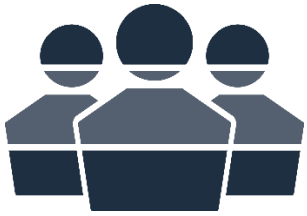
November 2020 Geophysical Survey Findings

14th December 2020

Work undertaken by Groundwater Relief on behalf of the International Organization for Migration

Please note that opinions expressed in this report do not necessary reflect those held by the IOM.



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Groundwater Relief is a charity of over 320 groundwater professionals who support the development and management of water resources in developing countries. We offer hydrogeological support to humanitarian and development organisations.

SIGNATORIES

Rev	Description	Approval	Title	Signature	Date
1	Draft	Geraint Burrows	Chief Executive Officer		14_12_20

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CONTENTS

SECTION 1: BACKGROUND

In the late part of 2019 the International Organisation for Migration procured an ABEM LS2 terrameter with funding from the Government of Japan. This equipment was purchased to support groundwater supply investigation work within the Cox's Bazar District of Bangladesh. Groundwater Relief were commissioned to use the equipment in January and February 2020 to delineate the boundaries between different geological formations. The data obtained supported the remapping of the geology of Cox's Bazar with the new version of the geology map available here:

https://www.dropbox.com/s/hyeotp6kr6649ny/Coxs_Bazar_Geology%20Map_2020.pdf?dl=0

In September 2020 Solidarities International (SI) and the IOM formed an MoU to enable SI to borrow the IOM's electrical resistivity equipment as part of a Groundwater Relief consultancy. Within the MoU it was agreed that Groundwater Relief would spend three days undertaking geophysical investigations on behalf of IOM mission objectives and three days undertaking investigations to support SI mission objectives.

The principal aims of the geophysical investigation for the IOM were to identify possible groundwater supplies within the Upper Bokabil Sandstone to the west of Leda refugee camp; and to support the further development of the Cox's Bazar groundwater model.

Geophysical surveying was undertaken by Groundwater Relief between 31st October to 6th November 2020. Several SI and IOM staff members, as well as eight or nine daily workers supported the survey work. Groundwater Relief trained IOM staff in the use of the equipment during the course of the survey work.

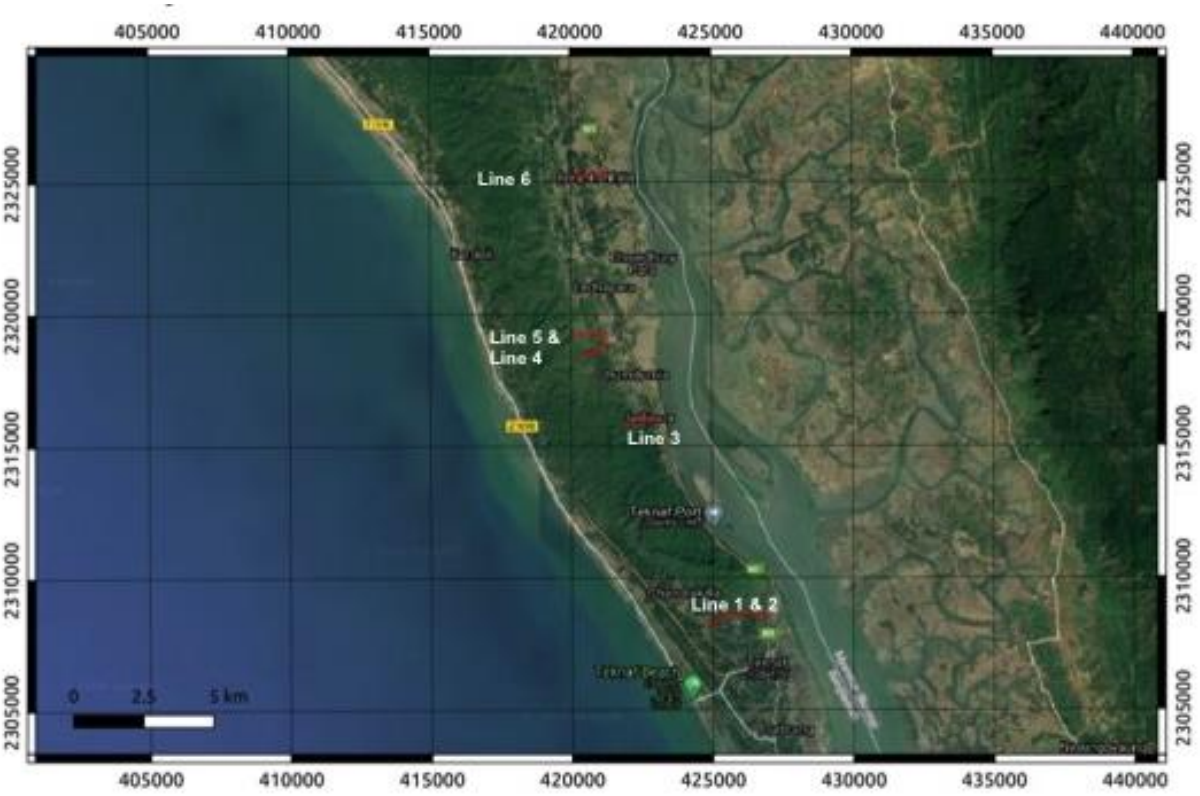
This report details the results of the surveys.

