CONTENTS

ASSESSMENT OF GEOTEXTILE TUBE DEWATERING TECHNOLOGY FOR TIMET PONDS, HENDERSON, NV

1.0 EXECUTIVE SUMMARY

The TIMET Henderson titanium/magnesium facility is located approximately 15 miles southeast of Las Vegas, NV. There are 16 retention/evaporation ponds at the site that need to be emptied as part of a larger remediation effort (see Figure 2-1). Material in the ponds includes spent caustics, operation process water, continuous sludge drier fines, leach liquid, and magnesium chloride. In many cases, a relatively dry crust overlays three to four feet of wet material beneath. A few ponds are active and have process water on top.

Field tests were performed from September 20-23, 2004 to determine the viability of geotextile tubes for dewatering material in the ponds. Seven ponds were sampled to provide data for a range of conditions that could be expected during a full-scale dewatering operation. This testing was performed subsequent to initial testing of four ponds in May 2004.

Testing has shown that despite the complex and varied nature of the material found in the TIMET ponds, much of the material can be dewatered using geotextile tubes. The hanging bag tests have shown that, with chemical conditioning, the material will dewater to a "dry" state (i.e. no visible free water) relatively quickly. One of the advantages of geotextile tubes is that if the material is not dry enough to meet certain requirements, it can be left in the tube for further dewatering. After one night of dewatering, material within the bags reached 15.3 to 79.4 % solids by weight. After one week, material in the bags ranged from 46.9 to 75.0 % solids by weight. Typically, full-scale geotextile tubes are allowed to dewater for weeks.

Based on the hanging bag tests conducted on 11 representative ponds, over two sampling periods, it is expected that geotextile tubes offer a viable technology for dewatering the material. Water and salt management will likely constitute major cost considerations for any dewatering operation at this site.

It is anticipated that much of the inorganic solids found in the ponds can be dewatered within the tubes to a relatively high percentage (50 - 75 percent by weight). It is likely that achieving 80% solids by weight may require air-drying after being removed from the tubes.

Geotextile tube technology is quite flexible, and can be employed without further hanging bag testing. Rough estimates of tube deployment space requirements can be made based on volumes within each pond. Other components such as polymer feed and water management can also be estimated based on a desired daily output or other metric.

2.0 INTRODUCTION

The TIMET Henderson titanium/magnesium facility is located approximately 15 miles southeast of Las Vegas, NV. There are 16 retention/evaporation ponds at the site (see Figure 2-1) that need to be emptied as part of a larger remediation effort. Material in the ponds includes spent caustics, operation process water, continuous sludge drier fines, leach liquid, and magnesium chloride. In many cases, a relatively dry crust overlays three to four feet of wet material below. A few ponds are active and have process water on top.

From chemical and manufacturing process perspectives, there are generally three types of ponds. Type I are spent caustic ponds, SW2 and SW3. These ponds are predominantly sodium chloride. Type II ponds are predominantly magnesium chloride and calcium chloride and include SW12 and HP4. These ponds have the lowest pH and are high in iron. Type III ponds include continuous sludge drier fines and operational process water. In recent years, material in these ponds has been mixed. Type III ponds can be further divided into Type III a and b, based on their dewatering flow rate properties and chemical usage. After being conditioned with a two-polymer dose of coagulant, type III-a ponds have a very high initial flow rate and logarithmically slow down as time progresses. These ponds include HP3, SW8 and SW9. Type III-b ponds have a much lower initial first flush and a steadier decline of flow rate with time and only required one polymer. These ponds generally have a lower salt concentration and include HP5, SW6, HP2 and SW11.

The last category is the ponds that are too dry for tubes to be an effective dewatering technology. This category includes SC1, SW4, SW5, SW7 and SW10 as listed in table 2-1.

Field tests were performed on May 27 and 28, and September 20-23, 2004 to determine the viability of geotextile tubes for dewatering material in the ponds. Eleven ponds (see Table 2-1) were sampled to provide data for a range of conditions that could be expected during a full scale dewatering operation. Test results of ponds HP5, HP4, SW3, and SW9 were presented in an earlier report and will be summarized herein. Tests conducted and results obtained for each pond tested in September will be discussed separately.

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PINCOCK, ALLEN & HOLT 274 Union Boulevard, Suite 200 Lakewood, Colorado 80228 Phone (303) 986-6950	BASIC REMEDIATION COMPANY	FIGURE 2-1 TIMET POND DESIGNATIONS	July/2004
Project No. 9352.01B	Project Name: Update Current Transport Study		Drawing Name: Fig2-1.dwg

Figure 2-1. Aerial photo of TIMET ponds.

May 2004			
HP5	Operational Process Water	Active pond with liquid on top	III-b
SW3	Spent Caustic	White salt crust layer on top	I
HP4	Magnesium Chloride	Brown salt crust layer on top	II
SW9	Continuous Sludge Drier Fines	Dark brown, top with desiccation cracks	III-a
September 2004			
HP2	OPW/MgCl	Silty Sand, Pale yellow brown	III-b
HP3	Operational Process Water	Fat Clay w/ sand to poorly graded sand w/ silt, drier on east end than west	III-a
SW11	Operational Process Water	Fat Clay, Black Sludge, no free water	III-b
SW8	Operational Process Water	Sludge to silt sand, eastern half liquid covered	III-a
SW2	Spent Caustic	White salt crust, poorly graded sand with silt	I
SW12	MgCl/OPW	Poorly graded sand w/ silt, liquid on top	II
SW6	CSDF/Spent Caustic	Poorly graded sand w/ silt	III-b
Dry Ponds			
SW10	OPW/CSDF	Dry	
SW7	OPW/CSDF	Mostly Dry, very steep access	
SW4	OPW/CSDF	Dry, very steep access (axle grease consistency	
SW5	OPW/CSDF	Dry w/ Lime slurry	
SC1	MgCl	Dry, very steep access	

Table 2-1. TIMET Ponds. Preliminary Characterization.

3.0 GEOTEXTILE TUBES

Geotextile Tubes have been in use since the early 1990s when the U.S. Army Corps of Engineers began evaluating custom-made tubes fabricated from permeable geosynthetic materials. These tubes are made of woven polypropylene or polyester fabrics, with tensile strengths ranging between 400 and 1,000 lb. per inch. They have been used for several purposes, two of which include filtration and dewatering. Typically, waste materials treated in the past with this technology have been characterized by a high percentage of fine particle sizes (i.e. passing the No. 200 sieve). Tubes can be constructed with circumferences up to 45 feet and lengths up to 250 feet long, and have been used in a variety of industrial applications.

When used for dewatering, the tubes are placed in a desired location and then hydraulically filled through fabric sleeves (fill ports). The slurry is pumped into the tubes and allowed to dewater to some degree before a refilling step is conducted. This repetition maximizes the amount of material that a tube can dewater. As water is released from the tube, material on the inside of the tube creates a filter cake, resulting in a two-stage filter. When designed correctly, the cake traps small particles while allowing water to pass through the filter cake. Polymers are often used to insure that the filter cake does not clog the fabric.

When a dewatering concept is used with the tubes, the tubes are sacrificed after the retained material has dried. The tubes are cut so that a loader can load the material into trucks or transport the material to a short-term drying pad to remove any additional water yet held within the material.

3.1 Choice of Geotextiles

The geotextiles chosen for testing at the TIMET ponds represent standard tube fabrics in the industry. The fabrics are representative in both physical and hydraulic properties. Specifically, three fabrics were initially chosen for testing.

Geotex® 46T

Geotex® 46T is a woven polypropylene fabric manufactured by SI Corporation. It has a water flow rate of 20 gallons per minute per square foot, an Apparent Opening Size (AOS) of U.S. Sieve No. 40, and wide width tensile strengths of 400 and 600 pounds per inch in the machine and cross machine directions, respectively. This fabric, and a similar fabric manufactured by the Nicolon Company, is the standard of the dewatering industry.

Geotex® 1016T

Geotex® 1016T is a woven polyester fabric manufactured by SI Corporation. It has a water flow rate of 6 gallons per minute per square foot, an Apparent Opening Size (AOS) of U.S. Sieve No. 60, and a wide width tensile strength of 1,000 pounds per inch in both the machine and cross machine directions. This fabric, and a similar fabric manufactured by the Nicolon Company, are used occasionally in the dewatering industry when working with fine-grained, inorganic sludges with little viscosity. Based on testing in May 2004, this fabric was not considered for further use at the TIMET facility.

