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Utilizing Volcanic Ash as a Natural Flocculant in Placer Settling Ponds

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Midnight Mines Ltd.

MERG is a cooperative working group made up of the federal and Yukon governments, Yukon First Nations, mining companies, and non-government organizations for the promotion of research into mining and environmental issues in the Yukon.

Utilizing Volcanic Ash as a Natural Flocculant in Placer Settling Ponds

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Summary

Under existing regulations, the discharge or effluent from placer miners' settling ponds must meet certain standards for the amount of clay and silt in suspension (suspended solids) and/or the amount of material settling out (settleable solids). Previous research indicates that manufactured flocculants could help miners meet these standards. Flocculants enable particles within water to contact each other and agglomerate to form larger particles which will settle out more rapidly. However these manufactured flocculants are expensive and may deposit foreign (deleterious) materials in the discharge waters. Based upon prior government research, it appears that volcanic ash might act as a natural flocculant.

Seven samples of volcanic ash were collected from various sites in the Yukon which were close to active placer mining areas. The samples were dried, sieved and analyzed to determine their characteristics. The ashes were found be quite different in grain size and possible source.

Lab testing concentrated on two samples of ash and sediment from the Big Creek Area (west of Carmacks). A series of tests were completed on the sediment samples, with varying amounts of ash being added. Readings were taken initially, and at 1 hour and 24 hour intervals to obtain the levels of material in suspension (suspended solids) and the measure of light penetration through the sample (turbidity). The objective of adding a flocculant (in this case, volcanic ash) was to decrease the amount of material in suspension and increase the amount of material settling out.

Preliminary results from this study indicate that the addition of volcanic ash (in amounts of 1 to 16 grams per litre) to sediment samples appears to be successful in decreasing the amounts of material in suspension and increase the amount of material settling out.

Additional, more comprehensive testing needs to be done to follow up on these initial encouraging results. This would include tests on the other ashes collected, as well as possible field testing of the ash within operating placer mines.

Acknowledgements

The authors would like to thank Mark Nowosad, Water Quality Technologist of the DIAND Mining Inspections for his continuous support and enthusiasm for this project. Bill LeBarge, Placer Geologist of the Exploration and Geological Services Division of DIAND provided expert advice, support, as well as samples and analyses for the study. Support from the Exploration and Geological Services Division, DIAND, the Mining Inspection Division of DIAND, and the Yukon Geology Program (DIAND/YTG), particularly in access to the Water Resoures Lab, and its equipment, as well as Mark Nowosad's time have made this project a reality. Discussions with Kim West and Duane Froese provided insight into the White River Ash and the tephra beds of the Klondike. We would like to express our appreciation to Ron and Bernie Johnson of Beron Placers, who collected the ash sample from Irish Gulch. As well, a thank you to all placer miners who were interested in the project and willing to be part of field tests in the future. A final thank you to Tanya Gates for the laboratory testwork.

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Executive Summary

Under the Yukon Placer Authorization, discharge from settling ponds must meet standards of suspended solids and/or settleable solids concentrations. Previous research indicates that manufactured flocculants could help miners meet these standards. However, these flocculants are quite costly and also may deposit additional deleterious materials into the discharge waters. Based upon the work of Mark Nowosad, Water Quality Technologist for the DIAND Mining Inspection Division, Yukon Region, it would appear that volcanic ash might act as a natural flocculant.

In order to follow up on this the work of Mark Nowosad, a total of seven ash samples were collected from various localities in the Yukon. The seven samples were dried, and sieved to determine their grain size. The ashes show a wide variety in grain size, and in possible source.

A series of lab tests were conducted on two of the ashes, known as the Big Creek Ash A and B, which are believed to be part of the White River Ash, the most predominant ash in the Yukon. Two sediment samples from the Big Creek area had been collected and analyzed in prior work undertaken in the Yukon Placer Deposit and Water Sampling Program. The testwork in this study included determining the characteristics of the Big Creek Ash A and B, as well as the sediment effluents from Big Creek. A series of jar tests were completed on the samples, where various amounts of Ash A and B were added to the sediment effluents. Readings were taken initially, and at 1 hour and 24 hour intervals of the suspended solids and turbidity. From these readings, the percentage of suspended solids and NTU removed from the sample were calculated. The settleable solids were also determined on the samples. The objective of adding a flocculant (in this case, ash) is to increase the percentage of suspended solids and NTU removed, as well as the settleable solids in the sample.

Initial results indicate that adding smaller portions (up to 1 gram/L) did not affect the suspended solids and turbidity. However, jar tests where larger quantities of ash (up to 16 gram/L) were added did appear to increase the amount of suspended solids and NTU removed from the sample, as well as increase the settleable solids.

Additional tests need to be completed with the other ashes from the Kluane and Klondike area on local effluent samples, as well as to test the ash from Big Creek on non-local effluent samples. Dependent upon results, the ash will be field tested at operating mines.

1. Introduction

Under the Yukon Placer Authorization, discharge from settling ponds must meet standards of suspended solids and/or settleable solids concentrations. Previous research indicates that manufactured flocculants could help miners meet these standards. However, these flocculants are quite costly and also may deposit additional deleterious materials into the discharge waters. Based on the work of Mark Nowosad, DIAND Mining Inspection Division, Yukon Region, it would appear that volcanic ash might act as a natural flocculant.

1.1 Objectives of the Study

There were three main objectives of this study:

1. Research and document localities of volcanic ash and their proximity to active placer mines in the Yukon
2. Test the hypothesis of volcanic ash as a natural flocculant through a series of lab tests
3. Prepare a list of placer miners willing to test the ash as a flocculant in their operations.

1.2 Yukon Placer Authorization (YPA) Guidelines

Placer mining operations must comply with the sediment discharge standards that pertain to the creeks which they mine upon. These discharge standards vary depending upon the type of creek affected. At present, the schedule of available sediment discharges allows for two types of standards – suspended solids and settleable solids. According to the YPA (1993):

> The sediment discharge standards have been developed using models based on suspended solids receiving water quality objectives. Since suspended solids cannot be easily measured in the field, the suspended solid standards have been expressed, where possible, in terms of settleable solids using empirical relationships developed from data collected in the Yukon over a period of seven years (1986 to 1992 inclusive). A suspended solids standard has been employed where the observed variability between the two measurements was found to be too large to provide acceptable protection standards.

The general standards allowable for different creek types are set out in Table 1 on the following page, taken from the YPA(1993).

Table 1 Schedule of Allowable Sediment Discharges General Standards	
Classification of Stream	**Concentration of Sediments Above Natural Background**
Types I and V	0*
Type II	< 200 mg/l*
Type III	<200 mg/l*
Type IV	Specific values for suspended solids and settleable solids for each creek

*or limit established in Table II (YPA, 1993) if that limit is less restrictive

The specific standards set for most actively mined creeks in the Yukon can be found within the Yukon Placer Authorization and Supporting Documents (1993).

The YPA (1993) provides the following definitions for settleable solids, suspended solids and turbidity: Settleable solids are sediments in the water that, when measured by an Imhoff cone test for one hour, settle to the bottom of the cone (measured in millitres/litre). Suspended solids are the solid particles (usually clay and silt particles) that move in suspension in water, either as a colloid or through the influence of the upward component of turbulent currents. Measurement (in milligrams/litre) takes place by passing the sample through a filter and weighing the amount of material on the filter. Turbidity is the measure of light penetration (diffusion) in water which can be measured using visual standards or electronic standards using Nephelometric Turbidity Units (NTU).

Placer miners have in almost all cases been able to meet the standards set out in the Yukon Placer Authorization, but in many cases have found it to be uneconomic to operate because of the high costs associated with the attainment of those standards. In some instances it has been physically impossible due to size constraints of narrow, steep valleys to put in the number of settling ponds of a size necessary to settle out the effluent. The cost of the equipment needed to recirculate water in zero discharge systems is often too high to justify a mining decision.

1.3 Sedimentation, Coagulation and Flocculation Theory

In order to understand the terms coagulation and flocculation, it is important to define sedimentation. According to Stanley & Associates and Canviro Consultants (1985) "Sedimentation refers to the gravity settling of suspended particulate matter from the aqueous phase due to the difference in specific gravity between the particles and water." Table 2 below shows the relationship between particle diameter and settling velocity.

Table 2
Relationship Between Particle Size and Particle Settling Rate

Particle Diameter (mm)	Particle Description	Settling Rate (mm/s)	Time Required to Settle 0.3 m
10	Gravel	1,000	0.3 s
1	Coarse Sand	100	3.0 s
0.1	Fine Sand	8	38.0 s
0.01	Silt	0.154	33 min
0.001	Clay upper limit	0.00154	55 hour
0.0001	Clay	0.0000154	230 days
0.00001	Colloid	0.000000154	63 years

Taken from Stanley & Associates and Canviro Consultants(1985)

The table above indicates that sedimentation alone is not an effective means of removing clays and colloids. Agglomeration of this material will create particles of sufficient diameter and density to settle by gravity.

Within water, particles usually carry a negative electrical charge. This charge prevents particle contact and agglomeration. Coagulation involves the addition and rapid mixing of chemicals to neutralize these charges, allowing interparticle contact and the formation of larger particles called floc. Gentle mixing of the wastewater will encourage floc growth, and is termed flocculation. (Stanley & Associates and Canviro Consultants, 1985). Flocculants can be neutral, or hold a negative (anionic) charge or a positive (cationic) charge. Synthetic flocculant aids act as a bridge between solids in suspension, helping to create larger "floc" (Reid Crowthers & Bethell Management, 1984).

1.4 Previous Research on Manufactured Flocculants relating to Placer Mining

Significant research has been completed on placer mining. Many of these studies address the issue of manufactured flocculants to help achieve effluent standards. The following text will summarize some of these studies.

According to Stanley Associates & Canviro Consultants (March 1985) a study carried out by Sigma in 1982 noted that simple settling ponds were not capable of achieving effluent specification without the addition of polymers. Conventional jar tests were carried out, and coagulation tests on 2 polyelectrolytes (an anionic and non-ionic) indicated the anionic was more effective in getting the suspended solid concentration to < 100 mg/l. For five different sites, the dosage added ranged from < 1 mg/l to 20 mg/l.

The Canadian Department of Environment and Department of Fisheries and Oceans completed a report in 1983 entitled "The Attainment and Cost of Placer Mining Effluent Guidelines". The report proposed how to obtain standards of 1000 mg/l, 100 mg/l and 0 mg/l suspended solids in waste water from placer miner operations. Three scenarios involving primary and secondary settling ponds were outlined. The study determined that some operations may have to use flocculants to attain the 100 mg/l or 0 mg/l standard due to clay content being too high, or due to restrictions on the size of settling pond possible to construct on the property. The study noted that no proven compound and dosage appeared to work better than others. Each creek has it own clay component and creek water chemistry. The flocculants need to be experimented with to find the best type/dose for the money. The type of clay within the creeks is important. Polyacrylamide (synthetic, organic compound) appeared to work well in Yukon streams.

This work was followed up by a 1984 study completed by Reid Crowther & Partners Limited and Bethell Management on the potential use of polyacrylamide flocculants in the Yukon Placer Mining Industry. Field studies were undertaken at 15 placer mine sites to determine the effectiveness of synthetic flocculant aids to remove suspended solids from placer mine effluents. The placer mine operations varied in scale (2-44 personnel, 7.6 to 300,000 m^3/yr water processed) and 40% of the mines recycled the water. At each site, the characteristics of the material processed and the influent and effluent water was determined. Six different flocculants were tested; 5 which were anionic polyacrylamides with varying molecular weight and charge density and the 6th which was a nonionic polyacrylamide. The study determined that synthetic flocculant aids can enhance the settling characteristics of placer operations. The non-ionic polymer, Percol E10 produced the best test results. However, no single flocculant was found to be best at all sites. A key comment was that the chemical characteristics of water and nature of soils in suspension appear to affect the performance of the flocculant aid.

Shannon & Wilson Inc. (1985) carried out a 3 phase study on Placer Mining Wastewater Treatment for the State of Alaska, Department of Environmental Conservation. The study reviewed costs, alternative processes, treatments, standards and new technology. Phase 1 involved an intensive literature review, where phase 2 focused on lab tests of chemicals for effluent clarification. The coagulants and flocculants tested in the lab were able to reduce placer mine effluents that contained 5,910 to 26,900 mg/l suspended solids with 10-36% clay content and turbidity in the 2,000 to 13,000 NTU range. Shannon & Wilson (1985) make reference to earlier studies that indicate coagulants/flocculants work better where there is a higher percentage of solids in the water. They recommended that coagulant/flocculant studies need to be conducted on samples with lower suspended solids.

Stanley & Associate and Canviro Consultants (1985) investigated the use of flocculants as a possible method of reducing the quantity of suspended solids in settling pond effluent. The studied involved mainly anionic types of flocculants. The results indicated that they worked well in reducing the sediment load. However, the flocculants were in powder form, and involved an elaborate mixing and feeding system, quite feasible for a large long-term operation, yet beyond the resources of the typical small narrow valley Yukon operator. This work was followed up by a study which identified placer mines which might benefit from flocculants, as well as carrying out several jar tests. Three operators showed interest in the project. A total of 11 different polymers in 4 different types (solid grade polyacrylamides, liquid dispersion polymer, emulsion polymer and cationic polymer) were run through jar tests. It appeared the suspended solids had a significant effect on the polymer efficiencies. This work led to the field trial in 1986. Conclusions from this study included that the feeding system capital cost was low and operating cost was low, yet the flocculant additions at this site gave marginal improvements in sediment treatment. However, the study indicated that the use of flocculants would have greater potential in situations where there is build up of unsettleable fines and where space for pond construction is limited.

P.K. Weber (1986) completed a review of the literature available for chemical flocculants in water clarification, to determine possible application to placer mining. This review included background organic/inorganic chemicals to treat wastewater, factors influencing effectiveness of these chemical compounds, methods of application, and estimates of capital costs including methods to estimate dosage requirements. This is a comprehensive review and there are many papers referenced that could provide additional information on flocculants.

Y.H. Shen (1987) completed a masters thesis on the use of flocculants to control turbidity in placer mining effluents. Shen noted the following hydrodynamic factors for flocculants are important: agitation, temperature, pulp density, particle size and method of flocculant addition. The following physio-chemical characteristics also play a role: Van der Waals Forces, electrical forces, flocculant bridging forces (electrostatic, hydrogen bonding, chemical bonding). The nature of the flocculant is also important: physical (dry, emulsion, liquid), molecular weight and the charge (non-ionic, anionic and cationic). Shen notes that the mechanism of flocculation using polymers is a very complex process and poorly understood.

1.5 Project Background

In 1999, 27 observation stations, using specialized monitoring instrumentation, were set up in the Big Creek area, within the Dawson Range Placer Mining Area (see Figure 1). These stations were set up by the Mining Inspection and Geology divisions of DIAND, in order to collect water quality data from the Big Creek drainage area. The instruments collected data continuously for a period of 4 months. Instruments were located upstream and downstream of any mining operations, at the headwaters and mouth of each stream in the basin and at key points along Big Creek and Seymour Creek. Additional stations were located at the stream class change points along the streams in the watershed and just below the points of discharge of one tributary into another receiving body of water or stream. Throughout the season, composite grab samples of stream water, streambed sediment and bank material from each site were collected. These samples were analyzed for a variety of parameters and the data collected from these analyses along with the monitoring stations data was recorded as part of the ongoing *Yukon Placer Deposit and Water Sampling Program*.

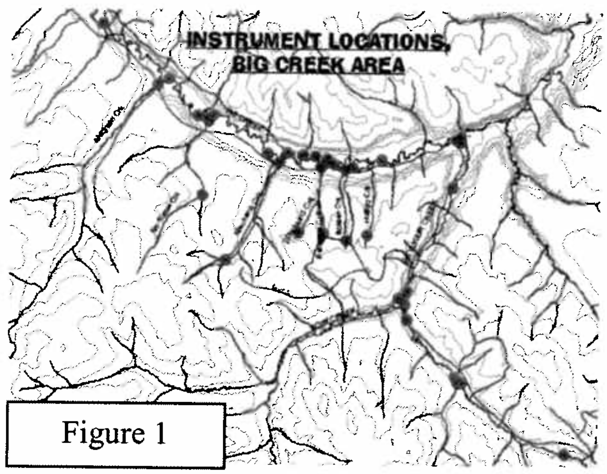


Figure 1

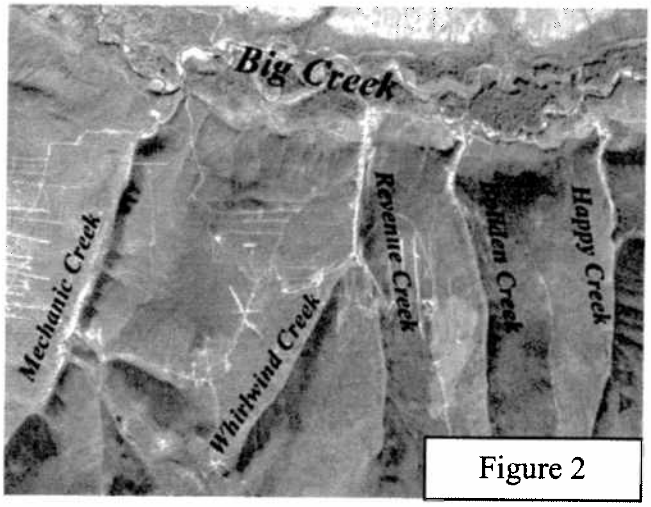


Figure 2

One area of particular interest was a section of Big Creek, less than ½ of a km long, located between the Revenue Creek and Boliden Creek confluences with Big Creek (See Figure 2). The analysis of the data and water samples collected from Big Creek, downstream of Revenue but upstream of Boliden indicated a major improvement in the water quality in this section. Water samples collected ½ km farther downstream from the Boliden / Big Creek confluence, did not show this same improvement, in fact degraded back to normal Big Creek background levels.

Through further research and site observations, it was determined that a very large bank deposit of volcanic ash (see Figure 3), located just upstream of the Boliden / Big Creek confluence, was being scoured by Big Creek. A large quantity of this ash was being mixed into the flowing waters.

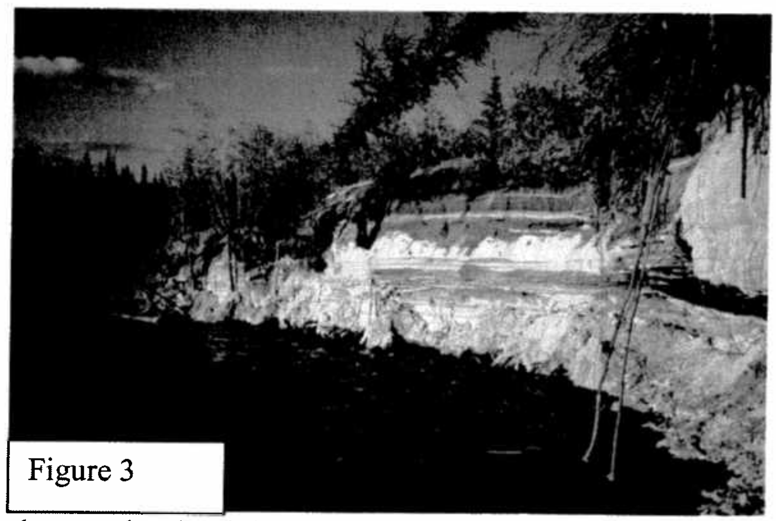


Figure 3

The clarity of the water was reduced to very low levels by the introduction of the ash but less than 200 meters downstream, the water was clear. There was little or no evidence of solids in the water (see Figures 4 and 5 on the following pages). There was however, a thick, floury deposit of material on the bottom of the creek, much heavier than anywhere else sampled along Big Creek. Grain size analysis of streambed samples, collected from above and below the ash deposit, indicated a major change in the grain size distribution and an increase in the amount of fines in the downstream sample when compared to those collected upstream.

It was concluded that something, most likely the ash, played a significant role in decreasing the solids concentration in the water. The ash helped to trap and settle the solids, depositing the combination on the streambed. Downstream from this settling point, very little trace of ash was found. The water quality of the creek reverted to normal background levels downstream of this point as the creek continued to erode fresh stream bank material and scour up more bottom sediment.

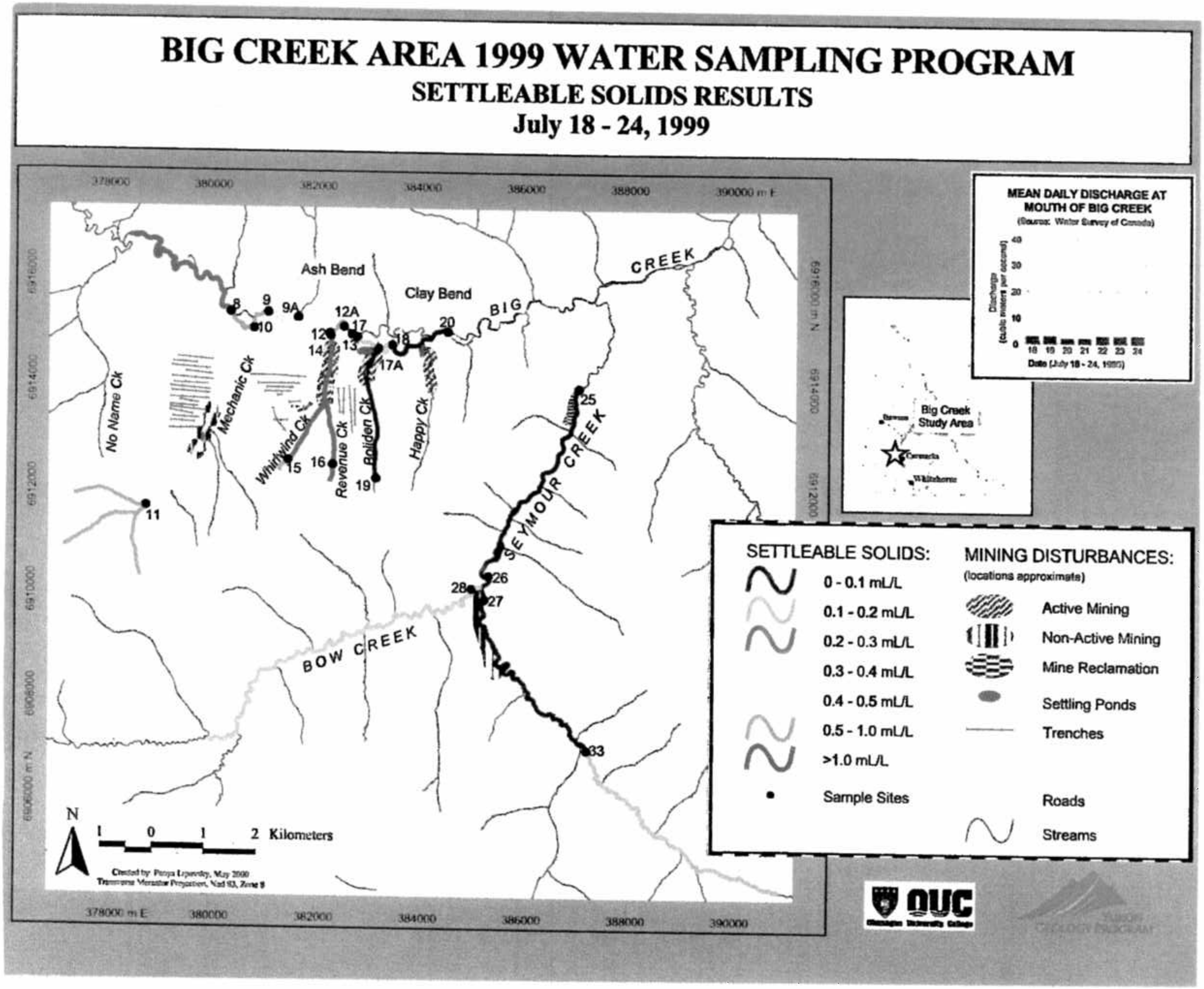


Figure 4 Big Creek Settleable Solids
(from Nowasad and Lebarge 2000)

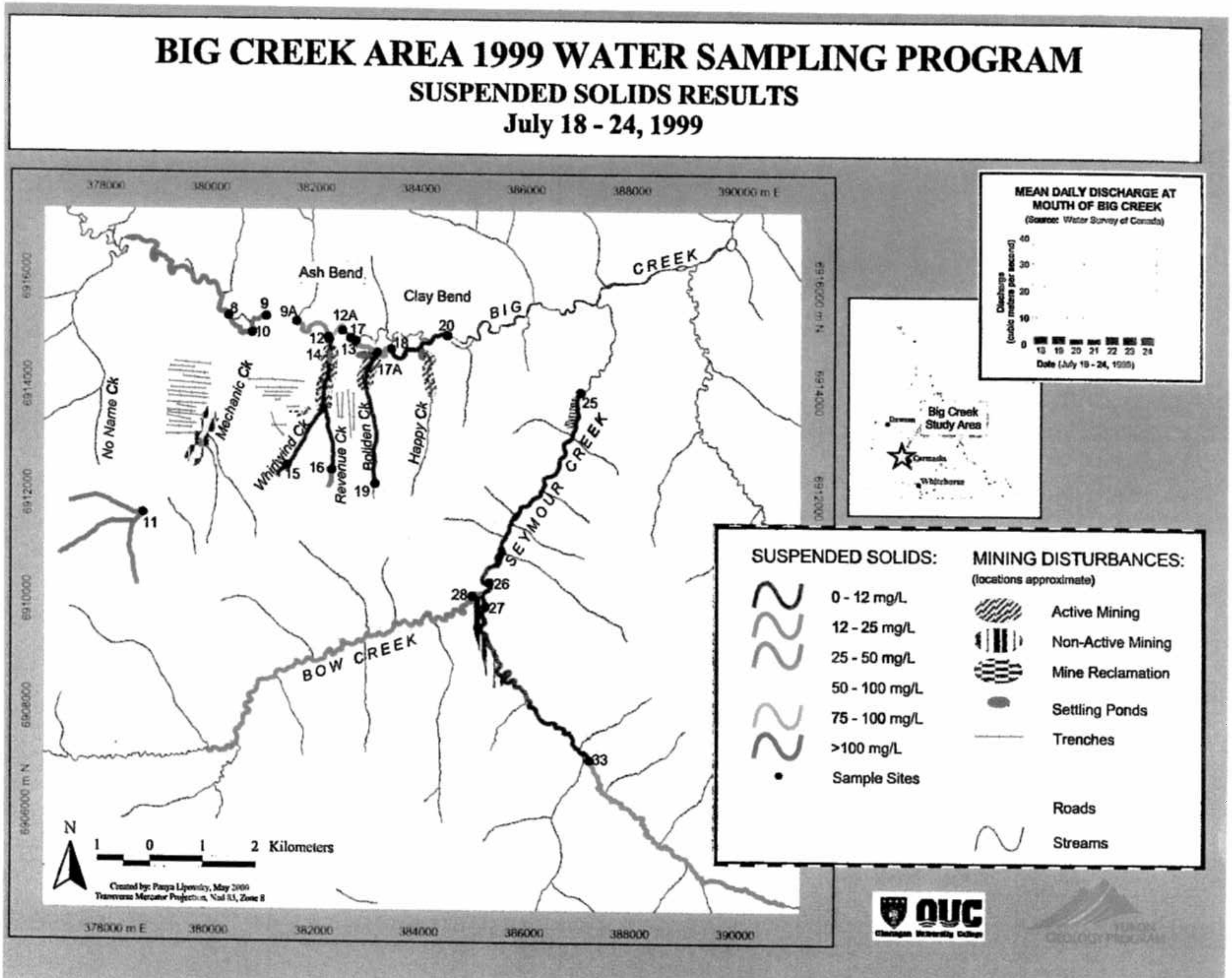


Figure 5 Big Creek Suspended Solids
(from Nowasad and Lebarge 2000)

1.6 Location of Ash in the Yukon

The White River Ash blankets much of the Yukon Territory as well as parts of the Alaska and Northwest Territories. Two separate lobes, a "northern" lobe and an "eastern" lobe represent two separate eruptions, the northern dated at 1890 BP and the eastern about 1250 BP. The ash covers 340,000 km^2 and contains an estimated 25-50 km^3 of tephra (bulk volume) (Richter et. al., 2000). Figure 6 (taken from Downes, 1985) shows a sketch map of the extent of the distribution of the ash.

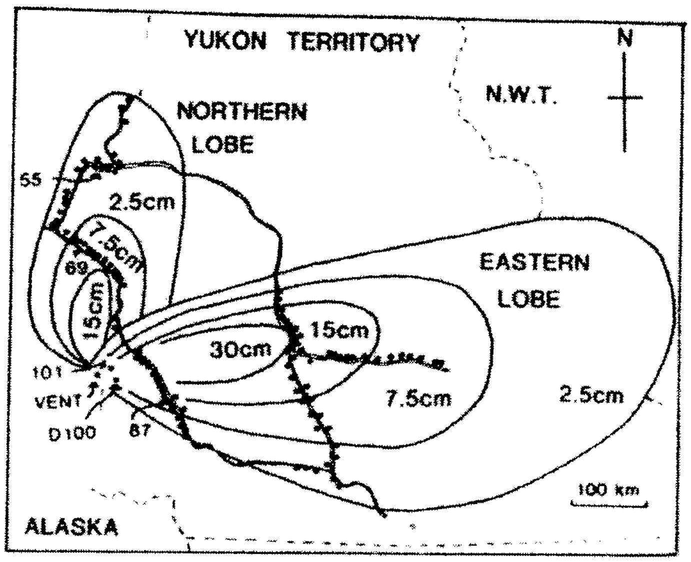


Figure 6: Sketch map of extent of White River Ash

The ash appears in thin bands in quarries, road cuts, and river banks and is found less than 1 m beneath the surface of the soil (Downes, 1985).

The White River Ash was first located in 1883 by Schwatka who was exploring the upper Yukon River Basin. Other early explorers (Dawson, 1888 and Hayes, 1892) documented the ash as well. A crude isopach map of the White River Ash was constructed as early as 1915 by Capps (Richter et al. 2000).

Field and laboratory studies recently completed by Richter et. al. (2000) indicate that Mount Churchill, in the St. Elias Mountains of southcentral Alaska, is the source of the eastern lobe of the White River Ash. However, investigation of the chemical variations within the two lobes by Downes in 1985 had determined that the ash comes from the same magma chamber, and therefore one source. Research is presently being undertaken by West (2001) on the White River Ash to develop a geochemical fingerprint to differentiate between the two lobes of ash.

In the Yukon, other tephras include the Old Crow tephra (150,000 years old), the Mosquito Gulch tephra (1.22 million years old) in the Bonanza Creek drainage and the Sheep Creek tephra from Ash Bend, Stewart River, also about 150,000 years old (Fuller and Jackson, 2001). Recent work in the Klondike area of the Yukon by Preece et. al. (2000) has determined 12 distinct tephra beds, seven which come from the volcanoes in the Wrangell volcanic field and four from the more distant eastern Aleutian arc-Alaska Peninsula region. The Dawson, Old Crow, Sheep Creek, Mosquito Gulch and Quartz Creek tephra beds had been identified prior to Preece's paper. Preece et. al. (2000) discuss the tephra beds as follows:

> Many tephra beds are thin, fine-grained, discontinous pods and some have been deformed and reworked by solifluction and other periglacial processes, commonly resulting in repetition of the tephra over a restricted stratigraphic interval of about one metre. All of the tephra beds have been given informal names, most of which have been taken from local geographic features.

Figure 7 taken from Preece et. al. (2000) shows the distribution of the Old Crow and Sheep Creek tephra beds as well as the location of the Klondike district in relation to the Aleutian-Alaska Peninsula arc, and the Wrangell Volcanic field.

