BOTSWANA WATER STATISTICS

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PREFACE

This is the first edition of 'Botswana Water Statistics (BWS)'publication produced by the Central Statistics Office (CSO). Prior to this, the office compiled two editions of Botswana Environment Statistics in 2000 and 2006 respectively, in which Water Resource Chapter was included. The publication has been necessitated by the global recognition of the need to incorporate considerations for the sustainable use of safe water in the socio-economic development planning process so as to ensure that the socio-economic development achieved is also sustainable.

The CSO did not conduct any survey to come up with data presented in this publication, rather the department used secondary data collected from various government departments, ministries, parastatal organizations, private companies and NGOs. Data in tables whose source(s) is (are) not indicated are from other Central Statistics Publications. Data was collected from Water Utilities Corporation, Ministry of Local Government, Department of Water Affairs, different District Councils across the country and publications such as 'Botswana National Water Master Plan 2004' and 'Inventory of Wetlands in Botswana'.

The Pressure-State-Response Model was used in preparing this publication. It was not possible to get the required data on all the variables that were necessary for the analysis and/or monitoring of the sustainable use of water resources and impact of anthropogenic activities on water sources. Consequently, some parts of the framework, particularly the 'impact' component, have not been adequately covered in the publication. For the same reason, the period of reference (base year) is not uniform in all cases within and between chapters.

The CSO acknowledges and extends gratitude to various departments and/ or organizations that provided the information used in this publication.

Thank you.

A. Majelantle
Government Statistician

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Miscellaneous Abbreviations

BCL	*Bamangwato Concessions Limited*
BOD	*Biochemical Oxygen Demand*
BNWMP	*Botswana National Water Master Plan*
BPC	*Botswana Power Corporation*
COD	*Chemical Oxygen Demand*
CSO	*Central Statistics Office*
DC	*District Council*
DWA	*Department of Water Affairs*
LA's	*Local Authorities*
MMEWR	*Ministry of Minerals, Energy and Water Resources*
NGO	*Non-Government Organizations*
NMPWWS	*National Master Plan for Wastewater and sanitation*
NSWC	*North South Water Carrier*
NTU	*Neo Turbidity Unit*
SADC	*Southern African Development Community*
TCU	*Total Colour Unit*
TDS	*Total Dissolved Solids*
TH	*Total Hardness*
TSP	*Total Suspended Particulates*
TSS	*Total suspended solids*
WAB	*Water Apportionment Board*
WSR	*Water Stress Ratio*

Chemical	***Name of Gases and Substances***	***Abbreviations/ Symbols Used in Tables***	
Al	*Aluminium*	*-/---*	*Not available*
As	*Arsenic*	*N/A*	*Not applicable*
B	*Boron*	*ND*	*No Data*
Ca	*Calcium*	*N/s*	*Not stated*
CH_4	*Methane*	*NV*	*No Value*
Cl	*Chlorine*	Mm^3	*Million cubic metres*
Cl_2	*Chloride Residual*	*Ml*	*Million litres*
CN	*Cyanide*	*Mg/l*	*Milligrams per litre*

Co	*Cobalt*
CO_2	*Carbon dioxide*
Cr	*Chromium VI*
Cu	*Copper*
F	*Flourides*
Fe	*Iron*
H_2O	*Water*
H_2SO_4	*Sulphuric Acid*
HC	*Hydrocarbons*
Hg	*Mercury*
K	*Potassium*
Mg	*Magnesium*
Mn	*Manganese*
N2O	*Nitrous oxide*
Na	*Sodium*
Ni	*Nickel*
Ni	*Nickel*
NO_3	*Nitrates*
NO_X	*Nitrogen oxides*
P	*Ortho Phosphate or soluble phosphate*
Pb	*Lead*
Ph	*Degree of acidity or alkalinity*
PH_4	*Potential Hydrogen*
PO_4	*Phosphorus*
Sb	*Antimony*
Se	*Selenium*
SO_2	*Sulphur dioxide*
SO_4	*Sulphate*
SOx	*Sulphur oxides*
TDS	*Total Dissolved Solids*
THM	*Trihalomethanes*
TOC	*Total Organic Carbon*
TH	*Total Hardness*
Zn	*Zinc*

1.0 EXECUTIVE SUMMARY

1.1 Introduction

Water resources are sources of water that are useful or potentially useful to humans. It is a basic need for human beings and is one of the major keys of any economic development of the world societies and a sustainable use of this resource is of utmost importance. The water resources problem is seen as a potential limit to development and a stress on population and economic growth. Africa's water resources are threatened by the increasing population trends which result in increase in water demand by various users. In Botswana this very precious resource is scarce due to the semi arid climatic condition of this country which is characterized by recurrence of drought.

It has been reported in the "Caricom Environment in Figures 2002" that freshwater[1] occupies a space of 2.5 percent of Earth's surface and it exists in the form of rivers, lakes, wells, reservoirs etc. It has been further reported in the same article that of the 2.5 percent of water on the earth surface, over two thirds is frozen in glaciers and polar ice caps, leaving only 0.007 percent which is available for human use.

Freshwater is a renewable resource, yet the world's supply of clean and freshwater is decreasing. It can be unsustainable if the rate of abstraction i.e. the volume per time unit abstracted exceeds the rate of replenishment of the resources. Factors such as rainfall, temperature, evaporation, and runoff have been identified as tools which determine water availability.

Statistics on water resources in Botswana presented in this publication are confined to inland water because the country is landlocked.

1.2 Geography

Botswana is a landlocked, semi-arid country with an approximate area of 582 000 km² and has a population of 1,680,863. It is located in the centre of Southern Africa. The population density in Botswana is 2.9 person/ km² (2001 Population and Housing Census).

Botswana is bordered to the north by Zambia, to the northwest by Namibia, to the northeast by Zimbabwe and to the east and southeast by South Africa. The country is an almost plateau with an average altitude of 1 000m; elevation ranges between 700m and 1300m. The lowest parts of the plateau surface are Ngami area and swamps of the Okavango River in the northwest, the salty pans of Makgadikgadi in the northeast and the area between the Shashe and the Limpopo Rivers in the east. The Okavango and Chobe Rivers are the only perennial rivers with their sources outside the country. Most of the rivers and valleys are ephemeral and usually dry except after rains. In the central parts of Kgalagadi, there are fossil valleys, created during periods of higher rainfall in the past.

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[1] Freshwater is naturally occurring water having a low concentration of salts. It is generally accepted as suitable for abstraction and treatment to produce portable water

1.3 Uses of Water

Water is used for various purposes which include agriculture, industrial, households, recreational, as well as environmental activities such as drinking source for wild animals and home to fish and other animals. Businesses also use water for a variety of purposes; washing dishes and flushing toilets in the offices, and manufacturing activities etc. The amount of water used depends on the type of business and the size of households.

In Botswana, water is mainly used for human consumption, wildlife, commercial, industry and institutional purpose although it varies per sector.

1.4 Sources of Water

The Ministry of Mineral Energy and Water Resources has the main responsibility for policy in the water sector. There are a number of institutions involved in water sector activities and these include, *inter alia*, Department of Water Affairs (DWA), Department of Geological Services (DGS), Water Utilities Corporation (WUC), Ministry of Local Government and the Ministry of Agriculture (MOA). The responsibility of water resources has been rationalized between these institutions for better management and planning. The country is supplied with both surface and groundwater and the three main water sources in Botswana are Dams, Rivers, and Boreholes.

1.5 Surface Water- Rivers

There are only two perennial rivers in the country namely Okavango and Chobe Rivers and are both situated in the north of the country. The rest of the rivers are ephemeral. However, ephemeral rivers are important in that they provide locations for dam sites.

The following river basins are formed by rivers:

- The Molopo/Nosop River forms the southern border between Botswana and South Africa., The river rarely flows due to low precipitation in the area.
- The Limpopo River forms the eastern border between Botswana and South Africa. Some rivers which drain into Limpopo are Notwane, Lotsane, Motloutse and Shashe Rivers. Since the rivers are situated in the eastern part of the country where majority of the people live, these rivers have been dammed to provide water to the population.
- Makgadikgadi Basin is fed by Boteti, Nata, Mosetse and Mosope Rivers.
- Kwando/Linyanti/Chobe River Basin originates from Angola, crosses Namibia and enters Botswana at Chobe in the north. The Savuti and Linyanti Rivers form part of the drainage basin in Botswana. From Botswana the Chobe River then flows into Zambezi River in Zambia and Zimbabwe.
- Okavango River basin is composed of the Okavango River and Delta. It also feeds the Makgadikgadi Pans through the Boteti River. (Proceedings of the Conference on Wetlands Management in Botswana, 1994)

1.6 Surface Water-Dams

Botswana is generally an arid country, with little surface water[2][2] except in the far north. Surface water resources are the main source of water supply for urban areas. Water from dams and rivers contribute about one-third to national water consumption. An increasingly large proportion of the population which resides in the urban areas as a result of urban migration is supplied by water from the dams.

Water Utilities Corporation (WUC) is responsible for the supply of water to the six urban/mining centres and other designated areas except for Orapa, which is supplied by the Debswana Company. According to the Population Projection 2001-2031 WUC served 414,020 (23 percent) of the total population of Botswana with water in 2008 and the population has increased by 11.4 percent from 366,626 in 2001 Population and Housing Census.

Table 1.1 The Storage Capacity of Large Dams in Botswana in Million Cubic Metres (MCM)

Name of Dam	Capacity MCM	Location
Gaborone	141.1	Gaborone (South East)
Bokaa	18.5	Bokaa (Kgatleng)
Nnywane	2.3	Lobatse (South East)
Shashe	85	Shashe (North East)
Letsibogo	100	Mmadinare (Central)
Molatedi*	201	RSA
Ntimbale	26	Tutume (North East)

Source: Water Utilities Corporation

NB* Although Molatedi Dam is in South Africa, it supplies water in Botswana.

Table 1.1 shows the storage capacity of large dams and their location. These dams provide surface water to urban areas. The biggest dam so far is the Gaborone dam with a storage capacity of 141.4 million cubic meters while the smallest is the Nnywane Dam with a storage capacity of 2.3 million cubic meters. Gaborone dam supplies water to two towns, Gaborone and Lobatse with a current population of 306,100 and 23,683 respectively (Population Projections for Botswana 2001-2031, CSO). The Dam is located along Notwane River and its water is supplemented by Bokaa Dam located along the Metsimotlhabe River in Kgatleng District.

Letsibogo dam represents the largest dam in Botswana in terms of mean annual reservoir yield. Its whole catchments are within Botswana and have an area of around 5 700km^2 with an estimated mean annual of 57 million cubic metres. The dam has a capacity of 100 milion cubic metres and an annual yield of 24 million cubic metres. The development of Letsibogo dam and the proposed lower Shashe Dam form part of the largest engineering project ever undertaken in Botswana, namely the North South Carrier Water Project (NSCW). (Water Utilities Corporation)

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[2] Surface water is all water naturally open to the atmosphere e.g. rivers, lakes, dams etc.

Table 1.2 Water Storage for Selected Dams by Year ('000 000 Cubic meters)

Year	Gaborone	% Full	Molatedi	% Full	Nnywane	% Full	Bokaa	% Full	Letsibogo	% Full	Shashe	% Full
1998	97.2	68.9	-	-	1.1	47.8	3.3	17.8	10.6	10.6	66.9	78.7
1999	95.8	67.9	-	-	1.4	60.9	9.6	51.9	37.2	37.2	72.4	85.2
2000	121.8	86.3	-	-	2.1	91.3	17	91.9	85.1	85.1	72.5	85.3
2001	125.9	89.2	-	-	1.8	78.3	17.7	95.7	67.7	67.1	73.3	86.2
2002	105.4	74.7	-	-	1.2	52.2	10	54.1	59.8	59.8	46.1	54.2
2003	79.5	56.3	-	-	0.9	39.1	7.4	40.0	72.7	72.7	55.0	64.7
2004	42.6	30.2	-	-	2.0	87.0	11.7	63.2	75.2	75.2	73.7	86.7
2005	50	35.4	-	-	1.8	78.3	7.6	41.1	67.5	67.5	85.2	100.2
2006	118.1	83.7	-	-	2.3	100	18.5	100	98.4	98.4	85.3	100.3
2007	79.6	56.4	-	-	1.21	52.6	7.2	38.9	76.0	76.0	71.6	84.2
2008	101.6	72.0	-	-	2.27	98.7	18.4	99.5	90.5	90.5	83.4	98.1

Source: Water Utilities Corporation

1.7 Groundwater Resources

Groundwater is the main source of portable water supply in Botswana. Much of the country (about 66 percent) depends entirely on groundwater. Groundwater resources are essential to many individuals, companies and communities to supply water for drinking, agriculture and industry. Major issues are the rate of groundwater replenishment relative to the rate of extraction, and its quality. Groundwater recharge is very limited, thus making the resource finite and non-renewable.

Department of Water Affairs (DWA) is responsible for supplying groundwater to seventeen (17) major villages and all smaller settlements through the District Councils. It is also responsible for protection of surface water resources from pollution and aquatic weeds and for administering the water legislation. On the other hand, District Councils are responsible for the operation and maintenance of water schemes in medium villages and smaller settlements. These schemes are constructed by DWA and on completion they hand them over to the respective Councils. The water supply system for rural villages in north-eastern and central part of Botswana is mainly based on boreholes, which exploit deep fractured aquifers. These sources are strained due to higher demand from various users.

For over 38 years, communal standpipes have been the main source of household water especially in the rural areas of Botswana. The excessive amount of water wastage from this water source has been a major concern of government in recent years. The government therefore decided to install prepaid water meters in major villages and rural communities across the country in an attempt to reduce wastage of water.

1.8 Water Abstraction

Water abstraction is the removal of water from any source, either permanently or temporarily, during a specified period of time. Most water is used as fresh water, some are saline. Depending on the environmental legislation in the relevant country, controls may be placed on abstraction to limit the amount of water that can be removed. Over abstraction can lead to rivers drying up or the level of groundwater aquifers reducing unacceptably.

The South African Geographical Journal entitled 'Water resources in Botswana with particular reference to the Savanna Regions" by du Plessis, A.J.E and Rowntree, K.M (2003) indicates that "Botswana is already experiencing so-called 'water stress' which is related to a number of factors such as rapidly increasing population leading to a sharp increase in water demand; low and variable rainfall, high rates of evaporation. The lifetime of surface and groundwater resources is limited to decades. Botswana shares four river basins with its neighboring countries. These results in a situation where 94 percent of the fresh water resources which Botswana can theoretically access originating outside its borders makes water resource management highly complex. Transnational sharing and management of water resources therefore plays a major role in securing sustainability of water resource."

Table 1.3 Dams Constructed in Botswana

Name of Dam	River	River Basin	Nearest Town	Full Supply capacity Mm^3
Gaborone	Notwane	Limpopo	Gaborone	141.1
Shashe	Shashe	Limpopo	Francistown	85
Bokaa	Metsimotlhabe	Limpopo	Gaborone	18.5
Nnywane	Nnywane	Limpopo	Lobatse	2.3
Letsibogo	Motloutse	Limpopo	Selibe-Phikwe	100
Mopipi	Boteti	Okavango	Orapa	100
Ntiimbale	Tati	Limpopo	Francistown	26.37
Dikgatlhong	Tati/Shashe	Limpopo	Selibe-Phikwe	400

Source: Water Utilities Corporation and Department of WaterAffairs

Table 1.3 shows all the dams constructed in Botswana. Ntimbale and Dikgatlhong are newly built and the projects are ongoing. Dikgatlhong will be the biggest dam in this country and Mopipi dam has long dried up.