ACE 70/105

ACE 70/105 is a new, high-strength woven polypropylene fabric manufactured by ACE Geosynthetics Enterprise Co. Ltd., of Taiwan. It has an Apparent Opening Size (AOS) of U.S. Sieve No. 50, and wide width tensile strengths of 400 and 600 pounds per inch in the machine and cross machine directions, respectively. This fabric uses slightly different fibers from the 46T and is slightly tighter relative to flow rate and AOS.

3.2 Potential Tube Application at TIMET Ponds

This method of dewatering may be amenable to drying the material contained in the TIMET Ponds. Existing pond material could be reformulated as a slurry and pumped into large geotextile tubes to dewater the pond materials. In the past, this technique has been used to dewater materials wherein the solid content was low, in the range of 10 to 20 percent. The methodology has been employed to increase the solid content to somewhere in the neighborhood of 60 percent. Of course, solid content of a "dry" material is entirely dependant on the specific gravity and constituents of the material. Tests have shown that geosynthetic tube dewatering of a slurry occurs as much as three times faster than open-air dewatering, and many times faster when polymers are added to the slurry (Gaffney and Moo-Young, 2000).

Because of the hygroscopic nature of the materials in the pond, where exposure to the atmosphere causes a salt crust to quickly retain water within crusted particles, the tube concept may provide a mechanism to improve the dewatering of the materials. The concept, at this stage, would be to construct a drainage pad that would serve as a layout area and drainage platform for the tubes. In some cases, a dewatering area is constructed using a plastic-lined and gently graded earthen pad surrounded by earthen berms. In other cases, the pad is constructed from asphalt or concrete. Several tubes would be placed on the pad at one time in sequential fashion wherein tube filling, dewatering and material loading would be occurring. Water draining from the tubes is expected to be supersaturated with salts. Dewatering fluids (effluent) resulting from the operation would be collected for processing and possible reuse or directed to a pond for evaporation or use in slurrying material. This pad facility could be constructed on top of or within existing cells so that the potential for additional contamination would be eliminated.

As the dewatering progresses, new tubes will be filled on the asphalt pad as old tubes are excavated and the material is hauled to the CAMU. This process would be repeated until all cells have been excavated and reclaimed. The goal of the processing would be to eliminate as much water from the material as cheaply as possible, with a final goal of about 20 percent moisture so that the primary water in the material is chemically bound. For some ponds, the process may require an additional step of drying beyond the geosynthetic tubes.

The use of an asphalt dewatering pad could greatly enhance evaporation potential from the tube, in addition to the normal gravity dewatering action. Our experience shows that pad temperatures in the range of 160 degrees F can be expected during summer months in Nevada. This should greatly assist in the dewatering process. Polypropylene geotextile tubes are black as well. In addition, as the dried material is hauled to the CAMU, if properly planned, additional drying may result from the material lay down process.

4.0 TESTING

Three representative ponds were sampled in September 2004 to characterize the geo-chemical components of the material to be found in the TIMET ponds. The purpose of the characterization was to allow a more detailed analysis of the entire dewatering process, including final disposal and effluent water management.

Water samples from SW2 (Type I), SW12 (Type II) and HP3 (Type III) were collected on September 20, 2004 and tested for total metals, cyanide, phosphorus, total alkalinity, carbonate and bicarbonate, fluoride, chloride, sulfate, nitrate and nitrite, ammonia and bromide.

Results are tabulated in Table 5-1. Ponds that contain primarily process water (Type III) are consistently neutral to slightly acidic with pH ranging 6.34 to 6.94. The magnesium chloride (Type II) ponds are acidic while spent caustic (Type I) ponds are slightly alkaline. Water from the ponds is saturated or possibly even super-saturated with dissolved salts. The laboratory noted that water samples were solidified or crystallized upon receipt. Most solids re-dissolved upon warming to room temperature, more consistent with summer conditions in Nevada. Dissolved salt concentrations ranged from 26,900 mg/L (2.69 percent) in process water pond HP-3 to 617,000 mg/L (61.7 percent) in magnesium chloride pond SW-12. The other ponds analyzed average about 30 percent dissolved solids.

For the spent caustic pond, sodium is the primary common metal species as would be expected. Calcium and magnesium are the predominate common metals present in the magnesium chloride pond. No single metal dominates the process water pond with calcium, magnesium, sodium, and titanium all being present at relatively high concentrations.

Of the conventional anions, chloride is present at the highest concentration in all three ponds though the spent caustic pond also contains relatively high concentrations of sulfate and carbonate and bicarbonate alkalinity.

"Bench scale" tests were performed on seven wet ponds that had not been tested previously (see table 2-1) to determine the response of slurry to different combinations of polymers. Once the best combination of polymers was determined, a buchner funnel test was performed as an initial assessment of the drainage rate of conditioned slurries through a geotextile fabric. For the tests conducted in September, buchner funnel tests were not performed on unconditioned slurries because the amount of salts present in the slurry tends to increase the viscosity and rapidly form a filter cake on the geotextile. After the best combination of polymers was determined, a hanging bag test was performed to calculate the drainage rate of conditioned slurries over time.

4.1 Pond HP-2 (Type III-b)

HP-2 consists of pale, yellow brown silt which contains calcium chloride. An excavator was used to dig a hole approximately two feet deep. Samples of water and sediment were obtained from this pond using a ponar sampler and bucket. The slurry used for testing purposes had a bulk density of 11.4 pounds/gallon (85 pounds/cubic foot), or a wet specific gravity of 1.38. *In situ* percent solids was tested and found to be 62.5% by weight. This included dissolved solids (salts). The pH of the sample was 5.4. The mixed sample had a light brown color and was representative of what could be pumped by either a small dredge or submersible pump.

Slurry was first tested using a gang stir with 1,000 ml samples to determine response from a variety of polymers. This testing is also called "bench scale" testing. Polymers tested were supplied by Aquamark, Inc. and represent a range of coagulants typically used in industrial dewatering. Polymers are titrated into the raw slurry and observations are made. The first test used a 0.2% solution of AQ 300, which is an anionic emulsion, into 1 Liter of raw slurry. No long term floc formation was present after the addition of 100mL. A small floc did for after the addition of 150mL, with some water present on the top.

Test #2 utilized a 0.2% solution of AQ 507, which is a cationic emulsion polymer, into 1 L of slurry. After titrating to a dosage rate of 200 ml, no floc formation was present and the test was abandoned.

Test #3 utilized a 0.2% solution of AQ 545, which is a cationic emulsion polymer with a high molecular weight, into 1 L of slurry. After the addition of 30mL, the slurry acquired a gooey consistency. After 70mL, no further changes were noted. Next, 70mL of the 0.2% solution of AQ 300 produced separation. At 200mL, a stable floc formed with slight water present on top.

Test #4 consisted of 0.2mL straight AQ 205 into a 500mL slurry immediately followed by 50mL of 0.2% solution of AQ 300. AQ205 is a liquid cationic coagulant. Initially, no changes were witnessed. After the addition of 100ml of AQ 300, the slurry became clumpy. At 150mL, a stable pin floc with separation appeared and at 200mL, there was a stable floc present throughout.

For test #5, 0.2mL AQ205 was injected directly into 500mL of slurry followed by 200mL of AQ 507. There were no noticeable affects. Next, 100mL of AQ 300 was added and a stable floc was present.

The final test, #6, utilized 0.2% solution of AQ 300 into 500mL of slurry. At 100mL, there was pin floc formation throughout the slurry. At 150mL, a big floc was present with clear water. Since this was a comparatively low dosage rate and a single polymer, Buchner funnel testing was then conducted using AQ300.

A Buchner funnel with a piece of geotextile is used to record drainage rates for comparison purposes. Slurry from the bench scale testing is poured into the funnel and drainage rates and properties are noted. This test can differentiate the relative effectiveness of different geotextiles and polymers. Test #1 utilized 350mL of raw slurry from HP5 and 0.2% solution of AQ300 through Geotex 46T woven polypropylene. 46T is the most open of the three tube fabrics. The drainage rate was acceptable and by 90 seconds, 45mL of effluent had passed through the geotextile.

