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**Water Development Report**

**Garbagal Reserve, Jigawa State, Bobi Reserve, Niger State**

**and Kachia Reserve, Kaduna State.**

**Summary:**

From March 13 through March 29, 2017, a ‘Water Development Team’, on behalf of the NGO, Schools for Africa, completed an initial assessment of the water resources and potential water development on the three grazing reserves, Garbagal, Bobi, and Kachia grazing reserves in Jigawa, Niger and Kaduna States. The team consisted of Phyllis Sortor (Schools for Africa), Chester Novak (Retired BLM State Hydrologist, Oregon), Bill Flansburg (ACTION International), Aliyu, (Aliyu Boreholes), Haruna Ali (Interpreter) and two police officers from Force Headquarters, Abuja.

The primary purpose of the survey was identification of priority water developments in the three reserves, in order to focus the limited donated funds from the NGO, Clear Blue Global Water Project, to those areas with the greatest need. After review of initial field reports collected prior to our trip (Haruna Ali) it was determined that new priority borehole (drilled wells) locations should meet a 4-fold criteria whenever possible:

* Provide for sanitary drinking water (Fulani Settlements).
* Provide livestock water to the grazing areas.
* Provide for community water (Schools and meeting places).
* Be located in locations that have no existing boreholes in the area.

We also directed priority to the repair of any boreholes on the reserves which are currently in disrepair. It is always more cost effective to repair these locations (hand pumps, pump pads, cattle troughs and pipe) than to drill new boreholes.

Summary recommendations are provided for each reserve reflecting their unique geology, vegetation, size, precipitation patterns and people.

The work is separated into 2 phases according to items to be done within the next 6 months (Phase 1) and those likely to be accomplished in the 2017 – 2018 period (Phase 2). Additional information such as improvement in the reserve maps is provided as a reference for past and future teams, as well as for development of grazing paddocks in the implementation of Holistic Grazing Management.

The Team had an extremely short time to accomplish a daunting task due to the size of the reserves, the distance between reserves, road conditions and the information needed, but by God’s grace the following report is submitted with confidence in His control over it all.

**Method:**

1. The Team and a Fulani leader or chief, (knowledgeable in the geography of the reserve) traveled existing roads and travel ways with a GPS (Garmin Oregon 600) to establish spatially correct boundary maps of the reserves, the grazing blocks and paddocks within.
2. With the updated map, we interviewed the Fulani tribal leaders concerning the general location of existing water sources and their ‘functionality’.
3. We requested these leaders to prioritize 4 locations for new boreholes (priority 1 – 4) with the 4-fold criteria in mind and where they felt water was most needed.
4. When time allowed, we visited examples of their water developments (boreholes, dams, hand dug wells, tanks) and recorded any repair or maintenance needed. In Garbagal reserve, we visited all the existing hand-pumps and water developments because the reserve is quite small.
5. We compared the areas that appeared to lack water on the maps to the priority sites that the leaders provided. Through questioning and some negotiation, we agreed to priority sites that for the most part fit the criteria and their priorities.
6. We visited the priority borehole sites and recorded the GPS locations.
7. Through interviews with the leaders, we developed a list of existing water sources that do not presently work and will need to be fixed.

**Products:**

1. Spatially corrected boundary maps for each reserve (see Appendix 1-3) which allow accurate measurement of distances and area involved with the grazing blocks/paddocks and the existing and developed water sources.
2. 12 priority boreholes sites (with 3 additional priority boreholes in the Bobi reserve) which the well driller (Aliyu) will begin drilling in Phase 1. (Appendix 1- 3 maps).
3. Tables of existing sites and their current functionality (Tables 2 – 4).
4. Cost estimates per water development (Table 1) and costs for Hand Dug Well Equipment (Table 2).
5. Recommendation for work in phase 1 and 2 in each reserve.

**Kachia Grazing Reserve**

**Kaduna State**

**Observations**

The Kachia Reserve has limited water development for the number of people and cattle residing in the 187,800 hectares (76,032 acres) reserve area. See table for a summary of the number and type of water development by grazing block. The reserve sets in typical Savannah vegetation zone and approximately a 900 mm a year precipitation zone with most rain occurring in July, August, and September period. Most of the prior ‘sanitary’ water developments have occurred along the main bisecting road. The interior of the reserve has scattered settlements throughout which often rely on surface water or hand dug exposed wells. The considerable area between the bisecting road and the river boundaries is basically without livestock water and will need further development in order to utilize a paddock system effectively.

