

DETERMINATION OF SHALLOW AND DEEP AQUIFER CHARACTERISTICS AND GROUNDWATER POTENTIAL IN SELECTED AREAS OF KELANI AND BOLGODA BASINS

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ABSTRACT

The lake Bolgoda, presumed to be the largest natural lake in Sri Lanka, covers almost 2/3 of the Kalutara district.. It composed of several lakes located in the low country wet zone of Sri Lanka. The main objective of the study was to determination of the shallow and deep aquifer characteristics and groundwater potential in selected areas of Kelani and Bolgoda basins. Arial photographs and satellite photographs of the two basins were studied and three areas were selected for detailed investigations (Area 01, Area 02, Area 03). 40 nos. of hydrogeological surveys were conducted within the study area and 11 test bore holes were drilled. 10 nos. of calibration tests were conducted on the test bore holes and 6 numbers were selected for 24 hours pumping tests. Water samples were chemically analyzed for 14 parameters and geochemical maps were prepared for EC and for total Iron.

The study results revealed the presence of two aquifer systems in the study area. The fractures in the basement rocks occur within the range of 20-50 below ground level. 06 tests bore holes reported yields over 100 liters per minute. Therefore, these bore holes can provide 978.00 m³/day, without causing any environmental impact in to the surrounding areas. Water with high EC and high Iron were identified within the study area.

INTRODUCTION

Most rivers drain directly in to the sea. But in areas of internal drainage, permanent or intermittent streams terminate in lakes or swamps. The lake Bolgoda, presumed to be the largest natural lake in Sri Lanka, covers almost 2/3 of the Kalutara district, extending from Anguruwatota to Piliyandala (Figure 01). It composed of several lakes located in the low country wet zone of Sri Lanka between longitudes E 79° 55' – 79° 58' and latitudes of N 6° 44' – 6° 48'. This system is made up of two interconnected lakes and their water

ways. The Northern lake belongs to both Colombo and Kalutara districts is fed by Weras Ganga and Bolgoda Ganga. The southern lake situated in Kalutara district is fed by Panape Ela. The Bolgoda area receives an average annual rainfall of about 2500 mm. The mean annual temperature is around 27 °C. The mean day relative humidity is around 72% and the mean night relative humidity is 87% (source: Meteorological department, Ratmalana).

A study was conducted in the selected areas of Bolgoda and Kelani basins in order to identify the aquifer characteristic and groundwater potential of the shallow and deep aquifer system of the area. Aerial photographs and satellite photographs of the two basins were studied and three areas were selected for detailed investigations.

Area 01

This 01 Km wide strip covers the areas of Palagama, Anurugoda, Kahathuduwa, Diyagama, Pitipana south, Owitigama, Meegoda, belongs to Bolgoda and Kelani river basins.

Area 02

The starts from Southern Bolgoda Lake, covering the area Medaduwa, Kudagonaduwa and Paraduwa. This area is mainly located in Bolgoda basin and part of it is located in Kalu ganga basin.

Area 03

Area 03 covers Hanwella to Ranala along the Low Level road. This belongs to Kelani river basin.