SECTION 2: GEOPHYSICAL SURVEY

Locations

The IOM, Dhaka University and Solidarities International were closely consulted when choosing the locations for the Electrical Resistivity Tomography (ERT) transects. The final locations are shown in Figure 1 below.

Figure 1: Geophysical Transect Locations



A total of 6 ERT surveys were conducted; 3 surveys for Solidarités International and 3 surveys for the IOM. 7.2 linear kilometres of cross-sectional data was collected, detecting geological information up to 200 metres below ground surface.

- Two transects were carried out to the west of Leda camp to look for new potential groundwater sources that could help augment the camp water supply.
- Two transects were undertaken to the west of Teknaf town to support the updating of understanding of aquifer systems in this southern part of the Teknaf peninsular.
- One transect was undertaken in Nhila to support the update of the Cox's Bazar groundwater model
- One transect was undertaken to the west of Camp 27 to help SI look for new potential groundwater sources that could help augment the camp water supply

Electrical Resistivity Tomography

2D Electrical Resistivity Tomography (ERT) is a technique that uses multiple electrodes to pass current through the ground in order to measure ground resistance. Current is induced in the ground using two current electrodes and the electrical potential drop is then read using two other electrodes. The vertical resolution of the subsurface resistivities is achieved by increasing the distance between the electrodes while the horizontal resolution is achieved by moving the electrodes laterally across the surface. The equipment enables current to be passed to all possible pairings of electrodes along an array, therefore collecting thousands of data pairings across an entire transect at various depths.

ERT creates two -dimensional cross sections of the electrical resistivity properties of the subsurface along a transect. As different lithological units have different resistivity properties, the derived resistivity model can be interpreted in terms of a geological cross section.

The IOM ABEM LS 2 system with four cables was used for the survey work. Each cable was 320m long with 16 electrode take outs each of 20-metre electrode spacing. The total length of a transect was therefore was 1.28km length which enabled a depth penetration of over 200m.

RESIPY was the software used for inversion of the data.

Uncertainties

There are several uncertainties that come with 2D ERT. Lateral resolution of geophysically imaged features is related to the minimum electrode spacing, which was 20 metres for all sections. A quantitative estimation of vertical resolution depends on a variety of factors such as the resistivity contrast of the feature, lateral continuity, the resistivity of the surrounding layers, etc. However, for practical purposes, a layer with a significant resistivity contrast can be identified if the thickness of that layer is at least 10% of the depth to the top layer. For example, a 1 metre thick layer can be identified at approximately 10 metres below ground surface and a 10-metre-thick layer can be identified at approximately 100 metres below ground surface.

The target aquifers are sands containing fresh water. Clay content and salinity are the main contributors to increasing formation conductivity (decreasing resistivity). As such, freshwater sands and gravels will appear as resistive bodies and clay and saline areas will appear as very low resistivities.. Therefore the purpose of the investigation work is to disparate between higher resistivities (e.g. Sandstone) and lower resistivities (shales, clays or saline water). Inverted resistivities of these bodies can be taken as accurate *within the measurement resolution of the method.* As such, for instance, a 0.5 m thick sand of 50 Ohm-m at a depth of 20 m may appear as a thicker layer of lower resistivity due vertical limitations of resolution.

Results and Interpretation

Overview

The results of each individual section are given below. They are also available to view via Google Earth through the following link:

https://www.dropbox.com/s/z534y6456rl9f4o/ERTNov20.kmz?dl=0

The raw data collected was inverted using RESIPY software. These results were interpreted with corresponding hydrogeological information and knowledge of the area from work undertaken with the IOM and Dhaka University over the course of 2019.