**SURFACE WATER**

1. **Rivers and streams**

The largest source of grazing water is the natural sources located around the outer boundary of the reserve: the Kaduna and Aduma Rivers. We visited the reserve during the traditional end of the dry season therefore observed flows at their lowest level of the year. The Kaduna River was observed at the end of the bisecting road, (trending North and South) and was flowing at approximately 1 – 2 cfs with an igneous rock control on the bed and banks. It was flowing clear and had fish and freshwater oysters adhering to the rocks. The high flow banks were approximately 150 ft. across and 12 ft high at high flows. Cattle are using the Kaduna River up to about 5 KM in distance from the river (per community tribal leader). The Aduma river was observed where it crosses the bisect road close to where the reserve is entered. It was not flowing but had pools of stagnated water perched by an igneous rock bed and containing coarse sand bars. Water could be flowing through the sand bar from pool to pool at very slow rates. Both rivers represent a continuous source of water in the dry season and therefore make a logical dry season paddock location (adjacency). The interior of the reserve has numerous intermittently flowing (seasonal) streams draining from the highlands (along the main road) to the rivers. Most of these were observed to be 2- 4% gradient with bedrock control and potential for retention dam construction.

1. **Dams**

In the reserve, there are earthen dams which store runoff from the wet season into the dry season. These are mostly located along seasonal streams that drain into the Kaduna and Aduma rivers. In discussions with the local leaders on 3-16-17 they identified 10 dams throughout the reserve, most of which were located within approximately 1 - 2 KM of the “bisecting road”. Of the 10, 8 have water year- round water available for cattle although they are reported to be silting in and are experiencing some erosion of the embankment or spillway.

Based on the one dam visited, it appears that depth and thus storage can be limited by the shallow underlying igneous bedrock. The earthen embankment was well vegetated with trees and the storage appeared to be halfway silted in (approximately 10 ft deep of storage). The spillway was eroding such that at some point the head cut would drain the dam however there appears to be several years of further functionality as the head cut and remaining spill looks to be armored by rock. There are concrete cattle troughs located below the spillway that are dry and cracked. It appears there must be a pipe from the dam pool but it was not located and was not functioning. There is an obvious change in vegetation along the stream riparian zone (an increase in trees) likely a response to higher soil moisture into the dry season. While we were in this reserve we could only visit 1 dam, but it would be suggested that each existing dam be visited to assess its maintenance needs and located (GPS) so as to help in the formation of paddocks and grazing plan.

**GROUNDWATER**

1. **Drilled boreholes**

While at the reserve, most of the man-made water developments we visited were drilled boreholes. These boreholes are often located close to the main road that bisects the reserve. The boreholes visited were developed by the Federal Government: ‘Millennium Development Goals Project, Federal Ministry of Agriculture’ as some signage indicates. We were able to visit 4 of hand-pump wells (MARK 2 PUMPS) and 1 solar well (At the main school location). These wells are estimated to be anywhere from 60 – 90 meters deep and have been developed in the hard, igneous rock that prevails in the reserve region. According to the local well driller, there is an aquiclude made up of igneous rock at approximately 20 to 30 meters with a confined aquifer below, followed by igneous bedrock below. According to the Fulani Leaders, there are 17 hand-pumps in the reserve, of which 6 are currently not working or have low yield. These have been located on a hand-drawn map but have not been visited nor can these be spatially relied on to provide information for distribution of water sources for cattle. It would be suggested that each hand-pump be visited to assess its condition and located (GPS) so as to help in prioritizing for service and upgrade to allow for drinking and cattle use in a sanitary manner.

These wells appear to have enough yield for the drinking water needs of the settlements and the cattle requirements however we did not perform any yield testing. We noted no separation in the hand pump /cattle trough development. The hand-pump basins were fitted with cattle troughs directly next to the drinking water spigots. This presents a sanitary issue when using these locations for drinking water.

Maintenance of the hand pumps for these boreholes is an ongoing need. The person that services the pumps is located in Kachia and apparently comes when requested. It is recommended that several of the pastoralists be trained in well pump maintenance and repair so they could fix these on a regular and timely schedule and perhaps provide a business opportunity.

