

# **Appendix D**

## ***Waste Management Plan***





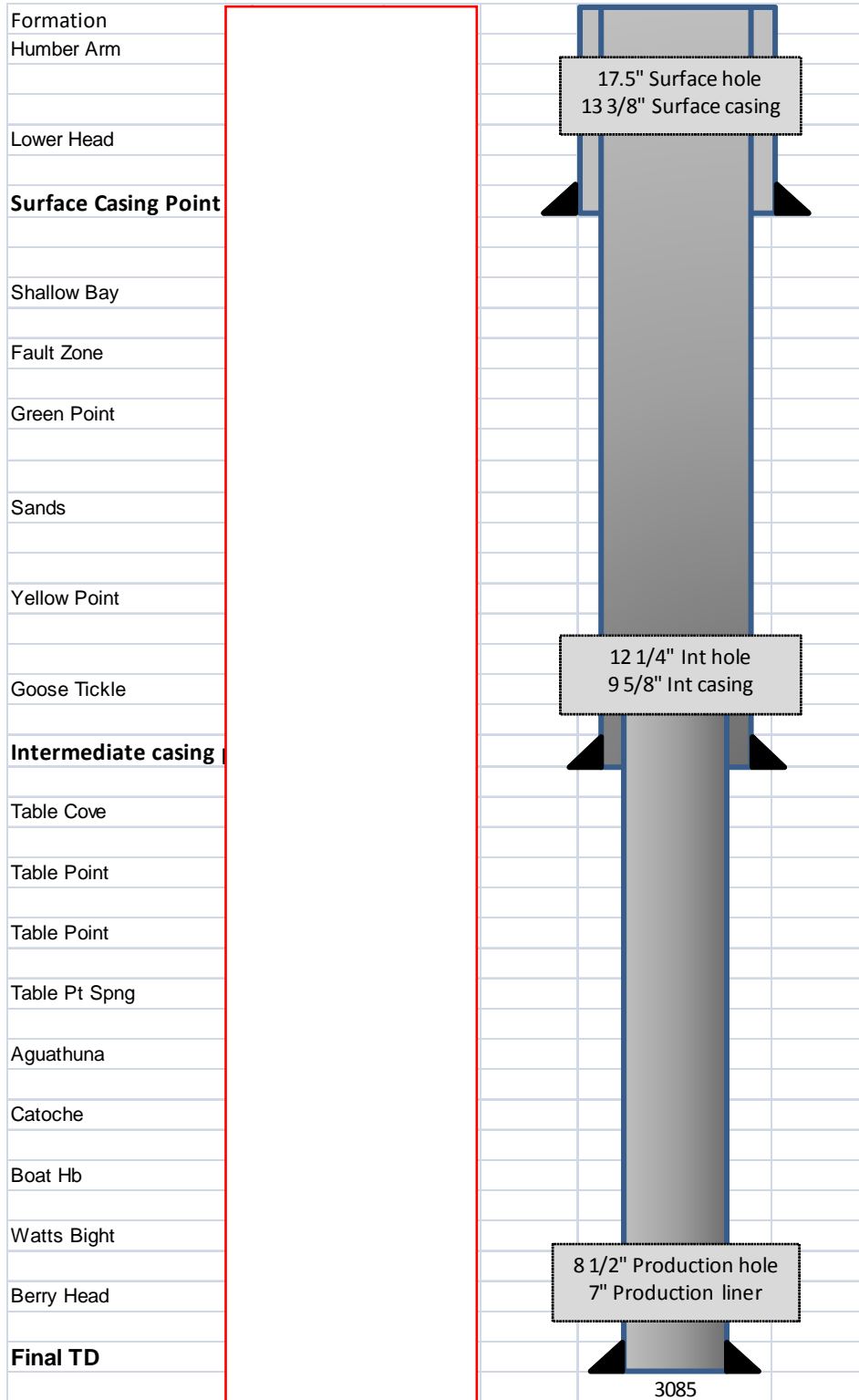
## **WASTE MANAGEMENT PLAN**

### **PARSON'S POND DRILLING PROGRAM**

Please note that the specific information contained herein regarding exploration well characteristics and dimensions, the nature and quantities of drilling materials to be used and associated wastes, etc will obviously vary between the various drill sites that comprise the Parsons Pond Exploration Drilling Program. The Waste Management principles and procedures outlined in this Plan are, however, generally applicable to each of these proposed wells - including that which is the subject of this EPR - and the Plan has therefore been included in order to illustrate the proponent's overall approach to managing the wastes associated with this exploration drilling project.

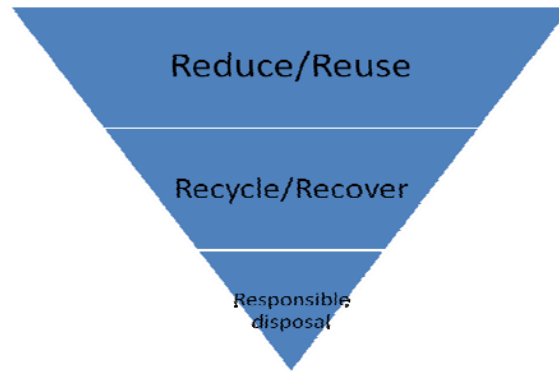
**STICK DIAGRAM FOR WELL #1:**

**PROPOSED CASING PROGRAM AND EXPECTED GEOLOGICAL ZONES**



## **OVERVIEW**

The Waste management on these wells will follow the outline of Directive 50 of the Alberta Energy and Utilities Board; relevant sections of Directive 50 have been re-printed in appendix three through six at the end of this document. Overall efforts will be to reduce and re-use as much of the fluid and solid waste as possible. The following is a brief outline of the procedures of waste management defined in this program:



### **Reduce the Volume of Waste Created**

- Inhibitive drilling fluids
- Improved solids control equipment and shaker screens

### **Reuse rather than Discard**

- Zero discharge or closed loop systems reclaim fluids for re-use in the active drilling system.

### **Recycle Waste into a Useable Product**

- Innovative treatment methods have been employed to turn waste products into products with economic value like converting drill cuttings into road base.

### **Recover Material from Waste Streams**

- Cuttings dryers
- Centrifuges

### **Responsible disposal**

- Use approved disposal methods
- Landfill

Efforts will be used to use only environmentally acceptable products in the fluid, testing protocols will be outline in this report as well.

## ATTITUDE

Attitude about waste management is almost as important as proper procedures and protocols. The ideas presented in here: reduce, reuse, recycle, recover and responsible disposal will only work when implemented by a staff that takes the idea of waste management seriously. In order to help the crews understand the importance of these issues, waste management should be added occasionally to the morning safety meetings on the rig. After all environmental stewardship is really a safety issue.

## EXPECTED WASTE VOLUMES

The following table summarizes the estimated waste volumes on the first well:

<b>Estimated</b>			
Interval	Volume cuttings (m <sup>3</sup> )	Volume drilling fluid (m <sup>3</sup> )	Total Volume Waste (m <sup>3</sup> )
Surface	1220	412	<b>1632</b>
Intermediate	1580	556	<b>2136</b>
Main	290	482	<b>772</b>
			<b>4540</b>

## WASTE MANAGEMENT PER INTERVAL

### SURFACE INTERVAL:

**INTERVAL 0 - 640 M**

**444.7 MM HOLE**

**349.7MM CASING**

**Drilling Fluid System: Water based Wyoming Bentonite / Native Clays**

Surface procedure:

### Reduce the Volume of Waste Created

Solids control equipment optimization is the key to reducing waste on surface hole. Run both centrifuges so that 100% of the volume being pumped is being processed through the equipment. Adjust the centrifuge bowl and scroll speeds to produce a dryer underflow. Utilize minimum 60% of shaker area and a maximum of 80%; use the same mesh screen on all panels of the shaker. Coarser screens may be required while drilling out the surface section but screen up as soon as conditions dictate that it is possible. Proper solids control is very important in reducing waste and the shaker is the first line of defense in this procedure. Remember that the shaker is only as good as its coarsest screen, all screens should be of the same mesh.

### Reuse rather than Discard

After drilling this section the drilling fluid will be stripped down to its solid and water components; this procedure is called de-watering (see appendix). The solids portion of the drilling fluid will be kept on location and mixed in the surface of lease (mix, bury, cover). The water recovered will be reused as build water for the next drilling fluid system.

Estimated Dewatering chemicals for surface interval			
	Sacks/15m3	Volume fluid de-watered	Total material required (sacks)
Envirofloc	3	412	82
Alkapam 1103	1	412	27

### Recycle Waste into a Useable Product

After testing (EC and SAR) the drill cuttings will be moved to the next location (or the gravel pit) and mixed into the building material for building the lease and access road. This will help to greatly reduce the cost of disposal.

### Recover Material from Waste Streams

Material will be recovered initially through the shakers and centrifuges and lastly through the de-watering process. Every effort will be to make the material as dry as possible for easy transport and storage.

### Responsible disposal

On this hole section we are not expecting any hydrocarbon influx. In the unlikely event of any hydrocarbon influx, all cuttings and fluid will be segregated into separate storage tanks and stored. This contaminated material will be hauled off to a class 1 landfill and disposed of.

Other types of responsible disposal include the MBC (Mix, Bury, Cover) procedure described earlier. All solids waste from the drilling fluid will be mixed into the surface lease at the end of the well.

### **Mud Product estimated usage:**

<b>Product</b>	<b>Unit Size</b>	<b>Estimated Units</b>
<b>BENTONITE</b>	40.00 kg	620
<b>S.A.P.P.</b>	22.68 kg	5
<b>DRILLING DETERGENT</b>	18.93 L	6
<b>SAWDUST</b>	sack	300
<b>CAUSTIC SODA</b>	22.68 kg	8
<b>XANTUM GUM</b>	22.68 kg	45

**Intermediate Interval:**

**INTERVAL 640 – 2410 M**

**311.0 MM HOLE**

**244.5 MM CASING**

**Recommended Mud system: Water based Inhibited Wyoming Bentonite**

Intermediate procedure:

**Reduce the Volume of Waste Created**

This section of the hole will yield the most waste both solids and liquids. In order to help reduce the waste the drilling fluid system will be an inhibited system using an amine inhibitor to help reduce hole washout. Hole washout can lead to excess cuttings and drilling problems. While it is not expected to have significant reactive shale; the addition of the amine inhibitor will ensure that if any reactive shale's are encountered they will be inhibited. Amine mud systems also help to control excessive particle size degradation allowing the solids control to work more effectively.

