Water Well Depth Proposal

Introduction

The African continent is in desperate need of assistance for clean water. It has the highest total volume of non-frozen surface water of any continent, yet much of this surface water is contaminated. The distribution is incredibly poor with only five percent of rural Africans obtaining piped water[1]. They also suffer the highest rates of waterborne illnesses from diseases like schistosomiasis, diarrhea, and typhoid fever. However, the most prevalent disease is cholera for which there have been outbreaks in the previous year in Niger, Cameroon, Zimbabwe, Nigeria, Somalia and many others. Another problem for the health of groundwater is lack of regulation on industrial practices that pollute bodies of water from effluent runoff.

One of the solutions for providing access to clean water is by digging wells to provide groundwater access to these communities. Many communities and outside organizations are already building these wells, but without proper construction these wells are easily contaminated and become dysfunctional after short periods of time. Creating deeper wells gives some inherent advantages to the quality and quantity of the groundwater we are using. A further distance from the surface means a greater amount of rock layers to pass through which act as natural filters and therefore the risk of potential contamination is decreased. The benefits of this approach include, more rock layers to pass through from the surface which act as natural filters, decreased sensitivity to surface land use practices, and drought resistance since there would no longer be a dependence on seasonal rainfall[2].

Hypothesis

If a water well is to deliver clean water effectively and sustainably then it must be dug to a minimum of 45 meters. Figure 1 shows an outline of the Embrace Relief well design that we implement on all our sites, which retains our quality standards for all contractors in Africa.

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[1] UNEP. (2010). “Africa Water Atlas”. Division of Early Warning and Assessment (DEWA). United Nations Environment Programme (UNEP). Nairobi, Kenya

[2] Digging Deeper: 4 Benefits of Well Deepening - Dalmik Well Drilling - Putnam. (n.d.). Retrieved June 12, 2019, from https://nearsay.com/c/237216/73036/digging-deeper-4-benefits-of-well-deepening