1. **Hand dug wells**

It is estimated that the most prevalent man-made water developments on the reserve are hand dug wells associated with the settlements. Settlements or small villages are scattered throughout the reserve with great need for drinking water. Most settlements located in the interior of the reserve have shallow open wells down to 10 meters, which rest on the first contact with the hard, igneous bedrock. They are often open at the ground surface with a diameter of about 4-5 ft. They do not appear to keep out surface runoff nor are they sanitized. This is the only type of drinking water source in the interior settlements and the areas located between the existing boreholes along the bisecting road. We viewed a deep, hand-dug well being excavated through extreme labor: shovel and bucket, in Block 5. We also observed drinking water sources that were dug by hand where the water was near the surface of the ground and highly vulnerable to contamination. It would be suggested that each settlement be visited to assess its water needs and located (GPS) so as to help in prioritizing for future drinking water development.

We were able to demonstrate the drilling of an ‘Auger’ well using the Water Step equipment we brought with us on the trip. Within 2 hours the Fulani were able to drill down 18 feet to the hard rock interface and into a water-bearing zone. This hole was cased, bailed and capped, leaving instruction for sanitizing once the water was bailed clear. The hole was completed at an 18 ft depth with the static water level rising to within 7.5 ft of the top of the casing. Re-charge of the well after bailing was relatively fast. Because of the shallow nature of the aquiclude, water for this development can be expected in many locations. Continuation of this type of drinking water development would be highly recommended for use in all the settlements throughout the reserve. It may take some trial and testing to find water in some locations, but the drilling is relative quick and the identification of best locations learned quickly. The pastoralists were very impressed and recognized the application of such a tool. This type of development along with training in sanitation could help the pastoralists greatly in improved health. These wells would need follow-up to install hand pumps, which could also be accomplished by the pastoralists themselves and offers an opportunity for a small business.

**MAP:**

The following is a table of the Kachia Reserve Blocks and their size as calculated from the new GPS map. The GPS total area accounts for 25,732 hectares less than the published area. This could be explained in part by the estimation of boundary location on the east side of the reserve, as it was not traveled due to a remote location without roads. Further discussion on the use of the Aduna River or the tributary as the eastern boundary could shed light on adjustment of area calculations for the eastern blocks. Adjustment of acres is not expected to account for more than a 10 – 20 % addition. It appears that the published area for the total Kachia Reserve is significantly over-estimated according to the comparison between published data and the GPS areas. The original gazetteing (survey record) of the reserve should be reviewed.

|  |  |  |  |
| --- | --- | --- | --- |
| BLOCK | AREA (Sq. KM) | HECTARES | ACRES |
| 1 | 52 | 5200 | 12849 |
| 2 | 110 | 11000 | 27182 |
| 3 | 46 | 4600 | 11367 |
| 4 | 82 | 8200 | 20263 |
| 5 | 45 | 4500 | 11120 |
| 6 | 63 | 6300 | 15568 |
| 7 | 17 | 1700 | 4201 |
| 8 | 11 | 1100 | 2718 |
| 9 | 77 | 7700 | 19027 |
| TOTAL | 503 | 50300 | 124295 |

