Preliminary Notes on Field Trip to the Confined Miocene Limestone Aquifer in Northeastern Sri Lanka, 24 September 2004

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Introduction

Water wells drilled by the Water Resources Board (WRB) in the Miocene limestone belt of northeastern Sri Lanka have been drilled as mud rotary with a 12.5-inch tricone bit using a bentonite-based drilling mud in the shallow confining unit (Quaternary and mainly Pleistocene siliciclastics) until refusal. Typically, an 8-inch diameter solid PVC casing is grouted in place and then drilling recommenced with either a 6-inch or 4.5-inch tricone roller bit to total depth within the confined Miocene limestone aquifer (Appendix I). Upon total depth the wells are air developed, sometimes up to a one week length of time. These wells commonly flow artesian upon completion, but are often are produced with a submersible pump. WRB may send a technical person out to the rig site to supervise collection of samples whiles drilling, but suspect this is done by drilling personnel and at widely spaced intervals.

Importantly, the WRB has drilled approximately several hundred water wells in the prolific confined Miocene limestone aquifer in northeastern Sri Lanka. It seems only electrical conductivity logs have been acquired in some of these wells. There is a huge potential to acquire modern geophysical borehole logs in these wells.

WRB has recently completed 25 wells between Madurankudi and Vamativillu as open-hole production wells, which produce from the karstic Miocene limestone. These typically have 30-40 m of open hole near the upper part of the karstic Miocene limestone and 8-inch diameter solid PVC surface casing and 6-inch diameter open hole (this is apparently the case for approximately 80% of these wells). Each has been drilled with a tricone rotary bit with mud and air developed.

Stop 1: Mangalaeliya wattha well (Figs. 1-4) completed in calcareous sandstone and in report by Wijesekara et al. (1999). Originally was an artesian well, but now on a submersible pump. Drilled in 1998.

Figure 1. Mangalaeliya wattha well in coconut plantation. Well is completed open hole and producing water from calcareous sandstone that is interpreted to be equivalent to the Miocene limestone of the confined limestone aquifer.


Figure 2. Mangalaeliya wattha well in coconut plantation. Well is on a submersible pump and triangular-shaped rods are used to pull pump.

Figure 3. Mangalaeliya wattha well in coconut plantation. Close-up of well head with electrical wires running down hole to submersible pump.

Figure 4. Mangalaeliya wattha well in coconut plantation. Left is Lasantha Perera, Water Resource Board, and field trip driver Terence Pathiraja on the right.

Stop 2: Banana plantation about 2 km north of the stop 1. Artesian well behind fenced area (Fig. 5). When drilled had an artesian head of about 3 m, but now artesian head is at about 2 m and assisted by a submersible pump.

Figure 5. Banana plantation about 2 km north of the stop 1. Artesian well is completed open hole and producing water from the confined limestone aquifer.

It appears that in the southern end of limestone belt, the Miocene aquifer is thin and the underlying sandstone thick. Present-day, long-shore transport is from north to south.

Stop 3: WRB drill rig near prawn farm at Karadipuval (Fig. 7). Rig is located about 0.5 km west of the Puttalam lagoon. Drilling rig is Japanese brand that can drill to depths of about 200 m. Presently drilling at a depth of about 30 m in the Pleistocene "confining unit" (Fig. 7). Rig will drill into Miocene limestone and hopefully produce from it. Well is being financed by prawn farmers that are experiencing salinities in their farm ponds (57 ppt salinity) that is too high for their aquaculture. Want to use well water to dilute their pond water (Fig. 8). Rig will drill to about 100 m with a 12 ¾” tricone roller bit and mud fluid, then set 8” solid PVC at the top of the Miocene limestone, and then drill to total depth with a 6 ½” tricone roller bit. Then complete open hole, after air developing. The Miocene aquifer is being recharged 2 ways: (1) vertical infiltration through Quaternary and mostly Pleistocene siliciclastic sediments, which may account for only about 10% of recharge and (2) recharge from highland or eastern uplands, which may account for about 90% of the recharge. Water table is probably about 15 m below the land surface in this area.

