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CARIBOO RECLAMATION PROJECT

AND

SEDIMENT CONTROL DURING THE CONSTRUCTION PHASE OF A MAJOR MINE

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ABSTRACT

This presentation will briefly discuss the Cariboo Reclamation Project and the effectiveness of various erosion control structures implemented during the construction phase of the Kemess South Project.

During the 1999 field season the Ministry of Energy and Mines implemented the Cariboo Reclamation Project aimed at cleaning up and reclaiming abandoned placer leases in the Quesnel to Barkerville area. Revenue collected from the seizure of the bonds on the properties was used as the basis for the funding of the project. The order of priority for the Cariboo Reclamation Project was to:

1) ensure public health and safety,
2) ensure there was no environmental risk,
3) remove abandoned equipment and debris,
4) recontour disturbed areas and deactivate roads,
5) revegetate disturbed areas.

The second part of this paper will discuss control of sediment during the construction phase of the Kemess South Project.

CARIBOO RECLAMATION PROJECT

Twenty-two abandoned placer mines in the Quesnel to Barkerville area were reclaimed using monies confiscated from reclamation securities. The Ministry of Energy and Mines contracted Wright Contracting of Barkerville, B.C. to carry out this work.

Reclamation work completed on two abandoned properties near Hixon, was carried out under Section 17 of the *Mines Act* at a cost of $5,900.00, paid for under the consolidated revenue fund. A contract was awarded to Lawayne Musselwhite to complete the work. Some examples of reclamation projects were:

Antler Creek

Location: 14 km southeast of Barkerville at California Gulch and Wolf Creek.

Site Condition:

Approximately 1.5 hectares was disturbed. No reclamation, or clean-up had been carried out by the Permittee. Sediment pond was intact and impounding water.

Abandoned Equipment:

Fuel tank contaminated internally with rust, scrap metal including make-shift grizzlies, crushed Atco trailer and cat blade.

Reclamation Completed:

All abandoned equipment and debris was removed from the property and disposed of in an appropriate manner. The sediment pond was breached and no longer impounds water. The disturbed area including the tailings were recontoured and seeded with a grass/legume seed mix.

Summit Creek

Location: Bowron Lake Road at the 2300 Road, approximately 6 km. from Bowron Lake.

Site Condition:

Approximately 8 hectares of disturbance. No reclamation or clean-up of the property had been carried out and no soil had been salvaged for reclamation. The majority of the area consisted of exposed gravel with sparse natural vegetation including willows, cottonwood, lodgepole pine and grasses invading the area.

Abandoned Equipment:

Washplant, gravel separator, metal screens, rollers and general debris.

Reclamation Completed:

All abandoned equipment and debris was removed from the property. Some recontouring was carried out to reduce slopes to 2:1 and swales were constructed to provide waterways during the spring melt and run-off. Spreading of soil was limited to the use of fines from the sediment ponds. The soil was used to cap some of the exposed gravel and subsequently the areas were seeded with a grass/legume seed mix.

Pleasant Valley Creek

Location: Bowron Lake Road at 4 km.

Site Condition:

Approximately 5 hectares of disturbance. Disturbance consisted of mounds of tailings, unvegetated exposed gravel and two settling ponds impounding water with a combined area of approximately 1.5 hectares.

Abandoned Equipment:

The only remaining material was a small amount of metal debris. All equipment had been removed.

Reclamation Completed:

The remaining metal debris was removed, settling ponds were pumped down and breached to provide permanent spillway and allow a controlled release of the impounded water. The tailings were recontoured to reconstruct the natural landscape and surface drainage of the area. Where available, fines were spread over exposed gravel and worked areas, and area was seeded with a grass/legume seed mix.

Tregellis Lake

Location: Southwest end of Tregellis Lake, at 8 km on the 2400 Road from Hwy. 26.

Site Condition:

Approximately 6 hectares of highly disturbed and unvegetated land. Disturbance consisted primarily of excavation workings, tailings, sedimentation ponds and access roads.

