APPENDIX S

ACID ROCK DRAINAGE POTENTIAL MEMO

POTENTIAL FOR ACID ROCK GENERATION – REVIEW OF WATER CHEMISTRY DATA

1.0 CONCLUSIONS

1. Water samples, collected from an existing mine pit and wells into the area to be mined, were alkaline and indicated minimal to no generation of acid rock drainage within the rock matrix. The samples also indicated the presence of readily soluble alkalinity within the rock matrix which very effectively neutralizes any generated acidity. This conclusion, based on an assessment of field water chemistry data, is consistent with the results of the acid/base accounting tests and the ongoing humidity cell test program.

2. The water chemistry data support the conclusion that future mining activity at the Moose River site has limited potential for the generation of acid rock drainage.

2.0 BACKGROUND

A review of the results of the static and humidity cell test results, given in the registration document and in the June 29, 2007 Golder Associated report, indicate little to no generation or potential for generation of acid mine drainage at this site. To supplement such evidence, the ground and surface water data from the mine areas (ore and waste rock) were reviewed to determine the generated acidity (if any), due to sulphide oxidation, and the residual acidity as a consequence of any neutralizing processes within the rock (referred to as *in situ* neutralization).

3.0 PIT WATER CHEMISTRY

Analytical data are available for water samples collected from an onsite pit, August 15, 2006 and January 25, 2007. Water in the pit apparently originates as surface drainage in contact with mined material and as groundwater which enters the pit.

The sample collected in August 2006 is alkaline (pH 7.92) as a consequence of the dissolution of carbonate alkalinity into the water. The presence of sulphate (28 mg/L) may be the result of secondary mineral dissolution and/or a low level of sulphide oxidation within the rock. The sample contained at least traces of aluminum (18 ug/L), arsenic (32 µg/L), manganese (16 µg/L), and zinc (7 µg/L). Iron was "not detected", due most likely to the relatively elevated pH of the sample. At this pH, any iron would be oxidized and precipitated as ferric hydroxide.

The pit water sample collected in January 2007 was slightly acidic (pH 6.46), due most likely to the inflow of surface runoff (snowmelt, bog drainage type water, and/or rainfall). Unlike the sample collected in 2006, this sample was turbid (13 NTU) and the reported "total metals" analyses would reflect elements extracted from the colloidal material by acid preservation of the samples prior to analysis, hence the very elevated levels of trace elements compared to the results for the sample collected in 2006 (aluminum: 453 µg/L;

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arsenic: 21.4 µg/L; chromium: 128 µg/L; iron: 1100 µg/L; manganese: 103 µg/L; zinc: 21.9 µg/L).

The sample collected in August 2006 had low turbidity, resulting in an acceptable cation/anion balance for water chemistry assessment and modeling purposes. Assessment of this sample indicates that in excess of 99.5% of the acidity, generated due to sulphide oxidation, is neutralized in situ. The second sample (collected in January 2007) could not be examined in a similar manner due to lack of a cation/anion balance, no doubt due to the turbidity of the sample (13 NTU).

4.0 GROUNDWATER CHEMISTRY

Groundwater samples were collected from within the proposed pit area (the WB1, WB2, WB3, WB4, WB7, and WB8 series). The water chemistry data indicate the groundwater is alkaline (range of pH is 7.01 to 8.08) and low in sulphate concentrations (ND to 19 mg/L), consistent with both a low level, if any, of acid generation and the presence of readily soluble alkalinity.

The groundwater samples were very turbid (23 to 130 NTU); hence the "total metals" concentrations reflect elements extracted from the colloidal material by acid preservation of the samples prior to analysis. Dissolved concentrations would be expected to be at lower concentrations.

5.0 SURFACE WATER CHEMISTRY

The water chemistry of surface water samples (the SW, SL, and LC series referred to in the registration report) is consistent with the influence of low-land runoff, snowmelt and/or rainfall. The water chemistry does not indicate dissolution of hard rock minerals from contact with groundwater or contact with mineralized surface water. The water is coloured and contains measurable total organic carbon, due most likely to humic and tannic acids from bog type drainage; low in turbidity; very low in total dissolved solids, including sulphate, and slightly acidic (pH range is 4.95 to 5.59 for samples collected in May 2007).

The surface water samples contained the commonly detected elements: aluminum, iron, and manganese, in addition to traces of arsenic, cadmium, chromium, and zinc. Each of these trace elements was at concentrations within the range of their levels in Canadian surface waters.

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APPENDIX T

ENGINEERED WETLANDS INFORMATION

Engineered Wetlands - Background

Engineered wetlands are manmade wetlands which have been designed to utilize various aspects of wetland functioning, particularly nutrient and contaminant removal. They are a cost-effective, environmentally friendly means of treating wastewater, and are becoming more widely used in Canada (Mayer and Kennedy 2002). Constructed wetlands can be used to treat wastewater from many sources, and are most commonly used to provide additional treatment of wastewater from homes and businesses, which has already been screened to remove solids. Individual sources of wastewater often add a constructed wetland to supplement an existing septic system or field. Constructed wetlands work well in systems with seasonally fluctuating flows, and are often used with wastewater treatment systems that serve hotels, campsites, resorts and recreational areas. In environmentally sensitive areas, constructed wetlands can be used with onsite systems to improve the quality of the effluent before it is released to the environment. Constructed wetlands are an inexpensive way to provide wastewater treatment and can be configured to treat a variety of effluent types, such as farm wastewater, landfill leachate, mining effluent, pulp and paper mill effluent, stormwater and sewage (Mitsch and Gosselink 1986, Mayer and Kennedy 2002, Vymazal 2005).

In constructed wetlands, as in natural wetlands, aerobic and anaerobic bacterial action provides the majority of wastewater treatment (Mitsch and Gosselink 1986). Beneficial bacteria decompose waste material in the wetlands, and convert it to decomposition products such as methane and carbon dioxide. They also convert some nutrients, such as nitrogen compounds, into forms usable by plants (Mitsch and Gosselink 1986). Constructed wetlands are effective at reducing loads of biological and chemical oxygen demand (BOD and COD), nitrogen and phosphorus (Fisher and Acreman 2004), and suspended solids, often to over 90%. They can also be effective at removing heavy metals (Cheng *et al.* 2002).

Wetlands are often designed as a series of linked ponds, or cells, each of which may serve a different purpose in water treatment. Once the desired level of a specific contaminant has been reached in a cell, the wastewater is transferred to the next cell where it may be treated for another contaminant before being released. In order for any of the processes in wetlands to work, the wastewater must remain in the system long enough for treatment to occur and for viruses in the wastewater to die-off naturally. Since they rely on biological activities by microbes, wetland treatment processes tend to speed up in warm weather and slow down in cold weather. Thus wetlands in cooler areas usually must be larger than those in warmer areas, due to the longer treatment time required.

Depending on size and type, constructed wetlands are usually inexpensive to build and operate but usually cost less than physical or chemical treatment facilities (Mitsch and Gosselink 1986). They can, however, require more land to construct. There are two main types of constructed wetlands, which differ in water flow patterns. These are discussed in the following paragraphs.

Surface Flow Wetlands

The first type is known as surface flow wetlands, sometimes called free water surface or open water surface wetlands. This type involves free water flow throughout the wetland and is equivalent to a natural marsh, both in appearance and the way water treatment occurs. As such, surface flow wetlands provide more natural wildlife habitat than do other types of constructed wetlands. The wetland plants filter wastes, regulate flow and provide surface area for bacterial activity. Once water enters a surface flow wetland cell, suspended matter in the water column begins to settle out due to the decreased flow speeds caused by plants. Submerged plants such as cattails and floating plants such as water lilies and duckweed also absorb nutrients and oxygenate the water. They also shade the water's surface and control algae growth. Plants also absorb nutrients, metals, and other substances, some of which can accumulate in their tissues (Jain *et al.* 1989). These substances may then be released when the plants decompose. For this reason, harvesting of plant materials before they decompose is often recommended for surface flow wetlands.

Subsurface Flow Wetlands

The second type of constructed wetlands are known as subsurface flow wetlands, and may also be referred to as horizontal subsurface flow, vegetated submerged bed, root-zone or rock-reed wetlands. Wastewater to be treated flows horizontally through the gravel bed, and thus is not exposed to the atmosphere. The saturated gravel and plant roots create optimal conditions for wastewater treatment. Because the wastewater is never exposed, odours are usually not a problem, and subsurface flow wetlands are often used for residential sewage treatment projects.

CRA INNOVATIVE TECHNOLOGY GROUP
EXPERIENCE

ENGINEERED WETLANDS

In an effort to develop and use more natural technologies, engineered wetlands have increasingly been established for treatment of municipal and industrial effluents. Engineered wetlands are suitable for low flow, long-term treatment scenarios. Wetlands have been used for the treatment of heavy metals, volatile organic compounds (VOCs), and polycyclic aromatic hydrocarbons (PAHs) in soil and groundwater, and are also used for the removal of biological loads, suspended solids and nutrient loads.

Wetlands provide a cost-effective innovative passive technology for the treatment of a wide range of domestic and industrial effluents. In addition to uses described above they are used for treatment in wastewater polishing processes, , landfill leachate, and stormwaters to attain more stringent water quality objectives and decrease or prevent exceedance of applicable guideline values at the discharge location.

Within the wetland, organic contaminants are captured and subsequently degraded by the wetland microbial populations; metal contaminants can be adsorbed onto the wetland soils or converted to insoluble salts. Wetland ponds also store runoff and rainfall, reduce flooding and soil erosion, and purify water by filtering wastes, sediments, and toxic compounds.

Wetlands are designed with several features each suited for the component requiring treatment. Stages may include deep ponds that include aquatic life, shallow surface flow with biological marsh species, subsurface flow substrates and marsh meadow system with deciduous plantings. Each methodology and selected plantings is targeted for the removal and treatment of different compounds.

The effectiveness of engineered wetland treatment for industrial wastes generally requires a pilot test to set the design parameters for full-scale application. CRA has conducted the following engineered wetlands projects:

Wetland to treat Acid Mine Drainage (AMD)

CRA constructed a pilot wetland using native and aquatic nursery stock Typha plants for the treatment of metals in acid mine drainage. The wetland was constructed at a non-active copper mining site. Drainage from a tributary is diverted to the wetlands via a dam constructed across the tributary. The drainage contains iron, copper, manganese, and other metals and has a typical pH range of 3 to 4. Flow volumes of 200 to 600 gallons per minute (gpm) enter the wetland and are regulated using a butterfly valve. The wetland divided into nine cells constructed of concrete barriers with limestone aggregate, native fill, hay bales, organic strata (mushroom compost), and aquatic plants over a geosynthetic clay liner. Ongoing effluent testing indicate the wetland is effectively reducing both total and dissolved metals while increasing discharge pH as designed for.

A site photo of the completed wetland is shown below:

Mercury Removal Wetland

CRA designed a one-acre pilot engineered wetland for treatment of mercury and chlorinated solvents in groundwater at a chemical manufacturing facility in Alabama. The wetland consists of a shallow water section containing a layer of peat to adsorb and precipitate the mercury followed by three treatment cells that will provide anaerobic and aerobic environments for dechlorination and degradation of the chlorinated compounds. The four units were planted with natural wetland species.

Engineered Pilot Wetland for the treatment of Dilute Waste Streams

CRA recently constructed a pilot wetland system at a manufacturing facility in Illinois for treatment of dilute waste streams including landfill leachate. The pilot test design included three wetland cells; one cell to receive batch loads of sludge, followed by two cells that will be fed with the dilute waste streams via a feed tank and can be run in either series or parallel. Groundwater and landfill leachate at the BP Joliet Works Site in Joliet, Illinois (Site) were characterized by the presence of a relatively low concentration of a range of organic compounds and metals. An anaerobic treatment system (operated by the chemical manufacturing plant) was in use at the Site to successfully treat over 700 gallons per minute (gpm) of plant process wastewaters and dilute wastewaters such as groundwater and landfill leachate. Engineered wetlands have been identified as a cost-effective alternative option, particularly for the treatment of the dilute waste streams at the Site. The use of engineered wetlands can potentially reduce the treatment costs, and enhance the capacity and flexibility of the existing plant-operated wastewater treatment system.

The system consisted of surface and subsurface flow cells designed to operate by gravity flow. The system was designed as a closed loop system. All wastewater treated through the pilot wetland system was routed to and treated through the Site wastewater treatment plant.

Results show the wetlands was effective in reducing the levels of contaminants of concern in the waste streams at this Site. Reductions in volatile and semi-volatile organic compounds and organic acids concentrations to non-detect levels were observed. Nitrate, specific conductivity, salinity, and total dissolved solids (TDS) were also substantially reduced by the wetland treatment.

Treatment of Landfill Leachate

CRA is currently designing a remedial system consisting of a phytoremediation buffer and engineered wetland to treat leachate at a landfill. The main chemicals of concern are benzene, toluene, ethylbenzene and xylenes (BTEX) compounds. A combination of phytoremediation and an engineered wetland treatment system has been identified as a cost-effective alternative option for the treatment. A phytoremediation buffer will serve to intercept groundwater prior to surface water seepage. An engineered wetland will be located downgradient to collect and treat any excessive water seepage. The wetland system will also play a crucial role during the winter months when the effectiveness of the trees has been reduced due to the change in season.

Atlantic Canada Installations

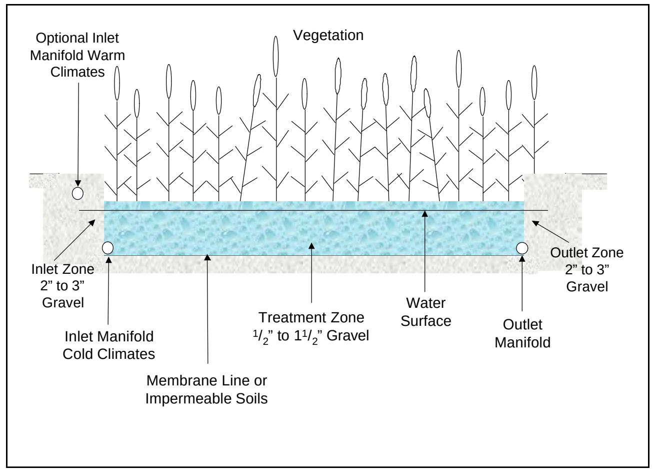
CRA staff has been involved in the concept development, design and construction of several wetland treatment facilities throughout Atlantic Canada. These facilities have been used for treatment of municipal and institutional wastewater, wastewater polishing and sediment and runoff control. Wastewater facilities are presently operating in Chapel Island (PEI) and the Westmoreland Institution (NB) and are being designed for the long term care facility in Corner Brook (NFLD), while a runoff treatment facility has been designed for the Guysborough Regional Landfill.

United States Environmental Protection Agency | Office of Water Washington, D.C. | EPA 832-F-00-023 September 2000

Wastewater Technology Fact Sheet
Wetlands: Subsurface Flow

DESCRIPTION

Wetland systems are typically described in terms of the position of the water surface and/or the type of vegetation grown. Most natural wetlands are free water surface systems where the water surface is exposed to the atmosphere; these include bogs (primary vegetation mosses), swamps (primary vegetation trees), and marshes (primary vegetation grasses and emergent macrophytes). A subsurface flow (SF) wetland is specifically designed for the treatment or polishing of some type of wastewater and are typically constructed as a bed or channel containing appropriate media. An example of a SF wetland is shown in Figure 1. Coarse rock, gravel, sand and other soils have all been used, but a gravel medium is most common in the U.S. and Europe. The medium is typically planted with the same types of emergent vegetation present in marshes, and the water surface is designed to remain below the top surface of the medium. The main advantages of this subsurface water level are prevention of mosquitoes and odors, and elimination of the risk of public contact with the partially treated wastewater. In contrast, the water surface in natural marshes and free water surface (FWS) constructed wetlands is exposed to the atmosphere with the attendant risk of mosquitoes and public access.



Source: Adapted from drawing by S.C. Reed, 2000.

FIGURE 1 SUBSURFACE FLOW WETLAND

The water quality improvements in natural wetlands had been observed by scientists and engineers for many years and this led to the development of constructed wetlands as an attempt to replicate the water quality and the habitat benefits of the natural wetland in a constructed ecosystem. Physical, chemical, and biochemical reactions all contribute to water quality improvement in these wetland systems. The biological reactions are believed due to the activity of microorganisms attached to the available submerged substrate surfaces. In the case of FWS wetlands these substrates are the submerged portion of the living plants, the plant litter, and the benthic soil layer. In SF wetlands the available submerged substrate includes the plant roots growing in the media, and the surfaces of the media themselves. Since the media surface area in a SF wetland can far exceed the available substrate in a FWS wetland, the microbial reaction rates in a SF wetland can be higher than a FWS wetland for most contaminants. As a result, a SF wetland can be smaller than the FWS type for the same flow rate and most effluent water quality goals.

The design goals for SF constructed wetlands are typically an exclusive commitment to treatment functions because wildlife habitat and public recreational opportunities are more limited than FWS wetlands. The size of these systems ranges from small on-site units designed to treat septic tank effluents to a $1.5x10^7$ liters per day (4 MGD) system in Louisiana treating municipal wastewater. There are approximately 100 systems in the U.S. treating municipal wastewater, with the majority of these treating less than $3.8x10^3$ m^3/day (1 MGD). Most of the municipal systems are preceded by facultative or aerated treatment ponds. There are approximately 1,000 small scale on-site type systems in the U.S. treating waste waters from individual homes, schools, apartment complexes, commercial establishments, parks, and other recreational facilities. The flow from these smaller systems ranges from a few hundred gallons per day to 151,400 liters per day (40,000 gallons per day), with septic tanks being the dominant preliminary treatment provided. SF wetlands are not now typically selected for larger flow municipal systems. The higher cost of the rock or gravel media makes a large SF wetland uneconomical compared to a FWS wetland in spite of the smaller SF wetland area required. Cost comparisons have shown that at flow rates above 227,100 liters per day (60,000 gallons per day) it will usually be cheaper to construct a FWS wetland system. However, there are exceptions where public access, mosquito, or wildlife issues justify selection of a SF wetland. One recent example is a SF wetland designed to treat the runoff from the Edmonton Airport in Alberta, Canada. The snow melt runoff is contaminated with glycol de-icing fluid and a SF wetland treating 1,264,190 liters per day (334,000 gallons per day) was selected to minimize habitat values and bird problems adjacent to the airport runways.

SF wetlands typically include one or more shallow basins or channels with a barrier to prevent seepage to sensitive groundwaters. The type of barrier will depend on local conditions. In some cases compaction of the local soils will serve adequately, in other cases clay has been imported or plastic membrane (PVC or HDPE) liners used. Appropriate inlet and outlet structures are employed to insure uniform distribution and collection of the applied wastewater. A perforated manifold pipe is most commonly used in the smaller systems. The depth of the media in these SF wetlands has ranged from 0.3 to 0.9 meters (1 to 3 feet) with 0.6 meters (2 feet) being most common. The size of the media in use in the U.S. ranges from fine gravel (≥0.6 centimeters or ≥ 0.25 in.) to large crushed rock (≥15.2 centimeters or ≥6 in.); A combination of sizes from 1.3 centimeters to 3.8 centimeters (0.5 to 1.5 inches) are most typically used. This gravel medium should be clean, hard, durable stone capable of retaining it's shape and the permeability of the wetland bed over the long term.

The most commonly used emergent vegetation in SF wetlands include cattail (*Typha* spp.), bulrush (*Scirpus* spp.), and reeds (*Phragmites* spp.). In Europe, *Phragmites* are the preferred plants for these systems. *Phragmites* have several advantages since it is a fast growing hardy plant and is not a food source for animals or birds. However, in some parts of the U.S. the use of *Phragmites* is not permitted because it is an aggressive plant and there are concerns that it might infest natural wetlands. In these cases cattails or bulrush can be used. In areas where muskrat or nutria are found, experience has shown that these animals, using the plants for food and nesting material, can completely destroy a stand of cattails or bulrush planted in a constructed wetland. Many of the smaller on-site systems serving individual homes use water tolerant decorative plants. The vegetation on a SF wetland bed is not a major factor in nutrient removal by the system and does not require harvesting. In cold climates, the accumulating plant litter on top of the gravel bed provides useful thermal insulation during the winter months. The submerged plant roots do provide substrate for microbial processes and since most emergent macrophytes can transmit oxygen from the leaves to their roots there are aerobic microsites on the rhizome and root surfaces. The remainder of the submerged environment in the SF wetland tends to be devoid of oxygen. This general lack of available oxygen limits the biological removal of ammonia nitrogen (NH_3/NH_4 - N) via nitrification in these SF wetlands, but the system is still very effective for removal of BOD, TSS, metals, and some priority pollutant organics since their treatment can occur under either aerobic or anoxic conditions. Nitrate removal via biological denitrification can also be very effective since the necessary anoxic conditions are always present and sufficient carbon sources are usually available.

The limited availability of oxygen in these SF systems reduces the capability for ammonia removal via biological nitrification. As a result, a long detention time in a very large wetland area is required to produce low levels of effluent nitrogen with typical municipal wastewater influents unless some system modification is adopted. These modifications have included installation of aeration tubing at the bottom of the bed for mechanical aeration, the use of an integrated gravel trickling filter for nitrification of the wastewater ammonia, and vertical flow wetland beds. These vertical flow beds usually contain gravel or coarse sand and are loaded intermittently at the top surface. The intermittent application and vertical drainage restores aerobic conditions in the bed permitting aerobic reactions to proceed rapidly. Cyclic filling and draining of a horizontal flow system has been successfully demonstrated at the 130,000 gallons per day SF wetland system in Minoa, NY. The reaction rates for BOD_5 and ammonia removal during these cyclic operations were double the rates observed during normal continuously saturated flow.

The phosphorus removal mechanisms available in all types of constructed wetlands also require long detention times to produce low effluent levels of phosphorus with typical municipal wastewater. If significant phosphorus removal is a project requirement then a FWS wetland will probably be the most cost effective type of constructed wetland. Phosphorus removal is also possible with final chemical addition and mixing prior to a final deep settling pond.

The minimal acceptable level of preliminary treatment prior to a SF wetland system is the equivalent of primary treatment. This can be accomplished with septic tanks or Imhoff tanks for smaller systems or deep ponds with a short detention time for larger systems. The majority of existing SF wetland systems treating municipal waste waters are preceded by either facultative or aerated ponds. Such ponds are not necessarily the preferred type of preliminary treatment. At most of these existing systems the SF wetland was selected to improve the water quality of the pond effluent. Since the SF wetland can provide very effective removal for both BOD_5 and TSS, there is no need to provide for high levels of removal of these constituents in preliminary treatments.

The SF wetland does not provide the same level of habitat value as the FWS wetland because the water in the system is not exposed and accessible to birds and animals. However, wildlife will still be present, primarily in the form of nesting animals, birds, and reptiles. If provision of more significant habitat values is a project goal it can be accomplished with deep ponds interspersed between the SF wetland cells. The first pond in such a system would be located after the point where water quality is approaching at least the secondary level

APPLICABILITY

SF wetland systems are best suited for small to moderate sized applications (≤ 227,100 liters/day or ≤60,000 gallons per day) and at larger systems where the risk of public contact, mosquitoes, or potential odors are major concerns. Their use for on-site systems provides a high quality effluent for in-ground disposal, and in some States a significant reduction in the final disposal field area is allowed. SF wetlands will reliably remove BOD, COD, and TSS, and with sufficiently long detention times can also produce low levels of nitrogen and phosphorus. Metals are removed effectively and about a one log reduction in fecal coliforms can be expected in systems designed to produce secondary or advanced secondary effluents.

ADVANTAGES AND DISADVANTAGES

Some advantages and disadvantages of subsurface flow wetlands are listed below.

Advantages

- SF wetlands provide effective treatment in a passive manner and minimize mechanical equipment, energy, and skilled operator attention.

- SF wetlands can be less expensive to construct and are usually less expensive to operate and maintain as compared to mechanical treatment processes designed to produce the same effluent quality.

- Year-round operation for secondary treatment is possible in all but the coldest climates.

- Year-round operation for advanced or tertiary treatment is possible in warm to moderately temperate climates. The SF wetland configuration provides more thermal protection than the FWS wetland type.

- SF wetland systems produce no residual biosolids or sludges requiring subsequent treatment and disposal.

- The SF wetland is very effective and reliable for removal of BOD, COD, TSS, metals, and some persistant organics in municipal wastewaters. The removal of nitrogen and phosphorus to low levels is also possible but requires a much longer detention time.

- Mosquitoes and similar insect vectors are not a problem with SF wetlands as long as the system is properly operated and a subsurface water level maintained. The risk of contact by children and pets with partially treated wastewater is also eliminated.

Disadvantages

- A SF wetland will require a large land area compared to conventional mechanical treatment processes.

- The removal of BOD, COD, and nitrogen in SF wetlands are continuously renewable processes. The phosphorus, metals, and some persistent organics removed in the system are bound in the wetland sediments and accumulate over time.

- In cold climates the low winter water temperatures reduce the rate of removal for BOD, NH_3, and NO_3. An increased detention time can compensate for these reduced rates but the increased wetland size in extremely cold climates may not be cost effective or technically possible.

- Most of the water contained in the SF wetland is anoxic and this limits the potential for nitrification of wastewater ammonia. Increasing the wetland size and detention time will compensate, but this may not be cost effective. Alternative methods for nitrification in combination with a SF wetland have been successful. SF wetlands cannot be designed for complete removal of organic compounds, TSS, nitrogen, and coliforms. The natural ecological cycles in these wetlands produce "background" concentrations of these substances in the system effluent.

- SF wetland systems can typically remove fecal coliforms by at least one log. This is not always sufficient to meet discharge limits in all locations and post disinfection may be required. UV disinfection has been successfully used in a number of applications.

- Although SF wetlands can be smaller than FWS wetlands for the removal of most constituents, the high cost of the gravel media in the SF wetland can result in higher construction costs for SF systems larger than about 227,100 liters per day (60,000 gallons per day).

DESIGN CRITERIA

Published models for the design of SF wetland systems have been available since the late 1980's. More recent efforts in the mid to late 1990's have produced three text books containing design models for SF wetlands (Reed, et al 1995, Kadlec & Knight 1996, Crites & Tchobanoglous, 1998). In all three cases, the models are based on first order plug flow kinetics, but results do not always agree due to the author's developmental choices and because the same databases were not used for derivation of the models. The Water Environment Federation (WEF) presents a comparison of the three approaches in their Manual of Practice on Natural Systems (WEF, 2000) as does the US EPA design manual on wetland systems (EPA, 2000). The designer of a SF wetland system should consult these references and select the method best suited for the project under consideration. A preliminary estimate of the land area required for a SF wetland can be obtained from Table 1 of typical areal loading rates. These values can also be used to check the results from the previously cited references.

The SF wetland size is determined by the pollutant which requires the largest land area for it's removal. This is the bottom surface area of the wetland cells and, for that area to be 100 percent effective, the wastewater flow must be uniformly distributed over the entire surface. This is possible with constructed wetlands by careful grading of the bottom surface and use of appropriate inlet and outlet structures. The total treatment area should be divided into at least two cells for all but the smallest systems. Larger systems should have at least two parallel trains of cells to provide flexibility for management and maintenance.

These wetland systems are living ecosystems and the life and death cycles of the biota produce residuals which can be measured as BOD, TSS, nitrogen, phosphorus and fecal coliforms. As a result, regardless of the size of the wetland or the characteristics of the influent, in these systems there will always be a residual background concentration of these materials. Table 2 summarizes these background concentrations.

It is necessary for the designer to determine the water temperature in the wetland because the removal of BOD, and the various nitrogen forms are temperature dependent. The water temperature in large systems with a long HRT (>10 days) will approach the average air temperature except during subfreezing weather in the winter. Methods for estimating the water temperature for wetlands with a shorter HRT (<10 days) can be found in the published references mentioned previously.

It is also necessary to consider the hydraulic aspects of system design because there is significant frictional resistance to flow through the wetland caused by the presence of the gravel media and the plant roots and other detritus. The major impact of this flow resistance is on the configuration selected for the wetland cell. The longer the flow path the higher the resistance will be. To avoid these hydraulic problems an aspect ratio (L:W) of 4:1 or less is recommended. Darcy's law is generally accepted as the model for the flow of water through SF wetlands and descriptive information can again be found in the published references mentioned previously. The flow of water through the wetland cell depends on the hydraulic gradient in the cell and on the hydraulic conductivity (k_s), size, and porosity (n) of the media used. Table 3 presents typical characteristics for potential SF wetland media. These values can be used for a preliminary estimate and for design of very small systems. For large scale systems the proposed media should be tested to determine these values.

TABLE 1 TYPICAL AREAL LOADING RATES FOR SF CONSTRUCTED WETLANDS

Constituent	Typical Influent Concentration mg/L	Target Effluent Concentration mg/L	Mass Loading Rate lb/ac/d*
Hydraulic Load (in./d)	3 to 12**		
BOD	30 to175	10 to 30	60 to 140
TSS	30 to150	10 to 30	40 to 150
NH_3/NH_4 as N	2 to 35	1 to 10	1 to 10
NO_3 as N	2 to 10	1 to 10	3 to 12
TN	2 to 40	1 to 10	3 to 11
TP	1 to 10	0.5 to 3	1 to 4

Note: Wetland water temperature » 20°C.

TABLE 2 "BACKGROUND" SF WETLAND CONCENTRATIONS

Constituent	Units	Concentration Range
BOD_5	mg/L	1 to 10
TSS	mg/L	1 to 6
TN	mg/L	1 to 3
NH_3/NH_4 as N	mg/L	less than 0.1
NO_3 as N	mg/L	less than 0.1
TP	mg/L	less than 0.2
Fecal Coliforms	MPN/100ml	50 to 500

Source: Reed et al., 1995 and U.S. EPA, 1993.

PERFORMANCE

A lightly loaded SF wetland can achieve the "background" effluent levels given in Table 2. In the general case, the SF constructed wetland is typically designed to produce a specified effluent quality and Table 1 can be used for a preliminary estimate of the size of the wetland necessary to produce the desired effluent quality. The design models in the referenced publications will provide a more precise estimate of treatment area required. Table 4 summarizes actual performance data for 14 SF wetland systems included in a US EPA Technology Assessment (EPA, 1993).

In theory, the performance of a SF wetland system can be influenced by hydrological factors. High evapotranspiration (ET) rates may increase effluent concentrations, but this also increases the HRT in the wetland. High precipitation rates dilute the pollutant concentrations but also shorten the HRT in the wetland. In most temperate areas with a moderate climate these influences are not critical for performance. These hydrological aspects need only be considered for extreme values of ET and precipitation.

OPERATION AND MAINTENANCE

The routine operation and maintenance (O&M) requirements for SF wetlands are similar to those for facultative lagoons, and include hydraulic and water depth control, inlet/outlet structure cleaning, grass mowing on berms, inspection of berm integrity, wetland vegetation management, and routine monitoring.

The water depth in the wetland may need periodic adjustment on a seasonal basis or in response to increased resistance over a very long term from the accumulating detritus in the media pore spaces. Mosquito control should not be required for a SF wetland system as long as the water level is maintained below the top of the media surface. Vegetation management in these SF wetlands does not include a routine harvest and removal of the

TABLE 3 TYPICAL MEDIA CHARACTERISTICS FOR SF WETLANDS

Media Type	Effective Size D_{10} (mm)*	Porosity, n (%)	Hydraulic Conductivity k_s ($ft^3/ft^2/d$)*
Coarse Sand	2	28 to 32	300 to 3,000
Gravelly Sand	8	30 to 35	1,600 to 16,000
Fine Gravel	16	35 to 38	3,000 to 32,000
Medium Gravel	32	36 to 40	32,000 to 160,000
Coarse Rock	128	38 to 45	16×10^4 to 82×10^4

* mm x 0.03937 = inches
** $ft^3/ft^2/d \times 0.3047 = m^3/m^2/d$, or x 7.48 = $gal/ft^2/d$

Source: Reed et al., 1995.

TABLE 4 SUMMARY OF PERFORMANCE FOR 14 SF WETLAND SYSTEMS*

Constituent	Mean Influent mg/L	Mean Effluent mg/L
BOD_5	28** (5-51)***	8** (1-15)***
TSS	60 (23-118)	10 (3-23)
TKN as N	15 (5-22)	9 (2-18)
NH_3/NH_4 as N	5 (1-10)	5 (2-10)
NO_3 as N	9 (1-18)	3 (0.1-13)
TN	20 (9-48)	9 (7-12)
TP	4 (2-6)	2 (0.2-3)
Fecal Coliforms (#/100ml)	270,000 (1,200-1,380,000)	57,000 (10-330,000)

* Mean detention time 3 d (range 1 to 5 d).
** Mean value.
*** Range of values.

Source: U.S. EPA, 1993.

harvested material. Plant uptake of pollutants represents a relatively minor pathway so harvest and removal on a routine basis does not provide a significant treatment benefit. Removal of accumulated litter is unnecessary, and in cold climates it serves as thermal insulation to prevent freezing in the wetland bed. Vegetation management may also require wildlife management, depending on the type of vegetation selected for the system, and the position of the water. Animals such as nutria and muskrats have been known to consume all of the emergent vegetation in constructed wetlands. These animals should not be attracted to a SF wetland as long as the water level is properly maintained. Routine water quality monitoring will be required for all SF systems with an NPDES permit, and the permit will specify the pollutants and frequency. Sampling for NPDES monitoring is usually limited to the untreated wastewater and the final system effluent. Since the wetland component is usually preceded by some form of preliminary treatment, the NPDES monitoring program does not document wetland influent characteristics. It is recommended, in all but the smallest systems that periodic samples of the wetland influent be obtained and tested for operational purposes in addition to the NPDES requirements. This will allow the operator a better understanding of wetland performance and provide a basis for adjustments if necessary.

COSTS

The major items included in the capital costs for SF wetlands are similar to many of those required for lagoon systems. These include land costs, site investigation, site clearing, earthwork, liner, gravel media, plants, inlet and outlet structures, fencing, miscellaneous piping, etc., engineering, legal, contingencies , and contractor's overhead and profit. The gravel media and the liner can be the most expensive items from this list. In the Gulf States where clay soils often eliminate the need for a liner the cost of imported gravel can often represent 50 percent of the construction costs. In other locations where local gravel is available but a membrane liner is required the liner costs can approach 40 percent of the construction costs. In many cases compaction of the in-situ native soils provides a sufficient barrier for groundwater contamination. Table 5 provides a summary of capital and O & M costs for a hypothetical 378,500 liters/day (100,000 gallons per day) SF constructed wetland, required to achieve a 2 mg/L ammonia concentration in the effluent. Other calculation assumptions are as follows: influent NH_3= 25 mg/L, water temperature 20°C (68°F), media depth = 0.6 meters (2 ft), porosity = 0.4, treatment area = 1.3 hectares (3.2 ac), land cost =$12,355/hectare ($5,000/ac).

TABLE 5 CAPITAL AND O&M COSTS FOR 100,000 GALLONS PER DAY SF WETLAND

Item	Cost $*	
	Native Soil Liner	Plastic Membrane Liner
Land Cost	$16,000	16,000
Site Investigation	3,600	3,600
Site Clearing	6,600	6,600
Earthwork	33,000	33,000
Liner	0	66,000
Gravel Media**	142,100	142,100
Plants	5,000	5,000
Planting	6,600	6,600
Inlets/Outlets	16,600	16,600
Subtotal	$229,500	$295,500
Engineering, legal, etc.	$133,000	$171,200
Total Capital Cost	**$362,500**	**$466,700**
O & M Costs, $/yr	$6,000/yr	$6,000/yr

* June 1999 costs, ENR CCI = 6039
**12,000 cy of 0.75 in. gravel

TABLE 6 COST COMPARISON SF WETLAND AND CONVENTIONAL WASTEWATER TREATMENT

Cost Item	Process	
	Wetland	SBR
Capital Cost	$466,700	$1,104,500
O &M Cost	$6,000/yr	$106,600/yr
Total Present Worth Costs*	$530,300	$2,233,400
Cost per 1000 gallons treated**	$0.73	$3.06

*Present worth factor 10.594 based on 20 years at 7 percent interest (June 1999 costs, ENR CCI = 6039).
**Daily flow rate for 365 d/yr, for 20 yr, divided by 1000 gallons

Source: WEF, 2000.

Table 6 compares the life cycle costs for this wetland to the cost for a conventional treatment system designed for the same flow and effluent water quality. The conventional process is a sequencing batch reactor (SBR).

REFERENCES

Other Related Fact Sheets

Free Water Surface Wetlands
EPA 832-F-00-024
September, 2000

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Constructed Treatment Wetlands

Natural wetland systems have often been described as the "earth's kidneys" because they filter pollutants from water that flows through on its way to receiving lakes, streams and oceans. Because these systems can improve water quality, engineers and scientists construct systems that replicate the functions of natural wetlands. Constructed wetlands are treatment systems that use natural processes involving wetland vegetation, soils, and their associated microbial assemblages to improve water quality.

How do treatment wetlands work?

Natural wetlands perform many functions that are beneficial to both humans and wildlife. One of their most important functions is water filtration. As water flows through a wetland, it slows down and many of the suspended solids become trapped by vegetation and settle out. Other pollutants are transformed to less soluble forms taken up by plants or become inactive. Wetland plants also foster the necessary conditions for microorganisms to live there. Through a series of complex processes, these microrganisms also transform and remove pollutants from the water.

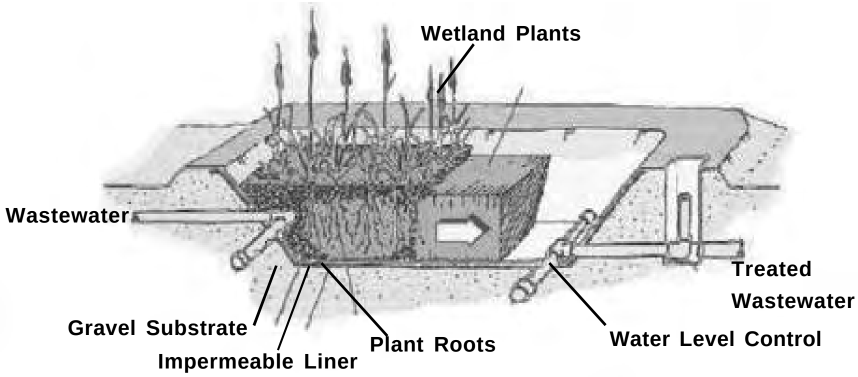
Nutrients, such as nitrogen and phosphorous, are deposited into wetlands from stormwater runoff, from areas where fertilizers or manure have been applied and from leaking septic fields. These excess nutrients are often absorbed by wetland soils and taken up by plants and microorganisms. For example, wetland microbes can convert organic nitrogen into useable, inorganic forms (NO_3 and NH_4) that are necessary for plant growth and into gasses that escape to the atmosphere.

Why build them?

Wetlands are some of the most biologically diverse and productive natural ecosystems in the world. While not all constructed wetlands replicate natural ones, it makes sense to construct wetlands that improve water quality and support wildlife habitat. Constructed wetlands can also be a cost-effective and technically feasible approach to treating wastewater. Wetlands are often less expensive to build than traditional wastewater treatment options, have low operating and maintenance expenses and can handle fluctuating water levels. Additionally, they are aesthetically pleasing and can reduce or eliminate odors associated with wastewater.

A Popular Idea

Designing and building wetlands to treat wastewater is not a new concept. As many as 5,000 constructed wetlands have been built in Europe and about 1,000 are currently in operation in the United States. Constructed treatment wetlands, in some cases involving the maintenance of important wetland habitat, have become particularly popular in the Southwest, where the arid climate makes the wetland habitat supported by these projects an especially precious resource.



Wetland plants and associated microorganisms treat wastewater as it flows through a constructed wetland system.

How are they built?

Constructed wetlands are generally built on uplands and outside floodplains or floodways in order to avoid damage to natural wetlands and other aquatic resources. Wetlands are frequently constructed by excavating, backfilling, grading, diking and installing water control structures to establish desired hydraulic flow patterns. If the site has highly permeable soils, an impervious, compacted clay liner is usually installed and the original soil placed over the liner. Wetland vegetation is then planted or allowed to establish naturally.

Design and Planning Considerations:

If planned and maintained properly, treatment wetlands can provide wastewater treatment and also promote water reuse, wildlife habitat, and public use benefits. Potentially harmful environmental impacts, such as the alteration of natural hydrology, introduction of invasive species and the disruption of natural plant and animal communities can be avoided by following proper planning, design, construction and operating techniques. The following guidelines can help ensure a successful project:

- Construct treatment wetlands, as a rule, on uplands and outside floodplains in order to avoid damage to natural wetlands and other aquatic resources, unless pretreated effluent can be used to restore degraded systems.
- Consider the role of treatment wetlands within the watershed (e.g., potential water quality impacts, surrounding land uses and relation to local wildlife corridors).
- Closely examine site-specific factors, such as soil suitability, hydrology, vegetation, and presence of endangered species or critical habitat, when determining an appropriate location for the project in order to avoid unintended consequences, such as bioaccumulation or destruction of critical habitat.
- Use water control measures that will allow easy response to changes in water quantity, quality, depth and flow.
- Create and follow a long-term management plan that includes regular inspections, monitoring and maintenance.

USDA, Natural Resources Conservation Service

This hog operation in Taylor County, Iowa, uses a wetland system constructed on a series of hillside terraces to filter and purify wastewater. Water quality tests indicated that the effluent from the treatment wetland was cleaner than that required for wastewater treatment plants.

Tres Rios Project Improves Water Quality

In 1990, city managers in Phoenix, Arizona, needed to improve the performance of their 91st Avenue Wastewater Treatment Plant to meet new water quality standards issued by the Arizona Department of Environmental Quality. After learning that upgrading their treatment plant might cost as much as $635 million, the managers started to look for a more cost-effective way to polish the treatment plant's wastewater discharge into the Salt River. A preliminary study suggested that the city consider a constructed wetland system that would polish effluent, while supporting high-quality wetland habitat for migratory waterfowl and shorebirds, including endangered species, and protecting downstream residents from flooding at a lower cost than retrofitting their existing treatment plant. As a result, the 12-acre Tres Rios Demonstration Project began in 1993 with assistance from the U.S. Army Corps of Engineers, the Bureau of Reclamation and EPA's Environmental Technology Initiative and now receives about two million gallons of effluent per day. The demonstration project was so successful that the city and the Bureau of Reclamation asked EPA for help in expanding the project to a full-scale, 800-acre project. For more information on the Tres Rios Constructed Wetlands Project, visit, http://phoenix.gov/TRESRIOS/

EPA 843-F-03-013
Office of Water
August 2004

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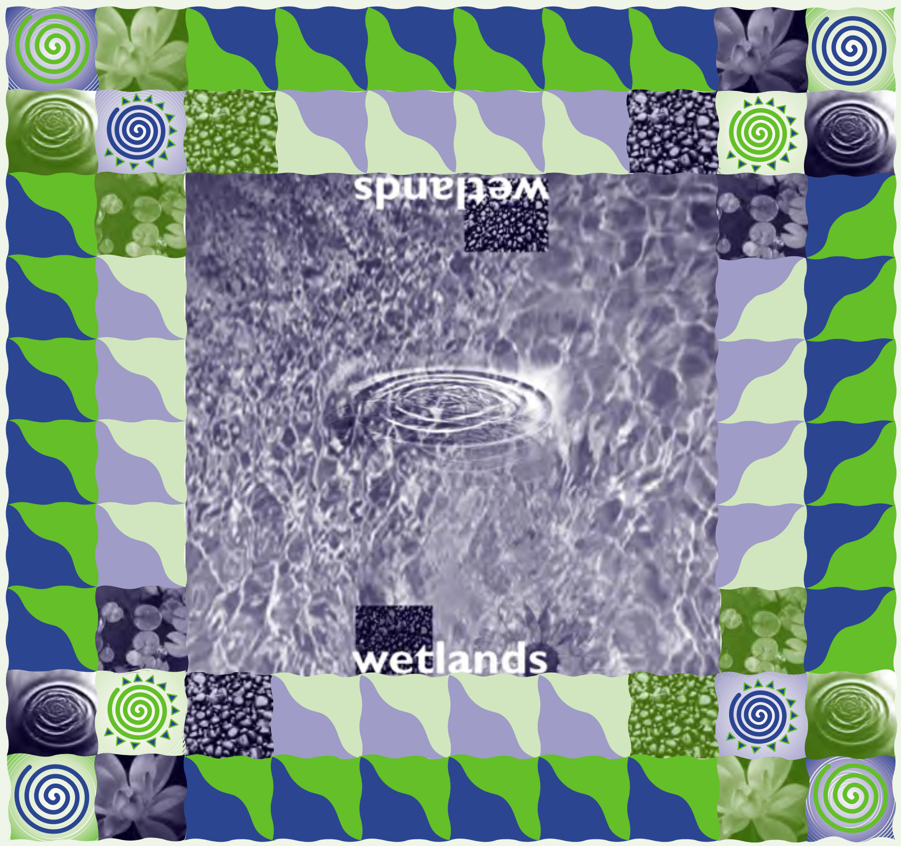
United States
Environmental
Protection Agency

Office of Wetlands, Oceans and Watersheds
Washington, DC
(4502F)

EPA 843-B-00-003
October 2000

GUIDING PRINCIPLES FOR CONSTRUCTED TREATMENT WETLANDS:

Providing for Water Quality and Wildlife Habitat



October 2000

Environmental Protection Agency

Natural Resources Conservation Service

U.S. Fish and Wildlife Service

National Marine Fisheries Service

U.S. Bureau of Reclamation

U.S. Army Corps of Engineers

Guiding Principles for Constructed Treatment Wetlands: Providing for Water Quality and Wildlife Habitat

Developed by the Interagency Workgroup on Constructed Wetlands

Environmental Protection Agency, U.S. Army Corps of Engineers, U.S. Fish and Wildlife Service, Natural Resources Conservation Service, National Marine Fisheries Service, and U.S. Bureau of Reclamation

** This is a guidance document only - it does not establish legally binding requirements or regulations*

This User's Guide Provides:

- Guiding principles for planning, siting, design, construction, operation, maintenance, and monitoring of constructed treatment wetlands.
- Information on current Agency policies, permits, regulations, and resources.
- Answers to common questions.

Acknowledgements

This document is the result of the collective efforts of many individuals. All members of the Interagency Workgroup on Constructed Wetlands, listed in Appendix V, worked extremely hard reviewing multiple drafts to make these Guiding Principles a reality. The Environmental Protection Agency's Wetlands Division extends its heartfelt gratitude to all Workgroup members for their contributions. The Wetlands Division would like to make special recognition of Bob Bastian and Fran Eargle, who led the efforts of the Workgroup from its inception, and of Matt Little, who worked tirelessly to develop the document and incorporate the comments of the members. It is the hope of the Workgroup that this guidance will help improve the planning, siting, design, construction, operation/maintenance, and monitoring of constructed treatment wetlands that aim to provide water quality and wildlife habitat.

Considerable insight into the design, construction, and operation issues facing treatment wetlands that support valuable wildlife habitat was gained by many members of the Workgroup during a Wetlands Roundtable meeting and field trip to Phoenix and ShowLow, AZ, in November 1997. The Workgroup greatly appreciated the input and assistance provided by Paul Kinshella and Roland Wass from the City of Phoenix and others associated with the Tres Rios Project, as well as the insights provided by many others, especially Bob Knight, Bob Kadlec, Sherwood Reed, Bob Gearheart, Brad Finney, Jim Kreissl, and Mel Wilhelm, all of whom shared many examples of interesting situations from their extensive personal experiences working with constructed wetlands projects in various parts of the country.

Disclaimer

This document provides guidance to Environmental Protection Agency (EPA) Regions, States, Tribes, Local Governments, and other organizations and individuals involved in the planning, siting, design, construction, operation/ maintenance, monitoring, and legal oversight of constructed treatment wetlands. It also provides guidance to the public and the regulated community on how EPA intends to exercise its discretion in implementing the Clean Water Act as it relates to constructed treatment wetlands. The guidance is designed to implement national policy on these issues. The document does not, however, substitute for the Clean Water Act or EPA's regulations; nor is it a regulation itself. Thus it cannot impose legally binding requirements on EPA, States, or the regulated community, and may not apply to a particular situation based upon the circumstances. EPA and State decision-makers retain the discretion to adopt approaches on a case-by-case basis that differ from this guidance where appropriate. EPA may change this guidance in the future.

Table of Contents

A. Purpose and Background

Purpose: *To promote the development of environmentally-beneficial constructed wetlands for water treatment systems by providing information on the legal, policy, and technical issues associated with these systems as well as guidelines for those developing and managing constructed treatment wetlands.*

Background: The number of constructed treatment wetland projects receiving wastewater from municipal and industrial treatment sources as well as agricultural and storm water sources has increased to more than 600 active projects across the United States. If planned properly, these treatment wetlands offer opportunities to regain some of the natural functions of wetlands and offset some of the significant losses in wetland acreage. In arid regions and communities reaching the limits of water availability, water reuse via these systems is an attractive option that may help achieve water conservation and wildlife habitat goals. With appropriate siting, design, preapplication treatment, operation, maintenance, monitoring, and management, these manmade systems can often emulate natural wetlands by providing integrated ecological functions within the watershed and landscape.

Constructed treatment wetland project proponents and regulators have expressed a desire for more efficient and consistent policy guidelines for the development and permitting of such projects, especially those providing both water quality and wildlife habitat benefits. An initial effort to develop this guidance was funded by Environmental Protection Agency (EPA) Environmental Technology Initiative (ETI) Program. A Workgroup[1] was formed to identify general policy and permitting issues for a constructed treatment wetlands project, the Tres Rios Constructed Wetlands in Phoenix, Arizona. The Tres Rios Constructed Wetlands project is a wildlife habitat and treatment wetland proposed by the City of Phoenix, the U.S. Army Corps of Engineers, the U.S. Bureau of Reclamation, and other organizations. For more information on the Tres Rios Constructed Wetlands Demonstration Project see their website at http://www.tresrios.net .

In September 1997, EPA convened a Federal Interagency Workgroup consisting of the U.S. Army Corps of Engineers, U.S. Fish and Wildlife Service, National Marine Fisheries Service, Natural Resources Conservation Service, and the U.S.

[1]The ETI Project Workgroup that participated in this effort included active participation by representatives from the City of Phoenix and their contractor, CH_2M-Hill (and Wetland Management Services); EPA and its contractor, SAIC; U.S. Bureau of Reclamation; U.S. Army Corps of Engineers; U.S. Fish and Wildlife Service; AZ Dept. of Water Resources; AZ Dept. of Environmental Quality; AZ Game & Fish Dept; along with extensive input from many local organizations interested in the proposed Tres Rios Project.

Bureau of Reclamation to evaluate the technical and policy issues identified by the ETI project team (see their final report entitled *Wetlands for Water Quality Management and Habitat Enhancement: Policy and Permitting Issues*, January 1997) in order to provide a starting point for a national policy dialogue and for analysis of the issues associated with these wastewater treatment systems and the wildlife habitat they may be able to provide. Common factors in successful constructed treatment wetland projects and lessons learned from less successful projects provided, in part, the basis for development of the technical and policy recommendations in these guidelines.

The process of writing and reviewing the guiding principles was highly educational, collaborative, and iterative. The Workgroup decided to ***focus upon and encourage those projects that not only provide water treatment, but also strive to provide water reuse, wildlife habitat, and public use benefits.*** While this document focuses on municipal wastewater treatment wetlands, many of the principles can be used to help guide other treatment wetland projects, such as those treating acid mine drainage, agricultural and urban storm water runoff, livestock and poultry operations, and industrial wastewater. Information from specific case study projects, and scientific literature was used to develop these principles, along with technical information provided by constructed wetlands experts and dialogue during the Workgroup meetings. We hope this document will facilitate the establishment of future projects, while improving compliance with the Clean Water Act (CWA).

B. What are Constructed Treatment Wetlands?

For the purposes of these Guiding Principles, constructed treatment wetlands are defined as engineered or constructed wetlands that utilize natural processes involving wetland vegetation, soils, and their associated microbial assemblages to assist, at least partially, in treating an effluent or other water source. In general, these systems should be engineered and constructed in uplands, outside waters of the U.S., unless the source water can be used to restore a degraded or former wetland (see II.B "Opportunities for Restoration of Degraded or Former Wetlands").

The degree of wildlife habitat provided by constructed treatment wetlands, or sections of these wetlands, varies broadly across a spectrum. At one end of the spectrum are those systems that are intended only to provide treatment for an effluent or other water source, in order to meet the requirements of the CWA, and that provide little to no wildlife habitat. At the other end are those systems that are intended to provide water reuse, wildlife habitat, and public use,

while also providing a final polishing function for a pretreated effluent or other water source. This guidance primarily addresses the latter end of this spectrum.

C. What Are the Guiding Principles?

The Guiding Principles are intended to:

- provide a framework for promoting sustainable, environmentally safe constructed treatment wetland projects.
- be usable nationally under a variety of settings and circumstances.
- educate and inform public and private decision makers, Federal, State, Tribal and Local regulatory and resource agency personnel, and the general public.
- provide guidance for environmental performance, especially for projects which are intended to provide water reuse, wildlife habitat, and public use, in addition to other possible objectives.
- highlight opportunities to restore and create wetlands.
- be applied, when appropriate, to any effluent or other source water treatment system as long as the source is adequately treated to meet applicable standards, protects the existing beneficial uses, and does not degrade the receiving waters.
- create opportunities for beneficial uses of dredged material, if feasible.
- minimize risks from contamination, toxicity, and vector-borne disease.
- be applied in a watershed context.
- be flexible enough to accommodate regional differences in climate, hydrogeomorphology, wildlife habitat needs, etc.
- complement Federal, Regional, State, Tribal, or Local authority, rules, and regulations and policies.