4.1.1 HP-2 Hanging Bag Tests

A hanging bag test was conducted on conditioned slurry from pond HP-2. The Hanging bag was supplied by Syntex Convertors, Ltd. of Manitoba, Canada. Based on the Buchner funnel testing, a dosage rate of 300 ml of 0.2% solution AQ 300 per 1,000 ml of raw slurry was used with 15 L of raw slurry in a geotextile bag made from Geotex 46T.

Approximately 19.5 L of conditioned slurry was poured into the bag and allowed to dewater. The initial drainage was a good constant drip. Drainage water was clear with a yellowish hue, and proceeded at a rate of approximately 200 ml per minute. After 5 minutes, drainage had decreased by more than half to 120ml/min. A sample of the effluent was collected for testing. The test was allowed to continue overnight, and after approximately 21 hours the material within the bag had percent solids by weight of 59.3.

Percent solids by weight is a parameter that is highly dependent on the specific gravity of the each dry solid component in comparison to water. For example, a biological waste dewatered to 25% solids would be considered dry while a steel sludge at 60% might be considered wet. The material in the TIMET ponds includes both dissolved solids and suspended solids. The reported value for percent solids in the hanging bag will represent primarily the dewatered, suspended solids. Much of the dissolved solids passed through the geotextile. This issue will be discussed in Section 5.

4.1.2 HP-2 Solids After One Week

After one week of dewatering, material from the bags had 73.2% solids by weight.

Figure 4-1. Material from HP-2 after one week of dewatering, September 2004.

4.2 Pond HP-3 (Type III-a)

HP-3 consists of sludge with fat clay and sand to poorly graded sand with silt (see Figure 4-1). An excavator was used to dig a hole approximately two feet deep. *In situ* percent solids was tested and found to be 14.9% by weight. Samples of water and sediment were obtained from this pond using a ponar sampler and bucket. The slurry used for testing purposes had a bulk density of 9.22 pounds/gallon (69 pounds/cubic foot), or a wet specific gravity of 1.11. The pH of the sample was 6.9. The mixed sample had a light brown color and was representative of what could be pumped by either a small dredge or submersible pump.

Slurry was first tested using a gang stir with 1,000 ml samples to determine response from a variety of polymers. This testing is also called "bench scale" testing. Polymers tested were supplied by Aquamark, Inc. Polymers are titrated into the raw slurry and observations are made. The first test used a 0.2% solution of AQ300 in 1L of raw slurry. Some clumping began at a dosage rate of 150 ml. At 200mL, there was almost a pin floc present throughout. A pin floc formed at 300mL and minor water separation began at a dosage rate of 400mL.

Figure 4-2. TIMET PondHP-3, September 2004.

Test #2 utilized 0.2% AQ 507 solution into 1 L of slurry. There were no results for this test even at high doses.

Test #3 utilized a combination of 0.2% AQ 545 followed by 0.2% solution of AQ 300, which is an anionic emulsion. When 50 ml of AQ 545 was added to 1L of slurry, slight thickening was observed. Next, 100mL of 0.2% solution AQ 300 was added and a pin floc formed. At 300mL, a larger floc was present. By the addition of a total of 350mL, it was determined that this was too high of a dosage rate.

For test #4, a double dose of AQ 545 was used. Initially, 50mL of 0.2% solution AQ545 was added to 500mL of raw slurry. Next, 100mL of 0.2% solution AQ

300 was added to the slurry and a good floc formed, but disappeared with vigorous stirring. A total addition of 150mL of AQ 300 resulted in a good stable floc.

Test #5 tried 0.4mL of raw AQ 205 in 500mL of slurry and then added 100mL of 0.2% solution AQ 300. An additional 50mL of AQ 300 was added and a good stable floc formed throughout with sight separation.

The final test, #6, started with 0.4mL of raw AQ 205 in 500mL of slurry. Next an initial dose of 150mL of AQ 300 was added. After 200mL of AQ 300, a good floc formed, but disappeared with stirring. A good stable floc formed at 250mL of AQ 300.

The Buchner funnel test was then performed. The first test utilized 50mL of 0.2% solution AQ545 and 150mL 0.2% solution AQ 300 of was added to 500mL of raw slurry (Bench Scale Test #4) from HP-3 through Geotex 46T woven polypropylene. Drainage was constant but slow.

The next test utilized slurry conditioned with the combination of raw AQ 205 and 0.2% AQ 300 at dosage rates of 0.4 ml and 150 ml respectively (Bench Scale Test #5), through the Geotex 46T geotextile. The drainage rate continued at a slow but steady pace and by 90 seconds of elapsed time, only 18mL of water had passed through the geotextile.

The last Buchner Funnel Test utilized the combination of raw AQ 205 and 0.2% solution AQ 300 through Geotex 46T geotextile at dosage rates of 0.4mL and 250mL, respectively (Bench Scale Test #6). The drainage rate was much higher than test 2, and by 90 seconds of elapsed time, 75mL of water had passed through the geotextile.

4.2.1 HP-3 Hanging Bag Tests

A hanging bag test was conducted on conditioned slurry from pond HP-3. Based on the Buchner funnel testing, a dosage rate of 0.4 ml AQ 205 and 250 ml of 0.2% solution AQ 300 per 500mL of raw slurry was used with 14.5L of raw slurry in a geotextile bag made from Geotex 46T. The hanging bag was supplied by Industrial Fabrics of Baton Rouge, LA.

Approximately 21.7 L of conditioned slurry was poured into the bag and allowed to dewater. Drainage water was initially very dirty, and proceeded at a rate of approximately 2,000mL per minute. After 3 minutes the filtrate began to clear. After 5 minutes, drainage had decreased to 300 mL/min. A sample of the effluent was collected for testing. After 3 hours of dewatering, no free water was present on top of the material. The test was allowed to continue overnight, and after approximately 16 hours, no visible free water remained in the bag and the material within the bag had a percent solids by weight of 15.3. Drainage continued at an acceptable rate throughout the test.

4.2.2 HP-3 Solids After One Week

After one week of dewatering, material from the hanging bags had a percent solids of 65.9 % by weight.

Figure 4-3. Material from Pond HP-3 after one week of dewatering, September 2004.

4.3 Pond SW-11 (Type III-b)

SW-11 is an inactive pond that received operational process water (see Figure 4-2). An excavator was used to dig a hole approximately two feet deep. *In situ* percent solids was 54.9% by weight. Samples of water and sediment were then obtained from this pond using a ponar sampler and bucket. The slurry used for testing purposes had a bulk density of 10.1 pounds/gallon (76.0 pounds/cubic foot) or a wet specific gravity of 1.22. The pH of the sample was 6.4. The mixed sample had a dark brown color and was representative of what could be pumped by either a small dredge or submersible pump.

Slurry was first tested using a gang stir with 1,000 ml samples to determine response from a variety of polymers. Polymers tested were supplied by Aquamark, Inc. Polymers are titrated into the raw slurry and observations are made. The first test used a 0.2% solution of AQ 507, which is a cationic emulsion polymer, into 500mL of slurry. At a dosage rate of 50 ml the conditioned slurry began to get chunky. At 130 ml, a pin floc formed and there was separation.

Figure 4-4. TIMET pond SW-11, September 2004.

Test #2 utilized a 0.2% solution of AQ 545 into 500 ml of slurry. Slight flocculation occurred at a dosage of 50 ml and larger floc and clean water separation occurred at a dosage of 75 ml. By 85 ml, a pin floc formed and separation was present. At 100 ml of polymer, results were similar to 85ml.

The Buchner funnel test was then conducted.. The first test utilized 130 ml 0.2% solution of AQ 507, into 500mL of slurry raw slurry from SW-11 through Geotex 46T woven polypropylene. Drainage was very slow and by 90 seconds, only 25 ml of effluent had passed through the geotextile material.

The second test tried 85 ml of 0.2% solution AQ 545 per 500 ml of raw slurry through Geotex 46T. The results were a slow but constant dewatering. By 90 seconds, 35 ml of effluent had passed through the geotextile material.

Finally, 100ml of the same solution as test 2 was added to 500 ml of raw slurry and tested through ACE 70/105. The results of this test were poor as by 90 seconds only 12 ml of material had passed through the geotextile material.