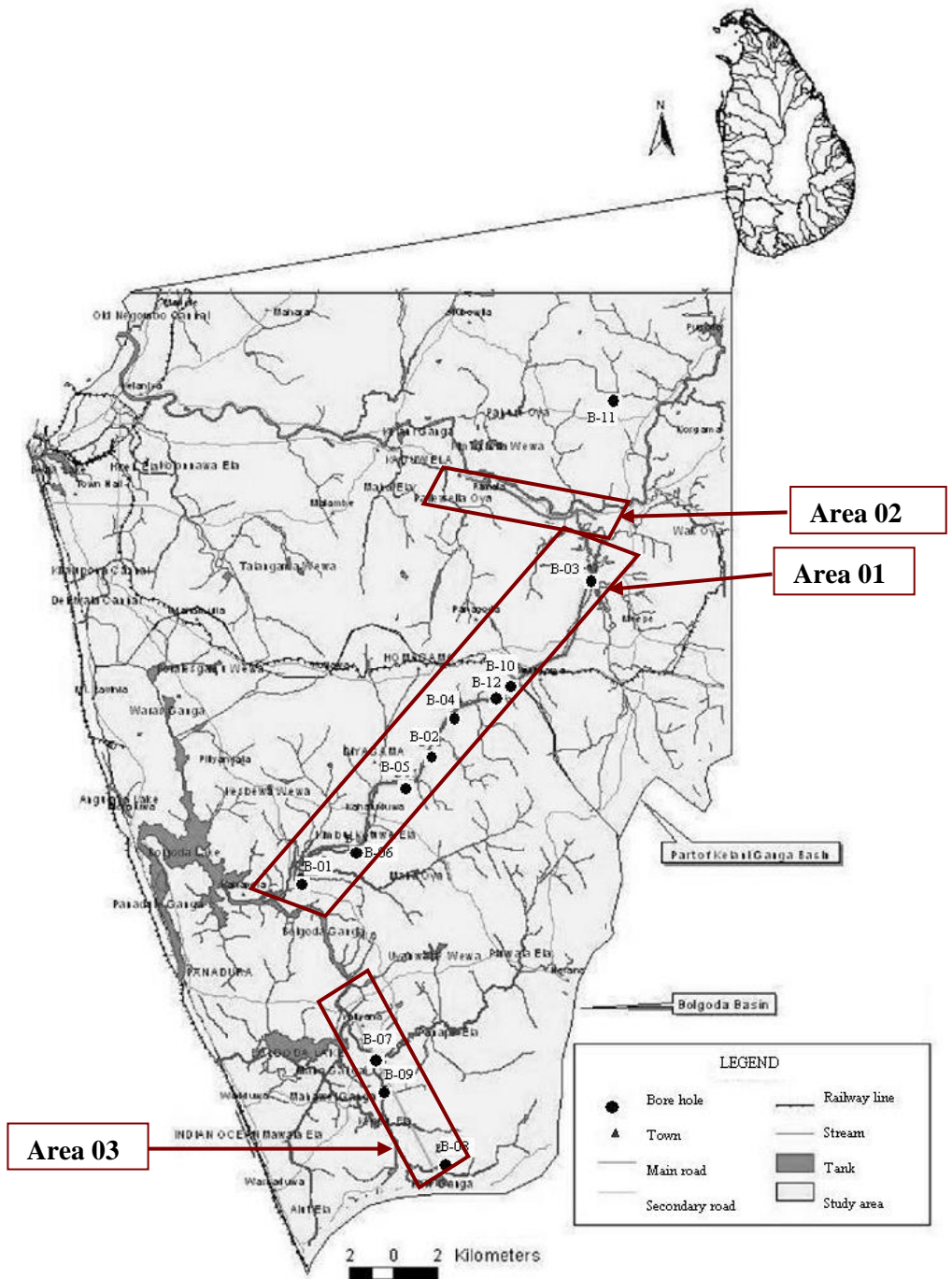


Figure 01: Location map of the study area

Geomorphology

Three major geomorphological units identified in the study area are

- Coastal sand belt – Old beach sand deposits and dune sand deposits ex: Ratmalana, Panadura, Wadduwa.
- Marshes bordering the flood plains - Consist of shallow water ponds, marshes and seasonally flooded grassland. eg: Bellanwila-Attidiya, Paragastota, Diyagama
- Low relief laterite hillocks - Laterites on elevated lands are scattered in the entire area. eg: Developed in areas of Maharagama, Kottawa, Piliyandala, Homagama and Bandaragama.

The Bolgoda basin contains 7 lakes (Bolgoda Lake North, Bolgoda Lake south, Uyanwatta wewa, Boralessgamuwa wewa, Walgama wewa, Gamanpila wewa, Kesbewa wewa) and one major lagoon (Lunawa).

Geology

The major rock types of the study area include hornblend biotite gneiss, garnet sillimanite gneiss, charnockite and charnokitic gneiss, granite/granitic gneiss, calc gneiss and quartzite (Figure 02). There are series of NNW – SSE shear zones running across the basins. Several antiforms and synforms are developed along these shear zones. Two faults running NE – SW directions intersect the Bolgoda basin.

