IFAS AGENCY for the GEF PROJECT

ARAL SEA BASIN PROGRAM
WATER & ENVIRONMENTAL MANAGEMENT PROJECT

COMPONENT C:
DAM SAFETY AND RESERVOIR MANAGEMENT

HAUZHAN DAM

SAFETY ASSESSMENT REPORT

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GIBB
LAWGIBB Group Member

In association with

SMEC

HAUZHAN DAM
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CONTENTS

UNITS AND ABBREVIATIONS

ASBP	Aral Sea Basin Program
CA	Central Asia
CMU	Component Management Unit
EA/EIA	Environmental Assessment/Environmental Impact Assessment
EC-IFAS	Executive Committee of IFAS
FSL	Full Storage Level
FSU	Former Soviet Union
FAO/CP	Food and Agriculture Organisation/World Bank Co-operative Programme
GDP	Gross Domestic Product
GEF	Global Environment Facility
ICB	International Competitive Bidding
ICOLD	International Commission on Large Dams
ICWC	Interstate Commission for Water Coordination
IDA	International Development Association of the World Bank
IFAS	International Fund to Save the Aral Sea
JSC	Joint Stock Company
LDL	Lowest Drawdown Level
M & E	Monitoring and Evaluation
NCB	National Competitive Bidding
NGO	Non-governmental Organisation
O & M	Operation and Maintenance
PIP	Project Implementation Plan
PIU	Project Implementation Unit
PMCU	Project Management and Coordination Unit
PMF	Probable Maximum Flood
RE	Resident Engineer
TA	Technical Assistance
TOR	Terms of Reference
SIC	Scientific Information Centre (of the ICWC)
SU	Soviet Union
SW	Small Works
VAT	Value Added Tax
WARMAP	Water Resource Management and Agricultural Production in CA Republics

masl	metres above sea level
Mm^3	million cubic metres
km^3	cubic kilometres = 1000 Mm^3
m^3/s	cubic metres per second
ha	hectare
hr	hour

1 INTRODUCTION

This report is one of ten reports prepared under Component C: Dam and Reservoir Management, of the Water and Environmental Management Project (WAEMP). The WAEMP is supported by a variety of donors, such as the Global Environment Facility (GEF) via the World Bank, the Dutch and Swedish Governments and the European Union, and is being implemented by the IFAS Agency for the GEF Project under the Aral Sea Basin Program.

1.1 Background to Project

In general, the WAEMP aims at addressing the root causes of overuse and degradation of the international waters of the Aral Sea Basin, and to start reducing water consumption, particularly in irrigation. The project also aims to pave the way for increased investment in the water sector by the public and private sectors as well as donors. The project addresses this aim in several components. Dam and Reservoir Management, the assignment with which this report is concerned, is one of them. The other components are: Water and Salt Management, the leading component, to prepare common policy, strategy and action programs; Public Awareness to educate the public to conserve water; Transboundary Water Monitoring to create the capacity to monitor transboundary water flows and quality; Wetlands Restoration to rehabilitate a wetland near the Amu Darya delta; and Project Management. The components have close links with each other.

The Dam and Reservoir Management Component focuses on four activities as follows:

a) Continuing an independent dam safety assessment in the region, improve dam safety, address sedimentation and prepare investment plans;
b) Upgrading of monitoring and warning systems at selected dam sites on a pilot basis;
c) Preparing detailed design studies for priority dam rehabilitation measures; and
d) Gathering priority data and preparation of a program for Lake Sarez.

The activities are grouped for work process purposes into two packages and will be executed simultaneously, according to an agreed schedule of works:

- Dam safety and reservoir management (including activities "a", "b" and "c");
- Lake Sarez safety assessment (covering activity "d").

The Dam Safety and Reservoir Management package covers the following areas: dam safety, natural obstructions, silting of reservoirs, control of river channels etc.

The activity covers the following 10 dams, two in each country:

Kazakhstan: Chardara and Bugun dams;
Kyrgyzstan: Uchkurgan and Toktogul dams;
Tajikistan: Kayrakkum and Nurek dams;
Turkmenistan: Kopetdag and Khauzkhan dams; and
Uzbekistan: Akhangaran and Chimkurgan dams.

Because of the need to safeguard human life, early priority is being given to safety reviews at each of the dams, which is the subject of this report.

1.2 Safety Assessment Procedures

The dam safety assessments are the first stage in the evaluation (including costing and economic justification), analysis, design and implementation of measures aimed at ensuring safe operation of the selected dams. They have been prepared based on a brief reconnaissance visit to each dam, discussions with the operating staff and a perusal of such information and data as was found to be readily available. No attempt has been made at this stage to analyse any of the data. A data collection and cataloguing procedure was initiated before commencement of the assignment but this process (to be carried out by National Teams) is still at an early stage in implementation.

