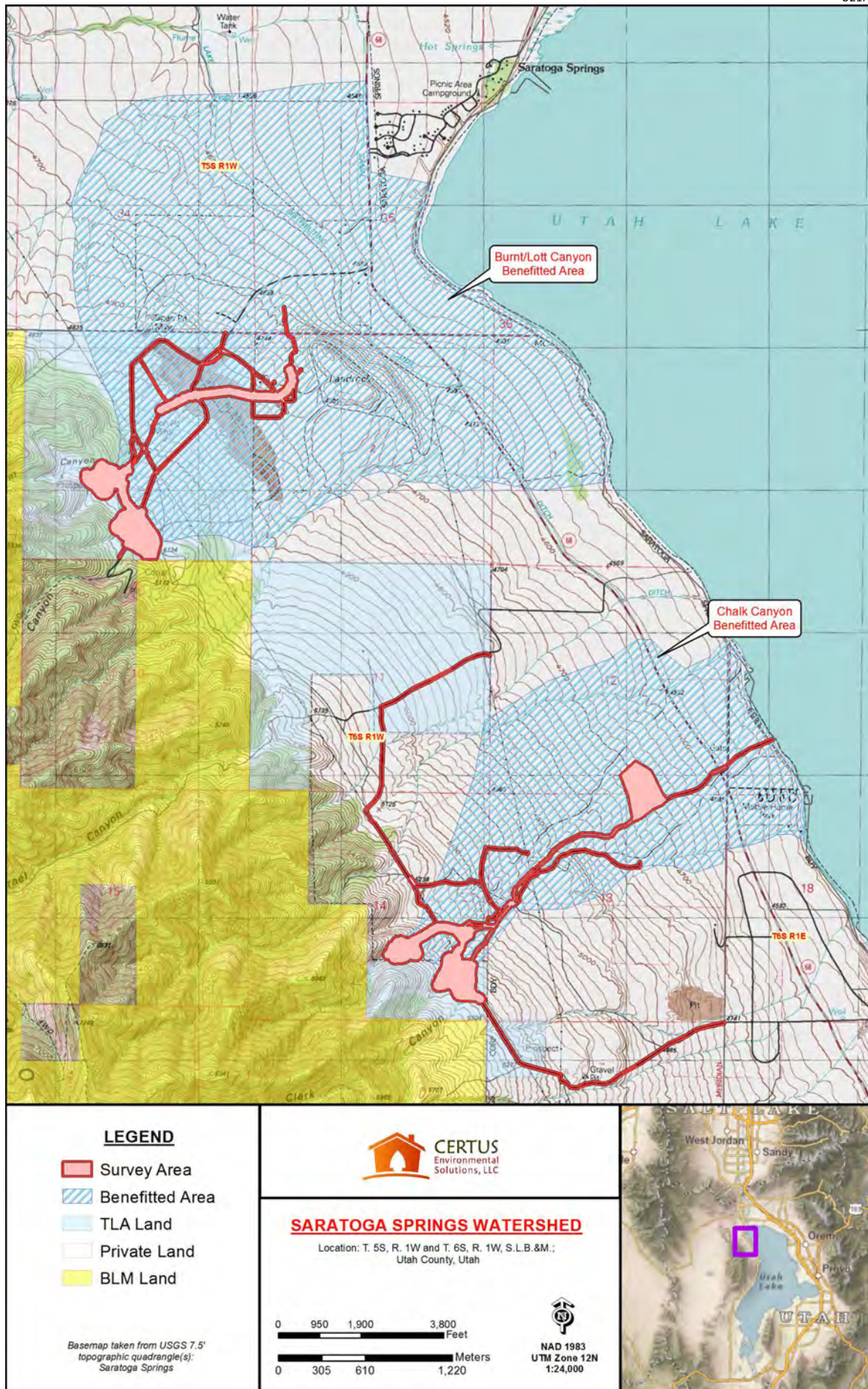


Figure 4. Benefitted Areas



Figure 5. Overview of northern survey area; looking northwest



Figure 6. Overview of southern survey area; looking west

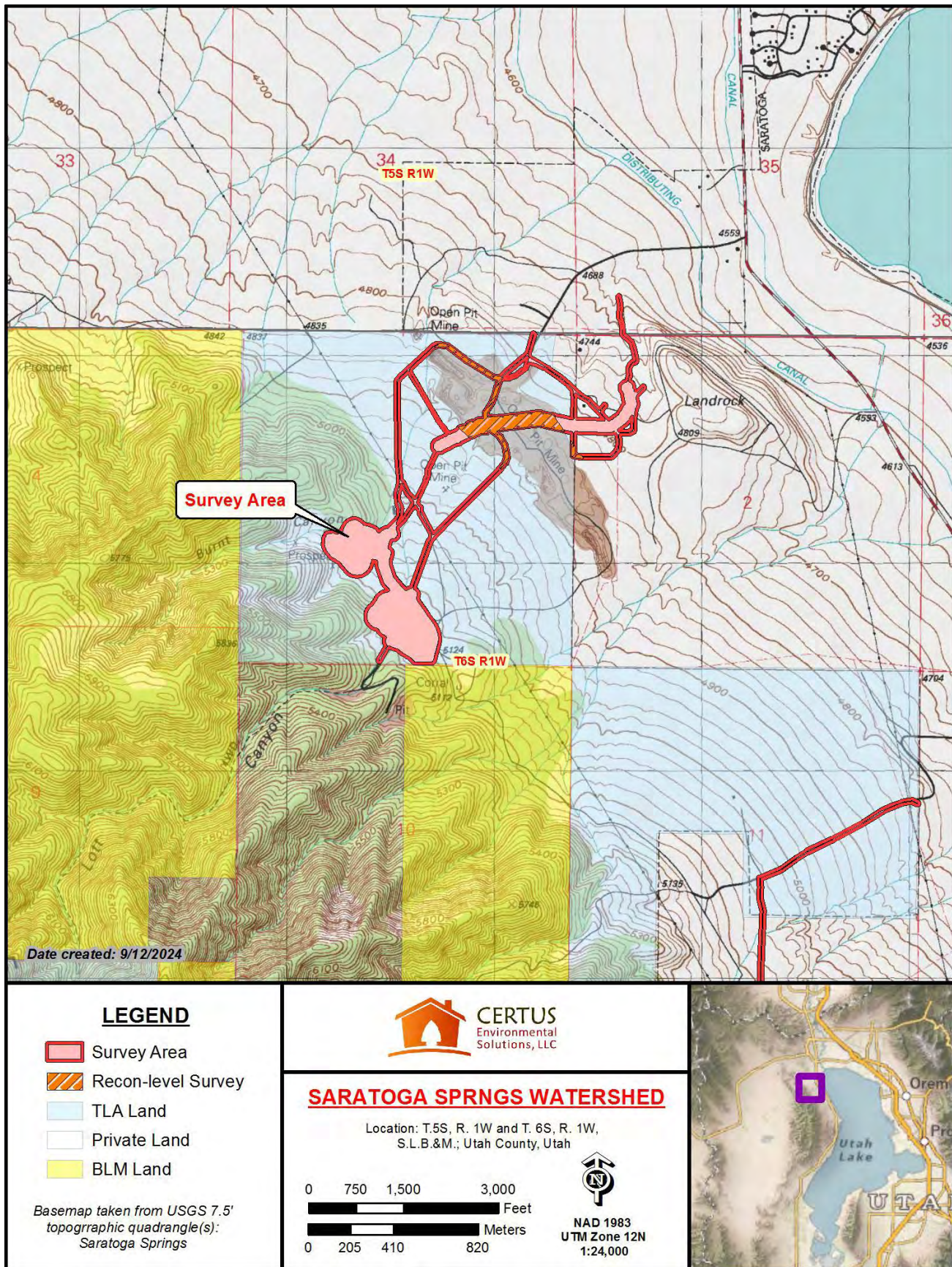


Figure 7. Location of reconnaissance-level cultural resources survey coverage

within the survey areas was accomplished using a handheld GPS unit capable of decimeter accuracy, aerial maps, and visual landmarks.

For the purpose of this project, the following criteria set forth by the Utah SHPO were used to define resources as an archaeological site (SHPO 2020):

- At least 10 artifacts of a single class (e.g., 10 sherds) within a 10-meter diameter area, except when all pieces appear to originate from a single source (e.g., one ceramic pot or one glass bottle) At least 15 artifacts that include at least 2 classes of artifact types (e.g., sherds, nails, glass) within a 10-meter area
- One or more archaeological features in temporal association with any number of artifacts
- Two or more temporally associated archaeological features without artifacts

The SHPO defines isolated finds (a.k.a., isolated artifacts or isolated occurrences) as those cultural resources that fall “below stated site thresholds” as defined above.

RESOURCE EVALUATION METHODS

Certus employs regulatory standard methods for evaluating the historical significance of cultural resources encountered during the field inventory. To that end, Certus evaluates all identified cultural resources for their eligibility for listing on the National Register of Historic Places (National Register). The evaluation considers the four criteria of the NRHP as listed in 36 CFR 60.4 and followed the guidelines issued by the National Park Service (NPS) in Bulletin 15, *How to Apply the National Register Criteria for Evaluation* (NPS 2002). The National Register criteria state that a resource may be considered eligible for listing on the National Register if it:

- **Criterion A** – is associated with events that have made a significant contribution to the broad patterns of our history; OR
- **Criterion B** – is associated with the lives of persons significant in our past; OR
- **Criterion C** – embodies the distinctive characteristics of a type, period, or method of construction, or represents the work of a master, or possesses high artistic values, or represents a significant and distinguishable entity whose components may lack individual distinction; OR
- **Criterion D** – has yielded, or may be likely to yield, information important in prehistory or history.

Resources considered potentially eligible for the National Register pursuant to one of the above criteria are also to be assessed for integrity of location, design, setting, materials, workmanship, feeling, and association. To be eligible for listing on the National Register, the resource must possess integrity of those elements directly related to the criterion or criteria under which it would be determined eligible.

FILE SEARCH AND ARCHIVAL REVIEW

Certus conducted a file search and review of archival information regarding past cultural resource surveys, known cultural resource sites, and potential cultural resource sites in and near the current survey area. This research was conducted October 28, 2021 and again on August 27, 2024. The background research included detailed review of the following sources:

- Utah Division of State History (UDSH) Sego and HUB databases;
- Historical topographic maps available through the Utah Geological Survey (UGS) and U.S. Geological Survey (USGS);
- Historical air photos available through the UGS and USGS;
- Historical General Land Office (GLO) maps; and
- Utah Statewide historic contexts

Certus also conducted a brief review of Sanborn maps, grazing, mining, water rights, and Master Title Plat records but did not identify any information of significance related to the current survey areas.

A separate file search was conducted for the Benefitted Areas and is discussed in more detail later in this report.

Sego and HUB File Search

According to Sego records, 22 prior regulatory-based cultural resource assessments have taken place within 1/2 mile of the current survey areas. These surveys took place between 1975 and 2023 with most occurring during or after 2004. Several of these surveys encompassed portions of the current survey areas, especially the northern of the two current survey areas. For the purpose of logistical simplicity and ensuring even “coverage” across the current survey areas, Certus reinventoried all previously inspected portions of the current survey area save for the aforementioned portion of the active open pit gravel/clay mine, which was inventoried by Bighorn Archaeological Consultants in 2016 under SHPO report number U16HO0834.

The Sego and HUB file search indicates that 15 archaeological sites have been documented previously in the 1/2 mile file search area. Three of the sites—42UT369 (an Indigenous temporary camp), 42UT2496 (a historical electrical transmission line) and 42UT2499 (Israel Canyon Road)—are located in the current survey areas. These sites are discussed in more detail in the **Findings** section of this report. The other previously reported sites in the file search area include historical roads, trash scatters, and rock alignments as well as two Indigenous temporary camps.

Archival Review

The earliest GLO map available online and showing detailed illustration of the general project area dates to 1856. Subsequent available maps date to 1890, 1916, and 1947. Of these, only the 1916 map illustrates any man-made features in the current survey areas. This map shows a series of roads and one electrical transmission line passing through the survey areas. These features were observed during the field inventory for the present undertaking and are discussed in the **Findings** section of this report.

Historical topographic maps are limited for the area. The earliest of sufficient scale to identify specific cultural features dates to 1951, with photorevisions from 1969 and 1975. This map depicts many of the same roads and the transmission line shown in the 1916 GLO map as passing through the current survey areas.

Historical air photos are also limited in availability for the survey area. Images from 1938 and 1969 were located. The previously noted roads are visible in the images, though the transmission line is not discernible. No other man-made features are obvious in the images.

FINDINGS

Certus identified two cultural resource sites in the survey area: 42UT2496 (a historical transmission line corridor) and 42UT2499 (a series of historical roads). Site 42UT369, which is shown in Utah SHPO records as being located in the survey on the shore of Utah Lake, has been destroyed by modern housing development. Certus did revisit the mapped site location and attempted to find the site undeveloped areas, but all lands in the former site location have been heavily disturbed. It is possible subsurface materials still exist in an extremely small section of the mapped site, but modern dwellings and utilities have resulted in deep soil excavation in the remaining site area.

The locations of the extant sites relative to the survey areas are shown in **Figure 9**, and descriptions and recommendation for National Register eligibility are provided below. Both sites are located in the southern of the two survey areas. No cultural resources were documented in the northern survey area.

Site 42UT2496, Transmission Line

Site 42UT2496 is a historical overhead electrical transmission line first illustrated on a 1916 GLO map of the area west of Utah Lake. The transmission line is not named on the 1916 map and is only labeled as “Transmission Line.” Topographic maps from the 1950s show the transmission line ending on the north in the Jordan Narrows area between Salt Lake and Utah counties and on the south at the south end of the Lake Mountains. It is likely the line extends beyond these termini, but its ultimate destination is unclear. Certus obtained a site number for the site in 2021; however, the Utah SHPO issued a second/duplicate number for the site in 2023. To minimize reporting disruption for the project under which the number was issued in 2023, Certus has adopted the second site number (42UT2496) and voided the earlier number.



Figure 8. Example of transmission line corridor; looking north

The portion of the site documented in 2023 overlaps with the segment documented by Certus in 2021; however, the segment documented by Certus is longer. As such, an update to the site record was prepared as part of the current undertaking.

The transmission line is an overhead structure consisting of wood H-posts with angled cross-brace members (see **Figure 8**). All of the posts/towers along the documented segment of the line have been replaced during the late-historic or early-modern periods though the alignment of the line appears consistent with that shown in the historical maps. The towers, which vary in height depending on terrain but generally do not appear to exceed 30 feet tall, carry eight electrical transmission lines. No historical artifacts or features were observed along the documented segment of the line. Certus documented a roughly 5,040-meter long segment of the transmission line as part of the current undertaking. Of this,

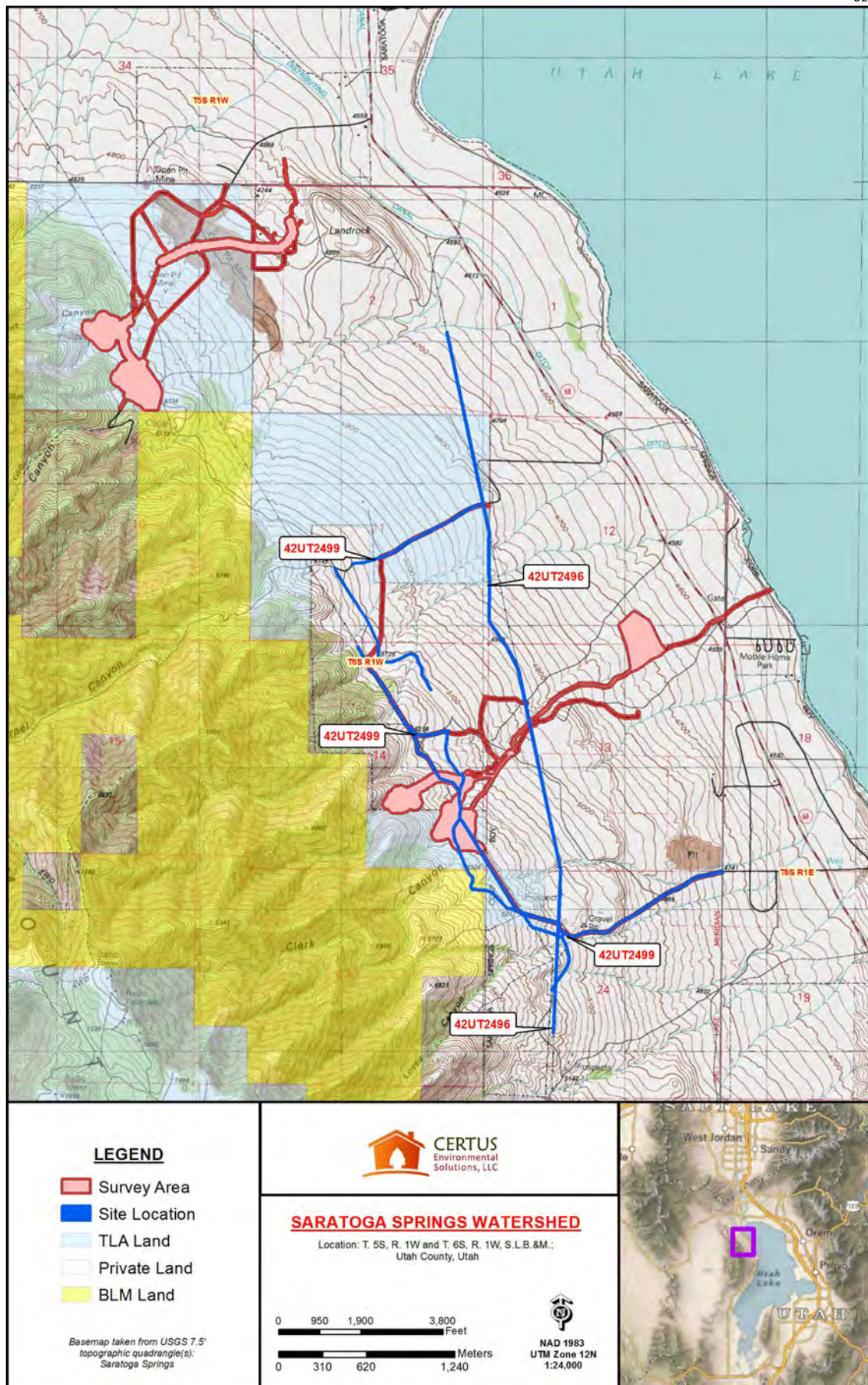


Figure 9. Survey results for northern survey area

approximately 1,000 meters near a new residential development was realigned to accommodate said development, and along another section north of that, the H-posts/towers were replaced with monopole towers where the transmission line passes through a second modern residential subdivision.

National Register Evaluation

Site 42UT2496 is a historical overhead electrical transmission line corridor that appears to date in origin sometime between 1890 and 1916. On the whole, this site retains integrity of location, materials, setting, and association. Its integrity of design and workmanship have been compromised by the replacement of the historical towers/posts, and its integrity of feeling has been compromised somewhat by the very likely expansion of the number of electrical lines carried by the towers as demand for electricity increased.

Certus recommends this site **ineligible** for the National Register under all criteria for the reasons outlined below. Although the site was also documented in 2023, no determination of eligibility has yet been made pursuant to that effort. The site was, however, recommended ineligible for the National Register under all criteria.

This site is associated with the historical theme of electrical infrastructure and, most likely, tangentially associated with the themes of settlement and industry. The subject transmission line shown on a 1916 GLO map would have been among the earlier long-distance electrical lines constructed across the foothills of the Lake Mountains to serve communities or commercial developments west of the Utah Lake; however, the line is not discussed in historical accounts of the area and its actual origin and destination are not fully illustrated in any historical maps. This suggests the line was seen at the time as a relatively non-noteworthy feature. Certus recommends site 42UT2496 eligible for the National Register under Criterion A for these reasons.

No information is available to identify any particular historically important person or persons in association with this site. Rather, it appears most likely the site was constructed by a larger organization or governmental body, which do not qualify for consideration under Criterion B. As such, Certus recommends site 42UT2496 ineligible for the National Register under Criterion B.

This site contains a number of structural features (i.e., the towers/posts), but these features were installed during the late-historic or early-modern periods to replace the original towers. They also are not notable for their engineering or construction character. Further, the segment of the transmission line documented here does not exhibit any unique engineering to overcome challenging terrain or other physical obstacles but is, rather, a simple linear feature of regularly spaced towers. The site does not represent a historical type, style, or manner of construction, is not the work of a master, and does not possess high artistic value. It also does not appear to be part of a larger cultural entity (e.g., a district or landscape) to which it might contribute. For these reasons, Certus recommends site 42UT2496 ineligible for the National Register under Criterion C.

This site has not yielded information important to improving our understanding of past human behavior and history and does not appear to have the potential to do so with additional investigation. The site comprises surface features with no associated activity loci having been identified. Given these considerations, Certus recommends site 42UT2496 ineligible for the National Register under Criterion D.

Site 42UT2499, Historical Roads/Israel Canyon Road

Site 42UT2499 is a series of unnamed and unimproved roads that provide access into the foothills of the Lake Mountains. Certus obtained a site number for the site in 2021; however, the Utah SHPO issued a second/duplicate number for the site in 2023. To minimize reporting disruption for the project under which the number was issued in 2023, Certus has adopted the second site number (42UT2499) and voided the earlier number. The portion of the site documented in 2023 overlaps with the segment documented by Certus in 2021; however, the segment documented by Certus is longer. As such, an update to the site record was prepared as part of the current undertaking.

Most of the roads appear to date to sometime between 1890 and 1916, when they first appear on GLO maps of the area. Some date slightly later and first appear on a 1938 aerial image of the area. All of the roads appear to have been used for exploration, recreational access, or perhaps personal extraction of limited timber resources as none access any specific developments or destinations other than canyons in the foothills. One of the roads may be associated with the construction of an electrical transmission line that passes through the area, and another is labeled on some modern maps and via on-the-ground signage as the Israel Canyon Road or the Lake Mountain



Figure 10. Typical road segment; looking northwest

Communications Road (Pagano 2023). Most of the roads documented as part of the current undertaking are simple 2-track roads measuring up to 4 meters wide (see **Figure 10**). The lower portions of a few of the roads extending west from residential developments into the foothills have been graded and widened to as much as 6 meters, possibly in association with the residential development. Beyond this, the roads are simple features created by repeated overland travel following the grades of the terrain and were not intentionally constructed. No roadway features, such as culverts or retaining walls, were observed along any of the documented segments.

National Register Evaluation

Site 42UT2499 is a series of historical roads dating between 1890 and 1938 in origin. They are more akin to social trails than constructed roads and appear to be associated with personal exploration, recreation, and possibly limited resource extraction during the earlier years of their creation. On the whole, this site retains integrity of location, materials, and association. Its integrity of setting and feeling has been compromised somewhat by the construction of modern housing developments nearby. Integrity of design and workmanship does not apply to this site.

Certus recommends this site **ineligible** for the National Register under all criteria for the reasons outlined below. Although the site was also documented in 2023, no determination of

eligibility has yet been made pursuant to that effort. The site was, however, recommended ineligible for the National Register under all criteria.

This site appears to be associated with the historical themes of personal exploration, recreation, and resource extraction but does not rise to a level of significance under any of them. The roads comprising the site are effectively social trails created from repeated use by individuals accessing the canyons and foothills for personal uses. They do not appear to have been intentionally constructed to access a particular destination or development area. Given these considerations, Certus recommends site 42UT2499 ineligible for the National Register under Criterion A.

No information is available to identify any particular historically important person or persons in association with this site. Rather, it appears most likely the site was created by a large number of unknown individuals repeatedly travelling across the same corridor. As such, Certus recommends site 42UT2499 ineligible for the National Register under Criterion B.

This site lacks architectural or engineering character and does not represent a type, style, or method of construction. It is not the work of a master and does not possess high artistic value. Additionally, it does not appear to be part of a larger cultural entity, such as a district or landscape, to which it might contribute. For these reasons, Certus recommends site 42UT2499 ineligible for the National Register under Criterion C.

This site has not yielded information important to improving our understanding of past human behavior and history and does not appear to have the potential to do so with additional investigation. The site comprises surface features with no associated activity loci having been identified. Given these considerations, Certus recommends site 42UT2499 ineligible for the National Register under Criterion D.

BENEFITTED AREAS REVIEW

As noted previously, the cultural resource assessment present herein includes an assessment of the Benefitted Areas related to the proposed watershed improvements. These areas are shown in **Figure 4**. The assessment consisted of a desktop review of available archival records to identify known cultural resources in these areas that would experience reduced impacts from flooding if the proposed watershed improvements are implemented. The Benefitted Area for the Burnt/Lott Canyon area encompasses seven previously documented (i.e., known) archaeological sites in addition to the sites newly documented during the current survey. Two historical buildings also were previously reported in the area, but both have since been demolished as part of modern residential development in the area. **Table 1** summarizes the known sites in the Burnt/Lott Canyon Benefitted Area.

Table 1. Known cultural resources in the Burnt/Lott Canyon Benefitted Area

Site #	Description	NRHP Eligibility
42UT944	Gardner Canal	Not Eligible
42UT946	Utah Lake Distributing Canal	Not Eligible
42UT1425	State Route 68 (Redwood Road)	Not Eligible
42UT1430	Historical artifact scatter	Not Eligible
42UT1745	Historical canal/ditch	Not Eligible
42UT1824	Historical artifact scatter	Undetermined
42UT1917	Historical transmission line	Not Eligible

The Benefitted Area for the Clark Canyon area encompasses four previously documented (i.e., known) archaeological sites in addition to the sites newly documented during the current survey. No historical buildings have been previously reported in this area. **Table 1** summarizes the known sites in the Clark Canyon Benefitted Area.

Table 2. Known cultural resources in the Clark Canyon Benefitted Area

Site #	Description	NRHP Eligibility
42UT369	Indigenous temporary camp (Destroyed)	N/A
42UT1425	State Route 68 (Redwood Road)	Not Eligible
42UT2496	Historical transmission line	Ineligible
42UT2497	Historical road	Ineligible

In all cases of previously reported sites, as well as any sites that may be present in the Benefitted Areas but not yet documented, potential future impacts from flooding would be reduced. This would be an improvement over current conditions. Sites in this area would still be subject to impacts from such actions as land development, off-road recreation, vandalism, and looting, but one source of impact—flooding—would be reduced or eliminated.

SUMMARY

Certus conducted a cultural resources inventory for proposed watershed improvements in Saratoga Springs, Utah. The inventory resulted in the documentation of two sites—a historical electrical transmission line (42UT2496) and a series of historical roads (42UT2499). Certus has recommended both newly documented sites ineligible for the National Register under all criteria. No prior determination of eligibility has yet been made for these sites based on the documentation of portions of them in 2023. The eligibility recommendations by Certus mean the sites would not qualify as historic properties under 36 CFR §800, and consideration and resolution of adverse effects would not be required.

The NRCS, in consultation with TLA, the Utah SHPO, and other consulting parties will make formal determinations of eligibility under 36 CFR §800 as part of their regulatory action.

REFERENCES CITED

- National Park Service (NPS). 2002. *How to Apply the National Register Criteria for Evaluation*. National Register Bulletin 15. Utah Centennial County History Series. Accessed online on January 9, 2014 at: <http://www.nps.gov/history/nr/publications/bulletins/nrb15/>
- Pagano, Sandy. 2023. Utah Archaeology Site Form for site 42UT2499. On file at the Utah State Historic Preservation Office, Salt Lake City.
- Utah State Historic Preservation Office (SHPO). 2020. *Archaeological Compliance Guide*. Utah Division of State History, Salt Lake City.

**Saratoga Springs Watershed Plan-EA
Technical Memorandum - 01**



TECHNICAL MEMORANDUM - 01

(DRAFT)

TO: Jeremy Lapin
Public Works Director
Saratoga Springs City

COPIES: Jason Roper – NRCS Engineer
Aimee Rohner – NRCS Engineer
File

FROM: Cody Moultrie, P.E.
Bowen Collins & Associates

DATE: June 14, 2024

SUBJECT: Saratoga Springs Watershed Plan EA Engineering Analysis

JOB NO.: 305-19-02

SECTION 1 - INTRODUCTION

1.1 INTRODUCTION

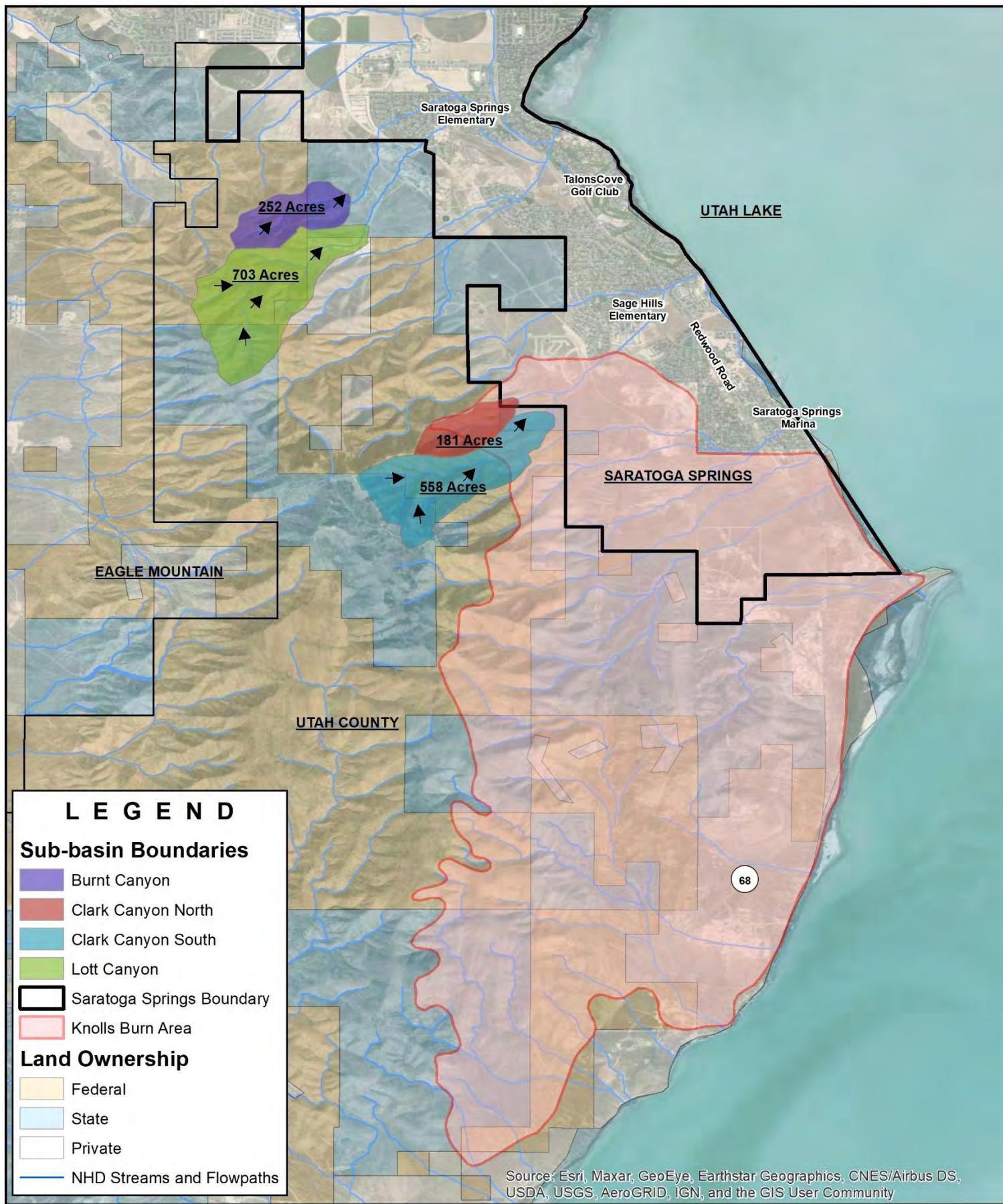
Saratoga Springs City, Utah contracted with Bowen Collins & Associates (BC&A) to prepare a Watershed Plan and Environmental Assessment (Plan-EA) for the Saratoga Springs Watershed in accordance with USDA Natural Resource Conservation Services (NRCS) guidelines and requirements. Key sub-consultants utilized in preparing this plan included Adaptive Environmental Planning (AEP) and Rosenberg Associates (RA). The funding for this project was provided by the NRCS. The Sponsor for this Plan-EA is Saratoga Springs City (Sponsor/City). The principal objective of the Plan-EA is to provide the Sponsor and NRCS with National Environmental Policy Act (NEPA) analysis and documents for various Sponsor-selected project sites within the Saratoga Springs City Watershed.

This project includes mitigating flooding from three drainage basins located on the west side of the City. Burnt Canyon and Lott Canyon basins drain into the northern part of City, while Clark Canyon drains to the south-central part. The flow path for these three drainage basins is through residential areas of the City and eventually to Utah Lake. The location of each of the three drainage basins is shown in Figure 1.

The topography downstream of Burnt and Lott Canyons is an alluvial fan with multiple potential flow paths. Currently, runoff from these Canyons collect in one or more of these flow paths. Some flow paths intersect existing pits created from clay removal which can act as an unofficial retention basin. The clay pits provide some protection to some nearby neighborhoods during smaller storm events, but these pits are not designed to function as retention or detention basins for larger storm events. These clay pits are going to be removed as the area is developed, at which point the downstream residential and commercial areas will face an increased risk of flooding. Alternatively, other flow paths bypass these clay pits and flow into existing channels that connect to existing Saratoga Springs

storm water management infrastructure. Runoff that follows this path can be managed during smaller storm events but poses a flooding risk during larger storm events. Additionally, recent wildfires have increased the potential for runoff by eliminating trees, shrubs, and other vegetation within the drainage basins.

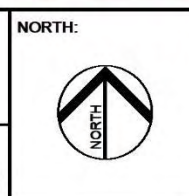
For these reasons, Saratoga Springs is at risk of flooding during a large storm event or after a wildfire, regardless of the path the flow might take. The purpose of this technical memorandum (TM) is to describe the engineering investigation of the causes and severity of this potential flooding. In addition, this TM will present recommended mitigation measures to prevent further flooding.



EXISTING DRAINAGE BASINS AND BURN AREA

SARATOGA SPRINGS CITY

SARATOGA SPRINGS WATERSHED PLAN EA



SCALE:

1 inch = 7,000 feet

FIGURE NO.

1

1.2 PURPOSE

The purpose of this Saratoga Springs Watershed Basin project includes the following Public Law 83-566 (PL-566) purposes:

- Flood Prevention (Flood Damage Reduction)

1.3 BACKGROUND AND PREVIOUS FLOODING EVENTS

Lott Canyon and Burnt Canyon drainage basins are 955 acres (1.49 square miles) combined and Clark Canyon drainage basin is 739 acres (1.15 square miles) in area and contain portions of forest, shrub, and other undeveloped landscapes. Wildfires have damaged and destabilized portions of these drainage areas making them more susceptible to flooding and debris flows from the eliminated and loosened vegetation. Figure 1 shows the approximate boundary of the recent Knolls Fire that occurred in July of 2020.

At the mouth of each of these canyons is an alluvial fan with multiple potential flow paths. For Clark Canyon there is a relatively well-established main channel which flows from Clark Canyon down to Utah Lake. Flows in minor rivulets on the Clark Canyon alluvial fan eventually run into this main channel. However, for Burnt and Lott Canyons the flow paths and channels in the alluvial fan are less defined. Multiple pathways exist that could convey runoff water directly to developed areas and cause flooding.

Other pathways lead to several clay pits that have been excavated immediately downstream of Lott Canyon and Burnt Canyon drainage areas. These clay pits have occasionally acted as an unofficial retention basin during small rain events, providing some protection to downstream areas from potential flooding. However, these clay pits were never sized or designed to accommodate routing larger storm events. In fact, recent development plans in the area show these clay pits being filled in to facilitate the construction of new residential and commercial developments. The uncertainty of the alluvial fan flow paths, combined with the expected filling-in of the clay pits, results in the existing development downstream of these canyons being at risk for potential flooding, both now and in the future. See Section 3 for more discussion of existing floodplain conditions.

Although no significant flooding events have yet occurred downstream of these drainage areas, the recent fires and removal of the clay pits increase the chances of smaller storm events causing potentially significant damage to the area.

A previous flood event from September 4, 2012 damaged the Jacob's Ranch neighborhood located between the drainage basins included in this project. Most of the drainage basins in the Lake Mountains on the western side of the City are very similar and susceptible to similar flooding events, especially in the wildfire damaged areas. The following Photo 1 to 7 show flooding and related damage from this storm event.



Photo 1. Flooding of residential properties in Saratoga Springs on September 4, 2012
(Source of All Photos: <https://www.deseret.com/2012/9/4/20506549/why-wasn-t-saratoga-springs-ready-for-the-flood#crews-continue-to-clean-up-after-flood-waters-and-mud-damaged-several-homes-and-property-in-saratoga-springs-tuesday-sept-4-2012>)



Photo 2. Sedimentation and flood damage from September 4, 2012



Photo 3. Sedimentation and flood damage from September 4, 2012



Photo 3. Basement flood damage from September 4, 2012



Photo 4. Basement flood damage from September 4, 2012



Photo 5. Sedimentation and flood damage from September 4, 2012



Photo 7. Sedimentation and flood damage from September 4, 2012

There is very little storm drain infrastructure between the base of the Lake Mountains and current development in Saratoga Springs. The existing defined canyon drainage channel transitions to an alluvial fan that is constantly changing flow paths with each storm event. This makes predicting the impacts of future storm events and preparing downstream neighborhoods for potential flooding difficult. Much of this area is planned for development soon, increasing the impacts of potential flooding and making mitigation more difficult as less space is left for flood control facilities.

1.4 EXISTING DATA

The analysis of the of the Saratoga Springs Watershed Basin Project utilized the data sources presented in Table 1.

Table 1
Study Data Sources

Data	Source	Description
LiDAR	Utah Automated Geographic Reference Center, (AGRC) 2014, 2018	0.5-meter resolution bare-earth digital terrain model (DTM) data set along the Wasatch Front and throughout Central Utah.
Aerial Imagery	ESRI, via ArcMap 10.8.1	Aerial imagery was used for the background of the figures and drawings and to determine existing land uses for hydrologic models
Soil Data	NRCS Web Soil Survey	Soil Survey Geographic Database (SSURGO) mapping data used to determine Hydrologic soil type for hydrologic models
Master Plan Studies and Reports	Bowen Collins & Associates	Reports used to determine capacity of downstream hydraulic structures and conduits
Land Cover Data	Multi-Resolution Land Characteristics Consortium (MRLC) 2019	National Land Cover Dataset. Surface cover characteristics for hydrologic models were determined from land cover.
Rainfall Data	NOAA Hydrometeorological Design Studies Center, Precipitation Frequency Data Server (PFDS)	NOAA Atlas 14 precipitation used to develop design rainfall depths, accessed August 2021.
Soil Characteristics	Rosenberg Preliminary Geotechnical Assessment	Rosenberg and Associates performed limited field evaluations at four potential debris basin sites
Field Survey	BC&A Field Reconnaissance	Field reconnaissance was completed by BC&A in July and November, 2021 to confirm site conditions, drainage paths, landcover, hydraulic structures, and damaged facilities.

SECTION 2 - HYDROLOGY

2.1 INTRODUCTION/OVERVIEW

BC&A developed detailed hydrologic models of the Burnt Canyon, Lott Canyon, and Clark Canyon drainage basins to understand existing and future flooding conditions caused by runoff generated from the canyon watersheds. The model was developed using HEC-HMS software. The development of the various parameters and elements of the model are discussed in detail in the sections that follow.

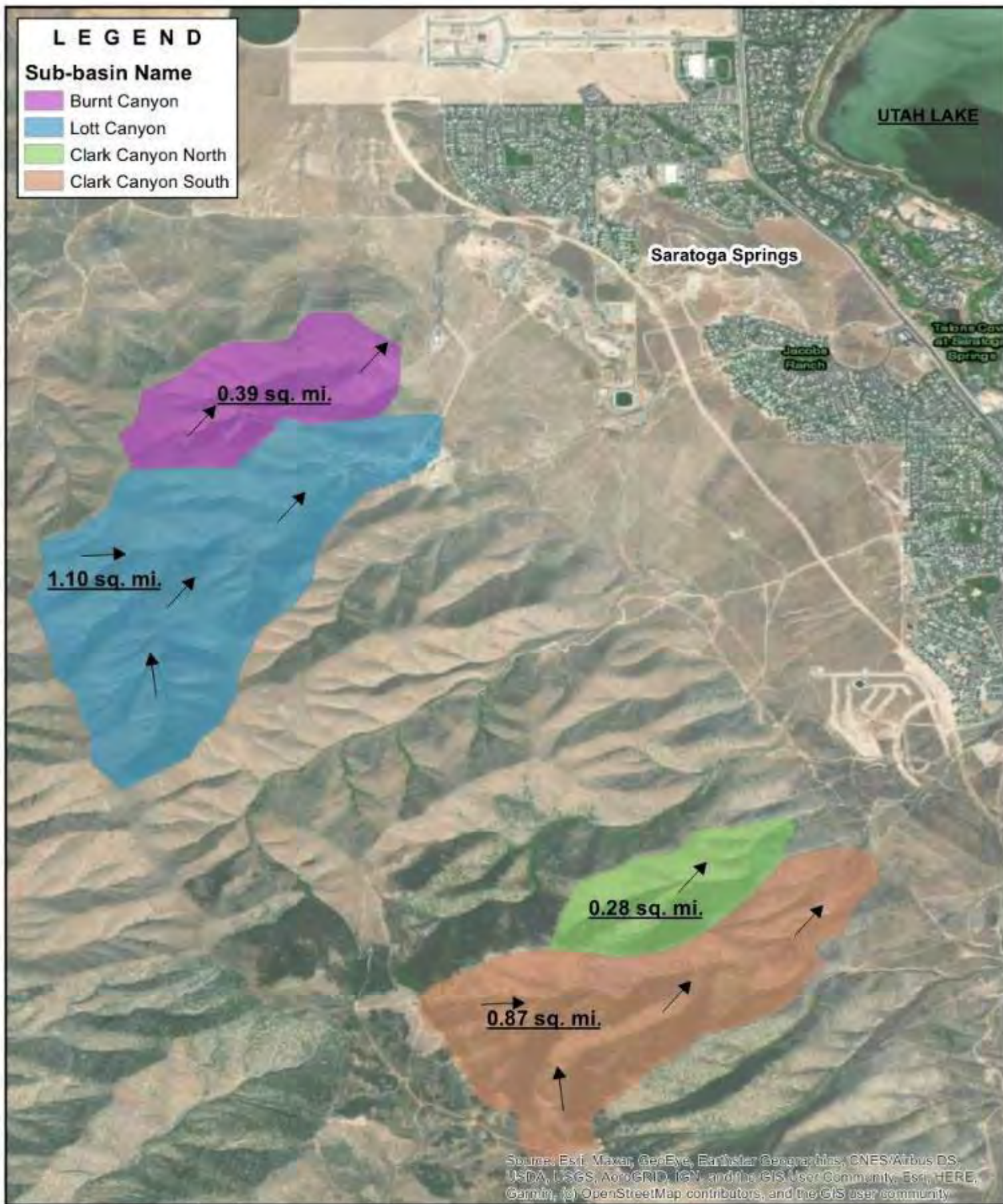
2.2 SUBBASIN HYDROLOGIC PARAMETERS

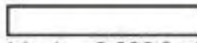
BC&A developed detailed hydrologic models of the Burnt Canyon, Lott Canyon, and Clark Canyon drainage basins to understand existing and future flooding conditions caused by runoff generated from a variety of storm events. A summary of the development of the model and hydrologic parameters is provided in the following sections.

2.2.1 SUBBASIN BOUNDARIES

To route runoff from these canyons to Utah Lake, both channel-only and debris basin alternatives were considered. In the following sections, hydrologic parameters are defined in relation to a debris basin design, as the debris basin embankment provides the downstream boundary for the hydrologic calculations. However, the hydrology modeled for the drainage basins for a debris basin alternative also applies to the channel-only alternatives.

Proposed debris basins are located near the bottom of each canyon outside of areas designated for future development. Suitable land was not available for a single debris basin to intercept all runoff from Clark Canyon. For Clark Canyon, two smaller debris basins are proposed, Clark Canyon North and Clark Canyon South, with associated smaller sub-basins. Utilizing the data sources listed in Table 1, along with field investigation, the general drainage area boundaries upstream of each proposed debris basin were refined into the sub-basin boundaries shown on Figure 2.



 BOWEN COLLINS & ASSOCIATES	HYDROLOGY MODEL DRAINAGE SUB-BASINS	NORTH: 	SCALE:  1 inch = 3,000 feet
	SARATOGA SPRINGS CITY SARATOGA SPRINGS WATERSHED PLAN EA		FIGURE NO. 2

2.2.2 TRANSFORM METHOD

The SCS Unit Hydrograph method was used in the hydrologic model to convert rainfall to runoff. This method requires “lag time” as an input parameter. The method used to determine watershed lag times for this study is described below.

- Undeveloped drainage areas – The watershed lag method described in NEH 630.1502(a) was used to estimate the lag time for each basin:

$$L = \frac{L^{0.8} (S+1)^{0.7}}{1,900Y^{0.5}} \quad (\text{eq. 15-4a})$$

Applying equation 15-3, $L=0.6T_c$, yields:

$$T_c = \frac{L^{0.8} (S+1)^{0.7}}{1,140Y^{0.5}} \quad (\text{eq. 15-4b})$$

where:

L = lag, h
 T_c = time of concentration, h
 L = flow length, ft
 Y = average watershed land slope, %
 S = maximum potential retention, in

$$= \frac{1,000}{cn'} - 10$$

where:

cn' = the retardance factor

The calculated time of concentration and lag time for each modeled sub-basin is provided in Table 3.

2.2.3 CURVE NUMBER

Runoff Curve Numbers (CN) were estimated for each sub-basin based on soil type and land use/vegetative cover.

Hydrologic soil group (HSG) maps were obtained from the NRCS Soil Survey Geographic (SSURGO) dataset and are shown on Figure 3. As shown in Figure 3, the majority of the drainage area for all three sub-basins are HSG B and D.

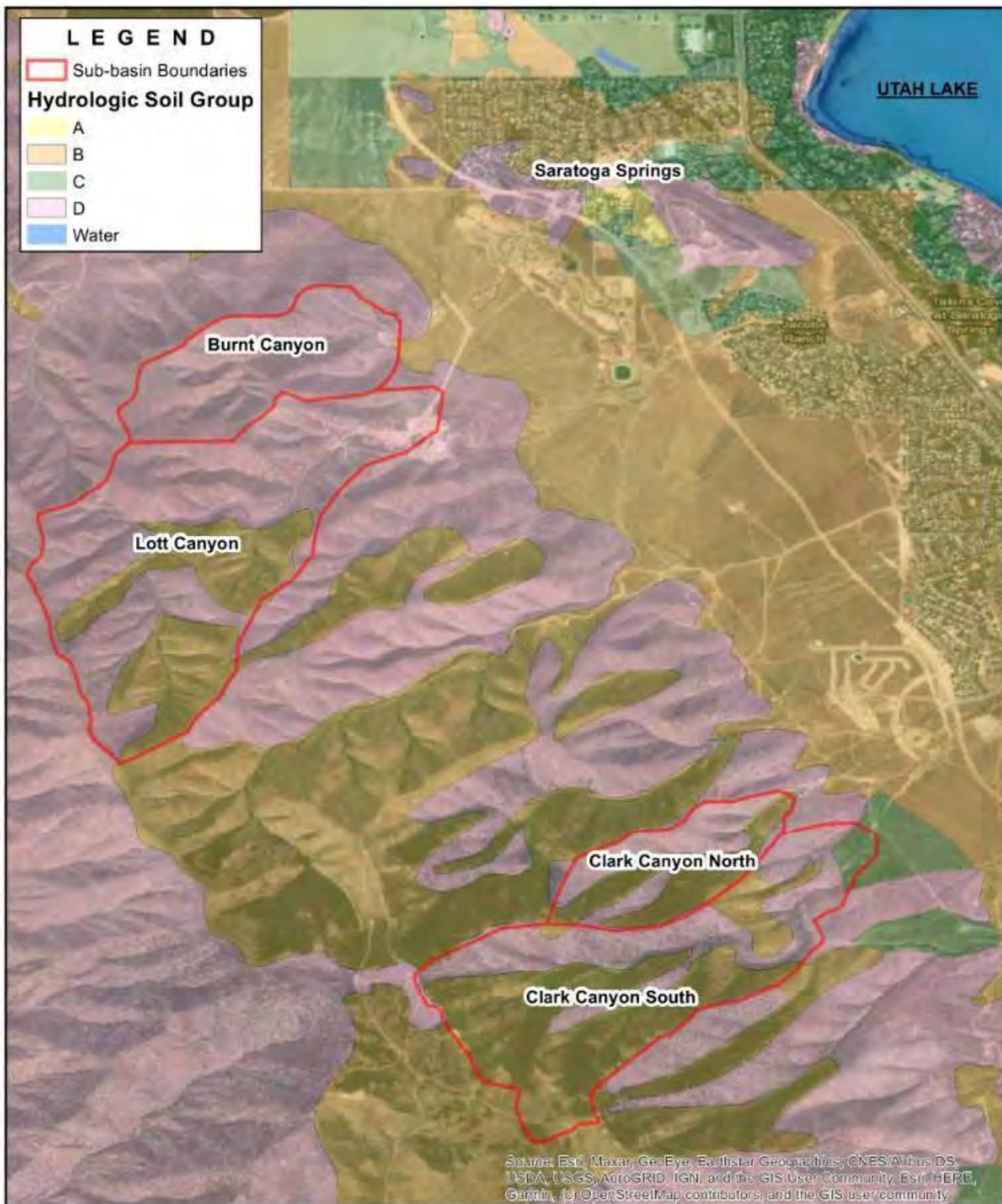
Land use or vegetative cover was determined by inspection of aerial imagery and the National Land Cover Dataset (NLCD). A section of the NLCD was clipped using GIS software for each sub-basin to determine the percentage of each land cover type. A map of land uses and vegetative cover present within the study area are shown on Figure 4.

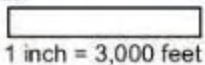
Using the land cover percentages and CNs in Table 2, composite CNs representing each sub-basin were calculated on a weighted area basis. The CNs used for hydrologic soil-cover complexes were based on information from NEH 630.0901. The Herbaceous areas were considered to be in “good” condition (ground cover greater than 70%) and the Desert Shrub/Pinyon Juniper/Forest Area areas were considered to be in “fair” condition (ground cover 30% to 70%).

Table 2
Curve Numbers for Hydrologic Soil-Cover Complexes

Land Use/Vegetative Cover	Hydrologic Soil Group			
	A	B	C	D
Herbaceous		62	74	85
Desert shrub	55	72	81	86
Pinyon Juniper / Forest Area		58	73	80

The calculated composite curve numbers for each sub-basin in the study area are provided in Table 3.



 BOWEN COLLINS ASSOCIATES	HYDROLOGIC SOIL GROUP MAP	NORTH: 	SCALE:  1 inch = 3,000 feet
	SARATOGA SPRINGS CITY SARATOGA SPRINGS WATERSHED PLAN EA	FIGURE NO: 3	

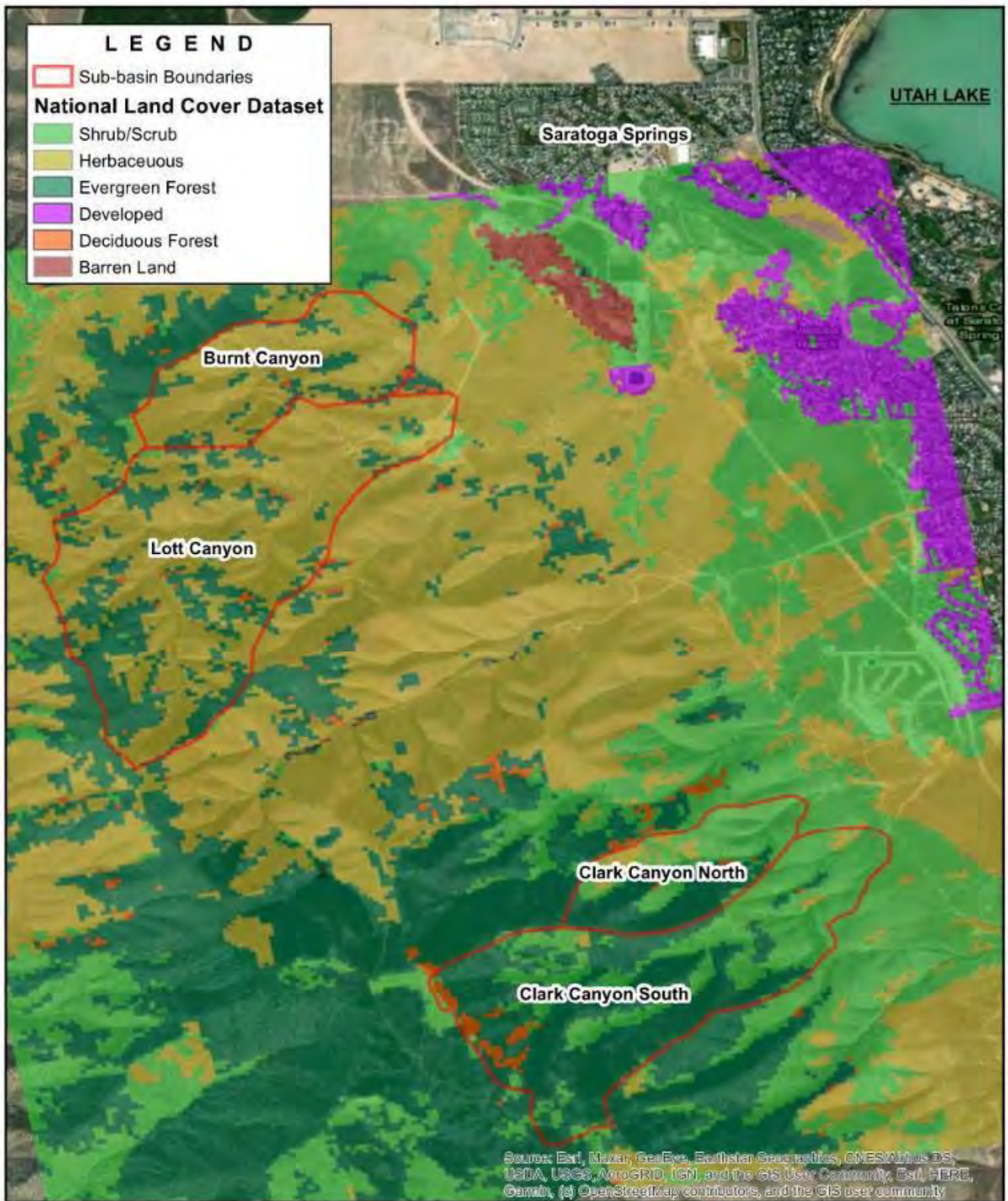


Table 3
Summary of Sub-basin Hydrologic Parameters

Basin ID	Drainage Area		Composite Curve Number	Time of Concentration (Tc) or Lag Time Calculation Method	Time of Conc. (Tc)		Lag Time	
	Acre	Sq. mi.			Hrs	Min	Hrs	Min
Burnt Canyon	250	0.39	83	SCS Lag Method	0.36	22	0.22	13
Lott Canyon	702	1.10	76	SCS Lag Method	0.73	44	0.44	26
Clark Canyon North	179	0.28	74	SCS Lag Method	0.36	22	0.22	13
Clark Canyon South	556	0.87	71	SCS Lag Method	0.77	47	0.46	28

2.3 DESIGN STORM PARAMETERS

A design storm is a synthetic rainfall event selected as a design standard that will be used to identify deficiencies and size needed flood protection measures. A design storm has a specified precipitation depth and temporal distribution. These depths and distributions are determined based on the type of storm being analyzed and the hazard potential rating of the various dams.

One goal of the proposed project is to reduce runoff flows generated from smaller, more frequent storms in the various canyons to a level that will not overwhelm existing downstream storm drain facilities. Each of the sub-basins included in this report is part of Saratoga Springs City's 2017 Storm Drain Capital Facilities Plan (SDCFP). The SDCFP defined available capacity in existing storm drain infrastructure downstream of the proposed basins and determined the runoff rates that would be allowed to enter the existing infrastructure from future development. Based on this information included in the SDCFP it was determined that the combined 100-year 24-hour release rate of the Lott and Burnt Canyon basins must not exceed 10.4 cfs and the release rate of the Clark Canyon basin must not exceed 46 cfs.

These release rates were referenced in sizing principal spillway outlet risers and conduits, debris basin volumes, and downstream discharge channels. While the 100-year, 24-hour storm was the design point for the debris basins, other return periods were modeled to evaluate the proposed debris basin's response to a range of storm events.

Channel-only alternatives do not provide significant attenuation of peak flows like the debris basin alternatives do. Therefore, the full peak flow from the 100-year, 24-hour storm was the design point for the channel-only alternatives. Other flow rates were also modeled to see how proposed channel facilities would perform at higher flow rates.

2.3.1 FLOOD HAZARD POTENTIAL RATING

A flood hazard potential rating analysis was performed to determine the dam hazard rating for the debris basin alternatives. An initial analysis of routing the runoff generated from a 100-year, 24-hour storm event through each debris basin was performed. The results of this analysis indicated that each of the four proposed debris basins will likely be considered to have High Hazard Potential by both

the NRCS and Utah Dam Safety due to the anticipated embankment height, debris basin storage volume, and proximity to residential development just downstream of the debris basins.

High Hazard Potential Dams require that additional storm events are modeled to help ensure that proposed structures will not fail, even during extreme weather events. Therefore, for this project, three types of storms were analyzed: 24-hour storms, NRCS Design Storms, and Utah Dam Safety Design Storms. These storm types are described in the following sections.

2.3.2 24-HOUR DESIGN STORMS

24-hour Storm Depths

Storm depths were retrieved from the National Oceanic and Atmospheric administration (NOAA) Precipitation Frequency Data Server (PFDS) which reports total storm depths for a specific geographic location based on NOAA Atlas 14 for various storm durations and return periods. The distance between Burnt and Lott Canyons and Clark Canyon is approximately 2.5 miles. While these canyons are relatively close to each other, NOAA Atlas indicated that storm depths in Clark Canyon were 5% to 7% higher than Burnt/Lott Canyons. For that reason, two sets of NOAA storm depths were used in this analysis. For the purposes of this project, two large storms occurring over all subject drainage basins at the same time were considered (one storm covering Burnt and Lott Canyons, and one storm covering North and South Clark Canyons). The extents of the considered design storms were approximated by the elliptical areas shown on Figure 5. Storm depths were obtained from the NOAA PFDS for the centroid of the ellipses. Point storm depth estimates for recurrence intervals from 2- to 500-years are provided in Table 4.

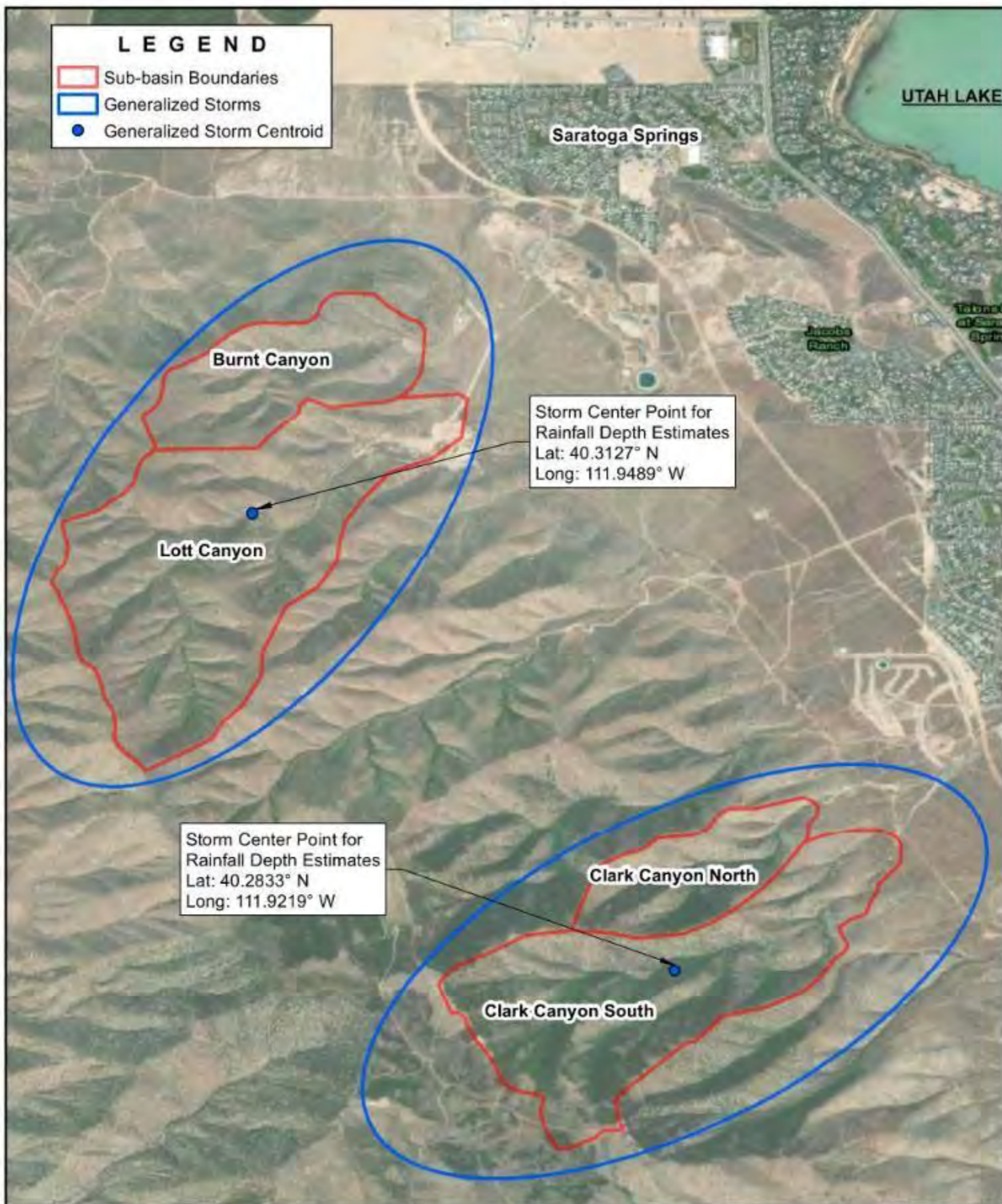
Supporting data for the storm depths from the NOAA PFDS can be found in Appendix A.

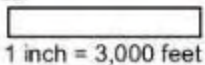
Areal Reduction Factor

Using the procedure described in NOAA Technical Report 24, the point storm depths were adjusted using an areal reduction factor to convert the point depths to area-averaged estimates covering the 2.5-square-mile, generalized storm areas shown in Figure 5. The areal reduction factor for a 24-hour storm and a 2.5-square-mile area is approximately 0.97. Areal adjusted depths are shown in Table 4.

Table 4
24-Hour Storm Depths (inches)

Location	Description	Recurrence Interval (years)						
		2	5	10	25	50	100	500
Burnt/Lott Canyons	NOAA Atlas 14 Point Depth (in)	1.17	1.39	1.58	1.82	2.01	2.2	2.77
	Areal Adjusted Depth (in)	1.13	1.35	1.53	1.76	1.95	2.13	2.69
Clark Canyon	NOAA Atlas 14 Point Depth (in)	1.33	1.59	1.81	2.11	2.32	2.55	3.08
	Areal Adjusted Depth (in)	1.29	1.54	1.75	2.04	2.25	2.47	2.99



 BOWEN COLLINS & ASSOCIATES	GENERALIZED DESIGN STORMS		NORTH: 	SCALE:  1 inch = 3,000 feet
	SARATOGA SPRINGS CITY SARATOGA SPRINGS WATERSHED PLAN EA			

24-Hour Storm Distributions

Two design storm distributions were considered for this component of the study: the 24-hour SCS type II and 24-hour WinTR-20 storms.

SCS Type II Storm Distribution: The 24-hour SCS Type II storm distribution is commonly used for detention basin design throughout Utah and is one of several regional design storms used by the NRCS.

WinTR-20 Storm Distribution: The 24-hour WinTR-20 storm is based on storm depths and durations obtained from NOAA Atlas 14. This storm distribution is specific to the project location. The development of this distribution is described in the draft chapter 4 of NEH 630 (Draft NEH 630.04). To create the distribution specific to this project, data from the NOAA Atlas PFDS was imported into NRCS WinTR-20 software. The software then smooths the data and generated storm distributions for various storm return periods.