II Guidelines for Siting Constructed Treatment Wetlands

A. Waters of the U.S. and Floodplains

Constructed treatment wetlands should generally be constructed on uplands (outside waters of the U.S.) and outside floodplains or floodways (unless the next section, II.B, applies) in order to avoid damage to natural wetlands and other aquatic resources. Also, wetlands constructed on uplands may be somewhat more predictable than natural wetlands in terms of pollutant removal efficiency and in structural soundness. This is believed to be due to the engineering of constructed wetlands to provide favorable flow capacity and routing patterns (excerpted from Strecker, et al., 1992). Consequently, siting may include consideration of such factors as flood control, hydraulic routing, flood damage potential, and wetland hydrology. (For more information on waters of the U.S., see VII.A "Clean Water Act and 'Waters of the U.S.,'" Appendix I: "Waters of the U.S.," and Executive Order 11988, *Floodplain Management*.)

B. Opportunities for Restoration of Degraded or Former Wetlands

Opportunities exist to use pretreated effluent, or other source waters, to restore degraded wetland systems. In general, you should only locate constructed treatment wetlands in existing wetlands, or other waters of the U.S., if (1) the source water meets all applicable water quality standards and criteria, (2) its use would result in a net environmental benefit to the aquatic system's natural functions and values, and (3) it would help restore the aquatic system to its historic, natural condition. Prime candidates for restoration may include wetlands that were degraded or destroyed through the diversion of water supplies, a common occurrence in the arid western U.S., and in heavily farmed or developed regions. You should avoid siting in degraded wetlands if the functions and values of the existing wetland will be adversely affected or water quality standards will be violated. The appropriate Regional/District or State authorities will make these determinations on a case-by-case basis. (Note: Many degraded wetlands are still considered waters of the U.S.)

C. Watershed Considerations

When developing a constructed treatment wetland, you should consider its role within the watershed, as well as within the broader ecosystem context of the region. Aspects of this role include: potential water quality impacts (physical, chemical, biological, thermal) to surface waters and groundwater; surrounding and upstream land uses; location of the wetland in relation to wildlife corridors or flyways; potential threats from the introduction of non-native plant or animal species; and local citizens' perception of the appropriateness of constructed treatment wetlands in their watershed. Whenever possible, your constructed treatment wetland project should be planned in the context of a community-based watershed program.

D. Water-Depleted and Effluent-Dependent Ecosystems

Constructed treatment wetland projects may provide valuable ecological benefits in regions where water resources, and especially wetlands, are limited due to climatic conditions and human-induced impacts, such as in the arid western U.S., heavily farmed regions, and developed areas. For example, in the arid west, there are often historic (now degraded) wetlands that no longer have a reliable water source due to upstream water allocations or sinking groundwater tables. Pretreated effluent from wastewater treatment plants and seasonal return irrigation flows may be the only sources of water available for these areas and their dependent ecosystems.

Please note that water quality standards and permitting requirements apply if these areas are still considered waters of the U.S. EPA has developed regional guidance to assist dischargers and regulators in demonstrating a net ecological benefit from maintenance of a wastewater discharge to a waterbody (*Guidance for Modifying Water Quality Standards and Protecting Effluent-Dependent Ecosystems*, U.S. EPA Region 9 Interim Final Guidance, 1992).

E. Other Site Selection Factors

The suitability of a site for constructing a treatment wetland may depend on the condition of one or more of the following factors: substrate, soil chemistry, hydrology/geomorphology, vegetation, presence of endangered species or critical habitat, wildlife, cultural/socioeconomic impacts including environmental justice issues, the surrounding landscape, land use/zoning considerations, and potential impacts to safety and health, such as impacts from major flooding events and vector-borne disease. Project proponents and permit applicants should carefully examine these factors and consult with applicable agencies in determining the most appropriate site(s) for their projects, and should follow the necessary environmental impact review procedures or other requirements in selecting the final project location and characteristics.

III Guidelines for Design of Constructed Treatment Wetlands

A. Minimal Impact

Adverse impacts to waters of the U.S. should be avoided. Potential adverse impacts may include, but are not limited to: disruption of the composition and diversity of plant and animal communities; alteration of the existing hydrologic regime of natural wetlands or adjacent surface water bodies; introduction and spread of noxious species; threats to fish and wildlife from toxins and/or pathogens; and degradation of downstream water quality and groundwater sources.

B. Natural Structure

Constructed treatment wetland designs should avoid rectangular basins, rigid structures and straight channels whenever possible (See Mitsch and Gosselink, 2000; Kusler and Kentula, 1989; National Research Council, 1992). The use of soft structures, diverse and sinuous edges in design configuration, and bio-engineering practices that incorporate the existing natural landscape and native vegetation in constructed treatment wetlands is encouraged. Use landform and gravity to your advantage and design your project for minimal maintenance. For example, sites, slopes, and grades can be used to create depth variability and diversity. Site planning should avoid conditions conducive to stagnant water and "short circuiting" and problems such as avian botulism and vector production.

C. Buffer Zones

Design the margins of your constructed treatment wetland system as natural transition zones, including woody vegetated buffer areas around the site. Where appropriate, integrate the facility with other natural resource features to provide wildlife corridors and open space.

D. Vector Control

Where necessary, design your facilities to minimize mosquito problems by minimizing the potential formation of stagnant water, facilitating vegetation management, and by using natural biological control mechanisms, such as mosquito fish, stickleback, etc. (where native), bats, and purple martins. Local mosquito abatement districts and local codes may provide valuable assistance in designing your project to minimize mosquito habitat. In some cases, it may be important to consider providing access for active vector control.

E. Hazing and Exclusion Devices

Hazing or wildlife exclusion devices, such as noise-making devices or netting and fencing, should be used if the effluent or other water source being treated is toxic or presents a significant threat to wildlife. Such devices may be necessary in facilities that are designed only for treatment, but their need should be decided on a case-by-case basis.

Using these wildlife control methods may also be necessary if excessive wildlife use is causing water quality problems. In some circumstances, <u>excessive</u> use of wetlands by wildlife can result in: (1) wildlife stress and disease problems, (2) degradation of water quality due to high loadings of nutrients, solids, and fecal coliform, and (3) erosion resulting from loss of vegetation due to over-grazing and trampling.

F. Dedicated Water Source

Plans should be made for maintaining the wetland habitat during periods of drought. Projects that are intended to provide wildlife habitat should have a dedicated water source for the life of the project and, if possible, beyond the life of the project to meet the long-term hydrological needs of the desired aquatic and terrestrial communities. When doing this, be sure that adequate water supplies remain in adjacent streams for aquatic use and if ground water is used, be sure that its mineral content is not toxic to plant species (for example, excess iron can kill some plants).

G. Biological Diversity and Physical Heterogeneity

Where appropriate, design your constructed treatment wetland to provide habitat with a diversity of native species comparable to similar wetlands in the region. Maximize vegetative species diversity, where appropriate, without increasing the proportion of weedy, nonindigenous, or invasive species at the expense of native species. Project plans should include mechanisms to control or eliminate undesirable species. The biological diversity of your project may be linked to, or dependent upon, physical heterogeneity. This could include having both surface and subsurface flow while providing some areas of open water, creating nesting islands for waterfowl, and leaving some upland and buffer areas for other nesting species. Developing a wide variety of wetland types will provide a range of diversity for different types of wildlife. Considerations may include seasonal hydroperiods, depth-flow changes, vegetative succession, and accumulation of sediments.

H. Seasonality and Capacity Exceedences

Your project design should be able to accommodate extremes in meteorologic conditions and temporary exceedences of water storage and treatment capacity. Considerations should be made for extremes in temperature and precipitation which can impact normal operations.

I. Forebays

Utilize sediment collection/settling forebays for treatment of storm water inflows and for additional treatment of wastewater. Design and locate the forebays for ease of maintenance and to achieve greatest protection of wetland habitat and receiving waters. Monitor forebay sediments, wetland vegetation tissues, and water quality to ensure the system is functioning properly and not becoming an attractive nuisance problem to wildlife. Identify an upland disposal site to dispose of accumulated sediments that is consistent with sediment disposal requirements and monitoring criteria and standards. Note that special disposal requirements may be applied for sediments containing hazardous waste materials.

J. Multiple Cells

The use of multiple cells may allow for residuals clean-out, repair of flow control structures, and specialized management of specific effluents without disruption of the overall systems operations. They also facilitate the flexibility of the system to manage different portions of the system (i.e., individual cells) for different purposes, such as the use of cells nearest the influent source to settle out sediment, final cells to strip out algae produced within the system, and other cells used to encourage the development of habitat and food production for specific wildlife species, etc. From a wastewater treatment standpoint, multiple cells often provide better treatment in part because "short circuiting" is minimized.

K. Maintenance Access

Design your constructed treatment wetland so that maintenance vehicles and personnel can safely and easily access the site with a minimum of disturbance. Proper access design will facilitate proper operation and maintenance of the wetland so that it performs as designed.

L. Public Acceptance

Consider the public's perception of your constructed treatment wetland project and its effects on neighboring populations and adjacent land uses. Take into account potential concerns like drinking water contamination, unpleasant odors, mosquitos, access by small children and other safety and health issues. By planning your project with community involvement early in the process, you will help ensure public support and approval for your goals and objectives while developing a safe project for everyone to enjoy.

M. Public Use

When appropriate, encourage public access and use, work with local educators to design informative displays to install at your project, and help foster community education programs, especially for projects developed for water reuse and wildlife habitat. In some cases, public access may need to be prevented due to safety and health concerns.

N. Pilot Projects and Design Criteria

A pilot project may be necessary for designing your full-scale project. If a pilot is not utilized, then design considerations should be fully described and made available to future operators and regulatory staff. To assist in project design, see the reference, *Constructed Wetlands Treatment of Municipal Wastewater Process Design Manual* (EPA 625-R-99-010), as well as other technical references such as those listed in Appendix IV. Planning, design, and construction information is available from Natural Resources Conservation Service (NRCS) offices nationwide; technical assistance may also be available from NRCS offices based on local priorities and workloads. EPA's North American Treatment Wetland Database is a good avenue for networking by owners and their designers. Information is generally not complete enough for design, as most of the data is not quality assured and key parameters may be missing.

IV Construction Guidelines for Constructed Treatment Wetlands

A. Construction Practices/Specifications/Drawings

Good construction practices should be followed during construction of your treatment wetland. Examples include properly evaluating the site, limiting damage to the local landscape by minimizing excavation and surface runoff during construction, and maximizing flexibility of the system to adapt to extreme conditions. Construction specifications and drawings should be utilized that clearly convey procedures to be used and required quality of final product. Note that a general construction storm water CWA Section 402 (NPDES) permit must be obtained for any projects 5 acres in size or greater (or 1 acre expected to begin in 2002). This permit requires development and implementation of a Storm Water Pollution Prevention Plan including best management practices to minimize pollutant loading during construction.

While designs should generally be kept as simple as possible to facilitate ease of construction and operation, the use of irregular depths and shapes can be highly beneficial to enhancing wildlife habitat value. Proper construction is best ensured by the involvement of experienced inspectors and equipment operators who are knowledgeable about wetlands creation and the goals of the project. Careful construction inspection is essential to ensuring that the project is constructed as designed.

B. Soils

If possible, avoid soil sources that contain a seed bank of unwanted species. Carefully consider the soil's permeability and the implications for ground water protection. Highly permeable soils may allow infiltration and possible contamination of groundwater and could prevent the development of hydrological conditions suitable to support wetland vegetation. You may need to use an impermeable barrier in some instances. Dredged material may be useful to help create a base substrate layer, however you may need to test it to ensure that it doesn't contain unwanted contaminants or materials. Matching a local dredging project's disposal need with a beneficial use solution such as creating a constructed treatment wetland is likely to be more practical, cost-effective, and environmentally advantageous when made as part of a broad, watershed-level planning effort. Contact your local U.S. Army Corps of Engineers office to see if there are any dredging projects in your area. For detailed guidance on beneficial uses of dredged material, please see the *Beneficial Use Manual - Identifying, Planning, and Financing Beneficial Use Projects Using Dredged Material* (EPA 842-B-98-001).

C. Vegetation Selection

Vegetation selection needs to accommodate the hydraulic operations of the wetland system and still support habitat objectives. In general, use a diversity of native, locally obtained species. You should obtain seeds from a local seed bank or seedlings from a local nursery, whenever possible. Native plants from existing wetlands may be harvested provided that removal of the plants does not result in damage to the existing wetland or violate any applicable Local, State, or Federal regulations. Species should be chosen both for water quality and wildlife habitat functions, if that is the intent of the project. The use of weedy, invasive, or non-native species should be avoided. Also consider the plants' abilities to adapt to various water depths and soil and light conditions at your site.

V Guidelines for Operation and Maintenance of Constructed Treatment Wetlands

A. Management Plan

Designers or managers who decide to create a treatment wetland must factor in long-term maintenance costs and needs to provide for the proper functioning of the wetland over time. Factor in these maintenance needs by creating a long-term operations, maintenance, monitoring, and funding plan that identifies the party or parties responsible for maintenance and monitoring of your project, their responsibilities, and the funding mechanisms. Some funding sources are listed in Appendix III, "Federal Funding Sources." The management plan needs to ensure maintenance of the functions the project is designed to provide. Where vector control is likely to be a concern, provisions to control vegetation will be an important component of the management plan. In some cases, you may need to secure performance bonds prior to facility approval.

B. Regular Inspections and Maintenance Activities

You will need to make regular inspections of your constructed treatment wetland. The definition of "regular" is case-specific and will depend on the design and operation of your treatment wetland. These considerations should be described in your maintenance plan. Examples of maintenance activities that you should conduct during these inspections include checking weir settings and the inlet and outlet structures, cleaning off surfaces where solids and floatable substances have accumulated to the extent that they may block flows, removing nuisance species and maintaining the appearance and general status of the vegetation and wildlife populations, and removing sediment accumulations in forebays. Save time and energy by conducting your routine monitoring activities, such as sample collections and wildlife counts, at the same time as your inspections.

C. Operator Training

Train and/or certify your operators in the operation and maintenance of constructed treatment wetlands. Where available, this may be done in cooperation with your State regulatory agencies, the facility engineer, and public or private training centers, as directed by the certifying entity. Seek assistance from regulators and local experts and attend constructed treatment wetland seminars and conferences for additional technical assistance.

D. Contingency Plan

Project designers and operators should jointly develop a contingency plan to address problems that could develop during facility operations. Such problems may be due to: unrealistic or unattainable goals; design, construction, or operational errors; or unpredictable events. The first situation can be addressed by revising project goals or regulatory criteria (e.g., water quality standards), the second by reducing system capacity, increasing its area, or changing operational practices, and the third by anticipation through conservative design. Contingency plans should include measures for determining and remediating nuisance conditions, addressing any toxicity observed in the wetland, and dealing with upstream treatment plant failure or bypass. Auxiliary storage basins can be helpful for dealing with many of these situations.

VI Guidelines for Monitoring Constructed Treatment Wetlands

A. Reference Wetland

Reference sites may be useful as a basis of comparison to identify various changes and impacts to your constructed treatment wetland ecology and to evaluate its success. Where feasible and appropriate, consider using more than one wetland of the same type (e.g., depressional, riverine), class, size, vegetative cover, hydroperiod, and geographic region (preferably nearby and within the same watershed), while allowing for natural variability, as a reference to measure the success of your project. Depending on your project's goals and objectives, you may want to compare only certain functions or characteristics of your treatment wetlands with the reference wetlands.

B. Methods and Criteria

Depending on the primary goals and objectives of your project, site monitoring can be used to determine the chemical, physical, and biological health of your project and its success in treating effluent or other water sources. Monitoring criteria may include water quality (surface and ground water), sediment quality, temperature, hydrology (fluctuation, loading, variability and flow pattern monitoring by means of tracer studies), plant, benthic macroinvertebrate, fish tissue analyses, toxicity testing, seasonal vegetation mapping or physical sampling, habitat structure and diversity (including species richness), and wildlife use surveys (birds, amphibians, macro-invertebrates, and fish, if appropriate). Certain species, such as migratory birds, will require Federal and State permits to collect for monitoring purposes. Also, nuisance insects should be monitored to evaluate the need for vector control measures. Where appropriate, methods for monitoring should draw from the scientific literature for assessing biological conditions. The specific details of your monitoring plan should be determined through discussions with the permitting agencies. If your State has a wetlands biomonitoring program, it may be appropriate to incorporate your efforts into the program. Volunteer monitoring groups, such as the Izaak Walton League or local schools, may be able to assist you with your monitoring efforts.

C. Early Identification of Potential Problems

Try to anticipate potential problems and monitor for potential dangers to the wetland ecosystem, such as bioaccumulation, avian botulism and other avian diseases, vector problems, invasion of non-native plants and animals, debris accumulation, and nuisance conditions, and be prepared to respond quickly. Potential responses to such problems should be described in your contingency plan.

D. Timeframe

Be sure to monitor the constructed treatment wetland for the entire life of the project to help ensure that the wetland system performs as designed and meets its ecological integrity goals.

VII Federal Permits and Other Legal Issues

Federal, State, Tribal, and/or Local regulations, in addition to those listed below, may be applicable. Please be sure to coordinate with the appropriate agencies on all projects and, when appropriate, have cooperative and collaborative planning and information-sharing sessions with community and business representatives, environmental groups, regulatory agencies, and the general public.

A. Clean Water Act and "Waters of the U.S."

"Waters of the United States" or "waters of the U.S." are those waters regulated by the Clean Water Act (CWA) (see definition in Appendix I). By definition, waste treatment systems designed to meet the requirements of the Clean Water Act are not considered waters of the U.S. (40 CFR 122.2 9). If, however, your constructed treatment wetland is constructed in an existing water of the U.S., the area will remain a water of the U.S. unless an individual CWA Section 404 permit is issued that explicitly identifies it as an excluded waste treatment system designed to meet the requirements of the CWA.

If your constructed treatment wetland is constructed in uplands and is designed to meet the requirements of the CWA, then it generally will not be considered a water of the U.S. under the waste treatment system exclusion to the definition of waters of the U.S. If the constructed treatment wetland is abandoned or is no longer being used as a treatment system, it may revert to (or become) a water of the U.S. if it otherwise meets the definition of waters of the U.S. This definition is met if the system has wetland characteristics (hydrology, soils, vegetation) *and* it is (1) an interstate wetland, (2) is adjacent to another water of the U.S. (other than waters which are themselves wetlands), or (3) if it is an isolated intrastate water which has a connection to interstate commerce (for example, it is used by interstate or foreign travelers for recreation or other purposes).

The U.S. Army Corps of Engineers and the EPA decide on a case-by-case basis whether or not particular bodies of water are waters of the U.S. Contact your U.S. Army Corps of Engineers district or regional Environmental Protection Agency office for more information on this subject. If your constructed treatment wetland, or a portion of your constructed treatment wetland, is considered a water of the U.S., then it falls under the jurisdiction of the CWA and one or more of the following sections of the CWA may apply. If the constructed treatment wetland is not itself a water of the U.S. but it discharges pollutants into a water of the U.S., the discharge requires a permit under CWA Section 402.

B. Clean Water Act Section 303 Water Quality Standards

Under the CWA, States and Tribes (and in a few cases EPA) are to adopt water quality standards for all waters of the U.S. Water quality standards include designated uses for water bodies, criteria to protect these designated uses, and an antidegradation policy (Section 303). Permits for discharges to waters of the U.S., including jurisdictional wetlands, must ensure the discharges will not cause or contribute to a violation of water quality criteria or impair designated uses in the receiving water or downstream waters. If there are no water quality standards specific to a wetland, the water quality standards for the adjacent open waterbody may be applied to the wetland, depending on your state's policies. Please see Appendix II, "Section 303 of the Clean Water Act," for additional information.

C. Clean Water Act Section 401 Certification

Projects involving a federally-licensed activity that may result in discharges to waters of the U.S. (such as a CWA Section 402 permit from EPA and/or a CWA Section 404 permit from the U.S. Army Corps of Engineers) require certification under Section 401 of the CWA. Your permit application will need certification that the proposed activity will not violate water quality standards or other State or Tribal requirements. This certification must come from the State or authorized Tribe in whose geographic jurisdiction the discharge would occur, or in some circumstances from EPA. Note that the State or Tribe may place conditions on its certification that are intended to prevent such violations. States and Tribes may waive certification.

D. Clean Water Act Section 402

The CWA Section 402 program, also known as the National Pollutant Discharge Elimination System (NPDES) program, regulates the discharge of pollutants (other than dredged or fill material, which is covered, below, under Section 404 of the Clean Water Act) from point sources into waters of the U.S. Over forty states are authorized by EPA to administer the NPDES permitting program within their state boundaries. The construction and/or operation of a treatment wetland may involve these discharges to waters of the U.S. and, as a result, require an NPDES permit.

If construction of the treatment wetland will disturb 5 acres or more (1 acre expected to apply in 2002), an NPDES permit for the discharge of storm water is required. In most areas of the country, EPA or State NPDES permitting authorities have issued storm water general permits for discharges from construction activities. These storm water general permits typically require operators of the construction project to submit a notice of intent (NOI) form, and prepare a site specific storm water pollution prevention plan, prior to disturbing any land at the site. For more information, please contact your NPDES permitting authority. A current list of State/Federal Storm Water Contacts is available at: http://www.epa.gov/owm/swlib.htm. For more information, see VIII., Question and Answer #1, and Appendix II, "Section 402 of the Clean Water Act."

E. Clean Water Act Section 404

If your construction activities involve the discharge of dredged or fill material (e.g., rock, sand, and soil) to waters of the U.S., you will need authorization under CWA Section 404. For example, if you wish to use a degraded jurisdictional wetland for wastewater treatment and plan to construct water control structures, such as berms or levees, this construction will typically involve discharges of dredged or fill material into that wetland. (Note: The use of existing wetlands for purposes of wastewater treatment is generally discouraged.) Subsequent maintenance may also require a permit, although Section 404(f) may exempt some routine maintenance from 404 permitting requirements. You should contact the U.S. Army Corps of Engineers (or the appropriate state agency) to determine the regulatory requirements associated with the proposed discharge of dredged or fill material. For more information, see Appendix II, "Section 404 of the Clean Water Act."

Compensatory Mitigation: In general, wetlands constructed or restored for the primary purpose of treating wastewater will not be recognized as compensatory mitigation to offset wetland losses authorized under federal regulatory programs. In some cases, however, components of constructed wetland treatment systems that provide wetland functions and values beyond what is needed for treatment purposes may be used for compensatory mitigation. For example, project sponsors may be eligible to receive mitigation "credit" for using treated effluent as part of a constructed treatment wetland system that restores or creates *additional* wetland acreage beyond the acreage needed for treatment purposes. The use of constructed treatment wetlands for mitigation for CWA Section 404 purposes is subject to approval by the U.S. Army Corps of Engineers, in consultation with other Federal and State resource agencies. Such decisions need to be made on a case-by-case basis, considering, among other factors, the appropriateness of the constructed treatment wetland to fully offset the anticipated impacts from the loss of natural wetlands.

F. Preapplication Treatment (see definition in Appendix I)

If your constructed treatment wetland is considered a water of the U.S. (e.g., is constructed in a water of the U.S.), you must treat the effluent, or other source water (storm water runoff, agricultural and livestock waste, etc.) prior to its entering the constructed treatment wetland sufficiently to meet all applicable water quality standards (and to prevent degradation of wildlife or biological integrity) and technology-based requirements. Municipal wastewater effluent generally must be treated to at least secondary levels before it enters waters of the U.S. (CWA Section 301). Other examples of treatment include best management practices for storm water and confined animal feeding operations.

G. Other Federal Legal and Programmatic Considerations (for descriptions, see Appendix II: Federal Statutes and Regulations)

- Clean Water Act Section 319 (Nonpoint Source Pollution Program)
- Estuary management plans under Clean Water Act Section 320
- Coastal Zone Management Act, including Reauthorization Amendments of 1990
- Endangered Species Act
- Fish and Wildlife Coordination Act
- Magnuson-Stevens Fishery Conservation and Management Act
- Migratory Bird Treaty Act
- National Environmental Policy Act
- National Wild and Scenic Rivers Act
- National Historic Preservation Act

VIII Questions and Answers

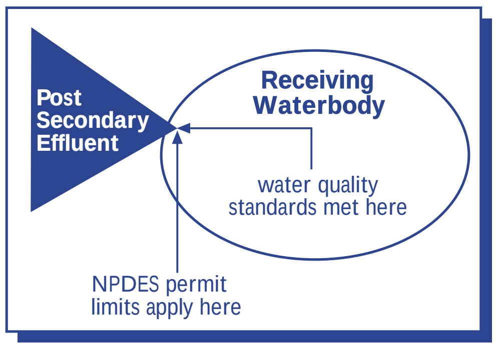
Question 1:

I am planning to build 50 acres of constructed treatment wetlands for post-secondary wastewater treatment of my small community's municipal wastewater effluent. I anticipate that the wetland will provide high value wetland habitat for wildlife and public use. Do I need any permits, do water quality standards apply to my project, and can I get mitigation credits?

If your new constructed treatment wetland is considered waters of the U.S. or will discharge pollutants to waters of the U.S., you will need a CWA Section 402 (NPDES) permit at the discharge point (please see the discussion on waters of the U.S. under VII.A and Appendix I). The permit's requirements will be based on the applicable water quality standards for the receiving waterbody. Three options for this are outlined below:

Option 1

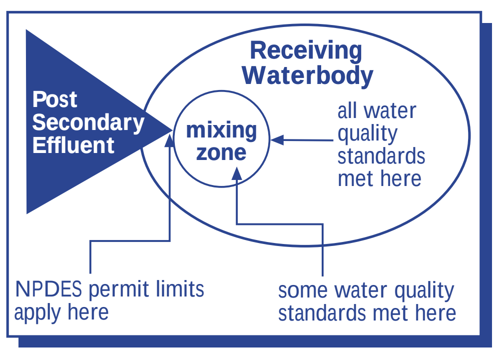
If the post-secondary effluent meets the applicable water quality standards requirements, you may receive a CWA Section 402 (NPDES) permit (with appropriate limits) to discharge directly into the waters of the U.S.



Option 1

Option 2

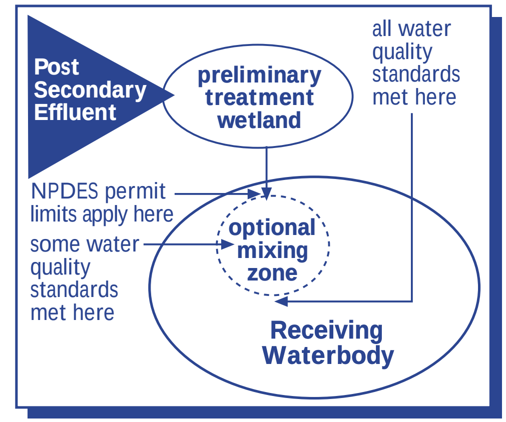
If the post-secondary effluent almost meets the applicable water quality standards for waters of the U.S., and can meet those standards within a short distance of the discharge, you may be able to use a mixing zone and receive a CWA Section 402 (NPDES) permit (with appropriate limits) to discharge directly into the waters of the U.S. Check with your state to see if mixing zones are allowed.



Option 2

Option 3

If the post secondary effluent will not meet the water quality standards for waters of the U.S. at or near the point of discharge, you may be able to discharge the post-secondary effluent to still another constructed treatment wetland that is not a water of the U.S. for further treatment. The discharge from this treatment wetland could then be treated in a manner similar to the effluent in Options 1 or 2.



Option 3

Be sure to coordinate with the appropriate NPDES permitting authorities prior to constructing the wetland. Also check with your state, because some states have developed specific water quality standards for wetlands, which may apply to your constructed treatment wetland project. Other water quality standards and technology-based effluent limitations may also apply, depending on the effluent source. For more information on standards, see VII: "Federal Permits and Other Legal Issues" and Appendix II, "Section 303 of the Clean Water Act."

If construction activities are proposed in existing wetlands or waters of the U.S., then the U.S. Army Corps of Engineers and appropriate State agencies must also be consulted for CWA Section 404 permitting (see VII.E, "Clean Water Act Section 404").

Portions of your project may be eligible for use as mitigation, depending on case-specific circumstances. Also, see the discussion of compensatory mitigation in VII.E, "Clean Water Act Section 404."

Question 2:

I live in an arid area and am hoping to use secondary wastewater effluent to restore a highly degraded natural wetland, while providing advanced treatment to the secondary effluent to meet requirements for downstream recreational use. Because of local water allocations and a drop in the water table, this site is now dry most of the year. The addition of effluent as a water source will help restore the wetland back to its historical hydrology and bring back the wetland dependent birds and wildlife. Do I still need permits and can I get mitigation credits for my restoration efforts?

Depending on the specific circumstances of your proposal, you may need federal authorization of your project. For example, if the particular degraded wetlands are considered waters of the U.S., discharges to create the waste treatment system will require a CWA Section 404 permit. A CWA Section 402 (NPDES) permit will also be required. As noted earlier, we encourage the use of appropriately treated effluent for restoration efforts only when it benefits the environment (See II.B "Opportunities for Restoration of Degraded or Former Wetlands.") Under some circumstances, portions of the restored wetland may be used as compensatory mitigation (see discussion of compensatory mitigation in VII.E "Clean Water Act Section 404").

Question 3:

Does my constructed treatment wetland become a water of the U.S. after it is no longer used as a treatment system?

If the treatment wetland is a water of the U.S., it will remain so after it stops being used as a treatment system. If the treatment wetland is not a water of the U.S., it may become (or revert back to, as the case may be) a water of the U.S. if it has wetland characteristics (hydrology, soils, and vegetation) and the following conditions apply: (1) it is an interstate wetland, (2) it is adjacent to another water of the U.S. (other than a water which is itself a wetland), or (3) it meets the interstate commerce requirements for an isolated intrastate water of the U.S. (for example, it is used by interstate or foreign travelers for recreation or other purposes). These decisions are made on a case-by-case basis. (See VII.A "Clean Water Act and 'Waters of the U.S.'")

Question 4:

If I need to perform general maintenance in the constructed treatment wetland, will I need a Section 404 permit to deposit removed vegetation or dredge sediments?

If the constructed treatment wetland is a water of the U.S., you may need a permit. Specifically, if the proposed activity involves discharges into waters of the U.S. or placement of fill material into waters of the U.S., a CWA Section 404 permit is needed unless the 404(f) exemption applies (see VII.E "Clean Water Act Section 404"). Activities such as building levees or sidecasting rock, sand, or soil into the wetland are likely to require such permits. We generally encourage constructing forebays in uplands to collect effluent and storm water prior to discharge to wetlands. You must obtain a permit to construct forebays in an existing wetland. Forebays should be designed to promote sedimentation and decrease the disruptive forces of the wastewater entering the system and thereby reducing impacts to water quality. Maintenance activities that are confined to

such areas will not require authorization if they do not involve discharges to waters of the U.S. Discharge from the maintenance of levees will likely be exempt from permit requirements under Section 404(f). (See VII.A and E for more information).

Question 5:

Will I need a groundwater permit for my constructed treatment wetland?

In general, groundwater protection permits are issued by State or Local agencies. You should coordinate with the appropriate State and Local agencies before you construct the treatment wetland. If the water in your constructed treatment wetland interacts with groundwater, then you may need a permit. If the wetland is lined with an impermeable liner, then interaction is unlikely and a permit may not be necessary. A Clean Water Act 402 (NPDES) permit may be required for discharges to groundwater where that groundwater has a direct hydrologic connection to surface waters of the U.S.

Question 6:

I am considering using constructed treatment wetlands to treat my municipality's stormwater flows. What general issues must I consider?

First of all, the treatment wetland should not be constructed in a waters of the U.S. unless you can sufficiently pretreat the stormwater flows to protect the values and functions of the waters of the U.S. Because storm water is an unpredictable effluent source and can contain high levels of toxic substances, nutrients, and pathogens, we strongly encourage that you construct the treatment wetland in uplands and use best management practices in these projects (see EPA's *Protecting Natural Wetlands: A Guide to Stormwater Best Management Practices*, EPA/843-B-96-001). Depending on the size of your municipality and other factors, you may need to get a CWA Section 402 (NPDES) permit. Be sure to contact all the appropriate wastewater authorities in your area during the early planning stages of this type of project.

Question 7:

Can I use constructed treatment wetlands to treat other effluents or source waters?

Yes, as long as you (1) generally avoid using natural wetlands which are waters of the U.S., (2) adequately pretreat the effluent or source water to protect the treatment wetlands and other nearby surface and groundwater sources, (3) contact the appropriate authorities, and (4) meet all applicable requirements. We also encourage you to follow the principles established in this document.

Appendix I

DEFINITIONS

COMPENSATORY MITIGATION
For the purposes of CWA Section 404, compensatory mitigation is the restoration, creation, enhancement, or in exceptional circumstances, preservation of wetlands and/or other aquatic resources for the purpose of compensating for unavoidable adverse impacts of a dredge or fill project which remain after all appropriate and practicable avoidance and minimization has been achieved.

CONSTRUCTED TREATMENT WETLAND
Engineered and constructed wetlands that utilize natural processes involving wetland vegetation, soils, and their associated microbial assemblages to assist, at least partially, in treating an effluent or other source water. In general, these systems should be engineered and constructed in uplands, outside waters of the U.S., unless the source water can be used to restore a degraded or former wetland (see II.B "Opportunities for Restoration of Degraded or Former Wetlands").

DEGRADED WETLANDS
Wetland systems that have lost some or all of their characteristic functions and values due to hydrologic alterations, discharges of fill material and/or other impacts such as pollutants, nuisance and invasive species, and discharge of point and nonpoint sources.

DESIGNATED USES
Classifications for waters of a State or Tribe by the State or Tribe that are to be achieved and protected. These uses must take into consideration the existing use and potential value of water for public water supplies, protection and propagation of fish, shellfish and wildlife, recreation in and on the water, agricultural, industrial, and other purposes including navigation. Note that in no case shall a State adopt waste transport or waste assimilation as a designated use for any waters of the U.S. (*40 CFR 131.10(a)*)

DISCHARGE OF POLLUTANTS
The addition of pollutants, including dredge and fill material, from a point source to waters of the U.S.

DREDGED MATERIAL
Material that is excavated or dredged from waters of the U.S.

EFFLUENT
Wastewater, normally treated.

FILL MATERIAL
Any material that has the effect of replacing an aquatic area with dry land or of changing the bottom elevation of a waterbody.

FLOODPLAIN
The area that would be inundated by the flood which has a 1% chance of occurring in any given year, also referred to as the "100-year" flood (National Flood Insurance Program definition).

FLOODWAY
That area of the watercourse plus adjacent floodplain lands which must be reserved in order to allow the discharge of the base flood ("100-year" flood) without increasing flood heights more than a designated amount (National Flood Insurance Program definition).

FOREBAY
An area within a management pond, wetland, etc., that is sized to capture sediments and other debris as the material enters the unit. This area is designed to provide for equipment access to facilitate periodic removal of accumulated material.

INVASIVE SPECIES
Species that spread rapidly, are frequently non-native to the region, and tend to out-compete more desirable native forms and to become dominant.

JURISDICTIONAL WATERS, or JURISDICTIONAL WETLANDS
See "Waters of the U.S."

MITIGATION
See "Compensatory Mitigation."

MIXING ZONE
An area where an effluent discharge undergoes initial dilution and is extended to cover the secondary mixing in the ambient waterbody. A mixing zone is an allocated impact zone where water quality criteria can be exceeded as long as acutely toxic conditions are prevented. Compliance with effluent treatment standards typically is measured at the edge of the mixing zone. (*Water Quality Standards Handbook - Second Edition,* EPA-823-B-94-005, p. GLOSS-4.)

MONOTYPIC
Having a nearly total dominance of one species of plant, such as *Phragmites australis*, or *Typha spp.*, within an area.

NONINDIGENOUS or NON-NATIVE SPECIES
Species which are not native to the environment in which they currently exist and have been introduced by and often proliferate because of human activities.

NONPOINT SOURCE (NPS) POLLUTION
Sources of pollution not defined by statute as point sources. NPS pollution results from the transport of pollutants into receiving waters via overland flow runoff within a drainage basin. Because NPS pollution is diffuse, its specific sources can be difficult to identify.

OTHER SOURCE WATERS
Categories of wastewater other than municipal wastewater, such as acid mine drainage, industrial wastewater, agricultural and urban runoff, effluent from livestock operations, landfill leachates, etc.

POINT SOURCE
Any discernible, confined, and discrete conveyance, including but not limited to, any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, landfill leachate collection system, vessel or other floating craft from which pollutants are or may be discharged. This term does not include return flows from irrigated agriculture or agricultural stormwater runoff. *(40 CFR § 122.2)*

PREAPPLICATION TREATMENT
The treatment of wastewaters prior to their introduction to constructed treatment wetlands, such that they do not negatively impact the wetlands' functions and values.

RESTORATION
"Return of an ecosystem to a close approximation of its condition prior to disturbance" and "the reestablishment of predisturbance aquatic functions and related physical, chemical and biological characteristics" (National Research Council, 1992).

SOURCE WATERS or WATER SOURCES
See "Other Source Waters."

STORMWATER
Flows and discharges resulting from precipitation events, such as rainfall or snowmelt, and include municipal and industrial stormwater runoff, combined sewer overflows (CSOs), and sanitary sewer overflows (SSOs). Urban stormwater runoff, which is often collected by storm drains and transported to receiving waters, can contain many pollutants that are accumulated as rainwater or snowmelt flow across the surface of the earth. Such pollutants include oil and grease, chemicals, nutrients, pesticides, heavy metals, bacteria, viruses, and oxygen-demanding compounds. (http://www.epa.gov/owm/wfaq.htm)

WATERS OF THE U.S.
All waters that are currently used or were used in the past, or may be susceptible to use in interstate commerce, including: all waters that are subject to ebb and flow of the tide; all interstate waters including interstate wetlands; all other waters such as intrastate lakes, rivers, streams including intermittent streams, mudflats, sandflats, wetlands, sloughs, prairie potholes, wet meadows, playa lakes, or natural ponds, the use, degradation or destruction of which would or could affect interstate or foreign commerce; all impoundments of waters otherwise defined as waters of the U.S. under this definition; tributaries of waters defined above; the territorial sea; and wetlands adjacent to waters (other than waters that are themselves wetlands) identified above. Courts have found that this includes such waters as isolated, intrastate waters which are used by migratory birds or which attract interstate travelers or from which fish or animals are or could be harvested and sold in interstate commerce. Waste treatment systems, including treatment ponds or lagoons designed to meet the requirements of the CWA, are excluded from waters of the U.S. If such treatment systems are abandoned and otherwise meet the definition of waters of the U.S., they become or revert to regulated waters of the U.S. (See the regulations for specific details: *40 CFR § 230.3(s)(1-7),122.2 and COE Regulations at 33 CFR § 328.3(a)(1-7))*

WATERSHED
The total drainage area contributing runoff to a single point or "hydrologically defined geographic areas. . . typically the areas that drain to surface waters or that recharge or overlay ground waters or a combination of both." (June 1996 EPA *Watershed Approach Framework*)

WETLAND

Those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas. (Definitions taken from EPA regulations at *40 CFR § 230.3(t)* and COE Regulations at *33 CFR § 328.3(b)*.)

FEDERAL STATUTES AND REGULATIONS

MAJOR FEDERAL PROGRAMS AND REGULATIONS THAT MAY APPLY TO CONSTRUCTED TREATMENT WETLANDS

The U.S. Congress enacted the Clean Water Act to RESTORE AND MAINTAIN THE CHEMICAL, PHYSICAL AND BIOLOGICAL INTEGRITY OF THE NATION'S WATERS.

Section 303 of the Clean Water Act.

States and Tribes are to develop water quality standards for all waters of the U.S., including wetlands, subject to EPA approval. These standards, at a minimum, must consist of three major components:

1. Designated Uses - These are environmental goals for each waterbody within a State or Tribe. Each body of water is given one or more designated uses, such as "groundwater recharge" or "aquatic life support." The goal of the State or Tribe is to achieve, protect, and maintain these designated uses.

2. Water Quality Criteria - States and Tribes develop water quality criteria to support the designated uses of each waterbody in their respective jurisdictions. The criteria are either narrative statements or numeric limits on factors affecting the waterbody's health. A number of states are now establishing biological criteria, in addition to the more traditional physical and chemical criteria, to help determine the health of wetlands.

3. Antidegradation Policy - All States must have antidegradation policy language consistent with *40 CFR § 131.12* in their water quality standards, and must develop appropriate implementation procedures. Antidegradation policies, at a minimum, must maintain and protect existing instream water uses and the level of water quality necessary to protect the existing uses. These policies also ensure the protection of water quality for a particular waterbody where the water quality exceeds levels necessary to protect fish and wildlife propagation and recreation on and in the water.

Section 319(b) of the Clean Water Act (Nonpoint Source (NPS) Pollution Program).

EPA has oversight for a national program to control nonpoint sources of pollution. This program requires that States develop management programs for the control of nonpoint source pollution. EPA emphasizes a watershed-based approach, which can include protection and/or restoration of wetlands and riparian areas.

Section 401 of the Clean Water Act.

Certification verifying compliance with a State or Tribe's water quality standards and other requirements is necessary is required for federally-permitted or licensed activities that involve discharges to waters of the U.S.

Section 402 of the Clean Water Act (National Pollutant Discharge Elimination System (NPDES)).

Clean Water Act Section 402 establishes a program to regulate the discharge of a pollutant (other than dredged or fill materials, which are covered under Section 404 of the Clean Water Act) from a point source into waters of the U.S. The Section 402 Program is administered at the Federal level by the EPA. A State or Tribe, however, can be authorized to administer all or part of the program, upon approval by the EPA. As of 1998, 43 States have assumed the NPDES program.

The CWA defines a "discharge of a pollutant" to mean any addition of any pollutant to navigable waters from any point source. The term "pollutant" is defined as dredged spoil, solid waste, sewage, sewage sludge, chemical wastes, biological materials, industrial, municipal, and agricultural waste, etc. discharged into water. A "point source" is a discernible, confined and discrete conveyance, such as a pipe, ditch, channel or sewer, etc. from which pollutants are or may be discharged.

The CWA prohibits discharge of a pollutant from a point source except in accordance with a permit. Discharges to waters of the U.S. may be authorized by obtaining and complying with the terms of a National Pollutant Discharge Elimination System (NPDES) permit. NPDES permits commonly contain numerical and narrative limits on the amounts of specified pollutants that may be discharged. These "effluent limitations" implement both technology-based and water quality-based requirements of the Act. Technology-based limitations represent the degree of control that can be achieved by point sources using various levels of pollution control technology. In addition, if necessary to achieve compliance with applicable water quality standards (see Section 303 above), NPDES permits must contain water quality-based limitations more stringent than the applicable technology-based standards.

Section 404 of the Clean Water Act.

CWA Section 404 establishes a program to regulate the discharge of dredged or fill materials into waters of the U.S. At the Federal level, the U.S. Army Corps of Engineers and the EPA administer the 404 program. The U.S. Fish and Wildlife Service and the National Marine Fisheries Service have important advisory roles.

The U.S. Army Corps of Engineers has the primary responsibility for the permit program and is authorized, after notice and opportunity for public hearing, to issue permits for the discharge of dredged or fill material. EPA's responsibilities include development of the environmental guidelines by which permit applications are evaluated and review of proposed permits. States can assume a portion of the permit program from the Federal government. As of 1998, Michigan and New Jersey have assumed the 404 program.

The basic premise of the Section 404 program is that no discharge of dredged or fill material can be permitted if a practicable alternative exists that is less damaging to the aquatic environment, or if the nation's waters would be significantly degraded. Accordingly, applicants for a Section 404 permit must demonstrate that no practicable alternative exists that would meet the basic purpose of the project and have less impact on the aquatic environment. Once potential impacts to the aquatic environment have been avoided and minimized to the maximum extent practicable, applicants are required to provide practicable compensatory mitigation, such as wetlands restoration or enhancement, to offset any remaining adverse effects.

Coastal Zone Act Reauthorization Amendments of 1990, Section 6217(g).

This program is jointly administered by EPA and National Oceanic and Atmospheric Administration (NOAA), and calls upon states to develop and implement State Coastal Nonpoint Source Pollution Control Programs. EPA and NOAA have developed guidance specifying management measures for nonpoint source pollution affecting coastal waters (*Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters*, EPA/84-B-92-002). Included in this guidance is a chapter on protection and restoration of wetlands and riparian areas, and the use of vegetated systems for nonpoint source control.

The Endangered Species Act (ESA).

The 1973 Endangered Species Act provides for the conservation of ecosystems upon which threatened and endangered species of fish, wildlife, and plants depend. Among other things, the ESA prohibits unauthorized taking, possession, sale, and transport of threatened and endangered species. It also requires Federal agencies to insure that any action authorized, funded or carried out by them is not likely to jeopardize the continued existence of listed species or modify their critical habitat. The U.S. Fish and Wildlife Service and National Marine Fisheries Service can provide information on the location of threatened or endangered species and their habitats.

Fish and Wildlife Coordination Act.

This Act authorizes the U.S. Fish and Wildlife Service and the National Marine Fisheries Service to cooperate with Federal, State, public, and private organizations in the protection of wildlife (including fish) and its habitat. It also requires that impacts to wildlife be given equal consideration in water-resource development programs. The U.S. Fish and Wildlife Service and the National Marine Fisheries Service must be contacted regarding all new Federal water projects or federally-authorized water projects that modify streams or other bodies of water.

Magnuson-Stevens Fishery Conservation and Management Act.

The 1996 amendments to this Act require the Fishery Management Councils to describe "essential fish habitat" (EFH) for managed fish, including shellfish. The Act also requires Federal agencies to consult with National Marine Fisheries Service on any federal action (including those federally-funded or authorized) that may adversely affect EFH. National Marine Fisheries Service regulations emphasize the use of existing coordination processes (e.g., National Environmental Policy Act, Fish and Wildlife Coordination Act) for accomplishing EFH consultation. National Marine Fisheries Service is required to provide EFH conservation recommendations to both Federal and State agencies whose actions would adversely affect EFH. Federal agencies are required to respond to these recommendations.

Migratory Bird Treaty Act (as amended).

This Act implements four international treaties that individually affect migratory birds common to the United States, Canada, Mexico, Japan, and the former Soviet Union. The Act establishes Federal responsibility for protecting and managing migratory and nongame birds, including the issuance of permits to band, possess or otherwise make use of migratory birds, and the establishment of season length, bag limits, and other hunting regulations. Except as allowed by implementing regulations, the Act makes it unlawful to pursue, hunt, kill, capture, possess, buy, sell, purchase, or barter any migratory bird, including the feathers or other parts, nests, eggs, or migratory bird products.

National Environmental Policy Act (NEPA).

NEPA requires Federal agencies to make informed, environmentally-responsible decisions when considering Federal actions that may have a significant impact on the environment, such as when issuing a Section 404 permit. Generally, agencies must evaluate potential environmental consequences of proposed actions using Environmental Assessments (EAs) and/or Environmental Impact Statements (EISs).

National Wild and Scenic Rivers Act.

This Act selects certain rivers of the nation that possess outstandingly remarkable scenic, recreational, geologic, fish and wildlife, historic, cultural, or other similar values; preserves them in a free-flowing condition; and protects them and their immediate environment for the benefit and enjoyment of present and future generations. It describes procedures and limitations for the control of lands in federally-administered components of the system and for dealing with the disposition of lands and minerals under Federal ownership. Rivers are classified as wild, scenic or recreational, and various prohibitions on the use of the waters and land apply, respectively. To preserve its current free-flowing condition, a designated river is protected from federally-supported dam building and other federally-authorized structural changes which would adversely effect the values upon which its designation was based.

National Historic Preservation Act.

This Act provides for the preservation of significant historical features (buildings, objects and sites). It established a National Register of Historic Places. Federal agencies are directed to take into account the effects of their actions on items or sites listed or eligible for listing in this National Register.

Appendix III

FEDERAL FUNDING SOURCES

EPA's Clean Water Act State Revolving Fund (SRF)

Purpose: Provides grant funds to States to help them establish state revolving fund (SRF) programs. States, in turn, offer loans and other types of financial assistance from their SRFs to municipalities, individuals, and others for high-priority water quality activities.

Projects: While traditionally used to build or improve wastewater treatment plants, loans are also used increasingly for: agricultural, rural, and urban runoff control; wetland and estuary improvement projects; stormwater flow control and sewer overflows; alternative treatment technologies such as constructed wetlands.

Assistance: States offer loan rates that are two to four percent below market rates. Some states offer even lower interest rates to small, economically disadvantaged communities. 1999 budget: $1.35 billion.

Eligibility: Municipalities, individuals, communities, citizen groups, and non-profit organizations, though each State ultimately determines eligibility.

Address: U. S. EPA, Office of Wastewater Management, 1200 Pennsylvania Avenue, N.W. (4204), Washington, DC 20460
Phone: (202) 564-0748
Facsimile: (202) 501-2338
E-mail: srfinfo.group@epa.gov
Web Site: www.epa.gov/OWM

EPA's Nonpoint Source Implementation Grants (319 Program)

Purpose: To help States, Territories, and Tribes develop and implement programs to prevent and control nonpoint source pollution, such as creating constructed treatment wetlands to clean-up urban runoff and agricultural wastes.

Projects: States, Territories, and Tribes receive grant money (and may then provide funding and assistance to local groups) to support a wide variety of activities, such as technical assistance, financial assistance, technical programs, education, training, technology transfer, demonstration projects (e.g., best management practices), and monitoring specific to nonpoint source implementation.

Assistance: Grants are first awarded to State agencies. Local organizations can then apply for grants through the agencies, but they must provide 40 percent of the total project or program cost as non-federal dollars. 1999 budget: approx. $200 million.

Eligibility: State, Local, and Tribal governments, nonprofit and local organizations, etc. (Check with your state contact.)

Address: U.S. EPA, Office of Wetlands, Oceans, and Watersheds, 1200 Pennsylvania Avenue, N.W. (4502F), Washington, DC 20460
Phone: (202) 260-1799
Facsimile: (202) 260-2356
E-mail: ow-general@epa.gov
Web Site: www.epa.gov/owow/NPS

Appendix IV

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Appendix V

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1200 Pennsylvania Avenue N.W. (4204), Washington, DC 20460
(292) 564-0748.

EPA Wetlands Division
1200 Pennsylvania Avenue N.W. (4502F), Washington, DC 20460,
(202) 260-1799

EPA Wetlands Information Helpline
(800) 832-7828, email: wetlands-hotline@epa.gov

National Marine Fisheries Service
Office of Habitat Conservation, 1315 East-West Highway, Silver Spring, MD 20910
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U.S. Bureau of Reclamation: Land Suitability and Water Quality
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(303) 445-2458

U.S. Fish and Wildlife Service
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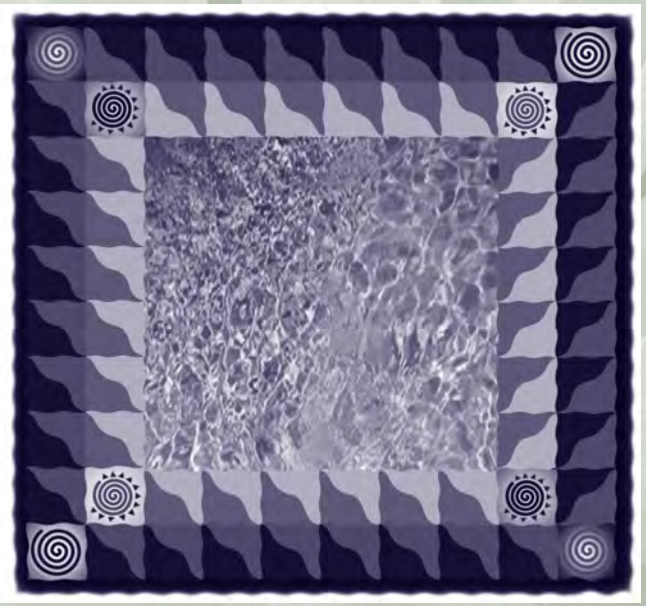

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APPENDIX U

PUBLIC OPINION SURVEY

Atlantic Gold

Moose River Gold Mine Survey

EXECUTIVE SUMMARY

September 2007

Prepared By

Peter M. Butler PhD

TABLE OF CONTENTS

INTRODUCTION

The findings presented in this summary are based on a survey of the opinions of Nova Scotians who are residents of the provincial riding of Eastern Shore, as well those who are residents of the Halifax Regional Municipality portions of Colchester Musquodoboit Valley and Guysburough-Sheet Harbour. The survey was carried out by NRG Research Group with offices in Vancouver, Calgary and Winnipeg. The objectives of the study as outlined below was to assess the attitudes of respondents on issues relating to the mining industry and the proposed development of a gold mine in the Moose River area.

The analysis presented in this report is based on data gathered from a sample of 502 respondents 18 years of age and older drawn from the voting population of the ridings. The survey was conducted by telephone from Winnipeg between September 19th and September 22nd, 2007. The sample frame provides a sufficient number of cases to be accurate to within +/- 4.5 percentage points, 95 out of 100 times.

Research consultant for the study was Dr. Peter M. Butler of Halifax who was assisted by Andrew Enns, Senior Vice President, NRG Research Group, Winnipeg Manitoba and David Dudka of Halifax.

OBJECTIVES

The purpose of this study was to assess the attitudes of residents of respondents, to the mining industry and its contribution to the economy of the area and in particular to attitudes and opinions about the proposed development of a gold mine in the area. Within this overall objective, the study was designed to yield information on the following:

- Key local and provincial issues on the minds of respondents with special reference to the economy of the ridings selected for study;
- Opinions about the importance of the mining industry relative to other industries in stimulating economic growth;
- Awareness and support for the proposed Moose River gold mine;
- The basis of support for parties and leaders in the event of a provincial election.

