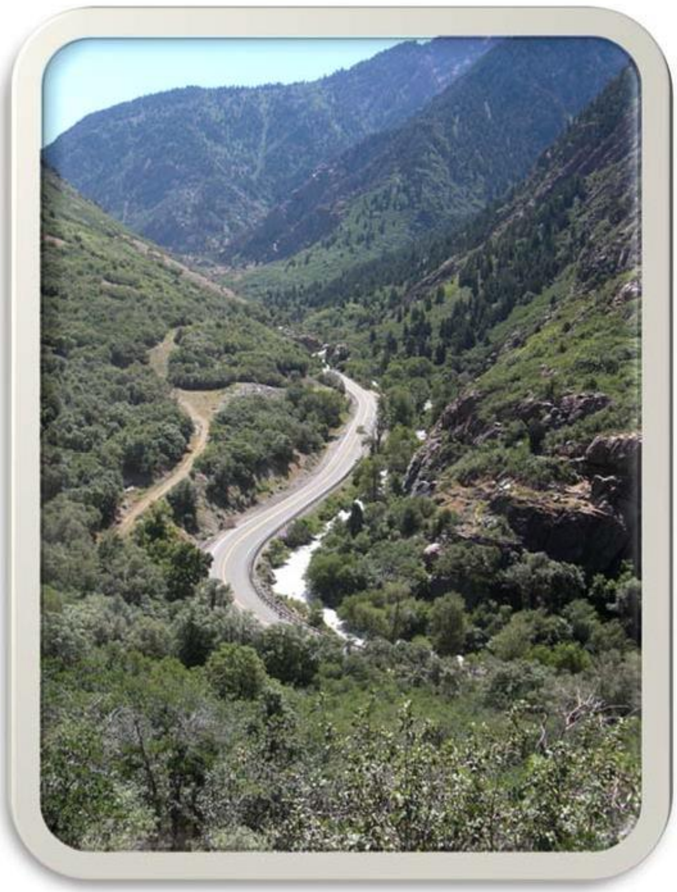
2017



BIG COTTONWOOD CANYON 3T IMPROVEMENT PROJECT

Managing Traffic, Trails, and Toilets

Preliminary Engineering Report
Prepared for the Big Cottonwood Community Council
May 2017

CVEEN 4910-001 [Spring 2017]
Department of Civil and Environmental Engineering
The University of Utah

THE UNIVERSITY OF UTAH

PROJECT TEAM LETTER

Dear Big Cottonwood Community Council:

The Civil and Environmental Engineering (CVEEN) 4910 Professional Practice and Design Class of Spring 2017 at the University of Utah is pleased to present the preliminary engineering report for the Big Cottonwood Canyon 3T Improvement Project (BCC3T). The team has considered many solutions to improve safety and access while preserving the beauty of the canyon. This report develops in greater detail alternatives that were selected based on their potential to be both sustainable and aesthetically pleasing while addressing principle needs presented by the Big Cottonwood Community Council. A major factor in our definition of sustainability is that the project be financially self-supporting. Although estimated costs and budgets may present significant constraints to project implementation in Big Cottonwood Canyon, the overall intention of the BCC3T is to present both immediately attainable solutions as well as a possible long-term vision. While potential political or legal constraints were considered in brief, the multijurisdictional nature of this project requires continued commitment and cooperation between public and private stakeholders, the structure of which agreements is beyond the scope of an engineering document.

Due to the time limits imposed by the University of Utah semester schedule, this preliminary engineering report cannot be as complete or in-depth as the complex situation of Big Cottonwood Canyon warrants. While the focus of the class was developing solutions that can be achieved through the lens of Civil Engineering, the Senior Design team hopes that this report can be useful in future planning discussions and community organization efforts for the diverse group of canyon stakeholders.

Our team deeply appreciates the involvement and encouragement of not only the Big Cottonwood Community Council, but also the cooperation of the following agencies: U.S. Forest Service, Utah Department of Transportation, Utah Transit Authority, Salt Lake County, Mountain Accord, Brighton, Solitude Mountain Resort, and the many private citizens who engaged with or commented on our work.

Sincerely,

CVEEN 4910 Senior Design Class of Spring 2017

EXECUTIVE SUMMARY

The purpose of this engineering report is to propose technically feasible and financially and environmentally sustainable solutions for the present and future needs in Big Cottonwood Canyon.

Big Cottonwood Canyon (BCC) is an increasingly popular natural recreation area that experiences issues with overcrowding and traffic congestion. There are not enough restrooms in the canyon to meet the current demand, which poses a threat to the water quality for Salt Lake Valley. In addition, high congestion in the canyon increases CO_2 emissions due to increased idling and travel times, which in turn impacts the air quality of the Salt Lake Valley. The congestion and overcrowding also makes the canyon an unsafe place for pedestrians and cyclists because of an increase in potential interferences. In some areas, the demand for parking is almost 4 times larger than the amount of available parking spaces on a day with average traffic. Therefore, a multi-stage comprehensive solution is necessary to address these issues.

Traffic congestion may be reduced and public safety improved by adopting the following proposed improvements: eliminating parking on the side of the road, restriping existing lots, increasing public transit services within the canyon, incorporating signs displaying live counts of available parking, and introducing a variable tolling system.

Roadway and trail safety may be improved by adopting the following proposed improvements: installing electronic pedestrian crossing signs in problematic areas, restriping bicycle lanes and separating automobile traffic, expanding inadequate shoulders to increase pedestrian safety, building a pedestrian bridge off the Lake Blanche Trail, and starting an 'Adopt A Trail' campaign in high traffic hiking locations to control trail erosion

Protecting the watershed may be accomplished by increasing the number of restroom stalls throughout the canyon at new and existing locations. This solution could be scaled to work within project limitations and budget by collecting data through a proposed pilot study to identify high use areas within Big Cottonwood Canyon and address the greatest needs as a priority.

The result of these proposals is a decrease in the number of people bringing single-occupant vehicles into the canyon, an increase in road capacity, increased public transit ridership, improved public health and safety, and the preservation of a vital watershed. A proposed variable tolling system could sustainably fund each of these improvements over time, thus resulting in a more enjoyable and sustainable experience of Big Cottonwood Canyon for all visitors.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

I. STATEMENT OF NEEDS

Big Cottonwood Canyon is a majestic, natural beauty that has become a beacon for recreation, admiration, and retreat year-round. According to the Outdoor Industry Association, at least 82% of Utah residents participate in outdoor recreation each year [1]. Big Cottonwood Canyon is located within the Uinta-Wasatch-Cache National Forest, which has a net acreage of 2.17 million and consists of seven ranger districts spanning Utah and Wyoming [2]. Popularly known as the "Forest Next Door," the Uinta-Wasatch-Cache is considered an Urban National Forest with a nearby population center of greater than 1 million residents [2]. Based on the size of the watershed according to the U.S. Forest Service, Big Cottonwood Canyon has a net area of 32,000 acres and is projected to host 3 million visitors per year by 2040 [3].

In comparison, Yellowstone National Park has a net acreage of 2.2 million, slightly less than the entirety of the Uinta-Wasatch-Cache National Forest, and approximately 4 million visitors per year [4]. Based on these visitation statistics, by 2040 Big Cottonwood Canyon will also host 75 percent of Yellowstone National Park's typical visitors in a land area this is approximately 1 percent of the size of Yellowstone.

According to the 2014-2015 Central Wasatch Visitor Use Survey, the majority of canyon visitors were local to Salt Lake County, and "access" was the most valued characteristic of Big Cottonwood Canyon; however, the current state of unmanaged access to Big Cottonwood Canyon has significant user and indirect costs pertaining to public safety, public health, and the potential for recreational enjoyment for all users [5]. For example, illegal and unsafe parking, pedestrian and cyclist interferences with automobile traffic, and restroom facility availability are common problems.

Existing conditions along the Wasatch Front in general and Big Cottonwood Canyon in particular have been extensively documented by other studies and research teams including, but not limited to, the 2014-2015 Central Wasatch Visitor Use Study, the Mountain Transportation Study, Wasatch Canyons Tomorrow, the Big Cottonwood Canyon General Plan, the Cottonwood Canyons Parking Study, and Mountain Accord [4,5,6,7,8,9,10]. The present preliminary engineering report takes into account the recommendations and findings of these studies while presenting a vision of Big Cottonwood Canyon as it may operate in the future.

II. VISION STATEMENT

Our vision for Big Cottonwood Canyon is develop systems and facilities that maintain the integrity of the environment and trails while also implementing efficient multimodal transportation, improved sanitation, and increased safety for all enthusiasts who visit and recreate in the canyon.

III. ALTERNATIVES STUDY OVERVIEW

The purpose of the Big Cottonwood Canyon 3T Improvement Project (BCC3T) is to develop solutions that address congestion, automobile/pedestrian safety, parking, and sanitation within Big Cottonwood Canyon. Our previously completed alternatives study (Appendix B) recommended solutions prioritized and ranked on six criteria: health and safety, affordability and sustainability, environmental impact, aesthetics, time to implement, and accessibility.

Addressing the known concerns of the Big Cottonwood Community Council regarding the "Three T's" (i.e., toilets, traffic, and trails) necessitated organizing potential alternatives into three themes: (1) traffic and parking improvements, (2) roadways and trails operation and improvements, and (3) environmental and sanitation considerations.

Within each theme, it became evident that potential solutions and engineered alternatives tended to require different levels of impact within Big Cottonwood Canyon. Some solutions provided substantial benefits, easily described and quantified, while other solutions required greater up-front investment, more complex evaluations, and an extended implementation timeline including potential changes in administrative requirements and the need for involved public involvement and additional environmental studies under the National Environmental Policy Act (NEPA).

Project themes and proposed solutions were therefore divided into low, medium, and high impact models, which allowed for an integrated evaluation of the complex recreational, environmental, and transportation contexts of the Canyon. Both the preliminary analysis and final recommendations were framed throughout the report in terms of these impacts.

Impact Levels

- Low Impact Models: Minimal impacts within the canyon, low construction times, fewer potential costs.

- Medium Impact Models: Medium impacts to the canyon, including additional infrastructure in targeted or high-use areas which may require a NEPA process and 1 to 2 years of implementation.
- High Impact Models: Comprehensive and wide-ranging impacts within the canyon. Long-term construction timelines and generally higher capital and maintenance costs. Such solutions typically required a NEPA process and 3 to 5 years of implantation.

BCC3T Alternatives Study Conclusions

While tolling or collecting user fees in any form is politically and publically controversial, the current state of relatively unmanaged access to Big Cottonwood Canyon has significant costs and impacts to public safety, public health, and the potential for recreational enjoyment for all users. Illegal and unsafe parking, pedestrian and cyclist interferences with automobile traffic, and restroom facility availability are common and well-studied problems.

The BCC3T team recommended a comprehensive, integrated approach incorporating the low impact models for traffic and parking, roadways and trails, and environmental concerns, respectively. These low impact models included parking lot restriping, increased signage and illegal parking enforcement, an “Adopt-A-Trail” program, and a pilot study using portable toilet facilities in order to determine where additional permanent facilities should be placed.

In addition to the low impact models, the medium impact model of recommending geofoam shoulder widening of the up-canyon lane, presented in the roadways and trails section, received favorable support and was highly recommended to reduce auto-pedestrian and auto-cyclist conflicts at problematic narrow sections of roadway throughout Big Cottonwood Canyon.

Finally, the traffic and parking team recommended implementing some form of user fee collection (i.e., basic access tolling, parking fees, variable parking fees, etc.) in order to manage traffic congestion and to provide a sustainable revenue stream for other recommended improvements. While parking or user fees may generate revenue, such a solution would not necessarily address congestion in the same way as basic access or variable tolling.

If tolling is implemented, then it becomes imperative to expand or include a free public transit option for access to popular trailhead and recreation destinations throughout Big Cottonwood Canyon, which in turn may require additional bus stops or other infrastructure improvements. Additional permanent sanitation facilities should also be considered as part of any long-term plan.

Each of these recommended alternatives are examined in further detail in the following sections of this report.

1 BIG COTTONWOOD CANYON: TRAFFIC AND PARKING

1.1 Introduction and Overview

Big Cottonwood Canyon (BCC) is an increasingly popular natural recreation area that experiences issues with overcrowding and traffic congestion. There are not enough restrooms in the canyon to meet the current demand, which poses a threat to the water quality for Salt Lake Valley. In addition, high congestion in the canyon increases CO_2 emissions due to increased idling and travel times, which in turn impacts the air quality of the Salt Lake Valley. The congestion and overcrowding also makes the canyon an unsafe place for pedestrians and cyclists because of an increase in potential interferences. In some areas, the demand for parking is almost 4 times larger than the amount of available parking spaces on a day with average traffic.

A multi-stage comprehensive solution is necessary to address these issues. The number of vehicles occupying or entering the canyon at peak times is greater than what the road can efficiently convey. Traffic congestion may be reduced and public safety improved by adopting the following proposed improvements: eliminating parking on the side of the road, restriping existing lots, increasing public transit services within the canyon, incorporating signs displaying real-time counts of available parking, and introducing a variable tolling system.

It is hoped that the implementation of these recommendations result in a decrease in the number of people bringing single-occupant vehicles into the canyon, an increase in roadway capacity, increased public transit ridership, and improved safety for all visitors, thus resulting in a more enjoyable and sustainable usage of the canyon.

1.2 Construction Phasing

Each proposal has been incorporated into construction phases, which are referenced throughout the preliminary engineering report. Proposed construction phases and costs for traffic and parking are included in Appendix II.

1.3 Tolling

In BCC, there are not enough adequate locations to park a vehicle. On peak days traffic can be bumper to bumper because of bottlenecking. These issues alone present safety risks to cyclists and pedestrians. “Utah’s 2011 population increased 41,743 people, or 1.5 percent from 2010, ranking Utah third among states in population growth” [7]. This growth rate implies that Utah’s population will more than double by 2060. This population growth will increase the amount of users that have access to BCC, and will only worsen the congestion and overuse problems BCC already experiences.

1.3.1 Variable Tolling

Several comparable tolling systems were analyzed and summarized in the Feasibility Study (Attachment B), including Mill Creek Canyon, American Fork Canyon, Zion National Park, and the Washington state highway tolling system among others. Based on the feedback received from the BCCC, the most preferable solution is to install a tolling system at the mouth of the canyon. It is recommended that the toll rate be variable depending on demand; during times where more vehicles were attempting to access the canyon the fee could increase. At times when there was little congestion in the canyon the fee could decrease. This variable tolling system allows the canyon to function at its optimal capacity when the tolls are working correctly, and hopefully it encourages users to plan and disseminate trip times so that so users are not entering the canyon with personal vehicles at congested times.

The tolling system proposed here is based off of current models used by Washington’s Department of Transportation. Variable-priced tolls can be used to restore the balance between supply and demand. It will cause people to rethink the way they do business and the way they organize their lives. For example, pricing a highway with higher tolls imposed during periods of peak demand may cause travelers to consider the value of their trip and either switch to non-peak times, carpool, switch to transit, or change their destination [8]. Ultimately, it is hoped that variably pricing BCC would yield the greatest travel efficiency and reliability while providing a revenue stream. This creates two significant benefits to already limited transportation funds [8].

If the primary objective of variable tolling is to manage traffic congestion, the prices could therefore be adjusted to most efficiently control the flow of vehicles. In the case of a managed lane, where the objective is to maximize flow and reliability in that lane, tolls will need to rise to the level required to maintain the desired traffic flow [8]. When traffic demand is low, the variable fee may also allow vehicles to access the canyon for free.

In addition, a tolling system could generate adequate revenue to provide services such as a shuttle system. The shuttle system could allow users to park their cars at the mouth of the canyon, and then ride the shuttle up BCC for free. Ultimately, this system should be designed to be self-supporting, including any funds to support future improvements to BCC.

Research on similar canyons such as Mill Creek and American Fork indicated that a tolling system could ease the overcrowding BCC currently experiences. Mill Creek and American Fork Canyons have successfully implemented tolling which decreased congestion, increased carpooling, and increased funding. Both currently have daily fees of $3 and $6, respectively as well as a $45 annual fee [9]. Further research is included in the previous Alternatives Study as Appendix B.

Several options were considered for the toll collection mechanism; among them an electronic tolling gantry and a stop-and-go tolling booth. However, drivers would most likely bottleneck at the entry points trying to pay their fees at a stop-and-go booth, which would cause considerable traffic problems and backups on all the roadways surrounding the canyon. Currently, the Washington Department of Transportation (WDOT) uses a gantry road signage system to incorporate electronic open road tolling (ORT) [8]. Gantries are beneficial as they often contain the apparatus for traffic monitoring systems and cameras, or open road tolling systems. The major advantage to ORT is that users are able to drive through the toll area at highway speeds without having to slow down to pay the toll [8]. In some installations, ORT may also reduce congestion at the plazas by allowing more vehicles per hour/per lane.

It is recommended that collection of tolls using ORT be conducted through either the use of transponders or automatic plate recognition [10]. These technologies are very suitable and reliable with gantry signage. Both methods aim to eliminate the delay on toll roads by collecting tolls electronically. Users may make an online toll deposit. Then, each time they pass through the gantry, monitors will electronically debit the accounts of registered car owners without requiring them to stop.

In consideration of current residents and employees in BCC, discounted rates may be adjusted easily through the ORT system. For example, a resident or employee may register their plate license number online and the system will automatically recognize the toll fee as a reduced or waived cost. Another solution would be to charge residents a yearly fee for a pass is similar to homeowners' association (HOA) fee. In addition, ski resorts currently subsidize the costs of the UTA bus system in order to provide easier transit for customers during the winter season. However, encouraging riders to use a free shuttle service for BCC transportation would provide additional benefits to the resorts because much of the cost could be borne by tolling revenues. Ski resorts could also coordinate with UTA to provide discounts in their ski pass for using the shuttle service.

Although the variable-price toll system seems to be most practical for BCC, it is difficult to estimate revenues for the initial year of operation. Based on an evaluation that assumes Level "C" as the targeted level of service, Table 1 shows a reasonable variable price fee schedule as a function of traffic flow rate.

Table 1: Proposed Variable-Price Fees Based on Traffic Flow Rate (Cars/Hour)

Variable-Price Fees	
Canyon Entry Access Fee	**Traffic Flow Rate (cars/hour)**
$0.00	0-24
$3.00	25-49
$4.00	50-99
$5.00	100-149
$5.50	150-199
$6.00	200-249
$6.50	250-299
$7.00	300-349
$7.50	350-399
$8.50	400+
$9.50	500+
$10.50	600+
$11.50	700+
$12.50	800+

This table shows a preliminary, conceptual estimate of a fee structure that might be required to reduce traffic volumes to maintain an operational standard of Level of Service "C", or better. However, user behavior may significantly change in the first years of tolling, as user expectations adjust. Most likely, at least one or more years of tolling data will be necessary in order to calibrate pricing so as to reduce congestion effectively and to provide expected revenues. Tolling fees may need further adjustments to fit economic trends and to reflect optimal use and congestion pricing relative to observed level of service. It is hoped that once users have become accustomed to tolling, data on user behavior will become more uniform and the tolling schedule more predictable.

Table 2: Projected Annual Revenues (7-Day per Week Operation of System)

REVENUE	$3,615,000
BUS COST	$1,577,000
RETAINED EARNINGS	$2,038,000

The projected annual revenues in Table 2 are based on 2016 hourly traffic data gathered from UDOT and assume that single vehicle traffic will be reduced by 30%. (This is a reasonable estimate based on the results of other variable tolling systems. London, for example, saw a 30% drop in traffic when implementing a similar system [11].) The projection above also assumes that the majority of the 30% decline of users will be using the bus, instead of single vehicles. For this reason, the yearly cost of bussing those users has been included in calculating retained earnings.

Even when factoring in the effects that additional buses might have on traffic flow, it was calculated that the variable tolling system might increase the capacity of the road by about 29% using the methodology outlined in the 2010 Highway Capacity Manual [12]. The total retained earnings from tolling including the costs for a 30% increase in bus service is approximately $2.038 M (Table 2).

Another pricing model was evaluated where tolls would only be collected on weekends (i.e., (Friday to Sunday). Table 3 shows estimates for this model using the same pricing information provided in Table 1, and also an expected 30% reduction in weekend traffic from implementation of tolling.

