AN EXAMINATION OF BEST PRACTICES FOR MINE SITE RECLAMATION: AN INVESTIGATION OF ONTARIO'S RECENT ENVIRONMENTAL ASSESSMENT CASES WHERE RECLAMATION IS EXPECTED

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An Examination of Best Practices for Mine Site Reclamation: An Investigation of Ontario's Recent Environmental Assessment Cases Where Reclamation is Expected.

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Abstract

Mining can have significant public health and environmental consequences such as deforestation, waste rock deposition, and toxic mine effluents. Standards for reclamation of Ontario mine sites are not clear as there is no received model. A strong policy framework is essential to develop a mine closure system that protects the environment. An Environmental Assessment is the first stage for reclamation investigation. By setting standards for reclamation, projects that complete an Environmental Assessment will be better prepared to meet environmental protection objectives. Based on determined objectives, the best practice for mine site reclamations must include: restoration of soils, systematic revegetation, reclamation of water and wildlife restoration through habitat formation. Based on the results, Ontario is ahead of the provinces evaluated for environmental reclamation. None of the countries reviewed have a firm policy on reclamation. The results demonstrate a high number of reclamation components not being evaluated at the environmental assessment level.

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Many Thanks Dr. Ronald Pushchak. You have been my north star in this research world. May I no longer be boring and may you now call me Andrea.

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1 Introduction and Background

With mining as a large part of Ontario's economy, its importance will be maintained for a significant portion of our future. The large number of new mining projects proposed for Ontario's northern communities means that there is currently an opportunity to have an impact on the future protection of the environment. Mining can have significant public health and environmental consequences such as deforestation, waste rock deposition, mine tailings and toxic mine effluents (Cowan *et al., 2010).* Reclamation of a mine site can help to eliminate these hazards, but the dependency of mining on ore prices and market needs, increases the odds of mine abandonments or poor levels of reclamation. Reclamation can help minimize the impact of mining, but abandoned mines can be costly to reclaim, and often pose environmental threats such as leaching tailings ponds and areas of potential collapse. Ontario currently has many abandoned mines, which has often been the resulted from bankruptcies or poor government management (Mackasey, 2000; Gelinas, 2002).

To avoid the problems of mine abandonment and ensure future and current mine reclamation, legislation requires a proponent to evaluate the impacts of a project prior to its start. The Ontario *Environmental Assessment Act* is one of the pieces of legislation to which many new mining projects are subject. Environmental assessments document an approval process based on information collected by the proponent. The assessment process reviews the potential impacts of the project, including social, economic and environmental. Since the intended purpose is for review of impacts it is important to provide a complete picture of the project's lifespan. It is essential that the people who approve environmental assessments are aware of how a site will be reclaimed and if it meets scientific acceptable practices while keeping the best interests of the communities. Therefore the objectives of this study are to investigate if reclamation requirements for Environmental Assessments in the mining sector are sufficient, based on scientifically acceptable information. This will be done by the development of the best practices associated with mine site reclamation based on scientifically accepted information.

Completion of a comparison to other provinces in Canada and the world, to determine if Ontario can strengthen its policy will be used to establish if more can be done. Demonstration of the lack of currently acceptable standards, a set of acceptable standards and an argument for inclusion into the Environmental Assessment procedure will be developed. The goal is to inform the people involved in the Environmental Assessment decision-making process, of what should be required to achieve remediation. By factoring this additional information into the process, projects that require costly cleanups and extensive damage can be prevented.

1.1 The Practice of Mining in Ontario

Mining in Ontario and Canada is an essential part of the economy. In 2010, the estimated value of total mineral production from mining was estimated to be $7.7 billion, along with employing 27 000 people and sustaining countless direct and indirect businesses (Burkhardt *et al*., 2011; Ministry of Northern Development and Mines, 2012; Ontario Mining Association, 2012). The consequences of mining include changing physical landscapes, social cultural impacts, and extensive environmental impacts (Gelinas, 2002). Some of the environmental impacts include deforestation, water contamination, habitat disruption and toxic substances released if sites are not properly reclaimed (Gelinas, 2002; Cowan *et al.,* 2010; Burkhardt *et al*., 2011; Hart *et al*., 2012).

In Ontario there are currently 33 operating mines, but many new mines are currently being proposed, especially for an area of Ontario's far north called the 'Ring of Fire' (Ontario Mining Association, 2012). The 'ring of fire' is a remote area, mostly untouched, with small populations in aboriginal communities, and some industry related to resource development. In the 'Ring of Fire' alone there are 21 mining claims (MNDM, 2012). This is the potential for 21 new mines, or 21 new source problems since each mine is a potential for pollutants. Each of these new source problems will have environmental and human impacts. The scale of the environmental impacts can be minimized with proper planning.

The mining industry is a volatile industry dependent on market prices of ore. When the price of a specific commodity increases, development becomes worthwhile to investors. If the price of a commodity begins to decrease, investors might halt production until the value rises again. This volatility is what leads to a high potential for mine abandonment (Mackasey, 2000). The type of ore being produced in a mine is also often the biggest indicator of what the possible environmental impacts of a mine might be whether abandoned or not (Burkhardt *et al*., 2011).

The types and amounts of ore will determine the lifespan of a mine as well as the types of waste and possible contamination that may occur (Burkhardt *et al.,* 2011). A mine in Canada can have a varying life span depending on: market value of product being mined, quality of ore, the volume of ore in the ground and much more. The life of a mine can be as short as 15 or as long as hundreds of years (Burkhardt *et al.,* 2011). Because of the variability in life spans as well as mining's sensitivity to resource prices, it is different than many other projects that may be subject to an environmental assessment, which may have longer life spans. Mines often have a finite closure point that will occur in a relatively short period of time, thus companies should aggressively evaluate how to reclaim a site, a process that is not currently required in Environmental Assessments in Ontario.

1.2 Environmental Impacts

The environmental impacts of mining are vast, and differ depending on the mining process and types of minerals extracted. In Ontario there are two types of ore extraction, underground and open pit. While underground mining is used to reach minerals that are deep in the ground, open pit mining collects minerals at or near the surface of the earth. Since open pit mining targets near-surface minerals, removal of the overburden greatly disrupts the land, along with production of extensive volumes of waste rock. In addition, open pit mining subjects surrounding areas to the risk of acid rain drainage, which can cause aquatic system impacts because mine waste leachates are typically acidic (Burkhardt *et al.,* 2011). Underground mining typically has a smaller foot print than open pit mining but can still cause many of the same extensive environmental impacts depending on the extraction process and waste material disposal methods. Some of these impacts include acid mine drainage, areas of potential collapse, mine waste deposits, mine effluent contamination (Burkhardt et al., 2011).

The three major components of the environment (soil, water and air) are all affected by mining activity. Soil at a mining site suffers the greatest impact, with water second and the atmosphere third (Dirner *et al.*, 2013). Specifically with underground mining, waste rock is piled in waste dumps changing the landscape and using productive land for excess materials. These dumps also have the ability to create acid mine drainage (AMD). Acid mine drainage is the acidic run-off from exposed sulfide mineral containing rock. This exposed rock reacts with water (often from rainfall) and air to form the acidic run-off. Acid mine drainage has an impact on soils and waterways, leaching toxic constituents such as arsenic, selenium and metals (Environmental Law Alliance Worldwide, 2010).

Acid mine drainage is considered one of the most significant threats to waterways, but additional practices can have impacts on water resources. Erosion of soils and sediment into surface waters creates a quality problem by increasing the sediment loading and introducing chemicals, especially during storm events. Erosion can be influenced by water volumes, velocity of runoff, precipitation, infiltration rates, vegetative cover, slope of ground, and the implementation of erosion control measures. Erosion in mining normally occurs in open pit areas and waste rock dumps (Environmental Law Alliance Worldwide, 2010; Greenpeace, 2010).

The waste produced from a mine site can have a major impact on both surface and ground water. Tailing impoundments and waste rock dumps can change water quality. Contamination of groundwater happens when leaching from these locations infiltrates the ground and reaches the water table. Additionally excess rain can cause an overflow at tailings sites releasing toxic effluent (Environmental Law Alliance Worldwide, 2010).

Dewatering of open pit mine sites can affect groundwater. If an open-pit mine is below the water table, continuous pumping of the site must occur. This practice is known to have negative effects on surface waters and near by wetlands as well as groundwater. It can reduce and eliminate surface water flows and degrade the water quality. It can decrease levels in any nearby domestic wells and also decrease water quality. It may take years for a drawdown area to reach normal levels after pumping stops (Environmental Law Alliance Worldwide, 2010).

Air quality is impacted during all stages of mining, but the operating stage has the greatest possible effect. Particulate matter air pollution can come from winds, exhaust emissions, and production processes. As well, air pollution from gas emissions can come from explosions, work vehicles, and production processing. This pollution quickly dissipates and is not really able to be reclaimed after its release (Environmental Law Alliance Worldwide, 2010).

Open-pit mines create a greater impact on soils and surface conditions as all surface material is removed to reach the ore. Removing this soil destroys forests and wildlife habitats and creates increased soil erosion (Greenpeace, 2010). Many ecosystems are destroyed as a open-pit mine changes flora and fauna, forestry, and water systems (Environmental Law Alliance Worldwide, 2010; Dirner *et al.*, 2013). Mining can also cause landslides and create excess noise and other unfavorable conditions for wildlife (Greenpeace, 2010; Dirner *et al.*, 2013).

1.3 Human Health Impacts

Mining also impacts communities and individuals close to the mine site. The creation of employment opportunities and an increase in standards of living are beneficial for those who can participate, but there are risks living near mine sites. Depending on the ore body, communities may be uprooted and forced to relocate, an inconvenience for those involved. The biggest concerns are human health impacts since they go hand in hand with mining practice, for both employees and surrounding communities. The significance of these impacts is dependent on the technologies used in mining practice and the types of mining being completed. The loss to access of clean water is potentially the most significant impact. The leaching of toxic chemicals into waterways increases the likelihood that drinking water supplies will be compromised especially with abandoned mines (Environmental Law Alliance Worldwide, 2010).

In addition to waterways, the health risks of a mining project, with the release of hazardous substances into water, air and soil, is significant. The risks may include contributing to an increase in mortality or serious life threatening illness and the potential hazard to human health if hazardous substances are improperly treated, stored, disposed of or managed (Environmental Law Alliance Worldwide, 2010).

The common health impacts based on Environmental Law Alliance Worldwide (2010) Report include:

- Surface and groundwater contamination
- Exposure to high concentrations of sulfur dioxide, particulates, and heavy metals
- Deposition of toxic elements from air emissions

Mine impacts can be the result of mine abandonment. The extent and significance of the impacts raise the question of mine site reclamation.

1.4 Mine Closures

Currently the Mining Act governs mine requirements for closure through the Ministry of Northern Development and Mines (MNDM). Previous to the introduction of legislation and regulations through the *Mining Act* in 1991, owners of mines had no legal responsibility to ensure that a mine was closed safely, with the natural and social environments considered. Because of the lack of regulations and the volatility of the mining industry, mine abandonment often occurred. If companies ceased operation due to poor economic performance, they filed for bankruptcy and thus were unable to properly close the site (Mackasey, 2000; Gelinas, 2002; Castrilli, 2010). Specifically in Ontario, there is a significant history of mine abandonment. Currently in Ontario there are more than 6 000 abandoned mines (Mackasey, 2000; Castrilli, 2010).

1.4.1 Mine Abandonment: Impacts

Problems arising from some abandoned mines include: poor public health and safety, environmental damages, and aesthetic concerns (Mackasey, 2000; Gelinas, 2002). Most public complaints are related to the aesthetics of an abandoned mine with little attention paid to the less visible problems of chemical and physical stability (Mackasey, 2000). Waterways and soils have been contaminated by toxic water leakages. The substances that are leaking include arsenic, cyanides, lead, copper, nickel and cadmium to name a few. Exposure to these substances will continue to degrade the environment and lead to a high risk of impact to human health. Materials may also become airborne causing respiratory problems for humans near the mine site. In addition, if mines are not properly reclaimed, open surfaces are created and areas of potential collapse may leave opportunity for serious injury. Some of sites are unknown increasing their threat (Mackasey, 2000; Gelinas, 2002). Mine abandonment is detrimental to the environment and a threat to human health.

The following are examples of two abandoned mines in Ontario. The First is an example of a large scale project that has undergone reclamation. The second is a smaller mine site, which will be reclaimed in the future.

1.4.1.1 Case Study One: Kam Kotia Mine, Timmins Ontario

History

The Kam Kotia mine is located approximately 17 miles west of the Town of Timmins in Ontario. It was originally mined as part of the World War II efforts to produce copper (Reynolds, 2002). The mine was owned by Hollinger Gold Mine, but was required by the government to mine copper (Reynolds, 2002). It operated in this status from September 1943 to December 1944. At the time of original operation, no roads to the ore body existed (Reynolds, 2002).

The Wartime Metals Corporation was the proponent that started the project and provided the capital and operating funds. It required that Hollinger manage the project and move staff from the gold mine to the copper mines (Reynolds, 2002).

In 1944 the mine funding was stopped as a cheap supply of copper was found in the United States. In that time Hollinger was able to produce 5.5 million pounds of copper at a loss. Hollinger then sold the mine to a mine developer that re-opened it in 1960 and again sold it to another mine developer who operated it until 1972. In 1973, Kam Kotia mines was bankrupt thus returning the property to the Crown (Reynolds, 2002).

In the 1970s the site was abandoned and the government obtained the 240 hectares. In its abandoned status the mine site was in alleged violation of the Environmental Protection Act, the Ontario Water Resources Act and the Fisheries act (Environmental Commissioner of Ontario, 2000).

Problem

The site is under reclamation but before the reclamation began, for 27 years it sat as a swamp. The water located in the swamp was acidic therefore it is filled with dead trees and rotting vegetation. In addition the waste rock at the site has high sulphide concentrations and tailings, which have oxidized, have created acidic runoff (Werniuk, 2001; Reynolds, 2002).

The Ministry of Natural Resources and the Ministry of the Environment prepared a site assessment that found significant contamination (Environmental Commissioner of Ontario, 2000). This contamination included destruction of site vegetation and acidic drainage leaking into the Kamiskotia and Little Kamiskotia rivers. This acid mine drainage has a pH of 2.5, along with exceedences of provincially regulated water quality objectives for copper, and zinc by 2000 and 1000 times respectively. In addition to exceeding acceptable levels for these metals, it also included elevated levels of nickel, manganese, aluminum, magnesium and sulphate (Environmental Commissioner of Ontario, 2000).

Reclamation

In 1999 the Province made a commitment to spend $27 million to reclaim the Kam Kotia Mine site area. The process was planned to take place over 4 years (Reynolds, 2002). The initial goal of the reclamation was to stop the acidic drainage from reaching the waterways as they are used for drinking water (Environmental Commissioner of Ontario, 2000).

The reclamation of the site was completed in a 5 stage process designed to deal with two unimpounded tailings areas located at the north and south ends of the site and an impounded area also located on the north part of the site (Reynolds, 2002; Herlin, 2008). The first stage included the construction of a lime addition treatment plant as well as a impoundment dam to hold the unimpounded tailings. The second stage of the reclamation was the relocation of the 330 000m^3 of impounded tailings on the south portion of the site to the new unimpoundment area and treated with lime by the treatment plant. The third stage included the relocation and neutralization of the unimpounded tailings from the northern portion of the site, approximately 645 000m^3 of material (Werniuk, 2001; Reynolds, 2002; Herlin, 2008). The fourth stage of treatment was the construction of a wet cover for the new impoundment area, and the fifth was the construction of an engineered dry cover for the previously impounded area, in addition to addressing any physical hazards on the site.

The reclaimed site required extensive and costly remediation by the government.

1.4.1.2 Case Study Two: Long Lake Gold Mine

The Long Lake Gold Mine is a historic gold mine, which is located in the Sudbury mining basin. This abandoned mine became a concern when the Long Lake Stewardship committee pushed for testing of the water near the abandoned mine because it was concerned the tailings were leaking (Kelly, 2013).

History

The Long Lake Gold Mine began operation in 1909, and was mined continuously until 1916. For much of the time it was the largest operating gold mine in Ontario (Kelly, 2013).

Problem

The Long Lake Gold mine fell under the Ministry of Northern Development and Mines priority list for heritage sites, which must be reclaimed, since it may be a hazard to humans or the natural environment (Kelly, 2013). The abandoned site is believed to be leaching arsenic into the Lake as of 2013.

Status

The MNDM is in the process of evaluating what should be done to reclaim the site. Ministry staff have worked to install some temporary measures such as erosion reduction and water sampling plans until a new Class Environmental Assessment process can be completed in 2014, after which a multi-phase reclamation plan is expected to be drafted. The project is estimated to cost between 9 and 12 million dollars (Environmental Commissioner of Ontario, 2013).

1.4.2 Mine Closures in the Modern Era

Current mine closure requires significantly more work than in the past. The *Mining Act* in Ontario requires proponents to produce a closure plan prior to the project start-up since 1991. This closure plan is required to contain some reclamation information but the main focus of it is the safety of the site (Ontario Government 2, 2012). Regulators recognize the environmental impacts of mines today much better than in the early 20th century.

Financial assurance is instrumental in today's mine closures. Every proponent is required to place a bond on the mining agreement as part of the *Mining Act* (Mackasey, 2000; Gelinas, 2002; Castrilli, 2010). Without this assurance, the reclamation requirements might not be met (Environmental Law Alliance Worldwide, 2010).

The process of closure is completed when the closure plan requirements are met and the land is turned back to the government. This is a rare occurrence, since the closure plan process has only been in place since 1996, and conditions are difficult to meet as years of monitoring are required. A survey of the Canadian government agencies by the National Orphaned/Abandoned Mines Initiative (NOAMI) shows that most of the legislation in place, currently, states that sites will not be approved without proper water contamination systems in place (Cowan *et al., 2010)*. This is an improvement to the 1996 amendments. But even with these improvements there are few details to identify what happens when the proponent abandons the site, even with financial assurance money set in place. This money is often not enough to meet the needs of third party reclamation (Mackasey, 2000). Third party reclamation is done by the private sector at the cost of the public sector.

1.5 Reclamation

Standards for reclamation of Ontario mine sites are not clear. There is some acceptable level of reclamation required by the MNDM, but there is no received model for reclamation that must be followed. This investigation is aimed to determine if there are better methods for reclamation evaluation to avoid mine abandonment impacts. Multiple ministries can be responsible for components of reclamation enforcement further confusing the situation. The Ministry of the Environment and Climate Change may be the first Ministry to require some level of detail from a proponent on reclamation in a required environmental assessment for project approval. Furthermore the MNDM will require reclamation information for the closure plan before the mine can begin operation.

The confusion surrounding reclamation begins at the terms used in legislation as described in the following section.

1.5.1 Terms: Rehabilitation, Reclamation and Remediation

With most legislation, wording and terminology used is important, thus when developing this study, an understanding of the terms used in legislation is essential. There are three main words used when it comes to the end of a mine's life and its environmental restoration. They are rehabilitate, reclaim and remedy. While they may seem interchangeable, there are slight differences in their meanings that can change proponent's interpretations of their legal requirements as well as the possibility that objectives can be achieved. The definitions of the words based on *The Handbook of Ecological Restoration* (Perrow and Davy 1, 2002).

Remedy: To rectify, make good

Reclaim: Bring back to a proper state, make land fit for cultivation

Rehabilitate: The act of restoring an ecosystem to previous conditions

As can be seen by the definitions, if the three terms were ranked by scale, remedy would be considered the least strict for a proponent as it discusses removing undesirable effects, versus rehabilitation, which would be the most strict as it requires a proponent to return an area to its former condition, assuming the ideal and most desirable is the rehabilitation objective. It can be estimated that rehabilitation would take significantly more effort, resources and time than the other two options, and it may even be considered impossible to return disturbed land back to its original state. Rehabilitation to pristine conditions in most cases is not possible. Thus, if one can aim for the middle term of reclamation, a considerable difference could be made while avoiding the impossibility of rehabilitation. Thus it is important to ensure that these terms are consistent in literature, and give the appropriate level of environmental support, while maintaining feasibility.

In documents presented by the Alberta Land Conservation and Reclamation Council in 1984, this idea of defining reclamation is explored (Sims *et al.*, 1984). The document develops five different components to reclamation. These components reiterate much of what is required in the definition stating that a proponents must ensuring the surface is conducive to plant growth, minimizing hazardous conditions, providing protection against wind and water erosion, ensuring biophysical productivity, and rendering natural systems self-sustaining without the assistance of man (Sims *et al.*, 1984).

1.5.2 *Mining Act*'s Rehabilitation Code

The *Mining Act* includes a section called the "Rehabilitation Code" Which identifies the 9 parts it requires to be rehabilitates.   These include:

- Protection of openings to surface
- Open pits
- Stability of crown pillar, room and pillar operations
- Tailings dams and other containment structures
- Surface water monitoring
- Ground water monitoring
- Metal leaching and acid-rock drainage requirements
- Physical stability monitoring
- Revegetation

A more detailed analysis is completed later in this report, but this part of the Act has very little to do with rehabilitation if the definition from the *Handbook of Ecological Restoration* is used. None of the sections of the *Rehabilitation Code* require a standard to be met. While important, monitoring and stability and safety are the main objectives as indicated in this portion the Act. The *Revegetation* part does touch on the topic of rehabilitation, but again no standards are presented.

1.5.3 Problems from Lack of Standards

Without a proper standard for reclamation it is difficult for all parties to be certain that objectives will be achieved. The needs and wants of surrounding communities in terms of land use requirements and the abilities of a proponent might not be the same. Detailed standards would ensure that proponents know a minimum requirement they must achieve and plan accordingly.   The lack of standards has lead to the deficiencies in current levels of mine reclamations, the last problem.

1.6 Current Levels of Mine Reclamation

Currently, new mine proponents are attempting to meet the regulations around reclamation that have been put in place by the Provincial Environmental Assessment Act, The Federal Environmental Assessment Act, and the MNDM Closure requirements. While these legal requirements may be met, this does not mean that the best practice standard of achievable reclamation is being met. In fact, it could be said that while the documented requirements may be met, that completion of them is not. There are very few mines that have reached a closed out designation and if they have, it is at costs much greater than initially budgeted.

1.7 Research Question and Objectives

Based on the current levels of reclamation and the obvious issues of mine abandonment, reclamation requirements are poorly placed within the Ministry of Northern Development and Mines.

This study will review Environmental Assessments completed in Ontario to determine if they are meeting scientifically determined best practices of reclamation.

To complete the investigation, a development of scientifically accepted best practices for reclamation will be completed. The investigation is looking for a minimum set of scientifically valid best practices. To determine if other jurisdictions have process similar to the desired outcome, an evaluation of Environmental Assessment policy in Ontario, other provinces and other countries will be completed. The final step to determined if as meeting scientifically accepted best practices is review of current mining environmental assessments to see if they are reaching reclamation best practices.

Therefore the Objectives for the study are:

1) Determine Scientifically acceptable best practices for reclamation
2) Compare Ontario policies to other Jurisdictions
3) Review and evaluate if reclamation best practices are being met in Ontario

These objectives will answer the research question: Does current Environmental Assessment practice achieve the best practices in mining reclamation legislation in Ontario?

This research is an examination of best practices for mine site reclamation investigation of Ontario's recent Environmental Assessment cases where reclamation is expected.

2 Literature Review

This study has three major objectives as follows:

1. Examine and analyze existing reclamation standards and practices in Ontario to see what current levels are being achieved.
2. Determine what is scientifically achievable in terms of reclamation best practices and what best practices leading jurisdictions are requiring from their proponents.
3. Apply these best practices to existing cases of mining Environmental Assessments in Ontario to determine the extent of differences in practice.

The following sections include information required to complete the objectives.

2.1 Environmental Assessments

An Environmental Assessment, either Federal or Provincial, is the potential first stage for remediation investigation or evaluation from a government approval. The original environmental assessment (EA) process can be credited to environmentalists of the 1960s who began to vocalize their concerns regarding local environmental changes from new sources of impacts that, at the time, required minimal approval of their effects on the environment. The progressive nature of the Environmental Assessment process was that of the precautionary principle, ensuring that future generations are not in short supply of resources (Noble 2, 2006). The objective of the original Acts and previous agreements and programs was to thoroughly identify and predict all impacts of a project. Through this identification, one could then find ways to minimize and correct any negative impacts, whether they were environmental, social or economical. The goal for the policy was to make decisions with a comprehensive knowledge of the environmental consequences (Noble 2, 2006).

2.1.1 Federal Environmental Assessments

Canada created a Federal Environmental Assessment program in 1973, which issued guidelines for environmental assessment (Noble 2, 2006). Cabinet committed to a program that assessed the impact to the environment by creating the Environmental Assessment and Review Process (EARP). The jurisdiction of the EARP included any Federal lands or Federal areas of control (Canadian Environmental Assessment Agency 2, 2012). The use of the program and guidelines rather than legislation ensured the Government's freedom to choose when an assessment was completed. Many departments moved very slowly to implement the procedures (Gibson, 2002). In the early 1980s, the Federal Government tried to strengthen the EA process after public criticism by pushing for legislation (Gibson, 2002). The Environment Minister had to compromise with stakeholders by introducing and formalizing the EARP with a "guideline order" under the *Government Organization Act*. After the Federal Government embarrassingly refused to participate in a review of the Rafferty-Alameda project, Justice Cullen stated that the "guidelines order" was legally binding and the Federal Government had the responsibility to complete an EA (Gibson, 2002). This lead the Federal Government to take the EA process more seriously and eventually develop proper legislation. In 1995, the *Canadian Environmental Assessment Act* was put into force, undergoing many changes from the original guidelines including a definition of the environment that excluded socio-economical and cultural effects (Gibson, 2002). In 1998, the Federal Government decided to handle duplicate assessments by addressing the issue with a harmonization program, which allowed for the Provinces and Federal Governments to work together to complete a singular Environmental Assessment (Gibson, 2002). In 2001, 2003 and 2010, amendments were made to the CEAA to streamline some projects, increase public participation and improve timeliness of Federal EA projects (Canadian Environmental Assessment Agency, 2012). The most recent amendments under Omibus bill C-38 completed in 2012 have diminished control of the CEAA. Some of the major changes include: Federal assessments are no longer required if provinces are providing their own equivalent; no assessment is required if pre-conditions are met; very short, binding timelines are in place and less public participation is permitted. These changes, along with changes to other Federal acts such as the *Navigable Waters Protection Act*, show the diminution of the environmental protection role of the CEAA (ecojustice, 2012).

2.1.2 Ontario Environmental Assessments

The Ontario provincial government passed the *Ontario Environmental Assessment Act* in 1976 to address environmental concerns raised about provincial projects (Noble 2, 2006; Miller, 2008). Since the development of the original act, many changes have been made, making the environmental assessment process less rigorous (Miller, 2008). This moves away from the intended goal of protection and wise management of the environment.

When it was created, "The [provincial] Act featured a bold purpose statement…aimed for 'the betterment of the people of the whole or any part of Ontario by providing for the protection, conservation and wise management in Ontario of the environment'" (Miller (29), 2008). In addition, it requested a rationale and need for every project along with an evaluation of alternatives to the project. This was to ensure a thoughtful and transparent planning process for public sector projects (Miller, 2008).

However, after implementation of the act in 1976, the Ontario Government was confronted with the complexity of completing environmental assessments by the proponents of projects. The issues included the large number of projects that fell under the legislation (even simple maintenance projects), the time it took to complete projects and the cost (Pushchak, 2013). The Government very quickly made changes and developed the Class EA system for projects that needed to be streamlined, providing exemptions for regular maintenance and small impact projects (Miller, 2008).

Again in 1996, major changes were made to the system. Stakeholder complaints about the efficiency of the process lead again to a modification to make it easier for project approval (Miller, 2008). This more efficient process required the proponent to create a Terms of Reference (ToR), which would then be approved by the Minister. These Terms of Reference solely describe the scope of the project, excluding the rationale or need for the project (Lindgren, 2010). In addition to changing the approval process, new shorter timelines were added for decision making so proponents could receive answers more quickly. One of the most significant changes was providing the Ministry with the power to assess what should be included in an environmental assessment and what can be referred to a hearing (Miller, 2008).

In 2006, again more changes were made to the Ontario *Class Environmental Act*, to improve the approval conditions for energy, waste and transit projects. Some of these changes included condensing environmental assessment timelines for these projects to 6 months, and removing the requirement of "need" to be considered (Miller, 2008). As the policy sits now, projects are rarely rejected (Miller, 2008). Since rejection is rare, portions of the environmental assessments have started to erode. Often, environmental assessment studies are not completed to the same quality of work or investigation standard, and "need" is no longer considered to the degree it should be. In addition, many provincial units are issuing permits and approvals for components of the project before the environmental assessment has been approved. This adds more pressure to grant the environmental assessment approval as money has already changed hands (Miller, 2008).

2.1.3 Mining and Environmental Assessments

Previously private sector projects, such as mining and mineral development were not subject to the environmental assessment process (Ministry of Northern Development and Mines, 2012). Traditionally the reasons a mine site may have required an Environmental Assessment were related to triggers from other Ministries' or the Federal Government. They typically have been related to electricity and power generation (federal EA), involvement of water bodies (provincial EA), and the development of a new highway (provincial EA) (Senes Consultants Ltd., 2008). An upgrade to a comprehensive environmental assessment may also come from designated regulations, the Minister's authority under the *Environmental Assessment Act* or voluntary agreements. In December 2012 changes to provincial regulations have introduced a Class EA system for all mining projects, which requires all mine projects to be subject to form of an environmental assessment, discussed further below (Ministry of Northern Development and Mines, 2012).

This change in the MNDM may increase the number of provincial EAs completed for mining projects. Many mining EAs were completed federally, but amendments to federal legislation through the 2012 Bill C-38 have changed two key components. The first component is that the federal governement no longer requires EAs for projects proposed by one of their ministries and, two if a provincial government is completeing an environmental assessment, the federal government may base any discisions on that assessment (David Suzuki Foundation, 2012). This is concering because provincial assessments have a narrower scope, esspecially if the MNDM is conducting Class Environmental Assessments which are far less extensive (David Suzuki Foundation, 2012).

2.1.3.1 Class Environmental Assessment and The MNDM Class Environmental Assessment

The class environmental assessment process was a change made to the Ontario *Environmental Assessment Act,* designed to ease the process for development projects that "needed" to be streamlined. This meant providing a possible exemption from completion of a comprehensive environmental assessments for regular maintenance and small impact projects. Class assessments were to be done where project scales were small, impacts were known and minor in extent (Miller, 2008). The Class Environmental Assessment document is a guide for assessing such small impact projects including a decision making process for different types of common projects (Ministry of Northern Development and Mines, 2012). One of the requirements for a project to be part of the mining Class Environmental Assessment system is that it has impacts that are "predictable and manageable" (Ministry of Northern Development and Mines, 2012).

The MNDM has produced a Class Environmental Assessment document following the Ontario Class Environmental Assessment policies. The document, just like other Class Environmental Assessment documents, is a decision making process for MNDM activities. It is designed to ensure that these activities "Under the *Mining Act*, are subject to the environmental assessment, and done as to protect the environment" (Ministry of Northern Development and Mines, 2012; SENES Consultants LTD., 2008).

When a project is too large and does not meet the requirements for a Class Environmental Assessment, it then is either voluntarily moved up to a comprehensive environmental assessment due to the larger than anticipated impact; or through an application for "bump ups" by stakeholders. These stakeholders who apply for the bump up believe the class environmental assessment process to be inadequate, thus request the comprehensive assessment be conducted (Ministry of Northern Development and Mines, 2012).

These changes add a new layer of confusion to the Environmental Assessments surrounding mining projects. A mining project can be subject to three different types of environmental assessments; a Class EA by the MNDM, Provincial EA by the Ministry of the Environment or Federal EA by Environment Canada.

The combined changes in policies continue to highlight the need for more intensive and detailed requirements for reclamation. A strong policy framework is essential to develop a mine closure system that protects the environment. This system must be robust, effective and fair, while including long term care regulations (Crown *et al*, 2010).

2.2 Federal Environmental Assessment: Reclamation Requirements

The *Canadian Environmental Assessment Act (CEAA),* contains very little detail regarding the requirements for the end of life of a project. The act states that (Canadian Government, 2012):

"19. (1) The environmental assessment of a designated project must take into account the following factors:…

(*e*) the requirements of the follow-up program in respect of the designated project"

This statement is vague, and does not request the proponent to provide significant details about reclamation. Federal regulations examined outside of the act are show in Appendix C: Documents Used for Policy Review and Relevant Information.

2.3 Provincial Environmental Assessment: Reclamation Requirements

Regarding the Provincial *Environmental Assessment Act*, the legal requirements for reclamation are presented in Part 2 of the *Environmental Assessment Act, section 6.1 Preparation of environmental assessment.* This section states that:

" the environmental assessment must consist of,...

(c) a description of,

(i) the environment that will be affected or that might reasonably be expected to be affected, directly or indirectly,

(ii) the effects that will be caused or that might reasonably be expected to be caused to the environment, and

(iii) the actions necessary or that may reasonably be expected to be necessary to prevent, change, mitigate or **remedy** the effects upon or the effects that might reasonably be expected upon the environment,

by the undertaking, the alternative methods of carrying out the undertaking and the alternatives to the undertaking;" (Ontario Government, 2010).

In this act, the use of the term "remedy" is very narrow. The act requests proponents to "mitigate or remedy the effects…", What is not clear is which of the "effects" are to be included. There is a difference in the effort levels between a remedy of individual effects such as an impact on vegetation versus the remedy of an entire site, which can include vegetation along with soil and water conditions.

In addition, the regulations as seen in Appendix C: Documents Used for Policy Review and Relevant Information have little information on the requirements for reclamation.

2.3.1 The Ministry of Northern Development and Mines and the *Mining Act*

As mentioned previously, two departments regulate the approvals of mines but only one regulates the components of mining operations after the approval. In Ontario, the department in charge of mining activities is the Ministry of Northern Development and Mines (MNDM) (Orr, 2006; Ministry of Northern Development and Mines, 2012). It aids in boosting Northern economies (many of which are based on the mining industry) and regulating "responsible land use" and "mineral resource development" (Ministry of Northern Development and Mines, 2012). The Ministry is able to regulate mining activities through the MNDM's *Mining Act* initially created in 1906, and amended in 1991 (Orr, 2006).

Under the MNDM, the *Mining Act* regulates all aspects of mining, from encouraging prospecting, mining claim staking and exploration to ensuring the safety of humans, regulating human health and dealing with environmental protection. The *Mining Act* does include a portion dedicated to the reclamation of mines and mining lands, ensuring abandoned and closing mines are adequately dealt with, but the Act is not specific nor does it present a clear indication of its expectations and additionally does not address all the issues related to reclamation (Orr, 2006; Ministry of Northern Development and Mines, 2012).

The MNDM defined mine closure as "the completion of mineral extraction, processing and transportation activities and the removal of the site facilities and infrastructure which supported these activities" (Ministry of Northern Development and Mines, 2012). In this statement, there is no mention of reclamation, rehabilitation or future land use. This is support for the idea that safety and the physical closing of the mine are the primary priorities rather than the reclamation of the mine site.

A mine site may go through a continuous reclamation throughout the life of the mine, with the final steps finished after exploration is completed. Each type of mining has its own reclamation issues. There is a difference in how an open pit versus an underground mine will be reclaimed, as well as a gold mine versus a diamond mine (Canary Institute, 2005).

2.4 The *Mining Act*: Reclamation Requirements

The *Mining Act* requires that proponents complete a closure plan, separate from an Environmental Assessment. Since they are completed separately, the important information presented in the closure plan is not necessarily presented in the Environmental Assessment, leading to discrepancy in information presented (MNDM, 2012). Closure plans do contain some reclamation information but its main focus is the safety of the site. They may included only a few points that refer to the remediation, rehabilitation, remedy and end use of the mine sites. The relevant sections, Section 24.2 and 24.3 include the following statements (Ontario Government 2, 2012).

"(2) The proponent shall complete the following minimum rehabilitative measures in accordance with the applicable standards, procedures and requirements of the [Rehabilitation] Code:...

All landfill sites and other waste management sites shall be rehabilitated...

14. All tailings, rock piles, overburden piles and stockpiles shall be rehabilitated or treated to ensure permanent physical stability and effluent quality.

15. All materials, or conditions created as a result of mining, that produce or may produce acid rock drainage or metal leaching shall be dealt with in accordance with the management plan [for acid mine drainage collection] referred to in section 59 of the [Rehabilitation] Code....

19. All disturbed sites shall be revegetated. O. Reg. 240/00, s. 24 (2); O. Reg. 194/06, s. 5.

(3) The proponent shall restore the site to its former use or condition or to an alternate use or condition that the Director sees fit. O. Reg. 240/00, s. 24 (3)" (Ontario Government 2, 2012).

Additionally *Schedule 1 part 2*, of the *Mining Act* provides more detail on rehabilitation requirements for open pit mining. These details in the *Mining Act* state:

"21. (1) Subject to subsections (2) to (6), open pits shall be rehabilitated by backfilling.

(2) Flooding may be used to rehabilitate an open pit if fully justified in the closure plan.

(3) Sloping may be used to rehabilitate an open pit if fully justified in the closure plan as being more appropriate than backfilling or flooding…

22. Where an open pit has a single vertical or near vertical drop of greater than 3 metres and a bench width of less than 3 metres and is not to be rehabilitated by the measure referred to in subsection 21 (1), a geotechnical study and report signed by a professional engineer shall be provided to state the long term stability of the structure.

23. If an open pit is flooded,

(a) additional rehabilitation is required only with respect to workings above the final ground water elevation;

(b) interim protection shall be provided until the final ground water elevation is reached;" (Ontario Government 2, 2012).

Some of the other parts of *Schedule 1* touch on reclamation issues such as water monitoring and acid rain drainage. They include the following information

" 57. (1) A [Sampling] program shall be undertaken to sample all materials remaining on the site that have been excavated, exposed or otherwise disturbed by mining activities, including but not limited to,

(a) drill core;

(b) metallurgical samples;

(c) pit walls;

(d) existing waste rock, ore, concentrate and overburden piles;

(e) construction rock; and

(f) tailings.

(2) The sampling program shall be undertaken in accordance with both of the following documents by a person who is qualified in Ontario as a professional geoscientist or agrologist, or as a qualified professional engineer in Ontario:

1. Guidelines for Metal Leaching (ML) and Acid Rock Drainage (ARD) at Mine Sites in British Columbia. 1998. British Columbia Ministry of Energy and Mines. 86p.

2. Draft Guidelines and Recommended Methods for the Prediction of Metal Leaching and Acid Rock Drainage at Mine Sites in British Columbia. 1997. British Columbia Ministry of Energy and Mines. 159p…

59. (1) Where the interpretation indicates that the materials have the potential for ML or ARD, a management plan shall be developed to ensure that these materials do not adversely affect the quality of the environment.

(2) In order to ensure the chemical and physical stability of the ML or ARD generating materials and that the quality of the environment is protected, the management plan shall consider, where appropriate,

(a) the design and construction of covers and diversion works; and

(b) the use of passive and active treatment systems.

