Best Management Practices Guidelines for Bats in British Columbia

CHAPTER 2: MINE DEVELOPMENTS AND INACTIVE MINE HABITATS




February 2016

Ministry of Environment

This page has been intentionally left blank

Executive Summary

The British Columbia Ministry of Environment in consultation with the Ministry of Energy, Mines and Natural Gas has developed this document for agencies, mining proponents, private landowners, researchers and consultants to provide guidance on how to minimize impacts to bats as a result of activities associated with the mining industry in British Columbia. Use of these guidelines demonstrates due diligence towards the protection of bats and their habitats in mines and in locations where mine developments occur in the province.

Chapter 2: Mine Developments and Inactive Mine Habitats is one chapter of Best Management Practices for Bats in British Columbia - a larger strategy identifying a number of resource sectors in the province of British Columbia most likely to impact bats and their habitats. The Introductory Chapter for the strategy reviews bat species, distribution and ecology in British Columbia and the Introduction should be reviewed in conjunction with industry/activity-specific Best Management Practices guidance in later individual chapters.

Each industry/activity-specific chapter follows a similar structure. Section 1 highlights particular aspects of bat ecology, behaviour and distribution that may be impacted or may benefit from a specific industry/activity (e.g., mining, development of wind power or caving). Section 2 describes the activities associated with specific industry or activities that are most likely to impact bats and their habitats. Section 3 outlines Best Management Practices. Section 4 lists monitoring and reporting priorities. Section 5 outlines knowledge gaps and information needs to improve adaptive management for bats in specific industries/activities.

Some of the issues discussed in this document are subject to ongoing research (e.g., the effectiveness of bat gating for different bat species, and the management of White-nose Syndrome). All activities related to assessing the quality of bat habitat or the impact of activities on bats should involve an experienced bat biologist qualified to conduct bat surveys.

British Columbia has a long history of mining; as a result there are many mine sites, sometimes in high concentrations, in parts of the province some of which are active but many that are inactive. Bats do not distinguish between man-made mines and natural cave habitats when selecting roosting sites. Mines are an important roost habitat for bats, and represent a critical habitat type when used as hibernation sites. Mines may also be used by non-reproductive bats as summer roosting habitat, and some species like the Townsend's big-eared bat may also use mines as maternity habitat in some

parts of the province. Mines may also potentially be used as swarming habitat towards the end of the active season. Re-opening old mine sites and mine closures can have significant impacts on local bat populations. New mines can affect bats and their habitats as well. The goal of the Best Management Practices for Bats is to help to minimize and mitigate the effects of mining activities on bats and their habitats in British Columbia.

Implementation of these bat conservation measures can be cooperatively managed by B.C. Ministries handling mine reclamation, closures and re-activations, the B.C. Bat Action Team (B.C. BAT), provincial wildlife specialists, the mining industry, the British Columbia Technical and Research Committee on Reclamation and the Canadian Land Reclamation Association.

Acknowledgements

This chapter of British Columbia's Best Management Practices Guidelines for Bats was written by Susan Holroyd (Holroyd Consulting) and Dr. Vanessa Craig (EcoLogic Research). The document is based on the Bat Conservation Strategy for British Columbia and Alberta (Craig and Holroyd 2004). Input and review was provided by Anne Moody, Larry Jones, Moss Giasson, Jennifer McConnachie (B.C. Ministry of Energy, Mines and Natural Gas), Dr. Cori Lausen (Wildlife Conservation Society Canada), Dr. Purnima Govindarajulu (B.C. Ministry of Environment), Dave Hobson (Alberta Environment and Parks), and members of the B.C. Bat Action Team (BCBAT). Thanks to Kirk Hancock (B.C. Ministry of Energy, Mines and Natural Gas) for production of maps and everyone who provided photos free of cost. Thanks to Al Hicks, Ted Down, Dave Fraser and Brenda Hartley for facilitating the review and approval process. Funding was provided by the B.C. Ministry of Environment and the Habitat Conservation Trust Foundation.

Photos front page, left to right: Townsend's Big-eared Bat, Jared Hobbs (courtesy of Hobbs Photo Images Co., Victoria, B.C.); Mine opening gated for bats in Penticton, British Columbia, Chris Godwin-Sheppard (Owl Moon Environmental, Calgary), Yuma Myotis, Christian Gronau (Cortes Island); Wetland in Glacier National Park, British Columbia, Jennifer Gleason.

Document citation:
Holroyd, S.L., and V.J. Craig. 2016. Best Management Practices for Bats in British Columbia, Chapter 2: Mine Developments and Inactive Mine Habitats. B.C. Ministry of Environment, Victoria, BC. 60pp.

Table of Contents

This page has been intentionally left blank

Section 1: Introduction

1.1 Purpose/Scope

This document is written for British Columbia mining proponents, British Columbia Ministries that deal with mining and mine reclamation (Ministry of Energy, Mines and Natural Gas and Ministry of Agriculture), and private landowners with mines on their property.

British Columbia has a rich history of mining and the industry continues to expand in this resource sector. Mines are an important roost habitat for bats, and represent a critical habitat type when used as hibernation sites or (more rarely) as nursery roosts. Bats do not distinguish between natural habitat in caves and the man-made habitat provided as a result of mining activities. Because of the large potential impact of mining activities on the quality of bat habitat and on bat populations directly, implementing Best Management Practices (BMPs) when working in and around mines is important to minimize negative effects on bats. The use of BMPs is particularly important in light of the emerging wildlife health crisis represented by White-nose Syndrome (WNS), which exacerbates any stresses bats are already experiencing.

Projects developed within the Ministry of Forests Lands and Natural Resource Operations framework - potential effects on "valued components" which may include bats and bat habitat must be identified (Environmental Assessment Office 2013*a,b*). This document provides Best Management Practices for bats and their habitats. Proponents who deal with management issues involving bats and their habitats can show due diligence by using these recommendations to support their management actions.

Research and inventory priorities outlined in this document will provide wildlife professionals and bat researchers with information for future adaptive management. Common goals and priorities of land managers and researchers can be met with collaboration and cooperation. Note that all impact assessments and surveys for bats should use the services of a trained and experienced bat biologist.

1.2 How to Use This Document

This document, Best Management Practices for Bats in British Columbia, Chapter 2: Mines and Inactive Mine Habitats, is one chapter of a larger strategy identifying a number of resource sectors in the province of British Columbia most likely to affect bats and their habitats. Chapter 1 of the larger strategy document provides in-depth information on bat ecology to set the context for the following resource sector specific chapters, and should be read in conjunction with each of these chapters. Chapter 2, this document, provides information on the potential impacts of mine management on bat populations in British Columbia, and best management practices to mitigate these impacts. Section 1 lists the objectives, briefly provides information about the species of bats using mines in British Columbia and their ecology as it relates to mines, and explains why mines represent important habitat for bats. It also includes information about the distribution of mines potentially used by bats in the province. This information provides context for the focus on particular mining resource-related activities that potentially impact bats and bat habitat outlined in Section 2 and for the Best Management Practices guidelines presented in Section 3. These BMPs represent the best recommendations for minimizing impacts to bats and their habitats, based on currently available information. Information from future research or practical experience may result in the modification of BMPs to better meet the objective of minimizing negative impacts to bat populations and bat habitat. Section 4 provides a discussion of monitoring and reporting needs and methodologies. Section 5 discusses the information needs required to improve adaptive management of mining activities to minimize impacts to bat populations and bat habitat. The glossary in Section 6 provides definitions of technical terms used in the document. Section 7 lists the literature cited in the document.

Some of the issues discussed in this document are subject to ongoing research (e.g., the effectiveness of bat gating for different bat species, and the management of White-nose Syndrome). All activities related to assessing the quality of bat habitat or the impact of activities on bats should involve a qualified, experienced bat biologist, as bats have unique adaptations and behaviours that require specialized knowledge and training. Qualified bat biologists should be up-to-date with current information and be experienced in bat handling and survey methodologies.

Hyperlinks (underlined in blue) connect to information within the document, or to information available on the World Wide Web (www). Links to the www will open in a separate window.

1.3 Objectives

The objectives of this document are to:

1. Describe the ecology and distribution of bats using mines in British Columbia and to discuss how bat biodiversity and abundance is influenced by habitat made available as a result of historic and present-day mining activity. (Section 1);
2. Describe how mining activities may impact bat populations and their habitat in British Columbia (mine openings, re-openings and closures). (Section 2);

Significant Use by bats includes any site used as a:

- Maternity Roost;
- Hibernating Roost;
- Migratory Stopover;
-Night Roost;
- Swarming Location (i.e., site for colonial reproductive behaviour); or
-Any site identified in the future with previously undocumented use that provides an essential habitat component for bats (e.g., winter foraging).

(Altenbach and Pierson 1995; Altenbach 1998; Tuttle and Taylor 1998; Milford 2000; C. Lausen, pers. comm.).

3. Provide a set of Best Management Practices that will maintain bat habitats and bat populations using mine-related resources in British Columbia. (Section 3);
4. Clarify monitoring and reporting requirements. (Section 4); and
5. Promote an adaptive management strategy by delineating areas where information is needed to update and improve BMPs. (Section 5)

1.4 Distribution and Ecology of Bats Using Mines in British Columbia

Fourteen of the sixteen species of bats found in British Columbia may roost in underground mine workings at some point during their annual life cycle; the remaining two foliage-roosting migratory species, Hoary Bat (*Lasiurus cinereus*) and Eastern Red Bat (*Lasiurus borealis*), do not (Chapter 1: Table 5). It is likely that all of the hibernating bat species in British Columbia use mines for swarming and as winter hibernacula, where suitable conditions are present. Swarming behaviour (i.e., where bats congregate at cave or mine sites in late summer/early fall for mating, and possibly courtship), is an essential link in the annual life cycle of bats (Cope and Humphrey 1977). Many species will also use mines in the summer, usually as for night-roosting (i.e., an evening rest stop during which bats congregate to digest consumed food, and perhaps undertake social behaviours before resuming foraging). Where conditions are appropriate, mines are also used by non-reproductive females or males for summer day-roosting. In British Columbia, the Blue-listed Townsend's Big-eared Bat (*Corynorhinus townsendii*) may use mines as nursery roosts; however, this would occur only in regions where daytime temperatures are consistently high throughout the breeding season, producing underground habitat with warm temperatures, such as in the dry Interior, the warmest portions of the Rocky Mountain Trench and the warmest parts of coastal British Columbia (Craig 2003; Hill et al. 2005, 2006). Recent work on South-eastern coastal Vancouver Island uncovered a maternity roost of Keen's Long-eared Myotis (*Myotis keenii*) in

Townsend's Big-eared Bat (*Corynorhinus townsendii*). Photo: Jared Hobbs.

an old mine location, quite a novel observation for British Columbia bat records (C. Lausen, pers. comm.). See Glossary Section 6 for definitions of maternity and nursery roosts.

British Columbia has been a major mining region since the mid-1800s and continues to play a substantial role in today's international markets (MEMPR 2007). Coal, minerals and metals such as copper, gold, silver, lead, zinc, and molybdenum comprise the majority of production and export (MEMPR 2007). During the century after the Fraser River gold rush, most mining activities took place underground, but open-pit mining has been favoured since the early 1960s, especially for copper. The British Columbia Ministry of Energy, Mines and Natural Gas (EMNG) maintains a Mineral Inventory (MINFILE) database, which contains information on size and location of current and historic mines (EMNG 2014). EMNG district offices retain drawings of underground and open pit workings (Mackasey 2000).

Mackasey (2000) estimates that there are 2900 historic mine sites with mineral occurrences in British Columbia. The MINFILE database indicates that there are approximately 1333 inactive, underground mines in the province (MEMPR 2007; K. Hancock, pers. comm.) with quite a few large mine developments. The number of mine sites available to bats could be higher than this as there are a number of mine sites without titles that are deep enough to possibly provide winter habitat for bats that are not in the MINFILE database. The biggest concentration of old mine sites lies in the southeastern portion of the province (Figure 1), with large numbers in the Kootenay Region around Nelson and Kaslo, as well as concentrations around Cranbrook, Kimberley and Fernie. Greenwood, the Kettle Valley, the Similkameen Valley, Princeton and Merritt, and areas north and east of Quesnel, also have a history of underground mines that are now inactive (Figure 1). Southwestern British Columbia also has a history of mining, with pockets of activity on southern Vancouver Island (Victoria and Nanaimo areas) and northern Vancouver Island (Campbell River and islands), as well as areas on the mainland coast (Figure 2). Any of these areas with warm summer climates and available, inactive, underground mine sites should be considered as having high potential for bat use. Bat diversity and abundance is considered higher in these areas, possibly due to the existence of adjacent suitable winter and summer habitats for bats (Findley 1995).

The primary habitats used by bats can be classified into roosting and foraging/drinking habitat, and swarming habitat used in the fall for courtship and reproductive behaviours. Detailed descriptions of these habitats and species variation in the use of these habitats are provided in Chapter 1, and summarized in Table 1 and 2. Given the focus of this document on mining, typical underground bat roost features are described below in more detail (based Pierson et al. 1999; USFWS 2009; Sherwin et al. 2009).

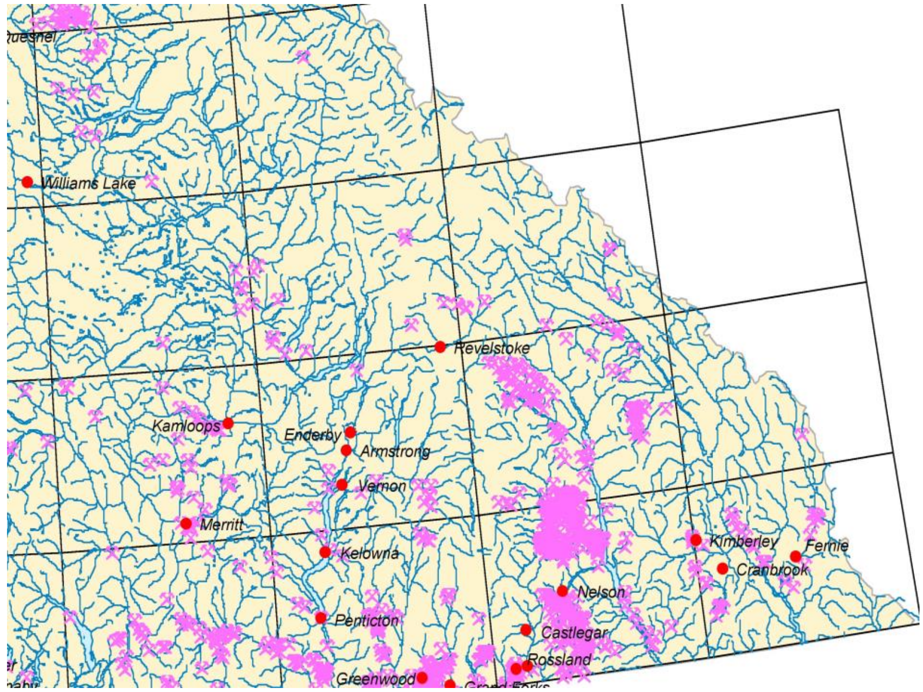

Figure 1. Inactive/underground mine occurrences in southeastern British Columbia, indicated by pink crossed-hammer symbols (map generated from MINFILE database; MEMPR 2007).

1. Cave/mine portal openings used by bats are a minimum of 30 centimetres in diameter.
2. Cave/mine passages that extend for 30 metres or more are most often used as winter hibernation sites;
3. Summer roosting sites, especially for Townsend's Big-eared Bat, can be quite shallow (<10 metres deep);
4. In winter, Keen's Myotis use caves >100 metres in length and above 500 metres above sea level with temperatures between 2.4 and 4°C with 100% humidity;
5. There is usually some amount of air flow in or out of the entrance; this may vary by day or season, and may not always be detectable. Too much airflow can make a site unsuitable.
6. Cave/mine entrances that are flooded or prone to flooding are not often used, but use may depend on frequency and extent of flooding.
7. Vertical passages that are at least 60 centimetres in diameter with some air flow may be used by bats;
8. Foliage and other vegetation in front of a cave/mine opening will not stop use by some species of bats. Bats can navigate through foliage. However, the more clutter that obscures the opening and the smaller the opening, the fewer the species that are likely to use it.

