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PEOPLE-CENTRED APPROACHES TO WATER AND ENVIRONMENTAL SANITATION

The Online Support and Training Project for the Groundwater Sector of Lao PDR

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Despite an abundance of favorable groundwater bearing deposits, ample recharge from rainfall and surface water bodies, and potential in terms of natural protection from the filtering through the porous formation, difficulties in locating exploitable quanttites of water at depth and problems with elevated concentrations of problematic elements such as iron and manganese, has resulted in general skepticsm and curtailment of investments in this sector. The Online Support and Training represents an attempt to alter this trend through providing ease of access to an extensive information base covering all aspects regarding the assessment and practical design and construction of groundwater resources in Lao PDR. This paper presents the Online Suppor and Training, its main features as well as key recent experiences with development of groundwater supply as part of the ongoing ADB funded Water Supply and Sanitation Sector Project for the Department of Housing and Urban Planning (DHUP) of Lao PDR.

Introduction

The Online Support and Training Project for the Groundwater Sector of Lao PDR can be accessed at www.laoshydrogeology.com. The overall objectives of the Online Support and Training project are to provide continuous support and stimulation to the development of urban groundwater supply activities in the Lao PDR. The project is funded by the Norwegian Agency for Development Cooperation (NORAD). In practical terms the project was initially designed to provide support for water supply projects based on groundwater, such as the ADB funded Water Supply and Sanitation Sector Project, implemented by Norconsult International for the Water Supply Authority (WASA). Moreover, the project serves as a professional reference site for people interested in various aspects of groundwater; in particular the conditions as found along the Mekong River and its tributaries.

Furthermore the project seeks to:

- Develop rapid and cost effective methodologies for the identification of ground water bearing formations, i.e. aquifer horizons. In other words, to find adequate deposits of sand (and gravel) buried in silts and clays, by means of resistivity imaging techniques coupled with specialised geological support;
- Design an optimal, customised and cost effective procedure for exploitation and safe exploitation of ground water for urban purposes;
- To provide a series of case studies complete with full sets of project histories, scientific approaches, data sets and evaluation techniques.

The objectives of this paper are dual. First, to give a brief summary of the context motivating the present study including its main features. Second, to present recent key experiences outlining the most common geological units and inherent technical challenges encountered during development of groundwater supply in Lao PDR.

Overall context - surface water vs. groundwater

National applied hydrogeology in Laos is presently in its infancy. With an abundance of surface water the ground water supply alternative has traditionally been given low priority. However, the use of surface water sources is not without problems. Increased use and consequent contamination of the waterways implies more costly purification processes in order to safeguard communities against water borne diseases and epidemics. The operation and maintenance of traditional water purification plants have become increasingly expensive due to increased costs of chemicals, logistics, plant construction and personnel. The search for groundwater based water supply solutions represents an attempt to alleviate this situation.

The alluvial deposits underlying almost all of Laos' waterways contain large quantities of ground water; a virtually limitless and sustainable source of water due to the proximity and potential recharge from surface water bodies. Similarly, considering the abundant rainfall largely exceeding 1500 mm per year, significant groundwater potential also exists within the sedimentary basins comprising the weathered sand/mudstone and karst terrains that make up the undulating lowlands of central and southern Laos. However, the use of groundwater is not without problems. The reason being (1)

the large heterogeneity of sub-surface strata complicating the location of exploitable quantities of water, and (2) the presence of mineralised strata yielding excessive concentrations of undesirable elements including iron, manganese and increased salinity with depth. Successful and sustainable utilization of groundwater resources therefore requires these factors to be controlled in an economically viable way. This goal can best be achieved through solid knowledge of the geology of groundwater occurrence and behaviour in terms of recharge, flow and hydrogeochemical characteristics.

Features of the online support and training

The Online Support and Training Project addresses the above disciplines individually including in depth explanation, examples of accompanying geophysical exploration, test pumping analyses methods, and combined through Case Studies and Data Sets containing assessments and records collected at the relevant locations. To facilitate further analysis and visualisation of thematic information such as mapping of variations in earth resistivity, aquifer properties and water quality, all data is geo-referenced and presented in easily accessible formats such as MS Word, Excel, etc. A more detailed overview of the main subject areas follows below:

Geology

This section gives an overview of the evolution of SE Asia, orogeny, and formation of the principal hydrogeological units such as the massive sand/mud stone formations of the Vientiane and the Savannakhet basins. The latter is complimented by petrographic analysis of thin sections enabling the reader to appreciate the rock texture and its mineralogy, properties that are fundamental in determining water-rock interactions.

Hydrogeology

This section puts the geo-hydrology in context with the larger Water Supply and Sanitation Sector Project, listing the sites where investigations either have been or are about to be carried out, including also the complete assessment or Case Study reports for the respective locations.