**Kachia Reserve Recommendations:**

1. **Phase 1:**
2. **Drilling of the 4 boreholes identified as priority for drinking and cattle water**. These were identified by both the Fulani leaders and the Water Development Team as serving the highest and best use at present time.
3. **Contract with local service man to repair and maintain the pumps that are not currently working**.
4. **Teach the pastoralists how to service their own pumps, provide tool packs, and encourage preventative maintenance.**
5. **Purchase additional auger equipment and well casing materials in order to start a “drinking water well program” in the reserve**. Teams of Fulani could be taught the drilling and development method along with proper ways to sanitize the wells and keep them clean and healthy to use. Once the Fulani have the equipment, they can be encouraged to form into teams according to blocks, where they could systematically drill sanitary wells for each settlement. These wells would need to be followed up with installation of hand-pumps and sanitary pads. Purchase these materials and teach the Fulani to install and build according to specifications.
6. **Build a spatially correct map of the Kachia reserve with the reserve boundaries, block boundaries, roads, water sources, streams , settlements and schools captured on a GPS to provide correct placement within the reserve**. The boundary maps are complete including blocks and paddocks. Follow-up in needed to record location of settlements, existing wells and their condition and potential sites for new dams. Further development of water (especially dams) will require correct location in relation to where the paddocks are placed.
7. **Phase 2:**
8. **Identify potential dam sites in the interior of the grazing blocks for development of water for cattle between where the boreholes are (along the Main Road (bisecting)and the Aduma and Kaduma rivers.** There are many seasonal streams that could be dammed and provide water through the dry season, this is evidenced by the existing dams and the presence of tributary streams throughout the reserve. Although these would not have the longevity of boreholes, it would be possible to place them for lower cost and maintain them over time if the equipment was locally available. Dams have the ability to provide immediate availability of water for cows while the boreholes need to be pumped to tanks to accomplish this. Once the paddocks are assigned, the appropriate streams could be assessed for their potential for dam placement.
9. **Once dam sites are identified, survey dam sites and stake according to excavation needed. Use dam design that promotes longevity, low maintenance and ease of cattle use.** This should be done prior to the intended time that heavy equipment would be moved to the reserve. Consider moving equipment to reserve and completing the dams in one “move in” during the Jan – March dry season period. Consider competing any maintenance needed on existing dams when the equipment is moving from site to site.
10. **Identify schools that do not have handpumps available. Potentially identify future boreholes at the schools that do not have boreholes and plan for their development.** This will allow teaching of good sanitary habits to future generations. This would also provide sanitary water access to households that don’t have sanitary water within the school radius, students could take it home every day.
11. **Develop a portfolio of projects, their priority, and estimated costs for use in fund raising.**

**Garbagal Grazing Reserve**

**Jigawa State**

**Observations**

The Garbagal Reserve encompasses 19,768 acres (8,003 hectares) is located near the town of Guri in the northern tier of Nigeria, just south of the Sahara Desert. It is obviously dryer than Kachia and Bobi Reserves, and there is noticeable wind erosion and encroachment from the Sahara (desertification). The reserve sets in a Sahel vegetation zone and approximately 500 to 700 mm a year precipitation zone with most rain occurring in the August and September period. Despite the drier precipitation zone surface water appears to be plentiful in some locations near the town of Guri due to irrigation canals coming from large reservoir projects. Farming exists whenever there is a canal in the area. In the Garbagal reserve however, the land appears parched and the people are extremely poor. At this time of the year there appears to be little vegetation except a few trees, scattered bush and a soil surface which is lost or moving. Subsoil horizons are exposed in much of the area.

Geologic references term this area as located in the ‘basement complex’. Interviews with the pump maintenance crew revealed that most wells are estimated to be anywhere from 70 - 80 meters deep and have been developed in areas with a surface zone of indurated laterite about 30 m thick, lying over another 30 meters of weathered basement rock and finished in 10 to 20 meters of hard fractured basement material. Well drilling in this area will require a hydraulic system that will push the cuttings out and thus will need a water tank truck available for the operation. The boreholes will likely need to be cased throughout the hole as the weathered basement material can cave. This will involve a higher cost per meter drilled compared to the other reserves.

**SURFACE WATER**

There is one canal (hand dug irrigation ditch) routed through the reserve and serving the farms on the northeastern side of the reserve. This was not flowing while we were there but is said to flow during the wet season and into part of the dry season. It may serve as a source for cattle into the dryer season as well but it sounds like availability is un-predictable in terms of consistency of flow. The Fulani say it is fed by a reservoir but the head gate system below the reservoir is questionable. There is one pond formed by an overflow point in the canal. This holds water through the dry season. The Fulani would prefer not to develop this pond further as it attracts farmers who would till the land along its edge, thus leading to conflict and more lost grazing land. There are no apparent natural surface water drainages, as little to no rainwater flows on the ground surface. Any precipitation is likely to infiltrate the soil surface immediately, is evaporated or collects where there is slower infiltration. There are some low-lying depressions that look like they may collect water due to the clay content of the soil (low infiltration) but these are very shallow and do not hold water into the dry season.

**GROUNDWATER**

There are 8 existing wells (deep boreholes) on the reserve, all of which the Fulani claim to have good plentiful water when working. The Fulani community services the pumps themselves, they have their own tools and necessary knowledge. There is a windmill pump which currently works, but is difficult to regulate (turn off) and they really don’t like it. They would rather have all hand pumps at the wells as they can be fixed and regulated easily. As in the other reserves, the hand pumps are all Mark 2 model. None of the pumps have livestock troughs large enough to water herds effectively and many of the sanitary pads are broken and in disrepair. (see table 2). The hand pump boreholes were drilled at varying times as a cooperative effort between the Jigawa State and Local Government ministries.