Abandoned Equipment:

Extensive amounts of metal debris and piping scattered throughout the property, including: a large washplant complete with a *grizzly* and conveyor, a fuel storage area, Rockford Power take-off diesel engine equipped with a pump, an old dragline, a tractor trailer, smaller trailers and structures.

Reclamation Completed:

All of the metal debris, machinery, equipment, trailers and wooden structures were removed from the property. Extensive recontouring was carried out on excavated areas, tailings piles, sediment ponds and roads to reconstruct the natural landscape of the property. Swales were constructed to provide stable waterways and water courses for seepage and run-off. All recontoured areas were seeded with grasses and legumes.

Quesnel River

Location: Downstream side of the Quesnel River Canyon.

Site Condition:

Approximately 2 hectares of disturbance, which appeared to have been recontoured to represent natural topography. Natural regeneration is well established and consists of spruce and cottonwood.

Abandoned Equipment:

One washplant.

Reclamation Completed:

The washplant was removed. No recontouring or revegetation was required.

Cottonwood River:

Location: Adjacent Hwy. 97 at Umity Pit Road, 4 km north of the Cottonwood Bridge.

Site Condition:

Approximately 1 hectare of disturbance consisting of exposed gravel and tailings. In addition, the access road was partially washed out. Abandoned Equipment:

One washplant remained on the property and the remainder of equipment and debris had been removed.

Reclamation Completed:

Reopened the road, constructed waterbars, removed and disposed of the washplant.

Hixon Creek Hydraulic Mine

Location: Approximately 5 km east of Hixon on Hixon Creek.

Site Condition:

A hydraulic placer operation which was abandoned in the 1930's. The 2 hectare area of concern was the former mine-site. The area has revegetated naturally, despite lack of reclamation work.

Abandoned Equipment:

Several of the original buildings with metal siding and roofing remained. Six abandoned vehicles (mostly trucks) and miscellaneous debris including engines and batteries were present.

Reclamation Completed:

All of the buildings were demolished and burned. The abandoned vehicles and debris were removed from the property to the regional disposal site or recycled. Remaining metal and non-combustibles were landfilled on the minesite. The disturbed area was seeded with a grass/legume seed mix.

Quesnel Gold Quartz Mine

Location: Adjacent Hixon Creek, 10 km southeast of Hixon.

Site Condition:

Abandoned underground operation with no reclamation work completed. Refuse dump still visible and the site has revegetated naturally.

Abandoned Equipment:

A 5 metre high timber log-beam ore bin with concrete footings was located on top of the hillside, and two small structures, of which one had collapsed into the creek. An unsecured open two-compartment shaft exposed to surface was considered a public and wildlife safety hazard.

Reclamation Completed:

The standing building was demolished, while the other was removed from Hixon Creek. The ore bin was demolished and all of the combustible material was burned. Concrete footings were placed in the open shaft and the shaft sealed. The refuse dump was covered with soil and seeded with a grass/legume mix.

SEDIMENT CONTROL AND MITIGATION MEASURES DURING CONSTRUCTION OF THE KEMESS SOUTH PROJECT

Background

The Kemess South Project is located in the Omineca Mountains, approximately 350 km northwest of MacKenzie and 250 km northeast of Smithers.

The Kemess South Project is a gold/copper mine, 12.5 square kilometres in surface area, that is designed to process 40 tonnes of ore per day. The project is serviced by a 380 km long, 230 kilovolt transmission line. Sediment control became a major environmental focus during development of the open pit, concentrator site, tailings pond, access roads, and airstrip.

Sediment Impacts

The greatest biological impact sediment can have is its effect on aquatic life, and aquatic habitat. Sediment can fill the voids necessary in spawning gravel for fish, forcing invertebrates out of the voids and from under rocks. Sediment will abrade, or clog the gills of invertebrates and fish species causing them to move out of an area. Sediment can blanket, or abrade algae life, which is the base of the food chain required by invertebrates and fish.

