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# Groundwater monitoring for mapping aquifers in Belize as a tool for climate change adaptation planning

Inception Meeting Report



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Client representative	Marisela Ricardez Garcia
Project manager	Azucena Rodriguez Yebra
Project director	Nigel Walmsley

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Prepared	Approved	Authorised
Azucena Rodriguez Yebra	George A F. Woolhouse	Nigel Walmsley

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# 1 Introduction

## 1.1 Project summary

In Belize, 56% of the population lives in rural areas where groundwater is a vital source for fresh water, and represents almost 95 per cent of the fresh water supply.

Groundwater is also used as a source of drinking water in the cities of the Corozal, Orange Walk, Cayo and Toledo Districts and in some rural areas of Toledo and Cayo. However, the existing aquifers and their annual recharge rate have not been quantified.

Increase in demand for fresh water resulting from increasing population, greater economic activity and agricultural expansion are threatening the quality and availability of fresh water. Each year during low rainy seasons exists the possibility of droughts due to low recharge of aquifers.

Transboundary aspects and distribution of population are other factors that affect the water sector. For example, central and northern regions (Orange Walk and Corozal) have much larger populations and higher agriculture zones for water intensive crops, but less water resources.

Although there is a need for groundwater information across the country, the priority area includes the New River watershed.

The Nationally Determined Contribution (2022)<sup>1</sup> indicated water resource assessment (especially groundwater) as part of the main actions to be implemented to build resilience.

The results of the prioritization of adaptation technology factsheets for the Water Sector documented in the technologies needs assessment (TNA) for adaptation (2017)<sup>2</sup> include:

- Drought Monitoring System for Northern Belize with Specific Focus on Groundwater Resources;
- Water Efficient Fixtures and Appliances;
- An Integrated Management Strategy for Water Safety for eight Rural Water Supply Systems in Belize.

The National Hydrological Service (NHS) is leading a process for building an inventory of existing data on groundwater. The objective is to identify and homogenize information that is currently available but spread among different agencies and institutions, and their various departments.

Requests have been made from the executive level of the Ministry (responsible for the NHS) to other ministries for sharing of relevant groundwater data. However, this is still a work in progress. Additionally, the Ministry of Rural Transformation has indicated that they do not geo-reference their wells.

Following the foreseen adaptation actions in the NDC and the TNA for Adaptation for the water sector, the National Climate Change Office of the Ministry of Sustainable Development, Climate Change, and Disaster Risk Management, and the National Hydrological Service (NHS) is implementing a project to develop a Groundwater Monitoring System for the New River Watershed.

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<sup>1</sup> Belize's Nationally Determined Contribution, 2022  
<https://unfccc.int/sites/default/files/NDC/2022-06/Belize%20Updated%20NDC.pdf>

<sup>2</sup> Technology Needs Assessment for Adaptation, 2017  
[https://unfccc.int/tclear/misc\\_/StaticFiles/gnwoerk\\_static/TNA\\_key\\_doc/3db7d7bbba4c4deebecbc11fd24fb67d/5331353e87a0488e861d1fe6aca1b747.pdf](https://unfccc.int/tclear/misc_/StaticFiles/gnwoerk_static/TNA_key_doc/3db7d7bbba4c4deebecbc11fd24fb67d/5331353e87a0488e861d1fe6aca1b747.pdf)

## 1.2 About this report

The purpose of this report is to detail the discussions held at the Inception Meeting for the Groundwater monitoring for mapping aquifers in Belize as a tool for climate change adaptation planning project held on November 16th, 2022. This report summarises the areas of interest of the Stakeholder Working Group (SWG) for the New River groundwater monitoring system. The report also documents identified data that are available to inform the development of the monitoring system. The report includes a record of the inception meeting, including the participants present; a summary of respective agency interests and needs; and a summary of data that is currently available.

# 2 Inception Meeting

## 2.1 Objectives

The Inception Meeting set out to achieve the following objectives:

- SWG members understand the project objectives, outputs, team and timescale;
- SWG members roles are understood;
- Issues facing groundwater resources in the New River area (which require monitoring) are identified and hotspots prioritised;
- SWG members identify the types of data and information on groundwater which would be most useful;
- Data and information which can inform the development of the monitoring system are identified.

## 2.2 Participation

SWG members from 6 of the 10 identified SWG agencies attended the Inception Meeting. Agencies present were:

1. National Hydrological Service (NHS) (Chair);
2. Belize Sugar Industries- ASR Group (BSI);
3. Belize Water Services Limited (BWSL);
4. Department of The Environment (DOE);
5. Forest Department (FD);
6. Ministry of Agriculture, Food Security and Enterprise (MOA).

The participants' list is included as Appendix 2 of this report.

25% of agency representatives present at the inception meeting were female.

Apologies were received from the following members of the SWG:

1. MAMAS Group- Orange Walk;
2. Department of Rural Transformation (DRT);
3. National Climate Change Office (NCCO);
4. Ministry of Economic Development (MED).