Figure 7

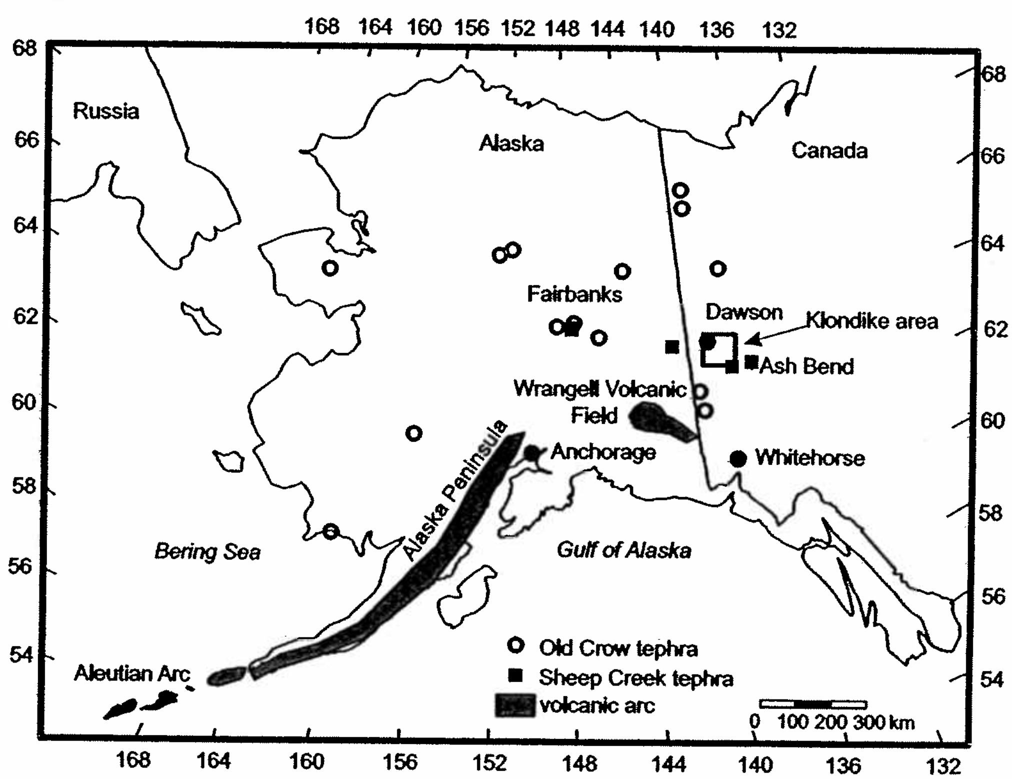
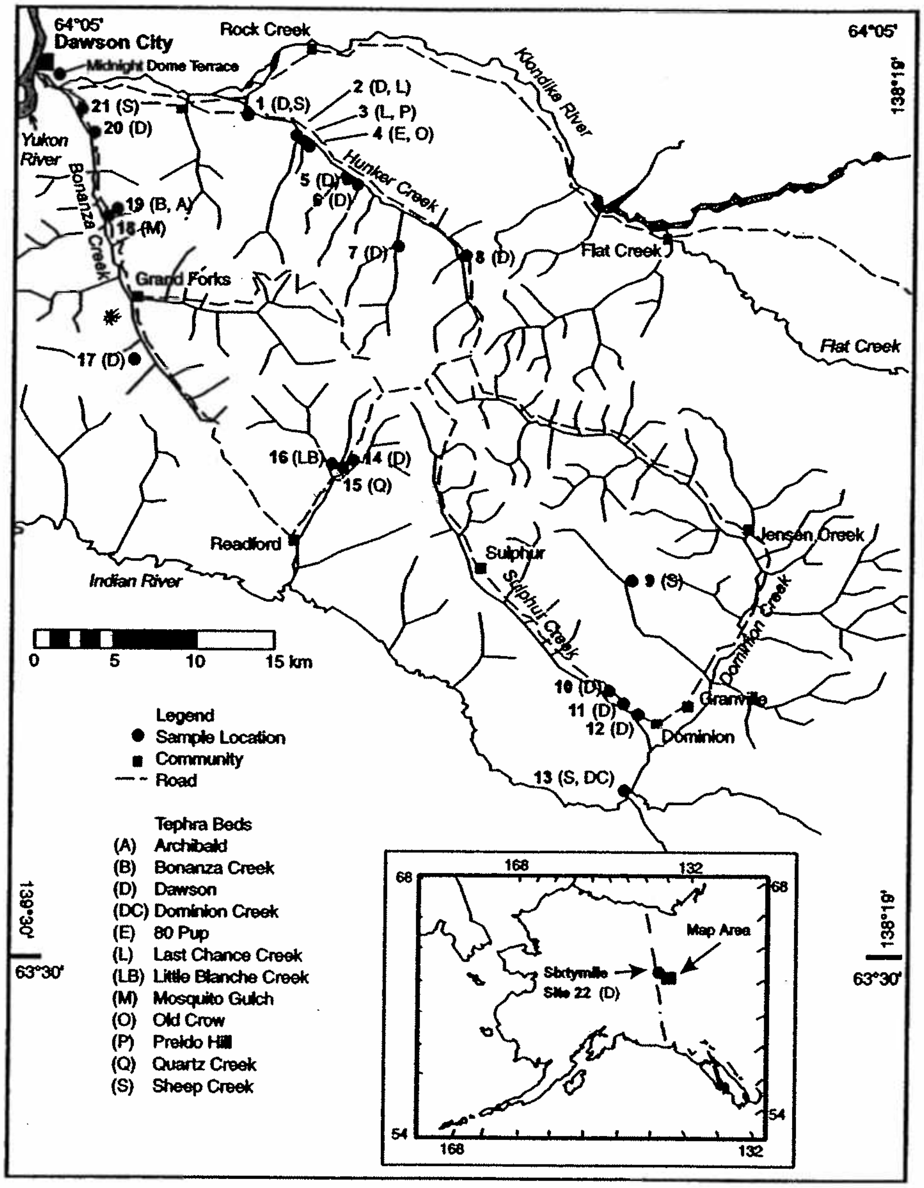


Figure 8 taken from Preece et. al. (2000) notes the locations of samples and the corresponding tephra beds in the Klondike District.

Figure 8



Additional work completed by Westgate et al (2000) on the Dawson tephra, the most prominent tephra bed in the Klondike, notes that the Dawson tephra bears a close resemblance to the Old Crow tephra. Both these tephras demonstrate a source in the Aleutian-Alaska Peninsula region. The source of this tephra is +700 km from the Klondike, indicating that the explosive eruption was of great magnitude, and that the Dawson tephra may also be distributed across the southern and central Alaska and Yukon.

Additional work is ongoing in the Dawson area on the tephra beds which will help provide additional information on the tephra in this area.

1.6 Location of Placer Mining Areas in the Yukon

Historic placer mining areas in the Yukon can be grouped into ten regions. These include Klondike, Sixtymile, Fortymile, Moosehorn Range, Clear Creek, Mayo, Stewart River, Dawson Range, Kluane area and Livingstone (see Figure 9 on the following page). Each area has its own geomorphic setting and depositional history, related to its glacial history (LeBarge, 1996).

The most active placer mining areas are found in the unglaciated areas of the Klondike, Sixtymile, Fortymile and Stewart River areas. Mayo, Clear Creek and the Dawson Range are the next most active areas.

It is difficult to determine the extent of the various ashes in the Yukon. Although the White River Ash has extensive coverage over the Yukon, the extent of the other ashes has not been determined. However, it appears that some type of ash, is present within all of the placer mining areas outlined on the following page.

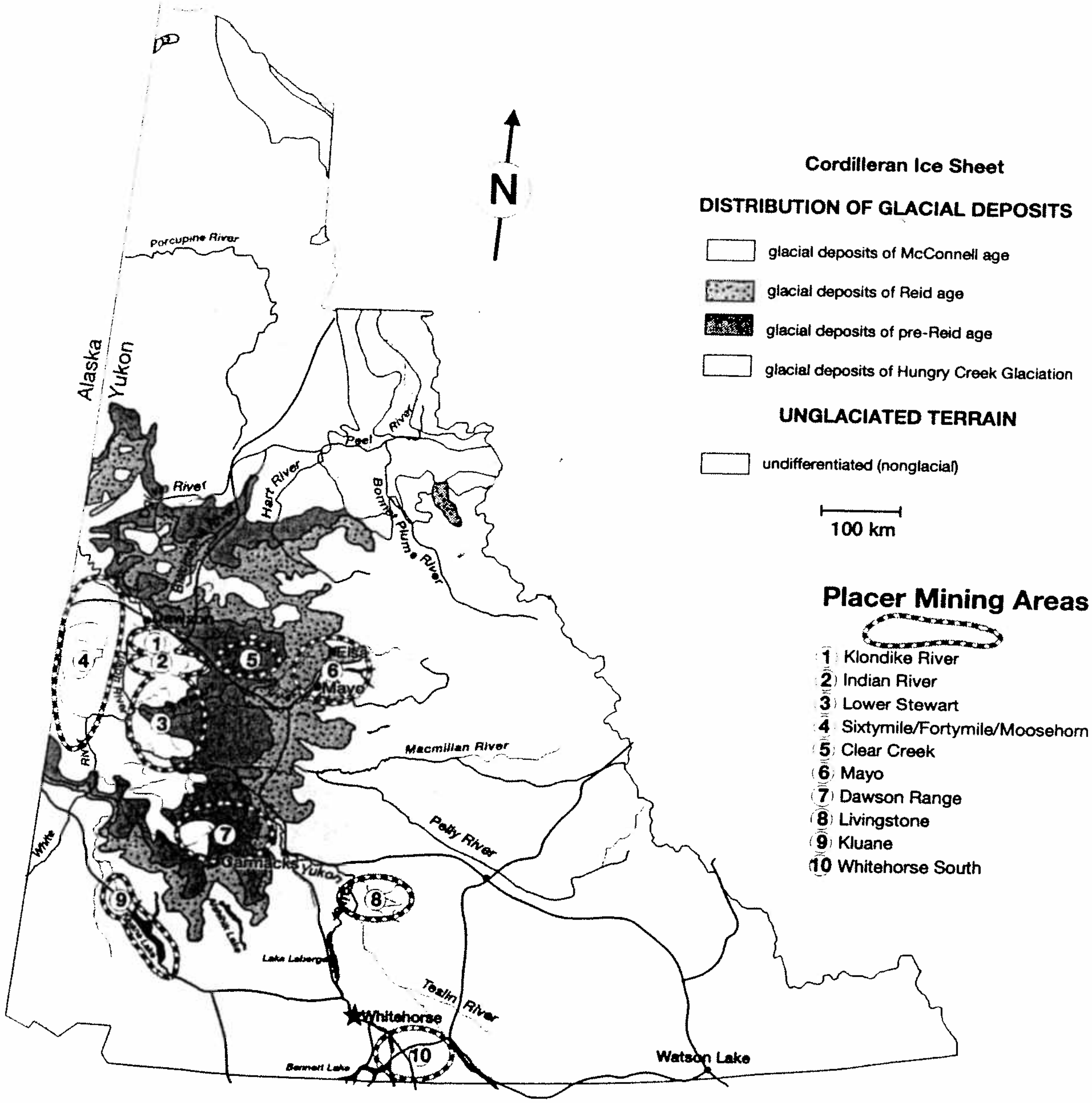


Figure 9 Extent of Pleistocene Glaciations and Placer Gold Mining Areas in Yukon (from Lebarge et. al., 2002)

2. Methodology

2.1 Collection of Samples

2.1.1 Ash Samples

A total of seven samples of ash were collected for this study. Three samples were collected from the Dawson Range Placer Mining Area (including Big Creek Ash A and Big Creek Ash B, and one from Caribou Creek). Two samples came from the Kluane Placer Mining Area. Donjek River 1, from near the Koidern River, and Donjek River 2 from just south of the Donjek River. Two areas were sampled in the Klondike Placer Mining Area; Irish Gulch and Sulphur Creek. The general locations of these samples sites are shown in Figure 10.

Big Creek Ash A and Ash B samples were collected from the same area of Big Creek, but from different layers within the deposit. The Big Creek "Ash Bend" volcanic ash deposit is approximately 3 metres in thickness (refer to Figure 3) and is located in the right limit bank of Big Creek near its confluence with Boliden Creek. The upper layer of the ash deposit was sampled as Big Creek Ash A and was made up of a clean, white fine silty layer of ash approximately 1 metre in thickness in the locality sampled. Ash A was covered by brown soil and organics beneath moss and willows. This layer was intermittently frozen in the area sampled. Big Creek Ash B sample was collected from a layer approximately 30 cm lower in the same deposit as Ash A. This layer was more than 2 metres thick yet appeared to have more inclusions of other matter (dirt, sand, sticks, organics etc.). Ash B is a slightly coarser ash than Ash A, more greyish brown in colour and contained more organics than Ash A. The bed from which the sample was taken appeared to be completely frozen in the location sampled.


Figure 11

Caribou Creek was collected in the right limit bank of Caribou Creek approximately 150 metres upstream from its confluence with Sunny Creek (a left limit tributary entering Caribou Creek approximately 1.5 km from its mouth). The ash bed in the location sampled was approximately 0.2 metres thick, and was composed of a thawed layer of fine silty white ash (see Figure 11). The ash layer was covered by organics and underlain by brown sand and gravel. In this area there are several beds of ash which have been found to be up to 1.3 metres thick. The location of the Big Creek and Caribou Creek samples can be found in Figure 12.

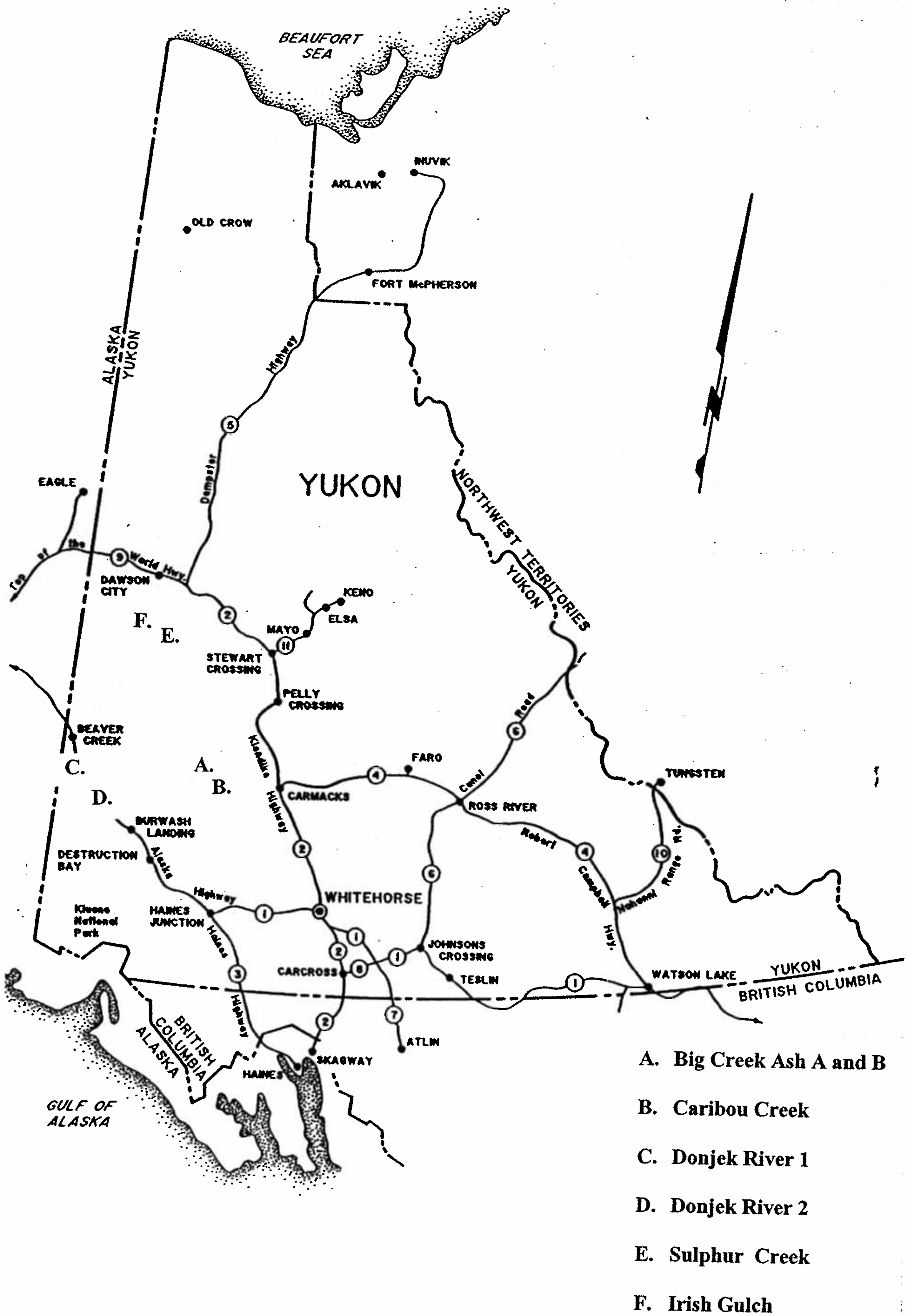


Figure 10 Location of Ash Samples Collected

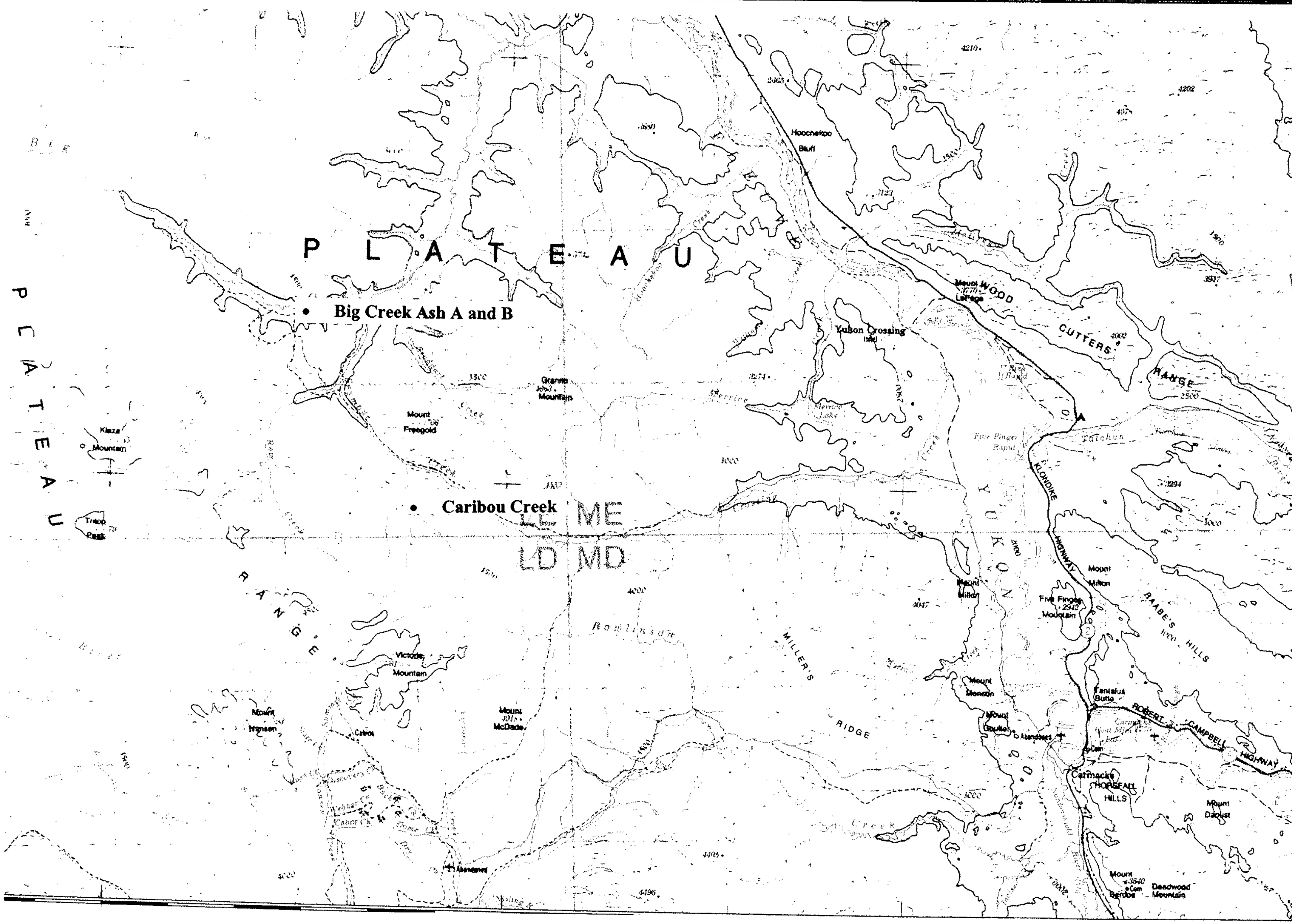


Figure 12 Location of Big Creek Area Ash Samples within the Dawson Range Placer Mining Area
1:250,000

Donjek River sample 1 was collected on the east side of the Alaska Highway in a roadside ditch approximately 2.2 km south of Pine Valley Lodge. The sample was collected from a 0.7 metre thick layer of sand size ash. The ash layer was capped by a layer of frozen high organic sediment (black muck) and organics (see figures 13 and 14).

Figure 13

Figure 14

Donjek River sample 2 was collected on the hill (in a roadside ditch) south of the Donjek River Bridge, north of the Northwestel tower site at km 1816.9. The sample was taken from a 0.4 metre thick bed of ash with organics above and black muck below (see figure 15). The ash exhibited a fine sandy texture and was slightly browner in colour than Donjek River sample 1. Refer to Figure 16 on the next page for the location of the Donjek River samples.

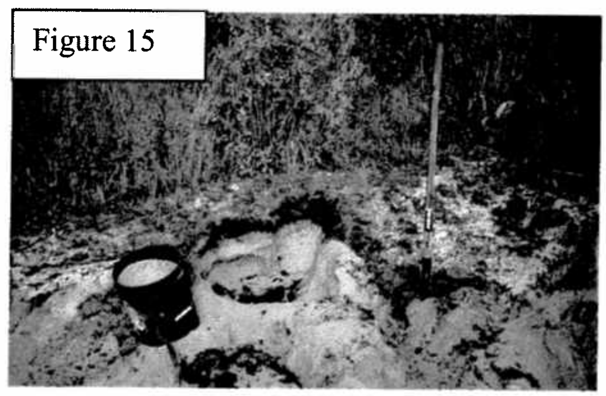


Figure 15

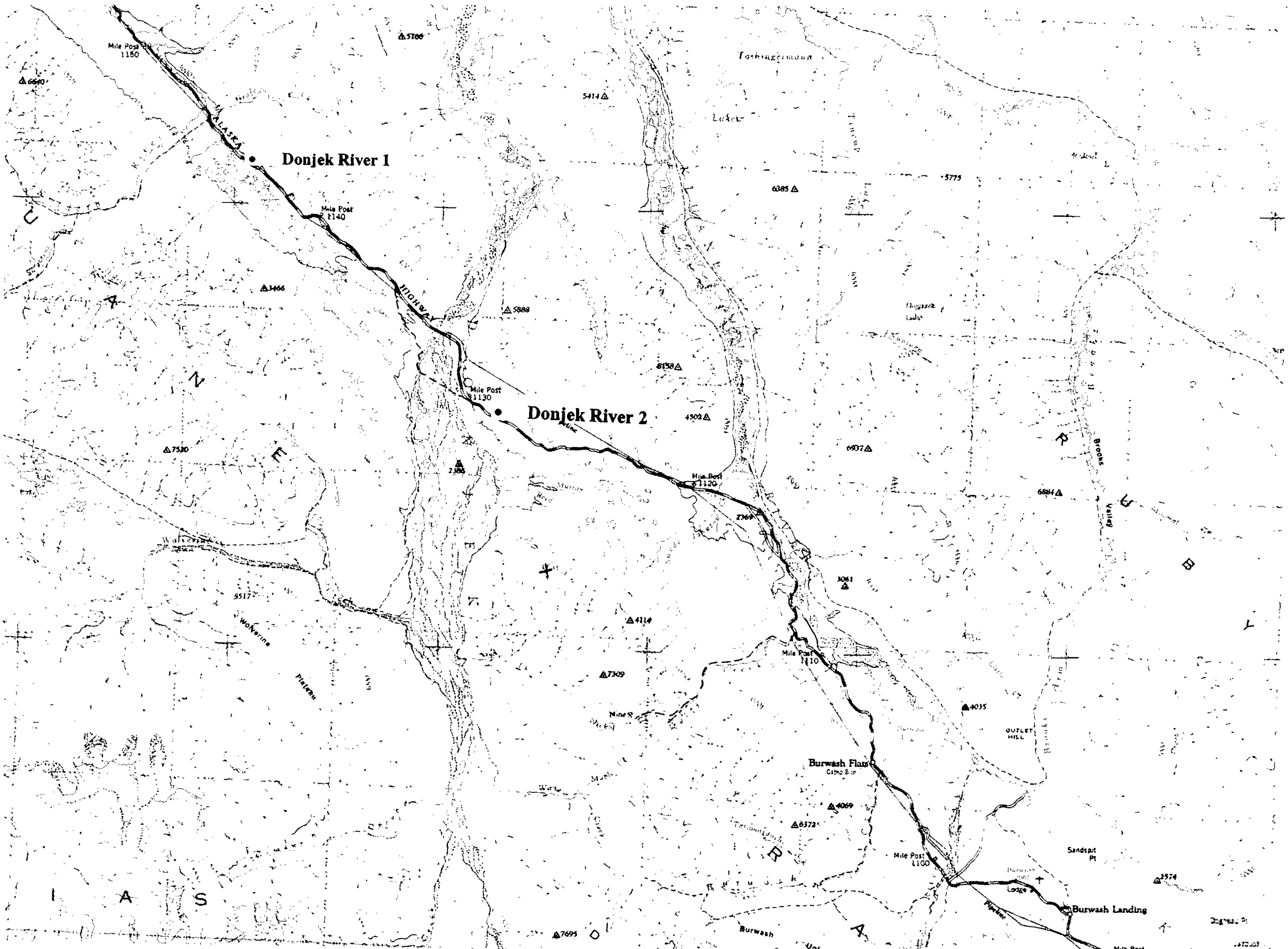


Figure 16 Location of Donjek River Area Ash Samples within the Kluane Placer Mining Area
1:250,000

Figure 17

The Sulphur Creek sample was taken from a thin bed of fine volcanic ash (<30 cm thick) (see figure 17) exposed in a road cut near the community settling pond on Sulphur Creek. Fine clays appeared above and below with brown organics and trees above. The ash was thawed, yet it was not possible to determine the lateral extent of the bed.

The Irish Gulch sample was recovered from a discontinuous bed of ash in the right limit of Irish Gulch, a left limit tributary to Eldorado Creek, which enters approximately one kilometre downstream from French Gulch. The sample was recovered from a 4 cm thick layer of fine grey ash. This sample was collected and provided to the proponents by the miner on Irish Gulch. The location of the Sulphur Creek and Irish Gulch samples can be found in figure 18 on the next page.

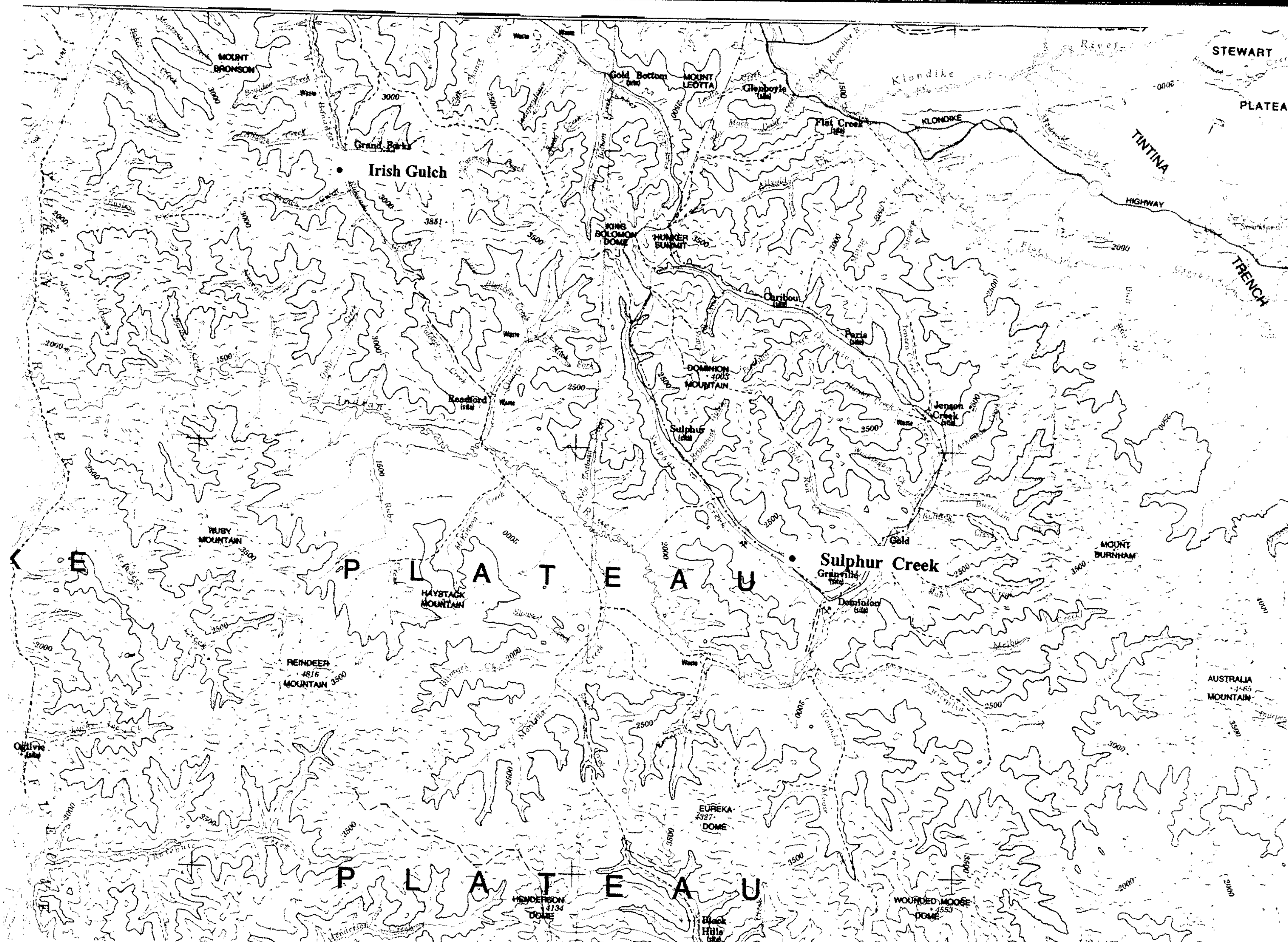


Figure 18 Location of Ash Samples within the Klondike Placer Mining Area 1:250,000

2.1.2 Collection of Sediment Samples

The Yukon Placer Deposit and Water Sampling Program is a joint research program between the Exploration and Geological Service Division, DIAND, Mining Inspection Division, DIAND; and the Yukon Geology Program (DIAND/YTG). The objectives of this program are to characterize the sedimentology of placer deposits by analyzing the grain size distribution of placer gold bearing gravels, in addition to characterizing the interaction between these sediments and water, both in a laboratory setting and during the mining process. During 1999, ten streams and rivers were targeted for this program. This included Big Creek, found in the Dawson Range Placer Mining Area, which hosted the Ash Bend referenced earlier in this report. Two samples were collected in close proximity to Ash Bend in 1999, namely Big Creek (BC) 99-1 and 99-01. BC 99-01 was a finer grained siltier sample, taken stratigraphically below BC 99-1 which was located in a coarser gravel material. Figure 19 below shows the section where the two samples were collected. The operators of the program carried out grain size analysis on the samples. Samples BC 99-1 and 99-01 were selected and used in the following lab tests.

Figure 19 Stratigraphic section where BC 99-1 and BC 99-01 were collected.

2.2 Laboratory Flocculant Tests

Lab work involved a series of tests which are described below:

Gravimetric Analysis- Solids Determination

Gravimetric analysis is based on determination of constituents or categories of material by measurement of their weight. Filtration is used to separate "suspended" or "particulate (nonfilterable) fractions from "dissolved" or "soluble" (filterable) fractions. The portion of a sample that will not pass through a 0.45μ filter represents the nonfilterable component of the sample while the portion that passes through the same 0.45μ filter represents the filterable component. Evaporation is then used to separate the water from any material suspended on the filter and like wise to separate water from any dissolved material collected as filtrate.