The field visits were made and the reports prepared by a team of international experts specialising in dam engineering and dam safety procedures. The team comprises experts from GIBB Ltd (United Kingdom) and its associate for this assignment, Snowy Mountains Engineering Corporation (SMEC) from Australia, together with members of a team of regional experts who have been contracted as individuals to work with the Consultants for this project. This team is referred to here as the International Consultants (IC). The International Consultants have been supported during the field visits by members of National Teams appointed for this project from each of the five Central Asian republics.

The principal members of the international team, who are the authors of this report, are the following: -

- Jim Halcro-Johnston (GIBB Ltd) – Team Leader
- Gennady Sergeyevich Tsurikov (Uzbekistan) – deputy Team Leader
- Edward Jackson (GIBB Ltd) – Dam Engineering Specialist
- Ljiljana Spasic-Gril (GIBB Ltd) – Geotechnical Engineer/Dam Structures Specialist
- Pavel Kozarovski (SMEC) – Hydrologist/Hydraulic Engineer
- E.V. Gysyn – Dams Specialist (Kazakhstan)
- E.A . Arapov – Hydraulic Structures Specialist (Turkmenistan)
- G.T . Kasymova – Energy Expert (Kyrgyz Republic)
- R. Kayumov – Hydrostructures Specialist (Tajikistan)
- R.G. Vafin – Hydrologist, specialising in reservoir silting (Uzbekistan)
- V.N. Pulyavin – Dam Instrumentation Specialist (Uzbekistan)
- N.A. Buslov – Dam Specialist (Turkmenistan)
- Y.P. Mityulov – Cost and Procurement Expert (Uzbekistan)
- N. Dubonosov – Mechanical Equipment Expert (Kyrgyz Republic)

Most of the above team members have contributed in the preparation of this report.

1.3 Scope of Safety Assessment

The safety assessments are made based on superficial evidence observed during the site visits, discussions with operating staff and subsequent discussions with members of the National Teams and an examination of such supporting design and construction documents as has been made available to the IC for review. (A full list of the documents reviewed is included as Appendix A)

The safety evaluation of the dam has required an assessment of the following factors:

(1) The **characteristics of the reservoir and dam site**, which includes the flood regime
for the river, and the geological conditions at the site;
(2) The **characteristics of the dam,** covering its design and present condition;
(3) The expected **standards of operation and maintenance** of the dams, its performance, and the implications for safety;
(4) The **effects on the downstream** area resulting from a failure of the dam or an excessive release of water.

The structure of this report reflects the scope of safety assessment. Chapter 2 presents a general description of the dam, including location, purpose, principal dimensions and assessment of its hazard rating in relation to the impact that a safety incident would have on the adjacent community. Chapter 3 discusses the design factors that principally affect the safety of the dam.

Comments on the condition and performance of the dam are given in Chapter 4 and in Chapter 5 an assessment of its safety is given.

Chapter 6 gives recommendations for studies, works and supplies to be undertaken in the interests of ensuring the safety of the dam and the downstream community. Conclusions and recommendations are summarised in Chapter 7.

The recommendations for safety measures given in this report must be regarded as tentative as their precise scope will depend on the outcome of further studies which are outside the scope of the present assignment. No attempts has therefore been made at this stage to evaluate the cost of the required remedial works or to carry out an economic justification for the works proposed, which will be necessary to support an application for funding. This will be carried out when the necessary studies and detail designs have been completed.

2 PRINCIPAL FEATURES AND DIMENSIONS OF THE DAM

2.1 Location, Purpose, and date of Construction

The off-line Hauzhan water reservoir is situated at Km 456 on the Karakum canal in Mary veloyat of Turkmenistan and 70 km west of the city of Mary (see Figure 1). The water reservoir can be accessed by road Ashgabad-Tedjen-Mary.

The purpose of the reservoir is to distribute Karakum canal water for irrigation and for uninterrupted clarified water supply for economical and drinking needs of Tedjen town and villages of Tedjen and Babadayhan etraps.

The dam was put into operation in 1975. The dam was designed by “Turkmenhyprovodhoz”.

2.2 Description of the Dam

The main structures include (see Figure 2):

- Regulator on the Karakum canal
- Inlet
- Dam
- Outlet

The regulator is situated at Km 456 on the Karakum canal and is intended to keep the canal water at a required level necessary for supplying the reservoir. The regulator comprises two sluices which are 12m wide. The stilling basin has a rectangular form extending in plan. The trapezoidal downstream spillway apron is protected against scour by gabions. The spillway openings are controlled by 2 service gates 12 x 6m, which are operated by a rope hoist of 40 t capacity.

