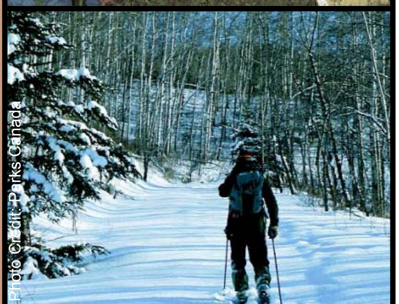
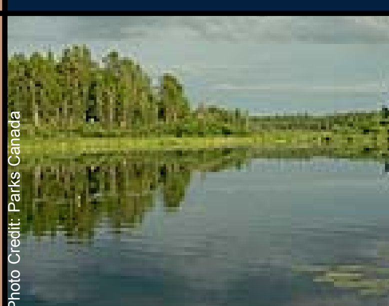


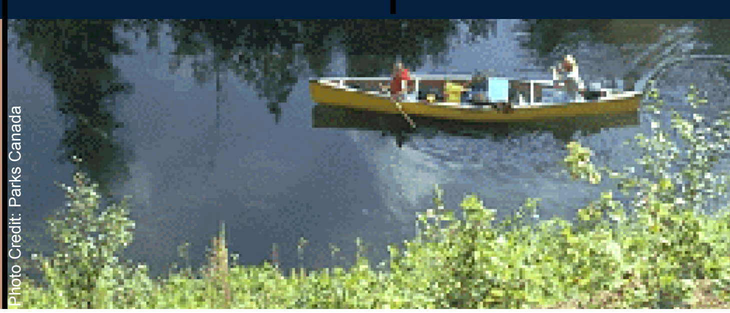
ASSESSMENT OF ENVIRONMENTAL AND HUMAN HEALTH EFFECTS FROM PROPOSED APPLICATION OF FORAY 48B IN WASKESIU, PRINCE ALBERT NATIONAL PARK OF CANADA

PREPARED FOR
PARKS CANADA WESTERN Canada Service Centre
CALGARY, ALBERTA



PREPARED BY

AXYS ENVIRONMENTAL CONSULTING LTD.
IN ASSOCIATION WITH
CANTOX ENVIRONMENTAL LTD. AND
NORTH/SOUTH CONSULTING INC.



April 2003
DS1069

AXYS

Assessment of Environmental and Human Health Effects from Proposed Application of Foray 48B in Waskesiu, Prince Albert National Park of Canada

Prepared for:
Parks Canada
Western Canada Service Centre
Calgary, AB

Prepared by:
AXYS Environmental Consulting Ltd.
Calgary, AB

In Association with:
Cantox Environmental Ltd.
North/South Consultants Inc.

April 2003

Acknowledgements

Alex Kolesch .... Project Manager
Bart Koppe .... Senior Advisor, Human Health
Candi Bezte and Craig Fazakas .... Aquatics and Water Quality
Christine McFarland .... Wildlife Health
Cindy Hubick .... Editing Technician
Erica Myles .... Human Health
Hollis McGrath .... Soils and Landforms, Climate and Air Quality
Kirk Strom .... Technical Lead
Lindsay Sachro .... Wildlife and Spruce Budworm Background
Lyn Turnbull .... Graphics
Patricia Stooke .... Editor
Tyler Colberg .... Vegetation

Overview of Findings

Parks Canada is considering a proposal by the Waskesiu Community Association to control a spruce budworm outbreak in the community of Waskesiu in Prince Albert National Park of Canada (PANP).

The proposal contains the recommendation for aerial application of Foray 48B (which contains the bacterium *Bacillus thuringiensis* subsp. k*urstaki* [Btk]) within Waskesiu townsite boundaries to control and reduce defoliating effects of the larval stage of spruce budworm. Parks Canada made a policy decision to consider the use of Foray 48B as a vegetation management option within the community. The spray program requires an environmental assessment pursuant to the Canadian Environmental Assessment Act. AXYS Environmental Consulting Ltd. was retained to prepare this environmental assessment.

The objective of the environmental assessment was a literature based review of the potential effects of Btk on ecosystem components and human health in the Waskesiu townsite area and, where warranted, the potential effects of the townsite spray program on PANP as a whole. Ecosystem components included atmosphere, soils, vegetation, wildlife and non-target terrestrial insects, water quality and aquatic organisms.

Human Health

Btk is not considered to be a human health hazard by Canada, the United States and the World Health Organization. There have been no documented cases of potential toxicity or endocrine disruption to humans or mammals in the many years of its use in Canada and in other countries. Btk exerts its toxic effects on Lepidoptera (butterflies and moths) by bindings to specific receptor sites only present on the membrane of the insect gut. There are no known similar sites in the gut of mammalian species (including humans).

In its registration of Btk, Health Canada is required to examine and review oral, inhalation, dermal, and ocular exposure animal studies on Btk. No evidence of any poisonous, infectious, or disease-causing effects was found. Scientists at the United States Environmental Protection Agency have found similar results. In a comparative review of the mammalian toxicity of Bt-based pesticides, no toxic or pathogenic effects were found.

Potential pathways of human exposure to Btk include inhalation, oral, dermal (skin) and ocular (eye) exposure. There is no evidence in the scientific literature or from surveillance programs reviewed that Btk is a human pathogen and has caused disease or illness in any population. There are therefore no human health impacts predicted from any of the exposure pathways assessed.

Wildlife

Btk application will result in direct mortality of non-target Lepidoptera. This effect is considered acceptable within the strategic goals and management direction for PANP and within the mandate of PANP to maintain ecological integrity because effects are considered short-term, localized and reversible through immigration of Lepidoptera following completion of the spray program. Btk application may result in a change in bird and small mammal populations, resulting from a decrease in availability of prey base (i.e., spruce budworm larvae). However, due to the small area (529 ha or less) of application within the national park, this impact is predicted to be small and short-lived. Predator species may switch prey or forage in adjacent non-affected areas.

Vegetation

Btk is not expected to have direct negative effects on vegetation. Longevity of Btk on foliage varies widely but generally lasts several days. Indirect impacts on vegetation, such as wide-ranging alteration of the disturbance regime in spruce-dominated forest and mortality of non target Lepidoptera that are required for pollination of some plant species are not expected to be significant. This conclusion was arrived at after considering the small scale of the treatment area (0.1 percent of Prince Albert National Park) and the mobility or immigration potential of winged Lepidoptera.

Soils and Landforms

There is uncertainty as to whether Btk will impact non-target soil organisms in the sprayed area. However, if non-target soil organisms were to be impacted by Btk spraying, losses would be small within the context of PANP and would likely be compensated over time by individuals of the same species moving into the treatment area after spraying. This potential impact is considered acceptable within the strategic goals and management directions for PANP. Groundwater contamination by leaching of Btk through the soil profile is not anticipated because of the relative immobility of Btk in soil.

Aquatics and Water Quality

The aerial application of Foray 48B in and near the town of Waskesiu will result in some of the pesticide being introduced into the aquatic environment, either from direct drift during spray application or in Btk contaminated runoff. Once in the lake, Btk will settle to the bottom sediments fairly rapidly as it readily binds to particulate matter, and the spores may remain viable in the sediments for an extended period of time (greater than 22 days). As Waskesiu Lake is somewhat susceptible to wind-induced mixing, it is possible that some spores may become re-suspended into the water column periodically. Because Btk is not considered an aquatic bacterium, it is not anticipated to proliferate in the aquatic environment. Even if a minimal amount of growth did occur it would not be sufficient to out-compete the local microbial populations present in aquatic sediments. The presence of this relatively small amount of Btk in the water and/or sediments, even over a potentially long period of time, is not anticipated to have any measurable effect on any aquatic organisms present in Waskesiu Lake. As such, there are no effects anticipated from the routine application of Btk in and around the town of Waskesiu and mitigation (aside from following label instructions) and monitoring activities are not required (unless specifically requested by the Department of Fisheries and Oceans upon their review of the project).

Air Quality

No evidence of negative impacts to the atmosphere or climate from aerial application of Btk was found during this review. There is potential for Btk to drift and be deposited outside the target spray area, however outdoor concentrations of Btk are expected to decrease quickly. One study documented an outdoor concentration of Btk to be reduced by half in the first 3.3 hours after spraying

Cumulative Effects

The effects of the proposed spray program need to be assessed for their contribution to cumulative effects of other actions in the park. The main project effect of the spray program will be to reduce the population of Lepidoptera in the townsite. Lepidoptera provide a food source for birds and mammals. The townsite is approximately 0.1 percent of the area of the park and, in comparison to other areas of the park, provides comparatively poorer habitat for birds and mammals that rely on Lepidoptera as a food source, as it is a developed townsite. As mobile species, these animals will disperse to areas adjacent to the townsite to forage if food sources are reduced within the townsite. No other activities within the park are predicted to act in a cumulative manner to reduce Lepidoptera as a food source for birds and mammals.

Public Consultation

Public comment included 53 written submissions received during the open houses as well as 183 e-mailed submissions and 6 faxes for a total of 242 written comments. Comments were primarily related to concerns for human health, ecological impacts and interpretation of national park policy. There was only one respondent who was concerned with the process of public consultation and the environmental assessment availability and process.

Concerns related to potential human health and environmental effects were investigated by examining the information source on which the concerns were based. Additional studies that were referenced in submissions during the public consultation process were reviewed and included in this assessment. In Waskesiu, significant public concern exists related to health effects. This concern warranted further investigation of specific information sources and topic areas that led to these concerns

Monitoring and Follow up

Should the spray program be undertaken, Parks Canada and the Waskesiu Community Association will develop a detailed communication program to advise visitors and residents weeks, days, and hours prior to spraying. A detailed SBW monitoring and follow up program will be developed if Parks Canada makes a decision to undertake the spray program

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Abbreviations

AXYS ..... AXYS Environmental Consulting Ltd.
Bt ..... *Bacillus thuringiensis*
Btk ..... *Bacillus thuringiensis* subsp. *kurstaki*
CCME ..... Canadian Council of Ministers of the Environment
CDC ..... Saskatchewan Conservation Data Centre
CE ..... cumulative effects
CEAA ..... Canadian Environmental Assessment Act
CFU ..... colony forming unit
COSEWIC ..... Committee on the Status of Endangered Wildlife in Canada
GPOP ..... Guiding Principles and Operational Policies
IPM ..... integrated pest management
IUCN ..... The World Conservation Union
LAA ..... local assessment area
LD ..... lethal dose
PANP ..... Prince Albert National Park
PCPA ..... Pest Control Products Act
PMRA ..... Pesticide Management Regulatory Agency
PRMU ..... Permanent Resident Management Unit
RAA ..... regional assessment area
SBW ..... spruce budworm
TSS ..... total suspended solids
USDA ..... United States Department of Agriculture
USEPA ..... United States Environmental Protection Agency
USLM ..... United States Library of Medicine
UV ..... ultraviolet
VEC ..... valued ecosystem component
WCA ..... Waskesiu Community Association Inc.
WHO ..... World Health Organization

1 Introduction

1.1 Background

1.1.1 Waskesiu and Spruce Budworm

Conifer forests in and around Prince Albert National Park (PANP) have been affected by an outbreak of spruce budworm (*Choristoneura fumiferana*), a species of forest lepidopteran that is indigenous to Canada's boreal forest. In its larval stage, the spruce budworm feeds on needles of conifer trees, primarily white spruce and balsam fir. When high-density populations of spruce budworm are sustained in an area over a period of years, older white spruce (*Picea glauca*) and balsam fir (*Abies balsamea*) stands become particularly vulnerable to severe defoliation and mortality. The current spruce budworm outbreak in PANP has resulted in defoliation of the mixed-age, white spruce stands that occur within Waskesiu townsite.

To address the possibility that continued defoliation may lead to mortality of white spruce trees in the townsite, the Waskesiu Community Council submitted a proposal to Parks Canada entitled *A Project Proposal to Apply Bio-pesticides on Waskesiu Townsite for the Purpose of Managing Spruce Budworm Infestations* (Waskesiu Community Association Inc. [WCA] 2002). The proposal recommends spraying Foray 48B, a commercial pesticide that contains the bacterium *Bacillus thuringiensis* subspecies (subsp.) *kurstaki* (Btk) within the Waskesiu townsite boundaries to control and reduce defoliating effects of the larval stage of spruce budworm. Parks Canada has responded to this concern by developing vegetation and spruce budworm outbreak management options and strategies in the context of the community vegetation management plan (*draft in preparation*; J. Weir, pers. comm.). Options for consideration to manage the spruce budworm outbreak include spraying Foray 48B. Further details on the life history of spruce budworm and effects of Btk are included in Appendix A.

AXYS Environmental Consulting Ltd. (AXYS) has been retained to perform an environmental impact assessment of the impacts of Btk on human health and the environment.

1.1.2 Environmental Setting

PANP is located 65 km north of the city of Prince Albert, Saskatchewan, and extends from townships 53 to 61 and ranges 1 to 5, west of the third meridian. Winters are long and cold with low precipitation, while summers are short and warm and experience most of the annual precipitation (Environment Canada 1986). The park is located on the southern fringe of the boreal forest and represents a unique environment within easy range of communities dominated by agricultural operations and grassland vegetation. Abundant water features are present in the park, providing recreational and educational opportunities for visitors from drier locations south of the park.

PANP is also valued for its role in supporting species of significance, such as woodland caribou, wild plains bison and white pelican, as well as intact predator, herbivore and furbearer populations (Parks Canada 1995). The park forms the largest protected wilderness area in Saskatchewan and comprises 0.6 percent of the province (Parks

Canada 1995). This wilderness area is important because it "provides visitors with the opportunity to experience remoteness, solitude and nature on its own terms" (Parks Canada 1995).

Aboriginal cultures have inhabited the area of PANP for at least 6000 years (Parks Canada 1995). Many archaeological sites are present within the park, representing habitation, fishing, hunting, tool and pottery making, and burial activities. In the past, the area that is now PANP supported fur trading, timber harvesting and commercial fishing operations (Parks Canada 1995). PANP is also recognized as the home and location of past conservation activities of noted naturalist Grey Owl. The current role of the park involves education regarding these heritage land uses, and a range of recreation activities including hiking, cross-country skiing, camping, swimming, golfing and boating.

1.2 Assessment Objectives

AXYS' main assessment objectives were to perform an environmental assessment and prepare a screening report pertaining to the Waskesiu Community Council's project proposal and Parks Canada's decision to consider spraying as a technique to control the spruce budworm infestation. More specifically, the objective of the assessment was to conduct a literature-based review of the potential effects of Btk on ecosystem components, human health and socioeconomic factors in the Waskesiu townsite area and, where warranted, the potential effects of the spray program on PANP as a whole. Ecosystem components were to include atmosphere, soils, vegetation, wildlife and non-target terrestrial insects, water quality and aquatic organisms.

1.3 Regulatory Requirements

An environmental screening is necessary to meet the requirements of the *Canadian Environmental Assessment Act* (CEAA) and the Prince Albert National Park Management Plan (Parks Canada 1995). Such a screening will be undertaken by Parks Canada as the Responsible Authority under Section 20 of the CEAA. The project proposal is defined as a project by its inclusion on the *Inclusion List Regulations*, which states:

> 13.2 The application within a national park, national park reserve, national historic site or historic canal of pest control products from an aircraft.

To provide Parks Canada with adequate information to complete the screening, this assessment has been structured to address the requirements of Section 16(1) under the CEAA. If the spraying project were to be approved, the superintendent may authorize the "removal, relocation or destruction of wildlife for scientific purposes or park management purposes" as outlined in Subsection 15(1)(e) of the *National Parks Wildlife Regulations*. This provision is listed in the *CEAA Law List Regulations*, which also triggers the requirement to conduct an environmental assessment under the CEAA. Consequently, Parks Canada is a Responsible Authority with respect to the spraying proposal, which requires an environmental assessment pursuant to the CEAA.

2 Project Description

The Waskesiu Community Association Inc. (2002) has proposed the aerial application of Foray 48B within Waskesiu townsite boundaries (approximately 529 ha) but excluding the fuel break management unit (Figure 1) in order to control defoliating effects of spruce budworm larvae on white spruce trees located within townsite boundaries. Application of Foray 48B will not occur in the fuel break management unit due to the elimination of spruce trees in this area.

This report assumes the details of a spray program as follows:

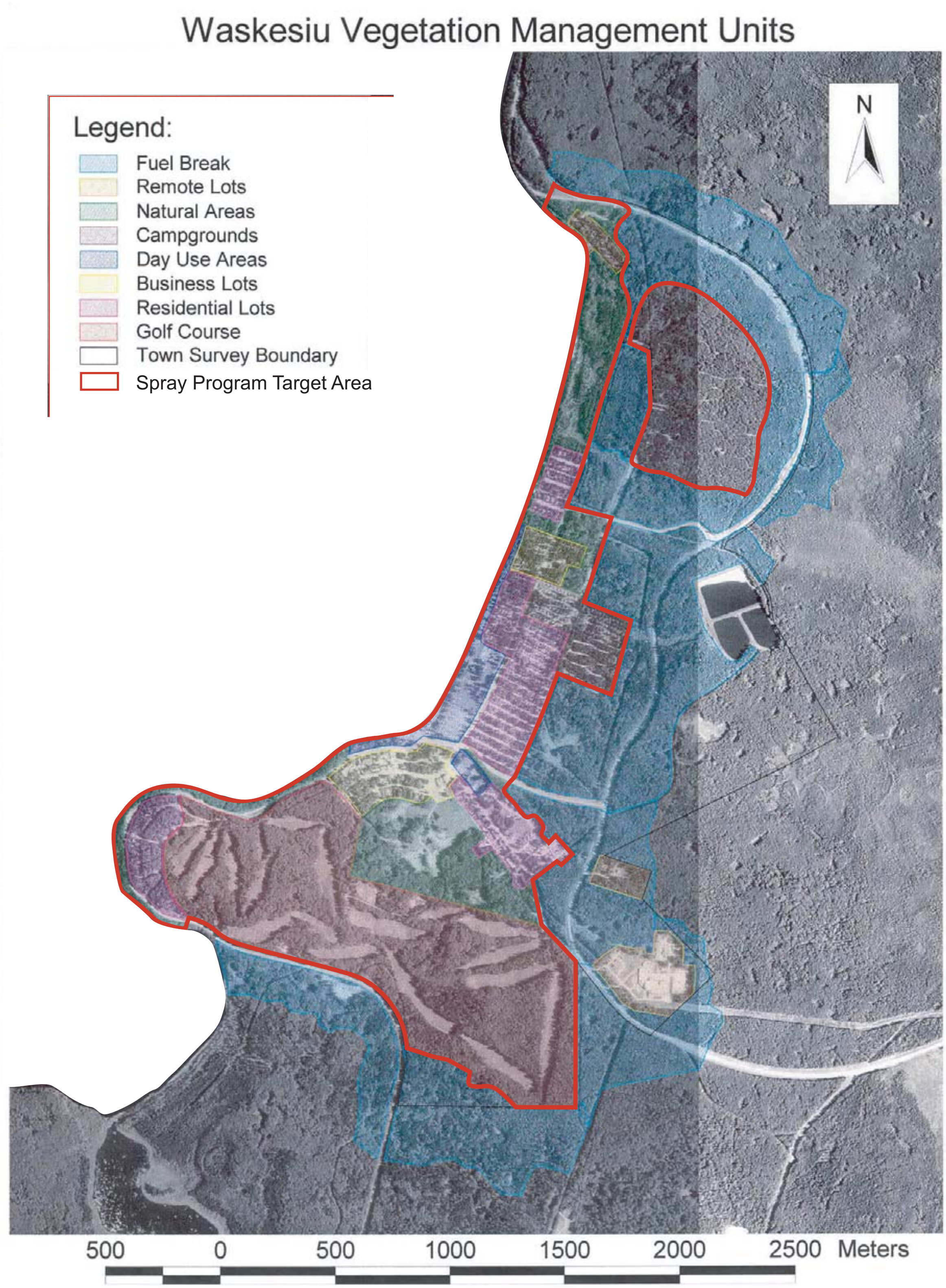
- applications of Foray 48B will be scheduled depending on spring weather conditions and larval development. In general, applications will occur between mid-May and mid-June, 2003[1] and are to be applied twice per year for up to a three-year period.
- aerial application by fixed wing air tractor
- use of approximately 2.4 L/ha (approximately 1,270 L) of Foray 48B for each application

The Waskesiu Community Association proposal also includes discussion of operational factors related to aerial application. These include a list of project activities, standard operating procedures, safe-handling procedures, personnel safety precautions and application constraints.

In brief, the proposed spray program will be based on known and tested operations from other areas. Spraying will take approximately 10 minutes for each application with the two applications occurring four to five days apart. Required conditions include a light breeze of up to 13 km/h (conditions of no wind are not suitable as some wind is required to drive the spray into the trees) and low humidity. Should the spray program be undertaken, Parks Canada and the Waskesiu Community Association will develop a detailed communication program to advise visitors and residents weeks, days, and hours prior to spraying. A detailed SBW monitoring and follow up program will be developed if Parks Canada makes a decision to undertake the spray program (Leeson pers. com.).

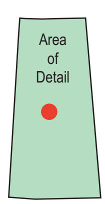
See the Waskesiu Community Proposal (WCA 2002) for information on proposed spray operations, monitoring activities and other operational factors.

[1] Timing of bio-pesticide application in relation to spruce budworm and spruce shoot development is critical to a successful spray program. The product must be present on the flaring new growth of spruce foliage while budworms are actively feeding. Infestations will be monitored in the community to determine when favourable conditions are reached for spraying.



SPRUCE BUDWORM SPRAYING EIA

Waskesiu Townsite Study Area



NORTH

Acknowledgements:
Prepared by AXYS Environmental Consulting Ltd.
Basemap prepared by: ______________

AXYS Environmental Consulting Ltd

DATE March 2003		SCALE See Above	
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REVISED H.M.	PROJECT DS1069		VOL 01

3 Policy and Legislative Context

3.1 Parks Canada Agency Legislation and Policy

As a community in a national park, Waskesiu must comply with legislative and policy requirements applicable to all national parks in Canada, as well as the specific management objectives set for PANP. Waskesiu maintains a commitment to conduct its operational activities according to these regulatory requirements. An overview of relevant legislation and policy affecting PANP and Waskesiu is presented below.

3.1.1 Canada National Parks Act

The *Canada National Parks Act* (Government of Canada 2000, Internet site) is the legislation under which Canadian national parks are established and managed. All existing activities occurring within national parks are subject to this Act and all proposed future activities or developments must be determined, planned and managed according to its direction. Section 4(1) of the Act states that national parks are:

> "*dedicated to the people of Canada for their benefit, education and enjoyment, subject to this Act and the regulations, and the parks shall be maintained and made use of so as to leave them unimpaired for the enjoyment of future generations*".

A primary guiding principal in the National Parks Act is that the:

> "*maintenance or restoration of ecological integrity, through the protection of natural resources and natural processes, shall be the first priority of the Minister when considering all aspects of the management of parks*" (Section 8(2)).

3.1.2 Parks Canada Guiding Principles and Operational Policies

The national parks mandate to protect ecological integrity over other concerns is also reflected in operational and administrative policies developed for Parks Canada. Parks Canada's Guiding Principles and Operational Policies (GPOP) (1994) outlines national park policy for the identification, establishment, protection and management of national parks in Canada. The primary objective of the policy is to:

> "*protect for all time representative natural areas of Canadian significance in a system of national parks, and to encourage public understanding, appreciation and enjoyment of this natural heritage so as to leave it unimpaired for future generations*" (Parks Canada 1994).

The first and overall guiding principle is the protection of ecological and commemorative integrity. The policy clearly states that:

> "*in every application of policy, this guiding principle is paramount*" (Parks Canada 1994).

Section 3.2.4 of the GPOP states that the manipulation of naturally occurring processes such as insect infestations may only be permitted if:

> "*the objectives of a park management plan prescribing how certain natural features or cultural resources are to be maintained cannot be achieved*" (Parks Canada 1994).

Objectives of the community management plan for Waskesiu, which must be recognized as a park management plan when reviewing matters of policy (Zinkan 2002), are that the visual character of the community and the native plant communities will be maintained (Parks Canada 2000).

Section 3.0, paragraph 4 of the GPOP states:

> "*To be effective, ecosystem management must be far-reaching and have a broad base of support. In particular, it requires understanding and collaboration among all those whose activities influence the ecological integrity of the park*" (Parks Canada 1994).

Community representatives have provided clear advice to Parks Canada as to how the spruce budworm and potential applications of Btk will affect local interests (WCA 2002). A vegetation management plan for the Waskesiu townsite is being developed by Parks Canada authorities in consultation with the public and representatives from the Waskesiu Community Council (Kingdon 2003).

3.1.3 Parks Canada Management Directive 2.4.1: Integrated Pest Management

Directive 2.4.1 "applies to all pest management related activities by Parks Canada or other authorized persons in facilities or on lands owned, administered, licensed or leased by Parks Canada, excluding those facilities or lands owned, administered, leased or licensed for residential purposes" (Parks Canada 1998a). This directive stipulates the conditions under which pesticide use will be considered in a National Park. These conditions include:

- to control pest activity for which there is no other control method is available
- to control pest infestations which interfere with the function or use of areas owned, administered or leased by Parks Canada
- to control target organisms or the encroachment of vegetation which threaten the integrity of cultural resources

Directive 2.4.1 is intended to minimize pesticide use on Parks Canada land and provide guidance on pesticide management. These goals are accomplished through the requirement for an Integrated Pest Management (IPM) plan prior to any pesticide application.

An IPM plan includes an outline for a site-specific IPM program. The key components of an IPM plan are identification of the pest, establishment of an action or treatment threshold, development of a monitoring program, selection and use of pest management strategies and evaluation and follow up (BioSys Consulting 1997). Parks Canada has prepared an IPM plan for the proposed spray program in PANP.

Pesticide application programs are to include posting of public notices and will be scheduled to avoid peak periods of visitor use, whenever possible. Environmental factors, such as impacts to plants and animals as well any effects on human health are to be considered for any proposed pesticide application program and reasonable measures will be implemented to prevent potential impacts. Pesticide applicators must meet federal, provincial or territorial standards for proper storage, handling, use and disposal of pesticides (Parks Canada 1998a).

3.1.4 Prince Albert National Park Management Plan (1995)

As required under the *Canada National Parks Act*, a management plan is to be developed for each national park and reviewed every five years (Section 11(1 and 2)). These documents are intended to provide a planning framework that balances the need for rigorous protection of ecological integrity with the public's entitlement to benefits, education and enjoyment from national parks. The current management plan for PANP was adopted in 1995 following a comprehensive review of the previous management plan and a detailed public consultation process (Parks Canada 1995). The plan provides the framework within which strategic planning and management of PANP takes place. The plan was devised and is implemented within the context of legislated and policy requirements of national parks management (Parks Canada 1995).

The management plan subdivides the park into five land-use classes or *zones* using categories established as part of Parks Canada's GPOP (Section 2.2; Parks Canada 1994). The proposed spray area within the Waskesiu townsite falls within an area designated as Zone V, Park Services, within the PANP zoning plan (Parks Canada 1995). This designation specifies that the area may contain a concentration of visitor services and support facilities as well as major park operation and administration functions. Specific activities, services and facilities in this zone will be defined and directed by the community planning process (Parks Canada 1995).

In the area adjacent to the Waskesiu townsite, there are two other land designations: Zones II and III.

Zone II, Wilderness Areas, are designated as land where the perpetuation of ecosystems with minimal human interference is the key consideration (Parks Canada 1995). Land within this zone provides opportunities for visitors to experience the natural and cultural heritage of the park through outdoor recreation activities that require minimal basic services and facilities. Motorized access and circulation are not permitted in Zone II areas.

Zone III, Natural Environment Areas, provide a similar function to the public as Zone II designations. Land within Zone III is used for recreational activities that require minimal services and facilities; however, motorized access of a controlled nature is permitted. Zone III areas include several lakes, campgrounds, day use areas and interpretive sites (Parks Canada 1995).

3.2 Waskesiu Community Plan

As mandated by the *Canada National Parks Act* and the GPOP, a community plan must be prepared by Parks Canada authorities for each community located in a park, based on direction contained in the park management plan (Government of Canada [2000, Internet site]; Section 33(1); Parks Canada 1994, Section 5.1.5). Primary objectives within the Waskesiu community management plan include protection of the visual character of the community, protection of native plant communities, and a collaborative approach to becoming a model community (Parks Canada 2000). The community plan also addresses ecological integrity as a primary concern.

Building on the direction of the community plan, the community and Parks Canada will develop a vegetation management plan for Waskesiu. A primary objective of the plan will be to have native vegetation characteristic of PANP represented in the townsite, including white spruce in a mix of ages and species (Zinkan 2002). This objective has the broad support of the community, provided it is achieved over a period of time that protects the visual character of the community (Zinkan 2002). Strategies foreseen in the vegetation management plan may include the short-term, selective application of Foray 48B in the townsite area (Zinkan 2002).

A decision to pursue vegetation management strategies involving the selective use of Foray 48B in and immediate to Waskesiu has been made by Parks Canada authorities based on the legislative and policy context (Zinkan 2002). However, application of Foray 48B can only proceed once an environmental impact assessment has been completed and it is concluded that it is unlikely that significant adverse environmental effects would result.

