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UNICEF Somalia

KISMAYO HYDROGEOLOGICAL STUDY

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KISMAYO HYDROGEOLOGICAL STUDY

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KISMAYO HYDROGEOLOGICAL STUDY

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1 INTRODUCTION

1.1 Background

UNICEF Somalia propose to rehabilitate the existing reticulated urban water supply system in Kismayo City, Southern Somalia. The original city water source, the Jubba River 32 km north of the city, is unsuitable to Kismayo's current needs due to running costs and the security situation to the north.

UNICEF Somalia therefore intend to develop an alternative water source to the west of the city. This water supply will comprise water wells tapping the lower aquifer identified by previous drilling at Laheley approximately 18 km west of the city.

1.2 Scope of Works

The scope of the current study is to:

- 1. identify the extent and hydrogeology of the lower Laheley aguifer
- 2. recommend four or five borehole sites that would best tap this aguifer
- 3. identify the expected water quality and yield of the aquifer
- carry out a topographical elevation survey from the recommended borehole sites to the existing Kismayo water reservoir
- 5. prepare a map of the study area indicating the extent of the aquifer the recommended borehole sites and the topographical survey results
 - 6. submit a report including results, recommendations and maps

4 and 5 are not included in the present report.

1.3 Selection of Approach to the Hydrogeological Study

Three conventional approaches requiring increasing levels of investment would normally be considered for a study of this type:

- Desk study of available mapping, aerial photography and borehole/well records.
- Desk study plus fieldwork including surface mapping if appropriate.
- Desk study, fieldwork and geophysical surveying.

A test drilling and pumping programme would then be carried out at the most promising sites.

Identification of the precise geometry of the lower aquifer using surface geophysical techniques is not considered to be a feasible option for this particular study. Electromagnetic and magnetic techniques are inappropriate and seismic techniques too expensive. Resistivity surveying, though relatively cheap is unlikely to provide any useful information. The unsaturated soils at surface are likely to have a very high resistivity, the high salinity upper aquifer very low resistivity, the confining layer low resistivity and the lower aquifer moderate resistivity. Interpretation of resistivity results

for such a system is likely to be inconclusive unless detailed calibration against existing boreholes is possible. Surface mapping is also unlikely to further define the subsurface structure at 200 m depth in such unconsolidated sediments. Drilling and test pumping are beyond the scope of the current study.

1.4 Hydrogeological Study Methodology

The adopted methodology was therefore a comprehensive desk study review of all existing data with a brief visit to the study area to measure water levels and take water samples from any available wells in the area. The data collation exercise attempted to obtain the following information for all wells in the area:

- borehole depth
- borehole elevation
- geological logs
- geophysical borehole logs
- well installation details
- static water levels
- borehole yields
- dynamic water levels
- test pumping data
- water chemistry analyses
- current borehole status

A Microsoft Access v.2.0 database has been constructed containing the above information. A copy of the software and the database are attached to this report. A hard copy printout of the database is included as Appendix A to this report. Figures 1 and 2 present the location of all the wells which have been entered onto the database.

Best estimates of the transmissivity and storage characteristics of the lower aquifer and achievable well yields were derived based on the available information. The water quality data were reviewed in an attempt to identify the extent of saline water in the lower aquifer. The effects of abstraction at sustainable yields on the distribution of saline water in the aquifer also considered to identify the optimum location for production boreholes.

1.6 Preliminary Water Demand

UNICEF Somalia have indicated that the water demand for Kismayo will be based on the following criteria:

- estimated population of 30,000
- daily per capita requirement of 20 litres
- an additional 25 per cent of domestic demand for livestock
- contingency

This implies a preliminary estimate for water demand of approximately 9 l/s (750 m³/d) not including contingency.

2 REGIONAL GEOLOGY AND HYDROGEOLOGY

2.1 General

Kismayo is located on the coast of Southern Somalia at Longitude 42°32′E, Latitude 0°21'S, approximately 180 km north-east of the border with Kenya and approximately 400 km south-west of Mugdisho.

Topographically the area comprises a flat coastal plain increasing at a rate of approximately 0.8 m/km towards the north-east reaching an altitude of approximately 100 m amsl at the Kenyan border.

A number of temporary or ephemeral water courses originate in North-east Kenya and flow into Somalia, drying up before they reach the coast. The Lagh Dera is the ephemeral extension of the Ewasa Ngiro River, which flows into the Lorian Swamp, a large marshy area in North-east Kenya. Beyond the Lorian Swamp the ephemeral Laaq Dheere heads north through Liboy on the border and subsequently east to Afmadow. Flows in the Ewasa Ngiro River have reduced during living memory and flows in the Laaq Dheere no longer reach Afmadow (Lane 1995).

The perennial Jubba River originates in the Ethiopian Highlands and flows south through Central Somalia issuing into the Indian Ocean approximately 12 km north of Kismayo town.

The regional geology of the area comprises fluvio-lagunal deposits of Tertiary age overlying limestones, shales and marls of Jurassic and Cretaceous age. This sedimentary sequence rests unconformably on Pre-Cambrian Basement rocks at depth.

2.2 North-east Kenya

2.2.1 Geology

The Tertiary deposits in North-east Kenya comprise the Merti Formation of Pliocene age to the north in the Ewasa Ngiro area and the Marafa Formation in the south. The Merti Formation extends east to the Kenya-Somalia border.

The Merti Formation comprises predominantly coarse grained fluyio-lagunal deposits probably laid down by a palaeo-Ewasa Ngiro River-Lagh Dera complex. These deposits become finer to the north, south and east presumably due to facies changes. They are described as "..red, white, grey, or tan colour and include friable to semiconsolidated gravel, grit, sand, silt and clay, generally intercalated in lenticular beds." (Swarzenski and Mundorff 1977) In North-east Kenya the upper part of the Merti Formation is composed of variously dry clay, up to 115 metres thick in some boreholes, or sandy clays, sandstones or mudstones (Lane 1995).

The thickness of the Merti Formation in North-east Kenya has been identified as 132 to 277 metres in four deep oil exploration boreholes (Lane 1995).

2.2.2 Hydrogeology



Water is encountered in the Kenyan Merti Formation at depths of 105 to 150 m bgl (Swarzenski and Mundorff 1977). The Merti aquifer is a confined aquifer with static water levels generally less than 10 metres above the top of the aquifer. The clays and mudstones in the upper part of the formation comprise the confining layers.

The central part of the Merti Formation, running along the axis of the Ewasa Ngiro drainage pathway, forms one of the best known productive aquifers in eastern Kenya. This highly transmissive aquifer is termed the Coarse Merti Aquifer by Lane 1995. The aquifer extends eastwards at least as far as the Somali border making a total length of at least 200 km, ranging from 20 to 90 km in width (Krhoda 1989). The static water levels in the Coarse Merti Aquifer fall to the east at a gradient of approximately 0.5 m/km near the border with Somalia (Lane 1995).

The finer parts of the Merti Formation to the north, south and east of the Coarse Merti Aquifer are less transmissive than the central aquifer and are treated separately as the Fine Merti Aquifer by Lane 1995. All boreholes in which Lane has identified the Fine Merti Aquifer in North-east Kenya have been entered on the database. Figure 3 presents a contour plot of the static water level data for the Coarse ad Fine Merti Aquifers in North-east Kenya and Somalia. Figure 3 indicates that higher static water levels occur in the Fine Merti Aquifer in North-east Kenya with regional groundwater flow chanelled in a south-easterly direction through the Coarse Merti Aquifer towards Somalia. Recharge to the Coarse Merti Aquifer is therefore from surface infiltration through the Lagh Dera and Lorian Swamp areas and lateral groundwater movement form the Fine Merti Aquifer.

2.3 Southern Somalia

2.3.1 Geology

The Tertiary deposits of Southern Somalia comprise fluvio-lagunal deposits of late Tertiary to Pleistocene age (Faillace and Faillace 1986).

These deposits are composed of clays, sandy clays, sands, silts and gravels generally intercalated in lenticular beds. The upper part of these deposits are described as grey and dark blue sandy clays of lagunal/shallow marine origin (Faillace and Faillace 1986). In eastern Somalia near the border with Kenya coarser deposits occur at Liboy while 65 km to the north at Dif finer deposits are noted (Lane 1995). It seems likely that the coarser deposits at Liboy represent an extension of the Coarse Merti Aquifer.

The majority of the fluvio-lagunal deposits which underlie Southern Somalia between the border with Kenya and Kismayo Town are clearly very similar to the Fine Merti of Northeast Kenya (Lane 1995). The thickness of these deposits is reported to vary between 20 and 250 metres (Faillace and Faillace 1986). In the coastal areas the finer grained upper parts of the fluvio-lagunal deposits are overlain by Recent coral limestones and dune deposits.

In conclusion the Coarse Merti, Fine Merti and fluvio-lagunal deposits are most likely to constitute a continuous geological unit. The Coarse Merti in North-east Kenya grades laterally into the Fine Merti to the north, west and south and the fluvio-lagunal deposits to the east in Somalia.

3 HYDROGEOLOGICAL DATA

3.1 Summary of Available Data

The available information can be summarised as follows:

- data for 26 wells/boreholes tapping the Fine Merti Aquifer in North-east Kenya have been entered onto the database, the locations of which are given in Figure 1.
- data for 38 wells/boreholes tapping the Fluvio-lagunal Aquifer in Southern Somalia have been entered onto the database, the locations of which are given in Figure 2.
- a discussion of the hydrogeological characteristics Fluvio-lagunal Aquifer in Faillace and Faillace 1995
- a discussion of the hydrogeological characteristics of the Coarse Merti, Fine Merti and Fluvio-lagunal Aquifers in Lane 1995

A hard copy of the database is included as Appendix A to this report.

In addition to the data obtained during the desk study carried out in Nairobi, a brief site visit was also planned. Due to security problems this visit was cancelled at the last minute. In order to obtain some up to date information from the area a questionnaire was produced, comprising questions aimed at non-technical local inhabitants concerning an operational borehole in Laheley. UNICEF staff subsequently completed this questionnaire when the security situation improved and a copy is attached as Appendix B. The details have also been added to the database.

3.2 Aguifer Parameters

The purpose of this section is to produce best estimates for the key characteristics and hydraulic parameters for the Fluvio-lagunal Aquifer in the Kismayo area.

3.2.1 Aquifer extent

The Fluvio-lagunal deposits underlie the whole of the area between Kismayo and the Kenyan border. Since these deposits are clastic in nature groundwater will occur in the spaces between the grains throughout the formation. Where clay-predominates the permeability of the material will be very low and abstraction of water will be difficult. Conversely where sandy material is dominant higher permeabilities will occur and abstraction of groundwater will become possible. The transmissivity of the aquifer, defined as the product of the permeability and aquifer thickness will therefore vary from location to location, depending on the proportion of sandy material present The available information for the Fine Merti Aquifer in Kenya and the Fluvio-lagunal Aquifer in Southern Somalia indicates that some sandy material occurs at virtually all locations. It is therefore considered that the potential for groundwater abstraction from the Fluvio-lagunal Aquifer exists wherever it occurs although the well yields will vary from location to location.

The aquifer portion of the fluvio-lagunal deposits generally occurs below 160 to 170 m bgl (Faillace and Faillace 1986).

3.2.2 Transmissivity

Very little data is available regarding the transmissivity of the Fluvio-lagunal Aquifer. A transmissivity range of 100 to 200 m²/d is given in Faillace and Faillace 1986. Only one estimate of transmissivity could be made for wells in Somalia based on specific well data. The dynamic water level and pumping data obtained on the questionnaire for the operational Laheley well indicate a drawdown of 36 metres for a yield of 3.7 l/s. The Logan Approximation of the Theim Equation for steady state flow is commonly used to estimate the transmissivity from a single well as follows:

$$T = 1.21Q/s_{w}$$

where Ω is the steady state discharge and s_w is the drawdown in the pumped well. For the Laheley well this gives an estimate of transmissivity of 11. It should be noted that the reported drawdown was probably not measured for steady state conditions, the discharge estimate for this well is very approximate and that the Logan Approximation does not take well losses into account. The net effect of these two factors is a low estimate for the transmissivity of this well.

Three values for the transmissivity of the Fine Merti are given in Lane 1995. Two Logan Approximations indicate transmissivities of 14 and 54 m²/d. Transmissivities of 750 and 840 m²/d, derived by the Cooper-Jacob and Theis Recovery methods respectively, are reported for a well at Merti. The test pumping data for this well were not available for this study and therefore re-analysis was not possible.

Based upon the sparse data available the estimate of transmissivity of 100 to 200 m²/d in Faillace and Faillace 1986 seems appropriate.

3.2.3 Aquifer storage

There are no values of storativity or specific storage for the Fluvio-lagunal Aquifer or the Fine Merti Aquifer. The average storativity value of 6 x 10⁻⁴ derived for the Coarse Merti Aquifer in Kenya is consistent with the observed confined conditions. A similar value is therefore anticipated for the Fine Merti and Fluvio-lagunal Aquifers.

3.2.4 Potential well yield

Faillace and Faillace 1986 report well yields of 4.2 to 5.5 l/s (15 to 20 m³/hr) Fluviolagunal Aquifer. This is consistent with the rough estimate of 3.7 l/s for the operational well at Laheley. The well yields quoted for 16 wells in the Fine Merti Aquifer indicate an average yield of only 1.2 l/s. It should be noted that these are operational yields and may be related to the available pump capacity. They therefore represent a minimum achievable well yield for this aquifer.

Based upon the sparse data available, the estimate of 4.2 to 5.5 l/s in Faillace and Faillace 1986 seems appropriate.

3.2.5 Hydraulic gradient

Data for eastern Kenya indicate a hydraulic gradient of approximately 0.5 m/km at the border with Somalia. The sparse water level data available for the Fluvio-lagunal Aquifer in Somalia. The static water level reported for the well at Haadweyn located approximately 25 km to the west of Kismayo implies a gradient of approximately 0.2 m/km towards the coast. This is consistent with the static water levels at Dif and Bibi

(see Figure 2). Other static water levels available for the area are lower than mean sea level which suggests that they are either not true static water levels or are the result of long term groundwater depletion due to pumping.

The lack of good quality groundwater level data makes an estimate of hydraulic gradient very difficult but a range of 0.2 to 0.5 seems appropriate.

3.2.6 Groundwater Flux

The groundwater flux is the rate that groundwater moves through a given block of aquifer perpendicular to the regional groundwater flow direction. The radius of the cone of influence of a well in a confined aquifer is likely to be approximately 3km. This means that a 6km width of aquifer would be affected by a pumping well. The flux is given by Darcy's Law:

$$Q = T.i.w$$

where T is transmissivity, i is hydraulic gradient and w is the width of aquifer considered. Table 1 gives the groundwater fluxes for a range of hydraulic gradients through a 6km width of the Fluvio-lagunal Aquifer assuming transmissivities of 100, 150 and $200 \text{ m}^2/\text{d}$.

Table 1 Groundwater fluxes in I/s through the a 6km width of the Fluvio-lagunal Aquifer in the vicinity of Kismayo.

Transmissivity	Hydraulic gradient (m/km)					
(m ² /d)	0.2	0.4	0.6	0.8	1.0	
100	1.4	2.8	4.2	5:6	7.0	
150	2.1	4.2	613	8:3/	1014	
200	2.8	5.6	8/3	11.1	1319	

3.3 Sustainable Yield

The available data for well yields indicates that in order to meet the 9I/s demand for Kismayo at least two wells discharging at 4.5I/s will be required. The shaded section of Table 1 indicates the transmissivity/hydraulic gradient scenarios for which the groundwater flux is greater than 4.5 I/s. If the groundwater flux is less than 4.5 I/s for a 6km width of aquifer then a 4.5I/s well yield would not be sustainable in the long term since the rate of groundwater entering the aquifer block would be less than the rate of removal. For the transmissivity/hydraulic gradient scenarios in the shaded section of Table 1 the removal of 4.5I/s from two separate 6km widths of the aquifer would produce a sustainable yield of 9I/s. The two wells would therefore have to be located at least 6km apart, equidistant from the coast. Clearly if the groundwater flux is less than 4.5I/s lower discharge rates would be required to ensure sustainability in the long term. For the worst case given in Table 1 if a transmissivity of 100 m²/d and a hydraulic gradient of 0.2 m/km are the actual case approximately six wells discharging at 1.5I/s each would be required spanning a 30km width of the aquifer.

4 GROUNDWATER CHEMISTRY DATA

4.1 Summary of Available Data

The available information can be summarised as follows:

- all available chemical data including 6 full major ion analyses for wells/boreholes tapping the Fine Merti Aquifer in North-east Kenya entered onto the database
- all available chemical data including 30 full major ion analyses for the wells/boreholes tapping the Fluvio-lagunal Aquifer in Southern Somalia entered onto the database.
- a discussion of the groundwater chemistry of the Fluvio-lagunal Aquifer can be found in Faillace and Faillace 1995
- a discussion of the groundwater chemistry of the Coarse Merti, Fine Merti and Fluvio-lagunal Aquifers can be found in Lane 1995

A hard copy of the database is included as Appendix A to this report.

In addition to the data identified above three water samples were collected from the operational well at Laheley by UNICEF staff and taken to Nairobi for analysis. The samples were collected after 15, 30 and 60 minutes of pumping and radar diagrams showing the major chemistry of the three samples are given in Figure 5. The analyses themselves are included as Appendix C to this report.