Table 1. Important roosting habitat features for bats (all seasons).

Roost Type	Description	Reference
Mines/ Tunnels	Although extensive use is expected most have not been monitored for bat activity; some hibernation sites are known; recent work indicates high bat use of underground structures of inactive mines. Mines are thought to be important winter habitats, but recent data indicates that they might be used in the summer as well.	Nagorsen et al. 1993; C. Lausen, pers. comm.
Cliff and Rock Complex	South/southwest facing; suitable crevices for roosting bats; uncluttered by vegetation for accessibility; situated to receive solar heating; karst features; may be high/steep to prevent predator access; close to foraging/drinking habitat These habitats may be used in the active season and potentially as winter habitat	Holloway and Barclay 2001; Chatwin 2004; Sarell 2004a
Caves	Although a number of species potentially use caves specific habitat selection is only known for a few (see text above); Caves are thought to be used mainly in the fall and winter, but may be used intermittently in the summer.	Chatwin 2004; Nagorsen et al. 1993
Forest cover and suitable trees	Wildlife trees (i.e., large diameter trees with large hollows with structural integrity that allows these trees to last many years on the landscape such as hollow western red cedar), decay class 2 or greater; peeling bark on trees with decay class 4 or greater (Masters et al 1979); Tree roosts can be used in the active spring/summer/fall seasons and also as overwintering sites. Data from the Kootenay Region indicates that some species of bats switch between underground and tree roost sites in the winter.	Lacki et al. 2007; Chatwin 2004; C. Lausen, pers. comm.; Nagorsen and Brigham 1993
Building s	Usually older structures with access for bats; especially outbuildings such as barns that have low potential for conflict with human interests. Buildings are thought to be used primarily in the summer, although there have been a few incidences of over-winter use.	Firman et al. 1995; Craig and Sarell 2012; C. Lausen, pers. comm.
Bridges	Often important as night-roosting habitat; structural features that offer roosting potential. Bridges are thought to be used only in the summer/active season.	Perlmeter 1996; Bat Conservation International

9. Bats can access mines via old buildings in front of entrances, such as a fan house. Buildings themselves may provide bat roosting habitat.

Table 2. Important active season (spring/summer/fall) foraging and drinking habitats for bats.

Activity	Habitat	Reference
Foraging	Riparian, wetlands, ponds, lakes	Brigham 1995
	Forest edges	Crampton and Barclay 1998; Estrada and Coates-Estrada 2001
	Deciduous forest	Nagorsen and Brigham 1993
	Shrublands	Nagorsen and Brigham 1993; Doucett et al. 2002
	Clearings	Doucett et al. 2002
Drinking	Uncluttered water bodies	Nagorsen and Brigham 1993; Adams and Hayes 2008

Of the thousands of abandoned mines surveyed for bats in the western USA, approximately half showed some type of use by bats, and 10% were used to a significant extent (Altenbach 1998). There has been limited survey effort for winter bat hibernation sites in British Columbia (Bryant 1987; Nagorsen et al. 1993; Davis et al. 1999; C. Lausen, pers. comm.). One of the only studies in British Columbia to look at winter bat activity in mines revealed that 17 of 20 mines surveyed had some sign of bat activity and two of these survey sites without bats had grates built across access points which may have limited bat access; five of the 20 sites were well used by bats, with activity detected at the entrances throughout the winter (C. Lausen, pers. comm.). Work is ongoing to examine winter use of mines in British Columbia; this ongoing research will provide a better understanding of the habitat available to bats from mine sites, and will help in the evaluation of the importance of particular sites for hibernating bats (C. Lausen, pers. comm.).

Hibernation sites, whether they are in caves or mines, represent critical habitat for hibernating North American bats (Humphrey 1975; Altenbach 1998; Bogan 2000; Racey and Entwistle 2003). Hibernating bats are highly vulnerable to disturbance. Being wakened by the presence of humans can ultimately cause mortality if critical fat reserves are depleted by waking events (Thomas et al. 1990; Thomas and Cloutier 1992; Thomas 1995); bats are also vulnerable during hibernation as torpid bats are slow to react and can be easily captured and killed.

Hibernating bats have specific microclimate requirements that are similar across groups of species. Most species require a particular temperature regime (usually from just above freezing to less than approximately 9˚C), specific airflow patterns and high humidity levels (Thomas et al. 1990; Thomas and Cloutier 1992; Nagorsen and Brigham 1993). These conditions can be changed and the site rendered ineffective as a hibernaculum by changes that affect the interior climate such opening and closing of tunnels, and changes to the vegetation or soil cover in, above and around the hibernation site (Nieland 2000). Mine closures or improperly gated portals also inhibit use of sites by bats (Tuttle and Taylor 1998). Distances travelled by bats underground to hibernate will depend on the suitability of the habitat, but bats have been found less that 30m from openings (e.g., Townsend's Big-eared Bat in the Cariboo region; Nagorsen et al. 1993); California Myotis and Silver-haired Bats in the West Kootenay (C. Lausen pers. comm.), to 150–700 metres underground in Missouri and upper-state New York (WVDEPOEB 2006). Potential hibernation sites that are suitable for bats are rare landscape features and this rarity makes them highly valuable.

1.5 White-nose Syndrome

In 2006, U.S. researchers reported an outbreak of an unidentified disease that has since killed millions of hibernating bats in both mines and caves, including the endangered Indiana Bat (*Myotis sodalis*; USDA Forest Service 2012). The researchers called the infection 'White-nose Syndrome' (WNS) after the characteristic white nose of infected bats caused by the recently discovered fungus *Pseudogymnoascus (Geomyces) destructans* (Gargas et al. 2009; Minnis and Lindner 2013). Bats may also develop fungus on the wing and tail membranes. White-nose Syndrome is now recognized as a significant wildlife crisis in the USA and Canada, which threatens to cause the extirpation and/or extinction of a number of hibernating bat species (Blehert et al. 2009). The death toll is expected to continue to rise as the disease spreads across the continent (USDA Forest Service 2012).

Indiana Bats (*Myotis sodalis*) showing typical "white nose" as a result of fungal infection by *Pseudogymnoascus* (prev. *Geomyces*) *destructans*. Photo: Al Hicks.

In winter 2009–2010, the disease was first discovered in Canada, in both Ontario (Ontario MNR 2013) and Quebec (Quebec MNRF 2010). In response to mass mortalities of three species of bats in eastern Canada, the Committee on the Status of Endangered Wildlife Species in Canada

(COSEWIC) conducted emergency assessments of the Little Brown Myotis (*Myotis lucifugus*), Northern Myotis (*Myotis septentrionalis*) and Tricoloured Myotis (*Perimyotis subflavus*), and assessed all three as Endangered (COSEWIC 2012). The federal environment minister made the decision to accept this listing for inclusion of these species under the *Species At Risk Act* on the 17th of December 2014 (Environment Canada 2014). Biologists project that WNS may reach the west coast of North America by 2017–2020 (Kunz 2009); modelling exercises have predicted WNS arriving at the Olympic Peninsula, Washington State, U.S.A. by 2027 (Ihlo 2013).

More information on White-nose Syndrome can be found in Chapter 1 and on the B.C. Wildlife Health website and at the Canadian Wildlife Health Cooperative website, please refer to both websites to find the most up-to-date information on the decontamination procedures and the precautionary steps to take to reduce the risk of spreading WNS in British Columbia. Research updates and disease spread maps can be found on the USFWS White-nose Syndrome website.

Section 2: Mining Activities with Potential Impact on Bats

This section discusses activities divided into two phases: The opening of mines and the closing of mines. These phases are further categorized within each phase as: The opening of new mines, the reopening of new mines, and the closing of active mines and the closing of inactive mines.

2.1 Opening Mines

Both the opening of new mines and reopening of old mines can potentially impact bat populations. The closing of inactive mines can be expected to have a higher impact than the closing of active mines.

2.1.1 New Mines

Developing new mine sites involves a number of general activities that accompany any industrial development such as clearing forest cover, developing roads, blasting rock for mine access and road building, developing support buildings as well as developing the actual mine. These general industrial development activities affect a number of habitat features important to bats: forest cover, which provides tree-roosting habitat [especially in older age-class trees, large trees, or trees with characteristics suitable for roosting bats, i.e., sloughing bark, cracks and crevices or suitable hollows (Vonhof 1996)]; caves, rock or cliff areas that provide roosting habitat (especially southwest-facing cliffs or slopes); and wetland and riparian areas that provide foraging or drinking habitat.

Removal of forest cover may cause direct mortality of bats through destruction of occupied tree roosts; the highest mortality would occur if removal occurred during spring through fall, the active period for bats. In some areas removal of forest cover may also contribute to loss of winter tree-roosting habitat. Removal of forest or vegetation may cause forest fragmentation, which may have negative or positive impacts on bats and their habitats. Negative effects include increased access for predators to bats roosting in trees and changes to interior forest conditions; positive effects include increased access to suitable roosting trees for bats and creation of bat flyways or commuting corridors.

Removal of vegetation cover (through physical or chemical treatments, or prescribed burning) may significantly alter temperature, surface hydrology and air flow thereby causing changes to summer and winter roosting conditions within mines. At one inactive mine site in the Kootenay region, bats switch between mine and forest roost sites throughout the winter (C.

Lausen, pers. comm.). Loss and/or degradation of native vegetation can also affect insect population abundance and thereby prey availability for bats. Road construction, and building and mine construction may destroy or degrade cliff or rock-roosting habitat for bats; it may also disrupt drainage patterns, causing degradation or flooding of roost features.

Loss or degradation of wetland foraging areas may occur directly due to construction, or indirectly, due to water extraction of mining activities that may result in a lowered water table. This may impact or even eliminate small, sensitive wetlands, waterways, ponds and pools that may provide important drinking or foraging habitat for bats.

Rock piles, tailings piles or tailings ponds may influence watercourses through physical disruption or through acidification or leaching of potential toxins present in parent materials at the mine site. Emergent aquatic insect prey can be contaminated through bioaccumulation of toxic levels of metals and/or organic compounds released through mining processes. Depending on mine type and/or extraction process, leachates in drinking water sources for bats could exceed acceptable levels for bats.

Noise/physical disturbance from blasting, dust or noise (vibrations) as a result of site preparation and construction or from mine activities can affect adjacent bat colonies (forest- or rock-roosting) in summer or winter. Blasting activities, in particular, can directly affect the integrity of underground roosting habitat in caves or mines through inadvertent collapse of features.

2.1.2 Re-opening Old Mines

Re-opening old mines may include all of the activities and potential impacts involved in opening new mines as described above. However, impacts may be more significant if bats are already using the old mines as summer and winter roosting habitats. Bats may also enter mines in winter to forage on hibernating insects (C. Lausen, pers. comm.). Reopening of these mines will, in most cases, result in direct loss of bat habitat unless mitigation planning can avoid disturbance to areas currently used by bats. In many cases, it may not be possible to avoid disturbing bats; therefore, timing of activities to avoid direct mortality of bats will be important.

2.2 Closing Mines

2.2.1 Closing Active Mines

Closing of active mines may have a lower impact on bat populations than the closing of inactive mines, because bats may not be using the underground features due to the disturbance of current mining operations. However, the closing of active mines offers the opportunity to potentially create suitable bat habitat in part as compensation of habitat lost due to other operations and as a biodiversity stewardship initiative.

2.2.2 Closing Old Mines

Inactive mines may be closed for public safety reasons or habitat remediation, resulting in the loss of potential roosting, hibernating and swarming sites for bats. Local bat populations can be severely impacted if mine closures occur during the period when mines are occupied by bats; the impact could be particularly severe for individuals that have high roost fidelity to the site (Altenbach 1998). Generally, bats using permanent-type roosts (definition in Glossary) such as hibernations sites show high roost fidelity (Lewis 1995); females also show high fidelity to roosts during pregnancy and lactation (Lewis 1995). Alternative suitable sites may not be known to the bats, or available to the population. Bats forced into using an unsuitable alternate site may have to change roost locations during the winter hibernation period, using up critical fat resources, or they may perish from either exposure to extreme cold, or starvation due to forced wakeful periods during periods of temperature fluctuations.

2.3 Spread of White-nose Syndrome

The emergence of White-nose Syndrome has added another potential means by which the mining industry could impact bat populations. The movement between mines of mine workers and equipment may inadvertently spread spores of *Pseudogymnoascus (Geomyces) destructans*, the fungus associated with WNS. While the primary mode of disease transfer seems to be due to bat-to-bat contact but transfer of fungal conidia (spores) via human clothing or equipment is a possible mechanism of spread. To date, WNS is not known to be in British Columbia, and models using bat-to-bat transfer project arrival of WNS on the west coast of North America between 2017–2027 (Kunz 2009; Ihlo 2013). However, the arrival could be hastened if humans could facilitate transfer of the pathogen spores, and proper decontamination procedures are not followed.

Section 3: Best Management Practices

Part A of this section applies to all types of mining activities and outlines four general phases involved in BMP implementation: assessment, planning, avoidance and mitigation. **Part B** provides specific BMPs for the four activities described in Section 2 (opening and closing of new and existing mines) and for reducing White-nose Syndrome transmission. This document provides general guidance but does not replace the need for an experienced bat biologist to develop detailed site and project specific plans.

Part A. Evaluating a Development and Initiating the BMP Process

Assessment	1. Define the assessment area in terms of the local area of impact of the development footprint, and a regional area of impact to assess ecosystem/population level effects. 2. Determine species present and estimate relative abundance if possible. 3. Assess presence, use and regional importance of specific bat habitats
Planning	1. Based on the assessment above and on existing data, assess level of risk posed by the mining activity, and determine whether specific bat management plans are necessary (Figure 3). 2. If management for bats is required, develop a "Protection Plan" with avoidance as the preferred strategy, with mitigation as the next preferred strategy, and with compensation (trade-off with conservation benefits outside the development area) as the final option.
Avoidance	1. Avoid displacement or mortality of bats using timing windows (temporal separation). 2. Avoid destruction/degradation of bat roosts by changing development plans to areas away from bat use habitats (spatial separation). 3. Avoid adverse impact on bats by modifying techniques used in the mining operation
Mitigation and compensation	1. Enhancement within development area to replace bat habitat features impacted by the development (e.g., bat boxes, pond creation, creation of artificial concrete 'caves'); 2. Plan for future recovery of the development site by the establishment of wildlife tree reserves (Masters et al 1979) and green tree recruitment for future roosting opportunities; 3. Compensatory protection outside development area resulting in "no-net-loss" at the regional level or at the level of bat populations (i.e., protecting equivalent habitat within the watershed outside of the development area).

3.1 Assessment

3.1.1 Establishing Assessment Area Boundaries

Mine resource proponents are responsible their own development area and this sets their project area boundaries; however there are advantages to managing the habitat and biological resource information at a landscape level beyond the borders of the development footprint. It may be useful to put the development in context with the provincially defined Landscape Unit (Landscape Units). Putting the development in a regional context enables better assessment of the relative importance of bat habitats within the development area e.g., if the only caves present in the region occur within the development area they would be given higher significance for bat roosting habitat compared to a karst rich region with a diversity of caves in close proximity, where the few caves in the development area may not be considered a limiting resource. Putting the development within a regional context will also enable the assessment of cumulative effects of multiple human resource developments (B.C. Ministry of Environment 2014a).

Delineating local and regional areas of impact start with compiling the available mapping resources such as:

1. Biogeoclimatic Maps
2. Forest Cover Maps
3. Wildlife Capability/Suitability Maps (existing map products within any provincial region may reside either with the Regional Wildlife Office or the Provincial Wildlife Section that coordinates wildlife mapping).
4. Remote Sensing Resources (aerial photographs, LANDSAT images, or any other digital mapping resources).

