Hydrogeologic Repository and Colombia Water Well Installation, September 2018*

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Search and Discovery Article #80724 (2020)**
Posted July 13, 2020

*Adapted from oral presentation given at 2020 AAPG Pacific Section Convention, 2020 Vision: Producing the Future, Mandalay Beach, Oxnard, CA, April 4-8, 2020
 DOI:10.1306/80724Saenz2020

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Abstract

US Naval Forces Southern Command U.S. 4th Fleet focused on subject matter expert exchanges in water well construction efforts in Colombia, South America. U.S. Forces Southern Command U.S. 4th Fleet coordinated with 22 Naval Construction Regiment (22NCR) and the U.S. Embassy to access the technical expertise on water well site selection, design, and installation efforts. Technical expertise was provided by Naval Facilities Engineering Command (NAVFAC) Engineering and Expeditionary Warfare Center (EXWC), 22NCR, and the Seabees. NAVFAC EXWC provided hydrogeologic and engineering technical field support to the Naval Mobile Construction Battalion One-Thirty-Three (NMCB 133) water well team for the Southern Partnership Station 2018 Water Well Project. NAVFAC EXWC and NMCB 133 successfully installed an 800-foot-deep water well in Riohacha, Colombia. This process utilized a 6-5/8-inch outer diameter and stainless steel threading casing, including 200 feet of wire wrap screen (0.020-inch) set within two-water production bearing zones. The team targeted, water screened through separate water bearing zones below ground surface to provide clean water to an indigenous Wayuu tribal village in a sub-arid region near Riohacha, Colombia. The area has experienced multiple consecutive years of drought, and the local community needed better access to clean drinking water. The Team intended the well to improve the well-being of those affected by the drought and alleviate problems caused by the scarcity of water. Well development efforts included using airlifting and dual swab methods during the initial phase, followed by a second airlift phase with an Aqua Clear PFD solution application, followed by the surging and purging of the well. The team calculates the preliminary water well yield that ranged up to 98 gallons per minute, producing good (“sweet”) water production capacity with minimal drawdown. Following the completion of the well, geologists and drillers remained onsite to complete the final pump installation, well testing, and the

installation of utility infrastructure for water distribution. The Colombian Ministry of Water informed the U.S. Navy that this effort has turned out to be the only fresh water well in the entire drought-stricken region. The well is currently producing up to 60 gpm, filling up tanker trucks with the capability of holding up to 2,000 gallons of water, and successfully hauling fresh drinking water daily to over 20 local villages.

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Executive Overview

Nature of Brief

- Technical Reports
- Colombia Water Well Installation
- Extreme drought affecting water supplies

Problem Statement

- EXWC is a growing warfare center that provides RDT&E, in-service engineering, and specialized facility and expeditionary solutions to the fleet, warfighter, and CNIC
- Seabees often construct facilities and utilities to support foreign nationals

Background / Actions to Date

- The strategic environment is changing rapidly; resources are constrained

Recommendation

- Continue the aggressive pursuit of EXWC mission, vision, and strategic initiatives

Introduction - Southern Partnership Station 2018 Water Well Project

- NAVFAC EXWC provided hydrogeologic and engineering technical field support to the NMCB 133 water well team
- NAVFAC EXWC and NMCB 133 successfully developed and installed an 800-foot-deep water well in Riohacha, Colombia

Figure 1. showing the Seabee Water Well drilling site located at Riohacha, Colombia.