4.2 Groundwater Regimes

The groundwater chemistry in the Coarse Merti, Fine Merti and Fluvio-lagunal Aquifers is summarised in the Electrical Conductivity (EC) contour plot presented in Figure 6. The EC is approximately proportional to the Total Dissolved Solids (TDS) of a solution and therefore provides a measure of the salinity of the groundwater. EC in microS/cm is approximately equal to 1.5 times the TDS in mg/l, an EC of 2,250 microS/cm representing the WHO maximum TDS guideline value of 1,500 mg/l (WHO 1993). Figure 6 clearly illustrates that the salinity of the groundwater in the Coarse Merti Aquifer is low with EC less than 2,000 microS/cm. The salinity of groundwater in the Fine Merti and coastal Fluvio-lagunal Aquifers however is considerably higher with EC up to 40,000 microS/cm at Qot Qot. It is interesting to note the tongue of lower salinity water extending towards the Kismayo area from the Coarse Merti Aquifer.

The groundwater chemistry of the shallow coastal aquifers is generally a very high TDS Sodium Chloride water type.

The groundwater chemistry of the Coarse Merti Aquifer is a low TDS, Sodium Bicarbonate water type which is indicative of freshwater recharge (Lane 1995).

The groundwater chemistry of the Fine Merti and coastal Fluvio-lagunal Aquifers is a high TDS, Sodium Chloride water type which implies a strong marine influence. For the Fine Merti in North-east Kenya this marine influence is a residual signature of the partially marine mode of deposition. For the coastal Fluvio-lagunal Aquifer this marine influence is probably a result of either horizontal saline intrusion from the Indian Ocean

or vertical leakage from the overlying shallow coastal aquifers which contain highly saline water.

At Yaak Bisharo a low TDS Sodium Bicarbonate/Chloride water type is reported (Faillace and Faillace 1986). This is consistent with fresher recharge from the Coarse Merti Aquifer of North-eastern Kenya (see Section 2.3.2 above).

A reduction in groundwater salinity with increasing depth has been noted at a number of locations in the Fluvio-lagunal Aquifer, such as Bilis Qooqani, Raabey and Hosingo. This does not necessarily occur in all areas however (Faillace and Faillace 1986). A well at Qot Qot was drilled through the shallow aquifer and cased through the confining layer into the main aquifer below. Although relatively fresh water with an EC of 3,700 microS/cm was initially obtained from this well the quality gradually decreased with time until it was abandoned 14 years after construction due to an EC of 40,000 microS/cm. Similarly wells at Laheley initially produced water with an EC of 3,500 microS/cm, but the currently operational well is yielding water of 5,400 microS/cm EC.

These observed decreases in water quality with time may be due to three factors :

- · saline water in the shallow aquifer corroding the well lining and entering the well,
- increased vertical leakage of saline water from the shallow aquifer through the discontinuous confining clays in the vicinity of the wells in response to pumping,
- horizontal saline intrusion into the main aquifer from the Indian Ocean in response to pumping.

For the well at Qot Qot it is not clear which is the dominant factor (Faillace and Faillace 1986). The rapid decrease in EC during pumping of the currently operational borehole at Laheley suggests that while pumping is not occurring saline water from the shallow aquifer is entering the lower aquifer from the upper aquifer through the borehole (see Figure 4). Whether this flow is through a poorly sealed annulus outside the casing or through the inside of the casing which has been corroded by the high salinity fluid in the upper aquifer is not clear. Depending on the magnitude of the leakage, the 5,400 microS/cm sodium chloride water type recorded after 30 and 60 minutes of pumping may therefore represent the water type in the Fluvio-lagunal Aquifer or may be a mixture of water from this and the upper aquifer. If it does represent the chemistry of the Fluvio-lagunal Aquifer the increase in EC from 3,700 to 5,400 microS/cm in this aquifer during the life of the well suggests that increased vertical leakage or horizontal saline intrusion in response to pumping has occurred.

4.3 Saline Intrusion

In coastal aquifers where hydraulic connection with the sea occurs, a dynamic balance between the denser saline water and the flowing fresher water occurs. In the majority of cases the balance results in a wedge of saline water protruding inland into the aquifer. The distance from the coast that this wedge protrudes is inversely proportional to the groundwater flux towards the sea in the aquifer. If groundwater is abstracted from the aquifer the flux towards the sea is reduced and the saline intrusion therefore moves further inland. The precise nature of the interface between the fresh and saline water may be relatively sharp or very diffuse with a gradual increase in salinity over a distance of several kilometres.

If the Fluvio-lagunal Aquifer is in hydraulic connection with the Indian Ocean in the vicinity of Kismayo long term abstraction of groundwater may result in significant saline intrusion. Figures 7 and 8 present the EC and chloride data for wells in the vicinity of

Kismayo. The increase in both parameters towards the coast implies that saline intrusion does exist in the Fluvio-lagunal Aquifer.

The groundwater at Yaak Bisharo is considered to represent the baseline fresh groundwater chemistry with an EC of 1,800 microS/cm and a chloride of 300 mg/l. Figure 9 presents a linear extrapolation of the minimal data available for EC and chloride to estimate the current location of the saline intrusion. These two plots suggest a current location 25km from the coast. If the groundwater flux through a 6km width of the aquifer is 9l/s and 4.5l/s is abstracted from a well then the groundwater flux is halved and the distance of saline intrusion from the coast doubled. This would imply that for the 9l/s flux scenario the potential for saline intrusion would exist up to 50km inland in response to pumping.

The precise form of the movement of saline intrusion in response to pumping is very difficult to estimate given the available data. In particular the timescale over which such intrusion may occur given the low abstraction rates may be very slow, however the basic assessment presented here clearly indicates a potential problem in the medium or long term.

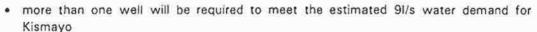
5 RECOMMENDED WELL LOCATIONS

5.1 Discussion

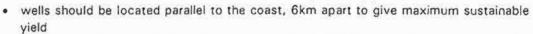
Based upon the limited data, the hydrogeology of the Fluvio-lagunal Aquifer in Southern Somalia can be summarised as follows:

- · generally confined but locally semi-confined in coastal areas
- · aquifer occurs below 160 to 170 m bql
- recharge through groundwater flow from the Coarse Merti Aquifer in North-eastern Kenya
- transmissivity in the range 100 to 200 m²/d
- · hydraulic gradient of 0.2 to 0.5 m/km towards the Indian Ocean
- potential well yields up to 5.5l/s
- · groundwater salinity increases closer to the coast
- · the groundwater in the shallow coastal aquifers is high salinity
- groundwater which meets WHO guidelines has only been identified in Yaak Bisharo
- sustainable well yields are probably less than the potential well yields due to the low groundwater flux through the aquifer
- saline intrusion in response to groundwater abstraction may also be significant due to the low groundwater flux through the aquifer

A number of basic conclusions can be drawn based upon the current understanding summarised above:







- the more wells provided the lower the required yield from each and therefore the safer the sustainable yield and the lower the risk of saline intrusion
- wells will need to be in excess of 170m deep
- well design must ensure that the Fluvio-lagunal Aquifer is completely sealed from the overlying shallow aquifers

Taking these conclusions into account three potential options are available:

Option A

Drill one well at Laheley approximately 20km from Kismayo and identify the groundwater chemistry. If the groundwater chemistry is acceptable drill a second well parallel to the coast 6km from the first. Abstract from each well at 4.5l/s monitoring dynamic water levels and EC on a monthly basis. If the first well identifies that the groundwater chemistry is not acceptable consider one of the other options.

This option would be the cheapest option since the discharge lines will be the shortest of the three options. However it is also the highest risk option. If the groundwater quality is not acceptable a well has been drilled which is of no use. If the groundwater quality is acceptable the location of these wells makes them highly susceptible to saline intrusion and/or leakage from the poor quality shallow aquifer in response to pumping.

Option B

If water with a TDS greater than the WHO maximum TDS guideline value of 1,500 mg/l (WHO 1993) is considered acceptable, drill two wells parallel to the coast 6km apart between Haadweyn and Yaak Bisharo approximately 35km from Kismayo. Abstract from each well at 4.5l/s monitoring dynamic water levels and EC on a monthly basis.

This option would cost more than Option A and less than Option C. Once an acceptable TDS was agreed the precise location of the wells could be estimated. There is still the risk for this option that saline intrusion may occur in response to pumping but the risk of this is less than that for Option A. The risk of leakage from the poor quality shallow aquifer in response to pumping is also likely to be less since the shallow aquifers are less frequently developed away from the coast.

Option C

Drill two wells parallel to the coast 6km apart in the vicinity of Yaak Bisharo approximately 45km from Kismayo. Abstract from each well at 4.5l/s monitoring dynamic water levels and EC on a monthly basis.

This option would be the most expensive option. However, the water should initially meet WHO guidelines and the risk of saline intrusion and/or leakage from the poor quality shallow aquifer in response to pumping is less than that for Options A. and B.

For all three options if dynamic water levels show a steady decrease with time from the commencement of pumping this implies that the discharge is greater than the sustainable yield. If this is the case the discharge should be reduced until the dynamic water level remains constant.

If the EC begins to increase this suggests that saline intrusion is occurring. If this is the case there is very little which can be done to save the well. The only way in which the well can be used is to act as a scavenger well. This would involve drilling a new well inland of that affected by saline intrusion and pumping both wells. The new well would then produce fresh water for human consumption while the old well would intercept the saline intrusion and pump saline water which would be disposed of at surface. Clearly there are major cost implications if saline intrusion occurs. It is always best to prevent saline intrusion occurring than to mitigate the results once it has occurred.

5.2 Optimum Well Design

The following design details are meant as a guide upon which a technical specification could be based.

Due to the depth of the aquifer, the use of plastic or uPVC well linings is not possible. The options are Glass Reinforced Plastic or Stainless Steel. If stainless steel is used Type 314 which is resistant to seawater should be used.

The wells should be drilled at 254mm (10") diameter to accommodate 152mm (6") well linings using direct rotary polymer flush methods. This method was successful in the Coarse Merti of North-eastern Kenya where temporary casing was not required using this method (Lane 1995).

The precise well design at each location will be decided on site based on drilling returns, water strikes and geophysical logs if available.

Screens with a 0.5mm slot size should be used and sufficient length of screen used to ensure a total open area such that the entrance velocity is 0.03m/s or less. A 2 to 4mm diameter grain size gravel pack should be entered into the annulus opposite the screened sections and a bentonite seal placed above the gravel pack in pellet form to ensure that leakage of saline water from the shallow aquifer down the annulus does not occur.

Development of the wells should include chlorination to breakdown polymers followed by airlifting at selected zones within the screen. The airlifting should comprise periods of continuous airlifting interspersed with periods of surging.

A submersible pump suitable for installation in a 152mm (6") diameter well lining and capable of pumping up to 5l/s against a total pumping head of 160m (eg Grundfos SP16-24).

6 SUMMARY

Southern Somalia is underlain at a depth of approximately 170m bgl by a confined Fluvio-lagunal Aquifer. The confining layer which separates this aquifer from the overlying shallow coastal aquifers is locally discontinuous. The low hydraulic gradients and moderate transmissivities in the vicinity of Kismayo suggest a low groundwater flux towards the Indian Ocean.

Maximum well yields of 4.5l/s are likely to be at or near the sustainable limit for such a low flux and the spacing of wells parallel to the coast is recommended. In addition if there is hydraulic connection between the Fluvio-lagunal Aquifer and the Indian Ocean pumping from the aquifer is likely to result in significant saline intrusion, although the timescale of this is impossible to estimate. The locally discontinuous nature of the confining layer also means that leakage of poor quality groundwater from the shallow aquifers in response to pumping from the Fluvio-lagunal Aquifer is also a potential problem.

Three options have been identified:

Option A

Drill one well at Laheley approximately 20km from Kismayo and identify the groundwater chemistry. If the groundwater chemistry is acceptable drill a second well parallel to the coast 6km from the first. Abstract from each well at 4.5l/s monitoring dynamic water levels and EC on a monthly basis. If the first well identifies that the groundwater chemistry is not acceptable consider one of the other options.

Option B

If water with a TDS greater than the WHO maximum TDS guideline value of 1,500 mg/l (WHO 1993) is considered acceptable, drill two wells parallel to the coast 6km apart between Haadweyn and Yaak Bisharo approximately 35km from Kismayo. Abstract from each well at 4.5l/s monitoring dynamic water levels and EC on a monthly basis.

Option C

Drill two wells parallel to the coast 6km apart in the vicinity of Yaak Bisharo approximately 45km from Kismayo. Abstract from each well at 4.5l/s monitoring dynamic water levels and EC on a monthly basis.

Option A is the cheapest option but has the greatest risk attached. Option C is the most expensive option but has the least risk attached. Option B lies somewhere between Options A and B in both cost and risk.

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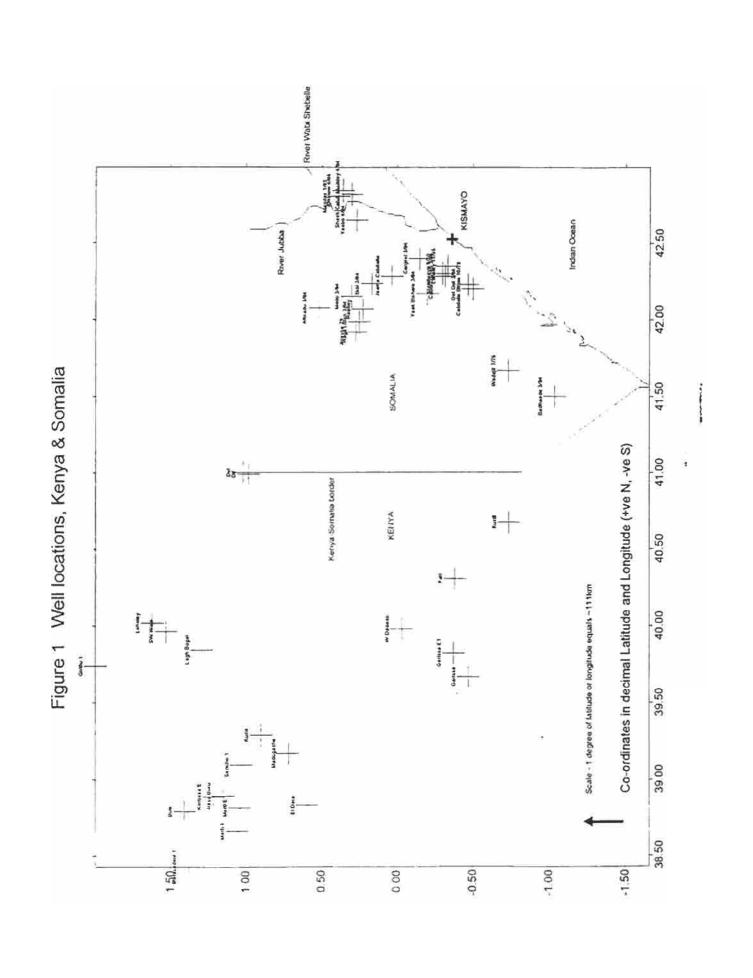
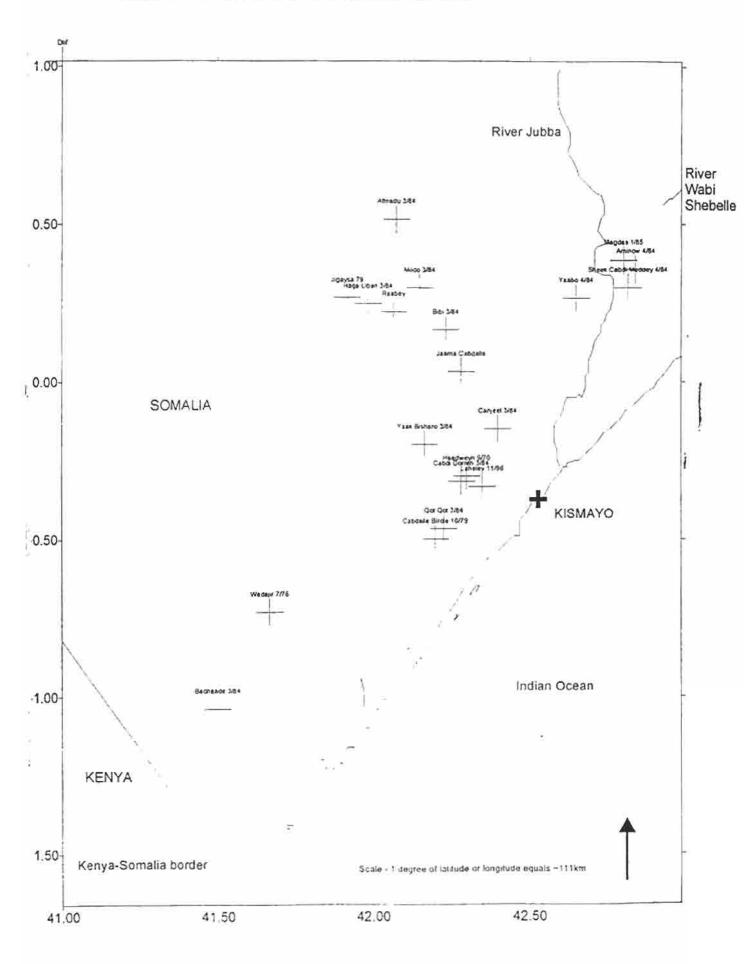
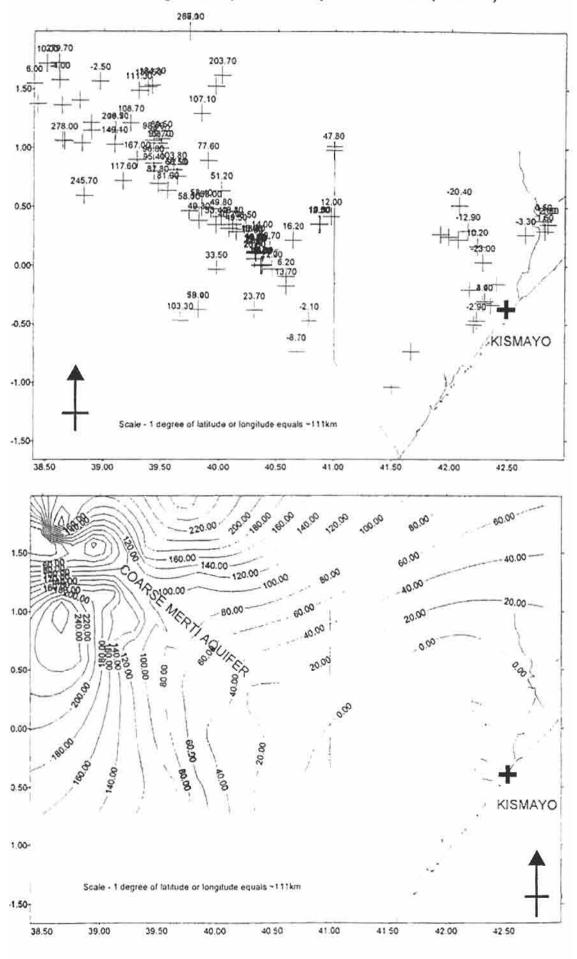