Approximately 34 percent of the total water supply is from surface water, whereas the remainder (66 percent) is from groundwater. However, surface water accounts for 90 percent of the total supply of water in urban areas such as Gaborone, Lobatse, Francistown and Selibe-Phikwe. Apart from major rivers such as Chobe and Limpopo tributaries, the Okavango Delta is one of the most important wetlands in Botswana and forms a major part of the surface water resources in Botswana. (Kgathi, et al 1999).

1.9 Water Quality

Water availability in the environment is determined by the climate. High temperatures can lead to high evaporation rates resulting in the depletion of the already low rainfall. It is reported in the "Caricom Environment in figures 2002"that clean and adequate water is vital for human health but water is often the main cause of many fatal diseases such as diarrhea, malaria or typhoid fever. Caricom Environment in figures 2002 further reports that in most developing countries people do not have access to save drinking water and drinking water has often been contaminated because of pollution from human activities.

Water quality standards are designed to provide us with understanding the critical importance of adequate supplies of clean, available fresh water for the environment, the country's economy and the quality of life. This section will provide a national and international perspective of water availability and the challenges faced by water suppliers in addressing water quality issues. Without sufficient supplies of clean water, human survival and the economic growth are at risk.

Botswana Bureau of Standards (BOBS) has established upper limits and ranges for chemical levels allowable in drinking water. Most of these levels allow a sufficient margin of safety. It must be noted that acceptable contaminant levels vary widely among individuals, for example, high sodium, which may be harmless for many people, can be dangerous for elderly, hypertensive persons, pregnant women, and people having difficulty in excreting sodium. (Botswana Bureau of Standards)

It is believed that if these contaminants are present in the water at levels above these standards, the contaminants may cause the water to appear cloudy or colored, or to taste or smell bad. This may cause a great number of people to stop using water from their public water system even though the water is actually safe to drink.

The effect of toxic contaminants on human health can be classified as either acute or chronic. The reaction to a substance causing serious illness or death in an individual within 48 hours after exposure is considered acute toxicity. Chronic toxicity is a longer term effect on health due to frequent exposure to small amounts of a toxic substance. Examples of chronic health effects are kidney and liver diseases, cancer, mental illness, etc. (Botswana Bureau of Standards)

1.10 Wetlands

Botswana host several wetlands of regional and global importance. Wetlands are marshes, swamps and bogs that have been used for centuries, but it is only in recent times that these landscape units have come to be grouped under the term "**wetlands**". Wetlands occupy the transitional zone between permanently wet and generally dry environments. They exhibit enormous diversity according to their genesis, geographical location, water regime and chemistry, dominant plants and soil or sediment characteristics. There may be a considerable variation within a single wetland area. Many different types of wetlands may be found in close proximity, forming not just different ecosystems, but wholly different landscapes. This general term has grown out of a need to understand and describe the characteristics and values of all types of land, and to wisely and effectively manage wetland ecosystems. However, there is no readily acceptable definition for the term primarily because of the diversity of wetlands and because the demarcation between dry and wet environments lies along a continuum. Moreover, the needs or reasons for defining wetlands also vary. Thus there is a plethora of definitions of wetlands in the literature. (Masundire, et al, 1998)

Generally, wetlands may be defined as lands where saturation with water is the dominant factor determining the nature of soil development and the types of plants and animal communities living in the soil and on its surface (Department of Environmental Affairs). The single most distinguishing feature that most wetlands share is soil or substrate that is at least periodically saturated with or covered by water. Wetlands are lands transitional between terrestrial and aquatic systems where the groundwater table is usually at or near the surface or the land is covered by shallow water. In an attempt to mould a working definition from the diverse definition, the Ramsar Convention proposed the following definition:

"areas of marsh, fen, peat land or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine waters the depth of which at low tides does not exceed six metres." *(Dugan, 1990).*

In addition, the Convention (Article 2.1) provides that wetlands:
"may incorporate riparian and coastal zones adjacent to the wetlands, and islands or bodies of marine water deeper than six metres at low tide lying within the wetlands".

As a result of these provisions, the coverage of the Convention extends to a wide variety of habitat types including peat land, mangroves, rivers, shallow coastal waters, coral reefs, but not deep sea. (Masundire, et al, 1998)

2.0 Population's Access to Water

The proportion of population that gets piped/tapped water whether from a private connection or communal tap is 87.01 percent (see table 2.1 below). A comparison between cities/towns and villages (urban and rural) shows that 99.5 percent of the population in cities/towns get piped or tapped water while in villages the proportion is 84.1 percent.

Table 2.1 Population by Districts and Principal Source of Water Supply

	Sources of Water Supply					
	Number of People			Percentages		
	Piped or Tapped	Other	Total	Piped or Tapped	Other	Total
Urban Cities/Towns						
Gaborone	181,294	333	181,627	99.8	0.2	100.0
Francistown	80,529	474	81,003	99.4	0.6	100.0
Lobatse	28,764	37	28,801	99.9	0.1	100.0
Selibe Phikwe	48,041	784	48,825	98.4	1.6	100.0
Orapa	8,306	-	8,306	100.0	-	100.0
Jwaneng	14,492	67	14,559	99.5	0.5	100.0
Sowa	2,726	-	2,726	100.0	-	100.0
Total	364,152	1,695	365,847	99.5	0.5	100.0
Urban and Rural Villages:						
Ngwaketse South	95,244	17,942	113,186	84.1	15.9	100.0
Ngwaketse West	8,826	1,645	10,471	84.3	15.7	100.0
Barolong	43,430	3,894	47,324	91.8	8.2	100.0
South East	57,209	2,668	59,877	95.5	4.5	100.0
Kweneng East	169,476	18,587	188,063	90.1	9.9	100.0
Kweneng West	31,066	8,857	39,923	77.8	22.2	100.0
Kgatleng	65,729	7,464	73,193	89.8	10.2	100.0
Serowe/Palapye	126,391	25,493	151,884	83.2	16.8	100.0
Central Mahalapye	93,510	14,814	108,324	86.3	13.7	100.0
Central Bobonong	49,076	17,526	66,602	73.7	26.3	100.0
Central Boteti	32,820	14,918	47,738	68.8	31.2	100.0
Central Tutume	96,660	26,036	122,696	78.8	21.2	100.0
North East	44,184	5,065	49,249	89.7	10.3	100.0
Ngamiland East	56,177	15,192	71,369	78.7	21.3	100.0
Ngamiland West	35,320	13,869	49,189	71.8	28.2	100.0
Chobe	14,737	1,811	16,548	89.1	10.9	100.0
Delta	423	1,134	1,557	27.2	72.8	100.0
Ghanzi	23,259	8,795	32,054	72.6	27.4	100.0
C.K.G.R	283	370	653	43.3	56.7	100.0
Kgalagadi North	13,787	2,280	16,067	85.8	14.2	100.0
Kgalagadi South	21,126	4,491	25,617	82.5	17.5	100.0
Total	1,078,733	212,851	1,291,584	83.5	16.5	100.0
Grand Total	**1,442,885**	**214,546**	**1,657,431**	**87.1**	**12.9**	**100.0**

Source: CSO: 2001 Population and Housing Census Dissemination Seminar

3.0 Ground Water Supply

3.1 Well fields in Botswana

Table 3.1 shows the developed water resource from different well fields in the country. This is the total amount of groundwater currently available countrywide. Some of the available resources are still under development; these are Masama, Botlhapatlou, Bobonong and Mabule Dolomit Cluster. The assumption is that the developed resources can supply the given amount of water daily.

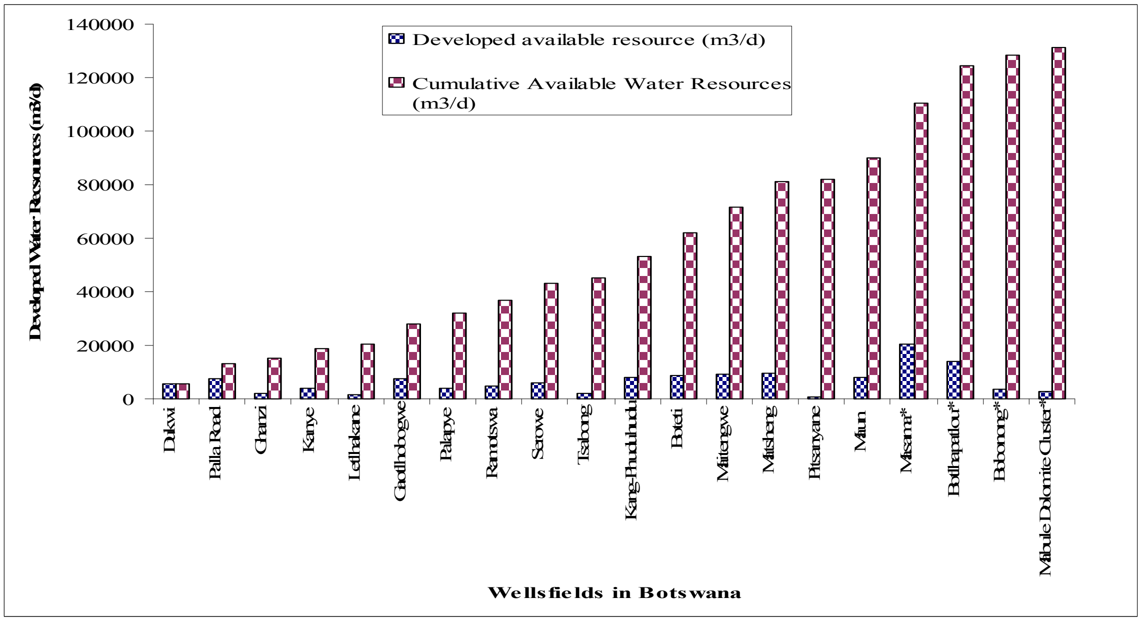
Table 3.1 The Availability of Groundwater in Botswana (2008)

Wellfield	Developed available resource (m^3/d)	Cumulative Resources developed (m^3/d)	Sustainable Resource (Mm^3/yr)
Dukwi	5700	5700	0.039
Palla Road	7500	13200	1.46
Ghanzi	1850	15050	0.68
Kanye	3950	19000	1.44
Letlhakane	1500	20500	0.06
Gaotlhobogwe	7500	28000	5.84
Palapye	4000	32000	1.64
Ramotswa	5000	37000	1.83
Serowe	6200	43200	1.28
Tsabong	2000	45200	0.73
Kang-Phuduhudu	7860	53060	3.27
Boteti	8950	62010	1.96
Maitengwe	9400	71410	3.43
Matsheng	9600	81010	3.52
Pitsanyane	1000	82010	0.37
Maun	8000	90010	10.07
Masama*	20480	110490	-
Botlhapatlou*	14000	124490	-
Bobonong*	3800	128290	-
Mabule Dolomite Cluster*	3000	131290	-

Source: Department of Water Affairs

NB: m^3/d refers to Cubic Metres per Day
Mm^3/yr refers to Million cubic metres per year
** Expected yield per day*

Figure 3.1: Cumulative Water Resource Developed (m^3/d) by Wellfields



NB: m^3/d denotes cubic metres per day
** expected yield per day*

Figure 1 is derived from Table 3.1 where available water resources developed are added together to produce cumulative totals. The chart shows that high yield of water is expected from Masama well field with expected yeild of 20,480 (m^3/d) followed by Botlhapatlou with expected yield of 14,000 (m^3/d).

Table 3.2 Sustainable Groundwater Resource in Botswana (2008)

Wellfield	Available Developed resource	Sustainable Resource (m^3/d	Current Abstraction (m^3/d)	Annual Abstraction (Mm^3/y)
Dukwi	5700	600	6600	2.44
Mahalapye	7500	4000	4000	1.48
Ghanzi	1850	1850	1850	0.69
Kanye	3950	3950	6900	2.56
Letlhakane	1500	950	1500	0.56
Palapye	4000	2700	3200	1.19
Ramotswa	5000	5000	4000	1.48
Serowe	6200	3500	4500	1.67
Tsabong	2000	300	1600	0.59

Source: Department of Water Affairs

Available developed resource in Dukwi Wellfield is estimated at 5, 700 m^3 per day. Currently the estimated abstraction is around 6600 m^3 per day, consisting of 1200 m^3, 1700 m^3 and 3700 m^3 per day being abstractions from Chidumela, Botash and the Dukwi boreholes respectively (See Table 3.2). Current abstraction is above sustainable limits; however predictions indicate that pumping at these high rates can be supported up to at least 2020.

3.2 Water Abstraction

The Department of Water Affairs (DWA) supplies the 17 major villages with water.

Table 3.3 Water Supply Demand for Major Villages - 2007

Village	Population - 2001 (CSO)	Annual Growth Rate (1991 - 2001)	Projected Population 2008	65% of Population Yard Connection	35% of Population House Connection	Demand YC (m^3/d)	Demand HC (m^3/d)	Avg Losses (%)	Losses (m^3/d)	Total Demand (m^3/d)
Kanye (Alone)	40,628	1.9	48,074	31,248	16,826	2,812	2272	50	2,542	7,626
Ramotswa	20,680	4.5	22,178	14,416	7,762	1,297	1048	40	938	3,283
Maun	43,776	1.7	59,253	38,514	20,738	3,466	2800	28	1,754	8,020
Tlokweng	21,133	5.3	29,061	18,890	10,171	1,700	1526	28	903	4,129
Tsabong	6,591	2.5	9,367	6,089	3,279	5,48	361	28	254	1,163
Moshupa	16,922	2.3	21,620	14,053	7,567	1,265	832	28	587	2,684
Tonota	15,617	1.3	19,367	12,589	6,779	1,133	915	28	573	2,622
Gantsi	9,934	2.9	14,051	9,133	4,918	822	541	28	382	1,745
Mahalapye	39,719	1.7	49,510	32,181	17,328	2,896	2339	28	1,466	6,702
Palapye	26,293	2.4	34,106	22,169	11,937	1,995	1612	28	1,010	4,617
Kasane (alone)	7,638	5.4	10,702	6,956	3,746	626	506	28	317	1,449
Mochudi (alone)	36,962	2.1	46,738	30,380	16,358	2,734	2208	28	1,384	6,327
Molepolole	54,561	2.8	69,812	45,378	24,434	4,084	3299	28	2,067	9,450
Serowe	42,334	1.2	52,610	34,196	18,413	3,078	2486	35	1,947	7,511
Thamaga	18,117	2.4	22,344	14,524	7,821	1,307	860	28	607	2,774
Letlhakane	14,962	4.0	20,996	13,647	7,348	1,228	992	28	622	2,842
Mogoditshane	32,843	4.8	52,798	34,319	18,479	3,089	2772	28	1,641	7,502
Totals	**448,710**	**2.89**	**582,587**	**378,682**	**203,906**	**34,081**	**27,367**	**30**	**18,995**	**80,444**

Source: Department of Water Affairs and Central Statistics Office Demography Unit

The observation from Table 3.3 is that the demand for water supply in 17 major villages was 80,444m^3/d in 2007; out of which 34,081m^3/d (42.37 percent) were yard connections and 27,367m^3/d (34.01 percent) were house connections. The average losses of water in major villages accounted for 30 percent of the total demand in 2007. The total yard and house connections in 17 major villages were 378,682 and 203,682 respectively, constituting 65 and 35 percent respectively from the 582,587 total population projections for 2008.

