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Evaluation of the potential for bank filtration along the Barranca river in Puntarenas, Costa Rica

Proyecto final de graduación para optar por el grado de
Licenciatura en Ingeniería en Construcción

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CONSTANCIA DE DEFENSA PÚBLICA DE PROYECTO DE GRADUACIÓN

Proyecto de Graduación defendido públicamente ante el Tribunal Evaluador, integrado por los profesores Ing. Gustavo Rojas Moya, Ing. José Andrés Araya Obando, Dr. Luis Guillermo Romero Esquivel, Ing. Braulios Umaña Quirós, como requisito parcial para optar por el grado de Licenciatura en Ingeniería en Construcción, del Instituto Tecnológico de Costa Rica.

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Abstract

Because of continuous potable water pollution and scarcity of sources, water utilities in CR are exploring alternate or cost-efficient water treatment methods such as bank filtration (BF). Such is case of the Barranca extraction site. The aim of this study is to evaluate the potential for BF at the mentioned location. The site consists of two operational pumping wells. The occurrence of riverbank filtration (RBF) was evaluated according to the geomorphological, hydrogeological, and geological criteria as well as water quality analysis. Lithological profiles, well dimensions, and water quality were provided. A topographic survey, pumping test, and a riverbed sediment analysis were conducted. Groundwater flow modeling was carried out with PMWIN to obtain final hydraulic heads and travel time. An operational scenario was modelled to determine a possible improvement to the site. Total extraction rate was measured at 12.53 L/s. The aquifer thickness was determined at ≈24 m and hydraulic conductivities were estimated to be 2.14×10^{-4}-2.57×10^{-4} m/s. A giving type stream was determined as an average difference of ≈4 m between surface and groundwater levels was obtained. Water quality analysis showed a reduction of up to 53.78±193.66 NTU in the wells. The model was determined to have a maximum 20 cm difference between calculated and observed heads. Water travel times were estimated. A 12% of the river water reaching the wells estimated to have a travel time of 80-110 days; 22%, 10-60 days; and 66%, ≤10 days. Results suggest the possibility to substitute the water treatment plant (WTP) for wells. Modeling showed a possibility to extract 80 L/s in five wells and operational cost evaluation estimated a 29% decrease in costs in respect to the WTP. The occurrence of RBF in the study site was concluded according to the criteria selected and corroborate by the modeling. This study demonstrates the potential for RBF as an alternate cost-efficient water pre-treatment method.

Keywords: Riverbank Filtration, Hydrogeology, Groundwater flow modeling

Resumen

Debido a la contaminación del agua potable y la escasez de fuentes, las empresas de agua en CR están explorando métodos alternativos o rentables de tratamiento de agua, tal como la filtración inducida (BF). Tal es el caso del sitio de extracción de Barranca. El objetivo de este estudio es evaluar el potencial de BF en el sitio mencionada. Este consta de dos pozos de bombeo. La ocurrencia de la filtración inducida en el lecho del rio (RBF) se evaluó por geomorfología, hidrogeología, geología y análisis de la calidad del agua. Litología, dimensiones de pozos y calidad del agua fue suministrado. Se realizó un estudio topográfico, prueba de bombeo y un análisis de sedimentos del río. Se modeló el flujo de agua subterránea con PMWIN obteniendo los niveles hidráulicos finales y el tiempo de viaje. Se modeló un escenario operativo para determinar una posible mejora del sitio. Un caudal de extracción total de 12,53 L/s se midió. El espesor del acuífero se determinó a ≈24 m y la conductividad hidráulica se estimó en 2.14×10^{-4}-2.57×10^{-4} m/s. Se determinó una diferencia promedio de ≈4 m entre el nivel del rio y del agua subterránea. El análisis calidad del agua mostró una reducción de hasta 53.78±193.66 UNT en los pozos. Se determinó una diferencia máxima en el modelo de 20 cm entre los niveles calculados y las medidos. Se estima que un 12% del agua del río que llega a los pozos tiene un tiempo de viaje de 80-110 días; 22%, 10-60 días; y 66%, ≤10 días. Los resultados sugieren la posibilidad de sustituir los pozos por la planta de tratamiento. La modelización mostró la posibilidad de extraer 80 L/s en cinco pozos y la evaluación de costos operativos estimó una disminución del 29% con respecto a la planta. La ocurrencia de RBF en el sitio del estudio se concluyó de acuerdo con los criterios seleccionados y corroborados por el modelo. El estudio demuestra el potencial de RBF como un método alternativo y eficiente de tratamiento de agua.

Palabras clave: Filtración inducida, hidrogeología, modelación de flujo de agua subterránea

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ESCUELA DE INGENIERÍA EN CONSTRUCCIÓN

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Preface

Costa Rica is a green plush country with plenty of rain and water and it has considered to be an inexhaustible resource. Its abundance has been taken for granted and was not properly looked out for. As the country's population increases surface water sources are over exploited, its contamination increases, and purification has become more challenging. Every day more chemicals and pharmaceuticals are dumped into rivers and streams. Contaminant concentrations increase, and new ones appear. Conventional purification methods are proving difficult to keep up with the production as the population grows. Water treatment plants are being saturated and must be scaled up. Costs increase and with that water prices. And through all this, most of the population is ignorant of danger and its consequents. Added to this, water has become scarcer in certain parts of the country for which new sources must be searched. Sustainability and cost-efficient treatment methods are also important issues to be considered in the search for new alternatives.

New water treatment methods and filtration systems are being researched in the country. BF has been applied in Europe for over than 130 years and has references to Biblical times (Exodus 7:24). The method has been investigated and refined. In the United States this method has been used as a pretreatment method for about 50 years. In Costa Rica however, the cases where the method was applied was done empirically. No official case or investigation has been reported.

The method consists of strategically placing wells at a certain distance from a river. These create a head difference between the river and the well which then induces a flow through a porous material towards the well. The porous material then acts as a natural filter for the water. The result being pre-treated or treated water ready for consumption. The benefit of using this method is the reduction in resources, time and labor usually used on a water treatment plant.

Climate changes and the El Niño-Southern Oscillation have put pressures on the county's water sources. This leading to water cuts by water utilities especially in the pacific regions of CR. In the central pacific town of Barranca is one of the towns suffering from this situation. There is an active ground and surface water extraction site which supplies the town which at first glance presents the possibility for RBF. The aim of this study is to verify the potential for BF at a well site along the Barranca river in Puntarenas. Various methods for the verification can be used. Since this research is one of the first, on this subject, in the country; a method that could be applied with studied subjects in the country was chosen. The method mainly being through geomorphological, hydrogeological, and geological criteria. A groundwater flow model was used though this to obtain travel times between the river and the well. The result, other than verifying the occurrence of RBF, is to provide operational recommendations for the improvement of the sustainability of the production of water extracted at the study site.

This study is aimed at researchers and water utility companies who are exploring new or alternate water treatment methods.

Regarding the people that helped me through this: First, I would like to thank my tutors Andrés Araya and Luis Romero for taking me under their wings. For always pushing me to learn more than I was taught, expecting me never to settle for the average, and helping me keep in mind that what we do is for improvement of that which surrounds us. To Professor Grischek and the work group at the HTW Dresden, thank you for all your help with this subject. To Dad, thank you for always providing, for encouraging me, and sharing your wisdom. None of this could have happened without you. To my siblings, thanks for understanding why I couldn't always come home and visit. I love you all. To my dear friends, thank you for accompanying me on this journey. You all understand this more than anyone else. Finally, thank you GOD for allowing this to happen. For helping me in my hard times. This is all for and because of you.

Introduction

As a consequence of continuous worldwide pollution and its effects on surface drinking water, water utilities have been exploring and employing new water treatment methods (Maeng, Ameda, Sharma, Grützmacher, & Amy, 2010). Traditional methods consisting of coagulation and flocculation, sedimentation, filtration, and disinfection have turned out to be complicated to implement in developing countries due to their high cost and lack of manpower (Kipkemoi, 2007). A cost-effective solution to this problem is the Bank Filtration method (Wardhani, 2010). According to Kipkemoi, 2007, BF is a water treatment method where surface water pollutants are removed or degraded as infiltrating water moves from a river or a lake, through the ground, to a well where the water is extracted. According to Schön, 2006, BF is the entry of river water into the aquifer induced by a hydraulic gradient. Wells located on a bank at a certain distance from a water source create a pressure head difference between the source and the aquifer. This induces water to flow down through the porous material in to the pumping wells (Maeng, 2010). Due to it being having similar surface water pumping or extraction costs, BF cuts costs in pre-treatment (which include, reagents, manpower, time, space, etc.). Various BF sites could be operated by one single operator, maintenance is low and the lack of need for backwashing allows a continuous operation. When the surface water source is a river, this treatment system is called riverbank filtration (RBF). Likewise, if a lake is used as a source the system is lake bank filtration (Ray, Jasperse, & Grischek, 2011).

In some European countries this mechanism of water treatment has been used effectively for over 100 years (Kuehn & Mueller, 2000) which suggests that they are leading countries in this method. In the United States this method has been used as pre-treatment process for removing microbial pathogens but has been applied as much as in Europe (Hiscock & Grischek, 2002). However, the use of Bank Filtration has been increased by water utilities as it has been proven to be more effective and sustainable around the world (Kipkemoi, 2007). In Latin America (BF) could have a great impact on the way water is managed. In Brazil research proved to remove turbidity and apparent color from water in a lagoon using this method (Romero, Segalla, & Luiz, 2012). In Bolivia BF also proved effective in removing turbidity and suspended solids in the water as well as coliforms (Camacho & Sánchez, 2004). There is a high potential for the use of BF worldwide. For example, in Venezuela, Paraguay, and Argentina there are cities with high population built over riverbanks where the potential use for the method is recommended (Ray, 2008). The main advantage of applying BF is bringing about a reduction in use of traditional water treatment methods, which require large amounts of chemicals and a treatment plant, even though chlorination or other disinfection methods are still required.

Costa Rica is a country known to have considerable water resources yet mostly concentrated in certain periods of the year. Certain regions of the country have long drought periods and, consequently water is scarce (Herrera, 2017). In the last year close to 114 000 people had been suffering from water scarcity problems. The number is predicted to reach 500 000 (10% of the population) in worst case scenario (Rojas, 2019). Cities in the great metropolitan area and in the norther regions of the country have had a limited availability in water resources. Various factors such as climate change, droughts, population increase, contaminated water sources, low recharge/extraction ratio in the aquifers, (Herrera, 2016; Ramírez, 2007), amongst others, have put considerable pressure on the water resources and traditional management methods (Saubes & Gálvez, 2015). Though BF is a widely studied treatment method around the world, there is no registered study in Costa Rica.

Although BF in general has great advantages over traditional water treatment methods it is not applicable at any site. Before applying RBF, the potential for the BF at a site must be verified.

Generally, criteria such as geomorphological, hydrological, hydrogeological, among other are considered when identifying sites. These criteria determine the flow of the water through the ground. Soil particle size as well as determine the flow velocity also has large influence on the level of filtration obtained (Fetter, 2001). If the criteria in the selected site doesn't fit within the acceptable range, either the flow will be too low to keep up with production, or so high that no filtration is obtained. Some authors proposed methodology intended to identify optimal sites based on geomorphological criteria only (Jaramillo, 2015). Surface and groundwater quality are aspects to be considered in the selection of a site using RBF. According to Grischek, 2007; Ray et al., 2011; Schubert, 2002 the inner bends of meandering rivers are preferred sites for RBF if the proportion of bank filtered water in the well should be high. This since a larger portion of water is reaching the wells due to a larger catchment area. Also, sediments deposit on the outer side of the bend which in turn decrease the infiltration of the water into the system. Coarse materials display high conductivity which is necessary in terms of hydraulic-yield. For more natural filtration, poorly-sorted granular material is preferred over well-sorted material due to a more complex network of pore spaces. Furthermore, deeper and bigger alluvial deposits yield higher groundwater storage and a longer flow path from the river system (Hiscock & Grischek, 2002; Jaramillo, 2015). Groundwater flow modeling is carried out in most cases to determine feasibility. Maximum yields and travel times can also be determined through modeling (W.-H. Chiang & Kinzelbach, 2001a). Modflow 2000 determines water flow through the governing groundwater flow (Harbaugh, Banta, Hill, & McDonald, 2000) equation which considers the hydrogeological data determined in the pre selection of the sites. Prediction models also allow the modeling of scenarios which help with selecting optimal sites for the implementation of BF wells.

In the town of Barranca, Puntarenas, a flood left approximately 66 000 people without water due to turbidity levels too high for the WTP to process (Presidencia de la República de Costa Rica, 2017). Also due to the recent problems, exploration of new sources and treatment methods have been considered for this region. In this site extraction wells have been operating to help supply the high demand. There is an interest by the Instituto Costarricense de Acueductos y Alcantarillados (AyA) for the potential use of RBF in this region. The study site was provided by the AyA. It is in the Pedregal-Procamar quarry in Barranca, Puntarenas. This research has the collaboration from the UEN de Investigacion of the AyA and Prof. Dr-Ing. Thomas Grischek form the University of Applied Sciences Dresden. As a result, the overall aim of this study was to evaluate the potential for bank filtration along the Barranca river in Puntarenas, Costa Rica. The specific objectives of the study were; (1) to verify if the wells that operate along the Barranca river are performing RBF using geomorphological, hydrogeological and geological criteria and water quality analysis, (2) to determine final hydraulic head and transit time between the river and the wells using PMWin and Pmpath, and (3) to provide operational recommendations for the improvement of the production of water extracted at the study site

Materials and Methods

The study was carried out as an applied investigation. It consisted of nine stages including field studies and modeling. The collected data was used to determine the first objective as it considers the hydrogeological, geological and geomorphological data. Data was verified through literature and personnel interviews. Data was analyzed using Ms Excel, maps were obtained using QGIS and Google Earth. Diagrams and drawings were carried out using AutoCad.

The study was carried out as shown in Figure 1.

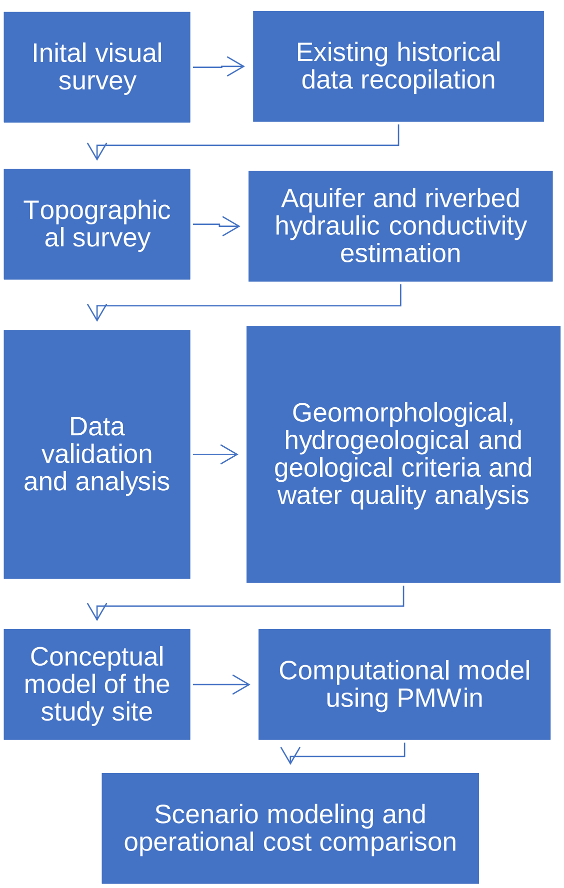

Figure 1 Workflow process followed for this study

Site selection, survey and preliminary data collection

The case study site for this research is located along the Barranca river in the town of Barranca, Puntarenas, Costa Rica. The site was selected for the study as it is an existing water extraction site for the AyA, located at an adequate distance from the river This case has the peculiarity of having the wells located inside the active Pedregal-Procamar stone crushing quarry.

The site consists of five pumping wells (PW), of which only two are operational. These are in an alluvial deposit. However, most of the area has been filled and compacted with material form the quarry. A weir was placed in the river to diverts water into an intake leading to a pumping station which supplies the town of Barranca and its vicinity (Figure 2).

The project is being carried out alongside the investigation branch of the AyA. Data pertaining to the wells such as: lithological profile for each perforation, extraction rates, dimensions and, history were provided by the AyA. The data provided were historical records form 1988 for PWs 1,2, and 3 and from 2016 and 2017 for PWs 5 and 6 respectively (annexes). Data was corroborated with officials and operators. Comments suggest that the top layers were thicker than the profile for the old records as construction was carried out in the area in recent years.

An initial visual survey was carried out as to determine the possibility of RBF. Preliminary data such as site location, contact information, well integrity and operational restrictions were determined.

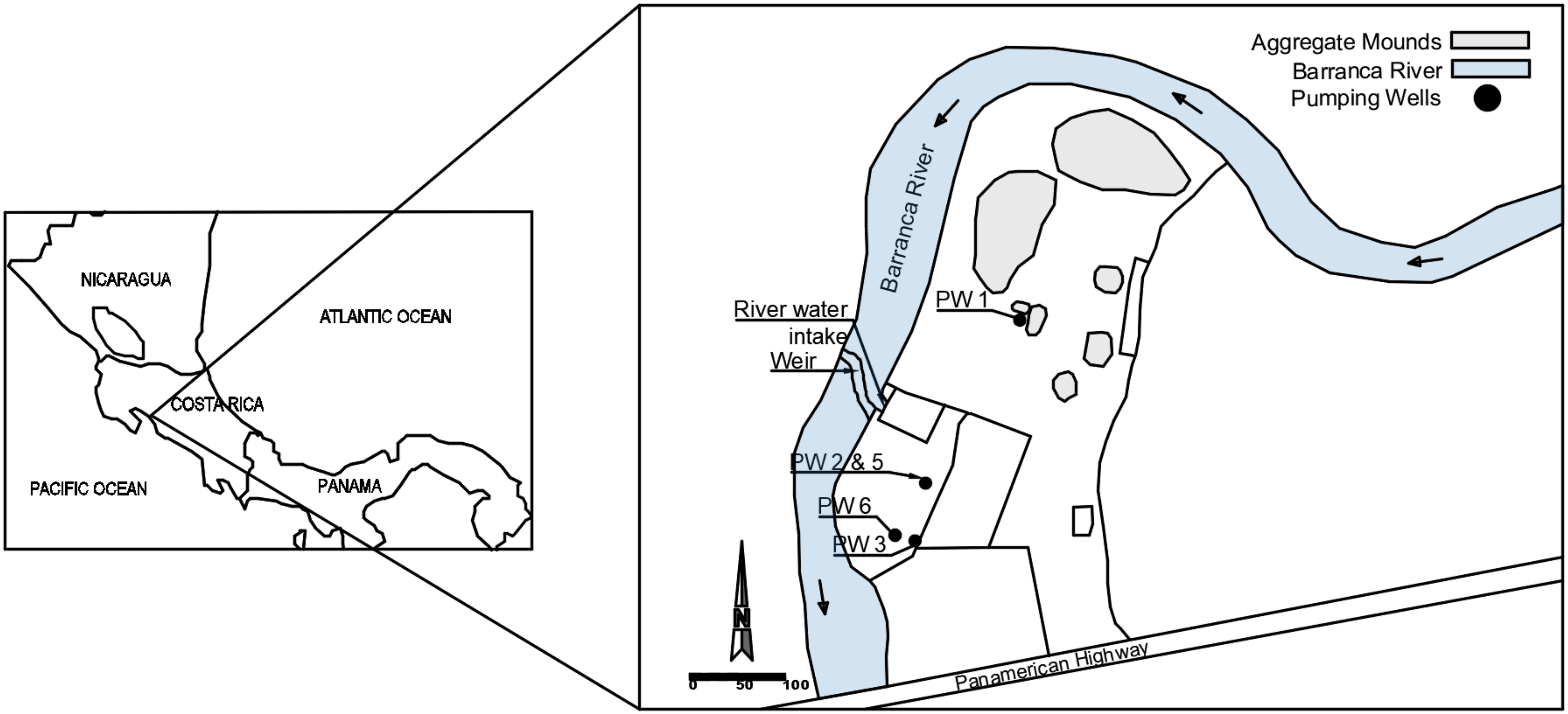

Figure 2 Location and map of study site

Historical water quality analysis was carried out by the Laboratorio Nacional de Aguas and were provided by the AyA. Well water analysis was identified in the reports by the well numbers. Information included physical-chemical analysis of raw water from the WTP in Barranca. This water is taken out of the Barranca river intake located at the study site. Raw water analysis from the wells were also provided. Comparisons were made between the raw river water and the well water.

The data registered was from 2008 to 2019. The well water data analyzed was registered from between 2013 and 2018 (annexes). A maximum of 90 samples were used in the river water analysis and in some cases only one measurement of a certain pollutant was registered. Well water analysis form all the wells were averaged and analyzed as one. Well water samples were less using a maximum of 20 samples. Measurements for concentrations of the same pollutant were averaged and the standard deviation was estimated. Concentrations of apparent color and turbidity were the measured in all the cases (up to 90 or 20 samples) as these tend to have the highest values (surpassing the maximum accepted values). Values related to water hardness and heavy metals were also analyzed this.

A survey of the well site was performed using and a Sokkia SET610k total station Leica GNSS RTK Rover (Table 1). The Rover was used to determine the exact coordinates for the site cairn as well as precise coordinates and elevations for the wells. The total station helped survey the topography of the surrounding area including the river and riverbank.

The river water level was measured at the edge of the river by positioning the base of the prism (used with the total station) at the water level. The river depth was assumed though this was done in the modeling stage of the study. Though the measurements were carried out in the transition time between the dry and rainy season. The most critical measurement would be when the water level is at its lowest (dry season). A lower river water level would imply a lower groundwater level. This however would have implied to wait six months. As the river was at its normal level according to the operators these values were considered to be adequate for the study. Further analysis would have to be carried out to verify the implications and its effects on the system.

Table 1 Topographic equipment

Brand	Model	Accuracy
Sokkia	SET610k	Angle accuracy: 6"
		Distance minimum display: 1mm
Leika GNSS	GS14	Static (phase) with long observations: Hz 3 mm + 0.1 ppm / V 3.5 mm + 0.4 ppm
		Static and rapid static (phase): Hz 3 mm + 0.5 ppm / V 5 mm + 0.5 ppm

Estimation of hydraulic conductivity

To estimate the hydraulic conductivity of the aquifer a constant rate pumping test including its recovery phase was performed (Figure 3 & Figure 4). The test was carried out alongside AyA well operators and officials (a total of 8 people was involved, 2 per well measured). Measurements were taken using electric contact tape measures with a precision of ±1.0cm used specifically for measuring water levels. The recovery phase was carried out prior to the actual test due to high demand of the site, limiting the maximum shut off period to about 3 hours as indicated by the AyA. The pumps had been running continuously for over 24 hours to ensure a stabilized flow condition. Due to a lack of observation wells, the non-functioning PWs (1, 2, and 6) were used as such. The frequency of the measurements from the shut off and startup of the pumps were (Table 2). Both pumps were shut off simultaneously. Measurement of the residual drawdown was then measured according to the frequency in Table 2. The residual drawdown is the level measured as the water rises. Once stabilization was reached the pumps were turned on simultaneously. The drawdown was measured according to Table 2. The test was finished once stabilization was reached. Stabilization was considered as a constant level (±0.01 m) for at least 15 minutes according to Paufler et al., 2018. The well discharge was measured using an Hydreka Chronoflo2 ultrasonic flow meter (0.012 L/s ± 0.5% of reading) which was fixed to the outgoing pipe of the well and measured every minute (Table 5).

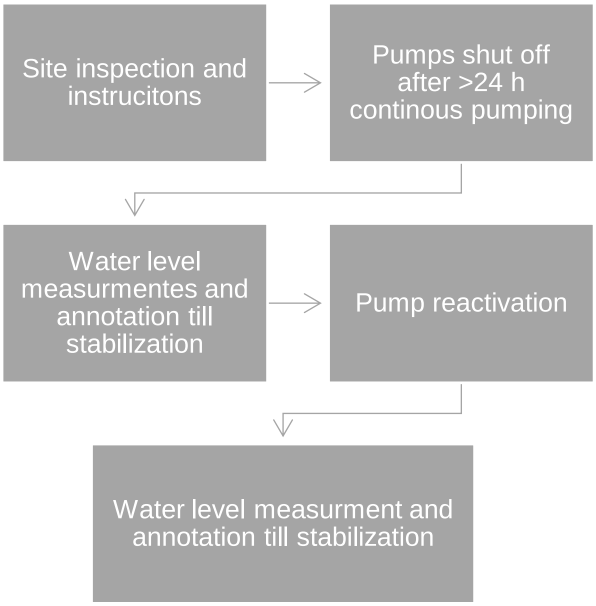

Figure 3 Basic diagram of pumping test process carried out

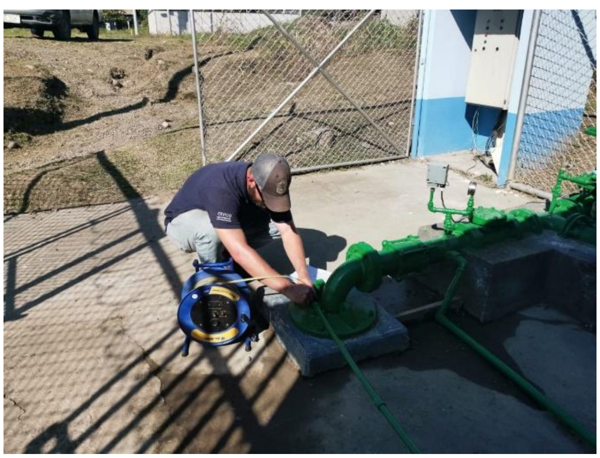
Figure 4 Water level measurements during pumping test

Table 2 Measurement frequency pumping test

Frequency, one measurement every:	Elapsed time, for the first:
1 min	5 min
5 min	5 to 60 min
15 min	60 to 120 min
30 min	120 to 240 min

Using pumping test data obtained, a residual drawdown (water level measured from the time the pump was shut off (t_0) to a specific time of the test (t_n)) versus time graph was created and results were and analyzed according to the Theis recovery method for single-wells in unconfined aquifers Equation 1 described by Kruseman & de Ridder, 1990. The aquifer was considered to be unconfined as it presents only a impermeable layer (Punta de Carballo) confining the lower level. The upper levels were considered to be alluvial deposit and highly preamble as such.

$$K = \frac{2.30Q}{D4\pi\Delta s'_w} \quad (1)$$

K, hydraulic conductivity in m/s; *D*, saturated aquifer thickness in m; *Q*, well discharge in m^3/d; s'_w, residual drawdown inside PW in m.

The K-values were estimated using equation 1 according to data from both functioning wells. The flow data obtained was close to those mentioned by the operators. The resulting k values were considered reasonable as they were close to the theoretical values found in the literature. This will be explained in the discussion section. The resulting hydraulic conductivities were averaged to obtain an approximate k-value for the aquifer in the area surrounding the wells. The estimation of the hydraulic conductivity for the rest of the area is discussed in the results and discussion section.

Riverbed sediment analysis

Five riverbed sediment samples were taken to estimate the hydraulic conductivity of the riverbed. The samples were taken at different points separated by about 100 m each (splitting the total distance analyzed in almost equal parts) along the shore of the Barranca river in front of the RBF wells (Figure 5). Each sample was that equivalent to a 1-gallon bucket. The limitation of only taking this sample once is that as river deposits more sediment the result may vary. Despite that, the value obtained gave a range in which future values could vary.

Figure 5 Sediment samples taken from the Barranca River

The samples were oven-dried at 110 ± 5 °C for 24 hours and separated according to the analysis required (granulometric analysis and permeability test). Percentage of materials finer than 75-µm (No. 200) sieve was estimated through washing according to Standard C117-17 (ASTM International, 2017). Sieve analysis and grain-size distribution curve were determined according to standard C136/136M-14 (ASTM International, 2014).

Hydraulic conductivity of the clogging layer was approximated by two methods. First, by using the disturbed granular samples taken from the river, the k-value was estimated by means of a constant head permeability test (Figure 6) according to standard T 215-14 (AASHTO, 2018). Second, since the samples used were deformed and this could influence the results in the constant head permeability test, the Hazen Method was used as verification according to Fetter, 2001; Kruseman & de Ridder, 1990; Weight & Sonderegger, 2001. This method consists in determining the theoretical k-value according to the granulometric distribution of the sample (equation 2). The results were analyzed and verified according to the theoretical values discussed later on.

$$k_{clog} = C(d_{10})^2 \qquad (2)$$

k_{clog}, estimated k-value of the clogging layer in m/s; C, sorting and grain size coefficient m*s^{-1}; d_{10} effective grain size in cm.

Figure 6 Constant head permeability test

Groundwater flow modeling and travel time estimation

The following methodological steps were taken according to Schön, 2006:

1. Preparation of the conceptual model, involving the survey and data interpretation regarding the geological system.
2. Translation of the conceptual model into the numerical model, involving definition of the input parameters, discretization of the area, definition of boundary conditions, simulation condition, and processing of the model.

Anderson et al., 2015 proposes the following workflow for modeling purposes.

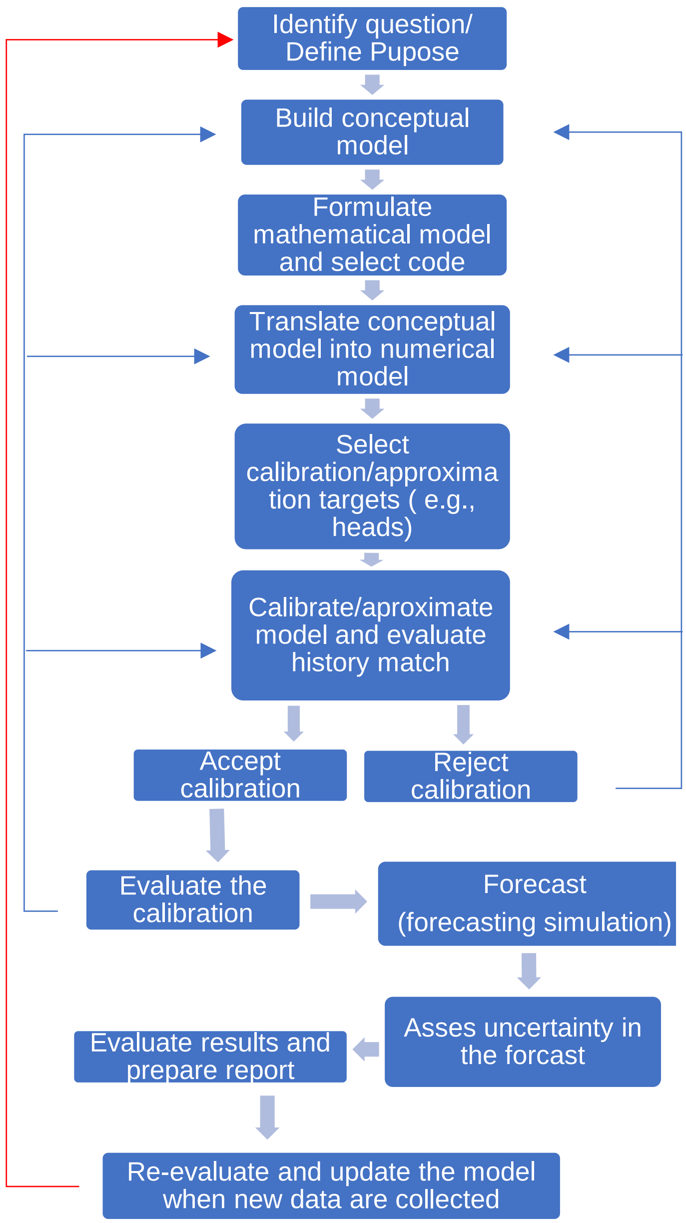

Figure 7 Applied groundwater flow workflow adapted from Anderson et al., (2015)

Conceptual model

The components of a conceptual model for groundwater flow are suggested by Anderson et al., 2015 as follows.

- Boundary conditions
- Hydrogeological properties
- Flow direction, sources and sinks
- Groundwater budget components

Boundary conditions of a conceptual model determine the mathematical conditions of the numerical model and are considered key components. The boundaries can be identified form potentiometric, topographic and geologic maps as well as site studies. Impermeable soils or rocks are considered boundaries as they do not permit the flow of water through them. During the conceptualization of the model for this study, the boundaries were determined by the Punta de Carballo rock formation surrounding the study area. This was also the inferior boundary for the model. This formation was determined by the lithological profiles provided by the AyA and was validated according to the Barranca geological map according to Denyer, Aguilar, & Alvarado, 2011.

The hydrogeological properties of the site are to be considered as these affect the flow of water thought the ground. Values such as riverbed infiltration rate (CRIV), ground vertical and horizontal hydraulic conductivity, and aquifer type were determined. Pumping test data provided the hydraulic conductivity and it was validated according to the theoretical values. Riverbed sediment analysis estimated infiltration rates from the river into the system. Lithological profiles gave an idea as to the type of aquifer and the thickness of the layers.

Flow direction was determined through a measurement of the water surface levels and the well static levels. Sources to be considered are groundwater, rainwater, rivers, lakes etc. In this case the only source considered was the river. The reason for this decision is discussed further on.

Groundwater budget balances the total input and output of the system. Sources and extraction conditions are to be considered. In this case the river and extraction wells were the only to be applied to the conceptual model. The reason for this will be explained further on

Computational model

Once the conceptual model was discretized and the input values were estimated the following process was carried out in PMWin. The PMWin manual (W.-H. H. Chiang & Kinzelbach, 2001) was consulted for step by step guide

1. Grid mesh size, layer number and map input
2. Layer type and boundary conditions
3. Parameter input
4. Extraction wells, observation wells, and river input
5. Model compilation
6. Comparison between observed and calculated head
7. Parameter modification
8. Steps 5 and 6
9. Error calculation
10. Particle tracking and travel time estimation
11. Result report

Mesh size was consulted to experienced modelers (T. Grischek, personal communication, October 2018). The layer number was determined by the lithological profiles. Maps were processed using GIS based software.

Layer types were determined by the type of aquifer. The boundaries were conditioned as no flow type by the surrounding bedrock.

The parameters were:

- Layer top and bottom: Estimated by topographic survey and lithological profiles
- Initial hydraulic head: approximated though measurement of well static levels
- Hydraulic conductivity: Estimated by pumping test data analysis.

The extraction wells were located by means of topographic survey and extraction rates by ultrasonic flow measurement. Observation wells were also located by survey and the levels by physical measurement. River surface levels were again determined by survey. River bed conductance was estimated by sediment analysis. Assumptions regarding thickness of clogging layer and water depth had to be made as they were not measured.

Model compilation was carried out and the calculated heads in the observation wells were compared to the observed values. To approximate these values k-values, riverbed infiltration rates, and well extraction rates were modified within the acceptable range stated in the literature. This will be discussed further on.

Operational scenarios

An operational scenario for the extraction site was modeled. This, to present technical and operational recommendations seeking to achieve an optimization and increase in the water production. The scenario was aimed at replacing the WTP with RBF wells. The purpose of removing the water intake is to hypothetically reduce costs in pre-treatment in the WTP by allowing the totality of the water supplied to be extracted through RBF wells.

To achieve this, a removal of the quarry (since extraction wells should not be inside a production site), a decompression of the soil, and a normalization of the k-value was assumed. This was done by following the steps of the previous section. The observation and extraction wells were removed. The k-value mas modified throughout the model to the values obtained by the pumping test. New wells were located. Estimating a population of approximately 3400 users (INEC, 2011) (a 1.16% populational growth rate was considered ("Costa Rica Demographics Profile 2018," 2018)) and a daily consumption of 200 L/d (AyA, 2017), an extraction rate of ≈ 80 L/s was estimated. Five wells were placed, using the software's well package, along the study site, at a maximum distance possible to ensure maximum filtration, with extraction rates of 16 L/s. No approximation was carried out since it is a hypothetical scenario. The only value checked was the total drawdown in the wells as this could not be lower than 1/3 of the total well depth which is where the pumps would be placed.

Operational costs for the proposed scenario were estimated. Data for water treatment costs were obtained from workshop done by the AyA in 2015 (Araya & Merizalde, 2015). A comparison between operational costs per cubic meter produced in a WTP and through RBF was made. The operational cost for the RBF wells was determined by estimating manpower, electric consumption, and chlorination costs per second. This was then multiplied by the time it takes the pumps to extract one cubic meter of water. The costs were taken from a cost breakdown for an operational well done in 2015. By this mean the costs were considered to be comparable. Details of this are found in the next section.

Results

The following sections show the results obtained from the given and collected data. Results pertaining to site description, surveys, well lithological profiles, water quality, aquifer and riverbed k-values were used as the selected criteria to analyze the potential for RBF at the site. The groundwater flow modeling corroborated the first step along with giving results as to travel times and the operational scenario selected

Site Description, survey and preliminary data collection

Upon arrival the first noticeable issue was the location of the well site. As observed in Figure 15, the PWs are located inside an active quarry. Figure 8 shows a clearer view of PW1 surrounded by large aggregate mounds and a rock crusher behind the well house. This well is non-operational due to formation of black sludge and bad odor in the water. The origin of the sludge and odor are unknown to the water company and no analysis has been made.

Figure 8 Location of pumping well 1 inside quarry

According to information provided by AyA, PW5 (Figure 9) and PW6 (Figure 10) were drilled in 2016 and 2017 respectively. This to substitute PW2 (Figure 9) and PW3 (Figure 11) which have been operating since 1988. Only PW5 has been activated while PW3 remains operating. At the PW3 site, a gas chlorination unit for all extracted water is housed.

Figure 9 Pumping wells 2 and 5

Figure 10 Pumping well 6

Figure 11 Pumping well 3 and chlorination station

At the surface water intake (Figure 13) at large amounts of sediment were observed. A stone and boulder weir (Figure 12) divert a large portion of the river towards the intake. The sediment settles at the intake and consists of fine sands mixed with decomposing organic material (mainly leaves were identified). The sand along the riverbank north of the weir also contained large amounts of this material the occasional flooding washes away the weir and the sediment. Since machinery operates upstream form the site, the water is visually highly turbid. The suspended material created by the machines were then carried and deposed along the bank of the river were flow was non-turbulent and at the water intake.

Figure 12 Weir at water intake

The topographic survey supplied surface elevations of the wells and the river at different locations. Measuring water levels before and after the pumping test provided dynamic and static levels in each well. The lithological information was supplied. The following profiles were obtained at each of the pumping wells (Figures 12, 13, 14). Table 3 shows the well dimensions.

The average river surface elevation north of the weir 54.61 m above sea level (asl). The furthest point and point closest to the base were used to calculate the average. In the same way, the southmost point and the base point were used to estimate the slope of the river south of the weir which was 2.42% (Figure 14).

Figure 13 Surface water intake sediment

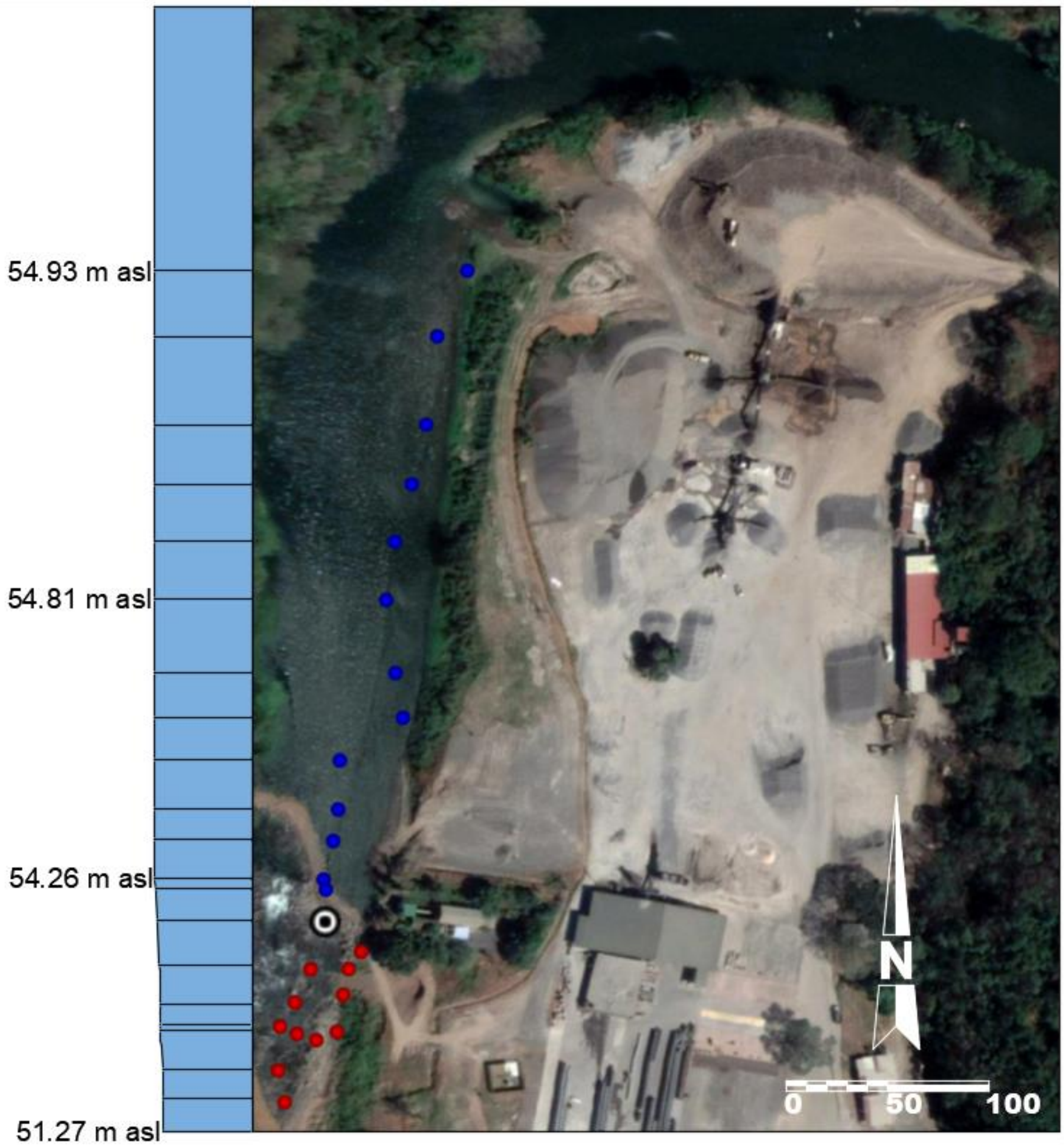

Figure 14 River surface elevation measurements

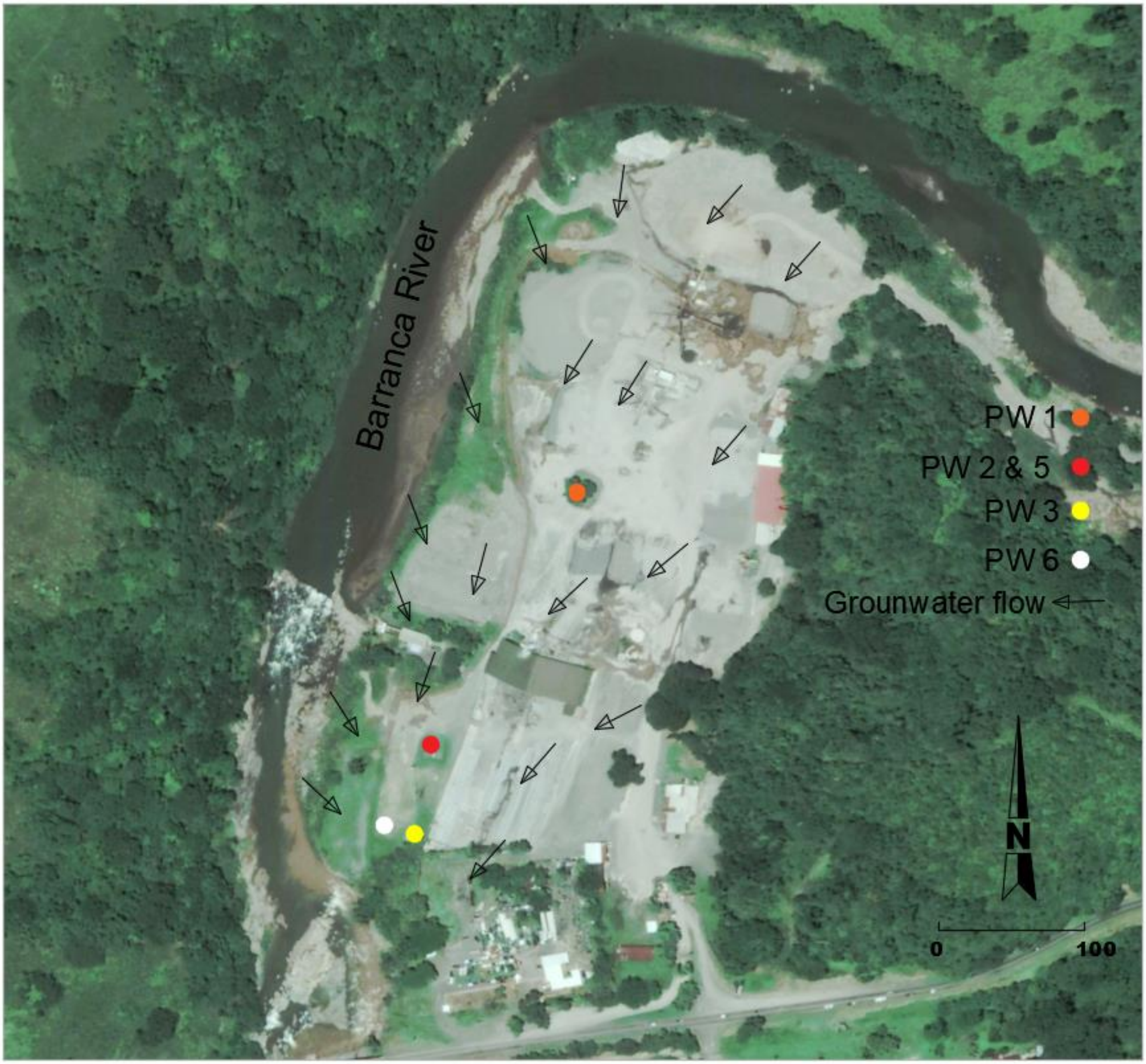

Figure 15 Aerial view of study site

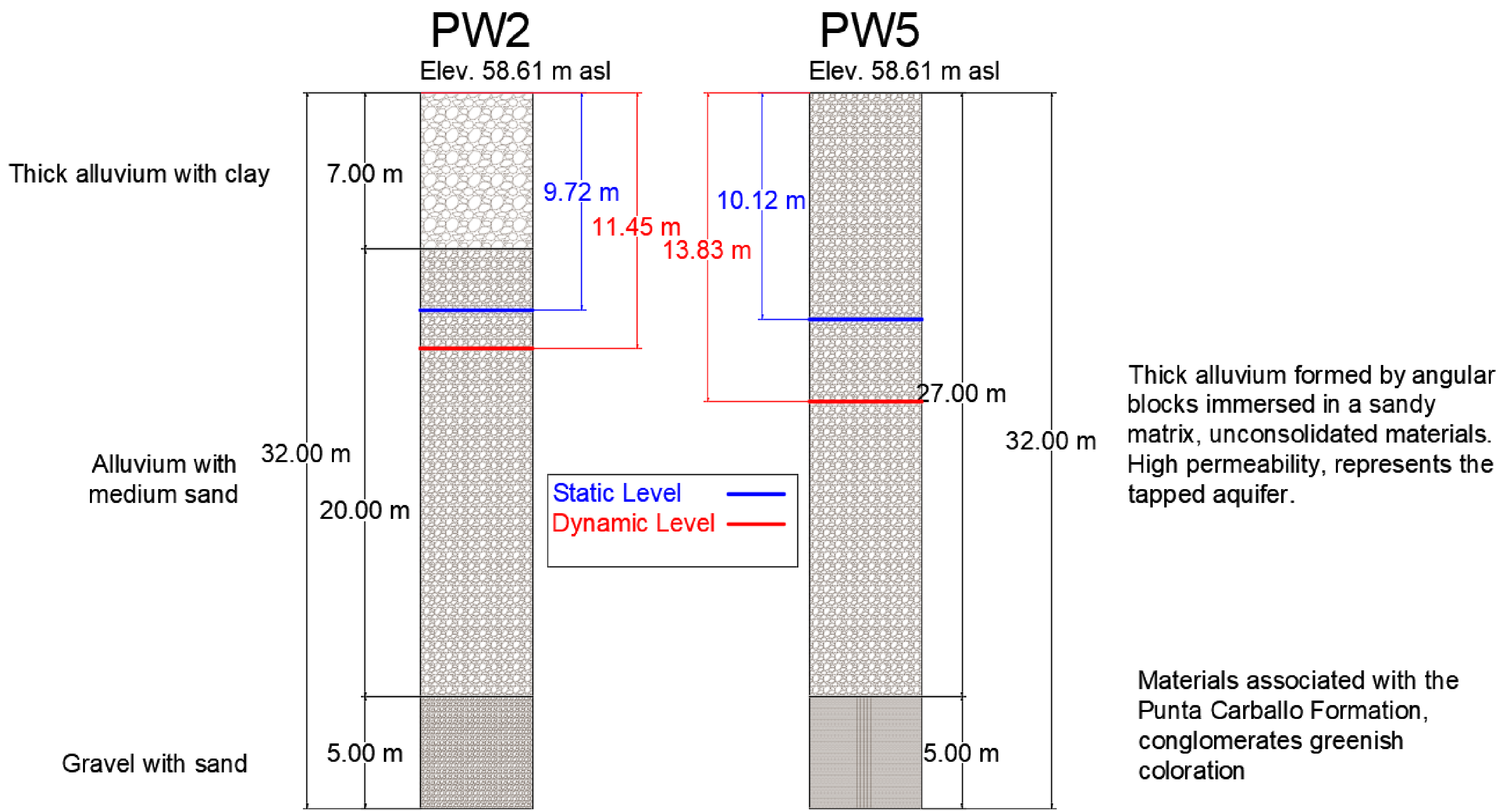

Figure 16 PW2 & PW5 Surface elevation, lithological profile and water level. Data provided by the Aya. Profile dates: Pw2 1988 and PW5 2016

