

Hydrogeological Assessment of the Brito Formation, Nicaragua

T22. Water Resources and Management in Coastal and Inland Aquifers – Emphasis on Small Island Developing States of the Caribbean

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Context and Objectives

- ▶ Water issues and concerns experienced by individual stakeholders, led to various research and assessment activities in the region. Alignment.
- ▶ Assimilate, synthesize and analyze data collected over the last five years to better understand the groundwater resources
- ▶ Provide interim guidance to inform policy, planning and decision-making
- ▶ Prioritize monitoring, further research, and critical data collection needs
- ▶ Help government, communities and stakeholders achieve current and future water demands in a sustainable manner that limits negative impacts to the aquifer



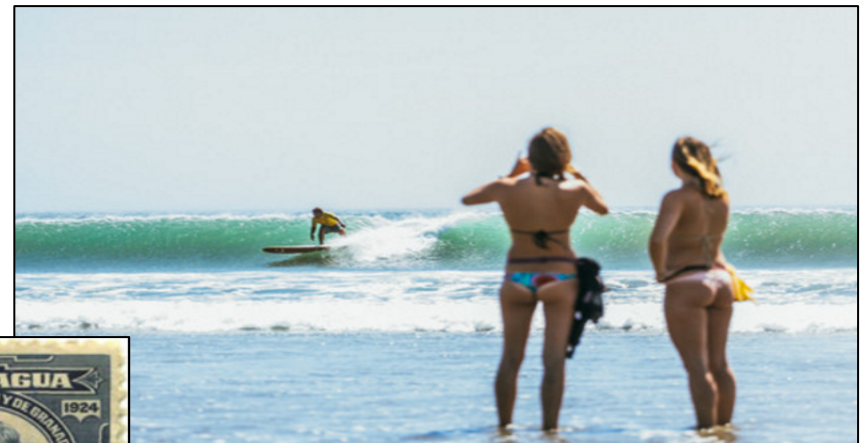
Source: UN OCHA

Introduction

- ▶ **Nicaragua's Pacific Coast**
- ▶ **Past Canal /Oil & Gas Activities**
- ▶ **Current Water Situation**
 - 95% (78 of 82) public water systems wholly or partially supplied by groundwater
 - Hand Dug Wells Prevalent For Domestic Supply (68% go dry seasonally)
 - Tourism and vacation home developments are largest groundwater user
- ▶ **Tourism & Development**



- **Global water security**
- **Local water governance and implications**
- **Nicaragua & the 'Emerald Coast'**



<http://www.tourist-destinations.net/2013/07/nicaragua-travel-guide.html>

“EMERGING DESTINATIONS”

- ▶ Arrivals expected to increase at a rate of 4.4% (2010 – 2030)
- ▶ Double that of arrivals to ‘advanced economies’ (UNWTO)