3.3 Fisheries Act

With respect to aerial spraying of Foray 48B over Waskesiu townsite and adjacent Waskesiu Lake, relevant sections of the *Fisheries Act* fall under the heading Fish Habitat Protection and Pollution Prevention. In particular, Section 35, subsection 1 states that:

> "*No person shall carry on any work or undertaking that results in the harmful alteration, disruption, or destruction fish habitat*".

Section 36, Subsection 3 states that:

> "*…no person shall deposit or permit the deposit of a deleterious substance of any type in water frequented by fish or in any place under any conditions where the deleterious substance or any other deleterious substance that results from the deposit of the deleterious substance may enter any such water*."

There are further subsections within Section 36, specifying that certain deleterious substances may receive authorization for deposit. If an authorization for deposit is received, the person authorized to make the deposit must comply, when directed in writing by the Minister, with conditions set out in the authorization. Conditions set out in an authorization may prescribe how the deleterious substance is to be deposited, and may require the conduct of environmental monitoring and reporting of results as required by the Minister in the authorization. Furthermore, under Section 37, any:

> "*…person who carries on or proposes to carry on any work or undertaking that results or is likely to result…in the deposit of a deleterious substance in water frequented by fish or in any place under any conditions where that deleterious substance or any other deleterious substance that results from the deposit of that deleterious substance may enter any such waters*"

is required to provide the Minister with plans, specifications, studies, procedures, schedules, analyses, samples or other information relating to the work or undertaking, sufficient to allow the Minister to determine whether there is likely to be a deposit of a deleterious substance and what, if any, measures would prevent that result or mitigate its effects.

As long as Foray 48B is used in accordance with label directions and limitations, a review of the proposed spray program by the DFO, as relates to the potential impact on fish and fish habitat, should not be necessary unless deemed so for other reasons by Parks Canada.

3.4 Pest Control Products Act

Pest control products in Canada are regulated by the *Pest Control Products Act* (PCPA). The PCPA regulates products used for the control of pests and the organic functions of plants and animals. The PCPA is administered by Health Canada and its Pest Management Regulatory Agency (PMRA). The PMRA is responsible for pest management regulation and registration, according to the PCPA and Pest Control Products Regulations.

The PCPA states that no person shall sell or import into Canada any control product unless the product has been registered as prescribed by the Act, conforms to prescribed standards, and is packaged and labeled as prescribed. According to the Pest Control Products Regulations, before making a registration decision regarding a new pest control product, an assessment of risks and value of the product is conducted, specific to its proposed use. The PMRA conducts a risk assessment that considers the inherent toxicity of a proposed product, its persistence and bioaccumulative nature, the degree to which humans and non-target organisms will be exposed, and any possible health hazards associated with the product. Pest control products are only registered by the PMRA if the data requirements for assessing value and safety have been adequately addressed, if the evaluation indicates the product has merit and value, and if the human and environmental risks associated with its proposed use are acceptable (Health Canada 2001a). According to Section 14 of the Pest Control Product Regulations, products need to undergo a renewal of registration every five years.

Conditions of registration can be placed on products. Non-compliance with conditions of registration is a violation of the PCPA and may lead to suspension, cancellation, use restrictions or the phasing out of a pest control product. The Minister may also cancel or suspend the registration of a product if its safety or merit are no longer acceptable.

The PCPA has assessed all Btk products registered for use in forests, woodlands and residential areas as restricted. Restricted class products require permits or licensing from the regulatory authorities in the province or territory for purchase and use.

3.4.1 Pest Management Regulatory Agency Regulatory Directive Dir96-04

The PMRA Regulatory Directive Dir96-04 (PMRA 1996, Internet site) provides direction on the aerial application of pesticides. The regulatory directive outlines labeling requirements and registration processes for application of pesticides by air. The directive states that aerial application will only be allowed as specified on the label of the pesticide. Additionally, the directive notes that set-backs or buffer zones may be established on a pesticide label at the time of registration on a case-by-case basis.

Foray 48B has been labeled for aerial application over residential areas (Hunt pers. comm.). The product label contains no information related to water or water bodies (Hunt pers. comm.).

3.4.2 New Pest Control Products Act

In response to a federal government initiative to reform the pest management regulatory system, the Canadian government renewed the PCPA, and this new legislation received royal assent on December 12, 2002. The new PCPA has not yet come into force and therefore does apply to the current application.

The new PCPA includes:

- a clear framework for a regulatory system that is even more comprehensive than the current law
- modern risk assessment concepts, including special consideration of children, infants and other vulnerable groups, and the need to assess aggregate exposure and the cumulative effects of pesticides that act in the same way
- opportunities for informed public participation in the regulatory system through consultation prior to major registration decisions, mechanisms to review decisions (e.g., review panels to reconsider major decisions for full registrations, special reviews of existing registrations) and access to information supporting pesticide registrations
- the proposed new Act also improves post-registration control of pesticides by requiring adverse effects reporting and strengthening the provisions for re-evaluation and special review, as well as enhancing enforcement capability through clearly defined offences, increased powers of inspectors and higher maximum penalties
- a clear legislative foundation for reducing pesticide risks that incorporates the principles of sustainable development
- a preamble that sets the tone for the substantive provisions of the legislation by recognizing the wide variety of factors that affect the manner in which pesticides are regulated in Canada (Health Canada 2003, Internet site)

The new PCPA requires special consideration of effects on sensitive populations such as infants and children. There has been no evidence from previous surveillance studies that demonstrates sensitivity of the elderly, immuno-compromised individuals, children, or infants to Btk (see Section 5.1.2 of this report for more information).

When Foray 48B is re-evaluated, the re-evaluation would be conducted under the new legislation.

4 Assessment Methodology

4.1 Issues Scoping and Assessment Approach

Scoping is the process of evaluating what potential interactions between the spraying program and the environment will be assessed. This process identifies issues that will be examined in the environmental impact assessment. Definitions for key technical words are provided in the Glossary (Appendix B).

Key issues addressed for each assessment component are listed below:

- Human Health: toxicity, pathogenicity and other effects that may arise. The assessment will include both the direct and indirect effects on people in PANP during the time of application.
- Wildlife: potential for direct and indirect effects on non-target insects and terrestrial wildlife species.
- Vegetation: potential effects on plants and plant communities and indirect effects on pollinating insects at the local (community) and park scales are assessed.
- Soils: micro and macro organism toxicity effects
- Aquatics and Water Quality: toxicity to aquatic invertebrates and fish, and impacts on water quality
- Air Quality: potential changes to air quality at local and PANP scales

Social and economic effects of the proposed spraying program are included to the extent that they relate to human health and environment-related values. Other social and economic issues (e.g., recreational opportunities, tourism revenue) were not included in this assessment due to their limited relevance to the proposed spray program, as described below.

The Pest Management Regulatory Agency, the agency responsible for regulating the use of the Foray 48B, notes that no special precautions are necessary or required in areas where spraying may occur. The agency says that individuals who have concerns should take reasonable precautions to avoid exposure during a spray program in the same way they would avoid pollen or other airborne materials during days when air quality advisories are issued. The agency also says that people can reduce their exposure by staying inside with their doors and window closed during the spray period, although this is not required.

The spray program will occur in the early morning (probably between 4:00 am and 6:00 am) and will last approximately 10 minutes, likely before most residents and visitors are active and outside. There are no recommended or required reasons for people to alter their behaviour and the spray program will occur at a time of limited outdoor activity in the townsite.

4.2 Spatial and Temporal Boundaries

The majority of the effects of the proposed spray program will be confined to the designated spray area and the immediately adjacent land to account for pesticide drift.

The proposed spray program also has the potential to affect mobile resources such as aquatic life, surface water and wildlife.

The Waskesiu townsite, excluding the Fuel Break Management Unit, was established as the target area for spraying and the area in which project-specific impacts on environmental and human resources would be assessed (see Figure 1). This area is approximately 529 ha.

To consider the contribution of the proposed spray program to cumulative effects (where applicable), the assessment area was expanded to the PANP boundary (Figure 2). This provides a regional context for the assessment of cumulative stressors on environmental resources, and it will allow for appropriate consideration of such issues as downstream aquatic and hydrological impacts. The use of the park boundary was also necessary to enable the evaluation of impacts in terms of the Parks Canada guiding principles of protection of ecological and commemorative integrity (Parks Canada 1995). The total area of the park is approximately 388,000 ha. The townsite is located in the east central portion of the park, and comprises 0.1 percent of the park's area.

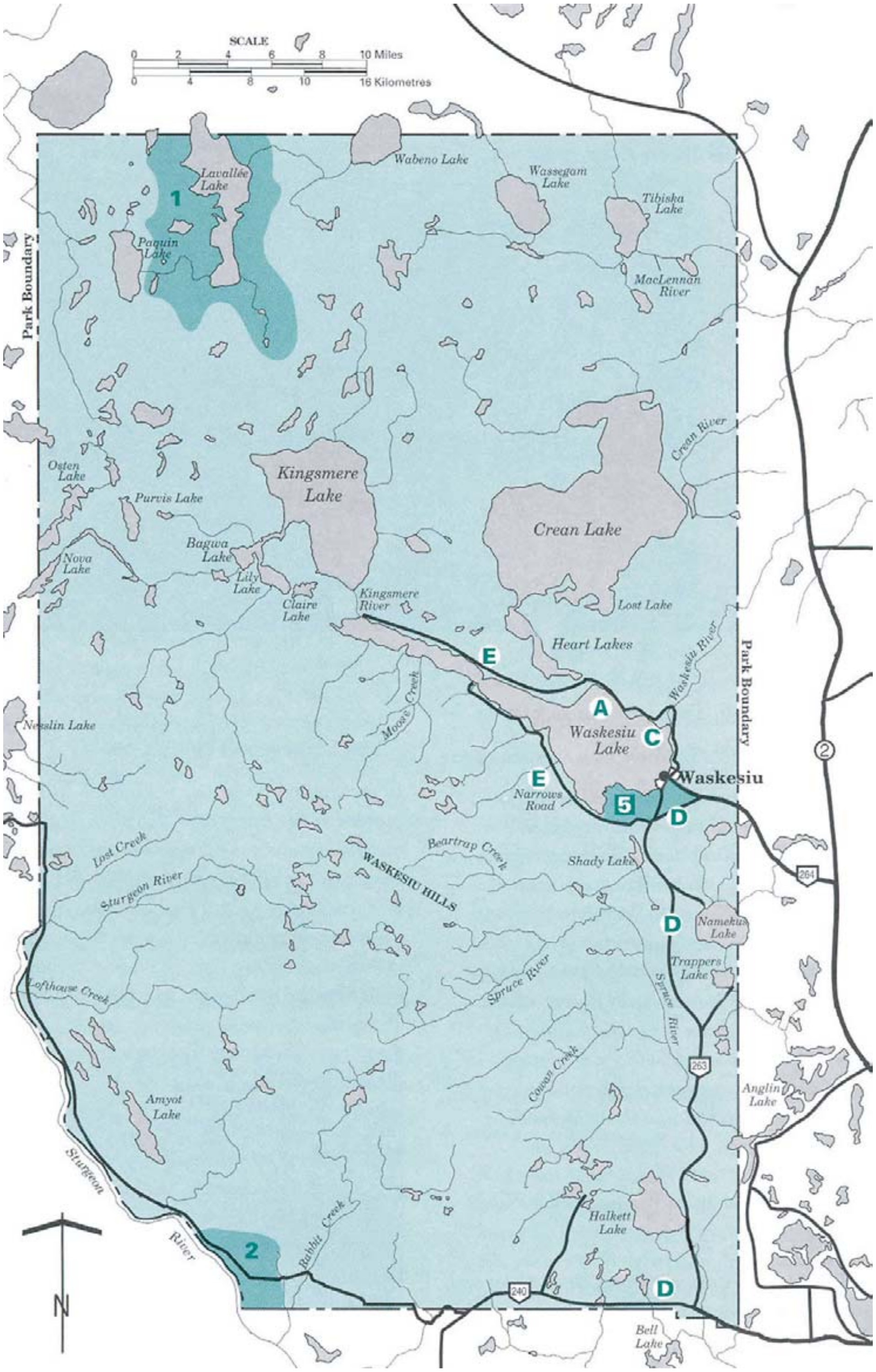
February 2003 was defined as the baseline scenario for the purposes of this assessment. The conditions of each resource were described at baseline, and this serves as the reference point for the assessment of project-specific and cumulative effects. The period over which effects are assessed varies with the discipline areas examined, and is described in the respective sections of this environmental impact assessment. The evaluation of residual project effects assumes that all mitigation measures have been implemented. For those resources where a toxic effect is predicted, the evaluation period has been extended to allow for the assessment of long-term residual impacts.

4.3 Evaluation of Impacts

Under Section 20 of the CEAA, the Responsible Authority for a project must decide whether or not the project is likely to cause significant adverse environmental effects.

In a national park setting, thresholds or objectives for resources are generally developed as strategic goals in the park management plan. In the PANP management plan, general objectives have been developed for the protection and provision of a variety of biophysical, cultural and recreational resources. While not specific enough to be adopted for use as explicit ecological thresholds or quantitative resource management goals, the general intent of the PANP management plan provides a framework for evaluating impacts after mitigation and the acceptability of the proposed activity. The following impact categories have been developed for use in this assessment document:

- **No Measurable Impact** – no measurable impact will occur to the resource in question in either the townsite or the park
- **Level I Impact** – a potential measurable effect on the resource in question that occurs largely within or near to the area of interest (townsite spray boundaries), and that is considered acceptable within the strategic goals and management directions for PANP
- **Level II Impact** – a potential measurable effect on the resource in question that is unacceptable within the strategic goals and management direction for PANP



PARK ZONING LEGEND

ZONE I - SPECIAL PRESERVATION

1 Lavalee Lake Pelican Colony

2 Fescue Grasslands Area

ZONE II - WILDERNESS

Wilderness Area

ZONE III - NATURAL ENVIRONMENT

5 Area south of Waskesiu townsite bounded by highway 264, highway 263/264 connector road. Narrows Road and Waskesiu Lake

ZONE IV - OUTDOOR RECREATION

(A) Waskesiu Lake

(C) Waskesiu Lake Marina and access right-of-way

(D) Right-of-way for Highway 263, 264, 240 and 263/264 connector Road

(E) Waskesiu Lake Scenic Drive (Narrows Road and Kingsmere Road)

ZONE V - PARK SERVICES

Waskesiu Townsite

SPRUCE BUDWORM SPRAYING EIA

Prince Albert National Park Study Area

Area of Detail

NORTH

Acknowledgements:
Prepared by AXYS Environmental Consulting Ltd.
Basemap prepared by: Parks Canada

AXYS Environmental Consulting Ltd

DATE March 2003		SCALE See Above	
DRAWN L.A.T.	CHECKED H.M.	FIGURE NO. 2	REV 01
REVISED H.M.	PROJECT DS1069		VOL 01

The Waskesiu townsite, an area of PANP zoned for public facilities and recreation, occurs within a region experiencing ongoing effects of various land uses and human activities. Where Level II project-specific impacts are determined likely to occur as a result of the proposed Foray 48B spray program, assessment of the interaction of these project effects with other ongoing effects in the community and the park will be undertaken.

4.4 Knowledge Deficiencies

Knowledge deficiencies are related to a lack of scientific research or insufficient site-specific information for the community of Waskesiu or PANP. Knowledge deficiencies identified in the environmental screening are discussed below.

The evaluation of impacts on non-target lepidopteran species was limited from the perspective of identifying species-specific impacts. While presence of the Committee on the Status of Endangered Wildlife in Canada (COSEWIC)-listed Monarch butterfly in PANP and Waskesiu was confirmed, species lists are not available for invertebrate populations in PANP or Waskesiu, as no censuses have been performed.

The relationships between plants and non-target Lepidoptera species are not well understood for this geographic region. Information confirming or refuting obligatory relationships, such as those necessary for pollination, between non-target Lepidoptera and plant species in Waskesiu was not found during this review and the potential impact of Btk on these species is not known.

There is some uncertainty in the scientific community as to whether Btk will impact non-target soil macro-organisms and which species are most at risk. Additionally, information is not available on current species composition of soil macro-organisms in Waskesiu.

No toxicity data specific to phytoplankton, periphyton or aquatic macrophytes related to Btk were identified within the literature. Few scientific studies to date have investigated the long-term (> 1 year) persistence of Btk in soil. Minimal information on the effects of the aerial application of Btk on air quality or climate is available.

These knowledge deficiencies, either singularly or in combination, do not affect the conclusions in this report.

5 Environmental Assessment

The environmental screening will include a thorough description of the impacts to valued ecosystem components, including natural and cultural resources and socioeconomic conditions, as a result of the proposed project. This description will include the geographical and temporal boundaries for each of the identified project-environment interactions. These impacts will be quantified where possible. Impacts to non-park lands, as a result of spray application and aerial drift, will also be identified and quantified where possible.

5.1 Human Health

5.1.1 Community Characteristics

5.1.1.1 Population and Visitor Characteristics

On summer weekends there are an average of 5000 residents, visitors, campers, and cottage and cabin owners that stay overnight at Waskesiu. The resident town population has changed significantly over last ten years, from a high of 200 to a current low of 50 (Parks Canada 2000). Resident Parks Canada staff have decreased in number, while commercial staff have increased. The lack of a school system and government restructuring may be the largest contributors to decrease in population (Parks Canada 2000).

PANP received 230,000 visitors during the 2001-2002 season. Visitation has increased 3 percent since 1997. From the 1998 gate survey of PANP (Parks Canada 1998b), the majority of visitors are from Saskatchewan (84 percent) and other provinces in Canada including Alberta (13 percent). The average party size visiting the park in 1998 was 3.3, with 69 percent of parties including adults 35–54, and 41 percent including children 11 or younger. The most important activities reported in the park were swimming and beach use (69 percent of respondents), and hiking and walking (58 percent of respondents). Other reported activities included picnicking, camping and golfing (Parks Canada 1998b).

The park is open for visitors year-round. Main campgrounds operate from mid-May to the end of September, but camping opportunities are available throughout the year including frontcountry and backcountry winter campgrounds.

The 1998 gate survey (Parks Canada 1998b) notes 73 percent of visitors were there on a repeat visit, and 63 percent of respondents stayed in the park at least overnight, with the highest proportion staying at least three nights. Of those staying overnight, 40 percent stayed in campgrounds, 24 percent stayed in a hotel or motel, 16 percent stayed in rented cabins, and 9 percent stayed in owned homes or cottages. Of those individuals camping in 1998, 40 percent stayed in tents, and 67 percent stayed three or more nights (Parks Canada 1998c).

5.1.1.2 Waskesiu Town Services

The town of Waskesiu is a mixture of cottages, cabins, staff residences, park facilities and commercial facilities. The town is divided into separate areas: a commercial core, cottage subdivisions, a cabin area, golf course and campground area. Town services include: cabins, lodges, motels, hotels, convention facilities, restaurants, grocery stores, a liquor store, a gas station, a post office, a Royal Canadian Mounted Police detachment and souvenir shops. The nearest hospital to Waskesiu is the Victoria Hospital in Prince Albert, approximately 90 km away.

The town is supplied with drinking water from Waskesiu Lake, which is treated at a local treatment plant. The town currently has a three cell sewer system, including a wetland and sand filter, which ultimately discharges into Waskesiu Lake. In the Waskesiu Community Plan, there were plans to upgrade the three lift stations of the sewage lagoon.

5.1.1.3 Health Indicators

No health-related information was available specifically about residents of Waskesiu and visitors to Waskesiu, so baseline information reported here outlines the health status of Saskatchewan residents as a whole.

Saskatchewan has an estimated population of 1,016,000. Approximately 57 percent of Saskatchewan residents reported themselves as having excellent or very good health in 2001 (Saskatchewan Health 2002a). In 1999, Saskatchewan residents had the fourth highest life expectancy at birth in Canada, at 78.6 years. In 1996, Saskatchewan had the third highest disability-free life expectancy in Canada at 68.6 years. The Saskatchewan infant mortality rate in 1999 was slightly above the Canadian average, at 5.9 deaths per 1000 live births (Saskatchewan Health 2002a).

In 2000–2001, 27 percent of Saskatchewan residents were smokers, slightly higher than the Canadian average. The current (2001) rate of teen (ages 12–17) smokers in Saskatchewan has doubled since 1994 from 10 percent to 20 percent. In the Canadian community health survey, 44 percent of Saskatchewan residents rated themselves as being moderately physically active, slightly above the Canadian average (Saskatchewan Health 2002b).

In 1998, respiratory disease, including lung cancer, was the third most common reason for hospitalization in Canada. In 1997, for children under five, asthma, pneumonia and bronchitis were frequently included in the top five diagnoses. The Canadian rate for physician-diagnosed asthma in 1999 was 8.4 percent for all ages. Hospitalization rates for asthma in Saskatchewan between 1996-1999 were 209 per 100,000 people, above the Canadian average of 143 (Health Canada 2001b). Asthma mortality rates for the same period were 1.51 (per 100,000) compared to the Canadian average of 1.24. In a survey of childhood asthma in 1995, 10 percent of surveyed students (ages 5–19) in Saskatoon had asthma, as compared to an average of 13 percent of students surveyed across Canada (Health Canada 2001b).

5.1.2 Health Effects of Btk

Btk is not considered a human health hazard in Canada, the United States and internationally (Health Canada 2000, United States Environmental Protection Agency [USEPA] 1998; World Health Organization [WHO] 1999, Internet site). There have been no documented cases of potential toxicity or endocrine disruption to humans or mammals in the many years of its use in Canada and in other countries (Health Canada 2000). Btk δ-endotoxins exert their toxic effects on lepidopterans by binding to specific receptor sites present on the membrane of the insect gut. There are no known similar sites in the gut of humans, regardless of age of the organism (USEPA 1998). The alkaline conditions necessary for Btk to become active are not present in the human gut.

In order to obtain registration in Canada, all microbial pest control agents, including Btk-based products, are subject to animal studies whereby products are applied to test animals by mouth, by skin or by inhalation. Irritation and hypersensitivity potentials of microbial products are also investigated. The results of these studies must show the product to be non-toxic and non-infective before registration is granted. In support of the Foray 48B product registration, the PMRA reviewed numerous mammalian studies that addressed the acute toxicity and infectivity of Btk through various routes of administration. These studies included acute oral, pulmonary, intravenous and intraperitoneal injection, primary dermal and eye irritation, dermal toxicity and hypersensitivity tests. Additional short-term and chronic dietary exposure studies have also been submitted in support of the Btk active ingredient. While some of these studies have shown that Btk can persist in certain tissues (spleen, liver and lungs) for several weeks after exposure to low and high levels, there is no evidence of toxicity, multiplication or infection in laboratory mammals.

Some mild respiratory, skin and eye irritation has been found in ground spray workers when exposed to elevated levels of Btk (Noble *et al*. 1992). The exposure rates of ground workers were up to 500 times greater than that of the general public standing outside during a spray operation. Irritation reported by spray workers and reported by some members of the public during Btk spray programs was not associated with subsequent disease or illness.

Scientific literature suggests that larger particulate matter (i.e., larger than 10 μm in diameter) may trigger asthma due its biogenic contents. In epidemiological health studies conducted in Canada and New Zealand, no increased symptoms or episodes of asthma were associated with Btk exposure (Noble *et al.* 1992; Capital Health Region 1999; Aer'aqua Medicine 2001). A surveillance program conducted by the Capital Health Region in British Columbia in 1999 specifically looked at children with asthma as a potential sensitive subpopulation. Even though exposure had increased in the asthmatic children study group, no evidence of increased health symptoms or health effects was found in this subpopulation. In this same study, the general population health survey showed no increase in reported health complaints from individuals with asthma.

USEPA's Reregistration Eligibility Decision (1998) comments on the ability of certain Bt products to produce the diarrhoeal enterotoxin usually associated with *Bacillus cereus* that results in food poisoning. The USEPA determined that although Bt strains could produce the diarrhoeal enterotoxin, it was at extremely low levels (much lower than those produced by *B. cereus*). *B. cereus* can be found naturally on many types of foods, but needs to multiply in foods to produce symptoms. The USEPA concluded in their assessment that there was no evidence to suggest that diarrhoeal episodes have been associated with use of Bt pesticides. The USEPA has now implemented production batch testing to reduce any potential for contamination by pathogenic bacteria or enterotoxins during the production process (USEPA 1998). No studies have found any association between use of Btk and an increase in diarrhoeal episodes in a population.

Both PMRA and EPA require production batch testing for contaminants and toxins. Assessment of quality assurance in the commercial formulation of microbial pest control products, particularly the monitoring of potential pathogens to humans, is a key component in the overall registration and evaluation of these products by the PMRA.

Depending on the manufacturing process employed by individual companies and the formulation ingredients used in specific products, monitoring criteria are set by Health Canada to ensure there is no human health and safety concerns associated with microbial contamination. Registered microbial pest control products sold in Canada must not exceed the set acceptable levels of microbial contaminants. In 1992, Health Canada officials, in consultation with representatives from the manufacturers established monitoring criteria for all *Bacillus thuringiensis* pest control products intended for sale in Canada, including Foray 48B. These criteria established standards for enterococci and coliform bacteria which are commonly used as indicators of poor sanitary hygiene and overall unsatisfactory quality control practices during the manufacturing and formulation processes. Since 1992, the manufacturer of Foray and DiPel Btk product lines have been diligent in submitting quality control certificates for these products, including Foray 48B, to the PMRA for review. The company is committed to maintain the bioburden standards and only those products meeting these standards are sold for use in Canada. No additional mitigative measures have been required expect for standard precautionary statements on first aid, storage and disposal. In order to ensure product stability and performance, the PMRA also requires that the product be used within 6 months of the date of manufacture.

In a case heard before the British Columbia Environmental Appeal Board in 1998 (Appeal No. 98-PES-03(b)), the board found that the proposed aerial spray program created an unacceptable risk of health problems to the residents of Langford, Colwood, Esquimalt, and Saanich. The Appeal Board 1998 subsequently decided that limited ground spraying of Foray 48B be allowed within the proposed spray sites. In a more recent case heard before the same Appeal Board in 2000 (Appeal No. 00-PES-001 to 004) the permit for aerial spraying of Foray 48B was upheld. The panel of the Environmental Appeal Board determined that the pesticide application authorized by the permit would not cause unreasonable adverse health effects in the City of Burnaby.

5.1.2.1 Experimental Exposure in Humans

There have been a limited number of experiments conducted on Bt in humans. In one study, 18 subjects ingested one gram of a commercial Btk product daily for five days. No health effects were noted on physical, laboratory or x-ray examination (Fisher and Rosner 1959). Five subjects also inhaled 100 mg of powder daily for five days, with no adverse health effects. In this experiment, the subjects were exposed to 10^9 spores of Btk/kg body weight by inhalation and 10^{10} spores of Btk/kg body weight by ingestion. These exposures are much higher than levels that the general public would be exposed to during an aerial spray program (Joung and Côté 2000).

5.1.2.2 Occupational Exposure

Noble *et al*. (1992) studied aerosol Btk exposure and subsequent nose and throat carriage of Bt by 120 workers during a major spray program for gypsy moth control in the lower mainland of British Columbia. The mean exposure values of workers ranged from 3.0×10^3 to 5.9×10^6 Bt spores/m^3 sampled air. Individuals working most shifts during the spray period were exposed to 5.4×10^6 to 7.2×10^7 organisms. The exposure rates of ground workers were up to 500 times greater than that of the general public standing outside during a spray operation. Nearly all the workers exposed to higher concentrations for several shifts (5 to 20) tested positive in nasal and throat swabs for Bt bacteria, and the majority of the workers had bacteria present in their nose and throat for 14 to 30 days.

During the spray program, some workers reported adverse symptoms, including chapped lips, dry skin, eye irritation, and nasal drip and stuffiness. The symptoms appeared to be transient and irritant in nature, with no serious health problems or days of work lost resulted (Noble *et al*. 1992). Workers were two to three times more likely to report symptoms than the control population. There was a direct relationship found between exposure level and symptoms. History of asthma, seasonal allergies or eczema seemed to influence the frequency of reported symptoms. No significant differences were found with respect to gender or smoking status. Facemasks and eye goggles were not worn by workers, even though there was a warning on the label to avoid contact with eyes, nose and throat.

Many manufacturers of Bt products monitor the exposure and the associated health risks of their workers. Over a period of 30 years of production, there have been no reports of such workers having been adversely affected (WHO 1999, Internet site).

A recent study on farm workers exposed to Bt from picking vegetables, found no occupationally related respiratory symptoms, but showed that there may be allergic skin sensitization and induction of IgE and IgG antibodies, indicating a potential immune response in workers (Bernstein *et al.* 1999).

5.1.2.3 General Population Exposures

United States authorities have concluded that on the basis of available epidemiological studies and the long history of use, no hazard has been identified for members of the public to Btk formulations (United States Department of Agriculture [USDA] 1995).

In the study mentioned above, Noble *et al.* (1992) examined the records of more than 26,000 telephone calls, 1140 family practice patients and 3500 admissions to hospital emergency department during the lower mainland Btk spray program in British Columbia. The health-related hotline calls reached a maximum (24 percent of total calls) the week right before the spraying, and dropped sharply after the spraying commenced on April 18. Of the 939 health-related calls (19,893 total calls) between April 15 and June 15, 247 calls reported health problems. Symptoms reported included: allergy symptoms (19 percent), flu (17 percent), nose and throat irritation (10 percent), respiratory (17 percent) (half of these asthma-related) and skin irritation (8 percent).

