MONITORING PLAN

The historical metal loading and current slow release of metals associated with the metallic and non-metallic debris deposited on site have resulted in impacted surface waters and sediments down-gradient of the Main Landfill (AEC 3) and more significantly down-gradient of the Vehicle Dump (AEC 2).

As the surface water metal contributions will continue with time (due to the presence of the waste debris), dredging of sediments and on-site treatment was not considered a viable option. In fact, pond and creek bathymetry would be affected by dredging, leading to a loss of natural habitat for fish, wildlife and benthic organisms which are a food source for fish and wildlife and possibly releasing metals (including Arsenic) to the water column.

1. Long-term Monitoring

The goal of the long-term monitoring program would be to ensure that present and future risks are negligible and that monitoring could be terminated with confidence, based on findings of no risk and no depreciation of site environmental status. The program would be developed specifically to:

- Inspect and monitor surface water integrity, flow rates, channelling and physical conditions;
- Monitor, evaluate and analyze for metals in surface waters over time; and
- Ensure the protection of human health and environment from exposure to chemicals of concern.

Both passive and active monitoring would be undertaken at the property. A site inspection program (passive monitoring) would be conducted to observe the physical condition of the surface water bodies. An active surface water monitoring program would be developed upon which future risk management decisions could be based. This plan would effectively provide an early warning system that could be implemented in association with a Contingency Plan and could provide the decision criteria for termination.

2. Passive In-Situ Treatment

In recent years, a variety of passive treatment systems have been developed that do not require continuous chemical inputs and that take advantage of naturally occurring chemical and biological processes to treat metal impacted waters. The primary passive technologies include constructed wetlands, anoxic limestone drains (ALD), successive alkalinity producing systems (SAPS), limestone ponds, and open limestone channels (OLC).

For the Vehicle Dump site, the existing drainage systems could be modified to reduce the surface water/sediment metal loading to the environment and Sylvia Grinnell River by:

- providing a predictable and steady flow path to the discharge points by enhancing the physical drainage systems with weirs, banks or channels to avoid overflow, flooding or hydraulically cross-connecting with other low-lying areas during heavy run-off periods ; and
- enhancing the natural treatment system to trap or remove metals along the flow path.

Enhanced wetlands are characterized by water-saturated soils or sediments with supporting vegetation adapted to reducing conditions in their rhizosphere. Often they consist of shallow excavations filled with flooded gravel, soil, and organic matter to support wetland plants such as *Typha*, *Juncus*, and *Scirpus* sp. Treatment depends on dynamic biogeochemical interactions as contaminated water travels through the constructed wetland.

At their present stage of development, passive systems can be reliably implemented as a single permanent solution for many types of metal impacted waters, which is similar in nature to that of the Vehicle Dump (AEC 2) and at a much lower cost than active treatment.

Selection of an appropriate passive system is based on water chemistry, flow rate, local topography and site characteristics. Mechanisms of metal retention within wetlands, listed in their order of importance, include: 1) formation and precipitation of metal hydroxides, 2) formation of metal sulfides, 3) organic complexation reactions, 4) exchange with other cations on negatively-charged sites, and 5) direct uptake by living plants. Other mechanisms include neutralization by carbonates, attachment to substrate materials, adsorption and exchange of metals onto algal mats, and microbial dissimilatory reduction of Fe hydroxides and sulfate.

The way in which a wetland is constructed ultimately affects how water treatment occurs. Two construction styles currently predominate: 1) "aerobic" wetlands consisting of *Typha* and other wetland vegetation planted in shallow (<30 cm), relatively impermeable sediments comprised of soil, clay or mine spoil, and 2) "anaerobic" wetlands consisting of *Typha* and other wetland vegetation planted into deep (>30 cm), permeable sediments comprised of soil, peat moss, spent mushroom compost, sawdust, straw/manure, hay bales, or a variety of other organic mixtures, which are often underlain or admixed with limestone. In aerobic wetlands, treatment is dominated by processes in the shallow surface layer. In anaerobic wetlands, treatment involves major interactions within the substrate.

Implementation: Prior to implementation, this approach requires that the site be well characterized and that the processes which affect surface water and sediment chemistry be well understood. For the Passive In-Situ Treatment to be successful, an in-depth evaluation of the chemical, biological and physical characteristics of the site would be conducted through seasonal monitoring, detailed hydrology studies and bench-scale treatment tests.

A summary of the monitoring plans is provided as follows:

Monitoring Plan	Long-term Monitoring	Passive Treatment
Project Goals	Ensure the protection of human health and environment from exposure to chemicals of concern.	
Operating Principle	Complete detailed monitoring of surface water and sediments, as required. Evaluated data based on trigger criteria and contingency plans	Enhance the natural removal of metals along the surface water flow systems prior to discharge to receiving bodies. Enhancements could include surface water drainage routing and construction of wetlands and filters to reduce chemical concentrations.
Protection of Human Health and the Environment	Yes	Yes
Degree of Site Disruption	Low	Moderate
Confidence Level	Low	Moderate
Estimated Time for Implementation	Long-term (>10 years)	2-3 years
Long-term Effectiveness	Low	High
Ease of Implementation	High	Moderate, studies required
Regulatory and Community Acceptance	Low	High
Estimated Capital Cost	**$100,000**	**$630,000**
Estimated Operating Cost (10 years)	**$300,000**	**$300,000**
Total Estimated Remediation Cost	**$400,000**	**$930,000**