4.3.1 SW-11 Hanging Bag Tests

A hanging bag test was conducted on conditioned slurry from pond SW-11. Based on the Buchner funnel testing, a dosage rate of 85 ml of 0.2% solution

AQ 545 per 500 ml of raw slurry was used with 15.2 L of raw slurry in a geotextile bag made from Geotex 46T. The hanging bag was supplied by Industrial Fabrics of Baton Rouge, LA.

Approximately 18.8 L of conditioned slurry was poured into the bag and allowed to dewater. Drainage water was initially extremely dirty, and proceeded at a rate of approximately 200 ml per minute. After 5 minutes, drainage had decreased nearly in half to 105 ml/min, and the clarity of the effluent was still cloudy. A sample of the effluent was collected for testing. The test was allowed to continue overnight, and after approximately 27 hours, the material within the bag had a percent solids by weight of 56.1%. Drainage continued well throughout the test.

4.3.2 SW-11 Solids After One Week

After one week of dewatering, material from the bags had a percent solids of 72.1% by weight.

Figure 4-5. Material from TIMET pond SW-11 after one week of dewatering, September 2004.

4.4 Pond SW-8 (Type III-a)

SW-8 is an active pond that receives operational process water. Samples of water and sediment were obtained from this pond using a ponar sampler and bucket. The slurry used for testing purposes had a bulk density of 9.85 pounds/gallon (73.6 pounds/cubic foot) or a wet specific gravity of 1.05. The pH of the sample was 6.9. Water in the pond had a blue color similar to Windex.

The mixed sample had a dark grey color and was representative of what could be pumped by either a small dredge or submersible pump. *In situ* percent solids was 34.6% by weight.

Slurry was first tested using a gang stir with 1,000 ml samples to determine response from a variety of polymers. Polymers tested were supplied by Aquamark, Inc. Polymers are titrated into the raw slurry and observations are made. The first test used a 0.2% solution of AQ 300 into 500 ml of raw slurry. At a dosage rate of 100 ml, good flocculation and separation occurred. However, the floc broke after vigorous stirring. At 200 ml, there was no major improvement.

Test #2 utilized a 0.2% solution of AQ 545 into 500 ml of slurry. At a dosage of 60 ml, slight thickening was observed. At 100 ml, no real improvement was noted and the test was abandoned.

Test #3 tested 2 ml of raw AQ 200 into 500 ml of raw slurry. Also, 100 ml of 0.2% solution of AQ 300 was added. The slurry thickened and a pin floc formed but was not stable.

For test #4, 50 ml of 0.2% solution AQ 507 was added to 500 ml of slurry. Immediately, a thickening and pin floc was observed. At 100 ml, not much change occurred. Then 100 ml of 0.2% solution AQ 300 was added and a nice, stable floc formed.

One more test, #5, was performed using 100 ml of 0.25 solution AQ 507 into 1,000 ml of raw slurry (a half-dose from test #4). Next, 200 ml of 0.2% solution AQ 300 was added ad a stable floc formed. However, this floc was smaller than the one present in test #4.

The Buchner funnel was then conducted. This test utilized 500 ml of slurry from pond SW-8 conditioned with 50 ml 0.2% solution AQ 507 and 100 ml of 0.2% solution of AQ 300 through Geotex 46T. At this dosage rate, drainage was constant. By 90 seconds, 50 ml of effluent had passed through the Geotex 46T.

4.4.1 SW-8 Hanging Bag Tests

A hanging bag test was conducted on conditioned slurry from pond SW-8. Based on the Buchner funnel testing, a dosage rate 50 ml 0.2% solution AQ 507 and 100 ml of 0.2% solution of AQ 300 per 500 ml of raw slurry was used with 16 L of raw slurry in a geotextile bag made from Geotex 46T. The hanging bag was supplied by Industrial Fabrics of Baton Rouge, LA.

Approximately 22.4 L of conditioned slurry was poured into the bag and allowed to dewater. Drainage water was initially very dirty, and proceeded at a rate of approximately 1,250 ml per minute. After 5 minutes, drainage had decreased to 137.5 ml/min, and the clarity of the effluent had somewhat improved. A sample of the effluent was collected for testing. The test was allowed to continue overnight, and after approximately 25 hours, the material within the bag was still very wet, but no free water was present. The material within the bag had a percent solids by weight of 33.1. Test results are presented in Appendix A.

4.4.2 SW-8 Solids After One Week

After one week of dewatering, material from the bags had a percent solids of 46.9% by weight.

Figure 4-6. Material from TIMET pond SW-8 after one week of dewatering, September 2004.

4.5 Pond SW-2 (Type I)

SW-2 is an inactive pond that received spent caustic (see Figure 4-7). An excavator was used to dig a hole approximately two feet deep. The surface of the pond was white in color. Samples of water and sediment were then obtained from this pond using a ponar sampler and bucket. The slurry used for testing purposes had a bulk density of 11.7 pounds/gallon (87 pounds/cubic foot) or a wet specific gravity of 1.41. An excess of salt was observed on the bottom of the mud balance after testing, possibly skewing the result. The pH of the sample was 8.9. The mixed sample had a brown color and was representative of what could be pumped by either a small dredge or submersible pump. *In situ* percent solids was 62.9% by weight including dissolved solids.

Figure 4-7. TIMET pond SW-2, September, 2004.

Slurry was first tested using a gang stir with 1,000 ml samples to determine response from a variety of polymers. Polymers tested were supplied by Aquamark, Inc. Polymers are titrated into the raw slurry and observations are made. The first test used a 0.15 ml of AQ 200 into 500 ml of raw slurry. Next, 115 ml of 0.1% solution of AQ 300 was added to the slurry and no changes were observed. Polymer was continuously added until flocking and separation occurred at 740 ml.

Next, test #2 utilized a 50 ml of 0.2% solution of AQ 507 into 500 ml of slurry. 100 ml of 0.1% solution AQ 300 was also added A floc formation started slowly, then increased. At a dosage of 150 ml, a pin floc was observed throughout. At 300 ml, a pin floc present, but no separation occurring.

For test #3, 75 ml of 0.5% solution AQ 200 was added to 500 ml of raw slurry. Also, 60 ml of 0.2% solution of AQ 300 was added. Initially, a very small floc formed. At a dosage rate of 75 ml, a pin floc formed throughout with separation and at 95 ml, a bigger floc and more separation occurred. Note that this polymer was successful, but was a very slow process requiring time and stirring.

For test #4, 100 ml of 0.5% solution AQ 200 was added to 500 ml of slurry. Then, 30 ml of 0.2% solution of AQ 300 was added. Immediately, floc formation started. 50 ml was determined to be the optimum dosage rate. Then

100 ml of 0.2% solution AQ 300 was added and determined to be too high of a dosage rate.

Next, test #5, 150 ml of 0.5% solution of AQ 200 was added to 500 ml of slurry (check notes with Doug), followed by 10 ml of 0.2% solution AQ 300. Initially, a pin floc began to for on the top of the slurry. The optimum amount of AQ 300 was determined to be 30 ml while 50 ml was too much.

Test #6 was performed using 30 ml of 0.2% solution AQ 300 and between 50 and 75 ml of 0.5% AQ 200 (Check with Doug) in 500 ml of slurry (check with Doug). At this dosage rate, a non-consistent pin floc began to form and the test was abandoned.

Test #7 experimented with just 0.2% solution AQ 300 in 500 ml of slurry (check with Doug). At a dosage rate of 30 ml a pin floc began to form and at 50 ml the pin floc was present throughout the slurry. At 70 ml, there was not much difference and the results steadily declined at dosage rates of 100 115 and 125 ml.

Test #8 utilized 0.45 ml of raw AQ 205 plus 75 ml of 0.2% solution (check with Doug) of AQ 300in 500 ml of slurry. Initially, no floc formed. Next, 50 ml of 0.2% solution (check with Doug) of AQ 545 was added and slight separation occurred. A total of 100 ml of this solution was added and no separation was observed.

4.5.1 SW-2 Hanging Bag Tests

It was determined that the bet floc formation occurred with Bench Scale Test #3. A hanging bag test was conducted on conditioned slurry from pond SW-2. A dosage rate 150 ml 0.5% solution AQ 200 and 190 ml of 0.2% solution of AQ 300 per 1,000 ml of raw slurry was used with 15.5 L of raw slurry in a geotextile bag made from ACE 70/105. The hanging bag was supplied by Syntex Convertors, Ltd. of Manitoba, Canada. This fabric was chosen due to results from pond SW3 in May of 2004.