Arrivals: 9% growth since 1994

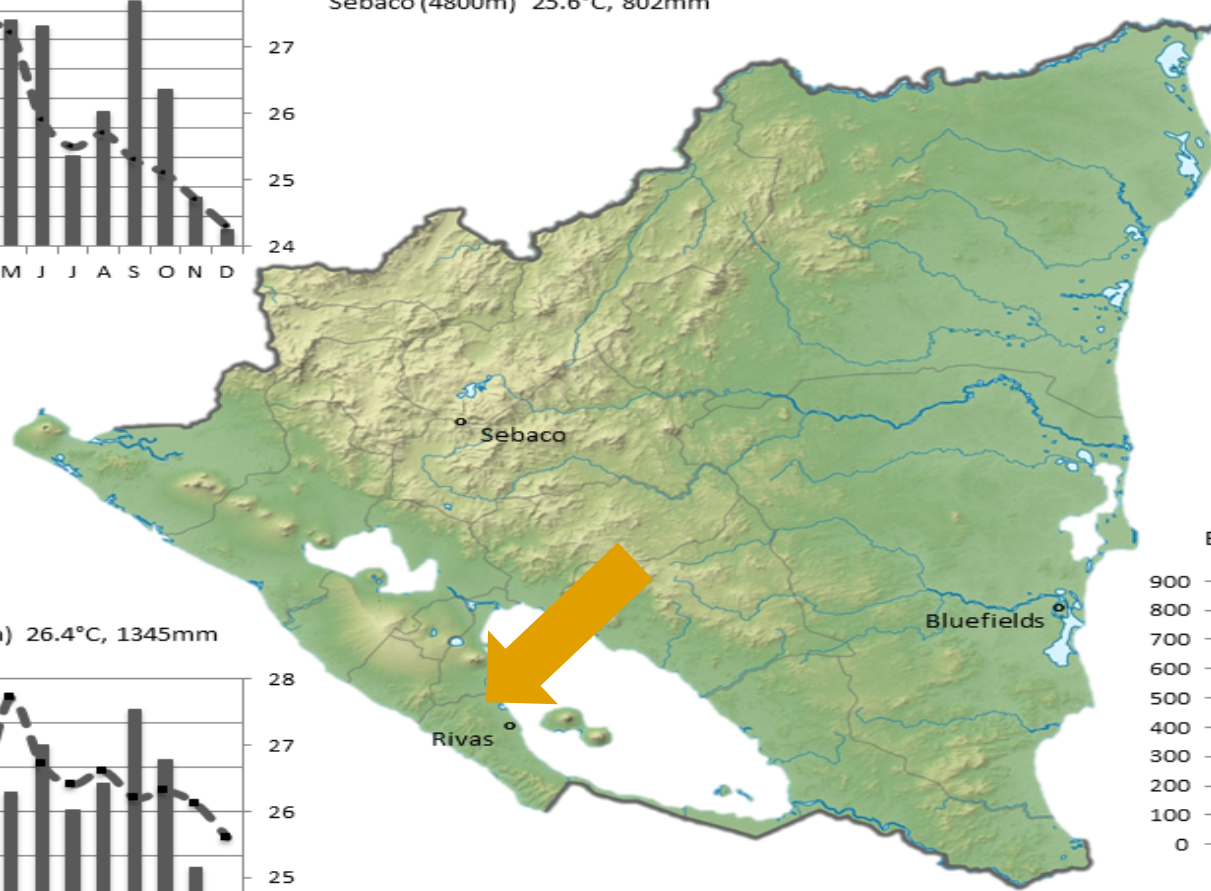
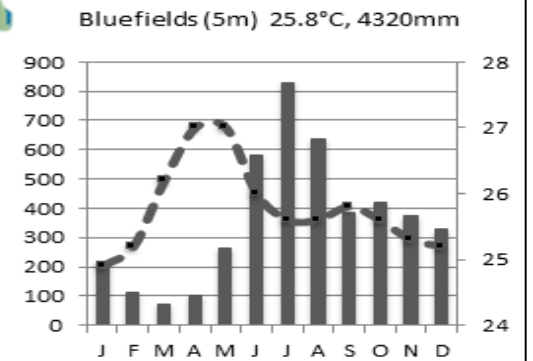
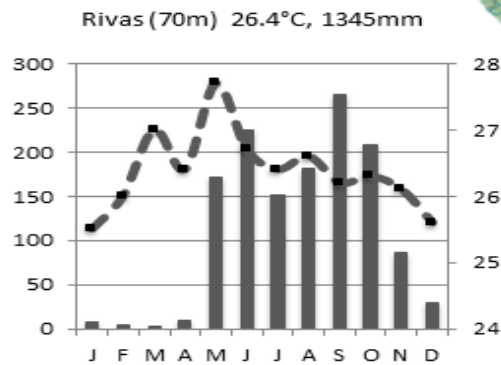
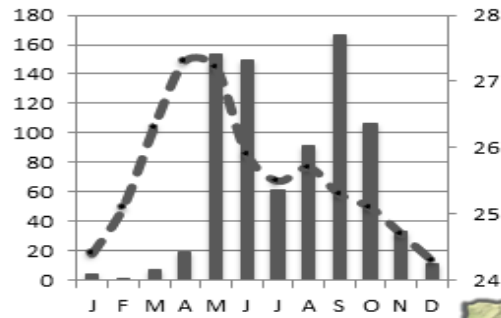
The Brito Formation, Study Area

► Geography & Climate

- 1300 km² area, 80 km along the coastline and inland up to 25 km
- 60% of the Rivas Department, approximately 40% of the Carazo Department, and a small portion of the Granada Department.
- 1646 mm/year avg precipitation
- Dry season, November – April
- Arid climate, long dry seasons, few perennial water bodies
- Interior mountains and Pacific coastal plain

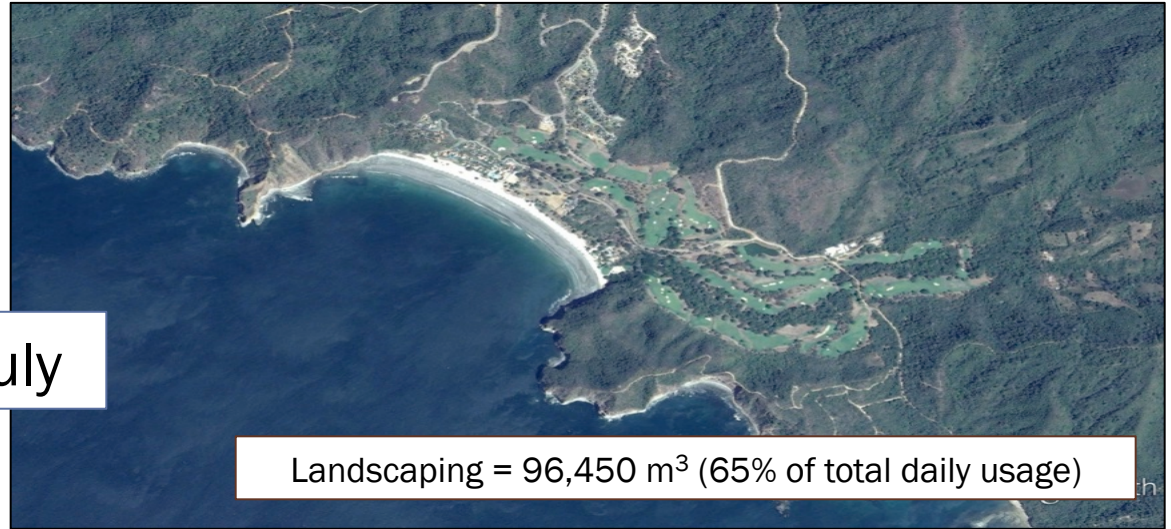
► Population

- Approximately 140,000 (25,000 in Tola Municipio)



