ANNAH NATUKUNDA FOR B4R

USAID/Uganda Biodiversity for Resilience Activity (B4R)

WATER QUALITY ASSURANCE PLAN (WQAP)

Agreement Number: 72061720CA00007

Activity Start Date and End Date: June 1, 2020 to June 1, 2025

AOR Name: Robert Bagyenda

Submitted by:

USAID/Uganda Biodiversity for Resilience Activity (B4R)
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Water Quality Assurance Plan

1. 1.1 PROJECT/ACTIVITY DATA

Project/ Activity Name:	USAID/Uganda Biodiversity for Resilience Activity (B4R)
Implementation Start/End:	June 1, 2020–June 1, 2025
Solicitation/Contract/Award Number:	72061720CA00007
Implementing Partner(s):	RTI International
Geographic Location(s):	Kidepo Valley National Park and Kalinzu Central Forest Reserve
Period of Performance:	January 1, 2023- June 1, 2025
Tracking ID/file name/Link of Parent (Source) IEE for Program/ Activity / D.O.	Uganda_NUDEIL_IEE_092109 (https://ecd.usaid.gov/document.php?doc_id=772) , and Uganda_ NUDEIL_IEE Amendment #1(https://ecd.usaid.gov/document.php?doc_id=42516) , Uganda NUDEIL IEE - AMD 2: https://ecd.usaid.gov/document.php?doc_id=53663
Tracking ID/link of WQAP	
Tracking ID/link of Other, Related Analyses:	

2. 1.2 ORGANIZATIONAL/ADMINISTRATIVE DATA

Implementing Operating Unit(s): (e.g. Mission or Bureau or Office)	USAID Uganda
Funding Amount:	$26,128,153
Lead BEO Bureau:	Africa
Prepared by:	RTI International
Date Prepared:	23 November 2022

Submitted by:	RTI International
Date Submitted:	23 November 2022
Implementing Partner individual contact and title, address, phone and email	RTI International Dr. Jennifer Talbot Plot 50 Upper Kololo Terrace, Kampala, Uganda +256 707 994 338 jtalbot@ugandbiodiversity.rti.org
USAID AOR Contact:	Robert Bagyenda rbagyenda@usaid.gov
Proposed subproject/ subgrant	Infrastructure for Biodiversity Conservation Activity in Kidepo Valley National Park and Kalinzu Central Forest Reserve
Location of WASH Activities	Kidepo Valley National Park and Kalinzu Central Forest Reserve

Certification:

I, the undersigned, certify that:

1. The information on this form and accompanying WQAP is correct and complete.
2. Implementation of these activities will not go forward until specific approval is received from the C/AOR.
3. All mitigation and monitoring measures specified in the WQAP will be implemented in their entirety, and that staff charged with this implementation will have the authority, capacity and knowledge for successful implementation.

(Signature) Jennifer Talbot (Date) 23 November 2022

(Print name) Jennifer Talbot

PROJECT/ACTIVITY NAME:

Infrastructure for Biodiversity Conservation Activity in Kidepo Valley National Park and Kalinzu Central Forest Reserve

Approval:		
Clearance:	_____ Robert Bagyenda, AOR Robert Bagyenda Digitally signed by Robert Bagyenda Date: 2022.12.28 11:46:18 +03'00'	_____ Date
Clearance:	_____ Jessica Okui Jessica Okui, Mission Environmental Officer Digitally signed by Jessica Okui Date: 2022.12.27 12:33:30 +03'00'	_____ Date
Clearance:	_____ David Kinyua, EA Regional Environmental Advisor David Kinyua Digitally signed by David Kinyua Date: 2022.12.20 07:42:57 +03'00'	_____ Date
Concurrence:	_____N/A_____	_____ Date

DISTRIBUTION: [*Customizable*]

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4. 3 ACRONYMS AND ABBREVIATIONS

AOR – Agreement Officer Representative
ASTM – American Society for Testing and Materials
AWF – African Wildlife Foundation
B4R – Biodiversity for Resilience Activity
CFR – Central Forest Reserve
EC – Electrical Conductivity
EMMP – Environmental Mitigation and Monitoring Plan
GOU – Government of Uganda
IBC – International Building Code
ISO – International Organization for Standardization
KCWA – Karenga Community Wildlife Area
KVNP – Kidepo Valley National Park
MCC – Murchison Community Conservancy
MWE – Ministry of Water and Environment
NFA – National Forestry Authority
NP – National Park
N.S. – Not specified
NTU - Nephelometric Turbidity Unit
PA – Protected Area
TCU – True Color Units
TDS – Total Dissolved Solids
UNBS – Uganda National Bureau of Standards
USAID – United States Agency for International Development
UWA – Uganda Wildlife Authority
WHO – World Health Organization
WQAP – Water Quality Assurance Plan