Geophysics

The presence of buried coarser sand/gravel lenses and fracture/ weathering zones in alluvial and consolidated sedimentary deposits respectively, is often a prerequisite for economic viable abstraction of groundwater. The latter can be quite difficult to locate efficiently and represents one important reason why investments into the drilling of wells have been considered unfavourably in the past, and present.

However, significant technological advances within the field of electrical resistivity techniques during the last few years have progressed fast. At present, rapid identification of buried coarse sand lenses has become routine. In particular, a technique named Resistivity Imaging can provide accurate sand identification within a 3-400m profile in a period of a few hours. Also, features such as karst, the presence of conductive layers, salt water stratification, etc. can be identified along the same lines.

In addition to providing overviews of the most commonly used geophysical methods, this section provides comprehensive professional support to the use and interpretation of electrical resistivity surveys and data, including reference to the Case Study Reports describing the interpretations at each examined location. The latter is important because interpretation will change in accordance with the sub-surface environment, and as the project gains experience. For example, a high resistivity area in a profile of an alluvial deposit typically indicated the presence of favourable lenses of gravel, while the same in a weathered sand/mudstone indicates more impermeable (dry) consolidated rock.

Water quality and sanitation

Problems with elements such as iron and manganese represents another reason for general scepticism to the use of groundwater in Lao PDR, (i.e. due to the associated aesthetic effects such as colour and the potential to stain clothing). With the exception of the younger parts of the sand/mudstone formations, where iron and manganese are released from the rock matrix itself, these elements are mainly present in the deeper parts of the aquifer. Their presence can consequently be reduced to within acceptable limits, provided special care is taken during well installation and design.

The section contains information on water quality sampling and analyses. Sanitation is only addressed at the reconnaissance level with overviews and inventories of latrine densities, and water quality in selected wells. As sample composition may change significantly between sampling and analyses in the laboratory, interpretation methods are emphasised. These range from simple analyses of charge balances to hydrogeochemical modelling to determine the reliability of the analyses and evolution of the sampled water respectively.

Test-pumping

Test pumping is fundamental to determining aquifer properties and the long term yield and operation of the well. This section describes test pumping in theory as well as in practice, through step-by-step examples and reference to the conducted interpretations in the respective Case Study Reports.

Well drilling

Considering the varied nature of sub-surface strata requiring different drilling methods, this section is devoted to explanations of the most common methods available in the Lao PDR, including the practical implications of the choice of drilling equipment with respect to interpretations of the hydrologic and chemical properties of the aquifer.

Figure 1. Overview of project areas

Illustrative results - Recent key experiences

At the moment groundwater based water supply has been constructed at two locations in Lao PDR. These are the towns of Ton Pheung and Outhoumphone. Their locations are shown in Figure 1 along with the locations of the other towns were the groundwater option has and is being evaluated. Together the experiences at Ton Pheung and Outhoumphone illustrate the challenges of,

- minimizing elevated levels of iron and manganese,
- well construction and design in unconsolidated sediments,
- locating weathered water bearing strata, and
- minimising saline upconing during pumping.

Ton Pheung

The town of Ton Pheung is situated on a lobe-like meandering of the Mekong, just south of the frontier between Myanmar and Thailand. The latter forms part of the Golden Triangle, an area that historically is well known for the growing of opium.

Groundwater characteristics at Ton Phueng consists of a semi-confined aquifer composed of permeable sand and gravel, which is fed by the fluctuating river stage and precipitation from rainfall. Water quality is generally good and low in mineral content in the top 1-2 meters of the water bearing formation. However, below this depth the water becomes anoxic (most likely due to the decomposition of organic matter in the formation). This causes entrapment of high concentrations iron and manganese.

Main challenges with respect to constructing a successful water supply system at Ton Pheung was therefore related to installing wells that would only extract water from the potable top part of the aquifer, while at the same time ensuring sufficient quantities of water using 1-2 production wells (i.e. to minimize costs and to simplify operation and maintenance). A third point is related to obtaining public acceptance and support for the proposed solution. An advantage here is that the people of Ton Pheung currently obtain their water supply from a number of hand-dug wells. Thus they are well aware of the groundwater potential provided the above criteria are met. However, this has proved an arduous task due (1) difficulties with locating suitable well sites and (2) practical problems with drilling in the unconsolidated formation. The latter being due to the fact that the formation changes from that of largely sand to coarse gravel and large boulders at the depth where groundwater is encountered. Penetrating these deposits have resulted in frequent equipment breakdown. Typically it has taken on the order of 1 month to construct and install one well.

