Assessment of Geotextile Tube Dewatering Technology for Timet Ponds, Henderson, Nevada

Prepared for
Basic Remediation Company

July 9, 2004
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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 1-1). 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 on May 27 and 28, 2004 to determine the viability of geotextile tubes for dewatering material in the ponds. Four ponds were sampled to provide data for a range of conditions that could be expected during a full-scale dewatering operation.

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. After one night of dewatering, material within the bags reached 34.8 to 74.7 % solids. Typically, full-scale geotextile tubes are allowed to dewater for weeks.

Based on the hanging bag tests conducted on 4 representative ponds, 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, especially for very fine-grained solids such as pond HP-5.

Geotextile tube technology is quite flexible, and can be employed without further 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.
Because of the encouraging results obtained from this test work, HC/PAH recommends additional work to further explore the potential of realizing value from the geotextile tube concept. HC/PAH recommends the following program:

1. Prepare a pre-feasibility cost study of using geotextile tubes to dewater Pond HP-4, inclusive of a process to further dry the material at the containment cell with a specific material handling concept. Prepare a specific plan to continue the work employing geotextile tube technology.

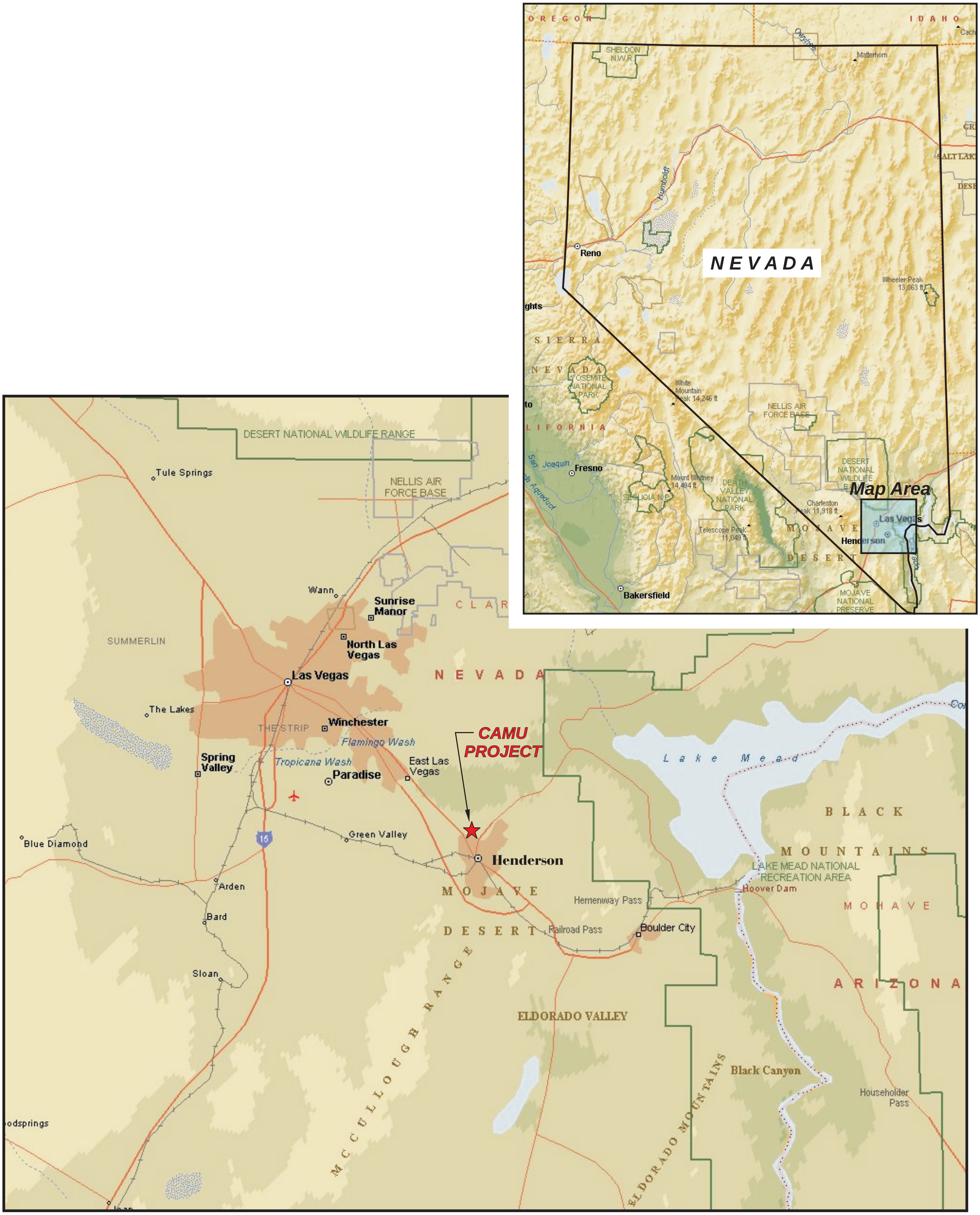
2. Fully describe the conditions existing in each pond by completing analytical testing and characterization of all pond materials, including *in situ* percent solids, metals and ions, and volume calculations;