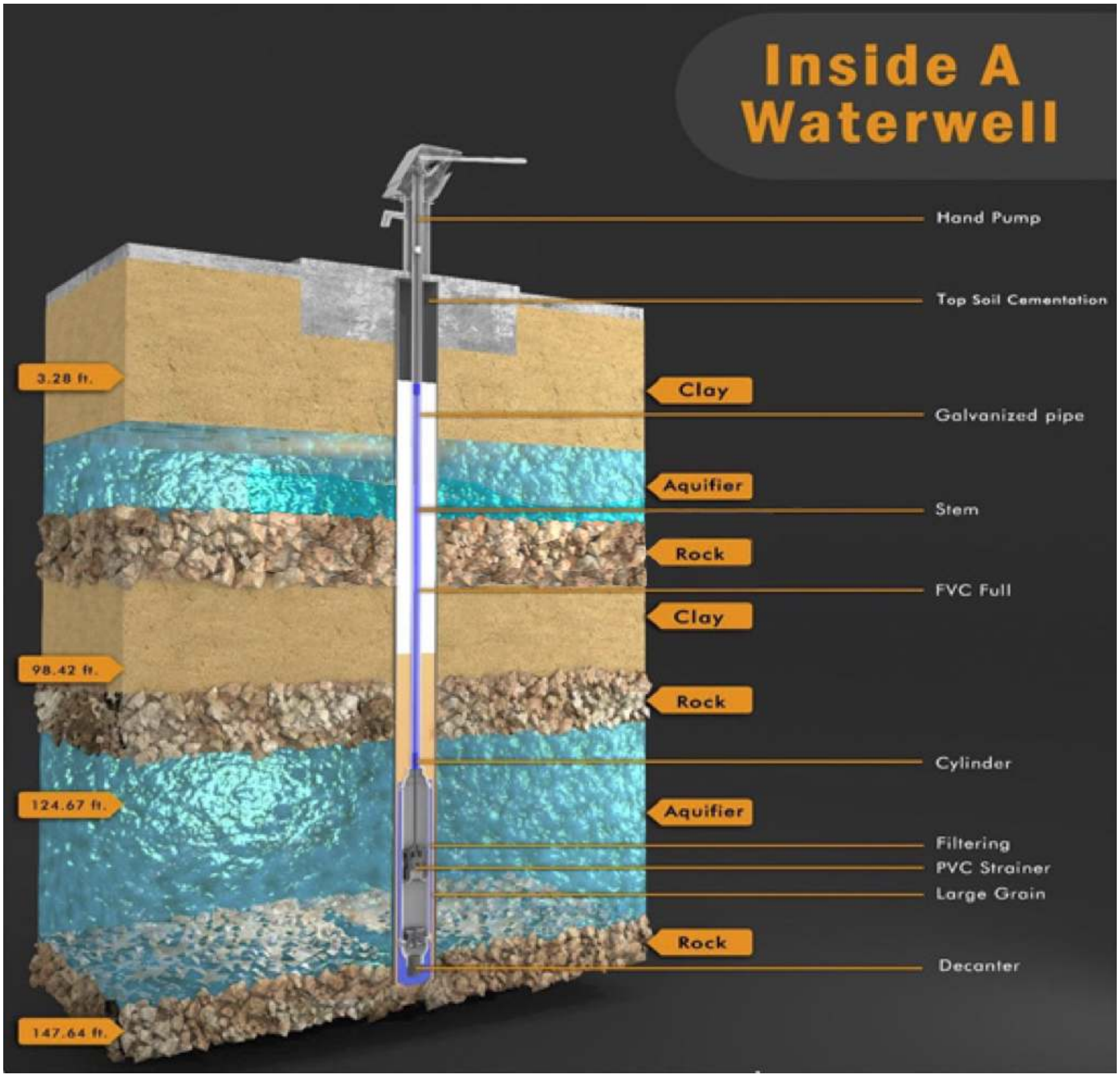


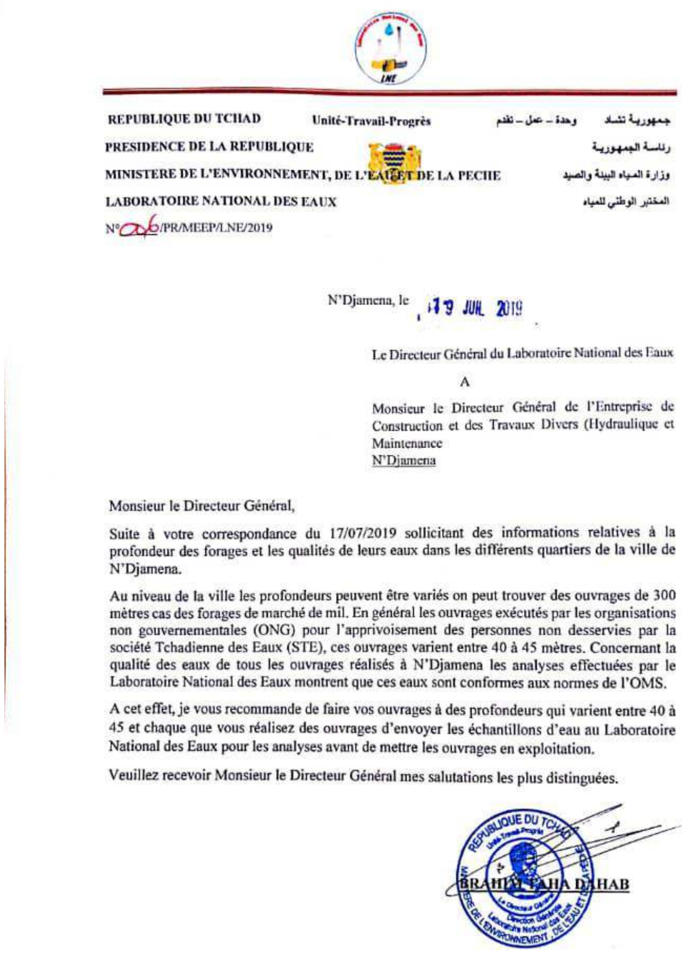
Figure 1. This diagram represents all the components that go into our well structures. The rock layers are based on assumptions of aquifer depths and will vary based on the local geography of a given area.

Embrace Relief Water Well Goals and Accomplishments

Embrace Relief is an NGO committed to humanitarian relief projects across the world through research based sustainable solutions. Projects such as water well construction in Africa are created to provide communities with a clean source of drinking water for years to come. In doing so, our goal is to allow these communities to thrive, because they will no longer be constrained by having to walk countless hours to find water. Our goal is to make sure that these villages of extreme poverty become places of economic opportunity with improved quality of life. We have constructed over 300 water wells across Africa with all of them still operational and several scheduled for construction later this year. All wells are designed to last at least five years without fail, but with our provided additional maintenance they are functional for at least ten years. The operational maintenance is also paid for where we replace parts like galvanized steel pipes to keep rust out of the water and maintain operational pumps.

Well Contamination

Our initial proposal for a well depth of 45 meters comes from a letter written by the National Water Laboratory run by the Ministry of the Environment in the Chad Republic. According to the letter we received from the ministry, “For this purpose, I recommend you to do your work at depths that vary between 40 and 45 and each time you carry out works”. This is in accordance with World Health Organization (WHO) standards as well as Chad’s National Water Laboratory for projects carried out by NGOs. Additionally, Embrace Relief always performs water quality testing at new sites as outlined in this letter by the laboratory director.