Complaints of respiratory and eye, nose or throat irritation were not more common in people living inside the spray zone, nor were they more common in people who tested positive for Btk. There was no evidence of an increase in people attending hospital emergency departments during the time of the spray, nor were there more individuals visiting emergency departments for asthma, or respiratory disease. No cases of infection with Btk were identified in any hospitalized patients (Noble *et al.* 1992).

The Capital Health Region in British Columbia coordinated a similar human surveillance study to determine the possible short term effects of aerial spraying of Foray 48B on southern Vancouver Island in 1999. The study included analysis of records from an asthmatic children's survey, a general population health survey, laboratory surveillance, air samples, doctor's office visits, emergency room visits and a telephone health support line.

Results showed no health effects in the general population from exposure to Btk during the spray program. There was no relationship found between the aggravation of asthma in children and aerial spraying of Foray 48B. There was a single case of a five year old asthmatic whose symptoms worsened during the spray program, but it was impossible to conclude whether this was the result of exposure to Foray 48B (Capital Health Region 1999). Some individuals did report symptoms they attributed to the spray program, and indicated they would be visiting emergency rooms for these symptoms, but the study did not find any increase in emergency room visits during the spray program, or detect any change in health status that could be linked to the spray program (Capital Health Region 1999).

Similar results were found in a health surveillance program that continued for two years after a Btk aerial and ground spray program in Auckland, New Zealand. This program investigated self-reported health concerns; doctor's consultation rates; and local, regional and national health data. No adverse health patterns were found at a population level. There was an increase in self-reported irritants, including respiratory, eye and skin irritants at time of spraying, but when these were followed up with an interview, review of health records and, at times, personal medical assessments, no significant disease or illness attributable to the spraying could be found (Aer'aqua Medicine Ltd. 2001). The most frequently reported concern was "fear of unspecified future disease", a potential indicator of psychological hazards associated with the spray program.

5.1.2.4 Clinical Case Reports

Despite the extensive use of Bt, published reports linking the pesticide to human disease or infection are limited. One case occurred after an 18 year old farmer splashed a commercial Btk product into his eye. The eye was irritated and developed a corneal ulcer several days after the accident. Bt was cultured from the ulcer. The eye was treated with a topical antibiotic and corticosteriod; the ulcer healed after two weeks of treatment. The authors linked the ulceration to Btk, but did not consider the fact it may have been caused by other factors and that the Btk only inhabited the ulcer (Samples and Buettner 1983). There are no other reports of Bt being associated with ocular infections in workers (WHO 1999, Internet site).

There are a few cases where other subspecies of Bt have been linked to infection. Warren *et al.* (1984) reported that a research worker developed a marked local reaction and lymph node inflammation following a needle stick injury when handling Bt ssp. *israelensis*. *Acinetobacter calcoaceticus* and Bt were cultured from the infection. The condition responded to penicillin. Damgaard *et al.* (1997) isolated Bt in burn wounds in two patients. None of the isolates showed any toxicity to Vero cells (a cell line that is particularly sensitive to certain pathogens).

Several human surveillance programs associated with the aerial application of Btk have found Btk isolates in biological tissues after the spray program (Nobel *et al.* 1992; Capital Health Region 1999; Aer'aqua Medicine 2001). In all of the surveillance programs mentioned above, including one conducted in Oregon State in 1995, the investigators concluded that virtually all of the Btk isolates were the result of sample contamination, and not linked to disease or infection (Capital Health Region 1999).

Despite the widespread use of Bt-based products, only two incidents of possible allergic reactions have been reported to the USEPA (McClintock *et al.* 1995). After a thorough review of these case studies, Bt was determined not to be the causative agent. In the recently released "Symptom complaints following aerial spraying with biological insecticide Foray 48B", Petrie *et al.* (2003) examined the effects of aerial spraying of Foray 48B on self-reported symptom complaints, health perceptions, and visits to healthcare providers. The study reported a significant increase in symptom complaints, a decrease in the overall self-ratings of health, and no change in the number of visits to general practitioners and healthcare providers following the aerial spraying of Foray 48B.

A significant increase in the total number of self-reported symptoms was reported, specifically: sleep problems, dizziness, difficulty concentrating, irritated throat, itchy nose, diarrhea, stomach discomfort, and gas discomfort. The authors also found a significant increase in self-reported symptoms of participants with pre-existing hay fever. These symptoms were reported by the participants before and after the aerial spraying of Foray 48B; however, the symptoms were self-diagnosed with no medical diagnoses of illness. In addition, the symptoms reported by the participants after the aerial spraying occurred during pollen season. Without consideration of a control group living outside the spray area, the authors declared that they were unable to directly attribute the increase in self-reported symptoms to the spray program.

The authors suggested that the reported neuropsychiatric and gastrointestinal symptoms were not likely to be related to pollen exposure. However, the increase in self-reported symptoms did not occur with an increase in physician visits.

The increase in self-reported symptoms and diminished perception of general well-being after aerial spraying could result from the likelihood that individuals who perceived themselves as affected would be more likely to respond in the follow-up questionnaire. This uncertainty could have been further amplified, as the study included 292 participants in the calculation of the baseline symptoms, but only 181 of the original participants in the calculation of the symptoms following the spray program. The study did not eliminate the results of the missing 111 surveys from its analysis of baseline conditions. If the 111 participants that did not respond to the follow-up questionnaire were of better perceived health both before and after the aerial spray program when compared to the other participants, inclusion of their survey results in the calculation for the baseline symptoms may have exaggerated the significance of the difference between the reports made before and after the spray program.

The use of a control group unexposed to Foray 48B would serve to strengthen estimates of association between exposure and adverse health consequences. Despite the limitations of the study, it is not unreasonable to imply that the application of pesticides has in the past resulted in heightened concerns regarding health impacts in exposed communities.

5.1.2.5 Sensitive Populations

There has been no evidence from previous surveillance studies that demonstrate sensitivity of the elderly, immuno-compromised, children or infants to Btk. The 1999 surveillance program in Victoria, British Columbia specifically looked at children with asthma as a potential sensitive subpopulation. Even though exposure had increased in the asthmatic children study group, no evidence of increased health symptoms or health effects was found in this subpopulation (Capital Health Region 1999). The USEPA concluded in its re-registration eligibility decision that no harm would result to infants and children from dietary exposure to residues of Bt (USEPA 1998).

Hernandez *et al.* (1999 & 2000) suggested that immune-suppressed mice might be susceptible to *Bacillus thuringiensis* subsp. *konkukian* infection. The World Health Organisation (WHO 1999), however, reviewed similar experiments performed by Siegel *et al.* (1987) and Siegel and Shadduck (1990) and determined that an intact immune system was not essential in protecting against Btk infection. Based on the aforementioned studies, WHO (1999) determined that immune-suppressed individuals are not at an increased risk of Btk infection. The 1992 Victoria surveillance program found no increased cases of infection in immune-suppressed persons that occurred during the time of spray (Noble *et al.* 1992).

Other surveillance studies also did not identify any subpopulations with adverse health impacts. In Noble *et al.* (1992), a history of asthma, seasonal allergies or eczema seemed to influence the frequency of reported symptoms in spray applicators, but no similar pattern was seen for public exposure in the same study. Of note, the occupational exposure levels were 500 times that of the exposed public.

With respect to reproductive concerns, ADBH (2002) concluded that there is no evidence available to suggest that Foray 48B causes miscarriages. Further, the health surveillance that occurred after Operation Ever Green showed no statistical difference between the birth weight, gestational age or birth defects of babies born from mothers inside or outside the spray area (Aer'aqua Medicine 2001).

Pathways of Exposure

Potential pathways of exposure to Btk for residents and visitors of Waskesiu include inhalation, ingestion and ocular and dermal exposure. The Waskesiu spray program is planned to take place in late May or early June, therefore the exposed population will include permanent residents of Waskesiu and park visitors. The geographic extent of the Waskesiu spray program includes the entire townsite, including campgrounds, day use areas, and business lots.

The total exposed population can be estimated at 5000, which is the average number of residents, visitors, campers, and cottage and cabin owners that stay overnight at Waskesiu on summer weekends (Parks Canada 2000). If spraying were to occur mid-week, the total number of individuals exposed would be reduced. According to the 1998 park gate survey, park visitors were most likely to have included a Saturday, Sunday or Monday in their park visit. The timing of the spraying will be dependant on the larval development of the spruce budworm and spruce shoot.

5.1.2.6 Inhalation Exposure

There is no evidence in the scientific literature or from surveillance programs that Btk is a human pathogen and has caused disease or illness in any population. There are therefore no human health impacts predicted from inhalation exposure to Btk during the Waskesiu spray program.

There is a potential for residents to inhale Btk directly during the aerial application of Foray 48B on Waskesiu townsite. The health risk assessment for the aerial and ground spray program in New Zealand determined that the droplets (100 µm diameter) of Foray 48B were not expected to penetrate further than the upper respiratory passages. Spore agglomerations of approximately 10–15 µm in diameter were expected to occur when the droplets dried, and these also would only be expected to penetrate as far as the upper to lower respiratory tract (Auckland Healthcare Service Ltd. 1997).

Nasal swabs and air samples were taken for both human surveillance studies following spraying of Foray 48B in British Columbia. Both Noble *et al.* (1992) and the Capital Health Region (1999) found positive nasal and air samples prior to the spray application and outside of the spray zone. Both studies determined that Btk was present in the environment of Victoria and Vancouver prior to the spray programs. Although an increase in culture-positive swabs was associated with the aerial spraying, no health effects or an increase in health symptoms were associated with these increases (Noble *et al.* 1992; Capital Health Region 1999). No evidence of increased health symptoms or health effects was found in the asthmatic children study group in the Victoria surveillance program (Capital Health Region 1999).

Teschke *et al.* (2001) measured airborne exposures to Btk during the aerial application of Foray 48B in Victoria, British Columbia. During the spraying, the average culturable airborne Btk concentration measured outdoors within the spray zone was 739 colony-forming units (CFU/m^3) of air. The outdoor concentrations decreased quickly with an initial half time of 3.3 h. Concentrations of Btk were also measured inside residences during the spraying where concentrations were initially two to five times lower than outdoors, but at five to six hours after spraying indoor concentrations exceeded those outdoors with an average of 244 CFU/m^3 compared to 77 CFU/m^3 outdoors. The study also found a drift of Btk outside the spray zone (a 125 to 1000 metre band). This drift was found to be related to fine aerosol sizes that remained airborne, and concentrations were related to wind speed and direction (Teschke *et al.* 2001). Human exposures to outdoor and indoor concentrations of Btk in Victoria did not result in any adverse health effects (Capital Health Region 1999).

Although there is no evidence of respiratory illness or disease associated with inhalation of Btk, Noble *et al.* (1992) reported an increase in self-reported respiratory irritation by spray workers during the spraying, and Aer'aqua Medicine Ltd. (2001) reported respiratory concerns as the most frequently reported health concern by Auckland residents. In both studies there were no associated increase in illness or disease (e.g., asthma, lower respiratory problems, lung disease) linked to these concerns.

5.1.2.7 Oral Exposure

There is no evidence in the scientific literature or from surveillance programs that Btk is a human pathogen and has caused disease or illness in any population. There are therefore no human health impacts predicted from oral exposure to Btk during the Waskesiu spray program.

Humans have been exposed to Btk in their natural environments for years, through water, soil, and the consumption of fruits, vegetables and other foods. Btk has been used for many years by organic and non-organic farmers throughout the world (Health Canada 2000). Btk is one of the few pesticides acceptable to organic growers as it is naturally occurring. Its safety record, and the results of more than 30 years of Bt investigation around the world, have led many countries including Canada, the United States, and most other countries where Bt products are currently registered, to declare it exempt from pesticide residue tolerances on food crops because of the minimal risk (Health Canada 2000).

In a review by Damgaard *et al.* 1996, strains of Bt belonging either to the subspecies *kurstaki* or *tenebrionsis* were found in pasta, pita bread and milk. In the 1999 surveillance studies conducted in Victoria, British Columbia (1999), Btk was observed on 3 of 17 food samples, and was distinguished from *B. Cereus*. The 1992 surveillance program by Noble *et al*. (1992) reported that 5 out of 10 vegetable samples were positive for Btk. The positive samples were obtained from both supermarkets and from organically grown products.

In some Asian countries, Bt subspecies *israelensis* (Bti) has been added to domestic containers of drinking water for mosquito control. From these high Bt exposures in drinking water, no adverse effects in humans have been reported (WHO 1999, Internet site). African rivers have been dosed with Bti at weekly intervals for blackfly control. No adverse effects in the human populations that drink the river water have been reported (WHO 1999, Internet site).

Btk will be sprayed adjacent to Waskesiu Lake at the Waskesiu townsite. Some Btk will likely enter the lake during the spray program from spray drift. Past studies have indicated that Btk can survive in lake water for one to two months (Menon and De Mestral 1985).

A study completed in Nova Scotia detected Btk in the municipal water system after a spray program (Menon and De Mestral 1985). It is therefore possible that a small amount of Btk may enter public water supplies during the Waskesiu spray program. However, the presence of Btk in water is not considered to cause any adverse effects on human health, as it is not a human pathogen. While it is possible that residents swimming in Waskesiu Lake may be exposed to low levels of Btk by inadvertedly consuming small amounts of water, this is not predicted to cause any adverse health effects. No human health effects are predicted from oral exposure of residents to Btk during the Waskesiu spray program.

5.1.2.8 Dermal Exposure

During the aerial application of Foray 48B in Waskesiu, individuals may be exposed to Btk through their skin via direct deposition on the skin, and indirect exposure through residues left in soil and lake water. There is no evidence in the scientific literature or from surveillance programs that Btk is a human pathogen and has caused disease or illness in any population. Therefore no adverse health effects are expected to result from dermal exposure to Btk during the Waskesiu spray program.

Damgaard *et al.* (1997) isolated Bt in burn wounds involving 30-70% of two patient's bodies. The Bt originated in the hot water the patients had been immersed in upon arrival at the burn center. None of the isolates showed any toxicity to Vero cells. Damgaard *et al.* (1997) concluded that Bt does not represent a health hazard when used as a microbial pesticide.

Hernandez *et al.* (1998 in ADHB 2000) isolated *Bacillus thuringiensis* subsp. *konkukian* from a severe war wound and found that the strain could infect immunosuppressed mice after cutaneous application. This particular strain is not found in Foray 48B, however.

Warren *et al.* (1984) reported that a research worker developed a marked local reaction and lymphadenitis following a needle stick injury when handling *Bacillus thuringiensis* subsp. *israelensis* and *Acinetobacter calcoaceticus* subsp. *antitratus*. *Acinetobacter calcoaceticus* and Bt were cultured from the exudate. The condition responded to penicillin and the patient recovered after 5 days. Auckland District Health Board (ADHB) (2002) states "there in no clear evidence that Bt was the sole cause of the infection" and suggests that *Acinetobacter calcoaceticus* is more likely the causative agent.

5.1.2.9 Ocular Exposure

During the aerial application of Foray 48B in Waskesiu, individuals may have some ocular exposure to Btk, via direct deposition into the eye. There is no evidence in the scientific literature or from surveillance programs that Btk is a human pathogen and has caused disease or illness in any population. Therefore no adverse health effects are expected to result from ocular exposure to Btk during the Waskesiu spray program.

There is one case in the scientific literature that links exposure to Btk to an ocular infection, but it has been criticized for not considering the option that Btk was simply occupying the eye and was not the cause of the infection (Joung and Côté 2000). Samples & Buettner (1983) reported that a farm worker developed a corneal ulcer in one eye. It had been accidentally splashed with a commercial Btk product and Bt was subsequently isolated from the affected eye. The eye was treated with a topical antibiotic and corticosteroid and the corneal ulcer resolved 14 days after treatment. The report attributed the corneal ulcer to Bt infection. However, the possibility that Bt may have been a non-pathogenic contaminant of the ulcer was not considered. There are no other reports of Bt being associated with ocular infections in workers (WHO 1999, Internet site).

The USDA has classified Bt as a mild eye irritant, which causes temporary irritation of the iris (USDA 2002, Internet site). Health Canada (PMRA) has assessed the irritation studies on Foray 48B and concluded that it is a mild eye irritant, thus requiring no cautionary statement on the front (principal) panel of the product label (Belliveau 2003). Noble *et al.* (1992) noted symptoms of eye irritation reported by spray workers during a ground spray program of Foray 48B. The workers were being exposed at levels 500 times greater than the general public, and the symptoms were transient in nature with no adverse health impacts resulting. No ocular irritation is expected for residents and visitors of Waskesiu from exposure to Btk during the spray program.

5.1.2.10 Psychological Hazards

Surveillance programs vary in their assessment of anxiety in the general public as a result of aerial applications of Foray 48B. According to the Capital Health Region (1999) study, the general population survey was unable to detect any effects on short term mental or physical health in the population pre- or post-spray, within or outside of the spray program. In the health risk assessment completed by Auckland Healthcare Services Ltd. (1997), they detected a great deal of community anxiety and reported a proportion of the population that considered their mental and physical health had decreased after the spray program.

5.1.2.11 Conclusion

There is no evidence in the scientific literature or from surveillance programs that Btk is a human pathogen and has caused disease or illness in any population. In considering all exposure pathways, no adverse health effects are predicted for residents or visitors of Waskesiu during the Waskesiu spray program.

Although not related to illness or disease, there may be some level I impacts experienced by residents in regards to respiratory irritation and anxiety and stress. Respiratory irritation could be characterized as similar to irritation as experienced by individuals when exposed to pollen or other airborne materials.

5.1.3 Proposed Mitigation

No mitigation is recommended with respect to adverse human effects as the assessment has shown that there will be no risk of adverse human health effects from proposed application of Foray 48B. Health Canada advises that although individuals may be exposed to Btk during the aerial spray programs, they are unlikely to experience any symptoms from this exposure (Health Canada 2000).

To reduce the potential for respiratory irritation associated with the spray program, the following mitigation measures are recommended:

Residents remain indoors during the aerial application, with doors and windows shut, and the timing of the spraying may be planned in early morning or at time where human outdoor exposure will be minimized. Health Canada and other jurisdictions, such as the British Columbia government have advised the public in similar manner, although it is not required by health officials (Health Canada 2000).

To reduce levels of anxiety and stress associated with the Waskesiu spray program, the public should be notified prior to the aerial applications, and parks staff in Waskesiu should be accessible to respond to concerns.

5.1.4 Residual Impacts

There is no evidence in the scientific literature or from surveillance programs that Btk is a human pathogen and has caused disease or illness in any population. Therefore no residual adverse health effects are expected to result from exposure to Btk during the Waskesiu spray program.

Based on the scientific literature and health studies cited in Sections 5.1.2 and 5.1.3, no adverse health effects are predicted for residents or visitors through exposure to Btk from inhalation, dermal, ocular or oral exposure during the Waskesiu spray program.

5.1.5 Cumulative Effects

As there are no predicted adverse effects on human health from the Foray 48B spray program, the spray program is not predicted to contribute to cumulative effects on human health with other park stressors.

5.2 Wildlife

5.2.1 Local Characteristics

5.2.1.1 Prince Albert National Park

Prince Albert National Park encompasses grassland, grassland-forest transition, boreal and permafrost environments. This diverse landscape supports a wide range of fauna including 58 mammal species, 230 bird species, five amphibian species, one species of reptile, 20 fish species, up to 92 species of butterflies, and an undetermined number of other terrestrial and aquatic invertebrates (Environment Canada 1986; Frandsen 2003, pers. comm.). The condition of wildlife populations and their associated habitats are measures of the strategic management goal of ecological integrity within PANP.

PANP's diverse assemblage of wildlife and insect species is in large part due to PANP's location along a transition zone between the boreal plain and prairie ecozones, resulting in the presence of many species that are at the limit of their typical ranges. Species associated with the prairie ecozone are at or near the northern extent of their ranges. These species include the prairie shrew, white-tailed jackrabbit, Richardson's ground squirrel, Franklin's ground squirrel, thirteen-lined ground squirrel, northern pocket gopher, Manitoban elk, western jumping mouse, raccoon and American badger. Species associated with the boreal plain ecozone are at or near the southern edge of their range.

These species include the water shrew, northern bog lemming, heather vole, river otter, American marten, gray wolf and woodland caribou (Environment Canada 1986).

Of PANP's mammal species, the park's bison herd has national significance as it represents the only herd of free-ranging plains bison (*Bison bison bison*) located within their historic range in a Canadian national park. The status of the plains bison is under review by COSEWIC and The World Conservation Union (IUCN), although, the population within the park does not occupy habitats near the townsite (Table 1) (Frandsen 2003, pers. comm.). The woodland caribou (*Rangifer tarandus caribou*) is also a species of special interest to the park as it is listed as a threatened species by COSEWIC (2002) (Table 1). Woodland caribou may potentially be found within five to 10 km of the Waskesiu townsite; however, this would be an uncommon occurrence (Frandsen 2003, pers. comm.). Moose (*Alces alces*), deer (*Odocoileus hemionus* and *Odocoileus virginianus*) and elk (*Cervus elaphus* subsp. *manitobensis*) are common throughout the park and can be found within the Waskesiu townsite. PANP population sizes are estimated at 1000 and 350 to 400 animals for moose and elk, respectively (Frandsen 2003, pers. comm.).

Representative bird species in PANP include breeding species, migrants and accidental wanderers (Environment Canada 1986; Frandsen 2003, pers. comm.). Waterfowl occur in the park wherever suitable marsh environments, abundant invertebrates, and plentiful emergent and submergent vegetation exist (Environment Canada 1986). Of the 22 waterfowl species that have been recorded, 14 species breed within the park (Environment Canada 1986). Of particular note is the second largest breeding colony in Canada of the American white pelican (*Pelecanus erythrorhynchos*) which nests in the northern portion of the park (Environment Canada 1986).

Species lists are not available for invertebrate populations in PANP, but the park supports a number of moths, butterflies and others insects. None of the Lepidoptera species currently listed as endangered or threatened by the COSEWIC occur in Saskatchewan (COSEWIC 2002). However, the monarch butterfly (*Danaus plexippus*) is a species of special concern (COSEWIC 2002), and occurs both in PANP and the Waskesiu townsite (Table 1) (Environment Canada 1986; Frandsen 2003, pers. comm.).

5.2.1.2 Waskesiu Townsite

An estimated 34 mammal species, six herpetile species, and 81 bird species have been known to use the townsite area as temporary or permanent habitat (Cumming 2002). However, almost all wildlife species present in the park are occasionally found within the townsite, including wolves, bears, muskrat, beaver, squirrels, skunks, a variety of birds, amphibians, fish and invertebrates (Frandsen 2003, pers. comm.).

Deer, elk and red foxes are commonly found in and near the townsite (Cumming 2002; Frandsen 2003, pers. comm.). An elk herd numbering approximately 100 head occupies the area between Waskesiu townsite, the eastern park boundary, and the south end of Waskesiu Lake. The golf course and the thinned deciduous forest in the community fuel break are used to the greatest degree by this herd (Frandsen 2003, pers. comm.). Approximately two to three black bears and their offspring reside in the townsite for more than two weeks annually and many transient bears are also seen within Waskesiu (Cumming 2002).

A wide variety of bird species nest in or visit the Waskesiu area and the lakeshore near the townsite. White pelicans have been observed foraging on Waskesiu Lake, typically from June 15 to July 20 (Environment Canada 1986). Barred owls (*Strix varia*) are known to nest along the access trail west of the Beaver Glen Campground (Cumming 2002). In the last few years there has been an observed increase in birds in Waskesiu that are known to forage preferentially upon spruce budworm larvae during budworm outbreaks. These include the Cape May warbler (*Dendroica tigrina*), bay-breasted warbler (*Dendroica castanea*), Tennessee warbler (*Vermivora peregrina*) and evening grosbeak (*Coccothraustes vespertinus*) (Parks Canada 2002). For these and other warbler species, some studies have shown positive correlations between warbler population densities and timing of budworm outbreaks (Christie 1998).

5.2.1.3 Special Status Species

There are a number of species identified as at risk by COSEWIC (2002) that may be found in PANP (Table 1). Of these species, only the monarch butterfly (*Danaus plexippus*) and the northern leopard frog (*Rana pipiens*) are commonly found in the Waskesiu townsite (Frandsen 2003, pers. comm.).

The monarch butterfly is migratory and can be found throughout southern Canada and into the central portions of the prairie provinces. The range of the monarch is associated with the distribution of milkweed plants on which it primarily lays its eggs. Monarch larvae feed on plants in the milkweed family, Asclepiadaceae, and the potato, tomato and nightshade family, Solanaceae (Bird *et al.* 1995). The monarch butterfly reaches Alberta in late May to early June on its migration north (Bird *et al.* 1995) and likely reaches Saskatchewan within a similar time period.

The northern leopard frog is found throughout Saskatchewan and in most Canadian provinces, although its presence is limited in British Columbia and the southern fringe of the Northwest Territories (Russell and Bauer 2000). It can be found in springs, streams, marshes and other permanent waterbodies, especially those with abundant aquatic vegetation. Insects, spiders and other small invertebrates are the primary food source for the northern leopard frog (Russell and Bauer 2000).

Table 1 Wildlife Species at Risk that may be found in Prince Albert National Park COSEWIC (2002)

Species	COSEWIC Status (2002)
Whooping crane (*Grus americana*)	Endangered
Sprague's pipit (*Anthus spragueii)*	Threatened
Anatum peregrine falcon (*Falco peregrinus anatum)*	Threatened
Woodland caribou (boreal population) (*Rangifer tarandus caribou*)	Threatened
Least bittern (*Ixobrychus exilis)*	Threatened
Short-eared owl (*Asio flammeus*)	Special Concern
Monarch butterfly (*Danaus plexippus*)	Special Concern
Wolverine (western population) (*Gulo gulo*)	Special Concern
Northern leopard frog (boreal population) (*Rana pipiens*)	Special Concern
Yellow rail (*Coturnicops noveboracensis*)	Special Concern
Plains bison (*Bison bison bison*)	Under review by COSEWIC and IUCN

5.2.2 Potential Project Effects

Animals and insects may be affected by the application of Btk through direct and indirect means. The potential for direct (toxic or pathogenic) effects may occur as a result inhalation of Btk, through dermal contact, or from ingestion of either plants or insects contaminated with Btk. Indirect effects may occur if Btk measurably impacts on a species' food source (e.g., target or non-target Lepidoptera), thus potentially affecting the species' recruitment and survival rates. In addition, indirect effects of the proposed spray application program may also include the effects of noise from low-flying aircraft required in the application of Foray 48B.

5.2.2.1 Direct Toxicity and Pathogenicity Effects

Amphibians and Reptiles

There is no indication that there are any adverse effects produced by Bt spraying on amphibians or reptiles (Joung and Côté 2000). WHO (1982) reported no Bt-related adverse effects in a review of laboratory and field studies on frogs (*Hyla regilla*, *Rana temporaria*), newts (*Taicha torosa*, *Triturus vulgaris*) and toads (*Bufo* species). Hence, with particular concern for the Northern leopard frog, which is known to occur in and around Waskesiu, no direct effects of proposed use of Foray 48B are anticipated.

Birds

The United States Library of Medicine (USLM 1995) has not found Bt to be toxic to birds. Based upon various toxicity studies of the mallard duck and the bobwhite quail, the USEPA (1998) states that Btk is not toxic or pathogenic to birds after acute or sub-acute testing. The mallard duck and the bobwhite quail were exposed to 1.6–2.9 g/kg Btk/day for five days and the study deemed Btk practically nontoxic. The LC_{50} was measured as greater than 1.8×10^{10} spores/kg body weight in both the mallard duck and the bobwhite quail (USEPA 1998). Similarly, Lattin *et al.* (1990a, 1990b) administered daily oral doses of 2857 mg/kg/day Btk formulation to young bobwhite quail (*Colinus virginianus*) and young mallards (*Anas platyrhynchus*) and observed no signs of toxicity or pathogenicity. In laboratory studies on Btk in cockerels, cornish chicks, laying hens and chicks, partridge, quail and wild pheasant, no adverse effects were observed (Fisher and Rosner 1959; Ignoffo 1973).

Avian chronic studies have not been required by the USEPA (1998) as a result of the lack of toxicity and pathogenicity in the acute and subacute testing.

Mammals

Bt is considered to be "practically nontoxic" to animals (Oregon State University [OSU] 1996, Internet site). Mammals have acidic stomachs that serve to degrade the Bt crystal to an atoxic form (Cooksey 1971). In addition, vertebrate cells were reportedly unsusceptible to the Bt toxin even after activation by insect digestive enzymes (Retnakaran *et al.* 1982). Available information shows there is no risk of direct toxic effects, infectivity, or pathogenicity for mammals in PANP with respect to the proposed use of Foray 48B. Eye irritation, as discussed in the section on human health, may occur in mammals, including household pets, following application of Btk. These effects are discussed further below.