2.3.3 NRCS DESIGN STORMS FOR DAMS

NRCS Design Storms for Dams were evaluated to develop the debris basin alternatives. The NRCS defines storm events and other parameters that must be modeled for high hazard potential dams in Technical Release 60 – Earth Dams and Reservoirs (TR-60). TR-60 requires that hydrographs from a variety of storm depths and durations be analyzed to determine proper sizing of the principal and auxiliary spillways. These hydrographs include the Freeboard Hydrograph, Principal Spillway Hydrograph, and Auxiliary Spillway Hydrograph. These design storms are discussed below.

Freeboard Hydrograph. NEH 630 Chapter 21 states that “the auxiliary spillway’s minimum freeboard and integrity are determined using a freeboard hydrograph (FBH)”. Figure 2-2 in TR-60 specifies that the FBH for a high hazard dam should be based on the Probable Maximum Precipitation (PMP) storm depth. The National Weather Service provides hydrometeorological reports to calculate PMP depths for various locations throughout the country. Hydrometeorological Report 49 (HMR49) covers the Colorado River and Great Basin Drainages, which includes Utah and surrounding areas. HMR49 contains instructions and worksheets that help calculate both local and general PMP storm depths and distributions. It was assumed that the same PMP values would apply to all four drainage basins.

TR-60 also states that the “NRCS allows consideration of special probable maximum precipitation (PMP) studies.” The State of Utah has published two such studies that modify the HMR49 PMP values based on storm duration and drainage basin area. These studies are titled “Probable Maximum Precipitation Estimates for Short-Duration, Small-Area Storms in Utah” (USUS) and “2002 Update for Probable Maximum Precipitation, Utah, 72-Hour Estimates, Area to 5,000 mi²” (USUL). These modified methods and values, which have been accepted by the NRCS, are the basis for determining the storm depths for the Saratoga Springs Debris Bains. Precipitation values calculated from HMR49, supplemented by USUS or USUL, were defined as Spillway Evaluation Precipitation (SEP) and were used to develop the FBH.

TR-60 states that both a 6-hour local and 24-hour general storm must be analyzed to determine the FBH. The temporal distribution for the 6-hr local storm was determined by using the methods identified in HMR49. The temporal distribution for the 24-hr general storm was based on the 5-point Rainfall Distribution as defined in NEH 630 Chapter 21. The resulting hydrographs for the local and general storms were routed through the basin in the hydrologic model. The runoff from the storm that produced the highest reservoir water surface elevation was found to be the 6-hour local storm and is referred to as the FBH. Design storm depths analyzed are provided in Table 5.

NRCS Auxiliary Spillway Hydrograph. In sizing the auxiliary spillway, NRCS TR-60 requires that the Auxiliary Spillway Hydrograph (ASH) is analyzed. The storm depth for the Auxiliary Spillway Hydrograph is a combination of the 100-year precipitation depth and the PMP depth, calculated by the following formula from TR-60 for a high hazard dam:

$$\text{Precipitation Depth} = P_{100} + 0.26(PMP - P_{100})$$

This precipitation depth is then distributed using NOAA Atlas 14 Volume 1 – Precipitation Frequency Atlas for the Semiarid Southwest United State. Based on experience of preparing many storm drain master plans throughout the state of Utah, BC&A has found that the NOAA Atlas 14 temporal distributions provides accurate, realistic results. Thus, NOAA Atlas 14 was used to find the temporal distributions for the 24-hour storm, based on the Second Quartile Distribution with a Cumulative Probability of Occurrence of 50% provided in NOAA Atlas 14 – Semiarid Southwest Convective Precipitation Area. Both 6-hour and 24-hour storm durations must be considered. These storm depths are listed in Table 5. The auxiliary spillway must be sized such that the auxiliary spillway hydrograph can be routed through the spillway, while maintaining adequate freeboard to contain wave action.

Wave Action: Wave action was estimated using methods and tables provided in Technical Release No. 69 (TR-69) – Riprap for Slope Protection Against Wave Action (NRCS, 1983). Wave height is a function of the wind speed, wind direction, and effective fetch length (the greatest straight line distance over open water from the dam). Wave height and runup was evaluated for Lott Canyon and these values were applied to each other basin. Using Method 2 described in TR-69, the effective fetch length of the basin was estimated to be 381 feet (0.07 miles). Using Figure 2 provided in TR-69 and assuming a wind speed of 50 mph and an effective fetch length of 0.07 miles, the estimated max wave height is 0.8 feet. Using Figure 11, the wave length is 11 feet and using Figure 12, the max runup is 0.8 feet. Thus, the auxiliary spillway hydrograph must be routed through the basin while maintaining a minimum of 1.0 feet of freeboard.

Wave erosion was also evaluated referencing TR-69. Figure 8 from TR-69 was used to determine the required weight of armor rock based on the calculated significant wave height. Figure 9 from TR-69 was then referenced to determine the rock size based on the rock weight. For the proposed basins, the significant wave height is 0.8 feet, upstream embankment slope is 3:1, and the rock size (D50) required is approximately 5 inches.

Principal Spillway Hydrograph

The NRCS requires that the auxiliary spillway crest elevation be 3 feet minimum lower than the elevation of the top of the embankment. Additionally, NRCS TR-60 requires that the principal spillway passes the Principal Spillway Hydrograph (PSH) on a watershed under normal soil moisture conditions (AMCII), without overtopping the auxiliary spillway. The PSH uses a combination of the 100-yr, 24-hour and 100-yr, 10-day precipitation depths. Methods for calculating the PSH are found in NEH 630, Chapter 21. The NRCS Water Resource Site Analysis (SITES) software has functionality to calculate the PSH and route it through the basins. For this design report, SITES was used to calculate and route the PSH through the basins to determine the maximum water surface elevation and set the minimum required auxiliary spillway crest elevation.

NOAA Atlas 14 Volume 1 – Precipitation Frequency Atlas for the Semiarid Southwest United States was referenced to find the 100-year storm depths. Table 5 lists the precipitation depths for the various design storms analyzed.

Table 5
Design Storm Depths

Sub-basins	Return Period	Depth (in) per Duration			
		6-hr	24-hr	72-hr	10-day
Burnt & Lott Canyons	PMP	12.36	9.27	13.45	-
	SEP^{1,3}	9.60	-	13.35	-
	100-yr^{2,3}	1.84	2.20	-	3.76
	ASH	3.86	4.04	-	-
Clark Canyon North & South	PMP	12.01	9.11	13.15	-
	SEP^{1,3}	9.34	-	13.10	-
	100-yr^{2,3}	1.98	2.55	-	4.73
	ASH	3.89	4.25	-	-

1. The SEP storm depth is used for the NRCS Freeboard hydrograph

2. The 10-day, 100-year storm depth is used for the NRCS Principal Spillway Hydrograph

3. The 6-hr SEP storm depth and the 6-hr, 100-yr storm depth is used for the Auxiliary Spillway Hydrograph

2.3.4 UTAH DAM SAFETY DESIGN STORMS FOR DAMS

The Utah Inflow Design Flood (IDF) was also evaluated to develop the debris basin alternatives. Per Utah Dam Safety the PMP durations that must be modeled are a 6-hr local storm and a 72-hr general storm. The 6-hour local storm SEP is also required to be routed by the NRCS and the development of this hydrograph was discussed in the NRCS Design Storm Section above. The 72-hour general storm was developed by referencing HMR49 and USUL, similar to the 24-hour general storm developed previously.

The storm distribution for the 6-hr local storm was determined by using the methods identified in HMR49. The storm distribution for the 72-hr general storm was provided by the State of Utah, and is also based on HMR49 methods. The resulting hydrographs for the local and general storms are referred to as Spillway Evaluation Floods (SEF) and routed through the basins in the hydrologic model. The runoff from the storm that produces the highest reservoir water surface elevation is referred to as the Inflow Design Flood (IDF).

Based on the results of the hydrologic routing model provided in the following section, the more critical SEF is calculated to be the 6-hr, local storm. Per Utah Dam Safety requirements, in addition to routing the 6-hr local SEF, the storm generated from the 100-yr, 6-hr precipitation event (or the 100-yr, 24-hr storm if the 24-hr general SEF controlled) on a saturated watershed (AMCIII) must also be routed through the basin while maintaining adequate freeboard to contain wave action from a fetch controlled 50 mph wind (minimum of 3 feet). The storm that produces the highest water surface elevation, while also accounting for allowable freeboard, is considered the IDF. Table 5 lists the precipitation depths for the various SEP and 100-year storm durations analyzed in this design report.

2.4 EXISTING CONDITIONS PEAK DISCHARGES

Between the 24-hour SCS Type II and WinTR-20 distributions, the WinTR-20 distribution typically produced the largest peak runoffs, therefore all runoff values for the 24-hour storms discussed and shown on the figures of this TM are from model runs using the WinTR-20 storm distribution. For other NRCS and Utah Dam Safety design storms, precipitation temporal distributions as described in

the relevant sections above were used. The peak flows and total runoff volumes for various return periods for each modeled sub-basin are summarized in Table 6.

Table 6
Existing Conditions Model Peak Discharge Summary

Storm Type	Storm Description	Temporal Distribution	Sub-basin Peak Discharge (cfs)				Runoff Volume (acre-ft)			
			Burnt Canyon	Lott Canyon	Clark Canyon North	Clark Canyon South	Burnt Canyon	Lott Canyon	Clark Canyon North	Clark Canyon South
24-hr Design Storms	2-yr	Win TR-20	36	12	5	5	4	4	1	2
	5-yr	Win TR-20	69	38	18	19	6	8	2	5
	10-yr	Win TR-20	104	74	35	43	8	12	4	8
	25-yr	Win TR-20	160	139	67	90	11	18	6	13
	50-yr	Win TR-20	213	204	98	139	14	23	7	17
	100-yr	Win TR-20	273	283	136	201	16	28	9	22
NRCS Design Storms	500-yr	Win TR-20	493	587	255	400	25	48	13	35
	6-hr Local SEP	HMR49	1873	3674	1027	2416	156	388	92	266
	24-hr General PMP	TR-60 5-point Distribution	196	509	126	369	148	363	87	252
	PSH	TR-60, SITES	50	76	21	41	-	-	-	-
	6-hr ASH	NOAA Atlas 14	220	457	116	287	45	93	22	58
	24-hr ASH	NOAA Atlas 14	71	154	40	106	50	107	27	73
Utah Dam Safety Design Storms	72-hr General SEP	Utah Dam Safety Distribution	158	427	105	317	232	596	144	426
	100-yr, 6-hr (AMCIII)	NOAA Atlas 14	137	261	75	192	30	53	14	38
	100-yr, 24-hr (AMCIII)	NOAA Atlas 14	51	109	31	86	39	76	21	60

SECTION 3 - FLOODING ANALYSIS

3.1 INTRODUCTION/BACKGROUND

Each of the sub-basins included in this report is part of Saratoga Springs City's SDCFP. The SDCFP defined available capacity in existing storm drain infrastructure downstream of the proposed basins and determined what future development runoff rates will be restricted to flowing into the existing infrastructure. Based on this information included in the SDCFP it was determined for the debris basin alternatives that the combined 100-year 24-hour release rate of the Lott and Burnt Canyon basins must not exceed 10.4 cfs and the release rate of the Clark Canyon Basins must not exceed 46 cfs.

In order to better evaluate flooding risks within the City, we developed a two-dimensional model of each of the floodplains. The development of this model is discussed in detail in the sections that follow.

3.2 FLOODPLAIN HYDRAULIC MODEL DEVELOPMENT

3.2.1 HYDRAULIC MODEL APPROACH

HEC-RAS version 5.0.7 was used to develop the project hydraulic models. Since major overland flooding occurs throughout the City, it was determined that the best modeling approach would be a two-dimensional (2D) flow analysis. All scenarios were modeled as 2D flow areas. A 2D hydraulic model has four main components: unsteady flow data, 2D flow areas, surface roughness values, and model boundary conditions at the upstream and downstream ends of the hydraulic model. The data and processes that were used to develop these model elements are described below.

3.2.2 UNSTEADY FLOW DATA

The 2D hydraulic model requires unsteady flow data. A total of 3 model inflow locations (one for each drainage area) were used in the hydraulic models to represent the respective inflows across the drainage area as shown in Figure 6. The HEC-HMS hydrologic model described in Section 2 of this TM provides peak runoff values as well as runoff hydrographs for each basin. The SCS unit hydrograph method was used in HEC-HMS to develop runoffs hydrographs for each sub-basin. This method provided a realistic hydrograph to enter into the hydraulic model. This method was repeated for all seven storm event frequencies (i.e. 2-, 5-, 10-, 25-, 50-, 100-, and 500-year events). The existing condition runoff hydrographs were used for all existing condition models. These existing runoff hydrographs were also used for the channel-only proposed condition. For the debris basin alternatives, the proposed condition runoff hydrographs were updated to reflect the reduction in peak flow due to attenuation in the basin.

3.2.3 2D FLOW AREA

The 2D flow area within HEC-RAS is generated based on several inputs that mainly include the following; a perimeter, underlying terrain data, computational cell size, and break lines. A perimeter was created that encompasses the resulting floodplains. Based on this perimeter, a grid was generated based on a given maximum cell size. The cell size was adjusted based on the given topography until a stable model run was achieved. This was determined by a courant number analysis of the model. The maximum cell size used for these hydraulic models was 20-feet square. This resulted in a grid consisting of approximately 172,000 cells for Burnt and Lott Canyons and 154,000 cells for Clark Canyon. HEC-RAS creates detailed hydraulic table properties for each cell based on the underlying terrain, which in this case is the 2014 0.5 meter and 2018 0.5-meter LiDAR

obtained from AGRC. The 2018 data was used where available and surrounding areas were filled in with the 2014 data. These tables incorporate details from the underlying terrain to represent the cell and cell faces, thus maintaining the details from the underlying terrain. Break lines were then added to the 2D flow area to align the cells faces with natural boundaries in the underlying terrain. These boundaries mainly consisted of roadway crests, embankments, and channels.

3.2.4 SURFACE ROUGHNESS VALUES

A Manning's roughness coefficient (n-value) must be given to each computational cell within the model. This was done by subdividing the floodplain area into two surface roughness subareas based on land use as indicated by 2019 aerial imagery. The n-value was then chosen based on the surface roughness representative of the land use of each sub area (Chow, 1959). Table 7 provides a summary of the roughness coefficients and subarea descriptions used in the hydraulic model.

Table 7
Roughness Coefficients used in Hydraulic Model

Description	Manning's n Values Used
Developed/Residential Areas	0.06
Channel / Brush / Open Areas	0.04

3.2.5 MODEL BOUNDARY CONDITIONS

Upstream and downstream boundary conditions were required at each model inflow area and at the downstream outlet of the model. The upstream boundary conditions (model inflow locations) were placed at their respective drainage outlets. Upstream boundary conditions were set to the basin discharge hydrographs determined by the HEC-HMS hydrology model discussed previously. At the upstream boundary locations, flow was distributed across the boundary by the model based on the slope of the terrain surface at the boundary. The downstream boundary condition was placed at Utah Lake. For the downstream boundary condition, a normal depth assumption was used. The model determines normal depth at the boundary using a user defined friction slope. This slope was determined by measuring the slope of the terrain surface at the boundary location. The downstream boundary condition was set far enough downstream to collect all surface water from flooding throughout the City.

3.2.6 EXISTING CONDITIONS FLOODPLAIN MAPPING

Figures 6 and 7 show the existing conditions floodplain maps for the 100- and 500-year events based on the above criteria. Each of the analyzed canyons are located above alluvial fans without a single defined channel. As a result, it is impossible to know what direction flow will go in a larger storm event. To account for the several possibilities, multiple flow paths were considered and modeled to determine the possible extents of flooding under a variety of different flow scenarios. In each of these scenarios, the flow was forced to one of the potential drainage paths and the corresponding flooding analyzed.

Figure 6 shows the resulting floodplain mapping for Burnt and Lott Canyons. The mapping represents the flow path that is likely to occur with the existing topography that would result in the greatest amount of downstream flooding. As can be seen in the figure, the floodplain shown in this figure largely avoids the clay pits area. In other modeled scenarios, the existing clay pit basins captured and retained most of the runoff flow which resulted in minimal flooding impacts in downstream developments in the model. In the near future, the clay pits will be filled in to

accommodate new development, so models showing minimal flooding due to runoff being captured in the clay pits were not considered accurate for planning purposes.

The floodplain mapping shown for Clark Canyon in Figure 7 represents the preferred flow path for the flow regardless of the initial path exiting the canyon in the alluvial fan. Because of the topography in the area, flows returned to the same flooding area in all alluvial fan flow paths analyzed.

As shown in these Figures, existing roads contain and convey most of the flooding, however some residential homes are flooded, especially those closest to the canyons. Figures showing the floodplains for all events modeled for this study, including the 2-, 5-, 10-, 25-, 50-, 100-, and 500-year events, are included in Appendix B for reference.



SECTION 4 - PROPOSED FLOOD MITIGATION ALTERNATIVE

4.1 BACKGROUND

To help mitigate the potential flooding in Saratoga Springs City below Burnt, Lott, and Clark Canyons, the following alternatives were evaluated.

1. Construct four new debris basins at the mouths of Burnt Canyon, Lott Canyon, and Clark Canyon to capture sediment and detain and attenuate expected flood flows. Debris basin construction includes installation of an earthen embankment, excavation of debris basin storage area, excavation of earthen auxiliary spillway, installation of principal spillway outlet riser and conduit, installation of access roads, and construction of downstream channels.
2. Construct two new larger debris basins. One basin would capture runoff from Burnt and Lott Canyon and would be located in the existing Clay Pits area. The other basin would capture runoff from Clark Canyon. Channels would be constructed to direct flow from the canyons to the debris basins.
3. Construct drainage channels that convey the design storm runoff directly to Utah Lake. This alternative would involve enlarging existing drainage channels, stabilizing the banks with a combination of rock and bio-engineered bank protection, installing new, larger culverts, and rebuilding roads where culverts were installed.
4. Do nothing.

Each of these alternatives will be discussed further below.

4.2 DESIGN LIFE AND PERFORMANCE REQUIREMENTS

The proposed debris basins are sized for a 100-year design life and must meet the requirements of NRCS TR-60 and Utah Dam Safety rules. These requirements include accounting for sediment deposition, routing the PSH and auxiliary spillway hydrograph (which uses 100-year storm depths), and routing the FBH. The combination of meeting these requirements set the minimum sizes for the debris basins and spillways.

Based on feedback from NRCS-Utah personnel, the typical performance of the debris basin and auxiliary spillway must first be sized based on a 50-year storm event. After sizing for a 50-year storm event, a 100-year storm event must be routed through the 50-year structure. If the resultant floodplain would be widespread or deep enough to potentially cause loss of life, then the structure must be redesigned to accommodate the 100-year storm event.

Similarly, any channel-only alternatives would also first be sized for a 50-year runoff event. If routing the 100-year runoff event through 50-year facility would cause potential loss of life due to the depth and velocity of the floodplain, then the channel would be enlarged to the 100-year design event.

For the Burnt and Lott Canyon projects, it was found that facilities designed for the 50-year runoff event were insufficient when routing the 100-year runoff through them. Therefore, the Burnt and Lott Canyon alternatives described in this section were sized based on the 100-year runoff event.

For the Clark Canyon projects, the 50-year designed debris basins were sufficient to route the 100-year runoff event. This is due primarily to the existing, relatively large drainage channel downstream of the proposed debris basins having sufficient excess capacity to contain the higher flow associated

with the 100-year event. The difference in size between an embankment designed for the 50-year event and one designed for the 100-year event is relatively small (1 to 2 feet difference in height of dam).

However, for the channel-only option, the 50-year runoff-designed facility was insufficient to convey the 100-year runoff event without causing potential loss of life. Therefore, the Clark Canyon channel option was sized based on a 100-year runoff event.

4.3 ALTERNATIVE 1 – FOUR EARTHEN EMBANKMENT DEBRIS BASINS

The first alternative evaluated includes construction of four debris basins on the watersheds upstream of Saratoga Springs City in Burnt Canyon, Lott Canyon, and Clark Canyon, as shown on Figure 8 and Figure 9. The purpose of these debris basins is to detain and attenuate expected flood flows and mitigate debris such that the basin outflow can be conveyed by the existing storm drain facilities, eliminating downstream flooding during the 100-year design event. The recommended improvements associated with Alternative 1 are summarized in Table 8.

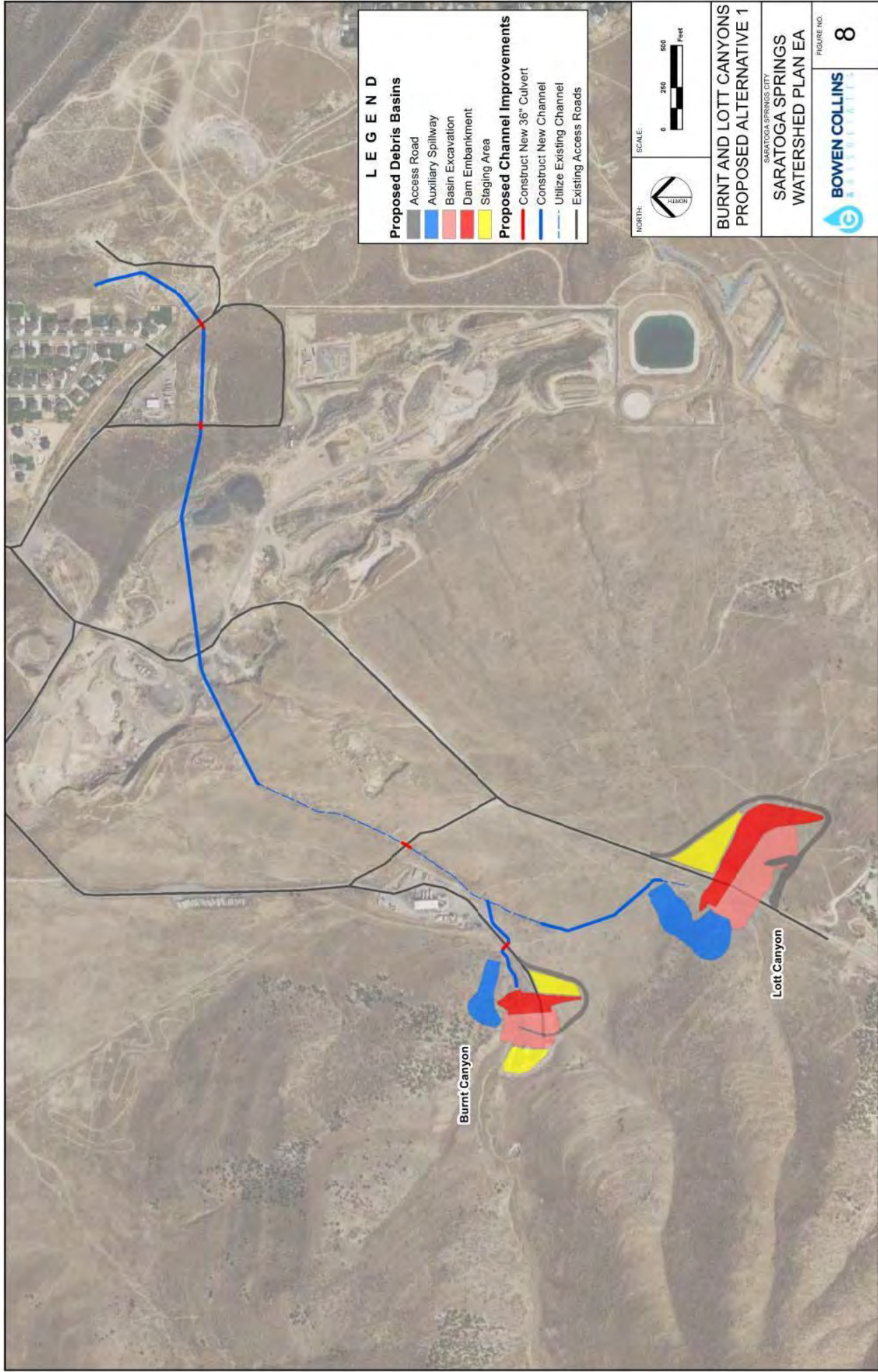




Table 8
Summary of Proposed Mitigation Measures – Alternative 1

No.	Description of Improvement	Result
I	Construct a new 18.4 ac-ft debris basin at the mouth of Burnt Canyon	Reduce the “Burnt Canyon” sub-basin peak 100-yr, 24-hr runoff from 274 cfs to 3.1 cfs
II	Construct a new 35.3 ac-ft debris basin at the mouth of Lott Canyon	Reduce the peak 100-yr, 24-hr runoff from “Lott Canyon” sub-basin from 283 cfs to 7.0 cfs.
III	Construct a new 6.0 ac-ft debris basin at the mouth of Clark Canyon (North)	Reduce peak 50-yr, 24-hr runoff from “Clark Canyon North” sub-basin from 98 cfs to 21 cfs.
IV	Construct a new 18.3 ac-ft debris basin at the mouth of Clark Canyon (South)	Reduce peak 50-yr, 24-hr runoff from “Clark Canyon South” sub-basin from 139 cfs to 25 cfs.
V	Construct a new drainage channel downstream of the Burnt Canyon, Lott Canyon, and Clark Canyon North Debris Basins that connects to existing drainage infrastructure	Control conveyance of Burnt, Lott, and Clark Canyon outflow

The overall reduction of peak runoff from Burnt Canyon, Lott Canyon, and Clark Canyon provides the following benefits:

- Reduces overall flooding in Saratoga Springs.
- Reduces runoff from Burnt Canyon and Lott Canyon to flow rates that can be conveyed by master planned storm drain facilities.
- Holding and controlling the release of runoff within the basins allows suspended sediment and debris to settle out in the basin.
- Sediment is accumulated in a centralized location, significantly reducing cleanup costs after a flood event.
- Provides the best overall protection to Saratoga Springs residents.

This alternative will be further explained in the following subsections.

4.3.1 PRELIMINARY GEOTECHNICAL EVALUATION

A preliminary geotechnical assessment of the four potential debris basin sites was performed by Rosenberg and Associates. This preliminary report consists of the findings of a desktop evaluation of general geotechnical conditions near the proposed sites. The report also includes results of a

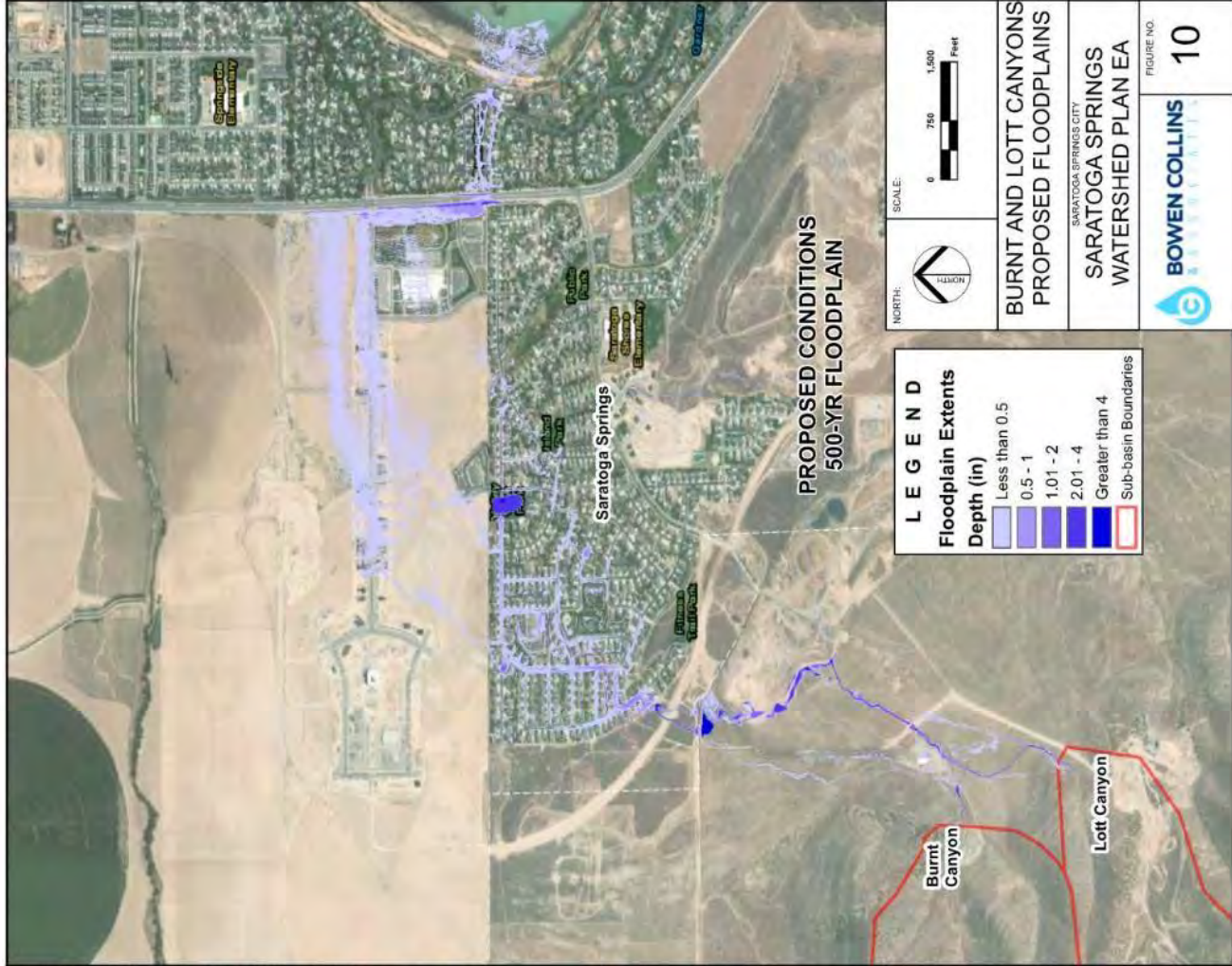
preliminary field investigation of the proposed sites. The purpose of this preliminary geotechnical report is to identify potential major fatal flaws, evaluate the general suitability of the soils for support of the proposed debris basin dams, and to estimate the erodibility of soils where spillways are proposed. The geotechnical report is provided in Appendix F and primary findings of the report are listed below:

- Geologic conditions mapped by the Utah Geological Survey in the project area include gray sandy to fossiliferous limestone bedrock, stream deposits, alluvial deposits at drainage mouths, and colluvial deposits on moderate slopes. The mapped bedrock deposits may provide a solid foundation for the proposed debris basin dams.
- No “Holocene-active” or “Conditionally active” faults, landslides, or karst features such as sinkholes or caves are documented within the proposed project sites.
- Field investigations near the proposed auxiliary spillway sites found that in most cases bedrock was encountered within 2 to 5 feet of the ground surface. Presence of shallow bedrock in these locations indicate that most of the proposed auxiliary spillways would not require additional armoring to prevent erosion.

Based on these preliminary findings, no fatal flaws were identified. However, the Geotech report notes that the alluvial and colluvial deposits may be susceptible to soil collapse and could experience moderate to strong ground shaking caused by seismic activity. For these reasons, it is recommended that during the design phase a more extensive geotechnical evaluation of subsurface conditions be conducted to verify the suitability of the bedrock layer as a foundation for the proposed dams, determine what if any conditioning would be recommended to stabilize the proposed dam foundations, evaluate the suitability of on-site materials for use in construction of the proposed dams, and to verify the extents of bedrock within the auxiliary spillway control sections and channels.

4.3.2 FLOODPLAIN MAPPING – ALTERNATIVE 1

Floodplain mapping showing the flooding downstream of the proposed debris basins for the 100- and 500-year events is shown on Figures 10 and 11. Additional floodplain maps showing the floodplain during the 2-, 5-, 10-, 25-, 50-, and 200-year events after the construction of the new debris basins are provided in Appendix B.



4.3.3 SEDIMENTATION

The National Engineering Handbook Section 3 Sedimentation notes, *“The design life of a reservoir is the period required for the reservoir to fulfill its intended purpose. Structures designed by the SCS in the watershed protection and flood prevention programs usually are designed for a life of 50 or 100 years. Provision must be made to ensure the full design storage capacity for the planned design life. This may mean cleaning out deposited sediment at predetermined intervals during the design life or, as is generally the situation, providing enough capacity to store all the accumulated sediment for the reservoir’s design life without diminishing the design water storage”*. The purpose of this section is to estimate the design sedimentation rate to be used in the design of the proposed basins. This sedimentation rate is based on an investigation of several different methods for estimating sedimentation rates, which will be discussed further below.

Sediment Specific Weight. Sedimentation rates provided in this TM are in units of acre-feet of sediment deposited per square-mile of watershed area per year. Often studies and calculation methods are provided in units of tons per acre per year. Converting from one unit system into another requires an estimate of the specific (unit) weight of sediment. The unit weight of sediment for the Burnt, Lott, and Clark Canyon watersheds was estimated to be 80 lbs/ft³. This estimate was taken from Table 8-1 from the NEH Section 3 – Sedimentation manual based on an aerated or submerged clay/silt/sand mixture. The 80 lbs/ft³ translates to a conservative sedimentation volume estimate and similar unit weights have been used on other NRCS Watershed Projects in the region.

Table 8-1.—Volume-weight of sediment by grain size

Grain size	Volume-weight of sediment	
	Submerged	Aerated
	lb/ft ³	lb/ft ³
Clay	35–55	55–75
Silt	55–75	75–85
Clay-silt mixtures (equal parts)	40–65	65–85
Sand-silt mixtures (equal parts)	75–95	95–110
Clay-silt-sand mixtures (equal parts)	50–80	80–100
Sand	85–100	85–100
Gravel	85–125	85–125
Poorly sorted sand and gravel	95–130	95–130

Figure 12. Table 8-1 from NEH Section 3 – Sedimentation

Sedimentation Yield Rate Methodology. When available, methods which rely on site survey data are considered superior to calculated or estimated methods since they depend on measurements of deposited material at the actual site. In the absence of site survey data at the four proposed debris basin sites, the following methods were used to analyze the sedimentation rates for the Burnt, Lott, and Clark Canyon watersheds:

1. U.S. Department of Agriculture (USDA) mapped sedimentation rates for the state of Utah.
2. Rangeland Hydrology and Erosion Model Web Tool (RHEM).

USDA Sediment Map. According to the USDA map of sedimentation rate in Utah, the Burnt, Lott, and Clark Canyon watersheds fall within a yield class 5 (0.1 to 0.2 ac-ft per square-mile per year). The average estimated yield rate for class 5 is 0.15 ac-ft per square-mile per year. The USDA sedimentation map overlaid on a map of the drainage area boundaries is provided in Appendix C for information.

RHEM Sediment Rate. The Rangeland Hydrology and Erosion Model (RHEM) is a web-based tool that is designed to provide sound, science-based technology to model and predict runoff erosion rates on rangelands and to assist in assessing rangeland conservation practice effects. The watershed characteristics and parameters input into the RHEM tool, along with the calculated output are provided in Table 9.

Table 9
RHEM Model Characteristics

DEBRIS BASIN WATERSHED	BURNT	LOTT	CLARK N	CLARK S
RHEM Model Version	2.3	2.3	2.3	2.3
State ID	UT	UT	UT	UT
Climate Station	Utah Lake Lehi	Utah Lake Lehi	Utah Lake Lehi	Utah Lake Lehi
Soil Texture	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam
Soil Water Saturation %	25	25	25	25
Slope Length (feet)	164.04	164.04	164.04	164.04
Slope Shape	Uniform	Uniform	Uniform	Uniform
Slope Steepness %	22	27	30	26
Bunch Grass Foliar Cover %	38	35	32	32
Forbs and/or Annual Grasses Foliar Cover %	0	0	0	0
Shrubs Foliar Cover %	10	15	25	23
Sod Grass Foliar Cover %	0	0	0	0
Total Foliar Cover %	48	50	57	55
Basal Cover %	0	0	0	0
Rock Cover %	10	10	10	10
Litter Cover %	0	0	0	0
Biological Crusts Cover %	10	10	10	10
Total Ground Cover %	20	20	20	20
AVERAGE ANNUAL RESULTS				
Avg. Precipitation (inches/year)	10.898	10.898	10.898	10.898
Avg. Runoff (inches/year)	0.142	0.138	0.133	0.134
Avg. Sediment Yield (ton/ac/year)	0.475	0.608	0.631	0.518
Avg. Soil Loss (ton/ac/year)	0.481	0.616	0.639	0.524
Avg. Sediment Yield (ac-ft/sq mi/year)	0.17	0.22	0.23	0.19

Assuming the unit weight of sediment of 80 lbs/ft³ discussed previously, the calculated average yield rate (annual soil loss) for Burnt Canyon of 0.475 ton/ac/year is converted to 0.17 ac-ft/sq mi/yr. Sediment yield rates in ac-ft/sq mi/yr for each other watershed were also calculated (see Table 9).

Design Sedimentation Rate. Table 10 below provides a summary of the sedimentation rates and estimated design life of the four proposed debris basins.

Table 10
Sediment Yield Rates for Burnt, Lott, and Clark Canyons

Source	Value Type	Yield Rate (ac-ft/sq. mi./yr)			
		Burnt Canyon	Lott Canyon	Clark Canyon North	Clark Canyon South
Sediment Yield Map (USDA 1973)	Minimum	0.1	0.1	0.1	0.1
	Maximum	0.2	0.2	0.2	0.2
	Average	0.15	0.15	0.15	0.15
RHEM Model (USDA 2013)	Calculated ¹	0.17	0.22	0.23	0.19
Average Estimate	Average²	0.16	0.186	0.19	0.17

Notes:

1. The average annual streamflow was estimated using the regression equation for un-gaged streams in Utah taken from Wilkowske et al. (2008).
2. Calculated sediment storage volumes do not account for trap efficiency.

As shown in Table 10, an average of the Sediment Yield Map value and RHEM model calculated value (0.16 ac-ft of sediment per square mile of drainage area per year) was used for the design sediment yield for the Burnt Canyon Debris Basin. Sediment yield rates for the other basins were also determined.

Trap Efficiency. The trap efficiency is an important measure of a debris basins ability to impound sediment and is a critical component of determining the ultimate life of the basin from the perspective of sediment deposition. Trap efficiencies can be estimated based on basin and watershed characteristics, and according to Figure 8-2 of NEH Section 3 – Sedimentation, trap efficiency is a function of the ratio of basin (sediment and floodwater) capacity to annual average inflow. The watershed characteristics used to estimate the trap efficiency for the proposed debris basins are provided in Table 11.

Table 11
Trap Efficiency Characteristics

Characteristic	Burnt Canyon	Lott Canyon	Clark Canyon North	Clark Canyon South	Remarks
Drainage Area (sq. miles)	0.39	1.1	0.28	0.87	
Estimated Flood Storage Requirement	15.3	25.2	3.5	11.2	(See Hydrology Section)
Estimated Design Life Sediment Yield	3.2	10.3	2.6	7.4	Assuming 50-year Design Life
Trap Efficiency	98%	98%	96%	96%	From Figure 1
Estimated Sediment Storage Req. (ac-ft)	3.1	10.1	2.5	7.1	(Sediment yield * Trap Efficiency, must assume trap efficiency and iterate)
Required Basin Capacity (ac-ft) ²	18.4	35.3	6.0	18.3	(Est. Flood Storage Req.+ Est. Sediment Storage Req.)
Average Annual Inflow (cfs)	0.11	0.27	0.08	0.22	See Note 1
Average Annual Inflow (ac-ft/yr)	81	197	61	161	
Capacity/Inflow	0.245	0.244	0.151	0.156	(Req. Basin Capacity/Avg. Annual Inflow)

Notes:

1. The average annual streamflow was estimated using the regression equation for un-gaged streams in Utah taken from Wilkowske et al. (2008). The regression equation applicable to the subject basin is based on drainage area.

Using the capacity/inflow ratios for the four basins and Figure 8-2 of NEH Section 3 – Sedimentation the trap efficiency for the basins was determined. It should be noted that for this estimation the “*primarily highly flocculated and coarse-grained sediments*” curve was used to be conservative. The estimated trap efficiency for the proposed basins is shown on Figure 13.

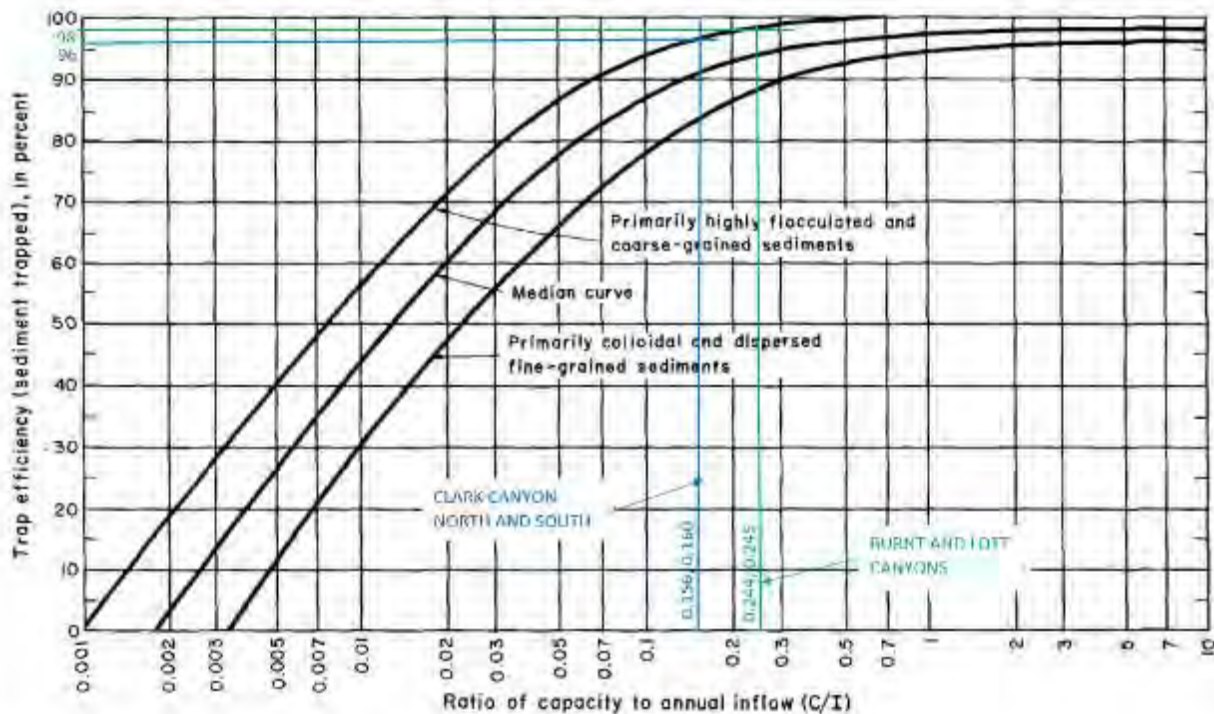


Figure 8-2.—Trap efficiency of reservoirs.

Figure 13. Trap Efficiency Curves (Figure 8-2 NEH Section 3)

As shown on Figure 13, the estimated trap efficiencies for the Burnt/Lott Canyon and Clark Canyon Debris Basins are 98% and 96% respectively.

The sediment storage volumes for the 50- and 100-year events were further evaluated based upon the estimated trap efficiencies calculated above (i.e. sediment volume x trap efficiency). The design sedimentation volumes for the proposed Debris Basins are as follows:

Burnt Canyon Debris Basin 50-year Volume	3.1 ac-ft
Burnt Canyon Debris Basin 100-year Volume	6.2 ac-ft
Lott Canyon Debris Basin 50-year Volume	10.1 ac-ft
Lott Canyon Debris Basin 100-year Volume	20.2 ac-ft
Clark Canyon North Debris Basin 50-year Volume	2.5 ac-ft
Clark Canyon North Debris Basin 100-year Volume	5.0 ac-ft
Clark Canyon South Debris Basin 50-year Volume	7.1 ac-ft
Clark Canyon South Debris Basin 100-year Volume	14.2 ac-ft

NRCS TR-60 recommends a design life for a debris basin of 50 to 100 years. A preliminary economic analysis indicated that the cost of more frequent sediment removal was less expensive than the additional capital cost required to increase the size and storage capacity of the debris. Therefore, the proposed debris basins are assumed to have a 100-year life, but capacity for 50 years of sediment

storage. After 50 years, the accumulated sediment must be removed to prolong the effective design life of the debris basin an additional 50 years.

Post Fire Sedimentation. The sedimentation rates and volumes discussed in the previous section assume historic or typical soil conditions and vegetation cover. These average rates were used to estimate total sediment volume over the 100-year life of the debris basins. It is possible that the soil and cover conditions may be different at time than the typical conditions assumed, especially after a wildfire. It is anticipated that sediment yield rates will be greater on a burned watershed.

Saratoga Springs has experienced wildfires in the recent past. In June 2012, the Dump Fire burned an area of approximately 6,000 acres and caused the evacuation of approximately 9,000 residents. On September 1, 2012, a large storm event occurred that centered over an unnamed tributary and Israel Canyon, within the Dump Fire burn area. The precipitation depth for the storm event was estimated to be 1.25 inches over a 25-minute duration, or approximately two times the 100-year flow. This high intensity storm caused erosion in the weakened watershed and resulted in debris and sediment being deposited within residential neighborhoods.

Shortly after this storm, a study was performed by the NRCS to estimate the volume of sediment that might be generated from the burned watershed for a range of storm events (Todea, 2019). Numerous methods were discussed to determine an estimate of the range of sediment. These methods generally agreed that the range of sediment volumes were 10,000 tons to over 50,000 tons for the post-fire 25- to 100-year storm events. The watershed analyzed as part of that study was 2.5 square miles, or approximately equal to the combined watershed areas of Burnt, Lott, and Clark Canyons. Assuming a soil weight of 80 lbs/ft³, the range of estimated sediment is 5.7 acre-feet to 28.7 acre-feet. The total combined sediment storage for the four proposed debris basins is 45.6 acre-feet. Based on the sediment estimates from the NRCS Dump Fire study, sediment produced from a 25-year storm event over the burned watershed would fill approximately 13% of the total proposed sediment storage. Similarly, a 100-year event would result in filling approximately 63% of the total proposed sediment storage.

For the purpose of sizing the proposed debris basins, it is assumed that the current portions of the watersheds that were damaged during the recent fire will recover over time and that the average sediment yield over the life of the debris basins can be based on average or typical conditions. It is recommended that the Standard Operating Plan for the proposed debris basins includes instructions for maintenance following a large runoff event on a potentially burned watershed. These directions should include the removal of sediment to account for the higher-than-typical volumes of sediment produced from the burned watershed.

4.3.4 DEBRIS BASIN CLASSIFICATION AND BREACH ANALYSIS

To define the design criteria for the debris basins, the hazard potential rating for the basins must first be classified. When classifying a dam, several factors are considered including the potential for damage to existing and future development due to a breach, failure or landslide in the dam. The NRCS NEM-210 Section 520.21.E provides the following criteria for classifying a dam:

1. Low Hazard Potential. – Dams in rural or agricultural areas where failure may damage farm buildings, agricultural land, or township and country roads
2. Significant Hazard Potential. – Dams in predominantly rural or agricultural areas where failure may damage isolated homes, main highways, or minor railroads, or interrupt service of relatively important public utilities.

3. High Hazard Potential. – Dams where failure may cause loss of life or serious damage to homes, industrial or commercial buildings, important public utilities, main highways, or railroads.

A dam breach analysis was completed for each of the four debris basins based on NRCS TR-60 methods. The depth of water at the dam at the time of failure (H_w) is less than 103-feet so the following equations were used for the analysis:

$$Q_{\max} = (1,100) B_r^{1.35}$$

Where $B_r = V_s H_w / A$

V_s = reservoir storage at time of failure

H_w = depth of water at time of failure

A = cross-sectional area of embankment at the assumed location of breach

But, not less than $Q_{\max} = (3.2) H_w^{2.5}$

Or more than $Q_{\max} = (65) H_w^{1.85}$

The H_w depth for the Burnt Canyon Debris Basin is shown on Figure 14 and the width of the valley at the water surface elevation corresponding to the depth (H_w) is shown on Figure 15.

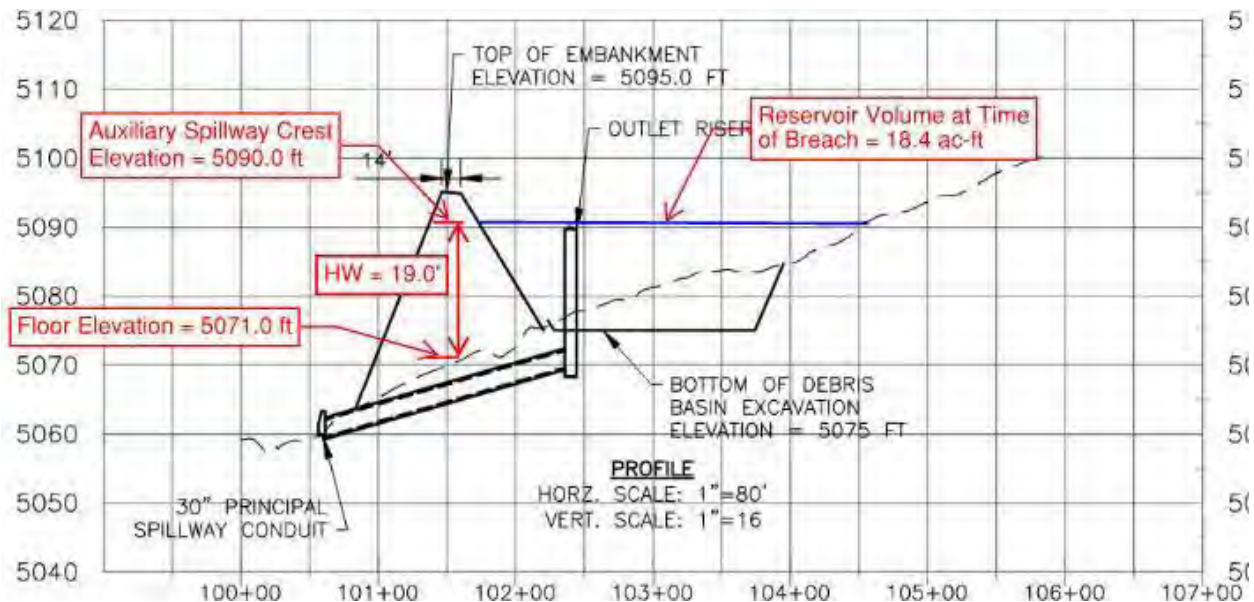


Figure 14. Burnt Canyon Debris Basin H_w Depth

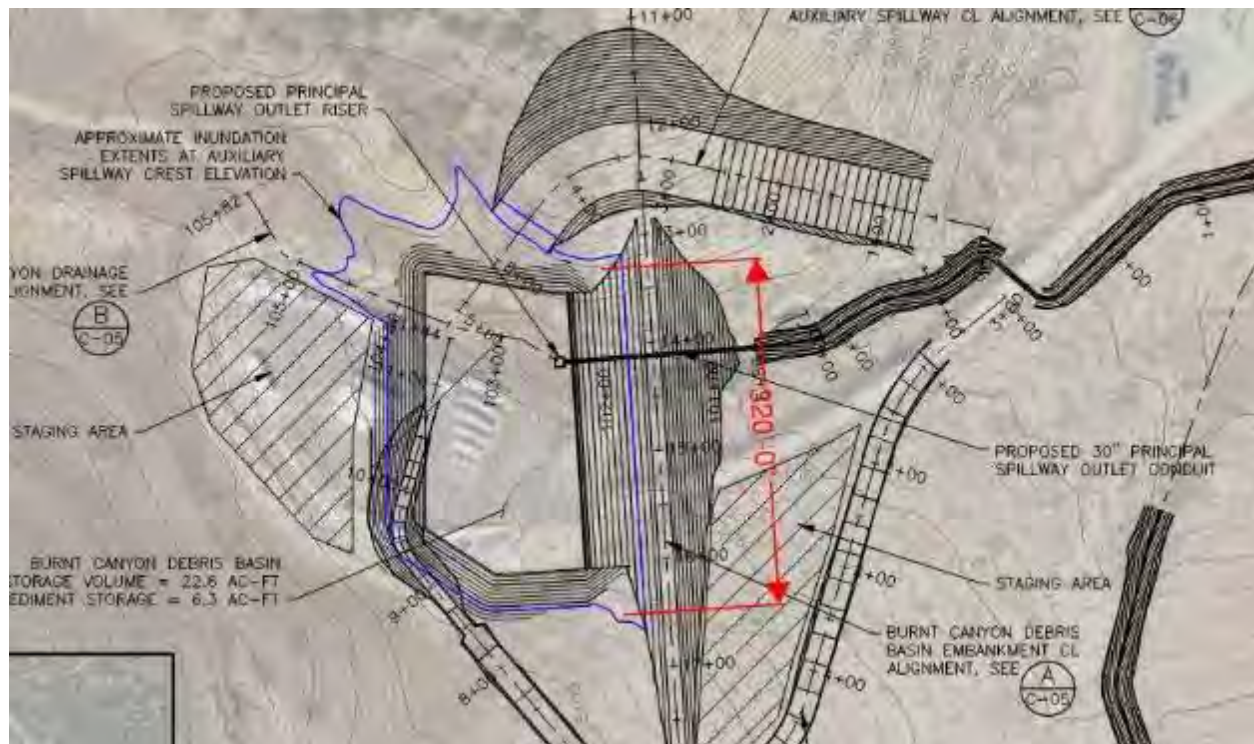


Figure 15. Burnt Canyon Debris Basin Width of Valley

Using the TR-60 method breach hydrograph development spreadsheet, supplied by the NRCS-Utah, and the above debris basin criteria, the peak breach discharge was calculated to be 5,035 cfs. This peak breach discharge is based on the minimum peak allowed by TR-60 (i.e. $Q_{\max} = (3.2)H_w^{2.5}$). The Breach hydrograph is shown on Figure 16. Peak breach discharges were calculated for the three other debris basins in a similar manner. Table 12 provides a summary of the input parameters and peak breach discharge calculations for each of the four debris basins and detailed calculations have been included in Appendix D for reference.

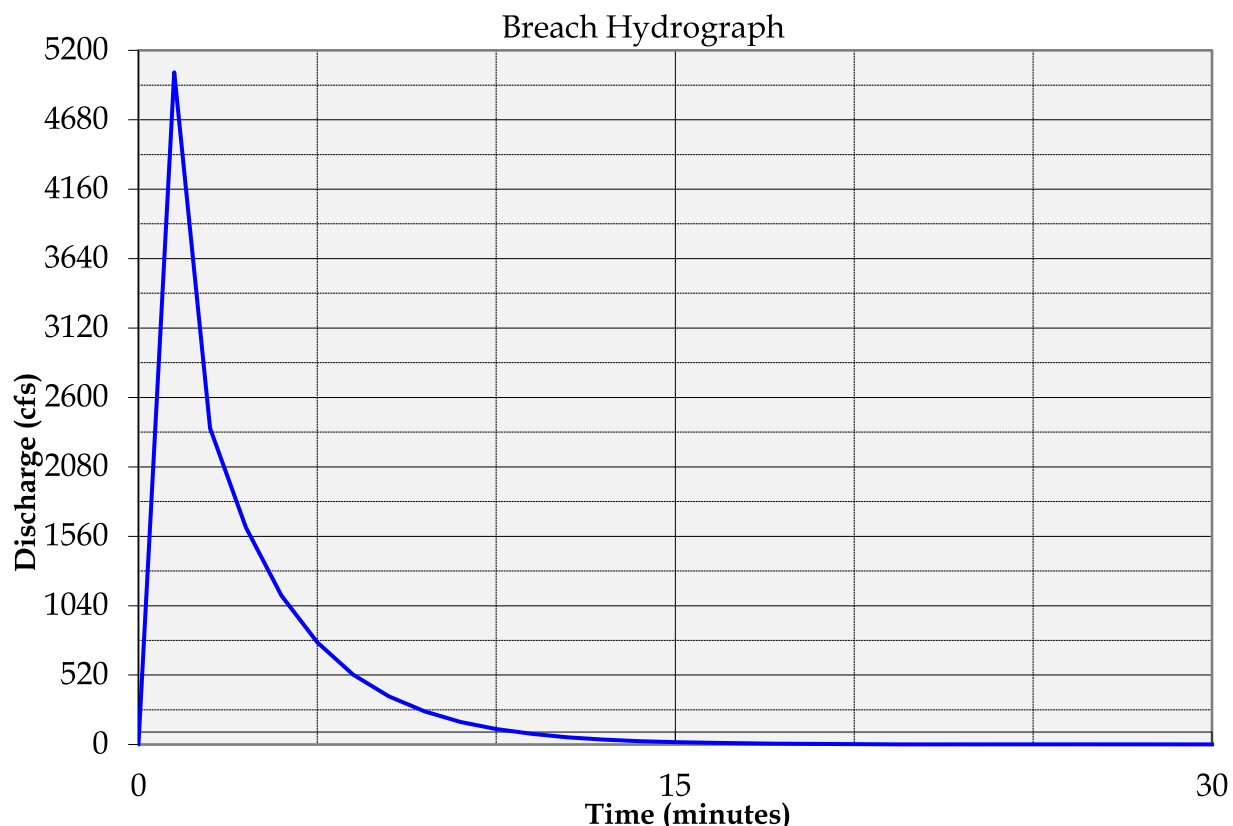


Figure 16. Burnt Canyon Debris Basin Breach Hydrograph

Table 12
Peak Breach Discharge Calculation Summary

Characteristic	Burnt Canyon	Lott Canyon	Clark Canyon North	Clark Canyon South
Dam Crest Elevation (ft)	5,095.0	5,145	5,342.0	5,244.5
WSE at Time of Breach (ft)	5,090.0	5,139.5	5,347.5	5,238.5
Valley Floor Elevation (ft)	5,071.0	5,120.0	5,321.0	5,218.0
Res. Vol. at Breach (ac-ft)	18.4	35.3	6.0	18.3
Valley Width at WSE (ft)	320	700.0	300	300
Depth of Water at Time of Breach, Hw (ft)	19.0	19.5	16.5	18.3
Embankment Cross Section Area (ft ²) ¹	1,779	1,913	1,397	2,127
Breach Factor	0.2	0.4	0.1	0.2
Qmax (cfs)	123	277	31	106
Min Qmax (cfs)	5,035	5,373	3,539	6,089

Notes:

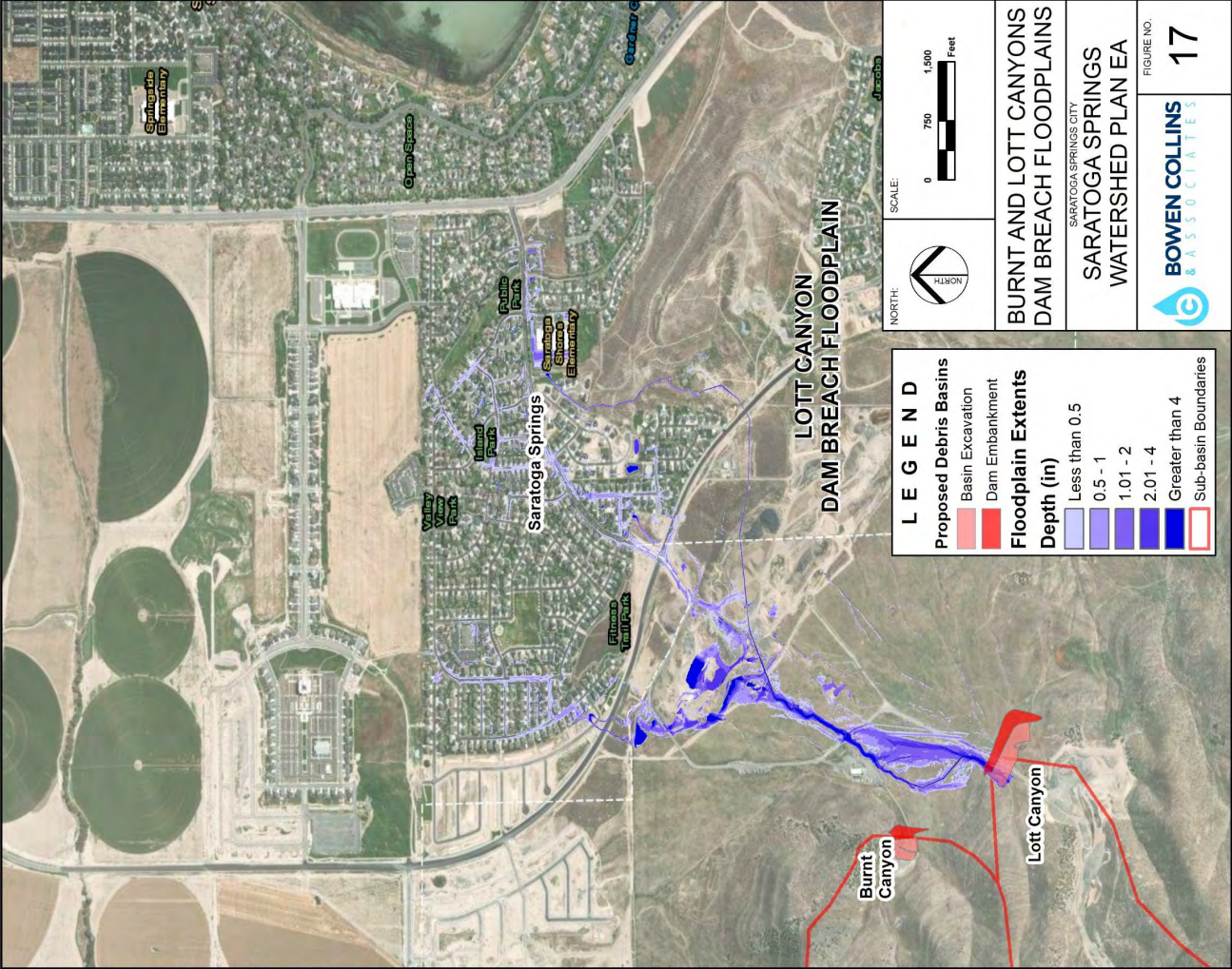
1. For each embankment: top width = 14 ft, upstream side slope = 3:1, downstream side slope = 2:1

Breach Inundation Results. The TR-60 method for breach peak flow determination meets NRCS requirements and was selected for the inundation analysis. The TR-60 peak breach discharge hydrographs were input into the previously developed 2D HEC-RAS hydraulic model to estimate the inundation model results and inundation maps. The results of the inundation analysis from a breach

in the Burnt Canyon or Lott Canyon Debris Basins are shown on Figure 17. Similar results for Clark Canyon North and South Debris Basins are shown on Figure 18.