Table 3: Annual Revenues (Weekend Only)

REVENUE	$2,330,000
COST	$881,000
RETAINED EARNINGS	$1,449,000

It is interesting to note that while tolling and bussing are only in place for three days of the week for this model, estimated total retained earnings is still about 71% of that realized for the 7 day a week model. From this, we conclude that tolling/bussing only on the weekends is also a viable and profitable solution, especially when considering that most of the intense congestion usually occurs on the weekends rather than on routine weekdays.

To estimate the future transportation demand in BCC, the traffic growth rate from 2011 to 2015 was averaged which resulted in a growth rate of about 7% (Table 4). This annual growth rate was subsequently used to project future growth for the years 2020 to 2040. If the traffic demand in the canyon grows by 7% per annum, the number of visitors to BCC in year 2040 is estimated to be about 28,000 vehicles per day. This projected growth is somewhat unreasonable, because the canyon roadway, as currently configured, cannot accommodate this level of traffic and maintain Level C service. Since the 7% growth estimate is somewhat high, a less aggressive 2% per annum growth rate was also evaluated (Table 5). Based on this estimate, the year 2040 AADT count is approximately 8,500 vehicles per day. This is a less aggressive estimate of future growth, nonetheless it still produces a very significant increase in traffic by year 2040.

Table 4: 7% Growth Rate Calculations

YEAR	AADT	% INC
2011	3840	--
2012	4045	5%
2013	4170	3%
2014	4500	7%
2015	5160	13%
5 Yr Avg Growth		7%
PREDICTION (at 7%)		
YEAR	AADT	
2020	7253	
2025	10196	
2030	14332	
2035	20145	
2040	28317	

Table 5: 2% Growth Rate Calculations

YEAR	AADT
2011	3840
2012	4045
2013	4170
2014	4500
2015	5160
Estimate growth	2%
YEAR	AADT (predicted)
2020	5697
2025	6290
2030	6945
2035	7667
2040	8466

Ultimately, future revenue projections were calculated using a 2% growth rate for 7-day tolling model (Table 6) and a weekend only tolling model (Table 7). These estimates include the variable price pricing from Table 1, a 30% traffic reduction due to busing, and assuming those same users would ride the bus. The 2040 and 2050 year revenue projections using a basic exponential growth equation varied between $2.8 M to $4 M for each model, respectively.

Table 6: Revenue Projections (7-Day)

7-Day Model	2016	2040	2050
Revenue	$3.62 M	$5.82 M	$4.00 M
Bus Cost	$1.58 M	$2.54 M	$3.10 M
Retained Earnings	$2.0 M	$3.28 M	$4.00 M

Table 7: Revenue Projections (Weekend Only)

Weekend Only Model	2016	2040	2050
Revenue	$2.33 M	$3.75 M	$4.57 M
Bus Cost	$881 K	$1.42 M	$1.73 M
Retained Earnings	$1.45 M	$2.33 M	$2.84 M

1.3.2 Tolling System Technology

To enact a variable toll, it is recommended that a tolling gantry be installed at the mouth of the canyon to read users' license plates with a camera and sensors. Gantries can have a variety of appearances; because of the natural environs in Big Cottonwood canyon and the two lane highway it would span, the proposed gantry will be as minimalistic in appearance and presence, as possible. The construction of the gantry is not a large project; however, because construction will require alterations and disruption of the environment, it may require NEPA permitting.

Several methods of enacting the toll were also considered. A booth system would not be capable of handling the volumes the canyon experiences. In contrast, a camera scanning system would not impede traffic flow into the canyon, however, a camera scanning system comes with its own obstacles.

Figure 1: Gantry for Tolling System [13]

A gantry system similar to that shown in Figure 1 would allow users to quickly and conveniently pay fees without delaying their travel up BCC. The initial capital costs for two tolling gantries, required equipment, and supporting systems was estimated to be about $1M ($0.5 M per gantry) with an estimated operations and maintenance cost of 30% of initial capital costs or $0.3 M per year. This latter cost includes costs associated with the payment system, data management, enforcement, technician support, etc. [14][15].

1.3.3 Utah Law and Automatic License Plate Reader Systems

According to State Bill SB 222 in 41-6a-2003 an automatic license plate reader system may not be used by a governmental entity, except as provided in Subsection (2). In this subsection, a governmental entity is allowed to use a plate reader if:

(a) by a law enforcement agency for the purpose of protecting public safety, conducting criminal investigations, or ensuring compliance with local, state, and federal laws;

(b) by a governmental parking enforcement entity for the purpose of enforcing state and local parking laws;

(c) by a parking enforcement entity for regulating the use of a parking facility;

(d) for the purpose of controlling access to a secured area;

(e) for the purpose of collecting an electronic toll; or

(f) for the purpose of enforcing motor carrier laws [16].

By Utah law, installing an electronic tolling system would be allowable. According to that stated above, a government entity is allowed to use an Automatic License Plate Reader to collect license plate data for tolling purposes. License plate data “may not be preserved for any purpose other than those described in Section 41-6a-2003” [16]. In other words, in the initial process of getting tolling approved for Big Cottonwood Canyon, a purpose for the tolling must be specified and the data collected cannot be used or shared except as specified in that original purpose. Furthermore, the plate data cannot be retained for more than nine months unless otherwise specified in 41-6a-2004-1c. Further evaluations may be required to insure that all pertinent Utah laws are met regarding the proposed tolling system and the collection of fees and data therefrom.

1.4 Transit

UTA currently operates all bus service in the canyon. This service is limited to the winter months (late November to early April) and runs from various points in the Salt Lake Valley to Solitude and Brighton Ski Resorts.

1.4.1 Bus Service Expansion

We recommend that UTA, or another entity, be contracted to provide expanded summer bus service within the canyon so that the buses can more efficiently act as a shuttle system. The proposed route would run from the mouth of the canyon (Park-N-Ride) to the Brighton main parking lot and return to the Park-N-Ride. In addition, it is also possible to create additional routes that run from various points in the Salt Lake Valley to the mouth of the canyon; however these routes should be separate from the canyon routes to minimize schedule inconsistencies within the canyon. Bus service expansion through the summer will allow individuals to access the canyon when there is no legal parking available. This plan also recommends that bus service in the canyon be provided at no cost to users to further encourage users to forego their individual vehicles. It is recommended that the bus service provider be compensated for all expenses relating to the summer canyon routes by using the revenue generated from the tolling system. In this way, the users paying the tolls will be able to see one of the canyon improvements the toll is facilitating.

1.4.2 Bus Stops

There are currently eleven existing, signed bus stop locations throughout the canyon. These locations include the Park-N-Ride at the bottom of the canyon, Donut Falls area, Spruces campground, Silver Fork Lodge, Solitude Ski Resort, Solitude Nordic Center and Brighton Ski Resort. Stops are found on either side of the road with the exception of the Park & Ride, Solitude and the Brighton Loop. Figure 1 shows the location of both existing and proposed bus stops within the canyon. It is proposed that construction for the S-curve stop (marked as “high priority” in the figure legend) begin during Phase 2 of construction. It is also proposed that construction for the stops marked as “potential stops” begin in Phase 3 of construction. This is because these latter stops were determined to be helpful to the successful operation of a summer bus route, but not considered essential. Please see Appendix II for additional proposed construction phasing details.

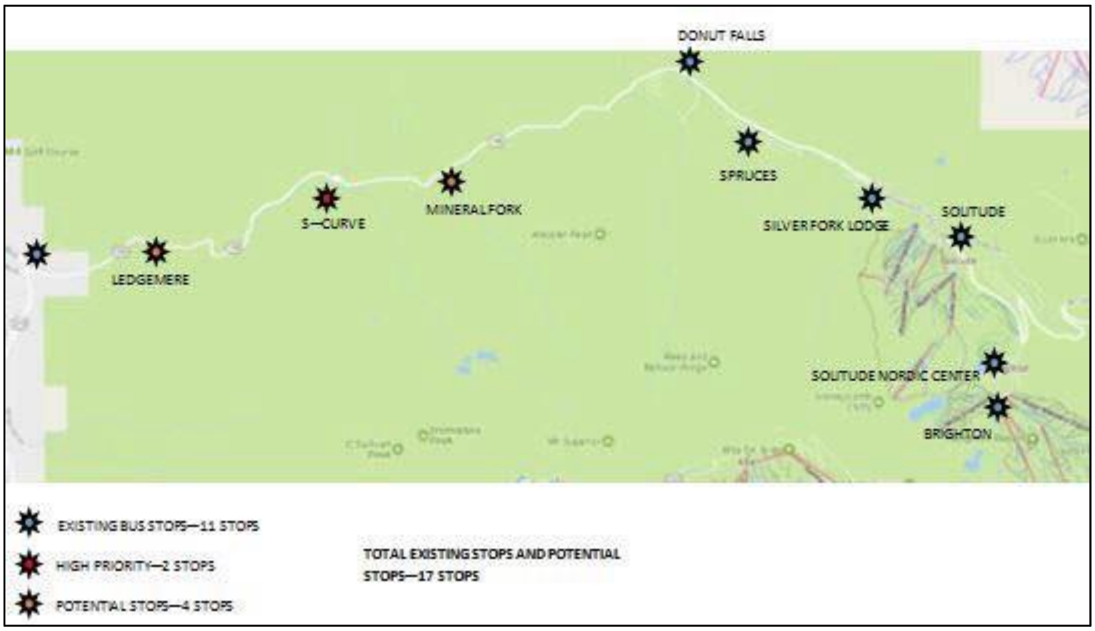


Figure 2: Bus Stop Locations

To determine the locations most useful as bus stops, satellite data from Friday July 8, 2016 was used to count the number of cars parked along the side of Utah State Route 190 (Big Cottonwood Scenic Byway) and in each lot except the Solitude lot and the Brighton lots. The number of available parking spots in each area was also estimated. Some areas included dirt pullouts that did not have distinct names. These spots are referred to as “Unnamed Area” in Table 1 in Appendix III. Spot counts for the Solitude and Brighton lots were determined from satellite data from Monday January 1, 2007, however this data may be unreliable because it was taken more than 10 years ago, and conditions in the canyon may have changed.

Target bus stop locations were then determined based on the number of cars parked at the site versus the number of parking spots available and the presumed use of the sites. Table 1 in Appendix III shows this data for all locations with more than 4 cars parked in parking pullouts or at least two cars parked on the road. If the predominant use of the site did not lend itself to busing, a stop was not recommended for the site. For example, if sites were primarily used for climbing or fishing access, the additional equipment requirements of the activity were taken as a disincentive to use public transit. Figure 1 in Appendix III shows all stops of interest, including those that were primarily identified as fishing or outdoor climbing access.

ADA compliance was not a requirement at the time the existing bus stops in the canyon were constructed, therefore they do not currently meet these requirements. However, if a bus stop were to be added at the S-curve, it would need to be ADA and safety compliant. Creating a bus stop at the S-curve is an involved project that requires a great deal of design, roadway expansion, and time to complete a NEPA process. This expansion will most likely require excavation and slope retaining. The S-curve is a dangerous area for pedestrians, and the installation of a bus stop will most likely increase the amount of pedestrians in the area. This potential increase therefore leads to an additional recommendation that a lighted crosswalk be installed on the downhill side of the curve. Also, it should be noted that construction in this vicinity will significantly reduce roadway capacity and operations for a short period of time.

It is also recommended that bus stops be constructed at two locations in addition to the previously mentioned S-curve stop. These stops will be at the Ledgemere picnic grounds and at the Mineral Fork hiking area. Both of these locations were identified as areas of need due to the popularity of the area and a lack of available parking. Each will have paved and signed pullouts on both sides of the road. This will bring the total number of signed bus stops in the canyon to 17. Aerial views of the proposed locations are included in Appendix I (Figures 2-4).

1.5 Parking

The canyon does not have the parking infrastructure to support the number of visitors it receives. This problem will worsen as the Salt Lake Metropolitan Area grows and a greater number of people have access to the canyon. In order to make the canyon safer for its users, it is recommended that current roadside parking be greatly reduced, if not eliminated, and the primary parking lots in the canyon be expanded. These improvements are required to continue to allow visitors to appreciate the canyon as a beautiful outdoor recreational space.

1.5.1 Parking Enforcement

Shoulder vehicular parking throughout the canyon is problematic. This safety by taking away space for cyclists and pedestrians using the canyon by severely reducing visibility and blocking biking pathways. Future restrictions on roadside parking should be communicated through the installation of signage informing users that parking is limited to designated lots. In addition, parking enforcement in the canyon is currently limited to areas where there is signage prohibiting parking, which is only the case for a short stretch of road. Parking is not enforced in areas like the S-curve, which can become dangerous if overcrowded. While current parking enforcement is carried out by the Unified Police Department (UPD), additional resources may be required for more comprehensive and involved parking enforcement. It is recommended that dedicated, and perhaps privatized, parking enforcement become an essential component of the proposed parking strategy. Nonetheless, the parking services and enforcement must be controlled by an agency with appropriate jurisdictional authority, whether it is the U.S. Forest Service, UPD, or a designated third party.

The purpose of parking enforcement is to improve safety and reduce congestion while also potentially providing additional revenues for maintaining parking facilities. Table 8 is an example of a potential fee (i.e., fine) schedule, and the terms therein for violations are taken from the Utah Vehicle Code (i.e., Uniform Fine/Bail Forfeiture Schedule, May 10, 2016).

Parking enforcement and fees goals/rules:

- Ensure that regulation enforcement is efficient, considerate and fair.
- Due to limited parking in the canyon, parking regulations are strictly enforced all day including holidays.
- Vehicles are not allowed to stay overnight unless in designated camping areas.
- Every vehicle must be parked in a designated area.

Table 8: Example Fee Schedule

VIOLATION	FINE AMOUNT	LATE PENALTY
No Parking	$55	$18
Double Parking	$30	$10
Obstruction of Roadway	$100	$25
Restricted Area	$55	$10
Fire Hazard	$200	$15
Overnight Parking	$50	$10
Parking in Area Not Designated	$50	$10
Parking in Space for Disabled	$250	$25
Blocking Space for Disabled	$250	$25
Parking on a Crosshatched Line	$250	$25
Animal in Prohibited Area	$130	$13
Insufficient or no Muffler	$170	$20
Removing or Damaging Street Road	$680	$68
Others		

Table 8 is an example of fines that might be applied in the canyon based on those from the University of California Santa Cruz Police Department [2] and City of Boston: Parking Ticket Fines and Codes [3]. The enacted fine schedule would ultimately be subjected to approval by the appropriate jurisdictions.

1.5.2 Parking Outside BCC

The current U.S. Forest Service management plan limits the total number of parking spots allowed in the canyon as a way to limit visitor impacts on the canyon environment. However, legal parking within the canyon is already reaching capacity on peak days. There currently exists multiple Park-N-Ride lots outside the canyon including locations at 6200 S. Wasatch Blvd., the Swamp Lot, and the Fort Union Pullout. The Avenues Consulting group suggested, in their Cottonwood Canyons Parking Study, expanding current parking facilities outside the canyon as well as constructing additional parking at the gravel pit. Cost estimates and details of these improvements can be found in their study [4]. Shuttle service into the canyon has also been linked to existing bus routes, TRAX stations, and high priority locations like the University of Utah and City Creek. Our study highly recommends continuing shuttle service to locations outside the canyon, as well as expanding this service to the summer seasons on holidays and weekends as needed. Expanding parking for bus stops outside the canyon should also be a priority whether this means additional construction or cooperation with organizations with existing parking facilities such as local schools or businesses.

1.5.3 Lot Restriping

We believe that parking capacity could be increased in several ways; it was determined that the most expeditious and cost-effective way to increase parking is to restripe the existing lots rather than expand the lot footprints. Many of the lots are striped inefficiently, and a preliminary estimate showed that lot capacity could be increased by up to 25%. For more details on this estimate, please see Appendix B. In comparison, lot expansion would probably involve a NEPA process before construction. A more immediate solution is desired, therefore restriping the lots is a more viable, short-term solution to the current problem. The lots recommended for restriping are: Park-N-Ride at the mouth of the canyon, S-curve lower lot, Donut Falls lot, and Solitude and Brighton ski resort lots. All recommended stalls have a typical 9-foot width and a minimum of 18-foot length. Drawings for the proposed striping plans for each site can be found in Appendix I. The estimation of the costs for these improvements considered striping, heavy duty paving and road base, sawcut (used to blend existing asphalt to new asphalt), and asphalt curbing. The total cost estimate for Phase 1 improvements is approximately $1.67 M for material and construction costs, and details can be found in Appendix II.

However, parking capacity in the canyon will most likely need to be increased once again before year 2040 is reached due to projected growth. Thus, it is also recommended that the footprint of some existing parking lots be expanded to allow more space at some future point as a long-term parking solution.

1.5.4 Signage

In order to encourage more efficient parking throughout the canyon, it is recommended that a system of parking signs be installed giving drivers a real-time count of parking spots that are available. This system would require the installation of magnetic detectors to identify the number of spots available in each lot as well as signage at the mouth of the canyon displaying those numbers to drivers. This sign would monitor and display parking availability for 4 different areas of parking: Brighton, Solitude, the S-curve area, and the Park and Ride parking lot(s). In the design of these signs, a point would be made to achieve a balance between aesthetics and functionality. A sign might look similar to that shown in Figure 3. We estimate that this parking availability system has a lump sum cost of $0.350 M for initial installation and capital costs [5], followed by an estimated operations and maintenance cost of $3.8 K per year for electricity and technician support [6].

Figure 3: Signage for Parking Availability

In addition to providing BCC users with timely information on parking availability, it is recommended that signage similar to that shown in Appendix I be installed to clearly delineate where users can or cannot park. This allows for more direct and accurate communication between enforcement and users. Regulatory signage facilitates safer conditions for pedestrians as well as vehicles and cyclists while improving traffic flow. This signage is particularly needed in the S-curve area, as it is a major area of traffic interference with pedestrians and cyclists.

2 BIG COTTONWOOD CANYON: ROADWAYS AND TRAILS

2.1 Background

The Roadways and Trails team specifically focused on improving safety between cyclists, pedestrians, and motorized vehicles. Conflicts within the canyon have warranted immediate intervention to ensure safety. Tables 1 and 2 below show a detailed report from Mountain Accord of crash statistics in the canyon. It is estimated that 376 crashes have occurred in Big Cottonwood Canyon since the canyon allowed public vehicle access. Of these 376 crashes, 14 were considered severe and 3 were fatal [1]. This high-conflict environment inspired solutions that mediate pedestrians, cyclists, and vehicular interaction to increase safety for all users in the canyon.

Table 9: Total Crashes and Crash Rate Summary (UDOT)

Total Crashes and Crash Rate Summary			
Canyon	Total Crashes	Crashes/year per mile	Crashes/year per MVMT
Parleys	1312	16.8	1.01
Big Cottonwood	376	5	4.82
Little Cottonwood	292	6	3.45

MVMT = Million Vehicle Miles Traveled

Table 10: Severe Crashes and Crash Rate Summary

Severe Crashes and Crash Rate Summary					
Canyon	Severe Injury Crashes	Fatal Crashes	Total Severe Crashes	Severe Crashes/year per mile	Severe Crashes/ year per HMVMT
Parleys	32	10	42	0.54	3.2
Big Cottonwood	14	3	17	0.23	21.8
Little Cottonwood	14	3	17	0.35	20.1

After identifying critical locations throughout the canyon, namely the S-Curve, and any blind corners without adequate shoulder width, the team designed an overall plan of proposed safety improvements.

2.2 Options

Options explored for the Preliminary Engineering Report included, but were not limited to:

- Electronic pedestrian crossing signs in problem areas
- Bicycle lane restriping and possible barrier placements for safety
- Shoulder expansion for areas with inadequate shoulder width for pedestrian safety
- Pedestrian bridge off Lake Blanche Trail to redirect pedestrian traffic through S-Curve
- 'Adopt A Trail' in high traffic hiking locations to control trail erosion

These proposals were selected based on design criteria and stakeholder inputs during the previous alternatives study phase (Appendix B). The goal of each option is to improve the safety of the canyon and give solutions that can be implemented within a reasonable timeframe. Proposals were designed for minimal impact to the watershed in order to streamline future environmental assessments or environmental impact statements as required by a potential NEPA process.