Ingestion

No adverse toxic effects, infectivity, or pathogenicity were observed by the USEPA (1998) at doses up to 4.7×10^{11} spores/kg in mammals. No acute toxicity has been observed in dogs, guinea pigs, mice or rats where the highest dose was 6.7×10^{11} spores per animal (OSU 1996, Internet site). A single oral dose of 10,000 mg/kg body weight produced no adverse effects in mice, rats or dogs. Additionally, no mortality was observed in rats after a single oral dose of 1.4×10^{7} CFU Btk and 2×10^{11} CFU commercial Btk formulation per animal (Fisher and Rosner 1959; Shadduck 1980). The USEPA concluded that ingestion of Bt posed no risk to the organisms.

No chronic toxicity has been observed in rats. No toxic effects were observed as the result of dietary administration of 8400 mg/kg body weight for 13 weeks in rats (Ray 1991). In addition, oral administration of 1.3×10^{9} Btk spores/kg/day to rats for three months was not toxic or infectious (McClintock *et al.* 1995). McClintock *et al.* (1995) also studied the effects of 8400 mg/kg/day of commercial Btk formulation fed to rats for two years. A reduced body weight was the only effect observed during weeks 10 to 104 of the study.

Repeated oral doses of 1×10^{12} CFU Btk formulation in sheep for 60 days, resulted in loose stool and moderate to marked lymphoid hyperplasia of the Peyer's patches in the caecum and colon (Hadley *et al.* 1987).

OSU's (1996) literature review of Bt states that there is no evidence that Bt causes reproductive, teratogenic (birth defects), mutagenic or carcinogenic effects in mammals. Rats given dietary doses of 8400 mg/kg/day for two years display no tumor-producing effects (Ray 1991).

Inhalation

The USEPA (1998) evaluated studies that measured acute pulmonary toxicity and pathogenicity in mammals and found no adverse toxic effects, infectivity, or pathogenicity at doses as high as 2.6×10^{7} spores/kg body weight.

The clinical signs were monitored for 15 days in 10 mice that were exposed to 2×10^{8} spores for 12 minutes (De Barjac *et al.* 1980). De Barjac *et al.* (1980) recovered no Bt in the lungs of the 10 mice. Siegel *et al.* (1987) exposed 27 rats to 2×10^{6} spores of commercial Bt formulation for 30 minutes. The rats were then euthanized and autopsied over 27 days. Three hours after exposure the rats' lungs contained 5.92×10^{3} CFU/g, which declined to non-detectable levels after seven days. No gross lung lesions were observed (Siegel *et al.* 1987). Similarly, 10 mice were exposed to 3×10^{10} spores of commercial Btk formulation four times over six days, and no clinical or gross pathology changes were reported (Fisher and Rosner 1959).

Dermal Exposure

The USEPA (1998) measured acute dermal toxicity and found no dermal toxicity at doses up to 4.7×10^{11} spores/kg body weight. Based on acute dermal laboratory tests in rabbits, the USDA (2002) considers Bt a mild-or non-irritant. A single dermal dose of 7200 mg/kg body weight did not produce toxicity in rabbits (Abbott Laboratories 1982). McClintock *et al.* (1995) reviewed studies, which indicated that dermal doses up to 2500 mg/kg body weight produced no toxic or pathogenic effect in rabbits. Fisher and Rosner (1959) applied 2.2×10^{6} CFU of commercial Btk product to the skin of scarified rabbits and found no skin inflammation or infection.

Ocular Exposure

Bt is a mild eye irritant, which causes reversible irritation of the iris (USDA 2002, Internet site). Redness and swelling around the eye of rabbits resulted from the direct application of 100g of formulated Bt to each eye (Siegel and Shadduck 1990). Likewise, McClintock's (1995) review found Bt to be a mild eye irritant following ocular administration.

Field Studies

Buckner *et al.* (1974 in Joung and Cote 2000) studied the effects of Bt treatments in the field on small mammals such as woodland jumping mice, deer mice, short-tailed shrews, common shrews, red-backed voles and eastern chipmunks. There were no observed effects on breeding birds and trapping data suggesting that no harm was done to the small mammal infrastructure in the Bt treatment areas.

Innes and Bendell (1989) further studied the effect of commercial Btk product on small mammal populations (eight rodent species and four shrew species) over a three-month period. The Btk-treated populations were deemed unaffected relative to the untreated populations, demonstrating that the ingestion of infected insects by small mammals will have no direct effect on small mammal populations (WHO 1999, Internet site).

Non-Target Lepidoptera and Other Insects

Studies of the effect of Btk on Lepidoptera species yield variable results (Joung and Cote 2000). Wagner *et al.* (1996, in Joung and Cote 2000) reported that although lepidopterans were not eliminated by a single spring application of Bt at 90 Billion International Units (BIU)/ha, early instar swallowtail butterflies (*Papilio* spp.) were sensitive to Bt-treated foliage up to 30 days after application. Boulton *et al.* (1999) conclude that early spring applications of Btk cause immediate reductions in many species of non-target lepidopteran, and that Btk is hazardous to many butterfly species. Lepidoptera populations were reduced for one to two years following Btk application in many studies (Boulton *et al.* 1999). However, except in areas that support small, isolated populations of lepidopterans, Bt does not seem to permanently affect butterfly populations (Joung and Cote 2000).

Btk is not considered toxic to honey bees and other non-lepidopteran insects including Neuroptera, Hymenoptera, Coleoptera, Arthropoda and Annelida group indicator species when applied according to label instructions (USEPA 1998; Joung and Cote 2000; PMRA 2000, Internet site; Valent BioSciences Corp. 2001). Btk is, however, toxic to bees and earthworms at doses greater than prescribed by the label (Information Ventures Inc. 1995). Some studies have found Btk to be toxic to nematode eggs, larvae and adults (Bottjer *et al.* 1985; Meadows *et al.* 1990, both cited in Addison 1993). Population decreases were also found for ground beetles and carabid beetles after application of Btk (Buckner *et al.* 1974, cited in Addison 1993; Obadofin and Finlayson 1977). It is not known what nematode and carabid species occur in the Waskesiu area, nor how these local species may or may not respond to Btk as reported in the studies above.

In summary, it is anticipated that application of Foray 48B may lead to mortality of non-target lepidopterans and other potential insect species such as nematodes and carabid beetles. These impacts may affect notable species such as the monarch butterfly (larvae), which is considered to be of special concern (COSEWIC 2002) in Canada. Because effects of application of Foray 48B in Waskesiu will be short term, reversible through immigration following spray operations, and localized in the context of PANP, effects are considered Level I and within acceptable levels within the context of PANP Management Plan guidelines and goals for ecological integrity.

5.2.2.2 Indirect Btk Effects

Amphibians and Reptiles

Immediately following spray operations, there is potential for species such as the Northern leopard frog to ingest budworm cadavers that may contain Btk. Because there are no reported direct toxicity effects of Btk on amphibians and reptiles, it is concluded that indirect ingestion also poses no risk of impact to species in the Waskesiu area.

Birds

No primary effects of Btk or Foray 48B applications have been reported in avian species. However, secondary impacts of Btk spraying on bird populations have been documented related to the reduction of food (caterpillars and other affected insects) abundance. In sprayed plots, there has been an observed reduction in the number of caterpillars ingested and, in cases where there was no supplementary food available, a reduction in the number of nesting attempts per bird per year (Gaddis and Corkran 1986; Rodenhouse and Holmes 1992). Despite the fewer nesting attempts, there was no observed reduction in the number of young produced per territory per season per year and after two years the caterpillar abundance in the treated area was equivalent to that of the control area (Rodenhouse and Holmes 1992).

The proposed spray program is intended to reduce spruce budworm populations from epidemic or very high levels to low to moderate levels. Based on past studies and those underway, this change in spruce budworm population is not anticipated to alter the number of larvae available to birds as a food source (McIntosh 2003, pers. comm.).

In independent studies, Bendell *et al.* (1990) and Hobson and Cumming (1995) both found that the reduction in caterpillar abundance due to Btk treatment resulted in a decrease in the overall number of warblers and thrushes. Similar studies were conducted on chicks of spruce grouse (Norton *et al.* 2001). Lepidopteran larvae make up approximately 64 percent of spruce grouse chicks' diet, as opposed to the mainly herbivorous diet of spruce grouse adults (Lattner 1982). Norton *et al.* (2001) monitored chick growth and gizzard content of the chicks raised in Btk-treated forest relative to those raised in the control sections of the forest. The Btk-treated chicks were found to grow 30 percent slower than those raised in the control areas. The reduced growth rate was attributed to a protein-deficient diet resulting from a lower abundance of larvae.

In contrast to the previous studies mentioned, Buckner *et al.* (1974 in Joung and Cote 2000) determined there were no significant reductions in 74 bird populations in a Canadian spruce-fir forest after aerial spraying of Btk. Likewise, Sopuck and Ovaska (2001) detected no adverse effects on the relative abundance, territory maintenance, and productivity of eight of 10 songbird species. The relative abundance of the spotted towee and the bushtit decreased post Btk treatment; however, the authors suggested that these declines were likely attributable to differences in habitat suitability and not a reduction in prey. Stantec (1998) found that chipping sparrows did not seem to be affected by Btk spraying as the spray program studied may not have reduced arthropod abundance below the level that might resulting breeding failure.

In summary, while field studies show variability in the indirect effects that Btk may have on bird populations, bird species in and around Waskesiu, particularly species such as Cape May warbler, bay-breasted warbler, and evening grosbeak that preferentially forage on spruce budworm larvae, may be locally affected by loss of budworm larvae. Effects may include dispersal away from the locally affected area, and potential reductions in nesting attempts or successes in the locally affected area. These effects are considered short term and, with immigration, reversible following completion of the proposed spray program.

Mammals

There is very little information available in regards to any secondary effects of Btk spraying on mammals. However, it may be presumed that true insectivorous species, such as shrews and bats, could be susceptible to the secondary effects of Btk treatment. Population dynamics, diet and prey selection of the masked shrew were observed post Btk application (Bellocq *et al.* 1992). Following the application of Btk in Waskesiu, there may be reductions in Lepidoptera food sources that may cause mammals such as shrews to disperse from the treatment area or reduce recruitment during the reproductive year. The decrease was suggested to have been the result of an altered dispersal behaviour that could be attributed to the reduction in prey species (Bellocq *et al.* 1992). In summary, while not extensively studied, available data indicate the potential for indirect effects on insectivorous mammals. Following proposed Btk application in Waskesiu and with potential reductions in lepidopteran food sources, mammals such as shrews may disperse from the area or potentially may see reductions in recruitment during that reproductive year. Bats forage on adult moths which, although likely to immigrate to some degree into the Waskesiu area later in the summer, may also see some continuation of decreased numbers as a food source for bats. Collectively, if these potential indirect effects of Btk application on mammals in Waskesiu were to occur, they would likely be localized within the context of PANP, reversible through immigration in years following spraying, and thus also temporary over time.

5.2.2.3 Noise Effects from Low-flying Aircraft

Proposed application of Foray 48B over Waskesiu is anticipated to occur twice during May through mid-June, and potentially will be conducted over a period of three consecutive years. The method of application, fixed-wing aircraft, will involve low altitude flights over the spray area, the noise of which in turn may lead to disturbance of local wildlife. The May and June period is particularly sensitive with respect to forest bird species, many of whose breeding periods overlap this period of time. For the following reasons, this potential disturbance-related impact is not, however, predicted to lead to measurable effects on breeding activity or local populations of breeding bird species during or following years of application. There are no species that occur in PANP that are also only known to occur in Waskesiu. Hence, within the context of PANP, no one species will be particularly vulnerable to disturbance-associated effects from aircraft noise over Waskesiu. Further, species that may nest in the Waskesiu townsite will already, to some degree, be tolerant of human activity, vehicle noises and other potential sources of disturbance. Finally, any effects of disturbance will be very short term and localized within the Waskesiu townsite boundaries. Consequently, while some short-term disturbances may occur, it is predicted that these will not result in any measurable effects on bird breeding populations in Waskesiu or PANP.

5.2.3 Proposed Mitigation

There are no mitigations recommended to address potential Level I direct toxicity effects on non-target lepidopterans as these potential effects will be localized, short term and reversible via immigration of mobile (winged) adults from areas encompassing Waskesiu. Similarly, as effects may be short term and localized, there is no mitigation recommended to address potential Level I indirect effects on mammals and birds that feed on spruce budworm and other lepidopterans. Nonetheless, in order to help achieve minimal impacts to terrestrial animals and non-target insects, it is recommended that application procedures outlined by Health Canada and the manufacturer be followed.

To help reduce chances of potential eye irritation in mammalian pets, mitigation recommended for this same effect in the human health component of this screening (Section 5.1.3), are recommended to be adopted here.

5.2.4 Residual Impacts

The use of Btk as a microbial insecticide, poses no significant threat of toxicity to non-target terrestrial wildlife at standard application levels. Some impact is possible, however, via secondary effects of Btk application on vertebrate species, particularly those that are primarily dependent upon lepidopteran invertebrates. If there are indirect effects on non-target species, they will be short term, reversible through migration from non-impacted habitats and small in scale with respect to the area and communities encompassed by PANP. Consequently, this is considered a potential Level I impact and is acceptable within the strategic goals and management directions for PANP.

With respect to forest insects, particularly non-target Lepidoptera, the application of Btk in Waskesiu will incur direct mortality. This effect is anticipated to be short term, reversible through immigration following spray operations, and localized in the context of PANP. This effect is, therefore, considered Level I and within acceptable levels within the context of PANP Management Plan guidelines and goals for ecological integrity.

5.2.5 Cumulative Environmental Effects

The proposed spray program will lead to direct, localized loss of lepidopterans within the Waskesiu area. This effect will in turn lead to a short-term, localized reduction in food availability for some insectivorous wildlife species. There is potential, then, for this Level I effect to interact with other ongoing or future foreseeable activities beyond the Waskesiu townsite boundaries, and that may affect, in cumulative fashion, Lepidoptera species populations in PANP. One future foreseeable activity that may result in such a cumulative effect is the prescribed burning of 1800 ha of forest in the MacLennan River area in the northeastern portion of PANP (Stolle 2003, pers. comm.). The prescribed burn will be undertaken during August and September of 2003, to create a fuel break between the Park and provincial lands, which in turn will more readily allow for natural fire regimes to occur within the Park. The forest to be burned is comprised of a variety of stand types, including mixedwood, early seral pine, and some older spruce stands.

Both prescribed burns and Waskesiu spray program will immediately incur direct mortality on Lepidoptera populations. Other wildlife and insect species will be affected by prescribed burning. However, the burn program is intended to allow for a more diverse forest composition to occur within the Park, which in turn will lead to diverse representation of Lepidoptera (and wildlife) species within PANP over the long term. This goal of allowing for a more natural fire regime and diverse forest insect and wildlife assemblage is counter to the localized goals of sustaining mature white spruce trees in Waskesiu. Over the long term, there will be no measurable cumulative effects from short-term temporal overlap between the Waskesiu spray program and prescribed burns in northeastern PANP. Overall, the predicted residual impacts from the aerial application of Btk will not combine with current and future developments to produce a measurable contribution to cumulative effects on wildlife and terrestrial insects in PANP. The predicted residual impacts from the aerial application of Btk will not combine with current and future developments to produce a measurable contribution to cumulative effects on wildlife and terrestrial insects in PANP.

5.3 Vegetation

5.3.1 Local Characteristics

Most of PANP is located in the Mid Boreal Upland Ecoregion (Saskatchewan Conservation Data Centre 2002). Distribution and composition of vegetation in PANP is influenced by the sub-humid, cool climate, and the undulating hummocky moraine deposits from the Pleistocene glacial period (Environment Canada 1986). Common tree species associated with moist well-drained upland sites in PANP include trembling aspen (*Populus tremuloides*), paper birch (*Betula papyrifera*), white spruce (*Picea glauca*), jack pine (*Pinus banksiana*) and balsam fir (*Abies balsamifera*), while larch (*Larix laricina*), black spruce (*Picea mariana*) and balsam poplar (*Populus balsamifera*) are associated with wet, poorly-drained lowlands (Environment Canada 1986). Common understorey plants species in PANP include bunchberry (*Cornus canadensis*), twinflower (*Linnaea borealis*), sarsaparilla (*Aralia nudicaulis*) and bishops cap (*Mitella nuda*) (Environment Canada 1986).

Vegetation in and around Waskesiu is primarily an aspen-white spruce forest type (Environment Canada 1986). This forest type is relatively common in PANP and occupies approximately 15 per cent of the total area (Environment Canada 1986). Other forest types located east of the town include a white spruce – larch community and a jackpine – white spruce community type (Environment Canada 1986).

The Waskesiu Community Plan outlines vegetation management objectives (Parks Canada 2000) including:

1. managing vegetation within the townsite such that species composition remains representative of southern Boreal Plains and Plateaux natural region
2. encourage leaseholders to maintain native vegetation on leaseholds
3. Parks Canada will replace stationary non-native species with native plant species on non-leasehold property
4. eradicate invasive species where possible or develop a plan to limit their dispersal if eradication is not possible
5. establish a tree planting program

5.3.1.1 White Spruce Defoliation and Mortality in PANP and Waskesiu

As discussed earlier, the spruce budworm outbreak that currently extends well beyond the boundaries of PANP has led to the defoliation of white spruce trees in Waskesiu since approximately 1996. In a recent assessment, BioForest Technologies Inc. (2002) estimated that 48.3 percent of white spruce in Waskesiu had experienced between 31 and 75 percent defoliation. The authors further predicted that 50 to 67 percent of white spruce in the townsite could be impacted, with 25 to 35 percent eventually suffering mortality.

This compares with a recent study from northern Alberta, where Volney and Stocks (2002) estimated that white spruce mortality rates incurred from an ongoing spruce budworm outbreak ranged from 2.21 to 2.76 percent of living trees per year, and with 22.7 percent of spruce trees experiencing mortality over a ten year period (1992 to 2002).

The majority of white spruce trees in Waskesiu are currently approximately 84 years old, having originated after a fire in 1919 (Croutch *et al.* 2002). Overall, the composition of white spruce in Waskesiu can be considered to be of mixed age due to planting of spruce that has occurred in more recent years. As 2003 will mark the fifth or sixth year of moderate to severe outbreak levels, and as mature trees experience mortality after four to five years of moderate to severe defoliation (MacLean 1980 *in* Meating 2002), tree mortality may occur in 2003. It should also be noted that, with or without the current budworm outbreak, natural aging processes would eventually begin to lead to incremental mortality in older trees over time.

5.3.1.2 Key Plant Species

Key vegetation species in both Waskesiu and PANP are those that have been identified as rare by the Saskatchewan Conservation Data Centre (CDC) (Appendix C). Common species that are significant for cultural reasons, such as white spruce and other coniferous species are also considered key species.

5.3.2 Potential Project Effects

The assessment of potential effects of Btk on vegetation considered the potential for direct toxicity effects, potential pathogenicity, the role that persistence could have if direct toxic effects were documented, and indirect effects, specifically the potential impact that Btk incurred losses of Lepidoptera or other organisms could have on specific plants or forest communities.

5.3.2.1 Btk Occurs Naturally

Btk occurs naturally in the environment and, in at least one study, has been found to occur on vegetation. In New Zealand, Bt was found to occur naturally on plants at a frequency of about 0.1 per cent of the total *Bacillus cereus B. thuringiensis* population (Damgaard *et al.* 1997 in Auckland Healthcare Service Ltd. 1997). Over 64 per cent of this Bt population was Btk, indicating that the population naturally persists either through natural propagation or through dispersal by insect larvae (Auckland Healthcare Service Ltd. 1997).

5.3.2.2 Potential Direct Effects of Btk on Vegetation

Toxicity of Btk is dependent on ingestion by an organism and exposure to appropriate digestive enzymes at pH of 9.0 to 10.5 (Falcon 1971 in Joung and Côté 2002, Internet site). Because plants do not ingest Btk and do not have mechanisms required to process it (Joung and Côté 2002, Internet site), plants cannot be affected directly by Btk. Available environmental assessment case studies and regulatory documents support this conclusion. There are currently no known reports of damage to plants caused by Btk (or Foray and DiPel) has been reported by USEPA (1998), Joung and Côté (2000), the Town of Nipawin (1999), and Valent Biosciences Corporation (2001). In addition, a Health Canada fact sheet does not include reports of negative impacts of Btk on vegetation and also specifies that Bt is one of the few pesticides acceptable to organic growers (Health Canada 2000).

5.3.2.3 Mutagenic Effects

Bt is believed to have mutagenic potential in plant tissue, although adverse effects from Bt on plant health have never been observed at field rates of application (Ray 1991; USDA 1995).

5.3.2.4 Persistence of Btk on Vegetation

Btk's potential to persist in the environment and on vegetation was raised as a potential area of concern in the Project Terms of Reference. As mentioned earlier, persistence is likely to be highly variable as Btk degradation is affected by a variety of factors including sunlight, rain, heat, acidic conditions, and microbes (BioForest Technologies Inc. 2002). BioForest Technologies Inc. (n.d.) reported that, in general, Btk could persist on foliage for three to seven days. Similarly, Sundaram *et al.* (1997, in Auckland Healthcare Service Ltd. 1997) found that Btk, following the application of Foray 48B, persisted on foliage for up to ten days when sprayed at a concentration of 1500 to 1600 ng/g of foliage. In contrast, Reardon and Haissig (1984) in Swadener (1994) found viable Btk spores were recovered from white spruce foliage one year after application. Despite variability in reports on persistence of Btk on vegetation, because there are no known toxicity effects to plants, persistence itself is not a factor in terms of having potential to exacerbate direct Btk impacts on plants.

5.3.2.5 Potential Indirect Effects of Btk on Vegetation

One way in which Btk may indirectly impact vegetation is through Btk's impact on non-target plant-pollinating species in the area. As noted in Section 5.2.2.1, the application of Btk will potentially lead to mortality of non-target Lepidoptera in the townsite. Theoretically, the loss of such non-target species may impact vegetation if mortality occurs to obligate pollinators for key plant species. Appendix D lists known relationships between individual butterfly species and plant families relevant to the park. Information confirming or refuting obligatory relationships between non-target Lepidoptera and rare vascular plant species in Waskesiu (Appendix C) was not found during this review and potential impact of Btk on these species is not known. Nonetheless, because the townsite is such a small area, the loss of mobile (winged) non-target Lepidoptera could readily be compensated by individuals of the same species that are free to immigrate into the treatment area from outside the townsite.

5.3.3 Proposed Mitigation

The assessment of available regulatory documents, scientific literature, and case studies indicates that there will likely be no direct impacts of Btk on vegetation in or around the townsite. Therefore, mitigation procedures specifically relating to direct or indirect effects of Btk on vegetation are not required.

5.3.4 Residual Impacts Classification

As indicated above, the proposed use of Btk in the townsite is anticipated to lead to no direct impacts on vegetation through either direct or indirect means.

5.3.5 Cumulative Environmental Effects

Because it is anticipated that there will be no impacts on vegetation from Foray 48B application in and near the townsite, the potential for Btk to interact with other factors that may be impacting on plants and plant communities is not a concern. Hence, an assessment of cumulative effects is not warranted.

5.4 Soils and Landforms

5.4.1 Local Characteristics

5.4.1.1 Prince Albert National Park

Prince Albert National Park is located primarily in the Waskesiu Hills Upland physiographic section, which is characterized by knolls and depressions comprised mainly of glacial till. Elevations range from 495 to 720 metres above sea level. (Environment Canada 1986). The effects of glaciation are evident throughout the park by the presence of a wide variety of glacial depositional and erosional features. Landforms such as glacial flutings, kame complexes, eskers, ice-thrust moraines, meltwater channels and terraces and kettles are present in PANP. However, these features occur in localized areas and the majority (approximately 70 percent) of the park is comprised of various types of ground moraine. Post-glacial landforms also occur such as organic deposits, sandspits, beach deposits and ice pressure ridges (Environment Canada 1986).

The dominant surficial material in PANP is till, which may be overlain by thin stratified deposits. Organic deposits accumulate in the depressions created by the hummocky landscape and on poorly drained plains. Organic deposits comprise approximately 20 percent of the park and are associated with landforms such as bowl bogs and fens, floating and stream fens. Glaciofluvial and glaciolacustrine materials are also present in PANP to lesser extents (Environment Canada 1986; Saskatchewan Institute of Pedology 1978a).

Soils in PANP are dominantly Gray Luvisols and Mesisols, although many subgroups are present in lesser amounts (Saskatchewan Institute of Pedology 1978b; Environment Canada 1986). The park is characterized by a complex soil distribution due to the high landscape variability.

Several sensitive landforms were identified by Parks Canada including organic landforms, permafrost and erosion-sensitive landforms such as beaches, banks and steep slopes (Environment Canada 1986). A unique marl deposit, organic soils, valley complex soils and erosion sensitive soils have also been identified as sensitive to disturbance (Environment Canada 1986).

5.4.1.2 Waskesiu

The Waskesiu townsite is located in the Emma Lake Upland physiographic subsection, which is an undulating to hummocky morainal plain. Elevation in this subsection ranges from 510 to 570 m and slopes are generally within 0.5 to 9 percent (Environment Canada 1986).

Glacial till parent material and Luvisolic soils are present throughout most of Waskesiu. Luvisolic soils formed on coarse textured glaciofluvial deposits and poorly drained Gleysolic and Organic soils may also be present (Saskatchewan Institute of Pedology

1978a; Saskatchewan Institute of Pedology 1978b; Environment Canada 1986; Cumming 2002). Brunisols and Regosols occur along the perimeter of Waskesiu Lake where coarse textured beach and lacustrine deposits retard soil development.

The dominant soil association in the community of Waskesiu is Waitville (Saskatchewan Institute of Pedology 1978a). Waitville soils are formed on medium to moderately fine, moderate to strongly calcareous glacial till. Drainage is generally good on upper and mid slopes, but can be imperfect or poor on lower slopes and in depressions. Several soil subgroups are classified within the Waitville association including Orthic Gray Luvisols, Dark Gray Luvisols, Gleyed Gray Luvisols and peaty Gleysols.

5.4.2 Potential Project Effects

5.4.2.1 Btk and Soil

Btk can be transferred into the soil through direct spraying, insect cadavers and runoff from vegetation. Btk can also potentially be released into the soil from an accidental spill during the proposed spray program. Three main issues arise from the literature regarding potential impacts to soil. These issues are the persistence and movement of Btk in the soil and its effect on non-target soil organisms.

Btk is a naturally occurring soil bacterium with a worldwide distribution, including Canada (Martin and Travers 1989 in Addison 1993). Indigenous Bt species (not necessarily Btk) have been found in Saskatchewan mixedwood soils at relatively low levels (Visser and Walker 1996). Btk occurs throughout a wide range of conditions including forest, agricultural, steppe and tundra soils.

Once absorbed into the soil and protected from UV radiation, Btk spores can survive for up to a year and possibly longer (Petras and Casida 1985; Cardinal and Marotte 1987; Delisle *et al.* 1991; McBride and Coyle 1981, all cited in Addison 1993; Auckland Healthcare Service Ltd. 1997). Visser and Walker (1996) found no decrease to viable Btk spore levels two years after spraying. Btk spores remain viable throughout a range of soil pH; however, the ability of the spores to germinate is pH dependent (Petras and Casida 1985 in Addison 1993). Research indicates that Btk spores will germinate at pH ≥4.8 (Saleh *et al.* 1970 in Addison 1993). No clear relationship between Bt and soil type, moisture content or temperature has been found (McBride and Coyle 1981; Petras and Casida 1985, cited in Addison 1993).

5.4.2.2 Btk Direct Impacts on Soil Organisms

Information available for the purposes of this assessment indicates some uncertainty with respect to potential toxic effect of Btk on soil organisms. The PMRA assesses the health and environmental risks of all pesticides, including assessment of environmental fate and toxicology, before registration and use in Canada (Health Canada 2001a). The pesticide proposed for application within Waskesiu, Btk formulation Foray 48B, has been approved for use by Health Canada with potential impacts on non-target soil organisms not discussed as being of concern. The USEPA (1998) concluded that studies show little to no toxicity or pathogenicity in the tested Neuroptera, Hymenoptera, Coleoptera, Arthropoda and Annelida group indicator species. In recent available assessment reports, the potential for Btk to affect soils and soil organisms from the application of Btk were not discussed (Ministry of Environment, Lands and Parks 1999; Nobel *et al.* 1992; Town of Nipawin 1999). Visser and Walker (1996) investigated the impact of repeated applications of Foray 48B on Collembola and mite populations in a Saskatchewan mixedwood stand. No effects of elevated levels of Btk on Collembola and mite populations were detected, in fact the highest mite populations (Oribatida, Mesostigmata and Prostigmata suborders) were found in stands recently sprayed with Foray 48B.

In contrast to the PMRA and USEPA reports, some studies have found Btk to be toxic to nematode eggs, larvae and adults (Bottjer *et al.* 1985; Meadows *et al.* 1990, both cited in Addison 1993). Population decreases were also found for ground beetles and carabid beetles after application of Btk (Buckner *et al.* 1974, cited in Addison 1993; Obadofin and Finlayson 1977). It is not known, however, what nematode and carabid species occur in the Waskesiu area nor how these local species may or may not respond to Btk as reported in the studies above. Additionally, early formulations of Btk-based pesticides often contained solvents and petroleum products, thus toxicity may reflect the effects of these additions rather than that of Btk. The current formulation of Foray 48B does not contain these products and is essentially water and starch based (McIntosh 2003, pers. comm.).