3. Conduct bench-scale and hanging bag tests on ponds that have not yet been tested and re-test pond HP-5 to analyze potential improvement in dewatering success by further trials with chemical conditioning agents;

4. Determine and recommend what additional tests, data, and information should be conducted and obtained to optimize the understanding of the pond materials and their behavior in the tubes;

5. Conduct a full-scale pilot test(s) to establish feasibility level of costs that can be expected;
   a. Establish for all the other ponds, the likelihood of costs and success, given results and costs for the pilot test and our understanding of the technology.
   b. Conduct a feasibility level design of the entire process inclusive of effluent water treatment and potential reuse.

6. Prepare an implementation plan and define the steps necessary to reduce overall program risk and provide needed information for BRC and regulatory agencies where approval will be required.



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PINCOCK, ALLEN & HOLT 274 Union Boulevard, Suite 200 Lakewood, Colorado 80228 Phone (303) 986-6950	BASIC REMEDIATION COMPANY	FIGURE 1-1 GENERAL LOCATION MAP FOR THE CAMU PROJECT	July/2004
Project No. 9352.01B	Prepared for Update Current Transport Study		Drawing Name Fig1-1.cdr

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. Malcolm Pirnie (1991) identified three distinct pond types in Figure 2-1. Blue ponds were characterized as operational process water (OPW), continuous sludge dryer (CSD) and a portion of the leach liquid (LL) waste stream. Green ponds were characterized as spent caustics (SC) and purple ponds characterized as LL and magnesium chloride.

Field tests were performed on May 27 and 28, 2004 to determine the viability of geotextile tubes for dewatering material in the ponds. Four 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. These ponds were considered by onsite personnel to cover the range of materials to be encountered. An excavation into pond SW-5 was also made but it was determined that this pond was relatively dry. Tests conducted and results obtained for each pond will be discussed separately.

TABLE 2-1
Basic Remediation Company
Preliminary Timet Pond Dewatering Tests
July 2004
Ponds Sampled for Geosynthetic Tube Dewatering Tests

Pond Designation	Material Source	Notes
HP5	Operational Process Water	Active pond with liquid on top
SW3	Spent Caustic	White salt crust layer on top
HP4	Magnesium Chloride	Brown salt crust layer on top
SW9	Continuous Sludge Drier Fines	Dark brown, top with desiccation cracks

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

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 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.

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. Any dewatering fluids (effluent) resulting from the operation would be collected for processing and possible reuse. 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. 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

4.1 *Pond HP-5*

HP-5 is an active pond receiving Operational Process Water (see Figure 4-1). 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 10.1 pounds/gallon (75.5 pounds/cubic foot), or a wet specific gravity of 1.21. The pH was tested by Hart Crowser's laboratory upon receipt of samples. The pH of the sample was 6.4. The mixed sample had a light brown color and was representative of what could be pumped by either a small dredge or submersible pump. *In situ* percent solids was not tested.