Each proposal was broken down into a detailed 3 phase system, which allows for each option to be implemented as funds become available.

2.3 Phase 1: Signage, Crosswalks, Adopt-A-Trail

The first phasing process was designed for immediate implementation within a 2 to 6 month construction time. The elements within this phase include a series of electronic, flashing pedestrian crossing signs that will alert drivers to where pedestrians are looking to cross. The proposed locations are:

- Crossing Utah SR-190 from North to South parking lots at Donut Falls Hiking Trail access points (40°38'58.36" N 111°38'53.23" W)
- Crossing Utah SR-190 from North to South parking lots at Silver Fork Lodge (40°38'01.71" N 111°36'43.31" W)

These locations accommodate the recommendations of the BCC3T Traffic and Parking team while addressing the most immediate safety concerns.

All signage will be implemented according to UDOT specifications, which includes a pre-crosswalk sign 90 feet from the actual location of the crosswalk and lowering the speed limit within 200 feet of these crosswalks to 35 mph [2]. This decrease in speed will allow for a safer crossing for pedestrians.

We propose that the electronic pedestrian signs include a radio transmitter that will alert all signs at that location to flash simultaneously. This radio transmitter will eliminate the need to excavate into the existing road to lay wires. All signs will be solar powered with a capacitor to store energy for use at night. This solar addition will eliminate use of the local power supply. Both design options will reduce construction time. The solar option will ensure that power costs are kept to a minimum.

This process will also include road striping for the pedestrian crossing areas and new striping to differentiate the dedicated bicycle paths up the canyon. In troublesome areas, we propose that concrete barriers be added to the shoulders to help ensure the safety and ease of access for bicyclists and pedestrians on foot.

This initial phase also includes an “Adopt-A-Trail” approach to road and hiking trail maintenance. Borrowing from the premise of the “Adopt-A-Highway” idea, local businesses and bicycle clubs would be tasked to take care of a certain section of road or trail. These companies and clubs would receive the opportunity of having their name on a ‘Taken Care By’ sign that would adorn that specific stretch of trail/road (Figure 4).

Figure 4: Adopt-A-Trail Sign

The sections of roadway that stretch along Utah SR-190 have been divided to accommodate a maximum of 20 bicycle clubs, approximately 1 per mile. The hiking trail assignments will be based on the popularity of the trail. For instance, Donut Falls, a very popular hike along the Big Cottonwood Canyon road, may have as many as 4 businesses assigned to trail maintenance. Each organization will be tasked to hike the trail once a month, for the months of April through October. As with less popular trails like the Lake Blanche Trail, 2 teams will be tasked to hike, each twice a year, for the months of April through October. An email was sent out to local businesses and bicycling clubs to gauge interest in this objective. Preliminary outreach has proven to be promising and many local organizations appear to be enthusiastic about participating in this, or a similar program.

Table 11 details the approximate costs of Phase 1, which has a total cost of about $0.4 M.

Table 11: Phase 1 Construction Costs

Phase 1			
Requirements	**Cost per Unit**	**Number of Units**	**Total Cost**
Electronic Speed Indicators [3]	$3,125	3	$9,375.00
Striping [3]	$2.39/ft	14.7 mi	$185,502
Pedestrian Crossing Signs [3]	$10,000.00	6	$60,000
Concrete Barriers [3]	$45.24/ft	200	$9,048
Convex Site Mirrors [3]	$150	4	$600
Construction	$3,000/day	5	$15,000
		Sub Total	$279,525
Maintenance	5%	every 3 years	$13,976.26
		Total (30 yr)	$405,312

2.4 Phase 2: Geofoam Shoulder Expansion

The second phase of our analysis included an assessment of vehicle-pedestrian interferences. The team visited Utah SR-190 to identify problem areas within the canyon. Identified on this trip was the lack of adequate shoulder space for bicyclists to safely maneuver. Subsequently, the team evaluated a shoulder expansion that would allow for a 6-foot widening, as well as a construction process that would eliminate the need for trucks or equipment to operate within the watershed. Further, it is proposed that the support for this shoulder expansion be made of expanded polystyrene (EPS) which is commercially known as geofoam. This light-weight embankment material has been adapted for highway infrastructure use statewide including the I-15 and I-80 reconstruction projects that took place in preparation for the Winter Olympics in 2002 [4]. Geofoam is a lightweight, recyclable material that can be cut to fit any desired shape and has sufficient strength to support vehicular traffic

[5]. Geofoam embankment will allow for an efficient, durable, and long-term performance when incorporated with the lane expansion design (Figure 5). Figure 6 shows how the recommended Geofoam inlay fill will be placed into the existing slope, as well as the support columns, fencing, and barrier configurations. This recommended design typical should be modified to fit the site conditions. Modifications may include variable slopes and use of higher density Geofoam at bus pullout locations. Please refer to Appendix 3 for additional drawings and calculations.

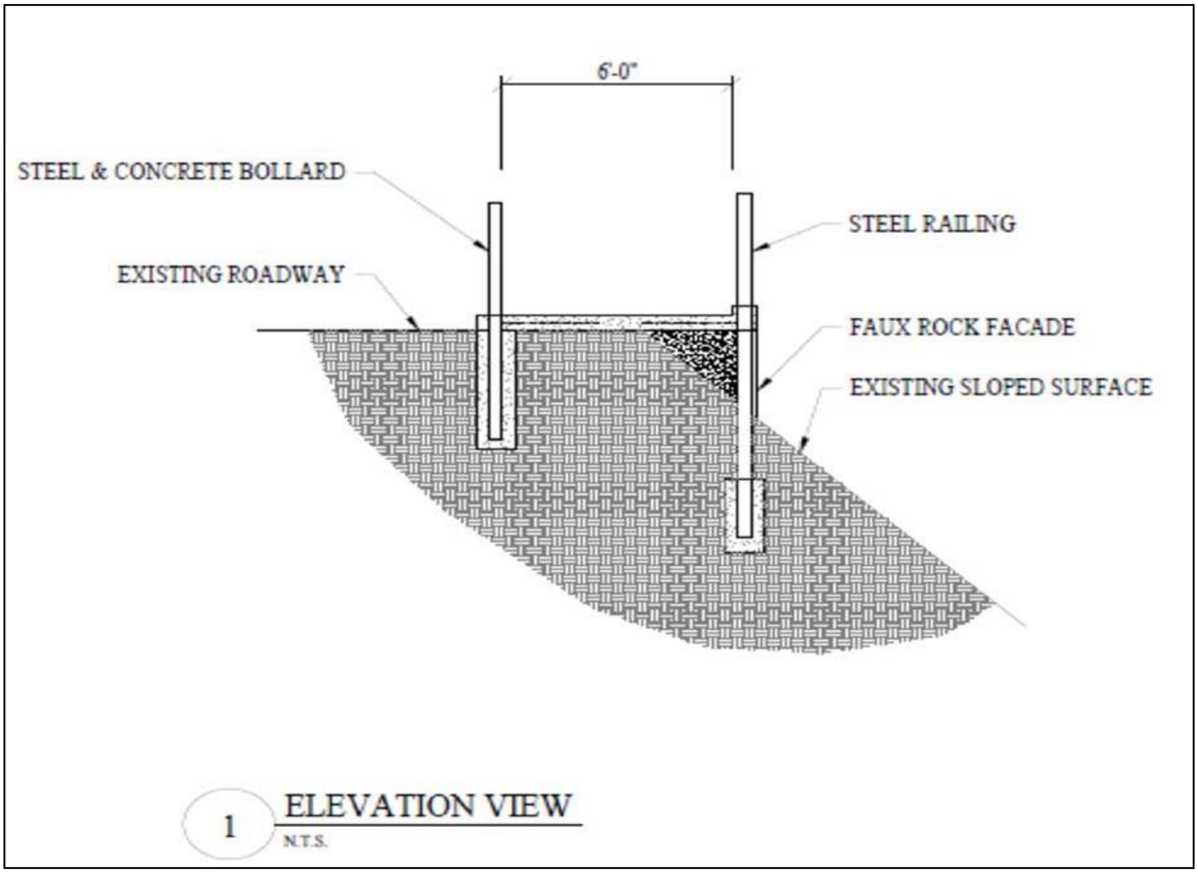


Figure 5: Typical Cross-Section of Geofoam Shoulder Expansion

The above typical cross-section can be adjusted to fit most slopes, and to hold any desired weight simply by increasing the density of the polystyrene, increasing the thickness of the concrete slab, and embedment length of the lateral support posts. Such adjustments will most likely be required for any road widening or expansion in proposed pull-off areas. Additional adjustment to the typical section, including the replacement of Geofoam with Gabion baskets may be required in areas where stream erosion is possible to the roadway shoulder. The proposed locations of the shoulder widening are:

- First blind corner East of S-Curve (40°37'59.00" N, 111°43'22.35" W)
- Second blind corner East of S-Curve (40°38'35.22" N, 111°42'21.93" W)

Other locations were identified as candidates pending the availability of funds. The cost of expanding the shoulder using this design is variable, depending on location as shown in Table 12).

Prior to final design and construction, the soil or rock conditions must be determined at the proposed sites. The ground conditions affect the techniques used to install the supporting columns in the slope, and whether or not concrete is needed to anchor the columns into the slope (Figures 5 and 6). The type of drilling required for imbedding the columns will vary from a simple auger drill for sandy soil, and a rock drill, if bedrock is encountered. Once the supporting columns are in place, the slope may need minor grading and installation of a bedding sand prior to placement of the Geofoam blocks. These blocks can then be placed on the prepared slope. The Geofoam will be capped and protected on the top surface by a reinforced concrete slab, and faced with faux rock façade, most likely constructed of colored shot-crete, or pre-cast concrete panels. The system will be finished with a tensioned cable fence, attached to the columns, to provide fall protection for pedestrians and cyclists (Figure 6). Depending on location and other geometric constraints, the path will be separated from the roadway using:

- Moveable concrete barriers for snow removal convenience.
- Moveable steel and concrete bollards for snow removal convenience.
- Lay flat plastic posts (less demanding locations).

Table 12: Phase 2 Construction Costs

Phase 2			
Requirements	**Cost per Unit**	**Number of Units**	**Total Cost**
Pedestrian Railing (Steel Posts w/ Steel Cables)[6]	$800/8ft section	75	$60,000
Geofoam [7]	$75/cy	500	$37,500
Concrete Slab [8]	$90/cy	37	$3,333
Rebar [9]	$0.75/ft	1000	$750
Shotcrete [10]	$5.5/sq.ft	3000	$16,500
Bollard [11]	$925.77/bollard	50	$46,288
Construction	$5,000/day	10	$50,000
		Sub Total	$214,372
Maintenance	5%	every 3 years	$10,718.58
		Total (30 yr)	$310,839

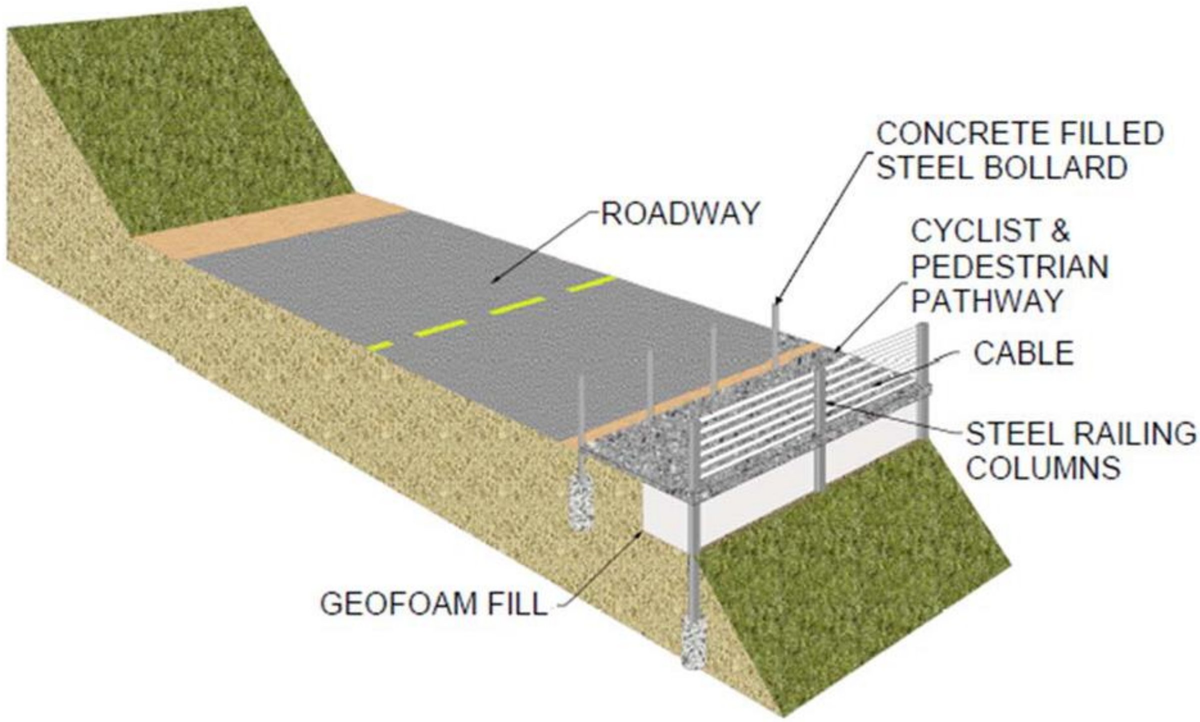


Figure 6: Schematic of Typical Section

2.5 Phase 3: S-Curve Transit Split

Lastly, the implementation of Phase III of recommended roadway and trail improvements may be necessary to provide additional safety and protection to pedestrians and cyclists along the most treacherous locations on Utah SR-190. It is recommended that this be accomplished in the S-Curve area by completely removing cyclists from the roadway. This separation requires a bypass that would take the cyclists and pedestrians off the roadway in the S-Curve, and onto the Lake Blanche trail (Figure 7). This already paved trail would require only a minimal amount of improvements in order to accommodate the bypass. The bypass could be reconnected to the roadway above the S-Curve via a pedestrian bridge that crosses Big Cottonwood Creek (Figure 7, yellow line). The red line in this figure delineates the pathway alignment which shows where the pathway would leave the roadway at the bottom of the S-Curve. The proposed trail path continues eastward where a recommended bridge (yellow line) would cross the stream and reconnect to the roadway. Lastly, is recommended that the bridge be constructed of prefabricated steel trusses, which would allow easy assembly and minimize construction time. The bridge could have a natural rock façade for aesthetical purposes to better match the environment of the canyon. Additional conceptual details and information about the bridge are given in Appendix B.

Figure 7: Existing Trail (red) and Proposed Bridge Location (yellow).

Table 13 itemizes the estimated total costs for Phase III. Costs identified for 'Bridge Fabrication' are a lump cost for the metal truss for the recommended bridge. The 'Environmental Requirements' under the 'Special Construction' category refers to any additional design or equipment needed to protect the watershed from construction debris.

Table 13: Phase 3 Costs

Phase 3			
Requirements	**Cost per Unit**	**Number of Units**	**Total Cost**
Concrete Abutments [12]	$90/cy	~100	$9,000
Bridge Fabrication [13]			$50,000
Special Construction	*(Equipment, Environmental Req'ts,etc.)*		$200,000
South Abutment			
Concrete [14]	$100/cy	~40	$4,000
Back Fill [15]	$15/cy	~110	$1,650
North Abutment			
Concrete [14]	$100/cy	~5	$500
HSS10x4x.5 x20 [16]	~$1/lb	~841	$841
Construction	$7,000/day	40	$280,000
		Sub Total	$545,991
Maintenance	5%	every 3 years	$27,299.55
		Total (30 yr)	$791,687

3 BIG COTTONWOOD CANYON: ENVIRONMENTAL AND SANITATION

3.1 Background

Preserving water resources in BCC is not only a significant environmental issue, but one of public health and safety. Preemptive measures to address potential water contamination and other environmental impacts are of key importance for the long-term preservation and use of the canyon. Per the USFS *Watershed Condition Framework* [1], Big Cottonwood Canyon is classified as a watershed "functioning at risk.' For Big Cottonwood Canyon, risks were primarily attributed to increased foot and vehicular traffic.

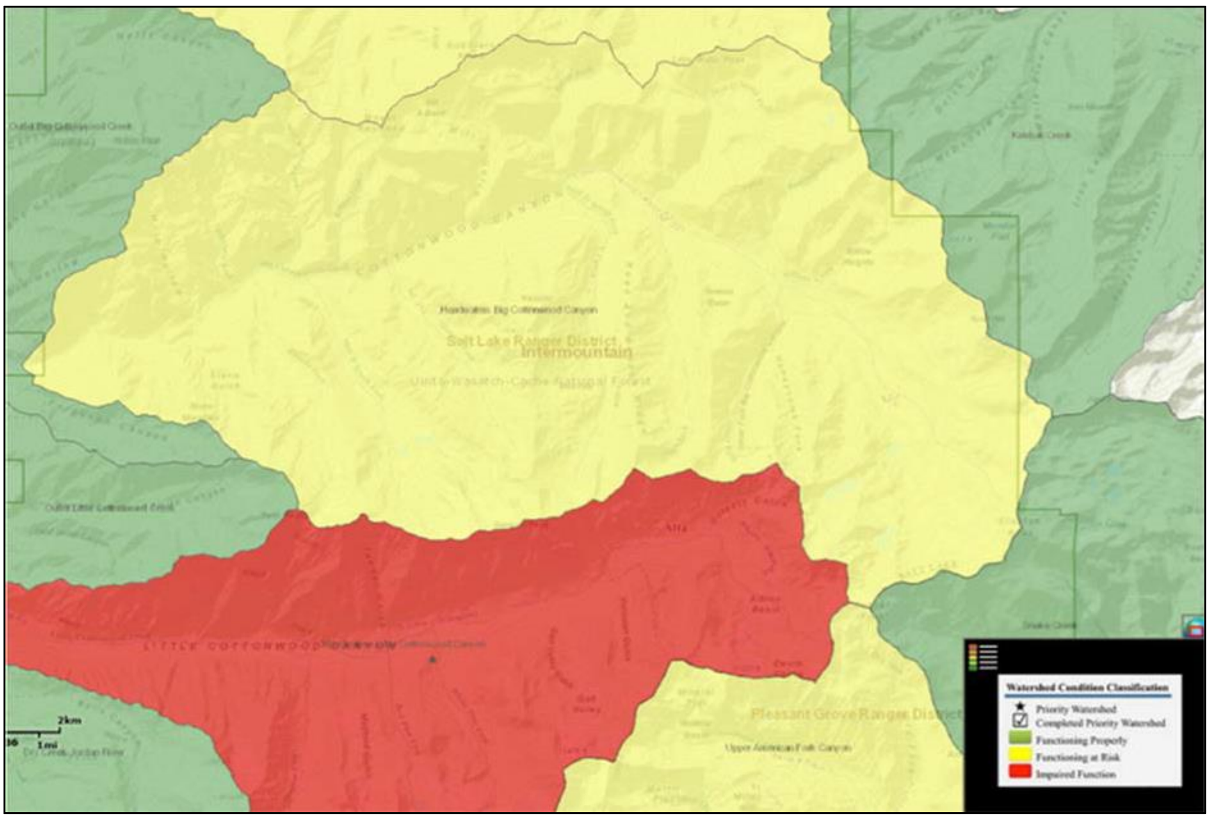


Figure 8: U.S. Forest Service Watershed Conditions for Big and Little Cottonwood Canyons

The expansion of sanitation facilities throughout the canyon is a major aspiration for many of the primary stakeholders. Improved facilities will enhance the users' experience in the canyon and preserve natural resources, while meeting current and projected needs. Constructing new restroom facilities will provide an affordable solution that will minimize the long-term impacts facing the city's water supply, as improving sanitation would prevent negative impacts on health for residents who rely on the canyon for their drinking water.