3.1.2 Establishing a Species List

The second step in the assessment phase is to determine the potential list of bat species that might be present in the area. Some resources available in British Columbia include:

1. Bats of British Columbia. Royal British Columbia Museum Handbook. Vol.1. Nagorsen and Brigham (1993).
2. British Columbia Species and Ecosystems Explorer also the NatureServe Explorer for bat species range maps and their current status in British Columbia and Canada.
3. Conservation Data Centre databases: hibernation sites for bats are coded as secure but may be released to proponents for environmental assessment purposes.
4. Species Inventory Database: locations for bats from provincial inventory or habitat studies.

It is important that the potential list of species obtained using the resources above be checked with site-specific field data gathered during the bat habitat assessment phase described in Section 3.1.3 below. Techniques described in the section below can also be used to assess relative abundance of bats present and/or using habitats with the mining development site.

3.1.3 Assessment of Bat Habitat Presence and Use

As with the potential species presence lists in the section above, the first step in bat habitat assessment at the development site is to check the Species Inventory Database for locations of roost sites, maternity colonies and other ecological studies in the area. Contacting the Ministry of Environment and Forest, Lands and Natural Resource operations regional wildlife biologist(s) could also lead to additional reports and studies. The Ministry may code some of the locations for hibernation sites or maternity sites for bats as 'sensitive' information; release of data may require direct contact with a British Columbia Ministry of Environment biologist. Habitat features that are important to bats for roosting, foraging and drinking may also be identified using remote sensing resources such as forest Cover maps which can be used to identify areas of older age-class trees that may provide roosting habitat. If Habitat Capability/Suitability mapping for bats exists for the project area these should be used to identify potential areas of roosting and foraging habitat.

Once the potential bat habitats have been identified using maps and existing information, then an experienced bat biologist should determine the appropriate survey design, survey techniques and survey intensity. Assessment of bat communities and their habitats should follow the Provincial standards and protocols for handling and data collection (RISC 1998). "Managing Abandoned Mines for Bats (Sherwin et al. 2009) and "Range-wide Indiana Bat Protection and Enhancement Plan Guidelines" (USFWS 2009) also provides a good set of guidelines for habitat assessment for bats. Some of the techniques are described below, and most of these techniques can use used to survey bat habitats above or below ground and in various seasons. Variations necessary to improve efficacy of surveys depending on season, mining activity and season are also discussed below.

To confidently assess bat usage of an area, sampling must encompass a variety of weather conditions and seasons. Poor weather conditions, such as rain, cold temperatures or high wind, can leave bats torpid in their roosts, which results in low capture rates in mist nets at sampling stations. Repeated sampling is important because bats may use a series of roosts in summer and winter; a roost appearing unoccupied during one or two sampling sessions might actually be important to a local bat population at other times. In a southern United States study using acoustic survey methods, while common species were detected sampling 2-5 nights, detection of rare species required more than 45 nights of surveys using 7-9 detectors per survey night (Skalak et al. 2012). **The current recommendation is for a minimum of a full year of surveys at all potential habitats in a site and preferably two years in a site rich with bat roosting habitat such as old abandoned mines (Altenbach et al. 2000).**

<u>Visual Surveys</u>

Visual surveys can be used for assessing roosting, swarming, and foraging/drinking habitat use; they can be used to assess bat activity in all seasons; and they can be used to assess above ground and below ground habitats. Visual surveys are primarily used for presence/not-detected data but visual emergence counts can be used to estimate relative abundance at roost sites.

1. Visual counts at maternity roosts at emergence (when bats leaving to forage around sunset) are useful for determining colony size; sites with multiple exit locations may require multiple observers and because of possible movements between roosts, multiple counts at roost locations may give more accurate assessments of number of bats.
2. In the non-hibernating period, visually surveying mine openings at dusk for exiting/flying bats could provide indication of roosting sites within the mine. Combining this with a longer period of echolocation call monitoring will increase detectability.

Big Brown Bat (*Eptesicus fuscus*). Photo: Jared Hobbs.

3. Visual surveys at mine openings in late summer or early fall that detect bats flying in and out of mines or caves may provide a good indication that the site is used for hibernation, as bats often exhibit swarming behaviour at such sites before entering them for the winter (Barclay et al. 1979; Fenton and Barclay 1980). In the United States, Washington State currently implements this kind of assessment with a requirement for qualified personnel to evaluate any orphaned or abandoned mine sites proposed for closure for potentially important wildlife habitat (Norman 2000).
4. Visual surveys at mine openings can help locate potential bat hibernation sites. The Colorado Department of Natural Resources developed a volunteer network that use bat detectors to conduct visual and acoustic evaluations of large, old inactive mine sites (BIMP 2002).

5. It is generally not cost effective to do visual surveys to watch for bats in winter at portals, since bat emergence numbers can be very low, even in hibernacula that contain substantial numbers of bats (C. Lausen, pers. comm.). Bats are easily missed, and it has been found using acoustic recordings, that often bats do not emerge until late in the night and emergence can be highly staggered across the night. Emergence times may correlate with moonlight and cloud cover, as snow amplifies moonlight levels, even with a partial moon (C. Lausen, pers. comm.).
6. Sherwin et al. (2009) compare detection probability of bats and costs of doing internal and external surveys, and recommend that internal surveys increase detection probability considerably under certain circumstances. Internal assessments provide information on past use by bats (e.g., piles of faeces, urine stains/crystallized accumulations, prey remains), and allow assessment of the potential suitability of a site for roosting based on the observed internal conditions (Sherwin et al. 2009). Internal assessments can provide information on size of hibernacula, species identity (potential collection of guano for DNA analysis), and assessment of baseline microclimate conditions in the hibernacula which is essential for future management of the hibernacula. However, because it is thought that bats generally do not feed in winter, not all hibernacula are expected to contain bat guano. It is also suspected that woodrats may consume bat carcasses, and thus caves/mines with heavy woodrat presence may retain less evidence of bat use (C. Lausen, pers. comm.).

   Repeated disturbance to bats in hibernation sites can reduce their survival by forcing them to use valuable stored food reserves (Thomas et al., 1990; Speakman et al. 1992). Extreme precautions need to be taken to ensure no harm to the bats, or the personnel entering the site as old mines and caves can have many hazards including toxic gases, unstable ground etc. At a minimum, precautions and protocols outline in the provincial standards (RISC 1998) need to be followed, but site specific precautions may be necessary to ensure safety of personnel. British Columbia Ministry of Environment decontamination protocols need to be followed (B.C. Wildlife Health Program 2016).

Echolocation/Acoustic Surveys

Passive acoustic sensors (bat detectors), which record the echolocation calls of bats, will provide information on bat presence, limited species identification, temporal and spatial patterns of bat activity, and very limited relative intensity of habitat use information. However, bat activity at a site can vary widely depending on season, weather, temperature and moon phase (Arnett et al. 2008; Baerwald and Barclay 2011; Johnson et al. 2011); therefore, it is not possible for do any comparative analysis on acoustic data unless there are accompanying metrological data (minimum temperature, precipitation, wind speed, barometric pressure and moon phase). Timing, duration, deployment design, equipment are described in the provincial standards document (RISC 1998). As with visual surveys, acoustic monitoring can be used for assessing roosting, swarming, and foraging/drinking habitat use; they can be used to assess bat activity in all seasons; and they can be used to assess above ground and below ground habitats.

1. Current acoustic monitoring systems can be set up to monitor over many months, optionally turning on at sunset and turning off at sunrise and/or subsampling throughout the day or night. While some automated systems are powered using solar panels others are designed to record long term on internal batteries, often Lithium D size for recording periods of up to one year. Continuous acoustic monitoring is recommended at all potential bat habitats for at least one year prior to initiation of mining activity, and increased to two years at high bat use sites**. Two years of non-detection of bat acoustic activity is required prior to permanent closure of potential bat habitat in caves and mine tunnels.**
2. Acoustic monitoring may be deployed during the non-hibernating season at foraging/drinking sites to confirm usage, assess temporal patterns and intensity of use. This information may be useful for overall planning and management of bat habitats is important summer habitat occurs nearby.
3. Fall surveys during swarming at portals to caves or mines can include both visual observation (at dusk) and use of acoustic bat detection systems. Because timing of swarming is largely unknown in British Columbia, acoustic detection during year one of monitoring can inform an approximate and appropriate observation period for year two of monitoring, especially if mistnet capture to confirm species and sex is a goal of year two sampling.
4. In winter, since bats are in a state of hibernation for several weeks at a time, activity is low, and the recommended technique for monitoring bats is long-term passive deployment of bat detectors at the entrance, or inside the mine (in the case of a deep, complex mine or when not all parts of a mine can be accessed safely). If the portal is small and the entrance accessible to allow the deployment of a detector at least 10 metres into the mine, dual microphones can be used to provide information about whether bats are entering/exiting mines. In winter, when bats usually fly alone, this technique can

provide some insight into whether bats are either hibernating in the mine or entering for only for a short period during night (e.g., to forage on hibernating insects in the mine; C. Lausen, pers. comm.).

5. It is not clear that bats echolocate as frequently or as loudly inside a mine/cave as they would in an open foraging environment, for example (M. Davis, pers. comm.). As such, strategic placement of acoustic recording equipment should include placement at portal entrances, or at pinch points or bends inside mines/caves where bats are forced to fly close to the microphone of the detector while navigating their environment. Some bat detectors have significantly lower sensitivity than others and must be positioned appropriately to account for this.

Mist-netting/Harp Traps

Mist-nets and harp traps are used to capture bats to confirm species identity, assess age, sex and reproductive status, to collect genetic samples and to affix radio-transmitters if necessary. This method is used once visual and acoustic monitoring confirms the presence of bats at a site, and is used to determine usage. The capture and handling of bats can only be done by experienced bat biologists with a valid B.C. Wildlife Act research permit. At a minimum, precautions and protocols outlined in the provincial standards (RISC 1998) need to be followed. British Columbia Ministry of Environment decontamination protocols need to be followed (B.C. Wildlife health Program 2016).

California Myotis (*Myotis californicus*) with radio-transmitter (Photo: Dr. Cori Lausen).

Radio-telemetry

Radio-telemetry can be extremely useful for determining the location of summer day roosts (such as maternity colonies), hibernacula, and in general spatial patterns of habitat use. Radio-telemetry is of limited use in determining the location of winter hibernation sites or roosts deep in mine sites, because the radio signal will be blocked by the mine or cave rock materials. Use of this technique in the fall, however, may yield the location of swarming sites, which could be subsequently surveyed to determine if they are used as hibernation sites. It is recommended that radio-tags should not exceed 5% of the animal's body mass (Aldridge and Brigham 1988), and therefore have a limited life-span of one to eight weeks (depending on the size of battery and the type of the transmitter). Due to the investment required for this technology, and the impact on the individual bat, radio-tagged bats should be followed each day and this may sometimes require aircraft support especially during the migratory season in the fall. Given the cost of deployment and intrusiveness on the animal, radio-telemetry should only be used when the required data (in particular location of significant roost sites) cannot be gathered in any other cost-effective way. If the bat cannot be located during daytime searches, evening position checks, especially during warm conditions, may determine whether the tag is still on the bat or is undetectable (e.g., bat roosting in an undetectable location, tag fallen off in an undetectable location or tag dead).

Infrared – beam Breakers/PIT-tagging

Other systems such as the infrared monitoring systems involve setting up infrared beams across entrance points of mines/caves or high activity areas where bats 'breaking' the beams are counted by a remote device (Sherwin et al. 2009). The system gives an index of activity but does not count individuals. PIT-tags (Passive Integrated Transponders) can be used on known populations and can be effective in mark-recapture studies (Kunz 2003). PIT-tag 'readers' can remotely read the PIT-tag as the bat flies past; however success with this technique depends on having a specific location where bats pass by the 'reader' at close enough range to be read. PIT-tagging has worked well in some studies (e.g., Adams and Hayes 2008). Capture-mark-recapture is the only technique available to estimate true population size of a roost.

The choice of technique used to assess bat habitat use and other parameters at a site will depend on site characteristics as well as the level of expected impact of the mining activity (Table 4). The choice of survey method and assessment design will require the expertise of a bat biologist.

3.2 Planning

At the end of the assessment phase (Year 1 or 2 depending on site and project design), determine whether further investigative work for bat presence and habitat use is required for effective management planning (Figure 3). If data are lacking or incomplete, further data gathering and re-assessment may be required.

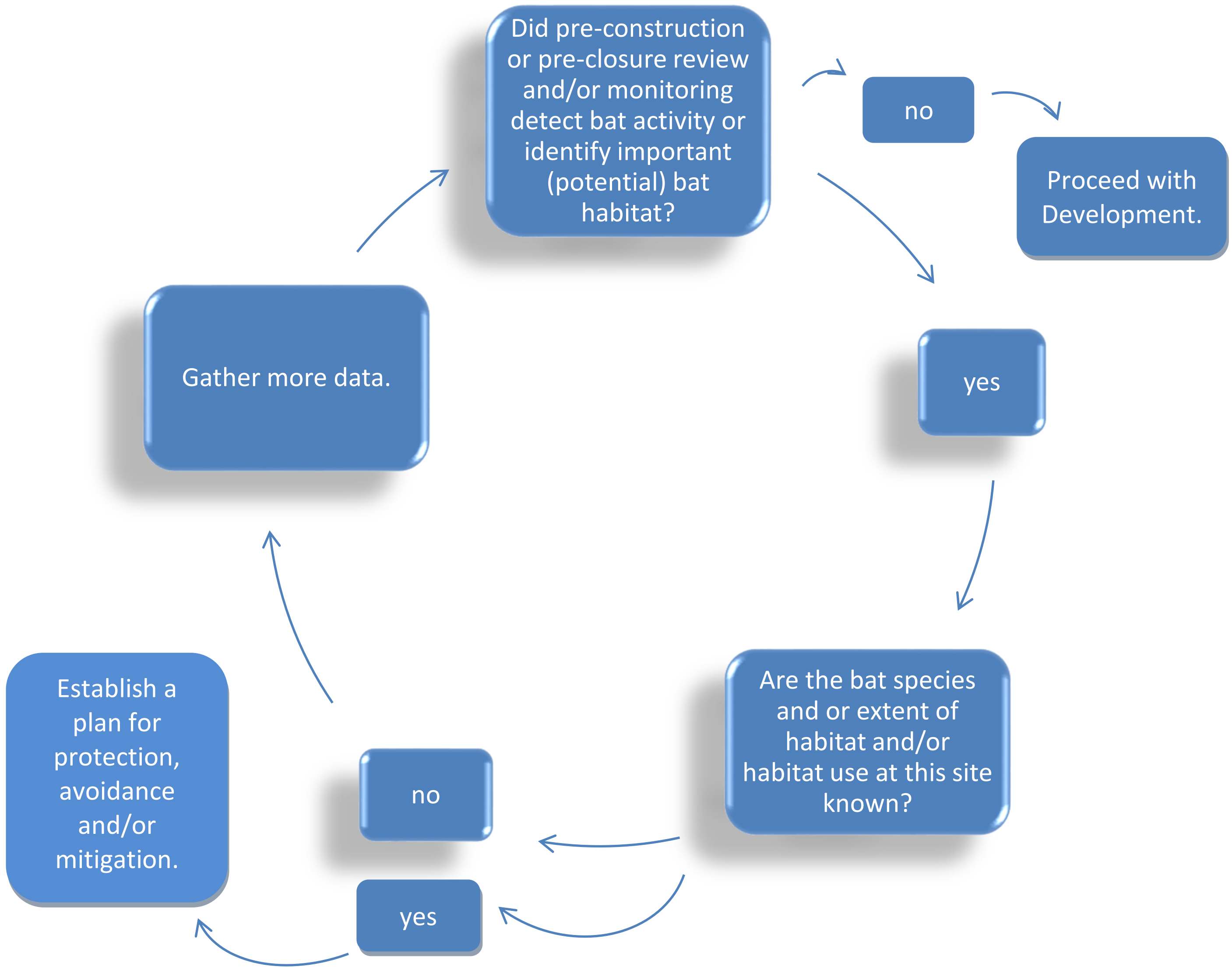

Figure 3. Planning flow chart.

