8-2011

Designing a Raw Water Fee Scheme for Groundwater Extraction in Cagayan de Oro, Philippines

Rosalina Palanca-Tan
Ateneo de Manila University, rtan@ateneo.edu

Designing a Raw Water Fee Scheme for Groundwater Extraction in Cagayan de Oro, Philippines

Rosalina Palanca-Tan

August, 2011

Comments should be sent to: Dr. Rosalina Palanca-Tan, Department of Economics, Ateneo de Manila University, Loyola Heights, Quezon City, Philippines.

Tel: 63 - 2 – 4265661

Fax: 63 - 2 – 4265661

Email: rtan@ateneo.edu

The Economy and Environment Program for Southeast Asia (EEPSEA) was established in May 1993 to support research and training in environmental and resource economics. Its objective is to enhance local capacity to undertake the economic analysis of environmental problems and policies. It uses a networking approach, involving courses, meetings, technical support, access to literature and opportunities for comparative research. Member countries are Thailand, Malaysia, Indonesia, the Philippines, Vietnam, Cambodia, Lao PDR, China, and Papua New Guinea.

EEPSEA is supported by the International Development Research Centre (IDRC); the Swedish International Development Cooperation Agency (Sida); and the Canadian International Development Agency (CIDA).

EEPSEA publications are also available online at http://www.eepsea.org.

ACKNOWLEDGMENTS

I wish to extend sincerest thanks to the many people and institutions that have contributed to this action research project. Foremost of them are my research collaborators from the National Water Resources Board -- Eng'r. Luis Rongavilla and Eng'r Milagros Velasco, and Eng'r. Jan Taat, hydrologist-consultant, who conducted the safe yield estimation for the study and wrote Chapter 2 of this report.

I deeply appreciate the high importance accorded to this water management policy initiative by both former NWRB Director Ramon Alikpalla and current Director Vicente Paragas, and Policy and Program Division's Officer-in-Charge, Ms. Isidra Penaranda. They all did their part to facilitate prompt and enthusiastic participation of NWRB in the project.

The receptiveness of the local government units in Cagayan de Oro is likewise gratefully acknowledged. The public declaration of concern and support for sustainable water resource management made by both former City Mayor Constantino Jaraula and current Mayor Vicente Emano had made this action research project possible. Both mayors consented to the more hands-on support and participation of Vice Mayor Ian Caesar Acenas and the full participation of the City Planning and Development Office (CPDO). Our research team is so fortunate to have worked with the extremely kind and hardworking CPDO Head, Mrs. Estrella Sagaral, who, with her strong and genuine commitment to address the water resource issue in Cagayan de Oro, willingly and enthusiastically assisted us in every way she could, every step of the way. We will never forget the motherly ways of Mrs. Sagaral that encouraged and inspired us all the time. In the conduct of the deep well inventory, deep well owners/operators survey and interviews, as well as of the consultation meetings, we were ably assisted by the industrious and cheerful staff of CPDO, namely; Ms. Ailel Sequia and Mr. James Arrabaca. Many thanks to all the other staff of CPDO for distributing letters of invitation and notices to deep-well owners; for patiently accompanying and driving us around the city during field visits and surveys, and for all sorts of assistance we have kindly received from them.

The legislative branch of the City Government had been equally supportive. I am grateful for the initial endorsements of Councilors Emmanuel Abejuela and Ian Mark Nacaya and the subsequent meetings with them and Councilors President Elipe and Alden Bacal. We appreciate the willingness and courage of Councilor Elipe to take on the major role of sponsoring the raw groundwater pricing ordinance in Cagayan de Oro. Thanks as well to Ms. Lalai Fillarca of the City Council's Office and Ms. Chai of the Vice Mayor's Office.

Other government officials who helped us in this endeavor and to whom we would like to extend much gratitude include DENR Region X former Director Maximo Dichoso who was also first Co-chair of CDO River Basin Management Council, Forest Resources Development Division Chief Mr. Fidel Gamos Jr., Legal Division Chief Atty. Florenda Yap, DENR River Basin Director Vicente Tuddao, DENR Region X Protected Area Management Bureau Chief Ms. Malou Montilla, Mt. Kitanglad Range National Park Officer Mr. Felix Mirasol, Laguna Lake Development Authority Manager Ms. Dolly Nepomuceno, Cagayan de Oro Water District (COWD) Chair of the Board Mr. Joel Baldelovar Jr. and all members of the Board, and COWD Asst. Manager Engr. Bienvenido Batar Jr.

I, and perhaps all the people of Cagayan de Oro, owe the biggest gratitude to Archbishop Antonio Ledesma from whom emanates the direction and inspiration to the

Social Action Center of the Archdiocese of Cagayan de Oro. The Center has taken the lead role in educating, arousing concern, and challenging the people of Cagayan de Oro to take action on the issue of groundwater. The Social Action Center under the guidance of Ms. Myrna Aboniawan Siose, among others, enabled our research team to easily reach the different stakeholder groups. The Center's endorsement of our groundwater conservation strategy has helped substantially.

Another highly regarded and influential personality in Cagayan de Oro to whom we owe much gratitude is former Xavier University President, Fr. Jose Villarin. Fr. Jett publicly endorsed our raw groundwater preservation strategy and graciously agreed to appear in our public campaign video. We would like to thank many other Xavier University faculty and staff who are also actively involved in the Social Action Center, particularly, Dr. Cecil Macabuac and Dr. Dexter Lo.

I would like to thank Cagayan de Oro news writers Mike Banos, Bong Fabe, Mark Francisco, and Louise Dumas whose articles have helped disseminate information.

I also with to thank Malou Perez, Lionel Dosdos, and Marilyn Palanca for competent research assistance and Cloyd Winstanley for the video production.

The financial assistance of the Environment and Economy Program for Southeast Asia is gratefully acknowledged. I would like to thank EEPSEA resource person, Dr. Nancy Olewhiler, for valuable suggestions on how to focus this action research project; EEPSEA Director, Dr. Hermi Francisco, for her interest in and encouragement to do action research projects such as this; and to EEPSEA Staff, Ms. Cathy Ndiaye for handling the administrative aspect of the grant.

Most of all, I thank and praise the Almighty Father, by Whose divine intervention, things have worked out, despite my being a neophyte in this field of action research.

To my beloved Matti

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

DESIGNING A RAW WATER FEE SCHEME FOR GROUNDWATER EXTRACTION IN CAGAYAN DE ORO, PHILIPPINES

Rosalina Palanca-Tan

EXECUTIVE SUMMARY

Our earlier study (Palanca-Tan and Bautista 2003) looked into groundwater depletion in Cagayan de Oro City (CDO) and the viability of collecting a raw groundwater fee to control the excessive abstraction of groundwater and to generate revenues to finance watershed preservation activities. This current study is an action research project that endeavored to push the CDO government to legislate and implement a raw groundwater pricing scheme as a resource management tool.

The project included a hydrological study that was done to estimate the safe yield of the CDO aquifer. The hydrological study also aimed to equip our research team with a better understanding and appreciation of the underlying procedures and data in the safe yield estimates and hence enable us to provide a clearer picture of the extent of the problem to local government officials, groundwater users, and the general public. Using the gradient method, we estimated the safe yield for the CDO aquifer to be in the range of 2.4-9.5 million m^3 per month.

The project required updating the earlier's study's list of groundwater extractors and the rate of groundwater extraction. We identified almost 40 new deep well systems constructed for subdivisions, hotels and malls that have mushroomed since 2000. These, together with the increased rate of withdrawal of the Cagayan de Oro Water District (COWD), have raised groundwater extraction to 4.67 million m^3 per month, 39% more than the 2000 estimate. Comparing this with the estimated safe yield of 2.4-9.5 million m^3 per month, it appears that a large portion of the natural discharge, and possibly even more, is used for water production in the city. This may be causing drawdown below sea level and local salt water intrussion that may explain the low groundwater levels registered in the Macasandig well field.

The policy advocacy component of the project entailed a series of multilevel consultations with different groups of stakeholders, namely: National Water Resources Board (NWRB), City Local Government units – both executive and legislative branches, Water District and private deep-well owners and operators, and the general public. As NWRB is the primary national government agency mandated for raw water pricing, its collaboration was sought right from the project conception stage. The project team with the participation of NWRB endeavored to push the CDO government to legislate and implement a raw groundwater pricing scheme as a resource management tool. To promote the acceptability of the proposed groundwater conservation strategy, a public information campaign was conducted from project conception, which included symposia and print media and video presentations. The enthusiastic support and cooperation of the Archdiocese of Cagayan de Oro greatly greatly helped the reserach team in reaching the different interest groups in the city.

Consultation meetings were undertaken involving NWRB, other national government agencies such as the Department of Environment and Natural Resources (DENR), CDO local government units, groundwater extractors, and the CDO River Basin Management Council to come up with a workable design and implementation plan for the raw groundwater pricing

policy. We recommend that NWRB, which has the legal mandate to impose raw water fee sby virtue of PD 424 and 1067, delegate this function to the CDO city government, which in turn may deputize the CDO River Basin Management Council, a multi-sectoral entity co-chaired by the DENR Region X Director and the Archbishop of CDO. We had gone as far as bringing the City Council to draft an Ordinance for the Raw Groundwater Pricing Scheme. As of this writing, the first Public Hearing on the draft Ordinance had been held.

1.0 INTRODUCTION

An earlier research titled "Metering and a Water Permits Scheme for Groundwater Use in Cagayan de Oro" (Palanca-Tan and Baustista 2003) looked into groundwater depletion in Cagayan de Oro City (CDO) and the viability of metering and collecting a groundwater fee to address two goals: (1) to control excessive abstraction of groundwater, and (2) to generate revenues that can be used to preserve water catchment areas. The study found a strong willingness to pay for raw water among the city's owners of groundwater supply systems, particularly the businesses. It also found that payers want to see that revenues from the raw water fee are used to maintain and preserve the watersheds to ensure a stable supply of water.

This current action research project aimed to design a raw groundwater pricing system for CDO. Specifically, the project objectives are to:

(1) Undertake a hydrological study to determine the characteristics of the aquifer and the optimal levels of extraction.

(2) Conduct a survey of deep well owners to obtain data on current and planned extraction.

(3) Undertake a literature review on groundwater and water pricing and its implementation.

(4) Design a water pricing strategy based on the actual and optimal rates of extraction, and consultation meetings among the National Water Resources Board (NWRB), CDO local government, groundwater extractors, and other stakeholders.

(5) Design an implementation strategy.

2.0 GROUNDWATER SAFE YIELD

2.1 The Concept of Safe-yield[1]

The safe yield of a groundwater reservoir (aquifer) is the maximum average annual pumping draft that can be continually withdrawn for useful purposes under a given set of conditions without causing undesirable results (State Water Rights Board 1962). This definition suggests the following concepts important to safe yield estimation:

(1) the capacity of the aquifer to store and transport groundwater to the abstraction wells;

(2) the abstraction wells, the depth at which they pump and their spatial arrangement;

[1] The hydrological study was undertaken by Eng. Jan Taat (Rivtalva Ventures, Inc.), the hydrologist-consultant for this project. This entire chapter is extracted from the report of Eng. Taat.

(3) a set of existing conditions: groundwater recharge by rain, rivers, irrigation, and groundwater discharge to springs, rivers, and oceans (these conditions also include land use and vegetation since these influence the recharge); and

(4) limit of groundwater abstraction: "overdraft" is a condition caused by pumping in excess of safe yield, which produces undesirable results such as chronic lowering of groundwater levels (toward depletion of supply), chronic depletion of groundwater storage, inducement of seawater intrusion, or other degradation of water quality and land subsidence.

The reaction of the groundwater level to groundwater abstractions depends on the aquifer and the boundary conditions. Consider the following situations:

Figure 1. Water balance, natural situation

In a natural situation (Figure 1), an aquifer receives water via recharge R. This water flows as groundwater through the aquifer where it can be stored and then discharged to a spring, river or the sea. In the dry season the recharge will be less than the discharge, and so the storage decreases. During the wet season the recharge is larger than the discharge, and so the storage increases. Averaged over a number of seasons, the storage is more or less constant (steady state). In a steady state, discharge equals recharge (D=R). The storage in an aquifer can be measured by the groundwater level. A decreasing groundwater level indicates a decreasing storage.

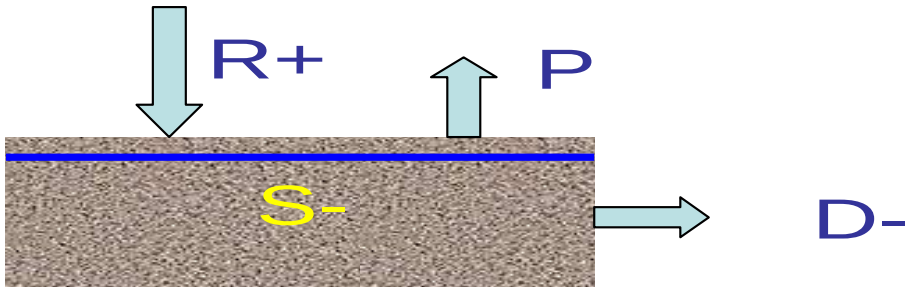

Figure 2. Water balance, with stable pumping

At the moment water is abstracted (Figure 2), the natural situation changes. Both the water storage in the aquifer and the groundwater level decrease. The decrease in the groundwater level in the aquifer might result in an increase of the recharge (e.g., infiltration from a river). Usually a decrease in the groundwater level will also decrease the discharge

from the aquifer (e.g., flow to the ocean or seepage to a river). After a period of time, a new steady state will be reached where the pumping rate and discharge equal the recharge (D+P=R).

Every groundwater abstraction lowers the groundwater level in the aquifer. However, such lowering does not necessarily lead to undesirable results. In planning abstraction rates, the expected effects can be estimated and evaluated in terms of undesirable results. During the operation of the well, the groundwater levels can be monitored and the estimations verified.

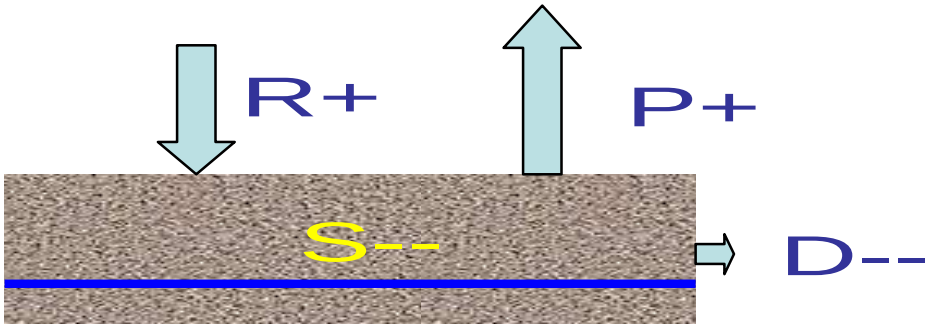

Figure 3. Water balance, with unsustainable pumping

With increasing pumping rates, a situation with a continuous long-term storage decrease might occur (Figure 3). Increasing the recharge and decreasing the discharge do not compensate the pumping. This situation is not sustainable since at a certain groundwater level the pumping has to be adjusted. As such, the projected rate can no longer be realized.

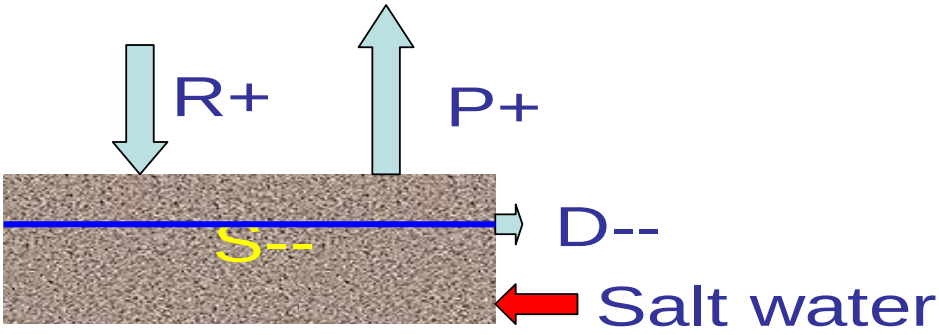

Figure 4. Water balance, with unsustainable pumping and salt water intrusion

Another possibility is a situation near the sea (Figure 4). When the groundwater level decreases too much, salt water from the sea starts to compensate the discharge due to pumping. The groundwater level may become constant (steady state) but the situation is not sustainable as the groundwater gradually becomes brackish and not fit for consumption and irrigation, clearly an undesirable result.