BURNT CANYON
DAM BREACH FLOODPLAIN



LOTT CANYON
DAM BREACH FLOODPLAIN

LEGEND

Proposed Debris Basins

- Basin Excavation
- Dam Embankment

Floodplain Extents

Depth (in)

- Less than 0.5
- 0.5 - 1
- 1.01 - 2
- 2.01 - 4
- Greater than 4
- Sub-basin Boundaries

NORTH

SCALE

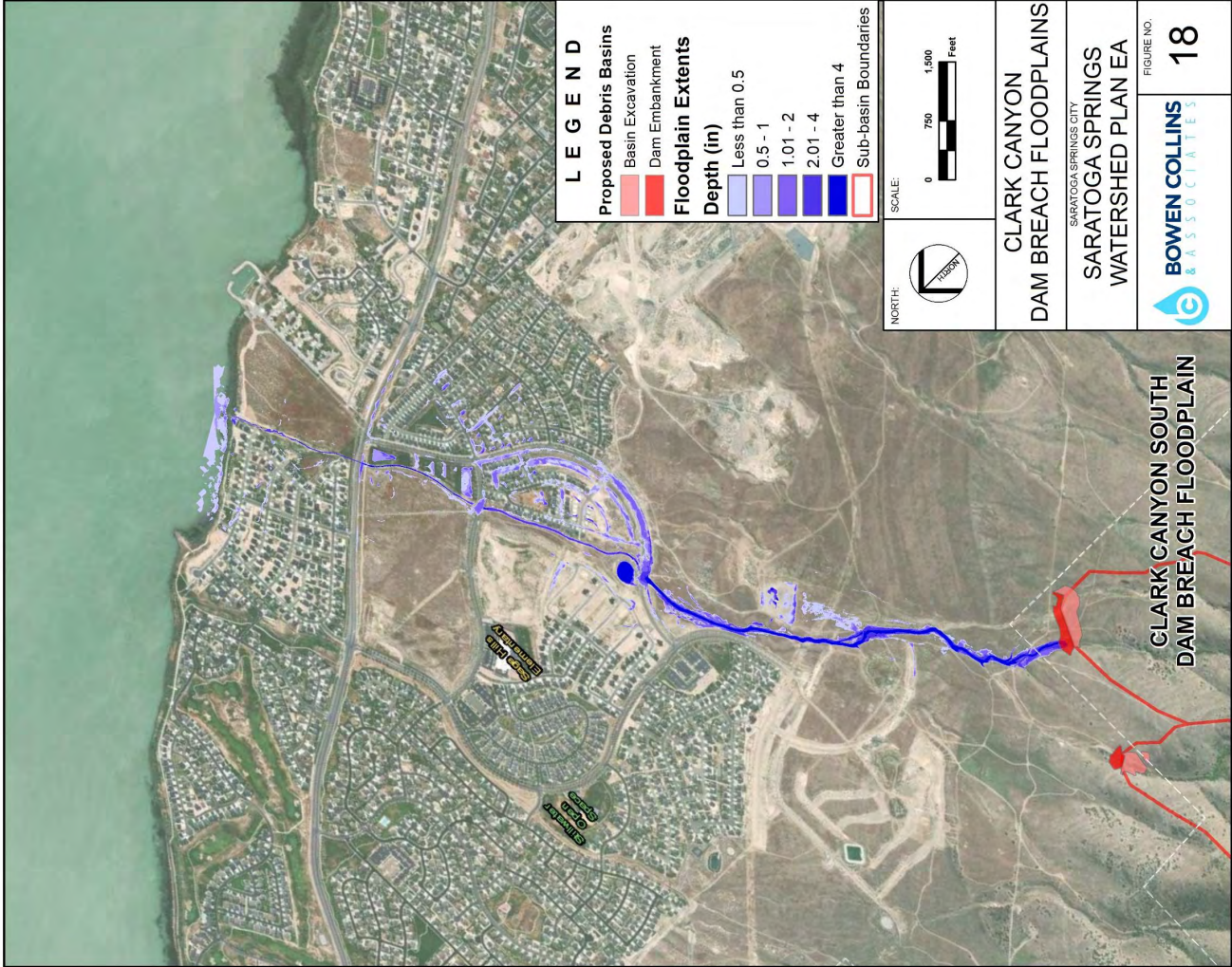
0 750 1,500 Feet

BURNT AND LOTT CANYONS
DAM BREACH FLOODPLAINS

SARATOGA SPRINGS CITY

SARATOGA SPRINGS
WATERSHED PLAN EA

S:\Saratoga Springs\3045-12-02 - Watershed Plan EA & GSA-1 Project\Figures_Report\Figure 17 Burnt Lott Breach Flood.mxd (mshillier, 8/30/2024)



LEGEND

Proposed Debris Basins

- Basin Excavation
- Dam Embankment

Floodplain Extents

Depth (in)

- Less than 0.5
- 0.5 - 1
- 1.01 - 2
- 2.01 - 4
- Greater than 4

Sub-basin Boundaries



CLARK CANYON
DAM BREACH FLOODPLAINS

SARATOGA SPRINGS CITY
WATERSHED PLAN EA

4.3.5 HAZARD POTENTIAL CLASSIFICATION

As shown in Figure 17 and Figure 18, the dam breach floodplains inundate numerous residential homes. The depths of the inundation within residential neighborhoods vary between 0 to 2 feet, with the floodplains for the larger basins (Lott Canyon and Clark Canyon South) impacting larger areas. Population at Risk and Loss of Life analyses were performed based on the dam breach floodplains for each debris basin.

Population at Risk was tabulated using the NRCS Consequences of Dam Failure computation worksheet. This worksheet assigns a typical population for each structure that is inundated by flood water and assigns a risk factor based on the inundation depth. Based on the structures impacted by flooding during the breach scenarios, the potential population at risk was identified for each basin.

The NRCS Consequences of Dam Failure computation worksheet was also used to identify the risk index or potential for loss of life if a breach of each debris basin were to occur. This risk index is determined by estimated by using the following formula:

$$RI = PAR \times FI \times FR$$

Where RI = Risk index, or estimated number of lives lost

PAR = Population at risk (as described above)

FI = Hydrologic failure index

FR = Fatality rate

The hydrologic failure index is a measure of how likely it is that a breach could occur. The methods by which a breach would likely occur is overtopping the dam or eroding an earthen spillway. Only the Clark Canyon South debris basin is proposed to have an earthen spillway, and this is reflected in its higher failure index. The fatality rate is estimation of how likely a given flood flow could cause loss of life and is based on the approximate depth times velocity of the flood flow and on the expected warning time. The depth times velocity is generally less than 50 ft²/s as the average floodplain width in each case is relatively wide. The debris basins are located relatively closely to existing residential neighborhoods, so the warning time was assumed to be less than 60 minutes. These parameters result in an estimated fatality rate of 0.007 for each debris basin. TABLE lists the risk index for each debris basin option.

Table 13
Population at Risk and Loss of Life

Parameter	Burnt Canyon	Lott Canyon	Clark Canyon North	Clark Canyon South
PAR	45	63	14	15
FI	8	9	7	51
FR	0.007	0.007	0.007	0.007
Risk Index	3	4	1	5

Based on the results of Population at Risk and Loss of Life analyses, the estimated damage to property and potential for loss of life within the inundated area justifies a classification of "High Hazard Potential" based on both NRCS and Utah Dam Safety criteria. Debris Basin Design Criteria

The design criteria for the proposed debris basins are based on the following requirements:

1. Design life of 100 years, which primarily refers to the volume of sediment that would be deposited in the debris basin over the life of the basin. The basins will have capacity for 50 years of sediment, and the design life assumes that sediment would be removed from the basin every 50 years.
2. Floodwater retarding storage volume determined by routing the 100-yr, 24-hr storm, 50-yr, 24-hr storm, and the Principal Spillway Hydrograph through the basin and principal spillway.
3. Maximum principal spillway outflow during the Q_{100} storm must not exceed capacity of downstream storm drainage facilities.
4. Active storage volume must be sufficient to contain the design life sediment volume plus the floodwater retarding storage volume.
5. Sizing of the principal and auxiliary spillways is based on NRCS TR-60 requirements assuming a High Hazard Potential dam classification.

Sedimentation and design flow rates are discussed in previous sections. Table 14 provides a summary of the design criteria for each of the four proposed debris basins. The following sections provide a discussion of the sizing of principal and auxiliary spillways for the proposed basins based on NRCS TR-60 criteria.

Table 14
Summary of Debris Basin Criteria

Parameter	Burnt Canyon	Lott Canyon	Clark Canyon North	Clark Canyon South
Active Storage Volume (Ac-ft) ¹	18.4	35.3	6.0	18.3
Sediment Storage Volume (Ac-ft) ²	3.1	10.1	2.5	7.1
Floodwater Retarding Storage Volume (Ac-ft) ³	15.3	25.2	3.5	11.2
Tributary Drainage Area (Ac)	250	704	179	557
Overall Height (ft) ⁴	31.4	30.5	36	32.5
Effective Height (ft) ⁵	19.5	19.5	21.6	21.6
Crest Width (ft)	14	14	14	14
Upstream Slope	3H:1V	3H:1V	3H:1V	3H:1V
Downstream Slope	2H:1V	2H:1V	2H:1V	2H:1V

Notes:

1. Active Volume is the volume from the auxiliary spillway crest to the invert of the outlet pipe (principal spillway).
2. Sediment storage volume is the capacity for sediment from the bottom of the basin to the invert of outlet #2.
3. Storage volume required to attenuate the design flood event assuming a 500-year sediment volume.
4. Overall Height is the difference in elevation between the top of the dam and the lowest elevation at the downstream toe.
5. Effective Height is the difference in elevation between the lowest open channel auxiliary spillway crest and the lowest point in the original cross section on the centerline of the dam.

4.3.6 PRINCIPAL SPILLWAY EVALUATION

The proposed principal spillway structures will be constructed as standard upright, covered, concrete inlet riser structures with staged orifice outlets and trash rack. The first and second outlets together are sized to convey the design storm event. The second outlet is also designed to convey the design storm event, assuming that the first outlet is plugged with sediment. The design storm events

were determined to be the 100-yr, 24-hr storm for the Burnt and Lott Canyon debris basins, and the 50-yr, 24-hr storm for the Clark Canyon North and South debris basins. The invert elevation of the second outlet is elevated to the anticipated 50-year sediment pool elevation. The top of the principal spillway structure will include a covered, ungated weir at approximately the same elevation as the auxiliary spillway crest. This opening will be elevated above the design event water surface elevation to act as an emergency overflow in the unlikely event that both orifices are plugged.

As mentioned previously, the Saratoga Springs City's 2017 SDCFP had defined available capacity in existing storm drain infrastructure downstream of the proposed basins and determined the runoff rates that would be allowed to enter the existing infrastructure from future development. Based on that information it was determined that the combined 100-year 24-hour release rate of the Lott and Burnt Canyon basins must not exceed 10.4 cfs and the release rate of the Clark Canyon basins must not exceed 46 cfs.

Design criteria for the principal spillways are provided in Table 15.

Table 15
Principal Spillway Design Criteria

Parameter	Burnt Canyon	Lott Canyon	Clark Canyon North	Clark Canyon South
Design Event	100-year, 24-hr		50-year, 24-hr	
Outlet #1 size	3"x3"	6"x6"	12"x12"	11"x11"
Outlet #1 invert elevation	5075.0	5126.5	5327.0	5226.0
Outlet #2 size	5"x6"	9"x9"	17"x17"	17"x18"
Outlet #2 invert elevation	5078.3	5130.9	5332.2	5231.7
Peak Inflow (cfs)	273.5	282.6	136.4	201.6
Peak Discharge, sediment pool empty (cfs)	3.6	7.5	20.5	17.2
Peak Water surface elevation, sediment pool empty	5087.2	5135.7	5333.4	5235.2
Peak Discharge, sediment pool full (cfs)	2.9	7.0	17.6	21.5
Peak Water surface elevation, sediment pool full	5089.3	5138.9	5337.1	5237.9

Schematic details of the principal spillway structure geometries and outlet configurations are shown in Figure 19.

OUTLET RISER ELEVATIONS				
BASIN	OUTLET PIPE IE "A"	1ST STAGE IE "B"	2ND STAGE IE "C"	TOP WEIR ELEVATION "D"
BURNT CANYON	5069.9	5075.0	5078.3	5089.4
LOTT CANYON	5123.6	5126.5	5130.9	5139.0
CLARK CANYON NORTH	5322.0	5327.0	5332.2	5337.1
CLARK CANYON SOUTH	5222.0	5226.0	5231.7	5238.0

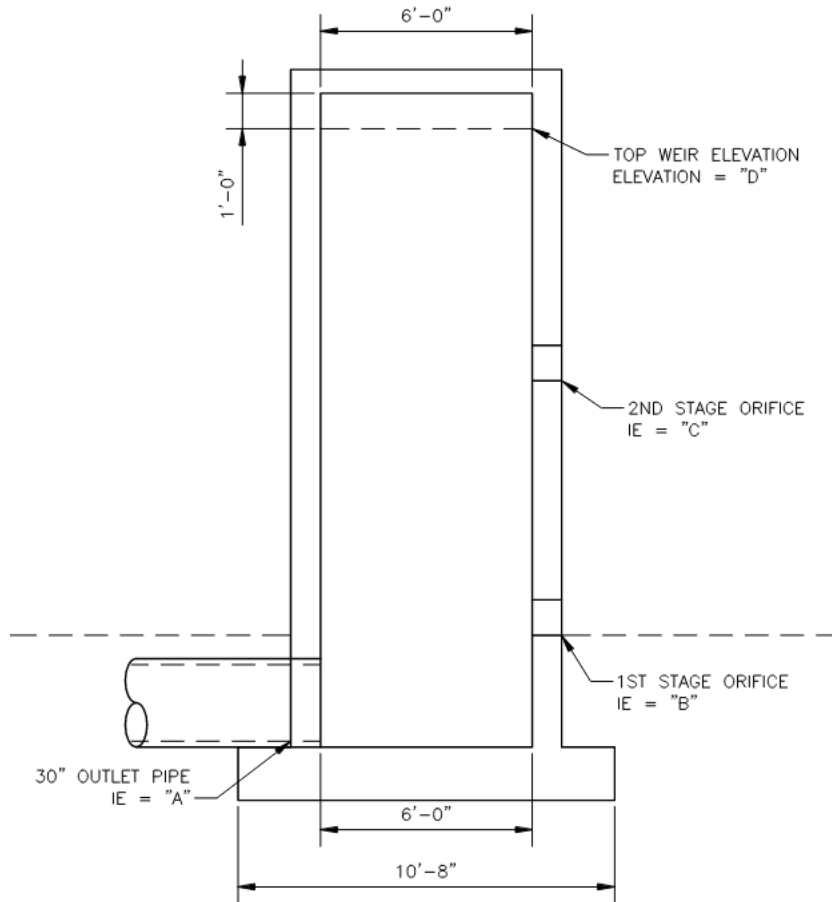


Figure 19. Debris Basin Principal Spillway Schematic

As mentioned in Section 2 – Hydrology, NRCS TR-60 requires that the principal spillway passes the Principal Spillway Hydrograph (PSH) on a watershed under normal soil moisture conditions (AMCII), without overtopping the auxiliary spillway. The PSH uses a combination of the 100-yr, 24-hour and 100-yr, 10-day precipitation depths (see Section 2 – Hydrology). Debris basins and principal spillways with dimensions based on values in Table 14 and Table 15 were input into NRCS SITES models to generate and route the PSH. These models assume that the 1st stage orifice is plugged with sediment and the stage storage table was modified to account for 50 years of sediment deposition. The results of these models are summarized in Table 16. For reference, the design storm (100-yr, 24-hr or 50-yr, 24-hr) routed water surface elevation is also included in Table 16.

Table 16
SITES Model PSH Routing Results Summary

Parameter	Burnt Canyon	Lott Canyon	Clark Canyon North	Clark Canyon South
50-yr Sediment Elevation (ft)	5,078.3	5,130.9	5,332.2	5,231.7
Peak PSH Inflow (cfs)	59.6	76.0	21.4	44.9
Peak Principal Spillway Discharge (cfs)	8.9	12.6	13.0	18.9
Time to Empty 85% of PSH After Max WSE Achieved (days)	6.2	5.35	5.69	6.86
Calculated Max. Water Surface Elevation (ft)	5089.7	5139.28	5334.84	5235.74
Design Storm Max Water Surface Elevation (ft)	5089.3	5138.9	5337.1	5237.9

Outlet Conduit

TR-60 indicates that the minimum allowable inside diameter of a principal spillway outlet pipe (on yielding foundations) is 30 inches. The minimum pipe diameter to meet anticipated design flows for each principal spillway is less than 30 inches. Therefore, each outlet conduit is recommended to be a 30-inch diameter pipe. To meet NRCS and Utah Dam Safety requirements for conduits through a dam embankment, each conduit will be welded steel pipe encased in concrete.

TR-60 states that joint use storage dams must “provide a gated opening or other reliable means to remove water from the conservation storage to meet project objectives.” As dry dams, the Saratoga Springs debris basins are not considered joint use dams; the purpose of the dams is flood control only. Therefore, a gated opening on the outlet pipe of the principal spillways is not recommended and is not included in the proposed design.

Outlet Orifice Capacity

Utah Dam Safety requires that “all outlets shall have the capacity to evacuate 90% of the active storage capacity of the reservoir within 30 days neglecting reservoir inflows.” This time to drain the active storage was calculated based on the capacity of the outlet ports and the stage storage curves for each proposed debris basin. Results of this analysis are provided in Table 17.

Table 17
Evacuation of 90% of Active Storage

Parameter	Burnt Canyon	Lott Canyon	Clark Canyon North	Clark Canyon South
Active Storage Volume (ac-ft)	18.4	35.3	6.0	18.3
WSE at Active Storage Volume (ft)	5092.3	5139.5	5337.5	5238.5
10% Active Storage (ac-ft)	1.84	3.53	0.6	1.83
WSE at 10% Active Storage Volume (ft)	5077.0	5128.12	5328.41	5227.62
Time to Evacuate 90% of Active Storage Volume (days)	6.2	4.6	0.2	0.5

The design outflow for the Burnt and Lott Canyon debris basin principal spillways are less than the design outflow for the Clark Canyon debris basins principal spillways. As noted previously, this difference in design outflow is based on the available capacity of downstream storm drainage facilities. Smaller principal spillway outflows for Burnt and Lott Canyons result in longer time to evacuate 90% of active storage volume, as can be seen in Table 17.

4.3.7 AUXILIARY SPILLWAY EVALUATION

The auxiliary spillway crest elevations for each of the four proposed debris basins were determined by evaluating the following two scenarios:

1. Principal Spillway Hydrograph: NRCS TR-60 requires that the minimum auxiliary spillway crest elevation for earthen spillways is equal to the peak water surface elevation observed when routing the PSH through the proposed debris basin.
2. Design Storms: To meet the needs of Saratoga Springs City, the principal spillway and debris basin must be sized such that the discharge from the basins during the routing of the design storm can be conveyed by the City's storm drain infrastructure or existing drainage channels. For Burnt and Lott Canyons, the design storm is the 100-yr, 24-hr storm. For Clark Canyon, the design storm is the 50-yr, 24-hr storm. The intent is that the principal spillway would be able to route the design storm without activating the top stage weir of the principal spillway inlet riser structure. The auxiliary spillway would then be set a few inches higher than the principal spillway top stage weir to provide a small elevation buffer to ensure the auxiliary spillway does not activate when routing the design storms (see Sections 2.3 and 4.2.5).

For each basin, the minimum auxiliary spillway crest elevation was set to be the higher of the water surface elevations calculated. The proposed spillways were modeled in an HEC-HMS model to determine the required auxiliary spillway crest length, freeboard, and dam embankment elevation. SEP storms discussed in the previous hydrology section were routed through the debris basins to determine the controlling auxiliary spillway hydrograph, FBH, and IDF. The 6-hr Local SEP was determined to be the controlling event. The following assumptions were incorporated into the HEC-HMS routing model:

- Subcatchment characteristics, hydrology method, stage-storage curves (including 100 years of sediment deposition unless noted otherwise), design storms, and principal spillway parameters as described in previous sections of this report.

- Starting water surface elevation set to the anticipated elevation of the design life sediment of principal spillway at the beginning of the simulated storm event.
- Auxiliary spillway stage discharge modeled as a broad crested weir ($C=2.63$). This conservative C value for the proposed trapezoidal spillways was used to help account for headloss at the entrance of the spillway and friction loss through the spillway.
- Principal spillway stage discharge relationship based on weir and orifice flow, as described previously.
- Principal spillway 1st stage port is completely blocked due to sediment deposition, and only the 2nd stage port is open.

Freeboard Hydrograph

The Freeboard Hydrograph was used to determine the auxiliary spillway's crest length and depth. An initial estimate for the auxiliary spillway crest length was assumed. The model was then run multiple times and iterated to determine a combination of spillway crest length and dam embankment elevation that was considered reasonable. Generally, the goal was to minimize the dam embankment elevation, while also minimizing the volume of excavation that would be required for the spillway. The spillway and spillway channel are assumed to be earthen. The result of this modeling is shown in Table 18.

Table 18
Auxiliary Spillway Design Criteria

Parameter	Burnt Canyon	Lott Canyon	Clark Canyon North	Clark Canyon South
FBH Peak Inflow (cfs)	1872.9	3673.8	1027.2	2416.1
Spillway Crest Elevation (ft)	5090.0	5139.5	5337.5	5238.5
Spillway Crest Length (ft)	64	120	44	80
Max Water Surface Elevation (ft)	5094.7	5144.6	5341.6	5243.5
Dam Crest Design Elevation (ft)	5095.0	5145.0	5342.0	5244.0
Flow Depth (ft)	4.7	5.1	4.1	5.0
Side Slope (H:V)	2:1	2:1	2:1	2:1
Peak Weir Flow (cfs)	1731.4	3599.7	992.3	2369.1
Slope (ft/ft)	0.005	0.005	0.005	0.005
Open Channel Lining	Earthen ($n' = 0.035$)			
Open Channel Flow Depth (ft) ¹	3.7	3.9	3.3	3.9
Open Channel Velocity (fps)	6.6	7.1	6.0	6.9

Notes:

1. Open channel flow depths calculated in the channel using Manning's Equation based on peak weir flow through the auxiliary spillway with 1 foot of freeboard.

The maximum water surface elevations shown on Table 18 were rounded up to the nearest foot to determine the recommended dam embankment elevation.

Auxiliary Spillway Hydrograph

The FBH was routed through the HEC-HMS model to determine spillway dimensions and freeboard and maximum flow through the spillway. The auxiliary spillway hydrograph must also be modeled

(with the same assumptions listed above) to verify that the spillway will perform adequately during less extreme storm events. TR-60 requires that the maximum water surface elevation observed when routing the auxiliary spillway hydrograph, plus sufficient freeboard to contain wave action, must be less than the crest of the dam. The freeboard required to contain wave action was estimated to be 0.8 feet, as described previously. Table 19 provides the results of this modeling effort. For each debris basin, the available freeboard when routing the auxiliary spillway hydrograph is greater than the estimated wave action depth, thus meeting the requirement of TR-60.

Table 19
Auxiliary Spillway Hydrograph Routing Summary

Parameter	Burnt Canyon	Lott Canyon	Clark Canyon North	Clark Canyon South
6-hr ASH Peak Inflow (cfs)	220.6	456.5	115.7	286.9
6-hr ASH Peak Outflow (cfs)	208.7	449.1	110.7	288.1
Max Water Surface Elevation (ft)	5091.1	5140.8	5338.4	5239.7
Peak Spillway Flow Depth (ft)	1.1	1.3	0.9	1.2
Embankment Crest Elevation (ft)	5095.0	5145.0	5342.0	5244.0
Required Freeboard for Wave Action (ft)	0.8	0.8	0.8	0.8
Available Freeboard (ft)	3.9	4.2	3.6	4.3

100-yr, 6-hr AMCIII Routing

Per Utah Dam Safety requirements, in addition to routing the 6-hr local SEF, the storm generated from the 100-yr, 6-hr precipitation event on a saturated watershed (AMCIII) must also be routed through the basin while maintaining adequate freeboard to contain wave action from a fetch controlled 50 mph wind (minimum of 3 feet) (See Section 2 – Hydrology). The HEC-HMS model was used to route this design storm, using the debris basin dimensions and modeling assumptions as listed in Section 4.2.6. Table 10-1 in NEH 630 Chapter 10 – Estimation of Direct Runoff from Storm Rainfall was used to estimate curve numbers for each saturated watershed. Results of the 100-yr, 6-hr storm on saturated watersheds are shown in Table 20.

Table 20
100-yr, 6-hr Saturated Watershed Hydrograph Routing Summary

Parameter	Burnt Canyon	Lott Canyon	Clark Canyon North	Clark Canyon South
CN (Saturated Watershed)	96	89	88	86
Peak Inflow (cfs)	137	261	75	192
Peak Outflow (cfs)	126	251	71	186
Max. Water Surface Elevation (ft)	5090.8	5140.3	5338.1	5239.3
Embankment Crest Elevation (ft)	5095.0	5145.0	5342.0	5244.0
Calculated Freeboard (ft)	4.2	4.7	3.9	4.7

As shown in Table 20, the calculated freeboard when routing the 100-yr, 6-hr storm on saturated watersheds for each of the proposed debris basins is greater than 3 feet, thus meeting the Utah Dam Safety requirement.

Auxiliary Spillway Integrity Analysis

As noted in Section 4.2.1 above, the preliminary geotechnical evaluation indicated that shallow bedrock was encountered at the test pits for the Burnt Canyon, Lott Canyon, and North Clark Canyon auxiliary spillway sites. The bedrock depth ranged from approximately 1.5 feet at Lott Canyon to approximately 5.5 feet at Burnt Canyon and North Clark Canyon. For these three sites, construction of the auxiliary spillway control sections and channels will require excavation into the bedrock layer and it is anticipated that no additional armoring for erosion prevention will be required.

The field investigation at the Clark Canyon South site did not encounter the bedrock layer. Additional armoring will likely be required for this site to prevent erosion of the auxiliary spillway soils.

To verify the integrity of the proposed Clark Canyon South auxiliary spillway, an erosion analysis was performed using the NRCS SITES modeling program. Soils information was obtained from the Geotechnical Studies performed by Rosenberg Associates (2021). The modeled soil parameters are provided in Table 21. Stage-storage curves, sediment pool elevations, principal spillway stage-discharge curves, and auxiliary spillway dimensions were input into the model based on the proposed structures described in the previous sections. Inflow design hydrographs were determined by the hydrology methods discussed in the previous section.

Table 21
Soils Parameters for Clark Canyon South Auxiliary Spillway SITES Model

Dry Density (lbs/cu.ft)	Plasticity Index	Head Cut Index	Percent Clay	Representative Diameter (in)
90	5	0.1	18	0.1

The results of the SITES model indicate that the proposed earthen spillways may experience significant erosion but would not fail during the passing of the Freeboard Hydrograph. Figure 20 shows the modeled extent of erosion experienced by the proposed Clark Canyon South Debris Basin spillway during the routing of the design storm. Results of the SITES analysis, including auxiliary spillway erosion charts and a summary of all input parameters for each debris basin, are provided in Appendix E.

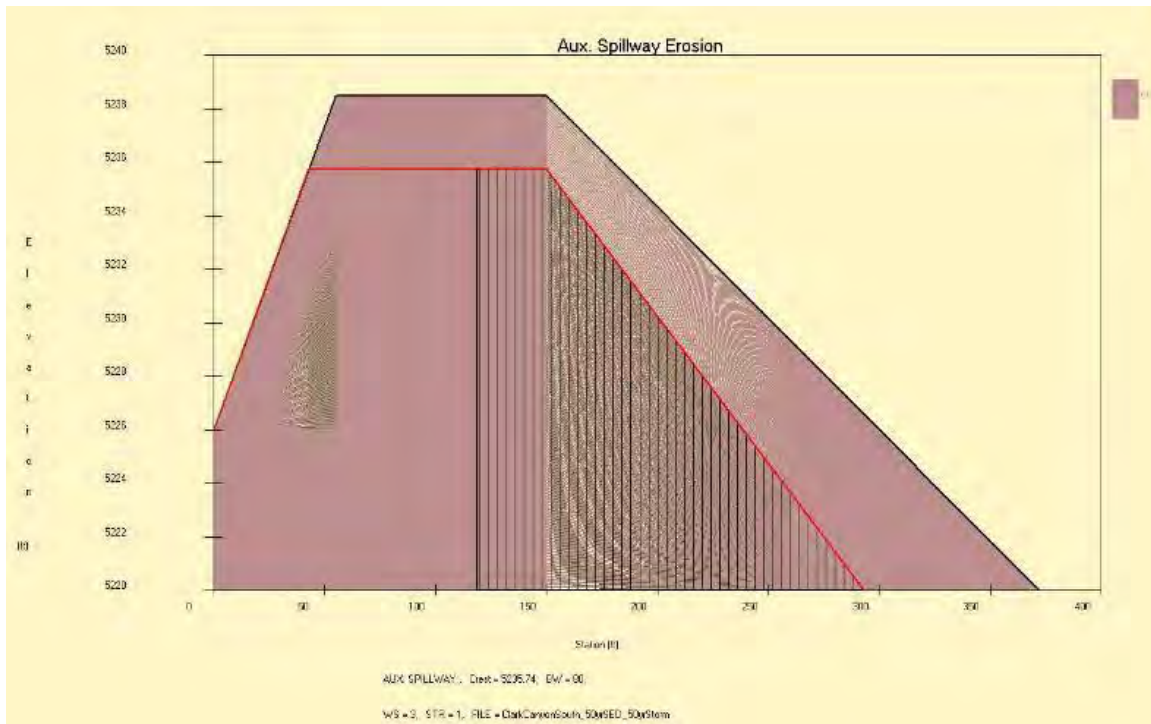


Figure 20: Proposed Auxiliary Spillway Erosion Profile

4.3.8 NORMAL POOL HAZARD FOR SEISMIC ANALYSIS

Utah Dam Safety defines a dry debris basin as one that under normal, everyday operating conditions, does not store water. During normal, everyday operation of these four debris they will typically be dry. These four basins are in a dry arid environment with typical annual precipitation of approximately 11.41-inches as shown in Figure 21. These basins are also located within sandy soils with significant infiltration. Due to the low precipitation and moderately high temperature, the pool of the debris basins under normal conditions is dry.

UTAH LAKE LEHI, UTAH (428973)

Period of Record Monthly Climate Summary

Period of Record : 06/01/1904 to 06/04/2016

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Max. Temperature (F)	36.3	42.0	50.4	61.5	71.5	81.7	89.8	87.5	77.9	64.9	48.4	38.3	62.5
Average Min. Temperature (F)	14.9	20.7	27.3	33.9	41.4	48.3	55.5	53.8	44.0	34.2	25.0	17.7	34.7
Average Total Precipitation (in.)	0.92	0.95	1.07	1.18	1.14	0.69	0.70	0.96	0.87	1.07	0.98	0.90	11.41
Average Total SnowFall (in.)	7.9	4.8	3.2	1.0	0.0	0.0	0.0	0.0	0.0	0.4	3.3	7.2	27.8
Average Snow Depth (in.)	2	1	0	0	0	0	0	0	0	0	0	1	0

Percent of possible observations for period of record.

Max. Temp.: 98.1% Min. Temp.: 98.1% Precipitation: 97.1% Snowfall: 93.9% Snow Depth: 83.3%

Check [Station Metadata](#) or [Metadata graphics](#) for more detail about data completeness.

Western Regional Climate Center, wrcc@dri.edu

Figure 21. Monthly Climate Summary for Utah Lake Lehi, Utah Weather Station
(Source: Western Regional Climate Center, <https://wrcc.dri.edu/cgi-bin/cliMAIN.pl?ut8973>)

During infrequent higher intensity storms or longer duration storms, runoff rates will overcome the infiltration rate and principal spillway discharge rates and runoff will accumulate in the basins. Neglecting infiltration and only accounting for outflow through the principal spillways, once filled to capacity in the 100-year event, the Burnt and Lott debris basins will drain completely in less than 10 days. Similarly, the Clark Canyon debris basins, which have larger principal spillway flow capacities, will drain completely in less than 2 days. The inflow and outflow hydrographs for the Lott Canyon and Clark Canyon South basins during the 100-year 24-hour are shown on Figures 22 and 23. Burnt and Clark Canyon North debris basins have hydrographs similar to Lott Canyon and Clark Canyon South, respectively.

Based on the data presented, the normal pool condition is dry and the normal pool consequence is low. The normal pool hazard classification is considered “low hazard”.

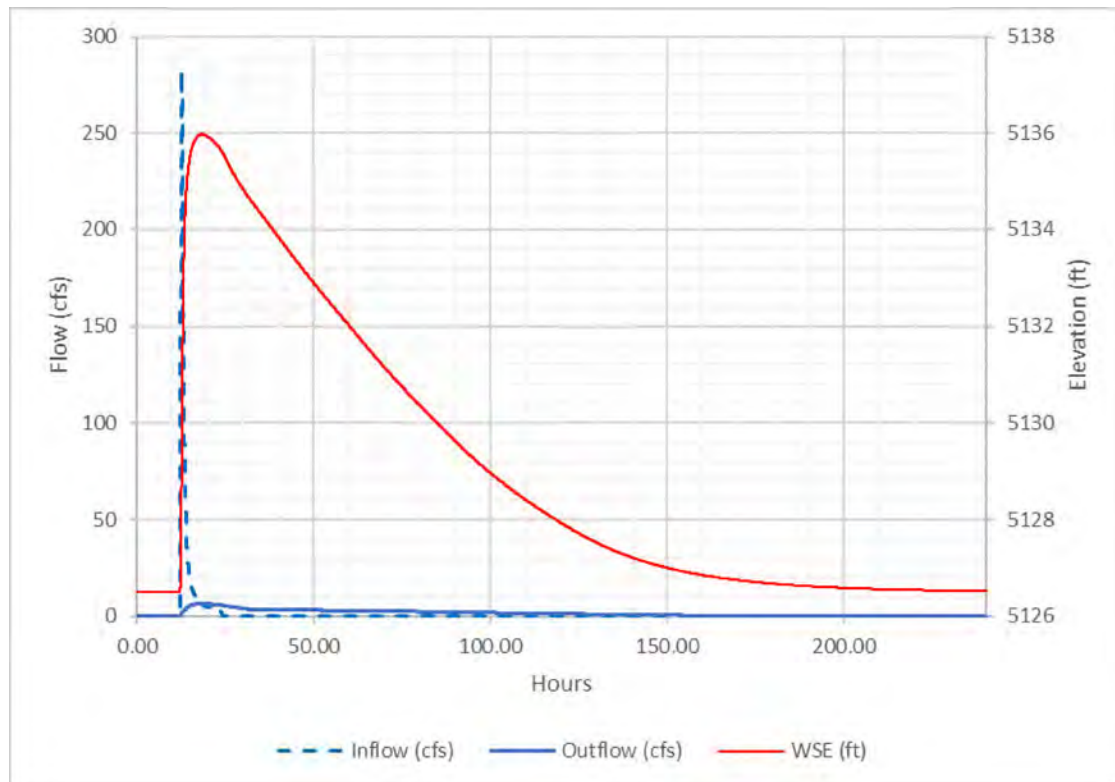


Figure 22: Lott Canyon Debris Basin 100-year; 24-hour Storm Output

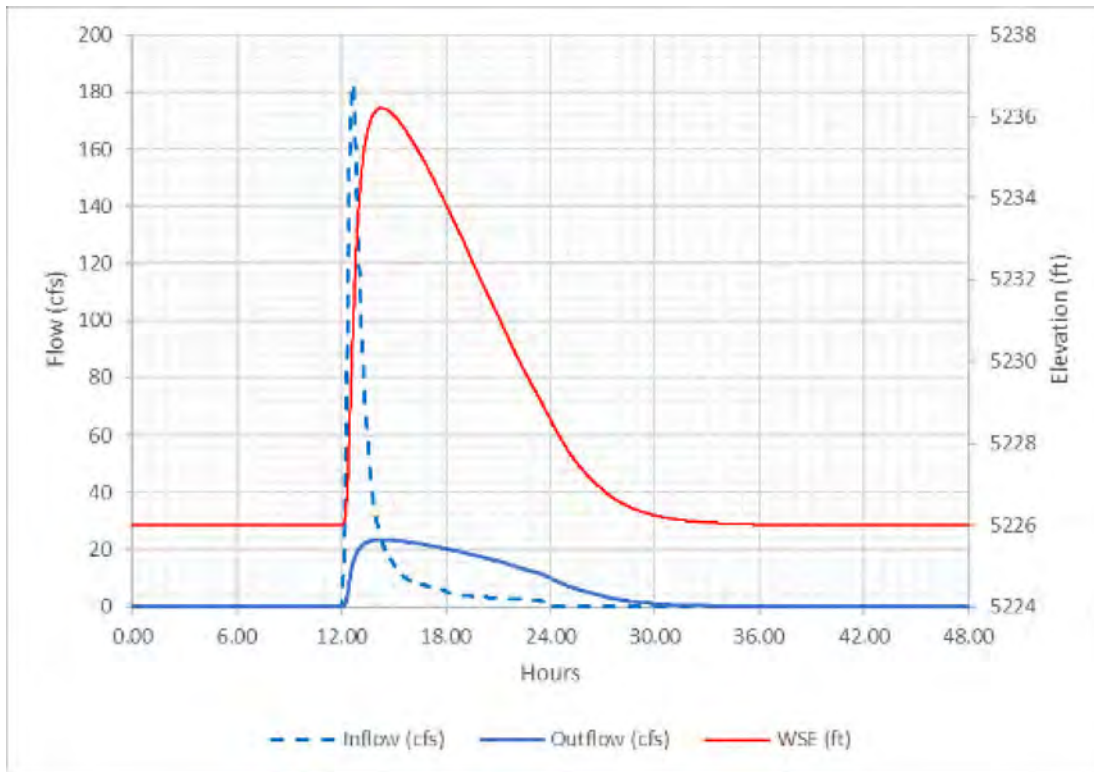


Figure 23. Clark Canyon South Debris Basin 100-year; 24-hour Storm Output

4.3.9 ESTIMATED CONSTRUCTION COST - ALTERNATIVE 1

The combined estimated construction cost for Alternative 1 – Earthen Embankment Debris Basins is approximately \$14.7 million (\$17.6 million with 20% contingency) as shown in Tables 22 through 26.

Table 22
Alternate 1 Estimated Construction Cost – Burnt Canyon Debris Basin

No.	Item	Quantity	Units	Unit Cost	Cost
1	Mobilization (5% of Subtotal)	1	LS	\$113,385	\$113,400
2	Site Prep / survey / misc	1	LS	\$95,000	\$95,000
3	Debris Basin Excavation	25,600	CY	\$12	\$307,200
4	Foundation Excavation	16,400	CY	\$12	\$196,800
5	Embankment Fill	22,500	CY	\$12	\$270,000
6	Auxiliary Spillway Excavation	17,100	CY	\$12	\$205,200
7	Excess Material Haul Off	59,100	CY	\$5	\$295,500
8	Access Road	1,000	LF	\$20	\$20,000
9	Install Type 'G' Cap on Dam Embankment Crest	500	LF	\$50	\$25,000
10	Type 'R' Drain Gravel	3,300	CY	\$80	\$264,000
11	Type 'Q' Filter Sand	3,300	CY	\$80	\$264,000
12	Rock Mulch (On Upstream Slope of Dam)	500	CY	\$40	\$20,000
13	6-inch Toe Drain Pipe (Perforated)	1,000	LF	\$40	\$40,000
14	Outlet Riser w/ Trash Rack	1	LS	\$60,000	\$60,000
15	30" Concrete Encased Steel Discharge Conduit	175	LF	\$1,000	\$175,000
16	Restoration	1	LS	\$30,000	\$30,000
				Subtotal	\$2,381,000

Table 23
Alternate 1 Estimated Construction Cost – Lott Canyon Debris Basin

No.	Item	Quantity	Units	Unit Cost	Cost
1	Mobilization (5% of Subtotal)	1	LS	\$268,170	\$268,200
2	Site Prep / survey / misc	1	LS	\$95,000	\$95,000
3	Debris Basin Excavation	102,600	CY	\$12	\$1,231,200
4	Foundation Excavation	35,300	CY	\$12	\$423,600
5	Embankment Fill	42,000	CY	\$12	\$504,000
6	Auxiliary Spillway Excavation	45,500	CY	\$12	\$546,000
7	Excess Material Haul Off	183,400	CY	\$5	\$917,000
8	Access Road	1,900	LF	\$20	\$38,000
9	Install Type 'G' Cap on Dam Embankment Crest	1,020	LF	\$50	\$51,000
10	Type 'R' Drain Gravel	7,100	CY	\$80	\$568,000
11	Type 'Q' Filter Sand	7,100	CY	\$80	\$568,000
12	Rock Mulch (On Upstream Slope of Dam)	500	CY	\$40	\$20,000
13	6-inch Toe Drain Pipe (Perforated)	2,040	LF	\$40	\$81,600
14	Outlet Riser w/ Trash Rack	1	LS	\$60,000	\$60,000
15	30" Concrete Encased Steel Discharge Conduit	230	LF	\$1,000	\$230,000
16	Restoration	1	LS	\$30,000	\$30,000
				Subtotal	\$5,631,600

Table 24
Alternate 1 Estimated Construction Cost – Clark Canyon North Debris Basin

No.	Item	Quantity	Units	Unit Cost	Cost
1	Mobilization (5% of Subtotal)	1	LS	\$82,835	\$82,800
2	Site Prep / survey / misc	1	LS	\$95,000	\$95,000
3	Debris Basin Excavation	22,700	CY	\$12	\$272,400
4	Foundation Excavation	8,500	CY	\$12	\$102,000
5	Embankment Fill	10,800	CY	\$12	\$129,600
6	Auxiliary Spillway Excavation	16,700	CY	\$12	\$200,400
7	Excess Material Haul Off	47,900	CY	\$5	\$239,500
8	Access Road	1,000	LF	\$20	\$20,000
9	Install Type 'G' Cap on Dam Embankment Crest	260	LF	\$50	\$13,000
10	Type 'R' Drain Gravel	1,700	CY	\$80	\$136,000
11	Type 'Q' Filter Sand	1,700	CY	\$80	\$136,000
12	Rock Mulch (On Upstream Slope of Dam)	300	CY	\$40	\$12,000
13	6-inch Toe Drain Pipe (Perforated)	520	LF	\$40	\$20,800
14	Outlet Riser w/ Trash Rack	1	LS	\$60,000	\$60,000
15	30" Concrete Encased Steel Discharge Conduit	190	LF	\$1,000	\$190,000
16	Restoration	1	LS	\$30,000	\$30,000
				Subtotal	\$1,739,500

Table 25
Alternate 1 Estimated Construction Cost – Clark Canyon South Debris Basin

No.	Item	Quantity	Units	Unit Cost	Cost
1	Mobilization (5% of Subtotal)	1	LS	\$ 215,070	\$ 215,100
2	Site Prep / survey / misc	1	LS	\$ 95,000	\$ 95,000
3	Debris Basin Excavation	101,300	CY	\$ 12	\$ 1,215,600
4	Foundation Excavation	23,800	CY	\$ 12	\$ 285,600
5	Embankment Fill	20,800	CY	\$ 12	\$ 249,600
6	Auxiliary Spillway Excavation	10,400	CY	\$ 12	\$ 124,800
7	Non-woven Geotextile Fabric	5,400	SY	\$ 6	\$ 32,400
8	Auxiliary Spillway Riprap Armoring (D50 = 24 in)	7,200	CY	\$ 60	\$ 432,000
9	Excess Material Haul Off	135,500	CY	\$ 5	\$ 677,500
10	Access Road	2,300	LF	\$ 20	\$ 46,000
11	Install Type 'G' Cap on Dam Embankment Crest	430	LF	\$ 50	\$ 21,500
12	Type 'R' Drain Gravel	4,800	CY	\$ 80	\$ 384,000
13	Type 'Q' Filter Sand	4,800	CY	\$ 80	\$ 384,000
14	Rock Mulch (On Upstream Slope of Dam)	600	CY	\$ 40	\$ 24,000
15	6-inch Toe Drain Pipe (Perforated)	860	LF	\$ 40	\$ 34,400
16	Outlet Riser w/ Trash Rack	1	LS	\$ 60,000	\$ 60,000
17	30" Concrete Encased Steel Discharge Conduit	205	LF	\$ 1,000	\$ 205,000
18	Restoration	1	LS	\$ 30,000	\$ 30,000
Subtotal					\$4,516,500

Table 26
Alternate 1 Estimated Construction Cost – Downstream Discharge Channels

No.	Item	Quantity	Units	Unit Cost	Cost
1	Mobilization (5% of Subtotal)	1	LS	\$ 26,670	\$ 29,300
2	Site Prep / survey / misc	1	LS	\$ 40,000	\$ 40,000
3	New Drainage Channel	6,500	LF	\$ 60	\$ 189,000
4	Toe Protection, 12-in Riprap	1,880	CY	\$ 130	\$ 244,400
5	36" Culvert Installation	470	LF	\$ 220	\$ 103,400
6	18" Culvert Installation	50	LF	\$ 160	\$ 8,000
Subtotal					\$614,100

4.1 ALTERNATIVE 2 – TWO EARTHEN EMBANKMENT DEBRIS BASINS

The second alternative considered includes construction of two debris basins on the watersheds upstream of Saratoga Springs City. For this alternative, Burnt Canyon and Lott Canyon would both drain to a single, larger debris basin. The debris basin would be located within the area known as the Clay Pits. New channels would be required to convey larger flows from the canyons to the debris basins farther down the alluvial fan. A drainage channel out of the debris basin would also be built.

Similarly, Clark Canyon North and South would drain to a single debris basin. New channels would be required to convey larger flows from the canyons to the debris basins farther down the alluvial fan.

An initial analysis of this alternative indicated that each of the debris basins would need to be built on properties that are expected to be developed by private land owners. There were no locations identified on undevelopable land for the proposed debris basins that could capture runoff flows from the relevant canyons. For this reason, Alternative 2 was not evaluated further.

4.1 ALTERNATIVE 3 – DRAINAGE CHANNELS

4.1.1 CHANNEL DESIGN CRITERIA

A drainage channel option was evaluated as an alternative to constructing debris basins to control runoff and sediment from the study area canyons. For both Burnt/Lott Canyons and Clark Canyon, channels were sized based on conveying the runoff generated from a 100-year storm event.

Features of the channel only options include:

- Installing new channels, or expanding existing channels
 - Burnt/Lott Canyon: Length = 12,900 feet
 - Clark Canyon: Length = 11,300 feet
- Proposed channels are stabilized with riprap along the toes of the channel, drop structures placed at regular intervals to reduce flow velocity and erosion, and an erosion control blanket with vegetation on the banks
- Culverts crossing existing roads would be replaced if the existing culvert is unable to adequately convey the required 100-year flow
- Access roads would be built or expanded adjacent to the channel to allow for operation and maintenance personnel to gain access to the channel to remove sediment and debris
- Areas disturbed during construction would be restored and irrigation facilities would be installed to ensure adequate growth of vegetation intended to provide erosion control on the channel banks
- Drainage easements would be required along the length of the drainage channel. Easements would be approximately 60- feet wide to cover the top width of the channel and the adjacent access road.
- In some cases, due to limitations of where a drainage channel could physically be located, some residential homes would need to be purchased.

Figure 24 and Figure 25 show the proposed alignments for the Burnt/Lott Canyons and Clark Canyons Drainage Channels, respectively.



Figure 24: Alternative 3 – Burnt/Lott Canyon Drainage Channel Alignment

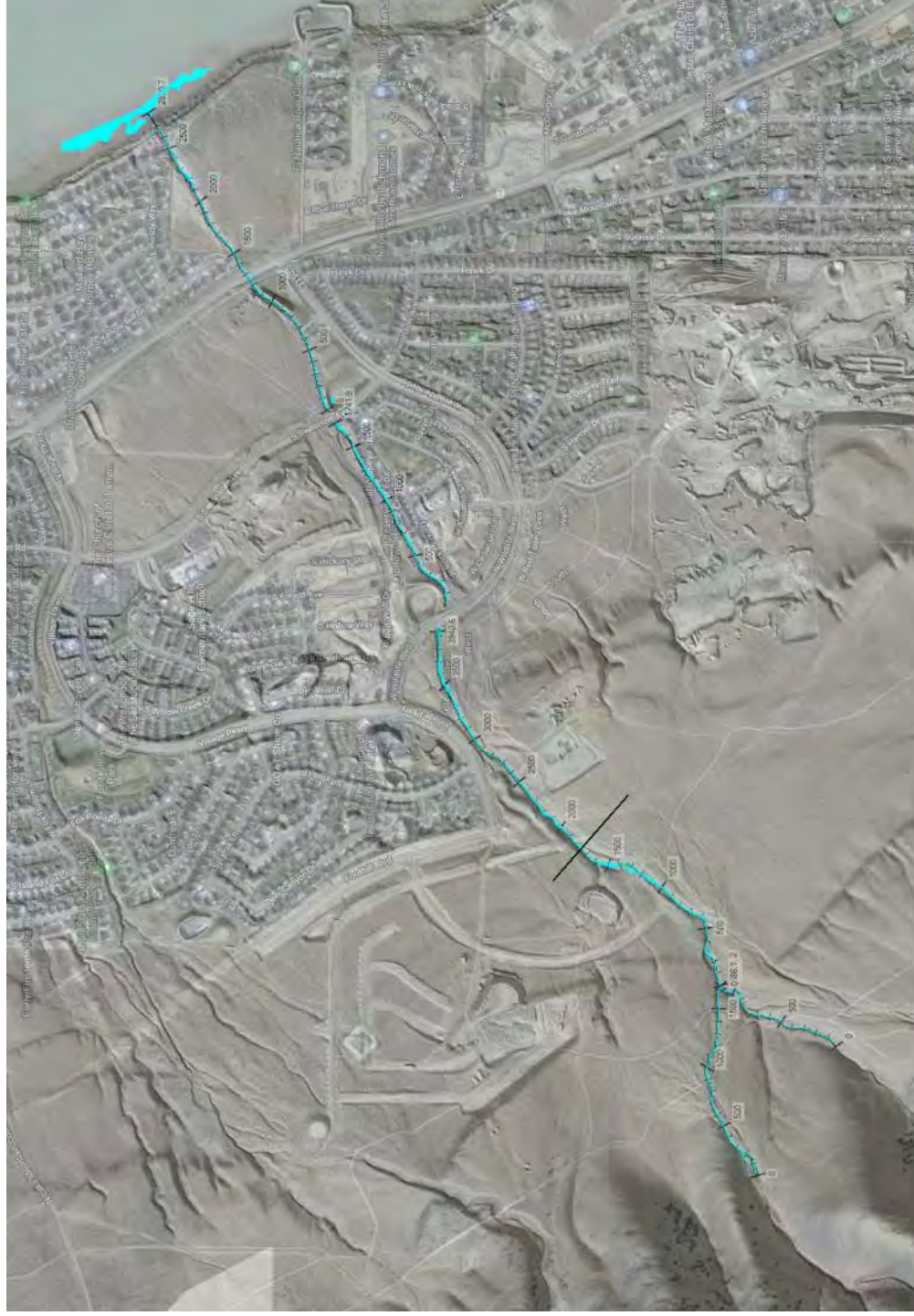


Figure 25: Alternative 3 - Clark Canyon Drainage Channel Alignment

Channel alignments were selected that utilized existing drainage channels where possible. A preliminary evaluation of the channel only option led to the following conclusions regarding the relative costs and benefits of the project:

- For conveying runoff flows from 100-year or less storm events, the channel option would perform similarly to the debris basin option (i.e. in both cases the runoff is sufficiently detained or contained to prevent damage to downstream facilities). However, for storms larger than 100-year, the channel option performs worse than the debris basin option due to the channel option's lack of significant attenuation of flood flows.
- The channel option would require more frequent maintenance than the debris basin option. Debris and sediment would frequently need to be removed from the channels to maintain adequate capacity for the design storm.
- The channel option does not provide significant sediment storage. Some sediment would accumulate near culverts when the in-channel flows slow, but most of the sediment produced during a large storm event would be conveyed to Utah Lake.
- Preliminary cost estimates were prepared for the channel only options based on the features described above. It was found that the cost of the channel option for Burnt/Lott Canyon was significantly higher than the debris basin option. This was due largely to property acquisition costs. The Burnt/Lott Canyon channel option would require constructing a new drainage channel through a residential neighborhood, and would likely require the purchase of multiple houses, in addition to other land and easement costs.
- The estimated cost of the Clark Canyon drainage channel option is slightly more than the estimated cost of the debris basin option.

Compared to the debris basin options, the channel options provide flood protection for a narrower range of storm events, do not provide significant sediment storage, would require frequent maintenance, and are estimated to have a higher cost. For these reasons, the channel only option is not recommended.

4.1.2 ESTIMATED CONSTRUCTION COST - ALTERNATIVE 3

The combined estimated construction cost for Alternative 3 – Drainage Channels is approximately \$20.9 million (\$27.2 million with 30% contingency) as shown in Tables 27 and 28.

Table 27
Alternate 3 Estimated Construction Cost – Burnt/Lott Canyon Drainage Channel

No.	Item	Quantity	Units	Unit Cost	Cost
1	Mobilization (5% of Subtotal)	1	LS	\$370,000	\$370,000
2	Field Survey and Staking	1	LS	\$30,000	\$30,000
3	Dewater and River Management	1	LS	\$30,000	\$30,000
4	Construction Access	1	LS	\$10,000	\$10,000
5	Sediment & Debris Removal, and Disposal	86,270	CY	\$30	\$2,588,100
6	Riprap D ₅₀ = 12-inch (reduced due to drop structures)	3,820	CY	\$130	\$496,600
7	6" Aggregate Base Course	2,864	CY	\$60	\$171,900
8	Restore Disturbed Areas (seed, coir logs, erosion control blanket). 3:1 slopes.	260,000	SF	\$5	\$1,300,000
9	Seed Restoration (disturbed areas for construction)	260,000	SF	\$1	\$260,000
10	Box Culvert	2	EA	\$600,000	\$1,200,000
11	Drop Structures	299	EA	\$4,000	\$1,196,000
12	Property Acquisition	10.2	AC	\$100,000	\$1,020,000
13	Homes Purchased	8	EA	\$750,000	\$6,000,000
Subtotal					\$14,672,600

Table 28
Alternate 3 Estimated Construction Cost – Clark Canyon Drainage Channel

No.	Item	Quantity	Units	Unit Cost	Cost
1	Mobilization (5% of Subtotal)	1	LS	\$280,000	\$280,000
2	Field Survey and Staking	1	LS	\$20,000	\$20,000
3	Dewater and River Management	1	LS	\$30,000	\$30,000
4	Construction Access	1	LS	\$20,000	\$20,000
5	Sediment & Debris Removal, and Disposal	42,410	CY	\$30	\$1,272,300
6	Riprap D ₅₀ = 12-inch (reduced due to drop structures)	1,680	CY	\$130	\$218,400
7	Restore Disturbed Areas (seed, coir logs, erosion control blanket). 3:1 slopes.	226,000.0	SF	\$5	\$1,017,000
8	6" Aggregate Base Course	2,519	CY	\$60	\$151,100

9	Seed Restoration (disturbed areas for construction)	226,000	SF	\$1	\$113,000
10	Drop Structures	295	EA	\$3,200	\$944,000
11	Mobilization (5% of Subtotal)	1	LS	\$280,000	\$280,000
12	Property Acquisition	12	AC	\$50,000	\$415,000
				Subtotal	\$6,280.800

4.2 ALTERNATIVE 4 - DO NOTHING

The No Action Alternative consists of the City choosing to leave the Burnt Canyon, Lott Canyon, and Clark Canyon drainage basins “as-is” with no future improvements. The City would continue to perform O&M activities to maintain the existing channel capacities. The annual cost for O&M is estimated at \$40,000 for the Burnt-Lott Canyon site and \$40,000 for the Clark Canyon site. Under this alternative there would still be the potential for significant flooding through Saratoga Springs City as shown in the existing conditions floodplain maps shown on Figure 6 and Figure 7. The number of potentially flooded homes will increase over time as development continues within Saratoga Springs.

4.3 CONCLUSIONS

Based upon this analysis, we recommend that Alternative 1 - constructing new debris basins at the mouth of Burnt Canyon, Lott Canyon, and two basins at Clark Canyon- be selected as the preferred alternative. Alternative 1 provides the greatest flood protection and the best method of controlling sediment and debris running off the drainage basins. Alternative 1 reduces the 100-year peak flood flows to a level which can be conveyed safely through existing storm drain infrastructure. It also prevents flood water from being dangerously conveyed down road rights-of-way. Each debris basin alternative includes installation of a new dam embankment, debris basin excavation, principal and auxiliary spillway installation, and access road installation. The improvements associated with Alternative 1 are summarized in Table 29 and shown on the design drawings included in Appendix G.

Table 29
Summary of Recommendations

ID	Recommendations
BC-1	Construct a new 18.4 ac-ft debris basin at the mouth of Burnt Canyon to reduce the “Burnt Canyon” sub-basin peak runoff from 274 cfs to 3.1 cfs
LC-1	Construct a new 35.3 ac-ft debris basin at the mouth of Lott Canyon to reduce the peak runoff from “Lott Canyon” sub-basin from 283 cfs to 7.0 cfs.
CC-1	Construct a new 6.0 ac-ft debris basin at the mouth of Clark Canyon (North) to reduce peak runoff from “Clark Canyon North” sub-basin from 98 cfs to 21 cfs.
CC-2	Construct a new 18.3 ac-ft debris basin at the mouth of Clark Canyon (South) to reduce peak runoff from “Clark Canyon South” sub-basin from 139 cfs to 25 cfs.
DC-1	Construct a new Drainage Channel and new culverts downstream of the Burnt Canyon, Lott Canyon, and Clark Canyon North Debris Basins that connects to existing drainage infrastructure to control conveyance of Burnt, Lott, and Clark Canyon outflow.

SECTION 5 - PROPERTY ACQUISITION

The Burnt Canyon, Lott Canyon, and Clark Canyon South debris basins are located on State of Utah owned property. This property is managed by the School and Institutional Trust Lands Administration (SITLA) as noted in Table 30. Saratoga Springs City plans to work with SITLA to obtain easements or property ownership for these three projects. The City anticipates that the property whereon the Clark Canyon North Debris Basin is located (currently owned by Fox Hollow LLC) will be deeded to the City as dedicated open space. Installation or expansion of drainage channels and installation of new culverts will require relatively small impacts to State and private property, as listed in Table 30.

Table 30
Areas of Property Acquisition

Work	Serial No.	Property Owner
Burnt Canyon Debris Basin	59:003:0001	State of Utah – School and Institutional Trust Lands Administration (SITLA)
Lott Canyon Debris Basin	59:003:0001	State of Utah – School and Institutional Trust Lands Administration (SITLA)
Burnt/Lott Canyon Drainage Channels	59:003:0004	State of Utah – School and Institutional Trust Lands Administration (SITLA)
	59:002:0173	Calvin K Jacob Family Partnership
	59:002:0160	Patriot Ridge LLC
Clark Canyon North Debris Basin	59:014:0011	SCP Fox Hollow LLC
Clark Canyon South Debris Basin	59:014:0002	State of Utah – School and Institutional Trust Lands Administration (SITLA)
Clark Canyon Drainage Channel	59:014:0002	State of Utah – School and Institutional Trust Lands Administration (SITLA)
	59:014:0014	Utah County
	59:013:0022	La Familial VSS LCC
Clark Canyon Drainage Channel Culverts	59:013:0053	Zenith Land Partners LLC

SECTION 6 - PRELIMINARY OPINION OF PROJECT COSTS

A summary of the conceptual level construction and installation costs for both the Burnt, Lott, and Clark Canyon Debris Basins are provided in Table 31. Note that the cost estimates include a 20-percent contingency for budgeting to account for unknown factors that may be present at the time of bid including variability in material pricing and bidding climate.

Table 31
Preliminary Opinion of Probable Project Costs

Preliminary Opinion of Project Cost 					
Project: Saratoga Springs Plan EA Projects			Date:	6/18/2024	
Owner: Saratoga Springs City, NRCS			Prepared by:	CM	
Item No.	Classification of Unit Price Work	Quantity	Unit	Unit Price	Amount
Construction Costs:					
1	Burnt Canyon Debris Basin	1	LS	\$ 2,381,100	\$ 2,381,100
2	Lott Canyon Debris Basin	1	LS	\$ 5,631,600	\$ 5,631,600
3	Burnt/Lott Canyon Discharge Pipeline Drainage Channels	1	LS	\$ 419,700	\$ 419,700
4	Clark Canyon North Debris Basin	1	LS	\$ 1,739,500	\$ 1,739,500
5	Clark Canyon South Debris Basin	1	LS	\$ 4,516,500	\$ 4,516,500
6	Clark Canyon Discharge Pipeline Drainage Channels	1	LS	\$ 194,400	\$ 194,400
SUBTOTAL:					\$ 14,688,400
Contingency				20%	\$ 2,937,700
CONSTRUCTION SUBTOTAL:					\$ 17,626,100
Other Installation Costs:					
Engineering				10%	\$ 1,762,600
Real Property Rights				7%	\$ 1,302,900
Natural Resources Rights				0%	\$ -
Permitting				0.50%	\$ 88,100
Relocation Payments				0%	\$ -
Administration				10%	\$ 1,762,600
OTHER INSTALLATION COSTS SUBTOTAL:					\$ 4,916,200
TOTAL COST:					\$ 22,542,300
This opinion of probable construction is based on experience with past projects of similar construction. It is understood that Bowen Collins & Associates has no control over economical factors or unknown conditions that may have a significant impact on actual project costs. Bowen Collins & Associates does not guarantee its cost estimates and accepts no liability for problems created by the difference in actual costs and this opinion of probable construction cost.					

SECTION 7 - STATEMENT OF LIMITATIONS

This document represents Bowen Collins & Associates professional judgement based on the information available at the time of its completion, and as appropriate for the project scope of work. Services performed in developing the content of this document have been conducted in a manner consistent with that level and skill ordinarily exercised by members of the engineering profession currently practicing under similar conditions. No warranty, express or implied, is made.