## 2.3 Meeting Structure

The Inception Meeting was held over a period of one day and utilized a mix of presentations and focused discussions to gather input from the SWG. The meeting agenda is included as Appendix 1 of this report.

## 2.4 Issues facing New River Watershed

The SWG identified the following seven key issues facing the New River during a focused discussion:

1. Saltwater Intrusion, in both river systems (Belize River, New River) and in coastal aquifers;
2. Climate change resulting in reduced levels of rainfall in future and potentially requiring more groundwater abstraction for irrigation;
3. Increased population pressures on water resources;
4. Persistent Organic Pollutants (POPs) in the New River;
5. Faecal coliform, nitrate and other pollutants occurring as a result of agricultural activities and the presence of point source pollution such as soakaways;
6. Trace pharmaceuticals in groundwater and;
7. Loss of forest cover and conversion to farmland with attendant changes in water demand for agriculture and agricultural runoff / infiltration of agrochemicals to aquifers.

## 2.5 Hotspots

The SWG identified the following areas of quality and quantity risks which require monitoring along the New River during a focused discussion:

1. Wells that are no longer viable due to limited supply or salination, being used as garbage dumps, pit latrines and soakaways;
2. Libertad, Caledonia, and wells in Consejo that are next to pit latrines;
3. Distilleries (Caribbean International Brewery, Cuello's Distillery);
4. Poultry producers (Blue Creek);
5. Shrimp industry (Libertad);
6. Mechanics and butchery shops;
7. Tortilla factories and;
8. Bottled water companies (Zeta Water, Trial Farm, Yo Creek, there are at least 5 in Corozal).

## 2.6 Stakeholder information needs and data availability

At varying points during the Inception Meeting, SWG representatives identified their needs and interested from the groundwater monitoring system. They also highlighted data availability and data that can be shared to advance the process of developing the groundwater monitoring system. Table 2.1 summarises by agency, these needs, and data points.

In addition to the SWG members, the National Meteorological Service holds rainfall data for gauges in the New River area, and the Geology Department holds information on the geology of the New River area based on existing geological maps and borehole records. These stakeholders have been approached to acquire this data to support the project.

Table 2.1: Stakeholder Information Needs and Data Availability

No.	Stakeholder	Information Needs/Interests with respect to groundwater / water resources	Available Data of relevance to groundwater management
1	<b>National Hydrological Service (NHS) (Chair)</b>	<ul style="list-style-type: none"> <li>Interested in the overall long-term sustainability of groundwater development and setting sustainable allocation licences, and pollution risk management (both nutrients and saline intrusion).</li> <li>Interested in better understanding groundwater system response to stressors (e.g., links between surface and groundwater issues), and transboundary issues with flow across border.</li> </ul>	<ol style="list-style-type: none"> <li>River flow data for two gauges on the New River.</li> <li>GWP-C Project well survey data.</li> <li>UNESCO transboundary aquifer report and mapping.</li> <li>Groundwater provinces map and GIS.</li> <li>Crop water requirement tool (draft under development by the NHS).</li> <li>Groundwater abstraction in the New River area by licenced users.</li> </ol>
2	<b>Department of the Environment (DOE)</b>	<ul style="list-style-type: none"> <li>Interested in water quality problems in the New River (nutrients / pesticides / POPs) and development of environmental water quality standards.</li> </ul>	<ol style="list-style-type: none"> <li>Water quality data / studies in New River area.</li> </ol>
3	<b>Ministry of Agriculture, Food Security, and Enterprise-Extension service (MOA)</b>	<ul style="list-style-type: none"> <li>Interested in groundwater water availability for farmers and dealing with the issue of salinity in some farm wells.</li> </ul>	<ol style="list-style-type: none"> <li>GIS or Excel file with coordinates of farms with wells, farm area and area of crop types within Orange Walk and Corozal.</li> </ol>
4	<b>Forest Department (FD)</b>	<ul style="list-style-type: none"> <li>Interested in monitoring land cover change and restoring degraded areas. Recognised that preserving forest cover supports healthy surface and groundwater systems.</li> </ul>	<ol style="list-style-type: none"> <li>GIS of land cover survey data for Corozal and Orange Walk.</li> </ol>
5	<b>Belize Water Service Limited (BWSL)</b>	<ul style="list-style-type: none"> <li>Interested in groundwater development (where to site new wells) to serve growing demand and new areas of development.</li> <li>Interested in better monitoring issue of rising nitrates.</li> <li>Interested in better understanding groundwater movement and source protection to avoid siting wells in areas at risk of pollution. Interested in monitoring of drought events, water quality and allocation of water resources.</li> </ul>	<ol style="list-style-type: none"> <li>Municipal water production, by location and type (groundwater / surface water) for the last 10 years.</li> <li>Well drilling logs for the New River area.</li> <li>Water quality sampling data from Orange Walk and Corozal systems (especially focussing on rising nitrate trends).</li> </ol>

No.	Stakeholder	Information Needs/Interests with respect to groundwater / water resources	Available Data of relevance to groundwater management
6	<b>Private sector-</b> Belize Sugarcane Industry-ASR Group (BSI)	<ul style="list-style-type: none"> <li>Interested in efficiency of water use and meeting targets for water use reduction and efficiency.</li> </ul>	1. 35 years of rainfall data.