Introduction

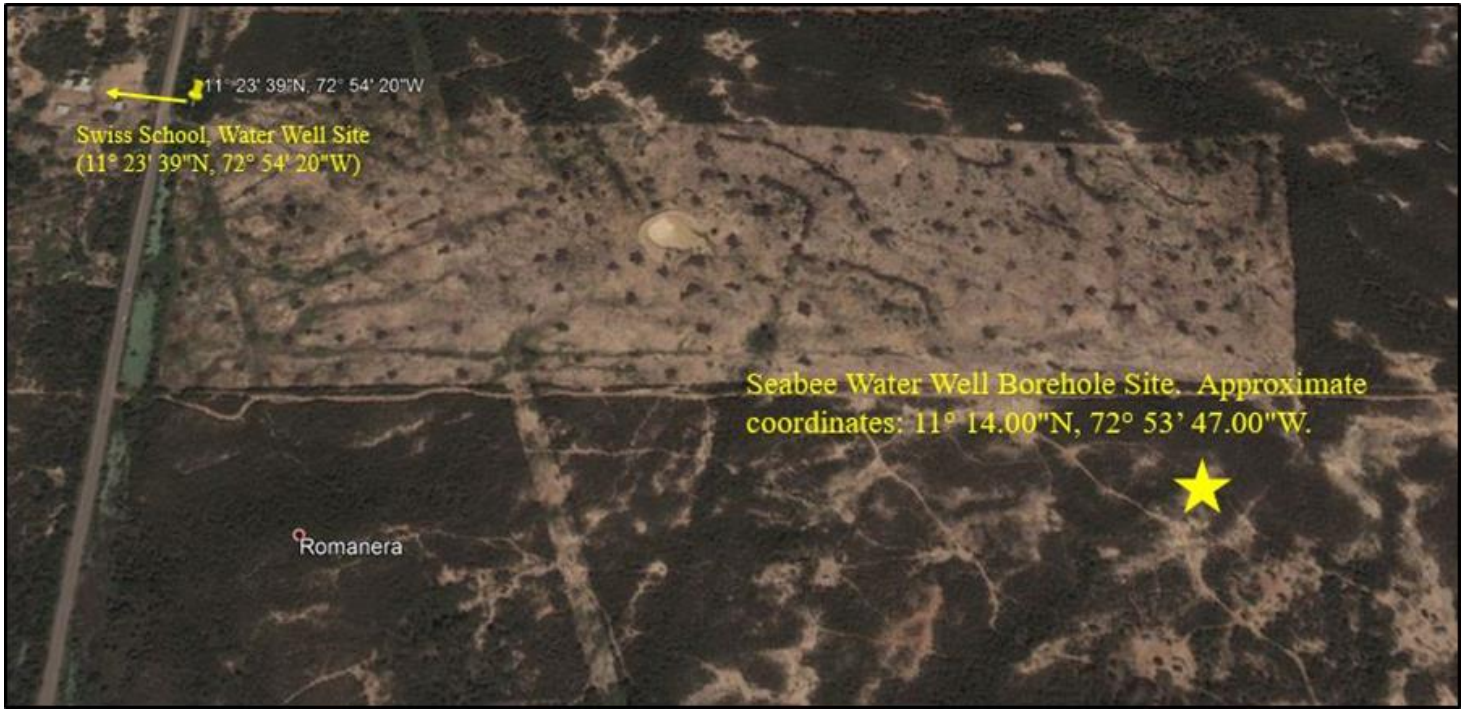
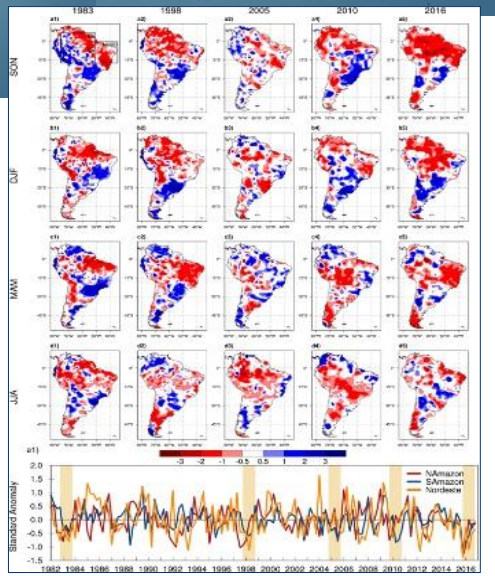


Figure 2. Selected Riohacha Water Well Site, along with its coordinates.

- During the 2018 program series, NMCB 133 built a water well in Riohacha, which would benefit the local Wayuu indigenous community located just south of the city.
- The area has experienced multiple consecutive years of drought, and the local community needed better access to clean drinking water.

SITE EVALUATION AND WELL DESIGN
South America is Highly Susceptible to Extreme Drought Conditions

REF:
https://www.accuweather.com/en/weather-news/accuweathers-south-america-summer-forecast-for-the-2018-2019-season/341734



Spatial maps and time series of standardized precipitation anomalies (dimensionless) calculated for the 1982–2017 period.

- South America is highly susceptible to extreme drought conditions.
- Recent events include two droughts (2005 and 2010) exceeding the 100-year return value in the Amazon and recurrent extreme droughts in the Nordeste region, with profound eco-hydrological and socioeconomic impacts.
- In 2015–2016, regions were hit by another drought. The severity of the 2015–2016 drought is unprecedented based on multiple precipitation products (since 1900).
- Tan-brown areas represent drought stricken areas in South America, including Colombia.

