7. Results of Environmental Impact Study

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Environmental impact analysis and mitigation planning were carried out based on (i) the project layout and feasibility-stage design that are described elsewhere in this Final Report, (ii) findings of the environmental baseline survey that are reported in "Environmental Baseline Survey on the Sihanoukville Combined Cycle Power Development Project Final Report" that are prepared by TEAM Consulting Engineering and Management Co., and summarized in "Environmental Impact Assessment Report for the Sihanoukville Combined Cycle Power Development Project" that are to be prepared separately by the JICA Study Team, and (iii) methods and formats specified or recommend by Cambodian environmental laws and major multilateral donors such as ADB and World Bank and that are also summarized in the EIA Report.

The results of the environmental impact analysis and mitigation planning are outlined in the following sections of this chapter.

7.1. Possible Environmental Impact of the Project

7.1.1. Impacts of Project Construction

Plans and Assumptions. Although construction planning is beyond the scope of the feasibility study, considerable attention has been given to the philosophy of expansion from 90 MW to 180 MW (See Section 6.5.3 of this Final Report). Highlights that are relevant for environmental impact assessment include:

a. In general, each stage will be constructed separately, one after the other.

b. Site grading for all stages will be carried out at the start of construction of Stage 1.

c. Some structures that will serve more than one stage (such as workshop, warehouse, fresh water pump pit, canteen, etc.) will be sized for Stage 1 to also serve Stage 2 or Stages 2 and 3.

d. Stacks, cooling water structures and pollution control systems for all units will be designed to comply with environmental requirements at ultimate site development of 270 MW even though the Stages 1 and 2 may operate for years before ultimate site development is achieved.

In addition, assumptions have been made about construction of each unit, for the purpose of environmental analysis, as follows:

- Construction will extend over 24 months.
- Peak labor force will number about 500 persons.
- Dormitories will not be provided because Sihanoukville is nearby.
- Fresh water required for construction will be about 50 m^3/day.
- Construction will involve international participation, but approaches for environmental control could vary widely depending on method of financing.

Potential Impacts. In this context, the main potential impacts of construction are outlined in the following paragraphs.

a. Traffic congestion and accidents along the access road. Deaths, accidents and significant traffic jams can be expected to occur along the access road between Sihanoukville Port and the site, due to the large number of existing structures close to the road, the high levels of existing traffic and economic activity on the road and adjacent areas and the addition of construction traffic, including commuting of workers from Sihanoukville.

b. Noise. Noise could become a health-damaging impact for persons living near the access road if night-time truck traffic increases in response to day-time traffic jams or other considerations.

c. Squatting and encroachment on areas near the plant site. Workers and camp followers (job seekers and workers' families) can be expected to try to create unplanned settlements near the site that could cause disease eidemics, safety problems, social conflicts, pollution of Prey Treng Pond, tree cutting, mortality of wildlife and mortality of protected species of birds that were observed in the areas during the environmental baseline survey.

d. Erosion and sedimentation during site preparation. Site preparation has the potential to cause erosion that could lead to significant sediment deposition and ecological alteration of Prey Treng Pond.

e. Siltation and salinzation during construction of cooling water system. Construction of the intake and discharge structures has the potential to smother marine benthos with silt or to cause salinization of soils or groundwater, depending on how seabed materials are handled.

f. Water pollution from spills, sanitary wastes and process wastes. Due to requirements for large quantities of fuels, chemicals, heavy equipment, construction materials, and toilets the construction stage has the potential to cause many kinds of water pollution to Prey Treng Pond due to spills or inadequate handling or treatment of wastes.

g. Resettlement of households from project areas. The number of households now existing on the project areas is small and impacts of resettlement could be small if the number of families does not increase and if compensation payments are sufficient for families to reestablish themselves. However, the scope and seriousness of the resettlement problem could increase dramatically if other families are permitted to settle on the site before construction begins, or if compensation and resettlement are delayed or insufficient for restoration of existing conditions.

h. Cumulative effects of interference with operating units. Some potential impacts can be expected to be greater for construction of Stages 2 and 3 than for construction of Stage 1, because of the presence and possibility for interaction of construction activities with one or two operating plants. These include pedestrian and vehicular accidents, damage to existing structures through collision and vibration, cumulative demands for water and space, cumulative pollution loads, noise, siltation of cooling water,

i. Temporary employment and economic activity. Although a breakdown of construction employment is not available, construction can be expected to create some local job opportunities and to stimulate economic activity for the 2-year

construction period of each unit.

j. Dust during site preparation and construction. Dust, which is caused by site preparation works and construction vehicles, may make surrounding atmosphere worse.