FIGURE 4-1
TIMET Pond HP-5, May 2004

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 AQ 200 which is a liquid cationic coagulant having a very high charge and very high molecular weight. Some thickening of the slurry was observed at a dosage of 0.3 ml but no floc formation or separation of free water was observed. Test #2 utilized a 0.1% solution of AQ 507 which is a cationic emulsion polymer. Floc formation began at a dosage rate of 100 ml. Separation of free water began at 170 ml. At 300 ml, large flocs were formed and settling was rapid. Test #3 utilized a 0.1% solution of AQ 306 which is a non-ionic emulsion. Slight flocculation occurred at a dosage of 200 ml and the test was stopped. Based on these results, Buchner funnel testing was then conducted.

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 raw slurry from HP5 through Geotex 46T woven polypropylene. Drainage was very slow and within 15 seconds the geotextile had clogged. 46T is the most open of the three tube fabrics. It was noted that despite the inorganic nature of the slurry, the amount of salts present in the slurry tended to increase the viscosity and rapidly form a filter cake on the geotextile.

Test #2 utilized slurry conditioned with AQ 507 at a dosage of 170 ml through 46T geotextile. The drainage rate was improved over test 1, and by 40 seconds of elapsed time, 27 ml of water had passed through the geotextile. Clogging of the geotextile was still apparent.

Test #3 utilized AQ 507 at a dosage rate of 300 ml through 46T geotextile. The drainage rate was dramatically improved over test 2, and by 40 seconds of elapsed time, 65 ml of water had passed through the geotextile. Drainage continued through the 90 seconds of the test, indicating that clogging potential had been reduced.

Test #4 utilized slurry conditioned with 300 ml of AQ 507 and a woven geotextile that has similar properties to the Geotex 46T. This geotextile was ACE 70/105 that is manufactured in Taiwan. Compared to Test #3, drainage was somewhat slower, although overall drainage properties were similar. Based on these tests, it was decided to conduct a hanging bag test utilizing the 46T fabric.

4.1.1 HP-5 Hanging Bag Tests

A hanging bag test was conducted on conditioned slurry from pond HP-5. Hanging bags were supplied by Syntex Convertors, Ltd. of Manitoba, Canada. Based on the Buchner funnel testing, a dosage rate of 300 ml of 0.1% solution AQ 507 per 1,000 ml of raw slurry was used with 11 L of raw slurry in a geotextile bag made from Geotex 46T.

Approximately 14.3 L of conditioned slurry was poured into the bag and allowed to dewater. Drainage water was initially cloudy, and proceeded at a rate of approximately 300 ml per minute. After 5 minutes, drainage had decreased by half to 150 ml/min, and the clarity of the effluent had improved. A sample of the effluent was collected for testing. The test was allowed to continue overnight, and after approximately 19 hours, no visible free water remained in the bag and the material within the bag had a percent solids by weight of 34.8.

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.

An important point to be made regarding the material in pond HP5 is that it took over an hour to discharge the additional water added in the chemical conditioning step. It is possible that further testing could better optimize the dosage rate, increase the solution strength and thereby reduce the amount of additional water used and/or change the polymer used. Hanging bag test results are presented in Appendix A.

4.2 *Pond SW-3*

SW-3 is an inactive pond that received spent caustic (see Figure 4-2). An excavator was used to dig a hole approximately two feet deep through the eight-inch salt crust. 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 12.45 pounds/gallon (93.4 pounds/cubic foot), or a wet specific gravity of 1.49. The pH was tested by Hart Crowser's laboratory upon receipt of samples. The pH of the sample was 6.4. The mixed sample had a reddish-brown color and was representative of what could be pumped by either a small dredge or submersible pump. *In situ* percent solids was not tested.

FIGURE 4-2
TIMET Pond SW-3, May 2004

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 0.1% solution of AQ 507 which is a cationic emulsion polymer. Some separation and possible floc formation began at a dosage rate of 150 ml. There was no further progress with higher polymer doses.

Test #2 utilized AQ 200 which is a liquid cationic coagulant having a very high charge and very high molecular weight. Some thickening of the slurry and possible floc was observed at a dosage of 0.2 ml but no improvement was observed with higher polymer doses.

