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Metering and A Water Permits Scheme for Groundwater Use in Cagayan de Oro

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This report makes suggestions for controlling the excessive abstraction of groundwater in Cagayan de Oro, Philippines. It finds strong evidence that the area's aquifers are being overexploited. It also finds a strong willingness to pay for water supply among the area's businesses. It advises that a tradable permit system for water abstraction would be an effective way to conserve groundwater. This approach could also generate money for conserving water catchment areas. However, the report also finds that major reforms in the national water monitoring and licensing authority would be necessary to ensure the success of any such scheme.

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January, 2003

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EXECUTIVE SUMMARY

With its fast growing population and booming economy, Cagayan de Oro (CDO) has started to mine its stock of groundwater. This is manifested by the drop in static and pumping water levels of the water district's production wells in recent years.

This research project examines the prospects of metering groundwater withdrawals, and of instituting a water permits scheme for groundwater abstraction. With this scheme, the sustainability of groundwater resources can be assured by limiting the amount of permits to the aquifer recharge rate or safe yield. The auction of permits allocates water according to willingness to pay (WTP) and generates revenues for system implementation and watershed protection.

The acceptability of the proposed scheme is determined from the survey of groundwater abstractors in CDO. The survey results indicate some WTP for raw water of about PHP 3.31 (USD 0.06) per m^3.

Estimates show that the initial capital outlays for meters and the recurring monitoring costs can be easily covered by proceeds from the auction of permits. The more crucial aspect of the proposed scheme, however, is the establishment of the institutional infrastructure necessary for its successful implementation. This entails major reforms in the National Water Resources Board (NWRB), the water monitoring and licensing authority in the country. NWRB must establish an effective presence in CDO, enhance its enforcement capacity, as well as institute an implementing structure and arrangement for the watershed protection and rehabilitation projects for which proceeds of the proposed scheme are earmarked.

1.0 INTRODUCTION

Cagayan de Oro (CDO) city, with its growing population and booming economy, appears to be depleting its groundwater supply. One indicator is the drop in pumping water level of some of the water district (WD) wells. The 1997-1998 survey of private well owners in the city conducted by the Institute of Philippine Culture (IPC) revealed that groundwater abstraction from privately-owned wells is roughly a third of the water district's production.[1] Among those who enjoy free access to the aquifer are the big industries which account for more than half of this private abstraction. The IPC study also revealed a number of issues concerning watershed management, groundwater use in CDO, groundwater undervaluation and unmonitored free access to the aquifer of

[1] The survey, funded by the Ford Foundation, was conducted by the Institute of Philippine Culture (IPC) as part of a three-year research project on watershed and groundwater depletion in Cagayan de Oro. The research monograph entitled "Watersheds and Groundwater Depletion in the Philippines: The Cagayan de Oro Experience" is available at the IPC (Bautista and Tan 2001).

private well owners. The present study reconsiders these issues and examines the prospects of metering, groundwater fee assessment, as well as the establishment of a system of permits as a means to sustainably manage groundwater resources.

For this research endeavor, a follow-up survey of private well owners was conducted in 2000 to accomplish two tasks[2]: (1) to validate and complete the findings of the 1997-1998 IPC survey; and (2) to survey the acceptability of metering groundwater withdrawals and of schemes to make all groundwater abstractors responsible for the value of raw water or to internalize groundwater's user cost. With the additional information and data from the follow-up survey, the authors updated and refined their previous estimates of groundwater withdrawals.

This paper consists of five sections. The next section draws heavily from the IPC report. It surveys groundwater use in the area. It shows how production capacity and actual groundwater abstraction of the Cagayan de Oro Water District (COWD) have grown over the years. Non-COWD groundwater withdrawal is estimated based on the surveys of industrial, commercial and institutional well owners as well as subdivision and barangay wells. The estimate of total groundwater withdrawal is then compared with the aquifer recharge rate or safe yield. Section two ends by presenting physical indicators of groundwater mining in the city.

The third section proposes a metering and water permits scheme to limit groundwater use in CDO to the safe yield. The results of the survey of private well owners to assess the acceptability and feasibility of the scheme are presented.

In the fourth section, the necessary expenditures and operating costs as well as the institutional requirements for the successful implementation of the scheme are examined.

The last section summarizes the main findings of the paper and discusses some limitations of water laws, policies and resource management institutions in the Philippines cited in the IPC study. These limitations must be addressed in order to institute the water permits scheme.

2.0 GROUNDWATER USE IN CAGAYAN DE ORO

2.1 The Study Area

CDO is a city consisting of a central poblacion (city center) and 40 village settlements (barangays), of which 23 are rural. The rural barangays include 10 coastal barangays with elevations of 2 to 6 meters above sea level (masl). The rest of the villages are located in lowland areas with slightly higher elevations of up to 10 masl.

Much of the 48,885-ha land within the boundaries of CDO is rolling to hilly with about 60% of the land having a slope steeper than 8%. The flat to gently sloping, if not

[2] The first survey concentrated on private well owners included in the data base of the Cagayan de Oro Water District (COWD). In the second survey, all establishments in the Poblacion and the main commercial and industrial areas in CDO were visited. For residential areas and city outskirts, barangay officials were interviewed.

undulating, lands are found only in the narrow coastal plains, the floodwaters of two rivers (Cagayan and Iponan) and the upland terraces.

Despite its hilly terrain, CDO hardly has primary or secondary forests. The natural forests in its vicinity are found in the mountainous areas of the neighboring provinces of Bukidnon and Lanao del Norte. More specifically, the residual and old-growth forests are situated within Mount Kitanglad Natural Park and Kalatungan Mountains which have elevations of at least 1,000 masl.

CDO sits on the coast of Macalajar Bay and within its political boundaries are three major watersheds with five major rivers and creeks draining into the bay. On the western boundary of the poblacion is Iponan River which drains a watershed located in the neighboring province of Lanao del Norte. Closest to the poblacion is Cagayan River which drains another watershed and is fed by five major river systems (Bubunaon, Tagite, Kalawaig, Alaan and Bulanog). The first three rivers have headwaters located in Mount Kitanglad Natural Park of Bukidnon Province while the other two originate from the Kalatungan Mountains. Among the three rivers originating from Mount Kitanglad, Bubunaon is nearest to the city.

Three other major rivers (Bigaan, Cugman and Agusan) and creeks traverse the city from its central and easternmost side to the coast. Together, these rivers help drain the third watershed which, like the second watershed, is partly bounded by Mount Kitanglad. However, the major rivers that drain the third watershed do not emanate from any of the headwaters in Mount Kitanglad Natural Park.

It is ironic that despite the numerous bodies of water within and around CDO, the city has no surface source of potable water. Existing surface water sources serve other purposes. Iponan River, for instance, is being used for irrigation by the National Irrigation Administration (NIA). Two communal irrigation systems servicing San Simon, Pagatpat, Canitoan, Opo and Iponan also draw water from the river while farmers direct the river water to their farms using the principle of gravity. In the upstream of Bubunaon River, the NIA has just completed the construction of a dam for the irrigation requirements of some Bukidnon towns while a private electric company has started work on the construction of a hydroelectric power dam.

2.2 Research Framework

A schematic diagram of the factors that affect the stock of groundwater and the effects and costs of its depletion is presented in Figure 1. The two major variables that determine the stock of groundwater are the amount of groundwater withdrawal and the aquifer recharge rate. The aquifer recharge rate is a function of the condition of the watershed, which is affected by forest and agricultural production activities which in turn are dictated by market demand and influenced by government policies. Changes in land use patterns brought about by economic growth and geographical shifts and increase of population likewise affect the aquifer recharge rate.

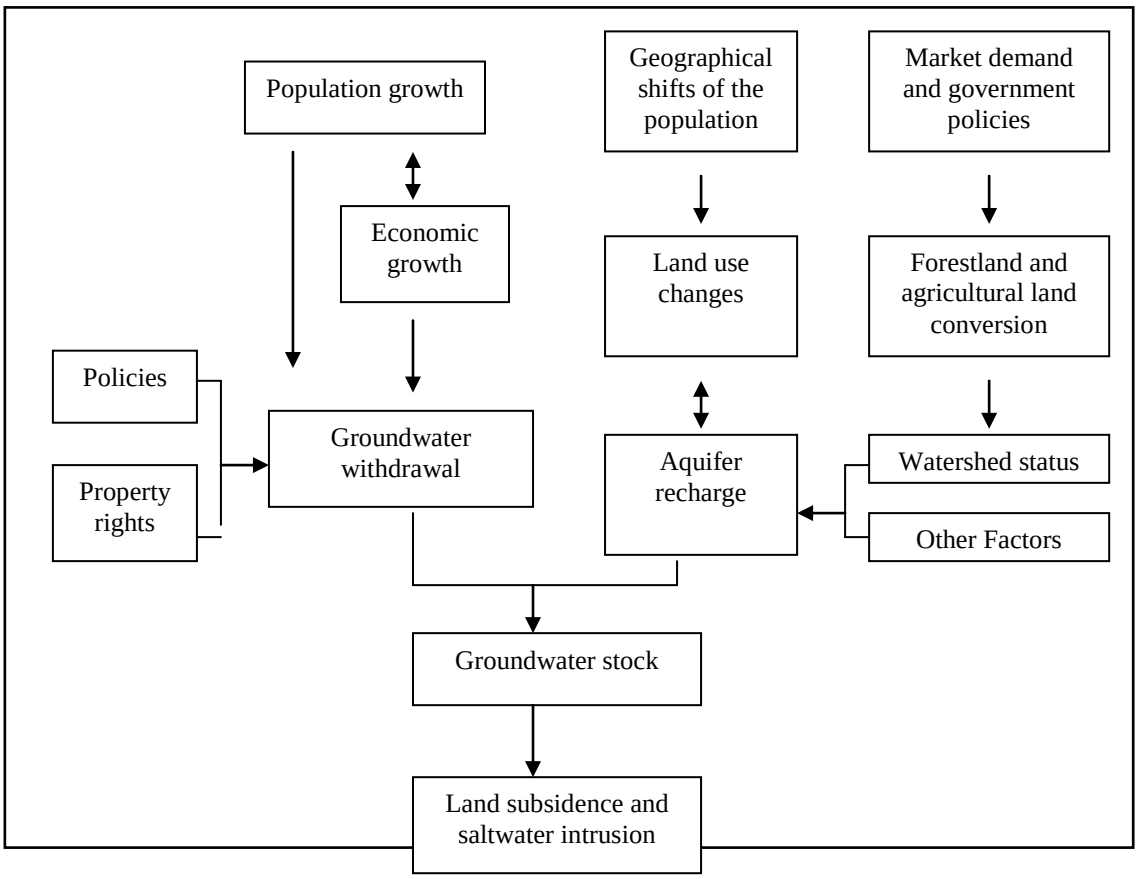

Figure 1. Groundwater Stock: Contributing Factors and Effects

Groundwater abstraction, on the other hand, intensifies as demand for water increases with population and economic growth. The rate of groundwater abstraction is also determined by policies on water use, ownership and pricing. Unmonitored withdrawal of groundwater and hence, a zero price for raw water, usually results in wasteful use of water.