## 2.7 Meeting record

**Date of meeting:** 16/11/22     
 **Time of meeting:** 9:45am-2:57pm     
 **Place of meeting:** Maracas Bar & Grill, Sarstoon Conference Room     
 **Recorded by:** Elishah St. Luce and Tanya Barona

	<b>NAME</b>	<b>INITIALS</b>	<b>ORGANIZATION</b>
<b>ATTENDEEES</b>	Minerva Gonzales	MGO	Forest Department
	Jorge Nabet	JNA	Forest Department
	Miguel Bolon	MBO	Agricultural Department
	Samuel Cocom	SCO	Agricultural Department
	Andy Che	ACH	Agricultural Department
	Fidel Olande	FLO	Agricultural Department
	Leonidas Sosa	LSO	Department of Environment
	Edgar Ek	EEK	Department of Environment
	Adrian Zetina	AZE	Belize Sugar Industry- ASR Group
	Tennielle Hendy (Chair)	THE	National Hydrological Service, MNRPM
	Rhona Lopez	RLO	National Hydrological Service, MNRPM
	Hugo Rancharan	HRA	Belize Water Service Limited
	George Woolhouse	GWO	Team Leader, HR Wallingford
	Lucien Chung	LCH	National Water Sector Expert
	Elishah St. Luce	ESL	Communications and Gender Expert
<b>ABSENT WITH APOLOGIES</b>	Elsa Cardinez		Department of Rural Transformation
	Dr. Lennox Gladden	LGL	National Climate Change Office
	Gina Young	GYO	National Climate Change Office
	Ms. Ophelia Novelo Coordinator	OPO	MAMAS Group- Orange Walk
	Mr. Leroy Martinez	LMA	Ministry of Economic Development
	Dr. Azucena Rodriguez Yebra	ARY	International Expert in Hydrology, HR Wallingford

## MINUTES

Agenda Item 1: Welcome remarks from the NHS and current status of groundwater information in Belize	
<b>Notes</b>	<p><b>GWO:</b> Welcomed participants to the Stakeholder Working Group (SWG) Inception Meeting. The meeting objectives were outlined as follows:</p> <ul style="list-style-type: none"> <li>- Understand the project objective, team, and time scale.</li> <li>- Establish roles of SWG members.</li> <li>- Identify issues facing groundwater within the project area.</li> <li>- Identify information on groundwater which is most useful to inform the development of the monitoring systems.</li> </ul> <p><b>THE:</b> Welcomed participants to the SWG and highlighted that groundwater data is available in Belize, but it exists on paper and not necessarily in an organised format that can be used.</p> <p><b>THE:</b> explained why the reasons for selection of the New River Watershed as follows:</p> <ol style="list-style-type: none"> <li>1. Transboundary nature of groundwater.</li> <li>2. Increase demands from agriculture.</li> <li>3. Challenges of upstream and downstream users of water resources in the New River watershed.</li> </ol> <p>There have been years of research which identifies that groundwater and surface water are inextricably linked. The two cannot be separated and needs be viewed as one resource.</p>
<b>Discussion</b>	None
<b>Action Items</b>	None
Agenda Item 2: Stakeholder Working Group members introduction and expectations from the projects	
<b>Notes</b>	<p>Participant introduction ensued.</p> <p><b>THE- National Hydrological Service (NHS):</b> Noted that the NHS has limited data on groundwater, based on the division of Belize into seven groundwater provinces, and some information on well locations and abstraction rates. This exists in paper form and not in an organized system, thus requiring some form of consolidating. The Service has produced a groundwater provinces map that has been validated through various initiatives facilitated by regional project grants, over the past 30 years. There remains continued technical cooperation with the IDB. Other projects assumed by the department includes:</p> <ul style="list-style-type: none"> <li>- GWPC- baseline survey for wells in the northern region;</li> <li>- Green Climate Fund (GCF)- groundwater investigation for transboundary aquifers (in the implementation phase);</li> <li>- Global Environment Facility (GEF) - establishing a monitoring system in the Belize River area.</li> </ul> <p>The New River is contiguous with the Rio Hondo/Candelaria aquifer. Groundwater management is not isolated but considers a comprehensive picture. Hence the project area was selected based on being transboundary, a downstream user and receiver of both surface water and groundwater, and the scale of agricultural activity in the area. The aim is to be proactive and not reactive. It was noted that there is currently no hydrogeologist on staff at the department.</p> <p><b>ACH- Ministry of Agriculture, Food Security and Enterprise (MOA):</b> Indicated that the Ministry of Agriculture is not currently monitoring groundwater.</p>