The inlet structure is located at Km 456 on the Karakum canal and consists of three conduits with an open chute at the end. The regulator is equipped with 3 service gates and 3 guard gates 5 x 5 m size, which are operated by an hydraulic hoist of 160t capacity.

The dam is an earth embankment, constructed in a compound way: from PK 0 to PK 26+35 – conventional fill; from PK 26+35 to PK 163+00 - hydraulically filled; from PK 163+00 to PK 349+59 – filling with soil compaction and following bringing of profile to design levels. The upstream slope of the foreshore is 1:30 to 1:50, the downstream slope 1:4 to 1:4.7 (see Figure 3). There is a pipe drain within the embankment.

The outlet is located within the embankment and consists of four conduits with a tower and open chute (see Figure 4). There is a free flow regime below the tower. There are four bottom and four guard gates each 2.7 x 3.5 m. Their operation is carried out by 8 screw hoists each of 50 t capacity.

The principal dimensions of the reservoir and the various components of the dam are given in Table 2.1.

2.3 Hazard Assessment

In many countries a formal classification system is used to define the risk a dam represents, in terms of the potential for loss of life and/or damage to property which could result in the event of flooding caused by failure of the dam or an extensive release of water. The magnitude of the risk depends partly on the characteristics of the dam and reservoir and partly on the conditions downstream of the dam. Risk factors based on the procedure set out in ICOLD Bulletin 72 (Reference 1) are shown in Tables B1 and B2 in Appendix B.

Based on the Tables in Appendix B, the total risk factor of 22 points (Table 2.2) puts the Hauzhan dam in Risk Class III, that is the second highest risk category.

Table 2.2 Hauzhan Dam – Risk Factor

		Points
Reservoir Capacity (Mm^3)	760	6
Dam Height (m)	14	0
Downstream Evacuation Requirements	>1000	12
Potential Damage Downstream	Low	4
	TOTAL	22

Table 2.1 Hauzhan Dam – Principal Dimensions

Principal Dimensions of Water Reservoir

Total storage capacity at FSL	
Design	875.0 Mm^3
Present	760.0 Mm^3
Active storage capacity at FSL	
Design	850.0 Mm^3
Present	720.0 Mm^3
Dead storage capacity at DSL	
Design	25.0 Mm^3
Present	40.0 Mm^3
FSL	212.40 masl.
DSL	205.60 masl.
Surface area at FSL	200.18 km^2

Inlet Structure

Type	Pipe regulator
Maximum discharge	250 m^3/s
Sill level	211.11masl.
Number of pipes	3 nos.
Size of pipes	5 mx 5 m
Hoist	GP-160t-6ps
Type of gates	Slide, welded – 6 nos.
Service 3,5x3 m.	3 nos.
Guard 3,5x3 m	3 nos.

Embankment

Type	Earth
Crest level	215.50 masl
Maximum dam height	14.30 m
Crest length	34.96 km
Crest width	8 m
Road width	6 m
Foundation width	400 m
Freeboard at FSL	3.10 m
Upstream slope	1:30-1:50
Downstream slope	1:4-1:4.7

Outlet Structure

Type	Pipe, with chute
Maximum design outlet capacity	180 m^3/s
Sill level	201.50 masl.
Number of pipes	8 nos.
Size of pipes	2.7 mx3.5 m.
Hoist	GP- 50t.
Type of gates	Slide botomm-8ps
Service, emergency, guard,	4nos each.

Regulator

Type	Pipe regulator
Maximum discharge	124 m^3/s
Holes	2(12x6m)
Sill level	212,40masl.
Type of gates	Slide – 2nos(12x6m)
Hoist	Rope

3 DESIGN CONSIDERATIONS

3.1 Hydrology

The annual intake of water to the Karakum canal from the Amudarya river is 13.8 km^3. 1.72 km^3 volume of runoff is regulated by the cascade of four reservoirs including Hauzhan, which allows the head intake maximum discharge to be cut from 741 m^3/s down to 610 m^3/s.

The maximum monthly mean design discharge flowing into the reservoir is 170 m^3/s, and the maximum outflow from the reservoir is 142 m^3/s. The annual average of the volume of water flowing into the reservoir is 2,960 Mm^3 and the outflow volume is 2,500 Mm^3.

The total volume of sediment for 24 years of maintenance is 115 Mm^3 and in 1999 the total volume of the reservoir became 760 Mm^3, including 40 Mm^3 of dead storage, and active capacity of 720 Mm^3.