SECTION 8 - REFERENCES

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APPENDIX A RAINFALL DATA

BURNT/LOTT CANYONS



NOAA Atlas 14, Volume 1, Version 5
Location name: Cedar Valley, Utah, USA*
Latitude: 40.3127°, Longitude: -111.9489°
Elevation: 5670.26 ft**
* source: ESRI Maps
** source: USGS



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

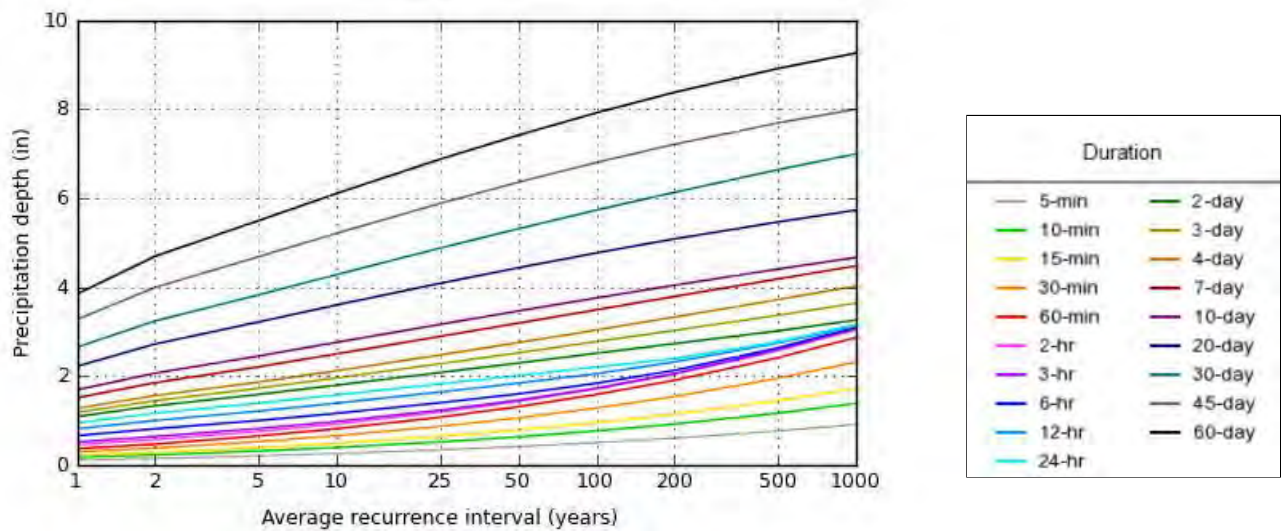
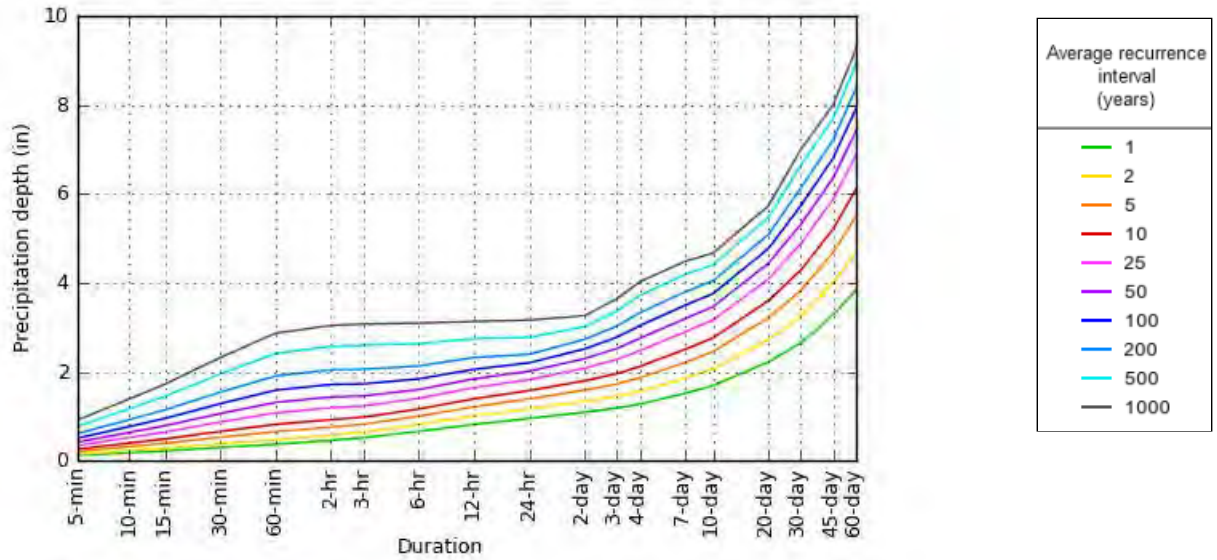
PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches) ¹										
Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.118 (0.102-0.139)	0.150 (0.130-0.176)	0.208 (0.179-0.245)	0.260 (0.221-0.308)	0.342 (0.285-0.406)	0.417 (0.339-0.499)	0.505 (0.399-0.607)	0.606 (0.463-0.741)	0.768 (0.559-0.956)	0.912 (0.638-1.16)
10-min	0.180 (0.155-0.211)	0.228 (0.198-0.268)	0.317 (0.273-0.373)	0.396 (0.337-0.468)	0.520 (0.433-0.618)	0.635 (0.516-0.759)	0.768 (0.607-0.924)	0.923 (0.704-1.13)	1.17 (0.851-1.46)	1.39 (0.971-1.76)
15-min	0.222 (0.192-0.262)	0.283 (0.246-0.332)	0.392 (0.338-0.462)	0.490 (0.418-0.580)	0.645 (0.537-0.766)	0.787 (0.640-0.941)	0.952 (0.752-1.15)	1.14 (0.873-1.40)	1.45 (1.05-1.80)	1.72 (1.20-2.18)
30-min	0.299 (0.259-0.353)	0.381 (0.332-0.448)	0.528 (0.456-0.622)	0.660 (0.563-0.781)	0.869 (0.723-1.03)	1.06 (0.862-1.27)	1.28 (1.01-1.54)	1.54 (1.18-1.88)	1.95 (1.42-2.43)	2.32 (1.62-2.94)
60-min	0.370 (0.321-0.436)	0.471 (0.410-0.554)	0.654 (0.564-0.769)	0.817 (0.696-0.967)	1.08 (0.895-1.28)	1.31 (1.07-1.57)	1.59 (1.25-1.91)	1.91 (1.46-2.33)	2.41 (1.76-3.01)	2.87 (2.01-3.63)
2-hr	0.458 (0.410-0.527)	0.576 (0.512-0.661)	0.757 (0.668-0.868)	0.924 (0.808-1.06)	1.19 (1.02-1.37)	1.43 (1.20-1.67)	1.72 (1.39-2.01)	2.05 (1.60-2.44)	2.57 (1.92-3.13)	3.04 (2.18-3.78)
3-hr	0.518 (0.469-0.584)	0.643 (0.581-0.725)	0.821 (0.739-0.926)	0.980 (0.875-1.11)	1.23 (1.08-1.40)	1.46 (1.25-1.68)	1.73 (1.44-2.03)	2.06 (1.66-2.47)	2.60 (1.99-3.16)	3.07 (2.26-3.82)
6-hr	0.662 (0.610-0.728)	0.816 (0.749-0.897)	1.00 (0.914-1.10)	1.16 (1.06-1.28)	1.40 (1.26-1.55)	1.60 (1.41-1.78)	1.84 (1.59-2.07)	2.13 (1.81-2.49)	2.63 (2.17-3.19)	3.10 (2.47-3.86)
12-hr	0.816 (0.752-0.893)	1.00 (0.922-1.10)	1.21 (1.12-1.33)	1.39 (1.27-1.53)	1.64 (1.49-1.81)	1.84 (1.65-2.04)	2.05 (1.81-2.30)	2.32 (2.01-2.63)	2.74 (2.32-3.21)	3.13 (2.56-3.90)
24-hr	0.951 (0.885-1.02)	1.17 (1.08-1.25)	1.39 (1.30-1.49)	1.58 (1.47-1.69)	1.82 (1.69-1.96)	2.01 (1.86-2.16)	2.20 (2.03-2.37)	2.39 (2.19-2.66)	2.77 (2.40-3.25)	3.16 (2.58-3.94)
2-day	1.09 (1.02-1.17)	1.33 (1.24-1.43)	1.59 (1.48-1.71)	1.80 (1.68-1.93)	2.08 (1.94-2.23)	2.29 (2.13-2.45)	2.51 (2.33-2.70)	2.73 (2.51-2.93)	3.02 (2.76-3.32)	3.26 (2.94-3.98)
3-day	1.18 (1.10-1.28)	1.45 (1.35-1.57)	1.73 (1.61-1.87)	1.96 (1.82-2.11)	2.28 (2.11-2.45)	2.52 (2.33-2.72)	2.78 (2.56-3.00)	3.03 (2.77-3.27)	3.37 (3.06-3.69)	3.64 (3.27-4.19)
4-day	1.28 (1.18-1.39)	1.56 (1.45-1.70)	1.87 (1.73-2.02)	2.12 (1.96-2.30)	2.47 (2.29-2.68)	2.75 (2.53-2.98)	3.04 (2.78-3.30)	3.33 (3.03-3.61)	3.72 (3.36-4.05)	4.03 (3.61-4.40)
7-day	1.51 (1.39-1.65)	1.85 (1.71-2.02)	2.21 (2.04-2.40)	2.50 (2.31-2.71)	2.89 (2.66-3.12)	3.19 (2.94-3.45)	3.49 (3.20-3.77)	3.79 (3.46-4.10)	4.18 (3.79-4.54)	4.48 (4.04-4.87)
10-day	1.69 (1.56-1.83)	2.07 (1.91-2.24)	2.45 (2.27-2.65)	2.76 (2.55-2.98)	3.16 (2.92-3.41)	3.46 (3.19-3.74)	3.76 (3.46-4.05)	4.04 (3.71-4.37)	4.41 (4.02-4.78)	4.67 (4.24-5.07)
20-day	2.22 (2.05-2.40)	2.72 (2.51-2.95)	3.22 (2.98-3.48)	3.60 (3.33-3.89)	4.09 (3.78-4.40)	4.44 (4.10-4.78)	4.77 (4.41-5.14)	5.09 (4.69-5.49)	5.47 (5.03-5.91)	5.73 (5.26-6.21)
30-day	2.65 (2.45-2.85)	3.24 (3.00-3.49)	3.83 (3.55-4.12)	4.28 (3.97-4.61)	4.88 (4.52-5.24)	5.31 (4.91-5.71)	5.73 (5.29-6.17)	6.13 (5.64-6.62)	6.64 (6.08-7.19)	7.00 (6.39-7.59)
45-day	3.27 (3.04-3.52)	3.99 (3.72-4.30)	4.68 (4.37-5.02)	5.21 (4.86-5.58)	5.88 (5.49-6.29)	6.36 (5.93-6.80)	6.80 (6.34-7.27)	7.21 (6.71-7.72)	7.69 (7.15-8.23)	8.00 (7.44-8.57)
60-day	3.84 (3.58-4.11)	4.69 (4.37-5.03)	5.49 (5.12-5.87)	6.11 (5.69-6.51)	6.88 (6.40-7.32)	7.41 (6.90-7.90)	7.92 (7.36-8.43)	8.38 (7.78-8.93)	8.91 (8.27-9.50)	9.26 (8.58-9.89)

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.

[Back to Top](#)

PF graphical

PDS-based depth-duration-frequency (DDF) curves
Latitude: 40.3127°, Longitude: -111.9489°



Maps & aerals

Small scale terrain



Large scale terrain



Large scale map



Large scale aerial



[Back to Top](#)

CLARK CANYON



NOAA Atlas 14, Volume 1, Version 5
Location name: Cedar Valley, Utah, USA*
Latitude: 40.2833°, Longitude: -111.9219°
Elevation: 6284.84 ft**
* source: ESRI Maps
** source: USGS



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

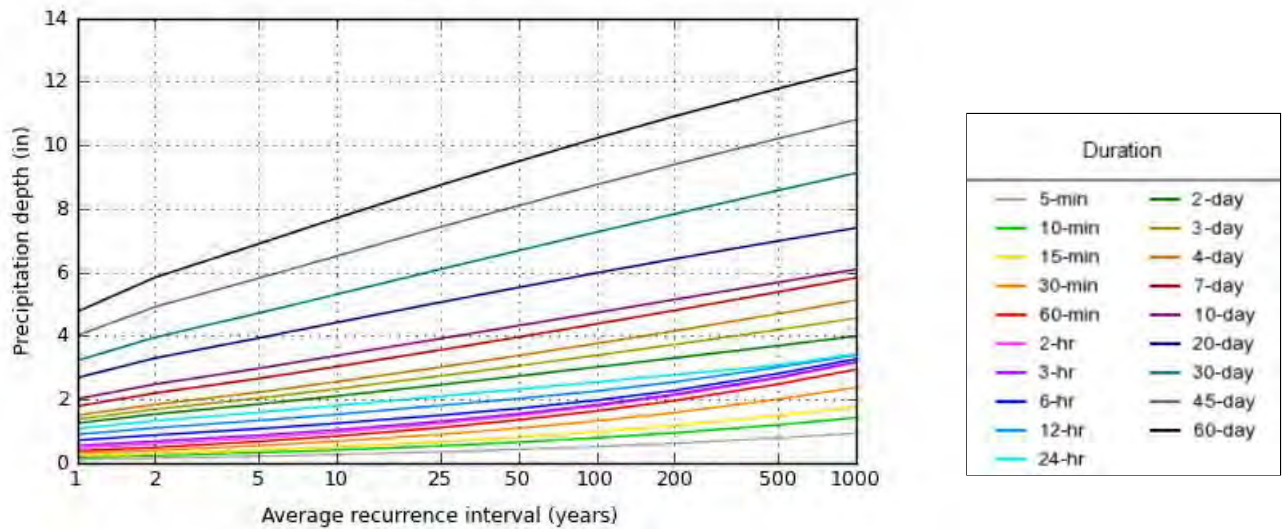
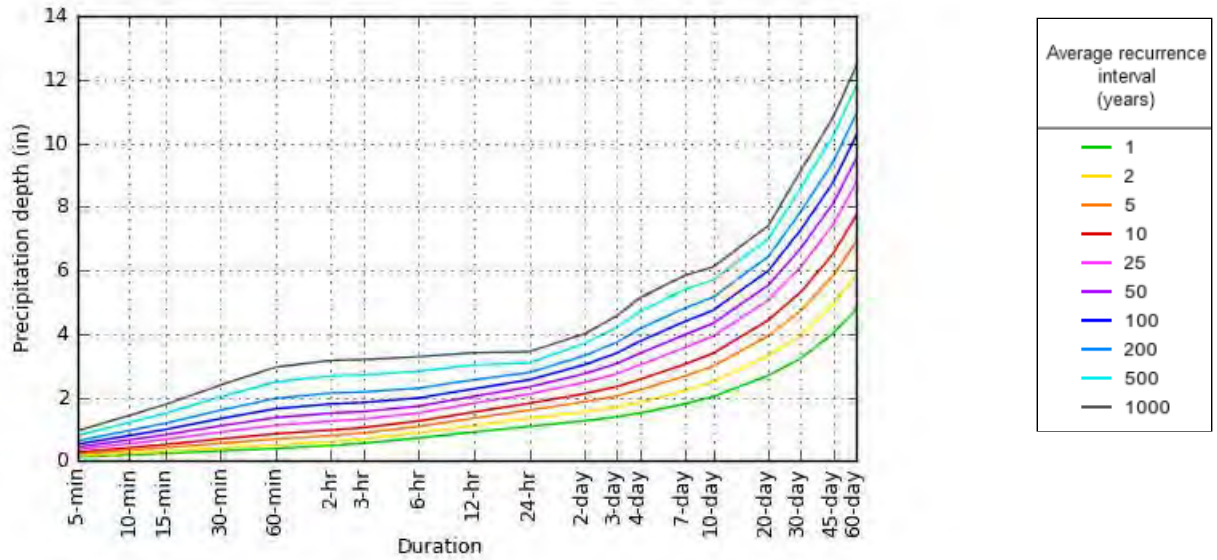
PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches) ¹										
Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.122 (0.106-0.145)	0.156 (0.136-0.184)	0.217 (0.186-0.255)	0.270 (0.230-0.321)	0.354 (0.295-0.422)	0.432 (0.350-0.517)	0.521 (0.412-0.628)	0.624 (0.477-0.765)	0.789 (0.575-0.985)	0.937 (0.656-1.19)
10-min	0.186 (0.161-0.220)	0.238 (0.207-0.280)	0.329 (0.284-0.389)	0.411 (0.350-0.488)	0.539 (0.449-0.643)	0.657 (0.533-0.788)	0.792 (0.627-0.956)	0.951 (0.726-1.16)	1.20 (0.875-1.50)	1.43 (0.998-1.81)
15-min	0.231 (0.200-0.273)	0.294 (0.256-0.348)	0.408 (0.352-0.482)	0.510 (0.434-0.605)	0.668 (0.556-0.797)	0.814 (0.661-0.976)	0.982 (0.777-1.19)	1.18 (0.899-1.44)	1.49 (1.09-1.86)	1.77 (1.24-2.24)
30-min	0.311 (0.269-0.368)	0.397 (0.345-0.468)	0.550 (0.473-0.649)	0.686 (0.584-0.814)	0.900 (0.749-1.07)	1.10 (0.890-1.32)	1.32 (1.05-1.60)	1.59 (1.21-1.94)	2.01 (1.46-2.50)	2.38 (1.67-3.02)
60-min	0.385 (0.333-0.455)	0.491 (0.427-0.580)	0.681 (0.586-0.803)	0.849 (0.723-1.01)	1.11 (0.927-1.33)	1.36 (1.10-1.63)	1.64 (1.30-1.98)	1.96 (1.50-2.40)	2.48 (1.81-3.10)	2.95 (2.06-3.74)
2-hr	0.481 (0.429-0.553)	0.604 (0.535-0.696)	0.793 (0.699-0.915)	0.968 (0.844-1.12)	1.25 (1.06-1.44)	1.50 (1.25-1.75)	1.79 (1.45-2.11)	2.13 (1.67-2.55)	2.67 (1.99-3.26)	3.16 (2.27-3.94)
3-hr	0.550 (0.497-0.622)	0.685 (0.617-0.772)	0.874 (0.783-0.986)	1.04 (0.927-1.18)	1.31 (1.15-1.49)	1.55 (1.32-1.77)	1.83 (1.53-2.12)	2.16 (1.76-2.58)	2.70 (2.10-3.29)	3.18 (2.39-3.98)
6-hr	0.716 (0.658-0.789)	0.882 (0.809-0.971)	1.08 (0.984-1.19)	1.25 (1.14-1.38)	1.50 (1.35-1.67)	1.72 (1.52-1.92)	1.98 (1.71-2.23)	2.28 (1.94-2.61)	2.81 (2.32-3.32)	3.28 (2.64-4.02)
12-hr	0.902 (0.831-0.988)	1.11 (1.02-1.22)	1.34 (1.23-1.47)	1.53 (1.40-1.69)	1.81 (1.63-2.00)	2.03 (1.81-2.25)	2.26 (1.99-2.54)	2.55 (2.21-2.89)	3.01 (2.55-3.48)	3.40 (2.81-4.05)
24-hr	1.08 (1.00-1.17)	1.33 (1.23-1.44)	1.59 (1.48-1.72)	1.81 (1.67-1.95)	2.10 (1.94-2.26)	2.32 (2.13-2.51)	2.55 (2.33-2.75)	2.78 (2.53-3.00)	3.08 (2.78-3.52)	3.43 (2.97-4.09)
2-day	1.26 (1.17-1.36)	1.54 (1.43-1.67)	1.85 (1.72-2.00)	2.11 (1.96-2.28)	2.46 (2.27-2.65)	2.74 (2.52-2.95)	3.02 (2.76-3.26)	3.31 (3.00-3.58)	3.69 (3.32-4.01)	4.00 (3.56-4.36)
3-day	1.38 (1.27-1.50)	1.69 (1.56-1.84)	2.04 (1.88-2.22)	2.33 (2.15-2.54)	2.74 (2.51-2.97)	3.06 (2.79-3.32)	3.39 (3.08-3.69)	3.73 (3.37-4.07)	4.20 (3.75-4.59)	4.56 (4.04-5.01)
4-day	1.50 (1.38-1.64)	1.84 (1.70-2.02)	2.23 (2.05-2.44)	2.56 (2.34-2.79)	3.02 (2.75-3.29)	3.38 (3.07-3.70)	3.76 (3.40-4.12)	4.15 (3.73-4.55)	4.70 (4.17-5.17)	5.13 (4.51-5.67)
7-day	1.79 (1.64-1.96)	2.20 (2.02-2.41)	2.66 (2.44-2.91)	3.04 (2.78-3.32)	3.56 (3.24-3.89)	3.96 (3.60-4.33)	4.38 (3.96-4.79)	4.80 (4.32-5.26)	5.38 (4.79-5.92)	5.83 (5.15-6.44)
10-day	2.02 (1.85-2.20)	2.48 (2.28-2.70)	2.98 (2.73-3.24)	3.38 (3.09-3.68)	3.92 (3.57-4.26)	4.33 (3.93-4.70)	4.73 (4.29-5.16)	5.15 (4.64-5.62)	5.69 (5.09-6.23)	6.10 (5.42-6.70)
20-day	2.68 (2.46-2.92)	3.30 (3.03-3.60)	3.93 (3.61-4.28)	4.43 (4.06-4.82)	5.06 (4.63-5.50)	5.53 (5.05-6.01)	5.98 (5.45-6.52)	6.43 (5.84-7.02)	6.99 (6.32-7.65)	7.40 (6.66-8.13)
30-day	3.22 (2.96-3.49)	3.96 (3.65-4.30)	4.72 (4.34-5.12)	5.31 (4.89-5.76)	6.10 (5.60-6.62)	6.68 (6.12-7.26)	7.27 (6.63-7.91)	7.84 (7.12-8.55)	8.58 (7.75-9.39)	9.13 (8.20-10.0)
45-day	4.01 (3.70-4.34)	4.92 (4.54-5.32)	5.81 (5.37-6.29)	6.51 (6.01-7.05)	7.43 (6.84-8.04)	8.10 (7.44-8.78)	8.76 (8.02-9.49)	9.40 (8.57-10.2)	10.2 (9.26-11.1)	10.8 (9.75-11.8)
60-day	4.76 (4.40-5.14)	5.84 (5.40-6.31)	6.90 (6.37-7.44)	7.71 (7.11-8.31)	8.74 (8.04-9.43)	9.49 (8.72-10.2)	10.2 (9.36-11.0)	10.9 (9.96-11.8)	11.8 (10.7-12.8)	12.4 (11.2-13.5)

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.

[Back to Top](#)

PF graphical

PDS-based depth-duration-frequency (DDF) curves
Latitude: 40.2833°, Longitude: -111.9219°



Maps & aerals

Small scale terrain



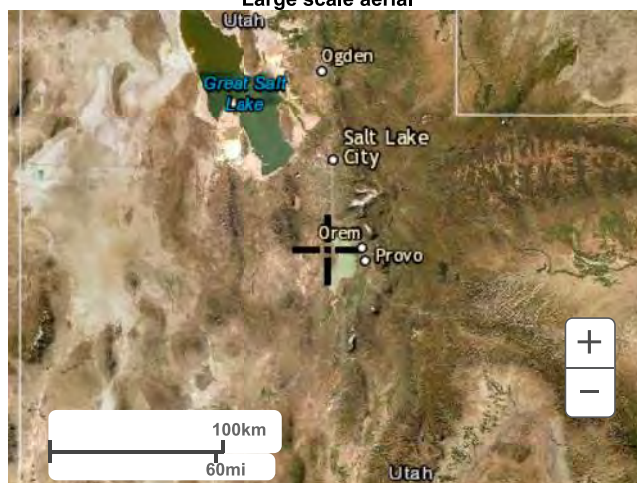
Large scale terrain



Large scale map



Large scale aerial



[Back to Top](#)

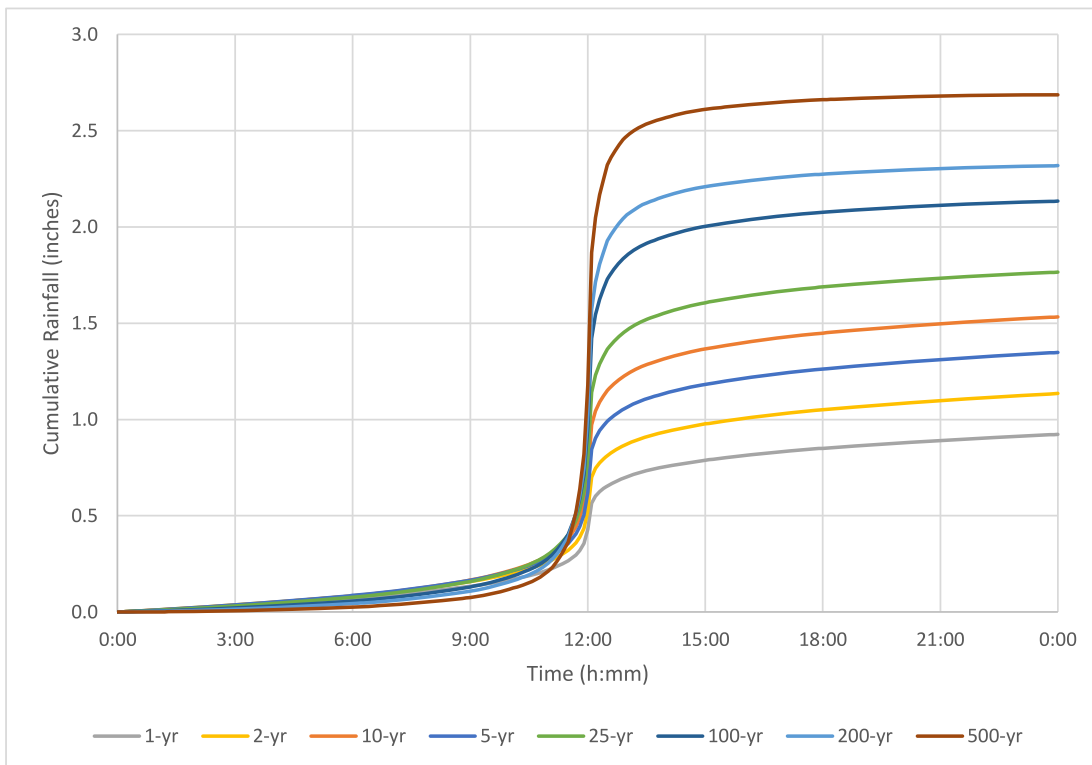
JOB TITLE Saratoga Springs Watershed Plan EA - Burnt/Lott Canyons
 CALC. BY DS
 CHECK BY CM
 SUBJECT: 24-Hr WinTR20 Distribution

DATE 08/30/21
 DATE 08/30/21

= cell requiring user input

Areal Reduction Factor (ARF)	
Basin Area	ARF
(mi ²)	
2.5	0.97

Storm Duration			NOAA Atlas 14 Rainfall Depth (inches)								
			Return Period								
Days	Hrs	Mins	1-yr	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	200-yr	500-yr
	24		0.95	1.17	1.39	1.58	1.82	2.01	2.20	2.39	2.77
ARF Adjusted Depths			0.92	1.13	1.35	1.53	1.77	1.95	2.13	2.32	2.69



6 min Interval		Unit Rainfall (inches)	Design Rainfall Distribution (Cumulative inches)								
Start	End		1-yr	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	200-yr	500-yr
-	0:00	-	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0:00	0:06	-	0.001	0.001	0.001	0.001	0.001	0.001	0.000	0.000	0.000
0:06	0:12	-	0.002	0.002	0.002	0.002	0.002	0.001	0.001	0.001	0.000
0:12	0:18	-	0.003	0.003	0.003	0.003	0.003	0.002	0.001	0.001	0.000
0:18	0:24	-	0.004	0.004	0.004	0.004	0.003	0.003	0.002	0.001	0.000
0:24	0:30	-	0.005	0.005	0.005	0.005	0.004	0.003	0.003	0.001	0.000
0:30	0:36	-	0.006	0.007	0.006	0.006	0.005	0.004	0.003	0.002	0.000
0:36	0:42	-	0.007	0.008	0.008	0.007	0.006	0.005	0.004	0.002	0.000
0:42	0:48	-	0.008	0.009	0.009	0.008	0.007	0.006	0.004	0.003	0.001
0:48	0:54	-	0.009	0.010	0.010	0.009	0.008	0.006	0.005	0.003	0.001
0:54	1:00	-	0.010	0.011	0.011	0.010	0.009	0.007	0.005	0.003	0.001
1:00	1:06	-	0.011	0.012	0.012	0.011	0.010	0.008	0.006	0.004	0.001
1:06	1:12	-	0.012	0.014	0.013	0.013	0.011	0.009	0.007	0.004	0.001
1:12	1:18	-	0.013	0.015	0.015	0.014	0.012	0.010	0.007	0.005	0.001
1:18	1:24	-	0.014	0.016	0.016	0.015	0.013	0.010	0.008	0.005	0.002
1:24	1:30	-	0.015	0.017	0.017	0.016	0.014	0.011	0.009	0.006	0.002
1:30	1:36	-	0.016	0.018	0.018	0.017	0.015	0.012	0.010	0.006	0.002
1:36	1:42	-	0.017	0.020	0.020	0.018	0.016	0.013	0.010	0.007	0.002
1:42	1:48	-	0.018	0.021	0.021	0.020	0.017	0.014	0.011	0.007	0.002
1:48	1:54	-	0.019	0.022	0.022	0.021	0.018	0.015	0.012	0.008	0.003
1:54	2:00	-	0.020	0.023	0.023	0.022	0.019	0.016	0.013	0.008	0.003
2:00	2:06	-	0.021	0.025	0.025	0.023	0.020	0.017	0.013	0.009	0.003
2:06	2:12	-	0.022	0.026	0.026	0.025	0.022	0.018	0.014	0.009	0.004
2:12	2:18	-	0.024	0.027	0.027	0.026	0.023	0.019	0.015	0.010	0.004
2:18	2:24	-	0.025	0.029	0.029	0.027	0.024	0.020	0.016	0.011	0.004
2:24	2:30	-	0.026	0.030	0.030	0.028	0.025	0.021	0.017	0.011	0.005
2:30	2:36	-	0.027	0.031	0.031	0.030	0.026	0.022	0.018	0.012	0.005
2:36	2:42	-	0.028	0.033	0.033	0.031	0.028	0.023	0.018	0.013	0.005
2:42	2:48	-	0.029	0.034	0.034	0.033	0.029	0.024	0.019	0.013	0.006
2:48	2:54	-	0.031	0.036	0.036	0.034	0.030	0.025	0.020	0.014	0.006
2:54	3:00	-	0.032	0.037	0.037	0.035	0.031	0.026	0.021	0.015	0.007
3:00	3:06	-	0.033	0.038	0.039	0.037	0.033	0.027	0.022	0.016	0.007
3:06	3:12	-	0.034	0.040	0.040	0.038	0.034	0.029	0.023	0.016	0.007
3:12	3:18	-	0.035	0.041	0.041	0.040	0.035	0.030	0.024	0.017	0.008
3:18	3:24	-	0.037	0.043	0.043	0.041	0.037	0.031	0.025	0.018	0.008
3:24	3:30	-	0.038	0.044	0.044	0.042	0.038	0.032	0.026	0.019	0.009
3:30	3:36	-	0.039	0.046	0.046	0.044	0.039	0.033	0.027	0.019	0.009
3:36	3:42	-	0.040	0.047	0.047	0.045	0.041	0.035	0.028	0.020	0.010
3:42	3:48	-	0.042	0.049	0.049	0.047	0.042	0.036	0.029	0.021	0.010
3:48	3:54	-	0.043	0.050	0.051	0.048	0.043	0.037	0.030	0.022	0.011
3:54	4:00	-	0.044	0.052	0.052	0.050	0.045	0.038	0.032	0.023	0.011
4:00	4:06	-	0.046	0.053	0.054	0.051	0.046	0.040	0.033	0.024	0.012
4:06	4:12	-	0.047	0.055	0.055	0.053	0.048	0.041	0.034	0.025	0.013
4:12	4:18	-	0.048	0.056	0.057	0.055	0.049	0.042	0.035	0.026	0.013
4:18	4:24	-	0.049	0.058	0.058	0.056	0.051	0.044	0.036	0.027	0.014
4:24	4:30	-	0.051	0.059	0.060	0.058	0.052	0.045	0.037	0.027	0.014
4:30	4:36	-	0.052	0.061	0.062	0.059	0.054	0.046	0.039	0.028	0.015
4:36	4:42	-	0.054	0.062	0.063	0.061	0.055	0.048	0.040	0.029	0.016
4:42	4:48	-	0.055	0.064	0.065	0.063	0.057	0.049	0.041	0.030	0.016
4:48	4:54	-	0.056	0.066	0.067	0.064	0.058	0.051	0.042	0.031	0.017

6 min Interval		Unit Rainfall (inches)	Design Rainfall Distribution (Cumulative inches)								
Start	End		1-yr	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	200-yr	500-yr
4:54	5:00	-	0.058	0.067	0.068	0.066	0.060	0.052	0.044	0.033	0.018
5:00	5:06	-	0.059	0.069	0.070	0.068	0.062	0.053	0.045	0.034	0.018
5:06	5:12	-	0.060	0.071	0.072	0.069	0.063	0.055	0.046	0.035	0.019
5:12	5:18	-	0.062	0.072	0.074	0.071	0.065	0.056	0.047	0.036	0.020
5:18	5:24	-	0.063	0.074	0.075	0.073	0.067	0.058	0.049	0.037	0.021
5:24	5:30	-	0.065	0.076	0.077	0.075	0.068	0.059	0.050	0.038	0.021
5:30	5:36	-	0.066	0.077	0.079	0.076	0.070	0.061	0.052	0.039	0.022
5:36	5:42	-	0.068	0.079	0.081	0.078	0.072	0.063	0.053	0.040	0.023
5:42	5:48	-	0.069	0.081	0.082	0.080	0.073	0.064	0.054	0.041	0.024
5:48	5:54	-	0.070	0.082	0.084	0.082	0.075	0.066	0.056	0.043	0.025
5:54	6:00	-	0.072	0.084	0.086	0.084	0.077	0.067	0.057	0.044	0.025
6:00	6:06	-	0.073	0.086	0.088	0.086	0.079	0.069	0.059	0.045	0.026
6:06	6:12	-	0.075	0.088	0.090	0.088	0.081	0.071	0.060	0.046	0.027
6:12	6:18	-	0.077	0.090	0.092	0.090	0.082	0.073	0.062	0.048	0.028
6:18	6:24	-	0.078	0.092	0.094	0.092	0.084	0.074	0.064	0.049	0.029
6:24	6:30	-	0.080	0.094	0.096	0.094	0.087	0.076	0.065	0.051	0.030
6:30	6:36	-	0.082	0.096	0.098	0.096	0.089	0.078	0.067	0.052	0.032
6:36	6:42	-	0.083	0.098	0.100	0.098	0.091	0.080	0.069	0.054	0.033
6:42	6:48	-	0.085	0.100	0.103	0.100	0.093	0.083	0.071	0.056	0.034
6:48	6:54	-	0.087	0.102	0.105	0.103	0.095	0.085	0.073	0.057	0.035
6:54	7:00	-	0.089	0.104	0.107	0.105	0.098	0.087	0.075	0.059	0.037
7:00	7:06	-	0.091	0.106	0.110	0.108	0.100	0.089	0.077	0.061	0.038
7:06	7:12	-	0.093	0.109	0.112	0.110	0.103	0.092	0.080	0.063	0.040
7:12	7:18	-	0.095	0.111	0.115	0.113	0.105	0.094	0.082	0.065	0.041
7:18	7:24	-	0.097	0.113	0.117	0.115	0.108	0.097	0.084	0.067	0.043
7:24	7:30	-	0.099	0.116	0.120	0.118	0.111	0.099	0.087	0.069	0.044
7:30	7:36	-	0.101	0.118	0.122	0.121	0.113	0.102	0.089	0.071	0.046
7:36	7:42	-	0.103	0.121	0.125	0.124	0.116	0.105	0.092	0.074	0.048
7:42	7:48	-	0.105	0.123	0.128	0.127	0.119	0.107	0.094	0.076	0.050
7:48	7:54	-	0.107	0.126	0.131	0.130	0.122	0.110	0.097	0.078	0.052
7:54	8:00	-	0.109	0.129	0.134	0.133	0.125	0.113	0.100	0.081	0.054
8:00	8:06	-	0.112	0.131	0.137	0.136	0.128	0.116	0.102	0.083	0.056
8:06	8:12	-	0.114	0.134	0.140	0.139	0.131	0.119	0.105	0.086	0.058
8:12	8:18	-	0.116	0.137	0.143	0.142	0.135	0.122	0.108	0.088	0.060
8:18	8:24	-	0.119	0.140	0.146	0.145	0.138	0.126	0.111	0.091	0.062
8:24	8:30	-	0.121	0.143	0.149	0.148	0.141	0.129	0.114	0.094	0.064
8:30	8:36	-	0.123	0.146	0.152	0.152	0.145	0.132	0.117	0.097	0.066
8:36	8:42	-	0.126	0.149	0.155	0.155	0.148	0.136	0.121	0.100	0.069
8:42	8:48	-	0.128	0.152	0.159	0.159	0.152	0.139	0.124	0.103	0.071
8:48	8:54	-	0.131	0.155	0.162	0.162	0.155	0.143	0.127	0.106	0.073
8:54	9:00	-	0.134	0.158	0.165	0.166	0.159	0.146	0.131	0.109	0.076
9:00	9:06	-	0.136	0.161	0.169	0.170	0.163	0.150	0.134	0.112	0.079
9:06	9:12	-	0.139	0.165	0.173	0.174	0.167	0.154	0.138	0.116	0.082
9:12	9:18	-	0.142	0.168	0.177	0.178	0.171	0.159	0.143	0.120	0.085
9:18	9:24	-	0.145	0.172	0.181	0.182	0.176	0.163	0.147	0.124	0.089
9:24	9:30	-	0.149	0.176	0.186	0.187	0.181	0.168	0.152	0.129	0.093
9:30	9:36	-	0.152	0.180	0.190	0.192	0.186	0.174	0.158	0.134	0.097
9:36	9:42	-	0.156	0.184	0.195	0.197	0.192	0.179	0.163	0.139	0.102
9:42	9:48	-	0.159	0.189	0.200	0.203	0.198	0.185	0.169	0.145	0.107
9:48	9:54	-	0.163	0.193	0.205	0.208	0.204	0.192	0.175	0.151	0.113

6 min Interval		Unit Rainfall (inches)	Design Rainfall Distribution (Cumulative inches)								
Start	End		1-yr	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	200-yr	500-yr
9:54	10:00	-	0.167	0.198	0.211	0.214	0.210	0.198	0.182	0.157	0.118
10:00	10:06	-	0.171	0.203	0.216	0.221	0.217	0.205	0.188	0.164	0.124
10:06	10:12	-	0.175	0.208	0.222	0.227	0.223	0.212	0.196	0.171	0.131
10:12	10:18	-	0.180	0.214	0.228	0.234	0.231	0.219	0.203	0.178	0.137
10:18	10:24	-	0.184	0.219	0.234	0.240	0.238	0.227	0.211	0.185	0.144
10:24	10:30	-	0.189	0.225	0.241	0.247	0.246	0.235	0.219	0.193	0.151
10:30	10:36	-	0.194	0.231	0.248	0.255	0.254	0.244	0.228	0.203	0.160
10:36	10:42	-	0.199	0.238	0.256	0.264	0.264	0.255	0.239	0.214	0.171
10:42	10:48	-	0.205	0.245	0.265	0.274	0.275	0.267	0.251	0.226	0.183
10:48	10:54	-	0.212	0.253	0.274	0.285	0.287	0.280	0.265	0.240	0.197
10:54	11:00	-	0.219	0.262	0.285	0.297	0.300	0.294	0.280	0.255	0.213
11:00	11:06	-	0.227	0.272	0.296	0.310	0.316	0.311	0.298	0.275	0.234
11:06	11:12	-	0.236	0.282	0.309	0.325	0.334	0.331	0.320	0.298	0.259
11:12	11:18	-	0.245	0.294	0.324	0.342	0.354	0.353	0.345	0.325	0.289
11:18	11:24	-	0.255	0.307	0.340	0.361	0.376	0.379	0.373	0.356	0.324
11:24	11:30	-	0.266	0.321	0.357	0.381	0.400	0.407	0.404	0.390	0.364
11:30	11:36	-	0.281	0.340	0.381	0.411	0.437	0.451	0.455	0.450	0.440
11:36	11:42	-	0.296	0.359	0.406	0.442	0.476	0.497	0.509	0.512	0.520
11:42	11:48	-	0.320	0.389	0.445	0.488	0.535	0.565	0.589	0.604	0.638
11:48	11:54	-	0.357	0.435	0.504	0.560	0.624	0.671	0.712	0.747	0.820
11:54	12:00	-	0.429	0.526	0.621	0.702	0.802	0.880	0.956	1.030	1.179
12:00	12:06	-	0.566	0.700	0.845	0.973	1.141	1.279	1.422	1.571	1.867
12:06	12:12	-	0.602	0.746	0.904	1.044	1.231	1.384	1.545	1.714	2.049
12:12	12:18	-	0.626	0.776	0.942	1.091	1.289	1.453	1.625	1.807	2.167
12:18	12:24	-	0.641	0.795	0.967	1.122	1.328	1.499	1.679	1.869	2.247
12:24	12:30	-	0.656	0.814	0.991	1.151	1.365	1.543	1.730	1.928	2.322
12:30	12:36	-	0.667	0.828	1.009	1.172	1.389	1.571	1.761	1.962	2.362
12:36	12:42	-	0.677	0.841	1.025	1.190	1.412	1.596	1.789	1.993	2.398
12:42	12:48	-	0.687	0.852	1.039	1.207	1.432	1.619	1.814	2.020	2.428
12:48	12:54	-	0.696	0.863	1.052	1.223	1.449	1.639	1.836	2.043	2.453
12:54	13:00	-	0.703	0.873	1.064	1.236	1.465	1.656	1.854	2.063	2.474
13:00	13:06	-	0.711	0.882	1.074	1.248	1.478	1.670	1.869	2.078	2.490
13:06	13:12	-	0.717	0.890	1.084	1.258	1.490	1.683	1.883	2.092	2.504
13:12	13:18	-	0.723	0.897	1.092	1.268	1.501	1.695	1.895	2.105	2.516
13:18	13:24	-	0.729	0.904	1.100	1.277	1.511	1.705	1.906	2.116	2.526
13:24	13:30	-	0.734	0.910	1.108	1.285	1.520	1.715	1.915	2.125	2.535
13:30	13:36	-	0.738	0.916	1.114	1.292	1.527	1.723	1.923	2.133	2.543
13:36	13:42	-	0.743	0.921	1.120	1.299	1.535	1.730	1.931	2.140	2.550
13:42	13:48	-	0.747	0.927	1.126	1.306	1.542	1.738	1.938	2.148	2.556
13:48	13:54	-	0.751	0.932	1.132	1.312	1.549	1.745	1.946	2.155	2.563
13:54	14:00	-	0.756	0.937	1.138	1.318	1.555	1.752	1.952	2.161	2.569
14:00	14:06	-	0.759	0.941	1.143	1.324	1.562	1.758	1.959	2.167	2.574
14:06	14:12	-	0.763	0.946	1.148	1.330	1.568	1.764	1.965	2.173	2.580
14:12	14:18	-	0.767	0.951	1.153	1.335	1.574	1.770	1.971	2.179	2.585
14:18	14:24	-	0.770	0.955	1.158	1.340	1.579	1.776	1.976	2.184	2.589
14:24	14:30	-	0.774	0.959	1.163	1.345	1.584	1.781	1.982	2.189	2.594
14:30	14:36	-	0.777	0.963	1.167	1.350	1.589	1.786	1.987	2.194	2.598
14:36	14:42	-	0.780	0.967	1.171	1.355	1.594	1.791	1.991	2.198	2.602
14:42	14:48	-	0.783	0.970	1.175	1.359	1.599	1.796	1.996	2.202	2.605
14:48	14:54	-	0.786	0.974	1.179	1.363	1.603	1.800	2.000	2.206	2.608

6 min Interval		Unit Rainfall (inches)	Design Rainfall Distribution (Cumulative inches)								
Start	End		1-yr	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	200-yr	500-yr
14:54	15:00	-	0.789	0.977	1.183	1.367	1.607	1.804	2.003	2.210	2.611
15:00	15:06	-	0.791	0.980	1.186	1.370	1.610	1.807	2.007	2.213	2.614
15:06	15:12	-	0.794	0.983	1.190	1.374	1.614	1.811	2.010	2.216	2.616
15:12	15:18	-	0.797	0.986	1.193	1.377	1.617	1.814	2.013	2.219	2.618
15:18	15:24	-	0.799	0.989	1.196	1.381	1.621	1.817	2.017	2.222	2.621
15:24	15:30	-	0.801	0.992	1.199	1.384	1.624	1.821	2.020	2.224	2.623
15:30	15:36	-	0.804	0.995	1.203	1.387	1.628	1.824	2.023	2.227	2.625
15:36	15:42	-	0.806	0.998	1.206	1.391	1.631	1.827	2.026	2.230	2.627
15:42	15:48	-	0.809	1.001	1.209	1.394	1.634	1.830	2.029	2.232	2.629
15:48	15:54	-	0.811	1.004	1.212	1.397	1.637	1.833	2.032	2.235	2.631
15:54	16:00	-	0.813	1.006	1.215	1.400	1.640	1.836	2.034	2.238	2.633
16:00	16:06	-	0.815	1.009	1.218	1.403	1.643	1.839	2.037	2.240	2.635
16:06	16:12	-	0.818	1.011	1.220	1.406	1.646	1.842	2.040	2.242	2.637
16:12	16:18	-	0.820	1.014	1.223	1.409	1.649	1.845	2.042	2.245	2.639
16:18	16:24	-	0.822	1.017	1.226	1.412	1.652	1.848	2.045	2.247	2.641
16:24	16:30	-	0.824	1.019	1.229	1.414	1.655	1.850	2.047	2.249	2.642
16:30	16:36	-	0.826	1.021	1.231	1.417	1.657	1.853	2.050	2.251	2.644
16:36	16:42	-	0.828	1.024	1.234	1.420	1.660	1.856	2.052	2.253	2.646
16:42	16:48	-	0.830	1.026	1.236	1.422	1.663	1.858	2.054	2.255	2.647
16:48	16:54	-	0.832	1.029	1.239	1.425	1.665	1.860	2.057	2.257	2.649
16:54	17:00	-	0.834	1.031	1.241	1.427	1.668	1.863	2.059	2.259	2.650
17:00	17:06	-	0.836	1.033	1.243	1.430	1.670	1.865	2.061	2.261	2.652
17:06	17:12	-	0.837	1.035	1.246	1.432	1.672	1.867	2.063	2.263	2.653
17:12	17:18	-	0.839	1.037	1.248	1.434	1.675	1.869	2.065	2.264	2.654
17:18	17:24	-	0.841	1.039	1.250	1.437	1.677	1.871	2.067	2.266	2.655
17:24	17:30	-	0.843	1.041	1.252	1.439	1.679	1.873	2.069	2.268	2.656
17:30	17:36	-	0.844	1.043	1.254	1.441	1.681	1.875	2.070	2.269	2.658
17:36	17:42	-	0.846	1.045	1.256	1.443	1.683	1.877	2.072	2.271	2.659
17:42	17:48	-	0.847	1.047	1.258	1.445	1.685	1.879	2.074	2.272	2.660
17:48	17:54	-	0.849	1.049	1.260	1.447	1.687	1.881	2.075	2.273	2.661
17:54	18:00	-	0.851	1.051	1.262	1.449	1.689	1.882	2.077	2.275	2.661
18:00	18:06	-	0.852	1.052	1.264	1.451	1.690	1.884	2.078	2.276	2.662
18:06	18:12	-	0.853	1.054	1.266	1.453	1.692	1.886	2.080	2.277	2.663
18:12	18:18	-	0.855	1.056	1.268	1.454	1.694	1.887	2.081	2.278	2.664
18:18	18:24	-	0.856	1.058	1.269	1.456	1.695	1.889	2.082	2.279	2.665
18:24	18:30	-	0.858	1.059	1.271	1.458	1.697	1.890	2.084	2.280	2.665
18:30	18:36	-	0.859	1.061	1.273	1.460	1.699	1.892	2.085	2.282	2.666
18:36	18:42	-	0.861	1.063	1.275	1.461	1.700	1.893	2.087	2.283	2.667
18:42	18:48	-	0.862	1.064	1.276	1.463	1.702	1.895	2.088	2.284	2.668
18:48	18:54	-	0.863	1.066	1.278	1.465	1.704	1.896	2.089	2.285	2.668
18:54	19:00	-	0.865	1.068	1.280	1.467	1.705	1.898	2.090	2.286	2.669
19:00	19:06	-	0.866	1.069	1.282	1.468	1.707	1.899	2.092	2.287	2.670
19:06	19:12	-	0.868	1.071	1.283	1.470	1.709	1.901	2.093	2.288	2.670
19:12	19:18	-	0.869	1.072	1.285	1.472	1.710	1.902	2.094	2.289	2.671
19:18	19:24	-	0.870	1.074	1.287	1.473	1.712	1.903	2.095	2.290	2.672
19:24	19:30	-	0.872	1.076	1.288	1.475	1.713	1.905	2.097	2.291	2.672
19:30	19:36	-	0.873	1.077	1.290	1.476	1.715	1.906	2.098	2.292	2.673
19:36	19:42	-	0.874	1.079	1.291	1.478	1.716	1.907	2.099	2.293	2.674
19:42	19:48	-	0.876	1.080	1.293	1.480	1.718	1.909	2.100	2.294	2.674
19:48	19:54	-	0.877	1.082	1.295	1.481	1.719	1.910	2.101	2.295	2.675

6 min Interval		Unit Rainfall (inches)	Design Rainfall Distribution (Cumulative inches)								
Start	End		1-yr	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	200-yr	500-yr
19:54	20:00	-	0.878	1.083	1.296	1.483	1.721	1.911	2.102	2.295	2.675
20:00	20:06	-	0.880	1.085	1.298	1.484	1.722	1.913	2.104	2.296	2.676
20:06	20:12	-	0.881	1.086	1.299	1.486	1.723	1.914	2.105	2.297	2.677
20:12	20:18	-	0.882	1.088	1.301	1.487	1.725	1.915	2.106	2.298	2.677
20:18	20:24	-	0.883	1.089	1.302	1.489	1.726	1.916	2.107	2.299	2.678
20:24	20:30	-	0.885	1.091	1.304	1.490	1.728	1.918	2.108	2.300	2.678
20:30	20:36	-	0.886	1.092	1.305	1.492	1.729	1.919	2.109	2.300	2.679
20:36	20:42	-	0.887	1.094	1.307	1.493	1.730	1.920	2.110	2.301	2.679
20:42	20:48	-	0.888	1.095	1.308	1.495	1.732	1.921	2.111	2.302	2.679
20:48	20:54	-	0.889	1.097	1.310	1.496	1.733	1.922	2.112	2.303	2.680
20:54	21:00	-	0.891	1.098	1.311	1.497	1.734	1.923	2.113	2.304	2.680
21:00	21:06	-	0.892	1.099	1.313	1.499	1.735	1.925	2.114	2.304	2.681
21:06	21:12	-	0.893	1.101	1.314	1.500	1.737	1.926	2.115	2.305	2.681
21:12	21:18	-	0.894	1.102	1.315	1.501	1.738	1.927	2.116	2.306	2.682
21:18	21:24	-	0.895	1.103	1.317	1.503	1.739	1.928	2.116	2.306	2.682
21:24	21:30	-	0.897	1.105	1.318	1.504	1.740	1.929	2.117	2.307	2.682
21:30	21:36	-	0.898	1.106	1.320	1.505	1.742	1.930	2.118	2.308	2.683
21:36	21:42	-	0.899	1.108	1.321	1.507	1.743	1.931	2.119	2.308	2.683
21:42	21:48	-	0.900	1.109	1.322	1.508	1.744	1.932	2.120	2.309	2.683
21:48	21:54	-	0.901	1.110	1.324	1.509	1.745	1.933	2.121	2.309	2.684
21:54	22:00	-	0.902	1.111	1.325	1.511	1.746	1.934	2.121	2.310	2.684
22:00	22:06	-	0.903	1.113	1.326	1.512	1.747	1.935	2.122	2.311	2.684
22:06	22:12	-	0.904	1.114	1.327	1.513	1.748	1.936	2.123	2.311	2.684
22:12	22:18	-	0.905	1.115	1.329	1.514	1.749	1.937	2.124	2.312	2.685
22:18	22:24	-	0.907	1.116	1.330	1.515	1.750	1.938	2.124	2.312	2.685
22:24	22:30	-	0.908	1.118	1.331	1.517	1.752	1.938	2.125	2.313	2.685
22:30	22:36	-	0.909	1.119	1.332	1.518	1.753	1.939	2.126	2.313	2.685
22:36	22:42	-	0.910	1.120	1.334	1.519	1.754	1.940	2.127	2.314	2.686
22:42	22:48	-	0.911	1.121	1.335	1.520	1.755	1.941	2.127	2.314	2.686
22:48	22:54	-	0.912	1.123	1.336	1.521	1.756	1.942	2.128	2.315	2.686
22:54	23:00	-	0.913	1.124	1.337	1.522	1.757	1.943	2.129	2.315	2.686
23:00	23:06	-	0.914	1.125	1.338	1.523	1.757	1.943	2.129	2.315	2.686
23:06	23:12	-	0.915	1.126	1.340	1.524	1.758	1.944	2.130	2.316	2.686
23:12	23:18	-	0.916	1.127	1.341	1.526	1.759	1.945	2.130	2.316	2.686
23:18	23:24	-	0.917	1.128	1.342	1.527	1.760	1.946	2.131	2.316	2.687
23:24	23:30	-	0.918	1.129	1.343	1.528	1.761	1.946	2.131	2.317	2.687
23:30	23:36	-	0.919	1.131	1.344	1.529	1.762	1.947	2.132	2.317	2.687
23:36	23:42	-	0.920	1.132	1.345	1.530	1.763	1.948	2.133	2.317	2.687
23:42	23:48	-	0.921	1.133	1.346	1.531	1.764	1.948	2.133	2.318	2.687
23:48	23:54	-	0.922	1.134	1.347	1.532	1.765	1.949	2.134	2.318	2.687
23:54	0:00	-	0.922	1.135	1.348	1.533	1.765	1.950	2.134	2.318	2.687

Table 6.1 -- General storm PMP computations for the Colorado River and Great basin

	Represent input cells
	Represents output cells
###	Represent calculated fields (do not edit)

Drainage	Burnt & Lott Canyons
Latitude	40.31268 , Longitude -111.9489

Month August

- Step a)
- Covergence PMP
- Figures 2.5 - 2.16 11.01 in.
 - Figure 2.18 55%
 - Step 1 x step 2 6.053768 in.
 - Figures 2.25 to 2.27 and table 2.7 68%
 - Step 3 x Step 4
 - Successive subtraction in step 5
 - Figures 2.28 and 2.29
 - Step 6 x step 7
 - Accumulated values of step 8

- b)
- Orographic PMP
- Figure 3.11a to d 3.21 in.
 - Figure 3.20 100%
 - Figure 3.12 to 3.17 100%
 - Steps 1 x 2 x 3 3.211964 in.
 - Table 3.9
 - Steps 4 x 5

- c)
- Total PMP
- Add Steps A9 and B6

- d)
- Intensity
- Divide total PMP by duration

Table 6.3 --Local storm PMP computation, Colorado River, Great Basin and California drainages. For drainage average depth PMP. Go to table 6.3B if areal variation is required.

- Steps
- Fig 4.5

Reduction for Elevation (not needed for elevations <5,000 ft)

5% decrease per 1,000 ft above 5,000

multiply step 1 by step 2a
 - USUS Adjustment

Successive subtraction in step 7

table 4.7

table 4.8

Time Sequence of Incremental PMP

Results	Precipitation
SEP 6 - hr local storm	9.6 in
SEP 6 - hr general storm	0.00 in
SEP 72 - hr general storm	13.35 in

Copy Attribute Data from Basin Shapefile

Paste here -->	FID	Shape	NAME	AREA_SQMI	LAT	LONG	Fig2_12	Fig2_18	Fig2_26	Fig3_11
	0	Point	Burnt & Lott Cai	2.502288	40.31268	-111.949	11.00685	55	67.56023	3.211964

2002 Update for PMP UT 72 Hr Est. Areas to 5,000 mi^2 (Donald Jensen) - Table 1, pg 4

Duration	6	12	18	24	48	72	72 hr PMP Distribution	Rain fall (in)	13.35 in
Time (hr)	6	12	18	24	48	72	Percent	Percent	
68%	85%	94%	100%	100%	116%	123%	0	0.0228	0.30
4.1	5.1	5.7	6.1	7.0	7.4	7.4	12	0.0684	0.91
4.1	1.1	0.5	0.4	1.0	0.4	0.4	18	0.1254	1.67
100%	100%	100%	100%	100%	100%	100%	24	0.2166	2.89
4.1	1.1	0.5	0.4	1.0	0.4	0.4	30	0.3756	5.01
4.1	1.1	0.5	0.4	1.0	0.4	0.4	36	0.67	8.94
4.1	5.1	5.7	6.1	7.0	7.4	7.4	42	0.772	10.31
4.1	5.1	5.7	6.1	7.0	7.4	7.4	48	0.8404	11.22
4.1	5.1	5.7	6.1	7.0	7.4	7.4	54	0.8974	11.98
4.1	5.1	5.7	6.1	7.0	7.4	7.4	60	0.943	12.59
4.1	5.1	5.7	6.1	7.0	7.4	7.4	66	0.9772	13.05
4.1	5.1	5.7	6.1	7.0	7.4	7.4	72	1	13.35

5.05	7.0	8.3	9.27	12.1	13.45 in.
11.35	--from USUL				

0.19	in/hr
------	-------

Table 15 in USUS	1	2	3	4	5	6
0.25	50	74	90	100	110	112
0.5	74	89.75	98.73	100.52	101.87	102.76
0.75	89.75	95.44	98.82	99.2	99.88	100.21
1.0	95.44	97.8208	98.77143	99.45006	99.718481	99.84896
1.25	97.8208	98.77143	99.45006	99.718481	99.84896	99.84896
1.5	99.45006	99.718481	99.84896	99.84896	99.84896	99.84896
1.75	99.718481	99.84896	99.84896	99.84896	99.84896	99.84896
2.0	99.84896	99.84896	99.84896	99.84896	99.84896	99.84896
2.25	99.84896	99.84896	99.84896	99.84896	99.84896	99.84896
2.5	99.84896	99.84896	99.84896	99.84896	99.84896	99.84896
2.75	99.84896	99.84896	99.84896	99.84896	99.84896	99.84896
3.0	99.84896	99.84896	99.84896	99.84896	99.84896	99.84896
3.25	99.84896	99.84896	99.84896	99.84896	99.84896	99.84896
3.5	99.84896	99.84896	99.84896	99.84896	99.84896	99.84896
3.75	99.84896	99.84896	99.84896	99.84896	99.84896	99.84896
4.0	99.84896	99.84896	99.84896	99.84896	99.84896	99.84896
4.25	99.84896	99.84896	99.84896	99.84896	99.84896	99.84896
4.5	99.84896	99.84896	99.84896	99.84896	99.84896	99.84896
4.75	99.84896	99.84896	99.84896	99.84896	99.84896	99.84896
5.0	99.84896	99.84896	99.84896	99.84896	99.84896	99.84896
5.25	99.84896	99.84896	99.84896	99.84896	99.84896	99.84896
5.5	99.84896	99.84896	99.84896	99.84896	99.84896	99.84896
5.75	99.84896	99.84896	99.84896	99.84896	99.84896	99.84896
6.0	99.84896	99.84896	99.84896	99.84896	99.84896	99.84896

Results	Time (hr)	Rain (in)	Cumulative (in)
0.00	0	0.000	0.00
0.25	0	0.021	0.00
0.50	0	0.041	0.00
0.75	0	0.062	0.00
1.00	0	0.083	0.00
1.25	0	0.125	0.00
1.50	0	0.166	0.00
1.75	0	0.208	0.00
2.00	0	0.250	0.00
2.25	4.2	4.426	0.43
2.50	2.0	6.431	0.21
2.75	1.3	7.767	0.14
3.00	0.8	8.602	0.09
3.25	0.208836	8.811	0.02
3.50	0.208836	9.019	0.02
3.75	0.208836	9.228	0.02
4.00	0.208836	9.437	0.02
4.25	0.031398	9.468	0.00
4.50	0.031398	9.500	0.00
4.75	0.031398	9.531	0.00
5.00	0.031398	9.563	0.00
5.25	0.010466	9.573	0.00
5.50	0.010466	9.584	0.00
5.75	0.010466	9.594	0.00
6.00	0.010466	9.605	0.00

Duration (hr) - Table 15 at end of Short Duration USUS document	1/4	1/2	3/4	1	2	3	4	5	6
43.39%	64.21%	78.10%	86.77%	95.45%	97.18%	98.49%	99.35%	99.78%	99.84%
4.2	6.2	7.5	8.4	9.2	9.4	9.5	9.6	9.6	9.6
4.2	2.0	1.3	0.8	0.8	0.8	0.8	0.8	0.8	0.8
0.083	0.167	0.332	0.500	0.667	0.833	1.000	1.167	1.333	1.500
4.18	2.00	1.34	0.83	0.52	0.31	0.19	0.11	0.06	0.04

Incremental ->	1.00	2.00	2.25	2.50	2.75	3.00	4.00	5.00	6.00
Cumulative ->	0.083	0.167	0.332	0.500	0.667	0.833	1.000	1.167	1.333
%->	0.009	0.026	0.046	0.067	0.089	0.096	0.096	0.096	1.000

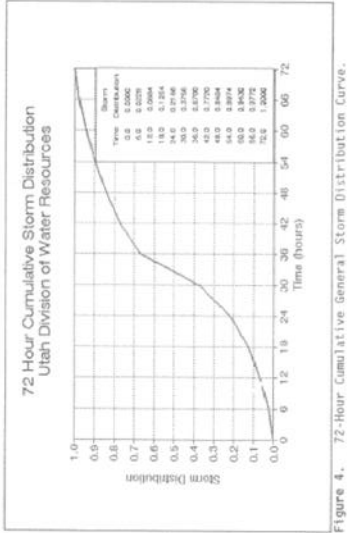
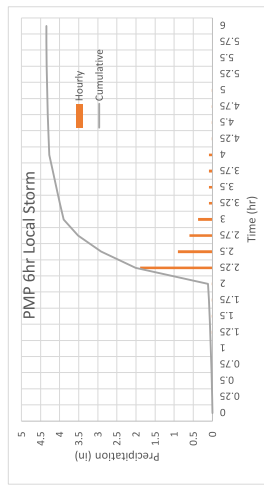


Figure 4. 72-Hour Cumulative Storm Distribution Curve.

