SALT INVESTMENT S.A.Z.F

Lake Assal Salt Project, Djibouti

Environmental Impact Assessment

Nov 2008

CONTENTS

List of Tables

List of Figures

List of Plates

Acronyms

ECO	Environmental Control Officer
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
IMS	Invasive Marine Species
ISERT	Institut Supérieur D'Etudes et de Recherches Scientifiques et Techniques,
MHUEAT	Ministère de l'Habitat, de l'Urbanisme, de l'Environnement et de l'Aménagement du Territoire
PANE	Plan d'action National pour l'Environnement
NAPB	National Action Plan for Biodiversity
NGO	Non-Goverment Organisation
SEL	Societe D'Exploitation du Lac

EXECUTIVE SUMMARY

1.0 Background

Djibouti's economy is mainly based on service activities which accounts for over two thirds of the country's GDP (African Development Bank, 1999). The Government's strategy is primarily aimed at improving the business climate with a view to private sector-driven growth which will create jobs and reduce poverty.

Lake Assal is situated about 100 km west of Djibouti and 20 km from the coast, at the Western end of the Gulf of Tadjourah and is at a mean altitude of 150 m below sea level. With 54 km^2 of pure brine fed directly by gravity from the Red Sea and 62 km^2 of ready made salt crust of high purity raw crystal salt, Lake Assal (Djibouti, East Africa) is the world's largest sea salt reserve. There are presently four official concession areas at the south eastern end of the lake. By late 2002, Société d'Exploitation du Lac and Société d'Exploitation du Salt Investment S.A de Djibouti were the largest producers with a combined 80% market share.

Djibouti recognises Lake Assal as a national "treasure" which should be in a protected area (National Environmental Action Plan, 2000). However, the salt is presently not being exploited properly i.e. uncontrolled exploitation, which is having a negative impact on the lake environment. The National Biodiversity Action Plan (2000) stresses the need for managing the exploitation of the salt.

In 2002 Cortec (Pty) Ltd completed a full Feasibility Study for Societe D'Exploitation du Lac (SEL) which investigated the feasibility of increasing the existing production capacity to 250 000 tons per annum. Since 2002, the Djibouti government's industrial policy in the salt sector has been to increase salt exports from Lake Assal, consolidate and regulate the industry, attract foreign investments, and be able to offer a country wide salt quality standard. Salt Investment S.A., in a partnership agreement between Société d'Exploitation du Lac (SEL) and Hardtechnologies Group S.L. ("Hardtech"), are now responsible for developing the salt project further and are established under the laws of Djibouti for the purposes of harvesting, refining, storing, transporting and exporting salt extracted from Lake Assal.

The purpose of the Lake Assal Salt Project is to expand Lake Assal crude salt production to approximately 6 million tons per year (compared to 1.2 million tons projected in the 2002 study), install, operate and maintain a complete salt industry plant for the production of all grades of salt. The project involves the installation, operation and maintenance of 1,000 tons per hour in aggregate harvesting capability, a 250 tons per hour mechanical salt washing and upgrading plant and a 10 tons per hour (expandable to 20 tons per hour) refining plant. The objectives of the Lake Assal Salt Project are to:

- provide the infrastructure for an efficient, productive and environmentally sustainable salt mining industry;
- produce and export high grade industrial salt, refined salt for edible consumption, and to export standards;
- provide employment for the local people;
- prevent and/or mitigate the negative environmental impacts and enhance the positive impacts on the natural lake environment

The present Environmental Impact Assessment and Environmental Management Plan has been updated to incorporate the additional proposed activities and associated potential impacts, of the Lake Assal Salt Project.

2.0 Environmental Policy and Legislation in Djibouti

The policy, legal and environmental framework of Djibouti essentially focuses on four main themes (desertification control, conservation of biodiversity, improvement of the population's living, and management of water supply). The country has ratified the international conventions on biodiversity, climate change, and desertification. During 1997 the National Environmental Action Plan (*Plan d'action National pour l'Environnement, PANE)* was launched and by 1999 the creation of the Ministry of Housing, Urbanism, Environment and Town & Country Planning (*Ministère de l'Habitat, de l'Urbanisme, de l'Enviornnement er de l'Aménagement du Territoire, MHUEAT).* The management of the environment falls under the mandate of Town and Country Planning.

The *Environmental Framework Law (No 106/AN00/4èmeL)* promulgated in the Government of Djibouti 29th October 2000, covers 68 articles related to protection of the environment, 9 of which are relevant to the present salt project. Articles *5, 7, 16, 28, 33, 52, 53, 54, 55, 56* define the national procedure in environmental impact assessment (EIA). The proposed salt mining activity falls under the *Activity Category 16: Extraction Activities*, which includes all exploitation activities and forestry.

The Country Report on Djibouti found that despite the relatively pristine state of parts of the coast and territorial waters, several coastal areas show alarming signs of degradation and threats to the marine environment are increasing rapidly (PERGSA, 2001). The most commonly noted impacts by this study were damage to coral reefs by anchors and trampling, littering and souvenir collection. Since the Lake Assal Salt Project will be shipping the salt from the project study area for the export market, maritime laws will apply.

There are a number of investors involved in the Lake Assal Salt Project, some of which have environmental policies related to development projects, these are: Overseas Private Investment Corporation (OPIC), African Development Bank (ADB), and European Investment Bank.

3.0 Proposed Lake Assal Salt Project

The purpose of the Lake Assal Salt Project is to expand the current raw salt production to approximately 6 million tons per year, and install, operate and maintain a complete salt industry plant for the production of all grades of salt and their derivatives. This involves operation and maintenance of 1,000 tons per hour in aggregate harvesting capability, a 250 tons per hour mechanical salt washing and upgrading plant and a 20 tons per hour refining plant. The plant is expected to process from 1.5 million tons of raw salt in its first year of production to 6 million tons per year by 2011. There will be four main sites of activity for the new salt project and the Table below summarises the activities at each site:

Summary of activities at each SITE of the Lake Assal Salt Project.

	Site	Structures	Size	Activities
SITE 1	Lake Assal	Solar salt ponds	20% of lake area (13km²)	Salt production - crystallisation
			Potentially the whole concession area – all the salt layer surface	harvesting
		Processing plant	300m x 110m	salt washing and processing
		Wash dam	3 acres (109 m x109m) (12,000m²)	Waste brine
SITE 2	Access road	Gravel road	7.5km	Transport of salt in trucks to and from lake site and ship loading site
SITE 3	Maintenance and accommodation	Maintenance and housing	35 hectares (35,9056m²)	Equipment maintenance, housing
SITE 4	Salt storage and ship loading site (beach)	Stockpiling area on the beach	442m x 152m	Trucks offloading salt onto stockpiling beach site.
		Ship loading system	Conveyor; Jetty (44m)	Movement of salt from storage area to ship
		Ship sailing		Sailing of ships in the Ghoubbet bay
		Desalination plant	8000 Gall/day ($30m^3$/day) 160sq ft (13 x 13m)	Production of potable water

4.0 Description of the Environment

Topography

The altitude in Djibouti varies from -155 m below sea level at Lake Assal to 2 021 m above sea level at Moussa Ali at the northern tip of the country. Lake Assal is in a closed depression of the

western region being surrounded by mountains and covering a surface area of 115 km^2. of which 65km^2 of the lake area is covered by salt pans. Since Lake Assal is 155m below sea level, the salty sea waters of the Red Sea flow by gravity from the Gulf of Ghoubbet through a 5 km long channel in basalt mountains into the east side of Lake Assal.

The maintenance and staff housing area is on a plateau above the Ghoubbet beach at 200m above mean sea level. The topography at the proposed salt storage area at the Ghoubbet beach is on a flattish area at sea level

Hydrology

There is no permanent river in Djibouti, and surface flow is directly related to rainfall, which takes the form of floods lasting anywhere from several hours to two to three days, depending on the heaviness of the rainfall and the surface of the catchment's area. The drainage patterns in the Assal catchment affect the lake since after rains, water runs off the hills and fills up the salt pans.

A number of permanent water points are located along the Kalou River valley and some temporary water points along the temporary water courses south of the lake. The shortage of water in Djibouti is exacerbated by the degradation of the groundwater tables which is occurring due to insufficient recharging capacity.

Lake Assal is divided into an “crystalised salt surface” and the high saline brine area. The crystalised salt section has a surface area of 54 km^2 and the salt reserves are reported to be up to 60m in depth and have been estimated by others at 300 million tons. The brine section has a 54km^2 surface area and a depth that may reach 40m. At 300g/l NaCl, the liquid reserves could vary from 4 to 8 million tons. The sea waters entering into Lake Assal are gradually converted into high quality brine by the effect of wind and sun and evaporate at an average rate of 460 million m^3 per year. The gradually concentrating brine is moved by the constant wind from east to west of the Lake and finally deposits the sodium chloride on the salt crust. There appears to be a balance between inflow and outflow. Some areas on the western bank and the Angalâlo River valley are prone to flooding . This potential flood zone is adjacent to but about 80m below the proposed site for the wash dam.

There is a hot spring adjacent to the road leading to Lake Assal (see Figure 4.1 and Plate 4.2) which has a salinity close to that of seawater at the source.

Geology

The territory around Lake Assal is volcanic and comprised of Basalt stratoïde (3.4 – 1 Ma) with the Ardoukôka Volcano being just 3 km from the edge of the lake at the -80 m contour line. Arable soil represents only 0.25% of the total area of the country (PANE, 2000). Sand flats occur in patches ranging from 1 km to about 6 km in length to the south of the lake. The lake is separated from the Gulf of Tadjourah by approximately 10 km of land and the semi-enclosed basin of Ghoubbet al-Kharâb, on the south-eastern side of the lake. Between Lake Assal and the bay of Ghoubbet-Kharab there is fault called the Assal-Ghoubbet Rift which permits percolation of seawater into the lake. The geology of this strip of land consists of recent basalt (less than 1 Ma).

Climate

Djibouti has a hot desert climate with two main seasons: October to April is the cool season with high humidity and rainfall on the coast; May to September is the hot season with tropical rain inland. May, June, September and October the variable north-easterly winds blow and in the summer very violent, dry, hot and dusty winds will blow from the west. The winds in the Ghoubbet beach region are predominantly blowing from an easterly direction i.e. blowing onshore at the salt storage site. The average monthly temperatures vary little with only a 6°C difference between min and max temps in any one month.

Rainfall is extremely variable both with peaks in January, April, May and October and virtually no rainfall from June to August. The mean annual rainfall in 1993 and 1997 was 773mm and 381mm, respectively, compared to 23mm in 1996. When floods occur in the lake's catchment, large amounts of sediment get washed down into the lake and settle on the salt flats.

Oceanography

Along the coast of Djibouti the tidal range is 0 – 3 m relative to Chart Datum, where 0 m is the spring low tide and the water level is about -1.5 m relative to mean sea level. Inside the Ghoubbet bay the tide amplitude is about 2 m and is generally 1 hour later that the Gulf of Tadjoura. The current velocities in the Ghoubbet were maximum 1 knot but in the Petit Passe (entrance to the Ghoubbet) tidal streams were strong – up to 7 knots.

The bathymetry of the bay at the beach site has relatively steep drop offs close to shore. The point where the ship would dock is approximately 26m deep. The wave height is higher than 1 m in 40% of the cases. The beach site is protected somewhat by the small islands just offshore the beach site from both wind and waves

Vegetation

The extreme climatic conditions in the Lake Assal area affect the vegetation with only low shrub occurring in isolated areas. Low shrub and some trees are present mainly to the right of the Lake Assal adjacent to the haul access road. One palm tree is present adjacent to the haul road but the road has been diverted around it.

Terrestrial Fauna

Small buck are present in the study area and appear to be abundant in the dry river beds, particularly next to the haul road. There are no wading birds to be found in the shallows of the Lake water and there is a noticeable absence of bird life within the Lake area. However, some birds of prey and sea bird were seen on site visits. Camels, sheep and goats were also seen grazing alongside the road in the study area.

Aquatic fauna

Shoals of a minnow fish species (similar to *Cypridodon variegates*), are found in the hot spring near Lake Assal. The spring water is close to that of seawater and has a total salt content of 39 g/l. This fish species is common in Caribbean and South American saltworks.

Marine environment

On the seaward side of the salt storage area is the semi-enclosed basin of Ghoubbet al-Kharâb which has high salinity rates and coral reefs of low species diversity. Crabs, and fish caught by locals were seen on the tourist beach at Dankalêlo. Very little marine research has been undertaken in the Ghoubbet itself however Pergsa (2001) does indicate that there are coral reefs all along the south-western side of the Ghoubbet and a small northern section of the bay near the mouth of the bay. Mangroves also occur in this area near the bay mouth.

Whale sharks (*Rhincodon typus*) have been recorded in the Gulf of Tadjoura all year round but are particularly abundant during the months October to January. Whale sharks are present in the Ghoubbet and are a popular attraction for divers and tourists in Djibouti.

Ecologically sensitive areas

Lake Assal and its environs is seen as a unique geological tourist site with the exploitation of salt at the lake as being one of the priorities in the management of the environment in Djibouti. Measures particularly concerned with the management of salt exploitation activities are to create a protected area of 10 kms, starting from the entrance to the lake, and to classify Lake Assal as a world heritage site.

Since little research has been done specifically in the area of Salt projects influence, there is no list of threatened or endangered species except for the whale shark (*Rhincodon typus*) which is present in the Ghoubbet bay.

Land use and land tenure

Traditional pastoral activities such as grazing of goats, cattle, sheep and camels is evident in the Lake Assal area, with the exploitation of the lakes' salt being the main land use in the study area. The land tenure in the study area is government land with the salt processing site having a 99 year lease.

Archaeological / cultural

The Ghoubbet is know as a prehistoric place of occupation. Tombs, clusters, ceramics and stone tools have been discovered in the area of Ghoubbet. There are many tombs in the gulf area and are made up of organized stone accumulation. The site at Dankalêlo (Monument 53), is an example of an important tomb site, but is east of the salt projects beach site and will not be affected by the projects activities.

Population

Djibouti’s population is mainly Muslim (95%) and comprises three ethnic groups, the Issas, Afars and Arabs with two main languages, French and Arabic. It is also relatively young (approximately 51% under 20 years old) and the literacy rate is low. Djibouti's population is largely nomadic in origin. Mostly nomadic people pass through and live temporarily in the study area but since the development of the salt industry, people are beginning to settle close to the salt operations.

Employment and Education

The poverty rate in Djibouti is high and around 62.7% of the population live below the poverty line. The level of education is such that only 28% of women can read and write compared with around 51.2% of males over 10 years (ADB, 1999). The new labour code protects the rights of all workers as well as giving new rights to women (who are explicitly recognised in the code for the first time), young people and disabled workers.

Previous salt exploitation activities provided employment for about 49 permanent staff and semi-permanent staff on a demand basis. The Lake Assal Salt Project forecasts to employ 212 people, including secondees from Consortium companies, local service contractors and expatriate personnel service contractors. Approximately 68% of its workforce will consist of citizens of Djibouti

Health and safety

Maternal and child health problems, respiratory infections (including tuberculosis) and diarrhoea constitute the country's most serious health problems (ADB, 1999). There are health problems associated with the salt mining activities such as skin infections, respiratory problems, and eye strain from sunlight, wind and reflection off the lake surface. Health care facilities are mainly in Djibouti City with an average of one health care centre per 15 000 inhabitants. In 1999, approximately 50% of country's 75 doctors are expatriates.

Infrastructure and services

The road to Lake Assal is paved with the main road to Ethiopia passing approximately 60 km to the South of Lake Assal. There are presently no services (electricity, piped water supply, and sanitation) to the Lake Assal area. Electricity at the salt processing site is presently supplied by a generator and barrels of water are located at points along the main road to the lake. A proposed new powerline will pass close to the maintenance / housing site and would be able to supply electricity in the future.

Djibouti is the main port for neighbouring land-locked countries within East Africa. All Ethiopia's imports and exports are transported between the port and Ethiopia by road transport. The rail line is operational but is currently the subject of an international rehabilitation and upgrade study. There is currently no port facility at the Ghoubbet beach site.

5.0 Economic Activities and Development Potential

Renewable Energy Projects

The Assal Geothermal Power Project is a renewable energy power project located just south of Lake Assal. There is wind turbine potential in the Lake Assal area and one of the proposed site is about 500m from Lake Assal, near the geothermal plant.

Extension of existing powerline grid

There are plans to expand the existing electricity grid in Djibouti with a proposal to supply power to the Lake Assal area.

Mineral exploitation/mining

There is potential for mining of perlite, dolomite, calcium, gypsum, clay, and pumice stone, but have not been sufficiently investigated.

Tourism Potential

The country's main tourism sites are the Day Forest, the Musha Islands and Lake Assal. There is a small tourist facility at Dankalêlo beach which is close to the salt storage area and ship loading jetty. The hot springs and Lake Assal are also tourist attractions to the area. There is potential to develop eco-tourism (deep-sea diving, whale shark sighting, cultural tourism) that are highly lucrative and environmentally friendly.

5.0 Key Environmental Impacts

The key environmental impacts identified and discussed in the present EIA report were identified by public consultation, site visits and a scoping matrix. The following key issues and potential impacts associated with the Lake Assal Salt Project are:

Key Positive Impacts

- The salt project will help create jobs and employment;
- Increase in export potential;
- Improve the standard of living of the villagers in Assal;
- The local economy will improve;
- Services and infrastructure to Lake Assal will improve;
- Provide a tourist attraction - educational aspect of salt production;
- Structuring and limitation of salt exploitation to certain areas only;
- Implementation of environmental management measures to mitigate negative impacts;

Key Negative Impacts

- Pressure on natural resources, especially water, but also land where erosion may be an issue;
- Decrease in aesthetic value of certain areas of Lake Assal;
- Vehicle movements on the lake Assal and between the lake and processing site;
- Increase in vehicle movements and hence safety risk;
- Increase in settlements hence increase in waste and sewage generation;
- Harsh climatic conditions and floods have a negative impact on the salt project activities.
- disturbance to the natural environment at lake Assal
- Increased shipping activity on the marine environment
- Loss of aesthetics in the Lake Assal and Dankalêlo tourist attraction areas due to salt mining activities (buildings, harvesters, access roads)

Water resources

Due to the scarcity of water resources in the study area, and the limited recharging capacity of groundwater, the potable water demand from the activities of the salt project will impose pressure on the water resources in the Lake Assal area. SALT INVESTMENT S.A is providing the nomads

with water (2,10l drums next to the road), however this water source may not be able to sustain the village once the capacity of salt production increases to 1 million tons. However, the desalination plant will be able to supply potable water supplies once completed.

Marine resources

The increased shipping activities anticipated for the transport of salt to export markets can potentially have an impact on marine life due to oil/fuel spillage, waste disposal, and damage to coral reefs. The following activities are expected at the salt projects port location, and the potential impacts associated with those activities:

Activities expected and the port location and their potential impacts on the environment.

Structure	Activity	Potential Impact
Conveyor system	Movement of bulk salt from shore to the ship	Accidental spills of salt into sea (operation phase)
Jetty structure	Construction of concrete bases on sea bed for pylons	Accidental spills of concrete into sea (construction phase)
Fixed anchor ropes from fixed buoys to ship	Construction of concrete bases on sea bed for permanent anchor buoys and ropes	Accidental spills of concrete into sea (construction phase)
Ships	Movement through the Ghoubbet gulf	Disturbance to megafauna such as whales sharks, dolphins and turtles.
		Emissions of fossil fuels whilst engines running
		Potential oils spills
	Anchored at beach site	Ballast water and hull biofouling potential introduction of Invasive Marine Species (IMS)
		Combustion emissions from ships' propulsion and auxiliary engines and boilers, mainly consisting of sulfur dioxide (SO_2), nitrogen oxides (NO), greenhouse gases.
		Marine vessel sewage and risk of localised marine and beach pollution
		Ship discharge of solid waste ends up on shoreline
	Sailing near beach site	Risk of ship grounding

Climatic conditions

The harsh climatic conditions in the Assal area have a negative impact on the salt project activities. The extreme temperatures, humidity and winds impose difficult working conditions on the lake. These conditions have a negative impact on the health of the workers, unless management measures are put in place. The effects of wind blown salt at both the lake Assal site and the salt storage beach site at the Ghoubbet will have a negative impact on the workers. The prevailing wind direction at the Ghoubbet in onshore so this impact can be mitigated if the workers wear face masks.

Removal of indigenous plants and loss of biodiversity

Destruction of vegetation has a multitude of negative effects on other environmental attributes which include reduced capacity for water infiltration, increased rate of surface runoff, reduced

groundwater recharge, reduced water quality through increased sedimentation, accelerated soil erosion, and loss of habitat for wildlife.

Access road and Vehicle transport of salt product

Increased potential for erosion occurs particularly on roadside slopes and causes downstream impacts on hydrological resources as a result of improper water management and siltation. Inadequate drainage structures exacerbate the problem of gully erosion and sedimentation.

Haul roads generate dust that creates a safety hazard, increases vehicle and road maintenance costs and cause a decrease in air quality. The Lake Assal Salt Project will be using large off-road haul trucks extensively to move the salt from the lake to the beach storage site. The greatest long-term health hazard of dust generated from hauling operations is due to inhalation of the respirable dust. Wet spray and foam are two options for dust control. Wet spray methods involve mixing a surfactant with water and the dust is controlled. Foam programs involve mixing a surfactant, water and air to produce foam that controls dust on the material being treated[1].

Physical impacts of the salt processing plant and work sites

The main negative impact that seems to be visible in all salt mines is the impact of heavy machinery on the landscape. The movement of bulldozers, front-end loaders and trucks whilst harvesting the salt have a negative aesthetic impact for visitors to the lake.

Housing of labour, and vehicle maintenance

Housing of labour, storing of vehicles, equipment, fuel and building materials will be required at the maintenance and housing site. Whenever possible work sites should be sited on land which is already impacted. At the and work sites, indiscriminate dumping of engine oils, fuel, lubricants or other solvents can contaminate soil and leach into subsoil water.

Economic and employment opportunities, and quality of life

The potential benefits which people expect to gain from the development of the salt mining activities include employment on a temporary or permanent basis. Small scale economic activities may also develop as a result of increased population in the area, and include sale of handicrafts, and local businesses which sell food and services.

Relocation of people and community development

Due to the lack of services and facilities in the Lake Assal area, workers demand higher wages to come and work in the Lake Assal area. To be able to attract people to work on the salt project at Lake Assal at reasonable wages, SALT INVESTMENT S.A have provided some services, such as water supply in barrels. The development of the community next to the salt processing plant has resulted in increased demand for services to the area.

Improved services and facilities

With the development of the salt mining activities, communities have settled in the area to be closer to their work. As a result, water is being supplied to the area and facilities have been or will be provided for the community that is settling there. For example, a Mosque has now been built at the settlement adjacent to the maintenance and housing buildings and there are plans for a school

[1] file:///C:/DOCUME~1/Shael/LOCALS~1/Temp/Saf4B.tmp/akj-industries.html

to built in the area. Power will also be supplied to the Lake Assal area, when the proposed geothermal and powerline extension projects go ahead. The settlements near the road will benefit most from the salt project.

Health and safety

The health problems associated with working on salt exploitation projects are skin infections, sore eyes, and respiratory illnesses. To address this problem, workers should wear protective clothing and minimise the amount of time spent during harvesting (work on a shift rotation system).

The safety of domestic livestock are at risk with the increase in traffic levels associated with the salt project. This has already been noted by some of the labourers living in the area.

Dust generated form the trucks on the haul road between the lake and the beach storage site will potentially be a health and safety hazard.

6.0 Evaluation and analysis of the potential impacts

The evaluation of potential impacts resulting from the salt project activities includes direct and indirect, temporary and permanent, and cumulative impacts on the environment. The approach used to assess the significance of the potential impacts and assess the efficacy of mitigation or enhancement measures is to apply significance ratings to each impact based on objective criteria, such as magnitude, extent and duration of that impact, to yield a final evaluation of the significance of impacts before and after mitigation. The application of significance ratings reduces the number of variables which need to be considered by the decision maker, whilst providing pertinent information about the implications of the salt operation at Lake Assal. The Environmental Management Plan (EMP) (a separate report) addresses the specific impacts identified in this analysis, in addition to providing the actions required to mitigate or enhance those impacts.

7.0 Summary

There are both potentially some long term positive and negative impacts resulting from the Lake Assal Salt Project. The negative impacts can be mitigated substantially if the Environmental Management Plan is strictly adhered to. For example, the scarcity of water resources in the study area will be mitigated by installing a desalination plant. The increased shipping activities anticipated for the transport of salt to export markets can potentially have an impact on marine life due to oil/fuel spillage, waste disposal, and damage to coral reefs. Mitigation measures such as penalties for ships leaking fuel and oil into the marine environment, no sewage or waste disposal from the ships is allowed whilst docked in the Ghoubbet, and ensure ballast water origin is from local marine waters. It is very important that an underwater survey of the marine environment in the area just offshore the beach storage area and around the small islands be initiated as soon as possible, and monitored on a regular basis during the operation phase.

The major direct negative impact associated with the operation of the haul access road will be generation of dust which creates a safety hazard, increases vehicle and road maintenance costs,

and is a health hazard due to inhalation of the respirable dust. Due to the water shortage in Djibouti, rather than watering the road surface to control the dust alternative methods of road dust control must be investigated e.g. application of chemicals or foam.

The visual impact of heavy machinery on the Lake Assal landscape whilst harvesting the salt will have a negative aesthetic impact for visitors to the lake. This can be mitigated by restricting main salt harvesting activities to weekdays, and enhancing the tourist value by building a "Visitors Centre" with tour guides explaining the salt operations. i.e. create a tourist attraction.

Housing of labour, storing of vehicles, equipment, fuel and building materials will be required at the maintenance and housing site. Proper management of the maintenance and housing site will result in minimal impact on the environment and in fact enhance the living conditions for workers.

The people who work at the harvesting site on the lake itself are exposed to harsh climatic conditions and the health risks associated with exposed/harsh conditions. The health problems associated with working on salt exploitation projects are skin infections, sore eyes, and respiratory illnesses. To address this problem, workers should wear protective clothing and minimise the amount of time spent during harvesting (work on a shift rotation system). In addition, a Clinic with modern equipment and a qualified doctor/nurse should be available not only for the workers but also the local communities.

With the development of the salt mining activities, communities have settled in the area to be closer to their work. As a result, water is being supplied to the area and facilities have been or will be provided for the community that is settling there. For example, a Mosque has now been built at the settlement adjacent to the maintenance and housing buildings and there are plans for a school to built in the area. Power will also be supplied to the Lake Assal area, when the proposed geothermal and powerline extension projects go ahead. The settlements near the road will benefit most from the salt project

In summary, the local communities in the Lake Assal region all see a better life for themselves due to the Lake Assal Salt Project. However, this can only happen if the salt project provides employment, improves sanitary conditions, schooling and education, and availability of drinking water. They expect the Salt Project to contribute to social growth and long term development in this region but they are clear on the fact that the environment must be protected and to respect their culture and traditions. The potential benefits which people expect to gain from the development of the salt mining activities include employment on a temporary or permanent basis. Small scale economic activities may also develop as a result of increased population in the area, and include sale of handicrafts, and local businesses which sell food and services.

Section 1.0

INTRODUCTION

1.1 Background

Djibouti's economy is mainly based on service activities which accounts for over two thirds of the country's GDP (African Development Bank, 1999). The country's manufacturing sector presently provides limited investment opportunities, although there is potential in the areas of salt processing and the production of building materials. The Government's strategy is primarily aimed at improving the business climate with a view to private sector-driven growth which will create jobs and reduce poverty.

Lake Assal is situated about 100 km west of Djibouti and 20 km from the coast, at the Western end of the Gulf of Tadjourah. The lake is a vast depression some 20 kms from the coast and is at a mean altitude of 150 m below sea level. With 54 km^2 of pure brine fed directly by gravity from the Red Sea and 62 km^2 of ready made salt crust of high purity raw crystal salt, Lake Assal (Djibouti, East Africa) is the world's largest sea salt reserve. The lake has a salinity of 25%, which makes it the world's saltiest lake. Approximately half of the surface area on the west side of the lake is covered by vast deposits of crystallised solid salt (50 km^2) and on the east by a highly saturated brine lake (Plate 1.1).

The salt on Lake Assal has been exploited for centuries by nomads with the extraction of salt representing an important source of revenue and playing an important role in the country's economy (National Biodiversity Action Plan, 2000). There are presently four official concession areas at the south eastern end of the lake. By late 2002, Société d'Exploitation du Lac and Société d'Exploitation du Sel de Djibouti were the largest producers with a combined 80% market share.

Djibouti recognises Lake Assal as a national "treasure" which should be in a protected area (National Environmental Action Plan, 2000). However, the salt is presently not being exploited properly i.e. uncontrolled exploitation, which is having a negative impact on the lake environment. For example, there is no waste management and plastic bags, petrol, waste water, old tractor tyres are just lying around. In addition, the conditions of work are extremely harsh with no health and safety guidelines being applied. The National Biodiversity Action Plan (2000) stresses the need for managing the exploitation of the salt and proposed the following two projects as part of the action plan:

Project 8.1: Environmental Impact Study on the Exploitation of Salt at Lake Assal
Project 8.2: Integrated Management Plan for Lake Assal

In 2002 Cortec (Pty) Ltd completed a full Feasibility Study for Societe D'Exploitation du Lac (SEL) which investigated the feasibility of increasing the existing production capacity to 250 000 tons per annum. An Environmental Impact Assessment (EIA) and Environmental Management Plan (EMP)

was undertaken as part of the 2002 feasibility study. The EIA was in accordance with World Bank guidelines and the Environmental Legislation in Djibouti, and provides some groundwork for Projects 8.1 and 8.2 of the NBAP (2000).

Since 2002, the Djibouti government's industrial policy in the salt sector has been to increase salt exports from Lake Assal, consolidate and regulate the industry, attract foreign investments, and be able to offer a country wide salt quality standard. Salt Investment S.A., in a partnership agreement between Société d'Exploitation du Lac (SEL) and Hardtechnologies Group S.L. ("Hardtech"), are now responsible for developing the salt project further and are established under the laws of Djibouti for the purposes of harvesting, refining, storing, transporting and exporting salt extracted from Lake Assal.

The purpose of the present salt project is to expand Lake Assal crude salt production to approximately 6 million tons per year (compared to 1.2 million tons projected in the 2002 study), install, operate and maintain a complete salt industry plant for the production of all grades of salt. The project involves the installation, operation and maintenance of 1,000 tons per hour in aggregate harvesting capability, a 250 tons per hour mechanical salt washing and upgrading plant and a 10 tons per hour (expandable to 20 tons per hour) refining plant.

The present EIA and EMP is an updated report incorporating the additional proposed activities and associated potential impacts, of the new Salt Project.

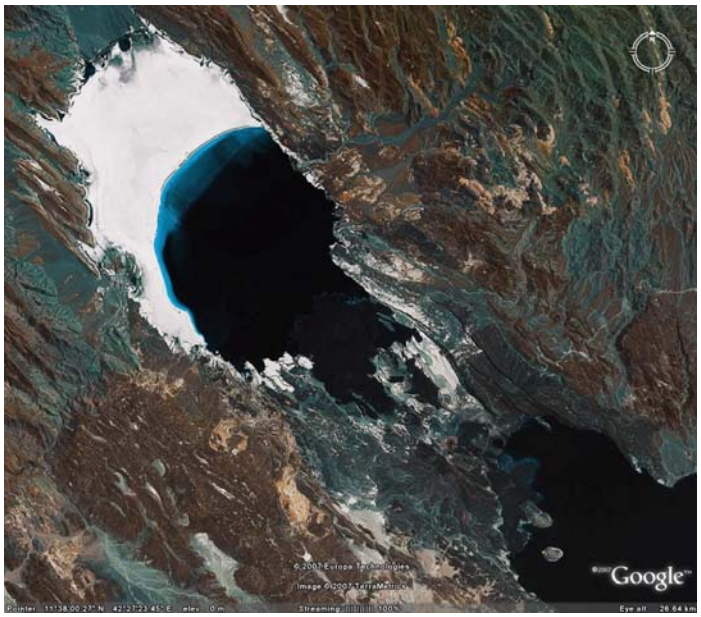

Plate 1.1: Lake Assal in Djibouti (Google Earth Image).

1.2 Objectives of the Lake Assal Salt Project

The objectives of the Lake Assal Salt Project are to:

- provide the infrastructure for an efficient, productive and environmentally sustainable salt mining industry;
- produce and export high grade industrial salt, refined salt for edible consumption, and to export standards;
- provide employment for the local people;
- prevent and/or mitigate the negative environmental impacts and enhance the positive impacts on the natural lake environment;

1.3 EIA Terms of Reference

The Terms of Reference for the 2002 EIA were to cover important aspects required by the funding agencies and are to undertake the following:

1. **Environmental Impact Assessment:**
    a. Study the effects on the environment that salt extraction will have on the area, and
    b. On the renewable resource of Lake Assal
2. **Socio-Economic Impact:**
    a. Describe the socio-economic impact salt mining operation will have on the local people living in the Lake Assal area.

The present EIA/EMP report is updated to include the potential environmental impacts of the additional salt exploitation activities and salt processing site at Lake Assal, the new salt storage and ship loading site at the Ghoubbet, and shipping activities in the Ghoubbet itself. The Environmental Authority in Djibouti (MHUEAT) were consulted (see **Appendix VI**) and agreed this was sufficient to update the existing EIA report for the new salt project.

Section 2.0

POLICY, LEGAL AND ADMINISTRATIVE FRAMEWORK

2.1 Environmental protection/policy in Djibouti

The Government of Djibouti's environmental policy focuses on four main themes (desertification control, conservation of biodiversity, improvement of the population's living, and management of water supply). The country has ratified the international conventions on biodiversity, climate change, and desertification.

The United Nations Conference on Environment and Development held in Rio de Janeiro 1992 marked a significant turning point in the protection of the environment in the world. Conscious of this new development strategy, the Government of Djibouti actively took part in the United Nations Conference of 1992 and prepared the first Report on Environment (1991) and created a National Committee for Environment – *Comité National pour l'Environnement (CNE)* (PANE, 2000).

In September 1996, after the internal armed conflicts ended, the Management of Development and Environment (*Direction de l'Amenagement du Territoire et de l'Environnement – DATE*) was formerly named. During 1997 the National Environmental Action Plan (*Plan d'action National pour l'Environnement – PNAE)* was launched and by 1999 the creation of the Ministry of Housing, Urbanism, Environment and Town & Country Planning (*Ministère de l'Habitat, de l'Urbanisme, de l'Enviornnement er de l'Aménagement du Territoire).* The management of the environment falls under the mandate of Town and Country Planning.

2.1.1 *National Environmental Action Plan (Plan d'action National pour l'Environnement – PANE, 2001-2010)*

The *Plan d'action National pour 'Environnement* (PANE, 2000) report was the result of a concerted effort over a period of two years. The aims and objectives of the Environmental Action Plan are to:

- to alleviate degradation of the environment;
- to review and improve management of solid and liquid waste;
- motivation and implication of all actors of environment;
- the promotion of new sustainable practices;
- the dissemination of environmental information.

Djibouti's Environmental Action Plan Report covers general aspects of the environment (physical, socio-economic, and political), the present situation of the environment, and strategies and actions to improve management of the environment.
One of the priorities in the management of the environment in Djibouti is to control the exploitation of salt at Lake Assal. The Action Plan states there must be an equilibrium between the salt mining

and tourism, as Lake Assal is seen as a unique geological tourist site. The following actions must be undertaken:

- Application of the mining code 1994
- Meetings of Inter-ministerial Committee 1998
- Undertake an environmental impact study on Lake Assal

Measures particularly concerned with the management of salt exploitation activities are to:

- Create a protected area of 10 kms, starting from the entrance to the lake.
- Impose a tax (for preservation of the site and quality of life for the people).
- Establish a plan for plots.
- Classify Lake Assal as a world heritage site.
- At the workers site supply enough water, treat used water, and remove solid waste.
- For the workers involved in the salt activities provide protected clothing and accessories.

