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# **Republic of Yemen**

## **Public Electricity Corporation Sana'a Emergency Power Project**

### **Environmental Assessment**

### **Executive Summary**

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### **Sana'a Emergency Power Project**

#### **Environmental Assessment**

#### **EXECUTIVE SUMMARY**

##### **Background**

The Public Electricity Corporation of Yemen (PEC), a state owned enterprise is presently planning to undertake implementation of the proposed Sana'a Emergency Power Project with financial support from the International Development Association (IDA), an affiliate of the World Bank Group. The objective of the proposed project would be to improve the availability and reliability of electricity in greater Sana'a, which is currently subject to serious power shortages. These shortages of electricity have various adverse social and economic impacts on the Sana'a region. Temporary measures to correct the problems have included development of an interconnection with Ta'iz and Aden; however, transfers of electricity from these cities is resulting in further disruption of energy availability at an increasing number of locations. The rapid expanding use of small generators in Sana'a to overcome the impact of power shortages is one example of adverse effects, which have significant local impacts to air quality and noise.

The proposed project includes the following physical investment components: (A) selected rehabilitation and upgrading activities for the existing 20 MW diesel-fueled power plant at the Dhahban Power Plant site; (B) installation of an additional 30 MW of generating capacity at the existing site; and (C) expansion and upgrading of Asser 132/33 kV substation also including debottlenecking elements of the 33 kV transmission network in Sana'a.

##### **Objective of the Environmental Assessment**

Consistent with the policies and procedures of the Government of Yemen and the World Bank, an environmental assessment has been developed as an element of the project preparation process. The objective of the assessment is to ensure that the proposed project components and activities under consideration are environmentally sound and sustainable and that any environmental consequences are recognised early in the project cycle and taken into account in the project design.

##### **Scope of Work**

The IDA has entered an agreement with the Danish consulting company, Carl Bro International a/s to carry out, on behalf of the PEC, an environmental assessment of the Sana'a Emergency Power Project. A site visit to Sana'a, Yemen was carried out in the period 30 November to 14 December 1997. Project documents and baseline data were identified and interviews with relevant authorities, institutions and persons carried out. A draft Environmental Assessment Report of the proposed project was submitted in the second half of January 1998 to the involved parties for comments. From the 9th to the

15th of February, a mission to Sana'a, Yemen for an interactive review of the draft report was carried out.

A Supplemental Environmental Study was prepared by an American consulting company, Golder Associates Inc. in order to complement the Environmental Assessment prepared by Carl Bro International a/s. This study included additional field studies conducted in July 1998. The Supplemental Environmental Study - which is provided as Annex K includes three elements: (A) air quality analysis; (B) recommendations for air quality monitoring; and (C) findings of a field-based review of proposed right-of-ways for the additional project-supported transmission lines.

The overall study has addressed, but not been limited to the following key issues: review of plant site; potential air quality impacts; cooling water requirements and impacts on water quality; waste management and disposal; workers health and safety; emergency management; fuel transport; and cultural heritage issues. The study has been carried out according to World Bank guidelines for environmental assessment (World Bank Operational Directive 4.01, "Environmental Assessment" and the "World Bank Environmental Guidelines").

### **Environmental Assessment**

The overall power project consists of 3 inter-related components:

- (A) selected rehabilitation and upgrading activities for the existing 20 MW diesel-fuelled power plant at the Dhahban Power Plant site.
- (B) installation of an additional 30 MW of generating capacity at the existing site.
- (C) expansion and upgrading of Asser 132/33 kV substation also including debottlenecking elements of the 33 kV transmission network in Sana'a. The existing power supply network is planned to be expanded in the Sana'a north-west area with new overhead 33 kV lines and underground cable lines.

Each of the three project components has been assessed for their potential environmental impacts using a checklist method. Project alternatives, although limited were also evaluated. The overall assessment has been summarised accordingly. The environmental impact of each project component was identified by superimposing project elements upon existing environmental conditions and then applying standard mitigation measures.

The evaluation of the current environmental conditions in the project area has been hampered to some extent by the limited availability of baseline data; however, the team has been able to develop analyses which allow for accurate analysis of key environmental risks associated with the proposed project. In addition, the environmental assessment includes recommendations for mitigation actions to address some key data gaps which would support more effective implementation of the proposed project and facilitate the development of future planned investments in the energy sector.



The diesel fuel used by the power plant is supplied by Yemen Petroleum Company from the refinery either in Ma'rib (180 km from Dhahban) or from the refinery in Aden (270 km from Dhahban). It is generally stated that the Aden Refinery supplies most of the diesel oil, but it has not been possible to obtain data on the exact amount of incoming diesel oil supplied by the Aden Refinery and Ma'rib refinery, respectively.

### **Legal and Administrative Framework**

The evaluation of the potential environmental impact and the establishment of proper mitigation measures has been influenced by the fact that Yemeni national environmental standards or guidelines regulating the environmental problems identified in analysis of the proposed project are reported to be in a draft stage and therefore they are not applicable for the project presently. Due to the absence of formally approved Yemeni environmental procedures and guidelines, those of the World Bank have been adopted for use in preparation of the environmental assessment with the agreement with the PEC and the Environmental Protection Council (EPC).

PEC's institutional capacity to handle and manage the environmental components in relation to the proposed project has been assessed to be extremely limited. There is no environmental department or other administrative framework devoted to environmental management within the PEC.

### **Public Consultations**

Under World Bank procedures, the borrower is expected to take the views of affected groups and local non governmental organisations (NGO's) fully into account in project design and implementation and in particular during the preparation of the EA. The purpose of taking the views of the affected people into account is to improve project viability.

A number of meetings and consultations were arranged for data collection to support of the EA and for interactive review of the draft report. A public consultation was held with local village leaders to obtain comments and answer questions concerning the proposed project. Meetings with relevant non-governmental-organisation's, NGO's were also arranged with the Yemen Water Protection Society and Friends for Nature. In addition, a copy of the draft EA report was submitted to the Yemeni branch of the Birdlife International, an international NGO, for review and comment.

In general, it can be concluded that the project overall was considered as a positive contribution for development of the infrastructure in the Sana'a area. A list of meetings held and conclusions are reported in the EA. Copies of the draft EA report were distributed for further review and made available at a number of locations including PEC, EPC and the World Bank Office in Sana'a.

### **Project-specific Environmental Assessment**

The environmental assessment for the three interrelated project components can be summarised as follows:

### *COMPONENT A. REHABILITATION OF THE EXISTING 4 UNIT 20 MW POWER PLANT*

The work included in the project component concerns selected rehabilitation and upgrading activities for the existing 20 MW diesel-fueled power plant at the Dhahban Power Plant mainly constituted by major overhauling and upgrading of the engines, auxiliary equipment of the engines, electrical generators, transformers, M.V. and L.V. boards and electrical auxiliary equipment of the power plant. Noise reduction measures, rehabilitation of the existing waste water and drainage system, improvement of environmental management procedures and emergency contingency plans are also included.

Due to the present low consumption of fuel oil (peak load operation of 1 unit) and the following minimum need for re-loading of the oil storage tanks, it has not been possible to include on-site evaluation of fuel oil loading procedures in the assessment. Observations made during site visits of previous spillage's of fuel oil at the place for loading of oil storage tanks indicates a need for updating of procedures for fuel oil loading. Assistance for updating of the present applied procedures has been included as a part of the proposed mitigation measures.