While Btk may be toxic to some soil organisms, the area to be sprayed encompasses a relatively small area of land within the context of PANP. Waskesiu is also situated beside forested terrestrial communities that will not be sprayed. As such, if non-target soil organisms were to be impacted by Btk spraying, losses would be small within the context of PANP and would likely be compensated over time by individuals of the same species moving into the treatment area after spraying is complete. Recolonization can also occur from populations lower in the soil profile that are not affected by the aerial application of Btk.

5.4.2.3 Competition with Indigenous Soil Microorganisms

Several studies have observed that Bt cannot compete successfully with other indigenous microorganisms, leading to a low likelihood of germination and population growth (Addison 1993; Auckland Healthcare Service Ltd. 1997). Limited germination of Btk spores was found in a Saskatchewan mixedwood soil, but after 5 days no microcolonies were present (Visser and Walker 1996). The persistence of Bt crystals in the soil is also dependent on the presence and activity of other microorganisms (West and Burges 1982, in Addison 1993).

5.4.2.4 Btk Movement Within Soil

The potential for movement of Btk within soil was of interest because of the associated potential for leaching into the groundwater. Results of several studies, however, indicate that Bt does not move or leach with groundwater (Krieg 1983, 1988; Delisle *et al.* 1991, all cited in Addison 1993; Martin and Reichelderfer 1989; DeLucca *et al.* 1981, both cited in Joung and Côté 2000).

5.4.2.5 Btk and Soil Nutrient Cycling

There is no report of an expectation that the introduction of Btk will affect nutrient cycling processes within the soil profile. Several researchers found no effects or population increases when studying the effect of Btk additions on fungi, nematodes, earthworms, and other soil organisms (Petras and Casida 1985; Benz and Altweg 1975; Krieg 1983, all cited in Joung and Côté 2000; Visser *et al.* 1994). Earthworms (*Eisenia foetida* and *Dendrobaena octaedra*), Collembola and mites are important for nutrient cycling in most forest ecosystems. These soil fauna were found to experience no adverse effects on survival, growth and reproduction from repeated Btk (Foray 48B and Dipel 48AF) exposure (Visser and Walker 1996).

5.4.3 Proposed Mitigation

Parks Canada will ensure that an appropriate spill contingency plan is in place to prevent, contain and clean up a spill in the event that one occurs. Detailed records of the spray program including location, rates, dates, ambient conditions and other relevant information will be documented for future interpretation and use.

5.4.4 Residual Impacts Classification

The PANP Management Plan outlines a vision statement to preserve biodiversity and sustain ecological integrity. Soils and landforms are an integral part of an ecosystem and residual impacts were evaluated in terms of their effect on ecological integrity.

Residual impacts on soils and landforms of the proposed Btk spraying program will be constrained to the spray area. The proposed spray program will not impact the sensitive landforms and soils identified by Parks Canada (see section 5.4.1.1). Movement of Btk into groundwater is not of concern due to the relative immobility of Btk in soil. Changes in soil productivity and fertility due to Bt are not likely because of Bt's natural occurrence in soil, lack of accumulation, and relatively short persistence (USDA 1995, cited in Joung and Côté 2000).

The proposed spray program may potentially result in the mortality of specific soil macroorganisms, such as certain beetle and nematode species. Impacts to the size of these populations are predicted to be small and reversible. This impact is expected to be of a minor scale because of the size of the proposed spray area and the presence of similar soil environments on adjacent lands and throughout PANP. Consequently, this is considered a potential Level I impact. A potential measurable effect on the resource in question may occur but largely within or near the townsite spray boundaries, and that is considered acceptable within the strategic goals and management directions for PANP.

5.4.5 Cumulative Environmental Effects

The predicted residual impacts from the aerial application of Btk will not combine with current and future developments to produce a measurable contribution to cumulative effects on soils and landforms in PANP.

5.5 Aquatics

5.5.1 Waskesiu Lake Hydrology

The Waskesiu Lake drainage basin has an approximate area of 102,200 ha and lies within the Churchill River drainage basin. Drainage to Waskesiu Lake originates entirely within PANP boundaries (Environment Canada 1986). The lake receives inputs from numerous small streams that drain into both Kingsmere (via the Kingsmere River) and Waskesiu lakes (Environment Canada 1986). The primary outlet of Waskesiu Lake is the Waskesiu River, which flows in a northeasterly direction to the Park Boundary and into Montreal Lake.

Waskesiu Lake is approximately 6,831 ha in area (Environment Canada 1986) with an average depth of 11.1 m and maximum known depth of 24 m (Evans and Robarts 1999). The eastern portion of the lake is relatively large and strongly affected by winds, while the western arm of the lake is narrow and not as deep (Environment Canada 1986). Landslides caused by erosion have been identified at Prospect Point, located to the south of the Waskesiu Lake townsite (Environment Canada 1986).

Waskesiu Lake is located in the Waskesiu Hills Upland and is generally characterized by knolls and depressions made up of glacial till often overlain by a thin layer of stratified drift. Organic and lacustrine deposits are present throughout the area. Slopes in the area range from 0.5 (in the Emma Lake Upland) to 30 percent (at the Waskesiu Escarpment) and drainage in the area is generally well developed. The area within the spray zone is dominated by poplar (*Populus tremuloides*) and white spruce (*Picea glauca*) stands (Environment Canada 1986).

5.5.2 Water Quality

Thermal stratification of Waskesiu Lake is very weak in most years due to strong windstorms that cause mixing from the top to the bottom. In periods of calm, a weak thermocline may form, but it is susceptible to disruption from winds (Environment Canada 1986). The water is somewhat hard (approximately 156 mg/L $CaCO_3$, Environment Canada 1986) with a slightly alkaline pH (8.2). Total phosphorus concentrations range between 0.004 to 0.02 mg/L (Golumbia 1989), with the upper end of this range approaching the 0.025 mg/L recommended for the prevention of unwanted excessive growths of phytoplankton and/or aquatic macrophytes (Williamson 2002).

An assessment of three storm sewage effluents that enter Waskesiu Lake in the breakwater zone near the town of Waskesiu indicated that total suspended solids (TSS), nitrate/nitrite-nitrogen, ammonia-nitrogen, total phosphorus and fecal coliform bacteria were often elevated in these discharges (Golumbia 1989). Ammonia concentrations within the effluent discharges were well below federal guideline levels for the protection of freshwater aquatic life (CCME 2002), however, total suspended solids exceeded this guideline on some occasions and fecal coliform counts were in exceedance of the recreational water quality guideline of 200 CFU/100 mL on a number of occasions (CCME 2002). Subsequent assessments of fecal coliform bacteria along the main beach did not identify elevated levels in most samples however, high levels were found on some occasions (Cherepak, unpublished data in Cumming 2002).

Sewage from the town of Waskesiu is currently treated in a series of two wetlands prior to entering Waskesiu Lake via Beaver Glen Creek. A sediment core revealed an increase in the rate of sedimentation and increases in the fluxes of carbon, nitrogen, and phosphorus to Waskesiu Lake that largely began in 1950s (Cumming 2002). As changes of a similar magnitude were not noted in other lakes within the park (Kingsmere and Crean lakes) it was concluded that these increases were largely related to increases in human activity in and around Waskesiu Lake (Cumming 2002).

The breakwater near the main beach shelters the beach area from lake currents. This has reduced the natural flushing of the lake in this area, altering sediment transport and increasing the rate of sedimentation (Golumbia 1989, Cumming 2002).

Elevated levels of DDT have been identified in sediments near the breakwater and at Prospect Point, and polynuclear aromatic hydrocarbons were elevated in sediment samples from around one boat slip and a marina channel (Evans 1997).

Valued ecosystem components (VECs) were identified within the "Environmental Assessment of the Waskesiu Community Plan" (Cumming 2002) and from a review of the Prince Albert National Park Management Plan (Parks Canada 1995). Water quality is the primary VEC of concern with respect to this project. In particular, water quality should not be degraded in such a way as to affect its potability, recreational use (swimming/boating), and ability to support aquatic biota. Issues of concern with respect to this VEC include alterations in bacterial and nutrient levels within the lake and the potential toxic effects of the application of Foray 48B to aquatic organisms, including species of phytoplankton, zooplankton, aquatic macrophytes, benthic invertebrates, and fish.

5.5.3 Phytoplankton and Macrophyte Species Composition

Phytoplankton populations have been assessed in Waskesiu Lake on numerous occasions between 1941 and 1965 and periphyton and phytoplankton were also assessed in 1972 (Environment Canada 1986). Further assessments were undertaken in 1993 and 1994 (Evans and Robarts 1999). The periphyton and phytoplankton known to occur in Waskesiu Lake were listed in Mayhood *et al.* 1973 in Environment Canada 1986.

Within the breakwater area near the town of Waskesiu, there are generally high densities of aquatic macrophytes, including *Myriophyllum sp*., *Potamogeton vaginatis*, *Potamogeton richardsonii*, and *Ceratophyllum hippurus*, as well as several species of algae (Golumbia 1989). A listing of all species identified in Waskesiu Lake is provided in Golumbia (1989).

5.5.4 Invertebrate Species Composition

The benthic fauna within Waskesiu Lake have been described primarily by Rawson (1929, 1936, 1960, 1961 in Environment Canada 1986). The dipteral larval family Tendipedidae (*Chironomus plumosus*) was the most abundant benthic fauna in Waskesiu Lake (85 percent) with Oligochaeta, Sphaeriidae, Ephemeroptera, Gastropoda, and Ostracoda making up the balance (Rawson 1929 in Environment Canada 1986). Tendipedidae were also found to be the most abundant, in terms of numbers, within other lakes in the southern portion of the park (Mayhood *et al.* 1973 in Environment Canada 1986).

The inshore zones of Waskesiu Lake support the greatest numbers of littoral fauna, with particular concentrations in areas containing aquatic vegetation, notably *Chara* (Stevenson 1942 in Environment Canada 1986). Lake areas containing bare sand and gravel bottoms were found to support the lowest populations of littoral fauna. The most abundant types were Tendipedidae, followed by Amphipoda and Sphaeriidae. If mass is considered, Trichoptera followed by Ephemeroptera, Amphipoda and Thenipedidae were the most important groups (Stevenson 1942 in Environment Canada 1986). An ecological evaluation of Trichoptera found their abundance to be greatest at depths of 2.5 m. Shallow areas show limited numbers because of wave actions promoting agitation and scouring. The lack of aquatic vegetation in deeper waters also limits faunal numbers (Milne 1941, 1943 in Environment Canada 1986).

5.5.5 Fish Species Composition

There are 18 fish species that occur in Waskesiu Lake (Environment Canada 1986). Common sport fishes include northern pike (*Esox lucius*), walleye (*Stizostedion vitreum*), yellow perch *(Perca flavescens*) and burbot (*Lota lota*). Other abundant large-bodied fishes include lake whitefish (*Coregonus clupeaformis*), lake cisco (*C. artedi*), white sucker (*Catostomus commersoni*), and longnose sucker (*C. catostomus*). Lake trout (*Salvelinus namacush*) have been known to occur, but are rare. General life histories for these fish and are summarized in Didiuk (1986b). Nine forage fish species have been identified from Waskesiu Lake and are listed in Didiuk (1986b). Specific habitat utilization information (i.e., spawning, rearing and overwinter sites) is limited; however, some spawning locations for Waskesiu Lake northern pike and walleye have been identified. The Mud Creek – Beartrap Creek drainage is an important spawning site of both species and there are numerous walleye spawning sites within Waskesiu Lake itself (Environment Canada 1986). The walleye spawning sites in Waskesiu Lake, including a few sites near the townsite, are subject to water quality problems, such as siltation. Currently, no fish species in Waskesiu Lake receives any special status designation under COSEWIC (COSEWIC 2002) or the *Species at Risk Act* (Canada).

5.5.6 Nature of Potential Project Effects

5.5.6.1 Persistence of Btk in Water/Environmental Fate

Btk may enter the water through direct application, runoff, or through the feces of animals that have ingested Btk (Joung and Côté 2000). Once in the water, Btk will remain viable for some time, as it was found in stream and reservoir water following aerial application in Nova Scotia 8 to 12 days after spraying (Menon and De Mestral 1985 in Joung and Cote 2000). In lake water held in the laboratory, approximately 50 percent of Btk cells remained viable after 70 days (Menon and De Mestral 1985 in Joung and Cote 2000). Sedimentation rate of Bt cells in the aquatic environment is fairly rapid as they readily adsorb to sediments and precipitate out of the water column in all but the fastest flowing streams (WHO 1999, Internet site). Contact of the cells with mud had been shown to rapidly deplete their toxicity; however, the spores may remain viable in the sediments for an extended period of time (at least 22 days, Ohana *et al.* 1987). Due to the susceptibility of Waskesiu Lake to wind-induced mixing, spores may be reintroduced to the water column from the sediments during the open-water season, and if still present, could also be introduced back into the water column from the sediments during fall and spring turnovers. As Bt it is not known as an aquatic bacterium, it is not expected to proliferate in the aquatic environment (USEPA 1998).

5.5.6.2 Potential Effects of Btk on Aquatic Biota

No measurable effects on water quality or aquatic biota are anticipated from the routine application of Foray 48B.

This is based on a review of field studies specific for Btk that did not identify effects on numerous aquatic invertebrates, including Trichoptera (caddisflies), Ephemeroptera (mayflies), Plecoptera (stoneflies), Odonata (dragonflies), Coleoptera (water beetles), Diptera (flies), Amphipoda (amphipods), Decapoda (crayfish), Hydracarina (water-mites), Hirudinea (leeches), Hydrozoa (freshwater hydra), Nematoda (roundworms), Oligochaeta (segmented worms), Porifera (freshwater sponges), Pulmonata (freshwater snails), Pelecypoda (clams, mussels), and Turbellaria (flatworms) and two species of fish, common white sucker and smallmouth bass (*Micropterus dolomieui*) (Buckner *et al.* 1974 in Joung and Cote 2000; Eidt 1985 in Joung and Cote 2000; Otvos and Vanderveen 1993 in Joung and Cote 2000; USDA 1995; Surgeoner and Farkas 1990 in Joung and

Côté 2000). Furthermore, there is no evidence that consumption of Bt-infected insects has adversely affected fishes to any noticeable degree (Surgeoner and Farkas 1990 in Joung and Côté 2000). A review of the literature on Bt and its byproducts did not identify any known effects on semi-aquatic and aquatic plant life (USEPA 1998).

Bluegill sunfish (*Lepomis macrochirus*), sheepshead minnow (*Cyprinodon variegates*) and rainbow trout were exposed to high levels of Btk-Dipel (100 to 500 times expected environmental levels) in water and food in 30 or 32 day static trials, with no adverse effect on fish survival, and no resulting lesions (Christensen 1990a,b,c in WHO 1999). Studies of Foray 48B on *Daphnia magna* and rainbow trout have not identified any organisms at risk (Valent Biosciences Corporation 2001).

In some instances *Daphnia magna* has shown a moderate level of toxicity (5 to 50 mg/L LC_{50}) to Btk, however, this was related to factors other than the delta-endotoxin (the active ingredient). This toxicity appears to be related to heat-labile, soluble impurities from the production methodology (in particular, the composition of the growth media used in the culture of Btk cells (USEPA 1998). This issue has been addressed by the standardization of the manufacturing process and various quality control testing requirements (USEPA 1998).

5.5.7 Proposed Mitigation

5.5.7.1 Routine Application

With the exception of existing non-forested beach, the close proximity of the spray area with Waskesiu Lake allows for no buffering (a no-spray zone) to entirely eliminate chances of Btk from entering the lake. Small amounts that will enter the lake either by direct spray in nearshore areas and/or by aerial drift are not anticipated to result in effects on water quality and, therefore, no mitigation is required. It has been noted that Btk is one of the only registered pesticides that the EPA has not issued restrictions/buffer zones for adjacent waterbodies (Bioforest Technologies Inc. 2002). In general, however, application procedures outlined by the manufacturer are recommended to be adopted in the Waskesiu spray program. In order to minimize drift and maximize application to within the townsite spray area, it is recommended that flight lines for the spray program be determined prior to application and that clearly avoid any overlap with the lake. It is also recommended that the spray program be undertaken during weather conditions that minimize drift and favour the retention of Btk to within the spray area.

5.5.7.2 Accidental Spills

To mitigate the effects of a spill of Btk directly to the aquatic environment, it is recommended that the product not be stored in areas where a spill would result in the product entering the lake. Aside from spill prevention, no mitigation efforts would be recommended.

5.5.8 Residual Impacts

5.5.8.1 Routine Application

No residual impacts are anticipated from the routine application of Foray 48B in and near Waskesiu Lake.

5.5.8.2 Accidental Spills

A spill of Foray 48B into the water may result in a decrease in pH sufficient to result in the temporary impairment of the aquatic community. Increases in turbidity/TSS and colour from the Btk suspension could also be sufficient to affect some forms of aquatic life. While Foray 48B does contain phosphorus and/or nitrogen-containing compounds (Swadener 1994, BioForest Technologies 2002), the level of phosphorus (which are associated with fermentable solids left over after the growth of Btk bacteria) is so minute such that it would not contribute to an increase in eutrophication (Belliveau, pers. comm.). It is anticipated that once any potential toxic conditions dissipate, that affected biota will recover and/or be replaced by similar organisms from the surrounding environment. Toxicity under these circumstances would most likely be related to the rapid change in pH and not the toxicity of the Btk itself.

5.5.9 Cumulative Environmental Effects

5.5.9.1 Routine Application

As effects are not anticipated to occur in the aquatic environment from the routine aerial application of Foray 48B in and near Waskesiu townsite, the potential for the pesticide to interact with other factors that may be affecting the aquatic community are not a concern. As such, an assessment of cumulative effects is not warranted.

5.5.9.2 Accidental Spill

A spill of Foray 48B into the water may result in a decrease in pH sufficient to result in the impairment of the aquatic community. Increases in turbidity/TSS and colour from the Btk suspension could also be sufficient to affect some forms of aquatic life.

Cumulative toxic effects could occur as the toxic effects of a decrease in pH may exacerbate toxicity related to elevated levels of pesticides (DDT) or hydrocarbons, which have been identified at some locations within the breakwater area.

5.6 Climate and Air Quality

5.6.1 Local Characteristics

Climatic conditions in PANP and in Waskesiu vary considerably throughout the year, due in large part to the mid-latitude, continental location of PANP. Winters are long and cold with low amounts of precipitation, while summers are short and warm and experience most of the annual precipitation (Environment Canada 1986). The mean annual temperature at Waskesiu is 0.4°C (Environment Canada 2003, Internet site). Mean annual minimum and maximum temperatures are -5.3°C and 6.0°C, respectively.

PANP has a fairly dry climate but experiences greater precipitation rates than the prairies south of the park. Although most precipitation occurs in the summer, snowmelt is an important moisture source because of the long winters. Mean annual precipitation at Waskesiu is 467.2 mm of which 72 percent falls as rain (Environment Canada 2003, Internet site). Waskesiu has a mean frost-free period of 85 days (Environment Canada 1986).

Winds are generally strongest in the spring and fall, with the lightest winds occurring in the winter. The prevailing wind direction at Waskesiu is from the northwest. The mean annual wind speed from all directions is 8.9 km/h at Waskesiu. Mean wind speeds from 1977 to 1982 for May and June (potential spray period) are 8.8 and 8.6 km/h, respectively (Environment Canada 1986). Mean relative humidity in May and June is 51.3 and 57.8 percent, respectively.

5.6.2 Potential Project Effects

No evidence of negative impacts to the atmosphere or climate from aerial application of Btk was found during this review. Literature sources reviewed include but were not limited to Health Canada (2000), USEPA (1998), Joung and Côté (2000), Auckland Healthcare Service Ltd. (1997), Ministry of Environment, Lands and Parks (1999), Noble *et al.* (1992) and Town of Nipawin (1999). There is potential for Btk to drift and be deposited outside the target spray area. A study by Teschke *et al.* (2001) found drift outside the spray zone in a 125 to 1000 m band. The outdoor concentration of Btk was found to decrease quickly with an initial half time of 3.3 hours.

5.6.3 Proposed Mitigation

Parks Canada will ensure that aerial application of Btk will be constrained to the atmospheric conditions specified for use to minimize pesticide drift.

5.6.4 Residual Impacts

No residual impacts are predicted on climate or atmospheric conditions from the proposed Btk aerial spray program.

5.6.5 Cumulative Environmental Effects

Because there will be no project effects on climate and atmospheric conditions, the aerial application of Btk is not predicted to contribute to cumulative effects of existing and future developments on climate and atmospheric conditions.

6 Conclusions

Project-specific environmental effects of the proposed spraying of Foray 48B on the Waskesiu townsite to control spruce budworms will be either immeasurable or mitigable to ensure accordance with PANP and the Waskesiu community strategic goals and objectives. In general, those goals are intended to ensure maintenance of ecological integrity and protection of environmental and cultural resources throughout the park and community. Conclusions on the projects' anticipated residual effects on specific environmental and cultural components are summarized in Table 2.

6.1 Human Health

Contact of the Btk formulation with respiratory systems may result in irritation and is therefore considered a Level I impact. Public anxiety in relation to the spray program may result and is predicted to be a Level I impact. Public notification of spray timing and advising people to stay indoors at that time will minimize contact and help to ease concerns. Public education and availability of park staff to answer concerns will help to reduce stress. Public notification to mitigate any chances for respiratory, eye irritation or other concerns will also benefit people's pets. No cumulative effects on human health are predicted to result from Btk application.

6.2 Wildlife and Terrestrial Insects

Btk application will result in direct mortality of non-target Lepidoptera and possibly also, soil macroorganisms such as nematodes and carabid beetles. This effect is considered Level I and within the mandate of PANP to maintain ecological integrity because effects are considered short-term, localized and reversible through immigration following completion of the spray program. Btk application may result in a short-term change in bird and small mammal populations, resulting from a decrease in availability of prey base (i.e., spruce budworm larvae). Owing to the small area of application within the ecosystem, this Level I impact is predicted to be small, short-lived and reversible by natural processes. Predator species may switch prey or forage in adjacent non-affected areas.

6.3 Vegetation

Btk is not expected to have direct negative effects on vegetation. Longevity of Btk on foliage varies widely but generally lasts several days. Indirect impacts on vegetation through localized reductions in lepidopteran pollinators will lead to no direct impacts on vegetation in Waskesiu. This conclusion was arrived at after considering the small scale of the treatment area and the mobility or immigration potential of winged Lepidoptera.

6.4 Soils and Landforms

There is uncertainty as to whether Btk will impact non-target soil organisms in the sprayed area. However, if non-target soil organisms were to be impacted (Level I) by Btk spraying, losses would be small within the context of PANP and would likely be compensated over time by individuals of the same species moving into the treatment area after spraying. This potential impact is acceptable within the strategic goals and management directions for PANP. Groundwater contamination by leaching of Btk through the soil profile is not anticipated because of the relative immobility of Btk in soil. No cumulative effects on soils and landforms are predicted to result from Btk application.

6.5 Aquatics and Water Quality

The aerial application of Foray 48B in and near the town of Waskesiu will result in some of the pesticide being introduced into the aquatic environment, either from direct drift during spray application or in runoff containing Btk. Once in the lake, Btk will settle to the bottom sediments fairly rapidly as it readily binds to particulate matter, and the spores may remain viable in the sediments for an extended period of time (greater than 22 days). As Waskesiu Lake is somewhat susceptible to wind-induced mixing, it is possible that some spores may become re-suspended into the water column periodically. Because Btk is not considered an aquatic bacterium, it is not anticipated to proliferate in the aquatic environment. Even if a minimal amount of growth did occur it would not be sufficient to out compete the local microbial populations in aquatic sediments. The presence of this relatively small amount of Btk in the water and/or sediments, even over a potentially long period of time, is not anticipated to have any measurable effect on any aquatic organisms present in Waskesiu Lake. As such, there are no effects anticipated from the routine application of Foray 48B in and around the town of Waskesiu and mitigation (aside from following label instructions) and monitoring activities are not required (unless specifically requested by the Department of Fisheries and Oceans upon their review of the project).

6.6 Climate and Air Quality

Foray 48B is not expected to have negative effects on air quality.

Table 2 Summary of Issues, Residual Effects, Mitigation and Cumulative Effects of Btk Application

Component	Issue	Residual Effects	Mitigation and Recommendations	Cumulative Effects
Human Health	Toxicity	Level I (short-term respiratory irritation)	• advise residents to stay inside during application • time spray to ensure minimal human exposure; mitigation also benefits pets (food covered; pets indoors during spray)	None
	Pathogenicity	None	None	None
	Anxiety	Level I	• notify residents prior to application • make Park staff available to respond to concerns	None
Wildlife	Toxicity	None	None	None
	Pathogenicity	None	None	None
	Secondary effects (loss of Lepidoptera as a food source of insectivorous wildlife)	Level I	• short term, small scale, and reversible effect • acceptable effect within strategic goals of PANP	None
Non-target Lepidoptera and other select insects	Toxicity	Level I	• short term, small scale, and reversible effect • acceptable effect within strategic goals of PANP	None
Vegetation	Toxicity	None	None	None
	Mutagenicity	None	None	None
	Secondary effects	None	None	None
Soils and Landforms	Toxicity	Level I (potential toxicity to soil invertebrates)	• short term, small scale, and reversible effect • acceptable effect within strategic goals of PANP	None
	Contamination (ground water)	None	None	None
Aquatics and Hydrologic Resources	Contamination (lake water)	None	None	None
	Toxicity	None	None	None
Climate and Air Quality	Contamination	None	None	None

7 Public Consultation

7.1 Public Consultation Process

The draft environmental assessment was posted for public review on the website of AXYS Environmental Consulting Ltd. on March 31, 2003, starting a two-week public consultation period undertaken by Parks Canada.

On March 31, the DRAFT Environmental Assessment and a schedule of the Open House meetings, was sent to numerous stakeholders and governments including:

- Montreal Lake Cree Nation
- Waskesiu Community Council
- Waskesiu Chamber of Commerce
- Waskesiu Cottage Owners Association
- Waskesiu Cabin Owners Association
- Saskatchewan Environmental Society
- CPAWS - Saskatchewan Chapter
- Environment Canada
- Pest Management Regulatory Agency

Copies of this material were also made available at PANP offices and in the public libraries in Prince Albert (2 copies), Saskatoon (5 copies), and Regina (10 copies).

Two public open houses were held:

- Monday April 7th, 13:00 - 21:00, Radisson Hotel, Saskatoon, SK (73 attended)
- Tuesday April 8th, 13:00 - 21:00, Travelodge Hotel, Prince Albert, SK (23 attended)

Additionally, Parks Canada met with the eight members of the Montreal Lake Cree Nation on Wednesday April 9th, at the band office in Montreal Lake, SK and with Prince Albert National Park staff and residents of Waskesiu Lake in Waskesiu Lake, SK (32 attended).

7.2 Results of Public Consultation

Public comment included 53 written submissions received during the open houses as well as 183 e-mailed submissions and 6 faxes for a total of 242 written comments. Comments were primarily related to concerns for human health, ecological impacts and interpretation of national park policy. There was only one respondent who was concerned with the process of public consultation and the environmental assessment availability and process.

Concerns related to potential human health and environmental effects were investigated by examining the information source on which the concerns were based. Additional studies that were referenced in submissions during the public consultation process were reviewed and included in this assessment. In Waskesiu, significant public concern exists related to health effects. This concern warranted further investigation of specific information sources and topic areas that led to these concerns. Appendix E, Follow-up Investigation of Human Health Concerns, contains the results of this investigation.

8 Bibliography

8.1 Literature Cited

Addison, J.A. 1993. Persistence and Nontarget Effects of *Bacillus thuringiensis* in Soil: A Review. *Canadian Journal of Forest Research*. 23:2329–2342.

Aer'aqua Medicine Ltd. 2001. *Health Surveillance following Operation Ever Green: A programme to eradicate the white-spotted tussock moth from the eastern suburbs of Auckland*. May 2001. Report to the Ministry of Agriculture and Forestry. Auckland, NZ.

Auckland District Health Board (ADHB). 2002. Health Risk Assessment of the 2002 Aerial Spray Eradication Program for the Painted Apple Moth in Some Western Suburbs of Auckland: A Report to the Ministry of Agriculture and Forestry.

Auckland Healthcare Service Ltd. 1997. *Health Risk Assessment of the Proposed 1997-1998 Control Program for the White-spotted Tussock Moth in the Eastern Suburbs of Auckland*. Auckland Healthcare Service Limited, Public Health Protection Services. Report for the Ministry of Forestry.

Bellocq, M.I., J.F.Bendell and B.L. Cadogan. 1992. Effects of the insecticide *Bacillus thuringiensis* on *Sorex cinereus* (masked shrew) population, diet and prey selection in a jack pine plantation in northern Ontario. *Canadian Journal of Zoology*. 70:505–510.

Bernstein, I., J. Bernstein, M. Miller, S. Tierzieva, D. Bernstein, Z. Lummus, M. Selgrade, D. Doerfler and V. Seligy. 1999. Environmental Health Perspectives. 107(7):575–582.

