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Interim Report

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1 SUMMARY

This document reports on the rehabilitation of gates and lifting mechanisms at Wadi Tuban and Wadi Zabid.

Both sites were visited early in the project period to assess the overall scope of the work and to review the types of gate in use, their design and their current condition.

The vertical sluice gates, radial gates and lifting mechanisms at Wadi Zabid were designed, manufactured and installed to a high standard. The equipment has been well maintained and is currently in good operational condition. Some of the vertical sluice gates have been damaged due to vandalism.

There is a greater variety of vertical sluice gates, radial gates and lifting mechanisms at Wadi Tuban. The earliest radial gates were designed, manufactured and installed to a high standard. They are still operational but some require new skin plates. Russian designed radial gates and lifting mechanisms were installed in the seventies and are of very heavy construction. Some of the Russian gates and mechanisms were replaced in 1998 with locally made ones. The locally made designs are generally satisfactory; although the standard of fabrication is low.

The majority of the rehabilitation of gates and mechanisms is needed at Wadi Tuban. A condition assessment was undertaken at each of the fourteen main weir structures and individual reports are included in Appendix A. The assessment of the vertical sluice gates on the canal system is ongoing with the total number of gates, at around 2000, being substantially more than expected.

This report comments on the design, installation and condition of the various gate types at both wadis. It further discusses operation and maintenance and proposes a preventive maintenance schedule for Wadi Tuban gates.

Proposals are made for improving the design of both radial and vertical sluice gates and detailed sketches have been provided.

A number of issues need to be resolved: -

- There are differing opinions on the need for adequately sealing radial gates. The new locally made gate seals are poorly designed; the designer does not consider sealing to be important. Irrigation project staff has commented on the large amount of leakage over the top of these gates.
- There are varying degrees of gate rehabilitation and guidance is needed on what is expected.
- Vertical sluice gates can be replaced at high cost or can be repaired to make them operational.
- The heavy Russian gates and mechanisms can be overhauled, completely replaced or provided with new wire rope lifting mechanisms. The lifting mechanisms can be designed using locally manufactured gears or high quality factory built, imported gearboxes similar to those used at Wadi Zabid.

2 INTRODUCTION

This document reports on the rehabilitation of gates and lifting mechanisms at Wadi Tuban and Wadi Zabid.

Both sites were visited early in the project to assess the overall scope of the work and to review the types of gate in use, their design and their current condition.

The PIU Director for the Irrigation Improvement Project at Wadi Zabid, provided copies of the site layout drawings and detail drawings for the gates.

At Wadi Tuban a meeting was held with the Ministry of Agriculture and Irrigation in Aden to discuss the availability of drawings and design information. Detail drawings of the existing gates and technical information were requested and promised. After a long delay some sketches were received..

Two basic types of gate are installed in both irrigation schemes. Radial gates are used in the main weir structures and canal head regulators and vertical sluice gates are installed in the off-takes from the primary and secondary canals. Some main weir structures have a combination of both types of gate. During operation the gates are generally either open or closed. The radial gates at the head regulators may be used in the partially open position to restrict the flow and also reduce the amounts of sediments being carried into the canal.

3 RADIAL GATES

Four different radial gate designs have been used within the Wadi Tuban irrigation scheme:

- Imported radial gates manufactured by Armco were installed on weirs constructed in the early sixties.
- Russian designed gates were installed in weirs constructed during 1971-74.
- Locally designed and manufactured gates were installed under the 1998 Land and Water Conservation Project to replace some of the Russian gates.
- Italian manufactured radial gates designed by American consulting engineers Tipton and Kalmbach were installed at Wadi Zabid around 1976.

Table 3.1 Summary of Gate Details on Main Weir Structures at Wadi Tuban

Location	Radial Gates						Vertical Sluice
	Armco 2.4 m	Armco 3.6 m	Russian 2.4 m	Russian 3.6 m	Local 2.4 m	Local 3.6 m	
Al Arais					2	4	
Ras Al Wadi		1	2		3		2 no. 1.5 x 2.4 2 no. 1.6 x 2.1
Faleg Al Nino				1			1 no. 1.55 x 1.55
Faleg Al Aiad			1	3	1	1	
Al Khabeth							3 no. 1.55 x 1.55
Al Gadid							2 no. 2.1 x 1.7
Al Fakeel				1			1 no. 1.5 x 1.6
Mujahid				3	2	1	
Al Wahat	4						2 no. 2.1 x ?
Beizag	2	4					
Al Taalb							1 no. 1.55 x 1.55
Al Khadram				3	2	1	
Al Bustan			6		4	2	
Al Manasirah							5 no. 3.5 x 1.67
Totals	6	5	9	11	14	9	19

3.1 ARMCO GATES AND LIFTING EQUIPMENT

Armco gates are installed at Beizag Weir, Al Wahat Weir and a single Armco gate is installed on the central intake of Ras Al Wadi.

These are lightweight gates of bolted construction. Two widths of gate have been installed, 8 feet (2.4 m) and 12 feet (3.6 m). The skin plates are about 1/16th of an inch (1.5 mm) thick, galvanized corrugated steel. Three horizontal channel sections behind the skin plate provide lateral stiffening. The backstays are angle sections connected between the horizontal channels and the pivot plate.

Flexible rubber "L" side seals are installed on the upstream face of the skin plate and seal against the smooth concrete surface of the sidewalls. A heavy duty "P" seal is bolted to the bottom of the gate to provide sealing against the concrete apron. A flat rubber sheet seal is bolted to the soffit of the concrete inlet and seals against an angle section bolted across the top of the gate.

The 2.4 m wide gates have a single manually operated lifting winch bolted to the concrete structure above the gate at the gate mid-point. A single wire rope is fitted to eyebolts fixed at the two bottom corners on the front of the skin plate. The wire rope is of sufficient length to form a triangle between the bottom corners and the centre top of the gate.

A second wire rope, wound around the winch drum, drops vertically from the winch drum and is fastened to the gate wire rope near the top of the gate, in front of the skin plate.

The gate-lifting winch is a manually operated worm and wheel drive. The worm is keyed to a vertical shaft. At the upper end a removable hand wheel is fitted for operation of the winch. The lower end of the shaft sits in a thrust bearing. The horizontally mounted drive pinion shaft is directly coupled to the winch drum.

The 3.6 m wide gates have two lifting points close to the vertical edges and are raised by a single winch that drives a horizontal shaft with two wire rope drums attached.

3.1.1 COMMENTS ON THE DESIGN AND INSTALLATION

The gate assemblies are well designed and have been manufactured to a high standard. The lightweight construction enables each gate to be raised by a low capacity winch. The drawback of this design is that the low gear ratio may not sustain the weight of the gate when it is raised. To retain the gate in the raised position the operator can insert a steel bar through the pinion casting holes or as currently observed, a piece of cardboard is inserted between the worm and pinion teeth.

The sidewall concrete is relatively smooth, vertically flat and provides a good surface to seal against. There is a clearance of about 20 mm each side between the skin plate and the sidewalls. The tight clearance ensures that the side seals remain on the upstream side of the skin plates. This provides an effective seal and minimizes the risk of debris becoming trapped between the gates and the sidewalls. No trapped debris was observed during the inspections of this gate type.

A steel rubbing strip would normally be recommended for the side seals to make contact with but in the original installations the sidewalls have generally been constructed to a good dimensional tolerance and with a smooth finish, enabling a good seal to be achieved. The seals are subject to relatively few gate movements so they have little wear and provide an acceptable design life.

The gates and lifting equipment require little maintenance. The steelwork should be painted at 5 yearly intervals; the winch bearings, pivot bearings, gears and wire ropes require annual cleaning and re-greasing.

3.1.2 CURRENT CONDITION

Considering that the gates are about 40 years old they have withstood the harsh conditions very well. There is no sign of physical damage to the skin plates from stones carried in the flash floods. The gates at Al Wahat are still in excellent condition, the gate skin plates at Beizag and Ras Al Wadi have corroded and require replacement; the remaining components are still in good serviceable condition.

The likely cause of corrosion of some skin plates is due to abrasion of the skin plate due to sand and stones carried in suspension in the floodwater. The resulting damage to the paintwork would have left the steel surfaces exposed to corrosion. The weir structures at Ras al Wadi and Beizag are near the top of the wadi and get considerably more exposure to floods than Al Wahat weir, which is the last weir in the wadi.

The relatively good condition of the gates at Al Wahat is due to the use of good quality materials, the high standard of manufacture and installation and infrequent use.

3.2 RUSSIAN DESIGNED GATES AND LIFTING EQUIPMENT

The Russian designed gates are of very heavy-duty construction. Deep section horizontal and vertical stiffeners heavily reinforce the skin plate.

Because of the heavy construction the lifting equipment is equally robust. The gates are lifted by long screw jacks fitted to both ends of the gates. The vertical screws are connected to a horizontal shaft through bevel gears. A further bevel gear box is mounted along the horizontal shaft into which is connected the hand drive. Two shaft couplings and a dog clutch is also incorporated with in the drive system.

3.2.1 COMMENTS ON THE DESIGN AND INSTALLATION

The gates are a stark contrast to the lightweight Armco design. The heavy construction of the gates requires a highly geared system to enable the gates to be manually raised. The combination of gears and screws is very inefficient and it takes many turns of the hand-wind handle to raise a gate. It takes two men to rotate the winding handle during lifting and needs up to five operators taking turns to lift a single gate. The time taken to raise this design of gate is significantly longer than the wire rope operated mechanisms.

3.2.2 CURRENT CONDITION

Lack of maintenance, possibly due to the complex nature of the mechanisms, has led to premature failure of many of the gate lifting systems. Some of the lifting mechanism components are missing or damaged beyond repair. A few individual gate installations are still in operational condition.

Some of the remaining gates are still in good structural condition but the lifting mechanisms are not operational. In these circumstances it may be cost effective to overhaul the lifting mechanisms using spare parts salvaged from other installations. An alternative option would be to design a wire rope lifting mechanism with a suitably sized gearbox to raise a gate in less time.

3.3 LOCALLY DESIGNED GATES AND LIFTING EQUIPMENT

Twenty-six Russian designed radial gates were replaced in 1998 under the Land and Water Conservation Project with locally designed radial gates and associated lifting machinery.

The skin plates are rolled from flat sheet steel and suitably reinforced with three horizontal channel sections. Three angle section backstays are connected between the horizontal stiffeners and the pivot plate on each side. The gates are of bolted construction due to the requirement for galvanized steel plates and sections. Flat rubber sheet seals are fitted to the bottom and sides.