Figure 2 Well locations, Southern Somalia



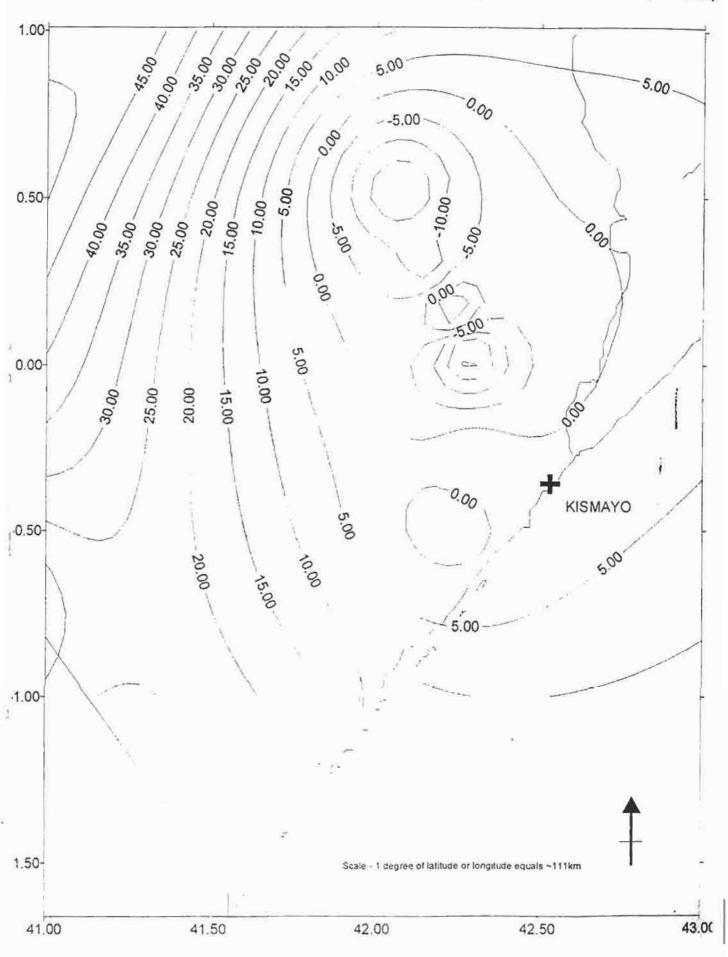
Co-ordinates in decimal Latitude and Longitude (+ve N, -ve S)

Figure 3 Static water levels in Coarse Merti, Fine Merti and Fluvio-lagunal Aquifers, Kenya & Somalia (m amsl)



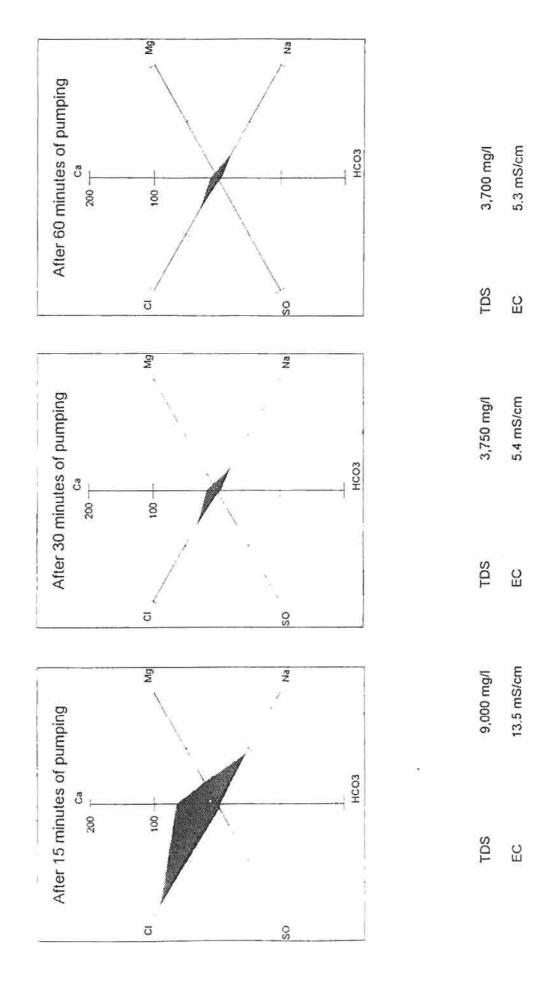
Co-ordinates in decimal Latitude and Longitude (+ve N, -ve S)

Figure 4 Static water levels in Fluvio-lagunal Aquifer, Southern Somalia (m amsl)



Co-ordinates in decimal Latitude and Longitude (+ve N, -ve S)

Figure 5 Groundwater chemistry radar diagrams, well at Laheley



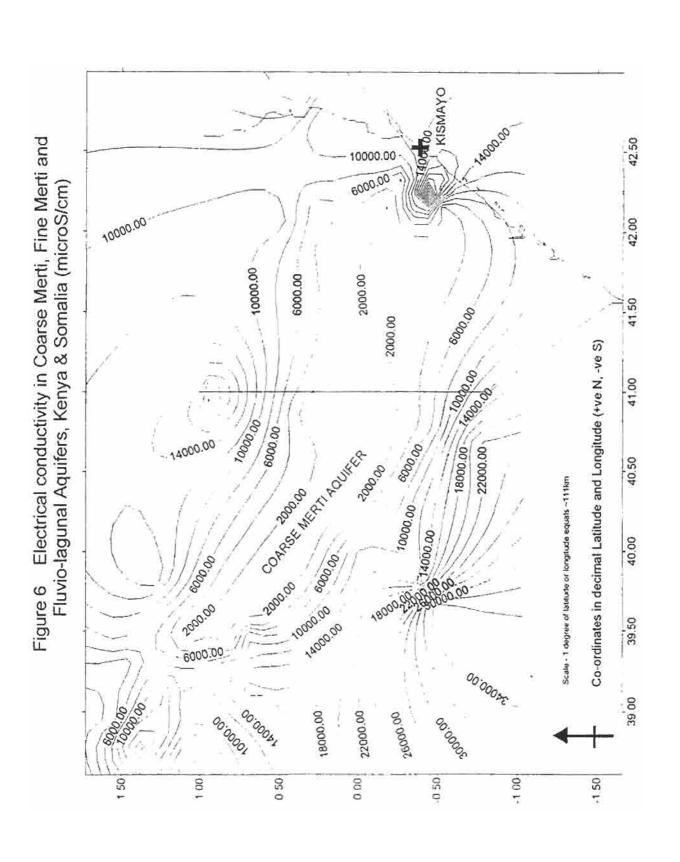
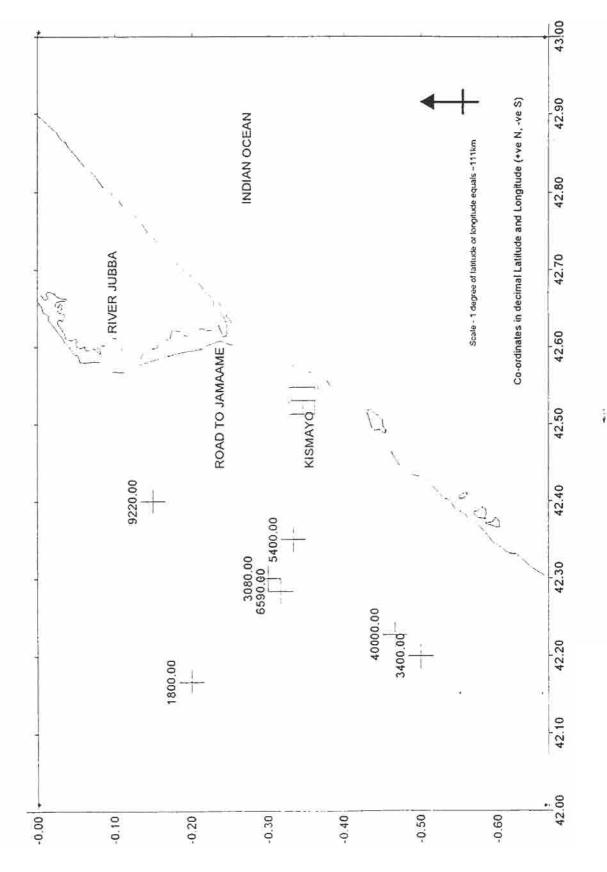
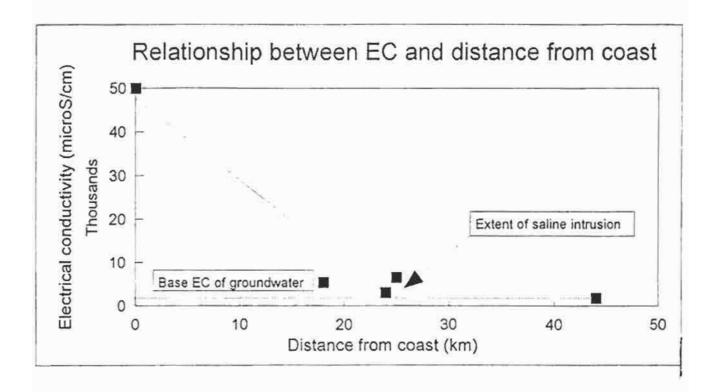


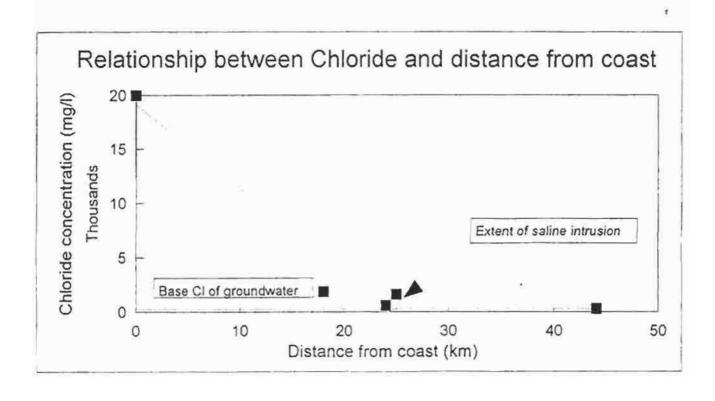
Figure 7 Electrical Conductivity in Fluvio-lagunal Aquifer, Kismayo area (microS/cm)



43,00 42,90 Co-ordinates in decimal Latitude and Longitude (*ve N, -ve S) INDIAN OCEAN Figure 8 Chloride concentration in Fluvio-lagunal Aquifer, Kismayo area (mg/l) Scale - 1 degree of latitude or longitude equals - 111km 42,80 RIVER JUBBA 42.70 42.60 ROAD TO JAMAAME 42,50 KISMAYO 42,40 2680 00 42.30 88 558 18771 06 42.20 300 00 42.10 42.00 09.0--0.50 -0.00 -0.10 -0.20 -0.30 -0.40

Figure 9 Extent of saline intrusion from linear extrapolation of EC and Chloride plots





APPENDIX A

WATER WELL DATABASE

Well Location: Easting: 41 Well Owner; Ground Level (m amsi): 1 Well Depth (mbgl);	150 Geo	Northing: Current Status:		1.0167
Weil Owner; Ground Level (m amsi):				1.0167
Ground Level (m amsi):				
		Name of the last o		***
vvea Depai (mogi),		iogy: io-lagunal deposits	Candu alou	Hydrogeology:
Borehole Diameter (mm): Installation Details:	COVE	ring sand, gravel, a	ind sandy clay	
Drilled in 1975				
Geophysical Data:				
Static Water Level (m amsl): Dynamic Water Level (m amsl): Yield (l/s): Test Pumping Data:	Drilling In	formation:		
		Trai	nsmissivity (m^2/d):	
		1	raulic Conductivity (rage:	m/d)
Chemical Analyses:			EC (MicroS/cm): 13200
Sample date 30/3/84			pH;	8
			TDS (mg/l):	10144
			Total Hardness	(mg/l): 1398
Bicarbonate (mg/l): 104	Sulphate (mg/l):	715	Chloride (mg/l);	4151
Calcium (mg/l): 202	Magnesium (mg/l):	217	Sodium (mg/l):	2025
ion Balance Error (%)8		General Comments	5.	
Data Sources:	G			
Faillace & Faillace 1986				

Well Number 2 Well N	Name:	Diif 3/8	34	
Well Location:				
Easting: 41 Well Owner:	Northing Current			1.0167
Ground Level (m arnsi). 150	Geology:			Hydrogeology:
Well Depth (mbgl). 202 Borehole Diameter (mm): Installation Details: Drilled in 1973	Fluvio-laguna covering sand layers, maris. 1986)	d. gravel, a	- Sandy clay nd sandy clay sillace & Faillace	
Geophysical Data:				
Static Water Level (m amst): Dynamic Water Level (m amst): Yield (Vs): Test Pumping Data:	orlling Information	i.		
		Hyd	nsmissivity (m*2/d): raulic Conductivity (
Chemical Analyses:			EC (MicroS/cm	14200
Sample collected 30/3/84			pH: TDS (mg/l): Total Hardness	9160 (mg/l): 1626
Bicarbonate (mg/l): 89l Sulphate (mg	y/I):	842	Chloride (mg/l);	4598
Calcium (mg/l); 257 Magnesium (Ion Balance Error (%): 11.6		236 Comments	Sodium (mg/l):	2022
Data Sources:				
Faillace & Faillace 1986				

Well Number 3	/ell Name:	Badhaa	ade 3/84	
Welf Location:				
Easting: 41.5	Nor	thing:	-1.0	389
Well Owner:	Cur	rent Status:	Probably usable	
Ground Level (m amsi): 62	Geology		Hydro	geology:
Well Depth (mbgl): 145		gunal deposits - sand, gravel, an		
Borehole Diameter (mm):	layers, n	naris. (Qcl of Fail		
Installation Details:	1986)			
Geophysical Data:				
Static Water Level (m arnsi):	Drilling Inform	ation:		
Dynamic Water Level (m amsl):				
Yield (l/s):				
Test Pumping Data:				
		Trans	smissivity (m^2/d):	
		Hydra	aulic Conductivity (m/d):	
		Stora	ge:	
Chemical Analyses:			EC (MicroS/cm);	10000
Sample collected 25/3/84. It is considered likely that	t the Na + K value	was	pH:	7.9
generated by assuming a zero ion balance.			TDS (mg/l):	6612
			Total Hardness (mg/l)	1146
Bicarbonate (mg/l): 58i Sulpha	ate (mg/l);	445	Chloride (mg/l)	3225
Calcium (mg/l) 285 Magne	esium (mg/l):	154	Sodium (mg/l):	1755
Ion Balance Error (%)	Ger	neral Comments	8	
Data Sources				
Faillace & Faillace 1986				
	fi e			

Well Number	4	Well Na	ame:	Wada	jir 7/76		
Well Location							
Easting:	41 6667			Northing:		-0.7333	
Well Owner:				Current Status.	Abandonned		
Ground Level (m amsl)			Geole	ogy		Hydrogeol	ogy:
Well Depth (mbgl):				o-lagunal deposits ring sand, gravel, a			
Borehole Diameter (mm)			layers	s, marls. (Qcl of F			
Installation Details:		1	1986)			
Geophysical Data							
Geophysical Data:			i i				
		1					
Static Water Level (m ams	n):	Oril	ling Inf	ormation:			
Dynamic Water Level (m a	msl):						
Yield (I/s):							1
Test Pumping Data:							
				Tra	insmissivity (m*2/d)		
				Нус	draulic Conductivity	(m/d);	
				Sto	orage;		
Chemical Analyses:					EC (MicroS/cm	n): [
Sample collected on 22/7/7	6. Error noted:	the sum of the ion	ic anal	yses is	pH:	F	7.4
greater than the TDS					TDS (mg/l):	F	3440
					Total Hardness	(mg/l);	1554
Bicarbonate (mg/l)	12660	Sulphate (mg/l)	t.	2436	Chloride (mg/l);		1536
Calcium (mg/l):	736	Magnesium (m	g/l):	384	Sodium (mg/l):	[5500
Ion Balance Error (%)			7,9	General Comment	ts:		
Data Sources.	_			The well was abar water	ndonned due to the s	aity nature o	of the
Faillace & Faillace 1986				0.40/8/			
			1 1				

