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Waste Management in a Desert Environment, Yemen

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Abstract

An integrated waste management plan was developed and implemented in a remote desert petroleum-producing region of Yemen. Challenges included: an absence of in-country contractors that recycle, handle hazardous, non-hazardous, and mixed waste; sensitive receptors including nearby communities, groundwater and desert ecosystems; limited options for safe disposal within the petroleum block; logistical challenges of transporting waste long distances in sand sea environments, and historical ad hoc disposal practices by previous operators that created waste liabilities. Occidental of Yemen (Oxy) and Walsh Environmental Scientists and Engineers (Walsh) consulted in-house stakeholders (geophysical exploration, exploration drilling, production managers, operations, and HES) and external stakeholders (Ministry of Oil and Mineral Resources, local tribal leaders and government officials, contractors, and NGOs) and developed an integrated waste management plan that is functional, cost effective, and addresses concerns of local and national stakeholders in the logistically challenging sand sea environment. The Waste Management Plan was developed consistent with Oxy's Worldwide Standard of Care that involves the principle elements consisting of: regulatory compliance; segment/business unit HES performance objectives; correction or cessation of any activities that pose an unacceptable risk to health, safety, or to the environment; and a risk evaluation and mitigation program that achieves consistent results worldwide. The waste management plan presents clear principals for managing waste streams, which include reuse, recycling, incineration, proper storage, and final disposal to prevent exposure to sensitive receptors. The important improvements in waste management are: construction of a centralized waste management facility that collects and processes waste streams from nearby production areas and remote drilling pads; lining of pits, and location outside active channels of wadis away from houses and agricultural fields; re-injection of some liquid wastes, and an active program of remediating pre-existing environmental impacts from previous operations.

Introduction

A waste management plan was developed and implemented in a remote desert petroleum-producing region of Yemen. Challenges included: an absence of in-country contractors that recycle, handle hazardous, non-hazardous and mixed waste; sensitive receptors including nearby communities, groundwater and desert ecosystems; limited options for safe disposal within the petroleum block; logistical challenges of transporting waste long distances in sand sea environments, and historical ad hoc disposal practices by previous operators that created waste liabilities.

Description of Sensitive Environment

A remote petroleum block (Block S-1) located in the province of Shabwa is currently being explored and developed for oil (See Figure 1, Location of Block S-1 in Yemen).

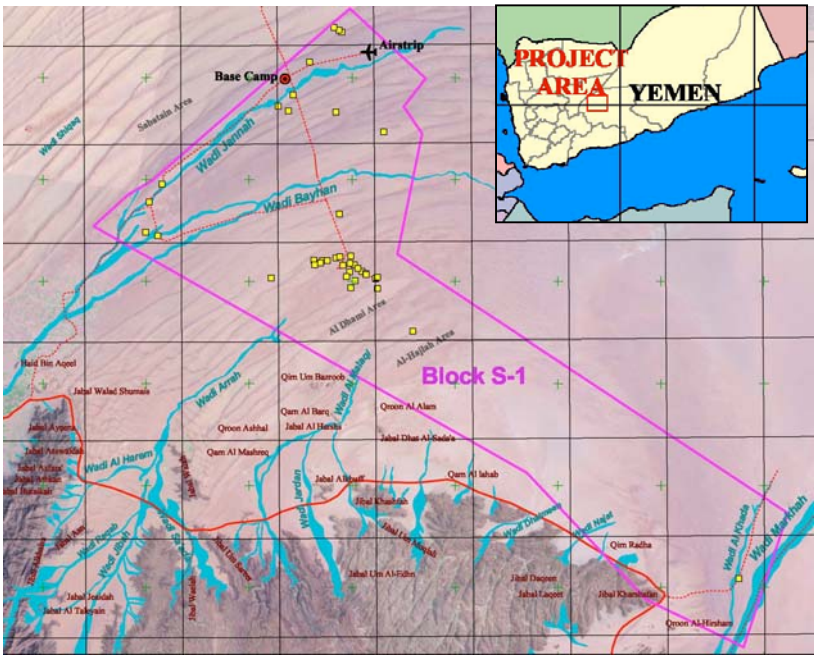

Figure 1. Block S-1 is located in central Yemen, in an area primarily composed of sand seas. Yellow squares denote existing well pads.