It is hard to find objective and sharp criteria for safe yield. Since groundwater is valuable and safe water supply has a high priority, some undesired results may have to be

accepted. In the end, the decision on safe yield becomes economic - the balance between the cost of the undesired effects and the benefits of groundwater use. The geo-hydrological analysis helps to estimate the effects of groundwater abstraction and can be used in this decision-making.

2.2 Groundwater and Aquifer Characteristics

2.2.1 Abstraction and groundwater level decline

The Cagayan de Oro Water District (COWD) accounts for about 70% of groundwater extraction in CDO (Palanca-Tan and Bautista 2003). Most of the COWD wells can be found in the well fields of Macasandig, Balulang, Canaanan, and Bugo. Figure 5 presents the latest (mostly 2009/2010) measured static levels of COWD wells. As of May 2010, the total amount of abstraction was 121,000 m^3/day (44 million m^3/year).

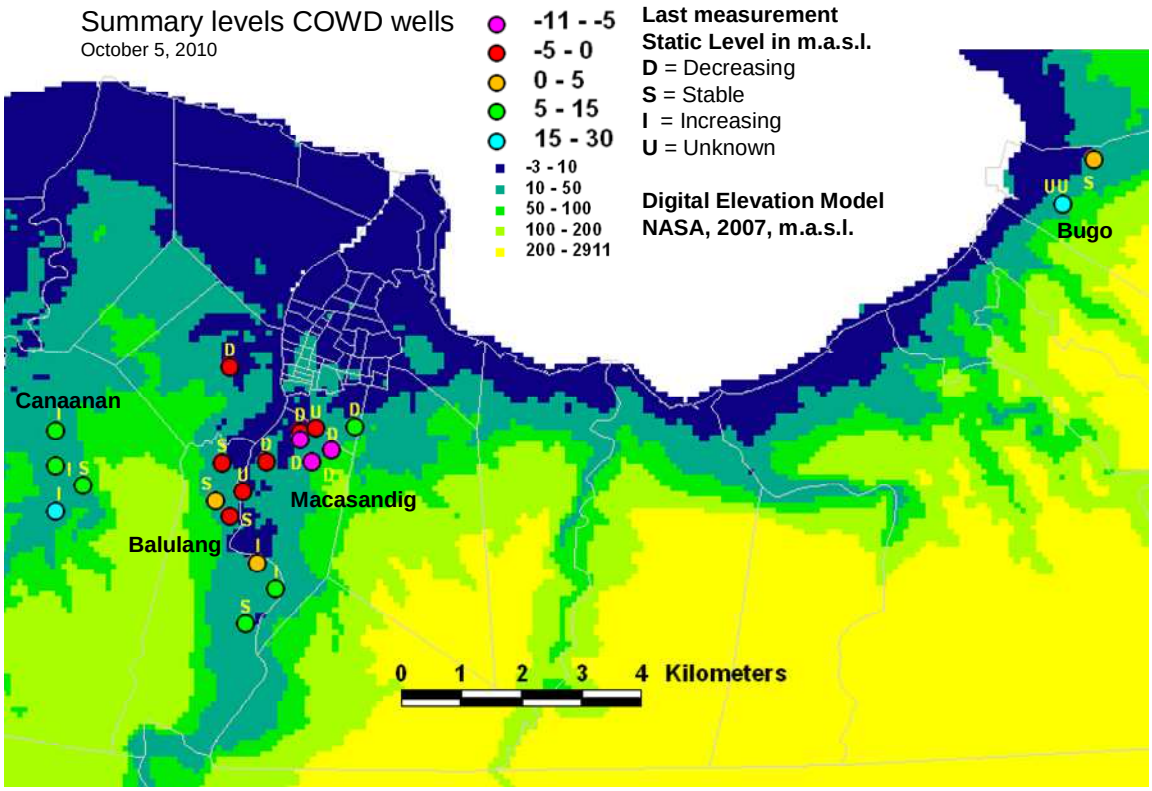

Figure 5. Location and status of some COWD production wells

The Macasandig well field is the oldest. The COWD abstraction rate in May 2010 was 37,000 m^3/day (14 million m^3/year) or 31% of the total. The static levels have been decreasing since the end of the 1970s and are now about 10 m below sea level.

On the other side of the Cagayan River is the Balulang well field. The abstraction rate in May 2010 was 31,000 m^3/day (11 million m^3/year) or 26% of the total. Data on static levels are available from 2000 only. Until 2006 the wells behaved like the Macasandig wells, but after 2006 some wells stabilized or recovered. This coincided with the production of drinking water from river water by Rio Verde (COWD's bulk water supplier from 2007). The

production in Balulang is still substantial. The static levels of the most southern wells are above sea level; the northern wells are a few meters below.

The Calaanan well field is in the Iponan watershed, west of the Cagayan River. The abstraction rate in May 2010 was 4,600 m^3/day (2 million m^3/year) or 4% of the total. According to a COWD operator, the Calaanan well field is connected to the same pipeline as the Rio Verde delivery. The abstraction wells are shut down if the pressure in the pipeline is high enough. This explains the low production rate in May 2010. The Calaanan wells showed a large decrease in static level until the start of Rio Verde operations in 2007. After the start of the use of river water, the static levels increased to about 10 m above sea level.

The Bugo well field is in the very east of CDO. The abstraction rate in May 2010 was 48,000 m^3/day (18 million m^3/year) or 40% of the total. Only very limited static level data are available. COWD well no. 5's level is falling, but still almost 5 m above sea level.

Based on the data presented, we may conclude that COWD water production from its wells locally decreases the groundwater level by a maximum of 20 m. The groundwater levels are locally lower than the sea water level.

2.2.2 Well depth and groundwater flow

COWD uses deep wells for water abstraction as illustrated in Figure 6, which plots well depth versus percentage of total abstraction. Wells less than 100 m deep account for only 3% of produced water. Most of the water (64%) is abstracted at a depth of 200 m or more. The surface level of the wells is mostly around 10 m above sea level.

Deep wells abstract water that is recharged on a large distance stream upwards, while shallow wells abstract water from nearby recharge (Figure 6). Water abstracted in CDO could be from recharge from Bukidnon rather than from Cagayan de Oro. The water that is not abstracted is likely discharged to the sea.

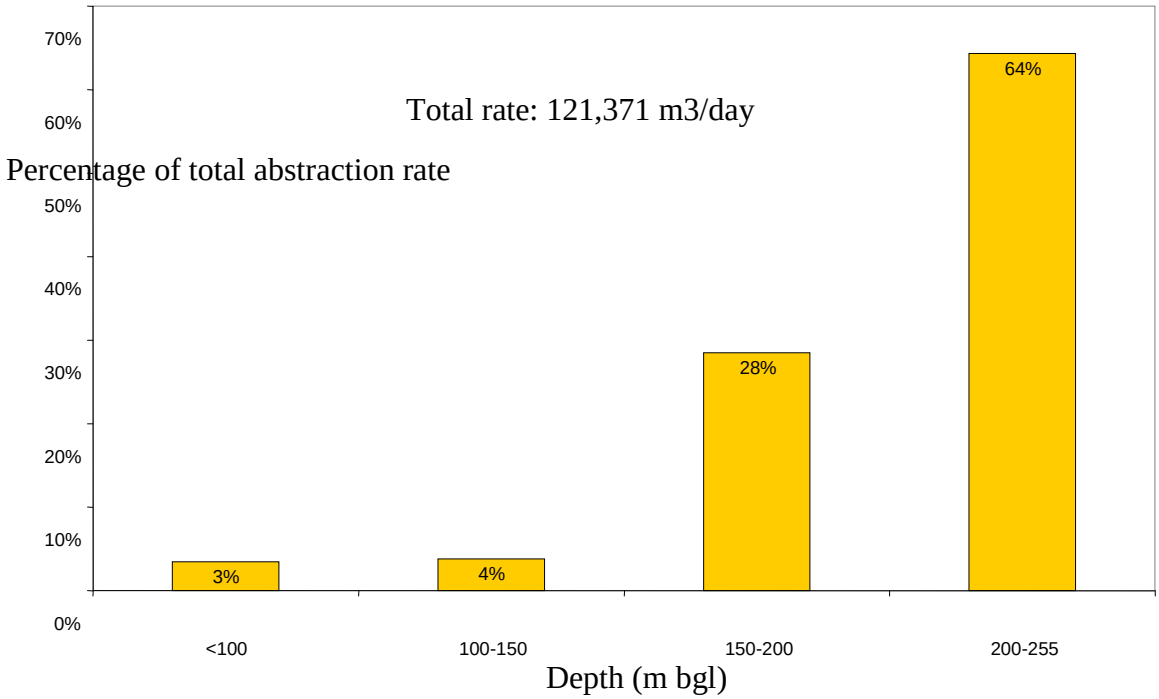

Figure 6. COWD wells: depth and abstraction rate, May 2010

Figure 7 presents a schematic view of the aquifer and the aquitard. The aquifer consists of water permeable soil layers (e.g., gravel, sand, limestone, sandstone) that transport groundwater horizontally while the aquitard is made up of impermeable or low permeable layers (e.g., loam, clay, basalt, granite) where the horizontal flow is negligible. Often some vertical flow (infiltration or seepage) is possible. Groundwater wells are constructed with screens in aquifers, because it is impossible to abstract water from aquitards due to the low permeability. It will help to discuss the properties of aquifers and aquitards, because they determine how much water can be transported.

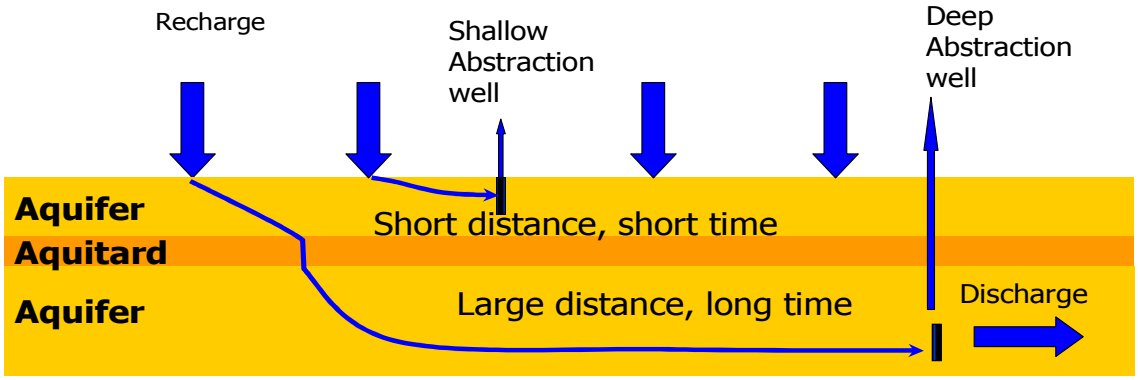

Figure 7. Schematic view of flow to a shallow well and a deep well (vertical cross section)

2.2.3 Aquifer transmissivity, aquitard resistance, and groundwater level

Groundwater flow is described by the Law of Darcy, which states that the specific groundwater discharge is proportional to the gradient:

$$q = -iK \qquad \text{(Equation 1)}$$

where q is specific discharge ($m^3/d/m^2$), i is hydraulic gradient (m/m), and K is aquifer permeability (m/d).

The Law of Darcy assumes the groundwater flow to be laminar, the kinetic energy negligible, and the fluid properties (density, viscosity) homogeneous. For most groundwater systems these assumptions are valid. However, at near pumping wells or in underground channels in Karstic areas, the groundwater flow may become turbulent and the Law of Darcy is less accurate.

For an aquifer with a thickness D, the transmissivity $T=KD$ (m^2/d) can be determined by pumping tests. The flow through a 1 meter wide cross section of the aquifer is:

$$Q' = -iKD = -iT \qquad \text{(Equation 2)}$$

where Q' is discharge per meter aquifer ($m^3/d/m$), D is aquifer thickness (m), and T is aquifer transmissivity (m^2/d).

In aquitards the flow is vertical. The specific flow rate is:

$$q = \frac{(H_1 - H_2)}{D} K_v = \frac{(H_1 - H_2)}{C}, \qquad \text{(Equation 1)}$$

where q ia specific discharge in downward direction ($m^3/d/m^2$), H_1 is groundwater level in the aquifer above the aquitard (m.a.s.l.), H_2 is groundwater level in the aquifer below the aquitard (m.a.s.l.), K_v is vertical permeability of the aquitard (m/d), and C is resistance of the aquitard D/K_v (d).

The permeability of the aquifer and aquitard depends on the type of material they consist of, which is determined by the geology.

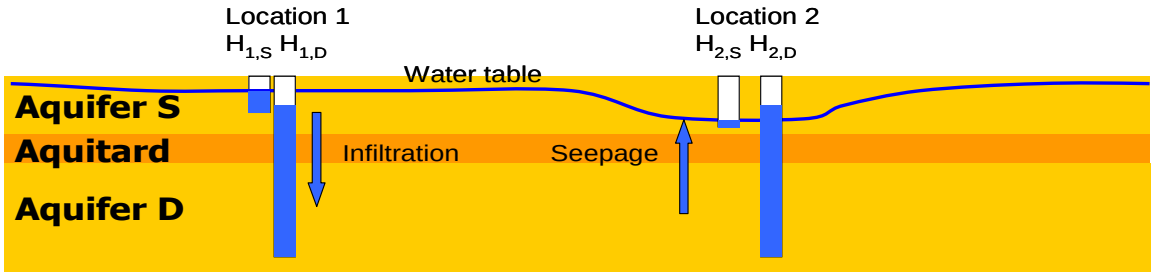

Figure 8. Groundwater levels and vertical flow (vertical cross section)

In Equation 3, the term “groundwater level in an aquifer” appears. It should be noted that this level may not necessarily be the same as the water table. The difference is illustrated in Figure 8. In location 1 the level of the shallow aquifer S is higher than the level of the deeper aquifer D. The static level in the well $H_{1,D}$ will be lower than the water table. This

situation results in infiltration from the shallow aquifer to the deeper aquifer. In location 2 the level of the shallow aquifer S is lower than the level of the deeper aquifer D. The static level in the well $H_{2,D}$ will be higher than the water table. The resulting upward flow is called seepage.

2.3 Geology

Our project collaborators from the National Water Resources Board (NRWB) conducted geo-resistivity tests in April 2010 and came up with a report (NWRB 2010) from which we excerpted the geologic description below.

The oldest rocks in Misamis Oriental, the province where CDO city is located, are the pre-Tertiary schists, slates, and ultramafic rocks previously referred to as the basement. The above Cretaceous rocks are unconformably overlain by the Eocene Himalyan Formation composed of metamorphosed volcanic and sedimentary rocks. This formation is in turn locally overlain by patches of lower Miocene recrystallized limestone. The Tood Formation consisting of sedimentary rocks and basalt with intercalated pyroclastics overlies the Himaylan Formation.

Widespread in Misamis Oriental and underlying most of the low hills fringing the high ridges is the Opol Formation. This sedimentary and pyroclastic rock unit conformably contacts with the older formations. Fringing the coastline and capping older formations is the Pliocene Indahag Limestone including the Laguindingan Coral Reef Limestone. Along the coast is Recent Alluvium composed of semi-compacted sand, gravel shale, and tuffaceous sandstone.

The geologic units of the study area and its immediate vicinity, and the main geologic formations are discussed below.

Recent Alluvium. The recent alluvial deposits are confined to the mouths of major drainage systems, outwash plains, and along narrow coastal belts. These recent coral reefs and unconsolidated sediments deposited along the coast, coastal flats, in the flood plains and channels of the various drainage systems and in the alluvial fans and deltas formed by rivers and creeks. The unconsolidated sediments consist essentially of clay, silt, sand, and/or gravel interlayered with each other. The recent coral reefs, on the other hand, are concentrated along or very near the present coastline.