LNE

REPUBLIQUE DU TCHAD Unité-Travail-Progrès جمهورية تشاد وحدة – عمل – تقدم

PRESIDENCE DE LA REPUBLIQUE رئاسة الجمهورية

MINISTERE DE L’ENVIRONNEMENT, DE L’EAU ET DE LA PECHE وزارة المياه البيئة والصيد

LABORATOIRE NATIONAL DES EAUX المختبر الوطني للمياه

N°026/PR/MEEP/LNE/2019

N’Djamena, le 19 JUIL 2019

Le Directeur Général du Laboratoire National des Eaux

A

Monsieur le Directeur Général de l’Entreprise de Construction et des Travaux Divers (Hydraulique et Maintenance
N’Djamena

Monsieur le Directeur Général,

Suite à votre correspondance du 17/07/2019 sollicitant des informations relatives à la profondeur des forages et les qualités de leurs eaux dans les différents quartiers de la ville de N’Djamena.

Au niveau de la ville les profondeurs peuvent être variés on peut trouver des ouvrages de 300 mètres cas des forages de marché de mil. En général les ouvrages exécutés par les organisations non gouvernementales (ONG) pour l’approvisionnement des personnes non desservies par la société Tchadienne des Eaux (STE), ces ouvrages varient entre 40 à 45 mètres. Concernant la qualité des eaux de tous les ouvrages réalisés à N’Djamena les analyses effectuées par le Laboratoire National des Eaux montrent que ces eaux sont conformes aux normes de l’OMS.

A cet effet, je vous recommande de faire vos ouvrages à des profondeurs qui varient entre 40 à 45 et chaque que vous réalisez des ouvrages d’envoyer les échantillons d’eau au Laboratoire National des Eaux pour les analyses avant de mettre les ouvrages en exploitation.

Veuillez recevoir Monsieur le Directeur Général mes salutations les plus distinguées.

BRAHIM TAHA DAHAB

Figure 2. This letter comes from the National Water Laboratory of the Republic of Chad. Translated, it outlines the procedure for building water wells in rural areas of Chad. In these areas, the Lab recommends that the well depth be between at least 40-45 meters as conforming to standards that all NGOs are held to.

First, one of the issues with shallower wells is the contamination of bacteria and parasites into the water. These contribute to over twenty water borne disease in West Africa which include schistosomiasis, typhoid fever, cholera, diarrhea, and botulism[3]. In a Brazilian study of 66 wells it was found that wells of the greatest depth contained the lowest amount of contamination. They were divided by wells of less than 5 meters, 5-10 meters, 10-15 meters, and greater than 15 meters. In this order it was found that there was less and less total coliforms, E. Coli, various other bacteria, and yeast. Another study comparing well depth with bacteria count in wells from the University of Colorado found there to be a statistically significant correlation between the two factors. Of the 30 wells tested, it was found that those with depths lower than 60 meters were much more likely to suffer from bacteria contamination than wells deeper than 60 meters. It was found that the deeper the wells the less likelihood of seepage from runoff and septic tanks.[4]

Furthermore, to avoid the issues brought on by sanitation it is important to note how significant it is to the frequency of waterborne illnesses. This is especially significant in sub-Saharan Africa where they have the worst sanitation issues of any region in the world. In this region only 30% of people are covered for improved sanitation facilities.[5] Several studies indicate that nitrate pollution coming from sanitation of people as a combination of human and livestock runoff are the most significant factor to African groundwater contamination[6][7].

Next, various chemicals and heavy metals can leach into the water from local industrial and agricultural processes. In the same Brazilian study it was found that the depth also correlated with less acidity, turbidity, and fluorine and chlorine counts. Metals like arsenic are also damaging to humans, because of their link to skin, lung, and liver cancer[8]. In a study in Bangladesh conducted across over 4,000 wells, there was statistical data showing that the correlation between arsenic detection and well

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[3] Thomas Weiss. (2018). Water-borne Diseases: Types and Information. Retrieved June 26, 2019, from Disabled World website: https://www.disabled-world.com/health/water-diseases.php

[4] Gonzales, T. R. (2008). The Effects That Well Depth and Wellhead Protection Have on Bacterial Contamination of Private Water Wells in the Estes Park Valley, Colorado. Journal of Environmental Health, 71(5), 17–23. Retrieved from JSTOR.