	<p><b>FOL-MOA:</b> Added that geospatial information is lacking.</p> <p><b>ACO- MOA:</b> Highlighted that is important for MOA to get a handle on agricultural water consumption.</p> <p><b>LSO-Department of Environment (DOE):</b> Stated that the DOE is responsible for pollution control prevention and protection of water resources. The Department has available a bathymetry assessment for the watershed in the project area. The monitoring of groundwater users is important to the DOE because they generate wastewater. It is anticipated that a robust stakeholder engagement plan is achieved.</p> <p><b>EEK- DOE:</b> Added that the DOE provides a licencing service, acting as a regulatory and permitting agency, accruing information necessary for granting clearance. Surface water quality monitoring has been occurring for the past 2.5 years and noteworthy faecal coliform reading surpasses readable levels. Furthermore, sediment analysis found traces of DDT and other heavy metals in recent results at 5 sites. All this information is available at the department and may be useful as the circumstances for groundwater may be similar.</p> <p><b>JNA-Forest Department (FD):</b> Mentioned that the FD is conducting a multiyear land use mapping which commenced in 2018. Documented land use changes are relevant to the project.</p> <p><b>MGO-FD:</b> Noted the above is relevant to groundwater’s restoration ability.</p> <p><b>AZE- Belize Sugar Industry (BSI):</b> Shared that the sugar industry is currently 98% rain feed and requires minimal irrigation, which is sourced from surface natural springs. The Belize Sugar Industry (BSI) is in the conceptual stage of attaining sustainable irrigation to decrease consumption by 50% by 2030.</p> <p><b>HRA- Belize Water Service Limited (BWSL):</b> Expressed that the BWSL provides potable water via a series of wells containing water in the purest form, which currently only requires disinfection. Increased population and future droughts threaten groundwater supply as pressures may lead to saltwater intrusion. Diversified sources such as reverse osmosis or treatment may become necessary.</p> <p><b>LCH- Consultant:</b> Indicated role in the project as national water expert and data collector.</p> <p><b>ESL- Consultant:</b> Shared role in the project as communications and gender expert.</p>
<b>Discussion</b>	None
<b>Action Items</b>	<ol style="list-style-type: none"> <li>1. Share groundwater provinces map with SWG members using contact information on registration sheet. (Person responsible, THE).</li> </ol>
<b>Agenda Item 3: HR Wallingford presentation on the project and role of SWG</b>	
<b>Notes</b>	<p><b>GWO:</b> Presented to the participants.</p> <p>Project Objective:</p> <ul style="list-style-type: none"> <li>- Design a groundwater quality monitoring system and identify water risk for the supply of water for diverse groundwater users in Belize.</li> </ul> <p>Main Outputs:</p> <ul style="list-style-type: none"> <li>- Communication plan and workplan;</li> <li>- Map stakeholders and establish working group;</li> <li>- Assess groundwater availability, water demand, and hydrogeology;</li> <li>- Design an integrated monitoring system for the country to manage groundwater resources in target area;</li> <li>- Establish enabling factors implementation.</li> </ul>

	<p>Working Group Role:</p> <ul style="list-style-type: none"> <li>- Provide data and information to support the study;</li> <li>- Use requirements for groundwater data and information;</li> <li>- Coordination and harmonisation with existing portfolios and projects.</li> </ul> <p>Steps in the process:</p> <ul style="list-style-type: none"> <li>- Develop a workplan;</li> <li>- Create a working group;</li> <li>- Review current and future water demands;</li> <li>- Review hydrogeology of Belize and determine areas of greatest risk;</li> <li>- Consider best approach;</li> <li>- Consider funding;</li> <li>- Develop road map;</li> <li>- Provide training;</li> <li>- Project closure.</li> </ul>
<p><b>Discussion</b></p>	<p><b>EEK:</b> Asked if a Terms of Reference for the working group exists to aid with understanding the role of the working group. Also, there is a need to establish a representative and alternative from each member organisation, to ensure continuity.</p> <p><b>THE:</b> Responded by saying none was developed, however each organisation has identified a primary and an alternate.</p> <p><b>LSO:</b> Asked about the Ministry of Rural Transformation’s participation as it relates to stakeholder representation and suggested including the National Association of Village Council (NAVCO) to capture the multitude of waterboards. Additional overarching entities to consider includes the Chamber of Commerce whose members include the recourse users such as poultry operations and distilleries.</p> <p><b>THE:</b> It was noted the Chamber of Commerce would be considered as a representative group for the private sector. However, the Ministry of Economic Development was recommended to also join the SWG since they may be able to assist with helping to find funding the finance the monitoring systems. The Department of Rural Transformation was selected to speak on rural water systems, among other things.</p> <p><b>ESL:</b> Informed that the District Association of Village Council (DAVCO) and NAVCO were considered but it was uncertain how well they would be able to speak on issues related to water boards as there is occasionally conflictual relationship between water boards and their respective Village Councils. The Department of Rural Transformation was seen to be a more representative agency who may be able to speak to rural water supply and use.</p>
<p><b>Action Items</b></p>	<ol style="list-style-type: none"> <li>1. Develop Terms of Reference for SWG (Person Responsible: ESL).</li> <li>2. Explore inclusion of Chamber of Commerce on SWG (Persons Responsible: THE, ESL).</li> </ol>
<p><b>Agenda Item 4: Introduction to the importance of groundwater and pressures facing groundwater resources</b></p>	
<p><b>Notes</b></p>	<p><b>GWO:</b> Presented on groundwater uses, pollution, pressures facing groundwater and key challenges.</p> <p>Groundwater pressures includes:</p> <ul style="list-style-type: none"> <li>- Heavy use for public supplies, rural communities, and private entities (Belize Water Service Limited, Distilleries and Poultry companies);</li> <li>- Agricultural uses for farm irrigation paired with the unknown rate of abstraction;</li> <li>- Base flow needs to support New River flows in dry season drought conditions;</li> <li>- Eutrophication.</li> </ul>