METHODS

To achieve the research objectives, the survey consultant recommended a quantitative research approach. This involved a telephone interview conducted from the NRG Research call center in Winnipeg, Manitoba.

The data was collected using a Computer Aided Telephone Interviewing System (CATI). This technique was employed as it is the most cost-effective means for collecting public opinion data. Taking an average of fifteen minutes to complete, calls were placed between the hours of 6PM and 9:30 PM Halifax time.

The population consists of all residents of Eastern Shore, Musquodoboit Valley and Sheet Harbour, 18 years of age and older. Male and female respondents were selected in proportion to the population of the areas, using a 50/50 sex quota. A total of 502 interviews were completed, with 307 in Easter Shore, 96 in the Musquodoboit Valley and 99 in Sheet Harbour.

Effective survey research must be based on a sample truly representative of the universe of interest. A systematic random sampling technique was employed to gather the data for this study, which produces a random sample with probability of selection proportionate to size.

SUMMARY OF FINDINGS

THE ISSUES

The top of mind issues for residents of this region of Nova Scotia, at this time, have to do with the *economy* (13%), *road maintenance (11%) and crime (10%)* (see Table 1). It is also interesting to note that *crime* is identified more frequently than *health care* as an unaided third choice. Other important issues included taxes/property taxes and Health Care. In unaided mention, the proposed Moose River Gold Mine was mentioned by only 1% of the respondents. One in five residents (21%) were unable to identify any issue that is very important to their community.

Table 1: Top Issue

Top Issue	Top Mention	1st + 2nd Mention
Employment/Economy	13%	18%
Road Maintenance	11%	21%
Crime	10%	14%
Taxes/Property Taxes	8%	13%
Health Care	8%	12%
Cars/Speeding	2%	4%
Environment	4%	8%
Public Transportation	3%	5%
Education	3%	5%
More Children's Activities	3%	4%
Communications/High Speed	2%	4%
Gas Prices/Fuel Prices	2%	3%
Moose River Pit Mine	**1%**	**1%**
Watershed Issues	1%	1%
Other	7%	15%
Don't Know	21%	N/A

Top Three Issues by Region

Eastern Shore	Guysburough-Sheet Harbour	Colchester-Musquodoboit Valley
Crime (13%) Road Maintenance (10%) Taxes (10%)	Employment/Economy (21%) Road Maintenance (17%) Health Care (12%)	Employment/Economy (31%) Health Care (10%) Road Maintenance (8%)

When the three ridings (regions) are considered separately the relative importance of the issues changes. Concerns about *employment* and the *economy* are considered the most important issues by residents of Guysburough-Sheet Harbour (21%) and especially by residents of Colchester-Musquodoboit valley (31%). By contrast, there is little consensus among respondents of Eastern

Shore on what the top issues facing the area are at present. But clearly, they are much less concerned about matters relating to the economy than are other residents of eastern Nova Scotia. The most frequently mentioned concerns are *crime* (13%) *road maintenance* (10%) and *taxes* (10%). These tend to be second and third choices respectively, in the other two ridings. The development of the Moose River mine is clearly not an important issue to voters in any of the ridings at this time.

Overall, there are few demographic effects on perceptions of these issues. Concerns about employment and the economy are most likely to be expressed by residents in the *35-54 age* (16%) cohort as well as those who are *middle income* earners (20%). This issue is also more likely to be a concern among those who have lived in the areas for twenty or more years.

The effect that top issues could have in determining the way residents of these eastern ridings might vote in a provincial election is captured in Table 2. As shown, a majority of respondents (27%) offer a **don't know** response to the question '*what is the most important issue in determining which party you will vote for in the next provincial election?*' On the other hand, there is clearly some association between perceptions of the top issues and their opinion about what could influence the way they will vote.

Table 2: Most Important Issue To Vote Intention

	%
Creating More Jobs	10%
Economy	9%
Candidate/Party Platform	7%
Ending right to strike for Health Care Workers	2%
Environment (General)	6%
Education	5%
Honest/Trustworthiness of candidate	5%
Health Care (General)	5%
Taxes	4%
Reducing Wait Times	2%
Moose River Gold Mine	**<1%**
Community Safety	<1%
Other	12%
Don't Know	27%

Most Important Issue To Vote Intention by Riding

Eastern Shore	Guysborough-Sheet Harbour	Colchester-Musquodoboit Valley
Economy (10%) Party Platform (8%) Candidate Honesty (7%)	Creating Jobs (15%) Economy (7%) Environment (7%)	Creating Jobs (20%) Economy (8%)

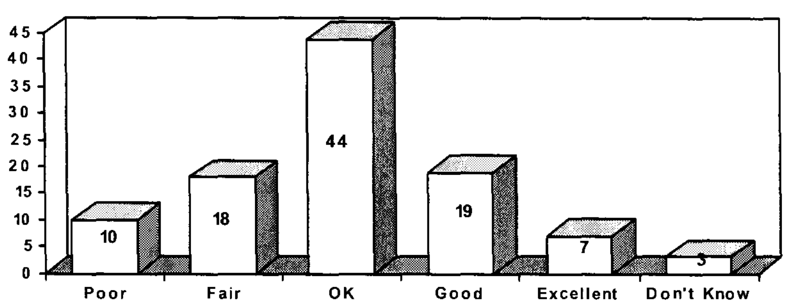
About one in five (19%) residents of this area of Nova Scotia, indicate that *job creation* and the *economy* will be an important influence on their voting choices. Moreover, also shown in Table 2 this perception is shared in each of the three ridings, but it is a view which is most frequently expressed by residents of Colchester-Musquodoboit Valley (20%). Two other points are worthy of note here; candidates and party platforms receive less than 10% of mentions overall, yet candidate honesty appears to have some significance among residents of Eastern Shore. And, among these residents of Eastern Shore where *crime* is identified as the top issue *community safety* receives 1% of mentions. Clearly these are not very structured opinions! Secondly, the proposed Moose River mine development appears not to resonate as a potential campaign issue at all!

The economy and jobs as a vote driver is most often mentioned by respondents who are under 55 years old ; as well as those who are *high income earners* ($80,000+) and those who are longer term (over ten years) residents of the area. Indeed, it should be noted that the refusal rate on this question was extremely low at 4% indicating that we might have some confidence in the reliability of the answers.

PERCEPTIONS OF THE LOCAL ECONOMY AND ECONOMIC GROWTH

Given the importance of economic issues to the people of these ridings in eastern Nova Scotia, it is interesting to find that respondents are generally positive about it. A majority (44%) of the ratings of the local economy cluster at **3** on a scale of 1(poor) to 5(excellent) with a mean overall rating of **2.9**. These findings are summarized in Table 3. The table also shows that ratings are higher than the average rating (X=3.2) in the Eastern Shore riding and lower than average in the other two ridings. Females, *younger* respondents (18-2years) middle income earners ($30K - $80K per annum) are most likely to give above average ratings to the local economy.

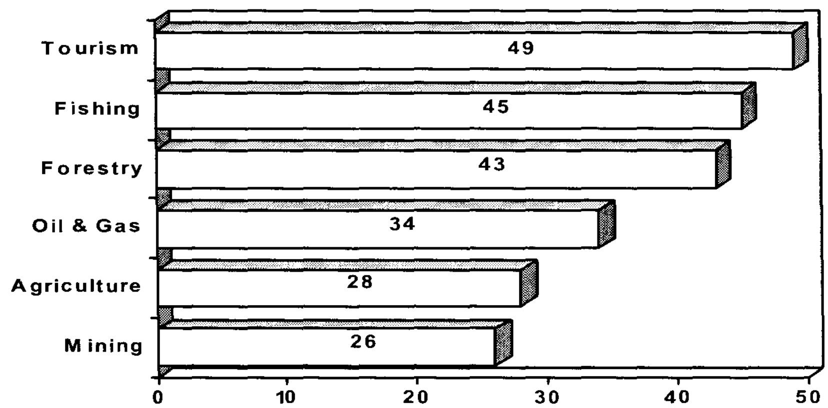
Table 3: Ratings of the Local Economy



Eastern Shore	Guysburough-Sheet Harbour	Colchester-Musquodoboit Valley
3.2	2.5	2.5

Opinions about the ability of the mining industry to stimulate future economic growth relative to six other industries which are important to this province. Are presented in Table 4, They are: *mining, tourism, fishing, forestry, agriculture* and *oil and gas.*

Table 4: Industries That Are Important to Future Economic Growth



A majority of respondents (49%) identify the tourism industry first with future economic growth and the mining industry last (26%). Residents of Musquodoboit Valley (53%) are the most likely to believe tourism is the pathway to a better economy as are people who are over 35 years (50%); *middle and high income earners* and those who have lived in the region for less than 5years. The fishing industry is mentioned as the second (45%) most important industry for growth in the region. Again this view is most likely to be expressed by residents of Musquodoboit Valley (65%). It is also most often identified by females and respondents who are over 50 years of age, Those who mention mining as being important to growth tend to be residents of the Guysburough-Sheet Harbour riding, and are most likely to be males.

In sum, opinions of the industries which will foster economic growth do not favour mining. At this time residents of the three ridings do not perceive that this industry will contribute much to the economy. And despite the seasonal nature of tourism and the short term employment opportunities offered in this industry, respondents believe it is a good employer for the area.

AWARENESS AND SUPPORT OF THE MOOSE RIVER GOLD MINE PROPOSAL

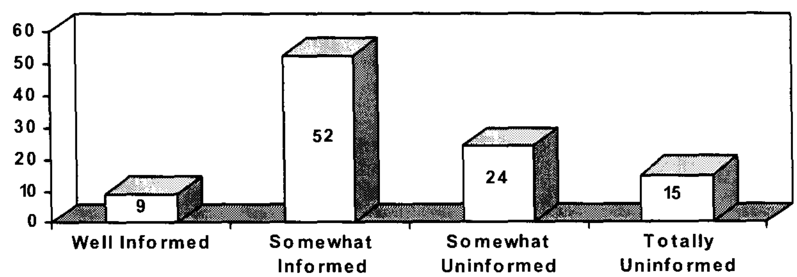
Two out of every three (66%) respondents have heard of the proposal to develop a gold mine in Moose River. The most familiar are residents of Guysburough-Sheet Harbour (Table 5) although a majority of the residents in each riding have heard of the project. Moreover, long term residents of the three areas, those who have resided in the areas for over thirty years are most likely to be familiar with the proposal (79%), correspondingly people who are *55 years* (76%) and older are also most familiar with it.

Table 5: Awareness of the Gold Mine By Area

Eastern Shore	Guysburough-Sheet Harbour	Colchester-Musquodoboit Valley
59%	75%	81%

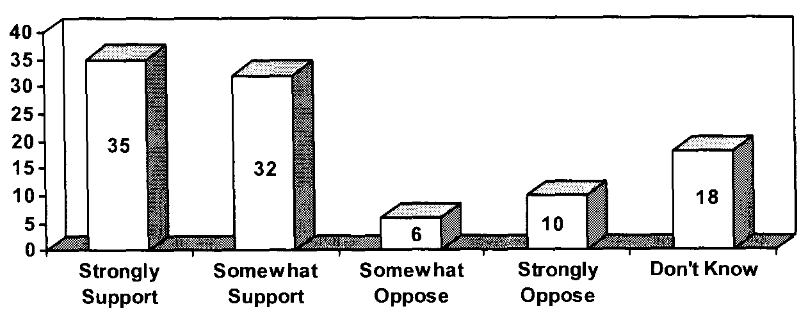
Table 6 also shows that a majority of respondents (61%) indicate they are informed about the proposed development of the gold mine. This belief is most likely to be offered by residents of Musquodoboit Valley (69%), *residents over 55 years*, and *middle income earners*. About 39% are uniformed and are most likely to be residents of Eastern Shore (44%), females (43%) *younger residents*. 18 –24 years old (48%) and higher income earners. Although these percentages reflect small numbers and offer only directional information.

Table 6: Feel Informed about the Proposed Gold Mine



A majority of respondents report that their main sources of information about the proposed gold mine are found in newspapers, as well as radio and television reports. This is true for all demographic groups in the sample. Word of mouth reports from neighbours and news from other residents is being reported by only one in every five respondents (20%) Moreover, meetings and community associations are reported as a source of information by a small minority of those interviewed (4%). Therefore, it appears that an effective public information campaign which may be contemplated, should be directed at news releases which might be carried by the media.

Table 7: Support and Opposition To The Gold Mine Proposal



Eastern Shore	Guysburough-Sheet Harbour	Colchester-Musquodoboit Valley
61%	75%	82%

There is clearly majority support for this project being expressed by residents of the areas studied. Again, over two thirds of respondents (68%) support the proposal (see Table 7). In fact over one in every three (35%) has indicated that they *strongly* support the proposal while only 15% are opposed to it. The Table also shows Colchester-Musquodoboit Valley residents are most likely to be in favour of further development of the mine. These are most likely to be *males* (70%), those who are *first time voters* (18-34 years) as well as lower and middle income earners of the area. Those who have lived in the ridings for over thirty years (79%) tend to be the strongest supporters of the project

Opponents of the development indicate they are concerned with its *environmental impact* (30%), *water quality impact* (25%) and possible *pollution* (21%). On the other hand it appears that they would be most likely to consider supporting the mine development if the developer **exceeds** provincial environmental standards and receives government approval (See Table 8). However, the table also indicate that 42%, the largest proportion of respondents would remain opposed to the project regardless of what is done.

Table 8: Opponent Would Switch If……

	%
Developer meets all provincial environmental standards and received government approval.	13%
Developer exceeds all provincial environmental standards and received government approval.	38%
Both of the Above	1%
None of the Above	42%
Don't Know	5%

In summary, the proposal to develop the gold mine general appeals to the residents of the three ridings. The residents of Eastern Shore riding are the least supportive of the concept of the three groups of residents but nevertheless show that a majority (61%) are in favour of seeing it happen. Communications about the project will have to be carefully crafted as it appears that many opponents will remain that way regardless of how it is presented, mainly because they fear the environment impacts associated with mining projects. On the other hand, employment and the economy is likely to be a vote driver for all three ridings in the event of a provincial election. Communications relating to the project would be advised to emphasize the economic benefits of a gold mine, in a part of Nova Scotia that has few options. The belief in the environmental friendliness of tourism needs to be addressed as it is simply a seasonal industry that won't employ enough people to make it an alternative. That said, mining must be presented as less of environmentally unfriendly source of jobs, if it can be. The levels of public concern about the environment will dominate any media story on mining development projects in the near future and it will prove to be a difficult project to sell to public opinion in the Halifax area, where the media is located, even if job creation is a reasonable outcome of the development.

Appendix A
Survey Instrument

Appendix B
Data Tables

APPENDIX V

TMF DAM FAILURE STUDY

Golder Associates Ltd.

2390 Argentia Road
Mississauga, Ontario, Canada L5N 5Z7
Telephone: (905) 567-4444
Fax: (905) 567-6561

Golder Associates

REPORT ON

DAM BREAK FLOODING STUDY
ATLANTIC GOLD
TAILINGS MANAGEMENT AREA
TOUQUOY, NOVA SCOTIA

Submitted to:

Atlantic Gold
Suite 701
220 Pacific Highway
Crows Nest, NSW, 2065
Australia
Attention: Peter Carter
General Manager Operations

DISTRIBUTION:

1 Copy - Atlantic Gold
1 Copy - Golder Associates Ltd.

October 2007 07-1118-0041 (2000)

EXECUTIVE SUMMARY

Golder Associates Ltd. (Golder) has been retained by Atlantic Gold (Atlantic) to provide a preliminary design of the tailings management area (TMA) as part of the project feasibility study. A dam break study for the proposed tailings dams is part of Golder's scope of work. The findings of the dam break study are presented in this report.

The primary objective of the dam break study was to evaluate potential failure mechanisms of the proposed TMA containment structures and the resulting downstream impacts. The failure mechanisms considered were piping, overtopping, and embankment failure due to earthquake or other unknown causes with or without the release of the retained tailings pond. Dam breach due to water erosion has the greatest potential for tailings release and transport downstream. Embankment failure for a non-water retaining structure may result in a flow slide of the liquefied tailings (mud flow).

The dam breach analyses presented in this report do not consider the probability of failure; it was assumed that any dam could potentially fail.

There are a total of five dams at the Touquoy TMA: Dams A, B, C (containment sections of the TMA Pond) and Dams D and E (containment sections of the Polishing Pond, Figure 3). From the perspective of dam breach modelling, the selected dams are identical in terms of configuration, but different in elevation, and volume of retained water.

The following scenarios were reviewed:

1. Piping failure of Dam B followed by either piping or overtopping of Dam E, and
2. Overtopping failure of Dam B followed by either piping or overtopping of Dam E.

The results of the dam breach analysis are presented in Table 3.

The most likely and conservative scenario is the piping failure of Dam B followed by either piping or overtopping failure of Dam E.

DAM EROSION AND FLOODING ANALYSIS

The numerical modelling of dam failure due to piping and overtopping involved simulation of the dam breach formation. The analysis was based on the US National Weather Service (NWS) – BREACH model. For each dam, the numerical model provided estimates of the peak flow through the dam breach, the breach dimensions, and timing of the dam failure. Because of the short distance between the Polishing Pond Dam and Scraggy Lake (approximately 300 m), the flood wave movement downstream of the breached dam was not simulated with an specific model.

Modelling Assumptions:

- The analysis was carried out for the TMA configuration just prior to closure.
- Dam failure may occur due to either piping or overtopping. Piping is the most plausible mechanism of failure. Dam overtopping cannot happen under ordinary circumstances because all dams have been designed to contain the Probable Maximum Flood (PMF). Overtopping may happen, however, if the spillway is blocked, due to lack of maintenance.
- The emergency spillways of the dams were considered to be completely blocked which gives a very conservative approach to this analysis.
- The selected basic scenario is the piping failure of Dam B followed by either piping or overtopping failure of Dam E.

Results of Dam Breach Analysis

The simulated peak discharge through the dam breach, the time of the peak discharge occurrence, breach characteristics and the volume of water released are shown in Table 3.

TMA Dam B Piping Failure

- The estimated total volume of water released from the TMA as a result of the piping failure is 1.79 million m^3.
- The estimated time of the dam failure is 7.0 hours and the peak discharge through the breached dam would occur approximately 18 minutes after the beginning of the piping failure (Figure 5).
- In the event of piping failure, the breach had a trapezoidal shape with a width of 36.6 m at the top, a width of 7.6 m at the bottom, and a depth of 14.0 m from top to bottom.
- The estimated peak discharge through the dam breach is 1, 200 m^3/s.

Polishing Pond Dam E Piping and Overtopping Failure Following Piping Failure of Dam B

- The entire tailings pond will be drained in both modes of the failure. The estimated total volume of water released from the TMA as a result of the overtopping failure is 2.45 million m^3. The estimated total volume of water released from the TMA as a result of the piping failure is 2.1 million m^3. Therefore, the downstream flooding is more severe in the event of dam failure due to overtopping than due to piping.
- The estimated time of the dam piping failure is approximately 8.0 hours and the peak discharge would occur approximately 31 minutes after the beginning of the failure. Whereas the estimated time of overtopping failure is approximately 6.0 hours and the peak discharge would occur approximately 21 minutes after the beginning of the failure (Figures 6 and 7).
- In the event of piping failure, the breach had a trapezoidal shape, with a width of 11.9 m at the top, a width of 4.6 m at the bottom, and a depth of 7.3 m from top to bottom.

- In the event of overtopping failure, the breach had a trapezoidal shape, with a width of 24.7 m at the top, a width of 8.8 m at the bottom, and a depth of 7.3 m from top to bottom.
- The estimated peak discharge through the dam breach is 500 m^3/s in case of piping failure and 1,000 m^3/s in case of overtopping failure.

Results of Downstream Flooding Analysis

The flood wave movement was not modelled because of the short distance from the breached dam to Scraggy Lake (approximately 300 m). Scraggy Lake has a water surface area of 698 ha and 21 million m^3 of water. In case of dam failure, the flood wave movement will be attenuated by the lake. As a result of the dam failure, the surface water level of the lake would increase by 35 cm in the most conservative scenario of failure (Dam E failure following Dam B piping failure).

MUD FLOW ANALYSIS

Dam failure due to an earthquake is the most likely scenario. The width of the breach is likely to be less than 100 m. Based on the analysis, the spilled tailings would travel a distance of approximately 600 m. In this case, most of the material of the flow slide will be retained in the Polishing Pond downstream of Dam B (the Polishing Pond length is approximately 550 m). The volume of released tailings was estimated to be 500,000 m^3 which is considered to be very conservative since it does not consider the internal dyke which will limit tailings accumulation behind Dam B.

CONCLUSION

The overall conclusion from the dam break analysis is that significant environmental or ecological impact is not anticipated in the event of failure of the dams. At present human safety risks are low as the downstream areas are not inhabited. Physical impact would be limited to a potential increase in the water level of Scraggy Lake by about 35 cm under the most likely and significant failure scenario (piping failure of Dam B followed by overtopping of Dam E) and the deposition of approximately 24,500 tonnes of sediments in the bottom of the lake. This would have a significant immediate impact on the fish population and habitat in Scraggy Lake but is not anticipated to be a long-term issue (fish habitat can be regenerated).

A comprehensive care, maintenance and surveillance program should be established to ensure the long term stability of the tailings facility. Of prime importance will be management of the pond water level and maintenance of the spillways.

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APPENDIX W

MOOSE MANAGEMENT PLAN

MOOSE (*Alces alces americana*) MANAGEMENT PLAN
FOR TOUQUOY GOLD

INTRODUCTION

Eastern moose (*Alces alces americana*) in mainland Nova Scotia have been listed as "endangered" under the *Nova Scotia Endangered Species Act* (NSESA) (2003). Historical records of eastern moose in the Moose River Gold Mines area are limited; however moose were abundant across the landscape prior to European settlement (Parker 2003, Snaith and Beazley 2004) and may have used habitats in and around the Project area. Nova Scotia has undergone significant habitat conversion, degradation and fragmentation due to human activities since European settlement. As a result, the small and fragmented moose populations remain at varying densities and may be limited by small population sizes, reproductive fecundity, interspecific competition, mineral toxicity/deficiency, depredation, disease, resource availability and habitat alteration/loss (Snaith and Beazley 2004). Based on Parker (2003), 10 distinct moose populations occur on mainland Nova Scotia including (in order of density), Cobequid (600), Tobeatic (150), Antigonish-Guysburough (80), Sable (50), Chebucto (30), Pictou (25), Sheet Harbour (20), Pubnico (20), Woods Harbour (15) and Slave (15). Further communication with NSDNR regional biologist Doug Archibald (NSDNR 2006) confirmed an additional population (20) in the Tangier Grand Lake Wilderness Area. (See Figure 9.5 of the Environmental Assessment Registration Document for the Touquoy Gold Project for locations of mainland moose populations).

To address mainland moose populations as required by the NSESA (2003), the Nova Scotia Mainland Moose Recovery Team worked in conjunction with the Nova Scotia Department of Natural Resources (NSDNR) to develop the "Recovery Plan for Moose in Mainland Nova Scotia" (NSDNR 2007). The objectives of the recovery plan are to maintain and enhance the current populations, distributions and habitats, mitigate threats that limit recovery and initiate research to address priority knowledge gaps that may impact recovery efforts.

DDV Gold has reviewed the Recovery Plan (NSDNR 2007) and additional draft guidelines set by NSDNR for proponents undertaking environmental assessments in moose habitat on the mainland. The purpose of this report is to establish a Moose Management Plan for DDV Gold to facilitate the exchange of knowledge on mainland moose in the Moose River Gold Mines area with the NSDNR. The Recovery Plan summarizes the actions required to better understand moose populations in mainland Nova Scotia including research, monitoring, management, education and stewardship. DDV Gold, throughout the course of mine development activities, will provide information to fill in knowledge gaps in the areas discussed below.

KNOWLEDGE GAPS

Research

The NSDNR recognized the need for research on mainland moose in Nova Scotia. The NSDNR has proposed actions to be initiated including (1) improving the understanding of the weight and interrelationship(s) of threats and limiting factors, (2) improving the understanding of habitat suitability, availability and selection, and improving efforts to provide insight into the structure and genetic profile of mainland moose, and (3) investigating the cause of death/illness of all moose found dead and apparent "sick' moose (NSDNR 2007). Cumulative long-term habitat loss through development requires research to understand tolerance levels and carrying capacity for moose at the landscape level (NSDNR 2007).

DDV Gold will work with the NSDNR to provide information and assist in reducing existing knowledge gaps in research by:

1. Documenting moose sightings around the development site and providing reports to the NSDNR to help establish trends in population dynamics and provide critical information for the direction of the recovery plan.

2. Performing microhabitat assessments at moose sighting locations (i.e., visual sighting, pellets, footprints) around the Touquoy Gold Project site based on established protocols from the scientific literature. Microhabitat assessments would describe vegetation characteristics and associated habitat predictor variables. Quantitative and qualitative information of habitat selection by moose in mainland Nova Scotia is minimal. Although the NSDNR recommends GPS telemetry collars would provide data on special aspects of their biology, vegetative assessments at moose sighting locations can provide useful information on microhabitat requirements of mainland moose.

3. Documenting accurate knowledge on the health, incidence of disease and mortality rates of moose and immediately providing all information to the NSDNR for research purposes.

4. Working with NSDNR to facilitate a working relationship to maintain habitat connectivity for moose in the landscape surrounding the Touquoy Gold Project site.

5. Partner with appropriate organizations to support and conduct research.

Monitoring

In order to understand the population ecology of Nova Scotia mainland moose, the NSDNR recognized the need for a more rigorous monitoring program. To properly manage mainland moose populations, the NSDNR has proposed actions including (1) initiating a rigorous long-term monitoring program to provide reliable data on the distribution and demographics of moose on the mainland Nova Scotia and (2) establish means of monitoring the impact of severity of each factor (threat) known to inhibit growth of localized moose herds/groups (NSDNR 2007).

At present, pellet group and aerial surveys are the manner in which the distribution and population demographics of moose are evaluated; however NSDNR recognized the problems associated with the existing strategy given they are performed during the winter and provide little information on summer distributions.

DDV Gold will work with the NSDNR to provide information and assist in reducing existing knowledge gaps in monitoring by:

1. Providing long-term seasonal accounts and frequency of occurrence of moose around the Touquoy Gold Project site.

2. Providing staff with information pertaining to the identification of moose and their activities (e.g., age and sex identification, evidence of breeding behaviours) for the purpose of monitoring population demographics.

3. Recording sightings and maintaining a database on-site for NSDNR to review.

4. Providing a better understanding of moose breeding, wintering and rutting grounds in the Moose River Gold Mines area.

Management

The NSDNR acknowledges the demand for proper management of mainland moose to maintain and/or enhance their population status. The NSDNR has proposed actions to be initiated including (1) develop and implement a strategy to reduce poaching, (2) decrease occurrence of preventable mainland moose mortality, (3) determine the feasibility of translocating adult moose and/or orphans from New Brunswick, and (4) review and adapt forest management practices in known moose habitat (NSDNR 2007).

Although DDV Gold is not responsible for managing mainland moose populations, DDV Gold acknowledges their responsibility to conduct appropriate operations with the consideration of moose and moose habitat.

DDV Gold will work with the NSDNR to provide information and assist in reducing existing knowledge gaps in management by:

1. Preventing moose poaching in the area of the site with the use of warning and municipal by-laws signs. Any evidence of moose poaching will be reported to the local RCMP and NSDNR.

2. Reducing motor vehicle collision by limiting all mine vehicles to a 50 km/hour speed limit.

3. Limiting access for moose to the pit areas using berms and fencing. DDV Gold will consult with NSDNR on the success rate of this strategy.

4. Avoiding active wintering/calving areas if any are identified, *i.e.* disturbance will not occur in these areas during active wintering and or calving periods.

5. Limiting use of ATVs on-site for all purposes except those required for mining related activities.

6. Maintaining vegetative buffers to provide moose browse and shelter whenever possible.

7. Controlling public access in the active mine/processing area.

8. Working with NSDNR to minimize disturbance to possible moose habitat, in the event roads and corridors are required outside the active mine site.

9. Consulting with NSDNR during the Project to develop a Land Management Plan and Reclamation Plan.

10. Enacting a no wildlife harassment policy on the Touquoy Gold Project site.

Education

Providing education and awareness to the public (and staff) is paramount to the recovery plan for maintaining and/or enhancing mainland moose populations. The NSDNR has identified the demand for public education of mainland moose and has proposed actions to be initiated including raising public awareness of mainland moose such as, the threats to individuals and populations and the active recovery efforts (NSDNR 2007).

DDV Gold acknowledges their responsibility to educate employees and the public in the local area of the mine on moose and their habitat associations. DDV Gold will work with the NSDNR to provide information and assist in reducing existing knowledge gaps in education by:

1. Providing education and awareness to DDV Gold staff pertaining to the application of the moose management recovery plan.

2. Partnering with related environmental groups to provide public education and awareness on the recovery plan and the associated threats to mainland moose populations.

Stewardship

The NSDNR recognized the need for stewardship to effectively manage mainland moose in Nova Scotia. The NSDNR has proposed actions to be initiated including (1) promote public reporting of poaching and moose observations, (2) engage partners in recovery efforts, and (3) engage landowners in stewardship of mainland moose and their habitat (NSDNR 2007). In addition to the commitments by NSDNR on the recovery of the mainland moose, ongoing support by a wide of dedicated partners including foresters, First Nations, hunters, industry, landowners, universities and conservation organizations in needed (NSDNR 2007).

DDV Gold will work with the NSDNR to provide information and assist in reducing existing knowledge gaps in stewardship by:

1. Offering the local public with a stewardship package of information about the best available management practices to enhance and support mainland moose recovery on their lands, based on recommendations and guidelines outlined by the NSDNR.

SUMMARY

The NSDNR recognized the lack of information on moose populations in mainland Nova Scotia and clearly states that "insufficient qualitative, quantitative, spatial and temporal information exists at this time necessary to identify core habitat for mainland moose". In the best interest in maintaining Nova Scotia mainland moose populations and their habitat, DDV Gold has developed this management plan to assist the NSDNR in their recovery efforts of mainland moose.

REFERENCES

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Snaith, T.V. and K.F. Beazley. 2004. The distribution, status and habitat associations of moose in mainland Nova Scotia. Proceeding of the Nova Scotian Institute of Science 42:263-317.

APPENDIX X

EMPLOYMENT MANAGEMENT POLICY

EMPLOYEE MANAGEMENT POLICY
TOUQUOY GOLD PROJECT
DDV GOLD LTD

HIRING

Given:

- candidates of equivalent merit
- Local area being defined as the Musquodoboit Valley and Eastern Shore within 100 km of the mine site

Will preferentially hire employees living within 100 km of the mine site.

Will hire expatriate Nova Scotians returning home to the local area second.

Will hire Nova Scotians from the rest of the province third.

Will hire from outside Nova Scotia fourth.

Will target 90% of employees to come from the local area.

OPPORTUNITY

Will run job fairs in the Musquodoboit Valley and on the Eastern Shore prior to start-up.

Will preferentially advertise jobs through the three local Job Search Centres (JSCs); Middle Musquodoboit, Porter's lake, and Sheet Harbour.

Will aid employees in achieving high school equivalency.

Will provide equal opportunity employment.

TRAINING

Will collaborate with JSCs to identify eligible candidates for pre-employment training.

Will take advantage of provincial programs to offer employment to qualified candidates with limited work experience.

Will partner with local institutions to develop and offer training which could lead to employment.

Will partner with local institutions and industry to develop certification programs in non-traditional fields.

Will assist employees in achieving trade certification.

Will support apprentice programs.

CONTRACTORS

Given:

- Contractors of equivalent merit:

Will preferentially hire contractors based within 100 km of mine site.

Will require significant, continuous, long-term contractors to target 75% of employees from local area.

Where:

Significant	= > 10 employees
Continuous	= personnel on site > 3 days per week more than 1 week per month
Long-term	= contracts lasting more than 1 month

OTHER

Will have a dedicated human resources manager.

Will offer industry competitive wages.

Will offer summer employment to full-time students with preference given to:

Students from Nova Scotia enrolled in minerals engineering, earth sciences and environmental studies.

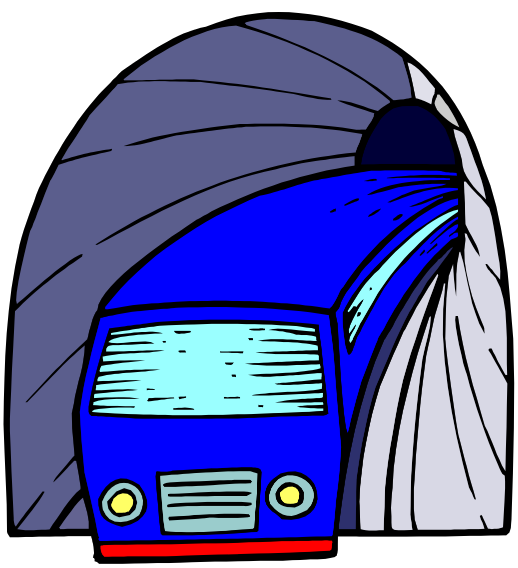
Students from the local area given students of equivalent merit.

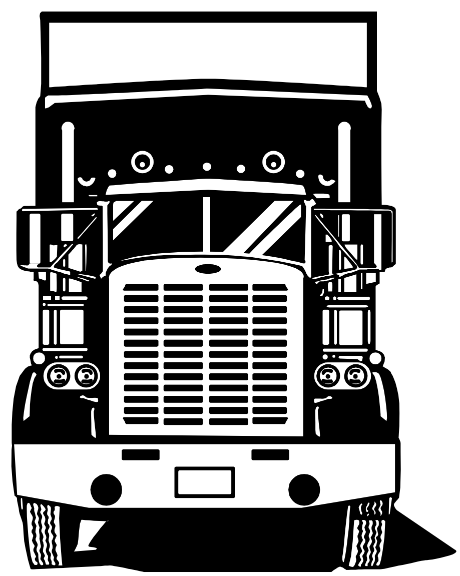
APPENDIX Y

CYANIDE TRANSPORT ROUTE REPORT

Atlantic Gold Route Risk Assessment

Rail/Truck Service





DUPONT®

The miracles of science®

DuPont Canada Transportation Route Risk Assessment

Atlantic Gold Mine – Halifax-Truro, Nova Scotia

INTRODUCTION

Du Pont Canada is a diversified science company, headquartered in Mississauga, Ontario and serving customers across Canada and in more than 40 other countries. From our beginnings in 1877, our strength has been our ability to meet the needs of our customers. Today, we deliver science-based solutions that make real differences in people's lives around the world in areas such as food and nutrition, health care, apparel, safety and security, construction, electronics and transportation. Look closely at the things around your home and workplace, and chances are, you'll find dozens of items made with DuPont materials.

Our corporate vision is to be the world's most dynamic science company, creating sustainable solutions essential to a better, safer, healthier life for people everywhere. As we work towards this vision we do so while ensuring we fully adhere to our core values. Safety, concern and care for people, protection of the environment and personal and corporate integrity, are this company's highest values, and we will not compromise them.

DuPont Canada is a member of the Canadian Chemical Producers Association (CCPA). As a CCPA member DuPont fully adheres to the Codes of Practice and Guidelines laid out in the CCPA's Responsible Care® Program. Responsible Care® includes having in place policies and procedures that will address the following Responsible Care® Codes of Practice:

- Community Awareness & Emergency Response (CAER)
- Research & Development
- Manufacturing
- Transportation
- Distribution
- Hazardous Waste Management

The Transportation Code is designed to ensure that chemicals and chemical products are transported in a way that minimizes the risk of injury to people moving the goods, to people along the transportation route, and to the environment. Third-party companies hired to carry companies' goods are expected to operate according to the principles of Responsible Care. Companies must evaluate carriers of their materials on safety performance and programs, inspection and maintenance procedures for equipment, and selection and training of drivers and support staff. If carriers cannot meet the expected standards, they will not be hired. Employees of third-party carriers, and people living in communities along the transportation route, should have access to the same health and safety information as company employees. Transportation routes should be chosen to minimize the exposure of people and environmentally sensitive areas to the potential hazards caused by chemicals and products. Each company will have an up-to-date, operational transportation emergency response plan to deal with hazards, contain and clean up releases, provide technical advisors at accident scenes, and assist local emergency response forces.

DUPONT CANADA MOTOR CARRIER SAFETY AUDIT PROGRAM

The DuPont Canada Motor Carrier Safety Audit process includes a comprehensive on site review of a Motor Carrier with specific attention to the following areas:

- Company Safety Indicators
- Driver Hiring Practices
- Driver Training
- Ongoing Driver Management
- Dangerous Goods Training & Reporting
- Carrier Emergency Response Capabilities
- Driver / Shop Equipment Inspections
- Bulk Tank Maintenance & Inspection (Where Applicable
- Disposal Of Chemical Heels (Where Applicable)
- Carrier Safety/Training Organization
- Carrier Dangerous Goods Experience
- Carrier Security Plan / Customs Accreditation

Following an audit, the motor carriers are issued a rating of Satisfactory or Unsatisfactory based on the result of their Assessment.

SODIUM CYANIDE - EMERGENCY RESPONSE

All DuPont shipping documents for Sodium Cyanide to Canada display the Chemical Transportation Emergency Centre (CHEMTREC) Emergency Response Telephone number. CHEMTREC is a 24/7 resource that coordinates and communicates a broad range of critical information that may be needed by emergency responders to mitigage a hazardous material related incident. They are able to provide technical information that can be conveyed immediately to an incident scene.

DuPont Canada has had in place a Transport Canada registered Emergency Response Assistance Plan (ERAP), since the introduction of the Canadian Transportation of Dangerous Goods (TDG) Regulations in 1985. Our current plan which was last reviewed by Transport Canada in 2007 and found to be in full compliance with Section 7 of the TDG Regulations covers a number of materials for which a Canadian ERAP is required, including Sodium Cyanide. The DuPont Canada ERAP activation number which is shown on all shipping documents in conjunction with our ERAP number rings into the DuPont North American Emergency Response Center located in Belle West Virginia. From that point, any emergency response would be coordinated by trained Technical Advisors who would use a combination of DuPont expertise and professional emergency response personnel, approved under the Canadian Emergency Response Contractors Alliance (CERCA) to deal with the safe handling and remediation of the incident.

Should CHEMTREC receive a call for technical information associated with a transportation incident, they have been advised by DuPont to provide the necessary information and to contact the DuPont North American Emergency Response Center at Belle to assume mitigation.

TRANSPORTATION RISK ASSESSMENT

Projected Transportation Dates:

Packaging: 1 Tonne UN Specification package consisting of a polypropylene super sac with a polyethylene over bag contained in a wooden box.

Projective Volumes: 1,300,000 pounds

Transport Routing – CN Rail to Truro NS / Brookville Transport to Destination

Canadian National Railway

CN rail is a Canadian Responsible Care® partner and have been certified to the Responsible Care Management System. (RCMS). As such, they adhere with the Transportation Code of Practice outlined on Page 1 of this document. DuPont Management of Sodium Cyanide transportation via rail using CN was part of DuPont's Sodium Cyanide Code Audit earlier this year. A copy of the Du Diligence Verification Audit is attached.

Responsible Care ®:

Responsible Care® is a performance improvement initiative established by the Canadian Chemical Producers' Association (CCPA) in 1985, and the American Chemistry Council (ACC) in the United States in 1988. The initiative was launched to address public concerns about the use, manufacture, and distribution of chemicals. Through Responsible Care®, member and partner companies commit themselves to continuous improvement in the areas of employee and public health and safety, and to environmental quality.
Chemical industry associations in more than 45 countries have now embraced the ethic of Responsible Care®. Together, these countries produce more than 80 per cent of the world's total chemical products.

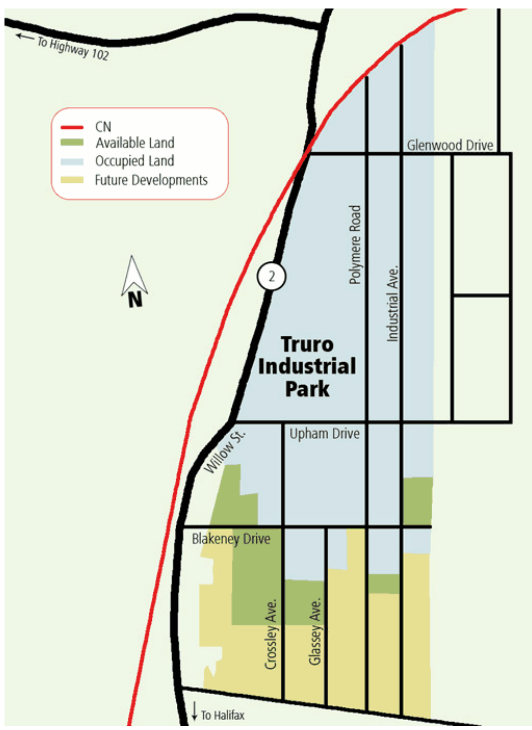
Responsible Care® is a global movement committed to the continuous improvement of all aspects of the chemical industry's environmental, health, and safety performance. It is also dedicated to ensuring openness in communication about its activities and its achievements.

Emergency Response:

Emergency response plans are in place at all major rail yards. For accidents in transit, CN has a trained team knowledgeable in chemical emergency response, and first responders trained through its TransCAER initiative. CN's claims department monitors and settles claims for anyone evacuated from an area due to a rail incident. Trained risk management personnel investigate each incident.

Transfer of Material at CN's Halifax Facility (Truro Industrial Park)

Location: Truro, New Scotia
Park Size: 267 acres
Lot Size: Flexible from 1 to 6 acres
Zoning: Industrial - light and medium
Services: Water
Sewer / storm sewer
Hydro
Highway Access: 1 km from Highway 102 Exit 13
6 km south of Trans Canada Highway Exit 15 via Highway 102
99 km from Port of Halifax
189 km from Moncton, N.B.
Rail Access: Along CN main line and spur line servicing the industrial park
Additional track layout will depend on future lot development
Features: CN yard with public rail access located at 3 km of Truro Industrial Park
Land Owner: Province of Nova Scotia
Colchester Regional Development Agency
Website: www.corda.ca



Brookville Transport

Based in Saint John NB, Brookville Transport operates a fleet consisting of over 200 late model tractors.
Safety is a great concern for Brookville Carriers Van, their customers, the traveling public, and drivers. Brookville's policies and objectives always put safety first. They are committed to operating up-to-date and well-maintained equipment.

In April 2007, Brookville underwent a DuPont Canada Motor Carrier Safety Audit at which time they received a Satisfactory rating, which is the highest rating available under the DuPont Canada protocol.
Personnel at Brookville were given Awareness Training in the safe handling of Sodium Cyanide by DuPont in June 2007.

Transportation Route Risk Assessment

Transport Routing:
CN Rail to Truro NS – Product transfer from railcar to dry van - Brookville Transport to destination.

CN Rail to Truro NS:
Rail route from Memphis, TN to Truro, NS will be determined by CN based on their internal policies and procedures, which consider safety assessments for the movement of any hazardous materials.

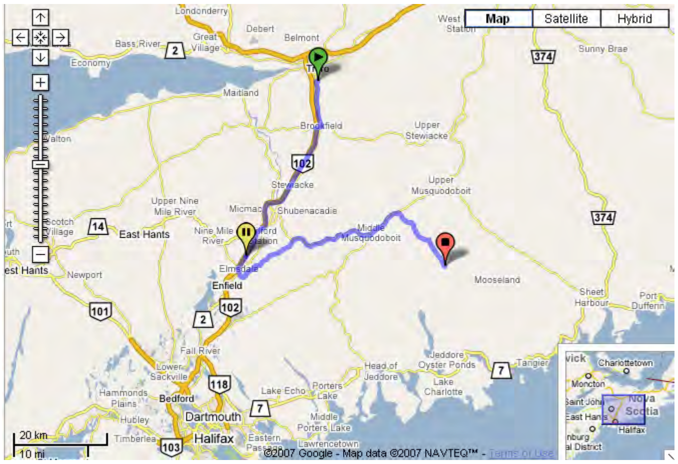
Product transfer from railcar to dry van:
Halifax and Truro are the two main rail yards were the transfer of product could be done close to the final destination. Truro will be utilized instead of Halifax because of the following reasons:

- Shorter rail distance from Memphis, TN.
- Located on a less populated area, reducing the exposure of hazardous materials with any local communities.
- Product would not need to be transported via rail or truck in and out of big urban areas in Truro, as opposed to Halifax, where the rail terminal is located very close to downtown.
- Routing from Truro to final destination avoids passing through major water bodies, reducing an environmental exposure in case there was any incident during transportation.

Brookville Transport to destination:
The entire route from Truro to the final destination has been already reviewed and assessed by Brookville Transport.

Shipments will initially move south through highway 102, as this would be the safest road available and the one that would allow the fastest response in case there were any incidents. Choosing this highway will also avoid passing through local communities.

Trucks would then turn left at exit 8 for Hwy-214 toward Lantz/Elmsdale/Enfield, turning left again at Old Trunk Road (227). Later on they would merge into Hwy-224 continuing on it through Middle Musquodoboit until they turn right at Moose River Road, which would be followed until reaching the mine site location at Moose River-Gold Mine road.



After Brookville's assessment of this route, it has been confirmed that all roads are in good driving conditions and the only concern would be a narrow bridge on Hwy-224, about 20 kilometers before the mine site.

This bridge can accommodate 30 ton logging trucks, so there shouldn't be any problems for truck loaded with sodium cyanide, but regardless of this Brookville will contact local authorities and verify.

Conclusion

The DuPont analysis of this route has been performed in partnership with Brookville Transport & CN Rail. With the information available at this time, it is our opinion that these shipments can be managed safely and securely without incident.

Should there be any questions related to this study please contact: Don Bisson, DuPont Canada, 250-765-8342

Cyanide Code Transportation Due Diligence Verification Audit

AUDIT REPORT

DuPont Management of Sodium Cyanide Transportation via Rail using the Canadian National Railway

Report Date: May 18, 2007

Lead Auditor: Nicole Jurczyk
Technical Auditor: Eric Adair

Management System Solutions, Inc.
www.mss-team.com

AUDIT REPORT

Name of Sodium Cyanide Producer: DuPont – Memphis Plant
DuPont Chemical Solutions Enterprise
Organizations Audited: DuPont Sourcing & Logistics
Names of Railways within scope: Canadian National Railway
Scope of Audit: DuPont Sodium Cyanide Transportation via Rail using the Canadian National Railway
Audit Dates: Audit Dates: 12/12-14/2006, 1/17/2007, 2/19-20/2007

Executive Summary:

The DuPont Corporate Sourcing & Logistics group located in Wilmington, Delaware manages the domestic transportation of sodium cyanide via rail. This audit was performed to confirm that DuPont practices "Due Diligence" in the management of its sodium cyanide supply chain to ensure that cyanide is transported in a manner that is consistent with the requirements of the Cyanide Code Transportation Protocol. The scope of this audit report is the rail transportation of solid sodium cyanide via the Canadian National Railway (CN). The packaging types involved in the audit included hopper car, intermediate bulk containers (IBCs), FLO-BINS® and drums. The transportation equipment is dependent upon final destination. At the time of the audit, cyanide destined for international ports was packed into sea containers, Mexico destinations was receiving boxcar shipments, and hopper cars were being sent to Carlin.

The rail segments either start at the Memphis rail head (IBCs and drums) or the DuPont Memphis plant (FLO-BINS® and hopper cars. All of these types of packages and transportation equipment were evaluated during the audit. Depending on the destination, the CN either completes the entire rail transport of the product or the product is switched to another railroad along the route. Other railroads were within the scope of the due diligence audit. The details regarding the conformance of other railroads to Cyanide Code requirements are contained within separate reports.

Some Code requirements such as shipment tracking and container management are addressed differently depending on whether the shipment is going to travel by land or by sea. Terrestrial shipments are largely managed directly by the Rail group within the Logistics organization of DuPont. Shipments that involve a sea component are largely managed by the ocean carriers who will transport the cargo to the international port. The ocean carriers that underwent a due diligence evaluation as part of the Cyanide Code audit process in February 2007 were: Maersk, MSC, APL, MOL, and Hamburg Sued.
These ocean carriers supply transportation equipment that is used for rail and ultimately ocean transport, they track shipments from the railhead to the port, and they have responsibility to ensure that all inter-modal movements are performed appropriately and by trained personnel.

As per section 2 of the ICMI *Auditor Guidance for the Use of the Cyanide Transportation Verification Protocol*, dated September 2006, information maintained by DuPont was reviewed to confirm that it has evaluated these partners and implemented necessary management measures to ensure the safe transport of its materials. Information pertaining to DuPont standard management practices, management systems used by the CN, as well as information from the ocean carriers and freight forwarder involved in the movement was reviewed. Details of the information evaluated are listed in each section of this report.

The following individuals were interviewed on-site and/or remotely during the due diligence audit:

DuPont DCSE / Sourcing & Logistics	Nicole Jurczyk	May 18, 2007
Name of Facility	Lead Auditor	Date

- Logistics Manager - Cyanides
- Senior Buyer – Rail Logistics
- Safety, Health, and Environmental Manager – Sourcing & Logistics
- Product Stewardship Manager - Cyanides
- North American Cyanides Safety Manager
- Modal Leader – Rail
- North American Logistics Manager
- Transportation Coordinator (Fleet Manager)
- Bulk Equipment Fleet Engineer – Rail
- Freight Forwarder

The audit was performed by a Transportation Audit Team that fulfills all ICMI requirements. The audit team concluded that DuPont practices appropriate due diligence in the management of the rail transportation of its sodium cyanide using the Canadian National Railway. Management practices were found to be appropriate for assuring that sodium cyanide is transported with this railway in accordance with the principles of the Cyanide Code Transportation Protocol.

Audit Team Findings

DuPont implements management programs, practices and procedures and maintains records that show due diligence in the management of sodium cyanide transportation using the Canadian National Railway.

The management of sodium cyanide transportation along this segment was found to be:

- ☑ consistent
- ☐ substantially consistent
- ☐ not consistent

with the International Cyanide Management Code.

Audit Company:	Management System Solutions, Inc. www.mss-team.com
Audit Team Leader:	Nicole Jurczyk E-mail: CodeAudits@mss-team.com
Names and Signatures of Other Auditors:	Eric Adair
Date(s) of Audit:	12/12-14/2006, 1/17/2007, 2/19-20/2007

I attest that I meet the criteria for knowledge, experience and conflict of interest for Code Verification Audit Team Leader, established by the International Cyanide Management Institute and that all members of the audit team meet the applicable criteria established by the International Cyanide Management Institute for Code Verification Auditors.

I attest that this Summary Audit Report accurately describes the findings of the due diligence verification audit. I further attest that the verification audit was conducted in a professional manner in accordance with the International Cyanide Management Code Verification Protocol for Cyanide Transportation Operations and using standard and accepted practices for health, safety and environmental audits.

DCSE / Sourcing & Logistics ______________________ June 18, 2007

Name of Facility Signature of Lead Auditor Date

DuPont DCSE / Sourcing & Logistics ____Nicole Jurczyk ____ May 18, 2007

Name of Facility Lead Auditor Date

1. TRANSPORT: ***Transport cyanide in a manner that minimizes the potential for accidents and releases.***

<u>*Transport Practice 1.1:*</u> *Select cyanide transport routes to minimize the potential for accidents and releases.*

The management of rail transport is:

☑ consistent with Transport Practice 1.1
☐ substantially consistent
☐ not consistent

Summary of the basis for this finding:

DuPont chose to transport Sodium Cyanide via rail instead of truck in the 1980s. The railway that services DuPont out of Memphis is the Canadian National Railway (CN), which is privately owned. The railway maintains control over routing and employs specific safety measures to ensure the safest transit of hazardous materials possible. The railroad is a certified Responsible Care® Partner company. As such, their rail management system has been audited by a 3rd – party auditing firm and has been found to be suitable and effective. A 2006 safety presentation was reviewed for the CN. Interviews confirmed that the railway routes the hazardous shipments in such a way to reduce transit time and keep the cars moving.

The CN is part of the TRANSCAER® (<u>T</u>rans*portation* <u>C</u>*ommunity* <u>A</u>*wareness and* <u>E</u>*mergency* <u>R</u>*esponse)* organization. Records regarding safety performance and the commitment to safe transportation through communities were reviewed and found to be consistent with Cyanide Code requirements. Rail transport is generally understood to be safer than truck transport. Association of American Railroads (AAR) evaluations have stated that trucks are 16 times more likely to be involved in an accident than trains.

<u>*Transport Practice 1.2:*</u> *Ensure that personnel operating cyanide handling and transport equipment can perform their jobs with minimum risk to communities and the environment.*

The management of rail transport is:

☑ consistent with Transport Practice 1.2
☐ substantially consistent
☐ not consistent

Summary of the basis for this finding:

Training records and safe handling procedures were reviewed for both Memphis-based shipping operations (DuPont Plant and LEMM packaging) and at the LEMM Carlin terminal during the March 2006 audit. At the time of the audit, LEMM was packing and shipping IBCs and drums, and DuPont personnel were loading and shipping hopper cars and FLO-BINS®. Training records indicated that employees had received appropriate training in safe operating procedures, regulatory requirements, and security measures.

Training records for packers indicated that employees have received appropriate training in safe operating procedures, regulatory requirements, and security measures. Training for the local truck transporter that brings the cargo to the railhead is part of a separate audit report and is outside the scope of this report.

The CN is certified to RCMS®. The RCMS certificate was reviewed during the audit. The fulfillment of required training is a specific requirement of RCMS. Although no railroad training files are maintained by DuPont, information regarding the safety practices of the CN is maintained on file. The CN safety presentation was reviewed as part of this due diligence audit.