As in the surface section solids control equipment optimization will be key to reducing waste. Typically in a hole section this large the density of the fluid is controlled by good solids control and dumping solids contaminated mud when the density and low gravity solids get to high and then diluting with more water. This dump and dilute mentality leads to even more waste and water usage. In this hole section (and the next hole section) instead of dumping and diluting the mud; excessive low gravity solids will be controlled by running the centrifuges at all times. If the low gravity solids exceed 7% by volume then mud will be removed from the system (approximately 20m<sup>3</sup> at a time) and dewatered with the recovered water being re-introduce into the system and removed solids stored on location and Mix-bury-covered on the wellsite after completion of the drilling. Testing for LGS (low gravity solids) is a simple test using a mud balance and the following formulas

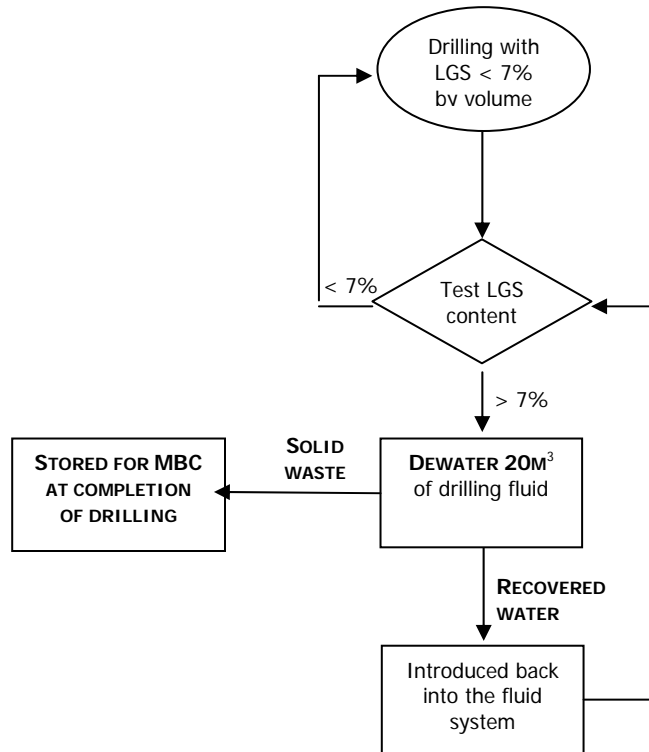
With no barite (weight material):

$$(\% \text{ Solids}) = [(Mud \text{ Weight (kg/m}^3) / 1000) - 1] \times 0.625$$

Using this formula, the maximum mud weight while drilling this section should be about **1115 kg/m<sup>3</sup>**



The following flowchart summarizes the process.



Both centrifuges will be run at all times, if/when the LGS rise to over 7% one centrifuge will be used to do the de-watering and the other will be used on the active system. This will require that an open topped premix tank be on location situated close to the centrifuges and polymer injection tank. Run both centrifuges so that 100% of the volume being pumped is being processed through the equipment. Adjust the centrifuge bowl and scroll speeds to produce a dryer underflow. Utilize minimum 60% of shaker area and a maximum of 80%; use the same mesh screen on all panels of the shaker. Coarser screens may be required while drilling out the surface section but screen up as soon as conditions dictate that it is possible. Proper solids control is very important in reducing waste and the shaker is the first line of defense in this procedure. Remember that the shaker is only as good as its coarsest screen; all screens should be of the same mesh size.

#### Reuse rather than Discard

After drilling this section a portion of the drilling fluid will be stripped down to its solid and water components (de-watered as per previous section). Approximately 200m<sup>3</sup> of drilling fluid from the intermediate section should be saved for the main hole, the rest stripped. De-watering the intermediate section will be somewhat different than the

surface section and will require a slightly different polymer mix. The solids portion of the drilling fluid will be kept on location and mixed in the surface of lease (mix, bury, cover). The water recovered will be reused as build water for the next drilling fluid system.

Estimated Dewatering chemicals for intermediate interval			
	Sacks/15m <sup>3</sup>	Volume fluid de-watered	Total material required (sacks)
Envirofloc	3	556	111
Zetag 7692	1	556	37
Alkapm 1103	1	556	37

Recycle Waste into a Useable Product

After testing (EC and SAR) the drill cuttings will be moved to the next location (or the gravel pit) and mixed into the building material for building the lease and access road. This will help to greatly reduce the cost of disposal.

Recover Material from Waste Streams

Material will be recovered initially through the shakers and centrifuges and lastly through the de-watering process. Every effort will be to make the material as dry as possible for easy transport and storage.

Responsible disposal

On this hole section we are not expecting any hydrocarbon influx. In the unlikely event of any hydrocarbon influx, all cuttings and fluid will be segregated into separate storage tanks and stored. This contaminated material will be hauled off to a class 1 landfill and disposed of.

Other types of responsible disposal include the MBC (Mix, Bury, Cover) procedure described earlier. All solids waste from the drilling fluid will be mixed into the surface lease at the end of the well.

**Mud Product estimated usage :**

<b>Product</b>	<b>Unit Size</b>	<b>Estimated Units</b>
BENTONITE	40.00 kg	835
CAUSTIC SODA	22.68 kg	22
DRISPAC	22.68 kg	80
AMINE	18.93 L	56
ALCOMER 60RD	25.00 kg	50
XANTUM GUM	22.68 kg	80
SODA ASH	22.68 kg	10
BARITE	40.00 kg	400
SAWDUST	sack	200
CALCARB 0 GRIND	25.00 kg	250
CALCARB 325 GRIND	25.00 kg	250
LIGNITE	22.68 kg	160
DESCO CF	11.34 kg	15
BICARB OF SODA	22.68 kg	40
CTRIC ACID	22.68 kg	40

**MAIN HOLE:**

**INTERVAL 2410 – 3085 M**

**216 MM HOLE**

**178.9 MM CASING**

Main hole procedure:

The main hole waste management will closely follow the procedure of the intermediate hole section. The procedures are repeated for the sake of completeness.

**Recommended Mud system: Water based Inhibited Wyoming Bentonite**

**Reduce the Volume of Waste Created**

This section of the hole will yield a significant amount of waste both solids and liquids. In order to help reduce the waste the drilling fluid system will be an inhibited system using an amine inhibitor to help reduce hole washout. Hole washout can lead to excess cuttings and drilling problems. While it is not expected to have significant reactive shale; the addition of the amine inhibitor will ensure that if any reactive shale's are encountered they will be inhibited. Amine mud systems also help to control excessive particle size degradation allowing the solids control to work more effectively.

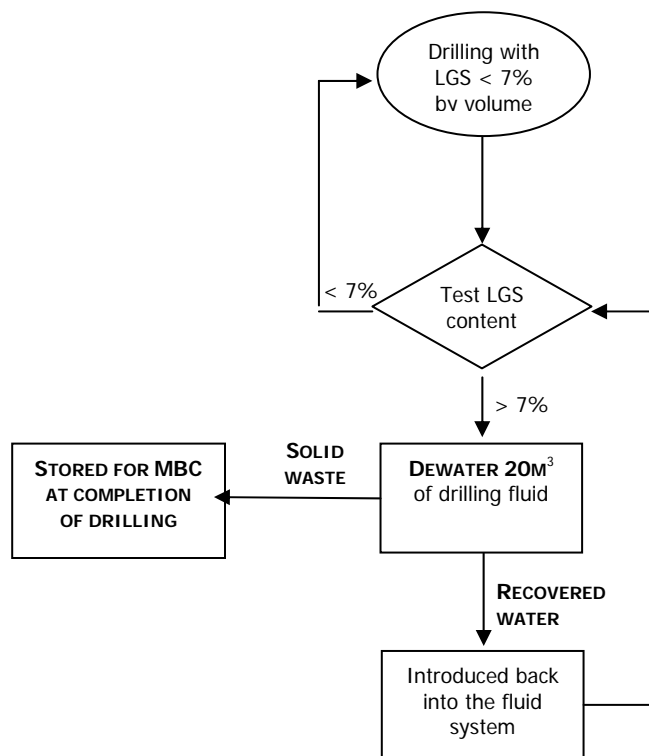
As in the surface section solids control equipment optimization will be key to reducing waste. Typically in a hole section this large the density of the fluid is controlled by good solids control and dumping solids contaminated mud when the density and low gravity solids get to high and then diluting with more water. This dump and dilute mentality leads to even more waste and water usage. In this hole section (and the next hole section) instead of dumping and diluting the mud; excessive low gravity solids will be controlled by running the centrifuges at all times. If the low gravity solids exceed 7% by volume then mud will be removed from the system (approximately 20m<sup>3</sup> at a time) and dewatered with the recovered water being re-introduce into the system and removed solids stored on location and Mix-bury-covered on the wellsite after completion of the drilling. Testing for LGS (low gravity solids) is a simple test using a mud balance and the following formulas

With no barite (weight material):

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Using this formula, the maximum mud weight while drilling this section should be about **1115 kg/m<sup>3</sup>**

The following flowchart summarizes the process.



Both centrifuges will be run at all times, if/when the LGS rise to over 7% one centrifuge will be used to do the de-watering and the other will be used on the active system. This will require that an open topped premix tank be on location situated close to the centrifuges and polymer injection tank. Run both centrifuges so that 100% of the volume being pumped is being processed through the equipment. Adjust the centrifuge bowl and scroll speeds to produce a dryer underflow. Utilize minimum 60% of shaker area and a maximum of 80%; use the same mesh screen on all panels of the shaker. Coarser screens may be required while drilling out the surface section but screen up as soon as conditions dictate that it is possible. Proper solids control is very important in reducing waste and the shaker is the first line of defense in this procedure. Remember that the shaker is only as good as its coarsest screen; all screens should be of the same mesh size.

Reuse rather than Discard

After drilling this section the drilling fluid will be stripped down to its solid and water components (de-watered as per previous section). De-watering the main hole section will be somewhat similar to the intermediate hole section. The solids portion of the drilling fluid will be kept on location and mixed in the surface of lease (mix, bury, cover). The water recovered will be reused as build water for the next drilling fluid system.

Estimated Dewatering chemicals for Main interval			
	Sacks/15m3	Volume fluid de-watered	Total material required (sacks)
Envirofloc	3	482	96
Zetag 7692	1	482	32
Alkapm 1103	1	482	32

Recycle Waste into a Useable Product

After testing (EC and SAR) the drill cuttings will be moved to the next location (or the gravel pit) and mixed into the building material for building the lease and access road. This will help to greatly reduce the cost of disposal.

Recover Material from Waste Streams

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tanks and stored. This contaminated material will be hauled off to a class 1 landfill and disposed of.

Other types of responsible disposal include the MBC (Mix, Bury, Cover) procedure described earlier. All solids waste from the drilling fluid will be mixed into the surface lease at the end of the well.

**Mud Product estimated usage :**

<i>Product</i>	<i>Unit Size</i>	<i>Estimated Units</i>
<b>BENTONITE</b>	40.00 kg	200
<b>CAUSTIC SODA</b>	22.68 kg	5
<b>DRISPAC</b>	22.68 kg	25
<b>AMINE</b>	18.93 L	10
<b>ALCOMER 60RD</b>	25.00 kg	10
<b>XANTUM GUM</b>	22.68 kg	25
<b>SODA ASH</b>	22.68 kg	10
<b>BARITE</b>	40.00 kg	250
<b>SAWDUST</b>	sack	200
<b>CALCARB 0 GRIND</b>	25.00 kg	100
<b>CALCARB 325 GRIND</b>	25.00 kg	100
<b>LIGNITE</b>	22.68 kg	25
<b>DESCO CF</b>	11.34 kg	15
<b>BICARB OF SODA</b>	22.68 kg	20
<b>CTRIC ACID</b>	22.68 kg	20

Continuous Improvement

Proper waste management includes a commitment for constant monitoring and improvement. After successfully completing the first well, the basic plan is to further reduce waste on the other wells in the project. We can use the PDCA cycle as a model for this project.