Where very permeable and coarse grained alluvial deposits exist, groundwater rich reservoirs are found, especially if the beds are well sorted and porous and the interstices between grains are hydraulically connected.

Holocene to Pleistocene Bulua Limestone. This limestone formation is observed in Barangay Bulua and in the army compound at Camp Evangelista. A small outcrop is likewise encountered on the road to Malasag Spring near the highway. Generally porous, coralline, poorly bedded, and karstic, this limestone occupies the northern flank of the Cagayan terrace gravel.

Holocene to Pleistocene Cagayan Terrace Gravels. The formation is composed of interbedded conglomerate, gravel, sand, shale, and tuffaccous sandstone, making it capable of direct recharge from rainfall with good horizontal permeability.

Pleistocene Bukidnon Formation. The formation is shallow marine depositional environment, from volcanic ejecta of boulders, gravel, sandstone, tuff mud, and ash. It is estimated to be 700-800 meters thick and is the source of the large-producing wells of COWD.

Pliocene Iponan Clastics. The Iponan Clastics are exposed in a narrow elongated strip east of Iponan River. They are composed of poorly sorted conglomerate, sandstone, and shale. The sandstone and shale are carbonaceous in places. Bedding planes are generally well-defined, trending either northeast or northwest and dipping 5 to 20 degrees northeast or northwest, respectively. The total thickness of this formation is about 50 meters.

Pliocene Indahag Limestone. This Pliocene occurs along the seashore from Opol westward to Lugait and Iligan City. The coralline limestone is massive to well-bedded, dull white to brown and red. It is interbedded with thin layers of calcareous sandstone and limy tuff. The thickness ranges from 250 to 300 meters.

From a groundwater point of view, the formation has interesting hydrogeological characteristics. Springs are relatively abundant in this formation, suggesting good permeability. In highly karstified and poorly consolidated coralline, limestone yields of more than 10 lps are common.

Upper Miocene Opol Formation. The Opol Formation covers most of the low hills, fringing the high ridges in the western half of Misamis Oriental. The formation consists mainly of agglomerate, with interbeds of tuff, tuffaceous pebbly sandstone, and conglomerate. The agglomerate consists of volcanic rock fragments set in a buff to gray, tuffaceous, and pumiceous matrix.

In terms of groundwater availability, these formations could constitute poor to medium aquifer yielding properties. Wells drilled into the formation have yields ranging from 0.18 to 6.30 Ips. The Opol Formation is estimated to be 100-150 meters thick.

Ultramafic Complex and Umalag Schist. Underlying the extremely rugged grounds in the east-central portion of the study area are the two oldest rock formations: ultramafic complex and Umalag schist. The ultramafic complex is composed of dunite, pyroxene peridotite, and serpentinite; it is dated Cretaceous. On the other hand, the Umalag schist is the oldest rock consisting of metamorphic rocks that vary from crystalline schist to green schist facies. These two formations, in fault contact with each other, are generally impermeable."

The area of the described geology is smaller than the CDO River Watershed and is valid for a strip of 10 km wide along the coast around CDO City. Most of the abstractions are within this strip, but the groundwater might come from further land inward recharge. Due to time limitations the geology of high areas in Bukidnon is not included.

2.4 Safe Yield Estimates

Two methods were used to estimate safe yield. The first method is based on the water balance of the CDO River Watershed. The second method utilizes the natural hydraulic gradient and aquifer transmissivity to estimate the discharge to the sea.

2.4.1 Safe yield based on the CDO River watershed

The flow of the precipitation in the CDO Watershed is presented in Figure 9. Part of precipitation P evaporates or is used by plants. This process is called evapotranspiration (ET). The remaining water is partly discharged by the CDO River or flows through the aquifers to the sea. The water in CDO River comes from surface runoff during strong rains as well as groundwater river discharge.

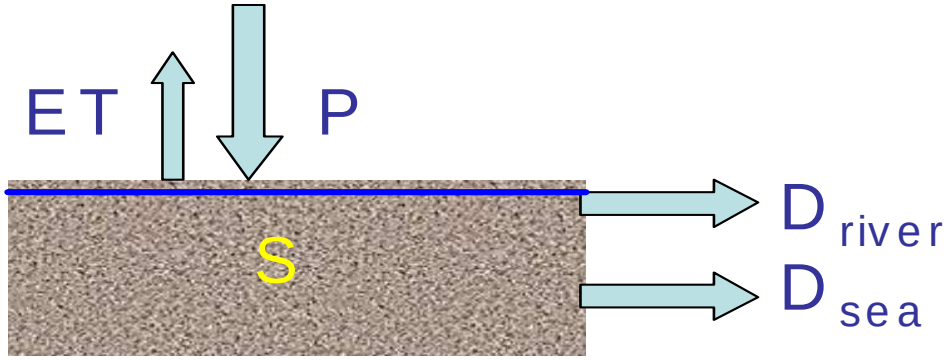

Figure 9. Water balance of the CDO River watershed (natural conditions)

Since CDO is near the sea and groundwater abstractions are deep, the wells abstract groundwater that under natural conditions would flow to the sea. Therefore it is reasonable to relate the safe yield and the discharge to the sea.

Assuming a steady natural state situation, we can neglect the water storage S in the aquifer, and the water balance is:

$$Q_P - Q_{ET} - Q_{River} - Q_{Sea} = 0, or$$
$$Q_{Sea,WS} = Q_P - Q_{ET} - Q_{River} \quad \text{(Equation 4)}$$

where Q_P is flow rate precipitation (m^3/year), Q_{ET} is flow rate evapotranspiration (m^3/year), Q_{River} is flow rate of CDO River (m^3/year), and $Q_{Sea,WS}$ is flow rate discharge from watershed to sea (m^3/year).

The precipitation is usually measured in rain gauge stations. These stations measure the average rainfall intensity I (mm or inch) over a period (day or year). The flow is calculated by integrating intensity (m/year) over the area (m^2):

$$Q_P = \int I \, dA \quad \text{(Equation 5)}$$

The same holds for evapotranspiration:

$$Q_{ET} = \int ET \, dA \quad \text{(Equation 6)}$$

Often net precipitation (precipitation - evapotranspiration) is used in the calculation:

$$Q_{P,n} = Q_P - Q_{ET}, \; and$$
$$Q_{Sea,WS} = Q_{P,n} - Q_{River} \quad \text{(Equation 7)}$$

It should be noted that not all groundwater flowing under CDO infiltrates into the CDO River watershed area. The dimensions of the watershed are determined by the shape of

the ground surface, while the catchment area of the groundwater flow is determined by the aquifers, aquitards, and boundary conditions. If we assume that the specific discharge to the sea ($m^3/d/m^2$) for the watershed area is the same as for the groundwater catchment area, then

$$Q_{Sea,GW} = \frac{A_{GW}}{A_{WS}} Q_{Sea,WS}, \qquad \text{(Equation 8)}$$

where $Q_{Sea,\ GW}$ is groundwater flow to the sea (m^3/year), A_{GW} is catchment area of the groundwater (m^2), and A_{WS} is the catchment area of the watershed (m^2).

The net precipitation and the discharge of the CDO River have to be determined to calculate the discharge to the sea.

2.4.1.1 Cagayan de Oro River watershed

The watershed of CDO River consists of an area of 136,047 ha south of the city. The largest part is in the municipality of Talakag. Other local government units involved are Libona, Baungon, Iligan City, and CDO City. The watershed covers the provinces of Bukidnon, Misamis Oriental, and Lanao del Norte. Since most of the watershed is in Bukidnon, the Community Environment and Natural Resources Office (CENRO) in Talakag is in charge of managing the watershed.

Elevation. The watershed ranges from the Kitanglad and Kalatungan mountains (2500 masl) to CDO City where collected water discharges into Macajalar Bay. Using 90 m solution data (PHILGIS 2010), the elevation distribution was calculated (Figure 10).

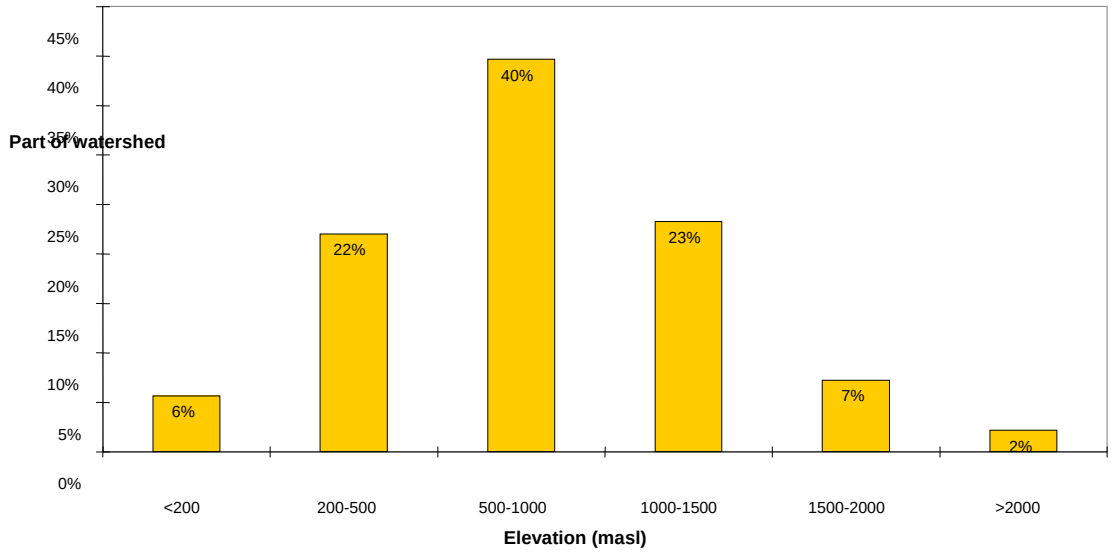

Figure 10. Elevation distribution of the Cagayan de Oro River watershed

A large part (40%) is between 500 and 1000 masl. The average elevation is 828 masl. As discussed in the next section, elevation and precipitation are related.

Land use. Although CDO City and the municipalities are developing fast, the built-up area covers only 2% of the watershed (Table 1). About 62% of the watershed area is wooded

land and 36% is grassland and cultivated crop areas. It should be noted that in the higher plains, the crops planted and the scale of cultivation differ from those in the lower areas.

Table 1. Land use classification in the CDO River watershed, 2010

Land Use Class	Code	Area (ha)	Area (%)
Closed forest, broadleaved	NF4F	17,804	13%
Forest plantation, broadleaved	FPB	0	0%
Mangrove forest	NFM	68	0%
Open forest, broadleaved	NF2B	18,885	14%
Other wooded land, shrubs	Sh	32,572	24%
Other wooded land, wooded grassland	WGL	15,591	11%
Natural, grassland	GL	16,833	12%
Cultivated, perennial crop	PC	7,976	6%
Cultivated, annual crop	AC	23,923	18%
Built-up area	BUA	2,137	2%
Inland water	IW	241	0%
Total		**136,031**	**100%**

Source: Cagayan de Oro River Council (2010)

Precipitation and evapotranspiration. The only currently available rainfall data in the watershed area ares from Lumbia Airport (160 masl), CDO City. This station is not representative of the entire watershed area since in the higher parts the rain is much stronger. Additional data from Malaybalay (Bukidnon, 623 masl) were used.

Table 2a. Rainfall and reference evapotranspiration in Cagayan de Oro

	Rainfall (mm/day)	**Monthly Rainfall (mm)**	**Reference Evapotranspiration (mm/day)**	**Monthly Reference Evapotranspiration (mm)**
January	3.7	116	3.3	102
February	2.5	69	3.6	99
March	1.7	52	4.1	127
April	1.4	41	4.3	128
May	3.1	97	4.0	125
June	6.9	208	3.9	117
July	6.7	207	3.9	121
August	6.7	208	4.0	123
September	7.5	226	4.0	119
October	5.7	176	3.8	116
November	4.6	138	3.5	104
December	2.9	90	3.3	101
Average/Total	4.5	**1,628**	3.8	**1,382**
Net Rainfall Intensity RI = 1,628 mm/year – 90% of 1,382 mm/year = **383** mm/year				

Table 2b. Rainfall and reference evapotranspiration in Malaybalay

	Rainfall (mm/day)	**Monthly Rainfall (mm)**	**Reference Evapotranspiration (mm/day)**	**Monthly Reference Evapotranspiration (mm)**
January	3.3	103	3.2	100
February	3.8	106	3.5	97
March	3.3	101	3.7	114
April	3.6	108	4.1	122
May	7.9	244	3.8	117
June	10.7	320	3.6	108
July	10.4	322	3.4	105
August	10.4	323	3.4	105
September	11.4	341	3.6	109
October	10.4	323	3.5	108
November	6.5	195	3.3	99
December	5.4	166	3.1	95
Average/Total	7.3	**2,652**	3.5	**1,281**
Net rainfall intensity (RI) = 2,652 mm/year – 100% of 1,281 mm/year = **1,371** mm/year				

Source: FAO database CLIMWAT for CROPWAT, (http://www.fao.org/nr/water/infores_databases_climwat.html)

Tables 2a and 2b show, as expected, that the rainfall in Malaybalay is higher than in CDO. The difference in the reference evapotranspiration from ETo is only small. Louis Berger International Incorporated (1992) reports a rainfall of over 3,000 mm/year in areas above 1,500 masl.

The reference evapotranspiration is the evapotranspiration of grassland with sufficient water supply during the whole year. As an example, the evapotranspiration of pineapple on bare ground is only 30% of ETo; that of sugarcane is 120% of ETo. Under normal conditions (not like the El Niño in April/May 2010), the clay/loam soil in Cagayan and Bukidnon will store enough water for evapotranspiration during the dry season for a rainfall like Malaybalay. For a rainfall like Cagayan there could be some depletion in April.

CDO River Discharge. A CENRO report (1999) cites data on CDO River discharge (Table 3) from the National Irrigation Authority. It is not clear when these values were measured. The variation in specific discharge (flow rate per surface area) of the sub-watersheds is rather high (749-1,688 mm/year). The sub-watersheds with the highest specific discharge, Bubunawan and Tumalaong Rivers, are just south of CDO City.

Table 3. Data from CDO River and some selected tributaries

River	Location	Area (km^2)	Discharge (l/s)	Discharge (Mm^3/year)	Specific Discharge (mm/year)
1. Batang		301	7,147	226	749
2. Bubunawan		270	14,945	472	1,748
3. Munigi	Bayanga	36	960	30	846
4. Pigkutin	Ticalaan	195	6,409	202	1,036
5. Tumalaong		178	9,536	301	1,688
Cagayan	**Lumbia**	**1,360**	**33,883**	**1,069**	**786**
Sum (1-5)		980	40,881	1,290	1,316
Estimate from 5.		**1,360**	**54,837**	**1,731**	**1,316**

If we accumulate the discharge of the five sub-watersheds, which cover 70% of the CDO watershed area, the discharge (40,881 L/s) would be larger than reported for the CDO River (33.883 L/s). Using the average specific discharge of the five sub-watersheds, the calculated discharge of the CDO River is 54,837 L/s or 1,731 million m^3/year.

A second source of data for the discharge rate is DwoI (2010). The document contains a table that gives monthly average discharge and its standard deviation. Table 4 also includes the calculated specific discharge.

Table 4. Cagayan de Oro River discharge, 1955-1963

Month	Average Discharge (Mm^3)	Standard Deviation (Mm^3)	Average Discharge (l/s)	Specific Discharge (mm/day)	Specific Discharge (mm/year)
January	289	133	107,967	6.86	2504
February	237	127	97,999	6.22	2273
March	212	85	79,271	5.03	1839
April	179	57	69,236	4.40	1606
May	237	81	88,456	5.62	2052
June	271	103	104,375	6.63	2421
July	311	106	116,178	7.38	2695
August	337	72	125,926	8.00	2921
September	325	85	125,536	7.97	2912
October	321	54	119,926	7.62	2782
November	262	84	101,254	6.43	2349
December	332	126	124,070	7.88	2878
Total / Average	**3,224**	**739**	**105,056**	**6.67**	**2437**

The difference in discharge values in Table 3 and Table 4 (a factor 2) is rather large, even after taking into account changes in climate or land use.