There are indications of aggravating groundwater abstraction and slowing recharge of the aquifer in CDO. Population growth from the 1980s to the mid-1990s exerted a significant pressure on groundwater resources. Owing to high in-migration, the average annual population growth rate of CDO city from 1980 to 1995 was 4.2% which was about double the annual population increase in Northern Mindanao and the entire country (see Table 1). Data also show that population growth in the city was faster in the 1990-1995 period than in the previous decade**.**

Table 1. Population Growth in Cagayan de Oro City - 1980, 1990, 1995

Barangay	*Population*			*Population Growth Rate*
	1980	*1990*	*1995*	
Poblacion barangays (40)	41,288	37,713	34,568	- 1.18
Percent Share	18	11	8	
Non-poblacion barangays (17)	147,682	247,003	314,617	5.04
Percent Share	65	73	74	
Rural barangays (23)	38,342	54, 882	79,129	4.83
Percent Share	17	16	18	
Total	227,312	339,598	428,314	4.22
Percent Share	100	100	100	

Apart from absolute growth, the geographical distribution of the population has changed. While the number of people in the poblacion 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 of the poblacion also rose because of in-migration which accompanied commercial and economic growth.

The growth and geographical shifts of the population necessarily entail an increase in the 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 tenfold from 1985 to 1995 as a result of economic growth. 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 has more than doubled the so called built-up area in the city.

The effect of land use change on the aquifer's recharge capacity in CDO in the 1985-1995 period may, however, be negligible because of the small proportion of the total built-up area despite the increase during the period. The more significant determinants of the current stock of groundwater supply may be the level of groundwater withdrawal and the land use changes as well as watershed activities outside of the city.

Table 2. Declared Land Uses in Cagayan de Oro - 1985 and 1995

Land Type	*1985 Area (ha)*	*Percentage*	*1995 Area (ha)*	*Percentage*	*Annual Percentage Change*
Agricultural	45,908	94	21,846	45	- 5
Residential	2,223	5	4,699	10	11
Commercial	120	0	244	0	10
Industrial	50	0	571	1	104
Institutional	81	0	13	0	- 8
Tax-exempt lands[a]	48	0	2,738	6	560
Open spaces[b]	455	1	18,774	38	403
Total	48,885	100.00	48,885	100	

Source: Research and Statistics Division, City Assessment Department, Cagayan de Oro 2000

Notes: [a] These are government, religious and educational properties.

[b] These include rivers, swamps, creeks and undeclared properties.

2.3 Cagayan de Oro Water District (COWD) Water System

2.3.1 Production Wells

COWD is the water utility that serves the water requirements of CDO. In 1973, Presidential Decree (PD) No. 198 created the Local Water Utilities Administration (LWUA). LWUA has two tasks. The first is to create water districts (WDs) which are to be quasi-public corporations managing local water supply development and operations. The second task is to provide financial and technical support to WDs for communities with populations of more than 20,000. COWD, established in the same year by LWUA, became the first WD in the Philippines. Starting with only 3,500 in 1973, COWD's service connections grew 15-fold to more than 53,000 in 1999.

Prior to COWD, administration and management of waterworks operations were the responsibility of the city government. The water supply in the city at that time was sourced from eleven low-capacity deep wells and one spring source (Malasag) and was gravely inadequate to meet its needs. The water system was poorly maintained and water produced from six of the 11 well sources did not meet recommended water quality standards.

COWD was tasked to improve, expand, operate and maintain the water supply system of CDO. Its scope of work was to include wastewater collection, treatment and disposal facilities. LWUA was to provide financial and technical assistance to COWD in the performance of its functions.

Immediately after the creation of COWD, the Master Plan for the development of water resources for CDO was drafted.[3] The Master Plan provided for three phases of water system development in the city.

Before the implementation of the first phase of the Master Plan, four old wells - namely, Bugo Bantiles Well, Gaston Park Well, Cogon Market Well and Carmen Market Well - were utilized by COWD as main sources of water supply. Of these wells, only Bugo (Bantiles)[4] was retained for normal system operations. The other three were only maintained as stand-by wells and utilized for non-domestic purposes such as fire-fighting until 1983.

Construction for Phase 1 of the Master Plan was undertaken from 1975 to 1978. Funded by a PHP 32 million (USD 598,000) loan from LWUA, five production wells (PW), four (PW # 1, 2, 3, and 4) in Macasandig and one (PW # 5) in Bugo were completed. Phase 2 expansion was started in 1983. Implemented with loans from the Asian Development Bank amounting to PHP 96 million (USD 1.794 million), it resulted in six new wells; PWs # 7, 8 and 9 were located in Macasandig; PWs # 10 and 12 in Calaanan; and PW # 11 in Bugo.

Phase 3, which is still ongoing, is funded by a loan of PHP 500 million (USD 9.344 million) from the Overseas Economic Cooperation Fund (OECF). Under the third expansion phase, PW # 3A in Macasandig was constructed to replace PW # 3 which was decommissioned in June 1991. Another well constructed in the vicinity of the Macasandig area is PW # 16.

In the Bugo area, construction of four wells (PW # 20, 21, 22 and 23) is being undertaken while in the Calaanan area, two wells (PW # 15 and 18) are already completed and operational. A new location – Balulang – has been explored in this third expansion phase. Six wells have been completed in this new site, four of which (PW # 14, 17, 19, and 27) are already being utilized while the other two (PW # 25 and 26) are to be commissioned within the year.

[3] The consulting firm for this Master Plan was Wilson-Montgomery.
[4] This Bugo Well, renamed production well PW # 6, is still operational up to the present.

Table 3. Selected Characteristics of COWD Wells

Name	*Location*	*Depth (meters)*	*Year constructed*	*Discharge (liters per second)*			
				Jun 83	*Nov 91*	*Nov 97*	*Jul 00*
PW 6	Bantiles, Bugo	18	1965	32	19	16	-
PW 2	Bontula, Macasandig	220	1976	103	95	70	76
PW 3	Macasandig	117	1996	101	-	-	-
PW 5	Reyes, Bugo	76	1976	50	38	34	44
PW 1	Macasandig	248	1977	91	95	121	152
PW 4	Macasandig	211	1977	113	126	82	58
PW 7	Macasandig	200	1985	-	126	95	102
PW 8	Ramonal Village, Nazareth	255	1986	-	150	125	156
PW 9	Biasong, Macasandig	236	1987	-	150	112	124
PW 12	PN Roa Subd., Calaanan	139	1991	-	-	28	17
PW 3a	Macasandig	204	1994	-	-	118	95
PW 14	Balungis, Balulang	150	1994	-	-	78	96
PW 15	Calaanan	104	1994	-	-	55	30
PW 10	PN Roa Subd., Calaanan	122	1996	-	80	55	22
PW 16	Tomas Saco, Nazareth	187	1996	-	-	78	151
PW 11	Bantiles, Bugo	152	1997	-	-	117	136
PW 17	Balulang	186	1997	-	-	44	36
PW 18	Pueblo de Oro, Calaanan	132	1997	-	-	32	19
PW 19	Balulang	216	1997	-	-	150	12
PW 20	Villa Trinitas, Bugo	200	1997	-	-	63	76
PW 21	Villa Trinitas, Bugo	194	1998	-	-	-	120
PW 22	Villa Trinitas, Bugo	200	1999	-	-	-	120
PW 23	Agusan	200	1999	-	-	-	120
PW 25	Villa Angela, Balulang	226	1999	-	-	-	61
PW 26	Balulang	216	1999	-	-	-	46
PW 27	Macanhan, Carmen	207	1999	-	-	-	66
PW 24	Balulang	57	2000	-	-	-	40
PW 28	Phasco Vill., Tablon	159	2000	-	-	-	114
PW 29	Phasco Vill., Tablon	201	2000	-	-	-	114

Sources of Data: TCGI 1983, LBII 1992 and COWD for well discharge rate in June 1983; November 1991; and November 1997 and July 2000; respectively.

2.3.2 Groundwater Production and Consumption

Annual data on capacity, actual production and consumption are shown in Table 4. COWD production capacity increased to 102 thousand m^3/day in 1997 from a starting level of 13 thousand in 1978. The slight declines in 1998 and 1999 were due to the decline in the yield of several of the older wells and even some of the newer wells in the Calaanan and Balulang areas constructed during the Phase 2 expansion. It should be noted also that most of the wells in the Phase 3 expansion were not yet fully operational during these years.

Until 1978, capacity was overutilized reflecting the inadequate water supply system prevailing during the time. The first increase in COWD's production capacity resulting from the Phase 1 program took effect in 1979. Initially, however, residents were not interested in getting water from COWD due to the high connection fees. Hence, capacity was grossly underutilized until 1981. Recognizing the problem, COWD administrators devised a payment scheme by which the connection fee was spread and included in the concessionaire's monthly billings over a period of time. This scheme resulted in a noticeable improvement in capacity utilization.

The variability of capacity utilization from the second half of the 1980s to the 1990s suggests a pattern. As the number of wells increased in the late 1980s, early 1990s, 1996 and 1997, capacity utilization declined. However, it rose in response to the growth in groundwater consumption - from 66% in the 1980s to an average of 78% by the 1990s - reaching its highest capacity utilization rate of 85% in 1995. With the continuing expansion program geared towards long-term projections of water demand, actual production - while consistently below its potential - grew with increasing capacity utilization over time.