#### *Climate and Air Quality*

An air quality impact analysis has been performed for nitrogen dioxide (NO<sub>2</sub>), sulfur dioxide (SO<sub>2</sub>) and particulate matter (PM10) emissions due to baseline and future operations. The Industrial Source Complex Short-Term (ISCST3) dispersion model, Version 97360, was used to evaluate the potential impact due to pollutant emissions from the existing and proposed diesel units. All calculations have been made on the basis of a fuel oil analysis for light diesel oil - grade 2 from Aden Refinery. The air quality analysis showed that a stack height of 27 meters is required also on the existing rehabilitated power plant in order to ensure compliance with the World Bank ambient air quality guidelines (Ref. Annex K). Presuming that a satisfactory rehabilitation of the diesel engines is carried out, it is assessed that the emission of oil aerosols from the ventilation outlets on the roof of the engine hall does not represent any significant impact.

An agreement has been included as a part of the project that fuel with characteristics equal or better than 0.2 percent maximum sulfur content, 0.01 percent maximum ash content and a Cetane Index of 52 or better would be used in the rehabilitated power plant.

The calculated pollutant emissions for the existing and proposed sources at the plant are presented in Table E-1.

**Table E-1 Comparison of Pollutant Emissions for the Existing and Proposed Sources at the Dhahban Plant to the World Bank Guidelines (ref. Annex K)**

Comparison of Pollutant Emissions for the Existing and Proposed Sources at the Dhahban Plant to the World Bank Guideline

Source	Pollutant	Emission (g/Nm <sup>3</sup> )	World Bank Guideline (g/Nm <sup>3</sup> )
<b>Existing Operations</b>			
Unit 1- Unrehabilitated	NO <sub>x</sub>	0.80	2.30
	SO <sub>2</sub>	0.37	2.00
	PM	0.05	0.05
<b>Future Operations</b>			
Rehabilitated Units 1 to 4	NO <sub>x</sub>	2.26	2.30
	SO <sub>2</sub>	0.705	2.00
	PM	0.05	0.05
Proposed- Units 1 to 5	NO <sub>x</sub>	2.26	2.30
	SO <sub>2</sub>	0.705	2.00
	PM	0.05	0.05

Note: Existing operations include one unit since only one unit was in operation during the site visit by Golder personnel.

#### *Water Resources for Cooling Water Requirements*

A de-mineralising unit (an ion exchanger) is installed in the power plant and is used for purification of the cooling water for the diesel engines due to the high mineral content of the raw well water which otherwise would precipitate, causing clogging in the cooling system. The de-mineralising process rejects 32% of the raw water when producing 68%, which leads to a total demand of raw water for the cooling process at the existing plant of 3.4 m<sup>3</sup>/day. Estimating a raw water need of 5 m<sup>3</sup>/day for the new power plant, a total need for raw water at the existing and the new power plant is estimated in the range of 10 m<sup>3</sup>/day

The de-mineralising unit has a capacity of 15 gal/min = 82 m<sup>3</sup>/day, which is assessed to be sufficient for cooling purposes. The capacity of the 15 kW pump installed in the well is 500 m<sup>3</sup>/day, which is sufficient.

The water resource in the north-western part of the Sana'a plain, where the Dhahban Power Plant is situated, is generally groundwater abstraction from the Tawilah sandstone aquifer. The Western well-field supplying Sana'a with domestic water, has an abstraction of approximately 22,700 m<sup>3</sup>/day from 19 wells.

It is accordingly assessed that the water abstraction for cooling water purposes and domestic water use at the Dhahban Power Plant will not cause any noticeable effects on the water balance in the area.

#### *Impact on Water Quality*

The original waste water system at Dhahban Power Plant is divided in a drainage system (mainly for drainage of rain water) and an oil spillway system for handling of oil polluted waste water.

It is assessed that the water from the drainage system does not pose any risk to the ground water resources as long as the drainage pipe system is intact and does not drain any oil polluted area. It is assessed that the sewage water component of the drainage water does not constitute any risk to the ground water resources. It is recommended to pH-neutralise the reject water from the ion exchanger before discharge. When neutralised, the individual components of the reject water do not cause any environmental concern.

An extension to the original oil spillway system has later been constructed by the PEC. The present routines for use of this later constructed extension of the oil spillway system for discharge of oily water and waste oil into a non-lined underground reservoir do not comply with good environmental standards. It is strongly recommended that these routines are stopped as soon as possible. It is further recommended, as a part of the rehabilitation project, that the constructed extension of the original oil spillway system should be closed as soon as possible and alternative solutions for handling the waste stream from the oil spillway system should be implemented.

The environmental problems related to the presence of significant amounts of oil products discharged into the underground reservoir with the subsequent potential risk of pollution of groundwater resources have been assessed, based on available data. Using a conservative approach and taking into consideration some contradictions in the collected data, it cannot be ruled out that the previous routines for oily waste handling may constitute a pollution threat to the groundwater resources in the local area. Proposal for a mitigation action is included as a part of the proposed environmental mitigation plan in the EA.

#### *Waste Management*

Procedures for proper management of waste including oily waste at plant level should be implemented. General procedures for the final safe disposal of oily waste and waste oil have to be developed at PEC level. Proposal for an assistance project in this respect is included as a part of the EA.

#### *Human External Environment Including Ambient Noise Level*

A number of mitigation measures for noise reduction are included in the project. This includes supply of noise barrier on the air roof extractors, supply of air intake silencers in the intake air duct of the engines, supply of exhaust gas silencers in the exhaust gas duct of the engines, supply of a sound proff cladding on the external wall close to the

existing engine hall. After implementation of the proposed measures, the ambient noise level from the rehabilitated plant is expected to meet World Bank guidelines for ambient noise.

#### *Workers Health and Safety*

As mentioned in the previous section, a number of mitigation measures for noise reduction are included in the rehabilitation project. The internal noise levels at the engine hall after rehabilitation (estimated 100-105 dB(A)) are however not expected to fully meet World Bank guidelines (95 dB(A) for new constructed power plants). It is therefore recommended that personal hearing protection be used in combination with temporary noise reducing measures during maintenance operations. Occupational health and safety conditions for the power plant workers will be improved at a number of specific points as a part of the project. This will be implemented with assistance from an international environmental consultant in co-operation with national responsible authorities.

#### *Fire Fighting and Emergency Set-up*

No fire or emergency plan was identified at the plant. A simple contingency plan which describes the general procedures and contact points in case of fire or other emergency incidents will be implemented as a part of the project.

#### *Historical and Cultural Resources*

It is assessed that potential historical and cultural interests will not be affected by this component of the project. The proposed project has been reviewed by the antiquities authorities.

### ***COMPONENT B. CONSTRUCTION OF A NEW 5 UNIT 30 MW POWER PLANT AT A SITE ADJACENT TO THE EXISTING PLANT SITE AND WITHIN THE EXISTING AREA OF PEC***

The work included in the proposed project component concerns installation of 5 diesel generator sets, each having a site max. rating of 6,000 kW, associated mechanical equipment, common station equipment, electrical works and civil works. The civil works cover foundation of diesel generator sets and relevant auxiliaries, building for diesel generator sets and building for control of the plant. A number of noise reducing measures, construction of a new waste water and drainage system including treatment units for oily waste water, improvement of environmental management procedures and emergency contingency plans will also be included under the proposed project.