Shallow groundwater (into the dry season) does not seem to exist on this reserve. What drinking water that is available is located at the existing boreholes (deep drilled). We did not demonstrate the hand auger well drilling at this reserve, nor do we feel this is a viable method of providing the Fulani sanitary drinking water.

At our initial meeting, the Fulani leaders had identified 4 priority areas for new boreholes. During our days on the reserve, we built a spatially correct map with the GPS and visited all the boreholes and water sources in order to determine coverage of available water. We explained the priority criteria: our desire to locate the boreholes where they can provide both drinking water and livestock water while being available to share between paddocks, settlements and schools. They agreed and provided some refinement of locations (Map Appendix 1).

**MAP**

As in other reserves, we have not seen any maps that depict the boundaries of the Garbagal reserve. When we arrived, the Fulani had updated their former hand drawn map with areas of paddocks along with the water sources, settlements and other physical features. During our first afternoon, we traveled the outer boundary and captured a GPS track of the line. Not surprisingly it is quite different than the hand drawn in some locations. On this reserve, there are drums (55 gallon drums partially buried in the ground) placed in some boundary locations (NE corner and line) and there may be more although none were seen. This seems a good method to communicate boundary lines to encroaching agricultural interests.

The following is a table of the Garbagal Reserve blocks and their size as calculated from the new GPS map. The GPS total area accounts for 18,284 hectares less than the published area. This is a significant difference in total area and cannot be accounted for in any estimation of boundary location. When traversing the reserve in making the GPS map, it was obvious that the reserve was small evidenced in how quickly we were able to drive around the outer boundary and visit all the water sources. In retrospect, it may be advisable to look for more drums outside the estimated boundary lines along the west, south and east lines. The northern line is bound by a major road. The original gazetteing (survey record) of the reserve should be reviewed for accuracy and any maps depicting the reserve should be forthcoming from the appropriate ministry. If the GPS map stands as being the best estimate of area, there is a significant limitation for grazing capacity on this reserve.

|  |  |  |  |
| --- | --- | --- | --- |
| PADDOCK | AREA (Sq. KM) | HECTARES | ACRES |
| 1 | 0.8 | 80 | 198 |
| 2 | 0.5 | 50 | 124 |
| 3 | 0.3 | 30 | 74 |
| 4 | 0.7 | 70 | 173 |
| 5 | 0.7 | 70 | 173 |
| 6 | 0.8 | 80 | 198 |
| 7 | 0.7 | 70 | 173 |
| 8 | 0.5 | 50 | 124 |
| 9 | 0.5 | 50 | 124 |
| 10 | 0.2 | 20 | 49 |
| 11 | 0.3 | 30 | 74 |
| TOTAL | 6 | 600 | 1484 |

**Garbagal Reserve Recommendations:**

1. **Phase 1:**
2. **Drill the 4 boreholes identified as priority for drinking and cattle water**. These were identified by both the Fulani leaders and the Water Development Team as serving the highest and best use at present time.
3. **Fix all sub-standard wellhead pads, replace needed pumps and retrofit existing pumps to include cattle troughs that are separated from the well head.**
4. **Build a spatially correct map of the Garbagal reserve with the reserve boundaries, paddock boundaries, roads, water sources, settlements and schools are captured on a GPS to provide correct placement within the reserve**. The boundary maps are complete including paddocks, roads, canal and existing wells. Follow-up GPS mapping of the settlements and school should be accomplished during the time of the Phase 1 drilling. Distance to water for the settlements could be determined after this, and determination if additional boreholes are needed especially in relation to use by paddocks.
5. **Indicate the urgent need for maps and survey data for this reserve with the authority in Jigawa State. Determine why there is such a significant difference between what the team found and the published area data. Use this information in planning any Phase 2 projects.**
6. **Phase 2.**
7. **Explore the use of small garden plots utilizing the overflow from the drinking water boreholes.** This method was seen at one handpump to be successful and a great way to use the overflow water as an effective irrigation method. This could provide needed nutrition to an impoverished people.

**Bobi Grazing Reserve**

**Niger State**

The Federal Ministry of Agriculture reports the Bobi reserve encompasses approximately 30,235 hectares, (74,712 acres) and is located within central Nigeria SE of Kontagora, due east of the town of Tegina in the Niger State. This reserve lies in the 900mm to 1100mm annual precipitation zone and has a greater prevalence of trees, understory shrubs and grasses than in the other two reserves.