(3) In order to meet the objectives of the closure plan, wet and dry covers for materials that have ML or ARD potential shall be designed and constructed in accordance with best engineering practices and be certified by a qualified professional engineer" (Ontario Government 2, 2012).

The final part of *Schedule 1* outlines the revegetation requirements of a mine after closure. It states that

" The objectives of this Part are to,

(a) stabilize surface materials and provide protection from wind and water erosion;

(b) improve the appearance and aesthetics of the site;

(c) enhance natural vegetation growth and establish self-sustainable vegetation growth; and

(d) support the designated end use of the site.

(2) A site shall not be considered to be closed out until sufficient vegetative growth, where specified in the closure plan, has been achieved to meet the objectives stated in subsection (1)." (Ontario Government 2, 2012).

A proponent might be interested in speeding up the reclamation process because, once it has received a closed out approval, the proponent can remove the liability of the property from its books. It costs companies money to own the land, thus it is in their best interest to rid themselves of the land if it will no longer be mined for ore (Cowan *et al*, 2010).

The use of the word "rehabilitation" in the closure plan may create disjointed requirements for the proponent as the environmental assessment process uses the term remedy to describe their requirements. It is also proven to be unrealistic to reach the level of "rehabilitation" at it refers to a pristine level of rehabilitation. Since such requirements are unachievable, it further creates confusion and disjointed reviews between levels of approvals.

In terms of reclamation requirements, the Mining Act fails to establish best practice standards for proponents to meet, specifically for 'after site' conditions. Reclamation to "support the designated end use of the site" fails to acknowledge that the site could change uses over time limiting the possible future options. For sites where development is not likely to happen in the near future, this type of reclamation is minimal in nature.

2.4.1 Comparison between Environmental Assessments and Closure Plans

As presented above, the government has presented post-closure site rehabilitation guidelines in the *Mining Act.* These requirements include the development of a closure plan (Ontario Governement 2, 2012); however, reclamation requirements outlined by the *Environmental Assessment Act* are minimal, vague and open to interpretation. Furthermore, the *Mining Act*'s focus on safety in combination with the other issues can lead to inappropriate development approval (Ontario Government, 2010).

For the approval of projects at the initiation stage, the details of reclamation should be required. By including this information with secondary approvals, the risk of improper reclamation increases. The closure plans are heavily focused on the safety of a site after the mine has been shut down. While this is an essential part of the mine closure process, the reclamation could be focused on heavily. While the lack of content required is an issue in terms of mine abandonment and insufficient mine reclamation, the lack of required content might have an effect on the focus in this area by the MNDM. The invested interest of the MNDM in mining project development and not necessarily environmental protection and promotion means that this approval is poorly placed in their hands. There is a conflict of interest as they have both purposes of regulating and promoting mining projects. The limited amount of environmental focus in the closure requirements may a reflection of this conflict. In addition, the environmental assessment process is intended to evaluate the whole life of a project, with reclamation and end-of-life impacts included.

By setting new standards for reclamation after mine closure, projects required to complete an EA will be better prepared to meet environmental protection objectives. By doing this at an EA level, project conflict can be avoid and future approvals can be made easier. If conditions are imposed in the EA, they can be used additionally in the closure plan. The EA can contain all the reclamation information of the closure plan, but allow for approval where a conflict of interest does not exist.

2.5 Achievable Reclamation based on Policy

Based on the information presented regarding federal and provincial requirements for remediation of a mine site, most of the details will not be considered until after project approval. If the Acts and regulations are followed to the letter, a closed mine site will have both ground water and surface water monitoring and be revegetated with no specific types of species. Waste dumps will be covered as a method to prevent acid mine drainage. Tailings dams will be disassembled, and stability of the site will be ensured. In addition fences will be placed around any open pits for safety along with signage. Nowhere in this documentation is a vision of preferred or acceptable land use. This means that no documents rise to the level of remediation of mine sites.

2.6 Scientifically Accepted Reclamation Best Practices

Since all of the earth's components interact, ecosystems have no finite boundaries. Impacts to one component of an ecosystem can affect others. Isolation of the impacts is difficult, thus isolation of reclamation can also be difficult. Components of an ecosystem can be categorized as major elements such as soils and waters. There are two attributes to an ecosystem, function and structure, each with different components that define successful restoration. A pristine ecosystem will have both high function and high structure, while development and destruction forces both downwards (Perrow and Davy 2, 2002). Natural processes can restore both structure and function, but they are very slow. Natural restoration in water (as long as the source is removed) can occur rapidity, but on land, the process can take significantly longer (Perrow and Davy 2, 2002). The purpose of reclamation should be returning both to both high function and structure.

Current academically accepted methods of reclamation and restoration do not focus on the simple "plant trees" method used in the past. The current practice does not aim to return a forest landscape to its original status, but to look to the future of the system, and find an optimal, biologically productive landscape (Rietbergen-McCracken *et al*., 2007)

For mining, the focus of the reclamation should be to build new but viable ecosystems at a site, because the distruction that can occur to the biological communities, in combination with the changes to the geological landscape, are near imposssible to rehabilitate (Berger, 2008). The two goals should be to protect human and biological health and to create a viable ecosystem (Keefer, 2000, Rietbergen-McCracken *et al.,* 2007; Berger, 2008; Ontario Government, 2010).

On a very basic level, an ecosystem, or the natural environment can be broken down into five main categories. These categories include water, soil, air, plants and animals (engscience, n.d.). This categorization is important for a form of targeted reclamation, but their interactions and the sub-categories among these are complicated. Air can be eliminated from reclamation consideration, as emissions from facilities quickly dissipate into the atmosphere and are virtually impossible to reclaim at the end of a project. Instead facilities and equipment should be equipped with the latest emission-reducing technologies.

Water can further be categorized into hydrology, surface water, groundwater and precipitation (Sims e*t al.,* 1984). Both hydrology and precipitation are not considered since hydrology is linked to the pre-existing geological structures, it cannot be reclaimed effectively, and precipitation is linked to air and the atmosphere and cannot be reclaimed (Wood, 2012). As a system, water can be connected to aquatic life and these two components in reclamation can be evaluated together due to their dependence on one another. Soil and land can be considered together with plant life as their dependence is strong.

Thus the systems are categorized for reclamation purposes into three categories:

- land, soil and plant life,
- water and aquatic life,
- wildlife.

These are the three categories for consideration of best practices when it comes to reclamation.

2.6.1 Reclamation of Land, Soil and Plant Life

The reclamation of soil, landscape and plant life can be grouped together since the growth of plants on the land surface is dependent on soils. *Designing the Reclaimed Landscape* offers a four-step approach to developing an ecologically preferred reclamation of a mine site. This approach is echoed in other literature (Keefer, 2000, Rietbergen-McCracken *et al.,* 2007; Berger, 2008).

The preferred process begins with ensuring the soil substrates are able to support plant life. This is done by reviewing the chemical and physical properties of the soil at a mine site, which, can have plant growth-inhibiting properties such as high or low pH, mineral concentrations that are toxic or poor water holding capacity (Sims *et al.,1984,* Keefer, 2000; Berger, 2008). The first step in reclaiming the site is taking the results of the chemical and physical property review, and altering the site soil to meet the original soil profile collected during the Environmental Assessment. This means using best practices to restore the pH levels, remove toxic substances and increase the soil's water holding capacity. This is essentially building the soil from scratch (Sims, 1984; Berger, 2008).

Phase two of the restoration should include increasing the quality of the soils built in phase 1. Covering the land with organic matter such as cover crops or mulch can enrich the soil. This process does three main things helps form more soil; increases the water holding capacity; and begins nutrient cycling. Nutrient cycling occurs when the wanted microorganisms such as mycorrhizal fungi and nitrogen-fixing bacteria are able to grow (Sims, 1984; Keefer, 2000; Berger, 2008).

Phase three of the restoration of soil and plant life is deciding on the types of plants, which will be placed on the site. Due to the circumstances and conditions of a mine site, it is best not to select only plants, which were historically found on the site. By limiting the plant selection to native species only, there is a lower chance of reproductive success (Berger, 2008). The types of plants that should be selected should be those that have the ability to handle difficult survival conditions, require minimal maintenance and also have limited ability to spread seeds. By mixing these types of plants with native species, over time the plants for which the soil is structured will prevail. This is based on the climax theory that is described the Section 2.6.1.1. The intent of the different types of plants is to have a selection that handles different ranges of light, moisture and nutrient conditions (Keefer, 2000, Rietbergen-McCracken *et al.,* 2007; Berger, 2008).

Berger (2008) also offers a table of traits that are ideal for plants selected. The following list was included in the table:

- Germinate readily from seed
- Be relatively fast growing
- Be tolerant of extreme sun and wind exposure as well as high soil and air temperatures
- Possesses a strong capacity for vegetative regeneration from suckers, stump sprouts, rhizomes, or branch layers
- Be able to grow in soils with high concentrations of heavy metals
- Be able to grow in soils with low pH
- Be tolerant of drought induced by course textures or highly compacted soils
- On wet sites, be tolerant of saturated soils with low oxygen tensions and high concentrations of toxic compounds
- Be able to form symbiotic relationships with a broad range of both ecto and endomycorrhizae
- On low nutrient sites, be able to form symbiotic relationships with nitrogen-fixing bacteria

The fourth step is one that will be part of all the phases of reclamation. The site will need continual monitoring and maintenance if there is a problem (Berger, 2008). Thus the objective of plant selection is to give a set of conditions needed to start the succession process.

2.6.1.1 Climax Theory in Ecology

Climax Theory in ecology is a concept based on the succession of species. It takes into account that as species grow, reproduce and die, they cause changes to the environment, these changes allow for other species to grow, reproduce and die. Eventually a site will reach equilibrium of species, which is called the climax (Westman, 1984; Berger, 2008).

2.6.2 Reclamation Water

As previously mentioned, mining activity can have a detrimental effect on water systems. The mining process requires water, which then produces a contaminated and toxic discharge effluent. This by-product is often acidic and contains high levels of metals, and sulphates (Wood, 2012). The effect on a site's water and nearby water systems is different for each site since the ore being processed is different at each location. The waste rock can contain different amounts of minerals, thus the tailings, runoff water and processing waters are also very different at each site. The main issues with water quality can be simplified into; acidic conditions, precipitates, metals loading, solids loading and turbidity (Wood, 2012).

The different systems in which water exists should be further categorized as that must be evaluated individually for potential reclamation. Hydrology refers to the water flow over and through the land. Since mining disturbs the land surface and subsurface, water hydrology generally is altered permanently, as it is not economically feasible to reclaim it (Sims *et al.,* 1984; Rietbergen-McCracken *et al.*, 2007). Part of the hydrology includes surface waters, groundwater and precipitation. Mining can affect the proportions of water, influencing what becomes groundwater and what becomes surface water (Sims *et al.,* 1984).

Tailings are included in the water system as they are created from the mining process, as one of the outputs from the mine processing, and this liquid-to-sludge-like byproduct is often stored in ponds. The tailings are treated, given time for contaminants to settle or stored for a significant period of time before any water can be released from the tailings ponds. Reclamation of the tailings to their original state is not always achievable thus proper planning must be done before mining begins (Sims *et al.,* 1984).

Again the preferred reclamation process for water systems and aquatic life is based on a number of sources. It begins with eliminating the pollution source and containing the contaminated water (Kumagai

& Vincent, 2003). For contamination that has reached water sources such as rivers and lakes, damming or other containment processes might be required. By containing the water, one is able to then move to the second step that includes treating the water for impacts related to pH, ferric precipitates, metal loading, solids loading, turbidity and other toxins. The water can be treated using any number of technologies in a possible series (Wood, 2012). Treating the water is the essential to moving forward in reclamation (Kumagai & Vincent, 2003). Some possible treatment options include pH modifications, ion exchange processes, biologically based treatments, adsorption-based treatments, electrochemically-based treatments and physical processes (Wood, 2012). Treatment of the contaminated water will be different for each site based on contaminants in the water and ecosystem requirements (Wood, 2012). Reclamation should be based on current technologies, not the possibility of future treatment through technological improvements. The following section provides information on treatment requirements.

2.6.2.1 Legislation Requirements for Water Release into the Environment

Ontario Water Resources Act: *Ontario Water Resource Act* outlines some rules for pollutant release. The *Ontario Water Resources Act* only applies to active mine operations, and thus the application of this legislation is not well suited for after mine closure. Mine tailings, impoundments and nearby contaminated water bodies may not be interpreted as actively discharging, further limiting responsibility. The following is the pollution release information presented in the *Water Resources Act* (Government of Ontario, 1990)*:*

"***Discharge of polluting material prohibited***

30. (1) Every person that discharges or causes or permits the discharge of any material of any kind into or in any waters or on any shore or bank thereof or into or in any place that may impair the quality of the water of any waters is guilty of an offence. R.S.O. 1990, c. O.40, s. 30 (1).

(2) Every person that discharges or causes or permits the discharge of any material of any kind, and such discharge is not in the normal course of events, or from whose control material of any kind escapes into or

in any waters or on any shore or bank thereof or into or in any place that may impair the quality of the water of any waters, shall forthwith notify the Ministry of the discharge or escape, as the case may be. R.S.O. 1990, c. O.40, s. 30 (2); 2006, c. 19, Sched. K, s. 3 (2)"

Measures to alleviate effects of impairment of quality of water

32. Where, in the opinion of a Director, it is in the public interest to do so, the Director, by order, may require a person who owns, manages or has control of a sewage works, water works or other facility which may discharge material into a water or watercourse that may impair the quality of the water, to do any one or more of the following:

1. To have available at all times, or during the periods specified in the order, the equipment, material and personnel specified in the order at the locations specified in the order to prevent, reduce or alleviate any impairment of the quality of the water or the effects of any impairment of the quality of the water.

2. To obtain, construct and install or modify the devices, equipment and facilities specified in the order at the locations and in the manner specified in the order.

3. To implement the procedures specified in the order.

4. To take all steps necessary to ensure that the procedures specified in the order will be implemented in the event that a water or watercourse becomes impaired or may become impaired.

5. To monitor and record the quality and quantity of any water specified in the order and to report thereon to the Director.

6. To study and to report to the Director upon,

    i. measures to control the discharge into a water or watercourse of a material specified in the order,

ii. the effects of the discharge into a water or watercourse of a material specified in the order,

iii. the water or watercourse into which a material specified in the order may be discharged. R.S.O. 1990, c. O.40, s. 32."

In summary, the accepted pollution concentrations that will be released are negotiated though the permits, based on specifics of the site during operation and mine closure process. While this legislation exists, it is difficult to enforce for closed or abandoned mines since proponents no longer own the land, have gone bankrupt, or little information exists due to the age of sites. In both reaching the closed out status and the in abandonment the sites are turned over to government, and they become a public responsibility. Treatment of the water will depend on whether contamination exceeds acceptable levels and if the release of pollutants is noticed, since often it slow and can do undetected for a number of years. In terms of effluent release the ideal situation would be that proponents were required to meet the Canadian Council of Ministers the Environment (CCME) guidelines.

Canadian Council of Ministers to the Environment (CCME): The CCME is an intergovernmental forum in Canada, for action on environmental issues. It produces interprovincial guidelines for scientific, technical and information documents (CCME, 2007). The tables in Appendix A detail the allowable release concentrations of contaminants approved by the CCME (Exall, *et al.*, 2010)

Across Canada there are three ways which pollution releases are managed. For example, there is a technology-based approach, which limits the release of contaminant concentrations from a point source based on economically feasible, available technology. The second method is based on assimilative capacity, and is the quantity of a substance that can be released into a water body during a specific period of time without causing harm. The third approach is to set discharge limits based on natural background levels (CCME, 2003). These are all options for determining what contaminants levels should be from a mine site.

Water release is a sensitive component. There are issues with erosion, changing water flows and aquatic ecosystems. Reclamation of lakes and rivers have different focuses, as water flows and interacts differently in each of them. The following sections are a continuation of the reclamation process starting after the water has been treated. The best methods to reestablish lake and river systems are discussed separately. The CCME offers these guidelines for discharge. These values have been obtained through intensive study, and determined to be the best achievable. The issue is that often discharge is site specific, thus proponents do not end up meeting these guidelines.

Lakes

In lakes, once toxins have been removed and tolerable pH established, treatment of nutrient loading is the next stage. Nutrients are dissolved minerals that may come from any number of processes including some mining. While they are are essential for aquatic plants like algae and bacteria to grow, elevated levels of some nutrients can cause rapid overgrowth of aquatic plants, lowering dissolved oxygen levels needed for aquatic wildlife. The most concerning of the nutrients are nitrogen and phosphorous because of their abundance and ability to cause rapid growth of algae and bacteria (Kumagai & Vincent, 2003). As stated previously, this growth causes an imbalance in the dissolved oxygen and carbon dioxide concentrations in the water as well as affecting the microorganisms and the production of organic matter (Marsh, 1991; Kumagai & Vincent, 2003).

The easiest method to ensure that a lake is successful in maintaining a proper aquatic profile with an ideal nutrient balance is to create a lake, which has a balanced “nutrient budget”. A nutrient budget refers to the input and outputs of nutrients to the system (Marsh, 1991).

Inputs in this budget come from four main sources, point sources, surface runoff, subsurface runoff and the atmosphere. Outputs are stream flow, seepage into the groundwater and burial of organic sediments containing nutrients. Plants and animals both living and dead represent storage of nutrients. The following equation is mathematical representation of the nutrient budget (Marsh, 1991).

$$P+R+O+G+A-Q-S-B=0$$

Where

P = Point source contributions

R = Surface runoff contributions

O = Organic sediment contributions

G =Groundwater contributions

A = Atmospheric contributions

Q = Losses to stream flow

S = Losses to groundwater

B = Losses to organisms and sediment burial

The intended goal is to measure all of these contributing factors and obtain a zero or balanced result. If the system is not in balance, the equation will not equal zero. In order to reverse a condition of excess nutrient, we assume the system is not zero, and try to increase the loss value or reduce impact to create a zero.

The province of Ontario has developed the Lakeshore Capacity Assessment Handbook based on this equation. The handbook was originally developed in the 1980s the most recent handbook published in May of 2010 (MOE, MNR MMAH, 2010). The handbook is a tool prepared to help protect the water quality in Ontario, and it is a simplistic planning tool. It can be used to determine the maximum allowable development that can occur on a lake without degrading the water quality as well as predict the expected effect of future development (MOE, MNR MMAH, 2010). If used backwards, this model can help to aid designers in making plant life, and landscaping decisions to ensure a nutrient balance in the lake systems when it comes to reclamation of a mine site. Nutrient balance is part of developing a healthy and viable lake, and thus by completing this evaluation the status of the lake can be interrupted and measured.

Once the water is ready for release, natural riparian and plant communities can be restored, and the known aquatic profile mimicked. Reestablishment of the desired species is best with the restored lake chemistry. Natural riparian, plants and aquatic species can be added (Kumagai & Vincent, 2003).

River Systems

River systems are different than lakes since they do not have the same significant mixing. Contamination in a river tends to move quickly downstream. The movement of water in a river is much quicker, supporting many different ecosystems. The movement of rivers has a wide range longitudinally and vertically (Perrow & Davy, 2002). For river restoration, the main focus must be on habitat rebuilding, thus after water is treated, the channel geometry must be resorted to previous conditions, or ones similar. This may prove difficult, but is essential for maintaining flows and developing a functional habitat for flora and fauna (Perrow & Davy, 2002). To build habitats, portions of the river must be narrow for "shredder" and "grazer" based aquatic life and other portions wider for "predator" and "collector" aquatic life. Proper restoration of riparian and plant communities based on information collected and aquatic profiles established prior to project start up will help with the reclamation process. Once this has been established, the addition of aquatic life can occur to finish the reclamation of the river system (Perrow & Davy, 2002).

Groundwater

Groundwater consists of many different water components, thus all contaminated groundwater should be treated; this includes pooled water that may form where open pits may have previously been. This pooled water creates more mine wastewater, which may be polluted. A portion of it may reach surface waters, but much of it will become part of the groundwater system. If the pollution filters through, it can pollute any aquifers located nearby (Sims *et al,*. 1984; Wood, 2012). Groundwater and aquifers have very long residence times thus this treatment is important. If the water has been treated, then no further steps are required, the water can then influtrate and move through the ground (Wood, 2012). Reforestation and vegitation can help with groundwater infultration (Sims *et al,*. 1984)

2.6.3 Wildlife

When it comes to terrestrial wildlife, there are two methods that may be used for reclamation: The first includes active manipulation of wildlife, encouraging them to move into the reclaimed area. The second is called habitat recreation, a method to enhance the natural capacity of wildlife populations to grow and colonize in an area. Both of these are accepted methods to ensure terrestrial wildlife and biological systems are reclaimed (Scott, Wehtje, & Wehtje, 2001).

2.6.4 Best Practices Summary

Based on systematically determined reclamation objectives, the best practice for mine site reclamations must include the following: restoration of soil's chemical and physical properties, and improving them to increase the quality and growing capacity. Vegetation must then be selected to for habitat development and likelihood of successful growth. For the reclamation of water and aquatic life best practices include treatment of any water contaminants followed by establishing proper hydraulics for rivers and a nutrient balance for lakes. Once this has been completed, aquatic life can be restored. Biological restoration begins once habitat formation occurs. This is achieved through vegetation and water restoration. Natural migration of wildlife into reclaimed areas will occur. These best practices, are achievable, based on collectable data during the environmental assessment and current technology.

3 Methods

3.1 Jurisdictional Comparison

Legislation outside of Ontario in locations that govern significant mining activity may have regulations associated with Environmental Assessments that address some of the concerns presented in the literature review. The Ontario *Environmental Assessment Act* and associated regulations can use these as a starting point for their own regulation development. Its important to evaluate what is happening in other parts of Canada, as mining and mineral development is regulated at the provincial level. Furthermore, countries with progressive mining policies might also have structures that could be adopted by the Ontario government.

To complete the jurisdictional analysis, select three provinces within Canada (British Columbia, Quebec and Saskatchewan) and three other countries (Australia, The United States of America and Sweden) were reviewed. The intention was to see if Environmental Assessments conducted in Ontario could learn from what others are doing successfully.

3.2 Selection of Provinces

The selection of which provinces to be reviewed was completed using specific criteria. These include:

- First, mining must be governed by provincial legislation (a comparison of provinces and not federally regulated process within Canada. Territories are governed by the Federal government)
- Second Provinces with the high mineral production and exploration value (Ontario Mine Association, 2012)
- Third Select the top three provinces

These criteria were used to determine that British Columbia, Quebec and Saskatchewan were the provinces that would be reviewed. The removal of all territories occurred because the mining in territories because there fall under Federal Jurisdiction.

Mineral production and exploration value is an important criterion since it can be used to eliminated province that have little to no mineral exploration. By picking provinces with significant mining operations, in theory the mining legislation should reflect this, and thus the Reclamation process requirements could be well developed and retained by Ontario. The investment into exploration means that future development is an almost certain possibility and thus new policy could influence these.

The interest lies in the concept that other provinces or countries may have an Environmental Assessment process that requires them to provide a specific Reclamation plan.

3.3 Selection of Countries

The selection of which countries to be reviewed was completed using specific criteria. These include:

- Developed or Developing Nation
- Legislation presented in English
- Significant Economical Resources invest in Mining (Geoscience Australia, 2012; Wood, 2012; The National Mining Association, 2013)
- Top Three Countries

The initial criterion used to determine which countries would be evaluated was binary: Whether it was a developing nation or developed nation. All developing countries were eliminated from possible contention, as they often lack progressive policies. Countries with non-English policies were not an option. The third criterion was whether the countries have significant mining resources. The top three countries to meet the criteria were Australia, the United States and Sweden all indicated as top mining countries in different areas of mining (AMMA, n.d). A significant mining resource is an important criterion since it can be used to eliminated countries that have little to no mineral exploration. By picking countries with significant mining operations, in theory the mining legislation should reflect this, and thus the Reclamation process requirements could be well developed and retained by Ontario. The investment into exploration means that future development is an almost certain possibility and thus new policy could influence these.

3.3.1.1 Provinces

For this study policies and best practices for mining and environmental assessments in British Columbia, Quebec and Saskatchewan were compared to those offered in Ontario. Documents reviewed for each province include:

Ontario:

- *Ontario Environmental Assessment Act* (Ontario Government, 2010)
- Regulation 334 – Organizations subject/exempt form the Act (Ontario Government, 1990)
- Ontario Regulation 345/93 – Private Sector Developers (Ontario Government, 2001)
- Website "steps" Description (Government of Ontario, 2015)

British Columbia:

- *Environmental Assessment Act* (British Columbia Government, 2014)
- Environmental Assessment Office User Guide (B.C. Environmental Assessment Office)

Saskatchewan:

- *Environmental Assessment Act* (Government of Saskatchewan)

Quebec:

- Environment Quality Act (Government of Quebec, 2015)

3.3.2 Provincial Data Collected

The data were collected through provincial websites. The websites were accessed and the acts and regulations from the site were evaluated. In addition, the *Report on the Legislative, Regulatory, and Policy Framework Respecting Collaboration, Liability, and Funding Measures in Relation to*

Orphaned/Abandoned, Contaminated, and Operating Mines in Canada was consulted for the study. It contained a summary of the conditions imposed by mining legislation in all the provinces and was used in conjunction with provincial sources.

3.3.3 Provincial Data Analysis

The provincial mine reclamation requirements were evaluated by answering the following series of questions. The questions are developed to determine if Other provinces have an Environmental Assessment process that requires a proponent to included detailed information on reclamation. Each Provence was subjected to the following list of Questions:

- Is a Provincial Environmental Assessment Act in place?
- Does the act or associated regulations require any reclamation (remedy or rehabilitation) information included in the Environmental Assessment report? If information is required, how is it presented? What does it state?
- Is this more specific, more stringent or more inclusive than the Ontario Legislation?

All requirements for remedy/reclamation and/or rehabilitation were identified, the specific information was extracted from the act and regulations and compared to Ontario. Answers to the questions were not to be binary.

3.3.3.1 Countries

For this portion of the study, legislation and regulations for mining in Australia, the United States and Sweden were selected. For this study policies and best practices for mining and environmental assessments in Australia, the United States and Sweden were compared to those offered in Ontario. Documents reviewed for each include:

Australia

- *Environmental Protection and Biodiversity Conservation Act* (EPBC Act, 1999)

United States

- Policy and Procedures for the Review of Federal Actions Impacting the Environment

Sweden

- Environment Code (Government Offices of Sweden, 2013)

3.3.4 Other Country Data Collection

The data were collected again though the use of government websites. Legislation and Regulations from the website were included in the evaluation. Research was completed to determine the legislation that most closely resembled the provincial *Environmental Assessment Act.* This legislation where reviewed.

3.3.5 Other Countries Data Analysis

The Countries were evaluated by answering the following series of questions. The questions were based on information to help strengthen Ontario's policies. Its intended purpose was to collect information about Environmental Assessment or new source protection reclamation requirements in other countries. The questions were as follows:

- Does the country have an Environmental Assessment Act or new source protection legislation?
- Does the Act or associated regulations require any reclamation (remedy or rehabilitation) information included in the Environmental Assessment report? If information is required, how is it presented? What does it state?
- Is this more specific, more stringent or more inclusive than the Ontario Legislation?

If requirements for remedy/reclamation and/or rehabilitation are identified, the specific information may be used for consideration in regulation development. Answers were not binary. The intent is to collect information that Ontario could use for review.

For the evaluations of countries, a national legislation and regulations was reviewed. The existence of state level legislation is recognized, but the is outside the scope of this review and a possible option for further research.

3.4 Setting of Best Practices for Reclamation

In addition to the policy information, reclamation principles were reviewed. Best practices were selected based on frequent discussions in literature as well as currently accepted scholarly information. The Best practices are a scientifically established basis for evaluation rather then a reiteration of The National Environmental Policy Act (NEPA) and other regulated forms that exist. The logic was the development of a minimum set of scientifically valid best practice.

Site reclamation was categorized into soil and plant life, water quality and aquatic life, and wildlife and a reclamation process was developed for each of them.

3.4.1 Scientific Data Collection: Development of Best Practices

The strategy for development of the best practices was not to create an exhaustive list, which would be impossible to achieve, but rather to develop a minimal functional set, guided by received science to be used generically. There are known exhaustive lists such as those provided by The National Environmental Policy Act.

The development of the best practices list comes from the information presented in the literature review. The information was collected through literature, journal articles and textbooks. Many ecological reclamation and landscape reclamation, and mining reclamation textbooks provided significant background information and combinations were used to develop basic reclamation steps considered best practices. Information was generalized, because not all mine sites are the same, and varying degrees of pollution in all stages can occur with countless numbers of pollutants in addition to all the other possible problems. The basic reclamation plan focused on soil, water, plant aquatic and wildlife.

The best practice for mine site reclamations must include the following :

- Restoration of soil's chemical and physical properties, and improving them to increase the quality and growing capacity (Keefer, 2000, Rietbergen-McCracken *et al.,* 2007; Berger, 2008).
- Vegetation must then be selected to for habitat development and likelihood of successful growth (Keefer, 2000, Rietbergen-McCracken *et al.,* 2007; Berger, 2008).
- Water and aquatic life best practices include treatment of any water contaminants followed by establishing proper hydraulics for rivers and a nutrient balance for lakes (Sims *et al,*. 1984; Perrow & Davy, 2002; Kumagai & Vincent, 2003; MOE, MNR MMAH, 2010; Wood, 2012).
- Natural migration of wildlife into reclaimed areas will occur as well as reintroduction of aquatic species (Scott, Wehtje, & Wehtje, 2001).

The list of best practiced developed from the information in the literature review is presented in the following section. This is a checklist of information hat should be discussed in an Environmental Assessment or a review to ensure that the proponent as adequately investigate the requirements of reclamation, and be able to hold them to that standard.

3.4.2 Scientific Data Analysis

The review of scientifically accepted data lead to a significant amount of information for proper site remediation. For the analysis, a summarized version of reclamation best practices was created. Table 1 is the summary that focuses on soil, plant life, water and wildlife investigation, and is used in the analysis.

Table 1: Best Practices Analysis Table

Question	Answer

Soil and Plant life	
Does the EA present…	
1) discussion of soil reclamation?	
i) Expected soil conditions/ problems discussed?	
2) methods to return soil to its original chemical profile (based on expected soil conditions)?	
3) methods to remove toxic substances?	
4) methods to increase in water holding capacity?	
5) methods to adjust the pH?	
6) discussion of enriching and building the soil?	
7) discussion of vegetation selection?	
8) discussion of the use of native species vs. non-native?	
9) discussion of the properties of vegetation to be planted?	
Water Systems and Aquatic Life	
Does the EA…	
1) discuss reclamation of water and water systems?	
i) Expected water/effluent conditions/ problems predicted?	
2) discuss the reclamation of the hydraulic impact?	
3) present discussion of pollution source removal and water containment?	
4) discuss the treatment of water contaminants?	
i) Ferric	
ii) Acidic	
iii) Metals loading	

iv) Solids loading	
v) Turbidity	
5) discuss how tailings impoundment areas will be treated before release to waterways?	
6) include the process for reclamation of lakes? (using the best practice steps)	
a) discuss how to restore nutrient balance?	
b) discuss how to replace plant and riparian habitat	
c) discuss how to replace aquatic life	
7) include the process for reclamation of rivers?	
a) discuss how to restore channel formation	
b) discuss how to replace plant and riparian habitat	
c) discuss how to replace aquatic life	
8) include the process for reclamation of groundwater	
a) require the treatment of open pit water and/or contaminated groundwater	
Wildlife	
1) discuss the reclamation of wildlife populations?	
2) Is either active manipulation of wildlife or habitat recreation discussed as reclamation methods?	
i) Is a plan for either presented?	

3.5 Analysis of Best Practice Use in Environmental Assessments

The final step to completion of the research is to apply the list of best practices to a series of Environmental Assessments completed in Ontario. Three Environmental Assessments were selected.

The selected assessments were completed in recent years, and thus were good examples of current state of post-closure mine reclamation discussion in Environmental Assessments. The assessments were the only three completed assessments for the development of a mine in Ontario. The assessments were completed at a federal level, since all were completed prior to the 2012 changes. But if completed at current time, the assessments may no longer be completed at the federal level, and instead at the provincial level.

The Environmental Assessments were evaluated using the best practices table. All information that is related to reclamation was extracted from the assessments and placed in Appendix B. The revaluation was a simple binary method, with either "yes" of "no" answer to each of the questions. If a question was not relevant to the site, they may choose the not applicable (n/a) option.

4 Results

4.1 Results of Policy Information

The following sections detail the results obtained from the completion of the study's jurisdictional analysis and the relative Environmental Assessment evaluations.

4.2 Provincial

There are six types of policy that can influence aspects of a mining project on a provincial level; three major policies that will be the focus for this evaluation as they can influence reclamation and three minor policies that do not influence reclamation. The major instruments include mining legislation, legislation about pollution control, and specific requirements in environmental assessment legislation. The legislation that is less relevant to abandoned mine reclamation includes workplace safety legislation, and planning legislation and common law (Castrilli, 2007). In most provincial cases, the Crown owns the mineral rights, but the rights may be obtained by others though methods presented in the mining laws and legislation. Since most of their focus is on mineral rights, many mining laws do not or previously did not address the issues of abandoned mine sites or end- of-use impacts (Castrilli, 2007).

Most provincial environmental legislation contains similar elements of prohibition of pollution, permits and approvals for discharge, authorities for applications, environmental assessments, remediation and cleanup orders (Castrilli, 2007). Reviewing the three major pieces of legislation ideas of policy adjustments for Ontario's Environmental Assessment act can be considered. A review of other provincial policies was completed to evaluate if other systems in the country were better meeting reclamation best practices.

4.2.1 Ontario's Policy

As stated previously, Ontario has the *Mining Act*, which is administered by the Ministry of Northern Development and Mines. The main purpose of the act is to encourage mineral exploration and development of mineral resources (Castrilli, 2007). The *Mining Act* requires proponents to complete a closure plan with some aspects of "rehabilitation" included in it.

For Environmental Laws that relate to mining in Ontario are *Environmental Protection Act*, *Ontario Water Resources Act* and the *Environmental Assessment Act*. The *Environmental Protection Act*'s main role in mining is limits on pollution discharge. The *Ontario Water Resources Act* is used for protection of ground and surface waters. The *Environmental Assessment Act* was constructed for the protection, conservation and wise management of Ontario's environments (Castrilli, 2007).

The Ontario *Environmental Assessment Act* details what must be included in the environmental assessment, including some of the environmental effects of undertaking the project and its alternatives. In addition it includes details of the mitigation measures of the activities (Castrilli 2007; Ontario Government, 2010). There is no specific section required in the environmental assessment that must be dedicated to reclamation.

4.2.2 Results for British Columbia

The following Table summarizes the results found for British Columbia's Environmental Assessment Legislation.

Table 2: Results from British Columbia

1)	Is a Provincial Environmental Assessment Act in place?
	Yes
2)	Does the act or associated regulations require any reclamation (remedy or rehabilitation) information included in the Environmental Assessment report? If information is required, How is it presented? What does it state?
	The following information regarding the report is included in the Act. It states that an **""assessment report"** means a written report submitted to ministers under section 17 (2), summarizing the procedures followed during, and the findings of, an assessment;"

	Documents including the Environmental Assessment Office User Guide describe the requirements of the Environmental Assessment report. There are no specifics on what must be included in the Environmental Assessment document regarding reclamation. In the *Environmental Assessment Act,* There is a section related to ceasing and remedy for a project, based on minister's order. It as follows: "**Minister's order to cease or remedy** **34** (1) If the minister considers that a reviewable project is not being constructed, operated, modified, dismantled or abandoned or, in the case of an activity that is a reviewable project, carried out, in accordance with an environmental assessment certificate, the minister, (a) if an environmental assessment certificate for the reviewable project has not been issued or has been issued but does not remain in effect, may order that construction, operation, modification, dismantling or abandonment of the project cease, or that the activity cease, either altogether or to the extent specified by the minister, until the proponent obtains an environmental assessment certificate, or (b) if an environmental assessment certificate for the reviewable project has been issued and remains in effect, may (i) order that construction, operation, modification, dismantling or abandonment of the project cease, or that the activity cease, either altogether or to the extent specified by the minister, until the holder of the certificate complies with it, or (ii) order that the holder of the certificate carry out, within the time to be specified in the order, measures specified by the minister in order to mitigate the effects of non-compliance." Further information is presented in Appendix C

3) Is this more specific? More stringent? More inclusive then the Ontario regulations?	
	No

4.2.3 Discussion of British Columbia's Results

In British Columbia, the primary mining legislation is the *Mines Act* administered by the Ministry of Energy, Mines and Petroleum resources. This Act's main purposes include approval of permits for regulating mines. This permit approval includes a portion for environmental impact, environmental protection and reclamation of land and water systems. There are two permits, one for exploration and the other for development. Each permit has different reclamation requirements.

The Ministry requires that annual reports be submitted for a five-year reclamation plan, a conceptual final reclamation plan and the estimated cost of reclamation. The proponents are required to maintain monitoring to ensure they are meeting their proposed protection and reclamation claims (Castrilli 2007).

In British Columbia, environmental management is regulated by the *Environmental Management Act,* under the Ministry of the Environment. It offers permits for industry operations and activities. These permits are for pollution discharge limits (Castrilli 2007).

Included in the *Environmental Management Act* is a "framework for remediation" of contaminated sites. This framework focuses on identifying contaminated sites, establishing liability, and includes a small portion that discuses soil relocation, but nothing more (British Columbia Government, 2014). It includes amendments that define exploration sites, advanced exploration sites and producing or past-producing mine sites (Castrilli 2007).

In British Columbia there is an Environmental Assessment Act, which may influence mining projects. The act defines the size and type of projects that maybe subject to the act. The threshold for mineral mining in British Columbia to qualify for an assessment has been increased recently filtering fewer projects into the Environmental Assessment program. To obtain an EA certificate, assessment methods are defined through both regulations and the Director of Environmental Assessments. Thus the requirements can be tailored to meet the project's needs.

British Columbia's legislation adds very little to reclamation. The policies do not address the CCME best practices nor does it contain any of the best practices derived from restoration science literature.

4.2.4 Results for Saskatchewan

The following Table summarizes the results found for Saskatchewan's Environmental Assessment Legislation.

Table 3: Results from Saskatchewan Policy

1) Is a Provincial Environmental Assessment Act in place?	
	Yes
2) Does the act or associated regulations require any reclamation (remedy or rehabilitation) information included in the Environmental Assessment report? If information is required, how is it presented? What does it state?	
	No, it states that the minister will make the decisions. "**7.3**(1) On receipt of an application and after considering the information or material submitted and any other factors that the minister considers appropriate, the minister shall make a determination that: (a) the proposed undertaking is a development; or (b) the proposed undertaking is not a development. (2) Subject to the regulations, the process and procedures to be followed in making a determination pursuant to subsection (1) are those that the minister considers advisable and may include any public notification, consultation or involvement in the process.