We proposed that increasing the number of stalls throughout the canyon at new and existing locations is the most effective way to protect the future integrity of the watershed. In addition, the number of these additions and improvements can be scaled to meet project limitations and budget. Several different options for restrooms, both vault and sewer connected, are available and were evaluated. Documentation of the projected associated costs and aesthetic design are provided in Appendix IV. However, the assessment herein in preliminary; additional information and data are needed to assess fully the areas with the greatest immediate need; hence a pilot study is recommended, as discussed in the next section.

3.2 Phase 1: Pilot Study

A Big Cottonwood Canyon Pilot Study consisting of a sample set of existing and prospective locations throughout the canyon will provide valuable information on frequency of usage. It is proposed that 10 locations be selected (i.e., Donut Falls, Mill B-S Curve, Silver Lake, Cardiff/Mill D, Willow Heights, Butler Fork, Guardsman's Pass, Lake Mary Trailhead, Dogwood Climbers' Area, and Storm Mountain Climbers' Area) and monitored over a one year test period using portable toilet facilities. The one-year duration will allow for the documentation of the effect of seasonal variability on usage during both summer and winter months.

It is proposed that usage frequency data be gathered and compiled using people counting systems. These devices are widely used in the retail industry to assess trends in visitation and use (Figure 9). This same concept can be applied to restrooms; each time someone enters a facility they will be counted by the device. Models that do not require wireless data are available and would require regular downloading of data by those conducting the study. Despite this limitation, these models may be more desirable for the study because wireless coverage is limited in the canyon and could result in data loss. These counters are made to withstand variable environmental conditions and may be mounted in an inconspicuous location. Most models have a battery life of approximately two years and would require minimal maintenance during the survey.

Figure 9: People Counting Device [1]

An additional benefit of conducting the usage survey is that the sanitation needs in the canyon could be temporarily addressed during the first year of tolling operations. Following the study, revenues from the variable tolling would be available to construct the first phase of restrooms. The primary costs associated with this study are the rental and maintenance of the portable units, which amounts to approximately $11 K per entire year. In addition, other costs for this study would be the purchase of 10 counters at an additional estimated cost $2.7 K [2].

Usage studies, similar to that proposed, have been conducted in other areas of the U.S. to address sanitation concerns. One notable example is the Denver Public Restroom Pilot Program. This study began in 2016 [2], and focuses on collecting data for public restroom usage, with the main intent of determining optimal locations for future expansion. Mobile facilities have been placed at strategic locations around the city, in areas with high suitability criteria. However, the cost of each facility is approximately $12 K per month. About $6 K is allocated to an attendant that maintains cleanliness and collects data [2]. However, the pilot study proposed for the BCC accomplishes many of the same goals at a much lower cost, on a scale appropriate for the canyon.

Following the pilot study, the 10 monitored areas would be ranked by usage volumes and the data collected from the SensMax counters. Once the 10 areas have been prioritized, an approximate 10-year construction cycle could be programmed for the construction phasing of permanent restroom structures. It is recommend that this second phase begin with the placement of permanent structures at a few high priority locations throughout the canyon. Funds obtained from the implementation of tolling would be programmed and used to finance new facilities at these locations. Every few years, additional locations could be chosen for upgrades based on priority (Appendix IV). It is recommended that construction and evaluation be conducted over a ten-year period, increasing the current toilet count from 14 toilets to 58 toilets. The implementation of this phase might be expedited depending on the rate of revenue generation from tolling. If the projected revenue realized is approximately $1-2 M, construction of adequate facilities could be hastened significantly and would result in an overall project cost savings.

3.3 Phase 2: Construction at High Priority Sites

At the beginning of Phase 2, the key areas with the highest traffic congestion will be targeted for the programming and construction of new sanitation facilities. These will likely include Donut Falls and Mill B-S Curve locations. Currently, there is 1 vault toilet at Donut Falls and 2 sanitary sewer connected toilets at Mill B-S Curve. Based on our projections, we recommend that these 2 locations receive 5 vault toilets at Donut Falls and 4 toilets connected to the sanitary sewer at Mill B-S Curve.

3.4 Phase 3: 10-Year Construction Plan

Over the 10-year period encompassing Phase 2, it is recommended that additional toilet facility locations be determined from the prioritization system established from the Phase 1 Pilot Study, or determined based on prioritization provided by the Big Cottonwood Community Council. Preliminary recommendation of facilities and cost estimates for 2-year increments is as follows.

Years 1-2 will be used to plan to improve toilets at Donut Falls and Mill B-S Curve. It is recommended that Donut Falls receive 5 vault toilets. One of these will be a single unisex restroom with an estimated cost of approximately $23 K, and it is recommended that the other 4 vault toilets be placed into double units with 2 male and 2 female toilets costing approximately $68 K [3 & 4]. For the Mill B-S Curve, sanitation sewer connected toilets are required. Four toilets are recommended at this location placed in a single unit restroom facility. This will house 2 female stalls, 1 male stall, and 1 male urinal [7, & 8]. The approximate costs for Donut Falls and Mill B-S Curve are estimated to be $91 K and $157 K, respectively [3, 4, 7, & 8]. The approximate total for year 4 is estimated to be $248 K [3, 4, 7, & 8].

Years 3-4 will be used to improve toilets at Silver Lake and Cardiff/Mill D. It is recommended that both locations receive 4 toilets connected to the sanitary sewer comprising restroom facility housing 2 female stalls, 1 male stall, and 1 male urinal. The approximate cost for each location will be $157,000, and the approximate total for year 4 will be $314 K [7 & 8].

Years 4-6 will be used to improve toilets at Willow Heights and Butler Fork. It is recommended that both locations receive 4 sewer connected toilets comprising a restroom facility housing 2 female stalls, 1 male stall, and 1 male urinal. The approximate cost for each location will be $157 K, and the approximate total for year 6 will be $314 K [7 & 8].

Years 6-8 will be used improve toilets at Guardsman's Pass and Lake Mary Trailhead. It is anticipated that Guardsman's Pass will require 5 vault toilets, of which 1 vault toilet will be a single unisex restroom that costing approximately $23 K. It is recommended that the other 4 vault toilets be placed in double units with 2 male and 2 female toilets costing approximately $68 K [3 & 4]. Six (6) toilets are proposed at the Lake Mary Trailhead with a restroom facility housing 3 female stalls, 2 male stall, and 1 male urinal [7 & 8]. The approximate cost for Guardsman's Pass and Lake Mary Trailhead will be $91 K and $165 K, respectively [3, 4, 7, & 8]. The approximate total cost for year 8 will be $256 K [3, 4, 7, & 8].

Years 9-10 will be used to improve sanitary facilities at Dogwood Climbers' Area and Storm Mountain Climbers' Area. It is recommended that both locations receive 4 sewer connected toilets consisting of 1 unit restroom facility housing 2 female stalls, 1 male stall, and 1 male urinal. The approximate cost for each location is estimated to be $157 K, and the approximate total for year 10 is $314 K [7 & 8].

3.5 NEPA and Costs

The construction of these sanitation facilities may require environmental review in accordance with the National Environmental Policy Act (NEPA). However, if impacts are minimal, a categorical exclusion may be granted [5]. The U.S. Forest Service could be a valuable partner in navigating the NEPA process according to appropriate agency standards.

The proposed facilities will have a positive environmental impact by protecting the watershed from human waste. Given the supporting documentation from the Phase 1 Pilot Study, and if no extraordinary circumstances arise, it is hoped that a regulatory decision will be made relatively quickly. Similar facilities already exist throughout the canyon and restroom facility impacts are already well-understood by the Forest Service. The only potential significant impacts may arise from the construction of the facilities, primarily due to the placement of additional sewer lines at locations where sewer connections are planned. If any portion of the project is declined during the NEPA process, changes to the original project plans may result in a compromise acceptable to all stakeholders. Lastly, if variable tolling were implemented in Big Cottonwood Canyon, the revenues obtained therefrom could also be used for additional facility maintenance. An itemized cost breakdown of all proposed facilities is available in Appendix IV.

4 FINAL PHASING AND COST ANALYSIS

4.1 Summary

Each BCC3T design team completed a phase analysis of the recommended alternatives (Table 14). The projected timeline to complete all phases occurs over a 12-year implementation period having six phases. Implementation of variable tolling is a cornerstone of this plan and is the mechanism used to generate the revenues necessary to fund and maintain the improvements. The BCC3T Improvement Project team recommends that an initial investment in tolling (preliminary and phase 1) be made in order to generate the revenues necessary to proceed to general phase 2, where improvements to both trails and sanitation can be funded. Revenues generated by the tolling system would then be reinvested in Big Cottonwood Canyon to expand bus services, construct additional bus stops, and reduce congestion and conflicts on Big Cottonwood Canyon Road.

Table 14: Final Phasing Plan

Phase	Year	Traffic & Parking Improvements	Bridges & Trails Improvements	Sanitation Improvements	Cost
Prelim	1	Prelim		Case Study	$ 480k
1	2	Phase 1			$ 3.5 mil
2	4	Phase 2	Phase 1	Phase 1	$ 1.5 mil
3	6	Phase 3	Phase 2	Phase 2	$ 900k
4	8		Phase 3	Phase 3	$ 900k
5	10			Phase 4	$ 300k
6	12			Phase 5	$ 350k
Total					$ 7.93 mil

The total investment required over the 12 year period would be approximately $8 M. The BCC3T project team believes that variable tolling (i.e., congestion pricing) will provide a sustainable source of revenue while increasing transit ridership to an ambitious 30% of canyon visitors.

4.2 The Case for Variable Tolling

4.2.1 Peak Traffic

Big Cottonwood Canyon experiences concentrated peak traffic flows of greater than 600 cars per hour over just a few hours (Figure 10, left). A basic access fee would not appropriately respond to the user demand during non-peak hours. Access is one of the most valued characteristics of Big Cottonwood Canyon, and a $3 basic fee could potentially price out normal users while being too generous to have an effect on congestion during the most heavily trafficked periods of the day. A variable pricing scheme will allow most users to continue to access Big Cottonwood Canyon for free while encouraging visitors to carpool or take public transit during peak usage times. The ideal variable pricing structure would both reduce vehicles per hour to a sustainable number and also extend the “width” of the peak from two hours to three hours, or more, in order to reduce overall congestion and to improve the level of service of the roadway (Figure 10, right).

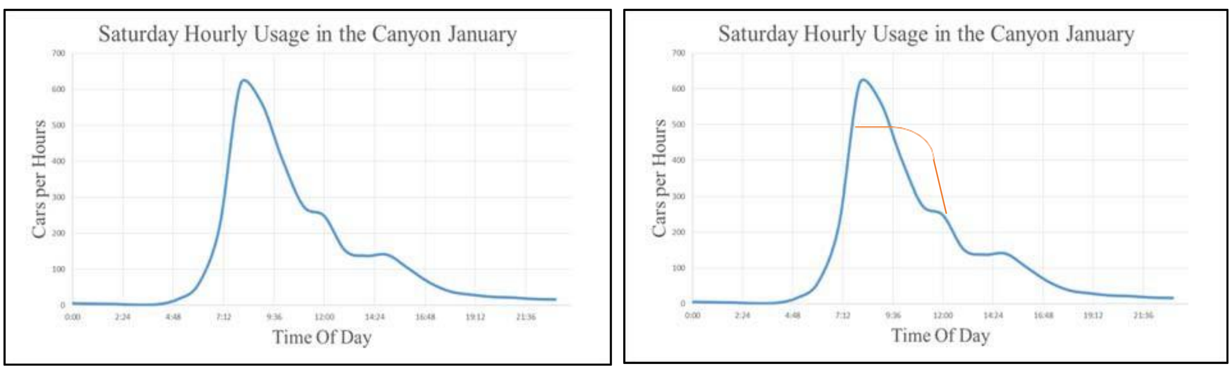


Figure 10: Typical BCC Traffic Saturday (Left) and Variable Tolling Concept (Right)

4.2.2 Cash flow Analysis

A preliminary cash flow analysis was conducted. This study estimates that the retained earnings of a weekend-only model would be approximately 71% of the earnings of a 7-Day model. This suggests that weekend-only congesting pricing and expanded bus service (Friday-Sunday) would be a viable option. Residents and stakeholders are generally familiar with the long waits to access Big Cottonwood Canyon on the weekends. A weekend-only model could potentially fund all the proposed improvements, mitigate the worst of the traffic congestion, and also be more acceptable to the general public. As the population of Salt Lake City and the Wasatch Front increases, it would also be possible to further adjust the variable pricing system to adapt to and accommodate future growth and improvements as needed.

Figure 11: Cash flow (7-Day vs. Weekend Only)

4.2.3 Economic Analysis

If a variable tolling concession in Big Cottonwood Canyon was operated for 10 years by a private/public partnership, a preliminary analysis suggests that it would realize retained earnings of $19 M when operating only on the weekends and $36 M, if operated all week (Table 13). This valuation suggests that if a variable tolling system were implemented, revenues could potentially sustain and support the proposed improvements (i.e., new permanent restroom facilities, road restriping, geofoam expansions, and expanded summer bus service) without the need to either levy additional property taxes or compete with other projects for funding from Salt Lake County.

Table 15: Summary Economic Analysis

Model	Annual Revenue	Annual Bus Costs	Annual Retained Earnings	Business Valuation	Payback Period	Retained Earnings over Design Life
Weekend Tolling	$ 2.4 mil	$ 1.0 mil	$ 1.5 mil	$ 29.0 mil	5 years	$ 19.0 mil
Everyday Tolling	$ 3.7 mil	$ 1.6 mil	$ 2.0 mil	$ 40.0 mil	4 years	$ 36.0 mil

4.3 Conclusion

While tolling or collecting user fees in any form may be politically and publically unpopular, the current state of unmanaged access to Big Cottonwood Canyon has significant costs and impacts to public safety, health, and the potential to degrade the recreational use and enjoyment for all users. Illegal and unsafe parking, pedestrian and cyclist interferences with automobile traffic, and lack of adequate restroom facilities are common and well documented issues.

The University of Utah Big Cottonwood Canyon 3T Improvement team recommends a comprehensive, integrated approach including variable tolling and phased construction in order to implement proposed solutions in a timely and cost-effective fashion. Further, a phased approach can better accommodate potential delays, inconsistent funding, or other potential obstacles, which are inevitable. It is recommended that the described phasing plan be overseen by a public entity, such as the Big Cottonwood Improvement District, which has been suggested by others in the past. This entity would be responsible for distributing tolling revenues and overseeing proposed improvements through the planning and implementation process.

This preliminary engineering report provides a range of possibilities to address the "3 Ts" issues of traffic, toilets, and trails while preserving the integrity and natural beauty of Big Cottonwood Canyon. The aim of study and its proposed recommendations is not to limit access by imposing additional fees, but rather to encourage users to think about the future ways they interact with and experience the "Forest Next Door" in a safer, healthier, and more sustainable manner for all.

4.4 Acknowledgements

The BCC3T Improvement Team would like to thank Dr. Steven Bartlett and Dr. Dave Eckhoff for their mentorship, engineering insight, and tireless feedback. Special thanks are due to Leo Blake, who designed the slides for the prior Alternatives Study. The team also deeply appreciates the involvement and encouragement of not only the members of the Big Cottonwood Community Council who commissioned the study, but also the cooperation of representatives from the U.S. Forest Service, the Utah Department of Transportation, the Utah Transit Authority, Salt Lake County, Mountain Accord, Brighton, and Solitude Mountain Resort. Finally, the many private citizens who engaged with or commented on our work were invaluable voices in determining the final direction of this report.

5 REFERENCES

5.1 Statement of Needs References

[1]Outdoor Industry Association. “Utah: the outdoor recreation economy.” Online. Available: outdoorindustry.com.

[2]U.S. Forest Service. “Uinta-Wasatch-Cache National Forest: Visitor guide.” U.S. Department of Agriculture. Online. Available: https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5370807.pdf

[3] U.S. Forest Service. “Resource management: watersheds in Salt Lake valley.” U.S. Department of Agriculture. Online. Available: https://www.fs.usda.gov/detailfull/uwcnf/landmanagement/resourcemanagement/?cid=fsem_035491&width=full

[4]National Park Service. “Visitation statistics.” Online. Available: https://www.nps.gov/yell/planyourvisit/visitationstats.htm

[5]C. C. Lamborn *et al.,* “2014-2015 Central Wasatch Visitor Use Study: Follow-Up E-Survey,” Institution for Outdoor Recreation and Tourism, Logan, UT, 2015.

[6]Fehr & Peers. “Mountain transportation study: final report.” Salt Lake County, UT, 2012. Online. Available: http://slco.org/pwpds/zoning/pdf/wasatchCanyonGeneralPlans/MTS_-_Report_-_FINAL.pdf

[7]Salt Lake County. “Wasatch canyons tomorrow.” Salt Lake City, UT, 2010. Online. Available: http://wfrc.org/Previous_Studies/2010%20Wasatch%20Canyons%20Tomorrow%20Final%20Report%20Dec10.pdf

[8]Salt Lake County. “Big Cottonwood Canyon general plan draft.” Salt Lake City, UT, 2013. Online. Available: http://slco.org/pwpds/pdf/BigCottonwood_-_DRAF.pdf

[9]Avenue Consultants. “Cottonwood canyons parking study.” Salt Lake City, UT, 2012. Online. Available:http://slco.org/pwpds/zoning/pdf/wasatchCanyonGeneralPlans/Cottonwood_Canyons_P.pdf

[10]Mountain Accord. “Mountain Accord final report.” Salt Lake City, UT, 2016. Online. Available: http://mountainaccord.com/mountain-accord-final-report/

5.2 Traffic and Parking References

[1] “Uniform Fine/Bail Forfeiture Schedule,” Administrative Office of the Courts, 10-May-2016. [Online]. Available: https://www.utcourts.gov/resources/rules/ucja/append/c_fineba/FineBail_Schedule.pdf

[2] Traffic and Parking Regulations: University of California Santa Cruz Police Department.

[Online]. Available: http://police.ucsc.edu/services/parking/parkreg.html

[3] "Parking ticket fines and codes." Boston.gov. N.p., 07 Nov. 2016. Web. 18 Apr. 2017. https://www.boston.gov/departments/parking-clerk/parking-ticket-fines-and-codes

[4] Avenue Consultants. (2012). Cottonwood Canyons Parking Study – Recommendations [Online]. Available: http://slco.org/pwpds/zoning/pdf/wasatchCanyonGeneralPlans/Cottonwood_Canyons_P.pd f

[5] “Traffic Control Systems Handbook: Chapter 6. Detectors,” U.S. Department of Transportation Federal Highway Administration, 01-Feb-2017. [Online]. Available: https://ops.fhwa.dot.gov/publications/fhwahop06006/chapter_6.htm

[6] “LED Sign Power Consumption,” LED Sign Solutions, 01-Jan-2017. [Online]. Available: https://ledsignsolution.com.au/led-signs-basics/led-sign-power-consumption-electriciy-cost.

[7] “Population,” Business & Utah, 2013. [Online]. Available: http://business.utah.gov/publications/population/. [Accessed: 01-Apr-2017].

[8] “Washington State Comprehensive Tolling Study Vol. 1", Washington State Transportation Commission, 2017. [Online]. Available: http://wstc.wa.gov/Rates/Tolling/WS_TollStudy_FinalReport_V1.pdf. [Accessed: 01- Apr-2017].

[9] Fehr and Peers. (2012, August). Mill Creek Canyon Transportation Feasibility Study [Online]. Available: http://slco.org/pwpds/zoning/pdf/wasatchCanyonGeneralPlans/Mill_Creek_Canyon_Tr.pdf

[10] Technologies that enable congestion pricing. U.S. Department of Transportation Federal Highway Administration. [Online]. Available: https://ops.fhwa.dot.gov/publications/fhwahop08042/fhwahop08042.pdf

[11]H. Nigel Morris, "The Big Question: Has the congestion charge been effective in reducing", The Independent, 2017. [Online]. Available: http://www.independent.co.uk/news/uk/home-news/the-big-question-has-the-congestion-charge-been-effective-in-reducing-londons-traffic-781505.html. [Accessed: 18- Apr- 2017].