5. 4 ACTIVITY OVERVIEW

a. 4.1 ACTIVITY DATA

Activity Name:	USAID/Uganda Biodiversity for Resilience Activity (B4R)
Technical Office:	Economic Growth
Activity Start Date and End Date:	June 1, 2020–June 1, 2025
Name of Prime Implementing Partner:	RTI International
Agreement Number:	72061720CA00007
Name of Sub-awardees	African Wildlife Foundation (AWF): $500,000 Viamo: $34,054 GBC: $86,126
Major Counterpart Organizations:	Uganda Wildlife Authority (UWA), National Forestry Authority (NFA)
Geographic Coverage (Name of Sub-Regions):	Kidepo Valley National Park (NP) area: Karenga Community Wildlife Area (KCWA) and seven clusters of Karamoja and Achwa Ranges Central Forest Reserves (CFRs) including, Timu, Morungole, Nyangea Napore, Lwala, and Rom. Districts: Karenga, Kaabong, Abim, Kotido, Kitgum, and Agago Murchison Falls NP area: Murchison Community Conservancy (MCC). Districts: Nwoya and Pakwach Budongo CFR. Districts: Masindi and Buliisa Lake Mburo NP area: Rurambira Conservancy. Districts: Isingiro and Kiruhura Queen Elizabeth Landscape: Kyambura Wildlife Reserve (KWR) District: Rubirizi; Kalinzu CFR. District: Rubirizi and Bushenyi
Geographic Coverage (Name of districts):	Karenga, Kaabong, Abim, Kotido, Kitgum, Agago, Pakwach, Nwoya, Masindi, Isingiro, Kiruhura, Rubirizi and Bushenyi
Implementing Partner individual contact and title, address, phone and email	RTI International Dr. Jennifer Talbot Plot 50 Upper Kololo Terrace, Kampala, Uganda +256 707 994 338 jtalbot@ugandbiodiversity.rti.org
Tracking ID/file name/Link of Parent (Source) IEE for Activity	Uganda Economic Growth IEE https://ecd.usaid.gov/document.php?doc_id=57070

Tracking ID/Link of WQAP	
Implementing Operating Unit	Uganda Mission; Office of Economic Growth
Funding Amount	$26,128,153
Lead BEO Bureau	Africa
Date Submitted	November 23, 2022

b. 4.2 ACTIVITY DESCRIPTION

The goal of the 5-year (2020–2025) USAID/Uganda Biodiversity for Resilience (B4R) Activity is to assist communities, the Government of Uganda (GOU), and the private sector to conserve and manage biodiversity in target ecosystems for lasting environmental and economic sustainability and increased community and household resilience. The Activity is being implemented in partnership with the Uganda Wildlife Authority (UWA), National Forestry Authority (NFA)district and local authorities in the targeted landscapes.

This goal will be achieved via three interrelated outcomes:

1. Economic, financial, and social investments are linked to and incentivize conservation.
2. Governance arrangements benefit biodiversity and enable communities to benefit from biodiversity.
3. GOU strengthens its sustainable management of targeted protected areas and biodiversity adjacent to protected areas (PAs).

In close coordination with the UWA and NFA, the USAID/Uganda B4R Activity aims to promote ecotourism and enhance private sector engagement in the Kalinzu Central Forest Reserve (CFR), as well as to increase the capacity of UWA to deliver on their ecological and threat monitoring and enforcement capacity in the Kidepo Valley National Park (KVNP) through specific construction activities, including:

Kalinzu Central Forest Reserve

- One (1) Visitor Center
- One (1) Canopy Walk
- One (1) borehole

Kidepo Valley National Park

- Three (3) ranger outposts at Karua, Kaekem and Imiliny
- Five (5) boreholes at Lokumoit Gate, Kaekem, Karua/Natedekitoi, Natabe Gate and Lokorimongin
- Six (6) low stream water crossings along Kidepo River, Kurao, Kalabe, Tongobore, Lopiripir and Nakao

UWA and NFA will serve as key partners and provide oversight and support during the construction of the canopy walk, visitor center and borehole in Kalinzu CFR (NFA), and the ranger outposts, boreholes and low water stream crossings in Kidepo (UWA).

The Kalinzu visitor center will include the primary structure, toilet blocks, a camping kitchen, camping toilet and showers, a guard house, and external works. Water access at the project site will include a rainwater harvesting system and a new well system, most likely a solar well near the proposed visitor center construction site. The Kidepo ranger outposts will include an accommodation block, kitchen block, meeting room, office with a store, VIP latrines, observation

tower, checkpoint guardhouse, and external works. In addition to the proposed boreholes, water access at the Kidepo ranger posts will be provided with rainwater harvesting systems. These facilities will require abstraction of water from surface or groundwater sources to meet the project water needs. The B4R team has developed this Water Quality Assurance Plan (WQAP) to ensure that the drinking water provided through this project meets the national standards. The WQAP presents the water quality standards for the water quality contaminants of concern, the necessary resources to complete the testing, means to ensure water quality remains compliant in the long-term, response protocols for water that does not meet quality standards, and measures for documentation and reporting of results.

6. 5 APPLICABLE WATER QUALITY STANDARDS

a. 5.1 USAID Water Quality Requirements

USAID recommends eight drinking water quality parameters at a minimum for assessment.[1]

Health-Related Parameters:

1) Arsenic
2) Fecal Coliform
3) Fluoride
4) Nitrate (as NO_3)

Operational-Related Parameters:

5) Electrical conductivity
6) Total Dissolved Solids
7) pH
8) Turbidity

The four health-related parameters were selected based on prevalence globally, potential for contaminating drinking water sources, and severity of illness as a result of exposure. The four operational parameters were selected based on ease of measurement, the potential to indicate the presence of other health related contaminants in a given water sample, and the potential to identify needed adjustments to water treatment procedures based on the measured values. Table 1 outlines specific justification for each of the parameters.