	(3) On making a determination pursuant to subsection (1), the minister may impose on the applicant any terms and conditions that the minister considers necessary or advisable." Please note that Saskatchewan does have mining legislation that details information regards specific types of reclamation. This information was not considered, in this evaluation analysis, as the intention is reclamation requirements at the new source legislation level.
3) Is this more specific? More stringent? More inclusive than the Ontario Legislation?	
	No

4.2.5 Discussion of Saskatchewan's Results

In Saskatchewan, mining practice is governed by the Crown Minerals Act, and established by the Department of Industry and Resources. The ministry is in charge of mineral deposit rights as well as royalty payments to the Crown. The only environmental component in the Crown Minerals Act is that a project can be cancelled for environmental protection reasons if the minister decides. The minister also has the power to decide where tailings, slimes and other waste products can be deposited. These regulations apply to anyone who is interested in leasing the rights to minerals on Crown land (Castrilli 2007).

The main environmental law in Saskatchewan is the *Environmental Management and Protection Act* administered by Saskatchewan Environment. Like the other provinces, it also requires the issuing of permits and assessment obligations for industry projects that involve construction, or alterations and operations of a pollution control facility as well as for exploration of mineral or decommissioning and reclamation of a mining site. Financial assurances by the proponent are used to fund the reclamation of the mine site, thus the cost must be estimated during the assessment (Castrilli 2007; Government of Saskatchewan, 2013).

Saskatchewan Environment also deals with the *Environmental Assessment Act*. The Act requires proponents to obtain approval before development. The proponent must conduct an environmental impact assessment meeting the guidelines. Any project can be subject to the *Environmental Assessment Act* if it meets the statutory definition by Saskatchewan Environment or if courts decide (Castrilli 2007).

Again the Saskatchewan regulation adds very little in terms of reclamation of a mine site. Best practices are not discussed in policies for reclamation.

4.2.6 Results for Quebec

The following Table summarizes the results found for Quebec's Environmental Assessment regulations.

Table 4: Results from Quebec's Policy

1) Is a Provincial Environmental Assessment Act (or parallel requirement) in place?	
	Yes
2) Does the act or associated regulations require any reclamation (remedy or rehabilitation) information included in the Environmental Assessment report? If information is required, How is it presented? What does it state?	
	The following information is presented in the Regulations associated with the Environmental Quality Act. "*(d)* a description of the different options to the project, in particular regarding its location, the means and methods of carrying out and developing the project, and all other variables in the project as well as reasons justifying the option chosen; *(e)* a list and description of measures to be taken to prevent, reduce or attenuate the deterioration of the environment, including the impacts listed in subparagraph *c* before, during and after the construction or development of the project, including, in particular, any equipment used or installed to reduce the emission, deposit, issuance or discharge of

	contaminants into the environment, any control of operations and monitoring, emergency measures in case of accident, and reclamation of the area affected." More information is available in appendix C.
3) Is this more specific? More stringent? More inclusive etc. then the Ontario Legislation?	
	No

4.2.7 Discussion of Quebec Results

In Quebec, most of the mining regulation comes from the Ministry of Natural Resources and Wildlife's *Mining Act*. The act went through amendments in 1995 that have changed proponents' obligations for rehabilitation of mining activity (Castrilli, 2007). Similar to Ontario, a rehabilitation and restoration plan must be submitted to the Minister before mining can commence.

The environmental laws are the responsibility of the Ministry of Sustainable Development, Environment and Parks, which administers the *Environmental Quality Act*. This act and its regulations determine licensing for mines, as well as the requirements for land reclamation plans; it prohibits contaminants and pollution. To obtain a license, an environment impact study is also required. There is no specific Environmental Assessment Act, but a portion of the *Environmental Quality Act* requires that an environmental impact study must be conducted in a similar manner to an Environmental Assessment (Government of Quebec, 2010).

The Quebec government offers nothing in terms of reclamation. Its policies are similar to Ontario's and do not touch on the best practices of reclamation.

4.3 Countries

Each country has its own methods of handling reclamation of mine sites. It might be dependent on the type of mining they participate in, or how large the mining industry is in their country. Most developing countries do not have developed environmental policies as do many developed countries. For this study the mine site reclamation policy for Australia, Sweden and the United states will be reviewed.

4.3.1 Results for Australia

The following Table summarizes the results found for Australia's Environmental Assessment Legislation.

Table 5: Results from Australia's Legislation

1) Does the country have an Environmental Assessment Act or new source protection legislation?	
	Yes. The *Environmental Protection and Biodiversity Act*
2) Does the Act or associated regulations require any reclamation (remedy or rehabilitation) information included in the Environmental Assessment report? If information is required, how is it presented? What does it state?	
	No
3) Is this more specific? More stringent? More inclusive etc. then the Ontario Legislation?	
	No

4.3.2 Discussion of Australia's Results

Australia is a very active mining county due to diversity in geology that allows for a number of different types of mining. Because of its importance they also have strong environmental laws for protection. The Environmental protection agency has created workable codes that deal with most of the potential issues that can arise from mining practice. The mine laws require all scenarios be anticipated during the initial planning procedures, even during prospecting. Mine closure and restoration is approved before mines can be developed (Wood, 2012). A mine reclamation plan is required by regulations in Australia, but the plans (different for each area of Australia) are all similar to the process seen in Canada. Much of it is the retrieval of baseline information.

The Environmental Assessment requirement is determined based on a proposal submitted by a proponent to the relevant government department. If the department determines that a mine project is likely to produce significant impacts, they will determine which level (federal or state) of assessment is required. The two levels represent different detail requirements as well as public participation levels (Norton Rose, 2012).

No information as to the document requirements in terms of reclamation exists in the regulations. For the most part, it appears it is the responsibility of the minister to set out this information (Norton Rose, 2012).

4.3.3 Results for Sweden

The following Table summarizes the results found for Sweden's Environmental Assessment Legislation.

Table 6: Results from Sweden's Legislation

1) Does the country have an Environmental Assessment Act or new source protection legislation?	
	Yes. The *Environmental Code*
2) Does the Act or associated regulations require any reclamation (remedy or rehabilitation) information included in the Environmental Assessment report? If information is required, how is it presented? What does it state?	
	Yes for some items The code specifically states the following about the release of wastewater: "Section: Wastewater shall be diverted and purified or treated in some other way in order to avoid detriment to human health or the environment. (Government Offices of Sweden , 2013)" The *Environmental Code* says the following regarding polluted areas and after-treatment: " Chapter 10. Polluted areas: Responsibility for investigation and after-treatment Section 1. This chapter shall be applicable to land and water areas, buildings and structures that are so polluted that they may cause damage or detriment to human health

	or the environment. Section 2. Persons who pursue or have pursued an activity or taken a measure that is a contributory cause of the pollution (operators) shall be liable for the after-treatment of areas, buildings and structures referred to in section 1… Section 4. After-treatment liability shall mean that the person who is liable for after-treatment shall, to the extent reasonable, carry out or pay for any after-treatment measures that are necessary in order to prevent or combat subsequent damage or detriment to human health or the environment. " The *Environmental Code* specifically states the following for environmental impact statements: "Contents of environmental impact statements: Section 7. An environmental impact statement relating to an activity or measure that is likely to have a significant environmental impact shall contain the information that is needed for the purpose referred to in section 3, including: 1. a description of the activity or measure with details of its location, design and scope; 2. a description of the measures being planned with a view to avoiding, mitigating or remedying adverse effects, for example action to prevent the activity or measure leading to an infringement of an environmental quality standard referred to in chapter 5; 3. the information that is needed to establish and assess the main impact on human health, the environment and management of land, water and other resources that the activity or measure is likely to have;

	4. a description of possible alternative sites and alternative designs, together with a statement of the reasons why a specific alternative was chosen and a description of the consequences if the activity or measure is not implemented; and 5. a non-technical summary of the information specified in points 1-4."
3) Is this more specific? More stringent? More inclusive than the Ontario Legislation?	
	No. Has similar requirements

4.3.4 Discussion of Sweden's Results

In Sweden, environmentally hazardous activities are taxed through an annual charge for environmental damage and clean up insurance. This tax is under the *Environmental Code* (1999) and covers mining operations. Sweden also requires that proponents who wish to build a new mine reclaim old mines in the area which they are developing (CCSG Associates, 2001). CCGS Associates summarize the requirements of the environmental code stating that the following is required from a proponent to complete are part of reclamation:

- Precautionary measures must be taken
- Use of best available technology
- Proponent must have knowledge of the environmental effects of the operation before its carried out
- Local criteria that must be respected regarding the environment, land and water
- Measures to conserve raw materials and energy are taken into account by the use of renewable energy and re-use of materials
- Choosing products that are less harmful to human heath and the environment
- Balancing the environmental value with expenses
- Polluter is liable to remediate damages in all cases

The *Environmental Code* in Sweden is an umbrella for most environmental policy. This ensures consistency in what is required, and offers one approval with the intention of doing what is best for the environment. In contrast Ontario has its policy is split between a number of different acts and ministries, making for gaps and inconsistencies.

4.3.5 Results for United States'

The following Table summarizes the results found for the United States' Environmental Assessment regulations.

Table 7: Results from United States Legislation

1) Does the country have an Environmental Assessment Act or new source protection legislation?	
	Yes: *National Environmental Policy Act*
2) Does the Act or associated regulations require any reclamation (remedy or rehabilitation) information included in the Environmental Assessment report? If information is required, how is it presented? What does it state?	
	No
3) Is this more specific? More stringent? More inclusive etc. than the Ontario Legislation?	
	No

4.3.6 Discussion of Unites States Results

In the United States, the *National Environmental Policy Act* is the legislation that governs Environmental Assessments. Through the Environmental Protection agency NEPA details the requirements for Environmental Assessments, nothing of which requires components of reclamation. NEPA does have mining regulations, but that are not included in the Environmental Assessment. In addition, legislation specific to watercourses such as the *Federal Water Pollution Control Act* and *Clean Water Act* apply to a mine site (Wood, 2012).

In addition the United States has the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) or "Superfund" used to treat and rehabilitate abandoned mines along with many other types of projects. While it is the only legislation in the world that uses current mining funds to deal with historical pollution, the funds are simply not enough (Wood, 2012). Mining projects in the United States have to pay into the superfund to support abandoned mine reclamation. The "Superfund" process was originally funded by a concessional allocation; but that fund was then later rolled into general revenues, thus the funds must now be supported by payments.

The "Superfund" process was systematically altered in the George W. Bush Era. Previously the fund was allocated by Congress and "earmarked" for contaminated site remediation. Bush made funding a Congressional expenditure/allocation rather than an established fund, and Congress reduced its funding as an annual allotment.

None of the countries reviewed have a firm regulatory requirement for reclamation, similar to the provinces. Sweden has the most advanced, as it considers all environmental impacts under one policy.

4.4 Existing Cases of Mining Environmental Assessments in Ontario

In Ontario, there are three environmental assessments that have been completed for possible for evaluation. They are the Marathon Mine project, the Rainy River Project and the Victor Diamond Mine.

1.1.1 Marathon PGM-CU Mine Project

The Marathon PGM-Cu Project is a mining development proposed by Stillwater Canada Inc. It is an open pit mine and milling process for the platinum group of metals, copper and iron located near Marathon Ontario. The mine site will be approximately 10km north of Marathon Ontario. The project will have a total surface area of 1700 ha including an open pit, waste storage areas and processing facility and associated tailings. The mining project will include the development of an open pit mine with access roads and transmission lines. The processing will be completed on site before off site smelting. (Stillwater Canada Inc., 2012). The project will include a number of new infrastructure projects. These include site access roads, a power transmission corridor, an explosives plant, an open pit, a mine rock storage area, an ore stockpile, primary and secondary crushers, a concentrator building, a concentration handling facility, a water management system, a process solids management facility, a water treatment plant and ancillary structures. It is estimated the operating life of the mine to be 11.5 years with an operating workforce of 360 people (Stillwater Canada Inc., 2012).

The open pit and infrastructure will create a loss of habitat and change to the landscape. In addition, there is a possibility of contamination of water from the process solids management facility and the tailings ponds. This is a concern for two main reasons: the project details that treatment of the water before discharge to Hare Lake will be done "as is necessary", and the settling pond has been designed for a 1 in 25 year, 24 hour rain event (Stillwater Canada Inc., 2012).

Appendix B includes the information examined from the environmental assessment regarding reclamation.

1.1.2 Rainy River Project

The Rainy River Project is a mining development proposed by New Gold Inc. It is an open pit gold mine located 65 km north-west of Fort Frances, Ontario. The site contains an open pit mine that will be 200 ha in size and 400 m in depth. It has been determined that the expected lifespan of the mine is to be 16 years of operation (amec, 2014). The project will consist of the open pit and an underground mine. The ore will be processed on site using the traditional method of cyanidation inside a gold recovery plant. The site will also include the following infrastructure: an open pit mine, underground mine, mineral waste stockpiles, a primary crushing and processing plant, tailings pond, an explosives factory, and any other required administrative buildings. The site will also require the relocation of a portion of Highway 600, and a transmission line approximately 17 km in length (amec, 2014).

Creating an open pit mine affects habitats and requires forest destruction, but the project at Rainy River produces other risks of contamination from the leaching acid mine drainage and tailings material from a failed ore rock pile, tailings dam or pond failure. The materials contained in these sites can have a significant impact on the environment. Some of these impacts include a loss of aquatic life and plant life anywhere near the site due to toxic nature of the waters (amec 2014).

Appendix B includes the information examined in the environmental assessment regarding reclamation.

1.1.3 Victor Diamond Mine

The Victor Diamond Project is a mining development proposed by De Beers Canada Inc. It is an open pit diamond mine located 90 km from Attawapiskat, Ontario.

The mine will include the following infrastructure: a quarry, sand and gravel pit, an open pit mine, an ore processing plant, warehouse and service buildings, stockpiles for possessed ore and mine rock, water management facilities, workforce accommodations, access roads, an air strip and fuel and power facilities. The operating life span of the mine is 12 years. The project's official environmental assessment began on in 2003 with approval in 2005 (CEAA, 2013). The construction of the mine began in 2005 after the approval reaching production in 2007 (DeBeers, 2012). The environmental assessment agency requires that the expected follow-up program will continue until 2033 (CEAA, 2013). Similar to the other sites, contamination coming from releases or leaching of chemicals and releases of tailings are the largest contamination concerns.

Appendix B includes the information examined in the environmental assessment.
The following sections detail whether existing mining environmental assessments discuss the details, abilities and limitations when it comes to meeting the scientific criteria presented previously.

4.5 Results of Environmental Assessment Evaluations based on Scientific Best Practices

4.5.1 Marathon PGM-Cu Project

The results for best practice evaluation of the Environmental Assessment for the Marathon PGM-Cu Project mining development proposed by Stillwater Canada Inc. are as follows. Appendix B includes the information pulled form environmental assessment regarding reclamation.

Table 8: Best Practices Analysis for Marathon PGM-Cu Project

Question	**Answer**
Soil and Plant life	
Does the EA present…	
1) discussion of soil reclamation?	Yes
i) Expected soil conditions/ problems discussed?	Yes
2) methods to return soil to its original chemical profile (based on expected soil conditions)?	No
3) methods to remove toxic substances?	No
4) methods to increase in water holding capacity?	No
5) methods to adjust the pH?	No
6) discussion of enriching and building the soil?	No
7) discussion of vegetation selection?	Yes
8) discussion of the use of native species vs. non-native?	No
9) discussion of the properties of vegetation to be planted?	Yes
Water Systems and Aquatic Life	

Does the EA…	
1) discuss reclamation of water and water systems?	Yes
i) Expected water/effluent conditions/ problems predicted?	Yes
2) discuss the reclamation of the hydraulic impact?	No
3) present discussion of pollution source removal and water containment?	No
4) discuss the treatment of water contaminants?	
i) Ferric	No
ii) Acidic	No
iii) Metals loading	No
iv) Solids loading	No
v) Turbidity	No
5) discuss how tailings impoundment areas will be treated before release to waterways?	No
6) include the process for reclamation of Lakes? (using the best practice steps)	No
a) discuss how to restore nutrient balance?	No
b) discuss how to replace plant and riparian habitat	No
c) discuss how to replace aquatic life	No
7) include the process for reclamation of Rivers?	Yes
a) discuss how to restore channel formation	Yes
b) discuss how to replace plant and riparian habitat	No
c) discuss how to replace aquatic life	No
8) include the process for reclamation of Groundwater	No
a) require the treatment of open pit water and/or	No

contaminated groundwater	
Wildlife	
1) Does the EA discuss the reclamation of wildlife populations?	Yes
2) Is either active manipulation of wildlife or habitat recreation discussed as reclamation methods?	Yes
i) Is a plan for either presented?	Yes

The results demonstrate a high number of reclamation components not being evaluated at the environmental assessment level. A "No" in any category demonstrates a failure to properly evaluate reclamation best practices. The Marathon PGM-CU Project evaluates approximately one third of the best practice criteria being met in the environmental assessment. This means that two thirds of best practice measures are not discussed. This is clearly a failure of an evaluation of the end-of-life remediation of a mine site.

1.1.4 Rainy River Project

The results from the evaluation of the Rainy River Project mining development proposed by New Gold Inc. are as follows. The use of best practices in their environmental assessment is shown in Table 9. Appendix B includes the information examined from the environmental assessment regarding reclamation.

Table 9: Best Practices Analysis for Rainy River Project

Question	Answer
Soil and Plant life	
Does the EA present…	
1) discussion of soil reclamation?	Yes

i) Expected soil conditions/ problems discussed?	No
2) methods to return soil to its original chemical profile (based on expected soil conditions)?	No
3) methods to remove toxic substances?	No
4) methods to increase in water holding capacity?	No
5) methods to adjust the pH?	No
6) discussion of enriching and building the soil?	Yes
7) discussion of vegetation selection?	Yes
8) discussion of the use of native species vs. non-native?	Yes
9) discussion of the properties of vegetation to be planted?	No
Water Systems and Aquatic Life	
Does the EA…	
1) discuss reclamation of water and water systems?	Yes
i) Expected water/effluent conditions/ problems predicted?	Yes
2) discuss the reclamation of the hydraulic impact?	No
3) present discussion of pollution source removal and water containment?	Yes
4) discuss the treatment of water contaminants?	
i) Ferric	No
ii) Acidic	Yes
iii) Metals loading	No
iv) Solids loading	No
v) Turbidity	No
5) discuss how tailings impoundment areas will be treated before release to	Yes

waterways?	
6) include the process for reclamation of Lakes? (using the best practice steps)	N/A
a) discuss how to restore nutrient balance?	N/A
b) discuss how to replace plant and riparian habitat	N/A
c) discuss how to replace aquatic life	
7) include the process for reclamation of Rivers?	
a) discuss how to restore channel formation	Yes
b) discuss how to replace plant and riparian habitat	Yes
c) discuss how to replace aquatic life	No
8) include the process for reclamation of Groundwater	
a) require the treatment of open pit water and/or contaminated groundwater	No
Wildlife	
1) Does the EA discuss the reclamation of wildlife populations?	No
2) Is either active manipulation of wildlife or habitat recreation discussed as reclamation methods?	No
i) Is a plan for either presented?	No

The results demonstrate a high number of reclamation components not being evaluated at the environmental assessment level. A "No" in any category demonstrates a failure to properly evaluate reclamation best practices. The Rainy River Project evaluates around 40% of the best practice criteria in the environmental assessment. This means approximately 60% of best practice measures are not discussed. This is clearly a failure of an evaluation of the end-of-life of a mine site.

1.1.5 Victor Diamond Mine

The Victor Diamond Project best practices evaluation is presented in Table 10 is a mining development

Appendix B includes the information pulled form environmental assessment regarding reclamation.

Table 10: Best Practices Analysis for Victor Diamond Mine

Question	Answer
Soil and Plant life	
Does the EA present…	
1) discussion of soil reclamation?	Yes
i) Expected soil conditions/ problems discussed?	No
2) methods to return soil to its original chemical profile (based on expected soil conditions)?	Yes
3) methods to remove toxic substances?	No
4) methods to increase in water holding capacity?	No
5) methods to adjust the pH?	No
6) discussion of enriching and building the soil?	Yes
7) discussion of vegetation selection?	Yes
8) discussion of the use of native species vs. non-native?	Yes
9) discussion of the properties of vegetation to be planted?	No
Water Systems and Aquatic Life	
Does the EA…	
1) discuss reclamation of water and water systems?	Yes
i) Expected water/effluent conditions/ problems predicted?	No
2) discuss the reclamation of the hydraulic impact?	Yes

3) present discussion of pollution source removal and water containment?	No
4) discuss the treatment of water contaminants?	
i) Ferric	No
ii) Acidic	No
iii) Metals loading	No
iv) Solids loading	No
v) Turbidity	No
5) discuss how tailings impoundment areas will be treated before release to waterways?	No
6) include the process for reclamation of Lakes? (using the best practice steps)	No
a) discuss how to restore nutrient balance?	No
b) discuss how to replace plant and riparian habitat	No
c) discuss how to replace aquatic life	No
7) include the process for reclamation of Rivers?	No
a) discuss how to restore channel formation	No
b) discuss how to replace plant and riparian habitat	No
c) discuss how to replace aquatic life	No
8) include the process for reclamation of Groundwater	No
a) require the treatment of open pit water and/or contaminated groundwater	No
Wildlife	
1) Does the EA discuss the reclamation of wildlife populations?	Yes
2) Is either active manipulation of wildlife or habitat recreation discussed as	Yes

reclamation methods?	
i) Is a plan for either presented?	No

The results demonstrate a high number of reclamation components not being evaluated at the environmental assessment level. A "No" in any category demonstrates a failure to properly evaluate reclamation best practices. The Victor Diamond Mine Project evaluates approximately one quarter of the best practice criteria in the environmental assessment. This means that approximately three quarters of best practice measures are not discussed. This is clearly a failure of an evaluation of the end-of-life of a mine site.

5 Discussion

The idealistic expectation that mines sites can be reclaimed to pristine conditions given the guiding policies is very quickly shattered as research into this study area begins. What is obvious is that mine sites, with time and a proper reclamation process, may be returned to a viable ecosystem condition. Much of this depends on data collection and information at the initiation of a mining project. This information aids in as targets for the site after closure. The best way to ensure that proper reclamation occurs at the end-of-life of a mine is to regulate it at the start of the process. The initial stage of approvals, and the stage where a majority of the pre-development condition data are collected, is the environmental assessment stage. Using the predevelopment information, a reclamation plan can be developed and included in this initial approval. Presumably, this plan should follow best practices for reclamation

Current regulation in Ontario calls for reclamation plan approval completed with the mine closure plan. This closure plan is regulated by the MNDM, a department also responsible for development and promotion of mineral exploration. The reclamation approval could be considered poorly placed here, as there is a possibility of conflicting focuses. This is supported by the designated requirements of the closure plan, which focus mainly on the safety of the site and lack the depth of detail for the determined reclamation.

As can be seen from the cases reviewed, the planned reclamation efforts vary considerably. Each Assessment reviews the reclamation processes required differently. Consistency in what is discussed for a reclamation project can make the evaluation process easier. The *Environmental Assessment Act* and supporting documents do not include requirements for reclamation that the proponent must meet. Without this information based on best practices, investigation into reclamation is different for each report and lacking in detail. Approvers of these reports agree to development without an understanding of what the site conditions will be after the mining process finishes, an importance component based on the purpose of the environmental assessments. The difference in reclamation evaluation can been seen from the results. Best practice criteria are met between a quarter and 40% of the time. None of the cases evaluated even half of the best practice criteria, demonstrating a significant gap, and a failure of reclamation evaluation.

The best practices for reclamation are both achievable and general enough that they can be applied to any mine site using the not applicable answer for components that are not on site. However, as revealed in the Regulation review, these best practices are not required at any levels of legislation as guidelines or regulation. Without this information available to practitioners, it is almost certain that a best practice level of reclamation will not occur.

The first objective of this report was to examine and analyze Ontario's mine reclamation requirements. This was completed by reviewing both the *Environmental Assessment Act* and the *Mining Act*.

The second objective of this report was to establish the degree of reclamation that meets best practices. This would ensure acceptable levels expectations of public for responsible management. This was completed through the best practices development by examining the scientifically accepted literature in Chapter 2. It was determined that there was a lack of a universally received model in current requirements in active mining jurisdictions. Best practice standards are possible and best introduced at the EA level of approval.

The third objective was to determine if Ontario could improve its process. This was completed by comparing practices of other jurisdictions to the Ontario process. What the results show is that Ontario is at par or better than other major mining countries and provinces in remediation, in no other jurisdiction is reclamation of mine site required at an EA level. One possible explanation is that this is a relatively new process that has not had full time to develop.

5.1 Limitation

The study completed face several significant limitations. The first limitation is the availability of environmental assessments. Since private sector projects are not always subjected to environmental assessment legislation, the number of assessments completed in Ontario is limited. Most of the assessments have been completed in recent years, as projects have gotten larger and need for assessment has become more apparent. The life cycles of these newer mines have not finished and thus, a comparison of what was presented in closure plans/environmental assessments to what was actually carried out could not be completed. This would be an interesting area of study in the future.

The age of many mines also influences how many assessments exist. Many mines are not "new", as their ore bodies have been explored previously, and increases in the price of metals often cause the re-exploration of the sites as ores become economically more valuable. These re-opened mines do not require environmental assessment.

The inclusion of an older assessment where a mine has been given the closed-out designation would have added to the study, as it would have given an idea of how long it takes to achieve a closed-out designation as well as the conditions observed at a closed-out site. Little information was available regarding sites that achieved a closed-out designation. The limited number of sites that are designated as closed-out supports the notion that not enough is being done to ensure that proper reclamation has been achieved.

Reviewing only legislation in English-speaking countries limited the countries that could be compared to Ontario. It is possible that other countries have a more progressive policy that was missed.

In terms of developing the set of best practices for ecological reclamation, time limitations proved to be the greatest issue. There are many books and papers that detail reclamation practices, some conflicting and some supporting. To combat this, sources provided in textbooks were considered of highest value, as they have been reviewed and published and used in courses, which continues to provide support of the text. Journal articles were used next to show continued support of the information, as some of the data may have been considered old.

5.2 What Can Ontario Learn from Other Parts of Canada?

Based on the results obtained, Ontario is ahead of the other provinces evaluated in terms of environmental reclamation in Environmental Assessments. However, by allowing ministers to negotiate what must be included in an environmental assessment, other provinces have limited consistency in their EA reports. Regulations that require a reclamation section along with the other components of an environmental assessment report is the only way to meet the need. Mining legislation across the provinces are similar in this respect. In most of provinces, the reclamation component of mining is evaluated though the Ministry associated with mining. The proposed site reclamation typically is not completed until after the submission of the Environmental Assessment (if required), and they are each evaluated independently.

5.3 What Can Ontario Learn from Other Countries?

While Australia and the United States have similar processes for dealing with mining projects, Sweden offers a few ideas that if adopted by Canada could change how mining operations are completed. Regulating mining at a federal level would mean that mining projects would be subject to the more rigorous federal environmental process that requires more detail and investigation. Additionally Sweden's *Environmental Code* imposes conditions requiring that a proponent adopt and reclaim and old site before approval of a new site as an innovative way to deal with current issues of many abandoned mines.

5.4 The Quarry Project

There have been some attempts to have projects complete a high-level successful reclamation at the environmental assessment level. In April 2011 the Highland Companies applied to build a limestone quarry in the Township of Melancthon (Township of Melanchthon, 2012). The Quarry would be at a former potato farm site, whose conditions are some of the best in Ontario for agriculture because of its climate. Since the farmland is of high value, the Highland Companies purposed to "rehabilitate" the land to agricultural quality. Land cover is sorted into Classes depending on soil quality among other factors.

Only 0.5% of Canada's land is considered Class 1 Agricultural, and the Quarry is in a portion of a Class 1 area, thus the importance of rehabilitation is essential. Due to this very specific land class type, the project was not approved. If it would have been approved, It could have been a barometer for success of reclamation projects in Ontario and Environmental assessment approval.

5.5 Successful Rehabilitation and Reclamation

Ontario does have cases of successful rehabilitation and reclamation, presented by S.E. Yundt in a report by Stantec in 2010. In this report, successful rehabilitation effors of aggregate and quarry sites are presented, a practice that can be considered similar to open pit mining (Yundt, 2010). In Ontario the *Aggregate Resources Act* defines the minimum rehabilitation requirements. The act states that:

"**48.** (1) Every licensee and every permittee shall perform progressive rehabilitation and final rehabilitation on the site in accordance with this Act, the regulations, the site plan and the conditions of the licence or permit to the satisfaction of the Minister. R.S.O. 1990, c. A.8, s. 48 (1)."

While this is not extremely specific in process, it does state "progressive rehabilitation", which requires more to be done than simply adding vegetation.

The report divides examples of reclamation into sites that have had exceptional and successful rehabilitation, Agricultural Rehabilitation-Field Crops, Agricultural Rehabilitation-Specialty Crops, Rehabilitation to Biodiversity, and finally Reclaimed lands and Water Management. In each example of a successfully completed reclamation, the desired land use was restored. The following are a few examples from the report. Proof that if proper legislation is in tact, successful reclamations is possible (Yundt, 2010).

The Royal Botanical Gardens Hamilton Ontario: This garden site was created from an abandoned gravel pit. The Reclamation began in 1929 when a rock garden was created which eventually lead to more rehabilitation and a first class horticultural collection. This site is a national historical site, and is revered worldwide. It is considered to play a crucial environmental role in conservation, education horticulture and science (Royal Botanical Gardens, N.d.).

Lafarge Canada Inc. East Paris Pit: This site is a rehabilitated sand and gravel pit located in Paris, Ontario. The site was rehabilitated to meet agricultural standards and has been producing high yielding corn, wheat and soybeans crops.

Kelso Quarry Park: This was previously a site for a limestone quarry for Toronto. Since it is located in Milton Ontario, it is situated in both the Niagara Escarpment and Greenbelt, meaning it has significant ecological value. It was determined that total reclamation would be required. The site began its rehabilitation in the 1970s planting grasses and native trees, and developing a lake (Yundt, 2010).

What these sites prove, is that if given the proper dedication and commitment, a site can reach a level of reclamation that permits good future use of the land. It is important the proponents are required to be part of this process.

5.6 What Should Be Changed

Based on the study presented above the following recommendations can be made:

- Request the inclusion of a reclamation section in Environmental Assessments
- Specific types of projects (such a mining) which must complete a more comprehensive assessment on reclamation
- Implementation of the requirements for the best practice reclamation steps are followed
- Establishment of an immediate project rejection if reclamation technology does not exist

6 Conclusions

In conclusion, best practices for reclamation are not used in Environmental Assessment reporting. This is in part because reclamation requirements in regulations are not specific. They are not adequate to achieve the level of reclamation, which should be achieved. The key reclamation requirements to meet are absent from legislation. Legislation and government structure does not make best practices of reclamation a focus for mining projects. While mine closure is evaluated after project approval through the Environmental Assessment process, the closure plans mostly focus on site safety. The legislation in the selected provinces and countries does have better processes, but does show that this policy idea is innovative.

The future of reclamation of mine sites is not assured or adequately funded by proponents. The attempts made by the Ontario Government to develop a bond process is the start, but history has shown that the bond values do not meet the costs for reclamation on their most basic level, let alone reaching best practices standards. If this gap is not addressed, future mine abandonment of unreclaimed sites will be very likely.

Changes to help standardize the Environmental Assessment process by requesting a specific section in reports for detailed reclamation discussion would be the ideal method to ensure that proper evaluation is completed. The process should require that best practices are used. Because of the variability in life spans as well as mining's sensitivity to resource prices, it is different than many other projects that may be subject to an environmental assessment, which may have longer life spans. Mines often have a finite closure point that will occur in a relatively short period of time, thus companies should aggressively evaluate how to reclaim a site, a process that is not currently required in Environmental Assessments in Ontario. The processes described could be incorporated into the new Class Environmental Assessment system developed for mine sites. The inclusion of this as part of the manual that already exists in completion requirements could be easily be done.

Appendix A: CCME Requirements

Canadian Council of Ministers of the Environment

CCME

Le Conseil canadien des ministres de l'environnement

Users are advised to consult the Canadian Environmental Quality Guidelines introductory text, factsheet, and/or protocols for specific information and implementation guidance pertaining to each environmental quality guideline.

		Water Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
1,1,1-Trichloroethane **CASRN** 71556	Organic Halogenated aliphatic compounds Chlorinated ethanes	*No data*	Insufficient data	1991	*No data*	Insufficient data	1991
1,1,2,2- Tetrachloroethene PCE (Tetrachloroethylene) **CASRN** 127184	Organic Halogenated aliphatic compounds Chlorinated ethenes	*No data*	110	1993	*No data*	Insufficient data	1993
1,1,2,2-Tetrachlorethane **CASRN** 79345	Organic Halogenated aliphatic compounds Chlorinated ethanes	*No data*	Insufficient data	1991	*No data*	Insufficient data	1991
1,1,2-Trichloroethene TCE (Trichloroethylene) **CASRN** 79-01-6	Organic Halogenated aliphatic compounds Chlorinated ethenes	*No data*	21	1991	*No data*	Insufficient data	1991

		Water Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
1,2,3,4-Tetrachlorobenzene **CASRN** 634662	Organic Monocyclic aromatic compounds Chlorinated benzenes	*No data*	1.8	1997	*No data*	Insufficient data	1997
1,2,3,5-Tetrachlorobenzene	Organic Monocyclic aromatic compounds Chlorinated benzenes	*No data*	Insufficient data	1997	*No data*	Insufficient data	1997

Users are advised to consult the Canadian Environmental Quality Guidelines introductory text, factsheet, and/or protocols for specific information and implementation guidance pertaining to each environmental quality guideline.

		Water Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
1,2,3-Trichlorobenzene **CASRN** 87616	Organic Monocyclic aromatic compounds Chlorinated benzenes	*No data*	8	1997	*No data*	Insufficient data	1997

		Water Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
1,2,4,5-Tetrachlorobenzene	Organic Monocyclic aromatic compounds Chlorinated benzenes	*No data*	Insufficient data	1997	*No data*	Insufficient data	1997
1,2,4-Trichlorobenzene **CASRN** 120801	Organic Monocyclic aromatic compounds Chlorinated benzenes	*No data*	24	1997	*No data*	5.4	1997
1,2-Dichlorobenzene **CASRN** 95501	Organic Monocyclic aromatic compounds Chlorinated benzenes	*No data*	0.7	1997	*No data*	42	1997
1,2-Dichloroethane **CASRN** 1070602	Organic Halogenated aliphatic compounds Chlorinated ethanes	*No data*	100	1991	*No data*	Insufficient data	1991
1,3,5-Trichlorobenzene	Organic Monocyclic aromatic compounds Chlorinated benzenes	*No data*	Insufficient data	1997	*No data*	Insufficient data	1997
1,3-Dichlorobenzene **CASRN** 541731	Organic Monocyclic aromatic compounds Chlorinated benzenes	*No data*	150	1997	*No data*	Insufficient data	1997

		Water Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
1,4-Dichlorobenzene **CASRN** 106467	Organic Monocyclic aromatic compounds Chlorinated benzenes	*No data*	26	1997	*No data*	Insufficient data	1997
1,4-Dioxane		NRG	NRG	2008	NRG	NRG	2008
3-Iodo-2-propynyl butyl carbamate IPBC **CASRN** 55406-53-6	Organic Pesticides Carbamate pesticides	*No data*	1.9	1999	*No data*	*No data*	*No data*
Acenaphthene PAHs	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	*No data*	5.8	1999	*No data*	Insufficient data	1999

Users are advised to consult the Canadian Environmental Quality Guidelines introductory text, factsheet, and/or protocols for specific information and implementation guidance pertaining to each environmental quality guideline.

