Water Resources Management: Vulnerability of Coastal Aquifers to Climate Change & Human Effects (UNESCO-Graphic).

Groundwater Governance & Sustainable Development
Montevideo, Uruguay (April-2012)
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Water & Sewerage Corporation – The Bahamas
Water Resources Management Unit (WRMU)
What is different about the Water Resources in The Bahamas?

- **Hydro-geology**
  - Freshwater lenses float on seawater at depth.

- **Land Elevations**
  - 80% of the land within 5-ft (1.5-m) of mean sea level.

- **Subsurface - Inverted Geotherm Conditions.**
  - Indicative of a high degree of exchange with the surrounding ocean.
Priority Areas of Concern for Water Resources Management - Bahamas

- Climate change as it relates to rising sea levels, and storm surges associated with tropical storms – N Andros Graphic [Sustainable Development]

- Present transition from natural water supply areas (fresh groundwater supplies) to reverse osmosis sources and the total abandonment of these areas, leading to the possible development of the unprotected areas [Groundwater Governance]

- Land & coastal development, excavation of Wetland Areas, Marina Construction;

- Over-extraction of groundwater lenses, and distribution water losses due to the antiquated systems;

- Industrial and commercial effluents, their disposal, and storage.
Groundwater Governance – The Bahamas
Existing Water Related Regulations

Several Policies and Legislation do exist and are applied in certain critical areas with regard to water governance:

- WSC Act (1976) – Existing Water Resources Regulations for areas under the use and control of WSC for the provision of water,
- Environmental Health Act of the Ministry of Health (1987),
- Ministry of the Environment Act (2010) – Established Ministry for the combined water and environmental regulations,
- Building Control Act & Regulations of Ministry of Works & Utilities (1971),
- Ministry of Agriculture, Fisheries, and Local Government Acts,
- Bahamas Forestry Act (2010) – partial protection to certain water resource areas,
- The Public Utilities Commission,
- The BEST Commission.
Sustainable Development

Effects on the North Andros Water Resources, as a result of 2004 Storm Surge (Hurricane Frances!):

- The barging scheme wellfields are approximately 12,000-Acres (4,858-Hectares), with an available freshwater supply of 6,000,000-GPD (22,712-m3/Day). The area consists of the ‘Old’ and ‘New’ (Phases I & II) Wellfields.

- Storm surge across wetlands to the west of the wellfield area (distance of 0.9-miles or 1.5-km from wellfield), into the western trenches, and extending to the most eastern trenches of Phases I & II;

- Construction of the open, interconnected trench system facilitated the movement of sea-water throughout the wellfield;

- Trench Water Quality Compromised – Increase of composite salinities in 70% of the supply trenches from 330-mg/L (max) to a range of 1,300 to 15,000-mg/L. Chloride readings of 114-mg/L, down to minus eleven feet (3.35-meters) below ground level in the monitoring wells;

- Groundwater lenses not compromised, but the 4.5-MGD Shipments into the island of New Providence affected (Note: Andros = 2,300 Sq Miles or 5,956.97 Sq Km; Fresh Groundwater = 209.92-Mil Gal. Available, 0.38-Mil Gal. Demand);

- The overall effect on the water resources as a result of continued or repetitive sea-water inundation is a concern. No further occurrences' of storm surge since Oct-2004, but the resources continue to be monitored for the effects of the surge.

- Water Quality in Oct-2007: Trench Salinity Range between 1,000 to 3,000-mg/L.
The GRAPHIC Programme...

...to raise awareness of the importance of groundwater as a resource, and its vulnerability to climate change; to promote study areas around the world ("case studies") that can provide key research with high transfer value.

GRAPHIC provides a platform for exchange of information through case studies, thematic working groups, scientific research, and communication.

GRAPHIC serves the global community through providing scientifically-based and policy-relevant recommendations. GRAPHIC uses regional and global networks to improve the capacity to manage groundwater resources.
How Come the Bahamas & Andros?

