Most Sustainable Approach to Treated Wastewater Disposal: *Passive Evaporation Pond*

by Ir. Jiunn S. Tan and Mr. Mohan Damuderan

A development plan for Diyarbekir and Magtymguly fields in Turkmenistan is already in the pipeline. These fields are located in Block 1, between 30km and 100km offshore Turkmenistan in the Caspian Sea. Technip Malaysia is developing the Turkmenistan Block 1 project and has been appointed as the engineering design consultant.

As part of the development, an Onshore Gas Terminal (OGT) will be constructed at Kiyanly, Turkmenistan. This gas production facility is expected to generate a significant amount of industrial and domestic wastewater from its operation. One of the major challenges in designing the OGT is in the disposal of treated industrial and domestic wastewater due to extremely stringent Turkmenistan regulations on effluent discharge. In view of this, there is a lack of proven technology that could treat the industrial and domestic wastewater to meet the Caspian Sea discharge requirements.

METHOD SELECTION WITH THE LEAST ENVIRONMENTAL IMPACT

The stringent effluent discharge regulation has resulted in the project having to evaluate various methods for the final disposal of the treated wastewater. Figure 1 shows the various disposal methods studied as potential solutions. The aim of the study was to determine the most environmentally friendly and cost effective method of wastewater disposal while taking into consideration the 'zero wastewater discharge' policy. The study has resulted in the selection of the passive evaporation pond method as the best option in comparison with other disposal methods. The other disposal methods that were considered included the injection of the wastewater into deep underground strata, mechanically spray evaporation pond and membrane treatment for water reuse. The major advantages of the passive evaporation pond method are as follows:

i) No discharge of wastewater into the Caspian Sea thus meeting the "Zero Wastewater Discharge Policy"
ii) No requirement for electrical power for the operation and maintenance of the evaporation pond
iii) Potential increase of green cover/vegetation due to the presence of a new contained water body holding treated wastewater on the existing barren land
iv) Low VOC (Volatile Organic Compound) evaporation and sludge accumulation as the wastewater is treated to IFC (International Finance Corporation) Standards prior to disposal into the evaporation pond
v) Aesthetically pleasing and non intrusive environment since the evaporation pond will have suitable landscaping surrounding the pond area

EVAPORATION POND

Evaporation ponds are commonly used as a method to remove the liquid fraction of industrial and domestic wastes. When designed, constructed, operated and maintained properly, evaporation ponds have been proven to be an environmentally friendly and safe method of disposing wastewater without contaminating underlying groundwater. Hence, the project has adopted the Best Available Technology (BAT) in the design of passive evaporation ponds to cater for the treated wastewater discharge from the OGT. As an added precaution, the evaporation pond is located more than 2km from the Caspian Sea to provide an adequate buffer zone from the Caspian Sea and other establishments.

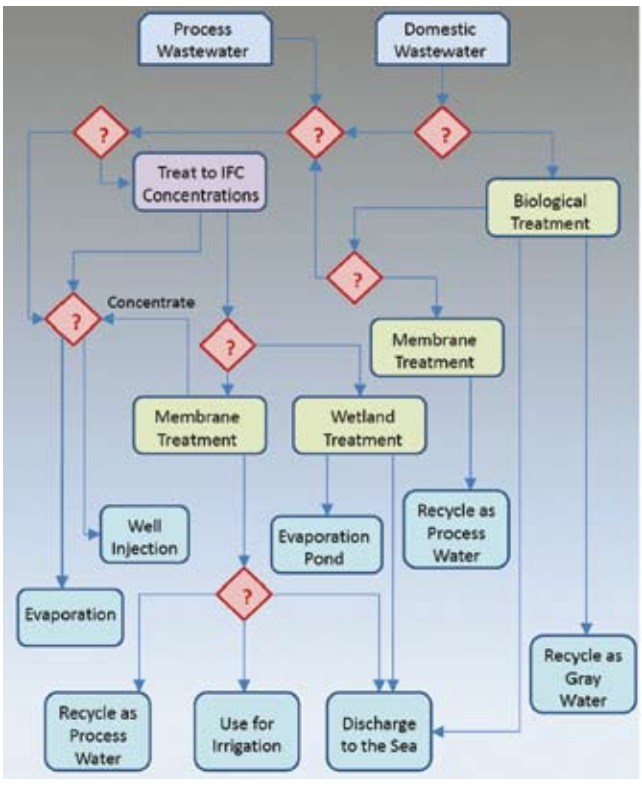

Figure 1: Methods

a) Best Available Technology - Design Features

The following are the key design features that were incorporated to prevent any seepage/ leaching of wastewater into the groundwater:

- The evaporation pond is located on existing high ground, thus ensuring significant separation distance from the groundwater level
- The evaporation pond design utilises a double liner system with an intervening leak collection, detection and recovery system for total groundwater protection and enhanced seepage protection. This state-of-the-art double liner system technology has been proven to prevent groundwater contamination.