OBJECTIVE OF THE STUDY

Determination of shallow and deep aquifer characteristics and groundwater potential in selected areas of Kelani and Bolgoda basins.

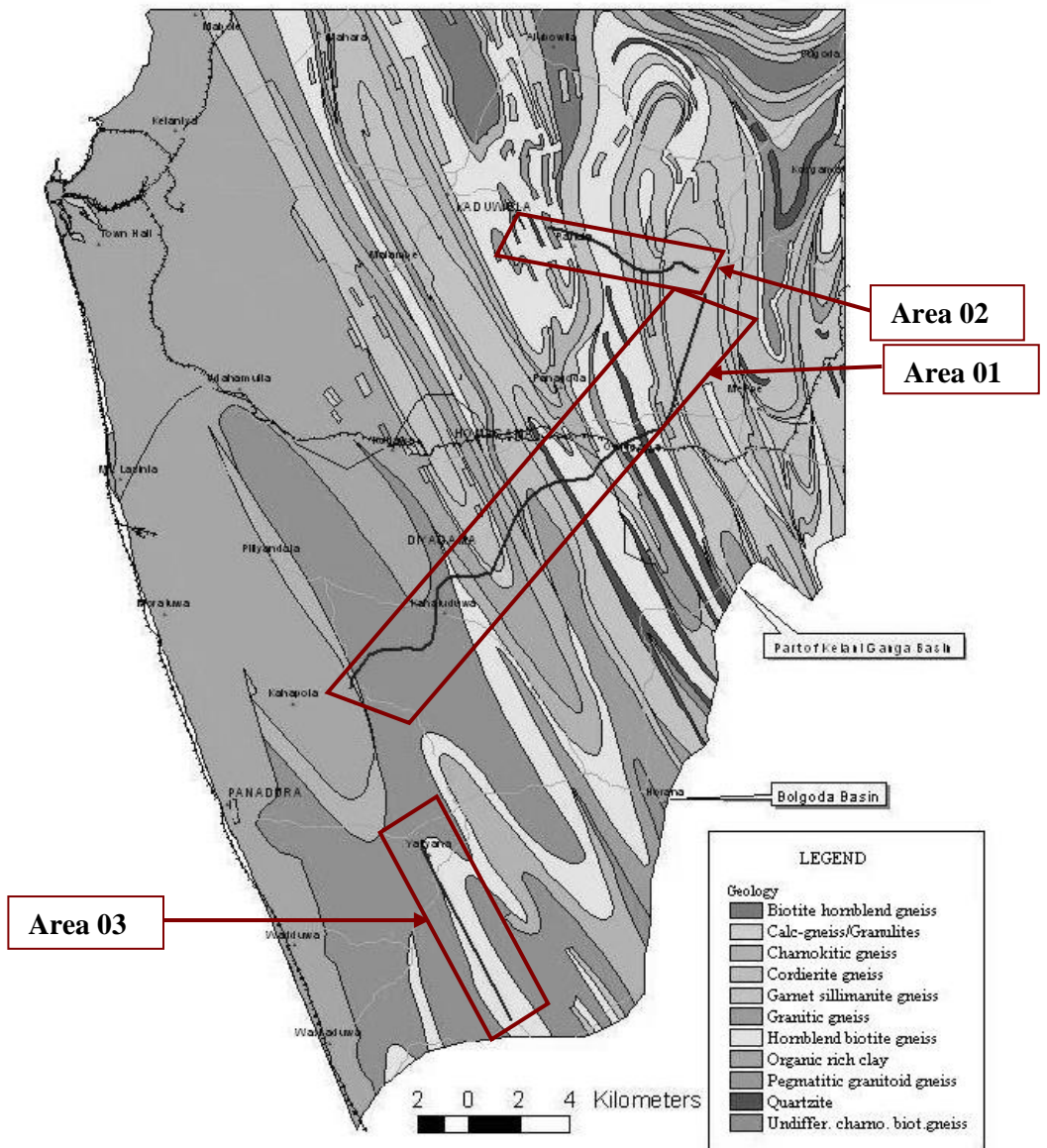


Figure 02: Geology map of the study area

METHODOLOGY

The methodology included carrying out hydrogeological surveys in selected areas, drilling of test bore holes, carrying out 24 hour pumping test together with water quality analysis. Before carrying out investigations, available hydrogeological data were collected in the three respective areas. The data