Plan

The initial plan is set out in this document. As the well continues inevitably a new suggestion or techniques about reducing waste will evolve. This new suggestion or technique must be documented and reviewed. It will be established that the objectives and processes necessary to deliver results in are in accordance with the expected output (reducing waste). Reducing waste is the focus.

Do

Implement the new suggestion or technique.

Check

Measure the new processes and compare the results against the expected results to ascertain any differences. For these wells a simple spreadsheet should suffice. The waste will be recorded with plans to reduce waste even more on future wells. Here is an example of such a spreadsheet:

Date	Water in (m <sup>3</sup> )	Water pumped off (m <sup>3</sup> )	Drilling fluid de-watered (m <sup>3</sup> )	Solids removed from mud (m <sup>3</sup> )	Drill solids (m <sup>3</sup> )	Other waste (m <sup>3</sup> )	notes
Total							

Act

Analyze the differences to determine their benefit. If there is a benefit add the new process to the plan. There will come a point where no further processes or techniques will reduce waste any further; at this point a step change (or government regulation) will need to happen for further reductions in waste.

## **Appendix 1**

### **Solids Control**



**RIG SHAKERS.** Run the shakers with finest screens possible. Until the fluid is conditioned coarse screens may be required, however once the mud is conditioned the finest screens possible should be used 210's or finer. Best shaker performance is when the fluid travels at least half way down the last screen panel. Try to operate with the shaker deck angle at a minimum. Unless required due to viscosity etc., do not jack the shakers up to maximum angle and operate over long periods. As we will be recovering mud at the drying shaker, some mud running off the primary shakers will improve the cut and not be a concern.

**SHAKER SCREENS.** Always use the same screen mesh size across the full screen deck. Do not mix and match screens from finer to coarse. For example if 210 mesh size is determined to be the screens to use, screen the shaker 210/210/210/210. Always allow the fluid to travel at least half way down the last screen panel.

**WATER USE & RIG WASH WATER.** Record daily volume (cubic meters) of water used for rig use. Try to keep wash water to a minimum. Use brushes and buckets and wash guns at a minimum. Recycle wash water where opportunity and equipment allows unless advised by the mud engineer or drilling foreman.

**CENTRIFUGES.** 2 fully variable high speed, high volume, centrifuges are recommended for this projects. Centrifuges should be capable of a combined processing rate of 2.6 m<sup>3</sup>/min when drilling 311 hole sections. The centrifuges will be rigged up to operate in parallel or in series. See Operating procedures below. Also general aspect centrifuge operation in parallel & series layout is shown below (Fig 1 & 2)

**CENTRIFUGE OPERATION WHEN UNWEIGHTED** (Fig. 1) Operate the centrifuges in parallel mode when unweighted, that is, both centrifuges should discard underflows to the shale tank and discharge fluid to the active system. ***Both centrifuges should be operating at maximum bowl speed and flow rate.*** Once the desired density is achieved, the centrifuge backdrive differential should be adjusted to dry up the solid discard. If density starts to increase the backdrive should be adjusted to increase the wetness of the discard and improve the centrifuge cut point.

**CENTRIFUGE OPERATION WHEN WEIGHTED** (Fig 2) ***Service hand required to operate the system and train rig personnel initially.*** Normal practice has been to shut off the centrifuges during drilling with increased mud densities. To increase the life of the mud system and improve fluid performance, operations will continue to process fluid while weighted with the centrifuges operating in series to control low gravity drilled solids build up. Operate the centrifuges in series, that is, the first centrifuge will take suction from the active system discarding barite cake to a recovery system line where it is jetted back to the active mud system. The first centrifuge overflow discharges to the second centrifuge feed. The second centrifuge will process the fluid from the first centrifuge discarding underflow to the shale tank for disposal and return the polished overflow to

the active system. The first centrifuge should be operated at a bowl speed of between 800 – 1000 rpm. This will preferentially remove barite as barite has a specific gravity of 4.2 almost double that of drilled solids. As the overflow fluid from the first centrifuge will still contain some barite and high concentrations of drilled solids, the second centrifuge will be used to polish the fluid before returning to the active system. As there will still be some barite lost to the second centrifuge underflow flow, the centrifuge system flow rate will need to be adjusted up or down so that the active mud system is not shocked by lower densities. The second centrifuge should be operated at highest bowl speed (3200 rpm), taking the full flow from the first centrifuge overflow. The backdrive should be adjusted to control underflow dryness or centrifuge cut as outlined above.

Figure 1: Centrifuge Operation in Parallel (Un-weighted)

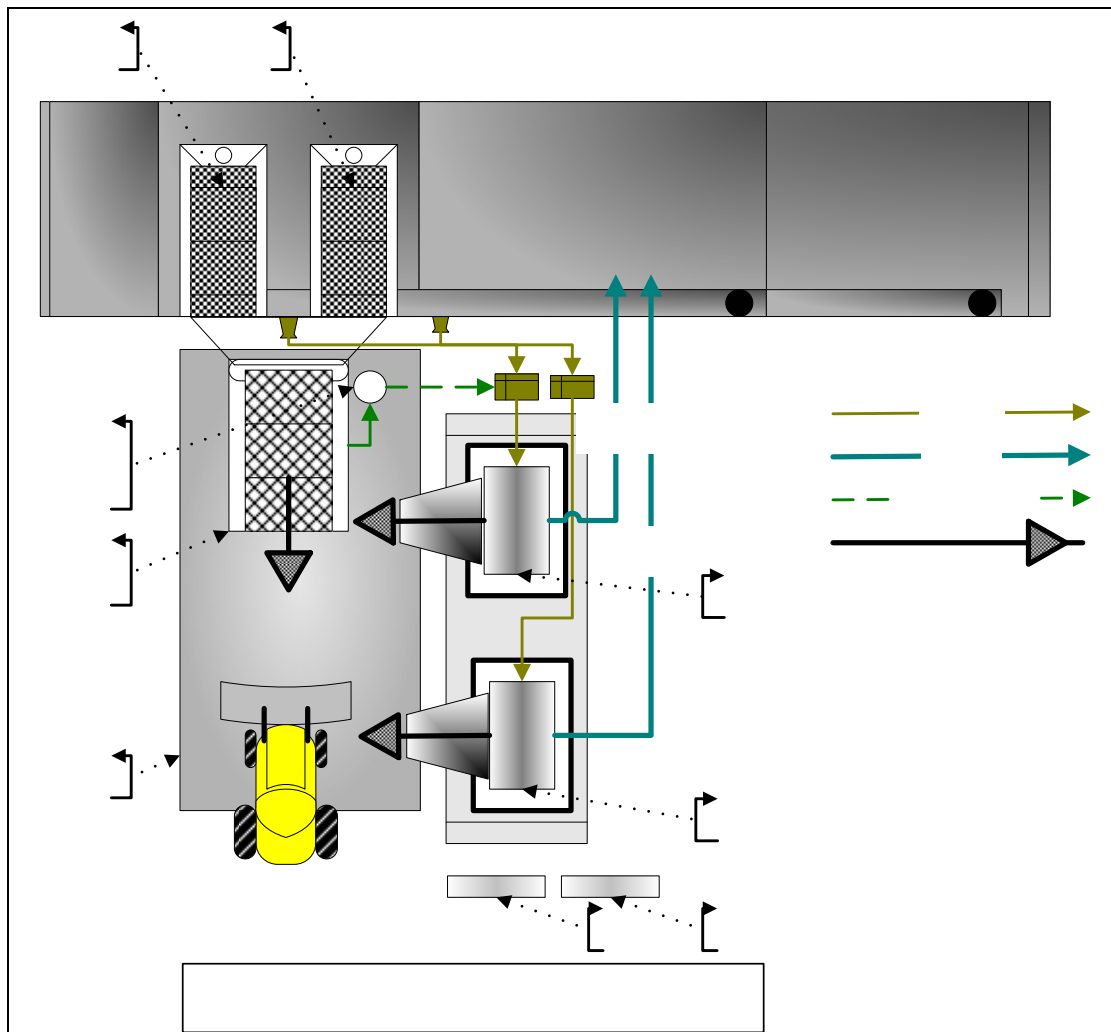
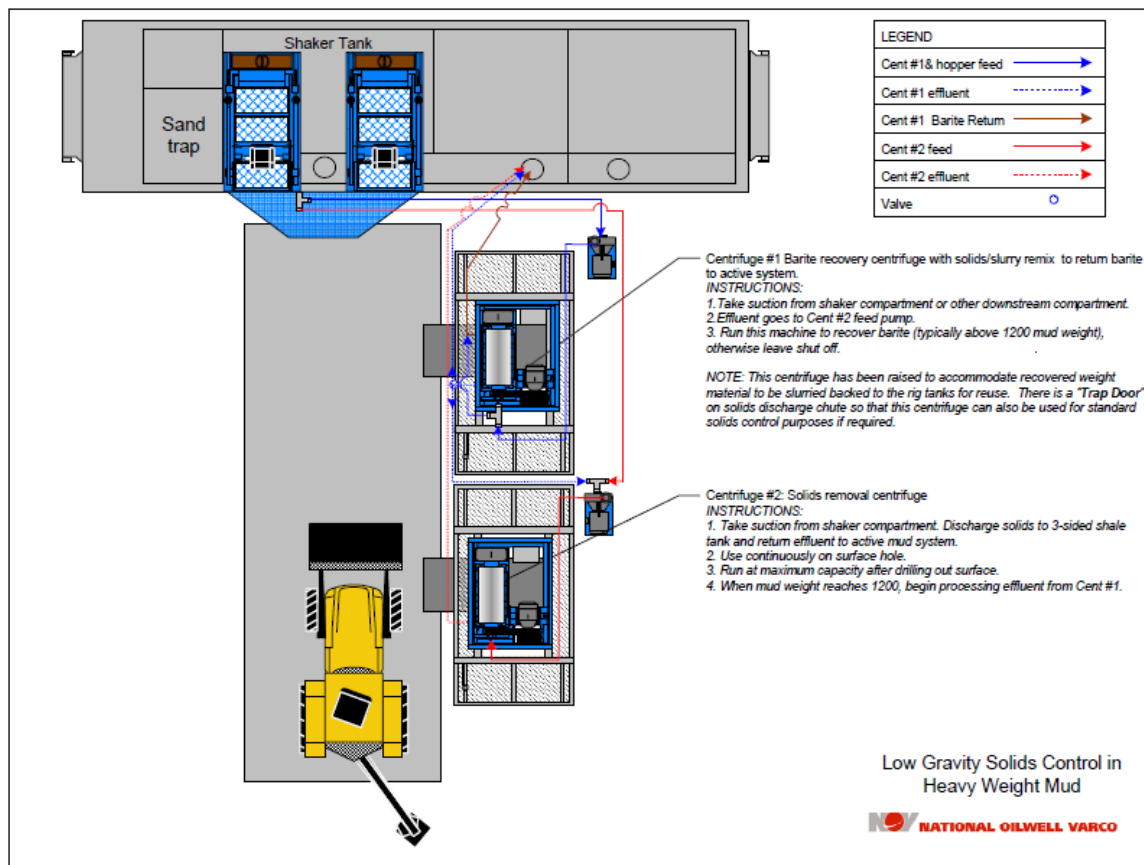


Figure 2: Centrifuge Operation in Series (Weighted)



## **Appendix 2**

### **De-watering Sumpless Drilling**

## **SUMPLESS DRILLING**

### **AN ECONOMIC DRILLING WASTE HANDLING ALTERNATIVE**

#### **ABSTRACT**

With the increasing requirement for sumpless or reduced drilling waste applications, drilling fluid dewatering systems have become an acceptable alternate waste reduction method. As the technology becomes more widely used, industry has identified problems and inefficiencies with the current technology, and thus has developed solutions and alternate treatment methods to improve operations and economics. With the application of specific chemical technologies, equipment design and project planning, the data has consistently shown that sumpless drilling is an economic drilling waste handling method.