2.1.2 *National Action Plan for Biodiversity (Stratégie et Programme a'Action National sur la Diversité Biologique)*

The National Action Plan for Biodiversity Report, 2000 (*Stratégie et Programme a'Action National sur la Diversité Biologique, 2000)* was the logical sequence to the national document on biological diversity of Djibouti published December 1999. This strategy and action programme is sectorial based and registered in the PANE.

The National Action Plan for Biodiversity has gathered new information and created an inventory of present biological resources in the country, assessed the causes of degradation in biological diversity, and filled gaps in information whilst evaluating Djibouti's biological diversity. The resultant knowledge analyses the environmental problems, present and future causes, and takes into account the International Conventions of Biodiversity, 18 topics of which constitute the fundamental strategy of the biodiversity action plan.

Theme 8 of the National Action Plan for Biodiversity (NAPB) covers he mineral resources of Djibouti. The problems associated with mineral resources in the country are that potential mineral deposits have not been fully investigated (e.g. perlite, calcium, clay) or that they are not economically viable. Salt (Lake Assal) is the only mineral exploited but is not managed correctly with the result the environment is being damaged. ***Those with mining/exploitation permit holders (see section 2.3.1 below) are not permitted to damage the environment and are to ensure hygiene and security to workers. There will be penalties if there is violation of articles in the protection of the environment***.

The NAPB principal risks in mineral resources are:

- Disorderly exploitation of Lake Assal;
- Pollution of Lake Assal;
- No respect for the Mining Code.

In response to these risks, the NAPB aims to:

- Stop damages being caused by the extraction and transport of salt;
- Help to minimise and favour restoration;
- Develop and put in place sustainable mining practices e.g. rehabilitation of exploited sites, recycling of waste, protection of soil decontamination.

The action plans to achieve these aims are two Projects (see **Appendix I** for details**)**:

Project 8.1: Environmental Impact Study on the Exploitation of Salt at Lake Assal
The principle aim of this project are to investigate the ecological and socio-economic impact of the salt exploitation at Lake Assal.

Project 8.2: Integrated Management Plan for Lake Assal
The principle aim of this project is to develop an integrated and comprehensive management plan for Lake Assal, including both mining and tourism developments. The management plan must combine development planning with the local community.

2.2 Environmental Legislation

In Djibouti, there is a lack of environmental assessments (NAPB, 2000), with one of the reasons being that information on the natural resources of the country is fragmented and of variable quality. Information is distributed amongst different organisations (ministries, NGOs etc.) and is insufficient to make environmental evaluations. The NAPB states that the principle risks with environmental assessments in Djibouti are:

- An absence of direction in environmental evaluation;
- Weakness in national competency in this domain.

The aims of the NAPB are to:

- Reinforce institutional capacity and technical ability for environmental analysis;
- See that the impact evaluations of all projects are included in "the Public Investment Programme";
- Integrate impact studies in the initial phase of projects, follow up, and in policies, plans and programmes;
- Sensitize the public and government ministries to the importance of the environment.

The action plan to achieve these aims is *Project 14.1: Develop a directive specifically for environmental evaluations of projects to include a Public Investment Programme.* The following sections describe the two laws which are aimed specifically for protection of the environment in Djibouti.

2.2.1 *Environmental Framework Law (Cadre de l'Environnement,) LOI No. 6/AN00/4èmeL*

The *Environmental Framework Law (No 106/AN00/4èmeL)* promulgated in the Government of Djibouti 29th October 2000, covers 68 articles related to protection of the environment. The Articles relevant to the present salt project are as follows:

Article 5: Management of the environment is regulated by the following principles:

- The protection and conservation of the environment is in general interest;
- All components of the environmental constitute is a national inheritance, which must be passed on to future generations;
- Actually, all citizens as well as all moral persons have a duty to:
- All utilisations of environmental resources must undertake and environmental assessment

Article 35: All activities being detrimental at a legitimate installation or (recognise ?) top soil or sub-soil - soil is the responsibility of the developer. Anything detrimental must be corrected.

Article 36: All sites having a purpose to exploitation have to be restore to original state. Those restored to state is the responsibility of the exploiter according to the conditions stated in the impact study or according to the measures specified by the Ministry in charge of environment.

Article 52: The state will see to the integration of environmental aspects in all new developments. They will put in place environmental management tasks, in particular: evaluate the environmental strategy; environmental impact study; environmental follow-up.

Article 53: A strategic environmental evaluation is needed in two conditions: the planning of a sector or when a large project will potentially influence important factors in the equilibrium of the environment notably, water resources, desertification, natural resources, demography.

Article 54: An environmental impact study is compulsory for all activities susceptible to environmental impacts. The impact study is approved by the Ministry in charge of the environment. The scope of the application will conform to the regulations.

Article 55: The environmental impact study must investigate all possible impacts of an activity. All persons potentially affected by an activity have a right to be informed and heard. The conditions of the procedure are as defined by the regulatory route.

Article 56: The follow-up of the environmental study is strictly followed by the impact study. It consists of an examination of the guidelines prescribed the impact study laws.

Article 61 : Anyone who contravenes the points in article 5 of the present law is punishable to the amount of 200 000 to 500 000 000 Djibouti Francs.

2.2.2 *Definition of Environmental Impact Assessment Procedures (Portant définition de la procédure d'étude d'impact environnemental (DECRET No.2001-0011/PR/MHUEAT)*

Articles in the *Environmental Framework Law (LOI No. 106/AN00/4ème) 5, 7, 16, 28, 33, 52, 53, 54, 55, 56* define the national procedure in environmental impact assessment (EIA). The environment is defined as "*the whole natural and artificial medium including human, social and cultural which affect animal, plant and human species and also maintaining environmental and natural spaces"*. All activities capable of negatively affecting the environment must undertake an impact study beforehand. The impact study must be integrated in the feasibility study. The proposed salt mining activity falls under the **Activity Category 16: Extraction Activities,** which includes all exploitation activities and forestry.

Article 5 in the DECRET No.2001-0011/PR/MHUEA states that nobody can start activities which potentially affect the environment without satisfying the decree. The evaluation of the impact study is ratified by the certificate of authorisation by the ministry. The impact study can go to a public hearing. Any activity which has not undertaken an EIA can be suspended. The EIA must reflect the predicted impacts of the project on the environment and must include the following:

- Description of the activity and investment, and reasons and justification of the choice of site.
- A description of the initial state of the natural environment, socio-economic and human environment, that could potentially be affected by the study.
- An analysis of the potential impacts – direct and indirect, temporary, and permanent. Impacts on the landscape, fauna, flora, air, soil, climate, marine status, biological equilibrium, resources, health etc.
- The social impact must include cultural and economic factors of the local communities, hygiene, sanitation, noise vibration, smell, radiation and others.
- Mitigation and management measures that the Client will undertake and the cost of those measures.
- Estimation of the residual impacts after construction.
- For large projects, estimation of cost, personnel, programme, and risk assessment.

2.3 Protection of the marine environment

The current status of the coastal zone in Djibouti was recently described as part of the Strategic Action Plan (SAP) for the Red Sea and Gulf of Aden (PERGSA, 2001). Although the Red Sea is still one of the least ecologically disturbed seas relative to other enclosed seas, it is in increasing jeopardy from over exploitation, pollution and coastal developments. The Country Report on Djibouti for the SAP found that despite the relatively pristine state of parts of the coast and territorial waters, several coastal areas show alarming signs of degradation and threats to the marine environment are increasing rapidly (PERGSA, 2001).

PERGSA/HAR (1998) undertook a quantitative field survey of a number of sites along the coast of Djibouti with the report indicating the impact of visitor's activities on these locations. The most commonly noted impacts by this study were damage to coral reefs by anchors and trampling, littering and souvenir collection. The Environmental Management Plan of this report provides guidance to protection and management of the marine coastal environment of Djibouti.

Since the Lake Assal Salt Project will be shipping the salt from the project study area for the export market, maritime laws will apply:

- The United Nations Convention on the Law of the Sea (1985).
- Law 76-599 on pollution caused by ships (1976)
- Law 64/AN/83 approving four international conventions regarding maritime navigation (1983)

- Law 94/AN/89 approving adherence to four international conventions on marine water pollution (1989)

The Directorate of Maritime Affaires (DAM) is in charge of prevention and prohibition of all violations of national and international legislation concerning marine pollution and maritime traffic.

2.4 Administrative requirements

The EIA report must be in French and Arabic**,** and five copies submitted to the Client. The EIA is evaluated by the Ministry of Environment until they are satisfied with the study. The evaluation is in two stages: by the ministry and by the public. Six months is the time limit for an EIA to be authorised by the ministry. Once the EIA report is submitted to the ministry, the EIA is available on site for 15 days and thereafter 30 days for the public to comment. The application of the Mining Code (No. 66/AN/94 3), which is presently in draft form, will represent an additional guarantee in the protection of the environment.

2.5 Investors Environmental Legislation

There are a number of investors involved in the Salt Project, some of which have environmental policies related to development projects. Below is a summary of the Investors who have environmental policies/guidelines: Overseas Private Investment Corporation (OPIC), African Development Bank (ADB), and European Investment Bank :

(1) *Overseas Private Investment Corporation (OPIC)*

OPIC is an agency of the US Government with a mandate to facilitate and encourage U.S. private investment in developing countries and emerging markets (OPIC Environmental Handbook, 2004). Since 1985, OPIC has had a strong environmental mandate and have produced an “OPIC Environmental Handbook” (February 2004) with guidelines for environmental impact assessments. OPIC will assure that the projects it supports are consistent with sound environmental and worker rights standards.

According to OPIC’s environmental guidelines the Lake Assal Salt Project is a Category B project because a limited number of specific environmental and social impacts may result which can be avoided or mitigated by adhering to generally recognized performance standards, guidelines or design criteria. Meaning that few if any of the impacts are likely to be irreversible, that they are site-specific, and that mitigatory measures can be designed more readily than for Category A projects. The EA normally consists of a limited environmental review, an environmental mitigation or action plan, an environmental audit or a hazard assessment and incorporating them into the project.

The project mainly involves capacity expansion near the existing site at Lake Assal, a new wash dam site, and upgrading of the existing maintenance and accommodation area. However, the site where the salt storage and ship loading is to take place i.e. near the Dankelo beach site at the

Ghoubbet is a new development. Hazardous materials are not used or produced in this project. Mitigation measures for potential environmental and social impacts are identified and incorporated into the current EIA/EMP report.

(2) *African Development Bank*

In January 2004 the Boards approved the new Bank Group Policy on the Environment, which incorporates and redefines the former policy on environmentally sustainable development. in Africa[2]. The new policy acknowledges that to sustain economic growth in Africa, there is an urgent need to preserve and enhance the ecological capital that enriches such growth.

The Integrated Environmental and Social Assessment Guidelines (IESA) guidelines are designed to ensure that both environmental and social issues are mainstreamed in Bank projects throughout the project cycle.

(3) *European Investment Bank*

The European Investment Bank (EIB) supports EU environmental policy (EIB Environmental And Social Practices Handbook, September 2007). The EIB supports the pursuit of sustainable development through its lending activities, by the financing of environmental projects, by safeguarding the environment where possible, and by trying to improve where practicable, the environmental and social outcomes of all projects. Under these EIB guidelines, the Lake Assal Salt Project could be categorised Projects where an EIA should be considered an Annex II project, section 23. *Extractive industry, including mining, extraction of minerals by fluvial dredging*.

[2] http://www.afdb.org/portal/page?_pageid=473,969906&_dad=portal&_schema=PORTAL

Section 3.0 DESCRIPTION OF SALT MINING ACTIVITY

3.1 Project location

Djibouti, at the junction of the Red Sea and the Gulf of Aden, covers a surface area of 23,200 km^2 with most of the coastline lying in the narrow Gulf of Tadjourah (Figure 3.1). A shallow, narrow opening separates the semi-enclosed basin of Ghoubbet al-Kharab with the Gulf of Tadjourah. The Ghoubbet al-Kharab bay has high salinity rates and is 200 m deep (PERGSA, 2001). The salt project is located at Lake Assal and on the NW side of the Ghoubbet al-Kharab, approximately 20 km to the West of the Gulf of Tadjourah and 120 km from the capital Djibouti (Figure 3.1).

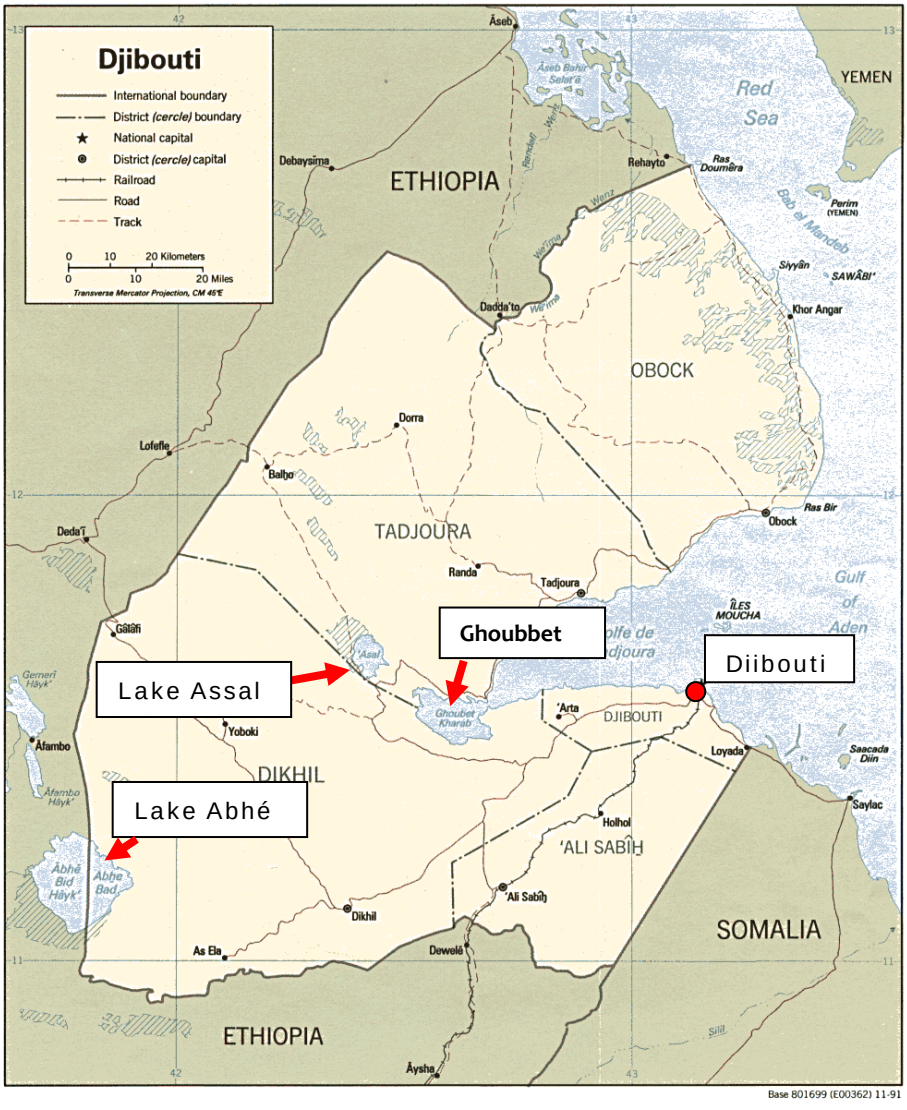

Figure 3.1. Location of the salt project in Djibouti, inland from Djibouti city.

3.2 Existing Operation

3.2.1 Present concession area

The development of the Djibouti salt industry has traditionally been constrained by over reliance on the single 250,000 tons per year Ethiopian market, absence of reliable water and energy supply, lack of basic infrastructure for workers (drinking water, sanitation), lack of foreign investment, inadequate regulatory framework and lack of upgrading and refining technology to access international markets. The existing plant consists of two bulldozers to extract the salt, three shovel loaders, ten trucks, buildings, housing facilities, a storage area, an oil pumping station, a generator, an oil compressor and various small tools, belts and conveyors.

The registered concession area is 3 km long and 2 km wide (5 km^2) with some of this extending into the lake (Plate 3.1). Harvesting extends 50 m into the lake and therefore the harvesting area is 15 ha. If it is assumed that a realistic rate of evaporation of 3 000 mm per annum, the natural production yield for the existing concession area is 86 000 tons per annum (based on the current harvesting methods).

Plate 3.1. View of SEL's present concession area (April 2001).

3.2.2 *Harvesting*

Salt is harvested by means of mechanical equipment from the edge of the lake. A bulldozer is used to rip into the salt bed (Plate 3.2). The loose salt is then pushed onto a pile with the bulldozer where the salt is allowed to dry down (Plate 3.3).

Plate 3.2. Harvesting of salt by bulldozers (April 2001).

Plate 3.3. Salt piles left to dry (April 2001).

3.2.3 *Loading and Hauling*

Thirty-five m^3 Tipper trucks are loaded by a front-end loader. The trucks then transport the salt to the processing area, located approximately 20 km from Lake Assal (Plate 3.4). The site is close to the sea and over looks the bay of Ghoubbet el Kharab.

Plate 3.4. Old salt processing site (arrow) over looking the bay of Ghoubbet el Kharab.

3.2.4 *Processing and Packing*

Lumps and plates of older layers of salt deposits are removed as a direct result of the harvesting method employed. Labourers equipped with 14lb hammers crush the lumps and plates of salt. Once crushed the labourers then load the salt into bags – the bags are weighed (50kg) and closed with a piece of string (Plates 3.5 and 3.6).

Plate 3.5. Processing of salt at processing plant.

Plate 3.6. Packing of salt into bags.

3.2.5 *Storage*

Currently the packed 50kg bags are stored in the open. The number of days that it is actually raining is far and few in between and at the present capacities, a warehouse could be regarded as a luxury.

3.3 Proposal to increase salt production to 6 million tons per annum

The purpose of the First Generation Project is to expand Lake Assal raw salt production to approximately 6 million tons per year, install, operate and maintain a complete salt industry plant for the production of all grades of salt and their derivatives. The First Generation Project involves the installation, operation and maintenance of 1,000 tons per hour in aggregate harvesting capability, a 250 tons per hour mechanical salt washing and upgrading plant and a 20 tons per hour refining plant. The plant is expected to process from 1.5 million tons of raw salt in its first year of production to 6 million tons per year by 2011.

There will be **four main centres of activity (Figure 3.2)**. Table 3.1 summarises the activities at each site :

1. **SITE 1**: Lake Assal salt production, harvesting, processing site and wash dam
2. **SITE 2**: Access road for salt transportation
3. **SITE 3**: Maintenance / Staff accommodation site
4. **SITE 4**: Salt storage and ship loading beach site

Table 3.1. Summary of activities at each SITE of the Lake Assal Salt Project.

	Site	Structures	Size	Activities
SITE 1	**Lake Assal**	Solar salt ponds	20% of lake area (13km²)	Salt production - crystallisation
			"	harvesting
		Processing plant	300m x 110m	salt washing and processing
		Wash dam	3 acres (109 m x109m) (12,000m²)	Waste brine
SITE 2	**Access road**	Gravel road	7.5km	Transport of salt in trucks to and from lake site and ship loading site
SITE 3	**Maintenance and accommodation**	Maintenance and housing	35 hectares (35,9056m²)	Equipment maintenance, housing
SITE 4	**Salt storage and ship loading site (beach)**	Stockpiling area on the beach	442m x 152m	Trucks offloading salt onto stockpiling beach site.
		Ship loading system	Conveyor; Jetty (44m)	Movement of salt from storage area to ship
		Ships sailing		Sailing of ships in the Ghoubbet bay
		Desalination plant	8000 Gall/day ($30m^3$/day) 160sq ft (13 x 13m)	Production of potable water

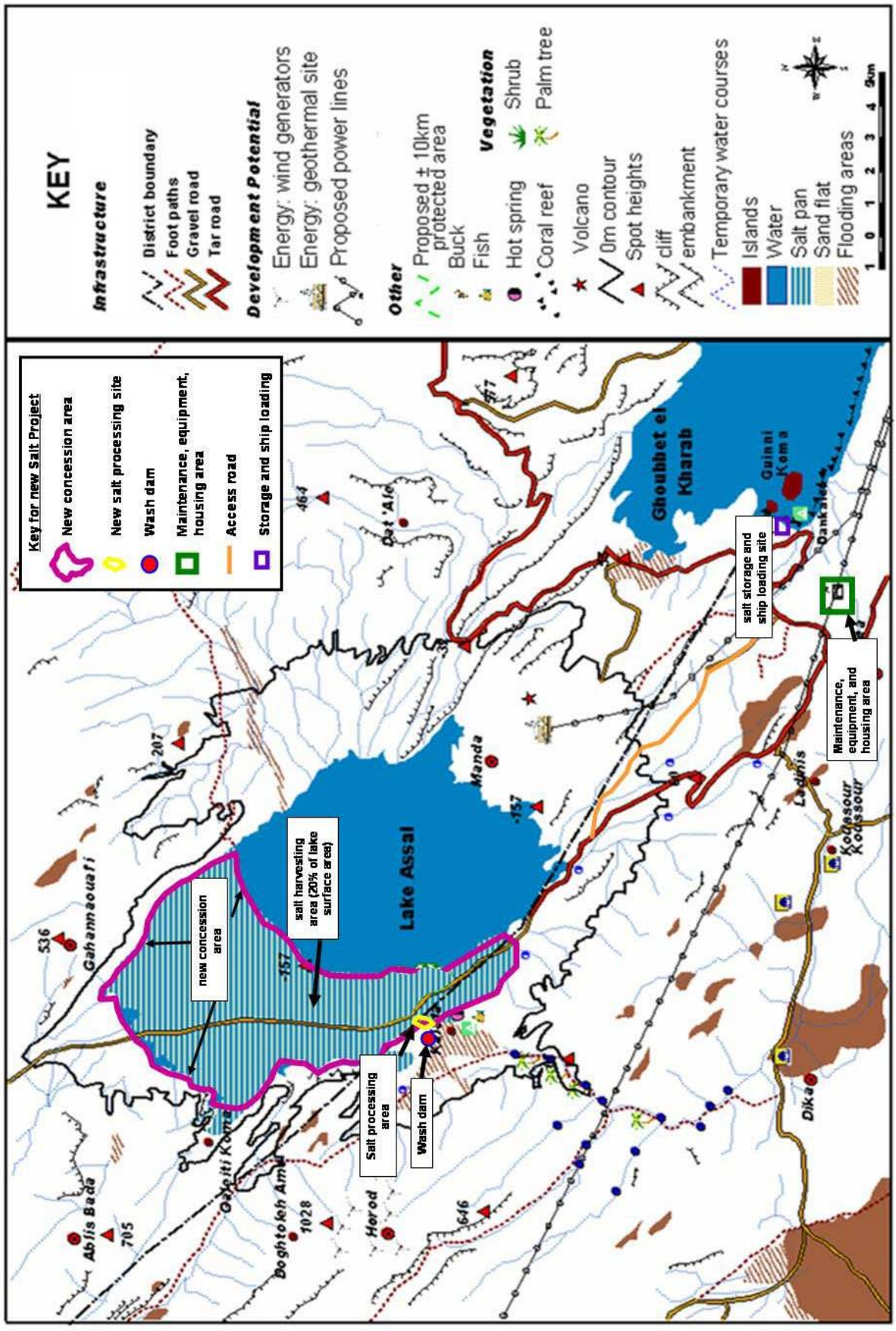

Figure 3.2. Location of the new Salt Project's activities.

3.3.1 *SITE 1: Lake Assal salt production, harvesting, processing plant and wash dam*

The policy of the Djibouti government to conserve the environment at Lake Assal would be upheld and a minimum of fixed structures and/or installations are planned in the lake area. At the Lake there will be a maximum of 2 harvesters, pulled by tractors, up to five pieces of additional equipment for building/maintaining salt berms (front end loaders and dozers). There will be a permanent fuel and maintenance station at the Lake.

Salt re-generation/ production

Solar salt ponds which will be built on the surface of the existing salt bed at Lake Assal. These ponds will cover a continuous area of approximately 20% of the Lake's salt surface area (13km^2) Although, the total concession area is the whole lake salt crust area (Figure 3.3).

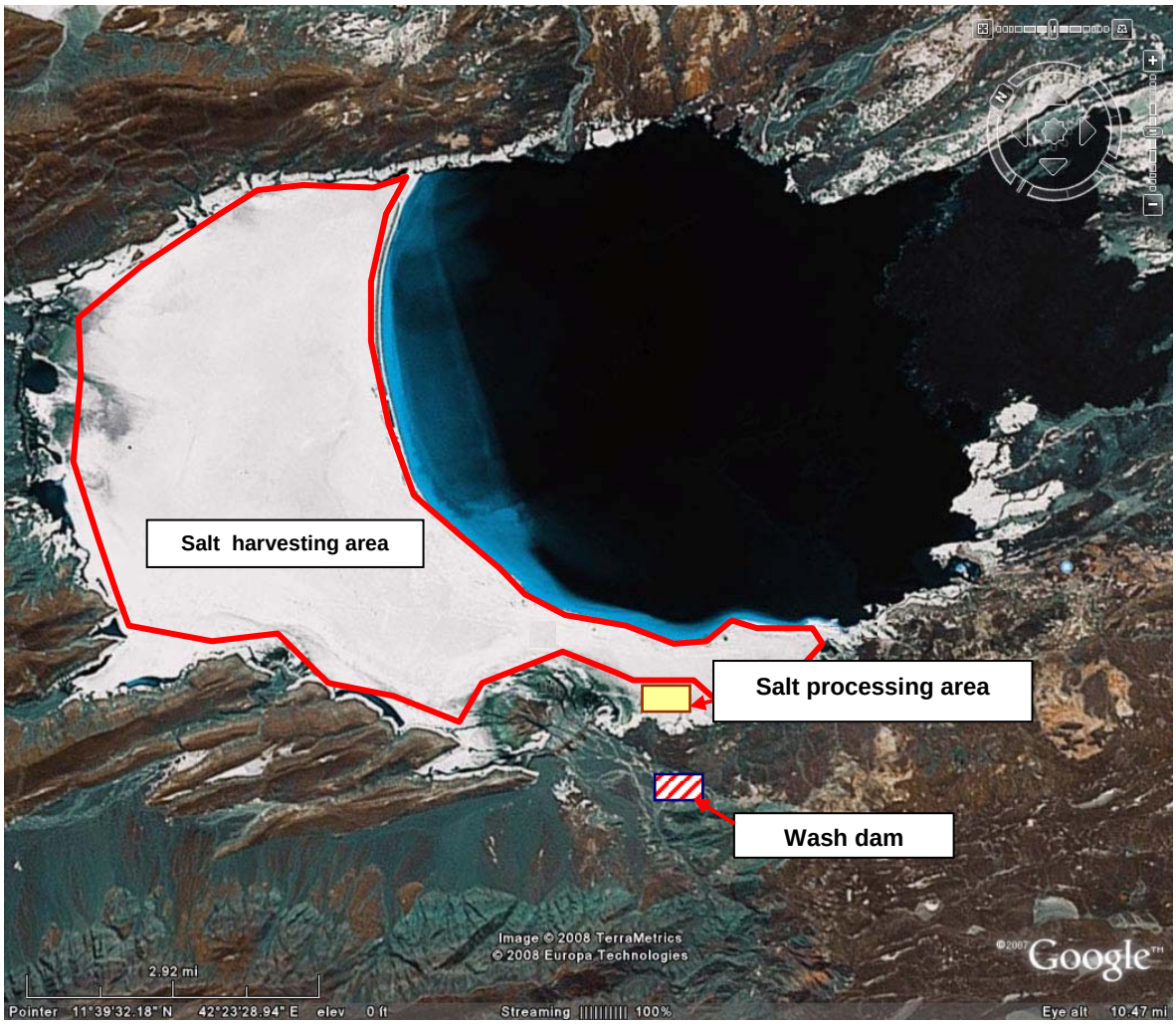

Figure 3.3. SITE 1: Lake Assal salt production and processing site. The red solid line indicates total concession area.

Previous studies relied on 'natural' formation of salt which was supposedly produced by annual rainfall washing onto the Lake. The original feasibility study in 2002 estimated that the existing operation is not conducive to produce 1.2 million tons per annum. Not even if all of the shoreline is used would enough salt be produced and re-generated to accommodate the projected capacity. Others estimated the total re-generation capacity of the lake at 2 million tons per annum.

The present Salt project takes the approach that they will produce higher quality salt by building a solar pond evaporation system. They will build the 'walls' of the ponds from salt pushed into long windrows on the Lake. Inside these artificially built ponds they will flood saturated brine from Lake Assal onto the existing surface of the salt bed and allow evaporation to create new salt. Under the effect of high sun radiation and wind, water will be drawn out of these ponds by natural evaporation, creating increasingly saline brines from which salt will crystallize within 90 days.. This method aims to never diminish the existing volume of the natural salt reserve on Lake Assal.

More solarization ponds and ultimately more evaporation surface area would be required if the climatic conditions and/or the rate of salt regeneration changes. The 'liquid' portion of Lake Assal is estimated to contain 120,000,000 of salt in a concentrated brine liquid suspension. It is continually regenerated by seawater from the Ghoubbet which is at a higher elevation than Lake Assal. The seawater, from the Ghoubbet will continually replenish the Lake, gallon for gallon, as fast as brine is pumped out of the Lake, and onto the surface of the salt bed.

The salt making process to be employed at Lake Assal is closely parallel to the natural system. Salt harvested from the lake will naturally contain small amounts of calcium and magnesium that are contained in the brine. The washing process will mechanically remove some of these non-NaCl components from the salt.

Harvesting of the salt at the lake

Collection of the salt off the crystallizer will be done with mechanical harvesters that break up the rock-hard salt and scrape up sheets of salt 12 to 15 centimetres deep with a blade that operates like a snowplough. The scrapped ponds will then be refilled with natural sea brine pumped from the lake. The proposed harvesters will harvest and automatically load haul trucks as they drive alongside the harvesters.

Processing plant

The wash plant and stock piling area will be located at Lac Assal and will cover a 'footprint' of 10 acres, and will be built on top of 1 meter thick layer of compacted gypsum which has been reclaimed from the shore of Lac Assal (Plate 3.7). Details of the salt processing plant facilities and equipment are shown in Figure 3.4 and Table 3.2. The salt operation will only produce bulk salt for export; all storage will be outside stockpile storage.

Plate 3.7. Compacted gypsum pad at the lake on top of which will be the processing plant.

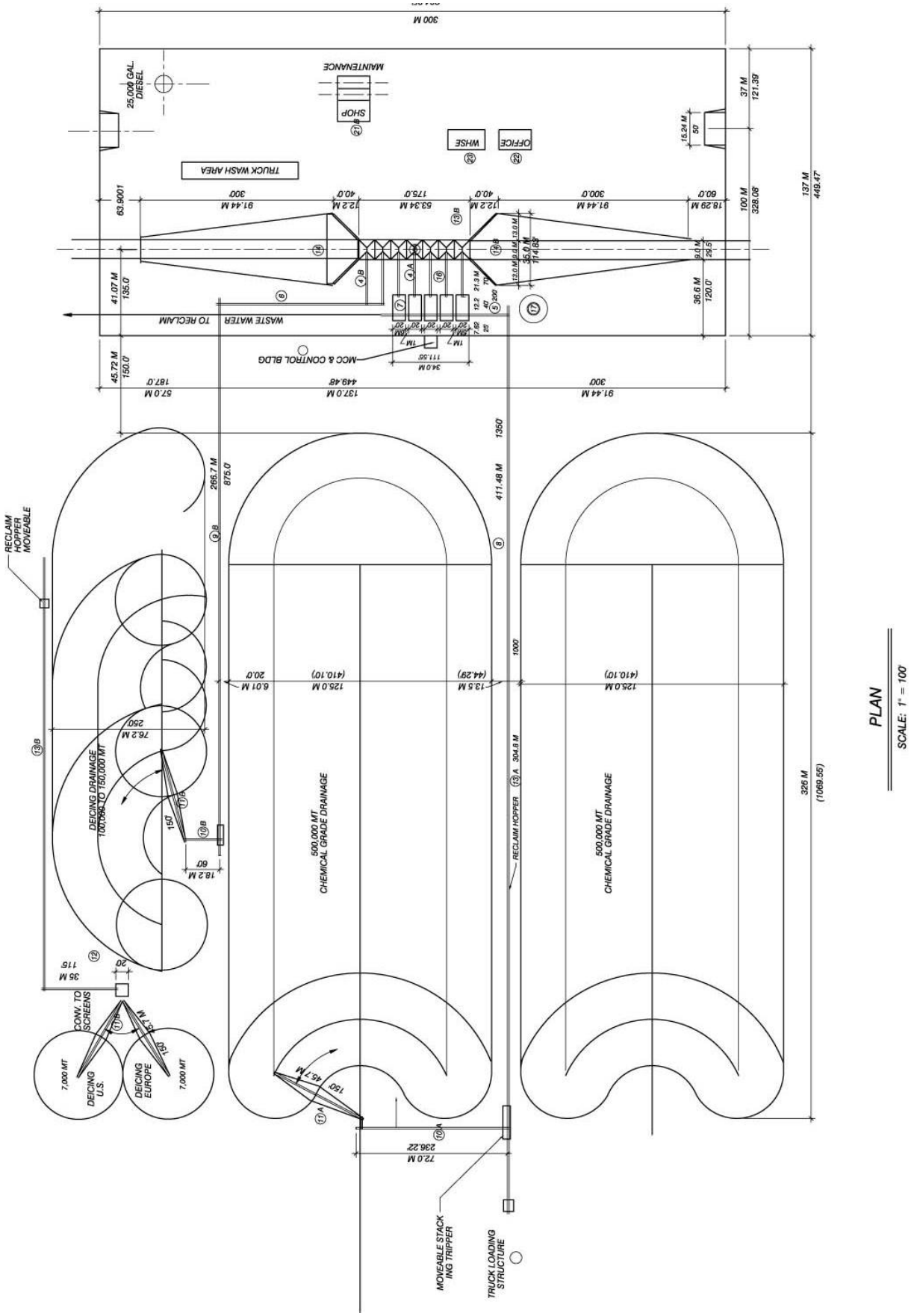

Figure 3.4. Salt processing plant facilities and equipment at the lake site.

Table 3.2. Salt processing plant facilities and equipment at the lake site.