Test #3 utilized a combination of AQ 200 followed by 0.1% solution of AQ 300, which is an anionic emulsion. AQ 200 was added at a rate of 0.2 ml per 1,000 ml of raw slurry. When 100 ml of AQ 300 was added, some slight separation of free water was observed. AQ 200 was increased to 0.3 ml and 200 ml of AQ300 was added. Flocculation occurred with free water separation visible on the surface. When the AQ 300 was increased to 230 ml, the conditioning was excellent.

The Buchner funnel test was then performed. Test #1 utilized raw slurry from SW3 through Geotex 46T woven polypropylene. Drainage was initially quick with very dirty effluent but within 10 seconds, the geotextile had clogged. As noted earlier, despite the inorganic nature of the slurry, the amount of salts present in the slurry tended to increase the viscosity and rapidly form a filter cake on the geotextile.

Test #2 utilized slurry conditioned with the combination of AQ 200 and AQ 300 at dosages of 0.3 ml and 230 ml respectively, through the 46T geotextile. The drainage rate continued at a slow but steady pace and by 90 seconds of elapsed time, only 19 ml of water had passed through the geotextile.

Test #3 utilized the same conditioned slurry through an ACE 70/105 geotextile. The drainage rate was doubled over test 2, and by 90 seconds of elapsed time, 34 ml of water had passed through the geotextile.

4.2.1 SW-3 Hanging Bag Tests

A hanging bag test was conducted on conditioned slurry from pond SW-3. Based on the Buchner funnel testing, a dosage rate of 0.3 ml AQ 200 and 230 ml of 0.1% solution AQ 300 per 1,000 ml of raw slurry was used with 11.2 L of raw slurry in a geotextile bag made from ACE 70/105.

Approximately 11.46 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 1,200 ml per minute. After 5 minutes, drainage had decreased to 150 ml/min, and the clarity of the effluent had begun to improve. A sample of the effluent was collected for testing. The test was allowed to continue overnight, and after approximately 18 hours, no visible free water remained in the bag and the material within the bag had a percent solids by weight of 54.4. An important point to be made regarding the material in pond SW3 is that it took only 15 minutes to discharge the additional water added in the chemical conditioning step. Drainage continued at an acceptable rate throughout the test. Test results are presented in Appendix A.

4.3 *Pond HP-4*

HP-4 is an inactive pond that received magnesium chloride waste water (see Figure 4-3). An excavator was used to dig a hole approximately two feet deep through the crust. 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 12.64 pounds/gallon (94.6 pounds/cubic foot) or a wet specific gravity of 1.52. The pH was tested by Hart Crowser's laboratory upon receipt of samples. The pH of the sample was 5.7. 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 not tested.

FIGURE 4-3
TIMET pond HP-4, May 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 0.1% solution of AQ 507 which is a cationic emulsion polymer. Floc formation began at a dosage rate of 135 ml. Some separation of dirty water was seen, and large crystals were observed at the bottom.

Test #2 utilized a 0.1% solution of AQ 300 which is an anionic emulsion. Slight flocculation occurred at a dosage of 50 ml and larger floc and clean water separation occurred at a dosage of 60 ml. This combination of low dosage rate and good flocculation is very cost effective. Therefore, based on these results, Buchner funnel testing was then conducted.

The Buchner funnel test was then conducted. Of the ponds sampled, slurry from HP-4 held the most promise of dewatering without the aid of polymers. It was therefore decided to try drainage of raw slurry through the fabrics. Test #1 utilized raw slurry from HP4 through Geotex 1016T woven polyester. Drainage was very slow and within 20 seconds the geotextile had nearly clogged. 1016T is a tightly woven, hydrophilic fabric that is sometimes used with inorganic fine-grained sludges. It was noted that despite the inorganic nature of the slurry, the amount of salts present in the slurry tended to increase the viscosity and rapidly form a filter cake on the geotextile. By this time in the testing, it was certain that drainage of the slurry conditioned with AQ 300 would perform acceptably in the Buchner funnel.

