

Waste treatment and disposal options for the oil & gas sector

Module 3

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Government's role

- National government should have firm policies in place related to the management of the various waste streams along with providing clarity about the conditions upon which options can be approved.
- Operators are responsible for the management of the wastes generated and selection of the handling and disposal options in compliance with government's policies, requirements, preferred options, and restrictions, if any.

Required waste management information

For government to execute its role and to define a waste management policy direction, there is a need to:

- Identify the main waste streams that are expected to be generated during the various phases of offshore exploration and production activities.
- Characterize these wastes to the extent possible (quantities and quality).
- Identify and review waste management options using a set of pre-defined comparative criteria.

Government policy makers

- The main government policy makers in this context are:
 - Ministry of Environment
 - Ministry of Energy & Water
 - National Petroleum Administration
 - Or other similar agencies or ministries
- The oil-companies should apply the Government's policies to the development of their Waste Management Plans – which should in turn be submitted for review and approval prior to implementation.

Development of a waste management framework

- To develop a national strategic waste management framework, several interrelated activities should be undertaken, including reviewing the following:
 - International strategies, best practices & technologies for the O&G sector, taking into consideration the waste management hierarchy and different waste management phases.
 - The local context including legal, regulatory and institutional considerations in relation to waste management.
 - Existing infrastructure and technological capabilities available within Lebanon.

Key waste streams

Key waste streams anticipated are:

- Drilling fluids (water based, oil based and synthetic based)
- Drilling cuttings (water based, oil based and synthetic based)
- Cementing wastes
- Produced water
- Hypersaline produced water
- NORM wastes

Waste volumes

To calculate waste volumes, these assumptions were made by consultants:

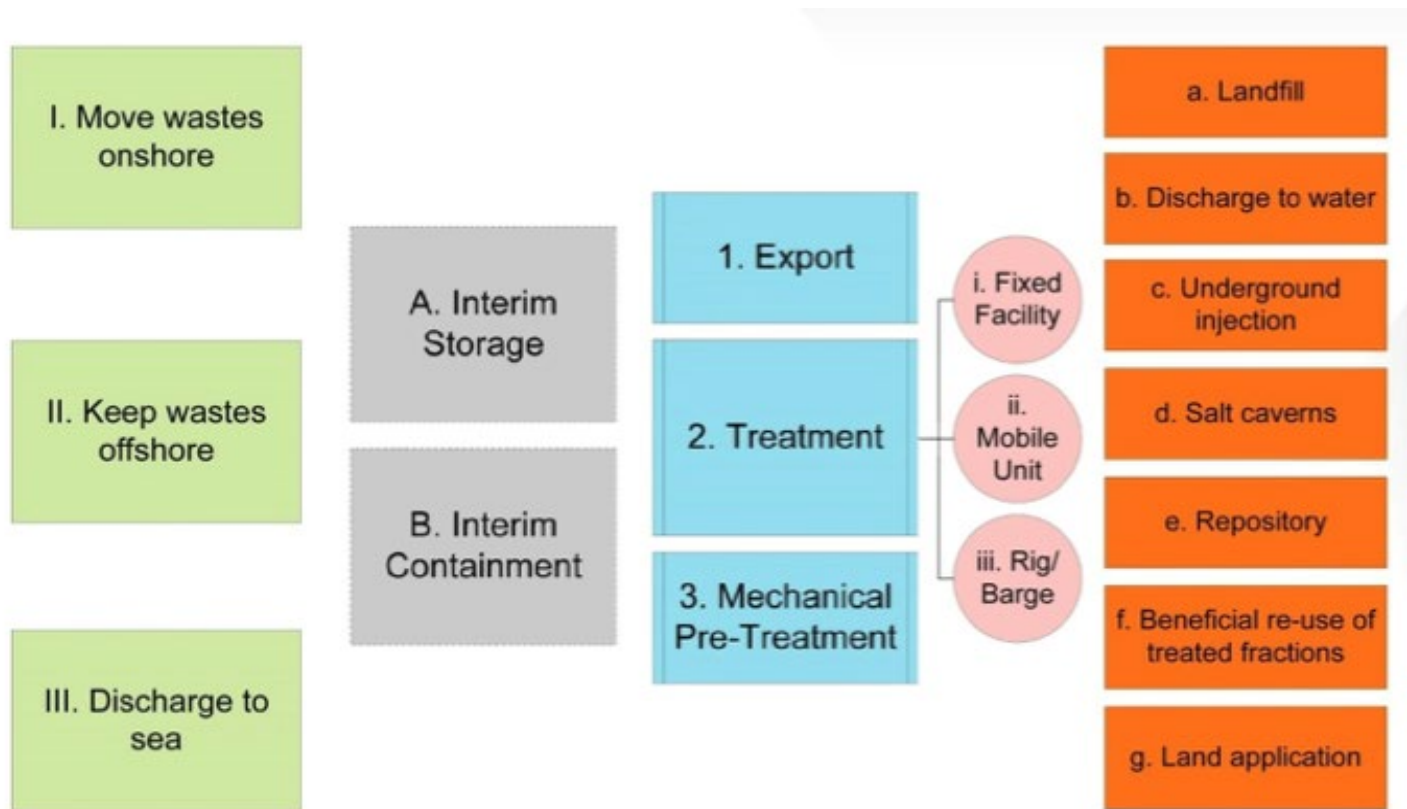
- Up to two exploration wells could be drilled in a single year
- Drilling depths of 4,400 meters from the sea bottom are used for calculations purposes
- Production rates of hydrocarbons will range from 0.2 tcf/year for gas (with no oil production) and a higher estimate of 1.1 tcf/year of gas and up to 13 million barrels of oil per year