#### *Climate and Air Quality*

All calculations have been made on the basis of a fuel oil analysis for light diesel oil - grade 2 from Aden Refinery. In order to meet the requirements when operating the existing and the new power plant simultaneously, also the necessary stack height for the new plant has been calculated. A stack height of 27 meters is required in order to ensure that the requirements in the World Bank guidelines for new power plants will

not be exceeded during simultaneous operation of both plants (Ref. Annex K). The results of the calculations are shown in table E-1.

An agreement has been included as a part of the project that fuel with characteristics equal or better than 0.2 percent maximum sulfur content, 0.01 percent maximum ash content and a Cetane Index of 52 or better would be used in the rehabilitated plant and the new power plant.

#### *Water Resources Including Cooling Water Requirements*

Estimating a raw water need of 5 m<sup>3</sup>/day for the new power plant, a total need for raw water at the existing and the new power plants is estimated in the range of 10 m<sup>3</sup>/day.

The de-mineralising unit has a capacity of 15 gal/min = 82 m<sup>3</sup>/day, which is assessed to be sufficient for cooling purposes. The capacity of the 15 kW pump installed in the well is 500 m<sup>3</sup>/day, which is sufficient.

The water resources in the north-western part of the Sana'a plain, where the Dhahban Power Plant is situated, are generally groundwater abstraction from the Tawilah sandstone aquifer. The Western well-field supplying Sana'a with domestic water, has an abstraction of approximately 22,700 m<sup>3</sup>/day from 19 wells.

It is accordingly assessed that the overall water abstraction for cooling water purposes and domestic water use at the Dhahban Power Plant will not cause any noticeable effects on the water balance in the area.

#### *Impact on Water Quality*

Waste water treatment is included as an element of the project. As a part of the proposal the waste water system from the existing plant will be combined with the new system in order to establish an effective system for waste water treatment at the Dhahban Power Plant. This implies that the joint oil/water separator should be dimensioned according to the dimensions in a joint waste water system.

It is recommended that the design of the waste water system at the existing plant is used in the new plant, which includes a division of the system into a clean-water system for areas that are not supposed to be oil polluted and an oil spillway system for areas that risk being polluted with diesel or lube oil.

#### *Waste Management*

Procedures for proper management of waste including waste oil and oily waste at plant level will be implemented as a part of the proposed project. General procedures for final safe disposal of oily waste and waste oil should be developed at PEC level. Proposal for an assistance project in this respect is included as a part of the proposed environmental mitigation plan in the EA.

*Human External Environment Including Ambient Noise Levels*

A number of mitigation measures for noise reduction are included in the project. These measures mainly concern supply of higher efficiency exhaust gas silencers, supply of higher efficiency intake air silencers, design of air exhaust louvers with sound barriers, internal partition walls for engine maintenance. After implementation of proposed measures, the ambient noise level from the rehabilitated plant is expected to meet World Bank guidelines for ambient noise.

*Workers Health and Safety*

As mentioned in the previous section, a number of mitigation measures for noise reduction are included in the rehabilitation project. The internal noise levels at the engine hall after rehabilitation (100 - 105 dB(A)) are although not expected to fully meet World Bank guidelines (95 dB(A) for new constructed power plants). It is therefore recommended that personal hearing protection is utilised in combination with temporary noise reducing measures during maintenance operations. Occupational health and safety conditions for the power plant workers will be improved at a number of specific points as a part of the project. This will be implemented with assistance from an international environmental consultant in co-operation with national responsible authorities.

*Fire Fighting and Emergency Set-up*

A simple contingency plan which describes the general procedures and contact points in case of fire or other emergency incidents will be implemented as a part of the proposed project. The plan will cover both the existing and the new plants.

*Historical and Cultural Resources*

The proposed project has been reviewed by the antiquities authorities. It is evaluated that potential historical and cultural interests will not be affected by the project, but the construction company should be informed about present rules and regulations in case unrecorded archaeological and/or historical values are identified during construction activities. To address this concern, the construction contractor will be instructed to use archaeological "chance find" procedures in case such materials are encountered during excavation activities.

The proposed project has been reviewed by the antiquities authorities.

***COMPONENT C. EXPANSION AND UPGRADING OF ASSER 132/33 kV SUBSTATION ALSO INCLUDING DEBOTTLENECKING ELEMENTS OF THE TRANSMISSION NETWORK IN SANA'A.***

Assessment of the project component for expansion and upgrading of Asser substation, including debottlenecking elements of the transmission network in Sana'a, - is influenced by the fact that this project component is not finally designed at the present stage. The assessment is based on data collected during site visits conducted in December 1997, July 1998 and on documentation provided by PEC.

*Asser substation subcomponent*

The 132/33 kV Asser substation on the west side of Sana'a was constructed in 1982. The substation is the main bulk supply point to the Sana'a system. Asser substation is supplied from a 132 kV line about 150 km long that runs from Dhamar substation in the south to Amran substation in the north. Dhamar substation in turn is connected to the overall PEC grid that is supplied mainly from the three steam plants Al Hiswa in the south and Ras Katenib and Al Mukha in the west.

The physical rehabilitation and construction work at Asser substation is restricted to:

- construction of a double circuit 132 kV open switchyard with two bus sections.
- addition of a third 60 MVA power transformer.
- extension of access road behind the existing 33 kV switchgear building.
- extension of 33 kV switchgear building to accommodate additional panels.

*Transmission line subcomponent*

Based on discussions with the PEC management, the following policy for construction of right-of-ways for power overhead lines was outlined:

- to apply existing right-of-ways or to construct right-of-ways along existing roads and highways.
- to avoid construction of overhead lines passing over existing building and houses.
- if unavoidable for construction of the overhead line, to negotiate conditions for right-of-way passing private land with land owners.

Specific project documents for the construction of transmission lines including a right-of-way map have been prepared. A single-line and impedance diagram for Sana'a power distribution system elaborated by Bechtel in 1993 for a previous study forms the basis for the planned construction of transmission lines.

An initial assessment was prepared by Carl Bro International a/s and supplemented by the study of Golder Associates Inc. The assessment has been based on a visual inspection of the planned right-of-way as drawn on the map by PEC. According to the information obtained and the visual site inspection, no land use interests will be affected by the right-of-way of the 33 kV overhead lines. Due to the scarce vegetation and the location in a peri-urban area, and according to the information obtained from the visual site inspection, no vegetation and wildlife interests will be affected by the right-of-way of the 33 kV overhead lines. Based on the fact that the location of the overhead lines is in existing overhead line clearances or along roads and according to the information obtained from the visual site inspection, it is further assessed that no human external environment interests will be affected by the right-of-way of the 33 kV overhead lines. No resettlement is planned for the project. Due to the location of the overhead lines in existing overhead line clearances or along roads and according to the information obtained from the visual site inspection, no historical and cultural resources will be affected by the right-of-way of the 33 kV overhead lines.



Only small impacts are expected from the construction of the planned overhead lines/underground cables. Consultancy assistance for PEC has been included in the project in order to ensure that World Bank environmental guidelines for power line construction are respected.

A preliminary review conducted by PEC, at the request of the World Bank, did not identify the presence of any transformers known to have PCB's; however, the environmental mitigation plan would include an independent review of PCB's in transformers.