7.1.2. Impacts of Operation

During the feasibility study, considerable effort was made to find project design concepts that would avoid or reduce operation-stage impacts. The following discussions are based on the concepts that were adopted. The effort and concepts are outlined in Section 7.2.

Potential Impacts. The main potential impacts of operation are outlined in the following paragraphs, even though they do not appear to be serious.

a. Air Pollution. With natural gas as the main fuel, the project will increase the levels of NO_2 and CO in areas surrounding the project. However, except on hilltops near the site, the increases will result in concentrations that are far below allowable maximum levels. When diesel oil is used as fuel, NO_2 and SO_2 levels will increase furthermore in a similar pattern, and particulates will increase slightly.

b. Water pollution. With large quantities of fuels and chemicals on site, along with permanent operating staff, the potential will exist for water pollution to occur as a result of accidental spills, fire fighting activity or inadequate operation or maintenance of sanitary and chemical wastewater treatment systems. The area most likely to be affected, due to its small size and close proximity to the plant site would be Prey Treng Pond.

c. Mortality of marine ichthyoplankton. Ichthyoplankton counts are typical of productive fisheries areas and heating and chlorination of cooling water can be expected to kill most fish eggs and larvae that pass through the cooling system. However, several features of the counts suggest that serious impacts fish populations will be unlikely: (i) ichthyoplankton densities are consistently lower in the

immediate vicinity of proposed locations of the structures than in areas further out to sea, (ii) no particular species appear to be concentrated heavily near the intake structure, and (iii) ichthyoplakton are abundant throughout the year although total numbers and species composition do fluctuate seasonally.

Effects of discharged cooling water on other ichthyoplankton are expected to be very minor due to rapid mixing near the discharge nozzles. Within a few tens of meters of the nozzles (even at Stage 3 operation), water temperature is expected to return to within 1 to 2 ° C. of ambient seawater temperature.

d. Permanent employment and economic activity. The plant can be expected to contribute positively to employment and economic activity in the Sihanoukville area for the duration of project operations.

7.2. Impact Mitigation Planning

Mitigation of impacts through avoidance and minimization of project and environmental conflicts is an important general theme of the feasibility study that is already documented by the following events:

a. The JICA Study Team includes an environmental specialist to actively pursue environmental matters.

b. Environmental considerations have been addressed from the beginning of the feasibility study and were an integral part of project site selection and evaluation.

c. The feasibility study includes a year-long environmental baseline survey to develop information for a full environmental impact assessment and environmental mitigation plan for the project. This survey was initiated in September 2000 and will be completed in August 2001.

d. Preliminary design of the cooling water intake and discharge structures has already reduced the potential for aesthetic impacts and impacts of construction by arranging

for cooling water pipes to be placed under the seabed; cooling water pipes to be constructed without generating large quantities of spoils requiring off-site disposal.

e. Arrangements for chlorination of the cooling water have already considered chlorine shocking, which may be less damaging to marine ichthyoplankton (fish eggs and larvae) than continuous chlorination. Chlorine shocking is being recommended as long at it does not prove to be inadequate to control bio-fouling in the Sihanoukville marine environment. If continuous chlorination is determined to be necessary (by operating experience) than it will be used.

f. Preliminary design work for the cooling water discharge structures has already attempted to reduce the size of the thermal mixing zone by the design and placement of the structures, and by rearranging the locations of the respective structures to reduce the risk of recirculation of heated water, although the risk of recirculation has not been completely eliminated.

g Cumulative effects of constructing one unit while operating one or more other units have already been considered to ensure the adequacy of dry-season water supply and available space for construction laydown.