#### **INTRODUCTION**

The use of on-line closed loop circulating systems to achieve drilling waste reduction is gaining popularity both in the Canadian market and in other areas around the world. The recent introduction of dewatering services to further close the loop of drilling fluid circulating systems has been adapted from technology used in the mining, industrial sludge and sewage waste treatment industries.

Increasing the efficiency of solids control equipment has been of primary concern to the drilling industry for many years. However, the emphasis in the past has been to utilize the solids control equipment as solids “classifiers” to optimize mud properties in order to control such variables as solids content, solids distribution, mud rheology and fluid loss control. These properties affect important drilling parameters such as rate of penetration, hole stability, mud rings, formation damage and drilling costs. Since these objectives did not include entirely closing the circulating loop or “clarifying” fluids, significant volumes of liquid drilling wastes containing ultra-fines were generated and disposed of in a sump or pit. The introduction of environmental regulations and the better understanding of the economics of running an efficient close system with chemical assistance has resulted in increased use of dewatering technology in the drilling industry.

The term “closed system” has been used for some time in the drilling industry to describe various solids control layouts and drilling practices. For the purpose of this evaluation, a closed system is one where all excess mud from either dilution or waste from conventional solids control equipment is further processed using coagulation and flocculation chemical technology in conjunction with decanting centrifuges and specialized dewatering equipment. This results in all solids being removed from the waste drilling mud while the liquid portion is recycled back to the active mud system for

reuse. The purpose of utilizing this technology is to reduce or eliminate the need for a sump.

Dewatering technology has evolved from the experimental of new technology to an acceptable drilling waste handling alternative. However, the dewatering technology was derived from other industries and developed to suit the conditions for “floc water drilling”, “fluids management” and solids control technology. Although operationally a success, the use of this technology has, in the past, brought with it problems specific to the drilling industry and associated with recycled fluid compatibility, high chemical costs and system inefficiencies. Improved chemical and equipment technologies in combination have eliminated these inefficiencies and have consistently proven to be a cost-effective solution to drilling waste handling.

### **COST EVALUATION AND COMPARISON**

The following report compares waste handling costs to drilling with a sump on location, with a sump off lease using a vacuum truck, and to drill sumpleless utilizing a dewatering system. The wells evaluated are single well applications and are put into five categories based on project days. Costs are grouped as follows; 10 day projects, 15-day projects, 30-day projects, 45-day projects and 60-day projects. Each grouping was evaluated separately but for the purpose of a general guide, all wells were averaged and graphed for a quick reference. Extremely high construction costs, which are often experienced in Rocky Mountain drilling operations or special requirements in environmentally sensitive areas, were not included in this study. These cases are almost always sumpleless and must be considered individually.

Over the past two years, data has been accumulated evaluating dewatering costs and comparing these numbers to conventional drilling waste handling of an on-lease sump and in cases where a sump on location is not possible, an off-lease sump utilizing vacuum trucks. The data utilized was generated from an excess of 70 dewatering projects. Relevant data was gathered from clients to compare costs. This data included costs such as operator sump construction, sump clean up costs, rates and hours for vacuum trucks, mobilization/demobilization rates of sump construction/cleaning equipment, environmental clean up data and other auxiliary equipment. All costs shown are tangible only and are based on normal operating Canadian conditions. No intangible savings such as reduced mud costs, increased drilling rate, positive public relations, reduced water consumption or reduced liability are included. These factors are based individually through experience with clients who now drill projects sumpleless where and when they can; public relations are an exceptional factor when arbitration is being dealt with through landowners.

Cost parameters included in each of the three drilling waste handling methods are as follows:

### **Sump on lease**

SUMP CONSTRUCTION  
Sump cleanup  
Solids control  
Auxiliary equipment used  
Dewatering chemicals  
Rig up/tear out costs  
Waste analysis

### **Sump built off lease**

SUMP CONSTRUCTION  
Sump cleanup  
Solids control  
Auxiliary equipment used  
Dewatering chemicals  
Rig up/tear out costs  
Vacuum truck costs  
Waste analysis

### **Sumpless dewatering**

WASTE ANALYSIS  
Solids control  
Dewatering equipment  
Dewatering chemicals  
Rig up/tear out costs  
Technical supervision

Note: Landspreading while drilling was excluded from this study as most applications are on a single/multiple well projects less 5 days in duration and no solids control equipment is/was required.

- lease preparation is shorter on sumpless projects as no holes need to be dug
- project completion eliminates any cleanup required after rig leaves location
- service rig has 360' of working area around wellhead
- drilled/stripped solids are worked into lease soil
- on multiple well projects, endhole mud can be utilized as spud mud on next location

There are five other areas that can maximize the benefits of dewatering and help reduce costs. These areas need to be addressed prior to initiating a dewatering project.

- Co-ordinate all the services involved
- Select equipment to fit the drilling program
- Match chemical treatment with drilling fluid compatibility requirements
- Determine recycled fluid compatibility requirements
- Determine the disposal requirements before project start-up

Although many operators are familiar with dewatering operations, many of the service companies utilized on a drilling project either are not familiar with or have not been directly involved in dewatering project, and yet many play a major role in the success of the project.

To complete a dewatering project's objectives, "a closed system" needs to be classified by the operator as a "fluid management program" and as such, each service company and their representatives having an impact on the program and should be made aware of their role and responsibilities before the project commences. A dewatering operation is linked to the following well parameters:

- Solids control requirements
- Drilling fluid types and parameters required to drill the well
- Well depth and hole size

- Drilling problems expected
- Winter operations, boiler capacities, enclosures
- Recycled fluid compatibility
- The operators construction department
- Environmental considerations
- Rig operation and cleaning
- Water and vacuum truck requirements
- Public relations

## **CONCLUSION**

A closed drilling fluid system utilizing proper dewatering technologies and operating techniques is not only a preferable drilling and environmental fluid management operation, but also has economic advantages on all drilling projects. If proper planning and coordination of procedures are incorporated than the amount of drilling waste produced is minimal. The waste would be defined as “drilled solids” and “no liquids”. With no liquid wastes to contend with there is no requirement for a remote sump to be built for that product. All drilled solids can be left on location in a bermed area and be incorporated into the lease once the project is complete. Consider the fact that the centrifuges are mainly on location to be utilized for solids control; they can also be used as “clarifiers” to deal with the liquid waste product for optimum equipment utilization.

The consumption of water is dramatically reduced due to the fact that it is continually being recycled for reuse.

A factor to consider is that costs normally seen on the construction “AFE budget” are now moved into the drilling “AFE budget”. With these two departments working in conjunction with each other, projects realize a 10% - 15% reduction in costs once both expenditures are finalized and grouped together and then compared to other projects of the same duration and degree of work. We have always in the past been instructed from drilling departments that “sumpless systems” were expensive. After working with clients and having the cooperation of “drilling” and “construction” departments, the realization of how the monies were spent, became real.



## **Appendix 3:**

### **Soil Quality and Assessment**

### **3.1 Soil Quality and Assessment for Sites Used to Manage Drilling Waste 3.1 Soil Endpoints**

Tables 3.1, 3.2, and 3.3 set out the salt, hydrocarbon, and trace element endpoints for soils that have received drilling wastes. The EUB has adopted these endpoints from the AENV *Alberta Tier 1 Soil and Groundwater Remediation Guidelines* (2007) and *Salt Contamination Assessment & Remediation* (2001). Note that Section 2.4.5 of the *Alberta Tier 1 Soil and Groundwater Remediation Guidelines* states that

- Tier 1 guidelines are used to evaluate chemical concentrations in soil. They can also be used to evaluate chemical concentrations resulting from the mixing of industrial by-products or organic material into soil.

Should AENV develop new soil quality guidelines or provide updates to existing guideline values, licensees must adjust the endpoints set out in Tables 3.1, 3.2, and 3.3 accordingly.

### **3.2 Soil Salinity Endpoints**

The EUB has adopted soil endpoints for salinity from AENV *Salt Contamination Assessment & Remediation Guidelines* (2001). The criteria set out in Table 3.1 of this directive identify suitable soil horizon and rating categories for each drilling waste disposal method, as well as acceptable initial soil and final soil/waste salinity endpoints. Appendix 2 describes calculations, correction factors, and soil/waste lab mixes that can provide guidance with respect to meeting the salinity endpoints.

Licensees must ensure that the following salinity related requirements are met.

Licensees must sample the receiving soil of the site at the soil horizon and depth applicable for the disposal method as identified in Table 3.1, and analyze it to verify that the background soil electrical conductivity (EC) and sodium adsorption ratio (SAR) values are within the initial criteria specified in Table 3.1.

For soils that have received previous applications of drilling waste, true background EC and SAR values must also be established by taking samples beyond the perimeter of the drilling waste disposal area. The maximum increases in EC and SAR values set out in Table 3.1 must be relative to true background values.

Licensees must only use the landspray, landspray-while-drilling, disposal onto forested Public Lands, and pump-off disposal methods on topsoils within the good soil rating category.

Licensees must only conduct the landspread and land treatment disposal methods in subsoils that are within the good or fair soil rating category and are at a maximum depth profile of 1 m.

Licensees must only conduct the mix-bury-cover disposal method in subsoils that are deeper than 1 m. Mix-bury-cover disposals occurring at a depth profile between 1 and 1.5 m must only occur on subsoils within the good and fair soil rating categories, while those occurring at a profile deeper than 1.5 m are not restricted to subsoils within specific soil rating categories.

For each disposal method and applicable soil horizon and depth, licensees must ensure that the EC and SAR of the waste/soil mix do not exceed the allowable changes from background soil values as set out in Table 3.1.

Licensees must ensure that drilling waste disposals occurring on topsoils or in shallow subsoils (up to 1 m in depth) within the good soil rating category do not exceed the maximum sodium loading rate of 250 kg/ha for topsoils or 500 kg/ha for shallow subsoils, as specified in Table 3.1.