Figure 3.2: Total Water Demand (m^3) and losses in Major Villages in 2007

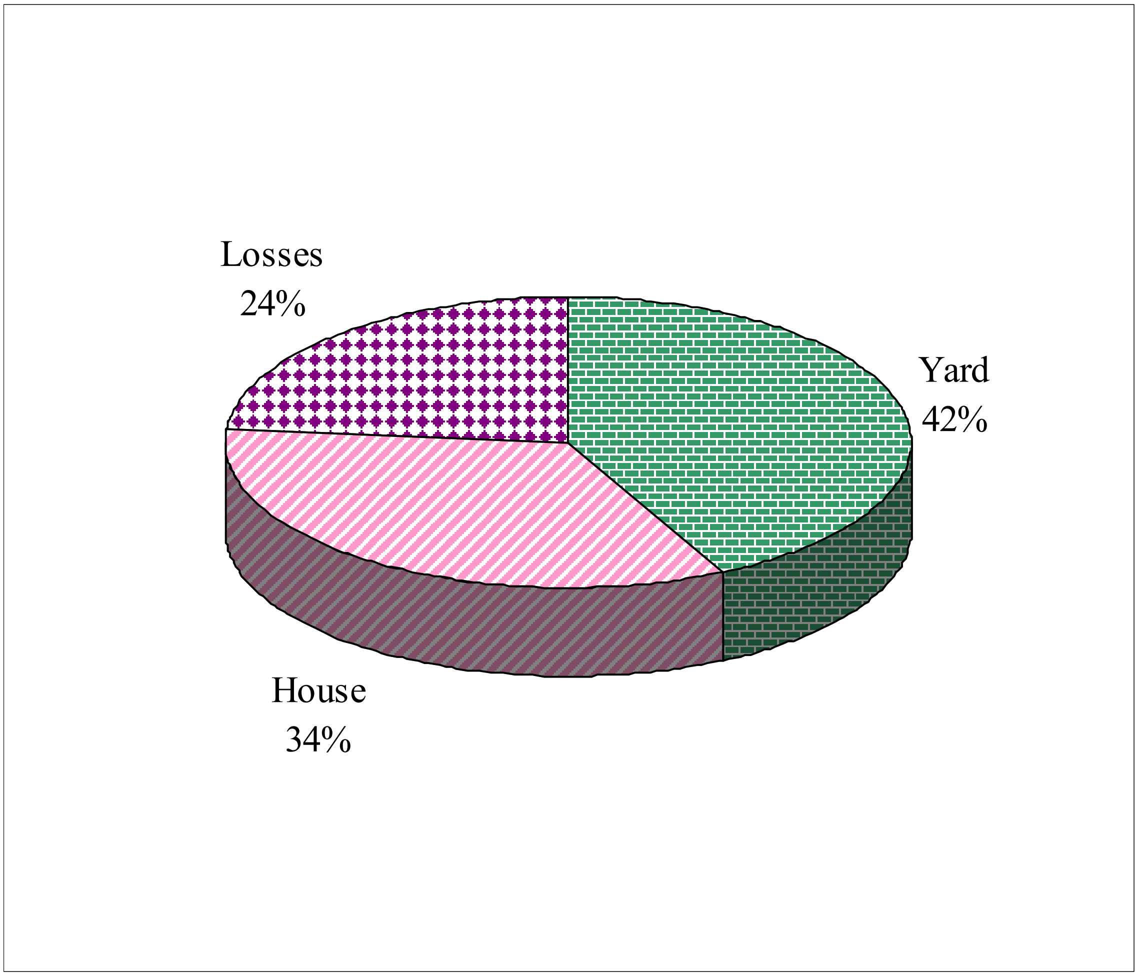


Figure 3.2 illustrates the water demand and loses for major villages in 2007. Water connected to yards accumulates to 42 percent while the water connected to houses is 34 percent. The water lost through pipe leakages, pipe bursts, unaccountable water usage was 24 percent in 2007.

Table 3.4 Water Production, Consumption and Losses for the 17 major Villages (m^3) (1996 – 2008)

Year	Population Projections	Production	Consumption	Losses	% Loss
1996/1997	338,471	13,277,150	9,789,922	3,487,228	26.3
1997/1998	347,491	14,178,572	11,400,259	2,778,313	19.6
1998/1999	356,776	17,347,164	13,271,365	4,075,800	23.5
1999/2000	366,983	18,162,739	14,274,201	3,888,538	21.4
2000/2001	376,324	19,721,824	15,110,723	4,611,102	23.4
2001/2002	385,935	21,714,743	16,409,409	5,305,334	24.4
2002/2003	396,109	22,997,730	17,390,400	5,607,330	24.4
2003/2004	406,154	23,683,119	17,497,449	6,185,670	26.1
2004/2005	415,850	25,176,190	18,158,147	7,018,043	27.9
2005/2006	425,829	24,423,840	17,943,215	6,480,625	26.5
2006/2007	437,051	26,778,575	18,788,870	7,372,582	27.5
2007/2008	446,958	27,021,729	19,553,208	7,468,521	27.8

Source: Department of Water Affairs

The production of water in major villages has increased over the years, showing an upward trend since 1997/1998 financial years up to the 2008. The population projections for the major villages also went up (See appendix 1, Table 2.2, page 61) and this might be the reason for the increase in the production of water. The other observation from the table is that the pattern of water consumption for villages under consideration has also increased over time. The losses of water increased as the production and consumption pattern went up. The financial years 2004/2005, 2006/2007 and 2007/2008 accounted for 27.9, 27.5 and 27.8 percent of water loss respectively. A graphical presentation of water production, consumption and losses for 17 villages is shown in Figure 3.3.

Figure 3.3: Water Production, Consumption and Losses (m^3) for the 17 major Villages (1996/1997 to 2007/2008)

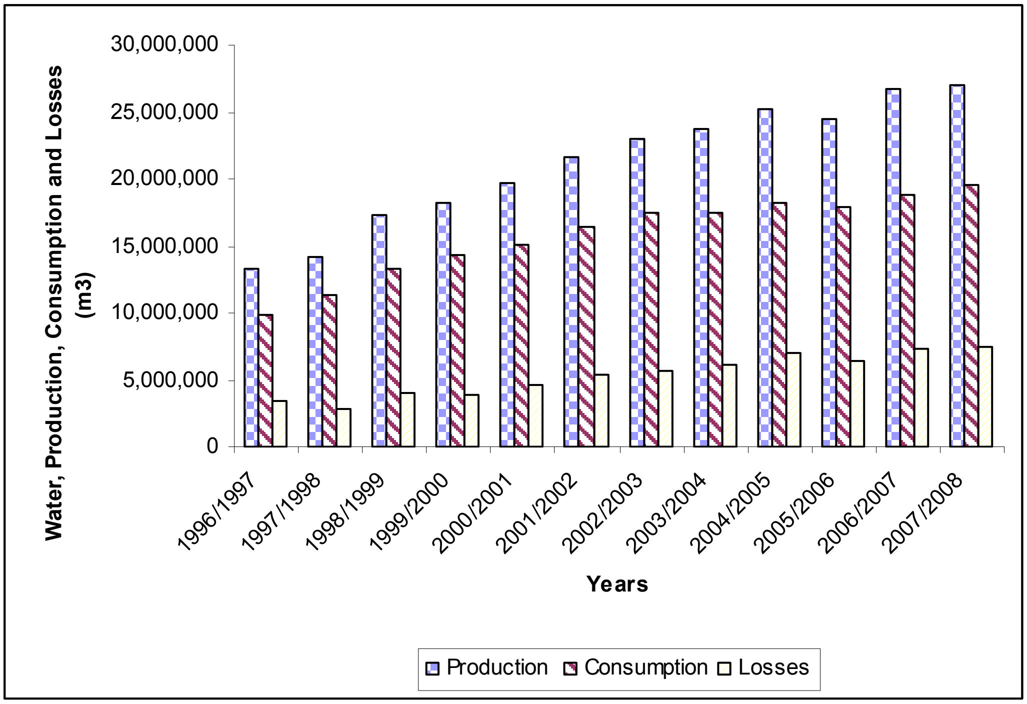


Figure 3.3 is derived from Table 3.4. Water production and consumption increases with years and so are the population sizes from major villages (See Table 3.4). Despite the water restrictions and water conservations, the water loss has been increasing considerably during 2004/05, with a reduction of 0.6% in 2005/06, increasing again from 2006/07 and 2007/08 respectively.

Figure 3.4 displays the 2008 water consumption in major villages categorized by activities; thus domestic, commercial, institution and industry. It shows that more water is being used for domestic consumption and varies according to villages (See Table 3.7 from appendix I). Maun registered the highest domestic consumption of water with 1,220,282m^3 in 2007/2008 followed by Mogoditshane, Serowe and Tlokweng with 1,093,419m^3, 997,433m^3 and 992,216m^3 respectively. The second highest consumer of water is the commercial sector followed by institutions and industries.

Figure 3.4 illustrates the 2008 water consumption pattern for major villages categorized by activities; the figures were extracted from Table 3.7 from appendix I.

Figure 4: Water Consumption (m^3) in Major Villages Categorized by Activities (2008).