- Meeting of GRAPHIC Expert Committee with Latin American/Caribbean section of IHP (Belize City, Belize, Nov. 2007)
- First location meeting and field trip – Selected GRAPHIC committee members and local and regional experts (Nassau, Bahamas, March, 2008)
- Work plan session with local Bahamian agencies, USGS, USACE, TNC (Nassau, Bahamas, March, 2009)
The Bahamas...

- Low lying carbonate “platform” islands with little topographic relief

- Lack of topography means little surface-water runoff, heavy reliance on fresh groundwater floating on deeper salt water (augmented by desalination)
Andros Island

- At 2,300 square miles (5,956.97 Sq Km); Andros is the largest island in the Bahamas and the fifth-largest island in the Caribbean
- 80% of Andros is less than 5-ft above sea level
- Extremely vulnerable to sea-level rise and topical storm surge
Storm Surge Vulnerability...

- Sept 2-4, 2004: Hurricane Frances (Category 4) passes directly over the Bahamas and eastern US.
- Nearly complete destruction of the Bahamas agricultural economy, several homes destroyed, at least 3 deaths.
- The associated storm surge on Andros Island pushed several feet of ocean water onto the north end of the island inundating the freshwater collection trench network. This part of the collection system is being pumped but remains contaminated by salt.
The North Andros Barging Scheme Wellfields were recently utilized to supply 50% of the present demand to the island of New Providence. Exploitation of this aquifer is considered to be medium to high (thru 2011).

In excess of 10-years of simultaneous data exists for the area: Measurements of quantified extraction, as well as water quality (temp, level, conductivity) are available. Rainfall is available and limited piezometric level data is on file.

Previous detail studies are available that characterize the topography, geology, hydrogeology, and its hydrologic behavior.

Four immediate individuals available, with water resources experience: Dr. Richard Cant (Hydrogeology), Mr. Philip Weech (Hydrology/Environment), Mr. Michael Swann (Hydrologist-Water Quality), and Mr. John Bowleg (Engineering/Hydrology). A total of four technicians/servicemen are available to assist (between Nassau and Andros).

Given the 2004 inundation of seawater into the wellfield area, and the displacement of all the freshwater contained in Phases I, & II; both the Bahamas Government and WSC remain favorable to additional hydrological studies of the area.

(Note) Previous ‘MoRSCA PDF-B’ Submission - Management of Risks to the Sustainability & Integrity of Coastal Aquifer Systems in SIDS.
Key Resource Management Questions...

- How is the dynamic stability of the fresh groundwater lens related to weather events?
- How will the groundwater lens respond to changes in the frequency and intensity of tropical storms or incremental sea-level rise?
- Are there specific areas of the groundwater resource that should be protected for future development as a drinking-water supply?
- How long before sea-level rise removes this as a viable water supply; what is the planning horizon for developing alternatives?
Long-Term Plan of Study...

- Install wells; refine extent of the lens; and monitor event driven, seasonal, and pumping effects on the freshwater lens.
- Improve the data archive and data management system for the study area.
- Develop a conceptual model and understanding of the water budget for the freshwater lens – ongoing studies of area by Simon Frasier University, BC, Canada (2012).
- Numerically model the system to permit simulation and forecasting of the impacts of management decisions and climate change.
- Use of Deep Wells (reverse geothermal conditions in the Bahamas): For Ocean Thermal Energy Conversion (OTEC) Research, & continued use for Treated Effluent Disposal?
Refine extent of, and monitor seasonal and pumping effects on, the freshwater lens.

- Inventory existing well network and verify location, depth, and integrity.
- Install approximately 20 additional wells at critical locations and depths, weekly monitor water levels.
- Instrument selected wells with water-level pressure transducers and conductivity monitors.
- Erect and telemeter a data collection tower for evapotranspiration, energy budget, and meteorological data.
- Evaluate effects of pumping trench-network collection system on freshwater lens.
- Train staff in the monitoring and maintenance of the field data network.
Water Resources Assessment of The Bahamas

MOST RECENT UPDATE

Produced By: U.S. Army Corp’s of Engineers (2004)

Compiled Using Existing WSC-WRMU Data and Reports. Data approved by the Bahamas Government.