Table 1. Justification for key drinking water quality parameters

WATER QUALITY PARAMETER	JUSTIFICATION FOR INCLUSION
Health-Related Parameters:	
Arsenic (As)	Arsenic is a naturally-occurring metalloid found in many parts of the world. Consumption of arsenic at high concentrations can lead to death, while long-term exposure at lower concentrations through drinking water sources can lead to a severe chronic illness called arsenicosis. Long-term exposure can result in thickening of the skin, darker skin, abdominal pain, diarrhea, heart disease, numbness and cancer. Following the discovery of several cases of arsenicosis as a result of USAID-funded water supply programs in the

[1] Water Quality Assurance Plan Africa Bureau Template Guidance Note – https://www.usaid.gov/environmental-procedures/environmental-compliance-esdm-program-cycle/special-compliance-topics/water/wqap-africa-guidance-note

	1990's, the Agency now requires the testing of arsenic in all water supply programs.
Fecal coliform	According to the WHO, the greatest risk to human health associated with drinking water is contamination by animal and human waste, which can lead to outbreaks of waterborne diseases. Therefore, the 'first priority in developing and applying controls on drinking-water quality should be the control of such outbreaks.' In general, the WHO has determined that the risk of contamination of water supplies with pathogens, particularly if they are from excreta, is far greater than the risk associated with chemical contamination. Fecal coliform, specifically Escherichia coli (E. coli), is a waterborne pathogen commonly linked to diarrheal disease, and is associated with both human and animal waste. The WHO estimates that diarrheal disease causes 1.5 million deaths annually, affecting mainly children in developing countries. Approximately 58% of these deaths are attributable to unsafe water supply, sanitation and hygiene. Other diseases that can be transmitted by microbial-contaminated water include typhoid fever, cholera, salmonellosis, dysentery, and botulism, as well as viral diseases including SARS, Hepatitis A, and Polio.
Fluoride (F-)	Fluoride is a naturally-occurring anion of fluorine which occurs in minerals and fluoride salts. In small quantities, fluoride can be helpful to human health and protect from tooth decay. However, in higher concentrations (above several parts per million), fluorides can cause pitting of teeth and skeletal problems including crippling fluorosis, anemia and stiff joints. Heavy concentrations of fluoride can be found naturally throughout northern Africa, the Middle East and central Asia.
Nitrate (NO_3^-)	Nitrate (NO_3^-) is an inorganic compound that is both produced synthetically and occurs naturally. Although nitrate does occur naturally in surface and groundwater, high levels of nitrate contamination in drinking water is most often due to improper treatment of animal wastes, leaching of septic or wastewater systems into drinking water sources, and excess fertilizer application with its subsequent infiltration or runoff into source waters. The consumption of high concentrations of nitrate (greater than 50 mg/L of NO_3^-) and the subsequent reduction of nitrate to nitrite (NO_2^-) can lead to methemoglobinemia in infants. The presence of nitrite in the blood converts hemoglobin to methemoglobin, which cannot carry oxygen, and can lead to brain damage or death at high enough concentrations. This process is often complicated by the presence of microbial contamination and subsequent gastrointestinal infection.

Operational-Related Parameters:	
Electro-conductivity	Conductivity is a measure of the ability of water to pass an electric current, and is influenced primarily by the presence of inorganic dissolved solids such as chloride, nitrate, sulfate, and phosphate anions (ions that carry a negative charge) or sodium, magnesium, calcium, iron, and aluminum cations (ions that carry a positive charge). Healthy freshwater systems have a range of 150 and 500 µhos/cm (microsiemens per centimeter), but the value may vary greatly depending on the geology and mineral deposits. Sharp changes to electro-conductivity from baseline condition can indicate an influx of wastewater from industrial or agricultural activity. For this reason, elevated electro-conductivity values may indicate the need for additional testing.
Total Dissolved Solids (TDS)	TDS is closely related to conductivity and is a measure of all ion particles that are smaller than 2 microns (0.0002 cm). Thus, TDS is a close approximation of salinity (although dissolved organic matter and other compounds may be included in the TDS measurement). High TDS can also indicate high alkalinity or hardness. Sharp changes in TDS indicate changes to the overall water quality. Water hardness can influence the effectiveness of water treatment, and thus is useful to monitor in order to inform effective water treatment.
pH	pH is a measure of the balance between hydrogen ions (H^+) and hydroxide ions (OH^-), with a pH of 7.0 being neutral. Surface water sources normally range from a pH of 6.5 to 8.5, while groundwater sources can range from 6 to 8.5. In general, water with higher acidity (pH < 6.5) could be corrosive and contribute to elevated levels of metals (iron, manganese, copper, lead, and zinc) as a result of leaching from the aquifer substrate, plumbing fixtures, and piping. Waters with higher alkalinity (pH > 8.5) indicate hardness (high concentration of dissolved minerals, particularly calcium and magnesium) and could contribute to mineral deposits along the water supply network. Although hardness is not a health concern, it can be distasteful.
Turbidity	Turbidity is a measure of the clarity or cloudiness of water and could be caused by silt, sand, mud, chemical precipitates, algae, bacteria, and other microscopic organisms. Turbidity is easy to measure and can be an indicator of contaminant loading. Further testing will be required to determine specific contaminant loading.

b. 5.2 Host Country Regulations - Uganda National Bureau of Standards

In addition to the eight USAID-recommended parameters detailed above, the Uganda National Bureau of Standards (UNBS) includes additional parameters from their 2014 Potable Water-