[12] Highway Capacity Manual 2010," Transportation Research Board, vol. 4, Dec-2010. [Online] Available: http://www.hcm2010.org/system/datas/85/original/Chapter%2031%20-%20Signalized%2 0Intersections%20Supplemental.pdf

[13] Image Available: https://wsdotblog.blogspot.com/2014_10_01_archive.html

[14] "Toll Gantry Levels of design with estimated costs" and "Eastside Corridor Express Toll Lane Operating and Maintenance Costs." [Online]. Available: http://www.planhillsborough.org/wp-content/uploads/2015/12/Toll-Gantry-Levels-of-design-with-estimated-costs.pdf

[15] "Eastside Corridor Express Toll Lane Operating and Maintenance Costs" [Online]. Available:https://www.wsdot.wa.gov/sites/default/files/2009/12/29/App3Final_OperatingandMaintenanceCostsSummary.pdf

[16] "Utah State Legislature," SB0222, 12-May-2015. [Online]. Available: https://le.utah.gov/~2015/bills/static/SB0222.html. [Accessed: 03-Apr-2017].

5.3 Roadways and Trails References

[1] 2017. [Online]. Available: http://mountainaccord.com/wp-content/uploads/2016/10/MA-Final-Report-July16.pdf. [Accessed: 18- Apr- 2017].

[2] *Udot.utah.gov*, 2013. [Online]. Available: https://www.udot.utah.gov/main/uconowner.gf?n=3000306255336296. [Accessed: 18- Apr- 2017].

[3] *Udot.utah.gov*, 2017. [Online]. Available: https://www.udot.utah.gov/main/uconowner.gf?n=3000306255336296. [Accessed: 18- Apr- 2017].

[4] R. Aaboe and T. Frydenlund, 2011. [Online]. Available: http://www.civil.utah.edu/~bartlett/Geofoam/48a%20-%2040%20years%20of%20experience%20final%202011-05-26.pdf. [Accessed: 18- Apr- 2017].

[5] "Strength - Geofoam.org", *Geofoam.org*, 2017. [Online]. Available: http://www.geofoam.org/considerations/strength/. [Accessed: 18- Apr- 2017].

[6] "Metals Depot", *Metalsdepot.com*, 2017. [Online]. Available: https://www.metalsdepot.com/. [Accessed: 03- Apr- 2017].

[7]"EPS Pricing Calculator [Universal Foam Products". *Univfoam.com,* 2017. [Online]. Available: http://univfoam.com/pricing-calculators/eps-pricing. [Accessed; 03-Apr-2017].

[8] "Concrete Calculator and Price Estimator - Find Cubic Yards and Bags of Concrete Needed for Slabs and Footings - Inch Calculator", *Inch Calculator*, 2017. [Online]. Available: http://www.inchcalculator.com/concrete-calculator/. [Accessed: 18- Apr- 2017].

[9] "Learn how much it costs to Install Rebar.", *Homeadvisor.com*, 2017. [Online]. Available: http://www.homeadvisor.com/cost/outdoor-living/steel-reinforcement-bars-pricing/. [Accessed: 18- Apr- 2017].

[10] 2017. [Online]. Available: http://www.kalmatron.com/files/Files1/INDEXa/KALMATRON_ECONOMY.pdf. [Accessed: 18- Apr- 2017].

[11] "Frequently Asked Questions: Bollards & Post Covers", *Bollards by Reliance Foundry*, 2017. [Online]. Available: http://www.reliance-foundry.com/bollard/faqs-bollards#gref. [Accessed: 18- Apr- 2017].

[12] "Concrete Calculator and Price Estimator - Find Cubic Yards and Bags of Concrete Needed for Slabs and Footings - Inch Calculator", *Inch Calculator*, 2017. [Online]. Available: http://www.inchcalculator.com/concrete-calculator/. [Accessed: 18- Apr- 2017].

[13] "Cost of a pedestrian bridge? | Excel Bridge Manufacturing", *Excelbridge.com*, 2017. [Online]. Available: http://www.excelbridge.com/for-owners/cost. [Accessed: 18- Apr- 2017].

[14] "Concrete Calculator and Price Estimator - Find Cubic Yards and Bags of Concrete Needed for Slabs and Footings - Inch Calculator", *Inch Calculator*, 2017. [Online]. Available: http://www.inchcalculator.com/concrete-calculator/. [Accessed: 18- Apr- 2017].

[15] "Fill Dirt Cost: How Much is a Truckload?", *Braen Stone*, 2017. [Online]. Available: http://www.braenstone.com/2016/08/cost-fill-dirt/. [Accessed: 18- Apr- 2017].

[16]"Steel in Salt Lake City | Wasatch Steel", *Wasatch Steel*, 2017. [Online]. Available: http://www.wasatchsteel.com/?gclid=CjwKEAjwz9HHBRDbopLGh-afzB4SJABY52oFdKpniuR3V3hC1zvPpfuNaWyfFsH2IlS6QXZSSPM8EBoClO3w_wcB. [Accessed: 18- Apr- 2017].

5.4 Environmental References

[1] “2015 Salt Lake County Integrated Watershed Plan,” slco.org. [Online]. Available: http://slco.org/uploadedFiles/depot/publicWorks/fwatershed/resources/2015SLCoIWP.pdf

[2] "People Counting System For Toilets". Sensmax.eu. N.p., 2017. Web. 18 Apr. 2017.

[3] Pyzyk, Katie. "What Is Denver Learning From Its Public Restroom Pilot Program?". CityLab. N.p., 2017. Web. 18 Apr. 2017.

[4] “BOOM Clovermist Standard Toliet Elevations,” boomcon.com. [Online]. Available: http://www.boomcon.com/2014pricelists/STD%20Drawing.pdf.

[5] “BOOM Clovermist Vault Toilets,” boomcon.com. [Online]. Available: http://www.boomcon.com/2013pricelists/2013%20Boom%20Clovermist%20Single%20GSA.pdf

[6] "National Environmental Policy Act Review Process | National Environmental Policy Act | US EPA". Epa.gov. N.p., 2017. Web. 18 Apr. 2017.

[7] “Taos Standard Sanitation Sewer Connected Toilets,” [Online]. Available: http://cxtinc.com/taos.asp

[8] “Montrose Standard Sanitation Sewer Connected Toilets,” [Online]. Available: http://cxtinc.com/montrose.asp

APPENDIX I - ADDITIONAL FIGURES AND TABLES

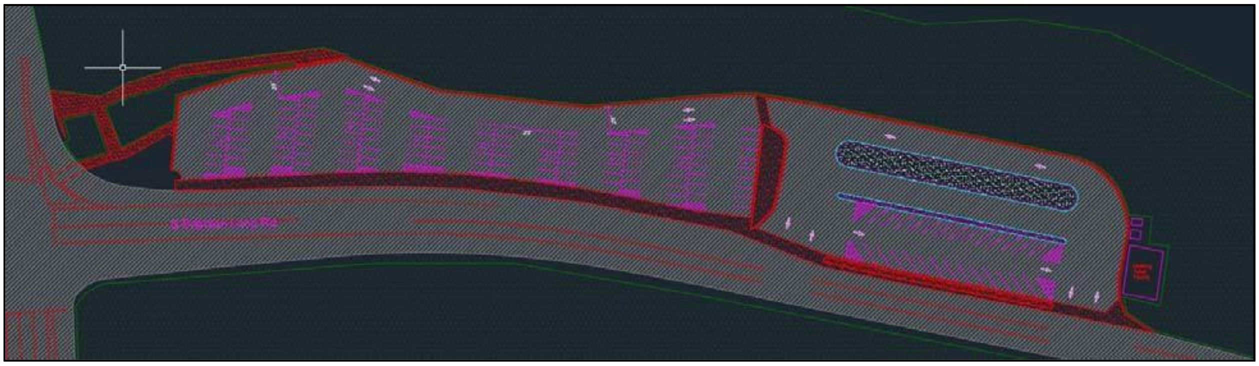


Figure 12: Proposed Striping Plan for Canyon Entrance

Figure 13: Proposed Striping Plan for Lower S-curve Lot

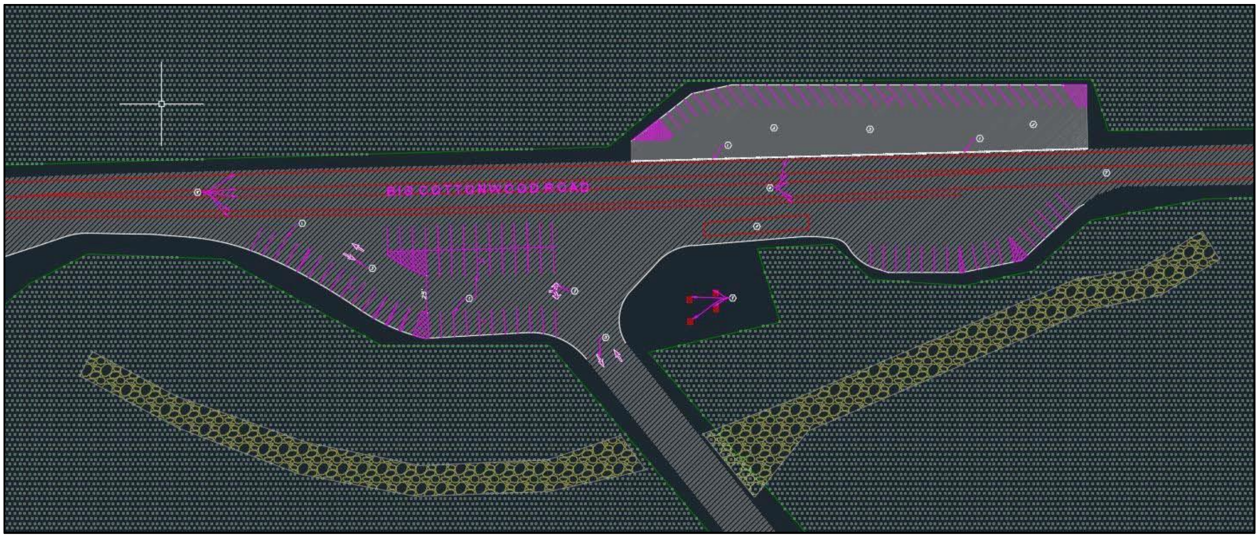


Figure 14: Proposed Striping Plan for Donut Falls Lot

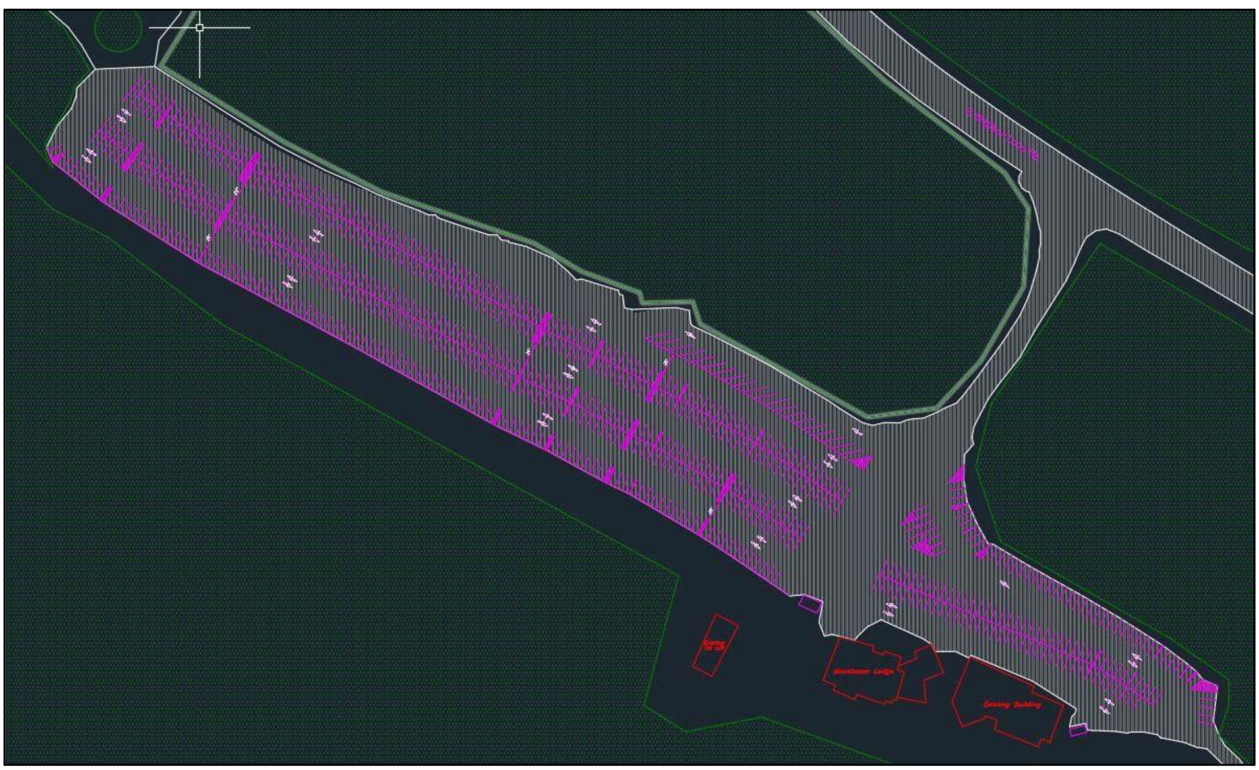


Figure 15: Proposed Striping Plan for Solitude Lot

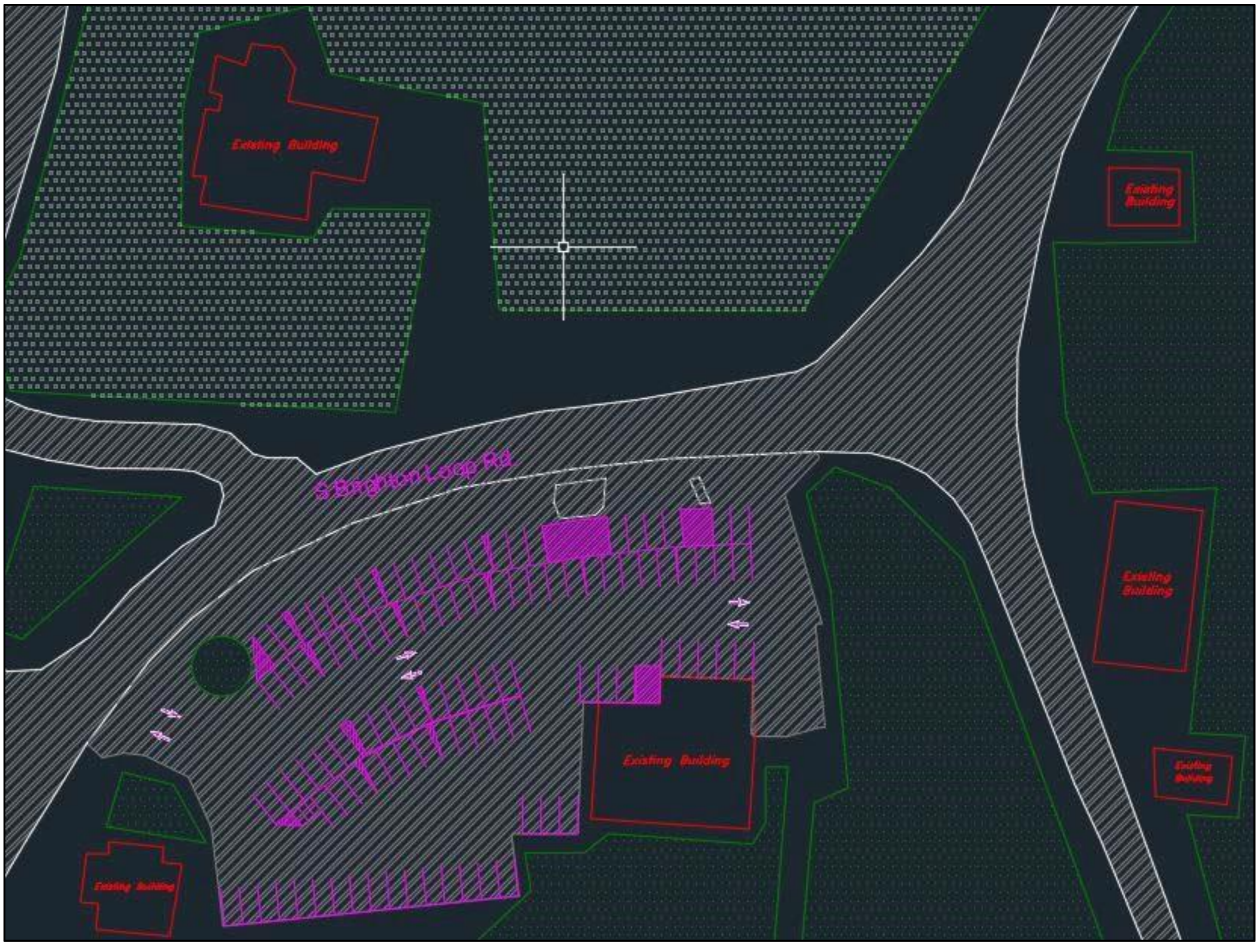


Figure 16: Proposed Striping Plan for Brighton Restaurant Lot

Figure 17: Proposed Striping Plan for Main Brighton Lot

Figure 18: Bus Stop and Bike Lane Locations at Ledgemere Picnic Grounds

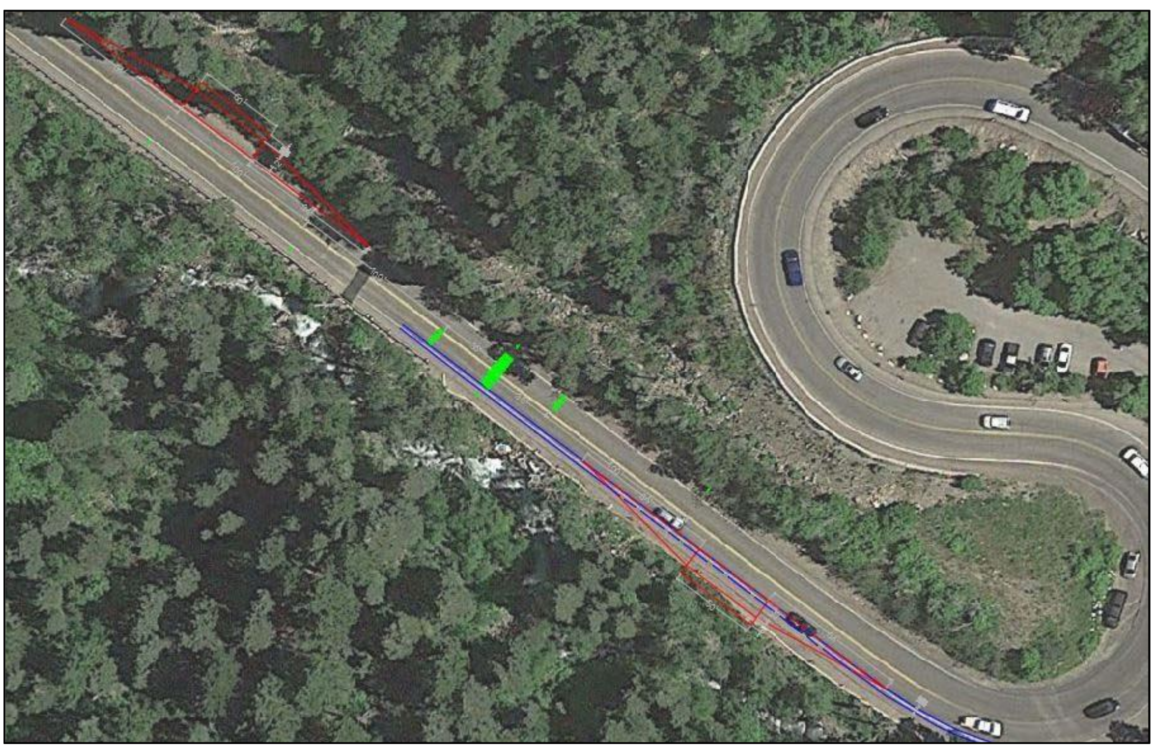


Figure 19: Bus Stop, Bike Lane and Crosswalk Locations at S-Curve

Figure 20: Bus Stop and Bike Lane Locations at Mineral Fork

Table 16: Spot Count Data from July 8, 2016

	Available Parking Spots	Number of Cars Parked in Area on July 8th, 2016	Difference
Park & Ride	85	67	18
Unnamed Area	5	1	4
Dogwood	30	1	29
Unnamed Area	7	0	7
Unnamed Area	7	1	6
Ledgemere	10	4	6
Unnamed Area	20	5	15
Unnamed Area	7	0	7
Unnamed Area	5	0	5
Unnamed Area	5	0	5
Birches	10	0	10
Unnamed Area	5	0	5
Broadsfork	15	2	13
Stairs Gulch	17	21	-4
Storm Mountain	70	16	54
Mule Hollow	10	5	5
Unnamed Area	15	0	15
S Turn	40	155	-115
Unnamed Area	7	0	7
Hiking Trail	10	3	7
Unnamed Area	12	1	11
Unnamed Area	25	0	25
Unnamed Area	5	1	4
Unnamed Area	17	0	17
Mine	7	13	-6
Unnamed Area	17	1	16
Fishing Area	15	0	15
Unnamed Area	20	0	20
Unnamed Area	10	3	7
Unnamed Area	15	0	15
Butler Fork	15	17	-2
Unnamed Area	25	1	24
Donut Falls	100	79	21
Jordan Pines (Off Hwy)	45	31	14
Donut Falls	17	36	-19
North Fork	32	30	2
Unnamed Area	12	0	12
Spruces	200	50	150
Unnamed Area	12	1	11
Silver Fork Lodge	46	36	10
Willow Heights	12	13	-1
Unnamed Area	15	1	14
Solitude	650	26	624
Solitude Condos	150	35	115
Unnamed Area	7	0	7
Unnamed Area	25	8	17
Redman Campground	10	0	10
Solitude Nordic Center	300	105	195
Brighton	600	163	437
Guardsman Pass Road	15	1	14
Unnamed Area	7	0	7
Unnamed Area	0	5	-5
Unnamed Area	5	0	5
Guardsman Pass	17	32	-15
Totals	2840	970	1870