include yield, static water level and water quality of the existing bore holes. With the available data, hydrogeological investigations were carried out using electrical resistivity survey method. Schlumberger array was used to carry out vertical electrical soundings in order to locate favorable sites for test bore holes. 40 soundings were conducted in the study area.

Test drilling

11 number of 60 m deep test bore holes were drilled using both mud and air drilling techniques. The technical data of the test bore holes are given in Table 01.

Aquifer tests

Considering the water availability of test bore holes calibration tests were performed on 10 number of test bores for a period of 6 hours. Based on the calibration test results, 6 number of test bore holes were selected for long term (24 hours) pumping tests. The analytical results of the pumping tests are given in Table 02.

Chemical analysis

Samples were collected from 11 bore holes and chemically analyzed for 14 parameters (Temperature, Turbidity, pH, EC, Total hardness, Total alkalinity, Total dissolved solids, Calcium, Magnesium, Iron, Chloride, Sulphate, Fluoride, Salinity). The analytical results of the water samples are given in Table 03. Using the data collected during the study (120 nos. of deep well data), chemical maps were prepared for EC and Iron.

Table 01. The technical data of the test bore holes

| Bore hole No. | Location / Coordinates | Total depth (m) | Flushing yield (l/min) | Static water level (m bgl) | Fractures (m) |
|---------------|--|-----------------|------------------------|----------------------------|---|
| B-01 | Kahatawela N 6 ^o 45.479' E 79 ^o 57.064' | 60.0 | 690.0 | 1.60 | 18.00 -18.50 24.10 -24.20 30.00-30.08 42.10-42.20 58.10- 58.20 |
| B-02 | Weeramagiline Amuna N 6 ^o 48.456' E 80 ^o 0.217' | 60.0 | 100.0 | 1.80 | 11.30-11.40 12.50-12.60 25.10-25.18 |
| B-03 | Kekunagodellawatte , Panaluwa N 6 ^o 52.763' E 80 ^o 4.063' | 60.0 | 230.0 | 3.50 | 31.00-31.08 33.0-33.68 43.08-43.12 43.70-43.80 |
| B-04 | Mawathgama N 6 ^o 49.452' E 80 ^o 0.752' | 60.0 | 400.0 | 1.30 | 10.25-10.40 15.10-15.18 32.10-32.20 |
| B-05 | Jayawardenawatta N 6 ^o 47.687' E 79 ^o 59.615' | 8.3 | Not determined | Not determined | Not determined |
| B-06 | Palagama N 6 ^o 46.060' E 79 ^o 58.429' | 60.0 | 40.0 | 1.85 | 19.00 -19.10 37.00 – 37.15 |
| B-07 | Ambagasowita N 6 ^o 41.013' E 79 ^o 58.872' | 60.0 | 115.0 | 1.00 | 20.10 – 20.20 27.00 – 27.60 44.10 – 44.20 53.00 – 53.15 |
| B-08 | The Salvation Army Land, Mudagomuwa N 6 ^o 38.441' E 80 ^o 00.665' | 60.0 | 130.0 | 1.00 | 18.10 – 18.20 20.50 – 20.60 39.00 – 39.50 52.10 – 52.30 |
| B-09 | Paragasthota N 6 ^o 40.221' E 79 ^o 59.15' | 60.0 | 20.0 | 1.00 | 20.50 -20.60 50.00- 50.40 |
| B-10 | Kajugahayatadeniya, Owitigama N 6 ^o 50.22' E 80 ^o 2.255' | 60.0 | Nil | Nil | 19.00 -19. 10 46.00 - 46.20 54.05 - 54.30 57.00 - 57.20 59.00 - 59.20 |
| B-11 | Pahala Hanwella N 6 ^o 54.282' E 80 ^o 4.700' | 60.0 | 375.0 | 2.00 | 16.90 – 16.95 21.20 – 21.35 43.60 – 43.70 48.80 – 49.10 |
| B-12 | Pansal Handiya Road, Pitipana N 6 ^o 49.850' E 80 ^o 1.855' | 60.0 | 50.0 | 2.00 | 15.00 -17.00 26.00 – 27.00 (clay filled) 49.20 – 49.30 |