For international shipments, the inter-modal moves at the ports are controlled by the ocean carrier. The ocean carriers were also evaluated by means of a due diligence audit. The details pertaining to the ocean carrier systems are within the ocean carrier due diligence reports. Records showing that ocean carriers address the need for hazardous materials handling were reviewed as part of the ocean carrier due diligence audit. Information from the carriers also indicated that they have systems in place to ensure that inter-modal moves are performed by appropriately licensed and qualified personnel.

Transport Practice 1.3: *Ensure that transport equipment is suitable for the cyanide shipment.*

The management of rail transport is:

☑ consistent with Transport Practice 1.3
☐ substantially consistent
☐ not consistent

Summary of the basis for this finding:
The CN maintains an RCMS certification and periodically undergoes a full management system audit which would typically include the preventive maintenance of equipment. Transportation equipment and its maintenance varies widely depending on the type of package and the final destination of the shipment. This section of the report is discusses each scenario separately.

Hopper Car Shipments:
DuPont ships bulk sodium cyanide briquettes in bulk hopper cars that are built to AAR specifications. The loaded hopper cars are checked prior to departure to ensure that all ports are secured and that the weight does not exceed 263,000 pounds. Bills of lading were reviewed as part of this audit to confirm weight and type of rail car. Interviews with the Rail Fleet Manager confirmed that the hopper cars meet the USDOT special provision for the transport of sodium cyanide, solid requiring that rail hopper cars be sift-proof, water-tight, and have metal covers. AAR certified mini-shops inspect the hopper cars as they leave the DuPont facility and as they enter it. The safety appurtenances, braking systems, and connection mechanisms are inspected. Repairs are either done by the certified mini-shops or by the certified full service repair facilities.

Boxcar Shipments:
DuPont uses leased boxcars to ship the solid sodium cyanide to Mexico over the U.S. / Mexico border at Nuevo Laredo. Certificates of compliance for the boxcars and the record of the Department of Transportation approval for the Flo-Bins® (competent authority certificate) were reviewed and found to be acceptable. The boxcars are periodically inspected and taken out of service when necessary. Bills of lading were also reviewed as part of this audit. The auditors were able to confirm that shipments are being made in approved packages and boxcars. Boxcar repairs are done by certified mini-shops or by certified full service repair facilities.

Sea Container Shipments:
The inter-modal freight containers used for transport of export shipments are owned and controlled by the ocean carriers that will carry the containers to international destinations. DuPont has contractual agreements with all of its ocean carriers that require that they comply with Chemical Distribution Institute – Marine Packed Cargo program (CDI-MPC) safety requirements and the International Maritime Dangerous Goods (IMDG) Code. These contracts were reviewed during the audit. DuPont has contractual provisions with all of its ocean carriers that require verification audits to be performed of the carriers.

DuPont ensures authorized packaging is used for the solid sodium cyanide. Package specifications were reviewed during this audit and were found to be compliant. The LEMM packaging operation was audited and certified to the Cyanide Code using the Cyanide Code Production Protocol in March 2006. LEMM checklists and procedures require an inspection of the cargo and containers to ensure that all equipment is deemed to be safe for transport.

Additionally, DuPont tracks transportation incidents for all transportation modes throughout the world. The incident tracking database was reviewed during the audit. No rail transportation incidents involving sodium cyanide shipments have occurred in this segment in over 10 years.

Transport Practice 1.4: *Develop and implement a safety program for transport of cyanide.*

The management of rail transport is:

☑ consistent with Transport Practice 1.4
☐ substantially consistent
☐ not consistent

Summary of the basis for this finding:
DuPont has confirmed that the CN maintains a certified Responsible Care management system. Additionally, the CN is a member of TRANSCAER. A CN safety presentation on file with DuPont details the CN safety program, their improvements in safety performance, and their initiatives that are in place as part of their RCMS commitment to continual improvement. The safety programs for the loading of the cyanide were reviewed and were found to be in

compliance with the Cyanide Code during the DuPont Sodium Cyanide Production verification audit in March 2006.

Records showing that Maersk and MSC hold safety program certifications were reviewed during the ocean carrier due diligence audit. Additionally, carriers self-reported to DuPont that they extensively train their personnel on hazardous materials handling. Information from the carriers also indicated that they have systems in place to ensure that inter-modal moves are performed by appropriately licensed and qualified personnel.

Transport Practice 1.5: *Follow international standards for transportation of cyanide by sea and air.*

This section of the code was deemed to be outside of the scope of this report. DuPont does not ship cyanide by air. The ocean transport of cyanide is the subject of a series of separate ocean carrier reports.

Transport Practice 1.6: *Track cyanide shipments to prevent losses during transport.*

The management of rail transport is:

☑ consistent with Transport Practice 1.6
☐ substantially consistent
☐ not consistent

Summary of the basis for this finding:
Shipping papers were reviewed for all package and transportation equipment types. Auditors confirmed that seal numbers are recorded on the bills of lading and other shipping papers. This enables personnel along any portion of the segment to confirm that the containers have not been opened.

Hopper Car Shipments:
The sodium cyanide shipments leave the DuPont plant (Woodstock, TN) via the CN railway and are transferred to the UP railroad at the Memphis, TN interchange. UP maintains control of the shipments until they reach the DuPont sidings in Vivian, NV (Carlin Terminal). There are five rail yards that are normally used during this transportation segment.

Interviews with the Transportation Coordinator indicated that cyanide shipments are tracked continuously by DuPont. A “No Movement” report is reviewed daily to determine if any rail cars have not moved within the past 24 hours. Examples of these reports were reviewed as part of the audit. The Transportation Coordinator contacts the railroad and takes appropriate action if the car has not moved in the past 24 hours. DuPont has direct access to transponder information that is used to track individual railcar movements. DuPont also has direct access to coded information that describes the status of the car. If the hopper car is in need of repair, it is entered into the DuPont DURAMS tracking database. This database houses all the information regarding car repairs, inspections, and status while the car is at the service facility. Samples of records from this database were reviewed as part of the audit.

Boxcar Shipments:
The sodium cyanide shipments leave Memphis via the CN railway and are transferred to the UP railroad at the Memphis, TN interchange. UP maintains control of the shipments until they reach Nuevo Laredo, Mexico. After the boxcars are brought over the border, the Mexican railroads take control of the shipment. Interviews with the Logistics Manager indicated that the boxcars have individual identification numbers that are tracked by the Car Track Coordinator within the Sourcing & Logistics – Rail Group.

The boxcars are sealed and the seal numbers are noted. Shipping papers were reviewed and this practice was confirmed. Boxcars are not opened at the border, and contents are confirmed upon arrival at the Mexican warehouse. The Logistics Manager is updated daily on the status of rail shipments. Shipments that are delayed at the border or elsewhere are investigated immediately.

Sea Shipments:
Once packed, the containers are trucked to the Memphis railhead. This movement is addressed through a separate evaluation and report. Once the containers are loaded onto the rail chassis, the ocean carrier is responsible for tracking the shipment to its final destination port. The CN and the ocean carriers have automated tracking capabilities. DuPont has limited visibility into the actual location of export shipments, but the ocean carriers assume responsibility for the shipment's location and proper handling at the Memphis railhead. The ocean carriers submitted information to DuPont describing their tracking abilities. The audit team found the information to be acceptable.

2. INTERIM STORAGE: ***Design, construct and operate cyanide trans-shipping depots and interim storage sites to prevent releases and exposures.***

Transport Practice 2.1: *Store cyanide in a manner that minimizes the potential for accidental releases.*

The management of rail transport is:

☑ consistent with Transport Practice 2.1
☐ substantially consistent
☐ not consistent

Summary of the basis for this finding:
Trans-shipping depots and interim storage sites are maintained by the railways. The CN maintains an RCMS certification and it is a Responsible Care® Partner. The ocean carriers who arrange the sea shipments track the shipments and coordinate with the railroads to ensure appropriate handling. The safety presentation from the CN was reviewed that shows that the railway maintained a good safety performance.

Hopper cars are designed to be sift-proof and water-tight. They are weighed after loading and weighed upon receipt. Hopper car specifications, records of approval, and adherence of shipments to weight restrictions were reviewed during the audit and found to be acceptable. Deliveries to the Carlin facility are made in the presence of Carlin Terminal employees. The hopper cars are brought within the site fence-line upon delivery. Seals are placed on all ports to enable verification that the hopper car was not opened during transit. Employees were trained on security plans and procedures that resulted after DuPont implemented its security upgrades performed as part of its commitment to Responsible Care®. Training records were reviewed during the audit.

All DuPont package types used for solid sodium cyanide conform to IMO and US DOT requirements. Certifications and approvals were reviewed for all package types during the due diligence audit. The shipping containers provide secondary containment for the packages. Maersk and MSC both have stated that they adhere to IMDG code requirements and safety program certification records were reviewed during the audit. Additionally, safety checklists and seals are used by LEMM after the containers are packed. This process was reviewed during the on-site audit of LEMM in March 2006. The seal enables verification that the container was not opened during transit.

3. EMERGENCY RESPONSE: ***Protect communities and the environment through the development of emergency response strategies and capabilities***

Transport Practice 3.1: *Prepare detailed emergency response plans for potential cyanide releases.*

The management of rail transport is:	☑ consistent with Transport Practice 3.1 ☐ substantially consistent ☐ not consistent

Summary of the basis for this finding:

The DuPont emergency response plan for transportation incidents was reviewed during on-site Cyanide Code audits in March 2006. The plan was found to be appropriately detailed. Different types of emergencies are addressed by the plan and the steps to be taken for on-site and off-site notifications are clear. The roles and responsibilities of the DuPont response personnel are well defined. Interviews during this audit confirmed awareness of the emergency response plan. The same emergency systems are used for any type of transportation emergency. The railroads participate in the TRANSCAER organization and are instructed to contact CHEMTREC, who then contacts the DuPont Cyanide Hotline. The safety presentation reviewed from the CN confirmed that they have full emergency response teams available to respond to rail emergencies.

Transport Practice 3.2: *Designate appropriate response personnel and commit necessary resources for emergency response.*

The management of rail transport is:	☑ consistent with Transport Practice 3.2 ☐ substantially consistent ☐ not consistent

Summary of the basis for this finding:

The DuPont emergency response plan was audited during the March 2006 Cyanide Code Production audit. The plan clearly designates roles & responsibilities, call-out procedures, and list current phone numbers. DuPont offers immediate technical assistance for any cyanide spill, and offers emergency resources for spills that might occur near a DuPont site. DuPont contracts with CHEMTREC to ensure that appropriate notifications and emergency response is initiated if there is an incident. DuPont ensures emergency contact information (telephone number), and initial response information is clearly identified on every shipping paper for each shipment of Sodium Cyanide. DuPont has established its confidence in the CN's abilities to respond to an emergency through interacting with them through TRANSCAER and safety forums. The records from the 2006 DuPont Rail Safety & Security Forum were reviewed during the audit.

Transport Practice 3.3: *Develop procedures for internal and external emergency notification and reporting.*

The management of rail transport is:	☑ consistent with Transport Practice 3.3 ☐ substantially consistent ☐ not consistent

Summary of the basis for this finding:

The DuPont's "Cyanides Global Response Plan for Off Site Incidents" details the notification procedures for external emergencies. Procedures are in place to ensure that timely communications and notifications are made in the event of an emergency. Examples of CHEMTREC correspondence were reviewed. Records showed that communication between the railroads and DuPont is appropriate for ensuring timely notification of railway incidents. Interviews with the freight forwarder were held during the due diligence audit to confirm awareness of emergency notification procedures. An emergency notification procedure used by the freight forwarder for DuPont cyanide shipments was also reviewed and found to be acceptable during the audit.

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Transport Practice 3.4: *Develop procedures for remediation of releases that recognize the additional hazards of cyanide treatment chemicals.*

The management of rail transport is:	☑ consistent with Transport Practice 3.4 ☐ substantially consistent ☐ not consistent

Summary of the basis for this finding:
DuPont product stewardship personnel and environmental personnel are involved in developing comprehensive environmental plans in the event of an on-site spill. In the event of an off-site spill, DuPont emergency response personnel are sent to the scene. DuPont coordinates clean-up efforts with professional remediation services. DuPont cyanide experts coordinate any remediation with the remediation service. Interviews during the March 2006 Cyanide Code Production audit confirmed that DuPont experts are very aware of the additional hazards of cyanide treatment chemicals and they would communicate these hazards to necessary personnel in the event of a spill.

Transport Practice 3.5:	*Periodically evaluate response procedures and capabilities and revise them as needed.*
The management of rail transport is:	☑ consistent with Transport Practice 3.5 ☐ substantially consistent ☐ not consistent

Summary of the basis for this finding:
The rail emergency response procedures and plans are practiced and reviewed through the TRANSCAER organization. As confirmed during the 2006 Production Audit, DuPont sites review the adequacy of their ERPs regularly and conduct several drills per year. Drill critiques are conducted with those involved. Action items for revisions to the plans are identified, as necessary, and tracked to closure. The Cyanide Hotline personnel are periodically involved in drills performed by sites and transportation partners. Safety conferences are held with rail and ocean carriers periodically. The adequacy of emergency preparedness plans is one of the topics discussed at these conferences.

APPENDIX Z

CANADIAN DAM ASSOCIATION SAFETY GUIDELINES

Approved as Principles, October 2005

DRAFT

Dam Safety Guidelines

2005 October 1, 2006

CDA ACB

Preface

Ownership of dams in Canada includes various levels of government, utilities, mining companies, pulp and paper companies and private dam owners. Regulation of dam safety in Canada is primarily a provincial responsibility, with federal agencies having jurisdiction over some aspects related to international boundary waters covered by treaty with the United States. Some provinces have enacted specific dam safety regulations, while others use existing Acts or Regulations to authorize the design, construction, inspection, operation, rehabilitation, alteration or decommissioning of dams. In any case, legal regulations take precedence over guidelines produced by non-governmental organizations.

In 1995, after three years of effort by working groups across the country, the Canadian Dam Safety Association (CDSA) issued *Dam Safety Guidelines.* In 1997, the CDSA merged with the Canadian Committee on Large Dams (CANCOLD), to form the Canadian Dam Association (CDA). The Canadian Dam Association published a revised version of the *Dam Safety Guidelines* in 1999.

Since 1995, the Guidelines have been in widespread use in Canada and suggestions for improvement have been made. In 2003, the Dam Safety Committee embarked on an intensive process of soliciting input and suggestions for revisions and additions from the membership through the internet and workshops across the country. The Dam Safety Committee and working groups reviewed the comments and incorporated them as appropriate in this document.

Thus, the *Dam Safety Guidelines* are a product of the membership of the Canadian Dam Association. A large number of individuals have contributed to the Guidelines – the first issue in 1995, the revisions in 1999, and the current 2006 edition. The 2006 version of the *Dam Safety Guidelines* will consist of two parts:

- ***Principles**,* which are the fundamentals of dam safety, applicable to all dams.
- ***Practices and Procedures***, which suggest methodologies and practices that may be used to meet the Principles.

The Principles apply to all dams – new, existing, and closed – within the definition of "dam" outlined in Section 1. The Practices and Procedures series will similarly cover all types of dams, although a particular document may address only a specific situation. A Glossary is provided to define terms that are used throughout the Dam Safety Guidelines. Additional definitions may be provided in the Practices and Procedures.

The *Dam Safety Guidelines* assume that the user is suitably experienced and knowledgeable in the relevant specialized fields. The Guidelines are not intended as a textbook nor as a substitute for the experience and judgement of a person familiar with the many complexities of dam safety practice.

It is the intention of the Canadian Dam Association to review and update the Guidelines as the need arises. While every reasonable effort has been made to ensure validity and accuracy of the information presented in the Guidelines, the Canadian Dam Association and its membership disclaim any legal responsibility for such validity or accuracy.

1 Dam Safety Management

A dam is defined as a barrier constructed to enable the storage or diversion of water, water containing any other substance, fluid waste or fluid tailings, providing that such barrier could impound 30,000 m^3 or more and is 2.5 m or more in height. The height is measured vertically to the top of the barrier, as follows:

- From the natural bed of the stream or watercourse at the downstream toe of the barrier, in the case of a barrier across a stream or watercourse
- From the lowest elevation at the outside limit of the barrier, in the case of a barrier that is not across a stream or watercourse

In these *Dam Safety Guidelines*, "dam" includes works (appurtenances) and systems incidental to, necessary for, or in connection with, the barrier. The definition may be expanded to include "dams" under 2.5 m in height or which can impound less than 30,000 m^3, if the consequences of operation or dam failure would be unacceptable to the public, such as: dams which create hydraulic conditions posing a danger to the public, dams with erodible foundations where breach could lower the reservoir more than 2.5 m, or dams retaining contaminated substances.

Principle 1.1 –

The public and the environment shall be protected from the consequences of dam failure as well as release of any or all of the stored volume of water and/or tailings behind a dam.

- Dam safety management is management of the risks associated with dams. Principles of risk management incorporate traditional standards-based methods as well as risk assessment techniques where suitable. Standards-based methods typically rely on classification of dams in terms of the consequences of failure.

- In the case of dams that retain contaminants of any sort, the protection to the public and the environment extends to seepage and other pathways not necessarily associated with catastrophic failure of the retaining structures. Thus, "failure" includes environmental non-compliance.

- Consequences of dam failure are the damages above and beyond those that would have occurred even if the dam had not failed. These "incremental consequences" may be less than the total damages caused by a natural flood.*

- The estimate of consequences should include:

  - Both downstream and upstream damages

  - Cascade effects where a series of dams exists in a given drainage basin

  - Release of contaminants to the environment

Principle 1.2 –

The standard of care to be exercised by the dam designer and owner shall be commensurate with the consequences of dam failure.

- Regulatory requirements in the applicable jurisdiction take precedence over other standards or guidelines unless they include lesser dam safety requirements than widely used standards and guidelines. The absence of specific regulation does not negate the owner's responsibility for safe dam management.

Principle 1.3 –

Due diligence shall be exercised at all stages of a dam's life cycle.

- The life cycle of a dam typically includes the stages of design, construction, operation, decommissioning and long-term closure.

* In these Guidelines, the term "consequences of failure" refers to "incremental consequences".

Principle 1.4 –

A dam safety management system shall be in place, incorporating responsibilities, policies, plans and procedures, documentation, training, review and correction of deficiencies and non-conformances.

- The dam owner should maintain an inventory of dams to which these Guidelines apply.

- Responsibility for all aspects of dam safety should be defined. The dam Owner is responsible for dam safety and regulatory compliance and any delegation of responsibility should be clearly defined by the Owner.

- Policies for dam safety should be developed and documented.

- Plans and procedures should be developed and implemented at all stages of a dam's life cycle for key dam safety activities including:
  - Operation, maintenance and surveillance (see Section 2)
  - Emergency preparedness (see Section 3)
  - Dam Safety Reviews (see Section 4)
  - Dam safety analysis (see Section 5)

- The dam safety management system should include a process for follow-up and correction of deficiencies and non-conformances in a reasonable time.

- Documentation should be maintained up-to-date so that a permanent record exists of the design, construction, operation and performance of the dam, and the management of its safety. Such documents should include: design documents, instrumentation readings, inspection and testing reports, Dam Safety Review reports, operational records, investigation studies, current closure plans and other technical data.

- All individuals with responsibilities for dam safety activities should be adequately qualified and trained. The content and frequency of the training programs should be appropriate to develop and maintain competency. Training records should be maintained.

- Deficiencies in dam performance, supporting infrastructure, operation, maintenance, surveillance, security procedures and the management system should be prioritized and addressed.

- The dam safety management system should be reviewed regularly and reported to senior management representatives of the dam owner.

2 Operation, Maintenance and Surveillance

Principle 2.1 –

Requirements for the safe operation, maintenance and surveillance of the dam, shall be suitably documented and contain sufficient information in accordance with the consequences of dam failure.

- Documentation (log book, records, reports, etc) should be maintained to show compliance with these requirements.

Principle 2.2 –

Documented operating procedures shall be followed for the dam and applicable discharge equipment to address normal, unusual and emergency conditions.

- Procedures should be in place to:
  - Address the impact of operations on the public, the environment and other stakeholders and licensed users of the water.
  - Provide notification of changing flows or conditions
  - Identify recreational use areas, restricted zones, and public awareness programs.
  - Ensure regulatory or other established limits on reservoir levels, tailings beach length and/or freeboard for tailings dams, rates of water rise or drawdown and discharge rates in both the upstream and downstream environs are identified.
  - Review the capabilities of all flow control equipment, including back-up supplies, to operate under all conditions.
  - Manage debris and ice to ensure operability of discharge facilities.
  - Address impact of unauthorized site entry or equipment operations.
  - Identify developing dam emergencies for activation of response plans
- Operating procedures should consider the availability of reliable data for dam operations, including:
  - Headwater and tailwater elevations
  - Tailings management issues including winter operations for tailings dams
  - Remote indications of flow control equipment operation
  - Flood forecasting information
  - Operations of other dam owners affecting inflows to the reservoir and the need for operations to discharge excess inflows

Principle 2.3 –

Documented maintenance procedures, including public safety and security measures, shall be followed to ensure that the dam remains in a safe and operational ready condition.

- Maintenance activities should be prioritized, carried out and documented with due consideration of dam safety implications.
- Maintenance of flow control equipment should be carried out to ensure it remains in a safe and operational ready state.
- Maaintenance procedures for dams in a closure/decommissioned condition should take into account the availability of appropriate personnel to perform the maintenance activities.

Principle 2.4 –

Documented surveillance procedures shall be followed for the dam to provide early identification and timely mitigation of conditions which might affect dam safety.

- Surveillance activities should cover potential failure modes.
- The level of surveillance should be in accordance with the consequences of failure or known condition.
- Surveillance (inspection and instrumentation data) should consider previous observations, thresholds and identifies changes or trends impacting dam safety.
- Required actions should be established in the event abnormal performance or observations are identified.
- Special inspections may be required following unusual events such as floods or seismic activities.

Principle 2.5 –

Flow control equipment shall be tested and be capable of operating as required.

- Test procedures should take into consideration upstream and downstream effects including public safety and environmental concerns.
- Normal and standby power sources, as well as, both local and remote controls should be included in test procedures.
- Testing should be documented.

3 Emergency Preparedness

Principle 3.1 –

An effective emergency management process shall be in place for the dam.

- The level of detail required in any emergency preparedness/response plan should be commensurate with the consequences of failure.
- The absence of government regulations does not negate the owner's responsibility for emergency preparedness planning.

Principle 3.2 –

The emergency management process shall include internal emergency response procedures to guide the dam operator and site staff through the process of responding to an emergency situation at a dam.

- Internal roles and responsibilities for emergency response should be clearly defined and understood.
- Potential dam safety hazards (natural, structural and/or human actions) should be addressed; consistent with identified failure modes and consequences of failure.
- Any dam safety incidents and emergencies should be documented and investigated in order to improve dam safety and emergency preparedness.
- The following procedures should be included in an internal emergency response plan:
  - Surveillance response, mitigation and monitoring for developing emergencies
  - Notifications to site and owner's staff, downstream responders and persons at risk
  - Site access
  - Provision of emergency power equipment
  - Appropriate communication systems with upstream and downstream dams.
  - Inundation maps and critical flood information.

Principle 3.3 –

The emergency management process shall ensure that effective emergency preparedness procedures are in place for the use of external response agencies having responsibilities for public safety within the floodplain.

- The emergency management process should be documented, distributed, and clearly communicated in advance, to all response agencies having responsibility for public safety within the floodplain.
- Roles and responsibilities of the dam owner and the response agencies should be defined and accepted.

- Potential dam safety hazards (natural, structural and/or human actions) and corresponding notification procedures should be defined.
- Inundation maps and critical flood information should be available to downstream response agencies to assist them in identification of critical infrastructure that may be affected by large releases or the failure of a dam.
- Where no formal response agency exists downstream of a dam, the dam owner should have in place reasonable and practical measures to protect those at risk.

Principle 3.4 –

The emergency management process shall ensure that adequate staff training, and plan testing and updating is carried out.

- All persons with response roles should be appropriately trained.
- Internal and external emergency procedures should be tested and exercised regularly .
- Emergency plans should be updated regularly.

4 Dam Safety Review

Principle 4.1 –

A safety review of the dam ("Dam Safety Review") shall be carried out periodically.

- Activities of the Dam Safety Review should include a visual inspection of the dam, as well as review of:
  - Consequences of dam failure
  - Operation, maintenance and surveillance documentation and practices
  - Emergency preparedness plans and procedures
  - Previous Dam Safety Reviews
  - Up-to-date dam closure plan for tailings dam
  - Dam safety analyses including:
    - Failure modes (physical and geochemical)
    - Inflow design flood
    - Seismic loads
    - Other loads and load combinations
    - Stability and performance
    - Reliability and functionality of discharge facilities
    - Overall effectiveness of dam safety management at the dam
- The frequency required for the Dam Safety Review should be based on: consequences of failure, external hazards, failure modes, ongoing surveillance program and demonstrated dam performance.
- The level of detail may be modified on the basis of: previous assessments, complexity of the dam, continuity of surveillance and records, external and internal hazards, operating history, dam performance and age, and the need for public protection during operation.
- The Dam Safety Review should be documented in a formal report with conclusions and recommendations to permit the dam Owner to conform to accepted practices in dam safety and to comply with regulations.

Principle 4.2 –

A qualified registered professional engineer shall be responsible for the technical content, findings and recommendations of the Dam Safety Review and report.

- The Dam Safety Review findings and recommendations should be independent of conflict of interest.

5 Dam Safety Analysis

The purpose of dam safety analysis is to determine the capability of the dam and systems to retain the stored volume and to pass flows around and through the dam in a safe controlled manner and in the case of tailings dams, to maintain geochemical stability of the facility.

Dam safety analysis includes analysis of hazards, failure modes and effects, operating reliability, dam response (e.g. stability), human factors, and emergency scenarios. The design, construction and operation should be integrated to ensure that the design intent has been incorporated into the dam.

The analytical methods are typically deterministic, based on dam classification and standards; they may also be based on probabilistic risk assessment. In any case, the same principles apply.

Dam safety decisions are directed to: prevention of failure sequence initiation, control of a deteriorating situation, and mitigation of situations where the failure sequence cannot be stopped.

Dam safety analysis requires an interdisciplinary approach that encompasses engineering disciplines such as:

- Hydrotechnical
- Seismic
- Geotechnical
- Structural
- Geochemical (environmental)
- Flow control equipment (mechanical-electrical)

Principle 5.1 –

The dam system and components under analysis shall be defined.

- The dam system should include all water retaining and conveyance structures, tailings management system components, the reservoir and the downstream area, flow control equipment, and subsystems supporting safety (e.g. access roads and notification systems).
- The boundaries of the system should be identified.
- The data and information about the dam system should be adequate (sufficient quantity and quality) for reliable assessment of the safety status of the dam.

Principle 5.2 –

External and internal hazards to the proper functioning of the dam shall be defined.

- Hazards may change in nature and significance at different stages of a dam's life.
- External hazards, which are beyond the control of the dam owner, include:
  - Meteorological events such as floods, intense rain events, temperature extremes and the effects of ice, lightning strikes and wind storms.

- Seismic events such as natural seismic events as well as those caused by mining or reservoir-induced seismicity.
- Reservoir environment hazards such as upstream dams and unstable slopes.
- Human actions such as vandalism and sabotage.

- Internal hazards may arise from the ageing process or errors and omissions in:
  - Design
  - Construction
  - Maintenance
  - Operation
  - Plans and procedures

Principle 5.3 –

Failure modes, sequences and combinations shall be identified for the dam.

- Failure modes may change in nature and significance at different stages of a dam's life.
- Failure characteristics, including extent and rate of development, are determined to an appropriate level of detail.
- The analysis addresses the manner in which failure modes and failure sequences can be detected.

Principle 5.4 –

The dam shall safely retain the reservoir and any stored solids, and pass environmentally acceptable flows as required for all loading conditions ranging from normal to extreme loads, commensurate with the consequences of failure.

- The analysis of consequences should appropriately consider life safety, property and infrastructure damage, socioeconomic losses including heritage losses, and environmental and ecological degradation.
- The consequences of failure should be analyzed in conjunction with corresponding failure modes.
- Design loads and design criteria should be commensurate with the consequences of dam failure.

Hydrotechnical considerations:

- The maximum flood for which the structure is designed or evaluated (the Inflow Design Flood, IDF) should be selected, based on incremental consequences of failure.
- Statistical inflow floods should be determined using current practices. If required, the Probable Maximum Flood (PMF) is determined;

- The capacity of the hydraulic control structures should be verified and their capability to perform under extreme conditions is assessed. They should be capable of safely passing the IDF. Operating rules should be established for emergency conditions.
- The freeboard at all structures should be evaluated for normal and extreme conditions. It should exceed the minimum required freeboard established to minimize the probability of dam overtopping by waves.

Seismic considerations:

- The level of ground motion for which the structure is designed or evaluated (the Earthquake Design Ground Motion, EDGM), should be based on the consequences of dam failure.
- The EDGM should be based on a site-specific seismic hazard assessment by qualified specialists for a specified annual exceedance probability (AEP).
- The seismic hazard analysis should consider regional and local seismicity and seismotectonics, including any identified active seismogenic fault sources. Appropriate ground motion relations for the region need to be evaluated and applied for the assessment.
- The effects of local subsurface conditions should be taken into account either in developing the EDGM or in the analysis of the dam structure.

Geotechnical considerations:

- Design of new structures and assessment of existing structures should be carried out using normal and extreme loads consistent with the site conditions, applicable regulations, and current good practice in the industry.
- Adequacy of structures and foundations to resist all specified loading conditions should be assessed on the basis of appropriate acceptance criteria. These include all the criteria for safety regarding slope stability, bearing capacity, seepage conditions, freeboard, protection against erosion by waves, etc.
- The analysis method and level of detail should depend on the type and configuration of the structure as well as the consequences of failure.
- Acceptance criteria for assessment of stability should reflect the degree of uncertainty associated with the analysis and understanding of the imposed loads and material properties.

Structural considerations:

- Design of new structures and assessment of existing structures should be carried out using normal and extreme loads consistent with the site conditions, applicable regulations, and current good practice in the industry.
- Adequacy of structures and foundations to resist all specified loading conditions, including interactions with geotechnical interfaces, should be assessed on the

basis of appropriate performance indicators. These include the position of the resultant force, normal and shear stresses and calculated sliding and strength factors.

- The analysis method and level of detail should depend on the type and configuration of the structure as well as the consequences of failure.

- Acceptance criteria for assessment of stability should reflect the degree of uncertainty associated with the analysis and understanding of the imposed loads and material properties.

Geochemical (environmental) considerations:

- The potential environmental impacts of seepage and releases from the facility should be evaluated for all stages of the dam's life.

- For tailings dams that impound tailings with sulphide content, potential oxidation processes for both operating and closure periods should be appropriately evaluated.

- Acceptance criteria for environmental performance should be set by the appropriate compliance standards for each given facility.

Flow control equipment:

- Flow control equipment should be able to reliably handle the expected operating loads and site conditions, retaining or releasing water upon demand.
- The capability of equipment should be assessed with consideration of both normal and extreme conditions, based on the consequences of equipment failure.

Glossary

Acceptable risk - The level of risk (the combination of the probability and the consequence of a specified hazardous event) which the public are prepared to accept without further management. Acceptability of risk may be reflected in government regulations.

Annual Exceedance Probability (AEP) - Probability that an event of specified magnitude will be equalled or exceeded in any year.

Abutment - That part of the valley side or other supporting structure against which the dam is constructed.

Appurtenances - Structures and equipment on a project site, other than the dam itself. They include, but are not limited to, such facilities as intake towers, powerhouse structures, tunnels, canals, penstocks, low-level outlets, surge tanks and towers, gate hoist mechanisms and their supporting structures, and all critical water control and release facilities. Also included are mechanical and electrical control and standby power supply equipment located in the powerhouse or in remote control centres.

Base of dam - General foundation area of the lowest portion of the main body of a dam.

Beach - The exposed tailings above the pond water level in a tailings impoundment.

Catchment - Surface area which drains to a specific point, such as a reservoir; also known as the watershed or watershed area.

Classification (dam) - A system by which dams are assigned to categories usually based on consequences of failure, so that appropriate corresponding dam safety standards may be applied. Some classification systems go beyond the consequences and consider other dam characteristics such as vulnerability to various hazards.

Consequences of dam failure - Impacts in the downstream as well as upstream areas of a dam resulting from failure of the dam or its appurtenances. For purposes of these Guidelines, the term "consequences" refers to the damages above and beyond the damages that would have occurred, for the same natural event or conditions, even if the dam had not failed. These may also be called "incremental consequences" of failure.

Dam - Barrier which is constructed for the purpose of enabling the storage or diversion of water, water containing any other substance, fluid waste or fluid tailings, providing that such barrier could impound 30,000 m^3 or more and is 2.5 m or more in height. The height is measured vertically to the top of the barrier, as follows:

(i) from the natural bed of the stream or watercourse at the downstream toe of the barrier, in the case of a barrier across a stream or watercourse
(ii) from the lowest elevation at the outside limit of the barrier, in the case of a barrier that is not across a stream or watercourse

"Dam" is herein defined to include works (appurtenances) incidental to, necessary for, or in connection with, the barrier.

For purposes of these guidelines, this definition may be expanded to include "dams" under 2.5 m in height or which can impound less than 30,000 m^3, if the consequences of failure would be unacceptable to the public, such as:

- Dams which create hydraulic conditions posing danger to the public.
- Dams with erodible foundations where a breach could lower the reservoir more than 2.5 m.
- Dams retaining contaminated substances.

Dam Safety Review - Comprehensive formal review carried out at regular time intervals to determine whether an existing dam is safe, and if it is not safe, to determine required safety improvements.

Decommissioned dam – Dam that has reached the stage in its life cycle when both dam construction and the intended use of the dam have been permanently terminated in accordance with a decommissioning plan.

Earthquake Design Ground Motion (EDGM) - The level of earthquake ground motion at the location of a dam for which a dam structure is designed or evaluated.

Emergency - In terms of dam operation, any condition which develops naturally or unexpectedly, endangers the integrity of the dam, upstream or downstream property or life, and requires immediate action.

Emergency plan - Document(s) that contain procedures for preparing for and responding to emergencies at the dam or its appurtenances, including communication directories and inundation maps.

Extreme event - Event which has a very low annual exceedance probability (AEP).

Extreme loads - The rare loadings imposed by extreme events such as large earthquakes, floods and landslides.

Failure (of dam) - In terms of structural integrity, the uncontrolled release of the contents of a reservoir through collapse of the dam or some part of it. In terms of geochemical integrity, the uncontrolled release of contaminants from the reservoir/tailings impoundment.

Failure mode - Mode in which element or component failures must occur to cause loss of the system function. At a general level, there are three dam failure modes: dam overtopping, dam collapse, and contaminated seepage. At a lower level, failure *effects* become the failure *modes* at the next higher level in the system.

Foundation - Rock and/or soil mass that forms a base for the structure, including its abutments.

Freeboard - Vertical distance between the water surface elevation and the lowest elevation of the top of the containment structure.

Hazard - A system state or set of conditions that together with other conditions in the system environment could lead to a partial or complete failure of the system. Hazards may be external (originating outside the system) or internal (errors and omissions or deterioration within the system).

Incremental consequences of failure - Incremental losses or damage which dam failure might inflict on upstream areas, downstream areas, or at the dam, over and above any losses which might have occurred for the same natural event or conditions, had the dam not failed.

Inflow Design Flood (IDF) - Most severe inflow flood (volume, peak, shape, duration, timing) for which a dam and associated facilities are designed.

Inspection - An inspection of the dam to observe its condition. Inspections are carried out much more frequently than Dam Safety Reviews.

Maximum Design Earthquake – See Earthquake Design Ground Motion (EDGM)

Maximum Normal Level (MNL) - Maximum normal operating water surface level of a reservoir. Also called "full supply level".

OMS Manual - Operation, Maintenance and Surveillance Manual, which documents procedures for safe operation, maintenance and surveillance of a dam.

Outlet works - Combination of intake structure, conduits, tunnels, flow controls and energy dissipation devices to allow the release of water from a dam.

Owner - Person or legal entity, including a company, organization, government unit, public utility, corporation or other entity which is responsible for the safety of the dam. The person or legal entity may either hold a government license to operate a dam or retain the legal property title on the dam site, dam and/or reservoir.

Probable Maximum Flood (PMF) - Estimate of hypothetical flood (peak flow, volume and hydrograph shape) that is considered to be the most severe "reasonably possible" at a particular location and time of year, based on relatively comprehensive hydrometeorological analysis of critical runoff-producing precipitation (snowmelt if pertinent) and hydrologic factors favourable for maximum flood runoff.

Regulatory agency - Usually a government ministry, department, office or other unit of the national or provincial government entrusted by law or administrative act with the responsibility for the general supervision of the safe design, construction and operation of dams and reservoirs, as well as any entity to which all or part of the executive or operational tasks and functions have been delegated by legal power.

Reservoir - Body of water, fluid waste or fluid tailings which is impounded by one or more dams, inclusive of its shores and banks and of any facility or installation necessary for its operation.

Reservoir capacity - Total or gross storage capacity of the reservoir at full supply level.

Return period - Reciprocal of the annual exceedance probability (AEP).

Risk - Measure of the probability and severity of an adverse effect to health, property, or the environment. Risk is estimated by the mathematical expectation of the consequences of an adverse event occurring (i.e., the product of the probability of occurrence and the consequence").

Safe dam - Dam which does not impose an unacceptable risk to people or property, and which meets safety criteria that are acceptable to the government, the engineering profession and the public.

Spillway - Weir, channel, conduit, tunnel, chute, gate or other structure designed to permit discharges from the reservoir.

Spillway crest - Uppermost portion of the spillway overflow section.

Tailings dam - Dam, including foundations, water control structures and base of the impounding basin, which is constructed to retain tailings or other waste materials from mining operations.

Tailwater level - Level of water in the discharge channel immediately downstream of a dam.

Toe of dam - Junction of the downstream (or upstream) face of dam with the ground surface (foundation). Sometimes "heel" is used to define the upstream toe of a concrete gravity dam.

Top of dam - Minimum elevation of the uppermost surface of a dam proper, not taking into account any camber allowed for settlement, curbs, parapets, guard rails or other structures that are not a part of the main water-retaining structure. This elevation may be a roadway, walkway or the non-overflow section of a dam.

APPENDIX AA

TMF OMS MANUAL

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REPORT ON

OPERATION MAINTENANCE AND SURVEILLANCE MANUAL
TOUQUOY MINE
TAILINGS MANAGEMENT FACILITY
NOVA SCOTIA

Submitted to:

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DISTRIBUTION:

3 Copies - Atlantic Gold
2 Copies - Golder Associates Ltd.

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ABSTRACT

Atlantic Gold (Atlantic) has retained Golder Associates Ltd. (Golder) to prepare an Operation, Maintenance and Surveillance Manual (OMS Manual) to be used as a guideline for the Tailings Management Facility (TMF) at the Touquoy Mine in Nova Scotia. It is important to note that this manual is a working document and, as such, it requires updating as people and/or operations are modified.

The structures associated with the TMF are as follows:

- The Main Tailings Containment Perimeter Dam,
- The Polishing Pond Dam,
- The tailings delivery and distribution system,
- The water reclaim system,
- The Effluent Treatment System,
- The discharge and decant structures,
- The emergency spillways,
- The environmental monitoring system,
- The seepage collection system,
- Diversion ditches,
- Tailings facility access roads, and
- Dam instrumentation.

This manual is organized as follows:

Abstract
1. Introduction
2. Roles and Responsibilities
3. Facility Description
4. Facility Operations
5. Facility Maintenance
6. Surveillance Procedures
7. Emergency Response Plan
8. References

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1.0 INTRODUCTION

This Operation, Maintenance and Surveillance (OMS) Manual has been prepared in general accordance with the latest guidelines entitled "Developing an Operation, Maintenance and Surveillance Manual for Tailings and Water Management Facilities" developed by the Mining Association of Canada (MAC).

The goal of the OMS Manual is to provide guidance to the operators of the TMF for both normal and special operating conditions. In general, the TMF is to be operated with the lowest level of personnel involvement as practicable.

The objectives of this OMS Manual are to define and describe the following:

- Roles and responsibilities of personnel assigned to the facility;
- Procedures and processes for managing change;
- The key components of the facility;
- Procedures required to operate, monitor the performance of, and maintain a facility to ensure that it functions in accordance with its design, meets regulatory and corporate policy obligations, and links to emergency planning and response; and
- Requirements for analysis and documentation of the performance of the facility.

Construction of the TMF is planned for completion in 2008. Quality Assurance (QA) during construction will be provided by the design engineering consulting firm (Golder Associates).

The primary consultants involved with the project include Golder (Tailings Facility Design), Ausenco Ltd. (overall mine feasibility) and Conestoga Rovers and Associates (Environmental and Permitting). A list of references is included in Section 8.0.

Tailings slurry will be pumped to the TMA via a single, 250 mm diameter High Density Polyethylene (HDPE) pipeline, which will run from the plant site located on a hill northwest of the TMF to the northwest corner of the TMF. The tailings line will then be extended, as required along the tailings containment dam to build beaches along the perimeter using a spaced spigot and end discharge arrangement. The discharge points will be adjusted as required to ensure that a tailings beach is formed and that water flow continues to the south where it will be decanted and either pumped back to the mill (recycled) or pumped to the water treatment plant. Treated water will be discharged initially into a Polishing Pond where it will be retained until suitable water quality is achieved and then released to the environment. Appropriate storm attenuation has been included in the design of the TMF.

TMF Emergency Response Plan

Level 3 Emergency Response Activities

All emergencies are responded in the manner described in Section 6. Certain emergency response activities are of specific importance to Level 3 emergencies which are considered serious (overflow) or catastrophic (failure). These are explained below:

Shutdown

In an overflow or dam failure situation it is essential to cease processing operations. The discharge of tailings into the TMF promotes the uncontrolled release of water or tailings solids from containment under these circumstances. Shutdown must be controlled and orderly according to approved procedures so that the re-start of operations can be effected with a minimum of difficulty. Shutdown due to imminent overflow or dam failure conditions will include the open pit as (1) mining equipment will be used to respond to the emergency and (2) the pit may be used as a reservoir for excess water in the TMF.

Discharge to the Open Pit

It may be possible to prevent an overflow by deliberately pumping water from the tailings impoundment into the open pit. To do this, approximately 400 m of reclaim water line would have to be relocated from the ramp accessing the mill to the road leading to the open pit. Relocation of this pipeline could be accomplished in six hours using mill maintenance personnel and equipment from the mine.

Pumping could be conducted at a peak rate of 500 m3/hr by the reclaim water pump located in the decant tower. If desired the tailings pipeline could also be employed to pump water from the TMF to the open pit. It would take 12 hours to relocate this pipeline and connect it to the second pump in the decant tower which is used to feed the Effluent Treatment Plant. Two pumps could conceivably pump 1000 m3/hr of water from the TMF to the pit.

It should be recognized that under 1/200 year storm conditions, in-flow to the TMF would be approximately 6,000 m3/hr. Even with two pumps feeding two pipelines, capacity would only be 15% of the expected in-flow for the 1/200 year storm, never-the-less this option could prevent an overflow depending on circumstances or be used to lower the pond level if it was found that the integrity of the dam was compromised.

Evacuation

A Level 3 emergency at the TMF presents a hazard to personnel on the dam. Although the spillways allow the dam to accommodate an overflow without suffering structural damage risk of failure under these circumstances is heightened. If the dam were to fail, the dam structure would be unstable. In both instances, the TMF would be evacuated and only essential personnel would be permitted access.

An overflow or partial dam failure would result in a rise in the level of Scraggy Lake and increased flow into the Fish River. A catastrophic dam failure would create a flood wave in Scraggy Lake. It would be unlikely for a partial failure or overflow to occur without some warning. Evacuation of the downstream area would be effected if XIP protocol were invoked. In the event of a sudden, catastrophic dam failure there would be no opportunity to evacuate Scraggy Lake and the downstream area. In all three scenarios, risk to human life is minimized by (1) the low probability of such an event and (2) the limited use of the area.

Containment

In the event of a dam failure, a series of internal dykes and dam walls will retard the movement of tailings and minimize uncontrolled release. Tailings will be inclined to move south, down gradient, rather than east or west due to the prevailing slope of the ground. **The bulk of the tailings solids are stored behind four barriers**: the Tailings Pond Divider Dyke, the Main (south) Dam wall, the Treatment Pond Divider Dyke, and the Polishing Pond dam wall.

The mining fleet will be used to deliver material to the dam to repair a weakened section of the dam or build containment dykes to prevent the spread of disturbance from an uncontrolled release. Suitable material will be available in the waste rock stockpile. The haul from the stockpile to the South Dam is only 2-3 minutes.

Siltation Barrier

If an overflow or failure appears imminent, a siltation barrier will be deployed in Scraggy Lake either at the narrows, 2 kilometres from the north end of the lake. The barrier will consist of a net constructed of braided steel cable filled with hay bales. Personnel will be able to reach the barrier quickly (10 min) by inflatable boat. The barrier will be deployed mechanically by use of an electric winch. The barrier will be put in place on the shore at the start of operations and checked monthly to ensure its serviceability.

The purpose of the barrier is not to hold back a mass of tailings if they enter the lake. Rather it is intended to slow the flow of water as it moves through the lake causing suspended sediment to drop to the bottom. In this way, contamination by tailings sediments can be confined to the north end of Scraggy Lake and the majority of the downstream watershed spared.

Monitoring

In the event that XIP protocol is invoked or an uncontrolled release form the TMF occurs, the frequency of downstream water quality monitoring will be increased to once every twelve hours. Water quality will be checked at (1) the north end of Scraggy Lake, (2) the outlet of Scraggy Lake, (3) the inlet of Lake Charlotte, and (4) the outlet of Lake Charlotte. In addition to water quality, hourly surveys of settlement plates and dam crest levels will be conducted to determine the stability of the dam structures.

This information will enable project management to determine the impact of any uncontrolled release, provide a record of water quality throughout the emergency, and provide information which will help guide emergency response decisions.

TMF Emergency Response Plan

Tailing Dam Emergency Decision Process

Although extremely low in probability, the most likely chain of events leading to a tailings dam overflow or dam failure would be an extreme precipitation event in excess of the 1/200 year storm in an average year or the 1/100 wet year at the height of the spring thaw.

Such an event would result in an in-flow to the TMF of more than 493 mm in a 24 hour period. This would activate the facility spillways but would not in and of itself result in a dam failure. To ensure maximum warning of such circumstances developing, a series of protocols exist which implement heightened levels of surveillance in response to changing conditions.

Routine Monitoring Protocol

Under routine monitoring protocols pond levels will be read and recorded daily from measuring gauges installed in the tailings and polishing ponds. During extended periods of high precipitation or intense precipitation events monitoring frequency will be increased at the discretion of the HS&E Superintendent.

Elevated In-Flow Protocol (EIP)

When the tailings pond level rises such that freeboard (distance between pond level and the spillway invert) is reduced to less than 1 meter, the Elevated In-Flow Protocol is triggered. Monitoring frequency of the pond level is increased to once every hour.

Hourly measurements will be continued as long as the pond level continues to rise. After six continuous hours of pond level decrease the monitoring frequency will be reduced to every six hours and will remain as such until freeboard increases to more than 1 meter (below the spillway).

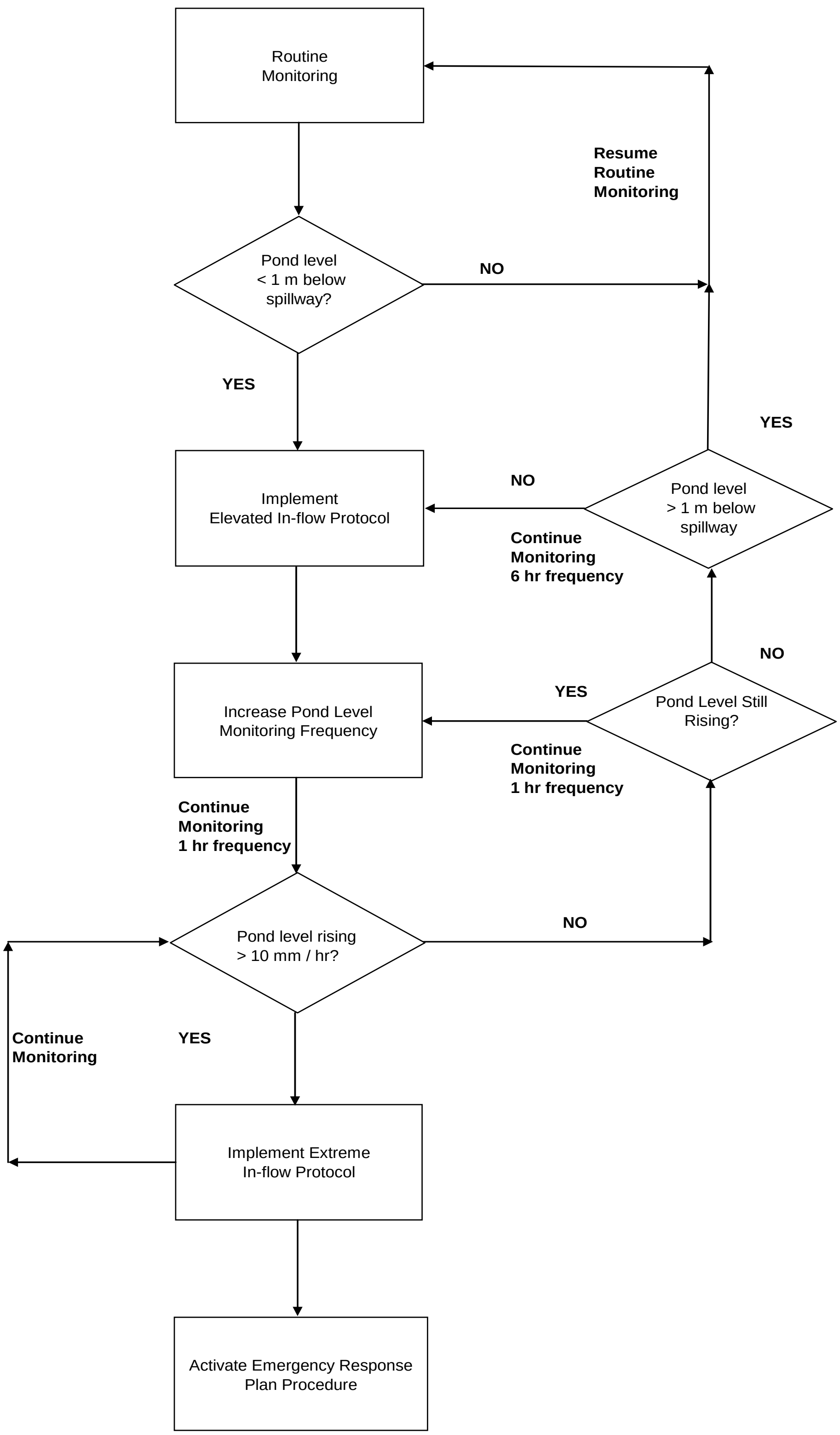
When pond level is stabilized 1 meter or more below the spillway, monitoring frequency will return to daily.

Extreme In-Flow Protocol (XIP)

If measurements under the EIP show that the pond level is rising faster than 10 mm per hour the Extreme In-Flow Protocol is triggered. Under these conditions, it is conceivable that the tailings impoundment will overflow into the design spillways in 24 hours.

Triggering of the XIP automatically activates the mine Emergency Response Plan. In the case of a possible tailings facility overflow this means operational shutdown and the immediate implementation of measures intended to prevent or mitigate the effects of an uncontrolled release from the TMF.

Monitoring continues after the XIP is triggered. Once a six hour period of decreasing rate of pond level rise is observed, the emergency status can be cancelled and operations can resume under the Elevated In-Flow Protocol described previously.



TMF Emergency Decision Process

TMF Emergency Response Plan

Tailings Dam Overflow or Dam Failure Responsibilities

In the event of a sudden, unexpected dam failure resulting from the 1/10,000 year earthquake, the following actions would be taken:

First Person on the Scene

Role: Report the emergency and serve as initial On-Scene Leader

- Notify Security/First Aid (S/FA)
- Ask for assistance
- Maintain contact with S/FA
- Remain in a safe location
- Direct ER personnel to scene

Security/First Aid

Role: Implement notification process and facilitate ER communications

- Notify area supervision (Mill Foreman and Mill GF)
- Notify management (GM, Mine, Mill, and HS&E Supt)
- Notify local emergency services
- Announce an emergency and clear radio Channel 1
- Facilitate communication for ER
- Keep a log of events

General Manager

Role: Support ER from command post and liaise with off-site parties

- Go to ER Command Post (S/FA office)
- Co-ordinate ER
- Notify off-site parties (corporate mgmt, local/municipal gov't, regulators, and media)
- Arrange for off-site resources (contractors, consultants)

HS&E Superintendent

Role: Support ER from command post in a Level 1 emergency and serve as On-Scene Leader in a Level 2 or 3 emergency

- Go to the scene
- Take charge as the on-scene leader
- Provide GM with situation reports
- Request appropriate assistance
- Order increased downstream monitoring
- Direct ER activities

Safety Officer

Role: Serve as On-Scene Leader in a Level 1 emergency and lead ER Team in a Level 2 or 3 emergency

- Cordon off area
- Ensure all personnel accounted for
- Ensure downstream area clear
- Lead ER team (if employed)

Environmental Tech

Role: Conduct and report increased frequency monitoring in the event of an imminent or actual loss of containment; deploy siltation barrier

- Increase downstream monitoring frequency
- Increase TMF monitoring frequency
- Communicate monitoring results to management

Mill Superintendent

Role: Co-ordinate Process Department activities with the emergency response

- Co-ordinate mill activities with ER
- Dispatch operations and maintenance personnel to scene as required
- Direct Mill Foreman to shut down mill
- Instruct Mill General Foreman to relocate decant pipeline

Mill General Foreman

Role: Direct Process Department operations and maintenance personnel in ER activities

- Direct operations and maintenance personnel in ER
- Relocate decant pipeline
- Oversee shutdown of Effluent Treatment Plant
- De-energize TMF substation if necessary

Mine Superintendent

Role: Co-ordinate Mine Department activities with emergency response

- Direct Mine Foreman to shut down open pit and prepare it to accept tailing water
- Provide heavy equipment for dam repair or containment (trucks, excavators, dozers)
- Support relocation of decant pipeline (crane, dozer, grader)
- Dispatch equipment/personnel to deploy siltation barrier
- Ensure dam stability monitoring frequency is increased

Mine General Foreman

Role: Direct Mine Department resources in ER activities

- Direct heavy equipment engaged in ER

Mine Engineering

Role: Provide increased frequency monitoring of dam stability

- Conduct survey monitoring to determine dam stability

TMF Emergency Response Plan

General Emergency Response Procedure

Activation

The Emergency Response (ER) procedure is activated either by (1) discovery of an emergency situation or (2) as a function of the Elevated and Extreme In-Flow Protocols. Upon discovery, the person at the scene will notify Security/First Aid by radio or phone. If the emergency is invoked as a result of XIP protocol, Security/First Aid will similarly be informed to start the notification procedure.