BioForest Technologies Inc. 2002. *A review of the eastern spruce budworm: Likely impacts and management options in Prince Albert National Park*. Prepared for: Save Our Spruce Committee. Sault Ste. Marie, ON.

BioSys Consulting. 1997. *Integrated Pest Management Information Manual*. Prepared for Department of Canadian Heritage, Parks Canada. Ottawa, ON.

Bird, C.D, G.J. Hilchie, N.G. Kindla, E.M. Pike and F.A.H. Sperling. 1995. *Alberta Butterflies*. The Provincial Museum of Alberta. Edmonton, AB.

Boulton, T.J., D.A. Rohlfs and K.L. Halwas. 1999. *Non-target Lepidoptera on Southern Vancouver Island: Field assessments during a gypsy moth eradication Program involving three aerial applications of Btk.*

Canadian Council of Ministers of the Environment (CCME). 2002. Canadian environmental quality guidelines. Canadian Council of Ministers of the Environment, Winnipeg, MB.

Capital Health Region. 1999. *Human Health Surveillance during the Aerial Spraying for control of North American Gypsy Moth on Southern Vancouver Island, BC, 1999*. A report to the Ministry of Environment, Lands and Parks, Province of British Columbia. Prepared by BC Capital Health Region, Victoria, BC.

Cerezke, H.F. 1991. *Forestry Leaflet no. 9: Spruce budworm*. Natural Resources Canada, Canadian Forest Service, Northern Forestry Centre, Edmonton, AB.

Christie, D. 1998. Forest bird monitoring in Fundy National Park. Case Study In: *State of the Greater Fundy Ecosystem*. Woodley S., G. Forbes and A. Skibicki (ed.). Greater Fundy Ecosystem

Research Project, University of New Brunswick Faculty of Forestry and Environmental Management, Fredericton, NB.

Committee on the Status of Wildlife in Canada (COSEWIC). 2002. Canadian Species at Risk, May 2002.

Cooksey, K.E. 1971. The protein crystal toxin of *Bacillus thuringiensis*: Biochemistry and mode of action. In: *Microbial control of insects and mites*. B.D. Burges and N.W. Hessey, (ed.). Academic Press, New York, NY.

Croutch, S., B. Pollock, M. Valleau and C. Witzel. 2002. *The scope of impacts resulting from an aerial Btk spray program in Waskesiu Townsite*.

Cumming, K. 2002. *Environmental assessment of the "Waskesiu Community Plan"*. Parks Canada, Western Canada Service Centre, Winnipeg, MB.

Damaard, P.H., Granum, P.E., Bresciani, J., Torregrossa, M.V., Eilenberg, J., and Valentino, L. 1997. Characterization of *Bacillus thuringiensis* isolated from infections in burn wounds.

Dupont, A., L. Belanger, and J. Bousquet. 1991. Relationships between balsam fir vulnerability to spruce budworm and ecological site conditions of fir stands in central Quebec. Canadian Journal of Forest Research. 21:1752–1759.

Environment Canada, Parks. 1986. Prince Albert National Park Resource Description and Analysis. Natural Resources Conservation, Environment Canada, Parks, Prairie and Northern Region, Winnipeg, MB.

Erdle, T.A. and D.A. MacLean. 1999. Stand growth model calibration for use in forest pest impact assessment. *For. Chron.* 75:141–152.

Evans M.S. and R.D. Robarts 1999. *The limnology of Waskesiu Lake, Prince Albert National Park, Saskatchewan: July 1992 to October 1994 studies with historical comparisons*. National Water Research Institute. Report nr N.W.R.I. Contribution series No. 99-13. Saskatoon, SK.

Evans MS. 1997. *Interim report on stable isotope, organochlorine contaminant and polynuclear aromatic hydrocarbons contaminants studies in Waskesiu Lake pilot investigations in 1994/95*. National Hydrological Research Institute. Saskatoon, SK.

Golumbia, T. 1989. Water Quality Assessment: Waskesiu Lake Waterfront December 1989. Natural Resource Conservation Prairie and Northern Region Canadian Parks Service. Technical Report 89-8/PA.

Government of Canada. 2000. Canada National Parks Act.

Health Canada. 2000. *Fact Sheet on the Bacillus thuringiensis subspecies kurstaki.* Health Canada. February 2000.

Health Canada. 2001a. Pest Management Regulatory Agency – Overview Document.

Hernandez E., Ramisse F., Cruel T. le Vagueresse R., and Cavallo J. 1999. *Bacillus thuringiensis* sertype H34 isolated from human and insecticidal strains serotypes 3a3b and H14 can lead to death of immunocompetent mice after pulmonary infection. FEMS Immunology and Medical Microbiology. 24:43–47.

Hernandez E., Ramisse F., Cruel T. le Vagueresse R., and Cavallo J. 2000. Super-Infection by *Bacillus thuringiensis* H34 Or 3a3b can lead to death in mice infected with the influenza A virus. FEMS Immunology and Medical Microbiology. 29:177–181.

Hobson, K.H. and E.E. Cumming. 1995. *Big River Btk spray program: Forest birds, a progress report on the 1993-95 field program*. Canadian Wildlife Service. Saskatoon, SK.

Innes, D.G.L. and Bendell, J.F. 1989. The effects on small-mammal populations of aerial applications of *Bacillus thuringiensis*, fenitrothion, and Matacil(R) used against jack pine budworm in Ontario. *Can J Zool.* 67:1318–1323.

Joung, K. and Côté, J. 2000. *A Review of the Environmental Impacts of the Microbial Insecticide Bacillus thuringiensis.* Technical Bulletin No. 29. Agriculture and Agri-Food Canada. Research Branch. Horticultural Research and Development Centre.

Kingdon, G. 2003. *Q & As: Spruce Budworm and Btk. Internal Document*. Parks Canada, Banff, AB.

MacLean, D.A. and W.E. MacKinnon. 1997. Effects of stand and site characteristics on susceptibility and vulnerability of balsam fir and spruce to spruce budworm in New Brunswick. *Canadian Journal of Forest Research*. 27:1859–1871.

Meating, J. 2002. Letter to J. Weir (Prince Albert National Park). September 2, 2002.

Noble, M.A., P.D. Riben and G. Cook. 1992. *Microbiological and Epidemiological Surveillance Programme to Monitor the Health Effects of Foray 48B Btk Spray*. Prepared for: Ministry of Forests, Province of British Columbia. Prepared by: UBC, Department of Pathology and Health Care and Epidemiology, and University Hospital, Vancouver, BC.

Norton, M.L. J.F. Bendell, L.I. Bendell-Young and C.W. Leblamc. 2001. Secondary effects of the pesticide *Bacillus thuringiensis* on chicks of the Spruce Grouse (*Dendragapus Canadensis*). *Archives of Environmental Contamination and Toxicology*. 41:369–373.

Obadofin, A.A. and D.G. Finlayson. 1977. Interactions of Several Insecticides and a Carabid Predator (*Bembidion lampros* (Hrbst.)) and their Effects on *Hylemya brassica* (Bouché). *Canadian Journal of Plant Science*. 57:1121–1126.

Parks Canada. 1994. *Guiding Principles and Operational Policies*.

Parks Canada. 1995. *Prince Albert National Park management plan*. Publication no. RO25-000-EE-A1.Canadian Heritage, Ottawa, ON.

Parks Canada. 1998a. *Parks Canada Management Directive 2.4.1 – Integrated Pest Management*. Parks Canada, File C-6261-0. December, 1998.

Parks Canada. 1998b. *Prince Albert National Park Gate Survey*. Parks Canada

Parks Canada. 1998c. *Prince Albert National Park Campgrounds Survey*. Parks Canada.

Parks Canada. 2000. *Waskesiu Community Plan*. Heritage Canada. Ottawa, ON.

Parks Canada. 2002. *Fact sheet: Spruce budworm Choristoneura fumiferana*. *Nature of Potential Project Effects.* Prince Albert National Park, Waskesiu, SK.

Petrie, K., Thomas, M., and Broadbent, E. 2003. Symptom complaints following aerial spraying with biological insecticide Foray 48B. The New Zealand Medical Journal, March 2003, Vol. 116 No. 1170.

Ray, D.E. 1991. Pesticides derived from plants and other organisms. In: *The Handbook of Pesticide Toxicology.* W. J. Hayes, Jr. and E.R. Laws, Jr. (ed.). Academic Press, New York, NY.

Retnakaran, A., G.G. Grant, T.J. Ennis, P.G. Fast, B.M. Arif, D. Tyrell and G. Wilson. 1982. *Development of environmentally acceptable methods for controlling insect pests of forests*. Forest Pest Management Institute, Canadian Forest Service, Information Report FPM-X-62.

Russell, A.P. and A.M. Bauer. 2000. *The Amphibians and Reptiles of Alberta*.

Samples J.R. and H. Buettner. 1983. Corneal ulcer caused by a biologic insecticide (Bacillus thuringiensis). *Am J Ophthalmol*. 95(2):258–260.

Saskatchewan Conservation Data Centre. 2002. Rare Plant Database. Saskatchewan Environment. Regina, SK.

Saskatchewan Institute of Pedology. 1978a. *Prince Albert National Park Saskatchewan Surficial Deposit Map*. Surveys and Mapping Branch, Energy, Mines and Resources, Ottawa, ON. Map Scale 1:300,000.

Saskatchewan Institute of Pedology. 1978b. *Prince Albert National Park Saskatchewan Soil Order Map.* Surveys and Mapping Branch, Energy, Mines and Resources, Ottawa, ON. Map Scale 1:300,000.

Saskatchewan Environmental Society (SES). 2003. *The Case Against Overhead Pesticide Spraying in the Townsite of Waskesiu Lake, Prince Albert National Park of Canada*.

Sawatsky, P. 2003. Regional Pesticides Manager for Saskatchewan/Manitoba. January 13, 2003. Pest Management Regulatory Agency, Heath Canada, Winnipeg, MB.

Sopuck, L. and K. Ovaska. 2001. Responses of songbirds to aerial spraying of the microbial insecticide *Bacillus thuringiensis* var. *kurstaki* (Foray 48B®) on Vancouver Island, 1999–2000. Final Report. Biolinx Environmental Research Ltd. Sidney, British Columbia, Canada.

Sopuck, L., K. Ovaska and B. Whittington. 2002. Responses of songbirds to aerial spraying of the microbial insecticide *Bacillus thuringiensis* var. *kurstaki* (Foray 48B) on Vancouver Island, British Columbia, Canada. *Environ Toxicol Chem*. 21:1664–1672.

Stantec Consulting Ltd. 1998. Indirect effects of Spruce Budworm control programs on forest songbird productivity. Prepared for Saskatchewan Environment and Resource Management. Saskatoon, Saskatchewan. File: 1-32-51007

Swadener, C. 1994. *Bacillus thuringiensis* (Bt). *Journal of Pesticide Reform*. 14(3):13–20.

Teschke, K., Y. Chow, K. Bartlett, A. Ross and C. van Netten. 2001. Spatial and Temporal Distribution of Airborne *Bacillus thuringiensis* var. *kurstaki* during an Aerial Spray Program for Gypsy Moth Eradication. *Environmental Health Perspectives*. Volume 109, Number 1.

Town of Nipawin. 1999. *Spruce Budworm Aerial Spray Program General Information*. Town of Nipawin, Saskatchewan.

United States Environmental Protection Agency (USEPA). 1998. *Reregistration eligibility decision, Bacillus Thuringiensis.* United States Environmental Protection Agency. March 1998. Washington DC.

Valent BioSciences. 2001. *Protecting Our Forests – Protecting our Future*. Forestry Technical Manual. Foray and Dipel. Valent Biosciences Corporation.

Visser, S., J.A. Addison and S.B. Holmes. 1994. Effects of DiPel® 176, a *Bacillus thuringiensis* subsp. *kurstaki* (B.t.k.) formulation, on the soil microflora and the fate of B.t.k. in an acid forest soil: a laboratory study. *Canadian Journal of Forest Research*. 24:462–471.

Visser, S. and Walter, B. 1996. Monitoring Growth and Persistence of *Bacillus Thuringiensis* subsp. *kurstaki* (Btk) in Forest Soils and Response of Nontarget Soil Fauna to Repeated Spraying of Mixedwood Stands with Foray (registered trademark symbol) 48B. Internal government report. Forestry Branch, Saskatchewan Environment and Resource Management. Prince Albert, SK.

Volney, W.J.A. and B.J. Stocks. 2002. *Trip Report: Spruce budworm cause mortality concerns in Prince Albert National Park and Lac La Ronge Provincial Park*. Natural Resources Canada, Canadian Forest Service, Edmonton, AB.

Warren R.E., D. Rubenstein, D.J. Ellar, J.M. Kramer and R.J. Gilbert. 1984. *Bacillus thuringiensis* var. israelensis: Protoxin activation and safety. *Lancet* 24:678–679.

Waskesiu Community Association Inc. (WCA). 2002. *A project proposal to apply bio-pesticides on Waskesiu Townsite or the purpose of managing spruce budworm infestation*. Waskesiu, SK.

World Health Organization (WHO). 1982. *Data sheet on the biological control agent Bacillus thuringiensis serotype H-14* (de Barjac 1978). Geneva, World Health Organization (WHO/VBC/79.750 Rev. 1).

Wilson, G.R. and T.G. Benoit. 1993. Alkaline pH Activates *Bacillus thuringiensis* Spores. *J Invert Pathol* 62:87–89.

Zinkan, C. 2002. *Legislation and policy context for vegetation management interventions in, and immediate to, the park community of Waskesiu*. Parks Canada Agency, Banff, AB.

8.2 Personal Communications

Belliveau B. 2003. Head, Biopesticides Evaluation Section, Health Evaluation Division, Pest Management Regulatory Agency. April 15, 2003.

Frandsen D. 2003. Conservation Biologist, Prince Albert National Park, Saskatchewan. March 2003 (various days).

Hunt, B. 2003. Communications Advisor, Parks Canada. March 26, 2003.

Leeson. B. 2003. Senior Environmental Assessment Scientist, Parks Canada. Calgary, Alberta. April 14, 2003.

McIntosh, R.L. 2003. Forest Insect and Disease Specialist, Forest Ecosystems Branch - Saskatchewan Environment. Prince Albert, Saskatchewan. April 8, 2003.

Sawatsky, P. 2003. Regional Pesticides Manager for Saskatchewan/Manitoba. January 13, 2003. Pest Management Regulatory Agency, Heath Canada, Winnipeg, MB.

Stolle, N. 2003. Chief Park Warden, Prince Albert National Park, Saskatchewan. March 28, 2003.

Volney, J. 2003. Research Scientist, Natural Resources Canada, Edmonton, AB.

Weir, J. 2003. Vegetation Ecologist, Prince Albert National Park, Saskatchewan. March 2003 (various days).

8.3 Internet Sites

Audubon Society and Cornell Laboratory of Ornithology (ASCLO). 2002. *Warbler Watch Identification Guide*. Accessed at: http://www.birdsource.org/index.html.

British Columbia Environmental Appeal Board. 1998. Appeal No. 98-PES-03(b). Accessed at: http://www.eab.gov.bc.ca/pest/98pes03b.htm

British Columbia Environmental Appeal Board. 2000. Appeal No. 00-PES-001 to 014. Accessed at: http://www.eab.gov.bc.ca/pest/00PES001_014.htm.

British Columbia Ministry of Forests. 1995. *Defoliator Management Guidebook*. Victoria, BC. Accessed at: http://www.for.gov.bc.ca/tasb/legsregs/fpc/fpcguide/defoliat/defoltoc.htm.

Environment Canada. 2003. *Canadian Climate Normals 1971-2000 – Waskesiu Lake*. http://www.msc-smc.ec.gc.ca/climate/climate_normals.

Government of Canada. 2000. *Canada National Parks Act* (c. 32). Queen's Printer. Ottawa, ON. Accessed at: http://laws.justice.gc.ca/en/N-14.01/text.html.

Health Canada. 2001b. *Childhood asthma in Sentinel Health Units. Findings of the Student Lung Health Survey 1995-1996*. Population and Public Health Branch. Health Canada. Accessed at: http://www.hc-sc.gc.ca/pphb-dgspsp/publicat/rdc-mrc01/pdf/rdc0901e.pdf

Health Canada. 2003. *New Pest Control Products Act*. Health Canada Information Sheet. Accessed at: http://www.hc-sc.gc.ca/pmra-arla/english/legis/pcpa-e.html.

Information Ventures, Inc. 1995. *Bacillus thuringiensis: Pesticide Fact Sheet*. Prepared for the USDA, Forest Service. Accessed at: http://www.infoventures.com/e-hlth/pestcide/bacillus.html.

Joung, K. and Cote, J. 2000. A review of the environmental impacts of the microbial insecticide *Bacillus thuringiensis*. Agriculture and Agri-Food Canada Research Branch. http://res2.agr.ca/stjean/crdh.dtm (02/18/03).

Kuceral, D.R. and P.W. Orr. 1981. *Spruce budworm in the eastern United States*. USDA Forest Service Forest Insect and Disease Leaflet no. 160. Accessed at: http://www.na.fs.fed.us/spfo/pubs/fidls/sbw/budworm.htm.

Oregon State University (OSU). 1996. *Pesticide Information Profiles: Bacillus thuringiensis*. Accessed at: http://ace.orst.edu/info/extoxnet/pips/bacillus.htm.

Parks Canada. 1994. *Guiding Principles and Operational Policies*. Canadian Heritage, Parks Canada. Ottawa, Ont. Accessed at: http://www2.parkscanada.gc.ca/Library/PC_Guiding_Principles/Park1_e.htm.

Parks Canada. 1999a. *Environmental Management Issues*. Parks Canada. December 1999. Accessed at: http://www2.parkscanada.gc.ca/NATRESS/ENV_CON/ENV_STE/em_iss_e.htm.

Parks Canada. 1999b. *Parks Canada Guiding Principle and Operational Policies*. Parks Canada. Accessed at: http://www2.parkscanada.gc.ca/Library/PC_Guiding_Principles/Park35_e.htm.

Pest Management Regulatory Agency (PMRA). 1996. *Tebufenozide: Consultation Document G96-01*. Accessed at: http://www.hc-sc.gc.ca/pmra-arla/english/pdf/prdd/prdd_g9601-e.pdf.

Pest Management Regulatory Agency (PMRA). 2000. *Fact Sheet on the Bacillus thuringiensis subspecies kurstaki*. Accessed at: http://www.hc-sc.gc.ca/pmra-arla/pdf/fact/fs_bacillus-e.pdf.

Pest Management Regulatory Agency (PMRA). 2001. Foray® 48B label transcript. Health Canada, Ottawa, ON. Accessed at: http://64.26.129.82/oldlabelold/24000-24999/24977.pdf.

Saskatchewan Health. 2002a. Saskatchewan Comparable Health Indicators Report. September 2002. Accessed at: http://www.health.gov.sk.ca/info_center_comparable_health_indicators_report.html

Saskatchewan Health. 2002b. *Saskatchewan Health Annual Report. 2001-2002*. Government of Saskatchewan. Regina, SK. Accessed at: http://www.health.gov.sk.ca/info_center_pub_SaskHealth_2001_02_Annual_Report.pdf

United States Department of Agriculture (USDA). 2002. Forest Service Pesticide Sheets: *Bacillus thuringiensis*. Accessed at: http://www.infoventures.com/e-hlth/pestcide/bacillus.html.

United States Environmental Protection Agency (USEPA). 1998. *Bacillus thuringiensis* subspecies *kurstaki* strain M-200 (006452): Ingredient Fact Sheet. Accessed at: http://www.epa.gov/oppbppd1/biopesticides/ingredients/factsheets/factsheet_006452.htm.

United States Environmental Protection Agency (USEPA). 1998. Reregistration Eligibility Decision: *Bacillus thuringiensis*. United States Environmental Protection Agency, Prevention, Pesticides and Toxic Substances. http://www.epa.gov/REDs/0247.pdf.

United States Environmental Protection Agency (USEPA). 2000. *Bt Plant-Pesticides Biopesticides Registration Action Document*. Accessed at: http://www.epa.gov/oscpmont/sap/2000/october/brad3_enviroassessment.pdf.

Williamson D. 2002. Manitoba water quality standards, objectives, and guidelines. Final draft, November 2002. Water Quality Management Section. Water Branch. Manitoba Conservation. Accessed at: http://www.gov.mb.ca/environ/prgareas/water/mwqsog00.pdf

World Health Organization (WHO). 1999. *Environmental Health Criteria 217: Bacillus thuringiensis.* Accessed at: http://www.inchem.org/documents/ehc/ehc/ehc217.htm.

World Health Organization (WHO). 2002. *The WHO Recommended Classification of Pesticides by Hazard and Guidelines to Classification 2000-2002*. Accessed at: http://www.who.int/pcs/docs/Classification%20of%20Pesticides%202000-01.pdf.

Appendix A Background Information Review on *Bacillus thuringiensis* subsp. *kurstaki* and Spruce Budworm

A.1 Spruce Budworm

A.1.1 Introduction

The spruce budworm (SBW) (*Choristoneura fumiferana* Clem.) is a native insect in North American coniferous and mixedwood forests. Primary host tree species are balsam fir (*Abies balsamea),* white spruce (*Picea glauca*), red spruce (*P. rubens*), and black spruce (*P. mariana*), while tamarack (*Larix* spp.), hemlock (*Tsuga* spp.), and white pine (*Pinus strobus*) may also be affected (Cerezke 1991). Conditions that foster SBW outbreaks include contiguous areas of mature and overmature preferred host trees, abundant staminate flowers on mature trees, and early summer droughts three to four years prior to outbreaks (British Columbia Ministry of Forests 1995, Internet site; Mattson *et al.* 1987 in BioForest Technologies Inc. 2002).

SBWs typically undergo a 20-30 year population cycle in western Canada. The last outbreaks in the Waskesiu area occurred in 1910, 1940 and the late 1960s. Population peaks typically last six to seven years, however historic outbreaks have lasted up to 17 years (Volney and Stocks 2002). The abundance of mature white spruce in PANP and drought conditions may foster a prolonged peak outbreak. The current outbreak began in 1996 in PANP and in 1998 in the Waskesiu townsite. Volney and Stocks (2002) predict that the outbreak will continue until 2009.

A.1.2 Life History

In Canada, the SBW undergoes one life cycle per year. Moths emerge in late June to late July and mate soon thereafter. Females lay up to 200 egg masses, each containing an average of 20 eggs, over a one to two week laying period (Cerezke 1991). Females are attracted to stands with a high proportion of host trees that are typically older, tall and flowering, with conical tops (Morris 1963 in BioForest Technologies Inc. 2002). Eggs hatch in late July or August after 10 to 14 days in incubation.

The first larval instar (L1) is photosensitive and moves to the tips of branches where new foliage is developing. At high density, L1 larvae can disperse using silken threads (British Columbia Ministry of Forests 1995, Internet site). L1 larvae feed for one week before spinning a hibernaculum in bark scales, bark fissures, staminate flower bracts and on lichens (BioForest Technologies Inc. 2002). L1 larvae molt within the hibernaculum and overwinter as L2 larvae (Mattson *et al*. 1987 in BioForest Technologies Inc. 2002).

L2 larvae emerge in late April to mid-May and move towards shoot tips. As many of the new buds of the host plant are unopened, L2 larvae tunnel into old needles, unopened buds and staminate flowers. They feed on new foliage as it emerges. If population densities are high, larvae will backfeed on old foliage (BioForest Technologies Inc. 2002).

Four to six weeks are required for the budworm to complete growth and molting from the L2 to L6 instars. In this time, larvae undergo a 1500x increase in size, achieving a length of 20 to 30 mm (Cerezke 1991). The L6 larvae feed for five days (Fast and Dimond 1984 in BioForest Technologies Inc. 2002) and are responsible for 80 to 87 percent of defoliation (Miller 1977 in BioForest Technologies Inc. 2002, Blais 1979 in BioForest Technologies Inc. 2002, Cerezke 1991). Pupation begins in mid to late June and lasts 10 to 14 days after which moths emerge. Adults (moths) can disperse with the aid of wind currents for 50 to 100 km (Volney and Stocks 2002). Dispersal is greater from stands with higher rates of defoliation (Volney and Stocks 2002).

A.1.3 Impacts on Vegetation

A.1.3.1 Defoliation and Tree Mortality

Defoliation is typically heaviest and occurs first at tree crowns (Erdle and MacLean 1999 in BioForest Technologies Inc. 2002). Crown defoliation disrupts the translocation of water, metabolites and hormones, and leads to a decreased capacity for tree respiration and growth. A proportional relationship has been defined between growth reduction and degree of defoliation (e.g., 50 percent cumulative defoliation leads to 50 percent growth reduction) (Erdle and MacLean 1999 in BioForest Technologies Inc. 2002). Eventually, lead shoots die, top mortality occurs, and attack from secondary insect species can occur (e.g., bark beetles, root rot) (Montgomery *et al.* 1982 in Meating 2002). In one study, Blais 1981 (in Meating 2002) found that when defoliation levels in trees exceeded 75 percent, 100 percent of balsam fir and 65 percent of white spruce died. In a recent SBW outbreak in northwestern Alberta, the annual mortality rate of white spruce was between 2.2 and 2.8 percent (Volney and Stocks 2002). Batzer and Bean 1962 (in BioForest Technologies Inc. 2002) estimated that of the trees that manage to survive SBW outbreaks, 50 percent would have dead tops. Dead trees and dead top sections are more susceptible to toppling under snow and ice loads, and are more prone to wind damage.

A.1.3.2 Factors that Affect Defoliation and Mortality Rates

All host trees are susceptible to SBW, however, their vulnerability and the outcome of SBW attack is influenced by many factors. These include the following:

- Host tree species – balsam fir tend to exhibit greatest vulnerability and higher rates of mortality, followed by white spruce, red spruce and black spruce (MacLean and MacKinnon 1997)
- Stand composition – stands with greater than 35 percent hardwoods typically sustain lower levels of mortality than do stands with greater amounts of conifer trees (MacLean and MacKinnon 1997). Black spruce present as a pure stand is generally not as heavily infested as when it occurs in mixed stands with white spruce and balsam fir (Blais 1957 in BioForest Technologies Inc. 2002).
- Stand closure – relatively open stands tend to be more vulnerable to infestations than do closed forests (British Columbia Ministry of Forests 1995, Internet site)
- Fire suppression – fire suppression and the retention of mature or older growth forest predispose these stands to SBW attack (British Columbia Ministry of Forests 1995, Internet site)
- Tree and stand health – stress in forests, such as that induced from excessive heat in excessively dry balsam fir stands or excessively wet or dry black spruce stands, is associated with greater mortality in SBW outbreaks. Trees in stressed environments have higher foliar nitrogen concentrations, which are related to larger female SBW moths. Trees that are stressed prior to infestation will be affected first.
- Tree and stand age – mature stands begin to die after four to five years of a moderate to severe SBW outbreak, while immature stands suffer mortality after six to seven

years. Older stands (120 to 190 years) are more susceptible than are younger stands (40 to 110 years) (BioForest Technologies Inc. 2002).

- Climatic conditions – warm dry springs and ensuing drought conditions may promote both SBW larval success and population densities, and the prolongation of outbreaks
- Number of years at outbreak level – After 12 years of sustained defoliation, a stand typically suffers complete mortality (BioForest Technologies Inc. 2002)
- Topography – as it relates to soil drainage, as higher tree loss is associated with excessively dry and wet sites (Dupont *et al*. 1991; Osawa 1989 in BioForest Technologies Inc. 2002)
- Stand location in relation to surrounding infested stands – moth dispersal is higher in stands with high SBW densities in comparison to those with low densities. Crowded conditions on an individual tree can cause larvae to disperse through transport by wind currents on silken threads.

A.1.4 Impacts of Spruce Budworm on Forests in Prince Albert National Park

In 2002 in Waskesiu, 48.3 percent of white spruce surveyed had defoliation levels between 31 and 75 percent. In the best-case scenario without intervention, it is projected that 50 percent of white spruce in the townsite will be seriously affected, with 25 percent mortality and the remainder suffering dead tops. The most probable case scenario projects that 67 percent of the trees will be affected, with 35 percent mortality (BioForest Technologies Inc. 2002). The majority of trees in the townsite are approximately 84 years old, having originated after a fire in 1919 (Croutch *et al.* 2002). As 2003 will mark the fifth or sixth year of moderate to severe outbreak levels, and as mature trees experience mortality after four to five years of moderate to severe mortality (MacLean 1980 in Meating 2002), tree mortality may be experienced in 2003.

A.2 Btk Overview

Bacillus thuringiensis subsp. *kurstaki* (Btk) is a gram-positive, aerobic, rod-shaped soil bacterium that is selectively bred and commercially produced for insecticidal use (USEPA 1998). It was first used as an insecticide in France in 1938, and in Canada in 1960. It has also been successfully used in Saskatchewan. The proposed insecticide, Foray 48B (Pest Control Product Registration Number 24977- 12.7 BIU per litre *Bacillus thuringiensis* subsp. *kurstaki*) is registered in Canada by the Pest Management Regulatory Agency for the control of SBW in forests, woodland areas and residential areas (Sawatsky 2003). It is generally considered less toxic and has fewer environmental effects than conventional pesticides (Swadener 1994).