3.2 Geology and Seismicity

The reservoir is located at the south-east border of the Kara-Kum desert, at the zone adjoining the piedmont plain developed along the northern footslopes of Kopetdag mountains.

Geomorphologically it can be divided into two parts:

- north-east slope of Murgab upland
- geoxijurrassic delta plain

The first part occupies the north-east part of the dam site and comprises a convex rise sloping in the north-west direction. There are wind blown sand hills that form large-sized ridges with a height from 10 to 30 m oriented in the north-west direction and hillocks that have barhanes shape with 3 - 5 m height. The sands here are fine sands of different sizes that are yellow in colour.

The second part is a weakly dissected plain slightly sloping in the north-west direction. The north part of it is formed by sand ridges with a height of 5 - 10 m; in the central and south part there are widely developed takyrs. The plain comprises young alluvium and alluvial fan deposits of Inclub delta, usually consisting of layers of sand, sandy silt, silt and clay. The ground generally comprises fine sands often with thin interlayers of clay up to 10 m below the surface.

Before construction of the reservoir the ground water table was at 8 - 15 m depth from the surface. The ground water table has risen by 5-8 m after the reservoir impoundment.

The seismic intensity of the site is VIII on MSK scale.

3.3 Construction Materials and Properties

The main mass of the embankment was hydraulically filled using local materials: sands, sandy silts and silts. The angle of internal friction for: sands - 28^0 ; sandy silts - 26^0; silts - 25^0, silt cohesion - 0.05 kg/cm^2.

The density of the soil matrix in natural conditions: sands - 1.49 t/m^3; sandy silts - 1,46 t/m^3; silts - 1,56 t/m^3.

Liquefaction of the saturated grounds in the supported mass happens as a result of hydrodynamic processes as affected by seismic acceleration. This type of seismic deformation is observed in fine-grained loose materials and, depending on intensity, may lead to partial or full loss of structural stability. The hydraulically filled soils of the embankment and also those filled by layer using compaction plant, are similar in density and grading, with the prevailing particle size more than 0.2 mm, up to 80% being silt and sandy silt. Soil density of the core wall is up to 1.63 - 1.7 g/cm^3. Liquefaction of the saturated soils of the embankment has not been checked during design stage.

3.4 Seepage Control Measures

Lines of sheet piling have been driven at all of the hydraulic structures.

3.5 Reservoir Draw-off Works

Filling and draw-down of the reservoir water is carried out in accordance with the control schedule, which is linked with the schedule of water transfer through all “Karakum canal system”. The water reservoir filling and draw-off schedule is worked out in accordance with “Operating rules of Hauzhan water reservoir” requirements, which exclude the possibility of creating conditions that threaten the stability of the structure.

The “Operating rules…” regulate the limit on the acceptable rate of draw-off and filling of the water reservoir which is equal to 10 cm. The filling of the water reservoir higher than FSL is forbidden.

3.6 Performance Monitoring Instrumentation

The water reservoir instrumentation are the following:

- water level gauge - 8 ps.
- current meter (GR-21) - 1 ps
- rod HB-10 - 1 ps

- geodetic reference point - 2 ps

There is no other instrumentation available on the dam.

3.7 Hydropower Facilities

None

4 DAM CONDITION AND PERFORMANCE

4.1 Comments Arising out of Inspection

The IC, in company with representatives from the Turkmen National Team and Engineers from the site visited the dam on 19/20 October 1999. Areas inspected included the whole of the embankment and the draw-off works.

The reservoir level at the time was 211.86 masl, equivalent to a storage volume of 655 Mm^3.

It was found out during the inspection:

- The centre of the dam does not have dependent, up-to-date communication with the outlying structures (inlet and outlet structures), so there is no central control point.
- The reservoir inlet and outlet structures do not have instrumentation for measuring water levels, discharges and volume.
- There is no lighting on the dam.
- The control structures do not have an electricity supply as stipulated by the project, also there is no reserve diesel generator of the necessary power.
- The operating staff of the outlet structure do not have spare parts for maintenance of the lifting mechanisms.
- There are no piezometers .
- The regulator at Km 456, regulating the water levels and discharges between the main (South) canal and the inlet of the Hauzhan water reservoir, constructed in 1965 with a design discharge capacity of 124 m^3/s, does not meet the present requirement for discharge of 180 – 200 m^3/s and is in a pre-emergency condition due to scour of the tail water in the area of rock protection.
- The equipment is under the control of untrained employees in respect of its operation. The rope hoists were not tested by “Gosgortehnadzor“ and are in emergency condition.
- All gate surfaces of the outlet structure need urgent testing and partial replacement.