First Response

If an emergency situation is discovered, the first person at the scene is to:

- Notify Security/First Aid
- Explain the situation and ask for assistance
- Take corrective action only if trained and safe to do so
- Wait in a safe location for assistance and to direct the ER team to the site

Communications

Most communications during an emergency will be by radio. Discovery of an emergency could be through direct observation or via the process plant alarm system. When an emergency is discovered, Security/First Aid will announce an emergency situation and clear radio channel 1 for use during the emergency response. The Security/First Aid office will be the site command centre for the duration of the emergency.

The Mine Emergency Response Team will be notified by pager. Once notified, individuals will make their way to the Security/First Aid office in preparation to respond. Once an emergency response is underway, if practical, phones in the effluent treatment plant at the TMF should be used by a designated person to provide situation updates to the command centre.

Notification

The degree of notification is linked to the seriousness of the emergency. For a Level 1 emergency, Security/First Aid will notify operations supervision in the affected area to the General Foreman level and the site Safety Officer.

For a Level 2 emergency, Security/First Aid will notify department management in the affected area up to Superintendent level and the HS&E Superintendent. Local off-site emergency services may also be notified as required by the situation.

For a Level 3 emergency, Security/First Aid will notify site management up to the General Manager and the HS&E Superintendent. Supervision and management in the affected area will be the highest priority for notification. Local off-site emergency services and/or additional contract resources may also be notified as required.

Notification of regulatory authorities, local government, or corporate management will be the responsibility of the General Manager or his designate.

Shutdown

In the event of an emergency, activities in the affected area will cease. This will depend on the severity of the emergency. For example, a Level 1 vehicle accident at the TMF would not require the shutdown of tailings discharge while an activation of the facility spillways, a Level 3 event, would call for a general shutdown of all operations on site.

Evacuation

The area affected by an emergency will be cleared and cordoned off. A Level 1 event would see the immediate area reserved, a Level 2 event the entire TMF, and a Level 3 event the entire mine site.

Evacuation from the TMF area will be to a rally point where all persons can be accounted for. The rally point at the TMF is either (1) the Effluent Treatment (ET) Plant or (2) the NW corner of the TMF if the ET plant is in the emergency area.

Response

Following the announcement of an emergency, the HS&E Superintendent will proceed to the scene and take charge as the On-scene Leader (OSL). The OSL will assess the situation and inform Security/First Aid of the nature of the response required and the resources necessary. The OSL will inform Security/First Aid if a limited or general shutdown is required and if off-site emergency services are required.

The site Safety Officer will report to the ER Team page, assemble the team at the Security/First Aid office, and the assessment of the OSL before responding. Superintendents from other departments will stand by and be ready to provide assistance as required.

Deactivation

When the emergency response is complete the OSL will inform Security/First Aid that the emergency situation is over and give the “ALL CLEAR”.

Resumption of Operations

The Safety Officer can give permission for the resumption of operations after a Level 1 emergency. The HS&E Superintendent can give permission to resume operations after a Level 2 emergency. Only the General Manager can give permission to resume operations after a Level 3 emergency and only after a comprehensive TMF inspection has been performed. Such an inspection may require the integrity of the facility to be confirmed by a qualified third party depending on the nature of the event that caused the shutdown.

TMF Emergency Response Plan

Emergency Classification

Emergencies are classified as Level 1, 2, or 3. As the level increases so does the seriousness of the emergency. The characteristics of each emergency level and typical examples are shown below.

	Level 1	Level 2	Level 3
Resources	Department	Site/Local	Site/Local/Off-Site
On-Scene Leader	Safety Officer	HS&E Supt	HS&E Supt
ER Responsibility	Mill GF	Mill Supt	General Manager
Notification			
Internal	Dept Mgmt	Site Mgmt	Corporate Mgmt
External	None	Local ER Services	Public/local gov't
Area Control	Scene	TMF	Mine Site
Example	Minor MVA	MVA with injuries	Dam overflow
	Minor fire	Major fire	Dam failure
	Minor t-line leak	T-line rupture	
	Downed powerline	Serious Injury	
	Chemical spill		

Emergency Classifications

Level 1 emergencies are routine incidents that can be handled within the department. They are managed at the General Foreman level by the Safety Officer and typically entail property damage and production loss but no significant injury or environmental impact.

Level 2 emergencies are incidents that result in serious injury or potential environmental impact. Management of these incidents is largely internal although local emergency services such as fire department or ambulance may be required. The impact of the incident is limited to the mine site itself.

Level 3 emergencies are incidents which have major human health, safety, and/or environmental impact off site. The two incidents of this nature related to the TMF are an overflow or a dam failure. The design of the facility and operating procedures employed make incidents of this nature extremely unlikely. Never-the-less, in the event of a Level 3 emergency, local government and emergency organizations would be notified to reduce any resulting hazard to the general public.

Reporting of incidents to regulatory authorities will be conducted as required by law regardless of the internal classification applied. Only the General Manager and the HS&E Superintendent will communicate with off-site regulators to ensure that information communicated is accurate and controlled.

APPENDIX BB

KINETIC TEST SUMMARY

TECHNICAL MEMORANDUM

Golder Associates Ltd.
2390 Argentia Road
Mississauga, ON, Canada L5N 5Z7

Telephone: 905-567-4444
Fax Access: 905-567-6561

TO:	Peter Carter	**DATE:**	June 29, 2007
FROM:	Aurelia Lebegin/Ken DeVos	**JOB NO:**	06-1118-041c
EMAIL:			
RE:	Humidity Cell Test Summary and Recommendations for Continuing Some Cells – Atlantic Gold Touquoy Project		

1.0 BACKGROUND

Golder was retained by Atlantic Gold to conduct a geochemical evaluation of the Touquoy project. This memorandum provides a brief summary of currently ongoing geochemical testwork and recommendations to Atlantic Gold with respect to the ongoing laboratory test work.

Geochemistry work was initiated in Mid-2006 with completion of an on-site sampling program. M. Herrell of Golder Associates visited site and reviewed available drill core to select samples to be representative of potential materials from the deposit. Following selection of samples a static test program was initiated with results presented in December of 2006. Following completion of the static test program 10 waste rock samples of various lithologies were selected for longer term kinetic testing to evaluate potential changes in chemistry over time. Results for the initial 16 weeks of testing were presented in a draft report in May of 2007. Twenty weeks of test data are currently available for most test cells with the exception of one tailings test cell (CND1).

In addition to the waste rock samples, two tailings samples were provided. Initially, a master-composite head sample provided by Atlantic was leached and detoxified by SGS Lakefield in Ontario, Canada, under the direction of Atlantic's metallurgist, Sydney-based Peter Lewis and Associates to produce a tailings sample reported to be representative of the expected process by-product at the Touquoy site (Lewis, 2006). Due to the expected homogeneity of the Touquoy deposit, only one tailings sample was prepared to represent the tailings materials that will be produced during operations (Lewis, 2006). Following analyses of this sample, and discussions with Atlantic Gold and their metallurgists it was determined that an additional sample would be required for evaluation of cyanide degradation rates, and to help assess potential variability in tailings materials, hence materials for a second tailings sample were shipped to SGS Lakefield and a second sample was prepared under the direction of Peter Lewis and Associates.

With respect to laboratory test work, Golder provides advice and recommendations to Atlantic Gold who are responsible for retaining and directing the laboratory work. The purpose of this memo is to provide recommendations to Atlantic Gold regarding continuation or termination of ongoing test cells. Actual results from the test cells are discussed in the May 2007 draft Static and Kinetic test report, or will be included in the follow up final report regarding static and kinetic test work. An interim technical memorandum on the status of the CND tailings kinetic test results will be provided separately.

2.0 ONGOING GEOCHEMISTRY TESTWORK

It is our current understanding that kinetic testing is still underway on the 10 kinetic samples and one of the tailings samples. The status of the kinetic testing of these samples is summarized in Table 1.

Figures 1 through 12 provide graphic summaries of the results for key parameters for the testwork that is currently underway. Based on the results, Table 1 provides a recommendation regarding either continuation of testing, or termination of the kinetic test cell. The rational for continuation or termination of test cells is as follows:

- Following an initial stabilization period, if the chemistry over the last 8 to 10 weeks of testing is, or continues to be stable then it is likely that the test cell has reached somewhat of an equilibrium condition and testing should be discontinued, especially if the test cell is not expected to become acidic.

- If the chemistry of the last 3 to 5 weeks of the test period is somewhat erratic, or if the values show trends (e.g. pH declining trend and/or sulphate, arsenic or carbonate on an increasing trend) then the test cells should be continued for an additional period of time and reassessed after the next 10 to 20 week period.

3.0 RECOMMENDATIONS REGARDING KINETIC TESTING

Should Atlantic Gold want additional data which may provide marginally more certainty with respect to the long term stability and water quality of these materials they may choose to continue all of the cells, however, based on the data received to date the following suggestions are provided to guide Atlantic Gold to guide their decisions regarding continuation of the Kinetic test cells:

- Based on the observed reasonably stable leachate chemistry from samples 06-006 (Figure 1), 06-049 (Figure 3), 06-079 (Figure 4), 06-012 (Figure 5), 06-051 (Figure 6), , 06-070 (Figure 7), and 06-085 (Figure 10), and Tailing Sample CND2 (Figure 12) it is recommended that kinetic testing of these samples be discontinued.

- For samples 06-017 (Figure 2), 06-068 (Figure 8) and 06-039 (Figure 9) arsenic and aluminum trends have increased over the last 8 to 10 weeks of testing. It is recommended that kinetic testing of these cells continue until at least week 40 and that the results be reassessed after week 28 and week 38 to determine if the test cells should continue beyond 40 weeks in duration.

- For sample CND1 (Figure 11) only 6 weeks of data has been provided by the laboratory and it is recommended that this cell be continued to at least 20 weeks and reassessed at week 18 to determine weather the testing should continue beyond week 20.

4.0 CLOSURE

We look forward to discussing these recommendations with you at your convenience. Please feel free to contact us should you have any questions or require clarification on any of the topics discussed.

AL/KJD/kjd

Table 1: Status of Kinetic Testing

Test ID	Lithology	Start Date	Latest Sample	Current / Total (weeks)	Status	Recommended Action	Objective/Rationale for Termination / Continuation
					Waste Rock		
06-006	Argillite (<5% Greywacke)	9-Jan-07	26-Jun-07	24	Currently Ongoing	Terminate Testing	Relatively stable chemistry, not expected to become acid generatiing based on ABA data.
06-017	**Argillite (<5% Greywacke)**	**9-Jan-07**	**26-Jun-07**	**24**	**Currently Ongoing**	**Continue Testing**	Not expected to become acid generatiing but alkalinity, Ca, Co, and As unstable or on an upward trend
06-049	Argillite (<5% Greywacke)	9-Jan-07	26-Jun-07	24	Currently Ongoing	Terminate Testing	Relatively stable chemistry , not expected to become acid generatiing based on ABA data
06-079	Argillite (<5% Greywacke)	9-Jan-07	26-Jun-07	24	Currently Ongoing	Terminate Testing	Relatively stable chemistry , not expected to become acid generatiing based on ABA data
06-012	Argillite (5-49% Greywacke)	9-Jan-07	26-Jun-07	24	Currently Ongoing	Terminate Testing	Relatively stable chemistry , not expected to become acid generatiing based on ABA data
06-051	Composite	9-Jan-07	26-Jun-07	24	Currently Ongoing	Terminate Testing	Relatively stable chemistry , not expected to become acid generatiing based on ABA data
06-070	Composite	9-Jan-07	26-Jun-07	24	Currently Ongoing	Terminate Testing	Relatively stable chemistry , low expection of becoming acid generatiing based on ABA data
06-068	**Greywacke (<20% Argillite)**	**9-Jan-07**	**26-Jun-07**	**24**	**Currently Ongoing**	**Continue Testing**	Increasing Trends in Ca, Al, As
06-039	**Greywacke (20-50% Argillite)**	**9-Jan-07**	**26-Jun-07**	**24**	**Currently Ongoing**	**Continue Testing**	Increasing Trends in Al, As
06-085	Marginal Ore	9-Jan-07	26-Jun-07	24	Currently Ongoing	Terminate Testing	Relatively stable chemistry , not expected to become acid generatiing based on ABA data
					Tailings		
CND1	**Master-composite head sample**	**24-Apr-07**	**29-May-07**	**5**	**Ongoing May07**	**September 07**	Additional data needed to develop long term trends
CND2	Master-composite head sample	25-Oct-06	21-Mar-07	21	Terminated Mar07	Terminated Mar07	Stable chemistry

Total # of Cells	**12**
Active Cells	**11**

Figure 1

Summary of Humidity Cell Results

Sample 06-006

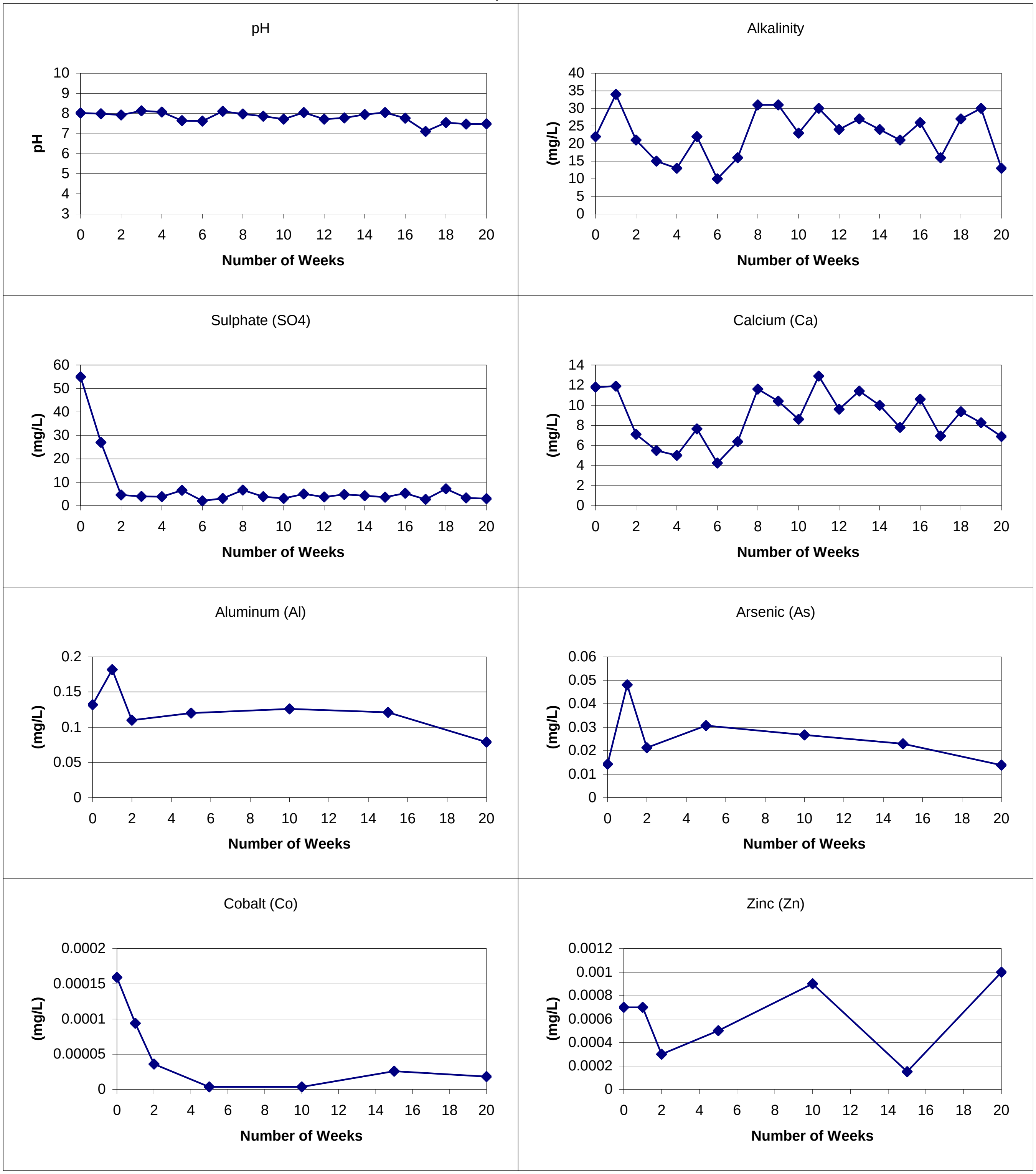


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Figure 2

Summary of Humidity Cell Results

Sample 06-017

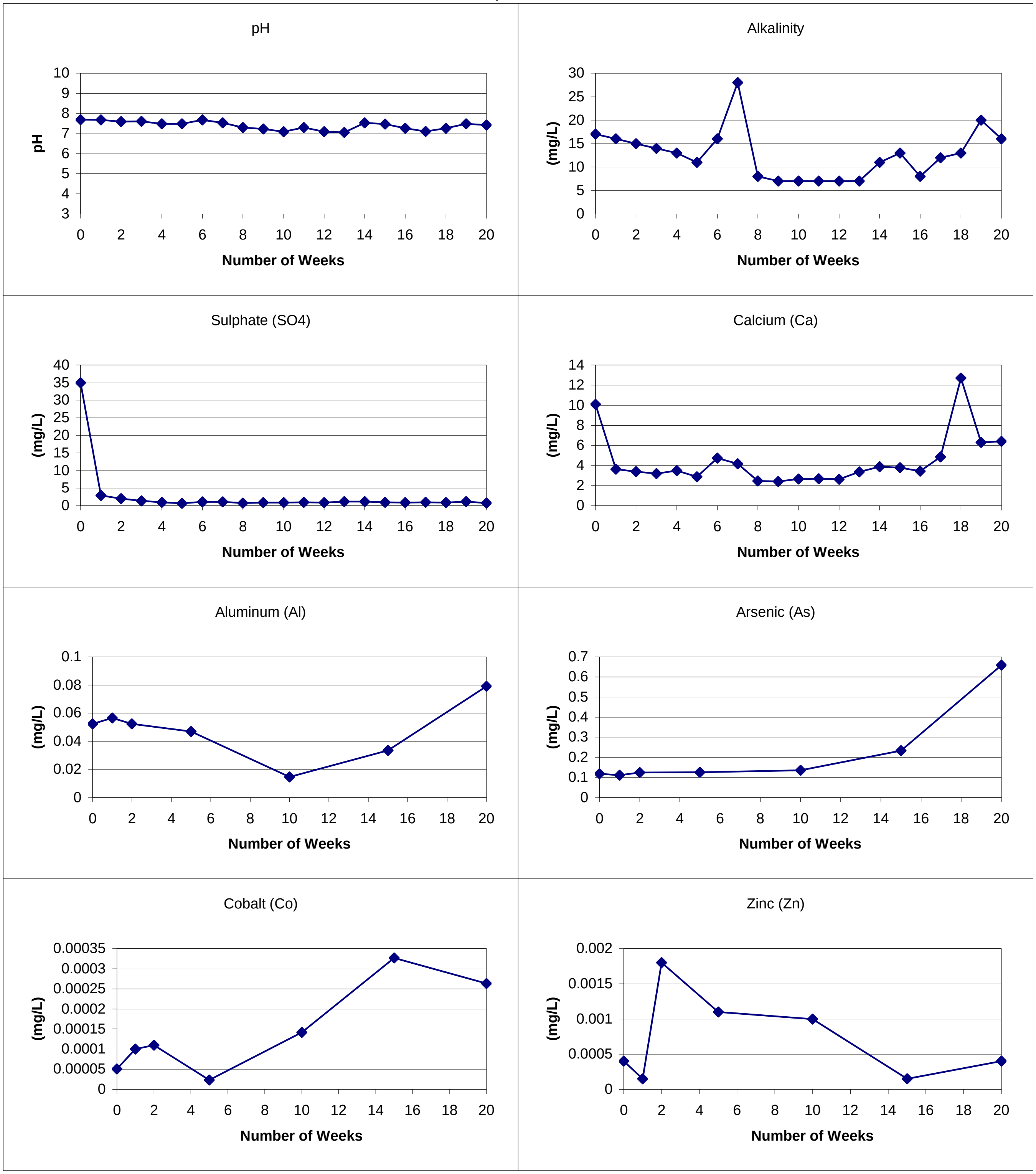


Figure 3

Summary of Humidity Cell Results

Sample 06-049

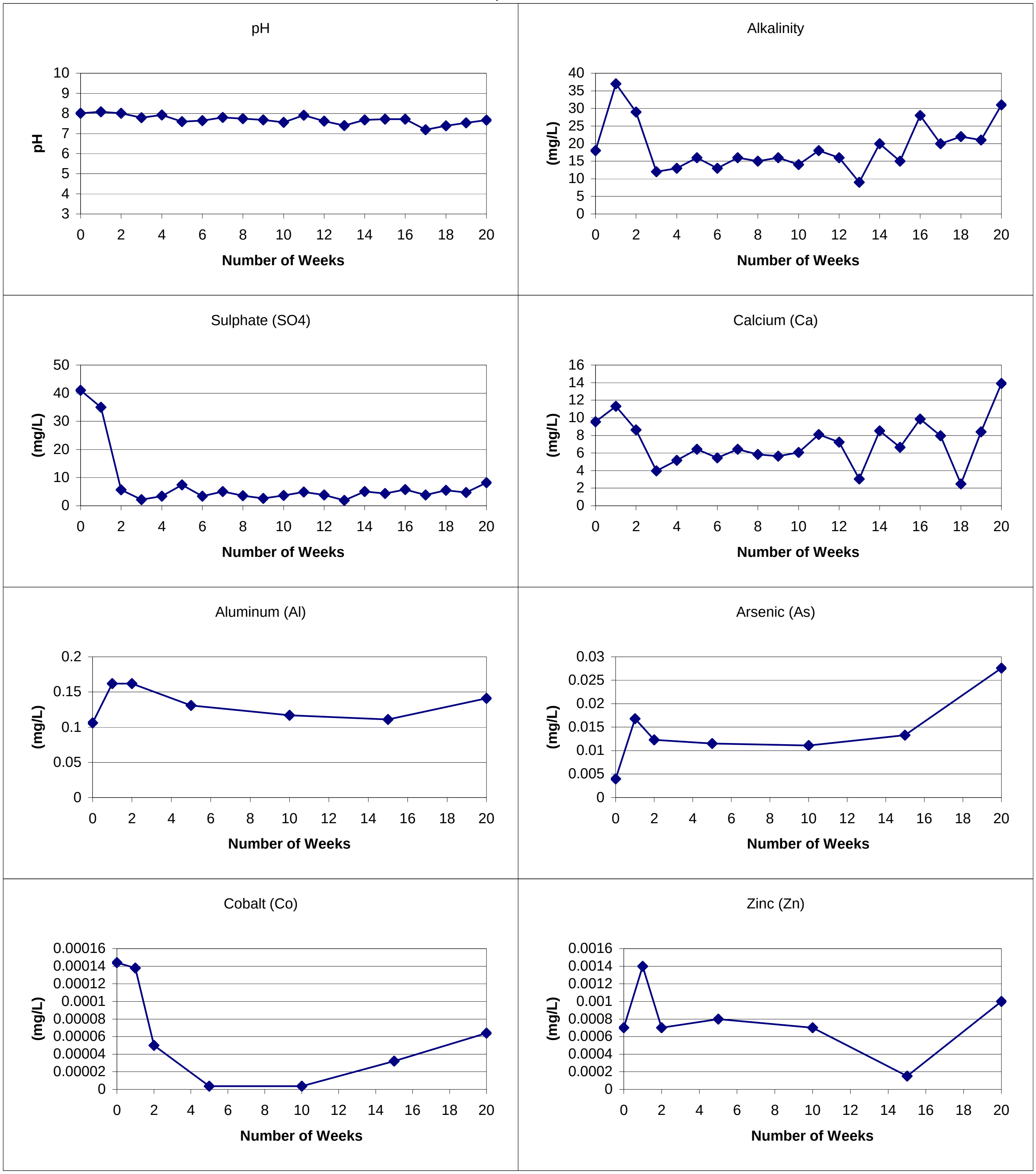
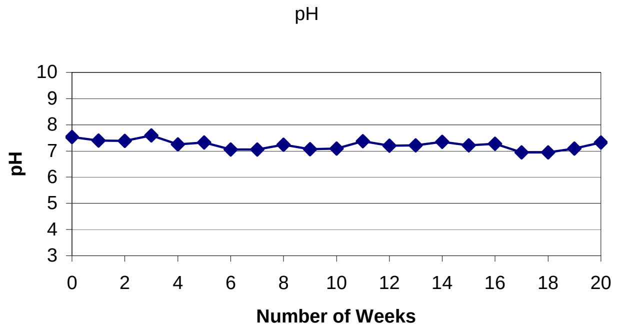
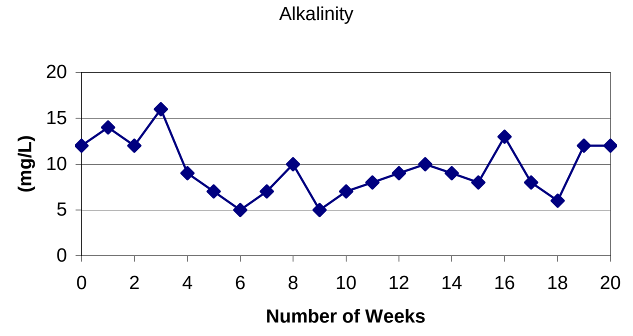
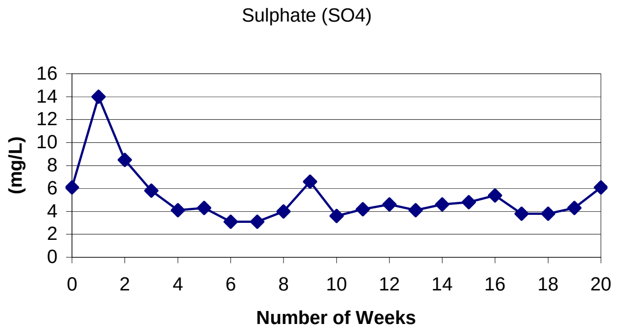
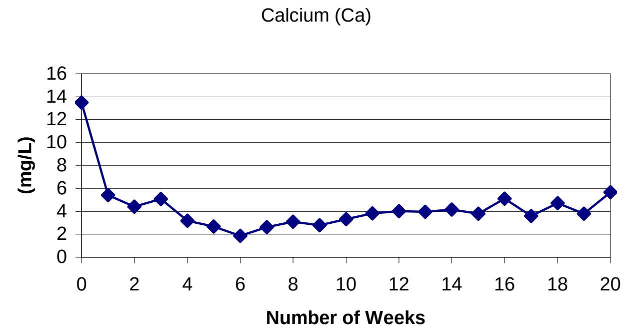


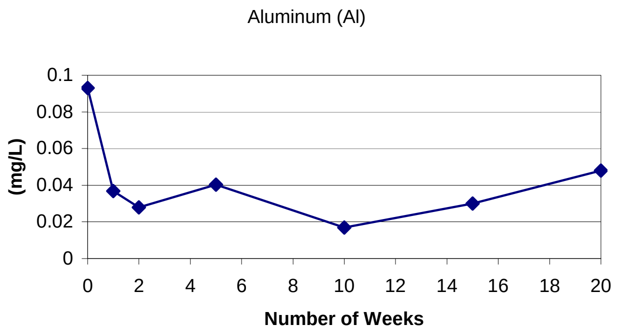
Figure 4
Summary of Humidity Cell Results
Sample 06-079

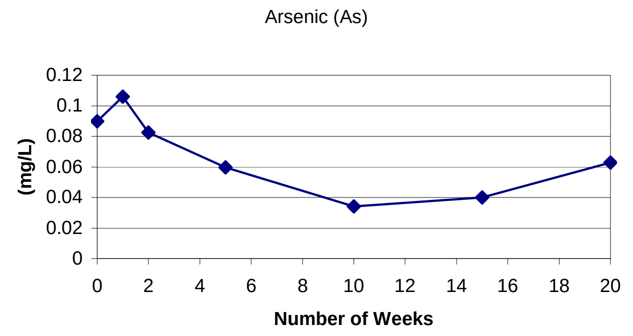


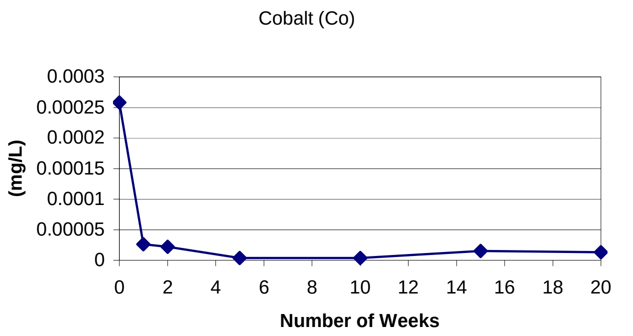












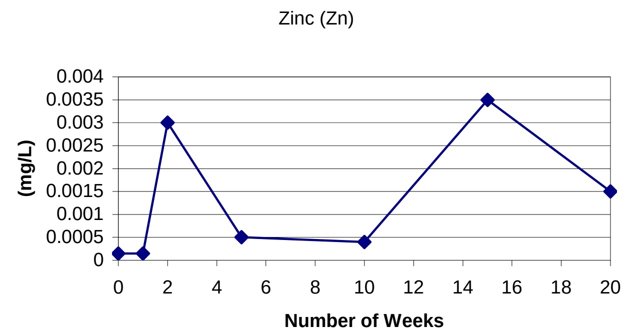


Figure 5

Summary of Humidity Cell Results

Sample 06-012

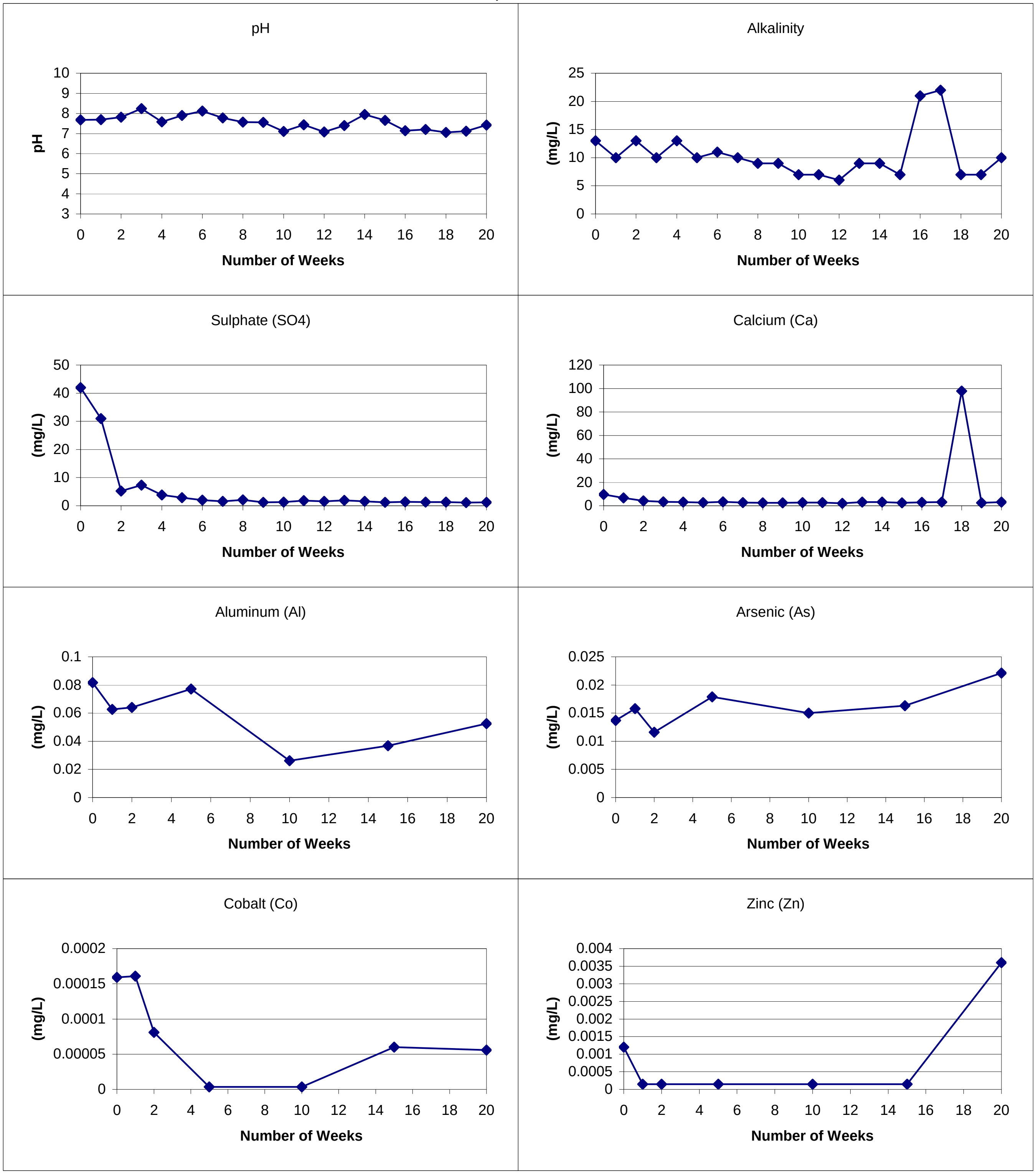


Figure 6

Summary of Humidity Cell Results

Sample 06-051

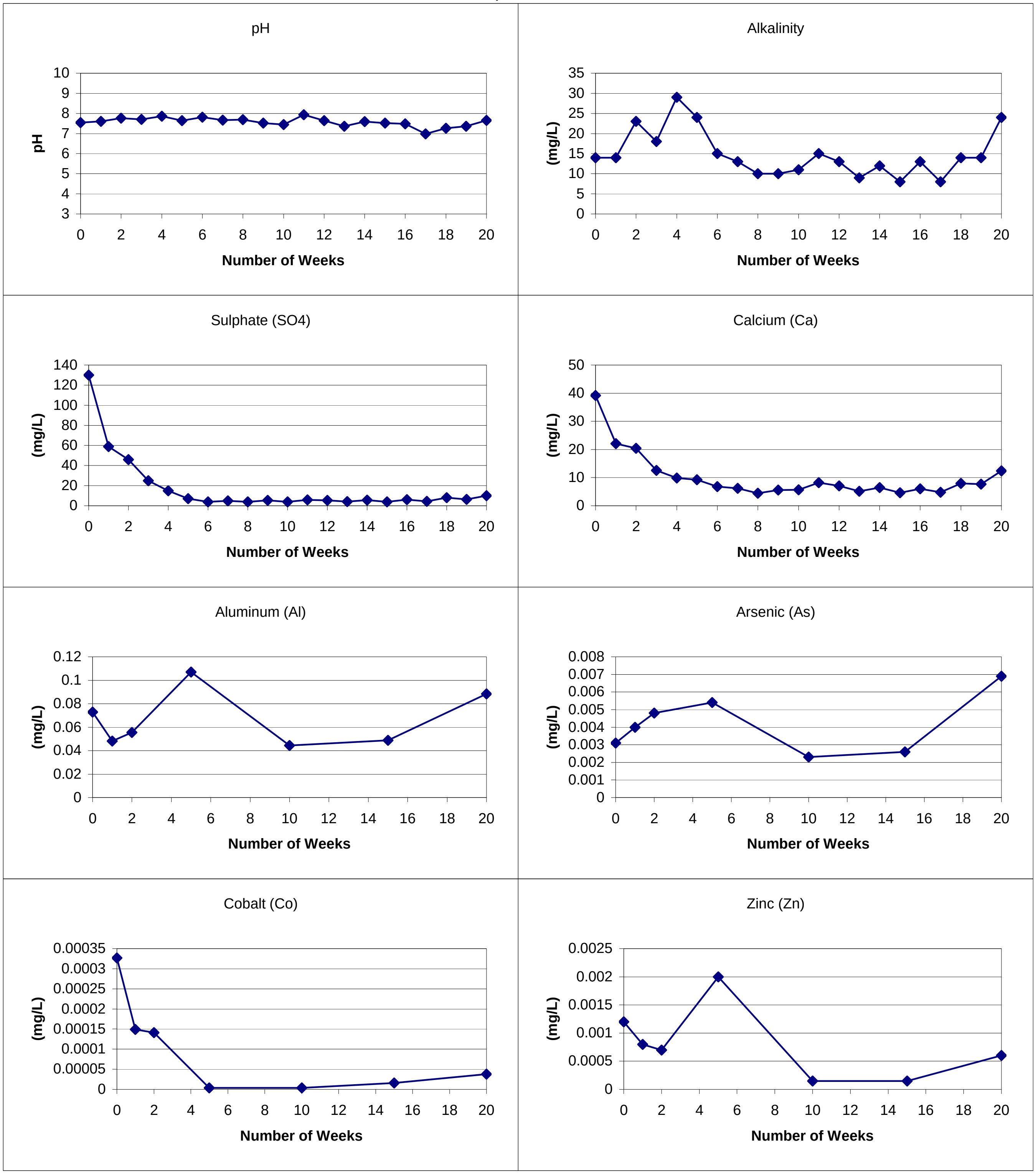


Figure 7
Summary of Humidity Cell Results
Sample 06-070

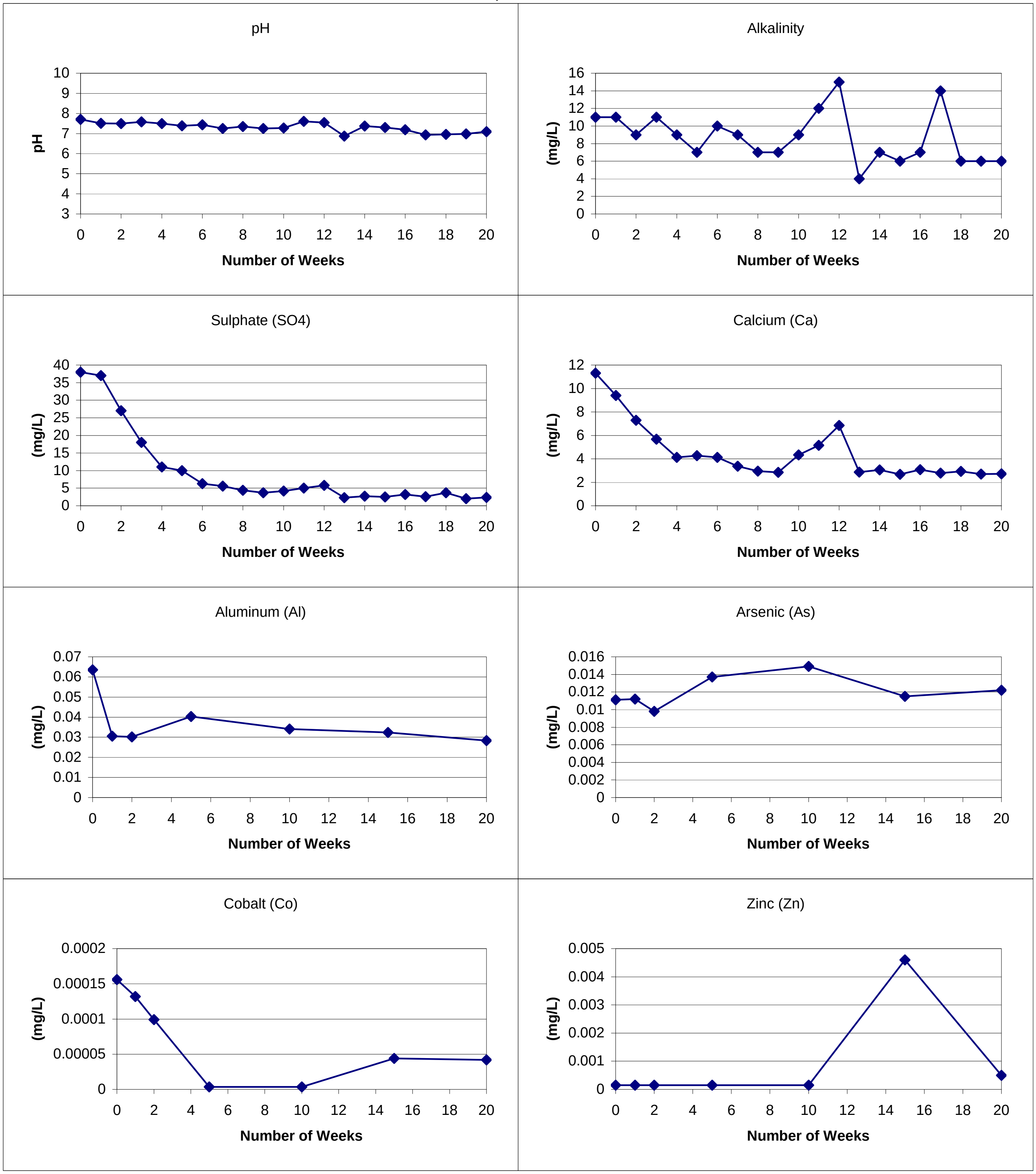


Figure 8
Summary of Humidity Cell Results
Sample 06-068

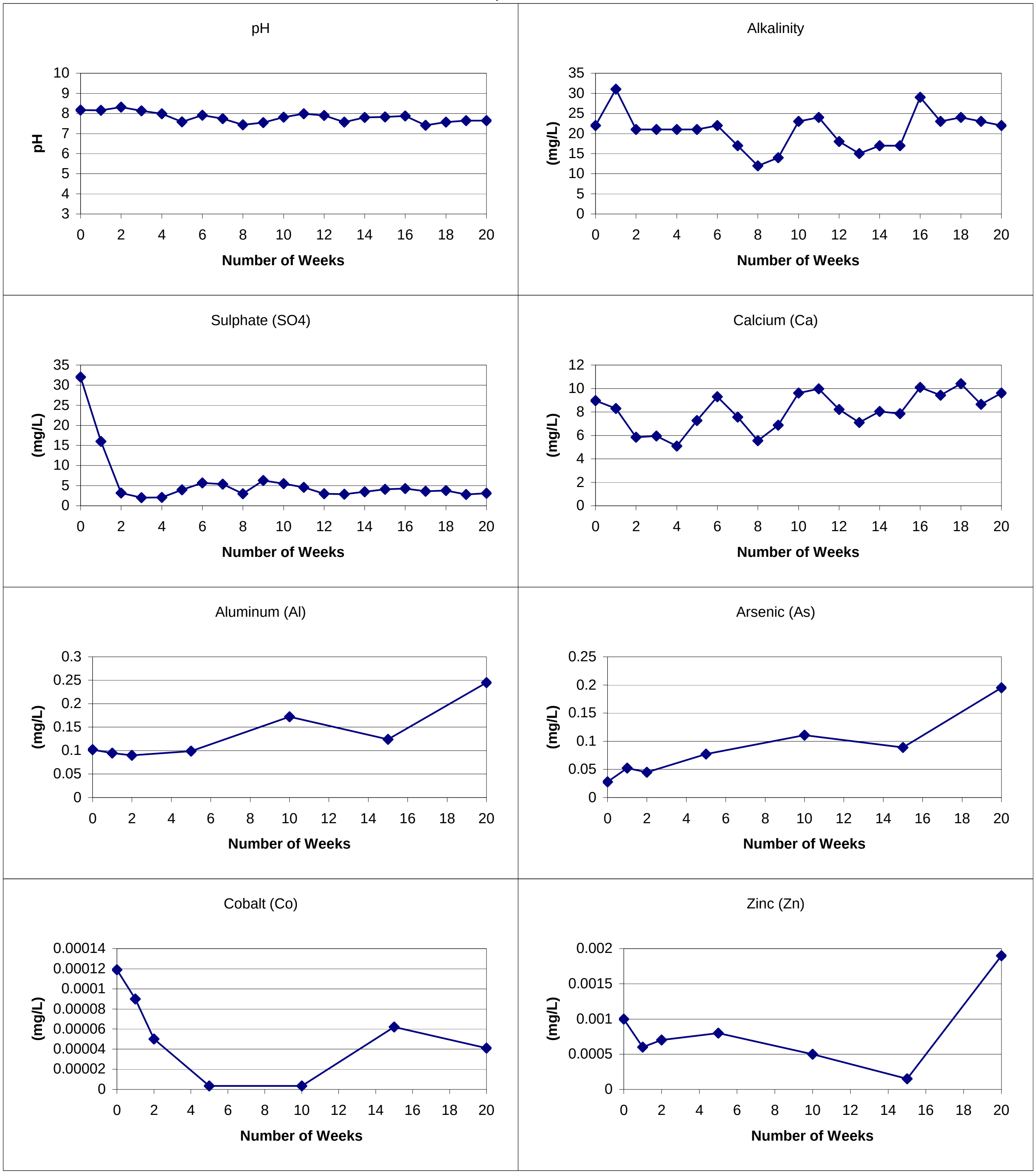


Figure 9
Summary of Humidity Cell Results
Sample 06-039

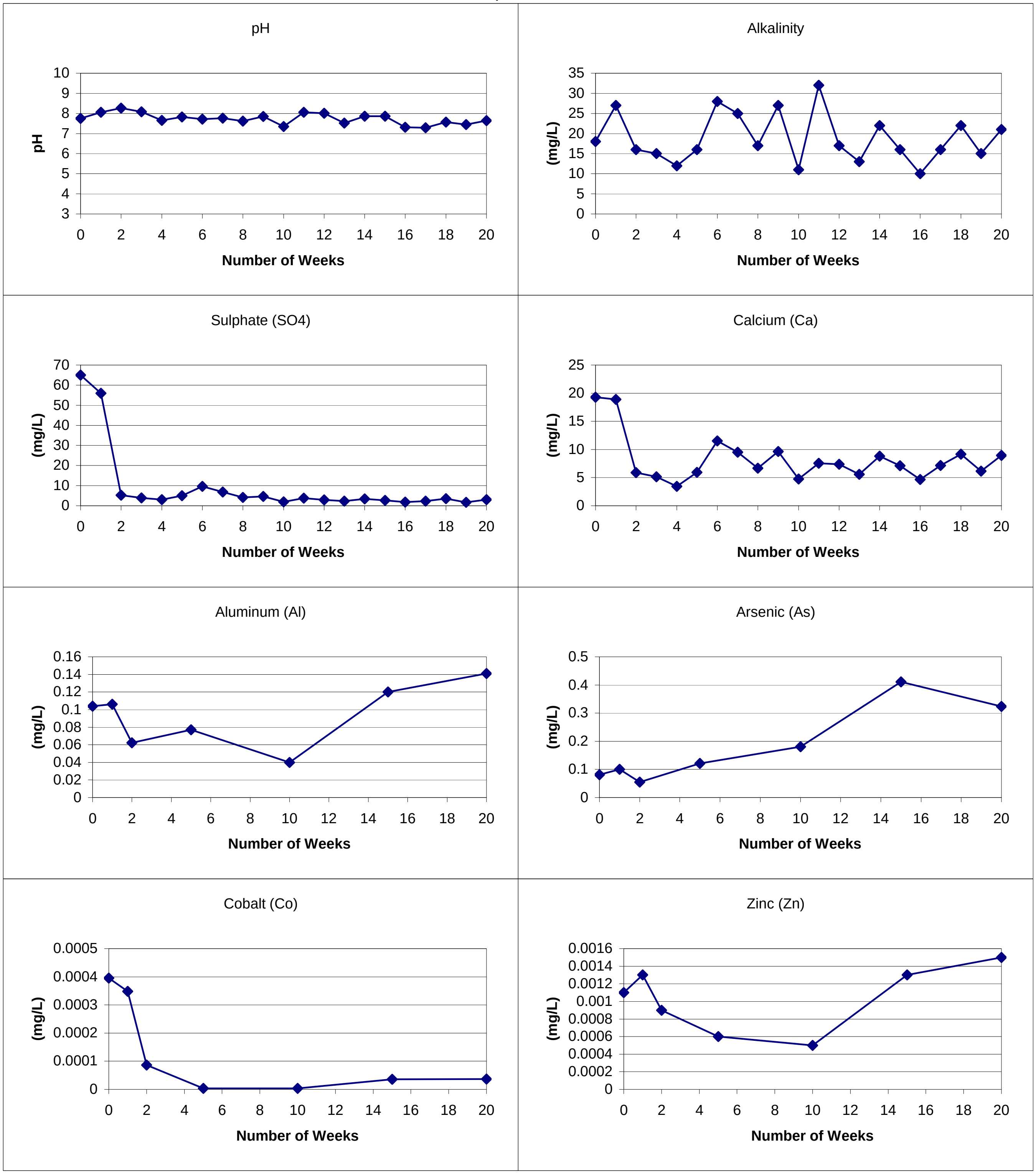


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Figure 10
Summary of Humidity Cell Results
Sample 06-085