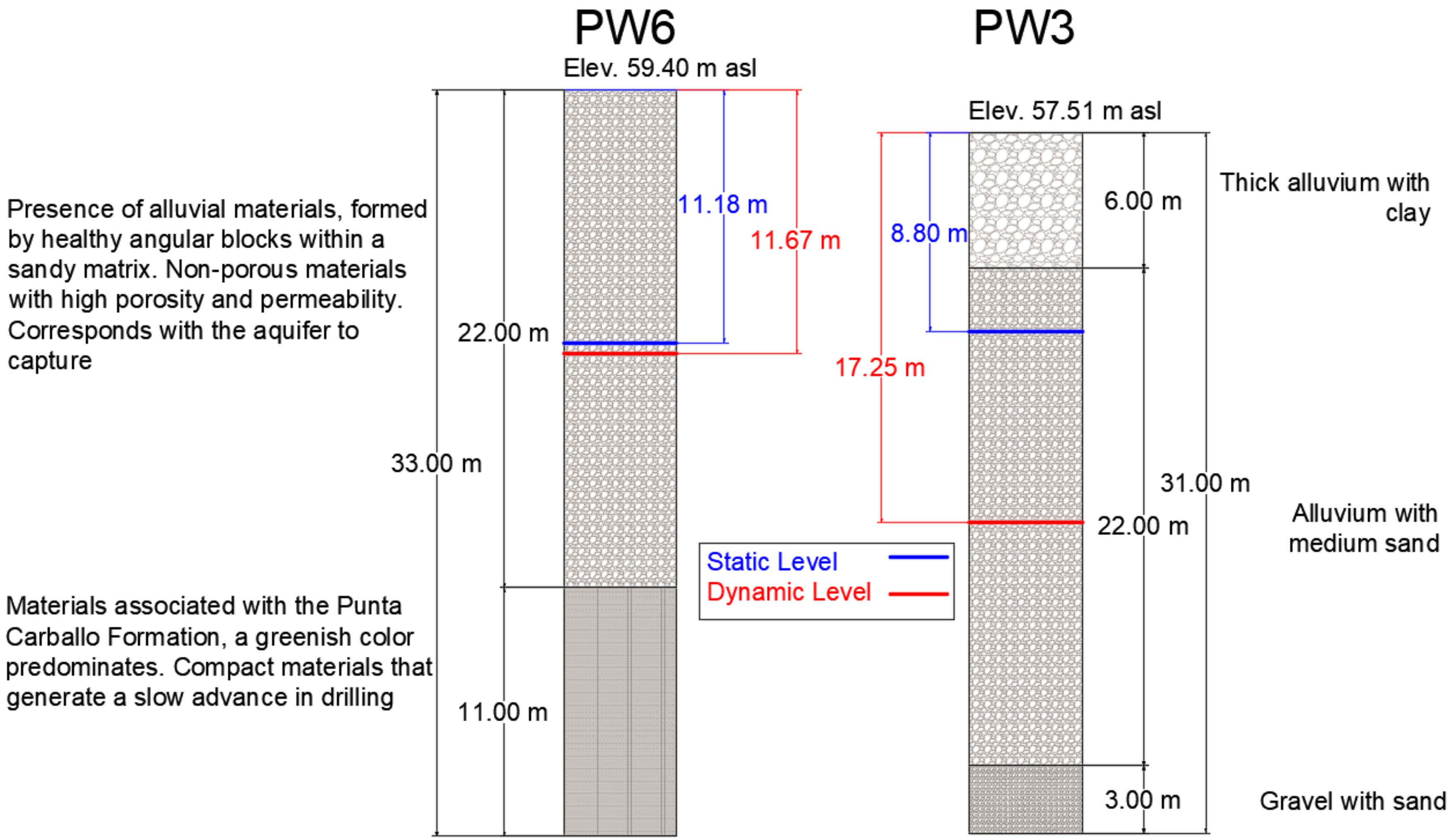

Figure 17 PW3 & PW6 Surface elevation, lithological profile and water level. Data provided by the Aya. Profile dates: Pw3 1988 and PW6 2016

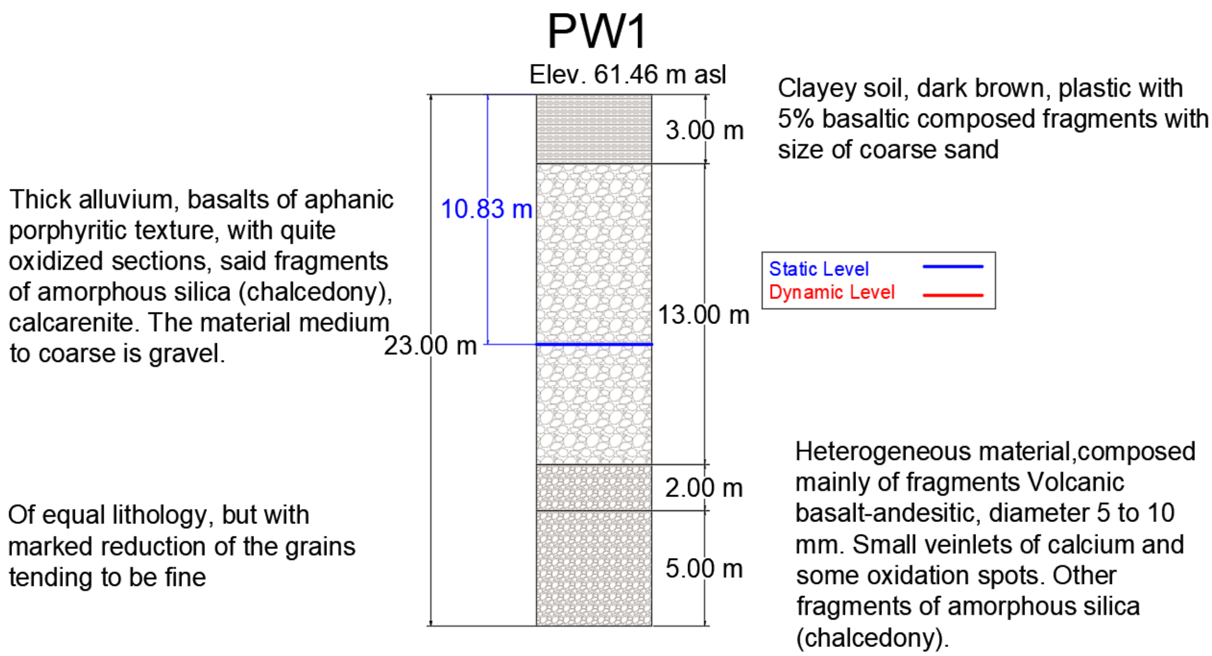

Figure 18 PW1 Surface elevation, lithological profile and water levels. Data provided by the Aya. Profile dates 1988

Table 3 Well profile dimensions

Pumping well		1	2	3	5	6
Perforation Year		1988	1988	1988	2016	2016
Length (m)	Perforation	23.00	32.00	32.00	32.00	33.00
	Casing	11.00	14.95	22.00	14.50	15.50
	Screen Filter	12.00	17.05	9.00	16.50	15.50
Depth (m)	Screen Filter	9.65	10.95	13.5	9.00	10.00
Diameter (mm)	Perforation	300	300	300	437.5	437.5
	Casing	200	200	200	250	250
	Screen Filter	200	200	200	250	250

Using the lithological information, the river and terrain surface elevations, water levels, and well profile information; the following conceptual cross section was obtained (Figure 19). A summary of the absolute static and dynamic water levels in meters above sea level is shown in Table 7.

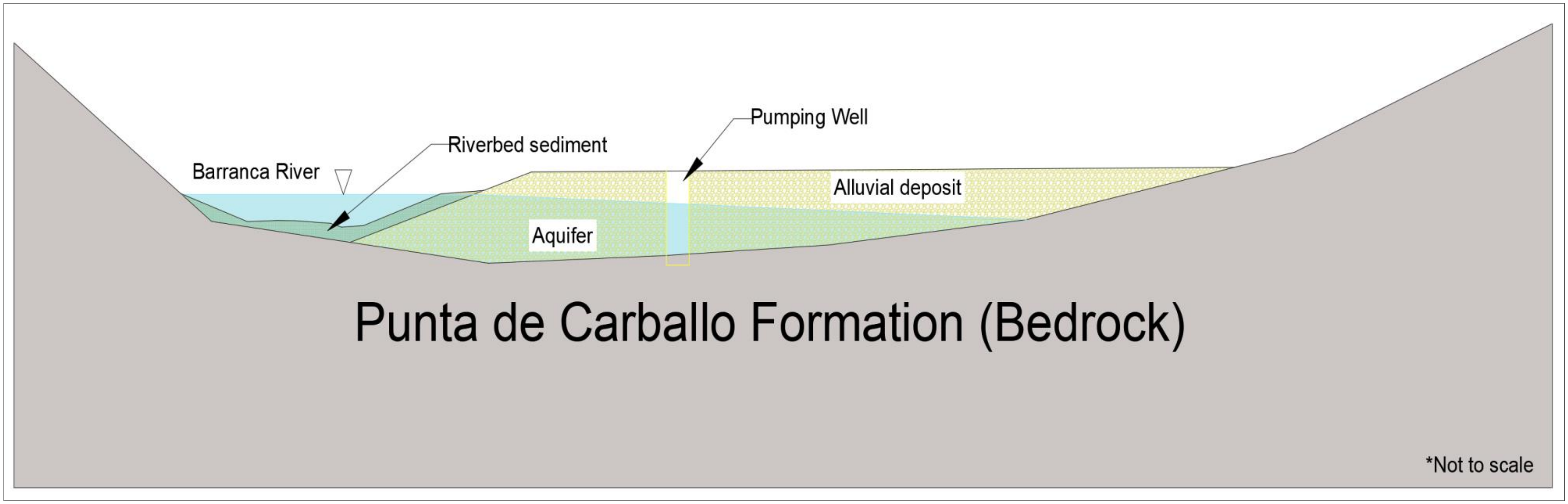

Figure 19 Conceptual cross section for the river-aquifer system at study site

Water quality

Crude water quality analysis from river and the wells were provided by the AyA. The well water was samples were all averaged and analyzed together. Since the WTP is used for removing turbidity from the river water; the reduction of this parameter was the focus of the analysis (Figure 20) as RBF could potentially act as a pre-treatment method. Related to the turbidity is apparent color, which also decreases notably. These two parameters are significantly higher than the maximum accepted values. As these two are comprised of suspended matter which contain other contaminants it is crucial that these are analyzed. A general comparison between other contaminants measured in the river and wells is shown (Table 4). There is a noticeable increase in alkalinity, conductivity, calcium and magnesium concentrations which are correlated to the decrease in pH. Figure 21 shows the distribution of turbidity levels measured in raw river water and the well water. As observed the levels in the river on average are higher than those in the well. The dots in red are the outliers which reach values of up to 400 NTU.

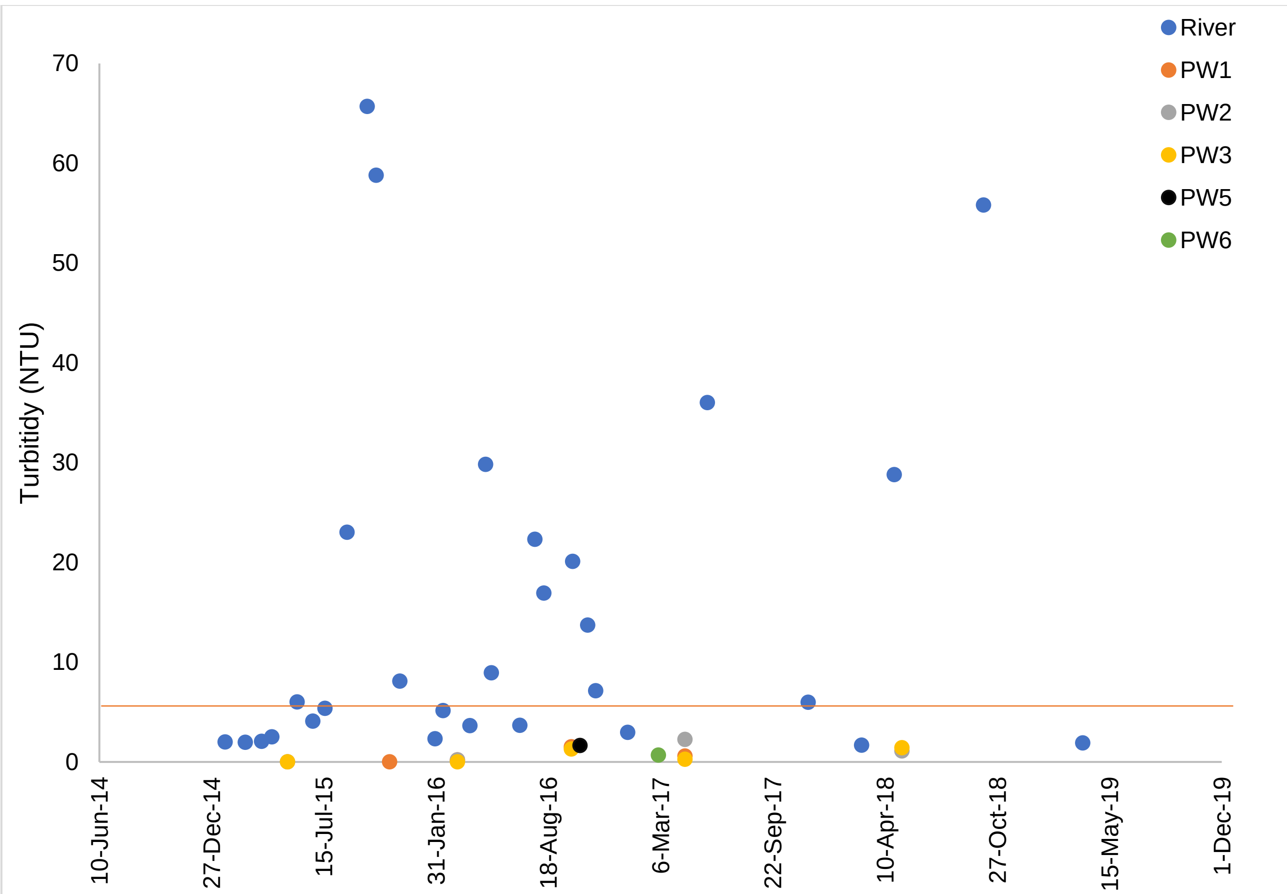

Figure 20 Turbidity variation over time in river and wells

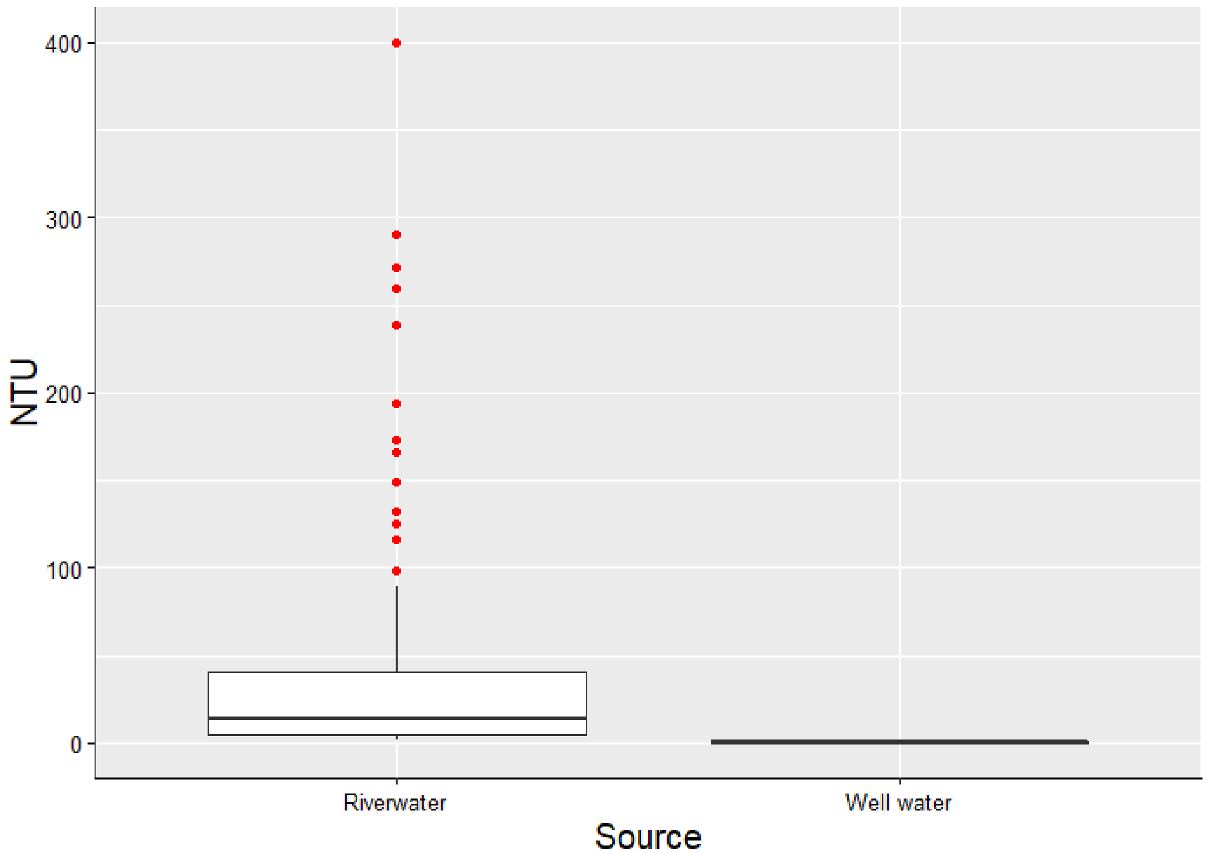

Figure 21 Turbidity concentration distribution boxplot

Table 4 Water quality analysis			
Parameter	**River water**	**Bank filtrate**	**Max. acceptable value**
pH	7.57 ±0.39	7.21 ±0.22	6.5
Alkalinity (mg/l)	49 ±11	127 ±39	-
Conductivity (µS/cm)	181 ±38	285 ±52	400
Apparent Color (UPt-Co)	**133 ±194**	**0.22 ±0.94**	15
Turbidity (NTU)	**54 ±127**	**0.65 ±0.74**	5
Calcium (mg/l)	19 ±3	38 ±9	100
Magnesium (mg/l)	4.0 ±0.34	7.9 ±1.91	50
Manganese (µg/l)	54	46 ±120	500
Arsenic (µg/l)	0.60	0.62 ±0.41	10
Copper (µg/l)	3.2	0.97 ±1.7	2000
Aluminum (µg/l)	79 ±155	18.5 ±36	200
Chloride (mg/l)	4.5 ±2.5	7.0 ±2.7	25
Sulfate (mg/l)	15.4 ±6.2	13.5 ±3.9	25
Fluoride (mg/l)	0.08 ±0.08	0.10 ±0.19	0.7

Estimation of aquifer k-value

Figure 22 and Figure 23 show the recovery phase of the pumping test in PW 3 and PW 5. The values with labels are the values used for estimating the k-value of the aquifer as well as the maximum and minimum levels. Figure 24 contains the enveloped graph of the complete pumping test for all wells except PW1. Pumping well 1 was only measured twice during the test as it is not in the direct vicinity of the operational wells. The levels were measured in PW1 (Table 7) as an acceptance parameter, measured at a long distance from the main well, for the modeling stage.

According to the data shown in recovery phase graphs and dividing Equation1 by the saturated aquifer thickness (*D*), the k-value for the aquifer surrounding PW 3 & 5 was estimated (Table 6). Theoretical values according to literature suggest k values of 10^{-2} -10^{-4} m/s for optimal RBF. This however will be discussed further in the next chapter.

Table 5 Well discharge rates in m3/s

PW	3	5
Maximum	$5.33X10^{-03}$	$7.61X10^{-03}$
Average	$4.82X10^{-03}$	$7.53X10^{-03}$
Minimum	$4.68X10^{-03}$	$7.46X10^{-03}$

Table 6 Estimated aquifer hydraulic conductivity

PW	5	3
Q (m^3/d)	27.10	17.35
Δs_w	0.39	0.17
D (m)	16.5	20.2
KD (m^2/d)	12.72	18.68
K (m/d)	0.77	0.92
K (m/s)	$2.14x10^{-04}$	$2.57x10^{-04}$

Table 7 Absolute static and dynamic levels inside wells

Static Levels			
PW	Water level from surface (m)	Point elevation (m asl)	Absolute water level (m asl)
1	10.46	61.46	51.00
2	9.72	59.40	49.68
3	8.80	57.51	48.71
5	10.12	59.40	49.28
6	11.18	58.62	47.44
Dynamic levels			
1	10.46	61.46	51.00
2	12.05	59.40	47.35
3	17.25	57.51	40.27
5	13.83	59.40	45.57
6	11.64	58.62	46.98

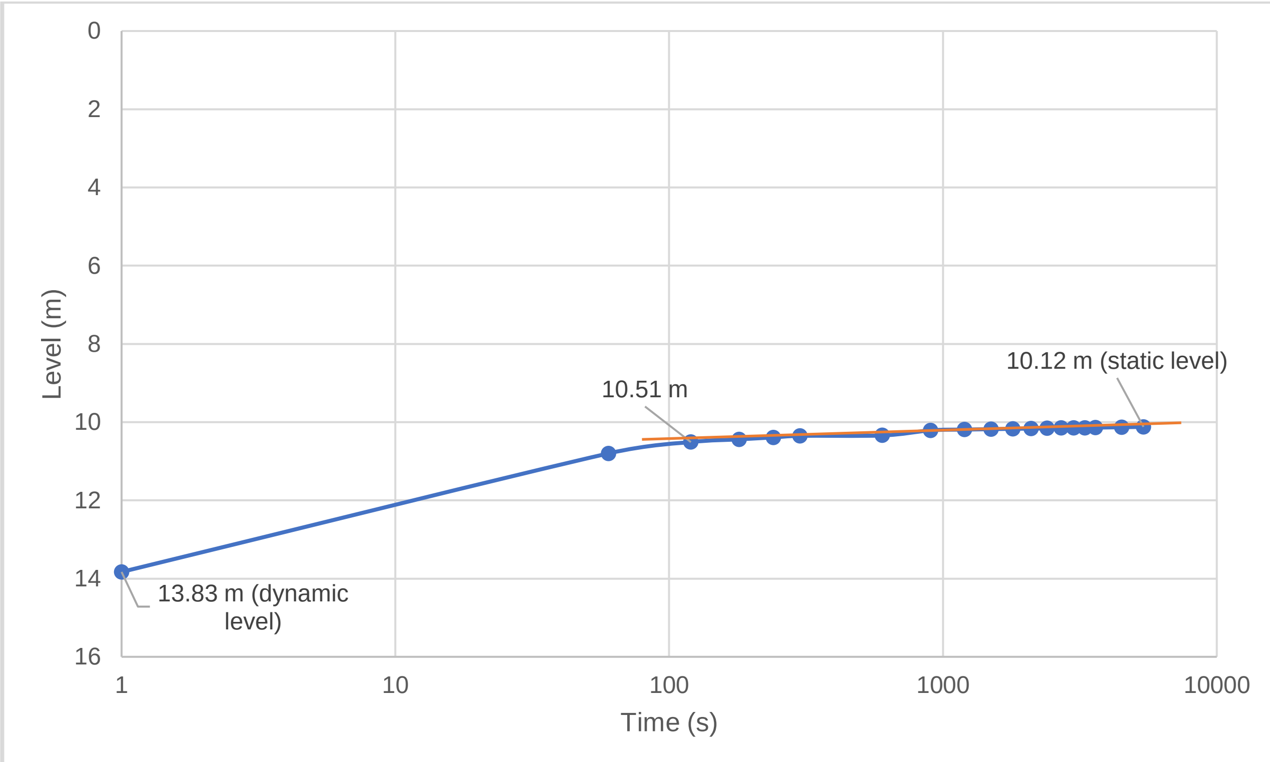

Figure 22 Recovery phase PW 5

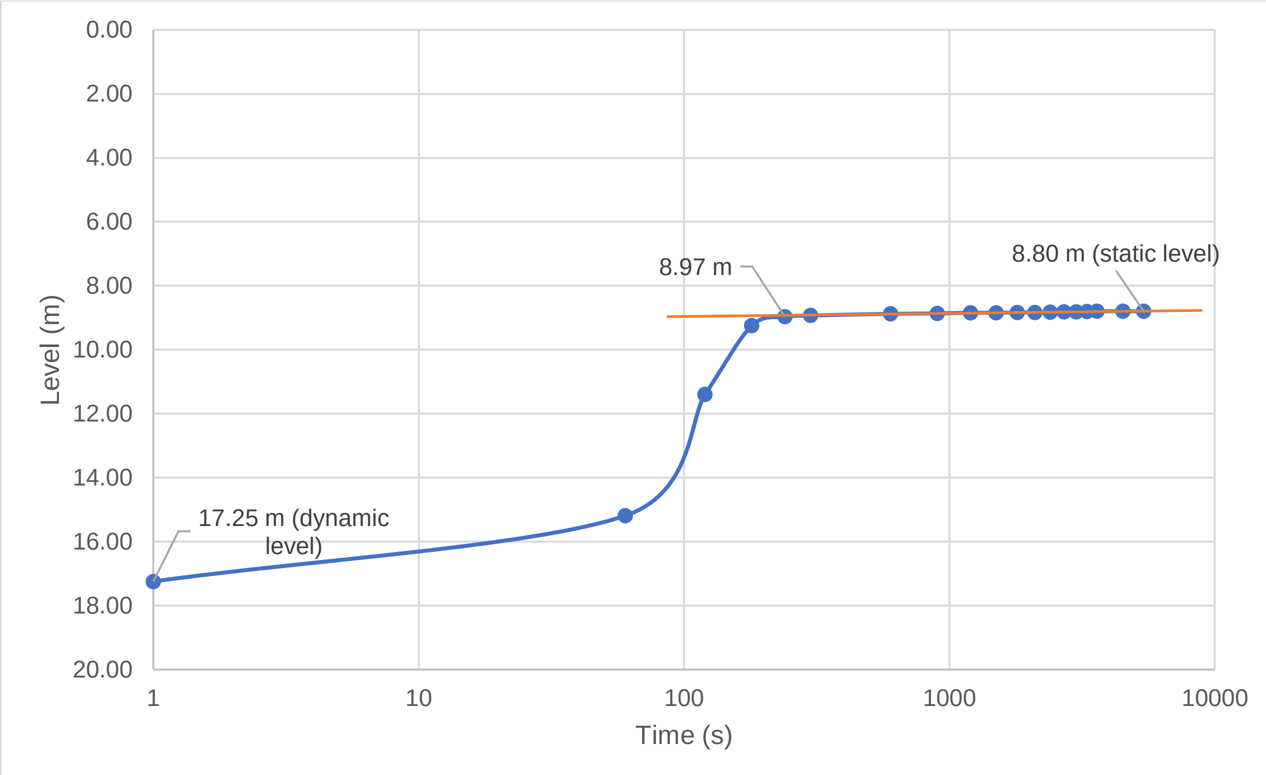

Figure 23 Recovery phase PW 3

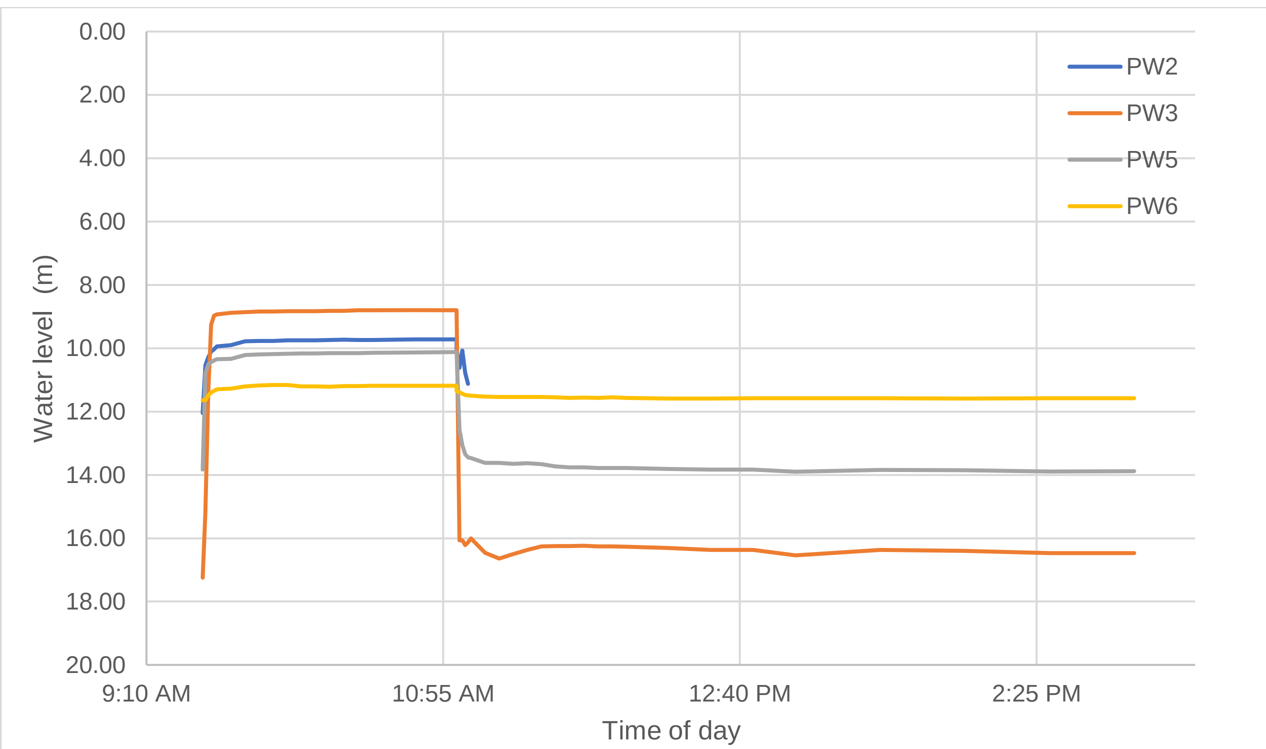

Figure 24 Complete pumping test results in all wells

Riverbed sediment analysis

Error! Reference source not found. Using the riverbed samples taken the granulometric distributions were determined (appendices). These distributions also determine that the sand is a well graded medium sand according to Fetter, 2001. Since the percentage of fines in the riverbed is less than 10% (appendices) a constant head permeability test was carried out (Table 8). Hydraulic conductivity of the riverbed clogging layer was estimated from the grain size distribution (Table 9). As observed there is a significant difference between one method and the other, about one order of magnitude between each method. These values however are within the acceptable range for RBF. During the modeling process this range is used to reach the most accurate result possible. The fact that the sampling was only done once could imply a change in the results over time. This because the sediments change constantly over time as the river washes and deposits new material.

Table 8 Estimated k-value for river sediment samples using the constant head permeability test

Sample	Manometers (cm)			Head, h, cm	Q (cm^3)	t (s)	Q/At	h/L	k (cm/s)	k (m/s)
	H1	H2	L (ΔH)							
1	7.40	1.35	6.05	22.00	150.00	59.84 59.69 58.66	0.08	3.64	2.19E-02	$2.19x10^{-05}$
2	7.75	1.55	6.20	22.50	150.00	159.20 161.49 161.07	0.03	3.63	8.13E-03	$8.13x10^{-06}$
3	7.40	1.25	6.15	22.00	150.00	146.52 150.59 146.34	0.03	3.58	8.96E-03	$8.96x10^{-06}$
4	7.75	1.50	6.25	22.50	150.00	39.11 38.73 38.85	0.12	3.60	3.38E-02	$3.38x10^{-05}$
5	7.40	1.53	5.87	22.00	75.00	85.59 85.94 88.29	0.03	3.75	7.30E-03	$7.30x10^{-06}$

Table 9 Theoretical k-value for riverbed sediment

Sample	D_{10} (mm)	Sorting	C	k *Hazen* (m/s)
1	0.35	Well	110	$1.35x10^{-04}$
2	0.25	Well	110	$6.88x10^{-05}$
3	0.28	Well	110	$8.32x10^{-05}$
4	0.33	Well	110	$1.16x10^{-04}$
5	0.18	Moderate	90	$2.92x10^{-05}$

Groundwater flow modeling and travel time estimation

Conceptual model

The geological data used in the conceptual model were taken from the lithological profiles for the wells provided by the AyA. The lower layer was confirmed to be true according to the Barranca geological map by Denyer, Aguilar, & Alvarado, 2011. The upper layers were correct as they pertained to formations found in alluvial deposits.

The model covers an approximate area of 3500 m which reach the outer no flow boundaries and is within the area of the collected data. It consists of three predominant layers. The two upper layers (approximately 24–27 m thick), formed by alluvial deposition, are comprised by large angular block immersed in a sandy matrix. The soil is highly permeable and unconsolidated though exceptions are to be made in certain areas. The first layer is limited by the terrain surface and was considered to have a depth of approx. 12 m. This was decided so that the remaining 12 – 15 m of the alluvial deposit could be assigned to the second layer. Around the wells this depth was set equal to the length of the screen filters. The third layer consists of a geological formation known as Punta de Carballo. This formation, which is mainly comprised of sandstone (Denyer et al., 2011), has low horizontal hydraulic conductivity (10^{-11} – 10^{-5} m/s) in comparison to the layer of granular soil above (10^{-6} – 10^{-2} m/s) (Fetter, 2001; Kruseman & de Ridder, 1990; Weight & Sonderegger, 2001). Therefore, this layer is the inferior boundary of the aquifer. Vertical hydraulic conductivity is approximately ten percent of the horizontal (Todd & Mays, 1980). As the geological formation of the hill across the river on the western and northern limits of the study area as well as the hill on the eastern limit are also considered to be Punta de Carballo, these were selected to be the outer boundaries of the model.

Since most of the area of the alluvial plain in this model is actively being used by the quarry, certain assumptions regarding hydraulic conductivity were made. Due to a high transit of heavy machinery, vibration from rock crushers and the brick factory, as well as stress added from the buildings and large aggregate mounds, compaction and consolidation of the soil in these areas were assumed (Das, 2010). Considering Boussinesq's method for vertical stress calculation, the top layer of these areas was assigned a lower hydraulic conductivity and were increased as the depth increased. Assuming higher stress in the upper layers leading to higher compaction and consolidation, a k-value of $1x10^{-5}$ m/s was assumed. A k-value of $7.5x10^{-5}$ m/s was given to the second layer. Only the unused area surrounding the PWs was assigned the k-value estimated during the pumping test.

The hydraulic head was taken from the static levels measured during the pumping test and the river head measured during the topographical survey. The historical data was not used as there was a difference of up to 5 m with the measured values. Since the surrounding area is comprised of a nearly impermeable geological formation and no evidence of a groundwater source was found, the only water source used in the model was that of the river. This however is explained in more detail in the results and discussion. Any rainwater input to the model was thought-out to be insignificant since the catchment area is a small hill east of the site and the top layer was considered to have low permeability.

Computational model

Total travel times from the river to the wells were estimated by groundwater flow and transport modeling using Modflow-2000 code (Harbaugh et al., 2000) with Processing Modflow for Windows (PMWIN) (W.-H. Chiang & Kinzelbach, 2001b).

The model domain covered an area of 500 m x 700 m. To cover this area, a mesh consisting of 50 columns and 70 rows comprised of 10 x 10-meter cells was created. The mesh was later refined to 0.20 m (well diameter) around the operating PWs and increased gradually to 10 m at the boundaries.

The cells pertaining to the eastern, western, and northern hills (Figure 25) were set as inactive boundaries (IBOUND = 0). As no water sources were considered, other than the river, the remaining cells were left as active with the default values of 1. (Active cells allow increase or decrease in hydraulic head. A value of -1 fixes the head and could be used to simulate an alternative water source)

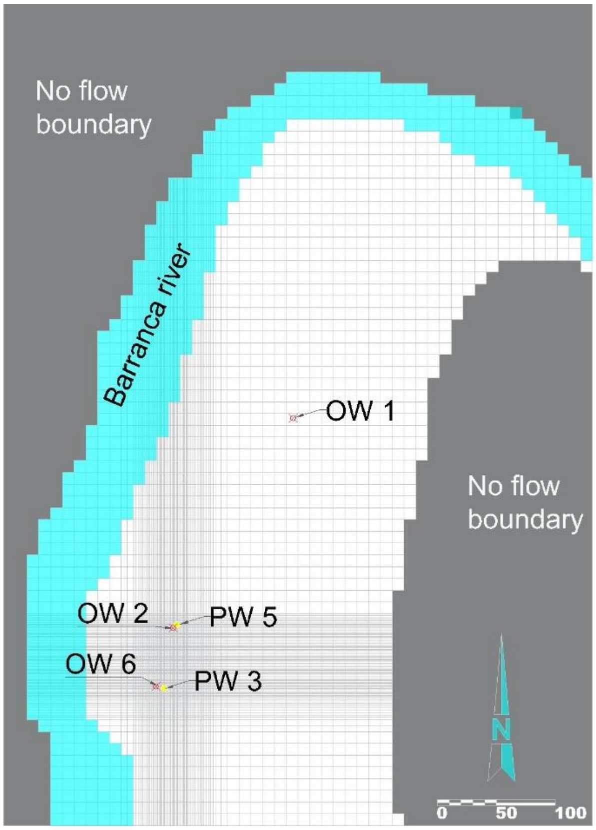

Figure 25 Discretization of catchment area and preliminary model prior to pumping

The three layers, as mentioned above, were added to the model. The top of the surface layer was assigned according to the data gathered during the survey. Pumping well elevations were used as reference and levels in between were interpolated linearly. The elevation of the area surrounding PW1, which is the maximum elevation in the model at 61.46 m asl, was assigned the same elevation as the PW. From there a gradual decline in elevation was assigned till the levels of the remaining wells were reached, the minimum being 57.51 m asl. The top of the second layer was assigned by subtracting 12 m from the top of the first layer. The top of the third layer, corresponding to the bedrock, was then set at 34 m asl which was provided by the lithological profiles. Layer bottoms were set automatically except for the third layer which was set at 29.46 m asl.

Initial hydraulic head (phreatic level) was set at 50 m asl. This in level was determined by averaging the static levels measured in the five wells.

Horizontal hydraulic conductivity was set at $1x10^{-5}$ m/s for the top layer considering that this layer is less permeable due to higher compaction and stress. For the second layer, the k-value was initially set at $1x10^{-4}$ m/s as a theoretical value then increased or lowered according to the correlation between the observed and the calculated hydraulic head values. Caution was taken as this value could not be lower than the theoretical value for this type of soil. The final value was set at $7.5x10^{-5}$ m/s. This value however, was only assigned to the used area pertaining to the quarry (Figure 15). In the unused area surrounding the wells, the estimated k-value obtained by the pumping test was used. For the third layer, a theoretical k-value for sandstone was set. The vertical hydraulic conductance was set at ten percent of the horizontal value for each layer and section (Weight & Sonderegger, 2001).

Using the MODFLOW river package, the Barranca river was defined. Hydraulic head elevation was measured during the survey. For the section above the weir, the slope was estimated to be very low at 0.24% and was chosen to be neglected as done by Paufler et al., 2018. The riverbed depth and the clogging layer thickness were as this information was not available, and measurement was not feasible. Hydraulic conductance of the riverbed or CRIV (W.-H. Chiang & Kinzelbach, 2001a) was estimated (Equation 3). This was done as the model requires the hydraulic conductivity in area unit per second for the riverbed and not in length unit per second as the ground does

$$CRIV = \frac{k_{clog} * A}{M} \quad (3)$$

CRIV, hydraulic conductance of the riverbed in cm^2/s; *A,* area of the river cell in m^2; *M,* thickness of the clogging layer in m.

The PW 3 and PW 5 were then set using MODLOW's well package. Since the screen filter length of the wells were, on average, approximately the same as the thickness of the second layer; the wells were set in this layer only. The operational extraction rates were tried variating between the maximum and minimum rates till the correct results were obtained.

A preliminary run was carried out to ensure that the results were within the range of measured levels. Changes such as CRIV, elevations or layer thickness, and hydraulic conductivities were made within the allowable range to approximate the results to the measured values.

Once the parameters were adjusted, a refinement of the mesh, mentioned above, was carried out. This, to obtain cells with sizes equal to the diameter of the wells which in turn results in a more precise result. Since the cell refinement options are rather limited, to obtain a 0.20 m x 0.20 m (PW diameter) cell size around at the wells, refinement was carried out in two steps. Initially, they were refined by a factor of 10, obtaining a 1 m x 1m cell at the well. Then, they were gradually increased by a factor of 2.5 until they reached the initial size. To the 1 m cells, refinement was applied again by a factor of 5 obtaining the 0.20 m cells. Finally, a graduation was made by a factor of 2.5 reaching the initial size of 1 m. Cell size dependent parameters like CRIV were automatically adjusted. Wells, however, had to be redefined to fit the newly adjusted mesh size.

The three remaining PWs that were not in use were set as observation wells (OW) in the model since there were no OW available. The observation well allow a more accurate measurement since there is a skin factor in an active well which affects the measured results (Kruseman & de Ridder, 1990). The measured levels during the pumping test were used as comparison parameters to ensure that the model results were reasonable and grounded changes could be made if not.