Well Number 5	Well Name:	Jigaysa 7	9	
Well Location;				
Easting: 41.9167 Well Owner:		orthing: urrent Status;		0.2694
Ground Level (m amsi)	Geolog	y:		Hydrogeology:
Weil Depth (mbgl): Borehole Diameter (mm): Installation Details:	coverin	agunal deposits - Sar g sand, gravel, and si maris. (Oct of Faillace	andy clay	
Geophysical Data:				
Static Water Level (m amsl). Dynamic Water Level (m amsl): Yield (l/s): Test Pumping Data:	Drilling Infor	mation:		
		5,63	ssivity (m^2/d): c Conductivity (n	n/d):
Chemical Analyses:			EC (MicroS/cm)	3500
Sample collected in 1979.			pH: TDS (mg/l): Total Hardness ((mg/l):
Bicarbonate (mg/l):	Sulphate (mg/l):	Chi	oride (mg/l):	
Calcium (mg/l):	Magnesium (mg/l):	Soc	lium (mg/l):	
Ion Balance Error (%)	Ge	neral Comments		
Data Sources	_			
Faillace & Faillace 1985				

UNICEF Somalia GIBB Ltd Kismayo Hydrogeological Study Well Number 6 Well Name: Haga Liban 3/84 Well Location 41.9833 Easting Northing: 0.25 Well Owner: Current Status: Ground Level (m amsl): 28.1 Geology: Hydrogeology: Well Depth (mbgl): 150 Fluvio-lagunal deposits - Sandy clay covering sand, gravel, and sandy clay Borehole Diameter (mm) layers, marls. (Qcl of Faillace & Faillace Installation Details Drilled in 1979 Geophysical Data: Static Water Level (m amsl): Onlling Information: Dynamic Water Level (m amsi) Yield (l/s). Test Pumping Data: Transmissivity (m^2/d): Hydraulic Conductivity (m/d): Storage: EC (MicroS/cm): 4270 Chemical Analyses: Sample collected 28/3/84. 8.6 TDS (mg/l): 2624 Total Hardness (mg/l) 64 388 161 Chloride (mg/l): 1010 Sulphate (mg/l): Bicarbonate (mg/l) Sodium (mg/l): 19 706 Calcium (mg/l) Magnesium (mg/l): Ion Balance Error (%) -10.4 General Comments:

Data Sources:

Faillace & Faillace 1986

Well Number	7	Well Nam	e: Raab	ey 3/84		
Well Location:						
Easting: 4	2.0567		Northing:		0.225	
Well Owner:			Current Status:			
Ground Level (m amsi):		G	eology;		Hydrogeo	logy:
Well Depth (mbgl): Borehole Diameter (mm):		la	uvio-lagunal deposit vering sand, gravel, vers, maris. (Qcl of i	and sandy clay		
Installation Details:			186)			
Drilled in 1979						
Geophysical Data:						
Static Water Level (m amsl): Dynamic Water Level (m amsl); Yield (l/s);		Drilling	Information:			
Test Pumping Data:	~ <u> </u>					
			1	ansmissivity (m^2/d)		
			1 %	oraulic Conductivity	(m/d):	
			St	orage:	1	
Chemical Analyses				EC (MicroS/cn	n):	4480
Sample collected 28/3/84. Error I	noted: Bica	arbonate analysis gre	ater than Total	pH:	[8.8
hardness.				TDS (mg/l):		2728
				Total Hardness	s (mg/l);	155
Bicarbonate (mg/!):	441	Sulphate (mg/l)	137	Chloride (rng/l):		1066
Calcium (mg/l)	16	Magnesium (mg/l):	28	Sodium (mg/l):		1078
ion Balance Error (%).	9.7		General Commen	its:		
Data Sources.			Static Water Leve	el 27 5 m bgl		
Faillace & Faillace 1986						

Well Number	8	Well Name	Raabe	y 1/58	
Well Location					
Easting:	42.0667		Northing:		0.225
Well Owner:			Current Status:		
Ground Level (m amsi):		Ge	ology:		Hydrogeology
Well Depth (mbgl)			vic-lagunal deposits		
Borehole Diameter (mm)		lay	ering sand, gravel, ers, maris. (Qcl of F		
Installation Details:		196	36)		
Drilled in 1956					
Geophysical Data:					1
Static Water Level (m amsl).		Drilling !	nformation:		
Dynamic Water Level (m ams	0	= -			
Yield (Vs):					
Test Pumping Data:					
3.5-2.0 1.111 - 2.01 - 2.01 - 2.01			Tra	nemissivity (m^2/d):	
			1	draulic Conductivity (
				orage:	
				n ugu.	
Chemical Analyses				EC (MicroS/cm)
Sample collected 12/1/58				pH:	
				TDS (mg/l).	5100
				Total Hardness	
Bicarbonate (mg/l):	809	Sulphate (mg/l):	352	Chloride (mg/l):	2352
Calcium (mg/l)		Magnesium (mg/l)	35	Sodium (mg/l):	1900
Ion Balance Error (%)	-1-	Taginasan (11.3-1)		, and the second second	1500
ion Balance Effor (%)			General Comment	ts.	
Data Sources					
Failtace & Failtace 1986					
				21	

Well Number 9	Well Name:	Afmad	u 3/84	
Well Location:				
Easting: 42 075		Northing:		0.5167
Well Owner:		Current Status:	Possibly usabl	e
Ground Level (m amsl):	19.6 Geok	ogy:		Hydrogeology:
Well Depth (mbgl):		o-lagunal deposits ing sand, gravel, a		
Borehole Diameter (mm):		s, maris. (Qcl of Fa		
Installation Details:	1500	5		
Geophysical Data:				
Caroni Sala.				
	1			
Static Water Level (m amsl):	Drilling Info	ormation:		
Dynamic Water Level (m arnsl):				
Yield (l/s):				
Test Pumping Data:				
		1	nsmissivity (m^2/d):	
			fraulic Conductivity (n	iva).
			aga.	
Chemical Analyses:			EC (MicroS/cm)	11060
Sample collected 30/3/84, Error noted: Bica	arbonate analysis greater	than Total	pH;	8.5
hardness.			TDS (mg/l):	6764
			Total Hardness	(mg/l): 237
Bicarbonate (mg/l): 603	Sulphate (mg/l):	633	Chloride (mg/l):	3056
Calcium (mg/l): 29	Magnesium (mg/l):	40	Sodium (mg/l):	2184
Ion Balance Error (%): -5.8	,	General Comments	s:	
Data Sources	-			
Faillace & Faillace 1986	7			
	4)			

Well Number	10	Well Nam	ne: Afma	du 7/75		
Well Location:						
Easting:	42.0751		Northing:		0.5166	
Well Owner:			Current Status;	urrent Status; Possibly usable		
Ground Level (m amsl):		19.6	eology:		Hydrogeology:	
Well Depth (mbgl):			luvio-lagunal deposi overing sand, grave		1	
Borehole Diameter (mm):		ta	yers, marts. (Qcl of 986)			
Installation Details:			300)			
Drilled in 1956			*			
Geophysical Data:						
Static Water Level (m amsl): Dynamic Water Level (m amsl): Yield (l/s): Test Pumping Data:		20.4 Drilling	Information;			
			н	ransmissivity (m^2/d) lydraulic Conductivity torage:		
Chemical Analyses				EC (MicroS/cn	n):	
Sample collected 22/7/75 it is of generated by assuming a zero in		kely that the SO4 va	ilue was	pH; TDS (mg/l): Total Hardness	7.5 8560	
Bicarbonate (mg/l):	390	Sulphate (mg/l):	5874		126	
Calcium (mg/l):	368	Magnesium (mg/l)	250	Sodium (mg/l):	2200	
fon Balance Error (%)			General Comme	nts;		
Data Sources			Water level -30	m amsi in Jul 1975	wnen sample collected	
Faillace & Faillace 1986						

Well Number 11 Well	Name:	Afmad	u 8/70	
Well Location				
Easting: 42.0752	No	rthing:		0.516
Well Owner;	Cu	rrent Status:	Possibly usab	le
Ground Level (m amsi): 19.6	Geology			Hydrogeology:
Well Depth (mbgl):		gunal deposits sand, gravel, a		
Borehole Diameter (mm):	layers, r	narts. (Qcl of Fa	aillace & Faillace	
Installation Details:	7 (1900)			
Geophysical Data:	1			0
	7 /			
	11			
Static Water Level (m amsl):	Drilling Inform	nation		
Dynamic Water Level (m amsi):		21.5247.223		
Yield (I/s):				
Test Pumping Data:				
		Trai	nsmissivity (m^2/d):	
		Hyd	raulic Conductivity (r	m/d):
		Stor	rage:	
Chamical Analysis			EC (MicroS/cm)	11950
Chemical Analyses. Sample collected 31/8/70. It is considered likely that the	e Na + K value	was	pH:	7.2
generated by assuming a zero ion balance.			TDS (mg/l):	8200
			Total Hardness	(mg/l): 440
Bicarbonate (mg/l): 2635 Sulphate (mg/l):	595	Chloride (mg/l);	2277
Calcium (mg/l): 96 Magnesius	m (mg/l):	49	Sodium (mg/l):	2618
ion Balance Error (%).	Ge	neral Comments	5	
Data Sources	-			
Faillace & Faillace 1986	11			
	N or			
	4			

Well Number	12	Well N	lame:	Miid	0 3	3/84			
Well Location:	20.								
Easting: Well Owner:	42.15			Northing: Current Status	5:	[0.3
Ground Level (m amsl):		23.1	Geolo	ogy:				Hydro	geology:
Well Depth (mbgl): Borehole Diameter (mm): Installation Details: Drilled in 1977		180	cover	o-lagunal depo ing sand, grav s, marls. (Qcl	el, a	and san	dy clay		
Geophysical Data:									
Static Water Level (m amsi): Dynamic Water Level (m amsi Yield (l/s): Test Pumping Data:):	D	rilling Info	ormation:					
		1			Нус		ivity (m^2/d) Conductivity		
Chemical Analyses:						E	(MicroS/cr	m):	5030
Sample collected 28/3/84							l: IS (mg/l); tal Hardnes	s (mayl)	8.5 3028
Bicarbonate (mg/l):	839	Sulphate (mg/	n):	26	(8)		de (mg/l):		1122
Calcium (mg/l):	16	Magnesium (r	mg/l);		6	Sodiu	m (mg/l):		728
Ion Balance Error (%)	21.5			Seneral Comm	ente	s			
Data Sources			=			- 13			
Faillace & Faillace 1986								14	

Well Number	13	Wel	l Name	e: [N	liido	1/58		
Well Location								
Easting: Well Owner:	42.15]	Northing:			0.	3
Ground Level (m amsl):		23.1	Ge	ology:			Hydroge	eology:
Well Depth (mbgl):		95				- Sandy clay	T	
Borehole Diameter (mm).						and sandy clay aillace & Faillace		
Installation Details:			;196	36)				
Drilled in 1956								
Geophysical Data:								
Static Water Level (m amsl): Dynamic Water Level (m amsl): Yield (l/s): Test Pumping Data:	si):	-12.9	Drilling I	nformation	ĝ.			
Tool Full pring Date.				-	Tra	ensmissivity (m^2/d):		
				î		draulic Conductivity		
					Sto	orage;		
Chemical Analyses						EC (MicroS/cn	n).	
Sample collected 14/1/58						pH:		
						TDS (mg/l):		4530
						Total Hardness	s (mg/l):	
Bicarbonate (mg/l):	622	Sulphate (mg/l):		400	Chloride (mg/l):		1984
Calcium (mg/l):	24	Magnesiu	m (mg/l)		24	Sodium (mg/l):		1705
ion Balance Error (%)	0.67			General (Comment	is.		
Data Sources				Water lev		m amsl in March 198	83 when s	ample
Faillace & Faillace 1986				49/49/04				
				i				
L								

Well Number 14	Well Name:	Miido		
Well Location:				
Easting: 42,15		hing: rent Status:		0.3
			74.5	
Ground Level (m amsi): Well Depth (mbgl). Borehole Diameter (mm). Installation Details.	Fluvio-lag covering			rogeology;
Geophysical Data:				
Static Water Level (m arnsl): Dynamic Water Level (m arnsl): Yield (l/s): Test Pumping Data:	Drilling Inform		1	
		Нус	nsmissivity (m^2/d); fraulic Conductivity (m/d); rage;	
Chemical Analyses:		0	EC (MicroS/cm): pH: TDS (mg/l); Total Hardness (mg/l	7000
Bicarbonate (mg/l)	Sulphate (mg/l):	250	Chloride (mg/l):	2200
Calcium (mg/l):	Magnesium (mg/l)		Sodium (mg/l):	
ion Balance Error (%):	Gen	eral Comment	s:	
Data Sources	-			
Faillace & Faillace : 986	e 			

Well Number 15 Well N	ame: Y	aak B	Bisharo 3/84	4	
Well Location;					
Easting: 42.1667 Well Owner;	Northing: Current S	tatus:		-0	.2
Ground Level (m amsl):	Geology:			Hydrog	eology:
Well Depth (mbgl):	Fluvio-lagunal			T	
Borehole Diameter (mm):		gravel, as Qcl of Fa	nd sandy clay illace & Faillace	1	
Installation Details:	1986)			1	
Geophysical Data					
Static Water Level (m amsl): Dri	iling Information:				
Dynamic Water Level (m amsl):					
Yield (Vs):					
Test Pumping Data:					
		Tran	ismissivity (m^2/d):		
		Hydr	raulic Conductivity (m/d):	
		Store	age:		
100			of Maria Color Coat Coat Coat Coat Coat Coat Coat Coat		
Chemical Analyses:			EC (MicroS/cm);	1800
Sample collected 27/3/84.			pH:		8.8
	V 25		TDS (mg/l): Total Hardness	(ma/l)	1348
Bicarbonate (mg/l): 299 Sulphate (mg/l		74	Chloride (mg/l):	(mg/i).	308
Calcium (mg/l): 6i Magnesium (m		14	Sodium (mg/l):		308
Ion Balance Error (%): 1.7					300
E 5 5 7 M A	General C	omments	<u> </u>		
Data Sources:	-				
Faillace & Faillace 1986					
	1 1				

Well Number	16 V	Vell Name:	Cabdal	le Birole 1	0/79
Well Location:					
Easting	42.2	Nor	thing:		-0.5
Well Owner:		Cur	rent Status:	Destroyed	
Ground Level (m amsl);	10	Geology			Hydrogeology:
Well Depth (mbgi):	200		gunal deposits -		
Borehole Diameter (mm):		layers, n	sand, gravel, an earls. (Qcl of Fail	d sandy clay lace & Faillace	
installation Details;		1986)			
Drilled in 1978					
Geophysical Data:		_			
Static Water Level (m amsi):		Drilling Inform	ation:		
Dynamic Water Level (m amsi):					
Yield (l/s):					
Test Pumping Data:		4			
			Trans	smissivity (m^2/d):	
				aulic Conductivity ((m/d):
			Stora	ge:	
Chemical Analyses:				EC (MicroS/cm	340
Sample collected 28/10/79.				pH:	
			1	TDS (mg/l):	
				Total Hardness	(mg/l):
Bicarbonate (mg/l):		ate (mg/l):		Chloride (mg/l):	
Calcium (mg/l):	Magn	esium (mg/l):		Sodium (mg/l):	
Ion Balance Error (%):		Ger	eral Comments		
Data Sources		1			
Faillace & Faillace 1986					

Well Number	17 W	ell Name:	Qot Q	ot 3/84		
Well Location:						
Easting: 42	2278		Northing:		-0.4667	
Well Owner:			Current Status:			
Ground Level (m amsl):	13,1	Geok	ogy:		Hydrogeolo	gy:
Well Depth (mbgl);	215		o-lagunal deposits ing sand, gravel, a			
Borehole Diameter (mm):		layers	s, maris. (Qcl of F			
Installation Details:		1986)		i	
Drilled in 1976		Î				
Geophysical Data:						
Static Water Level (m amsi): Dynamic Water Level (m amsi): Yleid (Vs):		Drilling Info	ormation:			
Test Pumping Data:						-
			Tra	nsmissivity (m^2/d):		
				fraulic Conductivity	(m/d):	
			Sto	rage:		
Chemical Analyses				EC (MicroS/cm	n):	40000
Sample collected 27/3/84. Error no	ted: TDS/EC high	1.0		pH;	_	
			1	TDS (mg/l):	=	39776
				Total Hardness	s (mg/l):	7832
Bicarbonate (mg/l):	52 Sulphal	e (mg/l):	2227	Chloride (mg/l):		16771
Calcium (mg/l):	752 Magnes	sium (mg/l);	1 446	Sodium (mg/l):	10	6162
Ion Balance Error (%):	10 9	3	General Comment	S		
Data Sources:						
Faillace & Faillace 1986						
		-				
		1				

Well Location: Easting: 42.2278 Northin	ng:		
	ng:	1	
Well Owner: Curren	t Status:	-0.48	367
Ground Level (m amsl): 13.1 Geology:		Hydro	geology:
covering sal	nal deposits - Sai nd, gravel, and s s. (Qcl of Faillac	andy clay	
Geophysical Data:			
Static Water Level (m amsl): Dynamic Water Level (m amsl): Yield (Vs): Test Pumping Data:	on:		
		ssivity (m^2/d); c Conductivity (m/d);	
Chemical Analyses:		EC (MicroS/cm):	
Sample collected 27/3/76.		pH: TDS (mg/l): Total Hardness (mg/l):	7.9 3704 300
Bicarbonate (mg/l): Sulphate (mg/l):		oride (mg/l):	550
Calcium (mg/l): Magnesium (mg/l):		dium (mg/l):	
Ion Balance Error (%): General	d Comments:		
Data Sources:			
Faillace & Faillace 1986			