Evaporating a known volume of sample and measuring the weight of any residual solids can determine the amount of total solids contained in a water sample. All three concentrations, total suspended, total dissolved and, total solids can be reported as a mass to volume ratio (usually mg/L) using these and other gravimetric methods.

Suspended Solids:

Suspended solids are undissolved materials in wastewater, which will not pass through a glass fiber filter. In lab analysis, a portion of a well-mixed sample is filtered through a glass fiber filter of known weight.

After the filtration process, the filter with the residue is oven-dried until a constant weight, for the filter and residue, is obtained. By subtracting the initial weight of the filter from the weight of the filter plus residue and knowing the volume of sample filtered, it is possible to obtain the concentration of the suspended solids present in the original sample.

Conductivity, Total dissolved solids (TDS):

Electrolytic conductivity is the capacity of ions in a solution to carry electric current and is the reciprocal of the solution resistivity. Current is carried by inorganic dissolved solids (e.g. chloride, nitrate, sulphate, and phosphate anions) and cations (e.g. sodium, calcium, magnesium, iron, and aluminium). These may also be referred to as "total dissolved solids (TDS)". Conductivity goes up with an increase in total dissolved solids, so we can say that conductivity is proportional to total dissolved solids. TDS is an empirically derived value from the conductivity measurement. The concentration of dissolved solids in a water-based solution (expressed in milligrams per Litre) is equal to approximately 50% of the solutions conductivity value (measured in μS/cm).

The range for natural surface waters in the Yukon is between 50-250 μS (micro-siemens), however input from mine drainage can elevate the specific conductance of the receiving water as high as 1,000μS.

Total Settleable Solids:
The amount of settleable matter in a solution gives an empirical estimate of the type and extent of treatment required and general quality of water. Settleable solids can be reported as either a volume (ml/L) or a weight (mg/L) basis. To determine total settleable solids, a well-mixed sample is placed in a special settling device called an Imhoff cone, and allowed to settle under quiescent conditions for some specified time period.

The ***standard method*** (American Public Health et al, 1992) calls for a settling period of one hour and a cone having a volume of one liter. It is necessary to gently rotate the cone, or stir the contents slowly, after a period of 45 minutes to prevent the deposition of matter on the inside surface of the cone. At the end of the prescribed settling period, the volume of the settled material is read from a scale etched on the outside of the cone, making sure to read the graduation mark nearest the top of the settled matter. If there is very little settled material, i.e. below the bottom graduation mark (0.1 ml/L), then it is indicated on the inspection report as being <0.1 ml/L or below measurable limit. Total settleable solids concentrations are usually reported in a volumetric (ml/L) and not a weight bases.

Figure 20 below shows a series of Imhoff Cones that were utilized during some of the flocculant tests.

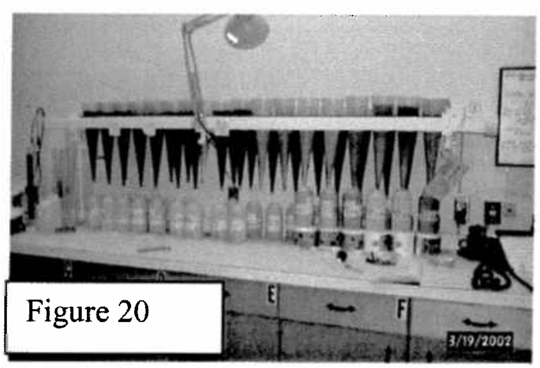


Figure 20

pH

pH is the hydrogen ion concentration in a solution, therefore it is an indication of the balance between the acidity and basicity of a solution. Fresh water pH is most commonly 4 to 9 pH units, on a scale of 14, with 1 being extremely acidic and 14 being extremely basic. Surface waters will tend to be "basic" or "alkaline" and ground waters will be acidic. The presence of carbonates, bicarbonates, and hydroxides increases the basicity of water and free mineral acids and carbonic acids will raise the acidity. For example, acid mine drainage can greatly lower the pH. Sometimes, in the spring freshet, snow melt causes a pulse of acidity which is potentially harmful to fish during their sensitive development stage. Also toxic to fish is aluminium which tends to dissolve more readily at a higher pH. If you ever notice that lake water has a milky appearance, it is probably because the lake has a pH higher than 9 which lowers the solubility of calcium carbonate, making it precipitate. Drinking water should be 6.5 to 8.3 pH units.

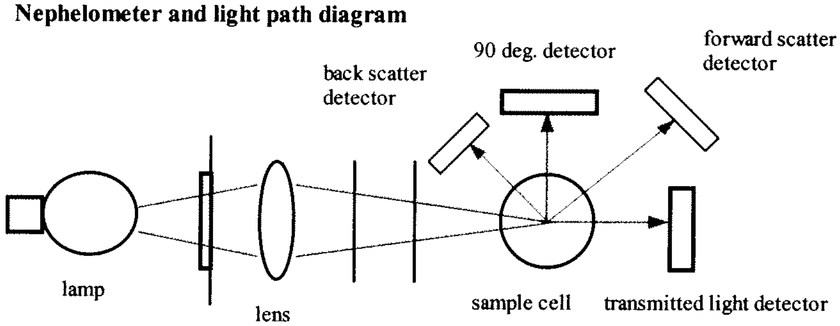
Turbidity

Insoluble particles of soil, organics, microorganisms, and other materials impede the passage of light through water by scattering and absorbing the rays. This interference of light passages through water is referred to as turbidity. Turbidity is a measure of the suspended particles content of water. Silt, clay, organic matter, plankton, and microscopic organisms can be held in suspension. We measure turbidity "by comparing optical interference of suspended particles to the transmission of light in water." High turbidity blocks the passage of light, thereby reducing photosynthesis of submerged, rooted aquatic vegetation and algae. This threatens the food supply for fish and suppresses their productivity. Turbidity in a lake will be much lower than in a turbulent river during the spring freshet. Generally, turbidity is used by the public to judge the quality of drinking water, thereby basing it only on its appearance.

The earliest method for determination of turbidity used a Jackson candle turbidimeter in which a candle flame was viewed through a column of water contained in a calibrated glass tube. Units of turbidity using this apparatus are expressed as, Jackson Turbidity Units (JTU). Since the lowest value that could be measured directly by this technique was 25 units, the Jackson candle turbidimeter was limited in application to turbid waters. The maximum accepted turbidity for drinking water is 5 Jackson Turbidity Units, which is roughly equivalent to 1 Nephelometric Turbidity Unit.

Commonly less than one unit is measured using a pre-calibrated commercial turbidimeter (nephelometer). Units of turbidity using a nephelometer are expressed as Nephelometric Turbidity Units (NTU). Light from a tungsten-filament lamp is focused and passed through the water sample. Transmitted and forward scatter detectors receive light passing through the sample. The backscatter detector measures light scattered back towards the light source. The 90° scatter detector receives light scattered by particles in the water at a right angle to the light beam.

Nephelometer and light path diagram



The turbidimeter shown in the above figure can measure turbidities in the non-ratio mode in excess of forty NTU up to 10,000 NTU, and in the ratio mode from less than 1 NTU down to zero. The backscatter detector is incorporated in order to permit measurement of very high turbidity. In the ratio mode for low turbidity forward scatter is negligible compared to transmitted light and the measurement is a ratio of 90°scattered light to transmitted light. This ratio mode provides calibration stability, linearity over a wide range and negates the affect of color in the water sample.

2.2.1 Sample Preparation

2.2.1.1 Ash

Each sample of raw ash was spread out in the lab and left to dry naturally. The samples were then split and dry sieved to #10, #18, #35, #60, #120, #230 and minus #230 Tyler screens. After weighing the individual fractions, the minus #230 portion was saved for hydrometer analysis of the silt/clay ratio. An archive of each sample was kept. Wet sieving was completed on Big Creek Ash A and B in order to verify the dry sieve results, and to determine if the sample dissolves or breaks down once it becomes wet.

2.2.2 Testwork

In addition to the dry sieving of the ash samples, a total of 126 lab tests were completed. Preparation of the samples, and running the tests involved a total of 240 hours in the lab (6 weeks).

2.2.2.1 Big Creek Ash A and B

The characteristics of Big Creek (BC) Ash A and BC Ash B alone were determined by measuring pH, conductivity (in uS), initial turbidity (in NTU) and initial suspended solids (in mg/L). A one-hour imhoff cone test was then conducted at which time the settleable solids (in ml/L), turbidity and suspended solids were measured. The ash was then allowed to settle for another 23 hrs at which time a 24hr reading of suspended solids and turbidity was measured. BC Ash A and BC Ash B had initial, 1 hr and 24hr readings for suspended solids and turbidity allowing for the comparison between the two parameters. The percent removed suspended solids and percent removed NTU was determined from this comparison.

Additional tests on the various fractions of BC Ash A and B were also completed. Five samples were prepared; the first using 10 grams of raw ash in one liter and the remaining using 10 grams of +60, +120, +230 and minus 230 grain size sieved ash material respectively. No sediment was added to these samples. The initial, 1 hour and 24 hour parameter readings were then determined as done previously.

Analysis was concentrated towards BC Ash A and BC Ash B as there was a sufficient amount of geographically similar sediment available. Due to time and economic constraints it was not possible to test all 7 samples of ash. Each ash sample was sieved and hydrometer tested, however, only BC Ash A and BC Ash B were used for the jar testing analysis.

2.2.2.2 Big Creek (BC) 99-01 and 99-1

Before jar tests were conducted, a number of sediment effluent samples were made up and one liter of each was drawn as a control. Two samples of Big Creek sediment were used, BC 99-01 and BC 99-1. The sediment effluent was measured for the same parameters as the ash samples (pH, conductivity, turbidity, suspended solids, settleable solids and 1hr and 24hr readings of suspended solids and turbidity).

2.2.2.3 Jar Testing

The jar testing was conducted as follows:

1- Varying concentrations of ash were added increasingly to six (6) jars.
2- One (1) liter sediment effluent was decanted into the jar.
3- The samples were then mixed at full rpm (100) for 2 minutes.
4- The rpm was then reduced to 60 for 3 minutes.
5- The rpm was then reduced a final time to 20 for 15 additional minutes, for a total mix time of 20 minutes.
6- After mixing the samples were measured for pH, conductivity, turbidity, suspended solids and temperature.
7- They were then placed into the imhoff cone for one hour, at which time suspended solids, turbidity and settleable solids were measured.
8- The cones were left for another 23 hours and then the suspended solids and turbidity were measured a final time.

The mixing stages were varied in order to replicate a typical placer operation sluicing system. Full rpm was designed to equal the time the material spends in a sluice box, 60 rpm equates to the time spend in flowing from the sluice system to and into the primary settling pond. The final stage of 20 rpm would replicate the time spent flowing to and into the final settling pond.

The concentrations of ash used in the jar test analysis were as follows:

Jar Test #	Sample	Flocculant Added	Rerun
1	BC 99-01 effluent	.25, .5, 1 grams Big Creek Ash A .25, .5, 1 grams Big Creek Ash B	Yes
2	BC 99-01 effluent	1,2,4,6,8,16 grams Big Creek Ash A	Yes
3	BC 99-1 effluent	1,2,4,6,8 grams Big Creek Ash A	Yes
4	BC 99-01 effluent	.25, .5, 1 grams Big Creek Ash A .25, .5, 1 grams Big Creek Ash B	Yes
5	BC 99-01 effluent	1,2,4,6,8,16 grams Big Creek Ash A (diluted)	Yes

A photo and schematic of the jar testing apparatus can be seen in figures 21 and 22.

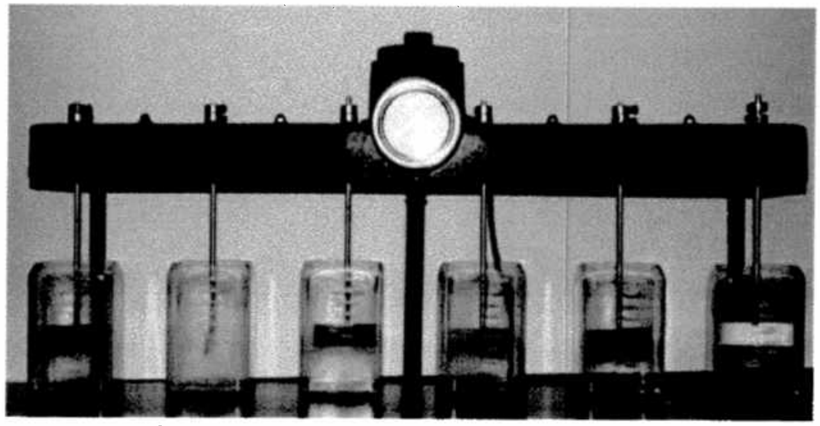
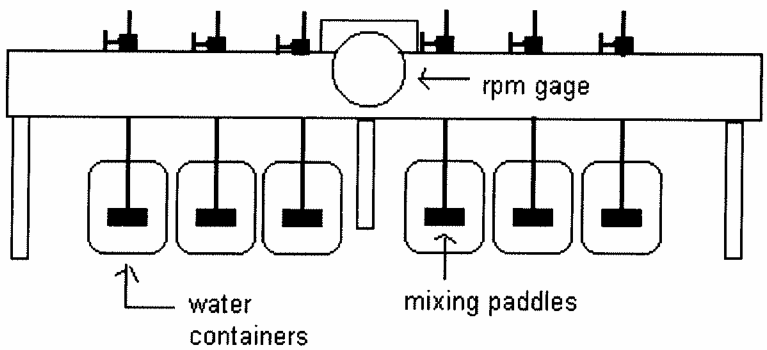


Figure 21 Photo of Jar Testing Apparatus

Figure 22 Schematic of Jar Testing Apparatus



2.2.2.4 Varying Concentration of Sediment Effluent

An additional test involved varying the concentration of BC 99-1 sediment effluent and keeping the ash concentration constant was carried out. This test involved only BC Ash A. The concentration of the BC Ash A was kept at 6g/L for six samples while the concentration of sediment varied from 5.0 to 10.0 to 15.0 to 20.0 to 25.0 to 30.0 g/L. Each time the sediment effluent concentration was increased, a control sample was also taken. An ash concentration of 6g/L was chosen as previous analysis results showed it gave the highest percent removal of suspended solids.

3. Results

3.1 Sample Analysis

3.1.1 Ash Samples

Detailed tabular results of the dry and wet sieving of the ash samples are located in Appendix A. The graphs on the following pages (Figures 23-29) shows the dry and wet sieve results for Big Creek Ash A and B, and the dry sieve results for the Caribou Creek, Donjek River 1 and 2, Sulphur Creek and Irish Gulch ashes. Table 3 shows the corresponding grain size name for the particle sizes plotted on the graphs.

Table 3
Particle Diameter/Grain Size

Particle Diameter	Grain Size
	Very fine pebble
2.0 mm	
	Very coarse sand
1.0 mm	
	Coarse sand
0.500 mm	
	Medium sand
0.250 mm	
	Fine sand
0.125 mm	
	Very fine sand
0.062 mm	
	Coarse silt
	Medium silt
0.01 mm	
	Fine silt
	Medium clay
0.001 mm	
	Fine clay

Big Creek Ash A

Figure 23 a

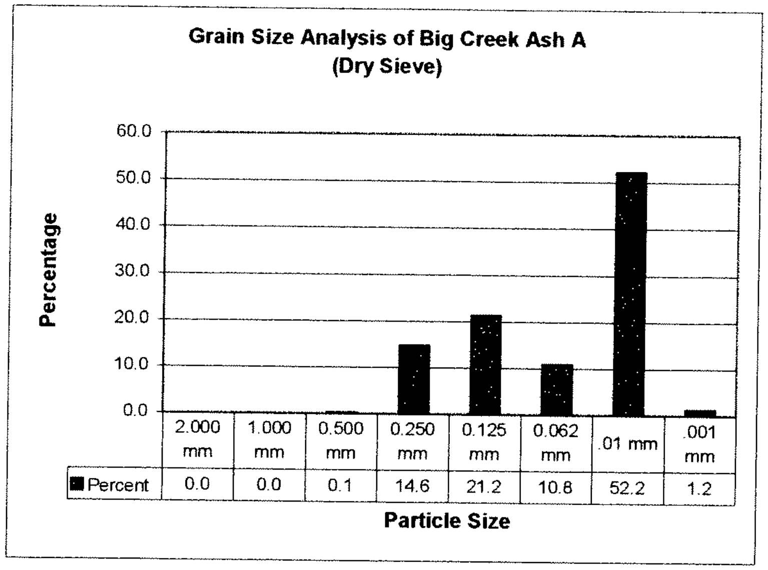
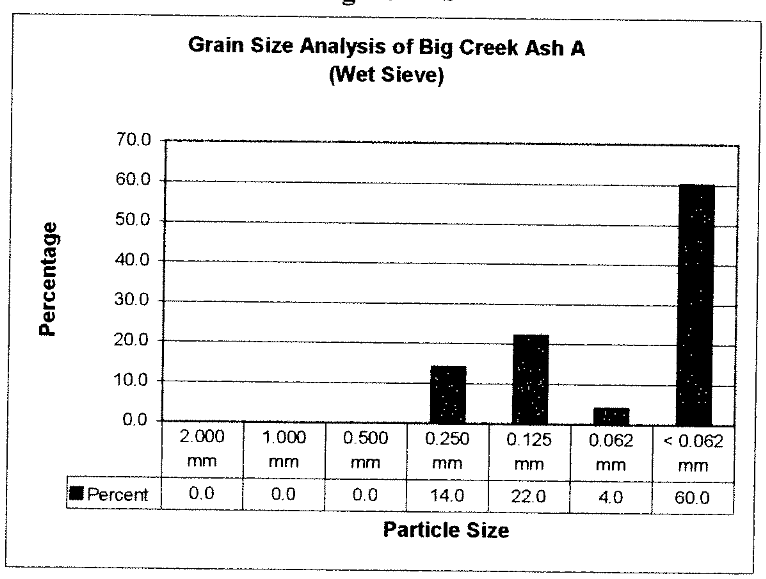


Figure 23 b



Big Creek Ash A appears to be composed mainly of fine/medium silt, and indicates similar results when wet sieved.

Big Creek Ash B

Figure 24 a

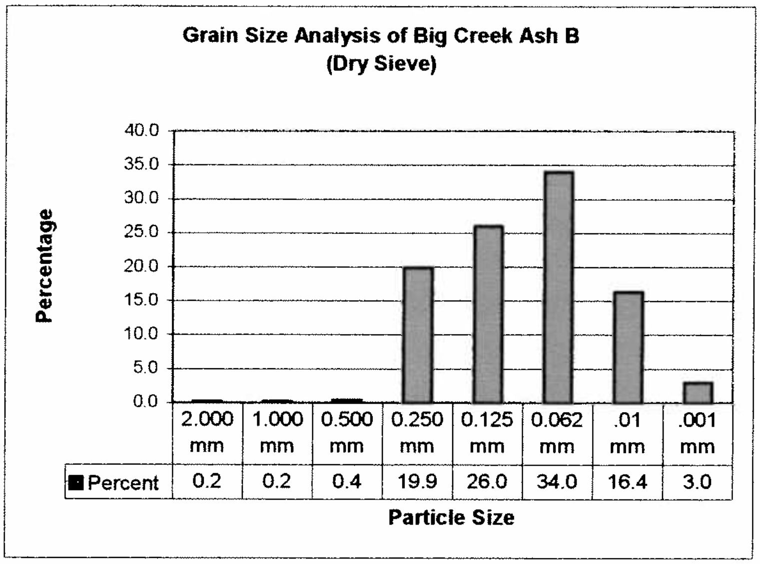
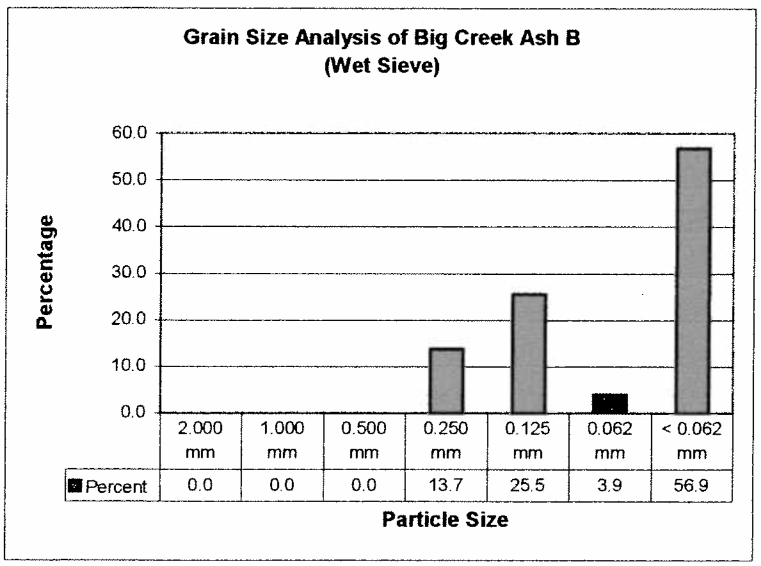


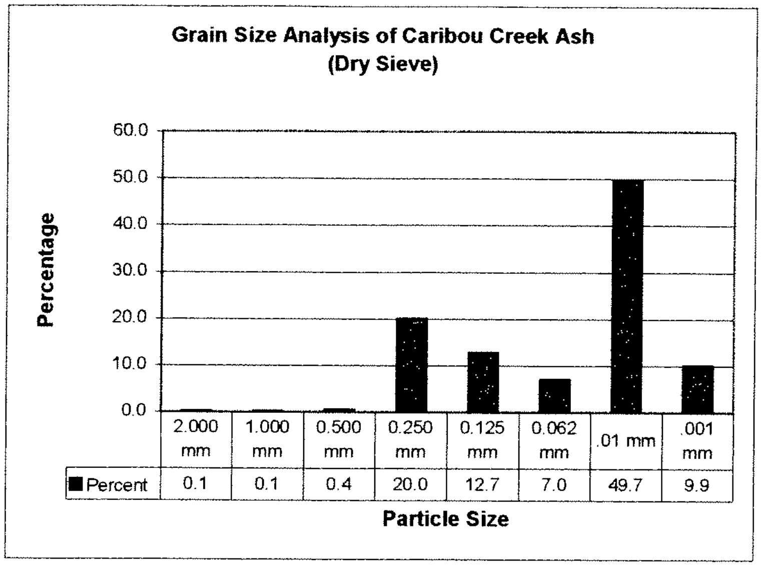
Figure 24 b



Big Creek Ash B is composed primarily of coarse silt and very fine sand. When the sample was wet sieved the portion of the sample <0.062 mm increased from 19.4% to 56.9% indicating breakdown of particles when the sample gets wet. Note that the wet sieve analyses Big Creek Ash A and B are almost identical, yet the dry sieve analyses are very different.

Caribou Creek Ash

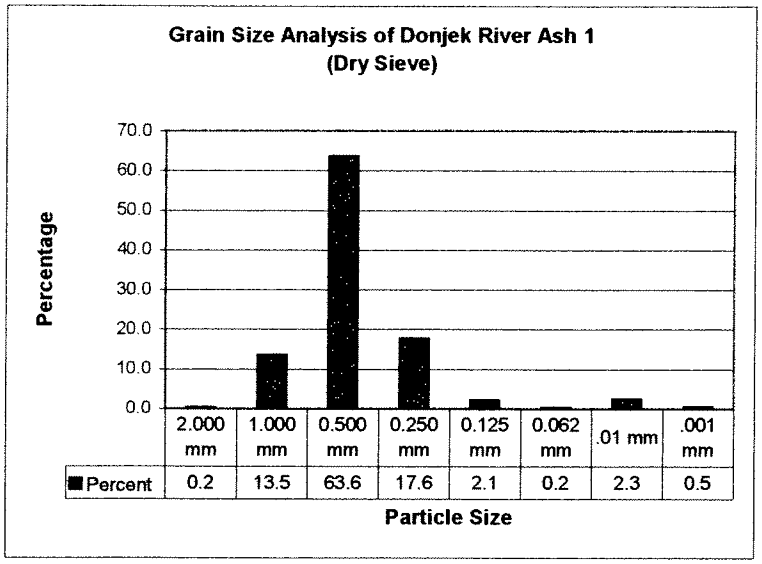
Figure 25



The Caribou Creek Ash is composed of close to 50% fine to medium silt. The sample also has a 10% clay content, the highest in all of the ash samples collected.

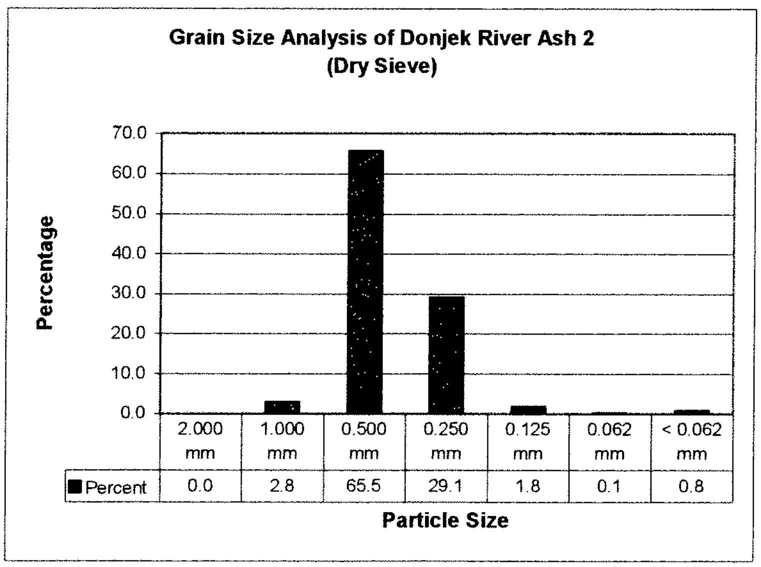
Donjek River Ash 1

Figure 26



Donjek River Ash 2

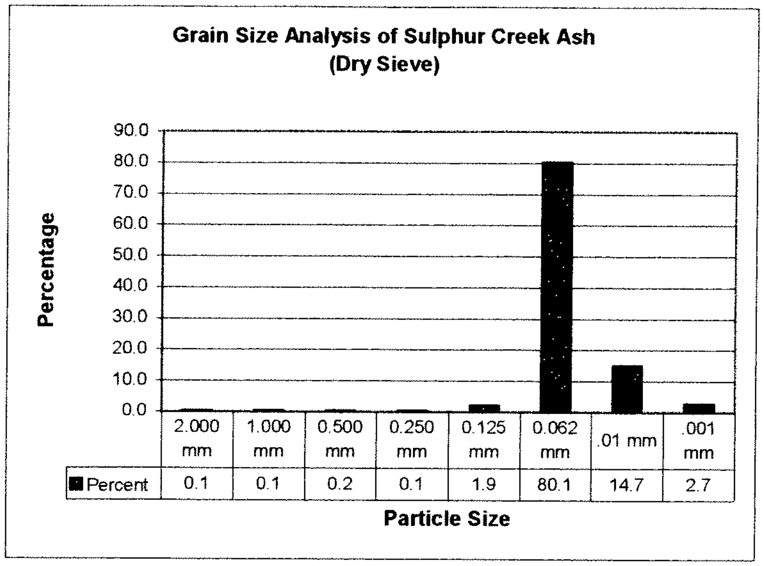
Figure 27



The grain size analysis indicates that the Donjek River ashes are much coarser than the other ashes collected. The majority of the samples are medium to coarse sand, with <1% clay. The coarseness of the samples may indicate a proximity to source.

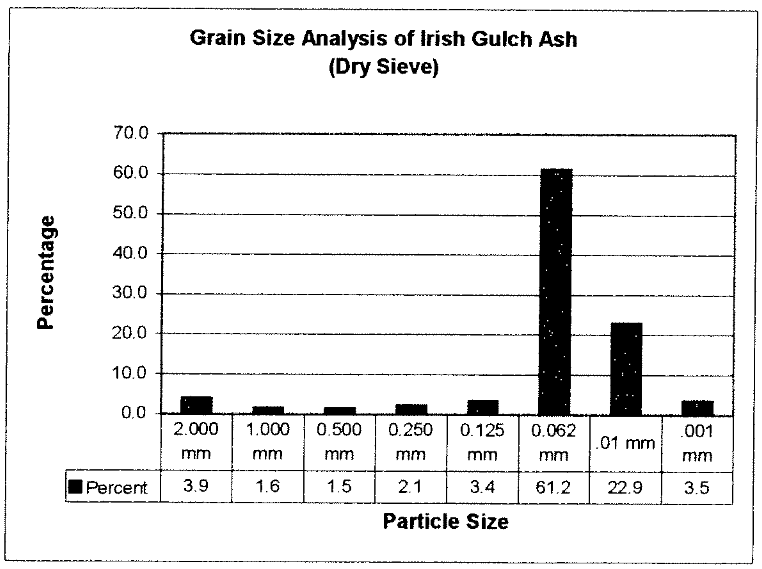
Sulphur Creek Ash

Figure 28



Irish Gulch Ash

Figure 29



Both the Sulphur Creek and Irish Gulch ashes are mainly composed of coarse silt to very fine sand.

3.1.2 Sediment Samples

Grain size analysis of the BC 99-1 and 99-01 samples are located in Appendix A as well. The graphs below (Figures 30-31)show the plots of the dry sieving.

Figure 30

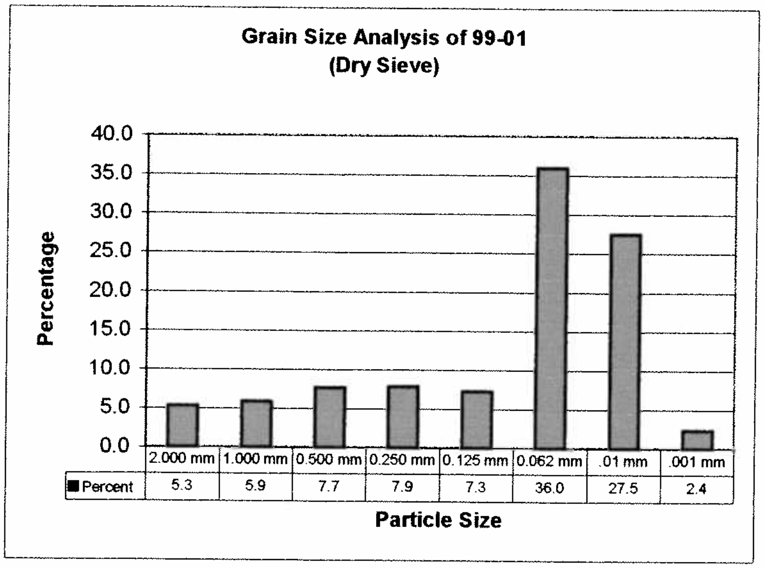
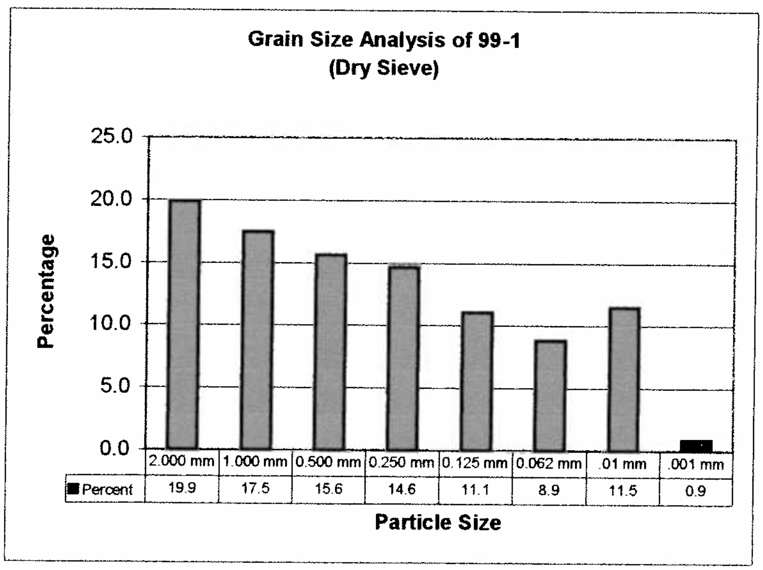


Figure 31



Sample 99-01 is finer grained than Sample 99-1. Approximately 60% of its composition is silt to very fine sand. In sample 99-1 close to 80% of the sample is larger than fine sand, with equal percentages up to coarse sand. In referring back to Figure 19, sample 99-01 was taken from the lower bed, and sample 99-1 was taken from the coarser material overlying the finer sediments.