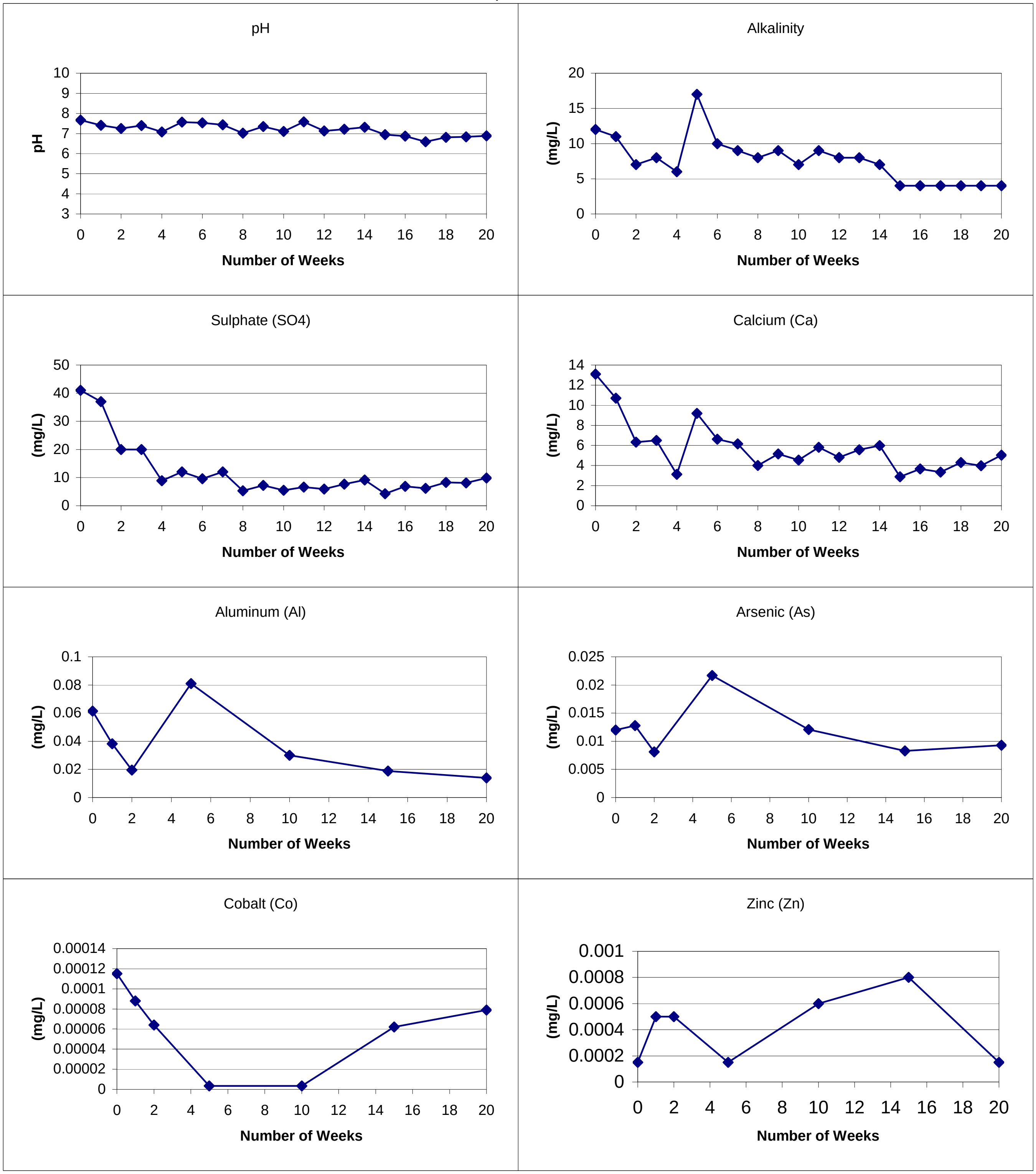


Figure 11

Summary of Humidity Cell Results

Sample CND1

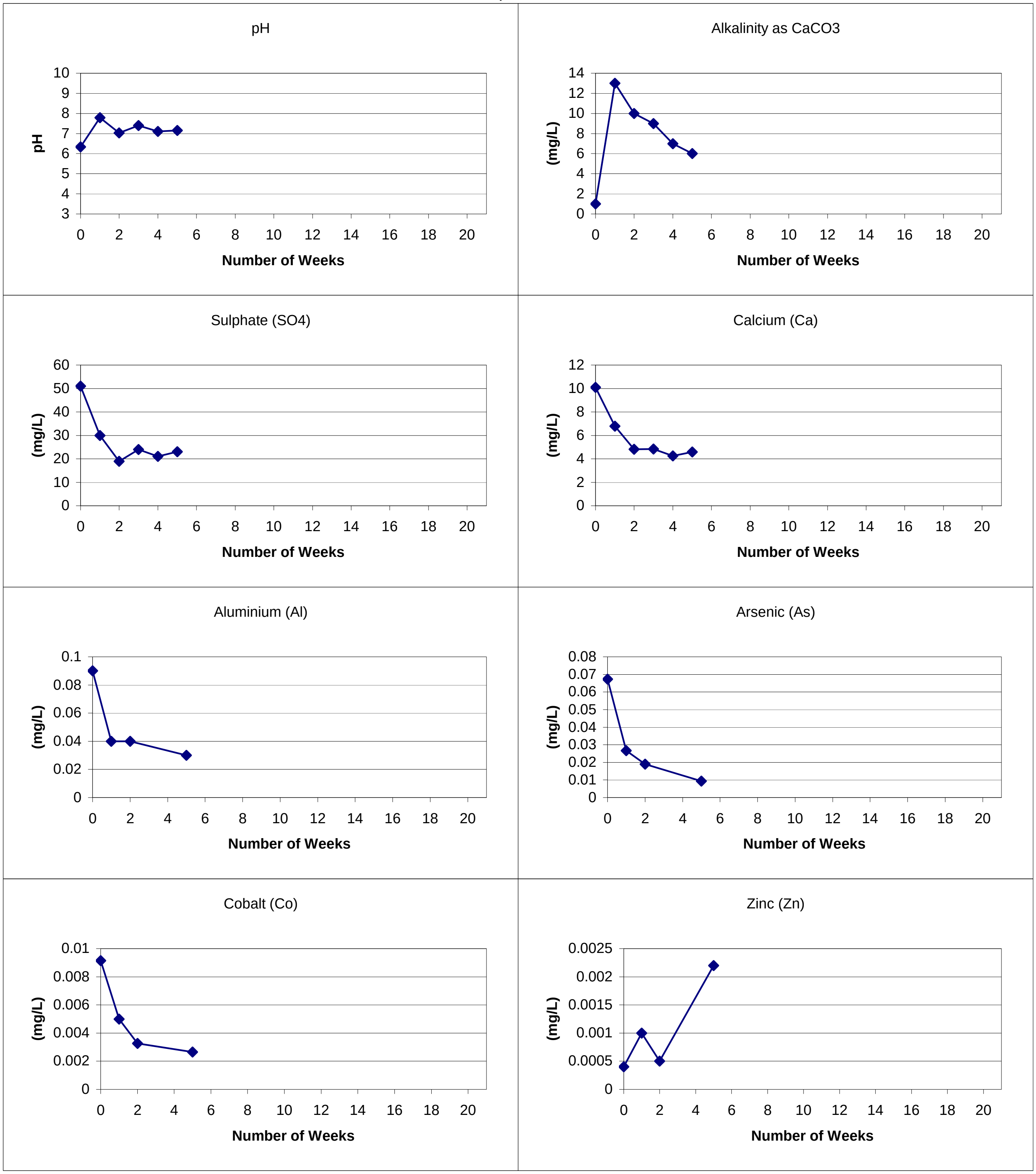
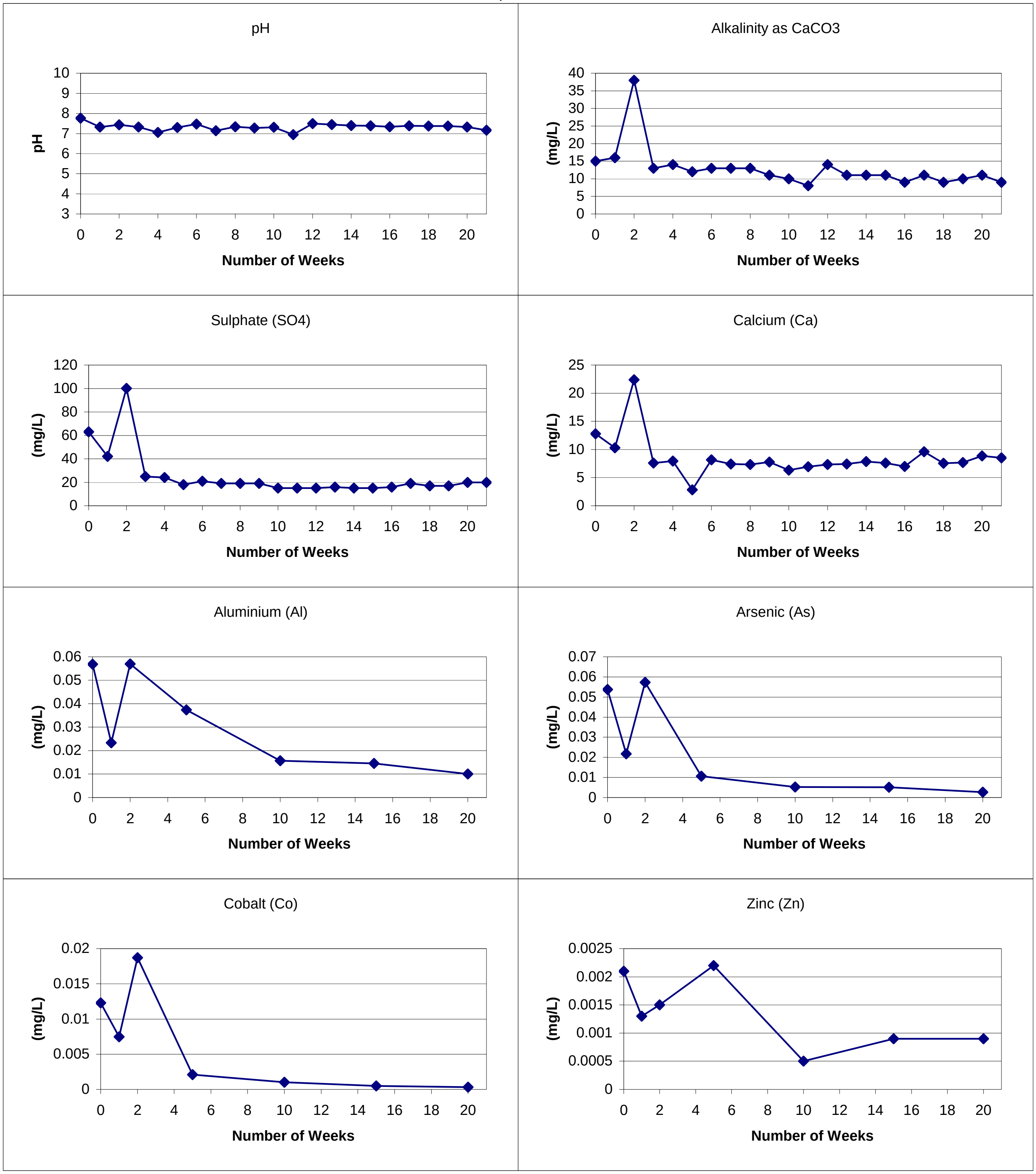


Figure 12

Summary of Humidity Cell Results

Sample CND2



APPENDIX CC

FATE OF CYANIDE REAGENT MEMO -
KP PHINNEY

FATE OF CYANIDE REAGENT - TOUQUOY GOLD PROJECT

Approximately 816 tonnes per year (t/a) of sodium cyanide will be used for the extraction of gold from the ore. This amount of sodium cyanide will contain approximately 433 tonnes of cyanide (CN^-). The "fate" of this reagent, during the processing of the ore and the subsequent treatment of wastewater, is summarized in Table 1 and Table 2.

Approximately 1% of the cyanide reagent will be volatilized or otherwise lost to the environment during the processing of the ore to recover elemental gold. The 1% estimate is an industry-derived value from observations at many gold mining operations. Most of this cyanide will be lost to the atmosphere as hydrogen cyanide gas (HCN). The remaining cyanide will be oxidized by the SO2/air treatment process to generate substantially less toxic cyanate (CNO^-). Approximately 96% of the cyanide in the tailings will be converted to cyanate by this process. Thus, the tailings, as discharged into the tailings pond, will contain approximately 413 tonnes of cyanide in the form of cyanate and 16 tonnes of residual cyanides in the forms of free cyanide, hydrogen cyanide, and metal cyanide complexes.

The degradation of these cyanide compounds will continue in the tailings pond. Volatilization of cyanide as hydrogen cyanide gas is the primary process for the removal of the non-cyanate forms of cyanide in tailings ponds. Approximately 14 tonnes of cyanide will be volatilized from the tailings pond. The cyanate form will hydrolyze to ammonia and bicarbonate alkalinity. The ammonia can be expected to be present in the tailings pond and receiving streams primarily in the ammonium form due to the relatively low pH within the local streams and lakes. Similarly, the bicarbonate alkalinity can be expected to be released into the atmosphere as carbon dioxide, again due to the low pH of streams and lakes within this region of Nova Scotia. On this basis, the hydrolysis of cyanate will produce approximately 697 tonnes of carbon dioxide and 286 tonnes of ammonium ion on an annual basis.

Annually, less than 2.5 tonnes of cyanide will be released at prescribed concentrations, 1.0 mg/L CN_{TOT} (MMER) at discharge and 0.005 mg/L CN_{FREE} (CCME) in receiving waters, determined by regulating authorities not to pose a risk to human health or harm the environment.

Table 1 - Losses and Conversion of Cyanide in the CIP Plant

Item	Quantity (t/a)	Comment
Sodium cyanide reagent consumption in the CIP Plant	433 as CN^-	Added to the circuit as sodium cyanide
Losses and Conversion of Cyanide in the CIP Plant • Loss of cyanide as HCN due to volatilization within the CIP plant • Conversion of cyanide to cyanate in the SO2/air treatment plant • Loss of cyanide as "total" cyanide in the tailings	4 as CN^- 413 as CN^- 16 as CN^- 433 as CN^-	Losses from process equipment Cyanide is in the form of "free" and "metallo" cyanides in the tailings.

Table 1 Cont'd - Losses and Conversion of Cyanide in the Tailings Pond and Environment

Item	Quantity (t/a)	Comment
Loss of cyanide as HCN due to volatilization from the tailings pond	14 as CN^-	
Conversion of cyanate to carbon dioxide and ammonium	698 as CO_2 286 as NH_4^+	Hydrolysis is slow and may continue in the environment; the low pH of receiving streams will favour formation of carbon dioxide and ammonium ions.
Discharge of residual cyanides as "total" cyanide from the tailing pond	2.5 as CN^-	Cyanide is in the form of "metallo" cyanides in the tailings pond discharge

Table 2 - Overall Carbon/ Nitrogen Balance for Cyanide Reagent Touquoy Gold Project

Item	Carbon (t/a)	Nitrogen (t/a)
Addition to system from reagent use (sodium cyanide)	200	233
Losses from the system • Loss from CIP Plant by volatilization • Loss from Tailings Pond by volatilization • Conversion of cyanate by hydrolysis • Residual discharges from tailings pond	1.8 6.5 190 1.5 200	2.2 7.5 222 1.4 233

APPENDIX DD

EFFLUENT TREATMENT TESTWORK

An Investigation into

EFFLUENT TREATMENT TESTWORK

prepared for

ATLANTIC GOLD

Project 11373-003 – Report No. 3
October 25, 2007

NOTE:
This report refers to the samples as received.

SGS Lakefield Research Limited | P.O. Box 4300, 185 Concession Street, Lakefield, Ontario, Canada K0L 2H0
Tel: (705) 652-2000 Fax: (705) 652-6365 www.met.sgs.com www.sgs.com
Member of the SGS Group (SGS SA)

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Executive Summary

Laboratory testwork was conducted at SGS Minerals Services Laboratory in Lakefield, Canada, to apply Inco's SO_2/air method for treating a pulp from cyanidation of an ore sample from DVD Gold's Touquoy Project, to produce detoxified pulp for environmental testing.

The ore sample (M 1142 TAM) was ground in a laboratory ball mill to a P_{80} size of approximately 150 µm, for leaching using the conditions of the previous cyanidation test conditions (Atlantic Gold Project 11373-003, Report No. 2, June 19, 2007). The leached pulp was pre-screened at 35 mesh (420 µm) to remove any coarse solids, to facilitate pumping of the slurry during cyanide destruction.

Cyanide destruction testwork using Inco's SO_2/Air process was conducted on the leached pulp, to produce treated slurry containing <10 mg/L residual CN_{WAD}, for downstream testing. The pulp sample responded well to detoxification using the SO_2/air process. The combined product (solution phase) contained 6.1 mg/L CN_T, 6 mg/L CN_{WAD}, 9.42 mg/L Cu and 0.07 mg/L Fe. The overall reagent addition (excluding the batch test) was 2.7 g SO_2, 2.63 g hydrated lime and 0.14 g Cu per g CN_{WAD} in the feed.

The downstream testwork was conducted using a procedure provided by Atlantic Gold NL. The combined cyanide destruction product pulp was agitated and aerated overnight to remove volatiles and to stabilize the mixture. The pulp was then split into two portions. One portion was allowed to age at room temperature for several weeks. The other portion was allowed to stand overnight, and the supernatant solution was then collected for testing for arsenic removal.

The results indicated that aerating the slurry overnight (after cyanide destruction) lowered the residual cyanide and metals to 3.5 mg/L CN_T, 3.1 mg/L CN_{WAD}, 7.94 mg/L Cu and <0.01 mg/L Fe.

A series of arsenic removal optimization tests was conducted on the supernatant solution, and the results indicated that a ferric sulphate addition equivalent to a Fe-to-As mass ratio of 20-to-1 was adequate for lowering the dissolved As level to 0.04 mg/L. A bulk arsenic removal test was then carried out on the supernatant solution (at the indicated Fe-to-As mass ratio of 20-to-1), followed by flocculation with 0.5 mg/L of Magnafloc 338. The flocs were allowed to settle for 30 minutes, and the supernatant solution was collected for analysis of turbidity, dissolved As and other metals and species of interest.

The results showed that treating the cyanide destruction supernatant solution with ferric sulphate, followed by flocculation, reduced the concentrations of residual cyanide and arsenic to 1.6 mg/L CN_T, 1.5 mg/L CN_{WAD} and 0.04 mg/L As.

The same test procedure was applied to the supernatant solution collected from the aged cyanide destruction pulp. The results indicated that aging the cyanide destruction pulp at room temperature for 56 days reduce the residual cyanide and copper concentrations in solution from 3.5 mg/L CN_T, 3.1 mg/L CN_{WAD} and 7.9 mg/L Cu to 0.21 mg/L CN_T, 0.19 mg/L CN_{WAD} and 0.24 mg/L Cu. However, the arsenic concentration was unchanged at 0.47 mg/L, while the Fe concentration increased slightly from <0.01 mg/L to 0.15 mg/L.

Treating the supernatant solution of the aged cyanide destruction pulp with ferric sulphate, at a Fe-to-As mass ratio of 20-to-1 followed by flocculation, further reduced the concentrations of dissolved cyanide, copper and arsenic to 0.03 mg/L CN_T, 0.09 mg/L Cu and 0.006 mg/L As.

Introduction

SGS Minerals Services Laboratory in Lakefield, Canada, was contracted by Atlantic Gold NL to conduct a laboratory test program to apply Inco's SO_2/air process for treating a cyanide pulp from leaching of a gold ore sample from DDV Gold's Touquoy Gold Project, to destroy cyanide and produce pulp for environmental testing.

The test program was directed by Mr. Peter Carter of Atlantic Gold NL, and consisted of a bulk cyanidation test followed by cyanide destruction of the leached pulp. The tailings produced were treated with ferric ions for arsenic removal. The details of the testwork are documented in this report.

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Testwork Summary

1. Feed Sample

The feed sample (three pails containing 12 bags of -10 mesh ore labelled M 1142 TAM, approximately 70 kg in combined mass) was received at Lakefield on July 3, 2007, and was given a reference number 0020-JUL07.

A head sample was rifled out from one of the bags of sample and submitted for gold and silver analysis. The results of the head analysis are presented in Table 1. The sample assayed 0.73 g/t Au, which was lower than the head grade of 1.38 g/t Au, back calculated from the bulk cyanidation test

Table 1. Head Analysis

Head Sample	Au g/t	Ag g/t
Sample from one of the 12 bags	0.73	<0.5
Back calculated from Test CN 2	1.38	<0.6

2. Grinding Tests

The objective of the grinding testwork was to calibrate the laboratory ball mill for estimating the time required for milling the ore sample to the target particle size distribution for cyanidation. Two grinding tests were conducted in a 10-kg laboratory ball mill using 10 kg of sample per test. The results are summarized in Table 2, and the details of the experiments are appended (Appendix 1).

Table 2. Results Grinding Tests

Test	Grind Time min/10 kg	Product K_{80} µm
G1	14.5	157
G2	15.0	152

3. Cyanidation Test

The ore sample (50 kg) was ground in the 10-kg ball mill for 15 minutes per batch of 10 kg. The mill discharge was adjusted with tap water to 50% solids for gold leaching. The cyanidation test was conducted using the following conditions:

Feed:	*Ground in ball mill to P_{80} approximately 150 µm*
Pulp Density:	*50% solids (adjusted using Lakefield tap water)*
Leach Method:	*Direct cyanidation*
Leach pH:	*10.5 with hydrated lime*
NaCN in Solution:	*0.5 g/L (0.050%) at start, then maintain 0.2 g/L if required*
Oxygenation of Slurry:	*Natural agitation in air (DO approx 8 mg/L)*
Leach Time:	*20 hours*
Samples:	*2, 4, 8, 12, 20 hours for pH, DO, NaCN*
Au and Ag Analysis:	*Final solution and leached residue*

Following leaching, a pulp sample was taken and filtered. The filtrate was submitted to the Analytical Laboratory for analysis of Au and Ag. The filter cake was thoroughly washed with water before submitting for gold and silver assay.

The results of the cyanidation test are summarized in Table 3 and the details of the experiment are appended (Appendix 1).

Table 3. Results of Cyanidation Test

Test	Pulp Dens. %	Leach pH	Leach Reten. Time h	Leach NaCN Conc. (g/L) Start	Leach NaCN Conc. (g/L) Maint'ed	Leach NaCN Added kg/t	Leach NaCN Consu. kg/t	Leach CaO Added kg/t	Leach CaO Cons. kg/t	Leach DO_2 (ppm) 0-h	Leach DO_2 (ppm) 20-h	Gold in Res. g/t	Gold Calc. Head g/t	Gold 20-h Extrac. %
CN 2	50	~10.5	20	0.5	0.2	0.50	0.06	0.22	0.22	7.0	8.1	0.23	1.38	83.3

The cyanide addition was 0.5 kg/t, and all of this was added at the beginning of the leach. The free cyanide concentration was above 0.2 g/L NaCN throughout the test, and further addition of sodium cyanide was not required. The cyanide consumption was 0.06 kg/t. The lime addition was 0.22 kg/t equivalent CaO, and all of the added lime was consumed in the leach. The dissolved oxygen level in the cyanide pulp varied between 7 ppm and 8.1 ppm. The gold extraction after 20 hours of leaching was 83.3%.

4. Cyanide Destruction Testwork

The leached pulp was passed through a 35-mesh (420 µm) sieve to remove any coarse solids. This was to facilitate pumping of the feed slurry during continuous cyanide destruction (CND) testing. A sample of the solution was submitted for analysis of CN(total), CN_{WAD}, SCN, CNO, Cu, Fe, Ni, Zn, SO_4 and a multi-element ICP scan.

Cyanide detoxification testwork was carried out using conditions previously provided by Golder Associates (Test DS2 in Appendix IV of AMMTEC's Report No. A10174). A large reactor (7 litres in volume) was used for processing the entire volume of the leached pulp (approximately 67 litres) at a target retention time between 80 and 90 minutes.

Sodium metabisulphite was used as the source of SO_2, and copper sulphate was added to provide Cu^{2+} for catalytic purpose. Air was bubbled into the pulp to provide oxygen for the cyanide oxidation reaction:

$$2\,CN^- + Na_2S_2O_5 + 2\,O_2 + 2\,OH^- \rightarrow 2\,CNO^- + Na_2SO_4 + SO_4^{2-} + H_2O \qquad (1)$$

Hydrated lime slurry was used to maintain the pulp in the reactor at approximately pH 8.5, providing the OH^- ion required for the above reaction. As per the standard procedure for cyanide destruction using Inco's SO_2/air method, the reactor was first filled with the feed pulp. The required amount of copper sulphate was added. The pulp was treated in batch mode with $Na_2S_2O_5$ and air to reduce the concentration of CN_{WAD} in solution to less than 10 ppm. This produced the starting pulp for the continuous test, and established the required experimental conditions (catalyst, oxygen and redox potential). The feed slurry and the copper sulphate pumps were then turned on to start the continuous cyanide destruction. The CN_{WAD} concentration in the reactor was monitored during the test using the picric acid method.

A series of tests was carried out at various SO_2 additions, in an effort to attain the target CN_{WAD} of <10 ppm at the minimum SO_2 addition rate. At the end of each test, the treated pulp was combined and a solution sample was taken for analysis of CN_{WAD}, Cu and Fe. The products from all the cyanide destruction tests were combined, and a solution sample was taken for analysis of CN_T, CN_{WAD}, Cu and Fe.

A procedure was provided by Atlantic Gold NL ('Bench Scale Test for Arsenic Removal - Revision Date: July 10, 2007') for use in conducting downstream testwork on the cyanide destruction product to reduce arsenic in solution. A copy of the procedure is included in Appendix 2.

The combined cyanide destruction product pulp was agitated and aerated overnight (approximately 18 hours) to remove volatiles and to stabilize the mixture. The pulp was then vigorously agitated and split into two portions. One portion was stored at room temperature, in a plastic container with a loose cover, and allowed to age by undisturbed exposure to the atmosphere for several weeks. The other portion was allowed to sit overnight for the removal of free-settling, suspended solids. The supernatant solution was collected for testing. A sample of the solution was submitted for the following analyses:

- *Turbidity*
- *pH*
- *Chemical oxygen demand*
- *Total cyanide*
- *Weak acid dissociable cyanide*
- *Metals scan for dissolved metals, including arsenic*
- *Major dissolved cations: calcium, magnesium, sodium, potassium*
- *Major dissolved anions: sulphate, chloride, and total alkalinity*
- *Dissolved ammonium (ammonia) and nitrite/nitrate.*

The results are presented in Tables 4 (feed and combined product analyses) and 5 (cyanide destruction), and plotted in Figure 1. The details of the experiments and analyses are included in Appendices 1 and 3, respectively.

The feed (solution phase) contained 247 mg/L CN(total), of which 242 mg/L was CN_{WAD}, 37 mg/L SCN, 5.52 mg/L Cu, 2.09 mg/L Fe, 1.5 mg/L Ni, and 102 mg/L Zn.

The cyanide destruction circuit was operated at a retention time of approximately 86 minutes. The copper addition was 0.14 g Cu (added as copper sulphate pentahydrate) per g CN_{WAD} in the feed. The cyanide leach pulp responded well to detoxification using Inco's SO_2/air process. The residual CN_{WAD} in the treated product decreased from 26 mg/L to 2.3 mg/L with increasing SO_2 addition from 2.28 g to 2.87 g per g CN_{WAD} in the feed. This SO_2 addition rate is close to the stoichiometric amount based on equation (1) above, and is at the low end of the range (2.5 to 5.0 g/g CN_{WAD}) that is typical of commercial gold plants.

The combined treated pulp analyzed 6.1 mg/L CN_T, 6 mg/L CN_{WAD}, 9.42 mg/L Cu and 0.07 mg/L Fe. After aeration, the residual cyanide and metals decreased to 3.5 mg/L CN_T, 3.1 mg/L CN_{WAD}, 7.94 mg/L Cu and <0.01 mg/L Fe. The overall reagent addition (excluding batch Test 8) was 2.7 g SO_2, 2.63 g hydrated lime and 0.14 g Cu per g CN_{WAD} in the feed.

Table 4. Cyanide Destruction Testwork – Feed and Product Analyses

Analysis (Solution Phase)		Cyanide Destruction Feed	Combined Product Before Aeration	Combined Product After Aeration	Analysis (Solution Phase)		Cyanide Destruction Feed	Combined Product Before Aeration	Combined Product After Aeration
Reference		00545-JUL07	00846-JUL07	10673-LUL07	Reference		00545-JUL07	00846-JUL07	10673-LUL07
pH		10.4	8.3	7.9	Ag	mg/L	0.09	…	0.00053
Turbidity	NTU	…	…	7.7	Al	mg/L	3	…	0.06
CN_T	mg/L	247	6.1	3.5	As	mg/L	4	…	0.478
CN_{WAD}	mg/L	242		3.1	Ba	mg/L	0.013	…	0.0605
CN_F	mg/L	237	…	…	Be	mg/L	< 0.002	…	0.00005
CNS	mg/L	37	…	…	B	mg/L	…	…	0.053
CNO	mg/L	2.3	…	…	Bi	mg/L	< 1	…	< 0.00002
SO_4	mg/L	120	…	1400	Ca	mg/L	14	…	240
Alkalinity	mg/L $CaCO_3$	…	…	96	Cd	mg/L	< 0.09	…	0.00009
COD	mg/L	…	…	91	Co	mg/L	< 0.3	…	0.243
NH_3+NH_4	mg/L N	…	…	99	Cr	mg/L	< 0.1	…	0.0015
Cl	mg/L	…	…	20	Cu	mg/L	5.52	9.42	7.94
NO_2	mg/L	…	…	<0.06	Fe	mg/L	2.09	0.07	< 0.01
NO_3	mg/L	…	…	1.26	K	mg/L	30	…	61
					Li	mg/L	< 2	…	0.017
					Mg	mg/L	0.56	…	7
					Mn	mg/L	0.04	…	0.0911
					Mo	mg/L	< 0.6	…	0.0635
					Na	mg/L	230	…	556
					Ni	mg/L	1.50	…	0.039
					P	mg/L	< 5	…	0.02
					Pb	mg/L	< 2	…	0.0011
					Sb	mg/L	< 1	…	0.0277
					Se	mg/L	< 3	…	0.005
					Si	mg/L	…	…	2.94
					Sn	mg/L	< 2	…	0.0032
					Sr	mg/L	0.05	…	0.427
					Ti	mg/L	< 0.02	…	0.0027
					Tl	mg/L	< 3	…	0.0003
					U	mg/L	< 1	…	0.00296
					V	mg/L	< 0.2	…	0.00071
					Zn	mg/L	102	…	0.0567

Table 5. Results of Cyanide Destruction Testwork

Test	Mode	Pulp Dens. %	Reten. Time min	Total Test Time min	Composition (Solution Phase) pH	CN_T mg/L	CN_{WAD} mg/L	Cu mg/L	Fe mg/L	Zn mg/L	Ni mg/L	SCN mg/L	Reagent Addition g/g CN_{WAD} SO_2 Equiv.	Lime	Cu[2]	g/L Pulp SO_2 Equiv.	Lime	Cu[2]
Feed (Test CN 2 Pulp)		50	…	…	10.4	247	242	5.52	2.09	102	1.50	37	…	…	…	…	…	…
CND 8	Batch	50	158	…	8.5	na	0.9[1]	na	na	na	na	na	4.35	4.41	0.14	0.78	0.79	0.024
CND 9A	Continuous	50	87	95	8.6	na	26[1]	29.7	0.08	na	na	na	2.28	1.96	0.15	0.41	0.35	0.026
CND 9B	Continuous	50	87	122	8.6	na	19[1]	19.3	0.06	na	na	na	2.40	2.47	0.14	0.43	0.44	0.025
CND 9C	Continuous	50	85	180	8.5	na	10[1]	8.28	0.06	na	na	na	2.77	2.71	0.13	0.49	0.48	0.023
CND 9D	Continuous	50	86	360	8.4	na	2.3[1]	0.53	<0.05	na	na	na	2.87	2.82	0.14	0.51	0.50	0.024
Combined CND Pulp[3]					8.3	6.1	6.0[1]	9.42	0.07	na	na	na	2.70	2.63	0.14	0.48	0.47	0.024

na: not analyzed
[1] by Picric acid method
[2] Cu added as $CuSO_4\ 5H_2O$
[3] Reagent addition calculated from Test CND 9A to 9D

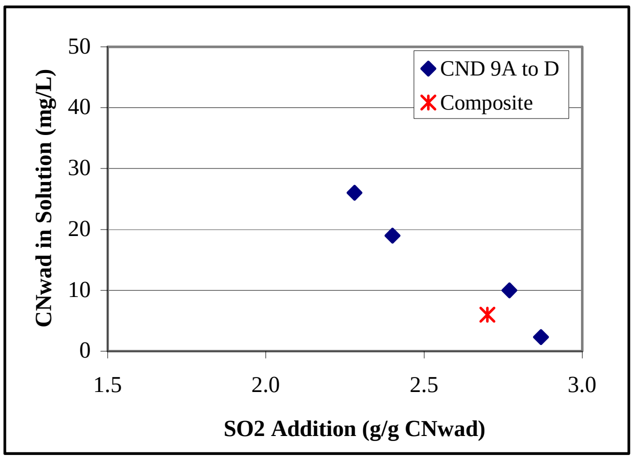


Figure 1. Residual CN_{WAD} versus SO_2 Addition

5. Arsenic Removal and Flocculation Testwork

5.1. Arsenic Removal Tests on Cyanide Destruction Supernatant Solution

A series of arsenic removal tests (Tests AS-1 to 3) was conducted on the supernatant solution collected from the aerated cyanide destruction pulp. The experiments were carried out using the procedure provided by Atlantic Gold NL (Appendix 2). The feed solution was placed in a beaker. Agitation was provided using a magnetic stirrer. The required amount of ferric sulphate was added and the solution was mixed for 30 minutes. Hydrated lime was added as required to maintain the solution within the pH range of 6.5 to 8. Following the test, the solution was allowed to stand for 30 minutes. A sample of the supernatant solution was taken for analysis of turbidity and dissolved As. The results are presented in the first block of Table 6.

Adding ferric sulphate to the solution at a Fe-to-As mass ratio of 10-to-1 (Test AS-2) lowered the As concentration in solution from 0.478 mg/L to 0.074 mg/L. Doubling the ferric sulphate addition to a Fe-to-As mass ratio of 20-to-1 (Test AS-1) reduced the As concentration in solution to 0.04 mg/L. An increase in the ferric sulphate addition to a Fe-to-As mass ratio of 60-to-1 further reduced the As concentration in solution to 0.009 mg/L.

The turbidity values of the supernatant solutions were 7.7 NTU for the feed, 6.3 NTU for Test AS-2, 14 NTU for Test AS-1, and 46 NTU for Test AS-3. The increase in the turbidity of the test product was due to the increase in the amount of ferric hydroxide formed with increasing sulphate addition.

Table 6. Arsenic Removal Tests on Cyanide Destruction Supernatant Solution

Test	Feed Solution Volume L	Ferric Addition Fe g/L	Ferric Addition Fe/As g/g	pH	Lime g/L	Retention Time Mixing min	Retention Time Settling min	Dissolved As mg/L	Supernatant Solution Turbidity NTU
Feed	…	…	…	8.3	…	…	…	0.478	7.7
2	0.6	0.005	10	7.7	…	30	30	0.074	6.3
1	0.6	0.010	20	7.7	0.013	30	30	0.040	14
3	0.6	0.030	60	7.7	0.065	30	30	0.009	46
4	8	0.010	20	7.7	…	30	30	0.016	17
Feed*	…	…	…	8.3	…	…	…	0.472	4.5
5	2	0.010	20	7.3	0.01	30	30	0.016	20

*Supernatant solution taken from combined CND product after standing at room temperature for 54 days

It was decided to apply the ferric sulphate dosage of Test AS-2 (20 g Fe per g As) to a bulk arsenic removal test (Test AS-4), to produce treated product for flocculation and settling testwork. The results the bulk test are included in Table 6.

5.2. Coagulation/Flocculation Tests on Final Product after Arsenic Removal

A series of five flocculation scoping tests (Tests F 1A-1E) was conducted on Test AS-4 product using the procedure provided by Atlantic Gold NL (Appendix 2). The objective of the tests was to determine the best flocculant dosage for flocculation and settling of the precipitate. Each test was carried out in a beaker using 100 mL of Test AS-4 product. The flocculant (Magnafloc 338) dosages were 0.5, 1, 2, 4 and 6 mg/L of solution. The ease of floc formation, relative size of flocs, relative rate of settling, and residual turbidity were observed after 5, 10 and 30 minutes of settling.

The results are presented in Table 7, and photographs taken during the test are included in Appendix 4. The flocculant dosage of 0.5 mg/L solution produced the best results, and was selected for the 1-litre test (Test F2) to generate product for analysis.

Table 7. Flocculation Scoping Tests

Test	Magnafloc 338 mg/L	After 5 minutes of Settling			
		Relative Size of Flocs	Relative Rate of Settling	Relative Turbidity	Comments
F 1A	0.5	Fine	Medium-slow	High	Initially flocs were small but gradually increased in size throughout test.
F 1B	1.0	Very fine	Slow	High	
F 1C	2.0	Very fine	Slow	High	
F 1D	4.0	Very fine	Slow	High	
F 1E	6.0	Very fine	Slow	High	

Test	Magnafloc 338 mg/L	After 10 minutes of Settling			
		Relative Size of Flocs	Relative Rate of Settling	Relative Turbidity	Comments
F 1A	0.5	Fine	Slow	Medium	Most solids remained suspended some settled.
F 1B	1.0	Very fine	Slow	Medium	
F 1C	2.0	Very fine	Slow	Medium	
F 1D	4.0	Very fine	Slow	Medium	
F 1E	6.0	Very fine	Slow	Medium	

Test	Magnafloc 338 mg/L	After 30 minutes of Settling			
		Relative Size of Flocs	Relative Rate of Settling	Relative Turbidity	Comments
F 1A	0.5	Fine	Slow	Almost clear	0.5 mg/L and 1 mg/L additions produced the clearest solutions after 30 minutes of settling.
F 1B	1.0	Very fine	Slow	Almost clear	
F 1C	2.0	Very fine	Slow	Low	
F 1D	4.0	Very fine	Slow	Low	
F 1E	6.0	Very fine	Slow	Low	

A larger scale flocculation/settling test (Test F2) was conducted in a 1-litre graduated cylinder using 1 litre of Test AS-4 product. After 30 minutes of settling, a sample of the supernatant solution was submitted to the analytical laboratory for determination of turbidity, pH and the following analyses:

- *Total cyanide*
- *Weak acid dissociable cyanide*
- *Metals scan for dissolved metals, including arsenic*
- *Major dissolved cations: calcium, magnesium, sodium, potassium*
- *Major dissolved anions: sulphate, chloride, and total alkalinity*
- *Dissolved ammonium (ammonia) and nitrite/nitrate.*

The results are presented in Table 8, and the analytical reports are included in Appendix 3. Treating the cyanide destruction supernatant solution with ferric sulphate, at a Fe-to-As mass ratio of 20-to-1, followed by flocculation, reduced the concentrations of residual cyanide and As to 1.6 mg/L CN_T, 1.5 mg/L CN_{WAD} and 0.04 mg/L As (dissolved).

Table 8. Flocculation Test on Product from Arsenic Removal Test AS-4

Analysis		Test AS-4				Analysis		Test AS-4			
		Feed (CND Sup. Solution)	Product Superna-tant Sol'n	Test F2 - Flocculated Supernatant Sol'n				Feed (CND Sup. Solution)	Product Superna-tant Sol'n	Test F2 - Flocculated Supernatant Sol'n	
				Whole	Dissolved					Whole	Dissolved
Reference		00545-JUL07		10560-AUG07		Reference		00545-JUL07		10560-AUG07	
pH		7.9	7.7	7.6	…	Ag	mg/L	0.00053	…	0.00148	0.00143
Turbidity	NTU	7.7	17	2.0	…	Al	mg/L	0.06	…	0.11	< 0.01
CN_T	mg/L	3.5	…	1.6	…	As	mg/L	0.478	0.016*	0.294	0.0402
CN_{WAD}	mg/L	3.1	…	1.5	…	Ba	mg/L	0.0605	…	0.061	0.0588
SO_4	mg/L	1400	…	1300	…	Be	mg/L	0.00005	…	< 0.00002	< 0.00002
Alkalinity	mg/L $CaCO_3$	96	…	91	…	B	mg/L	0.053	…	0.0447	0.0437
COD	mg/L	91	…	…	…	Bi	mg/L	< 0.00002	…	0.00008	< 0.00001
NH_3+NH_4	mg/L N	99	…	97.8	…	Ca	mg/L	240	…	239	230
Cl	mg/L	20	…	21	…	Cd	mg/L	0.00009	…	0.000656	0.000311
NO_2	mg/L	<0.06	…	<0.6	…	Co	mg/L	0.243	…	0.228	0.19
NO_3	mg/L	1.26	…	<0.5	…	Cr	mg/L	0.0015	…	0.0007	0.0012
NO_2 + NO_3	mg/L	…	…	<0.6	…	Cu	mg/L	7.94	…	6.3	5.57
						Fe	mg/L	< 0.01	…	4.67	0.01
						K	mg/L	61	…	61.1	73.4
						Li	mg/L	0.017	…	< 0.002	< 0.002
						Mg	mg/L	7	…	7.31	7.61
						Mn	mg/L	0.0911	…	0.148	0.114
						Mo	mg/L	0.0635	…	0.0637	0.0584
						Na	mg/L	556	…	437	475
						Ni	mg/L	0.039	…	0.023	0.0141
						P	mg/L	0.02	…	0.03	0.02
						Pb	mg/L	0.0011	…	0.00188	0.00018
						Sb	mg/L	0.0277	…	0.0109	0.0124
						Se	mg/L	0.005	…	0.007	0.008
						Si	mg/L	2.94	…	2.79	2.45
						Sn	mg/L	0.0032	…	0.00063	< 0.0003
						Sr	mg/L	0.427	…	0.435	0.445
						Ti	mg/L	0.0027	…	0.0283	0.0005
						Tl	mg/L	0.0003	…	< 0.0001	< 0.0001
						U	mg/L	0.00296	…	0.00485	0.00535
						V	mg/L	0.00071	…	0.0005	< 0.00006
						Zn	mg/L	0.0567	…	0.0577	0.0259

*Filtered at 0.45 µm.

5.3. Arsenic Removal Tests on Aged Cyanide Destruction Supernatant Solution

A sample of the supernatant solution from the cyanide destruction pulp, after aging for approximately 56 days at room temperature, was collected. A head sample was submitted for analysis. The results are shown in Table 9 and included in Appendix 3.

A bulk arsenic removal test (Test AS-5) was conducted on 2 litres of the above supernatant solution using the same conditions as for Test AS-4 (Fe-to-As mass ratio of 20-to-1) to generate product for a flocculation/settling test.

A flocculation and settling test (Test F3) was carried out on 1 litre of Test AS-5 product, in a 1-L graduated cylinder, using the same procedure as for Test F2 above. The results are included in Table 6 (arsenic removal) and Table 9 (chemical analyses). The test details are appended (Appendix 1).

Aging of the cyanide destruction pulp, at room temperature for 56 days, reduced the residual cyanide and copper concentrations in solution from 3.5 mg/L CN_T, 3.1 mg/L CN_{WAD} and 7.9 mg/L Cu to 0.21 mg/L CN_T, 0.19 mg/L CN_{WAD}, and 0.24 mg/L Cu. However, the arsenic concentration was unchanged at 0.47 mg/L, and the Fe concentration actually increased slightly from <0.01 mg/L to 0.15 mg/L.

Treating the supernatant solution of the aged cyanide destruction pulp with ferric sulphate, at a Fe-to-As mass ratio of 20-to-1, followed by flocculation, further reduced the concentrations of dissolved cyanide, Cu and arsenic to 0.03 mg/L CN_T, 0.09 mg/L Cu and 0.006 mg/L As. The concentrations of total CN_T, Cu and CN_{WAD} in the supernatant solution (including suspended solids) were 0.44 mg/L, 0.20 mg/L and 0.12 mg/L, respectively.

Table 9. Flocculation Test on Product from Arsenic Removal Test AS-5

Analysis		Test AS-5			
		Feed (Aged CND Sup. Sol'n)	Product Superna-tant Sol'n	Test F3 - Flocculated Supernatant Sol'n	
				Whole	Dissolved
Reference		10387-SEP07		10427-SEP07	
pH		8.2	7.3	8.0	…
Turbidity	NTU	4.54	20	3.97	…
CN_T	mg/L	0.21	…	0.44	0.03
CN_{WAD}	mg/L	0.19	…	0.12	…
SO_4	mg/L	1300	…	1400	…
Alkalinity	mg/L $CaCO_3$	135	…	98	…
COD	mg/L	75	…	75	…
NH_3+NH_4	mg/L N	17.6	…	17.1	…
Cl	mg/L	24	…	24	…
NO_2	mg/L	<0.6	…	<0.6	…
NO_3	mg/L	<0.5	…	0.12	…

Analysis		Test AS-5			
		Feed (Aged CND Sup. Sol'n)	Product Superna-tant Sol'n	Test F3 - Flocculated Supernatant Sol'n	
				Whole	Dissolved
Reference		10387-SEP07		10427-SEP07	
Ag	mg/L	0.00021	…	0.00032	0.00003
Al	mg/L	0.09	…	0.04	< 0.01
As	mg/L	0.472	0.016*	0.17	0.006
Ba	mg/L	0.0602	…	0.0641	0.0565
Be	mg/L	< 0.00002	…	< 0.00002	< 0.00002
B	mg/L	0.0432	…	0.0455	0.0419
Bi	mg/L	< 0.00001	…	0.00006	< 0.00001
Ca	mg/L	215	…	215	204
Cd	mg/L	< 0.000003	…	< 0.000003	< 0.000003
Co	mg/L	0.224	…	0.217	0.214
Cr	mg/L	0.0008	…	< 0.0005	< 0.0005
Cu	mg/L	0.24	…	0.201	0.0883
Fe	mg/L	0.15	…	4.46	0.02
K	mg/L	…	…	66.8	63.2
Li	mg/L	< 0.002	…	< 0.002	< 0.002
Mg	mg/L	10.1	…	10.3	9.25
Mn	mg/L	0.054	…	0.132	0.125
Mo	mg/L	0.0668	…	0.0548	0.0483
Na	mg/L	681	…	610	634
Ni	mg/L	0.0046	…	0.0071	0.0062
P	mg/L	< 0.01	…	0.01	< 0.01
Pb	mg/L	0.0014	…	0.00175	0.00037
Sb	mg/L	0.0123	…	0.0108	0.008
Se	mg/L	0.003	…	< 0.001	0.001
Si	mg/L	3.05	…	2.98	2.38
Sn	mg/L	< 0.0003	…	0.0002	0.00006
Sr	mg/L	0.431	…	0.44	0.41
Ti	mg/L	0.0008	…	0.0238	0.0003
Tl	mg/L	0.000149	…	0.00012	0.000161
U	mg/L	0.00242	…	0.00213	0.0016
V	mg/L	0.00076	…	0.00047	0.0001
Zn	mg/L	0.02	…	0.027	0.018

*Filtered at 0.45 µm.

Conclusions

A laboratory test program was conducted at SGS Minerals Services laboratory in Lakefield, Canada, to apply Inco's SO_2/air process for treating a cyanide pulp from leaching of a gold ore sample from DDV Gold's Touquoy Gold Project, to produce cyanide destruction pulp for environmental testing. The following conclusions can be drawn from the testwork:

- The ore sample (M 1142 TAM) head grade calculated from the bulk cyanidation test was 1.38 g/t Au and <0.6 g/t Ag.

- The cyanide gold extraction after 20 hours of leaching was 83.3%. The sodium cyanide addition was 0.5 kg/t and all of this cyanide was added at the beginning of the leach. The cyanide consumption was 0.06 kg/t NaCN. The lime addition was 0.22 kg/t equivalent CaO, and all of the added lime was consumed in the leach.

- The cyanide pulp responded well to detoxification using Inco's SO_2/air process. The residual CN_{WAD} in the treated product decreased from 26 mg/L to 2.3 mg/L with increasing SO_2 addition from 2.28 g to 2.87 g per g CN_{WAD} in the feed. The copper addition was approximately 0.14 g per g CN_{WAD} in the feed. The optimum SO_2 addition rate of ~2.8 g/g CN_{WAD} is close to the stoichiometric amount based on equation (1) above (Section 4), and is at the low end of the range (2.5 to 5 g/g CN_{WAD}) that is typical of commercial gold plants.

- Aerating the cyanide destruction product overnight to remove volatiles and to stabilize the pulp lowered the residual cyanide and metals from 6.1 mg/L CN_T, 6 mg/L CN_{WAD}, 9.42 mg/L Cu and 0.07 mg/L Fe to 3.5 mg/L CN_T, 3.1 mg/L CN_{WAD}, 7.94 mg/L Cu and <0.01 mg/L Fe.

- It was possible to reduce the dissolved arsenic concentration in the cyanide destruction supernatant solution from 0.47 mg/L to 0.04 mg/L by addition of ferric sulphate, at a Fe-to-As mass ratio of 20-to-1. Treating the arsenic removal product with 0.5 mg/L Magnafloc 338 followed by settling, reduced the concentrations of residual cyanide to 1.6 mg/L CN_T and 1.5 mg/L CN_{WAD}.

- The concentrations of cyanide and copper in the cyanide destruction product could be reduced substantially by aging. Aging the cyanide destruction pulp at room temperature for 56 days reduced the residual cyanide and copper concentrations in solution from 3.5 mg/L CN_T, 3.1 mg/L CN_{WAD} and 7.9 mg/L Cu to 0.21 mg/L CN_T, 0.19 mg/L CN_{WAD} and 0.24 mg/L Cu. However, the arsenic concentration was unchanged at 0.47 mg/L, while the Fe concentration increased slightly from <0.01 mg/L to 0.15 mg/L.

- It was possible to lower the concentrations of dissolved cyanide, copper and arsenic in the supernatant solution of the aged cyanide destruction pulp to 0.03 mg/L CN_T, 0.09 mg/L Cu and 0.006 mg/L As by treating the solution with ferric sulphate, at a Fe-to-As mass ratio of 20-to-1 followed by flocculation.

Appendix 1

Details of Tests

Project 11373-003 **Grind Tests** Operator: CS Date: July 16, 2007

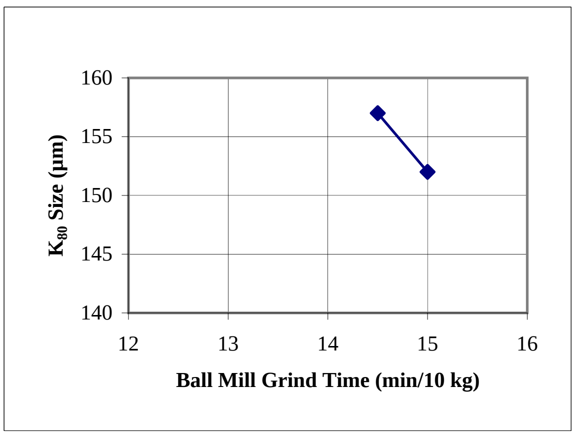
Purpose: To provide data for milling sample for gold leaching.

Procedure: A 10-kg test charge (-10 mesh) was ground in the 10-kg ball mill.
The mill discharge was vigorously agitated and a sample was taken and filtered.
The filter cake was submitted for size diztribution analysis.

Feed: 10 kg (-10 mesh) DDV Gold sample (M 1142 TAM).
Ground at 65% solids in 10-kg lab ball mill.

Data:

Test	Grind Time min/10 kg	Product K_{80} Size µm
G1	14.5	157
G2	15.0	152

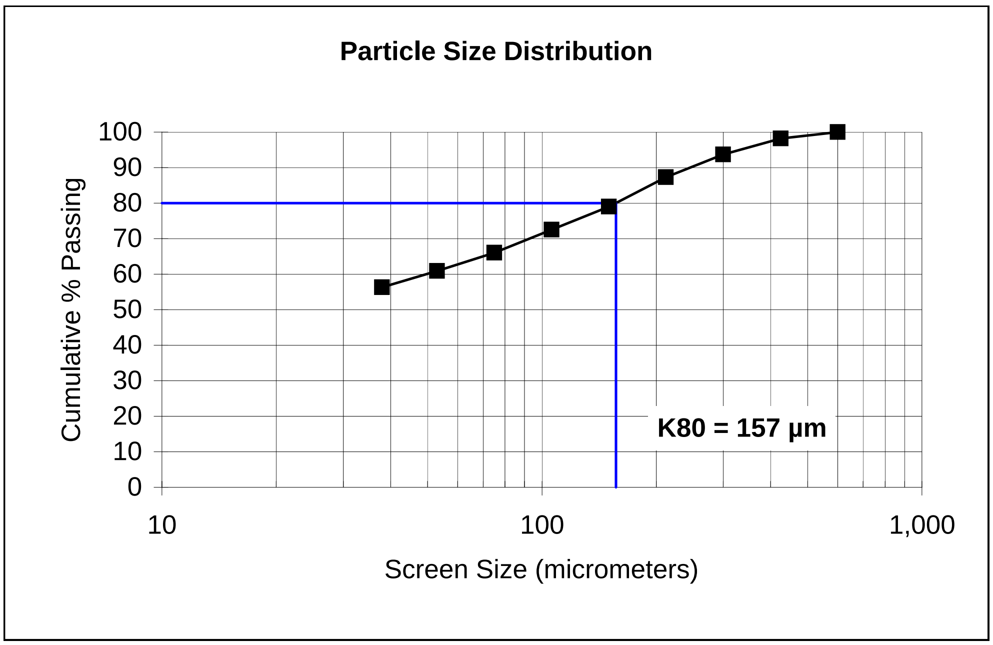


SGS Minerals Services
Size Distribution Analysis

Project No. **11373-003**

Sample: **14.5 min/10 kg** Test No.:

Size		Weight	% Retained		% Passing
Mesh	µm	grams	Individual	Cumulative	Cumulative
28	600	0.0	0.0	0.0	100.0
35	425	4.1	1.8	1.8	98.2
48	300	10.2	4.5	6.3	93.7
65	212	14.7	6.5	12.7	87.3
100	150	18.7	8.2	21.0	79.0
150	106	14.9	6.5	27.5	72.5
200	75	14.7	6.5	34.0	66.0
270	53	11.6	5.1	39.1	60.9
400	38	10.6	4.7	43.7	56.3
Pan	-38	128.0	56.3	100.0	0.0
Total	**-**	**227.5**	100.0	**-**	**-**
K80	**157**				

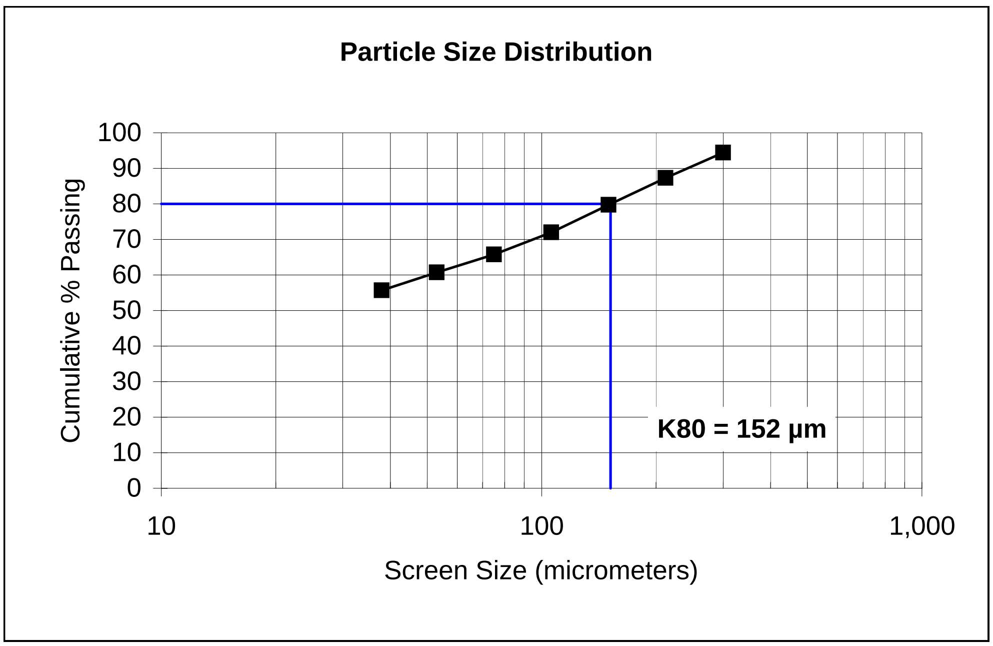


SGS Minerals Services
Size Distribution Analysis

Project No.
11373-003

Sample: **15 min/kg** Test No.:

Size		Weight	% Retained		% Passing
Mesh	µm	grams	Individual	Cumulative	Cumulative
48	300	12.0	5.6	5.6	94.4
65	212	15.3	7.1	12.7	87.3
100	150	16.1	7.5	20.3	79.7
150	106	16.6	7.7	28.0	72.0
200	75	13.3	6.2	34.2	65.8
270	53	10.9	5.1	39.3	60.7
400	38	10.7	5.0	44.3	55.7
Pan	-38	119.4	55.7	100.0	0.0
Total	**-**	**214.3**	100.0	**-**	**-**
K80	**152**				



Project 11373-003 **Test CN 2** Operator: CS, TC July 16 2007

Purpose: Bulk Cyanidation of feed to prepare pulp for CND work.