EQUIPMENT SUMMARY

1 2	SALT HARVESTER UNIT PRE-HARVEST RIPPER UNIT	FAB. FAB.	-	6.0 CUT 6.0 CUT	1500 T/HR 1500 T/HR	-	VARIABLE VARIABLE	1 1
3	SALT HAUL UNITS TRUCK & TWO TRAILERS 30T EA.	MFG.	30 TON	-	-	-	-	5 TRACTORS 10 TRAILERS
4A 4B	HOPPER DISCHARGE CONVEYOR CHEM. SALT & DEICING SALT	MFG.	30" 30"	70' 90'	400 T/H 200 T/H	25 10	300 FT/M 250 FT/M	5 2
5	COLLECTION CONVEYOR CHEMICAL SALT FROM WASHER	MFG.	48"	200'	1600 T/H	50	400 F/M	1
6	COLLECTION CONVEYOR DEICING SALT	MFG.	36"	270'	400 T/H	25	250 FT/M	1
7	SALT WASHING UNITS WITH SCREW WASHER & SCREEN	FAB.	SCREEN 12' x 30'	20' W 40' L	200 T/H	50 SCREW WASHER	-	5
8	CHEMICAL SALT STACKING CONVEYOR & TRIPPER & RAILS	MFG. FAB.	48"	1350'	1600 T/H	150	400 F/M	1
9	DEICING SALT STACKING CONVEYOR & TRIPPER & RAILS	MFG. FAB.	36"	875'	400 T/H	50	300 F/M	1
10A 10B	TRANSFER CONVEYORS CHEM. & DEICING MOBILE	MFG.	48" 36"	236' 60'	1600 T/H 400 T/H	60 15	400 F/M 250 F/M	1 1
11A 11B	RADIAL STACKING CONV. 45' PILE FOR CHEM & DEICING SALT	MFG. MFG.	48" 36"	150' LG 45' HIGH	1600 T/H 400 T/H	125 30	475 F/M 250 F/M	1 2
12	FEED HOPPER - SCREEN BLDG & FEED CONVEYOR	FAB. MFG.	30"	115' LG 30' HIGH	400 T/H	15	300 F/M	1 1
13A 13B	CHEM SALT RECLAIM & HOPPER DEICING SALT RECLAIM & HOPPER	MFG. MFG.	48" 30"	1000' 680'	1600 T/H 400 T/H	150 50	475 F/M 300 F/M	1 1

FACILITIES SUMMARY

ITEM NO.	DESCRIPTION	MTG.	SIZE	HEIGHT	HP REQ'D.	NO. REQ'D.
14	SITE PREPARATION & GRADING ACCESS ROAD & PORT ACCESS	COMP. SOIL	244' LG 2 SIDES	7.3 M 24.0 FT	-	2 SECTIONS
15	TRUCK DUMP STRUCTURE RETAINING WALLS & HOPPERS	STEEL, CONC. & TIMBER	30' WIDE 180' LONG	24.0 FT	-	7 HOPPERS
16	CONCRETE FOOTINGS - SLABS AND SITE WORK	CONC.	250' x 150'	-	-	JOB
17	SEA WATER TANK & PIPING & PUMPS - WASH MAKEUP	-	50,000 GAL.	-	60 HP	1 TANK 2 PUMPS
18	BRINE WASH SYSTEM - RESERVOIR, PIPING & PUMPS	-	50,000 GAL.	-	60 HP	2 PUMPS
19	GENERATORS	MFG.	-	-	-	2 SECTIONS
20	ELECTRICAL - POWER & LIGHTING - MCC CONTROL BLDG	FAB. MFG	-	-	-	JOB
21	SHOP & MAINTENANCE BLDG. TIRES & LUBRICATION	CONST.	25,000 GAL. DIESEL	-	-	1
22	OFFICE - LUNCH ROOM - REST ROOMS & SANITARY WASTE	CONST.	-	-	-	1
P-13	OPERATIONS & WAREHOUSE	CONST.	-	-	-	1
24	CULINARY WATER SYSTEM & STORAGE TANK	FAB.	100 GPM	-	10 HP	JOB
25	PUMP STATION TO SUPPLY BRINE TO CRYSTALLIZER AREA.	MFG. DIESEL	3,500 GPM	-	DIESEL ENGINE	1

The quality of the product exported depends upon the application and the standard specifications prescribed by the Issuer's customers. After upgrading, solar salt crystals typically range in size from 2 to 10 millimetres. In the case of industrial salt, the crystals may be dispatched without crushing. Table 3.3 summarises the composition of the salt.

Table 3.3. Composition of the salt product.

	Ca	Mg	SO4
unwashed salt	0.448 mg/L	0.343 mg/L	0.609 mg/L
washed salt	0.264 mg/L	0.138 mg/L	0.407 mg/L
Amount removed	0.184 mg/L	0.205 mg/L	0.202 mg/L
amount/1000 tons	1.8	2	2

All power will be generated by three 685kv CAT diesel generators. One of the generators will be used to pump lake water into the solar ponds. Table 3.4 summarises the predicted emissions from these three CAT diesel generators and the corresponding IFC Guidelines (International Finance Corporation, World Bank Group, Environmental, Health, and Safety Guidelines, April 30, 2007).

Table 3.4. Predicted **emissions from the three CAT diesel generators at the Lake Site, and the corresponding IFC Guidelines limits.**

	PREDICTED EMMISSIONS[1]					IFC GUIDELINES[2]			
SITE 1	**Power source**	**Engine**	**Fuel type**	**Fuel quantity**	**Fuel storage**	**Particulate Matter (PM) 50 - 100**	**Sulfur Dioxide (SO2) 1.5% - 3%**	**Nitrogen Oxides (NOx) 1460 - 1850**	**Dry Gas, Excess O2 Content (%) 15%**
Lake Site	**3 x 685kV CAT diesel generators**	CAT C18 ATAAC ACERT engine meets US EPA Tier 3 emission	diesel	15 gal/hr each	10570 gal	5.0 mg/Nm^3	1%	1420 mg/Nm^3	No Information

[1] Hardtech; [2] International Finance Corporation, World Bank Group, Environmental, Health, and Safety Guidelines (April 30, 2007)

Wash dam

The only ongoing wash water waste will be heavy calcium/magnesium brine from two concentrators which will be part of the 4200 acre pond solar production facility just inland from the Lake (Plate 3.8). The washeries brine pond area is to be covered with geomembrane to avoid seepage.

Plate 3.8. Wash dam site over the hill from the lake edge to the left of the flood plain.

Wash water from wash operations will be collected in settling ponds to allow sediment to percolate out of wash water. They will supplement wash water with additional well water and seawater. Wash water at Lac Assal will be a blend of brackish well water and salt water from Lac Assal. Most of the calcium/magnesium precipitates out before being pumped onto the existing salt flats for further evaporation. The waste wash water of the Lake Assal salt project will not look like the

analysis from a typical 'virgin' sea salt solar operation. Approximately 500,000m^3 of waste wash water will be generated each year. Half of this will be recycled and reused as sedimentation occurs. The composition of the wash water discharge is shown in Table 3.5:

Table 3.5. Composition of the wash water from the wash dam.

	WASH WATER[1]			IFC GUIDELINES[2]							
	Ca	Mg	SO4	pH 6 - 9	BOD (mg/l) 30	COD (mg/l) 125	Total nitrogen (mg/l) 10	Total phosphorus (mg/l) 2	oil and grease (mg/l) 10	TSS (mg/l) 50	Total coliform bacteria (MPNP/100ml) 400
Wash water (Lake Assal)	3625 mg/L	10546 mg/L	2610 mg/L	7.2	NA[3]	NA[3]	NA[3]	NA[3]	NA[3]	NA[3]	NA[3]
Used wash water	3625 mg/L	10546 mg/L	2610 mg/L	7.2	NA[3]	NA[3]	NA[3]	NA[3]	NA[3]	NA[3]	NA[3]

[1]Gal wash water/1000 tons = 67500; [2] International Finance Corporation, World Bank Group, Environmental, Health, and Safety Guidelines (April 30, 2007); [3]The septic sewage standards do not apply to this wash pond. No applicable EHS standards. The only constituents going into that pond will be lake brine and salt made from the lake brine. The purpose of the pond is to settle the salt in the pond so that the brine can be reused .

The solid waste management and the sewage and sanitation system at the Lake site are summarised in Table 3.6 and Table 3.7, respectively.

Table 3.6. Solid waste management at the Maintenance and Housing site.

	SOLID WASTE MANAGEMENT					
SITE	type of solid waste system	amount of waste/day	waste type	treatment disposal	hazardous waste	transportation
SITE 1: Lake Site	dumpster	1/2 ton	paper/ cardboard	haul to certified site	stored for pick up	outside contractor

Table 3.7. Solid waste management at the Lake site.

SITE	SEWAGE SYSTEMS		IFC GUIDELINES[1]							
	type of sewage system	amount of sewage	Ph 6 - 9	BOD (mg/l) 30	COD (mg/l) 125	Total nitrogen (mg/l) 10	Total phosphorus (mg/l) 2	oil and grease (mg/l) 10	TSS (mg/l) 50	Total coliform bacteria (MPNP/100 ml)
SITE 1: Lake Site	closed septic	20 people	est 6-9	<10	<50	est <10	est <2	<5	<10	<2.2

[1] International Finance Corporation, World Bank Group, Environmental, Health, and Safety Guidelines (April 30, 2007)

3.3.2 *SITE 2: Access Road from the lake to the Ghoubbet*

Once the washed salt has been drained it will be loaded and hauled from Lac Assal to the stockpile area at the Ghoubbet by a fleet of heavy, off road haul trucks. Thirty-three trucks are projected at full production but will initially start out with 11 operating trucks. Salt will be transported to the site of the Ghoubbet port where it will be conveyed onto salt stacks up to 10 meters high prior to being exported to world refineries, de-icing customers and chlor-alkali producers as bulk unwashed salt.

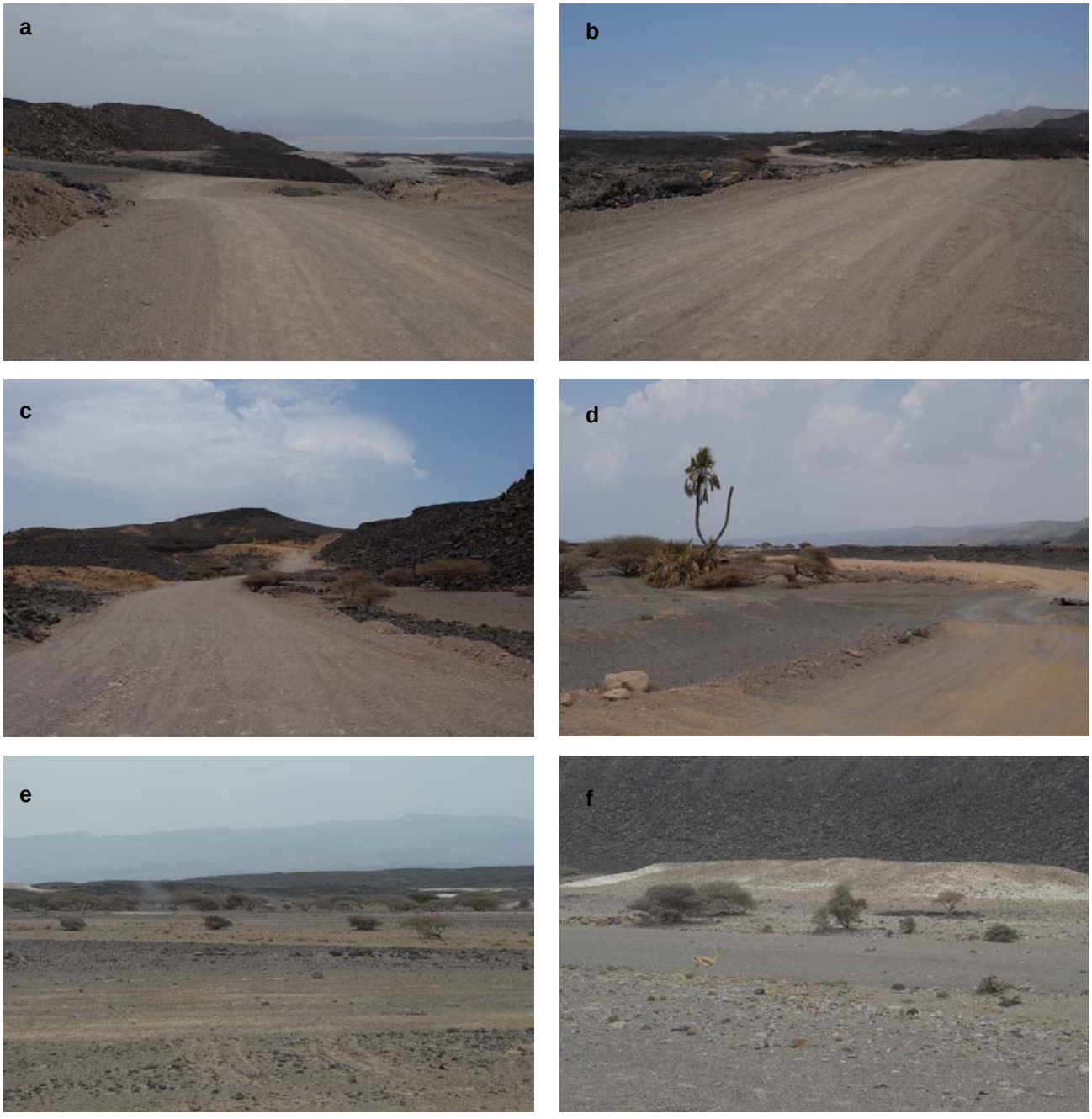

Plate 3.9 a – f. Photographs of the haul road presently under construction (June 2008). a – start of the haul road, b – start of haul road, c – steeper section of haul road, d – palm tree next to road, e – terrain next to the road, f – small buck crossing road.

A dedicated 7.7km haul road is under construction between the lake site and the Ghoubbet area (Plate 3.9). This road will bypass the village on the main road and so will minimise the impact of the haul truck traffic on this main road. The haul road is being built using local gravel stone which is compacted and is suitable for heavy off-road mining trucks. The road will by pass any trees and will have not permanent structures. The haul road passes through some dry river beds where culvert-type structure will need to be built. Small buck were observed grazing in the area, and a number of trees are present in the area.

3.3.3 *SITE 3: Maintenance / Staff accommodation site*

The Issuer will own and operate an office complex for project management, administrative, technical, logistical and support staff. The existing area of SEL's old refinery building and adjacent work areas will become the maintenance shop and equipment parking area (Figure 3.2, Plate 3.10). New housing units have been built next to the maintenance area (Plate 3.10c & d) and will be used for housing of technical people, maintenance shop, lay-down area for equipment and offices.

Plate 3.10 a –b. SITE 3 – maintenance, offices and accommodation site. a – offices, b – vehicle maintenance building, c – housing, d – staff housing, e – fuel depot, f – solid waste disposal site.

The power supply at the maintenance/housing site is from "2 x 455kVA CAT diesel generators, the emissions of which are all within the IFC Guidelines (Table 3.8).

Table 3.8. Predicted emissions from the two CAT diesel generators at the Maintenance and Housing Site, and the corresponding IFC Guidelines limits.

	PREDICTED EMMISSIONS					IFC GUIDELINES[1]			
SITE 3	Power source	Engine	Fuel type	Fuel quantity	Fuel storage	Particulate Matter (PM) 50 - 100	Sulfur Dioxide (SO2) 1.5% - 3%	Nitrogen Oxides (NOx) 1460 - 1850	Dry Gas, Excess O2 Content (%) 15%
Maintenance / Staff Housing	**2 x 455kVA CAT diesel generators**	CAT C15 ATAAC ACERT engine meets US EPA Tier 3 emission regulations	diesel	14.1 gal/hr each	56000 gal	3.1 mg/Nm3	1%	1349.2 mg/Nm3	No Info

[1] International Finance Corporation, World Bank Group, Environmental, Health, and Safety Guidelines (April 30, 2007)

A comprehensive plan is in place for sewage and solid waste disposal at this maintenance and housing area (Tables 3.9 and 3.10). The solid waste area will be fenced off and the solid waste regularly removed to a permitted waste disposal site about 30 minutes from the maintenance/accommodation area. There is also a routine burning of solid waste on site.

Table 3.9. Solid waste management at the Maintenance and Housing site.

	SOLID WASTE MANAGEMENT					
SITE	type of solid waste system	amount of waste/day	waste type	treatment disposal	hazardous waste	transportation
SITE 3: Maintenance / Staff Housing	dumpster	2 tons	food misc. trash	haul to certified site	stored for pick up	outside contractor

Table 3.10. Sewage and sanitation management at the Maintenance and Housing site, and the corresponding IFC Guidelines limits.

	SEWAGE SYSTEMS		IFC GUIDELINES[1]							
SITE 3	type of sewage system	amount of sewage	Ph 6 - 9	BOD (mg/l) 30	COD (mg/l) 125	Total nitrogen (mg/l) 10	Total phosphorus (mg/l) 2	oil and grease (mg/l) 10	TSS (mg/l) 50	Total coliform bacteria (MPNP/100 ml)
Maintenance / Staff Housing	**closed septic**	120 people	est 6-10	<10	<50	est <10	est <2	<5	<10	<2.3

[1] International Finance Corporation, World Bank Group, Environmental, Health, and Safety Guidelines (April 30, 2007)

3.3.4 *SITE 4: Salt storage and ship loading at the Ghoubbet*

Figure 3.5 shows the location of the salt storage beach site and ship loading area. The site preparation earthworks necessary to prepare the beach and ship jetty sites at the Ghoubbet is described below. This work must be done before foundations can be laid and equipment set in place to stack salt at the beach and place the salt on ships at the jetty. The beach site will also house infrastructure items such as the desalination unit making domestic water, diesel fuel tanks, and electrical power generation. The emissions from the CAT generators are shown in Table 3.11, the solid waste management in Table 3.12, and the sewage/sanitation systems in Table 3.13.

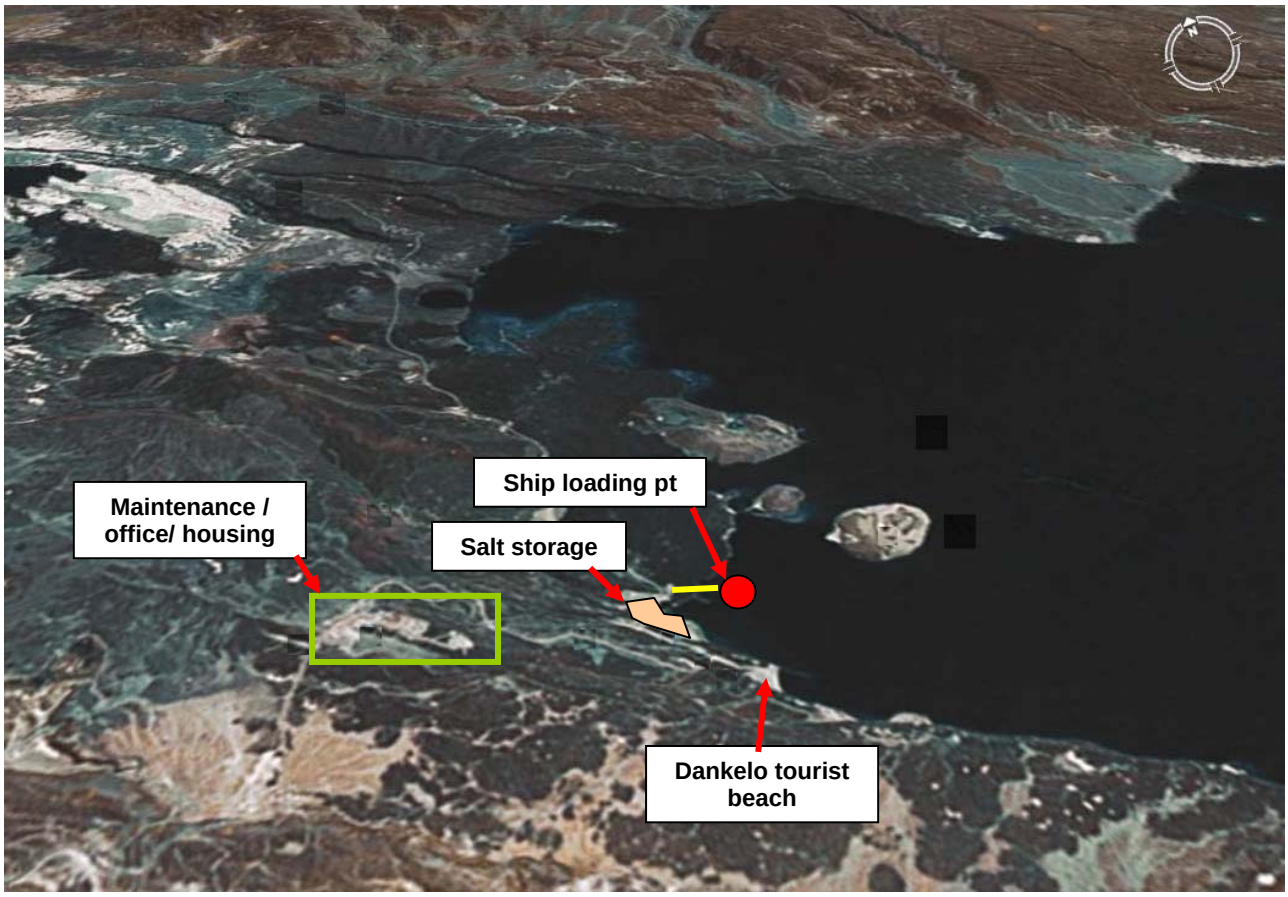

Figure 3.5. Location of the salt storage beach area and the ship loading point.

Table 3.11. **Predicted emissions from the two CAT diesel generators at the Salt Storage Ghoubbet Site, and the corresponding IFC Guidelines limits**

	PREDICTED EMMISSIONS					IFC GUIDELINES[1]			
SITE 4	Power source	Engine	Fuel type	Fuel quantity	Fuel storage	Particulate Matter (PM) 50 - 100	Sulfur Dioxide (SO2) 1.5% - 3%	Nitrogen Oxides (NOx) 1460 - 1850	Dry Gas, Excess O2 Content (%)
Salt storage and loading	**Estimate 3 x 685kVA CAT diesel generators**	CAT C18 ATAAC ACERT engine meets US EPA Tier 3 emission regulations	diesel	15 gal/hr each	6600 gal	5.0 mg/Nm3	1%	1420 mg/Nm3	No Information

[1] International Finance Corporation, World Bank Group, Environmental, Health, and Safety Guidelines (April 30, 2007)

Table 3.12. Solid waste management at the Salt Storage Ghoubbet Site.

	SOLID WASTE MANAGEMENT					
SITE 4	**type of solid waste system**	**amount of waste/day**	**waste type**	**treatment disposal**	**hazardous waste**	**transportation**
Salt storage and loading	dumpster	1/2 ton	paper/ cardboard	haul to certified site	stored for pick up	outside contractor

Table 3.13. Sewage and sanitation management at the Salt Storage Ghoubbet Site, and the corresponding IFC Guidelines limits.

	SEWAGE SYSTEMS		IFC GUIDELINES[1]							
SITE 4	**type of sewage system**	**amount of sewage**	**Ph 6 - 9**	**BOD (mg/l) 30**	**COD (mg/l) 125**	**Total nitrogen (mg/l) 10**	**Total phospho rus (mg/l) 2**	**oil and grease (mg/l) 10**	**TSS (mg/l) 50**	**Total coliform bacteria (MPNP/100 ml)**
Salt storage and loading	**closed septic**	20 people	est 6-11	<10	<50	est <10	est <2	<5	<10	<2.4

[1] International Finance Corporation, World Bank Group, Environmental, Health, and Safety Guidelines (April 30, 2007)

Beach Storage Site

The bulk salts will be stored initially at Lac Assal to allow dewatering. Once salt is dewatered to under 3% moisture it will be transported to the Ghoubbet on outdoor stacks 10 meters high located in front of the belt conveyors that will be used to load them. The Issuer has unlimited access to land for this purpose.

Salt produced at Lake Assal will be transported to the beach site for stockpiling in preparation for shipping. Salt will be segregated into three stacks at the beach. The largest stack will be for chemical grade salt. There will be two smaller stacks for deicing salt – one for the US market and one for the EU market. When a ship arrives at the port for loading, the salt will be moved from the beach stacking area to the port and onto the ship.

Trucks carrying salt from the Lake will arrive at the beach site and discharge salt into elevated hoppers. The hoppers will direct the salt onto belt conveyors that move the salt to the appropriate stack. Dozers will push the salt off the stacks onto belt conveyors that move the salt to the ship loading system.

The beach site is already a relatively flat area (Plate 3.11) and the natural slope of the beach is to be maintained. However, some natural and manmade structures need to be removed, added or modified to fully prepare the area. The site will be graded to be flat, to existing highway elevation, this will allow haul trucks to exit/enter work area without need to climb existing grade.

A perimeter dike will be created to protect the salt from the ocean. A natural rock formation along the northeast part of the shoreline will form part of the dike. A new dike will be built along the southeast shore where none exists now. Natural rainwater runoff from the watershed northwest from the beach will have to be guided around the salt stack by building a drainage ditch. A drain pipe will be placed through the dike at that point to let rainwater run into the ocean. The dike will be constructed of soil found on site with a clay core and will be built to a height of 1.5m above the existing elevation. The dike will be installed with an impermeable core running from the top of the dike down to bedrock. The core will prevent seawater from pushing through the dike. Core methods and materials to be approved by owner.

Rainwater from the other side of the highway is routed through culverts under the road to the beach area. Three culverts discharge into the NW corner of the beach area. A drainage ditch will be built to channel rainwater around the stack area to the sea. The open design ditch and is to be approximately 5m wide and 1m deep. The area to the extreme northern end of the site will be filled and levelled. Two pipes will be installed to allow storm water to flow into the existing lagoon. Details of the equipment and facilities at the beach storage site are shown in Figure 3.6 and Table 3.14.

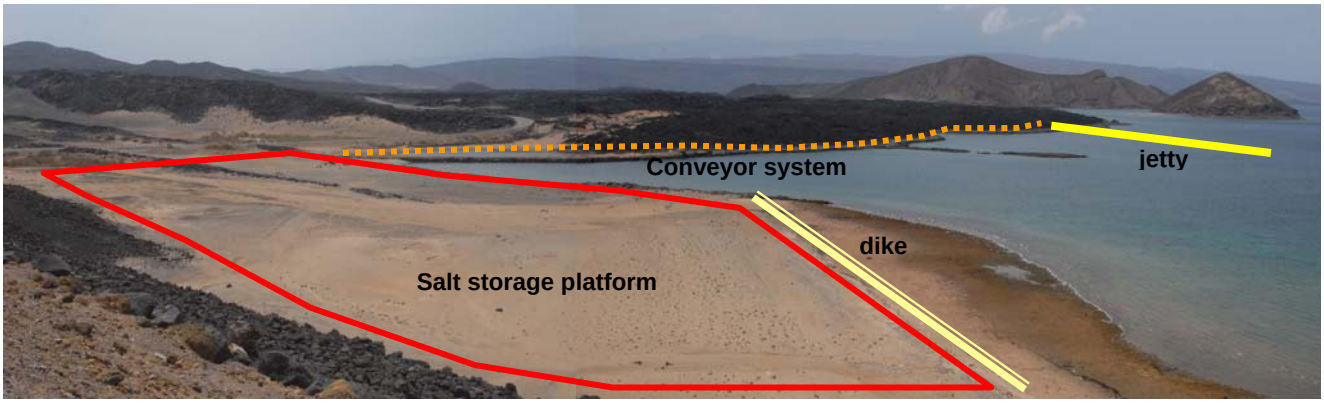

Plate 3.11. Beach area to be used for salt storage. Location of the conveyor system and jetty for loading onto the ship is also indicated.

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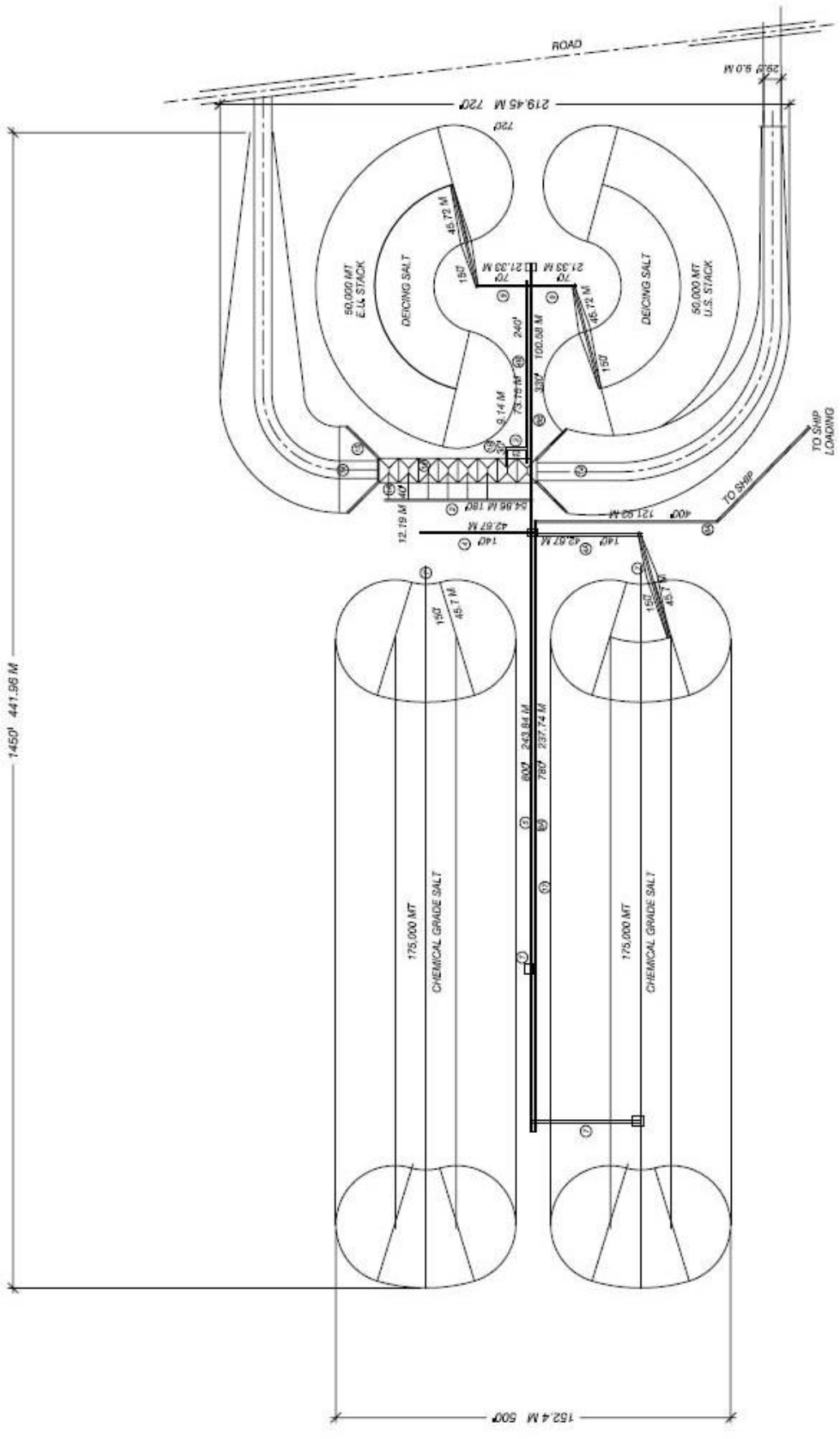

Figure 3.6. Layout for the storage of the salt at the beach site.

Table 3.14. Salt storage facilities and equipment at the beach site.

EQUIPMENT SUMMARY

ITEM NO	DESCRIPTION	TYPE	SIZE	HORSEPOWER CAPACITY	LENGTH	NO. REQ'D
P-1A P-1B	HOPPER DISCHARGE CONV. CHEMICAL HOPPER DISCHARGE CONV. DEICING	BELT BELT	30" 30"	AREA	AREA	AREA
P-2	CHEMICAL GRADE SALT	BELT	48"	AREA	AREA	AREA
P-3	DEICING GRADE SALT	BELT	36"	AREA	AREA	AREA
P-4A P-4B	TRANSFER CONVEYOR - CHEMICAL TRANSFER CONVEYOR - DEICING	BELT BELT	48" 36"	AREA	AREA	AREA
P-5 (T)	STACKING CONVEYOR CHEM & TRIPPER ASSEMBLY	BELT	48"	AREA	AREA	AREA
P-6A P-6B	FOR CHEMICAL & HOPPER FOR DEICING SALT & HOPPER	BELT BELT	54" 36"	AREA	AREA	AREA
P-7	CHEMICAL GRADE SALT	BELT	48"	AREA	AREA	AREA
P-8A P-8B	RECLAIM TO SHIP LOADER RECLAIM TO SHIP LOADER	BELT BELT	54" 54"	AREA	AREA	AREA
P-9	TRANSFER TO RADIAL CONV. DEICING GRADE SALT-	BELT	36"	AREA	AREA	AREA
P-10	RADIAL STACKING CONVEYOR DEICING SALT	BELT	36"	AREA	AREA	AREA
P-11	RADIAL CONVEYOR FROM PILE W/ PUSH FEED HOPPER - CHEM & DEICING	BELT FAB	54" 20 TON	AREA	AREA	AREA

FACILITIES SUMMARY

ITEM NO	DESCRIPTION	TYPE	SIZE		LENGTH	NO. REQ'D
P-13	SITE PREPARATION & GRADING ACCESS ROAD & PORT ACCESS	AREA	500' X 700'			JOB
P-14	TRUCK DUMP RAMPS	COMPACTED SOIL	-			2
P-15	TRUCK DUMP RETAINING WALLS	REINFORCED CONCRETE	24' HIGH 60' WINGS			2
P-16	TRUCK DUMP STRUCTURE & CONCRETE SLAB	STEEL, TIMBER & CONCRETE	200' LONG 30' WIDE 24' HIGH			1
P-17	CHEMICAL SALT CONVEYOR SITE & RAILS FOR TRIPPER	COMPACTED FILL, STEEL RAILS & TIES	700' X 50' X 1.75'			1
P-18	SALT STOCKPILE PREP & GRADING	AREA 1000' X 500'	AREA			JOB
P-19	SITE ELECTRICAL & LIGHTING	TOTAL AREA 400' X 1200'	AREA			1
P-20	ELECTRICAL GENERATOR	-	AREA			1 + SPARE

Ship loading system

Adjacent to this stockpile area will be the ship loading area (see Plate 3.11) which will consist of a loader/conveyer system and ships moorings. Plate 3.12 illustrates the type of jetty system to be used. A jetty will be constructed 1000 m from the beach stockpile area. This jetty will be perpendicular to the shore and will have a ship loader system capable of loading vessels up to 100,000 ton dwt at 2,000 tons per hours. A conveyor belt will transport salt from the beach to the jetty/loader.

Ships will be escorted into loading position by tugs, attached to sea anchors and moved beneath the loader. Once the ships are loaded they will be escorted safely away from the jetty. This system is a copy of the loading systems now being used by salt producers in Mexico, Chile and two Australian locations. The final design if the jetty will be approved by an international shipping certification agency. Shipping activities in the Ghoubbet fall under the jurisdiction of the Djibouti Port Authority.

Plate 3.12. Jetty system used at Dampier Salt in Western Australia . The Lake Assal Salt Project will use a similar jetty structure for loading the bulk salt onto the ships. Note the sea anchors attached to the ship. **(source** http://www.dampiersalt.com.au/tnpn002785/prod/dsl/dslhome.nsf).

The salt on the stacks at the beach will be pushed onto belt conveyors by dozers. The ship loading system consists of a long belt conveyor that leaves the north end of the beach, runs along the existing shoreline, and delivers salt to the ship loading structure.

The work needed to install the ship loading system includes filling in a small triangle area at the north end of the beach, enhancing the existing single road crossing the lagoon into a double road, and installing an access road along the beach to the ship loading point.

The small triangle shaped area exists at the north side of the beach with seawater flowing into this area only at high tide. This area will be filled in with lava rock from the ridge, lava rock from the

access road construction, and native soil to about the high tide elevation. The finish elevation is to match the surrounding area.

The existing one lane road connecting the shore to the lava bed will be widened to 5 meters to allow installation of the conveyor belt and light utility truck traffic.

An access road needs to be completed from the lagoon, along the existing shoreline to the point where the ship loading structure meets the shore. This road will be approximately 1000m long. It will be 5m wide and be run at the elevation of the existing road across the lagoon. Any fill material needed will come from the cut material removed for the road.

There will be no dredging required for the ship loading operation. The existing draft at 44m from the shore is 15 meters which is adequate for large ship loading. The jetty which extends out the first 44 meters will be built on piling (hollow steel tubes pounded into sea bottom, then filled with concrete). Ships will have a continuous draft of 15 meters, from the time the enter the ships enter Djiboutian waters, the Ghoubbet, and the jetty, even at low tide.