Significant bat roost:

- Any hibernaculum or swarming site;
- A roost used by a nursery colony of a Red- or Blue-listed species (any number of individuals), or a nursery roost used by more than six females of other species (can include mixed species groups);
- A roost used by a maternity colony of Red- or Blue-listed species (any number of bats), or a maternity roost used by more than four females of other species (can include mixed species groups);
- Any permanent-type day roost used by a male or a non-reproductive female of a Red- or Blue-listed species, or > 10 males/non-reproductive females/juveniles of other species (can include mixed species groups);
- Any night roost used by a Red- or Blue-listed species or > 10 bats of other species (can include mixed species groups);
- Any regularly-used roost of a species listed under Schedule 1 of SARA (any number of individuals); or,
- Any roost deemed significant by an experienced bat biologist.

If sufficient data exist, the importance of the development site to local bat populations should be assessed against the level of disturbance arising from project implementation (Table 4) to determine if a management plan for bats is required. For example, the presence of a "Significant Roost" will trigger a management plan for bats on the site.

To determine if these significant bat habitats are within the area of influence of the development site activities and to estimate buffer distances, straight-line estimates of maximum distances travelled by bats can be used (Lacki et al. 2007). Spatial use by bats can vary significantly among bat species, life-stages, sexes, and can also vary depending on season (Lacki et al. 2007) Chapter 1 provides a detailed description of distance travelled and home range size of bats (Chapter One: Introduction – Appendix One). As a general guidance a Protection Plan for bats should be developed if the development footprint is within (adapted from USFWS 2009):

- 16 kilometres of an occupied hibernaculum of a listed bat species (i.e., any bat species on the British Columbia Provincial Red- or Blue-List or Federally listed as Endangered or as a candidate as an Endangered species
- 8 kilometres of an occupied hibernaculum of an unlisted bat species, or a female/juvenile capture location of a listed bat species 4 kilometres of any significant roost or significant maternity roost (adapted from USFWS 2009).

If a management plan for bats is required, it might involve both "Avoidance" measures (Section 3.3) and "Mitigation and Compensation" measures (Section 3.4) when impacts to bats cannot be completely avoided.

3.3 Avoidance

There are two ways of avoiding impacts to bats and bat activities: temporal avoidance (the setting of timing windows for activities); and spatial avoidance (the setting of appropriate buffers).

Timing Windows

A pattern of events in the bat lifecycle can be generalized (Figure 5); appropriate dates for particular areas of British Columbia should be made after consultation with a local bat expert.

Yuma Myotis (*Myotis yumanensis*) pup, Cortes Island. Photo: Christian Gronau.

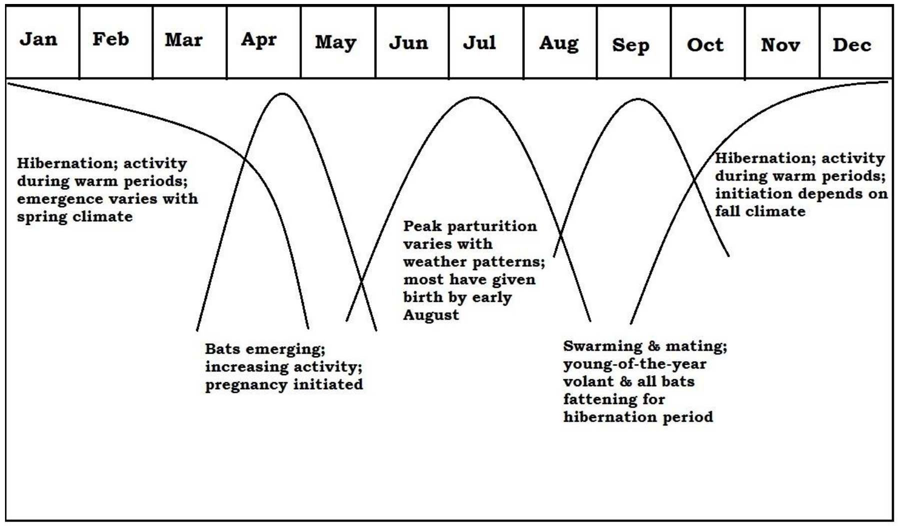

Figure 5. General seasonal patterns of activities of bats in British Columbia.

In British Columbia, sensitive time periods (such as hibernation or parturition/raising young) will vary slightly depending on the biogeoclimatic zone and season-to-season variation in weather. Cool, wet springs are correlated with later birth periods; conversely, an early, warm spring can bring bats out of hibernation earlier and initiate the reproductive period earlier (Grindal et al. 1992; Holroyd 1993). It is not unusual to have variation in timing of emergence and birth (parturition) of two to three weeks between years with significantly different climatic conditions; these may occur between years in the same area or between areas with significantly different climatic conditions in a given year (Grindal et al. 1992; Holroyd 1993).

Spatial Avoidance

Impacts to high use bat habitats can also be avoided or diminished by moving development activities away from these habitats. Setback distances vary based on the degree to which bat habitat (including surrounding vegetation and soils) will be affected by the proposed development or resource extraction. Activities that either create permanent structures, or that affect soils, or that are expected to have long-term effects on vegetation or hydrology (long-term is defined as effects that persist for greater than ten years) have the largest setback distances compared to activities that have little or no effects on vegetation or soils have the smallest setback distances (ABSRD 2011; Table 4).

Table 4. Three levels of impact (low, medium and high) to bats and their habitats as a result of human activities; to use in planning acceptable activities within the management zones around significant bat roosts (adapted from Alberta Sustainable Resource Development 2011).

Level of Disturbance	Examples	Acceptability
Low impact disturbances are often infrequent; habitat is not being modified by the activities; and the duration of the activity is relatively short (i.e., hours).	• Land surveying • Recreational trail users (hiking) especially where trails traverse areas of winter use such as talus slopes, or rock outcrops	• Extra caution should be used immediately adjacent to the roost. • Acceptable in the 1-kilometre special management zone all year, and within the 100-metre core area within timing windows. o Maternity sites – avoid activities between May to August. o Hibernation sites – avoid activities between October and April.
Medium impact disturbances are usually high in frequency, may use vehicles and other equipment, and may involve small habitat modifications and the duration is relatively long (i.e., days).	• Seismic drilling • Recreational trail construction	• Not acceptable in the 100-metre core area during the occupied period. • May be acceptable in the 100-metre core area when bats are not occupying the site and where the activity does not degrade the habitat (upon review by an experienced bat biologist). • Acceptable in the 1 kilometre special management zone within the suggested timing windows o Maternity sites – avoid activities between May to August. o Hibernation sites – avoid activities between October and April.
High impact activities generally involve disturbances that are high in frequency, involve vehicles and machinery, permanently modify the habitat by altering vegetation, soils, geomorphology and perhaps hydrology, and the impact is long term (i.e., more than 10 years).	• Construction • Blasting • Burning • Forest harvesting • Use of heavy equipment • Land clearing • Excavation • Road building • Recreational trail users (snowmobiling)	• Not acceptable in the 100-metre core area at any time (Sarell 2004*a*, 2004*b*; Chatwin 2004) • Possibly acceptable in the 1 kilometre special management zone (with review by an experienced bat biologist); activities should occur within the suggested timing windows: o Maternity sites – avoid activities between May to August o Hibernation sites – avoid activities between October and April • **Specifically for blasting activities**: either ensure sound concussion of less than 150 decibels and that shock wave is less than 1.5 p.s.i. and the peak particle velocity is less than 15 mm/second (MFLNRO 2014) or **maintain a setback of 2 kilometres** from occupied significant roost sites (Delaney 2002; M. Davis pers. comm.). Blasting may occur during periods when bats are not occupying the roost, however, ensure that the roost habitat is not degraded.

In most cases important bat habitats that require spatial avoidance will be "Significant Roost" sites as defined above and swarming sites, although foraging/drinking sites can also be considered important if they are limiting in the environment. Once there is indication that a habitat may be a "significant roost", the next step is to delineate the extent of these roost sites as there may not be sufficient field data to know exactly which crevice or tunnel is occupied. **For hibernation sites delineate the complete extent of underground wintering habitat including all portals as well as above ground features such as roost trees that may be used in winter.** For maternity roosting complexes, include the extent of rock roosting complex used and/or suitable forest-roosting habitat available in the area of known roost trees. In some cases, extent of roost area may need to be inferred from known average roost area sizes for particular species if no data are available (see Appendix 1, Chapter 1 *separate document* for review and summary).

Once these roost areas are delineated (considered the "roost complex polygon") and establish a 100-metre buffer around this polygon and identify this as a "core area" (Figure 4). Establishment of wildlife habitat areas for bats in British Columbia have employed a 100 metre radius "core area" to protect hibernation sites, where no harvest or salvage is permitted (Chatwin 2004; Sarell 2004ab). No activities that would modify

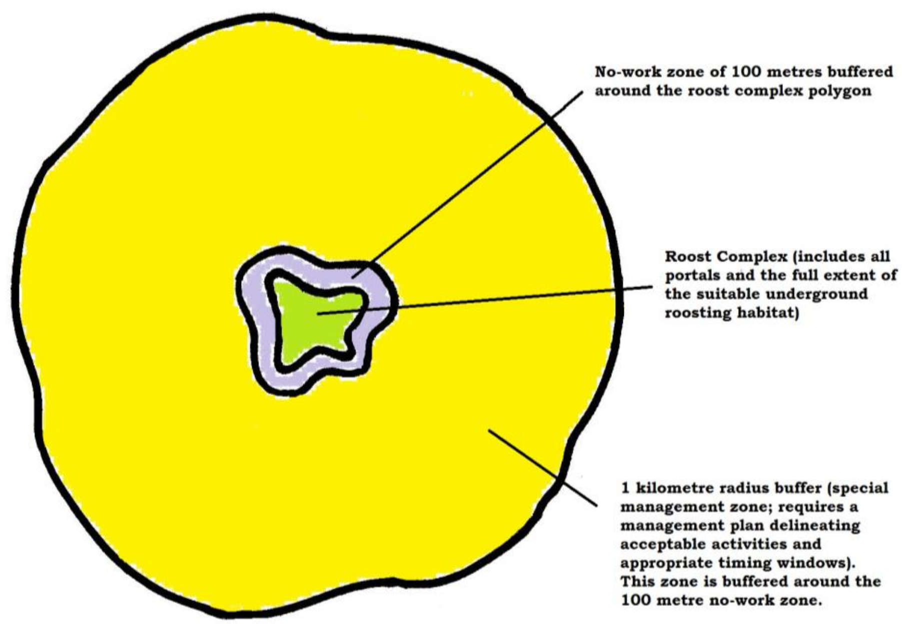

Figure 4. Delineate the roost complex or other important bat habitat area by mapping the entire extent of suitable habitat. For underground habitats this would include all portals and tunnels that can potentially provide roosting habitat for bats (Table 2). Establish a 100 metre wide "core area" and 1 kilometre wide "special management zone" around delineated important bat habitat. The timing and level of disturbance arising from mining operation activities is restricted in these areas.

the above or below ground habitat within this core would be allowed; during the "occupied period" no activities that would disturb hibernating or breeding bats would be allowed (depending on the roost-type). Allowable activities within the core area during the period when the habitat is unoccupied by bats would include low or moderate impact activities (Table 4). Unoccupied periods may vary slightly, depending on location within the province, climatic conditions and season, and should be determined by an informed and experienced bat biologist and coordinated with the regional wildlife specialist with British Columbia Ministry of Environment.

Beyond the roost complex polygon and the core area, an additional 1 kilometre special management zone is delineated where the timing and disturbance level of the activities is also restricted but to a lesser extent than the core area. When harvesting within the special management zone, structural elements important to bats, such as large diameter trees (30-50 cm dbh) and especially wildlife trees (classes 2-8; especially those with cracks, peeling bark, cavities or hollow interiors) (Masters et al 1979) and all ponderosa pine >50 cm dbh (Sarell 2004ab, Chatwin 2004) should be retained. Retain some smaller dbh green trees for future recruitment as large diameter wildlife trees that can be used by bats for roosting (Sarell 2004a, Chatwin 2004). When known maternity roost sites are within the development site, do not harvest trees between May to August within the core area and the special management zone around the roost (Sarell 2004a, Chatwin 2004). Within the special management zone employ only partial harvesting systems and maintain 70% basal area forest cover (Chatwin 2004) if possible. Near hibernation sites, do not harvest within the management zone between October to May (Chatwin 2004). Because some species of bats are known to use trees in conjunction with mines as hibernation sites (C. Lausen, unpublished data), the suitability of a mine as a hibernaculum may depend on the presence of nearby roost trees within a radius of up to 500 metres, and in these cases this area should be considered a no-cut zone in

Keen's Myotis (*Myotis keenii*) from Haida Gwaii. Photo: Dr. Cori Lausen.

addition to the 100 meter core area and precautions in the special management zone.

Determining Level of Disturbance

Wildlife species have variable tolerances for disturbance intensities, with higher levels of disturbance requiring greater mitigation (ABSRD 2011). Human activities have been divided into three disturbance impact categories (ABSRD 2011; Table 4). Prior to the initiation of human-activities near significant bat roosts, proponents should identify the expected level of disturbance and planned schedule of activities to establish acceptable timing windows and setbacks (Table 4).

3.4 Mitigation and Compensation

In most cases, it will not be possible to avoid all impacts to bats and bat habitats. Mitigation is defined as the measures implemented to control, reduce or eliminate potential adverse impacts of a project, including restorative measures (Environmental Assessment Office 2003). Implementation of mitigation measures should follow the mitigation hierarchy procedures of the B.C. Ministry of Environment (B.C. Ministry of Environment 2012; B.C. Ministry of Environment 2014b). Updates and additional information on the mitigation policy are available on the Ministry of Environment mitigation policy website. Mitigation may involve offering alternate habitat (such as artificial structures) to off-set the loss of roosting habitat as a result of development; planning to retain or re-build ponds and wetland areas that represent important drinking/foraging habitat for bats within the development area; long-term planning to retain or recruit currently young forest areas to serve as tree-roost habitat in the future; and/or replanting areas where forest clearing has disrupted connectivity corridors between roosting and drinking/foraging habitats.

Establish work plans that maintain the integrity of the habitat, ensure connectivity between roosting and foraging or drinking habitat; ensure these habitats remains effective for bats. Manage site development and water use at mine sites such that wetlands (small and large) and riparian areas are maintained. Maintain contiguous patches of forest where possible within the development area. Design the development to maintain surface vegetation and to minimize erosion effects; avoid introducing non-native plant species. Removal of vegetation cover in the immediate vicinity of underground sites such as mines and caves can affect roost microclimate.

Ensure that any water flowing away from the mine site meets minimum clean drinking water standards for wildlife (see the Environmental Protection Division of the B.C. Ministry of the Environment Ambient Water Quality Criteria for Wildlife). If water is unsafe for consumption, ensure that the site is inaccessible to wildlife including bats. For bats, increased clutter at the water surface will impede their ability to drink. If wetlands or riparian habitat is lost due to development, propose a plan to enhance this type of habitat for bats elsewhere on the development area or within the local region (or Landscape Unit – see Glossary). If bat colonies are known to occur in the development area, provide small ponds as drinking habitat for bats if possible.

Construction of bat-friendly gates in portals of known roosts is often considered to control access for people because of safety and liability considerations. Gates are not always in the best interest of the bats because installations can disrupt airflows and, if improperly installed, can prevent access for some bat species. There are numerous options for bat-gating and appropriate gate design is often site-specific because of the variation in size and type of opening and geomorphology of an area and the bat species using the site. Any bat-gate installation should involve an experienced bat biologist as well as an experienced bat-gate specialist. There are numerous sources of information on the variety of bat-gate designs available and one of the best resources continues to be Bat Conservation International.