The block consists primarily of sand sea (sandsheets, low, linear and transverse dunes) dissected by wadis that flow out of the metamorphic highlands to the south (See Figure 2, Geomorphic Map of Block S-1).

These sand seas have sparse vegetation dominated by shrubs (*Rhazya stricta, Calligonium crinitum, Leptadenia pyrotechnica, and Dipterygium glaucum*) and perennial grasses (*Panicum turgidum, Cyperus conglemeratus*). There are no trees in the block. The vegetation becomes denser towards the wadis and within the wadis is dominated by trees (*Acacia spp., Tamarix spp.*), shrubs and grasses found in the sandseas, and a variety of agricultural crops. This seemingly sparse ecosystem supports a diverse fauna. Mammals present include the fox (*Vulpes vulpes Arabica*. Figure 3).

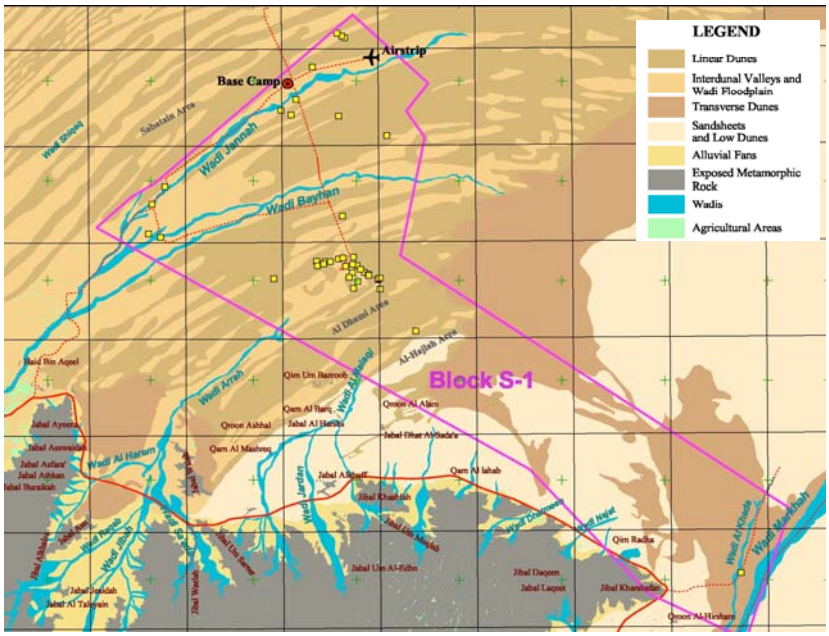

Figure 2. This geomorphologic map shows the major features of block S-1. Most of the agricultural and other land use occurs along the northern flank of the metamorphic mountains to the south of the block.

Reptiles present within Block S-1include the lizards *Pseudotrapelus sinaitus* and *Phrynocephalus arabicus* and the spiny tail lizard or Dhub, *Uromastyx spp*. Birds inhabiting the area include vultures (*Gyps fulvus*), Yemen thrush (*Turdus menachensis*), Bee-eater (Merops orientalis), and doves (*Columba livia, Streptopelia roseogrisea*). Insects present include the the economically important *Apis yemenitica*, a small, dark-colored bee that tolerates hot and dry conditions and is important for honey production in Yemen. Domesticated animals are also present in the region, particularly herds of sheep, goats, and camels (Figure 4).

The monsoon rains usually fall in March through May. They provide water for native plants in the sandseas and occasional surface flow in the wadis which is captured for irrigation and recharges local groundwater. There is increasing use of groundwater for irrigation during dry seasons, which has resulted in falling water tables and salination of both groundwater and agricultural soils.

Figure 3. Fox den dug into the root ball of a Tamarix shrub in a wadi

Historical Waste Management Practices

Yemen has very few options for management and disposal of wastes, and there have historically been no hazardous waste disposal facilities in the country. The tremendous difficulty of transporting hazardous wastes outside of the country for disposal (due to both the lack of improved roads in the block and the prohibitive cost of exporting the wastes) has led to the wastes being disposed of within the block, if they were collected at all.