In the following circumstances, licensees must sample the soil/waste mix after disposal and analyze it to verify that the endpoints set out in Table 3.1 have not been exceeded:

- a) The drilling waste is being managed by the pump-off or disposal onto forested Public Lands method and the waste EC is greater than 5.0 decisiemens per metre (dS/m) or the sodium loading rate exceeds 150 kg/ha.
- b) The drilling waste is being managed by the landspray or landspray-while-drilling disposal method and the waste EC is greater than 10.0 dS/m or the sodium loading rate exceeds 150 kg/ha.
- c) The drilling waste is being managed by the landspread disposal method and the waste EC is greater than 8.0 dS/m or its sodium concentration is greater than 2000 milligrams per litre (mg/L) (results from a saturated paste extract of drilling waste solids or an as-received filtrate of an oversaturated drilling waste).
- d) The drilling waste is being managed by the mix-bury-cover disposal method and the waste EC is greater than 10.0 dS/m or its sodium concentration is greater than 3000 mg/L (results from a saturated paste extract of drilling waste solids or an as-received filtrate of an oversaturated drilling waste).

**Table 3.1.**

<b>Soil salinity endpoints <sup>1</sup> Disposal method</b>	<b>Receiving soil horizon, category, and limiting initial salinity criteria <sup>2</sup></b>	<b>EC changes from background soil conditions (dS/m)</b>	<b>SAR changes from background soil conditions</b>	<b>Maximum sodium loading (kg/ha)</b>
Landspray, landspray while drilling, disposal onto forested public lands, pump-off	Topsoil <sup>3</sup> Good category EC < 2 dS/m SAR < 4	Soil/waste mix limited to a maximum increase of 1 unit beyond background soil EC, but not to exceed an EC <sup>4</sup> of 2 dS/m	Soil/waste mix limited to a maximum increase of 1 unit beyond background soil SAR, but not to exceed a SAR of 4	250
Landspread, land treatment	Subsoil <sup>5</sup> to 1 m Good category EC < 3 dS/m SAR < 4	Soil/waste mix limited to a maximum increase of 2 units beyond background soil EC, but not to exceed an EC of 3 dS/m	Soil/waste mix limited to a maximum increase of 3 units beyond background soil SAR, but not to exceed a SAR of 6	500
Landspread, land treatment	Subsoil to 1 m Fair category EC of 3 to 5 dS/m SAR of 4 to 8	Soil/waste mix limited to a maximum increase of 1 unit beyond background soil EC	Soil/waste mix limited to a maximum increase of 2 units beyond background soil SAR	Not applicable
Mix-bury-cover	Subsoil between 1 and 1.5 m Good or fair category EC ≤ 5 SAR ≤ 8	Soil/waste mix limited to a maximum increase of 2 units beyond background soil EC	Soil/waste mix limited to a maximum increase of 4 units beyond background soil SAR	Not applicable
Mix-bury-cover	Subsoil 1.5 m and deeper Good, fair, poor, or unsuitable category	Soil/waste mix limited to a maximum increase of 3 units beyond background soil EC	Soil/waste mix limited to a maximum increase of 6 units beyond background soil SAR	Not applicable

<sup>1</sup> Note that caution must be exercised when applying saline waste to hay and pasture land where salt-sensitive species are growing. Salt sensitive species include, but are not limited to, red clover, alsike clover, alfalfa, and timothy. The potential for damage to vegetation is especially high when the soil is dry. Extreme caution should be used when conducting disposals on no-till fields in the spring prior to seeding.

<sup>2</sup> Receiving soil categories are defined in accordance with AENV *Salt Contamination Assessment and Remediation Guidelines* (2001).

<sup>3</sup> Topsoil is the uppermost layer(s) of soil that consists of the L, F, H, O, and/or A horizons or the depth of tillage, whichever is greater.

<sup>4</sup> Some plant species will be sensitive to salinity levels below 2 dS/m (e.g., flax, clover, beans, some wheat varieties, peas, some garden crops, some forest species). Drilling waste disposal must not result in adverse effects.

<sup>5</sup> Subsoil is the layer of soil directly below the topsoil that consists of the B and C horizons and extends to bedrock. For salinity management, three depths are recognized: top of the subsoil to a depth of 1 m; subsoil from > 1 m to 1.5 m; and subsoil at a depth > 1.5 m.

### 3.3 Soil Hydrocarbon Endpoints

The EUB has adopted soil endpoints for hydrocarbons from the AENV *Alberta Tier 1 Soil and Groundwater Remediation Guidelines* (2007). Table 3.2 sets out the hydrocarbon soil quality endpoints for soils receiving drilling wastes. Endpoints are identified for coarse and fine grain soils for different land uses: natural area, agricultural, and residential/parkland. Appendix 3 provides guidance for predicting hydrocarbon concentrations for soil/waste mixes and the rationale for protocol revisions related to hydrocarbon endpoints, while equations to predict application rates can be found in Appendix 6.

Licensees must ensure that the following hydrocarbon related requirements are met.

Licensees must prevent soils that receive drilling wastes from exceeding the hydrocarbon endpoints set out in Table 3.2.

Licensees must sample drilling wastes in situations where a hydrocarbon-based drilling mud was used or where a water-based drilling mud was used and a hydrocarbon flag<sup>1</sup> was encountered during drilling. The sample must be analyzed in a lab for benzene, toluene, ethylbenzene, and xylene (BTEX), and hydrocarbon fractions F1 through F4. The analytical results must be used to select an appropriate management method for hydrocarbon-based drilling wastes and to determine spread rates for water-based drilling wastes that will prevent exceedances of the soil quality endpoints set out in Table 3.2.

- a) If a horizontal gas well is the only hydrocarbon flag encountered for a water-based drilling waste, hydrocarbon analyses can be reduced to BTEX and F1 hydrocarbon components; hydrocarbon fractions F2 through F4 are not necessary. Disposal may proceed prior to receipt of the analytical results; BTEX and F1 results must be used to determine the need for post-disposal soil/waste sampling and documented in the well file.

Licensees must sample the soil/waste mix after disposal in the following circumstances and analyze it to verify that the endpoints set out in Table 3.2 have not been exceeded:

- a) water-based drilling wastes being managed by the landspray, landspray-while-drilling, disposal onto forested Public Lands, landspread, or mix-bury-cover disposal methods where a hydrocarbon flag has been encountered and the concentration of any of the hydrocarbon components in the drilling waste exceeds two times the endpoint value for the applicable land use and soil texture as set out in Table 3.2;

- b) hydrocarbon-based or -contaminated drilling wastes being managed by land treatment; and
- c) biodegraded hydrocarbon-based or -contaminated drilling wastes (treated material from biodegradation in a contained system) being managed by the land treatment, mix-bury-cover, or landspread disposal method.

**Table 3.2.**

Soil hydrocarbon endpoints Hydrocarbon fraction	Natural area land use		Agricultural land use		Residential/parkland land use	
	Fine soil <sup>1</sup> (mg/kg)	Coarse soil <sup>2</sup> (mg/kg)	Fine soil (mg/kg)	Coarse soil (mg/kg)	Fine soil (mg/kg)	Coarse soil (mg/kg)
F1 (C <sub>6</sub> -C <sub>10</sub> , excluding BTEX)	210	210	210	24	210	24
F2 (>C <sub>10</sub> -C <sub>16</sub> )	150	150	150	130	150	130
F3 (>C <sub>16</sub> -C <sub>34</sub> )	1300	300	1300	300	1300	300
F4 (>C <sub>34</sub> )	5600	2800	5600	2800	5600	2800
Benzene	0.046	0.078	0.046	0.073	0.046	0.073
Toluene	0.52	0.49	0.52	0.49	0.52	0.49
Ethylbenzene	0.11	0.21	0.11	0.21	0.11	0.21
Xylenes	15	28	15	12	15	12

<sup>1</sup> Fine soils are those that have a median grain size less than 75 microns.

<sup>2</sup> Coarse soils are those that have a median grain size greater than 75 microns.

<sup>1</sup> Hydrocarbon flag means any situation that could introduce hydrocarbons into a water-based drilling waste and includes the following situations:

- the well is a horizontal oil or gas well,
- a diesel pill was added,
- other hydrocarbons were added to the drilling waste through drilling practices such as underbalanced drilling or drillstem testing, and
- the drilling waste contains visible hydrocarbons.

### 3.4 Soil Trace Element Endpoints

The EUB has adopted soil endpoints for trace elements from the AENV *Alberta Tier 1 Soil and Groundwater Remediation Guidelines* (2007); the endpoints are set out in Table 3.3. In situations where the soil/waste mix is expected to exceed the total barium value, licensees can follow AENV *Soil Quality Guidelines for Barite* (2004) to determine if the barite guidelines can be used at a particular site. Appendix 4 provides guidance in predicting trace element concentrations in drilling wastes and soil/waste mixes, while equations to predict application rates can be found in Appendix 6.

Licensees must ensure that the following trace element related requirements are met:

Licensees must prevent soils that receive drilling wastes from exceeding the trace element endpoints set out in Table 3.3 for the appropriate land use.

Licensees must determine the concentration of trace elements in the drilling waste using information from material safety data sheets (MSDS) or other product specification information for each mud additive/product used to formulate the mud system.

Licensees must sample drilling wastes and have the samples analyzed at a lab for trace elements when

- a) the cumulative concentration for any trace element (contributed by all mud additives/products) within the drilling mud system exceeds any of the concentrations set out in Table 3.3, or
- b) there is a lack of mud additive/product information to determine the concentration of the trace elements listed in Table 3.3 in the drilling wastes.

Licensees must use the analytical results to predict drilling waste spread rates that will prevent exceedances of the soil quality endpoints set out in Table 3.3.

If the analytical results for the drilling waste identify any trace elements in excess of the concentrations in Table 3.3, licensees must sample the receiving soil/waste mix after disposal and analyze it to verify that the endpoints in Table 3.3 were not exceeded.

**Table 3.3.**  
**EUB Draft Directive 050: Drilling Waste Management (September 2007) • 17**

Soil trace element endpoints—guideline values Element	Guideline value (mg/kg)		
	Agricultural land use	Natural area land use	Recreational/parkland land use
Antimony	20	20	20
Arsenic (inorganic)	17	17	17
Barium	750	750	500
Barite-barium <sup>1</sup>	3200	3300	3200
Beryllium	5	5	5
Boron (hot water soluble)	2	2	2
Cadmium	1.4	3.8	10
Chromium (total)	64	64	64
Chromium (hexavalent)	0.4	0.4	0.4
Cobalt	20	20	20

Soil trace element endpoints—guideline values Element	Guideline value (mg/kg)		
	Agricultural land use	Natural area land use	Recreational/parkland land use
Copper	63	63	63
Lead	70	70	140
Mercury (inorganic)	6.6	12	6.6
Molybdenum	4	4	4
Nickel	50	50	50
Selenium	1	1	1
Silver	20	20	20
Thallium	1	1	1
Tin	5	5	5
Vanadium	130	130	130
Zinc	200	200	200

<sup>1</sup> Total barium from AENV *Soil Quality Guidelines for Barite* (2004). The guidelines must be followed to determine if the site qualifies as a barite site. If it does not, than the 750 mg/kg total barium value applies.

### 3.5 Receiving Soil Assessment

Licensees must assess background soil conditions, as described below, to determine whether a site is appropriate to receive drilling wastes. Licensees must also use the assessment information to predict drilling waste spread rates that will prevent the soil/waste mix from exceeding salt, hydrocarbon, and trace element endpoints.