Finally, estimation of travel time between the wells and the river was carried out by particle tracking using PMPATH. This consisted of placing a particle of water (default for the program) and this in turn tracks the most likely path the particle would travel considering the site conditions set earlier. This also estimates the velocity with which said particle would travel through the ground. The only way to validate the result would be through a tracer test. But according to the literature the estimation is quite accurate if the model is approximated correctly.

Modeling results

The model was set up as described in the previous chapter. The initial parameters were set according to results obtained from the field and laboratory tests. The initial hydraulic head was assigned, and the model was run with the pumps deactivated. This to simulate natural water flow through the aquifer. These new hydraulic heads were then assigned to the model and the pumps were then activated.

Several iterations of the model were run, changing well discharge rates and k-values (within the limits) until the difference between observed and calculated hydraulic heads in the observation wells were minimal (Table 10).

Table 10 Observed vs calculated heads

OW	Calc (m asl)	Obs (m asl)	Difference (m)
1	51.02	51.00	0.02
2	47.15	47.35	0.20
6	47.09	46.98	0.11

A correlation graph between these heads was made by PMWIN for each iteration until the following was obtained (Figure 26).

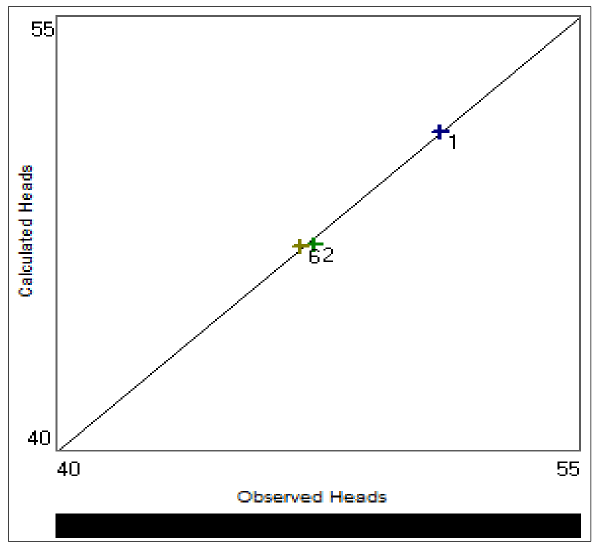

Figure 26 Comparison of calculated and observed heads

Once the approximation was reached a minimal difference to the observed values hydraulic head contour maps were made. Particle tracking was then carried out. Each arrow in the particle path represents 10 days of travel. In Figure 28 the green and red paths represent particle transports for PW 3 and PW 5 respectively. For PW3 there is a maximum of ≈110 days and a minimum of ≤10 days while in PW5 a maximum and minimum of ≈70 days and ≤10 days respectively. These travel times are determined by the distance from the well to the zone from which the water originates and the hydraulic conductivity of the ground. Three zones were designated, as shown in Figure 29 Using PMWIN's water budget function, the water percentages contribution from each zone was estimated (Table 11).

In order to visualize the travel times, a cumulative percent graph was made (Figure 27). As observed, the horizontal axis represents the travel times estimated. As the time decreases the frequency increases which agrees with Table 11 and Figure 29 as the larger portion of the water reaching the wells has low travel time. This also is conditioned by the distance of the wells from the river and the section from which it is taking the water.

Table 11 Water contribution per zone

	Contribution (L/s)	Percentage	Travel time (days)
Zone 1	1.45	12%	80-110
Zone 2	2.58	22%	10-60
Zone 3	7.77	66%	≤10
Total	11.80	100%	

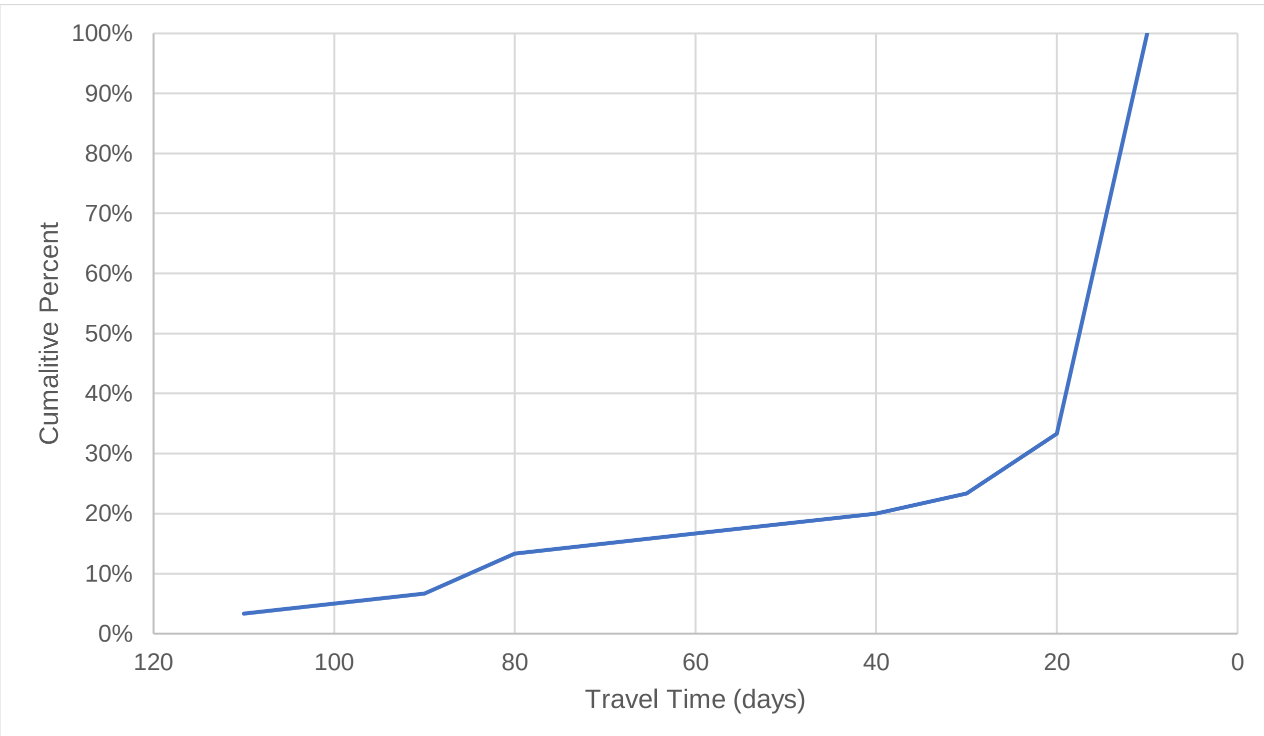

Figure 27 Cumulative percent of groundwater travel times

Operational Scenario

Due to the resuts pointing to RBF ocurrence in the site and the need for an alternative scenario was modeled. This to evaluate the importance new wells could have at the site. The operational scenario proposed consisted in substituting the surface water intake and WTP for a series of 5 wells. The total extraction rate was estimated at 80 L/s, 16 L/s per well (as explained in the previous chapter). Figure 30 showes the resulting heads and tavel times for the proposed wells. Final heads in all wells not including the well skin effect was estimated ≈ 44 m als, about 10 m above the confining layer. Average travel time was estimated to be 50 days.

Using 16 L/s extraction rate for each well and a total head of 120 psi (which is what the system currently operates at) a 22-kW pump was selected for each well. At an extraction rate of 0.08 m3/s a total of 12.5 s is needed to extract one cubic meter of water. According to production rates from a cost estimation done in 2014 and the use of the 5 pumps mentioned; the following cost estimation was made. The costs were estimated for one second of production then multiplied by 12.5 to obtain the cost to produce 1m^3 of water. Araya-Alvarez & Merizalde-Dobles, 2015 determined that the cost to produce 1 m^3 of water in a WTP was governed by the following regression: *₡/m³=1.065(Q)-3.84.* The cost breakdown using the proposed RBF scenario and the total cost for a WTP to produce one cubic meter running at 80 L/s are shown in Table 12. The total cost reduction using RBF in comparison to the WTP is of 29%.

Water budget for this scenario determined that a total of 128.8 L/s entered the aquifer system while only 80 L/s left. A total of 48.8 L/s reentered the stream.

Table 12 Water production cost estimation

Electric consumption costs				
	Power (kW/h)	Operation Time (h)	Cost (kW/h)	(₡/m^3)
Pumps	110.00	2.78E-04	₡120.00	₡45.87
Chlorination pump	0.25	2.78E-04	₡120.00	₡0.10
Meters	0.07	2.78E-04	₡120.00	₡0.03
Illumination	0.07	1.39E-04	₡120.00	₡0.03

Labor Costs	
Hourly salary operator	₡1,198.11
Chlorine gas costs	
kg/m^3	0.00015
¢/65kg tank	₡52,745.00
¢/kg chlorine gas	₡775.66
Cost m^3	₡1.44
Costs summary	
Labor (₡/m^3)	₡8.32
Social expenses (₡/m^3)	₡3.49
Electric consumption (₡/m^3)	₡46.03
Chlorine gas (₡/m^3)	₡0.12
Total Cost to produce 1 m^3 using RBF	₡57.96
Total cost to produce 1 m^3 of water in WTP	₡81.39
Difference	29%
Annual cost difference	₡59,103,781.84

Figure 28 Head contour map for approximated model

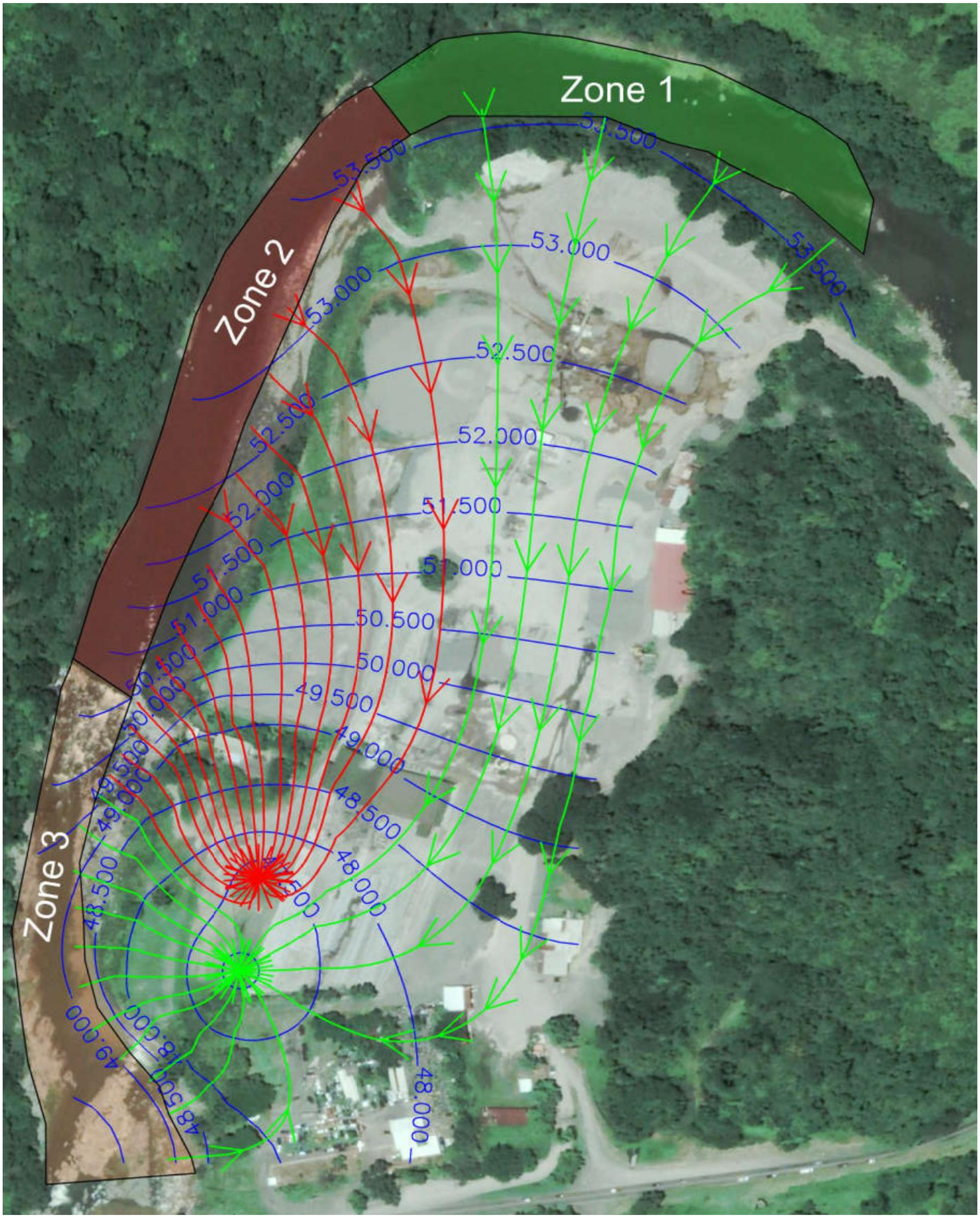

Figure 29 Particle tracking path for approximated model

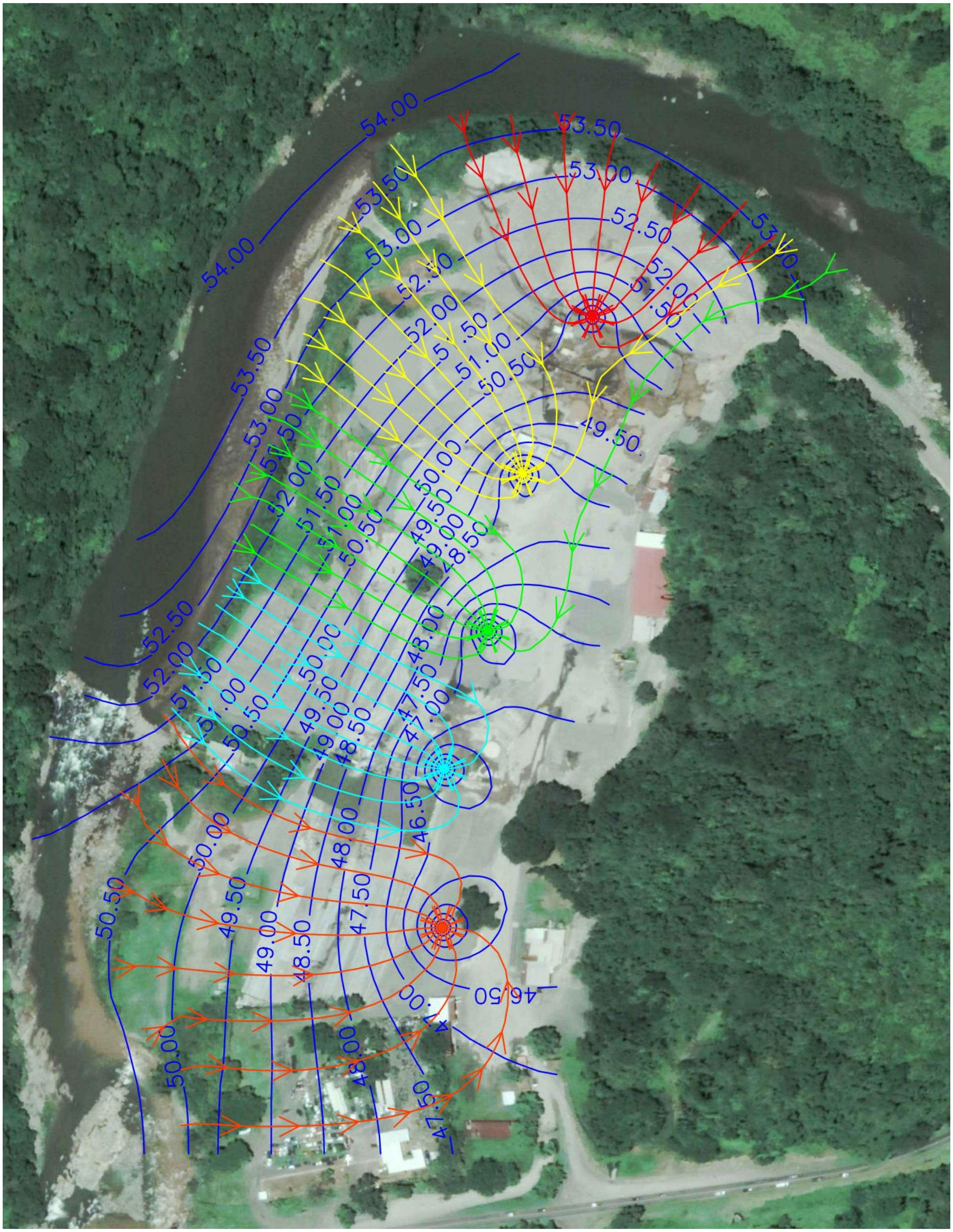

Figure 30 Model of proposed scenario

Discussion

The discussion in this section will analyze the obtained geomorphological, hydrogeological and geological results obtained. This will be compared to the literature and evaluate the potential for RBF at the study site. Using these results and those obtained from the groundwater flow modeling the potential for RBF was corroborated. Likewise, groundwater flow paths and travel times were discussed and associated to water quality data. Finally, the benefits of installing RBF wells in the site were analyzed.

RBF evaluation according to selected criteria

Analyzing morphological criteria of the river is an important step to consider when choosing or studying RBF sites. It is recommended that the location of the wells be on the inner side of a river bend (Jaramillo, 2015). This is to be considered since sediment carried by the river will tend to settle on the outer side of a bend, this decreasing the infiltration capability of the water into the aquifer through the riverbank (Schubert, 2002). Observing Figure 15, a sharp bend in the river is clearly noted. Also, the PWs are located on the inner side of this bend though not directly in front of it. This, though a simple observation, could imply a big difference between the amount of water that could be filtered into the system.

Riverbed composition influences in the water infiltration rate into the aquifer. If the bed is comprised of a clayey soil infiltration will be slow and production low. If the material consists of sand or gravel infiltration will be high and yield high. **Error! Reference source not found.**As classification suggest that the material as a well grated medium sand this would agree with this criterion. It must be considered that this was obtained by a single set of samples. As river washes and deposits sediment this may change and has to take into account.

In order to keep the riverbed from clogging and to maintain RBF Schubert, (2002) considers that the river must have some self-cleaning capabilities. Various methods are suggested however, it was considered that the bed would be cleaned regularly by the machinery and the occasional flooding of the river.

As to the infiltration rate estimation in the clogging layer of the river two methods were applied. The first method through constant head permeability test (AASHTO, 2018) using samples taken from the river (Table 8). Since the samples used were deformed, its accuracy could not be measured. Due to this, the Hazen method was applied (Equation 2) to the granulometric distribution. The Hazen method, according to, Fetter, 2001; Todd & Mays, 1980, estimates the hydraulic conductivity of a sandy sediment from the grain-size distribution curve. The method is applicable to sand where the effective grain size is between 0.1 and 3.0mm (Weight & Sonderegger, 2001). Table 9 shows the results for the k-value according to Hazen. Results show a difference in about one order of magnitude between methods. Chen, 2000 stated that since the original sediment structure of the riverbed are destroyed during sampling, the grain size analysis does not provide hydraulic conductivity. However, authors have used this method to determine k-values (Ghodeif, Grischek, Bartak, Wahaab, & Herlitzius, 2016; Ghodeif et al., 2018) A stand pipe test would be the most efficient way of estimating the infiltration rate of the clogging layer (Romero et al., 2012). The results obtained from the permeability test and using the Hazen method were between $1.35x10^{-04}$ - $2.92x10^{-05}$ m/s and $2.19x10^{-05}$ - $7.30x10^{-06}$ m/s respectively. These k-values however are within the range, stated by authors, for sands (Fetter, 2001; Todd & Mays, 1980; Weight & Sonderegger, 2001). Consequently, this range was considered in the modeling stage of the study in order to approximate the results as precisely to the measured results as possible.

Another conditioning factor with influences the potential for RBF is the hydrogeology of the site. (Hiscock & Grischek, 2002). RBF is dependent on the ability for the water from the river to flow towards a well. This ability is conditioned by the type of soil and its related conductivity. Geological formations with low hydraulic conductivities, such as unfractured rock, clay or silts, limit or restrict water flow through it. Opposite to this, soils such as sand or gravel and formations like karst limestone, fractured rock, or permeable basalts allow water to flow easily through them (Weight & Sonderegger, 2001). Since hydraulic conductivity depends on a variety of physical factors such as porosity, particle size, distribution and shape, arrangement of particles, and other factors (Todd & Mays, 1980); this determines the flow of water through it as well as any contaminant contained in it. A lower conductivity though limiting the amount of water, filters more contaminant due to smaller spaces between particles. Higher hydraulic conductivities along with proximity from extraction well to river ensure higher recharge and extraction rates though these could imply water quality problems (Bertin & Bourg, 1994).

To obtain a higher yield and maximum pollutant removal, a balance must be made between hydraulic conductivity and well distance. Studies have demonstrated that the optimum hydraulic conductivity for RBF is 10^{-2} -10^{-4} m/s. Alluvial deposits are considered to be optimal sites for RBF. This due to that they are comprised of gravel and sand deposits having conductivities within the recommended range (Weight & Sonderegger, 2001). Figure 16 through Figure 18 show the lithological profiles for all the wells in the site. The upper layers pertain to material found in alluvial deposits. Furthermore, a pumping test was carried out and values of 2.14×10^{-4} - 2.57×10^{-4} m/s were obtained. This confirming that the hydraulic conductivity of the site is adequate for RBF. The distance required for RBF is determined by the contaminant to be removed. In cases where turbidity is to be removed small distances are enough as the aquifer will act as a natural sand filter. In cases with chemicals or pharmaceuticals contaminants, large distances are required. Cases have reported up to 1.8 km between river and RBF wells site (Kulakov, Fisher, Kondratjeva, & Grischek, 2011). Ghodeif et al., 2018 reports having installed wells as close as 10 – 15 m from the river for pathogen removal. The wells at the Barranca study site are approximately 70 – 75 m from the river. This distance is within the range for RBF especially since the main contaminant to remove is turbidity (Dash et al., 2010).

"*River bank filtration can occur under natural conditions or be induced by lowering the groundwater table below the surface water level by abstraction from adjacent boreholes*" (Hiscock & Grischek, 2002). Figure 32 represents a type of flow condition in which there is mainly riverbank filtrate entering the wells. The presence of groundwater is little to none. The topographical survey estimated a surface water level of approximately 54.61 m asl for the section above the weir and 51.22 m asl below it (Figure 14). Likewise, the static and dynamic water levels inside the PWs are shown in Table 7. These levels are well below the surface water levels pointing to a natural occurrence of RBF even though the pumping could potentially increase the travel time. Likewise, the elevation suggest that the river is a losing type (Figure 31). Which is typical for areas where the groundwater is recharged by a stream. Since, the study site is a small area, the shallow alluvial deposit is sitting on impermeable bedrock, and it is bordered by a river on one side and a small hill on the other; it was assumed the subsurface water extracted by the well is riverbank filtrate (Figure 32). Further analysis would have to be carried out to verify this, but the evidence strongly suggest that this assumption is correct.

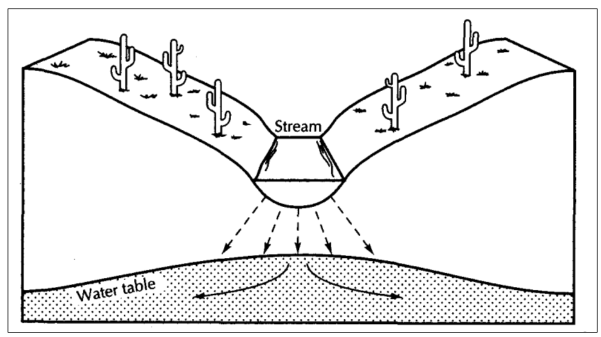

Figure 31 Losing type stream (Fetter, 2001)

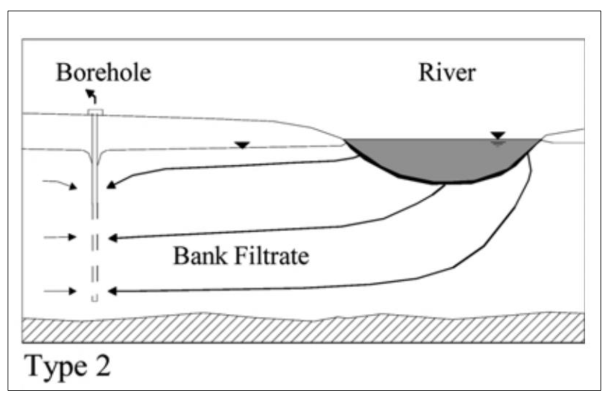

Figure 32 Schematic representation of type 2 flow condition at bank filtration site (*Hiscock & Grischek, 2002*)

Using the information collected, a generalized conceptual cross section was made (Figure 19). The figure clearly describes a losing type stream or river as well as type 2 flow condition suggesting RBF. As observed, the surface water flows naturally into the alluvial plain. Any extraction from the wells would possibly increase the velocity with which the water flows into the system.

Since the occurrence of RBF is evidence according to the previous criteria, a water quality analysis was carried out. The study site, as mentioned before, is in a quarry. Sand and gravel are extracted from the river to be crushed and sorted (Figure 15). The extraction of this material stirs up fine sands and sediments which are carried by the river and deposited at the weir and intake along with organic material. (Figure 13 & Figure 12). This water is then pumped to a WTP to be processed for consumption. Turbidity values in the river water, as observed in Figure 21, is on average ≈12 NTU (excluding outliers). Likewise, the boxplot for the well water turbidity analysis, shows an average value of near 0 NTU. As observed outliers reaching 400 NTU in the riverward is observed. These could be associate to excavation periods done upstream to the sampling point or flooding. Nevertheless, though the water travel times are low (discussed further on) the values measured in the wells vary insignificantly. This suggests an effective filtration trough RBF. Figure 20 and Figure 21 demonstrates the capability for RBF to decrease turbidity (Sandhu, Grischek, Kumar, & Ray, 2011) to values accepted by the health ministry. Decreto N° 32327-S, (2005) state a recommended value of <1 NTU and a maximum of 25 NTU. Table 4 shows an increase in alkalinity, conductivity, calcium and magnesium concentrations and consequently a decrease in pH. This could be due to the erosion and dissolution of the material forming the aquifer (Romero et al., 2012) as water passes through it. Another possible reason for this is that the brick factory located in the quarry increases the calcium concentration in the ground. Calcium is a significant ingredient in cement, and its concentration is correlated to the other factor. These values however are well below the accepted values stipulated by the health ministry.

Another strong indicator that RBF is occurring are the peaks in Figure 20. The large peaks in the river water concentrations are followed by small peaks in the well water concentrations and potentially act as a tracer (Dawe & Macquarrie, 2005). The effectiveness of contaminant removal is also noted in PW's which pertain to recent water analysis of the site

The criteria discussed in this section strongly suggest that RBF is being carried out as it agrees with that stated in the literature. The potential it has is reflected in the water quality comparison between river and well.

Limitations to be taken into account in using these criteria is the lack of information that there may be especially in more remote or unused sites. Localized geological and hydrogeological information was the main setback while carrying out this study.

Groundwater flow model

A groundwater flow model was created using PMWIN (W.-H. Chiang & Kinzelbach, 2001a). Its main purpose, to estimate travel time between the river and the PWs.

Prior to being able to set up the model, various input parameter had to be estimated. Among these parameters were surface and water levels, hydraulic conductivities (k-values), riverbed sediment hydraulic conductivity and well extraction rates.

Well discharge rates, as presented in Table 5, were estimated using an ultrasonic flow meter. Though all indications during the readings pointed to be accurate, a well operator expressed that the rates seemed low according to their measurements. Since these operational rates were not provided, the measured ones were used.

The horizontal k-values were estimated for the aquifer at PW3 an PW5 (Table 6). These values are determined by saturated aquifer thickness, discharge rates and interpretation of pumping test data. The aquifer saturated thicknesses were estimated as the difference between the absolute static level and top elevation of the confining layer. Only the static level was measured on site and can be verified as true. Data such as layer thicknesses could have been subject to change since some of the information is almost 40 years old. The reason for this uncertainty originated when a well site operator expressed that the terrain surrounding the well sites had been filled by the quarry in recent years (though information such as thickness of the fill or exact year were not known). Figure 24 however does demonstrate connectivity between wells since there seems to be a similar behavior pattern in each well; thus, a general k-value for the area surrounding the wells was used. The vertical hydraulic conductivity was used as 10% of the horizontal one (Chen, 2000; Weight & Sonderegger, 2001).

For the area in which the crusher is stationed and the aggregate mounds are places by the quarry, a lower k value was used. Das, 2010 states that consolidation (produced by an application of a load to the soil) and compaction (either by vibration or application of loads) decrease the void spaces between soil particles, therefore decreasing its porosity. As stated before, porosity is an influential factor for hydraulic conductivity. According to Boussinesq's theory (Das, 2010) however, the force applied decrease as the depth increases. All this would imply that the upper layer would have a lower conductivity and then it would gradually increase as the depth did. Assuming that this was the case, the upper layer of the model was set at $1.0\text{x}10^{-5}$ and the second layer $7.6\text{x}10^{-5}$. Both these values are in the lower end of range for k-values for the type of formation (Hydrogeology, 2006; Kruseman & de Ridder, 1990; Todd & Mays, 1980; Weight & Sonderegger, 2001).

The riverbed infiltration into the aquifer (CRIV) was then estimated using Equation 3. Since these results depended on the k-value for the riverbed sediment; they were directly input into the model as they were subject to change as the modeling was being carried out.

The river package in PMWIN simulates the seepage flow through the bottom of the riverbed and assumes that the riverbank is an impermeable wall as stated by Schön, 2006.

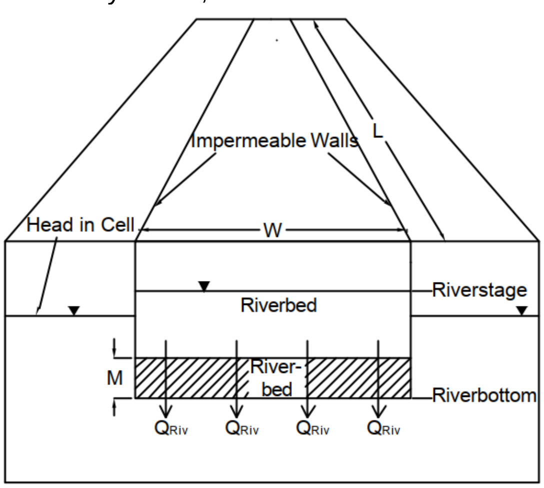

Figure 33 Schematic of river boundary(Schön, 2006)

This works in cases where the riverbed is large compared to the wetted riverbank. In cases where this differs, changes can be made to the model to cover the issue.

Once the information was clear and the assumptions were made for the missing data the model was then executed. Moflow-2000 code solves the governing groundwater-flow equation which is subject to initial and boundary conditions (Equation 4).

$$\frac{\partial}{\partial x}\left(Kxx\frac{\partial h}{\partial x}\right)+\frac{\partial}{\partial y}\left(Kyy\frac{\partial h}{\partial y}\right)+\frac{\partial}{\partial z}\left(Kzz\frac{\partial h}{\partial z}\right)+W=S_S\frac{\partial h}{\partial t} \quad (4)$$

Where Kxx, Kyy, Kxx, hydraulic conductivity along the x-, y- and z-coordinate axes, which are assumed to be parallel to the major axes of hydraulic conductivity [L/T]; *h*, hydraulic head [L]; *W*, is a volumetric flux per unit volume representing sources and/or sinks of water, with W<0 for flow out of the ground water system (e.g. well discharge), and W>0 for flow in [T^{-1}]; *SS*, specific storage of the porous material [L^{-1}]; *t*, time [T].

The ground-water-flow process solves equation 4 using the finite difference method in which the ground-water flow system is divided into a grid cell. For each cell there is a single point called a node, at which head is calculated (Harbaugh et al., 2000). The model was simulated in steady-state flow which is time independent and has no water contributed by storage (Anderson et al., 2015). To approximate the head in the model to the observed head, certain variation had to be made. Since Equation 4 is governed by 5 different variables, changes could be made to these in each iteration on PMWIN. Since in the governing equation ∂h/∂t is zero for steady-state flow (Anderson et al., 2015) and storage does not contribute; 3 variables are left. For the equation, W would equate to the extraction rate of the wells (Q) and would be negative these values, though having a deviation, could not be variated beyond the range. The hydraulic head (h) was set as constant at natural flow conditions. Finally, the hydraulic conductivity remained as the most uncertain variable. To approximate the calculated heads in the model the variables had to be modified all within the permissible range. Once the discharge rates and the calculated k-values (area surrounding the wells) had been set. the only remaining variable to be modified was the k-value for the quarry operated area. The value was set low in the range pertaining to alluvium as assumed above. A comparison was made between calculated and observed head until the difference obtained was minimal (Table 10) and the correlation between them was strong (Figure 26).

Figure 28 & Figure 29 show the final calculated heads and the particle tracking for the model. The contour map demonstrates a clear hydraulic gradient between river and wells. This supports the first objective in verifying the occurrence of RBF. Particle tracking shows the approximate path lines of water particles traveling from the river to the PWs. Two important observations are to be made. The first being the impact the location of the wells regarding the river bend. An important portion of the water entering PW3 obtained from the portion above the bend this allowing the water extraction to be higher. Secondly, travel time was estimated at ≤10 days minimum and 110 days maximum (each arrow represents 10 days). Water budged for the different zones estimate a 12% of this water had a travel time of between 80 and 110 days of travel time, a 22% between 10 and 60, and a 66% to be equal or under 10 days. Figure 27 agrees with the water budget and with Figure 29 as the cumulative percent of water reaching the wells increases as the travel time decreases. These travel times seems to be adequate as the distance the water particles are traveling at the k-values estimated would also take a similar time to reach the wells. The total sum of the infiltrated water, according to the model, is 0.3 L/s more than the extracted water. This points to a possibility that some of the water in the aquifer does return to the river. It is important to observe that having the wells places where they are helps increase travel time from the river to the well. This in turn increases the filtration the water receives improving the general quality of the water. Water quality analysis shows this to be enough time and distance (in this case) for removing turbidity.

The applicability of modeling in Costa Rica is determined by the amount of information there is. This goes in hand with the first section of the discussion. However, if the information is available, the value a model has is high as this allows to evaluate future possibilities and options that can be taken.

Operational scenario

The scenario, as mentioned, consisted of replacing the WTP with RBF operating wells. The reason for carrying out this scenario is would be to lower operational costs related to the WTP. As the WTP consist of various stages such as extraction, coagulation and flocculation, sedimentation, filtration, backwashing and disinfection it requires a plant, experienced operators, reagents, etc. This in turn leads to higher costs, manpower, and maintenance. Also, in flooding when the turbidity reaches extreme levels the plant can't process this and must cease production. A well-planned RBF site on the other hand eliminates most of the pre-treatment stages as the water is filtered as extraction is being carried out. This leaves only disinfection, in most cases. Various RBF sites can be operated by less people and maintenance is lower.

To achieve this, firstly, the operation of the quarry in that area would have to cease. This, as well as allow the plain to be used as wells sites, would also imply a compliance with the drinking water extraction site regulations. Ley Nº 276, (1942) states that a minimum distance of 200 meters from any source of drinking water must be observed. This is not the case for the study site as the quarry is directly surrounding the PWs. As the load over the soil should be removed and water would continue to flow through the aquifer; this should cause the granular soil to expand once again to its natural state. Thus, causing the k-value to normalize over the entire study area. Considering these two events the model was setup such that the entire aquifer had the same k-value as that calculated during the pumping test. The fact that the weir would be removed must be considered as it would increase the river gradient. This increase would mean that the shear stress at the river bottom would cause an unclogging effect on the riverbed sediment. Eventually this could cause the infiltration rates to increase, incrementing the total yield. The original sediment k-values calculated according to Hazen. The assumption was made that if the original infiltration rates were used these would be critical. If the required yield was matched and the system could maintain production, it would do so under a higher infiltration rate as well.

An estimated population of 34000 was obtained from a census conducted in 2011 and the average population growth percentage ("Costa Rica Demographics Profile 2018," 2018; INEC, 2011). Average consumption per person in a coastal town is estimated to be 200 L/d (AyA, 2017). A total of 80 L/s was estimated to be required to supply the users.

Five wells were placed in the model at a distance which tried to maximize the distance of the wells form the river uniformly. Figure 30 demonstrates that the proposed scenario, using five wells extracting a total of 80 L/s is plausible at the site.

Drawdowns are estimated to be average ≈44 m asl which is about 10 m above the aquifers confining layer. This would ensure enough space to install a submersible pump and have enough distance to consider the skin factor of the well (Kruseman & de Ridder, 1990). Travel times are approximately 50 days for all the wells as shown in Figure 30. And as mentioned above, this time is more than adequate for removing the number of contaminants contained in the river to this date.

Knowing that the RBF method is efficient in removing the turbidity contained in the river, a comparison between RBF and WTP costs was carried out. The WTP cost was estimated according to a study carried out in 2015 by (Araya & Merizalde, 2015). The study consisted in analyzing costs from different WTPs and creating a correlation between cost per cubic meter and production of the plant in liter per second. The estimated cost for a WTP running at 80 L/s is 81.39 ₡/m^3. Using operational and disinfestation costs from a similar time, the costs for the proposed RBF system was estimated at 57.91 ₡/m3 (Table 12). This cost is a total 29% cheaper than that of a WTP. This in annual costs represents nearly ₡60 million. Also, the water budget estimated that a total of 48.8 L/s was exiting the system meaning that the site has potential for more extraction.

Considering these factors, for this site, it would be cost beneficial to switch to RBF as well as environmentally friendlier as the exploitation of the site would diminish or cease.

Conclusions

A thorough investigation was conducted to evaluate the potential for riverbank filtration along the Barranca river, at the Procamar well site in Puntarenas, Costa Rica.

The potential for RBF was determined according to the geological, hydrogeological, and geomorphological criteria selected:

- Lithological profiles of the wells determined the that the site is located on an alluvial plain with a hydraulic conductivity within the range for RBF.
- The alluvial deposit is sitting on a confining layer of sandstone.
- The wells are located on the inner side of a bend along the Barranca river increasing the input of water into the aquifer.
- Pumping test analysis reveal conductivities between 2.14×10^{-4} and 2.57×10^{-4} m/s around the wells.
- Riverbed sample analysis determined approximate that infiltration rates into the tapped aquifer are within the range for optimal RBF.
- A topographical survey determined terrain and river surface levels and further analysis determined that the system is comprised of a giving type river, with no evidence of natural groundwater in the system.
- The distance of the wells from the river were within the ranges for RBF and proved to be effective filtering the water.

Finally, water quality analysis along with the previous analysis strongly suggest the occurrence of RBF.

Water quality analysis suggest an efficient removal turbidity found in the river water through RBF. The turbidity present in the water is mainly due to the extraction of material upstream from the site. Other contaminants were present, yet they were within the acceptable limits. Analysis also concludes that RBF is an efficient and simple pre-treatment method for the river water.

Assumptions regarding the decrease in hydraulic conductivities in the areas used by the quarry due to high loads, transit, and vibrations were made according to Boussinesq's method and Das, 2010. Groundwater flow modeling suggest that the assumptions were correct and that the change in hydraulic conductivity are low closer to the surface and decrease as the depth increases.

Groundwater flow modeling using PMWIN estimated the travel time between the river and the PW. A maximum of 110 days was estimated and a minimum of ≤10 days. Water quality analysis suggest that these travel times are enough to remove high turbidity from the river water. Modeling also concludes the occurrence of RBF in the well sites.

An optimization scenario was executed in the PMWIN model. Results conclude that a substitution of the WTP for a series of wells operating through RBF possible. A cost benefit analysis concluded that the cost to run the RBF site could be 29% cheaper than a WTP operating at a same extraction rate. A water budged of the site estimates an extra 48.8 L/s which could be used while the decrease in the river levels is minimal.

Finally, the potential for riverbank filtration along the Barranca river is high. This study has proven that the method plays an important role in the providing drinking water to the town of Barranca in a simple and efficient manner. The investigation and proper implementation of this method should be continued in the country.

The availability or accessibility of needed information could present limitations to carry out further studies on RBF in Costa Rica.

Recommendations

Due to a large uncertainty regarding the k-value for the area around PW1, a pumping test should be conducted to obtain a more accurate model of the site. Investigation regarding recharge through rainwater or other sources should also be carried out as this could imply a higher capability in the system. Thickness of clogging layer should be determined as this affects the infiltration rate through the riverbed into the aquifer. An updated geological study should be obtained thus increasing the accuracy in which the model can predict scenarios. Studies regarding river and groundwater levels should be carried out in the drier times of the year as this would be the most critical condition. Surface water volume data could help determine the maximum amount of water that could be extracted in an RBF site. The model for this study should be calibrated and validated to ensure maximum accuracy for future predictions.

Investment in data loggers could ease monitoring in the wells as these measurements usually require long period measurements.

Observation wells should be placed between the river and the pumping wells to monitor levels and water quality.

Tracer tests should be implemented as a verification for travel times. Natural contaminants in the river could be used as tracers if the proper measurement is carried out.

For all well sites, proper limits for land use should respected as this affects the water quality and availability.

Geological maps with small scales could make locating a potential RBF site easier.

For implementation of this method in a new site careful prior research should be carried out. Even though costs and time for thorough research tend to by higher, the outcome is more efficient than most traditional methods.

Riverbank filtration is a cost-efficient method for removing contaminants from surface water. The potential for its implementation in Costa Rica is high and beneficial. A long-term investigation could be carried out. This to identify the potential sites for its application in the country. Due to each site being specific to its function, a large data base should be made or broadened. Information in most cases is available through its acquisition at times can be complicated. Once enough data is gathered, an Analytical Hierarchy Process could be carried out for similar type sites. This could potentially identify the optimal sites in the country for implementing RBF.

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Annexes

Information for PW 5

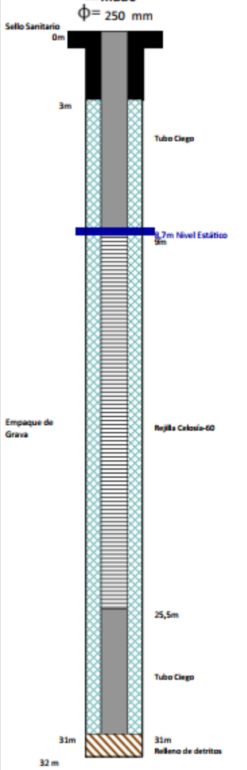
Instituto Costarricense de Acueductos y Alcantarillados
UEN Administración de Proyectos
Unidad Técnica de Perforaciones

Pozo N° 16-14 Pag. 1

Nombre: Procamar n°4 (I-2016)
N° Pozo SENARA/MINAE:

VALIDACIÓN: Informe generado por Luis Alonso Fallas Montoya el 07/09/2018. Nulo sin firma y sello de persona autorizada

Armado
ϕ= 250 mm



Ubicación

Localidad: Procamar
Coord: N 220277 - E 460289 **Elev(m):** 53 **Sist:** Lambert Norte
H/IGN: BARRANCA 3245 I **Provincia:** Puntarenas
Propietario: Sistemas Periféricos AyA **Cantón:** Esparza
Código: 06-02-01 **Distrito:** Espíritu Santo

Equipo de Perforación

Maquinaria: Dando T40w **Método:** Rotación con lodos
Perforador: Juan Carlos Valverde Fuentes **Orden Costos:** 0002016023-0
Inicio: 19/08/2016 **Final:** 12/10/2016 **Duración:** 54 días

Datos de Perforación

	Diámetro (mm)	Longitud (m)
Perforación	437.5	32
Tubería	250	14.5
Rejilla	250	16.5
Ademe	0	0

Material ACCA
Tiempo Desarrollo (h): 25
Desarrollo:
Aire comprimido

Datos Prueba de Bombeo

Fecha de prueba:	12/10/2016
Potencia bomba (hp):	50
Profundidad bomba (m):	25
Nivel estático (m):	8.7
Nivel dinámico (m):	18.05
Caudal prueba (l/s):	30
Abatimiento (m):	9.35
Coef.almacenamiento:	0
Transmisividad (m2/día):	3473
Caudal rec. (l/s):	28
Tiempo bombeo rec.(h):	20

Observaciones:
CRTM05 423961 E / 1105713 N. El pozo 16-14 se ubica en la margen izquierda del Río Barranca y sustituye al pozo BC-84. A partir de los resultados de la prueba de bombeo se recomienda un caudal de extracción de 28 L/s, considerando un abatimiento teórico de 9.97 m. Se recomienda un periodo de bombeo de 20 horas diarias con 4 horas de reposo que permitan una recuperación eficiente del acuífero. Equipo deberá de ser colocado a la profundidad de 27 m. Acuífero desarrollado en materiales aluvionales. Pozo Procamar 5 según el consecutivo de pozos construidos en la localidad.

Litología

0-27 m	Aluvión grueso conformado por bloques angulares inmersoso en una matriz arenosa, materiales inconsolidados.. Alta permeabilidad, representa el acuífero captado.
27-32 m	Materiales asociados a la Formación Punta Carballo, conglomerados coloración verdosa.

Instituto Costarricense de Acueductos y Alcantarillados
UEN Administración de Proyectos
Unidad Técnica de Perforaciones

Pozo N° 16-14 Pag. 2

Nombre: Procamar n°4 (I-2016)
N° Pozo SENARA/MINAE:

Imágenes

Máquina Perforadora Dando T40 empleada en las labores de perforación mediante el método rotación con lodos.

Zarta de perforación empleada durante la perforación del pozo. Visita de inspección día 22 de setiembre del 2016.

Prueba de bombeo realizada, caudal de prueba 30 L/s, agua extraida cristalina, libre de sedimentos.

Comportamiento de los abatimientos durante el desarrollo de la Prueba de bombeo efectuada por la UTP, cuadal de extracción 30 L/s.