4.3.1 HP-4 Hanging Bag Tests

A hanging bag test was conducted on conditioned slurry from pond HP-4. Based on the Buchner funnel testing, a dosage rate of 60 ml of 0.1% solution AQ 300 per 1,000 ml of raw slurry was used with 15.2 L of raw slurry in a geotextile bag made from Geotex 46T.

Approximately 16.1 L of conditioned slurry was poured into the bag and allowed to dewater. Drainage water was initially cloudy, and proceeded at a rate of approximately 890 ml per minute. After 5 minutes, drainage had decreased to 295 ml/min, and the clarity of the effluent had improved. A sample of the effluent was collected for testing. 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 74.7. An important point to be made regarding the material in pond HP4 is that it responded well to a low dose of polymer, and took slightly more than 1 minute to discharge the additional water added in the chemical conditioning step. Additionally, drainage continued well throughout the test. Test results are presented in Appendix A.

4.4 *Pond SW-9*

SW-9 is an inactive pond that received continuous sludge drier fines (see Figure 4-4). An excavator was used to dig a hole approximately two feet deep. The surface of the pond was dark brown in color, lacked the salt crystals found on other ponds and exhibited desiccation cracking. 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 12.6 pounds/gallon (93.6 pounds/cubic foot) or a wet specific gravity of 1.52. The pH was tested by Hart Crowser's laboratory upon receipt of samples. The pH of the sample was 6.2. 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 not tested.

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 AQ200 alone followed by the combination of AQ 300 and AQ 200 similar to that used for pond SW3. AQ 200 was added at a rate of 0.3 ml with no results. When 100 ml of AQ 300 was added there was still no result. At a dosage rate of 200 ml AQ300, however, flocculation occurred with free water visible on the surface.

FIGURE 4-4
TIMET pond SW-9, May 2004

Test #2 utilized a 0.1% solution of AQ 507, which is a cationic emulsion polymer. At a dosage of 100 ml, slight thickening was observed. This continued until pin flocs and separation were observed at 250 ml. It was determined that the conditioning used in test #1 provided better results and was more cost effective. Based on these results, Buchner funnel testing was then conducted.

The Buchner funnel was then conducted. Test #1 utilized slurry from SW9 conditioned with the combination AQ200/300 through ACE 70/105 woven polypropylene. At the dosage rate of 0.3 ml AQ200 and 200 ml AQ300 per 1,000 ml of raw slurry, drainage was surprisingly slow compared to earlier Buchner funnel tests. Since this dosage rate represented the initial floc formation, it was decided to increase dosage of AQ300 for the hanging bag test to 250 ml.

4.4.1 SW-9 Hanging Bag Tests

A hanging bag test was conducted on conditioned slurry from pond SW-9. Based on the Buchner funnel testing, a dosage rate of 0.3 ml AQ 200 and 250 ml of 0.1% solution AQ 300 per 1,000 ml of raw slurry was used with 15.2 L of raw slurry in a geotextile bag made from ACE 70/105.

Approximately 18.75 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 810 ml per minute. After 5 minutes, drainage had decreased to 87.5 ml/min, and the clarity of the effluent had greatly improved. A sample of the effluent was collected for testing. The test was allowed to continue overnight, and after approximately 15 hours, the material within the bag had the consistency of pudding. The material within the bag had a percent solids by weight of 54.7. Since water was still draining from the bag, it is assumed that a measurable amount of effluent would have been obtained given an amount of time equal to the other hanging bag tests. Test results are presented in Appendix A.

5.0 LABORATORY RESULTS

Three samples were taken during each hanging bag test and sent to labs for testing. Dewatered material was obtained from each hanging bag after dewatering overnight for a determination of percent solids by weight. Samples were also taken from the raw slurry prior to chemical conditioning and drainage water during each hanging bag test. These samples were tested for total solids, pH, specific gravity of the solids. The effluent water was tested for chlorides, sulfates, perchlorate, sodium, magnesium, total dissolved solids and total suspended solids (see Table 5-1). This information assists in determining the effectiveness of tube dewatering for each pond, and the design of the dredging process, tube filling, and effluent water management and reuse.