For soils that have received previous applications of drilling waste, licensees must determine true background values for EC and SAR and use these values when predicting spread rates to ensure that the allowable changes in EC and SAR from background soil conditions, set out in Table 3.1, are not exceeded.

In some circumstances, licensees must evaluate the resulting soil conditions upon completion of the drilling waste disposal. Therefore, the depth of each pre- and postdisposal sample must be representative of the soil/waste mixing depth for the specific type of disposal.

The assessment of soil conditions is related to the drilling waste disposal method and, as a minimum, licensees must ensure that the soil assessment consists of the following.

Landspray and landspray-while-drilling disposals typically occur on the topsoil of land outside of the well site or remote sump lease boundaries. Land selected for landspray or landspray-while-drilling disposal methods must have a slope that is less than 3 per cent and must not be within 100 m of a water body or water well. Samples to assess pre- and postdisposal (where applicable) soil conditions must be collected as follows:

- a) For every 4 ha of a disposal area, two sampling sites must be selected.



- b) Each sampling site must be a circular area with a 10 m radius, with the centre precisely located and documented (GPS [UTM], along with bearing and metres from a fixed point).
- c) A minimum of one composite sample for a 0 to 10 centimetres (cm) soil profile must be obtained from each sampling site. Each composite sample must be made up of ten subsamples.

Disposal of drilling waste onto forested Public Lands occurs on topsoil under pipeline agreements (PLAs), licences of occupation (LOCs), or mineral surface leases (MSLs) or on access roads or developed roads under an LOC or MSL. Land selected for this disposal method must have a slope that is less than 3 per cent and must not be within 100 m of a water body or water well. Samples to assess pre- and postdisposal (where applicable) soil conditions must be collected as follows:

- a) For every continuous 1 km of disposal distance and/or 1 ha of disposal area, a minimum of one composite sample for a 0 to 10 cm soil profile must be obtained. Each composite sample shall be comprised of three subsamples taken randomly within the distance or area. If the disposal areas are separated by a water body or an unsuitable disposal area, each separate section of the disposal area must be sampled.
- b) The receiving soil sampling site must be a circular area with a 10 m radius, with location (GPS) coordinates known for subsequent resampling.

Pump-off disposals typically occur on the topsoil of land outside of the well site or remote sump lease boundaries. Land selected for pump-off disposals must have a slope that is less than 3 per cent and must not be within 100 m of a water body or water well. Samples to assess pre- and postdisposal (where applicable) soil conditions must be collected as follows:

- a) For each hectare of disposal area, two sampling sites must be selected.
- b) Each sampling site must be a circular area with a 10 m radius, with the centre precisely located and documented (GPS [UTM], along with bearing and metres from a fixed point).
- c) A minimum of one composite sample for a 0 to 10 cm soil profile and for a 10 to 30 cm soil profile must be obtained from each sampling site. Each composite sample must be made up of ten subsamples.

Mix-bury-cover disposals must occur within deeper subsoils (at a depth profile between 1 and 1.5 m or deeper than 1.5 m) on the well site or on a remote sump location. Samples to assess pre- and postdisposal (where applicable) soil conditions must be collected as follows:

- a) For disposal areas that are 500 square meters ( $m^2$ ) or less, a minimum of one composite sample, comprising five subsamples, must be obtained.
- b) For disposal areas that exceed 500  $m^2$ , the area must be divided into equal plots that are no more than 500  $m^2$  in size and one composite sample, comprising five subsamples, must be obtained for each plot.
- c) Each subsample must be collected at the soil depth used for incorporation of the drilling waste (excluding clean fill/cap). Care must be taken to not dilute the waste/soil mix sample with soil taken from above or below the mix depth.

Landspread disposals must occur within shallow subsoils (maximum depth profile of 1 m) on the well site or on a remote sump location. Samples to assess pre- and postdisposal (where applicable) soil conditions must be collected as follows:

- a) For disposal areas that are 500  $m^2$  or less, a minimum of one composite sample, comprising five subsamples, must be obtained.
- b) For disposal areas that exceed 500  $m^2$ , the area must be divided into equal plots that are no more than 500  $m^2$  in size and one composite sample, comprising five subsamples, must be obtained for each plot.
- c) Each subsample must be collected from the 0 to 30 cm soil depth or from the depth of drilling waste/soil incorporation, whichever is less. Care must be taken to not dilute the waste/soil mix sample with soil from below the mix depth.

Each composite sample must be analyzed, as a minimum, for density, texture (i.e., coarse or fine grain), pH, EC, and SAR. The results must be compared to Table 3.1 to verify that the selected receiving soil is eligible for drilling waste disposal and then used to predict the ability for the resulting soil/waste mix to not exceed the soil endpoints. Postdisposal samples may require more extensive analyses, but must be taken from the same locations as the predisposal samples and collected within 60 days of the disposal.

When confirming compliance of the soil/waste mix with the hydrocarbon endpoints set out in Table 3.2, the analyses must be conducted on discrete soil samples, not composite samples.

Each sampling site must be representative of the landscape in the proposed disposal area and of the most sensitive part of the landscape (e.g., convergent footslopes and toeslopes are usually the most sensitive parts of the landscape and

may have naturally higher levels of sodium and sulphate or may have concentrated parameters from previous drilling waste disposals).

The sampling site must be representative of any previous drilling waste disposals that occurred within the disposal area.

The assessment of sites selected for sump construction or for land treatment and biodegradation in a contained system is more detailed than described above and is set out in Sections 6 and 13, respectively.

**Appendix 4:**

**Drilling Waste Assessment**

## **Drilling Waste Assessment**

**4.1 General Drilling Waste Sampling and Assessment** Appropriate sample collection, preservation, and storage are critical to obtain the data required to assess drilling wastes. The data, which are used to develop treatment or management plans, are only as valid as the sample. Licensees must obtain representative samples of the drilling waste for each discrete sump or drilling waste storage system at a given location. The sampling program must be designed to provide the information to support the specific program used to manage the drilling waste. Separate management of the different phases of the drilling waste requires that each phase (e.g., clear liquids, fluids, or solids) be sampled, whereas a total waste sample must be taken if the fluid and solid phases are to be managed together. In addition, licensees must separate and sample different mud systems used to drill different sections of a well and appropriately manage the separated drilling wastes.

### **4.2 Drilling Waste Sampling**

For sumps or drilling waste storage systems of an area less than or equal to 500 m<sup>2</sup>, licensees must collect samples from five locations. For sumps/storage systems of an area greater than 500 m<sup>2</sup>, licensees must sample one location for each 100 m<sup>2</sup> to a maximum of ten locations. The minimum distance at which samples should be taken from the edge of a sump is 1 m.

#### **Fluid Phase Sampling**

To collect the fluid phase of a sump:

- Collect individual subsamples according to the planned disposal procedure. Include any hydrocarbon layer in the sample if hydrocarbon will not be removed prior to disposal.
- Prepare a composite sample with equal amounts of five subsamples. Portions of the composite sample should be subsampled into containers as follows:
  - for trace element and major ion analyses, a minimum of 1 L in an uncoloured plastic container,
  - for toxicity assessment, 1 L in an acid-washed borosilicate glass container with a Teflon-lined lid, and
  - for hydrocarbons, 1 L in a properly cleaned glass jar with a Teflon-lined lid.

#### **Clear Liquid Phase Sampling**

To collect the clear liquid phase of a sump:

- Collect individual subsamples according to the planned disposal procedure.

- Prepare a composite sample with equal amounts of five subsamples. Portions of the composite sample should be subsampled into containers as follows:
  - for trace element and major ion analyses, a minimum of 1 L in an uncoloured plastic container,
  - for toxicity assessment, 1 L in an acid-washed borosilicate glass container with a Teflon-lined lid, and
  - for total dissolved hydrocarbons, 40 millilitres (mL) of the composite sample in a septum-capped glass vial. Fill vial to overflowing and replace cap securely.

### **Solid Phase Sampling**

To sample the solid phase of a sump:

- Place a minimum of 2 kg of the composite sample, comprising equal amounts of five subsamples, in an uncoloured plastic container. If a plastic bag is used, care must be taken to avoid losing sample (puncture, leakage) and obscuring the sample label. Double or triple bagging is recommended.
- For oil content, place 1 L of the composite in a properly cleaned glass jar with a Teflon-lined lid.

### **Total Waste Sampling**

To obtain a total waste sample of a sump:

- Take a sample of the entire depth of the sump, encompassing both the fluid and solid phase. **A total waste sample must not be made up of individually sampled fluid and solid phases.**
- Collect individual subsamples according to the planned disposal procedure.
- Prepare a composite sample with equal amounts of five subsamples.

Portions of the composite sample should be subsampled into containers as follows:

- for trace element and major ion analyses, a minimum of 1 L in an uncoloured plastic container,
- for toxicity assessment, 1 L in an acid-washed borosilicate glass container with a Teflon-lined lid, and
- for oil content, 1 L in a properly cleaned glass jar with a Teflon-lined lid.

See Appendix 6 for more information on drilling waste sampling.

### 4.3 Drilling Waste Toxicity Assessment

The luminescent bacteria toxicity test has been established as the industry standard for the evaluation of drilling waste toxicity. The EUB has set a pass threshold of 75 per cent for an EC50(15) (i.e., the aqueous concentration of the drilling waste that halves the initial light output of the luminescent bacteria after 15 minutes must be 75 per cent or greater). Refer to Appendix 5 for reference methods and procedures for toxicity testing using luminescent bacteria, as well as for details regarding the drilling fluid additive/mud product listing for potential toxicity (i.e., Petroleum Services Association of Canada [PSAC] Mud List).

Assessment of drilling waste toxicity is related to the drilling mud system, as well as the disposal method, and licensees must meet the following toxicity assessment related requirements.

Drilling wastes being managed by the landspray-while-drilling or disposal onto forested Public Lands method are limited to nontoxic, freshwater gel chemical mud systems and are not required to be tested for toxicity. Licensees must manage drilling waste from these mud systems by another disposal method if changes to the drilling program present any uncertainties as to whether the drilling waste

- will pass a luminescent bacteria toxicity test ( $EC[50] \geq 75$  per cent),
- contains fluid additives/mud products that are not on the PSAC Mud List, or
- contains fluid additives/mud products in concentrations exceeding the PSAC Mud List toxicity threshold level.

Drilling wastes being managed by the landspray or pump-off disposal method must pass a luminescent bacteria toxicity test ( $EC50[15] \geq 75$  per cent) prior to disposal. Licensees must manage drilling waste by another method if the drilling waste fails the toxicity test.

Licensees must assess drilling wastes being managed by the landspraying or mix-bury-cover method for toxicity (luminescent bacteria toxicity test [ $EC50(15) \geq 75$  per cent] if

- the drilling fluid/mud system contains one or more fluid additives/mud products at a level above the toxicity threshold level on the PSAC Mud List,
- the drilling fluid/mud system contains an additive/product for which a PSAC Mud List toxicity threshold level has not yet been established, or
- a hydrocarbon flag was encountered (see Section 3.3).