Soil Erosion

In order to deal with sedimentation, it is necessary to understand the basic principles of soil erosion and erosion control. The two major sources of erosion is the splash effect from raindrop impacts and excessive flows in ditches, or intercepts.

The splash effect is the result of impacts of the raindrops on a bare soil surface. Initially a raindrop is absorbed into the soil and the soil becomes moist. As the rainfall event continues, considerable splashing occurs. The impact dislodges small soil particles into a turbid solution and disperses them as part of the splash droplet. Plate-shaped soil particles will stack on top of each other filling and sealing soil voids that act as entry points for water into the soil profile. As the rainfall event continues, the soil surface will become sealed as a crust forms, further reducing the rate of infiltration and, in severe cases, fully preventing infiltration.

The splash effect is easily observed on unprotected agricultural fields during the winter months in the Lower Mainland. The unprotected soil surface will have a smooth sheen from the surface crust. While the fields can have standing water on them, 20 cm below the surface, soil moisture may be below field capacity. This is the result of the formation of an impervious crust on the soil surface.

On a level surface, the dispersal of soil particles is uniform in all directions. On a sloping surface, there is a net movement of soil particles down slope. As the rainfall event continues and the rate of precipitation exceeds the rate of infiltration, surface ponding, and/or run-off will occur. The initial dispersal of soil particles downslope, with no clear concentration, or direction of flow is referred to as sheet erosion. As surface run-off increases during a rainfall event, rill erosion begins which may ultimately lead to gully erosion if left unchecked.

Sediment Removal Techniques

There are various techniques for the removal of sediment which can be implemented during the construction phase of a major project:

- Surface Roughening - Surface roughening increases total surface area, providing a larger area for infiltration, and creates depressions which enhance the amount of water absorbed. It should be noted that this is only a temporary measure, as a protective vegetative cover must be established.

- Gradient Terraces and Simple Terraces - The terraces allow for the run-off to concentrate on the terrace platform, reducing velocity of flow, to enhance infiltration. A vegetative cover, particularly on the terrace platform, will act to slow surface water flow, and therefore lessen the effect of sediment transport.

- Sediment Traps - Sediment traps are usually small structures located in ditches, intercepts, or other water diversion works. They allow an area where the flow can temporarily slow down to near standing, allowing for a significant portion of the silt load to settle. Traps are usually associated with ditch plugs, culvert inverts and sediment control structures installed in diversion works. Sediment traps can be easily cleaned with an excavator.

- Seepage (exfiltration) Basins - are large structures, often up to 2 ha. that collect run-off from a large area and allow the silt-laden water to exfiltrate into the ground, therefore terminating further overland flow.

- Sediment Ponds - are significantly large in-stream structures which trap silt laden water, providing time for the silt to settle. These structures do not filter the flow, but rather decant from the surface where the concentration of sediment is the lowest. A series of sediment ponds, often referred to as polishing ponds, can be constructed allowing the surface of each sediment pond to decant into the pond below, allowing for continuous settling.

- Flocculation of Sediments - Flocculation is a chemical process where a flocculating agent bonds with the silt particles and the subsequent increase in mass causes the particles to settle. Flocculation can be used in association with settling ponds or a series of polishing ponds. Flocculation plants have been installed adjacent to sensitive habitat areas where there is insufficient area for settling ponds or seepage basins.

Erosion Control

A vegetative cover is the most effective measure of preventing surface erosion. A vegetative cover such as grasses and legumes will protect the soil from the splash effect from raindrop impacts, while providing points of entry for the precipitation. Used in areas where run-off will concentrate, or be directed, it can provide surface stability, minimizing or preventing soil erosion.

In areas where there may be a problem with precipitation during the germination and initial growth period, a protective cover over the seedbed may be necessary to protect the seedbed from soil erosion. Protective covers may include strawmatting, hydro-seeding, or mulches.