4.2 Assessment of Performance Monitoring Results

Assessment of the results of the monitoring carried out (observation of water levels, discharges and volumes of filling and draw-off, phreatic surface, condition of tail and head water) is in accordance with “ Operation rules of Karakum canal system” , “Operation rules of Hauzkhan water reservoir” and also with orders and protocols.

The monitoring records and their assessment are available, but there was not sufficient time to study them.

4.3 Dam Safety Incidents

There were no emergency situations at the dam during the period of operation of the water reservoir, but there is an emergency situation at the regulator at Km 456.

4.4 Maintenance Procedures and Standards

The Operation Standards and Rules of Hauzhan water reservoir are defined by Technical Projects of Karakum canal.

The operation rules of Hauzhan water reservoir were elaborated by the institute “Turkmengiprovodkhoz in 1983. The rules were extended by “Basis of Karakum canal technical operation in modern conditions” (1997).

The implementation of the above mentioned documents is obligatory for operational organisations, independent of which department they belong to.

4.5 Existing Early Warning & Emergency Procedures

The structure complex of Hauzhan water reservoir has an obsolete communication system with the central control point of the Karakum canal, and there is no connection with outlying structures. Actions of the maintenance personnel in an emergency situation are determined by the job description defined by the chief of the water resources department.

5 SAFETY ASSESSMENT

5.1 General

The safety assessment is based on the following general criteria:

(1) Structural safety
The dam, along with its foundations and abutments, shall have adequate stability to withstand extreme loads as well as normal design loads.

(2) Safety against floods
The reservoir level shall not rise above the critical level (maximum flood level) for the largest possible flood. Gate mechanism and power units must remain fully operational and accessible at all times.

The dam should have adequate facility for rapid lowering of the reservoir level in case of emergency.

(3) Safety against earthquakes
The dam shall be capable of withstanding ground movements associated with the maximum design earthquake (MDE) without release of the reservoir. The selection of the appropriate value of MDE is based on an assessment of the consequences of dam failure (Section 2.3).

(4) Surveillance
Arrangements for inspection, surveillance and performance monitoring of the dam should ensure that a danger arising from damage, defect in structural safety or an external threat to safety is recognized as soon as possible, so that all necessary measures can be taken to control the danger.

Adequate emergency planning, early warning and communications facilities shall be in place to ensure the safety of the downstream population in case of emergency.

In the light of the review of the design and performance of the Hauzhan dam, the findings of the condition assessment, and the review of the hydrological and geological conditions, the following conclusions are drawn regarding the safety of the dam:

5.2 Structural Safety

5.2.1 Embankment

This hydraulic fill dam appears to have operated completely successfully since completion of the first stage in1996; the second stage is currently under construction.

Information obtained from the operating staff indicates that the dam is well monitored and inspected regularly.

The phreatic surface within the downstream shoulder is not measured, and no piezometers are installed. The downstream face is said to be inspected frequently when the reservoir is full and there are no reports of seepages emerging from the slope. However, the borrow areas downstream of the embankment are very wet and it is possible that seepage emerging in these areas would not be noticeable.

Seepage from the drains is understood to be minimal, although not measured. It is not known whether settlement measurements are made.

It is important that sufficient instrumentation is installed in the first stage embankment to allow the performance of the embankment and the effect of the stage 2 construction work to be properly monitored. For a large hydraulic fill embankment this would comprise measurement of pore pressures, seepage and horizontal and vertical deformations. An instrumentation system should be installed to allow the necessary measurements to be made.

Both faces of the embankment are in satisfactory condition.

5.2.2 Draw-off Works

The draw-off works have been constructed for the future operating condition when the Stage 2 construction works are complete, so that they are presently of large capacity in comparison with the normal flows into the reservoir. However, the Karakum Canal, which is at a water level about 5m above FSL, skirts the top end of the reservoir, which raises the possibility that any breach in the canal dyke would result in the canal emptying itself into the reservoir. In these circumstances, failure to respond by opening the outlet gates could result in overtopping of the embankment.

The operating condition of the draw-off works appears to be generally satisfactory. However, the operating staff said that they have not carried out any inspections inside the water conduits in recent years, so that the condition of the concrete, including the joints, is unknown. It is presently difficult to arrange access into the conduits because of the high tailwater level in the stilling basin, and the need to maintain irrigation water supplies at all times.

It is understood that the channel downstream of the draw-off works has restricted capacity (180 - 200 m^3/s) which in practice limits the size of release that can be made from the draw-off works.