“The Emerald Coast”

July



Landscaping = 96,450 m³ (65% of total daily usage)

Dry Tropical Forest

February



Golf Course = 375,000 m³ (45% of total daily usage)

Image © 2015 DigitalGlobe

Google earth

Geological Setting

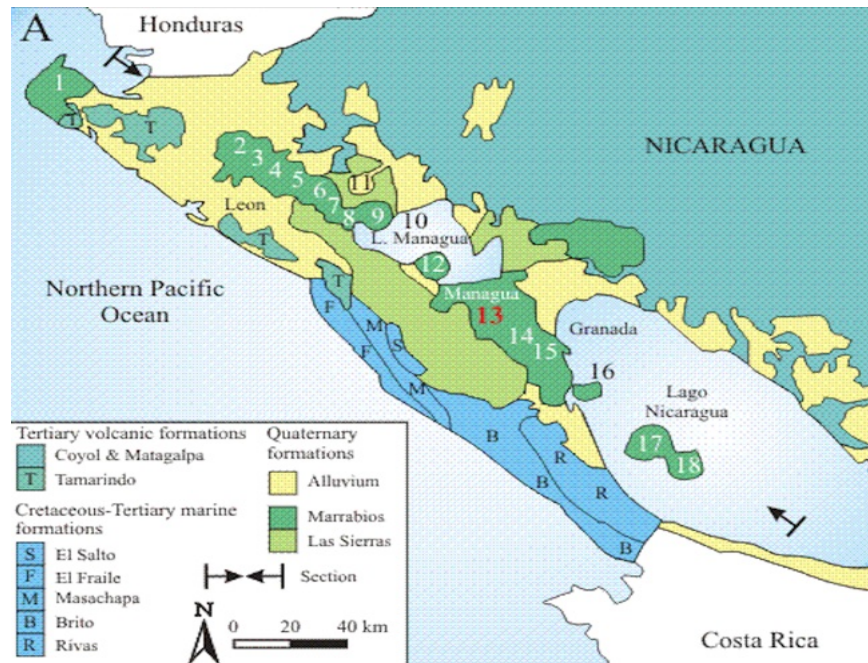
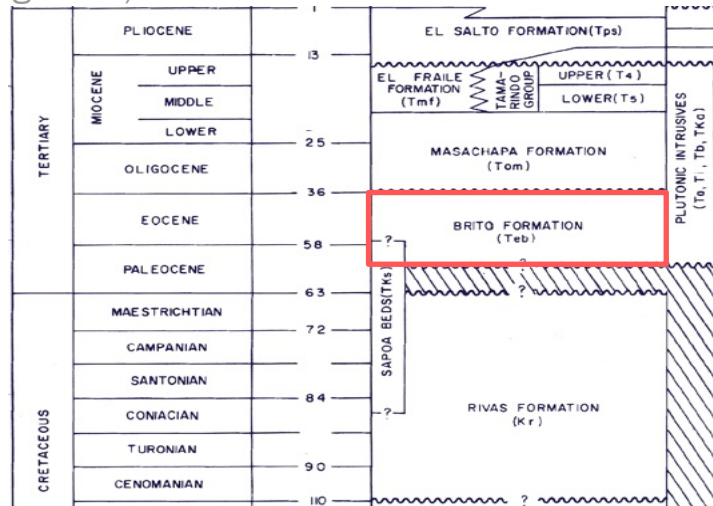
Brito Fm outcrops across 1284 square km, 80km along the coast and up to 25 km inland

2,500 m thick in areas, generally dipping SW

Sandstone, tuffaceous sandstone & siltstone, shale, limestone and graywacke. Basal conglomerate

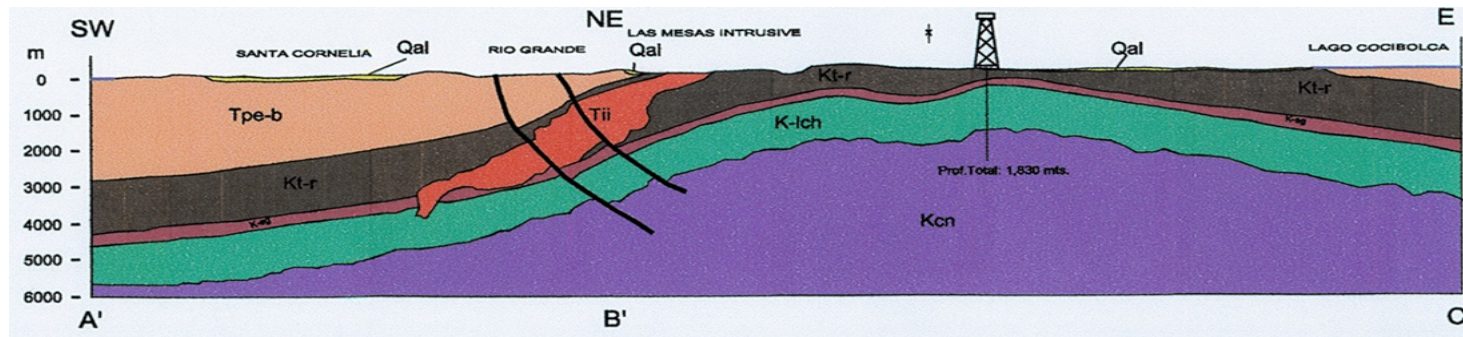
Intrusions (dikes, sills & small stocks)