As a measure for lost summer roosting habitat, proponents may consider constructing alternate habitat such as bat boxes, artificial roost trees that simulate trees with loose bark (Noteman 1998; Dillingham et al. 2003) and rock roosts using specifications suitable for the geographical location and with input from a bat specialist. Proponents may also compensate for lost habitat through protection of suitable habitat nearby. Tree roosting bats typically use a series of roosts in relatively close proximity however the number of roosts used and distances between roost will vary depending on the bat species and the forest type (Barclay and Kurta 2007; Carter and Menzel 2007). For Silver-haired Bats, it is estimated that they require 21 snags per hectare (BCI 2014); thus mitigation may require 15-20 artificial roost structures per hectare of forest lost. Bat house design preferences of British Columbia's different bat species are still not well-understood; use a variety of site locations and bat house designs, such as rocket-boxes and multi-chambered boxes to provide a variety of thermal profiles for roosting bats. Follow suggestions provided by Bat Conservation International and BC Community Bat Program, with southwest-facing boxes, painted black, on poles or trees ≥3 metres above the ground (BCI 2014) but adapt the locations and designs as advised by a bat biologist understanding that these recommendations will evolve over time and are likely to be different in different regions. Ensure boxes are accessible to bats (open flyways without clutter). Distribute boxes throughout the area

Double-check to ensure that gate design and spacing between bars is appropriate for bat species found in the installation location!

in appropriate locations. Monitor houses to determine level of occupancy; ensure there is a plan in place for long-term maintenance of artificial roost structures.

Alternative winter roosting habitat might include providing protection to nearby alternate cave or mine sites through installation of bat-friendly gates or other protective measures (installed under the supervision of a bat specialist), or creation of artificial cement hibernacula (e.g., The Nature Conservancy in Tennessee 2013) although effectiveness of artificial hibernation structures remains to be proven.

To reduce the cumulative effects of developments on wildlife, attempts should be made to place all new human developments in locations that minimize vegetation, soil, and hydrology disturbance. This could include areas where the soils and vegetation have been disturbed by previous developments.

Not every mine site is critical for bat conservation (Tuttle and Taylor 1998) and effective bat conservation planning conducted at a landscape-level scale could result in trade-offs and compensation outside the development footprint (Racey and Entwistle 2003; Miner and Stoker 2005). Based on existing vegetation, human development, and land uses in each specific area, resource managers may decide to allow development or resource extraction closer to the wildlife key area/sites than recommended in Table 4 with a 'trade-off' agreement to protect an alternate, high priority (perhaps because of the bat species present), vulnerable (perhaps because the site is very accessible to humans and possible vandalism) site outside the development footprint. Trade-offs may not be an option in all cases, but can be considered where appropriate. For example, if it is impractical to remediate or enhance wetlands and ponds in the development area, take the approach of "no net loss" and protect, enhance or remediate wetland, riparian or pond habitat in other areas within the landscape unit such that the total area of wildlife habitat does not decrease but is maintained or increased. Information sharing and considering cumulative effects amongst all resource sector proponents within a landscape unit improves the opportunities for tradeoffs and effective conservation (B.C. Ministry of Environment 2014a). This approach not only leads to better management and conservation of bats but can also make economic sense. However, a broad-scale, long-term, scientifically rigorous

Hibernating Silver-haired Bat (*Lasionycteris noctivagans*) from a mine in west Kootenay, B.C. Photo: Dr. Cori Lausen.

monitoring program should be implemented to ensure that wildlife species are not detrimentally affected by these alternative management practices.

Part B. Specific Best Management Practices for Different Mine Development Types

The four types of mining developments described above should all follow the general best management practices described in Part A above. However, some mining developments are more amenable to the implementation of some types of avoidance and mitigation measures than others and these are highlighted in the sections below and the general processes are summarized in Appendix 1.

3.5 Opening Mines

3.5.1 New Mines

1. At new mine development sites, use a preconstruction assessment to determine if there are any notable habitat features capable of providing summer or winter habitat for bats such as natural caves, cliff areas, rock complexes with roosting potential, old-growth forest areas, wetlands, ponds, slow-moving rivers, underground mine workings, tunnels, bridges, dams or underground openings. Also, check wildlife databases for historical records to ascertain whether winter or summer roosting habitat occur within the mine development site and/or might be affected by mine-development activities.
2. If there are records of bat use or if potential bat habitats are present, conduct pre-construction surveys to determine extent of bat use (Part A: Assessment). A minimum of one full year of monitoring is required, with the potential to increase to two years if data from Year 1 is not sufficient for the Planning phase.
3. Determine if bat use of the development site is significant and if important bat habitats are present in consultation with an expert bat biologist, the regional wildlife biologist and as required by the environmental assessment process.
4. If bat use and bat habitats are significant, the proponent should develop a plan protect the habitat and any bats present, avoiding these features if possible; it is unlawful in British Columbia to kill bats. Best management practises for avoidance and mitigation are described in detail in Part A Section 3.3 and 3.4
5. The opening of a new mine is particularly amenable avoidance measures before the development site is disturbed and there is

freedom to move plans prior to construction. All the other mining developments described in the following sections are constrained by existing infrastructure and building footprints.

6. It is also important to plan for the eventual safe closure of the mine once the extraction process is complete or becomes economically non-viable. The closure of these operations may happen decades after the start of operations but provisions for bat friendly closure procedures could be built into the terms of commitment at the start, and transferred with the sale of the mining operation to potential future owners of the operation.
7. The opening of new mines is also particularly amenable for assessing cumulative effects of the development (B.C. Ministry of Environment 2014a).
8. If there are no features capable of providing summer or winter habitat for bats on the proposed mine development area, and there are no historical records of bat roosting habitat in the mine development area, there is no need for further protection or enhancement plans. Photo documentation and other supporting information should be kept on file to support this assertion.
9. Once the mine is developed, exclude bats from active mining sites. The creation of tunnels and underground works, and some building structures may serve to attract bats but these may not be ideal due to ongoing mining activities. It would be best to exclude bats from such attractive habitats at the start rather than have to exclude them once they have colonized the newly created habitats.
10. Monitor bat management efforts in active mine areas to determine effectiveness of measures (are bats using alternate roosting habitat? Or have avoidance strategies worked?).
11. Decontamination protocols to minimize the introduction and transmission of White-nose Syndrome should be followed in all cases where bats are present. The current protocols are posted at: decontamination protocols to minimize the introduction and transmission of White-nose Syndrome (B.C. Wildlife Health Program 2016). See also the Canadian Wildlife Health Cooperative website for the most recent updates regarding White-nose Syndrome and decontamination (http://www.cwhc-rcsf.ca/wns_resources.php).

3.5.2 Re-opening Old Mines

The reopening of old mines could potentially have a significant impact on bat populations as current anecdotal survey data show that inactive mines are used extensively, especially in the winter months. With the potential emergence of White-nose Syndrome in British Columbia in the near future, the protection and management of winter habitat takes on the utmost importance.

1. If new areas are being developed within an old mine site, these new areas should follow all the steps outlined in section 3.4.1 (Opening of new mine sites), in addition to those highlighted below.
2. If old tunnels that have remained open to potential bat colonization are being reworked, they need to be rigorously checked for current bat activity. Ideally, automated long-term acoustic survey systems set up within mine portals or in mine tunnels should be in place for two years prior to re-development but at a minimum should provide data of at least one full year with coverage during all seasons (Altenbach et al. 2000). More than one year of information is best as historic sites may not be used by hibernating bats every winter, but may still provide important alternate roosting habitat for wintering bats that switch among a series of roosts.
3. If there are old tunnels on site but these are not going to be reworked, they still need to be monitored for bat activity. If bat activity is detected they should be appropriately gated to permit bat access (Section 3.4.3) but prevent unauthorized human access to ensure no disturbance for bats.
4. If bat activity is detected in one of the tunnels/portals that are going to be reworked, timing windows should be followed for the reopening of the tunnels so that human and mining activity starts when the roost is not actively being used as a hibernaculum or as a maternity roost (Best Management Practise section Part A Section 3.3). Bats may be deterred from re-entering a site by gating the opening to prevent bat access, and/or using bright-lighting to prevent bats from re-colonizing the roost site. If the site is being used by summer-roosting bats, offering alternate roost habitat such as bat boxes nearby may also encourage bats to move (Brown et al. 2000; Kellner and Rasheed 2002; Nagorsen 2009). At hibernation sites, exclusion and deterrents should be employed before bats start hibernating (before September/October) or after bats emerge from hibernation (April/May).
5. New mine developments at old mine sites may not directly involve the old underground workings or the areas underground that may be important to bats. If this is the case, it may be possible to work the site without damaging the roosting location or disrupting the bats.
6. Given the higher probability of bat presence in these older inactive mines, all equipment and persons entering sites that could potentially be used by bats need to adhere to the recommended provincial decontamination protocol (B.C. Wildlife Health 2016). See also the Canadian Wildlife Health Cooperative website for the most recent

updates regarding White-nose Syndrome especially in regards to the most recent protocols for decontamination.

7. Given that wildlife stewardship is a shared responsibility, it is recommended that the White-nose Syndrome Fact Sheet and decontamination protocol be distributed to all personnel working on the site (MOE 2014). This would increase the probability of reports of bat presence, habitat use, and can serve as an early warning system for potential adverse impacts on bats and bat habitat.

3.6 Closing Mines

The closure of mines usually leads to less human activity on a site and therefore less impact on wildlife. However, the underground workings of a mining operation and in some cases old buildings can serve as bat roosting sites and inappropriate closure can have negative impacts on local bat populations. The second potential impact on bat populations is the abandonment of toxic tailings ponds that may be used by bats as drinking and foraging sites, although examples of this are currently unknown in British Columbia. The primary focus of this section is on the gating of mines to provide continued access to bats for hibernation and potentially summer roost sites.

3.6.1 Closing a Recently Active Mine

In a highly active mine site, it may be less likely that bats find suitable roost sites for summer or winter roosting. Implementing a closure plan as soon as the active mining operations are completed is the most economical option. However, if the underground works with the highest potential for bat roosting are protected with bat-friendly gates, these 'new' mine roosting habitat can attract hundreds of bats (Ducummon 1999). In areas where there are several mine locations that might be used by bats, it is not economically feasible to gate all possible options. All possible sites should first be evaluated to determine the most ideal sites to be gated compared to those that may be permanently closed with less expensive options (Tuttle and Taylor 1998). Methods for permanently closing a mine include backfilling, collapsing entrance portals, plugging with materials, or construction of a bulkhead that seals the entrance. Gating some of the sites that may have high value as future hibernation sites (Chapter 1, and Section 3.1.3 and Table 1 of this chapter) should be considered as a biodiversity stewardship action. Prioritization for gating should be done in consultation with a bat expert and the regional wildlife biologist. Characteristics that lead to successful colonization by bats as overwintering sites are not well understood. Evaluating the success of these gating projects every three years for example will greatly add to our knowledge.

If a mine site suitable for winter roosting sits inactive for more than a year or two, it may become occupied by bats, (Ducummon 1999). If permanent closure is planned for these mines, a monitoring program as detailed in the section above (opening in-active mines) should be implemented to ensure that there is no bat activity. If bat activity is detected then, the closure plan should follow recommendations of the section below (closing an inactive mine).

3.6.2 Closing an Inactive Mine

Any mine with underground works that has been inactive for more than a year should be monitored for bat activity prior to closure. In British Columbia, there are a number of orphan inactive mines that are now used by bats. Prior to engaging in mine reclamation measures such as mine closure, conduct bat surveys in all seasons at least one year prior to closure (Altenbach et al. 2000); preferably two years. There are few records of hibernacula in British Columbia (Nagorsen et al. 1993) but until recently, there has been little effort to locate winter bat habitats. Recent work has indicated that many mines may host wintering bats (C. Lausen, pers. comm.); justifiably **all** mine locations should be surveyed for bat use prior to reclamation.

Little Brown Myotis (*Myotis lucifugus*). Photo: Al Hicks.

If wintering bats are detected or if the site has been identified as a "significant bat roost", a protection and enhancement plan should be developed (Part A: above). If bat-gates are considered for protection of the site, use experienced bat specialists, trained geotechnical engineering expertise and personnel experienced in developing bat-friendly gate systems (see Part A: above). Bat-friendly techniques are reviewed and widely available (e.g., techniques described in Dalton and Dalton 1995; Tuttle and Taylor 1998; Burghardt 2000; Navo and Krabacher 2002; Sherwin et al. 2009; see also Bat Conservation International – Caves and Mines Program).

Bat-friendly closures involve gate systems that allow bats access while maintaining natural air-flows in the mine or cave, but exclude humans. Gates can be set up with a removable bar or access gates that can allow human access if needed. Determine the type of gate suitable for the site. There have been recent advances in the design of gates to protect bat habitat and there are a variety of methods for closing off portals with different configurations (e.g., Fant et al. 2009; Sherwin et al. 2009). Assessments need to be site specific; consider the bat species using the site; and allow for monitoring of bat use. Based on gating experience in British Columbia and elsewhere, most

British Columbian bats appear amenable to gates (Table 5); however spacing between the bars needs to be set at a distance that allows all bat species to access the site, yet still exclude humans. The standard recommended spacing between horizontal bars is 14.6 centimetres (5 ¾ inches; BCI). Specifications and details regarding design, materials and installation protocols can be found on the Bat Conservation International website as part of their Caves and Mines program.

Table 5. Acceptance of gates by bats that may use caves and mines for summer maternity and/or winter hibernation roosting habitat (adapted from Currie 2000).

Species	Summer Roosts	Winter Roosts
Pallid Bat (*Antrozous pallidus*)	Yes	Unknown (probably will)
Townsend's Big-eared Bat (*Corynorhinus townsendii*)	Yes	Yes
Big Brown Bat (*Eptesicus fuscus*)	Unknown (probably will)	Yes
Silver-haired Bat (*Lasionycteris noctivagans*)	Yes (West Kootenay BC record)*	Yes (South Okanagan and West Kootenay, BC*, records)
Californian Myotis (*Myotis californicus*)	Yes	Yes
Western Small-footed Myotis (*Myotis ciliolabrum*)	Yes	Yes
Long-eared Myotis (*Myotis evotis*)	Yes (West Kootenay BC record)*	Unknown
Little Brown Myotis (*Myotis lucifugus*)	Yes (West Kootenay BC record)*	Yes
Northern Myotis (*Myotis septentrionalis*)	N/A**	Yes
Fringed Myotis (*Myotis thysanodes*)	Yes	Unknown (probably will)
Long-legged Myotis (*Myotis volans*)	Unknown (probably will)	Unknown (probably will)
Yuma Myotis (*Myotis yumanensis*)	Yes	Yes
Keen's Myotis (*Myotis keenii)*	Unknown	Unknown
Spotted Bat (*Euderma maculatum)*	Unknown	Unknown
Eastern Red Bat (*Lasiurus borealis)*	N/A	N/A
Hoary Bat (*Lasiurus cinereus)*	N/A	N/A

*Records from a gated mine in Beasley, B.C.; C. Lausen, unpublished data.
**Species not believed to use caves or mines as maternity roosts to a great extent, although males and non-reproductive females may use caves and mines during the summer.

Placing bat-friendly gates to exclude disturbance agents (such as people) from mines and caves has proven to be a very effective tool for protecting bats (Tuttle and Taylor 1998). The initial focus may be on mines used by sensitive species or species of conservation concern, however all bat hibernation sites should be considered a priority for protection as almost all our B.C. bat species may be vulnerable to White Nose Syndrome and face rapid decline. Bat-gate construction should take place during periods when disturbance of occupants is minimized (Altenbach 1998). The effectiveness of bat-compatible closures should be monitored to ensure that the roost remains suitable for the bats, since gates can potentially affect interior microclimates (especially temperature and air flow) and/or discourage some bat species from entering the structure (Currie 2000; Table 5). Anecdotal evidence suggests that some gates may be used opportunistically by predators of bats; setting gates further back in the mine/cave entrance in the shadows or twilight zone may help reduce predation rates and vandalism (M. Davis, pers. comm.).

Conduct all closure activities outside of the periods when bats may be present in the mine. This may vary depending on the area of the province and associated climatic conditions. This information should be obtained through pre-closure inventories for bats.