Well Number	19	Well Na	me:	Qot Q	ot 9/70		
Well Location:							
Easting: Well Owner:	42.2278		North	ing:		-0,46	67
Ground Level (m amsl):		13.1	Geology:			Hydrog	eology;
Well Depth (mbgl):		197			- Sandy clay		
Borehole Diameter (mm):					and sandy clay aillace & Faillace		1
Installation Details:			1986)				
Drilled in 1967							
Geophysical Data:							
Static Water Level (m amsl): Dynamic Water Level (m amsl): Yield (l/s): Test Pumping Data:	si):	-2.9 Drillie	ng Informa	tion:			
				Tra	insmissivity (m*2/d):		
				Ну	draulic Conductivity	(m/d):	
				Sto	orage!		
Chemical Analyses:					EC (MicroS/cm	1):	3700
Sample collected 1/9/70, it is generated by assuming a zer			K value wa	s	pH:		6.8
garanasa ay assaming a co	V 1011 2010110	,		1)	TDS (mg/l):		2364
_					Total Hardness	s (mg/l):	280
Bicarbonate (mg/l):	878	Sulphate (mg/l):		208	Chloride (mg/l):		595
Calcium (mg/l);	641	Magnesium (mg/	1):	291	Sodium (mg/l):		705
ion Balance Error (%):	0		Gene	ral Comment	s:		
Data Sources			Wate		m amsl in Sept 197	0 when s	ample
Faillace & Faillace 1986			- ONING	am¥*			
		1					

Well Number 20 Well Na	ame: Bibi 3	3/84	
Well Location.			
Easting: 42.2333 Well Owner:	Northing: Current Status:	Usable in Marc	0.1667 h 1993
Ground Level (m arnsl): 33.2	Geology	9	Hydrogeology:
Well Depth (mbgl): 137 Borehole Diameter (mm); Installation Details:	Fluvio-lagunal depos covering sand, grave layers, marls. (Qcl o 1986)	el, and sandy clay	
Geophysical Data:			
Static Water Level (m amsl): Dynamic Water Level (m amsl): Yield (l/s): Test Pumping Data:	ling Information:		
	3	Transmissivity (m*2/d); Hydraulic Conductivity (m Storage:	/d):
Chemical Analyses:		EC (MicroS/cm):	3980
Sample collected 28/3/84. It is considered likely that the Na generated by assuming a zero ion balance.	K value was	pH: TDS (mg/l): Total Hardness (i	8.9 2636 mg/l): 81
Bicarbonate (mg/l): 577 Sulphate (mg/l)	84	•	869
Calcium (mg/l): 26 Magnesium (mg/l):	g/l): 4	Sodium (mg/l):	804
fon Balance Error (%): 0	General Comme	ents:	
Data Sources: Faillace & Faillace 1985		8 m amst in March 1984 vells one abandonned.	when sample

Well Number 21 Well N	ame:	Bibi		
Well Location:				
Easting: 42.2333 Well Owner:	Norti	ning: ent Status:		0.1667
Ground Level (m amsi): 33.2	Geology:			Hydrogeology:
Well Depth (mbgl) Borehole Diameter (mm); Installation Details:	covering s	sand, gravel,	- Sandy clay and sandy clay ailface & Failface	
Drilled in 1956				
Geophysical Data:				
Static Water Level (m amsi); Dynamic Water Level (m amsi): Yield (Us): Test Pumping Data:	lling informa	tion:		
		Ну	insmissivity (m^2/d): draulic Conductivity orage:	
Chemical Analyses:			EC (MicroS/cm pH: TDS (mg/l): Total Hardness	
Bicarbonate (mg/l) Sulphate (mg/l)):	230	Chloride (mg/l):	2110
Calcium (mg/l); Magnesium (m	g/l);		Sodium (mg/l):	
Ion Balance Error (%):	Gene	ral Comment	s:	
Data Sources	-			
Faillace & Faillace 1986				

Well Number	22	Well	Nam	e: <u>C</u>	abdi	Dor	rreh 3/8	4	
Well Location:									
Easting: 4	2.2833			Northing: Current S	tatus:			-0.31	67
Ground Level (m amsl):		20.5	Ge	ology.				Hydrog	geology;
Well Depth (mbgl): Borehole Diameter (mm): Installation Details: Drilled in 1973			colay	vering sand, ers, marls. (86)	gravel,	and sa	ndy clay		
Geophysical Data:									
Static Water Level (m amsl): Dynamic Water Level (m amsl): Yield (l/s): Test Pumping Data:			Drilling	Information:					
					Ну		sivity (m^2/d) Conductivity		
Chemical Analyses:						E	C (MicroS/cr	n):	6590
Sample collected 27/3/84. It is of generated by assuming a zero id			Na • K	value was		T	H: DS (mg/l); otal Hardnes:	s (mg/l):	7.9 3944
Bicarbonate (mg/l):	310	Sulphate (m	ng/l);		480	Chlor	ride (mg/l):		1655
Calcium (mg/l):	19	Magnesium	(mg/l)		21	Sodh	um (mg/l):		1396
ion Balance Error (%):	0			General C	ommen!	ts:			
Data Sources:									
Faillace & Faillace 1986									
			Th.						

Well Number 23 Well N	ame: Jaam	a Cabdalla	
Well Location:			
Easting: 42.2833 Well Owner:	Northing: Current Status:	0.	0333
Ground Level (m amsl): 17	Geology:	Hyd	rogeology:
Well Depth (mbgl): 85 Borehole Diameter (mm): Installation Details: Drilled in 1954	Fluvio-lagunal deposit covering sand, gravel, layers, marls. (Qcl of I 1986)	and sandy clay	
Geophysical Data:			
Static Water Level (m amsl): -23 Dri Dynamic Water Level (m amsl): Yield (l/s): Test Pumping Data:	ling information:		
	Ну	ansmissivity (m^2/d); ydraulic Conductivity (m/d); orage:	
Chemical Analyses:		EC (MicroS/cm): pH: TDS (mg/l): Total Hardness (mg/)): 200
Bicarbonate (mg/l): Sulphate (mg/l	350	Chloride (mg/l):	2460
Calcium (mg/l): Magnesium (m	g/I):	Sodium (mg/l):	
Ion Balance Error (%):	General Commer	nts:	
Data Sources:	Water level -28 m	amsl in ???????? when s	ample collected
Faillace & Failface 1986			

Well Number 24 Well N	ame: Haa	dweyn 9/70	
Well Location:			
Easting: 42.3 Well Owner:	Northing: Current Status		-0.3
Ground Level (m arnsi): 18.9	Geology.	Hv	drogeology;
Well Depth (mbgl): 192	Fluvio-lagunal depo		
Borehole Diameter (mm):	covering sand, grav layers, maris. (Qcl o	el, and sandy clay of Faillace & Faillace	
Installation Details:	1986)		
	100		
Geophysical Data:			
	*		
	1		
Static Water Level (m amsl): 3.9 Dri	lling Information:		
Dynamic Water Level (m amsl):	3		
Yield (l/s):			
Test Pumping Data:			
		Transmissivity (m^2/d):	
		Hydraulic Conductivity (m/d)):
		Storage:	
40.000		FO NE	200
Chemical Analyses: Sample collected 8/9/70. It is considered likely that the Na	K value was	EC (MicroS/cm): pH:	3080
generated by assuming a zero ion balance.	it raide itas	TDS (mg/l):	2470
		Total Hardness (mg	
Bicarbonate (mg/l): 1415 Sulphate (mg/l)	13	=	625
Calcium (mg/l): 120 Magnesium (m	g/l); 2	4 Sodium (mg/l):	842
ion Balance Error (%): 0	General Comm	ents:	
Data Sources		8.1 m amsl in Sept 1970 wh	en sample
Faillace & Faillace 1986	collected		
	i J		

Well Number	25 Wel	Name): [F	laadw	eyn 6/67		
Well Location:							
Easting: Well Owner:	42.3	1	Northing Current			-(0.3
5× 00 50 5.				Status,			
Ground Level (m amsl):	18.9	-	ology:			Hydrog	eology:
Well Depth (mbgl)	192	cov	ering sand	i, gravel, a	 Sandy clay and sandy clay 		
Borehole Diameter (mm): Installation Details;		198		(Qcl of Fa	aillace & Faillace		
Geophysical Data:							
Static Water Level (m amst): Dynamic Water Level (m amst):	4.4	Drilling Is	nformation	ĸ			
Yield (Vs):							0
Test Pumping Data:							
					nsmissivity (m^2/d)		
					traulic Conductivity	(m/d):	
				Stor	rage:		
Chemical Analyses:					EC (MicroS/cr	n):	
Sample collected 25/6/67					pH:	6	
					TDS (mg/l):		4700
					Total Hardness	s (mg/l);	
Bicarbonate (mg/l):	Sulphate (mg/l):		241	Chloride (mg/l):		1548
Calcium (mg/l):	Magnesius	m (mg/l);			Sodium (mg/l):		
ton Balance Error (%)			General	Comments	š:		
Data Sources:					m amsl in June 196	67 when s	sample
Faillace & Faillace 1986		1	collected				

Well Number 26	Well Nam	e: Lahele	ey 3/84	
Well Location:				
Easting: 42.35 Well Owner:		Northing: Current Status;		-0.3333
Ground Level (m amsl):	G	eology:		Hydrogeology:
Well Depth (mbgl): Borehole Diameter (mm): Installation Details: Drilled in 1978	la la	uvio-lagunal deposits overing sand, gravel, yers, marls. (QcI of F 986)	and sandy clay	
Geophysical Data:				
Static Water Level (m amsl): Dynamic Water Level (m amsl): Yield (Vs):	Drilling	Information:		
Test Pumping Data:			ansmissivity (m^2/d):	
		Ну	draulic Conductivity orage:	
Chemical Analyses:			EC (MicroS/cm	n): 3490
Sample collected 27/3/84			pH: TDS (mg/l): Total Hardnéss	2088 s (mg/l): 205
Bicarbonate (mg/l): 283	Sulphate (mg/l):	140	Chloride (mg/l):	841
Calcium (mg/l): 26	Magnesium (mg/l):	34	Sodium (mg/l):	582
Ion Balance Error (%):		General Commen	ts:	
Data Sources				
Faillace & Faillace 1986				

Well Number	27	Well Nan	ne: [ahele	ey 9/70		
Well Location:							
Easting: Well Owner:	42.35		Northing	S.		-0.3333	3
Ground Level (m amsi):			eology:			Hydroge	ology:
Well Depth (mbgl)					s - Sandy clay	T	7
Borehole Diameter (mm)		- 1	yers, marls		and sandy clay aillace & Faillace		
Installation Details:			986)				
Geophysical Data:							
T.i							
Static Water Level (m amsl):		Drilling	Information	1;			
Dynamic Water Level (m ams	st):						
Yield (I/s):							
Test Pumping Data:				-			
					ansmissivity (m^2/d)		
				1	draulic Conductivity	(m/d):	
				Sto	orage:	1	
Chemical Analyses:					EC (MicroS/cr	n):	6400
Sample collected 8/9/70. It is	considered l	ikely that the Na + K	value was		pH:	[6.4
generated by assuming a zero analyses is greater than the T		Error nated, the sui	n grune ioni		TDS (mg/l):	[4396
					Total Hardnes	s (mg/l).	800
Bicarbonate (mg/l):	1269	Sulphate (mg/l):		559	Chloride (mg/l):		1543
Calcium (mg/l):	160	Magnesium (mg/l)	-	97.	Sodium (mg/l):		1417
Ion Balance Error (%):	0		General	Commen	ts:		
Data Sources:					15 m bgl. Water leve e collected	el 177 m bg	t in Sept
Faillace & Faillace 1986		*					

Well Number 28	Well Nan	ne: L	ahele	y 7/67		
Well Location:						
Easting 42.35		Northing:			-0.333	3
Well Owner:		Current S	itatus:	i		
Ground Level (m amsl):		eology:			Hydroge	ology:
Well Depth (mbgl):				- Sandy clay and sandy clay		
Borehole Diameter (mm)	18	yers, marts. (986)	(Qcl of Fa	aillace & Faillace		
Installation Details.						
Geophysical Data:						
Charles Address Association and the	Della-	. tatava at an				
Static Water Level (m amsi): Dynamic Water Level (m amsi):	Drilling	Information:				
Yield (Vs):	==					
Test Pumping Data:						
			Tra	nsmissivity (m^2/d):	j	
			Hyd	draulic Conductivity (m/d):	
		1	Sto	rage;		
Chemical Analyses:			-	EC (MicroS/cm): [
Sample collected 27/7/67				pH; TDS (mg/l):	Ī	2200
				Total Hardness	(mg/l):	LEVO
Bicarbonate (mg/l):	Sulphate (mg/l):		430	Chloride (mg/l):	, , ,	588
Calcium (mg/l):	Magnesium (mg/l)	:		Sodium (mg/l);		
Ion Balance Error (%):		General C	Comment	S.		
Data Sources:		A STATE OF THE STA		5 m bgl. Water level	177 m bo	al in Sept
Faillace & Faillace 1986				collected		34.
		1				
						1
					-	

Well Location: Easting: 42.4 Well Owner: Ground Level (m amsi):	Northing: Current Status: Geology:	-0.	15
Well Owner: Ground Level (m amsi):	Current Status:	-0.	15
	Geology:		
Mali Davida (mball)		Hydrog	geology
Well Depth (mbgl): 184 Borehole Diameter (mm): Installation Details:	Fluvio-lagunal deposits - covering sand, gravel, ar layers, marls. (Qcl of Fai 1986)	nd sandy clay	
Geophysical Data:			
Static Water Level (m amsl): Dynamic Water Level (m amsl): Yield (l/s): Test Pumping Data:	rilling information:		
		smissivity (m^2/d); aulic Conductivity (m/d); age;	
Chemical Analyses:		EC (MicroS/cm):	9810
Sample collected 27/3/84,		pH: TDS (mg/l):	6248
Bicarbonate (mg/l): 189 Sulphate (mg	yi): 752	Total Hardness (mg/l): Chloride (mg/l):	2833
Calcium (mg/l): 51 Magnesium (Sodium (mg/l):	2032
Ion Balance Error (%): 2.4	General Comments		
Data Sources:	,		
Faillace & Faillace 1986			

Well Number 30 Well N	Name: Canjeel 10/83
Well Location:	
Easting: 42.4 Well Owner:	Northing: -0.15 Current Status:
Ground Level (m amsl):	Geology: Hydrogeology:
Well Depth (mbgl);	Fluvio-lagunal deposits - Sandy clay
Borehole Diameter (mm):	covering sand, gravel, and sandy clay layers, marls. (Qcl of Faillace & Faillace
Installation Details:	1986)
Geophysical Data	
Static Water Level (m arnsl): Dr	Drilling Information:
Dynamic Water Level (m amsl):	
Yield (I/s):	
Test Pumping Data:	
	Transmissivity (m^2/d):
	Hydraulic Conductivity (m/d):
	Storage:
Chemical Analyses:	EC (MicroS/cm): 7600
Sample collected 23/10/83.	pH: 7.9
	TDS (mg/l):
	Total Hardness (mg/l):
Bicarbonate (mg/l): 386i Sulphate (mg/	y/l): 651 Chloride (mg/l): 2480
Calcium (mg/l): 58i Magnesium (n	(mg/l): 54i Sodium (mg/l): 1524
Ion Balance Error (%): 11.1	General Comments:
Data Sources:	1
Failface & Failface 1986	3

Well Number	31	Well N	lame	C	anje	el 8/70		
Well Location:			==					
Easting: Well Owner:	42.4			Northing: Current S	talus;		-0.	15
Ground Level (m armsl):			Geo	ology:			Hydrog	eology:
Well Depth (mbgl):	(9)	182	Fluv	io-lagunal		s - Sandy clay	~2000	
Borehole Diameter (mm):						and sandy clay aillace & Faillace		
Installation Details:			198	6)				
Geophysical Data:								
Static Water Level (m amsl): Dynamic Water Level (m am:	si).	De	rilling In	formation				
Yield (I/s):	1							
Test Pumping Data:					Tra	ansmissivity (m^2/d):	
				1		draulic Conductivity		
					Sto	orage;		
Chemical Analyses:						EC (MicroS/c	m):	10250
Sample collected 29/8/70. It						ρH;		7.2
generated by assuming a zero analyses is greater than the T		, Error noted, the	sum o	the ionic	i	TDS (mg/l):		6106
						Total Hardnes	s (mg/l):	1160
Bicarbonate (mg/l):	830	Sulphate (mg/	1):		790	Chloride (mg/l):		2726
Calcium (mg/l)	112	Magnesium (n	ng/l):		214	Sodium (mg/l):		1976
ion Balance Error (%):	0			General C	omment	s:		
Data Sources			-			45 m bgt. Water level e collected	el 137 m b	gl in August
Faillace & Faillace 1986			76	, or o mile	. ouriga	- sameutes		
			8					
				L				

Well Number 32 Well	Name:	Yaabo	4/84	
Well Location				
Easting: 42.65 Well Owner:		hing: rent Status:		0.2667
Ground Level (m amsi): 19	Geology:			Hydrogeology
Well Depth (mbgl):	Fluvio-lag	gunal deposits -	Sandy clay	
Borehole Diameter (mm): Installation Details:		sand, gravel, ar aris. (Qci of Fa	nd sandy clay illace & Faillace	
Geophysical Data:				
Static Water Level (m amsi): -3.3 Dynamic Water Level (m amsi): Yield (Vs): Test Pumping Data:	Drilling Inform	ation:		1
		Tran	smissivity (m*2/d):	
		Hydi	raulic Conductivity	(m/d):
		Stor	age.	
Chemical Analyses:			EC (MicroS/cm	1): 1175
Sample collected 6/4/84,			pH:	8.
			TDS (mg/l):	748
			Total Hardness	s (mg/l): 48
Bicarbonate (mg/l): 283 Sulphate (m	g/l)	976	Chloride (mg/l):	347
Calcium (mg/l); 74 Magnesium	{mg/i};	72	Sodium (mg/l):	186
Ion Balance Error (%) 16.3	Gen	eral Comments	E C	
Data Sources			-	
Faillace & Faillace 1986				