3.2 Laboratory Flocculant Tests

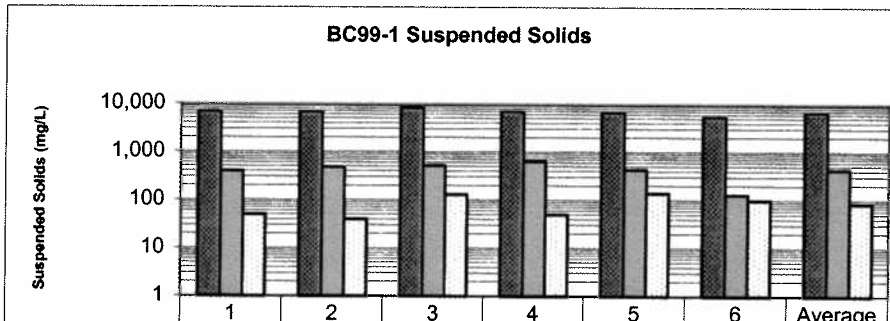
3.2.1 Big Creek 99-1 and 99-01 Characteristics

The results of the pH, conductivity, turbidity, suspended solids, settleable solids and temperature tests completed on effluent samples Big Creek 99-1 and 99-01 are presented in tables I and II in Appendix B.. Table 4 below records the results and average of the suspended solids and turbidity for six different samples of BC99-1 effluent. The suspended solids and turbidity were tested at 0, 1 and 24 hour intervals. Figures 32a and 32b show the results graphically.

Table 4

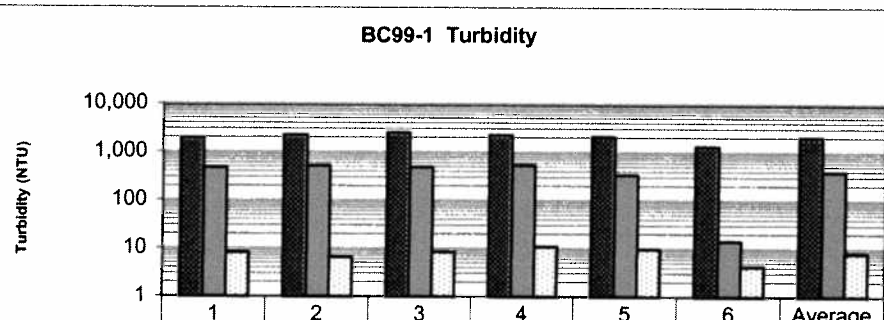
	BC 99-1	Suspended Solids (mg/L)			Turbidity (NTU)		
Lab #	**Comments**	**initial**	**1 hr**	**24hr**	**initial**	**1 hr**	**24hr**
7	1999 Big Cr 99-1 -230 Bag 116 combined w/ 1999 Big Cr 99-1 +230 sample at a +230:-230 ratio of 1:0.72 5g of +230 and 3.6g of -230	6830	400	50	1926	471	8.09
8		6690	480	40	2238	513	6.46
9		8100	520	130	2523	488	8.46
10		6860	630	50	2244	534	10.9
11		6560	430	140	2091	334	9.77
12	sediment sample was damaged	5310	130	100	1311	14	4.21
Average	**Average**	**6725**	**432**	**85**	**2056**	**392**	**7.98**

Figure 32a



	1	2	3	4	5	6	Average
0 hours	6830	6690	8100	6860	6560	5310	6725
1 hour	400	480	520	630	430	130	432
24 hours	50	40	130	50	140	100	85

Figure 32b



	1	2	3	4	5	6	Average
0 hours	1926	2238	2523	2244	2091	1311	2056
1 hour	471	513	488	534	334	14	392
24 hours	8.09	6.46	8.46	10.9	9.77	4.21	7.98

Table 5 below records the results and average of the suspended solids and turbidity for six different samples of BC99-01 effluent. The suspended solids and turbidity were tested at 0, 1 and 24 hour intervals. Figures 33a and 33b show the results graphically

Table 5

	BC 99-01	Suspended Solids (mg/L)			Turbidity (NTU)		
Lab #	**Comments**	**initial**	**1 hr**	**24hr**	**initial**	**1 hr**	**24hr**
1	1999 Big Cr 99-01 -230 Bag 91	8450	310	100	1521	199.0	4.38
2	combined w/ 1999 Big Cr 99-01 +230 sample	9930	350	100	1743	46.5	4.07
3	at a +230:-230 ratio of 1.2:1	9920	330	140	1815	23.8	1.61
4	6 g of +230 and 5 g of -230	10300	360	310	1500	31.0	2.35
5	1999 Big Cr 99-01 -230 Bag 91	9310	300	270	1689	40.0	3.35
6	combined w/ 1999 Big Cr 99-01 +230 sample	9650	310	270	1761	37.4	2.99
	Average	**9593**	**327**	**198**	**1672**	**63.0**	**3.13**

sample lifted, therefore 1hr reading for turbidity was disturbed

Figure 33a

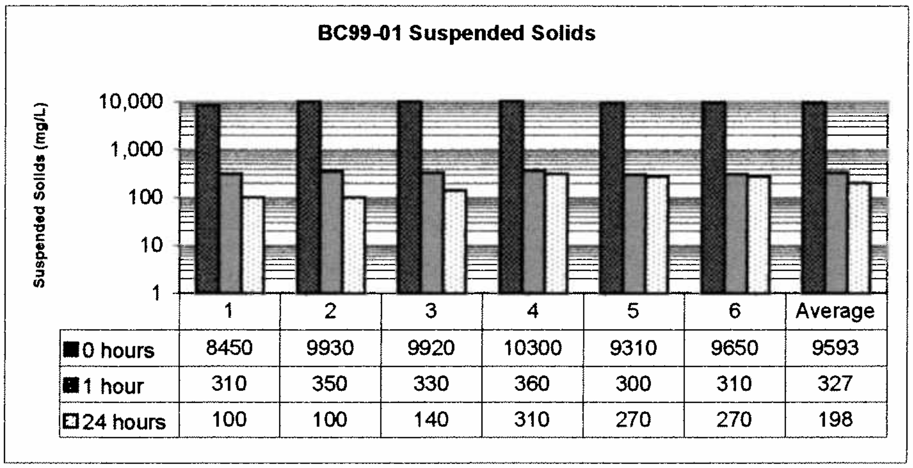
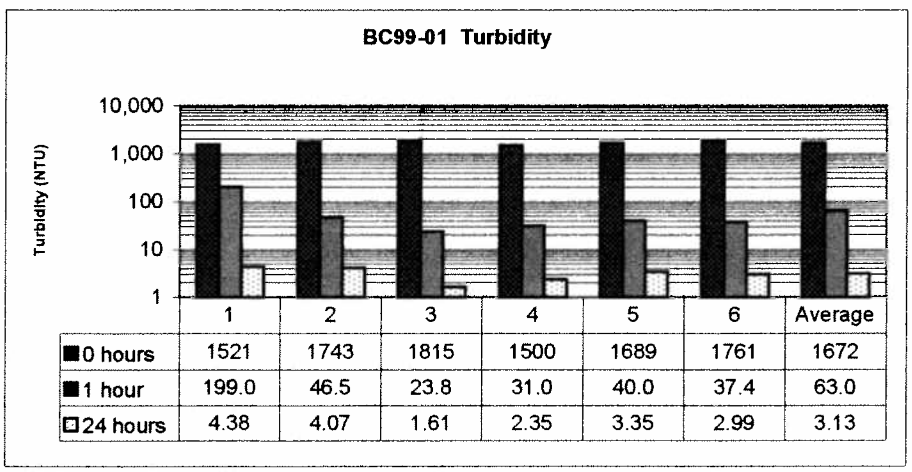


Figure 33b



BC99-1, the coarser grained of the two sediment samples (see 3.1.2) showed a lower average suspended solids reading initially and at the 24 hour mark than BC 99-01. However the 1 hour mark was less in BC 99-01. The average turbidity of BC99-1 was higher at all 3 time intervals than BC 99-01. Physical observations in the lab while carrying out this testwork indicated that BC 99-1 appeared to settle out on its own quicker than BC 99-01.

3.2.2. Big Creek Ash A and B Characteristics

The results of the pH, conductivity, turbidity, suspended solids, settleable solids and temperature tests completed on Big Creek Ash A and B are presented in tables III and IV in Appendix B. Table 6 below records the results of the suspended solids from 6 separate samples and their reruns for Big Creek Ash A. Figures 34a and 34b show the results graphically.

Table 6 Suspended Solids (mg/l)

		Initial					*rerun*		
Lab #	***Comments***	***Initial***	***1 hr***	***24hr***	***Lab #***	***Comments***	***initial***	***1 hr***	***24hr***
13	BC Ash A	6090	680	10	61	redo of Lab # 13	7100	660	90
14	"	7770	890	80	62	redo of Lab # 14	8940	990	70
15	"	6020	940	120	63	redo of Lab # 15	6910	1040	30
16	"	8940	1060	70	64	redo of Lab # 16	8040	1180	40
17	"	5590	730	50	65	redo of Lab # 17	8750	1140	90
18	"	6420	880	140	66	redo of Lab # 18	7780	1160	80
	Average	**6805**	**863**	**78**		**Average**	**7920**	**1028**	**67**

Figure 34a

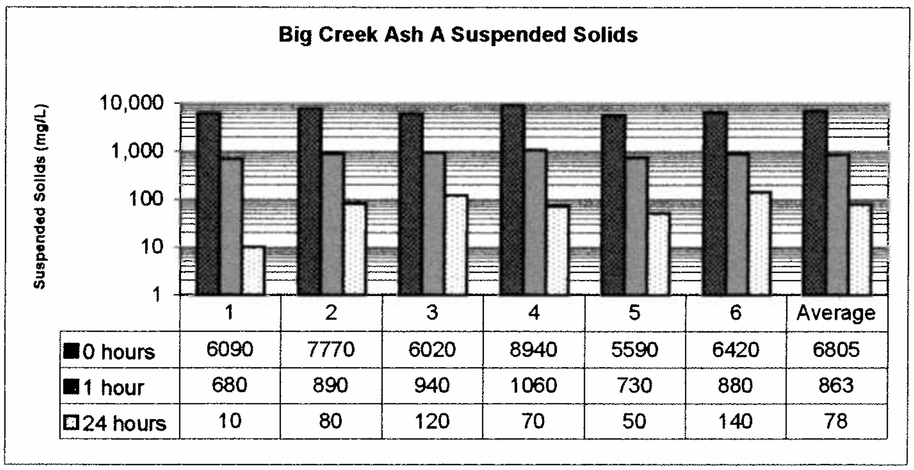


Figure 34b

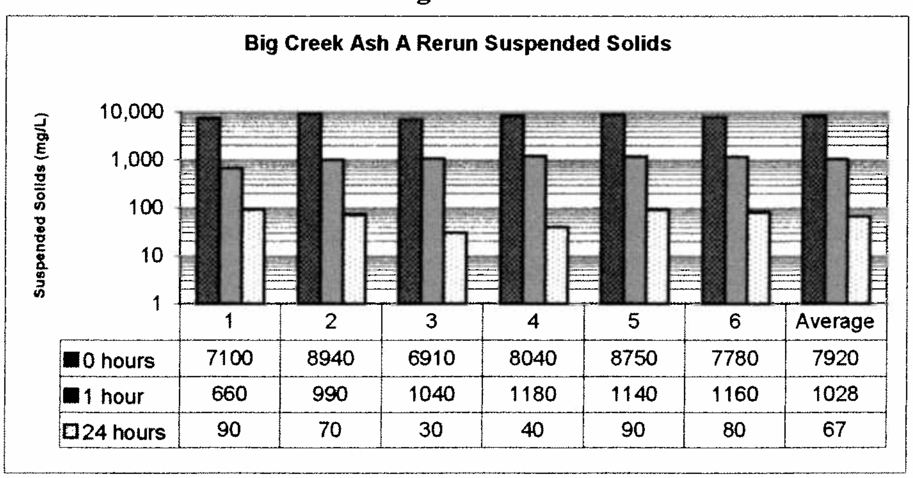
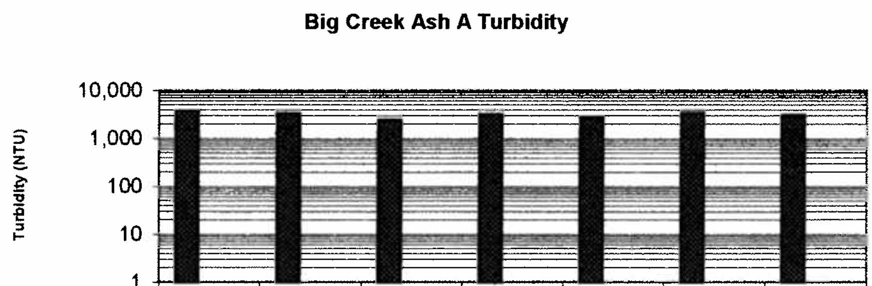


Table 7 below records the results of the turbidity and reruns for Big Creek Ash A, with the results being shown graphically in Figures 35a and 35b. Unfortunately, readings were not obtained for the initial 1 and 24 hours intervals on lab tests 13 through 18.

Table 7 Turbidity (NTU)

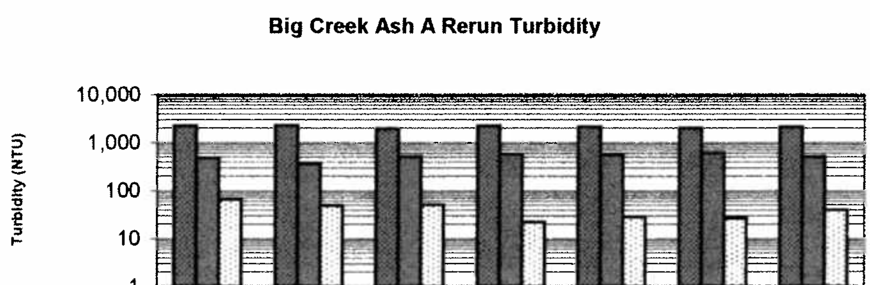
		Initial					*rerun*		
Lab #	***Comments***	***initial***	***1 hr***	***24hr***	***Lab #***	***Comments***	***initial***	***1 hr***	***24hr***
13	BC Ash A	3671	n/a	n/a	61	redo of Lab # 13	2193	472	65.0
14	"	3289	n/a	n/a	62	redo of Lab # 14	2283	361	49.0
15	"	2417	n/a	n/a	63	redo of Lab # 15	1980	511	49.8
16	"	3220	n/a	n/a	64	redo of Lab # 16	2193	572	22.2
17	"	2695	n/a	n/a	65	redo of Lab # 17	2148	559	28.5
18	"	3413	n/a	n/a	66	redo of Lab # 18	2022	602	26.2
	Average	**3118**	**n/a**	**n/a**		**Average**	**2137**	**513**	**40.1**

Figure 35a



	1	2	3	4	5	6	Average
■0 hours	3671	3289	2417	3220	2695	3413	3118
■1 hour	0	0	0	0	0	0	
□24 hours	0	0	0	0	0	0	0

Figure 35b



	1	2	3	4	5	6	Average
■0 hours	2193	2283	1980	2193	2148	2022	2137
■1 hour	472	361	511	572	559	602	513
□24 hours	65.0	49.0	49.8	22.2	28.5	26.2	40.1

Table 8 below outlines the data from lab work that tested various fractions of the Ash A. The suspended solids and turbidity results from these tests are plotted in Figures 36a and 36b.

Table 8

	BC Ash A	Suspended Solids (mg/L)			Turbidity (NTU)		
Lab #	**Comments**	**initial**	**1 hr**	**24hr**	**initial**	**1 hr**	**24hr**
61A	Control BC Ash A RAW, 10.0738g	6200	1050	50	3219	613	25.9
73	BC Ash A # 60 fraction, 10.0063g	530	290	60	468	207	37.8
74	BC Ash A # 120 fraction, 10.0044g	240	100	30	129	63.9	16.1
75	BC Ash A #230 fraction, 10.0052g	6520	910	60	3865	716	52.1
76	BC Ash A # min 230 fraction, 10.0041g	10110	1490	50	5658	1401	68.3
Average	**Average**	**4720**	**768**	**50**	**2668**	**600**	**40.0**

Figure 36a

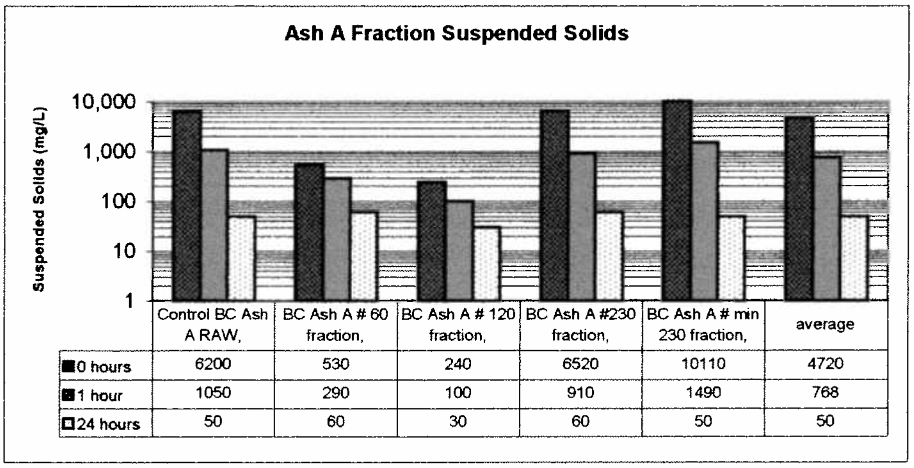
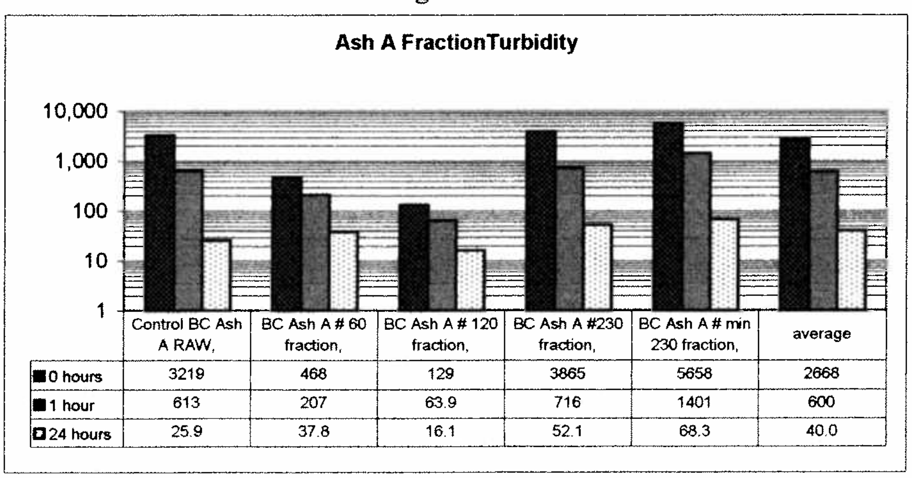


Figure 36b



The –230 and –120/+230 fraction of the ash contribute significantly to the suspended solid and turbidity numbers initially, yet the suspended solid values are in line with the other fractions after 24 hours. The turbidity values for these fractions are marginally higher after 24 hours.

Table 9 below records the results of the suspended solids and rerun for Big Creek Ash B, with the results being shown graphically in the Figure 37a and 37b beneath the table.

Table 9 Suspended Solids (mg/l)

		Initial					*Rerun*		
Lab #	***Comments***	***Initial***	***1 hr***	***24hr***	***Lab #***	***Comments***	***Initial***	***1 hr***	***24hr***
19	BC Ash B	7290	780	50	67	redo of Lab # 19	7360	770	80
20	"	7790	700	420	68	redo of Lab # 20	7740	800	300
21	"	6510	620	50	69	redo of Lab # 21	7920	840	100
22	"	7320	720	160	70	redo of Lab # 22	8150	1060	60
23	"	8110	620	80	71	redo of Lab # 23	7480	990	40
24	Sample was damaged	7650	660	530	72	redo of Lab # 24	7120	990	150
	Average	**7445**	**683**	**215**		**Average**	**7628**	**908**	**122**

Figure 37a

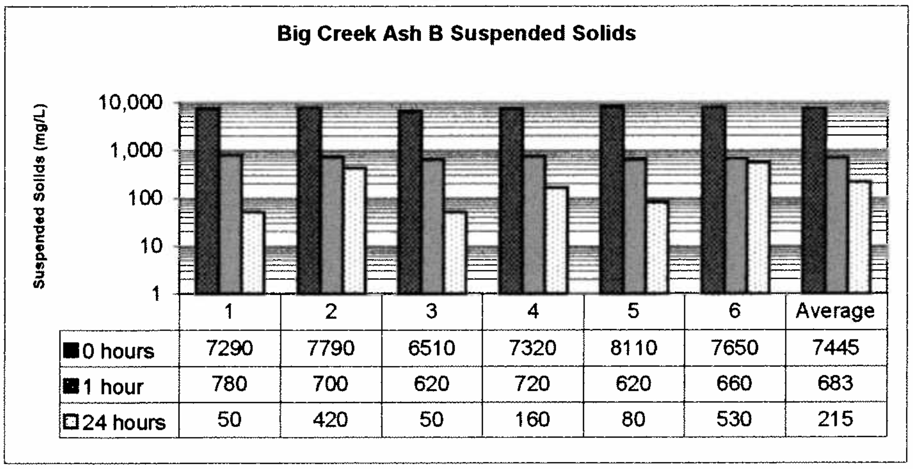


Figure 37b

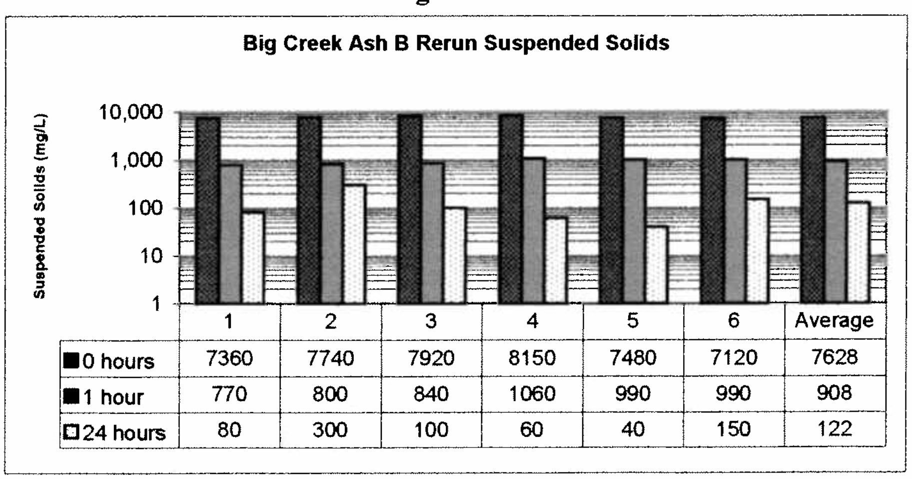


Table 10 below records the results of the turbidity and reruns for Big Creek Ash B, with the results being shown graphically in Figures 38a and 38b beneath the table. Unfortunately results were not obtained for the 1 and 24 hour readings of turbidity in the initial test.

Table 10 Turbidity (NTU)

		Initial					*rerun*		
Lab #	***Comments***	***Initial***	***1 hr***	***24hr***	***Lab #***	***Comments***	***initial***	***1 hr***	***24hr***
19	BC Ash B	3595	n/a	n/a	67	redo of Lab # 19	1941	521	50.5
20	"	4172	n/a	n/a	68	redo of Lab # 20	2211	433	320.0
21	"	3518	n/a	n/a	69	redo of Lab # 21	2244	413	46.4
22	"	3441	n/a	n/a	70	redo of Lab # 22	2067	551	27.1
23	"	3719	n/a	n/a	71	redo of Lab # 23	2169	602	37.0
24	Sample was damaged		n/a	n/a	72	redo of Lab # 24	2121	476	32.2
	Average	3595	n/a	n/a		**Average**	**2126**	**499**	**85.5**

Figure 38a

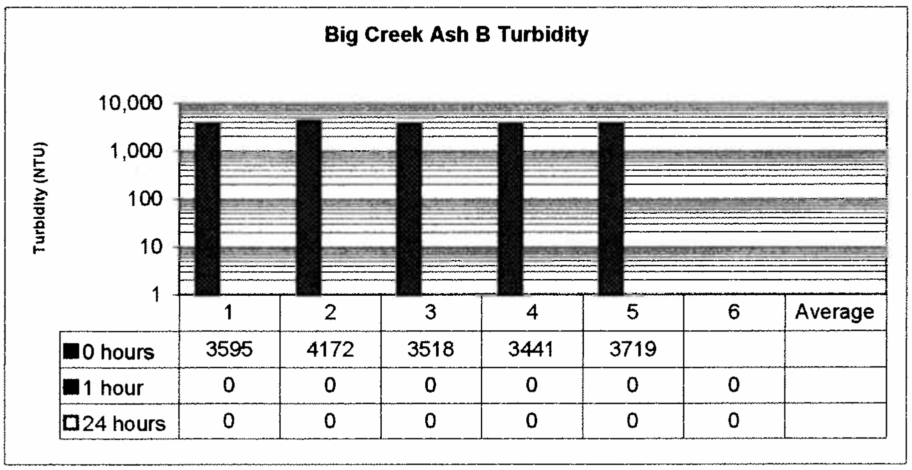


Figure 38b

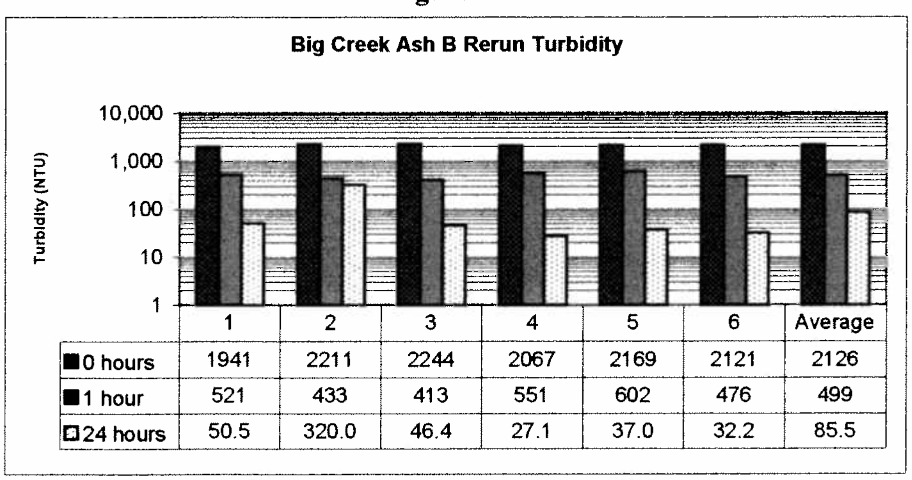


Table 11 below outline the data from lab work that tested various fractions of Ash B. The suspended solids and turbidity results from these tests are plotted in Figures 39a and 39b.

Table 11

	BC Ash A	Suspended Solids (mg/L)			Turbidity (NTU)		
Lab #	**Comments**	**initial**	**1 hr**	**24hr**	**initial**	**1 hr**	**24hr**
67A	Control BC Ash B RAW, 10.0228g	5400	790	70	3654	586	31.3
77	BC Ash B # 60 fraction, 10.0053g	440	200	50	272	11	32.1
78	BC Ash B # 120 fraction, 10.0024g	420	200	50	210	57	19.1
79	BC Ash B # 230 fraction, 10.0076g	8410	1170	40	3567	696	79
80	BC Ash B # min 230, 10.0098g	9430	1360	60	3990	1463	130
	Average	**4820**	**744**	**54**	**2339**	**563**	**58.3**

Figure 39a

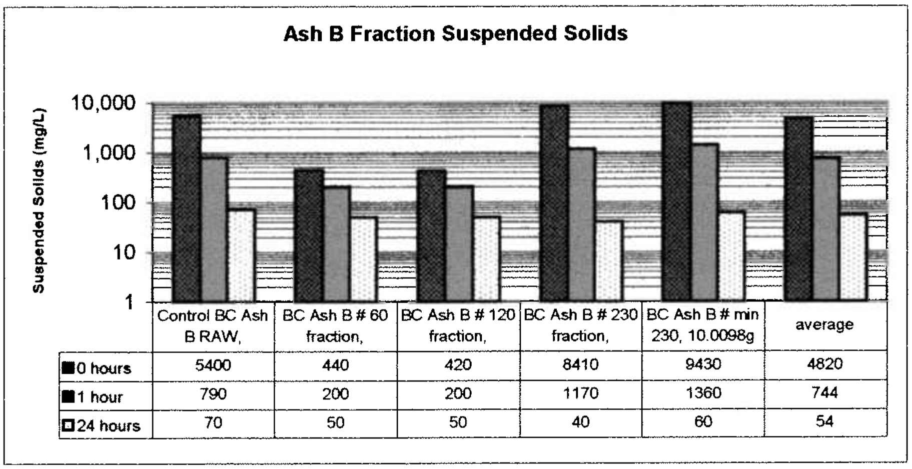
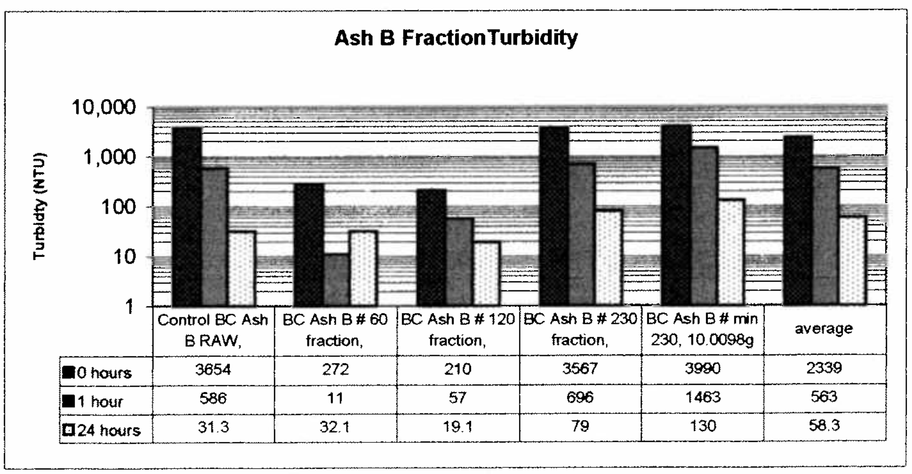


Figure 39b



The –120/+230 and –230 fraction contribute to the suspended solids initially, yet after 24 hours the suspended solid values for these fractions are comparable to the other fractions. In the turbidity the values after 24 hours are still significantly higher.

3.2.3 Jar Tests

3.2.3.1 Addition of 0.25 to 1.0 grams of Ash A/B to BC 99-01 Effluent

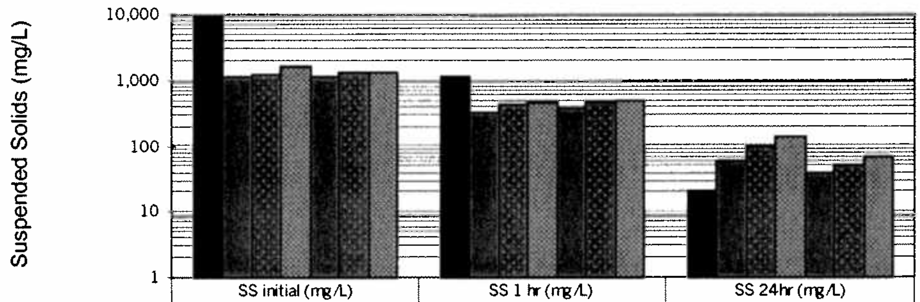
Jar Tests 1 and 4 involved adding 0.25, 0.50 and 1.0g of BC Ash A, and BC Ash B to a sample of BC99-01 effluent. Both jar tests were rerun. Table V in appendix B documents the measurements from these jar tests. Table 12 below summarizes the results of suspended solids for Jar Test 1 and its rerun. Figures 40a and 40b on the next page show these results graphically.