Approximately 18.8 L of conditioned slurry was poured into the bag and allowed to dewater. Drainage water was initially very dirty, and proceeded at a rate of approximately 400 ml per minute. After 5 minutes, drainage had decreased to 132.5 ml/min, and the clarity of the effluent was clearing. Note that during the dewatering observations, it was observed that the effluent was very salty. A sample of the effluent was collected for testing. The test was allowed to continue overnight, and after approximately 21 hours, the material within the bag was still very wet. The material within the bag had percent solids by weight of 53.1. Test results are presented in Appendix A.

4.5.2 SW-2 Solids After One Week

After one week of dewatering, material in the bag had a percent solids of 72.2% by weight.

Figure 4-8. Material from TIMET pond SW-2 after one week of dewatering, September 2004.

4.6 Pond SW-12 (Type II)

SW-12 is an active pond that receives operational process water, but has received MgCl in the past (see Figure 4-4). The surface of the pond was covered with water and the edges exhibited crystalline salts of various colors. An excavator was used to dig a hole approximately two feet deep. *In situ* percent solids was tested and found to be 86% solids by weight including dissolved salts. Samples of water and sediment were then obtained from this pond using a ponar sampler and bucket. The slurry used for testing purposes had a bulk density of 13.3 pounds/gallon (99.5 pounds/cubic foot) or a wet specific gravity of 1.55. The pH of the sample was 3.67. The mixed sample had a reddish color and was representative of what could be pumped by either a small dredge or submersible pump.

Figure 4-9. TIMET pond SW-12, September, 2004.

Slurry was first tested using a gang stir with 1,000 ml samples to determine response from a variety of polymers. Polymers tested were supplied by Aquamark, Inc. Polymers are titrated into the raw slurry and observations are made. The bench scale used a 0.2% solution of AQ 300 into 500 ml of raw slurry. Polymer was slowly added until floc formation began at a dosage rate of 80 ml. The floc became larger at 100 ml and by 150 ml, a small floc was present throughout the slurry and separation was observed.

Two Buchner funnel tests were then conducted. Test #1 utilized a 0.2% solution of AQ 300 into 500 ml of raw slurry ACE 70/105. Drainage was constant and by 90 seconds, 25 ml of effluent had passed through the ACE 70/105. The second test used the same conditioned slurry through Geotex 46T. The drainage rate was constant, but slow, and by 90 seconds only 14 ml of effluent had passed. Based on these results, the ACE 70/105 geotextile material was used for the hanging bag test.

4.6.1 SW-12 Hanging Bag Tests

A hanging bag test was conducted on conditioned slurry from pond SW-12. A dosage rate 150 ml 0.2% solution AQ 300 per 1,000 ml of raw slurry was used with 16.2 L of raw slurry in a geotextile bag made from ACE 70/105. The hanging bag was supplied by Syntex Convertors, Ltd. of Manitoba, Canada.

Approximately 21 L of conditioned slurry was poured into the bag and allowed to dewater. Drainage initially proceeded at a rate of approximately 950 ml per minute. After 5 minutes, drainage had decreased to 162.5 ml/min. After 3 hours of dewatering, the material was still very wet, free water was still present on top of the material and water was still dripping through the geotextile tube at 19.5 ml/minute. A sample of the effluent was collected for testing. The test was allowed to continue overnight, and after approximately 22 hours, the material within the bag was still very wet and free water was present on top of the material. The material within the bag had percent solids by weight of 79.4. Test results are presented in Appendix A.

4.6.2 SW-12 Solids After One Week

After one week of dewatering, material from the hanging bag had 75% solids by weight.

Figure 4-10. Material from TIMET pond SW-12 after one week of dewatering, September 2004.

4.7 Pond SW-6 (Type III-b)

SW-6 is an inactive pond that received spent caustic (see Figure 4-5). An excavator was used to dig a hole approximately two feet deep. The surface of the pond was covered with water and light brown in color. Samples of water and sediment were then obtained from this pond using a ponar sampler and bucket. The slurry used for testing purposes had a bulk density of 11.2

pounds/gallon (83 pounds/cubic foot) or a wet specific gravity of 1.32. The pH of the sample was 6.1. The mixed sample had a brown color and was representative of what could be pumped by either a small dredge or submersible pump. *In situ* percent solids was 50% solids by weight.

Figure 4-11. TIMET pond SW-6, September, 2004.

Slurry was first tested using a gang stir with 1,000 ml samples to determine response from a variety of polymers. Polymers tested were supplied by Aquamark, Inc. Polymers are titrated into the raw slurry and observations are made. The first test utilized a 0.2% solution of AQ507 into 500 ml of raw slurry. Polymer was slowly added until the slurry took on a chunky consistency at a dosage rate of 40 ml. By 60 ml, a pin floc had formed and by 70 ml a larger floc with separation formed. A dosage rate increased to 100 ml did not show much improvement and an optimum dosage rate of 75 ml of polymer per 500 ml of slurry was determined.

Test #2 experimented with a 0.2% solution of AQ 545 in 500 ml of slurry. At a dosage rate of 40 ml, the slurry became chunky and separation began. By 5 ml, a nice floc had formed and the optimum dosage rate was determined to be 55 ml of polymer per 500 ml of slurry.

4.7.1 SW-6 Hanging Bag Tests

A hanging bag test was conducted on conditioned slurry from pond SW-6. A dosage rate 55 ml 0.2% solution of AQ 545 per 500 ml of raw slurry was used with 14.4L of raw slurry in a geotextile bag made from Geotex 46T. The hanging bag was supplied by Industrial Fabrics of Baton Rouge, LA.

Approximately16 L of conditioned slurry was poured into the bag and allowed to dewater. Drainage initially proceeded at a rate of approximately 200 ml per minute and after 5 minutes, drainage had decreased to 130 ml/min. A sample of the effluent was collected for testing. The test was allowed to continue overnight, and after approximately 18.5 hours, the material within the bag was still dripping and very salty. The material within the bag had percent solids by weight of 39.1. Test results are presented in Appendix A.

4.7.2 SW-6 Solids After One Week

After one week of dewatering, material from the bag had 54.9% solids by weight.

Figure 4-12. Material from TIMET pond SW-6 after one week of dewatering, September 2004.

4.8 Pond SW-9 (Type III-a)

SW-9 was tested in May 2004. Slurry from this pond required two polymers to achieve satisfactory flocculation in the field. Since the use of two polymers increases the cost of dewatering, a sample was sent to the polymer manufacturer for a second opinion. A report from Aquamark, Inc. is included in Appendix A. There are a few important points. The first is that relatively high dosages were required, and that chemical shear was causing a breakdown of the floc, thus requiring more polymer. It is noted in the report that high salt content can cause this. Also included in Appendix A are the lab results. Total solids by weight for the raw slurry is 75.71%. After treating and dewatering, the total solids falls to 61.25%. While this result defies logic, it points to the numerical inconsistency caused by the saturated salt content of the samples found at TIMET. The raw slurry has a large percentage of dissolved solids, which are lost in the dewatering phase, thus the treated sample retained the suspended solids and the numerical value is less.

5.0 LABORATORY RESULTS

Based on the limited chemistry tests performed on the hanging bag effluent in May 2004, it was determined that more complete testing should be accomplished on three representative ponds. Chemistry results for Pond SW2 (Type I), Pond SW12 (Type II) and Pond HP3 (Type III) are shown in Table 5-1.

Type I ponds (spent caustic) are very high in dissolved sodium chloride. Type II ponds (Magnesium Chloride) are also extremely high in dissolved solids, predominantly magnesium chloride and calcium chloride. Type III ponds have a wide range of materials, including high amounts of iron, titanium, and lower quantities of dissolved salts.

5.1 Hanging Bag Test Results

Four samples were taken during each hanging bag test and sent to labs for testing. Material was obtained from each hanging bag after dewatering overnight for a determination of percent solids by weight. This was repeated after one week. Samples were also taken from the raw slurry prior to chemical conditioning and drainage water during each hanging bag test.

The hanging bag test is designed to give adequate information to determine the starting percent solids for comparison to the final percent solids. It became apparent, however, when reviewing the data in May 2004, that the magnitude of dissolved salts in the water dramatically complicated both the lab testing and the analysis.