Reportes de calidad de agua

No. Prueba	Tipo de prueba	No. Reporte	Fecha recolección muestra	Observaciones
1	Microbiológica	14935	12/10/2016	Según los resultados obtenidos, la muestra de agua evaluada es de calidad excelente, no se detecta presencia de coliformes fecales.
2	Físico-química	AyA-ID-10451-2016	12/10/2016	A partir de los resultados de los análisis, el agua es de calidad buena, los parámetros evaluados se encuentran por debajo de los valores máximos permisibles, cumpliendo satisfactoriamente los criterios de Calidad para Potabilización en Aguas de Pozos y Nacientes LNA 2012.

Ver validación en página 1

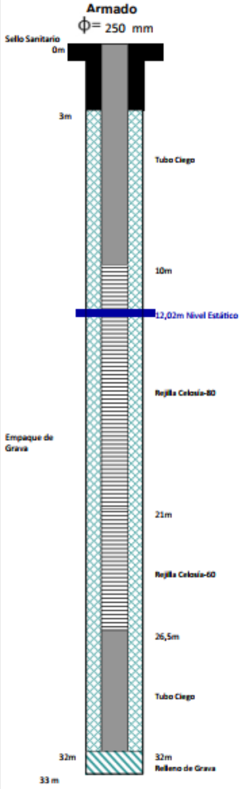
Information for PW 6

Instituto Costarricense de Acueductos y Alcantarillados
UEN Administración de Proyectos
Unidad Técnica de Perforaciones

Pozo N° 16-29 Pag. 1

Nombre: Procamar n°5 (II-2016)
N° Pozo SENARA/MINAE:

VALIDACIÓN: Informe generado por Luis Alonso Fallas Montoya el 07/09/2018. Nulo sin firma y sello de persona autorizada



Ubicación

Localidad: Procamar
Coord: N 220222 - E 460256 **Elev(m):** 56 **Sist:** Lambert Norte
H/IGN: BARRANCA 3245 I **Provincia:** Puntarenas
Propietario: Sistemas Periféricos AyA **Cantón:** Esparza
Código: 06-02-01 **Distrito:** Espíritu Santo

Equipo de Perforación

Maquinaria: Dando T40w **Método:** Rotación con lodos
Perforador: Juan Carlos Valverde Fuentes **Orden Costos:** 0002016040-0
Inicio: 14/10/2016 **Final:** 23/02/2017 **Duración:** 132 días

Datos de Perforación

	Diámetro (mm)	Longitud (m)
Perforación	437.5	33
Tubería	250	15.5
Rejilla	250	16.5
Ademe	0	0

Material ACCA
Tiempo Desarrollo (h): 24
Desarrollo:
Aire comprimido

Datos Prueba de Bombeo

Fecha de prueba:	01/03/2017
Potencia bomba (hp):	60
Profundidad bomba (m):	27
Nivel estático (m):	12.02
Nivel dinámico (m):	17.24
Caudal prueba (l/s):	12
Abatimiento (m):	5.22
Coef.almacenamiento:	0
Transmisividad (m2/dia):	336.81
Caudal rec. (l/s):	12
Tiempo bombeo rec.(h):	20

Observaciones:
A partir de la prueba de bombeo ejecutada en época de verano (1-03-2017) la UTP recomienda un caudal de extracción de 12 L/s considerando un periodo de bombeo continuo de 20 h diarias y 4 h de reposo para la recuperación del acuifero. Durante la prueba de bombeo el pozo a susituir Pozo n°3 (88-01) ubicado a 17. 5 m de distancia se encontraba en operación bajo un caudal de 7.5 L/s, por tal razon una vez fuera de operación el pozo n°3, es de esperar que el nuevo pozo tenga posibilidad de un mayor caudal de producción, con respecto al que ha sido recomendado. Pozo Procamar 5 según el consecutivo de pozos construidos en la localidad. Equipo de bombeo debe ser ubicado a la profundidad de 28 m.

Litología

0-22 m	Presencia de materiales aluvionales, conformados por bloques angulares sanos dentro de una matriz arenosa. Materiales inconsolidados de alta porosidad y permeabilidad. Corresponde con el acúifero a captar.
22-33 m	Materiales asociados a la Formación Punta Carballo, predomina una coloración verdosa. Materiales compactos que generen un avance lento en la perforación.

Instituto Costarricense de Acueductos y Alcantarillados
UEN Administración de Proyectos
Unidad Técnica de Perforaciones

Pozo N° 16-29 Pag. 2

Nombre: Procamar n°5 (II-2016)
N° Pozo SENARA/MINAE:

Imágenes

Labores de perforación mediante el equipo perforador T3Wn°4, el proyecto inicio en primera instancia con la máquina Dando.

Labores de limpieza del pozo 16-29 mediante la inyección de aire comprimido. La limpieza se prolongo por espacio de 24 Horas.

Caudal de extracción obtenido a partir de la prueba de bombeo del dia 1-03-2017. Agua cristalina libre de sedimentos finos.

Variación de los abatimiento durante el bombeo. Observese la recuperación del nivel, una vez que el caudal se regula a 12 L/s. Al final de la prueba el nivel dinámico se estabiliza.

Reportes de calidad de agua

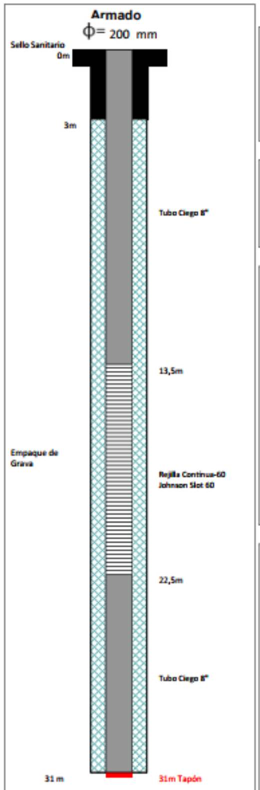
No. Prueba	Tipo de prueba	No. Reporte	Fecha recolección muestra	Observaciones
1	Físico-química	AYA-ID-01715-2017	01/03/2017	Según el resultado del análisis fisico-químico, la muestra evaluada es de calidad excelente, los valores de los parámetros evaluados se ubican por debajo de los valores máximos establecidos.
2	Microbiológica	15140	01/03/2017	Se determina que de acuerdo con el criterio microbiológico de evaluación de pozos, la muestra de agua es de calidad excelente, cumpliendo los requerimientos para consumo humano.

Information for PW3

Instituto Costarricense de Acueductos y Alcantarillados
UEN Administración de Proyectos
Unidad Técnica de Perforaciones

Pozo N° 88-01 Pag. 1
Nombre: Procamar n°3
N° Pozo SENARA/MINAE: INV-194

VALIDACIÓN: Informe generado por Luis Alonso Fallas Montoya el 07/09/2018. Nulo sin firma y sello de persona autorizada



Ubicación

Localidad: Procamar
Coord: N 220224 - E 460273 **Elev(m):** 0 **Sist:** Lambert Norte
H/IGN: BARRANCA 3245 I **Provincia:** Puntarenas
Propietario: Sistemas Periféricos Aya **Cantón:** Esparza
Código: 06-02-01 **Distrito:** Espíritu Santo

Equipo de Perforación

Maquinaria: 60 RL nº4 (antes 60RL2) **Método:** Percusión
Perforador: Pablo Mora **Orden Costos:**
Inicio: 26/05/1988 **Final:** 23/07/1988 **Duración:** 58 días

Datos de Perforación

	Diámetro (mm)	Longitud (m)
Perforación	300	31
Tubería	200	22
Rejilla	200	9
Ademe	300	0

Material FALTA
Tiempo Desarrollo (h): 10
Desarrollo:
Pistón
Observaciones:
Pozo conocido como Procamar N°3, pozo se encuentra en operación.

Datos Prueba de Bombeo

Fecha de prueba:	01/01/1900
Potencia bomba (hp):	0
Profundidad bomba (m):	0
Nivel estático (m):	0
Nivel dinámico (m):	0
Caudal prueba (l/s):	0
Abatimiento (m):	0
Coef.almacenamiento:	0
Transmisividad (m2/día):	0
Caudal rec. (l/s):	0
Tiempo bombeo rec.(h):	0

Litología

0-6 m	Aluviòn grande con arcilla.
6-28 m	Aluviòn grande con arenas medias.
28-31 m	Gravas arenas finas.

Instituto Costarricense de Acueductos y Alcantarillados
UEN Administración de Proyectos
Unidad Técnica de Perforaciones

Pozo N° 88-01 Pag. 2
Nombre: Procamar n°3
N° Pozo SENARA/MINAE: INV-194

Imágenes

Estado del pozo durante la visita de inspección a inicios del año 2016.

Reportes de calidad de agua

No. Prueba	Tipo de prueba	No. Reporte	Fecha recolección muestra	Observaciones

Ver validación en página 1

Information for PW2

Instituto Costarricense de Acueductos y Alcantarillados
UEN Administración de Proyectos
Unidad Técnica de Perforaciones

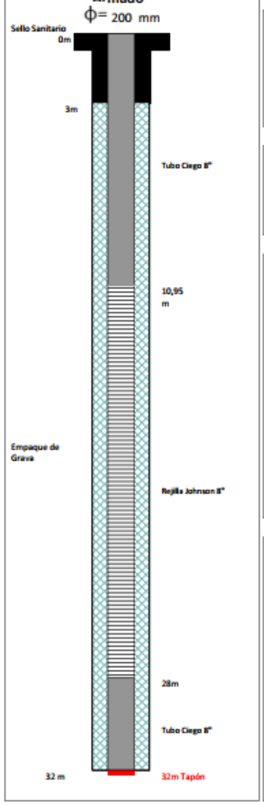
Pozo N° BC-84 Pag. 1

Nombre: Procamar n°2

N° Pozo SENARA/MINAE:

VALIDACIÓN: Informe generado por Luis Alonso Fallas Montoya el 07/09/2018. Nulo sin firma y sello de persona autorizada

Armado



Ubicación

Localidad: Procamar			
Coord: N 220276 - E 460288	**Elev(m):** 0	**Sist:**	Lambert Norte
H/IGN: BARRANCA 3245 I		**Provincia:**	Puntarenas
Propietario: Sistemas Periféricos AyA		**Cantón:**	Esparza
Código: 06-02-01		**Distrito:**	Espíritu Santo

Equipo de Perforación

Maquinaria:	60 RL nº3 (antes 60RL1)	**Método:**	Percusión
Perforador:	Pablo Mora	**Orden Costos:**	
Inicio: 07/04/1988	**Final:** 25/05/1988	**Duración:**	48 días

Datos de Perforación

	Diámetro (mm)	Longitud (m)
Perforación	300	32
Tubería	200	14.95
Rejilla	200	17.05
Ademe	300	0

Material Acero

Tiempo Desarrollo (h): 12

Desarrollo:

Pistón

Observaciones:

Este pozo es sustituido por el pozo construido en el año 2016, pozo 16-14.

Datos Prueba de Bombeo

Fecha de prueba:	31/05/1988
Potencia bomba (hp):	0
Profundidad bomba (m):	0
Nivel estático (m):	4.2
Nivel dinámico (m):	12.86
Caudal prueba (l/s):	9.7
Abatimiento (m):	0
Coef.almacenamiento:	0
Transmisividad (m2/día):	0
Caudal rec. (l/s):	0
Tiempo bombeo rec.(h):	0

Litología

0-7 m	Aluviòn grande con arcilla.
7-27 m	Aliviòn con arena media.
27-32 m	Grava con arena.

Instituto Costarricense de Acueductos y Alcantarillados
UEN Administración de Proyectos
Unidad Técnica de Perforaciones

Pozo N° BC-84 Pag. 2

Nombre: Procamar n°2

N° Pozo SENARA/MINAE:

Imágenes

Vista del estado del pozo al momento de la visita de inspección a inicios del año 2016.

Reportes de calidad de agua

No. Prueba	Tipo de prueba	No. Reporte	Fecha recolección muestra	Observaciones

Ver validación en página 1

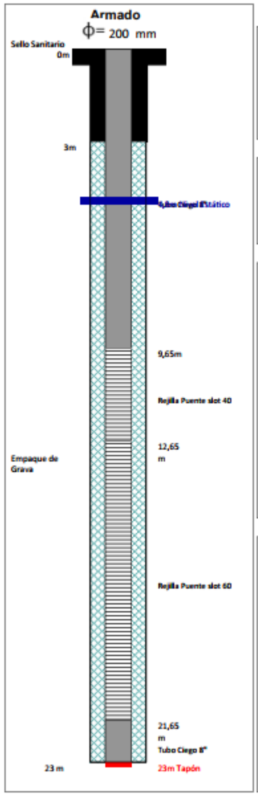
Information for PW1

Instituto Costarricense de Acueductos y Alcantarillados
UEN Administración de Proyectos
Unidad Técnica de Perforaciones

Pozo N° MI-16 Pag. 1

Nombre: Procamar n°1
N° Pozo SENARA/MINAE:

VALIDACIÓN: Informe generado por Luis Alonso Fallas Montoya el 07/09/2018. Nulo sin firma y sello de persona autorizada



Ubicación

Localidad: Procamar
Coord: N 220450 - E 460300 **Elev(m):** 0 **Sist:** Lambert Norte
H/IGN: MIRAMAR 3246 II **Provincia:** Puntarenas
Propietario: Sistemas Periféricos Aya **Cantón:** Esparza
Código: 06-02-01 **Distrito:** Espíritu Santo

Equipo de Perforación

Maquinaria: 60 RL nº4 (antes 60RL2) **Método:** Percusión
Perforador: Pablo Mora **Orden Costos:**
Inicio: 02/02/1988 **Final:** 07/04/1988 **Duración:** 65 días

Datos de Perforación

	Diámetro (mm)	Longitud (m)
Perforación	300	23
Tubería	200	11
Rejilla	200	12
Ademe	300	0

Material Acero
Tiempo Desarrollo (h): 0
Desarrollo:

Observaciones:

Datos Prueba de Bombeo

Fecha de prueba:	01/01/1900
Potencia bomba (hp):	0
Profundidad bomba (m):	18.5
Nivel estático (m):	4.69
Nivel dinámico (m):	10.13
Caudal prueba (l/s):	17.2
Abatimiento (m):	0
Coef.almacenamiento:	0
Transmisividad (m2/día):	0
Caudal rec. (l/s):	0
Tiempo bombeo rec.(h):	0

Litología

0-3 m	Suelo arcilloso, color cafè oscuro, plàstico con 5% de fragmentos de composiciòn basàltica de tamaño arena gruesa.
3-10 m	Aluviòn grueso, basaltos de textura afanìtica porfirìtica, con secciones bastante oxidadas, dichos fragmentos de silice amorfo (calcedonia), calcarenita. El material es grava de media a gruesa.
10-16 m	Idem anterior.
16-18 m	Material heterogèneo, compuesto principalmente por fragmentos vòlcanicos de composiciòn basalto-andesìtico con un diàmetro aprox. De 5 a 10 mm. Tiene ademàs ventillas de càlcita y algunas manchas de oxidaciòn. Otros fragmentos son de silice amorfo (calcedonia).
18-23 m	De igual litologìa, pero con marcada reducciòn de los granos tendiendo a ser finos.

Instituto Costarricense de Acueductos y Alcantarillados
UEN Administración de Proyectos
Unidad Técnica de Perforaciones

Pozo N° MI-16 Pag. 2

Nombre: Procamar n°1
N° Pozo SENARA/MINAE:

Imágenes

Estado del pozo Procaram n°1 durante la visita de inspección a inicios del año 2016.

Reportes de calidad de agua

No. Prueba	Tipo de prueba	No. Reporte	Fecha recolección muestra	Observaciones

Ver validación en página 1

Raw water quality analysis

INSTITUTO COSTARRICENSE DE ACUEDUCTOS Y ALCANTARILLADOS
LABORATORIO NACIONAL DE AGUAS

RESULTADOS DE ANÁLISIS FISICOQUÍMICOS DEL AGUA CRUDA DEL SISTEMA PC-A-17-BARRANCA - EL ROBLE- CHACARITA (2008-2019)

Para: Andrés Lazo Paez

De: Yuliana Solís Castro

FECHA DE MUESTREO	ID LAB	PUNTO DE MUESTREO	PARAMETRO	RESULTADO	UNIDADES
22-May-08	AYA-ID-02425-2008	CRUDA	Alcalinidad	41	mg/L
22-May-08	AYA-ID-02425-2008	CRUDA	Color Aparente	400	UPt-Co
22-May-08	AYA-ID-02425-2008	CRUDA	Color Verdadero	200	UPt-Co
22-May-08	AYA-ID-02425-2008	CRUDA	Dureza Total	80	mg/L
22-May-08	AYA-ID-02425-2008	CRUDA	Hierro (1-10 Fenantrolina)	0.41	mg/L
22-May-08	AYA-ID-02425-2008	CRUDA	Olor	Negativo	
22-May-08	AYA-ID-02425-2008	CRUDA	pH	7.6	
22-May-08	AYA-ID-02425-2008	CRUDA	Sulfatos (Cloruro de Bario)	41	mg/L
22-May-08	AYA-ID-02425-2008	CRUDA	Turbiedad	239	UNT
16-Jul-08	AYA-ID-03464-2008	CRUDA	Alcalinidad	52	mg/L
16-Jul-08	AYA-ID-03464-2008	CRUDA	Color Aparente	7.5	UPt-Co
16-Jul-08	AYA-ID-03464-2008	CRUDA	Color Verdadero	2.5	UPt-Co
16-Jul-08	AYA-ID-03464-2008	CRUDA	Dureza Total	60	mg/L
16-Jul-08	AYA-ID-03464-2008	CRUDA	Hierro (1-10 Fenantrolina)	0.09	mg/L
16-Jul-08	AYA-ID-03464-2008	CRUDA	Olor	Negativo	
16-Jul-08	AYA-ID-03464-2008	CRUDA	pH	7.45	
16-Jul-08	AYA-ID-03464-2008	CRUDA	Sulfatos (Cloruro de Bario)	13	mg/L
16-Jul-08	AYA-ID-03464-2008	CRUDA	Turbiedad	2.87	UNT
3-Oct-08	AYA-ID-04911-2008	CRUDA	Alcalinidad	47	mg/L
3-Oct-08	AYA-ID-04911-2008	CRUDA	Color Aparente	150	UPt-Co
3-Oct-08	AYA-ID-04911-2008	CRUDA	Color Verdadero	50	UPt-Co
3-Oct-08	AYA-ID-04911-2008	CRUDA	Dureza Total	47	mg/L
3-Oct-08	AYA-ID-04911-2008	CRUDA	Hierro (1-10 Fenantrolina)	0.83	mg/L
3-Oct-08	AYA-ID-04911-2008	CRUDA	Olor	Negativo	
3-Oct-08	AYA-ID-04911-2008	CRUDA	pH	6.8	
3-Oct-08	AYA-ID-04911-2008	CRUDA	Sulfatos (Cloruro de Bario)	6	mg/L
3-Oct-08	AYA-ID-04911-2008	CRUDA	Turbiedad	74.5	UNT
31-Oct-08	AYA-ID-05377-2008	CRUDA	Alcalinidad	41	mg/L
31-Oct-08	AYA-ID-05377-2008	CRUDA	Color Aparente	25	UPt-Co
31-Oct-08	AYA-ID-05377-2008	CRUDA	Color Verdadero	10	UPt-Co
31-Oct-08	AYA-ID-05377-2008	CRUDA	Dureza Total	56	mg/L
31-Oct-08	AYA-ID-05377-2008	CRUDA	Hierro (1-10 Fenantrolina)	0.3	mg/L
31-Oct-08	AYA-ID-05377-2008	CRUDA	Olor	Negativo	

31-Oct-08	AYA-ID-05377-2008	CRUDA	pH	7	
31-Oct-08	AYA-ID-05377-2008	CRUDA	Sulfatos (Cloruro de Bario)	18	mg/L
31-Oct-08	AYA-ID-05377-2008	CRUDA	Turbiedad	12.9	UNT
27-Nov-08	AYA-ID-06047-2008	CRUDA	Alcalinidad	23	mg/L
27-Nov-08	AYA-ID-06047-2008	CRUDA	Color Aparente	30	UPt-Co
27-Nov-08	AYA-ID-06047-2008	CRUDA	Color Verdadero	12.5	UPt-Co
27-Nov-08	AYA-ID-06047-2008	CRUDA	Dureza Total	27	mg/L
27-Nov-08	AYA-ID-06047-2008	CRUDA	Hierro (1-10 Fenantrolina)	0.09	mg/L
27-Nov-08	AYA-ID-06047-2008	CRUDA	Olor	Negativo	
27-Nov-08	AYA-ID-06047-2008	CRUDA	pH	7.2	
27-Nov-08	AYA-ID-06047-2008	CRUDA	Sulfatos (Cloruro de Bario)	8	mg/L
27-Nov-08	AYA-ID-06047-2008	CRUDA	Turbiedad	17.6	UNT
21-Jan-09	AYA-ID-00412-2009	CRUDA	Alcalinidad	48	mg/L
21-Jan-09	AYA-ID-00412-2009	CRUDA	Color Aparente	12.5	UPt-Co
21-Jan-09	AYA-ID-00412-2009	CRUDA	Color Verdadero	5	UPt-Co
21-Jan-09	AYA-ID-00412-2009	CRUDA	Dureza Total	52	mg/L
21-Jan-09	AYA-ID-00412-2009	CRUDA	Hierro (1-10 Fenantrolina)	0.23	mg/L
21-Jan-09	AYA-ID-00412-2009	CRUDA	Olor	Negativo	
21-Jan-09	AYA-ID-00412-2009	CRUDA	pH	7.5	
21-Jan-09	AYA-ID-00412-2009	CRUDA	Sulfatos (Cloruro de Bario)	17	mg/L
21-Jan-09	AYA-ID-00412-2009	CRUDA	Turbiedad	6.88	UNT
29-Apr-09	AYA-ID-02418-2009	CRUDA	Alcalinidad	59	mg/L
29-Apr-09	AYA-ID-02418-2009	CRUDA	Color Aparente	10	UPt-Co
29-Apr-09	AYA-ID-02418-2009	CRUDA	Color Verdadero	2.5	UPt-Co
29-Apr-09	AYA-ID-02418-2009	CRUDA	Dureza Total	63	mg/L
29-Apr-09	AYA-ID-02418-2009	CRUDA	Hierro (1-10 Fenantrolina)	0.37	mg/L
29-Apr-09	AYA-ID-02418-2009	CRUDA	Olor	Negativo	
29-Apr-09	AYA-ID-02418-2009	CRUDA	pH	7.75	
29-Apr-09	AYA-ID-02418-2009	CRUDA	Sulfatos (Cloruro de Bario)	19	mg/L
29-Apr-09	AYA-ID-02418-2009	CRUDA	Turbiedad	4.56	UNT
27-May-09	AYA-ID-02947-2009	CRUDA	Alcalinidad	48	mg/L
27-May-09	AYA-ID-02947-2009	CRUDA	Color Aparente	400	UPt-Co
27-May-09	AYA-ID-02947-2009	CRUDA	Color Verdadero	70	UPt-Co
27-May-09	AYA-ID-02947-2009	CRUDA	Dureza Total	67	mg/L
27-May-09	AYA-ID-02947-2009	CRUDA	Hierro (1-10 Fenantrolina)	0.23	mg/L
27-May-09	AYA-ID-02947-2009	CRUDA	Olor	Negativo	
27-May-09	AYA-ID-02947-2009	CRUDA	pH	7.25	
27-May-09	AYA-ID-02947-2009	CRUDA	Sulfatos (Cloruro de Bario)	25	mg/L
27-May-09	AYA-ID-02947-2009	CRUDA	Turbiedad	149	UNT
24-Jun-09	AYA-ID-03497-2009	CRUDA	Alcalinidad	0	mg/L
24-Jun-09	AYA-ID-03497-2009	CRUDA	Color Aparente	150	UPt-Co
24-Jun-09	AYA-ID-03497-2009	CRUDA	Color Verdadero	12.5	UPt-Co
24-Jun-09	AYA-ID-03497-2009	CRUDA	Hierro (1-10 Fenantrolina)	1.2	mg/L
24-Jun-09	AYA-ID-03497-2009	CRUDA	Olor	Negativo	
24-Jun-09	AYA-ID-03497-2009	CRUDA	Sulfatos (Cloruro de Bario)	10	mg/L
24-Jun-09	AYA-ID-03497-2009	CRUDA	Turbiedad	89.5	UNT

30-Jul-09	AYA-ID-04423-2009	CRUDA	Alcalinidad	49	mg/L
30-Jul-09	AYA-ID-04423-2009	CRUDA	Color Aparente	250	UPt-Co
30-Jul-09	AYA-ID-04423-2009	CRUDA	Color Verdadero	40	UPt-Co
30-Jul-09	AYA-ID-04423-2009	CRUDA	Dureza Total	68	mg/L
30-Jul-09	AYA-ID-04423-2009	CRUDA	Hierro (1-10 Fenantrolina)	0.41	mg/L
30-Jul-09	AYA-ID-04423-2009	CRUDA	Olor	Negativo	
30-Jul-09	AYA-ID-04423-2009	CRUDA	pH	7.55	
30-Jul-09	AYA-ID-04423-2009	CRUDA	Sulfatos (Cloruro de Bario)	24	mg/L
30-Jul-09	AYA-ID-04423-2009	CRUDA	Turbiedad	116	UNT
27-Aug-09	AYA-ID-05007-2009	CRUDA	Alcalinidad	43	mg/L
27-Aug-09	AYA-ID-05007-2009	CRUDA	Color Aparente	350	UPt-Co
27-Aug-09	AYA-ID-05007-2009	CRUDA	Color Verdadero	150	UPt-Co
27-Aug-09	AYA-ID-05007-2009	CRUDA	Dureza Total	62	mg/L
27-Aug-09	AYA-ID-05007-2009	CRUDA	Hierro (1-10 Fenantrolina)	0.85	mg/L
27-Aug-09	AYA-ID-05007-2009	CRUDA	Olor	Negativo	
27-Aug-09	AYA-ID-05007-2009	CRUDA	pH	6.95	
27-Aug-09	AYA-ID-05007-2009	CRUDA	Sulfatos (Cloruro de Bario)	27	mg/L
27-Aug-09	AYA-ID-05007-2009	CRUDA	Turbiedad	132	UNT
1-Oct-09	AYA-ID-05974-2009	CRUDA	Alcalinidad	53	mg/L
1-Oct-09	AYA-ID-05974-2009	CRUDA	Color Aparente	12.5	UPt-Co
1-Oct-09	AYA-ID-05974-2009	CRUDA	Color Verdadero	7.5	UPt-Co
1-Oct-09	AYA-ID-05974-2009	CRUDA	Dureza Total	62	mg/L
1-Oct-09	AYA-ID-05974-2009	CRUDA	Hierro (1-10 Fenantrolina)	0.23	mg/L
1-Oct-09	AYA-ID-05974-2009	CRUDA	Olor	Negativo	
1-Oct-09	AYA-ID-05974-2009	CRUDA	pH	6.95	
1-Oct-09	AYA-ID-05974-2009	CRUDA	Sulfatos (Cloruro de Bario)	15	mg/L
1-Oct-09	AYA-ID-05974-2009	CRUDA	Turbiedad	7.52	UNT
5-Nov-09	AYA-ID-06660-2009	CRUDA	Alcalinidad	38	mg/L
5-Nov-09	AYA-ID-06660-2009	CRUDA	Aluminio (Cianina de Eriocromo)	0.08	mg/L
5-Nov-09	AYA-ID-06660-2009	CRUDA	Color Aparente	500	UPt-Co
5-Nov-09	AYA-ID-06660-2009	CRUDA	Color Verdadero	300	UPt-Co
5-Nov-09	AYA-ID-06660-2009	CRUDA	Dureza Total	54	mg/L
5-Nov-09	AYA-ID-06660-2009	CRUDA	Hierro (1-10 Fenantrolina)	1	mg/L
5-Nov-09	AYA-ID-06660-2009	CRUDA	Olor	Negativo	
5-Nov-09	AYA-ID-06660-2009	CRUDA	pH	7.05	
5-Nov-09	AYA-ID-06660-2009	CRUDA	Sulfatos (Cloruro de Bario)	19	mg/L
5-Nov-09	AYA-ID-06660-2009	CRUDA	Turbiedad	272	UNT
28-Jan-10	AYA-ID-00527-2010	CRUDA	Alcalinidad	44	mg/L
28-Jan-10	AYA-ID-00527-2010	CRUDA	Aluminio (Cianina de Eriocromo)	0.1	mg/L
28-Jan-10	AYA-ID-00527-2010	CRUDA	Color Aparente	20	UPt-Co
28-Jan-10	AYA-ID-00527-2010	CRUDA	Color Verdadero	7.5	UPt-Co
28-Jan-10	AYA-ID-00527-2010	CRUDA	Dureza Total	58	mg/L
28-Jan-10	AYA-ID-00527-2010	CRUDA	Hierro (1-10 Fenantrolina)	0.28	mg/L
28-Jan-10	AYA-ID-00527-2010	CRUDA	Olor	Negativo	
28-Jan-10	AYA-ID-00527-2010	CRUDA	pH	7.4	
28-Jan-10	AYA-ID-00527-2010	CRUDA	Sulfatos (Cloruro de Bario)	23	mg/L

28-Jan-10	AYA-ID-00527-2010	CRUDA	Turbiedad	13.2	UNT
25-Feb-10	AYA-ID-01174-2010	CRUDA	Alcalinidad	41	mg/L
25-Feb-10	AYA-ID-01174-2010	CRUDA	Aluminio (Cianina de Eriocromo)	ND	mg/L
25-Feb-10	AYA-ID-01174-2010	CRUDA	Color Aparente	25	UPt-Co
25-Feb-10	AYA-ID-01174-2010	CRUDA	Color Verdadero	7.5	UPt-Co
25-Feb-10	AYA-ID-01174-2010	CRUDA	Dureza Total	60	mg/L
25-Feb-10	AYA-ID-01174-2010	CRUDA	Hierro (1-10 Fenantrolina)	0.18	mg/L
25-Feb-10	AYA-ID-01174-2010	CRUDA	Olor	Negativo	
25-Feb-10	AYA-ID-01174-2010	CRUDA	pH	7.6	
25-Feb-10	AYA-ID-01174-2010	CRUDA	Sulfatos (Cloruro de Bario)	21	mg/L
25-Feb-10	AYA-ID-01174-2010	CRUDA	Turbiedad	16.8	UNT
25-Mar-10	AYA-ID-01905-2010	CRUDA	Alcalinidad	34	mg/L
25-Mar-10	AYA-ID-01905-2010	CRUDA	Color Aparente	12.5	UPt-Co
25-Mar-10	AYA-ID-01905-2010	CRUDA	Color Verdadero	5	UPt-Co
25-Mar-10	AYA-ID-01905-2010	CRUDA	Dureza Total	52	mg/L
25-Mar-10	AYA-ID-01905-2010	CRUDA	Hierro (1-10 Fenantrolina)	0.18	mg/L
25-Mar-10	AYA-ID-01905-2010	CRUDA	Olor	Negativo	
25-Mar-10	AYA-ID-01905-2010	CRUDA	pH	7.65	
25-Mar-10	AYA-ID-01905-2010	CRUDA	Sulfatos (Cloruro de Bario)	19	mg/L
25-Mar-10	AYA-ID-01905-2010	CRUDA	Turbiedad	8.43	UNT
29-Apr-10	AYA-ID-02453-2010	CRUDA	Alcalinidad	45	mg/L
29-Apr-10	AYA-ID-02453-2010	CRUDA	Color Aparente	100	UPt-Co
29-Apr-10	AYA-ID-02453-2010	CRUDA	Color Verdadero	50	UPt-Co
29-Apr-10	AYA-ID-02453-2010	CRUDA	Dureza Total	70	mg/L
29-Apr-10	AYA-ID-02453-2010	CRUDA	Hierro (1-10 Fenantrolina)	0.3	mg/L
29-Apr-10	AYA-ID-02453-2010	CRUDA	Olor	Negativo	
29-Apr-10	AYA-ID-02453-2010	CRUDA	pH	7.5	
29-Apr-10	AYA-ID-02453-2010	CRUDA	Sulfatos (Cloruro de Bario)	19	mg/L
29-Apr-10	AYA-ID-02453-2010	CRUDA	Turbiedad	59.5	UNT
24-May-10	AYA-ID-03044-2010	CRUDA	Alcalinidad	25	mg/L
24-May-10	AYA-ID-03044-2010	CRUDA	Color Aparente	400	UPt-Co
24-May-10	AYA-ID-03044-2010	CRUDA	Color Verdadero	200	UPt-Co
24-May-10	AYA-ID-03044-2010	CRUDA	Dureza Total	52	mg/L
24-May-10	AYA-ID-03044-2010	CRUDA	Hierro (1-10 Fenantrolina)	0.25	mg/L
24-May-10	AYA-ID-03044-2010	CRUDA	Olor	Negativo	
24-May-10	AYA-ID-03044-2010	CRUDA	pH	7	
24-May-10	AYA-ID-03044-2010	CRUDA	Sulfatos (Cloruro de Bario)	28	mg/L
24-May-10	AYA-ID-03044-2010	CRUDA	Turbiedad	290	UNT
21-Jun-10	AYA-ID-03616-2010	CRUDA	Alcalinidad	47	mg/L
21-Jun-10	AYA-ID-03616-2010	CRUDA	Aluminio (Cianina de Eriocromo)	0.24	mg/L
21-Jun-10	AYA-ID-03616-2010	CRUDA	Color Aparente	100	UPt-Co
21-Jun-10	AYA-ID-03616-2010	CRUDA	Color Verdadero	50	UPt-Co
21-Jun-10	AYA-ID-03616-2010	CRUDA	Dureza Total	48	mg/L
21-Jun-10	AYA-ID-03616-2010	CRUDA	Hierro (1-10 Fenantrolina)	0.6	mg/L
21-Jun-10	AYA-ID-03616-2010	CRUDA	Olor	Negativo	
21-Jun-10	AYA-ID-03616-2010	CRUDA	pH	7.25	

21-Jun-10	AYA-ID-03616-2010	CRUDA	Sulfatos (Cloruro de Bario)	19	mg/L
21-Jun-10	AYA-ID-03616-2010	CRUDA	Turbiedad	49	UNT
26-Jul-10	AYA-ID-04498-2010	CRUDA	Alcalinidad	51	mg/L
26-Jul-10	AYA-ID-04498-2010	CRUDA	Aluminio (Cianina de Eriocromo)	0.17	mg/L
26-Jul-10	AYA-ID-04498-2010	CRUDA	Color Aparente	150	UPt-Co
26-Jul-10	AYA-ID-04498-2010	CRUDA	Color Verdadero	60	UPt-Co
26-Jul-10	AYA-ID-04498-2010	CRUDA	Dureza Total	50	mg/L
26-Jul-10	AYA-ID-04498-2010	CRUDA	Hierro (1-10 Fenantrolina)	0.36	mg/L
26-Jul-10	AYA-ID-04498-2010	CRUDA	Olor	Negativo	
26-Jul-10	AYA-ID-04498-2010	CRUDA	pH	7.3	
26-Jul-10	AYA-ID-04498-2010	CRUDA	Sulfatos (Cloruro de Bario)	12	mg/L
26-Jul-10	AYA-ID-04498-2010	CRUDA	Turbiedad	57.8	UNT
23-Aug-10	AYA-ID-05237-2010	CRUDA	Alcalinidad	40	mg/L
23-Aug-10	AYA-ID-05237-2010	CRUDA	Aluminio (Cianina de Eriocromo)	ND	mg/L
23-Aug-10	AYA-ID-05237-2010	CRUDA	Color Aparente	35	UPt-Co
23-Aug-10	AYA-ID-05237-2010	CRUDA	Color Verdadero	20	UPt-Co
23-Aug-10	AYA-ID-05237-2010	CRUDA	Dureza Total	42	mg/L
23-Aug-10	AYA-ID-05237-2010	CRUDA	Hierro (1-10 Fenantrolina)	0.25	mg/L
23-Aug-10	AYA-ID-05237-2010	CRUDA	Olor	Negativo	
23-Aug-10	AYA-ID-05237-2010	CRUDA	pH	7.1	
23-Aug-10	AYA-ID-05237-2010	CRUDA	Sulfatos (Cloruro de Bario)	12	mg/L
23-Aug-10	AYA-ID-05237-2010	CRUDA	Turbiedad	24.4	UNT
27-Sep-10	AYA-ID-06200-2010	CRUDA	Alcalinidad	38	mg/L
27-Sep-10	AYA-ID-06200-2010	CRUDA	Aluminio (Cianina de Eriocromo)	0.12	mg/L
27-Sep-10	AYA-ID-06200-2010	CRUDA	Color Aparente	600	UPt-Co
27-Sep-10	AYA-ID-06200-2010	CRUDA	Color Verdadero	300	UPt-Co
27-Sep-10	AYA-ID-06200-2010	CRUDA	Dureza Total	32	mg/L
27-Sep-10	AYA-ID-06200-2010	CRUDA	Hierro (1-10 Fenantrolina)	0.46	mg/L
27-Sep-10	AYA-ID-06200-2010	CRUDA	Olor	Negativo	
27-Sep-10	AYA-ID-06200-2010	CRUDA	pH	7.15	
27-Sep-10	AYA-ID-06200-2010	CRUDA	Sulfatos (Cloruro de Bario)	2	mg/L
27-Sep-10	AYA-ID-06200-2010	CRUDA	Turbiedad	260	UNT
25-Oct-10	AYA-ID-06751-2010	CRUDA	Alcalinidad	44	mg/L
25-Oct-10	AYA-ID-06751-2010	CRUDA	Aluminio (Cianina de Eriocromo)	N.D.	mg/L
25-Oct-10	AYA-ID-06751-2010	CRUDA	Color Aparente	40	UPt-Co
25-Oct-10	AYA-ID-06751-2010	CRUDA	Color Verdadero	17.5	UPt-Co
25-Oct-10	AYA-ID-06751-2010	CRUDA	Dureza Total	49	mg/L
25-Oct-10	AYA-ID-06751-2010	CRUDA	Hierro (1-10 Fenantrolina)	0.24	mg/L
25-Oct-10	AYA-ID-06751-2010	CRUDA	Olor	Negativo	
25-Oct-10	AYA-ID-06751-2010	CRUDA	pH	7.4	
25-Oct-10	AYA-ID-06751-2010	CRUDA	Sulfatos (Cloruro de Bario)	14	mg/L
25-Oct-10	AYA-ID-06751-2010	CRUDA	Turbiedad	20.5	UNT
22-Nov-10	AYA-ID-07618-2010	CRUDA	Alcalinidad	51	mg/L
22-Nov-10	AYA-ID-07618-2010	CRUDA	Aluminio (Cianina de Eriocromo)	N.D.	mg/L
22-Nov-10	AYA-ID-07618-2010	CRUDA	Color Aparente	12.5	UPt-Co
22-Nov-10	AYA-ID-07618-2010	CRUDA	Color Verdadero	5	UPt-Co

22-Nov-10	AYA-ID-07618-2010	CRUDA	Dureza Total	56	mg/L
22-Nov-10	AYA-ID-07618-2010	CRUDA	Hierro (1-10 Fenantrolina)	0.16	mg/L
22-Nov-10	AYA-ID-07618-2010	CRUDA	Olor	Negativo	
22-Nov-10	AYA-ID-07618-2010	CRUDA	pH	7.35	
22-Nov-10	AYA-ID-07618-2010	CRUDA	Sulfatos (Cloruro de Bario)	19	mg/L
22-Nov-10	AYA-ID-07618-2010	CRUDA	Turbiedad	5.74	UNT
15-Dec-10	AYA-ID-08263-2010	CRUDA	Alcalinidad	46	mg/L
15-Dec-10	AYA-ID-08263-2010	CRUDA	Aluminio (Cianina de Eriocromo)	N.D.	mg/L
15-Dec-10	AYA-ID-08263-2010	CRUDA	Color Aparente	12.5	UPt-Co
15-Dec-10	AYA-ID-08263-2010	CRUDA	Color Verdadero	7.5	UPt-Co
15-Dec-10	AYA-ID-08263-2010	CRUDA	Dureza Total	50	mg/L
15-Dec-10	AYA-ID-08263-2010	CRUDA	Hierro (1-10 Fenantrolina)	0.18	mg/L
15-Dec-10	AYA-ID-08263-2010	CRUDA	Olor	Negativo	
15-Dec-10	AYA-ID-08263-2010	CRUDA	ph	7.2	
15-Dec-10	AYA-ID-08263-2010	CRUDA	Sulfatos (Cloruro de Bario)	14	mg/L
15-Dec-10	AYA-ID-08263-2010	CRUDA	Turbiedad	5.8	UNT
24-Jan-11	AYA-ID-00548-2011	CRUDA	Alcalinidad	46	mg/L
24-Jan-11	AYA-ID-00548-2011	CRUDA	Aluminio (Cianina de Eriocromo)	N.D.	mg/L
24-Jan-11	AYA-ID-00548-2011	CRUDA	Color Aparente	5	UPt-Co
24-Jan-11	AYA-ID-00548-2011	CRUDA	Color Verdadero	2.5	UPt-Co
24-Jan-11	AYA-ID-00548-2011	CRUDA	Dureza Total	48	mg/L
24-Jan-11	AYA-ID-00548-2011	CRUDA	Hierro (1-10 Fenantrolina)	N.D.	mg/L
24-Jan-11	AYA-ID-00548-2011	CRUDA	Olor	Negativo	
24-Jan-11	AYA-ID-00548-2011	CRUDA	pH	7.65	
24-Jan-11	AYA-ID-00548-2011	CRUDA	Sulfatos (Cloruro de Bario)	13	mg/L
24-Jan-11	AYA-ID-00548-2011	CRUDA	Turbiedad	2.59	UNT
22-Feb-11	AYA-ID-01302-2011	CRUDA	Alcalinidad	50	mg/L
22-Feb-11	AYA-ID-01302-2011	CRUDA	Color Aparente	5	UPt-Co
22-Feb-11	AYA-ID-01302-2011	CRUDA	Color Verdadero	3	UPt-Co
22-Feb-11	AYA-ID-01302-2011	CRUDA	Dureza Total	52	mg/L
22-Feb-11	AYA-ID-01302-2011	CRUDA	Olor	Negativo	
22-Feb-11	AYA-ID-01302-2011	CRUDA	pH	7.5	
22-Feb-11	AYA-ID-01302-2011	CRUDA	Sulfatos (Cloruro de Bario)	15	mg/L
22-Feb-11	AYA-ID-01302-2011	CRUDA	Turbiedad	3.05	UNT
31-Mar-11	AYA-ID-02306-2011	CRUDA	Alcalinidad	56	mg/L
31-Mar-11	AYA-ID-02306-2011	CRUDA	Aluminio (Cianina de Eriocromo)	N.D.	mg/L
31-Mar-11	AYA-ID-02306-2011	CRUDA	Color Aparente	3	UPt-Co
31-Mar-11	AYA-ID-02306-2011	CRUDA	Color Verdadero	1	UPt-Co
31-Mar-11	AYA-ID-02306-2011	CRUDA	Dureza Total	66	mg/L
31-Mar-11	AYA-ID-02306-2011	CRUDA	Hierro (1-10 Fenantrolina)	0.13	mg/L
31-Mar-11	AYA-ID-02306-2011	CRUDA	Olor	Negativo	
31-Mar-11	AYA-ID-02306-2011	CRUDA	pH	7.5	
31-Mar-11	AYA-ID-02306-2011	CRUDA	Sulfatos (Cloruro de Bario)	19	mg/L
31-Mar-11	AYA-ID-02306-2011	CRUDA	Turbiedad	1.85	UNT
26-Apr-11	AYA-ID-02808-2011	CRUDA	Alcalinidad	58	mg/L
26-Apr-11	AYA-ID-02808-2011	CRUDA	Aluminio (Cianina de Eriocromo)	N.D.	mg/L