If the drilling waste passes the toxicity test and all other disposal parameters are met, then disposal can take place.

If the drilling waste assessed in accordance with requirement 2 or 3 above fails the toxicity assessment, licensees must have a sample of the drilling waste treated with coarse activated carbon (charcoal) in a lab and then have the charcoal-treated sample tested for toxicity using luminescent bacteria.

Treatment of a drilling waste sample with charcoal is designed to identify those wastes that are toxic due to their content of weakly water-soluble chemicals, such as hydrocarbons. In cases where hydrocarbon was added to the drilling waste and the test is expected to show toxic effects, the initial toxicity test can be conducted on the charcoal treated sample of drilling waste.

If the charcoal-treated drilling waste from requirement 4 above passes the toxicity test ( $EC_{50}[15] \geq 75$  per cent), licensees must have the drilling waste tested for hydrocarbon content (BTEX and hydrocarbon fractions F1 to F4; see Section 3.3). If hydrocarbons are detected, licensees must review the mud products used, as well as the drilling operations and completion practices, to rule out the potential for the presence of compounds that could contribute to toxicity but were masked by the hydrocarbons. Licensees can only proceed with drilling waste disposal if all the disposal parameters for the chosen disposal method can be met and there is confirmation that hydrocarbons are the only source of toxicity. If hydrocarbons are not detected, licensees must gather further data to determine the cause of the toxicity.

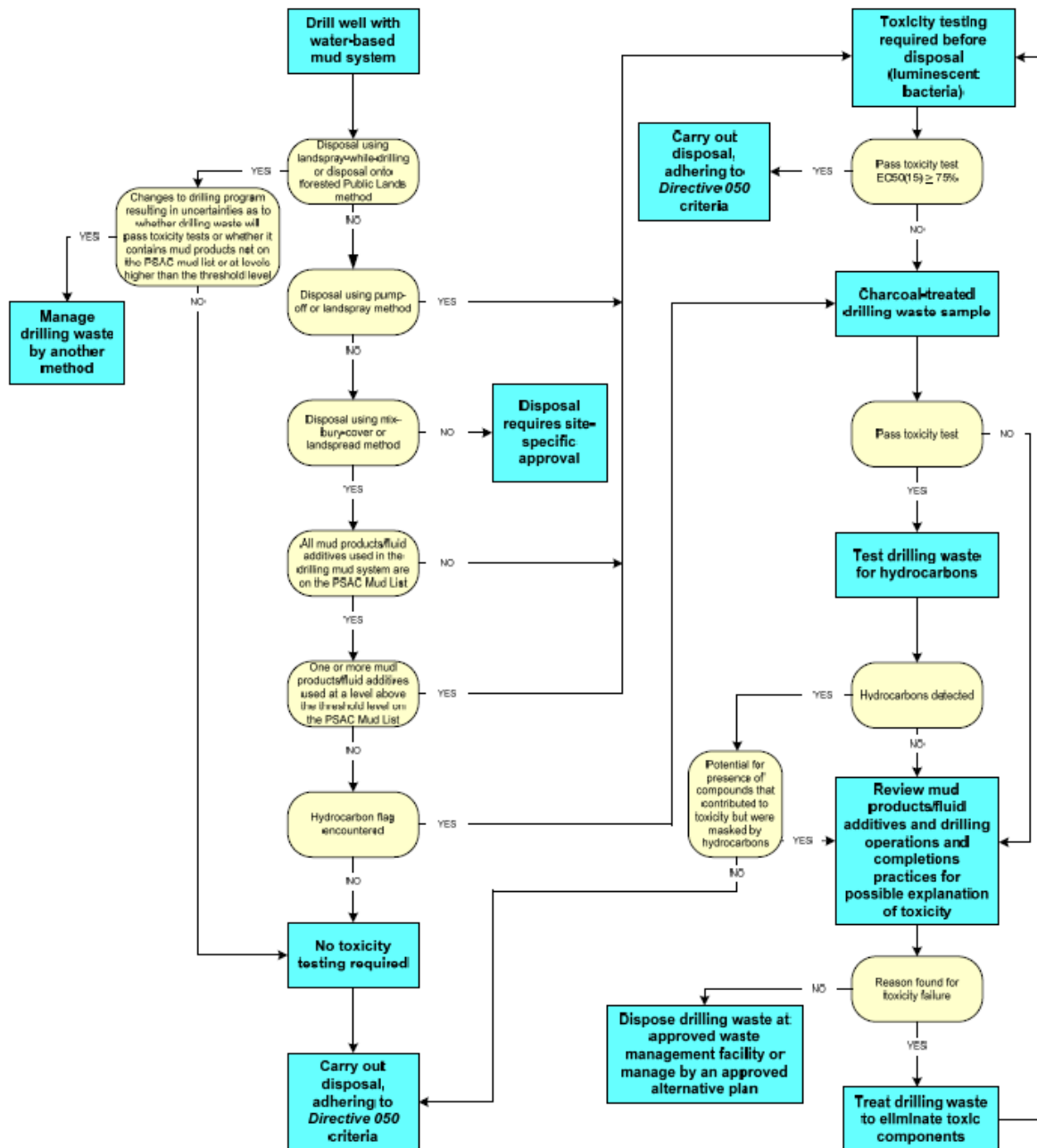
If the cause of toxicity cannot be determined or if the toxicity of the drilling waste cannot be controlled, licensees must send the drilling waste to an approved waste management facility or manage the drilling waste according to an alternative plan that has been approved by the EUB.

Toxicity that cannot be attributed to hydrocarbon content indicates that the drilling waste needs treatment and retesting before disposal. The PSAC Mud List should be examined for toxicological information on individual fluid additives/mud products. Operating practices at the well site should be reviewed to determine whether other conditions could have caused toxicity to develop (e.g., adding camp sewage or rig waste, such as chain oil, pipe dope, and rig wash, to the sump or storage system).

Additional lab testing may be required to determine if field treatment methods will reduce toxicity. This may include alternative toxicity assessments, aeration, pH adjustment, charcoal addition, flocculation, centrifugation, filtration, chemical precipitation, chemical oxidization, and natural biodegradation over time. Any in-field treatments must be followed by a retesting of the drilling waste to confirm that it meets the toxicity requirements. If time allows, acute terrestrial testing could be used to identify toxic constituents.



Figure 4.1 outlines the decision-making process described in this section.



## **Appendix 5**

### **Pump Off**

## 9 Pump-off

### 9.1 Introduction

The pump-off disposal method involves pumping the clear liquid portion of drilling wastes onto land that is usually vegetated through irrigation equipment, such as a big gun, sprinkler, gated pipe, or perforated hose. Application rates must be calculated to ensure that the receiving soil meets the endpoints set out in Section 3 directly after the drilling waste is applied and without the need to incorporate it into soil.

While pump-off is normally used as an off-site management option, this does not preclude pumping off small volumes on the well site that generated the drilling waste or on a remote sump site, provided the drilling waste was stored on the remote sump site. Small volumes of clear fluids may be pumped off onto access roads to the well site or on pipeline rights-of-ways provided these locations are leased or owned by the licensee and landowner/department/agency approval has been obtained.

### 9.2 Pump-off Requirements

Licensees must ensure that the following pump-off requirements are met:

Licensees must only use the pump-off disposal method for the portion of drilling wastes that qualify as clear liquids (i.e., fluids that appear nonturbid when sampled from the discharge point and may be colourless or have natural colour or staining).

Licensees must sample and analyze the clear liquids to ensure that they

- a) do not contain any visible hydrocarbons (defined as the observance of a rainbow sheen or an extractable petroleum hydrocarbon content [sum of the concentrations of the F2 to F4 fractions] greater than 100 mg/L);
- b) have a pH that is between 5.5 and 8.5; if the pH is adjusted, it must be reverified before pumping off; laboratory analysis is not required for a pH adjustment of less than 2 units;
- c) have an EC that does not exceed 10 dS/m; and
- d) pass a toxicity test before disposal (see Section 4.3); if the initial toxicity assessment fails, but passes after being charcoal treated, the fluids must be analyzed for BTEX and F1 to F4 hydrocarbon fractions and the sum of the results must be less than 100 mg/L for pump-off to proceed.

The receiving soil must be assessed as set out in Section 3.5 to determine its suitability for the pump-off disposal method and consent from the landowner or department/agency managing the land on behalf of the

provincial or federal Crown (see Section 1.6) must be obtained prior to the commencement of any pump-off activities.

The application rate must be no less than 100 m<sup>3</sup>/ha, but no greater than 1000 m<sup>3</sup>/ha.

Pump-off disposal of drilling wastes must not

- a) result in pooling, runoff, or land erosion,
- b) occur within 100 m of a water well or any water body,
- c) occur on land that has a slope that exceeds 3 per cent, or
- d) be discharged in a location where it could be reasonably expected to enter a water body.

If the waste is treated, licensees must resample and reanalyze it to determine the applicability of this disposal method.

Licensees must conduct post-disposal sampling of the soil/waste mix and compare the results to the applicable soil endpoints set out in Section 3 if

- a) the EC of the clear liquid exceeds 5.0 dS/m—analyze for EC and SAR, or
- b) the sodium loading rate exceeds 150 kg/ha—analyze for Na and SAR.

Table 9.1. Summary of pump-off disposal method

Preapplication conditions	Waste application rates/limits	Postapplication conditions	Testing requirements
<p>Receiving soil</p> <ul style="list-style-type: none"> <li>• topsoil with EC &lt; 2 dS/m, SAR &lt; 4</li> </ul> <p>Site</p> <ul style="list-style-type: none"> <li>• slope must be less than 3%</li> <li>• 100 m setback from a water well and a water body</li> <li>• not a location where it could be reasonably expected that discharged drilling waste could enter a water body</li> <li>• landowner or Crown department/agency consent for disposal</li> </ul> <p>Waste</p> <ul style="list-style-type: none"> <li>• limited to clear liquid portion of water-based drilling waste</li> <li>• must pass a toxicity assessment</li> </ul>	<p>Clear liquids</p> <ul style="list-style-type: none"> <li>• pH between 5.5 and 8.5</li> <li>• EC ≤ 10 dS/m</li> <li>• no visible hydrocarbons (no rainbow sheen or total petroleum hydrocarbons ≤ 100 mg/L)</li> <li>• if fails initial toxicity assessment, but passes after being charcoal treated, analyze for hydrocarbons; if total petroleum hydrocarbons &gt; 100 mg/L, do not proceed with pump-off</li> <li>• application rate between 100 m<sup>3</sup>/ha and 1000 m<sup>3</sup>/ha</li> <li>• pump-off must not result in pooling, runoff, or land erosion</li> </ul>	<p>Soil/waste mix limited to a maximum increase of 1 unit beyond background soil EC and SAR, but not to exceed an EC of 2 dS/m and an SAR of 4</p> <p>Maximum Na loading rate: 250 kg/ha</p> <p>Soil/waste mix must not exceed soil hydrocarbon and trace element endpoints in Tables 3.2 and 3.3</p>	<p>Receiving soil</p> <ul style="list-style-type: none"> <li>• EC and SAR</li> <li>• grain size</li> </ul> <p>Clear liquids</p> <ul style="list-style-type: none"> <li>• pH, EC, SAR, Na</li> <li>• toxicity assessment</li> <li>• hydrocarbons, if initial toxicity assessment fails, but passes after being charcoaled treated</li> </ul> <p>Waste/soil mix</p> <ul style="list-style-type: none"> <li>• EC, SAR, and Na, if clear liquids exceed an EC of 5 dS/m or if the Na loading rate exceeds 150 kg/ha</li> </ul>

**Appendix 6:**

**Mix, Bury, Cover**

## 10 Mix-Bury-Cover

### 10.1 Introduction

The mix-bury-cover (MBC) disposal method involves mixing drilling waste solids or total waste with subsoils on the well site or remote sump site, at a depth profile of 1 to 1.5 m or deeper than 1.5 m, to form a stabilized waste/soil mass that resides below the major rooting zone. **MBC must not be used for drilling wastes resulting from the use of hydrocarbon-based mud systems, unless the waste has undergone biodegradation.**

Typical mix-bury-cover methods are to

- mix waste and subsoil in the sump and cover;
- mix waste from the sump and subsoil on the surface, then put the mixture back in the sump and cover;
- bail the waste from the sump onto the lease surface, mix with the subsoil, and bury when filling in a cut; or
- spread the waste on the lease surface and allow it to dry; put the waste back into the sump, then mix and cover.

