

Backcountry Blackwater Management Options Analysis

Backcountry Energy Environmental Solutions

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FOR **Backcountry Blackwater Management Options Analysis**

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- A: LOCATION 1 COST TABLES**
- B: LOCATION 2 COST TABLES**
- C: LOCATION 3 COST TABLES**



1.0 Executive Summary

Analysis Overview

The goal of this analysis is to evaluate blackwater management options for remote alpine and subalpine huts and lodges in Canada's mountainous regions. Costs and environmental impacts have been evaluated for each of the management options. Due to different site conditions and usage, three huts operated by the Alpine Club of Canada have been evaluated:

- Location 1: Alpine, 100 overnights per year
- Location 2: Alpine, 3000 overnights per year
- Location 3: Subalpine, 800 overnights per year

For each of the locations, the following blackwater options have been evaluated:

- Pit toilets
- Barrel fly-outs
- Incinerating toilets
- Heated chamber composting toilets (different alpine and subalpine systems)
- Carry-out

It is important to consider that the hut and lodge users and operators do not want a system that destroys the sense of solitude in these areas, represents an irrational use of resources, or does not protect the spread of harmful pathogens. As a result, the goal of the recommended blackwater management solutions in this report is to protect water quality, prevent natural resource damage, and protect the aesthetic quality of the hut and its pristine environmental location.

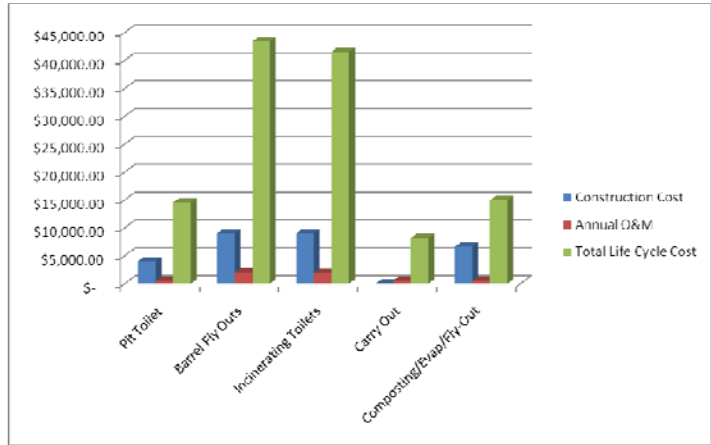
Proper planning at each site is critical to determine the size and use of each facility to prevent against overloading and system abuse.

Analysis Results: Costs

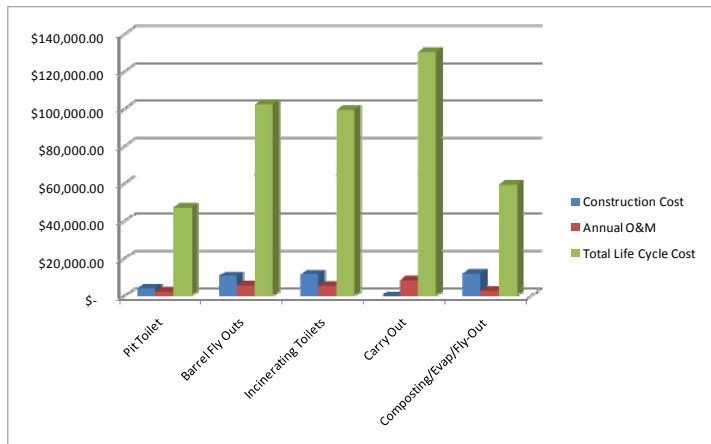
Construction, annual operations and maintenance and total life cycle costs have been evaluated for each of the hut locations and the blackwater options. The general analysis results are presented here.



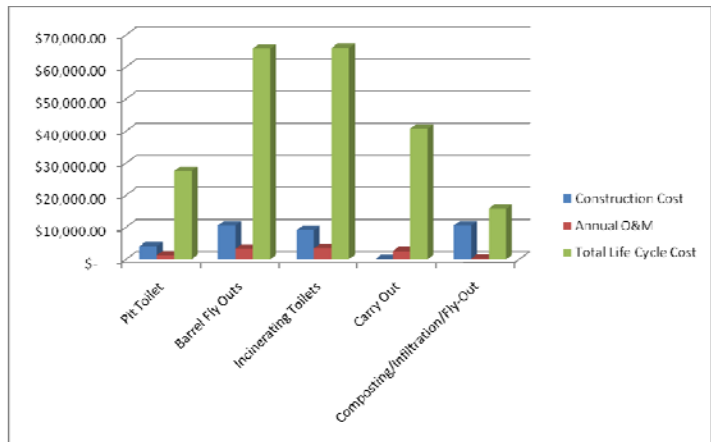
For **Location 1**, the incinerating toilets have the highest life cycle costs, while the carry-out option has the lowest. The composting toilet system has the second lowest total life cycle cost and does not require significant operations and maintenance by users. Estimated costs are shown in the figure to the right.



For **Location 2**, the carry out option has the highest life cycle cost while the pit toilet has the lowest. The composting toilet system has the second lowest total life cycle cost and does not require significant operations and maintenance by users. Estimated costs are shown in the figure to the right.



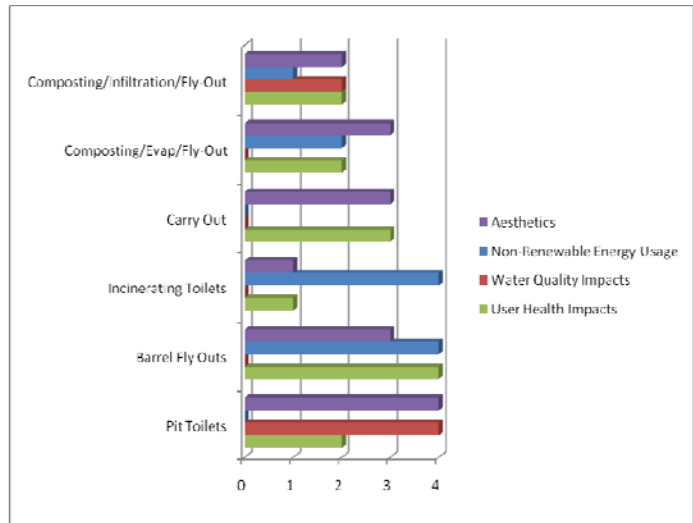
For **Location 3**, the incinerating toilet has the highest life cycle cost while the composting toilet system has the lowest. Estimated costs are shown in the figure to the right.





Analysis Results: Environmental Impacts

Environmental impacts including aesthetics, non-renewable energy usage, water quality impacts, and user health impacts have been compared among the blackwater management options evaluated in this report. Each impact has been rated from 1 to 5 (1 low, 5 high impact). The potential impacts associated with each management option vary across the options. The figure to the right shows the options, impacts and rating.





2.0 Introduction

This analysis addresses alpine and subalpine wastewater treatment and disposal options. These backcountry facilities typically are small buildings (huts and lodges) that provide shelter for hikers and skiers along with cooking and bathroom facilities. The remote locations and physical environments of these facilities limit the available wastewater management options. Owners and operators are required to be creative with their wastewater treatment options. Adequate waste treatment is necessary in order to preserve the pristine and ecologically sensitive sites where these huts are located. In addition, due to the remote nature of these sites, systems that are reliable and have a long lifespan are advantageous.

The purpose of this report is to provide a detailed evaluation of blackwater management solutions for backcountry huts and lodges in Canada's mountainous regions. This assessment evaluates construction, operation, and life-cycle costs. In addition to the cost assessment, a review of the environmental impacts of each option and their applicability in the subalpine and alpine environment was completed. The systems that were assessed include:

- Pit toilets
- Barrel fly-outs
- Incinerating toilets
- Heated chamber composting toilets
- Carry-out

The information contained in this report includes recommendations of the most appropriate blackwater management systems for any hut/lodge. The specific systems recommended are based upon geologic conditions, site hydrology, soils, geographic location, elevation, frequency of use, and available power sources. In our opinion, the recommended options are cost effective and environmentally sound solutions for managing blackwater at backcountry sites.

2.1 BLACKWATER DISCUSSION

Blackwater, otherwise known as brown water or sewage, is waste from toilets and urinals. Contents of blackwater typically include fecal matter, urine, toilet paper and any toilet flush water. Waterless toilets will generate blackwater without the flushing water component.

Proper treatment and handling of blackwater is critical due to the potentially dangerous pathogens in the water. Proper treatment is necessary to protect both public health and the environment, especially in remote and sensitive ecosystems.



Blackwater is one type of wastewater, another type is greywater. Greywater is wastewater from sinks and showers and does not contain the same pathogen concentration as blackwater. Greywater handling at the backcountry sites is also necessary, but is not addressed in this report.

2.2 STANDARD SEPTIC TANK DRAINFIELD APPLICATIONS

For most onsite applications, blackwater is typically handled with a septic tank and drainfield sometimes called a soil treatment unit. In some cases, secondary treatment is required for additional treatment of the wastewater between the septic tank and drainfield. The septic tank separates the liquid from the solid portion of the waste while a drainfield provides a discharge location for the liquid portion of the waste, commonly referred to as greywater. Sufficient soil treatment in the drainfield system renders the water clean enough to be released to the environment. Solids build up in the septic tank and are removed every few years (the actual pumping frequency depends on the sizing and usage of the system). According to the Energy, Water, and Waste Management Pilot Study, most lodge owners with septic systems are satisfied with the low cost of installation and ease of operations and maintenance.

A septic tank and drainfield are not feasible for most backcountry huts and lodges due to the size of the required tanks, equipment necessary for installation, electrical requirements and thin soils. This report will not review this option as it is not applicable to environmental conditions described in this report. A site evaluation detailing soil conditions, proximity to wetlands/streams, and wastewater flows is necessary to determine the feasibility of standard septic systems.