Noting that the mineral content of the water is going to be proportional to the residence time or the time of contact the groundwater experiences while flowing through the aquifer, the lowest mineral content is therefore likely to be found in areas of coarser more permeable sediments, and where these sediments lie at shallow depths reducing the travel distance for infiltrating recharge water. Following this line of reasoning, and using electrical resistivity to increase the chances of striking suitable sub-surface strata, a total of eight boreholes were attempted of which five have been installed. Of these five, three have demonstrated sufficient yield and acceptable water quality during long term test pumping. Two of the boreholes have been installed as production wells. Commissioning and handing over of the Water Supply Works is expected to take place in May/June 2004.

Outhoumphone/Xeno

Outhoumphone is located on a in middle southern portion of the country. The area is relatively flat, consisting mostly of rice-paddies. The aquifer is one of fractured sandstone/mudstone with a relatively low storage potential (less than 1 %). Due to the presence of evaporites (mainly gypsum) at depth, it is only the top 10 to 20 meters of the formation, which provides water of acceptable quality. As a result there were significant doubts as to whether the aquifer would provide sufficient water to meet the projected demand for an estimated future population (18,000) people. However, the areal extent of the aquifer is considerable, covering some 160 Km2 and recharge is on the order of 1500 mm per year, indicating (in theory) sufficient amounts of water. To examine this point in greater detail a groundwater model was developed for the entire area. The groundwater model allowed quantification of the multiple effects of pumping and recharge, and was consequently an important tool in supporting the case for constructing a water supply system based on groundwater. The remaining water supply alternative for the area would have been to defer investment, and wait for sufficient funds to construct a pipeline from the nearest surface water resource (the Mekong river) in Savannakhet located 35 Km West of Outhoumphone. The

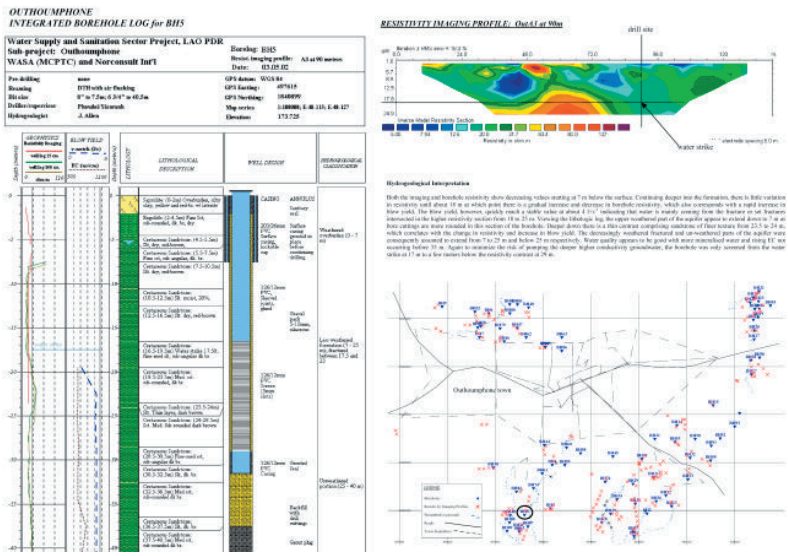

Figure 2. Example of data and interpretations

cost of the surface water is estimated at about 3 times that of the current groundwater alternative.

Construction of the groundwater supply system started in the middle of January of 2003 with pre-drilling of test-boreholes, which later pending yield would become production boreholes. In total over 100 boreholes were drilled. The boreholes were sited by a saturation electrical resistivity-imaging programme (more than 100 profiles) were conducted to locate potential water bearing fractures and strata. On average the success rate was 50-60 %, and about 50 boreholes have been chosen for production wells. These are distributed between 3 well fields in the north-western, eastern and southern parts with respect to the town centre. Location map is shown in Figure 2 together with the different types of data collected such as blow blow yield, conductivity and down the hole resistivity, and how these are collated and compared with observations of cuttings for hydrogeologic interpretations.

Concluding remarks

The groundwater supply systems at Ton Pheung and Outhoumphone are scheduled to be commissioned and handed over to the respective municipal authorities during 2004. Noting the current skepticism regarding the use of groundwater, the successful installations of ambitious groundwater supply systems in challenging geological formations represents pioneering achievements, a point which is likely to positively impact future initiatives and investments in the water sector.

For example, to our knowledge the groundwater supply system in Outhoumphone is unique with regards to urban water supply in not only Laos, but also Southeast Asia and perhaps significant parts of the world. The long-term sustainability of this and other projects will ultimately be determined by the capacity and skills of the local population to maintain the technical installations and comply with recommended pumping rates and schedules. These are important elements in groundwater management and protection.

But perhaps more importantly the experiences demonstrate the complexity of the natural settings and the need to communicate the lessons learned. It is here the real value of an Online Support and Training is evident, enabling the local geo-hydrologist access to an extensive information base and scientific tools. As a result it is hoped that the project will stimulate further interest in the potential of groundwater, to improving and promoting sustainable water services solutions within Lao PDR and the Mekong basin.

References

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