Procedure:
The ore (50 kg approximately -10 mesh) was ground in a 10-kg ball mill to a P_{80} of ~150 µm.
The mill discharge was adjusted with tap water to 50% solids in a 100-L plastic drum.
The pH was adjusted to pH 10.5 with hydrated lime.
Air was bubbled through the sample for the duration of the test.
NaCN (0.5 g/L) was added and the cyanidation was carried out with mixing for 20 hours.
The dissolved oxigen (DO), pH and NaCN levels were monitored at 2, 4, 8, 12, 20 hours.
The target DO was approximately 8 ppm. The pH was maintained with lime.
The NaCN concentration was maintained at 0.2 g/L if required.
After 20 hours solution and residue samples were submitted for Au and Ag.
The pulp was screened through a 20-mesh screen.
The pulp was split into 20-L plastic pails and placed in refrigerated storage.
A solution sample was then taken for analysis of CN(F), CN(T), CNS, CNO, SO_4, Cu,
Fe, Ni, Zn (by AA); and an ICP scan.

Feed: 50000 g
Pulp Density: 50% solids

Grind: 15 min/10 kg in 10-kg ball mill
P_{80}: ~150 µm (100 mesh)

Solution Volume: 50000 mL
pH Range: 10.5 with $Ca(OH)_2$

Cyanidation Time: 20 h
NaCN Concentration: 0.5 g/L
Allow to fall to 0.2 g/L.

Solution Samples: 2, 4, 8, 12 h for pH, DO, NaCN
20 h for Au and Ag

Reagent Consumption (kg/t of cyanide feed) NaCN: 0.06 CaO: 0.22
Reagent Addition (kg/t of cyanide feed) NaCN: 0.50 CaO: 0.22

Time	Added, Grams				Residual		Consumed		pH	DO
	Actual		Equivalent		Grams		Grams			ppm
hours	NaCN 95%	$Ca(OH)_2$	NaCN	CaO	NaCN	CaO	NaCN	CaO		
Cyanidation									7.8	
0-2	26.32	14.08	25.00	10.14	22.50		2.50		10.4-10.4	7.0
2-4	0.00	0.00	0.00	0.00	22.50		0.00		10.4-10.4	7.5
4-6	0.00	1.14	0.00	0.82	22.50		0.00		10.6-10.5	7.2
6-10	0.00	0.00	0.00	0.00	22.50		0.00		10.5-10.6	7.1
10-20	0.00	0.00	0.00	0.00	21.88	0.00	0.63		10.6-10.4	8.1
Total	26.32	15.22	25.00	10.96	21.88	0.00	3.13	10.96		

Results:

Product	Amount	Sample	Assays, mg/L, g/t		% Extraction	
	g, mL	mL	Au	Ag	Au	Ag
20h Preg	50000	310	1.15	0.09	83.3	15.3
Residue	50000	279	0.23	<0.5	16.7	84.7
Head (calc.)	50000		1.38	<0.6	100.0	100.0

Test CND 8	**Project 11373-003**	Operator: CS/NL	Date 18-Jul-07

Purpose: Batch SO_2/Air cyanide destruction test on bulk leach pulp to produce treated pulp with low residual CN(WAD) for starting continuous test.

Procedure: The pulp was placed in a 7.5-L tank. Mixing was provided with a laboratory agitator.
Compressed air was sparged into the pulp. Copper sulphate, if required, was added.
$Na_2S_2O_5$ solution was pumped to the reactor.
The pulp was maintained at the desired pH by the addition of lime slurry.
Samples were taken and analyzed for residual CN(WAD) using the picric acid method.
The treatment was carried out until the residual CN(WAD) level was < 10 mg/L.

Apparatus: Reactors 7 L volume (20 cm I.D.) with 4 x 2 cm baffles.
Lab agitators with a 8-bladed turbine impeller (8.8 cm diameter x 2.85 cm high).
Other standard laboratory equipment were used as required.

Feed Pulp: Barren pulp from Test CN-2 (solution analysis)

CN_T: 247 mg/L	CN_{WAD}: 242 mg/L	CN_F: 237 mg/L	CNO: 2.3 mg/L	SCN: 37 mg/L
Cu: 5.52 mg/L	Ni: 1.50 mg/L	Fe: 2.09 mg/L	Zn: 102 mg/L	
pH: 10.4	Pulp density: 50%			

pH: 8.5 with lime — Temperature: Ambient (19-23 C°)

Results:

Agitator Speed: 440 rpm

Flowrates (Avg.):				
$Na_2S_2O_5$:	50 g/L	1.02 mL/min	Air:	10 L/min
Lime:	50 g/kg	0.68 mL/min		
Cu:	33 mg/L			

Retention Time: 158 min to achieve approximately <10 mg/L CN(WAD) by picric acid method

Treated Pulp: 158 min
(mg/L solution)

pH:	8.5		
CN_{WAD}:	0.9 mg/L*		*By picric acid method

Reagent Added:			
158 min			
SO_2 (equivalent)	4.35 g/g CN_{WAD}	0.78	g/L pulp
Lime	4.41 g/g CN_{WAD}	0.79	g/L pulp
Cu	0.14 g/g CN_{WAD}	0.024	g/L pulp
Cu	32.9 mg/L solution		

Test CND 8 **Project No. 11373-003** Operator: CS/NL Date 18-Jul-(

Batch SO_2/Air Cyanide Destruction Test on Pulp from Test CN-2

Lapsed Time min	pH	EMF mV	Air Flow-rate L/min	Dis-solved O_2 mg/L	Agitation rpm	$Na_2S_2O_5$ Volume in Grad. Cylinder mL	Copper Sulphate in Grad. Cylinder mL	Lime Slurry Bottle Wt. g	CN_{WAD} mg/L	CN_{picric} mg/L	Cu mg/L	Fe mg/L	
	8.5	140	10	5+	400								1.5 mg/.
Feed	10.2	-58	10	8	440		…		242		5.52	2.09	37 mg/I
0	9.8	90	10	7.8	440	249	…	883					
30	8.5	65	10	7.0	440	219	…						
60	8.5	46	10	6.7	440	188	…			95			Sample
90	8.5	24	10	6.1	440	158	…			74			Sample
120	8.5	13	10	6.1	440	128	…			32			Sample
158	8.5	186	10	7.0	440	88	…	773		0.9			Sample

Feed: 7 L of pulp 50 % solids

Impeller: 8-bladed turbine, 8.8 cm dian

Solution volume: 5.16 L

Reactor: 7.0 L (20 cm inside diameter)

$Na_2S_2O_5$: 50 g/L at 1 mL/min.

Cu: 170 mg added 32.9 mg/L

Lime: 50 g/kg lime slurry

Retention time: As required to achieved < 10 ppm residual CN_{WAD}

CN_{picric}: CN_{WAD} by picric acid method.

Test CND 9A	**Project 11373-003**	Operator: CS/NL	Date 18-Jul-07

Purpose: Continuous SO_2/Air cyanide destruction test on bulk leach pulp to produce treated pulp with low residual CN(WAD) for environmental testing.

Procedure:
The treated pulp in the reactor was used for starting the continuous test.
Mixing was provided with a laboratory agitator.
Compressed air was sparged into the pulp. Copper sulphate, if required, was added.
$Na_2S_2O_5$ solution was pumped to the reactor.
The reactor was conditioned (without adding feed pulp) for approximately 5 minutes.
The feed pulp was switched on to start the continuous test.
The pulp was maintained at the desired pH by the addition of lime slurry.
Samples were taken and analyzed for residual CN(WAD) using the picric acid method.
The target residual CN(WAD) level was <10 mg/L.
A solution sample of the combined treated pulp was submitted for chemical analysis.

Apparatus:
Reactors 7 L volume (20 cm I.D.) with 4 x 2 cm baffles.
Lab agitators with a 8-bladed turbine impeller (8.8 cm diameter x 2.85 cm high).
Other standard laboratory equipment were used as required.

Feed Pulp: Barren pulp from Test CN-2 (solution analysis)

CN_T: 247 mg/L	CN_{WAD}: 242 mg/L	CN_F: 237 mg/L	CNO: 2.3 mg/L	SCN: 37 mg/L
Cu: 5.52 mg/L	Ni: 1.50 mg/L	Fe: 2.09 mg/L	Zn: 102 mg/L	
pH: 10.4	Pulp density: 50%			

pH: Approx pH 8.5 with lime — Temperature: Ambient (19-23 C°)

Results:

Agitator Speed: 440 rpm

Flowrates (Avg.):

$Na_2S_2O_5$:	45 g/L	1.04 mL/min	Air: 10 L/min
Lime:	50 g/kg	0.54 mL/min	
Cu:	2000 mg/L	1.02 mL/min	

Retention Time: 87 min

Treated Pulp: (mg/L solution)

pH:	8.6		
CN_{WAD}:	26	mg/L*	*By picric acid method
Cu:	29.7	mg/L	
Fe:	0.08	mg/L	

Reagent Added:

SO_2 (equivalent)	2.28	g/g CN_{WAD}	0.41	g/L pulp
Lime	1.96	g/g CN_{WAD}	0.35	g/L pulp
Cu	0.15	g/g CN_{WAD}	0.026	g/L pulp
Cu	35.6	mg/L solution		

Test CND 9A **Project 11373-003** Date 18

Continuous SO_2/Air CND Test on Pulp from Test CN-2

Lapsed Time min	pH	EMF mV	Air Flow-Rate L/min	DO2 mg/L	Mixer rpm	$Na_2S_2O_5$ in Grad. Cylinder mL	$CuSO_4$ in Grad. Cylinder mL	Lime in Cup g	CN_{WAD} mg/L	CN_{picric} mg/L	Cu mg/L	Fe mg/L	
Feed	8.6	168	10	8.0	440				242		5.52	2.09	1.5 mg/L Ni, 102 m
0	8.6	168	10	8.0	440	250	250	727					Condition reactor
5	8.6	170	10	7.9	440	242	244						Start feed pump
30	8.6	202	10	7.0	440	218	218			26			Sample O/
60	8.5	136	10	6.0	440	186	188			24			Sample O/
95	8.5	85	10	5.3	440	151	153	675		28			Sample O/
													Total samples
Avg	8.6	155	10	7.0	440					26			

Reactor: 7 L (20 cm inside diameter) with 4 x 2 cm baffles
Impeller: 8-bladed turbine, 8.8 cm diameter x 2.85 cm high
$Na_2S_2O_5$: 45 g/L at 1 mL/min.
$CuSO_4$: 2000 mg/L Cu at 1 mL/min
Lime: 50 g/kg slurry

Feed: 50% solids
Solution volume: 0.738 L/L pulp
Target feed flowrate: 80 mL/min
Target retention time: 85 min

Test CND 9B	**Project 11373-003**	Operator: CS/NL	Date 19-Jul-07

Purpose: Continuous SO_2/Air cyanide destruction test on bulk leach pulp to produce treated pulp with low residual CN(WAD) for environmental testing.

Procedure:
The treated pulp in the reactor was used for starting the continuous test.
Mixing was provided with a laboratory agitator. Compressed air was sparged into the pulp.
Copper sulphate, if required, was added.. $Na_2S_2O_5$ solution was pumped to the reactor.
The reactor was conditioned (without adding feed pulp) for approximately 5 minutes.
The feed pulp was switched on to start the continuous test.
The pulp was maintained at the desired pH by the addition of lime slurry.
Samples were taken and analyzed for residual CN(WAD) using the picric acid method.
The target residual CN(WAD) level was <10 mg/L.
A solution sample of the combined treated pulp was submitted for chemical analysis.

Apparatus:
Reactors 7 L volume (20 cm I.D.) with 4 x 2 cm baffles.
Lab agitators with a 8-bladed turbine impeller (8.8 cm diameter x 2.85 cm high).
Other standard laboratory equipment were used as required.

Feed Pulp: Barren pulp from Test CN-2 (solution analysis)

CN_T: 247 mg/L	CN_{WAD}: 242 mg/L	CN_F: 237 mg/L	CNO: 2.3 mg/L	SCN: 37 mg/L
Cu: 5.52 mg/L	Ni: 1.50 mg/L	Fe: 2.09 mg/L	Zn: 102 mg/L	
pH: 10.4	Pulp density: 50%			

pH: Approx pH 8.5 with lime — Temperature: Ambient (19-23 C°)

Results:

Agitator Speed: 440 rpm

Flowrates (Avg.):

$Na_2S_2O_5$:	50 g/L	0.98 mL/min	Air: 10 L/min
Lime:	50 g/kg	0.68 mL/min	
Cu:	2000 mg/L	0.98 mL/min	

Retention Time: 87 min

Treated Pulp: (mg/L solution)

pH:	8.6	
CN_{WAD}:	19 mg/L*	*By picric acid method
Cu:	19.3 mg/L	
Fe:	0.06 mg/L	

Reagent Added:

SO_2 (equivalent)	2.40 g/g CN_{WAD}	0.43 g/L pulp
Lime	2.47 g/g CN_{WAD}	0.44 g/L pulp
Cu	0.14 g/g CN_{WAD}	0.025 g/L pulp
Cu	34.1 mg/L solution	

Test CND 9B **Project 11373-003** Date 19

Continuous SO_2/Air CND Test on Pulp from Test CN-2

Lapsed Time min	pH	EMF mV	Air Flow-Rate L/min	DO2 mg/L	Mixer rpm	$Na_2S_2O_5$ in Grad. Cylinder mL	$CuSO_4$ in Grad. Cylinder mL	Lime in Cup g	CN_{WAD} mg/L	CN_{picric} mg/L	Cu mg/L	Fe mg/L	
Feed	9	53	10	10.1	440				242		5.52	2.09	1.5 mg/L Ni, 102 m
0	9.0	43	10	9.9	440	500	500	669					Condition reactor
16	8.7	46	10	6.1	440	480	480						Start feed pump
30	8.5	93	10	4.3	440	470	470			5.6			Sample O/
60	8.6	120	10	5.2	440	440	440			16			Sample O/
90	8.7	101	10	6.0	440	410	410			21			Sample O/
122	8.6	100	10	4.4	440	380	381	585		32			Sample O/
													O/
													Total samples
Avg	8.6	84	10	6.0	440					19			

Reactor: 7 L (20 cm inside diameter) with 4 x 2 cm baffles

Impeller: 8-bladed turbine, 8.8 cm diameter x 2.85 cm high

$Na_2S_2O_5$: 50 g/L at 1 mL/min.

$CuSO_4$: 2000 mg/L Cu at 1 mL/min

Lime: 50 g/kg slurry

Feed: 50% solids

Solution volume: 0.738 L/L pulp

Target feed flowrate: 80 mL/min

Target retention time: 85 min

Test CND 9C	**Project 11373-003**	Operator: CS/NL	Date 19-Jul-07

Purpose: Continuous SO_2/Air cyanide destruction test on bulk leach pulp to produce treated pulp with low residual CN(WAD) for environmental testing.

Procedure:
The treated pulp in the reactor was used for starting the continuous test.
Mixing was provided with a laboratory agitator. Compressed air was sparged into the pulp.
Copper sulphate, if required, was added. $Na_2S_2O_5$ solution was pumped to the reactor.
The reactor was conditioned (without adding feed pulp) for approximately 5 minutes.
The feed pulp was switched on to start the continuous test.
The pulp was maintained at the desired pH by the addition of lime slurry.
Samples were taken and analyzed for residual CN(WAD) using the picric acid method.
The target residual CN(WAD) level was <10 mg/L.
A solution sample of the combined treated pulp was submitted for chemical analysis.

Apparatus:
Reactors 7 L volume (20 cm I.D.) with 4 x 2 cm baffles.
Lab agitators with a 8-bladed turbine impeller (8.8 cm diameter x 2.85 cm high).
Other standard laboratory equipment were used as required.

Feed Pulp: Barren pulp from Test CN-2 (solution analysis)

CN_T: 247 mg/L	CN_{WAD}: 242 mg/L	CN_F: 237 mg/L	CNO: 2.3 mg/L	SCN: 37 mg/L
Cu: 5.52 mg/L	Ni: 1.50 mg/L	Fe: 2.09 mg/L	Zn: 102 mg/L	
pH: 10.4	Pulp density: 50%			

pH: Approx pH 8.5 with lime   Temperature: Ambient (19-23 C°)

Results:

Agitator Speed: 449 rpm

Flowrates (Avg.):

$Na_2S_2O_5$:	60 g/L	0.98 mL/min	Air: 13 L/min
Lime:	50 g/kg	0.77 mL/min	
Cu:	2000 mg/L	0.95 mL/min	

Retention Time: 85 min

Treated Pulp: (mg/L solution)

pH:	8.5	
CN_{WAD}:	10 mg/L*	*By picric acid method
Cu:	8.28 mg/L	
Fe:	0.06 mg/L	

Reagent Added:

SO_2 (equivalent)	2.77 g/g CN_{WAD}	0.50 g/L pulp
Lime	2.71 g/g CN_{WAD}	0.48 g/L pulp
Cu	0.13 g/g CN_{WAD}	0.024 g/L pulp
Cu	32.2 mg/L solution	

Test CND 9C **Project 11373-003** Date 19

Continuous SO_2/Air CND Test on Pulp from Test CN-2

Lapsed Time min	pH	EMF mV	Air Flow-Rate L/min	DO2 mg/L	Mixer rpm	$Na_2S_2O_5$ in Grad. Cylinder mL	$CuSO_4$ in Grad. Cylinder mL	Lime in Cup g	CN_{WAD} mg/L	CN_{picric} mg/L	Cu mg/L	Fe mg/L	
Feed	8.5	58	10	6	440				242		5.52	2.09	1.5 mg/L Ni, 102 m
0	8.4	63	10	6.8	440	495	355	584					Condition reactor
10	8.6	134	10	3.0	440	485	345						Start feed pump
30	8.6	163	10	3.5	440	470	330			1.7			Sample O/
60	8.5	161	11	3.5	455	440	300			1.8			Sample O/
90	8.5	155	15	3.9	455	410	270			2.4			Sample O/
120	8.5	144	15	3.8	455	380	245			3.2			Sample O/
150	8.6	175	15	6.9	455	350	215			19			Sample O/
180	8.4	114	15	8.5	455	319	184	445		30			Sample O/
													Total samples
Avg	8.5	139	13	5.0	449					10			

Reactor:	7 L (20 cm inside diameter) with 4 x 2 cm baffles	Feed:	50% solids	
Impeller:	8-bladed turbine, 8.8 cm diameter x 2.85 cm high			
$Na_2S_2O_5$:	60 g/L at 1 mL/min.	Solution volume:	0.738	L/L pulp
$CuSO_4$:	2000 mg/L Cu at 1 mL/min	Target feed flowrate:	80	mL/min
Lime:	50 g/kg slurry	Target retention time:	85	min

Test CND 9D	**Project 11373-003**	Operator: CS/NL	Date 20-Jul-07

Purpose: Continuous SO_2/Air cyanide destruction test on bulk leach pulp to produce treated pulp with low residual CN(WAD) for environmental testing.

Procedure:
The treated pulp in the reactor was used for starting the continuous test.
Mixing was provided with a laboratory agitator. Compressed air was sparged into the pulp.
Copper sulphate, if required, was added. $Na_2S_2O_5$ solution was pumped to the reactor.
The reactor was conditioned (without adding feed pulp) for approximately 5 minutes.
The feed pulp was switched on to start the continuous test.
The pulp was maintained at the desired pH by the addition of lime slurry.
Samples were taken and analyzed for residual CN(WAD) using the picric acid method.
The target residual CN(WAD) level was <10 mg/L.
A solution sample of the combined treated pulp was submitted for chemical analysis.

Apparatus:
Reactors 7 L volume (20 cm I.D.) with 4 x 2 cm baffles.
Lab agitators with a 8-bladed turbine impeller (8.8 cm diameter x 2.85 cm high).
Other standard laboratory equipment were used as required.

Feed Pulp: Barren pulp from Test CN-2 (solution analysis)

CN_T: 247 mg/L	CN_{WAD}: 242 mg/L	CN_F: 237 mg/L	CNO: 2.3 mg/L	SCN: 37 mg/L
Cu: 5.52 mg/L	Ni: 1.50 mg/L	Fe: 2.09 mg/L	Zn: 102 mg/L	
pH: 10.4	Pulp density: 50%			

pH: Approx pH 8.5 with lime   Temperature: Ambient (19-23 C°)

Results:

Agitator Speed: 455 rpm

Flowrates (Avg.):

$Na_2S_2O_5$:	60 g/L	1.00 mL/min	Air: 10 L/min
Lime:	50 g/kg	0.80 mL/min	
Cu:	2000 mg/L	0.96 mL/min	

Retention Time: 86 min

Treated Pulp: (mg/L solution)

pH:	8.4	
CN_{WAD}:	2.3 mg/L*	*By picric acid method
Cu:	0.53 mg/L	
Fe:	<0.05 mg/L	

Reagent Added:

SO_2 (equivalent)	2.87 g/g CN_{WAD}	0.51 g/L pulp
Lime	2.82 g/g CN_{WAD}	0.50 g/L pulp
Cu	0.14 g/g CN_{WAD}	0.024 g/L pulp
Cu	32.8 mg/L solution	

Test CND 9D **Project 11373-003** Date 20

Continuous SO_2/Air CND Test on Pulp from Test CN-2

Lapsed Time min	pH	EMF mV	Air Flow-Rate L/min	DO2 mg/L	Mixer rpm	$Na_2S_2O_5$ in Grad. Cylinder mL	$CuSO_4$ in Grad. Cylinder mL	Lime in Cup g	CN_{WAD} mg/L	CN_{picric} mg/L	Cu mg/L	Fe mg/L	
Feed	8	174	11	8.2	455				242		5.52	2.09	1.5 mg/L Ni, 102 m
0	8.0	174	11	8.2	455	500	500	440					Condition reactor
5	8.4	160	10	6.4	455	495	495						Start feed pump
30	8.4	169	10	4.0	455	470	475			1.1			Sample O/
60	8.4	156	10	3.8	455	440	445			1.7			Sample O/
90	8.5	150	10	3.7	455	410	420			2.1			Sample O/
120	8.6	149	10	3.6	455	380	390			2.3			Sample O/
150	8.5	153	10	3.5	455	350	360			2.4			Sample O/
180	8.4	155	10	3.4	455	320	330			2.6			Sample O/
210	8.5	154	10	3.2	455	290	300			2.5			Sample O/
240	8.4	157	10	3.6	455	260	272			2.7			Sample O/
270	8.4	161	10	3.3	455	230	245			2.7			Sample O/
300	8.5	155	10	3.2	455	200	215			2.6			Sample O/
330	8.5	150	10	3.4	455	170	185			2.7			Sample O/
360	8.4	150	10	3.3	455	141	156	154		2.5			Sample O/
Avg	8.4	157	10	4.0	455					2.3			Total samples

Reactor: 7 L (20 cm inside diameter) with 4 x 2 cm baffles
Impeller: 8-bladed turbine, 8.8 cm diameter x 2.85 cm high
$Na_2S_2O_5$: 60 g/L at 1 mL/min.
$CuSO_4$: 2000 mg/L Cu at 1 mL/min
Lime: 50 g/kg slurry

Feed: 50% solids
Solution volume: 0.738 L/L pulp
Target feed flowrate: 76 mL/min
Target retention time: 90 min

Project 11373-003 **Test AS-** **1** Operator: NL Date: Aug 2/07

Purpose: Arsenic removal from supernatant solution collected from cyanide destruction pulp.

Procedure: The feed solution (600 mL) was placed in a 1.5-L beaker.
The solution was mixed vigorously using a stir plate and a magnetic stir bar.
The initial pH of the solution was recorded.
The required amount of 0.02 M ferric sulphate solution was added.
The pH was maintained at the desired level for 30 minutes using lime.
After 30 minutes of stirring, the solution was allowed to stand for 30 minutes.
At the end of this time period, approximately 300 mL of the supernatant solution was removed.
The pH of this solution was recorded then submited for turbidity determination.
A small amount of the supernatant solution was milipore filtered (0.45 μm).
The filtrate was submitted for As analysis.

Feed: 600 mL supernatant solution from composite CND Test 9A-9D

Temp: Ambient (~25°C)

pH Range: 7-7.5 with dry lime

Reagent: 0.02 M ferric sulphate stock solution 5.04 mL

Time	Ferric Sulphate		pH	Dry Lime		Dissolved	Turbidity	Remarks
	Vol.	Fe/As				As		
min	mL	~g/g		g	g/L	mg/L	NTU	
0	…	…	8.3	…	…	0.478	7.71	Start mixing, solution clear.
0	5.04	20	6.4/8.6	0.008	0.013	…	…	Ferric added, sol'n yellowish brown.
30	…	…	7.7	…	…	…	…	Mixing stopped.
60	…	…	7.7	…	…	0.04	14*	Sampled.

*Supernatant solution after standing for 30 minutes

Project 11373-003 | **Test AS- 2** | Operator: NL | Date: Aug 10/07

Purpose: Arsenic removal from supernatant solution collected from cyanide destruction pulp.

Procedure: The feed solution (600 mL) was placed in a 1.5-L beaker.
The solution was mixed vigorously using a stir plate and a magnetic stir bar.
The initial pH of the solution was recorded.
The required amount of 0.02 M ferric sulphate solution was added.
The pH was maintained at the desired level for 30 minutes using lime.
After 30 minutes of stirring, the solution was allowed to stand for 30 minutes.
At the end of this time period, approximately 300 mL of the supernatant solution was removed.
The pH of this solution was recorded then submited for turbidity determination.
A small amount of the supernatant solution was milipore filtered (0.45 μm).
The filtrate was submitted for As analysis.

Feed: 600 mL supernatant solution from composite CND Test 9A-9D

Temp: Ambient (~25°C)

pH Range: 7-7.5 with dry lime

Reagent: 0.02 M ferric sulphate stock solution 2.52 mL

Time	Ferric Sulphate		pH	Dry Lime		Dissolved	Turbidity	Remarks
	Vol.	Fe/As				As		
min	mL	g/g		g	g/L	mg/L	NTU	
0	…	…	8.3	…	…	0.478	7.71	Start mixing, solution clear.
0	2.52	10	7.3	…	…	…	…	Ferric added, sol'n pale orange.
30	…	…	7.8	…	…	…	…	Mixing stopped.
60	…	…	7.7	…	…	0.074	6.3*	Sampled.

*Supernatant solution after standing for 30 minutes
Note: pH increased throughout the test without adding any lime

Project 11373-003 **Test AS- 3** Operator: NL Date: Aug 10/07

Purpose: Arsenic removal from supernatant solution collected from cyanide destruction pulp.

Procedure: The feed solution (600 mL) was placed in a 1.5-L beaker.
The solution was mixed vigorously using a stir plate and a magnetic stir bar.
The initial pH of the solution was recorded.
The required amount of 0.02 M ferric sulphate solution was added.
The pH was maintained at the desired level for 30 minutes using lime.
After 30 minutes of stirring, the solution was allowed to stand for 30 minutes.
At the end of this time period, approximately 300 mL of the supernatant solution was removed.
The pH of this solution was recorded then submited for turbidity determination.
A small amount of the supernatant solution was milipore filtered (0.45 μm).
The filtrate was submitted for As analysis.

Feed: 600 mL supernatant solution from composite CND Test 9A-9D

Temp: Ambient (~25°C)

pH Range: 7-7.5 with dry lime

Reagent: 0.02 M ferric sulphate stock solution 15.1 mL

Time	Ferric Sulphate		pH	Dry Lime		Dissolved	Turbidity	Remarks
	Vol.	Fe/As				As		
min	mL	g/g		g	g/L	mg/L	NTU	
0	…	…	8.3	…	…	0.478	7.71	Start mixing, solution clear.
0	15.12	60	5.3/7.4	0.039	0.065	…	…	Ferric added, sol'n orange colour
30	…	…	7.8	…	…	…	…	Mixing stopped.
60	…	…	7.7	…	…	0.009	46*	Sampled.

*Supernatant solution after standing for 30 minutes

Project 11373-003 **Test AS- 4** Operator: NL Date: Aug 20/07

Purpose: Arsenic removal from supernatant solution collected from cyanide destruction pulp.

Procedure: The feed solution (8 L) was placed in a 10-L bucket.
The solution was mixed vigorously using an impellar and mixer.
The initial pH of the solution was recorded.
The required amount of 0.02 M ferric sulphate solution was added.
The pH was maintained at the desired level for 30 minutes using lime.
After 30 minutes of stirring, the solution was allowed to stand for 30 minutes.
At the end of this time period, approximately 4 L of the supernatant solution was removed.
The pH of this solution was recorded then submited for turbidity determination.
This solution will then be used in the next phase of testing (Coagulation/Flocculation).

Feed: 8 L supernatant solution from composite CND Test 9A-9D.

Temp: Ambient (~25°C)

pH Range: 7-7.5 with dry lime

Reagent: 0.02 M ferric sulphate stock solution 67.2 mL

Time	Ferric Sulphate		pH	Dry Lime		Dissolved	Turbidity	Remarks
	Vol.	Fe/As				As		
min	mL	g/g		g	g/L	mg/L	NTU	
0	…	…	8.5	…	…	0.478	…	Start mixing, solution clear.
0	67.2	20	6.6	…	…	…	…	Ferric added, sol'n orange colour
30	…	…	7.3	…	…	…	…	Mixing stopped.
60	…	…	7.7	…	…	0.016	17*	Sampled.

*Supernatant solution after standing for 30 minutes

Project 11373-003 **Test AS-** **5** Operator: NL Date: Sept 19/07

Purpose: Arsenic removal from supernatant solution collected from aged cyanide destruction pulp.

Procedure: The feed solution (2 L) was placed in a 5-L bucket.
The solution was mixed using an over head mixer.
The initial pH of the solution was recorded.
The required amount of 0.02 M ferric sulphate solution was added.
The pH was maintained at the desired level for 30 minutes using lime.
After 30 minutes of stirring, the test product was spilt into two equal portions.
One portion was allowed to settle for 30 min while the other was used in flocculation testing.
The pH of the settling solution was recorded after 30 min and approximately 500mL was submitted for turbidity and dissolved As analysis.

Feed: 2 L supernatant solution from composite CND Test 9A-9D after aging at room temperature. from July 27, 2007 (54 days).

Temp: Ambient (~25°C)

pH Range: 7-7.5 with dry lime

Reagent: 0.02 M ferric sulphate stock solution 21.4 mL

Time	Ferric Sulphate		pH	Dry Lime		Dissolved	Turbidity	Remarks
	Vol.	Fe/As				As		
min	mL	g/g		g	g/L	mg/L	NTU	
0	…	…	8.3	…	…	0.472	4.54	Start mixing, solution clear.
0	21.4	…	6.4	…	…	…	…	Ferric added, sol'n orange colour
6	…	…	7.3	0.02	0.01			pH adjusted with lime
30	…	…	7.2	…	…	…	…	Mixing stopped.
60	…	…	7.3	…	…	0.016	20*	Sampled.

*Supernatant solution after standing for 30 minutes

11373-003 **DDV Gold Atlantic Gold - Touquoy** August 23, 2007

Technicians-NL

Test F 1: Flocculation Scoping Tests

Feed: Product from bulk Arsenic removal Test AS4.
Solution Volume: 100 mL of whole product from Test AS4 - test preformed in 150-mL beakers.

Magnafloc 338	5 minutes of Settling			
	Relative size of flocs	Relative rate of settling	Relative Turbidity	Comments
0.5 mg/L	Fine	Medium-slow	High	Initially flocs were small but gradually increased in size throughout test.
1.0 mg/L	Very fine	Slow	High	
2.0 mg/L	Very fine	Slow	High	
4.0 mg/L	Very fine	Slow	High	
6.0 mg/L	Very fine	Slow	High	

Magnafloc 338	10 minutes of Settling			
	Relative size of flocs	Relative rate of settling	Relative Turbidity	Comments
0.5 mg/L	Fine	Slow	Medium	Most solids remained suspended some settled.
1.0 mg/L	Very fine	Slow	Medium	
2.0 mg/L	Very fine	Slow	Medium	
4.0 mg/L	Very fine	Slow	Medium	
6.0 mg/L	Very fine	Slow	Medium	

Magnafloc 338	30 minutes of Settling			
	Relative size of flocs	Relative rate of settling	Relative Turbidity	Comments
0.5 mg/L	Fine	Slow	Almost clear	0.5 mg/L and 1 mg/L additions produced the clearest solutions after 30 minutes of settling.
1.0 mg/L	Very fine	Slow	Almost clear	
2.0 mg/L	Very fine	Slow	Low	
4.0 mg/L	Very fine	Slow	Low	
6.0 mg/L	Very fine	Slow	Low	

Note: 0.5mg/L dosage would be used in final floc test with the supernatant solution from that test being sent for analysis.

11373-003 **DDV Gold Atlantic Gold - Touquoy**

August 23, 2007

Technicians-NL

Test F 2: **Flocculation and Sample Analysis**

Feed: Product from bulk Arsenic removal Test AS4.

Solution Volume: 1 L of whole product from Test AS4 - test preformed in 1-L graduated cylinder.

Magnafloc 338 mg/L	30 minutes of Settling					
	Relative Size of Flocs	Relative Rate of Settling	Relative Turbidity	pH	Comments	Turbidity (NTU)
0.5	Fine	2	S	8.0	The flocs were initially small but gradually increased in size throughout test. Many flocs settled to the bottom, while some flocs attached to the side of the cylinder.	1.96

Note: Approx 600 mL of solution was siphoned off the top of cylinder and sent for analysis.

11373-003 **DDV Gold Atlantic Gold - Touquoy**

Sept 19 2007

Technicians-NL

Test F 3: Flocculation and Sample Analysis

Feed: Product from bulk Arsenic removal Test AS5.

Solution Volume: 1 L of whole product from Test AS 5 - test preformed in 1-L graduated cylinder.

Magnafloc 338	30 minutes of Settling					
	Relative size of flocs	Relative rate of settling	Residual turbidity	pH	Comments	Turbidity (NTU)
0.5mg/L	Fine-medium	Medium-slow	Low	7.3	The flocs were initially small but gradually increased in size throughout test. Many flocs settled to the bottom, while some flocs attached to the side of the cylinder.	3.97

Note: Approx 600 mL of solution was siphoned off the top of cylinder and sent for analysis.

Appendix 2

Procedure for Bench Scale Test for Arsenic Removal

BENCH SCALE TEST FOR ARSENIC REMOVAL

REVISION DATE: July 10, 2007

1.0 INTRODUCTION

Approximately 40 L of cyanidation wastewater (a solids/liquid mixture) will have been treated with SO_2/air for cyanide destruction. A portion of the treated mixture (10 to 20 L as available) will be allowed to "age" for several weeks (in the presence of any solids). The remaining portion will be used for bench scale arsenic precipitation tests by the addition of ferric iron to form basic ferric arsenates.

2.0 CYANIDE DESTRUCTION AND SAMPLE ANALYSIS

1. Treat the approximately 40 L sample for cyanide destruction using the SO_2/air process, as during previous testing for the Touquoy project (Appendix A in the registration document).

2. After treatment with SO_2/air, continue aeration "overnight" to remove volatiles and to "stabilize" the mixture.

3. With continued mixing to ensure a homogeneous mixture, separate the mixture into two portions of approximately equal volumes.

4. Allow one of the samples (can be stored in a bucket with a loose cover) to age by undisturbed exposure to the atmosphere for at least several weeks. Note the start date.

5. Allow the second sample to sit overnight for the removal of free-settling suspended solids. Decant the liquid portion for analysis and bench scale testing. Save the suspended solids (closed bucket or poly bag).

6. Analyze the liquid portion (referred to as "detox solution") as follows:

    Turbidity
    pH
    Chemical oxygen demand
    Total cyanide
    Weak acid dissociable cyanide
    Metals scan for **dissolved** metals, including arsenic
    Major **dissolved** cations: calcium, magnesium, sodium, potassium
    Major **dissolved** anions: sulphate, chloride, and total alkalinity
    Dissolved ammonium (ammonia) and nitrite/nitrate.

Prepared by: Keith Phinney, P.Eng.
Halifax, NS
1-902-457-3045

3.0 ARSENIC PRECIPITATION

1. Prepare at least 500 mls of ferric sulphate stock solution which contains 0.02 M iron:

   Example: if solid $Fe_2 (SO_4)_3.9H_2O$ is used to prepare the solution: Add 3.0 g of the salt to 500 ml of water to make an approximately 0.02 molar solution of ferric iron. Use distilled or demineralized water. Carefully (dropwise) add a small amount of concentrated sulphuric acid to the solution, if necessary to ensure all ferric iron is dissolved.

2. Treat a 1L sample of the detox solution for arsenic precipitation by adding iron stock solution with vigorous mixing and with adjustment of solution pH to within the range of 6.5 to 8.0 using hydrated lime powder. The dosage of 0.02 M iron stock solution is

   Volume (mls/L) = 0.107 x C/M for which C is the concentration of arsenic in the detox solution (mg/L) and M is the molarity of the iron stock solution. Example: C is 2 mg/L; molarity of the iron stock solution is 0.02, the dosage of stock solution is 11 mls.

3. Maintain vigorous mixing for approximately 30 minutes; periodically check the detox solution pH and adjust as necessary, by addition of hydrated lime powder, to obtain a mixture pH within the range of 6.5 to 8.0.

4. Allow the detox solution to sit for approximately 30 minutes for the removal of free-settling suspended solids. Measure the pH of the solution and obtain small portions of the clarified liquid for measurement of turbidity and measurement of the concentration of dissolved arsenic.

5. Repeat the above test sequence, with increasing dosages of iron stock solution (1.2 and 2 times the initial dosage) as necessary to achieve a dissolved arsenic concentration of less than 0.5 mg/L. (A larger dosage of iron may also be required to enhance coagulation and flocculation of the precipitated material). Select a recommended ferric iron dosage based on the test results.

6. Apply the appropriate dosage of ferric iron solution with pH adjustment to 6.5 to 8.0 to produce approximately 10 L of solution for coagulation/flocculation jar testing.

Prepared by: Keith Phinney, P.Eng.
Halifax, NS
1-902-457-3045

4.0 COAGULATION/FLOCCULATION AND SAMPLE ANALYSIS

1. Prepare at least 500 mls of Magnafloc 338 coagulant stock solution which contains 1 mg of coagulant per ml of stock solution. Use distilled or demineralized water.

2. Complete standard 1L jar tests at coagulant dosages of 0.5, 1.0, 2.0, 4.0, and 6.0 mg/L of coagulant (0.5, 1.0, 2.0, 4.0 and 6.0 ml of stock solution per L of solution). Note ease of floc formation, relative size of floc, relative rate of settling, and any residual turbidity after approximately 5 to 10 minutes of settling. The settling rate does not need to be measured as conservative clarification overflow rates will be used for engineering design of the ponds. Select a recommended coagulant dosage based on the test results.

3. Treat a 1 L sample with the recommended coagulant dosage, allow the sample to sit for approximately 30 minutes, and then analyze the clarified liquid for pH, turbidity, and dissolved concentrations of

   Total cyanide
   Weak acid dissociable cyanide
   Metals scan for **dissolved** metals, including arsenic
   Major **dissolved** cations: calcium, magnesium, sodium, potassium
   Major **dissolved** anions: sulphate, chloride, and total alkalinity
   Dissolved ammonium (ammonia) and nitrite/nitrate.

5.0 AGED SAMPLE

If desired at a later date, the aged sample of detox solution can be treated in accordance with the above procedures.

6.0 GENERAL

Treatment conditions may have to be modified based on observations during the bench scale program. Please contact Keith Phinney at 1-902-457-3045 to discuss and review any aspects of the tests.

Prepared by: Keith Phinney, P.Eng.
Halifax, NS
1-902-457-3045

Appendix 3

Details of Analyses

Client	(301) Carie S	Received	17-Jul-07 13:40
Reference	DDV Gold	Requested	19-Jul-07 13:40
Project	CALR-11373-003	Created	17-Jul-07 13:40
Batch	CN2	Finished	24-Jul-07 08:07
Supervisor	debbie	Samples	1,0,0 - 41

Notes:
RUSH requested on Cu, Fe
Cu, Ni, Fe, Zn by AA per C. Trang-EL
Sodium Cyanide Solution
Request to re-assay Zn per Carie S July 19/07-dg

Tag	Type	Sample ID	Au-DirAA mg/L	Ag mg/L	CN(T) mg/L	CNS mg/L	CNO mg/L	SO4 mg/L
1	SMP	Preg Sol'n	1.15	0.09	247	37	2.3	120
2	NOS	~SPK Blk	---	---	105%	99%	98%	---
3	NOS	~Blk	---	---	< 0.01	< 0.2	< 0.1	---

Tag	Dilutions Prep	Cu mg/L	Ni mg/L	Fe mg/L	Zn mg/L	Dilutions Prep	Zn mg/L	Cyanide solution Prep
1	1	5.52	1.50	2.09	102	1	100	1
2	---	---	---	---	---	---	---	---
3	---	---	---	---	---	---	---	---

Tag	Al mg/L	As mg/L	Ba mg/L	Be mg/L	Bi mg/L	Ca mg/L	Cd mg/L	Co mg/L
1	3.0	4	0.013	< 0.002	< 1	14	< 0.09	< 0.3
2	---	---	---	---	---	---	---	---
3	---	---	---	---	---	---	---	---

Tag	Cr mg/L	K mg/L	Li mg/L	Mg mg/L	Mn mg/L	Mo mg/L	Na mg/L	P mg/L
1	< 0.1	30	< 2	0.56	0.04	< 0.6	230	< 5
2	---	---	---	---	---	---	---	---
3	---	---	---	---	---	---	---	---

Tag	Pb mg/L	Sb mg/L	Se mg/L	Sn mg/L	Sr mg/L	Ti mg/L	Tl mg/L	U mg/L
1	< 2	< 1	< 3	< 2	0.05	< 0.02	< 3	< 1
2	---	---	---	---	---	---	---	---
3	---	---	---	---	---	---	---	---

Tag	V mg/L	W mg/L	Y mg/L
1	< 0.2	< 2	< 0.02
2	---	---	---
3	---	---	---

Client	**(2736) Nicky L**	Received	**18-Sep-07 14:40**
Reference		Requested	**21-Sep-07 14:40**
Project	**CALR-11373-003**	Created	**18-Sep-07 14:40**
Batch	**Env ICP-MS Metals**	Finished	**27-Sep-07 09:22**
Supervisor	**bgraham**	Samples	**1,0,0 - 44**

Notes:
Metals, anions, NH3 and ALk dissolved- samples have been filtered.
PH,Turb, COD, and CN samples total. - these cuts have not been filtered.
ckd ks-charged RUSH X2
RL for NO2, NO3 raised due to sample matrix. Sept 24/07 PS
cnT and cnwad distilled by lachat

Tag	Type	Sample ID	Turbidity NTU	pH units	Alkalinity mg/L as CaCO3	COD mg/L	CN(T) mg/L
1	NOS	~Analysis Start Date	18-Sep-07	19-Sep-07	19-Sep-07	19-Sep-07	20-Sep-07
2	NOS	~Analysis Start Time	15:43	09:23	09:23	16:31	16:20
3	NOS	~Analysis Approval Date	19-Sep-07	20-Sep-07	20-Sep-07	20-Sep-07	21-Sep-07
4	NOS	~Analysis Approval Time	10:49	16:45	16:45	11:09	08:40
5	SMP	As5 Head Sample	4.54	8.21	135	75	0.21

Tag	CNWAD mg/L	NH3+NH4 as N mg/L	SO4 mg/L	Cl mg/L	NO2 as N mg/L	NO3 as N mg/L	Ag mg/L	Al mg/L
1	21-Sep-07	19-Sep-07	18-Sep-07	18-Sep-07	18-Sep-07	18-Sep-07	21-Sep-07	23-Sep-07
2	12:00	10:20	19:53	19:53	19:53	19:53	10:59	12:27
3	21-Sep-07	20-Sep-07	21-Sep-07	24-Sep-07	24-Sep-07	24-Sep-07	21-Sep-07	27-Sep-07
4	14:50	11:59	15:07	09:57	09:57	09:57	14:29	09:18
5	0.19	17.6	1300	24	< 0.6	< 0.5	0.00021	0.09

Tag	As mg/L	Ba mg/L	Be mg/L	B mg/L	Bi mg/L	Ca mg/L	Cd mg/L	Co mg/L
1	21-Sep-07	21-Sep-07	21-Sep-07	21-Sep-07	21-Sep-07	23-Sep-07	21-Sep-07	21-Sep-07
2	10:59	10:59	10:59	10:59	10:59	12:27	10:59	10:59
3	21-Sep-07	21-Sep-07	21-Sep-07	21-Sep-07	21-Sep-07	27-Sep-07	21-Sep-07	21-Sep-07
4	14:29	14:29	14:29	14:29	14:29	09:18	14:29	14:29
5	0.472	0.0602	< 0.00002	0.0432	< 0.00001	215	< 0.000003	0.224

Tag	Cr mg/L	Cu mg/L	Fe mg/L	Li mg/L	Mg mg/L	Mn mg/L	Mo mg/L	Na mg/L
1	21-Sep-07	21-Sep-07	23-Sep-07	23-Sep-07	23-Sep-07	21-Sep-07	21-Sep-07	23-Sep-07
2	10:59	10:59	12:27	12:27	12:27	10:59	10:59	12:27

Tag	Cr mg/L	Cu mg/L	Fe mg/L	Li mg/L	Mg mg/L	Mn mg/L	Mo mg/L	Na mg/L
3	21-Sep-07	21-Sep-07	27-Sep-07	27-Sep-07	27-Sep-07	21-Sep-07	21-Sep-07	27-Sep-07
4	14:29	14:29	09:18	09:18	09:18	14:29	14:29	09:18
5	0.0008	0.240	0.15	< 0.002	10.1	0.0540	0.0668	681

Tag	Ni mg/L	P mg/L	Pb mg/L	Sb mg/L	Se mg/L	Si mg/L	Sn mg/L	Sr mg/L
1	21-Sep-07	23-Sep-07	21-Sep-07	21-Sep-07	21-Sep-07	23-Sep-07	21-Sep-07	23-Sep-07
2	10:59	12:27	10:59	10:59	10:59	12:27	10:59	12:27
3	21-Sep-07	27-Sep-07	21-Sep-07	21-Sep-07	21-Sep-07	27-Sep-07	21-Sep-07	27-Sep-07
4	14:29	09:18	14:29	14:29	14:29	09:18	14:29	09:18
5	0.0046	< 0.01	0.0014	0.0123	0.003	3.05	< 0.0003	0.431

Tag	Ti mg/L	Tl mg/L	U mg/L	V mg/L	Zn mg/L
1	21-Sep-07	21-Sep-07	21-Sep-07	21-Sep-07	21-Sep-07
2	10:59	10:59	10:59	10:59	10:59
3	21-Sep-07	21-Sep-07	21-Sep-07	21-Sep-07	21-Sep-07
4	14:29	14:29	14:29	14:29	14:29
5	0.0008	0.000149	0.00242	0.00076	0.020

Client	(2736) Nicky L	Received	19-Sep-07 15:37
Reference		Requested	26-Sep-07 15:37
Project	CALR-11373-003	Created	19-Sep-07 15:37
Batch	Env ICP-MS Metals	Finished	24-Oct-07 15:00
Supervisor	bgraham	Samples	2,0,0 - 45

Notes:
ckd ks
RL raised for NO2 due to sample matrix Sept 24/07 LP
cn(t) and cnwad distilled by lachat, tm
CN(T) added to sample 6 as requested by CT Oct. 24/07
DG

Tag	Type	Sample ID	Turbidity NTU	pH units	Alkalinity mg/L as CaCO3	COD mg/L	CN(T) mg/L
1	NOS	~Analysis Start Date	19-Sep-07	21-Sep-07	21-Sep-07	19-Sep-07	20-Sep-07
2	NOS	~Analysis Start Time	16:14	09:34	09:34	16:31	16:20
3	NOS	~Analysis Approval Date	20-Sep-07	24-Sep-07	24-Sep-07	20-Sep-07	27-Sep-07
4	NOS	~Analysis Approval Time	11:04	13:06	13:06	11:09	13:35
5	SMP	AS5 Floc Test	3.97	7.96	98	75	0.44
6	SMP	AS5 Floc Test Diss	---	---	---	---	0.03

Tag	CNWAD mg/L	NH3+NH4 as N mg/L	SO4 mg/L	Cl mg/L	NO2 as N mg/L	NO3 as N mg/L	Ag mg/L	Al mg/L
1	21-Sep-07	20-Sep-07	19-Sep-07	19-Sep-07	19-Sep-07	19-Sep-07	21-Sep-07	23-Sep-07
2	12:00	08:26	19:49	19:49	19:49	19:49	10:59	12:27
3	27-Sep-07	21-Sep-07	25-Sep-07	21-Sep-07	25-Sep-07	25-Sep-07	26-Sep-07	27-Sep-07
4	13:35	11:39	17:22	14:52	09:56	09:56	16:08	09:19
5	0.12	17.1	1400	24	< 0.6	0.12	0.00032	0.04
6	---	---	---	---	---	---	0.00003	< 0.01

Tag	As mg/L	Ba mg/L	Be mg/L	B mg/L	Bi mg/L	Ca mg/L	Cd mg/L	Co mg/L
1	21-Sep-07	21-Sep-07	21-Sep-07	21-Sep-07	21-Sep-07	23-Sep-07	21-Sep-07	21-Sep-07
2	10:59	10:59	10:59	10:59	10:59	12:27	10:59	10:59
3	26-Sep-07	26-Sep-07	26-Sep-07	26-Sep-07	26-Sep-07	27-Sep-07	26-Sep-07	26-Sep-07
4	16:08	16:08	16:08	16:08	16:08	09:19	16:08	16:08
5	0.170	0.0641	< 0.00002	0.0455	0.00006	215	< 0.000003	0.217
6	0.0060	0.0565	< 0.00002	0.0419	< 0.00001	204	< 0.000003	0.214

Tag	Cr mg/L	Cu mg/L	Fe mg/L	K mg/L	Li mg/L	Mg mg/L	Mn mg/L	Mo mg/L
1	21-Sep-07	21-Sep-07	23-Sep-07	23-Sep-07	23-Sep-07	23-Sep-07	21-Sep-07	21-Sep-07
2	10:59	10:59	12:27	12:27	12:27	12:27	10:59	10:59

Tag	Cr mg/L	Cu mg/L	Fe mg/L	K mg/L	Li mg/L	Mg mg/L	Mn mg/L	Mo mg/L
3	26-Sep-07	26-Sep-07	27-Sep-07	27-Sep-07	27-Sep-07	27-Sep-07	26-Sep-07	26-Sep-07
4	16:08	16:08	09:19	09:19	09:19	09:19	16:08	16:08
5	< 0.0005	0.201	4.46	66.8	< 0.002	10.3	0.132	0.0548
6	< 0.0005	0.0883	0.02	63.2	< 0.002	9.25	0.125	0.0483

Tag	Na mg/L	Ni mg/L	P mg/L	Pb mg/L	Sb mg/L	Se mg/L	Si mg/L	Sn mg/L
1	23-Sep-07	21-Sep-07	23-Sep-07	21-Sep-07	21-Sep-07	21-Sep-07	23-Sep-07	21-Sep-07
2	12:27	10:59	12:27	10:59	10:59	10:59	12:27	10:59
3	27-Sep-07	26-Sep-07	27-Sep-07	26-Sep-07	26-Sep-07	26-Sep-07	27-Sep-07	26-Sep-07
4	09:19	16:08	09:19	16:08	16:08	16:08	09:19	16:08
5	610	0.0071	0.01	0.00175	0.0108	< 0.001	2.98	0.00020
6	634	0.0062	< 0.01	0.00037	0.00800	0.001	2.38	0.00006

Tag	Sr mg/L	Ti mg/L	Tl mg/L	U mg/L	V mg/L	Zn mg/L
1	23-Sep-07	21-Sep-07	21-Sep-07	21-Sep-07	21-Sep-07	21-Sep-07
2	12:27	10:59	10:59	10:59	10:59	10:59
3	27-Sep-07	26-Sep-07	26-Sep-07	26-Sep-07	26-Sep-07	26-Sep-07
4	09:19	16:08	16:08	16:08	16:08	16:08
5	0.440	0.0238	0.000120	0.00213	0.00047	0.027
6	0.410	0.0003	0.000161	0.00160	0.00010	0.018

Client	**(2736) Nicky L**		Received	**24-Aug-07 08:12**
Reference			Requested	**31-Aug-07 08:12**
Project	**CALR-11373-003**		Created	**24-Aug-07 08:12**
Batch	**Env ICP-MS Metals**		Finished	**13-Sep-07 15:10**
Supervisor	**bgraham**		Samples	**2,0,0 - 44**

Notes:
ckdk s
RL raised for NO2, NO3, and Nitrates due to sample matrix
- Brad Aug 30
#6 smaple ID corrected Sep5/07 bg

Tag	Type	Sample ID	Turbidity NTU	Alkalinity mg/L as CaCO3	SO4 mg/L	Cl mg/L	NO2 as N mg/L
1	NOS	~Analysis Approval Date	24-Aug-07	29-Aug-07	30-Aug-07	31-Aug-07	30-Aug-07
2	NOS	~Analysis Approval Time	16:00	12:04	16:23	12:36	16:22
3	SMP	1L Floc Test-0.5mg/L (Whole)	1.96	91	1300	21	< 0.6
4	SMP	1L Floc Test-0.5mg/L (Dissolved)	---	---	---	---	---