2.3 URINE NEUTRALIZATION

According to Metcalf and Eddy, 80% of the nitrogen and 45% of the phosphates in blackwater comes from urine. Considering these high percentages of potentially toxic nutrients, adequate urine treatment is necessary before it can be released into the environment. In situations with suitable soil for a soil based urine disposal system, these nutrients are neutralized in the soil through chemical/biological processes and groundwater dilution. In alpine situations, urine collection can cause serious contamination and aesthetic concerns as there is inadequate soil cover to provide treatment before urine comes in contact with the rock surface and surface water sources.

Urine neutralization technologies are currently available, but rely on multi stage aeration and anoxic processes that may be difficult to reproduce in remote conditions. The blackwater management processes recommended in this report provide for urine treatment through soil disposal and evaporation are likely the lowest cost and least complex of available technologies.



3.0 Blackwater Management Options Evaluation Process

3.1 EVALUATION CRITERIA

Several blackwater management options have been evaluated in this report. These options have been evaluated based on two broad factors:

1. Cost – Construction, annual operations and maintenance and total life cycle
2. Environmental Impacts – user health impacts, water quality impacts, non-renewable energy use, and aesthetics.

3.1.1 Costs

The construction, annual operations and maintenance, as well as life cycles costs for each option discussed in Section 5 of this report have been evaluated. Costs are based on 2009 construction costs and previous experience with similar projects. In specific cases, costs may have been acquired from various vendors and suppliers worked with on past projects.

The following descriptions define each of these costs.

Construction Cost – The anticipated cost to build (construct) the identified blackwater management facilities. Since construction costs are incurred at the beginning of the project, construction costs are a capital cost.

Operation and Maintenance (O&M) Costs – The annual (cost per year) total for items such as labor, and power source.

Present Worth of Annual O&M – The amount of money that would have to be deposited in the bank today to pay for all of the annual O&M over the next 30 years.

Life Cycle Cost – The *total capital cost* added to the *present worth of the annual O&M*. Life cycle costs are used to identify the most cost-effective alternatives over the project period. The life cycle cost approach allows low construction/high O&M cost alternatives to be compared on an “apples-to-apples” basis with high construction/low O&M cost alternatives.

3.1.2 Environmental Impacts

The environmental impacts of each option have been evaluated based on a rating scale from 0 to 5 (0 - limited impact and 5 - high potential impact). The following environmental impacts have been compared among the blackwater management options:



User Health Impacts – This includes the potential for human contact with waste and the associated health implications.

Water Quality Impacts – The potential for blackwater to negatively impact both surface and groundwater resources.

Non-Renewable Energy Usage – The amount of non-renewable energy required for the system to operate.

Aesthetics – This includes aesthetic attributes of the system such as odors, convenience and visual impacts.

4.0 Existing Site Conditions

4.1 LOCATIONS

Besides a review of applicable blackwater treatment technologies, this report also evaluates three specific locations and provides recommendations on the most appropriate technologies. As identified in the January 21, 2009 Request for Proposal (RFP), these options include:

- Location 1: Alpine, 100 overnights per year (representative of low use alpine shelter)
- Location 2: Alpine, 3000 overnights per year (representative of high use alpine hut)
- Location 3: Subalpine, 800 overnights per year (representative of moderate use subalpine hut or lodge)

In July 2009, Stantec accompanied BEES personnel to two backcountry sites that provide examples of alpine and subalpine conditions: 1) the Bow Hut and 2) the Elizabeth Parker Hut. Further information on each of these huts is provided in the following sections.

4.1.1 *Alpine Conditions – Great Cairn Hut*

Alpine conditions are located at elevations above the tree line, which varies depending on the climatic and geologic conditions of each site. Subject to a much harsher climate (strong winds and colder temperatures), alpine areas are dominated by glacial moraine terrains (minimal soils, coarse gravels, bedrock exposures) with minimal vegetative cover. The Great Cairn Hut, shown in **Figure 4.1**, is located in the alpine region.



FIGURE 4.1 GREAT CAIRN HUT

The Great Cairn Hut sleeps up to 6 users per night and currently uses barrel fly-outs for blackwater disposal. The outhouses are located approximately 50 meters from the hut. Due to the difficult overland routes and its location within the Northern Selkirk Mountains (elevation - 1,830 meters), the hut only averages approximately 100 overnights per year. Water supply is provided by a small creek from the Haworth Glacier and wastewater maintenance costs for the facility average approximately \$2,000 per year.

4.1.2 Alpine Conditions – Bow Hut

The Bow Hut, shown in **Figure 4.2**, is also located within this alpine region.



FIGURE 4.2 BOW HUT

The Bow Hut sleeps up to 30 users per night and currently supports users with two barrel fly-out toilets. Located at an elevation of 2,350 meters, the hut is often used for ice climbing and mountaineering training. An average of 3,180 visitors per year have used the Bow Hut over the last three years. The average maintenance cost for wastewater management was \$5,000. Water supply is provided by snowmelt and glacial streams from the Wapta Icefields.

4.1.3 Subalpine Conditions – Elizabeth Parker Hut

Subalpine hut facilities are located below the tree line in diverse habitats ranging from meadow to forested communities. Soil profiles are generally more developed in these areas, but groundwater is typically close to the surface, flowing on the bedrock shelves. The Elizabeth Parker Hut (shown in **Figure 4.3**) is located within the subalpine areas surrounding Lake O’Hara. The environmental conditions at Elizabeth Parker Hut are similar to other lodges located in Canada’s mountainous regions.



FIGURE 4.3 ELIZABETH PARKER HUT

The Elizabeth Parker Hut (EP) sleeps up to 24 people per night and has averaged 4,342 users per year since 2006. Washroom facilities are provided through an outbuilding and barrel fly-outs while potable water is supplied through the nearby stream or snowmelt in the winter. Wastewater maintenance costs for the facility average approximately \$6,300 per year.



5.0 Blackwater Management Options

5.1 TECHNOLOGY OPTIONS

A number of blackwater management options have been evaluated in this analysis. Four of these options are applicable to both the alpine and subalpine sites and include:

- Pit toilets
- Barrel Fly-Outs
- Incinerating Toilets
- Carry-out

In addition to these four options, a composting toilet option has been evaluated for each of the site types. Because of differing site conditions at the alpine and subalpine cabins, a site-specific composting system has been evaluated for each. The components for each system include:

- Alpine system: composting toilet, evaporation tank (for liquids) and barrel fly-outs
- Subalpine system: composting toilet, onsite liquid infiltration field, and barrel fly-outs

5.2 EVALUATION PROCESS

After a review of the available technologies, construction and total life cycle costs were evaluated for the 3 hut location types identified in the RFP. Detailed cost tables for each of the options evaluated (all three hut/lodge locations) are provided in **Appendices A, B, and C**. The details of these costs are discussed in Sections 3 and 4 of this report.

Following the cost analysis, each of the blackwater management options were rated for potential environmental and aesthetic impacts. These impacts are also discussed further in Sections 3 and 4 of this report.

5.3 PIT TOILETS

5.3.1 *Technology Description*

A pit toilet or pit latrine is a simple form of waste handling in remote locations. Typically, a small structure is built over a waste collection pit. Pit toilet odors and vector attraction can be minimized through the inclusion of ventilation, although a draft needs to be created to properly ventilate the structure. Pits are moved and backfilled when the waste reaches within one foot of the original grade. Microorganisms in the soil eventually break down the waste. In the



alpine, the shallow bedrock layers make the digging of pits difficult, if not impossible. Pit toilets may be a viable solution in subalpine areas where there is sufficient soil depth

To provide adequate treatment of liquid waste, pit toilets need to have developed soils with good infiltrative qualities. Success of pits can be limited by poorly drained soils, high water table, steep slopes, shallow bedrock and cold temperatures. According to the Appalachian Trail Conference's "*Backcountry Sanitation Manual*", pit toilets can contaminate a radius of 15 meters from the pit location. However, in the alpine, pit toilets are a significant groundwater contamination risk from groundwater infiltrating through fractures in the bedrock and surfacing downslope, potentially contaminating a much larger area (*Backcountry Sanitation Manual*).

The Green Mountain Club, associated with the Appalachian Trail, has developed an alternative to the pit toilet, called a moldering privy. The difference between the two is that the moldering privy encourages slow, cool composting of the waste. Structures are constructed on ventilated cribs where the solids collect and the liquids infiltrate into the ground. Organic material, such as leaves and duff is mixed in with the solids as a carbon addition for composting.

A number of cribs are typically constructed and when one cell is full, the structure can be moved to a second cell, while the first cell goes through the composting process. This is still a relatively new process and is likely not applicable to alpine conditions, but may be applicable to the subalpine. The aesthetic concerns and environmental impact will be similar to the pit toilet, but the required footprint for new systems will be restricted to the composting cribs that are constructed and reused as compost is removed.

5.3.2 Costs

The construction and total life cycle costs of a pit toilet have been evaluated for each of the three locations discussed in Section 2 of this report. **Table 5.1** summarizes the results and Section 6 of this report compares the costs among options and locations.

TABLE 5.1 PIT TOILET COSTS

Location	Estimated Construction Cost	Estimated Yearly O&M	Estimated Life Cycle Cost
1: Alpine, 100 overnights	\$4000	\$400	\$14,516
2: Alpine, 3000 overnights	\$4,000	\$2,400	\$47,093
3: Subalpine, 800 overnights	\$4,000	\$1,200	\$27,547

5.3.3 Environmental Impacts

The environmental impacts discussed in Section 2 of this report have been evaluated for the pit toilet. **Table 5.2** summarizes the impacts, rating for the pit toilet (0=low impact, 5=high potential impact) and notes regarding the potential impacts of the system.