The gates are lifted by two wire ropes attached to a pair of rope drums. The drums are fixed to a horizontal shaft driven by a manually operated worm gear.

3.3.1 COMMENTS ON THE DESIGN AND INSTALLATION

The gates are reasonably well designed, of lightweight construction and have proven to be fit for the purpose. The gates and lifting equipment are based on the early Armco design. The gear ratio is higher because of the slightly heavier construction. An improvement on the Armco winch is the inclusion of a latch mechanism on the drive shaft to hold a raised gate in position.

The fabrication and installation of the gates is of a low standard. The clearances between the gate skin plate sidewalls are excessive.

There are a number of details on these gates that can be improved.

The Armco gates are top sealing. A rubber seal is attached to the soffit of the inlet concrete and seals against an angle section bolted to the top of the gate. The locally designed gates have been designed with a similar angle section detail but no rubber seal has been fixed to the inlet structure. The large gap between gate and structure results in major leakage when water level is above the top level of the gates.

The wire ropes extend down the front face of the skin plate at each end. The ropes pass through holes in the skin plate and are either held in place by a bulldog clamp on the other side of the skin plate or pass back through the skin plate and are clamped to the other part of the rope. This is not good engineering design. The sharp edges of the hole cut into the wire rope, a single bulldog clamp gives insufficient grip to achieve the full wire rope lifting capacity and when the rope is passed back through the skin plate the minimum bend radius of the rope is exceeded.

The sealing angle on top of the skin plate has been cut away to enable the rope to move sideways as a result of spooling onto the rope drum. The cut away section allows increased leakage at these two locations.

As the wire rope spools onto the rope drum the rope moves sideways across the front of the skin plate. The rope fouls the bolt heads on the front of the skin plate.

The plain pivot bearing slides onto the pivot stub cast into the vertical sidewall. To retain the bearing in position a piece of steel rebar is welded across the end face of the stub. This is not good engineering practice, but is effective.

No rubbing strips have been provided for the side seals to contact. There is either a groove in the concrete or a rough concrete finish. The gap is excessive enabling the seal to fold inwards resulting in substantial leakage through the side of the gates.

The lifting machinery has been retrofitted in place of the Russian machinery. The standard of workmanship for this installation work is very poor. Existing steelwork was flame-cut and

new steel welded to the remaining steelwork. In numerous instances the wire ropes foul the steelwork or the concrete; many shaft bearing block fixing bolts and grease nipples are missing.

3.3.2 CURRENT CONDITION

The gates are generally in good operational condition but with the inbuilt poorly designed details described above. The most serious faults with the gates are the poor side and top sealing details. The side seals tend to extrude through from the upstream face due to the excessive clearances between the sidewalls and the skin plate. As well as allowing significant flow through the sides, it also enables debris to enter the gap, which can result in sticking or jamming of the gate. No provision has been made for sealing the top of the gate.

The gate designer's response to the gate sealing criticism was that good sealing was not important for this application. The amount of water leaking through the gates was considered by the designer to be insignificant. This is an issue that needs to be discussed.

With a little more effort it would be possible to eliminate most of the design problems at minimal cost.

3.4 WADI ZABID GATES AND LIFTING EQUIPMENT

The existing gates are about 25 years old. Two radial gate designs are present; top sealing and overflow. The following is a summary of the radial gate sizes: -

- Overflow type: 3.0 m x 1.5 m
  5.0 m x 1.4 m
- Top Seal type: 3.0 m x 1.5 m
  5.0 m x 1.35 m

The skin plate is well reinforced with horizontal and vertical stiffeners and is of welded construction. The backstays are universal column sections and they are bolted to the front assembly.

The gates are hoisted by twin wire ropes attached to a pair of wire rope drums. The drums are mounted on a horizontal shaft driven by an Italian manufactured, two-stage worm gearbox. The gearbox ratios are 3:1 and 50:1 giving an overall ratio of 150:1. A padlock secures the permanently fitted hand-wind handle.

3.4.1 COMMENTS ON THE DESIGN AND INSTALLATION

The design of the radial gates is excellent and cannot be faulted. A great deal of attention has been given to every aspect of the design. The gates were also originally installed to a high standard and have operated satisfactorily for many years.

3.4.2 CURRENT CONDITION

The gate structures are painted with good quality paint providing adequate protection against corrosion. The operating machinery has received similar protection. Several of the gearboxes were observed to be leaking oil although it was not established whether it was a current problem or possibly an oil spillage during refilling.

The overall impression was that the installations were neat, tidy and aesthetically pleasing. The gates were well maintained and in excellent operational condition.

Table 3.2 **Summary of Gates Work on Main Diversion Structures at Wadi Tuban**

Location	Total Number of Gates	Number Installed / Replaced under LWCP	New gate and hoist	New gate Hoists	Repairs
Al Arais	6R	6R			6R
Ras Al Wadi	6R + 4V	3R		2R	6R+4V
Faleg Al Nino	1R + 1V		1V		1R
Faleg Al Aiad	6R	2R		2R	6R
Al Khabeth	3V				1V
Al Gadid	2V				
Al Fakeel	1R + 1V				1R+1V
Mujahid	6R	3R	1R	2R	4R
Al Wahat	4R + 2V		2V		4R
Beizag	6R				6R
Al Taalb	1R + 1V		1V		1R
Al Khadram	12R	3R		6R	12R
Al Bustan	12R	6R		6R	12R
Al Manasirah	5V				5R
Totals	**61R + 19V**	**23R**	**1R+4V**	**18R**	**64R+6V**

4 VERTICAL SLUICE GATES

The vertical sluice gates are generally of simple construction with a reinforced sliding plate retained within a steel frame. The plate is raised by means of a single, manually operated, threaded spindle. Most gates in this category are up to 1.6 m wide.

Two heavy-duty gates are installed in the centre intake of Ras al Wadi and each is raised by a single wire rope driven by a hand-operated winch.

At Wadi Tuban the gates are used to close off the flow of water through rectangular shaped culverts. The gate frames are cast into the concrete and are therefore more difficult to replace than if they were bolted in place as they are at Wadi Zabid.

Four deeper section vertical sluice gates are installed at Ras Al Wadi; a further five large, heavy duty, Russian designed gates are installed at Manasirah Weir. (refer to Appendix A – Wadi Tuban Weir Gate Condition Reports).

4.1 SINGLE SPINDLE GATES

At Wadi Tuban the gates are locally made. The design varies according to the gate size and when it was made. The gate frames are generally steel channel sections, held in place by the surrounding concrete. Angle sections reinforce the gate slide plate.

The spindles are manufactured from carbon steel and machined with a square acme type screw thread. A combined thrust bearing and drive nut is bolted to the frame cross-member for driving the vertical spindle.

The Wadi Zabid gates were manufactured by ATB, Brescia, in Italy. The gates have been mass-produced under controlled factory conditions to a high standard. The gates are designed to seal against a 2 m head of water. The gate slide plate overlaps the frame at the sides, bottom and top to provide a good watertight seal. The frame is fixed to the concrete structure by anchor bolts.

4.1.1 COMMENTS ON THE DESIGN AND INSTALLATION

The Wadi Tuban gate designs do not have a sealing strip on the frame for the top of the gate to seal against; this results in leakage.

Manufacture and installation quality are of a low standard. The criticisms include:

- Poor dimensional accuracy of fabricated components
- Rough flame cutting with sharp edges
- Irregular weld size and quality
- Insufficient stiffening of the frame guides; some gates have buckled and have been pushed inside the culvert by the water pressure.

Notwithstanding the above comments, the designs are simple and reasonably successful. The designs have been developed over the years and the most recent designs are greatly improved.

The materials of construction are adequate and the cost of manufacture is relatively cheap.

The Wadi Zabid gates are better designed and manufactured to a much higher standard. The bolted fixings make replacement of a complete gate a relatively quick and simple task.

The most common cause of failure is from deliberate mechanical damage. Bending of the threaded spindle to stop the gate from being opened or closed is a frequently seen occurrence.

4.1.2 CURRENT CONDITION

At the time of preparing this report only a small percentage of the gates have been inspected. The majority of the gates observed to date have been damaged or are not operational due to missing spindles, missing gate slides or damaged frames.

The total number of vertical gates in the Wadi Tuban area was indicated in the Project Preparation Report and Request for Proposals to be just over 1000. However, a more detailed field check has revealed that there are about 2000 such gates which all have to be inspected.

At the time of issue of this report all the main canal gates have been inspected and work on the distribution canal gates is in progress.

5 OPERATION AND MAINTENANCE

Each major structure has an appointed operator who is based at the weir structure. The gates are normally open or closed according to instructions from the Irrigation Department. Gates are manually operated using a hand-wind handle for radial gates. Hand-wind wheels or “cows horn” type handles are used for vertical sluice gates.

A preventive maintenance programme has been in operation at Wadi Zabid for many years and the current condition of the gates reflects this. After every flood the gates are inspected, cleaned and debris is removed from around the gates.

At Wadi Tuban the Russian built radial gates and the Russian built vertical sluice gates at Mujahid Weir are of heavy construction. The lifting mechanisms are highly geared and it takes longer to raise these types of gate. If the gates have to be raised quickly a team of operators or farmers are used, taking it in turn to wind the gates up.

The gates do not require frequent maintenance and the type of maintenance that is necessary is of a simple nature which unskilled labour can perform. The most common maintenance tasks are greasing of moving parts such as vertical spindles, open gears, wire ropes and bearings. An essential task is the removal of debris from around the gates after each flood. This is not done at Wadi Tuban.

More complicated tasks such as renewing ropes and seals and painting are infrequent and should be undertaken by skilled tradesmen.

Little maintenance has been carried out in the past and it is for this reason that the installations have deteriorated and are in need of rehabilitation.

A recommended preventive maintenance schedule is included in Appendix E.

6 GATE FABRICATION FACILITIES IN YEMEN

A visit was made to the Ministry of Agriculture and Irrigation, Aden. This facility was responsible for the design, fabrication and installation of radial gates at Wadi Tuban in 1998. They had also previously fabricated vertical sluice gates for Wadi Tuban.