Desalination Plant

A small desalination unit will produce 8000 gallons per day (30 m^3/day) unit, manufactured by Matrix Utilities Corp in Florida. It is an Reverse Osmosis unit with 25% recovery (Table 3.15). The effluent is concentrated sea water with 25% of the water removed. Discharge of the effluent will be to the sea beyond the shallow water. Based on experience, the effluent will be indistinguishable from sea water after about 1m from the discharge point. The EMP will include recommendations for a monitoring programme on the effects of effluent from the desalination plant.

The exact site for the desalination plant has not been designated but it will be at the beach location at the Ghoubbet. There will be an intake pump directly adjacent to the sea. The actual RO unit may be closer to the road, possibly 300ft from the sea. The RO unit will be housed in a container covering about 160sq ft (13 x 13m).

3.3.5 *Summary*

Figure 3.7 summarises the whole process of the Lake Assal Salt Project.

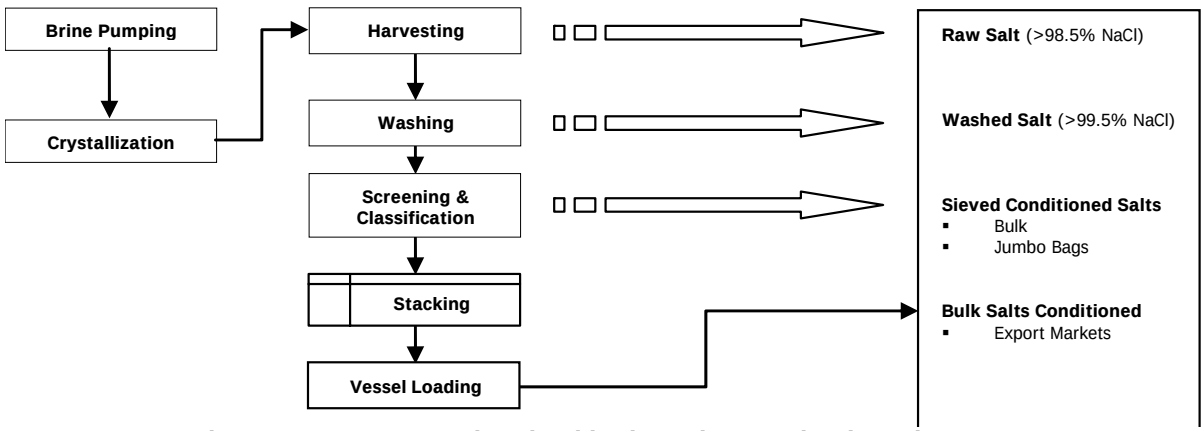

Figure 3.7. Processes involved in the Lake Assal Salt project.

Section 4.0

DESCRIPTION OF THE ENVIRONMENT

4.1 Biophysical Environment

4.1.1 *Topography*

The altitude in Djibouti varies from -155 m below sea level at Lake Assal to 2 021 m above sea level at Moussa Ali at the northern tip of the country (Figure 4.1). The country's terrain is dominated by arid plateau with the terrain inland being broken by a series of saltwater basins. The line between Lake Assal and Moussa Ali separates two distinct geological regions, 1) eastern region which consists of ridges forced by two faults systems, and the western region which consists of plains and depressions.

Lake Assal is in a closed depression of the western region being surrounded by mountains (Plate 4.1) and covering a surface area of 115 km^2. Sixty-five km^2 of the lake area is covered by salt pans (Figure 4.1). Since Lake Assal is 155m below sea level, the salty sea waters of the Red Sea flow by gravity from the Gulf of Ghoubbet through a 5 km long channel in basalt mountains into the east side of Lake Assal.

The mountains peak up to 1 028 m at Doghtôléh Amo west of the lake, and at 1 263 m to the north-east towards the Forét de Day mountains. The north-eastern and southern banks of the lake are relatively wide (up to 5 km in places) and are below the 0 m contour line.

Plate 4.1. The topography of Lake Assal, which is in a depression surrounded by mountains

The maintenance and staff housing area is on a plateau above the Ghoubbet beach at 200m above mean sea level. The topography at the proposed salt storage area at the Ghoubbet beach is on a flattish area at sea level (Plate 3.11).

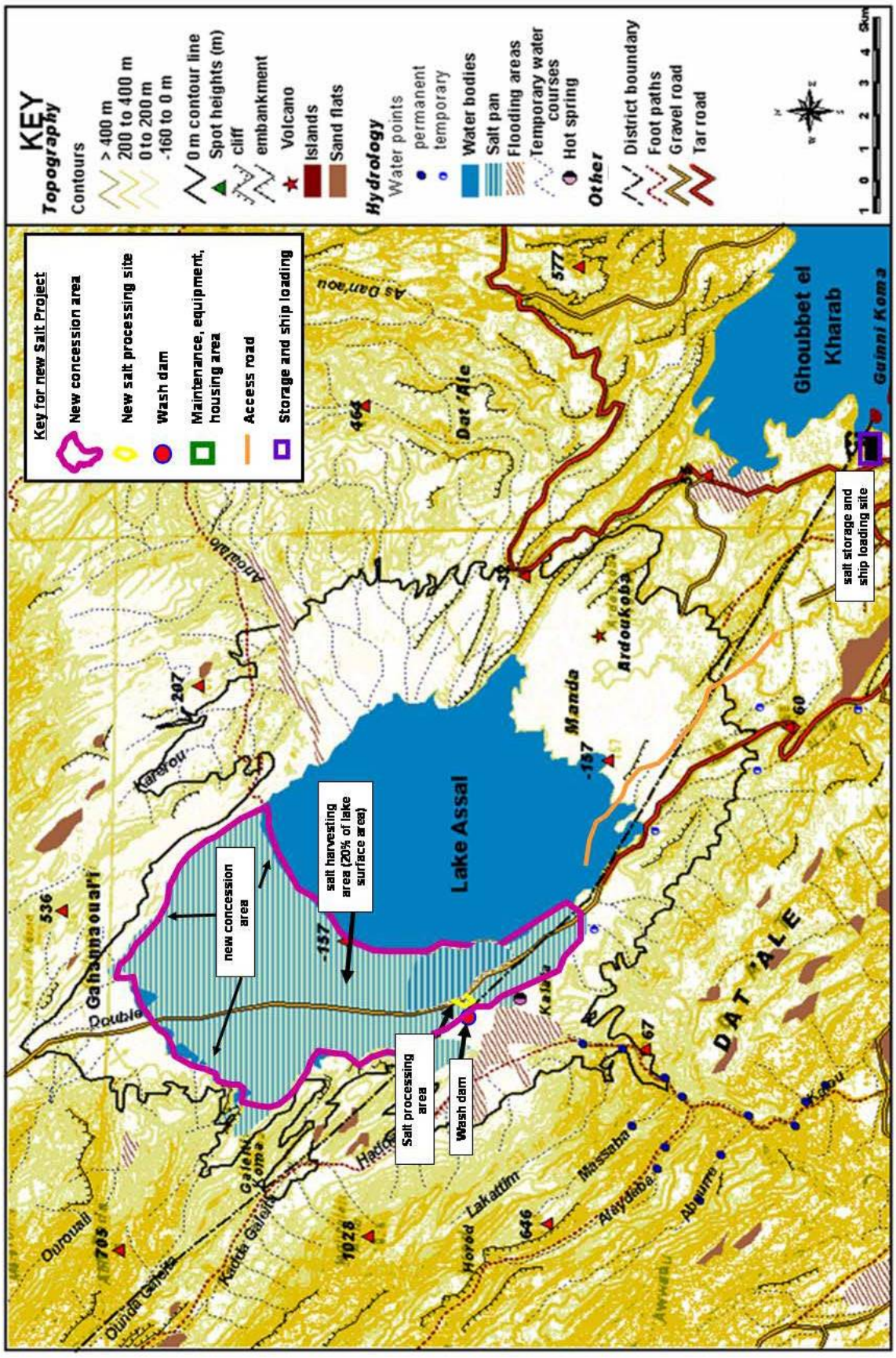

Figure 4.1. Topography and hydrology in the study area.

4.1.2 *Hydrology*

There is no permanent river in Djibouti, and surface flow is directly related to rainfall, which takes the form of floods lasting anywhere from several hours to two to three days, depending on the heaviness of the rainfall and the surface of the catchment's area. The drainage patterns in the Assal catchment affect the lake since after rains, water runs off the hills and fills up the salt pans.

A number of permanent water points are located along the Kalou River valley and some temporary water points along the temporary water courses south of the lake (Figure 4.1). The hydrological study done by the German co-operative in 1982 (German Cooperative, 1982) identified two other sources of water – alluviate water and deep water within the fissured basalt. All this water was found to be warm (from 35 up to 97^{o}C) and salty in various degrees. It also receives water from lake Abbe' (about 45 km south west of the Lake Assal, on the western border of Djibouti and Ethiopia - see Figure 3.1), which is very salty. The shortage of water in Djibouti is exacerbated by the degradation of the groundwater tables which is occurring due to insufficient recharging capacity.

There is a hot spring adjacent to the road leading to Lake Assal (see Figure 4.1 and Plate 4.2) which has a salinity close to that of seawater at the source: total salts in seawater varies from about 34 to 38 g/l (3.5 to 3.9º Baume) and the spring water sample had a total salt content of 39 g/l.

Plate 4.2. The hot spring at Lake Assal (April 2001).

Lake Assal is divided into an "crystalised salt surface" and the high saline brine area. The crystalised salt section has a surface area of 54 km^2 and the salt reserves are reported to be up to 60m in depth and have been estimated by others at 300 million tons. The brine section has a 54km^2 surface area and a depth that may reach 40m. At 300g/l NaCl, the liquid reserves could vary from 4 to 8 million tons.

The sea waters entering into Lake Assal are gradually converted into high quality brine by the effect of wind and sun and evaporate at an average rate of 460 million m^3 per year. The gradually concentrating brine is moved by the constant wind from east to west of the Lake and finally deposits the sodium chloride on the salt crust. There appears to be a balance between inflow and outflow. Inflow comprises mainly of storm water runoff and sub-terrainian inflow of brine and other water and outflow includes but is not limited to evaporation, possible leakage and salt harvested at present.

Some areas on the western bank and the Angalâlo River valley are prone to flooding (Figure 4.1). This potential flood zone is adjacent to but about 80m below the proposed site for the wash dam (see Plate 3.8).

Appendix II gives a detailed explanation of the hydrology and geology of Lake Assal, in French.

4.1.3 *Geology*

The Republic of Djibouti is located in the Afar Depression which is at the junction of three great tectonic axes: The Axes of the Red Sea and the Gulf of Aden, and the African continental Rift (Institut Supérieur D'Etudes et de Recherches Scientifiques et Techniques, ISERT). The Afar Depression corresponds to a zone of active volcanism and tectonic activity. The geology of the study area is shown in Figure 4.2.

The lake is separated from the Gulf of Tadjourah by approximately 10 km of land and the semi-enclosed basin of Ghoubbet al-Kharâb, on the south-eastern side of the lake (Plate 4.3). Between Lake Assal and the bay of Ghoubbet-Kharab there is fault called the Assal-Ghoubbet Rift which permits percolation of seawater into the lake. The geology of this strip of land consists of recent basalt (less than 1 Ma).

The territory around Lake Assal is volcanic and comprised of Basalt stratoïde (3.4 – 1 Ma) with the Ardoukôka Volcano being just 3 km from the edge of the lake at the -80 m contour line. Arable soil represents only 0.25% of the total area of the country (PANE, 2000). Sand flats occur in patches ranging from 1 km to about 6 km in length to the south of the lake.

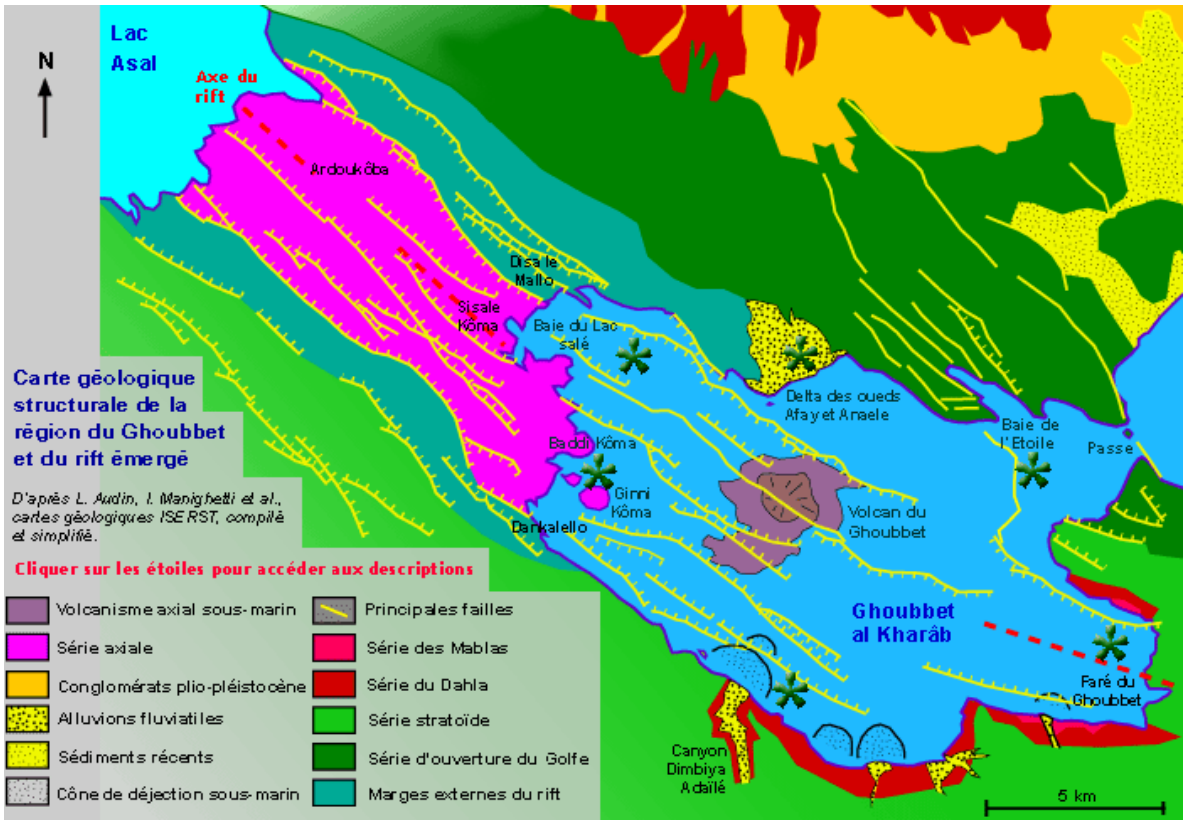

Figure 4.2. Detailed geology of the study area (source: www.jpb-imagine.com)

Plate 4.3. Looking north-east across the bay of Ghoubbet-Kharab, on the land separating Lake Assal with Ghoubbet-Kharab. Note: volcanic land and Guinni Koma Island.

Seismic monitoring takes place at a number of stations on the land between Lake Assal and the Ghoubbet al Kharab (Figure 4.3).

Appendix III gives a summary of the seismic activity in the region, in French (**source: www.jpb-imagine.com**).

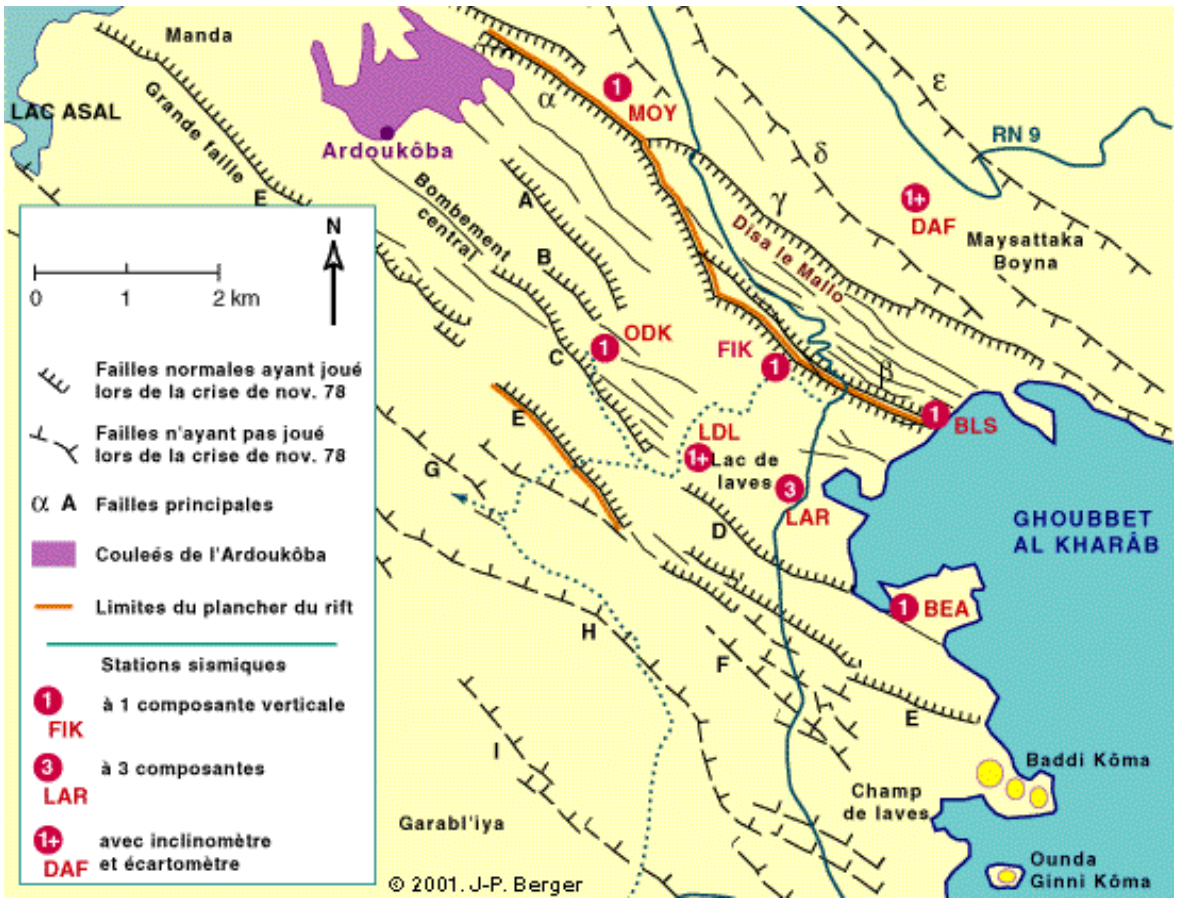

Figure 4.3. Seismic monitoring in the study area (source: www.jpb-imagine.com)

4.1.4 *Climate*

Djibouti has a hot desert climate with two main seasons: October to April is the cool season with high humidity and rainfall on the coast; May to September is the hot season with tropical rain inland. May, June, September and October the variable north-easterly winds blow and in the summer very violent, dry, hot and dusty winds will blow from the west.

Over the a seven year period (1992 to 1998) The average monthly temperatures vary little with only a 6°C difference between min and max temps in any one month, and with not more than a 9°C change from the hotter (May to September) to the cooler (October to April) months (Figure 4.4). In the cooler months humidity is usually over 70% whilst in the warmer months humidity fluctuates down to about 51 %.

Rainfall is extremely variable both intra- and interannually with peaks in January, April, May and October and virtually no rainfall from June to August (see Figure 4.4). The mean annual rainfall in 1993 and 1997 was 773 mm and 381 mm, respectively, compared to 23mm in 1996 (Annuaire Statistique de Djibouti, 2000).

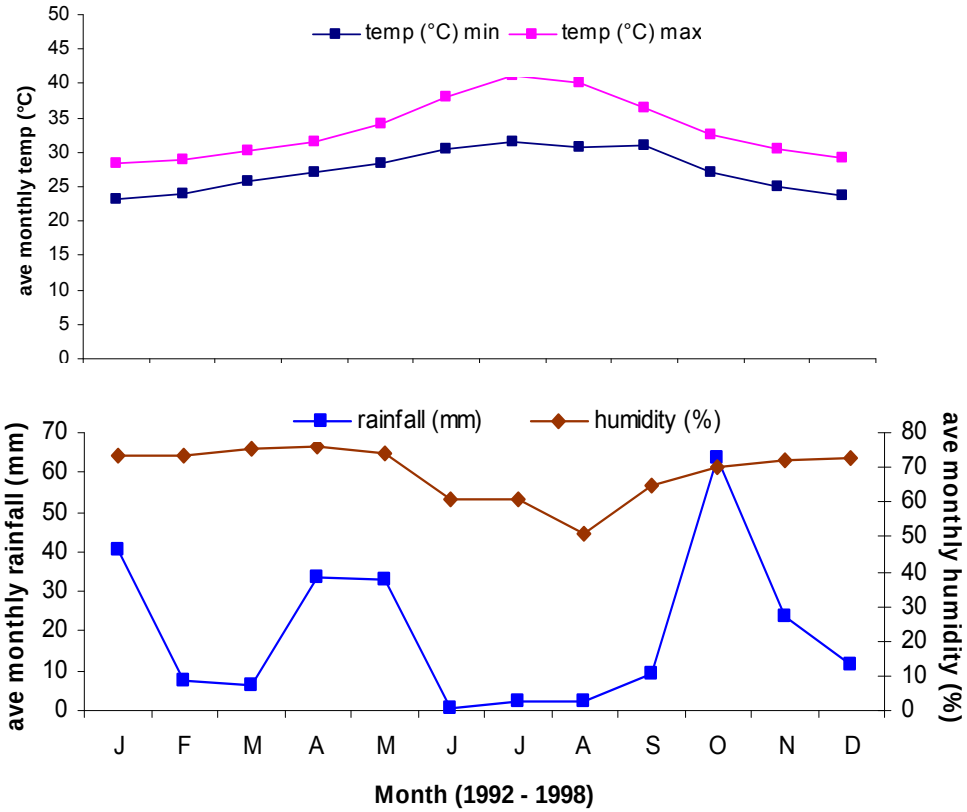

Figure 4.4. Average monthly temperature, humidity and rainfall from 1992 to 1998 (Annuaire Statistique de Djibouti, 2000).

The data from the *Annuaire Statistique de Djibouti (2000)* indicates large amounts of rain can fall over a short periods of time i.e. floods. For example, in January 1993, 243 mm of rain fell over 9 days, then in February 38 mm of rain fell over 5 days, and in March no rain at all. During 1997 no rain fell in February, April to July, and October then in November 269 mm of rain fell over 2 days.

The arid tropical climatic conditions at Lake Assal are ideal for salt production. The average temperature is around 33°C and during the summer (June/July) temperatures can get up to 50°C. The humidity varies between 40% in summer and 90% in winter. The rate of evaporation varies between 2 500 and 4 000 mm per annum. The annual rainfall varies between 175 and 200 mm per year.

When floods occur in the lake's catchment, large amounts of sediment get washed down into the lake and settle there (pers. obs – see Plate 4.4 where sediment layer lies just beneath salt layer).

Plate 4.4. Sediment layer beneath salt layer.

Figure 4.5 below show the wind rose at the measurement masts Ghoubbet and Gali Ma'aba at 40m height. The winds in this region are predominantly blowing from an easterly direction i.e. blowing onshore at the salt storage site.

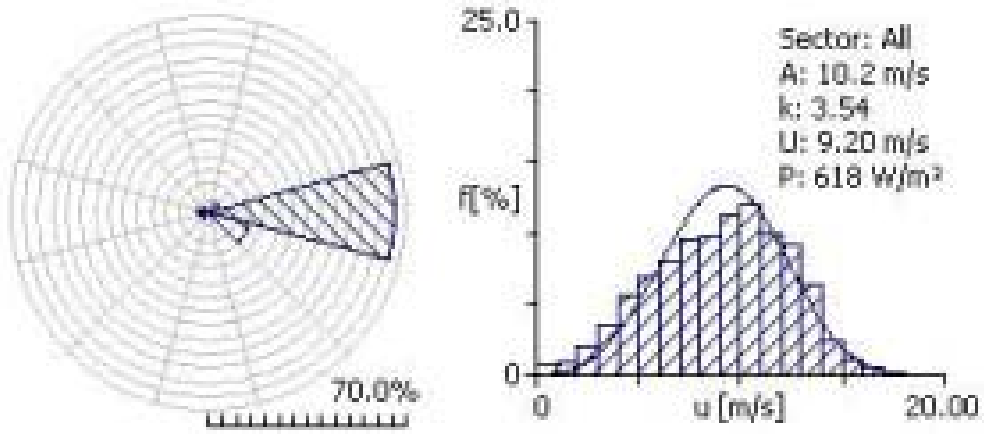

Figure 4.5. Wind rose and adjusted Weibull distribution at the measurements Ghoubbet mast at 40m.

Analysis of wind data for open sea conditions indicate 66% of the winds as easterly, whilst westerly winds occur 23% of the time (Technital, 2007). A maximum wind speed of 28 knots.

4.1.5 *Oceanography*

Since the Salt Project will involve shipping activities through the Ghoubbet bay, a description of the marine oceanography is necessary. Along the coast of Djibouti the tidal range is 0 – 3m relative to Chart Datum, where 0m is the spring low tide and the water level is about -1.5m relative to mean sea level. A recent study on a proposed port for the salt project (Technital, 2007) determined that inside the Ghoubbet the tide amplitude is about 2m and is generally 1 hour later that the Gulf of Tadjoura. The current velocity at the study site were maximum 1 knot but in the Petit Passe (entrance to the Ghoubbet) tidal streams were strong – up to 7 knots.

The bathymetry of the bay at the study area is shown in Figure 4.6 and shows relatively steep drop offs close to shore. The point where the ship would dock is approximately 26m deep.

The predicted wave directions for open sea conditions in the study area are 70% of the time from the eastern sector, and 30% of the time from the western sector (Technital, 2007). The wave height is higher than 1 m in 40% of the cases.

The beach site is protected somewhat by the small islands just offshore the beach site (Plate 3.11) from both wind and waves.

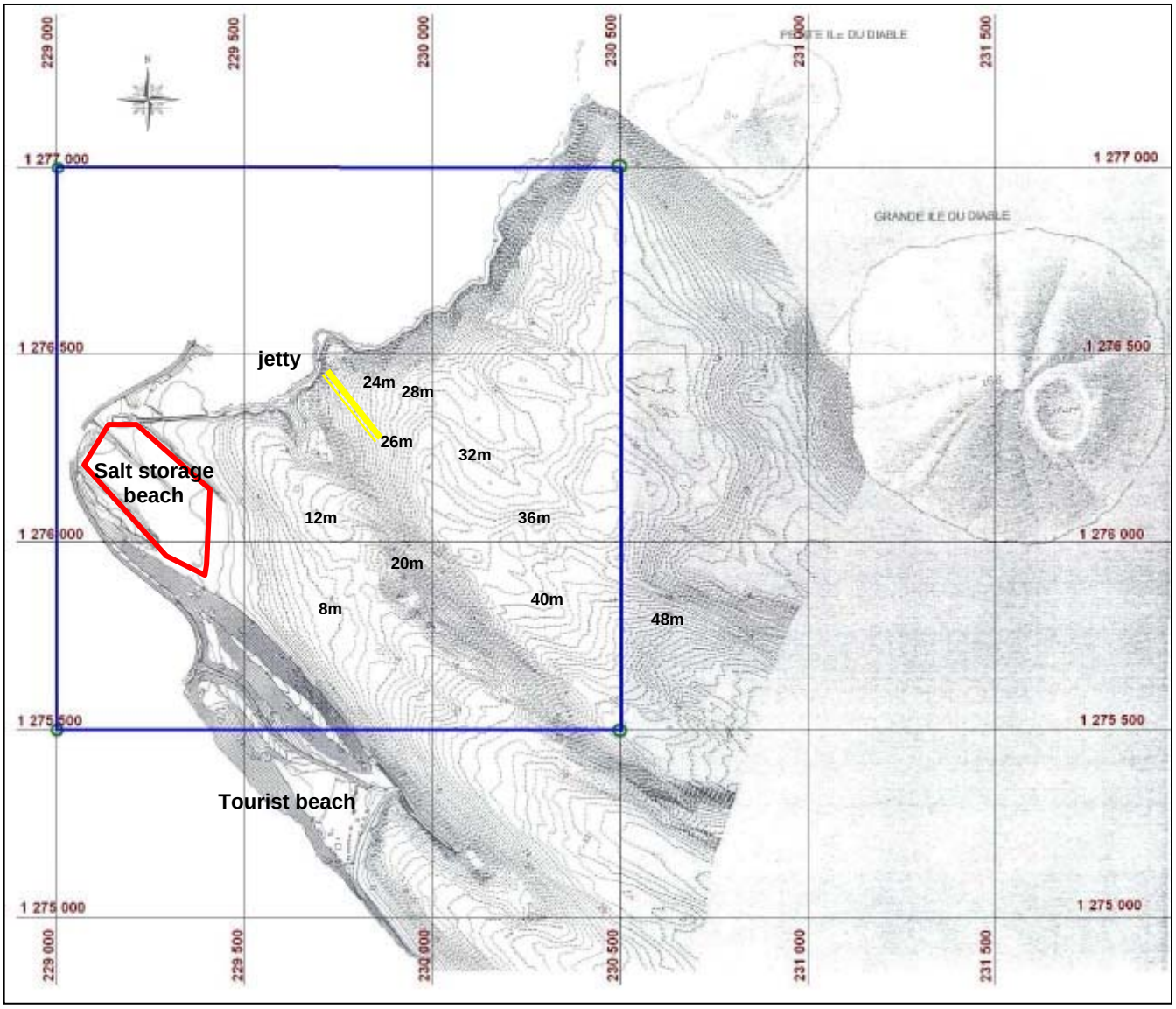

Figure 4.6. Bathymetry in the bay near the beach site.

4.1.6 *Vegetation*

The extreme climatic conditions in the Lake Assal area affect the vegetation with only low shrub occurring in isolated areas (Plates 4.5). Low shrub is present mainly to the right of the Lake Assal road, at Dika and Gaggadé, and along river gorges (Figure 4.7).

There quite a few shrubs and trees present in the area adjacent to the haul access road (see Plate 3.9) since this haul road passes adjacent to a dry river bed.

Plate 4.5. Low shrub adjacent to the road.

One palm tree is present adjacent to the haul road (Plate 3.9 d) but the road has been diverted around it. Palm trees are mainly present along the Kalou River about 4 km to the south of the concession area (Figure 4.7).

4.1.7 *Fauna*

Terrestrial

During the site visits (April 2001 and June 2008), small buck were observed grazing on the shrub along the roadside (Plate 4.7). There are no wading birds to be found in the shallows of the Lake water and there is a noticeable absence of bird life within the Lake area. However, some birds of prey and sea bird were seen in whilst on the site visit. Camels, sheep and goats were also seen grazing alongside the road in the study area (Plate 4.6).

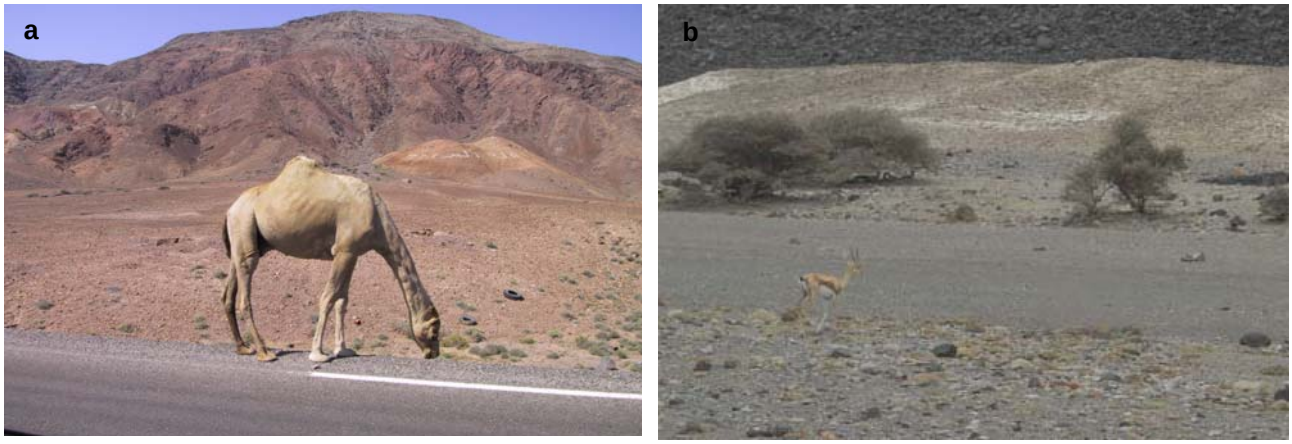

Plate 4.6. Animals grazing alongside the main road (a) and haul access road (b).

Aquatic

Shoals of a small fish species (Plate 4.7) were found in water of the hot spring near Lake Assal (see Plate 4.2). This fish species belongs to the Family Cyprinodontidae (minnows and killifishes) are very similar to *Cypridodon variegates* (sheepshead minnow), a common species in Caribbean and South American saltworks[3].

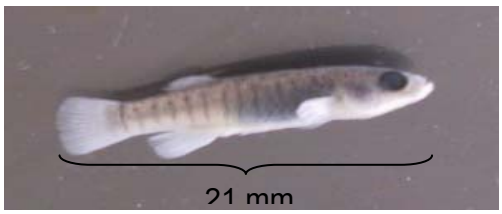

Plate 4.7. Small fish species, *Cyprinodon sp.*, found in the hot spring.

The water conditions where the fish are found had a salinity close to that of seawater (total salts in seawater varies from about 34 to 38 g/l OR 3.5 to 3.9º Baume) and the spring water sample had a total salt content of 39 g/l which is about 6º Baume[4]. Algal growth was also observed in spring water between 3.5 and 6º Baume. The temperature of the water was not measured but it is

[3] J.S. Davis, pers comm.
[4] B. Dangerfield, pers. comm.

estimated to be at least 80ºC at the source. Algae was also present in the surface layer of the salt of Lake Assal (Plate 4.8).