5.3 Safety against Floods

The reservoir is filled directly from the Karakum Canal and apparently has no independent catchment, the natural drainage line in this very flat area being the Tedgen river. There is therefore not seen to be any danger from floods.

5.4 Provision for Emergency Draw-down

Draw-down of the reservoir in case of emergency can be achieved by means of the draw-off sluices. The maximum draw-off rate when the reservoir is at full storage level is about 310m^3/s, giving a maximum draw-down rate of some 0.13 m/day (1m/week). This is not a high rate and it would take several weeks to relieve a significant proportion of the load on the embankment in case of emergency.

5.5 Safety against Earthquakes

5.5.1 Seismic design criteria

In the original design seismic input parameters and stability analysis in seismic condition are assumed to have been carried out in accordance with procedures given in the Russian Seismic Standards (Reference 2). According to the Russian Seismic Standard, a seismic design coefficient (K_g) is derived for a site based on MSK earthquake intensity scale. The coefficients are derived based on 1:500 year earthquake. The required minimum factor of safety in seismic conditions is always greater than unity.

However, the current practice based on the guidelines given in ICOLD Bulletin 72 (Reference 1) is to assess dam safety against two representative design earthquakes that are as follows:

OBE - Operating Basis Earthquake
MDE - Maximum Design Earthquake

Where:

- OBE, or “no damage earthquake” is the earthquake which is liable to occur on average not more than once during the expected life of the structure (of not less than 100 years). During an OBE, the dam and its ancillary works should remain functional but may need repair. The required minimum factor of safety for the OBE earthquake should be greater than unity.

- MDE or “no failure earthquake” is the earthquake that will produce the most severe level of ground motion under which the safety of the dam against catastrophic failure should be ensured. For dams which are classified to be Risk Class III a recommended return period of MDE is 10,000 years (Reference 3). For this earthquake displacements of the crest are assessed and compared with the allowable wave freeboard.

It is assumed that the dam safety has not been assessed for OBE and MDE earthquakes and it is recommended to carry out additional engineering studies (See Section 6.2.4) to evaluate dam performance in those conditions.

As a part of safety assessment a check should also be carried out to evaluate the height of seismic waves (seismic seiche) of the reservoir which may occur during a seismic event and which requires the additional height to be added to the standard “static” freeboard.

5.5.2 Liquefaction of fill and foundation materials

No mention was made during the site inspection of the dam ever having been affected by an earthquake. However, an embankment constructed of saturated, low density hydraulic fill is vulnerable to damage during seismic shaking, and it is recommended to carry out further in-situ testing to verify the properties of the embankment and foundation materials in order to assess possible soil strength reduction and displacements that could occur during strong earthquakes.

5.5.3 Ancillary works

It is possible that the outlet works building, including the overhead crane, would also be vulnerable to damage by an earthquake. Any damage which impaired the function of the crane in operating the draw-off gates would have important dam safety implications, and an assessment should be made of the likely impact of an earthquake on such items.

5.6 Other Safety Matters

A number of other matters will need further examination as part of a more comprehensive safety assessment than has been possible during the present study, for instance:

5.6.1 Safety of access

While the dam crest and draw-off works can be accessed from both sides, the chance that extreme events (e.g. floods, earthquake) would completely severe both are remote, unless the roads are cut due to washouts, collapsed culverts etc.

5.6.2 Security of electricity supply

It is unlikely that 100% security of electricity supply for gate operation can be assured in all circumstances, and a standby generator to operate the draw-off control gates in emergency is recommended.

5.6.3 Canal structures

The reservoir is filled from the Karakum canal by way of two intakes taking water from the canal immediately upstream of a gated regulator structure. The latter is said to be in a poor condition and is due to be reconstructed when funds become available. The canal passes around the upstream end of the reservoir over a distance of about 20 km and the normal water level in the canal is 2 m above the embankment crest level. A failure of the canal bank could therefore result in water flowing into the reservoir and possibly overfilling it if the inflow exceeded the dam draw-off capacity. The possibility of such an emergency occurring is very remote and could be controlled by using the regulator to close the canal flow. At the worst combination of outlet breakdown and canal failure, it would take approximately 10 days to fill half of the storage between the FSL (212.4 masl) and the dam crest (215.5 masl). The travel time between regulating structure at chainage 326 km and the dam is two days, which provides sufficient time to prevent an overtopping accident.

It is obviously desirable that the regulator should be reconstructed to improve the canal operation, though whether the cost could properly be allocated to improving the safety of the Hauzhan dam is open to question.