	<p><b>Key Challenges:</b></p> <ul style="list-style-type: none"> <li>- Pressures on groundwater;</li> <li>- Population growth (20% and 30% increase in Orange Walk and Corozal respectively from 2012-2021);</li> <li>- Land use changes (for agriculture, 2009 to present shows a trend of increasing nitrogen use);</li> <li>- Long term climate change (temperature increase, rainfall decrease, decreased groundwater recharge of river flows, sea level rise, saline intrusion in coastal aquifers, coastal flooding);</li> <li>- Lack of data and information on aquifers characteristics, sustainable yields, and present consumptive use.</li> </ul> <p><b>LCH:</b> Highlighted saltwater intrusion as an area of concern. Additionally, pollution from agricultural run-off could eventually pollute abstraction wells. The time frame in which that occurs varies depending on the depth of aquifers, however, once contaminated, they remain that way for extended periods of time. Projections indicate a full-scale treatment plant may be require in the future to provide potable water, with will lead to price hikes for consumers.</p> <p><b>ESL:</b> Informed the participants that a gender analysis is undertaken to incorporate a gender perspective into the development of the groundwater monitoring system. The uses and impacts vary from one gender to the next. This adds to the source of information. Gender participation gaps, for example, in the working group are explored, to ensure that all gender's views and perspectives are considered.</p> <p><b>MGO:</b> Asked whether gender assessment would look at ethnic differences. The North is not as ethnically diverse as other parts of the country, but in certain communities, there are Yucatec maya groups.</p> <p><b>ESL:</b> Informed that looking at unique needs of indigenous groups like the Yucatec Maya is useful for assessments of this nature.</p> <p><b>HRA:</b> Informed that BWSL has been moving towards integrating gender into their operations. The Company has made concrete steps to ensure that more women are represented in technical fields and the gender issues are considered in water sector. HRA offered to assist with setting up a conversation with the Human Resource Department on this issue, if one is desired.</p>
<p><b>Discussion</b></p>	<p>Top priority groundwater issues in the New River watershed and hot spot locations (lead by ESL).</p> <p><i>Groundwater Issues</i></p> <p><b>AZE:</b> Mentioned that rainfall data shows a disparity from 35 years ago. This assures the need to switch from rainfall to abstraction for irrigation, in the future.</p> <p><b>EEK:</b> Mentioned that surface water records on the New River shows saltwater intrusion up to San Estevan Village. Of note, there are currently no national water standards, only for effluent. There is also a lack of proper land use planning, e.g., community development, location of agricultural development and road development. There is loss of forest cover resulting from improved access to new areas which exacerbates illegal logging. Lastly, an education and outreach system are need to change people's perception of water availability and the extent of impact.</p> <p><b>THE:</b> Added that saltwater intrusion is observed 17 miles from the coast in central Belize, however that is furthest point monitored. The possibility that intrusion goes further inland exists. Groundwater is the baseflow for the river, therefore whatever occurs in groundwater will eventually manifest in the surface water. The rate at which this happens is based on the geology of the substrate. Quicker transfer is seen in karst and limestone areas like that of the project area.</p>