JOB TITLE Saratoga Springs Watershed Plan EA - Clark Canyon

CALC. BY DS

DATE 08/30/21

CHECK BY CM

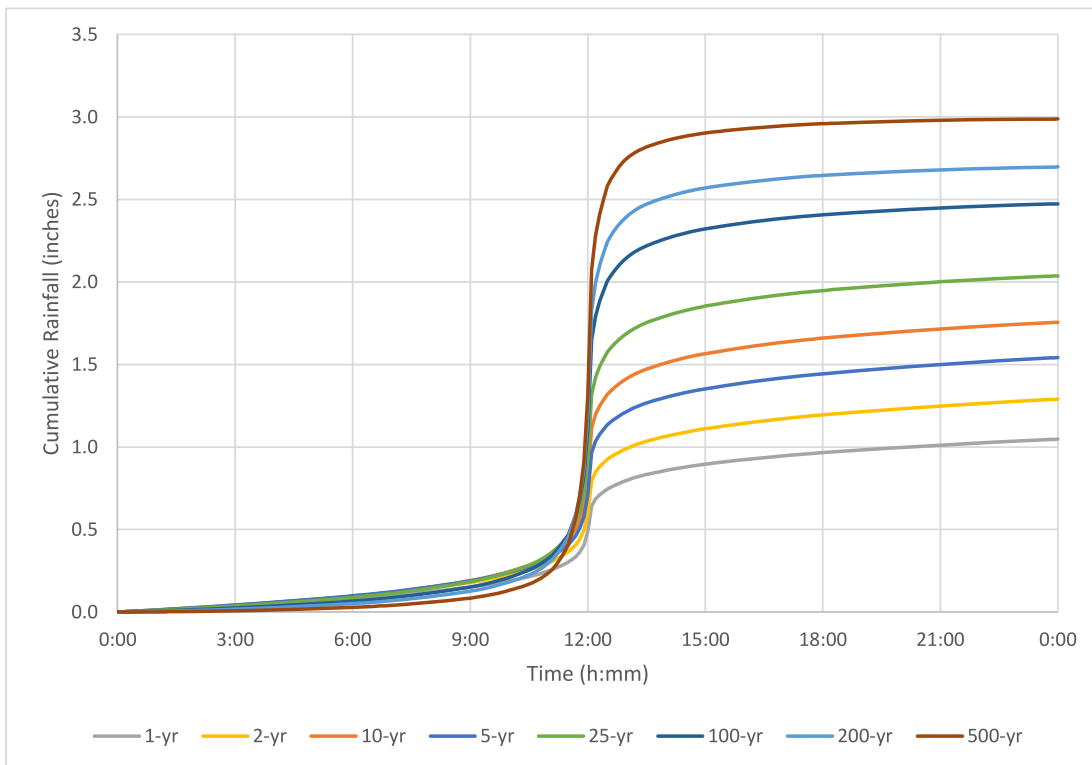
DATE 08/30/21

SUBJECT: 24-Hr WinTR20 Distribution

 = cell requiring user input

Areal Reduction Factor (ARF)	
Basin Area	ARF
(mi ²)	
2.5	0.97

Storm Duration			NOAA Atlas 14 Rainfall Depth (inches)								
			Return Period								
Days	Hrs	Mins	1-yr	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	200-yr	500-yr
	24		1.08	1.33	1.59	1.81	2.10	2.32	2.55	2.78	3.08
ARF Adjusted Depths			1.05	1.29	1.54	1.76	2.04	2.25	2.47	2.70	2.99



6 min Interval	Unit Rainfall	Design Rainfall Distribution (Cumulative inches)
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6 min Interval		Unit Rainfall (inches)	Design Rainfall Distribution (Cumulative inches)								
Start	End		1-yr	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	200-yr	500-yr
-	0:00	-	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0:00	0:06	-	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.000	0.000
0:06	0:12	-	0.002	0.002	0.002	0.002	0.002	0.002	0.001	0.001	0.000
0:12	0:18	-	0.003	0.004	0.004	0.003	0.003	0.002	0.002	0.001	0.000
0:18	0:24	-	0.004	0.005	0.005	0.005	0.004	0.003	0.002	0.001	0.000
0:24	0:30	-	0.005	0.006	0.006	0.006	0.005	0.004	0.003	0.002	0.000
0:30	0:36	-	0.006	0.007	0.007	0.007	0.006	0.005	0.004	0.002	0.000
0:36	0:42	-	0.008	0.009	0.009	0.008	0.007	0.006	0.004	0.003	0.000
0:42	0:48	-	0.009	0.010	0.010	0.009	0.008	0.006	0.005	0.003	0.001
0:48	0:54	-	0.010	0.011	0.011	0.011	0.009	0.007	0.006	0.003	0.001
0:54	1:00	-	0.011	0.013	0.013	0.012	0.010	0.008	0.006	0.004	0.001
1:00	1:06	-	0.012	0.014	0.014	0.013	0.011	0.009	0.007	0.004	0.001
1:06	1:12	-	0.013	0.015	0.015	0.014	0.012	0.010	0.008	0.005	0.001
1:12	1:18	-	0.014	0.017	0.017	0.016	0.014	0.011	0.009	0.005	0.001
1:18	1:24	-	0.016	0.018	0.018	0.017	0.015	0.012	0.009	0.006	0.002
1:24	1:30	-	0.017	0.020	0.020	0.018	0.016	0.013	0.010	0.007	0.002
1:30	1:36	-	0.018	0.021	0.021	0.020	0.017	0.014	0.011	0.007	0.002
1:36	1:42	-	0.019	0.022	0.022	0.021	0.018	0.015	0.012	0.008	0.002
1:42	1:48	-	0.021	0.024	0.024	0.022	0.020	0.016	0.013	0.008	0.003
1:48	1:54	-	0.022	0.025	0.025	0.024	0.021	0.017	0.014	0.009	0.003
1:54	2:00	-	0.023	0.027	0.027	0.025	0.022	0.018	0.015	0.010	0.003
2:00	2:06	-	0.024	0.028	0.028	0.027	0.024	0.019	0.015	0.010	0.004
2:06	2:12	-	0.026	0.030	0.030	0.028	0.025	0.021	0.016	0.011	0.004
2:12	2:18	-	0.027	0.031	0.031	0.030	0.026	0.022	0.017	0.012	0.004
2:18	2:24	-	0.028	0.033	0.033	0.031	0.028	0.023	0.018	0.012	0.005
2:24	2:30	-	0.029	0.034	0.034	0.033	0.029	0.024	0.019	0.013	0.005
2:30	2:36	-	0.031	0.036	0.036	0.034	0.030	0.025	0.020	0.014	0.006
2:36	2:42	-	0.032	0.037	0.038	0.036	0.032	0.027	0.021	0.015	0.006
2:42	2:48	-	0.033	0.039	0.039	0.037	0.033	0.028	0.022	0.016	0.006
2:48	2:54	-	0.035	0.040	0.041	0.039	0.035	0.029	0.024	0.016	0.007
2:54	3:00	-	0.036	0.042	0.042	0.040	0.036	0.030	0.025	0.017	0.007
3:00	3:06	-	0.037	0.044	0.044	0.042	0.038	0.032	0.026	0.018	0.008
3:06	3:12	-	0.039	0.045	0.046	0.044	0.039	0.033	0.027	0.019	0.008
3:12	3:18	-	0.040	0.047	0.047	0.045	0.041	0.034	0.028	0.020	0.009
3:18	3:24	-	0.042	0.048	0.049	0.047	0.042	0.036	0.029	0.021	0.009
3:24	3:30	-	0.043	0.050	0.051	0.049	0.044	0.037	0.030	0.022	0.010
3:30	3:36	-	0.044	0.052	0.053	0.050	0.045	0.038	0.032	0.023	0.010
3:36	3:42	-	0.046	0.053	0.054	0.052	0.047	0.040	0.033	0.024	0.011
3:42	3:48	-	0.047	0.055	0.056	0.054	0.049	0.041	0.034	0.025	0.012
3:48	3:54	-	0.049	0.057	0.058	0.055	0.050	0.043	0.035	0.026	0.012
3:54	4:00	-	0.050	0.059	0.060	0.057	0.052	0.044	0.037	0.027	0.013
4:00	4:06	-	0.052	0.060	0.061	0.059	0.053	0.046	0.038	0.028	0.013
4:06	4:12	-	0.053	0.062	0.063	0.061	0.055	0.047	0.039	0.029	0.014
4:12	4:18	-	0.055	0.064	0.065	0.063	0.057	0.049	0.041	0.030	0.015
4:18	4:24	-	0.056	0.066	0.067	0.064	0.059	0.050	0.042	0.031	0.015
4:24	4:30	-	0.058	0.067	0.069	0.066	0.060	0.052	0.043	0.032	0.016
4:30	4:36	-	0.059	0.069	0.071	0.068	0.062	0.053	0.045	0.033	0.017
4:36	4:42	-	0.061	0.071	0.072	0.070	0.064	0.055	0.046	0.034	0.018
4:42	4:48	-	0.062	0.073	0.074	0.072	0.066	0.057	0.048	0.035	0.018
4:48	4:54	-	0.064	0.075	0.076	0.074	0.067	0.058	0.049	0.037	0.019

6 min Interval		Unit Rainfall (inches)	Design Rainfall Distribution (Cumulative inches)								
Start	End		1-yr	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	200-yr	500-yr
4:54	5:00	-	0.065	0.077	0.078	0.076	0.069	0.060	0.051	0.038	0.020
5:00	5:06	-	0.067	0.078	0.080	0.078	0.071	0.062	0.052	0.039	0.021
5:06	5:12	-	0.069	0.080	0.082	0.080	0.073	0.063	0.054	0.040	0.021
5:12	5:18	-	0.070	0.082	0.084	0.082	0.075	0.065	0.055	0.042	0.022
5:18	5:24	-	0.072	0.084	0.086	0.084	0.077	0.067	0.057	0.043	0.023
5:24	5:30	-	0.073	0.086	0.088	0.086	0.079	0.069	0.058	0.044	0.024
5:30	5:36	-	0.075	0.088	0.090	0.088	0.081	0.070	0.060	0.045	0.025
5:36	5:42	-	0.077	0.090	0.092	0.090	0.083	0.072	0.061	0.047	0.026
5:42	5:48	-	0.078	0.092	0.094	0.092	0.085	0.074	0.063	0.048	0.026
5:48	5:54	-	0.080	0.094	0.096	0.094	0.087	0.076	0.065	0.049	0.027
5:54	6:00	-	0.082	0.096	0.098	0.096	0.089	0.078	0.066	0.051	0.028
6:00	6:06	-	0.083	0.098	0.101	0.098	0.091	0.080	0.068	0.052	0.029
6:06	6:12	-	0.085	0.100	0.103	0.100	0.093	0.082	0.070	0.054	0.030
6:12	6:18	-	0.087	0.102	0.105	0.103	0.095	0.084	0.072	0.055	0.031
6:18	6:24	-	0.089	0.104	0.107	0.105	0.097	0.086	0.074	0.057	0.033
6:24	6:30	-	0.091	0.106	0.110	0.107	0.100	0.088	0.076	0.059	0.034
6:30	6:36	-	0.093	0.109	0.112	0.110	0.102	0.090	0.078	0.061	0.035
6:36	6:42	-	0.095	0.111	0.115	0.112	0.105	0.093	0.080	0.063	0.036
6:42	6:48	-	0.097	0.113	0.117	0.115	0.107	0.095	0.082	0.065	0.038
6:48	6:54	-	0.099	0.116	0.120	0.118	0.110	0.098	0.085	0.067	0.039
6:54	7:00	-	0.101	0.118	0.123	0.120	0.113	0.100	0.087	0.069	0.041
7:00	7:06	-	0.103	0.121	0.125	0.123	0.116	0.103	0.090	0.071	0.042
7:06	7:12	-	0.105	0.124	0.128	0.126	0.119	0.106	0.092	0.073	0.044
7:12	7:18	-	0.107	0.126	0.131	0.129	0.122	0.109	0.095	0.076	0.046
7:18	7:24	-	0.110	0.129	0.134	0.132	0.125	0.112	0.098	0.078	0.048
7:24	7:30	-	0.112	0.132	0.137	0.135	0.128	0.115	0.100	0.080	0.049
7:30	7:36	-	0.114	0.135	0.140	0.138	0.131	0.118	0.103	0.083	0.051
7:36	7:42	-	0.117	0.137	0.143	0.142	0.134	0.121	0.106	0.086	0.053
7:42	7:48	-	0.119	0.140	0.146	0.145	0.137	0.124	0.109	0.088	0.055
7:48	7:54	-	0.122	0.143	0.150	0.148	0.141	0.127	0.112	0.091	0.057
7:54	8:00	-	0.124	0.146	0.153	0.152	0.144	0.131	0.115	0.094	0.060
8:00	8:06	-	0.127	0.149	0.156	0.155	0.148	0.134	0.119	0.097	0.062
8:06	8:12	-	0.129	0.153	0.160	0.159	0.152	0.138	0.122	0.100	0.064
8:12	8:18	-	0.132	0.156	0.163	0.163	0.155	0.141	0.125	0.103	0.066
8:18	8:24	-	0.135	0.159	0.167	0.166	0.159	0.145	0.129	0.106	0.069
8:24	8:30	-	0.137	0.162	0.170	0.170	0.163	0.149	0.133	0.109	0.071
8:30	8:36	-	0.140	0.166	0.174	0.174	0.167	0.153	0.136	0.113	0.074
8:36	8:42	-	0.143	0.169	0.178	0.178	0.171	0.156	0.140	0.116	0.076
8:42	8:48	-	0.146	0.172	0.181	0.182	0.175	0.160	0.144	0.119	0.079
8:48	8:54	-	0.149	0.176	0.185	0.186	0.179	0.165	0.147	0.123	0.082
8:54	9:00	-	0.152	0.179	0.189	0.190	0.183	0.169	0.151	0.126	0.084
9:00	9:06	-	0.155	0.183	0.193	0.194	0.188	0.173	0.156	0.130	0.087
9:06	9:12	-	0.158	0.187	0.198	0.199	0.193	0.178	0.160	0.135	0.091
9:12	9:18	-	0.161	0.191	0.202	0.204	0.198	0.183	0.165	0.139	0.095
9:18	9:24	-	0.165	0.196	0.207	0.209	0.203	0.189	0.171	0.144	0.099
9:24	9:30	-	0.169	0.200	0.212	0.214	0.209	0.194	0.177	0.150	0.103
9:30	9:36	-	0.173	0.205	0.218	0.220	0.215	0.201	0.183	0.156	0.108
9:36	9:42	-	0.177	0.210	0.223	0.226	0.221	0.207	0.189	0.162	0.114
9:42	9:48	-	0.181	0.215	0.229	0.232	0.228	0.214	0.196	0.168	0.119
9:48	9:54	-	0.185	0.220	0.235	0.239	0.235	0.221	0.203	0.175	0.125

6 min Interval		Unit Rainfall (inches)	Design Rainfall Distribution (Cumulative inches)								
Start	End		1-yr	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	200-yr	500-yr
9:54	10:00	-	0.190	0.225	0.241	0.246	0.242	0.229	0.211	0.183	0.132
10:00	10:06	-	0.194	0.231	0.247	0.253	0.250	0.236	0.218	0.190	0.138
10:06	10:12	-	0.199	0.237	0.254	0.260	0.258	0.245	0.227	0.198	0.145
10:12	10:18	-	0.204	0.243	0.261	0.268	0.266	0.253	0.235	0.207	0.153
10:18	10:24	-	0.209	0.249	0.268	0.275	0.275	0.262	0.244	0.216	0.160
10:24	10:30	-	0.214	0.255	0.275	0.283	0.283	0.271	0.254	0.225	0.168
10:30	10:36	-	0.220	0.262	0.284	0.293	0.293	0.282	0.265	0.236	0.178
10:36	10:42	-	0.226	0.270	0.293	0.303	0.305	0.294	0.277	0.248	0.190
10:42	10:48	-	0.233	0.279	0.303	0.314	0.318	0.308	0.291	0.263	0.204
10:48	10:54	-	0.241	0.288	0.314	0.326	0.331	0.323	0.307	0.279	0.219
10:54	11:00	-	0.249	0.298	0.325	0.340	0.347	0.339	0.325	0.297	0.237
11:00	11:06	-	0.258	0.309	0.339	0.355	0.365	0.359	0.346	0.320	0.260
11:06	11:12	-	0.268	0.321	0.354	0.373	0.385	0.382	0.371	0.347	0.288
11:12	11:18	-	0.278	0.335	0.370	0.392	0.408	0.408	0.400	0.378	0.322
11:18	11:24	-	0.290	0.349	0.388	0.413	0.434	0.437	0.432	0.414	0.361
11:24	11:30	-	0.303	0.365	0.408	0.437	0.462	0.470	0.469	0.454	0.405
11:30	11:36	-	0.319	0.386	0.436	0.471	0.505	0.520	0.528	0.523	0.489
11:36	11:42	-	0.337	0.408	0.465	0.506	0.550	0.573	0.590	0.595	0.578
11:42	11:48	-	0.363	0.442	0.508	0.559	0.617	0.653	0.683	0.703	0.709
11:48	11:54	-	0.405	0.494	0.576	0.642	0.720	0.774	0.825	0.869	0.911
11:54	12:00	-	0.487	0.598	0.710	0.804	0.925	1.015	1.108	1.198	1.311
12:00	12:06	-	0.643	0.796	0.966	1.114	1.317	1.476	1.648	1.828	2.076
12:06	12:12	-	0.684	0.848	1.034	1.196	1.420	1.598	1.791	1.994	2.278
12:12	12:18	-	0.711	0.882	1.078	1.250	1.487	1.677	1.884	2.101	2.410
12:18	12:24	-	0.728	0.904	1.107	1.285	1.532	1.730	1.946	2.174	2.498
12:24	12:30	-	0.745	0.925	1.134	1.319	1.575	1.781	2.005	2.242	2.582
12:30	12:36	-	0.758	0.941	1.154	1.342	1.603	1.813	2.041	2.283	2.627
12:36	12:42	-	0.769	0.956	1.172	1.364	1.629	1.842	2.074	2.319	2.666
12:42	12:48	-	0.780	0.969	1.189	1.383	1.652	1.869	2.103	2.350	2.700
12:48	12:54	-	0.790	0.981	1.203	1.401	1.672	1.891	2.128	2.377	2.728
12:54	13:00	-	0.799	0.992	1.217	1.416	1.690	1.911	2.149	2.399	2.751
13:00	13:06	-	0.807	1.002	1.229	1.429	1.706	1.928	2.166	2.417	2.768
13:06	13:12	-	0.814	1.011	1.240	1.442	1.719	1.943	2.182	2.434	2.784
13:12	13:18	-	0.821	1.020	1.250	1.453	1.732	1.956	2.196	2.448	2.797
13:18	13:24	-	0.828	1.028	1.259	1.463	1.744	1.968	2.209	2.461	2.809
13:24	13:30	-	0.833	1.035	1.267	1.472	1.754	1.979	2.220	2.472	2.819
13:30	13:36	-	0.839	1.041	1.274	1.480	1.762	1.988	2.229	2.481	2.827
13:36	13:42	-	0.844	1.047	1.281	1.488	1.771	1.997	2.238	2.490	2.835
13:42	13:48	-	0.849	1.053	1.288	1.496	1.779	2.006	2.247	2.498	2.842
13:48	13:54	-	0.853	1.059	1.295	1.503	1.787	2.014	2.255	2.506	2.849
13:54	14:00	-	0.858	1.065	1.301	1.510	1.795	2.022	2.263	2.514	2.856
14:00	14:06	-	0.863	1.070	1.308	1.517	1.802	2.029	2.270	2.521	2.862
14:06	14:12	-	0.867	1.075	1.314	1.523	1.809	2.036	2.278	2.528	2.868
14:12	14:18	-	0.871	1.081	1.319	1.530	1.816	2.043	2.284	2.535	2.874
14:18	14:24	-	0.875	1.085	1.325	1.536	1.822	2.050	2.291	2.541	2.879
14:24	14:30	-	0.879	1.090	1.330	1.541	1.828	2.056	2.297	2.547	2.884
14:30	14:36	-	0.883	1.095	1.335	1.547	1.834	2.062	2.303	2.552	2.889
14:36	14:42	-	0.886	1.099	1.340	1.552	1.839	2.067	2.308	2.557	2.893
14:42	14:48	-	0.890	1.103	1.345	1.557	1.844	2.072	2.313	2.562	2.897
14:48	14:54	-	0.893	1.107	1.349	1.561	1.849	2.077	2.318	2.566	2.900

6 min Interval		Unit Rainfall (inches)	Design Rainfall Distribution (Cumulative inches)								
Start	End		1-yr	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	200-yr	500-yr
14:54	15:00	-	0.896	1.111	1.353	1.566	1.854	2.082	2.322	2.570	2.903
15:00	15:06	-	0.899	1.114	1.357	1.570	1.858	2.086	2.326	2.574	2.906
15:06	15:12	-	0.902	1.118	1.361	1.574	1.862	2.090	2.330	2.577	2.909
15:12	15:18	-	0.905	1.121	1.365	1.578	1.866	2.094	2.334	2.581	2.911
15:18	15:24	-	0.907	1.125	1.368	1.582	1.870	2.098	2.337	2.584	2.914
15:24	15:30	-	0.910	1.128	1.372	1.586	1.874	2.102	2.341	2.587	2.916
15:30	15:36	-	0.913	1.131	1.376	1.589	1.878	2.105	2.345	2.591	2.919
15:36	15:42	-	0.916	1.134	1.379	1.593	1.882	2.109	2.348	2.594	2.921
15:42	15:48	-	0.918	1.138	1.383	1.597	1.885	2.113	2.351	2.597	2.924
15:48	15:54	-	0.921	1.141	1.386	1.600	1.889	2.116	2.355	2.600	2.926
15:54	16:00	-	0.923	1.144	1.389	1.604	1.893	2.120	2.358	2.603	2.928
16:00	16:06	-	0.926	1.147	1.393	1.607	1.896	2.123	2.361	2.606	2.930
16:06	16:12	-	0.928	1.150	1.396	1.611	1.900	2.126	2.364	2.608	2.932
16:12	16:18	-	0.931	1.153	1.399	1.614	1.903	2.130	2.367	2.611	2.934
16:18	16:24	-	0.933	1.156	1.402	1.617	1.906	2.133	2.370	2.614	2.936
16:24	16:30	-	0.936	1.158	1.405	1.620	1.909	2.136	2.373	2.616	2.938
16:30	16:36	-	0.938	1.161	1.408	1.623	1.912	2.139	2.376	2.619	2.940
16:36	16:42	-	0.940	1.164	1.411	1.626	1.915	2.142	2.379	2.621	2.942
16:42	16:48	-	0.942	1.167	1.414	1.629	1.918	2.145	2.381	2.623	2.943
16:48	16:54	-	0.945	1.169	1.417	1.632	1.921	2.147	2.384	2.626	2.945
16:54	17:00	-	0.947	1.172	1.420	1.635	1.924	2.150	2.386	2.628	2.947
17:00	17:06	-	0.949	1.174	1.422	1.638	1.927	2.153	2.389	2.630	2.948
17:06	17:12	-	0.951	1.177	1.425	1.641	1.930	2.155	2.391	2.632	2.950
17:12	17:18	-	0.953	1.179	1.428	1.643	1.932	2.158	2.393	2.634	2.951
17:18	17:24	-	0.955	1.181	1.430	1.646	1.935	2.160	2.396	2.636	2.952
17:24	17:30	-	0.957	1.184	1.433	1.648	1.937	2.162	2.398	2.638	2.954
17:30	17:36	-	0.959	1.186	1.435	1.651	1.940	2.165	2.400	2.639	2.955
17:36	17:42	-	0.961	1.188	1.437	1.653	1.942	2.167	2.402	2.641	2.956
17:42	17:48	-	0.962	1.190	1.440	1.655	1.944	2.169	2.404	2.643	2.957
17:48	17:54	-	0.964	1.192	1.442	1.658	1.946	2.171	2.405	2.644	2.958
17:54	18:00	-	0.966	1.194	1.444	1.660	1.948	2.173	2.407	2.646	2.959
18:00	18:06	-	0.968	1.196	1.446	1.662	1.950	2.175	2.409	2.647	2.960
18:06	18:12	-	0.969	1.198	1.448	1.664	1.952	2.176	2.411	2.649	2.961
18:12	18:18	-	0.971	1.200	1.450	1.666	1.954	2.178	2.412	2.650	2.962
18:18	18:24	-	0.973	1.202	1.452	1.668	1.956	2.180	2.414	2.651	2.963
18:24	18:30	-	0.974	1.204	1.454	1.670	1.958	2.182	2.415	2.653	2.964
18:30	18:36	-	0.976	1.206	1.456	1.672	1.960	2.184	2.417	2.654	2.965
18:36	18:42	-	0.977	1.208	1.458	1.674	1.962	2.185	2.418	2.655	2.965
18:42	18:48	-	0.979	1.210	1.460	1.676	1.964	2.187	2.420	2.656	2.966
18:48	18:54	-	0.981	1.212	1.462	1.678	1.966	2.189	2.422	2.658	2.967
18:54	19:00	-	0.982	1.214	1.464	1.680	1.968	2.190	2.423	2.659	2.968
19:00	19:06	-	0.984	1.215	1.466	1.682	1.970	2.192	2.424	2.660	2.969
19:06	19:12	-	0.985	1.217	1.468	1.684	1.971	2.194	2.426	2.661	2.969
19:12	19:18	-	0.987	1.219	1.470	1.686	1.973	2.195	2.427	2.662	2.970
19:18	19:24	-	0.988	1.221	1.472	1.688	1.975	2.197	2.429	2.664	2.971
19:24	19:30	-	0.990	1.223	1.474	1.689	1.977	2.199	2.430	2.665	2.972
19:30	19:36	-	0.991	1.224	1.475	1.691	1.978	2.200	2.432	2.666	2.972
19:36	19:42	-	0.993	1.226	1.477	1.693	1.980	2.202	2.433	2.667	2.973
19:42	19:48	-	0.994	1.228	1.479	1.695	1.982	2.203	2.434	2.668	2.974
19:48	19:54	-	0.996	1.230	1.481	1.697	1.984	2.205	2.436	2.669	2.974

6 min Interval		Unit Rainfall (inches)	Design Rainfall Distribution (Cumulative inches)								
Start	End		1-yr	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	200-yr	500-yr
19:54	20:00	-	0.997	1.232	1.483	1.698	1.985	2.206	2.437	2.670	2.975
20:00	20:06	-	0.999	1.233	1.485	1.700	1.987	2.208	2.438	2.671	2.975
20:06	20:12	-	1.000	1.235	1.486	1.702	1.988	2.209	2.439	2.672	2.976
20:12	20:18	-	1.002	1.237	1.488	1.704	1.990	2.211	2.441	2.673	2.977
20:18	20:24	-	1.003	1.238	1.490	1.705	1.992	2.212	2.442	2.674	2.977
20:24	20:30	-	1.005	1.240	1.492	1.707	1.993	2.213	2.443	2.675	2.978
20:30	20:36	-	1.006	1.242	1.493	1.709	1.995	2.215	2.444	2.676	2.978
20:36	20:42	-	1.007	1.243	1.495	1.710	1.996	2.216	2.445	2.677	2.979
20:42	20:48	-	1.009	1.245	1.497	1.712	1.998	2.217	2.447	2.678	2.979
20:48	20:54	-	1.010	1.247	1.498	1.714	1.999	2.219	2.448	2.679	2.980
20:54	21:00	-	1.012	1.248	1.500	1.715	2.001	2.220	2.449	2.679	2.980
21:00	21:06	-	1.013	1.250	1.502	1.717	2.002	2.221	2.450	2.680	2.981
21:06	21:12	-	1.014	1.251	1.503	1.718	2.004	2.223	2.451	2.681	2.981
21:12	21:18	-	1.016	1.253	1.505	1.720	2.005	2.224	2.452	2.682	2.982
21:18	21:24	-	1.017	1.254	1.506	1.722	2.007	2.225	2.453	2.683	2.982
21:24	21:30	-	1.018	1.256	1.508	1.723	2.008	2.226	2.454	2.683	2.982
21:30	21:36	-	1.019	1.257	1.509	1.725	2.009	2.228	2.455	2.684	2.983
21:36	21:42	-	1.021	1.259	1.511	1.726	2.011	2.229	2.456	2.685	2.983
21:42	21:48	-	1.022	1.260	1.513	1.728	2.012	2.230	2.457	2.686	2.984
21:48	21:54	-	1.023	1.262	1.514	1.729	2.013	2.231	2.458	2.686	2.984
21:54	22:00	-	1.025	1.263	1.516	1.730	2.015	2.232	2.459	2.687	2.984
22:00	22:06	-	1.026	1.265	1.517	1.732	2.016	2.233	2.460	2.688	2.985
22:06	22:12	-	1.027	1.266	1.518	1.733	2.017	2.234	2.461	2.688	2.985
22:12	22:18	-	1.028	1.268	1.520	1.735	2.019	2.235	2.462	2.689	2.985
22:18	22:24	-	1.030	1.269	1.521	1.736	2.020	2.236	2.462	2.689	2.985
22:24	22:30	-	1.031	1.271	1.523	1.737	2.021	2.237	2.463	2.690	2.986
22:30	22:36	-	1.032	1.272	1.524	1.739	2.022	2.238	2.464	2.691	2.986
22:36	22:42	-	1.033	1.273	1.526	1.740	2.023	2.239	2.465	2.691	2.986
22:42	22:48	-	1.034	1.275	1.527	1.741	2.025	2.240	2.466	2.692	2.986
22:48	22:54	-	1.035	1.276	1.528	1.743	2.026	2.241	2.466	2.692	2.987
22:54	23:00	-	1.037	1.277	1.530	1.744	2.027	2.242	2.467	2.693	2.987
23:00	23:06	-	1.038	1.279	1.531	1.745	2.028	2.243	2.468	2.693	2.987
23:06	23:12	-	1.039	1.280	1.532	1.746	2.029	2.244	2.469	2.694	2.987
23:12	23:18	-	1.040	1.281	1.534	1.748	2.030	2.245	2.469	2.694	2.987
23:18	23:24	-	1.041	1.283	1.535	1.749	2.031	2.246	2.470	2.694	2.987
23:24	23:30	-	1.042	1.284	1.536	1.750	2.032	2.247	2.471	2.695	2.987
23:30	23:36	-	1.043	1.285	1.537	1.751	2.033	2.247	2.471	2.695	2.987
23:36	23:42	-	1.044	1.286	1.539	1.752	2.034	2.248	2.472	2.696	2.987
23:42	23:48	-	1.045	1.288	1.540	1.753	2.035	2.249	2.472	2.696	2.988
23:48	23:54	-	1.047	1.289	1.541	1.755	2.036	2.250	2.473	2.696	2.988
23:54	0:00	-	1.048	1.290	1.542	1.756	2.037	2.250	2.474	2.697	2.988

HMR 49 Worksheet

Table 6.1 -- General storm PMP computations for the Colorado River and Great basin

Represent input cells
Represents output cells
Represent calculated fields (do not edit)

Drainage
Latitude
40.28335, Longitude -111.9219

Month
August

Watershed Name- Clark Canyon North & South
Watershed Area = 2.5 sq. miles
72-Hr USUL Adjustment = 99.84%

2002 Update for PMP UT 72 hr Est. Areas to 5,000 mi² (Donald Jensen) - Table 1, pg 4

Step a) Convergence PMP
1 Figures 2.5 - 2.16 11.02 in.
2 Figure 2.18 55%
3 Step 1 x step 2 6.061065 in.
4 Figures 2.25 to 2.27 and table 2.7 68%

5 Step 3 x Step 4
6 Successive subtraction in step 5
7 Figures 2.28 and 2.29
8 Step 6 x step 7
9 Accumulated values of step 8

b) Orographic PMP
1 Figure 3.11a to d 3.05 in.
2 Figure 3.20 100%
3 Figure 3.12 to 3.17 100%
4 Steps 1 x 2 x 3 3.046596 in.
5 Table 3.9
6 Steps 4 x 5

c) Total PMP
1 Add Steps A9 and B6

d) Intensity
1 Divide total PMP by duration

Duration	6	12	18	24	48	72	72 hr PMP Distribution	Rain fall (in)	13.10 in
Time (hr)	Percent	0	0	0	0	0	Percent	0.00	0.30
68%	85%	94%	100%	100%	116%	123%	%	0.0228	0.30
4.1	5.2	5.7	6.1	7.0	7.5	in.		0.0684	0.90
4.1	1.1	0.5	0.4	1.0	0.4	in.		18	0.1254
100%	100%	100%	100%	100%	100%	100%	%	24	0.2166
4.1	1.1	0.5	0.4	1.0	0.4	in.		30	0.3756
4.1	1.1	0.5	0.4	1.0	0.4	in.		36	0.67
4.1	5.2	5.7	6.1	7.0	7.5	in.		42	0.772
4.1	5.2	5.7	6.1	7.0	7.5	in.		48	0.8404
4.1	5.2	5.7	6.1	7.0	7.5	in.		54	0.8974
4.1	5.2	5.7	6.1	7.0	7.5	in.		60	0.943
4.1	5.2	5.7	6.1	7.0	7.5	in.		66	0.9772
4.1	5.2	5.7	6.1	7.0	7.5	in.		72	1

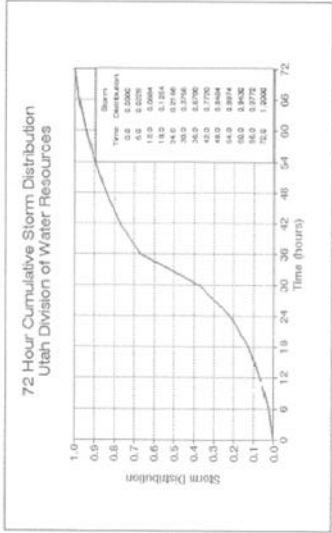


Figure 4. 72-Hour Cumulative Storm Distribution Curve.

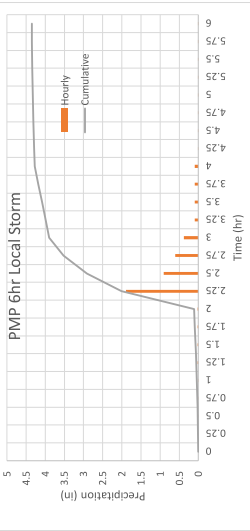
Time (hr)	0	1	2	3	4	5	6
0.75	90	100	110	112	113.5	114.5	115
0.5	74	89.75	98.73	100.52	101.87	102.76	103.21
0.25	66.42	80.78	89.75	98.73	100.52	101.87	103.21
0.1	62.03	75.44	83.82	92.2	93.88	95.14	96.39
0.05	64.24485597	78.13415282	86.81182	95.49454	97.23003	98.53544	99.39571

Table 6.3 --Local storm PMP computation, Colorado River, Great Basin and California drainages. For drainage average depth PMP. Go to table 6.3B if areal variation is required.

Steps
1 Fig 4.5
2a Reduction for Elevation (not needed for elevations <5,000 ft)
5% decrease per 1,000 ft above 5,000
b multiply step 1 by step 2a

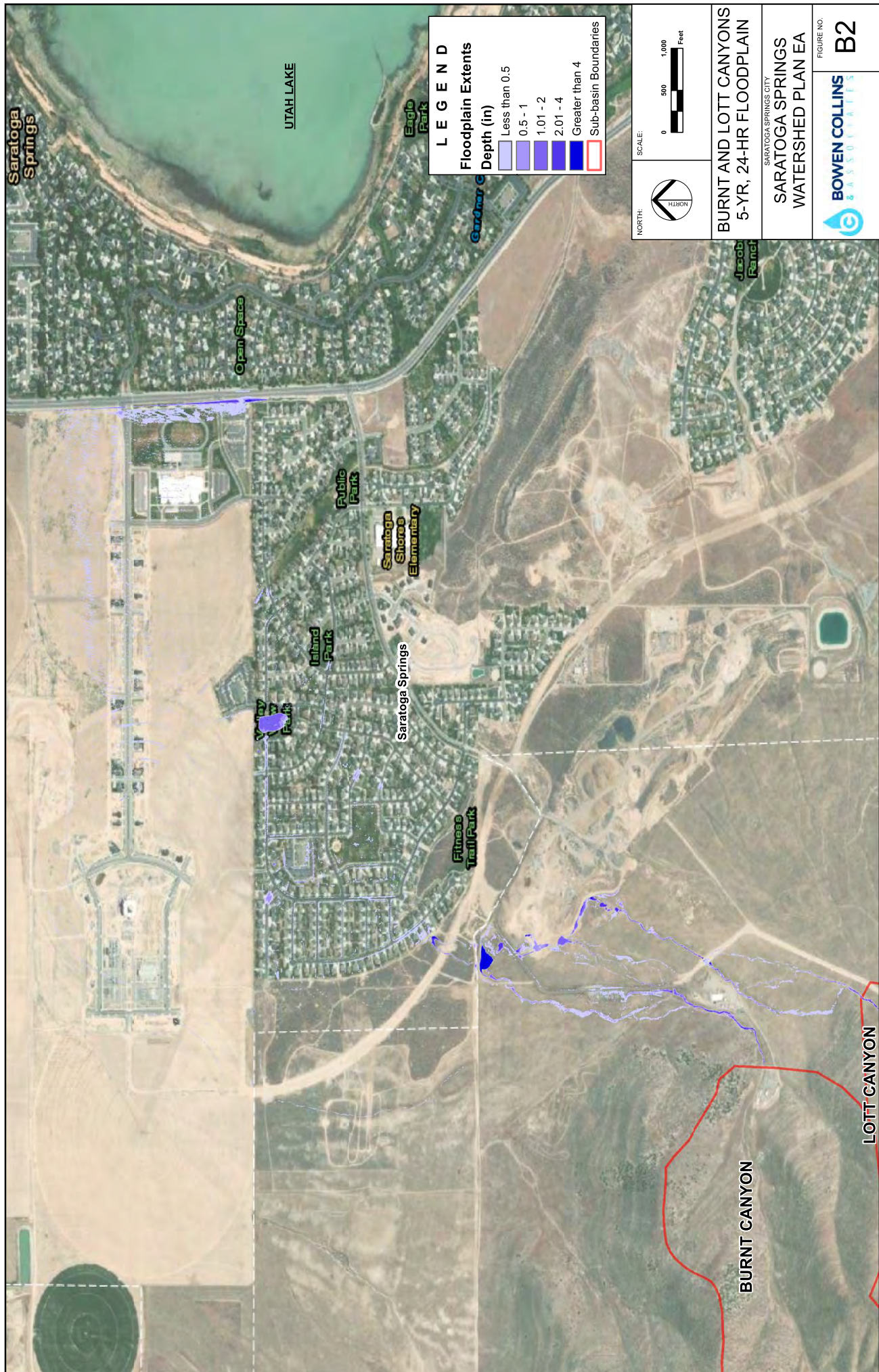
USUS Adjustment	1/4	1/2	3/4	1	2	3	4	5	6
43.41%	64.24%	78.13%	86.81%	95.49%	97.23%	98.54%	99.40%	99.83%	99.83%
4.1	6.0	7.3	8.1	8.9	9.1	9.2	9.3	9.3	9.3
4.1	1.9	1.3	0.8	0.81	0.16	0.12	0.08	0.04	0.04
0.080	0.162	0.119	0.812	0.122	0.043	0.043	0.043	0.043	0.043
4.06	1.95	1.30	0.81	0.15 min breakdown of most intense hr	0.15 min breakdown of most intense hr	0.15 min breakdown of most intense hr	0.15 min breakdown of most intense hr	0.15 min breakdown of most intense hr	0.15 min breakdown of most intense hr

Incremental -> 1.00 2.00 2.25 2.50 2.75 3.00 4.00 5.00 6.00
Cumulative -> 0.08 0.16 4.06 1.95 1.30 0.81 0.81 0.12 0.04
%> 0.080 0.243 4.303 6.251 7.550 8.362 9.174 9.296 9.337
%> 0.009 0.026 0.461 0.670 0.809 0.896 0.983 0.996 1.000



Results	Precipitation
SEP 6 - hr local storm	9.34 in
SEP 6 - hr general storm	0.00 in
SEP 72 - hr general storm	13.10 in

APPENDIX B FLOODPLAIN MAPS



LEGEND

Floodplain Extents

Depth (in)

- Less than 0.5
- 0.5 - 1
- 1.01 - 2
- 2.01 - 4
- Greater than 4
- Sub-basin Boundaries

NORTH

SCALE:

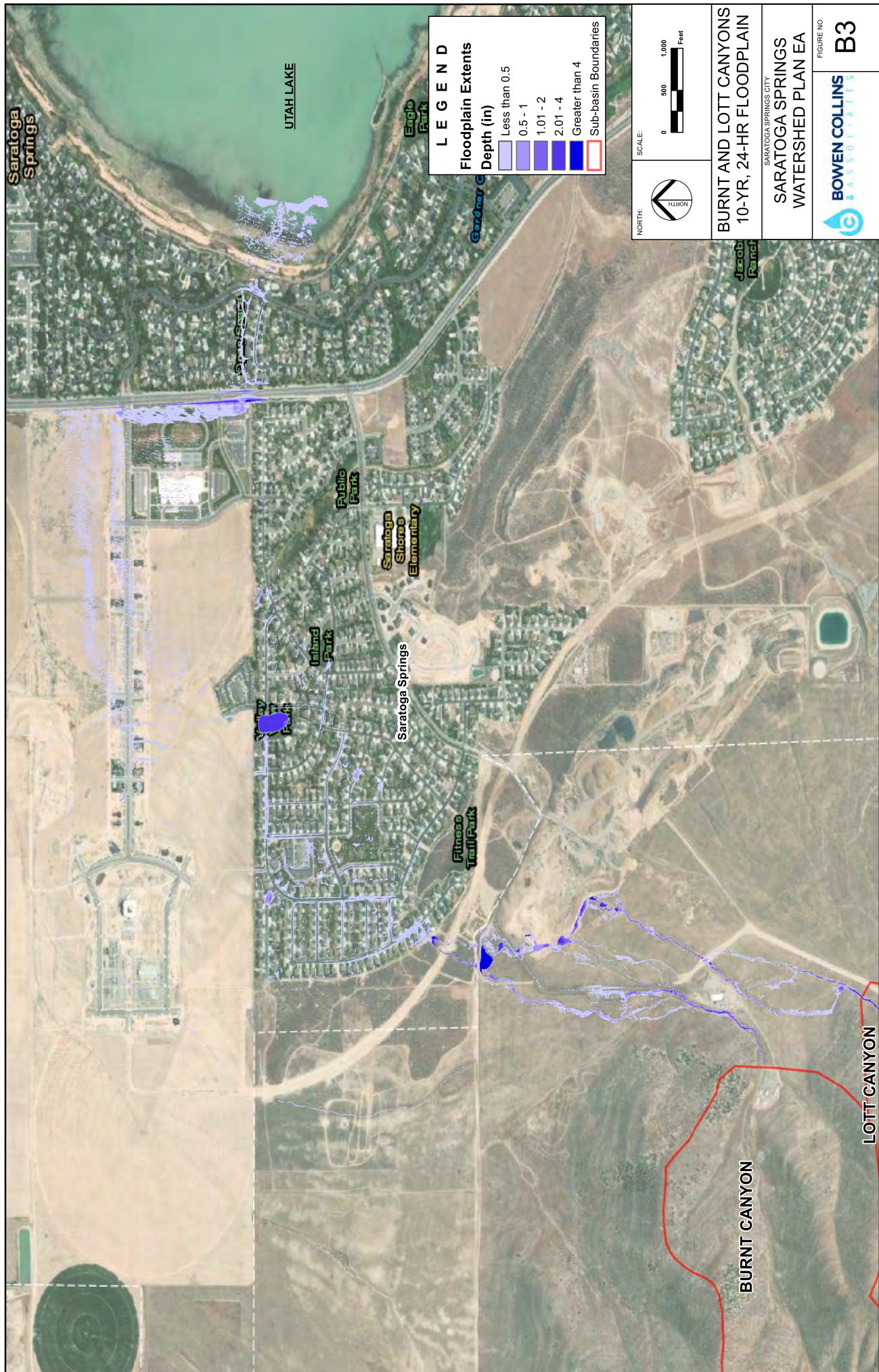
0 500 1,000 Feet

BURNT AND LOTT CANYONS
5-YR, 24-HR FLOODPLAIN

SARATOGA SPRINGS CITY
SARATOGA SPRINGS
WATERSHED PLAN EA

BOWEN COLLINS
& ASSOCIATES

FIGURE NO. **B2**



LEGEND

Floodplain Extents

Depth (in)

- Less than 0.5
- 0.5 - 1
- 1.01 - 2
- 2.01 - 4
- Greater than 4
- Sub-basin Boundaries

NORTH

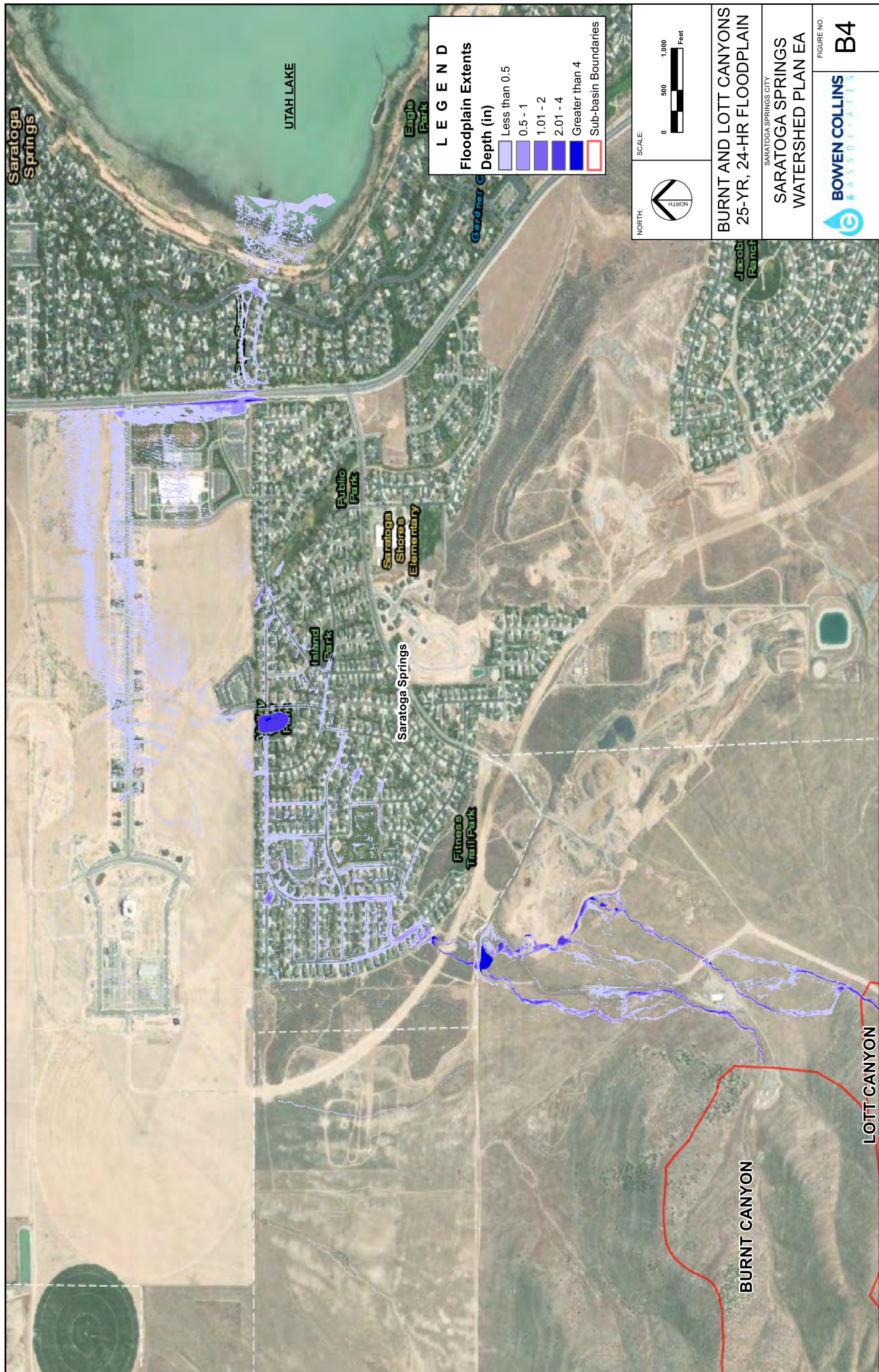
SCALE:

BURNT AND LOTT CANYONS
10-YR, 24-HR FLOODPLAIN

SARATOGA SPRINGS
WATERSHED PLAN EA

BOWEN COLLINS
& ASSOCIATES

FIGURE NO. **B3**



LEGEND

Floodplain Extents

Depth (in)

- Less than 0.5
- 0.5 - 1
- 1.01 - 2
- 2.01 - 4
- Greater than 4
- Sub-basin Boundaries

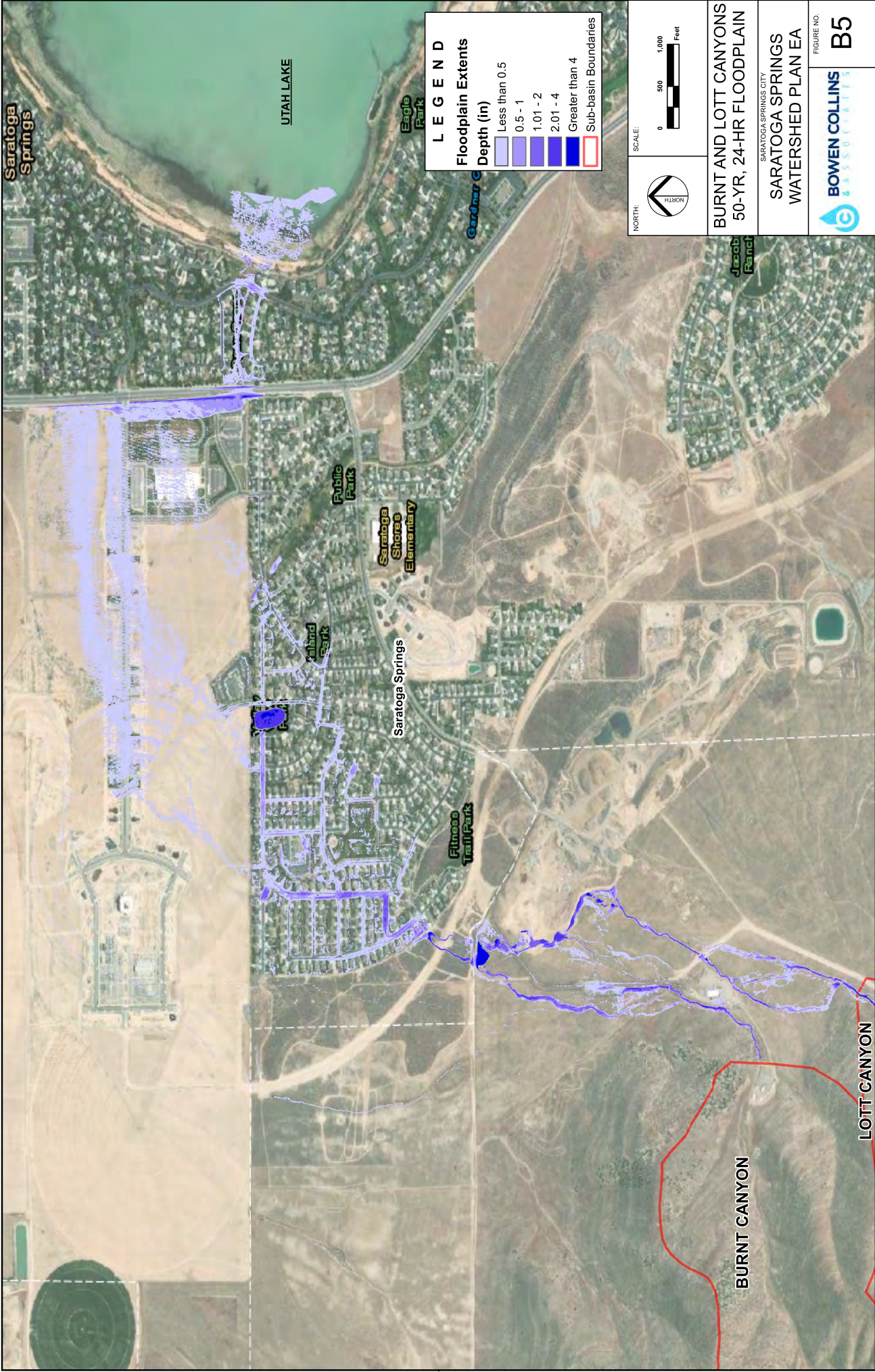


BURNT AND LOTT CANYONS
25-YR, 24-HR FLOODPLAIN

SARATOGA SPRINGS CITY
SARATOGA SPRINGS
WATERSHED PLAN EA

BOWEN COLLINS
& ASSOCIATES

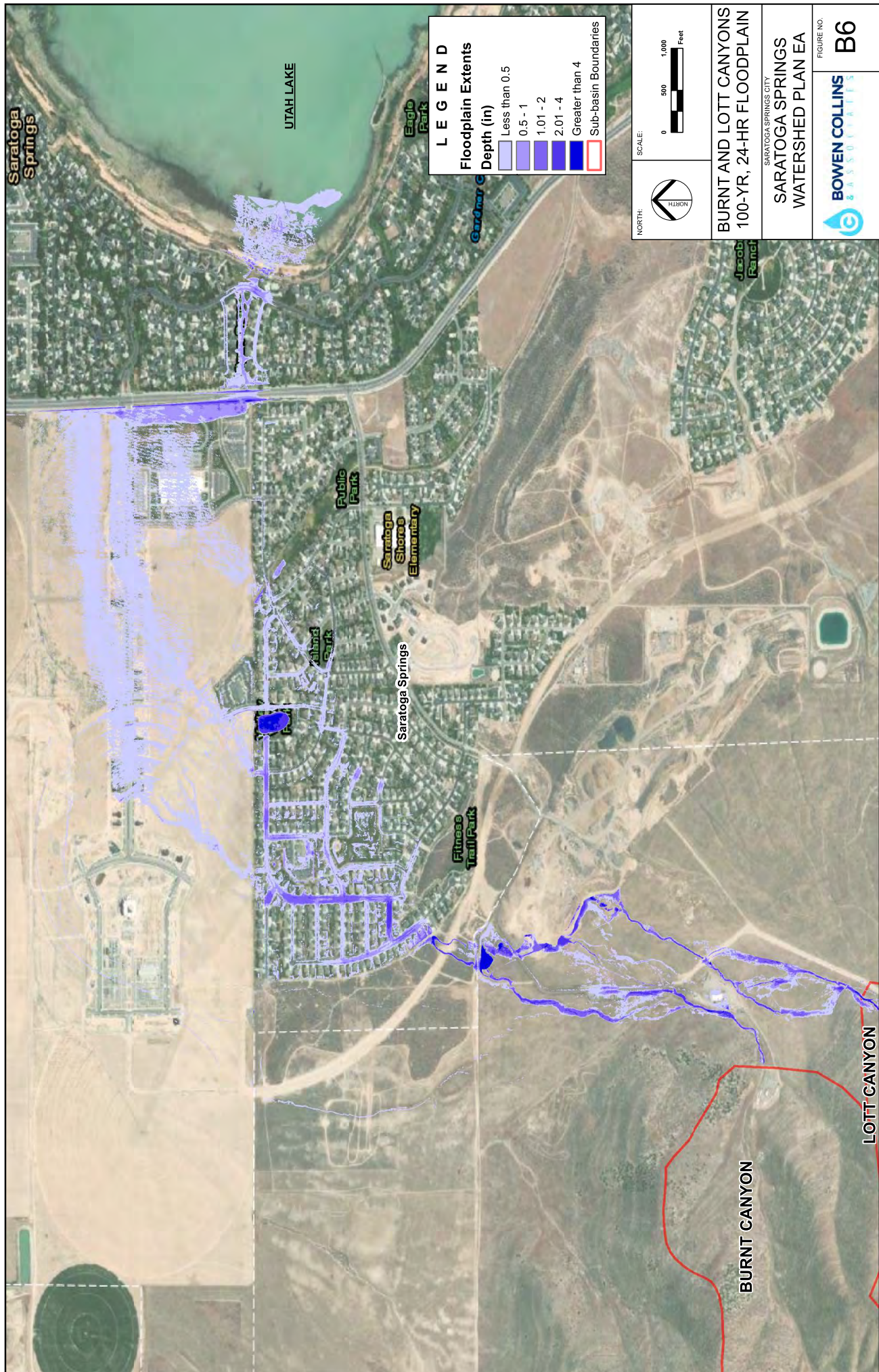
FIGURE NO. **B4**



BURNT AND LOTT CANYONS
50-YR, 24-HR FLOODPLAIN

SARATOGA SPRINGS CITY
SARATOGA SPRINGS
WATERSHED PLAN EA

FIGURE NO.
B5
BOWEN COLLINS
& ASSOCIATES



LEGEND

Floodplain Extents

Depth (in)

- Less than 0.5
- 0.5 - 1
- 1.01 - 2
- 2.01 - 4
- Greater than 4
- Sub-basin Boundaries

NORTH

SCALE:

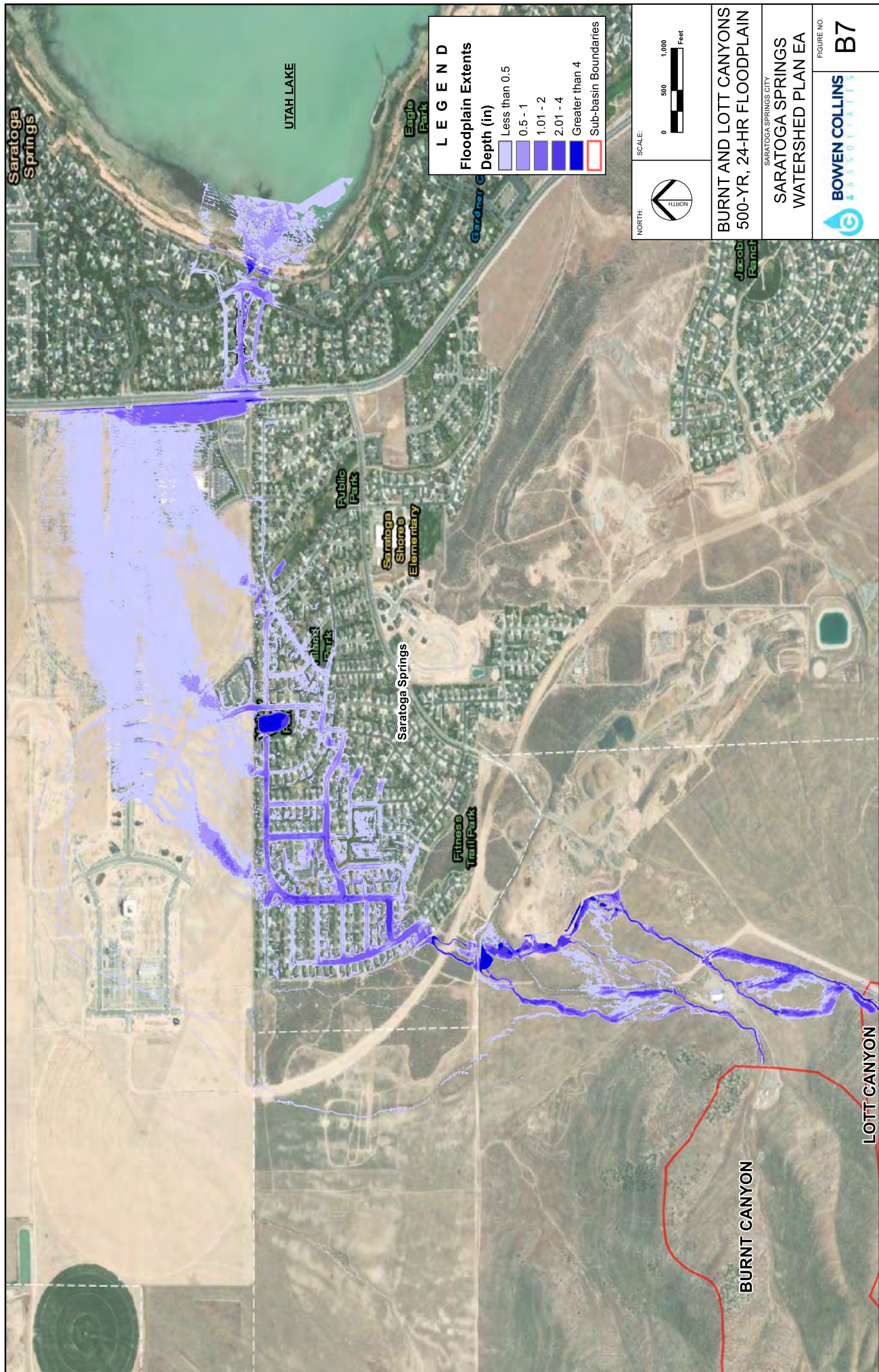
0 500 1,000 Feet

BURNT AND LOTT CANYONS
100-YR, 24-HR FLOODPLAIN

SARATOGA SPRINGS CITY
SARATOGA SPRINGS
WATERSHED PLAN EA

FIGURE NO.
B6

BOWEN COLLINS
& ASSOCIATES



BURNT AND LOTT CANYONS
500-YR, 24-HR FLOODPLAIN

SARATOGA SPRINGS CITY

SARATOGA SPRINGS
WATERSHED PLAN EA



LEGEND

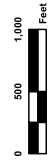
Floodplain Extents

Depth (in)

- Less than 0.5
- 0.5 - 1
- 1.01 - 2
- 2.01 - 4
- Greater than 4
- Sub-basin Boundaries



SCALE:

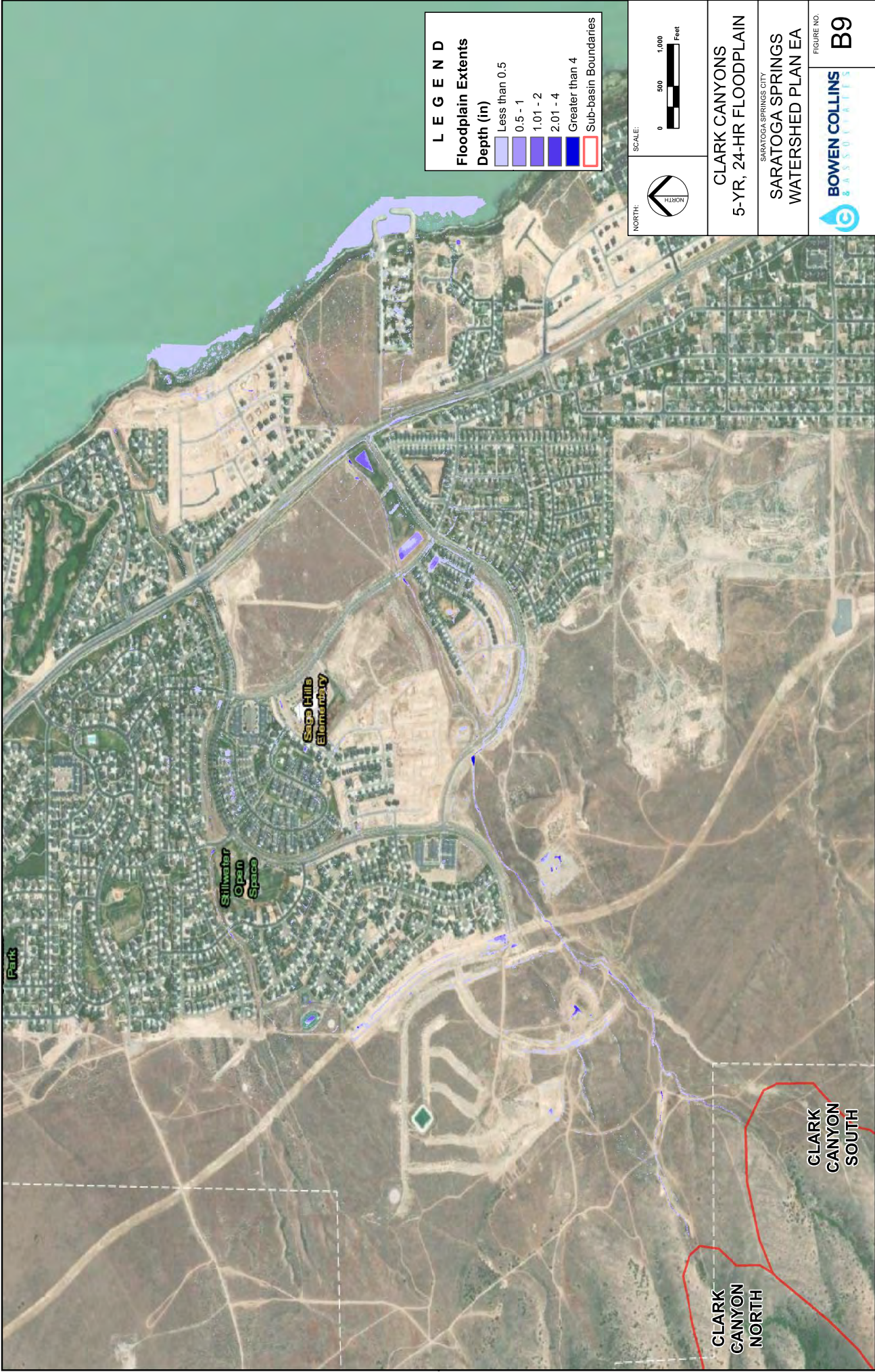


CLARK CANYONS
2-YR, 24-HR FLOODPLAIN

SARATOGA SPRINGS CITY
SARATOGA SPRINGS
WATERSHED PLAN EA

FIGURE NO.
B8

BOWEN COLLINS
& ASSOCIATES



LEGEND

Floodplain Extents

Depth (in)

- Less than 0.5
- 0.5 - 1
- 1.01 - 2
- 2.01 - 4
- Greater than 4
- Sub-basin Boundaries



CLARK CANYONS
5-YR, 24-HR FLOODPLAIN

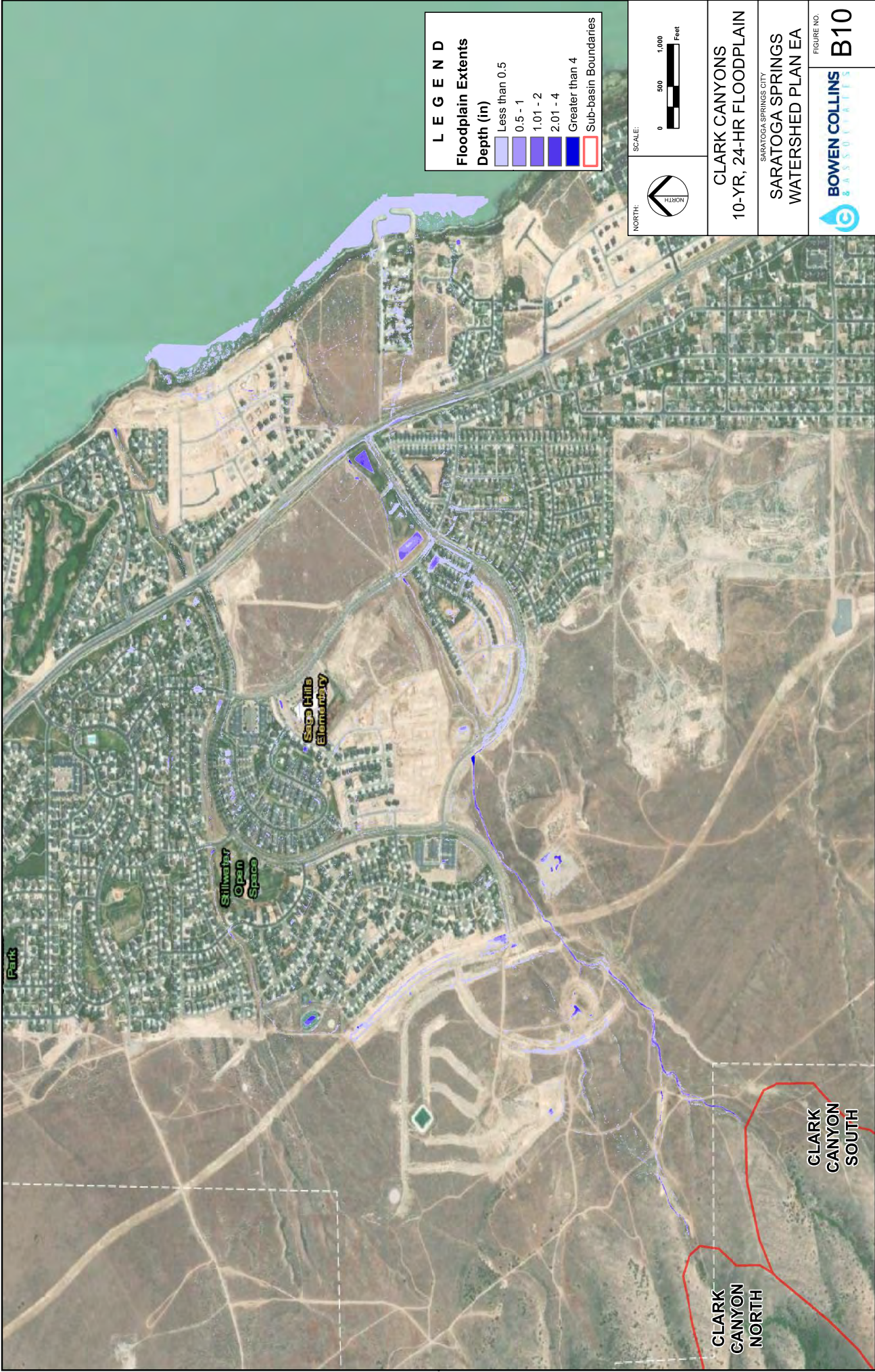
SARATOGA SPRINGS CITY

SARATOGA SPRINGS
WATERSHED PLAN EA

FIGURE NO.