2.4.1.2 Estimation of the water balance

The net precipitation and the discharge rate of the CDO River have to be estimated to calculate the discharge to the sea. Then, using equation 4, the flow from the watershed to the sea is calculated by subtracting the river flow from the net precipitation. Finally the total flow to the sea is calculated using an estimate of the aquifer area.

Net precipitation. Table 5 summarizes the calculation of net precipitation. The watershed area is divided into sub-areas according to altitude. It is assumed that the lowest range has “CDO” precipitation and reference evapotranspiration, and that data for Malaybalay are valid for areas 200-1500 masl. For areas above 1500 masl, a higher estimate is used.

Table 5. Estimation of net precipitation

Altitude (masl)	Area (%)	Precipitation Intensity (mm/year)	Ref. ETo (mm/year)	Crop Coefficient K_c (-)	Net Prec. Intensity I_n (mm/year)	Area x I_n (mm/year)
Less than 200	6	1628	1382	0.8	522	30
200-500	22	2652	1281	1.0	1371	302
500-1000	40	2652	1281	1.0	1371	544
1000-1500	23	2652	1281	1.0	1371	319
1500-2000	7	3000	1281	1.0	1719	125
>2000	2	3500	1281	1.0	2219	48
Total	100					**1367**

The crop coefficient is a correction factor for land use:

$$I_n = I - K_C ETo \qquad \text{(Equation 9)}$$

Crop coefficients can be found in FAO (1998). The lower areas contain built-up areas with less evaporation. Further, shortage of precipitation at the end of the dry season might reduce evapotranspiration. Therefore a crop coefficient of 0.8 is used. To determine the average net rainfall intensity, the area weighted mean is determined in the last column of Table 5. An intensity of 1367 mm/year over the watershed area of 1360 km^2 results in a net precipitation flow $Q_{P,n}$ of 1860 million m^3/year. Depending on the assumed crop coefficients and precipitation in higher areas, the value of $Q_{P,n}$ will vary from 1500 to 2300 million m^3/year.

Sources of information on the discharge of CDO River are described in the preceding section. The adjusted value from CENRO (1999) is 1731 million m^3/year. The value from DwoI (2010) of 3224 million m^3/year is inconsistent with estimated net precipitation flow above; that is, more water flows in the river than the net rainfall provides.

Discharge of groundwater to the sea. The discharge of groundwater from the watershed to the sea is net precipitation flow minus CDO River discharge. Since not only groundwater from the CDO watershed area flows to the sea, a larger area is taken into account (Figure 11).

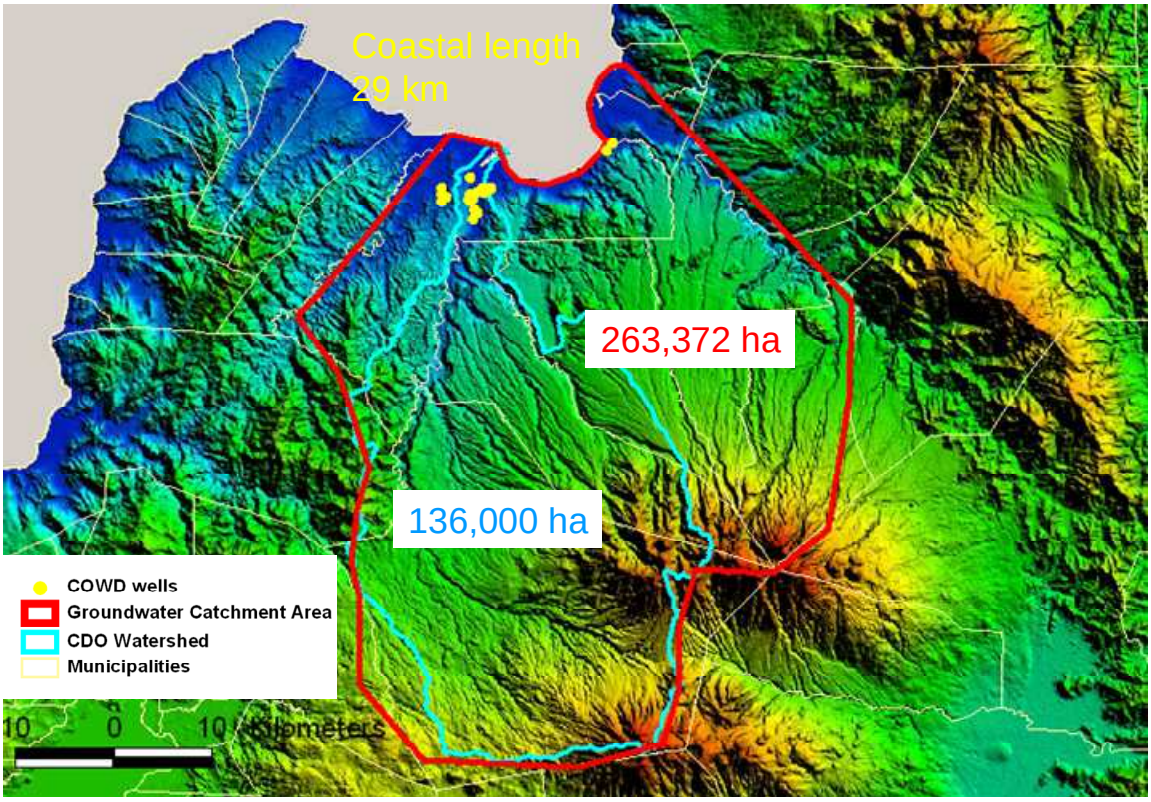

Figure 11. Area of the CDO River watershed and catchment area of the groundwater flowing to the sea

An overview of the four scenarios based on previously described assumptions is presented in Table 6a. The estimated groundwater flow from the groundwater catchment area to the sea ranges from 0 to 1140 million m^3/year. This large spread is caused by the uncertainty in river discharge and net precipitation estimates and the fact that groundwater flow is the difference between these two large terms. Groundwater abstraction of COWD is 44 million m^3/year, much less than the maximum groundwater flow estimate but much higher than the low estimate. This points to the need to check other methods to estimate safe yield.

Table 6a. Estimation of groundwater flow to the sea

Scenario	Net Precipitation Flow $Q_{P,n}$ (Mm^3/year)	CDO River Flow Q_{River} (Mm^3/year)	Groundwater to Sea, Watershed $Q_{Sea, WS}$ (Mm^3/year)	Groundwater to Sea, Catchment Area $Q_{Sea, AQ}$ (Mm^3/year)
1	1500	1731	0	0
2	1860	1731	129	249
3	2300	1731	589	1140
4	2300	3224	0	0

The water balance in the Louis Berger study (1992) is shown in Table 6b below for comparison. It is not clear whether the rainfall intensity in Table 6b is net or gross. Results of the recalculation of the balance suggest that evapotranspiration would only be 22 mm/year, making the 3,000 mm/year almost a net rainfall intensity, which is extremely high. The river discharge is described as "adjusted yield" and is consistent with the mean value for the 1955-1963 data set from DwoI (2010). The resulting flow to the sea is comparable with the second scenario estimate (Table 6a).

Table 6b. Water balance of the Cagayan watershed (Louis Berger International 1992)

Area (km^2)	**Rain I (mm/year)**	**Q_{riv} (Mm^3/year)**	**$Q_{Sea,GW}$ (Mm^3/year)**
1,312	3000	3529	259

2.4.2 Safe yield based on groundwater gradient and aquifer transmissivity

Under natural conditions the groundwater under CDO is discharged to the sea. The gradient of groundwater levels slopes toward the sea. The amount of water flow is dependent on the gradient and the properties of the aquifer (permeability, thickness, and transmissivity). The discharge to the sea is a measure of the safe yield. The safe yield must be less than the discharge to prevent salt water intrusion. The formulas used in estimating the discharge to the sea are discussed in section 2.2.3. The data requirements and sources for our estimates are discussed below.

Transmissivity data are often collected during tests performed before the installation of pumping wells. The following transmissivity data are presented in the recent NWRB geo-resistivity survey of Misamis Oriental (NWRB 2010).

Table 7. Aquifer transmissivity from well tests in Cagayan de Oro

Well	**Location**	**Year**	**CD[1] Transmissivity (m^2/day)**	**RT[1] Transmissivity (m^2/day)**
COWD #2	Macasandig	1976	6525	3625
COWD #4	Buntola,Nazareth	1977	2094	1508
COWD #5	Bugo (Reyes Village Subd)	1975	5324	-

Notes:

(1) CD transmissivity is the transmissivity measured by drawdown while RT transmissivity is transmissivity measured by recovering (rising after drawdown). Theoretically, the two must be equal as transmissivity is an aquifer property and is independent of the test method.

The transmissivity values in Table 7 are quite high. The likely maximum permeability for sand/gravel mixtures is 90 m/day[2]. For a transmissivity of 3,000 m^2/day, a total thickness of 33 meters of sand/gravel layers is needed, which is rather thick[3]. Noting that locations of wells are chosen in the part of the aquifer with the highest transmissivity and as representative transmissivity is needed to calculate safe yield, the extreme high values were ignored and, as in the first methodology, two variants were introduced in the calculation: one assuming a transmissivity value of 1,000 m^2/day and the other, 3,000 m^2/day.

The calculation of the gradient used static water levels (measured right after well construction[4]) presented in NWRB's 2010 Geo-resistivity Survey of Misamis Oriental, and data on distance of well to sea as measured in Google Earth. The ground level needed to relate the static level to meters above sea level was obtained from LWUA. The data on COWD production well no. 10 were sourced from COWD. A well jut after construction is assumed to have a natural static level. This is obviously not the case for COWD production well no. 4 as the well was influenced by already operational wells in the Macasandig well field.

Table 8. Data for well to sea gradient calculation

Well	Name	Location	Year	Static Level (masl)	Distance from Sea (m)	Gradient (m/m)
3945-18	Army Hospital	Patag	1967	11.85	2,300	0.0052
3945-3	Bgy. Canitoan	Canitoan	1953	10.17	4,700	0.0022
3945-41	COWD#4	Buntola,Nazareth	1977	-0.35	3,000	
3945-40	COWD#2	Macasandig	1976	6.97	2,800	0.0025
3945-32	Lumbia Airport	Lumbia	1953	30.00	10,000	0.0030
3945-94	COWD#5	Bugo	1975	8.50	1,200	0.0071
10026	COWD#10	P.N. Roa Calaanan	1987	12.43	6,200	0.0020

[2] U.S. Geological Survey, Documentation of Spreadsheets for the Analysis of Aquifer-Test and Slug-Test Data. Open-File Report 02–197, Carson City, Nevada 2002

[3] The LBBI (? please spell out) study also observed very high transmissivity values for CDO and attributed these large transmissivities to faults and fractures (? reference?).

[4] It is assumed that the wells just after construction have a natural static level. This was not the case for COWD well no. 4, which was influenced by existing and operational wells in the Macasandig well field. Hence, the value for COWD #4 was excluded in the calculation.

In calculating the gradient, the pressure in the sea was assumed as 0 masl. The wells, however, are about 200 m deep and, due to the higher density of salt water compared with fresh water, the fresh water pressure in the sea was 5 masl. The likely effect is a decrease in the gradient. Hence, a second calculation was performed using a pressure of 2.5 masl.

Although the abstraction wells are concentrated in a limited number of locations[5], the total length (29 km) of the CDO coast was used in the calculation.

Table 9. Estimated natural groundwater discharge to the sea, CDO

Variant	Discharge (m^3/day)	Discharge (Mm^3/year)
Low: T=1000 m^2/d; sea pressure of 2.5 masl	80,452	29
High T=3000 m^2/d; sea pressure of0 masl	317,455	116

The calculated discharges presented in Table 9 correspond to water that is not only infiltrated in CDO but also in Bukidnon, and thus should be compared with the values derived for the CDO aquifer in the water balance method. The figures in Table 9 are an order of magnitude lower. Compared with the current production of COWD alone of 115,000 m^3/day or 42 million m^3/year (May 2010), this indicates that a large portion of the natural discharge, and possibly even more, is used for water production, causing a drawdown below sea level and local salt water intrusion. This finding is consistent with the low groundwater levels (below sea level) found in the Macasandig well field.

3.0 GROUNDWATER EXTRACTION

3.1 Continuing Economic and Population Growth in CDO

Economic activities and population in CDO have grown fast since the 1980s. Owing to high in-migration, the average annual population growth rate of CDO city from 1980 to 1995 was 4.2%, which is about double the annual population increase in northern Mindanao and the entire country (Table 10). Population growth in the city was faster in the 1990-1995 period than in the preceding decade**.** Apart from absolute growth, the geographical distribution of the population changed also. While the number of people in the *poblacion*

[5] The effect of the concentration of the wells in well fields will be determined later and further adjustments in the estimation will be made accordingly.

dropped in absolute terms during the 1990-1995 period, the population of the non-*poblacion* and rural areas grew markedly especially in the first half of the 1990s. Some residents moved out of the central business district and government area to the city's outskirts possibly because of the more affordable land and housing and the low population density in those areas. Population outside the *poblacion* also rose because of in-migration that has accompanied commercial and economic growth. The growth and geographical shifts of the population necessarily entailed an increase in built-up areas and changes in land use. Data on land use changes from the City Assessment Department reveal that residential and commercial areas almost doubled, reflecting the urbanization process, while industrial lands grew more than ten-fold from 1985 to 1995 as a result of economic growth (Table 11). The new subdivisions were established either along the rivers and bay or on more elevated areas while the new commercial and industrial establishments were erected along the main highways. The increase in the proportion of lands under residential, commercial, and industrial establishments from 5% in 1985 to 11% in 1995 more than doubled the so called built-up area in the city.

Table 10. Population in Cagayan de Oro, 1980-2007

	Population			**Average Annual Growth Rate (%)**	
	1980	**1995**	**2007**	**1980-1995**	**1995-2007**
Poblacion	41,288 (18)	34,568 (8)	40,595 (7)	-1.18	1.58
Non-*poblacion* and rural *barangays* (villages)	186,024 (82)	393,746 (92)	517,577 (93)	7.44	2.86
Total	227,312 (100)	428,314 (100)	558,272 (100)	4.22	2.76

Source: Cagayan de Oro City Planning and Development Office
Note: Figures in parentheses are percent shares.

Table 11. Declared land uses in Cagayan de Oro, 1985-2007

Land Use	Area (ha)			Average Annual Growth Rate (%)	
	1985	1995	2007	1985-1995	1995-2007
Agricultural	45,908 (94)	21,846 (45)	20,338 (42)	-5	-1
Residential	2,223 (5)	4,699 (10)	7,034 (14)	11	4
Commercial	120 (0)	244 (0)	833 (2)	10	20
Industrial	50 (0)	571 (1)	126 (0)	104	-6
Institutional	81 (0)	13 (0)	204 (0)	-8	122
Exempt and other properties	48 (0)	2,738 (6)	1,393 (3)	560	-4
Open spaces	455 (1)	18,774 (38)	18,958 (39)	403	0
Total	48,885 (100)	48,885 (100)	48,885 (100)		

Source: Cagayan de Oro City Planning and Development Office

Note: Figures in parentheses are percent shares.

Rapid economic growth in the city continued through the latter half of the 1990s and the 2000s. Average annual population growth of the city from1995 to 2006 was at a high rate of 2.8%. During this period, population in both *poblacion* and non-*poblacion*/rural *barangays* (villages) expanded, with the latter growing markedly faster. Thus, a similar trend as in 1980-1995 could be observed. From 1995 to 2007, built-up areas further expanded by 45%. This was largely due to the 241% increase and 50% increase in commercial and residential areas, respectively.

3.2 Cagayan de Oro Water District (COWD)

A survey of deep wells in 2000 showed that at that time, COWD was in the midst of its Phase 3 expansion project, which was funded by a PhP 500 million (USD 9.344 million) loan from the Overseas Economic Cooperation Fund. The expansion project increased the total number of COWD production wells to 29 (Table 12). As of May 2010, only 26 wells were operational; PW6 has not been used since 1999 while PW8 and PW12 were on stand-by for rehabilitation and reconditioning.