		Water Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
Acenaphthylene PAHs	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	*No data*	*No data*	1999	*No data*	*No data*	1999
Acridine PAHs	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	*No data*	4.4	1999	*No data*	Insufficient data	1999
Aldicarb **CASRN** 116063	Organic Pesticides Carbamate pesticides	*No data*	1	1993	*No data*	0.15	1993
Aldrin	Organic Pesticides Organochlorine compounds	*No data*	~~0.004~~	1987	*No data*	*No data*	*No data*
Aluminium	Inorganic	*No data*	Variable	1987	*No data*	*No data*	*No data*
Ammonia (total)	Inorganic Inorganic nitrogen compounds	*No data*	Table	2001	*No data*	*No data*	*No data*

		Water Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
Ammonia (un-ionized) **CASRN** 7664417	Inorganic Inorganic nitrogen compounds	*No data*	19	2001	*No data*	*No data*	*No data*
Aniline **CASRN** 62533	Organic	*No data*	2.2	1993	*No data*	Insufficient data	1993
Anthracene PAHs	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	*No data*	0.012	1999	*No data*	Insufficient data	1999
Arsenic **CASRN** none	Inorganic	*No data*	5	1997	*No data*	12.5	1997
Atrazine **CASRN** 1912249	Organic Pesticides Triazine compounds	*No data*	1.8	1989	*No data*	*No data*	*No data*
Benz(a)anthracene PAHs	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	*No data*	0.018	1999	*No data*	Insufficient data	1999

		Water Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
Benzene **CASRN** 71432	Organic Monocyclic aromatic compounds	*No data*	370	1999	*No data*	110	1999

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		Water Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
Benzo(a)pyrene PAHs	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	*No data*	0.015	1999	*No data*	Insufficient data	1999
Boron	Inorganic	29,000µg/L or 29mg/L	1,500µg/L or 1.5mg/L	2009	NRG	NRG	2009
Bromacil **CASRN** 314409	Organic Pesticides	*No data*	5	1997	*No data*	Insufficient data	1997

		Water Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
Bromoxynil	Organic Pesticides Benzonitrile compounds	*No data*	5	1993	*No data*	Insufficient data	1993
Cadmium **CASRN** 7440439	Inorganic	1.0	0.09	2014	NRG	0.12	2014
Captan **CASRN** 133062	Organic Pesticides	*No data*	1.3	1991	*No data*	*No data*	*No data*
Carbaryl **CASRN** 63252	Organic Pesticides Carbamate pesticides	3.3	0.2	2009	5.7	0.29	2009
Carbofuran **CASRN** 1564662	Organic Pesticides Carbamate pesticides	*No data*	1.8	1989	*No data*	*No data*	*No data*
Chlordane	Organic Pesticides Organochlorine compounds	*No data*	~~0.006~~	1987	*No data*	*No data*	*No data*
Chloride	Inorganic	640,000 µg/L or 640 mg/L	120,000 µg/L or 120 mg/L	2011	NRG	NRG	2011

		Water Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
Chlorothalonil **CASRN** 1897456	Organic Pesticides	*No data*	0.18	1994	*No data*	0.36	1994
Chlorpyrifos **CASRN** 2921882	Organic Pesticides Organophosphorus compounds	0.02	0.002	2008	NRG	0.002	2008
Chromium, hexavalent (Cr(VI)) **CASRN** 7440473	Inorganic	*No data*	1	1997	*No data*	1.5	1997
Chromium, trivalent (Cr(III)) **CASRN** 7440473	Inorganic	*No data*	8.9	1997	*No data*	56	1997
Chrysene PAHs	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	*No data*	Insufficient data	1999	*No data*	Insufficient data	1999

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		Water Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
Colour **CASRN** N/A	Physical	*No data*	Narrative	1999	*No data*	Narrative	1999
Copper	Inorganic	*No data*	Equation	1987	*No data*	*No data*	*No data*
Cyanazine **CASRN** 2175462	Organic Pesticides Triazine compounds	*No data*	2	1990	*No data*	*No data*	*No data*
Cyanide	Inorganic	*No data*	5 (as free CN)	1987	*No data*	*No data*	*No data*
Debris **CASRN** N/A	Physical	*No data*	*No data*	*No data*	*No data*	Narrative	1996
Deltamethrin **CASRN** 52918635	Organic Pesticides	*No data*	0.0004	1997	*No data*	Insufficient data	1997
Deposited bedload sediment	Physical Turbidity, clarity and suspended solids Total particulate matter	*No data*	Insufficient data	1999	*No data*	Insufficient data	1999
Di(2-ethylhexyl) phthalate **CASRN** 117817	Organic Phthalate esters	*No data*	16	1993	*No data*	Insufficient data	1993

		Water Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date
Chemical name	**Chemical groups**	**Short Term**	**Long Term**		**Short Term**	**Long Term**	
Di-n-butyl phthalate **CASRN** 84742	Organic Phthalate esters	*No data*	19	1993	*No data*	Insufficient data	1993
Di-n-octyl phthalate **CASRN** 117840	Organic Phthalate esters	*No data*	Insufficient data	1993	*No data*	Insufficient data	1993
Dibromochloromethane	Organic Halogenated aliphatic compounds Halogenated methanes	*No data*	Insufficient data	1992	*No data*	Insufficient data	1992
Dicamba **CASRN** 1918009	Organic Pesticides Aromatic Carboxylic Acid	*No data*	10	1993	*No data*	*No data*	*No data*
Dichloro diphenyl trichloroethane; 2,2-Bis(p-chlorophenyl)-1,1,1-trichloroethane DDT (total)	Organic Pesticides Organochlorine compounds	*No data*	~~0.001~~	1987	*No data*	*No data*	*No data*
Dichlorobromomethane	Organic Halogenated aliphatic compounds Halogenated methanes	*No data*	Insufficient data	1992	*No data*	Insufficient data	1992

		Water Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
Dichloromethane Methylene chloride **CASRN** 75092	Organic Halogenated aliphatic compounds Halogenated methanes	*No data*	98.1	1992	*No data*	Insufficient data	1992

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		Water Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
Dichlorophenols	Organic Monocyclic aromatic compounds Chlorinated phenols	*No data*	0.2	1987	*No data*	*No data*	*No data*
Diclofop-methyl **CASRN** 51338273	Organic Pesticides	*No data*	6.1	1993	*No data*	*No data*	*No data*

		Water Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
Didecyl dimethyl ammonium chloride DDAC **CASRN** 7173515	Organic Pesticides	*No data*	1.5	1999	*No data*	Insufficient data	1999
Diethylene glycol **CASRN** 111466	Organic Glycols	*No data*	Insufficient data	1997	*No data*	Insufficient data	1997
Diisopropanolamine DIPA **CASRN** 110974	Organic	*No data*	1600	2005	*No data*	Insufficient data	2005
Dimethoate **CASRN** 60515	Organic Pesticides Organophosphorus compounds	*No data*	6.2	1993	*No data*	Insufficient data	1993
Dinoseb **CASRN** 88857	Organic Pesticides	*No data*	0.05	1992	*No data*	*No data*	*No data*
Dissolved gas supersaturation **CASRN** N/A	Physical	*No data*	Narrative	1999	*No data*	Narrative	1999
Dissolved oxygen DO **CASRN** N/A	Inorganic	*No data*	Variable	1999	*No data*	>8000 & Narrative	1996

		Water Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
Endosulfan	Organic Pesticides Organochlorine compounds	0.06	0.003	2010	0.09	0.002	2010
Endrin	Organic Pesticides Organochlorine compounds	*No data*	~~0.0023~~	1987	*No data*	No data	*No data*
Ethylbenzene **CASRN** 100414	Organic Monocyclic aromatic compounds	*No data*	90	1996	*No data*	25	1996
Ethylene glycol **CASRN** 107211	Organic Glycols	*No data*	192 000	1997	*No data*	Insufficient data	1997
Fluoranthene PAHs	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	*No data*	0.04	1999	*No data*	Insufficient data	1999

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		Water Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
Fluorene PAHs	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	*No data*	3	1999	*No data*	Insufficient data	1999
Fluoride	Inorganic	*No data*	120	2002	*No data*	NRG	2002
Glyphosate **CASRN** 1071836	Organic Pesticides Organophosphorus compounds	27,000	800	2012	NRG	NRG	2012
Heptachlor Heptachlor epoxide	Organic Pesticides Organochlorine compounds	*No data*	~~0.01~~	1987	*No data*	*No data*	*No data*
Hexachlorobenzene	Organic Monocyclic aromatic compounds Chlorinated benzenes	*No data*	Insufficient data	1997	*No data*	Insufficient data	1997
Hexachlorobutadiene HCBD **CASRN** 87683	Organic Halogenated aliphatic compounds	*No data*	1.3	1999	*No data*	*No data*	*No data*

		Water Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
Hexachlorocyclohexane Lindane	Organic Pesticides Organochlorine compounds	*No data*	0.01	1987	*No data*	*No data*	*No data*
Imidacloprid **CASRN** 13826413		*No data*	0.23	2007	*No data*	0.65	2007
Iron	Inorganic	*No data*	300	1987	*No data*	*No data*	*No data*
Lead	Inorganic	*No data*	Equation	1987	*No data*	*No data*	*No data*
Linuron **CASRN** 41205214	Organic Pesticides	*No data*	7	1995	*No data*	*No data*	1995
Mercury **CASRN** 7439976	Inorganic	*No data*	0.026	2003	*No data*	0.016	2003
Methoprene **CASRN** 40596698		*No data*	0.09 (Target Organism Management value: 0.53)	2007	*No data*	Insufficient data	2007

		Water Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
Methyl tertiary-butyl ether MTBE **CASRN** 1634044	Organic Non-halogenated aliphatic compounds Aliphatic ether	*No data*	10 000	2003	*No data*	5 000	2003

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		Water Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
Methylchlorophenoxyacetic acid (4-Chloro-2-methyl phenoxy acetic acid; 2-Methyl-4-chloro phenoxy acetic acid) MCPA **CASRN** 94746	Organic Pesticides	*No data*	2.6	1995	*No data*	4.2	1995
Methylmercury	Organic	*No data*	0.004	2003	*No data*	NRG	2003
Metolachlor **CASRN** 51218452	Organic Pesticides Organochlorine compounds	*No data*	7.8	1991	*No data*	*No data*	*No data*

		Water Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
Metribuzin **CASRN** 21087649	Organic Pesticides Triazine compounds	*No data*	1	1990	*No data*	*No data*	*No data*
Molybdenum	Inorganic	*No data*	73	1999	*No data*	*No data*	*No data*
Monobromomethane Methyl bromide	Organic Halogenated aliphatic compounds Halogenated methanes	*No data*	Insufficient data	1992	*No data*	Insufficient data	1992
Monochlorobenzene **CASRN** 108907	Organic Monocyclic aromatic compounds Chlorinated benzenes	*No data*	1.3	1997	*No data*	25	1997
Monochloromethane Methyl chloride	Organic Halogenated aliphatic compounds Halogenated methanes	*No data*	Insufficient data	1992	*No data*	Insufficient data	1992
Monochlorophenols	Organic Monocyclic aromatic compounds Chlorinated phenols	*No data*	7	1987	*No data*	*No data*	*No data*

		Water Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
Naphthalene PAHs	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	*No data*	1.1	1999	*No data*	1.4	1999
Nickel	Inorganic	*No data*	Equation	1987	*No data*	*No data*	*No data*
Nitrate **CASRN** 14797-55-8	Inorganic Inorganic nitrogen compounds	550,000 µg/L or 550 mg/L	13,000 µg/L or 13 mg/L	2012	1,500,000 µg/L or 1500 mg/L	200,000 µg/L or 200 mg/L	2012

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		Water Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
Nitrite	Inorganic Inorganic nitrogen compounds	*No data*	60 NO_2-N	1987	*No data*	*No data*	*No data*

		Water Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
Nonylphenol and its ethoxylates **CASRN** 84852153	Organic Nonylphenol and its ethoxylates	*No data*	1	2002	*No data*	0.7	2002
Nutrients		*No data*	Guidance Framework	2004	*No data*	Guidance framework	2007
Pentachlorobenzene **CASRN** 608935	Organic Monocyclic aromatic compounds Chlorinated benzenes	*No data*	6	1997	*No data*	Insufficient data	1997
Pentachlorophenol PCP	Organic Monocyclic aromatic compounds Chlorinated phenols	*No data*	0.5	1987	*No data*	*No data*	*No data*
Permethrin **CASRN** 52645531	Organic Pesticides Organochlorine compounds	*No data*	0.004	2006	*No data*	0.001	2006
Phenanthrene PAHs	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	*No data*	0.4	1999	*No data*	Insufficient data	1999

		Water Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
Phenols (mono- & dihydric) **CASRN** 108952	Organic Aromatic hydroxy compounds	*No data*	4	1999	*No data*	*No data*	*No data*
Phenoxy herbicides 2,4 D; 2,4-Dichlorophenoxyacetic acid	Organic Pesticides	*No data*	4	1987	*No data*	*No data*	*No data*
Phosphorus	Inorganic	*No data*	Guidance Framework	2004	*No data*	Guidance Framework	2007
Picloram **CASRN** 1918021	Organic Pesticides	*No data*	29	1990	*No data*	*No data*	*No data*
Polychlorinated biphenyls PCBs	Organic Polyaromatic compounds Polychlorinated biphenyls	*No data*	~~0.001~~	1987	*No data*	~~0.01~~	1991
Propylene glycol **CASRN** 57556	Organic Glycols	*No data*	500 000	1997	*No data*	Insufficient data	1997

		Water Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
Pyrene PAHs	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	*No data*	0.025	1999	*No data*	Insufficient data	1999

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		Water Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
pH	Inorganic Acidity, alkalinity and pH	*No data*	6.5 to 9.0	1987	*No data*	7.0 to 8.7 & Narrative	1996
Quinoline PAHs	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	*No data*	3.4	1999	*No data*	Insufficient data	1999

		Water Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date
Chemical name	**Chemical groups**	**Short Term**	**Long Term**		**Short Term**	**Long Term**	
Reactive Chlorine Species total residual chlorine, combined residual chlorine, total available chlorine, hypochlorous acid, chloramine, combined available chlorine, free residual chlorine, free available chlorine, chlorine-produced oxidants	Inorganic Reactive chlorine compunds	*No data*	0.5	1999	*No data*	0.5	1999
Salinity	Physical	*No data*	*No data*	*No data*	*No data*	Narrative	1996
Selenium	Inorganic	*No data*	1	1987	*No data*	*No data*	*No data*
Silver	Inorganic	*No data*	0.1	1987	*No data*	*No data*	*No data*
Simazine **CASRN** 122349	Organic Pesticides Triazine compounds	*No data*	10	1991	*No data*	No data	*No data*
		Concentration	Concentration	Date	Concentration	Concentration	Date
Chemical name	**Chemical groups**	**Short Term**	**Long Term**		**Short Term**	**Long Term**	
Sodium adsorption ratio SAR		*No data*	*No data*	*No data*	*No data*	*No data*	*No data*
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date

		Water Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
Streambed substrate	Physical Turbidity, clarity and suspended solids Total particulate matter	*No data*	Narrative	1999	*No data*	Narrative	1999
Styrene **CASRN** 100425	Organic Monocyclic aromatic compounds	*No data*	72	1999	*No data*	*No data*	*No data*
Sulfolane Bondelane **CASRN** 126330	Organic Organic sulphur compound	*No data*	50 000	2005	*No data*	Insufficient data	2005
Suspended sediments TSS	Physical Turbidity, clarity and suspended solids Total particulate matter	*No data*	Narrative	1999	*No data*	Narrative	1999
Tebuthiuron **CASRN** 34014181	Organic Pesticides	*No data*	1.6	1995	*No data*	Insufficient data	1995

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		Water Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
Temperature	Physical Temperature	*No data*	Narrative	1987	*No data*	Narrative	1996
Tetrachloromethane Carbon tetrachloride **CASRN** 56235	Organic Halogenated aliphatic compounds Halogenated methanes	*No data*	13.3	1992	*No data*	Insufficient data	1992
Tetrachlorophenols	Organic Monocyclic aromatic compounds Chlorinated phenols	*No data*	1	1987	*No data*	*No data*	*No data*
Thallium	Inorganic	*No data*	0.8	1999	*No data*	*No data*	*No data*
Toluene **CASRN** 108883	Organic Monocyclic aromatic compounds	*No data*	2	1996	*No data*	215	1996
Toxaphene	Organic Pesticides Organochlorine compounds	*No data*	~~0.008~~	1987	*No data*	*No data*	*No data*
Triallate **CASRN** 2303175	Organic Pesticides Carbamate pesticides	*No data*	0.24	1992	*No data*	*No data*	*No data*

		Water Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
Tribromomethane Bromoform	Organic Halogenated aliphatic compounds Halogenated methanes	*No data*	Insufficient data	1992	*No data*	Insufficient data	1992
Tributyltin	Organic Organotin compounds	*No data*	0.008	1992	*No data*	0.001	1992
Trichlorfon **CASRN** 52-68-6		1.1	0.009	2012	NRG	NRG	2012
Trichloromethane Chloroform **CASRN** 67663	Organic Halogenated aliphatic compounds Halogenated methanes	*No data*	1.8	1992	*No data*	Insufficient data	1992
Trichlorophenols	Organic Monocyclic aromatic compounds Chlorinated phenols	*No data*	18	1987	*No data*	*No data*	*No data*
Tricyclohexyltin	Organic Organotin compounds	*No data*	Insufficient data	1992	*No data*	Insufficient data	1992

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		Water Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
Trifluralin **CASRN** 1582098	Organic Pesticides Dinitroaniline pesticides	*No data*	0.2	1993	*No data*	*No data*	*No data*
Triphenyltin	Organic Organotin compounds	*No data*	0.022	1992	*No data*	*No data*	1992
Turbidity	Physical Turbidity, clarity and suspended solids Total particulate matter	*No data*	Narrative	1999	*No data*	Narrative	1999
Uranium **CASRN** 7440-61-1	Inorganic	33	15	2011	NRG	NRG	2011
Zinc	Inorganic	*No data*	30	1987	*No data*	*No data*	*No data*

		Water Quality Guidelines for the Protection of Agriculture			
		Irrigation		Livestock	
		Concentration (µg/L)	Date	Concentration (µg/L)	Date
Chemical name	Chemical groups				
1,1,1-Trichloroethane **CASRN** 71556	Organic Halogenated aliphatic compounds Chlorinated ethanes	Insufficient data	1991	Insufficient data	1991
1,1,2,2- Tetrachloroethene PCE (Tetrachloroethylene) **CASRN** 127184	Organic Halogenated aliphatic compounds Chlorinated ethenes	Insufficient data	1993	Insufficient data	1993
1,1,2,2-Tetrachlorethane **CASRN** 79345	Organic Halogenated aliphatic compounds Chlorinated ethanes	Insufficient data	1991	Insufficient data	1991
1,1,2-Trichloroethene TCE (Trichloroethylene) **CASRN** 79-01-6	Organic Halogenated aliphatic compounds Chlorinated ethenes	Insufficient data	1991	50	1991

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		Water Quality Guidelines for the Protection of Agriculture			
		Irrigation		Livestock	
		Concentration (µg/L)	Date	Concentration (µg/L)	Date
Chemical name	Chemical groups				

		Water Quality Guidelines for the Protection of Agriculture			
		Irrigation		Livestock	
		Concentration (µg/L)	Date	Concentration (µg/L)	Date
Chemical name	Chemical groups				
1,2,3,4-Tetrachlorobenzene **CASRN** 634662	Organic Monocyclic aromatic compounds Chlorinated benzenes	Insufficient data	1997	Insufficient data	1997
1,2,3,5-Tetrachlorobenzene	Organic Monocyclic aromatic compounds Chlorinated benzenes	Insufficient data	1997	Insufficient data	1997
1,2,3-Trichlorobenzene **CASRN** 87616	Organic Monocyclic aromatic compounds Chlorinated benzenes	Insufficient data	1997	Insufficient data	1997
1,2,4,5-Tetrachlorobenzene	Organic Monocyclic aromatic compounds Chlorinated benzenes	Insufficient data	1997	Insufficient data	1997
1,2,4-Trichlorobenzene **CASRN** 120801	Organic Monocyclic aromatic compounds Chlorinated benzenes	Insufficient data	1997	Insufficient data	1997
1,2-Dichlorobenzene **CASRN** 95501	Organic Monocyclic aromatic compounds Chlorinated benzenes	Insufficient data	1997	Insufficient data	1997
1,2-Dichloroethane **CASRN** 1070602	Organic Halogenated aliphatic compounds Chlorinated ethanes	Insufficient data	1991	5	1991

		Water Quality Guidelines for the Protection of Agriculture			
		Irrigation		Livestock	
		Concentration (µg/L)	Date	Concentration (µg/L)	Date
Chemical name	Chemical groups				
1,3,5-Trichlorobenzene	Organic Monocyclic aromatic compounds Chlorinated benzenes	Insufficient data	1997	Insufficient data	1997
1,3-Dichlorobenzene **CASRN** 541731	Organic Monocyclic aromatic compounds Chlorinated benzenes	Insufficient data	1997	Insufficient data	1997
1,4-Dichlorobenzene **CASRN** 106467	Organic Monocyclic aromatic compounds Chlorinated benzenes	Insufficient data	1997	Insufficient data	1997
Aldicarb **CASRN** 116063	Organic Pesticides Carbamate pesticides	54.9	1993	11	1993
Aluminium	Inorganic	5000	1987	5000	1987
Aniline **CASRN** 62533	Organic	Insufficient data	1993	Insufficient data	1993
Arsenic **CASRN** none	Inorganic	100	1997	25	1997

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		Water Quality Guidelines for the Protection of Agriculture			
		Irrigation		Livestock	
		Concentration (µg/L)	Date	Concentration (µg/L)	Date
Chemical name	Chemical groups				
Atrazine **CASRN** 1912249	Organic Pesticides Triazine compounds	10	1989	5	1989
Beryllium	Inorganic	100	1987	100	1987
Boron	Inorganic	Variable	1987	5000	1987
Bromacil **CASRN** 314409	Organic Pesticides	0.2	1997	1100	1997
Bromoxynil	Organic Pesticides Benzonitrile compounds	0.33	1993	11	1993
Cadmium **CASRN** 7440439	Inorganic	5.1	1996	80	1996
Calcium	Inorganic	*No data*	*No data*	1 000 000	1987
Captan **CASRN** 133062	Organic Pesticides	Insufficient data	1991	13	1991
Carbaryl **CASRN** 63252	Organic Pesticides Carbamate pesticides	Insufficient data	1997	1100	1997

		Water Quality Guidelines for the Protection of Agriculture			
		Irrigation		Livestock	
		Concentration (µg/L)	Date	Concentration (µg/L)	Date
Chemical name	Chemical groups				
Carbofuran **CASRN** 1564662	Organic Pesticides Carbamate pesticides	Insufficient data	1989	45	1989
Chlordane	Organic Pesticides Organochlorine compounds	*No data*	*No data*	~~7~~	1987
Chloride	Inorganic	Variable	1987	*No data*	*No data*
Chlorothalonil **CASRN** 1897456	Organic Pesticides	5.8 (other crops)	1994	170	1994
Chlorpyrifos **CASRN** 2921882	Organic Pesticides Organophosphorus compounds	Insufficient data	1997	24	1997
Chromium, hexavalent (Cr(VI)) **CASRN** 7440473	Inorganic	8	1997	50	1997
Chromium, trivalent (Cr(III)) **CASRN** 7440473	Inorganic	4.9	1997	50	1997
Cobalt	Inorganic	50	1987	1000	1987
Coliforms, fecal (Escherichia coli) E. coli	Biological	100 per 100 mL	1987	*No data*	*No data*

		Water Quality Guidelines for the Protection of Agriculture			
		Irrigation		Livestock	
		Concentration (µg/L)	Date	Concentration (µg/L)	Date
Chemical name	Chemical groups				

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		Water Quality Guidelines for the Protection of Agriculture			
		Irrigation		Livestock	
		Concentration (µg/L)	Date	Concentration (µg/L)	Date
Chemical name	Chemical groups				
Coliforms, total Coliforms	Biological	1000 per 100 mL	1987	*No data*	*No data*
Colour **CASRN** N/A	Physical	*No data*	*No data*	Narrative	1999
Copper	Inorganic	Variable	1987	Variable	1987
Cyanazine **CASRN** 2175462	Organic Pesticides Triazine compounds	0.5	1990	10	1990
Cyanobacteria Blue-green algae	Biological	*No data*	*No data*	Narrative	1999

		Water Quality Guidelines for the Protection of Agriculture			
		Irrigation		Livestock	
		Concentration (µg/L)	Date	Concentration (µg/L)	Date
Chemical name	Chemical groups				
Deltamethrin **CASRN** 52918635	Organic Pesticides	Insufficient data	1997	2.5	1997
Dibromochloromethane	Organic Halogenated aliphatic compounds Halogenated methanes	Insufficient data	1992	100	1992
Dicamba **CASRN** 1918009	Organic Pesticides Aromatic Carboxylic Acid	0.006	1993	122	1993
Dichloro diphenyl trichloroethane; 2,2-Bis(p-chlorophenyl)-1,1,1-trichloroethane DDT (total)	Organic Pesticides Organochlorine compounds	*No data*	*No data*	~~30~~	1987
Dichlorobromomethane	Organic Halogenated aliphatic compounds Halogenated methanes	Insufficient data	1992	100	1992
Dichloromethane Methylene chloride **CASRN** 75092	Organic Halogenated aliphatic compounds Halogenated methanes	Insufficient data	1992	50	1992
Diclofop-methyl **CASRN** 51338273	Organic Pesticides	0.18	1993	9	1993

Chemical name	Chemical groups	Water Quality Guidelines for the Protection of Agriculture — Irrigation: Concentration (µg/L)	Irrigation: Date	Livestock: Concentration (µg/L)	Livestock: Date
Diethylene glycol **CASRN** 111466	Organic Glycols	Insufficient data	1997	Insufficient data	1997
Diisopropanolamine DIPA **CASRN** 110974	Organic	2 000	2006	Insufficient data	2006
Dimethoate **CASRN** 60515	Organic Pesticides Organophosphorus compounds	Insufficient data	1993	3	1993

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Chemical name	Chemical groups	Water Quality Guidelines for the Protection of Agriculture — Irrigation: Concentration (µg/L)	Irrigation: Date	Livestock: Concentration (µg/L)	Livestock: Date
Dinoseb **CASRN** 88857	Organic Pesticides	16	1992	150	1992

		Water Quality Guidelines for the Protection of Agriculture			
		Irrigation		Livestock	
		Concentration (µg/L)	Date	Concentration (µg/L)	Date
Chemical name	Chemical groups				
Endrin	Organic Pesticides Organochlorine compounds	*No data*	*No data*	~~0.2~~	1987
Ethylbenzene **CASRN** 100414	Organic Monocyclic aromatic compounds	Insufficient data	1996	2.4	1996
Ethylene glycol **CASRN** 107211	Organic Glycols	Insufficient data	1997	Insufficient data	1997
Fluoride	Inorganic	1000	1987	Variable	1987
Glyphosate **CASRN** 1071836	Organic Pesticides Organophosphorus compounds	*No data*	*No data*	280	1989
Heptachlor Heptachlor epoxide	Organic Pesticides Organochlorine compounds	*No data*	*No data*	~~3~~	1987
Hexachlorobenzene	Organic Monocyclic aromatic compounds Chlorinated benzenes	Insufficient data	1997	0.52	1991
Hexachlorocyclohexane Lindane	Organic Pesticides Organochlorine compounds	No data	*No data*	4	1987

		Water Quality Guidelines for the Protection of Agriculture			
		Irrigation		Livestock	
		Concentration (µg/L)	Date	Concentration (µg/L)	Date
Chemical name	Chemical groups				
Iron	Inorganic	5000	1987	*No data*	*No data*
Lead	Inorganic	200	1987	100	1987
Linuron **CASRN** 41205214	Organic Pesticides	0.071	1995	Insufficient data	1995
Lithium	Inorganic	2500	1987	*No data*	*No data*
Manganese	Inorganic	200	1987	*No data*	*No data*
Mercury **CASRN** 7439976	Inorganic	*No data*	*No data*	3	1987
Methylchlorophenoxyacetic acid (4-Chloro-2-methyl phenoxy acetic acid; 2-Methyl-4-chloro phenoxy acetic acid) MCPA **CASRN** 94746	Organic Pesticides	0.025	1995	25	1995
Metolachlor **CASRN** 51218452	Organic Pesticides Organochlorine compounds	28	1991	50	1991

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		Water Quality Guidelines for the Protection of Agriculture			
		Irrigation		Livestock	
		Concentration (µg/L)	Date	Concentration (µg/L)	Date
Chemical name	Chemical groups				
Metribuzin **CASRN** 21087649	Organic Pesticides Triazine compounds	0.5	1990	80	1990
Molybdenum	Inorganic	Narrative	1987	500	1987
Monobromomethane Methyl bromide	Organic Halogenated aliphatic compounds Halogenated methanes	Insufficient data	1992	Insufficient data	1992
Monochlorobenzene **CASRN** 108907	Organic Monocyclic aromatic compounds Chlorinated benzenes	Insufficient data	1997	Insufficient data	1997
Monochloromethane Methyl chloride	Organic Halogenated aliphatic compounds Halogenated methanes	Insufficient data	1992	Insufficient data	1992
Nickel	Inorganic	200	1987	1000	1987
Nitrate + Nitrite	Inorganic Inorganic nitrogen compounds	*No data*	*No data*	100 000 NO_3+NO_2-N	1987
Nitrite	Inorganic Inorganic nitrogen compounds	*No data*	*No data*	10 000 NO_2-N	1987
Pentachlorobenzene **CASRN** 608935	Organic Monocyclic aromatic compounds Chlorinated benzenes	Insufficient data	1997	Insufficient data	1997

		Water Quality Guidelines for the Protection of Agriculture			
		Irrigation		Livestock	
		Concentration (µg/L)	Date	Concentration (µg/L)	Date
Chemical name	Chemical groups				
Phenols (mono- & dihydric) **CASRN** 108952	Organic Aromatic hydroxy compounds	*No data*	*No data*	2	1987
Phenoxy herbicides 2,4 D; 2,4-Dichlorophenoxyacetic acid	Organic Pesticides	*No data*	*No data*	100	1987
Picloram **CASRN** 1918021	Organic Pesticides	Insufficient data	1990	190	1990
Propylene glycol **CASRN** 57556	Organic Glycols	Insufficient data	1997	Insufficient data	1997
Selenium	Inorganic	Variable	1987	50	1987
Simazine **CASRN** 122349	Organic Pesticides Triazine compounds	0.5	1991	10	1991
		Concentration	Date	Concentration	Date
Chemical name	Chemical groups				
Sodium adsorption ratio SAR		*No data*	*No data*	*No data*	*No data*

		Water Quality Guidelines for the Protection of Agriculture			
		Irrigation		Livestock	
		Concentration (µg/L)	Date	Concentration (µg/L)	Date
Chemical name	Chemical groups				
		Concentration (µg/L)	Date	Concentration (µg/L)	Date
Chemical name	Chemical groups				
Sulfolane Bondelane **CASRN** 126330	Organic Organic sulphur compound	500	2005	Insufficient data	2005

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		Water Quality Guidelines for the Protection of Agriculture			
		Irrigation		Livestock	
		Concentration (µg/L)	Date	Concentration (µg/L)	Date
Chemical name	Chemical groups				
Sulphate	Inorganic Inorganic sulphur compounds	*No data*	*No data*	1 000 000	1987
Tebuthiuron **CASRN** 34014181	Organic Pesticides	0.27 (cereals, tame hays, and pastures)	1995	130	1995

		Water Quality Guidelines for the Protection of Agriculture			
		Irrigation		Livestock	
		Concentration (µg/L)	Date	Concentration (µg/L)	Date
Chemical name	Chemical groups				
Tetrachloromethane Carbon tetrachloride **CASRN** 56235	Organic Halogenated aliphatic compounds Halogenated methanes	Insufficient data	1992	5	1992
Toluene **CASRN** 108883	Organic Monocyclic aromatic compounds	Insufficient data	1996	24	1996
Total dissolved solids (salinity) TDS	Physical Turbidity, clarity and suspended solids	Variable	1987	3 000 000	1987
Toxaphene	Organic Pesticides Organochlorine compounds	*No data*	*No data*	~~5~~	1987
Triallate **CASRN** 2303175	Organic Pesticides Carbamate pesticides	Insufficient data	1992	230	1992
Tribromomethane Bromoform	Organic Halogenated aliphatic compounds Halogenated methanes	Insufficient data	1992	100	1992
Tributyltin	Organic Organotin compounds	Insufficient data	1992	250	1992

		Water Quality Guidelines for the Protection of Agriculture			
		Irrigation		Livestock	
		Concentration (µg/L)	Date	Concentration (µg/L)	Date
Chemical name	Chemical groups				
Trichloromethane Chloroform **CASRN** 67663	Organic Halogenated aliphatic compounds Halogenated methanes	Insufficient data	1992	100	1992
Tricyclohexyltin	Organic Organotin compounds	Insufficient data	1992	250	1992
Trifluralin **CASRN** 1582098	Organic Pesticides Dinitroaniline pesticides	Insufficient data	1992	45	1992
Triphenyltin	Organic Organotin compounds	Insufficient data	1992	820	1992
Uranium **CASRN** 7440-61-1	Inorganic	10	1987	200	1987
Vanadium	Inorganic	100	1987	100	1987

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		Water Quality Guidelines for the Protection of Agriculture			
		Irrigation		Livestock	
		Concentration (µg/L)	Date	Concentration (µg/L)	Date
Chemical name	Chemical groups				
Zinc	Inorganic	Equation	1987	50 000	1987

		Sediment Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/kg dry weight)	Concentration (µg/kg dry weight)	Date	Concentration (µg/kg dry weight)	Concentration (µg/kg dry weight)	Date
Chemical name	Chemical groups	ISQG	PEL		ISQG	PEL	
2-Methylnaphthalene PAHs	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	20.2	201	1998	20.2	201	1998
Acenaphthene PAHs	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	6.71	88.9	1998	6.71	88.9	1998

		Sediment Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/kg dry weight)	Concentration (µg/kg dry weight)	Date	Concentration (µg/kg dry weight)	Concentration (µg/kg dry weight)	Date
Chemical name	Chemical groups	ISQG	PEL		ISQG	PEL	
Acenaphthylene PAHs	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	5.87	128	1998	5.87	128	1998
Anthracene PAHs	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	46.9	245	1998	46.9	245	1998
Aroclor 1254 PCBs	Organic Polyaromatic compounds Polychlorinated biphenyls	60	340	2001	63.3	709	2001
Arsenic **CASRN** none	Inorganic	5900	17 000	1998	7240	41 600	1998
Benz(a)anthracene PAHs	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	31.7	385	1998	74.8	693	1998

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		Sediment Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/kg dry weight)	Concentration (µg/kg dry weight)	Date	Concentration (µg/kg dry weight)	Concentration (µg/kg dry weight)	Date
Chemical name	Chemical groups	ISQG	PEL		ISQG	PEL	
Benzo(a)pyrene PAHs	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	31.9	782	1998	88.8	763	1998
Cadmium **CASRN** 7440439	Inorganic	600	3500	1997	700	4200	1997
Chlordane	Organic Pesticides Organochlorine compounds	4.5	8.87	1998	2.26	4.79	1998
Chromium (total) **CASRN** 7440-47-3	Inorganic	37 300	90 000	1998	52 300	160 000	1998
Chrysene PAHs	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	57.1	862	1998	108	846	1998
Copper	Inorganic	35 700	197 000	1998	18 700	108 000	1998

		Sediment Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/kg dry weight)	Concentration (µg/kg dry weight)	Date	Concentration (µg/kg dry weight)	Concentration (µg/kg dry weight)	Date
Chemical name	Chemical groups	ISQG	PEL		ISQG	PEL	
Dibenz(a,h)anthracene PAHs	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	6.22	135	1998	6.22	135	1998
Dichloro diphenyl dichloroethane, 2,2-Bis (p-chlorophenyl)-1,1-dichloroethane DDD	Organic Pesticides Organochlorine compounds	3.54	8.51	1998	1.22	7.81	1998
Dichloro diphenyl ethylene, 1,1-Dichloro-2,2-bis(p-chlorophenyl)-ethene DDE	Organic Pesticides Organochlorine compounds	1.42	6.75	1998	2.07	374	1998
Dichloro diphenyl trichloroethane; 2,2-Bis(p-chlorophenyl)-1,1,1-trichloroethane DDT (total)	Organic Pesticides Organochlorine compounds	1.19	4.77	1998	1.19	4.77	1998
Dieldrin	Organic Pesticides Organochlorine compounds	2.85	6.67	1998	0.71	4.3	1998

		Sediment Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/kg dry weight)	Concentration (µg/kg dry weight)	Date	Concentration (µg/kg dry weight)	Concentration (µg/kg dry weight)	Date
Chemical name	Chemical groups	ISQG	PEL		ISQG	PEL	
Endrin	Organic Pesticides Organochlorine compounds	2.67	62.4	1998	2.67	62.4	1998

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		Sediment Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/kg dry weight)	Concentration (µg/kg dry weight)	Date	Concentration (µg/kg dry weight)	Concentration (µg/kg dry weight)	Date
Chemical name	Chemical groups	ISQG	PEL		ISQG	PEL	
Fluoranthene PAHs	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	111	2355	1998	113	1494	1998
Fluorene PAHs	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	21.2	144	1998	21.2	144	1998

		Sediment Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/kg dry weight)	Concentration (µg/kg dry weight)	Date	Concentration (µg/kg dry weight)	Concentration (µg/kg dry weight)	Date
Chemical name	Chemical groups	ISQG	PEL		ISQG	PEL	
Heptachlor Heptachlor epoxide	Organic Pesticides Organochlorine compounds	0.6	2.74	1998	0.6	2.74	1998
Hexachlorocyclohexane Lindane	Organic Pesticides Organochlorine compounds	0.94	1.38	1998	0.32	0.99	1998
Lead	Inorganic	35 000	91 300	1998	30 200	112 000	1998
Mercury **CASRN** 7439976	Inorganic	170	486	1997	130	700	1997
Naphthalene PAHs	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	34.6	391	1998	34.6	391	1998

		Sediment Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/kg dry weight)	Concentration (µg/kg dry weight)	Date	Concentration (µg/kg dry weight)	Concentration (µg/kg dry weight)	Date
Chemical name	Chemical groups	ISQG	PEL		ISQG	PEL	
Nonylphenol and its ethoxylates **CASRN** 84852153	Organic Nonylphenol and its ethoxylates	1400	*No data*	2002	1000	*No data*	2002
Phenanthrene PAHs	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	41.9	515	1998	86.7	544	1998
Polychlorinated biphenyls PCBs	Organic Polyaromatic compounds Polychlorinated biphenyls	34.1	277	2001	21.5	189	2001
Polychlorinated dibenzo-p-dioxins/dibenzo furans PCDDs, PCDFs	Organic Polyaromatic compounds Polychlorinated dioxins and furans	0.85 ng TEQ/kg dry weight	21.5 ng TEQ/kg dry weight	2001	0.85 ng TEQ/kg dry weight	21.5 ng TEQ/kg dry weight	2001
Pyrene PAHs	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	53	875	1998	153	1398	1998

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		Sediment Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/kg dry weight)	Concentration (µg/kg dry weight)	Date	Concentration (µg/kg dry weight)	Concentration (µg/kg dry weight)	Date
Chemical name	Chemical groups	ISQG	PEL		ISQG	PEL	
		Concentration	Concentration	Date	Concentration	Concentration	Date
Chemical name	Chemical groups	ISQG	PEL		ISQG	PEL	
Sodium adsorption ratio SAR		*No data*	*No data*	*No data*	*No data*	*No data*	*No data*
		Concentration (µg/kg dry weight)	Concentration (µg/kg dry weight)	Date	Concentration (µg/kg dry weight)	Concentration (µg/kg dry weight)	Date
Chemical name	Chemical groups	ISQG	PEL		ISQG	PEL	
Toxaphene	Organic Pesticides Organochlorine compounds	0.1	No PEL derived	2002	0.1	No PEL derived	2002
Zinc	Inorganic	123 000	315 000	1998	124 000	271 000	1998

		Soil Quality Guidelines for the Protection of Environmental and Human Health				
		Concentration (mg/kg dry weight)	Concentration (mg/kg dry weight)	Concentration (mg/kg dry weight)	Concentration (mg/kg dry weight)	Date
Chemical name	Chemical groups	Agricultural	Residential/ parkland	Commercial	Industrial	
1,1,1-Trichloroethane **CASRN** 71556	Organic Halogenated aliphatic compounds Chlorinated ethanes	0.1	5	50	50	1991
1,1,2,2- Tetrachloroethene PCE (Tetrachloroethylene) **CASRN** 127184	Organic Halogenated aliphatic compounds Chlorinated ethenes	0.1	0.2	0.5	0.6	1997
1,1,2,2-Tetrachlorethane **CASRN** 79345	Organic Halogenated aliphatic compounds Chlorinated ethanes	0.1	5	50	50	1991
1,1,2-Trichloroethane	Organic Halogenated aliphatic compounds Halogenated methanes	0.1	5	50	50	1991
1,1,2-Trichloroethene TCE (Trichloroethylene) **CASRN** 79-01-6	Organic Halogenated aliphatic compounds Chlorinated ethenes	0.01	0.01	0.01	0.01	2006

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		Soil Quality Guidelines for the Protection of Environmental and Human Health				
		Concentration (mg/kg dry weight)	Concentration (mg/kg dry weight)	Concentration (mg/kg dry weight)	Concentration (mg/kg dry weight)	Date
Chemical name	Chemical groups	Agricultural	Residential/ parkland	Commercial	Industrial	
1,1-Dichloroethane	Organic Halogenated aliphatic compounds Chlorinated ethanes	0.1	5	50	50	1991
1,1-Dichloroethene Dichloroethylene	Organic Halogenated aliphatic compounds Chlorinated ethenes	0.1	5	50	50	1991
1,2,3,4-Tetrachlorobenzene **CASRN** 634662	Organic Monocyclic aromatic compounds Chlorinated benzenes	0.05	2	10	10	1991
1,2,3,5-Tetrachlorobenzene	Organic Monocyclic aromatic compounds Chlorinated benzenes	0.05	2	10	10	1991
1,2,3-Trichlorobenzene **CASRN** 87616	Organic Monocyclic aromatic compounds Chlorinated benzenes	0.05	2	10	10	1991

		Soil Quality Guidelines for the Protection of Environmental and Human Health				
		Concentration (mg/kg dry weight)	Concentration (mg/kg dry weight)	Concentration (mg/kg dry weight)	Concentration (mg/kg dry weight)	Date
Chemical name	Chemical groups	Agricultural	Residential/ parkland	Commercial	Industrial	
1,2,4,5-Tetrachlorobenzene	Organic Monocyclic aromatic compounds Chlorinated benzenes	0.05	2	10	10	1991
1,2,4-Trichlorobenzene **CASRN** 120801	Organic Monocyclic aromatic compounds Chlorinated benzenes	0.05	2	10	10	1991
1,2-Dichlorobenzene **CASRN** 95501	Organic Monocyclic aromatic compounds Chlorinated benzenes	0.1	1	10	10	1991
1,2-Dichloroethane **CASRN** 1070602	Organic Halogenated aliphatic compounds Chlorinated ethanes	0.1	5	50	50	1991
1,2-Dichloroethene	Organic Halogenated aliphatic compounds Chlorinated ethenes	0.1	5	50	50	1991

		Soil Quality Guidelines for the Protection of Environmental and Human Health				
		Concentration (mg/kg dry weight)	Concentration (mg/kg dry weight)	Concentration (mg/kg dry weight)	Concentration (mg/kg dry weight)	Date
Chemical name	Chemical groups	Agricultural	Residential/ parkland	Commercial	Industrial	
1,2-Dichloropropane	Organic Halogenated aliphatic compounds Halogenated methanes	0.1	5	50	50	1991

Users are advised to consult the Canadian Environmental Quality Guidelines introductory text, factsheet, and/or protocols for specific information and implementation guidance pertaining to each environmental quality guideline.