	<p>To add to existing issues, studies have shown that trace pharmaceuticals have been detected in natural groundwater state. Also, groundwater in Mexico, which feeds into Belize, had Lycosin which caused numerous cases of gastrointestinal issues.</p> <p><b>LSO:</b> Suggested that persistent organic pollutants (POPs) need to be monitored. Health implications are unknown, and chlorine application does not address that group of pollutant.</p> <p><b>HRA:</b> Noted that testing for POPs was conducted in 2008 and 2015 which both produced negative results. However, sediment testing has shown minute levels being present. Sediment samples were not taken from the New River. A third assessment is expected to occur in January 2023.</p> <p><i>Hotspot Locations</i></p> <p><b>THE:</b> Indicated hotspots includes wells that are no longer viable due to limited supply or salination, being used as garbage dumps, pit latrines and soakaways.</p> <p><b>E EK:</b> Identified Libertad, Caledonia, and wells in Consejo that are next to pit latrines as hotspots.</p> <p><i>Available Data</i></p> <p><b>THE:</b> Noted licencing data exists for wells however, farmer data is lacking as a result of reluctance to register and be licensed. A crop water requirement table to determine the range of use, was developed under the licencing scheme, which has been shared with the agriculture department and available for use by the project. Additionally, a water quality campaign was conducted 3 years ago with the Ministry of Health and Wellness (MOHW) and the DOE to establish baseline.</p> <p><b>LSO:</b> Noted that the MOA has a record of wells used for irrigation.</p> <p><b>JNA:</b> Reiterated that the FD use Collect Earth to classify 22-hectare plots across the country to map land use changes. The mapping separates crop land from grass land This data is disaggregated by different types of crop lands. This can be paired with crop water requirement to extrapolate useful data.</p> <p><b>AZE:</b> Mentioned that BSI has 35 years of data and indicated the Meteorological Service is another source that has multiple stations on the water belt along the New River.</p> <p>With regards to use of fertilizers, AZE informed that best guess estimation of farmers who use fertilizers indicate that approximately half of farmers use fertilizers. On average the dosage is 1 sac of fertilizer per hectare -18-5-20.</p>
<p><b>Action Items</b></p>	<ol style="list-style-type: none"> <li>1. Share PDF version of land use maps with LCH. (Person responsible, JNA);</li> <li>2. Share record of wells used for irrigation (Person responsible, LSO).</li> </ol>
<p><b>Agenda Item 5: Introduction to groundwater monitoring systems</b></p>	
<p><b>Notes</b></p>	<p><b>GWO:</b> Presented on groundwater monitoring systems.</p> <p>Types of monitoring systems:</p> <ul style="list-style-type: none"> <li>- Monitoring (leads to decision making and is the primary focus);</li> <li>- Forecasting.</li> </ul> <p>Examples of systems:</p>

	<ul style="list-style-type: none"> <li>- The global groundwater information system;</li> <li>- GGIS;</li> <li>- IGRAC.</li> </ul> <p>Considerations in the design of the system:</p> <ul style="list-style-type: none"> <li>- Preliminary assessment, fact finding;</li> <li>- Preliminary assessment of groundwater situation conflicts and trends sustainable monitoring;</li> <li>- Analysis and development of conceptual model analysis of institutional settings;</li> <li>- Inventory of data needs and specifications of monitoring objectives;</li> <li>- Design of monitoring program components for identified objectives.</li> </ul> <p>Questions to consider:</p> <ul style="list-style-type: none"> <li>- What is being monitored;</li> <li>- What are we monitoring;</li> <li>- Who are we monitoring for;</li> <li>- How will data be accessed;</li> <li>- Where will data be stored;</li> <li>- How will the data inform decision making;</li> <li>- Where will monitoring occur and with what frequency.</li> </ul>
<p><b>Discussion</b></p>	<p>What information could be provided by a groundwater monitoring system? Who could benefit from the different types of information and how? What are the prioritised areas to be monitored? (Lead by LCH)</p> <p><i>What information could usefully be provided by a groundwater monitoring system?</i></p> <p><b>THE:</b> Referred to the GCF project, stating a baseline is being established as it relates to groundwater contours, however, due to many points of abstraction, radial cone of depression is gotten. Important areas include the Lower southeast Rockstone Pond area, Caledonia, San Antonio Orange Walk, Consejo and Patchakan. Four hand pump monitoring stations have been selected on the margins of the transboundary water source. Wells were not selected next to rivers, or near the coast. These will be monitored twice per month, every other week.</p> <p><b>HRA:</b> Mentioned that information on water resources quality and quantity is important for drought management and decerning at what stage increased treatment will need to occur.</p> <p><i>What would SWG members like to see come out of the monitoring? Would Quality or Quantity be the Consensus?</i></p> <p>Both Quality and Quantity are relevant to the SWG.</p> <p>The consensus was the need to know if water is useable or not, and in cases where it is not, to be able to pinpoint the source of contamination or what is contributing to non-usability.</p> <p><i>Are there any NGOs would/could benefit from or contribute to this process?</i></p> <ul style="list-style-type: none"> <li>- Friends of New River (no longer active);</li> <li>- Programme for Belize Hill Bank;</li> <li>- The Mamas Group;</li> <li>- Corozal Sustainable Future Initiative (CSFI);</li> <li>- Sarteneja Alliance for Conservation and Development.</li> </ul>