Typically, a waste slurry is comprised of water and suspended solids. The water has a specific gravity of 1.0 and the solids have a specific gravity usually greater that 1.0. In some cases, the solids will have more than one component with dissimilar specific gravities, and an average specific gravity will often be sufficient to determine percent solids. Since percent solids is typically determined by weight, it is crucial that the specific gravity of the solids is known.

Analytical Data for TIMET Ponds
Sampling September 20-23, 2004

	Pond			
	SW-2	SW-12	HP-3	Blank
Solids	Type I	Type II	Type III	
Solids, Total Suspended	1500	1570	300	ND
Solids, Total Dissolved	363000	617000	26900	ND
General Chemistry				
Alkalinity as CaCO3, Total	11200	479	2950	ND
Carbonate as CaCO3	8400	ND	ND	ND
Fluoride	ND	ND	ND	ND
Chloride	165000	431000	8780	ND
Bicarbonate as CaCO3	2750	479	2950	ND
Sulfate	13300	ND	949	ND
Cyanide, Total	ND	0.01	ND	ND
Nitrate+Nitrite as Nitrogen	560	10200	15.8	ND
Ammonia as Nitrogen	2.87	364	22.7	ND
Phosphorus, Total	6.07	2.12	2.11	ND
Perchlorate				
Bromide	ND	ND	ND	ND

results given in mg/L (ppm)

Metals				
Aluminum	538	27700	17900	50
Barium	18.2	4350	508	5
Calcium	4910	20810000	924000	50
Iron	1500	114000	50900	20
Lithium	90.5	572	45.7	20
Magnesium	28800	4570000	231000	20
Manganese	353	64800	1390	5
Potassium	56200	89900	7020	2000
Silicon	1200	6620	24400	400
Sodium	27430000	237000	209000	300
Strontium	36.8	19000	1010	10
Titanium	8800	88400	311000	10

results given in micro g/L (ppb)

Table 5-1. Analytical Results of free water in ponds after crust was broken, September 2004.

Slurry from the TIMET ponds have a third component which affects both the actual dewatering and the ability to develop an accurate representation of the solids in the slurry. That component is supersaturated salt, which at times is dissolved and at other times in crystal form. Therefore, when accounting for the volumes in the various TIMET slurries, there is a volume of water, a volume of dissolved salts and a volume of inorganic solids. Drainage water from the bags carried very high percentages of salt in solution. The percent solids of the initial slurry, obtained by using an average specific gravity of both the inorganics and salts cannot be compared to the percent solids of the final material in the bags which is devoid of much of the salt. While this complicates the analysis, it does not affect the end result of the bag test, which showed that dewatering of the suspended solids was effective. Water Content, reported in Table 5-2 in percent, can be determined from the specific gravity and the wet bulk density. For example, the initial slurry from Pond HP-3 has a water content of 500% (five times as much water as solids). After dewatering overnight, the sample has lost more than half of its water.

It can be seen that the water content of the slurry was reduced overnight, by large factor in some cases, via drainage through the hanging bags. The filtration efficiency (i.e. the ability to retain fine-grained suspended solids within the bag) was also quite high. From a disposal perspective, percent solids by weight is most important, and after one week, the lowest value was a respectable 46.9% (see Table 5-3).

Pond Designation	Water Content %		Percent Solids by Weight		Specific Gravity (Dry)
	Initial Slurry (based on wet slurry)	Retained in bag (overnight)	Retained in bag (overnight)	After 1 week	Composite solids
	May 2004				
HP-5	600	187	34.8	N/A	2.54
SW-3	327	28	54.4	N/A	2.97
HP-4	560	20	74.7	N/A	1.74
SW-9/a	233	83	54.7	N/A	2.00
	September 2004				
HP-2	100	69	59.3	73.2	2.12
HP-3	500	239	15.3	65.9	2.34
SW-11	136	78	56.1	72.1	1.74
SW-8	250	201	33.1	46.9	2.15
SW-2	239	88	53.1	72.2	2.38
SW-12	35	26	79.4	75.0	1.91
SW-6	100	78	39.1	54.9	2.00

Table 5-2. Water Content and Percent solids by weight, TIMET pond hanging bag tests, May and September 2004.
Notes: /a. Still draining after 15 hours.

Pond Designation	Percent Solids by Weight			
	in situ	initial	final	1 week
HP-2	62.5	64.8	59.3	73.2
SW-2	62.9	51.8	53.1	72.2
SW-12	86.0	74.5	79.4	75.0
SW-6	50.0	51.2	39.1	54.9
SW-11	54.9	33.3	56.1	72.1
SW-8	34.6	25.8	33.1	46.9
HP-3	14.9	16.3	15.3	65.9

Table 5-3. Percent solids by weight, TIMET pond hanging bag tests, September 2004. Note that in situ and initial samples include high percentages of dissolved salt, skewing the results.

5.1 Discussion of Results

Testing has shown that despite the complex and varied nature of the material found in the TIMET ponds, the material can be dewatered using geotextile tubes. The hanging bag tests have shown that, with chemical conditioning, the material will dewater to a "dry" state (i.e. no visible free water) relatively quickly. One of the advantages of geotextile tubes is that if the material is not dry enough to meet certain requirements, it can be left in the tube for further dewatering. For ponds sampled during the May testing, material within the bags reached 34.8 to 74.7 % solids by weight after one night of dewatering. For ponds sampled during the September testing, material within the bags reached 15.3 to 79.4 % solids by weight after one night of dewatering. After one week, the lowest % solids by weight was 46.9, which was visibly dry (see Figure 4-6). Typically, full-scale geotextile tubes are allowed to dewater for weeks. Caution should be applied when interpreting success or failure based on a single percent solids measurement due to the fact that specific gravity and dissolved solids need to be more accurately defined. Specific results for each of the ponds will be discussed separately.

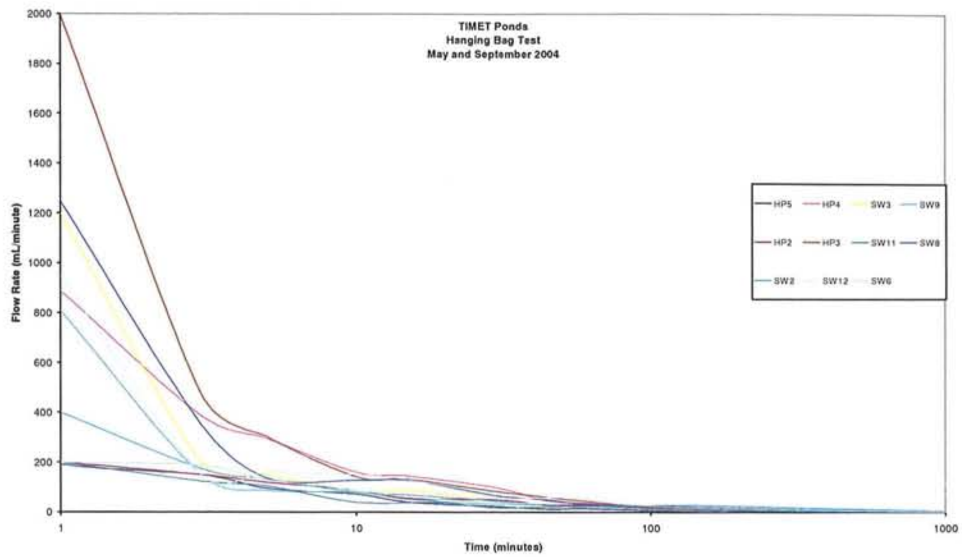

Figure 5-1. Drainage flow rate during hanging bag tests, TIMET ponds. May and September 2004.

5.2 Pond Characterization

5.2.1 Type I Ponds: Spent Caustic

Ponds with Spent Caustic had generally good dewatering characteristics. Type II ponds include SW-3 and SW-2. SW3 had a better initial flow rate with the first

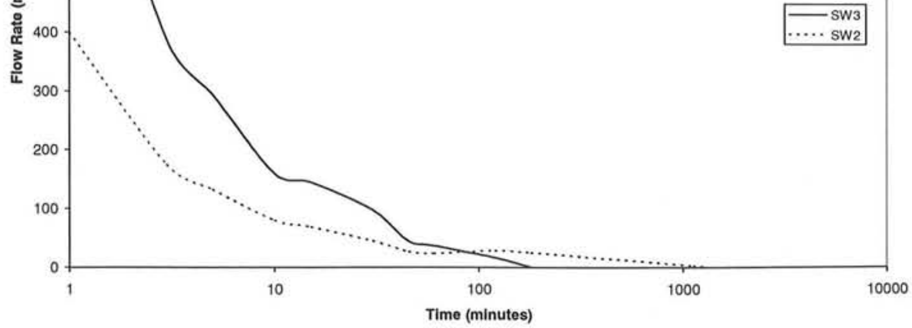

Figure 5-2. Drainage flow rate for Type I ponds during hanging bag tests, TIMET ponds. May and September 2004.

flush near 1200 mL/minute. Pond SW2 exhibited slower dewatering characteristics with a lower first flush and a steadily decreasing flow rate.