Actual consumption, likewise, falls short of actual production. Unaccounted water results from both leakages in the distribution system and illegal connections. This appears to be more of a problem in recent years. In the 1980s, unaccounted water was just about 17% of actual production. In the 1990s, more than 25% of production is non-revenue water. Leakages have increased due to the wearing out of equipment and distribution pipes. The expanding service area of the water district, the rapidly increasing density of the population and the mushrooming of squatters in certain parts of the city could have caused the increase in illegal connections. Operating with these leakages and illegal connections, the COWD has supplied the water needs of the growing population of CDO at a subsidized rate. Note, however, the declining trend in non-revenue water. In 1999, despite reduced water production, the consumption figure increased as a result of this improvement.

The level of water consumption by residential, government and industrial establishments[5] is presented in Table 5. With COWD concessionaires consisting mostly of households accounting for 87% of the total volume of water consumed, the consumption per connection was 31.8 m^3 for the month of December 1997. If there were 10 persons per connection, the per capita water consumption in 1997 would have been 3.2 m^3, a figure that hews closely to the average consumption of the service population (3.7 m^3). The imputed per capita consumption figure would be useful for estimating the groundwater use of the private sector and barangay communities.

[5] Industries, by COWD definition, include commercial and private institutions, and all other non-residential and non-government entities.

Table 4. COWD Production and Consumption Data, 1976-1999

Year	*Production Capacity*	*Production*		*Consumption*		*Unaccounted Water*	
		Volume (thousand m^3/day) (1)	*Capacity Utilization (%)*	*Volume (thousand m^3/day) (2)*	*Ratio of (2) to (1)*	*Volume (thousand m^3/day) (3)*	*Ratio of (3) to (1)*
1976		12.20		2.20	18.03	10.00	81.97
1977		12.10		5.10	42.15	7.00	57.85
1978	13.39	14.90	111.24	5.50	36.91	9.40	63.09
1979	22.73	14.80	65.12	10.30	69.59	4.50	30.41
1980	37.79	15.70	41.55	13.40	85.35	2.30	14.65
1981	44.17	19.20	43.47	15.70	81.77	3.50	18.23
1982	40.42	25.90	64.08	19.40	74.90	6.50	25.10
1983	38.90	27.80	71.46	23.10	83.09	4.70	16.91
1984	39.58	27.60	69.73	23.90	86.59	3.70	13.41
1985	45.00	29.70	66.00	24.80	83.50	4.90	16.50
1986	45.00	32.20	71.56	26.60	82.61	5.60	17.39
1987	45.00	34.50	76.67	28.95	83.91	5.55	16.09
1988	50.87	37.50	73.72	30.40	81.07	7.10	18.93
1989	67.31	40.50	60.17	34.41	84.96	6.09	15.04
1990	69.98	51.21	73.17	37.53	73.29	13.68	26.71
1991	68.92	56.44	81.89	39.48	69.95	16.96	30.05
1992	81.13	59.57	73.42	45.74	76.78	13.83	23.22
1993	88.36	64.93	73.49	45.16	69.55	19.77	30.45
1994	93.79	72.29	77.08	50.14	69.36	22.15	30.64
1995	85.49	72.38	84.67	52.78	72.92	19.60	27.08
1996	92.67	72.47	78.20	50.93	70.28	21.54	29.72
1997	102.13	83.23	81.50	59.39	71.36	23.84	28.64
1998	100.70	82.20	81.63	59.48	72.36	22.72	27.64
1999	96.94	77.26	79.70	58.54	75.77	18.66	24.15
Ave.	62.29	43.19	72.71	31.79	71.50	11.40	28.49

Table 5. Summary of COWD Water Billing Data, December 1997

Data	*Type of User*			*Total*
	Residential	*Government*	*Industrial*	
No. of connections	47,223	71	2,855	50,149
Percent share	94	0	6	100
Volume (m^3)	1,499,680	39,727	181,146	1,720,553
Percent share	87	2	11	100
Billing amount (PHP)	10,859,202	562,866	3,191,807	14,613,876
Percent share	74	4	22	100
Average price (PHP/m^3)	7.24	14.17	17.62	8.49
Consumption volume per connection (m^3)	31.76	559.54	63.45	291.41
Per capita consumption				
- assuming 6 persons/connection	5.29			
- assuming 10 persons/connection	3.18			
- population served (83% of 1997 population)	3.74			

Note: 1 USD = 53.51 PHP

2.3.3 Water Rates

Relative to residential and government users, industries' share of water consumption in 1997 was more significant in value terms. Although industries consumed only a tenth of the volume, they paid about a fifth of the total bill for water consumption because of the higher water rate for industries. Industrial establishments are charged twice the rates for residential users. The effective price of water for industries based on the actual consumption data in Table 5 was PHP 17.62 (USD 0.33) per m^3, more than double the effective rate for residential users.

With their rates set at twice the cost charged to residential users, industrial and commercial establishments have found it cheaper to pump water from their own wells.[6] Thus, the ability of the water district to serve more of the unconnected population at an effectively lower rate is constrained by the private pumping efforts of industries and other institutional users.

Government accounted for the remaining 2% of the volume and 4% of the value of water consumption. Although COWD's overall price of water was PHP 8.49 (USD 0.16), its effective water rate for government entities was PHP 14.17 (USD 0.26), almost double the residential rate. Considering that the same schedule of water rates is applied to residential and government users, the much higher rates of the latter may be owing to the bigger water pipes of government offices which entail higher charges. These government offices can therefore improve their efficiency in water use by using optimum sized pipes.

Figure 2 shows the minimum water rate charged by COWD since its establishment in August 1973. Despite a normal annual inflation rate of 10% and several bouts of escalating inflation - brought about by the 1973/1978 oil crises, the 1983-1985 foreign exchange crisis and the past few years' economic stagnation resulting in the increase of the consumer price index 18 times from 1973 to 1977 - COWD minimum water rates had only tripled from PHP 20.00 (USD 0.37) to PHP 60.00 (USD 1.12) for residential users and from PHP 40.00 (USD 0.75) to PHP 120.00 (USD 2.24) for commercial and industrial users. In real terms, the water rate for residential users had actually dropped from PHP 20.00 (USD 0.37) to PHP 3.30 (USD 0.06) while that for commercial and industrial users had declined from PHP 40.00 (USD 0.75) to PHP 6.70 (USD 0.13). In another 10 years, the projected water rates for residential as well as commercial and industrial users would be PHP 1.30 (USD 0.02) and PHP 2.60 (USD 0.05), respectively, assuming an inflation rate of 10% and no adjustments in the nominal rates. The decreasing water rates in real terms have thus maintained the illusion that there is no groundwater scarcity problem. Despite its growing scarcity, the price of groundwater in CDO has ironically diminished over the years.

[6] Xavier University, for instance, has its own deep well but it is also connected to the COWD. Except for drinking water, it normally gets its water from its deep well. It draws all its water requirements from the COWD only when its own deep well system breaks down. On this rare occasion, it pays a multiple of what its own deep well system normally costs it.

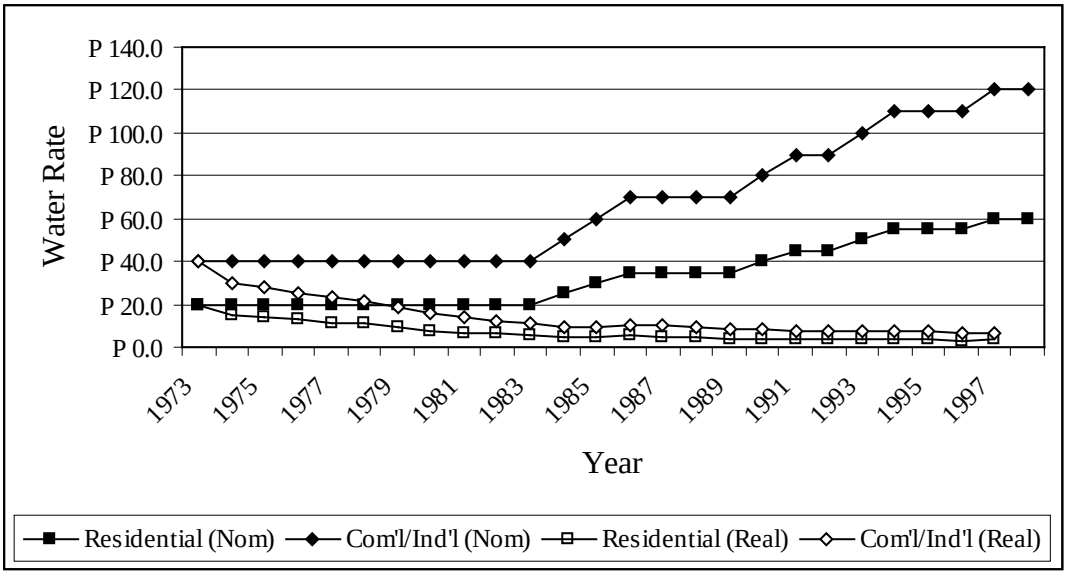

Figure 2. COWD Minimum Water Rate for Residential and Commercial/Industrial Users, Nominal and Real Terms, 1973-1997

Note: P = PHP

1 USD = 53.51 PHP

2.4 Non-COWD Water Systems

The long list of non-COWD wells reveals the extent of private water abstraction in CDO. Most of these private wells are dug without permission from the National Water Resources Board (NWRB). While there are more than 250 wells in the list, there are only about 17 permits issued for CDO by the NWRB between January, 1975 and September, 1997.

A survey of groundwater withdrawal from non-COWD wells was first undertaken in 1997-1998 for the IPC research project on watershed and water management in the Philippines. The survey covered the establishments with their own well systems as per COWD records. Interview guides included questions about the well systems such as date of construction, depth of the well, pump capacity as well as the establishment's daily and/or monthly water requirements; volume of water withdrawal from wells, volume of water provided by COWD (if applicable), as well as water supply problems and general water demand/supply situation in CDO. A follow-up survey was conducted in 2000 for this study primarily to determine the private well owners willingness to pay for raw water and their willingness to contribute to the protection and maintenance of the watershed to ensure a stable supply of water in CDO. In addition to the questions pertaining to the acceptability of metering and a raw water fee policy, the previous questions on the technical specifications of the well systems, water requirements, water withdrawals and water supply problems were also included in the follow-up survey in

order to validate and update the results of the first survey.[7] Most of the respondents for smaller establishments were the manager or the head of the organization and for the bigger and industrial establishments, technical or production personnel in managerial or supervisory positions.