Regional structure (anticline, homoclinal ridges, hogbacks)

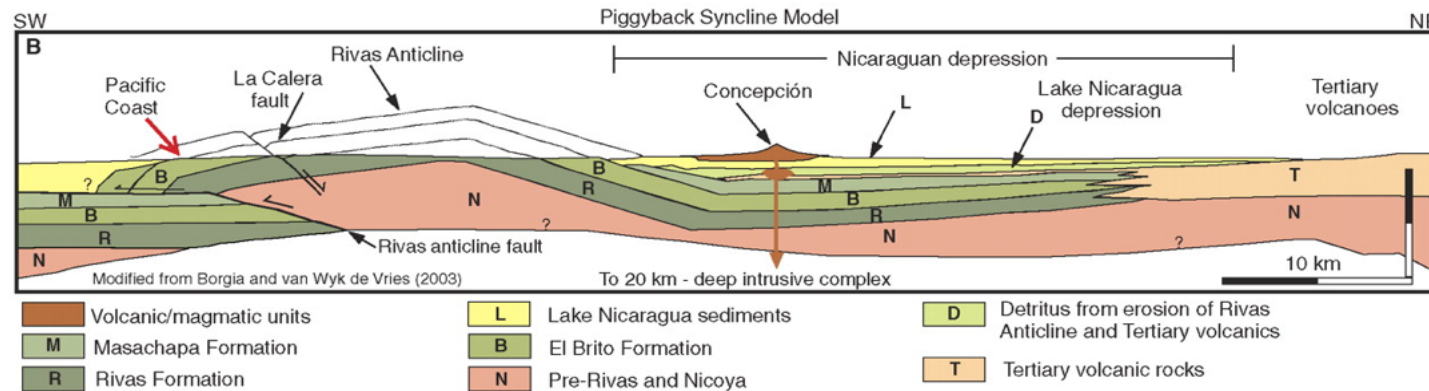


derived from the Mapa Geologico Preliminar 1:1,000,000 Managua (1973); van Wyk de Vries (1993) and van Wyk de Vries & Borgia (1996)

Geological Cross Sections



Instituto Nicaraguense de Energía (NE). 2002. Mapa Geologica Cuenca Sandino Pacifico. Escala 1:175000, 1 sheet.



Justin Funk et al. Geological Society of America Bulletin 2009;121:1491-1521

Research Activities

► Integration and synthesis of various efforts

- Reconnaissance & Water Point Inventories
 - 58 geo stations, 45 wells and springs (2014)
- Hydrogeological Mapping
 - Tola Municipio (2014)
- Hydrochemistry & Isotope Analysis
 - 9 sites in Tola Municipio
- Rock Properties and Mineralogy
 - 10 stations (mineral assays and porosity)
- Well Monitoring (conductivity & water levels)
 - 72 wells, 4 with data loggers
- Precipitation Monitoring
 - Various stakeholders



Results and Discussion



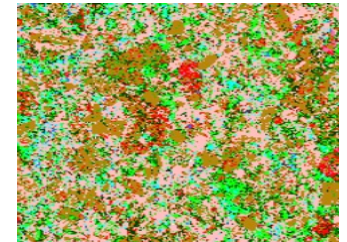
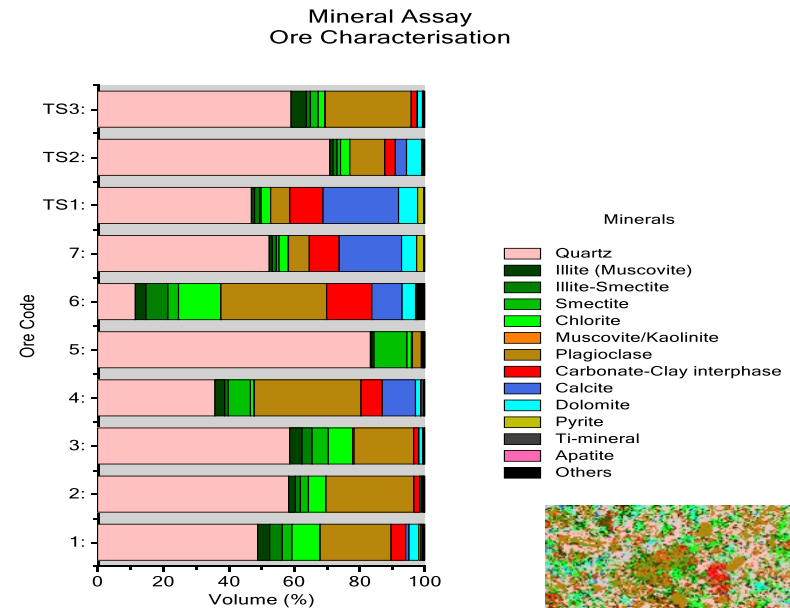
Source Rock Characteristics

► Brito Formation Properties

- Low primary porosity in formation (QEMSCAN <3%)
- Secondary porosity is driver for storage and flow of groundwater
- Predominately sandstone, mudstone, graywacke