UNICEF Somalia GIBB Ltd Kismayo Hydrogeological Study

Well Number	33	Well Nam	e: La	ahele	y 1/97		
Well Location: Laheley, S	Somalia						
Easting:	42.35		Northing:			-0.33	33
Well Owner:			Current S	tatus;	Operational		
Ground Level (m amsl):		Ge	ology:			Hydrog	eology;
Well Depth (mbgl);		210					
Borehole Diameter (mm):							
Installation Details:		ŧ					
Pump installed at 58.5 m bg	ıt.						
						1	ľ
Geophysical Data:							
							i
		1 1					ĺ
Static Water Level (m amsl)		Drilling	Information;				
Dynamic Water Level (m am	nsl):						h
Yield (I/s):		3.7					
Test Pumping Data:							
No. Logan Approximation or	nly.				insmissivity (m^2/d)		12
				Hyd	draulic Conductivity	(m/d):	
				Sto	rage:		
L.					and the last to th		
Chemical Analyses:			-		EC (MicroS/cn	n)_	5400
Two samples collected after values given here. CI (1,400	30 and 60 mir & 2,400) was	ns of pumping on 24/1 only main difference was a contract of the contract of	/97. Mean which may		pH:		7.7
account for the high IBEs (1 TDS of approx 10,000 mg/l,	7 & 10).A sam				TDS (mg/l):		3700
The diappiex release right		2000 2000 2000			Total Hardness	s (mg/l):	1250
Bicarbonate (mg/l):	360	Suiphate (mg/l);		180	Chloride (mg/l):		1900
Calcium (mg/l):	280	Magnesium (mg/l):		130	Sodium (mg/l):		920
ion Balance Error (%):			General C	omment	S;		
Data Sources:					24 m bgl and dynam		
Faillace & Faillace 1986			after 15 m	ins indic	n of drawdown. The ates leakage to the	well from	the shallow
		.51	aquifer. The		sis presented here r	nay there	fore be a mix
ľ		1	7/3=7/8=2				
L							

Well Number 34	Well Name	Magdas	1/85	
Well Location: At the Mosque, Magdas,	Somalia			
Easting: 42.8028 Well Owner:		Northing: Current Status:	0	3861
Ground Level (m amsl).	17.9 Geo	ology;	Hyd	rogeology:
Well Depth (mbgl):	20.4 Fine	e Merti aquifer (Lane 1	995)	
Borehole Diameter (mm):				
Installation Details:				
Shallow well, presumably large diameter.				
Geophysical Data:				
	i			
Static Water Level (m amsl):	0.5 Drilling Ir	nformation:		
Dynamic Water Level (m amsl);	_			
Yield (I/s):				
Test Pumping Data:				
			missivity (m^2/d):	
			ulic Conductivity (m/d):	
		Stora	ge:	
Chemical Analyses:			EC (MicroS/cm):	3990
Sodium concentration given is combined So	dium and Potassium.	a (pH;	7.7
		1	TDS (mg/l):	2428
			Total Hardness (mg/	n:
Bicarbonate (mg/l): 434	Suiphate (mg/l).	270	Chloride (mg/l):	939
Calcium (mg/l): 32	Magnesium (mg/l):	21	Sodium (mg/l):	661
ion Balance Error (%): 11.2		General Comments:		
Data Sources:		lon balance error una	acceptably high.	
Lane 1995				

Well Number	35	Well Nam	ne: Magd	as 4/84		
Well Location: Magdas, S	omalia				_311	
Easting:	42.8028		Northing:		0.38	61
Well Owner:			Current Status:			
Ground Level (m amsl)		17.9	eology:		Hydrog	eology:
Well Depth (mbgl):	1	20.6	ine Merti aquifer (La	ne 1995)		
Borehole Diameter (mm):						
Installation Details:						
Shallow well, presumably larg	ge diameter.					
Geophysical Data:						
Static Water Level (m amsl): Dynamic Water Level (m ams Yield (l/s): Test Pumping Data:	si):	1.5 Drilling	Information;			
			т т	ransmissivity (m^	2/d):	
			Н	lydraulic Conducti	vity (m/d);	
			s	lorage.		
Chemical Analyses:				EC (Micro	S/cm):	3710
Sodium concentration given i	s combined S	Sodium and Potassiu	m.	pH;		8.9
			- 5	TDS (mg/l):	2224
				et	ness (mg/l):	
Bicarbonate (mg/l):	315	Sulphate (rng/l):	259):- :	841
Calcium (mg/l):	16	Magnesium (mg/l)	31	Sodium (mg/l)	K	558
ion Balance Error (%)	11.9		General Comme	nts		
Data Sources			ion balance erro	r unacceptably hig	ph.	
Lane 1995						
		ì	5			

Well Number 36 Well	Name:	Sheek (Cabdi Mudde	y 4/84
Well Location: Sheek Cabdi Muddey, Somalia				
Easting: 42.8167 Well Owner:		orthing: urrent Status;		0.3
Ground Level (m amsi): 17.6 Well Depth (mbgl): 18 Borehole Diameter (mm): 18 Installation Details: Shallow well, presumably large diameter. Geophysical Data:	Geolog	y: erti aquifer (Lane 1		drogeology:
Static Water Level (m amsi): 1.6 Dynamic Water Level (m amsi): Yield (l/s): Test Pumping Data:	Drilling Inform	Trans	imissivity (m^2/d):	
Chemical Analyses: Sodium concentration given is combined Sodium and Po	otassium.	Stora	EC (MicroS/cm): pH: TDS (mg/l): Total Hardness (mg	8410; 8.7 5528
Bicarbonate (mg/l): 797 Sulphate (r Calcium (mg/l): 29 Magnesium Ion Balance Error (%): 9.8	(mg/l):		Chloride (mg/l): Sodium (mg/l):	1566 1502
Cata Sources:				

Well Number	37	Well Na	me:	Amino	w 4/84		
Well Location: Aminow. S	Somalia						
Easting: Well Owner;	42.8417			thing; rent Status;		0.35	83
Ground Level (m amsl);		21.1	Geology			Hydrog	geology:
Well Depth (mbgl):	J	20	Fine Me	ti aquifer (Lan	e 1995)	1	
Borehole Diameter (mm):							
Installation Details:			1				
Shallow well, presumably lar	ge diameter.						
Geophysical Data:							
Static Water Level (m amsl): Dynamic Water Level (m am Yield (l/s): Test Pumping Data:		2.6 Drift	ing Inform	ation;			
				Tra	nsmissivity (r	m^2/d):	
					draulic Condu		
				Sto	rage;		
Chemical Analyses					EC (Mic	roS/cm):	3410
Sodium concentration given	is combined S	Sodium and Potass	ium.		pH:		7.8
					TDS (m	g/l):	1600
				i	Total Ha	erdness (mg/l):	
Bicarbonate (mg/l):	252	Sulphate (mg/l):		259	Chloride (m	g/l):	813
Calcium (mg/l):	93	Magnesium (mg	γA);	138	Sodium (mg	9/1):	319
Ion Balance Error (%).	4.7		Ger	neral Commen	ts.		
Data Sources:			-				
Lane 1995			- Î				
			<				
			7				
			_		14		

Well Number 38	Well Name:	Aminov	v 3/71	
Well Location: Aminow, Somalia				
Easting: 42.8417 Well Owner:		Northing: Current Status:	0.	3583
Ground Level (m amsi): 21.	.1 Geold	pgy:	Hydr	rogeology
Well Depth (mbgl); 9. Borehole Diameter (mm): Installation Details: Shallow well, presumably large diameter.	5 Fine	Merti aquifer (Lane	1995)	
Geophysical Data:				
Static Water Level (m amsl): Dynamic Water Level (m amsl): Yield (l/s): Test Remoins Data:	6 Drilling Info	ormation		
Test Pumping Data:	<u> </u>		smissivity (m^2/d): aulic Conductivity (m/d): age:	
Chemical Analyses: Sodium concentration given is combined Sodium	um and Potassium.		EC (MicroS/cm) pH TDS (mg/l).	2798 7.7 1574
	ulphate (mg/l): lagnesium (mg/l):		Total Hardness (mg/l) Chloride (mg/l): Sodium (mg/l):	426
Data Sources Lane 1995			e error may indicate that een estimated assuming	

Well Number 101 Well	Name:	Lagh Bo	gal	
Well Location: Lagh Bogal, Kenya				
Easting: 39.8456	Nort	hing:		1.2908
Well Owner.	Curr	ent Status:	Abandoned	
Ground Level (m amsl): 226	Geology:			Hydrogeology:
Well Depth (mbgl) 175,4	Fine Men	aquifer		Water strike at
Borehole Diameter (mm)				155.5 m bgl
Installation Details:				
Geophysical Data:				
Scopilysical Sala.				
Static Water Level (m amsl): 107.1 Dynamic Water Level (m amsl): 104 Yield (l/s): 1.6 Test Pumping Data:	Drilling Informa	ation:		
No, Logans approximation only		1	missivity (m^2/d);	54
		Storag	ulic Conductivity (m	/d):
Chemical Analyses:			EC (MicroS/cm):	16000
			pH:	8.1
			TDS (mg/l):	11400
	-		Total Hardness (
Bicarbonate (mg/l): Sulphate (n	=		hloride (mg/l);	6080
Calcium (mg/l): 428 Magnesium	(mg/l);	S	Sodium (mg/l);	1
Ion Balance Error (%):	Gen	erai Comments:		
Data Sources				
Swarzenski & Mundorff 1977	1			

Well Number	102 W	ell Name	Kurdi			
Weil Location: Kurdi, Kenya						
Easting: 40 Well Owner:	.6728		Northing: Current Status:	Abandoned	-0.7378	
Ground Level (m amsl):	124	Geo	logy:		Hydrogeolo	ogy:
Well Depth (mbgl). Borehole Diameter (mm): Installation Details: 18.3 m of well screen Geophysical Data:	140.3	Fine	Merti aquifer ident	ified by Lane 1995		
Static Water Level (m amsi): Dynamic Water Level (m amsi): Yield (l/s): Test Pumping Data:	-8.7 -13.3 0.6	Drilling in	oformation;			
No, Logan approximation only			Tra	nsmissivity (m^2/d):		14
				draulic Conductivity (m/d):	0.8
Chemical Analyses:				EC (MicroS/cm	1):	22000
				pH;	=	7,1
				TDS (mg/l):		13400
				Total Hardness	(mg/l):	2070
Bicarbonate (mg/l);	460 Sulphat	te (mg/l):	4800	Chlorida (mg/l);		3570
Calcium (mg/l):	560 Magnes	sium (mg/l):	170	Sodium (mg/l):	Ī	3663
Ion Balance Error (%).	1.9		General Comment	S:		
Data Sources						
Swarzenski & Mundorff 1977						

Well Number 103	Well Name	Dif		
Well Location: Dif, Kenya				
Easting: 40.9908		Northing:		0.9819
Well Owner:		Current Status:	Abandonned	
Ground Level (m amsl): 15	Ge	ology:		Hydrogeology:
Well Depth (mbgl):	Pin	e Merti aquifer (Lane		Water struck at 112.8 m bgl.
Borehole Diameter (mm):				112.0 m bgi,
Installation Details:				
Drilled in 1956.				
Geophysical Data				
Static Water Level (m amsl): 47. Dynamic Water Level (m amsl): 1.		nformation:		
Test Pumping Data:	-			
		Tra	nsmissivity (m^2/d):	
		1	draulic Conductivity (m	/d):
		Sto	rage:	
Chemical Analyses			EC (MicroS/cm):	25000
			pH:	7.8
			TDS (mg/l):	15100
			Total Hardness (mg/l): 3300
Bicarbonate (mg/l): 200 S	Sulphate (mg/l):	1415	Chloride (mg/l).	8170
Calcium (mg/l): 495 N	Aagnesium (mg/l):	501	Sodium (mg/l):	
ion Balance Error (%)		General Comment	5.	
Data Sources:				
Swarzenski & Mundorff 1977				

Well Number 10)4 Well Na	me: N	Merti 1		
Well Location: Merti, Kenya					
Easting: 38.60 Well Owner;	529	Northing Current			1.0564
Ground Level (m amsl):	293	Geology:			Hydrogeology:
Well Depth (mbgl): Borehole Diameter (mm): Installation Details:		Fine Merti aqı	uifer (Lane 199		Vater struck at 30 n bgl.
Geophysical Data:					
Static Water Level (m amsi): Dynamic Water Level (m amsi): Yield (l/s): Test Pumping Data:	278 Drilli 277.4 5.8	ing Information):		
Analyses of pumping tests given in t	ane 1995			ssivity (m^2/d). Conductivity (m.	790
Chemical Analyses:				EC (MicroS/cm); pH: FDS (mg/l): Total Hardness (r	949 582
Bicarbonate (mg/l):	Sulphate (mg/l):			oride (mg/l):	
Calcium (mg/l):	Magnesium (mg	μ1):	Sod	lium (mg/l);	
Ion Balance Error (%).	-	General	Comments:		
Data Sources					
WRAS					

Well Number 105 Well	Il Name:	Merti 2		
Well Location				
Easting: 38.6473 Well Owner:		thing: rent Status:		1.0614
Ground Level (m amsl): 290	Geology:			Hydrogeology:
Well Depth (mbgl). 50 Borehole Diameter (mm): Installation Details.	Fine Mer	ti aquifer (Lane 199		Water struck at 42 m bgl.
Drilled in 1977 Geophysical Data:				
Static Water Level (m amsl): Dynamic Water Level (m amsl): Yield (Vs): Test Pumping Data:	Drilling Inform	ation		
No.			ssivity (m^2/d); c Conductivity (m	/d):
Chemical Analyses:			EC (MicroS/cm): pH; rDS (mg/l): rotal Hardness (r	
Bicarbonate (mg/l): Sulphate Calcium (mg/l): Magnesiu Ion Balance Error (%):	m (mg/l):	Chk	oride (mg/l): ium (mg/l):	
Data Sources EPW				

Well Location: Matasadeni, Kenya asting: 38,4288 Well Owner:	Northing:	
Vell Owner:	Northing:	
		1.375
	Current Status:	
round Level (m amsl):	Geology:	Hydrogeology:
Vell Depth (mbgl): 150	Fine Merti aquifer (Lane 1995)	Water struck at
orehole Diameter (mm)		66.0 m bgl.
stallation Details		
rilled in 1980		
eophysical Data:		
ynamic Water Level (m amst):	Drilling Information:	
est Pumping Data:	Transmissivity (i	mA2(d):
0.	Hydraulic Condu	
	Storage	issuity (tire)
hemical Analyses	EC (Mid	croSicm):
	pH:	
	TDS (m	g/l):
	Total Ha	ardness (mg/l):
icarbonate (mg/l): Sulphate (m	Chloride (m	ng/l).
alcium (mg/l): Magnesium	(mg/l) Sodium (me	g/i);
n Balance Error (%).	General Comments:	
ata Sources:	Static water level 60 m bgl.	
PW		

Well Number 107 We	II Name	Matasad	deni 2	
Well Location: Matasadeni, Kenya				
Easting: 38.6387		Northing:		1.3613
Well Owner:)	Current Status:	Abandoned	
Ground Level (m amsl):	Geo	ology:		Hydrogeology:
Well Depth (mbgl): 192.4	Fin	e Merti aquifer (Lane 1	995)	Water struck at
Borehole Diameter (mm)				147.0 m bgl.
Installation Details.				
Drilled in 1979				
Geophysical Data:	- i			
Static Water Level (m amsl); Dynamic Water Level (m amsl); Yield (l/s): Test Pumping Data:	Drilling Is	nformation:		
No.		Trans	missivity (m^2/d):	
			ulic Conductivity	
		Storaç	je:	
Chemical Analyses:			EC (MicroS/cm pH: TDS (mg/l): Total Hardness	
Bicarbonate (mg/l): Sulphate	(mg/l):		hloride (mg/l):	
	um (mg/l):		Sodium (mg/l):	
ion Balance Error (%)		General Comments:		
Data Sources:		Static water level 140	m bgi	
EPW				

Well Number 108 Well	Name	e: Bu	ule			
Well Location: Bule, Kenya						
Easting: 38.7917 Well Owner:	1	Northing: Current St	atus:	Abandoned	1.40	36
Ground Level (m amsi):	Geo	ology,			Hydrog	eology:
Weil Depth (mbgt): 200.7: Borehole Diameter (mm): Installation Details: Drilled in 1979	Fin	e Merti aquif	er (Lane 199	95)	Water 127.5 r	struck at n bgl.
Geophysical Data:						
Static Water Level (m amsl): Dynamic Water Level (m amsl): Yield (Vs): Test Pumping Data.	Drilling Ir	nformation				
No.				issivity (m*2/d): ic Conductivity (
Chemical Analyses:				EC (MicroS/cm pH: TDS (mg/l): Total Hardness		18000
Bicarbonate (mg/l): Sulphate (n	ng/l):		Ch	loride (mg/l):	10.09.0	
Calcium (rng/l): Magnesium Ion Balance Error (%).	n (mg/l):	General Co		dium (mg/l);		
Data Sources EPW/WRAS		Static water	r level 103 n	n ögl.		