Summary figures for the number of private wells according to the type of establishment operating them are given in Table 6. Of the 269 identified non-COWD wells, 31 are owned by industrial establishments while 94 are owned by commercial establishments. Government offices and entities account for 73 wells. Institutions such as schools and hospitals have 21 wells. Twenty-two wells in the lists are owned and operated by subdivisions while 28 wells are owned by private individuals.

Table 6. Number of Wells (Establishments) Outside of the COWD System, 2001

Type of Establishment	*Respondents*				*Non-Respondents No. of Wells (establishments)*		*Total Number Of Wells (establishments)*	
	Opera-tional Wells	*Abandoned Wells*	*Sub-Total Wells (establishments)*					
Big Industries	13	0	13	(4)	3	(2)	16	(6)
Medium Industries	5	0	5	(3)	4	(2)	9	(5)
Small Industries	4	2	6	(5)	0	(0)	6	(5)
Commercial	59	27	86	(73)	8	(5)	94	(78)
Government	44	16	60	(23)	13	(5)	73	(28)
Institution	14	0	14	(11)	7	(7)	21	(18)
Subdivision	10	11	21	(15)	1	(1)	22	(16)
Private	7	0	7	(7)	21	(17)	28	(24)
Total	150	56	212	(141)	57	(39)	269	(180)

[7] A copy of the interview guide used for the present study is included as Appendix 1. The previous IPC survey exhausted all existing establishments in the COWD list while 91 establishments responded fully to the follow-up survey of this study. In the conduct of the follow-up survey, however, our surveyors attempted to verify the completeness of the COWD list by identifying all commercial and industrial establishments with their own groundwater systems. All establishments in the Poblacion and other commercial/industrial areas in CDO namely Carmen, Osmena, Lapasan, Tablon, Purto, Gusa, Kauswagan and Cugman were visited and casually asked if they have a well. Further, to be discussed later, is the attempt of our surveyors in this present study to identify the number of private (residential use) wells by interviewing officials in the 72 barangays of CDO.

2.4.1 Industries and Commercial Establishments

Industries and commercial establishments account for only less than 3,000 of the more than 50,000 COWD connections. Many of the business and private institutional establishments have their own shallow or deep wells. These entities do not want to connect to COWD due to cost considerations. COWD is one of the more effective and profitable water utilities in the country as its rates not only cover maintenance, operating and capacity expansion costs but also result in modest profits. Rates for industrial and institutional users are set at twice the rates for residential users. Thus, it is cheaper for industrial and commercial establishments - especially the larger ones- to pump their water from their own wells.

A total of 8,412 business (industrial and commercial) establishments in CDO are listed with the Department of Trade and Industry (DTI). Industrial/commercial entities connected to COWD number 2,855 while some 94 business establishments have their own wells (125) as per COWD records. Hence, the water source of some 5,000 business establishments - about two-thirds of the total - is unaccounted for. There are three possibilities. First, it may be that some commercial and industrial units - especially the smaller, cottage-type, family-owned businesses - are reported as residential units so as to avoid the higher water charges for industries. Second, it may be that some of those in the DTI list are no longer operational. Third, there may still exist a number of wells - probably shallower and with smaller production capacity - which are not in the COWD list.

The COWD list distinguishes between industrial and commercial establishments with industries subdivided into big, medium and small. The “Big Industry” category includes six manufacturing firms; namely, Coca Cola, Pepsi Cola, Nestle, Del Monte, Alwana Wood Products and Misamis Wood Component with their own groundwater system. Del Monte alone has five wells with depth ranging from 50 to 125 meters (m). Nestle has four while Coca Cola, Pepsi and Alwana have two each. Misamis Wood has only one well. Coca Cola and Alwana are also getting water from COWD. One of these six firms reported withdrawing about 18,300 m^3 of water from their wells every day. This water production figure of just one industrial entity is already equivalent to more than a fifth (about 22%) of COWD’s production in 1997. Of these six big industrial firms, four responded to the survey. The combined private withdrawal of water from these four wells amounts to around 21 thousand m^3/day, more than a fourth of COWD production. (Please refer to Tables 6 and 7.)

Enterprises classified under medium (5 firms) and small industries (5 firms) have nine and six wells, respectively, with depth ranging from 10 to 60 m. Three of the five medium-sized industrial firms responded to the survey. These three firms withdraw some 586 m^3 of water from their five wells. Of the five small-scale firms in the COWD list, two are no longer in operation. The remaining three were interviewed. One of the two is a subsidiary and is located in the compound of one of the big-scale firms. Its withdrawal of groundwater is already included in the big firms' category. The other two reported a water withdrawal rate of 23 m^3/day.

Ninety-four wells are owned and used by 78 commercial establishments such as hotels, restaurants, shopping centers, banks, gasoline stations and others. Seventy-three of the 78 commercial establishments or 86 of the 94 wells were included in the respondents.

Remarkably, a substantial number (27) of the 68 wells were reported abandoned while three are still in the process of completion. A well located in Vamenta was reportedly abandoned due to salt water. The Social Security System (SSS) deep well in Carmen was said to be abandoned because the water discharged was muddy. The break-down of the pump was a reason cited by four responding commercial establishments. With the continuously expanding service area, connecting to COWD might have been preferred to replacing pumps and rehabilitating private wells. The surveyed commercial establishments reported a total daily water discharge from their wells of about 2,153 m^3.

2.4.2 Government

There are 73 wells under the charge of 28 public entities—the National Food Authority (NFA), Department of Local Governments (DILG), three schools, two hospitals, 19 barangays (communal wells), one market and one park. Twenty-three of these government entities operating 60 wells responded to the survey. Sixteen of these 60 wells are no longer in use. These abandoned wells include the two hospitals, three schools, two barangays and a park. The remaining 44 wells found to be still operational, discharge an average of 6,548 m^3 of water on a daily basis.

2.4.3 Institutions

Twenty-one wells are operated and used by 18 non-government educational, medical and other private institutions. Most of the institutional wells are just a few meters deep. Some of these institutional establishments are also connected to COWD. Xavier University, for instance, gets its drinking water from COWD and uses its own system for all of its other water requirements. Eleven of the private institutions (14 wells) responded to the survey. All 14 wells are still in use and produce an average of 1,838 m^3 of water per day.

2.4.4 Subdivisions

Some subdivisions are not covered by COWD. Most of these are on elevated areas that are not reached by COWD gravity-driven water distribution system. The COWD list shows a total of 22 private deep wells (which are 30 to 100 m deep) serving the water needs of 16 subdivisions. Fifteen of these subdivisions (21 wells) responded to the survey. Five of these subdivisions are no longer using their wells and are now getting water from COWD. One subdivision, Villa Angela, had turned over its five wells and is presently connected to COWD's distribution pipes. It was found that only nine of the 18 wells are still in use and one is not yet completed. The nine subdivisions, which still draw their water from their own wells, consume some 2,146 m^3 of water each day.

2.4.5 Private

This category refers to one, two or more households residing in a compound with their own groundwater system. There are 24 such entries in the COWD list but only seven were surveyed. These seven reported a combined water withdrawal of 26 m^3/day.

Due to the relative insignificance of each entry in this category in terms of size and hence, water production, entries in this category were not prioritized in the conduct of the interviews. This study’s research team, however, visited the offices of 72 barangays

in CDO to verify the total number of private/household wells. A total of 367 private household-use wells have been uncovered - most of which are shallow, open dug wells. With depths ranging from 5 feet (ft) to 15 ft, these wells are mostly operated by hand pumps or pumps that require the use of a bucket. Fifty-five wells are reported to be servicing the washing and drinking needs of several households.

2.5 Groundwater Depletion in Cagayan de Oro (CDO)

2.5.1 Groundwater Safe Yield

The continuing rapid growth of the population of CDO has raised concerns about the future availability of water in the region. Estimates of groundwater safe yield in the region are shown in Table 8. The 1991 LBII feasibility study on the Phase 3 expansion plan of COWD presents two sets of estimates. The first set utilizes the LWUA methodology which takes into account the area of the watershed. The procedure assumes that 75% of net rainfall goes to aquifer recharge. Net rainfall is defined as precipitation less streamflow and evapotranspiration. Groundwater safe yield is then calculated as the product of the aquifer recharge rate and the area of the watershed. The study area covered by the feasibility study includes Metro CDO and portions of Bukidnon and Lanao del Norte provinces. For the entire study area, data on precipitation, streamflow and evapotranspiration are averaged and a single annual groundwater recharge rate is applied. The resulting estimate for groundwater safe yield for the whole study area is 849 million m^3/year (2.3 million m^3/day). Misamis Oriental which comprises about three-fourths of the above watershed area has a groundwater safe yield of 637 million m^3/year (1.7 million m^3/day). The CDO drainage basin, encompassing about 30% of the whole watershed area, is estimated to recharge at a rate of 259 million m^3/year (710,000 m^3/day).

The second set of estimates is derived using the NWRB method. The procedure assumes that 10% of annual rainfall goes to groundwater recharge. Groundwater safe yield is simply calculated as the product of net rainfall and the groundwater available area.[8] This method arrives at a more conservative estimate of groundwater safe yield of the Misamis Oriental aquifer - 578 million m^3/year (1.6 million m^3/day). For CDO, specifically, groundwater safe yield on a daily basis is estimated to be 182,000 m^3. The feasibility study then concludes that groundwater supply in CDO will be adequate to meet the needs of the city before the year 2011 during which consumption in the city is projected to reach 204,945 m^3/day.

The most recent estimate of groundwater recharge in CDO is taken from the *Master Plan Study on Water Resources Management in the Philippines* (JICA, NWRB and DPWH 1998). The methodology applied in the JICA estimates is similar to the second set of estimates of the LBII study. The major difference lies in the assumed proportion of net rainfall. In the JICA study, only 5% of annual rainfall is assumed to go to groundwater recharge. Expectedly, the resulting estimates for groundwater recharge in the JICA study are about half of Set 2 estimates of the LBII study. For Misamis Oriental, the groundwater recharge rate is estimated at 274 million m^3/year (7.5 million m^3/day). The figure for CDO is alarming - exploitable groundwater is just about 34 million m^3/year or 93,970 m^3/day.

[8] Groundwater available area is assumed to be a certain proportion of land area. This proportion varies by region, province and city.