26-Apr-11	AYA-ID-02808-2011	CRUDA	Color Aparente	13	UPt-Co
26-Apr-11	AYA-ID-02808-2011	CRUDA	Color Verdadero	5	UPt-Co
26-Apr-11	AYA-ID-02808-2011	CRUDA	Dureza Total	63	mg/L
26-Apr-11	AYA-ID-02808-2011	CRUDA	Hierro (1-10 Fenantrolina)	0.14	mg/L
26-Apr-11	AYA-ID-02808-2011	CRUDA	Olor	Negativo	
26-Apr-11	AYA-ID-02808-2011	CRUDA	pH	8.05	
26-Apr-11	AYA-ID-02808-2011	CRUDA	Sulfatos (Cloruro de Bario)	26	mg/L
26-Apr-11	AYA-ID-02808-2011	CRUDA	Turbiedad	7.3	UNT
23-May-11	AYA-ID-03372-2011	CRUDA	Alcalinidad	49	mg/L
23-May-11	AYA-ID-03372-2011	CRUDA	Aluminio (Cianina de Eriocromo)	0.14	mg/L
23-May-11	AYA-ID-03372-2011	CRUDA	Color Aparente	300	UPt-Co
23-May-11	AYA-ID-03372-2011	CRUDA	Color Verdadero	125	UPt-Co
23-May-11	AYA-ID-03372-2011	CRUDA	Dureza Total	60	mg/L
23-May-11	AYA-ID-03372-2011	CRUDA	Hierro (1-10 Fenantrolina)	0.48	mg/L
23-May-11	AYA-ID-03372-2011	CRUDA	Olor	Negativo	
23-May-11	AYA-ID-03372-2011	CRUDA	pH	7.4	
23-May-11	AYA-ID-03372-2011	CRUDA	Sulfatos (Cloruro de Bario)	18	mg/L
23-May-11	AYA-ID-03372-2011	CRUDA	Turbiedad	166	UNT
27-Jun-11	AYA-ID-04400-2011	CRUDA	Alcalinidad	50	mg/L
27-Jun-11	AYA-ID-04400-2011	CRUDA	Aluminio (Cianina de Eriocromo)	N.D.	mg/L
27-Jun-11	AYA-ID-04400-2011	CRUDA	Color Aparente	15	UPt-Co
27-Jun-11	AYA-ID-04400-2011	CRUDA	Color Verdadero	8	UPt-Co
27-Jun-11	AYA-ID-04400-2011	CRUDA	Dureza Total	60	mg/L
27-Jun-11	AYA-ID-04400-2011	CRUDA	Hierro (1-10 Fenantrolina)	0.15	mg/L
27-Jun-11	AYA-ID-04400-2011	CRUDA	Olor	Negativo	
27-Jun-11	AYA-ID-04400-2011	CRUDA	pH	7.75	
27-Jun-11	AYA-ID-04400-2011	CRUDA	sulfatos	19	mg/L
27-Jun-11	AYA-ID-04400-2011	CRUDA	Turbiedad	8.87	UNT
26-Jul-11	AYA-ID-05038-2011	CRUDA	Alcalinidad	41	mg/L
26-Jul-11	AYA-ID-05038-2011	CRUDA	Aluminio (Cianina de Eriocromo)	N.D.	mg/L
26-Jul-11	AYA-ID-05038-2011	CRUDA	Color Aparente	30	UPt-Co
26-Jul-11	AYA-ID-05038-2011	CRUDA	Color Verdadero	15	UPt-Co
26-Jul-11	AYA-ID-05038-2011	CRUDA	Dureza Total	58	mg/L
26-Jul-11	AYA-ID-05038-2011	CRUDA	Hierro (1-10 Fenantrolina)	0.18	mg/L
26-Jul-11	AYA-ID-05038-2011	CRUDA	Olor	Negativo	
26-Jul-11	AYA-ID-05038-2011	CRUDA	pH	7.1	
26-Jul-11	AYA-ID-05038-2011	CRUDA	Sulfatos (Cloruro de Bario)	25	mg/L
26-Jul-11	AYA-ID-05038-2011	CRUDA	Turbiedad	16	UNT
29-Aug-11	AYA-ID-05781-2011	CRUDA	Alcalinidad	44	mg/L
29-Aug-11	AYA-ID-05781-2011	CRUDA	Aluminio (Cianina de Eriocromo)	0.14	mg/L
29-Aug-11	AYA-ID-05781-2011	CRUDA	Color Aparente	200	UPt-Co
29-Aug-11	AYA-ID-05781-2011	CRUDA	Color Verdadero	100	UPt-Co
29-Aug-11	AYA-ID-05781-2011	CRUDA	Dureza Total	45	mg/L
29-Aug-11	AYA-ID-05781-2011	CRUDA	Hierro (1-10 Fenantrolina)	0.5	mg/L
29-Aug-11	AYA-ID-05781-2011	CRUDA	Olor	Negativo	
29-Aug-11	AYA-ID-05781-2011	CRUDA	pH	7.42	

29-Aug-11	AYA-ID-05781-2011	CRUDA	Sulfatos (Cloruro de Bario)	8	mg/L
29-Aug-11	AYA-ID-05781-2011	CRUDA	Turbiedad	62.6	UNT
26-Sep-11	AYA-ID-06444-2011	CRUDA	Alcalinidad	49	mg/L
26-Sep-11	AYA-ID-06444-2011	CRUDA	Aluminio (Cianina de Eriocromo)	0.13	mg/L
26-Sep-11	AYA-ID-06444-2011	CRUDA	Color Aparente	250	UPt-Co
26-Sep-11	AYA-ID-06444-2011	CRUDA	Dureza Total	49	mg/L
26-Sep-11	AYA-ID-06444-2011	CRUDA	Hierro (1-10 Fenantrolina)	0.4	mg/L
26-Sep-11	AYA-ID-06444-2011	CRUDA	Olor	Negativo	
26-Sep-11	AYA-ID-06444-2011	CRUDA	pH	7.34	
26-Sep-11	AYA-ID-06444-2011	CRUDA	Sulfatos (Cloruro de Bario)	10	mg/L
26-Sep-11	AYA-ID-06444-2011	CRUDA	Turbiedad	98.5	UNT
23-Oct-11	AYA-ID-07219-2011	CRUDA	Alcalinidad	43	mg/L
23-Oct-11	AYA-ID-07219-2011	CRUDA	Aluminio (Cianina de Eriocromo)	0.13	mg/L
23-Oct-11	AYA-ID-07219-2011	CRUDA	Color Aparente	70	UPt-Co
23-Oct-11	AYA-ID-07219-2011	CRUDA	Dureza Total	45	mg/L
23-Oct-11	AYA-ID-07219-2011	CRUDA	Hierro (1-10 Fenantrolina)	0.24	mg/L
23-Oct-11	AYA-ID-07219-2011	CRUDA	Olor	Negativo	
23-Oct-11	AYA-ID-07219-2011	CRUDA	pH	7.65	
23-Oct-11	AYA-ID-07219-2011	CRUDA	Sulfatos (Cloruro de Bario)	12	mg/L
23-Oct-11	AYA-ID-07219-2011	CRUDA	Turbiedad	36.5	UNT
21-Nov-11	AYA-ID-07790-2011	CRUDA	Alcalinidad	44	mg/L
21-Nov-11	AYA-ID-07790-2011	CRUDA	Aluminio (Cianina de Eriocromo)	N.D.	mg/L
21-Nov-11	AYA-ID-07790-2011	CRUDA	Color Aparente	25	UPt-Co
21-Nov-11	AYA-ID-07790-2011	CRUDA	Dureza Total	43	mg/L
21-Nov-11	AYA-ID-07790-2011	CRUDA	Hierro (1-10 Fenantrolina)	0.19	mg/L
21-Nov-11	AYA-ID-07790-2011	CRUDA	Olor	negativo	
21-Nov-11	AYA-ID-07790-2011	CRUDA	pH	7.55	
21-Nov-11	AYA-ID-07790-2011	CRUDA	Sulfatos (Cloruro de Bario)	6	mg/L
21-Nov-11	AYA-ID-07790-2011	CRUDA	Turbiedad	15.1	UNT
11-Dec-11	AYA-ID-08260-2011	CRUDA	Alcalinidad	36	mg/L
11-Dec-11	AYA-ID-08260-2011	CRUDA	Aluminio (Cianina de Eriocromo)	N.D.	mg/L
11-Dec-11	AYA-ID-08260-2011	CRUDA	Color Aparente	42	UPt-Co
11-Dec-11	AYA-ID-08260-2011	CRUDA	Dureza Total	41	mg/L
11-Dec-11	AYA-ID-08260-2011	CRUDA	Hierro (1-10 Fenantrolina)	0.12	mg/L
11-Dec-11	AYA-ID-08260-2011	CRUDA	Olor	Negativo	
11-Dec-11	AYA-ID-08260-2011	CRUDA	pH	7.3	
11-Dec-11	AYA-ID-08260-2011	CRUDA	Sulfatos (Cloruro de Bario)	10	mg/L
11-Dec-11	AYA-ID-08260-2011	CRUDA	Turbiedad	5.44	UNT
1-Feb-12	AYA-ID-00649-2012	CRUDA	Alcalinidad	53	mg/L
1-Feb-12	AYA-ID-00649-2012	CRUDA	Aluminio (Cianina de Eriocromo)	N.D.	mg/L
1-Feb-12	AYA-ID-00649-2012	CRUDA	Color Aparente	21	UPt-Co
1-Feb-12	AYA-ID-00649-2012	CRUDA	Dureza Total	54	mg/L
1-Feb-12	AYA-ID-00649-2012	CRUDA	Hierro (1-10 Fenantrolina)	N.D.	mg/L
1-Feb-12	AYA-ID-00649-2012	CRUDA	Olor	Negativo	
1-Feb-12	AYA-ID-00649-2012	CRUDA	pH	7.54	
1-Feb-12	AYA-ID-00649-2012	CRUDA	Sulfatos (Cloruro de Bario)	14	mg/L

29-Feb-12	AYA-ID-01296-2012	CRUDA	Alcalinidad	57	mg/L
29-Feb-12	AYA-ID-01296-2012	CRUDA	Aluminio (Cianina de Eriocromo)	N.D.	mg/L
29-Feb-12	AYA-ID-01296-2012	CRUDA	Dureza Total	60	mg/L
29-Feb-12	AYA-ID-01296-2012	CRUDA	Hierro (1-10 Fenantrolina)	N.D.	mg/L
29-Feb-12	AYA-ID-01296-2012	CRUDA	Olor	Negativo	
29-Feb-12	AYA-ID-01296-2012	CRUDA	pH	7.26	
29-Feb-12	AYA-ID-01296-2012	CRUDA	Sulfatos (Cloruro de Bario)	17	mg/L
29-Feb-12	AYA-ID-01296-2012	CRUDA	Turbiedad	1.89	UNT
11-Apr-12	AYA-ID-02350-2012	CRUDA	Alcalinidad	59	mg/L
11-Apr-12	AYA-ID-02350-2012	CRUDA	Aluminio (Cianina de Eriocromo)	N.D.	mg/L
11-Apr-12	AYA-ID-02350-2012	CRUDA	Dureza Total	71	mg/L
11-Apr-12	AYA-ID-02350-2012	CRUDA	Hierro (1-10 Fenantrolina)	0.17	mg/L
11-Apr-12	AYA-ID-02350-2012	CRUDA	Olor	Negativo	
11-Apr-12	AYA-ID-02350-2012	CRUDA	pH	8.02	
11-Apr-12	AYA-ID-02350-2012	CRUDA	Sulfatos (Cloruro de Bario)	20	mg/L
11-Apr-12	AYA-ID-02350-2012	CRUDA	Turbiedad	4.76	UNT
22-May-12	AYA-ID-03380-2012	CRUDA	Alcalinidad	54	mg/L
22-May-12	AYA-ID-03380-2012	CRUDA	Dureza Total	62	mg/L
22-May-12	AYA-ID-03380-2012	CRUDA	Olor	Negativo	
22-May-12	AYA-ID-03380-2012	CRUDA	pH	7.9	
22-May-12	AYA-ID-03380-2012	CRUDA	Sulfatos (Cloruro de Bario)	17	mg/L
22-May-12	AYA-ID-03380-2012	CRUDA	Turbiedad	19.6	UNT
25-Jun-12	AYA-ID-04326-2012	CRUDA	Alcalinidad	50	mg/L
25-Jun-12	AYA-ID-04326-2012	CRUDA	Dureza Total	56	mg/L
25-Jun-12	AYA-ID-04326-2012	CRUDA	Hierro (1-10 Fenantrolina)	1	mg/L
25-Jun-12	AYA-ID-04326-2012	CRUDA	Olor	negativo	
25-Jun-12	AYA-ID-04326-2012	CRUDA	pH	7.94	
25-Jun-12	AYA-ID-04326-2012	CRUDA	Sulfatos (Cloruro de Bario)	16	mg/L
25-Jun-12	AYA-ID-04326-2012	CRUDA	Turbiedad	28.4	UNT
30-Jul-12	AYA-ID-05193-2012	CRUDA	Alcalinidad	39	mg/L
30-Jul-12	AYA-ID-05193-2012	CRUDA	Dureza Total	48	mg/L
30-Jul-12	AYA-ID-05193-2012	CRUDA	Hierro (1-10 Fenantrolina)	0.5	mg/L
30-Jul-12	AYA-ID-05193-2012	CRUDA	Olor	Negativo	
30-Jul-12	AYA-ID-05193-2012	CRUDA	pH	7.79	
30-Jul-12	AYA-ID-05193-2012	CRUDA	Sulfatos (Cloruro de Bario)	16	mg/L
30-Jul-12	AYA-ID-05193-2012	CRUDA	Turbiedad	30.9	UNT
26-Aug-12	AYA-ID-05824-2012	CRUDA	Alcalinidad	43	mg/L
26-Aug-12	AYA-ID-05824-2012	CRUDA	Dureza Total	46	mg/L
26-Aug-12	AYA-ID-05824-2012	CRUDA	Hierro (1-10 Fenantrolina)	1.8	mg/L
26-Aug-12	AYA-ID-05824-2012	CRUDA	Olor	Negativo	
26-Aug-12	AYA-ID-05824-2012	CRUDA	pH	7.65	
26-Aug-12	AYA-ID-05824-2012	CRUDA	Sulfatos (Cloruro de Bario)	12	mg/L
26-Aug-12	AYA-ID-05824-2012	CRUDA	Turbiedad	68.4	UNT
25-Sep-12	AYA-ID-06750-2012	CRUDA	Alcalinidad	58	mg/L
25-Sep-12	AYA-ID-06750-2012	CRUDA	Dureza Total	60	mg/L
25-Sep-12	AYA-ID-06750-2012	CRUDA	Hierro (1-10 Fenantrolina)	0.4	mg/L

25-Sep-12	AYA-ID-06750-2012	CRUDA	Olor		Negativo	
25-Sep-12	AYA-ID-06750-2012	CRUDA	pH		8	
25-Sep-12	AYA-ID-06750-2012	CRUDA	Sulfatos (Cloruro de Bario)		10	mg/L
25-Sep-12	AYA-ID-06750-2012	CRUDA	Turbiedad		26.5	UNT
21-Oct-12	AYA-ID-07359-2012	CRUDA	Alcalinidad		50	mg/L
21-Oct-12	AYA-ID-07359-2012	CRUDA	Dureza Total		55	mg/L
21-Oct-12	AYA-ID-07359-2012	CRUDA	Hierro (1-10 Fenantrolina)		4	mg/L
21-Oct-12	AYA-ID-07359-2012	CRUDA	Olor		Negativo	
21-Oct-12	AYA-ID-07359-2012	CRUDA	pH		7.9	
21-Oct-12	AYA-ID-07359-2012	CRUDA	Sulfatos (Cloruro de Bario)		1	mg/L
21-Oct-12	AYA-ID-07359-2012	CRUDA	Turbiedad		1062	UNT
20-Nov-12	AYA-ID-08251-2012	CRUDA	Alcalinidad		46	mg/L
20-Nov-12	AYA-ID-08251-2012	CRUDA	Dureza Total		50	mg/L
20-Nov-12	AYA-ID-08251-2012	CRUDA	Hierro (1-10 Fenantrolina)		0.22	mg/L
20-Nov-12	AYA-ID-08251-2012	CRUDA	Olor		Negativo	
20-Nov-12	AYA-ID-08251-2012	CRUDA	pH		7.6	
20-Nov-12	AYA-ID-08251-2012	CRUDA	Sulfatos (Cloruro de Bario)		13	mg/L
20-Nov-12	AYA-ID-08251-2012	CRUDA	Turbiedad		6.89	UNT
31-Jan-13	AYA-ID-00571-2013	CRUDA	Alcalinidad		60	mg/L
31-Jan-13	AYA-ID-00571-2013	CRUDA	Dureza Total		65	mg/L
31-Jan-13	AYA-ID-00571-2013	CRUDA	Hierro (1-10 Fenantrolina)		0.16	mg/L
31-Jan-13	AYA-ID-00571-2013	CRUDA	Olor		Negativo	
31-Jan-13	AYA-ID-00571-2013	CRUDA	pH		7.71	
31-Jan-13	AYA-ID-00571-2013	CRUDA	Sulfatos (Cloruro de Bario)		19	mg/L
31-Jan-13	AYA-ID-00571-2013	CRUDA	Turbiedad		2.31	UNT
28-Feb-13	AYA-ID-01405-2013	CRUDA	Alcalinidad		66	mg/L
28-Feb-13	AYA-ID-01405-2013	CRUDA	Coliformes fecales	Serie 5 tubos 10 mL a 0,1 mL	430	NMP/100 mL
28-Feb-13	AYA-ID-01405-2013	CRUDA	Dureza Total		69	mg/L
28-Feb-13	AYA-ID-01405-2013	CRUDA	Hierro (1-10 Fenantrolina)		0.24	mg/L
28-Feb-13	AYA-ID-01405-2013	CRUDA	Olor		Negativo	
28-Feb-13	AYA-ID-01405-2013	CRUDA	pH		7.64	
28-Feb-13	AYA-ID-01405-2013	CRUDA	Sulfatos (Cloruro de Bario)		21	mg/L
28-Feb-13	AYA-ID-01405-2013	CRUDA	Turbiedad		3.28	UNT
24-Apr-13	AYA-ID-02935-2013	CRUDA	Alcalinidad		64	mg/L
24-Apr-13	AYA-ID-02935-2013	CRUDA	Dureza Total		69	mg/L
24-Apr-13	AYA-ID-02935-2013	CRUDA	Hierro (1-10 Fenantrolina)		N.D.	mg/L
24-Apr-13	AYA-ID-02935-2013	CRUDA	Olor		Negativo	
24-Apr-13	AYA-ID-02935-2013	CRUDA	pH		7.63	
24-Apr-13	AYA-ID-02935-2013	CRUDA	Sulfatos (Cloruro de Bario)		18	mg/L
24-Apr-13	AYA-ID-02935-2013	CRUDA	Turbiedad		4.57	UNT
30-May-13	AYA-ID-03903-2013	CRUDA	Alcalinidad		36	mg/L
30-May-13	AYA-ID-03903-2013	CRUDA	Dureza Total		57	mg/L
30-May-13	AYA-ID-03903-2013	CRUDA	Hierro (1-10 Fenantrolina)		3	mg/L
30-May-13	AYA-ID-03903-2013	CRUDA	Olor		Negativo	
30-May-13	AYA-ID-03903-2013	CRUDA	pH		7.05	
30-May-13	AYA-ID-03903-2013	CRUDA	Sulfatos (Cloruro de Bario)		31	mg/L

30-May-13	AYA-ID-03903-2013	CRUDA	Turbiedad	173	UNT
24-Jun-13	AYA-ID-04812-2013	CRUDA	Alcalinidad	45	mg/L
24-Jun-13	AYA-ID-04812-2013	CRUDA	Dureza Total	53	mg/L
24-Jun-13	AYA-ID-04812-2013	CRUDA	Hierro (1-10 Fenantrolina)	0.4	mg/L
24-Jun-13	AYA-ID-04812-2013	CRUDA	Olor	Negativo	
24-Jun-13	AYA-ID-04812-2013	CRUDA	pH	7.2	
24-Jun-13	AYA-ID-04812-2013	CRUDA	Sulfatos (Cloruro de Bario)	21	mg/L
24-Jun-13	AYA-ID-04812-2013	CRUDA	Turbiedad	13.2	UNT
24-Jul-13	AYA-ID-05755-2013	CRUDA	Alcalinidad	49	mg/L
24-Jul-13	AYA-ID-05755-2013	CRUDA	Dureza Total	53	mg/L
24-Jul-13	AYA-ID-05755-2013	CRUDA	Hierro (1-10 Fenantrolina)	0.3	mg/L
24-Jul-13	AYA-ID-05755-2013	CRUDA	Olor	Negativo	
24-Jul-13	AYA-ID-05755-2013	CRUDA	pH	7.51	
24-Jul-13	AYA-ID-05755-2013	CRUDA	Sulfatos (Cloruro de Bario)	18	mg/L
24-Jul-13	AYA-ID-05755-2013	CRUDA	Turbiedad	10.8	UNT
14-Aug-13	AYA-ID-06144-2013	CRUDA	Alcalinidad	45	mg/L
14-Aug-13	AYA-ID-06144-2013	CRUDA	Dureza Total	52	mg/L
14-Aug-13	AYA-ID-06144-2013	CRUDA	Hierro (1-10 Fenantrolina)	8	mg/L
14-Aug-13	AYA-ID-06144-2013	CRUDA	Olor	Negativo	
14-Aug-13	AYA-ID-06144-2013	CRUDA	pH	7.29	
14-Aug-13	AYA-ID-06144-2013	CRUDA	Sulfatos (Cloruro de Bario)	11	mg/L
14-Aug-13	AYA-ID-06144-2013	CRUDA	Turbiedad	194	UNT
26-Sep-13	AYA-ID-07475-2013	CRUDA	Alcalinidad	50	mg/L
26-Sep-13	AYA-ID-07475-2013	CRUDA	Dureza Total	59	mg/L
26-Sep-13	AYA-ID-07475-2013	CRUDA	Hierro (1-10 Fenantrolina)	0.4	mg/L
26-Sep-13	AYA-ID-07475-2013	CRUDA	Olor	Negativo	
26-Sep-13	AYA-ID-07475-2013	CRUDA	pH	7.4	
26-Sep-13	AYA-ID-07475-2013	CRUDA	Sulfatos (Cloruro de Bario)	17	mg/L
26-Sep-13	AYA-ID-07475-2013	CRUDA	Turbiedad	24.4	UNT
3-Oct-13	AYA-ID-07682-2013	CRUDA	Alcalinidad	38	mg/L
3-Oct-13	AYA-ID-07682-2013	CRUDA	Dureza Total	45	mg/L
3-Oct-13	AYA-ID-07682-2013	CRUDA	Hierro (1-10 Fenantrolina)	6	mg/L
3-Oct-13	AYA-ID-07682-2013	CRUDA	Olor	Negativo	
3-Oct-13	AYA-ID-07682-2013	CRUDA	pH	7.2	
3-Oct-13	AYA-ID-07682-2013	CRUDA	Sulfatos (Cloruro de Bario)	10	mg/L
3-Oct-13	AYA-ID-07682-2013	CRUDA	Turbiedad	400	UNT
28-Nov-13	AYA-ID-09101-2013	CRUDA	Alcalinidad	58	mg/L
28-Nov-13	AYA-ID-09101-2013	CRUDA	Dureza Total	57	mg/L
28-Nov-13	AYA-ID-09101-2013	CRUDA	Hierro (1-10 Fenantrolina)	0.76	mg/L
28-Nov-13	AYA-ID-09101-2013	CRUDA	Olor	Negativo	
28-Nov-13	AYA-ID-09101-2013	CRUDA	pH	7.3	
28-Nov-13	AYA-ID-09101-2013	CRUDA	Sulfatos (Cloruro de Bario)	12	mg/L
28-Nov-13	AYA-ID-09101-2013	CRUDA	Turbiedad	14.8	UNT
10-Dec-13	AYA-ID-09552-2013	CRUDA	Alcalinidad	60	mg/L
10-Dec-13	AYA-ID-09552-2013	CRUDA	Dureza Total	59	mg/L
10-Dec-13	AYA-ID-09552-2013	CRUDA	Hierro (1-10 Fenantrolina)	0.6	mg/L

10-Dec-13	AYA-ID-09552-2013	CRUDA	Olor	negativo	
10-Dec-13	AYA-ID-09552-2013	CRUDA	pH	7.25	
10-Dec-13	AYA-ID-09552-2013	CRUDA	Sulfatos (Cloruro de Bario)	14	mg/L
10-Dec-13	AYA-ID-09552-2013	CRUDA	Turbiedad	15.4	UNT
29-Jan-14	AYA-ID-00474-2014	CRUDA	Alcalinidad	59	mg/L
29-Jan-14	AYA-ID-00474-2014	CRUDA	Dureza Total	57	mg/L
29-Jan-14	AYA-ID-00474-2014	CRUDA	Hierro (1-10 Fenantrolina)	0.14	mg/L
29-Jan-14	AYA-ID-00474-2014	CRUDA	Olor	Negativo	
29-Jan-14	AYA-ID-00474-2014	CRUDA	pH	8.06	
29-Jan-14	AYA-ID-00474-2014	CRUDA	Sulfatos (Cloruro de Bario)	15	mg/L
29-Jan-14	AYA-ID-00474-2014	CRUDA	Turbiedad	1.96	UNT
27-Feb-14	AYA-ID-01369-2014	CRUDA	Alcalinidad	67	mg/L
27-Feb-14	AYA-ID-01369-2014	CRUDA	Dureza Total	71	mg/L
27-Feb-14	AYA-ID-01369-2014	CRUDA	Hierro (1-10 Fenantrolina)	0.12	mg/L
27-Feb-14	AYA-ID-01369-2014	CRUDA	Olor	Negativo	
27-Feb-14	AYA-ID-01369-2014	CRUDA	pH	8.12	
27-Feb-14	AYA-ID-01369-2014	CRUDA	Sulfatos (Cloruro de Bario)	16	mg/L
27-Feb-14	AYA-ID-01369-2014	CRUDA	Turbiedad	2.71	UNT
12-Mar-14	AYA-ID-01791-2014	CRUDA	Alcalinidad	70	mg/L
12-Mar-14	AYA-ID-01791-2014	CRUDA	Dureza Total	83	mg/L
12-Mar-14	AYA-ID-01791-2014	CRUDA	Hierro (1-10 Fenantrolina)	0.14	mg/L
12-Mar-14	AYA-ID-01791-2014	CRUDA	Olor	Negativo	
12-Mar-14	AYA-ID-01791-2014	CRUDA	pH	7.93	
12-Mar-14	AYA-ID-01791-2014	CRUDA	Sulfatos (Cloruro de Bario)	27	mg/L
12-Mar-14	AYA-ID-01791-2014	CRUDA	Turbiedad	4.01	UNT
24-Apr-14	AYA-ID-03069-2014	CRUDA	Alcalinidad	69	mg/L
24-Apr-14	AYA-ID-03069-2014	CRUDA	Dureza Total	75	mg/L
24-Apr-14	AYA-ID-03069-2014	CRUDA	Hierro (1-10 Fenantrolina)	0.3	mg/L
24-Apr-14	AYA-ID-03069-2014	CRUDA	Olor	Negativo	
24-Apr-14	AYA-ID-03069-2014	CRUDA	pH	7.97	
24-Apr-14	AYA-ID-03069-2014	CRUDA	Sulfatos (Cloruro de Bario)	18	mg/L
24-Apr-14	AYA-ID-03069-2014	CRUDA	Turbiedad	3.83	UNT
28-May-14	AYA-ID-03896-2014	CRUDA	Alcalinidad	83	mg/L
28-May-14	AYA-ID-03896-2014	CRUDA	Dureza Total	71	mg/L
28-May-14	AYA-ID-03896-2014	CRUDA	Hierro (1-10 Fenantrolina)	0.6	mg/L
28-May-14	AYA-ID-03896-2014	CRUDA	Olor	Negativo	
28-May-14	AYA-ID-03896-2014	CRUDA	pH	7.66	
28-May-14	AYA-ID-03896-2014	CRUDA	Sulfatos (Cloruro de Bario)	22	mg/L
28-May-14	AYA-ID-03896-2014	CRUDA	Turbiedad	44.1	UNT
26-Jun-14	AYA-ID-04812-2014	CRUDA	Alcalinidad	56	mg/L
26-Jun-14	AYA-ID-04812-2014	CRUDA	Dureza Total	60	mg/L
26-Jun-14	AYA-ID-04812-2014	CRUDA	Hierro (1-10 Fenantrolina)	0.48	mg/L
26-Jun-14	AYA-ID-04812-2014	CRUDA	Olor	Negativo	
26-Jun-14	AYA-ID-04812-2014	CRUDA	pH	7.3	
26-Jun-14	AYA-ID-04812-2014	CRUDA	Sulfatos (Cloruro de Bario)	11	mg/L
26-Jun-14	AYA-ID-04812-2014	CRUDA	Turbiedad	5.66	UNT

24-Jul-14	AYA-ID-05553-2014	CRUDA	Alcalinidad	43	mg/L
24-Jul-14	AYA-ID-05553-2014	CRUDA	Dureza Total	47	mg/L
24-Jul-14	AYA-ID-05553-2014	CRUDA	Hierro (1-10 Fenantrolina)	0.75	mg/L
24-Jul-14	AYA-ID-05553-2014	CRUDA	Olor	Negativo	
24-Jul-14	AYA-ID-05553-2014	CRUDA	pH	7.19	
24-Jul-14	AYA-ID-05553-2014	CRUDA	Sulfatos (Cloruro de Bario)	8	mg/L
24-Jul-14	AYA-ID-05553-2014	CRUDA	Turbiedad	8.02	UNT
27-Aug-14	AYA-ID-06349-2014	CRUDA	Alcalinidad	59	mg/L
27-Aug-14	AYA-ID-06349-2014	CRUDA	Color Aparente Alto	273	UPt-Co
27-Aug-14	AYA-ID-06349-2014	CRUDA	Dureza Total	58	mg/L
27-Aug-14	AYA-ID-06349-2014	CRUDA	Hierro (1-10 Fenantrolina)	1	mg/L
27-Aug-14	AYA-ID-06349-2014	CRUDA	Olor	Negativo	
27-Aug-14	AYA-ID-06349-2014	CRUDA	pH	7.38	
27-Aug-14	AYA-ID-06349-2014	CRUDA	Sulfatos (Cloruro de Bario)	11	mg/L
27-Aug-14	AYA-ID-06349-2014	CRUDA	Turbiedad	31.1	UNT
9-Sep-14	AYA-ID-06797-2014	CRUDA	Alcalinidad	57	mg/L
9-Sep-14	AYA-ID-06797-2014	CRUDA	Color Aparente Alto	1150	UPt-Co
9-Sep-14	AYA-ID-06797-2014	CRUDA	Dureza Total	58	mg/L
9-Sep-14	AYA-ID-06797-2014	CRUDA	Hierro (1-10 Fenantrolina)	0.4	mg/L
9-Sep-14	AYA-ID-06797-2014	CRUDA	Olor	Negativo	
9-Sep-14	AYA-ID-06797-2014	CRUDA	pH	7.74	
9-Sep-14	AYA-ID-06797-2014	CRUDA	Sulfatos (Cloruro de Bario)	13	mg/L
9-Sep-14	AYA-ID-06797-2014	CRUDA	Turbiedad	125	UNT
20-Oct-14	AYA-ID-08162-2014	CRUDA	Alcalinidad	50	mg/L
20-Oct-14	AYA-ID-08162-2014	CRUDA	Color Aparente Alto	300	UPt-Co
20-Oct-14	AYA-ID-08162-2014	CRUDA	Dureza Total	52	mg/L
20-Oct-14	AYA-ID-08162-2014	CRUDA	Hierro (1-10 Fenantrolina)	1.2	mg/L
20-Oct-14	AYA-ID-08162-2014	CRUDA	Olor	Negativo	
20-Oct-14	AYA-ID-08162-2014	CRUDA	pH	7.2	
20-Oct-14	AYA-ID-08162-2014	CRUDA	Sulfatos (Cloruro de Bario)	10	mg/L
20-Oct-14	AYA-ID-08162-2014	CRUDA	Turbiedad	26.2	UNT
20-Jan-15	AYA-ID-00286-2015	CRUDA	Alcalinidad	58	mg/L
20-Jan-15	AYA-ID-00286-2015	CRUDA	Color Aparente Bajo	22	UPt-Co
20-Jan-15	AYA-ID-00286-2015	CRUDA	Dureza Total	57	mg/L
20-Jan-15	AYA-ID-00286-2015	CRUDA	Hierro (1-10 Fenantrolina)	N.D.	mg/L
20-Jan-15	AYA-ID-00286-2015	CRUDA	Olor	Negativo	
20-Jan-15	AYA-ID-00286-2015	CRUDA	pH	7.7	
20-Jan-15	AYA-ID-00286-2015	CRUDA	Sulfatos (Cloruro de Bario)	19	mg/L
20-Jan-15	AYA-ID-00286-2015	CRUDA	Turbiedad	2	UNT
25-Feb-15	AYA-ID-01242-2015	CRUDA	Alcalinidad	41	mg/L
25-Feb-15	AYA-ID-01242-2015	CRUDA	Color Aparente Bajo	21	UPt-Co
25-Feb-15	AYA-ID-01242-2015	CRUDA	Dureza Total	43	mg/L
25-Feb-15	AYA-ID-01242-2015	CRUDA	Hierro (1-10 Fenantrolina)	0.2	mg/L
25-Feb-15	AYA-ID-01242-2015	CRUDA	Olor	Negativo	
25-Feb-15	AYA-ID-01242-2015	CRUDA	pH	7.88	
25-Feb-15	AYA-ID-01242-2015	CRUDA	Sulfatos (Cloruro de Bario)	13	mg/L

25-Feb-15	AYA-ID-01242-2015	CRUDA	Turbiedad		1.97	UNT
26-Mar-15	AYA-ID-02357-2015	CRUDA	Alcalinidad		42	mg/L
26-Mar-15	AYA-ID-02357-2015	CRUDA	Color Aparente	Bajo	19	UPt-Co
26-Mar-15	AYA-ID-02357-2015	CRUDA	Dureza Total		43	mg/L
26-Mar-15	AYA-ID-02357-2015	CRUDA	Hierro (1-10 Fenantrolina)		0.12	mg/L
26-Mar-15	AYA-ID-02357-2015	CRUDA	Olor		Negativo	
26-Mar-15	AYA-ID-02357-2015	CRUDA	pH		7.57	
26-Mar-15	AYA-ID-02357-2015	CRUDA	Sulfatos (Cloruro de Bario)		11	mg/L
26-Mar-15	AYA-ID-02357-2015	CRUDA	Turbiedad		2.04	UNT
13-Apr-15	AYA-ID-02720-2015	CRUDA	Alcalinidad		60	mg/L
13-Apr-15	AYA-ID-02720-2015	CRUDA	Color Aparente	Bajo	18	UPt-Co
13-Apr-15	AYA-ID-02720-2015	CRUDA	Dureza Total		67	mg/L
13-Apr-15	AYA-ID-02720-2015	CRUDA	Hierro (1-10 Fenantrolina)		0.26	mg/L
13-Apr-15	AYA-ID-02720-2015	CRUDA	Olor		Negativo	
13-Apr-15	AYA-ID-02720-2015	CRUDA	pH		7.98	
13-Apr-15	AYA-ID-02720-2015	CRUDA	Sulfatos (Cloruro de Bario)		20	mg/L
13-Apr-15	AYA-ID-02720-2015	CRUDA	Turbiedad		2.49	UNT
28-May-15	AYA-ID-04008-2015	CRUDA	Alcalinidad		45	mg/L
28-May-15	AYA-ID-04008-2015	CRUDA	Color Aparente	Bajo	38	UPt-Co
28-May-15	AYA-ID-04008-2015	CRUDA	Dureza Total		53	mg/L
28-May-15	AYA-ID-04008-2015	CRUDA	Hierro (1-10 Fenantrolina)		0.4	mg/L
28-May-15	AYA-ID-04008-2015	CRUDA	Olor		Negativo	
28-May-15	AYA-ID-04008-2015	CRUDA	pH		7.45	
28-May-15	AYA-ID-04008-2015	CRUDA	Sulfatos (Cloruro de Bario)		18	mg/L
28-May-15	AYA-ID-04008-2015	CRUDA	Turbiedad		5.99	UNT
25-Jun-15	AYA-ID-05045-2015	CRUDA	Alcalinidad		39	mg/L
25-Jun-15	AYA-ID-05045-2015	CRUDA	Color Aparente	Bajo	36	UPt-Co
25-Jun-15	AYA-ID-05045-2015	CRUDA	Dureza Total		45	mg/L
25-Jun-15	AYA-ID-05045-2015	CRUDA	Hierro (1-10 Fenantrolina)		0.24	mg/L
25-Jun-15	AYA-ID-05045-2015	CRUDA	Olor		Negativo	
25-Jun-15	AYA-ID-05045-2015	CRUDA	pH		7.47	
25-Jun-15	AYA-ID-05045-2015	CRUDA	Sulfatos (Cloruro de Bario)		17	mg/L
25-Jun-15	AYA-ID-05045-2015	CRUDA	Turbiedad		4.08	UNT
17-Jul-15	AYA-ID-05610-2015	CRUDA	Alcalinidad		41	mg/L
17-Jul-15	AYA-ID-05610-2015	CRUDA	Color Aparente	Bajo	50	UPt-Co
17-Jul-15	AYA-ID-05610-2015	CRUDA	Dureza Total		46	mg/L
17-Jul-15	AYA-ID-05610-2015	CRUDA	Hierro (1-10 Fenantrolina)		0.2	mg/L
17-Jul-15	AYA-ID-05610-2015	CRUDA	Olor		Negativo	
17-Jul-15	AYA-ID-05610-2015	CRUDA	pH		7.41	
17-Jul-15	AYA-ID-05610-2015	CRUDA	Sulfatos (Cloruro de Bario)		17	mg/L
17-Jul-15	AYA-ID-05610-2015	CRUDA	Turbiedad		5.37	UNT
25-Aug-15	AYA-ID-06434-2015	CRUDA	Alcalinidad		35	mg/L
25-Aug-15	AYA-ID-06434-2015	CRUDA	Color Aparente	Alto	172	UPt-Co
25-Aug-15	AYA-ID-06434-2015	CRUDA	Dureza Total		42	mg/L
25-Aug-15	AYA-ID-06434-2015	CRUDA	Hierro (1-10 Fenantrolina)		0.96	mg/L
25-Aug-15	AYA-ID-06434-2015	CRUDA	Olor		Negativo	

25-Aug-15	AYA-ID-06434-2015	CRUDA	pH		8	
25-Aug-15	AYA-ID-06434-2015	CRUDA	Sulfatos (Cloruro de Bario)		12	mg/L
25-Aug-15	AYA-ID-06434-2015	CRUDA	Turbiedad		23	UNT
30-Sep-15	AYA-ID-08972-2015	CRUDA	Alcalinidad		44	mg/L
30-Sep-15	AYA-ID-08972-2015	CRUDA	Color Aparente	Alto	600	UPt-Co
30-Sep-15	AYA-ID-08972-2015	CRUDA	Dureza Total		56	mg/L
30-Sep-15	AYA-ID-08972-2015	CRUDA	Hierro (1-10 Fenantrolina)		1.7	mg/L
30-Sep-15	AYA-ID-08972-2015	CRUDA	pH		7.97	
30-Sep-15	AYA-ID-08972-2015	CRUDA	Sulfatos (Cloruro de Bario)		9	mg/L
30-Sep-15	AYA-ID-08972-2015	CRUDA	Turbiedad		65.7	UNT
16-Oct-15	AYA-ID-09709-2015	CRUDA	Alcalinidad		40	mg/L
16-Oct-15	AYA-ID-09709-2015	CRUDA	Coliformes fecales	Serie 3 tubos 10 mL a 0,1 mL	2400	NMP/100 mL
16-Oct-15	AYA-ID-09709-2015	CRUDA	Color Aparente	Alto	472	UPt-Co
16-Oct-15	AYA-ID-09709-2015	CRUDA	Dureza Total		50	mg/L
16-Oct-15	AYA-ID-09709-2015	CRUDA	Hierro (1-10 Fenantrolina)		2	mg/L
16-Oct-15	AYA-ID-09709-2015	CRUDA	Olor		Negativo	
16-Oct-15	AYA-ID-09709-2015	CRUDA	pH		6.73	
16-Oct-15	AYA-ID-09709-2015	CRUDA	Sulfatos (Cloruro de Bario)		16	mg/L
16-Oct-15	AYA-ID-09709-2015	CRUDA	Turbiedad		58.8	UNT
27-Nov-15	AYA-ID-11618-2015	CRUDA	Alcalinidad		54	mg/L
27-Nov-15	AYA-ID-11618-2015	CRUDA	Color Aparente	Alto	65	UPt-Co
27-Nov-15	AYA-ID-11618-2015	CRUDA	Dureza Total		62	mg/L
27-Nov-15	AYA-ID-11618-2015	CRUDA	Hierro (1-10 Fenantrolina)		0.12	mg/L
27-Nov-15	AYA-ID-11618-2015	CRUDA	Olor		Negativo	
27-Nov-15	AYA-ID-11618-2015	CRUDA	pH		7.61	
27-Nov-15	AYA-ID-11618-2015	CRUDA	Sulfatos (Cloruro de Bario)		14	mg/L
27-Nov-15	AYA-ID-11618-2015	CRUDA	Turbiedad		8.09	UNT
29-Jan-16	AYA-ID-00635-2016	CRUDA	Alcalinidad		58	mg/L
29-Jan-16	AYA-ID-00635-2016	CRUDA	Color Aparente	Bajo	27	UPt-Co
29-Jan-16	AYA-ID-00635-2016	CRUDA	Dureza Total		58	mg/L
29-Jan-16	AYA-ID-00635-2016	CRUDA	Hierro (1-10 Fenantrolina)		0.08	mg/L
29-Jan-16	AYA-ID-00635-2016	CRUDA	Olor		Negativo	
29-Jan-16	AYA-ID-00635-2016	CRUDA	pH		8.05	
29-Jan-16	AYA-ID-00635-2016	CRUDA	Sulfatos (Cloruro de Bario)		10	mg/L
29-Jan-16	AYA-ID-00635-2016	CRUDA	Turbiedad		2.3	UNT
12-Feb-16	AYA-ID-01067-2016	CRUDA	Alcalinidad		52	mg/L
12-Feb-16	AYA-ID-01067-2016	CRUDA	Color Aparente	Bajo	43	UPt-Co
12-Feb-16	AYA-ID-01067-2016	CRUDA	Dureza Total		57	mg/L
12-Feb-16	AYA-ID-01067-2016	CRUDA	Hierro (1-10 Fenantrolina)		0.32	mg/L
12-Feb-16	AYA-ID-01067-2016	CRUDA	Olor		Negativo	
12-Feb-16	AYA-ID-01067-2016	CRUDA	pH		8.4	
12-Feb-16	AYA-ID-01067-2016	CRUDA	Sulfatos (Cloruro de Bario)		8	mg/L
12-Feb-16	AYA-ID-01067-2016	CRUDA	Turbiedad		5.12	UNT
31-Mar-16	AYA-ID-02899-2016	CRUDA	Alcalinidad		58	mg/L
31-Mar-16	AYA-ID-02899-2016	CRUDA	Color Aparente	Bajo	20	UPt-Co
31-Mar-16	AYA-ID-02899-2016	CRUDA	Dureza Total		67	mg/L

31-Mar-16	AYA-ID-02899-2016	CRUDA	Hierro (1-10 Fenantrolina)		0.28	mg/L
31-Mar-16	AYA-ID-02899-2016	CRUDA	Olor		Negativo	
31-Mar-16	AYA-ID-02899-2016	CRUDA	pH		8.21	
31-Mar-16	AYA-ID-02899-2016	CRUDA	Sulfatos (Cloruro de Bario)		17	mg/L
31-Mar-16	AYA-ID-02899-2016	CRUDA	Turbiedad		3.64	UNT
28-Apr-16	AYA-ID-03891-2016	CRUDA	Alcalinidad		46	mg/L
28-Apr-16	AYA-ID-03891-2016	CRUDA	Color Aparente	Alto	279	UPt-Co
28-Apr-16	AYA-ID-03891-2016	CRUDA	Dureza Total		48	mg/L
28-Apr-16	AYA-ID-03891-2016	CRUDA	Hierro (1-10 Fenantrolina)		0.5	mg/L
28-Apr-16	AYA-ID-03891-2016	CRUDA	Olor		Negativo	
28-Apr-16	AYA-ID-03891-2016	CRUDA	pH		6.98	
28-Apr-16	AYA-ID-03891-2016	CRUDA	Sulfatos (Cloruro de Bario)		16	mg/L
28-Apr-16	AYA-ID-03891-2016	CRUDA	Turbiedad		29.8	UNT
8-May-16	AYA-ID-04149-2016	CRUDA	Alcalinidad		51	mg/L
8-May-16	AYA-ID-04149-2016	CRUDA	Color Aparente	Alto	81	UPt-Co
8-May-16	AYA-ID-04149-2016	CRUDA	Dureza Total		63	mg/L
8-May-16	AYA-ID-04149-2016	CRUDA	Hierro (1-10 Fenantrolina)		0.8	mg/L
8-May-16	AYA-ID-04149-2016	CRUDA	Olor		Negativo	
8-May-16	AYA-ID-04149-2016	CRUDA	pH		8.63	
8-May-16	AYA-ID-04149-2016	CRUDA	Sulfatos (Cloruro de Bario)		18	mg/L
8-May-16	AYA-ID-04149-2016	CRUDA	Turbiedad		8.93	UNT
28-Jun-16	AYA-ID-06402-2016	CRUDA	Alcalinidad		55	mg/L
28-Jun-16	AYA-ID-06402-2016	CRUDA	Color Aparente	Bajo	39	UPt-Co
28-Jun-16	AYA-ID-06402-2016	CRUDA	Dureza Total		60	mg/L
28-Jun-16	AYA-ID-06402-2016	CRUDA	Hierro (1-10 Fenantrolina)		0.18	mg/L
28-Jun-16	AYA-ID-06402-2016	CRUDA	Olor		Negativo	
28-Jun-16	AYA-ID-06402-2016	CRUDA	pH		8.17	
28-Jun-16	AYA-ID-06402-2016	CRUDA	Sulfatos (Cloruro de Bario)		15	mg/L
28-Jun-16	AYA-ID-06402-2016	CRUDA	Turbiedad		3.66	UNT
25-Jul-16	AYA-ID-07265-2016	CRUDA	Alcalinidad		48	mg/L
25-Jul-16	AYA-ID-07265-2016	CRUDA	Color Aparente	Alto	163	UPt-Co
25-Jul-16	AYA-ID-07265-2016	CRUDA	Dureza Total		56	mg/L
25-Jul-16	AYA-ID-07265-2016	CRUDA	Hierro (1-10 Fenantrolina)		0.36	mg/L
25-Jul-16	AYA-ID-07265-2016	CRUDA	Olor		Negativo	
25-Jul-16	AYA-ID-07265-2016	CRUDA	pH		8.07	
25-Jul-16	AYA-ID-07265-2016	CRUDA	Sulfatos (Cloruro de Bario)		6	mg/L
25-Jul-16	AYA-ID-07265-2016	CRUDA	Turbiedad		22.3	UNT
10-Aug-16	AYA-ID-07734-2016	CRUDA	Alcalinidad		49	mg/L
10-Aug-16	AYA-ID-07734-2016	CRUDA	Color Aparente	Alto	138	UPt-Co
10-Aug-16	AYA-ID-07734-2016	CRUDA	Dureza Total		64	mg/L
10-Aug-16	AYA-ID-07734-2016	CRUDA	Hierro (1-10 Fenantrolina)		0.8	mg/L
10-Aug-16	AYA-ID-07734-2016	CRUDA	Olor		Negativo	
10-Aug-16	AYA-ID-07734-2016	CRUDA	pH		8.25	
10-Aug-16	AYA-ID-07734-2016	CRUDA	Sulfatos (Cloruro de Bario)		14	mg/L
10-Aug-16	AYA-ID-07734-2016	CRUDA	Turbiedad		16.9	UNT
30-Sep-16	AYA-ID-09932-2016	CRUDA	Alcalinidad		68	mg/L