		Soil Quality Guidelines for the Protection of Environmental and Human Health				
		Concentration (mg/kg dry weight)	Concentration (mg/kg dry weight)	Concentration (mg/kg dry weight)	Concentration (mg/kg dry weight)	Date
Chemical name	Chemical groups	Agricultural	Residential/ parkland	Commercial	Industrial	
1,2-Dichloropropene (cis and trans)	Organic Halogenated aliphatic compounds Halogenated methanes	0.1	5	50	50	1991
1,3,5-Trichlorobenzene	Organic Monocyclic aromatic compounds Chlorinated benzenes	0.05	2	10	10	1991

		Soil Quality Guidelines for the Protection of Environmental and Human Health				
		Concentration (mg/kg dry weight)	Concentration (mg/kg dry weight)	Concentration (mg/kg dry weight)	Concentration (mg/kg dry weight)	Date
Chemical name	Chemical groups	Agricultural	Residential/ parkland	Commercial	Industrial	
1,3-Dichlorobenzene **CASRN** 541731	Organic Monocyclic aromatic compounds Chlorinated benzenes	0.1	1	10	10	1991
1,4-Dichlorobenzene **CASRN** 106467	Organic Monocyclic aromatic compounds Chlorinated benzenes	0.1	1	10	10	1991
2,3,4,6-Tetrachlorophenol	Organic Monocyclic aromatic compounds Chlorinated phenols	0.05	0.5	5	5	1991
2,4,6-Trichlorophenol	Organic Monocyclic aromatic compounds Chlorinated phenols	0.05	0.5	5	5	1991
2,4-Dichlorophenol	Organic Monocyclic aromatic compounds Chlorinated phenols	0.05	0.5	5	5	1991

		Soil Quality Guidelines for the Protection of Environmental and Human Health				
		Concentration (mg/kg dry weight)	Concentration (mg/kg dry weight)	Concentration (mg/kg dry weight)	Concentration (mg/kg dry weight)	Date
Chemical name	Chemical groups	Agricultural	Residential/ parkland	Commercial	Industrial	
Acenaphthene PAHs	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	Consult Factsheet	Consult Factsheet	Consult Factsheet	Consult Factsheet	2008
Acenaphthylene PAHs	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	Consult Factsheet	Consult Factsheet	Consult Factsheet	Consult Factsheet	2008
Aliphatics nonchlorinated (each)	Organic Non-halogenated aliphatic compounds	0.3	*No data*	*No data*	*No data*	1991
Anthracene PAHs	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	Consult Factsheet	Consult Factsheet	Consult Factsheet	Consult Factsheet	2008

Users are advised to consult the Canadian Environmental Quality Guidelines introductory text, factsheet, and/or protocols for specific information and implementation guidance pertaining to each environmental quality guideline.

		Soil Quality Guidelines for the Protection of Environmental and Human Health				
		Concentration (mg/kg dry weight)	Concentration (mg/kg dry weight)	Concentration (mg/kg dry weight)	Concentration (mg/kg dry weight)	Date
Chemical name	Chemical groups	Agricultural	Residential/ parkland	Commercial	Industrial	
Antimony	Inorganic	20	20	40	40	1991
Arsenic **CASRN** none	Inorganic	12	12	12	12	1997
Barium	Inorganic	750	500	2000	2000	2013
Benz(a)anthracene PAHs	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	Consult Factsheet	Consult Factsheet	Consult Factsheet	Consult Factsheet	2008
Benzene **CASRN** 71432	Organic Monocyclic aromatic compounds	Table	Table	Table	Table	2004
Benzo(a)pyrene PAHs	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	Consult Factsheet	Consult Factsheet	Consult Factsheet	Consult Factsheet	2008
Benzo(b)fluoranthene PAHs	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	Consult Factsheet	Consult Factsheet	Consult Factsheet	Consult Factsheet	2008

		Soil Quality Guidelines for the Protection of Environmental and Human Health				
		Concentration (mg/kg dry weight)	Concentration (mg/kg dry weight)	Concentration (mg/kg dry weight)	Concentration (mg/kg dry weight)	Date
Chemical name	**Chemical groups**	**Agricultural**	**Residential/ parkland**	**Commercial**	**Industrial**	
Benzo(k)fluoranthene PAHs	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	Consult Factsheet	Consult Factsheet	Consult Factsheet	Consult Factsheet	2008
Beryllium	Inorganic	4	4	8	8	1991
Boron	Inorganic	2	*No data*	*No data*	*No data*	1991
Cadmium **CASRN** 7440439	Inorganic	1.4	10	22	22	1999
Chromium (total) **CASRN** 7440-47-3	Inorganic	64	64	87	87	1997
Chromium, hexavalent (Cr(VI)) **CASRN** 7440473	Inorganic	0.4	0.4	1.4	1.4	1999
Chrysene PAHs	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	Consult Factsheet	Consult Factsheet	Consult Factsheet	Consult Factsheet	2008
Cobalt	Inorganic	40	50	300	300	1991
Conductivity	Physical	2 dS/m	2 dS/m	4 dS/m	4 dS/m	1991

		Soil Quality Guidelines for the Protection of Environmental and Human Health				
		Concentration (mg/kg dry weight)	Concentration (mg/kg dry weight)	Concentration (mg/kg dry weight)	Concentration (mg/kg dry weight)	Date
Chemical name	Chemical groups	Agricultural	Residential/ parkland	Commercial	Industrial	
Copper	Inorganic	63	63	91	91	1999

Users are advised to consult the Canadian Environmental Quality Guidelines introductory text, factsheet, and/or protocols for specific information and implementation guidance pertaining to each environmental quality guideline.

		Soil Quality Guidelines for the Protection of Environmental and Human Health				
		Concentration (mg/kg dry weight)	Concentration (mg/kg dry weight)	Concentration (mg/kg dry weight)	Concentration (mg/kg dry weight)	Date
Chemical name	Chemical groups	Agricultural	Residential/ parkland	Commercial	Industrial	
Cyanide	Inorganic	0.9	0.9	8	8	1997
Dibenz(a,h)anthracene PAHs	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	Consult Factsheet	Consult Factsheet	Consult Factsheet	Consult Factsheet	2008
Dichloro diphenyl trichloroethane; 2,2-Bis(p-chlorophenyl)-1,1,1-trichloroethane DDT (total)	Organic Pesticides Organochlorine compounds	0.7	0.7	12	12	1999

		Soil Quality Guidelines for the Protection of Environmental and Human Health				
		Concentration (mg/kg dry weight)	Concentration (mg/kg dry weight)	Concentration (mg/kg dry weight)	Concentration (mg/kg dry weight)	Date
Chemical name	Chemical groups	Agricultural	Residential/ parkland	Commercial	Industrial	
Dichloromethane Methylene chloride **CASRN** 75092	Organic Halogenated aliphatic compounds Halogenated methanes	0.1	5	50	50	1991
Dichlorophenols	Organic Monocyclic aromatic compounds Chlorinated phenols	0.05	0.5	5	5	1991
Diisopropanolamine DIPA **CASRN** 110974	Organic	180	180	180	180	2006
Ethylbenzene **CASRN** 100414	Organic Monocyclic aromatic compounds	Table	Table	Table	Table	2004
Ethylene glycol **CASRN** 107211	Organic Glycols	960	960	960	960	1999
Fluoranthene PAHs	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	Consult Factsheet	Consult Factsheet	Consult Factsheet	Consult Factsheet	2008

		Soil Quality Guidelines for the Protection of Environmental and Human Health				
		Concentration (mg/kg dry weight)	Concentration (mg/kg dry weight)	Concentration (mg/kg dry weight)	Concentration (mg/kg dry weight)	Date
Chemical name	Chemical groups	Agricultural	Residential/ parkland	Commercial	Industrial	
Fluorene PAHs	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	Consult Factsheet	Consult Factsheet	Consult Factsheet	Consult Factsheet	2008
Fluoride	Inorganic	200	400	2000	2000	1991
Hexachlorobenzene	Organic Monocyclic aromatic compounds Chlorinated benzenes	0.05	2	10	10	1991
Hexachlorocyclohexane Lindane	Organic Pesticides Organochlorine compounds	0.01	*No data*	*No data*	*No data*	1991

Users are advised to consult the Canadian Environmental Quality Guidelines introductory text, factsheet, and/or protocols for specific information and implementation guidance pertaining to each environmental quality guideline.

		Soil Quality Guidelines for the Protection of Environmental and Human Health				
		Concentration (mg/kg dry weight)	Concentration (mg/kg dry weight)	Concentration (mg/kg dry weight)	Concentration (mg/kg dry weight)	Date
Chemical name	Chemical groups	Agricultural	Residential/ parkland	Commercial	Industrial	

		Soil Quality Guidelines for the Protection of Environmental and Human Health				
		Concentration (mg/kg dry weight)	Concentration (mg/kg dry weight)	Concentration (mg/kg dry weight)	Concentration (mg/kg dry weight)	Date
Chemical name	Chemical groups	Agricultural	Residential/ parkland	Commercial	Industrial	
Indeno(1,2,3-c,d)pyrene PAHs	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	Consult Factsheet	Consult Factsheet	Consult Factsheet	Consult Factsheet	2008
Lead	Inorganic	70	140	260	600	1999
Mercury **CASRN** 7439976	Inorganic	6.6	6.6	24	50	1999
Molybdenum	Inorganic	5	10	40	40	1991
Monochlorobenzene **CASRN** 108907	Organic Monocyclic aromatic compounds Chlorinated benzenes	0.1	1	10	10	1991
Monochlorophenols	Organic Monocyclic aromatic compounds Chlorinated phenols	0.05	0.5	5	5	1991
Naphthalene PAHs	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	Consult Factsheet	Consult Factsheet	Consult Factsheet	Consult Factsheet	2008
Nickel	Inorganic	50	50	50	50	1999
Nonylphenol and its ethoxylates **CASRN** 84852153	Organic Nonylphenol and its ethoxylates	5.7	5.7	14	14	2002

		Soil Quality Guidelines for the Protection of Environmental and Human Health				
		Concentration (mg/kg dry weight)	Concentration (mg/kg dry weight)	Concentration (mg/kg dry weight)	Concentration (mg/kg dry weight)	Date
Chemical name	Chemical groups	Agricultural	Residential/ parkland	Commercial	Industrial	
n-hexane **CASRN** 110-54-3	Aliphatic hydrocarbon	Table	Table	Table	Table	2011
Pentachlorobenzene **CASRN** 608935	Organic Monocyclic aromatic compounds Chlorinated benzenes	0.05	2	10	10	1991
Pentachlorophenol PCP	Organic Monocyclic aromatic compounds Chlorinated phenols	7.6	7.6	7.6	7.6	1997
Phenanthrene PAHs	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	Consult Factsheet	Consult Factsheet	Consult Factsheet	Consult Factsheet	2008
Phenolic compounds, nonchlorinated	Organic Non-halogenated aromatoc hydroxy compounds	0.1	1	10	10	1991

Users are advised to consult the Canadian Environmental Quality Guidelines introductory text, factsheet, and/or protocols for specific information and implementation guidance pertaining to each environmental quality guideline.

		Soil Quality Guidelines for the Protection of Environmental and Human Health				
		Concentration (mg/kg dry weight)	Concentration (mg/kg dry weight)	Concentration (mg/kg dry weight)	Concentration (mg/kg dry weight)	Date
Chemical name	Chemical groups	Agricultural	Residential/ parkland	Commercial	Industrial	
Phenols (mono- & dihydric) **CASRN** 108952	Organic Aromatic hydroxy compounds	3.8	3.8	3.8	3.8	1997
Phthalic acid esters (each)	Organic Phthalate esters	30	*No data*	*No data*	*No data*	1991
Polychlorinated biphenyls PCBs	Organic Polyaromatic compounds Polychlorinated biphenyls	0.5	1.3	33	33	1999
Polychlorinated dibenzo-p-dioxins/dibenzo furans PCDDs, PCDFs	Organic Polyaromatic compounds Polychlorinated dioxins and furans	4 ng TEQ.kg-1	4 ng TEQ.kg-1	4 ng TEQ.kg-1	4 ng TEQ.kg-1	2002
Propylene glycol **CASRN** 57556	Organic Glycols	insufficient informationi	insufficient information	insufficient information	insufficient information	2006
Pyrene PAHs	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	Consult Factsheet	Consult Factsheet	Consult Factsheet	Consult Factsheet	2008
pH	Inorganic Acidity, alkalinity and pH	6 to 8	6 to 8	6 to 8	6 to 8	1991

		Soil Quality Guidelines for the Protection of Environmental and Human Health				
		Concentration (mg/kg dry weight)	Concentration (mg/kg dry weight)	Concentration (mg/kg dry weight)	Concentration (mg/kg dry weight)	Date
Chemical name	Chemical groups	Agricultural	Residential/ parkland	Commercial	Industrial	
Quinoline PAHs	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	0.1	*No data*	*No data*	*No data*	1991
Selenium	Inorganic	1	1	2.9	2.9	2009
Silver	Inorganic	20	20	40	40	1991
		Concentration	Concentration	Concentration	Concentration	Date
Chemical name	Chemical groups	Agricultural	Residential/ parkland	Commercial	Industrial	
Sodium adsorption ratio SAR		5	5	12	12	1991
		Concentration (mg/kg dry weight)	Concentration (mg/kg dry weight)	Concentration (mg/kg dry weight)	Concentration (mg/kg dry weight)	Date
Chemical name	Chemical groups	Agricultural	Residential/ parkland	Commercial	Industrial	
Styrene **CASRN** 100425	Organic Monocyclic aromatic compounds	0.1	5	50	50	1991

		Soil Quality Guidelines for the Protection of Environmental and Human Health				
		Concentration (mg/kg dry weight)	Concentration (mg/kg dry weight)	Concentration (mg/kg dry weight)	Concentration (mg/kg dry weight)	Date
Chemical name	**Chemical groups**	**Agricultural**	**Residential/ parkland**	**Commercial**	**Industrial**	
Sulfolane Bondelane **CASRN** 126330	Organic Organic sulphur compound	0.8	0.8	0.8	0.8	2006
Sulphur (elemental)	Inorganic Inorganic sulphur compounds	500	*No data*	*No data*	*No data*	1991
Tetrachloromethane Carbon tetrachloride **CASRN** 56235	Organic Halogenated aliphatic compounds Halogenated methanes	0.1	5	50	50	1991

Users are advised to consult the Canadian Environmental Quality Guidelines introductory text, factsheet, and/or protocols for specific information and implementation guidance pertaining to each environmental quality guideline.

		Soil Quality Guidelines for the Protection of Environmental and Human Health				
		Concentration (mg/kg dry weight)	Concentration (mg/kg dry weight)	Concentration (mg/kg dry weight)	Concentration (mg/kg dry weight)	Date
Chemical name	**Chemical groups**	**Agricultural**	**Residential/ parkland**	**Commercial**	**Industrial**	

		Soil Quality Guidelines for the Protection of Environmental and Human Health				
		Concentration (mg/kg dry weight)	Concentration (mg/kg dry weight)	Concentration (mg/kg dry weight)	Concentration (mg/kg dry weight)	Date
Chemical name	**Chemical groups**	**Agricultural**	**Residential/ parkland**	**Commercial**	**Industrial**	
Tetrachlorophenols	Organic Monocyclic aromatic compounds Chlorinated phenols	0.05	0.5	5	5	1991
Thallium	Inorganic	1	1	1	1	1999
Thiophene	Miscellaneous organic compound	0.1	*No data*	*No data*	*No data*	1991
Tin	Inorganic	5	50	300	300	1991
Toluene **CASRN** 108883	Organic Monocyclic aromatic compounds	Table	Table	Table	Table	2004
Trichloromethane Chloroform **CASRN** 67663	Organic Halogenated aliphatic compounds Halogenated methanes	0.1	5	50	50	1991
Trichlorophenols	Organic Monocyclic aromatic compounds Chlorinated phenols	0.05	0.5	5	5	1991
Uranium **CASRN** 7440-61-1	Inorganic	23	23	33	300	2007

		Soil Quality Guidelines for the Protection of Environmental and Human Health				
		Concentration (mg/kg dry weight)	Concentration (mg/kg dry weight)	Concentration (mg/kg dry weight)	Concentration (mg/kg dry weight)	Date
Chemical name	Chemical groups	Agricultural	Residential/ parkland	Commercial	Industrial	
Vanadium	Inorganic	130	130	130	130	1997
Xylene	Organic Monocyclic aromatic compounds	Table	Table	Table	Table	2004
Zinc	Inorganic	200	200	360	360	1999

		Tissue Residue Quality Guidelines for the Protection of Widlife Consumer of Aquatic Biota	
		Concentration (µg/kg diet wet weight)	Date
Chemical name	Chemical groups		
Dichloro diphenyl trichloroethane; 2,2-Bis(p-chlorophenyl)-1,1,1-trichloroethane DDT (total)	Organic Pesticides Organochlorine compounds	14	1997

Users are advised to consult the Canadian Environmental Quality Guidelines introductory text, factsheet, and/or protocols for specific information and implementation guidance pertaining to each environmental quality guideline.

		Tissue Residue Quality Guidelines for the Protection of Widlife Consumer of Aquatic Biota		
		Concentration (µg/kg diet wet weight)	Date	
Chemical name	Chemical groups			
Methylmercury	Organic	33	2001	
Polychlorinated biphenyls PCBs	Organic Polyaromatic compounds Polychlorinated biphenyls	Variable	1998	
Polychlorinated dibenzo-p-dioxins/dibenzo furans PCDDs, PCDFs	Organic Polyaromatic compounds Polychlorinated dioxins and furans	Variable	2001	
		Concentration	Date	
Chemical name	Chemical groups			
Sodium adsorption ratio SAR		*No data*	*No data*	
		Concentration (µg/kg diet wet weight)	Date	
Chemical name	Chemical groups			
Toxaphene	Organic Pesticides Organochlorine compounds	6.3	1997	

Chemical name	Chemical groups

Chemical name	Chemical groups
Sodium adsorption ratio SAR	

Appendix B: Environmental Assessment Examination

Marathon Mine Envronmental Assessment Reclamation Disucession

Section 2.0
Secontion 2.5 Temporal Boundaries of the Assessment

Though the site will be reclaimed on an ongoing basis to the extent practical during site preparation, construction and operations, a relatively intensive period of reclamation and decommissioning will commence following the cessation of operations. This intensive period of reclamation and decommissioning is anticipated to last approximately two years.

Environmental monitoring activities will take place on the site thereafter in order to verify the success of reclamation and decommissioning activities, and also to confirm that on-site water quality has stabilized such that there are no longer-term geochemistry concerns.

Section 3.0: Project Alternatives
3.2.1 Alternatives Means assessment Framework

3.2.2 3.2.2.1.2

In table under Technical Facotrs--> Amendability to Decommissioning/reclamation--> Alternatives that are more amenable to decommissioning and/or reclamation are preferred

Alternative Means Assessment
Evaluation of Alternatives (Site Access road)
It has been estimated that the reclamation effort associated with the two alternatives would be similar. The nature of these efforts (e.g., road decommissioning) would be determined during detailed mine closure planning and would respect and attempt to balance public, Aboriginal group and government desires as it pertains to future land and resource uses.
As indicated above, it has been estimated that the reclamation effort, and the costs associated with the two alternatives would be similar and that specific decommissioning/reclamation options would be determined during detailed mine closure planning.

Evaluation of Alternatives (Aggregate and Rock fill) Evaluation of Alternatives (Mining Methods

Evaluation of Alternatives (Concentrate Transport from the Mine Site to a Remote Processing
From a decommissioning and reclamation perspective, more effort would be required for the alternative that includes the rail load-out facility but no technical challenges would be expected in this regard. If this option went forward, rail load-out facility design factors would be incorporated that would consider the ultimate closure of the facility.

Evaluation of Alternatives (Processing Solids Deposition)

3.2.2.2.2 3.2.2.3.2

3.2.2.4.2

3.2.2.5.2

3.2.2.6.2

3.2.2.7 3.2.2.7.1

From a closure perspective each of the process solids consistencies is acceptable. Evaluation of Alternatives (Solid Non-hazardous Waste Disposal)

Closure – Reclamation Mine Rock Storage Area (MRSA)
Alternatives Considered
Closure of the MRSA will be based on the requirements as set out by the "Ontario Mining Act, Regulation 240/00. The primary objectives for the MRSA closure plan include:

· ensuring slope stability;
· ensuring run-off drainage control on and around the MRSA is maintained; and,
· pursuing reclamation strategies that are consistent with or promote post closure land use.

Alternatives specifically pertaining to the reclamation of the MRSA as it concerns covers and re-vegetation have been considered. The two alternatives considered are:

· passively allowing the MRSA to develop a soil layer and re-vegetate through natural process;

· proactively developing cover material and promoting re-vegetation via seeding.

The first alternative allows for the natural reclamation of the MRSA. Over time organic matter and other material will collect on the surface of the MRSA and in the interstices and will function as substrate for plant growth. Vegetation would take hold in these areas. The "greening" of the MRSA would likely take place naturally over several decades.
In the second alternative, reclamation of the MRSA would be proactive. Proactive reclamation of the MRSA would include placement of surface soils on the horizontal surfaces and subsequently seeding these surfaces.

Evaluation of Criteria

Biophysical Environment Factors
The primary differentiation between the two alternatives as it concerns the biophysical environment is the rate at which wildlife habitat and associated biological populations and communities would be re-established. A more rapid revegetation and re-colonization process is

desirable and for this reason the proactive reclamation of the MRSA is the preferred alternative for this criterion.

Socio-economic Environment Factors
Proactive reclamation of the mine site in general, including the MRSA, restores the site for post mine closure land uses in a shorter time frame. For this reason pro-active reclamation as described herein is preferred over passive reclamation.
Aboriginal Considerations
As indicated above, proactive reclamation of the MRSA restores the site for post mine closure Aboriginal land uses in a shorter time frame. For this reason pro-active reclamation as described herein is preferred over passive reclamation.

Technical Factors

3.2.2.7.2

Either reclamation strategy is technically feasible. A passive reclamation strategy is an acceptable alternative from the standpoint that natural re-vegetation of the MRSA would be successful over the long-term. Given an appropriate length of time (several decades perhaps) leaf litter and other organic and inorganic material will accumulate to the extent that vegetation would become established.
There are no technical issues associated with the success of proactively reclaiming the MRSA in the manner described in the second alternative. The timeframe over which successful re-vegetation would occur would be significantly reduced, as compared to the strategy of natural re-vegetation, by implementing the proactive reclamation plan.
Because of the reduced time-frame over which successful revegetation would occur for the proactive reclamation strategy it is the preferred alternative for this criterion.
Cost Factors
Passive reclamation is the more cost effective of the two MRSA reclamation alternatives considered and can therefore be characterized as preferred for this criterion. Proactive reclamation as described above would not be cost prohibitive to implement and is therefore deemed acceptable.
Overall Conclusion
The proactive MRSA reclamation strategy as described above was determined to be the preferred alternative.

3.2.2.8 Closure – Reclamation Processing Solids Manufactoung Facility(PSMF) 3.2.2.8.1 Alternatives Considered

Reclamation and closure of the PSMF will be based on the requirements as set out by the Ontario Mining Act, Regulation 240/00. The primary objectives for the conceptual PMSF

closure plan are:
· ensuring safe and secure storage of process solids in perpetuity;

· minimizing dust generation from the process solids surface;

· safely routing runoff and stream flows through, around and off the PSMF;

· ensuring that the surface water flows from the facility are of suitable quality; and,

· minimizing the visual impact of the facility on the surrounding environment.

Specific activities that will be implemented as part of the closure of the PSMF and associated structures comprise:

· contouring the downstream slopes of the PSMF embankments, cut slopes, access routes, other disturbed areas, etc., as necessary to remove any areas of concentrated runoff leading to erosion and sediment production;
· minimizing standing water on top of the PSMF;
· establishing vegetative cover over the surface of the process solids;
· decommissioning process solids delivery and distribution systems;
· decommissioning the water reclaim and excess water release systems;
· dismantling and removing other infrastructure not required beyond mine closure; and,
· providing ongoing monitoring of the PMSF for a period of time sufficient to confirm suitable water quality and ongoing stability of the facility.

Two alternative PSMF closure scenarios were considered pertaining to where run-off from the PSMF will drain over the long term. The PSMF falls within the Stream 6 subwatershed. During operations, excess water from the PSMF will be discharged to Hare Lake, which is within subwatershed 5 to the north of Stream 6. It would be possible at closure through the grading of the PSMF surface to make water drain to either subwatershed. Two alternatives were therefore considered:

· grading the PSMF surface and creating an overflow structure in the northwest corner of PSMF at closure to direct drainage to Hare Lake, maintaining the flow direction that was established during operations; and,
· grading the PSMF surface and creating an overflow structure in the southwest corner of PSMF at closure to direct run-off to Stream 6, restoring its natural drainage.

3.2.2.8.2 Evaluation of Alternatives Biophysical Environment Factors

The primary basis on which the two alternatives can be distinguished from one another concerns the net benefits that would accrue to the aquatic habitat in the Stream 6 subwatershed if the restoration of natural drainage patterns was completed in combination with further aquatic habitat restoration activities elsewhere in the subwatershed. The possibility of these restoration activities has been presented as a potential option in the fish habitat compensation strategy developed in support of this EIS (EcoMetrix, 2012g). Restoration of natural drainage patterns in the Stream 6 subwatershed was judged as the preferred alternative for this criterion.

Socio-economic Environment Factors

As above, the primary basis on which the two alternatives considered can be distinguished from one another concerns the net benefits that would accrue to the aquatic habitat in the Stream 6 subwatershed. From a socio-economic perspective the re-establishment of the natural drainage patterns would enable all current potential land uses in the subwatershed to be restored following mine closure. With this in mind, restoration of natural drainage patterns in the Stream 6 subwatershed was judged as the preferred alternative for this criterion.

Cost Factors

There are no significant differences in the costs associated with the implementation of either

of the two alternatives. Moreover, the alternatives are not cost prohibitive and can be

characterized as acceptable, and no basis for a preference was identified. Overall Conclusion

Restoration of natural drainage patterns whereby drainage from the PSMF is directed to the Stream 6 subwatershed is judged to be the preferred option.

Section 4.0
4.4.2 Early Aggreements 4.5.1 Ongoing Particiption

Section 5.0

5.1.5.1.2 Recent Mine Material Investigations
The various investigations were completed to allow an evaluation of water quality of the predicted effluent discharge and site drainage to the surrounding watersheds during operation and the quality of natural drainage from the site after closure and decommissioning.

Geology and Relationship to Acid Rock Drainage (ARD) and Metal Leaching--> Physical
5.1.5.2.1

Descriptions

Ultimately, during the post-closure phase the overburden material disturbed and stockpiled during operations can be used for reclamation purposes.

5.5.1 Work Scope
Terrain within the Project area was assessed with the aid of available topographic maps (1:20,000 to 1:50,000), LIDAR data collected at the Project site and aerial photographs of the area. Soils were assessed to gain a general understanding of the surficial soil and overburden characteristics within the project footprint, to characterize baseline surficial soil chemistry and to

describe the acid generation and metal leaching potential of overburden materials that will be excavated and subsequently stored on site or used for reclamation purposes.

Section 6.0
6.2 Assesent of the Effects
6.2.1 Atmospheric Effects
6.2.1.1 Assessment Context 6.2.1.1.4 Decommisioning and closure

During decommissioning and closure, fugitive dust emissions will result from dismantling and decommissioning activities. At closure, all exposed dust sources will be vegetated and progressive reclamation will be used wherever practicable to better control dust emissions

from overburden, mine rock and process solid areas. 6.2.3 Water Quality and Quantitiy

6.2.3.2.3 Decommisioning and closure
At mine closure and decommissioning, surface runoff from the PSMF will be directed back to the natural drainage route (i.e., to Stream 6), effluent will cease being discharged to Hare Lake and the Hare Creek subwatershed, the pits will be allowed to flood (as applicable) and the subwatersheds associated with the MRSA will drain to the main pit and to the Pic River. Overflow from the pits will overtime eventually discharge to the Pic River through Streams 2 and 3, unless re-routed.

At mine closure and decommissioning the MRSA catch basins will be dewatered and

removed, assuming stormwater and seepage quality from the MRSA meets provincial and

federal criteria. Accumulated sediment in the catch basins will be excavated and transferred

either to Cell 1 or a Satellite Pit for storage. The catch basin embankments will be breached

and contoured to suit the surrounding topography. The catch basin and embankment areas

will be re-graded and seeded and the original drainage patterns and stream beds will be

restored.
As noted in relation to the operations phase, there are five existing road and rail line

watercourse crossings that could be affected by the Project: Stream 1 at Camp 19 Road, Hare Creek at Highway 17, Hare Creek at Canadian Pacific Rail Line, Stream 6 at Highway 17, and Stream 6 at Canadian Pacific Rail Line. The Stream 1 and Hare Creek crossings should not be affected by Project closure as flows in these subwatersheds are anticipated to return to baseline conditions.

Following mine closure and decommissioning, peak flows will have the potential to increase in Stream 6 in the order of 5 to 7% at Highway 17 and 2 to 3% near the outlet to Lake Superior. These increases are relative to baseline conditions and will result from an increase in drainage area associated with construction of the PSMF. On closure and decommissioning, drainage from the PSMF will be directed to Stream 6. Review of hydraulic capacity of the Stream 6 watercourse crossings at Highway 17 and the Canadian Pacific Rail Line indicates that there is more than sufficient flow capacity to accommodate the potential flow increases

6.2.3.3.3 Decommisioning and closure

At closure, when stormwater and seepage quality from the MRSA have been shown to meet applicable criteria the catch basins will be dewatered and removed. Accumulated sediment in the catch basins will be excavated and transferred to Cell 1 or a Satellite Pit for storage. The catch basin embankments will be breached and contoured to suit the surrounding topography. The basin and embankment areas will be re-graded and seeded and the existing stream beds will be restored. No exceedances of water quality benchmarks in the Pic River are expected during decommissioning and closure.

After mine closure the natural flow regime of the Stream 6 subwatershed will be restored. The PSMF will be re-vegetated and natural stream channels and ponds will be created to collect surface runoff and direct it to the southwest where an outlet structure will be created to link the upper part of the watershed (which is the PSMF) and the lower part of the watershed which drains into Lake Superior. It is expected that the runoff water quality will be similar to existing baseline conditions once the natural flow regime in the Stream 6 subwatershed has been restored. (EcoMetrix, 2012f)

6.2.4 Fish and Fish Habitat

6.2.4.2 THE TITLE THING IS MESSED UP

Decommisioning and closure

Decommissioning and closure activities will include the removal of mine infrastructure such as buildings, power lines and roads, the re-grading of surface landscape features and the subsequent reclamation of previously disturbed areas. The mobilization of sediments into waterbodies or watercourses could result from any of these activities.

To the extent possible natural surface water drainage patterns will be restored after mine closure. The PSMF will be reclaimed (covered and revegetated) and surface water features created to restore the natural drainage patterns in the Stream 6 subwatershed. Water draining the reclaimed PSMF will be of similar quality to background conditions across the Project site. Portions of the MRSA will be reclaimed and surfaces re-graded as necessary to improve drainage. The natural surface water drainages for Streams 2 and 3 will be restored once it has been demonstrated that water quality would be protective of aquatic biota therein.

6.2.5 Terrain and Soils

6.2.5.1.3 Decommisioning and closure

Material in any overburden stockpiles that remain at closure will be used for site reclamation purposes. Baseline soil quality characterization indicates that overburden material would be suitable for reclamation purposes (EcoMetrix, 2012b). This includes acid-base accounting and metal leaching data that indicate that soils do not have the potential to adversely affect water quality.

As discussed in the Project Description (Section 1.4), reclamation of the MRSA will be proactive. Horizontal surfaces will be covered with overburden and/or topsoil and subsequently revegetated using native seed. Once it has been demonstrated that water draining the MRSA meets all applicable regulatory requirements the water collection system will be dismantled and natural flows will be returned to the four subwatersheds draining the MRSA.

6.2.6 Veggitation
6.2.6.1.2 Decommisioning and closure

At the cessation of operations the mine site reclamation and revegetation of previously disturbed areas would intensify. It is estimated that a total of approximately 400 ha of land will be actively reclaimed to establish a vegetative cover during the first five years of closure. Reclaimed areas will include the PSMF, about 20% of the MRSA, the satellite pits that have been utilized for mine rock and/or process solids storage and linear corridors that are not required to support remaining site activities. Subsequent to this active phase of revegetation natural processes of revegetation and plant succession will occur. Any active revegetation will include the use of native species. Grass and herb species may be used for the purposes of revegetation though other alternatives, such as establishing forest cover (e.g., an even-aged conifer dominated forest to provide potential caribou refuge habitat) will be considered during detailed closure planning in the context of potential long term end uses for the Project site.

It may also be feasible to introduce native rare plants to the site during reclamation activities to produce a net benefit to these species on a regional and/or provincial scale.

6.2.7 Wildlife
6.2.7.1.2 Decommisioning and closure

When the operational life of the mine concludes, all non-essential mine and mill facilities will be demolished or decommissioned. At decommissioning and closure the revegetation of the PSMF and MRSA will be underway to the maximum extent feasible. During the first years of decommissioning the interaction between the Project and wildlife will be similar to the site preparation and construction phase. There will be fugitive dust as well as noise from heavy machinery and light vehicles. After the operational phase adaptable local wildlife will likely have become habituated creating the potential for interactions between vehicles and wildlife and direct contact between workers and wildlife.

After decommissioning, closure should positively affect wildlife. There will be the initial creation of approximately 411 ha of grassland type habitat split between the PSMF (291 ha) and MRSA (120 ha). Also as part of the closure plan there will be stream and associated meadow habitat created from the east side of the PSMF flowing through the capped satellite pit complex.

Potential interaction between safety fencing and wildlife in the former pit area of the site may occur at closure. The pit area will be encircled to ensure public safety which may minimally affect the movement of certain wildlife temporarily. As closure progresses and the site is reclaimed by vegetation there will be recolonization by expanding "natural" habitat on the site and potential increases in the occurrence of species that prefer grassland type habitat.

Site roads are estimated to be decommissioned to the extent possible and reclaimed as wildlife habitat. This mitigates the possibility of increased hunting and/or trapping pressure on furbearers, moose and other wildlife species due to increased access to previously inaccessible locations.

Furbearers

During decommissioning of the Project there will be no additional negative effects on furbearers. Furbearers that inhabit the Project site at this time will likely have adjusted to human activity and associated noise disturbances. Closure activities including revegetation of the PSMF and MRSA may potentially increase the presence of certain furbearers in response to potential increases in prey inhabiting these grassland habitats. Red fox and weasels and other species that prey on small mammal species may become more prevalent within the project site. Forest dwellers such as marten and fisher likely will not be affected by the closure plan in the near term. In the long term as vegetative succession proceeds throughout the Project site, forest inhabiting species may immigrate back to the site, dependent on available habitat. The effects of the decommissioning and closure on furbearers should be limited to the SSA and LSA with the effects being positive in near term and neutral in the long term.

Moose

During decommissioning the effects on moose will be the same as those outlined in the previous two phases. Noise and dust disturbance from machinery engaged in the decommissioning activities such as building demolition may cause avoidance behaviour in the short term. However, by decommissioning, moose in the area are likely to be habituated and therefore their distribution within the SSA and LSA will not likely change as a result of these activities.

At closure the rate of revegetation on reclaimed areas will determine the rate that moose migrate back into areas of the Project they did not use during operations. The MRSA and PSMF will likely be revegetated with grasses initially to stabilize the soils, but as succession continues and forested areas begin to expand, early successional tree species such as willow and aspen may provide increased moose browse in the near term compared to baseline. The constructed stream through the satellite complexes may also provide aquatic plant species preferred by moose. The effect of closure on the moose population in the SSA and LSA is

likely positive in the long-term. Grey Wolf

As discussed in previous phases the grey wolf population and distribution within the Project Site and SSA and LSA will be greatly affected by the prey populations. If more moose move into the area in response to improved habitat during closure then potentially more wolves may follows. Grasses used for revegetation may create habitat more suitable for white-tailed deer, rather than moose, also potentially increasing wolf numbers in the LSA. However, deer populations may be limited by winter conditions rather than food availability. Proceeding through the closure phase as road and areas of operations are reclaimed by vegetation, easily travelled corridors for predators will be minimized potentially changing wolf distribution in the local area and decreasing predation rates. The potential and magnitude of the effect of decommissioning and closure on grey wolf are indirect and tied to the effect on prey species.

Black Bear

Bears that inhabit the periphery of the Project site during operations are likely to remain throughout the decommissioning phase. By decommissioning, local bears will be habituated to human activity. Activities of demolition are not likely to change the distribution or density of bears within the project.

Proceeding to closure, increased bear density is possible. Decreases in human activity may allow "non-habituated" bears to inhabit the site. Also initial creation of 411 ha of grassland could be a good spring food source for bears. The disturbance of the mine activity during operations will have fragmented the forest and potentially increased its habitat value for bears. As revegetation occurs, if successional plants such as blueberry increase this may also increase the seasonal use of the site by bears. The magnitude of the effects of this phase on

black bear will be positive and limited to the LSA. Migratory Birds

During decommissioning all large buildings and unnecessary transmission lines will be

removed. This will have a positive effect by decreasing the hazards associated with collisions

for all bird species. Noise disturbance may affect some migratory birds in the SSA; however,

the SSA is not a major migratory flyway and therefore the effects during decommissioning

will be small.