Specification[2]. The Ugandan 2014 Potable Water-Specification is directly adopted from the East African Standard, EAS 12: 2014 for potable water. This document includes minimum recommendations for both treated and natural potable water. Treated potable water is water that has undergone processes such as flocculation, coagulation, sedimentation, filtration and disinfection whereas natural potable water is water that is from natural sources and fit for human consumption without undergoing any form of treatment that will alter its original chemical composition and bacteriological purity. Seven of the eight USAID-recommended parameters are included, apart from arsenic. Additionally, several parameters that are commonly encountered in Uganda are included. This standard defines the minimum monitoring parameters as the following:

Physiochemical

1) EC or TDS
2) Color*
3) Turbidity
4) Taste*
5) Odor*

Microbiological

6) Fecal coliform bacteria
7) Shigella spp.*
8) Salmonella spp.*

Chemical

9) Fluoride
10) Nitrate
11) Nitrite*
12) pH
13) Aluminum*
14) Total Iron*
15) Ammonia*
16) Residual Chlorine*,**

* parameters recommended by UNBS but not included in the USAID required testing standard
** Residual chlorine is intended for treated water systems and will not be used for the project.

c. 5.3 Minimal Requirements

The Ugandan Ministry of Water and Environment through its Directorates of Water Development (DWD) and the Directorate of Water Resources Management (DWRM) is responsible for the regulation of water supplies in Uganda. In order to comply with national guidance and maintain consistency at the project sites, B4R will use the Ugandan standards as a basis for assessing potable water access. The team will use the US EPA National Primary Drinking Water Regulations (2009) and the WHO 2017 Guidelines for Drinking-water Quality[3] as a comparison as needed.

The B4R project will use the UNBS standard as the minimal acceptable baseline for water quality. These standards are identified in Table 2-A and Table 2-B. USEPA and WHO values are provided only for comparison.

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[2] Uganda Standard, US EAS 12: 2014, Potable water — Specification http://extwprlegs1.fao.org/docs/pdf/uga205721.pdf

[3] Guidelines for drinking-water quality: fourth edition incorporating the first addendum. Geneva: World Health Organization; 2017. License: CC BY-NC-SA 3.0 IGO. - https://apps.who.int/iris/bitstream/handle/10665/254637/9789241549950-eng.pdf

TABLE 2-A: APPLICABLE HUMAN HEALTH-RELATED DRINKING WATER QUALITY PARAMETERS OF CONCERN

USEPA GUIDANCE			HOST COUNTRY REGULATIONS		WHO GUIDANCE	
Parameter	Limit	Frequency	Limit	Frequency	Limit	Frequency
Arsenic	0.01 mg/l	quarterly	0.01 mg/l	Monthly	0.01 mg/l	N.S.
Fecal Coliform*	00/100 ml	quarterly	00/100 ml	Monthly	00/100ml	N.S.
E. coli	00/100 ml	quarterly	00/100 ml	Monthly	00/100 ml	N.S.
Fluoride	4.0 mg/l	N.S.	1.5 mg/l	Monthly	1.5 mg/l	N.S.
Nitrate (as NO_3)	10 mg/l	N.S.	45 mg/l	Monthly	50 mg/l	N.S.
Nitrite (as NO2)	1 mg/l	N.S.	0.003 mg/l	Monthly	3 mg/l	N.S.
Lead as Pb	0.015 mg/l**	N.S.	0.01 mg/l	Monthly	0.01 mg/l	N.S.
Turbidity	5 NTU	N.S.	25 NTU	Monthly	N.S.	N.S.
Shigella in 100 mL	N.S.	N.S.	00/100 ml	Monthly	N.S.	N.S.
Salmonella in 100 mL	N.S.	N.S.	00/100 ml	Monthly	N.S.	N.S.
Ammonia (as NH3) (mg/l)	N.S.	N.S.	0.5 mg/l	Monthly	N.S. The threshold odor concentration of ammonia at alkaline pH is approximately. 1.5 mg/l, and a taste threshold of 35 mg/l has been proposed for the ammonium cation	N.S.

Notes: * Analysis for thermos-tolerant coliforms (TtC) bacteria, or Escherichia coli.
** Maximum Contaminant Level not provided. Treatment Technique is required at this level to reduce the contaminant in drinking water.

TABLE 2-B: APPLICABLE OPERATIONAL-BASED DRINKING WATER QUALITY PARAMETERS OF CONCERN

USEPA GUIDANCE			HOST COUNTRY REGULATIONS		WHO GUIDANCE	
Parameter	Limit	Frequency	Limit	Frequency	Limit	Frequency
Lead as Pb	0.015 mg/l**	N.S.	0.01 mg/l	Monthly	0.01 mg/l	N.S.
Total Iron (as Fe)	0.3 mg/l		0.3 mg/l	Monthly	N.S. There is usually no noticeable taste at iron concentrations below 0.3 mg/l, although turbidity and color may develop	N.S.
Total Dissolved Solids	500 mg/l	N.S.	1500 mg/l	Monthly	1000 mg/l	N.S.
Color	15 TCU		50 TCU	Monthly	N.S. (15 TCU is detectable by humans)	N.S.
Taste	N.S.	N.S.	Not objectionable	Monthly	N.S. (recommends free of taste)	N.S.
Odor	3 threshold odor number		Odorless	Monthly	N.S. Recommends free of odor	N.S.
pH	6.5 - 8.5	N.S.	5.5 - 9.5	Monthly	N.S.	N.S.
Aluminum (as Al+++) (mg/l)	0.05 to 0.2 mg/l	N.S.	0.2 mg/l	Monthly	N.S. 0.1-0.2 mg/l often leads to consumer complaints	N.S.
Residual Free Chlorine	4.0 mg/l	N.S.	0.2-0.5 mg/l	Monthly	5 mg/l	N.S.