30-Sep-16	AYA-ID-09932-2016	CRUDA	Color Aparente	Alto	145	UPt-Co
30-Sep-16	AYA-ID-09932-2016	CRUDA	Dureza Total		59	mg/L
30-Sep-16	AYA-ID-09932-2016	CRUDA	Hierro (1-10 Fenantrolina)		0.8	mg/L
30-Sep-16	AYA-ID-09932-2016	CRUDA	Olor		Negativo	
30-Sep-16	AYA-ID-09932-2016	CRUDA	pH		7.68	
30-Sep-16	AYA-ID-09932-2016	CRUDA	Sulfatos (Cloruro de Bario)		12	mg/L
30-Sep-16	AYA-ID-09932-2016	CRUDA	Turbiedad		20.1	UNT
27-Oct-16	AYA-ID-10909-2016	CRUDA	Alcalinidad		52	mg/L
27-Oct-16	AYA-ID-10909-2016	CRUDA	Color Aparente	Alto	118	UPt-Co
27-Oct-16	AYA-ID-10909-2016	CRUDA	Dureza Total		53	mg/L
27-Oct-16	AYA-ID-10909-2016	CRUDA	Hierro (1-10 Fenantrolina)		0.56	mg/L
27-Oct-16	AYA-ID-10909-2016	CRUDA	Olor		Negativo	
27-Oct-16	AYA-ID-10909-2016	CRUDA	pH		7.5	
27-Oct-16	AYA-ID-10909-2016	CRUDA	Sulfatos (Cloruro de Bario)		12	mg/L
27-Oct-16	AYA-ID-10909-2016	CRUDA	Turbiedad		13.7	UNT
10-Nov-16	AYA-ID-11462-2016	CRUDA	Alcalinidad		61	mg/L
10-Nov-16	AYA-ID-11462-2016	CRUDA	Color Aparente	Alto	61	UPt-Co
10-Nov-16	AYA-ID-11462-2016	CRUDA	Dureza Total		55	mg/L
10-Nov-16	AYA-ID-11462-2016	CRUDA	Hierro (1-10 Fenantrolina)		0.34	mg/L
10-Nov-16	AYA-ID-11462-2016	CRUDA	Olor		negativo	
10-Nov-16	AYA-ID-11462-2016	CRUDA	pH		7.16	
10-Nov-16	AYA-ID-11462-2016	CRUDA	Sulfatos (Cloruro de Bario)		10	mg/L
10-Nov-16	AYA-ID-11462-2016	CRUDA	Turbiedad		7.12	UNT
6-Jan-17	AYA-ID-00078-2017	CRUDA	Alcalinidad		63	mg/L
6-Jan-17	AYA-ID-00078-2017	CRUDA	Color Aparente	Bajo	21	UPt-Co
6-Jan-17	AYA-ID-00078-2017	CRUDA	Dureza Total		52	mg/L
6-Jan-17	AYA-ID-00078-2017	CRUDA	Olor		Negativo	
6-Jan-17	AYA-ID-00078-2017	CRUDA	pH		7.2	
6-Jan-17	AYA-ID-00078-2017	CRUDA	Sulfatos (Cloruro de Bario)		6	mg/L
6-Jan-17	AYA-ID-00078-2017	CRUDA	Turbiedad		2.94	UNT
11-Mar-17	AYA-ID-02068-2017	CRUDA	Coliformes fecales	Serie 5 tubos 10 mL a 0,1 mL	70	NMP/100 mL
28-May-17	AYA-ID-04986-2017	CRUDA	Alcalinidad		52	mg/L
28-May-17	AYA-ID-04986-2017	CRUDA	Aluminio	ICP	736.2	µg/L
28-May-17	AYA-ID-04986-2017	CRUDA	Antimonio		N.D.	µg/L
28-May-17	AYA-ID-04986-2017	CRUDA	Arsénico	ICP	0.6	µg/L
28-May-17	AYA-ID-04986-2017	CRUDA	Cadmio	ICP	N.D.	µg/L
28-May-17	AYA-ID-04986-2017	CRUDA	Calcio		16.8	mg/L
28-May-17	AYA-ID-04986-2017	CRUDA	Cloruros		3.44	mg/L
28-May-17	AYA-ID-04986-2017	CRUDA	Cobre	ICP	3.2	µg/L
28-May-17	AYA-ID-04986-2017	CRUDA	Color Aparente		74	UPt-Co
28-May-17	AYA-ID-04986-2017	CRUDA	Conductividad		154	µS/cm
28-May-17	AYA-ID-04986-2017	CRUDA	Cromo	ICP	N.D.	µg/L
28-May-17	AYA-ID-04986-2017	CRUDA	Dureza de Calcio		42	mg/L
28-May-17	AYA-ID-04986-2017	CRUDA	Dureza Total		58	mg/L
28-May-17	AYA-ID-04986-2017	CRUDA	Fluoruros		N.D.	mg/L
28-May-17	AYA-ID-04986-2017	CRUDA	Fosfatos		N.D.	mg/L

28-May-17	AYA-ID-04986-2017	CRUDA	Hierro	ICP	0.581	mg/L
28-May-17	AYA-ID-04986-2017	CRUDA	Magnesio		3.8	mg/L
28-May-17	AYA-ID-04986-2017	CRUDA	Manganeso	ICP	53.8	µg/L
28-May-17	AYA-ID-04986-2017	CRUDA	Mercurio		N.D.	µg/L
28-May-17	AYA-ID-04986-2017	CRUDA	Niquel	ICP	D.	µg/L
28-May-17	AYA-ID-04986-2017	CRUDA	Nitratos		N.D.	mg/L
28-May-17	AYA-ID-04986-2017	CRUDA	Nitritos		N.D.	mg/L
28-May-17	AYA-ID-04986-2017	CRUDA	Olor		Aceptable	
28-May-17	AYA-ID-04986-2017	CRUDA	pH		8.37	
28-May-17	AYA-ID-04986-2017	CRUDA	Plomo	ICP	D.	µg/L
28-May-17	AYA-ID-04986-2017	CRUDA	Selenio		N.D.	µg/L
28-May-17	AYA-ID-04986-2017	CRUDA	Sulfatos		12.19	mg/L
28-May-17	AYA-ID-04986-2017	CRUDA	Temperatura		27.6	ºC
28-May-17	AYA-ID-04986-2017	CRUDA	Turbiedad		36	UNT
28-May-17	AYA-ID-04986-2017	CRUDA	Zinc		49.2	µg/L
24-Nov-17	AYA-ID-11970-2017	CRUDA	Alcalinidad		57	mg/L
24-Nov-17	AYA-ID-11970-2017	CRUDA	Calcio		16.8	mg/L
24-Nov-17	AYA-ID-11970-2017	CRUDA	Cloruros		3.87	mg/L
24-Nov-17	AYA-ID-11970-2017	CRUDA	Color Aparente		11	UPt-Co
24-Nov-17	AYA-ID-11970-2017	CRUDA	Conductividad		167	µS/cm
24-Nov-17	AYA-ID-11970-2017	CRUDA	Dureza de Calcio		42	mg/L
24-Nov-17	AYA-ID-11970-2017	CRUDA	Dureza Total		58	mg/L
24-Nov-17	AYA-ID-11970-2017	CRUDA	Fluoruros		0.17	mg/L
24-Nov-17	AYA-ID-11970-2017	CRUDA	Fosfatos		N.D.	mg/L
24-Nov-17	AYA-ID-11970-2017	CRUDA	Magnesio		4	mg/L
24-Nov-17	AYA-ID-11970-2017	CRUDA	Nitratos		D.	mg/L
24-Nov-17	AYA-ID-11970-2017	CRUDA	Nitritos		N.D.	mg/L
24-Nov-17	AYA-ID-11970-2017	CRUDA	Olor		Aceptable	
24-Nov-17	AYA-ID-11970-2017	CRUDA	pH		8.38	
24-Nov-17	AYA-ID-11970-2017	CRUDA	Sulfatos		11.49	mg/L
24-Nov-17	AYA-ID-11970-2017	CRUDA	Temperatura		23.2	ºC
24-Nov-17	AYA-ID-11970-2017	CRUDA	Turbiedad		5.96	UNT
27-Feb-18	AYA-ID-01769-2018	CRUDA	Alcalinidad		58	mg/L
27-Feb-18	AYA-ID-01769-2018	CRUDA	Calcio		19.3	mg/L
27-Feb-18	AYA-ID-01769-2018	CRUDA	Cloruros		8.68	mg/L
27-Feb-18	AYA-ID-01769-2018	CRUDA	Coliformes fecales	Serie 5 tubos 10 mL a 0,1 mL	49	NMP/100 mL
27-Feb-18	AYA-ID-01769-2018	CRUDA	Color Aparente		4	UPt-Co
27-Feb-18	AYA-ID-01769-2018	CRUDA	Conductividad		174	µS/cm
27-Feb-18	AYA-ID-01769-2018	CRUDA	Dureza de Calcio		48	mg/L
27-Feb-18	AYA-ID-01769-2018	CRUDA	Dureza Total		64	mg/L
27-Feb-18	AYA-ID-01769-2018	CRUDA	Fluoruros		0.1	mg/L
27-Feb-18	AYA-ID-01769-2018	CRUDA	Fosfatos		N.D.	mg/L
27-Feb-18	AYA-ID-01769-2018	CRUDA	Magnesio		3.9	mg/L
27-Feb-18	AYA-ID-01769-2018	CRUDA	Nitratos		N.D.	mg/L
27-Feb-18	AYA-ID-01769-2018	CRUDA	Nitritos		N.D.	mg/L
27-Feb-18	AYA-ID-01769-2018	CRUDA	Olor		Aceptable	

27-Feb-18	AYA-ID-01769-2018	CRUDA	pH		7.97	
27-Feb-18	AYA-ID-01769-2018	CRUDA	Sulfatos		15.14	mg/L
27-Feb-18	AYA-ID-01769-2018	CRUDA	Turbiedad		1.66	UNT
10-Mar-18	AYA-ID-02371-2018	CRUDA	Coliformes fecales	Serie 5 tubos 10 mL a 0,1 mL	330	NMP/100 mL
26-Apr-18	AYA-ID-04031-2018	CRUDA	Alcalinidad		62	mg/L
26-Apr-18	AYA-ID-04031-2018	CRUDA	Calcio		23.1	mg/L
26-Apr-18	AYA-ID-04031-2018	CRUDA	Coliformes fecales	Serie 5 tubos 10 mL a 0,1 mL	23	NMP/100 mL
26-Apr-18	AYA-ID-04031-2018	CRUDA	Color Aparente		46	UPt-Co
26-Apr-18	AYA-ID-04031-2018	CRUDA	Conductividad		227	µS/cm
26-Apr-18	AYA-ID-04031-2018	CRUDA	Dureza de Calcio		58	mg/L
26-Apr-18	AYA-ID-04031-2018	CRUDA	Dureza Total		75	mg/L
26-Apr-18	AYA-ID-04031-2018	CRUDA	Magnesio		4.1	mg/L
26-Apr-18	AYA-ID-04031-2018	CRUDA	Olor		Aceptable	
26-Apr-18	AYA-ID-04031-2018	CRUDA	pH		8.01	
26-Apr-18	AYA-ID-04031-2018	CRUDA	Turbiedad		28.8	UNT
4-May-18	AYA-ID-04662-2018	CRUDA	Coliformes fecales	Serie 5 tubos 10 mL a 0,1 mL	70	NMP/100 mL
2-Jun-18	AYA-ID-05530-2018	CRUDA	Coliformes fecales	Serie 5 tubos 10 mL a 0,1 mL	5400	NMP/100 mL
4-Jul-18	AYA-ID-06883-2018	CRUDA	Cloruros		4.42	mg/L
4-Jul-18	AYA-ID-06883-2018	CRUDA	Coliformes fecales	Serie 5 tubos 10 mL a 0,1 mL	490	NMP/100 mL
4-Jul-18	AYA-ID-06883-2018	CRUDA	Color Aparente		21	UPt-Co
4-Jul-18	AYA-ID-06883-2018	CRUDA	Conductividad		161	µS/cm
4-Jul-18	AYA-ID-06883-2018	CRUDA	Fluoruros		0.12	mg/L
4-Jul-18	AYA-ID-06883-2018	CRUDA	Fosfatos		N.D.	mg/L
4-Jul-18	AYA-ID-06883-2018	CRUDA	Nitratos		D.	mg/L
4-Jul-18	AYA-ID-06883-2018	CRUDA	Nitritos		N.D.	mg/L
4-Jul-18	AYA-ID-06883-2018	CRUDA	Olor		Aceptable	
4-Jul-18	AYA-ID-06883-2018	CRUDA	pH		7.46	
4-Jul-18	AYA-ID-06883-2018	CRUDA	Sulfatos		13.02	mg/L
2-Oct-18	AYA-ID-09903-2018	CRUDA	Alcalinidad		50	mg/L
2-Oct-18	AYA-ID-09903-2018	CRUDA	Calcio		16.4	mg/L
2-Oct-18	AYA-ID-09903-2018	CRUDA	Cloruros		2.09	mg/L
2-Oct-18	AYA-ID-09903-2018	CRUDA	Conductividad		141	µS/cm
2-Oct-18	AYA-ID-09903-2018	CRUDA	Dureza de Calcio		41	mg/L
2-Oct-18	AYA-ID-09903-2018	CRUDA	Dureza Total		56	mg/L
2-Oct-18	AYA-ID-09903-2018	CRUDA	Fluoruros		D.	mg/L
2-Oct-18	AYA-ID-09903-2018	CRUDA	Magnesio		3.8	mg/L
2-Oct-18	AYA-ID-09903-2018	CRUDA	Nitratos		1.75	mg/L
2-Oct-18	AYA-ID-09903-2018	CRUDA	Nitritos		N.D.	mg/L
2-Oct-18	AYA-ID-09903-2018	CRUDA	pH		7.28	
2-Oct-18	AYA-ID-09903-2018	CRUDA	Sulfatos		9.52	mg/L
2-Oct-18	AYA-ID-09903-2018	CRUDA	Temperatura		23.7	ºC
2-Oct-18	AYA-ID-09903-2018	CRUDA	Turbiedad		55.8	UNT
28-Mar-19	AYA-ID-02554-2019	CRUDA	Alcalinidad		67	mg/L
28-Mar-19	AYA-ID-02554-2019	CRUDA	Calcio		23.3	mg/L
28-Mar-19	AYA-ID-02554-2019	CRUDA	Coliformes fecales	Serie 5 tubos 10 mL a 0,1 mL	Negativo	NMP/100 mL
28-Mar-19	AYA-ID-02554-2019	CRUDA	Color Aparente		D.	UPt-Co

28-Mar-19	AYA-ID-02554-2019	CRUDA	Conductividad	241	µS/cm
28-Mar-19	AYA-ID-02554-2019	CRUDA	Dureza de Calcio	58	mg/L
28-Mar-19	AYA-ID-02554-2019	CRUDA	Dureza Total	77	mg/L
28-Mar-19	AYA-ID-02554-2019	CRUDA	Magnesio	4.7	mg/L
28-Mar-19	AYA-ID-02554-2019	CRUDA	Olor	Aceptable	
28-Mar-19	AYA-ID-02554-2019	CRUDA	pH	8.21	
28-Mar-19	AYA-ID-02554-2019	CRUDA	Turbiedad	1.9	UNT

LABORATORIO NACIONAL DE AGUAS

AYA-ID-07839-2013

INFORME DE RESULTADOS

AYA-FPT-011B

Tres Ríos, Cartago
Teléfono: (506) 279-5118
Fax: (506) 279 5973
email: dmora@aya.go.cr

DATOS DE LA MUESTRA

Cliente:	REGION PACIFICO CENTRAL			**Proc. muestreo**	AYA-PT-019-5
Contacto:	Ing. German Araya Montezuma			**Muestreado por**	Canales José Fco
SISTEMA:	**CARMEN LYRA-LA GUARIA-MOJONCITO**			**Fecha de muestreo**	09-sep-13
				Fecha de ingreso :	09-oct-13
Muestreo:	POZO POCAMAR 2			**Fecha de Reporte:**	17-oct-13
Dirección:	LLAVE DE CHORRO			**Inicio Análisis MIC:**	
				Teléfono:	2663-67-98
PROVINCIA:	Puntarenas	**CANTON:**	Puntarenas	**Tipo de muestra:**	Agua
e-mail:	garayam@aya.go.cr	**Fax:**		**Hora de recolección:**	14:15

DETALLE REPORTE DE RESULTADOS ANALISIS

PARAMETRO	E	RESULTADO	UNIDADES	INCERT	LD	LC	METODO	V.A.	V.MAX
Aluminio	*	19	µg/L	1,0	1,0	4,0	3125 B		200
Antimonio	*	N.D.	µg/L	0,10	0,20	0,30	3125 B		5
Arsénico	*	N.D.	µg/L	1,0	2,0	3,0	3113 B		10
Cadmio	*	N.D.	µg/L	0,30	0,40	0,90	3113 B		3
Cobre	*	N.D.	µg/L	1,0	1,0	2,0	3113 B	1000	2000
Cromo	*	N.D.	µg/L	1,0	2,0	3,0	3113 B		50
Hierro	*	18	µg/L	4,0	5,0	7,0	3113 B		300
Manganeso	*	N.D.	µg/L	4,0	5,0	6,0	3113 B	100	500
Mercurio	*	N.D.	µg/L	0,10	0,11	0,15	3125 B		1
Niquel	*	N.D.	µg/L	2,0	3,0	5,0	3113B		20
Plomo	*	N.D.	µg/L	1,0	2,0	3,0	3113B		10
Potasio	*	2,2	mg/L	0,80	1,0	1,5	3500-K B		10
Selenio	*	N.D.	µg/L	0,10	0,20	0,70	3125B		10
Sodio	*	10,3	mg/L	1,9	2,0	2,5	3500-Na B	25	200
Zinc	*	N.D.	µg/L	1,0	2,0	3,0	3125 B		3000

INCERT: Corresponde a la Incertidumbre expandida k=2 para un 95% de confianza
LD: Límite de Detección en las unidades del parámetro analizado
LC: Límite de Cuantificación en las unidades del parámetro analizado
METODO: Correponde al código del Standard Methods for the Examination of Water and Wastewater.
N.D.: No detectable bajo el límite de detección
D.: Detectable pero no cuantificable
* Ensayo acreditado. Ver alcance en www.eca.or.cr

**** Ensayo no acreditado**

Página 1 de 32	Editado e impreso por **AYA 2006**	**Aprobado por:** ***Dr. Darner Mora Alvarado***

LABORATORIO NACIONAL DE AGUAS

AYA-ID-07839-2013

INFORME DE RESULTADOS

AYA-FPT-011B

Tres Ríos, Cartago
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Fax: (506) 279 5973
email: dmora@aya.go.cr

DATOS DE LA MUESTRA

Cliente:	REGION PACIFICO CENTRAL			**Proc. muestreo**	AYA-PT-019-5
Contacto:	Ing. German Araya Montezuma			**Muestreado por**	Canales José Fco
SISTEMA:	**CARMEN LYRA-LA GUARIA-MOJONCITO**			**Fecha de muestreo**	09-sep-13
				Fecha de ingreso :	09-oct-13
Muestreo:	POZO POCAMAR 2			**Fecha de Reporte:**	17-oct-13
Dirección:	LLAVE DE CHORRO			**Inicio Análisis MIC:**	
				Teléfono:	2663-67-98
PROVINCIA:	Puntarenas	**CANTON:**	Puntarenas	**Tipo de muestra:**	Agua
e-mail:	garayam@aya.go.cr	**Fax:**		**Hora de recolección:**	14:15

DETALLE REPORTE DE RESULTADOS ANALISIS

PARAMETRO	E	RESULTADO	UNIDADES	INCERT	LD	LC	METODO	V.A.	V.MAX
Aluminio	*	19	µg/L	1,0	1,0	4,0	3125 B		200
Antimonio	*	N.D.	µg/L	0,10	0,20	0,30	3125 B		5
Arsénico	*	N.D.	µg/L	1,0	2,0	3,0	3113 B		10
Cadmio	*	N.D.	µg/L	0,30	0,40	0,90	3113 B		3
Cobre	*	N.D.	µg/L	1,0	1,0	2,0	3113 B	1000	2000
Cromo	*	N.D.	µg/L	1,0	2,0	3,0	3113 B		50
Hierro	*	18	µg/L	4,0	5,0	7,0	3113 B		300
Manganeso	*	N.D.	µg/L	4,0	5,0	6,0	3113 B	100	500
Mercurio	*	N.D.	µg/L	0,10	0,11	0,15	3125 B		1
Niquel	*	N.D.	µg/L	2,0	3,0	5,0	3113B		20
Plomo	*	N.D.	µg/L	1,0	2,0	3,0	3113B		10
Potasio	*	2,2	mg/L	0,80	1,0	1,5	3500-K B		10
Selenio	*	N.D.	µg/L	0,10	0,20	0,70	3125B		10
Sodio	*	10,3	mg/L	1,9	2,0	2,5	3500-Na B	25	200
Zinc	*	N.D.	µg/L	1,0	2,0	3,0	3125 B		3000

INCERT: Corresponde a la Incertidumbre expandida k=2 para un 95% de confianza
LD: Límite de Detección en las unidades del parámetro analizado
LC: Límite de Cuantificación en las unidades del parámetro analizado
METODO: Correponde al código del Standard Methods for the Examination of Water and Wastewater.
N.D.: No detectable bajo el límite de detección
D.: Detectable pero no cuantificable
* Ensayo acreditado. Ver alcance en www.eca.or.cr

**** Ensayo no acreditado**

Página 1 de 32	Editado e impreso por **AYA 2006**	**Aprobado por:** ***Dr. Darner Mora Alvarado***

LABORATORIO NACIONAL DE AGUAS

AYA-ID-08432-2014

INFORME DE RESULTADOS

AYA-FPT-011B

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email: dmora@aya.go.cr

DATOS DE LA MUESTRA

Cliente:	REGION PACIFICO CENTRAL			**Proc. muestreo**	AYA-PT-019-5
Contacto:	Ing. German Araya Montezuma			**Muestreado por**	Canales Canales J
SISTEMA:	**CARMEN LYRA-LA GUARIA-MOJONCITO**			**Fecha de muestreo**	18-oct-14
				Fecha de ingreso :	04-nov-14
Muestreo:	POZO POCAMAR 1			**Fecha de Reporte:**	11-nov-14
Dirección:	LLAVE DE AFORO			**Inicio Análisis MIC:**	
				Teléfono:	2663-67-98
PROVINCIA:	Puntarenas	**CANTON:**	Puntarenas	**Tipo de muestra:**	Agua
e-mail:	garayam@aya.go.cr	**Fax:**		**Hora de recolección:**	11:35

DETALLE REPORTE DE RESULTADOS ANALISIS

PARAMETRO	E	RESULTADO	UNIDADES	INCERT	LD	LC	METODO	V.A.	V.MAX
Aluminio	*	N.D.	μg/L	1,0	1,0	4,0	3125 B		200
Antimonio	*	N.D.	μg/L	0,10	0,20	0,30	3125 B		5
Arsénico	*	0,8	μg/L	0,10	0,20	0,30	3125 B		10
Cadmio	*	N.D.	μg/L	0,10	0,20	0,30	3125 B		3
Cobre	*	3	μg/L	1,0	2,0	3,0	3125 B	1000	2000
Hierro	*	289	μg/L	1,0	2,0	3,0	3125 B		300
Manganeso	*	316	μg/L	1,0	2,0	3,0	3125 B	100	500
Mercurio	*	N.D.	μg/L	0,10	0,11	0,15	3125 B		1
Niquel	*	N.D.	μg/L	1,0	2,0	3,0	3125 B		20
Plomo	*	N.D.	μg/L	0,10	0,20	0,50	3125 B		10
Potasio	*	2,4	mg/L	0,80	1,0	1,5	3500-K B		10
Selenio	*	N.D.	μg/L	0,10	0,20	0,70	3125B		10
Sodio	*	14,2	mg/L	1,9	2,0	2,5	3500-Na B	25	200
Zinc	*	3	μg/L	1,0	2,0	3,0	3125 B		3000

INCERT: Corresponde a la Incertidumbre expandida k=2 para un 95% de confianza
LD: Límite de Detección en las unidades del parámetro analizado
LC: Límite de Cuantificación en las unidades del parámetro analizado
METODO: Correponde al código del Standard Methods for the Examination of Water and Wastewater.
N.D.: No detectable bajo el límite de detección
D.: Detectable pero no cuantificable
* Ensayo acreditado. Ver alcance en www.eca.or.cr
**** Ensayo no acreditado**

Condiciones Ambientales:

Página 5 de 32	Editado e impreso por **AYA 2006**	**Aprobado por:** ***Dr. Darner Mora Alvarado***

LABORATORIO NACIONAL DE AGUAS

AYA-ID-08433-2014

INFORME DE RESULTADOS

AYA-FPT-011B

Tres Rios, Cartago
Teléfono: (506) 279-5118
Fax: (506) 279 5973
email: dmora@aya.go.cr

DATOS DE LA MUESTRA

Cliente:	REGION PACIFICO CENTRAL			**Proc. muestreo**	AYA-PT-019-5
Contacto:	Ing. German Araya Montezuma			**Muestreado por**	Canales Canales J
SISTEMA:	**CARMEN LYRA-LA GUARIA-MOJONCITO**			**Fecha de muestreo**	18-oct-14
				Fecha de ingreso :	04-nov-14
Muestreo:	POZO POCAMAR 2			**Fecha de Reporte:**	11-nov-14
Dirección:	LLAVE DE AFORO			**Inicio Análisis MIC:**	
				Teléfono:	2663-67-98
PROVINCIA:	Puntarenas	**CANTON:**	Puntarenas	**Tipo de muestra:**	Agua
e-mail:	garayam@aya.go.cr	**Fax:**		**Hora de recolección:**	11:40

DETALLE REPORTE DE RESULTADOS ANALISIS

PARAMETRO	E	RESULTADO	UNIDADES	INCERT	LD	LC	METODO	V.A.	V.MAX
Aluminio	*	N.D.	μg/L	1,0	1,0	4,0	3125 B		200
Antimonio	*	N.D.	μg/L	0,10	0,20	0,30	3125 B		5
Arsénico	*	0,7	μg/L	1,0	2,0	3,0	3113 B		10
Cromo	*	N.D.	μg/L	0,10	0,50	1,60	3125 B		50
Hierro	*	N.D.	μg/L	1,0	2,0	3,0	3125 B		300
Manganeso	*	N.D.	μg/L	1,0	2,0	3,0	3125 B	100	500
Mercurio	*	N.D.	μg/L	0,10	0,11	0,15	3125 B		1
Niquel	*	N.D.	μg/L	1,0	2,0	3,0	3125 B		20
Plomo	*	N.D.	μg/L	0,10	0,20	0,50	3125 B		10
Potasio	*	2,3	mg/L	0,80	1,0	1,5	3500-K B		10
Selenio	*	N.D.	μg/L	0,10	0,20	0,70	3125B		10
Sodio	*	10,2	mg/L	1,9	2,0	2,5	3500-Na B	25	200
Zinc	*	5	μg/L	1,0	2,0	3,0	3125 B		3000

INCERT: Corresponde a la Incertidumbre expandida k=2 para un 95% de confianza
LD: Límite de Detección en las unidades del parámetro analizado
LC: Límite de Cuantificación en las unidades del parámetro analizado
METODO: Correponde al código del Standard Methods for the Examination of Water and Wastewater.
N.D.: No detectable bajo el límite de detección
D.: Detectable pero no cuantificable
* Ensayo acreditado. Ver alcance en www.eca.or.cr
**** Ensayo no acreditado**

Condiciones Ambientales:

Página 7 de 32	Editado e impreso por **AYA 2006**	**Aprobado por:** ***Dr. Darner Mora Alvarado***

LABORATORIO NACIONAL DE AGUAS

AYA-ID-03558-2015

INFORME DE RESULTADOS

AYA-FPT-011B

Tres Ríos, Cartago
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Laboratorio de ensayo
Alcance de Acreditación Nº LE 049
Acreditado a partir de: 11.02.2008
Alcance disponible en www.eca.or.cr

DATOS DE LA MUESTRA

Cliente:	REGION PACIFICO CENTRAL	**Proc. muestreo**	AYA-PT-019-5
Contacto:	Ing. German Araya Montezuma	**Muestreado por**	Guzmán Carlos
SISTEMA:	**CARMEN LYRA-LA GUARIA-MOJONCITO**	**Fecha de muestreo**	11-may-15
		Fecha de ingreso :	12-may-15
Muestreo:	POZO POCAMAR 1	**Fecha de Reporte:**	21-may-15
Dirección:	LLAVE DE CHORRO	**Inicio Análisis MIC:**	
		Teléfono:	2663-67-98
PROVINCIA:	Puntarenas **CANTON:** Puntarenas	**Tipo de muestra:**	Agua
e-mail:	garayam@aya.go.cr **Fax:**	**Hora de recolección:**	12:22

DETALLE REPORTE DE RESULTADOS ANALISIS

PARAMETRO	E	RESULTADO	UNIDADES	INCERT	LD	LC	METODO	V.A.	V.MAX
Alcalinidad	*	88	mg/L	1,0	2,0	3,0	2320		
Aluminio	*	D.	µg/L	1,0	1,0	4,0	3125 B		200
Antimonio	*	N.D.	µg/L	0,10	0,20	0,30	3125 B		5
Arsénico	*	1,0	µg/L	0,10	0,20	0,30	3125 B		10
Cadmio	*	N.D.	µg/L	0,10	0,20	0,30	3125 B		3
Calcio	*	31,3	mg/L	1,0	1,5	2,0	3500-Ca B	100	
Cloruros	*	11,57	mg/L	0,81	1,30	1,10	4110B Cro	25	250
Cobre	*	N.D.	µg/L	1,0	2,0	3,0	3125 B	1000	2000
Color Aparente	*	N.D.	UPt-Co	1,0	2,0	4,0	2120 C	5	15
Conductividad	*	222	µS/cm	1,0	2	4	2510	400	
Cromo	*	N.D.	µg/L	0,10	0,50	1,60	3125 B		50
Dureza de Calcio	*	78	mg/L	2,0	2,0	3,0	3500-Ca D		
Dureza Total	*	100	mg/L	2,0	2,0	3,0	2340 C	300	400
Fluoruros	*	D.	mg/L	0,027	0,040	0,100	4110B Cro		0,7-1,5
Fosfatos	*	N.D.	mg/L	0,32	0,40	0,80	4110B Cro		
Hierro	*	5,4	µg/L	1,0	2,0	3,0	3125 B		300
Magnesio	*	5,3	mg/L	0,10	0,50	1,0	3500 B	30	50
Manganeso	*	N.D.	µg/L	1,0	2,0	3,0	3125 B	100	500
Mercurio	*	N.D.	µg/L	0,10	0,11	0,15	3125 B		1
Niquel	*	N.D.	µg/L	1,0	2,0	3,0	3125 B		20
Nitratos	*	N.D.	mg/L	0,53	0,81	1,40	4110B mo		50
Nitritos	*	N.D.	mg/L	0,026	0,040	0,10	4110B Cro		0,1
pH	*	6,91		0,10	0,10	0,20	4500-H+	6,0-8,0	
Plomo	*	0,6	µg/L	0,10	0,20	0,50	3125 B		10

Página 9 de 32	Editado e impreso por **AYA 2006**	**Aprobado por:** ***Dr. Darner Mora Alvarado***

LABORATORIO NACIONAL DE AGUAS

AYA-ID-03558-2015

INFORME DE RESULTADOS

AYA-FPT-011B

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Laboratorio de ensayo
Alcance de Acreditación Nº LE 049
Acreditado a partir de: 11.02.2008
Alcance disponible en www.eca.or.cr

PARAMETRO	E	RESULTADO	UNIDADES	INCERT	LD	LC	METODO	V.A.	V.MAX
Potasio	*	2,4	mg/L	0,80	1,0	1,5	3500-K B		10
Selenio	*	N.D.	µg/L	0,10	0,20	0,70	3125B		10
Sodio	*	9,3	mg/L	1,9	2,0	2,5	3500-Na B	25	200
Sulfatos	*	19,37	mg/L	0,79	0,81	1,60	4110B Cro	25	250
Turbiedad	*	D.	UNT	0,10	0,12	0,15	2130 B	<1	5
Zinc	*	3,9	µg/L	1,0	2,0	3,0	3125 B		3000

INCERT: Corresponde a la Incertidumbre expandida k=2 para un 95% de confianza

LD: Límite de Detección en las unidades del parámetro analizado

LC: Límite de Cuantificación en las unidades del parámetro analizado

METODO: Correponde al código del Standard Methods for the Examination of Water and Wastewater.

N.D.: No detectable bajo el límite de detección

D.: Detectable pero no cuantificable

* Ensayo acreditado. Ver alcance en www.eca.or.cr

**** Ensayo no acreditado**

Condiciones Ambientales:

Observaciones:

Las determinaciones efectuadas, cumplen con el Reglamento para la Calidad del Agua Potable 32327-S.

A. Urbina C.

Licda. Azucena Urbina Campos
Jefe del Laboratorio Química

LABORATORIO NACIONAL DE AGUAS

AYA-ID-03559-2015

INFORME DE RESULTADOS

AYA-FPT-011B

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Laboratorio de ensayo
Alcance de Acreditación Nº. LE-049
Acreditado a partir de: 11.02.2008
Alcance disponible en www.eca.or.cr

DATOS DE LA MUESTRA

Cliente:	REGION PACIFICO CENTRAL			**Proc. muestreo**	AYA-PT-019-5
Contacto:	Ing. German Araya Montezuma			**Muestreado por**	Guzmán Carlos
SISTEMA:	**CARMEN LYRA-LA GUARIA-MOJONCITO**			**Fecha de muestreo**	11-may-15
				Fecha de ingreso :	12-may-15
Muestreo:	POZO POCAMAR 2			**Fecha de Reporte:**	21-may-15
Dirección:	LLAVE DE CHORRO			**Inicio Análisis MIC:**	
				Teléfono:	2663-67-98
PROVINCIA:	Puntarenas	**CANTON:**	Puntarenas	**Tipo de muestra:**	Agua
e-mail:	garayam@aya.go.cr	**Fax:**		**Hora de recolección:**	12:26

DETALLE REPORTE DE RESULTADOS ANALISIS

PARAMETRO	E	RESULTADO	UNIDADES	INCERT	LD	LC	METODO	V.A.	V.MAX
Alcalinidad	*	93	mg/L	1,0	2,0	3,0	2320		
Aluminio	*	D.	µg/L	1,0	1,0	4,0	3125 B		200
Antimonio	*	N.D.	µg/L	0,10	0,20	0,30	3125 B		5
Arsénico	*	1,0	µg/L	0,10	0,20	0,30	3125 B		10
Cadmio	*	N.D.	µg/L	0,10	0,20	0,30	3125 B		3
Calcio	*	31,0	mg/L	1,0	1,5	2,0	3500-Ca B	100	
Cloruros	*	9,03	mg/L	0,81	1,30	1,10	4110B Cro	25	250
Cobre	*	N.D.	µg/L	1,0	2,0	3,0	3125 B	1000	2000
Color Aparente	*	N.D.	UPt-Co	1,0	2,0	4,0	2120 C	5	15
Conductividad	*	223	µS/cm	1,0	2	4	2510	400	
Cromo	*	N.D.	µg/L	0,10	0,50	1,60	3125 B		50
Dureza de Calcio	*	78	mg/L	2,0	2,0	3,0	3500-Ca D		
Dureza Total	*	100	mg/L	2,0	2,0	3,0	2340 C	300	400
Fluoruros	*	N.D.	mg/L	0,027	0,040	0,100	4110B Cro		0,7-1,5
Fosfatos	*	N.D.	mg/L	0,32	0,40	0,80	4110B Cro		
Hierro	*	16,0	µg/L	1,0	2,0	3,0	3125 B		300
Magnesio	*	5,5	mg/L	0,10	0,50	1,0	3500 B	30	50
Manganeso	*	N.D.	µg/L	1,0	2,0	3,0	3125 B	100	500
Mercurio	*	N.D.	µg/L	0,10	0,11	0,15	3125 B		1
Niquel	*	N.D.	µg/L	1,0	2,0	3,0	3125 B		20
Nitratos	*	N.D.	mg/L	0,53	0,81	1,40	4110B mo		50
Nitritos	*	N.D.	mg/L	0,026	0,040	0,10	4110B Cro		0,1
pH	*	7,66		0,10	0,10	0,20	4500-H+	6,0-8,0	
Plomo	*	N.D.	µg/L	0,10	0,20	0,50	3125 B		10

Pagina 11 de 32	Editado e impreso por **AYA 2006**	**Aprobado por:** ***Dr. Darner Mora Alvarado***

LABORATORIO NACIONAL DE AGUAS

AYA-ID-03559-2015

INFORME DE RESULTADOS

AYA-FPT-011B

Tres Ríos, Cartago
Teléfono: (506) 279-5118
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Laboratorio de ensayo
Alcance de Acreditación Nº. LE-049
Acreditado a partir de: 11.02.2008
Alcance disponible en www.eca.or.cr

PARAMETRO	E	RESULTADO	UNIDADES	INCERT	LD	LC	METODO	V.A.	V.MAX
Potasio	*	2,4	mg/L	0,80	1,0	1,5	3500-K B		10
Selenio	*	N.D.	µg/L	0,10	0,20	0,70	3125B		10
Sodio	*	9,7	mg/L	1,9	2,0	2,5	3500-Na B	25	200
Sulfatos	*	8,63	mg/L	0,79	0,81	1,60	4110B Cro	25	250
Turbiedad	*	N.D.	UNT	0,10	0,12	0,15	2130 B	<1	5
Zinc	*	8,2	µg/L	1,0	2,0	3,0	3125 B		3000

INCERT: Corresponde a la Incertidumbre expandida k=2 para un 95% de confianza
LD: Límite de Detección en las unidades del parámetro analizado
LC: Límite de Cuantificación en las unidades del parámetro analizado
METODO: Correponde al código del Standard Methods for the Examination of Water and Wastewater.
N.D.: No detectable bajo el límite de detección
D.: Detectable pero no cuantificable
* Ensayo acreditado. Ver alcance en www.eca.or.cr

**** Ensayo no acreditado**

Condiciones Ambientales:

Observaciones:

Las determinaciones efectuadas, cumplen con el Reglamento para la Calidad del Agua Potable 32327-S.

A. Urbina C.

Licda. Azucena Urbina Campos
Jefe del Laboratorio Química

LABORATORIO NACIONAL DE AGUAS

AYA-ID-03560-2015

INFORME DE RESULTADOS

AYA-FPT-011B

Tres Ríos, Cartago
Teléfono: (506) 279-5118
Fax: (506) 279 5973
email: dmora@aya.go.cr

Laboratorio de ensayo
Alcance de Acreditación Nº: LE-049
Acreditado a partir de: 11.02.2008
Alcance disponible en www.eca.or.cr

DATOS DE LA MUESTRA

Cliente:	REGION PACIFICO CENTRAL			**Proc. muestreo**	AYA-PT-019-5
Contacto:	Ing. German Araya Montezuma			**Muestreado por**	Guzmán Carlos
SISTEMA:	**CARMEN LYRA-LA GUARIA-MOJONCITO**			**Fecha de muestreo**	11-may-15
				Fecha de ingreso :	12-may-15
Muestreo:	POZO POCAMAR 3			**Fecha de Reporte:**	21-may-15
Dirección:	LLAVE DE CHORRO			**Inicio Análisis MIC:**	
				Teléfono:	2663-67-98
PROVINCIA:	Puntarenas	**CANTON:**	Puntarenas	**Tipo de muestra:**	Agua
e-mail:	garayam@aya.go.cr	**Fax:**		**Hora de recolección:**	12:32

DETALLE REPORTE DE RESULTADOS ANALISIS

PARAMETRO	E	RESULTADO	UNIDADES	INCERT	LD	LC	METODO	V.A.	V.MAX
Alcalinidad	*	86	mg/L	1,0	2,0	3,0	2320		
Aluminio	*	17,0	µg/L	1,0	1,0	4,0	3125 B		200
Antimonio	*	N.D.	µg/L	0,10	0,20	0,30	3125 B		5
Arsénico	*	1,1	µg/L	0,10	0,20	0,30	3125 B		10
Cadmio	*	N.D.	µg/L	0,10	0,20	0,30	3125 B		3
Calcio	*	30,4	mg/L	1,0	1,5	2,0	3500-Ca B	100	
Cloruros	*	11,63	mg/L	0,81	1,30	1,10	4110B Cro	25	250
Cobre	*	N.D.	µg/L	1,0	2,0	3,0	3125 B	1000	2000
Color Aparente	*	N.D.	UPt-Co	1,0	2,0	4,0	2120 C	5	15
Conductividad	*	220	µS/cm	1,0	2	4	2510	400	
Cromo	*	N.D.	µg/L	0,10	0,50	1,60	3125 B		50
Dureza de Calcio	*	76	mg/L	2,0	2,0	3,0	3500-Ca D		
Dureza Total	*	99	mg/L	2,0	2,0	3,0	2340 C	300	400
Fluoruros	*	D.	mg/L	0,027	0,040	0,100	4110B Cro		0,7-1,5
Fosfatos	*	N.D.	mg/L	0,32	0,40	0,80	4110B Cro		
Hierro	*	8,6	µg/L	1,0	2,0	3,0	3125 B		300
Magnesio	*	5,5	mg/L	0,10	0,50	1,0	3500 B	30	50
Manganeso	*	N.D.	µg/L	1,0	2,0	3,0	3125 B	100	500
Mercurio	*	N.D.	µg/L	0,10	0,11	0,15	3125 B		1
Niquel	*	N.D.	µg/L	1,0	2,0	3,0	3125 B		20
Nitratos	*	N.D.	mg/L	0,53	0,81	1,40	4110B mo		50
Nitritos	*	N.D.	mg/L	0,026	0,040	0,10	4110B Cro		0,1
pH	*	7,40		0,10	0,10	0,20	4500-H+	6,0-8,0	
Plomo	*	D.	µg/L	0,10	0,20	0,50	3125 B		10

Página 13 de 32	Editado e impreso por **AYA 2006**	**Aprobado por:** ***Dr. Darner Mora Alvarado***

LABORATORIO NACIONAL DE AGUAS

AYA-ID-03560-2015

INFORME DE RESULTADOS

AYA-FPT-011B

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Laboratorio de ensayo
Alcance de Acreditación Nº: LE-049
Acreditado a partir de: 11.02.2008
Alcance disponible en www.eca.or.cr

PARAMETRO	E	RESULTADO	UNIDADES	INCERT	LD	LC	METODO	V.A.	V.MAX
Potasio	*	2,4	mg/L	0,80	1,0	1,5	3500-K B		10
Selenio	*	N.D.	µg/L	0,10	0,20	0,70	3125B		10
Sodio	*	9,4	mg/L	1,9	2,0	2,5	3500-Na B	25	200
Sulfatos	*	19,71	mg/L	0,79	0,81	1,60	4110B Cro	25	250
Turbiedad	*	N.D.	UNT	0,10	0,12	0,15	2130 B	<1	5
Zinc	*	5,5	µg/L	1,0	2,0	3,0	3125 B		3000

INCERT: Corresponde a la Incertidumbre expandida k=2 para un 95% de confianza

LD: Límite de Detección en las unidades del parámetro analizado

LC: Límite de Cuantificación en las unidades del parámetro analizado

METODO: Correponde al código del Standard Methods for the Examination of Water and Wastewater.

N.D.: No detectable bajo el límite de detección

D.: Detectable pero no cuantificable

* Ensayo acreditado. Ver alcance en www.eca.or.cr

**** Ensayo no acreditado**

Condiciones Ambientales:

Observaciones:

Las determinaciones efectuadas, cumplen con el Reglamento para la Calidad del Agua Potable 32327-S.