Table 7. Estimated Groundwater Withdrawal and Capacity Utilization, Non-COWD and COWD Wells, 2001

Non-COWD Wells	*Groundwater Withdrawal*[a]		*Surveyed Capacity*[a]	*Capacity Utilization (%)*
	Surveyed[b]	*Estimated*		
Big Industry	21,009.2 (61)	21,209.2	36,813.7	57
Medium Industry	585.6 (2)	635.6	6,050.0	10
Small Industry	23.4 (0)	23.4	nd	
Commercial	2,153.0 (6)	2,543.4	6,514.9	33
Government	6,548.1 (19)	7,726.8	nd	
Institutions	1,838.4 (6)	2,441.4	4,607.1	40
Subdivisions	2,146.2 (6)	2,154.6	12,133.8	18
Private	26.0 (0)	84.0	157.3	17
Estimated Subtotal	34,330.2 (100)	36,818.4 (32)		
COWD Wells		77,260.0 (68)	102,130.0	82
Estimated Total		114,078.4 (100)		

Notes: [a]Measured in m^3/day.

[b]Figures in parentheses are % shares in Estimated Subtotal.

There is no doubt that the 1991 LBII study's estimate of 182,000 m^3/day for the groundwater safe yield for CDO has to be updated and adjusted downward. There has been extensive conversion of forest and agricultural lands into commercial, industrial, and residential use in CDO. As indicated in an earlier section, total built-up area from 1985 to 1995 had almost doubled from 4.70% to 8.63% of CDO's total area. The rapid expansion of the built-up areas has serious negative implications on the water absorption capacity and hence, the water recharge rate of the aquifer. Exploitable groundwater for CDO at present may therefore be substantially lower than the 1991 estimate of 182 thousand m^3 and the most recent JICA estimate of 94 thousand m^3/day may indeed be safer to assume.

Table 8. Estimates of Groundwater Safe Yield - 1991 and 1998

	Thousand m^3/day		*Thousand m^3/day*
	LBII (COWD FS) 1991		
	LWUA Method	*NWRB Method*	*JICA 1998*
CDO, portions of Bukidnon and Lanao del Norte	2,326		
Misamis Oriental	1,745	1,584	751
Cagayan de Oro (CDO)	710	182	94

2.5.2 Estimation of Total Groundwater Withdrawal

For the year 1999, COWD's actual water production amounted to 77,260 m^3/day. It is not useful to simply compare COWD's water production with the groundwater safe yield of CDO. There is a big number of wells in CDO which are not owned by COWD and water withdrawals from these non-COWD wells may be substantial. COWD services only 80% of the population of the city and this ratio largely pertains to residential demand for water. Many of the industrial, commercial and institutional water users have their own wells and are not served by COWD. The industrial/commercial and other institutions with their demands, although small in number, represent a significant portion of water consumption in the city. Hence, to come up with a more precise assessment of groundwater depletion, all withdrawals of water from both COWD and non-COWD wells must be calculated.

The 141 establishments (with 212 private wells) which responded to our surveys reported a total groundwater abstraction of 34,330 m^3/day. On the other hand, water consumption of the 39 establishments (with 57 wells) which did not respond to the survey was estimated based on available data on their operations. For industrial and commercial establishments, information on the type of business or products, volume of production or sales, factory or office floor area and number of personnel/workers was gathered. Estimates of water consumption were based on number of beds for hospitals; number of classrooms, students and academic and non-academic staff for schools; as well as number of lots, average lot area and present occupancy rate[9] for subdivisions. Overall, the estimated water withdrawal from non-COWD wells amounted to about 36,818 m^3/day.

2.5.3 Groundwater Level

Comparing the JICA recharge rate with the estimated groundwater withdrawal from COWD and non-COWD wells of 114,000 m^3/day will lead to the conclusion that groundwater mining is already taking place in CDO. That groundwater production has gone beyond the safe yield is manifested by the drop in the water level of COWD wells.

[9] There are a few establishments which could not be located. These are classified as non-respondents and their water consumption is equated to zero.

Data on the static water level (SWL) of COWD wells point to depleting groundwater resources in the city. There are only four COWD production wells (PWs) for which SWL data are available for several years. These four wells are in the three major locations for COWD wells and hence, the data, however limited, may be representative of the condition in the different groundwater areas in the city. PW # 2 in Macasandig had a SWL of 18 ft in 1983. In 1988, its SWL had dropped to 25 ft. By 1994, it was further down to 38 ft. The rate of depletion accelerated such that just after a year, in 1995, the SWL fell by another 10 ft to 48 ft. PW # 7, also in Macasandig, recorded a drop in its SWL from 5 ft in 1989 to 17 ft in 1993. The Calaanan production well (PW # 10) had a SWL of 14 ft in 1987. Its SWL was still 17 ft in 1991 but in 1992, it plunged to 47 ft. Even in Bugo, where the aquifer is known to have better characteristics, the stock of groundwater is contracting. COWD's PW # 5 in Bugo was free flowing in 1989. By 1993, its SWL was already 8 ft below ground.

Initial static water levels (SWLs) of the different COWD wells constructed in different years support the observation above. Wells dug in the eighties had SWL of less than 20 ft. From 1993, initial SWLs were exceeding 30 ft.

Data on COWD wells likewise reveal falling pumping water levels (PWL). A sample of eight COWD wells are used for the regression analysis undertaken to determine the annual drop in the PWL of the CDO aquifer. The regression results reveal statistically significant declines in the PWL of COWD production wells in Macasandig of about 3 ft per year.[10] The fall in the pumping water level of the Bugo well is slower at 1 ft per year. For the Calaanan wells, the rate of fall in the water level ranges from 7 to 14 ft per year.

[10] The much faster depletion rate of 19 feet per year for PW # 7 is ignored as further investigation revealed that the sudden fall in the pumping water level of the well from 48 ft in 1991 to 75 ft in 1992 was brought about by a change in pump capacity from 100 hp. to 125 hp.

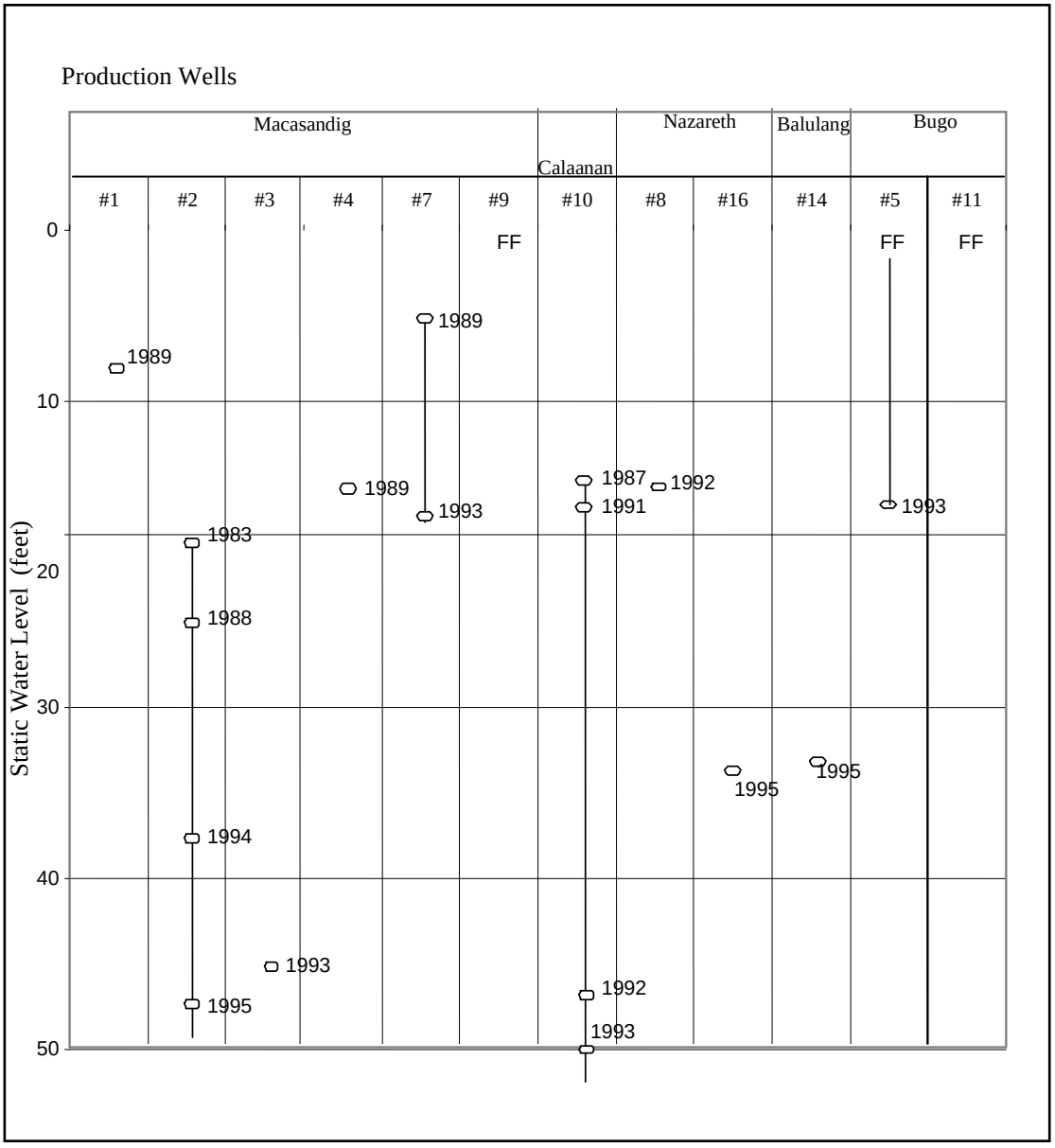

Figure 3. Static Water Level (SWL) of COWD Wells

Table 9. Regression Results: Change in PWL of COWD Wells

COWD Well no.	*Intercept (t-statistic)*	*Coefficient (t-statistic)*	R^2	*F*
Macasandig				
1	- 6303.3 (- 2.62)	3.21 (2.66)	0.50	7.08
2	- 5749.3 (- 5.51)	2.92 (5.57)	0.80	31.06
4	- 5807.2 (- 2.35)	2.96 (2.39)	0.42	5.73
7	3.8 (1.02)	19.48 (6.87)	0.97	99.20
9	- 5811.9 (- 4.55)	2.94 (4.60)	0.78	21.17
Bugo				
5	- 1941.0 (- 3.45)	0.99 (3.50)	0.61	12.28
Calaanan				
10	- 15119.6 (- 10.80)	7.64 (10.88)	0.96	6.49
12	- 28262.5 (- 6.14)	14.24 (6.17)	0.91	38.07

3.0 A GROUNDWATER WITHDRAWAL PERMITS SCHEME FOR CDO

Indicators of groundwater mining and depletion in CDO are discussed in the previous section. First, data on static and pumping water levels of COWD wells in different locations clearly manifest a falling trend.