REF: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5517600/

SITE EVALUATION AND WELL DESIGN

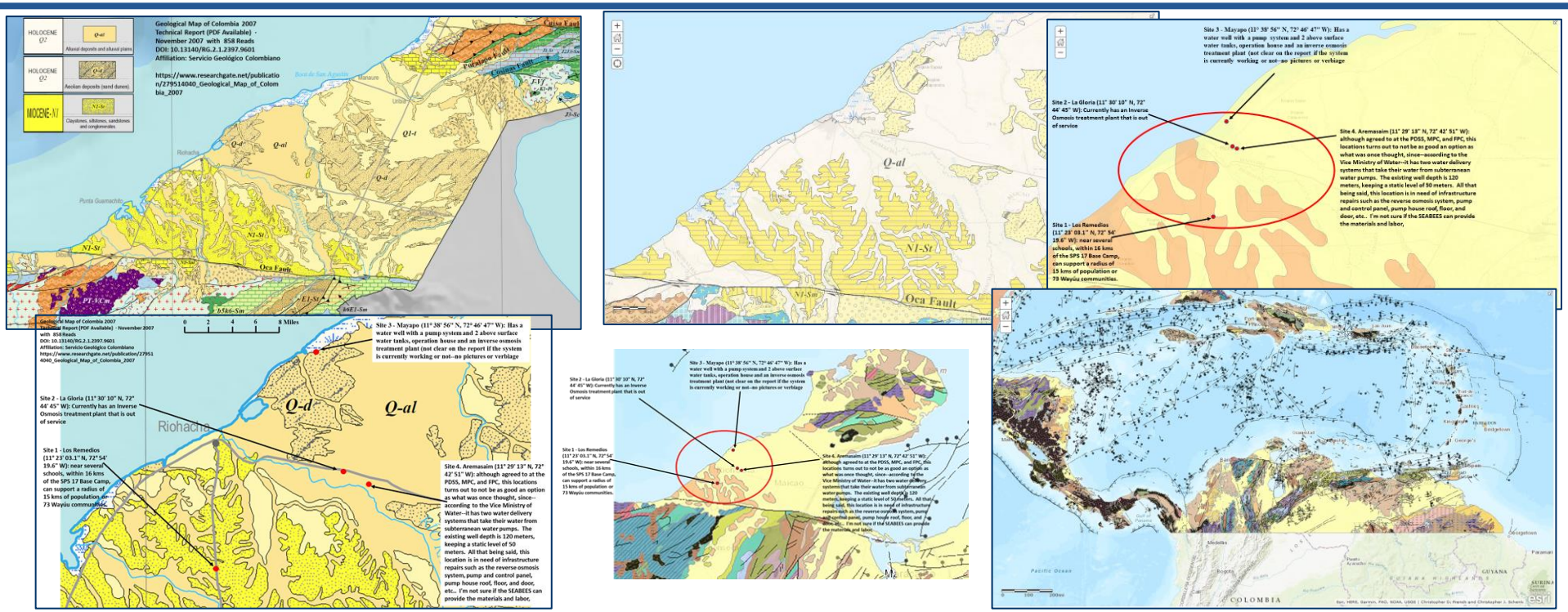
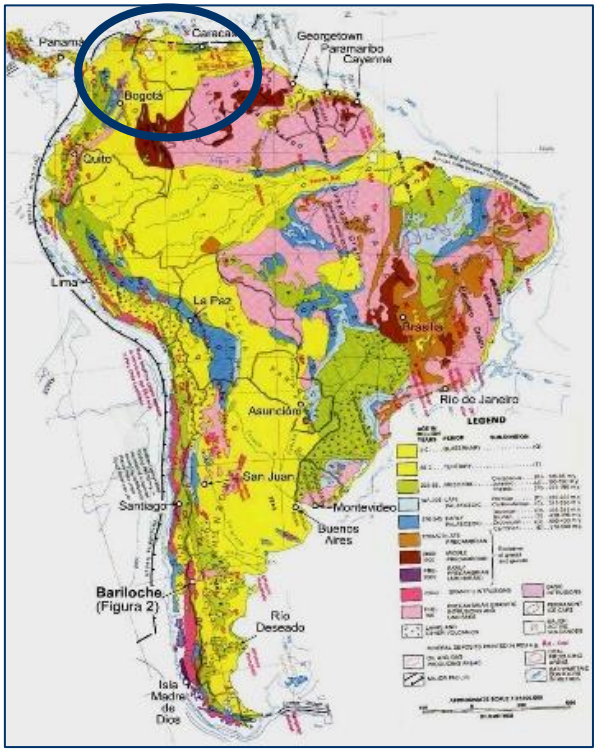


Figure 3. Compilation of a few maps used for site assessment.

- NAVFAC EXWC completed a preliminary assessment entitled, “Hydrogeologic Preliminary Technical Assessment for Colombia, Sites 1, 2, 3, 4, 5, Criteria for Selection,” dated February 8, 2018.
- Naval Construction Group received report covering major aspects of design for water well siting, design, drilling, installation, development, and completion at the Riohacha well site in Colombia.
- Utilized NAVFAC EXWC’S Engineering & Water Resource Database

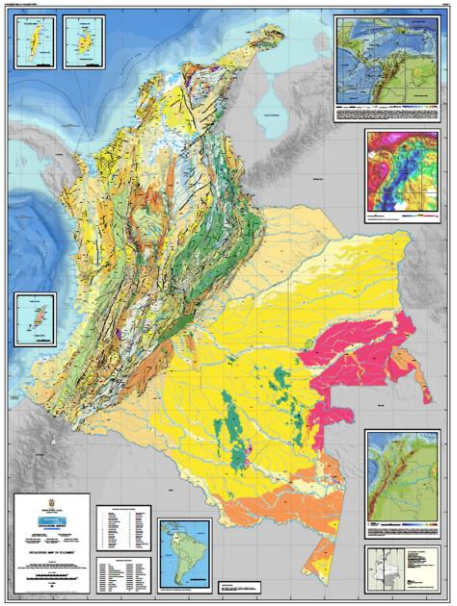
SITE EVALUATION AND WELL DESIGN, CONT.