TABLE 5.2 PIT TOILET ENVIRONMENTAL IMPACTS

Impact	Rating	Notes
User Health Impacts	2	Potential for waste contact if toilet is not maintained/cleaned
Water Quality Impacts	4	Potential for leakage of waste into ground and particularly surface water. Potential for impacts to water quality are high at alpine sites because of the lack of soil
Non-Renewable Energy Usage	0	No non-renewable energy requirements
Aesthetics	4	Toilet system can be odorous and must be moved every few years. Will be located outdoors and cold in winter.

5.4 BARREL FLY-OUTS

Fly-out of waste is an option currently utilized at a number of the backcountry sites. The barrel fly-out option limits onsite environmental degradation, but is both costly and potentially dangerous. This option has been compared to the other available options in this analysis. Example hut fly-out facilities are shown in **Figure 5.1**.



Figure 5.1: Barrel Fly-Out Facilities



During hut maintenance, 150 liter barrels of blackwater are flown out (three per flight) to a base station located near the closet highway. A pumper truck evacuates the barrels and takes the waste to a certified wastewater treatment site. Barrels are then returned for reuse in the hut. Hut users are responsible for removing and sealing the barrels when they reach capacity.

5.4.1 Costs

The construction and total life cycle costs of the barrel fly-out blackwater management system have been evaluated for each of the three locations discussed in Section 2 of this report. **Table 5.3** summarizes the results and Section 6 of this report compares the costs among options and locations. Fly-out costs are based on existing data provided by BEES on a per user basis.

TABLE 5.3 BARREL FLY-OUT COSTS

Location	Estimated Construction Cost	Estimated Yearly O&M	Estimated Life Cycle Cost
1: Alpine, 100 overnights	\$9,000	\$2,000	\$43,378
2: Alpine, 3000 overnights	\$10,500	\$5,500	\$102,189
3: Subalpine, 800 overnights	\$10,500	\$3,260	\$65,702

5.4.2 Environmental Impacts

The environmental impacts discussed in Section 2 of this report have been evaluated for the barrel fly-out option. **Table 5.4** summarizes the impacts, rating for the barrel fly-out (0=low impact, 5=high potential impact) and notes regarding the potential impacts of the system.

TABLE 5.4 BARREL FLY-OUT ENVIRONMENTAL IMPACTS

Impact	Rating	Notes
User Health Impacts	4	High potential for contact with waste when barrels must be exchanged. Helicopter fly-outs can be dangerous in windy conditions.
Water Quality Impacts	0	Waste is separate from the environment.
Non-Renewable Energy Usage	4	Helicopter fly-outs require non-renewable energy
Aesthetics	3	Visitor management of the waste barrels is not desirable. Existing facilities are clean with minimal odours.

5.5 INCINERATING TOILETS

Incinerating toilets are a waterless toilet option for waste management in remote locations. **Figure 5.1** shows a typical incinerating toilet system. The waste is incinerated in a chamber separate from the toilet and creates a sterile ash byproduct that needs to be removed and properly disposed. Typically, ash is flown out of the site in barrels or carried out in smaller loads throughout the season. The toilet requires more energy than the other management options. As shown in **Figure 5.2** it requires both electricity and fuel. Both propane and electric incineration units are available. However, according to Storburn International, a leading supplier of incineration toilets, gas powered units are twice as expensive as the electric variety.

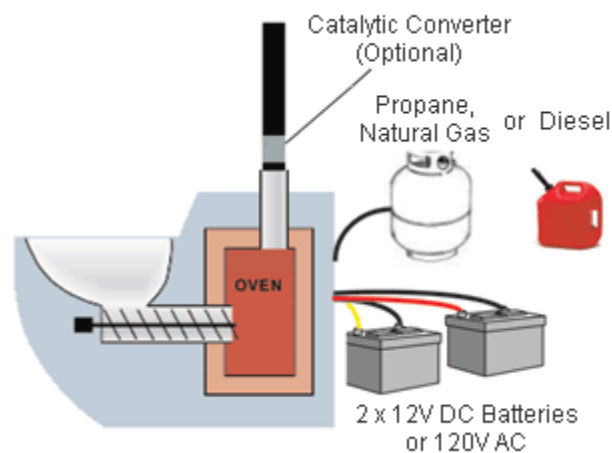


FIGURE 5.2 INCINERATING TOILET SYSTEM (SOURCE: ECOJOHN)

Incinerating toilets are typically used in situations of zero discharge and a single user facility. Alpine hut locations typically cannot meet the rigorous power demands of multiple incineration events and amount of use would likely overwhelm the facility. However, propane powered toilets are used in alpine situations and can support a higher capacity if solids and liquids are separated. In all cases, a full-time custodian is necessary at incinerating toilet installations to manage incineration events and the power supply.

5.5.1 *Advantages and Disadvantages of Incinerating Toilets – User Feedback*

In British Columbia and Alberta, incinerating toilets are currently used in both the alpine and subalpine. Both the Powder Creek Lodge (Purcell Mountains) and Selkirk Lodge (East of Revelstoke in the Albert Icefields) have been using incinerating toilets for at least 20 years and are satisfied with the technology. At both lodges, a full time operator is available to maintain the incinerating units and a separate toilet facility is provided for liquids. Since electrical power is not available, both lodges use gas powered units. At the Selkirk Lodge, two 500 gallon propane tanks that are 60-65% full are flown in by helicopter each year.



Based on user feedback and other available resources, advantages and disadvantages to incinerating toilets are summarized below:

- | Advantages | Disadvantages |
|---|---|
| <ul style="list-style-type: none"> • Waterless – flush water is not required • Harmful nutrients and pathogens are destroyed during incineration • Waste volume is reduced by 95% • End products are sterile and can be flown out • Odourless, if not overloaded | <ul style="list-style-type: none"> • Requires energy source – gas or electric • Propane tanks need to be flown in yearly and can be dangerous • In high capacity situations, liquids and toilet paper must be separated out • Overloaded toilets can be very unpleasant • Potentially valuable nutrients in waste are destroyed • Full-time operator required |

5.5.2 Costs

The construction and total life cycle costs of an incinerating toilet system have been evaluated for each of the three locations discussed in Section 2 of this report. **Table 5.5** summarizes the results and Section 6 of this report compares the costs among options and locations.

TABLE 5.5 INCINERATING TOILET COSTS

Location	Estimated Construction Cost	Estimated Yearly O&M	Estimated Life Cycle Cost
1: Alpine, 100 overnights	\$9,000	\$1,885	\$41,505
2: Alpine, 3000 overnights	\$11,500	\$5,250	\$99,317
3: Subalpine, 800 overnights	\$9,000	\$3,380	\$65,856

5.5.3 Environmental Impacts

The environmental impacts discussed in Section 2 of this report have been evaluated for the incinerating toilet option. **Table 5.6** summarizes the impacts, rating for the incinerating toilet (0=low impact, 5=high potential impact) and notes regarding the potential impacts of the system.

TABLE 5.6 INCINERATING TOILET ENVIRONMENTAL IMPACTS

Impact	Rating	Notes
User Health Impacts	1	Contact with waste is very low. Ash from waste is safe to remove and can be walked or flown out of the site.
Water Quality Impacts	0	Waste is separate from the environment
Non-Renewable Energy Usage	5	Waste incineration requires large amount of energy when compared to other options
Aesthetics	1	Toilet is similar to a flush toilet in function. High usage may cause overloading of toilet.

5.6 CARRY-OUT

Waste carry-out is a blackwater management option that significantly reduces the requirement to construct and maintain onsite toilet facilities. The Wag Bag, shown in **Figure 5.3**, is an example of a commercially available carry-out bag. Other available options include the Travel John Kit and the “Poop Tube”, both commonly available through manufacturer websites. Our understanding is that Wag Bags are currently being piloted at the Great Cairn Hut.

For the purposes of this analysis, it is assumed that facility operators will provide these bags to visitors.



FIGURE 5.3 WAG BAG CARRY-OUT CONTAINER

5.6.1 Costs

The construction and total life cycle costs of waste carry-out have been evaluated for each of the three locations discussed in Section 2 of this report. **Table 5.7** summarizes the results and Section 6 of this report compares the costs among options and locations.



TABLE 5.7 CARRY-OUT COSTS

Location	Estimated Construction Cost	Estimated Yearly O&M	Estimated Life Cycle Cost
1: Alpine, 100 overnights	-	\$500	\$8,144
2: Alpine, 3000 overnights	-	\$8,000	\$130,311
3: Subalpine, 800 overnights	-	\$2,500	\$40,722

5.6.2 Environmental Impacts

The environmental impacts discussed in Section 2 of this report have been evaluated for the waste carry-out option. **Table 5.8** summarizes the impacts, rating for the waste carry-out (0=low impact, 5=high potential impact) and notes regarding the potential impacts of the system.

TABLE 5.8 CARRY-OUT ENVIRONMENTAL IMPACTS

Impact	Rating	Notes
User Health Impacts	3	Waste must be handled by each visitor increasing the potential for waste contact.
Water Quality Impacts	0	Waste is separate from the environment.
Non-Renewable Energy Usage	0	Carry-out does not require any energy inputs.
Aesthetics	3	Carry-out is less aesthetically pleasing for the user, but can increase the aesthetics of the hut sites by eliminating onsite waste management.

5.7 COMPOSTING TOILETS

Composting toilets provide both liquid-solid separation and waste decomposition. Composting toilets are evaluated for use at the backcountry sites as part of a larger system. A system has been developed for each of the site types: alpine and subalpine. **Figure 5.4** shows a typical installation of a waterless composting toilet system.