	<p><i>Where are additional hotspots located?</i></p> <ul style="list-style-type: none"> <li>- Distilleries (Caribbean International Brewery, Cuello's Distillery);</li> <li>- Poultry producers (Blue Creek);</li> <li>- Shrimp industry (Libertad);</li> <li>- Mechanics and butchery shops;</li> <li>- Tortilla factories;</li> <li>- Bottled water companies (Zeta, Trial Farm, Yo Creek, at least 5 in Corozal).</li> </ul> <p><i>Who would be the custodians of the data, and would data be accessed?</i></p> <p><b>THE:</b> Stated that the NHS would be responsible for data. Currently data can be accessed upon request submitted to the data analyst, who extracts QA/QC data for sharing. This guarantees a controlled environment.</p> <p><i>Would the preferred data system be cloud based?</i></p> <p><b>THE:</b> Mentioned that the NHS has been in dialogue with Total Business Solutions (TBSL) to create a dashboard, similar to what is developed for reporting on flood data, to display GCF data at a particular instance. This will not be downloadable and will not function as a repository. Time series data will not be available online.</p> <p><i>How many wells would need to be monitored in the project area, and is there a minimum per, e.g. sq km?</i></p> <p><b>GWO:</b> Stated the number of wells depends on the level of confidence aiming to be achieved. There is a general rule of thumb as it relates to the size and characteristics of the aquifer.</p> <p><b>THE:</b> Mentioned that sampling according to stratification is not possible, and the best scientific justification is used for well selection, as placement must be strategic. Literature review, Mexican studies and a UNESCO validation has occurred, and additional aquifer investigations studies will be done. The GCF tries to capture the south-eastern flow, therefore three sites are on the actual Rio Hondo while the others are on the fringe near Patchakan, Caledonia and Maskall. This leaves a gap in the middle that this project is expected to cover.</p> <p>Noteworthy:</p> <p><b>THE:</b> Stated that due to the outflow from transboundary regions, Belize has a 13% dependency ratio, the highest in the region. The situation is dire, due to pressures being placed on an already limited resource from interrupting natural drainage, covering existing drainage, and guaranteed development in neighbouring countries. Artificial storage can lower the 13% dependency. Retention Ponds between the twin towns in Cayo has been considered for this.</p> <p><b>HRA:</b> Noted that BWSL has also looked into this option at Double Run. Between Rock Pond and Double Run there are marked difference in the colour of water. There is a colour and turbidity issue after Belmopan.</p>
<b>Action Items</b>	None
<b>Agenda Item 6: HR Wallingford progress up to date/ next steps/ data discussion</b>	
<b>Notes</b>	<b>GWO:</b> Reiterated the progress to date and shared the next steps in the project.

	<p><b>LCH:</b> Expressed the need for a good conceptual understanding of the groundwater system in order to design the monitoring system.</p>
<p><b>Discussion</b></p>	<p><i>Data Needs:</i></p> <ul style="list-style-type: none"> <li>- Groundwater flow needs to be assessed (isotope testing does not occur in country and is very costly).</li> <li>- Geological mapping and borehole records, pumping test results.</li> <li>- Hydrogeological data such as groundwater level surveys, maps, location of springs (essentially artisan wells that act as springs, bubbling and trickling. These are located in the Albion area, Consejo, Caribbean International Brewery and other areas of Orange Walk).</li> <li>- NHS has some Cenote information (located at mining site, cane fields, and Little Belize).</li> <li>- Groundwater level survey, well location and static water (NHS has information for 2014, 2015, 2021 &amp; 2022).</li> <li>- NHS has records of rainfall and river flow data.</li> <li>- Estimate of extraction rates can be determined through Licensing scheme, NHS can provide data on wells and reported abstraction rates.</li> <li>- The MOA has information on Agriculture water use. However, data from Mennonite communities is not accessible. MOA does have the farm sizes and the types of crops in the BAIMS system, but no data on quantities of water used for agriculture. If this information can be gathered, crop water requirement might be possible. The best approach to collecting data from these communities is to speak to elders first to seek data.</li> <li>- The NHS has a group water requirement tool that may be useful in determining use of water in these communities.</li> <li>- Mennonites farmers in Cayo and OW use pivot systems.</li> <li>- The Mennonite community in Cayo has agreed to share information with the NHS through the GCF project. Elders were engaged first.</li> <li>- Water quality data is collected by the NHS licencing scheme. Applicants are required to submit quality data.</li> <li>- MOHW may also be a good source of data on water quality.</li> <li>- BWSL collects data on water quality from well drilling logs.</li> <li>- Forestry has forest coverage data.</li> <li>- DOE has the New River study results and sediment analysis (available in hard copy).</li> </ul> <p><i>Noteworthy:</i></p> <ul style="list-style-type: none"> <li>- MOA informed that they have received complaints from farmers of wells that are drying up and complaints of salinity in Maskal, Bomba, Nargo Bank, RockStone Pond.</li> </ul> <p><i>Next Steps.</i></p> <p><b>GWO:</b> Listed the projected next steps:</p> <ul style="list-style-type: none"> <li>- Output 2, Prepare workshop report and refine SWG document, November 2022;</li> <li>- Output 3, Project team to continue follow up with SWG members for data and information and draft deliverable, January 2023;</li> <li>- Output 4, Begin scoping monitoring system options.</li> </ul>
<p><b>Action Items</b></p>	<ol style="list-style-type: none"> <li>1. Submit Workshop report, presentations to SWG (Responsible Person: ESL);</li> <li>2. Follow up with agencies to fill data gaps (Responsible Person: LCH).</li> </ol>
<p><b>Agenda Item 7&amp;8: Final discussion and comments from SWG &amp; Closing Remarks</b></p>	