Wintering bats generally hibernate between November and April. Areas of the province that warm early may see bat activity in very early spring, but in colder areas of the province, bats may hibernate well into April. For summering bats, maternity colonies may set up in early spring (generally late April to May); young bats and mothers likely disperse from maternity sites by late August/September. Again, this may vary depending on weather conditions and the climate of the area (Grindal et al. 1992). Confirmation of expected windows of bat activity should be made with local bat experts for any given area of the province.

Management of these sites should include measures to protect the bats by preventing human access during winter hibernation periods (or other periods of bat activity). Road closures and education and awareness campaigns can be effective deterrents to human access.

If bats are detected but the site is either unstable or unsafe for wildlife (due to high levels of contaminants or radiation), appropriate bat exclusion techniques (such as barriers equipped with one-way valves) should be employed prior to permanent closure (see Brown and Berry 1997). If a gate is not suitable, look at alternatives, such as fencing or extending or stabilizing the opening with the use of a large culvert that can then be gated (Sherwin et al. 2009). Use of fencing around an opening, allows bats a free flight-path to enter the site but prevents human access.

Monitor the mine post-gating to assess if the gating is successful. Determine what species of bats are using the site (compare pre-gating diversity and numbers to post-gating diversity and numbers). If vandalism is an issue, determine how to prevent vandalism, employing strategies such as decreasing accessibility of the site or installing surveillance cameras; consider education and awareness programs or signage.

3.7 Spread of White-nose Syndrome

The best way to prevent human mediated introduction of White Nose Syndrome and to stop subsequent spread is follow the most up-to-date recommendations for decontamination. Since active research is ongoing on the most cost-effective methods, routinely check the British Columbia Wildlife Health page for updates (here; B.C. Wildlife Health Program 2016); review updates from the United States Fish and Wildlife Service (here); and the Canadian Wildlife Health Cooperative (http://www.cwhc-rcsf.ca/). Personnel entering bat hibernation habitats should be able to recognize signs of White-nose Syndrome in bats, and should contact BC Wildlife Health Program immediately is they suspect they are seeing signs of White Nose Syndrome.

1. Stay out of British Columbia mines and caves unless it is absolutely necessary to enter.
2. Under no circumstances should equipment (e.g., boots, headlamps, helmets, unwashed clothing, etc.) that has been used in WNS-infected zones or in European or Asian mines or caves be used in British Columbia mines or caves. If underground WNS-infected zones are knowingly entered into, this must be done with equipment that: will stay in that zone and be used there only; is disposable; can be submersed in 10% bleach; or can be soaked in 50°C water for 20 minutes (see Decontamination protocols; B.C. Wildlife Health Program 2016).
3. Signs of WNS symptoms on bats should be immediately reported to the B.C. Ministry of Environment and B.C. Wildlife Health Program.
4. Distribute the WNS fact sheet to all workers who enter mines (B.C. Wildlife Health Program 2016), including workers who will operate equipment inside mines where the equipment has originated from outside the local area.
5. Minimize internal surveys and assessments. Instead, use acoustic or infrared technologies to determine presence or absence of bat activity. Long-term continuous acoustic monitoring in all seasons, with special emphasis on continuous monitoring during late fall, winter and early spring, can establish whether the mine is being used by overwintering bats. Mines should only undergo an internal survey if deemed

necessary by an experienced bat biologist; particularly if bat activity is detected but species cannot be accurately identified; or other monitoring methods have failed or have been deemed inadequate; or other reasons exist that require an internal survey.

6. Information signs should be posted at the openings of all mines warning the public of the possible mine-to-mine or cave-to-mine transmission of this fungal pathogen. Geocaching and recreational mine exploration should be strongly discouraged.

Section 4: Monitoring and Reporting

The best management practises outlined above will generate survey, monitoring and effectiveness assessment data and reports. A Wildlife Act Permit is required if trapping or other methods that involve touching the bats are used in the project. Under the permit conditions, data and reports must be submitted to the Wildlife Species Inventory database. Although a Wildlife Act Permit is not required for acoustic monitoring, counts of emerging bats or other visual surveys, it is strongly suggested that the data and reports be submitted to the Wildlife Species Inventory database. It may also be beneficial to report to the BatCaver program (www.BatCaver.org) if bats are suspected of using a mine site and follow-up activities are needed.

The following will provide key pieces of information for effective management of bat habitat and populations:

- Monitoring: occupation rates of mines in all seasons by bats, including hibernation, and summer/maternity roosting.
- Monitoring: activity patterns (entry and exit times, seasonal variation, feeding behaviour, swarming or other behaviours) within mines as revealed by acoustic monitoring and internal surveys.
- Monitoring: features of mines occupied versus unoccupied by bats. Provincial Ministries (Ministry of Energy and Mines) - maintain databases (numerical data and spatial data) of all mine locations (use existing provincial databases MINFILE and “2001 Inventory of Abandoned Mines” in British Columbia).
- Monitoring: success of gating (continued or discontinued occupancy by bats, numbers and types of bat species using mines, time periods when site is occupied, characterize use by bats, e.g., hibernation, swarming, winter foraging, or other behaviours).
- Reporting: submit the following to MINFILE database and Wildlife Species Inventory database - locations of unoccupied/occupied/gated mines, types of mines, types of gates, success of gating project.
- Reporting: to Wildlife Species Inventory database (and optionally to CDC database) - locations (UTM, legal and written description) of occupied/gated mines, as well as surveyed unoccupied mines (gated or not), size and depth of underground workings, dimensions and number of portals, dates of surveys, types of mines, types of gates, success of gating project and if present, numbers of bats, and species

of bats. Collection of guano and DNA analysis may be required to verify species identification

- Data Management: In addition, track bat occupancy, potential suitability of site for hibernating bats, survey history, and management strategies employed (e.g., gates, fences, signs). Monitor gating projects pre- and post-gate installation to determine effectiveness. Track usage, population size, trends in population, and effects on mine microclimate due to installed gate design (Grandison 2000). House this information in the appropriate data repository (e.g., Wildlife Species Inventory database, B.C. Conservation Data Centre)
- Follow up conservation measures with an effectiveness evaluation. Communicate with regional wildlife staff.
- If bats are observed incidentally during a mine exploration or surveys, please report this information to the Incidental Wildlife Observation database. In these cases, the species identity of the bat will probably be unknown and so the observation can just be entered as “bats”. This will enable further follow-up investigation with bat surveys.

Section 5: Information Needs to Improve Adaptive Management

In B.C. the utilization of mines by bats as roosting and hibernation habitat is not well understood. Better characterization of underground habitats for bats will assist in a more accurate assessment of habitat suitability, resulting in better protection for bats and reduced costs for the project in the future. It will also improve conservation efforts by enabling managers to choose the most optimum locations for bat protection measures, and inform mitigation and compensation plans.

Information needs include better characterization of habitat (especially hibernation sites) and better understanding of the ecological reasons why a particular site is important (such as how it may function to provide winter drinking water or food, or how adjacency of winter and summer habitats might be important for various bat species). Specific needs are as follows:

1. Document and map locations of mines used by bats (hibernating, summer day/night use, swarming) as these are not currently will characterized for B.C.
2. Characterize suitability of mines as bat habitat from known sites, using information such as type of mine, mine configuration, size, microclimate, air flow and preferences of each bat species.
3. Evaluate availability of mine sites suitable for bat hibernation and determine the proportion of available and suitable mines that are occupied. This information will help determine if habitat is limiting for bats or if there are particular sites that are more important than others. This can help prioritize conservation efforts for bats.
4. Research to roost fidelity, colony sizes, preferred locations, seasonality of use is necessary to help determine the importance of mines as available roosting habitat. Focus should not be on at-risk species alone, as all crevice-using bat species are at risk with the emergence of White-nose Syndrome.
5. Determine whether selection of mines by bats as hibernacula is influenced by other animals including the presence of overwintering insects and bushy-tailed woodrats (*Neotoma cinerea*).
6. Determine critical time periods when mines are used by bats. This may vary depending on location within the province (perhaps by biogeoclimatic zone).

7. Develop standards and evaluate new ‘remote’ research techniques for identifying and monitoring bat species that inhabit mines. Refining techniques can reduce monitoring costs, and the need for internal surveys (safer to personnel and less disturbance to bats).
8. Evaluate the success of bat gate designs to maintain/enhance bat populations and to ensure public safety (see Ludlow and Gore 2000).
9. Evaluate the success of mitigation and compensation techniques such as wetland building, bat boxes provision and construction of artificial hibernacula.
10. Research the feasibility of evicting bat colonies from mines that cannot be gated, and their acceptance of alternate habitat.
11. Survey water bodies near mines to determine if there are water quality problems and assess potential effects on bat populations in BC.

Section 6: Glossary

Acoustic Survey/Echolocation Survey: A method of detecting bats using an ultrasonic bat detector. Detectors may be hand-held ('active surveys') or connected to an electronic system ('passive surveys') for long periods of recording independent of human observation.

Adit: A horizontal mine passage driven from the surface (Thomson 2002).

Bat Detector: Any device used to render the ultrasonic calls of a bat audible to the human ear (Resources Inventory Standards Committee 1998).

Bachelor roost: A roost used by one or more males during the day.

Best management practices: Methods, measures, or practices designed to prevent or reduce the resulting effects of human-related activities or industry. Usually, BMPs are applied as a system of practices rather than a single practice (Dunster and Dunster 1996).

Blind: A mine passage without lateral workings (Thomson 2002).

Cave: A natural cavity in the earth that connects with the surface, contains a zone of at least partial darkness, and is large enough to admit a human. For the purposes of cave management, this term also includes any natural extensions, such as crevices, sinkholes, pits, or any other openings that contribute to the functioning of the cave system (adapted from Resources Information Standards Committee 2003).

Crevice: A narrow crack or opening, or a fissure or a cleft, not large enough to admit a human. In addition to using caves, bats may roost in crevices and other cracks or surface openings within caves, in rocks, in rock outcrops, and on exposed cliff faces (Nagorsen and Brigham 1993; Nagorsen et al. 1993; Lewis 1995).

Day roost: A roost where bats rest during the day in spring/summer/fall. Day-roost types include maternity roosts, bachelor roosts, and mixed male/non-reproductive female/yearling groups. Use of a specific day roost may be seasonal or variable within a season.

Echolocation: An orientation system based on generating sounds and listening to their returning echoes to locate obstacles and prey (Nagorsen and Brigham 1993).

Ephemeral roost: A bat roost in a feature where the characteristics important to bats (e.g., microclimate) may change quickly and/or unpredictably. For example, an area under sloughing tree bark.

Fertilization: The impregnation of the egg by the male sperm cell (Nagorsen and Brigham 1993).

Flyway: Any corridor used by bats commuting between roost and foraging areas. Flyways make excellent sites for capturing bats in mist-nets and harp-traps. Often delimited by physical structures such as vegetation or buildings (Resources Inventory Standards Committee 1998).

Forage: To hunt for food.

Gestation Period: The length of the pregnancy; the time from fertilization until the birth of the foetus (Nagorsen and Brigham 1993).

Gleaner: A bat that can capture prey on the leaves and twigs of vegetation or on the ground (Nagorsen and Brigham 1993).

Goal: Goals provide general purpose and direction. They are the end result of ultimate accomplishment toward which an effort is directed. They generally should reflect perceived present and future need. They must be capable of being effectively pursued (B.C. Ministry of Forests Glossary of Terms). An ideal; a desired endpoint; frequently defined in abstract terms. Goals are qualitative and are achieved by means of objectives (Dunster and Dunster 1996).

Guidelines: A set of recommended or suggested methods or actions that should be followed in most circumstances to assist administrative and planning decisions, and their implementation in the field. Guidelines may consist of policy statements, procedures, or checklists. They are provided as a broad framework of recommended actions to be taken and, therefore, provide some flexibility for decision-making. Note that guidelines cannot, by definition, be mandatory; such actions are prescribed by regulations or rules (Dunster and Dunster 1996).

Harp-trap: A specialized trap designed exclusively for capturing bats (Resources Inventory Standards Committee 1998).

Hibernaculum: A site where one or more bats hibernate in winter (pl. Hibernacula). A specific hibernaculum may be used by bats only part of the winter, and may not be used every winter.

Hibernation: A state of lethargy characterized by a reduction in body temperature and metabolic rate (Nagorsen and Brigham 1993).

Impact assessment: A study of the potential future effects of resource development on other resources and on social, economic and/or environmental conditions (B.C. Ministry of Forests Glossary of Terms).

Inventory: A single enumeration of an ecological system; generally carried either as a basis for estimating potential yield or to establish a benchmark. An inventory may act as one point in time in a monitoring program. Ecological inventories may be more comprehensive and spatially/temporally discrete than monitoring activities (Quayle 2003).

Lactation: The period of milk production by females mammals nursing young (Resources Inventory Standards Committee 1998).

Landscape Unit: An area of land and water used for long-term planning of resource management activities. It is important for designing strategies and patterns for landscape-level biodiversity and for managing other forest resources. A landscape unit may be used by the DM to establish objectives for any purpose permitted under section 2 of the Forest Practices Code of British Columbia Act (MOF and MELP 1999).

Maternity colony: An aggregation of females in spring, summer, or fall. The colony may include pregnant females (may not be visibly pregnant early in the season), lactating females with or without young-of-year, or post-reproductive females. A maternity colony may consist of a group of females within a single maternity roost (e.g., building, cave), or a group of females roosting singly or in small groups in close proximity and maintaining a long-term social relationship, adhering to the fission-fusion model (Metheny et al. 2007; Kerth et al. 2011; e.g., in crevices within a cliff or boulder field, in a forest stand under sloughing bark of trees). A roost used by such a colony is called a maternity roost.

Maternity roost: a roost used outside of the winter period by adult females that are capable of reproduction.

Mitigation: Measures implemented to control, reduce or eliminate a potential adverse impact of a project, including restorative measures (Environmental Assessment Office 2003).

Monitoring: Repeated, systematic measurements done with a specific purpose in mind. Monitoring is focused on measurements over time in order to detect the change toward, or away from, a stated standard or objective. Monitoring is part of the cycle of assessment and evaluation that is linked to management activities (Quayle 2003).

Nocturnal: Active at night.

Night roost: A roost where bats rest at night between foraging bouts. Bats may roost singly or congregate.

Nursery colony: A type of maternity colony containing mainly nursing adults with young (summer), or an aggregation of mainly volant pups (late summer/early fall). A roost used by such a colony is called a nursery roost (C. Lausen, pers. comm.).

Nursery roost: A roost where females congregate to give birth and raise their young (adapted from Knight and Jones 2009). A nursery roost is a type of maternity roost.

Objective: A quantifiable, measurable and defined target, capable of attainment within a defined period of time. Objectives are the means by which goals are achieved and should include four main components: 1. They must state the desired outcome (i.e., what is to be accomplished); 2. They must indicate the time period within which the expected outcome is to be achieved; 3. They must include measurement factors, such as quantity, quality, or cost, so that the fulfilment of the objective can be verified; 4. They must indicate who is responsible for achieving the indicated result. Desirable (but not absolutely essential) elements of objectives are a description of how they will be achieved and an indication of who will determine whether the results have been achieved. Objectives are typically narrower and shorter in range than goals, and serve as milestones toward goal achievement (Dunster and Dunster 1996).

Ovulation: Maturation and release of the egg before fertilization.

Parturition: Birth.

Permanent roost: A roost that is available for bat use over many years and has suitable characteristics (e.g., microclimate, access) that remain stable over time. Examples of permanent roosts include caves, cliffs, mines, bridges, buildings, and large hollow trees of a slow-decaying species such as western redcedar (*Thuja plicata*).

Portal: The entrance to an adit or tunnel (Thomson 2002).

Pup: A bat born during the current year.

Rehabilitation: The restoration of ecosystem functions and processes in a degraded system or habitat (Dunster and Dunster 1996).

Reporting: The process of effectively communicating the results of monitoring and their potential implications to a target audience (Quayle 2003).

Roost: A daytime retreat or night-time resting place.

Shaft: A vertical mine opening from the surface (Thomson 2002) may also apply to cave systems.