- Strawmatting - Strawmatting, often referred to as enviromatting, is a straw product embedded in a nylon or cotton mesh that can be rolled out over the soil surface. The layer of straw will act as a protective surface, reducing raindrop impacts, while allowing the seed mix to germinate and establish. The matting needs to lie on a smooth soil surface to be effective and is ideally suited to designed swales, ditches, intercepts, or intermittent waterways. The use of this material is also effective in remote areas where transport of large equipment and access is difficult.

- Hydro-seeding - Hydro-seeding is the hydraulic application of a seed and fiber mulch to a soil surface. It is a relatively expensive operation and is most effective where large areas need to be seeded, or seeded quickly, with relatively easy access to move the equipment to the site. Hydro-seeded material acts as a fiber matrix, temporarily providing a protective cover for the soil until seed is established. 'The fiber can be applied by itself, or can be bonded with a tackifier to strengthen the fiber mat.

- Mulches - An inexpensive alternative to enviromatting and hydroseeding, is the use of loose straw. A straw bale can be broken and the straw spread over the exposed soil surface to a depth of 20 cm. This acts to protect the exposed soil, while allowing the underlying seed to germinate.

Sediment Control Structures Implemented at the Kemess Mine Site

Numerous types of sediment control structures can be used in ditches, intercepts and other diversionary works and waterways. These include the use of silt (filter) fences, straw bales and gravel/sand bag dams. The following comments relate the author's experiences with the use of these structures during the construction phase of the Kemess South Project, where a high volume of run-off occurred.

Silt (Filter) Fencing

Silt fences were used in ditches, diversions and small water courses and in general were found to be ineffective.

Silt fences are one of the most commonly used methods of sediment control and are often used along roadsides and highways. Their installation involves attaching a filter fabric to stakes anchored at the base of the ditch or potential waterway.

Silt fencing is best used in situations with very low velocity and volume. Silt fences should never be used in situations where there is any significant rate of flow. They are also suited as a final sediment control structure adjacent to streams, or waterways and need to be used in conjunction with other sediment control structures.

Most of the literature and courses advocate the use of these structures as an in-stream method of filtering silt from a flow. As with most filtering structures or equipment, the fabric will clog and the structure will begin to impound water and fail. Frequently they will fail at the base or around the sides of the structure. The increase in the velocity of the flow from around or under the structure will usually result in the erosion of the sidewall or base of the diversion structure. Now the sediment control structure has become a source of sediment it was intended to control. To prevent failure, a high frequency of inspection and maintenance is required.

Due to their limitations and high maintenance, the usefulness of silt fences is questionable, and the majority of their implementation tends to be more cosmetic than functional.

Straw Bales

Straw bales are a commonly used form of sediment control and are intended to be installed in a ditch or other diversionary structures. Their installation involves the use of an excavator to trench out a "flat" base, anchoring the straw bale with stakes and packing gravel around the upstream base and sides. Extra work is required to ensure the sidewalls and the base of the ditch or diversion structure are shaped to fit the bale.

As with silt fencing, straw bales are used to slow and filter the flow. If not monitored and maintained on a regular basis, these structures too will tend to clog and impound water. As the impounded water deepens, water will escape from under, between and around the ends of the bale. Once again the structure installed to control sediment may become a source of sediment.

These structures do have their place and can be made much more effective with the installation of an upstream sediment pond.

Gravel/Sand Bag Dams

Probably the most effective structure for the removal of sediment in ditches, or diversionary works at the Kemess Mine, was the use of gravel/sandbag structures. These structures used gravel or sand filled bags placed in the diversion structure to act as a dam. While they do initially have the ability to filter sediment, they mainly function by impounding water and decanting from the top centre of the structure where the concentration of sediment is lowest.

The installation of these structures involves layering the sand or gravel bags on a smooth surface within the diversion structure. The top row of sand or gravel bags needs to have a very shallow v-shape and centre bag removed. This shape functions as a modified v-notch weir, decanting the surface of the impounded water through a controlled point of discharge. Controlling the point of discharge from the structure will prevent the impounded water escaping from around the ends of the structure, causing erosion of the sidewalls of the ditch or diversion structure. This structure can conform to the perimeter of the diversion structure, rather than fitting the diversion structure to the sediment control structure.