B9

BOWEN COLLINS
ASSOCIATES



LEGEND

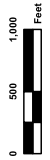
Floodplain Extents

Depth (in)

- Less than 0.5
- 0.5 - 1
- 1.01 - 2
- 2.01 - 4
- Greater than 4
- Sub-basin Boundaries



SCALE:

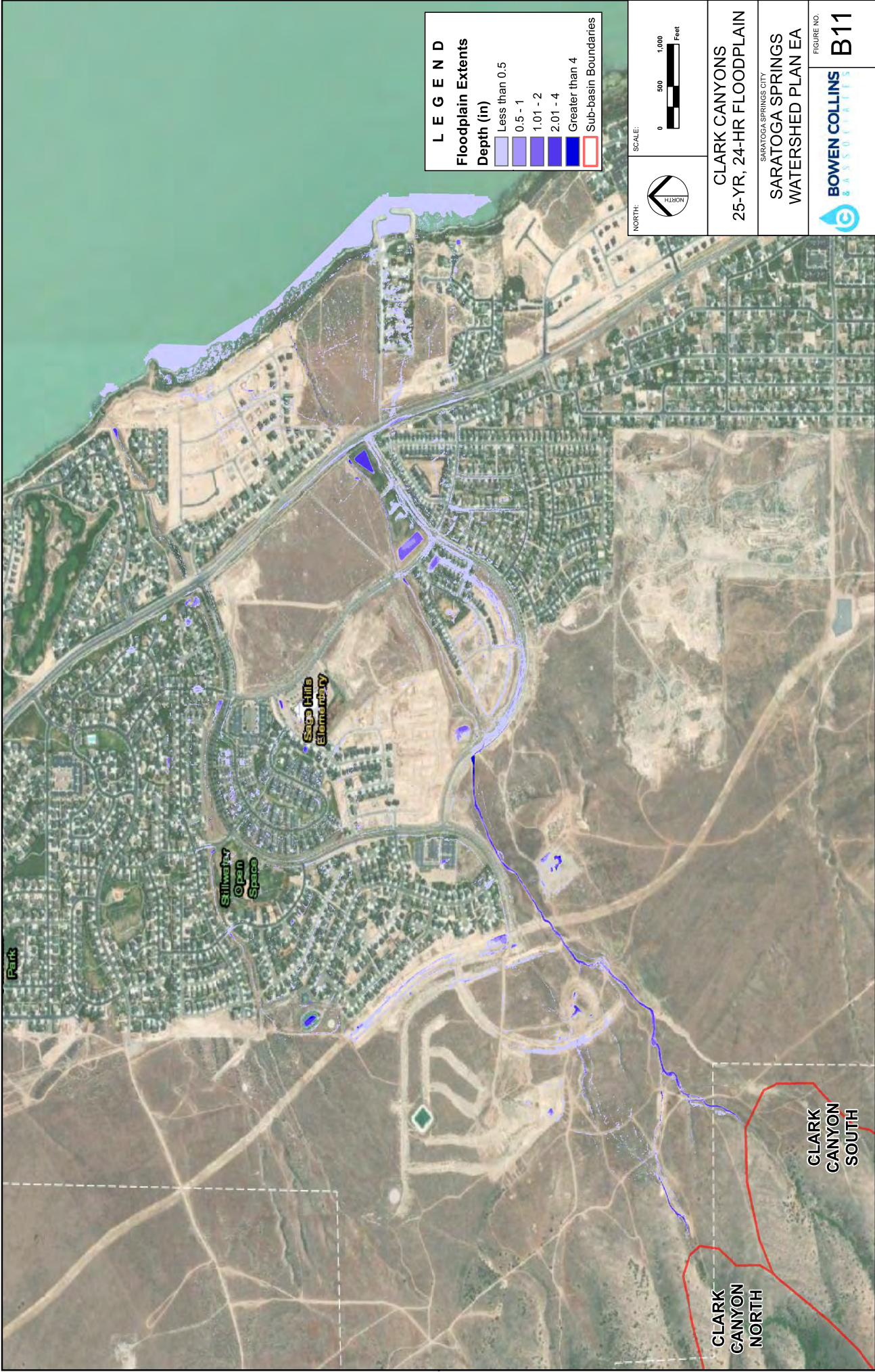


CLARK CANYONS
10-YR, 24-HR FLOODPLAIN

SARATOGA SPRINGS CITY
SARATOGA SPRINGS
WATERSHED PLAN EA

FIGURE NO.
B10

BOWEN COLLINS
& ASSOCIATES



LEGEND

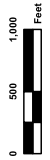
Floodplain Extents

Depth (in)

- Less than 0.5
- 0.5 - 1
- 1.01 - 2
- 2.01 - 4
- Greater than 4
- Sub-basin Boundaries



SCALE:

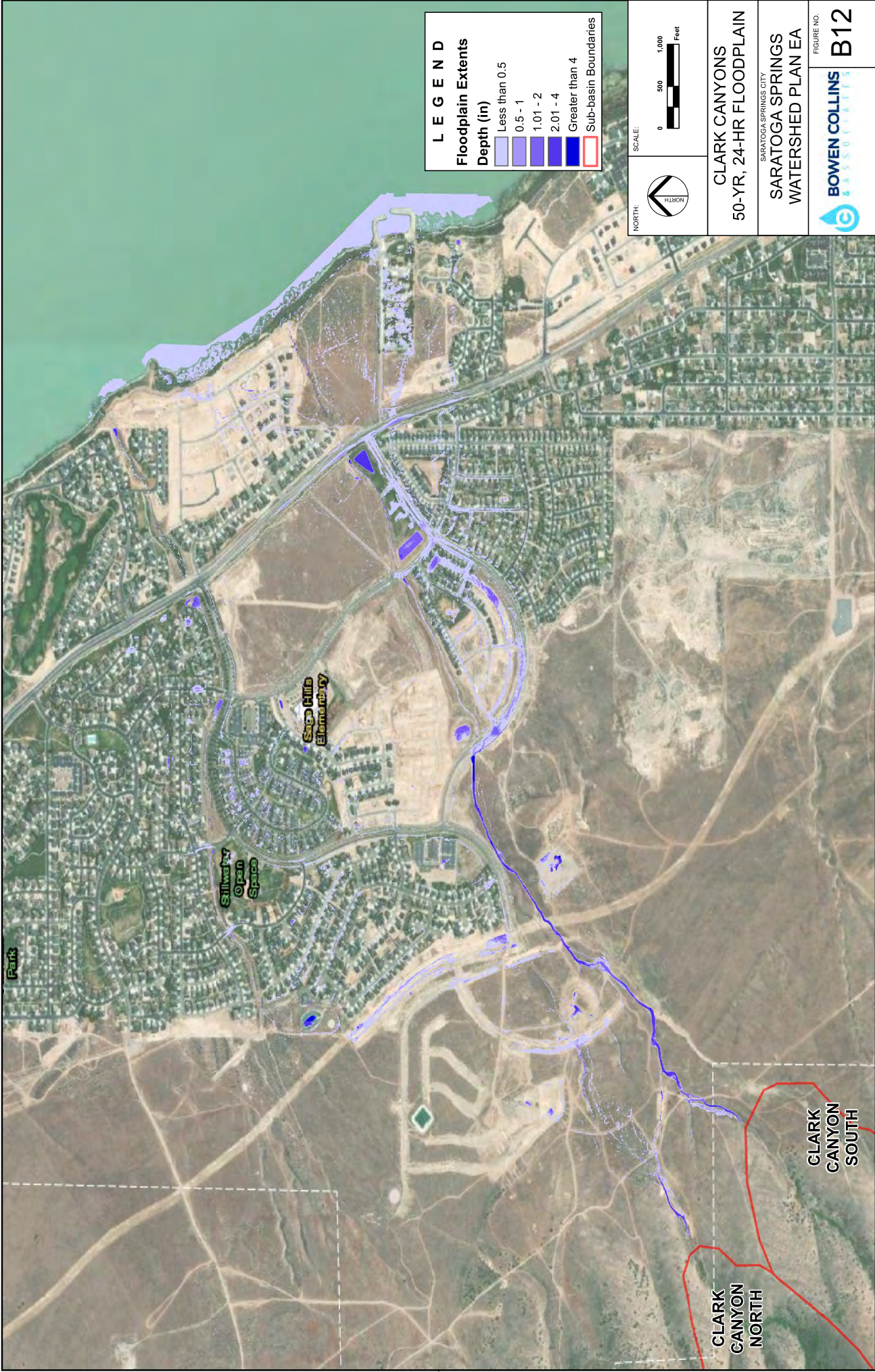


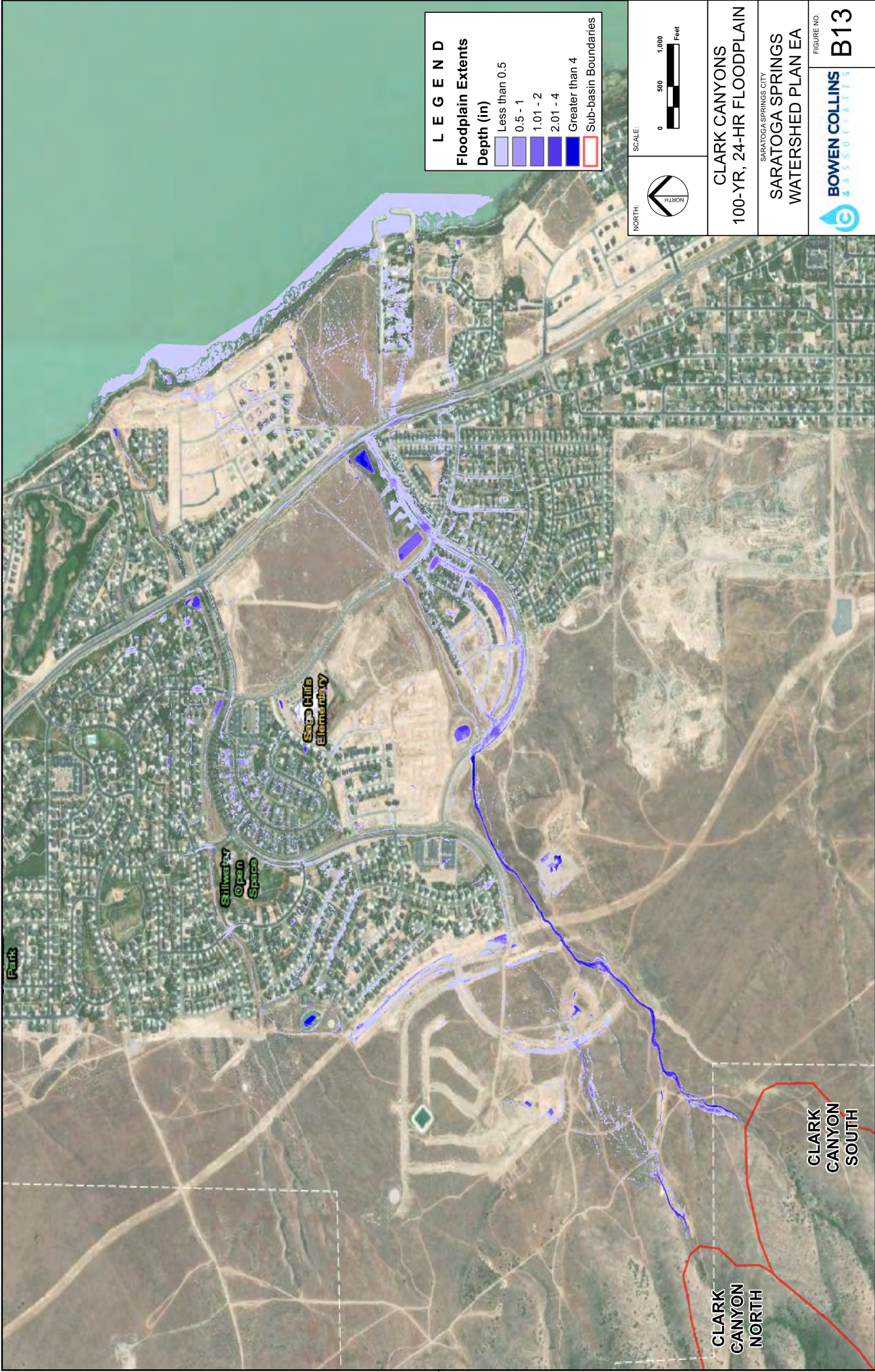
CLARK CANYONS
25-YR, 24-HR FLOODPLAIN

SARATOGA SPRINGS CITY
SARATOGA SPRINGS
WATERSHED PLAN EA

FIGURE NO.
B11

BOWEN COLLINS
& ASSOCIATES





LEGEND

Floodplain Extents

Depth (in)

- Less than 0.5
- 0.5 - 1
- 1.01 - 2
- 2.01 - 4
- Greater than 4
- Sub-basin Boundaries



CLARK CANYONS
100-YR, 24-HR FLOODPLAIN

SARATOGA SPRINGS CITY
SARATOGA SPRINGS
WATERSHED PLAN EA

FIGURE NO.
B13

BOWEN COLLINS
& ASSOCIATES



LEGEND

Floodplain Extents

Depth (in)

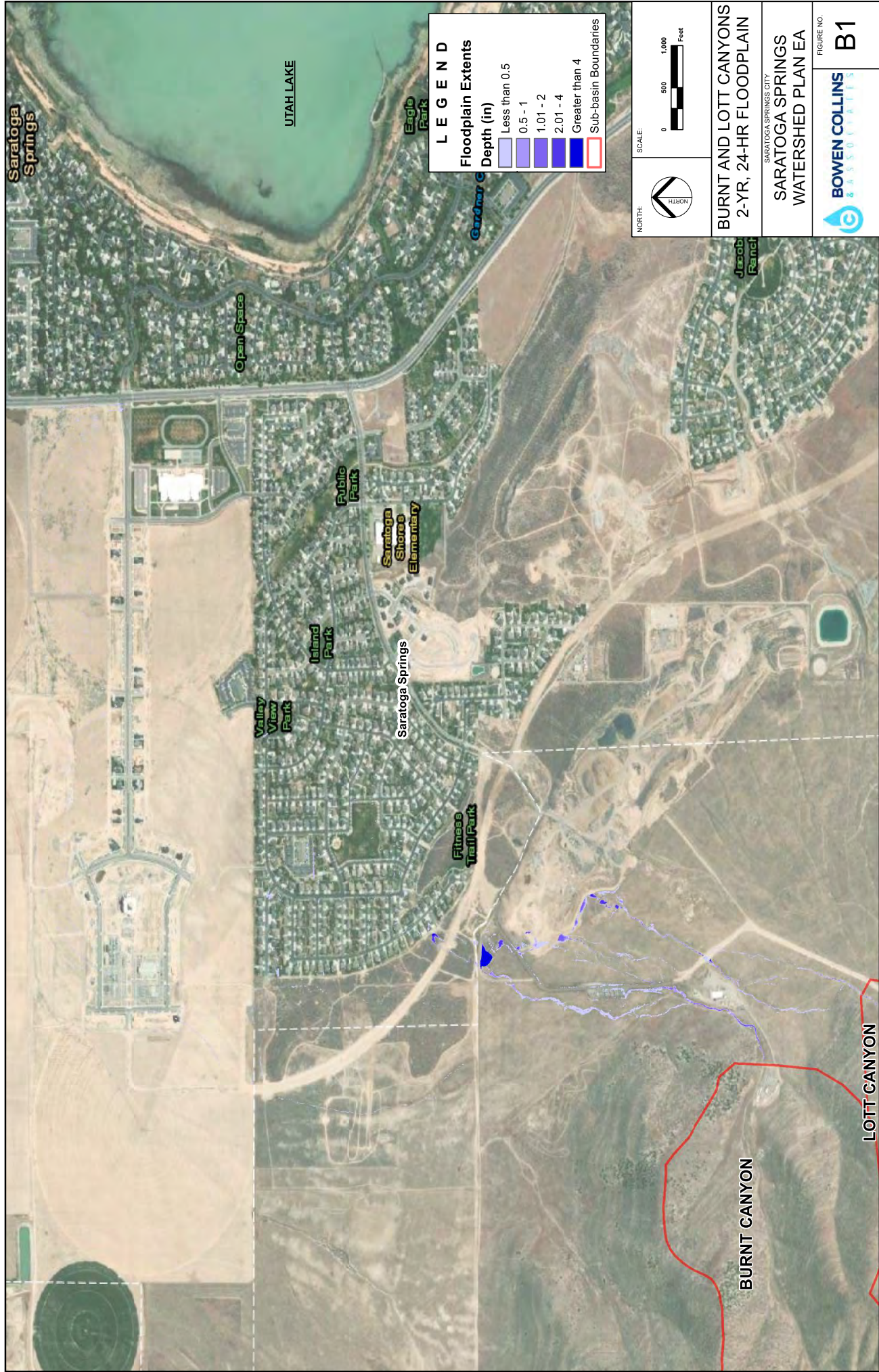
- Less than 0.5
- 0.5 - 1
- 1.01 - 2
- 2.01 - 4
- Greater than 4
- Sub-basin Boundaries



SCALE:



CLARK CANYONS 500-YR, 24-HR FLOODPLAIN	
SARATOGA SPRINGS CITY	
SARATOGA SPRINGS WATERSHED PLAN EA	
FIGURE NO.	B14



APPENDIX C

SEDIMENTATION

Sediment Yield Estimates

Source	Value Type	Yield Rate	Burnt Canyon		0.39 sq mi		Yield Rate	Lott Canyon	
			50-year		100-year			50-year	
		(ac-ft/sq mi/yr)	cu yd	ac-ft	cu yd	ac-ft	(ac-ft/sq mi/yr)	cu yd	ac-ft
Sediment Yield Map (USDA 1973)	Minimum	0.1	3,146	2	6,292	4	0.1	8,873	6
	Maximum	0.2	6,292	4	12,584	8	0.2	17,747	11
	Average	0.15	4,719	3	9,438	6	0.15	13,310	8
RHEM Model (USDA 2013)	Calculated ¹	0.17	5,489	3	10,978	7	0.22	19,816	12
Average Estimate	Average	0.16	5,104	3.2	10,208	6.33	0.19	16,563	10

Notes:

1. Assumes a unit weight of sediment of 80 lbs/ft³ for Sand, from Table 8-1: Volume-Weight of Sediment by grain size, NEH, Chapter 8 Sedimentation)

Table 8-1.—Volume-weight of sediment by grain size

Grain size	Volume-weight of sediment	
	Submerged	Aerated
	<i>lb/ft³</i>	<i>lb/ft³</i>
Clay	35–55	55–75
Silt	55–75	75–85
Clay-silt mixtures (equal parts)	40–65	65–85
Sand-silt mixtures (equal parts)	75–95	95–110
Clay-silt-sand mixtures (equal parts)	50–80	80–100
Sand	85–100	85–100
Gravel	85–125	85–125
Poorly sorted sand and gravel	95–130	95–130

Drainage Area Main Street DB

375 Ac

USDA Map	
Watershed Annual Yield	142 cu yd/yr
	0.088 ac-ft/yr
50-year Sediment	7090 cu yd
	4.4 ac-ft
100-year Sediment	14180 cu yd
	8.8 ac-ft

RHEM analysis	
unit weight of sediment	80 pcf
Avg Annual Sediment Yield	0.475 ton/ac/yr
	950 lbs/ac/yr
	0.4398 cu yd/ac/yr
	0.1745 ac-ft/sq. mi/yr
Watershed Annual Yield	164.93 cu yd/yr
	0.1022 ac-ft/yr
50-year Sediment	8247 cu yd
	5.11 ac-ft/yr
100-year Sediment	16493 cu yd
	10.22 ac-ft/yr

1.1 sq mi		Yield Rate	Clark Canyon N		0.28 sq mi		Yield Rate	Clark Canyon S		0.87 sq mi	
100-year			50-year		100-year			50-year		100-year	
cu yd	ac-ft	(ac-ft/sq mi/yr)	cu yd	ac-ft	cu yd	ac-ft	(ac-ft/sq mi/yr)	cu yd	ac-ft	cu yd	ac-ft
17,747	11	0.1	2,259	1	4,517	3	0.1	7,018	4	14,036	9
35,493	22	0.2	4,517	3	9,035	6	0.2	14,036	9	28,072	17
26,620	17	0.15	3,388	2	6,776	4	0.15	10,527	7	21,054	13
39,633	25	0.23	5,235	3	10,470	6	0.19	13,353	8	26,706	17
33,126	21	0.19	4,311	2.7	8,623	5.3	0.17	11,940	7.4	23,880	14.8

Estimated from Online RHEM tool

Burnt Canyon						
Version	2.3					
State ID	UT					
Climate Station	Utah Lake Lehi					
Soil Texture	Sandy Loam					
Soil Water Saturation %	25					
Slope Length (feet)	164.04					
Slope Shape	Uniform					
Slope Steepness %	22					
Bunch Grass Foliar Cover %	38					
Forbs and/or Annual Grasses Foliar Cover %	0					
Shrubs Foliar Cover %	10					
Sod Grass Foliar Cover %	0					
Total Foliar Cover %	48					
Basal Cover %	0					
Rock Cover %	10					
Litter Cover %	0					
Biological Crusts Cover %	10					
Total Ground Cover %	20					
AVERAGE ANNUAL RESULTS						
Avg. Precipitation (inches/year)	10.898					
Avg. Runoff (inches/year)	0.142					
Avg. Sediment Yield (ton/ac/year)	0.475					
Avg. Soil Loss (ton/ac/year)	0.481					
RETURN FREQUENCY RESULTS FOR YEARLY MAXIMUM DAILY						
Variable	2 yr	5 yr	10 yr	25 yr	50 yr	100 yr
Rain (inches)	0.746	1.022	1.208	1.523	1.625	1.923
Runoff (inches)	0.03	0.179	0.35	0.493	0.747	0.897
Soil Loss (ton/ac)	0.154	0.623	1.07	1.583	2.685	2.802
Sediment Yield (ton/ac)	0.152	0.611	1.063	1.554	2.684	2.799
RETURN FREQUENCY RESULTS FOR YEARLY TOTALS						
Variable	2 yr	5 yr	10 yr	25 yr	50 yr	100 yr
Rain (inches)	5.47	7.332	8.254	9.4	10.486	10.842
Runoff (inches)	0.035	0.245	0.475	0.747	0.901	0.991
Soil Loss (ton/ac)	0.168	0.84	1.303	2.459	2.876	3.868
Sediment Yield (ton/ac)	0.165	0.818	1.29	2.414	2.872	3.811

Lott Canyon						
Version	2.3					
State ID	UT					
Climate Station	Utah Lake Lehi					
Soil Texture	Sandy Loam					
Soil Water Saturation %	25					
Slope Length (feet)	164.04					
Slope Shape	Uniform					
Slope Steepness %	27					
Bunch Grass Foliar Cover %	35					
Forbs and/or Annual Grasses Foliar Cover %	0					
Shrubs Foliar Cover %	15					
Sod Grass Foliar Cover %	0					
Total Foliar Cover %	50					
Basal Cover %	0					
Rock Cover %	10					
Litter Cover %	0					
Biological Crusts Cover %	10					
Total Ground Cover %	20					
AVERAGE ANNUAL RESULTS						
Avg. Precipitation (inches/year)	10.898					
Avg. Runoff (inches/year)	0.138					
Avg. Sediment Yield (ton/ac/year)	0.608					
Avg. Soil Loss (ton/ac/year)	0.616					
RETURN FREQUENCY RESULTS FOR YEARLY MAXIMUM DAILY						
Variable	2 yr	5 yr	10 yr	25 yr	50 yr	100 yr
Rain (inches)	0.746	1.022	1.208	1.523	1.625	1.923
Runoff (inches)	0.027	0.176	0.344	0.488	0.736	0.892
Soil Loss (ton/ac)	0.192	0.801	1.386	2.083	3.492	3.642
Sediment Yield (ton/ac)	0.187	0.786	1.367	2.038	3.491	3.637
RETURN FREQUENCY RESULTS FOR YEARLY TOTALS						
Variable	2 yr	5 yr	10 yr	25 yr	50 yr	100 yr
Rain (inches)	5.429	7.306	8.169	9.355	10.479	10.843
Runoff (inches)	0.032	0.237	0.466	0.736	0.889	0.978
Soil Loss (ton/ac)	0.209	1.072	1.656	3.201	3.734	5.028
Sediment Yield (ton/ac)	0.205	1.046	1.629	3.136	3.727	4.95

Clark Canyon North						
Version	2.3					
State ID	UT					
Climate Station	Utah Lake Lehi					
Soil Texture	Sandy Loam					
Soil Water Saturation %	25					
Slope Length (feet)	164.04					
Slope Shape	Uniform					
Slope Steepness %	30					
Bunch Grass Foliar Cover %	32					
Forbs and/or Annual Grasses Foliar Cover %	0					
Shrubs Foliar Cover %	25					
Sod Grass Foliar Cover %	0					
Total Foliar Cover %	57					
Basal Cover %	0					
Rock Cover %	10					
Litter Cover %	0					
Biological Crusts Cover %	10					
Total Ground Cover %	20					
AVERAGE ANNUAL RESULTS						
Avg. Precipitation (inches/year)	10.898					
Avg. Runoff (inches/year)	0.133					
Avg. Sediment Yield (ton/ac/year)	0.631					
Avg. Soil Loss (ton/ac/year)	0.639					
RETURN FREQUENCY RESULTS FOR YEARLY MAXIMUM DAILY						
Variable	2 yr	5 yr	10 yr	25 yr	50 yr	100 yr
Rain (inches)	0.746	1.022	1.208	1.523	1.625	1.923
Runoff (inches)	0.023	0.171	0.334	0.479	0.72	0.886
Soil Loss (ton/ac)	0.191	0.839	1.404	2.129	3.702	3.855
Sediment Yield (ton/ac)	0.186	0.823	1.399	2.112	3.702	3.854
RETURN FREQUENCY RESULTS FOR YEARLY TOTALS						
Variable	2 yr	5 yr	10 yr	25 yr	50 yr	100 yr
Rain (inches)	5.378	7.152	8.153	9.235	10.477	10.84
Runoff (inches)	0.026	0.219	0.452	0.72	0.874	0.957
Soil Loss (ton/ac)	0.21	1.115	1.716	3.22	3.945	5.207
Sediment Yield (ton/ac)	0.206	1.087	1.688	3.154	3.941	5.128

Clark Canyon South						
Version	2.3					
State ID	UT					
Climate Station	Utah Lake Lehi					
Soil Texture	Sandy Loam					
Soil Water Saturation %	25					
Slope Length (feet)	164.04					
Slope Shape	Uniform					
Slope Steepness %	26					
Bunch Grass Foliar Cover %	32					
Forbs and/or Annual Grasses Foliar Cover %	0					
Shrubs Foliar Cover %	23					
Sod Grass Foliar Cover %	0					
Total Foliar Cover %	55					
Basal Cover %	0					
Rock Cover %	10					
Litter Cover %	0					
Biological Crusts Cover %	10					
Total Ground Cover %	20					
AVERAGE ANNUAL RESULTS						
Avg. Precipitation (inches/year)	10.898					
Avg. Runoff (inches/year)	0.134					
Avg. Sediment Yield (ton/ac/year)	0.518					
Avg. Soil Loss (ton/ac/year)	0.524					
RETURN FREQUENCY RESULTS FOR YEARLY MAXIMUM DAILY						
Variable	2 yr	5 yr	10 yr	25 yr	50 yr	100 yr
Rain (inches)	0.746	1.022	1.208	1.523	1.625	1.923
Runoff (inches)	0.024	0.172	0.336	0.481	0.722	0.887
Soil Loss (ton/ac)	0.158	0.688	1.192	1.723	3.033	3.165
Sediment Yield (ton/ac)	0.154	0.675	1.171	1.704	3.033	3.161
RETURN FREQUENCY RESULTS FOR YEARLY TOTALS						
Variable	2 yr	5 yr	10 yr	25 yr	50 yr	100 yr
Rain (inches)	5.389	7.152	8.153	9.234	10.477	10.84
Runoff (inches)	0.028	0.222	0.455	0.722	0.876	0.961
Soil Loss (ton/ac)	0.173	0.909	1.408	2.636	3.236	4.259
Sediment Yield (ton/ac)	0.17	0.89	1.386	2.585	3.23	4.193

Burnt Canyon			Explanation
Drainage Area	0.39 sq mi		
Estimated Flood Storage Requirement	13.7 ac-ft		(HEC-HMS - WinTR-20_24-hr_100-yr storm)
Estimated Design Life Sediment Yield	6.3 ac-ft		
Trap Efficiency	98%		(iterate)
Estimated Sediment Storage Requirement	6.2 ac-ft		
Required Basin Capacity	19.9 ac-ft		(Est. Flood Storage Req. + Est. Sediment Storage Req.)
Average Annual Inflow (StreamStats)	0.11 cfs		
	81 ac-ft/yr		
	0.245		
Capacity/Inflow (C/I)			

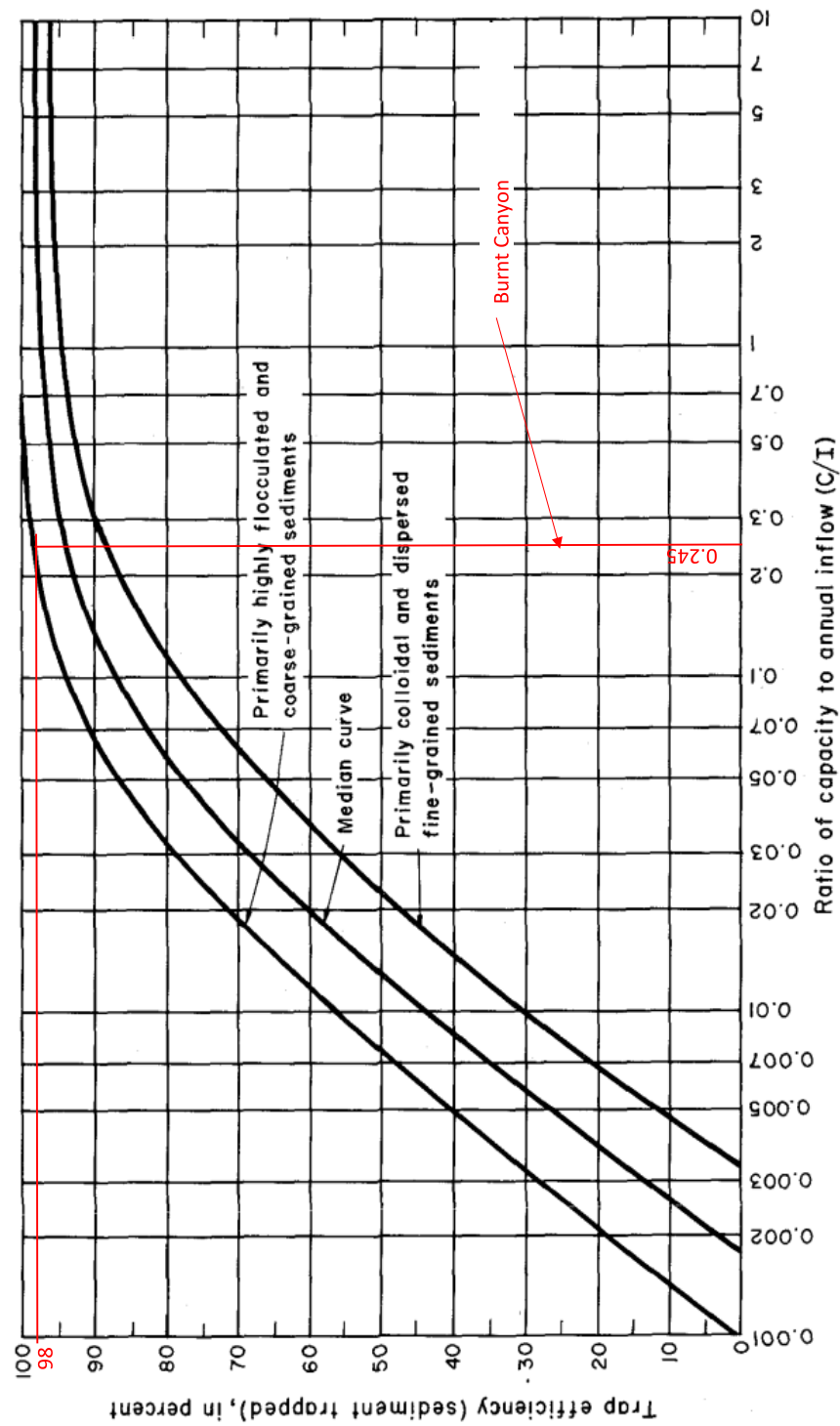


Figure 8-2.—Trap efficiency of reservoirs.

Lott Canyon			Explanation
Drainage Area	1.1 sq mi		
Estimated Flood Storage Requirement	28.1 ac-ft		(HEC-HMS - WinTR-20_24-hr_10-yr storm)
Estimated Design Life Sediment Yield	20.5 ac-ft		
Trap Efficiency	98%		(iterate)
Estimated Sediment Storage Requirement	20.1 ac-ft		
Required Basin Capacity	48.2 ac-ft		(Est. Flood Storage Req.+ Est. Sediment Storage Req.)
Average Annual Inflow (StreamStats)	0.27 cfs		
Capacity/Inflow (C/I)	197 ac-ft/yr		
	0.244		

0.00

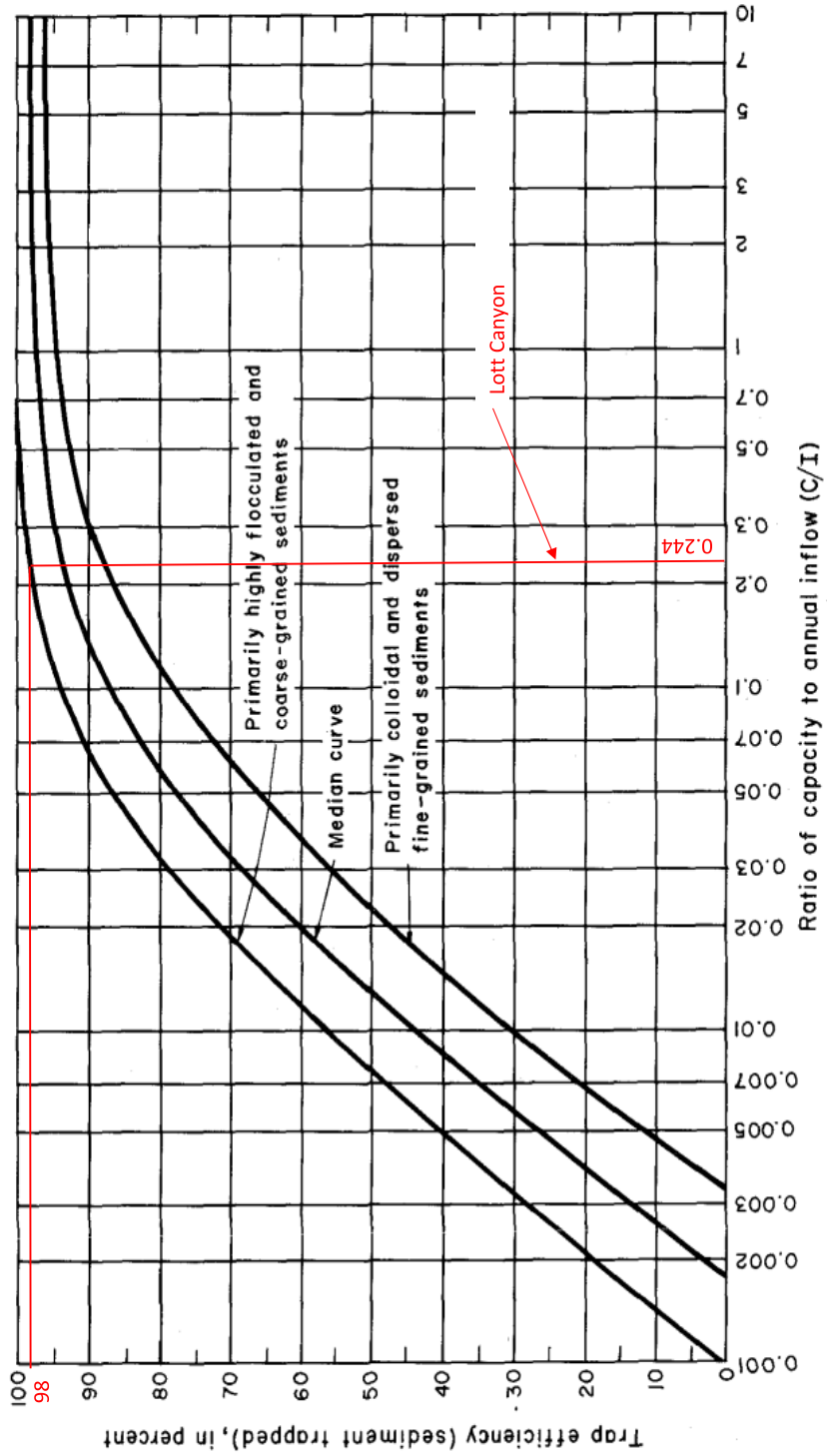


Figure 8-2.—Trap efficiency of reservoirs.

Clark Canyon			Explanation
Drainage Area	0.28 sq mi		
Estimated Flood Storage Requirement	4.1 ac-ft		(HEC-HMS - WinTR-20_24-hr_50-yr storm)
Estimated Design Life Sediment Yield	5.3 ac-ft		
Trap Efficiency	96%		(iterate)
Estimated Sediment Storage Requirement	5.1 ac-ft		
Required Basin Capacity	9.2 ac-ft		(Est. Flood Storage Req.+ Est. Sediment Storage Req.)
Average Annual Inflow (StreamStats)	0.08 cfs		
Capacity/Inflow (C/I)	61 ac-ft/yr		
	0.151		

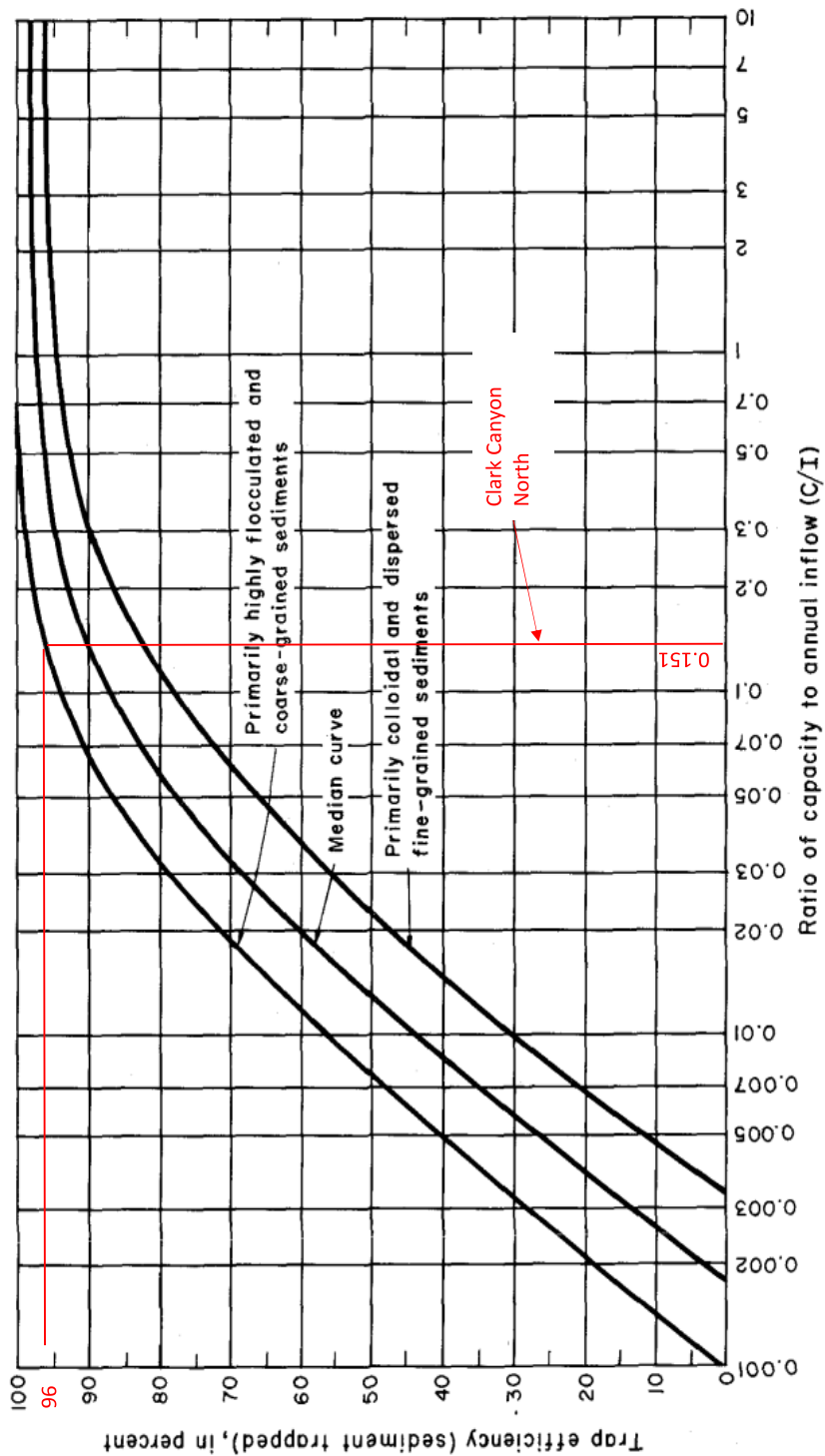


Figure 8-2.—Trap efficiency of reservoirs.

Clark Canyon			Explanation
Drainage Area	0.87 sq mi		
Estimated Flood Storage Requirement	10.9 ac-ft		(HEC-HMS - WinTR-20_24-hr_50-yr storm)
Estimated Design Life Sediment Yield	14.8 ac-ft		
Trap Efficiency	96%		(iterate)
Estimated Sediment Storage Requirement	14.2 ac-ft		
Required Basin Capacity	25.1 ac-ft		(Est. Flood Storage Req.+ Est. Sediment Storage Req.)
Average Annual Inflow (StreamStats)	0.22 cfs		
	161 ac-ft/yr		
Capacity/Inflow (C/I)	0.156		

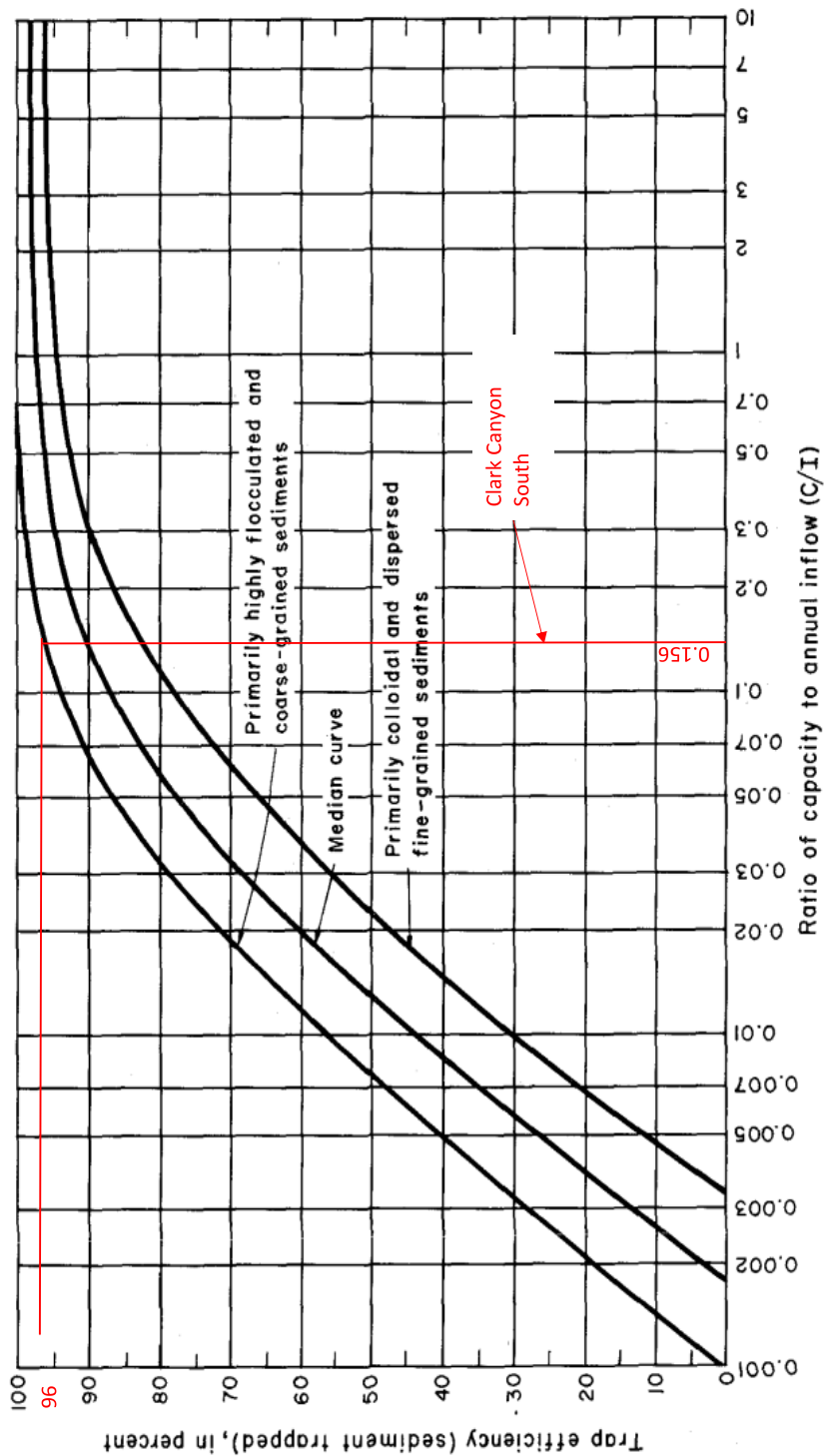


Figure 8-2.—Trap efficiency of reservoirs.

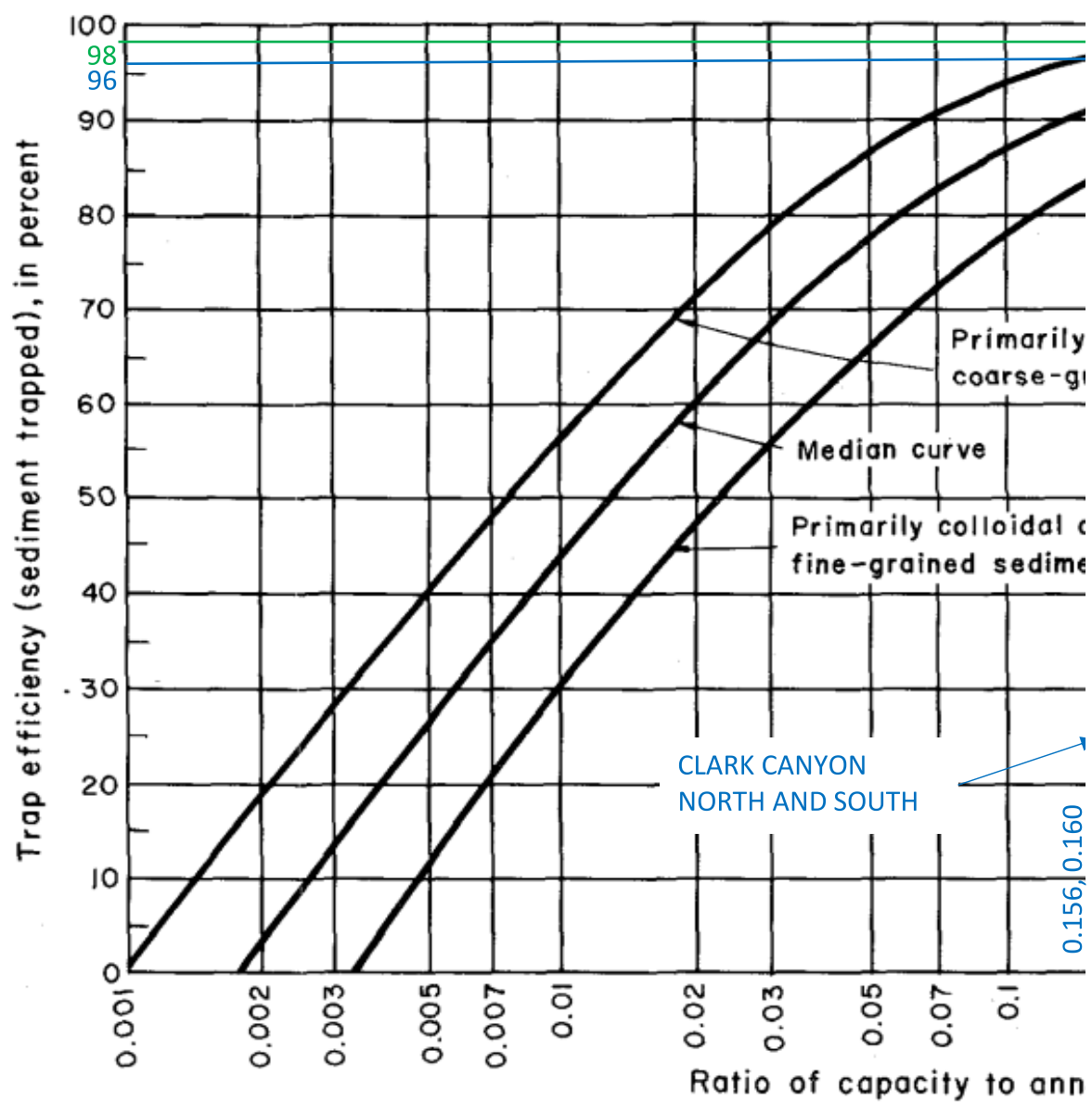
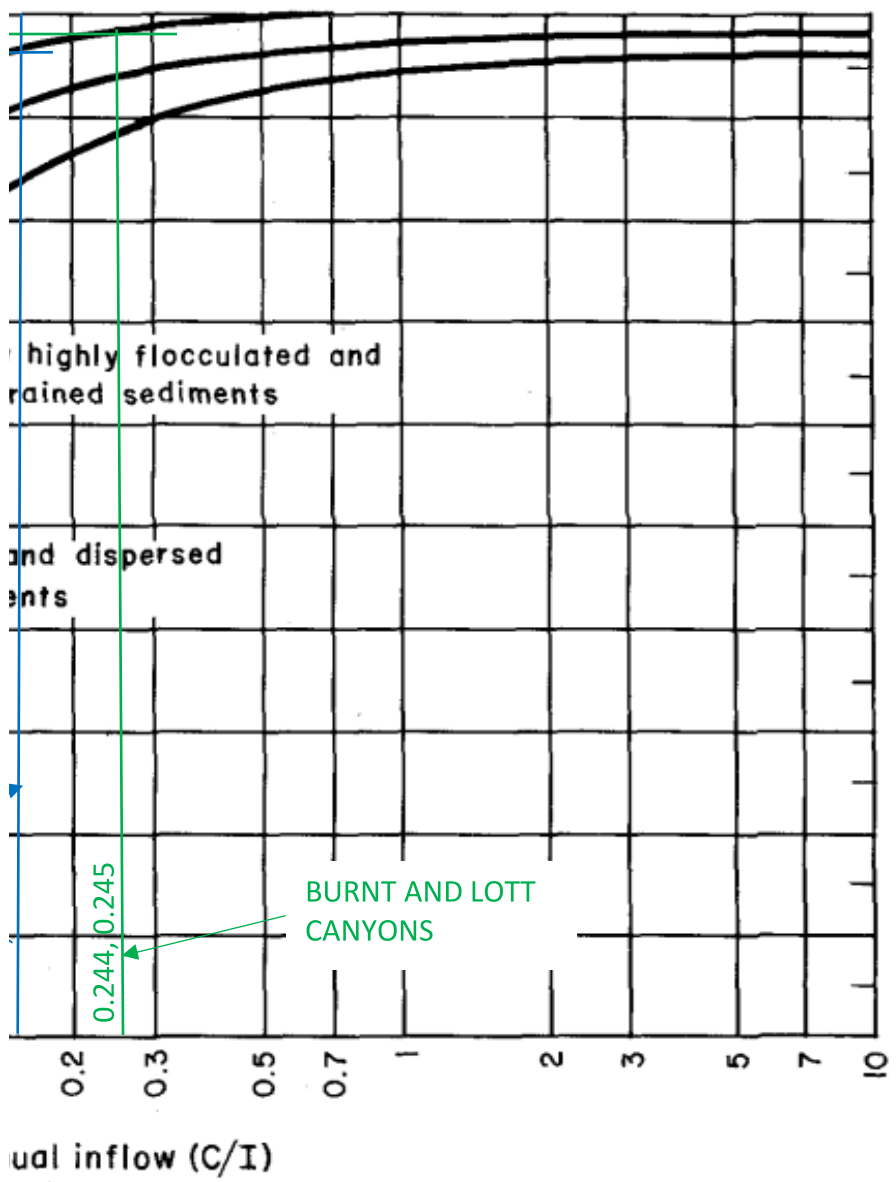


Figure 8-2.—Trap efficiency of reservoirs.



APPENDIX D

DAM BREACH ANALYSIS

Dambreach Hydrographs via TRs 60 & 66 NRCS guidance (Burnt Canyon)

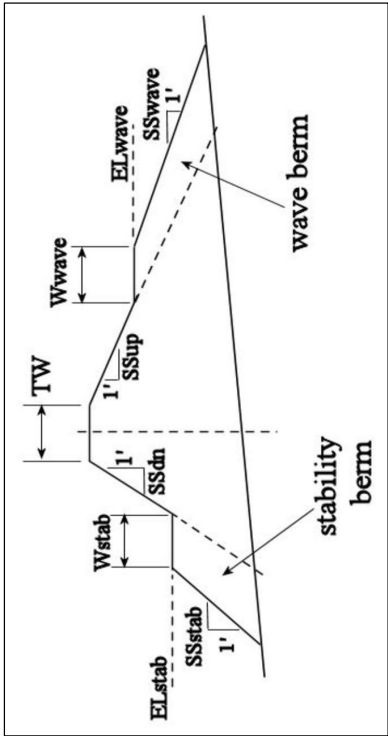
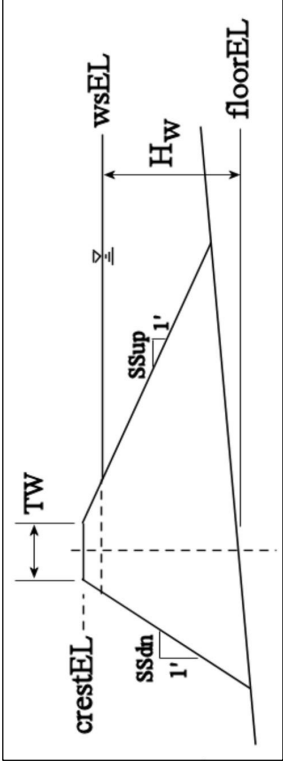
version 2, April 2020

Input data required:

data	variable	explanation
5095	crestEL	dam crest elevation
5090	wsEL	w.s. elev at time of breach
14	TW	dam top width (feet)
3	SSup	dam side slope (upstream, SSUp:1)
2	SSdn	dam side slope (downstream, SSdn:1)
5071	floorEL	valley floor elev
18.4	Vs	resv vol at time of breach (acre-feet)
320	L	valley width at dam axis & w.s. elev (feet)
	ELwave	top of wave berm elevation
	Wwave	width of top of wave berm feet
	SSwave	wave berm side slope (SSwave:1)
	ELstab	top of stability berm elevation
	Wstab	width of top of stability berm (feet)
	SSstab	stability berm side slope (SSstab:1)
1	ts	timestep (minutes) for breach hydrograph

breach hydrograph

output variable	results	time (min)	Q (cfs)
T	438	0	0
(L < T)?	Y	1	5035
H _w	19	2	2369
Q ₁	11025	3	1625
(H _w < 103)?	Y	4	1115
A _{wave}	0	5	765
A _{stab}	0	6	525
A	1776	7	360
Br	0.20	8	247
Q ₂	123	9	169
Q _{min}	5035	10	116
(Q ₂ < Q _{min})?	Y	11	80
(Q ₂ > Q ₁)?	N	12	55
(Q ₁ < Q _{min})?	N	13	37
Q _{max}	5035	14	26



auto-scale hydrograph

801504.00

24.00

Dambreach Hydrographs via TRs 60 & 66 NRCS guidance (Clark Canyon North)

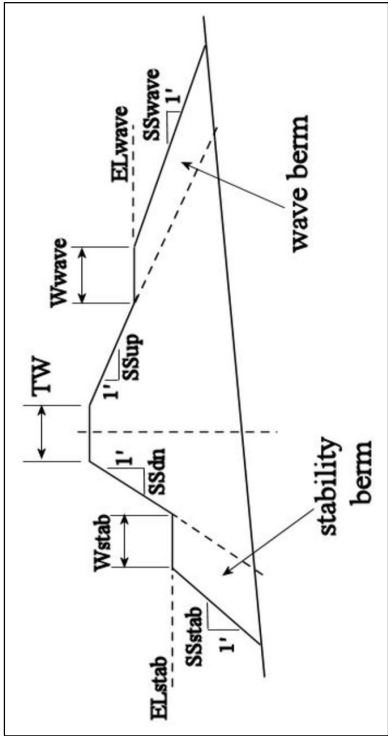
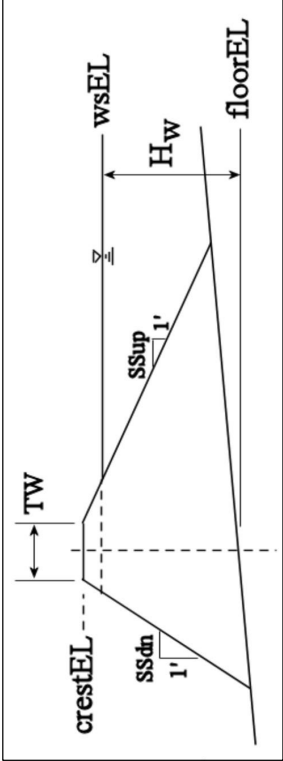
version 2, April 2020

Input data required:

data	variable	explanation
5342	crestEL	dam crest elevation
5337.5	wsEL	w.s. elev at time of breach
14	TW	dam top width (feet)
3	SSup	dam side slope (upstream, SSUp:1)
2	SSdn	dam side slope (downstream, SSdn:1)
5321	floorEL	valley floor elev
6	Vs	resv vol at time of breach (acre-feet)
300	L	valley width at dam axis & w.s. elev (feet)
	ELwave	top of wave berm elevation
	Wwave	width of top of wave berm feet
	SSwave	wave berm side slope (SSwave:1)
	ELstab	top of stability berm elevation
	Wstab	width of top of stability berm (feet)
	SSstab	stability berm side slope (SSstab:1)
1	ts	timestep (minutes) for breach hydrograph

breach hydrograph

output variable	results	time (min)	Q (cfs)
T	417	0	0
(L < T)?	Y	1	3539
H _w	16.5	2	697
Q ₁	8365	3	309
(H _w < 103)?	Y	4	137
Awave	0	5	61
Astab	0	6	27
A	1397	7	12
Br	0.07	8	5
Q ₂	31	9	2
Q _{min}	3539	10	1
(Q ₂ < Q _{min})?	Y	11	0
(Q ₂ > Q ₁)?	N	12	0
(Q ₁ < Q _{min})?	N	13	0
Q _{max}	3539	14	0



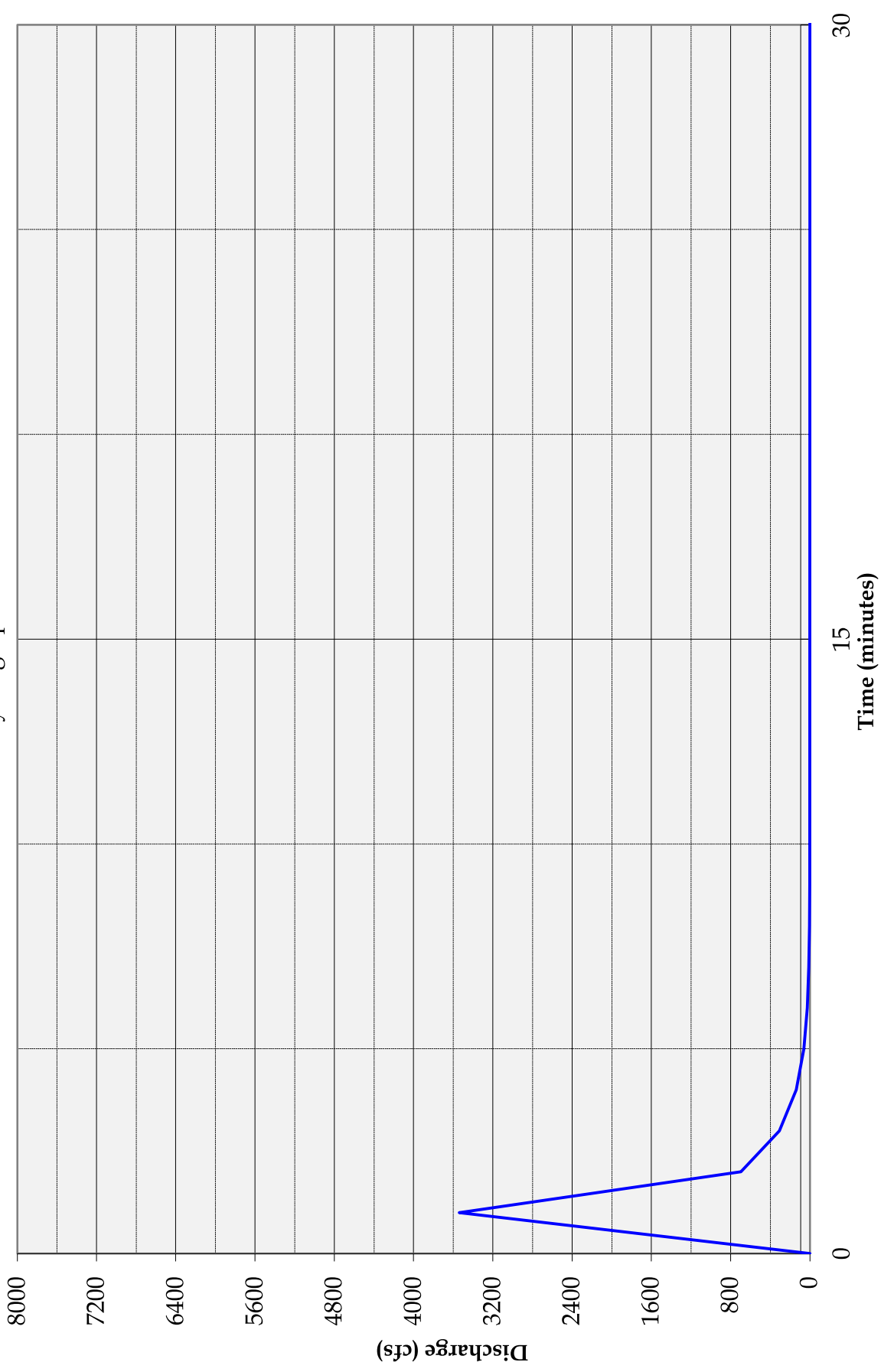
auto-scale hydrograph

261360.00

21.00

4.50

Breach Hydrograph



Dambreach Hydrographs via TRs 60 & 66 NRCS guidance (Clark Canyon South)

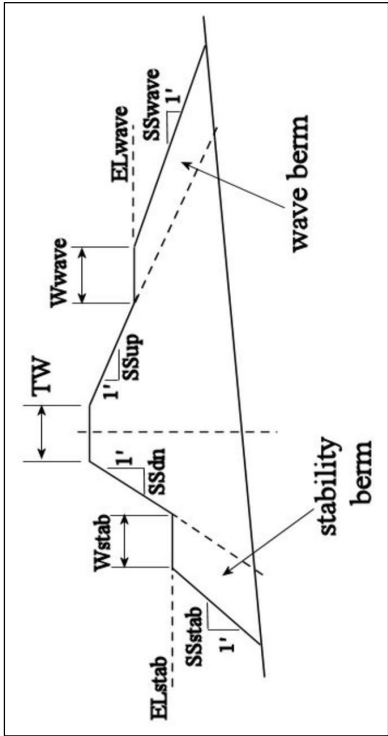
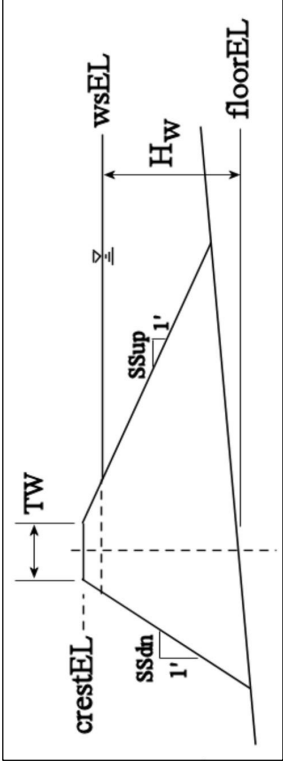
version 2, April 2020

Input data required:

data	variable	explanation
5244.5	crestEL	dam crest elevation
5238.5	wsEL	w.s. elev at time of breach
14	TW	dam top width (feet)
3	SSup	dam side slope (upstream, SSUp:1)
2	SSdn	dam side slope (downstream, SSdn:1)
5218	floorEL	valley floor elev
18.3	Vs	resv vol at time of breach (acre-feet)
300	L	valley width at dam axis & w.s. elev (feet)
	ELwave	top of wave berm elevation
	Wwave	width of top of wave berm feet
	SSwave	wave berm side slope (SSwave:1)
	ELstab	top of stability berm elevation
	Wstab	width of top of stability berm (feet)
	SSstab	stability berm side slope (SSstab:1)
1	ts	timestep (minutes) for breach hydrograph

breach hydrograph

output variable	results	time (min)	Q (cfs)
T	450	0	0
(L < T)?	Y	1	6089
H _w	20.5	2	2435
Q ₁	11584	3	1540
(H _w < 103)?	Y	4	974
Awave	0	5	616
Astab	0	6	389
A	2127	7	246
Br	0.18	8	156
Q ₂	106	9	98
Q _{min}	6089	10	62
(Q ₂ < Q _{min})?	Y	11	39
(Q ₂ > Q ₁)?	N	12	25
(Q ₁ < Q _{min})?	N	13	16
Q _{max}	6089	14	10



auto-scale hydrograph

797148.00

26.50

Dambreach Hydrographs via TRs 60 & 66 NRCS guidance (Lott Canyon)