Both Type I ponds utilized the same polymer combination and geotextile fabric. The best flocculation occurs using the cationic AQ 200 in conjunction with the anionic AQ 300. Hanging bag test were for both ponds employed ACE 70/105 geotextile material.

5.2.2 Type II Ponds: Magnesium Chloride

Type II, MgCl, include SW 12 and HP4. These ponds consist of predominantly magnesium chloride and calcium chloride. Both ponds had a good first flush with initial flow rates near 900 mL/min.

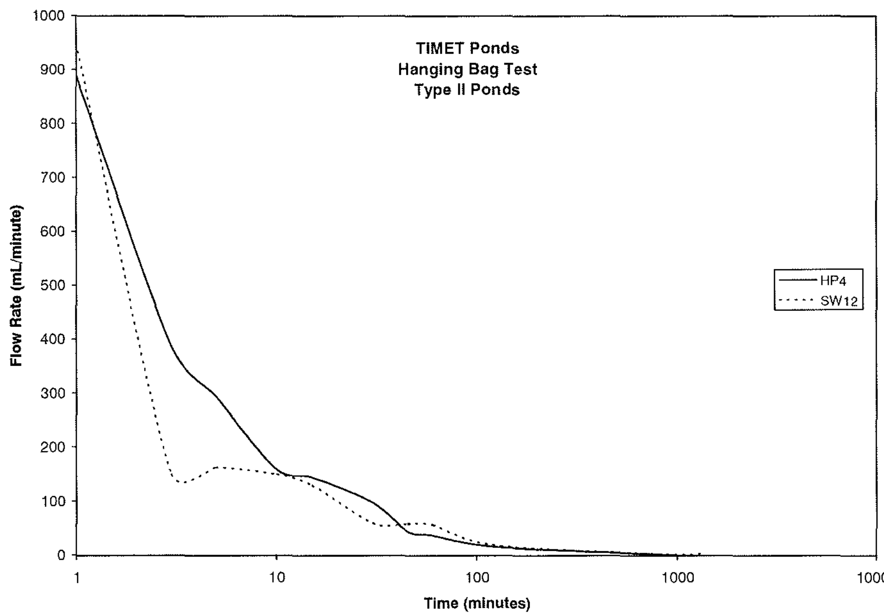

Figure 5-3. Drainage flow rate for Type II ponds during hanging bag tests, TIMET ponds. May and September 2004.

The anionic AQ 300 was found to be the best polymer for dewatering Type II ponds. However, different geotextile fabrics were used during the hanging bag test. Pond SW12 dewatered best through ACE 70/105, while HP4 dewatered best using Geotex 46T.

5.2.3 Type III Ponds: Operational Process Water and Continuous Sludge Drier Fines

Based on dewatering properties, material from Type III ponds can be classified into two categories; Type III-a and III-b. Type III-a ponds have a very high initial flow rate and logarithmically slow down as time progresses. These ponds include HP3, SW8 and SW9. Type III-b ponds have a much lower initial first flush and a steadier decline of flow rate with time. The typical logarithmic dewatering pattern was not as apparent in these tests. These ponds include HP5, SW6, HP2 and SW11.

Differences in dewatering characteristics may be attributed to the amount pf polymers added to the slurries. Type III-a ponds exhibited good dewatering characteristics. A good first flush of effluent is followed by slower but constant dewatering. These ponds are similar in that, while all the flocculants were not exclusively cationic or anionic, all three had a combination of two polymers added to the initial slurry. The Anion polymer AQ300 was used in all three of Type III-a hanging bag tests.

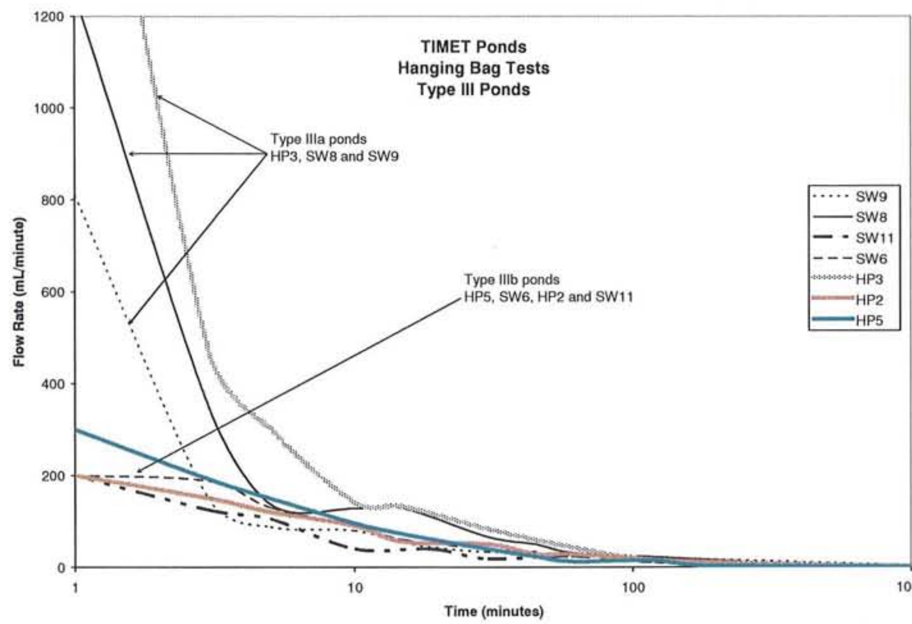

Figure 5-4. Drainage flow rate for Type III ponds during hanging bag tests, TIMET ponds. May and September 2004.

Type III-b ponds displayed relatively poorer dewatering characteristics. The common thread between all Type III-b ponds is the use of a singe polymer during the hanging bag test. Again, Type III-b's were not tested with anions or cations exclusively, but all three ponds were conditioned with a single polymer.

All of the Type III-b and two of the three Type III-a ponds utilized the woven polypropylene fabric Geotex® 46T, manufactured by SI Corporation. Type III-a pond SW9 was the only exception. The hanging bag test was performed using ACE 70/105, manufactured by ACE Geosynthetics Enterprise Co. Ltd., of Taiwan.

5.3 Pond Summary

5.3.1 Pond HP-2 (Type III-b)

This pond (HP-2) is a Type III-b pond with approximate dimensions of 800 ft X 260 ft and an estimated 1-foot deep resulting in approximately 7,704 cubic yards. At this volume, and making a very conservative assumption of zero volume reduction, 10, 45-ft circumference by 200 linear foot tubes would be required. Assuming the use of Geotex 46T and a price per linear foot of $20, this pond would require $40,000 for the geotextile tubes only. Polymers would increase the cost per cubic yard by approximately $1.00, or $7,704. Combined geotextile tube and polymer costs for dewatering this pond could be in the range of $47,704. These prices are estimates and would need to be verified by suppliers. Additionally, the actual volume in the pond would need to be determined.

5.3.2 Pond HP-3 (type III-a)

Pond HP-3 (Type III-a) is approximately 1720 ft X 260 ft and an estimated 2 feet deep resulting in approximately 33,126 cubic yards. At this volume, and making a very conservative assumption of zero volume reduction, 42, 45-ft circumference by 200 linear foot tubes would be required. Assuming the use of Geotex 46T and a price per linear foot of $20, this pond would require $168,000 for the geotextile tubes only. Polymers would increase the cost per cubic yard by approximately $2.00, or $66,252. Combined geotextile tube and polymer costs for dewatering this pond could be in the range of $234,252. These prices are estimates and would need to be verified by suppliers. Additionally, the actual volume in the pond would need to be determined.