The following is a summary of the technical discussions: -

- The facility cannot roll corrugated sheets for replacement of skin plates for Armco gates.
- The welders have received training but do not have formal certification.
- The facility manufactures all gate components including shafts and thrust bearings/nuts.
- The steel plate and sections are purchased from Dubai and are produced to international standards. The steel used for the previous gates was DIN grade St 37 sections and plate grade St 43, shafts were to BS 97081, nuts were bronze SAE 660.
- The radial gates fabricated for LWCP were specified to be galvanized. Because of this the gates were of bolted construction. It would be cheaper to produce welded gates. Galvanized plates and sections were purchased from Dubai. After cutting and drilling, the edges were painted.
- Currently there are no facilities for galvanizing or zinc metal spraying in Aden.
- It is possible for gates to be grit blasted and painted using international standard paints.
- It would be possible in the future to provide wire ropes with crimped terminations.
- Wire ropes used on gates are not galvanized but last for over 7 years.
- 50 – 70% of the production capacity is for gates.

A number of technical questions were asked relating to gear ratios and efficiencies but could not be answered. Drawings of the existing locally made gates and Russian gates were requested and would be provided.

A tour of the manufacturing facilities followed. The machine shop includes a number of machine tools including lathes, universal grinders, cylindrical grinders, radial drill, and a universal mill. The machinery is ex-Russian and was said to be new when installed in the seventies. There was very little activity going on at the time of the visit. It was noted that a number of blank castings for gear pinions were stored in a corner of the machine shop. They are capable of machining worm gears and pinion gears.

The fabrication shop was also quiet with little activity. The fabrication equipment included a 2m wide bending roll, a guillotine and various welding machines. The workshop itself was spacious with an overhead crane.

Some previously fabricated gate frames were stacked up. The standard of fabrication was very poor. The steel channels were corroded and a red primer had been sprayed on top of the rust. The ends of steel sections were flame cut with rough jagged edges, the welding was untidy; weld spatter was prevalent; weld slag was not chipped off.

If the project gates are to be made at this facility the standard of fabrication will have to be raised.

The specification for the gates will be of a higher fabrication standard than the previous gates. It will be essential for the gates to be inspected during manufacture to ensure the quality is acceptable and in accordance with the specification.

7 DESIGN CRITERIA FOR NEW GATES AND LIFTING MECHANISMS

There are a number of important criteria that must be incorporated into the future design of gates for this project.

To achieve cost effective installations the gates will be designed to suit the existing concrete structures. Radial gate overall dimensions will not deviate from the existing gates. The geometry of the sidewalls, pivot bearings and lifting mechanisms is fixed, no major structural modifications will be made.

The gates are used relatively infrequently. There is little justification for designing high quality gates with expensive imported materials. The locally produced gates installed in 1998 have proven to be fit for the purpose and inexpensive to manufacture. Future gate designs shall be based on the existing gates using locally available fabrication facilities and materials.

The ambient conditions in the wadis are hot and dry most of the time and their location is sufficiently distant from the coast to be free from the highly corrosive saline atmosphere found on the coast. The gates do not normally sit in standing water for extended periods. Galvanizing is not considered to be essential for the gates.

Previously the gates were specified to be fabricated from galvanized steel plates and sections. This added to the cost as the materials had to be brought specially from Dubai. The gate construction had to be bolted to avoid extensive damage to the galvanizing, this also added to the cost of the gates. The proposed gates shall be of mainly welded construction.

Some design details on the local gates are not good engineering practice but have been found to work without detrimental effect on the gate operation.

The main cause of gate failure has been due to deliberate mechanical damage by farmers. This is a significant problem that must be resolved. It is impractical and would be too costly to beef-up gate designs to resist vandalism.

Maintenance of the existing gates has not been effectively undertaken in the past and has contributed to premature failure of gates. It would be possible to design almost maintenance free gate installations using expensive materials such as stainless steels and self-lubricating bearings. However it is considered to be more cost effective to introduce a planned maintenance regime for the future.

Protection of steelwork with a paint system is necessary to prolong the life of the gates. If no protection is provided the gates will corrode. The rate of corrosion will vary considerably dependent on location. The gates at the upper reaches of the wadis are often permanently wetted by the base flow. The gates are also subjected to abrasive attack more frequently during floods. Corrosion is more rapid in these areas. Further downstream the structures are less frequently wetted and the ambient conditions are hot and less humid. The gates at Al Wahat are an example of this. Al Wahat is the final structure on the wadi and even though the gates have been installed for 40 years, the gates show no signs of corrosion.

8 PROPOSED STANDARD RADIAL GATES

The radial gates at Wadi Zabid are in good operational condition and do not require replacement.

The proposed standard radial gates for Wadi Tuban will be similar in design to the existing locally produced gates but with the following modifications.

Instead of the wire ropes passing through holes in the front of the skin plate, the ropes shall terminate with a hydraulically crimped clevis and shall then be fixed to a lifting bracket welded to the front of the skin plate. (see Sketch 1 in Appendix C)

The gates shall be mostly of welded construction. The backstay assemblies will be bolted to the horizontal stiffeners to assist installation onto the existing cast-in pivot stubs. The gates shall be grit blasted and painted to a high standard to ensure a minimum 10-year life without recoating.

Welded construction will be cheaper to fabricate. The problem of the wire rope fouling the bolt heads will be overcome.

In place of the welded steel rebar to retain the pivot bearing, the stub should be drilled and tapped to receive two M8 screws. A circular disc can then be fixed to the end of the stub to retain the pivot bearing. (see Sketch 2 in Appendix C)

Side rubbing strips shall be fixed to the sidewalls to improve the side sealing and reduce the amount of debris trapped at the side of the gates. (see Sketch 3 in Appendix C). The side rubbing strips will be adjustable during installation to give accurate clearances between the skin plate and the side-rubbing strip. It will compensate for some of the poor quality, originally constructed civil works.

The gate-lifting machinery should be installed on a factory made base-plate that can be installed on site with the minimum of cutting and welding. The machinery replaces existing Russian machinery. The previous installations were assembled on site and the quality of installation was very poor. Factory built installations should be of a higher quality and should overcome the problem of wire ropes and drums fouling steelwork.

9 PROPOSED STANDARD VERTICAL SLUICE GATES

The design of replacement gates will be heavily influenced by the design of the existing structures.

There are major differences between the gates at Wadi Zabid and Wadi Tuban. At Wadi Zabid the gates are bolted to a concrete structure and are used to seal a circular pipe intake. At Wadi Tuban the guide frames are generally cast into the structure and seal a rectangular culvert.

Replacement gates at Wadi Zabid will be similar in design to the existing vertical sluice gates. The existing gates were imperial sizes; the replacement gates will require fixing hole dimensions to be identical to the original gates.

The cross beam needs to be bolted to the vertical guides to enable the gate slide to be removed.

The original thrust bearing assembly manufactured in Italy can be replaced with a locally manufactured bearing assembly. The cross beam will need to be drilled to suit the different fixing positions.

A sketch of a typical replacement gate for Wadi Zabid is included in Appendix D.

The rectangular culverts at Wadi Tuban have been individually built with larger dimensional tolerances and a wider range of sizes.

Many of the gates are buried under sand or are unable to be operated making it difficult to measure the culvert dimensions during the site inspections.

The specification will need to place the responsibility on the contractor to accurately measure the culverts before manufacture of the gates to ensure that the correct sized gate is installed.

Many of the replacement gates will have to be custom built to suit the existing dimensions. This will add to their cost.
The guide frames are generally 100 x 50 mm channel sections. These have been cast into the concrete with “fish tails” for additional strength. Breaking out the concrete to replace guide frames will entail significant and costly civil works. The existing guide frames should be re-used wherever possible.

The factors mentioned above will place the emphasis on the need for inspection during fabrication and close site supervision if good quality installations are to be achieved. Diligent dimensional checks will have to be made in the workshop and on site.

The proposed standard design is similar to the most recent local design. One improvement is the addition of a sealing plate across the top of the gate. Other proposed differences include the welding of angle stiffeners instead of bolted construction and welding of vertical stiffeners to reinforce the plate edges. Fitting of a rubber seal at the bottom of the gate is not considered to be necessary.

10 COST ESTIMATES

Current costs for gates and gate components have not yet been obtained.

Repair / replacement of gates formed a significant part of the rehabilitation costs for Wadi Tuban as estimated in the Project Preparation Report. This estimate is summarised below:

Gates	**Unit**	**No.**	**Rate**	**Amount**
Replace radial gate + hoist	No.	48	9,000.00	US$432,000
Replace vertical gate + hoist	No.	186	1,100.00	US$204,600
Replace vertical gate hoist	No.	349	750.00	US$261,750
Repair /maintain gate	No.	371	350.00	US$129,850
Total				**US$1,028,200**

The substantial increase in the quantity of vertical gates to be inspected is likely to result in an increase in the number of gates requiring attention. However, it may be feasible to reduce the unit cost of the work by:

(a) Reducing the standard of repair works to one that provides serviceability but does not attempt to provide a design life of, say, 30 years.

(b) Undertaking maintenance works on the gates as part of the ongoing maintenance programme rather than contracting the work. If a mobile welding machine is obtained then the maintenance can be extended to include repair / replacement of some components where no workshop input is required.

11 GUIDELINES FOR FIELD ASSESSMENT OF EXISTING GATES

There are insufficient funds within the project to replace all existing gates. The priority is to rehabilitate the gates at the major weir structures.

Where a gate or its associated lifting mechanism is not currently operational and is considered to be beyond economic repair it will be replaced.

Where a gate or its associated lifting mechanism is in operational condition but in need of maintenance, spare parts or modification, it will be rehabilitated.

Some of the Russian built radial gates and vertical sluice gates (at Mujahid Weir) are either in operational condition or can be repaired and overhauled at minimal cost. These gates take longer to lift than the lighter weight locally produced gates. However it is considered that the cost of replacing all of this type of gates cannot be justified on the basis that new gates will be quicker and easier to operate.

The communication system for advising operators of an impending flood will be improved under this project. It should provide operators with more time to prepare gates. If the time available to raise gates is extended it makes it less important to replace the Russian lifting mechanisms.

To avoid the expense of breaking out guide frames, existing cast-in frames will be used wherever possible providing they are not damaged. A list of major components needed for each gate will be prepared. These components will include the gates slide, threaded spindle, cross beam and thrust bearing assembly.