Tag	NO3 as N mg/L	NO2+NO3 as N mg/L	NH3+NH4 as N mg/L	CN(T) mg/L	CNWAD mg/L	Ag mg/L	Al mg/L	As mg/L
1	30-Aug-07	30-Aug-07	05-Sep-07	13-Sep-07	13-Sep-07	31-Aug-07	31-Aug-07	04-Sep-07
2	16:22	16:22	11:38	13:58	13:57	13:35	11:37	15:08
3	< 0.5	<0.6	97.8	1.60	1.53	0.00148	0.11	0.294
4	---	---	---	---	---	0.00143	< 0.01	0.0402

Tag	Ba mg/L	Be mg/L	B mg/L	Bi mg/L	Ca mg/L	Cd mg/L	Co mg/L	Cr mg/L
1	04-Sep-07	04-Sep-07	04-Sep-07	04-Sep-07	31-Aug-07	04-Sep-07	04-Sep-07	04-Sep-07
2	15:08	15:08	15:08	15:08	11:37	15:08	15:08	15:08
3	0.0610	< 0.00002	0.0447	0.00008	239	0.000656	0.228	0.0007
4	0.0588	< 0.00002	0.0437	< 0.00001	230	0.000311	0.190	0.0012

Tag	Cu mg/L	Fe mg/L	K mg/L	Li mg/L	Mg mg/L	Mn mg/L	Mo mg/L	Na mg/L
1	05-Sep-07	31-Aug-07	04-Sep-07	31-Aug-07	31-Aug-07	04-Sep-07	04-Sep-07	04-Sep-07
2	15:41	11:37	15:08	11:36	11:35	15:08	15:08	15:08
3	6.30	4.67	61.1	< 0.002	7.31	0.148	0.0637	437
4	5.57	0.01	73.4	< 0.002	7.61	0.114	0.0584	475

Tag	Ni mg/L	P mg/L	Pb mg/L	Sb mg/L	Se mg/L	Si mg/L	Sn mg/L	Sr mg/L
1	04-Sep-07	31-Aug-07	04-Sep-07	04-Sep-07	04-Sep-07	31-Aug-07	04-Sep-07	31-Aug-07
2	15:08	11:35	15:08	15:08	15:08	11:35	15:08	11:35
3	0.0230	0.03	0.00188	0.0109	0.007	2.79	0.00063	0.435
4	0.0141	0.02	0.00018	0.0124	0.008	2.45	< 0.0003	0.445

Tag	Ti mg/L	Tl mg/L	U mg/L	V mg/L	Zn mg/L	filter Prep
1	04-Sep-07	04-Sep-07	04-Sep-07	04-Sep-07	04-Sep-07	29-Aug-07
2	15:08	15:08	15:08	15:08	15:08	11:05
3	0.0283	< 0.0001	0.00485	0.00050	0.0577	---
4	0.0005	< 0.0001	0.00535	< 0.00006	0.0259	1

Client	(2736) Cuong Trang	Received	27-Jul-07 07:54
Reference		Requested	03-Aug-07 07:54
Project	CALR-11373-003	Created	27-Jul-07 07:54
Batch	Env ICP-MS Metals	Finished	13-Aug-07 14:01
Supervisor	bgraham	Samples	1,0,0 - 44

Notes:
Metals, anions, NH3 and ALk dissolved- samples have been filtered.
PH,Turb, COD, and CN samples total. - these cuts have not been filtered.
ck dks

Tag	Type	Sample ID	Turbidity NTU	pH units	Alkalinity mg/L as CaCO3	COD mg/L	CN(T) mg/L
1	NOS	~Analysis Start Date	27-Jul-07	27-Jul-07	27-Jul-07	30-Jul-07	31-Jul-07
2	NOS	~Analysis Start Time	11:19	13:15	13:15	23:08	17:31
3	NOS	~Analysis Approval Date	31-Jul-07	31-Jul-07	31-Jul-07	31-Jul-07	03-Aug-07
4	NOS	~Analysis Approval Time	08:46	08:51	08:51	09:15	16:27
5	SMP	Detox Solution	7.71	7.92	96	91	3.50

Tag	CNWAD mg/L	NH3+NH4 as N mg/L	SO4 mg/L	Cl mg/L	NO2 as N mg/L	NO3 as N mg/L	Ag mg/L	Al mg/L
1	30-Jul-07	27-Jul-07	31-Jul-07	31-Jul-07	31-Jul-07	31-Jul-07	02-Aug-07	31-Jul-07
2	18:02	09:55	20:09	20:09	20:09	20:09	08:00	17:52
3	13-Aug-07	31-Jul-07	03-Aug-07	03-Aug-07	03-Aug-07	03-Aug-07	03-Aug-07	02-Aug-07
4	07:24	14:28	11:06	11:06	11:06	11:06	15:07	09:41
5	3.09	99.0	1400	20	< 0.06	1.26	0.00053	0.06

Tag	As mg/L	Ba mg/L	Be mg/L	B mg/L	Bi mg/L	Ca mg/L	Cd mg/L	Co mg/L
1	02-Aug-07	02-Aug-07	02-Aug-07	02-Aug-07	02-Aug-07	31-Jul-07	02-Aug-07	02-Aug-07
2	08:00	08:00	08:00	08:00	08:00	17:52	08:00	08:00
3	03-Aug-07	03-Aug-07	03-Aug-07	03-Aug-07	03-Aug-07	02-Aug-07	03-Aug-07	03-Aug-07
4	15:07	15:07	15:07	15:07	15:07	09:41	15:07	15:07
5	0.478	0.0605	0.00005	0.053	< 0.00002	240	0.00009	0.243

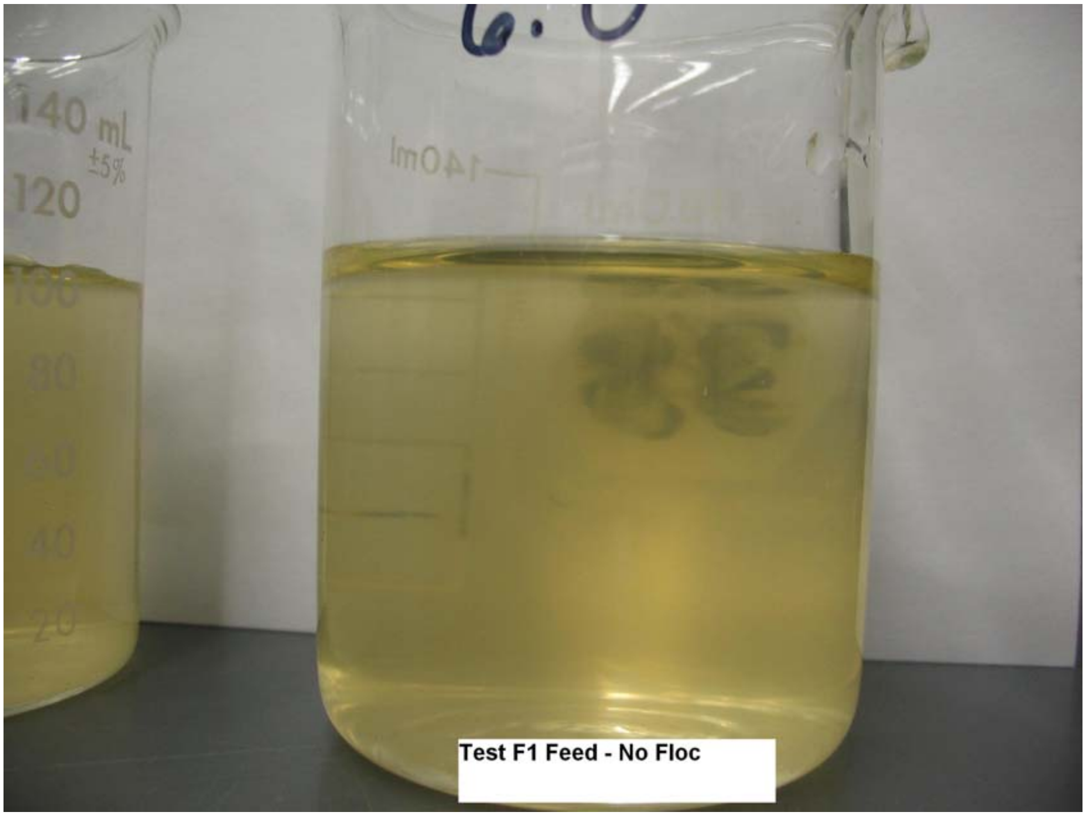
Tag	Cr mg/L	Cu mg/L	Fe mg/L	K mg/L	Li mg/L	Mg mg/L	Mn mg/L	Mo mg/L
1	02-Aug-07	02-Aug-07	31-Jul-07	31-Jul-07	31-Jul-07	31-Jul-07	02-Aug-07	02-Aug-07
2	08:00	08:00	17:52	17:52	17:52	17:52	08:00	08:00
3	03-Aug-07	03-Aug-07	02-Aug-07	02-Aug-07	02-Aug-07	02-Aug-07	03-Aug-07	03-Aug-07
4	15:07	15:07	09:41	09:41	09:41	09:41	15:07	15:07
5	0.0015	7.94	< 0.01	61.0	0.017	7.00	0.0911	0.0635

Tag	Na mg/L	Ni mg/L	P mg/L	Pb mg/L	Sb mg/L	Se mg/L	Si mg/L	Sn mg/L
1	31-Jul-07	02-Aug-07	31-Jul-07	02-Aug-07	02-Aug-07	02-Aug-07	31-Jul-07	02-Aug-07
2	17:52	08:00	17:52	08:00	08:00	08:00	17:52	08:00
3	02-Aug-07	03-Aug-07	02-Aug-07	03-Aug-07	03-Aug-07	03-Aug-07	02-Aug-07	03-Aug-07
4	09:41	15:07	09:42	15:07	15:07	15:07	09:42	15:07
5	556	0.0390	0.02	0.00110	0.0277	0.005	2.94	0.0032

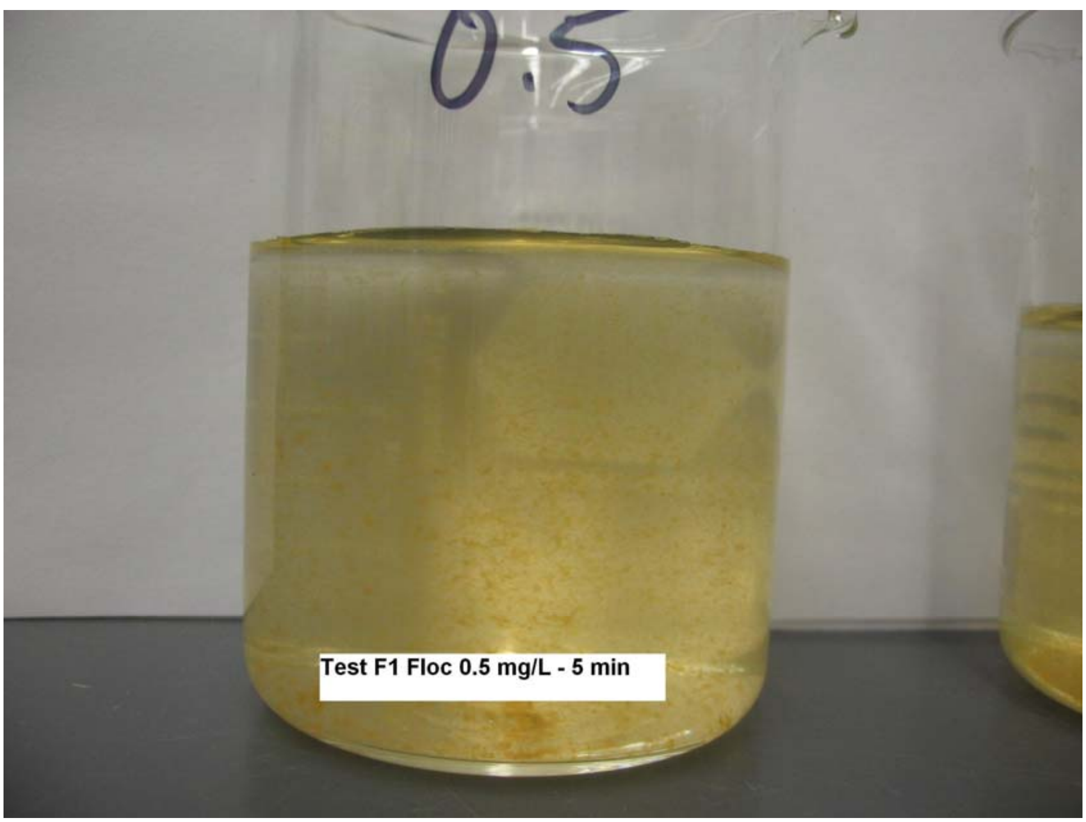
Tag	Sr mg/L	Ti mg/L	Tl mg/L	U mg/L	V mg/L	Zn mg/L	pH Check <2
1	31-Jul-07	02-Aug-07	02-Aug-07	02-Aug-07	02-Aug-07	02-Aug-07	27-Jul-07
2	17:52	08:00	08:00	08:00	08:00	08:00	15:31
3	02-Aug-07	03-Aug-07	03-Aug-07	03-Aug-07	03-Aug-07	03-Aug-07	27-Jul-07
4	09:42	15:07	15:07	15:07	15:07	15:07	15:31
5	0.427	0.0027	0.0003	0.00296	0.00071	0.0567	1.00

Appendix 4

Photographs of Settling Tests



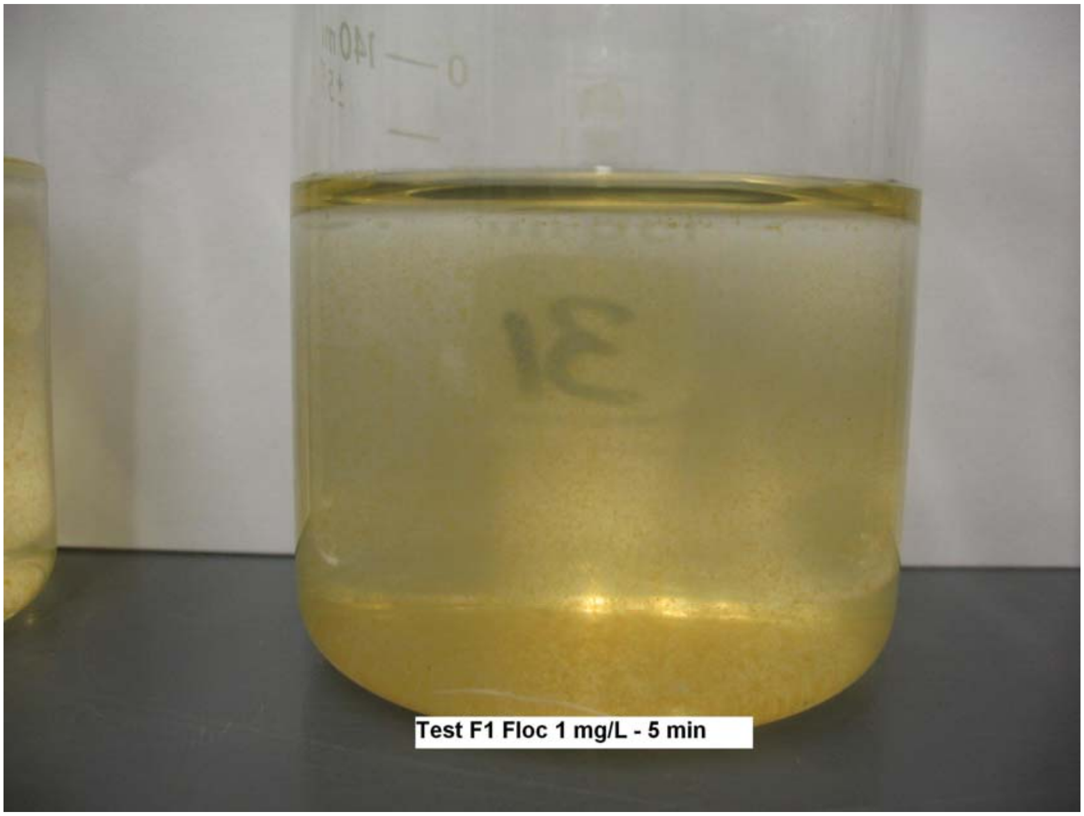
Test F1 Feed - No Floc



Test F1 Floc 0.5 mg/L - 5 min

Test F1 Floc 0.5 mg/L - 10 min

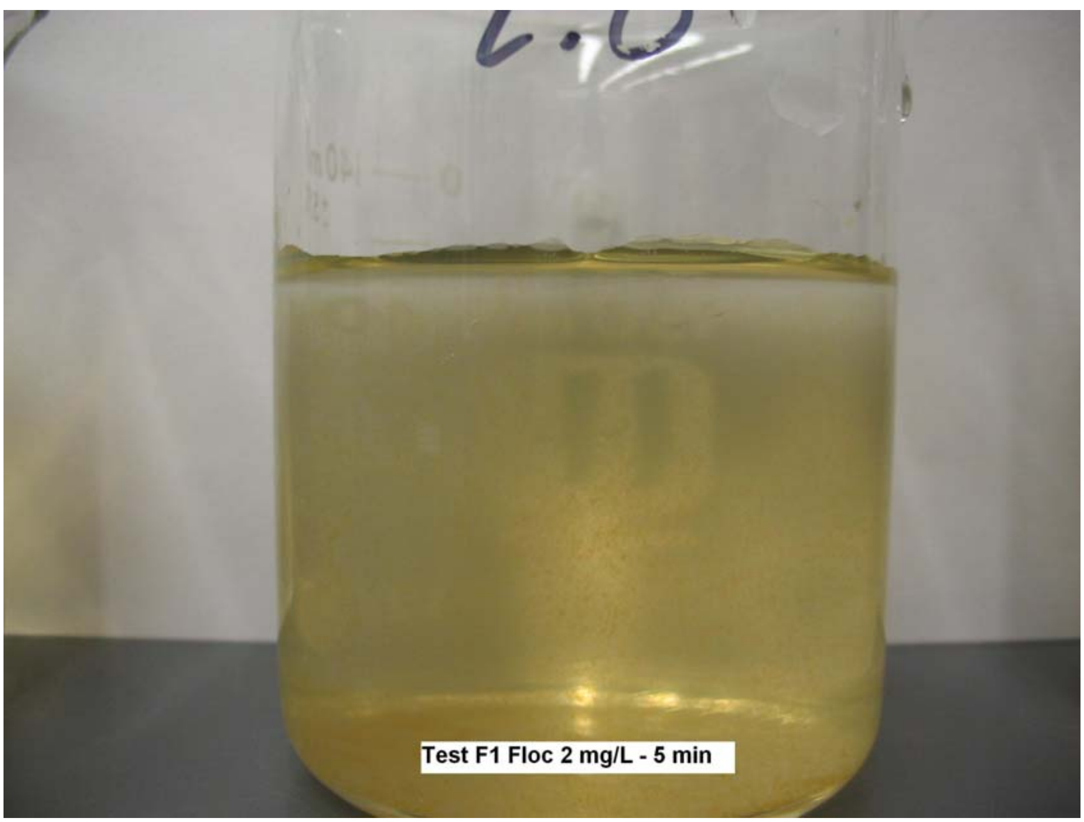
Test F1 Floc 0.5 mg/L - 30 min



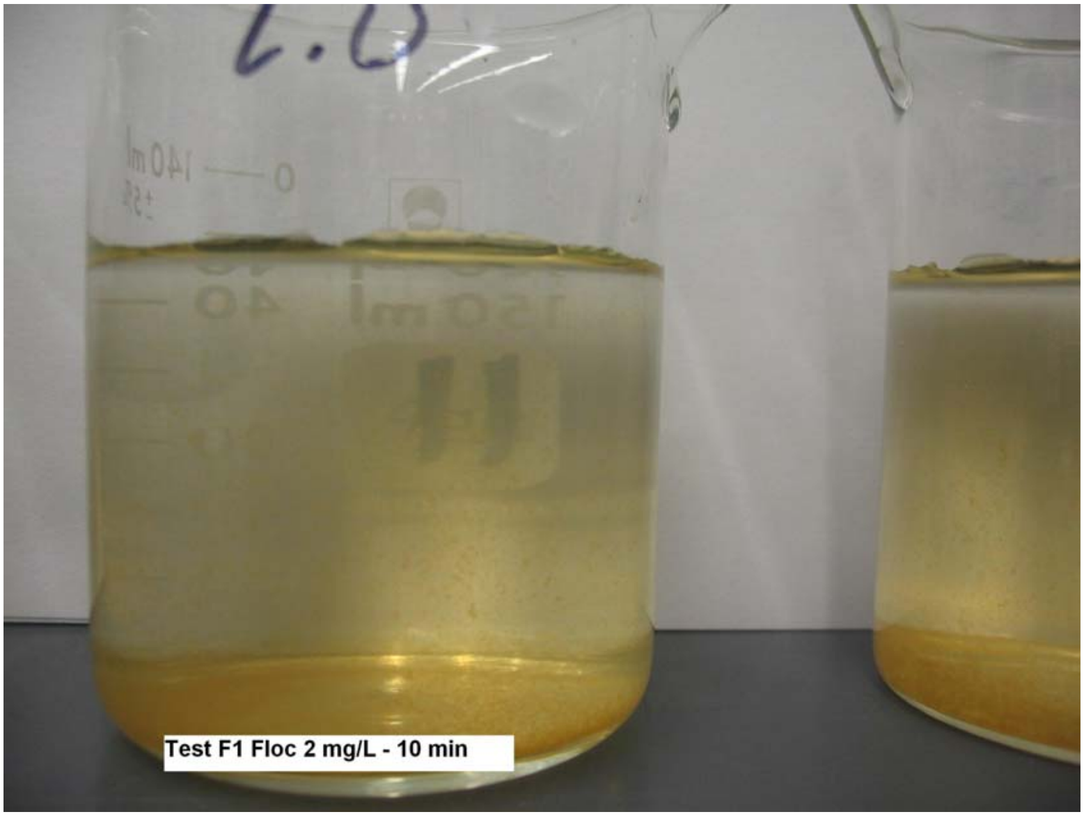
Test F1 Floc 1 mg/L - 5 min

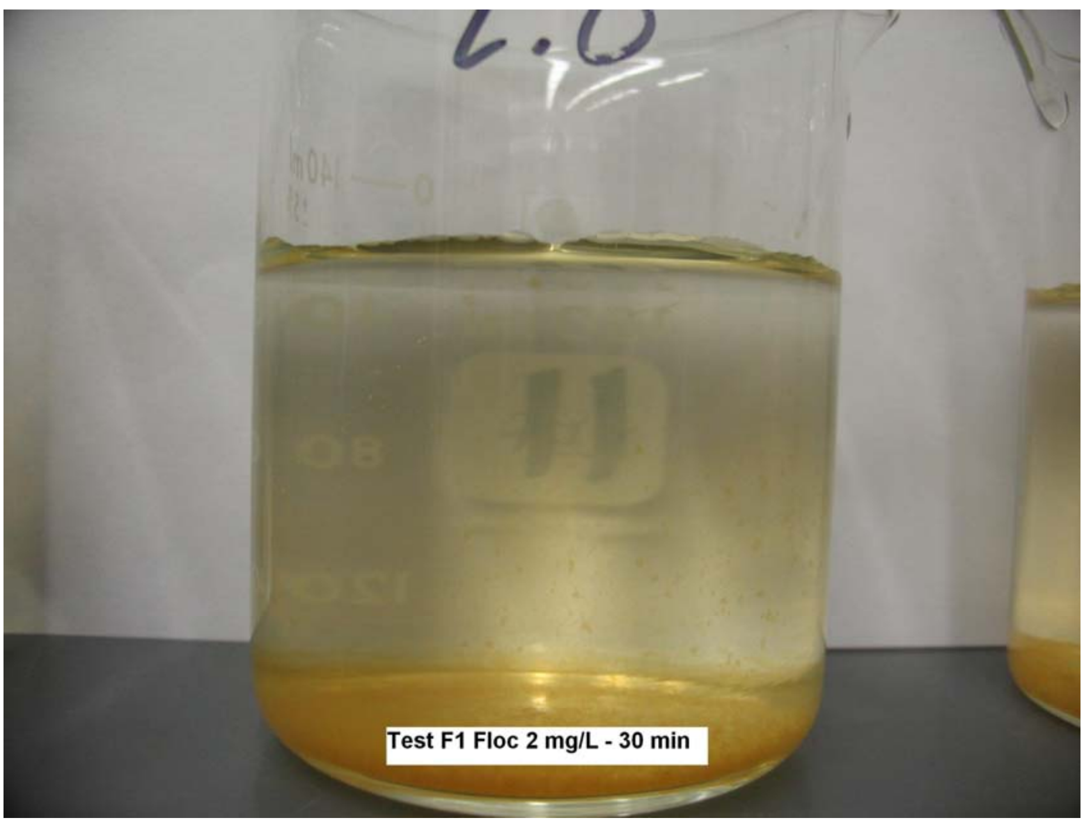
Test F1 Floc 1 mg/L - 10 min

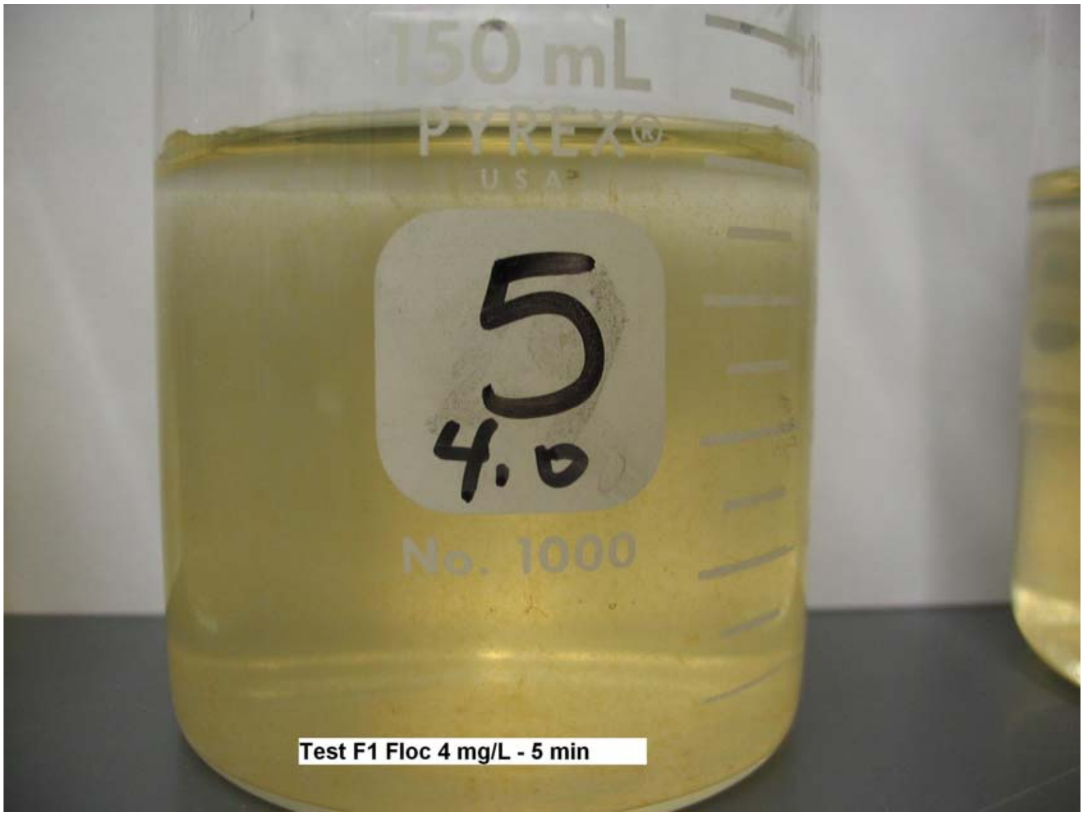
Test F1 Floc 1 mg/L - 30 min



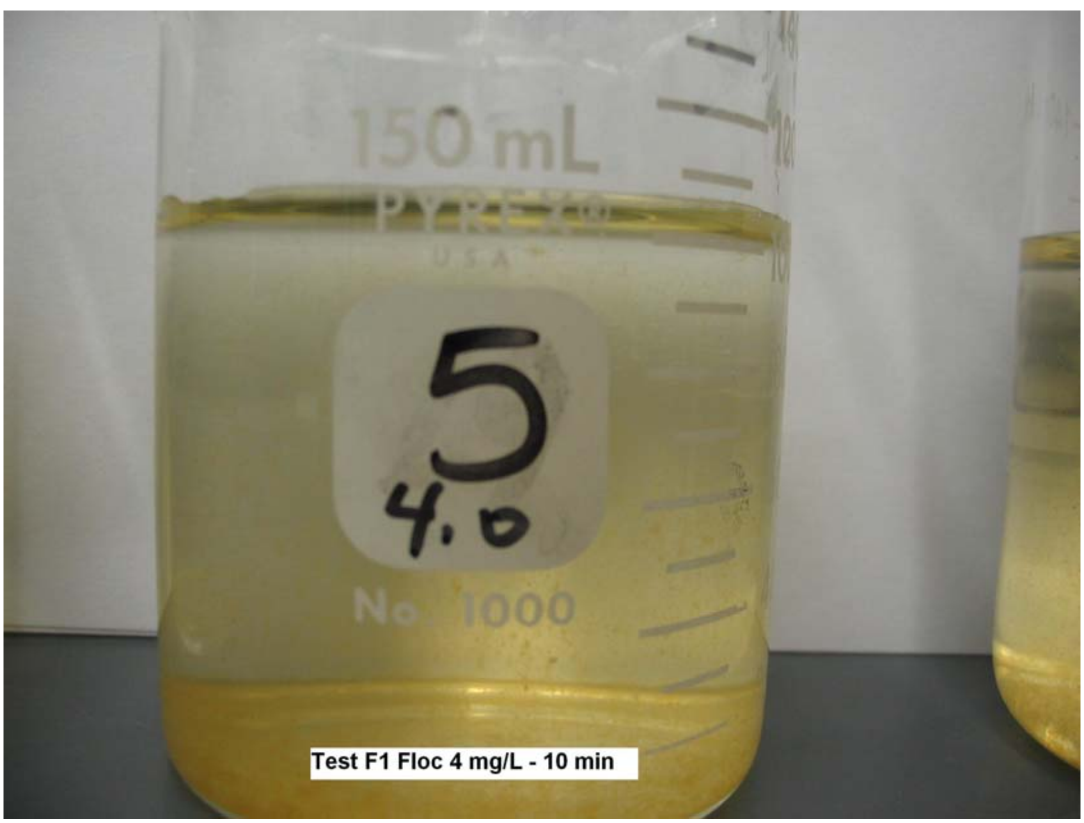
Test F1 Floc 2 mg/L - 5 min


Test F1 Floc 2 mg/L - 10 min

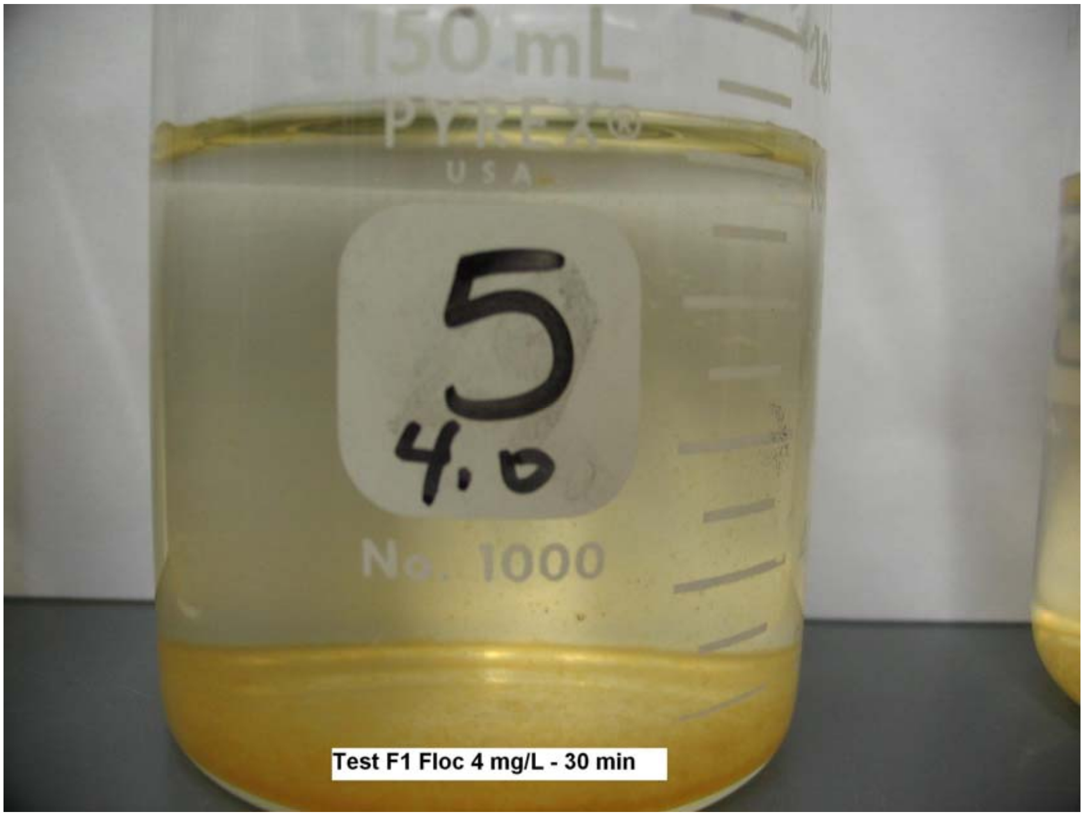

Test F1 Floc 2 mg/L - 30 min



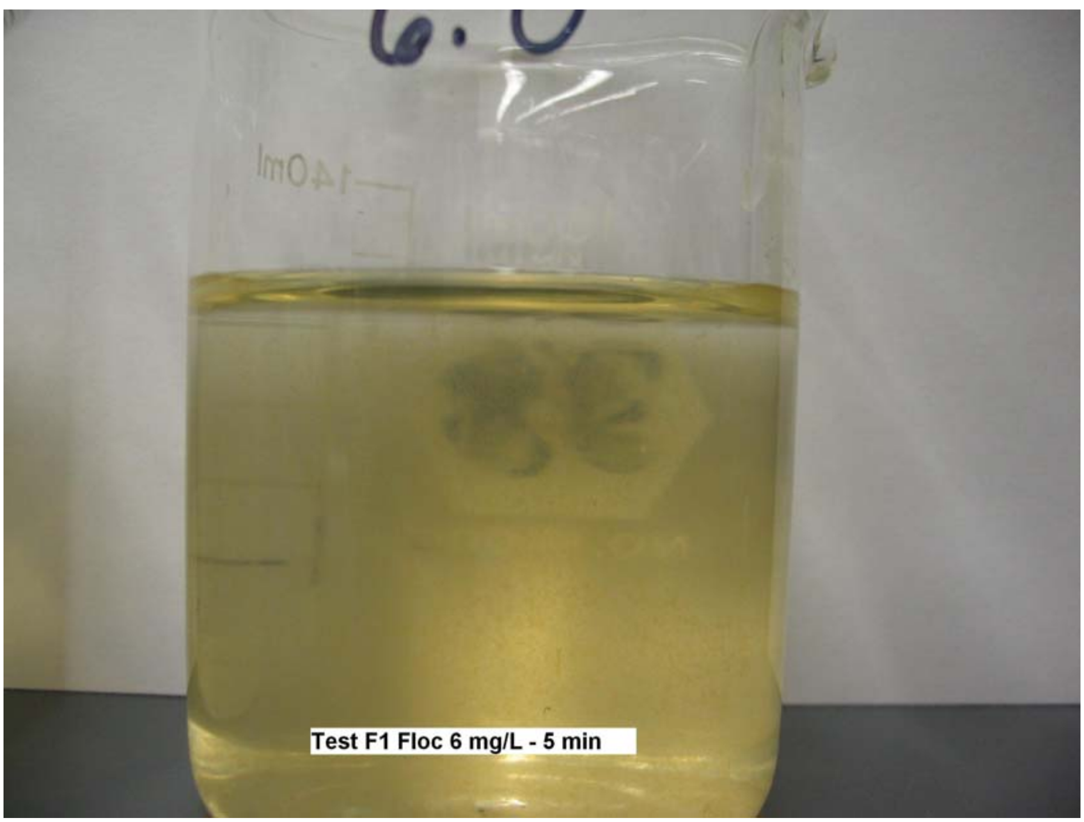
Test F1 Floc 4 mg/L - 5 min

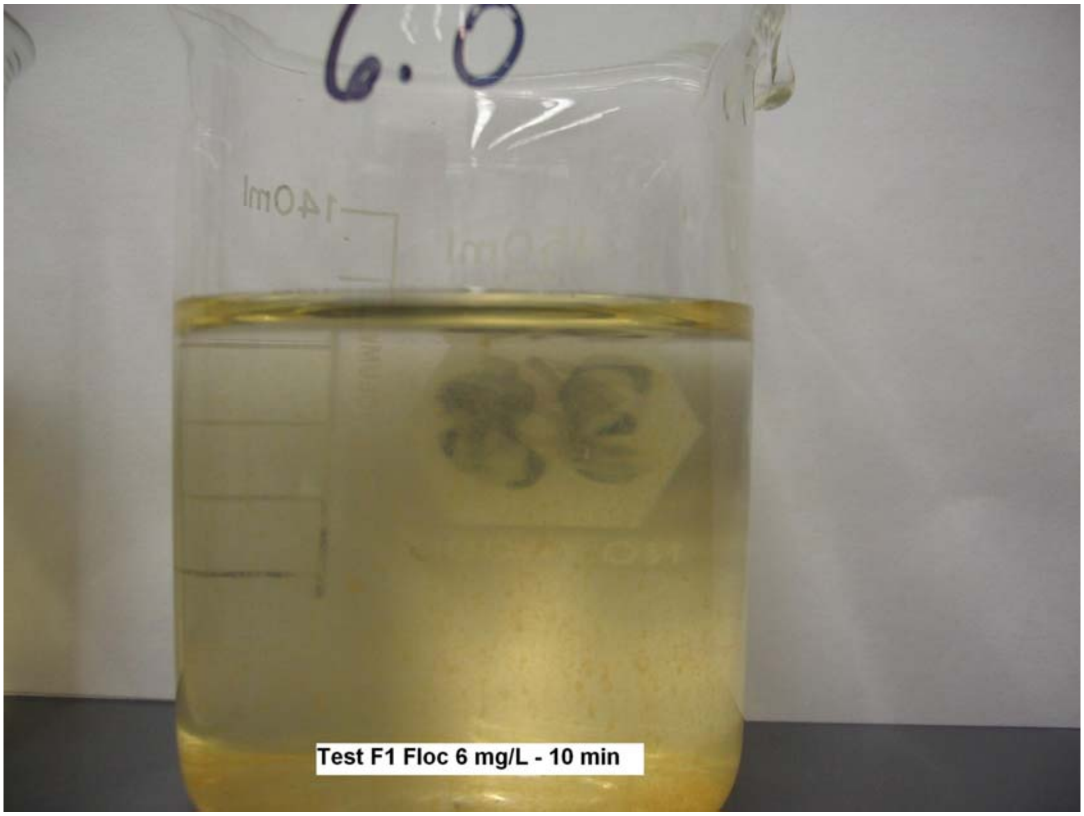


Test F1 Floc 4 mg/L - 10 min

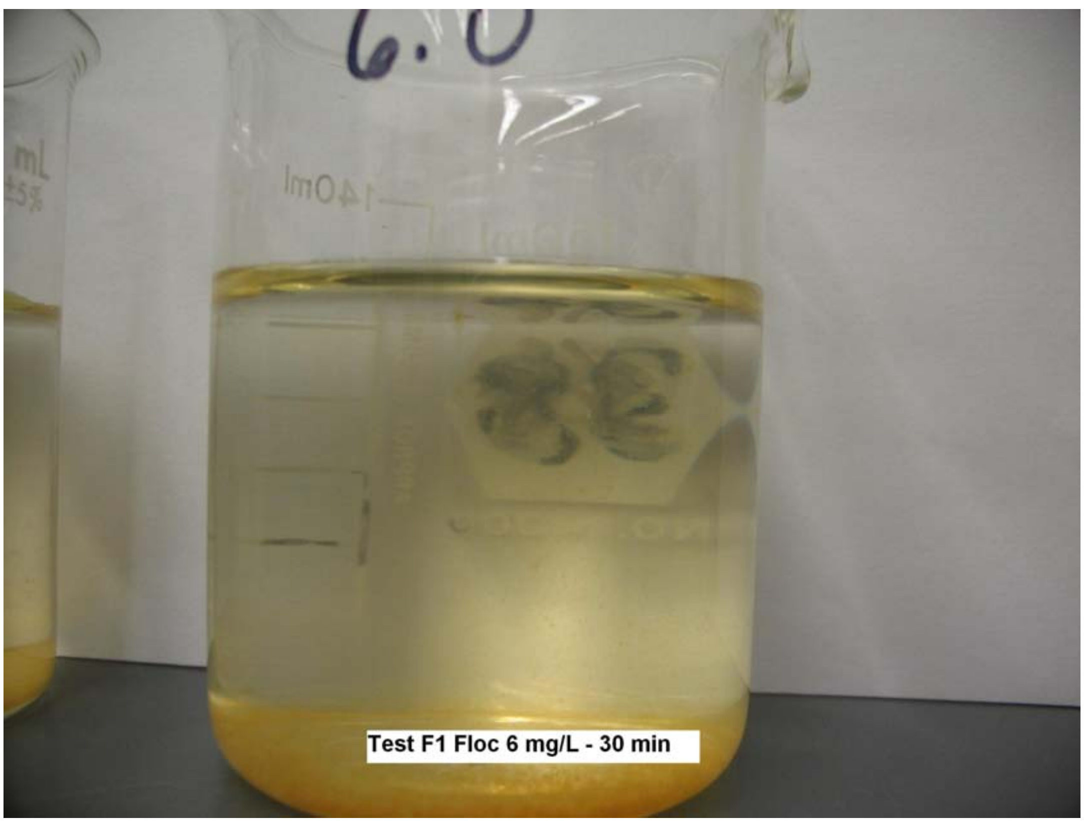


Test F1 Floc 4 mg/L - 30 min

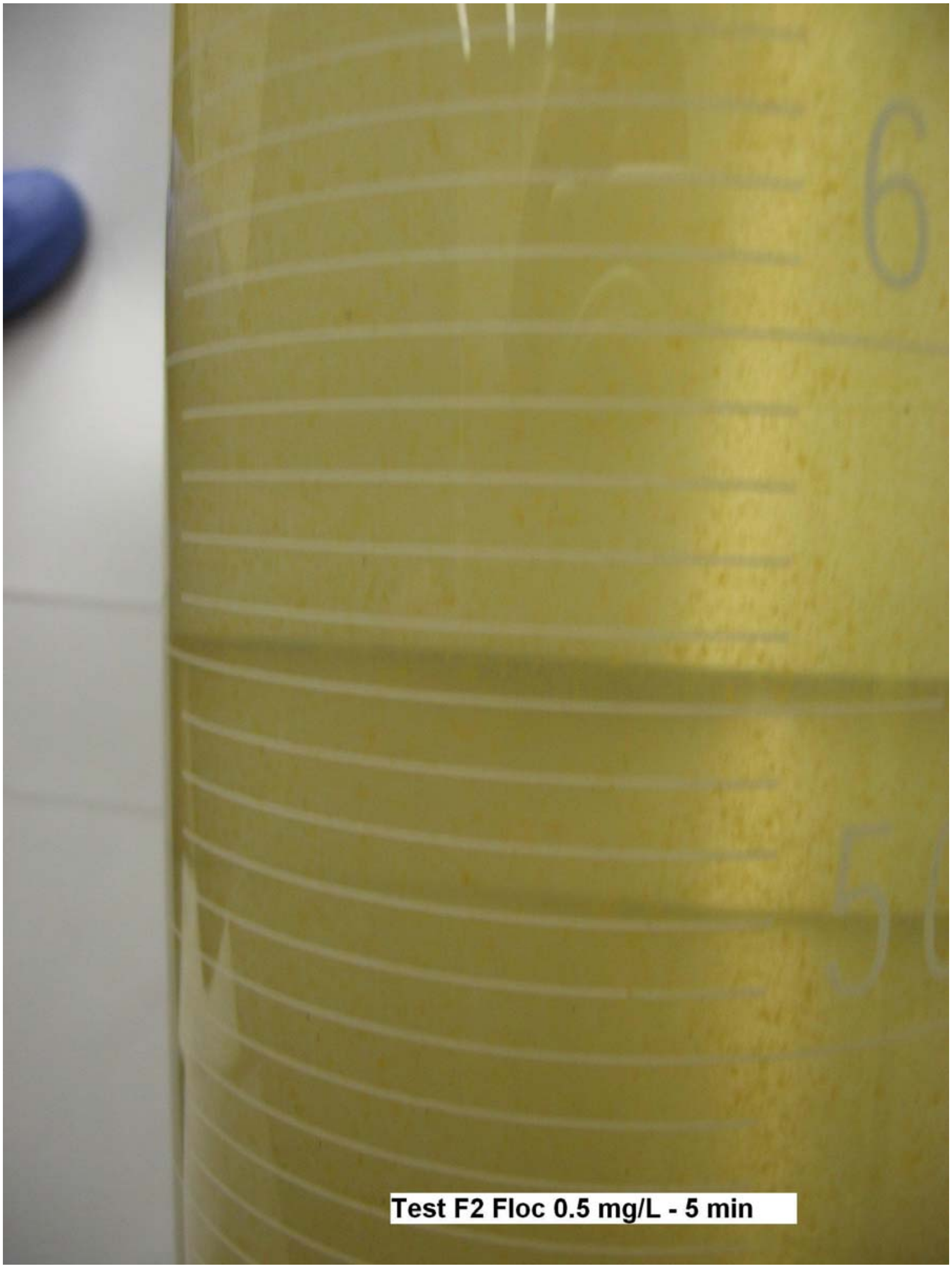

Test F1 Floc 6 mg/L - 5 min

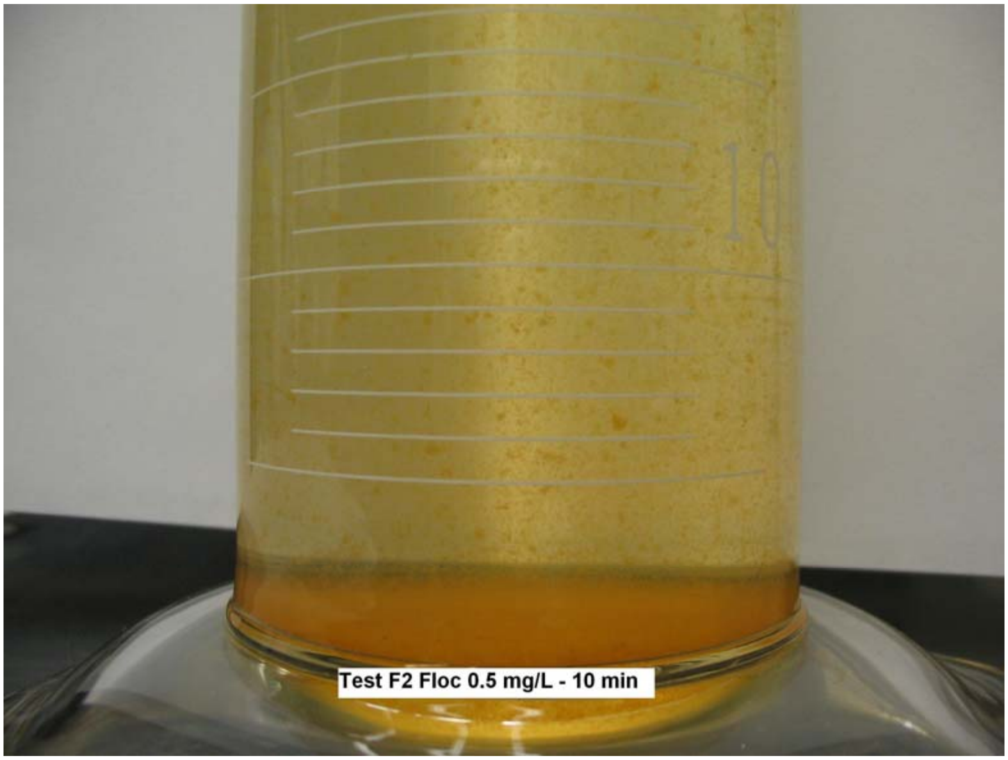


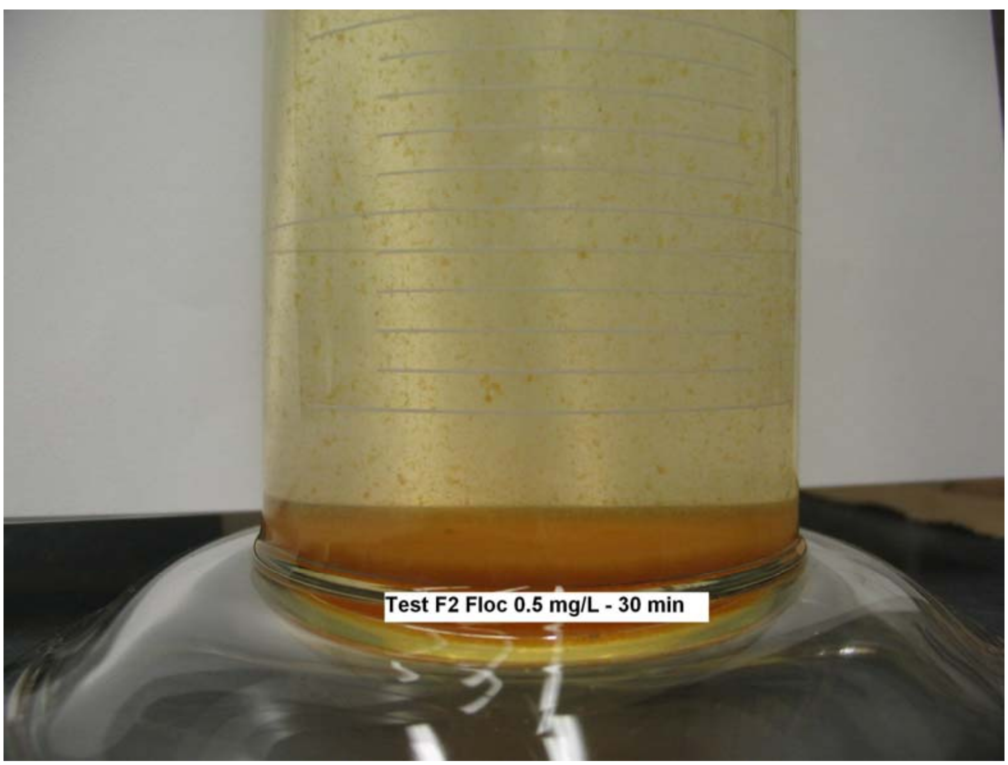
Test F1 Floc 6 mg/L - 10 min

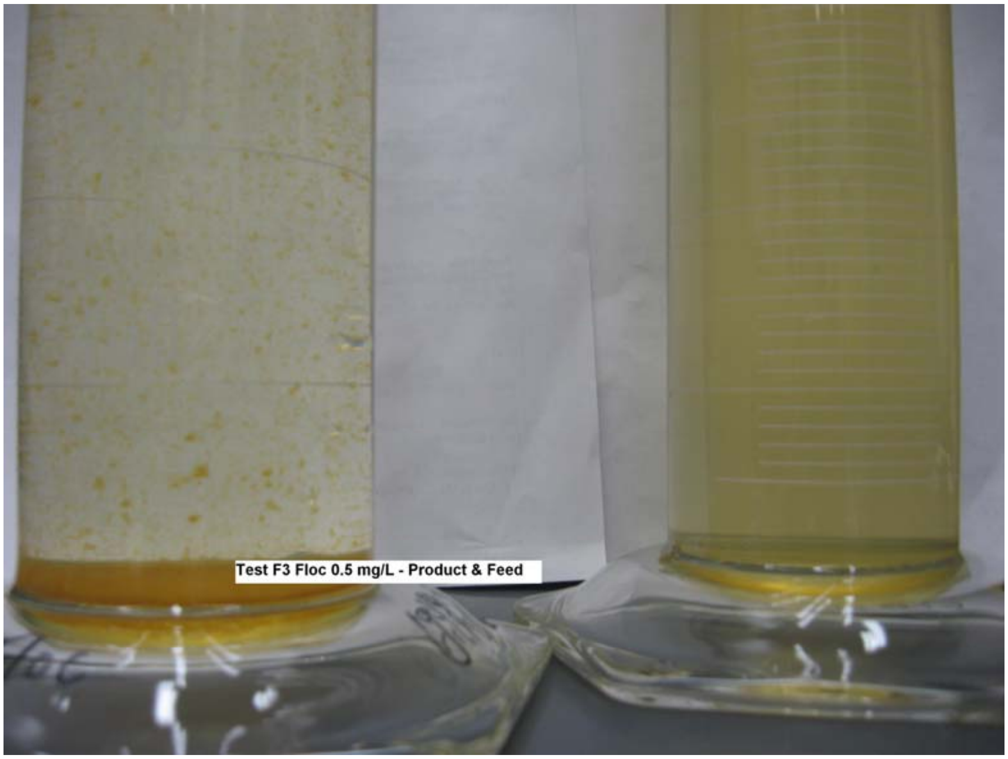


Test F1 Floc 6 mg/L - 30 min


6
5
Test F2 Floc 0.5 mg/L - 5 min


Test F2 Floc 0.5 mg/L - 10 min


Test F2 Floc 0.5 mg/L - 30 min


Test F3 Floc 0.5 mg/L - Product & Feed