A Proposal for Evaluating the Impact of the 2004 Tsunami on the Hydrology of Groundwater and Surface Water of Selected Coastal Aquifers, Sri Lanka

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It is proposed that the following items should be considered for evaluating the impact of the 2004 tsunami on (1) the interaction between groundwater (spanning onshore and offshore coastal areas) and surface-water flows, and (2) groundwater and surface-water quality in selected coastal study areas.

After study areas have been selected, the following plans of action should be considered for each area:

Short Term effort:

Benefit: immediate improvement of healthy water-supply needs to local populous and collection data for longer term modeling effort:

1. Map, evaluate, and catalog existing construction of wells, boreholes, and pits.
2. Collect (if necessary), evaluate, and catalog water-quality parameters of wells, boreholes, and pits.
3. Summarize construction and water-quality data, which includes parameter rankings and characterizations, on a computer spreadsheet.
4. Identify, and evaluate the local daily demand in water use for future modeling needs.
5. Record anecdotal reports of where groundwater came to the surface prior to the tsunami surge. If abundant, map and use to plan in well drilling. There could be a relationship between aquifer transmissivity and the location of these events.
6. Evaluate whether some water-supply wells could be outfitted with solar panels, submersible pumps, and storage tanks to improve productivity. (Work with organizations such as Tillers International to identify very-low maintenance pumps that could be more appropriate for some areas.)
7. Conduct numerous time-domain electromagnetic (TDEM) and borehole conductivity surveys in selected parts of the study area to assist in producing a first order freshwater-saltwater interface map. Drill and collect geologic and borehole geophysical data for input into a reliable TDEM "conductivity" model.
8. Using the information from the TDEM, borehole conductivity surveys, and public needs locate new water-supply wells that can provide local people with a clean and safe drinking-water supply.
9. Install new water-supply and monitoring wells. Each well will be drilled and geologic samples (cores/split spoons) acquired to depth. The boreholes will be

logged using advanced borehole geophysical tools. Monitor wells will be installed in contaminated and non-contaminated areas. Both water-supply and monitor wells will have slotted screens. Geophysical tools to be used should include 3-arm caliper, natural gamma ray, electromagnetic induction, spontaneous potential, fluid resistivity, fluid temperature, full wave-form sonic, digital optical borehole imager, heat-pulse flowmeter, spinner flowmeter, electromagnetic flowmeter, and acoustic borehole imager.

10. Characterize groundwater ages in new wells through the use of isotopic signatures of water (tritium, helium, and carbon and oxygen isotopes) to determine if the groundwater is connate freshwater, saltwater, or recent Tsunami inflow.
11. Conduct wet permeability analyses on all unconsolidated sediments to estimate permeability and porosity and analyze all whole cores for measurement of horizontal hydraulic conductivity (Kh) and vertical hydraulic conductivity (Kv) and porosity.
12. Conduct and analyze slug tests on all new wells. Calculate in-situ Kh for each screened interval.
13. Investigate the ability to install monitoring equipment for water quality and pumping level in each new pumping water-supply well. Data could be sent via through satellite and the internet links to Sri Lankan and staff working on this project. Establish a safe "yield" for new pumping water-supply wells. Install instrumentation, if feasible.
14. Using information obtained in task 5, construct and establish self-sufficient pumping and water-storage tank farms. Tanks will be maintained by Sri Lankan scientists and government.
15. Summarize water quality, safe yield, and hydrogeologic data for all monitor and water-supply wells. If available, monitor real-time data on line. Summarize performance of equipment and station.

Longer Term effort:

Characterizing the "surge basin" that includes and extends from the drainage basin

This work would begin after the Short Term Effort work is generally completed. Since general topography and bathymetry is not known in many parts of the world it should be assumed this is the case in Sri Lanka study areas. The wave patterns, historical water quality, and surge heights would allow investigators to define that part of the drainage basin that was affected by the Tsunami. What is this?

1. Meet with groundwater and surface-water modeling group to determine what data are needed for their modeling effort.
2. Onshore topography and offshore bathymetry can be obtained using LIDAR and LADS systems. LIDAR appears to have few limitations on the LIDAR but LADS may be limited to a depth of 170 feet below sea level. All data should be referenced to best vertical and horizontal datum or relative datum. Data will be used to develop topographic and bathymetric contours and TIN coverages of the study area.

3. Create a GIS coverage of all LADS, LIDAR and resisitivity work. Rectify an aerial base map to local coordinate system.
4. If no unified reference datum is available in Sri Lanka than a relative network should be established for the area of study. Tops of all wells should be surveyed to establish the elevation of the ground surface (verifying LIDAR data), top of PVC casing, and longitude and latitude.
5. Conduct a TDEM and borehole conductivity survey at the selected basins to map in detail the freshwater-saltwater interface.
6. If appropriate conduct a water-based resistivity survey to assist in definition of the freshwater-saltwater interface, eg., in lagoons or near offshore marine.
7. Areas inundated by tsunami run-up have been termed surge areas. Identify areas within a drainage basin that are outside the surge areas in order to install monitor wells to obtain pre-tsunami water conditions.
8. Install clusters of monitor wells (with screened intervals based on site lithology). A wide variety of water quality sampling should be carried at each well cluster and spacing between cluster should consider this objective. The deepest well in each cluster should be continuously cored for geological samples and the open borehole logged with the same geophysical tools used in the sort-term effort to identify paths of groundwater flow, measure water quality, and lithologic changes that relate to aquifer attributes.
9. If feasible, install water-quality sensors (such as temperature and salinity) and pressure transducers in wells and surface-water stations to monitor water levels and density differences within the well bore. This will allow the monitoring of transient conditions affected by rainfall and tidal influences. Data needs to be collected and placed in a data base for future analysis and QA/QC.
10. Collect transient data on the same frequency (15 or 30 minutes). All data should have numerous sampling points so that future analysis will not be hindered by the lack of data collection.
11. If feasible, periodically deploy portable groundwater velocity equipment in the wells to evaluate horizontal groundwater movement (velocity and direction) under various tidal conditions. Wells should be constructed with this use in mind.
12. Quarterly, collect and analyze water-quality samples for all surface-water sites (fresh and saltwater) and for all groundwater wells. Sampling parameters should be for ionic and isotopic constituents to establish the age and source of the groundwater and surface water. This data should be compared to water quality obtained by the down hole geophysical logging equipment, ages of groundwater, direction of ground water flow. Review sampling frequency after one year.
13. Using data collected in Task 6, deploy seepage meters offshore. Sampling should be concurrent with sampling and water level recording onshore.
14. Collect shallow high-resolution seismic or ground-penetrating radar data or both in rivers, estuaries, and shallow offshore to establish depth to crystalline bedrock (assuming a crystalline basement is near the surface) and stratigraphic characteristics of the aquifer.

15. Begin data compilations and analysis within 6 to 12 months after data collection begins. Construct potentiometric maps of groundwater surface. Make sure data is useable in the modeling effort.
16. Construct 3-dimensional conceptual hydrogeologic model for use as input into numeric and analytical models.
17. Work with Sri Lankan government to plan a salt-water intrusion network. Drill and install and a basin-wide saltwater-intrusion monitoring network.
18. Summarize data and write a draft report.
19. Presentation of field data and interpretations to the Sri Lankan government as one or more journal articles.