LIST OF APPENDICES

A. WADI TUBAN WEIR GATE CONDITION REPORTS

A 1. AL ARAIS

A 2. RAS AL WADI

A 3. FALEG AL NINO

A 4. FALEG LADH

A 5. AL KHABT

A 6. AL FAQIH

A 7. MUJAHED

A 8. AL-WAHT

A 9. BEIZAG

A10. AT THALAB

A11. AL KHADARAM

A12. AL BUSTAN

A13. AL MANASIRA

A14. AL-GADID

WADI TUBAN GATE DETAILS – Location Of Structure: Al Arais Weir
Number/Type of gates: 6 no. radial gates
Description of gates: The weir was originally constructed in 1972 with Russian designed gates. All 6 no. gates were replaced with locally made gates in 1998. Four gates are 3.6m wide x 1.52m high the other two gates are 2.4m wide x 1.4m high. The original lifting machinery was replaced with wire rope winches.
Condition of Gates and Lifting Machinery: The two smaller gates do no fully close due to the wire rope being too short. One of the smaller gates needs a new sill beam; there is currently a large gap under the gate on one side. The side seals on all gates have extruded through and there is debris trapped in the gaps. The wire ropes foul the bolt heads on the skin plate. The wire ropes and drums foul the lifting machinery steelwork in places. Paint is flaking off the lifting machinery. The 6 no.gates and lifting mechanisms are in operational condition and only require minor remedial works.
Recommended Rehabilitation Works: All gates: Fit side rubbing plates to reduce trapped debris and improve sealing. Provide new wire ropes of sufficient length to leave 3 spare turns on drum when gate is fully lowered. Fit new side seals. Fit top seal to built in steel beam, if agreed. Grind back steelwork locally on lifting frames where it fouls wire ropes and drums. Re-paint lifting machinery. Fit guards over open gearing. Gate no. 2: Install new sill beam for gate to seal against.
Cost Estimate:

Photographs of Al Arais Weir:

WADI TUBAN GATE DETAILS – Location Of Structure: Ras Al Wadi Weir

Number/Type of gates: Right Bank: 5 no. radial gates
Centre Intake: 1 no. radial gate and 4 no. vertical sluice gates

Description of gates:

Right Bank: Was constructed around 1980 with Russian designed gates. All five radials are 2.4m wide x 1.55m high x 2m radius. Three of the radial gates were replaced with locally made gates and lifting mechanisms in 1998.

Centre Intake: Appears to be older maybe early sixties. The radial gate has a corrugated skin plate similar to Armco gates installed at that time. It is 3.54m wide x 1.9m high x 1.9m radius. The gate is raised by two wire ropes attached to a pair of drums horizontally mounted and manually operated by a worm gear.

The vertical sluice gates are 1.5m wide x 2.4m high (2 no.) and 1.6m wide x 2.1m high (2 no.). The two 2.4m high gates are raised by means of a single wire rope driven by a worm gear winch with a single wire rope drum. A central threaded spindle raises the other two gates.

Condition of Gates and Lifting Machinery:

Right Bank: The two remaining Russian gate operating machinery is not operational and need to be replaced. The three locally made gates are in operational condition but in need of some minor improvements.

Centre Intake: The radial gate (gate no.3) needs a new skin plate; the rest of the structure and lifting mechanism is sound.
Vertical gate no.1 (furthest from right bank) has a damaged sill plate that needs repair.
Part of gate no.2 was buried in sand; the visible part looked in good condition. Gates 1 and 2 need new wire ropes.
Gate no.4 has a missing lifting spindle otherwise appears to be operational.
Gate no.5 has a damaged spindle; otherwise appears to be operational.

Recommended Rehabilitation Works:

Right bank: Replace the two Russian lifting mechanisms with wire ropes and hand operated winches.
Install side-rubbing strips to the sidewalls of all five radial gates.
New side and bottom seals for the three local gates.
New top seals for all five gates, if agreed.
Guards over the gearing for all five lifting mechanisms.
Centre Intake: Repair sill beam to gate no.1, new wire ropes for gates 1 & 2, new skin plate for gate no.3, new spindles for gates 4 & 5.

Cost Estimate:

Photographs of Ras al Wadi Weir:

WADI TUBAN GATE DETAILS – Location Of Structure: Faleg Al Nino Weir

Number/Type of gates: 1 no. radial gate
1 no.vertical sluice gate

Description of gates:

The Russians constructed the control structure around 1974.

Radial Gate: The gate is retained within grooves cast into the sidewalls. Dimensions are 3.62m wide x 1.45m wide x 1.52m radius. A single winch drives a horizontal shaft with two wire rope drums. The wire rope is a single rope that passes from one drum down to the top of the gate across the gate and up to the other drum. The gate is of solid construction and is structurally sound.

Vertical Sluice Gate: Nominal dimension are 1.52m wide x 1.55m high. 50mm shaft diameter, 3.85m shaft length, height from bottom of gate to top of concrete structure is approx 4m. The gate is installed over a rectangular culvert. Poor quality local manufacture.

Condition of Gates and Lifting Machinery:

Radial: No maintenance has been carried out for a considerable time. No drain holes in lower horizontal stiffener resulting in trapped sediments and corrosion of the skin plate. The wire rope was broken and was temporarily fixed on one side only to enable it to be lifted. The rope fouls the concrete. The open mesh grating under the winding mechanism was missing.

Vertical Sluice: The gate appeared to be in good operational condition. The shaft was well lubricated.

Recommended Rehabilitation Works:

Radial: Overhaul winch gearbox, refill with grease. Provide new wire rope with sufficient length for three spare turns on rope drums when gate is fully lowered. Wire rope to be correctly clamped at rope drums. Replace missing floor grating. Provide large diameter drain holes in lower horizontal stiffener. Replace top, bottom and side seals. Grit blast and repaint. Lubricate pivot bearings.

Vertical Sluice: Remove existing gate and frame and replace complete assembly.

Cost Estimate:

Photographs of Faleg Al Nino Weir:

WADI TUBAN GATE DETAILS – Location Of Structure: Faleg Al Aiad Weir

Number/Type of gates: 6 no. radials

Description of gates:

The Russians built the weir in 1971. It has two smaller gates 2.4m wide x 1.58m high x 1.92m radius and four larger gates 3.57m wide x 1.39m high x 1.55m radius. One large gate and one of the smaller gates were replaced in 1998 with locally made gates and lifting machinery. The original Russian gates are of very heavy construction. The lifting machinery is similarly very heavy and highly geared taking a considerable time and effort to raise the gates.

The lifting equipment for the replacement gates comprises of a manually operated worm gear connected to a horizontal shaft fitted with two wire rope drums. The wire ropes connect to the front of the gate. The same size winch is used for both gate sizes. (500mm dia. Pinion, 140mm drum width, 120mm drum dia. 60mm dia. shaft, 13mm dia. wire ropes)

Condition of Gates and Lifting Machinery:

The remaining Russian gates and associated lifting machinery appear to be in operational condition. The bottom of the gates is embedded in sand and stones and is currently unable to be moved. The locally made gates are in good operational condition although one of the wire ropes on the smaller gates is damaged.

Recommended Rehabilitation Works:

Russian gates: Remove all sand and stones from around bottom of gates. Make large diameter holes in bottom stiffeners, fit new side and bottom seals, remove local areas of corrosion and repaint gates. Completely overhaul lifting mechanisms or alternatively replace the mechanisms with wire ropes and winches.

Local gates: Replace broken wire rope; install guards over open gears.

Cost Estimate:

Photographs of Faleg Al Aiad Weir:

WADI TUBAN GATE DETAILS – Location Of Structure: Al Khabet Weir
Number/Type of gates: 3 no. vertical sluice gates
Description of gates: Nominal dimensions: 1.55m wide x 1.55m high. Standard vertical spindle design. Installed within last 5 years.
Condition of Gates and Lifting Machinery: The three gates are in operational condition. One gate has a slightly bent spindle. The thrust bearing fixing bolts on one side do not align with the cross member and have not been drilled. Poorly designed and installed.
Recommended Rehabilitation Works: Straighten the bent spindle. (1 no. gate) Replace thrust bearing retaining plates, properly drilled to suit cross beam.
Cost Estimate:

Photographs of Al Khabet Weir:

WADI TUBAN GATE DETAILS – Location Of Structure: Al Fakeel Weir

Number/Type of gates: 1 no. radial gate
1 no. vertical sluice gate

Description of gates:

Radial: Nominal dimensions: 3.6m wide x 1.5m high x 1.44m radius. The gate was locally made and installed within the last 5 years. The gate is raised by two wire ropes attached to drums mounted on a horizontal shaft driven by a manually operated worm gear winch.

Vertical Sluice: Nominal dimensions: 1.5m wide x 1.6m high. Standard vertical spindle design. Recently installed.

Condition of Gates and Lifting Machinery:

The radial gate and winch are in good operational condition. The side seals are extruded through the side gaps. There is a variable tapered side gap on both sides. The sidewalls do not appear to be vertical.

The water pressure has pushed the vertical sluice gate inside the culvert, distorting the gate slide, buckling the guide frame and bending the spindle. The angle side guides were not welded adequately or supported sufficiently and have collapsed under the water pressure.

Recommended Rehabilitation Works:

Radial: Install side rubbing strips to the sidewalls, fit a guard over the open gears, fit new grease nipples (3 no.)

Vertical Sluice: Remove the gate slide plate, angle guides inside the channel guides, top cross beams and spindle. Weld new angle guides inside the channel guides as per the drawing for the standard replacement gate. Straighten the spindle and re-use if possible. Fit new slide plate and cross beams(as per standard design). Ensure that the existing guide channels are completely encased in concrete over the three sides.

Cost Estimate:

Photographs of Al Fakeel Weir:

WADI TUBAN GATE DETAILS – Location of Structure: Mujahid Weir

Number/Type of gates: 6 no. radial gates

Description of gates:

The Russians constructed the weir in 1971. Two smaller gates 2.4m wide x 1.58m high x 1.92m radius and four larger gates 3.57m wide x 1.39m high x 1.55m radius. One of the larger gates and both of the smaller gates were replaced in 1998 with locally made gates and lifting mechanisms.

Condition of Gates and Lifting Machinery:

Smaller gates (nos. 5 and 6) appear to be in good operational condition although gate no.6 is partially buried in deep sand and cannot be lifted. The worm gear for gate no. 6 has been slightly damaged, possibly overloaded.
Gate no.4 (Russian design) is not operational and has not been maintained and is beyond repair. The concrete close to the lifting mechanism has been damaged and needs repair. Gates 2 and 3 (Russian) are in operational condition but in need of maintenance. The bevel gearbox cover plates are missing. The gates currently cannot be fully raised as the gates foul the sidewalls. The threaded rod that lifts the gates also fouls the concrete. Gate no. 1 (local) is operational, a guard has been installed over the open gears.