Significant bat roost:

- Any hibernaculum or swarming site;
- A roost used by a nursery colony of a Red- or Blue-listed species (any number of individuals), or a nursery roost used by more than six females of other species (can include mixed species groups);
- a roost used by a maternity colony of Red- or Blue-listed species (any number of bats), or a maternity roost used by more than four females of other species (can include mixed species groups);
- Any permanent-type day roost used by a male or a non-reproductive female of a Red- or Blue-listed species, or > 10 males/non-reproductive females/juveniles of other species (can include mixed species groups);
- Any night roost used by a Red- or Blue-listed species or > 10 bats of other species (can include mixed species groups);
- Any regularly-used roost of a species listed under Schedule 1 of SARA (any number of individuals); or,
- Any roost deemed significant by an experienced bat biologist.

Standard: Quantifiable and measurable thresholds that are typically defined in law or regulation, and are mandatory. A statement that outlines how well something should be done, rather than how it should be done. A standard does not necessarily imply fairness or equity, nor an absolute knowledge of cause-and-effect linkages. Standards are typically established using a combination of best available scientific knowledge, tempered by cautious use of an established safety (caution) factor (Dunster and Dunster 1996).

Stewardship: Caring for the land and associated resources so that healthy ecosystems can be passed on to future generations (Dunster and Dunster 1996).

Swarming: Behaviour associated with nocturnal flights that are made through potential hibernacula by aggregations of bats in late summer or fall (Nagorsen and Brigham 1993).

Torpor: A short-term (daily) state of inactivity achieved by lowering the body temperature and reducing the metabolic rate in order to conserve energy (Nagorsen and Brigham 1993).

Tunnel: A horizontal mine passage that is open at both ends (Thomson 2002).

Volant: Capable of flying.

Winze: A mine opening sunk downward from inside to connect lower levels or explore areas beneath a level (Thomson 2002).

Yearling: A bat born in the previous reproductive year.

Young-of-year: A bat born during the current reproductive year.

Section 7: Additional Information

Links to additional information

- BC BAT Fact Sheet on White-nose Syndrome
- Regions of British Columbia
- The Karst Inventory Standards and Vulnerability Assessment Procedures for British Columbia
- Karst Management Handbook for British Columbia
- Copies of all official legislation for the province of British Columbia is available online
- Ministry of Environment Guidelines and Best Management Practices for environmental stewardship

Additional Information on Bats

- The British Columbia Species and Ecosystems Explorer has information on all the species of bats in the province
- The British Columbia Bat Action Team (BCBAT) is a bat conservation group consisting of bat researchers, university students and professors that work on bats, wildlife consultants and government biologists.
- The Community Bat Programs of British Columbia help homeowners with bats and provides opportunity for property owners to be involved in bat research. An excellent resource when managing bats in buildings.
- Bat Conservation International has information about bat species, bat gating, and bat houses
- For the latest information on White-nose Syndrome, see the Canadian Wildlife Health Cooperative as well as British Columbia Ministry of Environment's Wildlife Health website. The U.S. Fish and Wildlife Service also provides the latest information on the spread of White-nose Syndrome across North America as well as up-to-date information on White-nose Syndrome research.

Section 8: References

Adams, R.A., and M.A. Hayes. 2008. Water availability and successful lactation by bats as related to climate change in arid regions of western North America. Journal of Animal Ecology 77:1115-1121.

Aldridge, H.D.J.N., and R.M. Brigham. 1988. Load carrying and maneuverability in an insectivorous bat: a test of the 5% "rule" of radio-telemetry. Journal of Mammalogy 69:379-382.

Altenbach, S. 1998. Abandoned mines as bat habitat. Cultural Resource Management 21:46-48.

Altenbach J.S., and E.D. Pierson. 1995. The importance of mines to bats: an overview. *In* B.R. Riddle, ed. Inactive mines as bat habitat: guidelines of research, survey, monitoring and mine management in Nevada. Biological Resources Research Center, University of Nevada, Reno, NV.

Altenbach, J.S., R. Sherwin, and P. Brown. 2000. Pre-mine closure bat survey and inventory techniques. *In* K.C. Vories and D. Throgmorton, eds. Proceedings of Bat Conservation and Mining: A technical interactive forum, St. Louis, Missouri. U.S. Dept. Interior, Office of Surface and Mining, Alton, IL, and Coal Research Center, Southern Illinois University, Carbondale, IL. 12pp.

Barclay, R.M.R. 1985. Long-versus short-range foraging strategies of hoary (*Lasiurus cinereus*) and silver-haired (*Lasionycteris noctivagans*) bats and the consequences for prey selection. Canadian Journal of Zoology 63:2507-2515.

Barclay, R.M.R., M.B. Fenton and D.W. Thomas. 1979. Social behaviour of the little brown bat, *Myotis lucifugus*. Behavioural Ecology & Sociobiology 6(2):137-146.

Bat Conservation International. 2000. B.C.I Highlights: A brief review of some of B.C.I's accomplishments in the last six months… BATS 18(4):14-15.

Bat Conservation International. 2003. Bats and Mines: Industry Partners. "Mining for habitat."

Barclay, R.M.R., and A. Kurta. 2007. Ecology and behavior of bats roosting in tree cavities and under bark. Chapter 2. Pp. 17-59 *in* M.J. Lacki, J.P. Hayes and A. Kurta, eds. Bats in Forests: Conservation and Management. John Hopkins University Press. 329pp.

BCI 2014. Bat Conservation International: Resources, Species Profiles. [Accessed September 2014, http://batcon.org/]

B.C. Ministry of Environment. 2012. Procedures for mitigating impacts on environmental values (environmental mitigation procedures). Final working draft. Available here

B.C. Ministry of Environment. 2014a. Addressing cumulative effects in natural resource decision making: a framework for success. February. 2014. Available here.

B.C. Ministry of Environment. 2014b. Environmental Mitigation Policy latest update. May 2014. Available here.

B.C. Ministry of Forests. 2003. Karst management handbook for British Columbia. B.C. Ministry of Forests, Victoria BC. http://www.for.gov.bc.ca/hfp/fordev/karst/Karst-Final-Aug1-web.pdf

B.C. Ministry of Forests. 2008. Glossary of forestry terms in British Columbia. Available here. http://www.for.gov.bc.ca/hfd/library/documents/glossary/

BIMP (Bats/Inactive Mines Project). 2002. Bats/Inactive Mines Project. Colorado Department of Natural Resources, Division of Wildlife. http://wildlife.state.co.us/Education/TeacherResources/ColoradoWildlifeCompany/DOWCWCSpr1996.htm [accessed May 2007]

Blehert, D.S., A.C. Hicks, M. Behr, C.U. Meteyer, B.M. Berlowski-Zier, E.L. Buckles, J.T.H. Coleman, S.R. Darling, A. Gargas, R. Niver, J.C. Okoniewski, R.J. Rudd, and W.B. Stone. 2009. Bat White-Nose Syndrome: An emerging fungal pathogen? Science 323(5911):227.

Bogan, M.A. 2000. Western bats and mining. *In* K.C. Vories and D. Throgmorton, eds. Proceedings of Bat Conservation and Mining: A technical interactive forum, St. Louis, Missouri. U.S. Dept. Interior, Office of Surface and Mining, Alton, IL, and Coal Research Center, Southern Illinois University, Carbondale, IL. 12pp. http://www.mcrcc.osmre.gov/Bats/Default.htm [accessed March 2007]

Brigham, R.M. 1995. Riparian habitat and its importance for roosting and foraging by insectivorous bats. Pp. 57-72 *in* K. H. Morgan and M. A. Lashmar, eds. Riparian Habitat Management and Research: A special publication of the Fraser River Action Plan. Proceedings of a workshop sponsored by Environment Canada, and the B.C. Forestry Continuing Studies Network, held in Kamloops, B.C. 4-5 May 1993. Environment Canada – Canadian Wildlife Service.

Brown, P.E., J.S. Altenbach and R.E. Sherwin. 2000. Evicting bats when gates won't work: unstable mines and renewed mining. *In* K.C. Vories and D. Throgmorton, eds. Proceedings of Bat Conservation and Mining: A technical interactive forum, St. Louis, Missouri. U.S. Dept. Interior, Office of Surface and Mining, Alton, IL, and Coal Research Center, Southern Illinois University, Carbondale, IL. 8pp.

Brown, P.E., and R.D. Berry. 1997. Renewed mining and reclamation: Impacts on bats and potential mitigation. National Meeting of the American Society for Mining and Reclamation, Austin, Texas, May 10-17, 1997. Pp. 196-201.

Bryant, A.A. 1987. A reconnaissance of potential bat hibernacula in the southern Okanagan Valley, British Columbia. Prepared for the World Wildlife Fund (Canada), B.C. Ministry of Environment, Lands and Parks, Victoria, and the Federation of B.C. Naturalists. 17pp.

Burghardt, J.E. 2000. Bat-compatible closures of abandoned underground mines in National Park system units. *In* K.C. Vories and D. Throgmorton, eds. Proceedings of Bat Conservation and Mining: A technical interactive forum, St. Louis, Missouri. U.S. Dept. Interior, Office of Surface and

Mining, Alton, IL, and Coal Research Center, Southern Illinois University, Carbondale, IL.

Carter, T.C., and J.M Menzel. 2007. Behavior and day-roosting ecology of North American foliage-roosting bats. Chapter 3. Pp. 61-81 *in* Bats in forests: conservation and management. Johns Hopkins University Press, Baltimore, MD, USA.

Chatwin, T.A. 2004. Keen's Long-eared Myotis, *Myotis keenii*. Accounts and Measures for Managing Identified Wildlife – Accounts V. 2004. 7pp. PDF

Cope, J.B., and S.R. Humphrey. 1977. Spring and summer swarming behavior of the Indiana bat, *Myotis sodalis*. Journal of Mammalogy 58: 93-95.

COSEWIC. 2012. Emergency assessment concludes that three bat species are endangered in Canada. http://www.cosewic.gc.ca/eng/sct7/Bat_Emergency_Assessment_Press_Release_e.cfm

Craig, V.J. 2003. British Columbia status report on Townsend's big-eared bat, *Corynorhinus townsendii*. Draft report. Prepared for B.C. Ministry of Water, Land and Air Protection. 45pp.

Craig, V.J., and S.L. Holroyd. 2004. Bat Conservation Strategy for B.C. and Alberta. Draft. Prepared for B.C. Ministry of Water, Land and Air Protection, Victoria, BC. 112pp.

Craig, J., and M. Sarell. 2012. Bats in buildings: Roost conservation and enhancement. P. 23-26. In: Urban Wildlife: Challenges and Management. Columbia Mountains Institute of Applied Ecology, April 2012, Cranbrook, BC. 142pp. PDF

Crampton, L. H., and R. M. Barclay. 1998. Selection of roosting and foraging habitat by bats in different-aged mixedwood stands. Conservation Biology 12:1347-1358.

Cryan, P. 2003. Seasonal Distribution of Migratory Tree Bats (*Lasiurus* and *Lasionycteris*) in North America. Journal of Mammalogy, 84(2):579–593 also listed as USGS Staff Published Research: Paper 119. Found at [http://digitalcommons.unl.edu/usgsstaffpub/119] accessed October 2012

Currie, R. 2000. An overview of the response of bats to protection efforts. 14pp. *In* K. C. Vories and D. Throgmorton, eds. Proceedings of Bat Conservation and Mining: A technical interactive forum, St. Louis, Missouri. U.S. Dept. Interior, Office of Surface and Mining, Alton, IL, and Coal Research Center, Southern Illinois University, Carbondale, IL.

Dalton, D.C., and V.M. Dalton. 1995. Closure methods including a recommended gate design. Pp. 130-135 *in* R. Riddle, eds. Inactive mines as bat habitat: guidelines for research, survey, monitoring and mine management in Nevada. Biological Resources Research Center, University of Nevada, Reno, NV.

Davis, M., A. Vandenburg, T. Chatwin, and M. Mather. 1999. Bat usage of cave systems on northern Vancouver Island. Unpublished report prepared for the Ministry of Environment, Lands and Parks, Nanaimo, B.C. Presented at the Species and Habitats at Risk Conference, February,

1999, Kamloops, BC.
[http://pacificcoast.net/~iskar/Update99/Bats1998.html]

Delaney, D.K. 2002. Prioritization of Threatened and Endangered Species Sound Research on Army Installations. U.S. Army Corps of Engineers, Engineer Research and Development Center and the Construction Engineering Research Laboratory (ERDC/CERL TR-02-30). 78pp.

Dillingham, C.P., S.P. Cross and P.W. Dillingham. 2003. Two environmental factors that influence usage of bat houses in managed forests of southwestern Oregon. Northwestern Naturalist 84:20-23.

Doucett, R.R., Broders, H.G., Quinn, G., and G.J. Forbes. 2002. Those vain aerial ways: determining the relative importance of aquatic and terrestrial insects in the diets of bats. Presentation to the 3rd International Conference on Applications of Stable Isotope Techniques, April 29-May 1, 2002. Flagstaff, Arizona, USA.

Ducummon, S.L. 1999. The North American bats and mines project: A cooperative approach for integrating bat conservation and mine-land reclamation. Proceedings of the 23rd Annual British Columbia Mine Reclamation Symposium, Kamloops, B.C. The Technical and Research Committee on Reclamation. Pp. 10-21.

Dunster, J., and K. Dunster 1996. Natural Resource Management Dictionary. University of B.C. Vancouver, BC. 380pp.

EMNG 2014. MINFILE Mineral Inventory. British Columbia Ministry of Energy and Mines [accessed September 2014: http://www.empr.gov.bc.ca/mining/geoscience/minfile/pages/default.aspx].

Environmental Assessment Office. 2003. Guide to the British Columbia environmental assessment process. March 2003.

Environmental Assessment Office. 2013*a*. Guideline for the selection of valued components and assessment of potential effects. Available here

Environmental Assessment Office. 2013*b*. Project information centre. Available here.

Environment Canada. 2014. Little Brown Myotis, Northern Myotis and Tri-coloured Bat. [accessed December 2015: http://www.registrelep-sararegistry.gc.ca/virtual_sara/files/gen_info/fs_chauvesouris_bats_gen-v03_0215_e.pdf]

Estrada, A., and R. Coates-Estrada. 2001. Bat species richness in live fences and in corridors of residual rain forest vegetation at Los Tuxtlas, Mexico. Ecography 24:94–102.

Fant, J., J. Kennedy, R. Powers Jr., and W. Elliot. 2009. Agency guide to cave and mine gates. Sponsered by the American Cave Conservation Society, Bat Conservation International, and the Missouri Department of Conservation. 29pp. Accessed March 2013 PDF

Fenton, M.B. 1969. Summer activity of *Myotis lucifugus* (Chiroptera: Vespertilionidae) at hibernacula in Ontario and Quebec. Canadian Journal of Zoology 47:597-602.

Fenton, M.B., and R.M.R. Barclay. 1980. *Myotis lucifugus*. Mammalian Species 142:1-8.

Findley, J.S. 1995. Bats: A community perspective. Cambridge University Press. 179pp.

Firman, M.C., C. Godwin and R.M.R. Barclay. 1995. Bat fauna survey of the west Shuswap and South Thompson River Region, B.C. Report for the Wildlife Branch, Ministry of Environment, Lands and Parks, Victoria, BC.

Gargas, A., M.T. Trest, M. Christensen, T.J. Volk, and D.S. Blehert. 2009. Geomyces destructans sp. nov. associated with bat white-nose syndrome. Mycotaxon 108:147-154.

Grandison, K. 2000. Monitoring and evaluating results of bat protection efforts. *In* K.C. Vories, and D. Throgmorton, eds. Proceedings of Bat Conservation and Mining: A technical interactive forum, St. Louis, Missouri. U.S. Dept. Interior, Office of Surface and Mining, Alton, IL, and Coal Research Center, Southern Illinois University, Carbondale, IL. 1pp.

Grindal, S.D., T.S. Collard, R.M. Brigham and R.M.R. Barclay. 1992. The influence of precipitation on reproduction by Myotis bats in British Columbia. American Midland Naturalist 128:339-344.