Bt is considered a narrow spectrum insecticide as 34 varieties of Bt are known and each is pathogenic to a different insect group. Btk is pathogenic to 2000 of the 11,000 species of the *Lepidoptera* genus including the SBW. Btk is toxic to susceptible *Lepidoptera* species if they occur in a feeding larval stage at the time of application (Boulton *et al.* 1999; Volney 2003, pers. comm.).

A.3 Effects of Btk on Spruce Budworm

To survive in adverse conditions, Btk produces asexual spores; during spore formation it also produces protein crystals (δ-endotoxins). When ingested by SBW larvae, the protein crystals react with the alkaline gut of the larvae and become toxic (Valent BioSciences Corp. 2001). The δ-endotoxins destroy the cells lining the gut, and feeding ceases within minutes. Larvae die of starvation or septicemia in two to five days.

Applications of Btk will not eliminate all SBW larvae; however, Btk is effective in reducing defoliation. Field trials of Foray 48B in Manitoba and Quebec (2.4L/ha undiluted) yielded 69 to 91 percent reductions in SBW populations (Valent BioSciences Corp. 2001). Development of resistance to Btk in the local SBW population is unlikely as the number of applications per year being considered (one to three applications) is very low (Valent BioSciences Corp. 2001; BioForest Technologies Inc. 2002).

A.3.1 Factors Influencing the Effectiveness of Btk

Efficiency of the spray depends on the formulation of the insecticide, aircraft height, relative humidity, insect and host development, wind speed and direction, temperature, host type, dosage and volume, and pest density (Valent BioSciences Corp. 2001; BioForest Technologies Inc. 2002). In terms of application effectiveness, it is recommended that application should occur when the relative humidity is greater than or equal to 50 percent, wind speed is between zero and 13 km/h (light to moderate winds with neutral stability as occurs at mid-morning and on cloudy days), temperature is between five and 21°C, and when air turbulence and temperature inversions do not affect settling of the insecticides (Valent BioSciences Corp. 2001; Waskesiu Community Association Inc. 2002). Application should take place after dew has evaporated and should not be applied when rain is forecast in the following six hours (PMRA 2001, Internet site; Valent BioSciences Corp. 2001). The post-spray conditions are as critical as the spray conditions; the temperature and precipitation in the days following application affect larval feeding behaviour and therefore the probability of ingestion (van Frankenhuyzen 1995 in BioForest Technologies Inc. 2002). Rain, acidic conditions and microbes will degrade Btk.

As the majority of defoliation occurs at the L6 stage, applying Btk in late May to mid-June, prior to the final larval stage is optimal (Cerezke 1991). Applying when host shoots elongate and leaves expand also improves exposure as coverage is improved by increased deposition area (Hansen and Dimond 1982 in BioForest Technologies Inc. 2002; PMRA 2001, Internet site).

A.4 Alternatives for Control of Spruce Budworm

Parks Canada reviewed other products for control of SBW in Waskesiu and did not identify other means that had the history and success of use as does Foray 48B. Btk based products are widely used in Saskatchewan and Foray 48B specifically is appropriate for use in residential areas (Leeson 2003, pers. comm.)

The following options are discussed as alternatives to the proposed spray program.

A.4.1 Tree Removal

Trees can be removed shortly before or after tree mortality (Cerezke 1991). Landowners would be responsible for tree removal from private land, while Parks Canada will be responsible for removal from public areas (BioForest Technologies Inc. 2002; Croutch *et al.* 2002). Where feasible, plans for tree removal as an alternative means with which to mitigate damage incurred from the budworm outbreak, would be developed in conjunction with reference to any pertinent sections of the vegetation management plan. Currently, the vegetation management plan is under development and not yet available for review.

A.4.2 Do Nothing

The SBW is a natural component of the boreal forest and pest outbreaks are part of the historic pattern of succession. The population cycle is currently at its peak and numbers will abate in the coming years (Volney and Stocks 2002). Populations may also decline naturally in years with late spring frosts and cool, wet summers (Cerezke 1991).

Many trees in the townsite are nearing the end of their life cycle; removal of hazardous trees may be required in the coming 10 to 20 years regardless of infestation effects (Croutch *et al.* 2002).

BioForest Technologies Inc. (2003) predict a probable scenario of an uncontrolled spruce budworm outbreak in Waskesiu in which there is 35% tree mortality, 50% with dead tops, and overall about 67% affected in some way.

A.4.3 Hand Picking

SBW larvae may be handpicked from small and ornamental trees that are accessible (Cerezke 1991). This alternative is not economically feasible or logistically possible for the entire proposed spray area (approximately 529 ha).

A.4.4 Washing Trees

Washing trees with a high-pressure hose is more expensive than spraying (BioForest Technologies Inc. 2002). It is also a non-specific means of control and will adversely affect many insects, nesting birds and some mammals. This method has not been through rigorous testing for effectiveness, is not economically feasible and would waste large quantities of water.

A.4.5 MIMIC

MIMIC is a synthetic ecdysone, a molting hormone. It causes a partial molt that prevents further feeding; the larvae die in a few days of starvation. Effects are specific to Lepidoptera larvae, so there is little non-target action on other types of insects or vertebrates (PMRA 1996, Internet site). It has been used in Manitoba and Alberta to control SBW but has not yet been applied in Saskatchewan (BioForest Technologies Inc. 2002).

A.4.6 Ground-based spraying

Ground-based spraying for SBW is an option for Btk application. The British Columbia Ministry of Forests notes that the use of hydraulic sprayers is the most effective method of ground application (Ministry of Forests 2003, Internet site):

"Foliage is usually sprayed until run-off is visible. Although limited by the maximum reach of the spray, hydraulic sprayers can be quite effective at delivering Btk into the crowns of trees. This method is a viable treatment option for eradication of gypsy moth if the populations are small and isolated in known areas. In addition, ground spraying can target only potential host vegetation and avoid treating other objects (houses, fences, etc.). Effectiveness decreases when tree crowns are very high or are dense and access to the trees themselves is difficult. Other disadvantages of this method of treatment (compared to aerial spraying) are:

- it is labour intensive (therefore more expensive);
- there is greater exposure to the insecticide to both the homeowner and the applicator;
- intrusive (requires entry onto private land; trucks and sprayers are set up in the streets for several days),
- it must be conducted throughout the day during the daylight hours when the public is out and about versus being conducted rapidly (less than 2 hours) in the early morning if sprayed aerially;
- very slow (takes several weeks to cover a fraction of the area treated from the air vs. less than two hours for aerial treatment); and,
- there is high localized drift during daylight hours since the wind tends to increase through the day"

A.5 Monitoring of Spruce Budworm

Monitoring is an important component of any pest management effort. Effective timing of Btk applications is dependant on an intensive monitoring program. Population surveys before and after application are important to evaluate the performance of the pest management program. Monitoring SBW populations can and should occur at various points throughout the lifecycle.

A.5.1 Egg Mass Surveys

Egg masses can be counted in August and September, shortly after they are laid. This is a reasonably accurate method of predicting population levels for the following year (BioForest Technologies Inc. 2002). The following sampling procedure for egg mass surveys is adapted from British Columbia Ministry of Forests (1995):

1. Collect samples at 30–50 m intervals from the mid-crown of mature, well-foliated trees. Understory or severely defoliated trees should not be selected for sampling.
2. Two 45 cm branch tips from the north and south aspects of well-foliated trees are randomly collected from each of 10 trees per site.
3. Width and length of each branch sample are measured and foliar area calculated:

$$\text{Foliar area } (m^2) = \left(\frac{\text{Length (cm)} \times \text{ width (cm)}}{100} \right) \div 2$$

4. The egg masses are counted, using a magnifying lamp or under ultraviolet lighting (egg masses fluoresce), and the information is recorded. Do not confuse the old and new egg masses.
5. All samples must be processed within one to two days of collection. Prolonged storage will result in sample desiccation and needle loss from the branches, thus rendering the samples useless.

6. Calculate the number of new egg masses per 10 m^2 of foliage.
7. Use the following formula and table to predict potential defoliation at each site. The formula to arrive at predicted defoliation is as follows:

$$\text{Rating}/10\ m^2\ \text{foliage} = \left(\frac{\text{Total no. new egg masses}}{\text{Total foliar area } (m^2)} \right)$$

Predicted defoliation by the western SBW based on the number of new egg masses/10 m^2 of foliage is listed below:

Number of Egg Masses/10 m^2	Predicted Defoliation
0	Nil
1-50	Light
51-150	Moderate
151+	Severe

A.5.2 Second Instar Larvae (L2) Surveys

L2 surveys can be performed from September to April before the larvae emerge from the hibernacula. These surveys assist in determining densities before spraying and defining the treatment area (British Columbia Ministry of Forests 1995, Internet site). "This technique requires rearing facilities and is more time consuming than the other predictive methodologies described for SBW and therefore is not recommended unless absolutely necessary" (British Columbia Ministry of Forests 1995, Internet site). Foliage is collected and rinsed with sodium hydroxide and larvae are subsequently separated from the solution. Alternately, larvae can be forced from diapause by chilling the sampled foliage and placing it in an emergence cage (British Columbia Ministry of Forests 1995, Internet site).

A.5.3 Third to Fourth Instar Larvae (L3 to L4) Surveys

Sampling at this stage can be performed in May and June to determine the effects of predation and parasitism on larval populations. Surveys can be completed visually, or mechanically, using baskets, drums or beating (BioForest Technologies Inc. 2002).

A.5.4 Pupal Surveys

Pupal surveys can be conducted in late June to July. Methods are similar to those used for L3 to L4 larvae. "Larval sampling is used to predict population trends and to evaluate efficacy of insecticide treatments. Larval sampling is usually done prior to, and at regular intervals following, a direct control program (pre- and post-spray sampling). Sample trees for pre- and post-spray assessment are established within and outside of designated spray blocks. To determine population trends, the same sample trees must be visited at each sample time" (British Columbia Ministry of Forests 1995, Internet site).

A.5.5 Adult Surveys

Adults can be counted in late June to late July. Numbers can indicate the occurrence and location of dispersal, the relative abundance of SBW in different stands, and population trends. Light or pheromone traps may be used. Light traps are non-selective so sorting for

SBW adults within all insects collected is required. Pheromone traps can be species or genus specific and can provide three types of information:

1. time series data for assessment of population trends
2. early warning of population fluctuations
3. estimates of SBW numbers to replace or augment other population surveys (Sanders 1985 in BioForest Technologies Inc. 2002)

A.6 Bibliography

A.6.1 Literature Cited

BioForest Technologies Inc. 2002. *A review of the eastern spruce budworm: Likely impacts and management options in Prince Albert National Park*. Prepared for: Save Our Spruce Committee and Prince Albert National Park. Sault Ste. Marie, ON.

Boulton, T.J., D.A. Rohlfs and K.L. Halwas. 1999. *Non-target Lepidoptera on Southern Vancouver Island: Field assessments during a gypsy moth eradication Program involving three aerial applications of Btk.*

Cerezke, H.F. 1991. *Forestry Leaflet no. 9: Spruce budworm*. Natural Resources Canada, Canadian Forest Service, Northern Forestry Centre, Edmonton, AB.

Croutch, S., B. Pollock, M. Valleau and C. Witzel. 2002. *The scope of impacts resulting from an aerial Btk spray program in Waskesiu Townsite*.

Dupont, A., L. Belanger, and J. Bousquet. 1991. Relationships between balsam fir vulnerability to spruce budwom and ecological site conditions of fir stands in central Quebec. Canadian Journal of Forest Research. 21:1752–1759.

Meating, J. 2002. Letter to J. Weir (Prince Albert National Park). September 2, 2002.

MacLean, D.A. and W.E. MacKinnon. 1997. Effects of stand and site characteristics on susceptibility and vulnerability of balsam fir and spruce to spruce budworm in New Brunswick. *Canadian Journal of Forest Research*. 27:1859–1871.

Sawatsky, P. 2003. Regional Pesticides Manager for Saskatchewan/Manitoba. January 13, 2003. Pest Management Regulatory Agency, Heath Canada, Winnipeg, Man.

Swadener, C. 1994. *Bacillus thuringiensis* (Bt). *Journal of Pesticide Reform*. 14(3):13–20.

United States Environmental Protection Agency (USEPA). 1998. *Reregistration eligibility decision, Bacillus Thuringiensis.* United States Environmental Protection Agency. March 1998. Washington DC.

Valent BioSciences. 2001. *Protecting Our Forests – Protecting our Future*. Forestry Technical Manual. Foray and Dipel. Valent Biosciences Corporation.

Volney, W.J.A. and B.J. Stocks. 2002. *Trip Report: Spruce budworm cause mortality concerns in Prince Albert National Park and Lac La Ronge Provincial Park*. Natural Resources Canada, Canadian Forest Service, Edmonton, AB.

Waskesiu Community Association Inc. (WCA). 2002. *A project proposal to apply bio-pesticides on Waskesiu Townsite or the purpose of managing spruce budworm infestation*. Waskesiu, SK.

A.6.2 Personal Communications

Leeson. B. 2003. Senior Environmental Assessment Scientist, Parks Canada. Calgary, Alberta. April 14, 2003.

Volney, J. 2003. Research Scientist, Natural Resources Canada, Edmonton, AB.

A.6.3 Internet Sites

British Columbia Ministry of Forests. 1995. *Defoliator Management Guidebook*. Victoria, BC. Accessed at: http://www.for.gov.bc.ca/tasb/legsregs/fpc/fpcguide/defoliat/defoltoc.htm.

Ministry of Forests. 2003. Ground Spraying of Btk for Gypsy Moth Control in B.C. Accessed April 16, 2003. http://www.for.gov.bc.ca/hfp/gypsymoth/ground.htm

Pest Management Regulatory Agency (PMRA). 2001. Foray® 48B label transcript. Health Canada, Ottawa, ON. Accessed at: http://64.26.129.82/oldlabelold/24000-24999/24977.pdf.

Appendix B Glossary

Glossary

Acute toxicity: Adverse effects occur within a short time (usually up to 14 days) after a single exposure of a test substance, or after multiple exposures that are given in a 24-hour period (IUPAC 1993, Internet site).

Annelida: Phylum of invertebrates comprised of segmented worms.

Antibody: Protein produced by the immune system that can specifically bind to the molecule that caused its formation (IUPAC 1993, Internet site).

Arthropod: Phylum describing segmented invertebrates with joined legs. This includes insects, spiders and crustaceans (NASA 2000, Internet site).

Autotrophic: Pertaining to an organism that can synthesize food from inorganic compounds (e.g., photosynthesize).

Benthic: "Pertaining to the bottom region of an ocean, lake or pond" (McGraw-Hill 1997, Internet site).

Biota: All living organisms.

Bog: Deposits consisting of sphagnum or forest peat formed in an ombrotrophic (nutrient poor) environment caused by the slightly elevated nature of the bog (SCWG 1998).

Bt crystals: The endotoxins produced by the Bt bacteria during their formation of spores.

Chronic toxicity: Adverse effects following exposures that occur over an extended period of time, or a large portion of the test species' lifetime (IUPAC 1993, Internet site).

Coleoptera: Order of insects with hardened forewings. Also known as beetles (Davies 1988).

Coliform bacteria: Group of bacteria common to the digestive tract of humans and animals. Their presence in water indicates fecal contamination (Gregorich *et al.* 2001).

Colony forming unit: a colony that has grown on a filter (when cultured in a lab) that originated from one microorganism in the sample (NASA 2000, Internet site).

Corneal ulcer: An ulcer in the cornea of the eye. An ulcer is a break in skin or mucous membrane with loss of surface tissue; often festers and corrupts like an open sore, and is associated with pus.

Culture-positive: A lab culture that is positive for the looked-for microscopic organism.

Cumulative effects: Effects on living organisms or the physical environment due to stress imposed by more than one mechanism (Gregorich *et al.* 2001).

Defoliation: Removal of foliage (e.g., leaves, needles).

Ecological integrity: "An ecosystem has integrity when it is deemed characteristic for its natural region, including the composition and abundance of native species and biological communities, rates of change and supporting processes." (Parks Canada Agency 2000).

Ecoregion: Part of an ecozone characterized by distinctive ecological responses of vegetation, soil, and water to climate (Haddon 1998, Internet site).

Ecozone: An area of the earth representative of large and generalized ecological units that are characterized by abiotic and biotic factors (Haddon 1998, Internet site).

Eluvial horizon: A soil horizon formed from the transportation of soil material in suspension or in solution within the profile by the downward or lateral movement of water (Gregorich *et al.* 2001).

Emergent vegetation: Aquatic plants in which most leafy growth occurs above water level (McGraw-Hill 1997, Internet site).

Endangered (COSEWIC status): "A species facing imminent extirpation or extinction" (COSEWIC 2002, Internet site).

Endocrine disruptor: Substance that disrupts the normal functioning of the endocrine system, which is the bodily system that is responsible for producing and secreting hormones into the bloodstream (IUPAC 1993, Internet site).

Endotoxin: A poison found in the cell membrane of some bacteria, which is released when the cell is damaged or destroyed (NASA 2000, Internet site).

Enzyme: A protein that, in small amounts, speeds up the rate of a biological reaction without itself being used up in the reaction (i.e., it acts as a catalyst) (NASA 2000, Internet site).

Epidemiology: A branch of science that studies the incidence, distribution, and control of diseases. It includes the study of such classic epidemics as the plague and cholera, but also includes all forms of disease that relate to the environment and ways of life (e.g., the link between smoking and cancer) (NASA 2000, Internet site).

Erosional features: Features formed through the wearing away of the land surface by water, wind, ice or other agents (Gregorich *et al.* 2001).

Eskers: A ridge of roughly stratified gravel and sand that was deposited by a stream flowing in or beneath the ice of a stagnant or retreating glacier, and was left behind when the ice melted (Gregorich *et al.* 2001).

Fen: Deposits consisting of sedge peat derived primarily from sedges with inclusions of partially decayed stems of shrubs formed in a eutrophic (nutrient rich) environment due to the close association of the material with mineral-rich waters (SCWG 1998).

Glacial deposition: Materials deposited after having been eroded and transported by glaciers (Gregorich *et al.* 2001).

Glacial till: Unstratified glacial drift deposited directly by the ice and consisting of clay, sand, gravel and boulders intermingled in any proportion (Gregorich *et al.* 2001).

Glaciofluvial: Material moved by glaciers and subsequently sorted and deposited by streams flowing from the melting ice (Gregorich *et al.* 2001).

Glaciolacustrine: Pertaining to material derived from or deposited in glacial lakes.

Gram-positive: Bacteria that retain a purple/blue colour when stained with crystal violet (Gram stain) (Gregorich *et al.* 1998). This indicates that the bacteria have no outer membrane.

Heat-labile: Easily destroyed by heat; the breakdown of chemical cross-links due to the influence of heat.

Hummocky: Pertaining to a complex sequence of slopes extending from somewhat rounded depressions or kettles of various sizes to irregular to conical knolls or knobs. The surface generally lacks concordance between knolls or depressions (SCWG 1998).

Hymenoptera: Order of insects with membranous wings, including sawflies, ants, bees, wasps and others (Davies 1988).

Illuvial horizon: A soil horizon in which material carried from an overlying layer has been precipitated from solution or deposited from suspension as a layer of accumulation (Gregorich *et al.* 2001).

Invasive species: A species that takes over a new habitat where it was not previously found. It often replaces or disrupts species that were there before.

Invertebrates: Animals without backbones including arthropods, molluscs and earthworms (Gregorich *et al.* 2001).

Kame: A mound, knob, or short irregular ridge, composed of stratified sand and gravel deposited by a subglacial stream as a fan or delta at the margin of a melting glacier, by a supraglacial stream in a low place or hole on the surface of the glacier, or as a ponded deposit on the surface or at the margin of stagnant ice (Gregorich *et al.* 2001).

Kettle: A depression in glacial drift, especially in outwash formed by the melting of a detached block of stagnant ice that was buried in the drift (Gregorich *et al.* 2001).

LD_{50}: Amount of a substance that causes the death of 50 percent of the organisms in a test population when absorbed by the body in a single dose (IUPAC 1993, Internet site).

Lepidoptera: large order of scaly-winged insects including the butterflies, skippers and moths.

Luvisol: A soil order with profile sequences demonstrating an eluvial and illuvial horizon in which silicate clay is the main accumulation product. These soils are commonly found under forest or forest-grassland transition in a moderate to cool climate (Gregorich *et al.* 2001).

Lymphadenitis: Inflammation of the lymph nodes (McGraw-Hill 1997, Internet site).

Lymphoid hyperplasia: Proliferation of normal cells resembling lymph tissue (Nephrogenic Diabetes Insipidus Foundation 2003, Internet site).

Macrophyte: Any plant visible to the naked eye (Gregorich *et al.* 2001).

Meltwater channel: A channel cut into solid rock or drift deposits by water flow in areas of former glaciation, but unrelated to the present drainage system (Gregorich *et al.* 2001).

Mesisol: A soil great group in the Organic order consisting of dominantly moderately decomposed organic material (SCWG 1998).

Microflora: Bacteria, fungi, algae and viruses (Gregorich *et al.* 2001).

Moraine: An accumulation of heterogeneous rubbly material, including angular blocks of rock, boulders, pebbles and clay, which has been transported and deposited by a glacier (Gregorich *et al.* 2001).

Mutagenic: Attribute of a substance that can cause heritable changes (mutations) of the genes (DNA) in a cell (IUPAC 1993, Internet site).

Mutagenicity: The degree to which a substance is mutagenic.

Native species: A species that is part of an area's original flora and fauna (i.e., not introduced by man) (Gregorich *et al.* 2001).

Nematode: A small worm that is common in most soils (Gregorich *et al.* 2001).

Neuroptera: Order of insects with two pairs of membranous wings, including alder-flies, lacewings, antlions, dobsonflies and snakeflies (Davies 1988).

Non-native species: A species that is not original to the flora and fauna of the area, but was transported there by humans.

Non-target: An organism affected by an agent, although it was not the intended target (IUPAC 1993, Internet site).

Organic deposit: Materials that have accumulated by growth and death of plants, and that contain more than 17 percent organic carbon (Gregorich *et al.* 2001).

Pathogen: An organism that causes disease or illness when it enters the body (NASA 2000, Internet site).

Pathogenicity: the ability of a parasite to afflict damage on the host.

Periphyton: Microscopic organisms found in the bottom of waterways or attached to submerged objects (Gregorich *et al.* 2001).

Persistence: The length of time that a substance remains in a particular environment before it is removed, or chemically or biologically transformed (IUPAC 1993, Internet site).

Pest: An organism that is regarded as harmful, irritating, or offensive to humans or to human interests (e.g., agricultural or forestry activities) (Gregorich *et al.* 2001).

Peyer's patches: Oval, elevated areas of lymphoid tissue on the mucous membranes of the small intestine, composed of many lyphoid follicles closely packed together (Medline Plus Health Information 2003, Internet site).

Physiographic: Refers to the geomorphology or landforms of an area (i.e., the form of the Earth's surface).

Phytoplankton: Microscopic, free-floating, autotrophic organisms in aquatic ecosystems (McGraw-Hill 1997, Internet site).

Secondary effect: An effect on a component (e.g., object, organism) that is not caused directly by an agent, but that results from the effects of the agent on other components, which then affect the component in question.

Special Concern (COSEWIC status): "A species is of special concern because of characteristics that make it is particularly sensitive to human activities or natural events" (COSEWIC 2002, Internet site).

Spore: A specialized form of a bacterial cell that may be used for dissemination, or survival of adverse conditions. It is more tolerant to extremes in temperature and moisture.

Submergent vegetation: Aquatic plants in which most or all growth occurs below water level.

Surficial material: The unconsolidated layer of material above bedrock and below soil; commonly related to glaciation deposition.

Threatened (COSEWIC status): "A species that is likely to become endangered if limiting factors are not reversed" (COSEWIC 2002, Internet site).

Till: Unstratified glacial drift deposited directly by ice and consisting of clay, sand, gravel and boulders intermingled in any proportion (Gregorich *et al.* 2001).

Titre: Concentration of a substance in a solution (McGraw-Hill 1997, Internet site).

Toxicity: The inherent potential or capacity of a material to cause adverse

Toxicology: The study of harmful substances and their effect on organisms. It is the study of the molecular structure of toxicants, the exposure of humans and animals, the absorption, distribution and processing of toxicants in the body, and the conditions caused by toxicants (NASA 2000, Internet site).

Toxin: "Poisonous substance produced by a biological organism such as a microbe, animal or plant" (IUPAC 1993, Internet site).

Transgenic plant: A genetically engineered plant that contains genes that were inserted into it from other organisms (e.g., viruses, animals or other plants) (McGraw-Hill 1997, Internet site).

Zooplankton: Small animal organisms that float passively in water (they have limited locomotive abilities) (McGraw-Hill 1997, Internet site).

B.1 Bibliography

B.1.1 Literature Cited

Gregorich, E.G., L.W. Turchenek, M.R. Carter and D.A. Angers. 2001. *Soil and Environmental Science Dictionary*. New York: CRC Press.

Haddon, B.D. 1998. Forest Inventory Terms in Canada, Third Edition: Part II: Glossary. *Canada's National Forest Inventory webpage*. Canadian Forest Service, Ottawa, ON. Accessed March 13, 2003. http://www.pfc.forestry.ca/monitoring/inventory/terms/glossary_e.html.

Parks Canada Agency. 2000. *"Unimpaired for Future Generations"? Protecting Ecological Integrity with Canada's National Parks*. Vol. I :A Call to Action. Report of the Panel on the Ecological Integrity of Canada's National Parks. Ottawa, ON.

Soil Classification Working Group (SCWG). 1998. *The Canadian System of Soil Classification*. Research Branch, Agriculture and Agri-Food Canada, Ottawa, ON.

B.1.2 Internet Sites

Committee on the Status of Endangered Wildlife in Canada (COSEWIC). 2002. Committee on the Status of Endangered Wildlife in Canada webpage. Accessed March 13, 2003. http://www.cosewic.gc.ca/index.htm.

International Union of Pure and Applied Chemistry (IUPAC). 1993. *Glossary for chemists of terms used in toxicology*. Pure and Applied Chemistry 65:2003–2122. Accessed March 13, 2003. http://www.sis.nlm.nih.gov/Glossary/main.html.

McGraw-Hill. 1997. *Plants, Animals, and the Environment Glossary*. Accessed March 13, 2003. http://www.mhhe.com/sciencemath/forestryenviron/pae/glossary.html.

Medline Plus Health Information. 2003. *Medical Dictionary*. U.S. National Library of Medicine and National Institutes of Health. Accessed March 28, 2003. http://www.medlineplus.gov.

National Aeronautics and Space Agency (NASA). 2000. *NASA Life Sciences Data Archive*. Accessed March 13, 2003.
http://lsda.jsc.nasa.gov/.

Nephrogenic Diabetes Insipidus Foundation. 2003. *Medical Definitions*. Accessed March 28, 2003. http://www.ndif.org/index.html.

Appendix C Plant CDC Species List

Tyler Colberg
4801 - 49th Ave
Olds, AB
T4H 1E1
13 Mar 2003

Dear Tyler Colberg

RE: R.CASKCDC*4812
PARKS CANADA SPRUCE BUD WORM SCREENING REPORT

A review of our manual and computer files indicates the presence of the following known occurrences of rare plants or animals in the area specified. Saskatchewan Environment and Resource Management (SERM) activity restrictions are listed below if applicable.