Table 12

	Jar Test #1	*Suspended Solids (mg/L) Initial*				*Jar Test #1 rerun*	*Suspended Solids (mg/L) rerun*		
Lab #	***Comments***	***initial***	***1 hr***	***24hr***	***Lab #***	***Comments***	***initial***	***1 hr***	***24hr***
25	BC 99-01 sed eff CONTROL for Jar Test #1	9200	1120	20	81	Rerun of JT # 1 - control sample Lab # 25	10960	200	60
27	JT # 1 1L BC 99-01 sed eff and **0.25g** Ash **A**	1150	320	60	82	Rerun of JT # 1 - Lab # 27	11330	330	50
28	JT # 1 1L BC 99-01 sed eff and **0.50g** Ash **A**	1230	410	100	83	Rerun of JT # 1 - Lab # 28	10860	360	70
29	JT # 1 1L BC 99-01 sed eff and **1.0g** Ash **A**	1660	450	140	84	Rerun of JT # 1 - Lab # 29	11240	480	30
30	JT # 1 1L BC 99-01sed eff and **0.25g** Ash **B**	1150	360	40	85	Rerun of JT # 1 - Lab # 30	10630	370	20
31	JT # 1 1L BC 99-01sed eff and **0.50g** Ash **B**	1260	440	50	86	Rerun of JT # 1 - Lab # 31	10020	370	50
32	JT # 1 1L BC 99-01 sed eff and **1.0g** Ash **B**	1270	470	70	87	Rerun of JT # 1 - Lab # 32	8380	440	140

Figure 40a

Jar Test # 1 - BC 99-01 effluent with varying concentrations of BC Ash A and B Suspended Solids

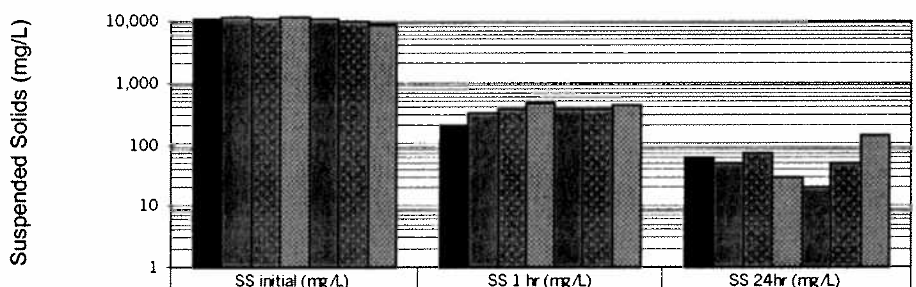


	SS initial (mg/L)	SS 1 hr (mg/L)	SS 24hr (mg/L)
Control	9200	1120	20
0.25 g Ash A	1150	320	60
0.50 g Ash A	1230	410	100
1.00 g Ash A	1660	450	140
0.25 g Ash B	1150	360	40
0.50 g Ash B	1260	440	50
1.00 g Ash B	1270	470	70

Time (hours)

Figure 40b

Jar Test # 1 Rerun - BC 99-01 effluent with varying concentrations of BC Ash A and B Suspended Solids



	SS initial (mg/L)	SS 1 hr (mg/L)	SS 24hr (mg/L)
Control	10960	200	60
0.25 g Ash A	11330	330	50
0.50 g Ash A	10860	360	70
1.00 g Ash A	11240	480	30
0.25 g Ash B	10630	370	20
0.50 g Ash B	10020	370	50
1.00 g Ash B	8380	440	140

Time (hours)

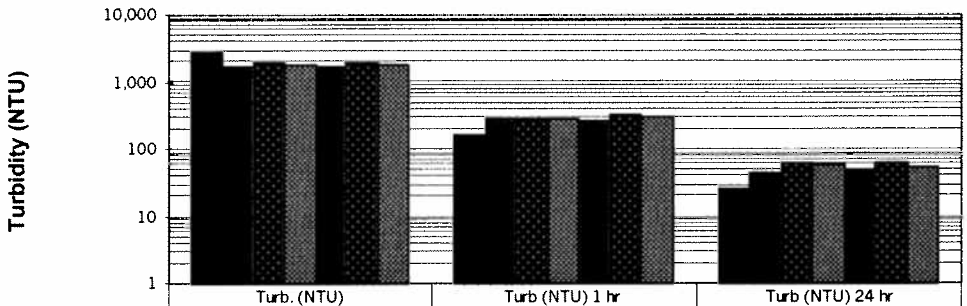
Table 13 below summarizes the turbidity results for Jar Test 1 and its rerun. Figures 41a and 41b on the next page show these results graphically.

Table 13

	Jar Test #1	***Turbidity (NTU) Initial***				***Jar Test #1 rerun***	***Turbidity (NTU) rerun***		
Lab #	***Comments***	***initial***	***1 hr***	***24hr***	***Lab #***	***Comments***	***initial***	***1 hr***	***24hr***
25	BC 99-01 sed eff CONTROL for Jar Test #1	2670	164	24.7	81	Rerun of JT # 1 - control sample Lab # 25	2847	108	9.88
27	JT # 1 1L BC 99-01 sed eff and **0.25g** Ash **A**	1731	281	45.1	82	Rerun of JT # 1 - Lab # 27	3262	186	30.5
28	JT # 1 1L BC 99-01 sed eff and **0.50g** Ash **A**	1899	271	61.6	83	Rerun of JT # 1 - Lab # 28	3542	209	18.1
29	JT # 1 1L BC 99-01 sed eff and **1.0g** Ash **A**	1776	290	59.3	84	Rerun of JT # 1 - Lab # 29	3959	221	20.8
30	JT # 1 1L BC 99-01sed eff and **0.25g** Ash **B**	1677	258	47.9	85	Rerun of JT # 1 - Lab # 30	3293	227	23.2
31	JT # 1 1L BC 99-01sed eff and **0.50g** Ash **B**	1890	322	60.9	86	Rerun of JT # 1 - Lab # 31	3241	208	21.3
32	JT # 1 1L BC 99-01 sed eff and **1.0g** Ash **B**	1743	307	53.2	87	Rerun of JT # 1 - Lab # 32	3274	238	35.4

Figure 41a

Jar Test # 1 - BC 99-01 effluent with varying concentrations of BC Ash A and B Turbidity

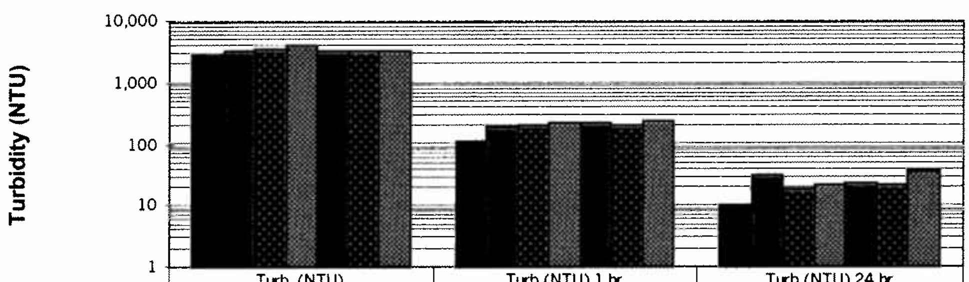


	Turb. (NTU)	Turb (NTU) 1 hr	Turb (NTU) 24 hr
Control	2670	164	24.7
0.25 g Ash A	1731	281	45.1
0.50 g Ash A	1899	271	61.6
1.00 g Ash A	1776	290	59.3
0.25 g Ash B	1677	258	47.9
0.50 g Ash B	1890	322	60.9
1.00 g Ash B	1743	307	53.2

Time (hours)

Figure 41b

Jar Test # 1Rerun - BC 99-01 effluent with varying concentrations of BC Ash A and B Turbidity



	Turb. (NTU)	Turb (NTU) 1 hr	Turb (NTU) 24 hr
Control	2847	108	9.88
0.25 g Ash A	3262	186	30.5
0.50 g Ash A	3542	209	18.1
1.00 g Ash A	3959	221	20.8
0.25 g Ash B	3293	227	23.2
0.50 g Ash B	3241	208	21.3
1.00 g Ash B	3274	238	35.4

Time (hours)

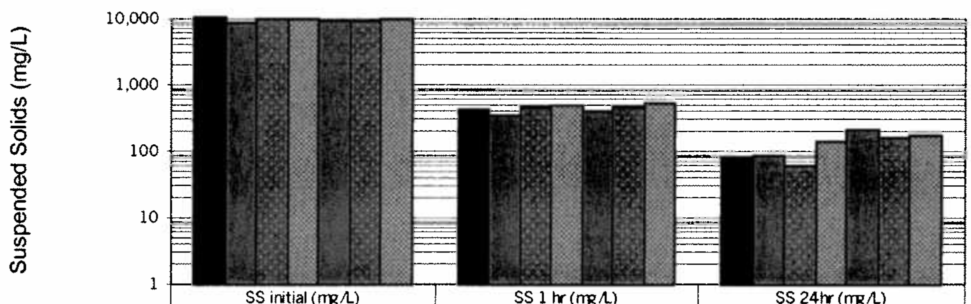
Table 14 below summarizes the results of suspended solids for Jar Test 4 and its rerun. Figures 42a and 42b on the next page show these results graphically.

Table 14

	Jar Test #4	*Suspended Solids (mg/L) Initial*				*Jar Test #4 rerun*	*Suspended Solids (mg/L) rerun*		
Lab #	***Comments***	***initial***	***1 hr***	***24hr***	***Lab #***	***Comments***	***initial***	***1 hr***	***24hr***
53	BC 99-01 sed eff CONTROL for Jar Test # 4	10470	420	80	119	rerun of JT # 4 - Lab # 53	10830	90	30
47	JT # 4 BC 99-01sed eff and **0.2546g** Ash **A**	8760	360	90	113	rerun of JT # 4 - Lab # 47	7920	110	110
48	JT # 4 BC 99-01sed eff and **0.5094g** Ash **A**	10220	460	60	114	rerun of JT # 4 - Lab # 48	7390	140	60
49	JT # 4 BC 99-01 sed eff and **1.0888g** Ash **A**	10190	510	140	115	rerun of JT # 4 - Lab # 49	8980	200	60
50	JT # 4 BC 99-01 sed eff and **0.2595g** Ash **B**	9180	400	210	116	rerun of JT # 4 - Lab # 50	8340	110	100
51	JT # 4 BC 99-01 sed eff and **0.5098g** Ash **B**	9560	480	160	117	rerun of JT # 4 - Lab # 51	9420	180	50
52	JT # 4 BC 99-01 sed eff and **1.0876g** Ash **B**	9960	540	180	118	rerun of JT # 4 - Lab # 52	9960	260	110

Figure 42a

Jar Test # 4 - BC 99-01 effluent with varying concentrations of BC Ash A and B Suspended Solids

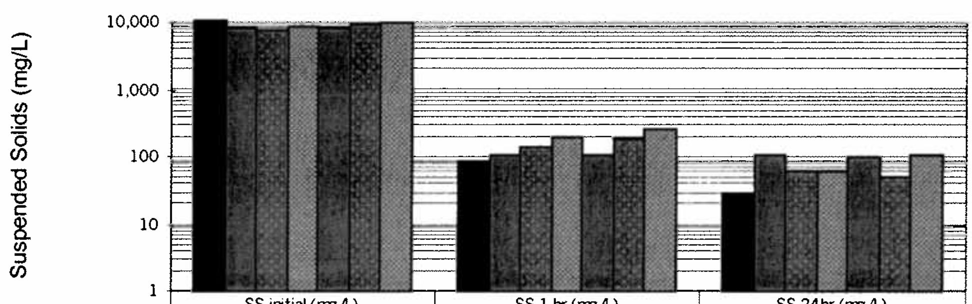


	SS initial (mg/L)	SS 1 hr (mg/L)	SS 24hr (mg/L)
Control	10470	420	80
0.25 g Ash A	8760	360	90
0.50 g Ash A	10220	460	60
1.00 g Ash A	10190	510	140
0.25 g Ash B	9180	400	210
0.50 g Ash B	9560	480	160
1.00 g Ash B	9960	540	180

Time (hours)

Figure 42b

Jar Test # 4 Rerun - BC 99-01 effluent with varying concentrations of BC Ash A and B Suspended Solids



	SS initial (mg/L)	SS 1 hr (mg/L)	SS 24hr (mg/L)
Control	10830	90	30
0.25 g Ash A	7920	110	110
0.50 g Ash A	7390	140	60
1.00 g Ash A	8980	200	60
0.25 g Ash B	8340	110	100
0.50 g Ash B	9420	180	50
1.00 g Ash B	9960	260	110

Time (hours)

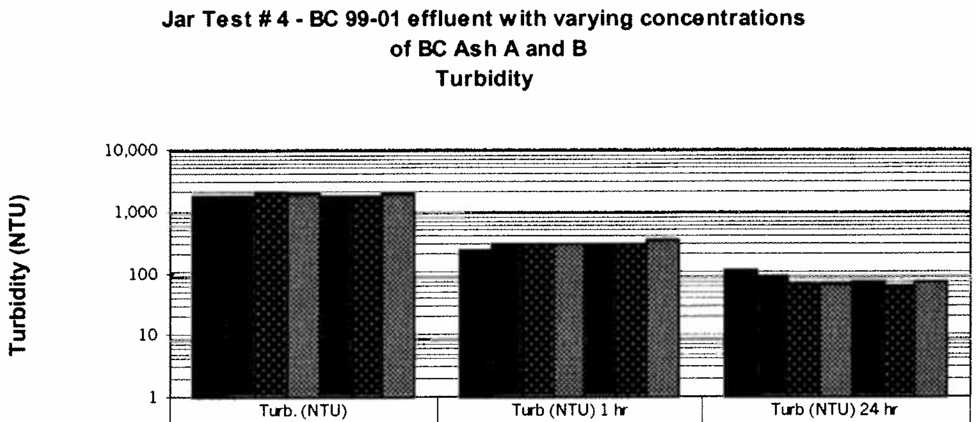
Table 15 below summarizes the turbidity results for Jar Test 4 and its rerun. Figures 43a and 43b on the next page show these results graphically.

Table 15

	Jar Test #4	*Turbidity (NTU) Initial*				*Jar Test #4 rerun*	*Turbidity (NTU) rerun*		
Lab #	**Comments**	**Initial**	**1 hr**	**24hr**	**Lab #**	**Comments**	**Initial**	**1 hr**	**24hr**
53	BC 99-01 sed eff CONTROL for Jar Test # 4	1806	231	109	119	rerun of JT # 4 - Lab # 53	1716	76.1	16.5
47	JT # 4 BC 99-01sed eff and **0.2546g** Ash **A**	1737	298	90.6	113	rerun of JT # 4 - Lab # 47	1905	121	53.9
48	JT # 4 BC 99-01sed eff and **0.5094g** Ash **A**	2055	300	64.3	114	rerun of JT # 4 - Lab # 48	1806	164	19.4
49	JT # 4 BC 99-01 sed eff and **1.0888g** Ash **A**	1923	296	64.6	115	rerun of JT # 4 - Lab # 49	1584	60.4	15.8
50	JT # 4 BC 99-01 sed eff and **0.2595g** Ash **B**	1818	297	71.4	116	rerun of JT # 4 - Lab # 50	1749	63.3	43.3
51	JT # 4 BC 99-01 sed eff and **0.5098g** Ash **B**	1758	286	61.8	117	rerun of JT # 4 - Lab # 51	1518	122	20.3
52	JT # 4 BC 99-01 sed eff and **1.0876g** Ash **B**	1965	343	69.5	118	rerun of JT # 4 - Lab # 52	1698	138	17.5

Comments:
Addition of the small amounts of Ash A and Ash B showed various results within the suspended solids or turbidity values run in jar tests 1 and 4, and their reruns. There was no set pattern that could be determined.

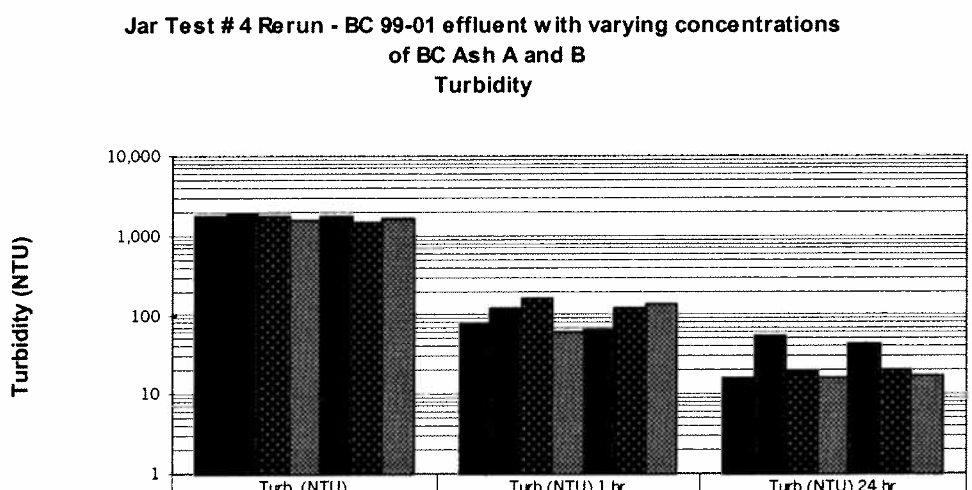
Figure 43a



	Turb. (NTU)	Turb (NTU) 1 hr	Turb (NTU) 24 hr
Control	1806	231	109
0.25 g Ash A	1737	298	90.6
0.50 g Ash A	2055	300	64.3
1.00 g Ash A	1923	296	64.6
0.25 g Ash B	1818	297	71.4
0.50 g Ash B	1758	286	61.8
1.00 g Ash B	1965	343	69.5

Time (hours)

Figure 43b



	Turb. (NTU)	Turb (NTU) 1 hr	Turb (NTU) 24 hr
Control	1716	76.1	16.5
0.25 g Ash A	1905	121	53.9
0.50 g Ash A	1806	164	19.4
1.00 g Ash A	1584	60.4	15.8
0.25 g Ash B	1749	63.3	43.3
0.50 g Ash B	1518	122	20.3
1.00 g Ash B	1698	138	17.5

Time (hours)

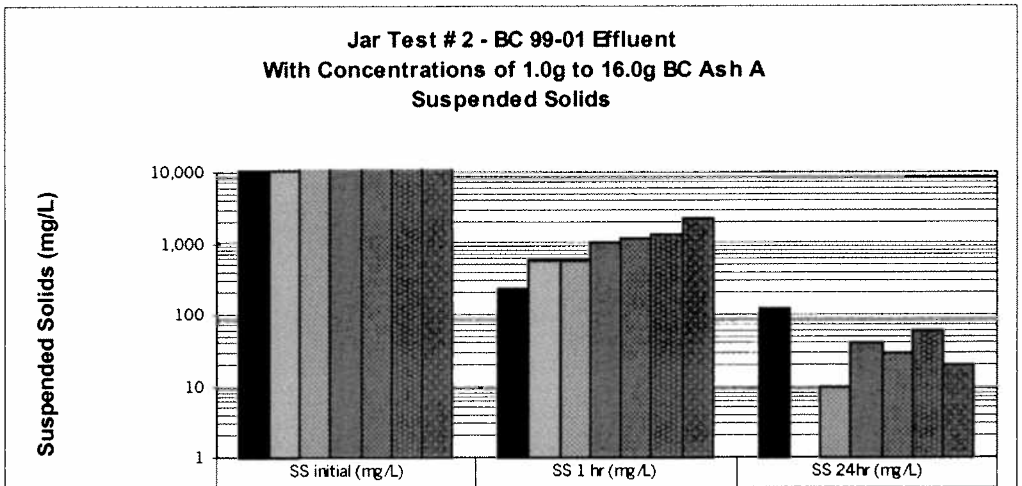
3.2.3 2 Addition of 1 to 16 grams of Ash A to BC 99-01 Effluent

Jar test 2 involved adding 1 to 16 grams of BC Ash A to BC 99-01 effluent, whereas Jar test 5 added 1 to 16 grams of BC Ash A to a sample of BC 99-01 dilute effluent. Both jar tests were rerun. Table VI in Appendix B shows the detailed results from the jar tests. Table 16 below summarizes the results of the suspended solids for Jar test 2 and its rerun. Figure 44a and 44b on the next page illustrate these results.

Table 16

	Jar Test #2	*Suspended Solids (mg/L) Initial*				*Jar Test #2 rerun*	*Suspended Solids (mg/L) rerun*		
Lab #	***Comments***	***initial***	***1 hr***	***24hr***	***Lab #***	***Comments***	***initial***	***1 hr***	***24hr***
33	1L BC 99-01 sed eff CONTROL for Jar Test #2	10930	230	120	88	Rerun of JT # 2 - Lab # 33	11800	440	0
34	JT # 2 1L BC 99-01sed eff and **1.0758g** Ash **A**	10740	560	0	89	Rerun of JT # 2 - Lab # 34	12190	470	20
35	JT #2 1L BC 99-01sed eff and **2.0210g** Ash **A**	11830	560	10	90	Rerun of JT # 2 - Lab # 35	11880	570	20
36	JT # 2 1L BC 99-01sed eff and **4.0712g** Ash **A**	14280	1030	40	91	Rerun of JT # 2 - Lab # 36	13900	730	40
37	JT # 2 1L BC 99-01 sed eff and **6.0348g** Ash **A**	15080	1150	30	92	Rerun of JT # 2 - Lab # 37	16510	1070	90
38	JT # 2 1L BC 99-01 sed eff and **8.0182g** Ash **A**	14390	1320	60	93	Rerun of JT # 2 - Lab # 38	14110	1440	50
39	JT # 2 1L BC 99-01 sed eff and **16.0372g** Ash **A**	17130	2220	20	94	Rerun of JT # 2 - Lab # 39	16920	2690	80

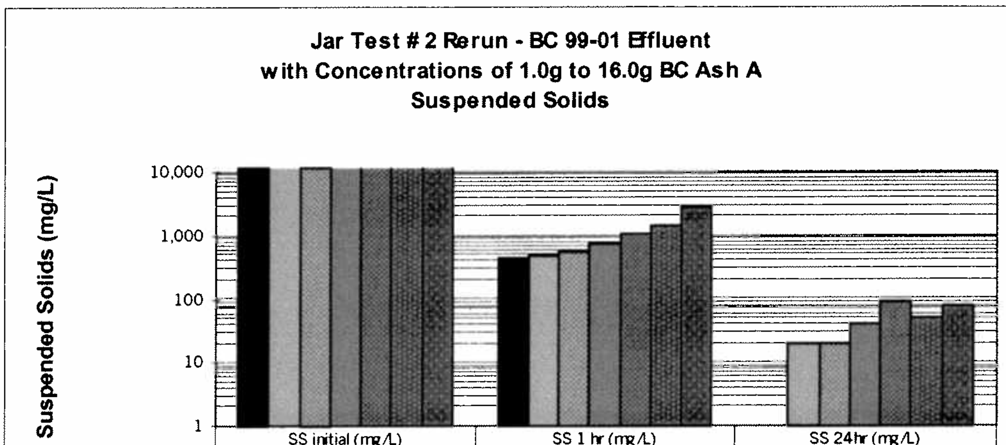
Figure 44a



	SS initial (mg/L)	SS 1 hr (mg/L)	SS 24hr (mg/L)
Control - mg/L	10930	230	120
1.0 g A - mg/L	10740	560	0
2.0 g A - mg/L	11830	560	10
4.0 g A - mg/L	14280	1030	40
6.0 g A - mg/L	15080	1150	30
8.0 g A - mg/L	14390	1320	60
16.0 g A - mg/L	17130	2220	20

Time (hours)

Figure 44b



	SS initial (mg/L)	SS 1 hr (mg/L)	SS 24hr (mg/L)
Control - mg/L	11800	440	0
1.0 g A - mg/L	12190	470	20
2.0 g A - mg/L	11880	570	20
4.0 g A - mg/L	13900	730	40
6.0 g A - mg/L	16510	1070	90
8.0 g A - mg/L	14110	1440	50
16.0 g A - mg/L	16920	2690	80

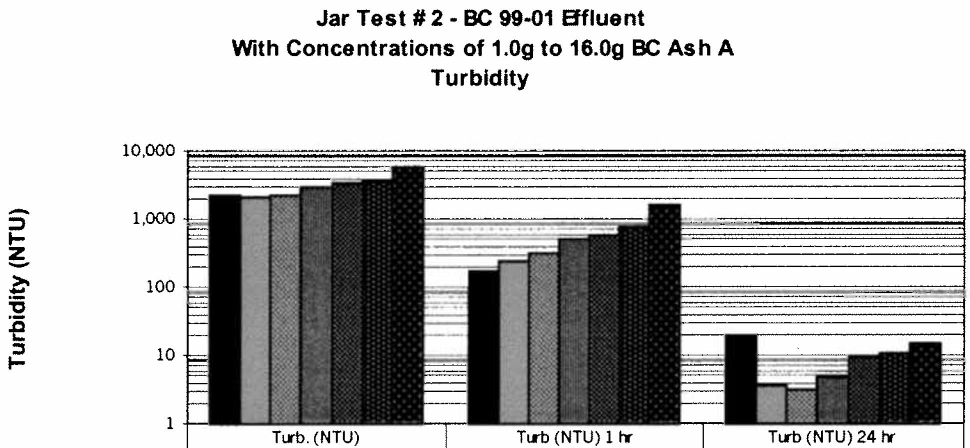
Time (hours)

Table 17 below summarizes the turbidity results for Jar Test 2 and its rerun. Figures 45a and 45b on the next page show these results graphically.

Table 17

	Jar Test #2	***Turbidity (NTU) Initial***				***Jar Test #2 rerun***	***Turbidity (NTU) rerun***		
Lab #	***Comments***	***initial***	***1 hr***	***24hr***	***Lab #***	***Comments***	***initial***	***1 hr***	***24hr***
33	1L BC 99-01 sed eff CONTROL for Jar Test #2	2331	174	20.1	88	Rerun of JT # 2 - Lab # 33	3424	183	18.8
34	JT # 2 1L BC 99-01sed eff and **1.0758g** Ash **A**	2172	247	3.5	89	Rerun of JT # 2 - Lab # 34	3890	244	20.2
35	JT #2 1L BC 99-01sed eff and **2.0210g** Ash **A**	2298	307	3.2	90	Rerun of JT # 2 - Lab # 35	3906	266	24.6
36	JT # 2 1L BC 99-01sed eff and **4.0712g** Ash **A**	2883	500	4.8	91	Rerun of JT # 2 - Lab # 36	3231	379	25.4
37	JT # 2 1L BC 99-01 sed eff and **6.0348g** Ash **A**	3345	599	9.3	92	Rerun of JT # 2 - Lab # 37	4011	514	24.0
38	JT # 2 1L BC 99-01 sed eff and **8.0182g** Ash **A**	3546	752	11.0	93	Rerun of JT # 2 - Lab # 38	3546	781	26.1
39	JT # 2 1L BC 99-01 sed eff and **16.0372g** Ash **A**	5643	1579	14.8	94	Rerun of JT # 2 - Lab # 39	6936	1886	36.6

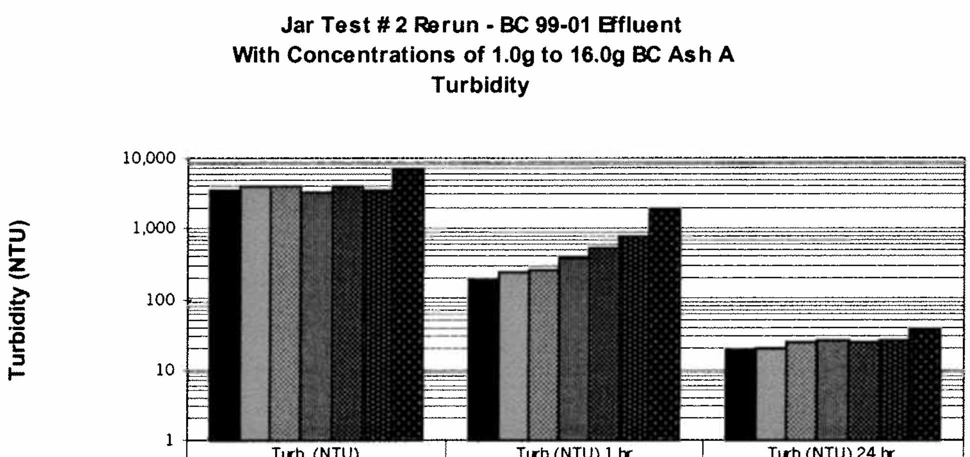
Figure 45a



	Turb. (NTU)	Turb (NTU) 1 hr	Turb (NTU) 24 hr
Control - mg/L	2331	174	20.1
1.0 g A - mg/L	2172	247	3.5
2.0 g A - mg/L	2298	307	3.2
4.0 g A - mg/L	2883	500	4.8
6.0 g A - mg/L	3345	599	9.3
8.0 g A - mg/L	3546	752	11.0
16.0 g A - mg/L	5643	1579	14.8

Time (hours)

Figure 45b



	Turb. (NTU)	Turb (NTU) 1 hr	Turb (NTU) 24 hr
Control - mg/L	3424	183	18.8
1.0 g A - mg/L	3890	244	20.2
2.0 g A - mg/L	3906	266	24.6
4.0 g A - mg/L	3231	379	25.4
6.0 g A - mg/L	4011	514	24.0
8.0 g A - mg/L	3546	781	26.1
16.0 g A - mg/L	6936	1886	36.6

Time (hours)

Table 18 below summarizes the results of the percentage of suspended solids and NTU removed from Jar Test 2 and its rerun. Figures 46a and 46b on the next page show these results graphically.

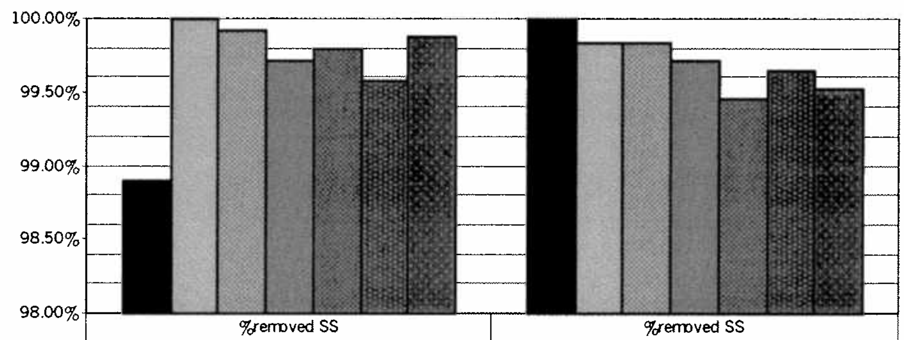
Table 18

	Jar Test #2	***% removed SS***	***% removed NTU***		***Jar Test #2 rerun***	***% removed SS***	***% removed NTU***
Lab #	***Comments***			***Lab #***	***Comments***		
33	1L BC 99-01 sed eff CONTROL for Jar Test #2	98.90%	99.14%	119	Rerun of JT # 2 - Lab # 33	100.00%	99.45%
34	JT # 2 1L BC 99-01sed eff and **1.0758g** Ash **A**	100.00%	99.84%	113	Rerun of JT # 2 - Lab # 34	99.84%	99.48%
35	JT #2 1L BC 99-01sed eff and **2.0210g** Ash **A**	99.92%	99.86%	114	Rerun of JT # 2 - Lab # 35	99.83%	99.37%
36	JT # 2 1L BC 99-01sed eff and **4.0712g** Ash **A**	99.72%	99.83%	115	Rerun of JT # 2 - Lab # 36	99.71%	99.21%
37	JT # 2 1L BC 99-01 sed eff and **6.0348g** Ash **A**	99.80%	99.72%	116	Rerun of JT # 2 - Lab # 37	99.45%	99.40%
38	JT # 2 1L BC 99-01 sed eff and **8.0182g** Ash **A**	99.58%	99.69%	117	Rerun of JT # 2 - Lab # 38	99.65%	99.26%
39	JT # 2 1L BC 99-01 sed eff and **16.0372g** Ash **A**	99.88%	99.74%	118	Rerun of JT # 2 - Lab # 39	100.00%	99.45%

The initial suspended solid and turbidity tests show that adding increasing amount of ash increases the intial suspended solid values, yet by 24 hours the samples with ash were showing better results than the control. However, on the rerun, the results were repeated for the initial and 1 hour, however the 24 hour indicated the control had better results than the samples with ash added. The plots for the percentage of suspended solids and NTU removed show some similarities. Jar Test #2 shows that the percent of suspended solids and NTU removed definitely increased over the control when ash was added. However, the rerun of the sample did not show any increase in the suspended solids or NTU when the ash was added.