Figure 6. Water Resources Board drill rig near prawn farm at Karadipuval.

Figure 7. Three sediment samples of the shallow confining unit collected from the subsurface at the drill rig near prawn farm at Karadipuval.


Figure 8. Prawn farm at Karadipuval, a short distance from drilling rig site.

Stop 4: Limestone quarry near village of Aruwakkaru. The Sri Lankan government has a 60% working interest in this mine and private sector 40%. Unfortunately, the industrial partner in operation of the mine requested that we did not photograph the quarry and provided a “guide” to insure photos were not taken and the trip was conducted safely, so only a few photos were digitally recorded within the quarry. The quality of the rock exposures in the walls of the quarry are compromised by explosive blasting of the rock and a film of “rock dust” covering the exposures. It is problematic to observe details in the textures of the rocks in the quarry because of the problem of “dust” coating all exposures. We visited on of many actively mined quarries. We were told by a mine engineer that the bottom of the quarry is composed of sandy clay or sand and clay that was deposited in a lagoon environment. About 3 m above the bottom of the quarry wall is a brownish laminated calcrete representative of a subaerial unconformity near the base of the Miocene limestone (Fig. 9). A second laminated calcrete and subaerial unconformity may occur another 1.5 m up along the quarry wall. It is speculated that a m-scale cyclostratigraphy could be present throughout the shallow-marine Miocene limestone succession, however, verification was not conducted because of higher parts of the limestone section being inaccessible. The mining engineer reported

Figure 9. Limestone quarry near village of Aruwakkaru. These limestone rocks are part of the confined Miocene limestone aquifer where present below the water table. The red arrow points to the quarry floor, which corresponds to a geologic contact between sandy clay or sand and clay (per. comm., quarry engineer) that underlies the overlying cream or yellowish colored limestone quarry walls. The lowermost black arrow shows the location of a laminated calcrete that represents a subaerial unconformity. The overlying dashed black arrow may also be a laminated calcrete. The dashed arrow shows about the maximum vertical extent of the quarry wall that was observed at close hand. Visible near the top of the quarry wall is pinnacle karst defining the top of the Miocene limestone that is filled in with maroon Pleistocene siliciclastics of the overlying regional confining unit.

that on occasion they blast through caves, however, the scale of these caves was never determined. Much of the limestone has a cream or yellowish color in the quarry and appeared to be of a shallow marine origin, as confirmed by the local presence of miliolid and archaiasinid(?) benthic foraminifera and also local occurrence of peloidal grainstones—based on samples scattered about on the quarry floor. The upper surface of the Miocene limestone has a spectacular pinnacle karst with both low and high areas filled in with maroon- or red-colored Pleistocene sand. A few samples of the Miocene limestone have been taken to Miami, Florida for petrographic analyses.

Stop 5: WRB office in Kalladi (Figs. 10-14). WRB is regularly using surface resistivity methods for locating suitable water-supply sites prior to well drilling (Figs. 11 and 12). Ninety-nine percent of the wells drilled by the WRB in the limestone belt have resistivity curves such as shown in figure 12. Have an EC conductivity down-hole tool for measuring borehole fluid conductivity in units of µs/cm. Rock cuttings collection is very limited—to part of the space of a small book shelf. Core collection is out of doors and in unmarked decaying boxes, and essentially useless, because of an absence of labels on samples and boxes (Fig. 13). Have a new water-chemistry lab (Fig. 14) that has same water chemistry capacities as lab in Columbo, but do not have a microbiology lab.

Figure 10. Water Resources Board office in Kalladi.

Figure 11. Resistivity instrumentation that has been used by the Kalladi Water Resources Board office during water resource exploration activities.