A. Urbina C.

Licda. Azucena Urbina Campos
Jefe del Laboratorio Quimica

LABORATORIO NACIONAL DE AGUAS

AYA-ID-10756-2015

INFORME DE RESULTADOS

AYA-FPT-011B

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Laboratorio de ensayo
Alcance de Acreditación Nº LE-049
Acreditado a partir de: 11.02.2008
Alcance disponible en www.eca.or.cr

DATOS DE LA MUESTRA

Cliente:	REGION PACIFICO CENTRAL	**Proc. muestreo**	AYA-PT-019-5
Contacto:	Ing. German Araya Montezuma	**Muestreado por**	Guzman Carlos
SISTEMA:	**CARMEN LYRA-LA GUARIA-MOJONCITO**	**Fecha de muestreo**	09-nov-15
		Fecha de ingreso :	10-nov-15
Muestreo:	POZO POCAMAR 1	**Fecha de Reporte:**	18-nov-15
Dirección:	LLAVE DE CHORRO	**Inicio Análisis MIC:**	
		Teléfono:	2663-67-98
PROVINCIA:	Puntarenas **CANTON:** Puntarenas	**Tipo de muestra:**	Agua
e-mail:	garayam@aya.go.cr **Fax:**	**Hora de recolección:**	12:04

DETALLE REPORTE DE RESULTADOS ANALISIS

PARAMETRO	E	RESULTADO	UNIDADES	INCERT	LD	LC	METODO	V.A.	V.MAX
Alcalinidad	*	116	mg/L	1,0	2,0	3,0	2320		
Calcio	*	40,3	mg/L	1,0	1,5	2,0	3500-Ca B	100	
Cloruros	*	6,30	mg/L	0,81	1,30	1,10	4110B Cro	25	250
Color Aparente	*	N.D.	UPt-Co	1,0	2,0	4,0	2120 C	5	15
Conductividad	*	288	µS/cm	1,0	2	4	2510	400	
Dureza de Calcio	*	101	mg/L	2,0	2,0	3,0	3500-Ca D		
Dureza Total	*	137	mg/L	2,0	2,0	3,0	2340 C	300	400
Fosfatos	*	N.D.	mg/L	0,32	0,40	0,80	4110B Cro		
Magnesio	*	8,8	mg/L	0,10	0,50	1,0	3500 B	30	50
Nitratos	*	D.	mg/L	0,53	0,81	1,40	4110B mo		50
Nitritos	*	N.D.	mg/L	0,026	0,040	0,10	4110B Cro		0,1
pH	*	6,88		0,10	0,10	0,20	4500-H+	6,0-8,0	
Sulfatos	*	17,60	mg/L	0,79	0,81	1,60	4110B Cro	25	250
Turbiedad	*	N.D.	UNT	0,10	0,12	0,15	2130 B	<1	5

INCERT: Corresponde a la Incertidumbre expandida k=2 para un 95% de confianza
LD: Límite de Detección en las unidades del parámetro analizado
LC: Límite de Cuantificación en las unidades del parámetro analizado
METODO: Correponde al código del Standard Methods for the Examination of Water and Wastewater.
N.D.: No detectable bajo el límite de detección
D.: Detectable pero no cuantificable
* Ensayo acreditado. Ver alcance en www.eca.or.cr
**** Ensayo no acreditado**

Condiciones Ambientales:

Página 15 de 32	Editado e impreso por **AYA 2006**	**Aprobado por:** ***Dr. Darner Mora Alvarado***

LABORATORIO NACIONAL DE AGUAS

AYA-ID-10757-2015

INFORME DE RESULTADOS

AYA-FPT-011B

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Laboratorio de ensayo
Alcance de Acreditación Nº LE-049
Acreditado a partir de: 11.02.2008
Alcance disponible en www.eca.or.cr

DATOS DE LA MUESTRA

Cliente:	REGION PACIFICO CENTRAL	**Proc. muestreo**	AYA-PT-019-5
Contacto:	Ing. German Araya Montezuma	**Muestreado por**	Guzman Carlos
SISTEMA:	**CARMEN LYRA-LA GUARIA-MOJONCITO**	**Fecha de muestreo**	09-nov-15
		Fecha de ingreso :	10-nov-15
Muestreo:	POZO POCAMAR 2	**Fecha de Reporte:**	18-nov-15
Dirección:	LLAVE DE CHORRO	**Inicio Análisis MIC:**	
		Teléfono:	2663-67-98
PROVINCIA:	Puntarenas **CANTON:** Puntarenas	**Tipo de muestra:**	Agua
e-mail:	garayam@aya.go.cr **Fax:**	**Hora de recolección:**	12:07

DETALLE REPORTE DE RESULTADOS ANALISIS

PARAMETRO	E	RESULTADO	UNIDADES	INCERT	LD	LC	METODO	V.A.	V.MAX
Alcalinidad	*	116	mg/L	1,0	2,0	3,0	2320		
Calcio	*	35,5	mg/L	1,0	1,5	2,0	3500-Ca B	100	
Cloruros	*	4,76	mg/L	0,81	1,30	1,10	4110B Cro	25	250
Color Aparente	*	D.	UPt-Co	1,0	2,0	4,0	2120 C	5	15
Conductividad	*	265	µS/cm	1,0	2	4	2510	400	
Dureza de Calcio	*	89	mg/L	2,0	2,0	3,0	3500-Ca D		
Dureza Total	*	125	mg/L	2,0	2,0	3,0	2340 C	300	400
Fosfatos	*	N.D.	mg/L	0,32	0,40	0,80	4110B Cro		
Magnesio	*	8,8	mg/L	0,10	0,50	1,0	3500 B	30	50
Nitratos	*	N.D.	mg/L	0,53	0,81	1,40	4110B mo		50
Nitritos	*	N.D.	mg/L	0,026	0,040	0,10	4110B Cro		0,1
pH	*	7,21		0,10	0,10	0,20	4500-H+	6,0-8,0	
Sulfatos	*	10,01	mg/L	0,79	0,81	1,60	4110B Cro	25	250
Turbiedad	*	1,2	UNT	0,10	0,12	0,15	2130 B	<1	5

INCERT: Corresponde a la Incertidumbre expandida k=2 para un 95% de confianza
LD: Límite de Detección en las unidades del parámetro analizado
LC: Límite de Cuantificación en las unidades del parámetro analizado
METODO: Correponde al código del Standard Methods for the Examination of Water and Wastewater.
N.D.: No detectable bajo el límite de detección
D.: Detectable pero no cuantificable
* Ensayo acreditado. Ver alcance en www.eca.or.cr
**** Ensayo no acreditado**

Condiciones Ambientales:

Página 17 de 32	Editado e impreso por **AYA 2006**	**Aprobado por:** ***Dr. Darner Mora Alvarado***

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INFORME DE RESULTADOS

AYA-FPT-011B

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Alcance de Acreditación Nº: LE-049
Acreditado a partir de: 11.02.2008
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DATOS DE LA MUESTRA

Cliente:	REGION PACIFICO CENTRAL			**Proc. muestreo**	AYA-PT-019-5
Contacto:	Ing. German Araya Montezuma			**Muestreado por**	Guzman Carlos
SISTEMA:	**CARMEN LYRA-LA GUARIA-MOJONCITO**			**Fecha de muestreo**	09-nov-15
				Fecha de ingreso :	10-nov-15
Muestreo:	POZO POCAMAR 3			**Fecha de Reporte:**	18-nov-15
Dirección:	LLAVE DE CHORRO			**Inicio Análisis MIC:**	
				Teléfono:	2663-67-98
PROVINCIA:	Puntarenas	**CANTON:**	Puntarenas	**Tipo de muestra:**	Agua
e-mail:	garayam@aya.go.cr	**Fax:**		**Hora de recolección:**	12:11

DETALLE REPORTE DE RESULTADOS ANALISIS

PARAMETRO	E	RESULTADO	UNIDADES	INCERT	LD	LC	METODO	V.A.	V.MAX
Alcalinidad	*	108	mg/L	1,0	2,0	3,0	2320		
Calcio	*	39,5	mg/L	1,0	1,5	2,0	3500-Ca B	100	
Cloruros	*	6,28	mg/L	0,81	1,30	1,10	4110B Cro	25	250
Color Aparente	*	N.D.	UPt-Co	1,0	2,0	4,0	2120 C	5	15
Conductividad	*	287	µS/cm	1,0	2	4	2510	400	
Dureza de Calcio	*	99	mg/L	2,0	2,0	3,0	3500-Ca D		
Dureza Total	*	135	mg/L	2,0	2,0	3,0	2340 C	300	400
Fosfatos	*	N.D.	mg/L	0,32	0,40	0,80	4110B Cro		
Magnesio	*	8,8	mg/L	0,10	0,50	1,0	3500 B	30	50
Nitratos	*	D.	mg/L	0,53	0,81	1,40	4110B mo		50
Nitritos	*	N.D.	mg/L	0,026	0,040	0,10	4110B Cro		0,1
pH	*	7,07		0,10	0,10	0,20	4500-H+	6,0-8,0	
Sulfatos	*	16,93	mg/L	0,79	0,81	1,60	4110B Cro	25	250
Turbiedad	*	N.D.	UNT	0,10	0,12	0,15	2130 B	<1	5

INCERT: Corresponde a la Incertidumbre expandida k=2 para un 95% de confianza
LD: Límite de Detección en las unidades del parámetro analizado
LC: Límite de Cuantificación en las unidades del parámetro analizado
METODO: Correponde al código del Standard Methods for the Examination of Water and Wastewater.
N.D.: No detectable bajo el límite de detección
D.: Detectable pero no cuantificable
* Ensayo acreditado. Ver alcance en www.eca.or.cr
**** Ensayo no acreditado**

Condiciones Ambientales:

Página 19 de 32	Editado e impreso por **AYA 2006**	**Aprobado por:** ***Dr. Darner Mora Alvarado***

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INFORME DE RESULTADOS

AYA-FPT-011B

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Laboratorio de ensayo
Alcance de Acreditación Nº: LE-049
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DATOS DE LA MUESTRA

Cliente:	REGION PACIFICO CENTRAL			**Proc. muestreo**	AYA-PT-019-5
Contacto:	Ing. German Araya Montezuma			**Muestreado por**	Guzmán Carlos
SISTEMA:	**CARMEN LYRA-LA GUARIA-MOJONCITO**			**Fecha de muestreo**	09-mar-16
				Fecha de ingreso :	10-mar-16
Muestreo:	POZO POCAMAR 1			**Fecha de Reporte:**	18-mar-16
Dirección:	LLAVE DE CHORRO			**Inicio Análisis MIC:**	
				Teléfono:	2663-67-98
PROVINCIA:	Puntarenas	**CANTON:**	Puntarenas	**Tipo de muestra:**	Agua
e-mail:	garayam@aya.go.cr	**Fax:**		**Hora de recolección:**	08:45

DETALLE REPORTE DE RESULTADOS ANALISIS

PARAMETRO	E	RESULTADO	UNIDADES	INCERT	LD	LC	METODO	V.A.	V.MAX
Alcalinidad	*	129	mg/L	1,0	2,0	3,0	2320		
Arsénico	*	N.D.	µg/L	1,0	2,0	3,0	3113 B		10
Calcio	*	36,3	mg/L	1,0	1,5	2,0	3500-Ca B	100	
Cloruros	*	5,11	mg/L	0,81	1,30	1,10	4110B Cro	25	250
Color Aparente	*	N.D.	UPt-Co	1,0	2,0	4,0	2120 C	5	15
Conductividad	*	293	µS/cm	1,0	2	4	2510	400	
Dureza de Calcio	*	91	mg/L	2,0	2,0	3,0	3500-Ca D		
Dureza Total	*	123	mg/L	2,0	2,0	3,0	2340 C	300	400
Fluoruros	*	0,12	mg/L	0,027	0,040	0,100	4110B Cro		0,7-1,5
Fosfatos	*	N.D.	mg/L	0,32	0,40	0,80	4110B Cro		
Hierro	*	15	µg/L	4,0	5,0	7,0	3113 B		300
Magnesio	*	7,8	mg/L	0,10	0,50	1,0	3500 B	30	50
Manganeso	*	9	µg/L	4,0	5,0	6,0	3113 B	100	500
Nitratos	*	N.D.	mg/L	0,53	0,81	1,40	4110B mo		50
Nitritos	*	N.D.	mg/L	0,026	0,040	0,10	4110B Cro		0,1
Olor	**	Negativo		N.A.	N.A.	N.A.	2150 B	Aceptable	Aceptable
pH	*	7,20		0,10	0,10	0,20	4500-H+	6,0-8,0	
Potasio	*	1,5	mg/L	0,80	1,0	1,5	3500-K B		10
Sabor	**	Negativo	N.A.		.		2160 B	Aceptable	Aceptable
Sodio	*	10,9	mg/L	1,9	2,0	2,5	3500-Na B	25	200
Sulfatos	*	13,19	mg/L	0,79	0,81	1,60	4110B Cro	25	250
Turbiedad	*	0,2	UNT	0,10	0,12	0,15	2130 B	<1	5

INCERT: Corresponde a la Incertidumbre expandida k=2 para un 95% de confianza
LD: Límite de Detección en las unidades del parámetro analizado

Página 21 de 32	Editado e impreso por **AYA 2006**	**Aprobado por:** ***Dr. Darner Mora Alvarado***

LABORATORIO NACIONAL DE AGUAS

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INFORME DE RESULTADOS

AYA-FPT-011B

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Laboratorio de ensayo
Alcance de Acreditación Nº LE-049
Acreditado a partir de: 11.02.2008
Alcance disponible en www.eca.or.cr

DATOS DE LA MUESTRA

Cliente:	REGION PACIFICO CENTRAL			**Proc. muestreo**	AYA-PT-019-5
Contacto:	Ing. German Araya Montezuma			**Muestreado por**	Guzmán Carlos
SISTEMA:	**CARMEN LYRA-LA GUARIA-MOJONCITO**			**Fecha de muestreo**	09-mar-16
				Fecha de ingreso :	10-mar-16
Muestreo:	POZO POCAMAR 2			**Fecha de Reporte:**	18-mar-16
Dirección:	LLAVE DE CHORRO			**Inicio Análisis MIC:**	
				Teléfono:	2663-67-98
PROVINCIA:	Puntarenas	**CANTON:**	Puntarenas	**Tipo de muestra:**	Agua
e-mail:	garayam@aya.go.cr	**Fax:**		**Hora de recolección:**	08:49

DETALLE REPORTE DE RESULTADOS ANALISIS

PARAMETRO	E	RESULTADO	UNIDADES	INCERT	LD	LC	METODO	V.A.	V.MAX
Alcalinidad	*	121	mg/L	1,0	2,0	3,0	2320		
Arsénico	*	N.D.	µg/L	1,0	2,0	3,0	3113 B		10
Calcio	*	35,5	mg/L	1,0	1,5	2,0	3500-Ca B	100	
Cloruros	*	4,85	mg/L	0,81	1,30	1,10	4110B Cro	25	250
Color Aparente	*	N.D.	UPt-Co	1,0	2,0	4,0	2120 C	5	15
Conductividad	*	285	µS/cm	1,0	2	4	2510	400	
Dureza de Calcio	*	89	mg/L	2,0	2,0	3,0	3500-Ca D		
Dureza Total	*	127	mg/L	2,0	2,0	3,0	2340 C	300	400
Fluoruros	*	0,12	mg/L	0,027	0,040	0,100	4110B Cro		0,7-1,5
Fosfatos	*	N.D.	mg/L	0,32	0,40	0,80	4110B Cro		
Hierro	*	23	µg/L	4,0	5,0	7,0	3113 B		300
Magnesio	*	9,3	mg/L	0,10	0,50	1,0	3500 B	30	50
Manganeso	*	7	µg/L	4,0	5,0	6,0	3113 B	100	500
Nitratos	*	N.D.	mg/L	0,53	0,81	1,40	4110B mo		50
Nitritos	*	N.D.	mg/L	0,026	0,040	0,10	4110B Cro		0,1
Olor	**	Negativo		N.A.	N.A.	N.A.	2150 B	Aceptable	Aceptable
pH	*	7,41		0,10	0,10	0,20	4500-H+	6,0-8,0	
Potasio	*	1,5	mg/L	0,80	1,0	1,5	3500-K B		10
Sabor	**	Negativo	N.A.		.		2160 B	Aceptable	Aceptable
Sodio	*	10,9	mg/L	1,9	2,0	2,5	3500-Na B	25	200
Sulfatos	*	8,46	mg/L	0,79	0,81	1,60	4110B Cro	25	250
Turbiedad	*	0,2	UNT	0,10	0,12	0,15	2130 B	<1	5

INCERT: Corresponde a la Incertidumbre expandida k=2 para un 95% de confianza
LD: Límite de Detección en las unidades del parámetro analizado

Página 23 de 32	Editado e impreso por **AYA 2006**	**Aprobado por:** ***Dr. Darner Mora Alvarado***

LABORATORIO NACIONAL DE AGUAS

AYA-ID-02065-2016

INFORME DE RESULTADOS

AYA-FPT-011B

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Laboratorio de ensayo
Alcance de Acreditación Nº LE-049
Acreditado a partir de: 11.02.2008
Alcance disponible en www.eca.or.cr

DATOS DE LA MUESTRA

Cliente:	REGION PACIFICO CENTRAL			**Proc. muestreo**	AYA-PT-019-5
Contacto:	Ing. German Araya Montezuma			**Muestreado por**	Guzmán Carlos
SISTEMA:	**CARMEN LYRA-LA GUARIA-MOJONCITO**			**Fecha de muestreo**	09-mar-16
				Fecha de ingreso :	10-mar-16
Muestreo:	POZO POCAMAR 3			**Fecha de Reporte:**	18-mar-16
Dirección:	LLAVE DE CHORRO			**Inicio Análisis MIC:**	
				Teléfono:	2663-67-98
PROVINCIA:	Puntarenas	**CANTON:**	Puntarenas	**Tipo de muestra:**	Agua
e-mail:	garayam@aya.go.cr	**Fax:**		**Hora de recolección:**	08:54

DETALLE REPORTE DE RESULTADOS ANALISIS

PARAMETRO	E	RESULTADO	UNIDADES	INCERT	LD	LC	METODO	V.A.	V.MAX
Alcalinidad	*	123	mg/L	1,0	2,0	3,0	2320		
Arsénico	*	N.D.	µg/L	1,0	2,0	3,0	3113 B		10
Calcio	*	36,3	mg/L	1,0	1,5	2,0	3500-Ca B	100	
Cloruros	*	5,08	mg/L	0,81	1,30	1,10	4110B Cro	25	250
Color Aparente	*	N.D.	UPt-Co	1,0	2,0	4,0	2120 C	5	15
Conductividad	*	295	µS/cm	1,0	2	4	2510	400	
Dureza de Calcio	*	91	mg/L	2,0	2,0	3,0	3500-Ca D		
Dureza Total	*	123	mg/L	2,0	2,0	3,0	2340 C	300	400
Fluoruros	*	0,11	mg/L	0,027	0,040	0,100	4110B Cro		0,7-1,5
Fosfatos	*	N.D.}	mg/L	0,32	0,40	0,80	4110B Cro		
Magnesio	*	7,8	mg/L	0,10	0,50	1,0	3500 B	30	50
Manganeso	*	8	µg/L	4,0	5,0	6,0	3113 B	100	500
Nitratos	*	N.D.	mg/L	0,53	0,81	1,40	4110B mo		50
Nitritos	*	N.D.	mg/L	0,026	0,040	0,10	4110B Cro		0,1
Olor	**	Negativo		N.A.	N.A.	N.A.	2150 B	Aceptable	Aceptable
pH	*	7,33		0,10	0,10	0,20	4500-H+	6,0-8,0	
Potasio	*	1,6	mg/L	0,80	1,0	1,5	3500-K B		10
Sabor	**	Negativo	N.A.		.		2160 B	Aceptable	Aceptable
Sodio	*	10,6	mg/L	1,9	2,0	2,5	3500-Na B	25	200
Sulfatos	*	13,16	mg/L	0,79	0,81	1,60	4110B Cro	25	250
Turbiedad	*	N.D.	UNT	0,10	0,12	0,15	2130 B	<1	5

INCERT: Corresponde a la Incertidumbre expandida k=2 para un 95% de confianza
LD: Límite de Detección en las unidades del parámetro analizado

Página 25 de 32	Editado e impreso por **AYA 2006**	**Aprobado por:** ***Dr. Darner Mora Alvarado***

INFORME DE RESULTADOS

AYA FPT 011B

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AYA-ID-09818-2016

Laboratorio de ensayo
Alcance de Acreditación Nº: LE-049
Acreditado a partir de: 11.02.2008
Alcance disponible en www.eca.or.cr

DATOS DE LA MUESTRA

Cliente:	REGION PACIFICO CENTRAL	**Proc. muestreo**	AYA-PT-019-5
Contacto:	Ing. German Araya Montezuma	**Muestreado por**	Canales Canales J
SISTEMA:	**PC-A-19-CARMEN LYRA-LA GUARIA-MOJONCITO**	**Fecha de muestreo**	28-sep-16
		Fecha de ingreso :	29-sep-16
Muestreo:	POZO POCAMAR 1	**Fecha de Reporte:**	07-oct-16
Dirección:	LLAVE DE CHORRO	**Inicio Análisis MIC:**	29-sep-16
		Teléfono:	2663-67-98
PROVINCIA:	Puntarenas **CANTON:** Puntarenas	**Tipo de muestra:**	
e-mail:	garayam@aya.go.cr **Fax:**	**Hora de recolección:**	12:08

DETALLE REPORTE DE RESULTADOS ANALISIS

PARAMETRO	E	RESULTADO	UNIDADES	INCERT	LD	LC	METODO	V.A.	V.MAX
Alcalinidad	*	257	mg/L	1,0	2,0	3,0	2320		
Aluminio	*	16,0	µg/L	1,0	1,0	4,0	3125 B		200
Amonio	*	N.D.	mg/L	0,10	0,1	0,15	4500-NH3	0,05	0,5
Antimonio	*	N.D.	µg/L	0,10	0,20	0,30	3125 B		5
Arsénico	*	0,9	µg/L	0,10	0,20	0,30	3125 B		10
Cadmio	*	N.D.	µg/L	0,10	0,20	0,30	3125 B		3
Calcio	*	68,5	mg/L	1,0	1,5	2,0	3500-Ca B	100	
Cloruros	*	12,35	mg/L	0,81	1,30	1,10	4110B Cro	25	250
Cobre	*	N.D.	µg/L	1,0	2,0	3,0	3125 B	1000	2000
Color Aparente	*	N.D.	UPt-Co	1,0	2,0	4,0	2120 C	5	15
Conductividad	*	445	µS/cm	1,0	2	4	2510	400	
Cromo	*	N.D.	µg/L	0,10	0,50	1,60	3125 B		50
Dureza de Calcio	*	171	mg/L	2,0	2,0	3,0	3500-Ca D		
Dureza Total	*	228	mg/L	2,0	2,0	3,0	2340 C	300	400
Fluoruros	*	0,44	mg/L	0,027	0,040	0,100	4110B Cro		0,7-1,5
Fosfatos	*	N.D.	mg/L	0,32	0,40	0,80	4110B Cro		
Hierro	*	25,1	µg/L	1,0	2,0	3,0	3125 B		300
Magnesio	*	13,7	mg/L	0,10	0,50	1,0	3500 B	30	50
Manganeso	*	442,0	µg/L	1,0	2,0	3,0	3125 B	100	500
Mercurio	*	N.D.	µg/L	0,10	0,11	0,15	3125 B		1
Niquel	*	N.D.	µg/L	1,0	2,0	3,0	3125 B		20
Nitratos	*	N.D.	mg/L	0,53	0,81	1,40	4110B mo		50
Nitritos	*	N.D.	mg/L	0,026	0,040	0,10	4110B Cro		0,1
Olor	**	Aceptable		N.A.	N.A.	N.A.	2150 B	Aceptable	Aceptable

Página 27 de 32	Editado e impreso por **AYA 2006**	**Aprobado por:** ***Dr. Darner Mora Alvarado***

INFORME DE RESULTADOS

AYA-FPT-011B

LABORATORIO NACIONAL DE AGUAS

Tres Ríos, Cartago
Teléfono: (506) 279-5118
Fax: (506) 279 5973
email: dmora@aya.go.cr

AYA-ID-09818-2016

Laboratorio de ensayo
Alcance de Acreditación Nº: LE-049
Acreditado a partir de: 11.02.2008
Alcance disponible en www.eca.or.cr

PARAMETRO	E	RESULTADO	UNIDADES	INCERT	LD	LC	METODO	V.A.	V.MAX
pH	*	7,11		0,10	0,10	0,20	4500-H+	6,0-8,0	
Plomo	*	N.D.	µg/L	0,10	0,20	0,50	3125 B		10
Potasio	*	3,2	mg/L	0,80	1,0	1,5	3500-K B		10
Sabor	**	Aceptable	N.A.		.		2160 B	Aceptable	Aceptable
Selenio	*	N.D.	µg/L	0,10	0,20	0,70	3125B		10
Sodio	*	16,9	mg/L	1,9	2,0	2,5	3500-Na B	25	200
Sulfatos	*	11,07	mg/L	0,79	0,81	1,60	4110B Cro	25	250
Temperatura	*	27,8	ºC	0,10			2550 B	18 a 30) º(	
Turbiedad	*	1,50	UNT	0,10	0,12	0,15	2130 B	<1	5
Zinc	*	11,6	µg/L	1,0	2,0	3,0	3125 B		3000

INCERT: Corresponde a la Incertidumbre expandida k=2 para un 95% de confianza

LD: Límite de Detección en las unidades del parámetro analizado

LC: Límite de Cuantificación en las unidades del parámetro analizado

METODO: Correponde al código del Standard Methods for the Examination of Water and Wastewater.

N.D.: No detectable bajo el límite de detección

D.: Detectable pero no cuantificable

* Ensayo acreditado. Ver alcance en www.eca.or.cr

**** Ensayo no acreditado**

Condiciones Ambientales:

Pozo Pocamar 2 fuera de operación.

Observaciones:

La suma de las concentraciones de Hierro y Manganeso, no cumplen con el Reglamento para la Calidad del Agua Potable 38924-S.

A. Urbina C.

Licda. Azucena Urbina Campos
Jefe del Laboratorio Química

Página 28 de 32	Editado e impreso por **AYA 2006**	**Aprobado por:** ***Dr. Darner Mora Alvarado***

LABORATORIO NACIONAL DE AGUAS

AYA-ID-09819-2016

INFORME DE RESULTADOS
AYA-FPT-011B

Tres Rios, Cartago
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Laboratorio de ensayo
Alcance de Acreditación Nº: LE-049
Acreditado a partir de: 11.02.2008
Alcance disponible en www.eca.or.cr

DATOS DE LA MUESTRA

Cliente:	REGION PACIFICO CENTRAL			**Proc. muestreo**	AYA-PT-019-5
Contacto:	Ing. German Araya Montezuma			**Muestreado por**	Canales Canales J
SISTEMA:	**PC-A-19-CARMEN LYRA-LA GUARIA-MOJONCITO**			**Fecha de muestreo**	28-sep-16
				Fecha de ingreso :	29-sep-16
Muestreo:	POZO POCAMAR 3			**Fecha de Reporte:**	07-oct-16
Dirección:	LLAVE DE CHORRO			**Inicio Análisis MIC:**	29-sep-16
				Teléfono:	2663-67-98
PROVINCIA:	Puntarenas	**CANTON:**	Puntarenas	**Tipo de muestra:**	Agua
e-mail:	garayam@aya.go.cr	**Fax:**		**Hora de recolección:**	12:30

DETALLE REPORTE DE RESULTADOS ANALISIS

PARAMETRO	E	RESULTADO	UNIDADES	INCERT	LD	LC	METODO	V.A.	V.MAX
Alcalinidad	*	168	mg/L	1,0	2,0	3,0	2320		
Aluminio	*	N.D.	µg/L	1,0	1,0	4,0	3125 B		200
Amonio	*	N.D.	mg/L	0,10	0,1	0,15	4500-NH3	0,05	0,5
Antimonio	*	N.D.	µg/L	0,10	0,20	0,30	3125 B		5
Arsénico	*	0,8	µg/L	0,10	0,20	0,30	3125 B		10
Cadmio	*	N.D.	µg/L	0,10	0,20	0,30	3125 B		3
Calcio	*	50,8	mg/L	1,0	1,5	2,0	3500-Ca B	100	
Cloruros	*	7,76	mg/L	0,81	1,30	1,10	4110B Cro	25	250
Cobre	*	N.D.	µg/L	1,0	2,0	3,0	3125 B	1000	2000
Color Aparente	*	N.D.	UPt-Co	1,0	2,0	4,0	2120 C	5	15
Conductividad	*	334	µS/cm	1,0	2	4	2510	400	
Cromo	*	N.D.	µg/L	0,10	0,50	1,60	3125 B		50
Dureza de Calcio	*	127	mg/L	2,0	2,0	3,0	3500-Ca D		
Dureza Total	*	159	mg/L	2,0	2,0	3,0	2340 C	300	400
Fluoruros	*	0,57	mg/L	0,027	0,040	0,100	4110B Cro		0,7-1,5
Fosfatos	*	N.D.	mg/L	0,32	0,40	0,80	4110B Cro		
Hierro	*	D.	µg/L	1,0	2,0	3,0	3125 B		300
Magnesio	*	7,8	mg/L	0,10	0,50	1,0	3500 B	30	50
Manganeso	*	N.D.	µg/L	1,0	2,0	3,0	3125 B	100	500
Mercurio	*	N.D.	µg/L	0,10	0,11	0,15	3125 B		1
Niquel	*	N.D.	µg/L	1,0	2,0	3,0	3125 B		20
Nitratos	*	2,31	mg/L	0,53	0,81	1,40	4110B mo		50
Nitritos	*	N.D.	mg/L	0,026	0,040	0,10	4110B Cro		0,1
Olor	**	Aceptable		N.A.	N.A.	N.A.	2150 B	Aceptable	Aceptable

Página 29 de 32	Editado e impreso por **AYA 2006**	**Aprobado por:** ***Dr. Darner Mora Alvarado***

LABORATORIO NACIONAL DE AGUAS

AYA-ID-09819-2016

INFORME DE RESULTADOS
AYA FPT 011B

Tres Rios, Cartago
Teléfono: (506) 279-5118
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Laboratorio de ensayo
Alcance de Acreditación Nº: LE-049
Acreditado a partir de: 11.02.2008
Alcance disponible en www.eca.or.cr

PARAMETRO	E	RESULTADO	UNIDADES	INCERT	LD	LC	METODO	V.A.	V.MAX
pH	*	7,02		0,10	0,10	0,20	4500-H+	6,0-8,0	
Plomo	*	0,6	µg/L	0,10	0,20	0,50	3125 B		10
Potasio	*	2,6	mg/L	0,80	1,0	1,5	3500-K B		10
Sabor	**	Aceptable	N.A.		.		2160 B	Aceptable	Aceptable
Selenio	*	D.	µg/L	0,10	0,20	0,70	3125B		10
Sodio	*	13,4	mg/L	1,9	2,0	2,5	3500-Na B	25	200
Sulfatos	*	18,78	mg/L	0,79	0,81	1,60	4110B Cro	25	250
Temperatura	*	28,7	ºC	0,10			2550 B	18 a 30) ºC	
Turbiedad	*	1,30	UNT	0,10	0,12	0,15	2130 B	<1	5
Zinc	*	9,2	µg/L	1,0	2,0	3,0	3125 B		3000

INCERT: Corresponde a la Incertidumbre expandida k=2 para un 95% de confianza
LD: Límite de Detección en las unidades del parámetro analizado
LC: Límite de Cuantificación en las unidades del parámetro analizado
METODO: Correponde al código del Standard Methods for the Examination of Water and Wastewater.
N.D.: No detectable bajo el límite de detección
D.: Detectable pero no cuantificable
* Ensayo acreditado. Ver alcance en www.eca.or.cr
**** Ensayo no acreditado**

Condiciones Ambientales:

Pozo Pocamar 2 fuera de operación.

Observaciones:

Las determinaciones efectuadas, cumplen con el Reglamento para la Calidad del Agua Potable Nº 38924-S.

Licda. Azucena Urbina Campos
Jefe del Laboratorio Química

Página 30 de 32	Editado e impreso por **AYA 2006**	**Aprobado por:** ***Dr. Darner Mora Alvarado***

INFORME DE RESULTADOS

AYA-FPT-011B

LABORATORIO NACIONAL DE AGUAS

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AYA-ID-10451-2016

Laboratorio de ensayo
Alcance de Acreditación Nº: LE-049
Acreditado a partir de: 11.02.2008
Alcance disponible en www.eca.or.cr

DATOS DE LA MUESTRA

Cliente:	REGIÓN PACIFICO CENTRAL*			**Proc. muestreo**	AYA-PT-019-5
Contacto:				**Muestreado por**	Cubillo Jose
SISTEMA:	**CARMEN LYRA**			**Fecha de muestreo**	13-oct-16
				Fecha de ingreso :	14-oct-16
Muestreo:	POZO POCAMAR 5			**Fecha de Reporte:**	21-oct-16
Dirección:	TUBO DE AFORO			**Inicio Análisis MIC:**	
				Teléfono:	
PROVINCIA:	Puntarenas	**CANTON:**	Esparza	**Tipo de muestra:**	Agua
e-mail:		**Fax:**		**Hora de recolección:**	12:00

DETALLE REPORTE DE RESULTADOS ANALISIS

PARAMETRO	E	RESULTADO	UNIDADES	INCERT	LD	LC	METODO	V.A.	V.MAX
Alcalinidad	*	173	mg/L	1,0	2,0	3,0	2320		
Aluminio	*	78,7	µg/L	1,0	1,0	4,0	3125 B		200
Amonio	*	N.D.	mg/L	0,10	0,1	0,15	4500-NH3	0,05	0,5
Antimonio	*	N.D.	µg/L	0,10	0,20	0,30	3125 B		5
Arsénico	*	0,9	µg/L	0,10	0,20	0,30	3125 B		10
Cadmio	*	N.D.	µg/L	0,10	0,20	0,30	3125 B		3
Calcio	*	44,3	mg/L	1,0	1,5	2,0	3500-Ca B	100	
Cloruros	*	7,13	mg/L	0,81	1,30	1,10	4110B Cro	25	250
Cobre	*	N.D.	µg/L	1,0	2,0	3,0	3125 B	1000	2000
Color Aparente	*	4	UPt-Co	1,0	2,0	4,0	2120 C	5	15
Conductividad	*	323	µS/cm	1,0	2	4	2510	400	
Cromo	*	N.D.	µg/L	0,10	0,50	1,60	3125 B		50
Dureza de Calcio	*	111	mg/L	2,0	2,0	3,0	3500-Ca D		
Dureza Total	*	147	mg/L	2,0	2,0	3,0	2340 C	300	400
Fluoruros	*	N.D.	mg/L	0,027	0,040	0,100	4110B Cro		0,7-1,5
Fosfatos	*	N.D.	mg/L	0,32	0,40	0,80	4110B Cro		
Hierro	*	77,2	µg/L	1,0	2,0	3,0	3125 B		300
Magnesio	*	8,8	mg/L	0,10	0,50	1,0	3500 B	30	50
Manganeso	*	16,5	µg/L	1,0	2,0	3,0	3125 B	100	500
Mercurio	*	N.D.	µg/L	0,10	0,11	0,15	3125 B		1
Niquel	*	N.D.	µg/L	1,0	2,0	3,0	3125 B		20
Nitratos	*	N.D.	mg/L	0,53	0,81	1,40	4110B mo		50
Nitritos	*	N.D.	mg/L	0,026	0,040	0,10	4110B Cro		0,1
Olor	**	Aceptable		N.A.	N.A.	N.A.	2150 B	Aceptable	Aceptable

Página 31 de 32	Editado e impreso por **AYA 2006**	**Aprobado por:** ***Dr. Darner Mora Alvarado***

INFORME DE RESULTADOS

AYA-FPT-011B

LABORATORIO NACIONAL DE AGUAS

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AYA-ID-10451-2016

Laboratorio de ensayo
Alcance de Acreditación Nº: LE-049
Acreditado a partir de: 11.02.2008
Alcance disponible en www.eca.or.cr

PARAMETRO	E	RESULTADO	UNIDADES	INCERT	LD	LC	METODO	V.A.	V.MAX
pH	*	7,46		0,10	0,10	0,20	4500-H+	6,0-8,0	
Plomo	*	N.D.	µg/L	0,10	0,20	0,50	3125 B		10
Potasio	*	2,5	mg/L	0,80	1,0	1,5	3500-K B		10
Sabor	**	Aceptable	N.A.		.		2160 B	Aceptable	Aceptable
Selenio	*	D.	µg/L	0,10	0,20	0,70	3125B		10
Sodio	*	12,3	mg/L	1,9	2,0	2,5	3500-Na B	25	200
Sulfatos	*	13,92	mg/L	0,79	0,81	1,60	4110B Cro	25	250
Turbiedad	*	1,64	UNT	0,10	0,12	0,15	2130 B	<1	5
Zinc	*	N.D.	µg/L	1,0	2,0	3,0	3125 B		3000

INCERT: Corresponde a la Incertidumbre expandida k=2 para un 95% de confianza

LD: Límite de Detección en las unidades del parámetro analizado

LC: Límite de Cuantificación en las unidades del parámetro analizado

METODO: Correponde al código del Standard Methods for the Examination of Water and Wastewater.

N.D.: No detectable bajo el límite de detección

D.: Detectable pero no cuantificable

* Ensayo acreditado. Ver alcance en www.eca.or.cr

**** Ensayo no acreditado**

Condiciones Ambientales:

Muestra recolectada después de 26 horas de bombeo. Profundidad: 31 m. Caudal: 30 L/s. Código de perforación del pozo: 16-14. Agua con apariencia limpia y cristalina.

Observaciones:

Agua de calidad buena, según los parámetros físicos-químicos evaluados, y los criterios de Calidad para Potabilización en Aguas de Pozos y Nacientes LNA 2012.

A. Urbina C.

Licda. Azucena Urbina Campos
Jefe del Laboratorio Química

Página 32 de 32	Editado e impreso por **AYA 2006**	**Aprobado por:** ***Dr. Darner Mora Alvarado***

INFORME DE RESULTADOS

AYA-FPT-011B

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Laboratorio de Ensayo
Alcance de Acreditación Nº. LE-049
Acreditado a partir de 11.02.2008
Alcance disponible en www.eca.or.cr

LABORATORIO NACIONAL DE AGUAS

AYA-ID-01715-2017

DATOS DE LA MUESTRA

Cliente:	REGIÓN PACIFICO CENTRAL*			**Proc. muestreo**	AYA-PT-019-5
Contacto:				**Muestreado por**	Carlos M.
SISTEMA:	**CARMEN LYRA-LA GUARIA-MOJONCITO**			**Fecha de muestreo**	02-mar-17
				Fecha de ingreso :	03-mar-17
Muestreo:	POZO POCAMAR 6			**Fecha de Reporte:**	13-mar-17
Dirección:	TUBO DESFOGUE			**Inicio Análisis MIC:**	
				Teléfono:	
PROVINCIA:	Puntarenas	**CANTON:**	Esparza	**Tipo de muestra:**	Agua
e-mail:		**Fax:**		**Hora de recolección:**	10:21

DETALLE REPORTE DE RESULTADOS ANALISIS

PARAMETRO	E	RESULTADO	UNIDADES	INCERT	LD	LC	METODO	V.A.	V.MAX
Alcalinidad	*	114	mg/L	1,0	2,0	3,0	2320		
Aluminio	*	D.	µg/L	1,0	1,0	4,0	3125 B		200
Amonio	*	N.D.	mg/L	0,10	0,1	0,15	4500-NH3	0,05	0,5
Antimonio	*	N.D.	µg/L	0,10	0,20	0,30	3125 B		5
Arsénico	*	1,0	µg/L	0,10	0,20	0,30	3125 B		10
Cadmio	*	N.D.	µg/L	0,10	0,20	0,30	3125 B		3
Calcio	*	34,2	mg/L	1,0	1,5	2,0	3500-Ca B	100	
Cloruros	*	4,37	mg/L	0,81	1,30	1,10	4110B Cro	25	250
Cobre	*	N.D.	µg/L	1,0	2,0	3,0	3125 B	1000	2000
Color Aparente	*	D.	UPt-Co	1,0	2,0	4,0	2120 C	5	15
Conductividad	*	260	µS/cm	1,0	2	4	2510	400	
Cromo	*	N.D.	µg/L	0,10	0,50	1,60	3125 B		50
Dureza de Calcio	*	85	mg/L	2,0	2,0	3,0	3500-Ca D		
Dureza Total	*	114	mg/L	2,0	2,0	3,0	2340 C	300	400
Fluoruros	*	D.	mg/L	0,027	0,040	0,100	4110B Cro		0,7-1,5
Fosfatos	*	N.D.	mg/L	0,32	0,40	0,80	4110B Cro		
Hierro	*	44,6	µg/L	1,0	2,0	3,0	3125 B		300
Magnesio	*	6,8	mg/L	0,10	0,50	1,0	3500 B	30	50
Manganeso	*	22,6	µg/L	1,0	2,0	3,0	3125 B	100	500
Mercurio	*	N.D.	µg/L	0,10	0,11	0,15	3125 B		1
Niquel	*	N.D.	µg/L	1,0	2,0	3,0	3125 B		20
Nitratos	*	D.	mg/L	0,53	0,81	1,40	4110B mo		50
Nitritos	*	N.D.	mg/L	0,026	0,040	0,10	4110B Cro		0,1

Pagina 1 de 12	Rige: 16/01/17 **AYA**	**Aprobado por:** ***Dr. Darner Mora Alvarado***

INFORME DE RESULTADOS

AYA-FPT-011B

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Laboratorio de Ensayo
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LABORATORIO NACIONAL DE AGUAS

AYA-ID-01715-2017

PARAMETRO	E	RESULTADO	UNIDADES	INCERT	LD	LC	METODO	V.A.	V.MAX
Olor	**	Aceptable		N.A.	N.A.	N.A.	2150 B	Aceptable	Aceptable
pH	*	7,03		0,10	0,10	0,20	4500-H+	6,0-8,0	
Plomo	*	N.D.	µg/L	0,10	0,20	0,50	3125 B		10
Potasio	*	2,0	mg/L	0,80	1,0	1,5	3500-K B		10
Selenio	*	N.D.	µg/L	0,10	0,20	0,70	3125B		10
Sodio	*	10,4	mg/L	1,9	2,0	2,5	3500-Na B	25	200
Sulfatos	*	12,95	mg/L	0,79	0,81	1,60	4110B Cro	25	250
Turbiedad	*	0,69	UNT	0,10	0,12	0,15	2130 B	<1	5
Zinc	*	20,5	µg/L	1,0	2,0	3,0	3125 B		3000

INCERT: Corresponde a la Incertidumbre expandida k=2 para un 95% de confianza

LD: Límite de Detección en las unidades del parámetro analizado

LC: Límite de Cuantificación en las unidades del parámetro analizado

METODO: Correponde al código del Standard Methods for the Examination of Water and Wastewater.

N.D.: No detectable bajo el límite de detección

D.: Detectable pero no cuantificable

* Ensayo acreditado. Ver alcance en www.eca.or.cr

**** Ensayo no acreditado**

Condiciones Ambientales:

Observaciones:

Las determinaciones efectuadas, cumplen con el Reglamento para la Calidad del Agua Potable Nº 38924-S.

A. Urbina C.

Licda. Azucena Urbina Campos
Jefe del Laboratorio Quimica

Pagina 2 de 12	Rige: 16/01/17 **AYA**	**Aprobado por:** ***Dr. Darner Mora Alvarado***

LABORATORIO NACIONAL DE AGUAS

INFORME DE RESULTADOS

AYA-FPT-011B

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Laboratorio de Ensayo
Alcance de Acreditación Nº. LE-049
Acreditado a partir de: 11.02.2008
Alcance disponible en www.eca.or.cr

AYA-ID-03380-2017

DATOS DE LA MUESTRA

Cliente:	REGION PACIFICO CENTRAL			**Proc. muestreo**	AYA-PT-019-5
Contacto:	Ing. German Araya Montezuma			**Muestreado por**	Acuña Acuña Wilb
SISTEMA:	**PC-A-19-CARMEN LYRA-LA GUARIA-MOJONCITO**			**Fecha de muestreo**	18-abr-17
				Fecha de ingreso :	19-abr-17
Muestreo:	POZO POCAMAR 1			**Fecha de Reporte:**	08-may-17
Dirección:	Llave de chorro			**Inicio Análisis MIC:**	
				Teléfono:	2663-67-98
PROVINCIA:	Puntarenas	**CANTON:**	Puntarenas	**Tipo de muestra:**	Agua
e-mail:	garayam@aya.go.cr	**Fax:**		**Hora de recolección:**	11:27

DETALLE REPORTE DE RESULTADOS ANALISIS

PARAMETRO	E	RESULTADO	UNIDADES	INCERT	LD	LC	METODO	V.A.	V.MAX
Alcalinidad	*	117	mg/L	1,0	2,0	3,0	2320		
Aluminio	*	16,5	µg/L	1,0	1,0	4,0	3125 B		200
Antimonio	*	N.D.	µg/L	0,10	0,20	0,30	3125 B		5
Arsénico	*	0,8	µg/L	0,10	0,20	0,30	3125 B		10
Cadmio	*	N.D.	µg/L	0,10	0,20	0,30	3125 B		3
Calcio	*	33,6	mg/L	1,0	1,5	2,0	3500-Ca B	100	
Cloruros	*	5,03	mg/L	0,81	1,30	1,10	4110B Cro	25	250
Cobre	*	3,7	µg/L	1,0	2,0	3,0	3125 B	1000	2000
Color Aparente	*	N.D.	UPt-Co	1,0	2,0	4,0	2120 C	5	15
Conductividad	*	270	µS/cm	1,0	2	4	2510	400	
Cromo	*	N.D.	µg/L	0,10	0,50	1,60	3125 B		50
Dureza de Calcio	*	84	mg/L	2,0	2,0	3,0	3500-Ca D		
Dureza Total	*	113	mg/L	2,0	2,0	3,0	2340 C	300	400
Fluoruros	*	N.D.	mg/L	0,027	0,040	0,100	4110B Cro		0,7-1,5
Fosfatos	*	N.D.	mg/L	0,32	0,40	0,80	4110B Cro		
Hierro	*	17,5	µg/L	1,0	2,0	3,0	3125 B		300
Magnesio	*	7,0	mg/L	0,10	0,50	1,0	3500 B	30	50
Manganeso	*	D.	µg/L	1,0	2,0	3,0	3125 B	100	500
Mercurio	*	N.D.	µg/L	0,10	0,11	0,15	3125 B		1
Niquel	*	N.D.	µg/L	1,0	2,0	3,0	3125 B		20
Nitratos	*	N.D.	mg/L	0,53	0,81	1,40	4110B mo		50
Nitritos	*	N.D.	mg/L	0,026	0,040	0,10	4110B Cro		0,1
Olor	**	Aceptable		N.A.	N.A.	N.A.	2150 B	Aceptable	Aceptable

Página 3 de 12	Rige: 16/01/17 **AYA**	**Aprobado por:** ***Dr. Darner Mora Alvarado***

LABORATORIO NACIONAL DE AGUAS

INFORME DE RESULTADOS

AYA FPT 011B

Tres Ríos, Cartago
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Laboratorio de Ensayo
Alcance de Acreditación Nº. LE-049
Acreditado a partir de: 11.02.2008
Alcance disponible en www.eca.or.cr

AYA-ID-03380-2017

PARAMETRO	E	RESULTADO	UNIDADES	INCERT	LD	LC	METODO	V.A.	V.MAX
pH	*	6,92		0,10	0,10	0,20	4500-H+	6,0-8,0	
Plomo	*	D.	µg/L	0,10	0,20	0,50	3125 B		10
Potasio	*	1,9	mg/L	0,80	1,0	1,5	3500-K B		10
Selenio	*	N.D.	µg/L	0,10	0,20	0,70	3125B		10
Sodio	*	9,7	mg/L	1,9	2,0	2,5	3500-Na B	25	200
Sulfatos	*	11,52	mg/L	0,79	0,81	1,60	4110B Cro	25	250
Turbiedad	*	0,58	UNT	0,10	0,12	0,15	2130 B	<1	5
Zinc	*	5,2	µg/L	1,0	2,0	3,0	3125 B		3000

INCERT: Corresponde a la Incertidumbre expandida k=2 para un 95% de confianza

LD: Límite de Detección en las unidades del parámetro analizado

LC: Límite de Cuantificación en las unidades del parámetro analizado

METODO: Correponde al código del Standard Methods for the Examination of Water and Wastewater.