**Summary of Assessment Results**

Table E-2 provides a detailed summary of the findings of the environmental assessment process. The table has been structured to include information on the findings and conclusions concerning potential environmental impacts and to identify proposed mitigation activities. This table is complemented by a series of tables which provide information on the analysis of alternatives (E-3), a mitigation plan (E-4) and a monitoring plan (E-5).

**Table E-2 Summary of Environmental Assessment**

<b>EA - Findings and Conclusions Potential Environmental Impact</b>	<b>Proposed Mitigation Measures Brief Description</b>
<p>1. <i>General conclusions</i></p> <p>1.1 No Yemeni national environmental standards or guidelines regulate the environmental problems identified in the proposed project. Instead, World Bank guidelines have been used as reference, where possible.</p> <p>1.2 The PEC capacity for handling and managing environmental components in relation to the proposed project is assessed to be very limited.</p> <p>1.3 The evaluation of the current environmental conditions in the project area has been hampered to some extent been hampered by the limited availability of baseline data.</p> <p>1.4 General procedures and options for final safe disposal of oily waste and waste oil are lacking and have to be developed at PEC level.</p>	<p>1A Assistance and Terms of Reference for institutional support of PEC should to be included as a part of the mitigation plan:</p> <p>1A<sub>1</sub> - Overall environmental consultancy assistance 1A<sub>2</sub> - Basic environmental management training.</p> <p>1B Environmental management of power plant operations should be included as part of the considered Operational and Maintenance Management Contract with an external contractor.</p> <p>1C EA includes recommendations for mitigation actions to address some key data gaps which would support more effective implementation of the proposed project and facilitate the development of future planned investments in the energy sector.</p> <p>1D Terms of Reference should be developed for an assistance project for development of general procedures and options for final safe disposal of oily</p>

EA - Findings and Conclusions Potential Environmental Impact	Proposed Mitigation Measures Brief Description
<p>1.5 No air quality monitoring programme, system or stations exist in the Sana'a area.</p>	<p>waste and waste oil.</p> <p>1F Terms of Reference should be developed for a baseline air quality monitoring programme.</p>
<p><b>2. COMPONENT A. Rehabilitation of the existing 4 unit 20 MW power plant</b></p> <p>2.1 Draft description of mitigating elements covering noise and waste water treatment are included in the project document for rehabilitation of the existing Dhahban Power Plant.</p> <p>2.2 An air quality analysis have showed that a stack height of 27 meters is required also on the existing rehabilitated power plant in order to ensure compliance with the World Bank ambient air quality guidelines</p> <p>2.3 Presuming that a satisfactory rehabilitation of the diesel engines is carried out, it is assessed that the emission of oil aerosols from the ventilation outlets at the roof of the engine hall does not represent any significant impact.</p> <p>2.4 It is assessed that the water abstraction for cooling water purposes and domestic water use will not cause any noticeable effects on the water balance in the area.</p> <p>2.5 It is assessed that the water from the drainage system does not pose any risk to the ground water resources as long as the drainage pipe system is intact and does not drain any oil polluted area.</p> <p>2.6 It is assessed that the sewage water component of the drainage water does not constitute any risk to the ground water resources.</p> <p>2.7 It is recommended to pH-neutralize the reject water from the ion exchanger before discharge. Thereafter, the individual components of the reject water do not cause any environmental concern.</p> <p>2.8 The present routines for use of the extended oil spillway system for discharge of oily water and waste oil into a non-lined underground reservoir do not comply with good environmental standards.</p> <p>2.9 Alternative solutions for handling the waste water stream from the oil spillway system should be implemented.</p>	<p>2A A detailed examination should be carried out for the existing drainage system, septic tank and oil spillway system in order to secure that pipes are intact and that the systems are functioning according to the original design.</p> <p>2B Stack height has to be raised to 27 meters. An agreement has been included as a part of the project that fuel with characteristics equal or better than 0.2 percent maximum sulfur content, 0.01 percent maximum ash content and a Cetane Index of 52 or better would be used in the rehabilitated power plant.</p> <p>2C A component for pH-neutralization of the reject water has to be included in the proposed project covering Component B and Component C.</p> <p>2D The present routines for discharge of waste water should be stopped immediately, the current extension of the oil spillway system closed, and an alternative system placed into operation.</p> <p>2E The oil spillway system should be replaced by construction of a simple oil/water separator system for handling discharged oil polluted wastewater from the oil spillway system.</p>

<b>EA - Findings and Conclusions Potential Environmental Impact</b>	<b>Proposed Mitigation Measures Brief Description</b>
<p>2.10 The environmental problems related to the presence of significant amounts of oil products discharged into the underground reservoir with an accompanying potential risk of pollution of groundwater resources have been assessed, based on available data. Using a conservative approach and taking into consideration some contradictions in the collected data, it cannot be ruled out that the previous routines for oily waste handling might constitute a pollution threat to the groundwater resources in the local area.</p>	<p>2F Terms of Reference should be prepared for a mitigation project for protection of ground water resources against potential oil pollution.</p>
<p>2.11 Procedures for management of oily waste at the power plant should be implemented.</p>	<p>2G<sub>1</sub> Simple oil waste management procedures should be developed for handling and collection of various types of oily waste at the power plant</p> <p>2G<sub>2</sub> Establishment of oil spill trays at "hot spots" and site preparation for long-term storage of oil polluted soil. Handling of oil polluted soil and oily water during construction</p> <p>2G<sub>3</sub> Establishment of additional temporary storage capacity for waste oil and oily waste.</p>
<p>2.12 The external noise level from the rehabilitated plant is expected to meet World Bank guidelines for ambient noise, when proposed noise abatement measures are implemented.</p>	<p>2H Proposed external and internal noise abatement measures should be implemented.</p>
<p>2.13 The internal noise levels at the engine hall after rehabilitation are not expected to meet World Bank guidelines.</p>	<p>2I Proposed internal noise abatement measures should be implemented.</p>
<p>2.14 Occupational health and safety conditions for the power plant workers should be improved at a number of specific points.</p>	<p>2J A number of recommendations should be implemented for improvement of working conditions in cooperation with expertise from the Department of Public Health and Safety under the Ministry of Labour and Vocational Training.</p>
<p>2.15 No fire or emergency plan was identified at the plant. It is recommended to prepare a simple contingency plan which describes the general procedures and contact points in case of fire or other emergency incidents.</p>	<p>2K A simple fire and emergency plan should be prepared</p> <p>2L Overall cleaning of the power plant hall should be established for removal of spilt oil and other flammable materials (especially in ventilation ducts/outlets and cable channels) in order to reduce the risk of fire.</p>
<p>2.16 It is assessed that potential historical and cultural interests will not be affected by the project.</p>	
<p>2.17 Observations made during site visits of previous spillage's of fuel oil at the place for loading of oil storage tanks indicates a need for updating of procedures for fuel oil loading.</p>	<p>2M Present fuel oil loading procedures should be updated.</p>