Table 02: Aquifer parameter and safe pumping yield of the wells

| Well No. | Location | Transmissivity (m ² /day) | | Constant Discharge rate (l/min) | Safe pumping rate (l/min) | Quantity (m ³ /day) |
|----------|---------------------------------|--------------------------------------|--------|---------------------------------|---------------------------|--------------------------------|
| | | Theis's | Walton | | | |
| B-01 | Kahatawala | 130.16 | 127.27 | 500 | 500 | 300 |
| B-02 | Weeramagilin Amuna | 37.29 | 32.72 | 140 | 140 | 84 |
| B-03 | Panaluwa | 5.54 | 6.13 | 150 | 100 | 60 |
| B-04 | Mawathgama | 45.82 | 60.28 | 400 | 400 | 240 |
| B-08 | Salvation Army Land, Mudagomuwa | 3.92 | 3.92 | 120 | 90 | 54 |
| B-11 | Pahala Hanwella | 50.90 | 65.45 | 400 | 400 | 240 |

Note: The recommended pumping duration of the above test bore holes are 10 hours per day.

Table 03: Chemical analysis of water samples

| Chemical parameters | Max. desirable level (SLS) | Max. permissible level (SLS) | B-01 | B-02 | B-03 | B-04 | B-05 | B-06 | B-07 | B-08 | B-09 | B-10 | B-11 | B-12 |
|-----------------------------|----------------------------|------------------------------|---------|-------|-------|-------|------|-------|---------|--------|-------|------|-------|-------|
| Temperature (°C) | - | - | 25.0 | 25.0 | 25.0 | 25.0 | - | 25.0 | 25.0 | 25.0 | 25.0 | - | 25.0 | 25.0 |
| Turbidity (NTU) | 2 | 8 | 155.0 | 17.5 | 32.9 | 32.0 | - | 20.0 | 60.0 | 26.0 | 23.0 | - | 5.9 | 11.0 |
| pH | 7-8.5 | 6.5-9 | 3.2 | 7.0 | 7.4 | 7.3 | - | 7.2 | 5.8 | 6.3 | 5.5 | - | 7.6 | 7.7 |
| Ec(µS/cm) | 750 | 3500 | 11720.0 | 179.0 | 120.0 | 217.0 | - | 199.0 | 30200.0 | 1829.0 | 586.0 | - | 179.0 | 184.0 |
| Total hardness (mg/l) | 250 | 600 | 2600.0 | 61.2 | 80.0 | 90.0 | - | 71.4 | 3825.0 | 306.0 | 204.0 | - | 56.1 | 76.5 |
| Total alkalinity (mg/l) | 200 | 400 | ND | 120.0 | 106.0 | 148.0 | - | 110.0 | 18.0 | 37.0 | 9.2 | - | 118.0 | 129.0 |
| Total dissolved solid(mg/l) | 500 | 2000 | 7735.0 | 118.0 | 79.2 | 143.0 | - | 131.0 | 19932.0 | 1207.0 | 386.0 | - | 118.0 | 121.0 |
| Ca ²⁺ (mg/l) | 100 | 240 | 640.0 | 20.4 | 12.0 | 16.0 | - | 18.3 | 408.0 | 69.4 | 44.9 | - | 20.4 | 22.4 |
| Mg ²⁺ (mg/l) | 30 | 140 | 242.0 | 2.4 | 12.1 | 12.1 | - | 6.1 | 681.0 | 32.3 | 22.3 | - | 1.2 | 4.9 |
| Fe ²⁺ (mg/l) | 0.3 | 1.0 | 5.6 | 2.1 | 0.9 | 0.2 | - | 1.1 | 2.5 | 3.1 | 4.5 | - | 1.1 | 3.1 |
| Cl ⁻ (mg/l) | 200 | 1200 | 3460.0 | 12.6 | 9.9 | 14.8 | - | 10.0 | 13860.0 | 368.0 | 30.2 | - | 7.5 | 10.0 |
| SO4 ²⁻ (mg/l) | 200 | 400 | 340.0 | 11.1 | 5.4 | 15.2 | - | 12.3 | 1610.0 | 95.0 | 297.0 | - | 12.1 | 6.5 |
| F ⁻ (mg/l) | 0.6 | 1.5 | 0.2 | 0.1 | 0.1 | 0.2 | - | 0.6 | 0.5 | 0.0 | 0.1 | - | 0.3 | 0.5 |
| Salinity (ppt) | | | 6.70 | 0.10 | 0.0 | 0.10 | - | 0.10 | 16.0 | 1.0 | 0.30 | - | 0.1 | 0.1 |