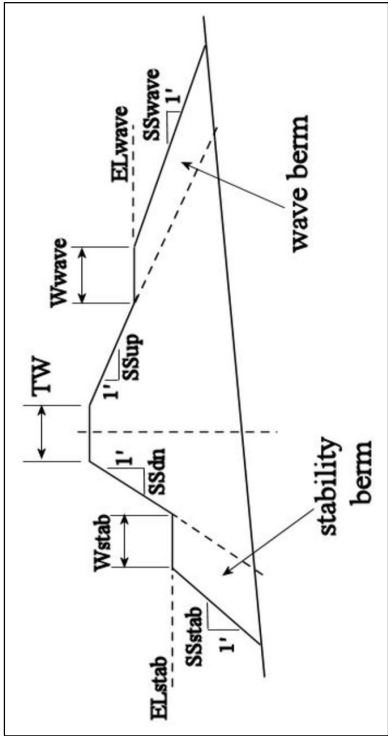
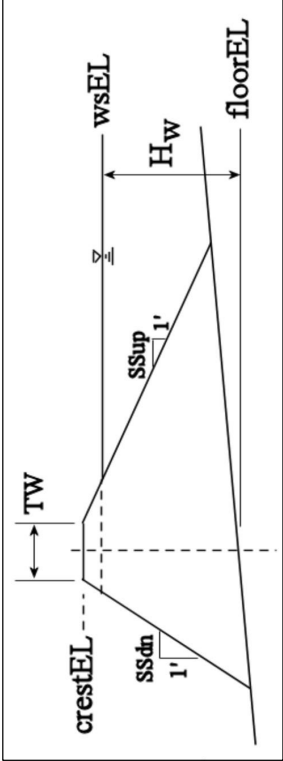
version 2, April 2020

Input data required:

data	variable	explanation
5145	crestEL	dam crest elevation
5139.5	wsEL	w.s. elev at time of breach
14	TW	dam top width (feet)
3	SSup	dam side slope (upstream, SSUp:1)
2	SSdn	dam side slope (downstream, SSdn:1)
5120	floorEL	valley floor elev
35.3	Vs	resv vol at time of breach (acre-feet)
700	L	valley width at dam axis & w.s. elev (feet)
	ELwave	top of wave berm elevation
	Wwave	width of top of wave berm feet
	SSwave	wave berm side slope (SSwave:1)
	ELstab	top of stability berm elevation
	Wstab	width of top of stability berm (feet)
	SSstab	stability berm side slope (SSstab:1)
1	ts	timestep (minutes) for breach hydrograph

breach hydrograph

output variable	results	time (min)	Q (cfs)
T	442	0	0
(L < T)?	N	1	5373
H _w	19.5	2	3533
Q ₁	15830	3	2865
(H _w < 103)?	Y	4	2323
Awave	0	5	1883
Astab	0	6	1527
A	1913	7	1238
Br	0.36	8	1004
Q ₂	277	9	814
Q _{min}	5373	10	660
(Q ₂ < Q _{min})?	Y	11	535
(Q ₂ > Q ₁)?	N	12	434
(Q ₁ < Q _{min})?	N	13	352
Q _{max}	5373	14	285



auto-scale hydrograph

5.50

25.00

COMPUTATION OF POPULATION AT RISK (PAR) DURING DAM FAILURE						
STATE	UT		BY		DATE	
DAM	Clark Canyon South		CHECKED BY		DATE	
YEAR BUILT		DESIGN HAZARD CLASS		DRAINAGE AREA		mi ²
WORK PLAN DATE		CURRENT HAZARD CLASS		DAM HEIGHT		ft
sht 1 of 3	STATIC FAILURE SCENARIO (ver. 2013-01)				NID ID	
Structures (Elevated) Impacted by Potential Breach	Number of Structures			PAR per Exposure with Inundation Depths >=2.0 Ft.	PAR	
	Inundation Depth Above Natural Ground		Total			
	<2.0 Ft	>=2.0 Ft.				
Mobile Homes	0	0		3		
Seasonal Use RV's	0	0		2		
Other	0	0				
Structures (With Foundations) Impacted by Potential Breach	Number of Structures			PAR per Exposure with Inundation Depths >=1.0 Ft.	PAR	
	Inundation Depth Above Natural Ground		Total			
	<1.0 Ft	>=1.0 Ft.				
Homes	18	3	21	3	9	
Seasonal Use Homes and Cabins	0	0		1.5		
Duplexes	0	0		5		
Apartments	0	0				
Commercial Buildings	0	0				
Schools (In Use)	0	0				
Schools (Not in Use)	0	0				
Hospitals	0	0				
Other	0	0				
Highways and Railroads	Number of Roads, Highways and Railways			PAR per Exposure with Inundation Depths >=1.0 Ft.	PAR	
	Road Overflow Depth		Total			
	<1.0 Ft	>=1.0 Ft.				
Main Local Roads and Minor State Highways						
Autumn Creek Dr	1	0	1	2	0	
Wildlife Blvd, Cedar Grove Lane, Rocky Creek W	0	3	3	2	6	
Major State and Minor Federal Highways						
Highway Name(s) or Number(s)				4		
Highway Name(s) or Number(s)				4		
Major Federal and Interstate Highways						
Highway Name(s) or Number(s)				8		
Highway Name(s) or Number(s)				8		
Railroads						
UPSF Freight Traffic Only				3		
Passenger Traffic				20		
TOTAL NUMBER OF PEOPLE AT RISK (PAR)					15	

COMPUTATION OF POPULATION AT RISK (PAR) DURING DAM FAILURE						
STATE	UT		BY		DATE	
DAM	Clark Canyon North		CHECKED BY		DATE	
YEAR BUILT		DESIGN HAZARD CLASS		DRAINAGE AREA		mi ²
WORK PLAN DATE		CURRENT HAZARD CLASS		DAM HEIGHT		ft
sht 1 of 3	STATIC FAILURE SCENARIO (ver. 2013-01)				NID ID	
Structures (Elevated) Impacted by Potential Breach	Number of Structures			PAR per Exposure with Inundation Depths >=2.0 Ft.	PAR	
	Inundation Depth Above Natural Ground		Total			
	<2.0 Ft	>=2.0 Ft.				
Mobile Homes	0	0		3		
Seasonal Use RV's	0	0		2		
Other	0	0				
Structures (With Foundations) Impacted by Potential Breach	Number of Structures			PAR per Exposure with Inundation Depths >=1.0 Ft.	PAR	
	Inundation Depth Above Natural Ground		Total			
	<1.0 Ft	>=1.0 Ft.				
Homes	3	4	7	3	12	
Seasonal Use Homes and Cabins	0	0		1.5		
Duplexes	0	0		5		
Apartments	0	0				
Commercial Buildings	0	0				
Schools (In Use)	0	0				
Schools (Not in Use)	0	0				
Hospitals	0	0				
Other	0	0				
Highways and Railroads	Number of Roads, Highways and Railways			PAR per Exposure with Inundation Depths >=1.0 Ft.	PAR	
	Road Overflow Depth		Total			
	<1.0 Ft	>=1.0 Ft.				
Main Local Roads and Minor State Highways						
Cedar Grove, Rocky Creek Way	2	0	2	2	0	
Wildlife Blvd	0	1	1	2	2	
Major State and Minor Federal Highways						
Highway Name(s) or Number(s)	0	0		4		
Highway Name(s) or Number(s)	0	0		4		
Major Federal and Interstate Highways						
Highway Name(s) or Number(s)	0	0		8		
Highway Name(s) or Number(s)	0	0		8		
Railroads						
UPSF Freight Traffic Only	0	0		3		
Passenger Traffic	0	0		20		
TOTAL NUMBER OF PEOPLE AT RISK (PAR)					14	

COMPUTATION OF POPULATION AT RISK (PAR) DURING DAM FAILURE						
STATE	UT		BY		DATE	
DAM	Lott Canyon		CHECKED BY		DATE	
YEAR BUILT		DESIGN HAZARD CLASS		DRAINAGE AREA		mi ²
WORK PLAN DATE		CURRENT HAZARD CLASS		DAM HEIGHT		ft
sht 1 of 3	STATIC FAILURE SCENARIO (ver. 2013-01)				NID ID	
Structures (Elevated) Impacted by Potential Breach	Number of Structures			PAR per Exposure with Inundation Depths >=2.0 Ft.	PAR	
	Inundation Depth Above Natural Ground		Total			
	<2.0 Ft	>=2.0 Ft.				
Mobile Homes	0	0		3		
Seasonal Use RV's	0	0		2		
Other	0	0				
Structures (With Foundations) Impacted by Potential Breach	Number of Structures			PAR per Exposure with Inundation Depths >=1.0 Ft.	PAR	
	Inundation Depth Above Natural Ground		Total			
	<1.0 Ft	>=1.0 Ft.				
Homes	166	21	187	3	63	
Seasonal Use Homes and Cabins	0	0		1.5		
Duplexes	0	0		5		
Apartments	0	0				
Commercial Buildings	0	0				
Schools (In Use)	1	0	1	805	0	
Schools (Not in Use)	0	0				
Hospitals	0	0				
Other	0	0				
Highways and Railroads	Number of Roads, Highways and Railways			PAR per Exposure with Inundation Depths >=1.0 Ft.	PAR	
	Road Overflow Depth		Total			
	<1.0 Ft	>=1.0 Ft.				
Main Local Roads and Minor State Highways						
Grandview Blvd, Alpine Dr, Hillsdale Dr	4	0	4	2	0	
				2		
Major State and Minor Federal Highways						
Highway Name(s) or Number(s)				4		
Highway Name(s) or Number(s)				4		
Major Federal and Interstate Highways						
Highway Name(s) or Number(s)				8		
Highway Name(s) or Number(s)				8		
Railroads						
UPSF Freight Traffic Only				3		
Passenger Traffic				20		
TOTAL NUMBER OF PEOPLE AT RISK (PAR)					63	

COMPUTATION OF POPULATION AT RISK (PAR) DURING DAM FAILURE						
STATE	UT		BY		DATE	
DAM	Burnt Canyon		CHECKED BY		DATE	
YEAR BUILT		DESIGN HAZARD CLASS		DRAINAGE AREA		mi ²
WORK PLAN DATE		CURRENT HAZARD CLASS		DAM HEIGHT		ft
sht 1 of 3	STATIC FAILURE SCENARIO (ver. 2013-01)				NID ID	
Structures (Elevated) Impacted by Potential Breach	Number of Structures			PAR per Exposure with Inundation Depths >=2.0 Ft.	PAR	
	Inundation Depth Above Natural Ground		Total			
	<2.0 Ft	>=2.0 Ft.				
Mobile Homes	0	0		3		
Seasonal Use RV's	0	0		2		
Other	0	0				
Structures (With Foundations) Impacted by Potential Breach	Number of Structures			PAR per Exposure with Inundation Depths >=1.0 Ft.	PAR	
	Inundation Depth Above Natural Ground		Total			
	<1.0 Ft	>=1.0 Ft.				
Homes	113	14	127	3	42	
Seasonal Use Homes and Cabins	0	0		1.5		
Duplexes	0	0		5		
Apartments	0	0				
Commercial Buildings	0	1	1	3	3	
Schools (In Use)	1	0	1	805	0	
Schools (Not in Use)	0	0				
Hospitals	0	0				
Other	0	0				
Highways and Railroads	Number of Roads, Highways and Railways			PAR per Exposure with Inundation Depths >=1.0 Ft.	PAR	
	Road Overflow Depth		Total			
	<1.0 Ft	>=1.0 Ft.				
Main Local Roads and Minor State Highways						
Grandview Blvd, Rocky Ridge Ln	2	0	2	2	0	
				2		
Major State and Minor Federal Highways						
Highway Name(s) or Number(s)				4		
Highway Name(s) or Number(s)				4		
Major Federal and Interstate Highways						
Highway Name(s) or Number(s)				8		
Highway Name(s) or Number(s)				8		
Railroads						
UPSF Freight Traffic Only				3		
Passenger Traffic				20		
TOTAL NUMBER OF PEOPLE AT RISK (PAR)					45	

EVALUATION OF POTENTIAL REHABILITATION PROJECTS

STATE	UT	DAM	Burnt Canyon	BY	CCM	DATE	5/30/2024
sht 2 of 5	FAILURE & RISK INDEXES						ver 2013-01

Adopted from Bureau of Reclamation "Risk Based Profile System"

see: <http://www.usbr.gov/dsis/risk/rbpsdocumentation.pdf>

LIFE LOSS:

Population-at-Risk [PAR], see NRCS dams inventory definition (number of people)

Estimate PAR for static loading failure; typically assume water at or above invert of the lowest open channel auxiliary spillway

Estimate PAR for hydrologic loading failure; typically assume water at or above invert of the lowest open channel auxiliary spillway

Estimate PAR for seismic loading failure; typically assume water at or above invert of the lowest non-gated spillway (sunny day failure)

	A
45	B
	C

Fatality Rates [FR] from dam breach

Adopted from BuRec "A Procedure for Estimating Loss of Life Caused by Dam Failure" DSO-99-06

see: http://www.usbr.gov/research/dam_safety/documents/dso-99-06.pdf

Flood Severity/Lethality [DV] is the average depth [D] times velocity [V] across flood plain (ft²/sec)

DV= (breach discharge - bank full discharge) / breach floodplain width

Warning Time [T] between failure warning and flood wave at population (minutes)

Flood Severity Understanding [U] of the warning issuer of the likely flooding magnitude

Scenario	Breach Discharge	Bankfull Discharge	Breach Floodplain Width	DV	Warning Time, T	Understanding, U
	(cfs)	(cfs)	(ft)	(ft ² /sec)	(minutes)	(N/A or Vague)
Static						
Hydrologic	5,035	5	3000	2	10	Vague
Seismic						

For DV≥50	T≤60	U=vague	FR=0.04
	T>60		FR=0.03
For DV<50	T≤60	U=vague	FR=0.007
	T>60		FR=0.0003

Estimate FR for static loading failure scenario

Estimate FR for hydrologic loading failure scenario

Estimate FR for seismic loading failure scenario

	D
0.007	E
	F

Scenario	Load Factor	Response Factor	Failure Index	Fatality Rate	PAR	Risk Index
Static Hydrologic Seismic	1					
	*	*	8	0.007	45	3
TOTAL=			8	TOTAL=		3

EVALUATION OF POTENTIAL REHABILITATION PROJECTS								
STATE	UT	DAM	Burnt Canyon	BY	CCM	DATE	5/30/2024	
sht 4 of 5		HYDROLOGIC FAILURE INDEX					ver 2013-01	
HYDROLOGIC LOADING:								
Total Spillway Capacity (PS&ES) for 6hr storm [Pfb], Work Plan Tbl 3 (rainfall inches)						9.6	A	
Obtained from Work Plan Tbl 3, or dams inventory data, or computer routings								
100 year, 6hr rainfall [P100] (inches)						1.9	B	
Probable Maximum Precipitation [PMP] (inches)						9.6	C	
if Pfb <= P100 = 1.88 enter 40								
if Pfb = P100+0.2(PMP-P100) = 3.424 enter 25								
if Pfb = P100+0.4(PMP-P100) = 4.968 enter 15								
if Pfb = P100+0.6(PMP-P100) = 6.512 enter 7								
if Pfb = P100+0.8(PMP-P100) = 8.056 enter 3								
if Pfb => PMP = 9.6 enter 1								
Enter interpolated value						1	D	
HYDROLOGIC UNCERTAINTY:								
Drainage Area [DA] (square miles)						0.39	E	
DA<10 enter 1.5 ; 10<DA<20 enter 1.4 ; 20<DA<50 enter 1.3 ; DA=>50 enter 1.2						1.5	F	
PIPE SPILLWAY PLUGGING:								
Pipe Diameter [D] (inches)						1	G	
D<12 enter 1.1; 12<=D<24 enter 1.0; 24<=D enter 0.9						1.1	H	
Riser & trash rack type:								
Non-standardized inlet enter 1.1, Open Top riser enter 1.0; Covered or Baffle Top enter 0.9						1.0	I	
EARTH SPILLWAY FLOW:								
Earth spillway flow depth [Des] from top of dam to spillway crest (feet)(10' max)						4.7	J	
DAM EROSION RESISTANCE:								
Non-plastic (PI<10) fill enter 2.0 ; Plastic core enter 1.7 ; Overtopping armoring enter 0.8						1.7	K	
Vegetal Cover Factor [Cf], see SITES or AH667						1.0	L	
http://www.pswcr1.ars.usda.gov/ah667/ah667.htm								
Cf <0.4 enter 1.1; Cf < 0.7 enter 1.0; Cf<1.0 enter 0.9; larger Cf enter 0.8						0.8	M	
EARTH SPILLWAY EROSION RESISTANCE:								
Low, can be excavated with hand tools, enter 2.0								
PI>10 and SPT blows<8, PI<10 and SPT blows>8, Kh<0.10, seismic velocity<2000fps								
Moderate, can be excavated with construction equipment, easy ripping, enter 1.2								
PI>10 and SPT blows>8, PI<10 and SPT blows>30, Kh<10, seismic velocity<7000fps								
High, very hard ripping, requires drilling and blasting, enter 0.2								
moderately hard rock, Kh>10, seismic velocity>7000fps						0.2	N	
Vegetal Cover Factor [Cf], see SITES or AH667						0.5	O	
Cf <0.4 enter 1.1; Cf < 0.7 enter 1.0; Cf<1.0 enter 0.9; larger Cf enter 0.8						1	P	
HYDROLOGIC FAILURE INDEX:								
dam overtopping breach: (2)(D)(F)(H)(I)(K)(M)						4	Q	
earth spillway breach: (D+5J)(F)(H)(I)(N)(P)						8	R	
larger of (2)(D)(F)(H)(I)(K)(M) or (D+5J)(F)(H)(I)(N)(P) but less than 300						8	S	

EVALUATION OF POTENTIAL REHABILITATION PROJECTS

STATE	UT	DAM	Clark Canyon North	BY	CCM	DATE	5/30/2024
sht 2 of 5	FAILURE & RISK INDEXES						ver 2013-01

Adopted from Bureau of Reclamation "Risk Based Profile System"

see: <http://www.usbr.gov/dsis/risk/rbpsdocumentation.pdf>

LIFE LOSS:

Population-at-Risk [PAR], see NRCS dams inventory definition (number of people)

Estimate PAR for static loading failure; typically assume water at or above invert of the lowest open channel auxiliary spillway

Estimate PAR for hydrologic loading failure; typically assume water at or above invert of the lowest open channel auxiliary spillway

Estimate PAR for seismic loading failure; typically assume water at or above invert of the lowest non-gated spillway (sunny day failure)

	A
14	B
	C

Fatality Rates [FR] from dam breach

Adopted from BuRec "A Procedure for Estimating Loss of Life Caused by Dam Failure" DSO-99-06

see: http://www.usbr.gov/research/dam_safety/documents/dso-99-06.pdf

Flood Severity/Lethality [DV] is the average depth [D] times velocity [V] across flood plain (ft²/sec)

DV= (breach discharge - bank full discharge) / breach floodplain width

Warning Time [T] between failure warning and flood wave at population (minutes)

Flood Severity Understanding [U] of the warning issuer of the likely flooding magnitude

Scenario	Breach Discharge	Bankfull Discharge	Breach Floodplain Width	DV	Warning Time, T	Understanding, U
	(cfs)	(cfs)	(ft)	(ft ² /sec)	(minutes)	(N/A or Vague)
Static						
Hydrologic	3,539	100	1200	3	10	Vague
Seismic						

For DV≥50	T≤60	U=vague	FR=0.04
	T>60		FR=0.03
For DV<50	T≤60	U=vague	FR=0.007
	T>60		FR=0.0003

Estimate FR for static loading failure scenario

Estimate FR for hydrologic loading failure scenario

Estimate FR for seismic loading failure scenario

	D
0.007	E
	F

Scenario	Load Factor	Response Factor	Failure Index	Fatality Rate	PAR	Risk Index
Static Hydrologic Seismic	1					
	*	*	7	0.007	14	1
TOTAL=			7	TOTAL=		1

EVALUATION OF POTENTIAL REHABILITATION PROJECTS								
STATE	UT	DAM	Clark Canyon North	BY	CCM	DATE	5/30/2024	
sht 4 of 5		HYDROLOGIC FAILURE INDEX					ver 2013-01	
HYDROLOGIC LOADING:								
Total Spillway Capacity (PS&ES) for 6hr storm [Pfb], Work Plan Tbl 3 (rainfall inches)						9.3	A	
Obtained from Work Plan Tbl 3, or dams inventory data, or computer routings								
100 year, 6hr rainfall [P100] (inches)						2.0	B	
Probable Maximum Precipitation [PMP] (inches)						9.3	C	
if Pfb <= P100 = 1.98 enter 40								
if Pfb = P100+0.2(PMP-P100) = 3.452 enter 25								
if Pfb = P100+0.4(PMP-P100) = 4.924 enter 15								
if Pfb = P100+0.6(PMP-P100) = 6.396 enter 7								
if Pfb = P100+0.8(PMP-P100) = 7.868 enter 3								
if Pfb => PMP = 9.34 enter 1								
Enter interpolated value						1	D	
HYDROLOGIC UNCERTAINTY:								
Drainage Area [DA] (square miles)						0.28	E	
DA<10 enter 1.5 ; 10<DA<20 enter 1.4 ; 20<DA<50 enter 1.3 ; DA=>50 enter 1.2						1.5	F	
PIPE SPILLWAY PLUGGING:								
Pipe Diameter [D] (inches)						1	G	
D<12 enter 1.1; 12<=D<24 enter 1.0; 24<=D enter 0.9						1.1	H	
Riser & trash rack type:								
Non-standardized inlet enter 1.1, Open Top riser enter 1.0; Covered or Baffle Top enter 0.9						1.0	I	
EARTH SPILLWAY FLOW:								
Earth spillway flow depth [Des] from top of dam to spillway crest (feet)(10' max)						4.1	J	
DAM EROSION RESISTANCE:								
Non-plastic (PI<10) fill enter 2.0 ; Plastic core enter 1.7 ; Overtopping armoring enter 0.8						1.7	K	
Vegetal Cover Factor [Cf], see SITES or AH667						1.0	L	
http://www.pswcr1.ars.usda.gov/ah667/ah667.htm								
Cf <0.4 enter 1.1; Cf < 0.7 enter 1.0; Cf<1.0 enter 0.9; larger Cf enter 0.8						0.8	M	
EARTH SPILLWAY EROSION RESISTANCE:								
Low, can be excavated with hand tools, enter 2.0								
PI>10 and SPT blows<8, PI<10 and SPT blows>8, Kh<0.10, seismic velocity<2000fps								
Moderate, can be excavated with construction equipment, easy ripping, enter 1.2								
PI>10 and SPT blows>8, PI<10 and SPT blows>30, Kh<10, seismic velocity<7000fps								
High, very hard ripping, requires drilling and blasting, enter 0.2								
moderately hard rock, Kh>10, seismic velocity>7000fps						0.2	N	
Vegetal Cover Factor [Cf], see SITES or AH667						0.5	O	
Cf <0.4 enter 1.1; Cf < 0.7 enter 1.0; Cf<1.0 enter 0.9; larger Cf enter 0.8						1	P	
HYDROLOGIC FAILURE INDEX:								
dam overtopping breach: (2)(D)(F)(H)(I)(K)(M)						4	Q	
earth spillway breach: (D+5J)(F)(H)(I)(N)(P)						7	R	
larger of (2)(D)(F)(H)(I)(K)(M) or (D+5J)(F)(H)(I)(N)(P) but less than 300						7	S	

EVALUATION OF POTENTIAL REHABILITATION PROJECTS

STATE	UT	DAM	Clark Canyon South	BY	CCM	DATE	5/30/2024
sht 2 of 5	FAILURE & RISK INDEXES						ver 2013-01

Adopted from Bureau of Reclamation "Risk Based Profile System"

see: <http://www.usbr.gov/dsis/risk/rbpsdocumentation.pdf>

LIFE LOSS:

Population-at-Risk [PAR], see NRCS dams inventory definition (number of people)

Estimate PAR for static loading failure; typically assume water at or above invert of the lowest open channel auxiliary spillway

Estimate PAR for hydrologic loading failure; typically assume water at or above invert of the lowest open channel auxiliary spillway

Estimate PAR for seismic loading failure; typically assume water at or above invert of the lowest non-gated spillway (sunny day failure)

	A
15	B
	C

Fatality Rates [FR] from dam breach

Adopted from BuRec "A Procedure for Estimating Loss of Life Caused by Dam Failure" DSO-99-06

see: http://www.usbr.gov/research/dam_safety/documents/dso-99-06.pdf

Flood Severity/Lethality [DV] is the average depth [D] times velocity [V] across flood plain (ft²/sec)

DV= (breach discharge - bank full discharge) / breach floodplain width

Warning Time [T] between failure warning and flood wave at population (minutes)

Flood Severity Understanding [U] of the warning issuer of the likely flooding magnitude

Scenario	Breach Discharge	Bankfull Discharge	Breach Floodplain Width	DV	Warning Time, T	Understanding, U
	(cfs)	(cfs)	(ft)	(ft ² /sec)	(minutes)	(N/A or Vague)
Static						
Hydrologic	6,089	200	1200	5	60	Vague
Seismic						

For DV≥50	T≤60	U=vague	FR=0.04
	T>60		FR=0.03
For DV<50	T≤60	U=vague	FR=0.007
	T>60		FR=0.0003

Estimate FR for static loading failure scenario

Estimate FR for hydrologic loading failure scenario

Estimate FR for seismic loading failure scenario

	D
0.007	E
	F

Scenario	Load Factor	Response Factor	Failure Index	Fatality Rate	PAR	Risk Index
Static Hydrologic Seismic	1					
	*	*	51	0.007	15	5
TOTAL=			51	TOTAL=		5

EVALUATION OF POTENTIAL REHABILITATION PROJECTS								
STATE	UT	DAM	Clark Canyon South	BY	CCM	DATE	5/30/2024	
sht 4 of 5		HYDROLOGIC FAILURE INDEX					ver 2013-01	
HYDROLOGIC LOADING:								
Total Spillway Capacity (PS&ES) for 6hr storm [Pfb], Work Plan Tbl 3 (rainfall inches)						9.3	A	
Obtained from Work Plan Tbl 3, or dams inventory data, or computer routings								
100 year, 6hr rainfall [P100] (inches)						2.0	B	
Probable Maximum Precipitation [PMP] (inches)						9.3	C	
if Pfb <= P100 = 1.98 enter 40								
if Pfb = P100+0.2(PMP-P100) = 3.452 enter 25								
if Pfb = P100+0.4(PMP-P100) = 4.924 enter 15								
if Pfb = P100+0.6(PMP-P100) = 6.396 enter 7								
if Pfb = P100+0.8(PMP-P100) = 7.868 enter 3								
if Pfb => PMP = 9.34 enter 1								
Enter interpolated value						1	D	
HYDROLOGIC UNCERTAINTY:								
Drainage Area [DA] (square miles)						0.87	E	
DA<10 enter 1.5 ; 10<DA<20 enter 1.4 ; 20<DA<50 enter 1.3 ; DA=>50 enter 1.2						1.5	F	
PIPE SPILLWAY PLUGGING:								
Pipe Diameter [D] (inches)						1	G	
D<12 enter 1.1; 12<=D<24 enter 1.0; 24<=D enter 0.9						1.1	H	
Riser & trash rack type:								
Non-standardized inlet enter 1.1, Open Top riser enter 1.0; Covered or Baffle Top enter 0.9						1.0	I	
EARTH SPILLWAY FLOW:								
Earth spillway flow depth [Des] from top of dam to spillway crest (feet)(10' max)						5.0	J	
DAM EROSION RESISTANCE:								
Non-plastic (PI<10) fill enter 2.0 ; Plastic core enter 1.7 ; Overtopping armoring enter 0.8						1.7	K	
Vegetal Cover Factor [Cf], see SITES or AH667						1.0	L	
http://www.pswcr1.ars.usda.gov/ah667/ah667.htm								
Cf <0.4 enter 1.1; Cf < 0.7 enter 1.0; Cf<1.0 enter 0.9; larger Cf enter 0.8						0.8	M	
EARTH SPILLWAY EROSION RESISTANCE:								
Low, can be excavated with hand tools, enter 2.0								
PI>10 and SPT blows<8, PI<10 and SPT blows>8, Kh<0.10, seismic velocity<2000fps								
Moderate, can be excavated with construction equipment, easy ripping, enter 1.2								
PI>10 and SPT blows>8, PI<10 and SPT blows>30, Kh<10, seismic velocity<7000fps								
High, very hard ripping, requires drilling and blasting, enter 0.2								
moderately hard rock, Kh>10, seismic velocity>7000fps						1.2	N	
Vegetal Cover Factor [Cf], see SITES or AH667						0.5	O	
Cf <0.4 enter 1.1; Cf < 0.7 enter 1.0; Cf<1.0 enter 0.9; larger Cf enter 0.8						1	P	
HYDROLOGIC FAILURE INDEX:								
dam overtopping breach: (2)(D)(F)(H)(I)(K)(M)						4	Q	
earth spillway breach: (D+5J)(F)(H)(I)(N)(P)						51	R	
larger of (2)(D)(F)(H)(I)(K)(M) or (D+5J)(F)(H)(I)(N)(P) but less than 300						51	S	

EVALUATION OF POTENTIAL REHABILITATION PROJECTS

STATE	UT	DAM	Lott Canyon	BY	CCM	DATE	5/30/2024
sht 2 of 5	FAILURE & RISK INDEXES						ver 2013-01

Adopted from Bureau of Reclamation "Risk Based Profile System"

see: <http://www.usbr.gov/dsis/risk/rbpsdocumentation.pdf>

LIFE LOSS:

Population-at-Risk [PAR], see NRCS dams inventory definition (number of people)

Estimate PAR for static loading failure; typically assume water at or above invert of the lowest open channel auxiliary spillway

Estimate PAR for hydrologic loading failure; typically assume water at or above invert of the lowest open channel auxiliary spillway

Estimate PAR for seismic loading failure; typically assume water at or above invert of the lowest non-gated spillway (sunny day failure)

	A
63	B
	C

Fatality Rates [FR] from dam breach

Adopted from BuRec "A Procedure for Estimating Loss of Life Caused by Dam Failure" DSO-99-06

see: http://www.usbr.gov/research/dam_safety/documents/dso-99-06.pdf

Flood Severity/Lethality [DV] is the average depth [D] times velocity [V] across flood plain (ft²/sec)

DV= (breach discharge - bank full discharge) / breach floodplain width

Warning Time [T] between failure warning and flood wave at population (minutes)

Flood Severity Understanding [U] of the warning issuer of the likely flooding magnitude

Scenario	Breach Discharge	Bankfull Discharge	Breach Floodplain Width	DV	Warning Time, T	Understanding, U
	(cfs)	(cfs)	(ft)	(ft ² /sec)	(minutes)	(N/A or Vague)
Static						
Hydrologic	5,373	5	3000	2	10	Vague
Seismic						

For DV≥50	T≤60	U=vague	FR=0.04
	T>60		FR=0.03
For DV<50	T≤60	U=vague	FR=0.007
	T>60		FR=0.0003

Estimate FR for static loading failure scenario

Estimate FR for hydrologic loading failure scenario

Estimate FR for seismic loading failure scenario

	D
0.007	E
	F

Scenario	Load Factor	Response Factor	Failure Index	Fatality Rate	PAR	Risk Index
Static Hydrologic Seismic	1					
	*	*	9	0.007	63	4
TOTAL=			9	TOTAL=		4

EVALUATION OF POTENTIAL REHABILITATION PROJECTS								
STATE	UT	DAM	Lott Canyon		BY	CCM	DATE	5/30/2024
sht 4 of 5		HYDROLOGIC FAILURE INDEX						ver 2013-01
HYDROLOGIC LOADING:								
Total Spillway Capacity (PS&ES) for 6hr storm [Pfb], Work Plan Tbl 3 (rainfall inches)							9.6	A
Obtained from Work Plan Tbl 3, or dams inventory data, or computer routings								
100 year, 6hr rainfall [P100] (inches)							1.9	B
Probable Maximum Precipitation [PMP] (inches)							9.6	C
if Pfb <= P100 = 1.88 enter 40								
if Pfb = P100+0.2(PMP-P100) = 3.424 enter 25								
if Pfb = P100+0.4(PMP-P100) = 4.968 enter 15								
if Pfb = P100+0.6(PMP-P100) = 6.512 enter 7								
if Pfb = P100+0.8(PMP-P100) = 8.056 enter 3								
if Pfb => PMP = 9.6 enter 1								
Enter interpolated value							1	D
HYDROLOGIC UNCERTAINTY:								
Drainage Area [DA] (square miles)							1.1	E
DA<10 enter 1.5 ; 10<DA<20 enter 1.4 ; 20<DA<50 enter 1.3 ; DA=>50 enter 1.2							1.5	F
PIPE SPILLWAY PLUGGING:								
Pipe Diameter [D] (inches)							1	G
D<12 enter 1.1; 12<=D<24 enter 1.0; 24<=D enter 0.9							1.1	H
Riser & trash rack type:								
Non-standardized inlet enter 1.1, Open Top riser enter 1.0; Covered or Baffle Top enter 0.9							1.0	I
EARTH SPILLWAY FLOW:								
Earth spillway flow depth [Des] from top of dam to spillway crest (feet)(10' max)							5.1	J
DAM EROSION RESISTANCE:								
Non-plastic (PI<10) fill enter 2.0 ; Plastic core enter 1.7 ; Overtopping armoring enter 0.8							1.7	K
Vegetal Cover Factor [Cf], see SITES or AH667							1.0	L
http://www.pswcr1.ars.usda.gov/ah667/ah667.htm								
Cf <0.4 enter 1.1; Cf < 0.7 enter 1.0; Cf<1.0 enter 0.9; larger Cf enter 0.8							0.8	M
EARTH SPILLWAY EROSION RESISTANCE:								
Low, can be excavated with hand tools, enter 2.0								
PI>10 and SPT blows<8, PI<10 and SPT blows>8, Kh<0.10, seismic velocity<2000fps								
Moderate, can be excavated with construction equipment, easy ripping, enter 1.2								
PI>10 and SPT blows>8, PI<10 and SPT blows>30, Kh<10, seismic velocity<7000fps								
High, very hard ripping, requires drilling and blasting, enter 0.2								
moderately hard rock, Kh>10, seismic velocity>7000fps							0.2	N
Vegetal Cover Factor [Cf], see SITES or AH667							0.5	O
Cf <0.4 enter 1.1; Cf < 0.7 enter 1.0; Cf<1.0 enter 0.9; larger Cf enter 0.8							1	P
HYDROLOGIC FAILURE INDEX:								
dam overtopping breach: (2)(D)(F)(H)(I)(K)(M)							4	Q
earth spillway breach: (D+5J)(F)(H)(I)(N)(P)							9	R
larger of (2)(D)(F)(H)(I)(K)(M) or (D+5J)(F)(H)(I)(N)(P) but less than 300							9	S

APPENDIX E

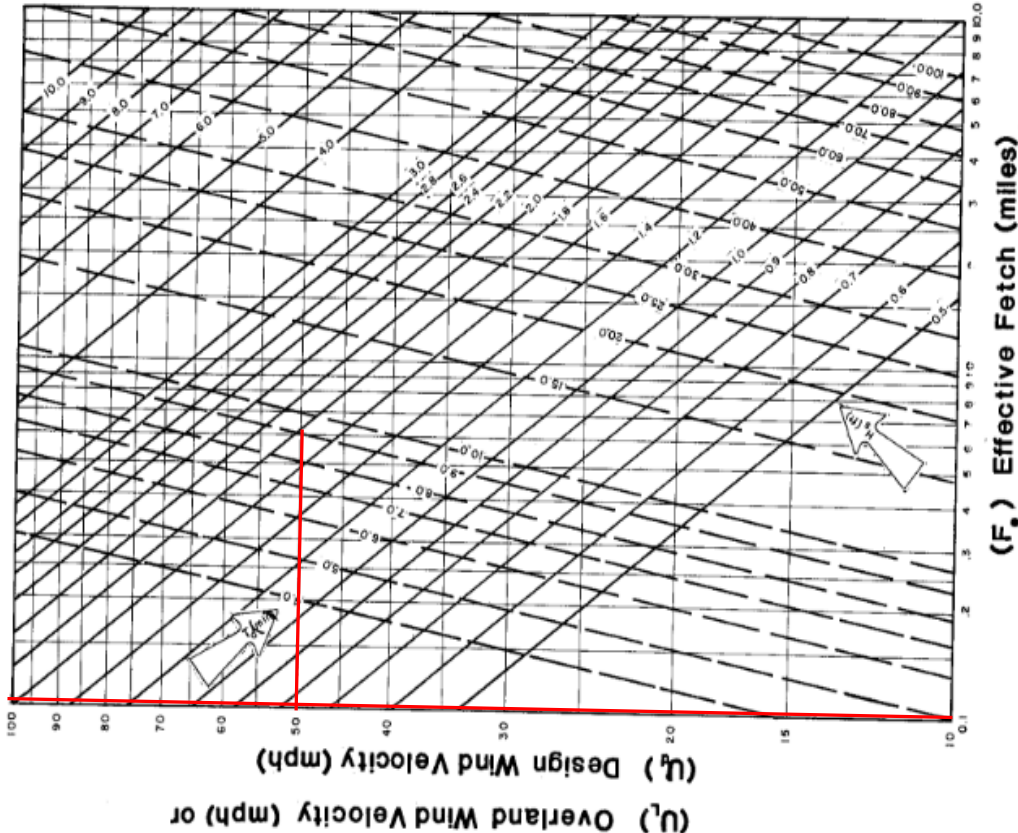
HYDRAULIC ANALYSIS

Effective Fetch Length - TR69 Method 2

Effective Fetch

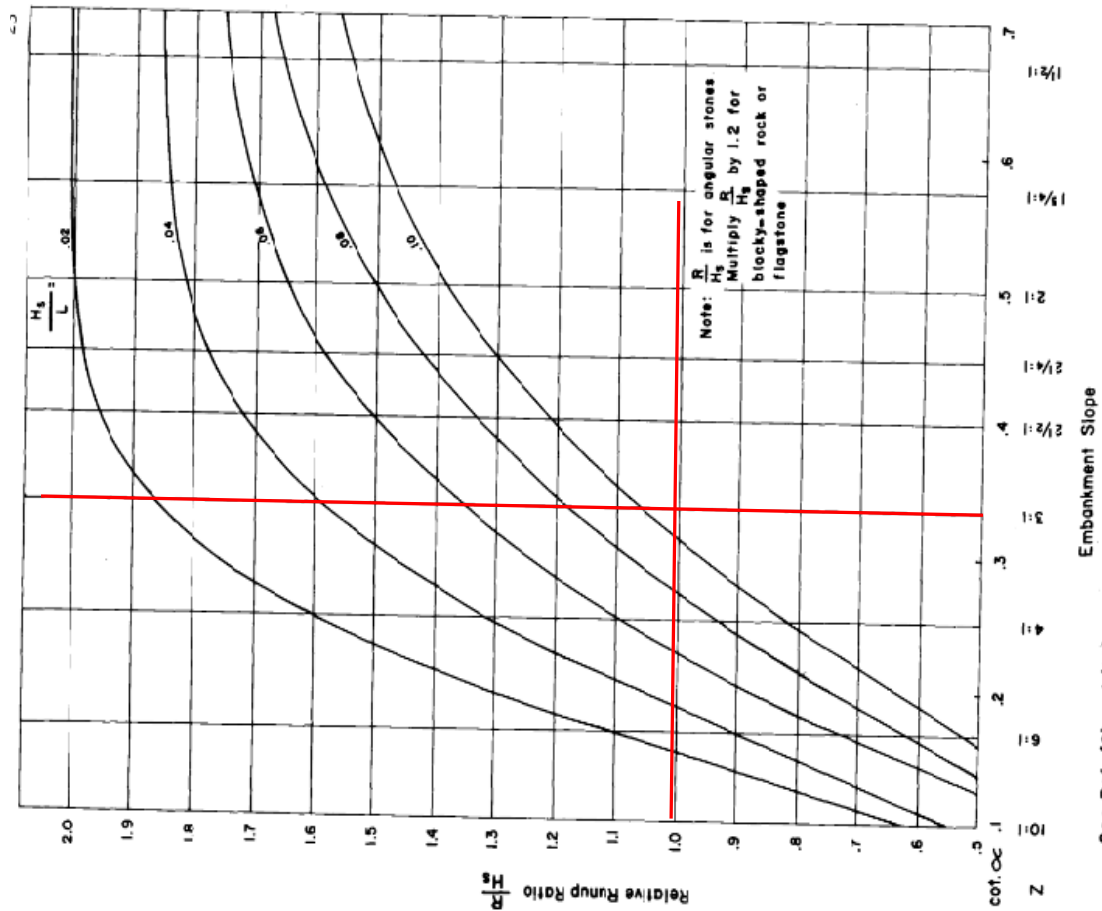
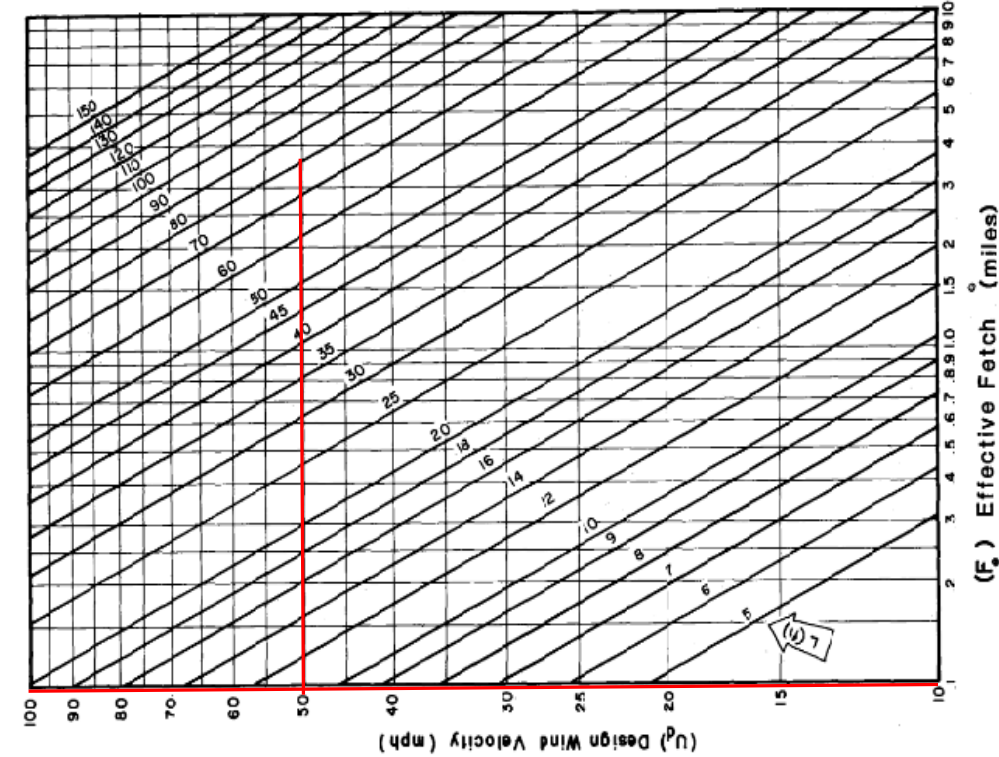
No.	1	2	3	4	5	6
	α	$\cos \alpha$	$\cos^2 \alpha$	Scale	Distance	
1	42	0.743	0.552	242	133.6	
2	36	0.809	0.655	250	163.6	
3	30	0.866	0.750	261	195.8	
4	24	0.914	0.835	275	229.5	
5	18	0.951	0.905	338	305.7	
6	12	0.978	0.957	511	488.9	
7	6	0.995	0.989	665	657.7	
8	0	1.000	1.000	668	668.0	
9	6	0.995	0.989	674	666.6	
10	12	0.978	0.957	595	569.3	
11	18	0.951	0.905	433	391.7	
12	24	0.914	0.835	331	276.2	
13	30	0.866	0.750	221	165.8	
14	36	0.809	0.655	216	141.4	
15	42	0.743	0.552	174	96.1	
			13.511	5854.0	5149.9	

Effective Fetch (Fe) = 381.2 ft
Effective Fetch (Fe) = 0.07 miles
Check = 0.07 miles
Hs (from Fig 2) = 0.8 ft
L (from Fig 11) = 11 ft
Hs/L = 0.072723
R/Hs (from Fig 12) = 1
Runup = 0.8 ft



REF. (2)
Equation: (A17) & (A18) From Appendix A
$$g \frac{H_s}{U^2} = 0.0026 \left(\frac{g F_e}{U^2} \right)^{0.47}$$
$$\frac{T}{U} = 0.46 \left(\frac{g F_e}{U^2} \right)^{0.28}$$

FIGURE 2
GENERALIZED CORRELATIONS
SIGNIFICANT WAVE HEIGHTS W
RELATED FACTORS
WNTC ENG. STAFF
PORTLAND, OREGON



Equation (A.21) From Appendix A

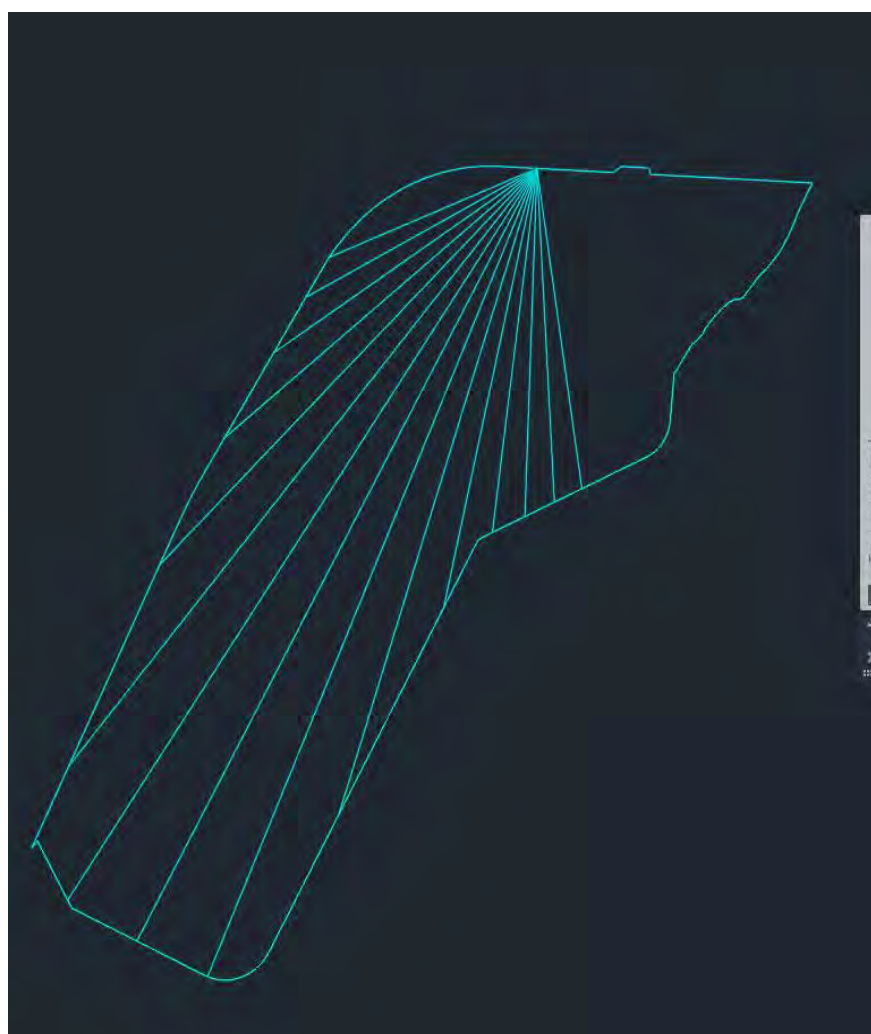
$$\frac{g\sqrt{L}}{U} = 1.041 \left(\frac{g F_e}{U^2} \right)^{0.28}$$

REF (2) (9)

FIGURE 12
WAVE LEN
RELATION.
WNTC ENG. STAFF
PORTLAND, OI

Note: See Ref. (2) and (20) and foot-
note 1 on page 9.
The surface smoothness represented by
these curves is simulated by a single
layer of rocks of uniform size.

FIGURE 12
WAVE RUNUP RATIO
WNTC ENG. STAFF
PORTLAND, OREGON

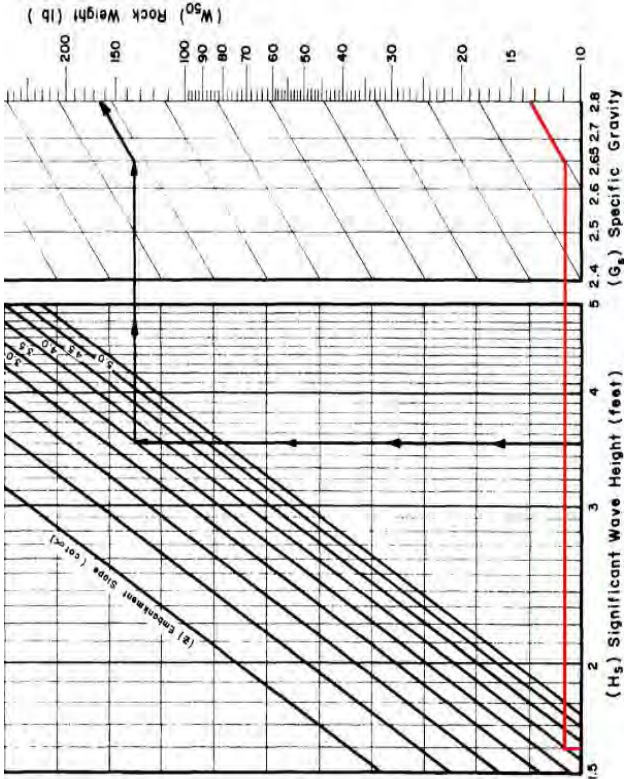


Source: <O:\Reference Library\NRCS\TR 69 - Wave Action\TR-69 Wave Action.pdf>

Significant Wave Height = 0.8 ft
Embankment Side Slope = 3 :1
Specific Gravity = 2.65

From Figure 8:
W50 Rock Weight = 13 lbs

From Figure 9:
D50 Rock Size = 0.41 ft 4.92 in
Max Size and Thickness = 0.615 ft 7.38 in

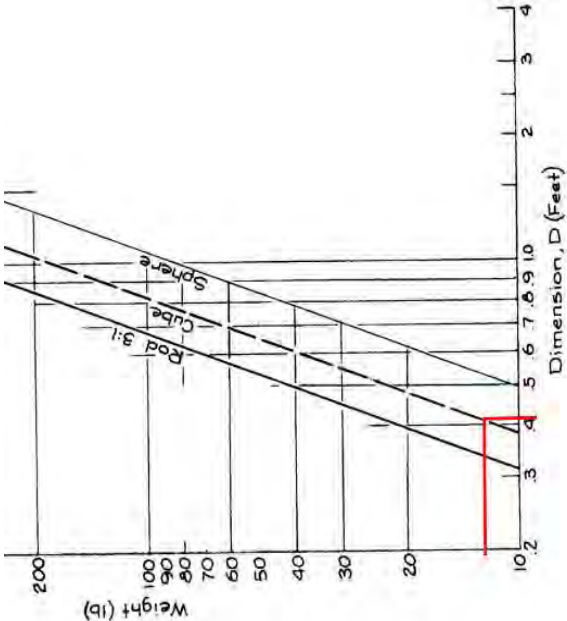


**FIGURE 8
ROCK
SIZE SELECTION**
WNTC ENG. STAFF
PORTLAND, OREGON

Equation (E 14), From Appendix E

$$W_{50} = \frac{19.5 G_s H_s^3}{(G_s - 1)^3 \cos \alpha}$$

REF (10)



**FIGURE 9
ROCK WEIGHT-SIZE
RELATIONSHIP**
WNTC, ENG. STAFF
PORTLAND, OREGON

$G_s = 2.6$
 $D = 1.0 \sqrt[3]{\frac{W}{62.4 G_s}}$ cube
 $D = 1.24 \sqrt[3]{\frac{W}{62.4 G_s}}$ sphere

APPENDIX F

GEOTECHNICAL REPORT

**Preliminary Geotechnical Assessment
Four Potential Debris Basin Sites
West of Saratoga Springs, Utah County, Utah**



Prepared for:

Bowen Collins & Associates
20 North Main, Suite No. 107
St. George, Utah 84790

Attn: Cody Moultrie, P.E.

ROSENBERG  **ASSOCIATES™**
CIVIL ENGINEERS LAND SURVEYORS

RA Project No. 11398-19
November 30, 2021

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November 30, 2021

11398-19

Bowen Collins & Associates
20 North Main, Suite No. 107
St. George, Utah 84790

Attn: Cody Moultrie, P.E.

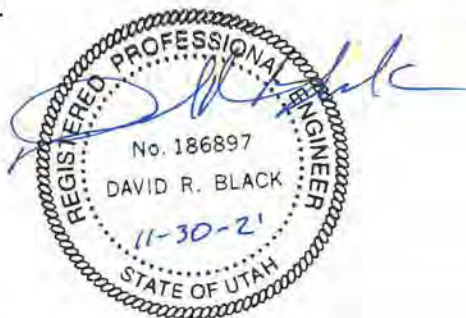
SUBJECT: Preliminary Geotechnical Assessment
Four Potential Debris Basin Sites
West of Saratoga Springs, Utah County, Utah

Gentlemen:

Enclosed are the findings of a preliminary geotechnical assessment performed at four (4) potential debris basin sites (within two general locations), in the hills west of Saratoga Springs City, Utah. High-level (mostly desktop) preliminary geotechnical information was requested to aid in preparation of the EA documents. The objectives of our services were to evaluate: (a) general geologic conditions and potential geologic constraints to construction; (b) general suitability of the native soils for support of the proposed dam embankments; (c) anticipated soil characteristics for use in preliminary modeling of spillway erosion potential; and (d) to recommend second phase investigations necessary for design and construction of the debris basins.

The preliminary findings and recommendations contained in this report are based on our review of the referenced documents, site reconnaissance, very limited field and laboratory investigation programs, interpretation of aerial photographs, and our geotechnical experience in areas with similar geologic conditions. If you have any questions concerning the information contained in this report, please contact us at your convenience at (435) 673-8586.

Sincerely,
ROSENBERG ASSOCIATES



David R. Black, P.E.
Principal Geotechnical Engineer

352 East Riverside Drive, Suite A-2 St. George, Utah 84790 (435) 673-8586 Phone • (435) 673-8397

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Table of Contents

0.0	EXECUTIVE SUMMARY	i
1.0	INTRODUCTION	1
2.0	SCOPE OF WORK	1
2.1	Review of Geologic Reports, Maps, and Aerial Photographs	1
2.2	Geologic Site Reconnaissance	2
2.3	Limited Field and Laboratory Investigations	2
2.4	Headcut Erodibility Index Evaluations	2
2.5	Preliminary Evaluation and Report Preparation	3
3.0	SITE GEOLOGIC CONDITIONS	3
3.1	Burnt Canyon and Loft Canyon Sites	3
3.2	Clark Canyon North and Clark Canyon South Sites	4
4.0	PHYSIOGRAPHIC AND SEISMIC SETTING	4
5.0	FAULTING	5
6.0	SITE DESCRIPTIONS	6
6.1	Burnt Canyon Site	6
6.2	Lott Canyon Site	6
6.3	Clark Canyon North Site	7
6.4	Clark Canyon South Site	8
7.0	LINEAMENT ANALYSIS	9
8.0	ANTICIPATED SOIL/BEDROCK CONDITIONS	9
8.1	Burnt Canyon Site	9
8.2	Lott Canyon Site	10
8.3	Clark Canyon North Site	10
8.4	Clark Canyon South Site	10
9.0	POTENTIAL GEOLOGIC HAZARDS	11
9.1	Collapsible Soils Susceptibility	11
9.2	Seismic Hazard	12

9.3	Secondary Effects of Seismic Ground Shaking.....	12
9.3.1	Liquefaction	13
9.3.2	Seismically Induced Differential Compaction.....	13
9.3.3	Earthquake-Induced Seiches and flooding	13
9.3.4	Seismically Induced Landsliding.....	13
9.3.5	Seismically Induced Rockfalls.....	13
9.3.6	Ground Lurching	13
10.0	GEOTECHNICAL CONSIDERATIONS/POTENTIAL CONSTRIANTS.....	13
10.1	Dam Foundation Support.....	13
10.2	Seepage and Piping Potential	14
10.3	Channel Abutments	14
10.4	Principal Spillways.....	14
10.5	Auxiliary Spillways.....	14
10.6	Headcut Erodibility Index Values.....	15
11.0	RECOMMENDATIONS.....	16
12.0	CLOSURE	17
13.0	REFERENCES.....	17

APPENDICES

APPENDIX A - FIGURES

Figure A1 Location Map

Figure A2 Location Map

Figure A3 Geologic Map

APPENDIX B – PRELIMINARY FIELD AND LABORATORY INVESTIGATIONS

APPENDIX C – SITE PHOTOGRAPHS

EXECUTIVE SUMMARY

The executive summary should not be used separately from the report and is only provided as an overview, to summarize the primary findings, conclusions, and recommendations. The executive summary may omit several details, any one of which could be crucial to the proper interpretation and application of the report and implementation of the recommendations.

Rosenberg Associates (RA) has performed a preliminary geotechnical assessment performed at four (4) potential debris basin sites in the hills west of Saratoga Springs City, Utah. The objectives of our services were to evaluate: (a) general geologic conditions and potential geologic constraints to construction; (b) general suitability of the native soils for support of the proposed dam embankments; (c) anticipated soil characteristics for use in preliminary modeling of spillway erosion potential; and (d) to recommend second phase investigations necessary for design and construction of the debris basins. At the time of the investigation, the study areas were generally undeveloped, vacant, and in a natural condition. Figures and photographs are presented in Appendix A and Appendix C, respectively.

Geologic conditions mapped by the Utah Geological Survey (UGS, Biek 2004) in the areas of the proposed debris basin sites as shown in Figure A3 in Appendix A include: (a) gray sandy to fossiliferous limestone bedrock associated with the West Canyon Limestone Formation (IPowc); (b) Stream deposits (Qal₁); (c) younger and older alluvial-fan deposits (Qafy) and (Qafo) deposited at drainage mouths; and (d) colluvial deposits (Qc) on moderate slopes.

No "Holocene-active" or "Conditionally active" faults, landslides, or karst features such as sinkholes or caves, are documented within or projecting towards the proposed Saratoga Springs debris basin sites. The nearest Quaternary fault is a segment of the Utah Lake Faults, located at least 2.3 miles east of the proposed debris basin sites.

Geologic hazards evaluated for potential impact to the proposed debris basins sites are associated with: (a) collapsible soil susceptibility; (b) seismic ground shaking; and (c) secondary effects of seismic ground shaking. Alluvial fan deposits mapped at the proposed debris basin sites have a genesis and texture conducive to collapse and, therefore, in our opinion represent a potential collapsible soil hazard. The proposed debris basin sites are in a seismically active region. During the life of the project, seismic activity associated with active faults in the area has the potential to generate moderate to strong ground shaking at the proposed debris basin sites. The potential for impact will depend on the final debris basin locations and proposed construction parameters.

Based on the findings of the preliminary investigations, we recommend:

1. Design level geotechnical investigations be conducted at each (or at least the selected) proposed debris basin sites to:
 - a. Evaluate in detail the site-specific subsurface soil, bedrock, and groundwater conditions by conducting thorough subsurface investigation and laboratory testing programs. Excavatability of the bedrock may be evaluated by geophysical survey methods.
 - b. Further evaluate the headcut erodibility index values at each proposed auxiliary spillway location.
 - c. The potential for seepage and piping through the fractured bedrock formations should be further evaluated and appropriate design recommendations provided to minimize seepage.
 - d. The presence of adverse construction conditions and geologic hazards, such as the potential for collapse, should be further evaluated. Appropriate design recommendations should be provided to address identified adverse construction conditions and/or geologic hazards.
 - e. Provide detailed geotechnical recommendations for general site grading, foundation support, and embankment construction. Embankment slopes should be evaluated under static, rapid draw down and seismic conditions.
 - f. Evaluate potential borrow resources by conducting subsurface explorations and laboratory soil testing. Laboratory testing should include but not necessarily be limited to gradation, hydrometer, Atterberg limits, and dispersivity tests.
2. Detention basin design including the design level geotechnical investigations should meet current NRCS and Utah State Dam Design Criteria.

1.0 INTRODUCTION

This report presents the findings of a preliminary geotechnical assessment performed at four (4) potential debris basin sites (within two general locations), in the hills west of Saratoga Springs City, Utah. High-level (mostly desktop) preliminary geotechnical information was requested of Rosenberg Associates (RA) to aid in preparation of the EA documents. The objectives of our services were to evaluate in the locations of the proposed debris basins: (a) general geologic conditions and potential geologic constraints to construction (e.g., faulting, landslides, liquefaction potential, etc.); (b) general suitability of the native soils for support of the proposed dam embankments; (c) anticipated soil characteristics for use in preliminary modeling of spillway erosion potential; and (d) to recommend second phase investigations necessary for design and construction of the debris basins.

As shown on the Location Maps provided by Bowen Collins, Figures A1 and A2 in Appendix A, the four (4) proposed debris basin sites are in moderately remote areas ranging from about $\frac{3}{4}$ to 1 mile west of Saratoga Springs. The four debris basin sites have been designated by Bowen Collins as: (1) Burnt Canyon; (2) Lott Canyon; (3) Clark Canyon North; and (4) Clark Canyon South. Access to the sites is via existing gravel roads as shown in Figures A1 and A2.

This report is intended for preliminary investigation and feasibility purposes only and not for design and construction of the proposed debris basins. Our services included only very limited subsurface investigation, soil sampling, and testing of on-site soils. Preliminary findings and recommendations contained herein are subject to the limitations presented in Section 12.0. Final design level geological and geotechnical investigations are recommended once details of the project have been finalized.

2.0 SCOPE OF WORK

2.1 Review of Geologic Reports, Maps, and Aerial Photographs

Available published geologic literature concerning rock units, surficial soil deposits, faulting, and seismicity in the area were reviewed (see Section 13.0, References). The geology of the proposed debris basin sites has been documented by Biek (2004). Pertinent information obtained from the geologic literature is summarized herein.

Stereo-paired aerial photographs (Section 13.0) of the debris basin sites were examined for the presence of photo-lineaments¹ indicative of possible geologic hazards such as faulting, slope instability (e.g., landslides), and karst topography.

2.2 Geologic Site Reconnaissance

A geologic site reconnaissance was performed by a senior geotechnical engineer (Bill Turner) and project geologist (Mark Larsen) from CMT Engineering Laboratories (a subconsultant with Rosenberg Associates) to: (a) evaluate general geologic conditions; (b) observe general surface conditions; and (c) field verify features observed on aerial photographs.

2.3 Limited Field and Laboratory Investigations

Limited field investigations were performed by CMT by excavating two test pits at each of the proposed debris basin locations. A total of 8 test pits were excavated, at the specific exploration locations requested by Bowen Collins, to depths ranging from 1½ to 12 feet below the existing site grade. Test pits with depths less than 12 feet encountered backhoe refusal either on limestone bedrock or on cobbles/boulders. Representative soil samples were obtained at selected intervals and transported back to the laboratory for further evaluation and testing. The laboratory testing program consisted of sieve analyses and Atterberg limits for soil classification purposes, and a modified consolidation (collapse) test. The results of the laboratory testing are presented in Appendix B.

Logs of subsurface conditions encountered in the test pits were recorded by field personnel and are presented in Appendix B. Photographs taken during the field investigations are presented in Appendix C.

2.4 Headcut Erodibility Index Evaluations

Preliminary engineering analyses were performed at the requested auxiliary spillway locations to evaluate a representative headcut erodibility index (Kh) value for each site. The analyses were performed by CMT in general accordance with the NRCS "Field Procedures Guide for the Headcut Erodibility Index" (NRCS, 2001).

¹ *Lineament*: A linear topographic, tonal, or vegetative surface feature presumed to reflect crustal structure.

2.5 Preliminary Evaluation and Report Preparation

Based on the results of the preliminary field and laboratory investigations, a head cut erodibility index was evaluated for the predetermined exploration site(s). Please note that the explorations were limited to a depth of 12 feet, or refusal, and that the head cut erodibility index evaluations are based on and representative of the subsurface conditions encountered at a specific location.