Second, COWD has found it increasingly difficult to identify shallow well areas where they can dig their new wells for their expansion programs. As early as the Phase 2 expansion, two wells (PW # 10 and 12) were located in Calaanan - a deep well area - with dilivium or tertiary sediments and low groundwater potential. Consequently, these two wells were falling behind, even the older ones in Macasandig and Bugo as revealed by their fast declining discharge rates (Table 3). Despite this, under the on-going Phase 3 expansion program, new wells are being constructed in Calaanan. Further, a new location – Balulang, also situated in a deep well area - was explored, with six wells constructed in this new site.

There are no new pump wells constructed in Macasandig by COWD. This perhaps indicates that COWD is aware that aquifers in Macasandig have already reached full utilization. Three of the eight COWD wells reported to be performing unsatisfactorily are located in Macasandig. These are PW # 2, 7 and 9. It should also be noted that apart from the COWD wells, several private wells have been identified in the area.

The CDO level and rate of population increase are not expected to abate because of its role as Northern Mindanao's regional center for commerce, finance and education. Hence, it is projected that there will be a continuous increase in water demand while groundwater depletion may accelerate if other water sources are not tapped and developed.

3.1 Groundwater Preservation

Groundwater is one important natural resource which needs to be preserved for future generations. Even in places where there are abundant surface water sources, groundwater becomes a necessary supplement to surface water supply in cases of prolonged drought. As such, it is an essential resource for agriculture and industry. In many countries, surface water is not sufficient to meet the enormous water requirements of irrigation during the dry season and groundwater is withdrawn to fill the gap. Industry is another sector whose water demand cannot be easily adjusted to seasonal variation in surface water supply. In times of seasonal shortages in surface water supply, the water utility rations supply to its various users. Water-intensive industries then resort to groundwater to continue their normal operations. The Philippines, in particular, is a country that is affected by El Nino and hence, requires that groundwater be preserved to ensure a year-round supply of water for agriculture, industry and municipal uses.

Apart from supplying water to municipal users, agriculture and industry, groundwater systems serve to sustain the flow of streams and rivers, as well as help maintain riparian and wetland ecosystems (U.S. Geological Survey 2000).

In addition to the above uses, the stock of groundwater has to be maintained as its depletion entails costs to society. Excessive withdrawal of groundwater is known to cause land subsidence and saltwater intrusion.

Land subsidence is the lowering of the land-surface elevation as a result of changes and movements of underground materials. Among the problems that may arise from land subsidence are changes in the elevation and slope of streams, canals and drains; severe coastal flooding, and permanent increase in flood risks; damages to engineering infrastructure such as roads and bridges, railroads, water pipelines, sanitary sewers, storm drains, canals and levees, as well as private and public buildings. In addition, critical environmental resources such as estuaries and agricultural lands may be affected, including gradual or sudden catastrophic fissuring of the earth's surface (Leake 1997).

Saltwater intrusion occurs when the water table falls lower than sea level. The seepage of seawater into fresh water aquifers severely affects the quality of water supply. This may result in increasing water treatment costs or quality deterioration that renders the groundwater unsuitable for human use - domestic, agricultural and industrial (Gach 1987).

Further, since it usually takes a long time for the effects of groundwater depletion to become observable, many of the future damages and cost may still be largely unknown at present.

3.2 Private Groundwater Abstractors and Their Willingness to Pay (WTP) for Raw Water: Survey Results

In the follow-up survey of establishments with groundwater supply systems conducted for this study, 91 participated. As mentioned earlier, the purpose of this follow-up survey is two-fold: (1) to determine the private well owners' assessment of their water requirements and their perceived sufficiency and sustainability of water supply in CDO relative to their present and projected demand in the future, and (2) to determine their willingness to pay (WTP) for raw water and contribute to the protection of the watershed to ensure a sustainable supply of water. A copy of the interview guide used for this survey is included as Appendix 1. The first set of questions pertains to a few basic information about the company.

Table 10. Survey Respondents by Type of Establishment

Type of Establishment	*Number of Establishments*	*% Share of Total*
Big Industry	4	4
Medium Industry	4	4
Small Industry	1	1
Commercial	42	46
Government	13	14
Institution	15	17
Subdivision	6	7
Private	6	7
Total	91	100

The second set of questions deals with the establishments' existing water supply systems, present water requirements and problems. Questions on the present water requirements and sources are included as preliminary to the questions on the problems private well owners are presently encountering. Another objective for including these questions is to verify the responses to the earlier survey conducted by the IPC research team for the watershed study.

About half of the respondents indicate problems with their present water systems, most of which (32) involve water quality. The next most frequently cited problems are the increasing power cost of the pump (9 respondents) and the high maintenance costs of the well system (8 respondents). Three indicate insufficient supply with one big industrial establishment observing a fall in the water level of its well system. Other problems cited by the respondents include breakdown of pumps (3 respondents), absence of water treatment facilities (2 respondents) and weak water pressure (1 respondent). A representative for a public/community well cites the growing number of consumers increasingly difficult to supply with the present well system. Of the remaining 46 surveyed entities, 30 (about a third) categorically indicate the absence of problems while 16 provide no answer (Table 11).

Table 11. Problems with Present Water Supply Systems

Problem	*Industry*	*Com'l*	*Govt*	*Institution*	*Subd*	*Private*	*Total (% Share)*	
Insufficient Supply	0	1	1	1	0	0	3	2.8
Falling Water Level	1		0		0	0	1	0.9
Increasing Power Use	3	2	0	3	1	0	9	8.5
High Maintenance Cost of Equipment	1	6	0	1	0	0	8	7.5
Poor Quality of Water	2	23	2	1	2	2	32	30.2
Others	1	2	1	3	0	0	7	6.6
No Problem	3	13	4	4	2	4	30	28.3
No Answer	2	5	5	3	1	0	16	15.1
Total	13	52	13	16	6	6	106	100.0

In the case of poor water quality, solutions cited by respondents include installation of treatment facilities (22 respondents); connecting to COWD (17 respondents); condemning the wells (3 respondents); digging other wells (2 respondents) and consulting the city health office (1 respondent). The problem of high maintenance costs due to the wear and tear of equipment, on the other hand, will be addressed by: connecting to COWD (17 respondents); building new well systems (16 respondents); change of pump and equipment (4 respondents); upgrading of equipment (2 respondents) and economizing on water use (1 respondent).(Table 12 and Table 13).

Table 12. Solutions to the Problem of Poor Water Quality

Solution	*Number of Respondents*	*% of Total No. of Responses*
Install treatment facilities	22	48
Connect to COWD	17	37
Others	7	15
Total	46	100

Table 13. Solutions to the Problem of High Maintenance Costs and Wear and Tear of Equipment

Solution	*Number of Respondents*	*% of Total No. of Responses*
Build a new well system	16	39
Connect to COWD	17	42
Others	8	19
Total	41	100

The third set of questions pertains to future water requirements and sources. Thirty-five establishments or 38% of the 91 respondents project an increase in their water needs while 41 (45%) think that their present demand levels will remain unchanged. The majority of the respondents (58) think that their present water supply systems will be sufficient to meet their present and future water requirements. Seventeen, about one-fifth of the respondents, indicate that their present systems will not be sufficient to meet future water needs[11] (Table 14).

Table 14. Future Water Requirements

Question	*Yes (% of Total)*	*No (% of Total)*	*No Answer (% of Total)*	*Total No. of Respondents*
Any expected increase in water requirements?	35 (38%)	41 (45%)	15 (15%)	91 (100%)
Is your present well system sufficient to meet future needs?	58 (64%)	17 (19%)	16 (18%)	91 (100%)

To address the problem of insufficient supply both at present and in the future, 21 respondents indicate they may resort to connecting to COWD[12], 19 indicate they may dig additional wells[13], three indicate they may move to another location and two may change or increase the pump capacity of their wells (Table 15).

Table 15. Solutions to the Problem of Insufficient Supply

Solution	*Number of Respondents*	*% of Total No. of Responses*
Construct new wells	19	42
Connect to COWD	21	47
Move to another location	3	7
Increase capacity of present well	2	4
Total	45	100

The last set of questions deals with the acceptability of a raw water fee, the willingness to contribute to watershed management and protection costs to ensure a stable supply of water and the preferred collection scheme. Of the 91 respondents, more than half (48 respondents) express some willingness to pay for raw water. The amount these private well owners are willing to shell out for every m^3 of water range from PHP 0.40 (USD 0.01) to PHP 10.00 (USD 0.19). The most frequently (18 out of 48 respondents) quoted amount is PHP 1.00 (USD 0.02) - the rate charged by two water districts in the

[12]The 35 who answered foresaw an increase in their water requirements while 17 specified the projected increase in volume.
[13]Six of the 19 gave details on their plan to construct new wells.

Philippines, namely the Laguna Water District and Metro Cebu Water District, on big commercial and industrial private (non-water district) groundwater abstractors in their service areas in the form of a production assessment fee. The big industrial establishment which report an amount of water abstraction equivalent to about 25% of COWD's production indicate a WTP of PHP 0.55 (USD 0.01) per m^3 of water. On the average, the 48 respondents indicate a WTP for raw water of PHP 3.31 (USD 0.06) per m^3.

Nine of the 91 respondents categorically indicate unwillingness to pay for raw water. These include 1 big industry, 6 commercial establishments, a convent school, and an individual well owner. The remaining 34, about a third of the respondents, have no answer. In most of these cases, the responding representative thinks that he alone cannot decide or even comment on the matter. The bigger establishments indicate that it is their head offices in Manila which take care of and decide on such matters (Table 16).