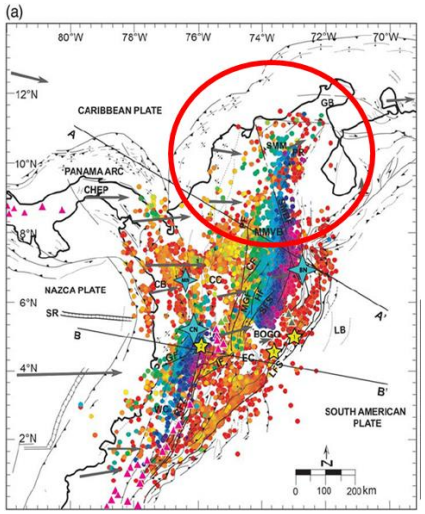
Figure 4. Compilation of a few maps used for site assessment.



These technical details included items such as:

- Surface Soil Types,
- Subsurface Conditions,
- Subsurface Structure (Faults, Folds, etc.),
- Topography – Geomorphology,
- Surface Water,
- Burrowing Animals,
- Biota: Flora and Fauna (trees),
- Animal Trails and Watering Holes
- Hydrogeologic and Stratigraphic Analysis,
- Tectonic and Seismic Analysis,
- Aquifer Classification,
- Water Quality Surface Water, and
- Groundwater Quality Surface





SITE EVALUATION AND WELL DESIGN, CONT.

NAVFAC EXWC extensively examined five potential Colombian sites for SPS18.

Pre-determined requirements included the environment, community impact, and need.

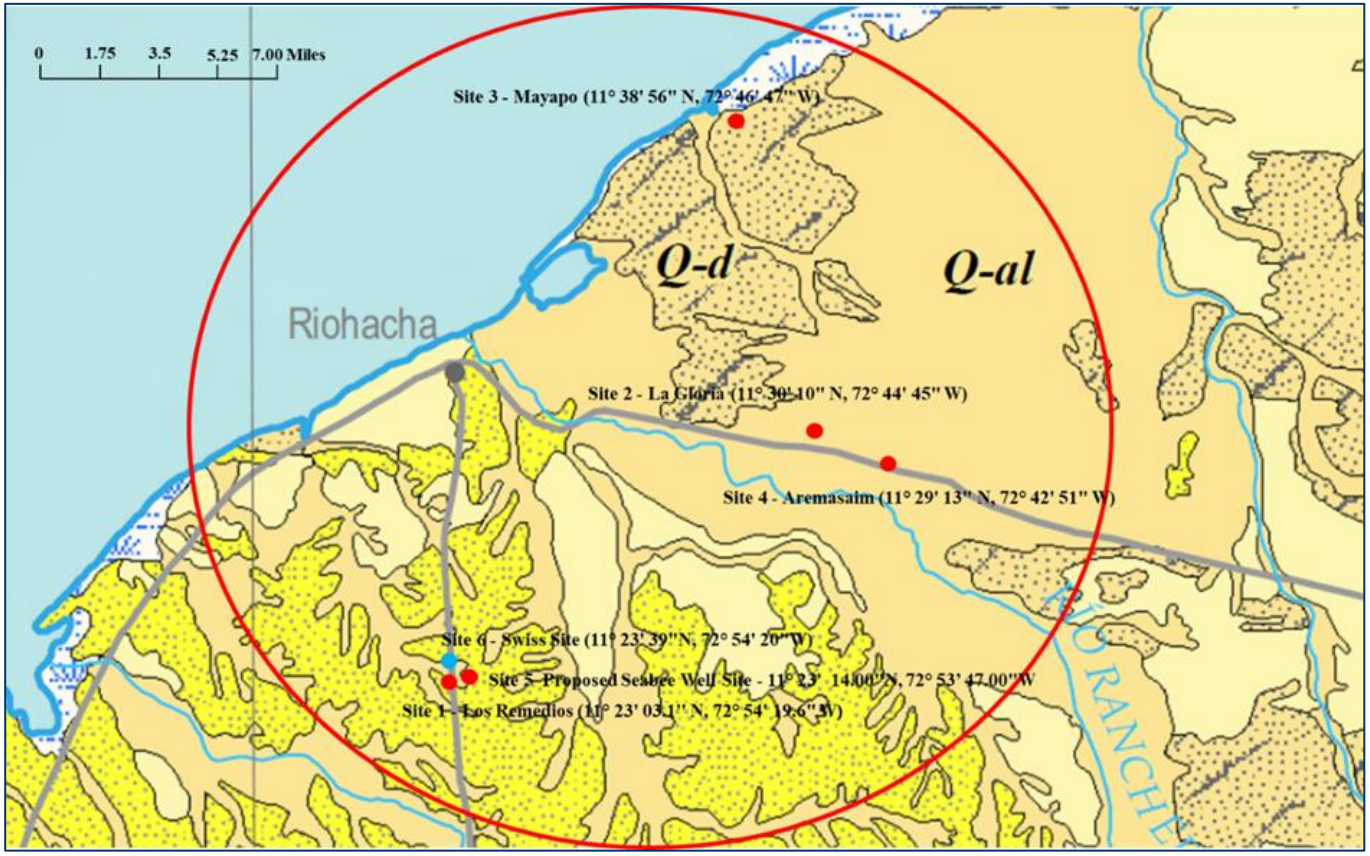


Figure 5. Geologic Map of Colombia with Five 5 Potential Water Well Sites.