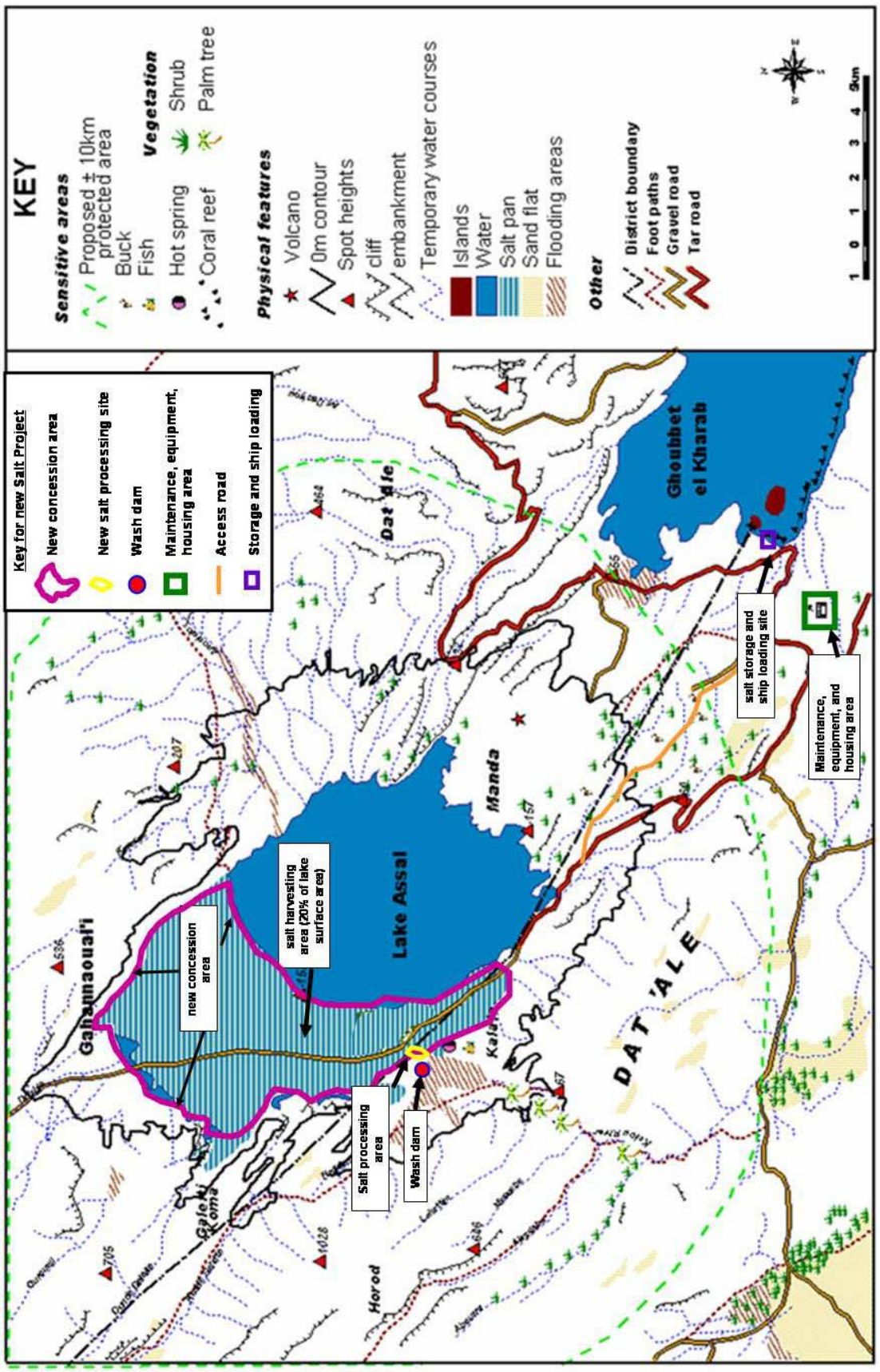

Figure 4.7. Vegetation and ecologically sensitive areas in the study area

Plate 4.8. Algae present at the source of the hot spring and in the top layer of the salt in Lake Assal.

Some research on biological systems of salt works has been done by Davis (1980) who has found that there are three different types of biological systems found in salt works: balanced, unbalanced and inadequate. The Lake water and salt floor appear to be very inert without any visible signs of life either in water column or on the floor. The clarity of the lake's water indicates a scarcity of organisms in the water column so may represent an unbalanced system

Marine

On the seaward side of the salt storage area is the semi-enclosed basin of Ghoubbet al-Kharâb (Plate 4.9), which has high salinity rates and coral reefs of low species diversity (PERSGA, 2001). The bay is 200 m deep and has the Guinni Kôma Islands about 1 km offshore at the western extreme end of the bay (Plate 4.9a). Crabs, and fish caught by locals were seen on the tourist beach at Dankalêlo (Plate 4.9b, c). Vast amounts of rubbish was also washed up on the beach.

Plates 4.9. The marine environment of the bay of Ghoubbet al-Kharâb.

On one of the sites visits (March 2002) the water in the bay of Ghoubbet el Kharâb near Dankalêlo showed a reddish discolouration, together with a strong odour, indicating the possible presence of a red tide (Plate 4.10).

Plate 4.10. The red discolouration of the water in the sea near Dankalêlo, March 2002.

In a report on the assessment of the coastal and marine environment of Djibouti (Obura, 1998) recommended the establishment of a number of marine protected areas, one of which is the Ghoubbet al Kharab. This particular study of 1998 did not actually sample the Ghoubbet al Kharab but suggested that this bay would not be significantly different from all the other areas surveyed in terms of principal species present. So very little research on the marine environment has actually been done in the Ghoubbet al Kharab itself. However, Pergsa (2001) does indicate that there are coral reefs all along the south-western side of the Ghoubbet (Figure 4.8) and a small northern section of the bay near the mouth of the bay. Mangroves also occur in this area near the bay mouth.

Most of the coastline of Djibouti lies along the narrow Gulf of Tadjoura, and east-west oriented trench with a maximum depth of 883m (Bouhlel, 1988). Surface salinity is about 36.5 ppt for most of the year but when the surface water flows out from the Red Sea, surface salinity may increase to 38-39 ppt (PERGSA, 2001). Mean surface temperatures vary between 25°C and 29°C and in March (end of winter) the thermocline lies at 60-80m. During summer, this thermocline rises from depths of 100 - 120m up to 40 - 50m which results in a burst of primary productivity attracting shoals of pelagic and semi-pelagic fish (Bouhlel, 1988).

Whale sharks (*Rhincodon typus*) have been recorded in the Gulf of Tadjoura all year round (Plate 4.11), but are particularly abundant during the months October to January[5]. These gentle giants, known as the "grand fish of the sea" are particularly abundant in the zone near d'Arta plage (Plate 4.11), where large concentrations of plankton occur. Scientist are still not sure where whale sharks actually breed.

[5] http://www.megaptera.org/requins-baleines-djibouti.html#Sc_ne_1

For a long time, these whale sharks have been observed in the Ghoubbet and are more than likely using this bay for feeding grounds since their movements are related to local plankton productivity. They are often associated with schools of pelagic fish that are probably feeding on the same prey organisms.. The whale shark is thought to be highly migratory but currently there is no direct evidence to support this hypothesis.

The whales sharks of Djibouti are considered to be threatened and are a protected species (Decree 22 April 2004 no. 2004-0065/PR/MHUEAT).

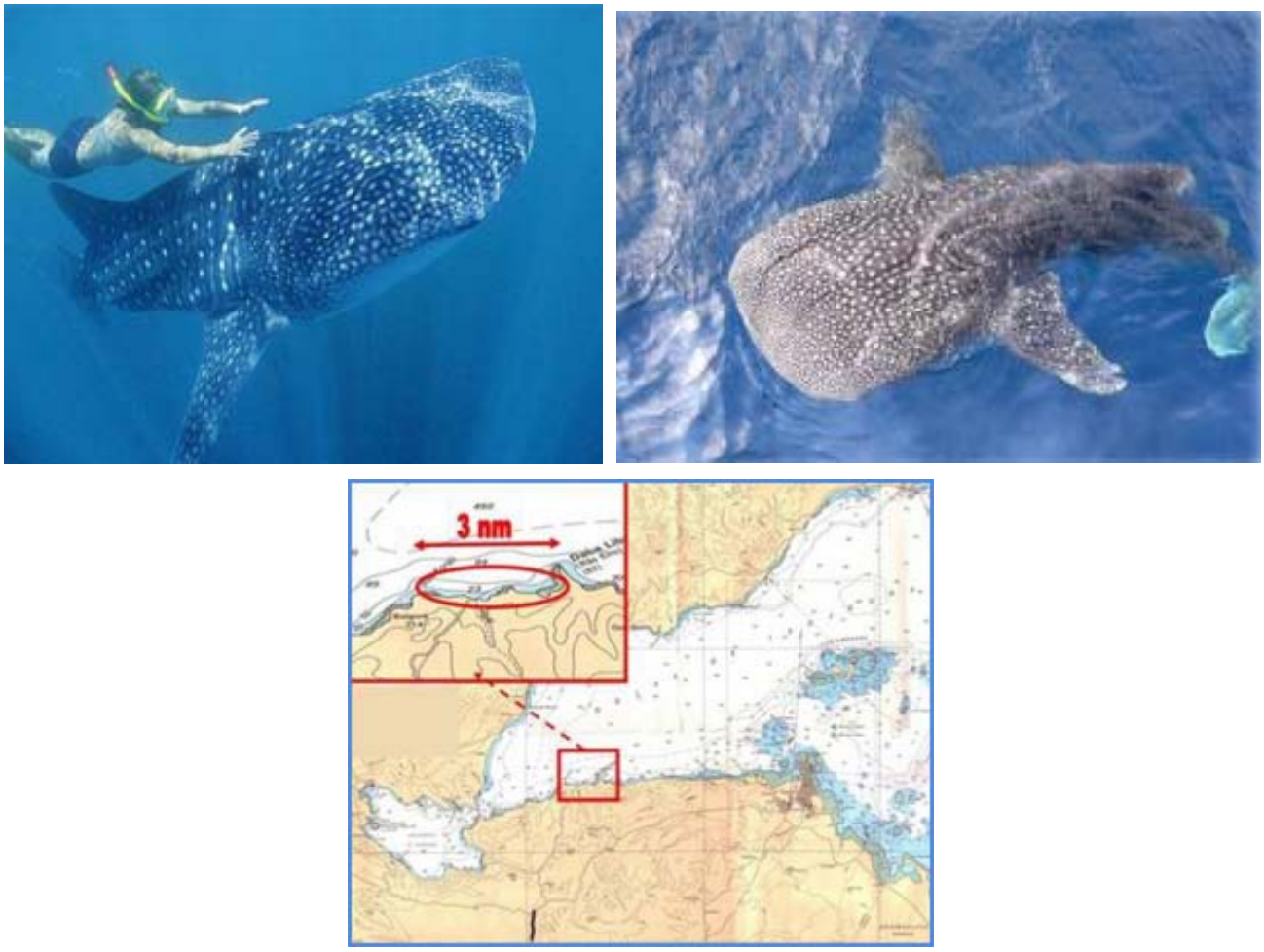

Plate 4.11. Whale sharks in the waters of Ghoubbet bay, Djibouti. Location of d'Arta plage where whales sharks are seen in large numbers.

Palaeontological evidence of bivalves, which appear to represent the genus *Soledletia,* have been found in Holocene lacustrine deposits at Lake Assal (van Damme and Gautier, 1994). These bivalves belong to the Mesodesmatidae, an exclusively marine family.

Figure 4.8. Existing and proposed protected areas in Djibouti (PERGSA, 2001)

4.1.8 *Ecologically sensitive areas*

Figure 4.7 shows the location of ecologically sensitive areas in the Lake Assal area. Lake Assal and its environs is seen as a unique geological tourist site with the exploitation of salt at the lake as being one of the priorities in the management of the environment in Djibouti. Measures particularly concerned with the management of salt exploitation activities are to create a protected area of 10 kms, starting from the entrance to the lake, and to classify Lake Assal as a world heritage site. The NAPB (2000) aims to reduce damages being caused by the extraction and transport of salt, help to minimise and favour restoration, and to develop and put in place sustainable mining practices e.g. rehabilitation of exploited sites, recycling of waste, protection of soil decontamination.

Any wildlife in study area should be protected. The biological community in the hot springs is potentially a sensitive habitat, although more research would need to be undertaken on the fish species occurring there.

The coastal zone in the bay of Ghoubbet el Kharab is ecologically sensitive and disturbance to coral reefs and intertidal communities must be minimised.

Since little research has been done specifically in the area of Salt projects influence, there is no list of threatened or endangered species except for the whale shark (*Rhincodon typus*) which is present in the Ghoubbet bay. The Environmental Management Plan of this report will include measures to protect the whale sharks from the shipping activities in the bay. In addition, a monitoring programme must be initiated in both the terrestrial and marine environment in the projects area of influence. A survey of the marine environment in the area just offshore the beach storage area and around the small islands should be initiated as soon as possible.

4.1.9 *Land use and land tenure*

Due to the harsh arid environment in Djibouti, the increase in desertification, and grazing pressure by ranching, the agricultural sector in the country is very weak comprising only 3% of the GDP (Annuaire Statistique de Djibouti, 2000) and less than 10% of the country's total surface area being suitable for cultivation. Traditional pastoral activities such as grazing of goats, cattle, sheep and camels is evident in the Lake Assal area, with the exploitation of the lakes' salt being the main land use in the study area. The land tenure in the study area is government land with the maintenance and housing site having a 99 year lease.

4.2 Archaeological / Cultural Environment

A comprehensive account of the archaeology in the Ghoubbet area is given on the following web site:http://translate.google.com/translate?hl=en&sl=fr&u=http://www.jpb-imagine.com/djibgeol/annexes/pretomb.html&sa=X&oi=translate&resnum=3&ct=result&prev=/search%3Fq%3DDankalelo%26hl%3Den . A brief description is provided here.

The Ghoubbet is know as a prehistoric place of occupation. Tombs, clusters, ceramics and stone tools have been discovered in the area of Ghoubbet (Poisblaud, 1999; Poisblaud *et al.* 2002). Prehistoric traces of occupations are found along the shore of the gulf, up until on the island of Guinni Koma. These structures are laid out in many places, in the middle of tools of stone dispersed and old ceramics.

Tombs

There are many tombs in the gulf area (Plate 4.12), representing various periods, but all exclusively made up of organized stone accumulation. For example, the surface formed by the sites of Dankalêlo and Dankalêlo Amo at the bottom of the gulf, are approximately 30 ha, reveal 122 funerary structures. Monument 53 of Dankalêlo, which has been studied extensively, is an example of an important tomb site (Plate 4.12). These funerary stone masses, belong to a very important megalithic tradition of monument in Djibouti. This area is to the east along the coast of the Ghoubbet, of the Salt Projects salt storage and ship loading area, and will not be affected by the project.

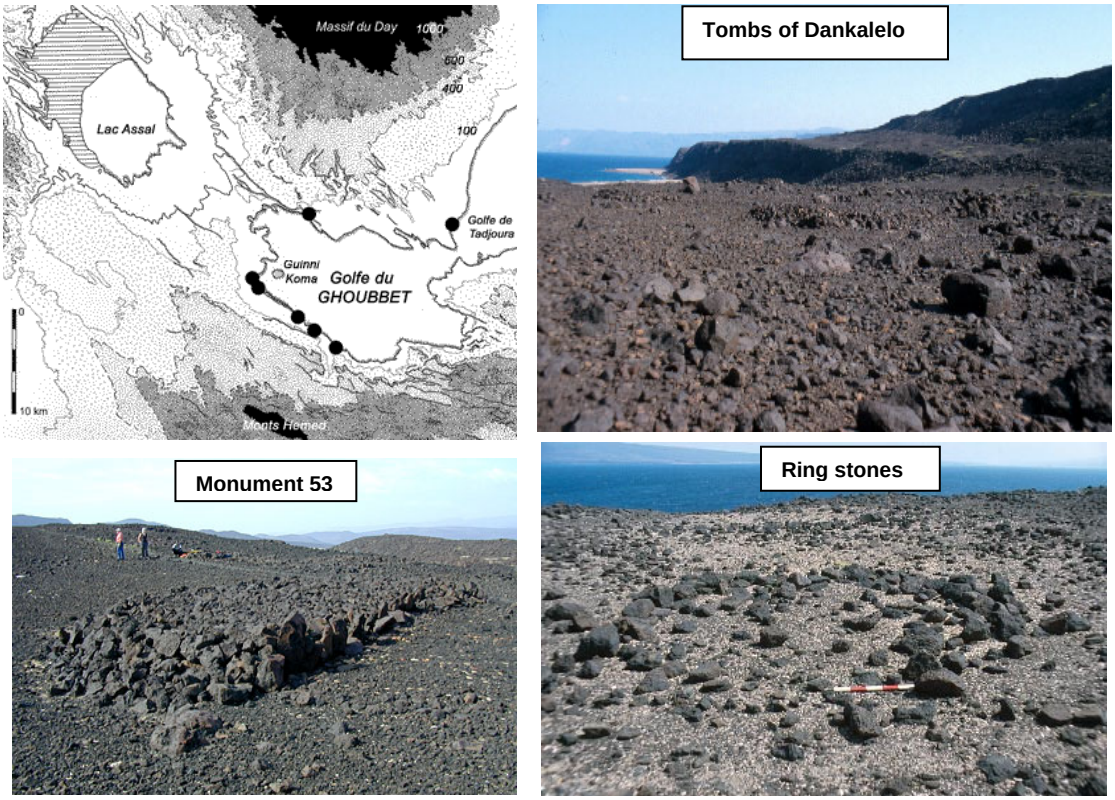

Plate 4.12. Tombs found in the Ghoubbet Gulf area (Photographic credit Benoït Poisblaud)

Clusters

The clusters are the most abundant archaeological structures in the Ghoubbet Gulf. They represent markers of the old passage of human groups. These clusters consist of shells deposited in heaps by the man.

At Dankalêlo is the largest cluster consisting of 4 agglomerated clusters, formed by several phases of deposits and stops (Plate 4.13). This suggests that people in the past occupied this area at various times over the ages. These clusters are mainly represented by oyster shells (99%).

The shells are however not the only food remainders discovered in the shelly clusters. Hearths are also present near the clusters. And are arranged in a basin of which the depth can reach 25 cm for a diameter between 30 cm and 1m. These hearths reinforce the idea of an intensive, local fishing activity in the Ghoubbet Gulf. Shards of ceramics were also found in these areas, verifying the prehistoric character of these structures.

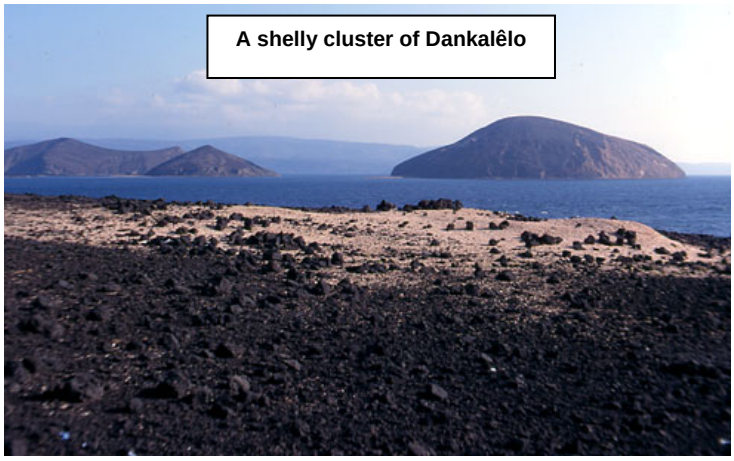

Plate 4.13. Shelly clusters and hearths in the Ghoubbet Gulf (Photographic credit Benoït Poisblaud).

Ceramics

Ceramics represents the identity of the groups which inhabited Ghoubbet. Transportable crockery (goblet, bowls etc.) are mainly present suggesting the temporary nature of the occupations. No large vase of storage have been found. Many decorations are seen on the shards of ceramics (Plate 4.14), with the broken line (like a zigzag) represents one of the markers of ceramics of Ghoubbet. Ceramic decorations are distinct of different cultures. Examples of these ceramics are shown in Plate 4.14).

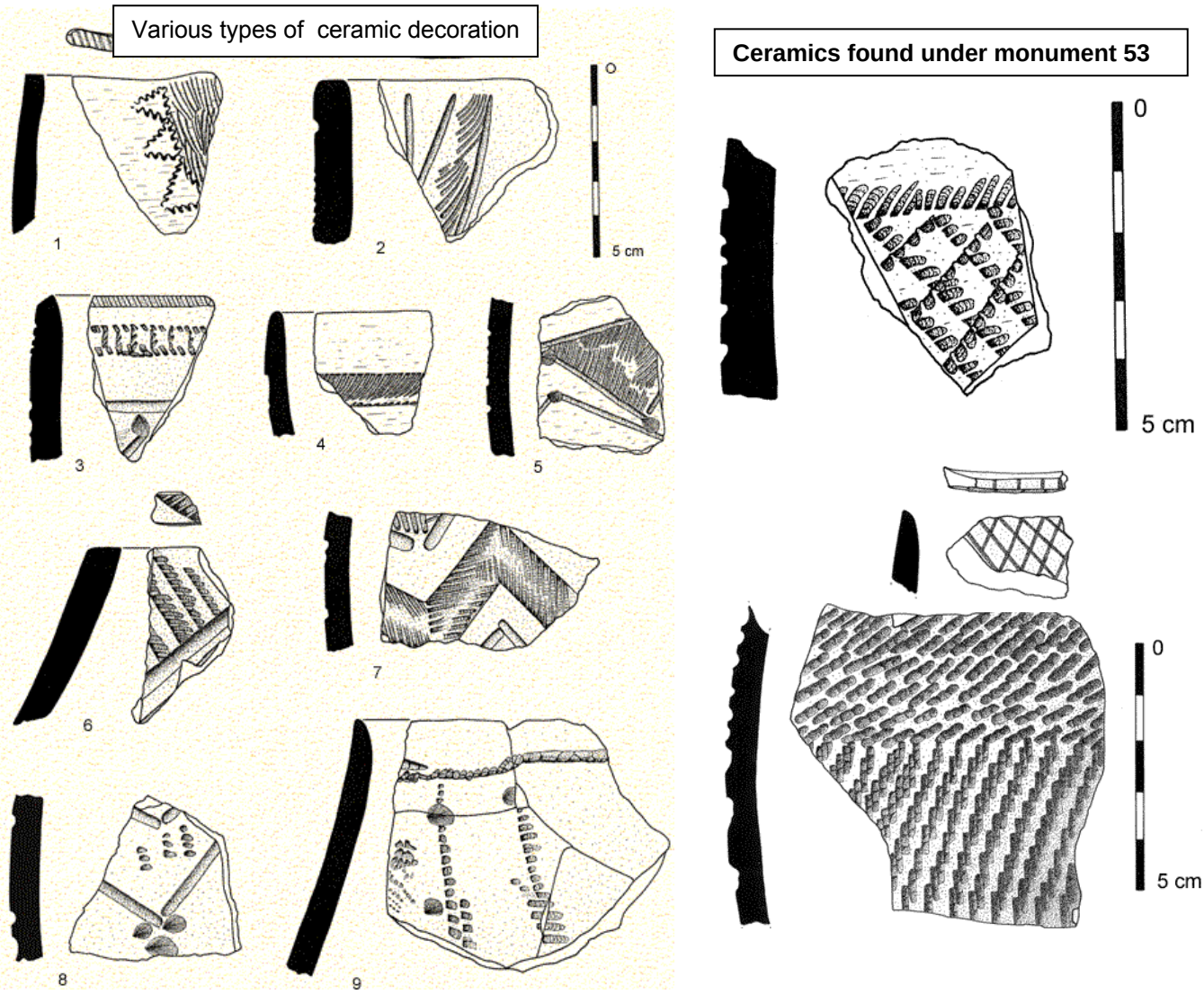

Plate 4.14. Examples of ceramics found in the Ghoubbet area.

Stone tools

Stone tools have primarily been found in the vicinity and even in clusters of shells (Plate 4.15).

Plate 4.15. Stone tools found in the Ghoubbet region.

4.3 Socio-Economic Environment

Djibouti's economy is little diversified and is based mainly on service activities (transport, communications, trade, tourism and banking) (ADB, 1999). The country has been experiencing economic difficulty since the mid-nineties with a poverty rate above the mean for Sub-Saharan Africa (62.7% compared with 45%).

To address the country's economic difficulties, the Government's strategy is primarily aimed at improving the business market with a view to promoting private sector growth, which will create jobs and reduce poverty.

4.3.1 *Population*

The population of Djibouti is around 650 000 inhabitants in an area of 23 000 km^2 , giving a density of 28.2 inhabitants per km^2 which is concentrated in urban areas (82% live in urban areas and 65% in the capital). The population is increasing at a rate of 3% per year (or 6% if illegal immigrants are taken into account) (PANE, 2000). Ethiopian and Somali refugees represent 12 – 30% of the population. In addition, about 10 000 Europeans (French military, Italians and Greeks) also live in the country.

The population is mainly Muslim (95%) and comprises three ethnic groups, the Issas, Afars and Arabs with two main languages, French and Arabic. It is also relatively young (approximately 51% under 20 years old) and the literacy rate is low. Djibouti's population is largely nomadic in origin.

Mostly nomadic people pass through and live temporarily in the study area but since the development of the salt industry, people are beginning to settle close to the salt operations (Plate 4.16).

Plate 4.16. Settlements adjacent to the road near the maintenance and housing site.

4.3.2 *Employment and education*

Estimates made on the basis of the Djibouti Survey of Households (EDAM, 1996) findings indicate that around 9.8% of the country's settled population live in conditions of extreme poverty. The poverty rate is high and around 62.7% of the population live below the poverty line. The incomes of those in living in poverty range from 3% to 16% of the incomes of the non-poor (ADB, 1999) but with most of the population being unemployed (around 40%).

Women play a key economic role in the country's development contributing to the informal sector (61% have employment). However, the level of education is such that only 28% of women can read and write compared with around 51.2% of males over 10 years (ADB, 1999). Most of the jobs in the formal sector are held by men which represent 84% of wage earners in the public sector. The illiteracy rate is high (40% for men and 67% for women).

The National Assembly has unanimously approved a new labour code, replacing the one introduced by the French more than 50 years ago. The changes will protect the rights of all workers as well as giving new rights to women (who are explicitly recognised in the code for the first time), young people and disabled workers.

The existing salt exploitation activities presently provide employment for about 49 permanent staff and semi-permanent staff on a demand basis. The increase in salt production will provide more permanent employment opportunities.

By September 30, 2007, the Lake Assal Salt Project forecasts to employ 212 people, including secondees from Consortium companies, local service contractors and expatriate personnel service contractors (Table 4.1). Approximately 68% of its workforce will consist of citizens of Djibouti.

Table 4.1. The following table shows the distribution of employees and secondees from partners and contractors expected at year-end 2010.

Payroll	Nationality	Status	Number	Functional Area
Hardtech	Djibouti	Permanent Payroll	10	Maintenance
Hardtech	Expatriates	Permanent Payroll	5	Management
Contractors	Expatriates	Permanent Payroll	30	Operations
Salt Investment S.A	Djibouti	Permanent Payroll	219	Operations
Consortium companies	Expatriates	Seconded (1-2 months a year)	22	Technicians
Contractors	Expatriates	Seconded (1-2 months a year)	10	Technicians
Total Personnel			**296**	

On-the-job training and an education program will be provided consistent with good international salt and utilities machineries installation, practice and maintenance designed to train its national employees to fill roles at all levels of its activities. Salt Investment S.A will also provide a benefits package for its employees who are nationals of Djibouti and for all expatriates. These benefits will

include private pension funds, as well as voluntary contributions for life insurance, health care allowance, access to a medical care facility, housing loans, and maintain a success sharing bonus for these employees and access to school for employee's children.

There are no other employment opportunities in the study except for the salt project. Locals try to make a living out of tourism by selling souvenirs collected from the local terrain and fishing in the Ghoubbet (Plate 4.17)


Plate 4.17. Locals making a living out of tourism and fishing.

4.3.3 *Health and safety*

Djibouti's health indicators are less favourable than those of most other African countries. Maternal and child health problems, respiratory infections (including tuberculosis) and diarrhoea constitute the country's most serious health problems (ADB, 1999). There are health problems associated with the salt mining activities such as skin infections, respiratory problems, and eye strain from sunlight, wind and reflection off the lake surface. Health care facilities are mainly in Djibouti City with an average of one health care centre per 15 000 inhabitants. In 1999, approximately 50% of country's 75 doctors are expatriates.

4.3.4 *Infrastructure and services*

Djibouti has air, rail, sea and road transport. The Djibouti-Ethiopia railway is the main rail link with 106 km in Djibouti and 675 km in Ethiopia. Road transport is underdeveloped with the road network comprising 2 905 km of roads of which 281 km are paved. The country owns a maritime port with a modern and well equipped container terminal in Djibouti City, hover there is currently no port facility at the Ghoubbet beach site.

The road to Lake Assal is paved (Figure 4.9), with the main road to Ethiopia passing approximately 60 km to the South of Lake Assal. There are presently no services (electricity, piped water supply, and sanitation) to the Lake Assal area.

Electricity at the salt processing site is presently supplied by a generator and barrels of water are located at points along the main road to the lake. The proposed new powerlines will pass right next to the new salt processing area so would be able to supply electricity in the future. Djibouti is

the main port for neighbouring land-locked countries within East Africa. All Ethiopia's imports and exports are transported between the port and Ethiopia by road transport. The rail line is operational but is currently the subject of an international rehabilitation and upgrade study.

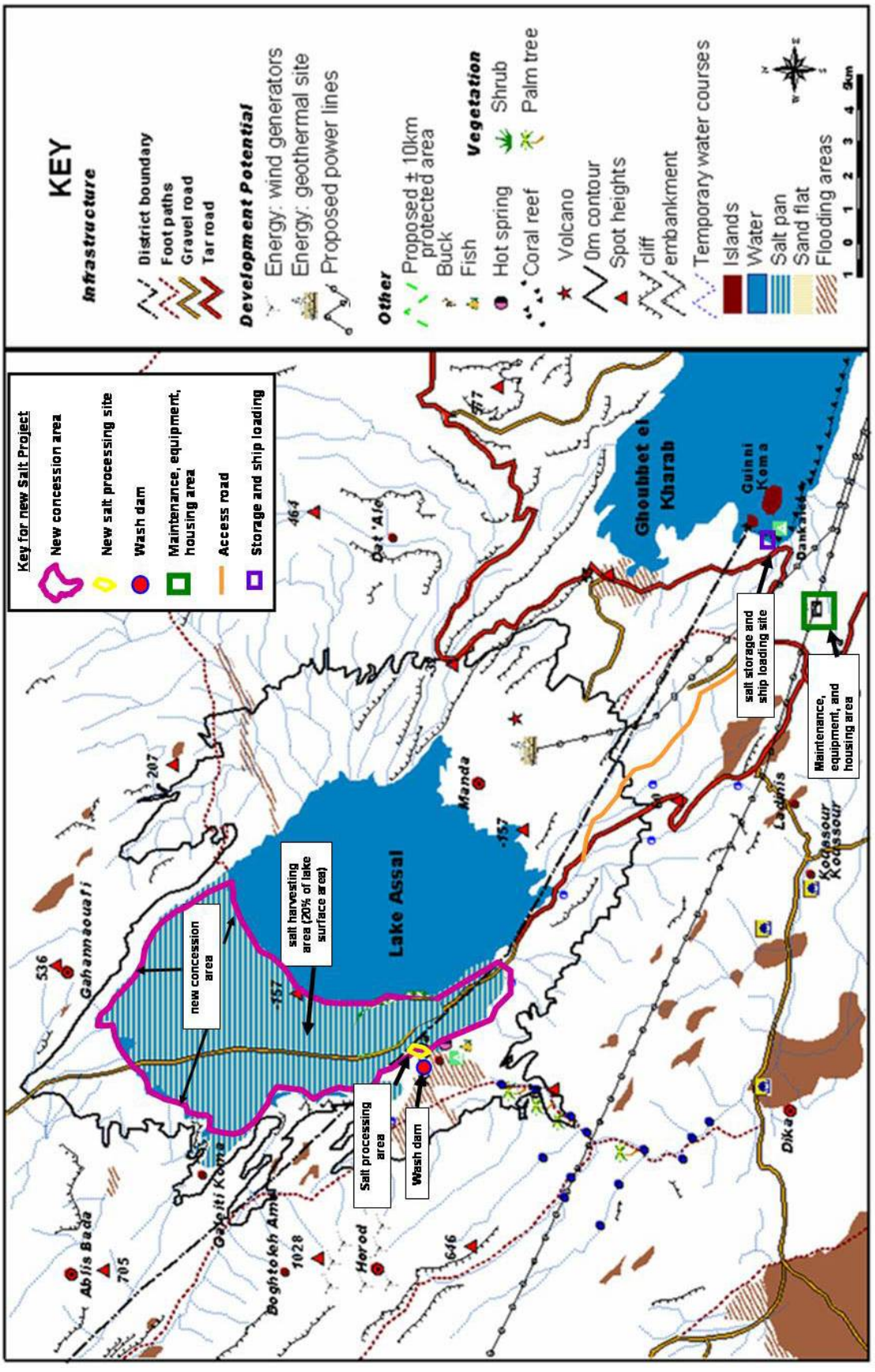

Figure 4.9. Infrastructure and potential developments in the study area.

4.4 Economic Activities and Development Potential

4.4.1 *Energy Production*

Geothermal energy / Renewable Energy Power Project

The Assal Geothermal Power Project (GDA, Feasibility Study of the Assal Geothermal Power Project, Republic of Djibouti, August 2000) is a renewable energy power project located just south of Lake Assal (see Figure 4.8). The existing diesel-fired generating units with geothermal power generating facilities (Plate 4.18) will be replaced by a 30 MW Assal Geothermal Plant which will significantly reduce the existing emissions of gases (e.g. CO, CO_2, SO_x, NO_x, HC, and PM).

Plate 4.18. The existing diesel-fired generating units at the Geothermal Power Plant site.

An environmental assessment is still to be undertaken on the Geothermal Project. The EA baseline study of the potentially affected environment will take into account the present state of the natural environment (air, water and land); human health and safety; social aspects (indigenous peoples and cultural property); and trans-boundary and global environmental aspects, such as climate change, ozone-depleting substances and adverse impacts on biodiversity.

Wind energy

There is wind turbine potential in the Lake Assal area and one of the proposed site is about 500m from Lake Assal, near the geothermal plant.

Extension of existing powerline grid

There are plans to expand the existing electricity grid in Djibouti with a proposal to supply power to the Lake Assal area (Figure 4.9).

4.4.2 *Mineral exploitation/mining*

There is potential for mining of perlite, dolomite, calcium, gypsum, clay, and pumice stone, but have not been sufficiently investigated.

4.4.3 *Tourism Potential*

Djibouti has an untapped tourist potential with eco-tourism being underdeveloped (ADB, 1999). The country's main tourism sites are the Day Forest, the Musha Islands and Lake Assal. There is a small tourist facility at Dankalêlo (Plate 4.19), close to the beach from the salt storage site (Figure 4.9). This site was identified as a site of potential interest to tourists by PERGSA 2001 (Fig. 4.8). The hot springs and Lake Assal are also tourist attractions to the area.

Plate 4.19. Tourist facility at Dankalêlo (a, b) in the bay of Ghoubbet el Kharâb, with Koma Island just offshore. Tourist area at Lake Assal (c, d) and on the road to Lake Assal – Canyon (e, f).

The country's tourism potential is based on its geological heritage as well as its rich and long-standing traditions and culture. This potential could be used to develop quality themes (eco-tourism, deep-sea diving, cultural tourism) that are highly lucrative and environmentally friendly.

However, the development of the sector has been hampered by numerous difficulties such as the high cost of transport, insufficient hotel infrastructure and the inaccessibility of major touristic sites. A strategic sector development plan has been prepared by the Government to encourage public and private sector partnership, promote appropriate investment, step up training in tourism trades and set up sector financing mechanisms such as the Djibouti Development Fund.

Section 5.0

SITE SUITABILITY

5.0 Site Suitability (source: Salt Investment Prospectus, Aug 2006)

For a solar salt works to be technically and economically viable, the most important factors are the following:

- Availability of land and its topography
- Accessibility to the market
- Soil conditions
- Meteorological conditions
- Availability of sea water/brine and its salinity

5.1 *Availability of land and its topography*

Flat land closest to the sea, lake or underground sources of brine, unfit for agricultural or other purposes is preferred for locating a salt works. The land chosen should be flat or very gently sloping (not greater than 30 to 400 centimetre per kilometre) in one direction so that it is possible to hold the brine in ponds at different stages and obtain an even cover with shallow depths and at the same time allow the brine to flow from one pond to another. The crystallizers where the deposition of salt takes place are the productive and, therefore, the most important part of the salt works.

By natural design, Lake Assal's topography weighs strongly in favour of the establishment of a solar plant there. As a result, the salt crust is arguably the largest salt crystallizer on earth and is sufficiently large to justify investment in mechanical harvesting machines.

5.2 *Soil conditions*

Brine in a salt works is held in large ponds with earth bottoms and allowed to concentrate by solar evaporation. The characteristics of the top one metre layer of the soil determine the capacity of the land to hold and evaporate brine at different stages of concentration. A gravely or sandy soil which is impervious is suitable. However, too clayey a soil will be weak under wet conditions and will impede proper harvesting of the salt. The bearing capacity of the soil is to be determined from the point of view of assessing its strength and suitability for construction of roads and embankments. A bearing capacity of at least 1 kilogram per square centimetre is required. If lower, it should be improved by addition of sand during the preparation of crystalliser floors.