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, that the magnitude of dissolved salts in the water dramatically complicated both the lab testing and the analysis.

TABLE 5-1
Basic Remediation Company
Preliminary Timet Pond Dewatering Tests
Analytical Results of effluent (after five minutes of drainage) from hanging bags, May 2004

TIMET Ponds
Analytical Results for Effluent from Hanging Bags

	Pond			
	SW-3	SW-9	HP-4	HP-5
Ions				
Chloride	102,000	130,000	191,000	62,600
Sulfate	9,500	315	ND	1,550
Perchlorate	40,100	12,200	4,770	1,130
Metals				
Sodium	140,000	19,000	7,430	5,600
Magnesium	1,120	37,200	70,600	11,800
Solids				
Total Dissolved Solids (TDS)	372,000	339,000	484,000	156,000
Total Suspended Solids (TSS)	1,090	2,270	54,200	333

*results given in mg/L (ppm)
ND= No Detect

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 are known. A complete characterization of the materials in the ponds has not been conducted.

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 (as seen in Table 5-1). 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. Percent solids by volume is a parameter that can be easily observed, and is reported in Table 5-2.

Table 5-2 presents the results of a volume analysis which accounts for both the total dissolved and total suspended solids in the raw slurry. It can be seen that the volume of slurry was reduced, by a factor of three in most 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 as seen by comparing the total dissolved solids in the effluent with the total suspended solids (Table 5-1).

TABLE 5-2
Basic Remediation Company
Preliminary Timet Pond Dewatering Tests
Percent solids by weight and volume, TIMET pond hanging bag tests, May 2004.

Pond Designation	Percent Solids by Volume		Percent Solids by Weight	Specific Gravity
	Initial Slurry	Retained in bag	Retained in bag	Composite solids
HP-5	6.2	17.0	34.8	2.54
SW-3	9.3	27.5	54.4	2.97
HP-4	15.2	60.6	74.7	1.74
SW-9[/a]	17.7	38.0	54.7	2.00

Notes: /a. Still draining after 15 hours.

5.1 *Discussion of Results*

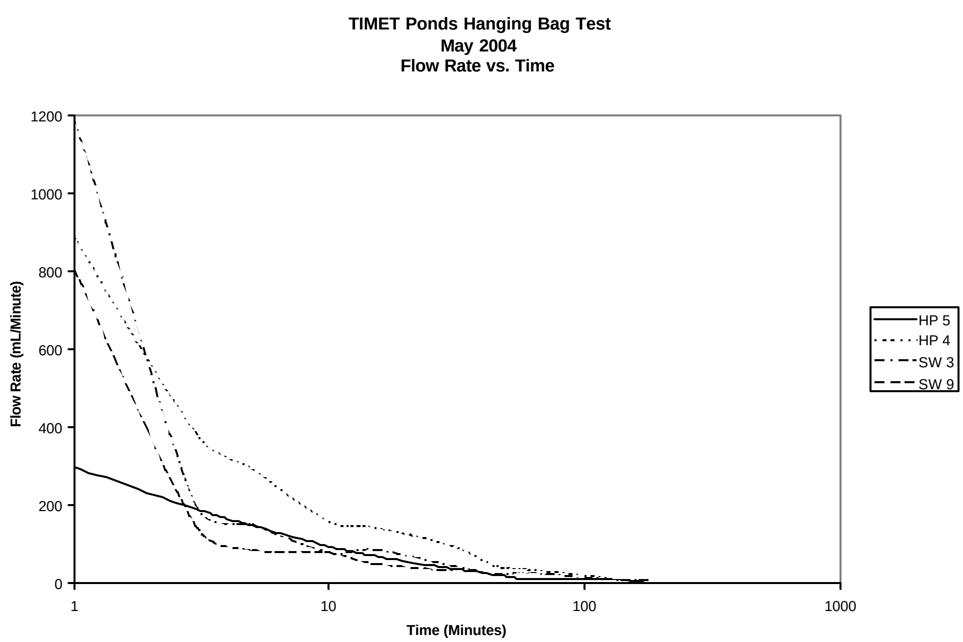
Testing has shown that despite the complex and varied nature of the material found in the TIMET ponds, the material can be dewatered using geotextile tubes. The hanging bag tests have shown that, with chemical conditioning, the material will dewater to a “dry” state (i.e. no visible free water) relatively 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. After one night of dewatering, material within the bags reached 34.8 to 74.7 % solids by weight. 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.