Well Number 109	Well Name:	Merti E		
Well Location, Merti, Kenya				
Easting: 38.8167: Well Owner:		rthing:	1.03	889
Ground Level (m amsl).	Geology	·	Hydro	geology
Well Depth (mbgl):	60 Fine Me	rti aquifer (Lane 1995		struck at
Borehole Diameter (mm)			34.0 π	n ogi,
Installation Details				
Dniled in 1978			Į.	
			4	
Geophysical Data				
			1	
	1		1	
			1	
Static Water Level (m amsi):	Drilling Inform	nation'		
Dynamic Water Level (m amsl):				
Yield (I/s):	2			
Test Pumping Data.				
No.		Transmiss	sivity (m^2/d):	
		Hydraulic	Conductivity (m/d):	
		Storage		1
		-		
Chemical Analyses:		ΕΕ	C (MicroS/cm);	4100
			H:	
			DS (mg/l):	2500
			otal Hardness (mg/l);	
	Sulphate (mg/l);		ride (mg/l):	
	Magnesium (mg/l):	Sodi	um (mg/l):	-
ion Balance Error (%).	Ge	neral Comments:		
Data Sources	Sta	tic water level 34.4 m	bgl	
EPW				
4				

Well Number 110 Well	Name:	El Dera	
Well Location: El Dera, Kenya			
Easting: 38.8311	Nort	hing:	0.5914
Well Owner:	Curr	ent Status	Abandoned
Ground Level (m amsl) 354	Geology		Hydrogeology:
Well Depth (mbgl): 124.4	Fine Men	i aquifer (Lane 1	1995)
Borehole Diameter (mm)			
Installation Details:	4		
Drilled in 1940	7 1		
	1 1		
Geophysical Data:	~ 5		
	7		
	1 1		
Static Water Level (m amsl): 245.7	Drilling Informa	ation"	
Dynamic Water Level (m amsl):			
Yield (Vs): 0.91			
Test Pumping Data:			
No.		Trans	smissivity (m*2/d):
140.		4000 00	N W 324
			aulic Conductivity (m/d):
		Stora	ge:
Chemical Analyses			EC (MicroS/cm):
			pH:
			TDS (mg/l):
			Total Hardness (mg/l):
Bicarbonate (mg/l) Sulphate (n	mg/l);		Chloride (mg/l):
Calcium (mg/l): Magnesium	n (mg/l):		Sodium (mg/l):
Ion Balance Error (%)			-
	Gene	eral Comments:	
Data Sources:			
EPW/Swarzenski & Mundorff 1977		, ř	
	N E		

Well Number 111 V	Vell Name:	Korbesa	E	
Well Location: Korbesa, Kenya				
Easting: 38.8894	No	rthing		1,2113
Well Owner:	Cu	rrent Status;	Abandoned	
Ground Level (m amsl).	Geology	5		Hydrogeology:
Weil Depth (mbgl): 180	Fine Me	rti aquifer (Lane 1	995)	Water struck at 54.0 m bgl.
Borehole Diameter (mm):				04.0 m bgi.
Installation Details.				
Drilled in 1979				
Geophysical Data:				
Static Water Level (m amsl) Dynamic Water Level (m amsl): Yield (l/s): Test Pumping Data:	Drilling Inform	nation		
No.		Trans	missivity (m*2/d):	
		Hydra	ulic Conductivity (n	n/d):
		Storag	je:	
Chemical Analyses			EC (MicroS/cm) pH: TDS (mg/l): Total Hardness	7970
Bicarbonate (mg/l): Sulph	iate (mg/l):		Chloride (mg/l):	(mg//
	esium (mg/l):		Sodium (mg/l):	
Ion Balance Error (%):	7.5		The state of the s	
	_	neral Comments		
Data Sources:	Sta	tic water level 30	m bgl	
EPW				

Well Number 112	Well Name	e: Iresa B	luru	
Well Location: Iresa Buru, Kenya				
Easting: 38.8926		Northing:		1.1452
Well Owner:		Current Status:		
Ground Level (m amsl)	Ge	ology:		Hydrogeology:
Well Depth (mbgl); Borehole Diameter (mm):	76 Fir	ne Merti aquifer (Lane	1995)	Water struck at 58.0 m bgl.
Installation Details				
Drilled in 1980				
Geophysical Data:				
Static Water Level (m amsl) Dynamic Water Level (m amsl): Yield (l/s): Test Pumping Data:	Orifling	information.		
No.		Tran	smissivity (m^2/d):	
		Hydr	raulic Conductivity	(m/d):
		Store	age:	
Chemical Analyses:			EC (MicroS/cm):
			pH:	
		4	TDS (mg/l):	
	250000		Total Hardness	(mg/1):
Bicarbonate (mg/l)	Sulphate (mg/l):		Chloride (mg/l):	
Calcium (mg/l):	Magnesium (mg/l)		Sodium (mg/l):	
ion Balance Error (%)		General Comments	ė:	-
Data Sources		Static water level 15	6 m bgl.	
EPW				
		ì		

Well Number	113	Well Nam	serich	10 1		
Well Location: Sericho, F	Kenya					
Easting: Well Owner;	39 0942		Northing: Current Status:		1.027	5
Ground Level (m amsi):		229 G	eology:		Hydroge	eology:
Well Depth (mbgl):		125 F	ne Merti aquifer (Lar	ne 1995)	Water s	
Borehole Diameter (mm).					100.6 m	bgl.
Installation Details:					ŀ	
Drilled in 1972. 6.1 metres of	of screen.					
Geophysical Data:						
Static Water Level (m amsi) Dynamic Water Level (m am Yield (Vs): Test Pumping Data:		0.83 Orilling	Information:			
No.			Tr	ansmissivity (m^2	/d):	
				draulic Conductiv		
				orage:	i i	
Chemical Analyses:		-11		EC (MicroS	/cm)	10400
Carbonate 312 mg/l. Fluorid	e 37 mg/l. Iron	0.80 mg/l.		pH:		8.5
				TDS (mg/l):		7970
				Total Hardn	ess (mg/l)	14
Bicarbonate (mg/l)	2920	Sulphate (mg/l):	800	Chloride (mg/l)		2470
Calcium (mg/l);	3	Magnesium (mg/l):	1	Sodium (mg/f):		2860
Ion Balance Error (%)	7.1		General Commen	ts:		
Data Sources						
Swarzenski & Mundorff 197	7					

Well Number 114 Well Na	sme: Seric	ho 2	
Well Location: Sericho, Kenya			
Easting: 39.0992	Northing:		1.1456
Well Owner:	Current Status:	Abandoned	
Ground Level (m arnsl): 239	Geology:		Hydrogeology:
Well Depth (mbgl): 91.5	Fine Merti aquifer (La	ne 1995)	Water struck at 50.3 m bgi.
Borehole Diameter (mm).	1		Joseph Control
Installation Details:			
Drilled in 1972			
Geophysical Data			
Static Water Level (m amsi): 216.7 Dril Dynamic Water Level (m amsl): Yield (l/s): Test Pumping Data:	ling Information:		
No.	н	ransmissivity (m^2/d): ydraulic Conductivity (r torage:	m/d):
Chemical Analyses		EC (MicroS/cm)	8000
Carbonate 552 mg/l. Fluonde 20.0 mg/l.		pH:	9.1
41		TDS (mg/l):	5660
		Total Hardness	(mg/l): 10
Bicarbonate (mg/l): 2050 Sulphate (mg/l)	827	Chloride (mg/l):	1080
Calcium (mg/l): 3 Magnesium (mg/l):	g/l): 1	Sodium (mg/l)	2200
ion Balance Error (%): 1.8	General Comme	nts:	
Data Sources:			
Swarzenski & Mundorff 1977] : 		

Well Number 115 Well N	lame: Se	rich	ю 3		
Well Location: Sericho, Kenya					
Easting. 39.0993	Northing:			1.14	59
Well Owner:	Current Sta	tus:	Abandoned		
Ground Level (m amsi): 236	Geology			Hydrog	geology:
Well Depth (mbgl): 51.8	Fine Merti aquife	r (Lan	e 1995)		struck at
Borehole Diameter (mm):				15.2 m	bgi.
Installation Details:					
Drilled in 1972					
Geophysical Data:					
Static Water Level (m amsl). 209.5 Dr. Dynamic Water Level (m amsl): Yield (l/s): Test Pumping Data:	rilling Information:				
No.		Tra	nsmissivity (m^2/d):	4	
	į	Hy	draulic Conductivity	(m/d):	
		Sto	rage:		
Chemical Analyses:			EC (MicroS/cn	1):	14000
Carbonate 996 mg/l. Fluoride 12.0 mg/l.		ì	pH:		8.6
			TDS (mg/l):		10000
		_	Total Hardness	s (mg/l):	40
Bicarbonate (mg/l): 2430 Sulphate (mg/		973	Chloride (mg/l):		2550
Calcium (mg/l): 16l Magnesium (n	ng/l)	0	Sodium (mg/l):		3860
Ion Balance Error (%) 12	General Cor	nment	S:		
Data Sources.					
Swarzenski & Mundorff 1977					
	Y				
	1				

Well Number	116	Well Nan	ne:	Mado	gashe		
Well Location: Madogash	ne, Kenya						
Easting:	39,1689		Northi	ing:		0.71	81
Well Owner:				nt Status	Abandoned		
Ground Level (m amsi):		253 (Seology:			Hydrog	eology:
Well Depth (mbgl):	18	8.2 F	ine Merti	aquifer (Lan	e 1995)		struck at
Borehole Diameter (mm):						181.5 r	n ogi,
Installation Details:						4	
Drilled in 1969						1	
Geophysical Data:							
Static Water Level (m amsi): Dynamic Water Level (m am Yield (l/s):		7.6 Orilling	3 Informati	ion:			
Test Pumping Data:		1					
No.					ansmissivity (m^2/d		
					draulic Conductivity	(m/d):	
				Sto	orage:		
Chemical Analyses:					EC (MicroS/c	m);	17000
Carbonate 422 mg/l, Fluoride	e 2.0 mg/l. Nitrat	e 57 mg/l			pH:		8.7
				1	TDS (mg/l);		10600
					Total Hardnes	så (mg/l):	66
Bicarbonate (mg/l):	3100	Sulphate (mg/l):		1630	Chloride (mg/l):		3100
Calcium (mg/l):	50	Magnesium (mg/l)		Ol	Sodium (mg/l);		3600
Ion Balance Error (%):	7 8		Gener	al Comment	is:		
Data Sources:							
Swarzenski & Mundorff 1977	7/WRAS						

Well Number 117 Well Na	me: Kune		
Well Location: Kune, Kenya			
Easting: 39.2886 Well Owner:	Northing: Current Status:	Abandoned	0.8978
Ground Level (m amsl): 285	Geology:		Hydrogeology:
Well Depth (mbgi): 152	Fine Merti aquifer (Lan	e 1995)	Water struck at 136
Borehole Diameter (mm):			m bgi,
Installation Details:			
Drilled in 1978			
Geophysical Data:			
Static Water Level (m amsi): 167 Drill Dynamic Water Level (m amsi): Yield (l/s): Test Pumping Data:	ing Information:		
No.	Tra	ensmissivity (m*2/d):	
		draulic Conductivity (r orage:	n/d):
Chemical Analyses:		EC (MicroS/cm)	10900
Fluoride 8.0 mg/l. Iron 1.80 mg/l.		pH	9.1
		TDS (mg/l):	6680
		Total Hardness	(mg/l): 46
Bicarbonate (mg/l): 2252 Sulphate (mg/l):		Chlonde (mg/l):	
Calcium (mg/l); 4 Magnesium (mg	/I): 81	Sodium (mg/l):	2400
ion Balance Error (%);	General Comment	is.	
Data Sources:			
EPW			

Iron 0.80 mg/l. Fluoride 9.4 mg/l. pH: 8.1	Well Number 118 W	ell Name:	Garissa		
Current Status Abandoned	Well Location: Ganssa, Kenya				
Static Water Level (m amst): 146 Geology Hydrogeology:	Easting. 39.6667	N	orthing		0.4728
Well Depth (mbgl): S4,9 Fine Merti aquifer (Lane 1995) Water struck at 42.7 m bgl.	Well Owner:	c	urrent Status	Abandoned	
Static Water Level (m amsi): 103.3 Drilling Information:	Ground Level (m amsl): 146	Geolog	Jy:	Hy	ydrogeology:
Static Water Level (m amsl): 103.3 Drilling Information:	Well Depth (mbgl): 54.9	Fine M	lerti aquifer (Lane 1		
Drilled in 1957	Borehole Diameter (mm):			42	2,7 m bgl.
Static Water Level (m amsi):	Installation Details.			1	
Static Water Level (m amsl):	Drilled in 1957				
Dynamic Water Level (m amst):	Geophysical Data:				
No. Transmissivity (m^2/d): Hydraulic Conductivity (m/d): Storage:	Dynamic Water Level (m amsl): Yield (l/s): 0.38	Drilling Infor	mation:		
Hydraulic Conductivity (m/d):	PRODUCTION SECURIO		Trans	missivity (m^2/d):	
Chemical Analyses: EC (MicroS/cm): 36000 Iron 0.80 mg/l. Fluoride 9.4 mg/l. pH: 8.1 TDS (mg/l): 22100 Total Hardness (mg/l): 80 Bicarbonate (mg/l): 1330 Sulphate (mg/l): 1580 Chloride (mg/l): 11400 Calcium (mg/l): Sodium (mg/l): Ion Balance Error (%) General Comments:):
Iron 0.80 mg/l. Fluoride 9.4 mg/l. pH: 8.1			Stora	ge:	
TDS (mg/l): 22100 Total Hardness (mg/l): 80 Bicarbonate (mg/l): 1330; Sulphate (mg/l): 1580; Chloride (mg/l): 11400 Calcium (mg/l): Sodium (mg/l): General Comments: Data Sources: Data Sources:	Chemical Analyses:			EC (MicroS/cm):	36000
Bicarbonate (mg/l): 1330 Sulphate (mg/l): 1580 Chloride (mg/l): 11400 Calcium (mg/l): Magnesium (mg/l): Sodium (mg/l): General Comments: Data Sources:	Iron 0.80 mg/l. Fluoride 9.4 mg/l.	-		pH;	8.1
Bicarbonate (mg/l): 1330 Sulphate (mg/l): 1580 Chloride (mg/l): 11400 Calcium (mg/l): Sodium (mg/l): Sodium (mg/l): General Comments: Data Sources:				TDS (mg/l):	22100
Calcium (mg/l): Sodium (mg/l): Sodium (mg/l): Ion Balance Error (%) General Comments: Data Sources:				Total Hardness (me	9/1) 80
Ion Balance Error (%) General Comments: Data Sources:	Bicarbonate (mg/l): 1330 Sulphat	e (mg/l)	1580	Chloride (mg/l):	11400
Data Sources	Calcium (mg/l): Magnes	sium (mg/l):		Sodium (mg/l):	
Control Systyphony CC 1 Medi	Ion Balance Error (%)	G	eneral Comments:		
Swarzenski & Mundorff 1977	Data Sources	-			
	Swarzenski & Mundorff 1977	1			
		N/			

Well Number 119 Well N	ame: Giriftu 1	
Well Location: Giriftu, Kenya		
Easting: 39.7422	Northing:	1.9908
Well Owner:	Current Status:	Abandoned
Ground Level (m arnsl) 302	Geology:	Hydrogeology:
Well Depth (mbgl): 55.8	Fine Merti aquifer (Lane	1995) Water struck at 11.6 m bgl.
Borehole Diameter (mm):		The mag.
Installation Details:		
Drilled in 1968		
Geophysical Data:		
l i		
1		4
1		
Static Water Level (m amsl): 287,1 Dri	lling Information:	
Dynamic Water Level (m amsi):	- * 103 324 1	
Yield (Vs): 0.16		
Test Pumping Data;		
No.	Trans	smissivity (m^2/d):
	Hydra	sulic Conductivity (m/d).
	Stora	ge:
Chemical Analyses:		EC (MicroS/cm);
Another borehole possibly in Fine Merti at Giriftu has a repor microS/cm (Lane 1995)	rted EC of 650	рН:
CONTROL NO 10 CONTROL		TDS (mg/l):
		Total Hardness (mg/l):
Bicarbonate (mg/l). Sulphate (mg/l)		Chloride (mg/l):
Calcium (rng/l) Magnesium (m	9/1):	Sodium (mg/l);
Ion Balance Error (%)	General Comments:	
Data Sources	==72====	
Swarzenski & Mundorff 1977		

Well Number 120 Wel	l Name;	Giriftu 2			
Well Location: Giriftu, Kenya					
Easting 39.7424	No	thing:		1,991	
Weil Owner:	_	Current Status: Abandon		ed	
Ground Level (m amsi): 302	Geology	3		Hydrogeology	
Well Depth (mbgl) 82	Fine Me	rti aquifer (Lane 1	995)	Water struck at	
Borehole Diameter (mm):	5			13.1 m bgi.	
Installation Details					
Drilled in 1970					
Geophysical Data:					
Static Water Level (m amsl): 266 Dynamic Water Level (m amsl): Yield (Vs): Test Pumping Data:	Drilling Inform	nation			
No.		Trans	missivity (m*2/d)		
		Hydra	ulic Conductivity	(m/d):	
		Stora	ge:		
Chemical Analyses:			EC (MicroS/cn	n):	
			pH;		
			TDS (mg/l):		
			Total Hardness	s (mg/l):	
Bicarbonate (mg/l) Sulphate (mg/l):	(Chloride (mg/l);		
Calcium (mg/l): Magnesiur	m (mg/l):		Sodium (mg/l):		
Ion Balance Error (%):	Ger	eral Comments:			
Data Sources	-		7.7		
Swarzenski & Mundorff 1977	-				
	1				

Well Number 121 Wel	l Name:	Garissa	E1	
Well Location: Garissa, Kenya				
Easting 39.8214	North	ning: ent Status:	-0.	3764
Ground Level (m amsi): 210	Geology		yd	ogeology:
Well Depth (mbgl): 231.8	Fine Mert	aquifer (Lane 19	95)	
Borehole Diameter (mm);				
Installation Details:				
Drilled in 1968				
Geophysical Data:				
Static Water Level (m.amsi) 73.4 Dynamic Water Level (m.amsi): 0.16	Drilling Informa	tion:		
Test Pumping Data:				
No.			nissivity (m*2/d; lic Conductivity =,-d):	
Chemical Analyses			EC (MicroS/cr	9400
Carbonate 48 mg/l			pH;	8.5
		Ť	TDS (mg/l):	5780
			Total Hardness = 19/1	160
Bicarbonate (mg/l). 338 Sulphate (mg/l).	1440 C	nloride (mg/l):	1880
Calcium (mg/l) Magnesius	m (mg/l):	Sc	odium (mg/l):	
Ion Balance Error (%):	Gene	ral Comments		
Data Sources:				
Swarzenski & Mundorff 1977				