At closure there is potential for positive changes for migratory birds within the site and local

study areas. Revegetation with appropriate native grasses will create increased habitat for bird species such as American Kestrel and Savannah Sparrow. (Northern Bioscience, 2012b). In the longer term as revegetation continues and succession leads to trees species replacing grasses more forest dwelling species will use the site. Until trees recolonize the site to recreate continuous tracts of forest, interior forest preferring birds will continue to be scarce. A decrease n human activity and influence on the site will benefit species that avoid such areas although there is a potential for a decrease in species and individuals that have become habituated to humans and have used buildings and site infrastructure for nesting and feeding locations. Potential interactions are not predicted to extend past the LSA and will be positive in both the near and long term.

Rainy River Environemtnal Assessment Reclamation Information

Section 3: Consulatation
3.5.1 Comments and concerns from stakeholders

Comments from each government agency were generally focussed on each agencies' regulatory authority, but can be grouped as follows:

Reclamation: post-closure water management, reclamation approaches, requests

Section 4: Project Description 4.1 Main Project Componenets

Rainy River Resources (RRR) proposes to construct, operate and eventually reclaim a new open pit and underground gold mine at the Rainy River Project (RRP) property.

The RRP is designed to:
Use well established, conventional technologies commonly used in northern Ontario gold mines and process plants;
Respect the interests of other property owners and land users in the area;

Minimize the overall footprint and associated environmental impacts; and

Render the site suitable for other compatible land uses and functions after the mine has closed and the land has been reclaimed.

4.3 Open Pit Mine
4.3.2 Site Preperation
4.3.2.2 Water Management

Water within the overburden and country rock will need continual removal (dewatering) during construction and throughout mine operation in order to safely extract the overburden and rock. Open pit dewatering will start during overburden stripping and will continue during mining operations.
This water will contain elevated suspended solids and potentially other parameters related to heavy equipment operation. The water will therefore be contained and if necessary, treated before it is discharged to the environment. Sump(s) will be developed in the base of the open pit to remove excess water that enters the pit, such as from direct precipitation and groundwater inflow. Water from the sump will be pumped to the mine rock pond for re-use or temporary storage. RRR does not plan to use dewatering wells such as those used at some other Ontario mining projects, as the overburden is clay-rich and the use of wells to dewater overburden is not expected to be successful in such conditions.

4.12 Water Management 4.12.1 General Approach

The RRP water management system is designed for water conservation. Best engineering efforts have been made to ensure maximum reasonable recycling of water while reducing the volume of excess water that must be returned to the natural environment. Water management for the RRP has been designed to the extent practicable, to:

Optimize the quantity and quality of excess water returned to the environment so as to minimize adverse flow and water quality effects to receiving water

systems;
Manage acid rock drainage potentials both during operations, and following

mine closure;

Collect and control all site effluents in accordance with Metal Mining Effluent Regulations and anticipated Provincial permitting requirements;

Minimize the number of final discharge points and the quantity of water

discharged; and
Excess water discharged to the environment must be capable of meeting applicable Federal

and Provincial guidelines for the protection of aquatic life (including the Provincial Water Quality Objectives for the protection of aquatic life; PWQO), or other scientifically defensible alternatives in the receiving watercourse (the Pinewood River). The compliance criteria are determined through the Provincial environmental approval process on a case by case basis, with the default requirement being the application of PWQO to the receiver if other values cannot be determined to be more suitable. To achieve these objectives, an integrated and adaptable water management system has been developed

The principal water discharge requiring management at the site will consist of the following:
Minewater from the open pit and underground mine

Water associated with the treated (SO_2/Air) tailings effluent from the process plant;
Runoff and seepage from the tailings management area and stockpiles (mine rock, low grade ore and overburden);

Water from the truck wash facility and other minor sources;

Treated domestic sewage water; and

General site area runoff.
An integrated water management and treatment system has been designed that relies on recycling water from various constructed ponds for process water in order to minimize the volume of fresh water taken from local watercourses and reduce the quantity of treated water requiring discharge.

The system has been designed to ensure a reliable water supply at all times of the year and to allow for contingencies, such as sequences of wet and dry years.

4.12.6 Final effluent quality and discharge

The results indicate that a high quality effluent approaching PWQO and CEQG values can be achieved through a combination of in- plant cyanide destruction using SO2/Air process combined with natural aging in the tailings management area and associated ponds.

For that component of the tailings management area discharge and seepage directed to the constructed wetland, further reductions in residual heavy metal and ammonia levels are expected, as wetlands adsorb residual heavy metals and take up residual ammonia as a nutrient. The efficiency of such uptake is seasonally dependant and is greatest during the active plant growing season.

To optimize both water quality and river flow effects, final effluent release to the Pinewood River at two separate locations is proposed: through constructed wetland to the Pinewood River at the Loslo Creek outflow (via lower Loslo Creek / Cowser Drain); and directly to the Pinewood River just downstream of the McCallum Creek outflow by pipeline. Figure 4-11 shows a schematic of the flow arrangements and typical annual average discharge rates. Further details are provided below. The rationale for using two separate discharge locations derives from the need to achieve water effective water quality treatment while at the same time minimizing adverse flow effects on the Pinewood River, under varying hydrologic operating conditions.

Discharging too much effluent through the constructed wetland would however, reduce the retention time and assimilative capacity of the wetland, and could also potentially cause excess erosion though the system. The release of effluent from the water management pond to the constructed wetland has therefore been capped at a nominal flow rate of 10,000 m3/d. If operational experience with the constructed wetland indicates that greater flow through rates can be achieved, while still maintaining effective water quality treatment, this discharge rate could potentially be increased.

The proposed effluent objectives for Ontario Regulation 560/94 and related parameters, are based on the development of scientifically-based protection of aquatic criteria developed from the application of United States Environmental Protection gency (US EPA) hardness equations in the case of copper, lead, nickel and zinc; and on the absence of salmonid (trout) species in the case of free cyanide (US EPA 2009). The toxicity of copper, lead, nickel and zinc to aquatic life is a function of hardness, where hardness reduces metal toxicity by inhibiting metal uptake by aquatic organisms.

The 0.005 mg/L protection of aquatic life value for arsenic is viewed as being overly conservative, as it is based on growth inhibition to a single algal specie, and there is little evidence of a credible risk to other freshwater species including: fish, invertebrates and plants, so long as arsenic values are retained at ≤0.05 mg/L (CCME 2001). A modified receiver target of 0.01 mg/L is therefore proposed for arsenic as being more than adequate, and scientifically defensible for the protection of aquatic life in the Pinewood River.

4.12.7.4 Water Course Diversion
The diversion will be constructed to provide like-for-like fish habitat replacement and will be stabilized before the original channel is closed in order to ensure continual safe passage of any fish.

4.14 Domestic and Industrial Waste Management
The total quantity of solid wastes that require storage over the life of the RRP is therefore estimated at approximately 96,000 m3 excluding the active reclamation phase of the project for which an onsite demolition waste landfill is proposed.
A bioremediation area may be developed for treatment of hydrocarbon affected soils rather than transporting these materials offsite. This need will be assessed during future engineering investigations.

4.18 Project Phases and Shedule

The approximate duration of the major RRP phases are as follows: Active reclamation: 2 years.

4.19 Decomissioning and Reclamation
Closure of the RRP site by RRR will be governed by the Ontario *Mining Act* and its associated Regulations and Codes. The *Act* requires that a Closure Plan be filed for any mining project before the project is undertaken, and that financial assurance be provided before any substantive development takes place to ensure that funds are in place to carry out the Closure Plan.
The objective of closure is to reclaim the mine site area to a naturalized and productive condition when mining ceases. The terms naturalized and productive are interpreted to mean a reclaimed site without infrastructure (unless otherwise negotiated), that while different from the existing environment, is capable of supporting plant, wildlife and fish communities; and other applicable land uses.

It is expected that the primary phase of active reclamation at the RRP will take approximately two years after operations cease. Thereafter, the site will be held in care and maintenance, until the open pit is fully flooded. Environmental monitoring and potentially effluent quality management by RRR will occur during this passive period of reclamation in accordance with the Closure Plan prepared and filed pursuant to the *Mining Act*.

Once the pit is flooded, an additional shorter period of active reclamation will occur to remove associated remaining project elements. A conceptual closure plan is provided in Appendix E and is described briefly in the text that follows. Environmental monitoring aspects are considered in Appendix E.

4.19.1 Open Pit and Underground Mine

Both the open pit and underground mine will flood naturally once dewatering activities cease. The open pit will be flooded to create a pit lake either passively through natural groundwater entry and precipitation inputs; or by active enhanced flooding of the open pit, using water pumped from an alternate source such as seasonal fresh water inputs (Attachment 1 in Appendix E). Flooding of the underground and open pit mine to surface is expected to take approximately

72 years using a moderately enhanced, flooding process. Consultation will be required to determine the preferred flooding approach.

Other measures to be taken to reclaim the open pit progressively or at closure may, or are likely to include:

Remove all infrastructure and equipment within the open pit and underground mine and clean up any petroleum hydrocarbons and/or explosives;

Shape and revegetate overburden pit slopes to a stable condition and to facilitate riparian habitat along the pit lake margins;

Block the entrance to the open pit and install a boulder or traditional security fence around the pit perimeter during or following active mining operations to ensure safety while the pit is flooding; and

Develop a spillway if needed, to allow the pit lake to eventually overflow to the Pinewood River.

Entrances to the underground mine will be blocked to ensure long term security.

4.19.2 Stock Piles
Progressive rehabilitation of mine rock and overburden stockpiles will be undertaken where practical once the maximum height of each stockpile has been reached and/or as each lift is completed, to minimize the amount of reclamation required at closure. All stockpiles will be re-shaped as necessary and stabilized if needed.

The overburden stockpile will be revegetated progressively, with final stabilization and revegetation occurring after overburden has been extracted for site reclamation.

The west mine rock stockpile will contain only NPAG mine rock. ARD / ML are not of concern, so RRR proposes to cover the stockpile with a layer of overburden and revegetate.

A multi-layered cover is proposed for the east mine rock stockpile as it will contain PAG. Encapsulation is proposed with a long term goal of controlling ARD. The side slopes will be progressively covered by a layer of compacted clay till to shed water, topped by a layer of NPAG to consume oxygen, another layer of compacted clay till, followed by a layer of clay till and a growth media to enable revegetation. The flat portion of the stockpile will have a similar cover, but will not include the lowest layer of clay till. Should a temporarily closure or early closure occur, the cover will be completed to ensure ARD / ML is properly managed.

RRR proposed to process all stockpiled ore during operation, therefore reclamation of the low grade or run of mine (high grade) stockpile should not be required. If necessary, the stockpiles will likely be reclaimed in a manner similar to that proposed for the east mine rock stockpile at early or final closur

Revegetation will occur through seeding, hydroseeding and/or hand planting of tree seedlings as appropriate, to expedite the colonization by indigenous plant species. Investigations will be completed to determine the feasibility of establishing specific wildlife habitats, such as those that might be used by Species at Risk, following closure. The investigations will also determine whether any amendments are required to the native till (overburden) to improve its suitability to provide a base for revegetation.

The principal concerns associated with closure of the tailings management area are long term slope stability, erosion control, drainage, vegetation cover and appearance, as well as prevention of ARD from the tailings. The tailings management area development plan currently provides for a water and overburden cover at closure to restrict oxygen contact with the tailings surface. Overflow spillway(s) will be developed or deepened to ensure efficient drainage of excess runoff. 4.19.4 Aggregate Sources

If quarries or pits are developed as aggregate sources during the construction and operation phases, these will be reclaimed according to Provincial approvals and standards, which may include natural flooding to create pond features.

4.19.5 Building, Machinery, Equipment and Infrastructure

A dedicated onsite demolition landfill is expected to be developed for the disposal of non-hazardous demolition wastes (such as concrete, steel, wallboard and other inert materials) generated by mine closure. It is expected that this demolition landfill will be developed within the east mine rock stockpile.

Salvageable machinery, equipment and other materials will be dismantled and taken off site for sale or re-use if economically feasible, or cleaned of oil and grease where appropriate and deposited within the onsite demolition landfill. Gearboxes or other equipment containing hydrocarbons that cannot be readily cleaned will be removed from equipment and machinery and trucked offsite for disposal at a licensed facility.

4.19.3 Tailings Management

All above grade concrete structures will be broken up and demolished to near grade elevation. Concrete structures and below grade facilities (if any) will be infilled if needed. Affected areas will be contoured, covered with overburden as needed and revegetated.

4.19.6 Petrolum Products, Chemicals and Explosives

All petroleum products and chemicals will ultimately be removed from the site. Empty tanks will be sold as scrap, re-used off site, or cleaned to remove any residual fuel / chemicals and deposited within the demolition landfill.

An environmental site investigation will be conducted at the end of operations or early in the closure phase. Soil found to exceed acceptable criteria will be remediated onsite or transported off site to an approved disposal facility.

Any explosives will be depleted towards the end of operations. Any remaining explosives will be either detonated on site or hauled offsite by an authorized transportation company.

4.19.7 Roads, pipeline and Power Distribution
Site roads may be scarified when no longer needed to support final reclamation, long term site management and environmental monitoring, assuming they are not required to support some other development on the site. Safety berms, if any, along the perimeter of haul roads will be re-shaped to near grade. Culverts will be removed and roads will be breached at the culvert locations on site to allow natural drainage.

Pipelines or pipeline sections will either be sealed and left in place; or purged if needed, dismantled and disposed of in the onsite demolition landfill.

Onsite power distribution lines and associated materials that have no salvage value will be dismantled and deposited in the demolition landfill. Other power equipment and materials will be taken off site for sale or re-use. 4.19.8 Site Drainage and Water Structures

The new alignment for the West Creek will naturalize over the life of the mine and will become the permanent creek channel, unless it is determined during closure planning that returning West Creek to its original route is preferred.

The Clark Creek diversion will remain in place to continue to divert drainage away from the east mine rock stockpile.

The pattern of general site drainage will remain in place at closure, with the exception of the removal of culverts at water crossings during site road reclamation activities. Water intake structure(s) at the Pinewood River (or other waterbodies if any) will be reclaimed by removing any structures and mechanical components for disposal in the demolition landfill.

4.19.9 Waste Management
At the end of reclamation activities, the onsite landfill(s) will be capped and revegetated in a manner consistent with the remainder of the site and environmental approval requirements.

6.2 Assessment of Alternative Methods Methadology 6.2.1 Performance Objectives

Performance objectives are meaningful attributes that are essential for the RRP success, and provide a basis for distinguishing between individual alternatives. The following performance objectives (or a subset thereof as appropriate for any given alternative) have been used:

Amenability to reclamation. 6.2.2 Evaluation Critera and Indicators

Amenability to Reclamation

Avoidance of safety and security risks to the general public

Attainment or maintenance of air quality point of impingement standards, or scientifically defensible alternatives

Attainment or maintenance of water quality guidelines for the protection of aquatic life, or scientifically defensible alternatives

Restoration of passive drainage systems

Provision of habitats for vegetation and wildlife species, including SAR

Provide opportunities for productive land uses following the completion of mining activities

Provide for an aesthetically pleasing site

Causes disturbance to the natural environment that requires limited reclamation

Causes disturbance to the natural environment that requires moderate to extensive reclamation
Mitigation of disturbance to the natural environment is not practical or feasible

This performance objective relates to the decommissioning or reclamation of the RRP and associated infrastructure (if any). The consideration of alternatives methods for closure is more complex than for other alternatives, because there are a number of subcomponents that require consideration.

6.3 Mining
6.3.2 Performance Objectives Evaluation

Criteria

Effect on public safety and security

Indicator

Effect on environmenta l health and sustainability

Effect on land use

Performance

Preferred

Acceptable

Unacceptable

The underground mining methods are preferred from a reclamation perspective, as neither alternative has an appreciable effect on the surface environment that will require reclamation. The open pit will be reclaimed as a pit lake, and the overburden and mine rock stockpiles will be vegetated and returned to productive habitat on closure. As a portion of the stockpiled mine rock is predicted to be PAG, this portion of the mine rock will need to be managed in the long term after closure to prevent adverse environmental impacts to the natural environment including downstream receiving waters. Open pit mining is rated as acceptable with appropriate mitigation related to ARD. Mitigation measures are available and practical.

6.4 Mine Water Management
6.4.2 Performace Objectives Evaluation : Amenability to Reclamation

The integrated site water management system will require reclamation at mine closure, irrespective of whether or not it is used for minewater management. Development of a separate minewater treatment pond system will add unnecessarily to mine reclamation requirements without providing any tangible overall benefit to the RRP. Use of an integrated site water management system for minewater management is preferred from the perspective of reclamation.

6.5 Mine Rock Overburden Management
6.5.2 Perfromance Objectives Evaluation: Amenability to Reclamation

The critical aspect of amenability to reclamation for all alternatives is the long term management of stockpile ARD potentials, and the ability to develop a site-wide integrated water management plan both during operations and at closure. Considerable efforts have been made during development of the RRP site plan, to develop a site-wide water management strategy that will allow residual PAG stockpile drainage to be directed to the open pit at closure. This strategy will allow use of the pit lake for water management (Section 4.19). Alternative A is too far removed from the open pit to allow passive drainage to the pit. Alternative B is also not suitably located for this function as it is positioned on the opposite side of the Pinewood River. Both alternatives are therefore rejected for this performance objective.
Alternatives C and E are both located immediately adjacent to the open pit and can therefore readily be incorporated into a pit-centred, site-wide water management system at closure. These alternatives are therefore rated as preferred. Major portions, but not all of the drainage and seepage from Alternative D can be directed to the open pit at closure. Drainage outside of the Pinewood River will have to be pumped to the pit. This alternative is rated as acceptable.

6.6 Processing
6.6.2 Performance Objectives Evaluation

The primary consideration for reclamation related to ore processing is tailings management area reclamation. With the use of the cyanidation process, the treatment of tailings for cyanide destruction in the process plant will reduce cyanide and associated dissolved metals to low levels prior to discharge to the tailings management area. Therefore neither cyanide nor dissolved metals will pose a concern after operations with that process. With use of either gravity concentration or flotation concentration alone, cyanide and associated dissolved metals are not present in the tailings slurry and therefore have no relevance to closure.

The more important considerations in regards to closure are ARD and neutral metal leaching potentials. Neither of which are directly related to the use or non-use of cyanide. The ARD and neutral metal leaching potentials will be affected by the use of flotation concentration, as the process concentrates the sulphide minerals and any associated heavy metals in the smaller volume (10 to 15% by mass) flotation concentrate tailings. Generating a smaller volume of potentially ARD and metal leaching tailings will make this material easier to manage for reclamation purposes. Other suitable measures are however, available to manage tailings which have not been concentrated.

All alternative processing methods lend themselves to reclamation. The flotation concentrate alternative, presents closure opportunities which are preferable to those associated with other alternatives, and this alternative when used in combination with cyanidation is preferred. The other alternatives are rated acceptable.

6.7 Processing Plant Effluent Management 6.7.2 Perfromace Objectives Evaluation

Use of in-plant cyanide destruction using the SO2/Air cyanide oxidation technology will prevent the accumulation of cyanide and metallo-cyanide complexes in the tailings pore water, negating the need for long term seepage collection and water management for these compounds at closure. This technology is therefore rated as preferred. The other two technology alternatives are rated as acceptable.

6.8 Tailings Management
6.8.2 Performace Objective Evaluation

The critical aspect of amenability to reclamation for all of the tailings management area alternatives is the long term management of tailings ARD potentials, as the tailings are PAG. The preferred strategy for managing tailings ARD potentials is to provide a permanent water cover at closure to limit oxygen contact with the tailings solids. If a complete water cover cannot be provided, then the alternative is to provide a water cover / low permeability cover, or low permeability cover alone. Covers are more expensive and are less effective for controlling oxygen exposure. Alternatives A and B lend themselves to development of a complete or partial water cover at closure and are rated as preferred. Alternatives C and D (and particularly D) are less suited to development of a water cover and will require more extensive soil covers, and are therefore rated as acceptable for this performance objective.

6.10 Aggregates
6.10.2 Performance Objects Evaluation

There are no substantive differences between any of the alternatives in terms of their

amenability to reclamation. All alternatives are rated as preferred for this alternative. 6.11 Water Supply

6.11.2 Performance Objectives Evaluation
All of the alternative measures considered herein lend themselves to easy reclamation. Slightly greater efforts will be required to reclaim the pipelines to area lakes. From a project perspective, all alternatives are rated as preferred, since reclamation efforts in all instances will be regarded as requiring limited reclamation.

6.13 Soilid Waste Management
6.13.2 Performance Objective Evaluation

From a closure perspective, offsite disposal to a licensed landfill is the preferred alternative, since this will not involve further project site closure liabilities or considerations. These liabilities are considered in the cost-effectiveness section.

From a broader closure perspective, irrespective of location (since closure and long term monitoring of landfills is required irrespective of whether or not they are linked to mine sites or mine site activities), use or expansion of an existing landfill site will be preferred, as opposed to development of a new site.

6.15 HWY 600 Re-alignment
6.15.2 Performance Objectives Evaluation

The road re-alignment will be transferred to Provincial control, following construction and MTO inspection. There are no plans to reclaim the Highway 600 re-alignment following completion of the RRP and the road re-alignment options have not been assessed for amenability to reclamation.

6.17 Power Supply
6.17.2 Perfromace Objectives Evlauation

On closure the diesel-fired generators will need to be removed along with fuel tanks. Any hydrocarbon affected soils associated with this alternative will be remediated as per regulatory requirements at the time. The transmission line will be removed and the ROW reclaimed through natural vegetation regrowth. Any air quality effects associated with on-site diesel generation will be negated upon cessation of power generation.

6.18 Transmission Line Routing
6.18.2 Perfromace Objective Evaluation

Each of the alternatives could be transferred to Hydro One Networks upon closure to reinforce the Provincial electrical grid, although it is not expected. All four alternatives are equal in amenability to reclamation and are rated as preferred.

6.19 Reclamation and Closure 6.19.1 Open Pit
6.19.1.1 Alternatives

The primary intent of reclamation and closure of the open pit is to achieve a physically safe and chemically stable environment. Based on the Feasibility level pit design, the open pit will have a total void volume of approximately 210 Mm3 to level with ground surface at cessation of mining. The open pit must be closed out in accordance with the Mine Reclamation Code of Ontario (the Code) pursuant to the Ontario *Mining Act*. Section 21 of the Code provides for the following strategies for reclamation and closure of open pits in order of preference: Backfilling (with mineral waste; preferred if feasible);
Flooding (if fully justified);
Sloping (if flooding or backfilling are not appropriate);
Boulder fencing or berming (if all of the above are impractical); and
Chain link fencing (if none of the above is practicable).

The Code also recognizes that different open pit closure strategies may be appropriate at different stages of closure. For example, boulder fence protection may be an appropriate measure until a pit is fully backfilled or flooded.
The Provincially-approved Amended ToR identified the following preliminary closure strategies for reclamation of the open pit:

Natural flooding;
Enhanced flooding; and
Backfilling with mineral waste.
Given the project volume of the open pit, flooding or backfilling will require from several years to several decades depending on the selected closure approach and its application. Installation of fencing alone as a permanent measure is not considered as the open pit will flood naturally once pumping ceases and the groundwater table is reasonably close to surface.

Proven alternative technologies considered for open pit closure are the following:
Natural flooding;
Natural flooding is defined herein to include flooding of the open pit with water that will drain by gravity to the open pit without pumping from external sources or adjustment of the operational water management practices (such as re-direction of creek flows). This will include as a minimum runoff and seepage from the immediate open pit catchment area. It will take an estimated approximate 97 years for the open pit to flood and stabilize at the natural water table level elevation with only these water inputs along with direct precipitation. The water table will reach the top of the bedrock in approximately 68 years (Appendix E, Attachment 1).

The existing predevelopment groundwater table in the open pit area is at or near surface, so it is expected that once fully flooded, the water level in the open pit will be close to the existing ground level. As such, an outlet will be constructed and the flooded pit will eventually overflow to the Pinewood River. The open pit will continue to be dewatered and will not be allowed to flood until underground mining is complete, unless stable bulkheads can be developed to hydraulically separate the open pit from the underground workings. Any such bulkheads will have to be designed to accommodate developing water heads in the flooding pit and as such, is not a preferred approach.

Water that collects in the open pit is expected to be affected by ARD developed from the pit walls and PAG mine rock contained in the east mine rock stockpile. As a result, the quality of this water will have to be managed to ensure that any pit overflow to the environment will be protective of aquatic life in the Pinewood River, the nearest receiver. Experience with other similar, deep pit lakes has shown that once fully flooded, these pit lakes tend to develop a stable chemocline at a depth of about 30 m below surface (Fisher and Lawrence 2006; Gammons and Duaime 2006; Sanchez Espana 2008). A chemocline is relatively sharp transition in pit water quality that occurs as a result of water density gradients and oxygen concentrations. Waters below the chemocline typically show elevated concentrations of parameters such as sulphate, ammonia and metals sensitive to low oxygen concentrations (such as iron and manganese).

Oxygenated waters above the chemocline generally contain low concentrations of these parameters. Various technologies are currently available for enhancing the quality of pit lake surface waters, such as lime addition to precipitate metals (Neil et al. 2009), and growth stimulation of selected bacteria and algae to sequester metals from the upper portion of the water column and to precipitate these to depth (McCullough 2008; Geller et al. 2009). With the natural flooding scenario, there will be no outflow from the open pit for many decades, which will allow more time to optimize pit water chemistry, potentially including the application of technologies not yet available. Should there be a requirement, water within the open pit could be treated either in situ or by means of a water treatment plant to ensure protection of receiving waters with either natural or enhanced flooding scenarios.

The end objective at closure is to produce a surface water overflow from the open pit that will be acceptable for passive discharge to the Pinewood River, with as little active management as feasible. Until such time as the open pit is fully flooded, perimeter fencing (boulder fence, berm or chain link fence) will be required to prevent inadvertent access to the pit.

Enhanced flooding;

Enhanced flooding will accelerate the pit flooding and reduce the time until flooded. Additional water sources that could be used to enhance the natural flooding of the open pit include the tailings management area, stockpile drainages and natural watercourses (West Creek, together with a portion of Pinewood River flows). Enhanced flooding could reduce the length of time for the open pit to flood to the top of bedrock to as little as a few decades depending on the level of water taking from surrounding watercourses deemed acceptable. With moderately enhanced flooding is anticipated to take approximately 54 years to flood to the top of bedrock and 73 years to surface (Appendix E, Attachment 1).

The primary advantages of enhanced flooding are to:
Reduce the risk to the general public from inadvertent access / trespass and resultant injury;
Reduce the time available for ARD development from exposed pit walls; and

Reduce the time to achieve a stabilized, self-sustaining water management

condition.
Principal disadvantages of enhanced flooding of the pit include:

Reduction(s) in watercourse flows and fish habitat while the pit is being flooded (West Creek, runoff to the Pinewood River and direct water taking from the Pinewood River); and

The need to stabilize water quality in the pit more quickly than for natural flooding, in preparation for pit overflow to the Pinewood River.

Partially backfill with tailings; and
Mining of the open pit is expected to be completed in year 10 of operations, followed by an additional approximately five years of underground mining. During this latter period, stockpiled ore from the open pit as well as ore extracted directly from underground will be processed, resulting in approximately 26 Mm3 of tailings solids requiring storage. The tailings during this period could be stored in the open pit rather than in the tailings management area, provided that the underground workings could be effectively sealed, such that there was no chance of inadvertent flooding of the underground workings. A water cover will be retained

over the tailings.
The primary advantages of this alternative are to:

Accelerate the rate of flooding of the open pit, although not substantially; Provide complete water cover / flooding of the tailings;
Reduce the capacity requirements for the tailings management area and
Allow earlier reclamation of the tailings management area, rather than waiting until the completion of operations.

There will also be power savings by pumping tailings from the process plant to the open pit, rather than pumping upgradient through a longer tailings pipeline to the tailings management area.

The critical aspect of this alternative which remains to be verified is the ability to safely separate the open pit from the underground workings at reasonable cost. There is an inherent sensitivity to flooding an open pit while a connected underground mine is actively being worked. Bulkheads may be used to separate the open pit from the underground and may be either natural (leaving a crown pillar of ore in place) or of engineered concrete. The feasibility of developing such bulkheads is a function of the mine design, geology and economics. For the RRP, a sizable crown pillar of ore in the order of 30 to 40 m thick might be required at any location where the underground workings approach the open pit wall to ensure a safe separation. Use of concrete is less likely to be preferred from the technical perspective as the mining process by its nature of explosives use, will fracture the surrounding rock. If there is any chance that the flooded pit with deposited tailings could break into the underground workings, this alternative will have to be rejected for safety reasons. Such an event could reasonably translate to a loss of life for the underground miners.
As this alternative relates to reclamation and closure, it could be retained as an alternative to be considered as a future optimization potential, if the alternative can be proven safe and economic at a later date

Backfill with mine rock and overburden.
Backfilling the open pit with mineral wastes is preferred if feasible. The advantage of backfilling is that the pit can be filled to surface in a comparatively short time (less than a decade), and that PAG mine rock can be permanently stored under water once flooded. It is estimated that the total volume of PAG rock will be in the order of 125 Mm3 (assuming total mine rock production of about 350 Mt and that broken rock has a density of about 2 t/m3). This rock can be placed in the open pit along with a volume of NPAG mine rock and covered with a thick layer (5 m or more) of clay till. The deposited material will then flood to near surface as the water table rises within the backfilled material to permanently seal the PAG mine rock.
The primary disadvantage and limitation of this alternative is cost. The costs for backfilling the 200 Mm3 pit will cost in the order of $1B. This cost is extremely prohibitive which is why the backfilling of large, single open pits generally does not occur. Backfilling is more prevalent at mining projects where multiple pits are present and the double-handling of mineral waste can be avoided. Moreover, in accordance with *Mining Act* financial assurance requirements, the $1B cost will have to be included as part of the closure bond, prohibitively adding to upfront capital costs for financing.

6.19.1.2 Performance Objective and Evaluation
Performance objectives applicable to open pit reclamation and closure are the following:

Cost-effectiveness;
Technical applicability;
Minimize effects (adverse) to the natural environment; and Amenability to reclamation.

A detailed assessment of the alternatives is presented in tabular form in Appendix O, utilizing methodologies, criteria and indicators described in Section 6.2. The following sections summarize results of the detailed assessment.

Cost-effectiveness

Natural flooding will extend site management and related costs to an unnecessarily long timeframe, which will increase overall project costs. Enhanced flooding of the open pit in as little time as reasonably practical while taking into consideration other factors as discussed below, will reduce the long term site management costs.

Partial backfilling of the open pit with tailings along with enhanced flooding is the most attractive alternative from the perspective of investment and overall financially viability. This alternative will not reduce long term site management costs, result in substantial savings in tailings management and will allow the tailings management area to be reclaimed during the operation phase. The critical aspect of this alternative which remains to be verified is the ability to safely separate the open pit from the underground workings at reasonable cost, to ensure that there is no potential for catastrophic flooding of the underground workings under any scenario.

The cost of backfilling the open pit with mineral wastes is estimated at approximately $1B and cannot be supported by the RRP. Therefore from an overall cost-effectiveness perspective, enhanced flooding and partially backfilling of the open pit with tailings, coupled with enhanced flooding, are the preferred alternatives, provided that security of the underground workings can guaranteed in the case of backfilling with tailings. Natural flooding is rated as acceptable and backfilling the open pit with mineral wastes is rated as unacceptable.

Technical Applicability

Each of the technologies considered herein is standard practice in the industry and can be implemented with predictable success, with the exception of tailings disposal in an open pit connected to active underground workings. The partial backfilling with tailings in the open pit during underground mining operations remains to be fully evaluated as technically viable. All of the alternatives are therefore rated as preferred for this performance objective, with the above noted caveat.

Effects to the Natural Environment

Allowing the open pit to flood naturally and at a slower rate will provide for longer term effluent containment without release. This will allow more time to stabilize pit water quality and if needed, more time to potentially implement new technologies that are currently not practical, are unproven, or are unknown. Flooding the pit more slowly will also divert less runoff away from area watercourses, thereby more effectively maintaining fish habitat. The disadvantages associated with this alternative are the exposure of the pit walls to oxidation for a longer period of time and a longer timeline to establish passive site drainage for the open pit.

Flooding the pit more quickly (enhanced flooding) will accelerate the timeline to establish passive site drainage from all parts of the site and will reduce the period of pit wall exposure to oxidation; but this approach will likely have adverse effects on downstream flows and fish habitat. There will also be less time to take advantage of potentially available new technologies. The principal advantage of discharging and storing tailings to the open pit during the final years of operation will be to accelerate reclamation of the tailings management area. This will allow for a more rapid stabilization of passive tailings management area drainage and establishment of terrestrial habitat around the tailings management area perimeter.

Placing all of the PAG mine rock back in the open pit and covering this PAG rock with NPAG mine rock and a clay till (overburden) cap, will remove any long term ARD potential once the system stabilizes. Backfilling the pit with rock and overburden will also allow for the re-establishment of terrestrial habitats in the pit area to support wildlife. From an environmental perspective, this is the overall preferred alternative. The other three alternatives are all rated as acceptable for effects to the natural environment, recognizing that optimization of the pit flooding rate will be required to achieve a balance between the rate of pit flooding and non-interference with downstream water flows and fish habitat.

Amenability to Reclamation

All aspects relevant to amenability to reclamation are discussed in the preceding sections. Backfilling with mine rock and overburden is the preferred alternative. All of the other alternatives are rated as acceptable, recognizing that optimization will be required with the flooding alternatives.

6.19.1.3 Summery Evaluation

The preferred alternatives are enhanced flooding and partially backfilling the open pit with tailings (coupled with enhanced flooding), provided that security of the underground workings can be guaranteed. In either case the rate of enhanced flooding will have to be balanced with downstream flow and fish habitat protection needs. For example, it may not be desirable to fully divert the re-aligned West Creek into the open pit at closure, as a means of accelerating pit flooding. Similarly, once the tailings management area has been reclaimed and tailings management area runoff has been stabilized to the point where it is acceptable for direct discharge to the Pinewood River without the need for any further treatment or management, it may be best from a downstream flow and fish habitat protection perspective to allow this flow to report to the Pinewood River and not to the open pit. Capturing some portion of the Pinewood River flow on a seasonal basis and diverting this flow to the open pit may be acceptable. Discussions with the regulators and other stakeholders will be required to determine the most appropriate mode of flood optimization, together with any adaptive management strategies.

Natural flooding is regarded as an acceptable alternative. Backfilling the open pit with mineral wastes is unacceptable despite the noted environmental advantages, as the cost of this action cannot be supported by the RRP.

6.19.2 Underground Mining 6.19.2.1 Alternatives

Approximately 3.1 Mt of ore and 1.5 Mt of mine rock will be removed from the underground mine (BBA 2013a). At the completion of mining the underground workings must be closed out in accordance Ontario Regulation 240/00, Amended O. Reg. 307/12. Subsection 24(2) of the Regulation specifies the following in relation to the closure of underground workings:

All ... mine openings to surface that create a mine hazard shall be stabilized and secured; and

All surface and subsurface mine workings shall be assessed by a qualified professional engineer to determine their stability, and any surface areas disturbed or likely to be disturbed by such workings shall be stabilized.

securing underground openings is typically achieved using reinforced concrete caps for shafts and vent raises, or other measures such as backfilling underground portals, as specified in the Code. If underground workings near surface are determined through engineering assessment to present a possible stability hazard such as possible future collapse of a crown pillar, the underground workings in question must be mitigated in accordance with the engineering assessment. Typically such remediation will involve backfilling underground stopes below the crown pillar with mine rock or other fill materials.

The Code also recognizes that different underground closure strategies may be appropriate at different stages of closure; for example, the use of fence protection as an interim measure.

The Provincially-approved Amended ToR provides for the following preliminary closure

strategies for reclamation of the underground workings: Natural flooding;

Enhanced flooding; and

Backfilling with mineral waste.
As with securing of the open pit, the primary intent of underground closure is to achieve a physically safe and chemically stable environment.

In the case of backfilling, backfilling of the underground workings as a general closure strategy is considered separate from any site specific backfilling that might be needed to stabilize near surface workings, such as crown pillars that may pose a safety hazard.

Natural Flooding

Natural flooding will involve allowing the underground workings to flood on their own, without water being actively pumped to the underground. Under a natural flooding scenario, deeper portions of the underground workings will be expected to flood within a few years, but upper portions of the underground workings will not become fully flooded until the open pit is flooded, as the water table within the underground workings will ultimately be controlled by the water table in the adjacent and overlying open pit. Flooding the open pit could take up to approximately 97 years (Section 6.18.1; Attachment 1 in Appendix E).

Enhanced Flooding

Enhanced flooding will reduce the length of time until the underground workings are flooded. Enhanced flooding could reduce the overall underground (and open pit) flooding time to as little as a few decades (Section 6.18.1; Attachment 1 in Appendix E). Additional water sources that can be used to flood the underground (and open pit) comprise all areas of site development including the tailings management area, stockpile drainages and West Creek, together with a portion of the Pinewood River flows.

The principal advantage of flooding the underground more aggressively will be to reduce the time available for ARD development from exposed underground working faces. Principal disadvantages associated with flooding the underground (and pit) more aggressively include: reductions in watercourse flows and fish habitat while the mine workings are flooding. Further details are provided in Appendix E (Attachment 1). With the natural flooding scenario, described above, there will be no outflow from the underground workings (and the open pit) for several decades, as groundwater and localized surface runoff will flow towards the workings.

If the underground workings were to be sealed off from the open pit, for any reason, as part of active mining, then the underground workings could be actively flooded much more quickly.

Backfill with Mineral Wastes

A substantive portion, but not all, of the underground workings will be filled with crushed mine rock backfill during mining operations. Backfilling during mining is required to provide structural stability. Without the use of backfill, it will not be feasible to effectively mine the entire underground ore body with planned mining methods.

6.19.2.2 Performace objectives and Evaluations
Performance objectives applicable to underground mine closure are the following:

Cost-effectiveness;
Technical applicability;
Minimize effects (adverse) to the natural environment; and Amenability to reclamation.

A detailed assessment of the alternatives is presented in tabular form in Appendix O, utilizing methodologies, criteria and indicators described in Section 6.2. The following sections summarize results of the detailed assessment.

Cost-effectiveness

Allowing the underground workings to flood passively is standard industry practice, has no added costs and does not confer any undue liabilities or risks. Enhanced flooding of the underground workings will only be effective if secured bulkheads were established to hydraulically isolate the underground workings from the open pit; otherwise any water added to the underground workings will simply equilibrate with the open pit water level. Additional costs will be incurred to construct the bulkheads and to pump water to the underground, with little benefit. Partial backfilling of the underground workings with mine rock is required in any event to support mining. Complete backfilling of the underground workings with crushed mine rock is not financially viable and will serve no water quality control purpose, as the void spaces within the mine rock backfill will not flood until the water level rises in the open pit. Natural flooding is therefore the preferred alternative. Enhanced flooding is considered acceptable. Complete backfilling is not proposed and is considered unacceptable.