Table 16. Willingness to Pay (WTP) for Raw Water

Amount (per m^3 of water)	*Industry*	*Com'l*	*Govt*	*Institution*	*Subd*	*Private*	*Total (% Share)*	
Below PHP 1.00	1	2	2	0	1	0	6	7
PHP 1.00	2	8	3	5	0	0	18	20
PHP 1.01 – PHP 5.00	0	4	2	2	2	3	13	14
PHP 5.01 – PHP 10.00	1	5	0	2	2	0	10	11
PHP 10.01 and above	0	1	0	0	0	0	1	1
Not willing	1	6	0	1	0	1	9	10
No answer							34	37
Total							91	100

Note: 1 USD = 53.51 PHP

Those who are willing to pay for raw water specify certain conditions for them to contribute. Twenty-three respondents want the assurance that the money will be put to good use, that is, it will benefit the whole community, not just certain sectors or institutions. Twenty respondents want the funds to be used specifically for water resources and watershed protection projects. One respondent would like to see the money being used to financially support the DENR. Two respondents want the assurance that there will be a steady supply of water if a raw water charge is to be imposed. Two respondents indicate that they are willing to give it a chance but they will only continue paying if there are positive results. An academic entity indicates that they will pay if that is the condition for the government to allow them to abstract water. Another respondent states that his establishment will pay as long as COWD does not put up a production well (PW) in its area.

On the whole, 25 respondents prefer to be consulted with regard to the use of the funds generated from the raw water charge. Only one is willing to leave the decision solely to the concerned government agency. Twenty-three respondents prefer the funds to be managed directly by them - the contributors in cooperation with one another (Table 17).

Table 17. Raw Water Charge Funds Management

Question	*Yes (% of Total)*	*No (% of Total)*	*No Answer (% of Total)*	*Total No. of Respondents*
Prefers to be consulted about use of funds?	25 (27%)	1 (1%)	65 (72%)	91 (100%)
Prefers to directly manage the funds with other payers?	23 (25%)	35 (39%)	33 (36%)	91 (100%)

Only nine respondents indicate a preference for a particular agency to collect the raw water fee. Four prefer to pay the fee through COWD. Two specify commercial banks. The remaining three answers are: the agency conducting the watershed project; a related government agency and a non-government organization (NGO).

A substantial number of respondents are already engaged in some form of forest and watershed protection activities. Forty-four respondents are engaged in tree planting projects. Two take part in river bank clean-up activities while two others engage in water treatment processes. Other activities cited are: river monitoring and preservation; sewerage inspection; donating seeds to non-government organizations (NGOs) as well as local governments units; park development; environmental seminars; information drive; and cash donations.

Overall, the survey indicates that there is some WTP for raw water among private groundwater abstractors in CDO. On the average, WTP of the surveyed establishments amounts to P 3.31 (USD 0.06) per m^3.

3.3 The Groundwater Withdrawal Permits Scheme

The groundwater depletion issue in CDO may be addressed with a system of groundwater withrawal permits. The stock of groundwater can be preserved by limiting the number of permits to the CDO aquifer's recharge rate of 94,000 m^3/day.

The water permits are to be allocated among groundwater abstractors through a yearly auction. This scheme accomplishes two objectives. One, permits are allocated according to WTP. The permit price resulting from the auction reflects CDO groundwater's true scarcity value - the price the marginal user is willing to pay. With the auctioning of permits, the government is thus not burdened with the technically difficult as well as politically and socially disruptive task of measuring the scarcity value or opportunity cost of groundwater - a task that becomes necessary if a system of water charges is instead implemented to ensure the rational use of water.

Two, the scheme can generate revenues that can be used for system implementation including monitoring and watershed management. If the amount of water for which permits are issued is set at 94,000 m^3/day (34.3 million m^3 per year) and if users are willing to pay PHP 3.31 (USD 0.06) per m^3 of water as revealed by the survey, total annual revenues from water permit sales would amount to PHP 113.6 million (USD 2.123 million). The minimal cost of monitoring and metering groundwater withdrawals, as discussed in the next section, shall leave the greater portion of this amount for

watershed protection projects. This shall be the contribution of groundwater users to water resources preservation in CDO.

Making the permits tradable offers further advantages. Firstly, trading allows more flexibility in the transfer of water to more productive or higher value uses. Secondly, with the potential to sell water permits, there is a greater incentive for the holders to economize on water use so as to realize extra revenues. Prospective buyers of permits, on the other hand, will have a strong incentive to employ all viable water conservation measures from the very start of a project or business enterprise so as to keep costs to a minimum. Finally, trading promotes voluntary compliance and policing of fellow groundwater abstractors. The potential for permit holders to generate income from trading permits can only be realized if groundwater withdrawal allocations and rules are strictly observed. Thus, complying with its allocation and ascertaining that everyone else does not exceed its allocation is the concern of all permit holders.

The regulatory and institutional requirements of, as well as, the legal framework essential for a system of groundwater withdrawal permits are the same whether or not the permits are tradable (Thobani 1997). Monitoring and enforcement measures and costs are likewise the same. And as mentioned above, compliance may even be enhanced if permits are tradable and hence, monitoring and enforcement may even be made simpler and easier.

A local chapter of the National Water Resources Board (NWRB), the water licensing authority in the Philippines, shall be responsible for the distribution and enforcement of groundwater permits in CDO. It shall conduct the auction of permits, and approve and process transfers of permits.

The auction must be carried out in an open and transparent manner:

(1) Through the use of the public media, the water licensing authority announces the auction dates and procedures.

(2) Water authority accepts offers during the specified bidding period.

(3) Permits are awarded to the highest bidders at the end of the bidding period.

(4) The buyer pays and the water licensing authority issues the permit.

Water permit trading, on the other hand, shall involve the following steps:

(1) A pump owner considers the option to buy or sell permits.

(2) A potential buyer or seller is sought either through personal contacts or intermediary.

(3) Contract is agreed between buyer and seller subject to the approval of the licensing authority.

(4) Application procedures for the transfer of water permits are carried out.

(5) Water licensing authority reduces or cancels the license of the seller and issues a new permit to the buyer.

All sales and transfers of permits must conform to existing rules on distance between wells, interference and salinity effects, and must not negatively affect the environment and society as a whole. Information on prices and volumes of all auctions and transfers of permits must be made public.

The water permit shall be defined volumetrically in terms of a fixed volume of groundwater withdrawals every month. Hence, monitoring shall entail the monthly reading of pump meters.

4.0 CAPITAL AND INSTITUTIONAL REQUIREMENTS

4.1 Metering

4.1.1 Meter Installation

Monthly monitoring of withdrawals is necessary to ascertain that permit holders are not exceeding their allocations. Estimates of meter cost and its installation by diameter and types of establishment are given in Table 18. The big difference between the costs for the 2-inch diameter well and 10-inch diameter well is due to the acquisition cost of the meter itself. Using these per unit costs of meters, the total cost of meter installation for the 269 wells of the 180 identified private, institutional as well as commercial and industrial establishments is estimated to be about PHP 8.6 million (USD 161,000). Dividing this total cost by the total amount of withdrawal by private well owners over a period of 30 years - the assumed life-span of the meter - results in an average capital cost of only PHP 0.02 (USD 0.0004) per m^3 of water.

4.1.2 Monitoring Costs

It may be most practical to deputize COWD to perform the monthly reading of meters of private well owners within their service areas as this task is already part of their day-to-day operations. Hence, the marginal and average cost of monitoring will be minimum. Assuming that this arrangement is acceptable, the average monitoring cost can be estimated by the actual expenses presently incurred by COWD's monitoring and meter reading department. This cost, according to the said department head of COWD, is about PHP 8.32 (USD 0.16) per connection. Dividing this per connection cost by the average volume of withdrawal of a non-COWD well owner results in a cost per m^3 of only PHP 0.002 (USD 0.00004).

Table 18. Cost Estimates for Meter Installation

A. Private Wells		
Cost of Water Meter (2”ϕ)		
Installation Cost		P16,200.00
a. Fabrication of flanges, reducers, etc.	P2,000.00	
b. Labor Cost	1,000.00	
c. Equipment rental (welding)	1,000.00	
d. Contingency	1,000.00	5,000.00
Total Cost per Well		P21,200.00
B. Small Industrial, Government and Institutional Wells		
Cost of Water Meter (4”ϕ)		
Installation Cost		P29,000.00
a. Fabrication of flanges, reducers, etc.	P4,000.00	
b. Labor Cost	2,000.00	
c. Equipment rental (welding)	2,000.00	
d. Contingency	2,000.00	10,000.00
Total Cost per Well		P39,000.00
C. Medium Industrial and Commercial Wells		
Cost of Water Meter (6”ϕ)		
Installation Cost		P57,600.00
a. Fabrication of flanges, reducers, etc.	P8,000.00	
b. Labor Cost	4,000.00	
c. Equipment rental (welding)	4,000.00	
d. Contingency	4,000.00	12,000.00
Total Cost per Well		P77,600.00
D. Other Industrial/Commercial Wells		
Cost of Water Meter (8”ϕ)		
Installation Cost		P88,500.00
a. Fabrication of flanges, reducers, etc.	P12,000.00	
b. Labor Cost	6,000.00	
c. Equipment rental (welding)	6,000.00	
d. Contingency	6,000.00	30,000.00
Total Cost per Well		P118,500.00

Note: P= PHP

1 USD = 53.51 PHP

4.2 Institutional Requirements: Issues and Potential Problems

Conferring rights to limit total groundwater abstraction to the sustainable recharge rate or safe yield as well as establishing a market to promote efficient water use and allocation entail amending existing laws on property rights within the public domain. Forestry and water codes consider environmental resources such as surface and groundwater to be part of the public domain or owned by the state. Article 6d of the *Water Code* specifies that "subterranean or groundwater found in private lands" belong to the state. Extending property rights to groundwater resources therefore requires a change in the legal treatment of public water resources. No trading of groundwater shares can commence unless property rights over those shares, at the very least, have been instituted.

Once instituted, the implementation of this water property rights scheme must be the responsibility of the water licensing authority. This authority is delegated by the Philippine government to National Water Resources Board (NWRB) (NWRB 1979). NWRB is empowered by the Water Code to issue water permits, as well as regulate and control water usage. As stated in Article 2d of the Code, "The utilization, exploitation, development, conservation and protection of water resources shall be subject to the control and regulation of the government through the National Water Resources Council." NWRB has the power to prevent appropriation of water without a water permit. It can penalize appropriators for failing to keep a record of water withdrawal or installing a regulating and measuring volume control device when required. Further, Article 83 of the Code authorizes NWRB to establish and collect reasonable fees or charges from water appropriators for water resources development. The Board may revise current charges - taking into consideration the rate of water withdrawal vis-à-vis other users - the water bearing potential of the source, environmental effects and other relevant factors.

NWRB, however, has not been effective in executing its mandate. A significant volume of water is drawn illegally or without permit. Even in Metro Manila where NWRB is based, wells are constructed without permits. The situation becomes more serious outside Metro Manila. In the case of CDO alone, only 6% of private non-domestic wells have been issued permits by NWRB.