In Djibouti, the soil conditions are ideal as the salt crust, 20 to 80 meters deep, constitutes a very strong and impermeable salt floor which provides the necessary ground bearing capacity to support heavy harvesting equipment. Furthermore, the climate and ground conditions continuously ensure the preservation of a salt floor one or more year's harvest thick. In addition, as a result of the basaltic nature of the land in the Ghoubbet there is no salt or clay contamination to contend

with, as is shown by measures of insoluble impurities content as low as 0.015%-0.050%in the raw salt harvested.

5.3 *Accessibility to market*

Salt is a low value commodity. In transportation to the market the freight element becomes an important factor. Therefore in order to be competitive, the salt works should be located close to the market or to a large seaport or rail head that will enable the salt to be shipped in bulk quantities. In several cases, this becomes the overriding factor in determining the location of the salt works. Djibouti is strategically positioned near the world's busiest shipping lanes. The Red Sea remains essentially an import market for dry bulk. Supply demand imbalances for dry cargo in the region provide opportunities for transportation price control.

5.4 *Meteorological factors*

The critical factor that affects the production of salt is the evaporation rate in shallow ponds. It is important that the net evaporation rate for the dry season should be positive and at least 500 millimetres for the site to merit consideration. In a salt works several meteorological parameters like temperature, incident radiation, relative humidity and wind velocity influence the net evaporation of brine at different concentrations.

The first and most important meteorological factor to consider is rainfall - the antitheses of evaporation. The rainfall pattern over at least ten years will reveal the duration of the dry season when salt production operations are feasible. The extent of salt production is determined by the evaporation rate during the dry season. To operate a solar salt works successfully, the annual rainfall should be as low as possible and its distribution restricted to a few months leaving a long clear weather period for salt manufacture. An area receiving rainfall not in excess of 600 millimetres within any span of 100 days during a calendar year is considered suitable.

However solar salt plants can also be successfully operated in areas where the total annual rainfall is as high as 1600 millimetres but is restricted to a very short and definite duration of 80 to 90 days during the year. Even during the dry season, showers not exceeding 15 to 20 millimetres in a single spell within 24 hours do not affect salt manufacturing operations.

The evaporation rate is influenced most by a high sunshine rate and air temperature which are usually interrelated. It will be beneficial if the site is subject to a hot inland or desert air. If the hot air is also dry it will further improve evaporation. The lower the relative humidity the greater the capacity of the evaporating body to take up more water vapour. However, the benefit conferred by the heat is more important than that conferred by dryness.

Wind, which is considered the least significant factor, occasionally assumes importance. It helps in the removal of air saturated with water vapour from the surface of the evaporating body and bringing in contact with it fresh unsaturated layers of the atmosphere thus increasing evaporation. However, the wind velocity should not be so high as to blow sand and dust into the works affecting the quality of salt. In certain desert regions despite other favourable conditions, so much sand is

blown by high velocity winds that solar evaporation becomes in fructuous and vacuum pan evaporation is preferred. A desirable range of wind speed which aids evaporation is 3 km to 15 km per hour. The direction of the wind is an equally important consideration. The wind blowing from over the desert is normally saturated with water vapour thus reducing evaporation. Wind blowing from over the land is dry and can take up water vapour until it attains saturation and thus aids evaporation.

Areas prone to cyclonic storms and tidal waves are not suitable. Once the site is fixed there is not much scope for altering the meteorological parameters. However, maximum advantage of prevailing factors can be obtained by suitable design. For instance, the ponds could be aligned normal to the prevailing wind rather than parallel to it. Also the ponds containing highly concentrated brines could be placed on the windward side. In the crystalliser area, absorption of incident radiation can be maximised by addition of a suitable dye.

Djibouti enjoys one of the highest evaporation rates in the world. Meteorological conditions in Djibouti have been favourable to the development of Lake Assal for millenniums. Djibouti possibly holds the world's record evaporation rate at 4,000 millimetres per year, due to the high solar radiation (at 2300 Kwh/yr, the highest on earth) and a strong unidirectional wind all year round. Temperatures range from 25 degrees centigrade up to 50 degrees centigrade and humidity is low year-round. There are no tides or cyclones in the area. Djibouti has annual rainfall of 200 mm/year, distributed through out the year in small precipitations. September's rainfall is somewhat higher but does not affect solar salt operations for more than 10 days. The wind speed averages 32.4 km per hour and can blow for 4,000 equivalent hours in a year.

5.5 *Brine availability and salinity*

The salinity of the intake brine and its availability in adequate quantities throughout the manufacturing season is an important factor. In the case of sea salt works, this involves a study of the salinity variation and a chemical analysis of seawater along the coast at different times during the season. Generally the concentration of undiluted seawater is 3 to 3.5 Be (NaCl content 2.7% to 3%). If there is appreciable dilution below these values, it calls for serious investigation since the output of the salt works is very much dependant upon the intake seawater salinity. If, instead of 3o Be, only 2o Be water is available, it could reduce the output of the salt works by as much as 50%.

Section 6.0

IDENTIFICATION OF IMPACTS

6.1 Scoping and Public Consultation

6.1.1 *Aim of scoping and public participation*

The purpose of scoping is to determine the key issues and concerns related to the salt operations, by consulting and involving the relevant authorities, stakeholders and interested and affected parties (I&APs). The main aim of public participation is to provide an opportunity for all I&APs to address their views and concerns regarding the proposed development. In addition, it ensures that only significant issues and reasonable alternatives are examined.

6.1.2 *Consultation with interested and affected parties (I&APs)*

A Briefing Paper and Questionnaire (**Appendix IV**) was distributed to key stakeholders and I&APs (**Appendix V**).

6.1.3 *Issues identified on site visits*

A site visit was undertaken to the Lake Assal area on the 26-27th April 2001. Issues noted during this site visit were:

- Nomadic stone huts have been moved to accommodate salt activities.
- Floods occur every ± two years and bring sediment down from the hills.
- They may build another access road to the salt plant since the existing one is 18 km of steep road and heavy trucks are using the road.
- Small buck and birds of prey were seen near the main road to the salt plant site.
- The salt project has priority in government.
- SALT INVESTMENT S.A supplies water to the locals – barrels are located at a number of points along the road, which are refilled every couple of days. Previously no-one wanted to work in this area because it is too hot and there is no water, therefore demanding high wages.
- There is a gypsum layer at the edge of the lake.
- The Lake Assal is in a very windy area.
- The drainage patterns in the Assal catchment affect the lake since after rains, water runs off the hills and fills up the salt pans.
- There is seismic activity in the area ?
- There is a health issue with the salt workers – they get sores on their feet. They suggested that the workers use Wellingtons and to wear protective eyewear.
- Red tide events in the bay of Ghoubbet el Kharâb ?

The concerns and/or issues raised by I&APs visited in 2001, and the completed Briefing Paper questionnaires, are summarised in Table 6.1 below.

Table 6.1. Concerns and/or issues raised by public consultation.

I&APs	Concerns and/or issues raised
Electricity Board (EDD)	❑ No power grid in Lake Assal area. ❑ Two proposed energy projects in salt project area: 1) Geothermal Plant, 2) Wind turbines. Solar energy is too expensive. ❑ When will salt project start ? ❑ EDD are planning to interconnect with the Ethiopian grid line (hydropower) – they are presently updating 10 yr old studies. ❑ There are some gas reserves near to border of Djibouti, in Ethiopia.
Finance, Economy and Privatisation	❑ Proposed salt project will help create jobs. ❑ Poor quality of infrastructure, water and electricity make costs too high for private investment.
Water Authority (Office National des Eaux de Djibouti – ONED)	❑ There is a proposed desalination plant near Lake Assal, with French funding. ❑ ONED supplies water to urban areas. The main town water supply is generally okay except in the hot season when there is they lack 40% of the demand. The current demand in Djibouti City is 35,000 m^3 per day. The cost of water is F65/m^3. ❑ There is a groundwater replenishment project with the Japanese Government – the aim is to improve the quality of water (not quantity – as they are already their maximum of groundwater supplies). ❑ There are 2 option for increasing water supply: 1) desalination - better option, 2) Lake Abhe - this needs treatment and a pipeline. ❑ There are insufficient water holes in rural areas. ❑ There are only dry rivers – the recharge of water holes in dry river beds is 15 million m^3 / yr. ❑ There is a problem with salt infiltration into the freshwater water supply. Therefore, they use boreholes at higher altitudes. ❑ Waste water is discarded into the sea.
Ministry Youth, Sport, Leisure, and Tourism (Ministre de la Jeunesse, des Sport, des Loisirs et du Tourisme)	❑ The historic political situation in Djibouti has hindered development. ❑ Lake Assal is a unique place and the government has put forward a plan and regulations to manage Lake Assal. Plan to make Lake Assal a protected area. ❑ Lake Assal area is also an important historical, cultural and archaeological area.
Social Fund (SF)	❑ There is funding from ADB for capacity building, rehabilitation of schools, clinics etc. These are community based activities. ❑ SF are interested in working in the Lake Assal area since the salt trade generate income. ❑ Salt production is providing an opportunity for employment resulting in a community settling there. There is now a Mosque at Lake Assal. ❑ There is a need for water services and infrastructure in Lake Assal area. ❑ SF organises the construction of schools (tenders for construction, local labour). ❑ The community is organised under the traditional structure of Chiefs. ❑ Graves for nomads are located where they died – indicated by a circle of

I&APs	Concerns and/or issues raised
	stones. ❑ SF has plans to work in the Assal area in 2002.
UNDP	❑ The country has done a biodiversity project – see Environmental Department.
Ministry of Environment (de l'Amenagement du territoire et l'Environnement)	❑ There is an Environmental Framework Law. ❑ Documents relating to environmental issues in Djibouti: o National Environmental Action Plan o National Action Plan for Biodiversity o Environmental Framework Law o Procedures for Environmental Impact Assessment
People's Palace	❑ The employment opportunity is welcomed ❑ The development of salt exploitation will be good for the country ❑ The salt project will improve the standard of living of the villagers in Assal.
ISERST – Department of Energy	❑ The development of the Assal salt will be a good thing for the country ❑ There may be some negative impacts associated with the salt development but these must be studied e.g. urbanization. ❑ Creation of employment. ❑ The salt project must take cognizance of the renewable energy projects currently underway at the research institute. ❑ Developing the sale of export of salt will improve the economic situation in Djibouti. ❑ The salt project must be developed in a sustainable manner to protect the lake.
Employees	❑ The salt project provides employment for the whole family ❑ Although the project will have some negative impacts, these do not out weight the positive impacts.. ❑ Increase environmental awareness through radio and television to help protect the lake environment. ❑ The distribution of water in the Assal area has resulted in an increase in settlements. ❑ The number of trucks transporting salt has increased which has resulted in increased animal kills (e.g. goats) on the road. ❑ The increase in population settling in Assal has resulted in an increase in waste e.g. many plastic bags are now scattered in the area. ❑ With more vehicles being present on the road there are more break downs which block the road, presenting a safety risk. ❑ The negative impacts of the salt project must not hamper the development of tourism in Assal ❑ The settlements establishing themselves in the Assal area are dispersed and not settling in an organized way – sanitation being one of the issues of concern.
MTS, Accountant	❑ It is good to export salt. ❑ The project will create more employment ❑ There may be negative impacts with the project but this does not mean the project must be stopped since it is important for the country.

Due to the scope of the salt project changing substantially from the 2001 feasibility study to the upgrade 2007/08, and additional site visit was undertaken 7- 9th June 2008. This site visit assessed the new site locations of the wash dam, salt pans, salt processing plant and ship loading site. In addition, community meetings were held and individual interviews in the project study area where 48 people responded. Issues and potential impacts noted during the site visit and community meetings in June 2008 are summarised in Table 6.2 and Table 6.3, respectively.

Table 6.2. Summary of additional issues and potential impacts identified on the site visit June 2008

Site	Issue and Potential environmental impacts
Lake Assal	salt processing plant site – at the edge of the lake.
	Wash dam site – near the Angalâlo River valley flood plain
	Nomad hut between the lake and the wash dam
Between Lake Assal and the Ghoubbet	New haul road passes through virgin territory – small buck present and trees
	Road passes through dry river bed – will need culverts
	Erosion potential at road edges
Maintenance and housing site	Cleanup of old salt operation machinery on site
	Washing of vehicles must have catch trays
Ghoubbet beach site	Salt storage area close to the tourist beach at Dankelo
	Ship traffic in the Ghoubbet and potential for disturbance to mega fauna such as whales sharks, dolphins and turtles.
	Visual impact of salt storage and ship loading structures to tourist area
	Effluent from desalination plant
	Waste disposal whilst ship anchored for 3 days
	Ballast water release into local waters whilst loading salt and potential for introduction of invasive marine species
	Combustion emissions from the ship whilst anchored

Table 6.3. Summary of issues and potential impacts identified at the community meetings held in June 2008.

Issue and Potential environmental impacts
Unemployment – they expect the Salt Project to provide jobs for all of them
No drinkable water
No sanitary facilities
Schools are lacking and therefore education
They expect the Salt Project to contribute to social growth and long term development in this region
However, they are clear on the fact that the environment must be protected
Respect their culture and traditions
They all see a better life for themselves due to the Lake Assal Salt Project

6.2 Scoping Matrix

A Scoping Matrix is a very effective method in highlighting the key issues and impacts that need to be addressed during a development. The method involved firstly identifying all the project actions/activities associated with the salt exploitation activities, and, secondly identifying all the environmental elements (both biophysical and socio-economic) potentially affected by the project actions.

The Scoping Matrix is then drawn up and with project actions on one axis and environmental elements on the other axis. Each project action is then assessed according to whether it potentially impacts upon each of the environmental elements. For simplicity, each impact is colour coded red for a high negative impact, orange for low negative impact, bright green for a high positive impact and pale green for low positive impact.

The results of the scoping matrix are shown Figure 6.1. The Scoping Matrix shows clearly that the majority of high negative impacts affect the biophysical environment and the high positive impacts affect socio-economic factors. Harvesting of the salt on Lake Assal can potentially impact negatively on the hydrology of the area due to water usage and hence pressure on water resources. Harvesting would also deplete the salt layer, if not managed sustainably.

Waste disposal on the lake where there are harvesting activities can potentially be damaging and are unsightly unless managed correctly. The positive side to harvesting and loading activities is the employment opportunities for local communities, although there are negative impacts on workers health. Also, the salt activities at Lake Assal are in close proximity to the tourist site just east of the salt processing site. The activities at the salt processing site will have enormous benefits for the local communities, who need employment. Additional building facilities in the study area will impose pressure on the water resources, and waste management but this can be mitigated.

Transporting the salt to the Ghoubbet beach site could negatively affect the land due to the access haul road since there is erosion potential, crossing of dry river bed, and grazing animals. However, by diverting the haul traffic away from the village on the main road, it reduces the impact of increased traffic on this village.

The vehicle maintenance and staff accommodation site is situated at the old salt processing site so is already in disturbed area. The existing infrastructure of buildings is being upgraded and improved and will have a positive impact on the area, providing employed and education opportunities. However, there will be an increased pressure on waste management and fresh water supply due to increased staff numbers.

The proposed salt storage area on the beach could potentially have a negative image on the beach fauna and marine environment, if not managed properly. There will be a negative impact on the aesthetics of this beach area which is adjacent to the tourist beach. A land spit does separated the two beaches which should hide the salt storage beach to some extent.

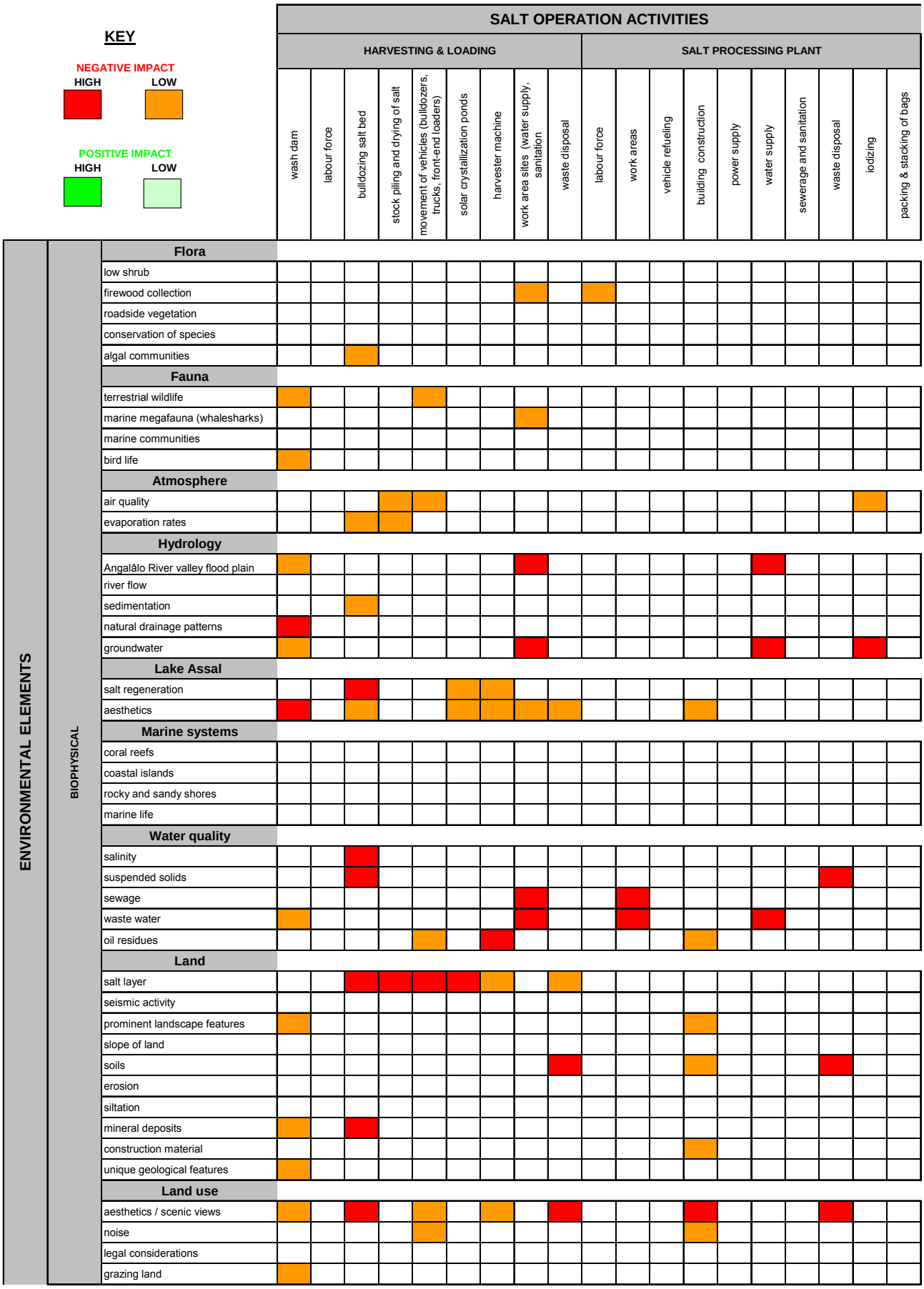

Figure 6.1. Scoping Matrix for the Lake Assal Salt Project

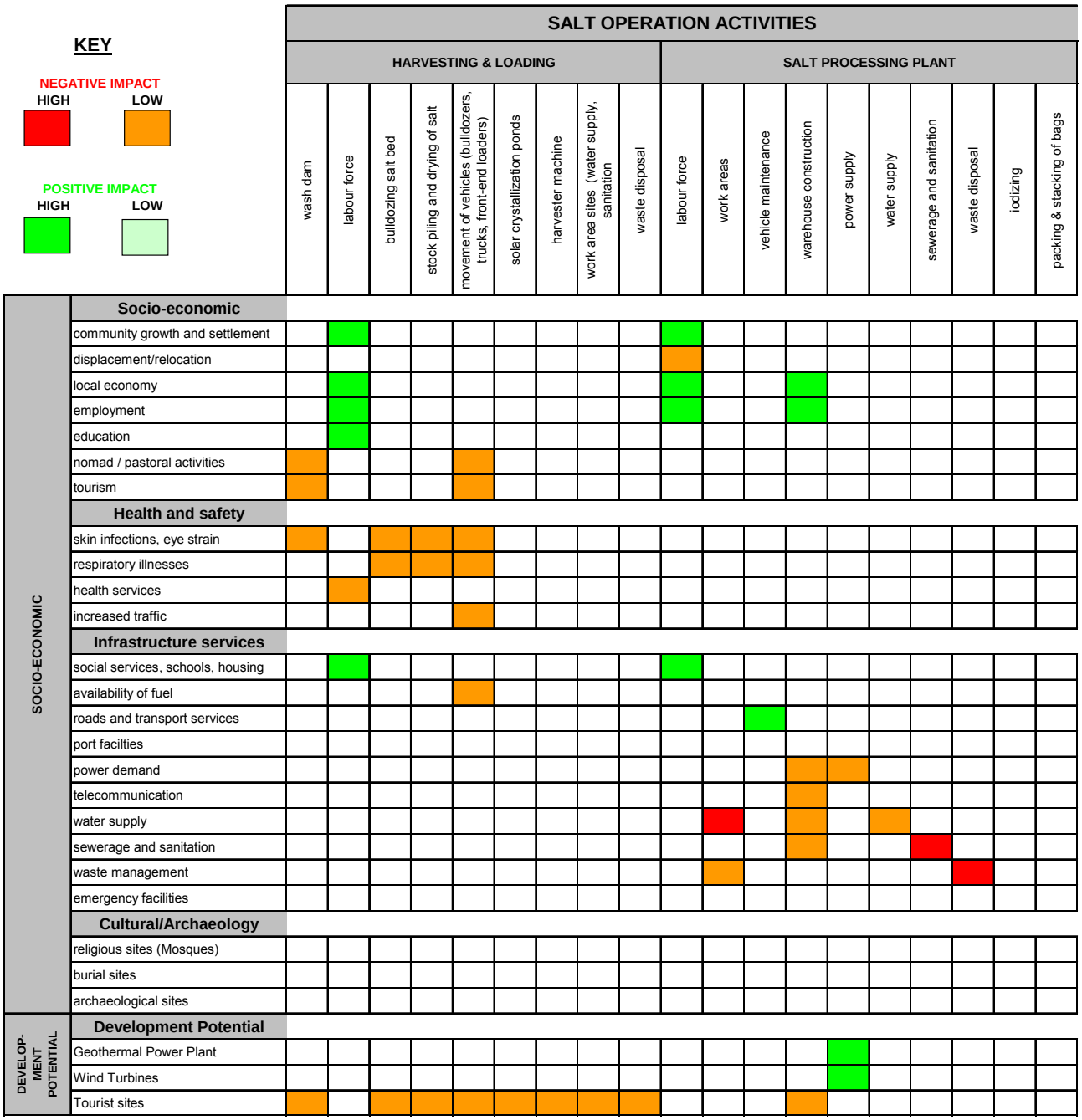

Figure 6.1 cont. Scoping Matrix for the Lake Assal Salt Project

Noise levels will also be increased along at this beach section, possible impacting on the tourists. This can only be determined once activities commence.

The salt conveyor system from the beach along the jetty and to the ship loading area will similarly have an aesthetic and noise impact on the tourist beach site. Ships anchored at the jetty will definitely be visible to the tourist beach thus having a negative impact on the aesthetics.

The desalination plant may impact on the marine environment if the effluent is not managed appropriately.

KEY

NEGATIVE IMPACT
HIGH LOW

POSITIVE IMPACT
HIGH LOW

ENVIRONMENTAL ELEMENTS			SALT OPERATION ACTIVITIES														
			TRANSPORT OF SALT			MAINTENANCE & STAFF BLDGS			SALT STORAGE SI			DISTIBUTION & EXPORT OF SALT					
			access road	vehicle movement	salt spills	vehicle maintenance	sewage & sanitation & waste disposal	staff accommodations	salt storage on beach	vehicle movement	beach dyke	anchored ships at Ghoubet beach site	conveyor loading system & jetty	transport of salt via the Ghoubbet - ships activities	supply chain / distributers	consumers	desalination plant
	BIOPHYSICAL	**Flora**															
		sand-trapping vegetation / low shrub															
		firewood collection															
		roadside vegetation															
		conservation of species															
		algal communities															
		Fauna															
		terrestrial wildlife															
		marine megafauna (whalesharks)															
		marine communities															
		bird life															
		Atmosphere															
		air quality															
		evaporation rates															
		Hydrology															
		Angalâlo River valley flood plain															
		river flow															
		sedimentation															
		natural drainage patterns															
		groundwater															
		Lake Assal															
		salt regeneration															
		aesthetics															
		Marine systems															
		coral reefs															
		coastal islands															
		rocky and sandy shores															
		marine life															
		Water quality															
		salinity															
		suspended solids															
		sewage															
		waste water															
		oil residues															
		Land															
		salt layer															
		seismic activity															
		prominent landscape features															
		slope of land															
		soils															
		erosion															
		siltation															
		mineral deposits															
		construction material															
		unique geological features															
		Land use															
		aesthetics / scenic views															
		noise															
		legal considerations															
		grazing land															

KEY

NEGATIVE IMPACT — HIGH / LOW

POSITIVE IMPACT — HIGH / LOW

		SALT OPERATION ACTIVITIES														
		TRANSPORT OF SALT			MAINTENANCE & STAFF BLDGS			SALT STORAGE SI			DISTIBUTION & EXPORT OF SALT					
		access road	vehicle movement	salt spills	vehicle maintenance	sewage & sanitation & waste disposal	staff accommodations	salt storage on beach	vehicle movement	beach dyke	anchored ships at Ghoubet beach site	conveyor loading system	transport of salt via the Ghoubbet - ships activities	supply chain / distributers	consumers	desalination plant
SOCIO-ECONOMIC	**Socio-economic**															
	community growth and settlement															
	displacement/relocation															
	local economy															
	employment															
	education															
	nomad / pastoral activities															
	tourism															
	Health and safety															
	skin infections, eye strain															
	respiratory illnesses															
	health services															
	increased traffic															
	Infrastructure services															
	social services, schools, housing															
	availability of fuel															
	roads and transport services															
	port facilties															
	power demand															
	telecommunication															
	water supply															
	sewerage and sanitation															
	waste management															
	emergency facilities															
	Cultural/Archaeology															
	religious sites (Mosques)															
	burial sites															
	archaeological sites															
DEVELOP-MENT POTENTIAL	**Development Potential**															
	Geothermal Power Plant															
	Wind Turbines															
	Tourist sites															

Figure 6.1 cont. Scoping Matrix for the Lake Assal Salt Project

The new Ghoubbet Port and the associated activities will have an impact on this beach area as a whole. The presence of ships along in the Ghoubbet will potentially have a negative impact on the marine life in the bay, particularly the whale sharks due to spillage of fuel, waste disposal, accidental collisions etc.

The most positive aspect of the salt project is the distribution and export of the final salt product which will bring revenue to distributors and increase the country's local economy.

6.3 Summary

The initial public consultation, the site visits and the scoping matrix identified the following key issues and potential impacts associated with the salt project:

Key Positive Impacts

- The salt project will help create jobs and employment;
- Increase in export potential;
- Improve the standard of living of the villagers in Assal;
- The local economy will improve;
- Services and infrastructure to Lake Assal will improve;
- Provide a tourist attraction - educational aspect of salt production;
- Structuring and limitation of salt exploitation to certain areas only;
- Implementation of environmental management measures to mitigate negative impacts;

Key Negative Impacts

- Pressure on natural resources, especially water, but also land where erosion may be an issue;
- Decrease in aesthetic value of certain areas of Lake Assal and Dankalêlo;
- Negative impact on the marine life in the Ghoubbet Gulf due to increased shipping activity;
- Vehicle movements on the lake itself and between the lake and processing site;
- Increase in vehicle movements and hence safety risk;
- Increase in settlements hence increase in waste and sewage generation;
- Harsh climatic conditions and floods have a negative impact on the salt project activities

Section 7.0

DESCRIPTION OF IMPACTS

7.1 Biophysical Impacts

7.1.1 *Water resources*

Due to the scarcity of water resources in the study area, and the limited recharging capacity of groundwater, the potable water demand from the activities of the salt project will impose pressure on the water resources in the Lake Assal area. At present fresh water is being trucked to the village - the nearest borehole is at the turnoff from the main road to Ethiopia approximately 60 km from the plant. SALT INVESTMENT S.A is providing the nomads with water (2,10l drums next to the road), however this water source may not be able to sustain the village once the capacity of salt production increases to 1 million tons. However, the desalination plant will be able to supply potable water supplies once completed.

On the other hand, the occurrence of floods and resulting sedimentation in the lake will have a negative impact on the production of clean salt in the lake.

7.1.2 *Marine resources*

The increased shipping activities anticipated for the transport of salt to export markets can potentially have an impact on marine life due to oil/fuel spillage, waste disposal, and damage to coral reefs.

The desalination unit will have an effluent of concentrated sea water with 25% of the water removed. Discharge of the effluent will be to the sea beyond the shallow water. Based on experience, the effluent will be indistinguishable from sea water after about 1 meter from the discharge point. The presence of red tide in the bay of Ghoubbet would be an issue to consider if seawater is going to be pumped up to the plant.

Ship Loading Activities – Potential Impacts

The definition of a harbour is a stretch of water where vessels can anchor, or secure to buoys or alongside wharves to obtain protection (by natural or artificial features) from storms and rough water (IFC, 2007). A port will include facilities for transferring cargo from shore to vessel or vessel to shore. Ports may also provide ship support facilities and services, including waste management and effluent discharge, maintenance of vehicles and equipment, painting and other vessel maintenance.

For the Lake Assal Salt Project, the loading of each ship with the bulk salt will take about three days and the ship will therefore be docked for a period time where waste management and effluent discharge will become an issue. The proposed jetty and ship loading system for the Lake Assal

Salt Project can therefore be defined as a "port" even though no breakwater or wharf is being constructed, but a jetty will be built.
The following activities (Table 7.1) are expected at the salt projects port location, and the potential impacts associated with those activities:

Table 7.1. Activities expected and the port location and their potential impacts on the environment.

Structure	Activity	Potential Impact
Conveyor system	Movement of bulk salt from shore to the ship	Accidental spills of salt into sea (operation phase)
Jetty structure	Construction of concrete bases on sea bed for pylons	Accidental spills of concrete into sea (construction phase)
Fixed anchor ropes from fixed buoys to ship	Construction of concrete bases on sea bed for permanent anchor buoys an ropes	Accidental spills of concrete into sea (construction phase)
Ships	Movement through the Ghoubbet gulf	Disturbance to megafauna such as whales sharks, dolphins and turtles.
		Emissions of fossil fuels whilst engines running
		Potential oils spills
	Anchored at beach site	Ballast water and hull biofouling potential introduction of Invasive Marine Species (IMS)
		Combustion emissions from ships' propulsion and auxiliary engines and boilers, mainly consisting of sulfur dioxide (SO_2), nitrogen oxides (NO), greenhouse gases.
		Marine vessel sewage and risk of localised marine and beach pollution
		Ship discharge of solid waste ends up on shoreline
	Sailing near beach site	Risk of ship grounding

Introduction of marine pests

The expected increase in marine international and domestic vessel traffic poses a high risk for the introduction of marine pests. From around the world there are many examples of Invasive Marine Species (IMS) being introduced and or translocated by a variety of vectors, including ballast water from international commercial shipping. The establishment of an IMS in a new environment can threaten biodiversity and aquatic health, as well as specific industries dependent on marine resources.

Large sea vessels for the salt transport can introduce the main vector for IMS translocation into the Ghoubbet gulf through ballast water and hull biofouling.

Disturbance to marine life

Large ships are likely to increasingly disturb and disrupt the use of the area by megafauna such as the whale sharks, dolphins and sea-turtles in Djibouti coastal waters.

Fuel

Cargo ships run on "bunker fuel," which can contain up to 5,000 times more sulfur than diesel [6]. Potential leakage of bunker fuel is an important issue to consider.

Ballast

A common and necessary practice to insure vessel stability whilst loading cargo is for vessels to take on and discharge ballast water. When cargo is loaded, the ballast water is released in amounts according to the design of the vessel and the profile of how the vessel is loaded.

When vessels take on ballast water (from the departure port), aquatic life indigenous to that region is often found in the water. When the water is discharged in another region, the discharged aquatic life may then thrive and disrupt the local ecological system. When there are no natural predators, the non- indigenous aquatic life will alter or destroy the natural marine ecosystem. One solution for preventing or greatly reducing the discharge of ballast-water non-indigenous aquatic life is mid-ocean ballast water exchange.

Air Emissions

The most significant sources of air pollutants from port operations include combustion emissions from ships' propulsion and auxiliary engines and boilers, mainly consisting of sulfur dioxide, nitrogen oxides, greenhouse gases (IFC, 2007).

Anti-Fouling Pollution (Tributyltin)

Fouling is the unwanted growth of biological material, e.g., barnacles, algae or molluscs, on the water-immersed surface of a vessel. When vessel hulls are clean and smooth, i.e., free of fouling, they travel faster through water and consume less fuel. To reduce fouling many shipping companies apply an anti-fouling coating, such as TBT paint, to the vessels hull. Anti-fouling TBT paints have been found to be effective in killing sealife attached to vessel hulls, but they also have been known to cause genetic alterations in other sealife and is extremely toxic in the marine environment (Talley, 2005)[7].

Wastewater and Waste management

Water effluents associated with port activities may include stormwater and sewage from port operations, as well as sewage, ballast water (e.g. from oil tankers), bilge water, and vessel cleaning wastewater from ships. Ship sewage and wastewater contains high levels of BOD and Coliform bacteria, with trace concentrations of constituents such as pharmaceuticals, and typically low pH levels. Wash water may contain residues such as oil. Pollutants in bilge water contain elevated levels of BOD, OD, dissolved solids, oil, and other chemicals that accumulate as the result of routine operations.

The type and amount of solid and liquid wastes associated with port operations may vary significantly depending on the nature of port operations and the types of ships serviced. Wastes originating at the port may include inert solid waste from cargo packaging and from administrative

[6] http://www.grist.org/biz/tp/2006/05/23/shipping/
[7] http://bpa.odu.edu/port/research/ENVIRONMENTAIMPACTS.doc

offices, as well as hazardous or potentially hazardous waste associated with vehicle maintenance operations (e.g. used lubricating oils and engine degreasing solvents). inert materials such as food packaging, and food waste.

Noise
Noise sources in ports include cargo handling, vehicular traffic, and loading / unloading containers and ships.

7.1.3 *Climatic conditions*

The harsh climatic conditions in the Assal area have a negative impact on the salt project activities. The extreme temperatures, humidity and winds impose difficult working conditions on the lake. These conditions have a negative impact on the health of the workers, unless management measures are put in place (e.g. protective clothing).

The effects of wind blown salt at both the lake Assal site and the salt storage beach site at the Ghoubbet will have a negative impact on the workers. The prevailing wind direction at the Ghoubbet in onshore so this impact can be mitigated if the workers wear face masks.

7.1.4 *Removal of indigenous plants and loss of biodiversity*

Removal of indigenous vegetation, even the low shrub, but also palm tress will reduce the biodiversity and aesthetics of the Lake Assal area. There must be minimal removal of any vegetation which can occur when building access roads.

Destruction of vegetation has a multitude of negative effects on other environmental attributes which include reduced capacity for water infiltration, increased rate of surface runoff, reduced groundwater recharge, reduced water quality through increased sedimentation, accelerated soil erosion, and loss of habitat for wildlife.