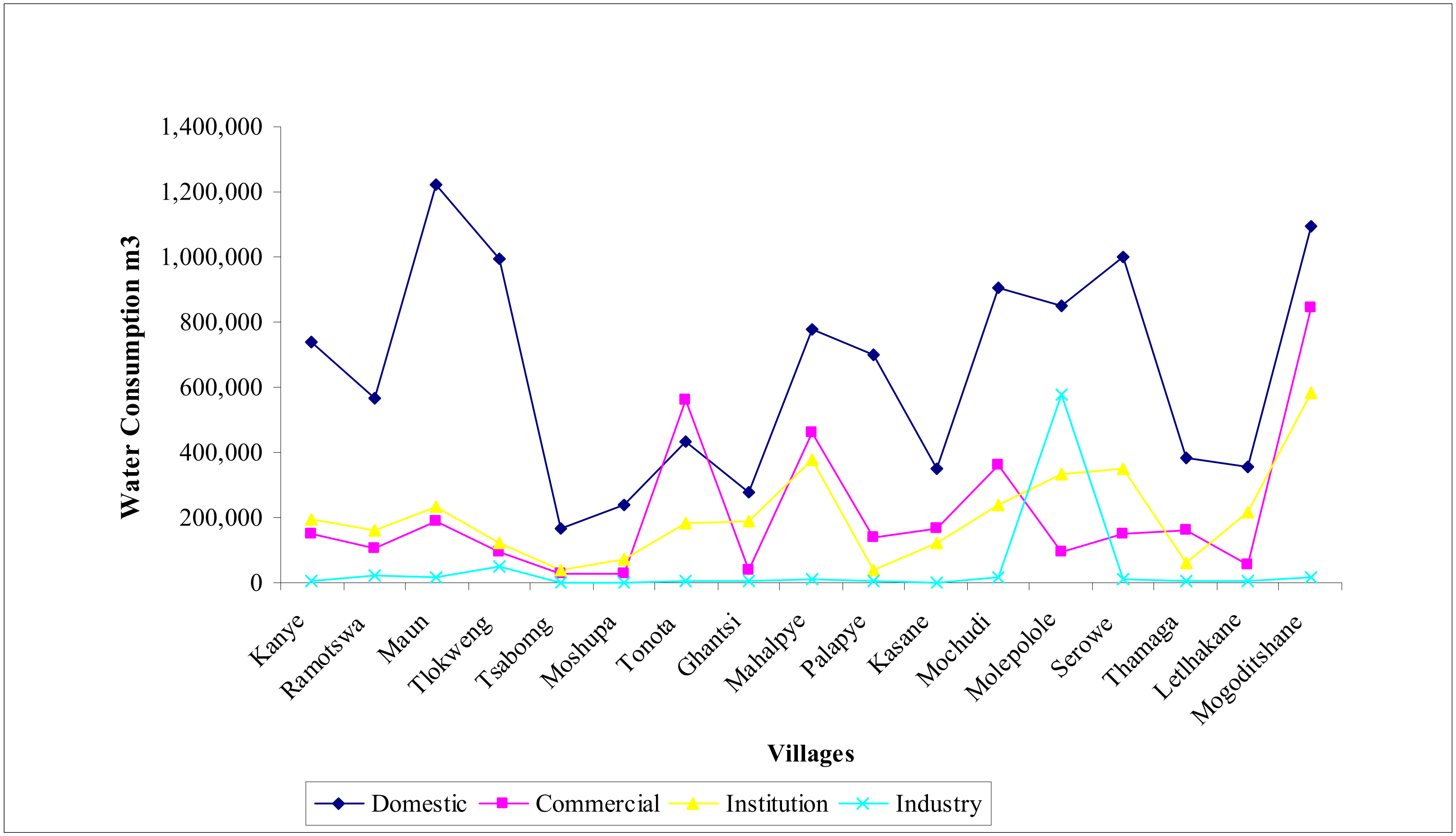


Figure 3.5: Water Production (m^3) in 17 Major Villages from 2004/05 to 2007/08

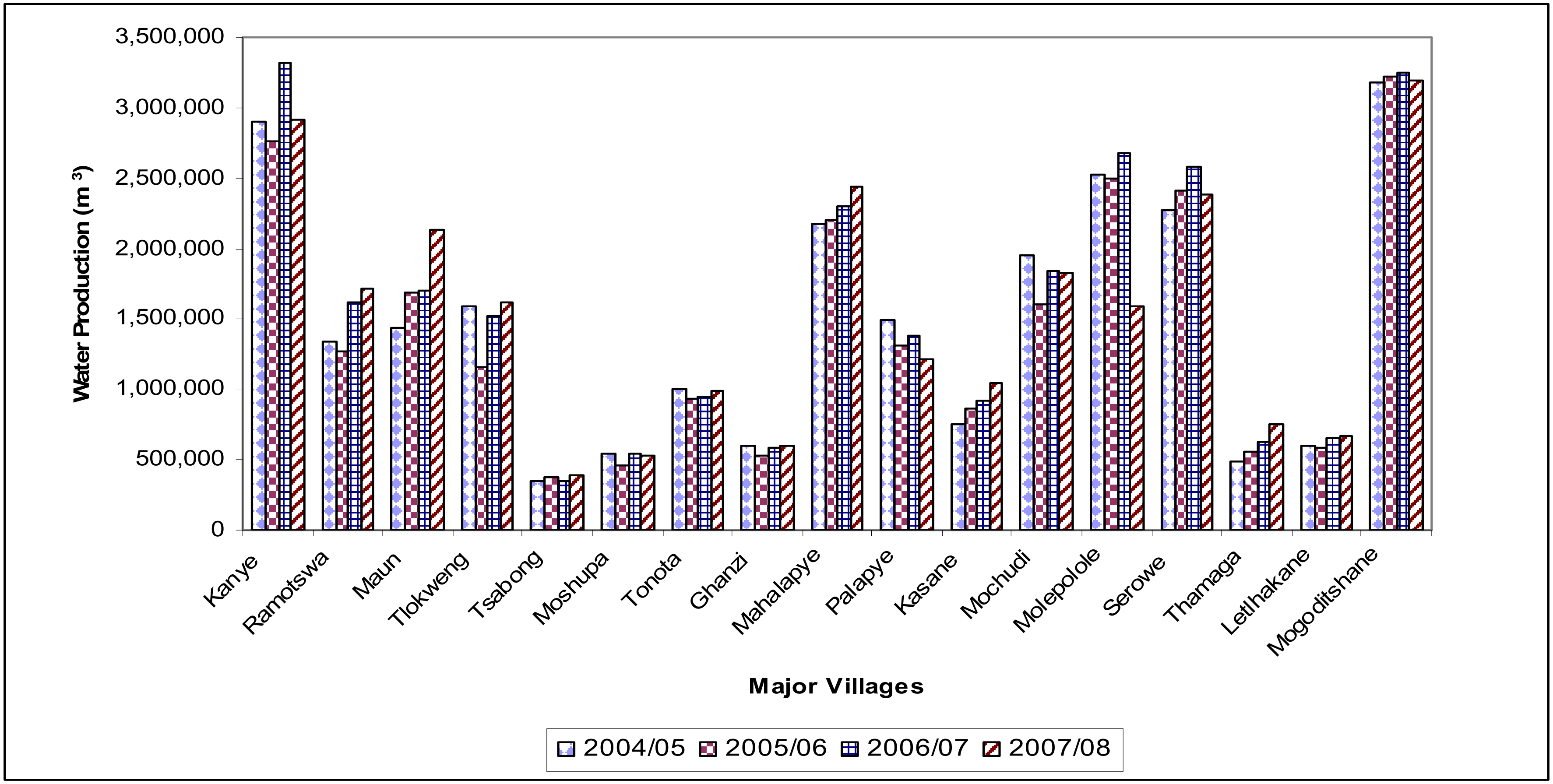


Figure 3.5 is derived from Table 3.5 in appendix I and illustrates water production for 17 major villages in the past 4 years. The production of water was low in Tsabong, Moshupa, Ghanzi, Thamaga and Letlhakane respectively. The lowest production in Tsabong and Ghanzi may be due to the shortage of rainwater in the two regions. In Moshupa, Thamaga and Letlhakane the reason for low water production may be due to small population in the areas which result in low water demand (See appendix 1, Table 2.2). High production of water was abstracted in Mogoditshane and Kanye respectively in those past 4 years.

Figure 3.6: Water Consumption (m^3) in 17 major villages from 2004/05 to 2007/08

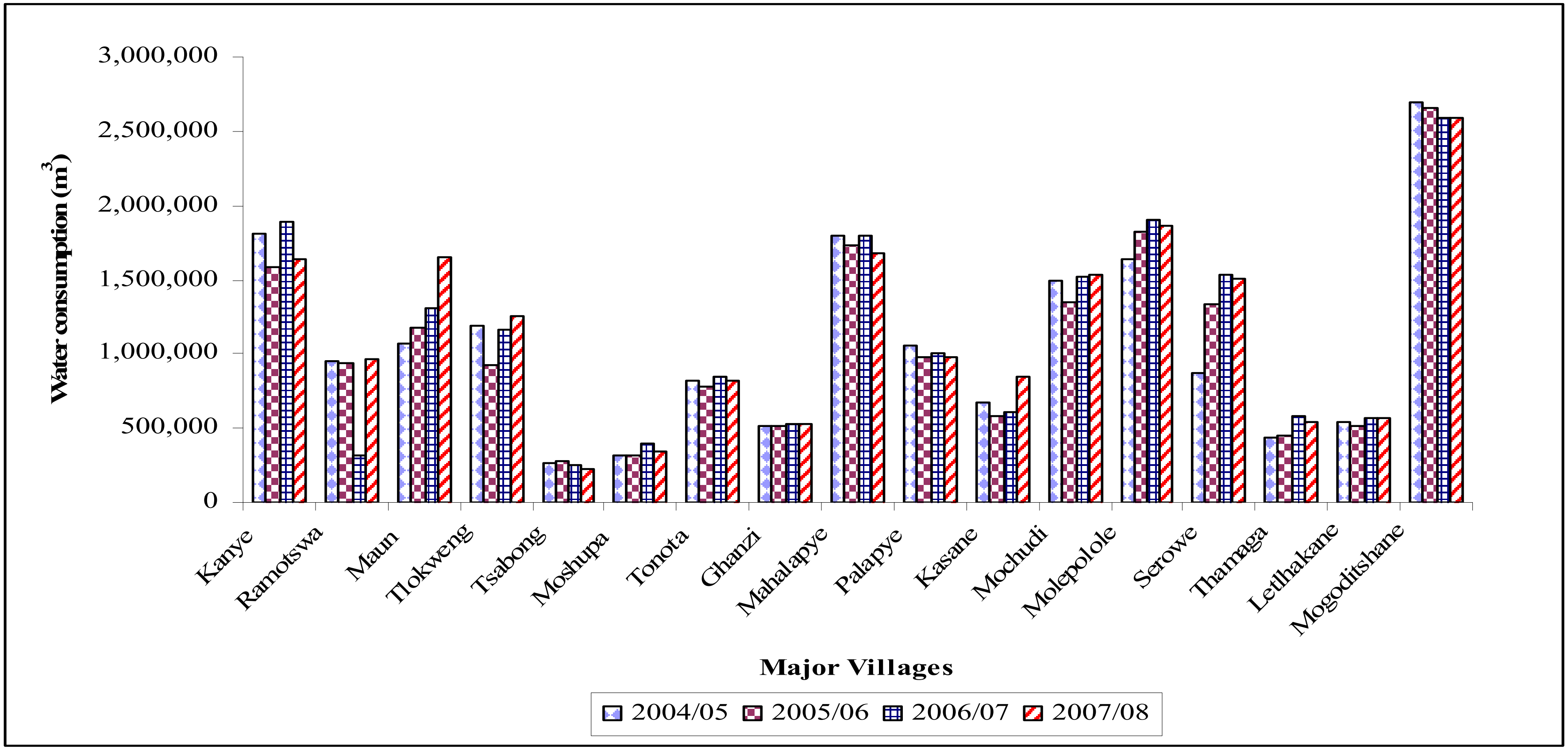


Figure 3.6 is derived from Table 3.6 (see appendix I) and it clearly shows that Mogoditshane is the largest consumer of water due to its periphery within Gaborone. Tsabong is the least water consumer due to its low water resource (See Table 3.2). Figure 3.6 also shows that in 2006/07 Ramotswa experienced low consumption of water due to little precipitation in those years.

4.0 Water Supplied by Local Authorities (District Councils) in Minor villages (2008)

4.1 The District Councils are responsible for the operation and maintenance of water schemes in medium villages and smaller settlements. These schemes are constructed by DWA and on completion hands them over to the respective councils.

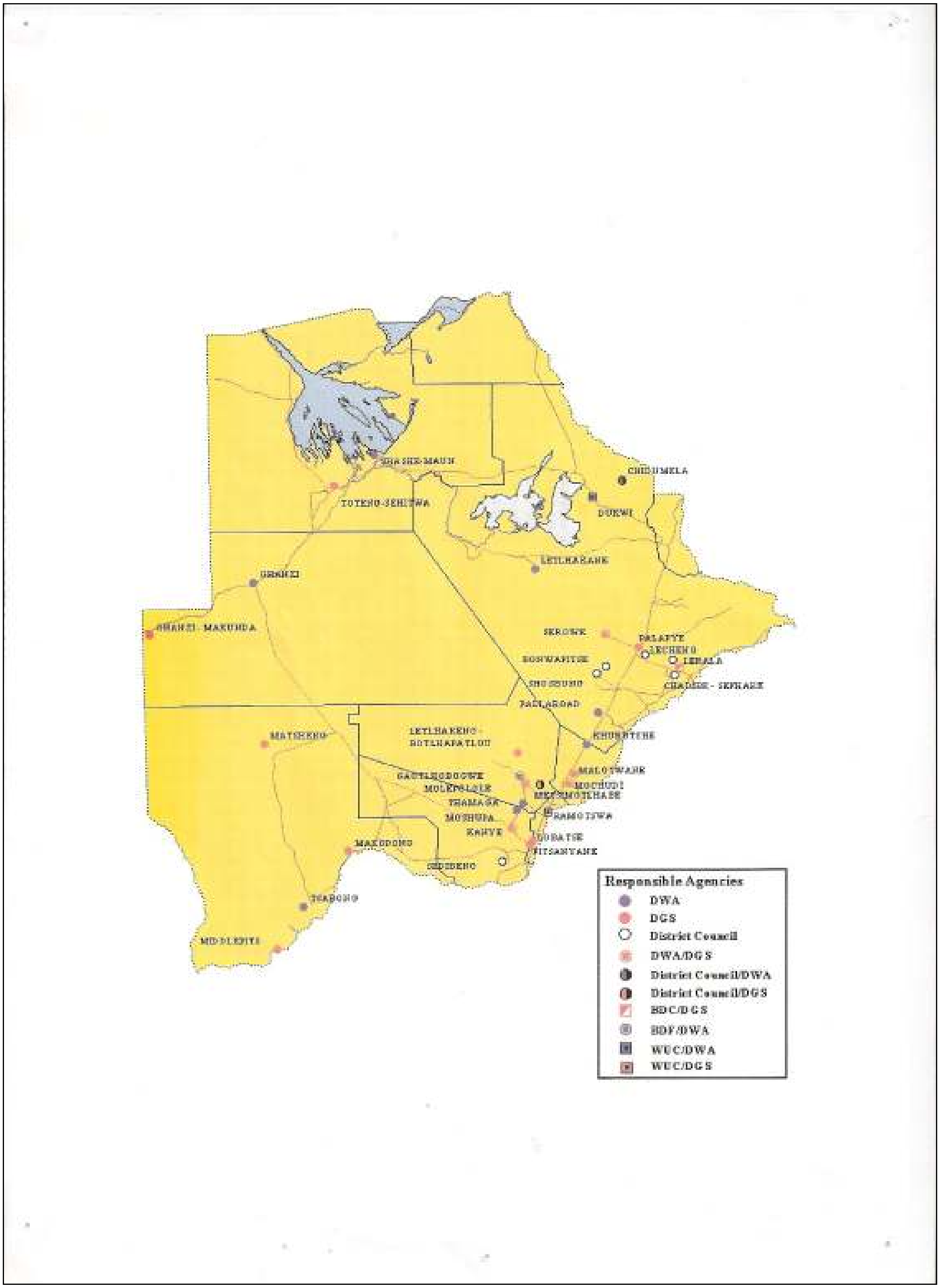
Table 4.1 Total Water Supply and Demand (m^3/d) by District (2008)

Disrict	Population Projections	Supply (m^3/d)	Demand (m^3/d)
Ghanzi District	4,855	634	489
Charleshill Sub District	7,828	1,105	319.6
Serowe/Palapye Sub District	46,166	4,884	2801
Bobirwa Sub District	47,338	3,762	3477
Boteti Sub District	18,315	1,875	1431
Mahalapye Sub District	53,069	5,872	3744
Kgatleng District	29,859	1,698	2140
South East District	7,419	714	836
Tutume Sub District	74,825	6,654	4291
Kanye/Moshopa Sub District	37,763	2,677	1893
Goodhope Sub District	35,309	2,310	2656
Mabutsane Sub District	5,900	543	439
Kweneng East Sub District	47,172	1,726	2028
Letlhakeng Sub District	18,587	1,373	1256
Kgalagadi District	24,261	948	1947
North East District	47,273	4,565	3578
Tonota Sub District	23,340	1,582	2299
Ngami Sub District	10,392	838	1339
Chobe District	6,202	780	386
Okavango Sub District	29,144	1,390	1724
Total	**575,017**	**45,930**	**39,074**

Table 4.1 displays the total amount of water supplied and demanded in cubic meters per day (m^3/d). The water is pumped everyday from the reservoirs to small villages in respective districts. The table indicates that the demand of water is low in Ghanzi district because of the resource scarcity (See Table 3.2) as well as the spatial population distribution. There is also low water demand in the Chobe District as the district has a high number of wildlife and the high density of population is only in Kasane which is supplied with water by Department of Water Affairs.

Tables 4.2- 4.21 in appendix 2 display population by settlement supplied with water by Local Authorities (LA's). Some of the villages' water supply and demand are not shown from their respective district councils due to unavailability of data from the Local Authorities. Some villages are supplied with water through interconnections from the bigger villages.

Figure 4.1: Map showing Water Resource Stations in Botswana



5.0 Water in Mining Sector

This section of the report presents source of water, total consumption, total water pumped, quality standard classification and waste water treatment for the mining sector in Botswana.

5.1 Morupule Colliery

The mine is currently being supplied by 3 boreholes. It also gets water from BPC when water from the boreholes is not sufficient. Morupule Colliery currently has a project which connects the mine to the North South Carrier; a 17km pipeline through Palapye to the mine.

Table 5.1 Amount of water pumped and supplied to Morupule (2002 – 2008)

Opening Stock	Budget	2002	2003	2004	2005	2006	2007	2008
No. 1 Borehole	12,000	10,411	9,462	8,362	4,970	5,741	2,385	0.0
No. 5B Borehole	4,800	2,401	5,845	288	0.0	0.0	0.0	0.0
No. 5A Borehole	6,528	8,921	7,431	5,199	647	1,486	4,482	6,388
No. 5C1 Borehole	36,000	-	2,542	31,264	29,441	25,291	26,198	25,675
No. 5C2 Borehole	36,000	-	-	16,039	15,590	11,220	14,611	12,261
Total Borehole Supply	**95,328**	**21,733**	**25,280**	**61,152**	**50,648**	**43,738**	**47,676**	**44,324**
B.P.C. Supply		501	2,258	854	14,097	1,016	2,271	18,645
Total	**95,328**	**22,234**	**27,538**	**62,006**	**64,745**	**44,754**	**49,947**	**62,969**
Consumption (Kiloliters)								
Mine Village	19,200	24,638	22,617	25,691	32,650	26,920	31,723	29,396
Mine Surface	16,800	18,313	18,763	18,210	15,283	13,504	14,952	14,611
Raw water transfer	24,000	27,476	25,791	28,924	25,189	11,384	13,520	17,213
Total Consumption	**60,000**	**70,427**	**67,171**	**72,825**	**73,122**	**51,808**	**60,195**	**61,220**

Source: Morupule Mines

The raw water transfer (as shown under consumption) in Table 5.1 is the untreated water piped underground for various uses such as cooling of machines and dust suppression. The source is mostly boreholes although sometimes when it rains the mine is able to harvest storm water through water tanks.

5.2 Jwaneng Mines

Table 5.2 shows the amount of water pumped from the mine's boreholes. The total water pumped from the Northern Wellfields is channelled through to Mine Reservoir for consumption by different users. The mine is given the right to abstract certain amount of water under water right agreement. From 2002 to 2005, the Water right was 1, 000, 000 m^3 and the limit was increased to 1, 200, 000 m^3 from 2006 to date as shown. The Jwaneng mine and Water Utilities Corporation also supplies Jwaneng Township with water (See Table5.3).