Figure 46a

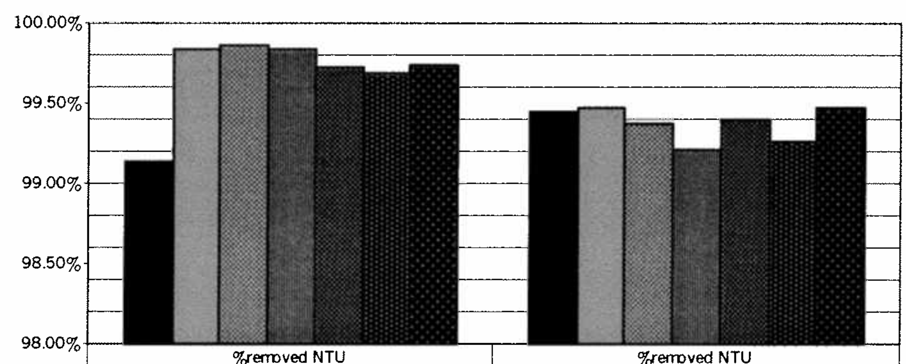
Jar Test # 2 and Rerun - Percentage of Suspended Solids Removed from BC99-01 effluent with additions of 1.0g to 16.0g BC Ash A



	%removed SS	%removed SS
control	98.90%	100.00%
1.0758 g Ash A	100.00%	99.84%
2.0210g Ash A	99.92%	99.83%
4.0712g Ash A	99.72%	99.71%
6.0348g Ash A	99.80%	99.45%
8.0182g Ash A	99.58%	99.65%
16.0372g Ash A	99.88%	99.53%

Figure 46b

Jar Test # 2 and Rerun - Percentage of NTU Removed from BC99-01 effluent with additions of 1.0g to 16.0g BC Ash A



	%removed NTU	%removed NTU
control	99.14%	99.45%
1.0758 g Ash A	99.84%	99.48%
2.0210g Ash A	99.86%	99.37%
4.0712g Ash A	99.83%	99.21%
6.0348g Ash A	99.72%	99.40%
8.0182g Ash A	99.69%	99.26%
16.0372g Ash A	99.74%	99.47%

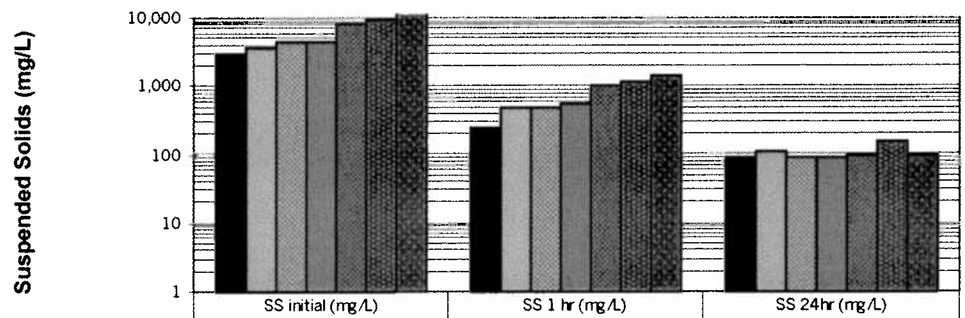
Jar test 5 added 1 to 16 grams of BC Ash A to a sample of BC 99-01 dilute effluent. This jar test was also rerun. As mentioned previously table VI in Appendix B shows the detailed results from the jar tests. Table 19 below summarizes the results of the suspended solids for Jar test 5 and its rerun. Figure 47a and 47b on the next page illustrate these results.

Table 19

	Jar Test #5	*Suspended Solids (mg/L) Initial*				*Jar Test #5 rerun*	*Suspended Solids (mg/L) rerun*		
Lab #	***Comments***	***initial***	***1 hr***	***24hr***	***Lab #***	***Comments***	***initial***	***1 hr***	***24hr***
54	BC 99-01 DILUTE sed eff CONTROL for Jar Test # 5	2910	240	90	120	rerun of JT # 5 - Lab # 54	2370	73	10
55	JT # 5 BC 99-01 dilute and **1.0328g** Ash **A**	3690	490	110	121	Rerun of JT # 5 - Lab # 55	2660	120	17
56	JT # 5 BC 99-01 dilute and **2.0379g** Ash **A**	4500	500	90	122	Rerun of JT # 5 - Lab # 56	3330	117	13
57	JT # 5 BC 99-01 dilute and **4.0379g** Ash **A**	4520	570	90	123	Rerun of JT # 5 - Lab # 57	4610	240	27
58	JT # 5 BC 99-01 dilute and **6.0119g** Ash **A**	7950	1000	100	124	Rerun of JT # 5 - Lab # 58	3560	343	37
59	JT # 5 BC 99-01 dilute and **8.0845g** Ash **A**	9660	1130	160	125	Rerun of JT # 5 - Lab # 59	5480	433	40
60	JT # 5 BC 99-01 dilute and **16.0932g** Ash **A**	15980	1380	100	126	Rerun of JT # 5 - Lab # 60	12000	757	40

Figure 47a

Jar Test # 5 - BC 99-01 Dilute Effluent
With Concentrations of 1.0g to 16.0g BC Ash A
Suspended Solids

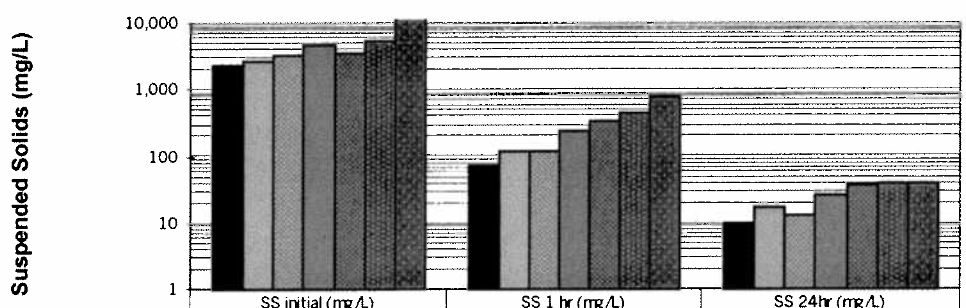


	SS initial (mg/L)	SS 1 hr (mg/L)	SS 24hr (mg/L)
Control - mg/L	2910	240	90
1.0 g A - mg/L	3690	490	110
2.0 g A - mg/L	4500	500	90
4.0 g A - mg/L	4520	570	90
6.0 g A - mg/L	7950	1000	100
8.0 g A - mg/L	9660	1130	160
16.0 g A - mg/L	15980	1380	100

Time (hours)

Figure 47b

Jar Test # 5 Rerun - BC 99-01 Dilute Effluent
With Concentrations of 1.0g to 16.0g BC Ash A
Suspended Solids



	SS initial (mg/L)	SS 1 hr (mg/L)	SS 24hr (mg/L)
Control - mg/L	2370	73	10
1.0 g A - mg/L	2660	120	17
2.0 g A - mg/L	3330	117	13
4.0 g A - mg/L	4610	240	27
6.0 g A - mg/L	3560	343	37
8.0 g A - mg/L	5480	433	40
16.0 g A - mg/L	12000	757	40

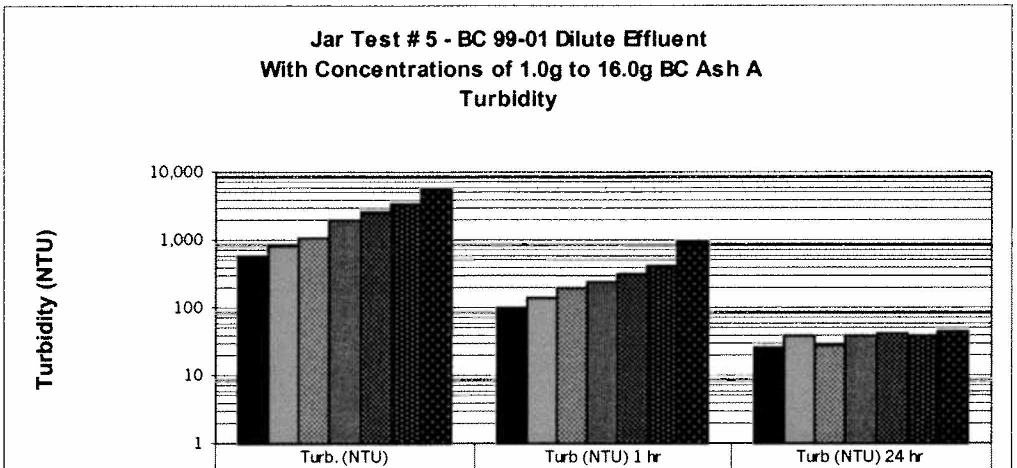
Time (hours)

Table 20 below summarizes the turbidity results for Jar Test 5 and its rerun. Figures 48a and 48b on the next page show these results graphically.

Table 20

	Jar Test #5	***Turbidity (NTU) Initial***				***Jar Test #5 rerun***	***Turbidity (NTU) rerun***		
Lab #	***Comments***	***initial***	***1 hr***	***24hr***	***Lab #***	***Comments***	***initial***	***1 hr***	***24hr***
54	BC 99-01 DILUTE sed eff CONTROL for Jar Test # 5	569	99	26.2	120	rerun of JT # 5 - Lab # 54	535	51.3	5.7
55	JT # 5 BC 99-01 dilute and **1.0328g** Ash **A**	802	138	39.0	121	Rerun of JT # 5 - Lab # 55	761	70.4	8.6
56	JT # 5 BC 99-01 dilute and **2.0379g** Ash **A**	1096	203	28.0	122	Rerun of JT # 5 - Lab # 56	977	61.2	9.1
57	JT # 5 BC 99-01 dilute and **4.0379g** Ash **A**	1995	246	38.6	123	Rerun of JT # 5 - Lab # 57	1878	147	17.3
58	JT # 5 BC 99-01 dilute and **6.0119g** Ash **A**	2665	317	40.8	124	Rerun of JT # 5 - Lab # 58	3035	224	20.1
59	JT # 5 BC 99-01 dilute and **8.0845g** Ash **A**	3449	401	38.2	125	Rerun of JT # 5 - Lab # 59	3938	269	24.3
60	JT # 5 BC 99-01 dilute and **16.0932g** Ash **A**	5595	920	44.2	126	Rerun of JT # 5 - Lab # 60	6603	606	27.3

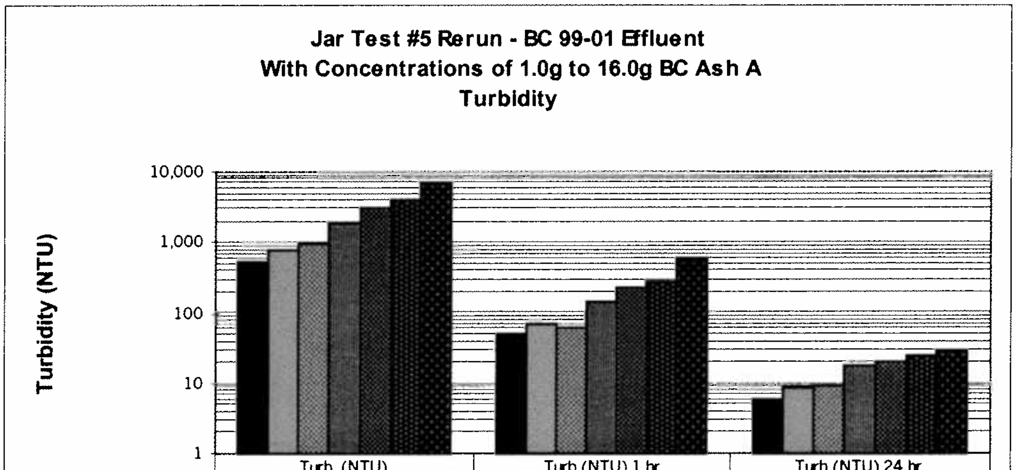
Figure 48a



	Turb. (NTU)	Turb (NTU) 1 hr	Turb (NTU) 24 hr
Control - mg/L	569	99	26.2
1.0 g A - mg/L	802	138	39.0
2.0 g A - mg/L	1096	203	28.0
4.0 g A - mg/L	1995	246	38.6
6.0 g A - mg/L	2665	317	40.8
8.0 g A - mg/L	3449	401	38.2
16.0 g A - mg/L	5595	920	44.2

Time (hours)

Figure 48b



	Turb. (NTU)	Turb (NTU) 1 hr	Turb (NTU) 24 hr
Control - mg/L	535	51.3	5.7
1.0 g A - mg/L	761	70.4	8.6
2.0 g A - mg/L	977	61.2	9.1
4.0 g A - mg/L	1878	147	17.3
6.0 g A - mg/L	3035	224	20.1
8.0 g A - mg/L	3938	269	24.3
16.0 g A - mg/L	6603	606	27.3

Time (hours)

Table 21 below summarizes the results of the percentage of suspended solids and NTU removed from Jar Test 5 and its rerun. Figures 49a and 49b on the next page show these results graphically.

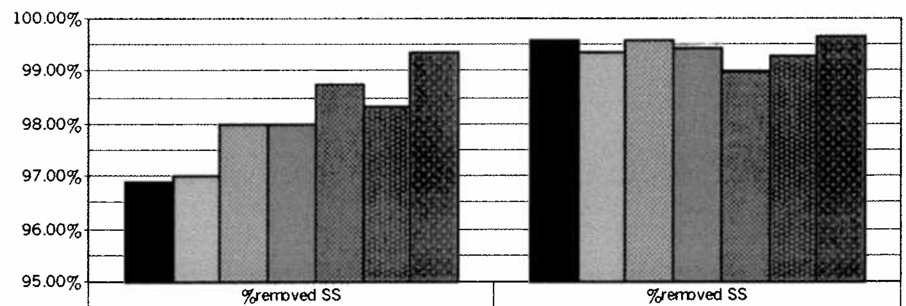
Table 21

	Jar Test #5	***% removed SS***	***% removed NTU***		***Jar Test #5 rerun***	***% removed SS***	***% removed NTU***
Lab #	***Comments***			***Lab #***	***Comments***		
54	BC 99-01 DILUTE sed eff CONTROL for Jar Test # 5	96.91%	95.40%	120	rerun of JT # 5 - Lab # 54	99.58%	98.93%
55	JT # 5 BC 99-01 dilute and **1.0328g** Ash **A**	97.02%	95.14%	121	Rerun of JT # 5 - Lab # 55	99.37%	98.87%
56	JT # 5 BC 99-01 dilute and **2.0379g** Ash **A**	98.00%	97.45%	122	Rerun of JT # 5 - Lab # 56	99.60%	99.07%
57	JT # 5 BC 99-01 dilute and **4.0379g** Ash **A**	98.01%	98.07%	123	Rerun of JT # 5 - Lab # 57	99.42%	99.08%
58	JT # 5 BC 99-01 dilute and **6.0119g** Ash **A**	98.74%	98.47%	124	Rerun of JT # 5 - Lab # 58	98.97%	99.34%
59	JT # 5 BC 99-01 dilute and **8.0845g** Ash **A**	98.34%	98.89%	125	Rerun of JT # 5 - Lab # 59	99.27%	99.38%
60	JT # 5 BC 99-01 dilute and **16.0932g** Ash **A**	99.37%	99.21%	126	Rerun of JT # 5 - Lab # 60	99.67%	99.59%

The suspended solid and turbidity tests for Jar test #5 indicates there appears to be no advantage to adding the Ash A to the samples. However, when reviewing the figures on the next page showing the percentage of suspended solids removed and the percentage of NTU removed, the results are encouraging. The initial Jar Test #5 indicated that there was a definite increase in the suspended solids and NTU removed with increasing ash. The rerun of the jar test did not show as strong of a trend, yet did indicate there is some benefit to adding the ash.

Figure 49a

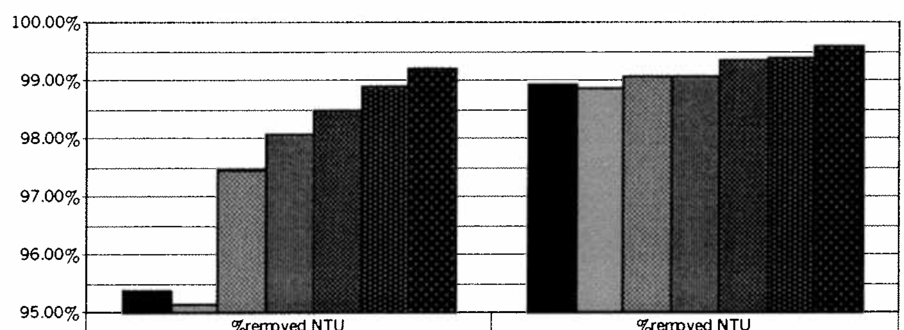
Jar Test # 5 and Rerun - Percentage of Suspended Solids Removed from BC99-01 dilute effluent with additions of 1.0g to 16.0g BC Ash A



	%removed SS	%removed SS
control	96.91%	99.58%
1.0758 g Ash A	97.02%	99.37%
2.0210g Ash A	98.00%	99.60%
4.0712g Ash A	98.01%	99.42%
6.0348g Ash A	98.74%	98.97%
8.0182g Ash A	98.34%	99.27%
16.0372g Ash A	99.37%	99.67%

Figure 49b

Jar Test # 5 and Rerun - Percentage of NTU Removed from BC99-01 dilute effluent with additions of 1.0g to 16.0g BC Ash A



	%removed NTU	%removed NTU
control	95.40%	98.93%
1.0328g ash A	95.14%	98.87%
2.0379g Ash A	97.45%	99.07%
4.0379g Ash A	98.07%	99.08%
6.0119g Ash A	98.47%	99.34%
16.0932g Ash A	98.89%	99.38%
16.0372g Ash A	99.21%	99.59%

Table 22 below summarizes the results of the settleable solids for Jar Tests 2 and 5 and their reruns. Figures 50a and 50b on the next page shows these results graphically.

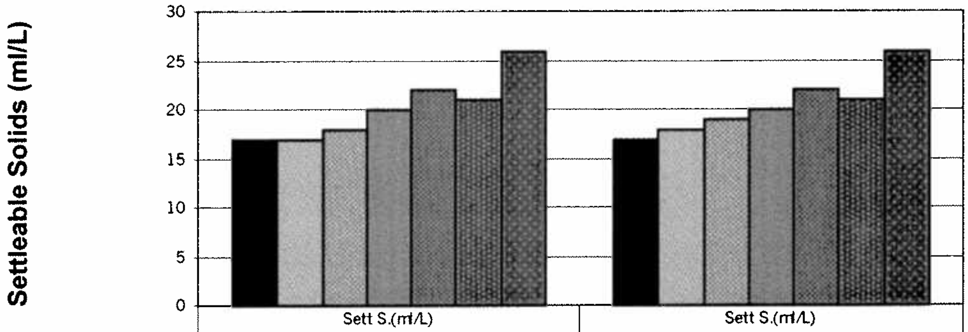
Table 22

	Jar Test #2 and rerun Settleable solids (ml/l)				***Jar Test #5 and rerun Settleable solids (ml/l)***		
Lab #	***Comments***	***initial***	***rerun***	***Lab #***	***Comments***	***intial***	***rerun***
33	1L BC 99-01 sed eff CONTROL for Jar Test #2	17	17	54	BC 99-01 DILUTE sed eff CONTROL for Jar Test # 5	4.5	4.5
34	JT # 2 1L BC 99-01sed eff and **1.0758g** Ash **A**	17	18	55	JT # 5 BC 99-01 dilute and **1.0328g** Ash **A**	5	5.5
35	JT #2 1L BC 99-01sed eff and **2.0210g** Ash **A**	18	19	56	JT # 5 BC 99-01 dilute and **2.0379g** Ash **A**	6	7
36	JT # 2 1L BC 99-01sed eff and **4.0712g** Ash **A**	20	20	57	JT # 5 BC 99-01 dilute and **4.0379g** Ash **A**	7.5	8.5
37	JT # 2 1L BC 99-01 sed eff and **6.0348g** Ash **A**	22	22	58	JT # 5 BC 99-01 dilute and **6.0119g** Ash **A**	10	10
38	JT # 2 1L BC 99-01 sed eff and **8.0182g** Ash **A**	21	21	59	JT # 5 BC 99-01 dilute and **8.0845g** Ash **A**	12	12
39	JT # 2 1L BC 99-01 sed eff and **16.0372g** Ash **A**	26	26	60	JT # 5 BC 99-01 dilute and **16.0932g** Ash **A**	19	20

As discussed previously, the results in the percentage of suspended solids and NTU removed appear to improve slightly with the addition of Ash A. The plots of the settleable solids on the next page indicate that there is an increase in the settleable solids with the increase of ash, in both the initial test and the rerun.

Figure 50a

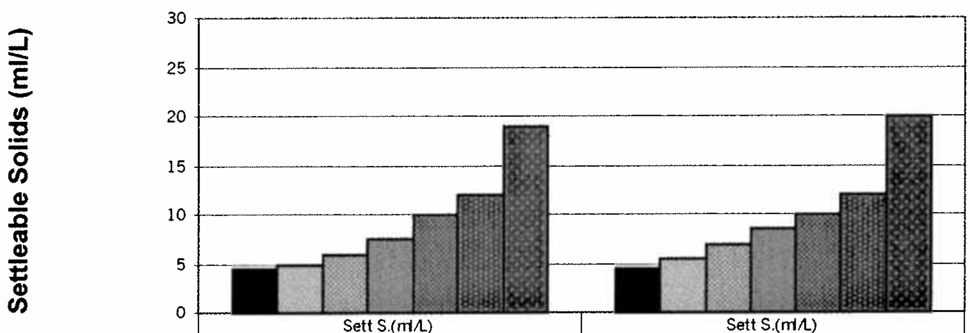
Jar Test # 2 and Rerun - Settleable Solids from BC99-01 effluent with additions of 1.0g to 16.0g BC Ash A



	Sett S.(ml/L)	Sett S.(ml/L)
control	17	17
1.0758 g Ash A	17	18
2.0210g Ash A	18	19
4.0712g Ash A	20	20
6.0348g Ash A	22	22
8.0182g Ash A	21	21
16.0372g Ash A	26	26

Figure 50b

Jar Test # 5 and Rerun - Settleable Solids from BC99-01 dilute effluent with additions of 1.0g to 16.0g BC Ash A



	Sett S.(ml/L)	Sett S.(ml/L)
control	4.5	4.5
1.0328g ash A	5	5.5
2.0379g Ash A	6	7
4.0379g Ash A	7.5	8.5
6.0119g Ash A	10	10
16.0932g Ash A	12	12
16.0372g Ash A	19	20

3.2.3 3 Addition of 1 to 8 grams Ash A to BC 99-1 Effluent

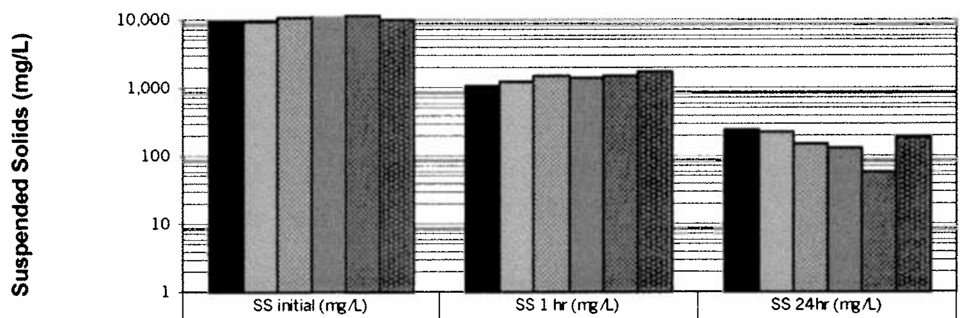
Jar test 3 involved adding 1 to 8 grams of BC Ash A to BC 99-1 effluent. Table VII in Appendix B shows the detailed results from the jar test and its rerun. Table 23 below summarizes the results of the suspended solids for Jar test 3 and its rerun. Figures 51a and 51b on the next page illustrate these results.

Table 23

	Jar Test #3	*Suspended Solids (mg/L) Initial*				*Jar Test #3 rerun*	*Suspended Solids (mg/L) rerun*		
Lab #	***Comments***	***initial***	***1 hr***	***24hr***	***Lab #***	***Comments***	***initial***	***1 hr***	***24hr***
40	BC 99-1 sed eff CONTROL for Jar Test # 3	9250	1080	240	107	rerun of JT # 3 - Lab # 40	9040	1010	80
41	JT # 3 1L BC 99-1 sed eff and **1.0817g** Ash **A**	9230	1230	220	108	rerun of JT # 3 - Lab # 41	9000	940	80
42	JT # 3 1L BC 99-1 sed eff and **2.0391g** Ash **A**	10740	1490	150	109	rerun of JT # 3 - Lab # 42	11570	940	100
43	JT # 3 1L BC 99-1 sed eff and **4.0951g** Ash **A**	12100	1420	130	110	rerun of JT # 3 - Lab # 43	12180	1230	70
44	JT # 3 BC 99-1 sed eff and **6.0477g** Ash **A**	11210	1550	60	111	rerun of JT # 3 - Lab # 44	10690	1510	60
45	JT # 3 BC 99-1 sed eff and **8.0228g** Ash **A**	10230	1700	180	112	rerun of JT # 3 - Lab # 45	11070	1500	70
46	JT # 3 the sixth concentration was not measured as there was an insufficient amount of BC 99-1 sed eff sample available	n/a	n/a	n/a		note sample 46 not included			

Figure 51a

Jar Test # 3 - BC 99-1 Effluent
With Concentrations of 1.0g to 8.0g BC Ash A
Suspended Solids

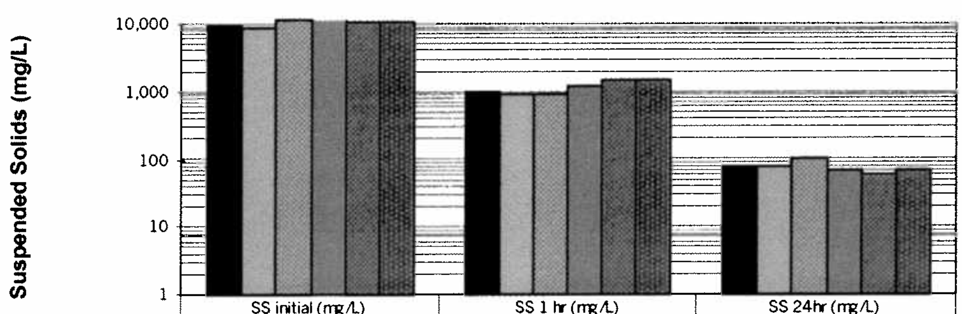


	SS initial (mg/L)	SS 1 hr (mg/L)	SS 24hr (mg/L)
Control - mg/L	9250	1080	240
1.0 g A - mg/L	9230	1230	220
2.0 g A - mg/L	10740	1490	150
4.0 g A - mg/L	12100	1420	130
6.0 g A - mg/L	11210	1550	60
8.0 g A - mg/L	10230	1700	180

Time (hours)

Figure 51b

Jar Test # 3 Rerun - BC 99-1 Effluent
With Concentrations of 1.0g to 8.0g BC Ash A
Suspended Solids



	SS initial (mg/L)	SS 1 hr (mg/L)	SS 24hr (mg/L)
Control - mg/L	9040	1010	80
1.0 g A - mg/L	9000	940	80
2.0 g A - mg/L	11570	940	100
4.0 g A - mg/L	12180	1230	70
6.0 g A - mg/L	10690	1510	60
8.0 g A - mg/L	11070	1500	70

Time (hours)

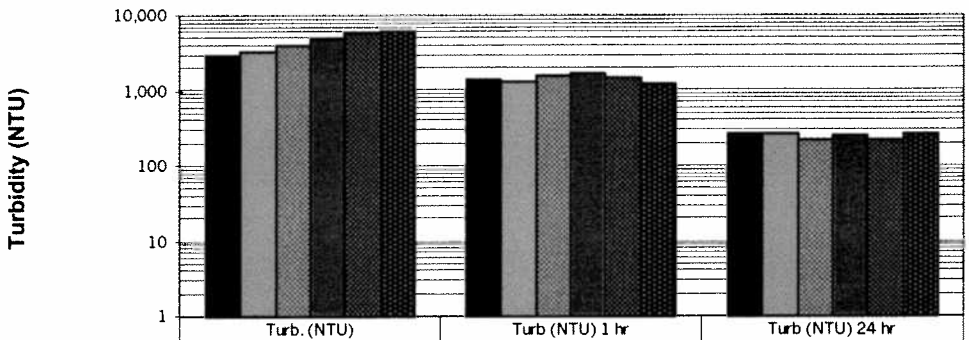
Table 24 below summarizes the turbidity results for Jar Test 3 and its rerun. Figures 52a and 52b on the next page show these results graphically.

Table 24

	Jar Test #3	***Turbidity (NTU) Initial***				*Jar Test #3 rerun*	***Turbidity (NTU) rerun***		
Lab #	***Comments***	***initial***	***1 hr***	***24hr***	***Lab #***	***Comments***	***initial***	***1 hr***	***24hr***
40	BC 99-1 sed eff CONTROL for Jar Test # 3	2988	1419	266	107	rerun of JT # 3 - Lab # 40	3687	2021	304
41	JT # 3 1L BC 99-1 sed eff and **1.0817g** Ash **A**	3252	1332	269	108	rerun of JT # 3 - Lab # 41	4128	2018	190
42	JT # 3 1L BC 99-1 sed eff and **2.0391g** Ash **A**	3873	1566	227	109	rerun of JT # 3 - Lab # 42	3507	1781	242
43	JT # 3 1L BC 99-1 sed eff and **4.0951g** Ash **A**	4773	1668	245	110	rerun of JT # 3 - Lab # 43	5655	3076	228
44	JT # 3 BC 99-1 sed eff and **6.0477g** Ash **A**	5598	1482	222	111	rerun of JT # 3 - Lab # 44	6204	2998	192
45	JT # 3 BC 99-1 sed eff and **8.0228g** Ash **A**	6126	1257	261	112	rerun of JT # 3 - Lab # 45	5811	3116	174
46	JT # 3 the sixth concentration was not measured as there was an insufficient amount of BC 99-1 sed eff sample available	n/a	n/a	n/a		note sample 46 not included			

Figure 52a

Jar Test # 3 - BC 99-1 Effluent
With Concentrations of 1.0g to 8.0g BC Ash A
Turbidity

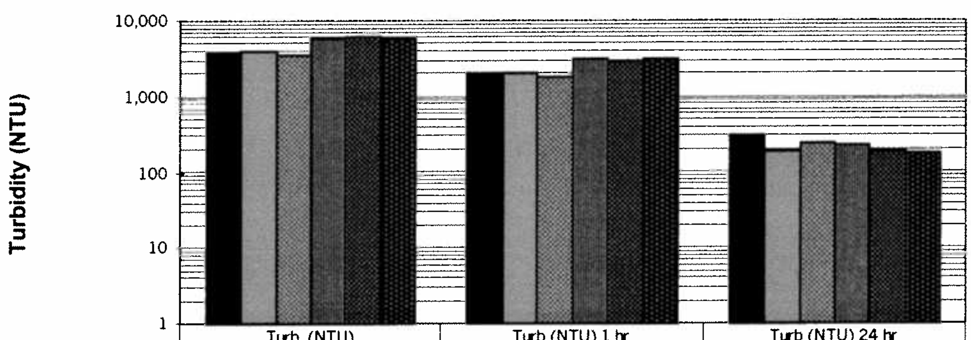


	Turb. (NTU)	Turb (NTU) 1 hr	Turb (NTU) 24 hr
Control - mg/L	2988	1419	266
1.0 g A - mg/L	3252	1332	269
2.0 g A - mg/L	3873	1566	227
4.0 g A - mg/L	4773	1668	245
6.0 g A - mg/L	5598	1482	222
8.0 g A - mg/L	6126	1257	261

Time (Hours)

Figure 52b

Jar Test # 3 Rerun - BC 99-1 Effluent
With Concentrations of 1.0g to 8.0g BC Ash A
Turbidity



	Turb. (NTU)	Turb (NTU) 1 hr	Turb (NTU) 24 hr
Control - mg/L	3687	2021	304
1.0 g A - mg/L	4128	2018	190
2.0 g A - mg/L	3507	1781	242
4.0 g A - mg/L	5655	3076	228
6.0 g A - mg/L	6204	2998	192
8.0 g A - mg/L	5811	3116	174

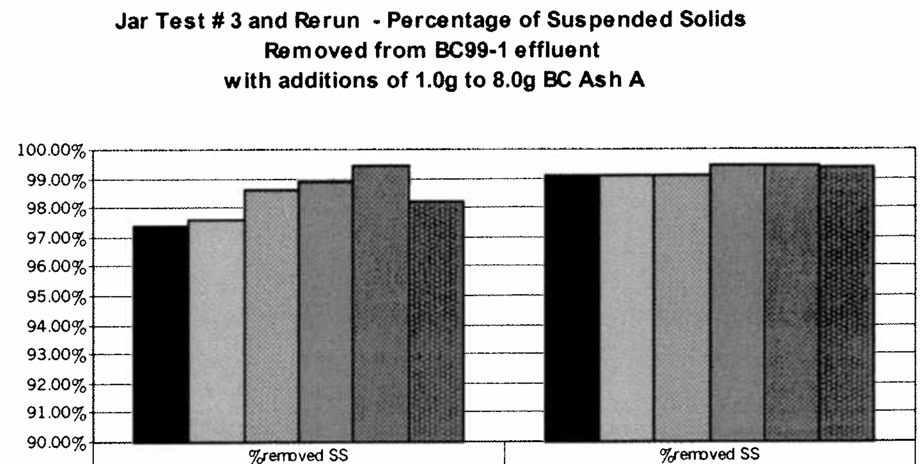
Time (Hours)

Table 25 below summarizes the results of the percentage of suspended solids and NTU removed from Jar Test 3 and its rerun. Figures 53a and 53b on the next page show these results graphically.