5.7 Safety Assessment – Summary

5.7.1 Principal matters of concern

On the basis of a brief examination the IC find no serious safety problems with the Hauzhan dam. However, being of hydraulic fill the embankment is vulnerable to instability due to loss of strength of the saturated low-density fill during earthquake shaking.

No piezometers are installed in the embankment, though surface evidence suggests that the internal water level is satisfactory.

The reservoir is filled from the main Karakum Canal (water level approx. 217.5 masl) by way of two intake structures having a combined flow capacity of 380 m^3/s. Thus in the absence of a surface spillway there appears to be a remote possibility that the reservoir could be overfilled should the outlet gates fail to operate and the inflow continue. The time taken for the reservoir to fill significantly above its normal level would be considerable, however, and the risk of the embankment actually being overtopped is low, but cannot be discounted.

5.7.2 Safety Statement

Static stability has not been checked as soil strength parameters are not available, but slopes are conventional and consistent with the construction materials used.

Apart from the risk of earthquake damage (which requires further study to confirm or otherwise) the Hauzhan dam appears to meet acceptable safety criteria.

As the reservoir is filled from the Karakum Canal and has no independent catchment the danger from floods is not significant, though it is remotely possible that malfunction of the draw-off works could result in overfilling of the reservoir which in the extreme could lead to overtopping of the embankment.

6 RECOMMENDED STUDIES, WORKS AND SUPPLIES

6.1 General

The review of the design of the dam, information obtained during the site inspections, and discussions with the site manager has enabled the IC to arrive at certain conclusions regarding the safety of the dam, which are discussed in Section 5. These conclusions, along with considerations of requirements for emergency management have provided the basis for an assessment of the need for additional studies, investigations, construction works and supplies necessary to bring it to an acceptable and sustainable standard of safety. However, it must be recognized that the need for further work might still become evident as an outcome of this work, as the preliminary conclusions are refined.

A more detailed specification and methodology for the work described in this Section is presented in the accompanying report `Methodology for Detailed Design of Priority Rehabilitation Measures'.

6.2 Additional Surveys, Investigations, Inspections and Studies

6.2.1 General

To provide the basic data for designing the works described below and for refining the conclusions of the safety assessment, additional information is required which is outside the scope of the present study. This work is described under the following headings:

- ground surveys
- ground investigations and inspections
- engineering studies

6.2.2 Surveys

(1) Topographic Surveys

The following ground surveys are recommended:

- embankment longitudinal crest profile;
- typical cross sections of the embankment to verify the `as-constructed' profile;

6.2.3 Ground Investigations and Inspections

The following investigations and surveys are recommended:

(1) Installation of embankment piezometers will involve a considerable amount of drilling in the embankment. It is recommended that during the course of this work in-situ testing should be carried out to verify the properties of the embankment and foundation material, and samples taken for laboratory testing.

(2) Inspections

To provide information on which to base a detailed assessment of required repairs and equipment, it is recommended that a detailed inspection of the embankment and associated works should be carried out and an inventory of defects, materials and repairs required prepared, covering:

- repairs to embankment upstream face (inspect when reservoir is at a low level);
- improvements to embankment drainage (inspect for seepages when reservoir is at high level);
- repairs to embankment downstream face protection and surface water drainage works;
- interior of draw-off culvert, upstream and downstream of gates;
- electrical wiring etc., and lighting;
- gates and hydraulic operating equipment;
- steelwork (e.g. gate tower stairs and landings);

6.2.4 Additional Engineering Studies

The following additional engineering/hydrological studies are recommended:

1) Review Reservoir Management Procedures, and freeboard allowance for wave run-up based on updated wind data.
2) Review the seismicity of the site, derive estimates of peak ground accelerations for Operating Basis Earthquake (OBE) and Maximum Design Earthquake (MDE).
3) Assess susceptibility of embankment material to liquefaction under seismic shaking. Review embankment static and seismic stability on the basis of measured properties of the in-situ materials, and determine deformations where factors of safety during seismic shaking are less than unity.

6.3 Construction Works

A preliminary assessment of the required construction works is made on the basis of the safety assessment and available data.

1) Embankment

- Prior to the investigation and inspections works it is necessary to carry out low cost rehabilitation works of the drainage system. These rehabilitation works should involve cleaning and deepening of the drainage canal at the downstream slope which would allow free draining of water.