EA - Findings and Conclusions Potential Environmental Impact	Proposed Mitigation Measures Brief Description
<p><b>3. COMPONENT B. Construction of a new 5 unit 30 MW power plant at a site adjacent to the existing plant site and within the existing area of PEC</b></p> <p>3.1 Draft descriptions of mitigating elements covering noise and waste water treatment are included in the project document for construction of a new 30 MW plant at the Dhahban power plant site.</p> <p>3.2 In order to meet the requirements when operating both power plants simultaneously, the necessary stack height for the new plant has been calculated. A stack height of 27 meters is required in order to ensure that the requirements in the World Bank guidelines for new power plants will not be exceeded during simultaneous operation of both plants.</p> <p>3.3 It is assessed that the water abstraction for cooling water purposes and domestic water use will not cause any noticeable effects on the groundwater balance in the area.</p> <p>3.4 It is recommended to combine the waste water system from the existing plant with the new system in order to establish an effective system for waste water treatment at the Dhahban Power Plant. This implies that the joint oil/water separator should be dimensioned according to the dimensions in a joint waste water system.</p> <p>3.5 It is recommended that the design of the waste water system at the existing plant is used at the new plant, which includes a division of the system in a clean-water system for areas that are not supposed to be oil polluted and an oil spillway system for areas of risk being polluted with diesel or lube oil.</p> <p>3.6 Procedures for management of oily waste should be implemented.</p> <p>3.7 Ansaldo provides proposals for abatement measures for reduction of noise emissions related to the operation of the diesel engines.</p> <p>3.8 The external noise level from the operation of the existing and the new power plant simultaneously is expected to be close to meet World Bank guidelines for ambient noise, if proposed noise abatement procedures are implemented.</p>	<p>3A The stack height should be increased to 27 m, rather than the proposed 15 m to allow the new plant to be in accordance with World Bank ambient air quality guidelines. An agreement has been included as a part of the project that fuel with characteristics equal or better than 0.2 percent maximum sulfur content, 0.01 percent maximum ash content and a Cetane Index of 52 or better would be used in the rehabilitated plant and the new power plant.</p> <p>3B A the new drainage and wastewater system should be designed and constructed according to principles laid down in the existing plant and with design of a simple oil/water separator common for both the existing and the new system.</p> <p>3C Simple oil waste management procedures should be developed for handling and collection of various types of oily waste at the power plant.</p> <p>3D The proposed PEC pilot project for identification of safe solutions for disposal of oily waste and waste oil should be implemented.</p> <p>3E Noise abatement measures proposed by Ansaldo should be included in the project.</p>

<b>EA - Findings and Conclusions Potential Environmental Impact</b>	<b>Proposed Mitigation Measures Brief Description</b>
<p>3.9 The indoor noise levels at the engine hall are not expected to meet World Bank guidelines, unless extensive noise abatement procedures are implemented.</p> <p>3.10 Occupational health and safety conditions for power plant workers should be included in the project.</p> <p>3.11 It is recommended to prepare a simple contingency plan which describes the general procedures and contact points in case of fire or other emergency incidents. The plan should cover both the existing and the new plant.</p> <p>3.12 It is evaluated that potential historical and cultural interests will not be affected by the project.</p>	<p>3F Noise abatement measures proposed by Ansaldo should be included in the project. If World Bank guidelines for internal noise can not be met, personal hearing protection has to be applied.</p> <p>3G Overall working conditions should be improved in cooperation with expertise from the Department of Public Health and Safety under the Ministry of Labour and Vocational Training.</p> <p>3H A simple fire and emergency plan should be prepared.</p> <p>3I The construction company should be instructed to use archaeological "chance find" procedures when encountering any archaeological materials during construction work.</p>
<p><b>4. COMPONENT C. Expansion and upgrading of Asser BSP 132/33 kV Substation including debottlenecking elements of the transmission network in Sana'a.</b></p> <p>4.1 Descriptions of the two project subcomponents have been identified. The component has been assessed by Carl Bro International and supplemented by the study of Golder Associates Inc.</p> <p>4.2 The assessment was based on a visual inspection of the right-of-way as drawn on the map provided by PEC.</p> <p>4.3 According to the information obtained and the visual site inspection, no land use interests will be affected by the right-of-way of the 33 kV overhead lines.</p> <p>4.4 Due to scarce vegetation and the location in a peri-urban area, and according to the information obtained from the visual site inspection, no vegetation and wildlife interests is assessed to be affected by the right-of-way construction of the 33 kV overhead lines.</p> <p>4.5 Due to the location of the overhead lines in existing overhead line clearances or along roads and according to the information obtained from the visual site inspection, no human external environment interest is assessed to be affected by the right-of-way of the 33 kV overhead lines. No resettlement is planned for the project.</p> <p>4.6 Due to the location of the overhead lines in existing overhead line clearances or along roads and</p>	<p>4A It is proposed as a part of the environmental assistance for PEC to include consultancy assistance to secure proper implementation of environmental mitigation measures related to project subcomponents concerning transmission network upgrading. A preliminary review conducted by PEC, at the request of the World Bank, did not identify the presence of any transformers known to have PCB's; however, the environmental mitigation plan is proposed to include an independent review of PCB's in transformers.</p> <p>4B Once the final alignment of the right-of-ways are determined, a consultation should be undertaken with</p>

EA - Findings and Conclusions Potential Environmental Impact	Proposed Mitigation Measures Brief Description
according to the information obtained from the visual site inspection, no historical and cultural resources will be affected by the right-of-way of the 33 kV overhead lines.	archaeological authorities.

**Analysis of Alternatives**

Table E-3 provides an overview of the analysis of alternatives including the no action alternative, which was conducted as an element of the environmental assessment. As a part of the environmental assessment, alternatives to the proposed project have to be described and detailed. Consequences and related impacts of the project alternatives are accordingly outlined. Three alternatives have been assessed: the No Action Alternative, the Gas Fuel Alternative and the Alternative Siting Alternative.

**Table E-3 Analysis of Alternatives**

Project Alternative	Major Environmental and Other Benefits	Major Environmental and Other Drawbacks
<i>No Action Alternative</i>		<ol style="list-style-type: none"> <li>1. Dhahban Power Plant power production can only be continued at a maximum effect of 8 MW (2 diesel units) for an unpredictable length of time in a short-term perspective.</li> <li>2. The unstable electricity supply in the Sana'a region will continue.</li> <li>3. The rapidly expanding use of small fuel-driven power generators in Sana'a to reduce the impact of power shortages will continue to increase.</li> <li>4. The identified problems related to previous routines for handling oily waste and waste water will not be solved.</li> <li>5. The opportunity to use the present project as a pilot project in PEC for environmentally sound handling of oily waste products will not be realized.</li> </ol>

Project Alternative	Major Environmental and Other Benefits	Major Environmental and Other Drawbacks
<i>Gas Supply Alternative</i>	<ol style="list-style-type: none"> <li>1. Use of natural gas as fuel will create less impact on the air quality.</li> <li>2. Use of natural gas will minimise problems with oil waste handling.</li> </ol>	<ol style="list-style-type: none"> <li>1. At present, no specific plans have been developed to supply the Sana'a region with natural gas from the Ma'rib area. Private sector investors give priority to development of pipelines for gas export rather than domestic use.</li> <li>2. Dual-fuel engines have to be selected involving higher investment costs.</li> <li>3. Taking Yemeni conditions into consideration, maintenance and general operation will be new and probably more complicated compared to diesel operations.</li> </ol>
<i>Alternative Siting</i>	<ol style="list-style-type: none"> <li>1. Site selection can in principle be made with respect to all concerned environmental and planning issues.</li> </ol>	<ol style="list-style-type: none"> <li>1. It will not be possible to take advantage of the already prepared site in Dhahban.</li> <li>2. All basic and technical facilities have to be developed from scratch.</li> <li>3. Land acquisition is necessary.</li> <li>4. Land acquisition in Yemen is in general an extremely complicated process. The tribal structure of Yemeni society and the lack of a cadaster system for land ownership registration will heavily influence the possibility for and availability of land for power plant siting.</li> <li>5. Rehabilitation and clean-up actions at the existing plant still have to be considered.</li> </ol>

**Mitigation Measures and Mitigation Plan**

Table E-4 provides a detailed summary of the Mitigation Plan recommended for the proposed project. It reviews each proposed mitigation action and links them to the findings presented in Table E-2. The presentation also provides information on the expected benefits from each proposed mitigation action, identified the party responsible for implementation and estimated costs for each intervention.