All inversions are displayed in the same scale and in this case, the following resistivities can be determined;

Table 1: Resistivity values and interpreted geology/hydrogeology

Resistivity (ohm-m)	Lithology	Key
0 – 10 ohm-m	Clays or saline groundwater	Blue to green colour

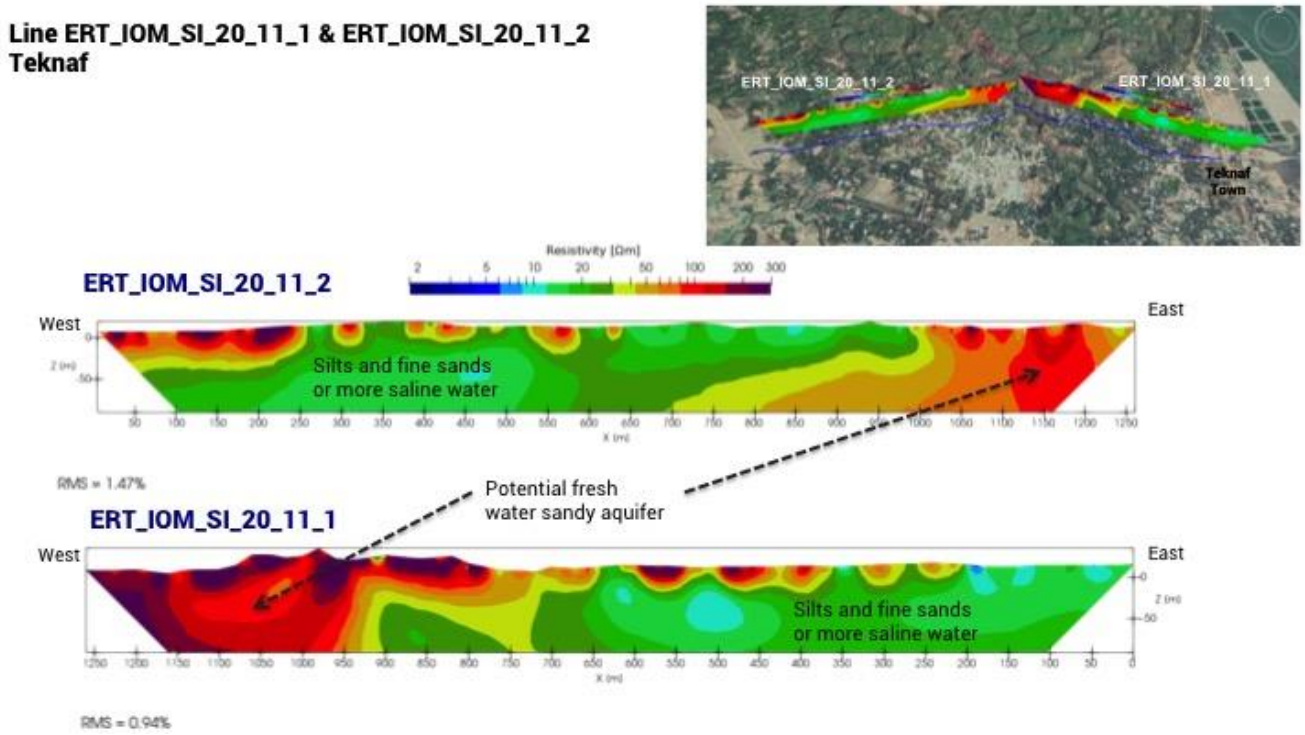
10 – 50 ohm-m	Silty shales with interlayered deposits	Green to yellow colour
50 – 100 ohm-m	Fine sands with possible silty interlayers	Yellow to orange colour
100 – 300 ohm-m	Sandier deposits (interpreted as Tipam Sandstone)	Orange to dark purple colour

ERT Transects – west of Teknaf Town

Two ERT transects were conducted to the west of Teknaf town (Figure 2). These transects found an area of high groundwater potential towards the middle of the peninsular just to the south of the point where a range of hills terminates.

A reasonable sized stream also passes close by and it is reasonable to assume that this locality would receive a high level of groundwater recharge. As such this locality is considered to offer a good target for a groundwater supply scheme.