NWRB fails to satisfactorily perform its duties mainly because it does not have any effective local presence or authority. In the provincial areas, the functions of NWRB are mainly delegated to deputized agencies and offices, usually the water districts (WDs). Application for well drilling and construction permits, for instance, are submitted to the water districts for their recommendation before forwarding to NWRB. In many cases, private well owners think that an approval from the water district is sufficient. Since NWRB has no representative office in the regions, policing can only be done by the water districts. For as long as there is no problem with the WD, wells can be constructed and groundwater abstraction can continue even without a permit from NWRB. Further, despite being deputized by NWRB to monitor water abstraction within their service areas, the WDs have no enforcement capacity.

The successful implementation of the proposed water permits scheme requires that the licensing authority establish an effective physical presence in CDO. This national regulatory agency must establish an office in the city which must be staffed by people

who have undergone thorough training on the concept of water as a depletable resource and its full economic value.

The licensing authority is likewise responsible for the strict enforcement of the penalty system. The system must provide for the suspension or cancellation of licenses for holders abstracting water in excess of their allocation. The effective implementation of this penalty system is crucial in ensuring that total withdrawal is kept within the sustainable recharge or safe yield.

Finally, there must be an implementing structure and arrangement for the watershed protection and rehabilitation projects which will be financed by proceeds from the proposed permit scheme. The survey of private well owners indicate willingness to pay (WTP) for raw water for as long as a stable supply is ensured. Sustainable groundwater use necessarily involves management of the watershed. The existing water policies in the Philippines give this responsibility to several government agencies such as NWRB, the WDs[14]. Department of Natural Resources (DENR), LWUA[15], Department of Public Works and Highway (DPWH), National Irrigation Authority (NIA), National Power Corporation (NPC) and Philippine National Oil Company (PNOC). NWRB is also delegated to be the coordinating body for the watershed projects of these government agencies. - but again, it has not been able to accomplish this mandate. This weakness may likewise be overcome if NWRB is to establish its presence in CDO. The representative office of NWRB in CDO will not only make possible close coordination of watershed activities of the different government agencies in the area, it can also pave the way for the active involvement of the local community in the effort. NWRB is to make sure that the proceeds from the auction of permits are distributed to national agencies and local organizations undertaking specific activities for the maintenance of water resources. These activities must be coordinated and must be geared towards the long-term. Records of revenues and disbursements must be well kept and open to the public with periodic financial reports.

5.0 SUMMARY AND CONCLUSION

Economic development has resulted in accelerating water demand in CDO. It has put pressure on the limited supply of groundwater—the principal source of water—in the city. This study looks at groundwater abstraction in CDO. A comparison of the total groundwater withdrawal with the sustainable yield of the CDO aquifer indicates mining of the resource. Data on static and pumping water levels of COWD wells in different locations in the city support this conclusion.

In examining the state of groundwater resources in CDO, the paper has brought to the fore some limitations of existing water resources laws and policies in the Philippines.

[14] Section 31 of the Provincial Water Utilities Act of 1973 states that the Water District (WD) shall "take over the management, administration, operation and maintenance of all watersheds within its territorial boundaries.

[15]The September 1995 Memorandum of Agreement (MOA) between the DENR and the LWUA brings the two agencies together to ensure the protection, rehabilitation and development of watershed areas. The MOA provides that the DENR is responsible for providing assistance "in the identification and delineation of watershed areas that support the water requirements of the water districts." The MOA also deputizes qualified personnel of the water districts "for effective watershed protection, management and conservation to preserve and sustain the hydro-geological and ecological productivity of the watersheds."

For one, water laws do not take into consideration the full economic value of water resources. The Water Code provides that water charges are to be set "to cover costs of installation of new services and meters; payments for the operating expenses of the district; maintenance and repairs; and a reasonable surplus for replacement, extension and improvement" (Section 37). Revenues from water charges may also be used for debt payment (Section 63) and for building up reserve funds for the expansion and improvement of the district's physical facilities (Section 41). There is no provision for a raw water fee in the Code. Hence, despite competing demands for water and its growing shortages, the value of water in its raw form has remained zero in the realm of State policy. This is reflected in the unmonitored withdrawal of water and hence, free access to the aquifer of private pump owners in CDO.

Also, despite provisions that point to the need to conserve, protect and manage the watershed ensuring a stable supply of surface and groundwater resources, the Code has not referred to any specific fund that can be utilized for watershed protection and development. Excluded from sections in the Code on the use of water charges, the watershed is not considered an input or capital resource in water production.

Two other problems in the government water policies are the meager financial resources allocated for watershed rehabilitation and protection as well as the limited involvement of local communities in this endeavor.

The proposed water permits scheme may serve to address these limitations. The auction and trading of groundwater withdrawal permits shall ensure that water is allocated to the highest value users and discourage wasteful use of the resource. The scheme can also generate revenues that can be earmarked for the preservation of the watershed.

The scheme necessitates metering water withdrawals of all pump owners. The capital costs of meters and the costs of monitoring can be fully covered by proceeds from the auction of permits. The more crucial aspect of metering, however, is the establishment of the institutional infrastructure necessary for the successful implementation of the scheme. The agency or agencies that will monitor groundwater withdrawals must have the capacity to enforce the scheme. A strict penalty system must be in place to ensure compliance.

The acceptability of the proposed scheme is determined in a survey of pump owners in CDO. The WTP for raw groundwater ranges from PHP 0.40 (USD 0.007) to PHP 27.00 (USD 0.50), with PHP 1.00 (USD 0.02) as the most frequent response. Remarkably, a consumer's WTP is not fixed but may vary. Based partly on one's orientation and information at a particular time on the particular goods under valuation, WTP may increase as one's knowledge and awareness grow in appreciation of the environment and inter-relatedness as well as benefits its resources provide. Hence, there is also a need to promote greater understanding and consensus on the positive value of raw groundwater.

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APPENDIX 1

INTERVIEW GUIDE

Interview Guide

Objectives of the Study:

1. to know the water situation and problems faced by the industry
2. to know the cost incurred by the industry to provide its water requirements
3. to determine the willingness to pay (WTP) of industry to ensure a steady supply of water.

Name of Interviewer: _____ Date: _____

I. Company Background

Name of Company: _____
Year established: _____

Location	Inclusive Years
_____	_____
_____	_____

II. Present Water Requirement and Sources

1. How much water (in gallons or cubic meters) is required in a day's and month's operation?
   Daily: _____ Monthly: _____

2. Volume of water obtained from own wells: _____
   From COWD: _____

3. How many wells does the company have? _____

	Year Constructed	Depth	Diameter	Capacity	Capacity Utilization	Water Level Past	Water Level Present
1)	_____	_____	_____	_____	_____	_____	_____
2)	_____	_____	_____	_____	_____	_____	_____
3)	_____	_____	_____	_____	_____	_____	_____
4)	_____	_____	_____	_____	_____	_____	_____
5)	_____	_____	_____	_____	_____	_____	_____

4. Problems with the present system:

   _____ insufficient supply (insufficient capacity of own wells)
   _____ falling water level. Any data on past and present static and/or pumping water level?: _____
   _____ increasing power consumption of well pump. Any estimate of the power cost per cubic meter of water pumped? _____
   _____
   _____ high maintenance cost of the well and pump, wear and tear of equipment. Estimate of monthly or yearly maintenance cost of the well and pump? _____

   _____ quality of water.
   _____ high chloride content

_____ others: Please specify quality problem: _____

_____ other problems. Specify: _____

5. How does the company plan to solve the problem:

In case of insufficient supply:
_____ build new wells. Give details: how many wells? _____
capacity? _____
other details: _____

_____ connect to COWD or increase consumption from COWD.
By how much: _____

_____ move plant/company to another location. Where? _____

In case of poor water quality:
_____ install treatment facilities. Specify: _____
_____ connect to COWD. How much water will be sourced from
COWD: _____
_____ others. Specify: _____

In case of high maintenance costs and wear and tear of equipment:
_____ build a new well system
_____ connect to COWD
_____ others. Specify: _____

III. Future Water Requirements and Sources

1. Any projected increase in water requirements? _____
By how much? _____ /day
_____ / month

2. Will present wells be sufficient to meet future requirements? _____
If not, do you plan to
_____ construct new wells? _____
How many? _____, Depth: _____, Capacity: _____
Estimated cost? _____
_____ connect to COWD
_____ move to another location. Where? _____

IV. The Company's Willingness to Pay for Water

1. How much will the company be willing to pay to improve the aquifer recharge rate and ensure a stable supply of groundwater (an amount that can be used and hence considered the company's contribution for forest or watershed protection)
_____ P 1.00/cm of water (Cebu's case)
_____ P 2.50 (Laguna's case)
_____ P 5.00
_____ P 9.00 (average effective rate of COWD)
_____ P 10.00
_____ P 17.00 (average COWD rate for commercial users)
_____ others. Specify amount: _____

2. Under what conditions would the company be willing to make contributions for the protection of the watershed to ensure stable supply of water? Please specify preferred collecting agency, watershed protection implementing agency. Will the company prefer that it be consulted about the use of the money for particular projects?

3. Will the company prefer to directly manage the fund with the other contributing companies instead of a separate collecting institution?

4. Any present or past activities/contribution of the company to forest and watershed protection in Cagayan de Oro? Please specify.

Note: P= PHP

1 USD = 53.51 PHP

APPENDIX 2 - GLOSSARY

CDO	Cagayan de Oro
COWD	Cagayan de Oro Water District
DENR	Department of Environment and Natural Resources
DILG	Department of Interior and Local Government
DPWH	Department of Public Works and Highways
DTI	Department of Trade and Industry
IPC	Institute of Philippine Culture
JICA	Japan International Cooperation Agency
LBII	Louis Berger International Incorporated
LWUA	Local Water Utilities Administration
NFA	National Food Authority
NGO	Non-Governmental Organisation
NIA	National Irrigation Authority
NWRB	National Water Resources Board
NPC	National Power Corporation
OECF	Overseas Economic Cooperation Fund
PD	Presidential Decree
PNOC	Philippine National Oil Company
PW	Production Well
PWL	pumping water level
SSS	Social Security System
SWL	static water level
TCGI	Technosphere Consulting Group Incorporated
WD	Water District
WTP	Willingness To Pay