**Table E-4 Mitigation Measures and Mitigation Plan**

<b>Proposed Mitigation Measures</b> (numbers in brackets refer to EA Summary Table)	<b>Expected Benefit</b>	<b>Party responsible for Implementation</b>	<b>Estimated costs (US \$)</b>
<i>1. General Mitigation Measures</i>			
1.1 Assistance and Terms of Reference for institutional support of PEC included as a part of the mitigation plan (1A):			
1.1.1 Overall environmental consultancy assistance (1A <sub>1</sub> ). TOR included as part of EA report.	- general follow-up of mitigation plan on issues allocated for PEC - institutional support for PEC	PEC in co-operation with international environment consultant	73,000 USD
1.1.2 Basic environmental management training (1A <sub>2</sub> ). TOR included as part of EA report.	- introduction of environmental management principles in PEC power plant management	PEC/EPC in co-operation with international environment consultant	88,000 USD
1.2 Assistance project for development of general procedures and options for final safe disposal of oily waste and waste oil (1C/3D). TOR included as part of EA report.	- identification of sustainable methods for handling and final disposal of waste oil within PEC	PEC/EPC in co-operation with international environment consultant	92,000 USD
1.3 A proposal for a baseline air quality monitoring program (1D). TOR included as part of EA report.	- provision of baseline air quality monitoring data to be used as background data for future energy projects	PEC/EPC in co-operation with international environment consultant	300,000 USD
<i>2. Structural Mitigation Measures</i>			
2.1 A detailed examination carried out for the existing drainage system, septic tank and oil spillway system (2A).	- to secure that existing piping is intact and that the systems are functioning according to the original design.	PEC - to be included in final contract - Contractor	Included in Ansaldo offer (see 2.4)
2.2 Equipment for pH-neutralization of the reject water (2C).	- to ensure proper quality of reject water before it enters the oil spillway system.	PEC - to be included in final contract - Contractor	50,000 USD
2.3 The present inappropriate routines for discharge of waste water should be stopped immediately and the later constructed extension of the oil spillway system closed. Provision of temporary storage for oily water (2D).	- to avoid further discharge of oil compounds into the existing oily water reservoir.	PEC - to be included in final contract - Contractor	Included in Ansaldo offer (see 2.4)
2.4 The oil spillway system reconstructed including construction of a simple oil/water separator system for	- to ensure proper future management of oily waste water.	PEC - to be included in final contract - Contractor PEC in	650,000 USD



Proposed Mitigation Measures (numbers in brackets refer to EA Summary Table)	Expected Benefit	Party responsible for Implementation	Estimated costs (US \$)
handling discharged oil polluted waste water from the oil spillway system. A the new drainage and wastewater system should be designed and constructed according to principles laid down in the existing plant and with design of a simple oil/water separator common for both the existing and the new system.(2E/3B)	- provision of quality assurance of the proposed spillway design.	co-operation with international environment consultant	Included in 1.1.1
2.5 Mitigation project for protection of ground water resources against potential oil pollution (2F). TOR included as part of EA report.	- to identify extent and further steps necessary, if extensive mitigation measures are needed.	PEC in co-operation with international environment consultant	133,000 USD (phase I)
2.6 Oil waste management			
2.6.1 Simple oil waste management procedures for handling and collection of various types of oily waste at the power plant (2G <sub>1</sub> /3C)	- to improve the overall management regime for oil waste management.	PEC in co-operation with international environment consultant	Included in 1.1.1
2.6.2 Establishment of oil spill trays at "hot spots" and site preparation for long-term storage of oil polluted soil. Handling of oil polluted soil and oily water during construction (2G <sub>2</sub> )	- to ensure minimised impact from accidental oil spill/long-term storage of oil polluted soil.	PEC - to be included in final contract - Contractor	Included in Ansaldo offer (see 2.4)
2.6.3 Establishment of additional temporary storage capacity (40 m <sup>3</sup> ) for waste oil and oily waste (2 G <sub>3</sub> ).	- to ensure that sufficient temporary storage capacity is in place for waste oil and oily waste.	PEC	2,000 USD
2.7. Proposed external and internal noise abatement measures for existing and new power plant to be implemented (2H/2I/3E/3F)	- to ensure compliance with World Bank guidelines for ambient and internal noise.	PEC - to be included in final contract - Contractor	445.000 USD to be negotiated
2.8 Overall cleaning of the existing power plant hall for removal of spilt oil and other flammable materials (especially in ventilation ducts/outlets and cable channels) (2L)	- to reduce fire and explosion risks	PEC - to be included in final contract - Contractor	Included in Ansaldo offer
2.9 Stack height at existing and new power plant raised to 27 m to allow for compliance with World Bank ambient air quality guidelines. (3A)	- to improve local air quality	PEC - to be included in final contract - Contractor	Included in 1.1.1
2.10 Updating of procedures for fuel oil loading (2M)	- to minimize accidental oil spill during fuel oil loading of storage tanks.	PEC in co-operation with international environment consultant	

Proposed Mitigation Measures (numbers in brackets refer to EA Summary Table)	Expected Benefit	Party responsible for Implementation	Estimated costs (US \$)
<i>3. Institutional Mitigation Measures (related to Dhahban Power Plant)</i>			
3.1 Environmental management of Dhahban power plant operations to be included as part of the considered Operational & Maintenance Management Contract with an external contractor (1B).	- to ensure that proper measures are used for environmental management	PEC	to be negotiated
3.2 Improvement of working conditions in cooperation with expertise from the Department of Public Health and Safety under the Ministry of Labour and Vocational Training (2I/3G)	- to ensure that working conditions at the power plant is in accordance with general standards	PEC in co-operation with international environment consultant	Included in 1.1.1
3.3. Preparation of a simple fire and emergency plan (2I/3H)	- to ensure that fast assistance and response is provided in case of accidents.	PEC in co-operation with international environment consultant	Included in 1.1.1
3.4 The construction company should be instructed to use archaeological "chance finding" procedures when encountering any archaeological materials during construction work. (3I)	- to ensure that potential archaeological values are not damaged or destroyed during construction.	PEC in co-operation with international environment consultant	Included in 1.1.1
3.5 Consultancy assistance to secure proper implementation of environmental mitigation measures related to project subcomponents concerning transmission network upgrading. (4A, 4B)	- that general environmental guidelines are observed during upgrading and construction activities	PEC in co-operation with international environment consultant	Included in 1.1.1

**Environmental Monitoring Plan**

Table E-5 provides a summary of the environmental monitoring plan for the proposed project. The environmental monitoring plan is proposed to be divided into two sections:

- (a) **Technical Assistance and Training for Monitoring Measures.** Assistance would be provided to PEC by a project-funded international environmental consultant to support the monitoring measures. This would include a series of practical training seminars for PEC management and Dhahban Power Plant staff on good environmental practices, proper health and safety measures, and emergency management procedures. This activity would include training of Yemeni personnel in the collection, interpretation and use of data in air quality management decisions.