Table 25

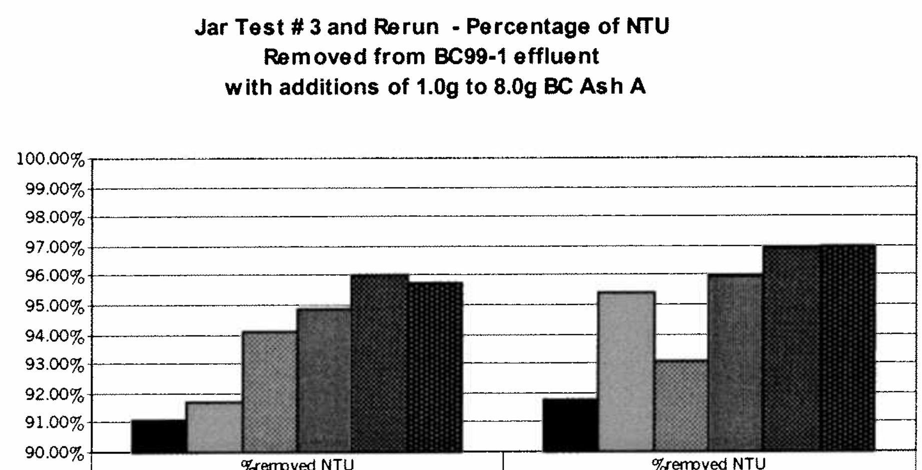
	Jar Test #3	***% removed SS***	***% removed NTU***		***Jar Test #3 rerun***	***% removed SS***	***% removed NTU***
Lab #	***Comments***			***Lab #***	***Comments***		
40	BC 99-1 sed eff CONTROL for Jar Test # 3	97.41%	99.12%	107	rerun of JT # 3 - Lab # 40	91.10%	91.75%
41	JT # 3 1L BC 99-1 sed eff and **1.0817g** Ash **A**	97.62%	99.11%	108	rerun of JT # 3 - Lab # 41	91.73%	95.40%
42	JT # 3 1L BC 99-1 sed eff and **2.0391g** Ash **A**	98.60%	99.14%	109	rerun of JT # 3 - Lab # 42	94.14%	93.10%
43	JT # 3 1L BC 99-1 sed eff and **4.0951g** Ash **A**	98.93%	99.43%	110	rerun of JT # 3 - Lab # 43	94.87%	95.97%
44	JT # 3 BC 99-1 sed eff and **6.0477g** Ash **A**	99.46%	99.44%	111	rerun of JT # 3 - Lab # 44	96.03%	96.91%
45	JT # 3 BC 99-1 sed eff and **8.0228g** Ash **A**	98.24%	99.37%	112	rerun of JT # 3 - Lab # 45	95.74%	97.01%

Figure 53a



	%removed SS	%removed SS
control	97.41%	99.12%
1.0817g Ash A	97.62%	99.11%
2.0391g Ash A	98.60%	99.14%
4.0951g Ash A	98.93%	99.43%
6.0477g Ash A	99.46%	99.44%
8.0228g Ash A	98.24%	99.37%

Figure 53b



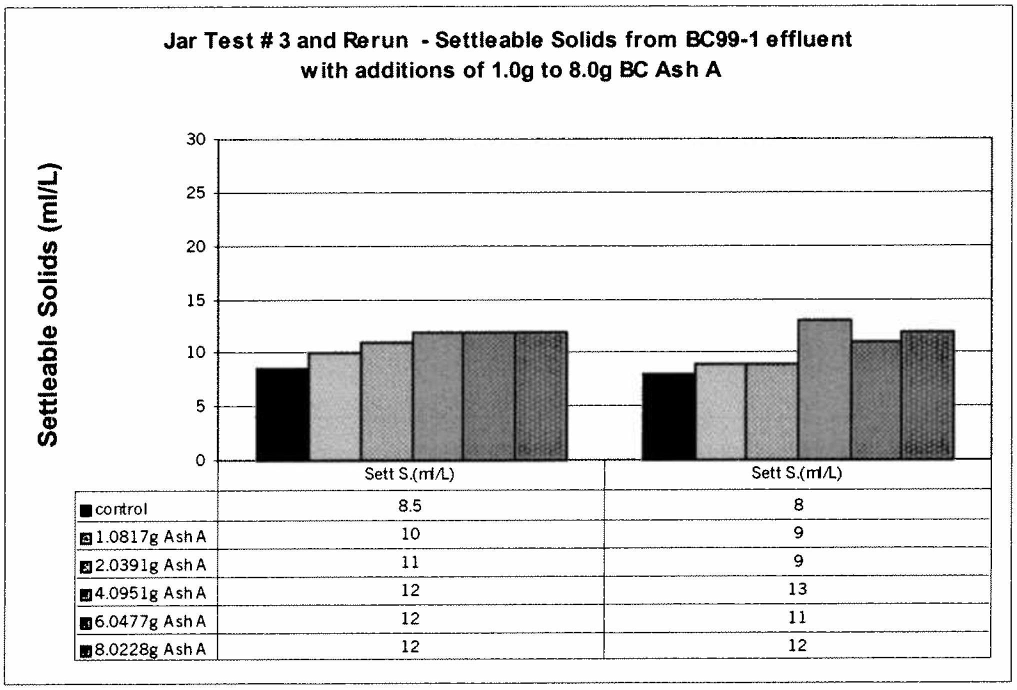
	%removed NTU	%removed NTU
control	91.10%	91.75%
1.0817g Ash A	91.73%	95.40%
2.0391g Ash A	94.14%	93.10%
4.0951g Ash A	94.87%	95.97%
6.0477g Ash A	96.03%	96.91%
8.0228g Ash A	95.74%	97.01%

Table 26 below summarizes the results of the settleable solids for Jar Test 3 its rerun. Figure 54 below shows the results graphically.

Table 26

	Jar Test #3 and rerun Settleable solids (ml/l)		
Lab #	***Comments***	***initial***	***rerun***
40	BC 99-1 sed eff CONTROL for Jar Test # 3	8.5	8
41	JT # 3 1L BC 99-1 sed eff and **1.0817g** Ash **A**	10	9
42	JT # 3 1L BC 99-1 sed eff and **2.0391g** Ash **A**	11	9
43	JT # 3 1L BC 99-1 sed eff and **4.0951g** Ash **A**	12	13
44	JT # 3 BC 99-1 sed eff and **6.0477g** Ash **A**	12	11
45	JT # 3 BC 99-1 sed eff and **8.0228g** Ash **A**	12	12

Figure 54



The suspended solid values appear to increase at the initial and 1 hour reading, yet are generally lower at the 24 hour marks for the samples that had ash added to them. The 24 hour readings on the turbidity also show a slight decrease in numbers overall for the samples that had ash added. The plot of the percentage of suspended solids removed indicates more solids being removed with ash added in the initial jar test and the rerun. The percentage of NTU removed appears to increase substantially when ash is added. The settleable solids also show a slight increase when the ash is added.

3.2.4 Varying Concentrations of Sediment Effluent

This series of tests involved holding the amount of ash constant (in this case, 6 g/L), while the concentration of sediment was varied from 5.0 to 30.0 g/L. Each time the sediment effluent concentration was increased, a control sample was also taken. Table 27 below summarizes the results of the percentage of suspended solids and NTU removed by adding additional sediment. The table also shows the difference in settleable solids corresponding to additions of sediment. A complete table (table VII) showing all the results is found in Appendix B. Figures 55a, 55b and 55c below and on the following pages illustrate the results of the table below.

Table 27

Lab #	*Comments*	*% SS removed*	*% NTU removedr*	*Settleable Solids (ml/l)*
95	Big Creek 99-1 CONTROL approx 5.0g/L sediment	98.29%	91.57%	4.5
96	BC 99-1 w/ 6.0g/L Ash A	99.59%	96.53%	10
97	BC 99-1 CONTROL approx 10.0g/L sediment	99.45%	94.27%	9
98	BC 99-1 w/ 6.0g/L Ash A	99.53%	97.19%	15
99	BC 99-1 CONTROL approx 15.0g/L sediment	99.65%	97.44%	11
100	BC 99-1 w/ 6.0g/L Ash A	99.80%	97.58%	18
101	BC 99-1 CONTROL approx 20.0g/L sediment	99.36%	96.18%	13
102	BC 99-1 w/ 6.0g/L Ash A	99.47%	98.15%	20
103	BC 99-1 CONTROL approx 25.0g/L sediment	99.51%	96.76%	15
104	BC 99-1 w/ 6.0g/L Ash A	99.57%	95.78%	21
105	BC 99-1 CONTROL approx 30.0g/L sediment	99.98%	95.62%	14
106	BC 99-1 w/ 6.0g/L Ash A	99.79%	97.36%	24

Figure 55a

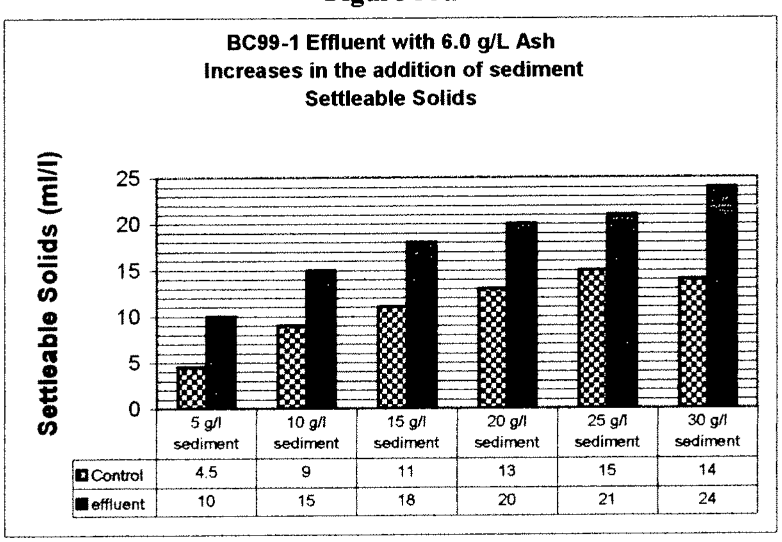
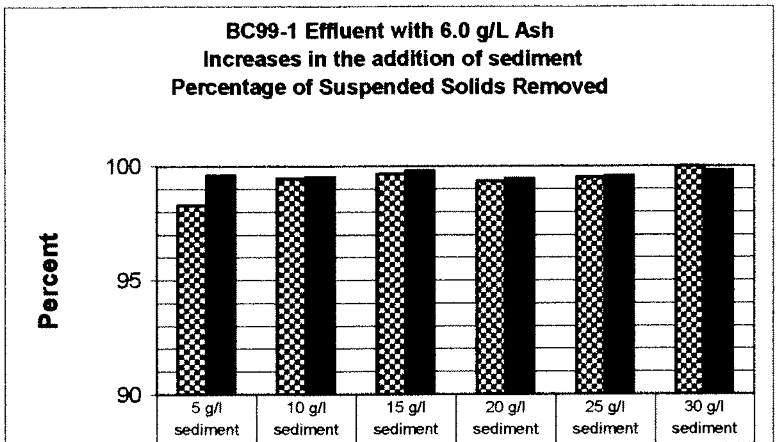
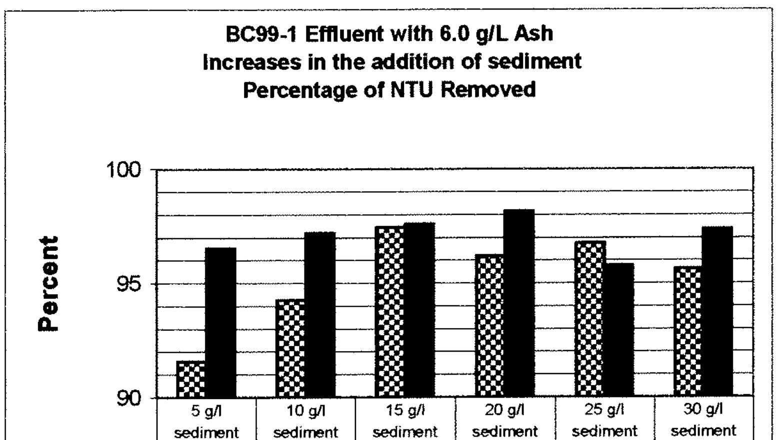


Figure 55b



	5 g/l sediment	10 g/l sediment	15 g/l sediment	20 g/l sediment	25 g/l sediment	30 g/l sediment
Control	98.29	99.45	99.65	99.36	99.51	99.98
effluent	99.59	99.53	99.8	99.47	99.57	99.79

Figure 55c



	5 g/l sediment	10 g/l sediment	15 g/l sediment	20 g/l sediment	25 g/l sediment	30 g/l sediment
Control	91.57	94.27	97.44	96.18	96.76	95.62
effluent	96.53	97.19	97.58	98.15	95.78	97.36

The tests indicate that the amount of settleable solids increases with increasing the concentration of the sediment effluent. Overall, the percentage of suspended solids and NTU removed also appear to increase with higher concentration of sediment effluent. However at the higher value of sediment effluent (25 g/L and 30 g/L) this relationship may not hold true.

4.0 Discussion

One of the objectives of the original study was to research and document localities of volcanic ash and their proximity to active placer mines in the Yukon. As noted in sections 1.6 and 1.7 of this report, the location of placer mining areas is fairly well documented in the Yukon, however, the distribution and amount of ash in the Yukon is not as well understood. There is significant research begin conducted on the ashes in the Klondike by Preece, Westgate and Froese, and on the White River Ash by West. These studies will enhance the knowledge regarding the ashes in the Yukon, and hopefully their distribution as well.

The second objective of the proposal was to test each of the ashes with placer mining sediment effluents from the same area. As well, the plan was to test ashes, such as the Big Creek Ash, on sediments from different placer mining areas, such as the Klondike. Originally 20 days of lab time had been booked to carry out all of this work. As can be seen from earlier sections in the report, a total of 6 weeks was spent in the lab. This time only allowed for the Big Creek ashes to be tested on the Big Creek sediment effluents. Each jar test that was run, had a rerun completed on the same sample. In some cases, the rerun results were different from the initial jar test results. At least one more rerun should have been done, in order to compare the results from at least 3 different tests. The authors now have a better understanding of the length of time necessary to carry out the various tests.

The grain size analysis of the different ashes expressed interesting results. The Big Creek ashes appear to be composed mainly of silt. Wet sieving of Big Creek Ash B saw a significant increase in the amount of fine grained material, suggesting particles breakdown when solution is added to the sample. Big Creek Ash A did not show this trend when it was wet sieved. Both Big Creek Ash A and B appear to have different characteristics when dry, yet seem to be virtually identical after breakdown in water. Although the two ashes were taken from the same stratigraphic section, they did sample different horizons, and appear to have different characteristics. Based on the widespread nature of White River Ash, preliminary interpretation suggests that the Big Creek ashes are part of the eastern lobe of the White River Ash. The Caribou Creek Ash had a significant component of clay (10%) relative to the other ashes (<1% clay). The cause of the higher clay component is unknown in this sample. Again, based upon location, it is assumed the Caribou Creek Ash is White River Ash.

The grain size analysis of the Donjek River ashes indicate these ashes are much coarser grained than the other ashes, interpreted to be due to their closer proximity to the source of the White River Ash. The two ash samples collected in the Klondike Placer Mining Area are predominantly coarse silt. As discussed earlier in the report, there are numerous ash horizons within the Dawson area. The Sulphur Creek and Irish Gulch samples are in closest proximity to locations of Dawson tephra, previously sampled by Preece et. al. (2000). Whether these two samples are Dawson tephra has not been determined.

In the original proposal, the ashes were to be analyzed in more detail (such as microprobe, SEM, and glass-fission-tracking). It was decided to determine whether the ashes did work as flocculants prior to having them analyzed due to cost parameters. Due to time and budget constraints neither of the Big Creek ashes were sent for analysis.

Preliminary results from the lab tests indicate that adding Big Creek Ash A to the two different Big Creek effluents appear to show an overall increase in the percentage of suspended solids and NTU removed, as well as an increase in settleable solids. There has not been enough testwork to determine if there is a direct relationship between the amount of ash added, and the amount of material removed or settled out.

The tests also indicate that adding smaller amounts (0.25, 0.50 and 1.0 g/L) of either Ash A or B did not appear to make a difference to the amount of material being removed or settled out. It does appear that adding ash in amounts of greater than 1 gram/L , increased the probability of material being removed or settled out.

Initially when adding ash, both the suspended solids and turbidity values increased in their initial readings, and at the 1 hour mark. However, after 24 hours, the numbers decreased significantly, in comparison to control samples. This is important to note, as most readings in the field that affect placer miners are taken at the 1 hour mark.

The tests where the ash was held constant and the concentration of the sediment effluent increased indicated that the percentage of suspended solids and NTU removed, as well as the settleable solids, increased. This seemed to hold true until the 25 to 30 g/L sediment effluent concentrations, where the results started to change. In previous work done on flocculants, many of the studies indicated that the material taken out of suspension seemed to work well with samples of higher concentration of the sediment effluent. Whether the increase in settleable solids is in any way partly due to the actual increase in the ash or in the concentration of the sediment effluent is unknown.

The original proposal suggested studying the ash to determine if it is a flocculant. In the course of this study, the authors have become aware of the difference between coagulation and flocculation. Whether the ash is actually acting as a "coagulant" versus a "flocculant" was not within the scope of this study, yet is something to keep in mind for future work. In other studies it was determined that flocculation depends upon ionic charges in many cases. In this study, the ionic charge of the ash was not determined, due to expense and time. This information would help in a better understanding of the ash as a flocculant (or possibly a coagulant?).

As noted by Shen (1987) the mechanism of flocculation is a very complex process and poorly understood. There are several hydrodynamic factors (i.e. agitation, temperature), physio-chemical characteristics (i.e. electrical forces) and the actual nature of the flocculant (i.e. physical, molecular weight, charge) that can affect flocculation. In some of the tests that do not seem to show results by adding the ash, one or several of the above factors may be playing a role.

The third objective of the program was to prepare a list of placer miners willing to test ash as a flocculant in the operations. The authors first outlined the proposed research idea at the Klondike Placer Miners Annual General Meeting held in September 2001 in Dawson City. At this time, several miner expressed interest in the project. Miners were again contacted during the Geoscience Forum and several who are based in the south during the winter were reached during the Cordilleran Roundup in Vancouver in January of 2002.

Ongoing discussions in person as well as telephone conversations were employed to inform several miners of progress on the project and to ascertain if there was interest in the mining community in participating in full scale production testing at their mine sites if results warranted. Miners active in most of the mining areas of the Yukon have expressed interest in hosting a test program. A preliminary list of candidates has been collected, yet will depend upon further lab tests and funding.

5.0 Recommendations

Preliminary results from this study indicate ash may act as a flocculant and reduce suspended solids in placer mining effluents. Further objectives would be to determine local sources of ash which would be economical for area miners to utilize. At present, the largest known beds of ash appear to be the White River Ash, which is found in significant deposits in the Kluane Area and the Big Creek Area. The focus of future studies should be on ashes which have considerable volume to them.

However, the authors believe that the original proposed tests of the Donjek River ashes and the Klondike ashes on effluent from their locality should be completed prior to any new ash collection and tests. As well, tests of the Big Creek and the Donjek River Ashes (if results are positive) on effluents from other areas should be undertaken. In this regard, the following program is recommended:

External Laboratory:

- Determine parameters of Big Creek Ash to identify its source (White River?)

Laboratory:

- Jar tests of Donjek River Ashes on Donjek River Effluent
- Jar tests of Sulphur Creek and Irish Gulch Ashes on relevant effluents
- Jar tests of White River Ash (Big Creek and Donjek River)on effluents from other placer mining areas
- Jar test of Big Creek Ash on Big Creek effluents modifying temperature and possibly other parameters (including ionic characteristics)

Field:

- Dependent upon results, field testing of ash as a flocculant within operating mines such as:
    - Big Creek Ash on Dawson Range Placer Mining Operations
    - Irish Gulch Ash on Irish Gulch Placer Mining Operation.

  The field testing would involve further studies on implementation, delivery systems, etc. which would be designed in consultation with the mine operators.

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Appendix A

DATE OF SIEVE:	14-Feb-02
SIEVED BY:	Tanya Gates
PROJECT:	MERG Ash Study
SECTION:	Big Creek A
UNIT:	
COMMENTS:	
SPLIT FRACTION:	
INITIAL SAMPLE WEIGHT:	3450

BAG REFERENCE NO.	4
For Sieve:	1616
For Archive:	1834

	A	B	C	D	E	F
SCREEN MESH NUMBER	Particle Size	Sample & Pan (g)	Pan Weight Dry (g)	Scale Over	Sample Weight Dry (g)	Description % Aggregates
Wt. # 4	4.757 mm					0.0
Wt. # 10	2.000 mm	450	450		0	0.0
Wt. # 18	1.000 mm	406	406		0	0.0
Wt. # 35	0.500 mm	370	368		2	0.1
Wt. # 60	0.250 mm	576	340		236	14.6
Wt. # 120	0.125 mm	668	326		342	21.2
Wt. # 230	0.062 mm	490	316		174	10.8
Wt. -230	< 0.062 mm	1236	374		862	53.3

TOTAL SIEVED WEIGHT	1616
DIFFERENCE	0
MATRIX %	100.0

		A	B	C	D	E	F
Hydrometer Sample	Hydrometer Correction	Dry Sample Weight (g)	40 Second Reading	8 Hour Reading	% Sand	% Silt	% Clay
-230 Material	1	50.425	46	2	10.75855231	87.25830441	1.983143282

Recommend wet sieve?	
Recommend second split?	

DATE OF SIEVE:	25-Feb-02
SIEVED BY:	Tanya Gates
PROJECT:	MERG Ash Study
SECTION:	Big Creek 'A' Ash
UNIT:	
COMMENTS:	Wet sieve sample
SPLIT FRACTION:	
INITIAL SAMPLE WEIGHT:	100

BAG REFERENCE NO.

For Sieve: 100

For Archive:

	A	B	C	D	E	F
SCREEN MESH NUMBER	Particle Size	Sample & Pan (g)	Pan Weight Dry (g)	Scale Over	Sample Weight Dry (g)	Description % Aggregates
Wt. # 4	4.757 mm					0.0
Wt. # 10	2.000 mm	450	450		0	0.0
Wt. # 18	1.000 mm	406	406		0	0.0
Wt. # 35	0.500 mm	368	368		0	0.0
Wt. # 60	0.250 mm	354	340		14	14.0
Wt. # 120	0.125 mm	346	324.0		22	22.0
Wt. # 230	0.062 mm	320	316		4	4.0
Wt. -230	< 0.062 mm	434.0	374		60	60.0

TOTAL SIEVED WEIGHT	100
DIFFERENCE	0
MATRIX %	100.0

		A	B	C	D	E	F
Hydrometer Sample	Hydrometer Correction	Dry Sample Weight (g)	40 Second Reading	8 Hour Reading	% Sand	% Silt	% Clay
-230 Material					#DIV/0!	#DIV/0!	#DIV/0!

Recommend wet sieve?	
Recommend second split?	

DATE OF SIEVE:	Feb 14,2002
SIEVED BY:	Tanya Gates
PROJECT:	MERG Ash Study
SECTION:	Big Creek B
UNIT:	
COMMENTS:	
SPLIT FRACTION:	
INITIAL SAMPLE WEIGHT:	4342

BAG REFERENCE NO.	5
For Sieve:	2200
For Archive:	2142

	A	B	C	D	E	F
SCREEN MESH NUMBER	Particle Size	Sample & Pan (g)	Pan Weight Dry (g)	Scale Over	Sample Weight Dry (g)	Description % Aggregates
Wt. # 4	4.757 mm					0.0
Wt. # 10	2.000 mm	454	450		4	0.2
Wt. # 18	1.000 mm	410	406		4	0.2
Wt. # 35	0.500 mm	374	366		8	0.4
Wt. # 60	0.250 mm	780	342		438	19.9
Wt. # 120	0.125 mm	896	324.0		572	26.0
Wt. # 230	0.062 mm	1064	316		748	34.0
Wt. -230	< 0.062 mm				426	19.4

TOTAL SIEVED WEIGHT	2200
DIFFERENCE	0
MATRIX %	100.0

		A	B	C	D	E	F
Hydrometer Sample	Hydrometer Correction	Dry Sample Weight (g)	40 Second Reading	8 Hour Reading	% Sand	% Silt	% Clay
-230 Material	1	50.4693	46	8	10.836885	75.29329711	13.86981789

Recommend wet sieve?	
Recommend second split?	

DATE OF SIEVE:	25-Feb-02
SIEVED BY:	Tanya Gates
PROJECT:	MERG Ash Study
SECTION:	Big Creek 'B' Ash
UNIT:	
COMMENTS:	Wet sieve sample
SPLIT FRACTION:	
INITIAL SAMPLE WEIGHT:	100

BAG REFERENCE NO.

For Sieve: 100.1607g

For Archive:

	A	B	C	D	E	F
SCREEN MESH NUMBER	Particle Size	Sample & Pan (g)	Pan Weight Dry (g)	Scale Over	Sample Weight Dry (g)	Description % Aggregates
Wt. # 4	4.757 mm					0.0
Wt. # 10	2.000 mm	468	468		0	0.0
Wt. # 18	1.000 mm	408	408		0	0.0
Wt. # 35	0.500 mm	386	386		0	0.0
Wt. # 60	0.250 mm	366	352		14	13.7
Wt. # 120	0.125 mm	354	328.0		26	25.5
Wt. # 230	0.062 mm	344	340		4	3.9
Wt. -230	< 0.062 mm	430.0	372		58	56.9

TOTAL SIEVED WEIGHT	102
DIFFERENCE	#VALUE!
MATRIX %	101.8

		A	B	C	D	E	F
Hydrometer Sample	Hydrometer Correction	Dry Sample Weight (g)	40 Second Reading	8 Hour Reading	% Sand	% Silt	% Clay
-230 Material					#DIV/0!	#DIV/0!	#DIV/0!

Recommend wet sieve?	
Recommend second split?	

DATE OF SIEVE:	14-Feb-02
SIEVED BY:	Tanya Gates
PROJECT:	MERG Ash Study
SECTION:	Caribou Creek
UNIT:	
COMMENTS:	
SPLIT FRACTION:	
INITIAL SAMPLE WEIGHT:	3428

BAG REFERENCE NO.	6
For Sieve:	1602
For Archive:	1826

	A	B	C	D	E	F
SCREEN MESH NUMBER	Particle Size	Sample & Pan (g)	Pan Weight Dry (g)	Scale Over	Sample Weight Dry (g)	Description % Aggregates
Wt. # 4	4.757 mm					0.0
Wt. # 10	2.000 mm	470	468		2	0.1
Wt. # 18	1.000 mm	410	408		2	0.1
Wt. # 35	0.500 mm	392	386		6	0.4
Wt. # 60	0.250 mm	674	354		320	20.0
Wt. # 120	0.125 mm	534	330		204	12.7
Wt. # 230	0.062 mm	452	340		112	7.0
Wt. -230	< 0.062 mm	1328.0	372		956	59.7

TOTAL SIEVED WEIGHT	1602
DIFFERENCE	0
MATRIX %	100.0

		A	B	C	D	E	F
Hydrometer Sample	Hydrometer Correction	Dry Sample Weight (g)	40 Second Reading	8 Hour Reading	% Sand	% Silt	% Clay
-230 Material	1	50.158	49	9	4.302404402	79.74799633	15.94959927

Recommend wet sieve?	
Recommend second split?	

DATE OF SIEVE:	14-Feb-02
SIEVED BY:	Tanya Gates
PROJECT:	MERG Ash Study
SECTION:	Donjek 1 Sept 6/01
UNIT:	
COMMENTS:	
SPLIT FRACTION:	
INITIAL SAMPLE WEIGHT:	3808

BAG REFERENCE NO.	2
For Sieve:	1950
For Archive:	1858

	A	B	C	D	E	F
SCREEN MESH NUMBER	Particle Size	Sample & Pan (g)	Pan Weight Dry (g)	Scale Over	Sample Weight Dry (g)	Description % Aggregates
Wt. # 4	4.757 mm					0.0
Wt. # 10	2.000 mm	472	468		4	0.2
Wt. # 18	1.000 mm	672	408		264	13.5
Wt. # 35	0.500 mm	1626	386		1240	63.6
Wt. # 60	0.250 mm	696	352		344	17.6
Wt. # 120	0.125 mm	368	328		40	2.1
Wt. # 230	0.062 mm	342	338		4	0.2
Wt. -230	< 0.062 mm				54	2.8

TOTAL SIEVED WEIGHT	1950
DIFFERENCE	0
MATRIX %	100.0

		A	B	C	D	E	F
Hydrometer Sample	Hydrometer Correction	Dry Sample Weight (g)	40 Second Reading	8 Hour Reading	% Sand	% Silt	% Clay
-230 Material	1	47.621	45	8.5	7.603788245	76.64685748	15.74935428

* after 24hrs, ash formed a solid impervious plug in the imhoff cone

Recommend wet sieve?	
Recommend second split?	

DATE OF SIEVE:	14-Feb-02
SIEVED BY:	Tanya Gates
PROJECT:	MERG Ash Study
SECTION:	Donjek 2 Sept 6/01
UNIT:	
COMMENTS:	
SPLIT FRACTION:	
INITIAL SAMPLE WEIGHT:	3988

BAG REFERENCE NO. 1

For Sieve: 2030

For Archive: 1958

	A	B	C	D	E	F
SCREEN MESH NUMBER	Particle Size	Sample & Pan (g)	Pan Weight Dry (g)	Scale Over	Sample Weight Dry (g)	Description % Aggregates
Wt. # 4	4.757 mm					0.0
Wt. # 10	2.000 mm				0	0.0
Wt. # 18	1.000 mm	464	408		56	2.8
Wt. # 35	0.500 mm	1714	384		1330	65.5
Wt. # 60	0.250 mm	942	352		590	29.1
Wt. # 120	0.125 mm	366	330		36	1.8
Wt. # 230	0.062 mm	342	340		2	0.1
Wt. -230	< 0.062 mm	388	372		16	0.8

TOTAL SIEVED WEIGHT	2030
DIFFERENCE	0
MATRIX %	100.0

		A	B	C	D	E	F
Hydrometer Sample	Hydrometer Correction	Dry Sample Weight (g)	40 Second Reading	8 Hour Reading	% Sand	% Silt	% Clay
-230 Material	n/a	n/a	n/a	n/a	n/a	n/a	n/a

* note not enough sample for silt/clay

Recommend wet sieve?	
Recommend second split?	