EXWC identified five sites for evaluation as shown in the Figure:

- Site 1: Lost Remedios
- Site 2: La Gloria
- Site 3: Mayapo
- Site 4: Aremasaim
- Site 5: Riohacha (preferred well site)

SITE EVALUATION AND WELL DESIGN, CONT.
Figures. Investigating Geo-Resistivity and Lithologic Correlation

Figure 6. Geoelectric cross section of NE 2 path and Riohacha Seabee Drill Site.

RESISTIVITY (Ω*m)	Lithological Correlation
< -1	Fine and granular material (marine clays); Sands with salt water
1.0 – 1.7	Fine and granular material (calys/claystones); Silts with saline to brackish water
1.7 – 2.9	Fine and granular materials (silt and clay/claystones); Saline to brackish water Fine
2.9 – 4.9	and granular materials (silt/siltstones); Saline to brackish water
4.9 – 8.4	Silty floor; Sand/sandstone/limestone and saturated claystones; Brackish water
8.4 – 14.2	Silt-sandy floor; Sand/sandstones of fine grain size/saturated limestone; Brackish
14.2 – 24.1	water
24.1 – 41.0	Silty floor; Sands of medium grain size/Sandstones of medium grain size/saturated limestone Sands/sandstones/saturated coarse limestone
41.0 – 69.8	Saturated sand and gravel; Rocks (sandstone/limestone) very fractured, saturated
69.8 - 119	Superficial dry materials; Gravel and saturated sand; Rocks (igneous, sandstone /limestone) very fractured, saturated?
119 - 202	Superficial dry materials; dry sands; saturated gravel; Rocks (igneous, sandstone /limestone) very fractured, saturated?
202 - 343	Superficial dry materials ; Rocks (igneous, sandstone/limestone) fractured
343 - 583	Superficial dry materials; Rocks (igneous, sandstone/limestone) slightly fractured
583 - 990	Superficial dry materials; Rocks (igneous, sandstone/limestone) very slightly fractured
990 - 1684	Superficial dry materials; Rocks (igneous, sandstones/limestone) compact, closed fractures?
1684 - 2862	Superficial dry materials; Rocks (igneous, sandstones/limestone) compact without fractures Superficial dry materials; Compact rock (sandstones/limestone)
2862 - <	

SITE EVALUATION AND WELL DESIGN, CONT.

Figure shows a geo-electric cross-section transect designated “SE 6” that is within the SPS18 area of interest, and passes near (within one mile west of) the proposed Riohacha well site.