Historical waste disposal practices by previous operators in the block included disposing mixed solid and liquid waste in burn pits. The resulting burned detritus is frequently blown across desert environment and trapped in the sparse vegetation foliage.

Figure 4. Camel grazing on the sparsely egetated dunes of Block S-1.

Because of the difficulty in transporting materials in the sand sea environment, previous operators often used open unlined pits near drilling sites and production facilities to collect and store wastes (Figure 5). This has led to impacts to the sandy environment. Food wastes disposed of in this manner attract mammals and birds. Oily waste liquids have been intentionally or accidentally discharged in these pits, in unlined evaportation pits, and in the open dune environments.

Figure 5. Ad hoc disposal of solid waste in an open, unlined pit at a drilling site.

Production flaring historically has been conducted in open-desert environment without security fencing or protection of soil or groundwater resources. In addition, oils and other chemicals that have been spilled or otherwise released in the sand seas have been left in place.

Containers (drums, etc.) that contained hazardous materials have been donated by previous operators to communities for re-use without concern for potential health risks posed by remaining residues.

The Goal and Process

Occidental Petroleum Corporation's (OPC's) Worldwide Standard of Care governs the conduct of Oxy's operations throughout the world. The Worldwide Standard of Care involves the following principal elements:

- Compliance with all applicable HES laws and regulations, as a minimum
- Establishment of worldwide Segment HES performance objectives
- Correction or cessation of any activities that pose an unacceptable risk to people's health and safety or to the environment
- A risk evaluation and mitigation program that achieves consistent results worldwide

In conducing baseline investigations for an Environmental and Social Impact Assessment (ESIA) for exploration activities within Block S-1, Oxy HES managers determined that the waste management and disposal practices that had been used in the block would not meet the criteria set forth by the Worldwide Standard of Care. As part of the ESIA process, Oxy then undertook an Environmental Management Plan as part of the ESIA that would adequately cover all proposed exploration, development, and production activities foreseen in Block S-1. An important part of this Environmental Management Plan was a waste management plan.

In-house stakeholders (Oxy geophysical exploration, exploration drilling, and production managers) and external stakeholders (Ministry of Oil and Mineral Resources, local tribal leaders, officials from the Shabwa Governate, contractors, and Non-Governmental Organizations) were consulted to during the process of creating a Waste Management Plan that is functional, cost effective, and addresses concerns of local and national stakeholders in the logistically challenging sand sea environment.

Oxy HES managers then worked to develop a comprehensive Waste Management Plan that is specific and easy to follow. The goal is to provide Oxy personnel and contractors in the field with a short, understandable document that gives them specific directions on what to do with each type of waste expected to be encountered.

Improved and Effective Waste Management

Guiding Principles. The resulting Waste Management Plan presents clear principles for managing waste streams that can be implemented in the logistically challenging desert environment of Yemen, which includes reuse, recycling, incineration, and final disposal to prevent exposure to the sensitive receptors in Block S-1.

These principles are:

- Wastes will be inventoried, and storage or final disposition will be recorded in a central recordkeeping system.
- Wastes will be recycled when possible or used to produce energy in the production process.
- Waste minimization will be a factor in decisions about future installations. Processes that produce less waste will be preferred if cost, schedules, and exploration or production goals are not adversely affected.
- Wastes will be collected and classified based on type and directed to a specific treatment and/or disposal stream. Different types of solid waste will not be mixed unnecessarily.
- Training modules will be provided so that all field personnel understand and can implement the waste management plan.
- A high degree of housekeeping will be enforced and regular inspections of the camp areas, accommodations, and offices should take place.
- Adequate resources will be allocated and equipment installed to manage the types and quantities of wastes that are produced.
- All contractors will be obligated to implement the Waste Management Plan.
- An ongoing program to evaluate and remediate waste liabilities in the block will be established. These wastes may include hydrocarbon- or chemical-contaminated soils, contaminated groundwater, or general trash in the desert.

In order to protect sensitive desert ecosystems, agricultural areas, groundwater, houses and agricultural resources, minimum buffer zones were established for liquid and solid waste disposal.