This report was prepared to present the findings of our preliminary geotechnical assessment of the proposed debris basin sites, together with logs of the explorations, site plans, laboratory test results, and recommends for second phase investigations necessary for design and construction of the debris basins.

3.0 SITE GEOLOGIC CONDITIONS

Geologic conditions mapped by the Utah Geological Survey (UGS, Biek 2004) in the areas of the proposed debris basin sites are shown in Figure A3. The site geologic conditions are described in the following subsections.

3.1 Burnt Canyon and Loft Canyon Sites

Geologic units documented in the area of the Burnt Canyon and Loft Canyon sites include:

- Oquirrh Group, West Canyon Limestone (IPowc) consisting of gray, sandy to fossiliferous limestone. The lower part forms ledges and upper part contains prominent cliff-forming limestone beds with irregular chert nodules and beds. Biek (2004) measured 1025 feet of West Canyon Limestone in the Lake Mountains.
- Younger alluvial-fan deposits (Qafy) which are deposited at drainage mouths and consist of mostly sand, silt, and gravel that are poorly stratified and poorly sorted.

During the site reconnaissance and limited field investigations, gray, limestone bedrock (IPowc) was encountered at each of the proposed auxiliary spillway locations (TP-1 and TP-3). Alluvial-fan deposits (Qafy) were encountered at each of the proposed embankment locations (TP-2 and TP-4).

3.2 Clark Canyon North and Clark Canyon South Sites

Geologic units documented in the area of the Clark Canyon North and Clark Canyon South sites include:

- Oquirrh Group, West Canyon Limestone (IPowc) consisting of gray, sandy to fossiliferous limestone. The lower part forms ledges and upper part contains prominent cliff-forming limestone beds with irregular chert nodules and beds. Biek (2004) measured 1025 feet of West Canyon Limestone in the Lake Mountains.
- Stream deposits (Qal₁) consisting of moderately sorted sand, silt, clay, and pebble to boulder gravel deposited in stream channels.
- Older alluvial-fan deposits (Qafo) which are similar to younger undifferentiated fan deposits (Qafy) consisting of mostly sand, silt, and gravel but form deeply dissected alluvial aprons.
- Colluvial deposits (Qc) consisting of poorly to moderately sorted, angular, clay- to boulder-size sediments deposited by slope wash and soil creep on moderate slopes and may be up to 20 feet in thickness.

During the site reconnaissance and limited field investigations, gray, limestone bedrock (IPowc) was encountered at the proposed Clark Canyon North auxiliary spillway location (TP-5) and at the proposed Clark Canyon South embankment location (TP-8). Alluvial-fan deposits (Qafo) were encountered at the proposed Clark Canyon North embankment location (TP-6) and at the proposed Clark Canyon South auxiliary spillway location (TP-7).

4.0 PHYSIOGRAPHIC AND SEISMIC SETTING

The four debris basin sites are within the Basin and Range physiographic province and within the Intermountain Seismic Belt (ISB) (Smith and Sbar, 1974). In Utah, most earthquakes are associated with the ISB (Smith and Arabasz, 1991), an approximately 150-km-wide, north-south trending zone of earthquake activity that extends from northern Montana to northwestern Arizona.

Large earthquakes are rare events in Utah County, but the hazards associated with earthquakes (ground shaking, surface fault rupture, landslides, rock falls, and liquefaction) have the greatest potential for producing catastrophic property damage, economic

disruption, and loss of life of any hazard in the area (Lund and others, 2008). Historically², earthquake-related surface rupture has not occurred in Utah County, but geologic evidence indicates that the Utah Valley has experienced at least four large surface faulting earthquakes during the last 8,000 years (within the Holocene epoch³, Machette and others, 1988).

The proposed Saratoga Springs debris basin sites are in a seismically active region. During the life of the project, seismic activity associated with active faults in the area has the potential to generate moderate to strong ground shaking at the proposed debris basin sites.

5.0 FAULTING

Earthquakes result from slippage on faults, therefore, from an earthquake-hazard perspective, faults are commonly classified as active, capable of generating damaging earthquakes, or inactive, not capable of generating earthquakes. The term "active fault" is frequently incorporated into regulations pertaining to earthquake hazards, and over time the term has been defined differently for different regulatory and legal purposes (Lund and others (2008).

For dams such as the proposed Saratoga Springs debris basin sites, the Natural Resources Conservation Service (NRCS, 2012) classifies faults as:

1. "Holocene-active" if the fault exhibits "... evidence of fault rupture within the past 12,000 years, or;
2. "Conditionally active" if the fault exhibits "... evidence of Quaternary fault rupture (<1.6 my), but its displacement history within the past 35,000 years is unknown.

The NRCS (2012) further stipulates, "Dams are usually not located on Holocene-active faults, and high-hazard dams with permanent storage may not be located on conditionally active faults without specific design features that address potential fault movement." No "Holocene-active" or "Conditionally active" faults were documented within or projecting towards the proposed Saratoga Springs debris basin sites. The nearest Quaternary fault

² The local verbal or written record.

³ Holocene: the geologic epoch of the Tertiary time period from about 11,700 years ago to the present (or 10,000 radiocarbon years to the present).

is a segment of the Utah Lake Faults, located at least 2.3 miles east of the proposed debris basin sites.

6.0 SITE DESCRIPTIONS

Pertinent physical parameters of the four (4) debris basin sites and associated embankments are discussed herein.

6.1 Burnt Canyon Site

The Burnt Canyon Site is in Section 3, Township 6S, Range 1W, at geographic coordinates N 40.3234° latitude, W -111.9377° longitude. Existing ground surface elevation near the center of the proposed embankment is about 5,080 feet above mean sea level. Pertinent physical features at Burnt Canyon follow, and are shown in Figure A1:

1. The top of the natural channel is about 150 feet wide and has incised about 15 feet into natural soils and limestone bedrock.
2. Side slopes of the incised channel range from 50% to 10% (i.e., very steep to slightly steep).
3. The channel bottom was dry at the time of our field investigations.
4. Vegetation consisted of moderate desert ground cover consisting of native grasses and desert scrub brush.
5. Alluvial silty to clayey gravel and cobble were observed along the canyon floor.
6. Some outcrops of limestone bedrock were observed near the area of proposed side slopes.

The proposed embankment will extend north-south across the channel approximately 500 feet. The auxiliary spillway is proposed at the north end of the left abutment.

6.2 Lott Canyon Site

The Lott Canyon Site is in Section 3, Township 6S, Range 1W, at geographic coordinates N 40.3198° latitude, W -111.9341° longitude. Existing ground surface elevation near the

center of the proposed embankment is about 5,137 feet above mean sea level. Pertinent physical features at Lott Canyon follow, and are shown in Figure A1:

1. The top of the natural channel is about 50 feet wide and has incised about 10 feet into natural soils.
2. Side slopes of the incised channel range from 30% to 10% (i.e., moderately steep to slightly steep).
3. The channel bottom was dry at the time of our field investigations.
4. Vegetation consisted of moderate desert ground cover consisting of native grasses and desert scrub brush.
5. Alluvial silty gravel and cobble with some boulders were observed along the canyon floor.
6. No outcrops of bedrock were observed along the channel floor and side slopes at the proposed debris basin location.

The proposed embankment will extend beyond the channel about 250 feet to the northwest and about 550 feet to the southeast, then turning another approximately 350 feet to the south. The auxiliary spillway is proposed at the northwest end of the left abutment.

6.3 Clark Canyon North Site

The Clark Canyon North Site is in Section 14, Township 6S, Range 1W, at geographic coordinates N 40.2938° latitude, W -111.9121° longitude. Existing ground surface elevation near the center of the proposed embankment is about 5,339 feet above mean sea level. Pertinent physical features at Clark Canyon North Site follow, and are shown in Figure A2:

1. The top of the natural channel is about 100 feet wide and has incised about 5 feet into natural soils.
2. Side slopes of the incised channel range from about 20% to 10% (i.e., slightly steep).
3. The channel bottom was dry at the time of our field investigations.

4. Vegetation consisted of moderate desert ground cover consisting of native grasses and desert scrub brush.
5. Alluvial silty gravel and cobbles with occasional boulders were observed along the canyon floor.
6. No outcrops of bedrock were observed along the channel floor and side slopes at the proposed debris basin location.

The proposed embankment will extend beyond the channel about 100 feet to the northwest and about 200 feet to the southeast. The auxiliary spillway is proposed at the southeast end of the right abutment.

6.4 Clark Canyon South Site

The Clark Canyon South Site is in Section 14, Township 6S, Range 1W, at geographic coordinates N 40.2922° latitude, W -111.9081° longitude. Existing ground surface elevation near the center of the proposed embankment is about 5,229 feet above mean sea level. Pertinent physical features at Clark Canyon South Site follow, and are shown in Figure A2:

1. The top of the natural channel is about 100 feet wide and has incised about 5 feet into natural soils and limestone bedrock.
2. Side slopes of the incised channel range from about 20% to 10% (i.e., slightly steep).
3. The channel bottom was dry at the time of our field investigations.
4. Vegetation consisted of moderate desert ground cover consisting of native grasses and desert scrub brush.
5. Alluvial silty gravel and cobbles with occasional boulders were observed along the canyon floor.
6. No outcrops of bedrock were observed along the channel floor and side slopes at the proposed debris basin location.

The proposed embankment will extend beyond the channel about 100 feet to the northwest and about 600 feet to the southeast. The auxiliary spillway is proposed at the southeast end of the right abutment.

7.0 LINEAMENT ANALYSIS

As part of the investigation, 1947, 1961, 1981, and 1993 stereo-paired aerial photographs (see Section 13.0) of the Saratoga Springs debris basin sites were examined for the presence of photo-lineaments representative of possible geologic hazards such as faulting, slope instability (e.g., landslides), and karst topography.

Review of the aerial photographs did *not* identify features indicative of:

1. Past landslides, such as hummocky and stair-step terrain, grabens, head-scarps, pressure ridges, displaced landforms, lobate deposits, convex surface morphology, etc.
2. "Holocene-active" or "Conditionally active" faults within or projecting toward the Gould Wash debris basin sites, such as fault scarps, vegetation lineaments, gullies, vegetation/soil contrasts, aligned springs and seeps, sag ponds, aligned or disrupted drainages, faceted spurs, grabens, and/or displaced landforms such as terraces, shorelines, geologic units, etc.
3. Karst topography, such as sinkholes or caves (karst topography, is a type of topography formed on limestone, gypsum, and other soluble rocks, primarily by dissolution; AGI, 2011).

8.0 ANTICIPATED SOIL/BEDROCK CONDITIONS

8.1 Burnt Canyon Site

The subsurface conditions encountered within the proposed auxiliary spillway location (TP-1) generally consisted of about 1 foot of surficial gray-brown, silty angular gravel overlying weathered limestone bedrock, associated with the West Canyon Limestone formation (IPowc), which became more competent with depth. Backhoe refusal was encountered at a depth of about 5½ feet.

Debris flow/alluvial fan deposits (Qafy) are present at the proposed embankment location. The subsurface conditions encountered at exploration location TP-2 generally consisted of about 2½ feet of brown, silty to clayey angular gravel topsoil overlying medium stiff, light brown silt with some fine sand and visible pinholes. Less pinholes were generally observed below a depth of about 5 feet. The exploration was terminated at a depth of about 12 feet. Groundwater was not encountered at either exploration location.

8.2 Lott Canyon Site

At the Lott Canyon proposed auxiliary spillway location (TP-3), the subsurface conditions generally consisted of about 8 inches of silty to clayey angular gravel overlying weathered limestone bedrock, associated with the West Canyon Limestone formation (IPowc). Backhoe refusal was encountered at a depth of about 1½ feet.

Debris flow/alluvial fan deposits (Qafy) are present at the proposed embankment location. The subsurface conditions encountered at exploration location TP-4 generally consisted of brown, silty gravel with sand, cobbles, and boulders up to 4 feet in diameter. The exploration was terminated at a depth of about 12 feet. Groundwater was not encountered at either exploration location.

8.3 Clark Canyon North Site

The subsurface conditions encountered within the proposed auxiliary spillway location (TP-1) generally consisted of about 8 to 10 inches of brown, silty gravel topsoil overlying light brown, silty gravel with angular cobbles and occasional small boulders (highly weathered limestone bedrock). More competent limestone bedrock associated with the West Canyon Limestone formation (IPowc), was encountered at a depth of 5 feet. Backhoe refusal was encountered at a depth of about 5½ feet.

Stream deposits (Qal₁) and debris flow/alluvial fan deposits (Qafo) are present at the proposed embankment location. The subsurface conditions encountered at exploration location TP-6 generally consisted of about 10 inches of brown silty to clayey gravel stream deposits overlying light brown, silty gravel with cobbles. The exploration was terminated at a depth of about 10 feet on cobbles and/or boulders. Groundwater was not encountered at either exploration location.

8.4 Clark Canyon South Site

Debris flow/alluvial fan deposits (Qafo) are present at the proposed auxiliary spillway location. At exploration location TP-7, the subsurface conditions generally consisted of

about 4 inches of dark brown silty gravel topsoils overlying light brown silty angular gravels and cobbles. The exploration was terminated at a depth of about 12 feet.

At the proposed embankment location (TP-8), the subsurface conditions generally consisted of about 3 inches of topsoil overlying reddish brown to brown silty gravel. Gray limestone bedrock associated with the West Canyon Limestone formation (IPowc), was encountered at a depth of about 2½ feet. Backhoe refusal was encountered at a depth of 3½ feet. No groundwater was encountered within the explorations at either location.

9.0 POTENTIAL GEOLOGIC HAZARDS

Geologic hazards evaluated for potential impact to the proposed debris basins sites are associated with:

1. Collapsible Soil Susceptibility
2. Seismic ground shaking, and
3. Secondary effects of seismic ground shaking.

The potential for impact will depend on the final debris basin locations and proposed construction parameters. Potential impacts associated with geologic hazards are discussed in the following paragraphs.

9.1 Collapsible Soils Susceptibility

Collapsible soils are relatively dry, low-density soils that decrease in volume or collapse under the load of a structure when they become wet. Collapsible soils may have considerable strength and stiffness in their dry natural state but can settle up to 10% of the susceptible deposit thickness when they become wet for the first-time following deposition causing damage to structures. Collapsible soils typically have a high void ratio, a corresponding low unit weight, and a relatively low moisture content, all characteristics that result from the initial rapid deposition and drying of the sediments. Alluvial fans are an example of this depositional environment and in many cases have a high collapsible soil hazard. Collapsible soils present in the Saratoga Springs area are typically geologically young materials, chiefly debris-flow sediments in alluvial fans, and lacustrine and colluvial deposits (UGS; Castleton and others, 2018).

Alluvial fan deposits mapped at the proposed debris basin sites have a genesis and texture conducive to collapse and therefore in our opinion represent a potential collapsible soil hazard. Soils with a pinhole structure, such as those observed at exploration location TP-2, are particularly susceptible to collapse. Preliminary laboratory test results indicated about 3.2% collapse when wetted at a load of 1,000 psf.

Site-specific investigations should be performed at each proposed debris basin site to evaluate the nature and extent of this potential hazard, and to provide recommendation for mitigation, if required.

9.2 Seismic Hazard

The three potential debris basin sites along Gould Wash are in a seismically active region. Ground shaking resulting from earthquakes associated with nearby and distant faults will occur. During the life of this project, seismic activity associated with active faults in the area has the potential to generate moderate to strong ground shaking at the potential debris basin sites.

9.3 Secondary Effects of Seismic Ground Shaking

Secondary effects of seismic ground shaking which should be considered for design of the proposed debris basins include liquefaction⁴, differential compaction⁵, seiches⁶ and flooding, landsliding, rock falls, and ground lurching⁷.

⁴ *Liquefaction*: A secondary effect of seismic ground shaking during which cohesionless soil is transformed from a solid to a liquid state as a result of increased pore pressure and reduced effective stress (AGI, 2011).

⁵ *Differential Compaction*: Compaction and settlement of loose natural soil deposits or uncompacted or poorly compacted fill due to earthquake ground shaking; differential settlements may occur due to spatial variations in soil properties. (FEMA, 2004).

⁶ *Seiches*: Oscillations or standing waves in an enclosed body of water (AGI, 2011).

⁷ *Ground-lurching*: The horizontal movement of soil, sediments, or fill located on relatively steep embankments or scarps as a result of seismic activity, forming irregular ground surface cracks. The potential for lurching is highest in areas underlain by soft, saturated materials, especially where bordered by steep banks or adjacent hard ground (CPUC, 2008).

9.3.1 Liquefaction

Liquefaction and associated lateral spread are not considered hazards at the potential debris basin sites due to the presence of relatively shallow bedrock and lack of shallow groundwater.

9.3.2 Seismically Induced Differential Compaction

Due to the presence of near surface bedrock at each of the potential debris basin sites, the potential for differential compaction as a result of seismic ground shaking is judged to be low.

9.3.3 Earthquake-Induced Seiches and flooding

Due to the intended use of the proposed debris basins (no permanent water storage), and the unlikelihood of a significant earthquake occurring when storm water is present within the basins, we consider the potential hazard of earthquake-induced seiches and flooding to be low.

9.3.4 Seismically Induced Landsliding

Although relatively steep natural slopes are present at some of the potential debris basin sites, the potential for seismically induced landsliding is low.

9.3.5 Seismically Induced Rockfalls

We consider the potential hazard of seismically induced rockfalls to be low.

9.3.6 Ground Lurching

Due to the presence of shallow bedrock, ground lurching is not considered a hazard at the proposed debris basin sites.

10.0 GEOTECHNICAL CONSIDERATIONS/POTENTIAL CONSTRIANTS

Geotechnical considerations and potential construction constraints are discussed in the following paragraphs. The potential for impact will ultimately depend on the dam location and proposed construction parameters.

10.1 Dam Foundation Support

Alluvial fan deposits will require excavation to a specified depth (ideally down to expose the underlying limestone bedrock if present within a reasonable depth). Treatment of the exposed rock surfaces after removal of unsuitable overlying materials will depend on the irregularities that are present. Construction activities may loosen rock or open joints in

originally satisfactory rock. Weathered/loose bedrock will require removal by stripping and scaling to expose undisturbed, competent limestone bedrock.

10.2 Seepage and Piping Potential

The potential for seepage and piping through the fractured limestone formations could be high. Cutoff trenches excavated into limestone bedrock may be required to reduce the potential for seepage and piping within the embankment.

Embankment drains and filters may be necessary.

Blanketing of the exposed bedrock upstream of the abutments may be required to prevent erosion and prevent piping of the embankment from water seepage through the fractured limestone formations.

10.3 Channel Abutments

It is anticipated that cutoff trenches into the competent limestone bedrock will be required at each abutment location. Blasting methods are discouraged to construct abutment cutoffs due to the potential to create additional fracturing of the limestone bedrock. Dental rock grout may be needed in fractured and jointed zones which cannot be penetrated to reduce permeability.

10.4 Principal Spillways

The principal spillway can be constructed within the embankment foundation material, unless relatively shallow limestone bedrock is encountered. If shallow bedrock is encountered the spillway can be constructed on bedrock which will likely require some excavation to provide uniform support. Rock excavation techniques should be anticipated where competent bedrock is encountered.

10.5 Auxiliary Spillways

Where auxiliary spillways are constructed in competent limestone bedrock, no additional erosion protection measures are anticipated. However, erosion protection measures should be anticipated where spillways extend through unconsolidated alluvial fan deposits.

10.6 Headcut Erodibility Index Values

Preliminary engineering analyses were performed at the requested auxiliary spillway locations to evaluate a representative headcut erodibility index (Kh) value for each site. The preliminary analyses were performed in general accordance with the NRCS "Field Procedures Guide for the Headcut Erodibility Index" (NRCS, 2001). The headcut erodibility index represents a measure of the resistance of the earth material to erosion. The index is the scalar product of the indices for its constituent parameters. The index takes the general form:

$$K_h = M_s \times K_b \times K_d \times K_s$$

where:

M_s = material strength number of the earth material

K_b = block or particle size number

K_d = discontinuity or interparticle bond shear strength number

K_s = relative ground structure number

Based on the results of the field and laboratory investigations, and our analyses, it is our opinion that the following headcut erodibility index (Kh) values are representative within the upper 10 feet at each of the following auxiliary spillway exploration locations.

Table 10.6: Preliminary Headcut Erodibility Index Values

Detention Basin Auxiliary Spillway	Exploration Location	Subsurface Conditions	Preliminary Kh Value
Burnt Canyon	TP-1	Weathered Limestone Bedrock	10
Lott Canyon	TP-3	Weathered Limestone Bedrock	10
Clark Canyon North	TP-5	Weathered Limestone Bedrock	10
Clark Canyon South	TP 7	Silty Gravel Soil	0.1

It should be noted that head cut erodibility index evaluations are based on, and representative of, the subsurface conditions encountered at the specific locations. Care should be taken in interpolating subsurface conditions beyond the exploration locations. Further evaluations should be performed at each proposed auxiliary spillway location as part of the design level geotechnical investigation(s).

11.0 RECOMMENDATIONS

Based on the findings of the preliminary investigations, we recommend:

1. Design level geotechnical investigations be conducted at each (or at least the selected) proposed debris basin site to:
 - a. Evaluate in detail the site-specific subsurface soil, bedrock, and groundwater conditions by conducting thorough subsurface investigation and laboratory testing programs. Excavatability of the bedrock may be evaluated by geophysical survey methods.
 - b. Further evaluate the headcut erodibility index values at each proposed auxiliary spillway location.
 - c. The potential for seepage and piping through the fractured bedrock formations should be further evaluated and appropriate design recommendations provided to minimize seepage.
 - d. The presence of adverse construction conditions and geologic hazards, such as the potential for collapse, should be further evaluated. Appropriate design recommendations should be provided to address identified adverse construction conditions and/or geologic hazards.
 - e. Provide detailed geotechnical recommendations for general site grading, foundation support, and embankment construction. Embankment slopes should be evaluated under static, rapid draw down and seismic conditions.
 - f. Evaluate potential borrow resources by conducting subsurface explorations and laboratory soil testing. Laboratory testing should include but not necessarily be limited to gradation, hydrometer, Atterberg limits, and dispersivity tests.
2. Detention basin design including the design level geotechnical investigations should meet current NRCS and Utah State Dam Design Criteria.

12.0 CLOSURE

The preliminary findings and recommendations contained in this report are based on: (1) review of the referenced documents; (2) site reconnaissance; (3) very limited field and laboratory investigation programs; (4) interpretation of aerial photographs; and (5) geotechnical experience in areas with similar soil conditions. If conditions are encountered at this site which are different from those described in this report, our firm should be notified so the preliminary recommendations presented herein can be re-evaluated for applicability to the new conditions.

This report was written for the exclusive use of Bowen Collins & Associates and the NRCS, only for the proposed project described herein, and prepared in accordance with the generally accepted standard of practice existing at the time the report was written. No warranty, express or implied, is made. Rosenberg Associates is not responsible for technical interpretations by others of the information described or documented in this report. Specific questions or interpretations concerning the findings and conclusions presented herein may require written clarification to avoid possible misunderstandings.

This preliminary geotechnical report is intended for site assessment purposes only and not for design and construction use. A final design level geotechnical investigation(s) will be required once details of the project development have been finalized.

13.0 REFERENCES

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UGS, 2021, Utah Geological Survey (UGS) Geoscience, Quaternary Faults, The UGS on-line interactive Quaternary Fault and Fold Database and Map of Utah.
<https://gis.utah.gov/data/geoscience/quaternary-faults>

UGS, 2021, Utah Geological Survey on-line interactive aerial imagery collection, accessed November 22, 2021. <https://geodata.geology.utah.gov/imagery>.

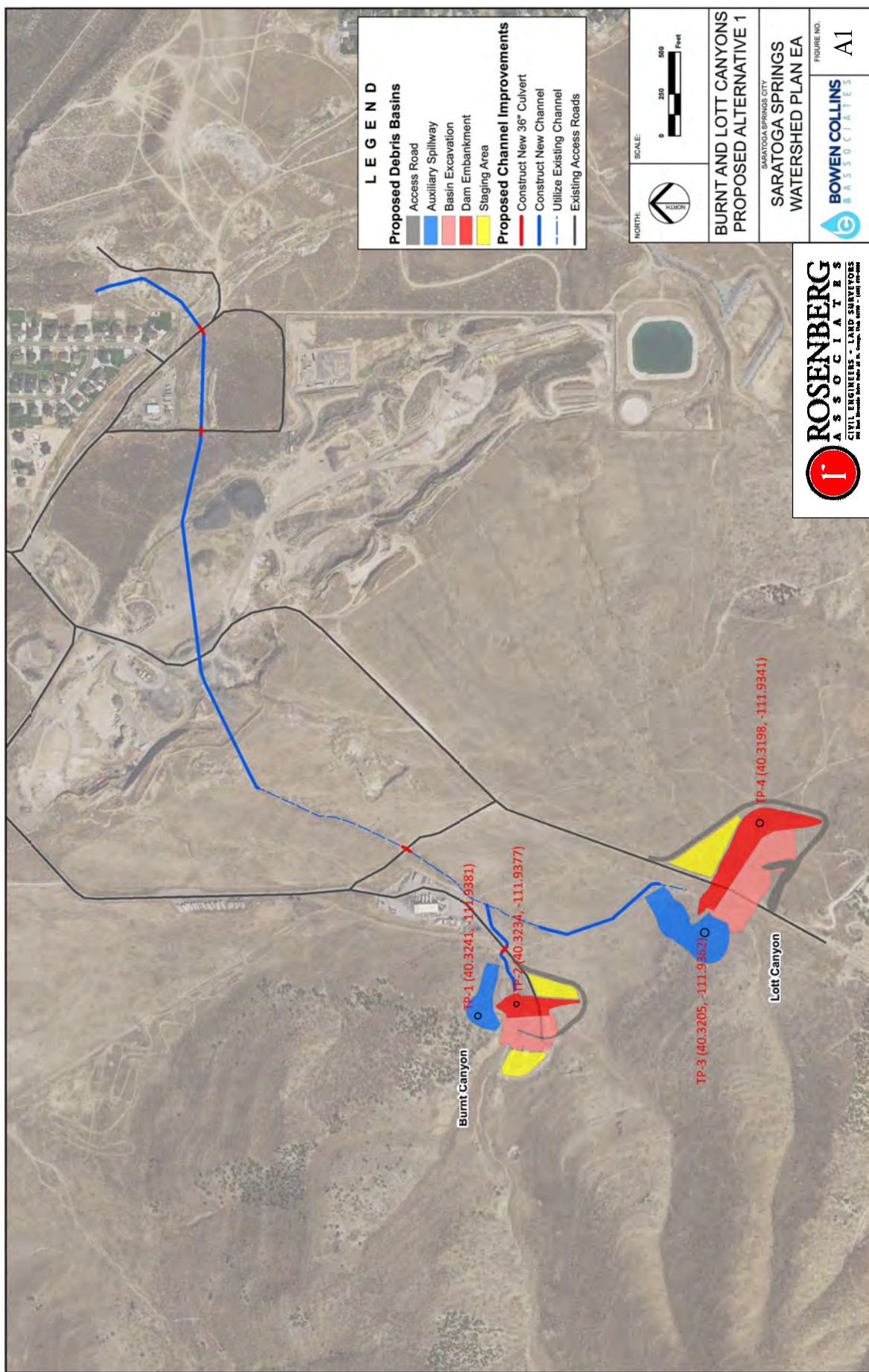
AERIAL PHOTOGRAPHS

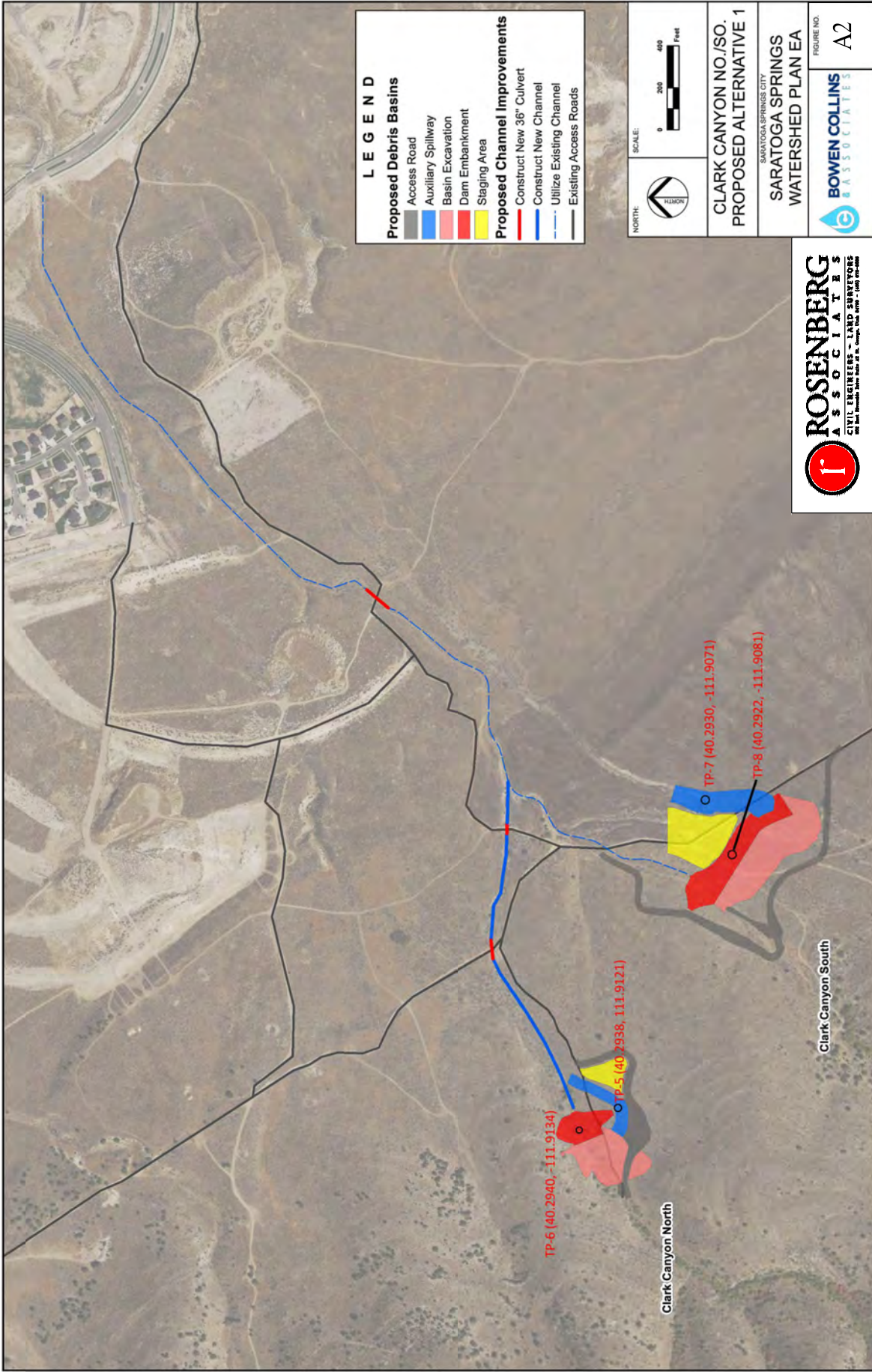
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UGS (2021)	9-20-1947	GS-EW	2-74, 2-75	1:24,000
	12-1-1961	BR400	12-155, 12-156	
	10-23-1969	GS-VCHF	1-330, 1-331	
	8-4-1981	NHAP81	107-44, 107-45	
	8-14-1993	NAPP	1118E-202, 1118E-203	

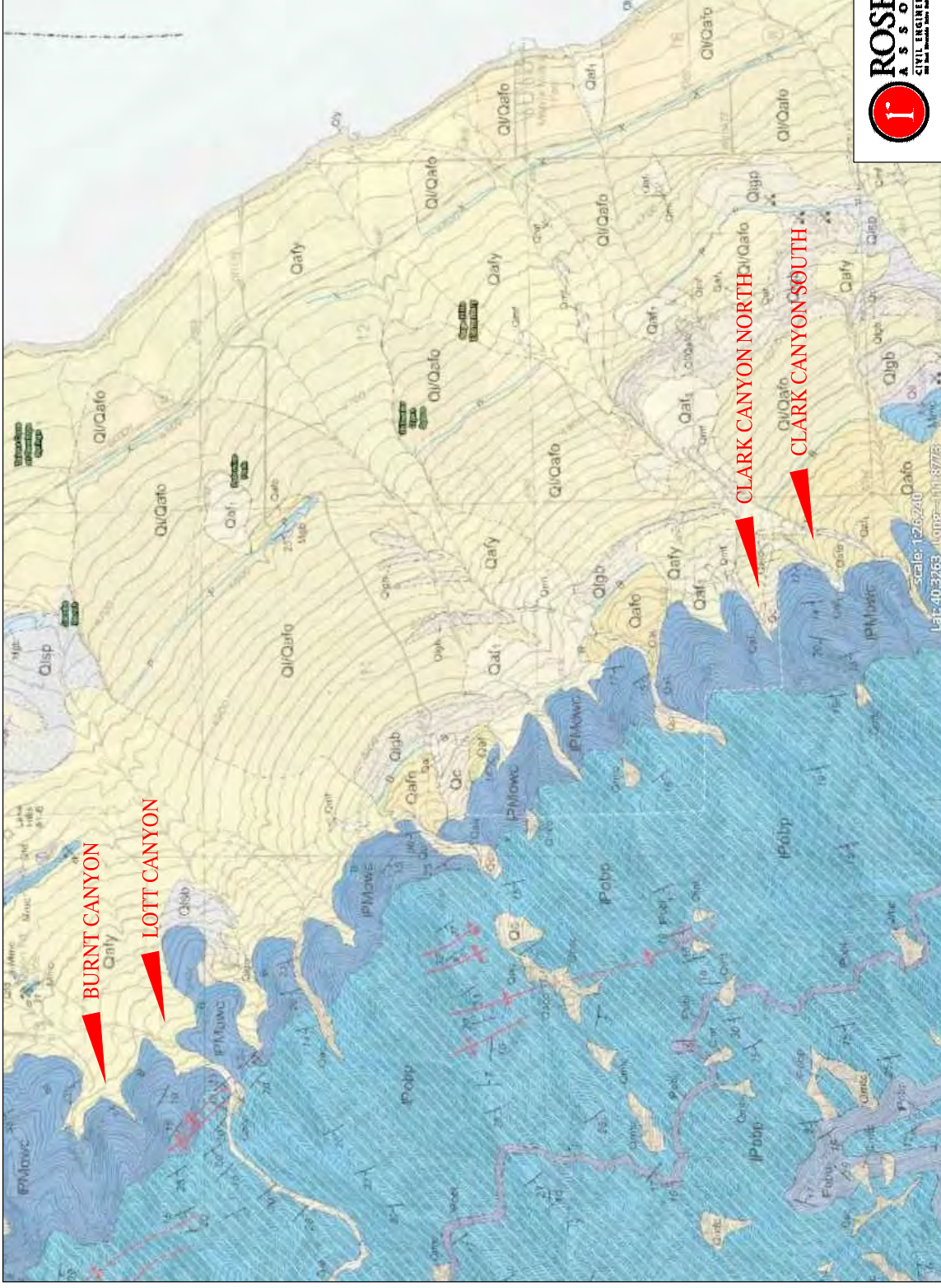
APPENDIX A

FIGURES

Figure A1	Location Map
Figure A2	Location Map
Figure A3	Geologic Map





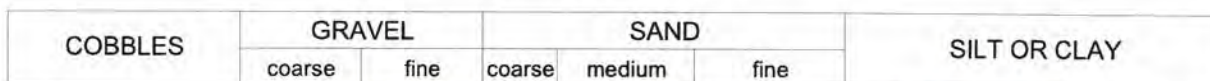


Reference:
Geologic Map of the Saratoga Springs 7.5
Quadrangle Utah County, Utah
by Robert F. Biek
2004

APPENDIX B

PRELIMINARY FIELD AND LABORATORY INVESTIGATIONS

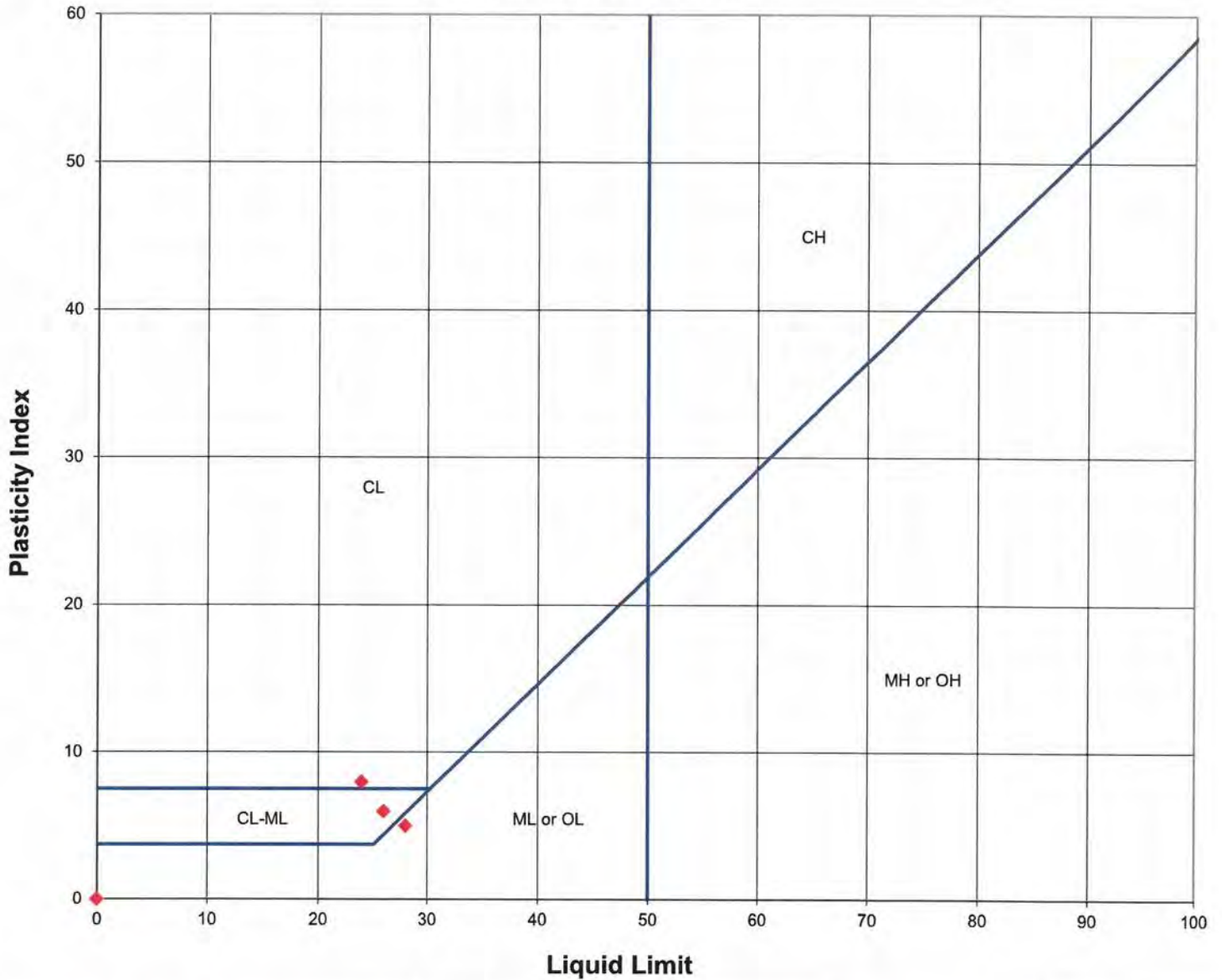
HYDROMETER



B1

Atterberg Limits (ASTM D4318)

PLASTICITY CHART



Sample ID	Liquid Limit	Plastic Limit	Plasticity Index
TP-1 @ 2'	28	23	5
TP-1 @ 4'	26	20	6
TP-2 @ 4'	24	16	8
TP-5 @ 3'	0	0	0

Saratoga Springs EA Project

Burnt, Lott & Clark Canyons, Saratoga Springs, Utah

CMTENGINEERING
LABORATORIES

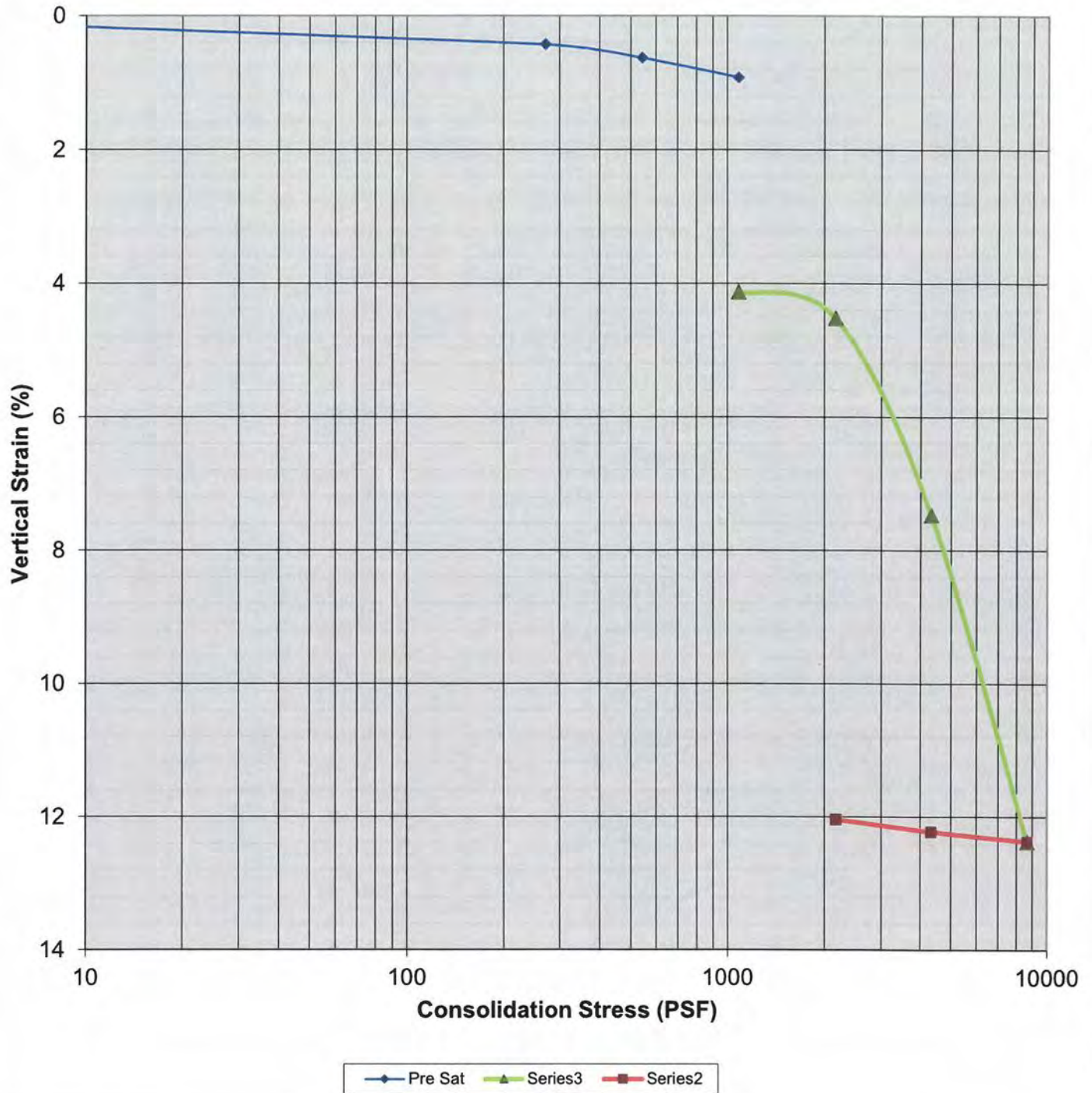
Lab Data

Date: 4-Nov-21
Job #: 17443

Figure:

B2

Consolidation Test: ASTM D2435



TP-2 @ 4.0'

Soil Class:	CL	LL:	24
Moisture :	13	PL:	16
Dry Density:	80	PI:	8

Saratoga Springs EA Project

CMT ENGINEERING
LABORATORIES

Figure:

Burnt, Lott & Clark Canyons, Saratoga Springs, Utah

Lab Data

Date:	4-Nov-21
Job #	17443

B3

Saratoga Springs EA Project

Burnt Canyon Site, Saratoga Springs, Utah

Test Pit Log

TP-1

Total Depth: 5.5'

Date: 10/26/21

Water Depth: (see Remarks)

Job #: 17443

Depth (ft)	GRAPHIC LOG	Soil Description	Sample Type	Sample #	Moisture (%)	Dry Density (pcf)	Gradation			Atterberg		
							Gravel %	Sand %	Fines %	LL	PL	PI
0		Topsoil; A-B horizon, brown silt/sand/angular gravel slightly moist										
1		Light Gray-Brown Silty GRAVEL with sand (GM), angular (weathered bedrock) moist, dense (estimated)										
2				1	8		57	25	18	28	23	5
3												
4		BEDROCK: Light Gray-Brown Gravel with silt (GP-GM), some sand, angular slightly moist, very dense (estimated)		2	5		79	10	11	26	20	6
5		REFUSAL AT 5.5'										
6												
7												
8												
9												
10												
11												
12												
13												
14												

Remarks: Groundwater not encountered during excavation.

Coordinates: 40.3241°, -111.9381°

Surface Elev. (approx): Not Given

Equipment: Rubber Tire Backhoe

Excavated By: Blaine Hone

Logged By: Olivia Roberts

Figure:

4

Saratoga Springs EA Project

Burnt Canyon Site, Saratoga Springs, Utah

Test Pit Log

TP-2

Total Depth: 12'

Date: 10/26/21

Water Depth: (see Remarks)

Job #: 17443

Depth (ft)	GRAPHIC LOG	Soil Description	Sample Type	Sample #	Moisture (%)	Dry Density(pcf)	Gradation			Atterberg		
							Gravel %	Sand %	Fines %	LL	PL	PI
0		Topsoil/potential debris flow; brown silty to clayey angular gravel moist, medium dense (estimated)										
1												
2												
3		Light Brown Silty CLAY (CL), some fine sand and pinholes slightly moist to moist, medium stiff (estimated)										
4				3	13	80			89	24	16	8
5												
6		pinholes grade out										
7												
8												
9												
10												
11												
12		END AT 12'										
13												
14												

Remarks: Groundwater not encountered during excavation.

Coordinates: 40.3234°, -111.9377°

Surface Elev. (approx): Not Given

Equipment: Rubber Tire Backhoe

Excavated By: Blaine Hone

Logged By: Olivia Roberts

Figure:

5

Saratoga Springs EA Project

Lott Canyon Site, Saratoga Springs, Utah

Test Pit Log

TP-3

Total Depth: 1.5'

Date: 10/26/21

Water Depth: (see Remarks)

Job #: 17443

Depth (ft)	GRAPHIC LOG	Soil Description	Sample Type	Sample #	Moisture (%)	Dry Density(pcf)	Gradation			Atterberg		
							Gravel %	Sand %	Fines %	LL	PL	PI
0		Topsoil/debris flow material; silty to clayey angular gravel slightly moist										
1		BEDROCK: Gray Limestone very dense (estimated)										
2		REFUSAL AT 1.5'										
3												
4												
5												
6												
7												
8												
9												
10												
11												
12												
13												
14												

Remarks: Groundwater not encountered during excavation.

Coordinates: 40.3205°, -111.9362°

Surface Elev. (approx): Not Given

Equipment: Rubber Tire Backhoe

Excavated By: Blaine Hone

Logged By: Olivia Roberts

Figure:

6

Saratoga Springs EA Project

Lott Canyon Site, Saratoga Springs, Utah

Test Pit Log

TP-4

Total Depth: 12'

Date: 10/26/21

Water Depth: (see Remarks)

Job #: 17443

Depth (ft)	GRAPHIC LOG	Soil Description	Sample Type	Sample #	Moisture (%)	Dry Density (pcf)	Gradation			Atterberg		
							Gravel %	Sand %	Fines %	LL	PL	PI
0		Topsoil										
1		Light Brown Silty GRAVEL (GM), some sand and cobble (debris flow material) dry, medium dense (estimated)										
2												
3												
4		grades with boulders 4' diameter										
5												
6		grades gray-brown		4	1		76	10	14			
7												
8												
9												
10												
11												
12		END AT 12'										
13												
14												

Remarks: Groundwater not encountered during excavation.

Coordinates: 40.3198°, -111.9341°

Surface Elev. (approx): Not Given

Equipment: Rubber Tire Backhoe

Excavated By: Blaine Hone

Logged By: Olivia Roberts

Figure:

7

Saratoga Springs EA Project

Clark Canyon North Site, Saratoga Springs, Utah

Test Pit Log

TP-5

Total Depth: 5'

Date: 10/26/21

Water Depth: (see Remarks)

Job #: 17443

Depth (ft)	GRAPHIC LOG	Soil Description	Sample Type	Sample #	Moisture (%)	Dry Density (pcf)	Gradation			Atterberg		
							Gravel %	Sand %	Fines %	LL	PL	PI
0		Topsoil; brown silty gravel moist										
1		Light Brown Silty GRAVEL with sand (GM), angular, some cobble and occasional small boulders (weathered bedrock) slightly moist, medium dense (estimated)										
2		grades gray										
3				5	5		57	23	20		NP	NP
4												
5		BEDROCK: Gray Limestone very dense (estimated)										
5		REFUSAL AT 5.0'										
6												
7												
8												
9												
10												
11												
12												
13												
14												

Remarks: Groundwater not encountered during excavation.

Coordinates: 40.2938°, -111.9121°

Surface Elev. (approx): Not Given

Equipment: Rubber Tire Backhoe

Excavated By: Blaine Hone

Logged By: Olivia Roberts

Figure:

8

Saratoga Springs EA Project

Clark Canyon North Site, Saratoga Springs, Utah

Test Pit Log

TP-6

Total Depth: 10'

Date: 10/26/21

Water Depth: (see Remarks)

Job #: 17443

Depth (ft)	GRAPHIC LOG	Soil Description	Sample Type	Sample #	Moisture (%)	Dry Density(pcf)	Gradation			Atterberg		
							Gravel %	Sand %	Fines %	LL	PL	PI
0		Topsoil; brown silty to clayey gravel										
1		Light Brown Silty GRAVEL and COBBLE (GM), debris flow deposits (2 distinct events) dry, medium dense (estimated) (soils are too coarse to obtain a representative sample)										
2												
3												
4												
5												
6												
7												
8												
9		grades with more cobbles and some boulders										
10		REFUSAL AT 10'										
11												
12												
13												
14												

Remarks: Groundwater not encountered during excavation.

Coordinates: 40.294°, -111.9134°

Surface Elev. (approx): Not Given

Equipment: Rubber Tire Backhoe

Excavated By: Blaine Hone

Logged By: Olivia Roberts

Figure:

9

Saratoga Springs EA Project

Clark Canyon South Site, Saratoga Springs, Utah

Test Pit Log

TP-7

Total Depth: 12'

Date: 10/26/21

Water Depth: (see Remarks)

Job #: 17443

Depth (ft)	GRAPHIC LOG	Soil Description	Sample Type	Sample #	Moisture (%)	Dry Density (pcf)	Gradation			Atterberg		
							Gravel %	Sand %	Fines %	LL	PL	PI
0		Topsoil; dark brown silty gravel										
1		Light Brown Silty GRAVEL and COBBLE (GM), angular, debris flow deposits dry, medium dense (estimated)										
2		(soils are too coarse to obtain a representative sample)										
3												
4												
5												
6												
7												
8												
9												
10												
11												
12		END AT 12'										
13												
14												

Remarks: Groundwater not encountered during excavation.

Coordinates: 40.293°, -111.9071°

Surface Elev. (approx): Not Given

Equipment: Rubber Tire Backhoe

Excavated By: Blaine Hone

Logged By: Olivia Roberts

Figure:

10

Saratoga Springs EA Project

Clark Canyon South Site, Saratoga Springs, Utah

Test Pit Log

TP-8

Total Depth: 3.5'

Date: 10/26/21

Water Depth: (see Remarks)

Job #: 17443

Depth (ft)	GRAPHIC LOG	Soil Description	Sample Type	Sample #	Moisture (%)	Dry Density(pcf)	Gradation			Atterberg		
							Gravel %	Sand %	Fines %	LL	PL	PI
0		Topsoil										
1		Reddish Brown to Brown Silty GRAVEL with sand (GM) slightly moist, medium dense (estimated)										
2												
3		BEDROCK: Gray Limestone very dense (estimated)										
4		REFUSAL AT 3.5'										
5												
6												
7												
8												
9												
10												
11												
12												
13												
14												

Remarks: Groundwater not encountered during excavation.

Coordinates: 40.2922°, -111.9081°

Surface Elev. (approx): Not Given

Equipment: Rubber Tire Backhoe

Excavated By: Blaine Hone

Logged By: Olivia Roberts

Figure:

11

Saratoga Springs EA Project

Burnt Canyon, Lott Canyon, Clark Canyon North and Clark Canyon South,
Saratoga Springs, Utah

Key to Symbols

Date: 10/26/21

Job #: 17443

① Depth (ft)	② GRAPHIC LOG	③ Soil Description	④ Sample Type	⑤ Sample #	⑥ Moisture (%)	⑦ Dry Density(pcf)	⑧ Gradation	⑨ Atterberg																																																															
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COLUMN DESCRIPTIONS																																																																							
① Depth (ft.): Depth (feet) below the ground surface (including groundwater depth - see water symbol below). ② Graphic Log: Graphic depicting type of soil encountered (see ② below). ③ Soil Description: Description of soils encountered, including Unified Soil Classification Symbol (see below). ④ Sample Type: Type of soil sample collected at depth interval shown; sampler symbols are explained below-right. ⑤ Sample #: Consecutive numbering of soil samples collected during field exploration. ⑥ Moisture (%): Water content of soil sample measured in laboratory (percentage of dry weight of sample). ⑦ Dry Density (pcf): The dry density of a soil measured in laboratory (pounds per cubic foot). ⑧ Gradation: Percentages of Gravel, Sand and Fines (Silt/Clay), obtained from lab test results of soil passing the No. 4 and No. 200 sieves. ⑨ Atterberg: Individual descriptions of Atterberg Tests are as follows: LL = Liquid Limit (%): Water content at which a soil changes from plastic to liquid behavior. PL = Plastic Limit (%): Water content at which a soil changes from liquid to plastic behavior. PI = Plasticity Index (%): Range of water content at which a soil exhibits plastic properties (= Liquid Limit - Plastic Limit).																																																																							
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UNIFIED SOIL CLASSIFICATION SYSTEM (USCS) SAMPLER SYMBOLS - Block Sample - Bulk/Bag Sample - Modified California Sampler 3.5" OD, 2.42" ID D&M Sampler - Rock Core - Standard Penetration Split Spoon Sampler - Thin Wall (Shelby Tube) WATER SYMBOL - Encountered Water Level - Measured Water Level (see Remarks on Logs)																																																																							

Note: Dual Symbols are used to indicate borderline soil classifications (i.e. GP-GM, SC-SM, etc.).

- The results of laboratory tests on the samples collected are shown on the logs at the respective sample depths.
- The subsurface conditions represented on the logs are for the locations specified. Caution should be exercised if interpolating between or extrapolating beyond the exploration locations.
- The information presented on each log is subject to the limitations, conclusions, and recommendations presented in this report.

Figure:

12

APPENDIX C

SITE PHOTOGRAPHS



Figure C1 – TP-2, Proposed Burnt Canyon embankment location.



Figure C2 – TP-2, Proposed Burnt Canyon embankment location.



Figure C3 – TP-6, Proposed Clark Canyon North embankment location .



Figure C4 – TP-8, Proposed Clark Canyon South embankment location.

APPENDIX G
30% DESIGN DRAWINGS

Included in Appendix E of the Plan-EA

Geologic Units

Geologic Units in the Saratoga Springs Watershed

Source: Biek 2004

Unit Symbol	Unit Name	Description
Qal ₁	Stream deposits (Holocene)	Moderately sorted sand, silt, clay, and pebble to boulder gravel deposited in stream channels.
Qaf ₁	Level-1 alluvial-fan deposits (Holocene to upper Pleistocene)	Poorly to moderately sorted, clay- to boulder-size sediment deposited principally by debris flows at the mouths of active drainages.
Qafy*	Younger undifferentiated alluvial-fan deposits (Holocene to upper Pleistocene)	Similar to Qaf ₁ , but forms coalesced apron of post-Bonneville sediment shed off the Lake and Oquirrh Mountains.
Qafo	Older alluvial-fan deposits (upper Pleistocene)	Similar to Qafy, but forms deeply dissected alluvial apron truncated by, and thus predating, the Bonneville shoreline.
Qaf	Alluvial-fan deposits (upper Pleistocene)	Similar to Qafo, but preserved as very deeply dissected remnants on the flanks of the southern Oquirrh Mountains.
Qfd	Mine-dump deposits (Historical)	Waste rock and overburden from clay quarries and one calcite quarry.
Qc	Colluvial deposits (Holocene to upper Pleistocene)	Poorly to moderately sorted, angular, clay- to boulder-size, locally derived sediment deposited by slope wash and soil creep on moderate slopes and in shallow depressions.
Qlgb	Lacustrine gravel and sand (upper Pleistocene)	Moderately to well-sorted, moderately to well-rounded, clast-supported, pebble to cobble gravel and lesser pebbly sand. Deposited at and below the highest Bonneville shoreline but above the Provo shoreline.
Qlsp	Lacustrine sand and silt (upper Pleistocene)	Coarse- to fine-grained lacustrine sand and silt, with minor gravel.
Qmf	Debris-flow deposits (Holocene to upper Pleistocene)	Very poorly sorted, subangular, cobble- to boulder-size gravel in a matrix of silt, sand, clay, and pebbles.
Qac	Alluvial and colluvial deposits (Holocene to upper Pleistocene)	Poorly to moderately sorted, generally poorly stratified, clay- to boulder-size, locally derived sediment deposited in swales, small drainages, and the upper reaches of larger ephemeral streams by fluvial, slope wash, and creep processes.
Qaco	Older alluvial and colluvial deposits (upper Pleistocene)	Similar to Qac, but forms isolated remnants deeply incised by adjacent streams.
Qmtc	Talus and colluvium (Holocene to upper Pleistocene)	Very poorly sorted, angular to subangular cobbles and boulders and finer-grained interstitial sediment deposited principally by rock fall on steep slopes.
Ql/Qafo*	Lacustrine deposits over older alluvial-fan deposits (upper Pleistocene)	Older alluvial-fan deposits planated by wave action and partly concealed by a discontinuous veneer of lacustrine deposits.
IPobp*	Butterfield Peaks Formation (Middle-Lower Pennsylvanian)	Interbedded, brown-weathering, fine-grained calcareous sandstone, medium-gray, fine-grained sandy limestone, minor orthoquartzite, and several limestone intervals.

Unit Symbol	Unit Name	Description
IPobu	Upper billiard ball limestone of Butterfield Peaks Formation	Light-gray-weathering, thin-bedded, fine-grained limestone with characteristic black spherical chert in the lower two-thirds of the unit.
IPobl	Lower billiard ball limestone of Butterfield Peaks Formation	Divisible into two parts: lower half has a ledge-forming basal bed several feet thick of medium-dark-gray, medium- to coarse-grained fossiliferous limestone overlain by thin- to medium-bedded, laminated and platy weathering, fine-grained limestone and argillaceous limestone. Upper half tends to be light- to medium-gray, medium- to thick-bedded limestone with planar and low-angle cross-stratification.
IPmowc*	West Canyon Limestone (lower Pennsylvanian to upper Mississippian)	Medium-light-gray to medium-gray, thick- to very thick bedded, fine- to medium-grained limestone and fossiliferous limestone.
Mmc	Manning Canyon Shale (upper Mississippian)	Lithologically diverse, interbedded, black to grayish purple, calcareous and carbonaceous shale and siltstone.
Mgb	Great Blue Limestone, undivided (upper Mississippian)	Limestone, undivided in the north central part of Saratoga Springs quadrangle due to inadequate exposure

Soil Types

Soil Map—Fairfield-Nephi Area, Utah, and Utah County, Utah - Central Part (WatershedBoundary)



**Natural Resources
Conservation Service**

Web Soil Survey
National Cooperative Soil Survey

3/14/2024
Page 1 of 4

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Map Unit Polygons

Soil Map Unit Lines

Soil Map Unit Points

Special Point Features

Blowout

Borrow Pit

Clay Spot

Closed Depression

Gravel Pit

Gravelly Spot

Landfill

Lava Flow

Marsh or swamp

Mine or Quarry

Miscellaneous Water

Perennial Water

Rock Outcrop

Saline Spot

Sandy Spot

Severely Eroded Spot

Sinkhole

Slide or Slip

Sodic Spot

Water Features

Streams and Canals

Transportation

Rails

Interstate Highways

US Routes

Major Roads

Local Roads

Background

Aerial Photography

Spoil Area

Stony Spot

Very Stony Spot

Wet Spot

Other

Special Line Features

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at scales ranging from 1:20,000 to 1:24,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service

Web Soil Survey URL: [Web Soil Survey](#)

Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Fairfield-Nephi Area, Utah

Survey Area Data: Version 17, Sep 8, 2023

Soil Survey Area: Utah County, Utah - Central Part

Survey Area Data: Version 16, Sep 8, 2023

Your area of interest (AOI) includes more than one soil survey area. These survey areas may have been mapped at different scales, with a different land use in mind, at different times, or at different levels of detail. This may result in map unit symbols, soil properties, and interpretations that do not completely agree across soil survey area boundaries.

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Jul 14, 2010—Jul 5, 2022

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
8002	Borvant cobbly loam, 8 to 25 percent slopes	207.4	2.4%
AdF	Amtoft, moist-Rock outcrop complex, 30 to 70 percent slopes	119.9	1.4%
BA	Beaches	0.2	0.0%
Bf	Birdow loam	5.1	0.1%
CaB	Calita loam, 2 to 4 percent slopes	10.3	0.1%
CcF	Calpac-Lundy complex, 30 to 70 percent slopes	1,215.4	14.1%
DdC	Donnardo stony loam, 2 to 8 percent slopes	2,276.4	26.5%
DdF	Donnardo stony loam, 25 to 40 percent slopes	297.1	3.5%
DhD	Dry Creek cobbly loam, 4 to 15 percent slopes	72.8	0.8%
GdDP	Goldrun loamy fine sand, hummocky, 0 to 10 percent slopes	29.2	0.3%
JbB	Juab loam, 2 to 4 percent slopes	30.7	0.4%
JbC	Juab loam, 4 to 8 percent slopes	594.1	6.9%
KcF	Kitchell-Rock outcrop complex, 30 to 70 percent slopes	523.6	6.1%
LdF	Lodar-Rock outcrop complex, 30 to 70 percent slopes	387.3	4.5%
LeF	Lundy-Rock outcrop complex, 30 to 70 percent slopes	952.3	11.1%
MbC2	Manassa silt loam, 2 to 5 percent slopes, eroded	124.6	1.5%
Mg	Mellor silt loam	220.6	2.6%
PK	Pits-Dumps complex	52.7	0.6%
SeF	Saxby, moist-Rock outcrop complex, 30 to 70 percent slopes	676.4	7.9%
WaB	Wales loam, 2 to 4 percent slopes	97.4	1.1%
Subtotals for Soil Survey Area		7,893.4	91.9%
Totals for Area of Interest		8,590.1	100.0%

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
HpF	Hillfield-Welby silt loams, 6 to 35 percent slopes	36.2	0.4%
Pd	Payson silty clay loam	18.6	0.2%
PnA	Pleasant Vale loam, 0 to 2 percent slopes	127.3	1.5%
PoC	Pleasant Vale loam, extended season, 3 to 6 percent slopes	88.9	1.0%
PsB	Pleasant Vale silty clay loam, 1 to 3 percent slopes	73.5	0.9%
ReC	Redola gravelly loam, 3 to 6 percent slopes	236.3	2.8%
RW	Rock land	49.4	0.6%
TaA	Taylorville silty clay loam, 0 to 1 percent slopes	4.5	0.1%
TaB	Taylorville silty clay loam, 1 to 3 percent slopes	24.4	0.3%
TcC2	Taylorville silty clay loam, extended season, 3 to 6 percent slopes, eroded	4.4	0.1%
W	Water	4.1	0.0%
WbB	Welby silt loam, 1 to 3 percent slopes	17.8	0.2%
WbC	Welby silt loam, 3 to 6 percent slopes	11.2	0.1%
Subtotals for Soil Survey Area		696.6	8.1%
Totals for Area of Interest		8,590.1	100.0%