► Well Yields

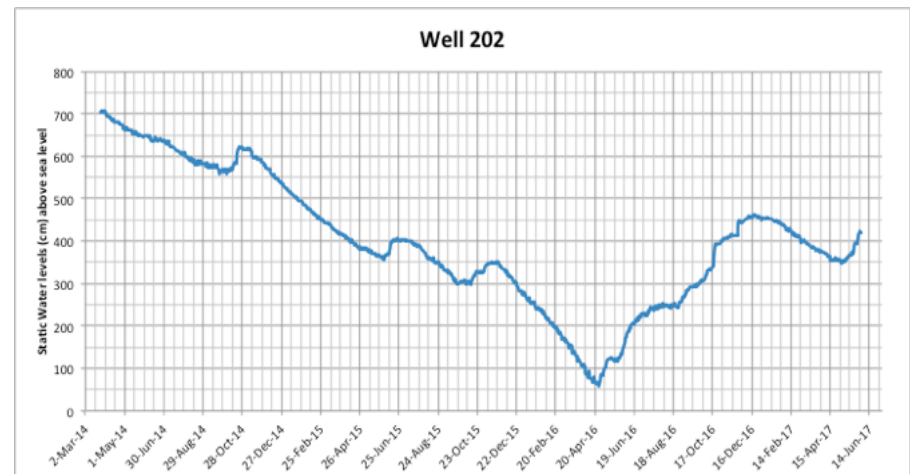
- Reported yields are typically less than 10 gallons/minute; low hydraulic conductivities from well tests



Groundwater Monitoring

► Results

- Water tables respond efficiently to precipitation
- Water levels in all Tola pumping wells steadily decreasing
- Evidence of saltwater intrusion in many wells

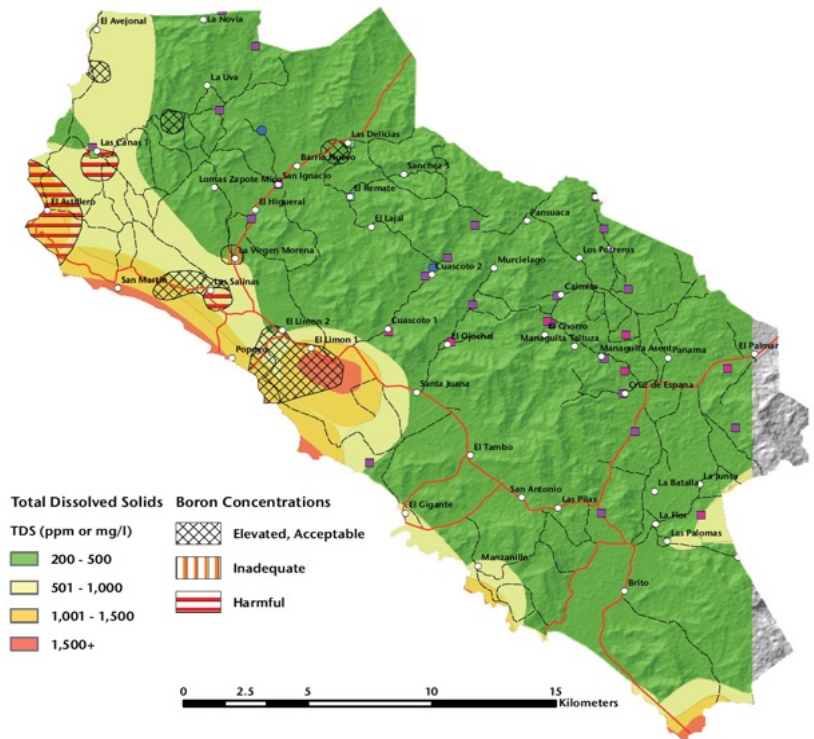
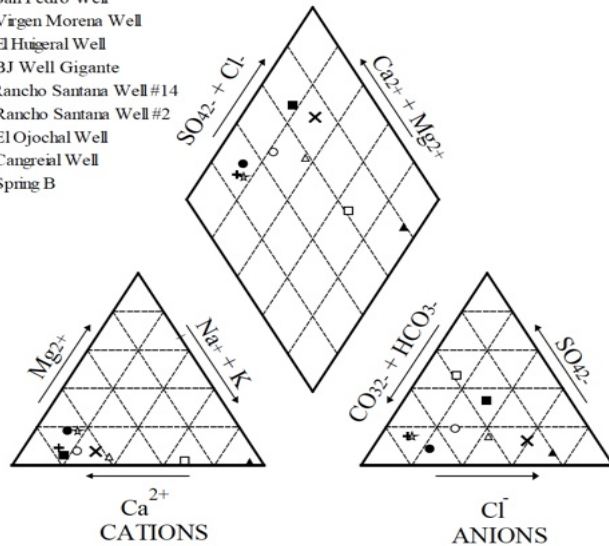