DISCUSSION

The well yield of 6 test bore holes reported over 100 liters per minutes (lpm), considered high yield which can be extracted from basement fractured hard rock aquifers. Two wells were reported with the yield ranging from 10 to 50 lpm. One well was reported dry. During the constructions of these bore holes; water was collected from the shallow aquifer (overburden) as well as from the fractured rock aquifers. Water availability in both aquifer systems was high in most of the locations. During the well constructions, sand - pebble size particles (Figure 03) were found in these locations. The pumping test data revealed that it is possible to produced 978.00 m³/day from the 06 test bore holes with the pumping of 10 hours per day.



Figure 03: Rounded/sub rounded Pebbles and Cobbles in Gem pits at Kepu Ela area.

The chemical data of the existing wells show that there is a fluctuation in EC and Iron in groundwater in the area. Therefore, geochemical maps were prepared for EC and Iron to see the spatial distribution of these two parameters. The electrical conductivity map of the area indicated that the EC value of water in the upper part of Area 01 is less than 750 $\mu\text{S}/\text{cm}$ and water in the lower part of Area 01 is between 750-3500 $\mu\text{S}/\text{cm}$. A very little part of the area, reported with high EC values of greater than 3500 $\mu\text{S}/\text{cm}$. More than half of Area 02 indicated EC values greater than 3500 $\mu\text{S}/\text{cm}$. Rest of the area indicate EC values in between 750-3500 $\mu\text{S}/\text{cm}$. The entire Area 03 shows EC values less than 750 $\mu\text{S}/\text{cm}$ (Figure 03). However, according to the Sri Lankan drinking water standard the maximum desirable level of EC is 750 $\mu\text{S}/\text{cm}$ and the maximum permissible level of EC is 3500 $\mu\text{S}/\text{cm}$.

Several Iron rich zones (>1.0 ppm) are reported in Area 01 and excess Iron (> 1.0 ppm) is reported in Area 02. Iron content of water in the Area 03 falls within the Sri Lankan drinking water standard level (0.3 -1.0 ppm).