Figure 21: UDOT Parking and Standing Signs Plaques

APPENDIX II – PROPOSED CONSTRUCTION PHASING AND COST ESTIMATES

Table 17: Preliminary Phase Design Items and Costs

Senior Design - Big Cottonwood Canyon Cost Estimate Project Name: Big Cottonwood Canyon County: Salt lake County Date: 3/27/2017				Engineer's Estimate		
Item No.	**Item Description**	**Quantity**	**Unit**	**Unit Price**		**Cost**
	Preliminary Phase					
1	Contract Time	150	Days	$ 1,270.00	/Day	$ 190,500.00
2	Public Information Services	1	Lump	$ 2,500.00	Lump	$ 2,500.00
3	Surveying for Phase 1	1	Lump	$ 35,000.00	Lump	$ 35,000.00
4	Engineering Plans/Design	1	Lump	$ 200,000.00	Lump	$ 200,000.00
5	Legal	1	Lump	$ 50,000.00	Lump	$ 50,000.00
				Subtotal		$ 290,000.00

Table 18: Phase 1 Design Items and Costs

Senior Design - Big Cottonwood Canyon Cost Estimate Project Name: Big Cottonwood Canyon County: Salt lake County Date: 3/27/2017				Engineer's Estimate		
Item No.	**Item Description**	**Quantity**	**Unit**	**Unit Price**		**Cost**
	Phase 1					
1	Contract Time	0	Days	0	per Day	$ -
2	On the Job Training	300	Hour	$ 10.00	Hour	$ 3,000.00
3	Mobilization	1	Lump	$ 145,000.00	Lump	$ 145,000.00
4	Public Information Service	3	Lump	$ 2,500.00	Lump	$ 7,500.00
5	Traffic Control	1	Lump	$ 200,000.00	Lump	$ 200,000.00
6	Silt Fence	8200	LF	$ 2.25	LF	$ 18,450.00
7	Sign "No Parking"	120	Each	$ 120.00	Each	$ 14,400.00
8	Striping	30100	LF	$ 1.00	LF	$ 30,100.00
9	HMA - 1/2 inch	362	Ton	$ 122.00	Ton	$ 44,164.00
10	Sawcut	377	Lump	$ 2,500.00	Lump	$ 942,500.00
11	Curb & Gutter	400	LF	$ 18.00	LF	$ 7,200.00
12	Gantry & Toll Technology	2	Lump	$ 500,000.00	Lump	$ 1,000,000.00
13	Surveying for Phase 2	1	Lump	$ 35,000.00	Lump	$ 35,000.00
14	Excavation	17456	CF	$ 8.00	CF	$ 139,648.00
15	Tolling Operations-Fee collection and equiment management	0	Year	$ 300,000.00	Year	$ -
16	Parking Enforcement	0	Year	$ 172,000.00	Year	$ -
17	Increased Bus Service	0	Lump	$ 1,580,000.00	Lump	$ -
18	Concrete Paving	8200	SF	$ 7.50	SF	$ 61,500.00
19	UTBC	14260	CF	$ 3.00	CF	$ 42,780.00
				Subtotal		$ 2,690,000.00

Table 19: Phase 2 Design Items and Costs

Senior Design - Big Cottonwood Canyon Cost Estimate Project Name: Big Cottonwood Canyon County: Salt lake County Date: 3/27/2017				Engineer's Estimate			
Item No.	**Item Description**	**Quantity**	**Unit**	**Unit Price**		**Cost**	
Phase 2							
1	Contract Time	150	Days	$	1,270.00	per Day	$ 190,500.00
2	Automated Sign "Parking Stalls"	1	Lump	$	350,000.00	Lump	$ 350,000.00
3	HMA - 1/2 inch	52	Ton	$	122.00	Ton	$ 6,344.00
4	Stripping S-Curve Bus Stop	0	LF	0		LF	$ -
5	Benches with Cover	2	Each	$	1,500.00	Each	$ 3,000.00
6	Concrete Paving	1	SF	$	7.50	SF	$ 7.50
7	Silt Fence	358	LF	$	2.50	LF	$ 895.00
8	Traffic Control	1	Lump	$	200,000.00	Lump	$ 200,000.00
9	Surveying for Phase 3	1	Lump	$	35,000.00	Lump	$ 35,000.00
10	Excavation	2508	CF	$	8.00	CF	$ 20,064.00
11	Temporary Bus Stop Sign	6	Each	$	200.00	Each	$ 1,200.00
12	Tolling Operation	0	Year	$	300,000.00	Year	$ -
13	Parking Enforcement	0	Year	$	172,000.00	Year	$ -
14	Increased Bus Service	0	Lump	$	2,534,000.00	Lump	$ -
15	Parking Availability System O&M	0	Year	0		Year	$ -
16	UTBC	12468	CF	$	3.00	CF	$ 37,404.00
				Subtotal			$ 650,000.00

THE UNIVERSITY OF UTAH

Table 20: Phase 3 Design Items and Costs

Senior Design - Big Cottonwood Canyon Cost Estimate Project Name: Big Cottonwood Canyon County: Salt lake County Date: 3/27/2017				Engineer's Estimate		
Item No.	**Item Description**	**Quantity**	**Unit**	**Unit Price**		**Cost**
Phase 3						
1	Contract Time	(	Days	0	per Day	$ -
2	HMA - 1/2 inch	123	Ton	$ 122.00	Ton	$ 15,006.00
3	Stripping Bus Stop	1	LF	$ 1.00	LF	$ 1.00
4	Benches with Cover	4	Each	$ 2,500.00	Each	$ 10,000.00
5	Concrete Paving	0	SF	0	SF	$ -
6	Silt Fence	2550	LF	$ 2.50	LF	$ 6,375.00
7	Traffic Control	1	Lump	$ 200,000.00	Lump	$ 200,000.00
8	Excavation	5950	CF	$ 8.00	CF	$ 47,600.00
9	Tolling Operation	0	Year	$ 300,000.00	Year	$ -
10	Parking Enforcement	0	Year	$ 172,000.00	Year	$ -
11	Increased Bus Service	0	Lump	$ 3,100,000.00	Lump	$ -
12	UTBC	4250	CF	$ 3.00	CF	$ 12,750.00
				Subtotal		$ 290,000.00

Table 21: Summary Cost of All Phases

Item	**Description**	**Total**
1	Preliminary Phase	$ 290, 000.00
2	Phase 1	$ 2, 690, 000.00
3	Phase 2	$ 650, 000.00
4	Phase 3	$ 290, 000.00
Subtotal		**$ 3,920,000.00**
15% Contingency		**$590,000.00**
Grand Total		**$4,510,000**

NB: Table 14 includes only the direct construction costs of each phase, excluding variable operation and maintenance costs. Operation and maintenance costs for each service during each phase are separately included in the tables for that phase.

APPENDIX III – ADDITIONAL FIGURES

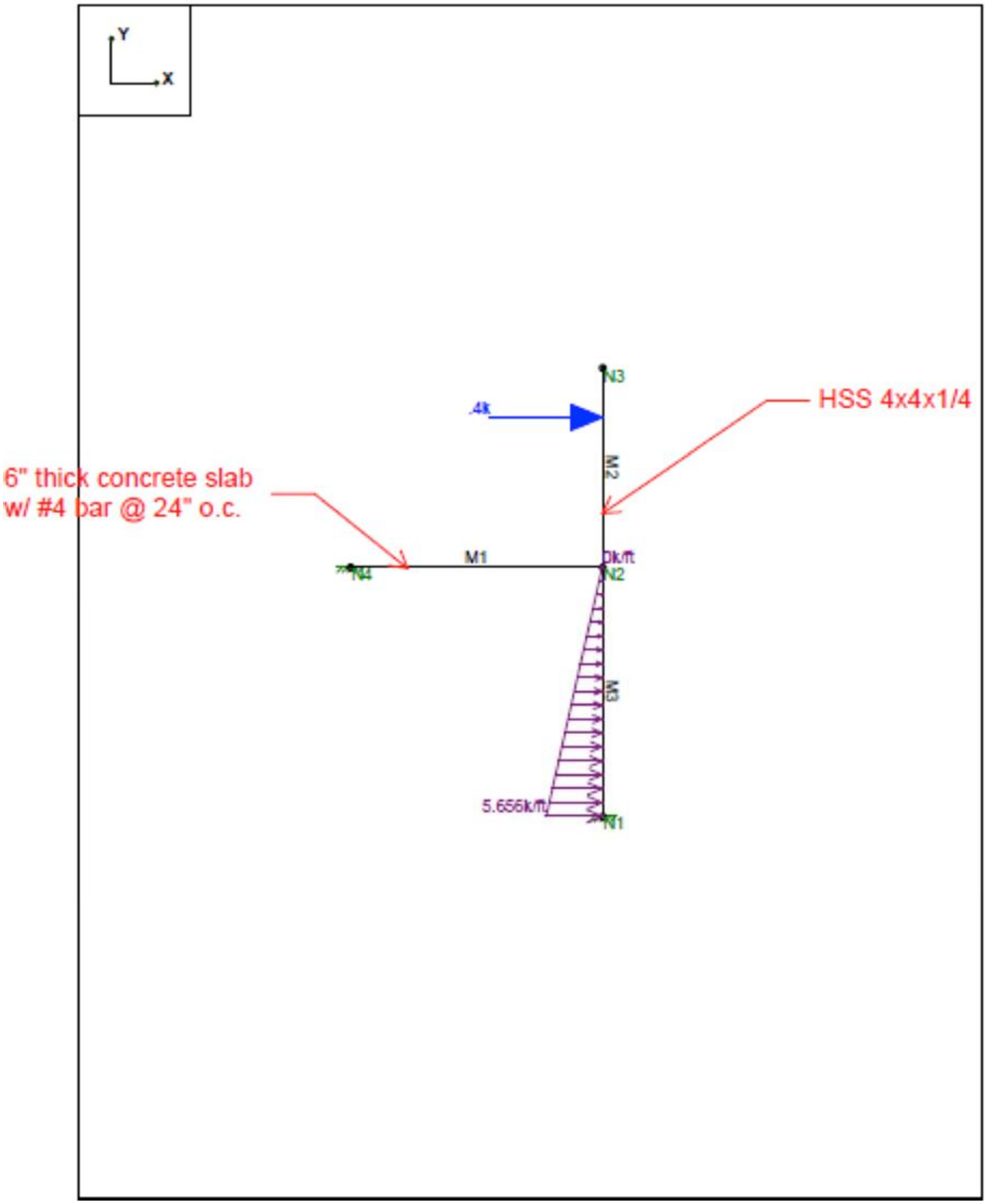


Figure 22: Geofoam Shoulder Expansion Details

Table 22: Typical Geofoam Section Details (Expected Forces and Displacements)

Member Distributed Loads

Member Label	Direction	Start Magnitude (k/ft, F)	End Magnitude (k/ft, F)	Start Location (ft or %)	End Location (ft or %)
M3	X	0	5.656	0	0

Joint Displacements

Joint Label	X Translation (in)	Y Translation (in)	Rotation (radians)
N1	0	0	0
N2	.001	0	6.338e-4
N3	.012	0	-5.121e-4
N4	0	0	0

Reactions

Joint Label	X Force (k)	Y Force (k)	Moment (k-ft)
N4	-4.39	.8	1.316
N1	-10.15	-.8	7.5
Totals:	-14.54	0	

Member Section Forces

Member Label	Section	Axial (k)	Shear (k)	Moment (k-ft)
M1	1	-4.39	.8	-1.316
	2	-4.39	.8	-.316
	3	-4.39	.8	.684
	4	-4.39	.8	1.685
	5	-4.39	.8	2.685
M2	1	0	0	0
	2	0	.4	0
	3	0	.4	.4
	4	0	.4	.8
	5	0	.4	1.2

RISA-2D Educational Version 1.0 [C:\RISA Technologies\RISA-2D Educational\untitled.r2e] Page 1

Table 23: Typical Geofoam Section Details (Continued)

Designer :

Checked By:_____

Member Section Forces

Member Label	Section	Axial (k)	Shear (k)	Moment (k-ft)
M3	1	-.8	-3.99	3.885
	2	-.8	-3.107	-.735
	3	-.8	-.455	-3.145
	4	-.8	3.963	-1.136
	5	-.8	10.15	7.5

APPENDIX IV – RESTROOM DETAILS

Restroom facilities were assessed from two different regional companies that specialized in sanitation sewer connected toilets and vault toilets. The companies were CXT Concrete and Boom Concrete.

CXT Concrete bathroom facilities are easily available for public purchase and is a local company. The buildings are typically factory assembled, and can be easily dropped into place for quick installation. CXT does not include the compaction or plumbing and mechanical work as part of their service. For the Midwest region, the price of installation varies between $10-20,000 for the Montrose and Taos units [6][7]. This work can be contracted out to geotechnical engineers, mechanics, and plumbers. The bathrooms are brought in on trucks in sections and then dropped into place using cranes. All the utility work and foundation work must be done prior to the placement of the restroom facility segments. The Montrose and Taos are bigger bathroom facilities that CXT offers, and the segments will be transported on several trucks.

Figure 23: Placement of CXT Unit [7][8]

Below are pictures and drawings of the Taos bathroom facility. This facility offers two sides with one stall for men and one for women.

Figure 24: Taos Restroom Facility [7]

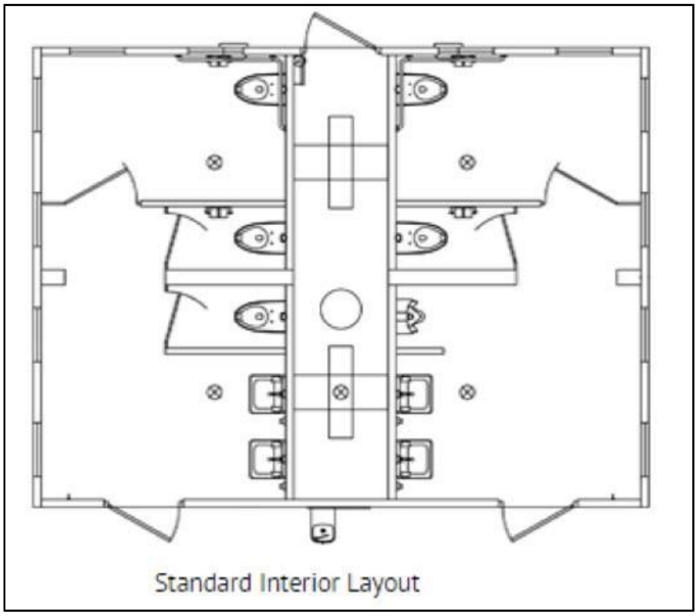


Figure 25: Taos Restroom Interior Details [7]

Below are pictures and drawings of the Montrose bathroom facility. This facility offers two sides with one stall and one urinal for the men's side, and two stalls for the women's side.

Figure 26: Montrose Restroom Facility [8]

Boom Concrete vault toilet facilities are also easily available for purchase and the company is based out of Newell, SD. The transportation cost, construction cost, installation cost and unit cost have been incorporated into the cost estimates. The Boom Standard Plus and Double vault toilets were proposed to accommodate areas where no sewer lines were available.

Figure 27: Clovermist PLUS Restroom [4]

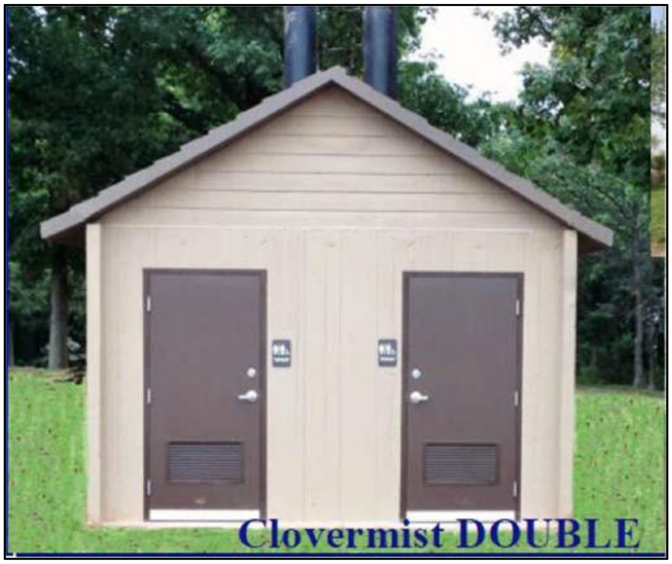


Figure 28: Clovermist DOUBLE Restroom [4]

Table 24: Costs for Each Proposed Location [4][5][7][8]

Vault Stalls	Sanitation Sewer Stalls	Location	Cost
5	0	Donut Falls	$91,000
0	4	Mill B-S Curve	$157,000
0	4	Silver Lake	$157,000
0	4	Cardiff/Mill D	$157,000
0	4	Willow Heights	$157,000
0	4	Butler Fork	$157,000
5	0	Guardsman's Pass	$91,000
0	6	Lake Mary Trailhead	$165,000
0	4	Dogwood Climbers' Area	$157,000
0	4	Storm Mountain Climbers' Area	$157,000