Figure 2: ERT Profile Line, Teknaf Town



ERT_IOM_SI_20_11_1 section available here:
https://www.dropbox.com/s/9rkv73iw6ki8pm6/ERT_IOM_SI_20_11_1.png?dl=0
ERT_IOM_SI_20_11_2 section available here:
https://www.dropbox.com/s/cpaxndrrj1vwo6z/ERT_IOM_SI_20_11_2.png?dl=0

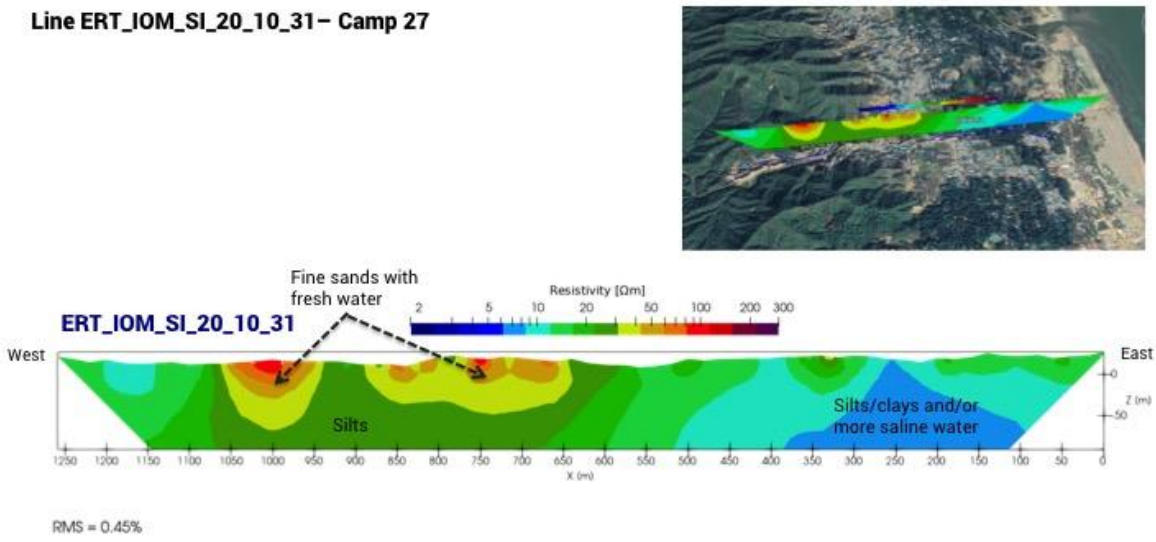
ERT Transect at Camp 27

This transect was run through camp 27 and to the west of the camp (Figure 4). The purpose of this line was to identify whether the Upper Bokabil Sandstone could offer an alternative water source for the refugees living in camp 27. Results from this line are mixed. Whilst a target was identified to the west of the camp, the target is of limited extent. It is recommended that a pilot borehole is drilled at the locality: 20.941440°, 92.251720°

Figure 3: ERT Profile Line, Camp 27

ERT_IOM_SI_20_11_3 section available here:

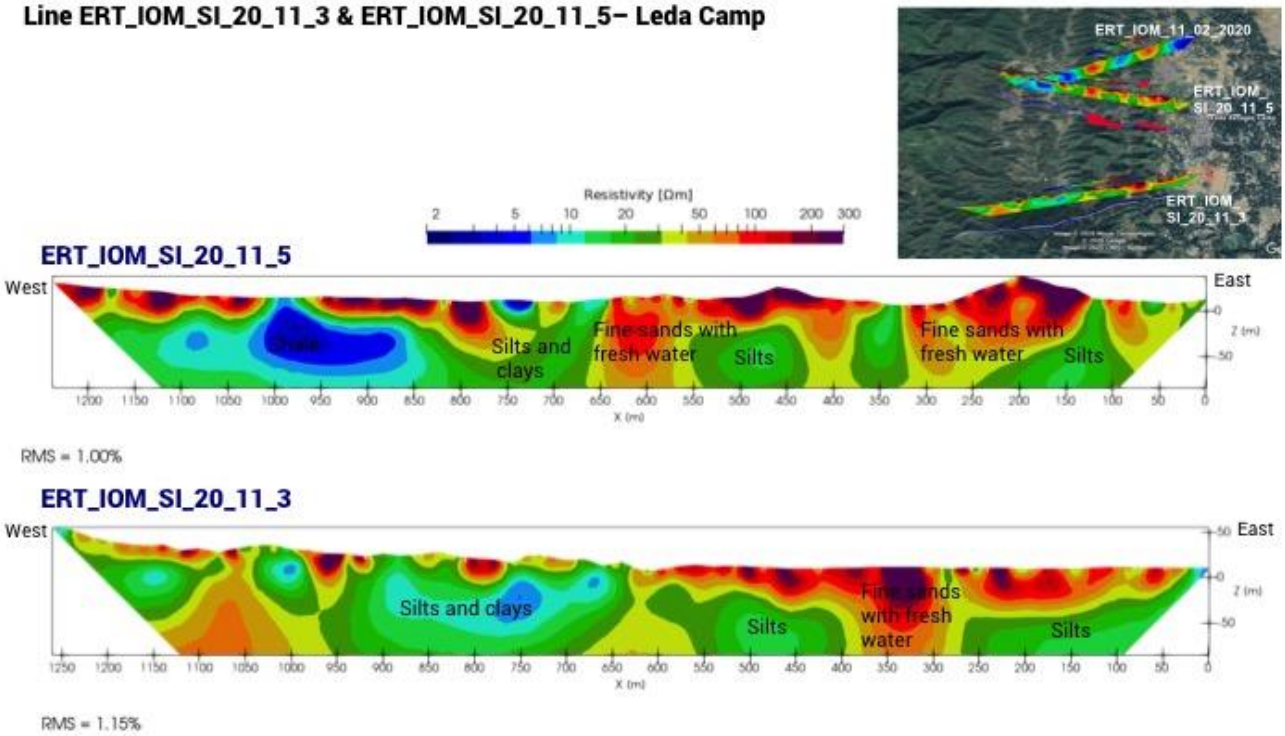
https://www.dropbox.com/s/1sl22v9w2t2jxs1/ERT_IOM_SI_20_10_31.png?dl=0



ERT Transects at Leda Camp

Two ERT transects were conducted to the west of Leda Camp (Figure 3). The purpose of these transects was to identify whether the Upper Bokabil Sandstone could offer an alternative water source for the refugees living in camp 25.

Figure 2: ERT Profile Line, Leda Camp



ERT_IOM_SI_20_11_3 section available here:
https://www.dropbox.com/s/fbjkb5oz4u53vm5/ERT_IOM_SI_20_11_3.png?dl=0
ERT_IOM_SI_20_11_5 section available here:
https://www.dropbox.com/s/3fscrw4t8onr987/ERT_IOM_SI_20_11_5.png?dl=0

A 3D section was produced using the two geophysical transects which crossed over (ERTwith each other (figure 5) which has supported the delineation of 3 potential drilling targets shown on figure 6.