Bobi Reserve is in a struggle for identity. After traveling along the main road, secondary roads, trails and the outer boundary, it is apparent that extensive farm encroachment occurs throughout the reserve not just along the boundary edge. Review of satellite imagery (2012 – Google Earth, 2016 – Google Map) reaffirms this conclusion, showing highly fragmented grazing parcels (mostly around Fulani settlements) among the greater agricultural land matrix. Some verbal estimates from the Fulani indicate over 90% of the reserve is in agriculture. This land use pattern presents a significant issue in terms of both water development, grazing management and overall existence for the Fulani tribe in the Bobi reserve.

This report will not cover the reasons behind the shift in land use other than noting that it appears to have occurred over the last 13 years and has affected the Fulani access to existing water sources. There are few cattle on the reserve at present largely because of the lack of food and the area that they can graze is diminished drastically by agriculture.

The geology of the Bobi reserve appears like Kachia Reserve in that there is ground surface evidence of igneous bedrock (granite/ schist) throughout the highlands of the reserve with additional horizontal layering of basalt in some of the highest elevations. Subsurface contact between these materials and the potential fracture along the contact could provide excellent ground water potential. Previous interviews with the tribal leaders (Haruna Ali, 2017) indicate that the existing wells are approximately 110 – 120 meters deep. The soils appear like laterites, reddish – yellow in color with iron/ magnesium enrichment, plentiful termite mounds and productivity evidenced by the extent of agriculture. The highest elevations occur along the ridge which the main road is located (bisecting the reserve, N – S trending). The land appears to fall away from this with numerous dry streams draining the interior of the reserve along which many dams have been built.

**SURFACE WATER**

Due to time constraints, we were not able to visit all the reserve water sources on this trip. From discussions with the tribal leaders, the reserve is generally well watered for grazing development as indicated on the hand-drawn map. The Fulani leaders claim there is a minimum of one dam (with year-round water) per block. Where we did see dams in our mapping, agricultural use was evident so it is unclear how useful they are to grazing at the present. Where the dams are in close proximity to Fulani settlements they are using them for drinking water. As in the other reserves, it is expected that the dams will need repair of eroding spillways and embankment if they are used for grazing in the future.

**GROUNDWATER**

By sheer geographic extent, it is assumed that most of the existing boreholes and hand-pumps are located in agricultural settlements. These boreholes are estimated to be approximately 100m+ in depth. There are Fulani settlements that travel over 1 km to get to the existing hand-pumps.

Shallow groundwater (into the dry season) may exist on some locations on this reserve (especially in the lowlands near the larger streams and river bottoms). Because of the fragmented grazing opportunity, location of the Fulani settlements and lack of time, we did not demonstrate the hand auger well drilling at this reserve. If all the settlements were GPS mapped, a determination of adjacency to likely shallow water development could be made. Follow-up with the hand auger method could be attempted on a limited basis and possibly provide for Fulani settlement drinking water in some areas.

**HANDPUMPS**

The Fulani claim there are 4 pumps that need repairs or new pumps. They have to send into Kontagora for a service man to maintain the pumps. Fixing and servicing the existing pumps should be a priority. As in the other reserves, the hand pumps are all Mark 2 pumps. None of the pumps have troughs large enough to water herds effectively (currently described as watering 3 – 5 cows at a time). The Fulani feel that troughs at these pumps are not necessarily needed because stock watering occurs at dams.

**MAP**

As in the other reserves, we have not seen any maps that officially depict the boundaries of the Bobi reserve. We are told they exist, but they remained absent, except those hand-drawn by the Fulani. When we arrived, the Fulani had updated their former hand-drawn map with adjustments to the blocks, settlements and other physical features. During our first afternoon, we traveled the outer eastern half of the reserve (BLOCK 6 & 7) boundary and captured a GPS track of the blocks. The following day we traversed the western boundary and interior to establish the boundary of Block 3. Not surprisingly, the GPS map is quite different from the hand drawn in some locations (See Appendix 3). The following is a table of Reserve Blocks and their size as calculated from the new GPS map. The GPS total area accounts for 14,965 Hectares more than the published area. This could be explained in part by the estimation of boundary location (estimated by Fulani representatives,) on the west side of the reserve, as it was not traveled due to the remote, un-roaded location. Further discussion on the use of existing roads or the estimated western boundary could shed light on adjustment of area calculations for the western blocks.