Three Years of Monitoring at Resort Well

Hydrochemistry

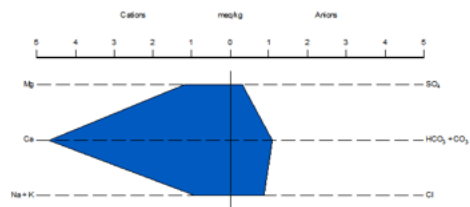
LEGEND

- San Pedro Well
- Virgen Morena Well
- El Huigeral Well
- BJ Well Gigante
- ▲ Rancho Santana Well #14
- △ Rancho Santana Well #2
- ✦ El Ojochal Well
- ✕ Cangrejal Well
- ☆ Spring B

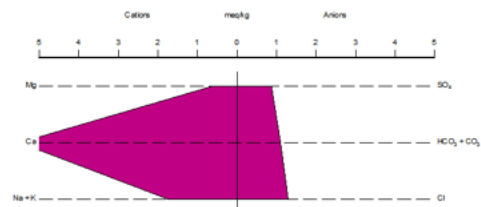


Hydrochemistry

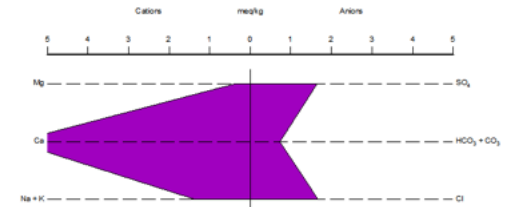
San Pedro Well



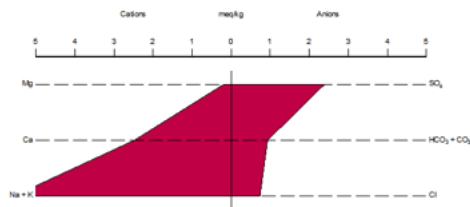
Virgen Morena Well



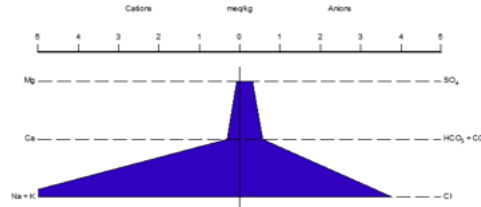
El Huigeral Well



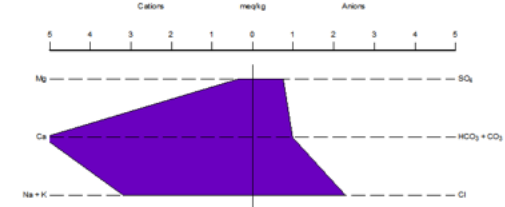
BJ Well Gigante



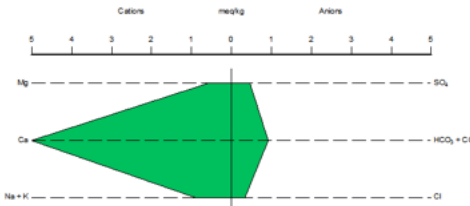
Rancho Santana Well #14



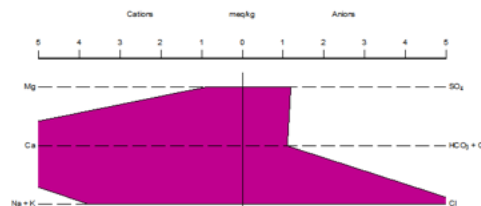
Rancho Santana Well #2



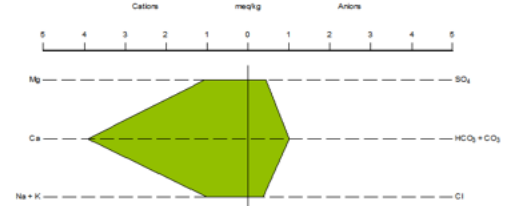
El Ojochal Well



Cangrejal Well



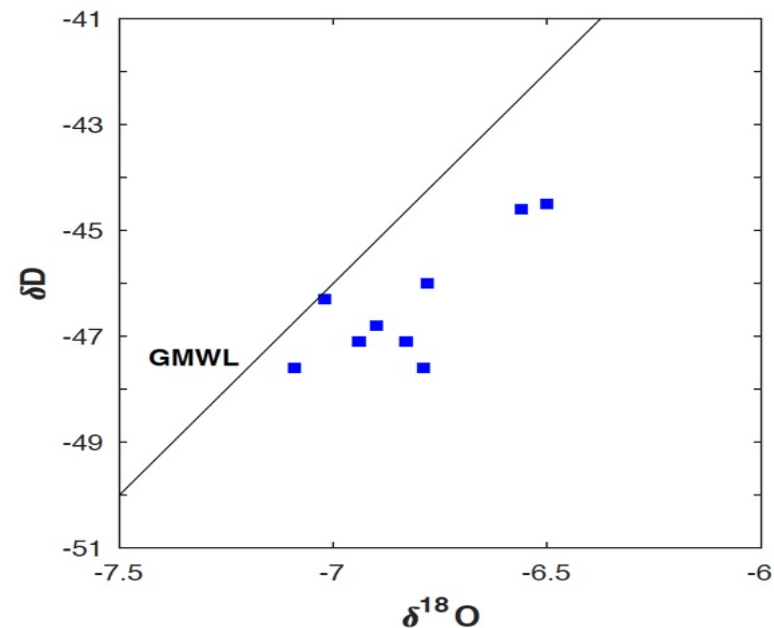
Spring B



Stable/Environmental Isotopes

Deuterium & ^{18}O

- ▶ **No correlation with elevation (mountainous areas)**
- ▶ **Close to GMWL**
- ▶ **Recharge partially from runoff / streamflow infiltration**
- ▶ **Distance from drainages**