Table 12. COWD wells

Name	Location	Year Const	Depth	Discharge (liters per second)				
				1983	1991	1997	2000	2010
PW6	Bantiles, Bugo	1965	18	32	19	16	Stand-by	
PW2	Bontula, Macasandig	1976	220	103	95	70	76	53
PW5	Reyes, Bugo	1976	76	50	38	34	44	29
PW1	Macasandig	1977	248	91	95	121	152	118
PW4	Macasandig	1977	211	113	126	82	58	57
PW7	Macasandig	1985	200		126	95	102	73
PW8	RamonalVil, Macasandig	1986	255		150	125	156	Rehab
PW9	Biasong, Macasandig	1987	236		150	112	124	134
PW12	PN Roa Subd, Calaaanan	1991	139			28	17	Recon
PW3a	Macasandig	1994	204			118	95	22
PW14	Balungis, Balulang	1994	150			78	96	71
PW15	Calaanan	1994	104			55	30	30
PW10	PN Roa Subd, Calaanan	1996	122		80	55	22	14
PW16	Tomas Saco, Nazareth	1996	187			78	151	59
PW11	Bantiles, Bugo	1997	152			117	136	115
PW17	Balulang	1997	186			44	36	63
PW18	Pueblo de Oro, Calaanan	1997	132			32	19	20

PW19	Balulang	1997	216			150	12	97
PW20	Villa Trinitas, Bugo	1997	200			63	76	51
PW21	Villa Trinitas, Bugo	1998	194				120	83
PW22	Villa Trinitas, Bugo	1999	200				120	101
PW23	Agusan	1999	200				120	112
PW25	Villa Angela, Balulang	1999	226				61	89
PW26	Balulang	1999	216				46	37
PW27	Macanhan, Carmen	1999	207				66	52
PW24	Balulang	2000	57				40	28
PW28	Phasco Vil, Tablon	2000	159				114	88
PW29	Phasco Vil, Tablon	2000	201				114	89

Source of data: COWD

COWD's last expansion project raised its groundwater production capacity by more than 30%, to about 130 thousand m^3 per day (Table 13). This enabled COWD to increase its water production from 77 thousand m^3 per day in 1999 to 117 thousand m^3 per day in 2006. This was tantamount to an increase of 52%, a rate much higher than the increase in its groundwater production capacity. The increase in production was also made possible by increasing capacity utilization of wells from a historical average of about 80% to about 90% in 2005 and 2006, reflecting the increasing strain on its groundwater supply systems.

Table 13. COWD production and consumption data, 1999-2010

Year	Production Capacity (m^3/day)			Production (m^3/day)	Groundwater Capacity Utilization (%)
	Groundwater	Surface Water	Total		
1999	96,940		96,940	77,256	79.69
2000	96,011		96,011	74,910	78.02
2001	94,186		94,186	78,914	83.79
2002	97,464		97,464	77,747	79.77
2003	105,065		105,065	87,085	82.89
2004	115,462		115,462	96,209	83.32
2005	122,643		122,643	111,733	91.10
2006	130,883		130,883	117,010	89.40
2007	133,641	40,000	173,641	133,385	69.88
2008	129,067	40,000	169,067	132,457	71.64
2009	129,067	40,000	169,067	145,331	81.61
2010	129,067	40,000	169,067	146,895	82.82

Source of data: Cagayan de Oro Water District

In 2007, COWD started buying bulk water from Rio Verde. Rio Verde sources its water from Bubunaon River, a tributary of Cagayan River. COWD committed to buy from Rio Verde a minimum of 40 thousand m^3/day in 2007-2010. Thus, of the total COWD water production of 133 thousand m^3/day in 2007, only 93 thousand m^3/day was extracted from the ground, a more relaxed capacity utilization rate of its wells of just 70%. Groundwater withdrawal rate for 2008 was slightly slower at 92 thousand m^3/day. With 40 thousand m^3/day bulk surface water purchased from Rio Verde, COWD is currently extracting groundwater at a rate of a little below 110 thousand m^3/day, about 30 thousand m^3/day more than in 1999.

The increase in COWD water production has been necessary supposedly to meet the continuing increase in demand for water in CDO as a result of continuing population and economic growth. Interestingly, data in Table 14 below suggest another thing. Between 1999 and 2010, the number of COWD service connections increased by 41% (3.2% annual average) and the length of COWD pipelines, by 48%. Surprisingly, water consumption or billed water during the same period grew only by 12%, an annual average growth rate of less

than 1%. Presumably, total water production (including surface water) had to be increased at a remarkably much higher rate of 90% because of the aggravating proliferation of unaccounted water which has surpassed 50% of COWD water production since 2007. According to COWD officials, the increase in the proportion of unbilled water is due to leakages in the distribution system as they are unable to replace old pipelines promptly due to budgetary constraints and government red tape, constraints they have been facing ever since the Water District was reverted to government control; some of it was also due topilferage. This points to an equally critical issue in water resource management in the city: inefficiency. The current status of groundwater depletion in Cagayan de Oro may be controlled to a substantial extent by addressing inefficiencies in the Water District's operations.

Table 14. COWD Service Connection, Pipeline, and Sales, 1999-2010

Year	No. of Service Connections	Length of Pipelines (m)	Production (m^3)	Consumption (billed water, m^3)	Unaccounted Water (%)
1999	54,343	339,992	28,198,382	21,366,680	24.23%
2000	55,470	341,384	27,342,239	20,384,885	25.45%
2001	55,425	349,229	28,803,751	20,470,217	28.93%
2002	58,194	357,664	28,377,625	19,901,310	29.87%
2003	60,327	376,833	31,785,978	21,592,997	32.07%
2004	62,087	384,317	35,116,160	22,230,808	36.69%
2005	64,284	421,661	40,782,458	23,031,094	43.53%
2006	66,168	435,424	42,708,791	22,983,821	46.18%
2007	68,421	456,419	48,685,349	23,008,670	52.74%
2008	70,944	467,351	48,346,968	22,497,424	53.47%
2009	74,020	481,114	53,045,855	23,266,261	56.14%
	76,351	504,754	53,616,511	23,916,766	55.39%
Growth Rate					
1999-2010	40.50%	48.46%	90.14%	11.93%	-
Annual Average	3.23%	3.75%	5.19%	0.87%	-

Source of data: Cagayan de Oro Water District

3.3 Non-COWD Groundwater Extraction

3.3.1 Additional groundwater extractors and deep well systems

From Table 14, it can be deduced that the increase in water demand in CDO due to continuing economic expansion and population growth has not been supplied by COWD but by private construction of deep wells. The past decade witnessed the mushrooming of hotels, commercial complexes, and residential subdivisions in CDO, most of which put up their own deep-well systems.

The research team's updated the list of non-COWD deep wells indicates that the number of industries and institutions (hospitals, schools) with their own deep well systems has remained the same, but the number of wells has increased. Two major establishments among them had constructed new wells. One of the five big industrial establishments in the 2000 list added two new wells in 2002 and 2003. One of the 18 institutional establishments constructed three new wells in 2000, 2003, and 2005.

Of the 36 establishments added to the 2000 list of commercial establishments with own deep well systems, 33 are hotels, 1 is a newly-developed shopping complex which dug three deep wells, 1 is a memorial park, and 1 is a bakeshop.

Six subdivision developers and management companies are providing through their own deep-well systems the water requirements of 27 subdivisions. Table 15 indicates the land area and number of units/lots of new subdivision developments. Though many of these lots and housing units are not yet occupied, this information gives us an idea of future groundwater extraction from their deep wells[6].

Table 15. List of new/additional subdivisions (granted permit to sell, 2000-2010) with own deep well systems (non-COWD)[1]

Subdivision/Location	Year License Granted	Area (m^2)	No. of Lots/ House & Lot Units
Crown Communities, Inc			
Portico I and II, Lumbia	2002, 2008	205,013	861
Lessandra Subdivision, Lumbia	2009	57,281	526

[6] There are a total of 11,173 units/lots (combined commercial and residential units); this multiplied by the average water consumption of an average household (low estimate as average daily household consumption was used even for commercial units for this initial estimate) will result in an additional daily water demand of about 25,000 m^3/day.

La Mirande, Lumbia	2007	115,416	245
Montana Vista I and II, Lumbia	2000, 2004	142,447	657
Frontiera, Frontiera II, Canotoan	June 2000	94,067	191
Brown Co., Inc.			
Xavier Estates Phase IIA, III, IV, Upper Balulang	2000, 2001, 2002, 2006, 2009, 2010	716,438	1,384 (1 institution)
Pueblo de Oro Development Corp			
The Courtyards at Pueblo de Oro, Macapagal Drive, Upper Carmen	2009	11,702 (land area)	Horizontal condo Cluster 1-6 units
Pueblo de Oro Township – Business Part I, II and III, Canitoan	2004, 2008	42,273	37 commercial lots
Forest View Home I and II, Canitoan	2008	40,930	519
Pueblo de Oro Township– Golf Estates (residential lots) Clusters 1-3, 6, 7 Canitoan	2000, 2001, 2007	239,194	294
Vista Verde Village I, II and III, Upper Canitoan	2005, 2007	91,804	377
Masterson Mile South, Upper Canitoan	2004	13.705	25 commercial lots
Regatta Square, Upper Canitoan	2004	21,325	37
Golden Glow Village North I and II, Upper Carmen	2001, 2004, 2009	204,522	678 189 commercial lots

Golden Glow Village Annex , Canitoan	2003	28,135	131
San Agustin Valley Homes Phase I and II, Canitoan	2001, 2002	219,002	1,591
Philamlife Village Phase I, II and III, Canitoan	2001	71,765	159
Golden Village Subdivision, Carmen	2004	11,637	18
Primavera Residences, Pueblo de Oro Township Business Park, Upper Carmen	2010	1,125 (land) 9,034.63(building)	116 9 commercial
Liberty Land Corporation			
Southview Homes, Upper Macasandig	2000	61,272	297
Southview Homes Annex, Upper Macasandig	2000, 2004	13,402	71
Woodland Heights, Upper Macasandig	2003, 2004	61,244	192 34 commercial lots
Kisan Lu Realty Inc			
Kisan Lu Pag-ibig City, Iponan	2003, 2005	249,201	1,208
Robinson's Homes, Inc.			
Robinson Hillborough Pointe II , Canitoan	2002	190,212	624
Fresno Parkview, Lumbia	2009	140,601	490
Monte del Sol (no info yet with HLURB)			(surveyed to have ongoing construction w/ deep well)

Johndorf Ventures Corporation			
Vista Grande, Canitoan	2005	26,654	204

Source of data on subdivisions in the list: HLURB, Region X, Projects Issued Licences to Sell Dataset

Note: List of new/additional subdivisions with own deep wells generated by actual survey of all subdivisions.

3.3.2 Deep well inventory and groundwater user survey

The research team with two NWRB staff conducted a deep-well inventory on 31 August-4 September 2010. The team stayed at the conference room of CPDO, CDO City Hall on 1-3 September 2010 to administer and receive inventory forms as well as to administer a groundwater user survey questionnaire. During those three days, 21 deep-well owners with 44 deep well systems came; they represented 17% of the 126 deep-well owners in the updated list (Table 16). It is to be noted that the number of deep-well owners in the present list is smaller than the old list, which was purged of establishments that are either non-existent or had already abandoned their wells (included in the list of 197 deep-well owners reported in the 2003 study).

Table 16. Deep-well owners/operators who submitted inventory and survey forms

	No. of Deep-well Owners/operators	**No. of Deep Wells**	**Reported Groundwater Extraction (m^3/day)**
Big industries	3	11	501,187
Medium industries	1	2	20,010
Commercial & hotels[1]	12	17	17,490
Subdivision owners/developers	2	8	86,725
Institutions	3	8	6,330
Total	**21**	**46**	626,045

Note: The six hotels that submitted the inventory and survey forms did not respond to the question on their actual groundwater extraction.

Three of the five big industrial establishments in CDO that submitted their inventory form and/or survey questionnaire have a combined groundwater withdrawal of more than 7,300 m^3/day. Although only one of the five medium-sized industrial establishments came, it

is the biggest among this group of establishments. Most of the commercial establishments, subdivision developers, and hotels that came for the consultation meeting and inventory were not in the old list. The two subdivision developers who came were supplying water for six big subdivisions that represented about a third of the newly developed subdivisions dependent on non-COWD supply systems. Ninety-eight percent of the combined water withdrawals of commercial establishments originate from just two of the six commercial establishments: a memorial park and a food processing establishment. The three institutions are two large universities and one hospital, all of which are also connected to COWD. Groundwater from their own deep wells is used only for cleaning and washing. It is noted, however, that one of the two universities recently dug two new deep wells. All six hotel owners did not specify their actual volume of water withdrawal.

Of the 21 deep-well owners who filled up the survey questionnaire, only eight responded to the question on the amount they would be willing to pay for raw water, which will serve as a contribution for watershed rehabilitation and preservation programs. A big industrial establishment (a soft drink bottling company) and one small commercial establishment (gasoline station) specified PhP 1.00/m^3 while two establishments (a memorial park and a hotel) specified PhP 2.00/m^3. An owner of four hotels indicated willingness to pay as much as PhP 5.00/m^3 and one commercial establishment, a lump-sum of PhP 3,000/month (an amount that is equivalent to PhP 12.50/m^3 of its groundwater withdrawal. Two establishments, one of which was the biggest real estate developer in CDO, indicated their willingness to cooperate and pay an amount that would be agreed upon by stakeholders. It is also interesting to note that seven of the eight who explicitly indicated willingness to pay have already made contributions to forest/watershed programs and are active in several environmental, civic, and business organizations. Most of the eight are major players in their respective industries. Further, all these eight deep-well owners indicated problems with their present deep well systems: five indicated quality problems (high iron content of water, total dissolved solids of 1,400), four indicated high maintenance costs of well and pump, and two indicated increasing power costs. Three of the eight expect an increase in water requirements.

3.3.3 Field survey of deep well owners/operators

To gather data on deep wells and groundwater extraction of the newly identified groundwater extractors and deep well systems (refer to section 3.3.1) that did not participate in the inventory, the research team and NWRB staff, with the assistance of CPDO personnel, visited these entities. Data gathered are summarized in Table 17.

Table 17. Visited deep-well owners/operators (did not participate in the survey)

	No. of Deep-well Owners/operators	**No. of Deep Wells**	**Reported Groundwater Extraction (m^3/month)**
Big industries	2	6	73,080
Commercial	23	28	56,198
Subdivision owners/developers	5	10	152,414
Total	**30**	**44**	281,692

3.3.4 Updated estimate of total groundwater extraction

The results of the field survey, together with those of the deep-well inventory and survey at the consultation meetings, were used to update the estimate of non-COWD groundwater extraction (Table 18).

Table 18. Non-COWD and COWD deep wells and groundwater extraction

Type of Establishment	2000			2011		
	No. of Establishments	No. of Deep Wells	Monthly Extraction (m^3)	No. of Establishments	No. of Deep Wells	Monthly Extraction (m^3)
Big industries	5	15	630,270	5	17	574,267
Medium industries	5	9	19,068	4	8	23,171
Small industries	1	2	702	1	2	702
Commercial	33	37	32,226	58	65	73,688
Government	28	57	231,804	28	57	231,804
Institution	18	21	73,242	18	24	74,577
Subdivision	7	11	64,638	7	18	242,250
Total non-COWD	97	152	1,051,950	121	191	1,220,459
COWD	1	29	2,310,000	1	29	3,450,000
Total groundwater extraction	98	181	3,361,950	122	220	4,670,459
Safe yield estimate						2.4-9.5 million m^3/mo

The study's updated estimate of non-COWD groundwater extraction hovered on 1.22 million m^3/month, 16% more than the 2000 estimate. This, combined with current COWD extraction of 3.45 million m^3/month, results in total groundwater use of 4.67 million m^3/month, 39% more than the 2000 estimate.

The gradient method yields a groundwater discharge (under natural conditions) in the range of 2.4-9.5 million m^3/month. This indicates that a large portion of the natural discharge, and possibly even more, is used for water production, causing drawdown below sea level and local salt water intrusion. This finding is consistent with the low groundwater levels (below sea level) found in the Macasandig well field.

4.0 GROUNDWATER MANAGEMENT AND PRICING MODELS

4.1 Existing Raw Water Pricing Schemes in the Philippines

Up until the present, raw water pricing schemes, which involve the imposition of user fees/charges on raw water (defined as water that is extracted, either diverted in the case of surface water or pumped in the case of groundwater), have been limited in the Philippines. The following is a discussion of the scant cases of raw water pricing schemes implemented in the Philippines so far.