- (b) **Air Quality Monitoring Program.** The project would support implementation of an air quality monitoring program that includes activities for emission and ambient air quality monitoring. It would support the purchase of basic portable emission monitoring equipment for measurement of stack gases at the rehabilitated and new power plants and the installation of an ambient air quality monitoring station. If determined to be necessary on the basis of initial operational experience, additional ambient air quality monitoring stations would be purchased. Technical training would be provided by suppliers concerning the operation and maintenance of the air quality monitoring equipment.

In addition, it is recommended that the EPC, in co-operation with PEC, seek funding from a bilateral donor to support a program for the collection of measured baseline data for air quality in the Sana'a region, which could be used for general environment management purposes and for the design of anticipated future investments in the power sector.

**Table E-5 Environmental Monitoring Plan**

<b>Monitoring Components</b>	<b>Expected Benefit</b>	<b>Party Responsible for Component</b>	<b>Estimated costs (US \$)</b>
<p><i>1. Technical Assistance and Training for Monitoring Measures</i></p> <p>Overall environmental consultancy assistance. TOR included as part of EA report. Would include training of Yemeni personnel in collection, interpretation and use of data in air quality management decisions.</p>	<p>- general follow-up on mitigation and monitoring plan on issues allocated for PEC - institutional support for PEC</p>	<p>PEC in co-operation with international environment consultant</p>	<p>Included in consultancy support for Mitigation Plan Implementation</p>
<p><i>2. Plant Specific Air Quality Pollution Monitoring Program</i></p> <p>Implementation of an air quality monitoring program that includes activities for emission and ambient air quality monitoring. A proposal for a baseline air quality monitoring program. TOR included as part of EA report. Purchasing of basic portable emission monitoring equipment for measurement of stack gases at the rehabilitated and new power plants is included along with installation of an ambient air quality monitoring station. Supplier provided training is planned for Yemeni personnel in the operation and maintenance of equipment.</p>	<p>- provision of air quality monitoring data to be used to support management of the rehabilitated and new power plants</p>	<p>PEC/EPC in co-operation with international environment consultant</p>	<p>300,000 USD</p>

Monitoring Components	Expected Benefit	Party Responsible for Component	Estimated costs (US \$)
<p><i>3. Proposed Baseline Regional Air Quality Monitoring Program</i></p> <p>Subject to availability of independent funding from a bilateral development donor, it is recommended that a baseline air quality monitoring program be undertaken for the Sana'a region to provide data for the planning and environmental assessment of future projects various sectors. Implementation of an air quality monitoring program that includes activities for emission and ambient air quality monitoring. Purchasing of basic portable emission monitoring equipment for measurement of stack gases at the rehabilitated and new power plants is included along with installation of an ambient air quality monitoring station. Supplier provided training is planned for Yemeni personnel in the operation and maintenance of equipment.</p>	<p>- provision of air quality monitoring data as background data for future energy and industrial projects. It would also support assessment of the emission impacts from vehicles.</p>	<p>EPC in co-operation with PEC and an international environment consultant</p>	<p>300,000 USD (to be sought from a bilateral donor)</p>

**Environmental Management and Training**

The overall capacity for environmental management within the PEC has during the present study been assessed to be very limited. In order to support PEC within these matters for the specific project, a biased approach for project specific assistance has been selected. It is accordingly suggested:

- to include specific consultancy assistance in relation to final development and implementation of environmental management measures specifically related to the Dhahban Power Plant operations (as listed in the mitigation plan), and
- to apply in parallel this assistance for monitoring and quality assurance of the implementation of the agreed structural environmental mitigation measures.

Besides this specific assistance arrangement, it has been agreed to include a specific training component in the project as a part of the ordinary PEC management training.

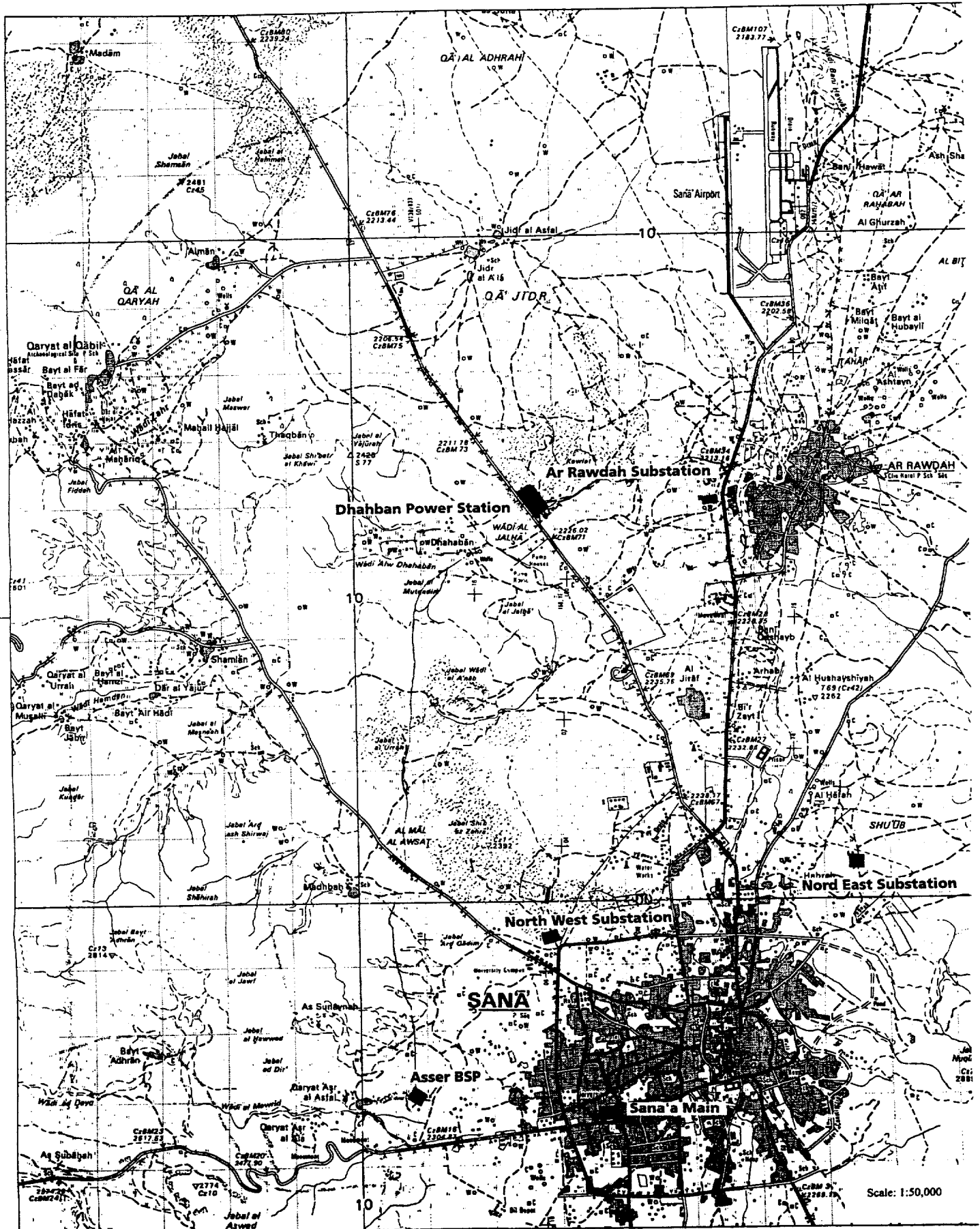
The main objective of including an environmental component in the management training programme is to provide the PEC planner, managers and management candidates with a general knowledge of the environmental issues and working environment aspects related to the operation of a power plant in Yemen.