d. 5.4 Rationale for Selection of Site- Specific Water Quality Parameters

The B4R Activity will construct boreholes for drinking water in both Kidepo Valley National Park and Kalinzu Central Forest Reserve. The drinking water quality parameters summarized in Tables 2-A and 2-B are the basis of water quality monitoring for this program and will be applicable for all constructed water points. The USEPA guidance values have been selected from the USEPA National Primary Drinking Water Regulations (2009). The WHO guidance values and limits are selected from the WHO Guidelines for Drinking-Water Quality (2017). The Ugandan guidance values are taken from the Ugandan 2014 Potable Water-Specification.

The B4R Construction Team collaborated with UWA and NFA to determine the applicable Ugandan standards and parameters of concern. In Kidepo Valley National Park, for instance, UWA has frequently seen elevated levels of iron, fluoride, color, total dissolved solids, and turbidity. For some parameters, the risk of contamination due to human activities is reduced at the B4R project sites because they are in protected forest areas with minimal human activities. However, the B4R Activity will test for all required Ugandan parameters.

The following list provides a short explanation rationale of the selection of parameters included in **Tables 2-A** and **2-B**:

Microorganisms

The most common and widespread health risk associated with drinking water is microbial contamination. There are several potentially waterborne bacterial pathogens commonly found in Uganda, including E. coli, Salmonella and Shigella.

1. Fecal coliform: Large numbers of coliforms indicate a high probability that other pathogenic bacteria or organisms, such as Giardia and Cryptosporidium, may be present.
2. E. coli: Test results indicating a presence of E. coli are most commonly a result of fecal contamination. This could also indicate a potential presence of pathogenic bacteria, protozoa or viruses.
3. Shigella: Shigella spp. can cause serious intestinal diseases, including bacillary dysentery. E. coli is a generally reliable indicator for Shigella spp. in drinking-water supplies, but testing for Shigella is required by the Ugandan government.
4. Salmonella: Salmonella contamination is most frequently a result of fecal contamination from sewage discharges, livestock and wild animals. Salmonella infections can cause clinical symptoms: gastroenteritis, bacteremia or septicemia, typhoid fever/enteric fever, and a carrier state in persons with previous infections.

Chemicals

According to WHO, only a few chemicals have been shown to cause widespread health effects in humans because of exposure through drinking-water when they are present in excessive quantities. These include fluoride, arsenic and nitrate. The following list provides brief information of chemical parameters selected and the basis for their selection.

7. Ammonia: The term ammonia includes both the non-ionized (NH_3) and ionized (NH_4^+) species. Ammonia originates from metabolic, agricultural and industrial processes and from disinfection with chloramine. Natural levels in groundwater and surface water are usually below 0.2 mg/l. Anaerobic groundwaters may contain up to 3 mg/l. Ammonia contamination can arise from cement mortar pipe linings. Ammonia in water is an indicator of possible bacterial, sewage and animal waste pollution.
8. Arsenic: In groundwaters, arsenic concentrations can be elevated significantly where there are sulfide mineral deposits and sedimentary deposits deriving from volcanic rocks.
9. Nitrate and Nitrite: Frequently present due to sewage contamination or agricultural runoff. Although these activities are not present around the project sites, the parameters are required by the Ugandan government.
10. Fluoride: Traces of fluorides are present in many waters, with higher concentrations often associated with groundwaters. Epidemiological evidence that concentrations above 1.5 mg/l carry an increasing risk of dental fluorosis and that progressively higher concentrations lead to increasing risks of skeletal fluorosis.
11. Chlorine: Difficulties in maintaining residuals at points in a distribution system or a gradual disappearance of residual may indicate that the water or pipework has a high oxidant demand due to growth of bacteria.

12. Aluminum: Elevated levels of aluminum can lead to consumer complaints as a result of deposition of aluminum hydroxide floe and the exacerbation of discoloration of water by iron.
13. Iron: On exposure to the atmosphere, ferrous iron oxidizes to ferric iron, giving an objectionable reddish-brown color to the water. Iron also promotes the growth of "iron bacteria ", which derive their energy from the oxidation of ferrous iron to ferric iron and in the process deposit a slimy coating on pipes.
14. Lead: Lead can leach into drinking water through contact with lead-containing materials such as pipes, fixtures, or solder or through erosion of natural deposits. The pH, temperature, and time in contact can all affect the amount of lead that leaches.
15. pH: This is an important parameter in determining disinfection efficacy. For effective disinfection with chlorine, the pH should preferably be less than 8; however, lower-pH water (<7) is more likely to be corrosive.

Physical

1. Turbidity: Higher turbidity levels are often associated with higher levels of disease-causing microorganisms such as viruses, parasites, and some bacteria. It also provides an indication of rapid changes in source water quality.
2. Suspended matter: Suspended particles in water can reduce the effectiveness of disinfectants. Pathogens are often aggregated or adherent to suspended solids in water.
3. Total Dissolved Solids: Can lead to consumer complaints. Drinking-water becomes significantly and increasingly unpalatable at TDS levels greater than about 1000 mg/l.
4. Electrical conductivity: Significant changes (usually increases) in conductivity may indicate that a discharge or some other source of disturbance has decreased the safety of the water source.
5. Color, odor and taste: Can lead to consumer complaints.