4.1.1 National Water Resources Board's annual water charge

Article 83 of the Water Code of the Philippines authorizes NWRB to establish and collect reasonable fees or charges from water appropriators. Apart from one-time application and filing fees for water permits, NWRB imposes annual water charges on water permit holders classified according to the kind of water use as follows (Table 19):

Table 19. NWRB annual water charge[1]

Water Use	Withdrawal Cost/Liter per Second Discharge (PhP)			
	Base Cost	Not More Than 10 lps	11-50 lps	More Than 50 lps
Municipal	5,000	5.50	8.50	11.00
Fisheries	500	2.75	4.25	5.50
Livestock (backyard/commercial)	500	2.75	4.25	5.50
Irrigation				
Communal/Individual	5,000	2.75	4.25	5.50
National/Corporation	5,000	5.50	8.50	11.00
Power generation	5,000	2.75	4.25	5.50
Industrial	5,000	10.25	15.80	20.45
Recreation	5,000	10.25	15.80	20.45
Others	5,000	10.25	15.80	20.45

Source: National Water Resources Board
Note: Revised rates per NWRB Resolution No. 010-0305 dated 21 March 2005.

The fees above are based on volume of water permits, that is, the granted discharge rate, not on actual rate of extraction. To provide some examples, below are calculated annual water charges for the 28 production wells of COWD. Total annual water charge for all COWD wells was calculated to be about PhP 158,000. Suppose this annual water charge is replaced by the proposed raw groundwater fee at a rate of PhP 1.00 per m^3, total raw water fee payment of COWD in a year would amount to about PhP 45 million. At a lower rate of PhP 0.50 per m^3, the total will still be 140 times the current annual water charge.

Table 20. Calculated annual water charge for COWD wells

Production Well No.	**Discharge**	**Annual Water Charge (PhP)**
1	152	6,672
2	76	5,836
3A	95	6,045
4	58	5,638
5	44	5,374
6	Stand-by	-
7	102	6,122
8	156	6,716
9	124	6,364
10	22	5,187
11	136	6,496
12	17	5,144
14	96	6,056
15	30	5,255
16	150	6,650
17	36	5,306
18	19	5,161

19	12	5,102
20	76	5,836
21	120	6,320
22	120	6,320
23	120	6,320
24	40	5,340
25	61	5,671
26	46	5,391
27	66	5,726
28	114	6,254
29	114	6,254
Total		158,556

The annual water charge is collected only from those who had applied and had been granted the water permit. In the Philippines, a very large number of wells are dug without permit from NWRB. In Cagayan de Oro, in particular, our 2003 study identified 269 non-COWD wells but only 17 well permits had been issued by NWRB between 1975 and 1997. In the current study, 36 additional commercial establishments and 29 new subdivisions were identified as having their own deep-well systems but NWRB records indicate only two additional wells have been registered after 1997.

NWRB has no collection agents for the annual water charge. According to NWRB, annual water charge payers either go to the NWRB office in Quezon City or send their payments via postal money order (PMO). Presumably, provincial permit holders pay by PMO. The schedule of payment depends on the date the permit was granted. It is doubtful, given the very lean manpower base of NWRB and the distribution of permit holders all over the Philippines, that payments of annual water charges are adequately monitored. A subdivision in the heart of Metro Manila with its own groundwater supply system, for instance, informed us during an interview that they do not go to NWRB to pay the annual water charge every year, even if the amount for payment is really minimal. But occasionally (once in a couple of years), an NWRB inspector would come to their subdivision. They pay only when asked to pay.

Thus, it may be deduced that compliance with NWRB's annual water charge is very limited. In CDO, for instance, an annual water charge amounting to about PhP 250,000 was

billed and collected in 2009 for 50 out of 68 water permit grantees (deep wells with permits)[7]. Presumably, the 50 deep wells included the 28 wells of COWD (which combined have an annual water charge of PhP 158,556, as shown in Table 20). If this is the case, only 22 other deep wells are paying the NWRB annual water charge, with a total amount of just about PhP 100,000.

It is noted that a committee in NWRB is currently reviewing its water permit system. Among the issues being tackled in the review is the validity period of the water permit, which at present has no expiration. The committee is discussing the possible introduction of a validity period for the water permit. The developments in this policy change initiative will be interesting to follow as this would allow a "depletable" property rights scheme suggested in Provencher's article below.

4.1.2 Water District's production assessment fee

In the Philippines, Water Districts (WDs) are quasi-public corporations that are created to manage local water supply systems development and operations. Section 31, paragraph (a) of Presidential Decree 198 authorizes WDs to commence, maintain, intervene, defend, and compromise actions or proceedings to prevent interference with or deterioration of water quality or natural flow of any surface, stream, or groundwater supply which may be used or useful for any purpose to the District or be a common benefit to the lands of its inhabitants. WDs are likewise authorized to adopt rules and regulations, subject to NWRB's approval, governing the drilling, maintenance, and operation of wells within its boundaries for purposes other than single family (dwelling) domestic use. Further, if production of groundwater and appropriation of spring waters by other entities for commercial or industrial use injure a WD's financial condition and/or impair its groundwater source, the WD may adopt and levy a groundwater production assessment fee or impose special charges at fixed rates to compensate for such loss.

Application to drill wells and to abstract groundwater or appropriate spring water will have to get clearance from the WD before NWRB processes the water permit application.

Laguna Water District (LWD). In August 1989, as per NWRB Resolution No. 02-0889, NWRB unanimously approved Laguna Water District's Rules Governing Groundwater Pumping and Spring Development within Its Territorial Jurisdiction. This empowers LWD to monitor and charge production assessment fees from owners and operators of deep well and spring water systems.

A sample Memorandum of Agreement (MOA) between LWD and a bottled water producer specifies a production assessment fee of PhP 1.00 per m^3 of water payable on a monthly basis. Total monthly charges are to be calculated based on actual water consumption to be determined using a water flow meter to be installed by LWD at the expense of the bottled water company.

[7] There is a discrepancy between the list of water permits granted (19 granted between 1975 and 2008) and the number of permit grantees in the annual water charge database of NWRB (68) for CDO. It may be that the annual water charge database includes permits granted before 1975.

An internal report of the LWD reveals that in 1999, LWD charged 37 companies a production assessment fee of PhP1.00 per m^3 of water. Total monthly collections of the production assessment fee amounted to PhP 230,910. This means that non-WD water withdrawal subjected to the production assessment fee was about 7,697 m^3 per day. The top two payers in the list paid PhP 40,878 and PhP 29,977. These were followed by a soft drink bottling company, paying a monthly fee of PhP 29,508. A branch of a commercial bank was paying a monthly fee of PhP 600, the second lowest in the list. The report noted that monthly charges per company were calculated based on the number of hours of operations of the pump and the discharge rate of the well, not on metered water extraction.

Metro Cebu Water District (MCWD). MCWD also collects a production assessment fee of PhP 1.00 per m^3 of water from one of the leading food and beverage companies in the Philippines. An interview with this food and beverage company located in Mandaue City, Cebu, revealed that it is not being metered by MWCD; the monthly charge is simply based on a fixed amount of groundwater withdrawal voluntarily indicated by the company to MCWD.

4.1.3 Laguna Lake Development Authority (LLDA)

In July 2010, the Laguna Lake Development Authority (LLDA) started collecting a raw water charge from Maynilad Waters, Inc., the concessionaire serving the western service area of the former Manila Waterworks and Sewerage Systems (MWSS). Negotiations regarding this raw water charge began several years back between the Ayala Land Properties Inc., which proposed to source water for its real estate projects from Laguna Lake. Before the purchase of raw water from LLDA even began, Ayala Land Properties, Inc. turned over the treatment facilities to Maynilad Waters, Inc.

The agreed schedule of raw water fee is as follows (Table 21):

Table 21. LLDA's schedule of raw water charge for Maynilad Waters, Inc.

Volume of Water	Raw Water Rate
100 million liters per day (mld) and below	PhP 0.30/m^3
101 -200 mld	PhP 0.25/m^3
201 mld and over	PhP 0.20/m^3

Source: Laguna Lake Development Authority

Currently, Maynilad Waters purchases 50 million liters (50,000 m^3) of water per day from LLDA, which amount to a daily bill of PhP 15,000.

Apart from selling raw water to Maynilad Waters, LLDA has also assumed from NWRB the responsibility of issuing water permits and collecting annual water charges for extractors of water from Laguna Lake. It started accepting applications for new water permits last year. The existing water permit grantees are yet to be turned over to LLDA by NWRB.

4.1.4 Special levy to support a program of improvements in the watersheds of Bukidnon

Another variety of a raw water pricing scheme that may be implemented soon in the province of Bukidnon, which is just adjacent to CDO, is a special levy on real properties that benefit from watershed improvement and preservation programs undertaken by the local government. Collection of real property taxes on entities that are heavily-dependent on water as a form of payment for use/extraction of water has already been done in other places such as in Orange County, California in the United States. Currently, in Bukidnon and in some other places in the Philippines, this is done on a case to case basis, and only with the voluntary cooperation of the real property owner.

Last year, the provincial government of Bukidnon drafted an ordinance for this special levy. The intention is to collect an amount that will cover up to 60% of the total cost of the watershed program (Section 4 of the Ordinance). This requires the formulation of a watershed management plan every 10 years on which the calculation of the total amount of levy will be based. As not all real properties benefit equally from the improvements, individual levies will be calculated based on the following rules: (1) real properties devoted to large-scale industrial agriculture using a significant amount of water shall collectively cover 75% of the total special levy, assessed on a per hectare basis; (2) all other real properties used for commercial purposes shall collectively cover the remaining 25%, assessed on a per hectare basis; and (3) real properties located in the general area that benefit from the improvements, devoted to residential use or for other purposes exempted by law from real property taxation, shall not be assessed a special levy (Section 4). The draft ordinance also provides for crediting of voluntary private programs currently being undertaken, as follows: "Recognizing the invaluable voluntary contributions of individuals, organizations and corporations in watershed conservation in Bukidnon, real property owners who are subject to the special levy and who have made a financial or in-kind contribution to watershed conservation consistent with the Bukidnon Watershed Management Plan shall be entitled to credit the value of their voluntary contribution to the assessed amount that the real property owner is required to pay. Crediting of voluntary contributions will only be allowed for the first three years of implementation. Thereafter, the real property owners are enjoined to pay the assessed levy to ensure consistent and sustained programming of the proceeds of the special levy" (Section 6). This special levy is to be collected by the Provincial Treasurer's Office following the regular schedule of payment of real property taxes. The fees collected will be directed to a special account to be held and administered by the Provincial Economic Enterprise Development and Management Office.

4.2 Raw Groundwater Pricing Models for CDO

Two raw groundwater pricing schemes can serve as models for CDO. Initially, raw groundwater pricing in CDO can follow the form of California's Orange County Water District's Pumping Tax. Eventually (which is not anymore covered by the timeframe of this current project), CDO could follow the framework suggested by Provencher's Depletable Property Rights Regime.

4.2.1 Orange County Water District's (OCWD) Pumping Tax (Blomquist 1992)

From 1945 to 1948, the average water level of the groundwater basin in Orange County, California fell from 20 feet above sea level to just 5 feet above sea level. In 1948, 250,000 acre-feet per year were being pumped from the basin, a rate that was tantamount to an annual overdraft of about 100,000 acre-feet and could have completely eliminated the water stored in the basin in 15 years. Water levels along the coast were below sea level, resulting in seawater intrusion. Users began to abandon wells along the coast as brackish groundwater moved inland 8,000 feet from 1945 to 1950. The technical experts in Orange County saw that artificial replenishment of the groundwater basin was needed to ensure the desired amount of water and to protect groundwater quality. There was an external source of replenishment water. What was uncertain at that time was where to get the funds to pay for the replenishment program.

The financial requirement was addressed by a pumping tax, which was called replenishment assessment. The pumping tax was preferred as apart from generating the funds needed for groundwater replenishment, it would also make pumpers pay according to the benefits they received, relieve non-pumpers from paying for replenishment except to the extent that they purchased water from pumpers, and build in conservation incentives without mandating conservation.

The pumping tax was supposed to be OCWD's water demand management instrument. It would add to the production costs of water, and this would internalize the externality or depletion costs of pumping, which would in turn induce water use savings and thus groundwater extraction. For this effect to materialize, however, the tax must be set high enough to raise production costs beyond the benefits derived from additional pumping. In practice, OCWD had not set the pump tax at such high level for the following reasons: (1) OCWD was committed to providing a plentiful water supply rather than restricting consumption, (2) increases in the pump tax was unpopular with pumpers, (3) OCWD was not allowed to discriminate among pumpers, (4) amount of pump tax was bounded above by the OCWD Act.

Thus, the pump tax had not really been employed by the OCWD for demand management. The guiding considerations in setting the pump tax rate were supply needs rather than demand. Each year, the tax rate was set at a level that would buy enough replenishment water to restore the average annual overdraft from the preceding five years plus one-tenth of the accumulated overdraft.

The pump tax required measurement and recording of well characteristics and data. Every pumper was required to register wells with the WD and to record and submit production records twice per year. Likewise, annual technical reports on basin conditions and groundwater production were given to water users to allow them to monitor basin conditions (e.g., water table and extent of saltwater intrusion, if any) and the effects of the replenishment program. Thus, one additional benefit from the institution and implementation of the pump tax was the regular generation of information and data necessary for sound water management.

Similarly, for political considerations, the raw water fee rate to be imposed in CDO cannot be high enough to serve as a demand management instrument. But it is hoped to signal to groundwater users the need to address the issue early enough and, more importantly, to generate a steady stream of revenues to fund watershed rehabilitation and preservation for the continuing recharge of the aquifer. Furthermore, the scheme shall pave the way for regular

monitoring of groundwater use and aquifer conditions, which is important for an effective management of groundwater resources in the city.

4.2.2 A 'Depletable' Property Rights Regime: a theoretical model

Provencher (1993) presents a theoretical model of a kind of 'depletable' private property rights regime wherein government initially allocates all groundwater stock as private shares and at the same time announces that at a specified future date a particular number of stock shares (enough to ultimately prevent the groundwater stock from falling below the optimal steady state level; that is, enough to allow a sustainable level of extraction from the aquifer) will be reclaimed from each groundwater extractor. Thus, if the objective of the regulator is to increase groundwater stock by X*, it will reclaim X* shares at time T. Anticipating this action, extractors would conserve stock shares to maintain their access to groundwater after the regulator's reclamation of the announced number of shares. Shares are tradable so that any one extractor can extract an amount that is greater than its shares through purchase of shares from other property rights holders. The path to the optimal steady-state therefore becomes smooth and influenced by the price of groundwater stock shares. The price per unit of groundwater established in the permit market matches the marginal value of groundwater in consumption.

Regular monitoring of groundwater use and aquifer conditions, along with the initial implementation of a raw groundwater fee scheme with fixed water rates and watershed protection programs, can result in better and more reliable estimates of the safe yield, thereby making a Provencher's depletable property rights regime doable for CDO. The raw groundwater pricing scheme in CDO is hoped to eventually follow Provencher's model.

5.0 DESIGNING THE RAW GROUNDWATER PRICING SCHEME

5.1 Policy Design Process

This policy advocacy project entailed a series of multilevel consultations with different groups of stakeholders as outlined below.

5.1.1 Seeking NWRB collaboration

In the Philippines, the NWRB is the national agency empowered by the Philippine Water Code to issue water permits and to regulate and control water usage in the country. Section 2 of Presidential Decree No. 424 provides that NWRB shall have the power to formulate and promulgate rules and regulations for the exploitation and optimum utilization of water resources, including the imposition on water appropriators of such fees or charges as may be deemed necessary for water resource development. Thus, the first necessary step in this action research project was to seek the collaboration of NWRB. NWRB has long been very keen on establishing a raw water fee system for groundwater abstraction from pump

owners in Metro Manila.[8] Thus, we presumed that it would be enthusiastic in working with us on this project to develop and try out a raw groundwater pricing scheme for CDO, a smaller and hence more doable case, as a model for Metro Manila (and eventually the whole Philippines).