Recommended Rehabilitation Works:

Gates 2 and 3: Completely overhaul lifting mechanisms, make large holes in lower horizontal stiffeners, adjust gates to enable them to lift fully, remove concrete locally as required.
Gate 4: Remove existing gate and lifting mechanism, repair concrete, install new locally made gate and lifting machinery.
Gates 5: Fit cover to open gears. Gate 6: Repair worm gear assembly, fit cover to open gears.
Install side-rubbing strips to all gates. Fit new seals and new wire ropes.

Cost Estimate:

Photographs of Mujahid Weir:

WADI TUBAN GATE DETAILS – Location Of Structure: Al Wahat Weir

Number/Type of gates: 4 no. radial gates
2 no. vertical sluice gates

Description of gates:

The weir was constructed in 1963. British made Armco radial gates were installed. The nominal dimensions are imperial sizes:8' x 4'6" x 5' (2.4m wide x 1.4m high x 1.5m radius). The radial gates have lightweight corrugated skin plates. The lifting mechanism is a single worm gear driving a wire rope drum with a single point of lift for each gate.

The vertical sluice gates are 2.1m wide. The depth could not be measured as the gates are buried in sand.

Condition of Gates and Lifting Machinery:

The radial gates and lifting mechanisms are in good operational condition. The vertical sluice gates are buried in sand. The crossbeam has buckled.

Recommended Rehabilitation Works:

The lifting mechanisms need to be overhauled and cleaned. New guards and grease nipples are required for the winches.

The vertical sluice gates need to be replaced with new gates. (Need to review if these gates are necessary).

Cost Estimate:

Photographs of Al Wahat Weir:


ADEH
MOCKBA

WADI TUBAN GATE DETAILS – Location Of Structure: Beizag Weir

Number/Type of gates: 6 no. radial gates

Description of gates:

The weir was constructed around 1965. Armco gates with corrugated steel skin plates were installed. Four gates are 12 feet wide (3.6m), the other two gates are 8 feet wide (2.4m). The smaller gates have a single wire rope lifting winch, the larger gates have twin wire ropes. The lifting mechanisms are the original Armco winches.

Condition of Gates and Lifting Machinery:

The corrugated skin plates on all six gates have deteriorated due to corrosion. The smaller gates have small holes near the bottom of the gates, the larger gates are in worse condition; they have large holes filled with trapped debris. The gate frames and pivots are in good condition and can be re-used. The side, top and bottom seals need replacement. The wire ropes should be replaced.

The lifting machinery is generally in good operational condition on all six gates. The side flange plate on gate 1 (nearest operators building) winch drum is broken but it does not affect the operation of the winch. A sheet steel guard has been fitted over gate no.5 winch, which gives protection to the open gearing. No safety latches are fitted to the gears. To avoid run-back, the operator inserts a piece of cardboard between the worm and pinion and this is effective. An alternative method is to insert a bar through the pinion holes.

Recommended Rehabilitation Works:

All gates: Existing corrugated skin plates, side seals, top seals, bottom seals and wire ropes to be replaced.

Gates 1,2,3,4 and 6 require sheet steel guard fitted over open gears.

Cost Estimate:

Photographs of Beizag Weir:

WADI TUBAN GATE DETAILS – Location Of Structure: Canal Al Taalb

Number/Type of gates: 1 no. radial gate
1 no. vertical sluice gate

Description of gates:

Radial Gate: Nominal dimensions are 3.62m wide x 1.45m high x 1.52m radius. The gate is Russian built and was installed in the early seventies. A single winch drives a horizontal shaft with two wire rope drums. The wire rope is a single rope that passes from one drum down to the top of the gate across the gate and up to the other drum. The winch is of Russian origin. The gate is of heavy solid construction.

Vertical Sluice Gate: Nominal dimension are 1.52m wide x 1.55m high. 50mm shaft diameter, 3.85m shaft length, height from bottom of gate to top of concrete structure is approx 4m. The gate is installed over a rectangular culvert. Poor quality local manufacture.

Condition of Gates and Lifting Machinery:

Radial: The gate was jammed in the raised position due to debris being trapped between the top of the gate and the concrete structure. No maintenance has been carried out for a considerable time. No drain holes in lower horizontal stiffener resulting in trapped sediments and corrosion of the skin plate. The gate is structurally sound and the winch was said to be in operational condition

Vertical Sluice: The gate was almost completely buried in sand and could not be moved. The operator reported that when water pressure is applied to the front of the gate the gate distorts and is pushed inside the culvert. The horizontal support at the top of the frame is distorted, so too are the thrust bearing retaining plates.

Recommended Rehabilitation Works:

Radial: Overhaul winch gearbox, refill with grease. Provide new wire rope with sufficient length for three spare turns on rope drums when gate is fully lowered. Wire rope to be correctly clamped at rope drums. Replace missing winch fixing bolt. Replace broken grease nipple on one pivot bearing. Provide large diameter drain holes in lower horizontal stiffener. Replace top, bottom and side seals. Mechanically clean corroded paintwork and repaint.

Vertical Sluice: Remove existing gate and frame and replace complete assembly.

Cost Estimate:

Radial:
Vertical Sluice:

Photographs of Al Taalb:

WADI TUBAN GATE DETAILS – Location Of Structure: Al Khadram Weir

Number/Type of gates: Left Canal: 6 no. radial gates
Right Canal: 6 no. radial gates

Description of gates:

The Russians built the weir in 1972. The left canal weir and right canal weir are identical. Both have two smaller gates 2.4m wide x 1.58m high x 1.92m radius and four larger gates 3.57m wide x 1.39m high x 1.55m radius. The two smaller gates and one larger gate and associated machinery were replaced in 1998 with locally manufactured gates and mechanisms.

The original Russian gates are of very heavy construction. The lifting machinery is similarly very heavy and highly geared taking a considerable time and effort to raise the gates. The remaining Russian gates and associated lifting machinery are no longer operational. The lifting equipment for the replacement gates is also locally manufactured. A manually operated worm gear connected to a horizontal shaft fitted with two wire rope drums is used for lifting the gates. The same size winch is used for both gate sizes. (500mm dia. Pinion, 140mm drum width, 120mm drum dia. 60mm dia. shaft, 13mm dia. wire ropes)

Condition of Gates and Lifting Machinery:

The three remaining original gates and machinery at both weirs are not operational the machinery needs to be replaced. The three locally made gates at both weirs are in operational condition but require some modifications to improve their effectiveness

The side seals should be renewed. Side rubbing strips are required. There are no top seals.

Recommended Rehabilitation Works:

Provide 3 no. new lifting mechanisms at each weir. Provide guards for the 6 no. existing winch gears. Provide side-rubbing strips for 12 no. gates.

Cost Estimate:

Photos of Al Khadram Weir:


СССР-РОВУ

WADI TUBAN GATE DETAILS – Location Of Structure: Al Bustan Weir

Number/Type of gates: Left Canal: 6 no. radial gates
Right Canal: 6 no. radial gates

Description of gates:

This weir is virtually identical to Al Khadram weir.

The Russians completed the weir in 1973. The left canal weir and right canal weir are identical. Both have two smaller gates 2.4m wide x 1.58m high x 1.92m radius and four larger gates 3.57m wide x 1.39m high x 1.55m radius. The two smaller gates and one larger gate and associated machinery were replaced in 1998 with locally manufactured gates and mechanisms.

The original Russian gates are of very heavy construction. The lifting machinery is similarly very heavy and highly geared taking a considerable time and effort to raise the gates. The remaining Russian lifting machinery is no longer operational. The lifting equipment for the replacement gates is also locally manufactured. A manually operated worm gear connected to a horizontal shaft fitted with two wire rope drums is used for lifting the gates. The same size winch is used for both gate sizes. (500mm dia. pinion, 140mm drum width, 120mm drum dia. 60mm dia. shaft, 13mm dia. wire ropes)

Condition of Gates and Lifting Machinery:

The three remaining original gates and machinery at both weirs are not operational the machinery needs to be replaced. The three locally made gates at both weirs are in operational condition but require some modifications to improve their effectiveness.

The backstays are slightly damaged on one of the smaller gates.

The side seals should be renewed. Side rubbing strips are required. There are no top seals.

Recommended Rehabilitation Works:

Provide 3 no. new lifting mechanisms at each weir. Provide guards for the 6 no. existing winch gears. Provide side-rubbing strips for 12 no. gates.

Cost Estimate:

Photographs of Al Bustan Weir:

WADI TUBAN GATE DETAILS – Location Of Structure: Al Manasirah Weir

Number/Type of gates: 5 no. Vertical sluice gates

Description of gates:

The gates are of very heavy construction. Nominal dimensions are 3.5 m wide x 1.67 m high. Deep section horizontal and vertical stiffeners reinforce the front skin plate. Rollers are fitted at the side of the four corners to take the thrust from the water pressure. A further four rollers attached to the back corners of the gate provide lateral constraint. The gates are raised and lowered by a pair of threaded bars fixed at the top corners of the gates. A horizontal shaft through a bevel gear drives the threaded bars. A further bevel gearbox is installed between the hand wind input shaft and the horizontal shaft.

Condition of Gates and Lifting Machinery:

The gates are structurally in good condition. Three of the gates are in operational condition but have not been well maintained. The two other gates needs some spare parts for the lifting mechanism.

Recommended Rehabilitation Works:

It requires significant effort and time to raise these gates due to their heavy construction. However in view of the infrequent operation and the location (it is the final weir in the wadi and gets the least water) the most cost effective solution may be to overhaul the gates. Each gate requires new side, top and bottom seals, the roller wheels need to be stripped down and lubricated, the bevel gearboxes should be drained, cleaned, refilled with oil and new cover plates fitted, the threaded shafts should be cleaned and re-greased, replacement parts i.e. drive shaft, gears, shaft covers could be salvaged from other installations where possible or manufactured. The gates should be repainted as necessary.

Cost Estimate:

It is assumed that some spare parts for the lifting mechanisms will be obtainable from other installations that are being scrapped. Most of the rehabilitation work is manual.

Photographs of Al Manasirah Weir:

WADI TUBAN GATE DETAILS – Location Of Structure: Al Gadid Intake
Number/Type of gates: 2 no. vertical sluice gates
Description of gates: Nominal gate dimensions are 2.1m wide x 1.7m high. The gates are retained within a 100 x 50 channel section frame and have a 4mm skin plate reinforced by bolted angle sections.
Condition of Gates and Lifting Machinery: The gates are relatively new. The design is acceptable. The quality of fabrication is satisfactory. The thrust bearing assembly is more compact than those previously seen. Spacer tubes have been fitted over the bolts between the retaining plates to avoid over compression and bending of the plates. The bottom seal is too long and unnecessary as the other sides do not have seals.
Recommended Rehabilitation Works: The gates do not require any rehabilitation work.
Cost Estimate: Nil

Photos:

B. SPECIFICATION FOR VERTICAL SLUICE GATE

B.1 MATERIALS OF CONSTRUCTION

The door, frame and associated brackets shall be fabricated from mild steel plates and sections. The spindle shall be manufactured from medium carbon steel. The nut shall be manufactured from phosphor bronze.