[5] Regional focus: Africa | International Decade for Action “Water for Life” 2005-2015. (n.d.). Retrieved July 3, 2019, from https://www.un.org/waterforlifedecade/africa.shtml

[6] Ouedraogo, I., & Vanclooster, M. (2016). A meta-analysis of groundwater contamination by nitrates at the African scale. Hydrology and Earth System Sciences Discussions, 1–43. https://doi.org/10.5194/hess-2016-120

[7] Xu, Y., & Usher, B. (2006). Issues of groundwater pollution in Africa. https://doi.org/10.1201/9780203963548.ch1

[8] Health risks of heavy metals | APEC Water. (n.d.). Retrieved June 27, 2019, from https://www.freedrinkingwater.com/water-education/quality-water-heavymeatal.htm

depth was more frequent at shallower depths. It was found that wells below 50 meters were much more likely to contain arsenic while those that were deeper than 50 meters were less likely to contain arsenic levels above WHO standards of 0.01mg/L[9]. In another study that took place in Northern India, water quality tests were taken three times in eight different well sites. In the only site that reached 50 meters we can see it has the best water quality index measurement, which is calculated by the total acidity, hardness, sulfate, fluoride, chloride, and total dissolved solids. All other sites ranged from 30 to 5 meters with higher amounts of contamination and the authors concluded, “Groundwater depth was found negatively correlated with chemical parameters”[10].

In a 2016 US Geological Survey study on Pennsylvania wells it was found that shallower wells were more likely to suffer from contamination issues. Those that were shallower were more likely to suffer brine intrusion and increased levels of total dissolved solids as well as bromine, lithium, and methane contamination. They found that the sources for the methane were from natural gas drilling nearby to the well sites bromide to be mixing of salts for road clearing. Therefore, surface applications can have great effects on the health of groundwater.[11]

Keys to Success

Climate change brings in a new challenge as far as groundwater recharge. We will see more heavy rain intensity, but the overall occurrence of rain will fall. In Nigeria for example, “The projected increase in precipitation variability, both in intensity and frequency, is most likely to lead to decrease in recharge.” This type of climate change will be present across much of Africa and will leave people particularly vulnerable to water and food insecurity. Providing wells that reach farther down from the surface allows communities to have consistent amounts of water even during these droughts by touching the lower parts of the upper aquifer. Thus, they are not completely dictated by recharge of recent rain events. “In general, most simulated models for climate change and variability predicted more than 70%

[9] Tonmoy, Fahim Nawroz, Rahman, Mafizur, & Kitawaki, Hidetoshi. (2009). Impact of ground water depth on arsenic and iron correlation in Bangladesh: GIS approach. International Journal of Applied Environmental Sciences, 4(4), 437+. Retrieved from http://find.galegroup.com.ezproxy.bucknell.edu/grnr/infomark.do?&source=gale&idigest=6f8f4a3faafd67e66fa023866730b0a1&prodId=GRNR&userGroupName=bucknell_it&tabID=T002&docId=A216041418&type=retrieve&PDFRange=%5B%5D&contentSet=IAC-Documents&version=1.0

[10] Gupta, P., & Sarma, K. (2014). Evaluation of groundwater quality and depth with respect to different land covers in Delhi, India. International Journal of Applied Science and Engineering Research, 2, 630–643. https://doi.org/10.6088/ijaser.020600004

[11] Clune, J. W., & Cravotta III, C. A. (2019). Drinking water health standards comparison and chemical analysis of groundwater for 72 domestic wells in Bradford County, Pennsylvania, 2016 (USGS Numbered Series No. 2018–5170; p. 76). Retrieved from U.S. Geological Survey website: http://pubs.er.usgs.gov/publication/sir20185170

decrease in recharge for south-western Africa by 2050. Thus, groundwater stress would be more severe in most parts of West Africa by 2050."[12]

When constructing wells, we want to make sure that we are able to provide enough water to sustain a community. In a New Hampshire study on private water wells it was found that if we propose wells that are too deep, we will start to see lower yields. As indicated in Figure 2 regardless of what type of well is being indicated by the 1-8 groupings there is a clear trend relating well depth and the average well yield.[13] While deeper wells do provide a greater quality of water it is important to consider how much quantity we can produce to support a community's needs.

The EPA and the Indiana Department of Health also have special recommendations for preventing the contamination of private wells that we are in accordance with based on the depth of our wells. As a precaution, surface or subsurface stored chemicals such as gasoline, diesel fuel, home heating oil, fertilizer, pesticides, etc. should be at least 100 feet away. Additionally, stables; animal barns or feeding pens; milkhouses, livestock runs; or silos should be 50 feet away. Our wells sites are researched to be away from sites like these that can easily contaminate the water supply and digging further into the ground prevents these various features from doing damage[14].