5.3.3 Pond SW-11 (Type III-b)

This pond is approximately 720 ft X 320 ft and an estimated 3 feet deep resulting in approximately 25,600 cubic yards. At this volume, and making a very conservative assumption of zero volume reduction, 32, 45-ft circumference by 200 linear foot tubes would be required. Assuming the use of Geotex 46T and a price per linear foot of $20, this pond would require $128,000 for the geotextile tubes only. Polymers would increase the cost per cubic yard by approximately $1.00, or $25,600. Combined geotextile tube and polymer costs for dewatering this pond could be in the range of $153,600. These prices are estimates and would need to be verified by suppliers. Additionally, the actual volume in the pond would need to be determined.

5.3.4 Pond SW-8 (Type III-a)

This pond (SW-8) is approximately 640 ft X 320 ft and an estimated 3 feet deep resulting in approximately 22,756 cubic yards. At this volume, and making a very conservative assumption of zero volume reduction, 29, 45-ft circumference by 200 linear foot tubes would be required. Assuming the use of Geotex 46T and a price per linear foot of $20, this pond would require $116,000 for the geotextile tubes only. Polymers would increase the cost per cubic yard by approximately $2.00, or $45,511. Combined geotextile tube and polymer costs for dewatering this pond could be in the range of $161,512. These prices are estimates and would need to be verified by suppliers. Additionally, the actual volume in the pond would need to be determined.

5.3.5 Pond SW-2 (Type I)

This pond (SW-2) is approximately 600 ft X 280 ft and an estimated 4 feet deep resulting in approximately 24,889 cubic yards. At this volume, and making a very conservative assumption of zero volume reduction, 32, 45-ft circumference by 200 linear foot tubes would be required. Assuming the use of ACE 70/105 and a price per linear foot of $18, this pond would require $115,200 for the geotextile tubes only. Polymers would increase the cost per cubic yard by approximately $1.25, or $31,111. Combined geotextile tube and polymer costs for dewatering this pond could be in the range of $146,311. These prices are estimates and would need to be verified by suppliers. Additionally, the actual volume in the pond would need to be determined.

5.3.6 Pond SW-12 (Type II)

This pond (SW-12) is approximately 800 ft X 340 ft and an estimated 2 feet deep resulting in approximately 20,148 cubic yards. At this volume, and making a very conservative assumption of zero volume reduction, 26, 45-ft circumference by 200 linear foot tubes would be required. Assuming the use of ACE 70/105 and a price per linear foot of $18, this pond would require $93,600 for the geotextile tubes only. Polymers would increase the cost per cubic yard by approximately $1.00, or $20,148. Combined geotextile tube and polymer costs for dewatering this pond could be in the range of $113,748.15. These prices are estimates and would need to be verified by suppliers. Additionally, the actual volume in the pond would need to be determined.

5.3.7 Pond SW-6 (Type III-b)

Pond SW-6 is approximately 600 ft X 280 ft and an estimated 3 feet deep resulting in approximately 18,667 cubic yards. At this volume, and making a very conservative assumption of zero volume reduction, 24, 45-ft circumference by 200 linear foot tubes would be required. Assuming the use of Geotex 46T and a price per linear foot of $20, this pond would require $96,000 for the geotextile tubes only. Polymers would increase the cost per cubic yard by approximately $1.00, or $18,667. Combined geotextile tube and polymer costs for dewatering this pond could be in the range of $114,666. These prices are estimates and would need to be verified by suppliers. Additionally, the actual volume in the pond would need to be determined.

5.4 Summary of Testing and Preliminary Design Considerations

Based on the hanging bag tests conducted on 11 of TIMET's wet ponds, it is expected that geotextile tubes offer a viable technology for dewatering the material. Labor, pumping equipment and infrastructure costs such as the tube deployment area have not been estimated at this point. Water and dissolved salt management will likely constitute major cost considerations for any dewatering operation at this site.

It is anticipated that much of the inorganic solids found in the ponds can be dewatered within the tubes to a relatively high percentage (50 - 75 percent by weight). It is likely that achieving 80% solids by weight may require air-drying after being removed from the tubes, especially for solids such as in ponds HP-5 and HP-3, and SW-6 and SW-8. After a more thorough cost analysis, it may be determined that dewatering certain older, inactive ponds (i.e. SW-5) through other means such as furrowing may be most effective. The three ponds at the western end of the property present logistics issues due to the steep embankments.

One of the interesting characteristics of much of the material is that given an opportunity, the material will release free water. This was seen when holes, created by the excavator, filled with water after sitting for a few hours (see Figure 5-5).

Figure 5-5. Pond SW-3 one hour after excavation, May 2004.

Other ponds that are presently covered with water such as HP-5 might be amenable to a floating dredge to move the slurry into the tubes for dewatering. Many of the ponds exhibit a dry crust, which when broken, reveal wet material beneath. A mobile, crane-mounted sludge pump could remove slurry from these ponds in discrete volumes, equal to the amount of free water available. It is unlikely that these ponds could be excavated in one operation. The value of the mobile sludge pump would be its continuous operation, moving from one pond to the next. As free water is removed in this manner, remaining sludge might become dry enough to haul or spread without placing it in the tubes.

The polymers that worked most effectively were emulsions. Emulsions require dilution with fresh water before use. This can be accomplished with static mixers or batch makedown units. Drainage water from the tubes could be reused as makedown water for the polymer feed system after treating by reverse osmosis, evaporation, or other salt removing technology. Due to the very high salt concentrations in most of the ponds, it will be economically prohibitive to desalinate water on site. Effluent water would then be returned to a pond for use in slurrying the solids, and fresh water can be brought to the site for dilution. Salt retained in crystal form within and on the bags did not have any noticeable negative impact on dewatering.

Once a slurry is available, it would be pumped to a polymer feed injection system. Since each pond responded differently in the hanging bag testing, and in some cases required two polymers, the feed system should be designed to easily accommodate changing slurry conditions. For example, while filling tubes from SW-3, AQ 200 would be fed directly into the pump discharge line and allowed to mix. Desalinated water would be pumped to a polymer make/down unit and mixed with AQ 300 emulsion. This polymer would then be injected into the pump discharge line prior to entry into a tube. If the mobile pump were then directed to pond HP-4, for example, both the AQ 200 and AQ 300 would be shut off and a solution of AQ 507 from a different make/down unit would be injected into the pump discharge line. Through the use of a header and valve arrangement, discharge could be to the same tube or to a new tube.

6.0 RECOMMENDATIONS

HC/PAH has demonstrated that geotextile tubes can be a successful method to dewater TIMET ponds. The field test programs conducted during May and September showed a range of dewatering successes. Pond HP-4, at 75% solids, achieved a very high final percent solids by weight after only one night of dewatering. Two other dewatering tests, ponds SW-3 and SW-9, were able to generate dewatering results of 55 percent solids by weight over the same period of time. HP-5, experienced dewatering to 35 percent solids by weight. Similarly, HP-3 obtained only 15.3% solids by weight overnight. But given time to dewater, HP-3 reached 65.9% solids.

The hanging bag test is a good indicator of whether or not geotextile tube technology can be used effectively for a given waste. It can not give quantitative results over a longer period of time because the bag is demonstrating short-term self-weight consolidation, filtration and drainage. A tube is much larger and utilizes increased pore pressures and pumping to accelerate the dewatering process. The only way to gather reliable data on the actual final percent solids achievable in a tube is to conduct a full-scale pilot test. A test could be designed to replicate the presumed second phase of the dewatering process - spreading and air drying. Small uniform samples could be exposed to varying temperatures to predict what drying effect the desert conditions might produce.

Based on results obtained thus far and experience on other large dewatering projects, we believe that dewatering with geotextile tubes will be a viable, cost-effective and extremely flexible method to dewater the TIMET ponds.

A program to further define the potential of geotextile tube technology would include the following:

1. Conduct a full-scale pilot test to establish the level of costs we can expect;
    a. Establish for all the other ponds, the likelihood of costs and success, given base costs for the pilot pond and our understanding of the technology.
    b. Conduct a preliminary design of the entire process including effluent water treatment and potential reuse.

2. Determine and recommend what additional tests should be conducted to optimize our understanding of the materials and their behavior in the tubes;
3. Determine and recommend what additional data and information is necessary to advance the program through a feasibility stage study;
4. Define the steps necessary to reduce overall program risk and provide needed information for BRC and regulatory agencies where approval will be required.

7.0 REFERENCES

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