The chemical composition, physical properties and dimensional tolerances of the mild steel plates and sections and carbon steel bar shall comply with recognised international standards.

Material certificates shall be provided to confirm compliance with international standards.

Materials and thread forms for nuts, bolts and washers shall comply with international standards, Nuts bolts and washers shall be galvanised.

B.2 WELDING

Plates and sections shall be welded as indicated on the contract drawings.

Welding shall be by manual metal arc method. All welds shall be 5 mm continuous fillet welds unless otherwise stated.

Welding procedures shall be designed to avoid excessive thermal stress and distortion of the metal plates and sections.

Welding slag and weld spatter shall be completely removed from the welds and metal surfaces.

B.3 FABRICATION

The edges of plates and sections shall be straight and square, sharp edges and burrs shall be removed.

Unless otherwise stated general fabrication tolerances shall be: -

- For dimensions below 1000 mm: $\pm$1 mm
- For dimensions of 1000 mm or above: $\pm$2 mm

B.4 PROTECTIVE TREATMENT

On completion of fabrication the gates shall be grit blasted and painted with a protective system that will provide a 10-year life without major maintenance. The proposed protective treatment shall be obtained from an international paint manufacturer and submitted to the Engineer for approval.

The proposed protective treatment shall include for site-applied paint treatment after completion of site installation works.

B.5 INSPECTION AND TESTING

The fabricator shall undertake dimensional checks of the gate components during fabrication and shall keep records of the checks. The records shall be made available for inspection by the Engineer.

On completion of a gate assembly, the gate shall be erected in the upright position and operated over its full range. The sealing faces shall be checked to ensure compliance with the design tolerances. The spindles shall be grease lubricated prior to gate operation. Access shall be provided for the gate inspector to operate the lifting mechanism.

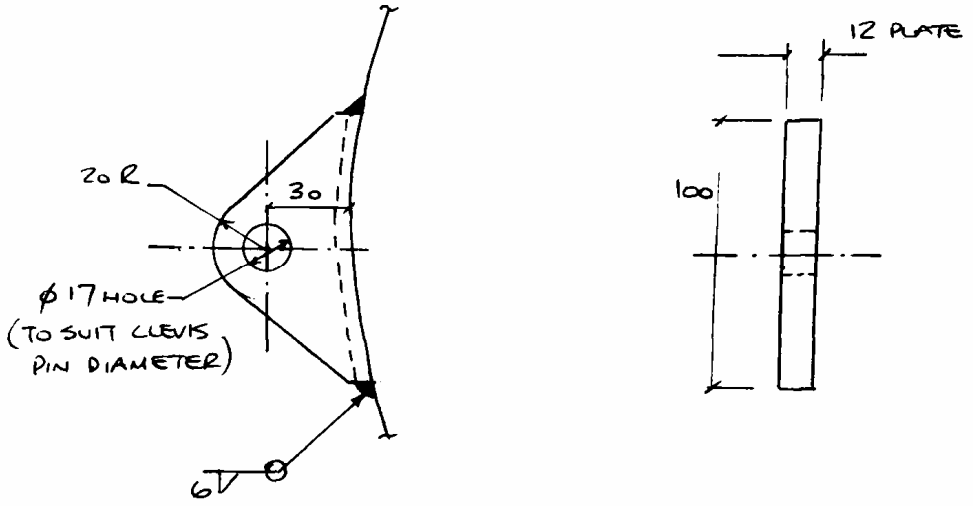
B.6 SITE INSTALLATION

The Contractor shall submit a method statement for site installation works.

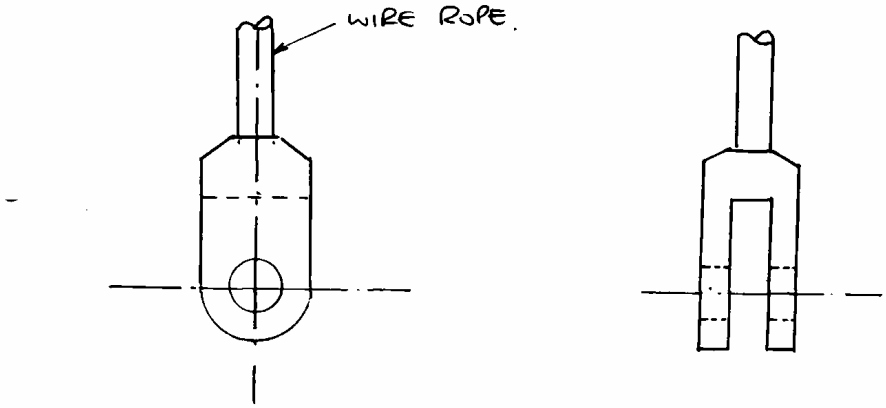
Existing guide frames shall be used wherever possible.

Site welding will be strictly in accordance with the drawings.

C. STANDARD RADIAL GATE DETAILS

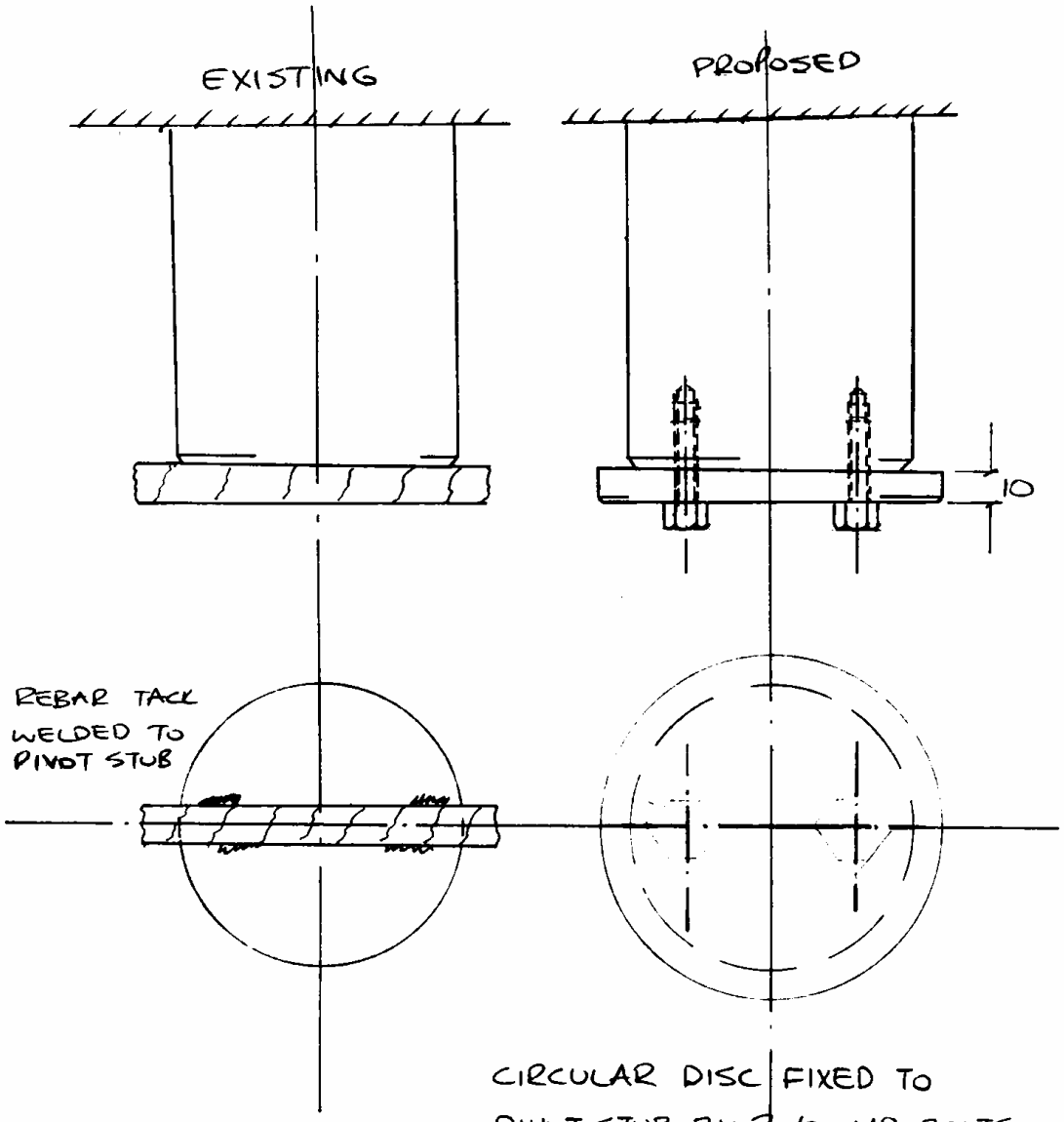


LIFTING POINT FOR WIRE ROPE (2 NO. PER GATE)