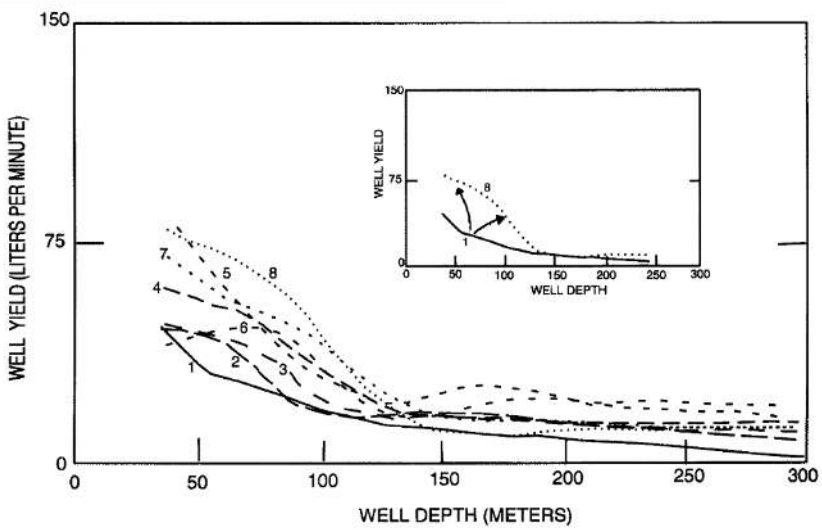

Figure 2. This data is comprised compares the average yield of a well with the depth it is dug to. The numbers 1-8 indicate groupings of types of wells built over 1984-1998. 1 being the earliest and 8 being the most recent.

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[12] Aizebeokhai, A. (2012). Potential impacts of climate change and variability on groundwater resources in Nigeria. African Journal of Environmental Science and Technology, 5. https://doi.org/10.5897/AJESTX11.001

[13] Drew, L. J., Schuenemeyer, J. H., Armstrong, T. R., & Sutphin, D. M. (2001). Initial Yield to Depth Relation for Water Wells Drilled into Crystalline Bedrock—Pinardville Quadrangle, New Hampshire. Groundwater, 39(5), 676–684. https://doi.org/10.1111/j.1745-6584.2001.tb02357.x

[14] ISDH: Recommended Standards For Private Water Wells. (n.d.). Retrieved June 12, 2019, from https://www.in.gov/isdh/23258.htm

Another point of success for us is constructing wells that are sustainable and last in communities for years to come. According to a 2009 report by The International Institute for Environment and Development (IIED) up to US$360m were spent on wells and boreholes that are no longer functional. As a result, 50,000 water supply points are not functioning across rural Africa. For example, across Uganda there are examples of poorly constructed wells where they were created too shallow and within a few years became subject to worm contamination.[15]

Conclusion

We propose that all wells created for communities in Africa to gain access to a sustainable water supply should be at least 45 meters. According to the data we researched we found that by digging to at least this depth we can provide water for a long time that remains clean even during periods of climate change[16]. Deepening a well is one of the most recommended solutions to ensure a drought-resistant water supply. This is because deep wells, which are further below the water table, are not likely to go dry during an arid period. However, we propose a 45 meter depth, because digging too deep will lower our total yields. Shallower wells can produce better short term yields but are heavily reliant on recharging of the aquifer based on precipitation. This is especially important for the incoming climate change that will bring longer droughts. Deep wells are usually constructed when a large amount of volume is required to be pumped. This summarizes a village well, because the villages consist of at least 2000 people. [17]

We also want these deeper wells to prevent communities from consuming water that may be affected by contamination. In some communities they have poor sanitation practices that lead to Cholera outbreaks, so creating a larger buffer allows for increased security. Industrial and agricultural processes nearby to a community can heavily alter surface water in ways that damages their health, so we work to prevent cancer and other bodily damage that toxic chemicals can cause. The studies researched show that providing a deeper well prevents these practices from interfering.

[15] Kelly, A. (2009, March 26). Money “wasted” on water projects in Africa. The Guardian. Retrieved from https://www.theguardian.com/society/katineblog/2009/mar/26/water-projects-wasted-money

[16] Digging Deeper: 4 Benefits of Well Deepening - Dalmik Well Drilling - Putnam. (n.d.). Retrieved June 12, 2019, from https://nearsay.com/c/237216/73036/digging-deeper-4-benefits-of-well-deepening

[17] Deep Well Systems. (n.d.). Retrieved June 18, 2019, from Griffin Dewatering website: https://www.griffindewatering.com/construction-dewatering/deep-well-system/

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