<b>Notes</b>	Project experts expressively thanked members for participation in the Stakeholder Working Group (SWG) Inception Meeting.
<b>Discussion</b>	None
<b>Action Items</b>	None

## Appendices

### A Meeting Agenda

Project: Groundwater monitoring for mapping aquifers in Belize as a tool for climate change adaptation planning

#### Stakeholder Working Group Inception Meeting (16th November)

##### Inception meeting agenda

09:30 – 09:50	Welcome remarks from NHS (and NCCO) and current status of groundwater information in Belize.
09:50 – 10:30	Introduction (3 min presentation) each member of SWG – expectations from the project.
10:30 – 11:00	HR Wallingford presentation on the project and role of the SWG.
11:00 – 11:15	Break.
11:15 – 12:00	<ul style="list-style-type: none"> <li>• Introduction to the importance of groundwater and pressures facing groundwater resources.</li> <li>• Discussion – Top priority groundwater issues in the New River watershed (e.g. pollution, over-abstraction, salinisation, flooding, gender) and hotspot locations.</li> </ul>
12:00 – 13:00	Lunch.
13:00 – 14:00	<ul style="list-style-type: none"> <li>• Introduction to groundwater monitoring systems.</li> <li>• Discussion - What information could be provided by a groundwater monitoring system? Who could benefit from different types of information and how? Prioritised areas to be monitored?</li> </ul>
14:00 – 14:15	Break.
14:15 – 14:30	HR Wallingford progress up-to-date / next steps / data discussion.
14:30 – 14:45	Final discussion/comments from SWG.
14:45 – 15:00	Closing remarks from NHS (and NCCO).

# B Sign-in Sheet



HR Wallingford  
Working with water



GOVERNMENT OF BELIZE  
MINISTRY OF NATURAL RESOURCES, PETROLEUM  
AND MINING  
P.O. Box 2120, St. John's, Belize City, Belize, C.A.  
Tel: (501) 224-3333 Fax: (501) 224-3300



CTCN  
Climate Technology Centre & Network  
19th Street, Washington, DC 20036

## Workshop: Belize groundwater monitoring inception workshop

### REGISTRATION FORM

Name:	Position:	Organisation:	Telephone and E-mail:
Hinewa Gonzalez	Forest Ranger	Forest Dept.	8221524 gonzalez.mie@govmail.gov.bz
Jorge Nabet	Forester	Forest Dept.	822-1524. gsmu.jinabet@forest.gov.bz
Miguel Bala	Application Developer	Dept. of the Environment	6710689 miguelbala@environment.gov.bz
Leonides Sosa	Environmental officer	Dept. of the Environment	822-2819 projects@environment.gov.bz
Samuel Coom	Extension Officer	Agriculture Dept.	614-3673 SamuelCoom0224@govmail.gov.bz



Name:	Position:	Organisation:	Telephone and E-mail:
Andy Che	Extension officer	Agriculture Department	663-2623. andyche19@gmail.com andy.che@agriculture.gov.bz
EDGAR EK	Deputy Chief Environmental Officer	Department of the Environment	deputy@environment.gov.bz
Adrian Zetina	Sustainable Ag Lead	BSI	614-5205 adrian.zetina@asr-group.com
Tanya Barona			613-3844 tanyabarona@gmail.com
Temielle Hardy	Principal Hydrologist	National Hydrological Service, MNR PM	630-0202 principal.hydrologist@naturalresources.gov.bz
RHONA HOPEZ	DATA Analyst	National Hydrological Service	610-5091 hydroanalyst@naturalresources.gov.bz
Hugo Rondon	W/WW QCM	BWSL	hugo.rondon@bwsl.com.bz

## C Photos

Workshop venue: Sarstoon Conference Room, Maracas Bar & Grill, Orange Walk, Belize.





## D Presentations

Presentation slides attached as separate pdf document



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HR Wallingford Ltd, Howbery Park, Wallingford, Oxfordshire OX10 8BA, United Kingdom  
tel +44 (0)1491 835381, Fax: +44 (0)1491 832233, email [info@hrwallingford.com](mailto:info@hrwallingford.com)  
[www.hrwallingford.com](http://www.hrwallingford.com)