h. Environmental standards of Cambodia and international donor institutions are being considered in the development of the project design and mitigating measures. In general, the design will follow Cambodian standards. Where there are gaps or ambiguities in the Cambodian standards, the design will follow World Bank or comparable guidelines. For example, the Cambodian emissions standards for NO_2 and SO_2 do not specify limits on combustion conditions that should accompany the maximum allowable concentrations of the emitted gases. Without this specification, the standards could theoretically be met by injecting excess air to lower the concentration of exhaust gases. Therefore, Cambodia's allowable concentrations for NO_2 and SO_2 emissions will be used for the design, but World Bank's condition limits for gas turbines of "dry at 15 % oxygen, 1.013 bar and 0 ° C" will also be applied.

i. Efforts to obtain plant makeup water from Prey Treng Pond without significantly

disrupting the seasonal water levels or ecological structure of the pond, or interfering with Sokimex's water supply, have already been considered in the choice of water source and preliminary design of the make-up water system. Tentative plans call for on-site water storage tanks with storage capacity sufficient to provide make-up water for 1 months. Water would be skimmed for storage from Prey Treng Pond during high flow periods of the rainy season and used as necessary during periods of dry-season low flows, with little effect on seasonal water levels or ecological phenomena of the pond.

j. Stack configuration and height have been established on the basis of more than 50 runs of the US EPA ISC3 (Industrial Source Complex 3) model. Finally 50 m height common stack (one for each stage) was selected to satisfy all Cambodian environmental standards even when diesel oil with 0.2% sulfur is used for three stage simultaneously.

k. To reduce costs, impacts and future interference of operating units and units under construction, construction of Stage 1 will include some facilities for Stages 2 and 3. For example:

   (i) Site preparation, access road reinforcement and structures required to cross the access road or railroad will be completed for all three stages.

   (ii) The workshop, warehouse, the potable water system, some tanks and pumps, some communications equipment and a few other items will be sized and constructed for Stages 1 and 2.

l. Public participation in mitigation planning has included interviews of selected stakeholders by the environmental baseline survey team concerning demographic, socio-economic, ecological, fisheries and archaeological conditions in the project area; and discussions between landowners (of areas required for the project) and the office of the 1st Deputy Governor of Sihanoukville concerning their willingness to sell their land to the project.

m. After Government approval of the project, a land acquisition committee will be formed to handle all aspects of land acquisition. This committee and the office of the Governor of Sihanoukville Municipal Province will handle all aspects of reset-

tlement of residents from the acquired land. Therefore the EIA report will not include any plans for resettlement or restoration of income of these residents.

7.2.1. Mitigation During Project Construction

a. Control traffic congestion along the access road. To minimize pedestrian injuries and deaths, and other traffic accidents, on the access road between Sihanoukville Port and the site, tender document clauses should require contractors to (i) train and control their drivers to operate vehicles at low speed (to be specified), and (ii) cover the costs for Sihanoukville Authorities to provide additional traffic police to (a) provide awareness training to residents along the access road on the dangers of construction traffic to their children and themselves, (b) direct traffic in congested areas and (c) control encroachment onto road shoulders, on a full-time basis, in congested areas along the road near Sihanoukville Port.

b. Control night-time noise along the access road. Night-time truck traffic between Sihanoukville Port and the site should be strictly controlled (possibly banned) to avoid health-damaging noise impacts on residents living near the road.

c. Control squatting, encroachment and wastewater. To prevent pollution of Prey Treng Pond, and outbreaks of water-borne diseases such as cholera, tender document clauses should include provisions that require the Contractor(s) to (i) treat all wastewater to satisfy Cambodian standards and to discharge treated effluents downstream of the weir of Prey Treng Pond and (ii) cover the costs for Sihanoukville Authorities to provide additional police to prevent employees and camp followers from settling in the vicinity of Prey Treng Pond.

d. Control diseases and promote safety. To control water-borne, mosquito-borne, sexually transmitted and other communicable diseases, and provide prompt treatment of construction injuries, tender documents or comparable legal instruments should include clauses that require the contractor(s) to:

   (i) Provide ample quantities of well-maintained latrines and potable water (to WHO standards) at all construction sites.

   (ii) Provide the resources for health screening and treatment of all new employees.

(iii) Provide an on-site first aid station, ambulance and driver, first aid equipment and supplies, and at least two personnel with first aid training.