Waste volumes

Waste Type (Exploration)	Total Waste per Well [m ³]	Waste Volume per Well [m ³]	Annual Volume of Waste [m ³]	Storage Area for 1 year [m ²]	Storage Area for 5 years [m ²]
Wet Drill Cuttings from <u>WBF</u>	7,642.60	432.60	865.20	1,300	6,500
Dirty <u>WBF</u>		7,210.00	14,420.00	21,630	108,150
Wet Drill Cuttings from <u>OBF</u>	2,671.50	1,153.60	2,307.20	3,460	17,300
Dirty <u>OBF</u>		1,517.90	3,035.80	4,555	22,775
Wet Drill Cuttings from <u>SBF</u> ²	5157.05	793.10	1,586.20	2,379	11,897
Dirty <u>SBM</u>		4,363.95	8,727.90	13,092	65,460
Cementing Wastes	110	110	220	330	1,650

Based upon these assumptions, the consultants produced estimates of waste generation and the storage space required to accommodate them throughout the exploration phase.

Managing offshore waste



WBDF disposal options

The analysed disposal options are subdivided into four strategic options for handling and disposal of water-based drilling fluids:

- Export (with or without onshore storage prior to export)
- Ship-to-shore for treatment/reuse/disposal (with fixed or mobile treatment facilities)
- Injection (offshore or onshore, with or without interim storage)
- Discharge to sea (with or without recovery of reusable fractions)

Waste disposal options evaluation

Evaluation Criteria	Sub-Criteria	I.a ¹	I.A.1 ^{2, 13}	I.A.2.i.a / I.2.i.a ³	I.A.2.ii.a / I.2.ii.a ⁴	I.A.2.i.f (a) / I.A.2.ii.f (a) ⁵	I.A.3.c / I.3.c ⁶	I.A.g / I.g ⁷	II.B.1 ⁸	II.B.2.iii.f (b) ⁹	II.3.c / II.B.3.c ¹⁰	III.3 ^{11, 12}
<u>Suitability</u>	<u>Environmental Impacts</u>	Yellow	Yellow	Yellow	Yellow	Green	Red	Yellow	Green	Yellow	Green	Red
	<u>Compliance with international conventions / standards</u>	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
	<u>In-country Value Addition</u>	Green	Yellow	Green	Green	Green	Yellow	Yellow	Red	Yellow	Red	Red
	<u>Effort to Regulator (Controllability)</u>	Green	Yellow	Yellow	Yellow	Green	Red	Yellow	Yellow	Red	Yellow	Red
	<u>Alignment with Industry Trends</u>	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Yellow
<u>Feasibility</u>	<u>Technical Practicability / Availability</u>	Yellow	Green	Yellow	Yellow	Green	Red	Yellow	Green	Yellow	Red	Yellow
	<u>Transportation/transfer requirements</u>	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Green	Green	Green
	<u>Infrastructure/ Land Requirements</u>	Yellow	Green	Green	Green	Green	Yellow	Green	Green	Green	Green	Green
	<u>Performance / Reliability</u>	Yellow	Green	Green	Green	Green	Yellow	Yellow	Green	Yellow	Yellow	Green
	<u>Cost</u>	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Green	Yellow	Green	Yellow	Green
<u>Acceptability</u>	<u>Public acceptance (expected)</u>	Red	Green	Yellow	Yellow	Yellow	Red	Red	Green	Yellow	Green	Red