Recharge & Storage

► Chloride Mass Balance

- 4.8% of annual precip
- 101,436,000 m³/year (0.102 km³/year) across Brito Fm
- 79 mm/year; 2.5 L/s per square kilometer
- 3,217 L/s total

$$R = P \times \frac{Cl_P}{Cl_{gw}}$$

► Aquifer Storage

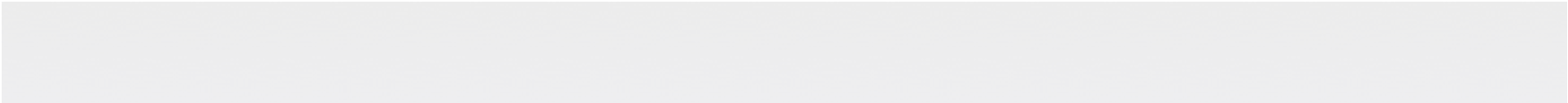
- 45 km³ 1970s estimate
- < 10 km³ possible based on new data

Continuing Research & Data Gaps

- Accurate inventory and estimate of groundwater abstraction
- More data collection and apply complementary methods to quantify and spatially understand groundwater availability
- Compilation and analysis of well drilling and testing records
- Testing and analysis of municipal and high yield wells throughout the region
- Monitoring of water levels and water quality along the coast
- Streamflow monitoring of select stream systems
- Data repository

Takeaways So Far....

- Discontinuous and spatially variable aquifer system, geometry of aquifer limits local availability
- Hydrochemistry indicators can be useful for understanding local groundwater vulnerability
- Aquifer storage, and recharge may be much less than previously assumed
- Significant aquifer vulnerability to overexploitation/population growth and climate change
- Considerable vulnerability to prolonged drought or megadrought
- The Brito formation is considered a part of the solution to serve the region's growing demands
- Past and continuing investments in the region have uncertain level of water security

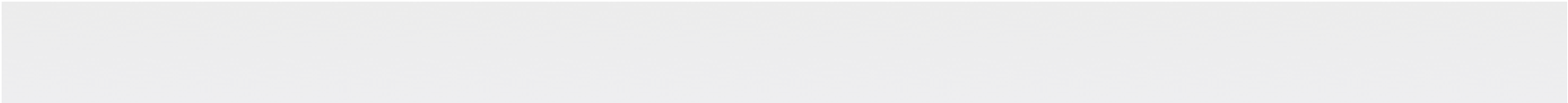


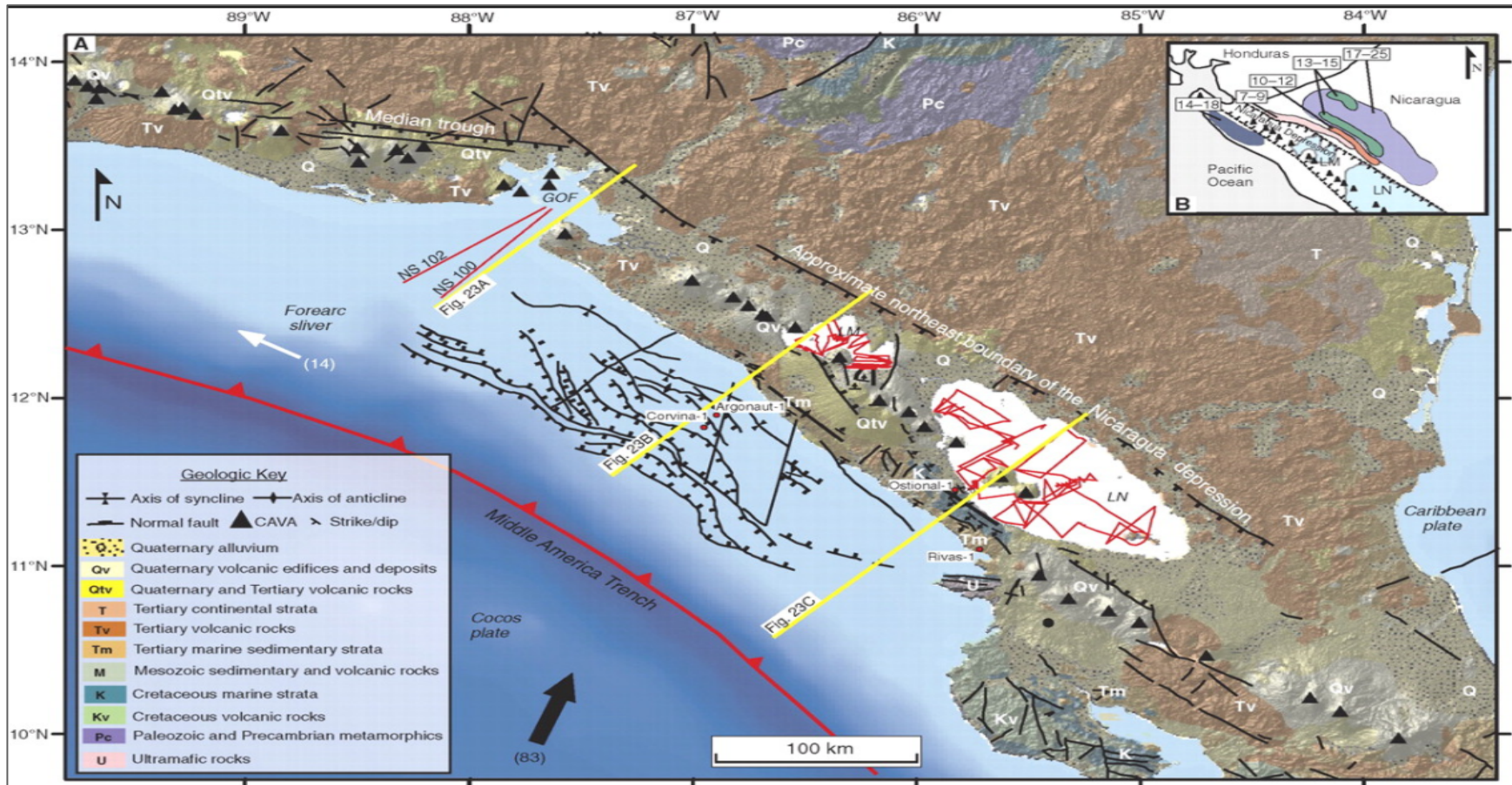
Thank You!