Table 5.3 Mine Reservoirs

Year	2002	2003	2004	2005	2006	2007	2008
MTP	370,579	477,495	476,989	514,930	388,204	443,834	438,309
BSP and Aquarium	11,509	14,030	49,476	27,283	26,169	33,063	29,957
Recrush -	169,206	293,906	184,492	234,872	121,769	245,753	145,510
Township (W.U.C)	143,479	147,881	209,630	178,189	146,779	154,613	142,030
Industrial -	68,521	54,070	18,013	6,970	8,335	31,587	20,680
Domestic -	5,647	7,519	8,464	10,369	4,255	7,379	7,795
Miscellaneous -	10,803	8,447	3,342	4,161	4,707	2,703	3,676
Total Water Consumed	**779,744**	**1,033,377**	**1,017,437**	**976,774**	**700,209**	**918,933**	**787,956**

Table 5.2 Northern Wellfields (2002 – 2008)

Year	2002	2003	2004	2005	2006	2007	2008
Borehole : A Leg -	61,598	131,427	109,033	124,560	113,355	138,664	104,069
Borehole : B Leg -	171,602	176,701	129,936	172,488	130,017	170,231	152,530
Borehole : C Leg -	179,039	181,507	142,343	135,958	102,445	141,356	105,406
Borehole : D Leg -	45,420	93,387	86,394	118,307	78,424	135,327	115,043
Borehole : E Leg -	106,993	122,557	102,253	122,155	97,376	131,618	118,452
Borehole : F Leg -	56,643	83,433	101,716	89,047	71,127	54,632	48,452
Borehole : G Leg -	75,025	112,322	106,550	114,757	95,869	131,693	105,913
Borehole : H Leg -	60,891	113,318	105,094	114,907	95,312	114,379	74,708
Total Water Pumped.	**798,495**	**1,014,651**	**883,319**	**992,179**	**783,925**	**1,017,899**	**833,836**
Water Right -	**1,000,000**	**1,000,000**	**1,000,000**	**1,000,000**	**1,200,000**	**1,200,000**	**1,200,000**

Source: Jwaneng Mines
Note: 2008 data was up to November 2008

5.3 Orapa and Letlhakane Mines

The Township is supplied by two reservoirs and all of them receive chlorine dosing to take care of the contamination that may be in the reticulation network including chemical and microbiological treatment. All the population of Orapa Township has access to safe drinking water and wastewater collecting system/sewerage.

Table 5.4 Water and Wastewater (M m^3) supply at Orapa mines (2004 – 2008)

Description	**Year 2004 M m^3/year**	**Year 2005 M m^3/year**	**Year 2006 M m^3/year**	**Year 2007 M m^3/year**	**Year 2008 M m^3/year**
Total Water Abstraction (Wellfields)	12,130	11,020	10,690	12,110	****
Total Water Used for mine processing activities	12,750	12,990	15,320	15,510	13,981
Potable water used	2,070	1,890	1,950	1,810	1,466
Quality Standard Classification	Class III	Class III	Class III	Class II	Class I
Waste Water Treatment Facility					
Capacity	5.00 M liters/day	5.00 M liters/day	5.00 M liters/day	5.00 M liters/day	5.00 M liters/day
Used Capacity	3,00 M Liters/day	3,00 M Liters/day	3,00 M Liters/day	3,00 M Liters/day	3,00 M Liters/day
Number of plants	1	1	1	1	1

****: Data Unavailable*
Source: Orapa-Letlhakane Mines

5.4 Botash Mines

Water Availability

Water abstracted for the mine is all groundwater. These are brine, brackish and portable water. Brine is the raw water fed to the plant to extract salt and soda ash. It is not used as drinking water and does not meet drinking water specifications. Brackish water is used for industrial purposes and not as drinking water. Potable water is supplied by Water Utilities Corporation from Dukwi wellfields. Table 5.5 shows water abstracted from Dukwi wellfields in the past 10 years. Sustainable abstraction for the Dukwi Wellfield is estimated to be 5700 m^3 per day. (See Table 3.2)

Table 5.5 Availability and types of water in Sowa Township (Mm^3) (1998 – 2008)

Year	Brine Abstraction Million(m^3)	Brackish Water (m^3)	Portable Water Supply (m^3)
1998	17.30	571,182	-
1999	17.03	606,020	-
2000	16.20	609,728	-
2001	17.64	591,828	338,630
2002	18.82	614,559	355,879
2003	19.21	569,003	312,113
2004	19.22	594,659	289,946
2005	19.51	563,624	336,956
2006	18.79	606,937	277,502
2007	21.01	587,326	246,111
2008	21.28	600,199	256,760
Average Total	**18.73**	**592,279**	**274,050**

Source: Botash mines

5.5 BCL Water flow

Table 5.6 shows the supply of water to Selibe-Phikwe BCL Mine. Raw water as shown in the third column is supplied by WUC from Shashe Dam and is mainly used for mining processing activities. Potable water is supplied by WUC from the Selibe-Phikwe water treatment plant and is used for human consumption and other related human activities.

Table 5.6 BCL Water Flow Rates (1998 – 2008)

Year	Potable water consumption m^3/month	Raw water consumption (m^3/hr)	Fissure water (overflow from Million Gallon Dam V-notch) (m^3/hr)	Water discharged to Environment (Lions Club V-notch) (m^3/hr)	Cooling Ponds V-notch (m^3/hr)
1998	-	435	440	267	-
1999	-	363	346	402	-
2000	-	457	287	279	-
2001	-	385	237	427	-
2002	109,984	416	177	283	-
2003	10,1468	422	212	348	-
2004	101,351	369	123	-	190
2005	105,248	406	148	-	122
2006	97,922	383	131	-	134
2007	95,210	423	86	-	162
2008	95,622	437	80	-	199

Source: BCL Mines

It should be noted that before April 2004, the Lion's Club V-notch overflow was the estimate of the BCL wastewater released to the environment into Motloutse river after treatment. The v-notch was submerged after the construction of the irrigation dam. The flow rate of wastewater is now measured at the Cooling Ponds V-notch, which is upstream of the Ni Removal plant. Water from the irrigation dam is used for irrigating the nearby tree orchard and watering surrounding livestock.

Fissure water (water that miners come across in aquifers when drilling) is estimated at 4 million litres per day and is pumped from the mine. Approximately 50 percent is re-used in the mining processing activities. Table 5.6 also shows that the average treated waste water in 2004, 2005, 2006, 2007 and 2008 from Cooling Ponds v-notch was 190m^3/hr, 122m^3/hr, 134m^3/hr, 162m^3/hr and 199m^3/hr respectively. All the wastewater is treated at the N1 Removal plant.

5.6 Tati-Nickel Water Supply

Tati-Nickel Mining Company buys its water from Water Utilities Corporation. The water is pumped from Shashe Dam as raw water and is used for different mining activities. Most of the water is recycled as shown in Table 5.7. The recycled water is called Return water. This return water is stored in two ponds, one being a 200 m^3 per hour pump capacity storage and the other being a 400 m^3 per hour pump.

Table 5.7 Tati-Nickel Water Consumption (2002 – 2008)

Year	WUC Raw water supply (m^3)	Recycled water (m^3) (200 m^3/hour)
2002	1,070,790	241,479
2003	2,036,320	341,255
2004	2,004,760	783,052
2005	2,287,480	970,457
2006	2,562,340	868,960
2007	2,446,630	711,594
2008	2,373,560	389,715

Source: Tati-Nickel Mine

Table 5.8 Amount of Recycled water (m^3) by Month 2008 (400 m^3/hour)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Amount (m^3)	61,377	70,842	44,597	44,146	12,475	57,290	10,4058	54,994	48,969	38,032	36,573	43,441

Source: Tati-Nickel Mine

Tati- Nickel Mine has a treatment plant used for treating water to produce portable water. This water is stored in a holding plant and is transferred straight to portable taps. The holding plant does not have a meter to measure the portable water produced.

6.0 Surface Water

Water from dams and rivers contribute about one-third to national water consumption. An increasingly large proportion of the population which resides in the urban areas as a result of urban migration is supplied by water from the dams.

6.1 Water Supply in Urban Areas

Water Utilities Corporation (WUC) is responsible for the supply of water to the six urban/mining centers and other designated areas except for Orapa, which is supplied by the Debswana Company. Water is abstracted from the major dams around the country which are under the administration of the Corporation.

Table 6.1 Total annual water abstraction from WUC dams (Mm^3) from 2002 to 2008)

	Gaborone	Nnywane	Letsibogo	Shashe	Bokaa	Molatedi
2002-2003	25.00	0.70	14.60	9.20	2.80	12.96
2003-2004	23.00	0.70	18.60	9.10	1.90	7.46
2004-2005	17.80	0.50	11.10	12.90	1.20	17.58
2005-2006	8.00	0.70	16.60	13.40	2.40	18.43
2006-2007	18.70	0.90	13.10	14.60	3.80	9.51
2007- 2008	22.30	0.80	3.20	14.40	5.30	6.44

Source: Water Utilities Corporation

Table 6.1 shows total annual water (Mm^3) abstracted from the major dams before the water is treated. WUC has treatment plants around the country and as the water is abstracted from the dams, it is then transferred to different treatment plants where the production of portable water takes place. Water abstracted from Gaborone Dam was at its lowest level in 2006, (8.00 Mm^3) due to very low rainfall in that year.

Table 6.2 Annual treated water productions (Mm^3) from 2002 to 2008

	Gaborone	Mmamashia	Mahalapye	Palapye	Selibe-phikwe	F/town
2002-2003	24,43	5,61	1,60	1,20	5,5	8,5
2003-2004	22,03	9,14	1,50	1,21	5,3	8,3
2004-2005	19,77	5,58	1,99	1,47	5,6	9,6
2005-2006	10,42	13,14	1,46	1,03	5,4	9,5
2006-2007	31,50	7,28	0,73	0,53	5,2	9,5
2007-2008	22,40	7,00	0,32	0,34	5,2	9,6

Source: Water Utilities Corporation

Table 6.2 shows the total amount of water produced from different treatment plants. Mahalapye and Palapye falls in the North South Carrier Scheme and comprises of a 360km long pipeline, water treatment plants and associated pump stations. Gaborone treatment plant gets its water from Gaborone dam and Molatedi dam which pours directly into Gaborone Dam; Mmamashia plant abstracts water from Letsibogo and Bokaa Dams, while Mahalapye, Palapye and Selibe-Phikwe are supplied by Letsibogo Dam. Shashe Dam supplies Francistown, Shashe village and Selibe-Phikwe waterworks.

Table 6.5 Water sales in thousand cubic meters from 2005/2006 – 2007/2008

	Total 2005/06	**Total 2006/07**	**Total 2007/08**
(a) Gaborone & Lobatse Combined			
Domestic	7,094	8,392	9,143
Government	10,119	11,719	12,543
Comm/Industrial	4,084	4,430	4,897
Total	**21,297**	**24,541**	**26,583**
(b) Selebi Phikwe Division			
Domestic	2,075	1,975	1,984
Government	1,367	1,212	1,205
Comm/Industrial	2,025	1,907	5,529
Total	**5,467**	**8,901**	**8,718**
(c)Francistown			
Domestic	2,287	2,363	2,525
Government	3,931	3,883	4,157
Comm/Industrial	2,018	2,275	2,250
Total	**8,236**	**8,521**	**8,932**
(d) Jwaneng			
Domestic	1,071	1.121	1,241
Government	309	295	296
Comm/Industrial	195	212	226
Total	**1,575**	**1,628**	**1,763**
(e) North South Carrier			
Government	**2,574**	**1,441**	**586**
(f) Total Potable Water Supply	**39,149**	**45,032**	**46,582**
BCL	**3,593**	**3,807**	**3,651**

Source: Water Utilities Corporation 2007/2008 Annual Report

Lobatse is supplied with water from Gaborone Water Works and Table 6.5 shows the combined total from 2005/06 to 2007/08 for both Lobatse and Gaborone. In 2007/2008 Gaborone water sales was 8,564 m^3 for domestic, 11,359 m^3 for government and 4,040 m^3 for commercial/industrial sales while Lobatse water sales for domestic, government and commercial/ industrial was 579 m^3, 1,184 m^3 and 857 m^3 respectively. Table 6.5 further shows that Government is the largest consumer in all urban areas except in Selibe Phikwe where industrial is leading. The North South Carrier water supply to the Government is the water sold to DWA to supply Mahalapye and Palapye. The pipeline runs through these two major villages from Letsibogo Dam to Mmamashia Plant near Gaborone.

Table 6.6 Total Water Consumption for all towns (1998 – 2008)

Year	Total Consumption in kilolitres	Sales in Pula	[1]Sales per Kilolitre	[2]Projected Population	Per Capita Consumption (kl/day)
1998	32,007,424	148,012,240	4.62	391,983	0.224
1999	26,372,110	133,164,012	5.05	409,230	0.177
2000	37,888,345	232,887,628	6.15	427,236	0.243
2001	48,415,944	387,204,438	8	446,878	0.297
2002	38,594,328	326,631,106	8.46	465,646	0.227
2003	47,245,350	430,247,650	9.11	485,204	0.267
2004	48,493,178	501,353,260	10.34	505,582	0.263
2005	43,507,553	405,119,463	9.31	526,817	0.226
2006	43,611,475	421,029,698	9.65	548,267	0.218
2007	47,287,224	466,665,882	9.87	569,101	0.228
2008	50,292,691	502,441,939	9.99	590,727	0.233

Source: Water Utilities Corporation

NB: [1]"Sales per kilolitre is derived when dividing Total Sales in Pula by Total Consumption in Kilolitres"
[2]"Projected Population from the Population Projections for Botswana 2001-2031 (CSO)

Table 6.6 shows the total water consumption for all towns supplied with water by Water Utilities Corporation and the total sales made from 1998 to 2008. Per capita consumption was higher in 2001, 2003 and 2004. It went down from 2005 due to water restrictions imposed by the government after the country experienced water shortages because of unreliable rainfalls.

6.2 Water Consumption per capita

Water Consumption per Capita (m^3/d) refers to the amount of water consumed or supplied over Population Supplied or consumer per year (365 days). Water consumption per capita is an indicator for the pressure that human demand places on the resources. In recent years there has been greater emphasis placed on per capita consumption data as a means of setting and measuring water conservation goals. Per capita consumption of drinking water has been fluctuating since 1991. The major cause of these fluctuations could be climatic changes. Per capita consumption is affected by a number of factors including climate variations; household and plot sizes; building densities and most importantly population increase.

Table 6.8 shows per capita consumption of water in towns/cities. Per capita consumption of water is high in Selibe-Phikwe when compared with other towns/cities. This is due to the mine's consumption of potable water combined with high usage in the domestic sub-sector. Domestic water usage is high in this town because the tariffs in Selibe-Phikwe are the lowest for bulk water supplied by Water Utilities Corporation. Furthermore, BCL mine has subsidized water for its employees.