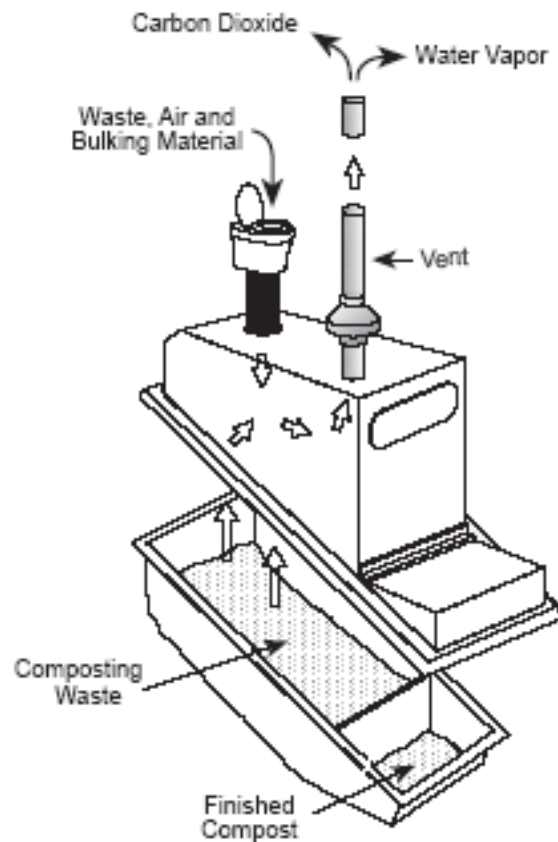


FIGURE 5.4 COMPOSTING TOILET SYSTEM (SOURCE: CLIVUS MULTRUM)

A composting toilet works by capturing the nutrients in waste and breaking them down into simple, stable compounds that have high value as plant nutrients. Waste is broken down by mesophilic organisms, which thrive in temperature from 20 to 44 degrees Celsius (C), such as bacteria, fungi, and red worms. Pathogens in the waste are killed by the active bacteria and organisms in the compost and the long residence time that the waste has in the composter.

A composting toilet needs nitrogen, carbon, and oxygen to function properly. The toilet waste provides the nitrogen and the ventilation shaft provides the oxygen, but carbon needs to be added to the system. Carbon can be added in the form of any type of bulking material (wood shavings, etc.) that will promote good aeration and moisture levels within the composter. Biological additives are available that speed up the composting process, which may be useful at the alpine huts due to the relatively short composting season.

Three end products are created by the composter. The largest product is the compost, which looks, feels, and smells like topsoil and if composted properly, is safe to handle. Solid compost is removed no more than once per year. The second end product is a concentrated liquid that is very rich in nutrients and can be a very beneficial fertilizer. Liquid is separated in the composting chamber after it infiltrates



through the solids and collects in the base of the composting unit. This product can sustain agricultural production without the ruination of soil. The third end product is gas. Carbon dioxide and water vapor are both produced, but are harmless as they are the same gases that humans exhale. If the toilet is overloaded and not maintained properly, hydrogen sulfide and methane can be produced and are not safe for human inhalation.

Without liquid separation, composting toilets can be compared to pit toilets as the liquids are not treated and potentially hazardous. However, it is estimated that for every 100 uses in a composting toilet, only 5 gallons of liquid waste is generated. Most liquid is utilized in the composting process and the remaining liquid can be collected in the base of the composting unit and flown out. If this concentrated liquid were to reach the soil/rock contact zone, it creates the potential for groundwater contamination similar to pit toilets.

Regular maintenance to the composting unit includes the addition of bulking material (once weekly), 4-12 liters of fresh water per day, raking and the removal of the liquid end product (once weekly). A liquid removal system is standard in most composting toilets and can gravity flow the product to a storage tank where it can be applied to soil via irrigation. If soils irrigation is not possible due to regulatory requirements, the liquid would have to be removed approximately once or twice a year.

5.7.1 Advantages and Disadvantages of Composting Toilets – User Feedback

During the review of this report, many existing lodge owner/operators responded with personal experiences with composting toilets. All feedback regarding the use and operation of composting toilets was positive. For example, the Amiskwi Lodge (north of Golden, BC) has two composting toilets that are currently heated with a small propane heater. With the exception of the rare heater failure, the toilets have been working exceptionally. Approximately 2-3 barrels of compost are removed every year and land applied. Odours are controlled with a small fan in the tank that forces air through a 4 inch exhaust pipe at the top of the roof. Users and the operator are pleased as odours are non-existent and the system is very low maintenance.

The Burnie Glacier Chalet uses a chambered system that, according to the owner, is treating the waste through anaerobic digestion, which is the same process in which waste is treated in a traditional septic tank. However, the custom design of this facility, which utilizes a concrete floor poured at a 30% slope to a length of 4.5 meters, appears to be similar to a “Pennsylvania Composter”. As described in the *Backcountry Sanitation Manual* (Appalachian Trail Conference), this technology uses slow aerobic digestion, which is similar to that of the moldering privy. Typically, anaerobic digestion does not work at high elevations due to the cold temperatures and short duration of biological activity that only occur during warm months. However, if located at a low enough elevation and temperatures are warm enough, anaerobic digestion could potentially occur. Regardless of the treatment method, the owner/operator reports that the system is working well and that waste has never been flown out and odours are not an issue.

Based on user feedback and other available resources, advantages and disadvantages to composting toilets are summarized below:

Advantages	Disadvantages
<ul style="list-style-type: none">• Waterless – flush water is not required• Harmful nutrients and pathogens are treated and removed• Waste volume is reduced by 80% - 90%• End product is sterile• Does not require full time operator – Guests can apply carbon source (wood chips)• Can handle higher usage than most available backcountry technologies	<ul style="list-style-type: none">• Requires heat to compost in Winter• Energy source is needed to power heaters and fan.• Capacity is limited to available technology and size of chamber• Potential for odors and insects if not well ventilated• Waste needs to be mixed during composting process• Overloaded toilets can be very unpleasant• Wood chips must be transported to site• Sterile end product is nutrient rich and could change alpine ecology and plant diversity

5.7.2 *Alpine Option: Composting toilets + Liquid Evaporation + Barrel Fly-Out*

The alpine composting toilet system option evaluated in this report includes an evaporation tank and waste fly-out when necessary. Due to the exposed bedrock and lack of soil in the alpine region, infiltration of liquid waste is not feasible. An evaporation tank is proposed with this system to minimize the required number of barrel fly-outs by evaporating the liquid waste and significantly reducing the overall waste volume.

According to *Wastewater Engineering* by Metcalf and Eddy, typical human waste is composed of over 90% liquid. Through the use of a composting toilet, the liquid waste can be separated from the solids and handled separately. An evaporation tank equipped with minimal aeration and heat and combined with the dry air conditions in the alpine region will be able to evaporate some of the liquid waste. For the purposes of this evaluation the following assumptions have been made about this system:

- Volume of waste per person per day: 1.89 liters (based on data provided by BEES)
- Percentage of liquid in waste: 90%
- Percentage of liquids evaporated in evaporation tank: 50%

Based on these assumptions the waste volume can be reduced by 45%. This also results in a 45% reduction in required barrel fly-out trips. **Figure 5.5** is a schematic of the alpine composting toilet system described here. The figure shows the additional inputs required for this system's operation. Both heat and aeration can be supplied from electricity generated by a wind turbine

or other power source. The composting toilet system can utilize the electricity generated by the turbine when it is not being consumed by other uses in the hut or lodge.

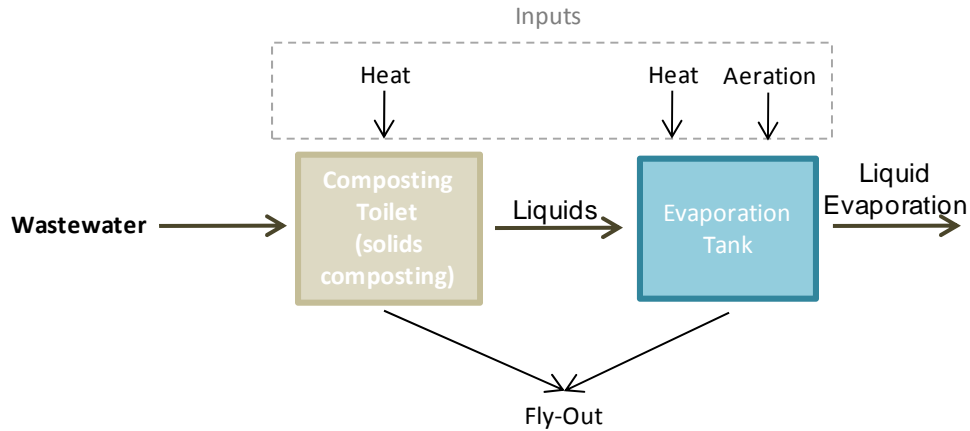


FIGURE 5.5 ALPINE SYSTEM SCHEMATIC

5.7.2.1 Costs

The construction and total life cycle costs of the alpine composting toilet system have been evaluated for each of the two applicable locations discussed in Section 2 of this report. **Table 5.9** summarizes the results and Section 6 of this report compares the costs among options and locations.

TABLE 5.9 ALPINE COMPOSTING TOILET SYSTEM COSTS

Location	Estimated Construction Cost	Estimated Yearly O&M	Estimated Life Cycle Cost
1: Alpine, 100 overnights	\$6,600	\$430	\$14,924
2: Alpine, 3000 overnights	\$12,000	\$2,750	\$59,194
3: Subalpine, 800 overnights	N/A	N/A	N/A

5.7.2.2 Environmental Impacts

The environmental impacts discussed in Section 2 of this report have been evaluated for the alpine composting toilet option. **Table 5.10** summarizes the impacts, rating for the alpine composting toilet system (0=low impact, 5=high potential impact) and notes regarding the potential impacts of the system.