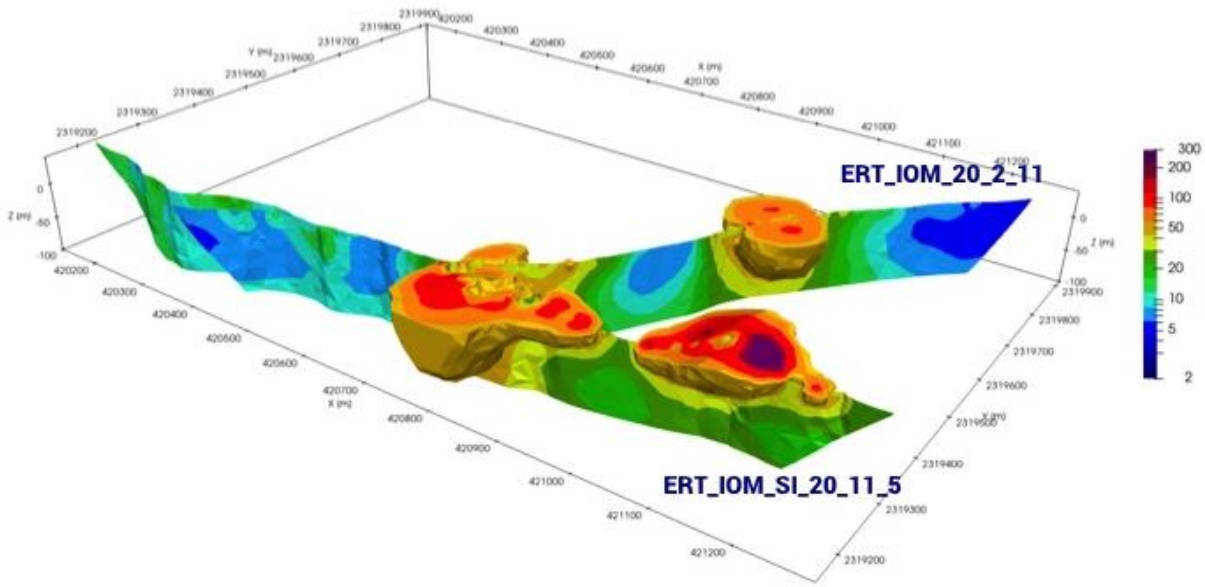


Figure 5: 3D cross section of ERT_IOM_SI_20_11_5 and ERT_IOM_20_2_11
Full versión of figure available here:
https://www.dropbox.com/s/iytypmjc5c03z33/Lines5_3D.png?dl=0

A video of this 3D model can be viewed through the below link:
https://www.dropbox.com/s/74j4pqnfmkkqs97/Lines5.mp4?dl=0

ERT Transect – Nhila

Finally one ERT transect was undertaken in Nhila to provide additional information to support a groundwater modelling update of the Tipam Aquifer system that is planned for early 2021 to be undertaken by Dhaka University.

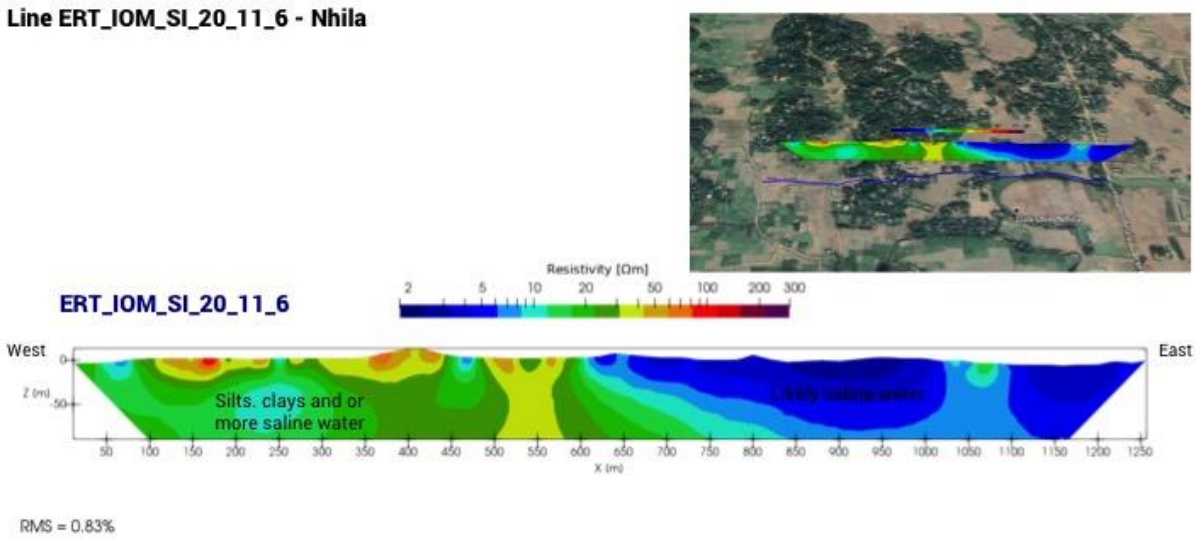


Figure 6: ERT Profile Line 6, Nhila
Section available here:
https://www.dropbox.com/s/ct0kccs0m96293m/ERT_IOM_SI_20_11_6.png?dl=0

SECTION 3: RECOMMENDATIONS

Water Supply Options for Leda

Based on the results of the ERT transect four possible drilling target has been identified to the west of Leda Camp.

These targets are detailed in Table 2 and are also provided as a KMZ file through the below link:
https://www.dropbox.com/s/loqj3jt0ebsns4z/Leda%20Pilot%20BH%20Locations.kmz?dl=0