Table 25: Total Cost by Facility Type

Sanitation Sewer Total	$1,264,000
Vault Total	$182,000
Grand Total	$1,446,000

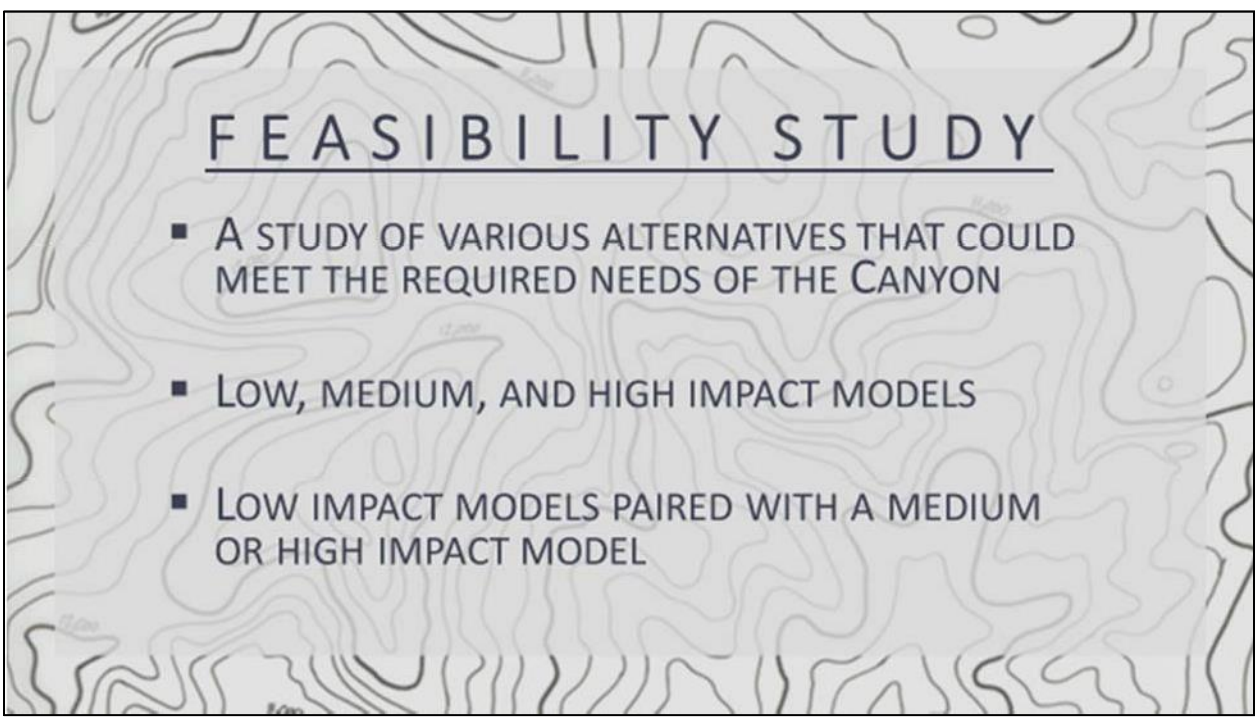
Table 26: Phasing Costs By Year [4][5][7][8]

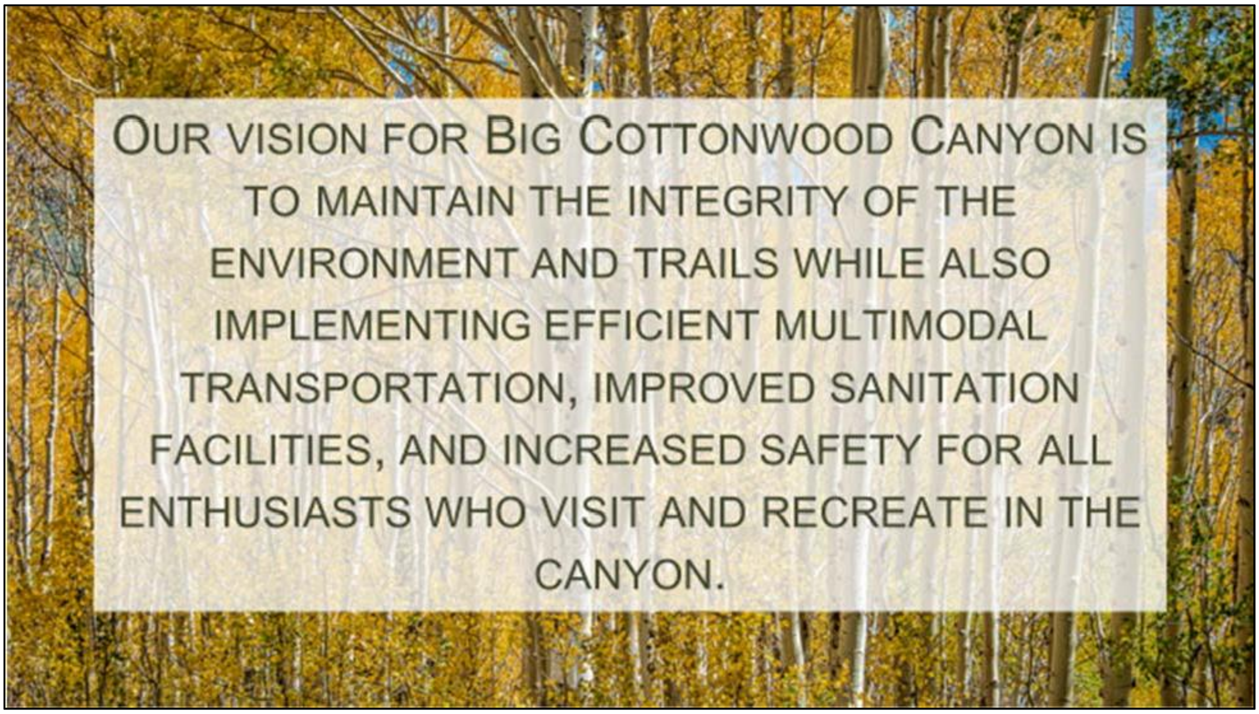
Environmental Phasing		
Time Frame	Cost	Locations
Year 2	$248,000	Donut Falls & Mill B-S Curve
Year 4	$314,000	Silver Lake & Cardiff/Mill D
Year 6	$314,000	Willow Heights & Butler Fork
Year 8	$256,000	Guardsman's Pass & Lake Mary Trailhead
Year 10	$314,000	Dogwood Climbers' Area & Storm Mountain Climbers' Area

fTable 27: Costs by Facility Type [4][5][7][8]

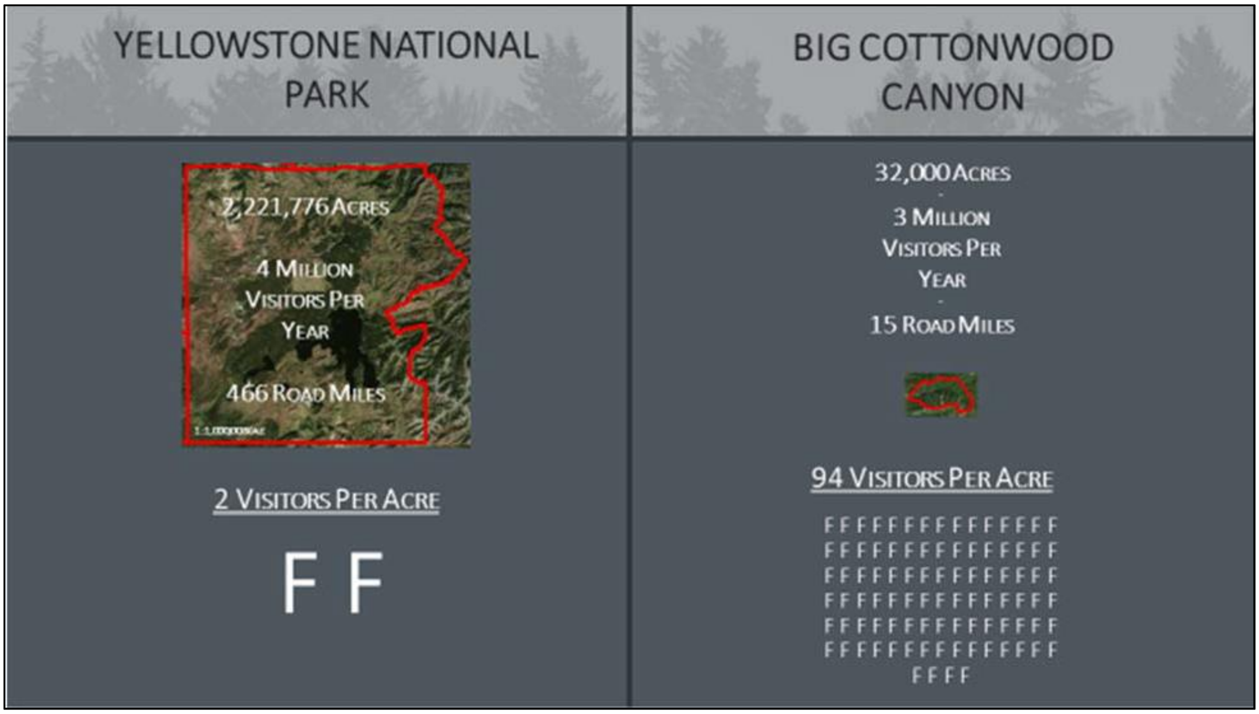
Cost	
Vault Stall (1-Boom Plus)	$23,000
Vault Stall (2-Boom Double)	$34,000
Sanitation Sewer Stall (4-Montrose)	$157,000
Sanitation Sewer Stall (2-Denali)	$88,000
Sanitation Sewer Stall (6-Taos)	$165,000

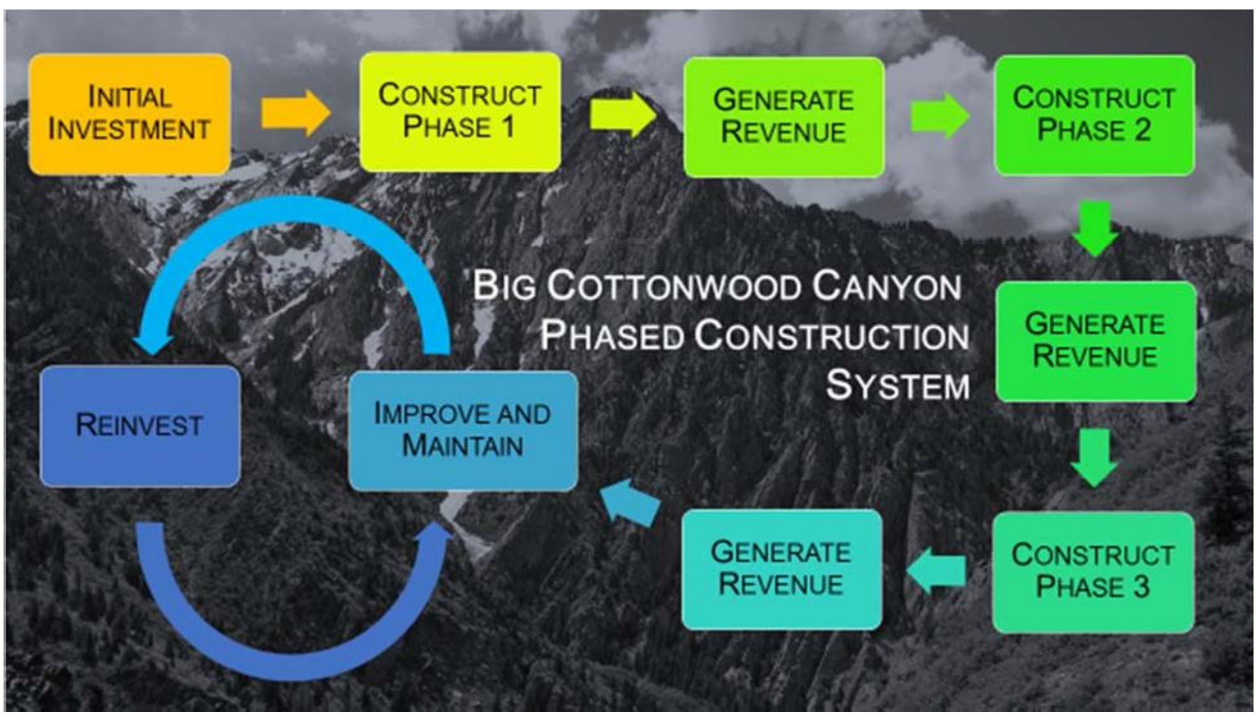
APPENDIX A: PRESENTATION SLIDES FOR PRELIMINARY ENGINEERING REPORT



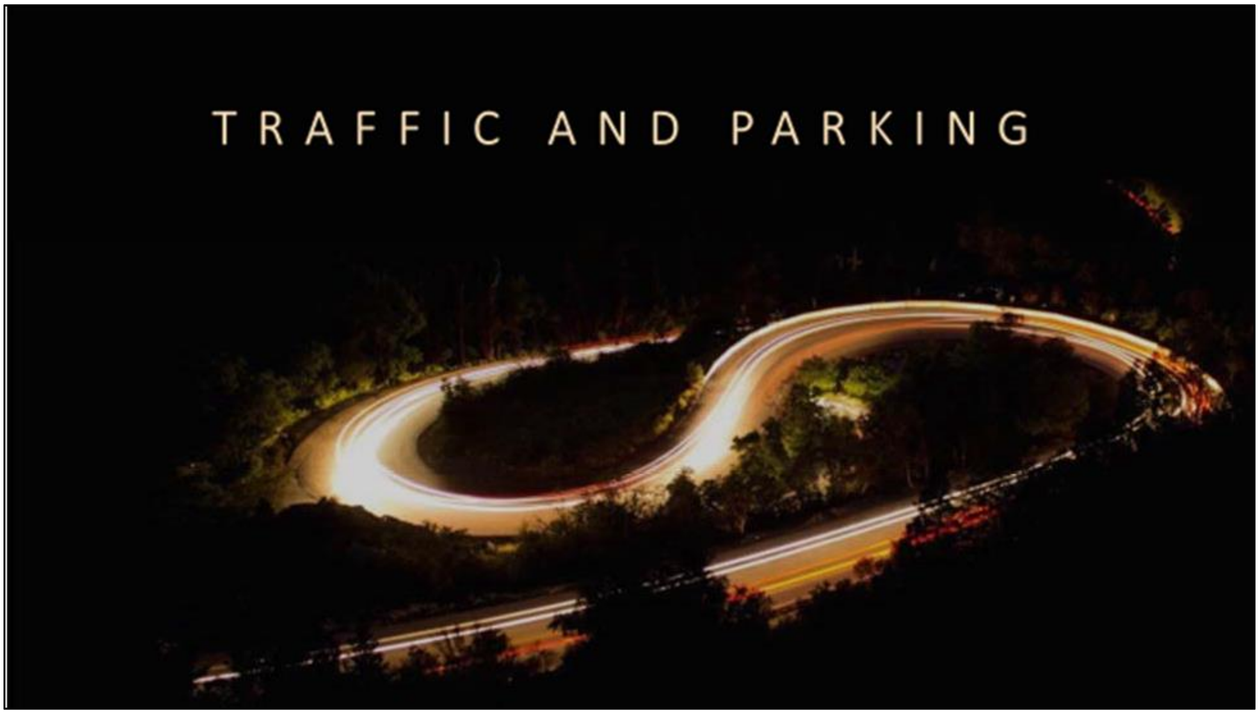

OUR VISION FOR BIG COTTONWOOD CANYON IS TO MAINTAIN THE INTEGRITY OF THE ENVIRONMENT AND TRAILS WHILE ALSO IMPLEMENTING EFFICIENT MULTIMODAL TRANSPORTATION, IMPROVED SANITATION FACILITIES, AND INCREASED SAFETY FOR ALL ENTHUSIASTS WHO VISIT AND RECREATE IN THE CANYON.


BIG COTTONWOOD CANYON NEEDS
TRAFFIC
TRAILS
TOLIETS


YELLOWSTONE NATIONAL PARK
2,221,776 ACRES
4 MILLION VISITORS PER YEAR
466 ROAD MILES
2 VISITORS PER ACRE
F F
BIG COTTONWOOD CANYON
32,000 ACRES
-
3 MILLION VISITORS PER YEAR
-
15 ROAD MILES
94 VISITORS PER ACRE
F F F F F F F F F F F F F F F
F F F F F F F F F F F F F F F
F F F F F F F F F F F F F F F
F F F F F F F F F F F F F F F
F F F F F F F F F F F F F F F
F F F F F F F F F F F F F F F
F F F F


INITIAL INVESTMENT
CONSTRUCT PHASE 1
GENERATE REVENUE
CONSTRUCT PHASE 2
GENERATE REVENUE
CONSTRUCT PHASE 3
GENERATE REVENUE
IMPROVE AND MAINTAIN
REINVEST
BIG COTTONWOOD CANYON PHASED CONSTRUCTION SYSTEM

THE UNIVERSITY OF UTAH



Traffic & Parking

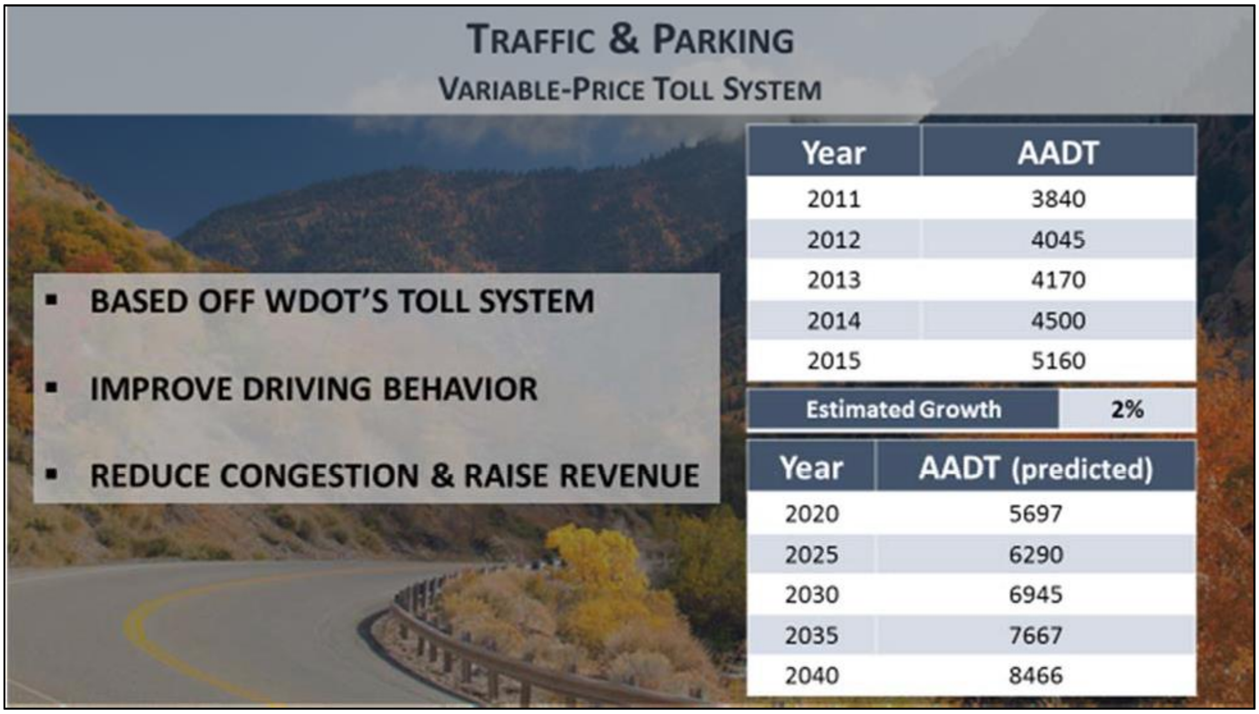
Variable-Price Toll System

- BASED OFF WDOT'S TOLL SYSTEM
- IMPROVE DRIVING BEHAVIOR
- REDUCE CONGESTION & RAISE REVENUE

Year	AADT
2011	3840
2012	4045
2013	4170
2014	4500
2015	5160

Estimated Growth	2%

Year	AADT (predicted)
2020	5697
2025	6290
2030	6945
2035	7667
2040	8466



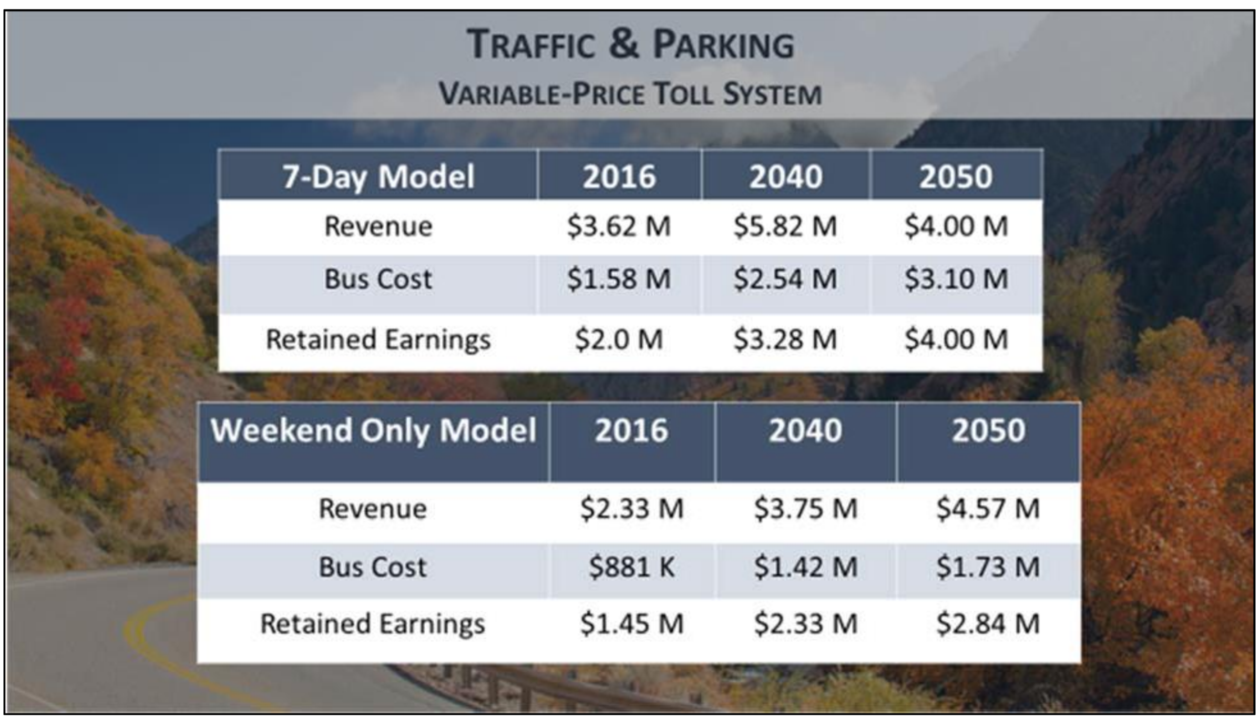
Traffic & Parking
Variable-Price Toll System