We first approached NWRB for the project in February 2009 via a letter sent to the Director of NWRB at that time. The Director responded promptly, referring us to the Board's Policy and Planning Division. We met with the Division's technical staff on 29 February 2009 to discuss the project concept.

That first meeting was followed by a series of meetings in October-December 2009 with the Division's Officer in Charge and technical staff, where they agreed to collaborate in the following ways: (1) provide access to all NWRB data on groundwater and deep wells in CDO and other NWRB materials, (2) spearhead the registration of groundwater pump owners in CDO (with the assistance of the Ateneo research team and the CDO city government), (3) conduct consultation meetings with CDO government officials, and (4) conduct consultation meetings/public hearings with pump owners.

NWRB assigned two technical staff members of the Policy and Program Division to the project: Eng'r. Luis Rongavilla, who as principal partner of the project would oversee and lead all forms of NWRB participation in the project (i.e., validation of groundwater resource status, groundwater withdrawal, users' registration, consultation meetings, etc) and Eng'r. Milagros Velasco, who would assist and accompany Eng'r. Rongavilla during trips to CDO.

During January-March 2010, the NWRB collaborating staff and the Ateneo research team brainstormed and discussed alternative legal and institutional frameworks for the proposed raw groundwater pricing scheme.

In April 2010, NWRB conducted a two-week deep well and groundwater resources validation survey in CDO with partial funding from the research project. Findings and data gathered from this survey were made available to the project's hydrologist for use in the safe yield study.

5.1.2 Getting the CDO government – both executive and legislative branches – to act

As the City Government would have a major role to play in the proposed raw groundwater pricing scheme, the endorsement of the City Mayor was sought during the conception stage of this project. A meeting with the Mayor took place on 29 June 2009. The major findings of the 2003 study (i.e., estimate of groundwater withdrawal exceeding the safe yield, data on declining water levels of COWD wells, and the plan to do a follow-up action research project to push for the implementation of a raw groundwater pricing scheme, which isthe policy recommendation in the 2003 study) were presented to the Mayor and officers of the City Planning and Development Office (CPDO). The following day, the Mayor issued a letter of endorsement for the proposed action research project. Convinced that the local government unit had to take a proactive stance on the protection of groundwater resources in

[8] In 2005-2006, our research team from Ateneo de Manila University was consulted by NWRB on this matter.

CDO to ensure a steady and ample supply of water over the entire city, he included in his letter two specific suggestions: (1) that NWRB require an endorsement from the City Government prior to granting of water permits and permits to drill wells in CDO, and (2) that the raw groundwater price be determined by a tripartite agreement among NWRB, the City Government and the project proponent.

A public forum was hosted by the Social Action Center of the Archdiocese of CDO on 30 June 2009, in which the findings and recommendations of the 2003 study were presented. Three news articles on the forum caught the attention of the legislative branch of the city government. In mid-August 2009, the head of the City Council's Committee on Public Works, moved for the City Council's endorsement of the proposed groundwater metering and pricing study. Consequently, the City Council adopted on 1 September 2009 a Resolution (no. 9795-2009) "favorably endorsing the past study and the proposed action research project to ensure the sustainability of water resources in CDO." Thereafter, the research team was invited by the Chair of the Committee on Public Utilities to make a presentation to the Committee session on 28 October 2009. Thus, the project had backing from both the executive and legislative branches of the city government from its conception stage.

With the national and local elections in the Philippines scheduled in May 2010, the research team together with NWRB opted to resume talks with the city government after the new set of city officials would have settled in their posts. The local elections resulted in a new Mayor and Vice Mayor. Through the head of the CPDO, a meeting was held with the newly-elected Vice Mayor and the Chair of the City Council's Committee on Environment on 19 July 2010. Moreover, the former Chair of the City Council's Committee on Public Utilities introduced the research team to the Committee's new Chair. The new local officials were likewise receptive to the proposed groundwater conservation strategy. They acknowledged the deteriorating condition of the CDO aquifer and the need to address the problem. After these meetings , collaboration of the city government in this action research project became official. CPDO, NWRB, and the research team planned an NWRB-supervised inventory of deep wells for 1-4 September 2010. As a prelude to the inventory, the first official consultation meeting with deep-well owners on the proposed raw groundwater pricing scheme was scheduled on 1 September 2010. CPDO distributed the letters of invitation issued and signed by the NWRB Director. Both inventory and consultation meeting were to be held at the City Hall. Thus, the executive branch of the City Government, through the CPDO, began to be an active player in the design of the proposed scheme in July 2010.

The period 31 August-4 September 2010 marked the start of the active involvement of the City Council. At their 31 August 2010 meeting, the research team and the City Council's Environment Committee Chair and Public Utilities Committee Chair drew up a plan for the formulation and passage of an ordinance to institute the raw groundwater pricing scheme. It was agreed that the two councilors would jointly sponsor the ordinance at the City Council. NWRB and the research team would assist the councilors in drafting the ordinance and providing the necessary studies and supporting data and documents. The councilors would call and officiate public hearings, during which NWRB and the research team would serve as resource persons.

The councilors intended to conduct two public hearings before the passage of the ordinance. The first hearing was held on 20 December 2010. After the first public hearing, the City Mayor, through the 6 January 2011 issue of *The Power*, the City Council's Official

Publication, made the following statement: “even if the city’s groundwater resources is [sic] not within the critical limit, the city government must institute measures to preserve it [sic] to avoid future problems.”

5.1.3 Finding a multi-sectoral implementating body

The survey of deep-well owners conducted for the 2003 study revealed their preference for a multi-sectoral body to collect the raw water fee and disburse the proceeds for watershed protection activities. As it turned out, the City Council Environment Committee Chair agreed with this view; he considered it most efficient for a nongovernment, multi-sectoral body to administer the raw water pricing scheme. Thus, this provision was included in the first draft of Raw Groundwater Pricing Ordinance. As that first draft was being circulated among NWRB officials and the first public hearing was being scheduled by the City Council, we learned about the plan to create the Cagayan de Oro River Basin Management Council (CDORBMC), and we immediately thought this council could take on the role of the proposed multi-sectoral body that will implement the raw groundwater pricing scheme.

The idea for a CDORBMC first popped out in April 2010 when the Climate Change Congress of the Philippines held its meeting in CDO, convened byArchbishop Ledesma of the Archdiocese of CDO. Present at the Climate Change Congress was the DENR Undersecretary at that time. One of the presentations dealt on the vulnerability of CDO to climate change, which alarmed DENR and civic groups in CDO. When the Undersecretary became DENR Secretary, he directed the Director of DENR Region X to look into the issue. The latter immediately convened a meeting with the Archdiocese Office on 30 June 2010, during which the plan to form the CDORBMC was born. Since then, a series of meetings were jointly convened by DENR Region X and the CDO Archdiocese Office, with the support and guidance of the Director of the DENR River Basin Control Office (RBCO). In these meetings, the geographical scope of the Cagayan de Oro River Basin, including the sub-watersheds it comprises, was defined, and the different stakeholder groups and key people in these groups were identified. The series of small group meetings culminated in a dialogue workshop held on 16-17 November 2010 that gathered representatives from eight identified sectoral groups, namely: local government units (LGUs) within the CDO River Basin[9], religious groups, national government agencies, security (Philippine National Police, Armed Forces of the Philippines), academe, business/service providers, social and people’s organizations, and nongovernment organizations. The main outcome of the workshop was the creation of an Interim CDORBMC with Archbishop Ledesma and the DENR Region X Director as co-chairs. The DENR RBCO Director would assist in the institutionalization of CDORBMC through an Executive Order (EO) of the President of the Philippines. Before adjourning the workshop, the first CDORBMC meeting was scheduled for 9 December 2010.

On 3 December 2010, just a few days before the scheduled first CDORBMC meeting, our team met with the DENR Region X Director to discuss and present the proposed raw groundwater pricing scheme for CDO and to invite the Council to be the scheme’s

[9] This includes CDO City; Talakag, Baungon, Libona, and Pangantucan in Bukidnon; Iligan City in Lanao del Norte; and the municipality of Bubong in Lanao del Sur.

implementing body. Manifesting interest and support for the proposal, the DENR Region X Director immediately gave instructions to include its presentation in the agenda of the CDORBMC meeting.

During the meeting, the DENR Region X Director discussed the proposed organizational structure and the DENR RBCO Director presented the draft Executive Order for comments and approval of the body. The Council decided to form four Technical Working Groups (TWG) on Watershed Rehabilitation, Local Governance, Community Development, and Resource Management; the lead organization/s and head for the four TWGs were also appointed.

After we presented the raw groundwater fee scheme proposal, the DENR Region X Director indicated that the scheme would fall under the Resource Management TWG. He supported the idea that water utilization fees should be collected by CDORBMC, whose main concern is the rehabilitation and preservation of the CDO River Basin.

The second CDORBMC meeting was held on 19 January 2011, during which the Rehabilitation, Local Governance and Community Development TWGs presented their tentative plans and proposals, andthe Resource Management TWG showed the public information campaign video of the raw groundwater pricing scheme. Moreover, CDO Representative Rufus Rodriguez presented to the Council his CDO environment-related house bills: one proposed to make the CDO watershed a protected area and the other proposed the creation of the Cagayan de Oro River Development Authority. He suggested that CDORBMC can be the interim body that can evolve into the CDO Development Authority. A model for the CDO Development Authority is the Laguna Lake Development Authority, which is now carrying out within its jurisdiction the water permit and raw water fee functions of NWRB. DENR officials also indicated that once the CDO watershed is declared a protected area, it would have its own Protected Area Management Bureau (PAMB) that would have the authority to collect raw water fees. These developments augur well for the raw groundwater pricing scheme as these will give it more legal and institutional support.

5.1.4 Public information campaign

A public awareness raising campaign was done through multi-sectoral public forums and news media. This was started as early as during the conception phase of the project.

The public forums were organized with the collaboration of the Social Action Center of the Archdiocese of Cagayan de Oro. The first forum, held on 30 June 2009 at the Archbishop Patrick Cronin Formation Center in St. Augustine Cathedral Complex, discussed mainly the findings and recommendations of the 2003 EEPSEA study. There were about 80 participants representing local and national government agencies (Cagayan de Oro City Water District, Regional Agricultural and Food Council, CDO City Agriculture Office, Misamis Oriental Provincial Planning & Development Offce, CDO local government-CPDO, DOST-X, DENR, CDA-10, and Party List COOP Natcco); academe, research institutions, and environmental NGOs (Xavier University, Liceo de Cagayan's Safer River, Capitol University, XU McKeough Marine Center, Mass Media Advocates for Environment Protection, Green Mindanao, Kagayan Watershed Alliance, and Task Force Macajalar); business groups (such as the Oro Chamber of Business and Commerce represented by its President); divisions and departments of the archdiocese (SAC, ACCESS, BEC-Enterprise

Ministry, Access, Social Communications Apostolate, Archdiocesan Good Governance Apostolate-Hijos del Nazareno, CDO Good Governance Inc., Minsac, Augustinian Sisters, Legal Resource Center, Cannosian Sisters, Augustinian Sisters, and Ecology Desk of the Ad-Extra Ministries); and other NGOs (Touch Foundation, Group Foundation, and Gising Barangay Movement). A number of media people (ABS-CBN, Mindanao Gold star Daily) also attended and covered the forum.

Three news articles on the 2003 EEPSEA study presented at the forum came out in the local papers: *Mindanao Gold Star Daily* (1 July 2009), *Sun Star Cagayan de Oro* (6July 2009), and *Business Mirror* (7 July 2009).[10] On 1 September 2009, the City Council adopted a resolution to endorse the findings of the past studies and a follow-up study to update the CDO groundwater condition and necessary measures to preserve it. On the same date, a news article citing a councilor's concern over the findings in the 2003 study and his recommendation to collect fees from deep well owners to finance environment programs appeared in *Gold Star Daily*[11].

At the second public forum, held on 21 July 2010 at the same venue, the concept and rationale of the raw groundwater pricing scheme was presented. It was organized by the Archdiocese Social Action Center and the Archdiocesan Center of Concern, Empowerment and Social Services (ACCESS) in partnership with Xavier University's Research and Social Outreach Cluster. A news article by Louise Dumas that came out in the July-August 2010 issue of *Bag-ong Lamdag*[12] reported about the role of raw water pricing in promoting efficient utilization of groundwater and generating revenue for watershed protection. Like the first forum, this second one was well-attended by the different groups mentioned above. There were also more participants from the private sector (representatives of companies with deep wells and deep-well construction contractors) in the second forum.

We prepared a 20-minute video presentation on the raw groundwater pricing scheme as a public information campaign tool. Titled "A Groundwater Conservation Strategy for Cagayan de Oro," the video explains the water cycle, causes and effects of groundwater depletion, state of groundwater resources in Cagayan de Oro, and the rationale for raw water pricing. The video features key personalities in CDO such as Archbishop Antonio Ledesma, Fr. Jose Villarin (President of Xavier University), Vice Mayor Caesar Ian Acenas, City Council Environment Committee Head Councilor President Elipe, CPDO Head Mrs. Sagaral, DENR Region X Director Dichoso, and NWRB Director Paragas. It was shown at the start of the first Public Hearing on the proposed Raw Groundwater Pricing Ordinance being put forward at the City Council by Councilors Elipe and Bacal on 21 December 2010 and as part of the report of the Resource Management TWG at the first CDORBMC meeting) held at the DENR Regional Office on 16 January 2011. Copies of the video had been shown and distributed to different sectoral groups in CDO.

[10] The news articles are: (1) Mike Banos' "NGOs endorse research plan on preservation of Cagayan de Oro's aquifers," Mindanao Gold Star Daily, 1 July 2009; (2) Bong Fabe's "Study: Oro groundwater depleted beyond recharge rate," Sun Star Cagayan de Oro, 6 July 2009; (3) Bong Fabe's "CDO groundwater severely depleted, study shows," Business Mirror, 7 July 2009.

[11] Francisco, Mark, "Fees for deep well diggers pushed", Gold Star Daily, 1 September 2009.

[12] Dumas, Louise, "ACCESS, XU host water pricing forum", Bag-ong Lamdag, July-August 2010.

5.1.5 Consultation with groundwater extractors

Some informal and unofficial consultations with groundwater extractors likewise took place when the project was still in its conception stage. On 29 June 2009, a meeting between COWD members and the Board of Directors and Management officers was also arranged. COWD is the single largest extractor of groundwater in CDO and, in principle, it must be covered by the raw groundwater fee scheme. Further, in the multi-sectoral forum hosted by the CDO Archdiocese on 30 June 2009, the business sector was represented by a key corporate officer of a major real estate developer, who was at that time President of the Oro Chamber of Commerce. A follow-up meeting with the Oro Chamber President was held on 28 October 2009.

Official consultation meetings[13] with groundwater extractors were began after the newly elected set of local government officials endorsed the project in July 2010. After the preliminary meetings with CPDO and the Vice Mayor's office in July and the follow-up communications in August, NWRB and the research team obtained an informal commitment from CDO's local government to collaborate on this project.Thereafter, NWRB and the research team, in close collaboration with CPDO, scheduled a well inventory and consultation meeting with deep well owners for 1 September 2010.

A total of 126 letters of invitations for a consultation meeting and three-day well inventory 'event' signed by the Executive Director of NWRB were issued to those in the updated list of deep-well owners through CPDOon the third week of August 2010.

More than 50 deep-well owners confirmed their attendance in the 1 September 2010 consultation meeting. Further, several inquiries and expressions of interest in the consultation meeting were received by the CPDO staff in the week, particularly the day, before the meetingAlso, follow-up calls to the invitees were made by the CDO-based research assistant. Despite these, however, only 17 deep-well owners actually attended the meeting.

The Consultation Meeting began with the Opening Remarks of the Director of CPDO Director. This was followed by the presentation of NWRB representative, Eng. Luis Rongavilla, who made a brief introduction of NWRB – its structure and functions including its raw water pricing mandate; and a discussion of the current water conditions in the Philippines with particular focus on Misamis Oriental and Cagayan de Oro. After the NWRB presentation, the Ateneo research team presented the concept of the raw water pricing scheme as a groundwater conservation strategy for Cagayan de Oro.