(iv) Make an arrangement and cover the costs for a local hospital in Sihanoukville to (i) receive seriously injured personnel from the project; and (ii) provide advice, training and supplies for preventing the spread of sexually transmitted diseases among the construction labor force and local communities.

e. Protect Prey Treng Pond from Sedimentation. To prevent sediment deposition in Prey Treng Pond, an erosion and sedimentation control plan should be an integral part of site preparation. Key elements of the plan should include (i) timing of earthmoving to minimize the exposure of bare soil during the rainy season, (ii) diversion of uncontrolled site runoff to areas downstream of the weir of Prey Treng Pond, (iii) establishment and maintenance of a sediment retention ponds for any water that enters Prey Treng Pond, (iv) prompt revegetation, paving or bio-engineering of graded areas and (v) monitoring the depth of Prey Treng Pond along surveyed cross-sections, from the start of site preparation until the completion of paving or revegetation.

f. Control spoils from cooling water system construction. To prevent smothering of marine benthos or salinization of inland soils during dredging of substrate for construction of the intake and discharge structures, spoils should be carefully controlled, for example by ponding on land close to the coast.

g. Management resettlement to provide adequate benefits without attracting newcomers to the site. To prevent the scope of resettlement from increasing before the start of construction, maintain tight control of project areas to prohibit new settlement. For the families that now inhabit the sites, provide adequate compensation and assistance directed toward reestablishing incomes and amenities.

h. Minimize interference with operating units. To minimize impacts of accidental damage to Stages 1 or 2 during construction of Stages 2 or 3,

(i) Changes to the site layouts of Stages 1 and 2 should be continuously controlled by the project, until Stage 3 construction is completed, to avoid en-

croachment on spaces required for delivery, erection, operation or maintenance of machinery for Stages 2 or 3.

(ii) As-built changes to Stages 1 and 2 should be meticulously documented and utilized in planning the design and construction of Stages 2 and 3,.

i. Provide convenient construction lay-down area for Stage 3. To insure that a safe and efficient lay-down area is available when needed for the construction of Stage 3, the ± 11-ha construction lay-down area for Stage 3, near the plant site, south of Prey Treng Pond, should be acquired by the project at the time of the decision to proceed with Stage 1, and controlled by the project until the completion of Stage 3, to prevent encroachment by squatters.

j. Provide guidance for temporary employment. To encourage the distribution of project benefits to affected persons and communities, tender documents should include clauses that state the project's priorities for contractor employment of Cambodian staff and that request the contractor(s) to cooperate with these priorities in making their staffing decisions. For example, the project may decide that first priority for employment should be given to persons whose houses or land were purchased by the project, second priority to residents of Stung Hav District, third priority to residents of Sihanoukville, and so on.

7.2.2. Mitigation During Project Operation

a. Monitor flue gas emissions. To insure that concentrations of flue gas emissions remain within predicted limits, stack gases should be monitored once each month to determine the concentration of NOx, SOx, and particulate emissions.

b. Prevent spills. To minimize the risk of impacts from accidental spills of fuel or chemicals, a spill prevention and control plan should be prepared for the transfer and storage of fuels and chemicals required for plant operations. Key elements of the plan should include:

(i) procedures for separated storage of chemicals that produce dangerous reactions upon contact.

(ii) procedures for avoiding accidental spills.

(iii) structures for the passive retention of large spills.

(iv) procedures and equipment for safely collecting and disposing of all spills, large and small.

(v) procedures for assuring that employees handling the chemical and fuels are properly trained and that the plan is properly implemented.

c. Monitor operation and maintenance of wastewater treatment facilities. Maintain logs of operation and maintenance activities, including periodic testing of effluents prior to discharge.

d. Monitor cooling water discharge and react to findings. To minimize impacts of cooling water discharge in Stages 2 and 3 (including the risk of recirculating heated cooling water):

(i) Chlorination activities should be monitored manipulated during the first year of operation with the objective of avoiding continuous chlorination if possible.

(ii) The temperature of sea water entering the cooling water system should be monitored continuously for at least the first year of operation of Stage 1 and the first year of combined operation of Stages 1 and 2.

(iii) The shape and context of the thermal plume should be determined monthly, during the same years, for high and low tidal periods, by (i) measuring sea water temperature and salinity, at 1-m vertical intervals and 10 to 100-m horizontal intervals, from the discharge structure to the edge of the plume in 4 directions; and (ii) measuring current speed and direction between the intake and discharge structures