Table 6.8 Water Consumption per capita in Towns (m^3/d) (1998 – 2008)

Year	Gaborone	Francistown	Lobatse	Jwaneng	Selibe-Phikwe	Sowa Town
1998	0.247	0.151	0.192	0.246	0.323	0.460
1999	0.175	0.115	0.148	0.175	0.252	0.263
2000	0.386	0.149	0.208	0.386	0.329	0.356
2001	0.288	0.208	0.252	0.288	0.539	0.482
2002	0.192	0.151	0.159	0192	0.312	0.301
2003	0.225	0.159	0.205	0.225	0.471	0.332
2004	0.227	0.162	0.203	0.227	0.441	0.268
2005	0.211	0.167	0.164	0.211	0.463	0.257
2006	0.192	0.175	0.170	0.192	0.416	0.266
2007	0.208	0.170	0.192	0.208	0.422	0.214
2008	0.184	0.178	0.211	0.184	0.433	0.233

Source: derived from Table 6.6

Table 6.9 shows water consumption per capita in 17 major villages. Mogoditshane, which is more urbanized than the other villages, has high water consumption compared to other major villages. This could be because Mogoditshane acts as satellite settlement for Gaborone city, therefore the population is relatively bigger compared to other surrounding villages. Another factor may be due to high consumption of water by activities such as commercial, industrial and institutions like the Botswana Defense Force camp (see figure 4 and Table 3.7 in appendix I).

6.9 Water Consumption per capita in Major villages (m^3/d) (1998 – 2008)

Villages	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Kanye	0.084	0.077	0.075	0.117	0.121	0.131	0.112	0.123	0.105	0.124	0.105
Ramotswa	0.033	0.072	0.074	0.064	0.058	0.064	0.051	0.074	0.069	0.022	0.066
Maun	0.092	0.091	0.085	0.079	0.095	0.080	0.078	0.087	0.095	0.103	0.129
Tlokweng	0.078	0.117	0.152	0.150	0.138	0.149	0.171	0.137	0.105	0.128	0.134
Tsabong	0.095	0.108	0.121	0.140	0.135	0.140	0.147	0.149	0.155	0.137	0.123
Moshupa	0.040	0.046	0.051	0.048	0.052	0.060	0.056	0.056	0.053	0.066	0.056
Tonota	0.110	0.155	0.135	0.140	0.162	0.180	0.163	0.172	0.162	0.173	0.168
Ghanzi	0.124	0.120	0.105	0.140	0.157	0.136	0.140	0.164	0.155	0.157	0.153
Mahalapye	0.101	0.126	0.123	0.111	0.126	0.122	0.135	0.140	0.132	0.135	0.125
Palapye	0.092	0.118	0.130	0.108	0.126	0.126	0.122	0.123	0.111	0.111	0.107
Kasane	0.197	0.188	0.192	0.062	0.191	0.181	0.018	0.205	0.170	0.169	0.227
Mochudi	0.067	0.079	0.084	0.390	0.100	0.123	0.124	0.125	0.112	0.124	0.123
Molepolole	0.038	0.052	0.065	0.064	0.059	0.079	0.082	0.083	0.090	0.092	0.088
Serowe	0.086	0.081	0.082	0.090	0.113	0.105	0.086	0.067	0.102	0.116	0.113
Thamaga	0.051	0.056	0.042	0.048	0.053	0.056	0.055	0.065	0.066	0.084	0.076
Letlhakane	0.083	0.084	0.077	0.083	0.089	0.092	0.096	0.096	0.088	0.093	0.090
Mogoditshane	0.284	0.276	0.312	0.310	0.298	0.285	0.292	0.270	0.255	0.238	0.228

Source: derived from Table 2.2 and Table 3.6

7.0 Government Revenue and Expenditure

7.1 Water Tariffs

Though the Department of Water Affairs is not a profit driven entity, government gets some revenue out of water production. Government fully controls water tariffs in urban and rural areas. In urban areas, the parastatal WUC proposes water tariffs, but the Minister of Minerals, Energy and Water Resources has to approve.

7.1.1 Urban Water Tariffs

WUC operates large dams, being Gaborone, Bokaa, Letsibogo, Nnywane, Shashe and the North South Water Carrier Project. The NSWC project supply water to urban areas such as Mahalapye and Palapye; WUC also imports water from South Africa (Molatedi dam) free as compensation of the dams on the South African side of the Notwane and Limpopo catchments. WUC only incurs transport cost of water from South Africa. WUC recovers its full supply costs through revenues earned on water sales. Urban water tariffs vary in different parts of the country, mostly due to differences in transport and corporation infrastructures. WUC uses a tariff structure whereby the first 10 cubic meters are supplied at a very low tariff rate; and subsequently increases as consumption increases. This tends to cushion the low income consumers as the high income consumers, who use more water, in a way subsidize the low income consumers. Gaborone has the highest tariffs due to the high transport costs. (Water Utilities Corporation)

7.1.2 Rural Water Tariffs (DWA and DCs)

Rural water tariffs are lower than the urban ones, as they primarily aim to recover the operational costs. Rural water charges are uniform throughout the country irrespective of the local supply costs. The price of water is higher, however, in villages supplied by the NSWC, due to the high costs of this supply source.

7.1.3 Self-Providers

No policy exists for water tariffs among self providers. Most self-providers pay supply costs, and it is apparently assumed that this reflect the resource value. The opportunity and depletion costs are not yet considered.

Table 7.1 Domestic and Business Consumers – 1st November 2004- March 2008

Tariff Band	Consumption per month (cubic metres)	Thebe per cubic meter Gab/Lob	Jwaneng	F/Town	S/Phikwe	Sowa
1	0-10	210	165	240	165	165
2	11-15	640	330	575	265	375
3	16-25	815	430	840	330	540
4	Above 25	1130	495	940	430	600
	Raw water (untreated)	330	..	200	235	..
5	Raw water Botash' BCL	..	..	..	90	185

Source: WUC Annual Reports

Table 7.2 Water Tariffs for Government, City, Town and District Councils 2008

Tariff Band	Consumption per month (cubic metres)	Thebe per cubic meter Gab/Lob	Jwaneng	F/Town	S/Phikwe	Sowa
1	0 - 10	440	240	500	240	240
2	11-15	1295	475	1175	385	540
3	16-25	1660	620	1695	475	785
4	Above 25	2270	725	1890	595	870
	Standpipe (Council)	1985	650	1330	505	..
	Bulk Water Treated (DWA and DC)	1610	585	1190	..	..
	Bulk Water untreated (DWA and DC)	590	..	..	280	..

Source: WUC Annual Reports

Charges for water consumed are based on a unit of one cubic metre and meter readings are made to the nearest whole unit.

Although the Government controls water tariffs, WUC proposes them based on its cost recovery measures. The tariffs in cities are higher (See Table 7.2) as compared to other towns because of the high standard of infrastructures which, in a way determine the charges. It should also be noted that Gaborone is partially supplied by Letsibogo Dam (in Mmadinare) and this might contribute to the high tariffs in the city.

8.0 Water Quality in Botswana

The guidelines for drinking water quality are used as the basis for regulation and standard setting to ensure the safety of drinking water. Botswana Bureau of Standard (BOBS) is the only organization in Botswana responsible for setting drinking water quality standards, guidelines and amendments of such. Its standards are being compared with World Health Organization guidelines in Table 8.1 (see Appendix 4), showing the selected water quality parameters. Water sources are monitored on a regular basis to assess its quality. There are various variables monitored by the Water Utilities Corporation to measure water quality. According to the BOS 32:2000, drinking water standard for all the tested parameters for the portable water sample comply with the standard as shown in Table 8.1 from Appendix IV. These variables are able to measure the level of contamination. The water quality standards are classified in three categories: Class 1- Ideal, Class 2- Acceptable and Class 3- Maximum allowable standard of water quality.

8.1 Physical and Organoleptic Requirements

a) Turbidity

It is a measure of the degree to which the water losses its transparency due to the presence of suspended particulates. The more total suspended solids in the water, the murkier it seems and the higher the turbidity. It is considered as a good measure of the quality of water. Turbidity is caused by various variables such as-:

- Sediments from erosion
- Re-suspended sediments from the bottom
- Waste discharge
- Algae growth
- Runoff

b) Total Dissolved Solids (TDS)

- "Dissolved solids" refer to any minerals, salts, metals, anions[3] or cations[4] dissolved in water. This includes anything present in water other than the pure water molecule and suspended solids. (Suspended solids are any particles/substances that are neither dissolved nor settled in the water, such as wood pulp.)
- Some dissolved solids come from organic sources such as leaves, silt, plankton, and industrial waste and sewage. Other sources come from runoff from urban areas, road salts used on street during the winter, and fertilizers and pesticides used on lawns and farms. (BOS 32:2000)

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[3] An **ion** is an atom or molecule which has lost or gained one or more valence electrons, making it positively or negatively charged. A negatively charged ion, which has more electrons in its electron shells than it has protons in its nuclei, is known as an **anion**

[4] Conversely, a positively-charged ion, which has fewer electrons than protons, is known as a **cation**

The TDS levels for the Water Utilities Corporation dams were way below the ideal water group, Class 1. The maximum level was recorded at Gaborone Dam and stood at 271.05 mg/l in February 2006.

c) pH

The balance of positive hydrogen ions (H+) and negative hydroxide ions (OH-) in water determines how acidic or alkaline (basic) the water is.

In a dam, the water's pH is affected by its age and the chemicals discharged by communities and industries. Most dams are basic (alkaline) when they are first formed and become more acidic with time due to the build-up of organic materials. As organic substances decay, carbon dioxide (CO_2) forms and combines with water to produce a weak acid, called "carbonic" acid — the same stuff that is in carbonated soft drinks. Large amounts of carbonic acid lower pH for water.

Table 8.2 pH Statistics from Distribution Points as compared to the BOS 32:2000 Standards as at February 2006

PH Statistic value at 25°C and BOS 32:2000	Treated Water Distributed				
	Gab	Bokaa	Shashe	Nnywane	Letsibogo
Average	6.61	6.12	6.54	4.94	6.18
Average[1]	7.95	7.91	7.70	7.93	7.44
Count	65	53	53	53	53
Count[1]	54	41	45	33	44
Max	8.53	8.44	8.27	9.19	8.45
Class 1 (Ideal) mg/l	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5
Class 2 (Acceptable) mg/l	5.5-9.5	5.5-9.5	5.5-9.5	5.5-9.5	5.5-9.5
Class 3 (Max. allowable) mg/l	5.0-10	5.0-10	5.0-10	5.0-10	5.0-10

Average - is calculated for the whole data, taking 'the not analyzed' data into the total count
Average[1] - it is calculated by summing the available data and dividing by the count
Count - is the total number of samples collected between this period
Count[1] - is the total number of samples collected monthly less the 'not analyzed' data
Gab- Gaborone Dam

8.2 Chemical Requirements: Inorganic macro- determinants

a) Calcium

Table 8.3 shows Calcium Concentration in mg/l as compared to different set of standards by W.H.O, W.U.C and Botswana Bureau of Standards. This is for the period April 2001 to August 2006.

Table 8.3 Calcium Concentration data in *mg/l* for the different Distribution Points as at April 2001 to August 2006

	Treated Water Distributed				
Calcium Statistic and BOS 32:2000	**Gab**	**Bokaa**	**Shashe**	**Nnywane**	**Letsibogo**
Average	13.27	13.92	12.14	7.17	14.30
Average[1]	14.87	15.70	13.41	10.27	16.85
Count	65	53	53	53	53
Max	59.77	48.00	26.95	25.00	29.00
Class 1 (Ideal) mg/l	80	80	80	80	80
Class 2 (Acceptable) mg/l	150	150	150	150	150
Class 3 (Max. allowable) mg/l	200	200	200	200	200

Average - is calculated for the whole data, taking 'the not analysed' data into the total count
Average[1] - it is calculated by summing the available data and dividing by the count
Count - is the total number of samples collected between this period
Count[1]- is the total number of samples collected monthly less the 'not analysed' data
Gab - Gaborone Dam

b) Hardness as $CaCO_3$ in mg/l

Hardness measures polyvalent cations (ions with a charge greater than +1) in water. Hardness affects the amount of soap that is needed to produce foam or lather. Hard water can leave a film on hair, fabrics, and glassware. Hardness of water is very important in industrial uses, because it forms scale in heat exchange equipment, boilers, and pipe lines. Some hardness is needed in plumbing systems to prevent corrosion of pipes.

Table 8.4, shows that for the period, April 2001 to August 2006, maximum hardness as $CaCO_3$ content was in the range of 200 and 500mg/l for all the five dams and one can conclude that this is Class 3 water for this particular parameter.

Table 8.4 Hardness as CaCO3 from the five Distribution Points against BOS 32: 2000 Standards as at April 2001 to August 2006

Hardness as $CaCO_3$ Statistic and BOS 32:2000	Treated Water Distributed				
	Gab	Bokaa	Shashe	Nnywane	Letsibogo
Average	29.31	27.19	33.01	17.09	42.60
Average[1]	57.73	40.02	79.53	26.65	62.72
Count	65	53	53	53	53
Count[1]	33	36	22	34	36
Max	118.24	233.00	109.00	100.00	115.10
Class 1 (Ideal) mg/l	20	20	20	20	20
Class 2 (Acceptable) mg/l	200	200	200	200	200
Class 3 (Max. allowable) mg/l	500	500	500	500	500

Average - is calculated for the whole data, taking 'the not analysed' data into the total count
Average[1] - it is calculated by summing the available data and dividing by the count
Count - is the total number of samples collected between this period
Count[1]- is the total number of samples collected monthly less the 'not analysed' data
Gab - Gaborone Dam

c) Chloride

Many of the most common diseases found in traumatized communities after a disaster or emergency are related to drinking contaminated water. The contamination can be from micro-organisms, natural or man made chemicals.

People who live in the same place all their lives and regularly drink contaminated water may develop some resistance to the contaminants and suffer little or no health problems. Communities affected by an emergency, however, are very different. Emergencies have three relevant effects on people:

- force people to move to new places where water quality is different from what they usually drink and for which they have no immunity;
- force people to live in poor conditions such as tents or temporary buildings which make it difficult to retain good hygiene practices; and
- Affect their diet, often lowering their nutritional level and making them more vulnerable to disease.

Table 8.5 Chloride Content for the five Distribution Points against BOS 32: 2000 Standards as at April 2001 to August 2006

Chloride Statistic and BOS 32:2000	Treated Water Distributed				
	Gab	Bokaa	Shashe	Nnywane	Letsibogo
Average	5.65	7.26	1.69	3.15	3.80
Average[1]	6.44	7.70	2.08	3.71	4.38
Count	65	53	53	53	53
Count[1]	57	50	43	45	46
Max	12.90	17.80	4.24	5.77	18.12
Class 1 (Ideal) mg/l	100	100	100	100	100
Class 2 (Acceptable) mg/l	200	200	200	200	200
Class 3 (Max. allowable) mg/l	600	600	600	600	600

Average - is calculated for the whole data, taking 'the not analysed' data into the total count
Average[1] - it is calculated by summing the available data and dividing by the count
Count - is the total number of samples collected between this period
Count[1]- is the total number of samples collected monthly less the 'not analysed' data
Gab - Gaborone Dam

d) Fluoride Concentration in mg/l

Fluoride is a chemical, which occurs naturally in most water supplies in concentrations ranging from 0.1 ppm to 10 ppm. The chemical originates in several minerals.

As groundwater passes through the earth and is exposed to these minerals, fluoride is dissolved and enters the water. The deeper the water flows through the earth, the more fluoride-containing minerals it will come in contact with, and the greater the fluoride concentration the water will be.