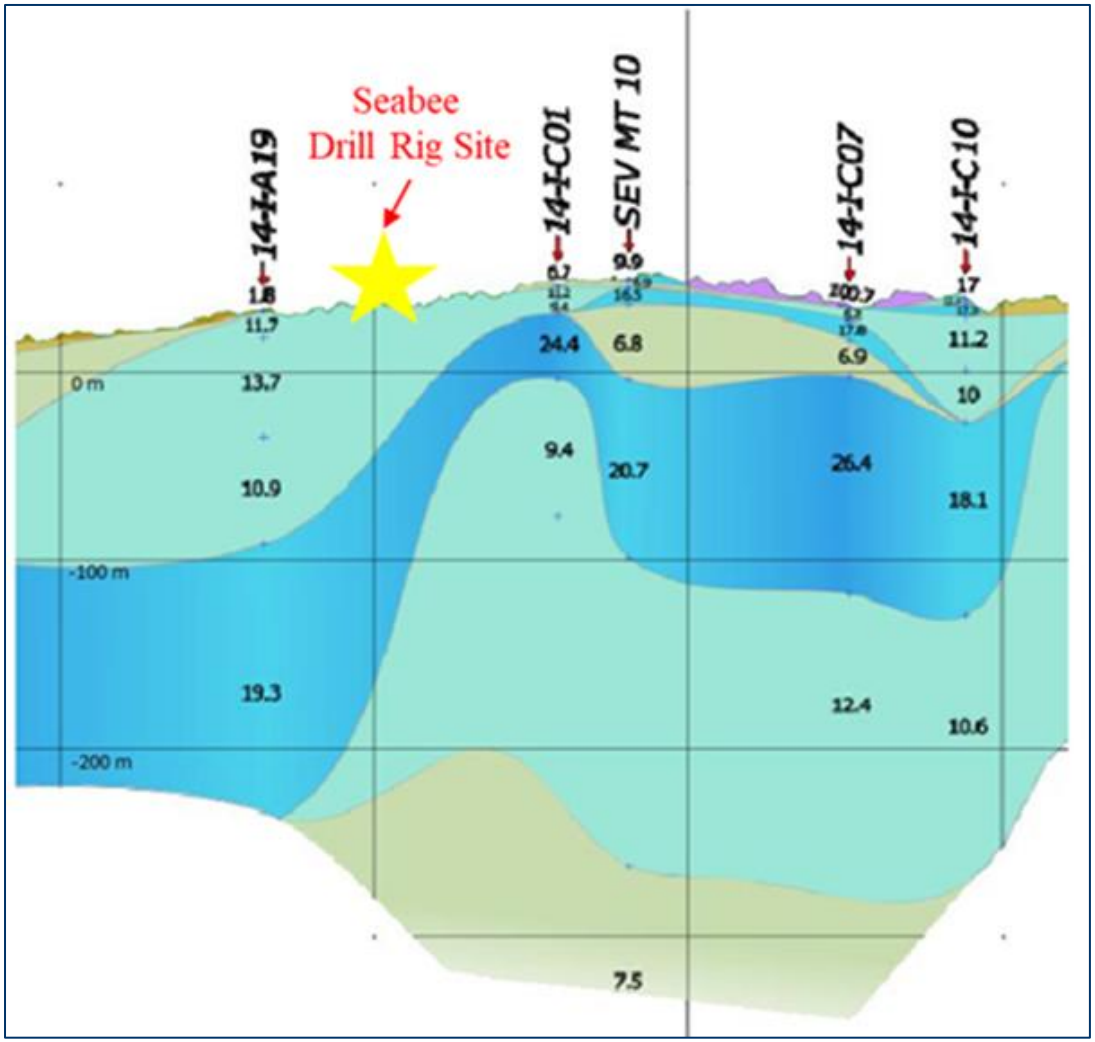


Figure 7. Geoelectric cross section of NE 2 path and Riohacha Seabee Drill Site.

SITE EVALUATION AND WELL DESIGN, CONT.

Electrical Resistivity Sounding Survey

- NAVFAC EXWC used regional geo-electrical resistivity surveys and investigations conducted by the Servicio Geologico Colombiano (2016) to conduct a preliminary evaluation of potential water well sites.

- As shown in Figure, the Water Resource Management Group of the Colombian Geological Service performed vertical geo-electrical resistivity soundings of boreholes in the La Guajira Department of Colombia, and correlated it with lithological corrections to formation water salinity.

Figure 8. Colombian Government Conducting an Electrical Resistivity Sounding Survey.

WATER WELL INSTALLATION

- NMCB 133 used the Water Well Drill Rig T450MIIA for well installation.
- Figure displays the initial effort involved conductor casing installation using a 16-inch wing bit, drilling down to 20 feet BGS.
- A conductor casing, with a diameter of 15 inches, was installed to a depth of 20 feet BGS for borehole stability and as a sanitary seal.

Figure 9. Water Well Drill Rig T450MIIA, Using a Mud Rotary Drilling.

Figure10. Stainless Steel Well Screens.

WATER WELL INSTALLATION, CONT.

- The second phase of the drilling involved a drilling effort using a 2-pass system to advance the borehole to a total depth of 800 feet BGS. The two-pass system included a first pass pilot hole using a 8 ¾-in Tri-cone drill bit to drill the pilot hole to 800 feet BGS. NAVFAC EXWC completed the Lithologic Log during this effort.

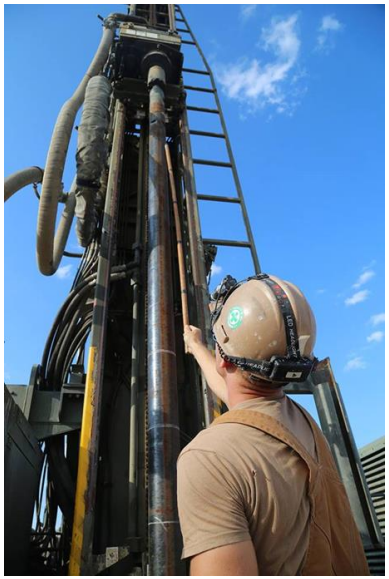


Figure 11. Water Well Drilling Operations and Determining Rate of Penetration

Figure 12. Filter Pack #3 Sand.

- To complete the well installation at the Riohacha site, drillers conducted the second pass using a 12 ¾-in Tri-cone drill bit to ream out final borehole 800 feet BGS.
- As-built construction specifications for the Riohacha Water Well installation is addressed in the following figures.

Figure 13. Placement of ¾-inch Gravel Pack Material During Well Installation

WATER WELL INSTALLATION, CONT.

Figure 14. Stainless Steel Well Screen, 0.02-inch Screen Slot Size.

Figure 15. Installation of Casing and Bentonite Chip Seal.