16. 6 TESTING

a. 6.1 Sample Collection and Field Measurement

i.6.1.1 Trained Personnel

B4R will require construction contractors to oversee collection of samples and perform field measurements for any potable water sources they are implementing. This will include the boreholes, rainwater harvesting systems, and connections to existing systems. Water quality analysis will be performed at a certified laboratory in Uganda which has well properly trained personnel and equipment that can carry out appropriate testing. Construction contractors will propose a testing lab that will be approved by RTI. While it is possible for a construction contractor to carry out the sampling independently, this will require that they create a robust chain of custody protocol system, trained staff and the qualified laboratory will need to agree to accept their samples for testing. Ongoing sampling and testing will be the responsibility of UWA or NFA in collaboration with the qualified laboratory.

ii.6.1.2 Equipment

The performance of water quality sampling and field measurement will be coordinated with the construction contractor, UWA or NFA, and the B4R team. Samples will be collected by the trained staff in the presence of the B4R team.

The sampling equipment includes:

- Seal clips
- Meter
- Stopwatch
- Batteries
- Standard buffer solutions for meter calibration (within expiration date)
- Deionized water
- Paper towels
- Dilute bleach solution (1:6)
- Sample containers
- Labels
- Log book
- Ziploc bags
- Strapping tape
- Cooler with ice
- Sterile gloves
- Safety glasses

iii.6.1.3 Procedures and Protocols

Sampling will be done for all water access points, regardless of whether or not they are intended to be used as a drinking water source. Water access points include new boreholes and rainwater harvesting systems in Kalinzu and Kidepo.

For **rainwater harvesting systems**, water quality will be tested at taps leaving the tank after final construction. Samples should be taken once the system reaches a state of equilibrium, typically after the second representative rainfall event. The first rainfall event will be used to flush the system. Routine testing is especially important for rainwater harvesting systems, as they are subjected to more changes from environmental factors.

For **newly constructed boreholes**, testing will be done once after drilling and again upon completion of the borehole works. For groundwater sources, the borehole should be pumped before being tested. Samples for analysis should be taken once water that is representative of the aquifer is found, i.e., once equilibrium conditions have been established (rather than stagnant water around the well, or water that has been affected by drilling). Samples should be taken from pumps allowed to flow for a period of time at a moderate rate to try to approximate normal operating conditions of the water point.

Assessments will be required to be carried by the construction contractor at each site, following the standards listed in this document and using a licensed laboratory within the recommended holding time (Table 3).

Table 3: Drinking Water Sampling Guidelines

Parameter	Bottle	Preservative	Maximum Allowable Holding Time	Instructions

Fecal coliforms, Shigella, and Salmonella	Sterile plastic	Sodium thiosulfate if the sample is chlorinated. Or cool to less than 10°C but don't allow to freeze	8 hours	Wear gloves when collecting samples. Do not rinse the bottles. The bottles are sterile, so care must be taken not to contaminate the bottle or cap. Once the distribution line is flushed and the flow reduced, quickly open the bottle (but do not set the cap down), hold the cap by its outside edges only, and fill the sample bottle to just above the 100 mL line leaving one-inch headspace. Cap the bottle immediately and place it into a cooler with ice for delivery or overnight shipment to the laboratory
Fluoride, Nitrates, Nitrites, EC, TDS, pH, and Turbidity	Plastic or glass	Cool to less than 4°C	24 hours	Check with the laboratory on the sample volume required for analysis. Wear gloves when collecting samples. Rinse the bottle and cap three times with sample water and fill the bottle to within one to two inches from the top. Place the sample into a cooler with ice for immediate delivery or shipment to the laboratory
Arsenic, Iron, Aluminum, and Ammonia	Plastic or glass	Nitric acid to pH less than 2	6 months	Check with the laboratory on the sample volume required for analysis. Wear gloves and eye protection when handling acid and while collecting samples. If the bottle contains a preservative, do not rinse the bottle. If the preservatives are not included in the bottle, rinse the bottle and cap three times with sample water, fill the bottle, and then carefully add the preservatives following the instructions provided by the laboratory. The bottle should be filled to within one to two inches from the top. Deliver or ship the samples to the laboratory. Note: If samples are not acid preserved, they must be received by the laboratory within 14 days of sampling

b. 6.2 Laboratory Analysis

i.6.2.1 Qualified Laboratories

The Ugandan National Water Quality Management Strategy utilizes a three-tier water and environment testing laboratory system. The laboratory system comprises a National Water Quality Reference Laboratory in the Directorate of Water Resources Management in Entebbe, four regional water quality laboratories in the Water Management Zones, and basic laboratories in District Local Governments and at all drinking water treatment facilities. The B4R team recommends contractors use the Ministry of Water and Environment (MWE) Regional Laboratory in Lira , MWE Regional Laboratory in Mbarara or National Water and sewerage Corporation (NWSC) Laboratory in Kampala.