Purpose of Fluoridation

Fluoridation is the process of adjusting the concentration of fluoride in public water supplies for the prevention of dental decay. Fluoride in water has been proven to prevent tooth decay among children and to prevent root tip rot. The chemical acts by strengthening the tooth enamel and by making the enamel more resistant to decay. This is a long-term process, with results usually being noticeable only after about 4 to 6 years.

Water from Bokaa dam has more fluoride content compared to the rest of the dams (See Table 8.6).

Table 8.6 Fluoride Content for the five dams against BOS 32: 2000 Standards as at April 2001 to August 2006

Fluoride Statistic and BOS 32:2000	Treated Water Distributed				
	Gab	**Bokaa**	**Shashe**	**Nnywane**	**Letsibogo**
Average	0.47	1.21	0.20	0.50	0.17
Average[1]	0.54	1.28	0.25	0.58	0.19
Count	65	53	53	53	53
Count[1]	57	50	44	46	46
Max	0.98	2.59	2.48	0.97	0.45
Class 1 (Ideal) mg/l	0.7	0.7	0.7	0.7	0.7
Class 2 (Acceptable) mg/l	1	1	1	1	1
Class 3 (Max. allowable) mg/l	1.5	1.5	1.5	1.5	1.5

Source: Water Utilities Corporation

Average - is calculated for the whole data, taking 'the not analysed' data into the total count
Average[1] - it is calculated by summing the available data and dividing by the count
Count - is the total number of samples collected between this period
Count[1]- is the total number of samples collected monthly less the 'not analysed' data
Gab - Gaborone Dam

e) Potassium Concentration in mg/l for the different Dams

The mineral potassium is of critical importance to human health. It plays a major role in how well the body functions. Athletes drink special beverages to replenish the potassium lost in perspiration. Individuals who take certain heart and blood pressure drugs that cause potassium loss are advised to take potassium supplements to assure that they have adequate potassium in their bodies. (BOS 32: 2000)

On average Gaborone and Bokaa dams have the highest potassium content compared to the rest of the dams (See Table 8.7).

Table 8.7 Potassium Content for the five dams against BOS 32: 2000 Standards as at April 2001 to August 2006

Potassium Statistic and BOS 32:2000	Treated Water Distributed				
	Gab	Bokaa	Shashe	Nnywane	Letsibogo
Average	6.00	6.29	3.53	2.51	5.13
Average[1]	6.72	6.66	4.45	4.16	7.15
Count	65	53	53	53	53
Count[1]	58	50	42	32	38
Max	11.20	13.90	11.80	16.20	17.90
Class 1 (Ideal) mg/l	25	25	25	25	25
Class 2 (Acceptable) mg/l	50	50	50	50	50
Class 3 (Max. allowable) mg/l	100	100	100	100	100

Average - is calculated for the whole data, taking 'the not analysed' data into the total count
Average[1] - it is calculated by summing the available data and dividing by the count
Count - is the total number of samples collected between this period
Count[1] - is the total number of samples collected monthly less the 'not analysed' data
Gab- Gaborone Dam

f) Sodium

When sodium levels increase, in high purity or ultra pure waters, it indicates the presence of unwanted dissolved impurities. In power plants, these impurities can have catastrophic effects when deposits occur on turbine blades or on the heat exchange surfaces of the boiler. All the dams have the right amounts of sodium in their waters; this is shown in Table 8.8.

Table 8.8 Sodium Content for the five Distribution Points against BOS 32: 2000 Standards as at April 2001 to August 2006

Sodium Statistic value at 25°C and BOS 32:2000	Treated Water Distributed				
	Gab	**Bokaa**	**Shashe**	**Nnywane**	**Letsibogo**
Average	8.44	9.73	4.19	12.59	5.48
Average[1]	10.76	11.82	5.29	14.19	6.76
Count	65	51	53	53	53
Count[1]	51	42	42	47	43
Max	18.81	23.30	26.50	20.40	30.10
Class 1 (Ideal) mg/l	100	100	100	100	100
Class 2 (Acceptable) mg/l	200	200	200	200	200
Class 3 (Max. allowable) mg/l	400	400	400	400	400

Average - is calculated for the whole data, taking 'the not analysed' data into the total count
Average[1] - it is calculated by summing the available data and dividing by the count
Count - is the total number of samples collected between this period
Count[1]- is the total number of samples collected monthly less the 'not analysed' data
Gab- Gaborone Dam

8.3 Testing Portable and Raw Water

a) Microbiology and chemical contents tests

Drinking water is routinely tested for the presence of indicator organisms, Total coliforms, E. coli, streptococci and chemical contents as follows;

i) The tests for both microbiology and chemical contents are done once every week for small towns that is Sowa, Lobatse, and Jwaneng and twice a week for bigger towns and cities namely Gaborone, Francistown and Selibi-Phikwe. Testing is also done daily at the plants.

ii) On average the corporation tests about 3500 to 4000 microbiological and chemical samples from its distribution network and another 1500 to 2000 from the plants annually, which translates to between 6 to 11 times the minimum requirement of the BOS 32: 2000 (National Drinking Water Standard).

iii) Results of indicator organisms, total coli forms, E. coli and streptococci for 2007/2008 are shown in Tables 8.9 - Table 8.14. The chemical tests are shown in Table 8.15

Microbiology Results for Water Supplied by WUC

Table 8.9 Gaborone Microbiology Total Analyses

Determinants	Units	Total Analyses	BOS 32:2000 95% Min Allowable Compliance	Number of Analysis indicating Compliance with 95% min	BOS 32:2000 4% Max Allowable Compliance	Non Compliance with 4% Max Allowance Compliance	BOS 32:2000 1% Max Allowable Compliance	Non Compliance with 1% Max Allowable Compliance
Total Coliform	**count/100ml**	1602	not detected	1528 (95.4%)	10	45 (2.8%)	100	27 (1.7%)
Faecal Coliform	**count/100ml**	1602	not detected	1580(99.3%)	1	6 (0.37%)	10	6 (0.37%)
Faecal Streptococci	**count/100ml**	1602	not detected	1600 (99.9%)	10	0	100	2 (0.1%)

Table 8.10 Francistown Microbilogy Total Analyses

Determinants	Units	Total Analyses	BOS 32:2000 95% Min Allowable Compliance	Number of Analysis indicating Compliance with 95% min	BOS 32:2000 4% Max Allowable Compliance	Non Compliance with 4% Max Allowance Compliance	BOS 32:2000 1% Max Allowable Compliance	Non Compliance with 1% Max Allowable Compliance
Total Coliform	**count/100ml**	1191	not detected	1191 (100%)	10	0	100	0
Faecal Coliform	**count/100ml**	1191	not detected	1191 (100%)	1	0	10	0
Faecal Streptococci	**count/100ml**	1078	not detected	1078 (100%)	10	0	100	0

Table 8.11 Selibe-Phikwe Microbiology Total Analyses

Determinants	Units	Total Analyses	BOS 32:2000 95% Min Allowable Compliance	Number of Analysis indicating Compliance with 95% min	BOS 32:2000 4% Max Allowable Compliance	Non Compliance with 4% Max Allowance Compliance	BOS 32:2000 1% Max Allowable Compliance	Non Compliance with 1% Max Allowable Compliance
Total Coliform	**count/100ml**	1331	not detected	1317(98.9%)	10	12(1.0%)	100	2(0.15%)
Faecal Coliform	**count/100ml**	1331	not detected	1327(99.7%)	1	3(0.2%)	10	1(0.1%)
Faecal Streptococci	**count/100ml**	444	not detected	444(100%)	10	0	100	0

Table 8.12 Lobatse Microbiology Total Analyses

Determinants	Units	Total Analyses	BOS 32:2000 95% Min Allowable Compliance	Number of Analysis indicating Compliance with 95% min	BOS 32:2000 4% Max Allowable Compliance	Non Compliance with 4% Max Allowance Compliance	BOS 32:2000 1% Max Allowable Compliance	Non Compliance with 1% Max Allowable Compliance
Total Coliform	**count/100ml**	600	not detected	594 (99%)	10	6 (1.0%)	100	0
Faecal Coliform	**count/100ml**	600	not detected	600 (100%)	1	0	10	0
Faecal Streptococci	**count/100ml**	600	not detected	600 (100%)	10	0	100	0

Table 8.13 Jwaneng Microbiology Total Analyses

Determinants	Units	Total Analyses	BOS 32:2000 95% Min Allowable Compliance	Number of Analysis indicating Compliance with 95% min	BOS 32:2000 4% Max Allowable Compliance	Non Compliance with 4% Max Allowance Compliance	BOS 32:2000 1% Max Allowable Compliance	Non Compliance with 1% Max Allowable Compliance
Total Coliform	**count/100ml**	468	not detected	464 (99.1%)	10	3 (0.6%)	100	1 (0.2%)
Faecal Coliform	**count/100ml**	468	not detected	467 (99.8%)	1	1 (0.2%)	10	0
Faecal Streptococci	**count/100ml**	468	not detected	468 (100%)	10	0	100	0

Table 8.14 Sowa Microbiology Total Analyses

Determinants	Units	Total Analyses	BOS 32:2000 95% Min Allowable Compliance	Number of Analysis indicating Compliance with 95% min	BOS 32:2000 4% Max Allowable Compliance	Non Compliance with 4% Max Allowance Compliance	BOS 32:2000 1% Max Allowable Compliance	Non Compliance with 1% Max Allowable Compliance
Total Coliform	count/100ml	138	not detected	138(100%)	10	0	100	0
Faecal Coliform	count/100ml	138	not detected	138(100%)	1	0	10	0
Faecal Streptococci	count/100ml	129	not detected	129(100%)	10	0	100	0

Table 8.15 Chemical Tests Results for Francistown and Gaborone

Chemical	Francistown			Gaborone		
	Average	Minimum	Maximum	Average	Minimum	Maximum
Alkalinity as CaCO3, mg/L	75.42	53.52	102.67	120.53	88.37	156.77
Bromide Br mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Calcium Ca, mg/L	21.46	13.30	25.90	20.31	10.40	41.93
Calcium Hardness as CaCO3, mg/L	42.49	34.19	52.25	42.57	9.22	61.00
Chloride, Cl mg/L	4.01	3.37	4.72	7.50	4.16	10.93
Conductivity uS/cm	134.37	119.83	145.19	211.34	134.83	281.50
Fluoride, F mg/L	0.13	<0.05	0.13	0.54	0.16	1.03
Iron Fe, mg/L	0.07	<0.05	0.07	0.27	0.06	0.49
Magnesium Mg, mg/L	4.53	2.70	5.85	8.46	4.28	19.40
Manganese Mn, mg/L	0.15	<0.02	0.15	0.01	0.00	0.03
Nitrate NO3, mg/L	0.29	<0.1	0.57	0.43	0.17	0.65
Nitrite NO2 mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
pH	7.68	7.49	7.82	7.71	7.26	8.06
Phosphate PO4, mg/L	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Potassium K, mg/L	3.88	1.25	6.83	4.96	0.68	9.80
Sodium Na, mg/L	4.63	2.15	6.77	10.34	5.22	16.51
Sulphate SO4, mg/L	0.48	<0.1	1.14	3.79	1.96	6.41
TDS	87.34	77.89	94.37	137.37	87.64	182.98
Temperature,Celcius,	22.65	15.70	27.32	21.30	3.20	27.20
Total Hardness as CaCO3, mg/L	62.36	43.77	78.28	86.25	63.08	122.72
Turbidity NTU	0.30	0.24	0.43	0.44	0.09	0.90

Table 8.15 Chemical Tests Results for Lobatse and Selibe-Phikwe (Continued)

Chemical	Lobatse			Selibe Phikwe		
	Average	Minimum	Maximum	Average	Minimum	Maximum
Alkalinity as CaCO3, mg/L	135.79	71.05	246.73	84.33	74.78	98.38
Bromide Br mg/L	0.12	<0.05	0.12	<0.05	<0.05	<0.05
Calcium Ca, mg/L	20.62	16.20	23.20	22.37	16.83	24.90
Calcium Hardness as CaCO3, mg/L	37.39	31.36	44.08	39.02	29.84	45.36
Chloride, Cl mg/L	7.04	6.19	8.14	3.65	2.42	4.18
Conductivity uS/cm	246.61	218.00	290.00	131.21	128.10	135.67
Fluoride, F mg/L	0.47	0.39	0.82	0.19	0.14	0.23
Iron Fe, mg/L	<0.05	<0.05	<0.05	0.07	<0.05	0.07
Magnesium Mg, mg/L	11.81	5.80	18.80	5.74	4.27	6.35
Manganese Mn, mg/L	0.09	<0.02	0.09	0.45	<0.1	0.86
Nitrate NO3, mg/L	<0.1	<0.1	<0.1	0.15	<0.1	0.15
Nitrite NO2 mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
pH	7.82	7.15	8.18	7.58	7.30	7.84
Phosphate PO4, mg/L	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Potassium K, mg/L	4.79	3.20	8.40	9.67	6.13	13.33
Sodium Na, mg/L	13.80	11.20	19.20	6.07	4.13	8.47
Sulphate SO4, mg/L	3.95	3.33	6.31	1.61	0.75	3.18
TDS	163.79	141.70	188.50	85.29	83.27	88.18
Temperature,Celcius,	21.42	14.00	26.00	26.29	18.00	32.03
Total Hardness as CaCO3, mg/L	77.73	66.03	108.39	63.33	56.72	72.07
Turbidity NTU	0.60	0.23	1.15	0.47	0.26	0.67

Table 8.15 Chemical Tests Results for Sowa and Jwaneng (Continued)

Chemical	Sowa			Jwaneng		
	Average	Minimum	Maximum	Average	Minimum	Maximum
Alkalinity as CaCO3, mg/L	404.75	356.00	480.44	386.29	222.25	483.92
Bromide Br mg/L	1.10	1.10	1.10	<0.05	<0.05	<0.05
Calcium Ca, mg/L	41.55	25.00	79.00	125.57	47.40	202.60
Calcium Hardness as CaCO3, mg/L	87.27	57.00	160.00	185.96	64.50	240.00
Chloride, Cl mg/L	192.51	176.75	211.67	80.91	0.00	110.25
Conductivity uS/cm	1423.28	1293.00	1485.00	972.85	925.00	1072.00
Fluoride, F mg/L	0.60	0.51	0.77	0.32	0.27	0.39
Iron Fe, mg/L	0.05	<0.05	0.05	<0.05	<0.05	<0.05
Magnesium Mg, mg/L	40.20	12.90	78.00	51.02	25.25	64.05
Manganese Mn, mg/L	0.12	<0.02	0.27	0.04	<0.02	0.05
Nitrate NO3, mg/L	<0.1	<0.1	<0.1	10.88	4.30	71.40
Nitrite NO2 mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
pH	7.69	7.21	7.98	7.26	7.06	7.85
Phosphate PO4, mg/L	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Potassium K, mg/L	5.50	4.60	9.00	6.08	3.00	11.60
Sodium Na, mg/L	216.18	186.00	240.00	46.02	6.05	72.50
Sulphate SO4, mg/L	78.47	44.50	96.00	9.23	5.95	10.60
TDS	925.13	840.45	965.25	632.35	601.25	696.80
Temperature,Celcius,	23.55	19.30	26.30	23.31	18.15	27.10
Total Hardness as CaCO3, mg/L	286.38	176.00	621.00	323.77	217.00	360.50
Turbidity NTU	0.31	0.21	0.52	0.35	0.19	1.03