|  |  |  |  |
| --- | --- | --- | --- |
| BLOCK | AREA (Sq. KM) | HECTARES | ACRES |
| 1 | 49 | 4900 | 12,108 |
| 2 | 92 | 9200 | 22,734 |
| 3 | 41 | 4100 | 10131 |
| 4 | 109 | 10900 | 26,934 |
| 5 | 27 | 2700 | 6672 |
| 6 | 90 | 9000 | 22239 |
| 7 | 44 | 4400 | 10873 |
| TOTAL | 452 | 45200 | 111,691 |

**BOBI Reserve Recommendations:**

1. **Phase 1**
2. **Drill the 4 boreholes identified as priority for drinking water to the Fulani settlements**. These were identified by both the Fulani leaders and the Water Development Team as serving the highest and best use at present time.
3. **In existing Fulani settlements, contract with local service man to repair and maintain the pumps that are not currently working. Fix all non- functioning hand- pumps, sub-standard wellhead pads, replace pumps where necessary.** While the 4 boreholes are being drilled, survey the existing Fulani settlements for pump needs. Where they are needed, service and repair the pumps in the existing Fulani settlements. Note which settlements do not have accessible water and compile a list for future well development. Rather than developing any more grazing water, put priority to fixing existing hand-pumps and developing drinking water boreholes to the Fulani settlements. There are 3 additional borehole sites already identified by Fulani leaders as being a priority.
4. **Teach the Fulani’s how to service their own pumps, provide tool packs, and encourage preventative maintenance.**
5. **Build a spatially correct map of the Garbagal reserve with the reserve boundaries, paddock boundaries, roads, water sources, settlements and schools are captured on a GPS to provide correct placement within the reserve**. The boundary maps are complete including blocks and paddocks. A follow-up map of the Fulani settlements and schools could be accomplished during the time the Phase 1 drilling is occurring. Distance to water for the settlements could be determined after this, and determination if additional boreholes are needed especially in relation to use by paddocks. Three additional priority boreholes have been identified (see Map of BOBI)
6. **Phase 2:**

**a. Followup with the GPS map using Google Earth/ Google Map or other recent satillite images to determine the extent of the agricultural encroachment in the Reserve.** Approach the authorities with the data, map and facts and make them aware of how this affects the original intent of the reserve and the Fulani people.

1. **Develop a portfolio of further projects such as schools, their priority, and estimated costs for use in fund raising.**

Water Development Report submitted by Chester Novak, Bill Flansburg and Phyllis Sortor, Schools for Africa.

TABLE 1: ESTIMATED WATER DEVELOPMENT COSTS

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| ITEM | ESTIMATED COST (Nigerian Naira) | ESTIMATED COST (USA Dollars) | UNIT (S) | Average Cost per 90 m deep well | COMMENT |
| Drilling | 9,000 | $20 | per meter | $1800 | Includes drilling, casing and completion. |
| Drill Site survey | 35,000 | $78 | per site | $78 | Geotech survey for optimum location |
| Complete set of wellhead: Mark 2 pump, 30 M of pump pipe and couplings, valves | 150,000 | $333 | per 1 well | $333 |  |
| extra pipe to complete borehole pump (average 60 m) | 7500(75,000) | $17($166) | per 6 m(per 60 m) | $166 |  |
| Drinking water sanitary pad | 25000 | $56 | per 1 well | $56 |  |
| Cattle Trough and access pipe | 225,000 | $500 | per 1 – 10 m long trough with buried access pipe to well head. | $500 |  |
| TOTAL |  |  |  | $2933.00 |  |
| ITEM | ESTIMATED COST (Nigerian Naira) | ESTIMATED COST (USA Dollars) | UNIT (S) | Average Cost per dam | COMMENT |
| D-4 CAT BulldozerMove in | 110,000 | $244 | per reserve | $61 | May only be needed in Kachia |
| D-4 CAT | 120,000 | $266 | per 8 hr day | $798 | May only be needed in Kachia |
| Equivalent Tracked Backhoe Move in | 70,000 | $155 | per reserve | $39 | May only be needed in Kachia |
| Tracked Backhoe | 80,000 | $177 | per 8 hr day | $531 | May only be needed in Kachia |
| TOTAL |  |  |  | $1429.00 |  |