James K. Adamson & G. Thomas LaVanchy

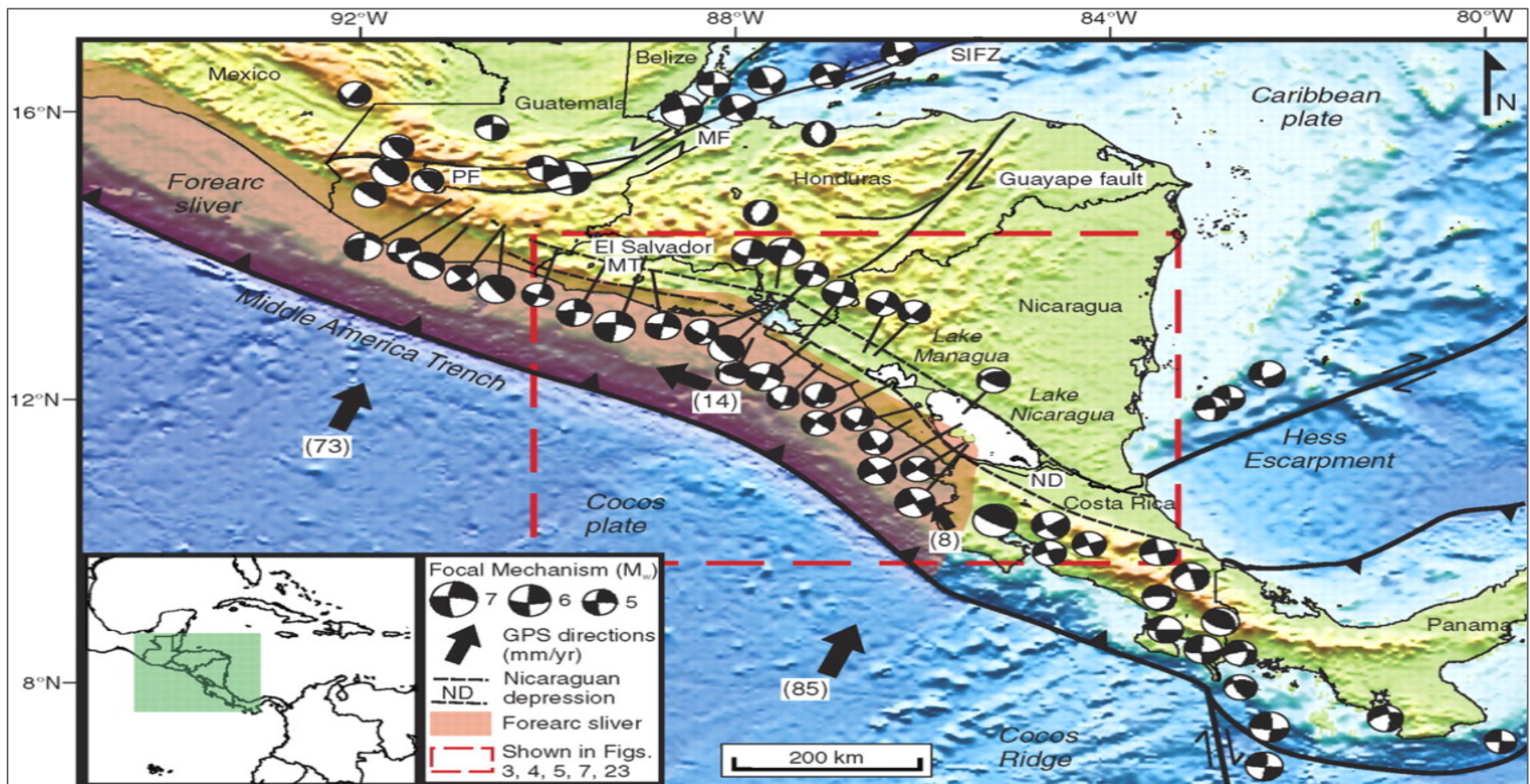
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Source: UN OCHA



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