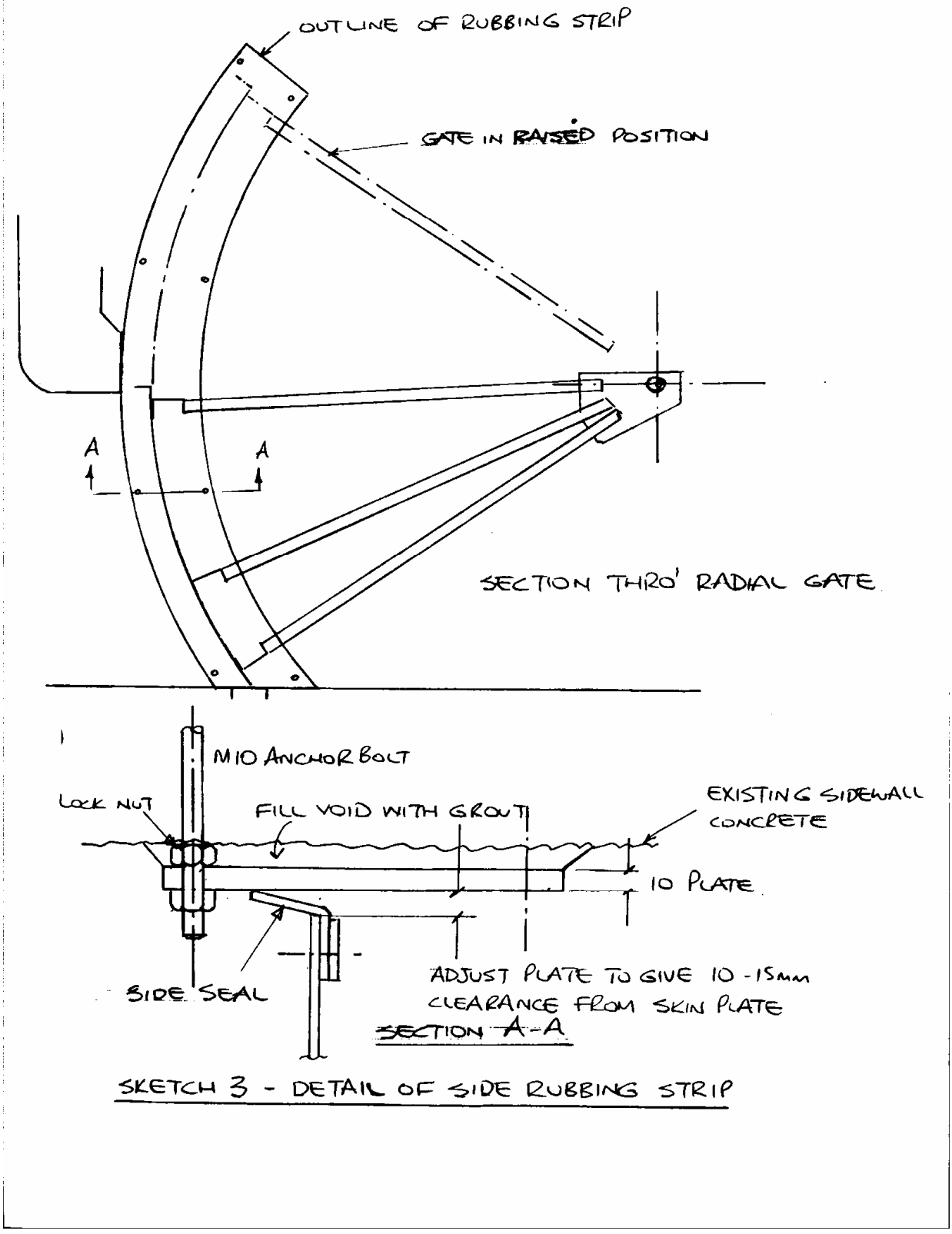


CLEVIS FOR FIXING WIRE ROPE TO GATE.
(INDICATIVE ONLY - NOT TO SCALE)

SKETCH 1



SKETCH 2 - PIVOT STUB RETAINER



SKETCH 3 - DETAIL OF SIDE RUBBING STRIP

D. STANDARD VERTICAL SLUICE GATE DETAILS

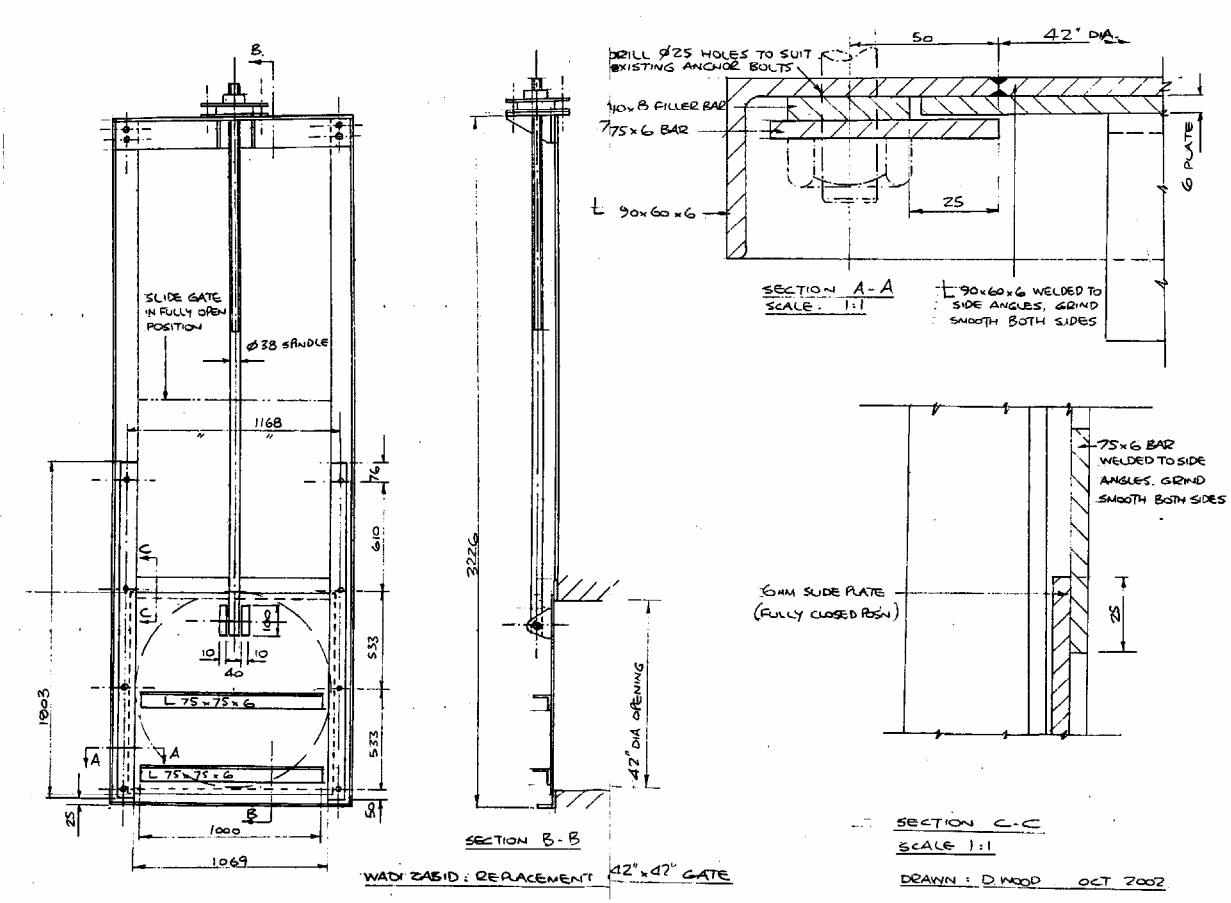


Figure 1 Sketch 1: Replacement 42” x 42” Vertical Sluice Gate for Wadi Zabid

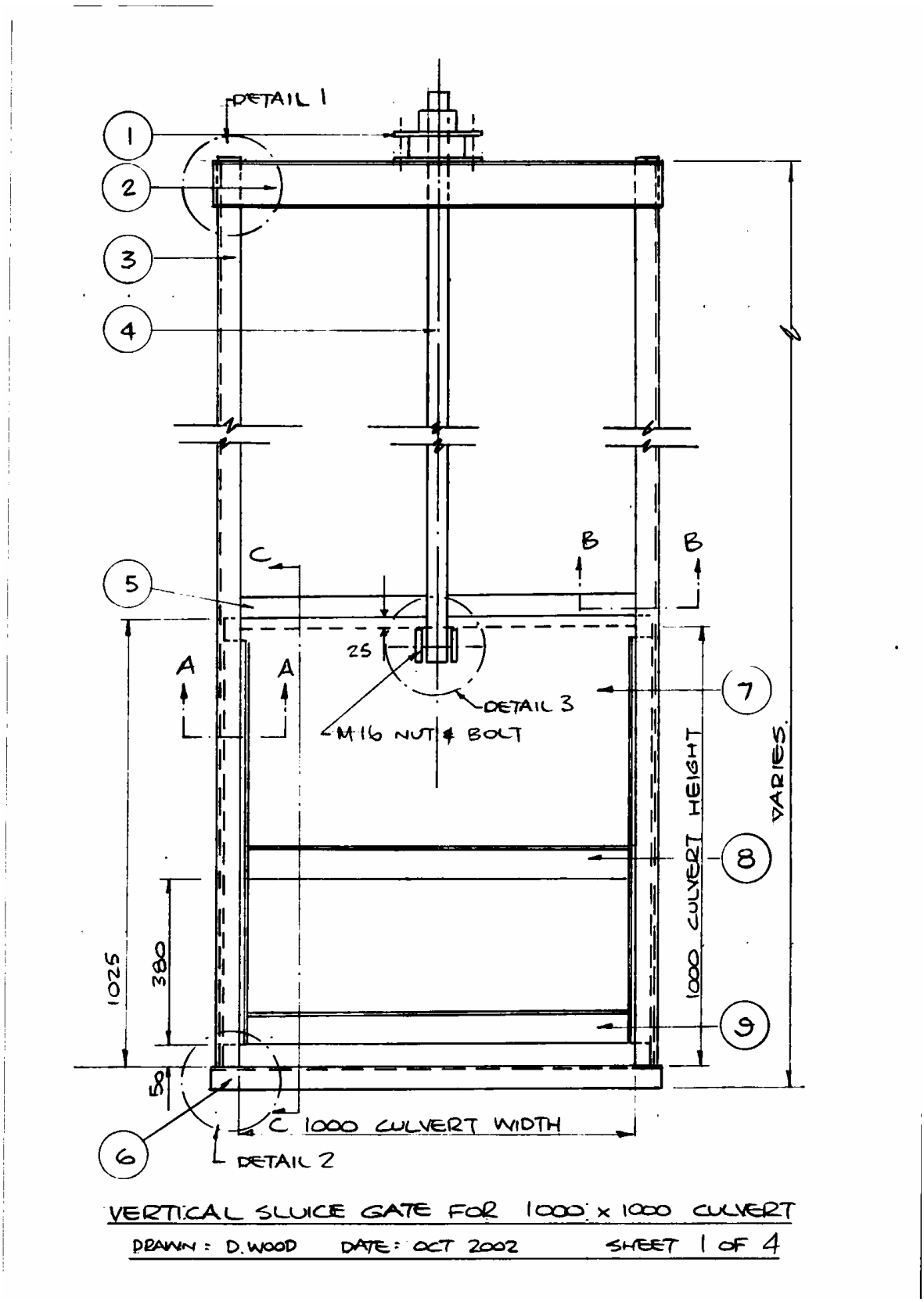
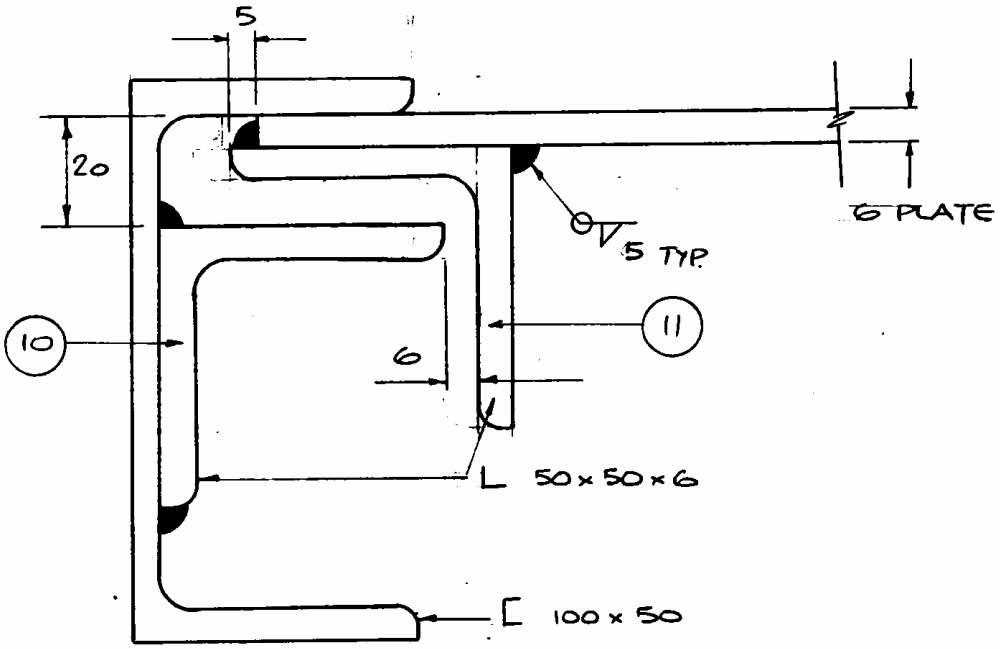
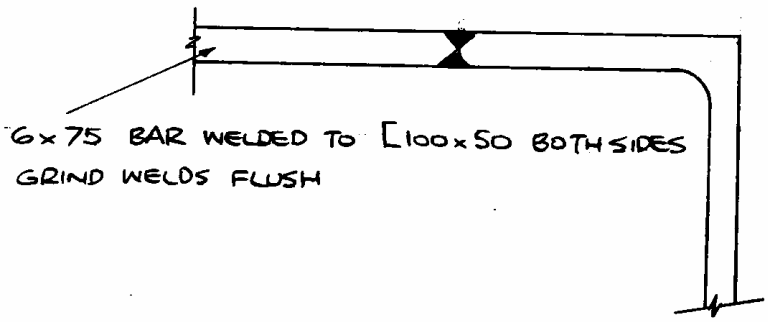