TABLE 5.10 ALPINE COMPOSTING TOILET SYSTEM ENVIRONMENTAL IMPACTS

Impact	Rating	Notes
User Health Impacts	2	Barrel exchange is required for this option, yet frequency between exchanges will be lower than the barrel fly-out option. Contact with waste is a potential during this exchange. Barrel fly-out can also be dangerous during high wind conditions.
Water Quality Impacts	0	Waste is separate from environment.
Non-Renewable Energy Usage	2	Non-renewable energy is required to fly-out barrels of blackwater.
Aesthetics	3	Visitor management of the waste barrels is not desirable, but is less frequent than the barrel fly-out option.

5.7.3 Sub-Alpine Option: Composting Toilet + Liquid Infiltration + Barrel Fly-Out

The sub-alpine blackwater management system evaluated in this report is similar to the alpine system with the exception of how liquids are managed. The sub-alpine regions typically have enough soil for the infiltration of liquid waste on the site. **Figure 5.6** is a schematic of the evaluated sub-alpine composting toilet system.

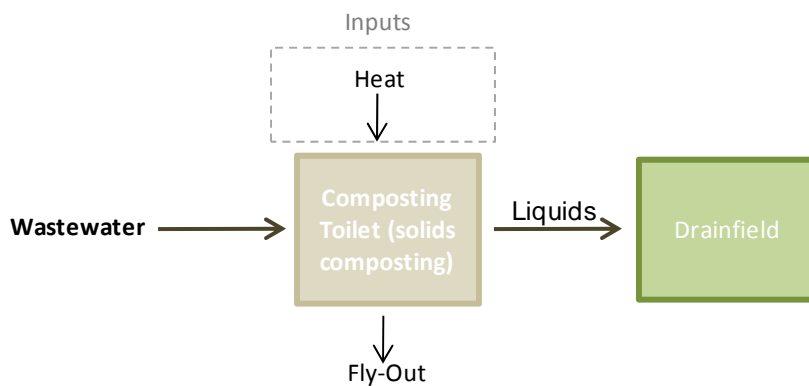


FIGURE 5.6 SUB-ALPINE SYSTEM SCHEMATIC



Because liquid waste can be managed on site the need for barrel fly-outs can be reduced even further than the alpine system. The following assumptions have been made regarding the sub-alpine system for this report:

- Volume of waste per person per day: 1.89 liters (based on data provided by BEES)
- Percentage of liquid in waste: 90%
- Percentage of liquids infiltrated on site: 100%

Based on these assumptions the waste volume can be reduced by 90%. This also results in a 90% reduction in required barrel-fly trips. This system for managing blackwater can significantly decrease management costs and requirements.

5.7.3.1 Costs

The construction and total life cycle costs of the subalpine composting toilet system has been evaluated for the one applicable location discussed in Section 2 of this report. **Table 5.11** summarizes the results and Section 6 of this report compares the costs among options and locations.

TABLE 5.11 SUBALPINE COMPOSTING TOILET SYSTEM COSTS

Location	Estimated Construction Cost	Estimated Yearly O&M	Estimated Life Cycle Cost
1: Alpine, 100 overnights	N/A	N/A	N/A
2: Alpine, 3000 overnights	N/A	N/A	N/A
3: Subalpine, 800 overnights	\$10,500	\$198	\$15,825



5.7.3.2 Environmental Impacts

The environmental impacts discussed in Section 2 of this report have been evaluated for the subalpine composting toilet option. **Table 5.12** summarizes the impacts, rating for the subalpine composting toilet system (0=low impact, 5=high potential impact) and notes regarding the potential impacts of the system.

TABLE 5.12 SUBALPINE COMPOSTING TOILET SYSTEM ENVIRONMENTAL IMPACTS

Impact	Rating	Notes
User Health Impacts	2	Barrel exchange is required for this option, yet frequency between exchanges will be lower than the barrel fly-out option. Contact with waste is a potential during this exchange. Barrel fly-out can also be dangerous during high wind conditions.
Water Quality Impacts	2	Liquid waste will be infiltrated into the site soils. Waste can potentially runoff into surface water if the infiltration field fails.
Non-Renewable Energy Usage	1	Non-renewable energy is required to fly-out barrels of blackwater.
Aesthetics	2	Visitor management of the waste barrels is not desirable, but is less frequent than the barrel fly-out option.

5.8 ENERGY SOURCES FOR COMPOSTING TOILETS

Due to the presence of katabatic winds and minimal tree coverage at many of the alpine huts, wind turbines are a feasible energy source consideration. An appropriately sized wind turbine provides a sufficient amount of electricity that is then stored in batteries. Depending on the needs of the hut, this electricity can be used to power stoves, heat water, heat the building, and provide light. Once the batteries are fully charged and electricity is still being generated, excess electricity, or the “dump load” could be transferred to a heater in a composting chamber. An aeration fan and pump could also be powered with individual batteries and electricity generated from the wind turbines. Worley Parsons is currently conducting a wind assessment at the Bow Hut to determine the feasibility of wind power source development (Ref: WorleyParsons, Dec. 2009 Draft. *“Wind Turbine Evaluation for Alpine and High Sub-Alpine Locations.”* Prepared for BEES).

In situations with wind speeds insufficient for wind turbine power generation, solar thermal power generation could be considered. In solar thermal applications, sunlight is not converted directly to electricity as with photovoltaics. Instead, sunlight heats a glycol-water mixture that could then be circulated through a network of pipes in the composting chamber. According to the Global Thermal Energy Council’s website (www.solarthermalworld.org), this solar technology is typically more efficient than photovoltaics as all the generated heat is transferred, in this case, to the composting chamber. A small photovoltaic cell would be necessary to power an aeration fan.

6.0 Blackwater Management Options Analysis and Comparison

6.1 COST COMPARISON

The construction, annual operations and maintenance and total life cycle costs have been estimated and compared for each of the hut locations identified. Detailed cost tables can be found in **Appendices A, B** and **C**. **Figures 6.1** through **6.3** below show the costs of the various blackwater management options for each of the hut locations.