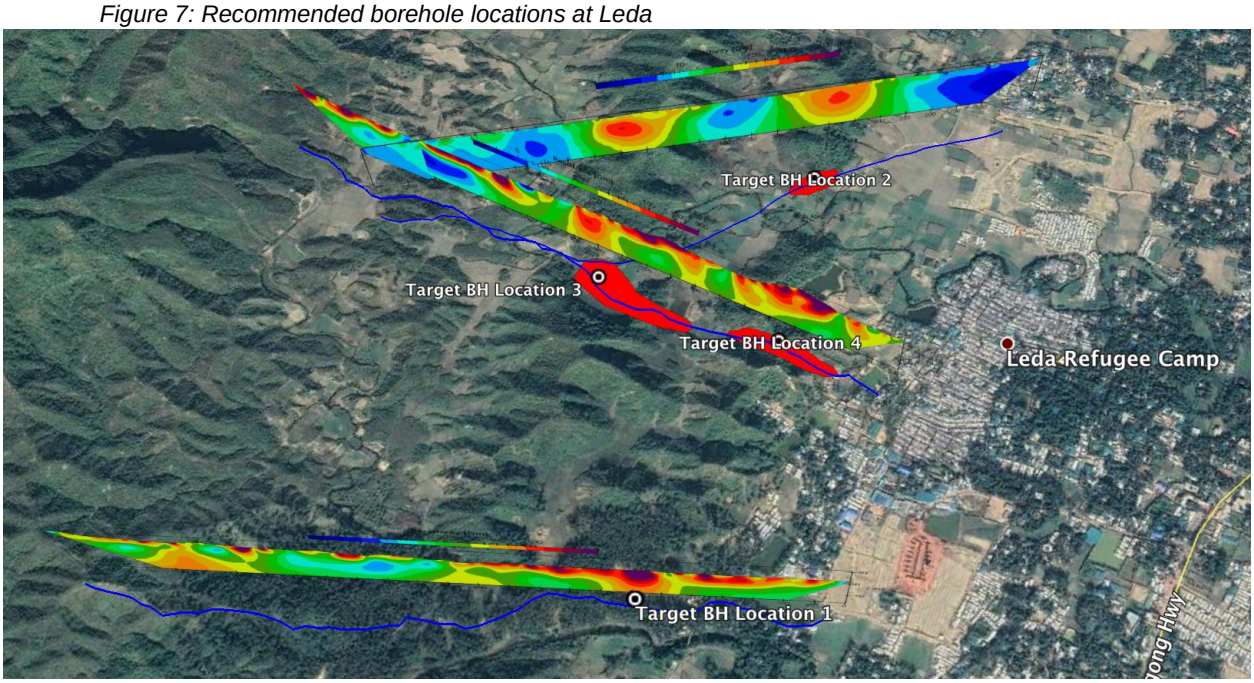
Table 2: Target borehole locations

Borehole Reference	Location	
	Latitude	Longitude
Target 1	20.967870°	92.241327°
Target 2	20.975598°	92.239909°
Target 3	20.972192°	92.237732°
Target 4	20.972531°	92.241023°

The aquifer identified might be a continuation of the formation known as the Upper Bokabil Sandstone.

It is recommended that a borehole be drilled at this locality to a depth of 400 feet. The borehole should be drilled at 12” diameter with installation of 6” casing and screen. The borehole should be carefully supervised 24 hours a day throughout the drilling process. Sieve analysis should be undertaken within all possible aquifers encountered. The sands are likely to be fine and so it should be planned to install a screen with a slot size of 0.4mm and a gravel pack of between 0.4 and 1mm diameter.
A down-the-hole geophysical survey should be undertaken following drilling and casing installation.

Figure 7: Recommended borehole locations at Leda



Water Supply Options for Teknaf

A considerable sized aquifer has been identified to the west of Teknaf Town. It is possible that this aquifer could provide a good water source for Teknaf.

It is recommended that boreholes be drilled within this aquifer system to ascertain its viability as a water source. There are plenty of potential locations to drill this target system. Suggested possible locations include: Latitude: 20.8772° Longitude: 92.2898 or Latitude: 20.8764°, Longitude: 92.2871°.

It is recommended that boreholes are drilled to 600 feet at 12 inch diameter with installation of 6" casing and screen. The borehole should be carefully supervised 24 hours a day throughout the drilling process. Sieve analysis should be undertaken within all possible aquifers encountered. A down-the-hole geophysical survey should be undertaken following drilling and casing installation.

REFERENCES

Literature

Groundwater Relief, Conceptual Understanding of the Principal Aquifer Systems in the Cox's Bazar District (May 2020)

Groundwater Relief, Phase 1 Groundwater Investigation, Cox's Bazar, Bangladesh (November 2017)

Groundwater Relief, Phase 2 Groundwater Works, Leda, Cox's Bazaar, Bangladesh (June 2018)