Table 4: Availability of Resources for Laboratory Analysis

Parameter	Test	Instrument Make/Model	Receiving Protocol
Color (TCU)	ISO 7887	Spectrophotometer	Physical Analysis
Turbidity (NTU)	ISO 7027	Turbidimeter	Physical Analysis
pH	ISO 10523	pH meter	Physical Analysis
Total dissolved solids	ASTM D 5907	Gravimetry	Physical Analysis

Aluminum (as Al^{+++})	ISO 12020	Spectrophotometer	Chemical Reaction
Total Iron (as Fe)	ISO 6332	Spectrophotometer	Chemical Reaction
Arsenic (as As)	ISO 11969	Spectrophotometer	Chemical Reaction
Ammonia (as NH_3)	ISO 11732	Spectrophotometer	Chemical Reaction
Nitrate (as NO_3)	ISO 7890	Spectrophotometer	Chemical Reaction
Fluoride (as F)	ISO 10359	Electrode	Chemical Reaction
Nitrite (as NO_2)	ISO 6777	Spectrophotometer	Chemical Reaction
Residual free Chlorine	ISO 7393	Spectrophotometer	Chemical Reaction
Fecal Coliform in 100 mL (analysis for E. coli)	ISO 9308-1	Bacteriological test kit	Incubation
Shigella in 100 mL	ISO 21567	Bacteriological test kit	Incubation
Salmonella in 100 mL	ISO 6785	Bacteriological test kit	Incubation

The disposal of consumables will be through qualified laboratories that follow national regulations on disposal of dangerous materials.

ii.6.2.2 QA/QC Reporting

For quality control and quality assurance, the laboratory must issue an original certificate and analysis report.

All the qualified laboratories have Quality Control Officers who are mandated to safeguard both the water samples and test results against any potential manipulation or destruction. Additionally, the managers of the laboratories periodically calibrate the water testing equipment to avoid potential contamination of the samples during testing.

17. 7 SUSTAINABILITY AND OPERATIONAL FACTORS

a. 7.1 Planning

i.7.1.1 Design and Construction

All designs for B4R were prepared by MBW's design team, which included both MBW and Studio FH (now Local Works). As such, MBW will continue to act in the role of "Designers of Record " and will work closely with the B4R Construction Team to resolve any RFIs and construction submittals in a timely manner and provide specific reviews as required in the contract documents. MBW followed International Building Code (IBC) standards and Ugandan Standards where relevant.

The construction and supervision of all works will be subcontracted to qualified contractors and consultants, respectively, with supervision from the B4R team. All the designs, materials and works will comply with national construction standards.

ii.7.1.2 Source Protection

Construction contractors will employ source protection measures to maintain water quality. This will include construction/installation of physical barriers to prevent entry, along with the engagement of security guards or water source caretakers to ensure that the measures are enforced and implemented. In cases of point water sources, UWA or NFA representatives will be trained to maintain the infrastructure. Construction contractors shall also ensure proper drainage of wastewater from point sources and prevention of stagnant water. Construction contractors are mandated to follow all EMMP requirements.

b. 7.2 Operational Sustainability

i.7.2.1 Routine Operations and Maintenance

MBW and UWA will develop a Maintenance Plan for all infrastructure works in Kidepo. A Maintenance Plan will also be developed between MBW and NFA for the works in Kalinzu. All Maintenance Plans will include all maintenance requirements including for safety as well as protection against impacts from climate change, such as extreme weather events. The maintenance plan will include care of water facilities.

Rainwater harvesting storage tanks should be flushed and cleaned on a bi-monthly basis or as needed if sooner. Chlorine tablets should be used for routine water treatment in accordance with specified dosing requirements as needed.

ii.7.2.2 Routine Monitoring and Testing

UWA and NFA will be responsible for water quality monitoring post-construction. The B4R Construction Team will recommend that they continue water quality monitoring of the constructed boreholes and water access points as part of their routine water quality surveillance. Testing is recommended monthly, as specified by the UNBS guidelines.

iii.7.2.3 Training

MBW along with the B4R Construction Team will provide maintenance training for UWA and NFA upon completion. Training will include turn-over certifications, manuals and drawings for all water systems.

18. 8 CORRECTIVE MEASURES

If water quality guidance levels are exceeded, the selection of the corrective measures to implement depends on a variety of factors, most of which depend on potentially unique site characteristics and local context. The two most important issues that will be considered prior to implementing a corrective response are:

- Does the exceedance present an immediate health risk to consumers?
- Are there alternative water sources which are accessible and safe?

For both newly developed sources and existing piped systems where extensions will be made, B4R will notify and consult with USAID and UWA/NFA regarding the exceedance and appropriate responses. If there is no immediate danger to the life and health of the beneficiaries, then additional information will be collected in order to select the proper corrective measures in consultation with knowledgeable water quality technical specialists, including USAID staff.

a. 8.1 Human Health-Related Drinking Water Quality Parameters of Concern

1. **Arsenic**: If arsenic levels are found to exceed the standards set forth in this WQAP, the water points will be condemned (or not constructed) and alternative sources will be selected in collaboration with the beneficiaries and local authorities.

2. **Fecal coliforms**: Where fecal coliforms of community point sources exceed the limit set in this WQAP, B4R will work with UWA or NFA to ensure that appropriate measures are implemented, which may include;

    - Investigate potential sources of contamination, particularly review the distances between water and wastewater systems or solid waste disposal management practices and remove the source of contamination, if possible;
    - Examine the well construction to ensure that the concrete apron and casing are sealed and in good condition, the well head is elevated such that runoff flows away from the concrete pad, and the well area is fenced to keep out livestock and animals;
    - Disinfect the infected well using the shock chlorination technique.
    - Instruct users to boil water if treatment is not effective.
    - If the contamination is likely to persist, mark the water supply as 'not for drinking water purposes'. Advise users to access alternative sources for potable purposes.