Preferred waste disposal options

Waste Stream	Preferred option
1. <u>WBDE</u>	<ul style="list-style-type: none">• <u>During Exploration:</u><ul style="list-style-type: none">○ Disposed of outside of Lebanon preferred option.○ IF excessive costs will be incurred, seek approval for <u>off-shore</u> disposal.• <u>During development and Production:</u><ul style="list-style-type: none">○ <u>reinjection</u> offshore or treatment ashore always following minimization of waste generation.
2. <u>WB Cutings</u>	<ul style="list-style-type: none">• <u>Exploration Phase:</u><ul style="list-style-type: none">○ <u>processing</u> of drill cuttings, stabilization/solidification followed by controlled disposal offshore,○ <u>ship</u> to shore for treatment, recovery of residues, and controlled disposed at sea of stabilized residues,○ Shipment outside Lebanon for treatment/disposal (as per Basel Convention requirements).• <u>During Development & Production</u><ul style="list-style-type: none">○ Reinjection offshore or treatment offshore or onshore with ultimate disposal of stabilized cuttings in the sea to act as artificial reefs.○ Disposal of water-based drill cuttings in the sea generated during development drilling is not allowed.

Preferred waste disposal options

Waste Stream	Preferred option
3. Oil & Synthetic BDF	<ul style="list-style-type: none"> • <u>Exploration Phase:</u> <ul style="list-style-type: none"> ○ Operators are encouraged to always use <u>WBDF</u> wherever possible. ○ Spent <u>QBDF</u> & <u>SBDF</u> should be: <ul style="list-style-type: none"> ▪ <u>disposed</u> of outside Lebanon (as per Basel Convention requirements); ▪ <u>controlled</u> disposal of stabilized/solidified residues in areas of low ecological significance ; ▪ <u>disposed</u> of in underground salt caverns onshore. ○ Disposal in Lebanese water is prohibited. • <u>During Development & Production</u> <ul style="list-style-type: none"> ○ <u>reinjection</u> offshore or treatment onshore.
4. Oil & Synthetic cuttings	<ul style="list-style-type: none"> • <u>Exploration Phase:</u> <ul style="list-style-type: none"> ○ Stabilization/solidification followed by controlled disposal offshore (not on continental-shelf). ○ Ship-to-shore for treatment, recovery of residues, and controlled disposed at sea of stabilized residues. ○ Shipment outside Lebanon for treatment/disposal (as per Basel Convention requirements), ○ Disposal onshore in underground salt caverns, if available and feasible. • <u>During Development & Production:</u> <ul style="list-style-type: none"> ○ Reinjection, or <u>treatment offshore</u> with ultimate disposal in the sea to act as artificial reefs. ○ As soon as a commercial discovery is made, private sector investment in a central waste management facility in Lebanon should be promoted.

Preferred waste disposal options

Waste Stream	Preferred option
5. Cementing Waste	<ul style="list-style-type: none"> • Exploration Phase: <ul style="list-style-type: none"> ○ Direct disposal (after pre-treatment) in the sea is not allowed. ○ Treatment onshore, stabilization and solidification followed by controlled disposal at the sea; ○ Treatment offshore, stabilization and solidification followed by controlled disposal at the sea; ○ Shipment outside Lebanon for treatment/disposal (as per Basel Convention requirements); ○ Disposal onshore in underground salt caverns, if available and feasible. • During Development & Production: <ul style="list-style-type: none"> ○ Re-injection <u>off-shore</u>.
6. Produced Water & <u>Hypersaline</u> Produced Water	<ul style="list-style-type: none"> • Onshore treatment / disposal prohibited. • The preferred option is reinjection offshore. • If reinjection is not feasible then disposal at sea is an option following <u>OSPAR's</u> risk-based approach. • No discharge on continental shelf or ridge.
7. NORM	<ul style="list-style-type: none"> • <u>If</u> NORM wastes are generated, the Lebanese Atomic Energy Center (<u>LAEC</u>) should be immediately notified <u>and wastes</u> brought to shore for storage at approved sites. • Longer term, the Lebanese government should develop a state-of-the-art NORM handling facility, adequately sited, and capable to store, treat and dispose of NORM wastes generated by the petroleum sector • With <u>LAEC</u> authorization, re-injection offshore is acceptable. • Disposal to the sea is prohibited.

Waste treatment and disposal options



- There are a range of waste disposal and treatment options:
 - Land-filling (burial)
 - Land-farming
 - Thermal technologies
 - Slurry injection
- Final technology selection will depend upon location, affordability and availability

Landfilling (burial)



During drilling, completion, and production operations, various wastes including muds, cuttings, produced water, tank bottoms, and others are created along with the oil and gas.

These wastes can be disposed of through a variety of methods.

On-shore – permanent burial onsite should not be permitted.