Figure 2a Replacement 1000 x 1000 Vertical Sluice Gate for Wadi Tuban, sheet 1 of 4



SECTION A-A
SCALE: 1:1



SECTION B-B
SCALE: 1:1

SHEET 2 OF 4

Figure 2b Replacement 1000 x 1000 Vertical Sluice Gate for Wadi Tuban, sheet 2 of 4

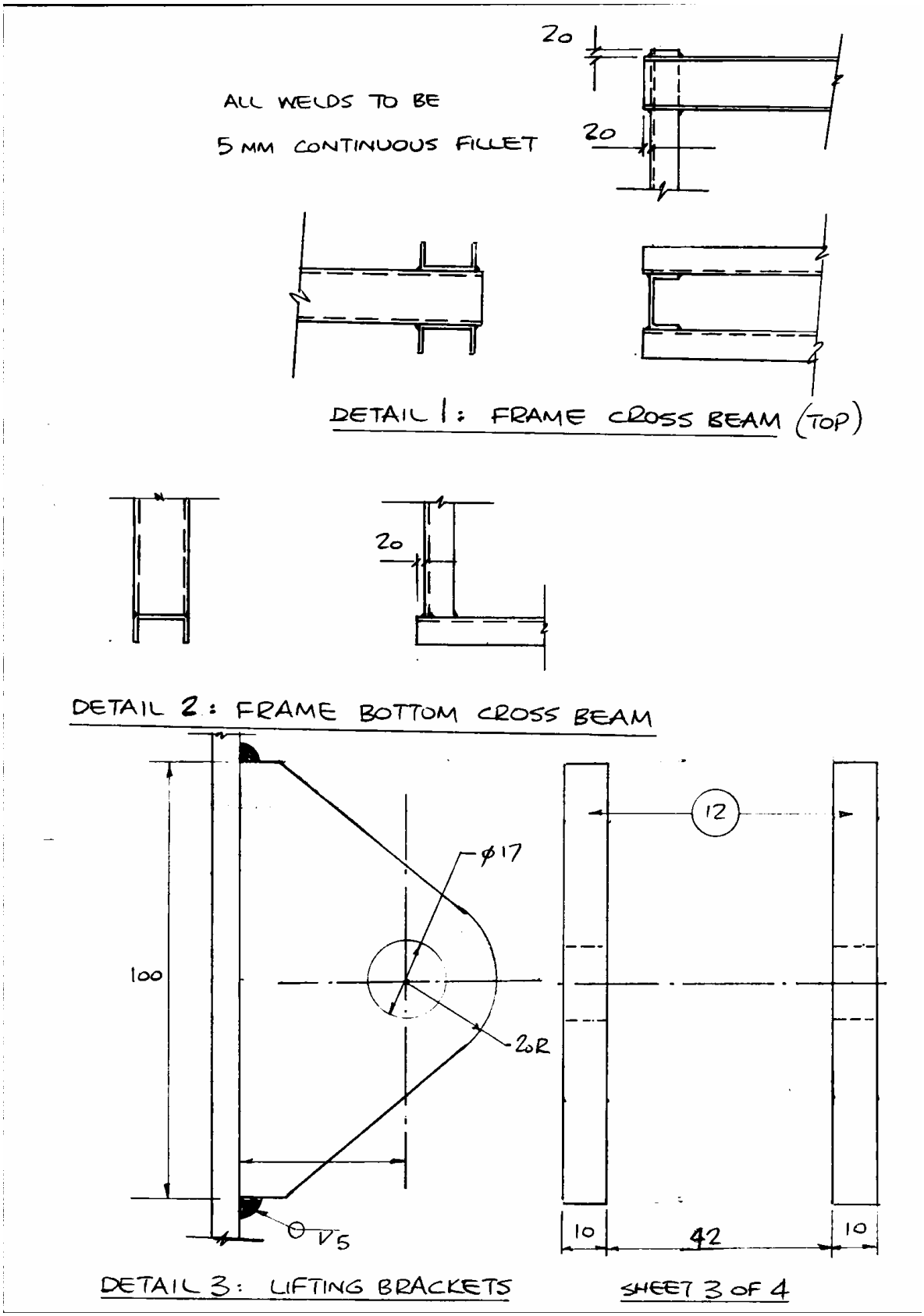
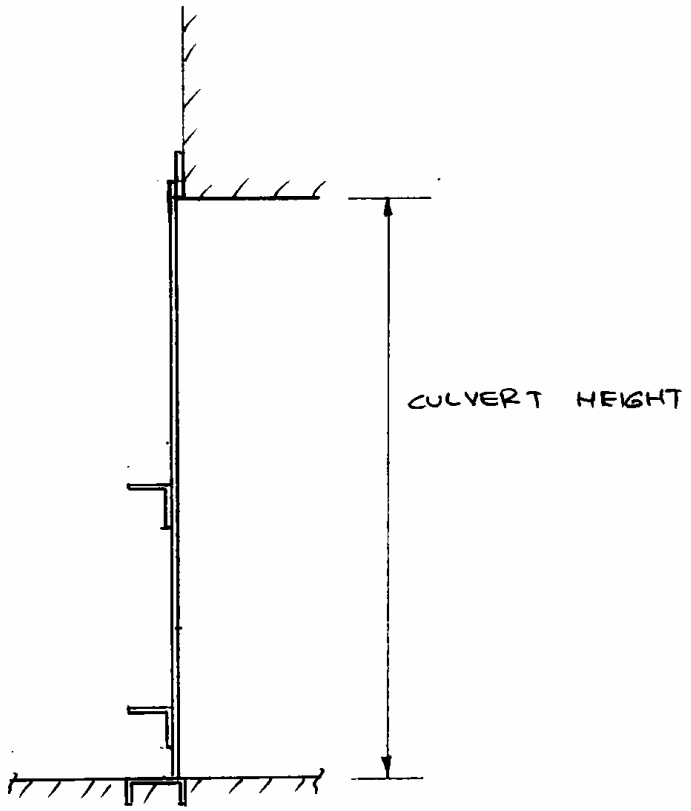


Figure 2c: Replacement 1000 x 1000 Vertical Sluice Gate for Wadi Tuban, sheet 3 of 4

SHEET 4 OF 4



SECTION C-C

ITEM	DESCRIPTION
1	THRUST BEARING/NUT ASSEMBLY
2	100 x 50 CHANNEL
3	100 x 50 CHANNEL
4	ø 40 SPINDLE
5	6 x 75 BAR
6	100 x 50 CHANNEL
7	6 PLATE
8	75 x 75 x 6 ANGLE
9	75 x 75 x 6 ANGLE
10	50 x 50 x 6 ANGLE
11	50 x 50 x 6 ANGLE
12	10 PLATE LIFTING BRACKETS.

Figure 2d: Replacement 1000 x 1000 Vertical Sluice Gate for Wadi Tuban, sheet 4 of 4

E. PROPOSED PREVENTIVE MAINTENANCE SCHEDULE

Frequency	Task
After every flood	Visually inspect gate structure and seals for damage and report any damage to the supervisor
	Remove debris, mud and stones from gate structure, side seals, bottom seals, wire ropes and pivot bearings
	Remove build up of sand and mud from in front of and behind the gate. Ensure the gate is able to seal effectively on the sill beam.
Annually	All of the above checks
	Clean and lubricate wire ropes, worm and pinion gears, threaded spindles
	Apply grease to grease nipples on support bearings, thrust bearing, pivot bearings
	Top up oil in bevel gearboxes
	Visually inspect wire rope fixings and ensure they are secure
	Check tightness of holding down bolts
	Visually check structure of gate for corrosion or damage to paintwork. Wire brush, prime and repaint as necessary.