DATE OF SIEVE:	14-Feb-02
SIEVED BY:	Tanya Gates
PROJECT:	MERG Ash Study
SECTION:	Irish 1 Sept 6/ 01
UNIT:	
COMMENTS:	
SPLIT FRACTION:	
INITIAL SAMPLE WEIGHT:	3486

BAG REFERENCE NO.	7
For Sieve:	1790
For Archive:	1696

	A	B	C	D	E	F
SCREEN MESH NUMBER	Particle Size	Sample & Pan (g)	Pan Weight Dry (g)	Scale Over	Sample Weight Dry (g)	Description % Aggregates
Wt. # 4	4.757 mm					0.0
Wt. # 10	2.000 mm	520	450		70	3.9
Wt. # 18	1.000 mm	434	406		28	1.6
Wt. # 35	0.500 mm	394	368		26	1.5
Wt. # 60	0.250 mm	378	340		38	2.1
Wt. # 120	0.125 mm	386	326		60	3.4
Wt. # 230	0.062 mm	1412	316		1096	61.2
Wt. -230	< 0.062 mm	848.0	376		472	26.4

TOTAL SIEVED WEIGHT	1790
DIFFERENCE	0
MATRIX %	100.0

		A	B	C	D	E	F
Hydrometer Sample	Hydrometer Correction	Dry Sample Weight (g)	40 Second Reading	8 Hour Reading	% Sand	% Silt	% Clay
-230 Material	1	50.3152	46	7	10.56380577	77.51136833	11.9248259

Recommend wet sieve?	
Recommend second split?	

DATE OF SIEVE:	14-Feb-02
SIEVED BY:	Tanya Gates
PROJECT:	MERG Ash Study
SECTION:	Sulphur Sept 8/01
UNIT:	
COMMENTS:	
SPLIT FRACTION:	
INITIAL SAMPLE WEIGHT:	3432

BAG REFERENCE NO. 3

For Sieve: 1682

For Archive: 1750

	A	B	C	D	E	F
SCREEN MESH NUMBER	Particle Size	Sample & Pan (g)	Pan Weight Dry (g)	Scale Over	Sample Weight Dry (g)	Description % Aggregates
Wt. # 4	4.757 mm					0.0
Wt. # 10	2.000 mm	452	450		2	0.1
Wt. # 18	1.000 mm	408	406		2	0.1
Wt. # 35	0.500 mm	370	366		4	0.2
Wt. # 60	0.250 mm	344	342		2	0.1
Wt. # 120	0.125 mm	358	326		32	1.9
Wt. # 230	0.062 mm	1664	316		1348	80.1
Wt. -230	< 0.062 mm	666	374		292	17.4

TOTAL SIEVED WEIGHT	1682
DIFFERENCE	0
MATRIX %	100.0

		A	B	C	D	E	F
Hydrometer Sample	Hydrometer Correction	Dry Sample Weight (g)	40 Second Reading	8 Hour Reading	% Sand	% Silt	% Clay
-230 Material	1	51.5729	46	8	12.74487182	73.68210824	13.57301994

* after 24hrs, the ash formed a solid impervious plug in the cone

Recommend wet sieve?	
Recommend second split?	

DATE OF SIEVE:	36586		
SIEVED BY:	CRYSTAL CLEAR WATER MONITORING		
PROJECT:			
SECTION:	BIG CR 99-1		
UNIT:			
COMMENTS:	silt ?		
	116B	116C	
SPLIT FRACTION:		3060	3376
INITIAL SAMPLE WEIGHT:			7990

BAG REFEREN(	116
For Sieve:	3060
For Archive:	3376

	A	B	C	D	E	F
SCREEN MESH NUM	article Size	Sample & Pan (g	an Weight Dry (g	Scale Over	nple Weight Dry	ription % Aggregates
Wt. # 4	**4.757 mm**				**1554**	**19.44931164**
Wt. # 10	**2.000 mm**	1020.9	416.3		604.6	19.9
Wt. # 18	**1.000 mm**	924.9	393		531.9	17.5
Wt. # 35	**0.500 mm**	826.1	350.8		475.3	15.6
Wt. # 60	**0.250 mm**	768.8	323.5		445.3	14.6
Wt. # 120	**0.125 mm**	666.6	329.1		337.5	11.1
Wt. # 230	**0.062 mm**	590.9	321.5		269.4	8.9
Wt. -230	**< 0.062 mm**	739.2	362.9		376.3	12.4

TOTAL SIEVED	3040.3
DIFFERENCE	19.7
MATRIX %	80.55068836

		A	B	C	D	E	F
Hydrometer Sample	Hydrometer Corr	Sample Weight)	Second Readir	8 Hour Reading	% Sand	% Silt	% Clay
-230 Material	**4**	**52.394**	**48**	**7**	**16.02091843**	**78.2532351**	**5.725846471**

Recommend wet sieve?

Recommend second split?

DATE OF SIEVE:	36586		
SIEVED BY:	CRYSTAL CLEAR WATER MONITORING		
PROJECT:			
SECTION:	BIG CR 99-01		
UNIT:			
COMMENTS:			
	91B	No Split	
SPLIT FRACTION:		1754	0
INITIAL SAMPLE WEIGHT:			3304

BAG REFEREN(91
For Sieve: 1754
For Archive: 0

Sample fell on floor

	A	B	C	D	E	F	
SCREEN MESH NUM	**article Size**	**Sample & Pan (g**	**an Weight Dry (**	**Scale Over**	**nple Weight Dry**	**ription % Aggregates**	
Wt. # 4	**4.757 mm**				**1550**	**46.91283293**	
Wt. # 10	**2.000 mm**	573	485.2		87.8	5.3	wood
Wt. # 18	**1.000 mm**	528.3	431		97.3	5.9	wood
Wt. # 35	**0.500 mm**	503.3	376.2		127.1	7.7	wood
Wt. # 60	**0.250 mm**	482.3	352		130.3	7.9	
Wt. # 120	**0.125 mm**	454.9	334.4		120.5	7.3	
Wt. # 230	**0.062 mm**	933.5	339.9		593.6	36.0	
Wt. -230	**< 0.062 mm**	773.5	280.1		493.4	29.9	
		TOTAL SIEVED	1650				
		DIFFERENCE	104				
		MATRIX %	53.08716707				

		A	B	C	D	E	F
Hydrometer Sample	Hydrometer Corr	**Sample Weight)**	**Second Readir**	**8 Hour Reading**	**% Sand**	**% Silt**	**% Clay**
-230 Material	**4**	**50.0777**	**41**	**7**	**26.11481757**	**67.89449196**	**5.990690467**

Recommend wet sieve?

Recommend second split?

Appendix B

Table I Big Creek (BC) 99-01 Characteristics

Lab #	Comments	pH	Cond (us)	Sett S.(ml/L)	SS Initial (mg/L)	SS 1 hr (mg/L)	SS 24hr (mg/L)	Turb (NTU) Initial	Turb (NTU) 1 hr	Turb (NTU) 24 hr	% removed SS	% removed NTU	Temp (deg C)	material weight (g)
1	1999 Big Cr 99-01 -230 Bag 91	7.45	534	14	8450	310	100	1521	199.0	4.38	98.82%	99.71%	17.0	11.1033
2	combined w/ 1999 Big Cr 99-01 +230 sample	7.65	528	15	9930	350	100	1743	46.5	4.07	98.99%	99.77%	17.4	11.2499
3	at a +230:-230 ratio of 1.2:1	7.67	521	15	9920	330	140	1815	23.8	1.61	98.59%	99.91%	17.4	11.1311
4	6 g of +230 and 5 g of -230	7.69	521	14	10300	360	310	1500	31.0	2.35	96.99%	99.84%	17.6	11.117
5		7.7	521	15	9310	300	270	1689	40.0	3.35	97.10%	99.80%	17.5	11.1054
6		7.68	524	14	9650	310	270	1761	37.4	2.99	97.20%	99.83%	17.3	11.1208
Average		**7.64**	**525**	**14.5**	**9593**	**327**	**198**	**1672**	**63.0**	**3.13**	**97.95%**	**99.81%**	**17.4**	**11.13792**

sample lifted, therefore 1hr reading for turbidity was disturbed

Table II Big Creek (BC) 99-1 Characteristics

Lab #	Comments	pH	Cond (uS)	Sett S.(ml/L)	SS Initial (mg/L)	SS 1 hr (mg/L)	SS 24hr (mg/L)	Turb. (NTU)	Turb (NTU) 1 hr	Turb (NTU) 24 hr	% removed SS	% removed NTU	Temp (deg C)	material weight (g)
7	1999 Big Cr 99-1 -230 Bag 116	8.31	545	8.5	6830	400	50	1926	471	8.09	99.27%	99.58%	17.5	8.7291
8	combined w/ 1999 Big Cr 99-1 +230 sam ple	8.36	541	8.5	6690	480	40	2238	513	6.46	99.40%	99.71%	17.6	8.6847
9	at a 230:-230 ratio of 1:0.72	7.90	533	8.5	8100	520	130	2523	488	8.46	98.40%	99.66%	16.6	8.7169
10	5g of +230 and 3.6g of -230	7.84	537	8.0	6860	630	50	2244	534	10.9	99.27%	99.51%	16.8	8.6211
11		7.81	544	9.5	6560	430	140	2091	334	9.77	97.87%	99.53%	16.0	8.808
12	sediment sample was damaged	7.80	543	12.0	5310	130	100	1311	14	4.21	98.12%	99.68%	16.3	8.6866
Average		**8.00**	**541**	**9.2**	**6725**	**432**	**85**	**2056**	**392**	**7.98**	**98.72%**	**99.61%**	**16.8**	**8.7077**

Table III Big Creek Ash A Characteristics

Lab #	Comments	pH	Cond (uS)	Sett S.(ml/L)	SS initial (mg/L)	SS 1 hr (mg/L)	SS 24hr (mg/L)	Turb. (NTU)	Turb (NTU) 1 hr	Turb (NTU) 24 hr	% removed SS	% removed NTU	Temp (deg C)	material weight (g)
13	Big Cr. 'A' Ash	8.18	555	11.0	6090	680	10	3671	n/a	n/a	99.84%	n/a	17.5	10.0849
14	"	8.12	543	12.0	7770	890	80	3289	n/a	n/a	98.97%	n/a	17.0	10.066
15	"	8.18	540	10.0	6020	940	120	2417	n/a	n/a	98.01%	n/a	17.1	10.006
16	"	8.24	551	11.0	8940	1060	70	3220	n/a	n/a	99.22%	n/a	17.0	10.0493
17	"	8.24	547	9.0	5590	730	50	2695	n/a	n/a	99.11%	n/a	17.0	10.0354
18	"	8.29	546	12.0	6420	880	140	3413	n/a	n/a	97.82%	n/a	17.0	10.0307
	average	**8.2083**	**547**	**10.8**	**6805**	**863**	**78**	**3118**	**n/a**	**n/a**	**98.83%**	n/a	**17.1**	**10.0454**
61	redo of Lab # 13 on 10.0738g Ash A (RO water used)	7.65	577	11.0	7100	660	90	2193	472	65.0	98.73%	97.04%	16.3	10.0738
62	redo of Lab # 14 on 10.0627g Ash A (RO water used)	7.6	579	11.0	8940	990	70	2283	361	49.0	99.22%	97.85%	15.9	10.0627
63	redo of Lab # 15 on 10.0682g Ash A (RO water used)	7.63	584	11.0	6910	1040	30	1980	511	49.8	99.57%	97.48%	16.1	10.0682
64	redo of Lab # 16 on 10.0430g Ash A (Tap water used)	7.83	334	10.0	8040	1180	40	2193	572	22.2	99.50%	98.99%	15.4	10.043
65	redo of Lab # 17 on 10.0908g Ash A (Tap water used)	7.87	314	10.0	8750	1140	90	2148	559	28.5	98.97%	98.67%	18.3	10.0908
66	redo of Lab # 18 on 10.0648g Ash A (Tap water used)	7.92	311	10.0	7780	1160	80	2022	602	26.2	98.97%	98.70%	16.8	10.0648
	average	**7.75**	**450**	**10.5**	**7920**	**1028**	**67**	**2137**	**513**	**40.1**	**99.16%**	**98.12%**	**16.5**	**10.0672**
61A	Control BC Ash A RAW, 10.0738g	8.33	575	10	6200	1050	50	3219	613	25.9	99.19%	99.20%	19.6	10.0738
73	BC Ash A # 60 fraction, 10.0063g	8.04	315	18	530	290	60	468	207	37.8	88.68%	91.92%	19.4	10.0063
74	BC Ash A # 120 fraction, 10.0044g	7.94	309	8.5	240	100	30	129	63.9	16.1	87.50%	87.52%	19.5	10.0044
75	BC Ash A #230 fraction, 10.0052g	7.79	309	11	6520	910	60	3865	716	52.1	99.08%	98.65%	19.4	10.0052
76	BC Ash A # min 230 fraction, 10.0041g	7.91	308	10	10110	1490	50	5658	1401	68.3	99.51%	98.79%	19.4	10.0041
	average	**8.00**	**363**	**11.5**	**4720**	**768**	**50**	**2668**	**600**	**40.0**	**94.79%**	**95.22%**	**19.5**	**10.0188**

Table IV Big Creek Ash B Characteristics

Lab #	Comments	pH	Cond (uS)	Sett S.(ml/L)	SS initial (mg/L)	SS 1 hr (mg/L)	SS 24hr (mg/L)	Turb. (NTU)	Turb (NTU) 1 hr	Turb (NTU) 24 hr	% removed SS	% removed NTU	Temp (deg C)	material weight (g)
19	Big Creek 'B' Ash	8.23	553	11	7290	780	50	3595	n/a	n/a	99.31%	n/a	17.2	10.0222
20	"	8.23	548	11	7790	700	420	4172	n/a	n/a	94.61%	n/a	17.0	10.0193
21	"	8.24	549	11	6510	620	50	3518	n/a	n/a	99.23%	n/a	17.0	10.0817
22	"	8.24	544	11	7320	720	160	3441	n/a	n/a	97.81%	n/a	17.1	10.0931
23	"	8.29	544	11	8110	620	80	3719	n/a	n/a	99.01%	n/a	17.0	10.0447
24	sample was damaged				7650	660	530		n/a	n/a	93.07%	n/a		
	average				**7445**	**683**	**215**				**97.11%**	**n/a**		
67	redo of Lab # 19 on10.0228g Ash B (RO water used)	7.64	599	11	7360	770	80	1941	521	50.5	98.91%	97.40%	15.9	10.0228
68	redo of Lab # 20 on 10.0657g Ash B (RO water used)*	7.64	603	12	7740	800	300	2211	433	320.0	96.12%	85.53%	14.9	10.0657
69	redo of Lab # 21 on 10.0508g Ash B (RO water used)	7.67	584	11	7920	840	100	2244	413	46.4	98.74%	97.93%	16.1	10.0508
70	redo of Lab # 22 on 10.0066g Ash B (Tap water used)	8.03	309	10	8150	1060	60	2067	551	27.1	99.26%	98.69%	15.1	10.0066
71	redo of Lab # 23 on 10.0254g Ash B (Tap water used)	8.07	301	10	7480	990	40	2169	602	37.0	99.47%	98.29%	14.3	10.0254
72	redoof Lab # 24 on 10.0983g Ash B (Tap water used)	8.09	296	10	7120	990	150	2121	476	32.2	97.89%	98.48%	13.3	10.0983
	average	**7.86**	**449**	**11**	**7628**	**908**	**122**	**2126**	**499**	**85.5**	**98.40%**	**96.05%**	**14.9**	**10.0449**
	*sample was down to 250ml af ter 24hrs													
67A	Control BC Ash B RAW , 10.0228g	8.49	583	10	5400	790	70	3654	586	31.3	98.70%	99.14%	18.7	10.0228
77	BC Ash B # 60 fraction, 10.0053g	8.00	315	17	440	200	50	272	11	32.1	88.64%	88.20%	19.0	10.0053
78	BC Ash B # 120 fraction, 10.0024g	7.92	313	8.5	420	200	50	210	57	19.1	88.10%	90.90%	19.1	10.0024
79	BC Ash B # 230 fraction, 10.0076g	7.93	304	10	8410	1170	40	3567	696	79	99.52%	97.79%	19.2	10.0076
80	BC Ash B # min 230, 10.0098g	7.86	311	10	9430	1360	60	3990	1463	130	99.36%	96.74%	19.1	10.0098
	average	**8.04**	**365**	**11**	**4820**	**744**	**54**	**2339**	**563**	**58.3**	**94.86%**	**94.55%**	**19.0**	**10.0096**

Table V Jar Tests 1 and 4
BC99-01 Effluent with Varying Concentrations of BC Ash A and B

Lab #	Comments	pH	Cond (uS)	Sett S.(ml/L)	SS Initial (mg/L)	SS 1 hr (mg/L)	SS 24hr (mg/L)	Turb. (NTU)	Turb (NTU) 1 hr	Turb (NTU) 24 hr	% removed SS	% removed NTU	Temp (deg C)	material weight (g)
25	BC 99-01 sed eff CONT ROL for Jar Test #1	7.46	265	18	9200	1120	20	2670	164	24.7	99.78%	99.73%	n/a	n/a
27	JT # 1 1L BC 99-01 sed eff and **0.25g** Ash **A**	7.98	274	17	1150	320	60	1731	281	45.1	94.78%	97.39%	17.7	0.25 g Ash A
28	JT # 1 1L BC 99-01 sed eff and **0.50g** Ash **A**	8.09	273	18	1230	410	100	1899	271	61.6	91.87%	96.76%	17.4	0.50 g Ash A
29	JT # 1 1L BC 99-01 sed eff and **1.0g** Ash **A**	8.15	278	18	1660	450	140	1776	290	59.3	91.57%	96.66%	17.3	1.00 g Ash A
30	JT # 1 1L BC 99-01sed eff and **0.25g** Ash **B**	8.21	279	16	1150	360	40	1677	258	47.9	96.52%	97.14%	17.2	0.25 g Ash B
31	JT # 1 1L BC 99-01sed eff and **0.50g** Ash **B**	8.22	272	15	1260	440	50	1890	322	60.9	96.03%	96.78%	17.2	0.50 g Ash B
32	JT # 1 1L BC 99-01 sed eff and **1.0g** Ash **B**	8.23	271	14	1270	470	70	1743	307	53.2	94.49%	96.95%	17.3	1.00 g Ash B
81	Rerun of JT # 1 - control sample Lab # 25	7.44	289	16	10960	200	60	2847	108	9.88	99.45%	99.65%	19.1	
82	Rerun of JT # 1 - Lab # 27	7.58	306	17	11330	330	50	3262	186	30.5	99.56%	99.06%	18.1	
83	Rerun of JT # 1 - Lab # 28	7.59	303	18	10860	360	70	3542	209	18.1	99.36%	99.49%	17.9	
84	Rerun of JT # 1 - Lab # 29	7.51	305	17	11240	480	30	3959	221	20.8	99.73%	99.47%	17.8	
85	Rerun of JT # 1 - Lab # 30	7.52	309	17	10630	370	20	3293	227	23.2	99.81%	99.30%	17.8	
86	Rerun of JT # 1 - Lab # 31	7.53	301	16	10020	370	50	3241	208	21.3	99.50%	99.34%	17.8	
87	Rerun of JT # 1 - Lab # 32	7.53	299	14	8380	440	140	3274	238	35.4	98.33%	98.92%	17.8	
53	BC 99-01 sed eff CONT ROL for Jar Test # 4	7.53	283	14	10470	420	80	1806	231	109	99.24%	93.96%	18.0	n/a
47	JT # 4 BC 99-01sed eff and **0.2546g Ash A**	7.48	283	13	8760	360	90	1737	298	90.6	98.97%	94.78%	18.8	0.2546g Ash A
48	JT # 4 BC 99-01sed eff and **0.5094g Ash A**	7.81	283	14	10220	460	60	2055	300	64.3	99.41%	96.87%	18.8	0.5094g Ash A
49	JT # 4 BC 99-01 sed eff and **1.0888g Ash A**	7.91	286	15	10190	510	140	1923	296	64.6	98.63%	96.64%	19.0	1.0888g Ash A
50	JT # 4 BC 99-01 sed eff and **0.2595g Ash B**	7.92	281	14	9180	400	210	1818	297	71.4	97.71%	96.07%	19.4	0.2595g Ash B
51	JT # 4 BC 99-01 sed eff and **0.5098g Ash B**	7.97	281	13	9560	480	160	1758	286	61.8	98.33%	96.48%	19.8	0.5098g Ash B
52	JT # 4 BC 99-01 sed eff and **1.0876g Ash B**	8.01	276	13	9960	540	180	1965	343	69.5	98.19%	96.46%	19.9	1.0876g Ash B
119	rerun of JT # 4 - Lab # 53	7.34	299	14	10830	90	30	1716	76.1	16.5	99.72%	99.04%	20.0	
113	rerun of JT # 4 - Lab # 47	7.08	305	14	7920	110	110	1905	121	53.9	98.61%	97.17%	19.8	
114	rerun of JT # 4 - Lab # 48	7.22	304	14	7390	140	60	1806	164	19.4	99.19%	98.93%	20.0	
115	rerun of JT # 4 - Lab # 49	7.23	305	15	8980	200	60	1584	60.4	15.8	99.33%	99.00%	20.0	
116	rerun of JT # 4 - Lab # 50	7.28	300	14	8340	110	100	1749	63.3	43.3	98.80%	97.52%	20.0	
117	rerun of JT # 4 - Lab # 51	7.33	303	14	9420	180	50	1518	122	20.3	99.47%	98.66%	19.9	
118	rerun of JT # 4 - Lab # 52	7.36	303	15	9960	260	110	1698	138	17.5	98.90%	98.97%	20.0	

Table VI Jar Tests 2 and 5
BC 99-01 Effluent with concentrations of 1 to 16 g BC Ash A
BC 99-01 Dilute Effluent with concentrations of 1 to 16 g BC Ash A

Lab #	Comments	pH	Cond (uS)	Sett S.(ml/L)	SS initial (mg/L)	SS 1 hr (mg/L)	SS 24hr (mg/L)	Turb. (NTU)	Turb (NTU) 1 hr	Turb (NTU) 24 hr	% removed SS	% removed NTU	Temp (deg C)	material weight (g)
33	1L BC 99-01 sed eff CONTROL for Jar Test #2	7.58	293	17	10930	230	120	2331	174	20.1	98.90%	99.14%	14.5	Control
34	JT # 2 1L BC 99-01sed eff and **1.0758g** Ash A	7.65	290	17	10740	560	0	2172	247	3.5	100.00%	99.84%	15.8	1.0758g Ash A
35	JT #2 1L BC 99-01sed eff and **2.0210g** Ash A	7.92	293	18	11830	560	10	2298	307	3.2	99.92%	99.86%	16.1	2.0210g Ash A
36	JT # 2 1L BC 99-01sed eff and **4.0712g** Ash A	8.00	292	20	14280	1030	40	2883	500	4.8	99.72%	99.83%	16.5	4.0712g Ash A
37	JT # 2 1L BC 99-01 sed eff and **6.0348g** Ash A	8.07	290	22	15080	1150	30	3345	599	9.3	99.80%	99.72%	16.8	6.0348g Ash A
38	JT # 2 1L BC 99-01 sed eff and **8.0182g** Ash A	8.11	291	21	14390	1320	60	3546	752	11.0	99.58%	99.69%	17.1	8.0182g Ash A
39	JT # 2 1L BC 99-01 sed eff and **16.0372g** Ash A	8.10	287	26	17130	2220	20	5643	1579	14.8	99.88%	99.74%	16.7	16.0372g Ash A
88	Rerun of JT # 2 - Lab # 33	7.25	309	17	11800	440	0	3424	183	18.8	100.00%	99.45%	20.5	
89	Rerun of JT # 2 - Lab # 34	7.47	317	18	12190	470	20	3890	244	20.2	99.84%	99.48%	19.9	
90	Rerun of JT # 2 - Lab # 35	7.44	319	19	11880	570	20	3906	266	24.6	99.83%	99.37%	19.9	
91	Rerun of JT # 2 - Lab # 36	7.49	316	20	13900	730	40	3231	379	25.4	99.71%	99.21%	19.9	
92	Rerun of JT # 2 - Lab # 37	7.49	323	22	16510	1070	90	4011	514	24.0	99.45%	99.40%	19.8	
93	Rerun of JT # 2 - Lab # 38	7.50	324	21	14110	1440	50	3546	781	26.1	99.65%	99.26%	19.9	
94	Rerun of JT # 2 - Lab # 39	7.45	315	26	16920	2690	80	6936	1886	36.6	99.53%	99.47%	19.9	

Lab #	Comments	pH	Cond (uS)	Sett S.(ml/L)	SS initial (mg/L)	SS 1 hr (mg/L)	SS 24hr (mg/L)	Turb. (NTU)	Turb (NTU) 1 hr	Turb (NTU) 24 hr	% removed SS	% removed NTU	Temp (deg C)	material weight (g)
54	BC 99-01 DILUTE sed eff CONTROL for Jar Test # 5	8.12	283	4.5	2910	240	90	569	99	26.2	96.91%	95.40%	19.7	Control
55	JT # 5 BC 99-01 dilute and **1.0328g** Ash A	8.16	289	5	3690	490	110	802	138	39.0	97.02%	95.14%	19.3	1.0328g ash A
56	JT # 5 BC 99-01 dilute and **2.0379g Ash A**	8.28	289	6	4500	500	90	1096	203	28.0	98.00%	97.45%	19.1	2.0379g Ash A
57	JT # 5 BC 99-01 dilute and **4.0379g Ash A**	8.27	291	7.5	4520	570	90	1995	246	38.6	98.01%	98.07%	19.2	4.0379g Ash A
58	JT # 5 BC 99-01 dilute and **6.0119g Ash A**	8.24	292	10	7950	1000	100	2665	317	40.8	98.74%	98.47%	19.1	6.0119g Ash A
59	JT # 5 BC 99-01 dilute and **8.0845g Ash A**	8.19	292	12	9660	1130	160	3449	401	38.2	98.34%	98.89%	19.1	8.0845g Ash A
60	JT # 5 BC 99-01 dilute and **16.0932g Ash A**	8.10	292	19	15980	1380	100	5595	920	44.2	99.37%	99.21%	19.2	16.0932g Ash A
120	rerun of JT # 5 - Lab # 54	7.72	304	4.5	2370	73	10	535	51.3	5.7	99.58%	98.93%	20.1	
121	Rerun of JT # 5 - Lab # 55	7.71	311	5.5	2660	120	17	761	70.4	8.6	99.37%	98.87%	19.9	
122	Rerun of JT # 5 - Lab # 56	7.84	309	7	3330	117	13	977	61.2	9.1	99.60%	99.07%	19.8	
123	Rerun of JT # 5 - Lab # 57	7.72	309	8.5	4610	240	27	1878	147	17.3	99.42%	99.08%	19.8	
124	Rerun of JT # 5 - Lab # 58	7.61	315	10	3560	343	37	3035	224	20.1	98.97%	99.34%	19.7	
125	Rerun of JT # 5 - Lab # 59	7.65	306	12	5480	433	40	3938	269	24.3	99.27%	99.38%	19.7	
126	Rerun of JT # 5 - Lab # 60	7.75	306	20	12000	757	40	6603	606	27.3	99.67%	99.59%	19.7	

Table VII Jar Test 3
BC 99-1 Effluent with concentrations of 1 to 8 g of BC Ash A

Lab #	Comments	pH	Cond (uS)	Sett S.(ml/L)	SS Initial (mg/L)	SS 1 hr (mg/L)	SS 24hr (mg/L)	Turb. (NTU)	Turb (NTU) 1 hr	Turb (NTU) 24 hr	% removed SS	% removed NTU	Temp (deg C)	material weight (g)
40	BC 99-1 sed eff CONTROL for Jar Test # 3	8.26	332	8.5	9250	1080	240	2988	1419	266	97.41%	91.10%	16.1	Control
41	JT # 3 1L BC 99-1 sed eff and **1.0817g** Ash A	8.36	345	10	9230	1230	220	3252	1332	269	97.62%	91.73%	15.9	1.0817g Ash A
42	JT # 3 1L BC 99-1 sed eff and **2.0391g** Ash A	8.33	349	11	10740	1490	150	3873	1566	227	98.60%	94.14%	15.9	2.0391g Ash A
43	JT # 3 1L BC 99-1 sed eff and **4.0951g** Ash A	8.32	351	12	12100	1420	130	4773	1668	245	98.93%	94.87%	n/a	4.0951g Ash A
44	JT # 3 BC 99-1 sed eff and **6.0477g** Ash A	8.25	351	12	11210	1550	60	5598	1482	222	99.46%	96.03%	16.1	6.0477g Ash A
45	JT # 3 BC 99-1 sed eff and **8.0228g** Ash A	8.2	361	12	10230	1700	180	6126	1257	261	98.24%	95.74%	16.2	8.0228g Ash A
46	JT # 3 the sixth concentration was not measured as there was an insufficient amount of BC 99-1 sed eff sample available	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
107	rerun of JT # 3 - Lab # 40	7.85	337	8	9040	1010	80	3687	2021	304	99.12%	91.75%	19.7	
108	rerun of JT # 3 - Lab # 41	7.92	349	9	9000	940	80	4128	2018	190	99.11%	95.40%	19.4	
109	rerun of JT # 3 - Lab # 42	7.99	348	9	11570	940	100	3507	1781	242	99.14%	93.10%	19.2	
110	rerun of JT # 3 - Lab # 43	7.97	350	13	12180	1230	70	5655	3076	228	99.43%	95.97%	19.1	
111	rerun of JT # 3 - Lab # 44	7.97	353	11	10690	1510	60	6204	2998	192	99.44%	96.91%	19.1	
112	rerun of JT # 3 - Lab # 45 * note sample 46 not included	7.97	359	12	11070	1500	70	5811	3116	174	99.37%	97.01%	19.1	

BC 99-1 6 g/L Ash A - added varying concentrations of sediment

95	Big Creek 99-1 CONTROL approx 5.0g/L sediment	7.9	303	4.5	3713	1210	63.33	2325	853	196	98.29%	91.57%	17.6
96	BC 99-1 w/ 6.0g/L Ash A	7.7	305	10	9730	840	40.00	5103	1531	177	99.59%	96.53%	17.6
97	BC 99-1 CONTROL approx 10.0g/L sediment	7.9	306	9	10220	780	56.67	3891	1889	223	99.45%	94.27%	17.7
98	BC 99-1 w/ 6.0g/L Ash A	7.8	314	15	14140	990	66.67	8385	1969	236	99.53%	97.19%	17.7
99	BC 99-1 CONTROL approx 15.0g/L sediment	7.9	314	11	15190	850	53.33	9069	3022	232	99.65%	97.44%	17.7
100	BC 99-1 w/ 6.0g/L Ash A	7.8	318	18	21690	1010	43.33	8880	2975	215	99.80%	97.58%	17.7
101	BC 99-1 CONTROL approx 20.0g/L sediment	7.9	313	13	13500	1010	86.67	6915	3446	264	99.36%	96.18%	17.8
102	BC 99-1 w/ 6.0g/L Ash A	7.8	322	20	14970	1250	80.00	13047	4270	242	99.47%	98.15%	17.6
103	BC 99-1 CONTROL approx 25.0g/L sediment	7.8	320	15	12370	1070	60.00	8415	4308	273	99.51%	96.76%	17.7
104	BC 99-1 w/ 6.0g/L Ash A	7.8	326	21	19960	1290	86.67	6348	4077	268	99.57%	95.78%	17.7
105	BC 99-1 CONTROL approx 30.0g/L sediment	7.8	317	14	14470	1460	3.33	4296	2121	188	99.98%	95.62%	17.7
106	BC 99-1 w/ 6.0g/L Ash A	7.7	326	24	21800	1080	46.67	7992	2076	211	99.79%	97.36%	17.8