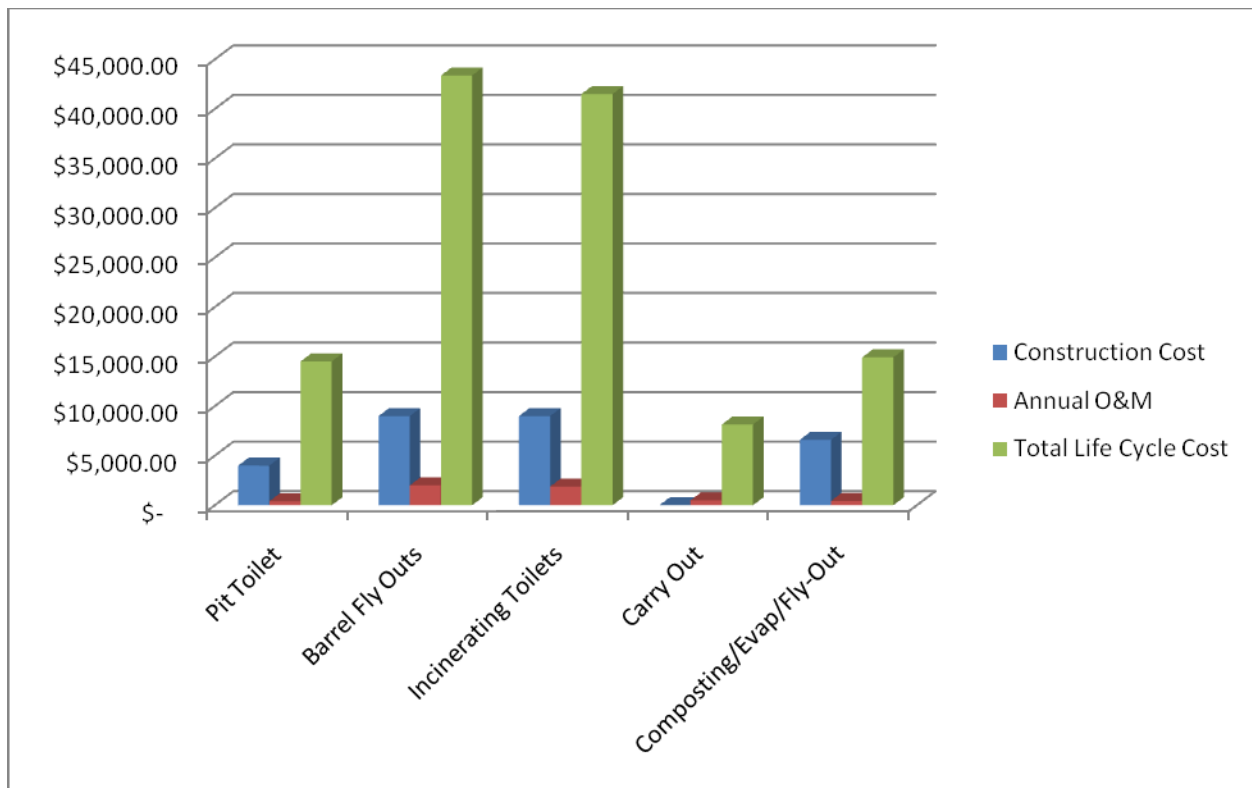


FIGURE 6.1 LOCATION 1 (ALPINE, 100 OVERNIGHTS PER YEAR) COST COMPARISON

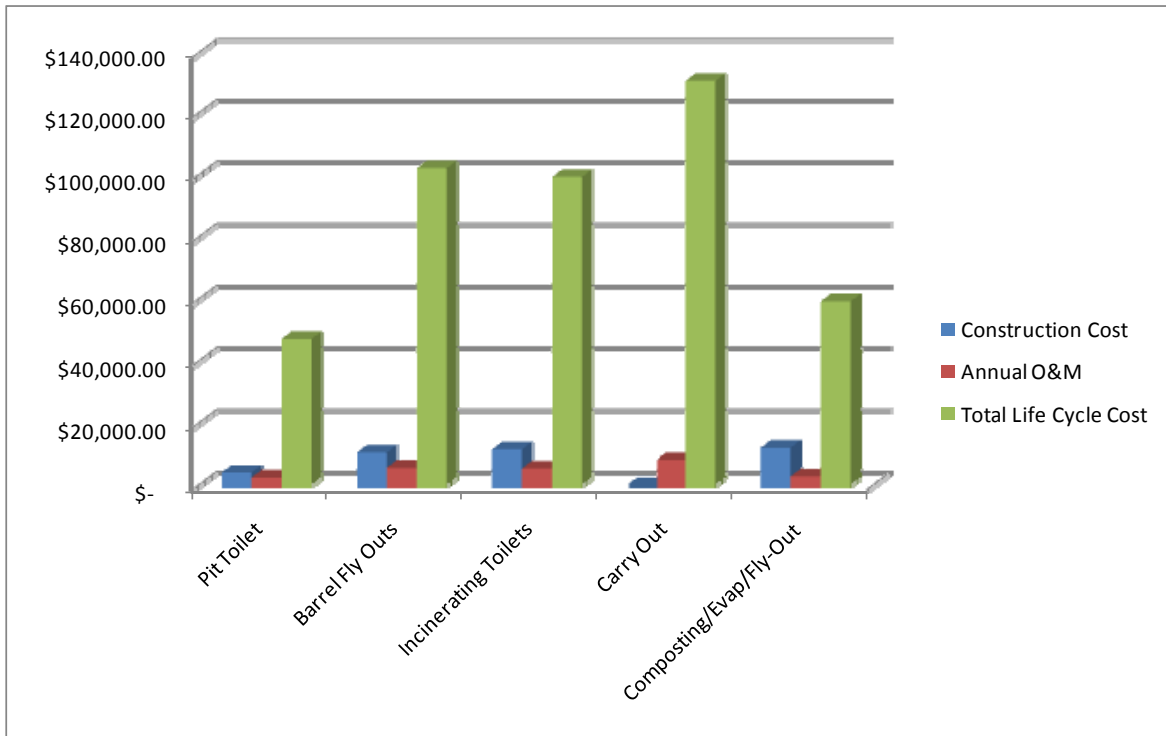


FIGURE 6.2 LOCATION 2 (ALPINE, 3000 OVERNIGHTS PER YEAR) COST COMPARISON

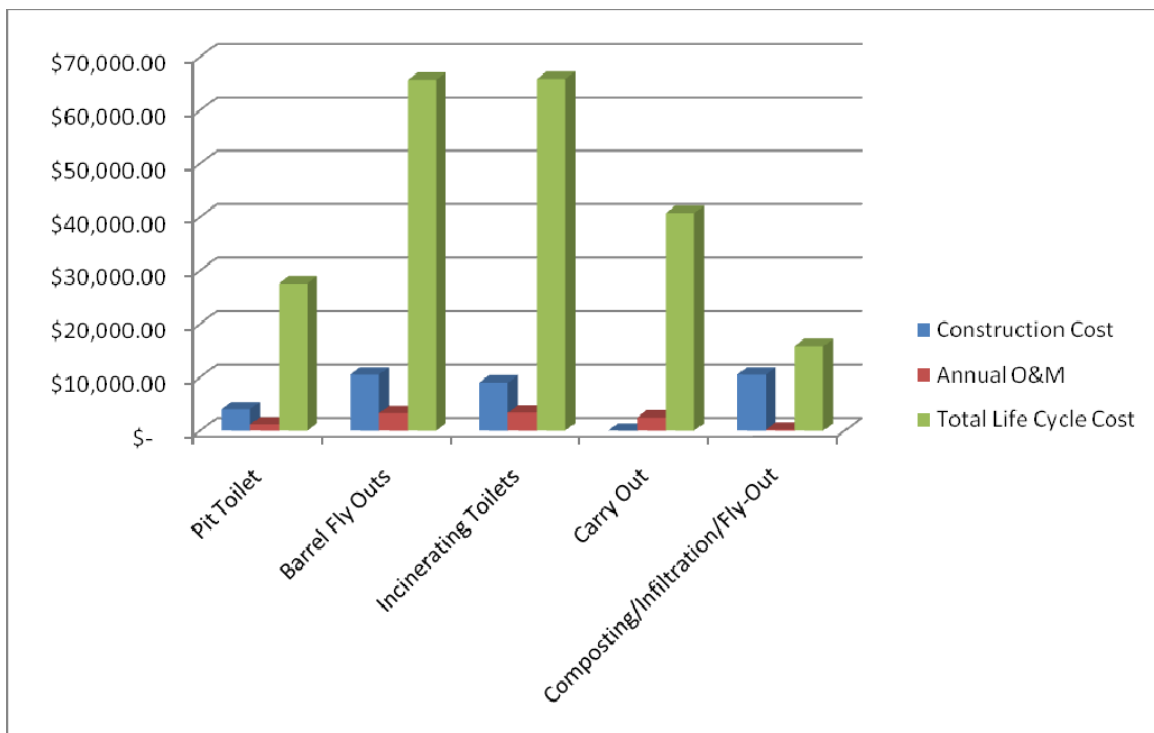


FIGURE 6.3 LOCATION 3 (SUBALPINE, 800 OVERNIGHTS PER YEAR) COST COMPARISON

6.2 ENVIRONMENTAL IMPACTS COMPARISON

Along with cost considerations, the environmental impact of each option was considered. For example, the current practice of barrel fly-out minimizes all water quality impacts, but the fly-out and barrel replacement process have considerable aesthetic and environmental impacts. Environmental impacts for all the options are summarized in **Figure 6.4**.

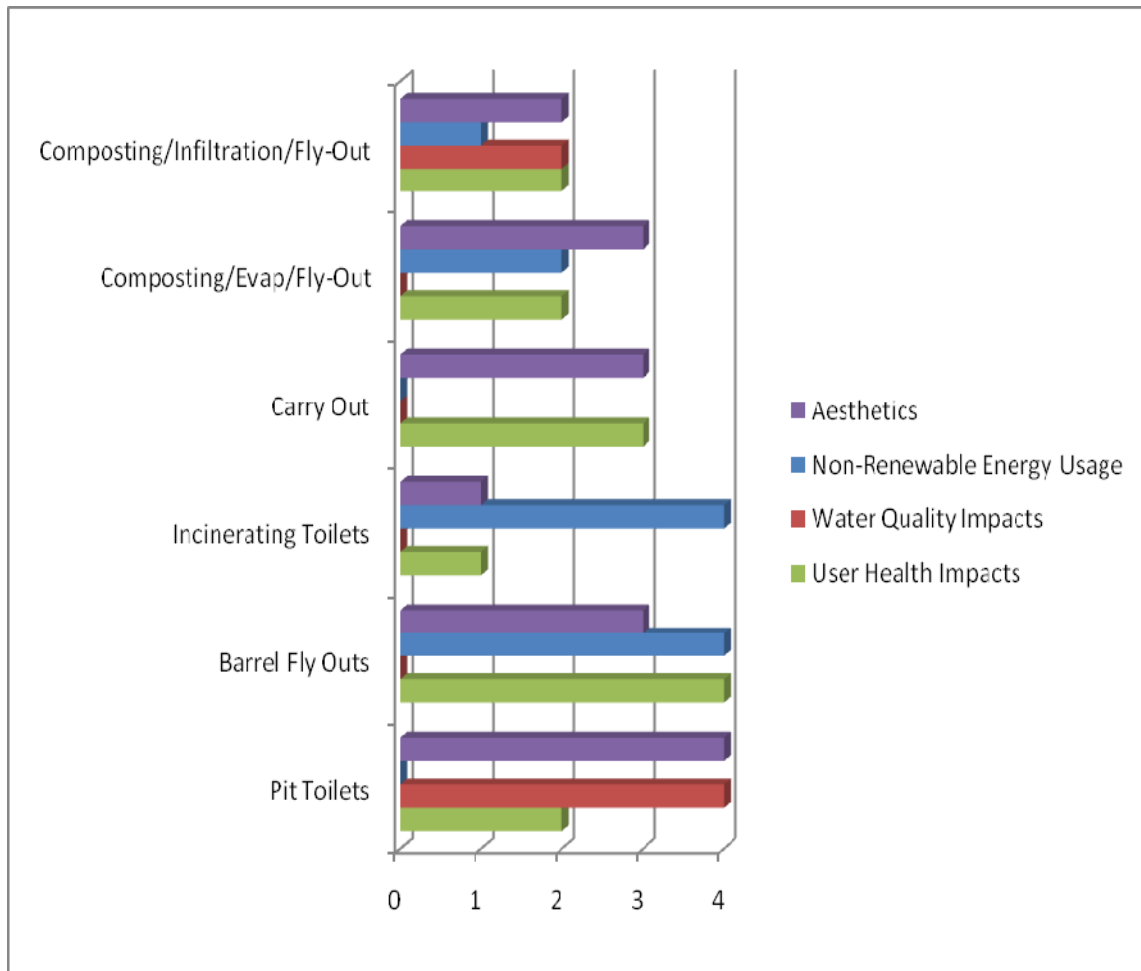


FIGURE 6.4 ENVIRONMENTAL IMPACTS COMPARISON



7.0 Summary and Recommendations

This report has reviewed a number of options for blackwater management at huts and lodges in Canada's mountainous regions. Each option has considerable merit in different environmental situations. It is important to consider that the hut users and operators do not want a system that destroys the sense of solitude in these areas, represents an irrational use of resources, or does not protect the spread of harmful pathogens. As a result, the goal of the recommended blackwater management solutions in this report is to protect water quality, prevent natural resource damage, and protect the aesthetic quality of the hut and its pristine environmental location.