7.1.5 *Access road and Vehicle transport of salt product*

The major direct negative biophysical impact associated with construction of access roads is erosion which is significant where highly erodible soils are common. Increased potential for erosion occurs particularly on roadside slopes and causes downstream impacts on hydrological resources as a result of improper water management and siltation. Inadequate drainage structures exacerbate the problem of gully erosion and sedimentation.

Construction of access roads may involve the bulldozing of vegetation, compression of the soil surface and possibly the deposition of fill material. Care should therefore be taken to site access roads to minimise the visual impact, and minimise the impacts on surrounding arable land or roadside vegetation.

Haul roads generate dust that creates a safety hazard, increases vehicle and road maintenance costs and cause a decrease in air quality. The Lake Assal Salt Project will be using large off-road haul trucks extensively to move the salt from the lake to the beach storage site. Observations of

dust emissions from haul trucks show that if the dust emissions are uncontrolled, they can be a safety hazard by impairing the operator's visibility[8] (Plate 7.1). This increases the probability for haul truck accidents. However, the greatest long-term health hazard of dust generated from hauling operations is due to inhalation of the respirable dust.

Plate 7.1. Dust generated from haul trucks.

Due to the water shortage in Djibouti, rather than watering the road surface to control the dust alternative methods of road dust control must be investigated. For example, treating haul roads is generally completed through the application of chemicals. Wet spray and foam are two options for dust control. Wet spray methods involve mixing a surfactant with water and the dust is controlled. Foam programs involve mixing a surfactant, water and air to produce foam that controls dust on the material being treated[9].

7.1.6 *Physical impacts of the salt processing plant and work sites*

The main negative impact that seems to be visible in all salt mines is the impact of heavy machinery on the landscape. The movement of bulldozers, front-end loaders and trucks whilst harvesting the salt have a negative aesthetic impact for visitors to the lake.

7.1.7 *Housing of labour, and vehicle maintenance*

Housing of labour, storing of vehicles, equipment, fuel and building materials will be required at the maintenance and housing site. Whenever possible work sites should be sited on land which is already impacted. At the and work sites, indiscriminate dumping of engine oils, fuel, lubricants or other solvents can contaminate soil and leach into subsoil water.

[8] www.cdc.gov/niosh/mining/pubs/pdfs/hrdcf.pd
[9] file:///C:/DOCUME~1/Shael/LOCALS~1/Temp/Saf4B.tmp/akj-industries.html

7.2 Socio-Economic Impacts

7.2.1 *Economic and employment opportunities, and quality of life*

The potential benefits which people expect to gain from the development of the salt mining activities include employment on a temporary or permanent basis. Small scale economic activities may also develop as a result of increased population in the area, and include sale of handicrafts, and local businesses which sell food and services.

Improved technology in harvesting the salt and upgrading the existing salt processing plant will result in an export quality salt product. This will ultimately lead to a source of revenue for the country and provide employment opportunities for distributors.

With an increase in employment comes an increase in quality of life for the people employed on the salt project. Increased employment will not only generated by the salt project, but also as a result of a community developing and the demand for other services such as shops and restaurants.

7.2.2 *Relocation of people and community development*

Due to the lack of services and facilities in the Lake Assal area, workers demand higher wages to come and work in the Lake Assal area. To be able to attract people to work on the salt project at Lake Assal at reasonable wages, SALT INVESTMENT S.A have provided some services, such as water supply in barrels. This has resulted in people relocating from urban areas (mainly Djibouti City) to the rural area of Assal where a community is now developing.

The development of the community next to the salt processing plant (see Plate 4.19) has resulted in increased demand for services to the area. There needs to be some structure developed for a township as the settlements already there are scattered with little thought for future development of a larger settlement. For example, sewerage, sanitation and waste disposal need to be managed in a structured manner with potential for future growth.

7.2.3 *Improved services and facilities*

With the development of the salt mining activities, communities have settled in the area to be closer to their work. As a result, water is being supplied to the area and facilities have been or will be provided for the community that is settling there. For example, a Mosque has now been built at the settlement adjacent to the maintenance and housing buildings and there are plans for a school to built in the area. Power will also be supplied to the Lake Assal area, when the proposed geothermal and powerline extension projects go ahead. The settlements near the road will benefit most from the salt project.

7.2.4 *Health and safety*

The people who work at the harvesting site on the lake itself are exposed to harsh climatic conditions and the health risks associated with exposed/harsh conditions. The health problems

associated with working on salt exploitation projects are skin infections, sore eyes, and respiratory illnesses. To address this problem, workers should wear protective clothing and minimise the amount of time spent during harvesting (work on a shift rotation system).

Improvements in the harvesting and salt processing technology will alleviate the health risks associated with this type of work. With employment comes increased income and quality of life.

The safety of domestic livestock are at risk with the increase in traffic levels associated with the salt project. This has already been noted by some of the labourers living in the area (see Table 6.2).

Dust generated form the trucks on the haul road between the lake and the beach storage site will potentially be a health and safety hazard. The greatest long-term health hazard of dust generated from hauling operations is due to inhalation of the respirable dust (median diameter <4 micrometers (µm)) and thoracic dust, which is equivalent to the EPA's definition of PM10 [particulate matter with a median diameter <10 µm] [10]. Exposure to respirable dust has long been considered a health hazard at surface mining operations. In one EPA study, a 50 µg/m^3 increase in the 24-hour average PM10 concentration was statistically significant in increasing mortality rates by 2.5%-8.5%. Long-term effects from PM10 are dependent upon the exposure to PM10 over the life of the worker. In light of the health and safety issues outlined above, of particular concern is the use of haul trucks on the haul road between Lake Assal operations and the beach storage site at the Ghoubbet.

Details on the Health and Safety aspects of the project is given in a separate Occupational, Health and Safety Report.

[10] www.cdc.gov/niosh/mining/pubs/pdfs/hrdcf.pd

Section 8.0

EVALUATION OF IMPACTS

8.1 Evaluation and analysis of the potential impacts

The evaluation of potential impacts resulting from the salt project activities includes direct and indirect, temporary and permanent, and cumulative impacts on the environment. The following Table 8.1 summarises the significant biophysical and socio-economic impacts identified for each of the project activities, and then shows an evaluation of their significance after mitigation measures have been applied.

The approach used to assess the significance of the potential impacts and assess the efficacy of mitigation or enhancement measures is to apply significance ratings to each impact based on objective criteria, such as magnitude, extent and duration of that impact, to yield a final evaluation of the significance of impacts before and after mitigation. The application of significance ratings reduces the number of variables which need to be considered by the decision maker, whilst providing pertinent information about the implications of the salt operation at Lake Assal. Table 8.2 summarises the assessment criteria used in this study.

Table 8.2. First step assessment criteria for evaluation of impacts[1]

FIRST STEP CRITERION	CATEGORIES
Extent or spatial influence of impact	**Local**/site specific; **Regional**; **National**; **International**
Magnitude of impact at that spatial scale	**High:** natural and/or social functions and/or processes are severely altered **Medium:** natural and/or social functions and/or processes are notably altered **Low:** natural and/or social functions and/or processes are negligibly or minimally altered
Duration if impact	**Short term** (ST): 0-5 yrs; **Medium term** (MT): 5-15 yrs; **Long term** (LT): 15+ yrs.

[1] **from Brownlie and Willemse (1996)**

Table 8.1. Before and after mitigation of potentially significant environmental impacts during pre-construction, construction and operational phases of the Lake Assal Salt Project.

SITE 1: LAKE ASSAL OPERATIONS (solar ponds, wash dam, salt processing plant)			
Environmental Impacts	***Before mitigation**	**Mitigation / enhancement measure**	***After mitigation**
PRE-CONSTRUCTION PHASE			
Damage to the natural environment of Lake Assal	local / high / LT **HIGH**	▪ Undertake Environmental Impact Assessment study	local / low / ST **LOW**
Uninformed public and government departments about the Lake Assal Salt Project	national / high / LT **HIGH**	▪ Ensure sufficient public consultation and that all key stakeholders are aware of the Lake Assal Salt Project. ▪ Undertake public consultation in the projects area of influence to establish any issues and/or concerns of the Salt Project from the local communities.	national / med / MT **MED**
Inadequate planning and design of salt operations at the Lake	national / med / LT **MED**	▪ Salt operations at the lake must be planned and designed with minimal impact on the environment and pressure on natural resources e.g. use of ground water	national / med / LT **MED**
Visual and noise impact of inappropriate siting of salt processing plant, wash dam, and work areas	national / high / LT **HIGH**	▪ Site salt processing plant and wash dam away from tourist areas	national / med / LT **MED**
CONSTRUCTION PHASE			
Groundwater contamination by oil, grease, and fuel in equipment areas	local / med / ST **MEDIUM**	▪ Control collection and recycling of lubricants ▪ Have precautions to avoid accidental spills	local / low / ST **LOW**
Movement and presence of vehicles (bulldozers, front-end loaders, trucks) on and around the lake	local / high / ST **MEDIUM**	▪ Control movement of construction vehicles. ▪ Provide "parking" areas for vehicles not being used at any one time	local / low / ST **LOW**
Visual impact of the salt construction activities at the lake to tourist areas	local / high / ST **MEDIUM**	▪ Minimise construction activities during peak tourist periods. ▪ Ensure site area is organised	local / low / ST **LOW**

*FIRST STEP CRITERIA - extent / magnitude / duration (ST, short term; MT, medium term; LT, long term)/ SIGNIFICANCE

		and clear of solid wastes.	
Noise impact of the construction activities at the lake	local / high / ST **MEDIUM**	▪ Minimise harvesting operations during peak tourism times i.e. weekends	local / low / ST **LOW**
Dumping of construction materials / spoil on land adjacent to processing plant activities	local / med / MT **MEDIUM**	▪ Management of waste materials must be stipulated in the management plan	local / low / ST **LOW**
Open borrow pits resulting in negative visual impact and potentially a safety hazard	local / med / MT **MEDIUM**	▪ Rehabilitate borrow pits to original landscape	local / low / ST **LOW**
Risk to health and safety of employees	local / high / MT **HIGH**	▪ Ensure all employees have safety gear – hard hats, gloves, steel-toed boots. ▪ Have emergency procedures in place in case of accidents.	local / med / ST **LOW**
OPERATIONAL PHASE			
Groundwater contamination by oil, grease, and fuel in equipment areas	local / med / LT **MEDIUM**	▪ Control collection and recycling of lubricants ▪ Have precautions to avoid accidental spills	local / **low** / ST **LOW**
Potential pollution of the lake environs by improperly sited latrines, lack of waste disposal facilities at works sites next to lake.	local / **med** / ST **MEDIUM**	▪ Ensure adequate facilities provided for workers ▪ Provide waste disposal facilities ▪ Restrict work sites to certain areas	local / **low** / ST **LOW**
Damage and/or loss of protection worthy areas resulting from salt harvesting activities.	national / **high** / LT **HIGH**	▪ Minimise salt exploitation area on Lake Assal ▪ Ensure salt production on the lake is sustainable i.e. being replenished at the same rate it is exploited.	local / **low** / ST **LOW**
Movement and presence of vehicles (bulldozers, front-end loaders, trucks) on and around the lake	**local / high / LT** **HIGH**	▪ Minimise area where harvesting vehicles move around ▪ Provide "parking" areas for vehicles not being used at any one time	**local / low / ST** **LOW**
Air contamination by iodizing and wind blown salt	local / med / ST **MED**	▪ Monitoring and control of air quality	local / low / ST **LOW**
Reduced natural salt regeneration on the lake due to over exploitation of salt layer	**regional / high / LT** **HIGH**	▪ Maintain sustainable exploitation of salt layer ▪ Monitor biological aspects of the salt works.	regional / med / LT **MED**
Visual impact of the salt operations at the lake to tourist areas	local / high / LT **HIGH**	▪ Locate wash dam and salt processing facility out of sight of the tourists. ▪ Ensure site area is organised	local / low / LT **MED**

		and clear of solid wastes.	
Noise impact of the salt operations at the lake	local / high / LT **HIGH**	▪ Minimise harvesting operations during peak tourism times i.e. weekends	local / low / LT **LOW**
Salt washing plant and stockpiling area – generation of waste, oil spillage etc.	local / med / ST **MEDIUM**	▪ Ensure strict control of waste ▪ Confine work area	local / low / ST **LOW**
Health problems associated with working in the lake's environment e.g. wind blown salt	local / high / MT **HIGH**	▪ Ensure all employees have safety gear – hard hats, gloves, steel-toed boots. ▪ Provide protective clothing for workers ▪ Provide health facilities for workers ▪ During windy conditions if air quality deteriorates, ensure workers where face mask.	local / med / ST **LOW**
Damage to potential tourism sites – reduce aesthetic value of Lake Assal	national / high / LT **HIGH**	▪ Ensure that potential tourist sites are provided with appropriate protection or that plans for any new developments are known. ▪ Have a “visitors centre” at the Salt Processing site where tourist can go to learn about the Lake Assal Salt Project. This would include a tour of the beach site as well.	national / med / LT **MED**
Positive impact of short and long term employment for locals	local / low / ST **LOW**	▪ Maximise employment of local labour where possible ▪ Careful attention to the recruitment of workers to ensure it is fair and also does not generate conflict. ▪ Optimise secondary/informal employment opportunities, especially for women ▪ Employ local guides for the “Tourist Centre” who also be able to explain the history of the area.	local / high / LT **HIGH**

SITE 2: HAUL ACCESS ROAD (7.5km)

(transport of salt from the lake to salt storage beach site)

Environmental Impacts	*Before mitigation	Mitigation / enhancement measure	*After mitigation
PRE-CONSTRUCTION PHASE			
Location of access road resulting in negative impact on the environment	local / med / LT **MED**	▪ Locate and design haul road with minimal impact on the environment.	local / low / ST **LOW**
Location of access road near tourist routes	local / high / LT **HIGH**	▪ Ensure aesthetic aspects considered in potential tourism development locations	local / low / ST **LOW**
CONSTRUCTION PHASE			
Loss and/or destruction of vegetation for access roads.	local / med / LT **MED**	▪ Minimise loss of vegetation ▪ Revegetate as soon as possible using local species	local / low / ST **LOW**
Improper access road construction methods which mar the landscape by leaving soils exposed, causing slips and landslides in steep areas	local / high / LT **HIGH**	▪ Avoid leaving exposed cut and fill areas ▪ Rehabilitate scarred sections as soon as possible ▪ Seed or plant erodible surfaces as soon as possible ▪ Ensure aesthetic aspects considered in potential tourism development locations ▪ Build culverts at dry river bed locations	local / low / ST **LOW**
Noise and Vibration: Generation of noise along the road corridor and at ancillary sites, particularly from heavy construction vehicles	local / med / ST **MED**	▪ Locate work compounds at least 0.5km from settlements. ▪ Maintain machinery and vehicles	local / low / ST **LOW**
Generation of dust from high traffic volumes	local / high / MT **HIGH**	▪ Cease operations during periods of dry windy weather, in areas where wind blown dust is causing a nuisance.	local / low / ST **LOW**
Disturbance to burial/grave sites	local / high / MT **HIGH**	▪ Ensure access roads and work areas are located away from graves sites ▪ Communities affected by the access road must be consulted as to the whereabouts of any burial sites, as well as other	local / low / ST **LOW**

		religious interest sites. ▪ Restrict movement of vehicles to existing roads	
unemployment of locals	local / high / LT **HIGH**	▪ Maximise employment of local labour during road construction. ▪ Careful attention to the recruitment of workers to ensure it is fair and also does not generate conflict. ▪ Optimise secondary/informal employment opportunities, especially for women	local / low / ST **LOW**
Increased risk for road accidents with increased vehicle movements	local / med / LT **MED**	▪ Install road traffic signs warning of wildlife in the area ▪ Install speed bumps next to settlements	local / low / ST **LOW**
OPERATIONAL PHASE			
Increased risk of soil erosion at roadside edges	local / high / LT **HIGH**	▪ Ensure adequate roadside maintenance of erosion control measures. ▪ Provide for storm water drainage and construct curbing to prevent water erosion onto paved roads.	local / low / ST **LOW**
Generation of dust from high traffic volumes on haul road	local / high / MT **HIGH**	▪ Use alternate methods of dust control (other than water) due to water shortage in the Lake Assal area e.g. applying chemical dust suppressants using the admix method, blending the product with the top few inches of surface material. Suppressants may also be applied as surface treatments. Chemical treatment can reduce emissions by 30 to 95 percent e.g. coal soap #10 on fill lines to the water trucks works by providing reduced surface tension of the water. This effect allows water to penetrate into the soil, providing more effective dust control OR RDS-16 is a calcium chloride based product which works by binding the fines in the road surface and drawing moisture from the atmosphere to	local / low / ST **LOW**

		replenish the dust control (AKJ Industries, Florida, USA). ▪ Limited use of water-absorbing (hygroscopic) salts with watering of road surface, will reduce how often you must water trafficked areas. ▪ High vehicle speed increases the amount of dust stirred up from unpaved roads and lots. Lowering the speed of a vehicle from 45 miles per hour to 35 miles per hour can reduce emissions by up to 22 percent. ▪ Apply surface chemical suppressants to untrafficked areas to form a less erodible soil surface i.e on the shoulder of the road ▪ Upgrade the road by adding surface gravel to reduce the source of dust emission; improving drainage and crown.	
Increased risk for road accidents with increased vehicle movements	local / med / LT **MED**	▪ Install road traffic signs warning of wildlife in the area ▪ Install speed bumps next to settlements ▪ Police speed limit of haul trucks on access road	local / low / ST **LOW**
Existence of a road across water courses will alter water flow.	regional / med / LT **HIGH**	▪ Maintain culverts, mitre drains and roadside drains clear of vegetation and debris to avoid damming up of water courses	local / med / ST **LOW**
Increased noise level with increased traffic flow	local / med / LT **MED**	▪ Enforce speed limits. ▪ Improved road surface should reduce noise levels due to more efficient operation of vehicles and less noise from vehicle tyres.	local / low / LT **LOW**

SITE 3: MAINTENANCE AND STAFF HOUSING (equipment, vehicle maintenance, staff housing)			
Environmental Impacts	***Before mitigation**	**Mitigation / enhancement measure**	***After mitigation**
PRE-CONSTRUCTION PHASE			
Negative impact on aesthetics of natural landscape	local / med / LT **MED**	▪ Locate and design staff housing with minimal impact on the landscape.	local / low / ST **LOW**
Existing site with old and broken machinery, vehicles etc. left lying around	local / high / MT **HIGH**	▪ Clean up existing site ▪	local / low / ST **LOW**
Inadequate drainage design causing localised pollution		▪ Locate equipment and buildings appropriately and install drainage to avoid localised pollution (e.g. concrete mixers, employees accommodation, stores, laboratories/workshop).	
Waste disposal sites	local / high / MT **HIGH**	▪ Locate solid waste disposal site away from buildings and people and plan regular waste removal	local / low / ST **LOW**
CONSTRUCTION PHASE			
Loss and/or destruction of natural areas outside the existing fenced maintenance building site	local / med / LT **MED**	▪ Confine construction activities to the demarcated maintenance/staff building area.	local / low / ST **LOW**
Sewage and sanitation	local / high / LT **HIGH**	▪ Ensure adequate sewage and sanitation management for construction workers. ▪ The Contractor must provide suitable sanitary arrangements at the construction personel. A minimum of 1 toilet will be provided per 15 persons at each working area. The Contractor must maintain, keep clean, neat and hygienic all site sanitation facilities	local / low / ST **LOW**
Solid waste disposal	local / high / MT **HIGH**	▪ Manage solid waste disposal	local / low / ST **LOW**
Washing of vehicles with local water supplies without catch trays	local / high / MT **HIGH**	▪ Use recycled water to clean vehicles and use catch trays underneath to catch runoff	local / low / ST **LOW**

Unemployment of locals	local / high / LT **HIGH**	▪ Maximise employment of local labour during construction of buildings. ▪ Careful attention to the recruitment of workers to ensure it is fair and also does not generate conflict. ▪ Optimise secondary/informal employment opportunities, especially for women	local / low / ST **LOW**
The presence of construction camps attracts market opportunists with informal roadside shops which are poorly managed in terms of health regulations and waste disposal.	local / med / MT **MED**	▪ Identify suitable sites for the establishment of small shops and other facilities servicing the construction camp.	local / low / ST **LOW**
OPERATIONAL PHASE			
Pollution of groundwater supplies	local / high / LT **HIGH**	▪ Specific drainage is required around fuel depots and ablution blocks to prevent runoff affecting groundwater.	local / low / ST **LOW**
Servicing of vehicles outside the vehicle maintenance building in oils and lubricants penetrating soil surface	local / high / MT **HIGH**	▪ All vehicles must be serviced in a designated area inside the maintenance building ▪ Catch trays must be installed	local / low / ST **LOW**
Oil or petrol spills at fuel depot	local / med / LT **MED**	▪ In the event of an oil/petrol spill, the spill must be cleaned up immediately and deposited at a registered landfill site	local / low / ST **LOW**
Spread of STD's and other diseases	local / med / LT **MED**	▪ Enlist the help of the local Health Centre to undertake workshops on STD's and AIDS Awareness for the workers ▪ Ensure the contract workers are aware of local health facilities ▪ Employ local communities living next to the maintenance site, so family structure is maintained	local / low / ST **LOW**
Indiscriminate disposal of waste around camp site	local / med / LT **MED**	▪ Designate restricted places for eating in working areas, and provide adequate refuse bins	local / low / ST **LOW**
Pressure on local water resources	local / med / LT **MED**	▪ Water for drinking purposes must be imported to the site. ▪ Use recycled water for	local / low / ST **LOW**

SITE 4: SALT STORAGE AND SHIP LOADING BEACH SITE			
Environmental Impacts	***Before mitigation**	**Mitigation / enhancement measure**	***After mitigation**
PRE-CONSTRUCTION PHASE			
Reduce the aesthetics of the Ghoubbet beach area	local / high / LT **HIGH**	▪ Locate and design salt storage area away from tourist beach site.	local / low / LT **LOW**
Damage to potential archaeological and cultural sites	local / high / LT **HIGH**	▪ Ensure public consultation identifies archaeological and cultural sites in the project area. ▪ Locate any buildings/operations to do with the salt project away from sensitive areas.	local / med / ST **LOW**
Damage and pollution to the marine environment	local / high / LT **HIGH**	▪ Plan ship loading facility with minimal impact on the marine environment. ▪ Appoint environmentally conscious shipping company. ▪ Locate desalination plant with minimal impact on the marine environment. ▪ An underwater survey of the marine environment in the area just offshore the beach storage area and around the small islands should be initiated as soon as possible.	local / low / LT **LOW**
CONSTRUCTION PHASE			
Increased construction vehicle traffic affecting local tourism	local / high / ST **HIGH**	▪ Ensure construction vehicles only operate on weekdays ▪ Put in place and police speed limits.	local / med / ST **MED**
Sedimentation of the marine environment when constructing the dyke and levelling at the beach storage area	local / high / ST **HIGH**	▪ Restrict building of the dyke to low tide periods only. ▪ Install temporary berms to prevent spillage of building materials into the sea. ▪ Restrict building activities during very windy conditions	local / low / ST **LOW**

*FIRST STEP CRITERIA - extent / magnitude / duration (ST, short term; MT, medium term; LT, long term)/ SIGNIFICANCE

Increased noise levels due to construction vehicles, affecting tourism	local / high / ST **HIGH**	▪ Restrict vehicle movement to weekdays	local / low / ST **LOW**
Spillage of cement in the sea whilst building of jetty pylons and sea anchors	local / high / ST **HIGH**	▪ Restrict building of jetty to calm sea conditions to minimise risk of cement spillage	local / low / ST **LOW**
Waste disposal on site	local / high / ST **HIGH**	▪ Allocate eating areas for construction staff and install bins for local refuse disposal. ▪ Ensure regular removal of waste to a designated waste disposal site	local / low / ST **LOW**
Sewage and sanitation on site	local / high / ST **HIGH**	▪ Ensure adequate latrines on site. ▪ Ensure regular removal of latrines	local / low / ST **LOW**
Pressure on local water resources	local / high / ST **HIGH**	▪ Import potable water for construction workers. ▪ Use recycled water for construction use.	local / low / ST **LOW**
OPERATIONAL PHASE			
Decrease in air quality due to wind blown dust and salt from salt storage area, affected health of workers	local / high / LT **HIGH**	▪ Monitor air quality at salt storage area ▪ Ensure salt is adequately covered and protected from wind. ▪ A Clinic with modern equipment and a qualified doctor/nurse should be available not only for the workers but also the local communities.	local / low / LT **LOW**
Salt being delivered via haul roads, increased traffic on main road to the beach	regional/ med / LT HIGH	▪ Transport salt during non-peak times. ▪ Police speed limits of haul trucks	local / low / LT **LOW**
Increased noise levels from salt operations on the beach	local / high / LT **HIGH**	▪ Limit peak loading activities to weekdays. ▪ Monitor noise levels and determine if tourist are affected	local / low / LT **LOW**
Sedimentation of the marine environment	local / high / LT **HIGH**	▪ Maintain dyke structure and beach graded area so that there is no sedimentation into the marine environment.	local / low / LT **LOW**
Spillage of salt from conveyor system	local / high / LT **HIGH**	▪ Maintain operation of conveyor system to prevent salt spillage. ▪ Ensure bulk salt is adequately secured.	local / low / LT **LOW**
Pressure on local water resources	local / high / LT **HIGH**	▪ All ships to use their own imported potable water resource whilst docked.	local / low / LT **LOW**

		▪ Water from desalination plant to be used only for salt operations and to supply locals.	
Pollution of marine environment from ships whilst docked (oils, fuel, sewage, ballast water)	local / high / LT **HIGH**	▪ Involve Djibouti Port in management of ships. ▪ Have penalties for ships leaking fuel/oil into marine environment. ▪ No sewage or waste disposal from the ships is allowed whilst docked in the Ghoubbet. ▪ Ensure ballast water origin is from local marine waters.	local / low / LT **LOW**
Ships sailing in the Ghoubbet having a negative impact on the whale sharks or any marine fauna in the bay		▪ Strict navigational routes which avoid the locations frequented by the whale sharks.	
Shipping loading activities impacting on local tourist beach.	local / high / MT **HIGH**	▪ Only have one main jetty operating for ship loading i.e. do not allow additional piers / jetties to built at this site. ▪ Ensure minimal pollution by shipping activities. Ensure Dankelo beach (Plate 4.10d) is cleaned up before ship loading activities start so that salt operations are not blamed for beach pollution. ▪ Ensure jetty/port does not interfere with existing and proposed tourist facilities in the bay ▪ Restrict ship loading to weekdays when tourist and/or locals are using the Dankelo beach.	local / low / LT **LOW**
Negative impact of salt operations on tourism	local / high / LT **HIGH**	▪ Help with beach cleanup operation at tourist beach – which is already polluted by visitors to the beach. ▪ Include salt storage and ship loading activities in the “visitors centre” tours for educational purposes.	local / low / LT **LOW**
Shipping opportunities	regional/ med / LT HIGH	▪ Contract out local tugs to facilitate the ships for loading. ▪ Appoint environmentally conscious shipping company	local / high/ LT **HIGH**
Increased economy	Local / med / LT HIGH	▪ Ensure percentage of profits of the Lake Assal Salt Project remain in Djibouti so the local	regional / high/ LT **HIGH**

		economy benefits in the long run. ▪ Assist local government in building of a clinic, school, and mosque in the study area.	
Job creation for potential distributors	regional/ med / LT HIGH	▪ Maximise opportunities for locals in the export of salt products	local / low / LT **LOW**

Section 9.0

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Section 10.0

APPENDICES

APPENDIX I : Projects 8.1 and 8.2 from the NAPB

Thème 8. Ressources minérales

Projet 8.1: Étude d'impact sur l'environnement de l'exploitation du sel au Lac Assal

I. Maître d'ouvrage :

Ministère de l'Energie et des Ressources Naturelles.

II. Justification et description générale du projet :

Une dizaine de sociétés exploitent actuellement le sel du Lac Assal (situé au nord-ouest) pour l'exporter vers l'Éthiopie, où il est utilisé dans l'industrie chimique (tanneries, engrais). Le lac Assal qui, avec ses 150 m au-dessous du niveau de la mer figure parmi les quelques rares dépressions de la planète, offre un spectacle grandiose au visiteur et fait partie du patrimoine géologique unique de la République. Or, depuis plus d'une année, les bulldozers et les camions roulant sur la banquise (superficie de 60 km²) remplacent désormais les anciennes « caravanes de sel » conduites par les nomades. A la défiguration paysagère du site, s'ajoutent comme effets negatifs la déformation de la surface de la banquise, la pollution des eaux du lac et de rudes conditions de travail. C'est pourquoi il s'avère impératif et urgent de réaliser une étude d'impact sur l'environnement (EIE) de ce type d'extraction, à travers, entre autres, la réalisation d'études hydrogeologiques, geochimiques et biochimiques sur le site.

III. Objectifs du projet :

Les résultats de ces diverses études devraient permettre de faire dans un premier temps un recensement des impacts écologiques (pollutions et dégradation du site) et socio-économiques de l'extraction du sel, qui reste une activité porteuse si exécutée de façon « durable », et dans un second temps, de remédier aux effets néfastes présents et d'établir des marges de sécurité pour une meilleure prévention de ceux-ci.

IV. Durée du projet :

- Huit mois.

V. Actions prioritaires :

A court terme

- Analyses géochimiques et biochimiques
- Études hydrogéologiques complètes (écoulements de surface et souterrains)
- Étude d'impact sur l'environnement
- Mise en place de groupes de travail.

A moyen terme

- Établissement d'un programme de surveillance continue (examens biochimiques et géochimiques) et d'un suivi de l'application des mesures proposées

VI. Résultats escomptés :

- Identification exhaustive des impacts négatifs
- Proposition de mesures concrètes et de solutions viables pour l'atténuation et la prévention des effets négatifs de l'exploitation du sel
- Restauration in situ du site
- Gestion rationnelle de l'extraction du sel

VII. Instruments choisis :

- Application du Code Minier
- Taxe ou redevance

VIII. Interrelations avec d'autres projets :

- Projet 8.2: Plan de gestion intégrée du Lac Assal

IX. Partenariats envisagés :

- ISERST
- Instituts de recherche étrangers spécialisés
- Universités (départements spécialisés) étrangères
- Bureau d'études compétent pour EIE
- Sociétés djiboutiennes d'exploitation du sel.

X. Financement :

Coût total : 20.000.000 FD *(115.000 USD)*

Financement acquis : 0%
Financement requis : 100%

Projet 8.2: Projet de plan de gestion intégrée du Lac Assal

I. Maître d'ouvrage :

Ministère chargé de l'Environnement

II. Justification et description générale du projet :

Une dizaine de sociétés exploitent actuellement le sel du Lac Assal (situé au nord-ouest) pour l'exporter vers l'Éthiopie, où il est utilisé dans l'industrie chimique (tanneries, engrais). Le lac Assal qui, avec ses 150 m au-dessous du niveau de la mer figure parmi les quelques rares dépressions de la planète, offre un spectacle grandiose au visiteur et fait partie du patrimoine géologique unique de la République. Or, depuis plus d'une année, les bulldozers et les camions roulant sur la banquise (superficie de 60 km²) remplacent désormais les anciennes « caravanes de sel » conduites par les nomades. A la défiguration paysagère du site, s'ajoutent comme effets négatifs la déformation de la surface de la banquise, la pollution des eaux du lac et de rudes conditions de travail.
Une fois réalisée l'étude d'impact de ces activités d'extraction sur le site (Projet 8.1), il sera nécessaire d'élaborer un plan de gestion intégré du site, de manière à assurer la cohabitation harmonieuse des activités d'exploitation commerciales et des activités touristiques.

III. Objectifs du projet :

1. Préserver l'intégrité du paysage du lac Assal;
2. Favoriser une intégration harmonieuse des activités d'extraction du sel et des visites touristiques;
3. Assurer au gouvernement un revenu provenant de ces activités
4. Associer les communautés locales au développement de ce projet.

V. Durée du projet :

- 3 ans.

V. Actions prioritaires :

A court terme
- Constitution d'un comité de gestion multipartite composé de représentants des compagnies de sel, des agences touristiques, du gouvernement et des populations locales
- Élaboration d'un plan de gestion

A moyen terme
- Établissement d'un programme de surveillance continue et d'un suivi de l'application des mesures proposées.

VI. Résultats escomptés :

- Restauration graduelle du site
- Gestion rationnelle de l'extraction du sel
- Mise en place de mesures concrètes et de solutions viables pour l'atténuation et la prévention des effets négatifs de l'exploitation du sel.
- Amélioration de l'expérience écotouristique.
- Autofinancement des activités de surveillance et de suivi.

VII. Instruments choisis :

- Application du Code Minier
- Taxe

VIII. Interrelations avec d'autres projets :

- Projet 8.1: Étude d'impact sur l'environnement de l'exploitation du sel au Lac Assal
- Projet 1.1.1 : Création d'une Agence des Aires Protégées.
- Projet 1.1.2 : Création de nouvelles aires protégées.

IX. Partenariats envisagés :

- Ministère de l'Énergie et des Ressources Naturelles.
- ISERST
- Office National du Tourisme
- Instituts de recherche étrangers spécialisés
- Universités (départements spécialisés) étrangères
- Sociétés djiboutiennes d'exploitation du sel.

X. Financement :

Coût total : à déterminer

APPENDIX II : Explanation of the hydrology and geology of Lake Assal, in French (source: http://www.jpb-imagine.com/djibgeol/asal/cadasal.html).

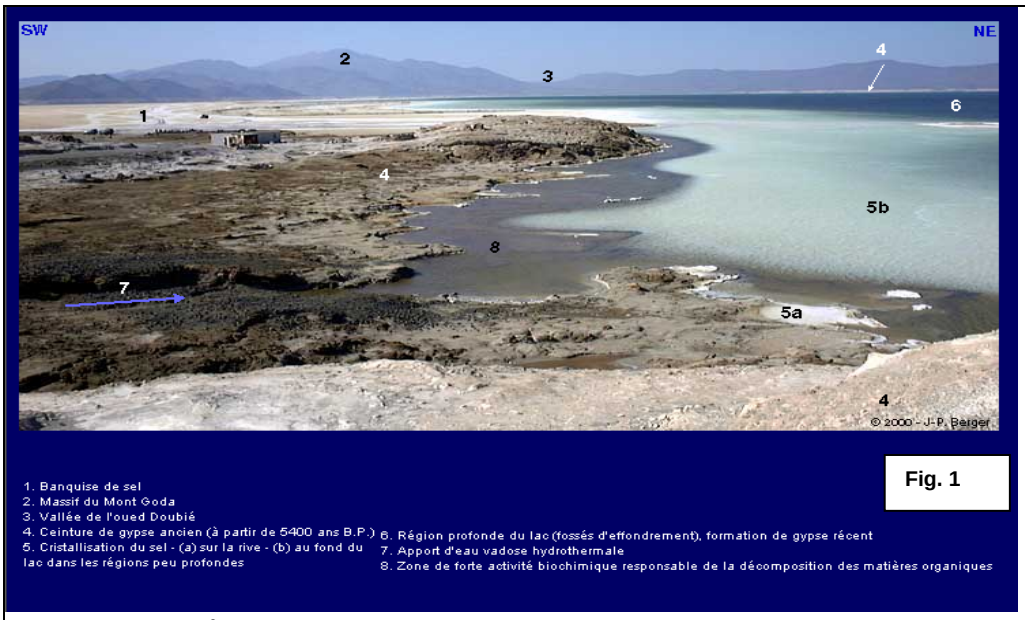


Fig. 1

LE LAC ASAL > généralités

Le lac Asal (Fig.1) se trouve à 9 km environ, au Nord-Ouest du Ghoubbet al Kharâb. Il est séparé du Ghoubbet par la barrière volcano-tectonique du plancher axial du Rift d'altitude + 155 m.