Scientific Name	Common Name	Global Rank	Provincial Rank	Habitat
Adoxa moschatellina	Musk-root	G5	S3	Moist, shady, mossy woods.
Senecio plattensis	Prairie ragwort or groundsel	G5S3	S4	Mesic grassland, sloughs, shores, often woods
Drosera anglica	English sundew or oblong-leaved sundew	G5	S3	Bogs, fens, wet “boggy” shores, and seepage areas, usually calcareous
Drosera linearis	Slenderleaf sundew	G4	S1	Calcareous “bogs” or fens
Pedicularis macrodonta	Purple or swamp lousewort	G4Q	S2	Wet marshy fens and bogs
Viola selkirkii	Great-spurred or Selkirk’s violet	G5?S2	S3	Moist rich deciduous, mixed or white spruce woods
Carex heleonastes	Hudson Bay sedge	G4	S2	Wet, open bogs, fens and shores
Carex pseudocyperus	Cyperus-like sedge	G5	S2S3	Marshy shores, pond margins & fens
Juncus stygius ssp. *americanus*	Moor or American bog rush	G5T5	S1S2	Boggy lake shores and calcareous bog-fens
Najas flexilis	Flexible naiad	G5	S2	Submersed aquatics in shallow water of ponds. protected lake bays, and quiet streams
Calypso bulbosa var. *americana*	Fairy slipper	G5T5?	S3	Mesic, usually, coniferous forests
Spiranthes lacera var. *lacera*	Northern slender ladies'-tresses	G5T5	S2S3	Moist to drying, sandy or peaty sites
Potamogeton strictifolius	Upright narrow-leaved pondweed	G5	S2	Immersed aquatics in shallow water of protected lake bays, ponds and slow streams
Scheuchzeria palustris ssp. *americana*	American scheuchzeria	G5T5	S3	Wet fens, open and treed bogs

The locations of the species are listed below:

Element	Zone	Easting	Northing
Adoxa moschatellina	13	415332	5980177
Senecio plattensis	13	428940	5974477
Senecio plattensis	13	440610	5974477
Senecio plattensis	13	440802	5980800
Drosera anglica	13	442971	5983655
Drosera linearis	13	442971	5983655
Drosera linearis	13	443402	5982590
Pedicularis macrodonta	13	433290	5958777
Viola selkirkii	13	415822	5980250
Carex heleonastes	13	428562	5974769
Carex pseudocyperus	13	423232	5982277
Carex pseudocyperus	13	433277	5980978
Juncus stygius ssp. *americanus*	13	442971	5983655
Najas flexilis	13	422702	5987300
Najas flexilis	13	422706	5987286
Calypso bulbosa var. *americana*	13	442710	5981100
Spiranthes lacera var. *lacera*	13	428940	5974477
Potamogeton strictifolius	13	423532	5973577
Scheuchzeria palustris ssp. *americana*	13	421532	5974477
Scheuchzeria palustris ssp. *americana*	13	442971	5983655

The following is a list of the Saskatchewan Environment and Resource Management activity restriction guidelines where applicable:

Species Name	Management Guidelines
Adoxa moschatellina	There are no restrictions on low intensity activities (foot, vehicle surveys) but there is a year round 25m buffer restriction between high intensity activities (drilling, trenching, seismic work) and the perimeter of any population.
Senecio plattensis	There are no restrictions on low intensity activities (foot, vehicle surveys) but there is a year round 25m buffer restriction between high intensity activities (drilling, trenching, seismic work) and the perimeter of any population.
Drosera anglica	There are no restrictions on low intensity activities (foot, vehicle surveys) but there is a year round 25m buffer restriction between high intensity activities (drilling, trenching, seismic work) and the perimeter of any population.
Drosera linearis	There are no restrictions on low intensity activities (foot, vehicle surveys) but there is a year round 25m buffer restriction between high intensity activities (drilling, trenching, seismic work) and the perimeter of any population.
Pedicularis macrodonta	There are no restrictions on low intensity activities (foot, vehicle surveys) but there is a year round 25m buffer restriction between high intensity activities (drilling, trenching, seismic work) and the perimeter of any population.
Viola selkirkii	There are no restrictions on low intensity activities (foot, vehicle surveys) but there is a year round 25m buffer restriction between high intensity activities (drilling, trenching, seismic work) and the perimeter of any population.
Carex heleonastes	There are no restrictions on low intensity activities (foot, vehicle surveys) but there is a year round 25m buffer restriction between high intensity activities (drilling, trenching, seismic work) and the perimeter of any population.
Carex pseudocyperus	There are no restrictions on low intensity activities (foot, vehicle surveys) but there is

Species Name	Management Guidelines
	a year round 25m buffer restriction between high intensity activities (drilling, trenching, seismic work) and the perimeter of any population.
Juncus stygius ssp. *americanus*	There are no restrictions on low intensity activities (foot, vehicle surveys) but there is a year round 25m buffer restriction between high intensity activities (drilling, trenching, seismic work) and the perimeter of any population.
Najas flexilis	There are no restrictions on low intensity activities (foot, vehicle surveys) but there is a year round 25m buffer restriction between high intensity activities (drilling, trenching, seismic work) and the perimeter of any population.
Calypso bulbosa var. *americana*	There are no restrictions on low intensity activities (foot, vehicle surveys) but there is a year round 25m buffer restriction between high intensity activities (drilling, trenching, seismic work) and the perimeter of any population.
Spiranthes lacera var. *lacera*	There are no restrictions on low intensity activities (foot, vehicle surveys) but there is a year round 25m buffer restriction between high intensity activities (drilling, trenching, seismic work) and the perimeter of any population.
Potamogeton strictifolius	There are no restrictions on low intensity activities (foot, vehicle surveys) but there is a year round 25m buffer restriction between high intensity activities (drilling, trenching, seismic work) and the perimeter of any population.
Scheuchzeria palustris ssp. *americana*	There are no restrictions on low intensity activities (foot, vehicle surveys) but there is a year round 25m buffer restriction between high intensity activities (drilling, trenching, seismic work) and the perimeter of any population.

The information detailed above represents the best available knowledge, to date, of the Saskatchewan Conservation Data Centre. The absence of any (more) occurrences may indicate a lack of information for the area rather than the absence of any rare plant, animal, plant community or other features of biological significance. The use of this information does not preclude the need for site investigation. Because the database is continually growing and improving the information in this response may be considered valid for a period of three months following the above date.

The use of this information is intended solely for use within the scope of the current request and is not to be re-used or sold without written permission from the Saskatchewan Conservation Data Centre. The Saskatchewan Conservation Data Centre shall be cited in any reports as the source for any information, provided by CDC staff, in connection with this request. Use of any information in this response indicates acceptance of these terms.

In order to enhance our knowledge of Saskatchewan's biodiversity and to improve future services to our clients we would request a copy of any report(s) produced in association with this request. We are particularly interested in the locations and status of plant and animal species. If we can be of any further assistance please feel free to contact the Saskatchewan Conservation Data Centre at (306)787-7196. We look forward to further cooperation in conservation planning.

Sincerely,

R. Jeffrey Keith
Information Manager/Zoologist

cc:

P.S. For a list of synonyms contact the SKCDC and ask for a check of the comments field in the ET (element tracking) file in BCD (Biological Conservation Database), or check their ftp site for updates (http://www.unibase.com/~biod

Appendix D Butterfly Species Known to use Species within Plant Families of the Boreal Biome in Alberta

Plant Families	Butterfly Species
Betulaceae	*Polygonia faunus rusticus*
	Polygonia faunus arcticus
	Erynnis icelus
	Nymphalis vaualbum j-album
	Boloria chariclea
	Limenitis (Basilarchia) archippus archippus
	Boloria frigga saga
Boraginaceae	*Vanessa cardui*
	Euphydryas anicia anicia
Cannabinaceae	*Polygonia satyrus*
Caprifoliaceae	*Celastrina ladon lucia*
	Celastrina ladon nigrescens
	Euphydryas editha beani
	Euphydryas editha hutchinsi
	Hesperia leonardus pawnee
	Lycaena (Epidemia) dorcas dorcas
	Lycaena (Epidemia) dorcas florus
	Papilio (Papilio) zelicaon
	Papilio (Pterourus) canadensis
	Speyeria mormonia eurynome
	Limenitis (Basilarchia) archippus archippus
	Poanes hobomok hobomok
	Aglais milberti milberti
	Papilio (Papilio) machaon hudsonianus
	Papilio (Papilio) machaon dodi
	Papilio (Papilio) machaon pikei
	Pyrgus communis
	Phyciodes batesii lakota
	Phyciodes cocyta
	Phyciodes pulchella
	Charidryas gorgone carlota
	Charidryas acastus
	Charidryas palla
	Vanessa atalanta rubria
	Vanessa cardui
	Euptoieta claudia
	Speyeria cybele leto
	Speyeria cybele pseudocarpentrerii
	Speyeria aphrodite manitoba
	Speyeria atlantis hollandi
	Speyeria electa beani
	Speyeria electa lais
	Boloria bellona jenistae
	Boloria chariclea
	Boloria improba
Cornaceae	*Celastrina ladon lucia*
	Celastrina ladon nigrescens
Crassulaceae	*Pyrgus centaureae freija*
	Pyrgus centaureae loki
	Euptoieta claudia

Plant Families	Butterfly Species
Cruciferae	*Pontia occidentalis occidentalis*
	Pieris oleracea
	Pieris rapae
	Euchloe ausonides mayi
	Anthocharis sara stella
	Pontia sisymbrii flavitincta
	Euchloe creusa
	Pontia protodice
Cyperaceae	*Satyrodes eurydice eurydice*
	Coenonympha inornata benjamini
	Cercyonis pegala ino
	Erebia disa mancinus
	Erebia discoidalis mcdunnoughi
	Oeneis macounii
	Oeneis chryxus chryxus
	Oeneis chryxus caryi
	Oeneis taygete edwardsi
	Oeneis jutta chermocki
	Oeneis jutta ridingiana
Ericaceae	*Satyrium liparops aliparops*
	Satyrium liparops fletcheri
	Incisalia (Deciduphagus) augustinus augustinus
	Lycaeides idas
	Boloria freija freija
	Incisalia (Deciduphagus) polia obscura
	Pygus centaureae freija
	Pyrgus centaureae loki
	Colias palaeno chippewa
	Colias interior
	Celastrina ladon lucia
	Celastrina ladon nigrescens
	Plebejus (Agriades) rusticus megalo
	Plebejus (Agriades) rusticus rusticus
Gramineae	*Amblyscirtes vialis*
	Polites mystic mystic
	Cercyonis pegala ino
	Carterocephalus palaemon mandan
	Hesperia leonardus pawnee
	Polites draco
	Erebia magdalena saxicola
	Oeneis alberta alberta
	Poanes hobomok hobomok
	Cercyonis oetus charon
	Hesperia comma manitoba
	Hesperia comma assiniboia
	Oarisma garita
	Coenonympha inornata benjamini

Plant Families	Butterfly Species
Grossulariaceae	*Polygonia faunus rusticus*
	Polygonia faunus arcticus
	Polygonia progne
	Polygonia gracilis
Juncaceae	*Oeneis jutta chermocki*
	Oeneis jutta ridingiana
Leguminosae	*Colias meadii elis*
	Colias canadensis
	Everes amyntula albrighti
	Lycaeides melissa
	Vanessa cardui
	Speyeria mormonia eurynome
	Erynnis persius borealis
	Erynnis persius fredericki
	Glaucopsyche lygdamus couperi
	Claucopsyche lygdamus oro
	Plebejus (Icaricia) acmon
	Papilio (Papilio) machaon hudsonianus
	Papilio (Papilio) machaon dodi
	Papilio (Papilio) machaon pikei
	Thorybes pylades
	Lycaeides idas
	Colias philodice
	Colias eurytheme
	Vanessa atalanta rubria
	Speyeria cybele leto
	Speyeria cybele pseudocarpentrerii
	Speyeria aphrodite manitoba
	Nymphalis antiopa
	Colias nastes streckeri
	Lycaena (Lycaena) cuprea snowi
	Plebejus (Plebejus) saepiolus amica
Malvaceae	*Vanessa cardui*
	Pyrgus communis
Pinaceae	*Incisalia (Incisalia) niphon clarki*
	Incisalia (Incisalia) eryphon eryphon
Plantaginaceae	*Euphydryas anica anica*
	Euphydryas editha beani
	Euphydryas editha hutchinsi
Polygonaceae	*Plebejus (Icaricia) acmon*
	Lycaena (Hyllolycaena) hyllus
	Lycaena (Epidemia) dorcas dorcas
	Lycaena (Epidemia) dorcas florus
	Lycaena (Epidemia) helloides
	Boloria napaea alaskensis
	Boloria eunomia dawsoni
	Lycaena (Epidemia) mariposa penroseae
	Euptoieta claudia
	Boloria eunomia nichollae

Plant Families	Butterfly Species
Polygonaceae (cont'd)	*Boloria eunomia triclaris*
	Boloria chariclea
Primulaceae	*Plebejus (Agriades) rusticus megalo*
	Plebejus (Agriades) rusticus rusticus
Ranunculaceae	*Boloria eunomia dawsoni*
	Boloria eunomia nichollae
	Boloria eunomia triclaris
Rosaceae	*Satyrium liparops aliparops*
	Satyrium liparops fletcheri
	Strymon melinus franki
	Harkenclenus titus immaculosus
	Boloria alberta
	Boloria astarte astarte
	Pyrgus centaureae freija
	Pyrgus centaureae loki
	Pyrgus ruralis
	Lycaena (Epidemia) dorcas dorcas
	Lycaena (Epidemia) dorcas florus
	Lycaena (Epidemia) helloides
	Celastrina ladon lucia
	Celastrina ladon nigrescens
	Limenitis (Basilarchia) archippus archippus
Salicaceae	*Erynnis icelus*
	Nymphalis antiopa
	Limenitis (Basilarchia) archippus archippus
	Limenitis (Basilarchia) arthemis rubrofasciata
	Papilio (Pterourus) canadensis
	Nymphalis vaualbum j-album
	Colias gigantea gigantea
	Colias gigantea harroweri
	Polygonia faunus rusticus
	Polygonia faunus arcticus
	Aglais milberti milberti
	Boloria eunomia dawsoni
	Boloria eunomia nichollae
	Boloria eunomia triclaris
	Boloria frigga saga
	Boloria improba
	Boloria chariclea
Scrophulariaceae	*Euphydryas anica anica*
	Euphydryas editha beani
	Euphydryas editha hutchinsi
Ulmaceae	*Polygonia interrogationis*
Umbelliferae	*Papilio (Papilio) machaon hudsonianus*
	Papilio (Papilio) machaon dodi
	Papilio (Papilio) machaon pikei
	Papilio (Papilio) zelicaon
Violaceae	*Euptieta claudia*
	Speyeria cybele leto
	Speyeria cybele pseudocarpentrerii
	Speyeria aphrodite manitoba

Plant Families	Butterfly Species
Violaceae (cont'd)	*Speyeria edwardsii*
	Speyeria callippe calgariana
	Speyeria callippe semivirida
	Speyeria hydaspe sakuntala
	Boloria eunomia dawsoni
	Boloria eunomia nichollae
	Boloria eunomia triclaris
	Boloria selene atrocostalis
	Boloria bellona jenistae

Source: Bird *et al.* 1995

Appendix E Follow-up Investigation of Human Health Concerns

This investigation was prompted, in part, by public concern surrounding the effects of Btk on people using anti-ulcer drugs and, more specifically, by public concern that the Draft Environmental Assessment for Public Consultation neglected to discuss reports which indicate adverse effects of Btk reactions in susceptible populations. Some public concerns specifically referred to the health effects reported and additional recommendations made to the Ministry of Agriculture and Forestry in the "Health Risk Assessment of the 2002 Aerial Spray Eradication Program for the Painted Apple Moth in Some Western Suburbs of Auckland" (ADBH 2002) and the British Columbia Environmental Appeal Board case: 98-PES-03(b). There were also concerns regarding the carcinogenicity of the inert chemicals in the product mixture and the potential Btk related health effects of swimming in Waskesiu Lake.

Based on the foregoing, the objectives of the investigation were:

- To address concerns surrounding the effects of Btk on people using anti-ulcer drugs.
- To address concerns of adverse effects in susceptible populations.
- To review the health effects reported and recommendations made to the Ministry of Agriculture and Forestry in the "Health Risk Assessment of the 2002 Aerial Spray Eradication Program for the Painted Apple Moth in Some Western Suburbs of Auckland".
- To review the relevant British Columbia Environmental Appeal Board cases (1998 & 2000).
- To address concerns regarding the carcinogenicity of the inert chemicals in the product mixture (i.e., Foray 48B).
- To address concerns regarding the potential Btk related health effects of swimming in Waskesiu Lake.

E.1 Anti-ulcer Drugs

Concern arose from the idea that people taking antacids or antagonists of acid production in the stomach, such as ranitidine, cimetidine or omeprazole, may be at increased risk of Btk related adverse effects as a result of reduced stomach acidity. Concerns were specifically based on comments attributed to an editorial submitted by Drobniewski (1994), who stated that only individuals with an absence or reduction of gastric acidity could face any risk from Bt. However, Drobniewski is referring solely to the possible effects of reduced gastric acidity, where it is not clear whether the intestine pH would be alkaline enough (i.e., 9-10) to activate the Bt toxin (ADHB 2002). Additionally, there is no evidence to indicate that the human gut has receptors to bind the Btk delta-endotoxin (Betz 2000). Drobniewski concludes, "there is no good evidence to discontinue use of *B. thuringiensis* in the developed and developing world on grounds of risk to human health". Finally, no increase in the cases of gastrointestinal symptoms has been reported in the populations in Vancouver, Oregon or Auckland, despite the common use of these gastric acid reducing agents (ADHB 2002).

E.2 Susceptible Populations

E.2.1 Children

The 1999 surveillance program in Victoria, British Columbia specifically looked at children with asthma as a potential sensitive subpopulation. Even though exposure had increased in the asthmatic children study group, no evidence of increased health symptoms or health effects was found in this subpopulation (Capital Health Region 1999). Further, the USEPA concluded in its re-registration eligibility decision that no harm would result to infants and children from dietary exposure to residues of Bt (USEPA 1998).

E.2.2 Immune-suppressed Individuals

Hernandez *et al.* (1999 & 2000) suggested that immune-suppressed mice might be susceptible to *Bacillus thuringiensis* subsp. *konkukian* infection. The World Health Organisation (WHO 1999), however, reviewed similar experiments performed by Siegel *et al.* (1987) and Siegel and Shadduck (1990) and determined that an intact immune system was not essential in protecting against Btk infection. Based on the aforementioned studies, WHO (1999) determined that immune-suppressed individuals are not at an increased risk of Btk infection. The 1992 Victoria surveillance program found no increased cases of infection in immune-suppressed persons that occurred during the time of spray (Noble *et al.* 1992).

In Noble *et al.* (1992), a history of asthma, seasonal allergies or eczema seemed to influence the frequency of reported symptoms in spray applicants, but no similar pattern was seen of public exposure in the same study. The occupational exposure levels were 500 times that of the exposed public.

E.3 Health Effects

E.3.1 Gastrointestinal Illness

ADHB (2002) reports that in 13 rat and 3 human studies no evidence of toxicity was found from the oral administration of Btk spores. In a number of these studies, viable Btk was in the stool of the test subjects after ingestion ceased. Despite the apparent presence of viable Btk in the gastrointestinal systems, no gastroenteritis-like symptoms were reported (ADHB 2002).

Surveillance studies from the Vancouver Spray Program reported no findings of any signs or symptoms that would indicate food poisoning or watery diarrhea (Noble *et al*. 1992). In a health report by the Washington State Department of Health, some cases of gastrointestinal illness were reported. However, there was no significant difference between the population exposed to the Btk spray and the non-exposed community (WSDH 1993).

E.3.2 Soft Tissue Infection

Samples & Buettner (1983) reported that a farm worker developed a corneal ulcer in one eye. It had been accidentally splashed with a commercial Btk product and Bt was subsequently isolated from the affected eye. The eye was treated with a topical antibiotic and corticosteroid and the corneal ulcer resolved 14 days after treatment. The report attributed the corneal ulcer to Bt infection. However, the possibility that Bt may have been a non-pathogenic contaminant of the ulcer was not considered. There are no other reports of Bt being associated with ocular infections in workers.

Damgaard *et al.* (1997) isolated Bt in burn wounds involving 30-70% of two patient's bodies. The Bt originated in the hot water the patients had been immersed in upon arrival at the burn center. None of the isolates showed any toxicity to Vero cells. Damgaard *et al.* (1997) concluded that Bt does not represent a health hazard when used as a microbial pesticide.

Hernandez *et al.* (1998 in ADHB 2002) isolated *Bacillus thuringiensis* subsp. *konkukian* from a severe war wound and found that the *Bt konkukian* strain could infect immunosuppressed mice after cutaneous application. This particular strain is not found in Foray 48B.

Warren *et al.* (1984 in Joung and Cote 2000) reported that a research worker developed a marked local reaction and lymphadenitis following a needle stick injury when handling *Bacillus thuringiensis* subsp. *israelensis* and *Acinetobacter calcoaceticus* subsp. *antitratus*. *Acinetobacter calcoaceticus* and Bt were cultured from the exudate. The condition responded to penicillin and the patient recovered after 5 days. ADHB (2002) states "there in no clear evidence that Bt was the sole cause of the infection" and suggests that *Acinetobacter calcoaceticus* is more likely the causative agent.

E.3.3 Pregnancy

With respect to reproductive concerns, ADBH (2002) concluded that there is no evidence available to suggest that Foray 48B causes miscarriages. Further, the health surveillance that occurred after Operation Ever Green showed no statistical difference between the birth weight, gestational age or birth defects of babies born from mothers inside or outside the spray area (Aer'aqua Medicine 2001).

E.3.4 Allergy

Despite the widespread use of Bt-based products, only two incidents of possible allergic reactions have been reported to the US EPA (McClintock *et al*., 1995). After detailed analysis, neither of these was considered to be causally related to Bt exposure.

No respiratory symptoms were found in farm workers exposed to Bt from picking vegetables. Individuals did, however, show that there might be allergic skin sensitization and induction of IgE and IgG antibodies, suggesting a potential immune response in the workers (Bernstein *et al*. 1999).

E.4 Review of "Health Risk Assessment of the 2002 Aerial Spray Eradication Program for the Painted Apple Moth in Some Western Suburbs of Auckland"

The "Health Risk Assessment of the 2002 Aerial Spray Eradication Program for the Painted Apple Moth in Some Western Suburbs of Auckland" makes the following recommendations to the Ministry of Agriculture and Forestry in the form of a Public Health Advisement:

"We do not expect toxic effects or infection from Foray 48B spray though if directly exposed to the spray or substantial spray deposits some people may complain of minor skin, eye and upper respiratory tract irritation, or aggravation of existing asthma or allergies. However, there is appreciable concern in the community and the lack of adequate epidemiological information will compound anxiety. Therefore, we advocate a precautionary approach and a policy of prudent avoidance to minimize exposure where possible."

The recommendations go on to give general advice for schools, food hygiene, drinking water, gardening, pool maintenance, cleaning outdoor surfaces, and advice for people with specific health concerns.

E.5 Review of the British Columbia Environmental Appeal Board case: 98-PES-03(b)

In a case heard before the British Columbia Environmental Appeal Board in 1998 (Appeal No. 98-PES-03(b)), the board found that the proposed aerial spray program created an unacceptable risk of health problems to the residents of Langford, Colwood, Esquimalt, and Saanich. The Appeal Board 1998 subsequently decided that limited ground spraying of Foray 48B be allowed within the proposed spray sites. In a more recent case heard before the same Appeal Board in 2000 (Appeal No. 00-PES-001 to 004) the permit for aerial spraying of Foray 48B was upheld. The panel of the Environmental Appeal Board determined that the pesticide application authorized by the permit would not cause unreasonable adverse health effects in the City of Burnaby.

E.6 Inert Chemicals as Carcinogens

Health Canada's Pest Management Regulatory Agency (PMRA) is responsible for ensuring that pesticides are safe based on the manufacture's full analysis of the product's formulation, which includes active and inert ingredients. Only scientifically reviewed products found to be of no or minimal health effect to humans are approved for use in Canada (PMRA 2000).

Concerns were raised that some of the inert chemicals in Btk product mixtures have been determined by the US EPA to be carcinogens. However, ADHB (2002) states that all but one of the Foray 48B inerts are listed under List 4B (substances with sufficient data to substantiate they can be used safely in pesticide compounds) on the US EPA's approval list of other (inert) pesticide ingredients (US EPA 2003). The remaining inert is listed under List 3 (inert ingredients on this list have not yet been determined to be of known potential toxicological concern nor have they been determined to be of minimal concern).

The inert compounds in Foray 48B are used in food, pharmaceutical and cosmetic products currently on the market, which are approved and licensed for their respective use (ADHB 2002). Some of the products have resulted in hypersensitivity, irritation, anaphylactic reactions, flatulence, abdominal discomfort, and diarrhea. ADHB (2002) stated that sensitization typically requires a significant primary exposure unlikely to occur in the exposed public (ADHB 2002). Eye, nose, throat, and skin irritation may occur from direct exposure to Foray 48B as a result of its moderate acidity (ADHB 2002). The ADHB (2002) states that the inert ingredients of Foray 48B are of low toxicity but that the potential may exist for a small number of individuals to demonstrate hypersensitivity to the inert chemicals as a result of previous exposure in food, cosmetics, and pharmaceutical agents. Health Canada does not identify any significant health risks for any ingredients in the formulation and considers Foray 48B safe for use in Canada (PMRA 2000).

E.7 Swimming in Waskesiu Lake

The presence of Btk in water is not considered to cause any adverse effects on human health, as it is not a human pathogen (McClintock *et al.* 1995). While it is possible that residents swimming in Waskesiu Lake may be exposed to low levels of Btk by consuming small amounts of water, this is not predicted to cause any adverse health effects as there is no evidence to suggest that the human gut has the required receptors for the Btk delta-endotoxin (Betz 2000).

E.8 References

Aer'aqua Medicine Ltd. 2001. Health surveillance following Operation Ever Green: A program to eradicate the white-spotted tussok moth from the eastern suburbs of Aukland. May 2001. Reported to the Ministry of Agriculture and Forestry. Auckland, NZ.

Auckland District Health Board (ADHB). 2002. Health Risk Assessment of the 2002 Aerial Spray Eradication Program for the Painted Apple Moth in Some Western Suburbs of Auckland: A Report to the Ministry of Agriculture and Forestry.

Betz, F.S. 2000. Safety and advantages of *Bacillus thuringiensis*-protected plants to control insect pests. Reg Toxicol Pharmacol. 32:156-173 (cited in ADHB, 2002).

Berstein, I., Bernstein, J., Miller, M., Tierzieva, S., Berstein, D., Lummus, Z., Selgrade, M., Doerfler, D., and Seligy, V. 1999. Environmental Health Perspectives. 107(7):575–582.

British Columbia Environmental Appeal Board. 1998. Appeal No. 98-PES-03(b).

British Columbia Environmental Appeal Board. 2000. Appeal No. 00-PES-001 to 014. http://www.eab.gov.bc.ca/pest/00PES001_014.htm

Capital Health Region. 1999. Human Health Surveillance during Aerial Spraying for control of North American Gypsy Moth on Southern Vancouver Island, BC, 1999. A report to the Ministry of Environment, Lands and Parks, Province of BC. Prepared by: BC Capital Health Region, Victoria, BC.

Damaard, P.H., Granum, P.E., Bresciani, J., Torregrossa, M.V., Eilenberg, J., and Valentino, L. 1997. Characterisation of *Bacillus thuringiensis* isolated from infections in burn wounds.

Drobniewski, F.A. 1994. A review: The safety of Bacillus species as insect vector control agents. Journal of Applied Bacteriology. 76:101–109.

Hernadez E., Ramisse F., Cruel T. le Vagueresse R., and Cavallo J. 1998. *Bacillus thuringiensis* subsp. *Konkukian* (serotype H34) superinfection: Case report and experimental evidence of pathogenicity in immunosuppressed mice. Journal of Clinical Microbiology. July 1998. Pg. 2138–2139 (cited in ADHB 2002).

Hernadez E., Ramisse F., Cruel T. le Vagueresse R., and Cavallo J. 1999. *Bacillus thuringiensis* sertype H34 isolated from human and insecticidal strains serotypes 3a3b and H14 can lead to death of immunocompetent mice after pulmonary infection. FEMS Immunology and Medical Microbiology. 24:43–47.

Hernadez E., Ramisse F., Cruel T. le Vagueresse R., and Cavallo J. 2000. Super-Infection by *Bacillus thuringiensis* H34 Or 3a3b can lead to death in mice infected with the influenza A virus. FEMS Immunology and Medical Microbiology. 29:177–181.

McClintock, J.T., Schaffer, C.R., and Sjoblad, R.D. 1995. A comparative review of the mammalian toxicity of *Bacillus thuringiensis*-based pesticides. Pestic Sci, 45:95–105.

Menon, A.S. and De Mestral, J. 1985. Survival of *Bacillus thuringiensis* var. *kurstaki* in waters. Water, Air, and Soil Pollution. 25:265–274.

Noble, M.A., Riben, P.D., and Cook, G. 1992. Microbiological and Epidemiological Surveillance Program to Monitor the Health Effects of Foray 48B Btk Spray. Prepared for: Ministry of Forests, Province of British Columbia. Prepared by: UBC, Department of Pathology and Health Care and Epidemiology, and University Hospital, Vancouver, BC.

PMRA (Pest Management Regulatory Agency). 2000. Fact Sheet on the *Bacillus thuringiensis* subspecies *kurstaki*. Health Canada. Ottawa, ON.

Samples, J.R. and Bruetter, H. 1983. Corneal ulcer caused by a biologic insecticide (*Bacillus thuringiensis*). Journal of Ophthalmology. 95(2):258–260.

Siegel, J.P. and Shadduck, J.A. 1990. Clearance of *Bacillus sphaericus* and *Bacillus thuringiensis* ssp. *israelensis* for mammals. J. Econ. Entomol. 83:717–723 (cited in Joung and Cote 2000, WHO 1999).

Siegel, J.P., Shadduck, J.A., and Szabo, J. 1987. Safety of the entomopathogen *Bacillus thuringiensis* var. *israelensis* for mammals. J Econ Entomol, 80:717–723 (cited in Joung and Cote 2000, WHO 1999).

US EPA (United States Environmental Protection Agency). 1998. Reregistration Eligibility Decision: *Bacillus thuringiensis*. United States Environmental Protection Agency, Prevention, Pesticides and Toxic Substances. http://www.epa.gov/REDs/0247.pdf

US EPA (United States Environmental Protection Agency). 2003. Pesticides, regulating Pesticides, List of Other (Inert) Pesticide Ingredients. http://www.epa.gov/opprd001/inerts/lists.html

WSDH (Washington State Department of Health). 1993. Report of Health Surveillance Activities, Asian Gypsy Moth Control Program. March 1993 (cited in ADHB 2002).

World Health Organisation (WHO). 1999. Environmental Health Criteria 217: *Bacillus thuringiensis*. http://www.inchem.org/documents/ehc/ehc/ehc217.htm