		2
Well Location: Garissa, Kenya		
	Northing: Current Status:	-0.3764
Ground Level (m amsl): 210 Geol	logy:	Hydrogeology:
Well Depth (mbgl): 231.8	Merti aquifer (Lane 199	5)
Borehole Diameter (mm):		
Installation Details:		
Drilled in 1968		
Geophysical Data:		
		1
Static Water Level (m amsl): 59 Drilling In:	formation:	
Dynamic Water Level (m amsi):		
Yield (l/s): 0.45		
Test Pumping Data:		
No.	Transmis	ssivity (m^2/d):
	Hydraulid	c Conductivity (m/d):
	Storage:	
Chemical Analyses		EC (MicroS/cm):
	,	pH:
	1	TDS (mg/l):
		Total Hardness (mg/l):
Bicarbonate (mg/l): Sulphate (mg/l):		oride (mg/l):
Calcium (mg/l) Magnesium (mg/l)	Sod	lium (mg/l)
Ion Balance Error (%)	General Comments	
Data Sources		
Swarzenski & Mundorff 1977		

Well Number 123 We	ell Name:	SW Waj	ir	
Well Location: Wajir, Kenya				
Easting: 39.9639	Northi	8		1.5272
Well Owner:	Curren	nt Status:	Abandoned	
Ground Level (m amsl): 233	Geology:			Hydrogeology:
Well Depth (mbgl): 107	Fine Merti	aquifer (Lane 19	995)	Water struck at 95.8 m bgl.
Borehole Diameter (mm)				
Installation Details:				
Drilled in 1940				
Geophysical Data:				
Static Water Level (m amsl): Dynamic Water Level (m amsl): Yield (l/s): Test Pumping Data;	Drilling Informati	on:		
No.			nissivity (m*2/d)	
		Storage		(mag).
Chemical Analyses			EC (MicroS/cn	n):
			pH:	
			TDS (mg/l):	
			Total Hardness	s (mg/t):
Bicarbonate (mg/l): Sulphate	A 100A		hloride (mg/l).	
Supplied that the supplied to	ium (mg/l):	Se	odium (mg/l):	
ion Balance Error (%)	Genera	al Comments;		
Data Sources:				
Swarzenski & Mundorff 1977				

	<u></u>	daab		
Well Location: Dadaab, Kenya				
Easting: 39.9767 Well Owner:	Northing: Current Status:		-0.0344	
Ground Level (m amsl): 171	Geology:		Hydrogeology:	
Weil Depth (mbgl). 165.3	Fine Merti aquifer (La	ne 1995)	Water struck at	
Borehole Diameter (mm):			145.8 m bgl.	
Installation Details:				
Drilled in 1971, 6.1 metres of screen.				
Geophysical Data:				
Static Water Level (m amsl): 33.5	orilling Information:			
Dynamic Water Level (m amsl):		11111		
Yield (l/s):				
Test Pumping Data:				
No.	Tr	ansmissivity (m^2/d):		
	H	draulic Conductivity (m/d):	
42-1-1-2	St	orage;		
Chemical Analyses:		EC (MicroS/cm): 11800	
Carbonate 152 mg/l, Iron 0.80 mg/l. Fluoride 5.2 mg/l.		pH;	8.7	
		TDS (mg/l):	8370	
		Total Hardness	(mg/l) 80	
Bicarbonate (mg/l). 994 Sulphate (mg	yl): 933	Chloride (mg/l):	3650	
Calcium (mg/l); 10 Magnesium ((mg/l): 13l	Sodium (mg/l):	5275	
Ion Balance Error (%). 23.4	General Commer	ts:		
Data Sources.	Unacceptably hig	h ion balance error.		
Swarzenski & Mundorff 1977				

Well Number 125 Wel	I Name:	Leheley		
Well Location: Leheley, Kenya				
Easting: 40 0181 Well Owner:	Northin	ng:	1.6181	
Ground Level (m amsi): 260	Geology:		Hydrogeology:	
Well Depth (mbgl) 126	Fine Merti a	quifer (Lane 1995		er struck at 64
Borehole Diameter (mm).			m b	gl.
Installation Details				
Drilled in 1981	- 1			
Geophysical Data:				
Static Water Level (m amsl): 203.7 Dynamic Water Level (m amsl): Yield (l/s): 0.83 Test Pumping Data	Drilling Information	on: ncountered at 85 r	n depth.	,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,
No.		Transmiss	sivity (m^2/d):	
			Conductivity (m/d):	
		Storage:		
Chemical Analyses:		E	C (MicroS/cm):	
		pl	4;	
		T	DS (mg/l):	
		To	otal Hardne'ss (mg/l): [
Bicarbonate (mg/l). Sulphate	(mg/l):	Chlor	ide (mg/l);	
Calcium (mg/l): Magnesiu	m (mg/l):	Sodiu	ım (mg/l):	
ion Balance Error (%).	Genera	Comments:		
Data Sources				
EPW				
	1			

Well Number 126	Well Nam	e: Fafi		
Well Location: Fafi. Kenya				
Easting: 40.3028	i	Northing:		-0.3836
Well Owner:		Current Status:	Abandoned	
Ground Level (m amsi):	135 G	eology.		Hydrogeology:
Well Depth (mbgl);	137.2 Fi	ne Merti aquifer (Lar	ne 1995)	Water struck at
Borehole Diameter (mm):				111.3 m bgl.
Installation Details:				
Drilled in 1960, 10.4 metres of screen.				
Geophysical Data:				
Static Water Level (m amsl): Dynamic Water Level (m amsl): Yield (Vs): Test Pumping Data:	23.71 Driffing	Information:		
No.			anneles bib. (= A0/d):	
140.		17	ansmissivity (m^2/d): draulic Conductivity (r	m/d)-
		All Control	orage:	nid).
			.,,,,,	
Chemical Analyses:			EC (MicroS/cm)	11300
Fluoride 2.3 mg/L			pH:	7.9
			TDS (mg/l):	6910
			Total Hardness	(mg/l): 390
Bicarbonate (mg/l);	Sulphate (mg/l).	671	Chloride (mg/l):	3180
Calcium (mg/l): 22	Magnesium (mg/l)		Sodium (mg/l):	
Ion Balance Error (%).		General Commen	ts:	
Data Sources				
Swarzenski & Mundorff 1977				

APPENDIX B

LAHELEY WELL QUESTIONNAIRE

WELL QUESTIONAIRE - KISMAYO HYDROGEOLOGICAL STUDY.

- You many times is the pump switched on/off a day?
 ONE TOME / DAY FOR 3 HRS.
- 2. Is the pump switched off because the water level drops too low or another reason, such as the storage tank is full? If another ceason, please explain below.

DUE TO THE GENESET WHICH IS VERY OLD.

- ABOUT 10 HRS, DUE TO THE PUMP OUT PUT.
- 4. What is the volume of the storage tank?
 40 mcu IT IS GROUND TANK.
- 5. How many pipes is the pump connected to?
 13 PIPES.

Dated 18th Octor 1996

	the stones removed from the borehole, and how deep were
he ston	as when the pump was lowered?
	THE GROUND AND AFTER FEW METERS THEY WENT THROUGH DESTACLE.
0	
What was	the water level in the well when the stones were removed?
	the water level in the well when the stones were removed?
what was	the water level in the well when the stones were removed?
24 m.	
Por how i	the water level in the well when the stones were removed? Tany weeks, or months, has the borehole been used since the are removed? FOR 15 DAYS.
For how stones we	many weeks, or months, has the borehole been used since the ere removed? FOR 15 DAYS.
or how stones we	many weeks, or months, has the borehole been used since the
For how stones we	many weeks, or months, has the borehole been used since the ere removed? FOR 15 DAYS.

APPENDIX C

LAHELEY WELL CHEMICAL ANALYSES

REPUBLIC OF KENYA

OFFICE OF THE PRESIDENT

Telephone: 725806/7 P.O. Box 20753

GOVERNMENT CHEMIST'S DEPARTMENT

NAIROBI, KENYA

REPORT ON CHEMICAL ANALYSIS OF WATER

Report Reference: P/WAT/VOL.I/97/15

Date: 24/1/97

Laboratory Sample No. 27/97

Date Received: 17.1.97

Sender: GIBB (EA) Ltd, Box 30020, NAIROBI Date Sample Taken:

Source: Borehole Kismayu - Sample I after 15 min

KISMAYU

RESULTS

PHYSICAL TESTS

(Hazen Units) Colour: 65

'. C

7.0

0 7

Deposit: Silt

Turbidity: Turbid (J.T.U.'s)
Odour: Noné (T.O.N.)

Taste:

pH:

Electrical Conductivity at 25°C (micro mhos/cm³)

1350

CHEMICAL TESTS

*							
Total Alkalinity as (TaCO.					mg/1(ppm) 260.0	me/l
			* *	• •	90	Nil	110 21 (3)
Phenolphthalein (CO)=	·:)	***	4.00	. € €2	260,0 -1	- 1-2-1 NO. 22 1. 1
Methyl Orange (HCC) ₃)—				· · · ·	260.0	*1.
Chloride (Cl)-	-		44		(49)	6400.0	- N
Sulphate (SO ₄)=		;••				340.0	
						Nil	
Nitrate (NO ₃)		•••	**	402)# #C /	Nil	¥ ¥
Nitrite (NO ₂)—	0.00	36.5	50.5	535	(5)(5)	~	
Fluoride (F)	• •	9.9		122	200	0.6	
Total Anions		~~					
					-	2060.0	
Sodium (Na)+	2.53	8/2	5.3	4/2/	• •	EE 0	
Potassium (K)+	1400	**		are:	30 V 1	55.0	
Calcium (Ca)++				58		1280	
Magnesium (Mg)++	4.7				ww	480,0	
2				***		0.45	
Iron (Total) (Fe)++	÷		* *	4.0	(V.V.)		
Manganese (Mn)++	***	e		**	*** 1	0.51	
Ammonia—Free & Sal	ine (1	(H ₄)+	277	***	1041 S	-	
Ammonia—Albuminoi	d (NI	I₄)÷	**	200	ж.		
(Pb Cu Zn)	• •		• •	Ty			
Total Cations					es 9		

Carbonate Hardness as (CaCO ₃)				mg/I (ppm) 260.0
Non-Carbonate Hardness as (CaCO ₁)				4940.0
DECOMPOSE PROPERTY SERVICES AND	***		-	5200.0
Total Hardness as (CaCO ₃)	¥0x	**		
Free Carbon Dioxide			_	11.0
Silica (SiO ₂)			. –	5.0
	595	9.51	<i>:</i> :	.0.5
Oxygen absorbed, 4 hr. at 27°C (P.V.)	***	990	-	9,000.0
Total Dissolved Solids, residue dried at	180°C			3,000.0

:60**.**0

REMARKS:

Neutral but excessively hard and mineralized water. Excessive colour should be removed and the water demineralized before it is declared suitable for human consumption.

Date 24th January, 1997

for:

Chemiat

JON/MWK.

Sample I

REPUBLIC OF KENYA

OFFICE OF THE PRESIDENT

Telephone: 725806/7 P.O. Box 20753

P. 004

GOVERNMENT CHEMIST'S DEPARTMENT

NAIROBI, KENYA

REPORT ON CHEMICAL ANALYSIS OF WATER

Report Reference: P/WAT/VOL. I/97/16

Date: 24/1/97

Laboratory Sample No. 28/97

Date Received: 17.1.97

Sender: GIBB (EA) Ltd, Box 30020, NAIROBI Date Sample Taken:
Source: Borehole - Sample 2 After 30 minutes

RESULTS

PHYSICAL TESTS

Colour: 20 ' (Hazen Units)

7.7

Turbidity: Olear

(J.T.U.'s)

Deposit: Slight silt -

Odour None (T.O.N.)

Taste:

Electrical Conductivity at 25°C (micro mhos/cm3)

1.00

pH:

5,400.0

CHEMICAL TESTS

					mg/1(ppm)	me/1
Total Alkalinity as CaCo	ο			Ç.,	368.0	
in the state of	•		7.7 2 0 - 1		Nil	
Phenolphthalein (CO)=		kinin En			368.000	Chief to the last and
Methyl Orange (HCO3)		10	"··		1,373.5	2
Chloride (Cl)—	• •	474	(*)	\$4€ B	5-1	* ,
Sulphate (SO ₄)=	**	***		20.50	175.0	
Nitrate (NO ₃)	272	20	14.4	991 -	Nil	
	2.2	-			Nil	. 5
Nitrite (NO ₂)—	**		••	300	1.08	
Fluoride (F)—	202	4.8	是更			
Total Anions	202	3436	. •	×3 =	025.0	
Sodium (Na)+	2.0	• •			925.0	2
Potassium (K)+					19.0	
	••				320.0	•
Calcium (Ca)++	10.01	***	• 3	• •	144.0	
Magnesium (Mg)++	12(2)	***	**	3 e 3		
Iron (Total) (Fe)+++	3.5	1/15	* *		0.49	
Manganese (Mn)++			7.636		0.07	
Ammonia—Free & Saline	(NH4)+	***	97	an e	(- :	
Ammonia—Albuminoid (N	(H ₄)+		e.e.	2.5		
Transfer of the Contract	2520		252	1271 -	<u> </u>	
(Pb Cu Zn)	* * 1	6.5		,		

P. 005

Carbonate Hardness as (CaCO ₃)		O 300	mg/I (ppm) 368.0
Non-Carbonate Hardness as (CaCO ₃)		64 WW 1	1,032.0
Total Hardness as (CaCO ₃)	2.27		1,400.0
Free Carbon Dioxide	***	see on	6.0
Sīlica (SiO ₂)		70% St	45.0
Oxygen absorbed. Ahr. at 27°C (P.V.)			• 0.75
Total Dissolved Solids, residue dried at 180	°C		3,750.0

REMARKS:

Very hard and excessively mineralized water.

Demineralization is recommended before the water

is used for human consumption.

0.520

175.0

1

it: Date 24th January, 1997 1,774.6

for:

JCN/MWK.

Sample 1.

REPUBLIC OF KENYA

OFFICE OF THE PRESIDENT

Telephone: 725806/7

P.O. Box 20753

GOVERNMENT CHEMIST'S DEPARTMENT

NAIROBI, KENYA

REPORT ON CHEMICAL ANALYSIS OF WATER

Report Reference: P/WAT/VOL.I/97/17

Date: 24/1/97

Laboratory Sample No. 29/97

Date Received: 17.1.97

Sender: GIBB (EA) Ltd., Box 50020, NAIROBI Date Sample Taken:

Source: Borehole - Sample 3

after I hour.

RESULTS

PHYSICAL TESTS

Colour: 5 (Hazen Units)

Turbidity: Clear

(J.T.U.'s)

Deposit: Debris/silto

Odour: -- None (T.O.N.)

Taste: 7.7 pH:

Electrical Conductivity at 25°C (micro mhos/cm3)

5,300.0

CHEMICAL TESTS

						-	
į.				10		mg/1(ppm)	<i>me</i> /1
Total Alkalinity as	CaCO ₃	••	•	***	—	360.0	
Phenolphthalein (CO	3)=:		·	(8/8)	g: 	Nil	
Methyl Orange (HC	00-)			360.04	Carte Of their spiller
Chloride (CI)—			4.4	2/2	Page	2,406.0	·
				5.5		190.0	
Sulphate (SO ₄)=	/4(#)	**	* •	X 96	X(+)	Nil	
Nitrate (NO ₃)	it c.	* •	109	9.6		Nil	
Nitrite (NO2)—	24147	**	• •	: •: •	=		•
Fluoride (F)	22	705	10	1	×	1.0	
Total Anions	200	707	DESC.	34(4)		=	
Sodium (Na)+	364°	40.0	(#00)			920.0	
			(2.5)		50.5	28.0	
Potassium (K)+	(#.F)				¥4. 	240.0	
Calcium (Ca)++	* *	**	(8) /W	5±1#7	15.01	120.0	
Magnesium (Mg)++	30	404)	\$15	19190		711 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1	
Iron (Total) (Fe)++	+	200	:::	19/50	-	0.09	
Manganese (Mn)++	**/	974	130	1000	K. i	C.04	
Ammonia-Free & Sal	ina O	TET NO					
			5/5	**		_	
Ammonia—Albuminoi	d (NE	L ₄)+		33 Sec.	2.0	-	
(Pb Cu Zn)	. · ·	• •	535	7.5(\$)			
Total Cations	œ.	**	**	4.6			

P. 007

0 t w t (0 00)			mg/I (ppm)
Carbonate Hardness as (CaCO ₃)	FC - FIR	(***	
Non-Carbonate Hardness as (CaCO ₃)			740.0
Total Hardness as (CaCO ₃)			1100.0
			8.0
Free Carbon Dioxide	5000	500 K	
Silica (SiO ₂)			80.0
Silica (SiO ₂)	• •		F
Oxygen absorbed. 4 hr. at 27°C (P.V.)	9.10	. 1-	0.2
Total Dissolved Solids, residue dried at	180°C	" · · · ·	3700.0
	secan En	F240	

REMARKS:

This water is similar to sample No. 28/97 and comments are the same.

7.7

C.r.ac

13.

Date 24th January, 1997

for:

J O MEUGI)

JCN/MWK.

Sample 3 1 hour.