Henderson, L.E., and H.G. Broders. 2008. Movements and resource selection of northern long-eared myotis (*Myotis septentrionalis*) in a forest-agriculture landscape. Journal of Mammalogy 89:952-963 PDF

Hill, T., A. Reid, R. Clarke, and J. Gwilliam. 2005. West Kootenay Townsend's Big-eared Bat Progress Report. Prepared for the Columbia Basin Fish and Wildlife Compensation Program, Nelson, BC, and FortisBC. 27pp.

Hill, T., A. Reid, R. Clarke, and J. Gwilliam. 2006. West Kootenay Townsend's Big-eared Bat Progress Report. Prepared for the Columbia Basin Fish and Wildlife Compensation Program, Nelson, BC., and FortisBC. DRAFT.

Holloway, G.L., and R.M.R. Barclay. 2001. *Myotis ciliolabrum*. Mammalian Species Account 670:1-5.

Holroyd, S.L. 1993. Influences of some extrinsic and intrinsic factors on reproduction by big brown bats (*Eptesicus fuscus*) in southeastern Alberta. M. Sc. thesis, University of Calgary, Calgary, AB. 126pp.

Humphrey, S.R. 1975. Nursery roosts and community diversity of Nearctic bats. Journal of Mammalogy, 56:321-346.

Ihlo, C.M. 2013. Predicting the spread of white-nose syndrome in bats: a strategy for prioritizing resources. M.E.M. Nicholas School of the Environment, Duke University, Durham, NC, U.S.A. 38pp.

Kellner, M., and S. Rasheed. 2002. Campbell River Bat Project: Inventory and habitat enhancement. Prepared for B.C. Hydro Bridge-Coastal Fish and Wildlife Restoration Program, Burnaby, BC. 63pp.

Kerth, G., N. Perony, and F. Schweitzer. 2011. Bats are able to maintain long-term social relationships despite the high fission-fusion dynamics of their groups.

Knight, T., and G. Jones. 2009. Importance of night roosts for bat conservation: roosting behaviour of the lesser horseshoe bat *Rhinolophus hipposideros*. Endang. Species Res. 8:79-96.

Kunz, T.H. 2003. Censusing bats: challenges, solutions and sampling biases. *In* T.J. O'Shea and M.A. Bogan, eds. 2003. Monitoring trends in bat populations of the United States and territories: problems and prospects. U.S. Geological Survey, Biological Resources Discipline, Information and Technology Report. USGS/BRD/ITR-2003-0003. 274pp.

Kunz, T.H. 2009. Event: Joint Oversight Hearing On "White-Nose Syndrome: What's Killing Bats In The Northeast?" U.S. Committee on Natural Resources. June 2009. Presentation to the Committee.

Kunz, T.H., Thomas, D.W., Richards, G.C., Tidemann, C.R., Pierson, E.D., and Racey, P.A. 1996. Observational techniques for bats. *In* D.E. Wilson, F.R Cole, J.D. Nichols, R. Rudran, and M.S. Foster, eds. Measuring and Monitoring Biological Diversity: Standard Methods for Mammals. Smithsonian Institution Press, Washington. Pp. 105-114.

Lacki, M.J., J.P. Hayes, and A. Kurta. 2007. Bats in Forests: Conservation and Management. John Hopkins University Press, Baltimore, MD, USA. 329pp.

Lausen, C.L., and R.M.R. Barclay. 2006. Winter bat activity in the Canadian prairies. Canadian Journal of Zoology 84:1079-1086.

Lewis, S.E. 1995. Roost fidelity of bats: a review. *Journal of Mammalogy* 76:481-496.

Ludlow, M.E., and J.A. Gore. 2000. Effects of cave gate on emergence patterns of colonial bats. Wildlife Society Bulletin 28:191-196.

Mackasey, W.O. 2000. Abandoned mines in Canada. Prepared for MiningWatch Canada by WOM Geological Associates, Sudbury, Ontario. 14pp. PDF Source: http://www.miningwatch.ca/

Maser, C., R.G. Anderson, K. Cromack Jr., J.T. Williams and R.E. Martin. 1979. Dead and down woody material. Pp. 78-95 *in* J.W. Thomas, tech. ed. Wildlife habitats in managed forests: the Blue Mountains of Oregon and Washington. USDA Forest Service Agricultural Handbook No. 553.

MEMPR (Ministry of Energy, Mines and Petroleum Resources). 2007. Webpage accessed May 2007. (http://www.em.gov.bc.ca/Subwebs/mining/History/default.htm).

Metheny, J.D., M.C. Kalcounis-Ruppell, K. Kolar, C.K.R. Willis, and R.M. Brigham. 2007. Genetic relationships of roost-mates in a fission-fusion society of tree-roosting big brown bats. Behav. Ecol. and Sociobiol. 62:1043-1051.

MFLNRO (B.C. Ministry of Forests, Lands and Natural Resources). 2014. A Compendium of Wildlife Guidelines for Industrial Development Projects in the North Area, British Columbia. Interim Guidance. 212pp.

Milford, H.E. 2000. Bat conservation in mine reclamation in eleven western states and the western interstate energy board perspective on habitat preservation. *In* K.C. Vories and D. Throgmorton, eds. Proceedings of Bat Conservation and Mining: A technical interactive forum, St. Louis, Missouri. U.S. Dept. Interior, Office of Surface and Mining, Alton, IL, and Coal Research Center, Southern Illinois University, Carbondale, IL. 6pp. http://www.mcrcc.osmre.gov/Bats/Default.htm [accessed March 2007]

Miner, K.L., and D.C. Stoker. 2005. Bats in the South Coast Ecoregion: status, conservation issues and research needs. USDA Forest Service General Technical Report, PSW-GTR-195. Pp. 211-227.

Minnis, A. M., and D.L. Lindner. 2013. Phylogenetic evaluation of *Geomyces* and allies reveals no close relatives of *Pseudogymnoascus destructans*, comb. nov., in bat hibernacula of eastern North America. Fungal biology 117:638-648.

B.C. Wildlife Health Program. 2016. Ministry of Environment and Ministry of Forests, Lands and Natural Resource Operations, British Columbia. [Accessed March 2016: http://www2.gov.bc.ca/gov/content/environment/plants-animals-ecosystems/wildlife/wildlife-health/wildlife-diseases/white-nose-syndrome].

MOF and MELP. 1999. Landscape Unit Planning Guide. British Columbia Ministry of Forests and Ministry of Environment, Lands and Parks, Victoria, British Columbia.

Nagorsen, D.W. 2009. Campbell River Bat Project: Bat House Mitigations. Bridge Coastal Fish and Wildlife Restoration Project #06.W.CBR.03 Prepared for: BC Hydro Bridge Coastal Fish and Wildlife Restoration Program Burnaby, BC. 24pp. PDF

Nagorsen, D.W., and R.M. Brigham. 1993. Bats of British Columbia. Royal British Columbia Museum Handbook. Vol.1. The Mammals of British Columbia. UB.C. Press, Vancouver. 164pp.

Nagorsen, D.W., Bryant, A.A., Kerridge, D., Roberts, G., Roberts, A., and M.J. Sarell. 1993. Winter bat records for British Columbia. Northwest Naturalist 74(3):61-66.

Navo, K.W., and P. Krabacher. 2002. Bat Ladder Gates. *In* K.C. Vorie, and D. Throgmorton, eds. Proceedings of Bat Gate Design: A Technical Interactive Forum. March 4-6, 2002. Austin, Texas. Southern Illinois University at Carbondale.

Nieland, J. 2000. Policies, management, and monitoring: protection of habitat using bat gates. *In* K.C. Vorie, and D. Throgmorton, eds. Proceedings of Bat Conservation and Mining: A technical interactive forum, St. Louis, Missouri. U.S. Dept. Interior, Office of Surface and Mining, Alton, IL, and Coal Research Center, Southern Illinois University, Carbondale, IL http://www.mcrcc.osmre.gov/Bats/Default.htm [accessed June 2007]

Norman, D.K. 2000. Washington's Inactive and Abandoned Metal Mine Inventory and Database. Washington Geology 28(1/2):16-18.

Noteman, L. 1998. Hidden housing – artificial bark for bats. BATS Magazine 16. No. 3.

Ontario Ministry of Natural Resources (MNR). 2013. Wildlife Management. Bats and White-nose syndrome. [http://www.mnr.gov.on.ca/en/Business/FW/2ColumnSubPage/278166.html accessed March 2014].

Perlmeter, S. 1996. Bats and Bridges: Patterns of night roost activity in the Willamette National Forest. Pp. 132-151 *in* R.M.R. Barclay and R.M. Brigham, eds. Bats and Forests Symposium. October 19-21, 1995, Victoria, B.C. Canada. Research Branch, British Columbia Ministry of Forests, Victoria BC. Working Paper 23/96.

Pierson, E.D., M.C. Wackenhut, J.S. Altenbach, P. Bradley, P. Call, D.L. Genter, C.E. Harris, B.L. Keller, B. Lengus, L. Lewis, B. Luce, K.W. Navo, J.M. Perkins, S. Smith, and L. Welch. 1999. Species conservation assessment and strategy for Townsend's big-eared bat (*Corynorhinus townsendii townsendii* and *Corynorhinus townsendii pallescens*). Idaho Conservation Effort, Idaho Department of Fish and Game, Boise, ID. 68pp.

Quayle, J. 2003. Glossary of Monitoring Terms.

Quebec Ministère des Ressources naturelles et de la Faune (MNRF). 2010. White-nose syndrome in bat populations. The presence of the syndrome is confirmed in Quebec. Press Release. 2pp. [http://www.batcon.org/pdfs/whitenose/QuebecWNSPressRelease.pdf – accessed March 2014].

Racey, P.A., and A.C. Entwistle. 2003. Conservation Ecology of Bats. Chapter 15. Pp. 680-743 *in* T.H. Kunz and M.B. Fenton, eds. Bat Ecology. University of Chicago Press. 779pp.

RISC (Resources Inventory Standards Committee). 1998. Inventory Methods for Bats. Standards for Components of British Columbia's Biodiversity No. 20. Version 2.0. Prepared by B.C. Ministry of Environment, Lands and Parks, Resources Inventory Branch for the Terrestrial Ecosystems Task Force, Resources Inventory Committee. Original version prepared by P.F.J. Garcia and R.M.R. Barclay. 58pp. PDF

Resources Inventory Standards Committee. 2003. Karst inventory standards and vulnerability assessment procedures for British Columbia. Version 2.0. Prepared by B.C. Ministry of Forests Research Branch for the Karst Task Force, Resources Inventory Standards Committee.123pp.

Sarell, M. 2004a. Spotted Bat, *Euderma maculatum*. Accounts and Measures for Managing Identified Wildlife – Accounts V. 2004. 7pp. PDF

Sarell, M. 2004b. Fringed Myotis, *Myotis thysanodes*. Accounts and Measures for Managing Identified Wildlife – Accounts V. 2004. 7pp. PDF

Sherwin, R.E., J.S. Altenbach, and D.L. Waldien. 2009. Managing abandoned mines for bats. Bat Conservation International Inc., Austin, TX. 107pp.

Speakman, J.R., D.J. Bullock, L.A. Eales, and P.A. Racey. 1992. A problem defining temporal pattern in animal behaviour: clustering in the emergence behaviour of bats from maternity roosts. Animal Behaviour 43:491-500.

Thomas, D.W. 1995. Hibernating bats are sensitive to nontactile human disturbance. Journal of Mammalogy 76:940-946.

Thomas, D.W., and D. Cloutier. 1992. Evaporative water loss by hibernating little brown bats, *Myotis lucifugus*. Physiological Zoology 65:443-456.

Thomas, D.W., M. Dorais, and J-M, Bergeron. 1990. Winter energy budgets and cost of arousals for hibernating little brown bats *Myotis lucifugus*. Journal of Mammalogy 71(3):475-479.

Thomson, B. 2002. Australian Handbook for the Conservation of Bats in Mines and Artificial Cave-bat Habitats. Australian Centre for Mining Environmental Research, Melbourne, Australia. 65pp.

Tuttle, M.D., and D.A.R. Taylor. 1998. Bats and mines (revised edition). Bat Conservation International, Resource Publication No. 3.

USDA Forest Service. 2012. Forest Service Extends Closure of Mines and Caves as New Studies Indicate 5.5 Million Bats Have Died: Closure seeks to protect bat species from White-Nose Syndrome. News Release 1 Aug 2012, U.S. Forest Service, Rocky Mountain Forest Region, Golden, Colorado. http://www.whitenosesyndrome.org/news/forest-service-extends-closure-abandoned-mines-and-caves-new-studies-indicate-55-million-bats

U.S.F.W.S. 2009. Range-wide Indiana Bat Protection and Enhancement Plan Guidelines. Joint publication of the U.S. Fish and Wildlife Service, the Interstate Mining Compact Commission, and the Department of the Interior Office of Surface Mining. 37pp.

Vonhof, M.J. 1996a. A comparison of the roost-site preferences of big brown bats (*Eptesicus fuscus*) and silver-haired bats (*Lasionycteris noctivagans*) in the Pend d'Oreille Valley in southern British Columbia. Pp. 62-80 *in* R.M.R. Barclay and R.M. Brigham, eds. Bats and Forests Symposium. October 19-21, Victoria, BC.

West Virginia Department of Environmental Protection Office of Explosives and Blasting (WVDEPOEB). 2006. Report of the Potential Effects of Surface Mine Blasts on Bat Hibernaculum. [http://www.mcrcc.osmre.gov/MCR/Resources/bats/pdf/2006_WV_OEB_Bats_Blasting.pdf] report accessed September 2012.

Wilkinson, L.C., and R.M.R. Barclay. 1997. Differences in the foraging behaviour of male and female big brown bats (*Eptesicus fuscus*) during the reproductive period. *Ecoscience*, 4:279-285.

Personal communication

Dr. Cori Lausen, bat specialist, Wildlife Conservation Society of Canada, Birchdale Ecological Ltd. PO Box 606, Kaslo, BC V0G 1M0. corilausen@birchdalebc.ca

Kirk Hancock, British Columbia Ministry of EMNG, MapPlace Resource Geoscientist

Gwyneth Cathyl-Bickford, Westwater Mining Ltd., Cumberland, BC.

Martin Davis, Vice President, Canadian Cave Conservancy, Tahsis, BC, V0P 1X0.

Appendix A

Table 1. Summary of best management process for opening or closing mine sites.

New Mine or Re-opening a mine; Closing a Recently Active or Inactive Mine					
Step One: Above Ground Assessment	1. Species distribution maps; generate list of possible species present. 2. Any known locations of bat roosts or bat inventory. 3. BEC zones within development area. 4. Highlight cliff areas and rock complexes; mine locations and caves. 5. Highlight water sources (wetlands, pools, riparian areas). 6. Highlight older age class forest. 7. Highlight GEMS (old, long-standing forest elements such as western red cedar).				
Step Two:	IF	THEN	AND	AND	AND
	Find a) caves or b) mines suitable for hibernation.	Require a description and mapping of the habitat element. Require a below ground assessment (upon determination by an experienced bat biologist).	Surveys	Planning: Significant roost (establish protective buffers; timing windows; acceptable activities)	Avoidance and/or Mitigation: bat-gating, signage, or other protective measure
	Find c) rock complex or d) cliff habitat suitable for summer roosting (especially within the species range of a Red/Blue-listed species and within a BEC zone associated with that species).	Require description and mapping of habitat element.	Surveys	Planning: Significant roost (establish protective buffers; timing windows; acceptable activities)	Avoidance and/or Mitigation
	Find e) old-growth forest habitat (especially within the species range of a Red/Blue-listed species and within a BEC zone associated with that species).	Require description and mapping of the extent of the habitat element.	Surveys	Planning: Establish protection for roost areas and green tree recruitment.	Avoidance and/or Mitigation
	f) GEM (such as dead standing, hollow western red cedar).	Require mapping of habitat element.	Protective measure for this habitat element.	Planning: Protect element on landscape where possible.	Avoidance