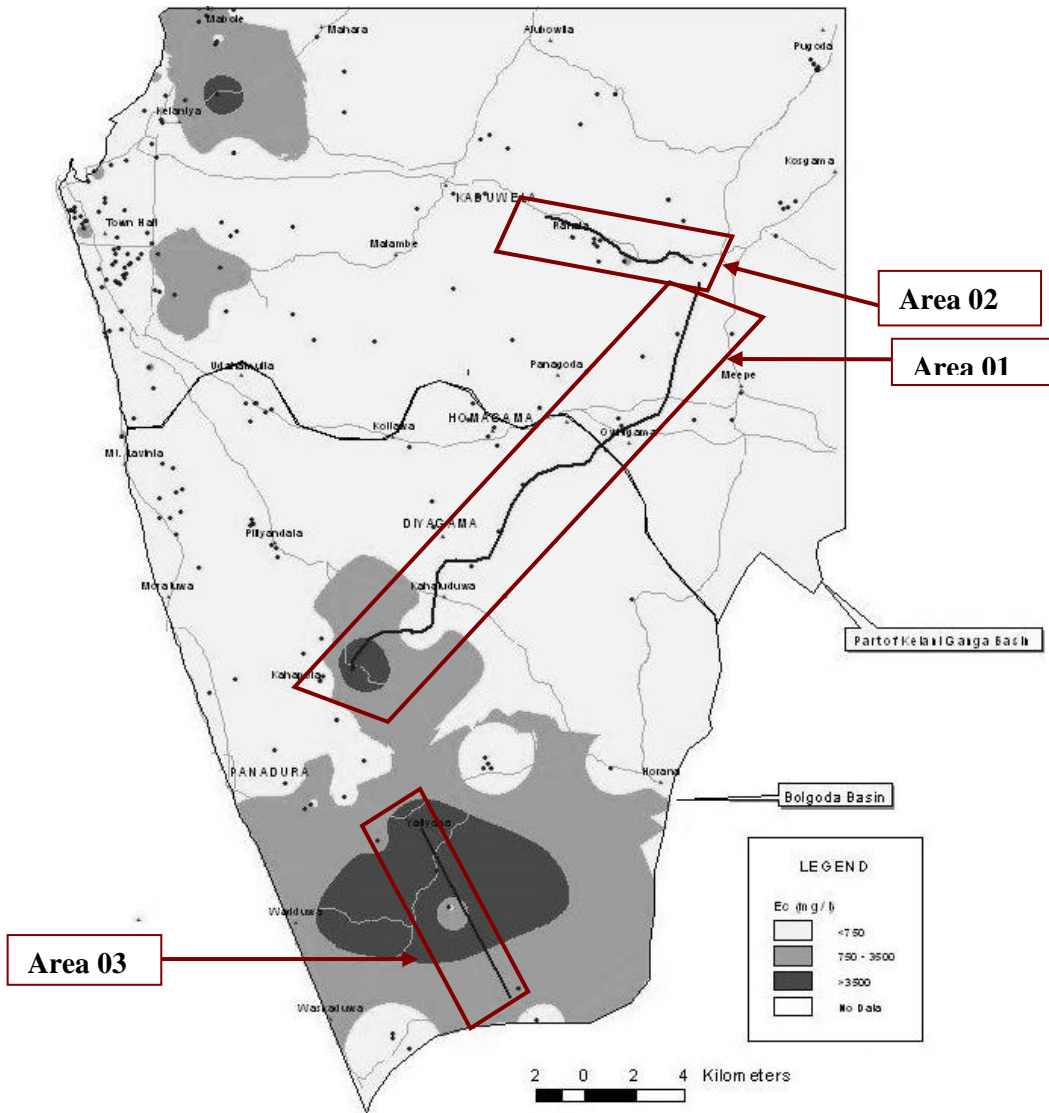


Figure 04 : Electrical conductivity variation in study area

CONCLUSIONS AND RECOMMENDATIONS

Considering the results of the study, the following conclusions and recommendations are made.

- Major aquifer which could be identified at the study area was a combination of the shallow unconfined aquifer and fractured hard rock aquifer. Quantity of water that can be tapped from this aquifer is different from place to place. Test drilling showed that the high yielding deep wells can be located after proper groundwater investigations. Many lineaments and Quartzite bands developed within the Bolgoda basin could be identified.
- The basement rocks are highly fractured and fractures occur within the range of 20-50 meters below ground level.
- The quantity of water that can be obtained from 6 number of the test bore holes is 978.00 m³/day, without causing any environmental impact.
- The electrical conductivity and Iron content of water in Area 01 and Area 03 are fairly good compare to Area 02.
- This study was mainly focused on groundwater development and assessment at selected areas of the Bolgoda basin. When considering entire basin, it is a populated area situated in Colombo and Kalutara districts. People who live in the Basin area use water supplied by the bordering basins such as the Kelani ganga and Kalu ganga catchments. Therefore, a comprehensive water study of the Bolgoda basin is suggested in order to identify high yielding water wells to implements localized water supply schemes within the basin area.

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