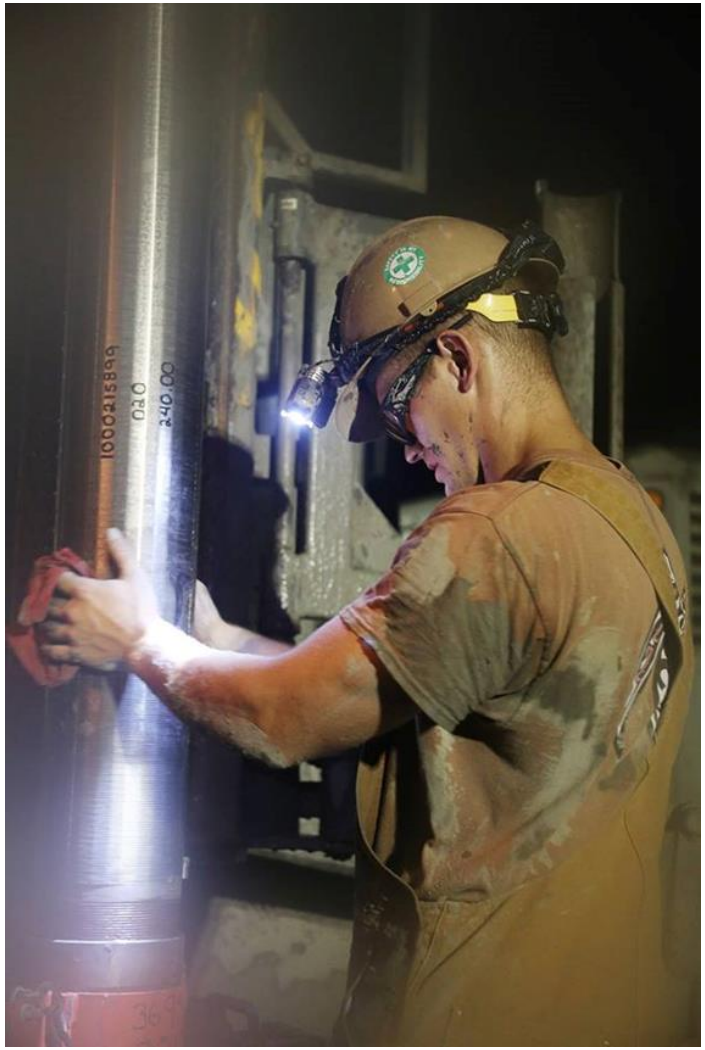


Figure 16. Stainless Steel Well Screen Installation.

WATER WELL DEVELOPMENT

Figure 17. Using Fresh Water for Surge and Purge Activities for Well Development.

Figure 18. Use of Air Lifting Technique for Well Development.

SUBMERSIBLE PUMP

Figure 19. Electric Submersible Pump Assembly

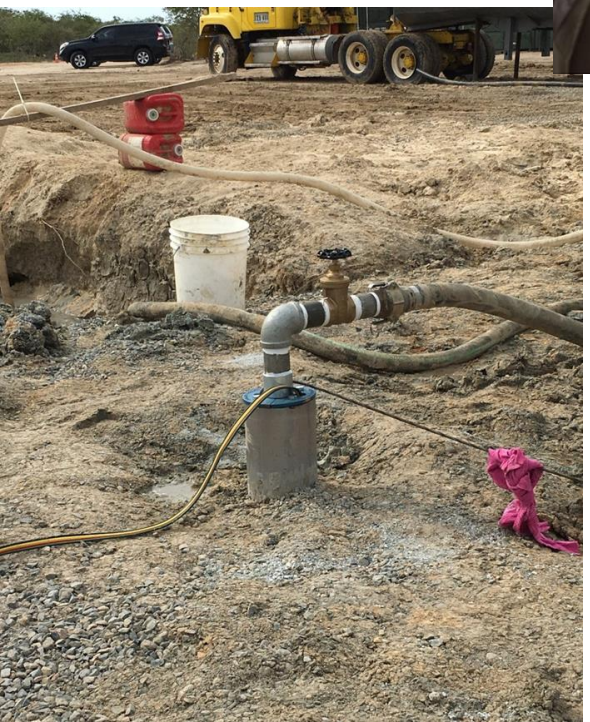


Figure 21. Water Well Head During Pump and Drawdown Test

Figure 20. Testing the Electric Submersible Pump

ABOVE GROUND COMPLETION

Figure 22. Above Ground Well Completion with Concrete Pad.

Figure 23. Final Riohacha Water Well Site with Concrete Pad, Control Box, and Water Tank.