Cette dépression évaporitique se situe à - 155 m au dessous du niveau de la mer. Elle est constituée (Fig.2): d'un lac de saumure (348 g/1 de sels dissous) d'une superficie de 54 km^2 et d'une profondeur comprise entre 20 et 40 m d'une « banquise » de sel en forme de croissant de 61 km^2 et d'une épaisseur maximale de 80 m. La croûte de sel surmonte le niveau du lac de 0,30 à 0,80m.

Fig. 2

PRINCIPALES CARACTÉRISTIQUES DU LAC ASAL

(d'après H.R. Langguth et P. Pouchan, 1975)

Position	• longitude	42° 25' Est
	• latitude	11° 40' Nord
	• altitude	- 157 m
Surface	• lac ouvert	54 km^2
	• croûte de sel (banquise)	61 km^2
Pluviosité	• moyenne annuelle au niveau du lac	200 mm
	• moyenne annuelle du bassin versant	150 à 250 mm
Température	• moyenne annuelle au niveau du lac	30°C
Bassin versant	• surface	600 km^2
	• altitude moyenne	+ 260 m
	• altitude maximale	> 1000 m
Évaporation	• moyenne annuelle	460 × 10^6 m^3
Profondeur	• moyenne	4 m
	• maximale	40 m
Croûte de sel	• épaisseur	entre 20 et 80 m
	• volume de la saumure dans les pores, cavernes et fissures dans et sous la croûte de sel, environ	1900 × 10^6 m^3
Saumure libre du lac	• volume	400 × 10^6 m^3

QUELQUES CHIFFRES

NaCl en % du poids	98,57 %	Cl^-	185,5 g.l^{-1}
Substances solubles autres que NaCl en % du poids	0,23 %	SO_4^{--}	3,10 g.l^{-1}
Calcium en % du poids	0,07 %	HCO_3^-	0,146 g.l^{-1}
Magnésium en % du poids	0,04 %	Na^+	94,0 g.l^{-1}
Sulphates en % du poids	0,05 %	K^+	4,5 g.l^{-1}
KIO_3	non détecté	Ca^{++}	2,95 g.l^{-1}
		Mg^{++}	12,2 g.l^{-1}

Mesures effectuées en 1999 par SGS Kenya Ltd (tableau de gauche) et en 1981 par le Laboratoire de Biogéologie de Nantes (tableau de droite)

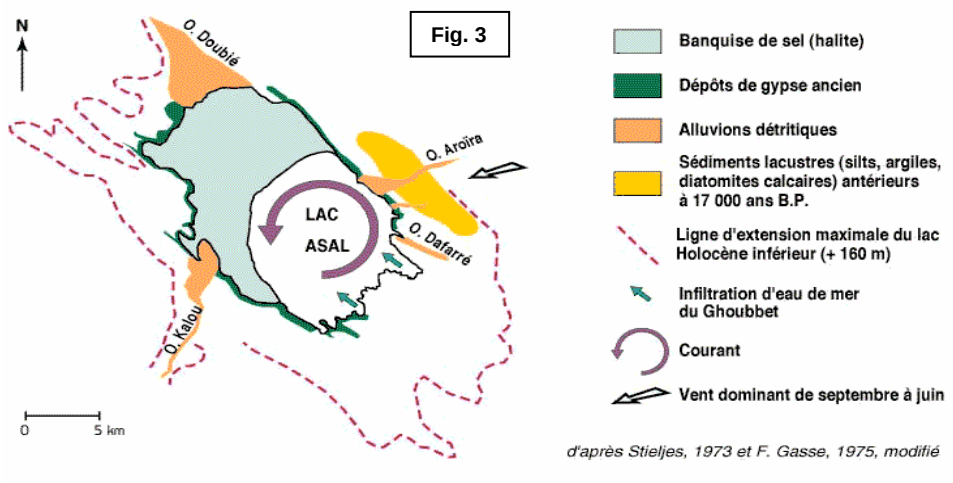
Des dépôts de gypse sont abondants dans le lac, gypse récent et autour du lac, gypse ancien formant une ceinture d'une dizaine de mètres au-dessus du niveau du lac. Le fond du lac est découpé en fossés structuraux, tout comme celui du Ghoubbet et se situe à un niveau identique de - 2OOm.

Les premières descriptions géologiques de ce secteur ont été effectuées en 1886 par M. Aubry. Les principales caractéristiques du lac Asal (Fig. 3) ont été décrites par H.R. Langguth et P. Pouchan (1975).

LES DÉPÔTS SÉDIMENTAIRES LACUSTRES > anté-Holocène et Holocène

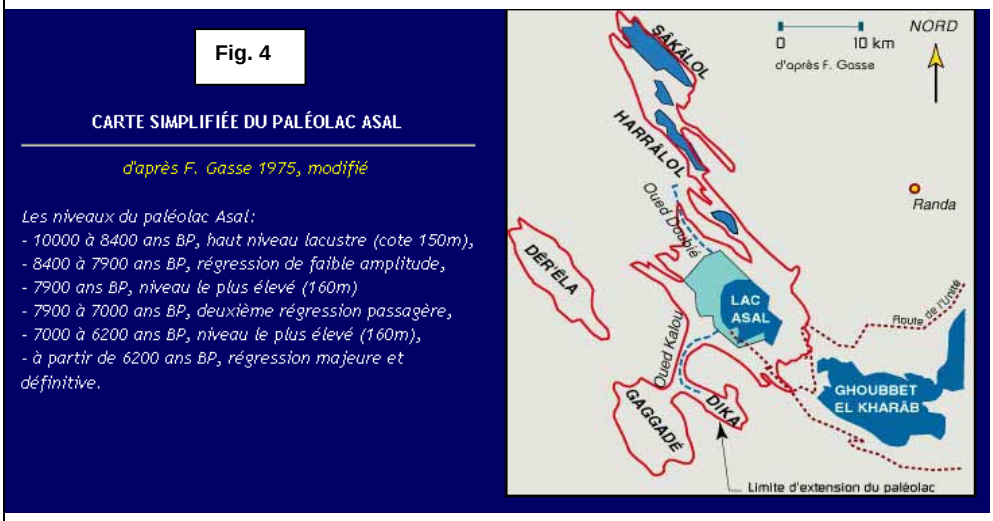
Les dépôts sédimentaires du lac sont d'âge quaternaire à récent (fig. 3). Les sédiments anté-Holocène (Pléistocène supérieur), situés surtout au Nord, à l'Est et réduit au Sud, correspondent à un régime lacustre à diatomites. Ils se sont formés probablement sous un climat moins aride.

L'extension des diatomites est étroitement liée au volcanisme et à la tectonique récente du rift. Au Sud-Est du bassin, les diatomites sont totalement absentes du fait des coulées basaltiques. Ces coulées présentent un faciès de volcanisme souvent subaquatique.



D'après la flore lacustre (épisode d'extension lacustre anté-Holocène, 25000 B.P.), il ressort que le lac était assez profond et d'un niveau probablement supérieur à celui du Ghoubbet, les eaux moins concentrées en sels minéraux excluant toute communication directe avec la mer. Le surplus du lac s'écoulait probablement vers le Ghoubbet. Des corrélations avec les plaines plus à l'Ouest, notamment l'Awash, (datation par méthode du C^{14} sur les coquilles de gastéropodes) fournissent un âge compris entre 35000 et 25000 ans B.P. (P. Rognon et F. Gasse, 1973), avec un climat plus frais et une pluviosité plus importante. À cette époque (27600 ans B.P.), la présence de coraux sur la rive Nord du golfe (Arrêt 4 et excursion en mer 7) atteste que le Ghoubbet appartenait au domaine marin (L. Stieltjes 1973).

Après une période d'exondation accompagnée d'un important dépôt de glacis d'érosion au Nord-Ouest, l'Holocène est caractérisé par un nouvel épisode d'ennoyage, matérialisé par des calcaires à faune dulçaquicole qui atteignent la côte 80, sauf au niveau du bombement, où ils peuvent s'élever jusqu'à la cote 110 du fait de la surrection (arrêt 8). Les dépôts lacustres, d'âge Holocène inférieur et moyen, sont représentés par des calcaires pulvérulents et des diatomites, abondants au Nord et à l'Est. Ils tapissent tous les fossés descendants vers le lac Asal.



Cette sédimentation carbonatée, continue de 8500 à 5300 ans B.P. (arrêt 16), est constituée de calcite et de calcite magnésienne. Ce sont des calcaires marneux, blancs à grisâtres, pulvérulents ou en plaquettes riches en diatomites. Ces formations, limitées par des escarpements subverticaux, sont réduites à quelques buttes témoins isolées et à de simples placages. Elles occupent des fossés tectoniques éloignés du lac actuel, la dépression d'Allol, plus au Nord, s'étendant à plus de 30 km au Nord-Ouest du lac. Ces dépôts sont absents sur le versant du Ghoubbet. Il y a plus de 6000 ans, la superficie du lac était de 1 100 km^2 (fig. 4) englobant, y compris le lac Asal, les dépressions du Sâkâlol, d'Harrâlol, du Dika, du Dêr'Êla et du Gaggade. Au Nord-Ouest du lac (oued Doubye), des anciennes lignes de rivage sont situées à plus de 160 m au niveau du rift émergé, *arrêt 8* (F. Gasse, 1975).

L'assèchement climatique entraîne la régression du lac et une concentration des eaux en sels minéraux, avec des dépôts de gypse autour du lac. La présence du gypse n'est pas seulement due au facteur climatique, mais aussi à un bouleversement volcano-tectonique entraînant des apports d'ions sulfates par hydrothermalisme et d'eau de mer du Ghoubbet par les fractures.

LES ÉVAPORITES > le gypse et le sel

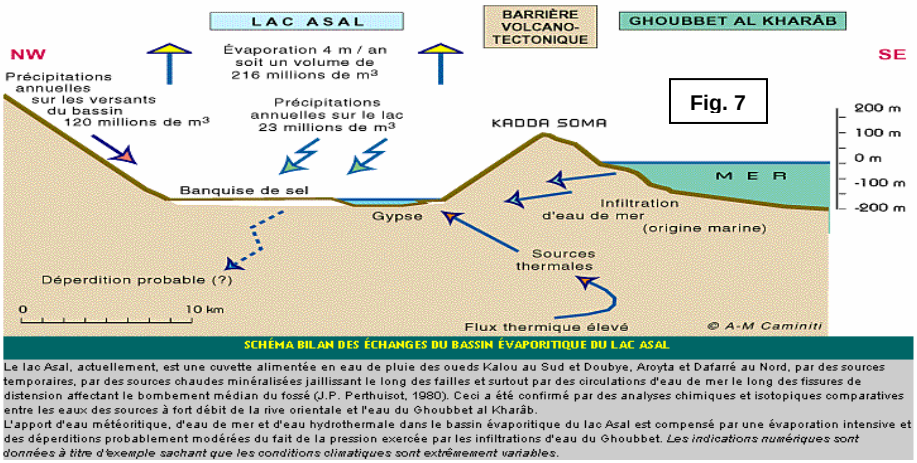


Fig. 7

SCHÉMA BILAN DES ÉCHANGES DU BASSIN ÉVAPORITIQUE DU LAC ASAL

Le lac Asal, actuellement, est une cuvette alimentée en eau de pluie des oueds Kalou au Sud et Doubye, Aroyta et Dafarré au Nord, par des sources temporaires, par des sources chaudes minéralisées jaillissant le long des failles et surtout par des circulations d'eau de mer le long des fissures de distension affectant le bombement médian du fossé (J.P. Perthuisot, 1980). Ceci a été confirmé par des analyses chimiques et isotopiques comparatives entre les eaux des sources à fort débit de la rive orientale et l'eau du Ghoubbet al Kharâb.
L'apport d'eau météoritique, d'eau de mer et d'eau hydrothermale dans le bassin évaporitique du lac Asal est compensé par une évaporation intensive et des déperditions probablement modérées du fait de la pression exercée par les infiltrations d'eau du Ghoubbet. *Les indications numériques sont données à titre d'exemple sachant que les conditions climatiques sont extrêmement variables.*

Le bassin évaporitique

L'alimentation du lac en eau et en sels dissous se fait principalement à partir du réservoir marin, à la faveur du réseau de failles longitudinales (axiales) du rift (Arrêts 8 et 13). Accessoirement cet apport est complété par les venues hydrothermales localisées. Ces eaux, fortement concentrées en sels minéraux à leur arrivée dans le lac, se concentrent rapidement et déposent du gypse sur le fond du lac. Au cours de leur circulation dans le lac (fig. 3), elles se concentrent encore par évaporation et finissent par déposer le sel (NaCl) qui constitue la banquise de sel (Fig. 7).

Le passage d'une sédimentation lacustre à une sédimentation saline et l'abaissement de la surface du plan d'eau sont dus à des facteurs tectoniques, climatiques, hydrologiques et cristallographiques: bombement, fracturation, évaporation de la nappe d'eau du lac et alimentation marine à sens unique, puis aridification du climat, et / ou colmatage des fissures par cristallisation des sels (carbonates et sulfates) à partir des eaux de mer ce qui aurait pour effet de réduire progressivement l'alimentation marine du lac.

Le sel: croissance minérale et origine

Le sel (halite), de nature tendre, friable, cristallise dans le système cubique. Sa couleur blanche, orange, rouge, jaune, grise, marron et même bleue dépend du type d'impuretés qu'il renferme (oxydes de fer, particules argileuses, matières organiques).

Les cristaux précipitent à partir d'une solution aqueuse supersaturée en chlorure de sodium (NaCl). La cristallisation prend place dans divers sites (cf. J.M. Rouchy et al., 1986 ; C.R. Handford, 1991). À l'interface air/saumure, une nucléation cristalline se crée et forme dans un premier temps des trémies de sel, puis des lamelles et enfin des radeaux (Fig. 8). La masse volumique des radeaux est toujours supérieure à la densité de la saumure, mais les radeaux, creux, sont maintenus en surface par les tensions capillaires tant que la surface de la saumure est calme, ils peuvent se souder et permettre la croissance d'une croûte (Fig. 8). Agités par le vent, les radeaux prennent l'eau, sombrent et se cimentent pour former un nouveau socle sédimentaire dans le lac. À partir de ce nouveau plancher, une cristallisation de direction préférentielle verticale, prend naissance pour former des cristaux en forme de cube, de chevron (Fig. 8) ou de cornet.

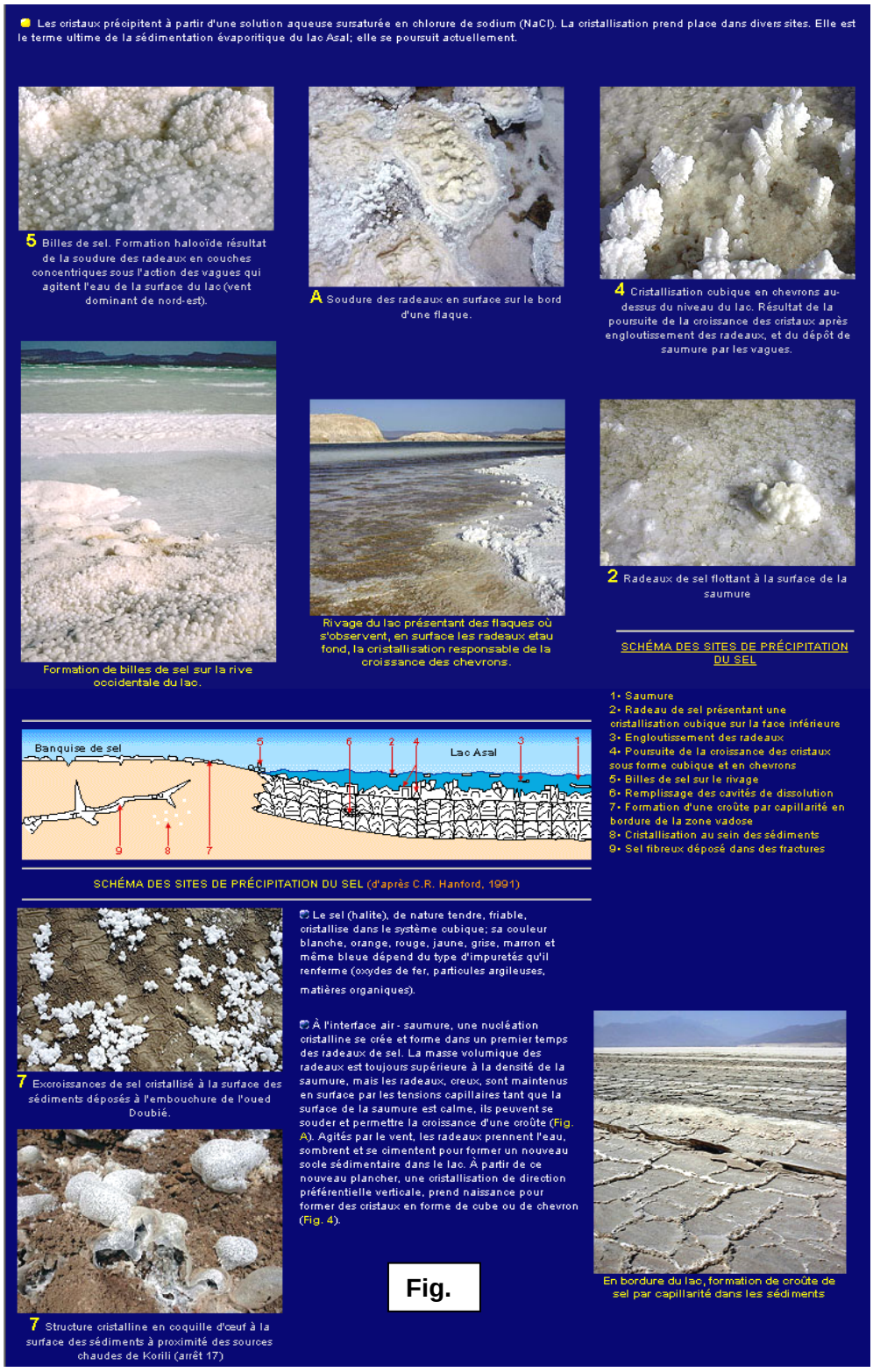
En bordure de cette vaste plaine de sel, s'accumulent des grains de sel arrondis, en barres lobées. Une étude granulométrique montre une croissance discontinue de ces grains. L'étude au MEB (microscope électronique à balayage) fait apparaître à la fois une structure fibro-radiaire et concentrique. Leur réseau cristallin est infesté de corps bactériens fossilisés (S. Castanier et al. 1992, 1999).

La formation de ces haloïdes pourrait être liée en partie à l'activité de populations bactériennes à la surface de ces grains et à leur régulation osmotique dans un environnement isotrope. Certaines bactéries dites halophiles extrêmes ne se développent qu'à partir de fortes concentrations salines (au dessus de 80 g/l). Ces bactéries ont résolu le problème directement en développant au cours de l'évolution une membrane cytoplasmique dont la structure est adaptée à un milieu extérieur fortement hypertonique. Leur existence est limitée à cette niche écologique très particulière (J. Lovelock, 1990). Localement, des billes de sel peuvent se déposer formant des bancs par cimentation (Fig. 8). Ces petites billes de sel, peuvent aller du plus petit grain millimétrique au galet de plus de 2 cm de diamètre.

Les formations gypseuses

Les dépôts gypseux correspondent à la dernière phase de régression du lac Asal commencée à partir de 6200 ans B.P.. Le gypse ancien est daté à partir de 5400 ans B.P.. A cette époque, le Lac Asal n'est plus un lac d'eau douce. L'apport d'eau de mer a été rendu possible par l'ouverture de fractures profondes entre le Ghoubbet al Kharâb et le Lac Asal. Comme pour les halites, deux phénomènes sont à l'origine de cette importante formation gypseuse:

- des événements tectoniques qui ont permis l'ouverture de fractures profondes entre le Ghoubbet et le Lac Asal.
- des changements climatiques responsables d'une forte évaporation du lac non compensée par les apports (Fig. 7) entraînant une régression jusqu'au niveau actuel.



Les dépôts de gypse n'ont pas cessé depuis 5400 ans. On distingue:
le gypse ancien formant une ceinture de quelques dizaines de mètres autour du Lac Asal, il repose au-dessus des dépôts carbonatés holocène correspondant aux différentes périodes du paléolac (Fig. 4) et sont souvent intercalés avec des événements volcaniques tardifs ;
le gypse récent qui cristallise sur les berges orientales où l'eau est moins concentrée (apport direct d'eau de mer par les fractures,et au fond du lac, donnant par transparence une couleur ocre à l'eau du lac (Fig. 1 et 6).

LA BANQUISE DE SEL DU LAC ASAL, LES OUEDS KALOU ET DOUBIÉ >

Le sel de la banquise a toujours été exploité par les Afars comme monnaie d'échange, transporté par caravanes vers l'Ethiopie et la Somalie. Il contient 98% de chlorure de sodium (analyse effectuée en 1981 et 1999, Fig.2). Depuis 1999, la banquise de sel est exploitée industriellement. Actuellement, une dizaine de compagnies installées sur les marges externes méridionales exploitent approximativement 150 mégatonnes de sel par an (1999), exportées par camion principalement vers l'Ethiopie (fig. 10). Trois oueds dont l'oued Kalou et l'oued Doubié terminent leur cours sur la banquise du lac Asal, ils apportent lors des pluies (en moyenne deux fois par an) de l'eau douce et charrient des matériaux fins et des débris végétaux qui recouvrent alors la banquise (fig. 9). Sur la rive septentrionale, les oueds Aroyra et Dafarré représentent les autres importants apports en eau vadose.

Lors des fortes pluies, les oueds comme l'oued Doubié et l'oued Kalou peuvent, certaines années, submerger la banquise. Ils déposent en surface une boue argileuse et des déchets végétaux. Durant l'assèchement la couche superficielle de dépôts détritiques présente une structure polygonale métrique. Les craquelures de dessiccation sont rebroussées sur les bords sous la croissance des cristaux de sel.
Par injection le sel sous-jacent dissous dans l'eau d'évaporation cristallise à nouveau en surface sous forme de petites sphères.

Fait apparaître un plan rapproché des formations de sel

- Au premier plan, la banquise occidentale du lac Asal (-155m), un mois après de fortes pluies.
- A droite, les basaltes de l'Assadô Kôma,
- En arrière plan, une butte de gypse ancien et la vallée de l'oued Doubié,
- Au fond, les reliefs du Mont Garbi (1888m).

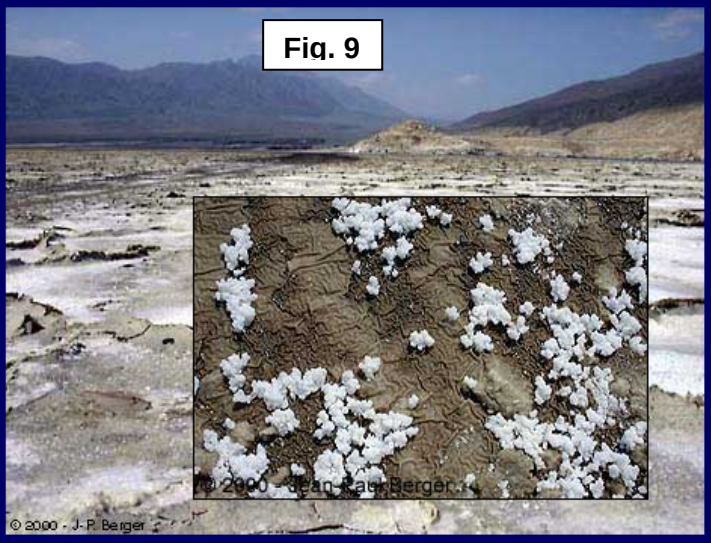


Fig. 9

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APPENDIX III : French explanation of the seismic conditions in the Lake Assal area.

RÉPARTITION DES SÉISMES PERCUS DANS LA RÉGION ENTRE 1986 ET 1989
séismes d'une magnitude égale ou supérieure à 2 *(d'après R. Omar)*

La majeure partie de la sismicité est concentrée sur une bande d'une dizaine de kilomètres de large, le long des fosses du Golfe d'Aden et du Golfe de Tadjourah. A l'ouest, au sud et au nord, la situation est plus diffuse et dépend des périodes: de 1974 à 1983, cette activité se pousuivait nettement dans le Ghoubbet et le rift d'Asal, de 1986 à 1989 (carte ci-contre), on observe une activité importante localisée au nord-ouest du Hanté et d'autres séismes plus rares affectant les marges comme cela à été le cas dans la Grand Bara, au sud du Ghoubbet.

On observe en République de Djibouti une activité sismique quasiment permanente liée à l'activité tectonique d'ouverture du Golfe de Tadjourah. Ce n'est que depuis 1972 que des mesures précises ont pu être effectuées suite à la mise en place de trois stations reliées en 1974 à l'Observatoire Géophysique d'Arta qui comporte 10 stations réparties autour du Golfe et du Rift.

L'activité journalière est d'ordre microsismique et peut atteindre 20 séismes dans le Golfe de Tadjourah (elle atteint assez fréquemment une magnitude 3 au niveau du plancher du rift). De manière épisodique on observe des crises comportant des séismes majeurs (de magnitude supérieure à 4) avec répliques pouvant durer un mois.

Ces crises résultent de la libération brutale d'énergie accumulée sous forme de contraintes le long de la frontière des plaques entre l'Arabie et l'Afrique qui rompent épisodiquement. Parmi ces crises on notera celles de mars et avril 1973, novembre et décembre 1978 (Ardoukôba), octobre 1979, octobre 1980, février 1997.

Mise à jour le 16.8.2001. (**source: www.jpb-imagine.com**)

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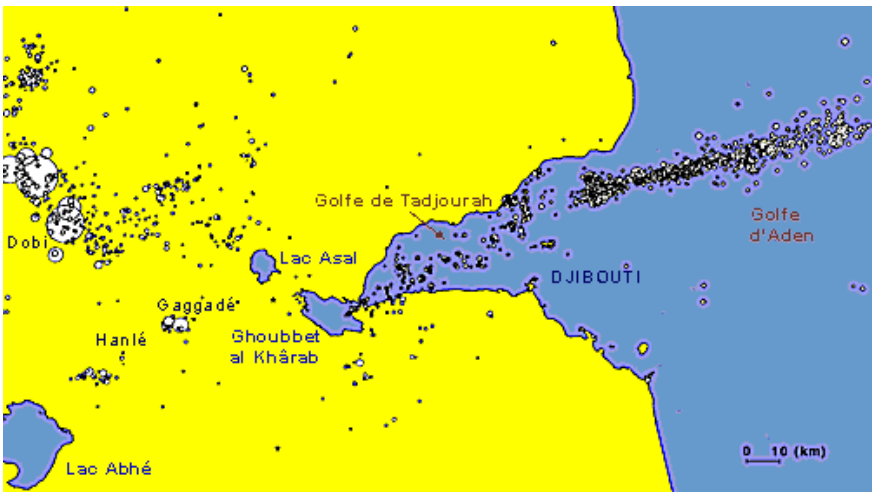

APPENDIX IV : Briefing Paper

DJIBOUTI SALT PROJECT
ENVIRONMENTAL ASSESSMENT – UPDATE : PUBLIC PARTICIPATION
Briefing Paper : JUNE 2008

Project Brief

Djibouti's economy is mainly based on service activities which accounts for over two thirds of the country's GDP. The country's manufacturing sector presently provides limited investment opportunities, although there is potential in the areas of salt processing and the production of building materials[1].

Lake Assal is situated about 100km west of Djibouti and 20km from the coast, at the Western end of the Gulf of Tadjourah (Figure 1). The western side of the lake is covered by vast deposits of crystallised solid salt which can potentially be mined and processed for local consumption and export to neighbouring territories.

Figure1. Map showing location of Lake Assal in the western end of the Gulf of Tadjourah.

In 2002 Cortec (Pty) Ltd completed a full Feasibility Study for Societe D'Exploitation du Lac (SEL) which investigated the feasibility of increasing the existing production capacity to 250 000 tons per annum. Since 2002, the Djibouti government's industrial policy in the salt sector has been to increase salt exports from Lake Assal, consolidate and regulate the industry, attract foreign investments, and be able to offer a country wide salt quality standard.

Salt Investment S.A., in a partnership agreement between Société d'Exploitation du Lac (SEL) and Hardtechnologies Group S.L. ("Hardtech"), are now responsible for developing the salt project further and are established under the laws of Djibouti for the purposes of harvesting, refining, storing, transporting and exporting salt extracted from Lake Assal.

The purpose of the present salt project is to expand Lake Assal crude salt production to approximately 6 million tons per year (compared to 1.2 million tons projected in the 2002 study), install, operate and maintain a complete salt industry plant for the production of all grades of salt. The project involves the installation, operation and maintenance of 1,000 tons/hr in aggregate harvesting capability, a 250 tons/hr mechanical salt washing and upgrading plant and a 10 tons/hr (expandable to 20 tons/hr) refining plant.

Proposed Project Activities

There will be four main centres of activity (Figure 3.2):

1. SITE 1: Lake Assal salt production, harvesting, processing site and wash dam
2. SITE 2: Access road for salt transportation
3. SITE 3: Maintenance / Staff accommodation site
4. SITE 4: Salt storage and ship loading beach site, then transport of salt via Ships through the Ghoubbet bay

Environmental Assessment

An integral part of the Djibouti Salt Project is to undertake an Environmental Impact Assessment which is a legal requirement of the World Bank for any new proposed development. The purpose of the EIA is to improve decision making and to ensure that project options under consideration are sound and sustainable.

The 2002 EIA/EMP determined that there are potentially a some long term negative impacts which could occur as a result of the new salt project. These impacts can, however, be mitigated substantially if the EMP is adhered to. The positive impacts of the project will benefit the economy of Djibouti in the short and medium, term

The present EIA and EMP is an updated report incorporating the additional proposed activities and associated potential impacts, of the new Salt Project.

Public Consultation / Participation

The purpose of the public consultation is to inform potential stakeholders and Interested and Affected Parties (I&APs) about the Djibouti Salt Project and provide them with the opportunity to raise any concern's and/or issues about the project.

Anyone who has an interest in the proposed Djibouti Salt Project should fill in the attached questionnaire and return it to the address given below (preferably by fax). More information about the EIA can be obtained from:

Dr Shael Harris, Environmental Scientist
PO Box 1750, Paulshof, 2056, Johannesburg
Tel./Fax: +27-11-803 6249, Cell: 082-565 9726
Email: shaelh@worldonline.co.za

DJIBOUTI SALT PROJECT
ENVIRONMENTAL ASSESSMENT : PUBLIC PARTICIPATION
Briefing Paper Questionnaire

NAME: .....
ADDRESS: .....
.....
.....
TEL:..... **FAX:**.....
ORGANISATION REPRESENTING: .....
CAPACITY: .....

Please answer the following questions and fax return as soon as possible to:
Dr Shael Harris - Fax: 07-11-803 6249

1. **Will the Proposed Djibouti Salt Project affect you directly ? If yes, state how.**

   .....
   .....

2. **Do you have any concerns about the proposed development ? If yes, state what.**

   .....
   .....

3. **Are you aware of potential negative impacts regarding this project ? If so, please note them down below and suggest how this impact can be avoided or mitigated.**

   .....
   .....
   .....

4. **Are you aware of anyone else who may have any concerns or interest in this project ? If yes, please make a copy of this questionnaire for them to fill in, or fill in their name and contact details below.**

   .....
   .....

APPENDIX V : Key Stakeholders and I&APs consulted for the Lake Assal Salt Project

Table 6.1. Interested and affected parties/persons contacted during the public consultation

Interested & Affected Parties/Persons	Position	Contact person	Tel	Fax	email	seen
MINISTRIES, GOVERNEMENT DEPARTMENTS						
Ministry of Environment (de l'Amenagement du territoire et l'Environnement)	1) Env. Policy 2) Minister	1) Mohamed Ali Moumin 2) H.E. Soulieman	35 10 20/35 10 97	35 48 37	metade@intnet.dj	yes
Office National des Eaux de Djibouti		Fouad Mohamed, A. Kamil	35 44 23		alkovleich@jahoo.fr	yes
Electricite de Djibouti (EDD)	1) Geothermie 2) Director	1) Abdou Mohamed Houmed 2) Jean-Paul Siry	35 28 51	35 43 96		yes
Finance, Economy & Privatisation	1) Economic Policy	1) Mohamed Douksieh				yes
Ministry de la Jeunesse, des Sports, des Loisirs et du Tourisme		S.E. Dini Abdallah Bililis	35 58 86	35 68 30	onta@intnet.dj	yes
Projet Fonds Social de Developpement	1) Director 2) Coordinator	1) M. Ahmed Araita Ali 2) Chantal Chevrier	35 82 82	35 79 79	fsdj@intnet.dj	yes
UNDP : United Nations Development Programme		Abdul Mohamed	(253) 352795	(253) 354812	PFN d'INFOTERRA, SERST, B.P. 486	yes
People's Palace	Deputy Director	Abayazid Humad Ali				yes
Department of Energy	Head	Said Ismael Awaleh				yes
NGOS						
Projet Fonds Social de Developpement	1) Director 2) Coordinator	1) M. Ahmed Araita Ali 2) Chantal Chevrier	35 82 82	35 79 79	fsdj@intnet.dj	yes
LOCAL COMMUNITIES						
Labourers						yes
Bus drivers						yes

APPENDIX VI – Correspondence with MHEUAT, August 2006

-----Original Message-----
From: dini abdallah omar [mailto:dini_omar@yahoo.fr]
Sent: 30 August 2006 10:14
To: Dr S. Harris
Subject: RE : Lake Assal Salt Project EIA

Dear S. Harris,

I found the Final EIA/EMP report. I think this report be sufficient if the mitigation measures are really implemented.

Regards.
Dini Abdallah

"Dr S. Harris" <shaelh@worldonline.co.za> a écrit :
Dear Mr Dini Abdallah

In April 2001 I met with Mohamed Ali Moumin (who was then in charge of environmental policy in Djibouti) with regards the Environmental Impact Assessment and Environmental Management Plan study for Société d"Exploitation du Lac (SALT INVESTMENT S.A) – on the exploitation of salt at Lake Assal. I was contracted through Cortec and SALT INVESTMENT S.A to undertake the environmental aspects of the project. Have you seen the Final EIA/EMP report ? Anyway I am not sure if you are aware that there are plans and finance now to go ahead with the project. However, the project plans to expand its production from 1.2 million tonnes per year projected to approx. 6 million tons per year. Please read below for details on the project:

Project:
The purpose of the project is to expand Lake Assal crude salt production to approximately 6 million tons per year (compared to 1.2 million tons p.a. projected in your last study in 2002), install, operate and maintain a complete salt industry plant for the production of all grades of salt. The project involves the installation, operation and maintenance of 1,000 tons per hour in aggregate harvesting capability, a 250 tons per hour mechanical salt washing and upgrading plant and a 10 tons per hour (expandable to 20 tons per hour) refining plant. The integrated plant will be supported by hybrid solar and Aeolian energy supply and clean potable water produced from lake waters by reverse osmosis.

EMP/Salt Investment S.Aac/Hardetch deal:
EMP Africa (US investment firm) is in advanced discussion stage to undertake a significant investment in this Project alongside other project's partner i.e. SALT INVESTMENT S.AAC (Societe d'exploitation du Lac Assal, the local Partner and Hardetech Group, a Spanish salt specialist, as the Technical Partner).

What would be required from the EIA/EMP report point of view ? Would the developers be required to upgrade the existing EIA/EMP report to deal with the expansion plans or would the existing report be sufficient ? EMP/Salt Investment S.Aac/Hardetch have approached me to assist in this regard i.e. upgrade existing EIA/EMP report.

Regards
Shael Harris

Dr Shael Harris
Geographic Environmental Solutions
PO Box 1750, Paulshof 2056,
Johannesburg, SOUTH AFRICA