Further it is the objective of the training component to provide the students with information on practical approaches which can be addressed in order to implement preventive actions and implement relevant precautions.

The present programme focuses on the “train-the-trainer” approach in order to ensure a long-term perspective in the training activities aimed for both the PEC and EPC. In addition to the focus of environmental sound operation of the power plants in Yemen the training programme also focuses on the environmental impact assessment procedures to be carried out in connection with planning and establishing new plants, transmission lines and similar infrastructure projects.

An outline of the training programme is included in as a part of the EA.

**SITE MAP - PROJECT AREA**



South West substation

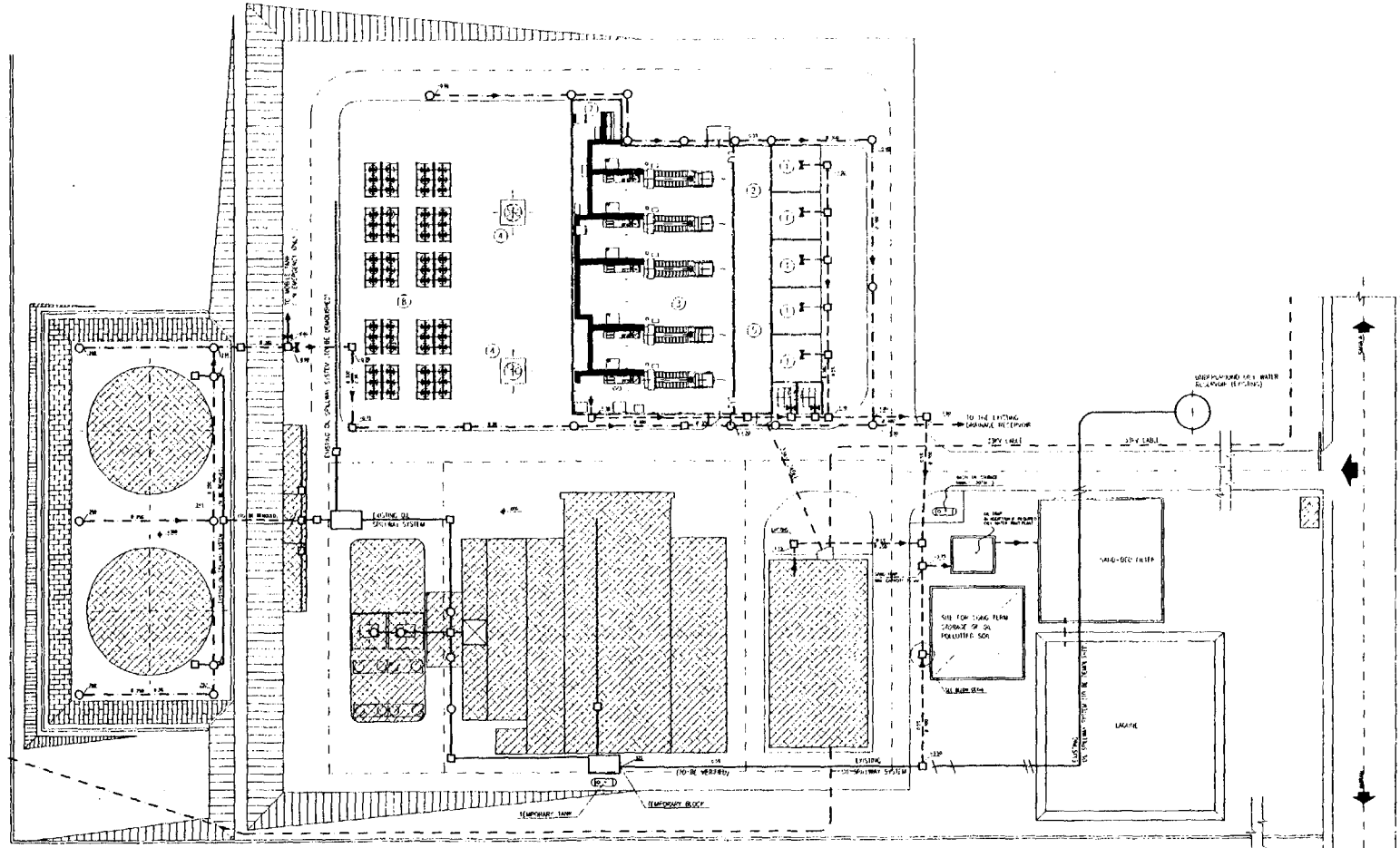
South East substation

**DRAFT SITE PLAN PREPARED BY ANSALDO ENERGIA**



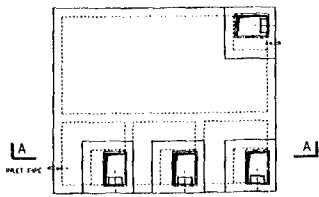


POS	LEGEND
1	MAIN TRANSFORMERS
2	LOW VOLTAGE BOARDS
3	POWER STATION
4	CHIMNEY
5	ELECTRICAL BOARD 33 KV
6	AUX TRANSFORMERS
7	MECHANICAL ANNEKE
8	RADIATORS UNITS

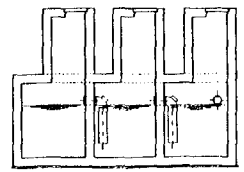


- NOTE**
- EXISTING
  - EXISTING DRAINAGES
  - FUTURE WATER DRAINAGES ( CONCRETE PIPES )
  - FUTURE OIL SPILLWAY SYSTEM ( PVC PIPES )
- FUTURE DRAINAGE LINES SHOW THE POSSIBLE ROUTE OF THE MAIN PIPES AND PITS, CONNECTION WITH EQUIPMENT AND INSIDE THE BUILDING IS TO BE PROVIDED WITH MINOR PIPES AND PITS
  - ELEVATIONS AND PIPE DIAMETERS ARE INDICATIVE ONLY TO BE DEFINED ACCORDING TO THE DRAINAGE NETWORK DESIGN (FUTURE)
  - EXISTING OIL SPILLWAY SYSTEM TO BE INSPECTED & VERIFIED
  - EXISTING DRAINAGE WATER LINE WILL BE SHOWN (LATER)

PLAN  
OIL TANK



SECTION A-A



SITE FOR LONG TERM STORAGE AREA DETAIL



SAND-BED FILTER AND LAGUNE DETAIL



NO.	DESCRIPTION	DATE	BY	CHECKED	APPROVED
01	ISSUE				
02	FIRST ISSUE				

PROJECT NO.	15VA	SCALE	1:250
DESIGNER	AND	DATE	1.250
<b>ANSALDO</b>			
DRAINAGES LAYOUT			
15VA A 0 UTX 0 011			