For the huts analyzed in this report, a combination system of a composting toilet, evaporation (or infiltration), and fly-out system is recommended. This option does require the installation of a power source at the huts to generate heat for composting and power for a small aeration pump. However, this power source (solar or wind) will also have the added benefit of eliminating the fly-in/out of propane tanks. Excess power not used for cooking and heating, or the "dump load" can be directed to the composting units to heat the chamber.

As shown in Section 6, the composting toilet is a low cost alternative suitable for all three environmental locations, provided a power source is available to provide heat to the composting process. In the absence of power source development at the huts, the recommended option will depend on the usage and location of the hut. For example, at the high-use alpine hut, pit toilets are the lowest cost. However, due to the associated environmental impacts, this is not a recommended option. In this situation, the continued use of barrel fly-outs would likely be the recommended alternative.

Each of the five blackwater management options has unique situations critical to success:

- Pit Toilets – Deep soils, large land area for replacement, moderate usage and climates.
- Barrel Fly-Outs –Thin soils, alpine hut, minimal land area available, accessible by helicopter
- Incinerating Toilet – Low use or single user toilets, minimal land area, minimal water supply, large power requirements, urine separation for high capacity toilets, daily maintenance
- Carry-Out – Low use, non-permanent structures, backpacking uses, responsible users
- Composting – power source to provide heat, alpine and subalpine environments

All blackwater management solutions can be successfully implemented if site conditions meet the requirements of the technology. Proper planning at each site is critical to determine the size and use of each facility to prevent against overloading and system abuse. The current practices at Alpine Club facilities are working, but put a strain on the maintenance staff. Alternative solutions have been provided in this report that can lead to a lower maintenance system, reduced barrel fly-outs and lower operating costs.



Stantec Consulting and the SD Consulting Group have enjoyed working with BEES and the Alpine Club on this project and we appreciate the efforts and information supplied by Karen and Jon Rollins (BEES). Our group strives to engineer innovative solutions for remote backcountry operations. We are grateful for projects such as these as they provide us with an opportunity for innovation and creative thinking. We look forward to working with you again in the future.



8.0 References

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Appendix A

Location 1 Cost Tables (Alpine, 100 overnights/year)

Table A.1
Pit Toilets
Location 1 (Alpine, 100 Overnights/Year)
Engineer's Opinion of Cost

ITEM	QUANTITY	UNIT*	UNIT PRICE	TOTAL PRICE
Pit Toilet Materials	1	ls	\$ 2,500	\$ 2,500
Materials Delivery	1	ls	\$ 1,500	\$ 1,500
CONSTRUCTION SUBTOTAL				\$ 4,000
Pit toilet relocation	4	hours	\$ 100	\$ 400
Toilet repair and maintenance	2	hours	\$ 100	\$ 200
ANNUAL OPERATION AND MAINTENANCE COSTS				\$ 400
Present Worth Capital Replacement	100%	Replacement	\$ 4,000	\$ 4,000
Present Worth of Annual O&M	30	yr @	4.5%	\$ 6,516
TOTAL LIFE CYCLE COSTS				\$ 14,516

Notes:

- 1) Assumes pit toilet is moved every 6 years
 - 2) Assumes materials can be transported by one helicopter trip
 - 3) Assumes pit toilet must be completely replaced 1 time in 30 year life
- *LS = Lump Sum Costing



Table A.2
Barrel Fly-Outs
Location 1 (Alpine, 100 Overnights/Year)
Engineer's Opinion of Cost

ITEM	QUANTITY	UNIT*	UNIT PRICE	TOTAL PRICE
Bathroom/Toilet Materials	1	ls	\$ 7,500	\$ 7,500
Materials Delivery	1	ls	\$ 1,500	\$ 1,500
CONSTRUCTION SUBTOTAL				\$ 9,000
Staffing and Transportation	1	ls	\$ 500	\$ 500
Barrel Fly-Out (Helicopter and Pumper Truck)	100	visitors	\$ 15.00	\$ 1,500
ANNUAL OPERATION AND MAINTENANCE COSTS				\$ 2,000
Present Worth Capital Replacement	20%	Replacement	\$ 9,000	\$ 1,800
Present Worth of Annual O&M	30	yr @	4.5%	\$ 32,578
TOTAL LIFE CYCLE COSTS				\$ 43,378

Notes:

- 1) Barrel fly-out cost based on current annual cost information provided by BEES
 - 2) Assumes materials can be transported in one helicopter trip
- *LS = Lump Sum Costing



Table A.3
Incinerating Toilets
Location 1 (Alpine, 100 Overnights/Year)
Engineer's Opinion of Cost

ITEM	QUANTITY	UNIT*	UNIT PRICE	TOTAL PRICE
Incinerating Toilet	1	units	\$ 7,500	\$ 7,500
Toilet Delivery	1	ls	\$ 1,500	\$ 1,500
CONSTRUCTION SUBTOTAL				\$ 9,000
Ash Removal	2	hours	\$ 75	\$ 150
Propane + Delivery	8.5	gallons	\$ 10	\$ 1,585
Toilet Repair and Maintenance	2	hrs	\$ 75	\$ 150
ANNUAL OPERATION AND MAINTENANCE COSTS				\$ 1,885
Present Worth Capital Replacement	20%	Replacement	\$ 9,000	\$ 1,800
Present Worth of Annual O&M	30	yr @	4.5%	\$ 30,705
TOTAL LIFE CYCLE COSTS				\$ 41,505

Notes:

- 1) Assumes toilet can be delivered in one helicopter trip
 - 2) Incinerating toilet cost based on information provided by EcoJohn
 - 3) Does not include wages for full time custodian
- *LS = Lump Sum Costing



Table A.4
Carry Out
Location 1 (Alpine, 100 Overnights/Year)
Engineer's Opinion of Cost

ITEM	QUANTITY	UNIT	UNIT PRICE	TOTAL PRICE
-	-	-	-	-
CONSTRUCTION SUBTOTAL				\$ -
Educationl Programming	10	hours	\$ 25.00	\$ 250
Carryout Bags	100	people	\$ 2.50	\$ 250
ANNUAL OPERATION AND MAINTENANCE COSTS				\$ 500
Present Worth Capital Replacement	100%	Replacement	\$ -	\$ -
Present Worth of Annual O&M	30	yr @	4.5%	\$ 8,144
TOTAL LIFE CYCLE COSTS				\$ 8,144

Assumptions:

- 1) Carryout bags based on cost of Wag Bags Dry Toilets



Table A.5
Composting Toilets with Liquid Evaporation and Barrel Fly-outs
Location 1 (Alpine, 100 Overnights/Year)
Engineer's Opinion of Cost

ITEM	QUANTITY	UNIT*	UNIT PRICE	TOTAL PRICE
Composting Toilet	1	units	\$ 4,000	\$ 4,000
Evaporation Tank	50	imp gallons	\$ 2.00	\$ 100
Heating and Aeration Equipment	1	ls	\$ 1,000	\$ 1,000
Materials Delivery	1	ls	\$ 1,500	\$ 1,500
CONSTRUCTION SUBTOTAL				\$ 6,600
Staffing and transportation	1	ls	\$ 350	\$ 350
Barrel Fly-Out (Helicopter and Pumper Truck)	100	visitors	\$ 0.80	\$ 80
ANNUAL OPERATION AND MAINTENANCE COSTS				\$ 430
Present Worth Capital Replacement	20%	Replacement	\$ 6,600	\$ 1,320
Present Worth of Annual O&M	30	yr @	4.5%	\$ 7,004
TOTAL LIFE CYCLE COSTS				\$ 14,924

Notes:

- 1) Assumes composting toilet and tank can be delivered in one helicopter trip
- 2) Assumes an electrical supply will be available for the composting toilet and evaporation tank (not included in cost estimate)
- 3) Electrical supply components and transmission is not included in construction cost
- 4) Composting toilet cost based on Sun Mar extra-high capacity non electric dry composting toilets

*LS = Lump Sum Costing





Appendix B

Location 2 Cost Tables (Alpine, 3000 Users per Year)

B.1
Pit Toilets
Location 2 (Alpine, 3000 Overnights/Year)
Engineer's Opinion of Cost

ITEM	QUANTITY	UNIT*	UNIT PRICE	TOTAL PRICE
Pit Toilet Materials	1	ls	\$ 2,500	\$ 2,500
Materials Delivery	1	ls	\$ 1,500	\$ 1,500
CONSTRUCTION SUBTOTAL				\$ 4,000
Pit toilet relocation	24	hours	\$ 100	\$ 2,400
Toilet repair and maintenance	8	hours	\$ 100	\$ 800
ANNUAL OPERATION AND MAINTENANCE COSTS				\$ 2,400
Present Worth Capital Replacement	100%	Replacement	\$ 4,000	\$ 4,000
Present Worth of Annual O&M	30	yr @	4.5%	\$ 39,093
TOTAL LIFE CYCLE COSTS				\$ 47,093

Notes:

- 1) Assumes pit toilet is moved every other year
 - 2) Assumes materials can be transported by one helicopter trip
 - 3) Assumes pit toilet must be completely replaced 1 time in 30 year life
- *LS = Lump Sum Costing



B.2
Barrel Fly-Outs
Location 2 (Alpine, 3000 Overnights/Year)
Engineer's Opinion of Cost

ITEM	QUANTITY	UNIT*	UNIT PRICE	TOTAL PRICE
Bathroom/Toilet Materials	1	ls	\$ 7,500	\$ 7,500
Materials Delivery	1	ls	\$ 3,000	\$ 3,000
CONSTRUCTION SUBTOTAL				\$ 10,500
Staffing and Transportation	1	ls	\$ 700	\$ 700
Barrel Fly-Out (Helicopter and Pumper Truck)	3000	visitors	\$ 1.60	\$ 4,800
ANNUAL OPERATION AND MAINTENANCE COSTS				\$ 5,500
Present Worth Capital Replacement	20%	Replacement	\$ 10,500	\$ 2,100
Present Worth of Annual O&M	30	yr	@ 4.5%	\$ 89,589
TOTAL LIFE CYCLE COSTS				\$ 102,189