5.2 *Pond HP-5*

This pond is an active pond with fine-grained sediment (78.8% passing the number 200 sieve). Based on limited lab testing, effluent from dewatering operations will contain high percentages of dissolved magnesium chloride with sodium chloride. A preliminary review of ions indicate that the material is not presently well characterized. It is likely that other minerals such as barium or calcium are present.

The material in the pond is covered by water, and therefore has the highest initial moisture content (lowest percent solids). It is not surprising that final percent solids by weight after 19 hours were relatively low at 34.8%. Additional dewatering time will increase the percent solids. The flow rate of effluent was also relatively slow compared to the other tests, however it was still within the range of acceptability (see Figure 5-1). This implies that additional improvements to the chemical conditioning could be made with further testing.

FIGURE 5-1
Drainage flow rate during hanging bag tests, TIMET ponds, May 2004



This pond (HP-5) is approximately 250 ft X 1,600 ft and an estimated 4 feet deep resulting in approximately 59,250 cubic yards. At this volume, and making a very conservative assumption of zero volume reduction, 76, 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 $304,000 for the geotextile tubes only. Polymers would increase the cost per cubic yard by approximately $1.00, or $59,250. Combined geotextile tube and polymer costs for dewatering this pond could be in the range of $360,000. 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 *Pond SW-3*

This pond was an inactive spent caustic pond with two distinct components; sodium chloride and inert, inorganic sediment. This pond also contained the highest amount of perchlorate in the drainage water (see Table 5-1). This sediment was also very fine-grained (88.8% passing the number 200 sieve). Based on limited lab testing, effluent from dewatering operations will contain high percentages of dissolved sodium chloride. Final percent solids by weight were 54.4%. Additional dewatering time will increase the percent solids. The flow rate of effluent was quite rapid compared to the other tests.

This pond is approximately 300 ft X 600 ft and 4 feet deep resulting in approximately 27,000 cubic yards. At this volume, and making a very conservative assumption of zero volume reduction, 34, 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 $122,000 for the geotextile tubes only. Polymers would increase the cost per cubic yard by approximately $1.25, or $34,000. Combined geotextile and polymer costs for dewatering this pond could be in the range of $156,000. These prices are estimates and would need to be verified by suppliers.

5.4 *Pond HP-4*

This pond was an inactive magnesium chloride pond. The sediment was almost completely fine-grained with 98.4% of the solids passing the 200 sieve. Based on limited lab testing, effluent from dewatering operations will contain high percentages of dissolved magnesium chloride with sodium chloride. Final percent solids were 74.7%, the highest of the four ponds tested. This may relate to the fact that this material had the lowest specific gravity at 1.74. The flow rate of effluent was quite rapid. The material in this pond was somewhat different than the others. The drainage water held the highest amount of both dissolved and suspended solids (Table 5-1) and was characterized by the highest percentage of magnesium chloride. Additionally, slurry from this pond required the least amount of polymer to achieve flocculation.

This pond is approximately 250 ft X 650 ft and 4 feet deep resulting in approximately 24,000 cubic yards. At this volume, and making a very conservative assumption of zero volume reduction, 31, 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 $124,000 for the geotextile tubes only.

Polymers would increase the cost per cubic yard by approximately $0.75 or $18,000. Combined geotextile and polymer costs for dewatering this pond could be in the range of $142,000. These prices are estimates and would need to be verified by suppliers.