- More comprehensive rehabilitation works should be carried out after the investigation and inspection works are completed. Performance monitoring instrumentation should be installed in the first stage embankment before completion of the second stage. The following is proposed:

- install new standpipe piezometers;
- install additional electrical (remote reading) piezometers at critical locations;
- install network of surface deformation measurement markers and fixed beacons, for precise measurement of horizontal and vertical displacements.
- Provide for measurement of seepage flows

- Carry out rehabilitation of upstream slope concrete facing slabs.
- Carry out immediately all the rehabilitation works which would prevent further suffosion and washing out of the material into Kyzylkymsk outlet conduit.
- Carry out other miscellaneous works that require immediate action.

2) Hydromechanical Equipment

The safety of the dam relies wholly on the proper operation of the hydromechanical equipment. Any necessary repairs and renewals should be undertaken immediately, and adequate standby electricity generating plant provided. It is recommended to pay attention and repair or replace the service gates of the inlet of the Kyzylkumsk conduit.

3) Outlet Works

Enlarge discharge channel downstream of outlet works. The present channel does not have sufficient capacity to accommodate full discharge from all gates fully open.

4) Miscellaneous

Other matters requiring attention discovered during the detailed inspections described above should be rectified.

6.4 Equipment and Supplies

A preliminary assessment of supplies needed, based on the Consultants' inspection and discussions with site managers, is as follows:

(1) Piezometers, the majority of these would be of standpipe type, but consideration should be given to installing a number of additional electrical (remote reading) type in critical locations.

(2) Surface movement measurement fixed beacons and targets, and deformation measuring equipment.

(3) Provide standby generator and associated housing and wiring.

(4) Provide communications system between inlet structures, dam outlet works, and other structures on the canal.

(5) Provide vehicles for dam operating staff to facilitate inspections and maintenance.

6.5 Emergency Planning Studies

The dam impounds a large reservoir and an emergency would result in the release of a large volume of stored water. It is essential that plans for dealing with such a situation are well prepared, and supported by an efficient organization, communications and alarm system.

A detailed emergency plan and instruction document should be prepared setting out the procedures to be followed, and the responsibilities of the site managers, regional engineers and civil authorities

6.6 Safety Measures - Priorities

The safety measures identified above are listed in Table 6.1 and assigned to one of three priority levels (I, II, III).

The proposed Priority levels are:

I - high priority; work to be carried out immediately
II - intermediate; work to be carried out within three years
III - low priority; the need to be kept under review.

Table 6.1 Hauzhan Dam - Dam Safety
Priorities for Studies, Works and Supplies

Item	Studies etc	Construction Works and Supplies		
		Priority I	Priority II	Priority III
1. Surveys (6.2.2)	☐			
2. Investigations on foundation grounds and supporting mass(6.2.3)	☐			
3. Engineering Studies (6.2.4)	☐			
4. Construction Works (6.3)				
• Instrumentation		☐		
• Outlet structure reconstruction and hydromechanical equipment		☐	☐	☐
• Enlargement/deepening of the outlet canal		☐		
• Miscellaneous Repairs		☐	☐	☐
5. Supplies (6.4)				
• Piezometers and deformation monitoring equipment		☐		
• Standby Generator		☐		
• Communications equipment		☐		
• Vehicles		☐	☐	☐
6. Emergency Planning Studies (6.5)	☐			

7 CONCLUSIONS

The IC conclude that on the basis of the information received and a brief inspection, the Hauzhan dam is in a generally satisfactory state. A number of requirements for rehabilitation have been identified, but the principal items to which high priority should be given are:

(a) Installation of piezometers and of a comprehensive deformation monitoring system, and thereafter regular monitoring of pore pressures, deformations and seepages;

(b) establishment of a reliable early warning system for the downstream population in the event of an emergency, supported by an efficient organization and communications system.

(c) Provision of reliable standby generation facilities.

(d) Provision of vehicles for operating staff.

APPENDIX A

HAUZHAN DAM

LIST OF DATA EXAMINED

Hauzhan Dam

Appendix A – List of Data Examined

1. World Bank June Mission, 1997

APPENDIX B

HAZARD ASSESSMENT PROCEDURE

APPENDIX B – HAZARD ASSESSMENT PROCEDURE

Table B1 Classification Factors

	Classification Factor			
Capacity ($10^6 m^3$)	>120 (6)	120-1 (4)	1-0.1 (2)	<0.1 (0)
Height (m)	>45 (6)	45-30 (4)	30-15 (2)	<15 (0)
Evacuation requirements (No of persons)	>1000 (12)	1000-100 (8)	100-1 (4)	None (0)
Potential downstream Damage	High (12)	Moderate (8)	Low (4)	None (0)

Table B2 Dam Category

Total Classification factor	Dam Category
(0-6)	I
(7-18)	II
(19-30)	III
(31-36)	IV

Ref: ICOLD Bulletin 72, (Reference 1)

DRAWINGS