\* in Nigeria Naira (at march 2017 exchange rates)

Table 2 Hand-Dug AUGER WELL equipment.

|  |  |  |  |
| --- | --- | --- | --- |
| ITEM | Cost\* | Quantity | Comment |
| Drill Kit: 5 inch Auger bit, chipping bit, 50 ft of drill stem, stem pins, travel bags | $1000 | 1 kit | Plan on $50.00 for shipping this kit and any additional products from AMS to the point of departure. For Shipping to Nigeria during a plane flight, plan on 2 bags per kit with little additional weight available |
| Individual 5 inch auger bits | $185 | 1 | combine with other order |
| Bailer Bucket parts | $35 | 1 kit | combine with other order |
| Well Repair Tool Kit | $1200 | 1 kit | Plan on $50.00 for shipping this kit and any additional products from AMS to the point of departure. For Shipping to Nigeria during a plane flight, plan on 1 + bags per kit as this is approximately 58 lbs. |
|  |  |  |  |

\* Does not include shipping

**Table 1. KACHIA RESERVE TABLE OF EXISTING WATER SOURCE DATA.**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| BLOCK # | Dams Functioning | Dams NOT Functioning | Boreholes Not Functioning | Boreholes Functioning | Adjacent River |
| 1 |  | 2 |  | 1 | ADUNA |
| 2 | 1 |  | 1 | 1 | KADUNA |
| 3 | 1 |  | 1 | 3 | KADUNA |
| 4 |  | 2 |  |  | KADUNA |
| 5 |  | 1 | 4 | 1 | ADUNA |
| 6 |  | 1 |  |  | ADUNA |
| 7 |  | 1 |  |  | ADUNA |
| 7-8 |  | 5 | 3 | 1 | ADUNA |
| 9 |  |  | 3 |  | KADUNA |

**Table 2. BOBI RESERVE TABLE OF EXISTING WATER SOURCE DATA.**

|  |  |  |
| --- | --- | --- |
| BLOCK # | TYPE OF SOURCE | COMMENT |
| 1 | 4 DAMS | ALL IN THE FEDERAL RANCH, NW CORNER, 2700 HECTARE AREA, water year-round |
| 2 | 1 DAM1 Handpump | Dam has year-round waterHandpump needs repair, Mallawa Fulani settlement. |
| 3 | 1 Solar pump1 Handpump1 DAM | Solar is good and there is a trough (Fodder Bank).Handpump not working (Livestock Service Center)Dam – water year-round |
| 4 | Bolo Bolo River1 well | River flows year-round as do tributary streams that flow into the river from the Block.Well never completed with a handpump (Tin Tin), needs to be assessed, with pump and pad installed. |
| 5 | 1 DAM1 Solar pump | Dam has water year-roundPump not functioning, never worked well. Question as to whether borehole is OK? This needs to be checked. (Gidanmainjin)  |
| 6 | 1 DAMNo Hand-pumps | Dam has year- round water |
| 7 | 1 small DAMNo Handpumps | Dam has low to no water during dry season. (Kilishi) Has a high population of Fulani |

|  |  |  |
| --- | --- | --- |
| Source | Need | Depth |
| Windmill well | Needs new drinking water pad. New valve (1.25”) to regulate water to cattle trough)  | 150 m deep |
| Hand-pump 1 : Paddock 1 | Hole in pump pipe, little suction. Replace hand pump pipe, redesign and install cattle trough away from drinking water pad. Needs new drinking water pad | 76 m deep |
| Hand-pump 2 | Needs installation of new cattle trough away from drinking water source | 75 m deep |
| Hand-pump 3 | Needs new drinking water pad. Install cattle trough away from drinking water pad.  | 70 m deep |
| Hand-pump 4 | Needs new pump (Mark 2), new drinking water pad and cattle trough. Needs a new foot valve in well. | 70 – 80 m deep |
| Hand-pump 5Paddock 10 | Needs new drinking water pad. Install cattle trough away from drinking water pad. Needs new foot valve in well. | 70 m deep |
| Hand-pump 6 | Needs new pump (Mark 2), new drinking water pad and cattle trough. May need a new foot valve in well. | 75 m deep |
| Hand-pump 7 | Needs new pump (Mark 2), new drinking water pad and cattle trough. May need a new foot valve in well. | 75 m deep |
|  |  |  |

**Table 3. GARBAGAL TABLE OF EXISTING WELL DATA.**