- BASED OFF WDOT'S TOLL SYSTEM
- IMPROVE DRIVING BEHAVIOR
- REDUCE CONGESTION & RAISE REVENUE

Year	AADT
2011	3840
2012	4045
2013	4170
2014	4500
2015	5160

Estimated Growth	2%

Year	AADT (predicted)
2020	5697
2025	6290
2030	6945
2035	7667
2040	8466



Traffic & Parking
Variable-Price Toll System

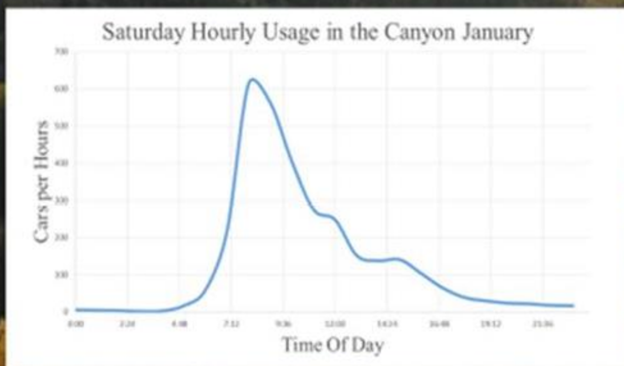
7-Day Model	2016	2040	2050
Revenue	$3.62 M	$5.82 M	$4.00 M
Bus Cost	$1.58 M	$2.54 M	$3.10 M
Retained Earnings	$2.0 M	$3.28 M	$4.00 M

Weekend Only Model	2016	2040	2050
Revenue	$2.33 M	$3.75 M	$4.57 M
Bus Cost	$881 K	$1.42 M	$1.73 M
Retained Earnings	$1.45 M	$2.33 M	$2.84 M

THE UNIVERSITY OF UTAH

Traffic & Parking

Smart Transportation



Variable-Price Fees

Canyon Entry Access Fee	Traffic Flow Rate (cars/hour)
$0.00	0-24
$3.00	25-49
$4.00	50-99
$5.00	100-149
$5.50	150-199
$6.00	200-249
$6.50	250-299
$7.00	300-349
$7.50	350-399
$8.50	400+
$9.50	500+
$10.50	600+
$11.50	700+
$12.50	800+

TRAFFIC & PARKING — TOLLING SYSTEM

- GANTRY
- NO LINE/NO DELAYS
- AUTOMATIC PLATE RECOGNITION
- FAST & EASY
- AESTHETICS
- ONLINE TOLL DEPOSIT

SPECIAL CONSIDERATION FOR CANYON

- EMPLOYEES
- RESIDENTS
- SEASON PASS HOLDERS


TRAFFIC AND PARKING
PHASE 1
Regulatory Signage
Parking Availability System
How Does it Work?
Vehicle Ground Loop Detection Circuit


TRAFFIC & PARKING
PARKING LOT IMPROVEMENT
183 PARKING SPOTS

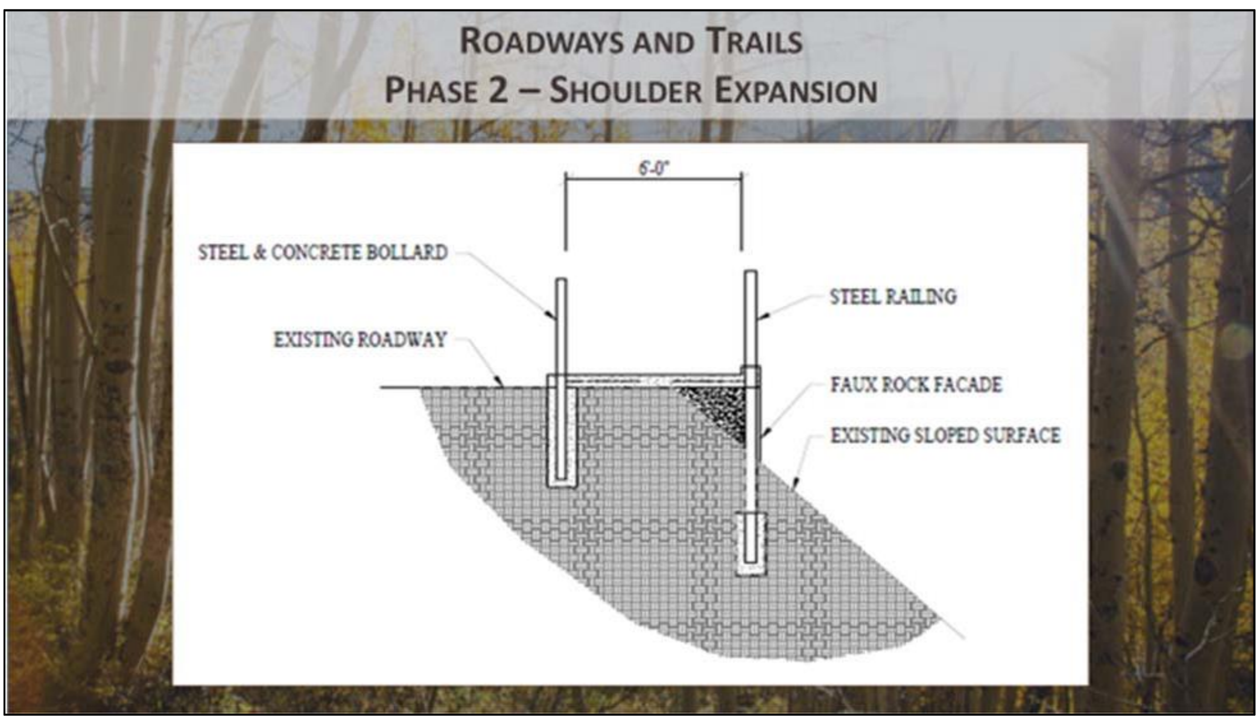

TRAFFIC & PARKING
BUS SERVICE
▪ YEAR ROUND SERVICE
▪ FREE SERVICE TO INCREASE RIDERSHIP
▪ FUNDED BY TOLLING REVENUE
▪ BUS FREQUENCY VARIES BY DEMAND


BUS STOPS AND CROSSWALKS
THREE NEW BUS STOP AREAS
• Ledgemere Picnic Grounds
• S-Curve Hiking Area
• Mineral Fork Hiking Area
THREE NEW CROSSWALK AREAS
• S-Curve
• Donut Falls
• Silver Fork Lodge
DONUT FALLS
SPRUCES
SILVER FORK LODGE
SOLITUDE
S-CURVE
MINERAL FORK
LEDGEMERE
SOLITUDE NORDIC CENTER
BRIGHTON
EXISTING BUS STOPS—11 STOPS
HIGH PRIORITY—2 STOPS
POTENTIAL STOPS—4 STOPS
TOTAL EXISTING STOPS AND POTENTIAL STOPS—17 STOPS

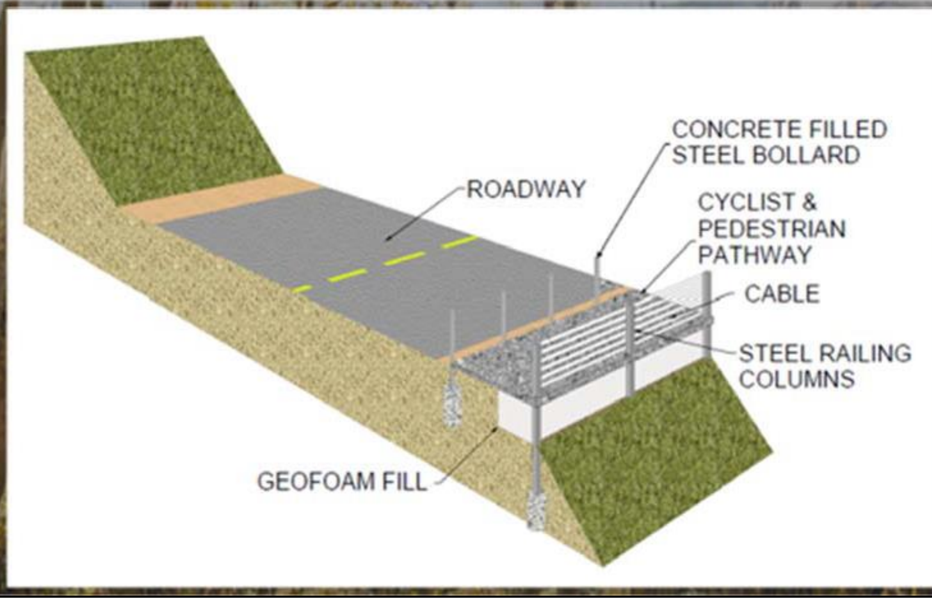

S-CURVE: BUS STOP AND CROSSWALK


ROADWAYS
& TRAILS


Roadways and Trails
Phase 1
Pedestrian Crossings
Reduced Speed Limits
Lighted Signs
Bike Lane Striping and Safety Signage
Adopt – A – Trail
Community Involvement
Cleaner Canyon
Local Business Advertisement

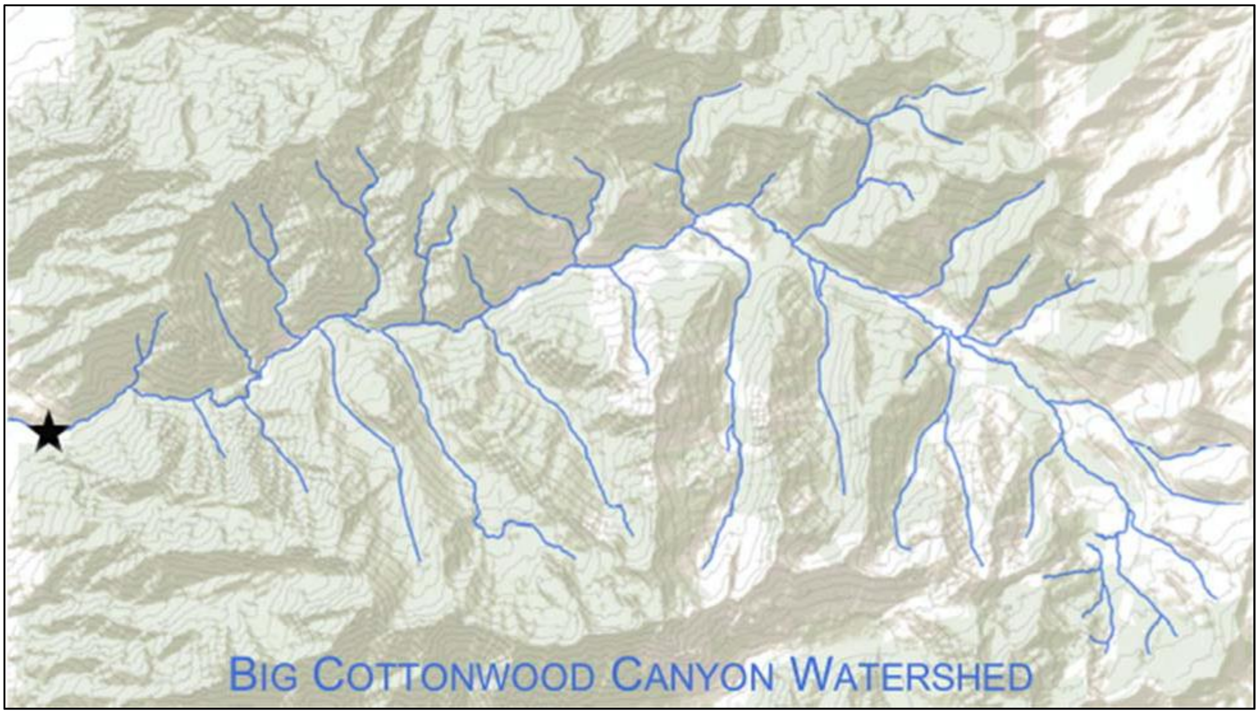

Roadways and Trails
Phase 2 – Shoulder Expansion
6'-0"
STEEL & CONCRETE BOLLARD
EXISTING ROADWAY
STEEL RAILING
FAUX ROCK FACADE
EXISTING SLOPED SURFACE

Roadways and Trails
Phase 2 – Shoulder Expansion Concept



Roadways and Trails
Phase 3 – Pedestrian Bridge Concept

Cost Analysis	Description	Total
Phase 1	Signs and Striping	$400,000
Phase 2	Road Expansion	$350,000
Phase 3	Bridge	$850,000
	Sum Total	$1,600,000


BIG COTTONWOOD CANYON WATERSHED


ENVIRONMENTAL
PHASE 2
• WITHIN 300 FEET OF STREAM, SEWER IS REQUIRED
• IF BUDGET IS SHORT, CAN COMPROMISE BY HAVING MORE VAULT TOILETS AT SELECT LOCATIONS

THE UNIVERSITY OF UTAH

- Watershed classified as at 'functioning at risk' by USFS
- Inconvenience for Canyon users, improve user experience
- Improvements long overdue (14 stalls vs 58 needed)

Pilot Study

- Used to determine what demand exists for services
- Initial Phase: Year long study to gather data and assess needs throughout canyon
- Similar study conducted in Denver

THE UNIVERSITY OF UTAH

PILOT STUDY

- 10 PORTABLE RESTROOM FACILITIES AT EXISTING AND PROPOSED RESTROOMS
- CONDUCT FOR A YEAR TO DETERMINE PEAK WINTER AND SUMMER DEMAND

PEOPLE COUNTER TECHNOLOGY

ENVIRONMENTAL
COST ANALYSIS

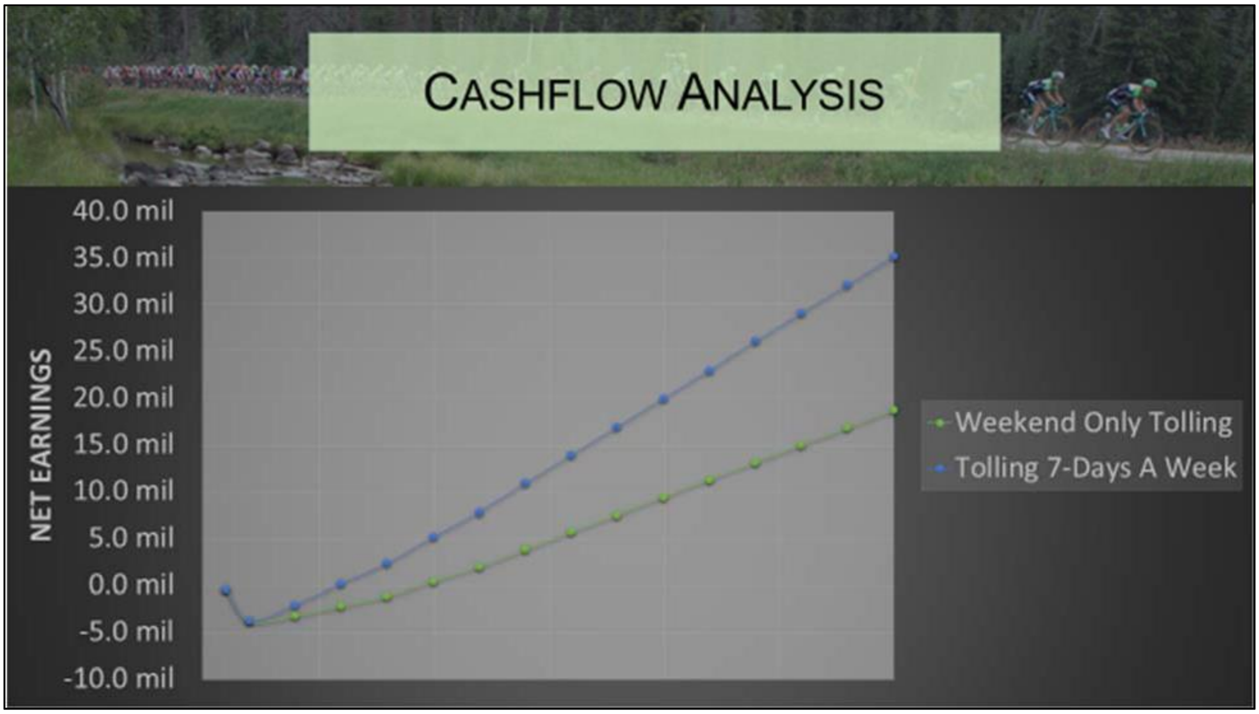
Vault Stalls	Sewer Stalls	Location	Cost
5	0	Donut Falls	$89,000
0	4	Mill B-S Curve	$157,000
0	4	Silver Lake	$157,000
0	4	Cardiff/Mill D	$157,000
0	4	Willow Heights	$157,000
0	4	Butler Fork	$157,000
5	0	Guardsman's Pass	$89,000
0	6	Lake Mary Trailhead	$165,000
0	4	Dogwood Climbers' Area	$157,000
0	4	Storm Mountain Climbers' Area	$157,000

ENVIRONMENTAL
COST ANALYSIS

Per Unit Cost	
1-Boom Plus Vault Stall	$23,000
2-Boom Plus Vault Stall	$33,000
2 Stall Sanitation Sewer (Denali)	$88,000
4 Stall Sanitation Sewer (Montrose)	$157,000
6 Stall Sanitation Sewer (Taos)	$165,000

BCC IMPROVEMENT PLAN
PHASING BREAKDOWN

Phase	Year	Traffic & Parking Improvements	Bridges & Trails Improvements	Sanitation Improvements	Cost
Prelim	1	Prelim		Case Study	$ 480k
1	2	Phase 1			$ 3.5 mil
2	4	Phase 2	Phase 1	Phase 1	$ 1.5 mil
3	6	Phase 3	Phase 2	Phase 2	$ 900k
4	8		Phase 3	Phase 3	$ 900k
5	10			Phase 4	$ 300k
6	12			Phase 5	$ 350k
Total					$ 7.93 mil



BCC IMPROVEMENT PLAN
ECONOMIC ANALYSIS

Model	Annual Revenue	Annual Bus Costs	Annual Retained Earnings	Business Valuation	Payback Period	Retained Earnings over Design Life
Weekend Tolling	$ 2.4 mil	$ 1.0 mil	$ 1.5 mil	$ 29.0 mil	5 years	$ 19.0 mil
Everyday Tolling	$ 3.7 mil	$ 1.6 mil	$ 2.0 mil	$ 40.0 mil	4 years	$ 36.0 mil


Brighton
Big Cottonwood Community Council
Solitude Mountain Resort
Thank You
Forest Service
U S
Department of Agriculture
SL
Salt Lake County
UDOT
Keeping Utah Moving
Mountain Accord
UTA
Utah Transit Authority