The efficiency of these structures can be further enhanced by constructing a sediment basin on the upstream side of the structure. An excavator is the best piece of equipment to prepare a smooth surface for the banks of the dam and construct the sediment basin, and at the same time can be used to make a smooth surface for the base of the dam structure. The sediment basin will increase the residence time, allowing for further settling of the sediment load of the flow.

By placing these structures in a cascading array, you allow each structure to decant into the lower structure, providing a continuous system of sediment settling and collection.

These structures are very stable and require low maintenance. Maintenance involves monitoring and the removal of the sediment from the sediment basin , usually with the use of an excavator. Even when the sediment basin is completely filled with sediment it will not fail, and discharge will continue to decant from the centre point of the structure. Once cleaned out, the structure will continue to function.

Over the long-term when the burlap decomposes, the structure will continue to function as a gravel or sand dam and will provide a base for reconstruction.

<u>In-stream Sediment Control Structures</u>

All in-stream sediment control structures were strictly confined to the area within South Kemess Creek approved under the *Fisheries Act* for habitat destruction. This included the dam footprint and the tailings impoundment on portions of South Kemess Creek and South Arm Creek.

There were three types of structures constructed. These were impervious till dams, settling basins, and a series of polishing ponds.

Impervious Till Dams

These impoundment structures were constructed with an impervious till core up to 3 metres in height and 20 metres in length. An approximate 0.5 ha. impoundment area was designed to create an area of standing water allowing sediment to settle. The flow was decanted from the surface of the impoundment where sediment concentration is lowest, through a series of 60 cm culverts. These structures proved to be quite effective in significantly reducing the silt load.

Settling Basins

These structures were constructed within the dam footprint from talus rock. They were designed to decant the surface of the impounded water through a series of 60 cm culverts. They were fairly effective at creating a pond of standing water, allowing the sediments to settle. However, their susceptibility to piping and the fine content of the suspended material, limited their effectiveness.

Polishing Ponds

A series of polishing ponds were constructed within the footprint of the dam, immediately upstream of the last till dam settling pond. The polishing pond consisted of a series of three impervious settling ponds approximately 450 square metres in surface area. Each discharged from the surface of the impounded water into the next lower pond and finally into the impoundment of the lower till dam. The impoundment area of the lower till dam was over 0.5 ha. These structures were stable and allowed additional sediment to be settled prior to the flow entering the final sediment control structure.

Collection Structures

Main Camp Settling Pond

This three hectare structure was constructed below the mill and camp area and is designed as a settling pond and exfiltration pond. All run-off from the camp and mill areas was directed to this structure. Presently the impounded water is pumped to the mill and used for process water, while during construction, its function was as a sediment control structure. *An* engineered spillway constructed on the east end of the pond provided a discharge point when the pond was to overflow. Prior to the pond overflowing, the impoundment was pumped from the surface at the opposite end from the inlet and piped down to a contained basin in fluvial gravel, where it exfiltrated into the groundwater. Pumping in this manner ensured the lowest concentration of sediment in the discharge.

This was a stable and effective structure.

Concluding Comments

The two primary limiting factors that created serious problems controlling sediment during the construction phase of the Kemess South Project, was a high volume of flow in a confined area, and the fineness of the suspended particles. Particle sizes were, on occasion, below the levels of detection, and contributed significantly to the overall particle size distribution.

The most effective sediment control structures for ditches and diversionary works was the use of gravel/sand bag dams with a sediment basin. These structures were effective, easily installed, required low maintenance and would not fail when filled with sediment.

The most effective sediment control structures for in-stream works was the use of till dams and polishing ponds.

All of these structures provide an area of still water allowing sediment to settle and decant from the surface where the concentration of the sediment is the lowest.

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