3. If **fluoride** levels are exceeded, alternative sources will be opted for.

4. If **nitrate** levels are exceeded, the following measures will be conducted;

    - Caution the users about the dangers of consuming nitrates/ nitrites especially on infants.
    - Perform an investigation of potential sources of contamination, such as nearby agricultural fertilizer application, or leaking septic tanks and remove the source of contamination, if possible;
    - Monitor to determine the efficiency the protection measures.
    - Identify alternative low-nitrate sources of water that can be used in place of the contaminated source.

5. If **nitrite** levels are exceeded, the following measures will be conducted;

    - Investigate potential sources of contamination, such as nearby agricultural fertilizer application, or leaking septic tanks, and remove the contamination, if possible. Effective treatment methods include ion exchange, reverse osmosis, biological denitrification and electrodialysis, which are capable of removing over 80% of nitrate from water to achieve effluent nitrate concentrations as low as 13 mg/l;
    - Restrict access to the water point to non-drinking water, non-domestic uses only (i.e., that water is used for irrigation purposes only).

6. If **ammonia** levels are exceeded, the following measures will be conducted;

    - Investigate potential sources of contamination, such as nearby agricultural fertilizer application, or leaking septic tanks, and remove the contamination, if possible. Ammonia can be removed by biological nitrification.

b. 8.2 Operational-Based Drinking Water Quality Parameters of Concern

The presence or absence of operational-based parameters of concern is an indicator of the existence or absence of potential contaminants in the form of inorganic, micro components.

1. If **electrical conductivity or TDS** levels are exceeded, the following measures will be conducted;

    - Caution users about the issue and interpret what it means in terms of their health.
    - Conduct full water quality analysis focusing on inorganic micro components/ metals common in the area like iron, copper, lead, Chromium and negatively charged ions of sulphates, chlorine, Nitrates.
    - Based on the findings of the full water quality analysis, proceed with possible preventative measures upon consultations with UWA and NFA

2. If **pH** levels are outside of the acceptable range, the following measures will be implemented;

    - Conduct an investigation of potential anthropogenic sources of contamination, such as nearby industrial activities including mining.
    - Identify alternative sources of water supply, if available.
    - Perform an investigation of potential natural sources, such as subsurface geology, to confirm that the low or high pH is a result of natural conditions.
    - If the pH exceedance is due to natural conditions, such as local geology, use appropriate materials for water supply extraction and distribution infrastructure (e.g. PVC riser mains).
    - Restrict water point access to non-drinking water, non-domestic uses only (i.e., that water is used for irrigation purposes only).

3. If **turbidity** levels are exceeded, the following measure will be implemented;

    - Conduct an investigation of possible causes, such as leakages that allow runoffs into the protected water point, inadequate water column in the well, poor design of lining/casing
    - Implement corrective measures to address any defects identified.

4. If **taste, odor, color** is objectionable, the following measure will be implemented;

    - Investigate potential sources should be performed when odor, color, or taste.
    - Consider if existing water treatment and distribution practices can affect the acceptability of drinking-water and to manage change and operations to minimize the risk of problems for acceptability as well as health.
    - Investigate changes in the quality of the raw water source or deficiencies in the treatment process.
    - Consult health authorities.

5. If **aluminum** or **iron** levels are exceeded, the following measure will be implemented;

    - Identify the source of contamination.
    - Consider a water treatment as a possible source of aluminum.
    - If the source of aluminum is a water treatment, optimize the treatment process.
    - Verify discoloration of water and the integrity of borehole casings and pumps as this can be a signal of the presence of iron.
    - Access to the water point will be restricted to non-drinking water, non-domestic uses only (i.e., that water is used for irrigation purposes only).

19. 9 EMMP WATER QUALITY REQUIREMENTS

This section provides a summary matrix of environmental mitigation and monitoring measures related to the water indicators.

Table 6: Summary of EMMP Water Quality Requirements

Activity	Impact	Mitigation Measure	Monitoring Indicator/Method	Frequency & Timing of Monitoring
Water quality impacts and potential risks to human health	The quality of water obtained from boreholes may not be satisfactory for human use and may pose a risk to human health.	1) UWA and NFA shall ensure that contractors drilling boreholes for potable water implement the USAID required Water Quality Assurance Plan (WQAP, see Annex H for the WQAP template), which will require USAID approval; that the requirement to use only laboratories certified by Ministry of Water and Environment (MWE) is included in the WQAP; that an initial test is conducted prior to opening the borehole for human use and that it complies with water quality standards; and that the contractor provides training to UWA on water quality testing. 2) UWA and NFA shall conduct water quality testing in compliance with the WQAP over the life of the contract.	1) WQAP completed (includes requirement regarding MWE certified labs); USAID approval obtained; initial testing completed, results in compliance with standards; training is conducted and UWA/NFA has the needed capacity. 2) Testing conducted	1) Monitor once WQAP is completed (specifies MWE-certified labs) and approved; review initial test results prior to water provision; monitor when training is conducted. 2) Monitoring reports to USAID in accordance with the schedule that will be stipulated in the WQAP