Technical Applicability

Natural and enhanced flooding are both technically feasible. Natural flooding is a common practice within the industry. Both are rated as preferred for this performance objective. Partial backfilling of the underground workings with crushed mine rock will occur during operations, as described above, but it will be technically difficult to backfill the entire underground workings. This alternative is rated as unacceptable.

Effects to the Natural Environment

The total volume of the underground workings is expected to be in the order of 1.8 Mm3, which represents less than 1% of the projected open pit volume. The underground workings will be connected to the open pit unless bulkheads are put in place to hydraulically isolate the underground workings from the open pit. Whether or not the underground workings flood naturally or in an enhanced manner, or are backfilled, will have little effect on overall water management at the site during mine closure; and hence little effect on site effluent discharge quality, receiving water quality or receiver fish habitat.

All alternatives are rated as preferred for this performance objective.

Amenability to Reclamation

Whether or not, the underground workings are flooded passively or in an enhanced manner or are backfilled, will have a negligible effect on site environmental conditions following closure.

All alternatives are rated as preferred for this performance objective.

6.19.2.3 Summary
Natural flooding of the underground workings is the preferred alternative based principally on costs. Enhanced flooding is rated as acceptable. Complete backfilling of the underground workings will be technically difficult, costly and will serve no purpose.

6.19.3 Stockpiles 6.19.3.1 Alternatives

There are four primary stockpiles associated with the RRP: West mine rock stockpile;
East mine rock stockpile;
Overburden stockpile; and

Low grade ore stockpile (Section 4.6).
The mine rock stockpiles and overburden stockpile will be present at the cessation of mining and processing operations at the RRP, although a substantive volume will be re-used for construction, development and reclamation purposes.

The low grade ore stockpile will contain that portion of the low grade ore generated from the open pit during the first approximately 10 years of mining that is not directly processed. It will be processed during the latter third of the mine life along with ore generated from the underground mine. There is no intent for the low grade ore stockpile to remain at closure. If the economics are such that the low grade ore cannot be viably processed, the low grade ore stockpile will be reclaimed in a manner consistent with the east mine rock stockpile, unless it can be demonstrated to be NPAG.

At the completion of mining the mineral waste stockpiles must be closed out in accordance with Ontario Regulation 240/00, amended O. Reg. 307/12, and the Code of the Ontario *Mining Act*. Section 24(2) of Regulation states the following:

All tailings, rock piles, overburden piles and stockpiles shall be rehabilitated or treated to ensure permanent physical stability and effluent quality.

Section 59 (2) of the Code states the following:

In order to ensure the chemical and physical stability of the ML or ARD generating materials and that the quality of the environment is protected, the management plan [for waste rock stockpiles] shall consider, where appropriate,

The design and construction of covers and diversion works; and

The use of passive and active treatment systems. Section 71 of the *Code* states the following:

When revegetating waste rock storage areas ... or other steeply sloped features,the following specific measures shall be considered, where appropriate:

Contouring to mimic local topography and blend into surrounding landscape. The application of soil to a depth sufficient to maintain root growth and nutrient requirements
The incorporation of organic materials, mulches and fertilizers based upon soil assessment.

The scarification or ripping of flat surfaces which may have been compacted by

heavy equipment.

Improving site drainage to prevent water erosion on rehabilitated areas.

The Provincially-approved Amended ToR provides for the following preliminary closure

strategies for reclamation of the RRP overburden and mine rock stockpiles: Re-use during construction;

Stabilize and cover / revegetate; Use in backfill; and
Engineered cover.

These alternatives are not necessarily mutually exclusive and are frequently used in combination with one another.
Re-use

An estimated 16 Mt of overburden and mine rock will be needed for site construction works, with the majority of this material being required for the construction of tailings dams and other RRP impoundment structures. An additional volume of overburden will be required for site reclamation. There are more than sufficient mineral wastes generated from the development of the open pit to provide the required materials.

Stabilize and Cover / Revegetate

For overburden and NPAG mine rock stockpiles, the standard reclamation approach is to contour the stockpiles either progressively during operation or at closure, and then to develop a stabilizing vegetative cover that will ultimately provide for other uses such as wildlife habitat. For he west mine rock stockpile, a layer of overburden will typically be applied over all or part of the stockpile, potentially organics or topsoil to assist with plant growth. Seed will be applied to initiate a ground cover, along with tree seedlings and shrub plantings, as appropriate to support wildlife.

Use in Backfill

Underground mining typically requires a quantity of backfill to fill underground voids after the ore has been removed to provide structural stability, which then allows the mining of adjacent areas. Without the use of backfill, it will not be feasible to effectively mine the underground RRP ore body with planned mining methods. Crushed rock fill is a common backfill material, although other materials are possible. Rock backfill material can consist of NPAG or NPAG materials and will be available over the entire underground mine life.

Engineered Cover

Engineered or composite covers may be used on mine rock stockpiles to control ARD development, as well as to provide for overall stockpile stability and wildlife habitat or other functions. The purpose of the engineered cover for ARD management is to limit precipitation and oxygen contact with the underlying reactive (PAG) material. Details of the engineered cover proposed for the RRP PAG stockpile are provided in Appendix E. Even with use of a well engineered cover, there will still be some precipitation infiltration into the stockpile that will discharge from the toe of the stockpile as seepage. This seepage will have to be collected and managed for potential ARD elements. The quantity and quality of this seepage will;

however, be vastly improved compared with that derived from use of a simple overburden

cover.

6.9.3.2 Performance Evalaution and Objectives

Performance objectives applicable to overburden and mine rock stockpile closure are the following:

Cost-effectiveness;

Technical applicability;
Ability to service the site effectively;
Minimize effects (adverse) to the natural environment; Minimize effects (adverse) to the human environment; and Amenability to reclamation.

A detailed assessment of the alternatives is presented in tabular form in Appendix O, utilizing methodologies, criteria and indicators described in Section 6.2. The following sections summarize results of the detailed assessment.

Cost-effectiveness

The most cost-effective management approach for overburden and mine rock resulting from the mine development is to utilize these materials for site construction, in underground mine backfill to the extent required to support mine operations and in reclamation, and then to contour and cover any remaining stockpiled material. Where such mineral wastes are needed and can be utilized, it is the most cost-effective to re-use these materials rather than to extract aggregate from another source. There are no plans to use stockpiled mineral wastes for open pit backfill (Section 6.18.1).

In regards to reclamation, the most cost-effective alternative is to develop a simple cover over both the west and east mine rock stockpiles. Development of a simple cover for reclamation of the east mine rock stockpile could potentially be more costly in the longer term, if ARD conditions were to develop. This could also present a risk for obtaining environmental approvals and negatively affect investor confidence.

Alternatives are therefore preferred from the cost perspective for selective uses as follows: Re-use during construction to the extent feasible based on site demand; Stabilize and cover / revegetate for overburden and west mine rock stockpiles only;

Use in backfill for underground mining only; and
Engineered cover for the east mine rock stockpile and any remaining ore stockpiles.

Technical Applicability

In regards to technical applicability, overburden and NPAG mine rock are preferentially used for construction. Mine rock (NPAG or PAG) is preferentially used for underground mine backfill and are preferred alternatives to the extent that materials are required. Simple covers are preferred for reclamation of NPAG rock stockpiles together with revegetation. Overburden stockpiles generally require revegetation. Engineered covers are being used increasingly in the industry to better control ARD development, and are preferred for PAG mine rock and for any low grade ore that might be left on surface at closure.

All alternatives are therefore preferred for selective uses from the technical perspective as follows:

Re-use during construction to the extent feasible based on site demand; Stabilize and cover / revegetate for overburden and west mine rock stockpiles only;

Use in backfill for underground mining only; and

Engineered cover for east mine rock and any remaining ore stockpiles.

Ability to Service the Site Effectively

Overburden and NPAG mine rock are proposed to be used preferentially for site construction rather than development of separate aggregate pits and quarries where materials are of equivalent utility. PAG mine rock may be acceptable for selected construction functions where there is limited risk of long term exposure to oxygen, such as internal access roads within the developing overburden stockpile. Mine rock is commonly used for underground backfill, and will be readily available when needed. Re-use during construction and use in backfill, are therefore preferred for the respective and limited uses discussed above. The ability to service the site effectively performance objective is not applicable to the alternatives of stabilize and cover / revegetate and engineered cover.

Effects to the Natural Environment

Utilization of a portion of mine mineral wastes for construction will reduce the volume and footprint of mineral waste stockpiles, and will reduce potential disturbance associated with obtaining construction materials from other sources. However, as noted above, only a small portion of mineral wastes can be disposed of in this manner. Utilization of a portion of mine mineral wastes for underground backfill will also reduce the volume and footprint of mineral waste stockpiles, and will reduce potential disturbance associated with obtaining backfill from other sources. Only a very small portion of the mineral wastes can be disposed of in this manner.

The bulk of the RRP mineral wastes must be reclaimed per Provincial mine closure planning requirements. Stabilize and cover / revegetate, and engineered cover will limit the release of suspended solids loadings to receiving waters and provide habitat for plant and animal species including SAR species. Use of an engineered cover will also inhibit ARD development and any associated metal loadings to receiving waters.

All alternatives are preferred from the perspective of natural environment effects for selective uses as follows:

Re-use during construction to the extent feasible based on site demand;

Stabilize and cover / revegetate for overburden and west mine rock stockpiles only;

Use in backfill for underground mining only; and

Engineered cover for the east mine rock stockpile and any remaining ore stockpiles.

Effects to the Human Environment

The use mine mineral wastes for construction and underground mine backfill will contribute to a reduction in overall mineral wastes that will otherwise need to be stockpiled on surface.

Revegetation of mineral waste stockpiles at closure will improve area aesthetics, and potentially contribute to local hunting and other outdoor recreational opportunities. Use of an engineered cover to better control ARD development from PAG rock will help to maintain receiving water quality and associated aquatic resources.

All alternatives are preferred from the perspective of human environment effects for selective uses as follows:

Re-use during construction to the extent feasible based on site demand; Stabilize and cover / revegetate for overburden and west mine rock stockpiles only;

Use in backfill for underground mining only; and

Engineered cover for the east mine rock stockpile and any remaining ore stockpiles.

Amenability to Reclamation

All alternatives are preferred from the perspective of reclamation for selective uses as follows:

Re-use during construction to the extent feasible based on site demand; Stabilize and cover / revegetate for overburden and west mine rock stockpiles only;

Use in backfill for underground mining only; and

Engineered cover for the east mine rock stockpile and any remaining ore stockpiles.

6.19.3.3 Summary
The alternatives considered herein are complementary to one another, and all alternatives are preferred for selective uses as per the following summaries.

Re-use during Construction and Use in Backfilling Operations

An estimated 16 Mt of overburden and NPAG rock will be required for tailings dam and other related construction, together with an estimated approximately 1.5 Mm3 of mine rock for underground mine backfill (subject to final design). Additional mine rock is also likely to be used for other site construction purposes such as for the development and maintenance of site roads. Therefore an estimated 5 to 10% of projected mineral wastes will be used to meet

Stabilize and Cover / Revegetate and Engineered Cover

For overburden and west mine rock stockpiles, the preferred reclamation approach is to stabilize the slopes of the stockpiles, and to cover mine rock with overburden in order to develop a self-sustaining vegetative cover. The preferred alternative for east mine rock stockpile (andunprocessed ore stockpile on surface at closure, if any) is to develop an engineered cover to better manage the potential for ARD development.)

6.19.4 Tailings Management Area 6.19.4.1 Alternatives

During the operation phase, the tailings management area will consist of a larger tailings solids repository and an associated internal tailings pond. At closure, the tailings management area is expected to contain an estimated 115 Mt of tailings solids, which will take the form of a wide perimeter beach of exposed tailings, occupying approximately 90% of the basin footprint, together with a smaller central tailings pond occupying approximately 10% of the basin. As the tailings solids are PAG, they must be isolated from exposure to oxygen at closure to prevent ARD development. Oxygen exclusion can be achieved through development of an approximately 2 m or greater water cover, or by means of an approximately 2 m or greater low- permeability overburden (or other) cover. Either alternative will keep the tailings solids saturated, restricting oxygen transport within the tailings pore spaces, and will act as a diffusion barrier restricting oxygen in the atmosphere from contacting the tailings surface.

The tailings dams and associated spillway(s) will be stabilized during operations for long term performance, with periodic inspections by a qualified engineer in accordance with regulatory requirements.
At the completion of mining the tailings management area must be closed out in accordance with Ontario Regulation 240/00, amended O. Reg. 307/12, and the Code. Section 24(2) of Regulation states the following:

All tailings, rock piles, overburden piles and stockpiles shall be rehabilitated or

treated to ensure permanent physical stability and effluent quality.

Sections 35 and 36 of the Code state:

The objective of this Part of the Code is to ensure the long term physical

stability of tailings dams and other containment structures.
The procedures and requirements set out in the Dam Safety Guidelines

published by the Canadian Dam Safety Association shall be given due regard by all persons engaged in the design, construction, maintenance and decommissioning of tailings dams and other containment structures.

Section 72 of the Code states:

When revegetating tailings surfaces, the following reclamation measures shall be considered, where appropriate:

Contouring to provide accessibility and good surface drainage while controlling surface erosion.
Removing any crests prone to wind erosion or creating/planting live wind breaks.

The scarification or ripping of crusted surfaces
The incorporation of organic materials and mulches.
Correcting the pH and adding fertilizer based upon soil assessment and vegetation requirements.
Applying soils or a gravel barrier.

The Provincially-approved Amended ToR provides for the following closure strategies for reclamation of the tailings management area:

Stabilize and permanent flooding;

Cover with mineral wastes and revegetate;
Stabilize and permanent flooding / cover with overburden and revegetate; and Cover with modified mineral waste and revegetate.

These various closure strategy alternatives are not necessarily mutually exclusive, and are frequently applied in combination with one another.

Stabilize and Permanent Flooding

The intent of flooding PAG tailings is to restrict oxygen contact with the tailings, thereby preventing the development ARD. ARD occurs when oxygen in combination with moisture reacts with sulphide materials present in the tailings to generate sulphuric acid which then acts to leach any metals present in the tailings. The water cover acts as an oxygen diffusion barrier between the overlying atmosphere and the underlying tailings. Some oxygen will be transferred from the atmosphere through the water cover to the flooded tailings solids surface, but quantities will be limited provided that the water cover is of sufficient depth. Industry experience has shown that a water cover of approximately 2 m or greater will provide an effective oxygen diffusion barrier. The second function of the water cover is to ensure that the underlying tailings remain saturated. Saturation restricts oxygen diffusion within the tailings pore spaces. The water cover should be of sufficient depth that it does not diminish to excessively low levels during periods of prolonged drought (or this effect is otherwise mitigated).

The major limitation to using water covers as the sole means of oxygen restriction is that this strategy requires the impoundment of considerable volumes of water in order to flood all exposed tailings beaches. In the case of the RRP, it is expected that the tailings beaches will form at an approximate slope angle of 1%. Therefore with exposed beach lengths in the order of 1 km at closure, the tailings basin pond level will have to be raised by about 12 m from the operating level condition to flood all exposed beaches. This results in a considerable volume of water being impounded in perpetuity, and will pose a long term dam stability risk, particularly

if ponded water is against the tailings dams.

Stabilize and Cover with Mineral Wastes and Revegetate

Low permeability overburden covers also provide an effective oxygen barrier. The cover needs to be thick enough and of appropriate material, such that they do not form deep desiccation cracks that will allow oxygen transport.

The principal limitations for developing a complete overburden cover are costs and the geometric limitations presented by the tailings surface. Covering a tailings surface of approximately 8 km2 to a depth of 2 m will therefore cost an estimated $80M, excluding costs for revegetation. The tailings surface geometry will also pose a concern. In order to drain the tailings pond which will be near the centre of the facility during operations, a substantial wedge of tailings will have to be removed in order to establish a drainage way / spillway.

Stabilize and Permanent Flooding / Cover with Overburden and Revegetate

This alternative is a combination of the two alternatives described above, whereby a central portion of the tailings surface will have enhanced flooding at closure by raising the operating pond surface; but the pond surface will not be raised to the extent that ponded water will contact the perimeter dams. Instead a perimeter zone of exposed tailings beach will be maintained, to keep the central pond away from the dams. This zone of exposed tailings beach and a contingency area where the water cover might not be retained during drought conditions will be covered with a low permeability layer of overburden. A drainage way / spillway will connect the central pond with the tailings management area perimeter as described for the complete cover scenario above, but the cut through the tailings solids in this case will be much smaller.

Cover with Modified Mineral Waste and Revegetate

This alternative involves placement of a depyritized tailings cover over the tailings surface. To produce depyritized tailings which are NPAG, a flotation circuit will be added to the milling process to remove the sulphide fraction of the tailings solids as a sulphide concentrate (typically about 10 to 15% of the tailings mass). The smaller quantity sulphide concentrate can be buried in the tailings management area, while the remaining 85 to 90% of the tailings which are non-reactive, could be placed as a chemically stable, NPAG cover over the PAG tailings produced during the majority of operations. The depyritized tailings cover will form an oxygen barrier similar to that described for the low permeability overburden cover. It will take approximately 3 years of processing to develop a cover of suitable thickness and uniformity. A soil cover will still be required on top of the depyritized tailings to support plant growth.

Developing a flotation circuit to generate a depyritized tailings cover for closure, that will still require an overlying soil cover for plant growth is not considered economic, or otherwise competitive with the alternatives described above, and is not considered further.

6.19.4.2 Performace objectives and Evaluation
Performance objectives applicable to reclamation and closure of the tailings management area are the following:

Cost-effectiveness;
Technical applicability and/or system integrity and reliability; Minimize effects (adverse) to the natural environment; and Amenability to reclamation.

A detailed assessment of the alternatives is presented in tabular form in Appendix O, utilizing methodologies, criteria and indicators described in Section 6.2. The following sections summarize results of the detailed assessment.

Cost-effectiveness

The most cost-effective approach to tailings management area closure will be to provide a water cover, as the perimeter tailings dams will already have been constructed to a height near to that required to support such a cover during mine operations (an additional approximately 12 m height is required). Developing a 2 m average thickness overburden cover over the entire tailings surface will cost an estimated $80M. The RRP cannot support such a cost, particularly as all or most of this cost will have to be posted early on as part of the Closure Plan financial assurance. Development of a complete overburden cover is therefore uneconomic, and is unacceptable. There is a potential concern with the long term risk of maintaining a complete water cover that also makes this alternative unacceptable from project financing / risk perspective, in addition to the extra costs of raising the dams. The preferred alternative is therefore a blending of the two alternatives, whereby a substantial portion of the tailings surface will be flooded at closure, supported by perimeter covered tailings beach around the tailings management area periphery to keep the central tailings pond away from the perimeter dams in the long term.

Technical Applicability and/or System Integrity and Reliability

Each of the alternatives is predictably effective in the ability to control ARD potentials, but provision of a complete water cover is rated as acceptable because there is greater risk associated with maintaining a large volume of ponded water against the tailings dams in perpetuity. The other two alternatives (low permeability cover and combined overburden / water cover) are rated as preferred for this performance objective.

Effects to the Natural Environment

All alternatives are capable of preventing the development of ARD and of protecting downstream wetlands and receiving waters. The principal limitation to use of the water cover alternative on its own is that it will not generate terrestrial habitat that will be capable of supporting plant and wildlife species. In contrast, the full overburden / soil cover alternative will generate an extensive area of terrestrial habitat (approximately 8 km2), once the tailings management area is fully restored, that will be capable of supporting plant and wildlife species. The mixed cover alternative (pond and perimeter overburden zone) will be capable of supporting terrestrial and wetland plant and wildlife species. The full water cover alternative is rated as acceptable, and the remaining two alternatives (low permeability cover and combined overburden / water cover) are rated as preferred.

Amenability to Reclamation

All alternatives proposed are capable of preventing the development of ARD and protecting downstream wetlands and receiving waters. The principal limitation to the complete water cover alternative is that it will not generate terrestrial habitat that will be capable of supporting plant and wildlife species and that it presents a greater long term potential risk. This alternative is rated as acceptable.

Development of a low permeability cover and combined overburden / water cover pose less long term potential risk because there will be no ponded water against the tailings dams and provide habitats that will support plant and wildlife species, potentially including SAR. Both of these alternatives are rated as preferred for this performance objective.

6.19.4.3 Summary

Establishment of a complete water cover alternative will be effective for ARD control and is the most cost effective alternative. This alternative carries an inherent long term potential risk because the ponding of water against the tailings dams is not preferred with respect to geotechnical stability, and unlike the other two alternatives will not provide any appreciable terrestrial or wetland habitat at closure. This alternative was consequently considered unacceptable overall. The complete overburden cover will also be effective for ARD control, will provide terrestrial habitat and will be associated with low risk; but this alternative will be prohibitively expensive, and is therefore also unacceptable. The combined alternative consisting of an enlarged central ponded area, surrounded by a perimeter zone of tailings covered with overburden, provides the best balance of environmental protection, cost and risk,

and is therefore the preferred alternative. 6.19.5 Building and Equipment

Principal buildings and related structures on the RRP site will include the following: Ore process plant;

Primary crusher;
Coarse ore stockpile transfer house; Administration building;
Mine office and dry;
Maintenance shop, warehouse; Truck wash; and
230 kV substation.

There will also be other minor buildings associated with the explosive manufacturing facility, security and pump houses.

Primary equipment will comprise:
Crushers and processing equipment housed at the primary crusher and in the

process plant;
Various conveyors, including linking the primary crusher, coarse ore stockpile

transfer house and the ore process plant;
Mobile heavy equipment (diesel and electric shovels, excavators, bulldozers, haul trucks, loaders, jumbos, bolter, load haul dump (LHD) vehicles, scissor lifts, crane trucks, grader, diamond drill, explosives loader, etc.);

Pumps / pump stations;
Underground ventilation equipment;
Electrical equipment associated with the substation and other facilities; and Other miscellaneous equipment.

The Provincially-approved Amended ToR provides for the following preliminary alternatives

for the disposal of buildings and equipment:
Destruction, removal and/or disposal according to applicable regulations; and Re-use of acceptable buildings and equipment.

Subsection 24(2) of O. Reg. 307/12 of the Ontario *Mining Act* states the following:
All buildings, power transmission lines, pipelines, waterlines, railways, airstrips and other structures shall be dismantled and removed from the site to an extent that is consistent with the specified future use of the land.

ll machinery, equipment and storage tanks shall be removed from the site to an extent that is consistent with the specified future use of the land.

It is generally interpreted that buildings and equipment, or parts thereof, that are not suitable for re-sale or re-use offsite, or for sale as scrap, can be permanently stored in an approved landfill on the mine site, in accordance with a site-specific Provincial approval (Environmental Compliance

Approval). Hazardous materials such as gear boxes containing petroleum products must be shipped to a licenced landfill capable of receiving such materials.

The two alternatives listed above are not mutually exclusive in that the offsite shipment of buildings and equipment or parts thereof, or scrap derived from such materials, is feasible only where markets for such materials are available. There is no guarantee that such a market will be available at the time of closure. Where markets for such materials are not available, and where these materials are non-hazardous, such materials will be landfilled onsite. Given this context, there are no building and equipment removal / disposal alternatives in the general sense of alternatives assessed elsewhere in this document. Rather, a blend of both alternatives will be implemented in accordance with available market conditions at the time of mine closure and applicable regulatory requirements.

The development of detailed tabular evaluations of performance objectives, criteria and indicators (per Appendix O), is therefore not appropriate to this set of alternatives, and has not been carried out.

6.19.6 Infrastructure 6.19.6.1 Alternatives

The principal RRP site infrastructure components include roads, pipelines (and associated pump stations and facilities) and transmission / power distribution lines. Alternatives relating to the decommissioning of these items as provided in the Provincially-approved Amended ToR are the following:

Decommission and remove and dispose of wastes in accordance with applicable

regulations;
Leave in place for future use; and

Reclaim in place. RRP-related roads are expected to include:

Re-aligned Highway 600; East Access Road;
Site haul roads; and

Site service roads.
RRP-related pipelines are expected to include:

Tailings discharge and reclaim lines; Final effluent discharge water line(s); and Other internal site water transfer lines.

RRP-related transmission lines are expected to include:
230 kV connecting line to the Provincial grid; and

Smaller capacity distribution lines for routing power arou
At the completion of mining site infrastructure must be closed out in accordance Ontario

Regulation 240/00, as amended by O. Reg. 307/12. Subsection 24(2) of the Regulation specifies the following in relation to roads, pipelines and transmission lines:

All buildings, power transmission lines, pipelines, waterlines, railways, airstrips and other structures shall be dismantled and removed from the site to an extent that is consistent with the specified future use of the land.

All transportation corridors shall be closed off and revegetated to an extent that is consistent with the specified future use of the land.

Since all RRP pipelines will have functions specific to the RRP, these pipelines have no reasonable potential value to other possible future land uses. The only alternative consistent with the Regulation is therefore to remove and dispose of the pipelines (in an onsite demolition landfill) once the pipelines are no longer required for site reclamation activities. Leaving the pipelines in place for future use, and/or reclaiming the pipelines in place, are not viable alternatives and are not considered further.

Similarly, it is expected that the 230 kV connecting line to the Provincial grid; and the smaller capacity distribution lines for routing power around the RRP site, will only have value to the RRP. In such an instance, the only alternative consistent with the Regulation is to dismantle the transmission / distribution lines and towers, cut the poles at the ground surface, and dispose of the materials in an onsite demolition landfill once power is no longer required for site reclamation activities. Preferentially, the poles and conductor will be re-used or recycled if possible. Substations will also require dismantling with associated materials either re-used or recycled if possible, or landfilled onsite. Leaving the 230 kV transmission line in place for future use and/or reclaiming the power infrastructure in place, are not viable alternatives and are not considered further. If a user was identified in the future that is willing to take over the 230 kV transmission line, substation and associated site distribution lines, the favoured alternative of decommissioning and disposal will need to be revisited.

The intent is that the re-aligned Highway 600 will become a permanent part of the regional road network. Reclamation is not proposed. Removal and disposal, or reclaiming in place are not viable alternatives and are not considered further.

The East Access Road will remain in place to access the RRP site as well as the limited number of properties on Marr Road. These roadways will become permanent and will be left in place for future use. Removal and disposal, or reclaiming in place are not viable alternatives and are not considered further.

Site haul roads and site service roads have a greater flexibility for potential future potential uses, and could therefore be either left in place for future use, or reclaimed in place. These roads are proposed to be reclaimed in place once they are no longer required to site maintenance and monitoring. The option of leaving the roads in place for use by others could be revisited at a later date.

6.19.6.2 Performace Evalauation
Based on discussion of the alternatives presented above, there are no real alternatives to dismantling and removing project-related pipelines and transmission lines once they are no longer needed. Similarly there are no alternatives other than to retain the function of the re-aligned Highway 600 and the new East Access Road. The only viable alternative consistent with the Regulation is to reclaim the site haul and service roads in place once they are no longer needed for Closure Plan implementation or site maintenance and monitoring.

The development of detailed tabular evaluations of performance objectives, criteria and

indicators, as per Appendix O, is therefore not appropriate to this set of alternatives, and has

not been completed. 6.19.6.3 Summary

Based on the above, the preferred alternatives are to dismantle and removing all project-related pipelines and transmission lines once they are no longer needed for Closure Plan implementation; to retain permanent use of the re-aligned Highway 600 and the new East Access Road; and to reclaim mine site area roads in place.

6.19.7 Drainage 6.19.7.1 Alternatives

RRP site drainage modifications include the installation of road culverts, ditching, various ponds, and the re-alignment of West Creek and Clark Creek. Alternatives relating to surface drainage restoration at closure, included in the Provincially-approved Amended ToR, are the following:

Stabilize and leave in place; and

Removal and restoration.
Culverts will be used to support site road development as required for cross-drainage control. Culverts will be left in place until the roads they service are no longer required and will be removed thereafter.

Ditching at the RRP site includes: Road-side ditching; and

Ditching to meeting Metal Mining Effluent Regulation effluent collection and management requirements.

Various ponds are present at the RRP site and include: Water management pond;

Mine rock pond;
Stockpile pond;
West Creek pond;

Water discharge pond and associated constructed wetland complex; and Terminal collection ponds associated with Metal Mining Effluent Regulation ditching.

Subsections 71(1), (5) and (7) of the Code state the following relative to site preparation and drainage controClofnotrofuirnianlgctlosmuriem,ircelsopceacltitvoeployg: *raphy and blend into the surrounding*

Improving site drainage to prevent water erosion on rehabilitated areas. Contouring and sloping of impoundment areas must be integrated with engineering design.

The general preference is to remove drainage features, and to contour and restore the associated lands wherever possible, unless the drainage features in question are integral to overall site water management following closure. Otherwise it will be the responsibility of the proponent to continue to monitor the function and stability of any such drainage features in accordance with Section 66 of the Code, and in accordance with Metal Mining Effluent Regulation requirements.

Ditching

The alternatives for road-side ditching are to stabilize and leave the ditches in place, or to backfill the ditches once the roadways in question are no longer needed. Roadside ditches will stabilize with vegetation over the course of the mine life, and will not pose a flood risk once the associated road culverts are removed. Backfilling the roadside ditches will therefore serve no purpose and is not proposed. The ditches will be left in place with any associated culverts removed.

Metal Mining Effluent Regulation ditching is needed to achieve compliance with the Regulation. Regulation-related ditching will therefore be left in place until such time as it can be demonstrated that Metal Mining Effluent Regulation monitoring of the involved mine component is no longer required. Once the mine becomes a recognized closed mine, regulation-related ditching will be stabilized and left in place, the same as for roadside ditching. Backfilling the Metal Mining Effluent Regulation ditches will serve no purpose and is not proposed.

Ponds

The water management pond will no longer be required once the tailings management area is fully reclaimed and is capable of generating a runoff of acceptable water quality, or it is directed to the open pit to assist with pit flooding. At such time maintaining water holding dams will create an unnecessary RRP liability. The water management pond dams will therefore be breached to prevent retention of water. Upstream dam faces that become exposed will be revegetated. The alternative of stabilizing and maintaining the water management pond in the long term will serve no purpose, and is not proposed.

The water discharge pond dam will be similarly breached once it no longer has a water management function.

The berms used to develop the constructed wetland will however, be left in place as this system will be designed to operate passively, and will have stabilized as a wetland complex during operations. The alternative of removing these berms at closure could prove problematic, as any such action could cause a sudden release of wetland sediments and associated metals to the Pinewood River.

The major function of the stockpile pond during mine operation will be to help prevent excess runoff from entering the open pit. As described above, once mining operations are completed, the intent will be to flood the pit as quickly as practicable. Maintaining the stockpile pond after mining is completed will therefore serve no function. The stockpile pond dam will be breached and the associated runoff directed to the pit. The alternative of maintaining the pond is rejected.

The principal function of the West Creek pond during operations will be to provide a freshwater source. The West Creek pond is also expected to comprise part of the RRP fish habitat compensation package. Once processing ceases, the West Creek pond will no longer have a water supply function, but it will still have a fish habitat compensation function and it will be retained as fish habitat.

The function of the mine rock pond is more complex. During operations, this pond will collect runoff and seepage from the east mine rock stockpile, as well as from open pit and underground dewatering. The accumulated water will be the primary water source for processing, with any excess water to be pumped to the tailings management area. At closure, the only water reporting to the mine rock pond will be runoff and seepage from the east mine rock stockpile which will then be directed to the open pit to help flood the pit, and to help manage site runoff and seepage. At closure there will likely still be some value in maintaining the mine rock pond, but the quantity of ponded water could be considerably reduced. The preferred alternative is to lower the dam, and stabilize in place.

Terminal ponds associated with Metal Mining Effluent Regulation ditching will be maintained until such time as the site or if applicable, individual site components become a recognized closed mine. At such a time, any applicable pond impoundment structures will be breached and the residual pond sites will be stabilized and restored.

Re-aligned West Creek and Clark Creek

West Creek and Clark Creek will be re-aligned as part of mine development to avoid direct drainage to the open pit and through the east mine rock stockpile, respectively. Over the course of mine development the re-aligned creek will become stabilized. The re-aligned creeks may also become part of the RRP fish habitat compensation works, and as such the intent at closure will be to leave the re-aligned creeks in place. Restoration of the original creek alignments is therefore not proposed.

6.19.7.2 Performace Objective and Evaluation

For ditching, the alternatives are to stabilize and leave in place, or to remove and restore. Removal will entail backfilling the ditches which will serve no purpose. Gradients at the RRP are sufficiently flat, such that there is no realistic potential for erosional scour of ditches. Providing a detailed review of the alternatives is therefore not warranted. The ditches will therefore mostly be left in place, with any associated culverts removed.
For the majority of the site ponds, the water holding function will no longer be required following closure. The exceptions are the West Creek pond and mine rock pond as described above. Since maintaining water impoundments unnecessarily will serve no function and will pose an environmental liability, a detailed evaluation of the alternatives is not required. Impoundments associated with all such ponds will be breached and the impoundment sites will be restored.

In regards to the West Creek and Clark Creek re-alignments the re-aligned creek will be left in place. There are no other reasonable alternatives.
The development of detailed tabular evaluations of performance objectives, criteria and indicators (per Appendix O), is therefore not appropriate to this set of alternatives, and has not been carried out.

6.19.7.3 Summary
Based on the above, the preferred alternatives are generally to stabilize site area ditching and leave it in place; breach (remove) all water holding ponds and restored the pond sites, with the exception of the West Creek pond and mine rock pond as described above; and to leave the re-aligned West Creek and Clark Creek in place.

7.0 Effect Assessment and Mitigation 7.1 Methodology
7.1.2 Effects Analysis

Similarly, during the decommissioning and closure, and post closure phases, environmental effects are expected to diminish as the site becomes reclaimed. The only effects that could potentially increase at that time are potential acid rock drainage (ARD) effects and socio-economic effects linked to declining employment.

7.5 Minor Creek System
7.5.4 Residual Environmental Effects

Development and operation of the RRP site will result in the net loss or alteration of approximately 27 ha of local creek and agricultural drain habitat. A strategy to offset the expected losses and alterations has been developed in cooperation with DFO and MNR to achieve a No Net Loss condition. The offset strategy consists of both offsite watershed estoration, and onsite like for like habitat replacement. Watershed restoration initiatives involve offsite stream restoration projects within the overall Pinewood River watershed, focused on improving the overall water quality and productivity of the watershed as a whole. Like for like habitat creation is the development of similar habitat on site that mimics or improves upon habitat conditions that have been displaced or otherwise lost due to the RRP. Some like for like habitat creation is possible during site development, through naturalizing creek diversion channels and pond areas associated with the West Creek and Clark Creek diversions, that may result in a significant portion of the fish habitat offset requirements.
The final No Net Loss Plan developed for the RRP will ensure that an appropriate level of habitat restoration is implemented to offset the unavoidable effects of the RRP on fish habitat and achieve a condition of no net loss to fisheries.

7.8 Vegitated Communities and Rare plants 7.8.3 Mitigation

RRR is committed to encouraging and, as practical, restoring the RRP site to productive, naturalized vegetation communities on cessation of mining. This will involve the active revegetation of peripheral tailings management area areas, the mine rock stockpiles and the remaining portions of the overburden stockpile, as well as the general mine site area. Commitments have been made to the MNR and other stakeholders, that RRP revegetation efforts at closure will include providing suitable habitat for SAR species, most notably whip- poor- will, and other species of interest, if practical.

Revegetation of the stockpiles will be undertaken using a combination of hydroseeding and hand planting of tree seedlings. Native seed mixes, where reasonably available commercially, will be used for hydroseeding, together with a nurse crop of oats, or equivalent (if necessary).

General revegetation of the RRP site is readily achievable with current technologies, as demonstrated by revegetation efforts previously employed at other mine sites in Ontario. Wildlife and vegetation recovery times will vary depending on the species / communities involved. With active revegetation programs as planned, early successional plant and wildlife communities would be expected to become established within three to five years of mine closure. The development of semi-mature poplar / spruce woodlands (the most common forest community type in the area) would be expected to occur over a period of approximately 40 to 60 years. Intermediate community types would develop during the intervening period. Mitigation measures described in this section are expected to be effective for their intended

purposes.
7.8.4 Residual Environmental Effects

Vegetation clearing will result in the removal of 1,352 ha of forested communities (includes treed swamp communities considered wetlands), 507 ha of wetland communities (including areas of coniferous swamp areas), 95 ha of treed and open rock, and mineral barren communities, and 385 ha of agricultural and meadow communities. Overall, 2,192 ha representing 8.5% of the overall NLSA of the vegetation communities will be directly disturbed. Revegetation of the RRP site following decommissioning will restore many of these communities. Two of three habitat locations supporting New England Violet and one of two habitat locations supporting Field Sedge will be directly impacted by RRP activities; however, it is anticipated that these species although Provincially rare, are locally common in the NRSA. With the implementation of mitigation measures and follow up monitoring, no significant adverse impacts to plants due to dust generation are expected.

Sound from mine construction, operation and decommissioning may impact ungulate behaviour. Ungulates in the area appear to show a high tolerance to sound disturbance (in that they are less likely to flee or show agitated or defensive behaviours). This adaptation to higher threshold levels of human disturbance allows deer to spend more time in fitness-enhancing activities such as grazing (since deer are less likely to be scared away from the food source by sound disturbance) but may also decrease their ability to detect predators and/or other environmental cues (Brown et al. 2012). Conversely, sound and other disturbances caused by the RRP may reduce natural predation of the local deer population by displacing local predators such as wolves. 7.9.4 Residual Environmental Effects

Vegetation clearing for the construction or implementation of RRP components and the re-alignment of Highway 600 will result in the removal of 1,352 ha of woodland habitat and 1,265 ha of deer yarding habitat. An additional 277 ha of agricultural lands and 79 ha of shrub lands providing foraging habitat will be cleared or substantively modified. It has been observed that White-tailed Deer within the NLSA have been desensitized to human presence and have been observed grazing at roadsides. This indicates that local deer are tolerant of human activities and may not abandon habitat adjacent to the RRP because of sound or other An additional 10.2 ha of Moose late winter habitat (consisting of numerous fragmented patches) will be lost. It is not anticipated that this loss of Moose late winter habitat will impact the local Moose population due to the currently low density of Moose in the region. 7.10 Furbearers

7.10.4 Residual Environmental Effects
Vegetation clearing associated with RRP development and the re-alignment of Highway 600 will result in a total loss of 1,352 ha of woodland habitat and 507 ha wetland habitat. This accounts for a 7.9% loss of the furbearer denning habitat within the NLSA. Additionally, 28 km of river shoreline will be impacted. Some furbearer species (American Marten, Red Fox, Short-tailed Weasel and Beaver), as well as Black Bear, are not expected to be overly sensitive to human presence. Lynx and wolf tend to avoid human presence, at least to some degree.