N.D.: No detectable bajo el límite de detección

D.: Detectable pero no cuantificable

* Ensayo acreditado. Ver alcance en www.eca.or.cr

**** Ensayo no acreditado**

Condiciones Ambientales:

Observaciones:

Las determinaciones efectuadas, cumplen con el Reglamento para la Calidad del Agua Potable Nº 38924-S.

A. Urbina C.

Licda. Azucena Urbina Campos
Jefe del Laboratorio Química

Página 4 de 12	Rige: 16/01/17 **AYA**	**Aprobado por:** ***Dr. Darner Mora Alvarado***

LABORATORIO NACIONAL DE AGUAS

AYA-ID-03381-2017

INFORME DE RESULTADOS

AYA-FPT-011B

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Laboratorio de Ensayo
Alcance de Acreditación Nº. LE-049
Acreditado a partir de: 11.02.2008
Alcance disponible en www.eca.or.cr

DATOS DE LA MUESTRA

Cliente:	REGION PACIFICO CENTRAL			**Proc. muestreo**	AYA-PT-019-5
Contacto:	Ing. German Araya Montezuma			**Muestreado por**	Acuña Acuña Wilb
SISTEMA:	**PC-A-19-CARMEN LYRA-LA GUARIA-MOJONCITO**			**Fecha de muestreo**	18-abr-17
				Fecha de ingreso :	19-abr-17
Muestreo:	POZO POCAMAR 2			**Fecha de Reporte:**	08-may-17
Dirección:	Llave de chorro			**Inicio Análisis MIC:**	
				Teléfono:	2663-67-98
PROVINCIA:	Puntarenas	**CANTON:**	Puntarenas	**Tipo de muestra:**	Agua
e-mail:	garayam@aya.go.cr	**Fax:**		**Hora de recolección:**	11:30

DETALLE REPORTE DE RESULTADOS ANALISIS

PARAMETRO	E	RESULTADO	UNIDADES	INCERT	LD	LC	METODO	V.A.	V.MAX
Alcalinidad	*	106	mg/L	1,0	2,0	3,0	2320		
Aluminio	*	131,1	µg/L	1,0	1,0	4,0	3125 B		200
Antimonio	*	N.D.	µg/L	0,10	0,20	0,30	3125 B		5
Arsénico	*	0,9	µg/L	0,10	0,20	0,30	3125 B		10
Cadmio	*	N.D.	µg/L	0,10	0,20	0,30	3125 B		3
Calcio	*	30,6	mg/L	1,0	1,5	2,0	3500-Ca B	100	
Cloruros	*	5,28	mg/L	0,81	1,30	1,10	4110B Cro	25	250
Cobre	*	N.D.	µg/L	1,0	2,0	3,0	3125 B	1000	2000
Color Aparente	*	D.	UPt-Co	1,0	2,0	4,0	2120 C	5	15
Conductividad	*	245	µS/cm	1,0	2	4	2510	400	
Cromo	*	N.D.	µg/L	0,10	0,50	1,60	3125 B		50
Dureza de Calcio	*	77	mg/L	2,0	2,0	3,0	3500-Ca D		
Dureza Total	*	104	mg/L	2,0	2,0	3,0	2340 C	300	400
Fluoruros	*	N.D.	mg/L	0,027	0,040	0,100	4110B Cro		0,7-1,5
Fosfatos	*	N.D.	mg/L	0,32	0,40	0,80	4110B Cro		
Hierro	*	147,8	µg/L	1,0	2,0	3,0	3125 B		300
Magnesio	*	6,6	mg/L	0,10	0,50	1,0	3500 B	30	50
Manganeso	*	54,3	µg/L	1,0	2,0	3,0	3125 B	100	500
Mercurio	*	N.D.	µg/L	0,10	0,11	0,15	3125 B		1
Niquel	*	N.D.	µg/L	1,0	2,0	3,0	3125 B		20
Nitratos	*	N.D.	mg/L	0,53	0,81	1,40	4110B mo		50
Nitritos	*	N.D.	mg/L	0,026	0,040	0,10	4110B Cro		0,1
Olor	**	Aceptable		N.A.	N.A.	N.A.	2150 B	Aceptable	Aceptable

LABORATORIO NACIONAL DE AGUAS

AYA-ID-03381-2017

INFORME DE RESULTADOS

AYA-FPT-011B

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Laboratorio de Ensayo
Alcance de Acreditación Nº. LE-049
Acreditado a partir de: 11.02.2008
Alcance disponible en www.eca.or.cr

PARAMETRO	E	RESULTADO	UNIDADES	INCERT	LD	LC	METODO	V.A.	V.MAX
pH	*	7,56		0,10	0,10	0,20	4500-H+	6,0-8,0	
Plomo	*	D.	µg/L	0,10	0,20	0,50	3125 B		10
Potasio	*	1,8	mg/L	0,80	1,0	1,5	3500-K B		10
Selenio	*	N.D.	µg/L	0,10	0,20	0,70	3125B		10
Sodio	*	8,9	mg/L	1,9	2,0	2,5	3500-Na B	25	200
Sulfatos	*	9,25	mg/L	0,79	0,81	1,60	4110B Cro	25	250
Turbiedad	*	2,24	UNT	0,10	0,12	0,15	2130 B	<1	5
Zinc	*	27,7	µg/L	1,0	2,0	3,0	3125 B		3000

INCERT: Corresponde a la Incertidumbre expandida k=2 para un 95% de confianza
LD: Límite de Detección en las unidades del parámetro analizado
LC: Límite de Cuantificación en las unidades del parámetro analizado
METODO: Correponde al código del Standard Methods for the Examination of Water and Wastewater.
N.D.: No detectable bajo el límite de detección
D.: Detectable pero no cuantificable
* Ensayo acreditado. Ver alcance en www.eca.or.cr
**** Ensayo no acreditado**

Condiciones Ambientales:

Observaciones:

Las determinaciones efectuadas, cumplen con el Reglamento para la Calidad del Agua Potable Nº 38924-S.

Licda. Azucena Urbina Campos
Jefe del Laboratorio Química

LABORATORIO NACIONAL DE AGUAS

AYA-ID-03382-2017

INFORME DE RESULTADOS

AYA-FPT-011B

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Laboratorio de Ensayo
Alcance de Acreditación Nº. LE-049
Acreditado a partir de: 11.02.2008
Alcance disponible en www.eca.or.cr

DATOS DE LA MUESTRA

Cliente:	REGION PACIFICO CENTRAL			**Proc. muestreo**	AYA-PT-019-5
Contacto:	Ing. German Araya Montezuma			**Muestreado por**	Acuña Acuña Wilb
SISTEMA:	**PC-A-19-CARMEN LYRA-LA GUARIA-MOJONCITO**			**Fecha de muestreo**	18-abr-17
				Fecha de ingreso :	19-abr-17
Muestreo:	POZO POCAMAR 3			**Fecha de Reporte:**	08-may-17
Dirección:	Llave de chorro			**Inicio Análisis MIC:**	
				Teléfono:	2663-67-98
PROVINCIA:	Puntarenas	**CANTON:**	Puntarenas	**Tipo de muestra:**	Agua
e-mail:	garayam@aya.go.cr	**Fax:**		**Hora de recolección:**	11:33

DETALLE REPORTE DE RESULTADOS ANALISIS

PARAMETRO	E	RESULTADO	UNIDADES	INCERT	LD	LC	METODO	V.A.	V.MAX
Alcalinidad	*	115	mg/L	1,0	2,0	3,0	2320		
Aluminio	*	8,2	µg/L	1,0	1,0	4,0	3125 B		200
Antimonio	*	N.D.	µg/L	0,10	0,20	0,30	3125 B		5
Arsénico	*	0,9	µg/L	0,10	0,20	0,30	3125 B		10
Cadmio	*	N.D.	µg/L	0,10	0,20	0,30	3125 B		3
Calcio	*	33,5	mg/L	1,0	1,5	2,0	3500-Ca B	100	
Cloruros	*	5,08	mg/L	0,81	1,30	1,10	4110B Cro	25	250
Cobre	*	N.D.	µg/L	1,0	2,0	3,0	3125 B	1000	2000
Color Aparente	*	N.D.	UPt-Co	1,0	2,0	4,0	2120 C	5	15
Conductividad	*	271	µS/cm	1,0	2	4	2510	400	
Cromo	*	N.D.	µg/L	0,10	0,50	1,60	3125 B		50
Dureza de Calcio	*	84	mg/L	2,0	2,0	3,0	3500-Ca D		
Dureza Total	*	113	mg/L	2,0	2,0	3,0	2340 C	300	400
Fluoruros	*	N.D.	mg/L	0,027	0,040	0,100	4110B Cro		0,7-1,5
Fosfatos	*	N.D.	mg/L	0,32	0,40	0,80	4110B Cro		
Hierro	*	5,5	µg/L	1,0	2,0	3,0	3125 B		300
Magnesio	*	7,0	mg/L	0,10	0,50	1,0	3500 B	30	50
Manganeso	*	N.D.	µg/L	1,0	2,0	3,0	3125 B	100	500
Mercurio	*	N.D.	µg/L	0,10	0,11	0,15	3125 B		1
Niquel	*	N.D.	µg/L	1,0	2,0	3,0	3125 B		20
Nitratos	*	N.D.	mg/L	0,53	0,81	1,40	4110B mo		50
Nitritos	*	N.D.	mg/L	0,026	0,040	0,10	4110B Cro		0,1
Olor	**	Aceptable		N.A.	N.A.	N.A.	2150 B	Aceptable	Aceptable

Página 7 de 12	Rige: 16/01/17 **AYA**	**Aprobado por:** ***Dr. Darner Mora Alvarado***

LABORATORIO NACIONAL DE AGUAS

AYA-ID-03382-2017

INFORME DE RESULTADOS

AYA-FPT-011B

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Laboratorio de Ensayo
Alcance de Acreditación Nº. LE-049
Acreditado a partir de: 11.02.2008
Alcance disponible en www.eca.or.cr

PARAMETRO	E	RESULTADO	UNIDADES	INCERT	LD	LC	METODO	V.A.	V.MAX
pH	*	7,19		0,10	0,10	0,20	4500-H+	6,0-8,0	
Plomo	*	D.	µg/L	0,10	0,20	0,50	3125 B		10
Potasio	*	2,0	mg/L	0,80	1,0	1,5	3500-K B		10
Selenio	*	N.D.	µg/L	0,10	0,20	0,70	3125B		10
Sodio	*	9,8	mg/L	1,9	2,0	2,5	3500-Na B	25	200
Sulfatos	*	11,54	mg/L	0,79	0,81	1,60	4110B Cro	25	250
Turbiedad	*	0,25	UNT	0,10	0,12	0,15	2130 B	<1	5
Zinc	*	4,6	µg/L	1,0	2,0	3,0	3125 B		3000

INCERT: Corresponde a la Incertidumbre expandida k=2 para un 95% de confianza

LD: Límite de Detección en las unidades del parámetro analizado

LC: Límite de Cuantificación en las unidades del parámetro analizado

METODO: Correponde al código del Standard Methods for the Examination of Water and Wastewater.

N.D.: No detectable bajo el límite de detección

D.: Detectable pero no cuantificable

* Ensayo acreditado. Ver alcance en www.eca.or.cr

**** Ensayo no acreditado**

Condiciones Ambientales:

Observaciones:

Las determinaciones efectuadas, cumplen con el Reglamento para la Calidad del Agua Potable N° 38924-S.

A. Urbina C.

Licda. Azucena Urbina Campos
Jefe del Laboratorio Química

Página 8 de 12	Rige: 16/01/17 **AYA**	**Aprobado por:** ***Dr. Darner Mora Alvarado***

LABORATORIO NACIONAL DE AGUAS

AYA-ID-04509-2018

INFORME DE RESULTADOS

AYA-FPT-011B

Tres Ríos, Cartago
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Laboratorio de Ensayo
Alcance de Acreditación Nº. LE-049
Acreditado a partir de: 11.02.2008
Alcance disponible en www.eca.or.cr

DATOS DE LA MUESTRA

Cliente:	REGION PACIFICO CENTRAL	**Proc. muestreo**	AYA-PT-019-5
Contacto:	Ing. German Araya Montezuma	**Muestreado por**	Canales Canales J
SISTEMA:	**PC-A-19-CARMEN LYRA-LA GUARIA-MOJONCITO**	**Fecha de muestreo**	10-may-18
		Fecha de ingreso :	10-may-18
Muestreo:	POZO POCAMAR # 2 Turbiedad * 1,40 UNT 0,10 0,12 0,15 2[illegible]	**Fecha de Reporte:**	07-jun-18
Dirección:	Llave de chorro Zinc * 4,8 µg/L 1,0 2,0 3,0 3125 B 3000	**Inicio Análisis MIC:**	
		Teléfono:	2663-67-98
PROVINCIA:	Puntarenas **CANTON:** PUNTARENAS	**Tipo de muestra:**	Agua
e-mail:	garayam@aya.go.cr **Fax:**	**Hora de recolección:**	10:35

DETALLE REPORTE DE RESULTADOS ANALISIS

PARAMETRO	E	RESULTADO	UNIDADES	INCERT	LD	LC	METODO	V.A.	V.MAX
Alcalinidad	*	134	mg/L	1,0	2,0	3,0	2320		
Aluminio	*	4,7	µg/L	1,0	1,0	4,0	3125 B		200
Antimonio	*	N.D.	µg/L	0,10	0,20	0,30	3125 B		5
Arsénico	*	0,5	µg/L	0,10	0,20	0,30	3125 B		10
Cadmio	*	N.D.	µg/L	0,10	0,20	0,30	3125 B		3
Calcio	*	39,6	mg/L	1,0	1,5	2,0	3500-Ca B	100	
Cobre	*	3,9	µg/L	1,0	2,0	3,0	3125 B	1000	2000
Color Aparente	*	N.D.	UPt-Co	1,0	2,0	4,0	2120 C	5	15
Conductividad	*	311	µS/cm	1,0	2	4	2510	400	
Cromo	*	N.D.	µg/L	0,10	0,50	1,60	3125 B		50
Dureza de Calcio	*	99	mg/L	2,0	2,0	3,0	3500-Ca D		
Dureza Total	*	133	mg/L	2,0	2,0	3,0	2340 C	300	400
Hierro	*	52,0	µg/L	1,0	2,0	3,0	3125 B		300
Magnesio	*	8,4	mg/L	0,10	0,50	1,0	3500 B	30	50
Manganeso	*	D.	µg/L	1,0	2,0	3,0	3125 B	100	500
Mercurio	*	N.D.	µg/L	0,10	0,11	0,15	3125 B		1
Niquel	*	N.D.	µg/L	1,0	2,0	3,0	3125 B		20
pH	*	7,23		0,10	0,10	0,20	4500-H+	6,0-8,0	
Plomo	*	D.	µg/L	0,10	0,20	0,50	3125 B		10
Potasio	*	2,5	mg/L	0,80	1,0	1,5	3500-K B		10
Selenio	*	N.D.	µg/L	0,10	0,20	0,70	3125B		10
Sodio	*	11,2	mg/L	1,9	2,0	2,5	3500-Na B	25	200
Temperatura	*	27,2	ºC	0,10			2550 B	18 a 30) º	

Pàgina 9 de 12	Rige: 16/01/17 **AYA**	**Aprobado por:** ***Dr. Darner Mora Alvarado***

LABORATORIO NACIONAL DE AGUAS

AYA-ID-04509-2018

INFORME DE RESULTADOS

AYA-FPT-011B

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PARAMETRO	E	RESULTADO	UNIDADES	INCERT	LD	LC	METODO	V.A.	V.MAX
Turbiedad	*	1,10	UNT	0,10	0,12	0,15	2130 B	<1	5
Zinc	*	16,5	µg/L	1,0	2,0	3,0	3125 B		3000

INCERT: Corresponde a la Incertidumbre expandida k=2 para un 95% de confianza
LD: Límite de Detección en las unidades del parámetro analizado
LC: Límite de Cuantificación en las unidades del parámetro analizado
METODO: Correponde al código del Standard Methods for the Examination of Water and Wastewater.
N.D.: No detectable bajo el límite de detección
D.: Detectable pero no cuantificable
* Ensayo acreditado. Ver alcance en www.eca.or.cr

**** Ensayo no acreditado**

Condiciones Ambientales:

El Pozo pocamar "1 está fuera de operación temporalmente.

Observaciones:

En este análisis puntual las determinaciones efectuadas, cumplen con el Reglamento para la Calidad del Agua Potable Nº 38924-S.

A. Urbina C.

Licda. Azucena Urbina Campos
Jefe del Laboratorio Quimica

Pàgina 10 de 12	Rige: 16/01/17 **AYA**	**Aprobado por:** ***Dr. Darner Mora Alvarado***

LABORATORIO NACIONAL DE AGUAS

INFORME DE RESULTADOS

AYA-FPT-011B

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AYA-ID-04510-2018

DATOS DE LA MUESTRA

Cliente:	REGION PACIFICO CENTRAL	**Proc. muestreo**	AYA-PT-019-5
Contacto:	Ing. German Araya Montezuma	**Muestreado por**	Canales Canales J
SISTEMA:	**PC-A-19-CARMEN LYRA-LA GUARIA-MOJONCITO**	**Fecha de muestreo**	10-may-18
		Fecha de ingreso :	10-may-18
Muestreo:	POZO POCAMAR # 3	**Fecha de Reporte:**	06-jun-18
Dirección:	Llave de chorro	**Inicio Análisis MIC:**	
		Teléfono:	2663-67-98
PROVINCIA:	Puntarenas **CANTON:** PUNTARENAS	**Tipo de muestra:**	Agua
e-mail:	garayam@aya.go.cr **Fax:**	**Hora de recolección:**	10:43

DETALLE REPORTE DE RESULTADOS ANALISIS

PARAMETRO	E	RESULTADO	UNIDADES	INCERT	LD	LC	METODO	V.A.	V.MAX
Alcalinidad	*	131	mg/L	1,0	2,0	3,0	2320		
Aluminio	*	N.D.	µg/L	1,0	1,0	4,0	3125 B		200
Antimonio	*	N.D.	µg/L	0,10	0,20	0,30	3125 B		5
Arsénico	*	0,4	µg/L	0,10	0,20	0,30	3125 B		10
Cadmio	*	N.D.	µg/L	0,10	0,20	0,30	3125 B		3
Calcio	*	40,4	mg/L	1,0	1,5	2,0	3500-Ca B	100	
Cobre	*	N.D.	µg/L	1,0	2,0	3,0	3125 B	1000	2000
Color Aparente	*	N.D.	UPt-Co	1,0	2,0	4,0	2120 C	5	15
Conductividad	*	309	µS/cm	1,0	2	4	2510	400	
Cromo	*	N.D.	µg/L	0,10	0,50	1,60	3125 B		50
Dureza de Calcio	*	101	mg/L	2,0	2,0	3,0	3500-Ca D		
Dureza Total	*	134	mg/L	2,0	2,0	3,0	2340 C	300	400
Hierro	*	N.D.	µg/L	1,0	2,0	3,0	3125 B		300
Magnesio	*	8,1	mg/L	0,10	0,50	1,0	3500 B	30	50
Manganeso	*	N.D.	µg/L	1,0	2,0	3,0	3125 B	100	500
Mercurio	*	N.D.	µg/L	0,10	0,11	0,15	3125 B		1
Niquel	*	N.D.	µg/L	1,0	2,0	3,0	3125 B		20
pH	*	7,22		0,10	0,10	0,20	4500-H+	6,0-8,0	
Plomo	*	D.	µg/L	0,10	0,20	0,50	3125 B		10
Potasio	*	2,6	mg/L	0,80	1,0	1,5	3500-K B		10
Selenio	*	N.D.	µg/L	0,10	0,20	0,70	3125B		10
Sodio	*	12,1	mg/L	1,9	2,0	2,5	3500-Na B	25	200
Temperatura	*	27,2	ºC	0,10			2550 B	18 a 30) º(	

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LABORATORIO NACIONAL DE AGUAS

INFORME DE RESULTADOS

AYA-FPT-011B

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Laboratorio de Ensayo
Alcance de Acreditación Nº. LE-049
Acreditado a partir de 11.02.2008
Alcance disponible en www.eca.or.cr

AYA-ID-04510-2018

PARAMETRO	E	RESULTADO	UNIDADES	INCERT	LD	LC	METODO	V.A.	V.MAX
Turbiedad	*	1,40	UNT	0,10	0,12	0,15	2130 B	<1	5
Zinc	*	4,8	µg/L	1,0	2,0	3,0	3125 B		3000

INCERT: Corresponde a la Incertidumbre expandida k=2 para un 95% de confianza

LD: Límite de Detección en las unidades del parámetro analizado

LC: Límite de Cuantificación en las unidades del parámetro analizado

METODO: Correponde al código del Standard Methods for the Examination of Water and Wastewater.

N.D.: No detectable bajo el límite de detección

D.: Detectable pero no cuantificable

* Ensayo acreditado. Ver alcance en www.eca.or.cr

**** Ensayo no acreditado**

Condiciones Ambientales:

El Pozo pocamar "1 está fuera de operación temporalmente.

Observaciones:

En este análisis puntual las determinaciones efectuadas, cumplen con el Reglamento para la Calidad del Agua Potable Nº 38924-S.

A. Urbina C.

Licda. Azucena Urbina Campos
Jefe del Laboratorio Química

Página 12 de 12	Rige: 16/01/17 **AYA**	**Aprobado por:** ***Dr. Darner Mora Alvarado***

Appendices

Pumping test annotation sheet

Sitio				
Nombre			**Fecha**	
Pozo			**Prueba**	
Observacion (min)	**Hora**	**Caudal (L/s)**	**Nivel (m)**	**Comentarios**
0	11:00 AM			
1	11:01 AM			
2	11:02 AM			
3	11:03 AM			
4	11:04 AM			
5	11:05 AM			
10	11:10 AM			
15	11:15 AM			
20	11:20 AM			
25	11:25 AM			
30	11:30 AM			
35	11:35 AM			
40	11:40 AM			
45	11:45 AM			
50	11:50 AM			
55	11:55 AM			
60	12:00 PM			
75	12:15 AM			
90	12:30 PM			
105	12:45 AM			
120	1:00 PM			
150	1:30 PM			
180	2:00 PM			
210	2:30 PM			
240	3:00 PM			

Recovery phase annotation sheet

Sitio				
Nombre			**Fecha**	
Pozo			**Prueba**	
Observacion (min)	**Hora**	**Caudal (L/s)**	**Nivel (m)**	**Comentarios**
0	9:00 AM			
1	9:01 AM			
2	9:02 AM			
3	9:03 AM			
4	9:04 AM			
5	9:05 AM			
10	9:10 AM			
15	9:15 AM			
20	9:20 AM			
25	9:25 AM			
30	9:30 AM			
35	9:35 AM			
40	9:40 AM			
45	9:45 AM			
50	9:50 AM			
55	9:55 AM			
60	10:00 AM			
75	10:15 AM			
90	10:30 AM			
105	10:45 AM			
120	11:00 AM			

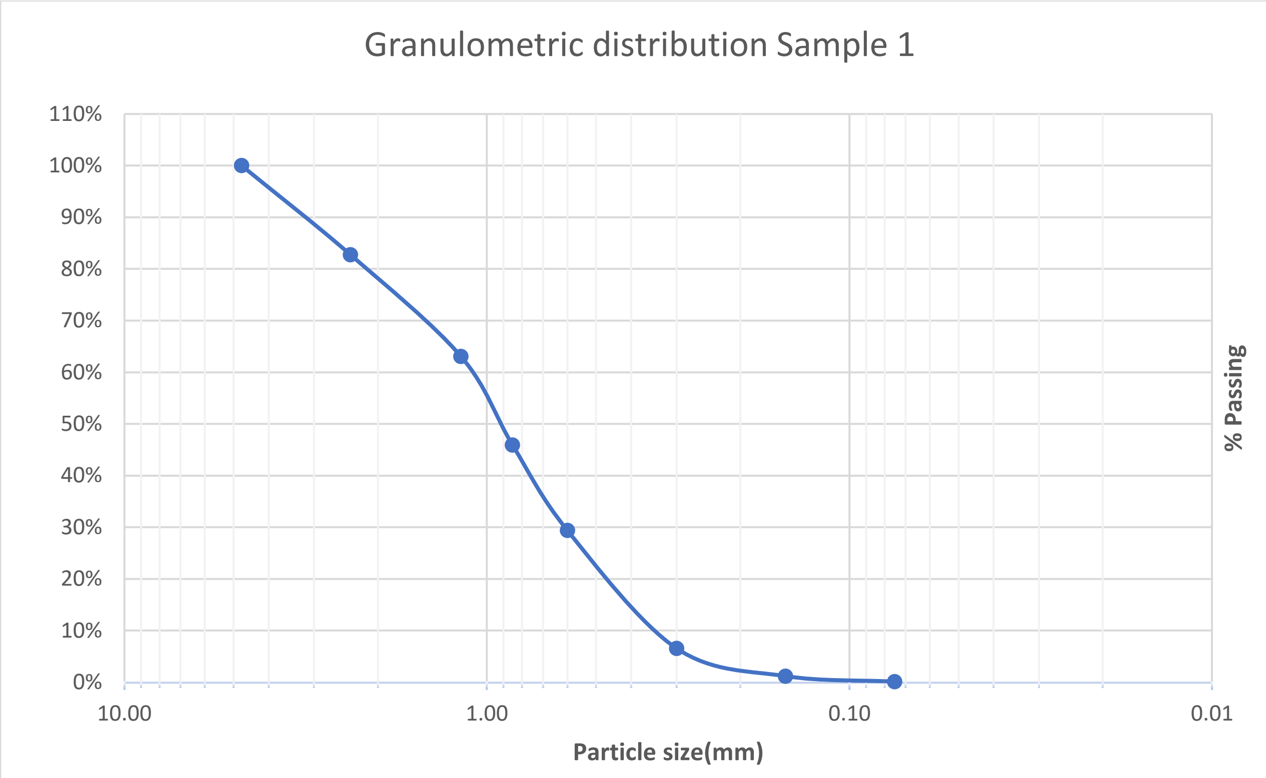
Granulometry for Barranca riverbed sediment sample 1					
Sieve #	**Size (mm)**	**Retained (g)**	**Retained %**	**Ret. Accumulated %**	**% Passing**
4	4.75	0	0.00%	0.00%	100.00%
8	2.38	55.69	17.24%	17.24%	82.76%
16	1.18	63.59	19.68%	36.92%	63.08%
20	0.85	55.45	17.16%	54.08%	45.92%
30	0.60	53.36	16.52%	70.60%	29.40%
50	0.30	73.78	22.84%	93.44%	6.56%
100	0.15	17.39	5.38%	98.82%	1.18%
200	0.07	3.45	1.07%	99.89%	0.11%
pan	-	0.26	0.08%	99.97%	-
∑ weight	322.97	Dry weight pre-wash		329.19	
Initial Weight	323.08	Dry weight post-wash		323.08	
Error	0.03%	Percentage of fines		**2%**	

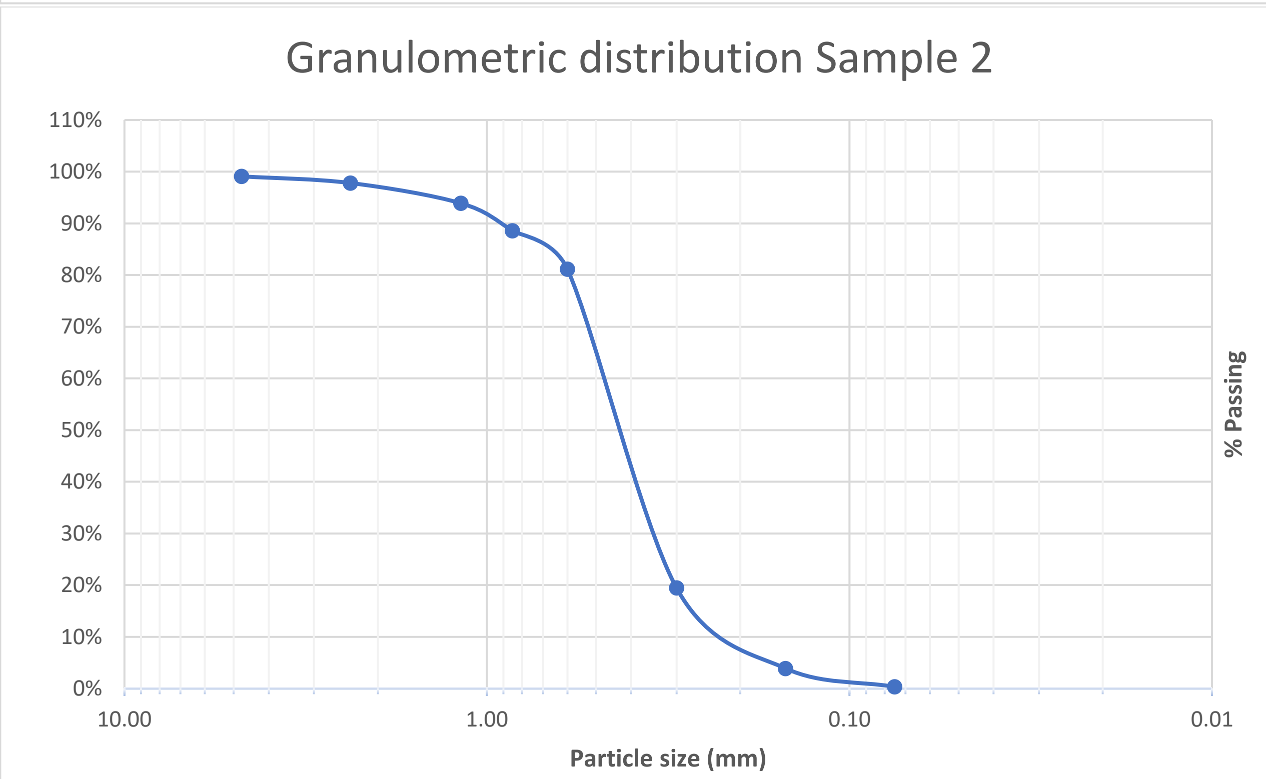
Granulometry for Barranca riverbed sediment sample 2					
Sieve #	**Size (mm)**	**Retained (g)**	**Retained %**	**Ret. Accumulated %**	**% Passing**
4	4.75	2.81	0.91%	0.91%	99.09%
8	2.38	3.98	1.29%	2.20%	97.80%
16	1.18	12.12	3.92%	6.11%	93.89%
20	0.85	16.42	5.31%	11.42%	88.58%
30	0.60	22.98	7.43%	18.86%	81.14%
50	0.30	190.75	61.68%	80.54%	19.46%
100	0.15	48.21	15.59%	96.13%	3.87%
200	0.07	11.02	3.56%	99.69%	0.31%
pan	-	0.88	0.28%	99.97%	-
∑ weight	309.17	Dry weight pre-wash		322.53	
Initial Weight	309.25	Dry weight post-wash		309.25	
Error	0.03%	Percentage of fines		**4%**	

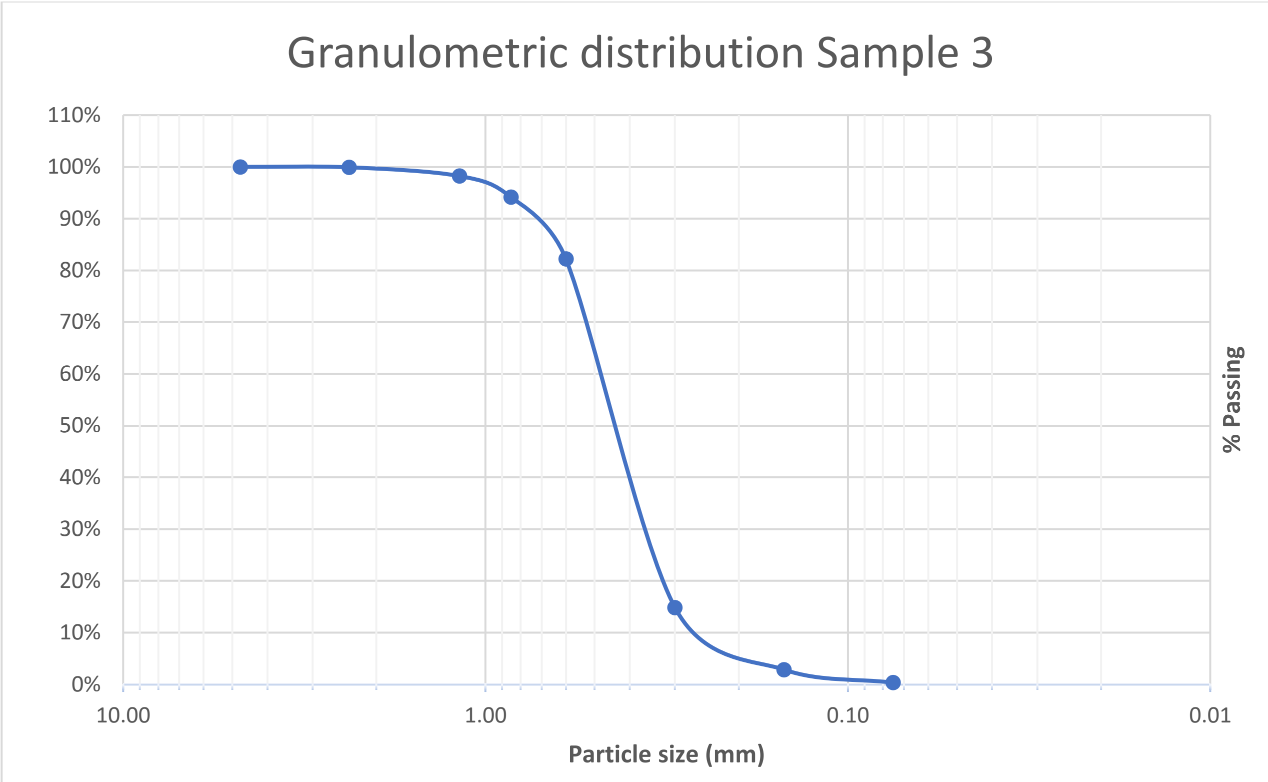
Granulometry for Barranca riverbed sediment sample 3					
Sieve #	**Size (mm)**	**Retained (g)**	**Retained %**	**Ret. Accumulated %**	**% Passing**
4	4.75	0	0.00%	0.00%	100.00%
8	2.38	0.27	0.08%	0.08%	99.92%
16	1.18	5.72	1.69%	1.77%	98.23%
20	0.85	13.88	4.09%	5.86%	94.14%
30	0.60	40.45	11.93%	17.79%	82.21%
50	0.30	228.43	67.38%	85.17%	14.83%
100	0.15	40.64	11.99%	97.16%	2.84%
200	0.07	8.53	2.52%	99.67%	0.33%
pan	-	1.01	0.30%	99.97%	-
∑ weight	338.93	Dry weight pre-wash		343.15	
Initial Weight	339.03	Dry weight post-wash		339.03	
Error	0.03%	Percentage of fines		**1%**	

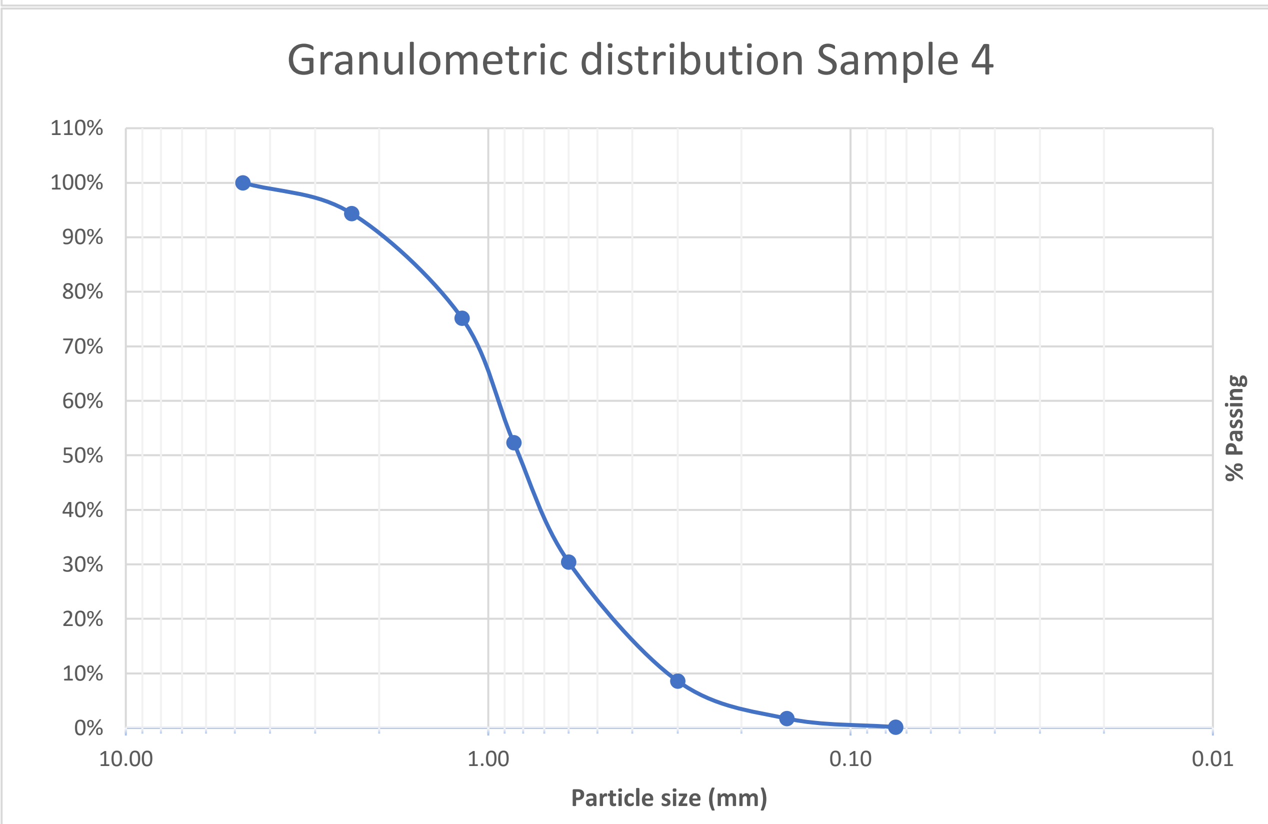
Granulometry for Barranca riverbed sediment sample 4					
Sieve #	**Size (mm)**	**Retained (g)**	**Retained %**	**Ret. Accumulated %**	**% Passing**
4	4.75	0	0.00%	0.00%	100.00%
8	2.38	19.91	5.64%	5.64%	94.36%
16	1.18	67.96	19.24%	24.88%	75.12%
20	0.85	80.58	22.81%	47.69%	52.31%
30	0.60	77.23	21.87%	69.56%	30.44%
50	0.30	77.13	21.84%	91.40%	8.60%
100	0.15	24.27	6.87%	98.27%	1.73%
200	0.07	5.6	1.59%	99.86%	0.14%
pan	-	0.46	0.13%	99.99%	-
∑ weight	353.14	Dry weight pre-wash		356.09	
Initial Weight	353.19	Dry weight post-wash		353.19	
Error	0.01%	Percentage of fines		**1%**	

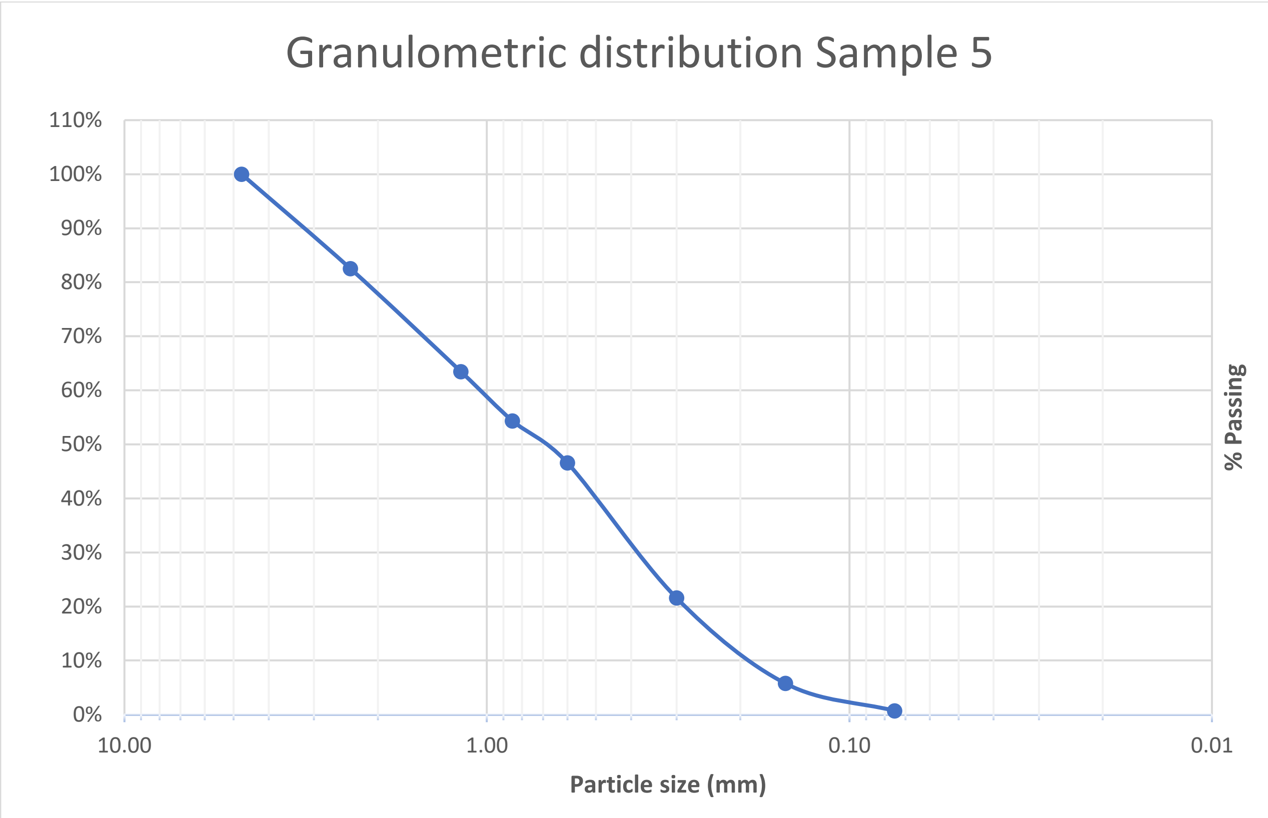
Granulometry for Barranca riverbed sediment sample 5					
Sieve #	**Size (mm)**	**Retained (g)**	**Retained %**	**Ret. Accumulated %**	**% Passing**
4	4.75	0	0.00%	0.00%	100.00%
8	2.38	54.64	17.47%	17.47%	82.53%
16	1.18	59.63	19.06%	36.53%	63.47%
20	0.85	28.54	9.12%	45.65%	54.35%
30	0.60	24.27	7.76%	53.41%	46.59%
50	0.30	78.24	25.01%	78.41%	21.59%
100	0.15	49.55	15.84%	94.25%	5.75%
200	0.07	15.8	5.05%	99.30%	0.70%
pan	-	2.04	0.65%	99.96%	-
∑ weight	312.71	Dry weight pre-wash		324.56	
Initial Weight	312.85	Dry weight post-wash		312.85	
Error	0.04%	Percentage of fines		**4%**	


Granulometric distribution Sample 1
110%
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
10.00
1.00
0.10
0.01
Particle size(mm)
% Passing


Granulometric distribution Sample 2
110%
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
10.00
1.00
0.10
0.01
Particle size (mm)
% Passing


Granulometric distribution Sample 3
110%
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
10.00
1.00
0.10
0.01
Particle size (mm)
% Passing


Granulometric distribution Sample 4
110%
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
10.00
1.00
0.10
0.01
Particle size (mm)
% Passing



Granulometric distribution Sample 5
110%
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
10.00
1.00
0.10
0.01
Particle size (mm)
% Passing