Probably due to the previous two public forums and the wide media coverage they generated, the meeting participants appeared to be convinced of the need to address the current situation with a raw water pricing scheme. They were, however, rather silent on the amount they would be able to afford and would be willing to pay. A representative of a big subdivision developer indicated that PhP 1.00 per m^3 may be too high. One participant asked when the raw groundwater pricing scheme would take effect. Another participant pointed out that watershed projects must not be limited to Cagayan de Oro but must include parts of the

[13] These consultation meetings are planned and initiated by the Ateneo research team together with NWRB, but are endorsed, called and officiated by CDO government.

neighboring province, Bukidnon, where the major part of the watershed that feeds the CDO aquifer is located. Interestingly, one concern raised by several participants during the consultation meeting is the difficulty of registering their wells with NWRB. They related that they have been trying to register their wells but they do not know where to go and what steps to take. One participant said he had approached some government agencies in CDO such as the DENR regional office but did not get a clear answer.

The First Public Hearing on the proposed Ordinance for Raw Groundwater Pricing was held on 20 December 2010 (the first City Council session and hearing conducted during the Christmas month). The invitation to the Public Hearing was issued and distributed by the City Council on 9 December 2010 to all deep-well owners (list provided by the research team) and other concerned parties. Apart from the Environment Committee Chair who presided over the Hearing, Councilors Annie Daba and Alexander Dacer were also present. Remarkably, four of the five big industrial firms with deep wells were at the hearing, as well as the COWD's Asst. General Manager, which means the major groundwater extractors accounting for about three-quarters of groundwater withdrawal were represented[14]. A few other deep-well owners and several staff of Rio Verde (the bulk water supplier) led by its Chief Executive Officer were also in attendance. Eng. Jan Taat, our team's Dutch hydrologist-consultant, presented the project's recent findings on the conditions of the CDO aquifer and clarified that some localized depletion (over withdrawal resulting in localized decline in water table and salt water intrusion) were taking place but the CDO aquifer in general is not yet in a critical condition. He, however, pointed out that CDO must not wait to act until it reaches a dangerous stage. Only a few comments were received; these were on other possible ways to conserve water (such as recycling and use of rain water), the industries' apprehension on the impact of the raw water price on their profitability and on the consumers through increase in prices, and watershed protection activities. In closing the hearing, the Environment Committee Chair encouraged all to submit to his office any comments and suggestions they may have regarding the proposed raw groundwater pricing ordinance. To date, only one major operator of deep wells (a major real estate developer who was not present at the hearing) that supplies water to several subdivisions in CDO has sent to the Councilor a reaction to the proposal. This entity expressed opposition to the scheme in view of the negative impact it may have on the economic development of CDO.

5.2 Legal Basis

There already exists in the Philippines a legal framework for a raw groundwater pricing scheme. This is provided in Presidential Decrees (PD) No. 424 and 1067, and Republic Act (RA) No. 7160.

PD Nos. 424 and 1067 confer on NWRB the legal mandate to institute, implement, and coordinate a raw water pricing scheme. PD No. 424 signed on 28 March 1974 provides that NWRB shall have the power to formulate and promulgate rules and regulations for the exploitation and optimum utilization of water resources; impose on water appropriators fees or charges that may be deemed necessary for water resource development; determine,

[14] These entities were not at the 1 September 2010 consultation meeting.

adjudicate, and grant water rights for surface and ground water; and coordinate and integrate water resource development of the country.

PD No. 1067 signed on 31 December 1976, referred to as the Philippine Water Code, further empowers NWRB to issue/suspend/revoke/approve transfer of permits for the appropriation and use of waters; impose and collect reasonable fees or charges for resource development; approve rules and regulations prescribed by other government agencies pertaining to the utilization, exploitation, development, control, conservation, or protection of water resources; and adjudicate all disputes relating to appropriation, utilization, exploitation, development, control, conservation, and protection of waters.

RA 7160 or the Local Government Code empowers the local government to undertake activities for the preservation of its resources and to collect fees for resource abstraction or environmental royalty fees.

5.3 Institutional Setup

PD No. 424 and PD 1067 give NWRB sufficient power to spearhead the introduction of the raw groundwater pricing scheme for Cagayan de Oro being pushed forward by this action research project. The successful implementation of such scheme, however, requires NWRB to have an effective physical presence in CDO.

The establishment of an extension office of NWRB in CDO for raw water pricing is financially not feasible at present. The budget situation of NWRB constrains the number of staff it can maintain. NWRB depends on the national budget, and allocations of the national government to NWRB fluctuate significantly from year to year. Further, income generated by NWRB goes to the national government's Department of Budget and Management (DBM) and a request to keep such income with NWRB to cover expenditures is very unlikely to be granted on a regular basis.

In view of NWRB's budgetary constraints in establishing a sub-structure in CDO, it is recommended that NWRB delegates its raw water pricing function to the CDO city government and the Regional Office of DENR (DENR Region X is based in CDO). This delegation can give further credence to the authority of the city government to collect resource abstractions fees as provided for in the Local Government Code. Invoking the Local Government Code, the Environment Committee of the City Council of CDO has proposed an Ordinance for the Raw Groundwater Pricing Scheme. The first Public Hearing on the proposed Ordinance was held on 20 December 2010.

The research team's discussions with local government officials, particularly the Vice Mayor, CPDO Director, and Environment and Public Utilities committee heads, have led to a consensus on the practicality and workability of deputizing a multi-sectoral body to implement the raw groundwater pricing scheme. This arrangement considers the LGU's difficulties in collecting charges and the preference of deep-well owners/groundwater abstractors for an NGO to undertake such responsibility. The the 2003 study as well as the current study's consultations reveal that groundwater abstractors are more likely to comply with the raw groundwater fee scheme if it is handled by a multi-stakeholder group and if proceeds from the scheme are used to fund watershed rehabilitation and preservation programs.

While the Raw Groundwater Pricing Ordinance was being drafted, the Cagayan de Oro River Basin Management Council (CDORBMC) was created after a series of meetings that culminated in a multi-sectoral workshop jointly convened and sponsored by DENR-RBCO, DENR Region X, and the Archdiocese of CDO. CDORBMC was identified as the multi-sectoral implementing body for the raw groundwater pricing scheme.

The schematic diagram for the deputization plan is shown in Figure 12 below.

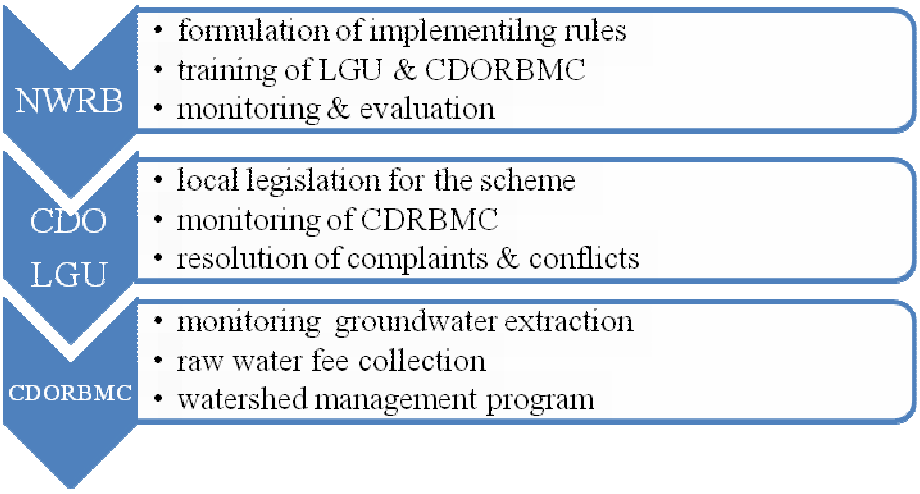

Figure 12. Raw water pricing scheme deputization plan

In this setup, NWRB will have three main functions: (1) definition and formulation of procedures and implementing guidelines; (2) training of LGU and the implementing multi-sectoral council (CDORBMC) staff; and (3) periodic monitoring and evaluation of the scheme implementation.

The city government's task is to legislate the Raw Groundwater Pricing Ordinance. Once the Ordinance is passed, it shall formally deputize the CDORBMC to implement the scheme. It shall conduct periodic monitoring of the raw groundwater fee scheme implementation by CDORBMC and assist in the resolution of complaints and conflicts related to the scheme.

In particular, the Raw Groundwater Pricing Scheme implementation will be under the CDORBMC's Resource Management Technical Working Group. As the scheme's implementing body, CDORBMC is in charge of monitoring the deep-well owners, collecting the raw groundwater fees, and preparing regular financial reports. It may decide to subcontract COWD to carry out the specific tasks of water meter installation, monthly meter reading and billing, and payment collection. If so, CDORBMC shall remunerate COWD for

these services[15]. CDORBMC shall also prepare and implement a 10-year watershed management plan that is to be financed with revenues from the raw groundwater pricing scheme.

5.4 Pilot implementation plan

5.4.1 Coverage

The pilot phase of the raw groundwater pricing scheme will cover only the business establishments, subdivisions, and other institutional users. Single family-owned, deep-well systems will be exempted (this is in consideration of monitoring costs). CDO legislators are also inclined to initially exempt COWD from the scheme.[16]

5.4.2 Fee rate

Initially, the groundwater fee will be set at a low flat rate (the rates that are currently being considered are PhP 1.00, PhP 0.50, and PhP 0.25 per m^3). Eventually, the fee will be set and adjusted from time to time by CDORBMC according to the administrative costs of the scheme and the financial requirements of the watershed protection programs as well as the effect of the charge on establishments' water use and financial condition, if any. Other rate structures (price differentiation according to type of use) may also be considered in the future.

5.4.3 Installation of meters

Meters will be installed by CPDO (with the technical assistance of NWRB and COWD). The cost of the meter will be shouldered by the deep-well owners.

5.4.4 Training of city government and CDORBMC staff

The staff of the city government and CDORBMC shall be trained by NWRB with the assistance of COWD. NWRB currently has some forms of training modules and systems procedures for a raw water pricing scheme, which may be modified to suit the specific case of CDO.

---

[15] This arrangement is feasible as the Water District is essentially government-owned and is under the control of the LGU (the members of the COWD Board of Directors are appointed by the City Mayor). It may also be most efficient as these tasks to be subcontracted to the Water District are part of its regular operations.

[16] During the project's conception phase, the research team also met with the COWD Board of Director and Officers, the single biggest extractor of groundwater in CDO. The meeting was held on the same date as the meeting with the Mayor (29 June 2009) and the same materials were presented. Not surprisingly, COWD Board and officers expressed apprehension about the raw groundwater fee scheme. Realizing that in principle COWD is covered by the scheme, its Board Chairman and the Acting General Manager indicated that with the financial difficulties currently experienced by the Water District, it may find difficulty in complying with the scheme and that in the event that the raw groundwater pricing scheme is implemented, they shall seek exemption from it.

6. 0 Concluding Remarks

This action research project endeavored to push the CDO government to legislate and implement a raw groundwater pricing scheme as a resource management tool. As revenues from the raw groundwater fee will be earmarked for watershed rehabilitation and preservation programs, the proposed scheme will be in the mode of payment for environmental services.

The project included a hydrological study that was done to arrive at an updated estimate of the safe yield of the CDO aquifer. The hydrological study also enabled the research team to better understand and appreciate the underlying procedures and data in the safe yield estimates, thereby were able to provide a clearer picture of the extent of the problem to local government officials, groundwater users, and the general public during the consultation meetings.

The project also entailed the updating of the 1999 list of groundwater extractors in CDO and the amount of groundwater extraction. A number of new deep-well systems were identified, mostly constructed for subdivisions, hotels, and malls that have mushroomed in CDO since 2000. The updated estimate of groundwater use in CDO is around 4.67 million m^3/month, 39% more than the 2000 estimate. The gradient method used in estimating the CDO aquifer safe yield indicated a groundwater discharge (under natural conditions) in the range of 2.4-9.5 million m^3/month. It is apparent that a large portion of the natural discharge is used for water production, causing drawdown below sea level and local salt water intrusion. This conclusion is consistent with the low groundwater levels (below sea level) found in the Macasandig well field.

The above research components of the project were coupled with advocacy steps involving public information campaign through symposia, media, and consultation meetings among NWRB, other national agencies such as DENR, CDO local government units, groundwater extractors, and the newly formed CDO River Basin Management Council to come up with a workable design and implementation scheme for the raw groundwater pricing policy.

For effective implementation of the scheme, we recommend that NWRB, which has the legal mandate to impose a raw water fee by virtue of PD 424 and 1067, delegate this function to the CDO city government, which in turn may deputize the newly formed CDO River Basin Management Council, a multi-sectoral entity co-chaired by the DENR Region X Director and the Archbishop of CDO.

The study had gone as far as bringing the City Council to draft an Ordinance for the Raw Groundwater Pricing Scheme. As of this writing, the first Public Hearing on the draft Ordinance had been held.

REFERENCES

Blomquist, W. 1992. *Dividing the Waters, Governing Groundwater in Southern California*. San Francisco, California: ICS Press.

Cagayan de Oro Water District (COWD). 2008. COWD Technical Profile. Cagayan de Oro City.

CENRO. 1999. Cagayan River Watershed Profile. CENRO, Talakag, Bukidnon.

DwoI. 2010. (Document without identification obtained from Dr. Tan, August 2010)

Food and Agriculture Organization (FAO). 1998. "Crop evapotranspiration - guidelines for computing crop water requirements." *FAO Irrigation and Drainage Paper* 56. http://www.fao.org/docrep/X0490E/x0490e0b.htm#chapter.

FAO. 2010. "CLIMWAT 2.0 for CROPWAT database." http://www.fao.org/nr/water/infores_databases_climwat.html

Japan International Cooperation Agency (JICA), National Water Resources Board (NWRB), and Department of Public Works and Highways (DPWH). 1998. Master Plan Study on Water Resources Management in the Republic of the Philippines, Final Report Manila.

Louis Berger International Incorporated (LBII). 1991. Feasibility Study for Water Supply Systems for Metro Cagayan de Oro, Philippine Assistance Program Support Project, United States Agency for International Development, Manila.

National Water Resources Board (NWRB). 2010. Geo-resistivity Survey of Misamis Oriental (prepared by WATCON Inc.), Quezon City.

NWRB. (undated). Economic Valuation of Groundwater in Metro Manila and Nearby Areas. Draft Final Report..

Palanca-Tan, Rosalina and G.M. Bautista. 2003. "Metering and a Water Permit Scheme for Groundwater Use in Cagayan de Oro." *EEPSEA Research Report* 2003-RR8, Singapore.

PHIGIS. 2010. Shuttle Radar Topography Mission - Digital Elevation Model, 90-m spatial resolution mosaic of entire country, 4.1 (2007), NASA, http://www.philgis.org/freegisdata.htm.

Provencher, Bill. 1993. "A Private Property Rights Regime to Replenish a Groundwater Aquifer." *Land Economics*, 69(4): 325-40.

Regional Development Council X. 2004. "Regional Physical Framework Plan, Region X, 2004-2030." Regional Land Use Committee/Regional Development Council/National Economic and Development Authority, December 2004.

Rosengrant, Mark W. and R.S. Meinzen-Dick. ____. "Water Resources in the Asia-Pacific Region: Managing Scarcity." *Asian Pacific Economic Literature* 32-53.

Shah, Tushaar. 1993. *Groundwater Markets and Irrigation Development: Political Economy and Practical Policy*. Oxford University Press, Bombay.

State Water Rights Board, 1962, “Report of Referee, City of Los Angeles v. City of San Fernando et. Al.” http://www.chinoaz.net/general/SafeYieldCom/pdf/SYandOverdraft.

Talakag Community Environmental and Natural Resources Office (CENRO). 1999. Cagayan River Watershed Profile, Bukidnon.

USGS. 2002. “Geological Survey, Documentation of Spreadsheets for the Analysis of Aquifer-Test and Slug-Test Data.” US Geological Survey, Open-File Report 02–197, Carson City, Nevada 2002.

World Bank. 1981. “Economic Aspects and Policy Issues in Groundwater Development.” World Bank Staff Working Paper No. 496.

World Bank. _____. GW•MATE Briefing Note 2, http://siteresources.worldbank.org/EXTWAT/Resources/GWMATEFlyer2008.pdf