7.9 Ungulates
7.9.1 Environmental Effects

Victor Dimond Mine Environemtnal Assessment Reclamation Information

1.0 Introduction
1.1 Project Overview and Background

Construction would be for a three year period starting in the winter of 2006, followed by a 12 year mine life, and a 5 year reclamation phase, with most reclamation occurring in the first 2 years of this period.

2.0 Project Description 2.1 Mining
2.1.3 Mining Activities

Overburden and muskeg will be stockpiled separately to ensure physical stability of the stockpiles, and to facilitate the use of these materials for site reclamation during operation and at closure of the mine.

2.1.5 Stockpiles
All site stockpiles will be designed to facilitate reclamation at closure.

2.1.6 Mine Water Characteristics, Management and Disposal

A pit sump will collect mine water from inside the open pit. Up to Year 6 of mining, the pit water will be non-saline, but will contain suspended solids, trace ammonia and hydrocarbons. The sump water will be pumped to a Phase 1, below grade settling pond for the removal of total suspended solids (TSS). Effluent from the settling pond will discharge to a linear fen system, prior to release by natural drainage into the Nayshkootayaow River (Figure 2-1). Residual suspended solids not collected in the settling pond will collect in the fen. Fen plants and muskeg will also take up much of the residual ammonia with no negative biological effects. Oil skimmers or absorbent materials will be used as required for the removal of any residual hydrocarbons prior to pumping.

Pit sump water from approximately Year 6 and later will be saline, as a result of residual passive inflow, and will be pumped to a lined, above grade settling pond (Phase 2 settling pond). Phase 2 settling pond effluent will discharge via the well field pipeline to the Attawapiskat River, once suspended solids have been removed and once drainage water salinity meets regulatory standards.

2.4

2.4.11 Demestric Sewage and Treatment and Disposal

The plant will be designed to produce an effluent that meets Ontario effluent discharge standards, and will include reactor tanks with aeration diffusers and decanters, multimedia/membrane filtration, aerobic digestion, ultraviolet disinfection, and sludge dewatering.

2.10 Closing Phase

The *CEA Act* requires that all phases of a project be considered. The project as identified for this

review included the construction, operations, modification, and final closure of the project. In addition the *Ontario Mining Act* and its associated Regulations and Codes govern mine site rehabilitation in Ontario. The *Act* requires that a closure plan (prepared separately) be filed for any mining project before the project is undertaken, and that financial assurances are provided to ensure that funds are in place to carry out the closure plan.

The objective of the closure plan is to provide measures for ultimate rehabilitation of the mine site area to a natural and productive condition on completion of mining activities. Specific details of the closure plan will change over time, and closure plans will be updated appropriately. It is expected that final closure of the Victor site will take approximately six years, although active (progressive) reclamation will be conducted primarily within the first two years of closure.

2.10.1 Open Pit

To close out the open pit, the pit will be actively flooded by pumping from the Attawapiskat River to create a pit lake. Prior to flooding the pit, all mining related infrastructure will be removed from the pit area, and the upper most slopes will be shaped and revegetated. Active filling (by pumping) will substantially decrease the time of infilling to less than 2 years. Otherwise, it will take an estimated 12 to 14 years for the pit to flood naturally. Actively flooding the pit will also reduce the number of years that flow supplementation of the Nayshkootayaow River will be required. Water quality in the resultant pit lake will start out as substantially fresh water, but over time will gradually become more saline, as groundwater seeps into the flooded pit from the surrounding bedrock aquifer. Increasing salinity of the pit lake over time will render it susceptible to oxygen-restricted conditions because of the effects of density gradients, leading to the formation of a meromictic lake. Meromictic lakes are not normally suited to development as aquatic habitat.

The final groundwater elevation in the pit lake is estimated at approximately 2 m below the surrounding ground surface, corresponding to the water levels in the exploration phase large diameter drill holes, which are connected to the same geological sequence as will be the open pit.

Outflow from the flooded open pit will be mainly subsurface, through the bedrock aquatic zone, to the adjacent rivers, as per groundwater currently occupying the bedrock zone that will become the open pit.

2.10.2 Buildings, Machinery, Equipment and Infrastructure

A separate, approved, landfill will be established at closure, within the mine rock stockpile, for the disposal of non-hazardous demolition wastes (such as concrete, steel, wallboard, and other inert materials).

Salvageable machinery, equipment and other materials will be dismantled and taken off site for sale or reuse if economically feasible. Alternatively, these items will be cleaned of oil and grease, where appropriate, and deposited within the on-site landfill. Gearboxes or other equipment containing hydrocarbons that cannot be readily cleaned will be removed from equipment and machinery and trucked off site for disposal at a licensed facility.

Buildings, including the accommodation complex, processing plant, incinerator, potable water treatment system, and sewage treatment system, will be demolished and disposed of in the landfill unless another economic alternative is available.

2.10.3Roads. Airstrips, Pipelines and Power Lines

Project specific winter roads will naturalize passively over time. River crossing areas will be actively revegetated during operations, as required.

Permanent Victor site roads (access roads and haul roads) will be scarified, resloped as appropriate, covered with overburden, and revegetated. Culverts and/or bridges will be removed, and natural drainage restored. The airstrip will be scarified, covered with overburden, and revegetated.

Above ground, on-site pipelines will be purged, dismantled, and disposed of in the Victor site landfill. Buried pipelines, or pipeline sections, will be purged/cleaned and left in place, if not readily removed, to minimize additional disturbance to the landscape. Surface expressions of buried pipelines, such as valve stations, will be removed.

The 115 kV transmission line from Attawapiskat to the Victor site, and on-site power lines and other power equipment and materials including oil-filled transformers will be removed. The new transmission line from Otter Rapids (or Pinard) to Kashechewan will be left in place as a permanent upgrade to the local power grid system.

2.10.4 Petroleum Products, Chemicals and Explosives

All petroleum products and chemicals will ultimately be removed from the site by licensed haulers for reuse or appropriate disposal.

2.10.5 Contaminated Soils

An environmental site investigation will be conducted at the end of operation or early in the closure phase. Soil found to exceed acceptable criteria will be bioremediated on site, and the treated soil will be either deposited within the demolition landfill, or spread, contoured, and revegetated.

Acceptable criteria are herein defined as being in accordance with Table 1 of the Ontario "Soil, Ground Water and Sediment Standards for Use Under Part XV.1 of the *Environmental Protection Act* – March 2004". These criteria will be applied to all contaminated soils, but would not apply to mineral stockpiles and related materials, which are exempt from waste designation in accordance with O. Reg. 347.

2.10.6 Ponds and Other Water Structures

The Phase 1 mine water-settling pond will be decommissioned as part of progressive reclamation activities. The flooded pond may be developed into fish habitat, if practicable. The Phase 2 above grade mine water settling pond will be drained, the liner punctured to facilitate drainage, and berms will be reshaped (pushed in), covered with overburden and seeded. Infrastructure will be transferred to the on-site landfill. Intake and outfall structures at the Attawapiskat River (water intake and well field water discharge) and the Nayshkootayaow River (flow supplementation pipeline) will be removed.

2.10.7Fine PCK Facility

The fine PK has no potential for acid generation or metal leaching (SRK 2003). The principal concerns associated with the closure of the fine PKC facility involve long-term slope stability, erosion control, drainage, vegetation cover, and aesthetics.

The PKC cells will be contoured to minimize ponding and promote natural drainage. Muskeg will be harrowed into the surface of the PKC facility, as appropriate, followed by revegetation (seeding and hand staking of tree seedlings). Perimeter and discharge ditches will be left in place. Progressive reclamation of Cell 1 and its associated dams will be completed during the operations phase. Cells 2 and 3 will be reclaimed at the end of mine operations.

2.10.8 Low Grade Ore, Mine Rock, Overburden, and Muskeg Stockpiles

The low-grade ore, coarse PK, and mine rock have no potential to generate net acidity, or to leach metals in concentrations that would be of environmental concern (SRK 2003). The principal concerns associated with the closure of the stockpiles therefore involve slope stability, erosion control, vegetation cover, and aesthetics. Progressive rehabilitation will be undertaken, where possible. Muskeg not required for reclamation at mine closure will be covered with mine rock and/or overburden and revegetated to remove any long-term fire hazards. Reclamation of stockpiles will include, where appropriate: covering with overburden, seeding/hydroseeding, and hand planting of tree seedlings.

2.10.9 Aggregate Sources

Reclamation of the quarries and pit is governed by the permits obtained under the *Aggregate*

Resources Act.

The north, central and south quarries will only be used for aggregate sourcing during the construction phase, and will subsequently flood and create pond features. The central (and potentially north quarry) will be partially filled with fine PK during the initial months of operation. Subsequently, the central quarry will serve as a polishing pond for the PKC facility. The north quarry will be allowed to flood naturally.

Water quality within the quarry ponds will be good and the ponds will be moderately deep, to a maximum of about 5 m. The pond shorelines will be enhanced to provide fish habitat and to improve fish support capability. The existing drainage ditch from the flooded central quarry to North Granny Creek will be enhanced to provide fish habitat, and to facilitate fish passage between the quarry pond and North Granny Creek, whereas the north quarry will be connected with a nearby muskeg pond. The flooded south quarry will not be developed as fish habitat because of its small size and isolated location (isolated from South Granny Creek).

Those portions of the sand and gravel esker that have been disturbed by excavation will be reshaped, amended with top soil as appropriate, and revegetated with jack pine and black spruce seedlings. The sand

and gravel pit will be substantially reclaimed as part of progressive reclamation, unless a portion of the pit is left open to access material through operations.

2.10.10 Waste Managmnet

The approved landfill located within the mine rock stockpile will be the primary repository for demolition wastes during closure. At the end of reclamation activities, the landfill will be capped with overburden and revegetated. It will be closed out in a manner consistent with Ministry of the Environment requirements as described in the landfill Certificate of Approval. The incinerator will be removed from the site for resale, if possible, or will be disposed in the landfill with the building.

2.10.11 Site Drainage

Site drainage will be restored to the extent practicable at the end of operations, including the removal of all culverts. The South Granny Creek diversion channel will naturalize over the project life, and will be retained as the new permanent creek channel.

2.10.13 Revegitation

The primary aim of the mine site reclamation/revegetation program is to control erosion, establish an initial plant cover, and accelerate the migration of native vegetation into the reclaimed area to re-establish a self-sustaining, natural vegetative cover. Revegetation of disturbed areas will be accomplished by a combination of grass and herb seeding, hand planting of tree seedlings, and natural regeneration. Research is currently underway at Laurentian University in Sudbury to determine optimal species and strategies for revegetation. Only species native to the region will be used for revegetation. Revegetated areas will be monitored for up to 10 years after closure to ensure that a self- sustaining vegetation cover is successfully established.

2.10.14 Schedule

Progressive rehabilitation will occur as reasonable during the construction and operation phases. Final closure of the Victor site is expected to occur over a period of approximately six years, which includes two years of active reclamation (Years 1 and 2), three years of care and maintenance where flow supplementation to the Nayshkootayaow River will occur if needed (Years 3 to 5), a subsequent year of final reclamation (Year 6) for removal of the infrastructure required to support flow supplementation, additional reclamation, and demobilization from the site.

2.10.15 Landscape After Closure

The current Victor landscape consists of flat expanses of muskeg, intersected by creeks and rivers. There are numerous small to large ponds within the site area.

Following site area rehabilitation, the existing flat muskeg landscape will be replaced by a more diversified landscape of low hills (former stockpiles) interspersed with muskeg areas and ponds, including larger ponds associated with the central and north quarries and the pit lake. Creeks and rivers will remain as they are in the pre-development condition, with the exception of the diverted portion of South Granny Creek. The hills will be forested with mixtures of spruce and poplar, and possibly jack pine. These forested environments will eventually develop vegetation communities similar to those, which currently border the Attawapiskat River and Nayshkootayaow River, and will consequently provide comparatively productive forest habitat for wildlife.

3.0 Evaluation of Alternatives 3.1AlternativeAssesement Methedology

The following performance objectives (or a subset thereof, as appropriate) have been used in the evaluations:

Amenability to reclamation. **Amenability to Reclamation**:

Causes disturbance to the natural environment that requires limited reclamation (preferred)

Causes disturbance to the natural environment that requires moderate to extensive reclamation (acceptable); and,

Mitigation of disturbance to the natural environment is not practical or feasible (unacceptable).

This performance objective relates to the decommissioning or reclamation of the various project aspects at closure. It is relevant to those aspects of the project that alter the landscape (e.g., roads and stockpiles), and/or require dismantling and either removal from site, or disposal on site (e.g., buildings).

3.2 Project Alternatives

Amenability to Reclamation

Amenability to reclamation was rated the same as for natural environment effects.

Based on the above, the Proponent selected proceeding with the project in the near-term as the overall preferred project alternative, delaying the project was considered acceptable, and abandoning the project was considered unacceptable, as this alternative received an unacceptable rating for cost- effectiveness.

(above Information)

From a natural environment perspective, the Proponent rated abandoning the project as the preferred alternative, as abandoning the project at this stage would result in no further environmental effects. Proceeding with the project, either in the near-term or with a delay, was rated as acceptable.

3.4 Mining Operations
3.4.2 Mining Methods
3.4.2.2 Performance Onjectives and Evaluation

Amenability to Reclamation: The two underground mining methods (shaft and ramp) are preferred from a reclamation perspective, as neither alternative has an appreciable effect on the surface environment. The open pit will be reclaimed to a pit lake on closure, and the overburden and mine rock stockpiles will be graded and vegetated, and returned to productive habitat (Section 2.10). Open pit mining is therefore rated as acceptable.

3.8 Onsite Infrastructure
3.8.2 Aggregate Sources 3.8.2.2 Performance Evaluation

Amenability to Reclamation: All three options will require reclamation at closure, likely as flooded ponds redeveloped as aquatic habitat. Given the scale of quarrying required, limited reclamation will be needed for all options.

3.8.5 Drainage Works- South Granny Creek 3.8.5.2 Performance Objectives and Evaluation

Amenability to Reclamation: Restricting mining operations and not altering the existing alignment of South Granny Creek is the preferred alternative with respect to amenability to reclamation (no reclamation required). Realignment of South Granny Creek is acceptable since it does not require modification or reclamation following mine closure.

3.8.9 Solid Waste Disposal
3.8.9.2 Performance objectives and Evaluation

Amenability to Reclamation: The incinerator would be dismantled and transported off site for sale, or disposed of during mine closure. Post-closure monitoring is not expected with this alternative.

The landfill would require capping with a low permeability cover at closure. The landfill, if used on its own, without being complemented by incineration, would continue to generate leachate following mine closure and would require monitoring for some period of time after closure, and therefore represents a potential long-term environmental liability. The landfill option is rated acceptable with respect to amenability to reclamation.

3.9 Offisite Infrastructure - Access and Power 3.9.3 Performance Objectives and Evaluation
3.9.3.6 Amenability to Reclamation

Vegetation communities along winter roads will readily regenerate on their own following completion of use; but tree planting will be required at river and creek crossings. This is a minor expense, and is not sufficient to distinguish between alternatives.

From the perspective of power supply, alternatives that involve on-site diesel generation are the simplest to reclaim. Transmission lines between Attawapiskat and the Victor site, and between Highway 11 and the Victor site would need to be removed. In this regard, the Attawapiskat to Victor site transmission line would be less costly to remove because it would be shorter (105 km), compared with a line following the SWAWR (385 km). It is not anticipated that a transmission line from Kapuskasing to Hearst would require removal at mine closure, as it would improve service to the local communities.

Alternatives 1, 2, 3 and 4 are therefore rated as preferred, and Alternatives 5 and 6 are rated as acceptable. This assumes that the pipeline associated with Alternative 1 would remain in place, and that that portion of the new coastal transmission line from Otter Rapids to Kashechewan (and possibly to Attawapiskat) would be left in place for use by the coastal First Nation communities.

3.10 Reclamation
3.10.1 General Considerations

The goals of reclamation and decommissioning for the VDP are to protect public health and safety, to provide physically and chemically stable conditions at closure, consistent with the surrounding environment, and to develop self-sustaining productive habitats for plants, wildlife, and fisheries resources. The following sections address the major project facilities that will remain in place after the completion of site reclamation.

3.10.2 Open Pit 3.10.2.1 Alternatives

Two reclamation alternatives are possible for the open pit: 1) Create/allow formation of a new pit lake; and,
2) Fill with overburden and mine rock.

Creation of a New Pit Lake

The open pit will naturally collect surface runoff and passive groundwater seepage once well dewatering ceases, filling or nearly filling the pit within approximately 14 years. Pumping water from the Attawapiskat River (through the dewatering pipeline) into the open pit is proposed by the Proponent to reduce the filling time to approximately 2 years. Active filling of the pit will also greatly assist with aquifer recovery in the bedrock, which will in turn reduce demands for flow supplementation of the Nayshkootayaow River during low flow periods. The cost of actively filling the open pit by pumping water from the Attawapiskat River is in the range of $3 million.

Backfill the Open Pit

Approximately 45 Mm^3 of mineral materials would be required to fill the open pit to surface. The principal limitation to such an undertaking is cost, estimated at well in excess of $100 million. There would also be the added cost of operating the dewatering pumps and the camp for an additional approximately 3 years during the period of backfilling, estimated at several 10's of millions of dollars.

3.10.2.2 Performance Objectives and Evaluation

Two performance objectives and evaluation criteria relative to reclamation of the open pit were considered by the Proponent:

Cost-effectiveness: The most cost-effective (preferred) option (apart from natural flooding) is to actively flood the open pit at closure (cost estimate $3 million). A cost of well in excess of $100 million would be added to the project cost to backfill the open pit. The Proponent considered refilling the open pit with mineral waste to be prohibitively expensive and unacceptable.

Minimize Effects to the Natural Environment: The reader is referred to the section on amenability to reclamation for a discussion of effects on the natural environment.

Minimize Effects to the Socio-economic Environment: Backfilling the open pit could have a small, but not significant positive effect on lands and resources used for traditional pursuits. Neither alternative is expected to have any meaningful effect on health related emissions, physical or cultural resources, or historical, archaeological, paleontological or architectural features. Both alternatives are rated as preferred for socio-economic considerations.

Amenability to Reclamation: Reclamation of the pit area to aquatic habitat would be acceptable, recognizing that the resulting pit lake could be moderately saline. Restoring the open pit area to terrestrial habitat by backfilling would be preferred, but would involve a delay of several years in bedrock aquifer recovery compared with the pit flooding option, as the pit would have to remain at least partially dewatered while it was being backfilled, and it would take longer for the fill material to saturate once backfilling was complete.

Summary Evaluation

The Proponent indicated that developing a new lake in the open pit was the preferred reclamation option (Table 3-1). The alternative of infilling the pit with overburden and mine rock was considered cost prohibitive and unacceptable.

The need to manage groundwater inflow during pit backfilling would place a cost and scheduling environmental effect burden on the backfilling alternative.

Government Position

The Government of Canada agrees with the positions outlined by De Beers in the CSEA and as summarized in this section of the CSR.

3.10.3 Demolition Waste

Non-hazardous demolition wastes that are not transported off site for reuse or sale would be disposed of on site, as off-site disposal would be cost-prohibitive and unacceptable.

3.10.3.1 Alternatives

The Proponent considered the following alternatives for the on-site disposal of demolition wastes:

1) Disposal of demolition wastes within the mine rock (or another) on-site stockpile

3) Disposal of demolition wastes in the open pit.

Disposal of Demolition Wastes within the Mine Rock Stockpile

This alternative involves the disposal of demolition wastes adjacent to the mine rock stockpile. The material would be subsequently covered with mine rock, soil and revegetated.

Disposal of Demolition Waste within a Landfill

With this alternative, an on-site, above grade landfill would be created at a location other than that associated with the mine rock (or other) stockpile.

Disposal of Demolition Wastes within the Open Pit

With this alternative, demolition wastes would be transported to the base of the dewatered pit, compacted, and covered with a layer of mine rock and/or overburden prior to flooding the pit to ensure that materials do not float to surface once the pit is flooded. Open pit dewatering (well fieldand sumps) and Nayshkootayaow River flow supplementation would continue until all demolition waste disposal operations were completed. The infrastructure required for these operations would still require subsequent disposal at another location.

3.10.3.2 Performace Evaluation

Performance objectives evaluated by the Proponent for reclamation of the open pit were the following:

Cost-effectiveness: Disposal of demolition wastes at the mine rock stockpile is the most cost- effective alternative, followed by the landfill alternative. The Proponent considered the transportation of wastes and cover material to the open pit to be cost prohibitive, and there would be a requirement to continue pit-dewatering operations during the reclamation phase.

Minimize Effects to the Natural Environment: The reader is referred to the section on amenability to reclamation for a discussion of effects on the natural environment.

Minimize Effects to the Socio-economic Environment: Demolition waste disposal alternatives are not expected to have any meaningful effect on health related emissions, physical or cultural resources, lands and resources used for traditional pursuits, or historical, archaeological, paleontological or architectural features. Both alternatives are rated as preferred for socio-economic considerations.

Amenability to Reclamation: Disposal of demolition wastes into the mine rock stockpile is the preferred alternative, as it is an environmentally safe and accepted disposal practice. Creation of a landfill at another undisturbed location would be acceptable, but would result in additional and unnecessary land disturbance. Disposal of demolition materials in the pit was regarded by the Proponent as unacceptable because buried demolition wastes have the potential to compromise water quality if maintained in a flooded condition.

Summary Evaluation

The Proponent indicated that disposal of demolition wastes in the mine rock stockpile was the preferred alternative (Table 3-1).

Disposal of demolition wastes within the open pit would generate a need to manage groundwater inflow during pit backfilling, placing a cost and scheduling environmental effect burden on the in-pit disposal alternative.

Government Position

The Government of Canada agrees with the positions outlined by De Beers in the CSEA and as summarized in this section of the CSR.

3.10.4 Stockpiles

All stockpiles will be contoured, covered with soil and/or peat, as appropriate, and revegetated using native species, either progressively during operation, or at closure. The Proponent indicated that there are no reasonable alternatives to this approach.

Government Position

The Government of Canada agrees with the positions outlined by De Beers in the CSEA and as summarized in this section of the CSR.

3.10.5 Infrastructure

On-site infrastructure such as access roads and the airstrip will be reclaimed once the majority of reclamation activities are completed. The Proponent considered that there were no other reasonable alternatives.

Off-site infrastructure at Attawapiskat (i.e., the barge landing facility, if constructed, the training centres, and the De Beers' office) would be transferred to the community. The transmission line from Attawapiskat to the Victor site would be dismantled unless another use for the line can be found.

Government Position

The Government of Canada agrees with the positions outlined by De Beers in the CSEA and as summarized in this section of the CSR.

3.10.6 Site Drainage

The realigned portion of South Granny Creek around the open pit will be maintained at closure, since fisheries habitat will have been established in the new (and longer) alignment.

6.6.2.3 Miratory Birds

6.6.2.3.1 Environmental Effects

Where habitat disturbances are unavoidable, the disturbed areas will be rehabilitated to naturalized productive wildlife habitat at closure. In most cases the rehabilitated habitats will be different from those that presently exist, in that following closure, the majority of disturbed areas will be elevated above the muskeg landscape, mainly in the form of mineral stockpile areas. It will not be possible to return these areas to fen and bog environments at closure because of the elevation changes, but the Proponent has committed to the development of wetlands within disturbed areas, as part of the site rehabilitation program, to the extent practicable.

Other disturbed habitats will be restored mainly as diverse forested habitats. 6.6.2.3.2 Mitigation

The primary mitigation strategy for limiting adverse effects to migratory birds will be maintaining a 200 m buffer zone along watercourses, to protect riverbank and creek margin forest habitats; developing a compact site; and rehabilitating disturbed sites to productive wildlife habitat at closure.

Appendix C: Documents Used for Policy Review and Relevant Information

Canadian Federal Legislation

Document: Regulation Designating Physical Activities

- **16.** The construction, operation, decommissioning and abandonment of a new

  (*a*) metal mine, other than a rare earth element mine or gold mine, with an ore production capacity of 3 000 t/day or more;
  (*b*) metal mill with an ore input capacity of 4 000 t/day or more;
  (*c*) rare earth element mine or gold mine, other than a placer mine, with an ore production capacity of 600 t/day or more;
  (*d*) coal mine with a coal production capacity of 3 000 t/day or more;
  (*e*) diamond mine with an ore production capacity of 3 000 t/day or more;
  (*f*) apatite mine with an ore production capacity of 3 000 t/day or more; or
  (*g*) stone quarry or sand or gravel pit, with a production capacity of 3 500 000 t/year or more.
- **17.** The expansion of an existing

  (*a*) metal mine, other than a rare earth element mine or gold mine, that would result in an increase in the area of mine operations of 50% or more and a total ore production capacity of 3 000 t/day or more;
  (*b*) metal mill that would result in an increase in the area of mine operations of 50% or more and a total ore input capacity of 4 000 t/day or more;
  (*c*) rare earth element mine or gold mine, other than a placer mine, that would result in an increase in the area of mine operations of 50% or more and a total ore production capacity of 600 t/day or more;
  (*d*) coal mine that would result in an increase in the area of mine operations of 50% or more and a total coal production capacity of 3 000 t/day or more;
  (*e*) diamond mine that would result in an increase in the area of mine operations of 50% or more and a total ore production capacity of 3 000 t/day or more;
  (*f*) apatite mine that would result in an increase in the area of mine operations of 50% or more and a total ore production capacity of 3 000 t/day or more; or
  (*g*) stone quarry or sand or gravel pit that would result in an increase in the area of mine operations of 50% or more and a total production capacity of 3 500 000 t/year or more.

Document: Prescribed Information for the Description of a Designated Project Regulation

GENERAL INFORMATION

- **1.** The project's name, nature and proposed location.

- **2.** The proponent's name and contact information and the name and contact information of their primary representative for the purpose of the description of the project.
- **3.** A description of and the results of any consultations undertaken with any jurisdictions and other parties including Aboriginal peoples and the public.
- **4.** The environmental assessment and regulatory requirements of other jurisdictions.
- **4.1** A description of any environmental study that is being or has been conducted of the region where the project is to be carried out.

PROJECT INFORMATION

5. A description of the project's context and objectives.

6. The provisions in the schedule to the *Regulations Designating Physical Activities* describing the project in whole or in part.

7. A description of the physical works that are related to the project including their purpose, size and capacity.

8. The anticipated production capacity of the project and a description of the production processes to be used, the associated infrastructure and any permanent or temporary structures.

9. A description of all activities to be performed in relation to the project.

10. A description of any waste that is likely to be generated during any phase of the project and of a plan to manage that waste.

11. A description of the anticipated phases of and the schedule for the project's construction, operation, decommissioning and abandonment.

PROJECT LOCATION INFORMATION

12. A description of the project's location, including

(*a*) its geographic coordinates;
(*b*) site maps produced at an appropriate scale in order to determine the project's overall location and the spatial relationship of the project components;
(*c*) the legal description of land to be used for the project, including the title, deed or document and any authorization relating to a water lot;
(*d*) the project's proximity to any permanent, seasonal or temporary residences;
(*e*) the project's proximity to reserves, traditional territories as well as lands and resources currently used for traditional purposes by Aboriginal peoples; and
(*f*) the project's proximity to any federal lands.

FEDERAL INVOLVEMENT

13. A description of any financial support that federal authorities are, or may be, providing to the project.

14. A description of any federal land that may be used for the purpose of carrying out the project.

15. A list of the permits, licences or other authorizations that may be required under any Act of

Parliament to carry out the project.

ENVIRONMENTAL EFFECTS

16. A description of the physical and biological setting.

17. A description of any changes that may be caused, as a result of carrying out the project, to

(*a*) fish and fish habitat as defined in subsection 2(1) of the *Fisheries Act*;
(*b*) aquatic species, as defined in subsection 2(1) of the *Species at Risk Act*; and
(*c*) migratory birds, as defined in subsection 2(1) of the *Migratory Birds Convention Act, 1994*.

18. A description of any changes to the environment that may occur, as a result of carrying out the project, on federal lands, in a province other than the province in which the project is proposed to be carried out or outside of Canada.

19. Information on the effects on Aboriginal peoples of any changes to the environment that may be caused as a result of carrying out the project, including effects on health and socio-economic conditions, physical and cultural heritage, the current use of lands and resources for traditional purposes or on any structure, site or thing that is of historical, archaeological, paleontological or architectural significance.

Ontario Legislation/Regulation

Document: Regulation 345/93: Private Sector Projects

In this Regulation,
"private sector developer" means a developer of land other than land belonging to Her Majesty in right of Ontario, a public body or a municipality. O.Reg. 345/93, s. 1.

2. (1) An enterprise or activity by a private sector developer is defined as a major commercial or business enterprise or activity and is designated as an undertaking to which the Act applies if it is,

(a) of a type listed in Schedule C of the Municipal Class Environmental Assessment that was approved on October 4, 2000 under section 9 of the Act; and

(b) a project provided for residents of a municipality for roads, water or wastewater. O. Reg. 345/93, s. 2 (1); O. Reg. 391/01, s. 1 (1).

(2) An undertaking designated under subsection (1) is exempt from section 5 of the Act if,

(a) no other environmental assessment has been submitted to the Minister; and

(b) the procedure for the undertaking is set out in the Municipal Class Environmental Assessment and its approval does not require a further approval under section 5 of the Act. O. Reg. 391/01, s. 1 (2).

3. Revoked: O. Reg. 391/01, s. 2.

4. This Regulation does not apply with respect to an enterprise or activity by a private sector developer that is commenced before June 7, 1993 if all of the contract drawings and plans related to the enterprise or activity are completed and submitted on or before November 30, 1993 to the municipal engineer of the municipality in which the enterprise or activity is being carried out. O.Reg. 345/93, s.4.

5. Copies of the approval and class environmental assessment referred to in this Regulation may be found in the public records maintained under section 30 of the Act. O. Reg. 391/01, s. 3.

Ontario Environmental Assessment Website

Individual EAs

Individual EAs are prepared for large-scale, complex projects with the potential for significant environmental effects. They require Ministry of the Environment and Climate Change approval.

Step 1: develop and submit a Terms of Reference

Proponent must:

- submit a Notice of Commencement to the Director, Environmental Approvals Branch
- submit a Terms of Reference summary form
- consult with the public, Aboriginal communities and government agencies
- document the consultation process and submit to the ministry with your Terms of Reference
- outline your plan for preparing and evaluating your environmental assessment
- prepare and submit the Terms of Reference document including:
    - the name and address of the proponent
    - how the environmental assessment will be prepared
    - purpose of the study or undertaking
    - description of and rationale for the undertaking and for alternatives
    - description of the existing environment and potential effects of the undertaking
    - assessment and evaluation
    - commitments and monitoring
    - consultation plan for the environmental assessment
    - flexibility to accommodate new circumstances
    - other approvals required

Ministry:

- consults with the public, Aboriginal communities and government agencies
- coordinates a technical review of the Terms of Reference document
- makes a recommendation to the Minister who decides whether or not to approve the Terms of Reference within 12 weeks from the date of submission to the ministry

The proponent has an opportunity to take a "time out" to amend the Terms of Reference.

The Minister can refer a matter to mediation before making a decision or the proponent can begin the mediation process. The Minister can't send a Terms of Reference to a hearing.

Step 2: prepare an environmental assessment

Proponent must:

- submit a Notice of Commencement to the Director, Environmental Approvals Branch
- prepare the environmental assessment document once the Terms of Reference is approved
- the EA document includes:
    - record of consultation
    - a monitoring framework that will be carried out if the undertaking is approved
    - a list of commitments

    - actions to prevent, reduce and manage environmental effects
    - environmental effects that may be caused
    - a review and evaluation of alternatives considered
    - results of the planning and decision-making process
    - the purpose of the project and a description of the undertaking
- consult the public, Aboriginal communities and government agencies

There are no limits on how much time a proponent can take to prepare the EA document.

Step 3: submit an environmental assessment

Proponent must:

- submit an Environmental Assessment summary form
- submit the environmental assessment document to the Director, Environmental Approvals Branch for review and decision by the Ministry of the Environment and Climate Change
-

Step 4: public and government review

The ministry coordinates public and government review of the EA document.

The ministry consults with:

- government experts
- Aboriginal communities
- the public
- any other interested party

The public has 7 weeks to comment.

Any time during the EA process, the proponent or any other interested persons can ask for mediation.

Step 5: Ministry of the Environment and Climate Change review

This includes:

- a review of all public, Aboriginal community and government agency comments
- the proponent's response to the comments
- a discussion on whether the proponent is in compliance with your approved terms of reference
- how the proponent has met the requirements of the Environmental Assessment Act

The ministry has 5 weeks to write and publish the Ministry Review.

Step 6: Public consultation on the Ministry Review

The public, government agencies, Aboriginal communities or any other interested party has 5 weeks to provide comments to the ministry.

During this time, anyone, including the proponent can:

- provide written comments to the Ministry of the Environment and Climate Change to identify any outstanding issues with suggestions for how they might be resolved
- request a hearing

Step 7: Minister's decision

The environmental assessment must be approved by the Minister of the Environment and Cabinet before the project can proceed.

Once public comment is finished on the Ministry Review, the Minister has 13 weeks to make a decision.

The Minister may:
- refer it to mediation
- refer it to the Environmental Review Tribunal for a hearing
- make a decision to approve, approve with conditions, or refuse the EA

Step 8: implement the project and monitor compliance
After the project has been approved, the proponent will need to gather other approvals as needed.

These could include requirements found in the:
- Environmental Protection Act
- Planning Act
- Ontario Water Resources Act
- Species at Risk Act

When the proponent has all approvals in place, construction can begin. The proponent must report on how they have complied with commitments in the environmental assessment and the conditions of the approval.

Legislated timelines
The government has legislative deadlines to ensure the reviews of a Terms of Reference and an environmental assessment are completed within a reasonable amount of time.

At a minimum, it takes:
- 12 weeks to review and make a decision on a Terms of Reference
- 30 weeks to review and make a decision on an environmental assessment

The review will take longer if the proponent needs time to change a report.

Compliance and monitoring
Proponents must comply with the commitments made in the environmental assessment and with the conditions of approval.

There are 2 types of monitoring:
- compliance monitoring
- effects monitoring

Compliance monitoring
Compliance monitoring looks at whether a project has been implemented:
- according to commitments made in the EA
- according the EA monitoring framework for all phases of construction and decommission
- conditions of approval

Proponents must provide annual compliance monitoring reports to the ministry.

Effects monitoring
Effects monitoring is used after EA project approval to:

• verify the expected environmental effects
• determine if additional impact management measures are required

If needed, the ministry may require additional effects monitoring such as monitoring air quality or emissions.

Saskatchewan

Saskatchewan Environmental Assessment Act

Chapter E-10.1 of the Statutes of Saskatchewan 1979-80 (effective August 25, 1980) as amended by the Statutes of Saskatchewan, 1983 c.77; 1988-89 c.42 and c.55; 1996 c.F-19.1;2002, c.C-11.1; 2010, c.11; and 2013, c.27.

British Columbia

British Columbia Environmental Assessment Act

Environmental Assessment Office User Guide

The application information requirements generally contain the following core elements:

- description of the project, including all key project elements;
- spatial and temporal boundaries of the assessment;
- consultation that will take place;
- project setting and characteristics, including a description of a wide range of baseline studies that the proponent will undertake;
- scope of the assessment, including a list of all potential effects that will be considered; methodology for assessing impacts and mitigating effects;
- assessment of the potential significant adverse affects, including proposed mitigation measures and residual effects; and,
- commitment to provide environmental management systems and monitoring plans.

Quebec

Environment Quality Act:

Regulation respecting environmental impact assessment and review

Document: PROJECTS SUBJECT TO THE ENVIRONMENTAL IMPACT ASSESSMENT AND REVIEW PROCEDURE

*(n.*8*)* the construction of an ore processing plant for:

- metalliferous ore or asbestos ore, where the processing capacity of the plant is 2 000 metric tons or more per day, except in the case of rare earth deposits;

- uranium ore;

- rare earth ore;

- any other ore, where the processing capacity of the plant is 500 metric tons or more per day;

*(n.*9*)* the construction of a metal products processing plant that has an annual production capacity of 20,000 metric tons or more;

*(n.*10*)* the construction of a mill that produces chipboard from wood fibre and has an annual production capacity of 50,000 m^3 or more;

*(n.*11*)* the construction of a plant that manufactures vehicles or aircraft, including parts for such vehicles, and has an annual production capacity of 100,000 metric tons or more;

(o) the construction or enlargement of one or more buildings in a livestock operation whose total number will equal or exceed 600 animal units in the case of liquid manure production or 1,000 animal units in the case of semi-solid or solid manure production within the meaning of the definitions in section 1 of the Draft Regulation respecting livestock operations published in the *Gazette officielle du Québec*of 28 May 1979, p. 3159;

(p) the opening and operation of:

- a metals mine or an asbestos mine that has a production capacity of 2 000 metric tons or more per day, except in the case of rare earths;

- a uranium mine;

- a rare earth mine;

- any other mine that has a production capacity of 500 metric tons or more per day.

….

“Mine” means all the surface and underground infrastructures used for the extraction of ore;

PREPARATION AND PRESENTATION OF AN ENVIRONMENTAL IMPACT ASSESSMENT STATEMENT

3. Parameters: An environmental impact assessment statement prepared pursuant to section 31.2 of the Act may deal with the following parameters:

(a) a description of the project mentioning, in particular, the desired objectives, the site (including the numbers of the original lots affected by the project), the project timetable, any subsequent operation and

maintenance activities, the amounts and characteristics of types of borrowed materials required, power sources, methods of management of waste or residue other than road construction residue, transportation activities inherent in the construction and subsequent operation of the project, any connection with land use planning and development plans, urban zoning plans or agricultural zoning and reserved areas within the meaning of the Act to preserve agricultural land (chapter P-41.1), and any related operations planned by the proponent of the project, as well as any other technical data and characteristics necessary to know and evaluate the effects of the project on the environment and to identify the required corrective or compensatory measures;

(b) a qualitative and quantitative inventory of the aspects of the environment which could be affected by the project, such as fauna, flora, human communities, the cultural, archeological and historical heritage of the area, agricultural resources and the use made of resources of the area;

(c) a list and evaluation of positive, negative and residual impacts of the project on the environment, including indirect, cumulative, latent and irreversible effects on the aspects identified in subparagraph*b* and a description of the area as it will appear after the project has been carried out and developed;

(d) a description of the different options to the project, in particular regarding its location, the means and methods of carrying out and developing the project, and all other variables in the project as well as reasons justifying the option chosen;

(e) a list and description of measures to be taken to prevent, reduce or attenuate the deterioration of the environment, including the impacts listed in subparagraph *c* before, during and after the construction or development of the project, including, in particular, any equipment used or installed to reduce the emission, deposit, issuance or discharge of contaminants into the environment, any control of operations and monitoring, emergency measures in case of accident, and reclamation of the area affected.

An environmental impact assessment statement on river works referred to in subparagraph *b* of the first paragraph of section 2 must deal only with the portion of the river directly affected by the project.

An environmental impact assessment statement must be designed and prepared according to a scientific method.

United States

Policy and Procedures for the Review of Federal Actions Impacting the Environment (1984)

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