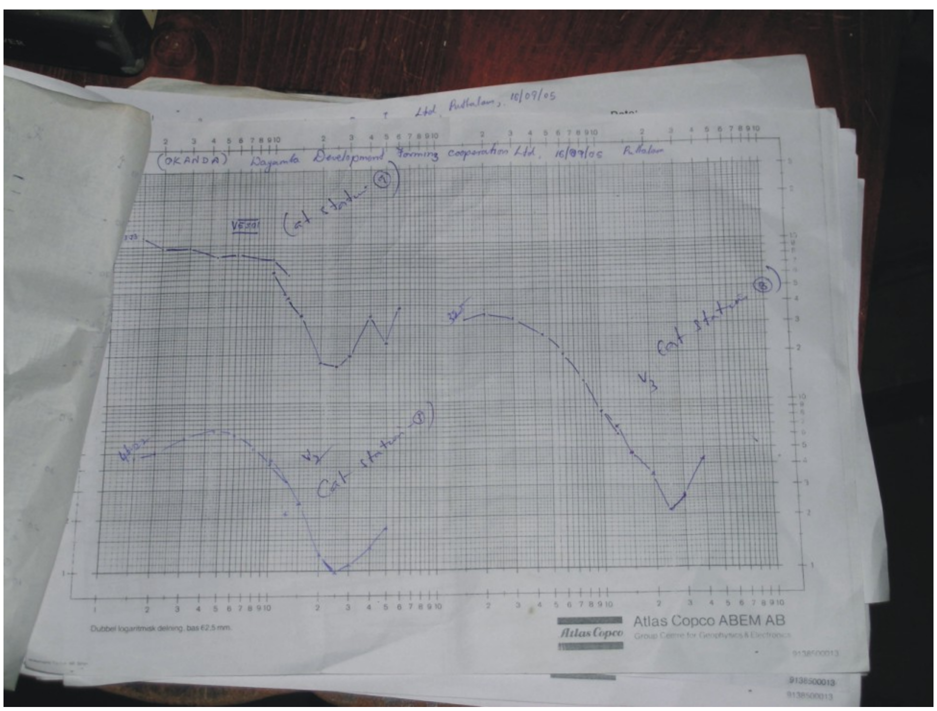


Figure 12. Resistivity plots that has been used by the Kalladi Water Resources Board office to interpret depths to limestone or fractured basement.

Figure 13. Collection of unmarked rock cores and core boxes at the Kalladi Water Resources Board office.

Figure 14. Water-quality laboratory at the Kalladi Water Resources Board office.

Some of the discussion of the day suggested that the LTTE that controls the north and northeast part of the confined aquifer in the Miocene limestone belt do not want to exploit this productive aquifer. The reason for this is not clear, but appears to have a relationship to the desire of the Tamils to preserve this “deep” underground aquifer indefinitely. So, the aquifer is only exploited as far north as the area of Mannar and not any further east.

Saltwater intrusion apparently is a present and emerging threat to the Miocene limestone belt that forms a trend of confined aquifers in northeastern Sri Lanka. In the Puttalam area, the WRB has recorded wells producing from the confined aquifer to have measured conductivities above drinking water standards, as much as 36,000 μs/cm, which is approaching conductivities characteristic of sea water. It is suggested that high density pumpage from this confined aquifer in the Puttalam area is the cause of the high measured conductivities, that is, overpumpage is suggested to be causing a lowering of the vertical hydraulic gradient in the confined limestone aquifer and causing in inland directed saltwater intrusion.

Benefits of the confined Miocene limestone aquifer on tsunami relief mission:

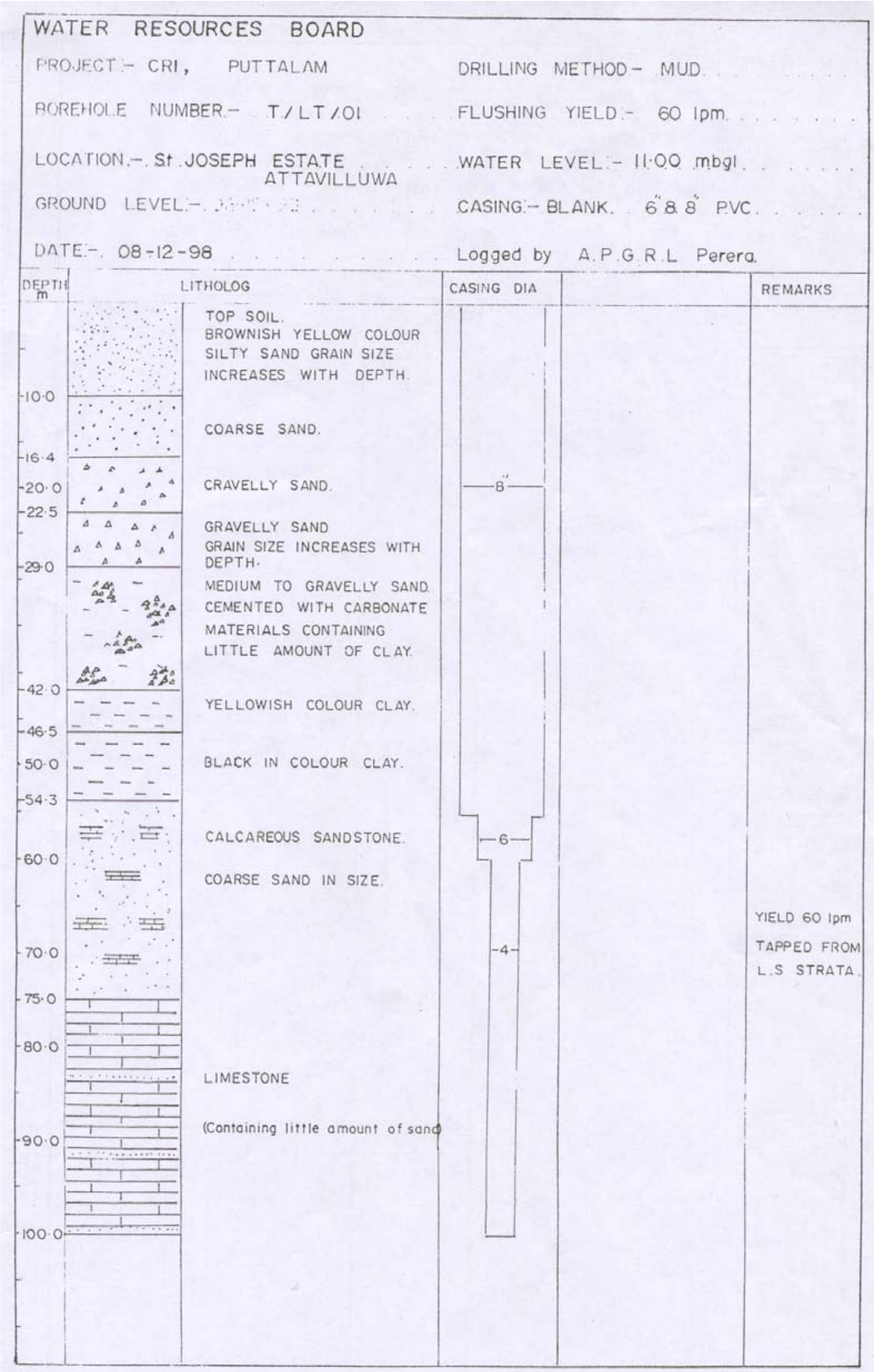
1. Refugee camps are on the ground in Puttalam and are using the confined water supply of the limestone belt.
2. Water from Vanathavilluwa Basin is being exported to tsunami impacted areas. (This is a very highly productive fresh ground-water basin. Limestone is very thick. 40-50 wells have been drilled in this basin with mud-rotary method and completed open hole following air development. Opportunity to log all these wells.)
3. This high-capacity confined aquifer was fortunately naturally protected from the impacts of the 2004 tsunami, and should be fully characterized and protected from any future tsunamis.

Figure 15. Fruit stand out side of Hindu temple on the eastern outskirts of Putallam.

References:

Wijesekara, R.S., Perera, A.P.G.R.L., Somasiri, L.L.W., and Vidhana Arachchi, L.P., 1999, Hydrogeological study on deep groundwater aquifers in the coconut growing areas of Puttalam District: Water Resources Board of Sri Lanka.

Appendix I:



Sample of well log from Wijesekara et al. (1999) showing hydrogeologic and well completion details of a well completed open hole in the confined Miocene limestone aquifer of northeastern Sri Lanka.