Key Components. An important part of managing the waste streams has been the construction of a purpose-built, centralized waste management facility at Oxy's Central Production Facility (CPF). This facility is used to collect and process waste streams not only from the CPF itself, but also from nearby production areas and remote well pads. This self-contained facility includes an area for classification and sorting of solid and liquid wastes, an incinerator, a drum crusher, an area for storing clean recyclables, a solid waste incinerator, and a landfill that includes segregated, marked areas for both hazardous and non-hazardous wastes.

The Waste Management Plan also includes a commitment to manage waste appropriately at remote geophysical camps and exploration drilling sites. This includes management of non-hazardous wastes in situ by recycling, incineration, and/or burial; and transport of hazardous waste to the CPF waste management facility.

After having established the waste management facility and guiding principles, a waste sorting matrix was developed that addressed the waste streams expected to be encountered during Oxy's tenure in Block S-1. This matrix classifies a total of 58 types of wastes, and provides recommended management and disposal options including (in order of preference):

1. Reclaim or Recycle
2. Dilute and Return to the Production System
3. Dispose in Produced Water Re-injection System
4. Incinerate/Burn
5. Biodegradation/Bioremediation
6. Bury in specially built lined, marked pits (Hazardous)
7. Bury in lined marked pits (Non-Hazardous)

Each of the 58 wastes has specific instructions as to its storage, handling, and disposal, with up to three disposal options provided for each waste.

Waste Management Procedures. Specific guidelines were established for solid, liquid and gas wastes. For solid wastes, the following general handling and disposal is followed:

- Housekeeping and regular inspections of the camp area, accommodations, and offices. At all camp locations sufficient containers for waste and rubbish are provided. Containers have lids to help prevent insects or animals from accessing the waste. Waste is removed from all camps on a regular basis.
- Drilling cuttings and muds are disposed of in a fenced lined pit, generally near the drilling site. Crude oil and water decanted from the pit are introduced into the production stream or a disposal well or evaporated in lined pits. The cuttings pit is closed by folding the liner over the pit and buried with clean sand or soil.
- Solid waste is classified into the following categories: hazardous, hazardous/non-hazardous, and non-hazardous wastes.
- Recyclable non-hazardous waste is reused within the block or exported to a recycling facility outside the block.
- Burnable non-hazardous waste is burned in an incinerator and waste ash is buried in lined pits at the landfill located at the waste management facility.
- Biodegradable organic waste is disposed of in a composting system at the waste management facility.
- Burn pits are used at remote sites and camps for burnable non-hazardous and biodegradable organic waste.
- Other non-hazardous waste is buried in a lined landfill at the waste management facility.
- Hydrocarbon contaminated sand or soil (including tank bottoms) is bio-remediated in a land farming facility or used for stabilizing sand within facilities.
- Hazardous waste is temporarily stored in appropriate containers within a lined landfill at the waste management facility. Hazardous waste is not disposed of at remote locations such as exploration drill locations.
- Concrete structures are removed or buried at the time of abandonment.

Handling and disposal of liquid wastes are highly important in the desert environment, as open liquids attract birds and other wildlife. The following general procedures are followed:

- Produced water and cutting lixiviates are stored and evaporated in lined pits; however, excess liquid from the pits are reinjected into the production stream or a disposal well, or evaporated in fenced lined pits.
- Liquid oily wastes are burned in the incinerator, or added to the production stream at a facility, or evaporated in fenced lined pits.
- Grey water are pumped to an infiltration field, or dispersed via a sprinkler system, at least 500 m from the facility or camp.
- Sewage waters are treated at a sewage treatment plant or discharged to an infiltration field 500 m from the facility or camp.
- Industrial waters is reinjected into the production stream or a disposal well, or evaporated in fenced lined pits.
- Hazardous liquid waste is burned in the CPF incinerator, added to the production stream, reinjected into a disposal well, or temporarily stored in adequate containers in the hazardous waste landfill at the CPF.

Results

The Waste Management Plan and facilities are in the process of implementation. The intial changes have resulted in improvements in waste anagement and mitigation of problems identified at the time a block acquision.

Conclusions

Effective waste management in remote desert environments requires the development of principals and plans that address the sensitivity of the environment, but also logistical limitations. Significant improvements have been made in Yemen on managing waste streams with little or no regional or national waste management services, by installing facilities within the petroleum block to manage waste streams. This system can be incorporated into waste management services as they become available in the country.