5.5 *Pond SW-9*

This pond contained continuous sludge drier fines and exhibited characteristics similar to lake sediment. The sediment was very fine-grained (D_{50}=XXX). This was the last pond sampled and had the least amount of time dewatering in the bag. Despite this, final percent solids were very good at 54.7%. Additional dewatering time will certainly increase the percent solids. The flow rate of effluent was acceptable, and similar to that found on a typical lake dredging project.

This pond is approximately 300 ft X 550 ft and 3 feet deep resulting in approximately 18,000 cubic yards. At this volume, and making a very conservative assumption of zero volume reduction, 23, 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 $82,800 for the geotextile tubes only. Polymers would increase the cost per cubic yard by approximately $1.25, or $22,500. Total material costs for dewatering this pond could be in the range of $105,300. These prices are estimates and would need to be verified by suppliers.

5.6 *Summary of Testing and Preliminary Design Considerations*

Based on the hanging bag tests conducted on 4 representative 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 pond HP-5. 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.

One of the interesting characteristics 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 5-2).

FIGURE 5-2
Pond SW-3 one hour after excavation, May 2004.

Other ponds that are presently covered with water such as HP-5 would 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. If this is economically prohibitive, effluent water can be returned to a pond for use in slurrying the solids, and fresh water can be brought to the site for dilution.

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.

Since the majority of dissolved salts remained in the effluent during the hanging bag tests, consideration must be given to a cost-effective desalination process. This holds true regardless of the dewatering technology employed. Salt retained in crystal form within the bags did not have any noticeable negative impact on dewatering. Cost effective methods of desalination may include crystallization which relies on chilling, or reverse osmosis.

6.0 RECOMMENDATIONS

HC/PAH has demonstrated that geotextile tubes can be a successful method to dewater TIMET ponds. The field test program conducted during May 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. The last pond, HP-5, experienced dewatering to 35 percent solids by weight. While in comparison this number is low, it does not rule out dewatering by geotextile tube. These results indicate a high success in 3 of the 4 ponds, without further analysis or efforts to improve results. When extrapolated to the remaining ponds, it is likely that 14 of the 16 TIMET ponds will dewater successfully while 2 active OPW ponds may need further refinement in the dewatering process.

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. HC/PAH recommend that we assess how the other ponds would respond to these simplified preliminary tests. One key to this is a detailed analysis of the material in the ponds including in situ % solids, all metals and a more thorough list of ions. Additionally, further bench scale testing to optimize polymer concentrations may be warranted for the active OPW ponds.

If a full-scale pilot project were considered, there are two approaches that could be taken. The first approach would be to dewater material from Pond SW-9 using full-size tubes and polymer injection to optimize and verify the process. Dewatered material would be spread and dried to achieve a final percent solids. Results of this test would give very detailed cost and time information. The second approach would be to dewater material from Pond HP-5 in a full scale test. Since the material in this pond was the most difficult to dewater, optimizing at full scale would give information that would be a worst-case scenario. Additionally, it is probably wise to conduct hanging bag tests on all remaining ponds to properly assess the value of geotextile tubes for each pond.

Based on the preliminary results, HC/PAH recommends the following program to further define the potential of geotextile tube technology:

1. Prepare a pre-feasibility cost study of using geotextile tubes to dewater Pond HP-4, inclusive of a process to further dry the material at the containment cell with a specific material handling concept. Prepare a specific plan to continue the work employing geotextile tube technology.

2. Fully describe the conditions existing in each pond by completing analytical testing and characterization of all pond materials, including *in situ* percent solids, metals and ions, and volume calculations;

3. Conduct bench-scale and hanging bag tests on ponds that have not yet been tested and re-test pond HP-5 to analyze potential improvement in dewatering success by further trials with chemical conditioning agents;

4. Determine and recommend what additional tests, data, and information should be conducted and obtained to optimize the understanding of the pond materials and their behavior in the tubes;

5. Conduct a full-scale pilot test(s) to establish feasibility level of costs that can be expected;
   a. Establish for all the other ponds, the likelihood of costs and success, given results and costs for the pilot test and our understanding of the technology.
   b. Conduct a feasibility level design of the entire process inclusive of effluent water treatment and potential reuse.

6. Prepare an implementation plan and 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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