Landfilling (burial)



Temporary onsite burial:

- Uses lined pits dug into the earth.
- Pits receive mud, drill cuttings, and other materials.
- Operators should not be allowed to drain the fluids from the pits and then bury the solids.
- If the pits are not properly lined there is a great risk of groundwater contamination from hazardous materials in the waste leaching into the soil.

Landfilling



- Offsite burial, should occur at an engineered landfill, designed for the permanent disposal of a variety of wastes including hazardous wastes and chemicals.
- The landfill must be double-lined, with clay or synthetic liners to protect groundwater.
- Other features include leachate treatment & methane gas control and treatment.

Landfilling



- Landfilling is typically cheaper than incineration, say USD 50/tonne compared to US\$ 100/tonne - for example.
- However, landfills cannot accept all haz-wastes – so, there is typically a need for other technologies such as incineration/thermal disorption .
- The landfill should cover the waste on a daily basis, and should be divided into internal cells for the disposal of different types of waste.
- To minimise the incidence of “leaching” – certain wastes can first be solidified in concrete – a form of stabilization.









Land farming

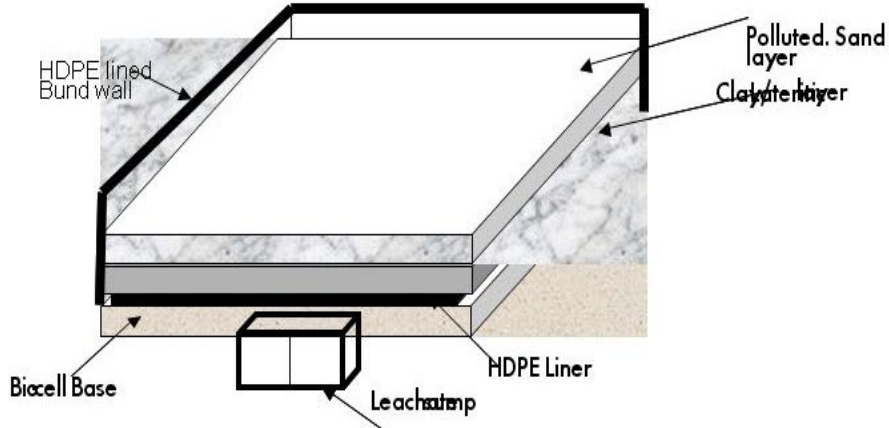


- The controlled & repeated application of wastes to the soil surface; a technique for reducing the concentration of oily, hydrocarbon-rich wastes.
- Can be used on its own, or as pre-treatment before wastes are disposed elsewhere – usually via landfilling.
- Often used for treatment of WBDMs, oily wastes and cuttings.

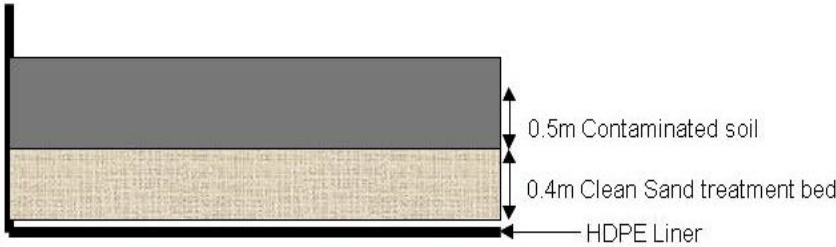
Land farming

- Landfarming is a low-cost technology – possibly in order of US\$10-25 /tonne.
- Landfarming typically promotes the microbial breakdown of hydrocarbons.
- This process is promoted by the addition of nutrients, moisture and air.
- Smaller cells, should be underlain by a low-permeability membrane to protect underlying soil and ground-water.

Engineered bio-cell



3-D VIEW REMEDIATION CONTAINMENT CELL



Thermal technologies



- Two main types - incineration and thermal desorption.
- Both are high-cost solutions – typically US\$100/tonne +.
- Both apply high temperatures to evaporate, combust, or breakdown hydrocarbons.
- Some additional treatment may be required to remove metals and salts.
- Thermal facilities can be either permanent or mobile.

Thermal technologies



- Special attention must be paid the quality of the gaseous emissions – particularly for carcinogens such as furans and dioxins – as well as heavy metals.
- This monitoring is a particularly specialised and expensive undertaking.
- With thermal technologies there are also issues with disposal of toxic ashes.
- Ongoing research into disposal of hazardous waste using existing cement-kilns such as in Egypt.

Slurry injection



- Solid waste is ground into small particles and mixed with liquid to create the slurry.
- This is then injected underground into rock formations through a disposal well.
- It requires higher pressure to induce rock fracturing thereby creating a disposal domain for the waste.
- But the international scientific jury is still out on this topic – with many not favouring it.

Thank you



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