Notes:

- 1) Barrel fly-out cost based on current annual cost information provided by BEES
 - 2) Assumes materials can be transported in two helicopter trips
- *LS = Lump Sum Costing



Table B.3
Incinerating Toilets
Location 2 (Alpine, 3000 Overnights/Year)
Engineer's Opinion of Cost

ITEM	QUANTITY	UNIT*	UNIT PRICE	TOTAL PRICE
Incinerating Toilet	1	units	\$ 10,000	\$ 10,000
Toilet Delivery	1	ls	\$ 1,500	\$ 1,500
CONSTRUCTION SUBTOTAL				\$ 11,500
Ash Removal	8	hours	\$ 75	\$ 600
Propane + Delivery	255	gallons	\$ 10	\$ 4,050
Toilet Repair and Maintenance	8	hrs	\$ 75	\$ 600
ANNUAL OPERATION AND MAINTENANCE COSTS				\$ 5,250
Present Worth Capital Replacement	20%	Replacement	\$ 11,500	\$ 2,300
Present Worth of Annual O&M	30	yr	@ 4.5%	\$ 85,517
TOTAL LIFE CYCLE COSTS				\$ 99,317

Notes:

- 1) Assumes toilet can be delivered in one helicopter trip
 - 2) Incinerating toilet cost based on information provided by EcoJohn
 - 3) Does not include wages for full time custodian
- *LS = Lump Sum Costing



Table B.4
Carry Out
Location 2 (Alpine, 3000 Overnights/Year)
Engineer's Opinion of Cost

ITEM	QUANTITY	UNIT	UNIT PRICE	TOTAL PRICE
-	-	-	-	-
CONSTRUCTION SUBTOTAL				\$ -
Educationl Programming	20	hours	\$ 25.00	\$ 500
Carryout Bags	3000	people	\$ 2.50	\$ 7,500
ANNUAL OPERATION AND MAINTENANCE COSTS				\$ 8,000
Present Worth Capital Replacement	100%	Replacement	\$ -	\$ -
Present Worth of Annual O&M	30	yr @	4.5%	\$ 130,311
TOTAL LIFE CYCLE COSTS				\$ 130,311

Assumptions:

- 1) Carryout bags based on cost of Wag Bags Dry Toilets



Table B.5
Composting Toilets with Liquid Evaporation and Barrel Fly-outs
Location 2 (Alpine, 3000 Overnights/Year)
Engineer's Opinion of Cost

ITEM	QUANTITY	UNIT*	UNIT PRICE	TOTAL PRICE
Composting Toilet	1	units	\$ 4,000	\$ 4,000
Evaporation Tank	500	imp gallons	\$ 2.00	\$ 1,000
Heating and Aeration Equipment	1	ls	\$ 1,000	\$ 1,000
Materials Delivery	1	ls	\$ 6,000	\$ 6,000
CONSTRUCTION SUBTOTAL				\$ 12,000
Staffing and transportation	1	ls	\$ 350	\$ 350
Barrel Fly-Out (Helicopter and Pumper Truck)	3000	visitors	\$ 0.80	\$ 2,400
ANNUAL OPERATION AND MAINTENANCE COSTS				\$ 2,750
Present Worth Capital Replacement	20%	Replacement	\$ 12,000	\$ 2,400
Present Worth of Annual O&M	30	yr @	4.5%	\$ 44,794
TOTAL LIFE CYCLE COSTS				\$ 59,194

Notes:

- 1) Assumes composting toilet and tank can be delivered in two helicopter trips
- 2) Assumes an electrical supply will be available for the composting toilet and evaporation tank (not included in cost estimate)
- 3) Electrical supply components and transmission is not included in construction cost
- 4) Composting toilet cost based on Sun Mar extra-high capacity non electric dry composting toilets

*LS = Lump Sum Costing





Appendix C

Location 3 Cost Tables (Subalpine, 800 users per year)

Table C.1
Pit Toilets
Location 3 (Subalpine, 800 Overnights/Year)
Engineer's Opinion of Cost

ITEM	QUANTITY	UNIT*	UNIT PRICE	TOTAL PRICE
Pit Toilet Materials	1	ls	\$ 2,500	\$ 2,500
Materials Delivery	1	ls	\$ 1,500	\$ 1,500
CONSTRUCTION SUBTOTAL				\$ 4,000
Pit toilet relocation	12	hours	\$ 100	\$ 1,200
Toilet repair and maintenance	8	hours	\$ 100	\$ 800
ANNUAL OPERATION AND MAINTENANCE COSTS				\$ 1,200
Present Worth Capital Replacement	100%	Replacement	\$ 4,000	\$ 4,000
Present Worth of Annual O&M	30	yr @	4.5%	\$ 19,547
TOTAL LIFE CYCLE COSTS				\$ 27,547

Notes:

- 1) Assumes pit toilet is moved every fourth year
- 2) Assumes materials can be transported by one helicopter trip
- 3) Assumes pit toilet must be completely replaced 1 time in 30 year life

*LS = Lump Sum Costing



Table C.2
Barrel Fly-Outs
Location 3 (Subalpine, 800 Overnights/Year)
Engineer's Opinion of Cost

ITEM	QUANTITY	UNIT*	UNIT PRICE	TOTAL PRICE
Bathroom/Toilet Materials	1	ls	\$ 7,500	\$ 7,500
Materials Delivery	1	ls	\$ 3,000	\$ 3,000
CONSTRUCTION SUBTOTAL				\$ 10,500
Staffing and Transportation	1	ls	\$ 700	\$ 700
Barrel Fly-Out (Helicopter and Pumper Truck)	800	visitors	\$ 3.20	\$ 2,560
ANNUAL OPERATION AND MAINTENANCE COSTS				\$ 3,260
Present Worth Capital Replacement	20%	Replacement	\$ 10,500	\$ 2,100
Present Worth of Annual O&M	30	yr @	4.5%	\$ 53,102
TOTAL LIFE CYCLE COSTS				\$ 65,702

Notes:

- 1) Barrel fly-out cost based on current annual cost information provided by BEES
 - 2) Assumes materials can be transported in two helicopter trips
- *LS = Lump Sum Costing



Table C.3
Incinerating Toilets
Location 3 (Subalpine, 800 Overnights/Year)
Engineer's Opinion of Cost

ITEM	QUANTITY	UNIT*	UNIT PRICE	TOTAL PRICE
Incinerating Toilet	1	units	\$ 7,500	\$ 7,500
Toilet Delivery	1	ls	\$ 1,500	\$ 1,500
CONSTRUCTION SUBTOTAL				\$ 9,000
Ash Removal	8	hours	\$ 75	\$ 600
Propane + Delivery	68	gallons	\$ 10	\$ 2,180
Toilet Repair and Maintenance	8	hrs	\$ 75	\$ 600
ANNUAL OPERATION AND MAINTENANCE COSTS				\$ 3,380
Present Worth Capital Replacement	20%	Replacement	\$ 9,000	\$ 1,800
Present Worth of Annual O&M	30	yr	@ 4.5%	\$ 55,056
TOTAL LIFE CYCLE COSTS				\$ 65,856

Notes:

- 1) Assumes toilet can be delivered in one helicopter trip
 - 2) Incinerating toilet cost based on information provided by EcoJohn
 - 3) Does not include wages for full time custodian
- *LS = Lump Sum Costing



Table C.4
Carry Out
Location 3 (Subalpine, 800 Overnights/Year)
Engineer's Opinion of Cost

ITEM	QUANTITY	UNIT	UNIT PRICE	TOTAL PRICE
-	-	-	-	-
CONSTRUCTION SUBTOTAL				\$ -
Educationl Programming	20	hours	\$ 25.00	\$ 500
Carryout Bags	800	people	\$ 2.50	\$ 2,000
ANNUAL OPERATION AND MAINTENANCE COSTS				\$ 2,500
Present Worth Capital Replacement	100%	Replacement	\$ -	\$ -
Present Worth of Annual O&M	30	yr @	4.5%	\$ 40,722
TOTAL LIFE CYCLE COSTS				\$ 40,722

Assumptions:

- 1) Carryout bags based on cost of Wag Bags Dry Toilets



Table C.5
Composting Toilets with Liquid Infiltration and Barrel Fly-Outs
Location 3 (Subalpine, 800 Overnights/Year)
Engineer's Opinion of Cost

ITEM	QUANTITY	UNIT*	UNIT PRICE	TOTAL PRICE
Composting Toilet (one unit)	1	ls	\$ 4,000	\$ 4,000
Drainfield (sized for 50 gpd)	1	ls	\$ 3,500	\$ 3,500
Materials Delivery	1	ls	\$ 3,000	\$ 3,000
CONSTRUCTION SUBTOTAL				\$ 10,500
Staffing and transportation	1	ls	\$ 70	\$ 70
Barrel Fly-Out (Helicopter and Pumper Truck)	800	visitors	\$ 0.16	\$ 128
ANNUAL OPERATION AND MAINTENANCE COSTS				\$ 198
Present Worth Capital Replacement	20%	Replacement	\$ 10,500	\$ 2,100
Present Worth of Annual O&M	30	yr @	4.5%	\$ 3,225
TOTAL LIFE CYCLE COSTS				\$ 15,825

Assumptions:

- 1) Assumes composting toilet and drainfield can be delivered in one helicopter trip
- 2) Assumes an electrical supply will be available for the composting toilet (not included in cost estimate)
- 3) Electrical supply components and transmission is not included in construction cost
- 4) Composting toilet cost based on Sun Mar extra-high capacity non electric dry composting toilets

*LS = Lump Sum Costing