Well licensees can use on-site management techniques (e.g., dewatering systems, solids control) or new and innovative technologies to pretreat drilling waste prior to use of this method. Refer to Section 16 regarding EUB approval for use of new technologies or treatment methods. The use of dewatering equipment, such as centrifuges or shakers, does not require EUB approval.

### 10.2 Mix-Bury-Cover Requirements

Licensees must comply with the following MBC requirements.

Licensees must sample the drilling waste by taking either

- a) a total waste (fluids and solids) sample, if both phases are being managed by MBC, or
- b) a solids sample, if only the solid phase is being managed by MBC.

Licensees must have the sample analyzed for the parameters listed below and use the results to determine the soil/waste mix ratio that will prevent the receiving soil from exceeding the soil endpoints set out in Section 3:

- a) pH,
- b) EC,

- c) SAR,
- d) nitrogen (N), if more than 400 kg of N were added to the mud system,
- e) trace elements, if the cumulative concentration of trace elements in mud additives/products added to the drilling mud system exceed the values set out in Table 3.3, and
- f) hydrocarbons (i.e., BTEX and F1 to F4 hydrocarbon fractions), if a hydrocarbon flag as encountered:
  - i) if a horizontal gas well was the only hydrocarbon flag encountered, the hydrocarbon analysis can be reduced to purgeable hydrocarbons (BTEX and F1 hydrocarbon fraction); disposal can proceed prior to receipt of the result; the disposal must be documented as being hydrocarbon flagged and the BTEX and F1 results must be included in the documentation for the well file and used to determine the need for postdisposal sampling of the soil/waste mix.

Licensees must also test the sample for toxicity if mud additives/products were added to the drilling mud system in concentrations exceeding the PSAC toxicity threshold levels (see Section 4.3) or if a hydrocarbon flag was encountered. The sample must pass the toxicity test; for those drilling wastes that only pass the toxicity test after being charcoal treated, licensees must confirm that the toxic response was due to the presence of hydrocarbon.

Licensees must assess the receiving soil as set out in Section 3.5 to determine its suitability for the MBC disposal method.

The subsoil and drilling waste must be mixed in a ratio of at least three parts subsoil to one part drilling waste. In addition,

- a) licensees may use predictive lab mixes or calculations to determine the soil/waste mix ratio for drilling wastes with an EC less than 10 dS/m or an Na concentration less than 3000 mg/L (in saturated paste extract or filtrate from oversaturated sample), and
- b) licensees must use predictive lab mixes to determine the soil/waste mix ratio for drilling wastes with an EC of 10 dS/m or more and an Na concentration of 3000 mg/L or greater (in saturated paste extract or filtrate from oversaturated sample).

Predictive lab or calculated mix ratios exceeding seven parts soil to one part waste preclude the opportunity to proceed with MBC operations (alternative options include treating and retesting the waste to verify the suitability of the method or choosing a more appropriate disposal method).

The disposal of drilling waste resulting in more than 400 kg nitrogen/ha must be restricted to subsoils of limited permeability (i.e., clay content of at least

20 per cent, a plasticity index [PI] equal to or greater than 10, and a liquid limit [LL] equal to or greater than 30).

The subsoil/waste mixture must be covered by a minimum of 1 m of clean fill. The EC and SAR of the clean fill must meet AENV *Salt Contamination Assessment & Remediation Guidelines* (2001) for the applicable soil rating category and depth at which it will be used.

Note that the use of naturally saline subsoils as the fill material may introduce unacceptable levels of salts within the rooting zone, and may interfere with the final reclamation process and objective to restore the site to equivalent land capability.

Licensees must not conduct the MBC disposal operation within 50 m of an on-site water well.

If the MBC disposal does not occur within 30 days from the sampling date, reasonable steps must be taken to ensure that the chemical and physical properties of the drilling waste have not be altered (i.e., change in chemistry, addition of more drilling waste or other materials); otherwise licensees must resample and reanalyze the drilling waste.

If the site has been previously used for disposal, the MBC disposal may proceed only if

- a) the soil quality endpoints set out in Section 3 will not be exceeded (the salinity levels must be relative to true background soil conditions),
- b) the MBC disposal occurs on an area of the site not previously used for drilling waste disposal and all MBC requirements are met,
- c) the landowner/department/agency consents to the additional disposal (see Section 1.6), and
- d) the use of the site for multiple disposals has not exceeded a duration of 5 years, and any reuse of a sump or alternative storage system has followed the requirements set out in Section 5.6.

Licensees must conduct post-disposal sampling of the soil/waste mix and compare the results to the applicable soil endpoints set out in Section 3 if

- a) the EC of the drilling waste exceeds 10 dS/m or the Na content of the drilling waste exceeds 3000 mg/L (in saturated paste extract or filtrate from oversaturated sample)—analyze for EC, SAR, and Na,



- b) the concentrations of trace elements in the drilling waste exceed the concentrations set out in Table 3.3—analyze for trace elements, or
- c) the concentration of hydrocarbons in the drilling waste exceeds two times the concentration for any of the parameters listed in Table 3.2 for the applicable land use type and soil type—analyze for BTEX and F1 to F4 hydrocarbon fractions.
  - i) If the only hydrocarbon flag encountered was a horizontal gas well, hydrocarbon analysis can be reduced to BTEX and F1 hydrocarbon components.

**Table 10.1.**

Summary of mix-bury-cover disposal method Preapplication conditions	Waste application rates/limits	Postapplication conditions	Testing requirements
<p>Receiving subsoil</p> <ul style="list-style-type: none"> <li>• between 1 and 1.5 m:</li> </ul> <p>≤ 5 dS/m, SAR ≤ 8</p> <ul style="list-style-type: none"> <li>• deeper than 1.5 m:</li> </ul>	<p>Solids or total waste</p> <ul style="list-style-type: none"> <li>• nitrogen: &gt; 400 kg/ha, restricted to subsoils with clay content ≥ 20%, PI ≥ 10, LL ≥ 30</li> </ul>	<p>Soil/waste mix limited to a maximum increase of</p> <ul style="list-style-type: none"> <li>• 2 units for EC and 4 units for SAR beyond background soil</li> </ul>	<p>Receiving soil</p> <ul style="list-style-type: none"> <li>• EC and SAR</li> <li>• clay content, PI, LL,</li> </ul>
<p>EC or SAR limits</p> <p>Site</p> <ul style="list-style-type: none"> <li>• 50 m setback distance between MBC operation and an on-site water well</li> </ul>	<p>hydrocarbon flag encountered (other than horizontal gas well), analyze drilling waste and use BTEX and F1 to F4 hydrocarbon results to calculate spread rates to prevent exceedances of criteria in Table 3.2</p>	<p>Soil/waste mix limited to a maximum increase of</p> <ul style="list-style-type: none"> <li>• 2 units for EC and 4 units for SAR beyond background soil</li> <li>• 3 units for EC and 6 units for SAR for MBC depths below 1.5 m</li> </ul>	<p>, if &gt; 400 kg of N were added to drilling waste</p> <ul style="list-style-type: none"> <li>• grain size</li> </ul>
<p>restricted to well site or remote sump site</p> <p>Waste</p> <ul style="list-style-type: none"> <li>• water-based drilling wastes or biodegraded hydrocarbon-based drilling wastes</li> <li>• solids or total waste</li> <li>• must pass a toxicity assessment if a hydrocarbon flag was encountered or mud additives/products were used in concentrations exceeding the PSAC toxicity threshold levels</li> </ul>	<p>hydrocarbon flag encountered (other than horizontal gas well), analyze drilling waste and use BTEX and F1 to F4 hydrocarbon results to calculate spread rates to prevent exceedances of criteria in Table 3.2</p>	<p>Soil/waste mix must not exceed soil hydrocarbon and trace element endpoints in Tables 3.2 and 3.3</p>	<p>Waste (solids or total waste)</p> <ul style="list-style-type: none"> <li>• pH, EC, SAR</li> <li>• N, if &gt; 400 kg of N were added to mud system</li> </ul>
<p>horizontal gas well is the only hydrocarbon flag, disposal may proceed, but analyze drilling waste for BTEX and F1; use results to determine need for post-disposal sampling</p>	<p>cumulative concentrations of trace elements in mud additives/products exceed values in Table 3.3, analyze drilling waste for trace elements; use results to calculate spread rates</p> <p>Subsoil/waste mixture must be at least 3 parts subsoil to 1 part drilling waste, but cannot exceed 7 parts subsoil to 1 part drilling waste</p> <p>Lab mixes must be used to determine soil/waste mix ratio when drilling waste EC ≥ 10 dS/m or Na ≥ 3000 mg/L (saturated paste extract or filtrate from oversaturated waste)</p>	<p>Soil/waste mix must not exceed soil hydrocarbon and trace element endpoints in Tables 3.2 and 3.3</p> <p>A minimum of 1 m of clean subsoil must cover soil/waste mixture</p>	<p>Waste (solids or total waste)</p> <ul style="list-style-type: none"> <li>• pH, EC, SAR</li> <li>• N, if &gt; 400 kg of N were added to mud system</li> <li>• trace elements, if concentrations exceeding Table 3.3 were added to the drilling mud system</li> <li>• hydrocarbons, if a hydrocarbon flag was encountered</li> <li>• toxicity assessment, if hydrocarbon flagged or potential mud additives/products toxicity</li> </ul>
			<p>Waste/soil mix</p> <ul style="list-style-type: none"> <li>• EC, SAR, and Na, if drilling waste EC &gt; 10 dS/m or Na &gt; 3000 mg/L (saturated paste extract or filtrate from oversaturated waste)</li> <li>• trace elements, if concentrations in drilling waste exceed Table 3.3</li> <li>• hydrocarbons, if concentrations in the drilling waste exceed two times any of those in Table 3.2 (only BTEX and F1 if horizontal gas well)</li> </ul>