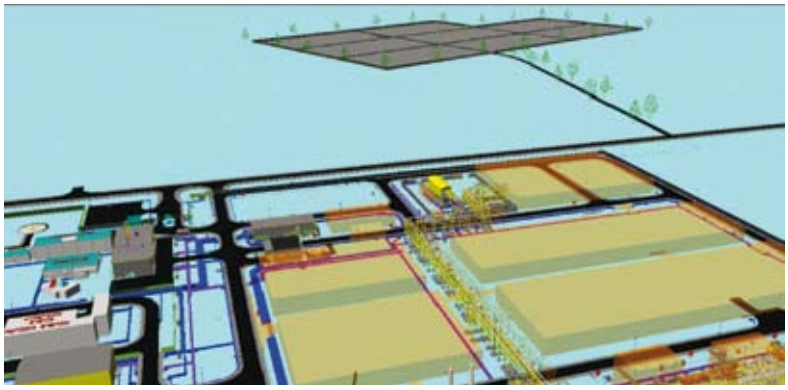

Figure 2: Site location of evaporation pond from OGT

The details of the components are as follows:

i) Upper (Primary) Liner System – The 2mm thick upper primary liner consists of a smooth HDPE (High Density Polyethylene) geo-membrane. This material is chosen for its long term performance, impervious and waterproof characteristics, chemical resistance properties, resistance to UV radiation, high tensile strength and high stress-crack resistance. The liner chosen is designed to withstand long term use and is expected to last more than 40 years. This material has satisfied some of the most stringent regulations and controls for storage, filling, handling, containment and treatment of contaminated fluids such as Germany's Water Conservation Act (WHG) and Britain's Environmental Protection Agency.

ii) Leak Collection and Secondary Liner using Geosynthetic Clay Liner (GCL) – In the event of an unlikely leak occurring in the upper primary layer, the leakage will be collected in the GCL layer. It will then be routed via gravity flow using perforated HDPE pipes to leak detection pits located at the perimeter of the evaporation ponds. This layer is made of GCLs that serve as an effective final waterproof barrier against potential risks of the wastewater on the environment. This material is a strong and durable non-woven geo-textile encapsulate which protects the layer of pure bentonite thus ensuring its long-term performance. This liner is designed to last more than 40 years and contains the highest quality natural sodium bentonite. The immediate swelling following installation is guaranteed to safely self-seal any unexpected mechanical damages. The GCL can also accommodate and adjust itself to earth deformations, such as differential settlements and steep slope applications.

b) Pond Sizing

The proper sizing of an evaporation pond depends on the accurate estimation of the annual evaporation rate. The salinity of the wastewater also influences the evaporation rate, therefore, a salinity coefficient must be introduced when computing the evaporation rate. Evaporation rate = k_1k_2 (pan evaporation) where k_1 is the pan coefficient and k_2 is the salinity coefficient. The ponds are designed and constructed to provide at least the minimum evaporative surface area needed for the maximum yearly volume of liquid to be discharged into the pond. The design parameters are based on the local climatic condition which is considered dry and hot for about 5 to 7 months out of a year. A limiting factor is the decrease in the evaporation rate during the winter months or wet season. The sizing involves two major parameters which are evaporative surface area and pond depth. A third minor parameter is the overall footprint size of the pond. The evaporation rate determines the evaporative surface area needed to balance wastewater flow into the pond and the rainfall that lands on the pond. The pond depth is based on surge capacity from peak wastewater flow, water storage, storage capacity from sludge/sediments, storms and freeboard. As such, a Water Balance Table was developed for the purpose of predicting the estimated surface area and volume required for the smooth operation of the evaporation ponds.

c) Installation, Operation and Maintenance

Apart from the design features that were incorporated, proper installation, operation and maintenance is required to ensure that the evaporation ponds are leak-proof throughout the lifecycle of the installation.

The following are the control measures that will be implemented in the project:

- Installation of HDPE liners and GCLs will be done or supervised by a specialist contractor for this type of installation
- Regular inspection by OGT personnel of the leak detection pits in order to detect any leakage in the early stages (on the upper liner) during the operation of the evaporation ponds. If a leakage is detected, the affected pond will be taken out of operation and the leak repaired immediately.

SLUDGE REMOVAL

The treated wastewater that will be sent to the evaporation pond will have a relatively low concentration of contaminants. The wastewater treatment equipment located upstream of the evaporation pond will ensure that the contaminant levels are kept within the following limits:

TSS	< 50ppm	Oil and Grease	<10ppm
BOD	< 50ppm	Phenol	<0.5ppm
COD	< 250ppm		

As a result of the low contaminant levels, sediment/sludge will only build up in the pond over a long period of time as the wastewater is expected to contain very small amounts of Total Suspended Solids (TSS). It is envisaged that the pond will only be required to be de-sludged once every several years of operation. For this purpose, a total of eight maintenance accesses have been provided around each pond. This walkway/ramp type access will be used by the vacuum truck operator to utilise hoses to remove/vacuum the sediment/sludge at the bottom of the pond into the vacuum truck. The vacuum truck will transport the sediment/sludge offsite for safe and proper disposal by third party contractors.

CONCLUSION

It is imperative that a detailed study and evaluation be conducted in the selection of wastewater disposal options in Turkmenistan because of the lack of clear regulations and requirements in Turkmenistan. The project achieved this by commissioning a specialist consultant to carryout a wastewater treatment and disposal feasibility study to identify the most sustainable solution. The specialist consultant assessed all the available options and concluded that the evaporation pond is the most sustainable and feasible option. A wastewater treatment plant will be installed upstream of the evaporation pond to treat the wastewater prior to discharge into the evaporation pond to reduce the contaminant loading on the evaporation pond.

In order to further develop the detailed design of the evaporation pond, the following activities were identified for further investigation by the design team:

- Detailed survey to be performed to ensure that the bund walls of the ponds are above the flood elevation
- Detailed geotechnical survey to be conducted to determine the soil properties
- In depth investigation of the groundwater to be conducted and groundwater monitoring network to be established. ■

NOTE:

The authors are practicing professional engineers/engineers with a major international contractor/consultant company in the oil and gas industry and are based in Kuala Lumpur.

REFERENCES

[1] ESI, 2009. Report for Onshore Gas Terminal Wastewater Treatment and Disposal Feasibility Study.

[2] Technip, 2009. Scope of Work on the Wastewater Feasibility Study on the Discharge Method.

[3] Technip, 2008. Basis of Design for Wastewater Treatment Plant.

[4] ESI, 2006, Preliminary Environmental Impact Assesment.