AS-BUILT WATER WELL CONSTRUCTION DIAGRAM

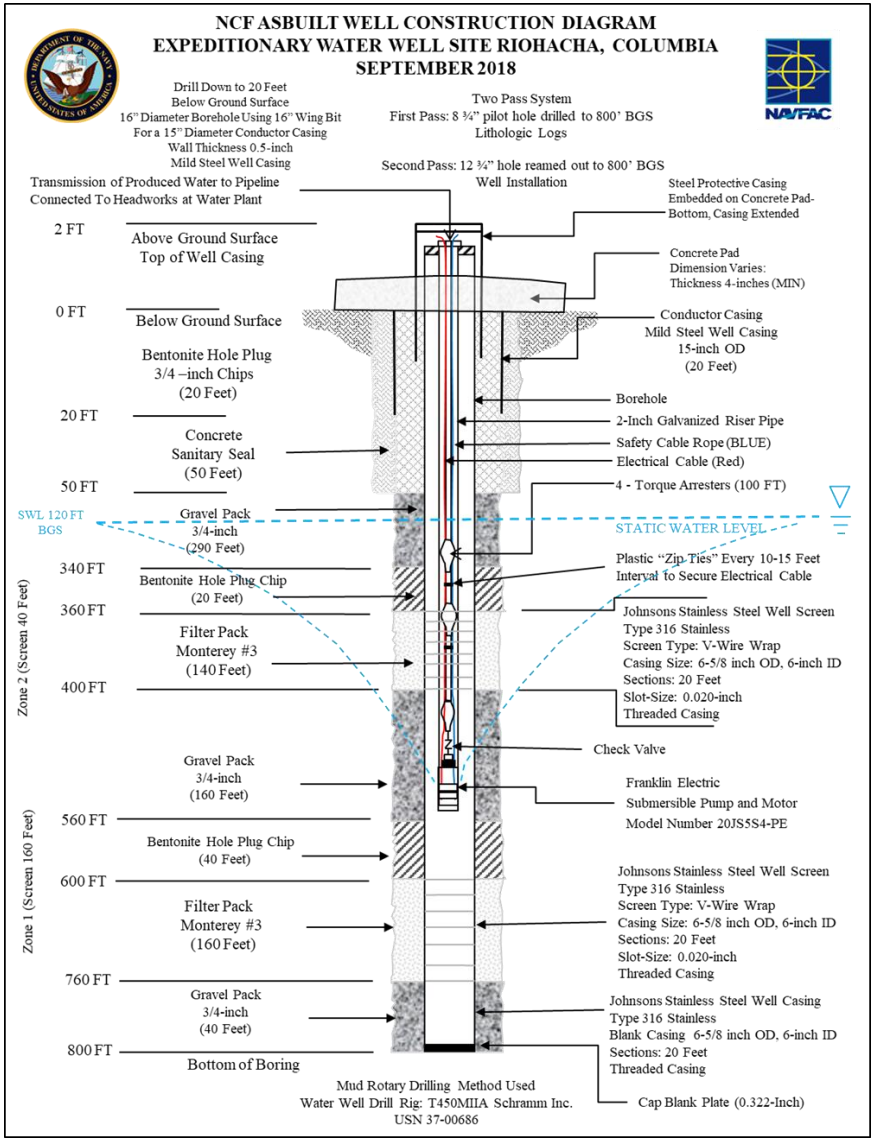


Figure. Riohacha Water Well Construction Diagram

As-built construction specifications for the Riohacha Water Well installation is addressed in the following figures.

- NMCB 133 conducting water well drilling operations and making the hole, as well as determining rate of penetration.
- Filter pack #3 sand used on site.
- Placement of ¾-inch gravel pack material during well installation.
- Stainless Steel Well Screen in 20-foot long sections.
- Stainless Steel Well Screen with a 0.02-inch screen slot size.
- Installation of casing and bentonite chip seal used.
- Installation of Stainless Steel Well Screen.
- Installation of Submersible Pump.
- Riohacha Water Well installation site, showing the gravel pack, tremmie pipe, and Water Well Drilling Rig.

Figure 24. Well Construction Diagram.

CONCLUSION

- NAVFAC EXWC assisted the NMCB 133 water well team in completing the final well design, installation, and development of a successful 800-foot deep water well.

- The two zones targeted water bearing below ground surface in effort to provide clean water to an indigenous Wayuu tribal village and the rest of the local community in a sub-arid region near Riohacha, Colombia.

- Development efforts included using airlifting and dual swab methods during the initial phase, followed by a second airlift phase with an Aqua Clear PFD solution application, followed by surging and purging of the well.

- The team calculates the preliminary water well yield at 60 gpm, producing good (“sweet”) water production capacity based on drawdown static head recovery.

- NMCB 133 remained onsite through end of October 2018 to complete above ground well completion, final pump installation, further testing, and the installation of the “up-hole” utility infrastructure for water distribution.

- The relationship between the geologist and water well team and their discussions in the field provided notable down-hole assessment value to the project.

CONCLUSION

CUSTOMERS COMMENTS

- EXWC provided spot on recommendations, specific to the Bench Mark that resulted in this successful drilling operation.
- EXWC provided daily assistance in design, development and installation of the well.
- The Columbian Ministry Of Water has informed USN that this has turned out to be the only FRESH water well in the entire drought stricken region.
- The well is currently producing 48-52 GPM. 1500-2000 gallon tankers are successfully hauling fresh drinking water daily to over 20 local villages.
- In discussions with the American Ambassador in Colombia, the success of this well highlighted one of the most important projects in present day Colombia.