Source: Water Utilities Corporation- Water Quality

Table 8.16 Water quality for Major villages by different parameters

Parameter	**BOS Standard limit (Class II))**	**Monitored Values**															
		Tonota	Serowe	Mahalapye	Maun	Molepolole	Mogoditshane	Palapye	Mochudi	Kanye	Ramotswa	Tlokweng	Ghanzi	Moshupa	Thamaga	Letlhakane	Tsabong
Physical Properties		Manyanda Wellfield	Mokwena, Makolojane & Setekwane	Palla road													
Turbidity	5 NTU	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV
Color	20 TCU	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV
Chemical properties																	
Chlorine residual	0.6-1.0 mg/l	0.58	NV	0.29	NV	0.6	NV	0.71	0.03	0.5	0.19	NV	NV	0.07	0.45	NV	NV
Ph	5.5-9.5	7.74	7.54	7.59	7.15	7.25	7	6.52	7.26	8.31	7.28	6.87	6.99	8.2	6.85	7.07	7.06
Total Hardness	200 mg/l	143.82	317.92	185	140.54	346.38	80.18	268.87	74.41	497.67	81.48	75.25	368.27	325.65	123.09	968.4	152.19
TDS	1000 mg/l	218	518	506	418	454	124	350	140	797	136	114	504	312	70	1668	3648
Sulphate	250 mg/l	7.35	58.76	11.4	27.97	13.46	9.46	18.69	2.67	36.18	3.98	4.02	77.87	5.22	0	091.96	465.99
Chloride	200 mg/l	23.07	41.56	158.42	4.98	58.25	7.17	91.7	9.15	154.2	7.86	7.63	54.91	8.62	12.43	0280.06	1631.8
Calcium	150 mg/l	40.5	75.2	40.85	47.79	113.03	17.35	56.94	20.46	123.5	20.1	17.02	105.65	66.64	47.85	240.1	32.11
Phosphorus	NV	0	0	0	0	0	0	2.13	0	0	0	0	0	0	0	0	0
Nitrite	3.0mg/l	0	0	0	0.36	0	0	0	0	0	0	0	0	0	0	0	0
Sodium	200 mg/l	15.2	0	85.95	135.55	25.87	9.64	40.4	9.75	97.7	10.24	10.5	106.65	9.92	1.42	248.7	776.6
Magnesium	70 mg/l	10.4	82.9	20.2	5.29	16.13	9.21	38.01	6.42	95.4	8.12	8.54	25.45	38.75	0	89.8	24.5
Iron	300ug/l	1.35	0.22	2.05	8.92	0.1	0.023	11.72	1.182	4.279	0.397	0.489	0	0.209	0	0.625	2.625
Manganese	100ug/lNV	0.643	0.02	0.203	0.296	0	0	2.128	0.118	0.324	0	0	0	0	0	0.155	0.11
Ammonium	200ug/l	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV
Aluminium	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV
Copper	200ug/l	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV
Zinc	1000ug/l	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV

Source: Department of Water Affairs

Table 8.16 Water quality for Major villages continued

Parameter	BOS Standard limit (Class II))	Monitored Values															
		Tonota	Serowe	Mahalapye	Maun	Molepolole	Mogoditshane	Palapye	Mochudi	Kanye	Ramotswa	Tlokweng	Ghanzi	Moshupa	Thamaga	Letlhakane	Tsabong
Physical Properties		Manyanda Wellfield	Mokwena, Makolojane & Setekwane	Palla road													
Toxic substances																	
Nitrate	45mg/l	3.15	47.81	13.08	6.75	3.05	14.2	5.94	3.11	26.65	13.06	4.86	20.76	6.27		141.79	58.16
Flouride	1.0mg/l	0.1	0	0.14	0.22	0	0.43	0.27	0.74	0.32	0.36	0.36	0.55	0		1.29	0.72
Lesd	10mg/l	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV
Cadmium	3.0ug/l	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV
Cyanide	70ug/l	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV
Microbiological variables																	
Faecal coliforms/100ml	1counts/100ml	0		20		0	0	6	0	0	0	0	0	0	0	0	30
Total coliforms/100ml	10counts/100m	0		20		0	0	6	0	0	0	0	0	0	0	0	30
Total organic carbon	8000ug/l	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV
Poly aromatic hydrocarbons	100ug/l	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV

Source: Department of Water Affairs

Table 8.17 Typical analysis of both brackish and potable water

	Brackish water	Portable water
pH	7.6	7.6
Total hardness, as $CaCO_3$, ppm	440	400
Ca hardness, ppm	340	310
Conductivity (µS/cm)	3080	2060
Total dissolved solids, ppm	2100	1350
Suspended solids, ppm	60	-
M. alkalinity, as $CaCO_3$, ppm	603	472
Sodium, as Na ppm	508	285
Chloride, as Cl^- ppm	563	349
Sulphates,as SO_4^{2-}ppm	80	-
Fluoride, as F	10	-
Silica, as SIO_2 ppm	71	80

Source: Botash mine

Table 8.17 shows water quality for brackish and portable water at Botash mine. Brackish water is used for industrial purposes and not as a drinking water. The quality of the water falls within Class III as defined by the BOS 32:2000 Drinking Water Quality specification (Botswana Bureau of Standards).

Table 8.18 Morupule Chemical Analysis carried out on 10/09/08

Test	Mine Garage Portable Water	Pipeline Manifold Water	CM Spray Water	CM Dam Water	BOS 32:2000 Maximum allowable
Nitrate mg/l	6	0.00	0.70	0.32	**45**
Fluoride mg/l	0.14	5.5	5.6	4.9	**1.5**
Magnesium mg/l	8	24	22	22	**100**
Calcium mg/l	14	14	22	12	**200**
Chloride mg/l	23.5	40.0	36.0	32.0	**600**
Potassium mg/l	3.3	4.8	4.5	4.5	**100**
Hardness mg/l	65	135	145	140	**500**
Total Alkalinity $CaCO_3$ mg/l	45	530	>530	>530	**500****
HCO_3 mg/l	55	640	>530	>530	..
CO_3 mg/l	25	320	>530	>530	..
Sulphate mg/l	7	195	160	170	**400**
Sodium mg/l	20.2	683.5	665.5	615.2	**400**
Conductivity µS/cm	247	2 590	2 600	2540	**3100**
TDS mg/l	124	1 300	1 290	983	**2000**
pH	7.03	8.11	8.33	8.39	**5.0 – 10.0**

***Canadian drinking water quality standard*

Table 8.19 Water Quality for Portable Water at Tati-Nickel Mine by Month (2008)

Month	Cond. (uS/cm)	pH	Turbidity	Free Chlorine (Mg/l)	Total Chlorine (Mg/l)	Combined Chlorine (Mg/l)	Alkalinity
Jan	220.50	7.26	111.38	0.12	0.25	0.13	18.21
Feb	151.99	7.13	118.98	0.28	0.31	0.26	19.89
Mar	149.69	7.27	107.63	0.22	0.34	0.29	19.46
Apr	146.62	7.36	105.17	0.14	0.26	0.15	17.71
May	884.82	7.36	75.93	0.25	0.34	0.19	34.46
Jun	135.34	7.41	63.60	0.21	0.38	0.23	21.25
Jul	145.40	7.58	24.57	0.21	0.39	0.17	21.07
Aug	164.77	7.65	31.73	0.18	0.31	0.12	19.00
Sep	164.81	7.57	24.52	0.25	0.40	0.15	21.98
Oct	159.56	7.68	28.88	0.24	0.37	0.12	24.22
Nov	186.34	7.58	14.13	0.24	0.39	0.15	24.62
Dec	156.37	7.55	22.61	0.23	0.41	0.28	23.18

Source: Tati-Nickel Mine

Table 8.19 shows water quality results from Tati-Nickel Mine during the year 2008. According to BOS 32: 2000 standards, the portable water at the mine met the required standards during that year.

9.0 Pressure on Water Resources

This chapter presents the effects of the human activities on water resources, including water use by man. The impact is in the form of changes both in quality and quantity of water. Water quality is indicated by concentration of chemical, biological and other pollutants in the water. The quantity aspects can include shortage of water in space and time or over supply in times of floods.

The growing pressure on water resources is a result of the increases in population, rapid urbanization and development. With more people moving into the cities and major settlements, the demand on water resources has increased, presenting a serious problem to the country which is drought prone. In response to this problem, the Government has come up with the National Water Master Plan which contains measures aimed at conserving the country's water resources.

According to State of Environmental Report (2002) over-exploitation, pollution and aquatic weeds are the main threats to water resources. The sources of pollution are industrial and domestic effluent from settlements, human waste from pit latrines and waste disposal on the dam catchment areas and shallow aquifers. Exotic aquatic weeds are also reported to be a threat to water resources and aquatic ecosystems through excessive evapo-transpiration and reduction in the quality because they cover the water body thus preventing the circulation of air and light.

Sometimes human beings alter the natural hydrological systems to get more benefits from water and in turn these changes lead to waterborne diseases, pressures on the ecosystems, soil erosion, water logging and loss of habitats and biodiversity.

Water can be used for different activities such as transport, habitats for fish, dilution of waste and recreation for humans. In Botswana water is mainly used for human consumption, commercial, industry and institutional purposes although it varies per sector. South-eastern Botswana is experiencing rapid urbanization thereby increasing urban water usage. Water sources are primarily surface water in the north, the Okavango and Chobe regions; underground water in the west, and both surface and groundwater in the south.

The government has been committed to the protection of the environment and the concept of sustainable development which ensures that:

(i) the present generation consumes a certain amount of water in a year or yield of the natural resources which are renewable;
(ii) the future generation meets its own needs from the said resources without being compromised.

In 2004 Water Utilities Cooperation and Department of Water Affairs came up with initiatives which addressed issues that affected water resources. These included penalties and an increase in water charges, an effort meant to discourage the population from wasting water.

The government of Botswana has introduced two main legal instruments as interventionist strategies to address the water resources issues, which are **Water Act** and **Waterworks Act** and other legislation which are related to water resources such as Aquatic Weeds Control Act Cap 34:04, and Public Health Act Cap 63:01.

10.0 Waste Water Planning and Management

Wastewater planning and management started in the 1990s. It is institutionally separated from fresh water management, making it more difficult to integrate water and wastewater management. Several institutions are involved in wastewater and sanitation services, including Department of Waste Management and Pollution Control (DWMPC), Local Authorities (Districts and Town councils), Department of Water Affairs (DWA) and the private sector. The roles of different stakeholders are summarized in Table 10.1

The DWMPC coordinates and monitors sanitation and waste management and promote effective and efficient implementation of sanitation and waste projects. Local Authorities take care of offsite wastewater systems and service on-site sanitation. The private sector is involved mostly with the provision of wastewater/sanitation services such as collection. The DWA monitors the discharge of wastewater and compliance with the set standards.

Table 10.1 Institutional responsibilities of wastewater and sanitation

Institution	Responsibilities
DWMPC	The department is responsible for the management of wastewater resources. It is responsible for the following in particular: • Policy administration and implementation; • Implementation and monitoring of NMPWWS; • Monitoring of the wastewater and sanitation sector performance; • Coordination at central and local government levels; and • Support of sector development, particularly capacity building of local authorities
Local authorities/ Councils	The local authorities govern the wastewater produced in an area, in terms of quality and quantity. In so doing, prevention of environmental pollution is improved. Local authorities perform the following duties: • Operation and maintenance of off-site wastewater systems; • Deal with new water connections and sanitation; • Service on-site sanitation (only as contractor) managing trade effluent discharge matters including enforcement; and • Executing the planning of wastewater and sanitation at local level.
DWA	The DWA is responsible for the issue of discharge permits. These permits show the holder different qualities of wastewater for different applications. The department also monitors the performance in relation to discharge and enforcement to counter compliance.
Private sector	The private sector is responsible for the provision of consulting services, construction of facilities and provision of wastewater/sanitation services like fleet management, billing and collection.

10.1 Policy towards wastewater

In response to perceived health and environmental risks, the Botswana Policy for Wastewater/Sanitation Management was developed to promote people's health and well-being through appropriate and sustainable wastewater/sanitation management and through mechanisms for the protection and conservation of water resources. The specific policy objectives are to (Government of Botswana 1999):

1. Create an enabling environment through institutional and organizational rationalization and development of an appropriate legislative framework;
2. Involve local authorities, communities and users in the planning and management of wastewater/sanitation to ensure sustainability;
3. Introduce pricing and cost-recovery principles and guidelines, and design effective and sustainable operation and maintenance systems;
4. Develop national effluent discharge quality standards; and
5. Encourage re-use and recycling of wastewater.

The policy emphasizes the role of economic incentives to manage wastewater, including: charges for wastewater/sanitation services, fines for non-compliance, linking effluent charges with water tariffs, and effluent agreements with companies. The policy advocated for the establishment of national effluent utilization quality standards, and refers to the 2005 EIA- legislation as an additional instrument.

The 1991 Botswana National Water Master Plan (BNWMP) and the 1999 Wastewater Policy provided the incentive to prepare the 2003 National Master Plan for Wastewater and sanitation (NMPWWS). The NMPWWS operates as the long-term strategy for wastewater treatment, re-use and recycling strategy. Its overall objective is to 'evaluate the current scenario on wastewater generation and disposal, on-site facilities and their impact on the environment , and to develop planning and implementation strategies for regulating the generation, collection and disposal of wastewater in an environmentally friendly way and acceptable manner'(SMEC et al, 2003, p.3).

11.0 Wetlands in Botswana

Wetlands in Botswana are associated with geomorphic units such as ephemeral rivers, topographic depressions such as pans and the alluvial fan derived delta - the Okavango Delta. The hydrology of these wetlands is controlled largely by the flow regime of the rivers. Associated with these wetlands is a wide variety of flora and fauna.

From analyses of TM Satellite imagery, it is estimated that there are about 25,000 km^2 of potential wetland area in Botswana. This is approximately 4 percent of the total land area of the country. While this may seem an insignificant proportion of the total land area of the country, it is extremely important to consider the aridity of the country as a whole. The country is divided into 4 districts: south-east, south-west, north-east and north-west. Of the total potential wetland area, 12 percent is in the south-west, 17.5 percent in the south-east, 24.2 percent in the north-east and 46 percent in north-west. On a regional basis potential wetlands constitute about 1.5 percent of the total land area of the south-west region, 3.8 percent of the south-east, 6.8 percent of the north-east and 8.5 percent of the north-west. This concurs well with the general distribution of rainfall in the country but also emphasises the significance of the Okavango Delta in the north-west. (Masundire, et al, 1998)

Wetlands occur in all districts of the country, although there is a degree of differentiation largely determined by the dominant geological and hydrological processes in the district. Wetlands in Botswana can be classified using a modified classification scheme derived from the scheme proposed by Dugan (1990). The attributes, values and uses of each wetland vary from wetland to wetland and from district to district. Wetlands, often described as being of national or international importance, tend to overshadow the local significance of wetlands to the districts in which they occur.

Wetlands in Botswana provide a variety of goods and services including water supply, fisheries, transport, timber and non-timber resources, tourism and recreation as well as ecosystem maintenance. Not all the wetlands offer the same goods and services nor do they do so to the same or similar extents.
There are threats facing many wetlands that arise mainly from competing demands on wetland resources. Such threats include over-exploitation and misuse of the resources offered by wetlands. The extent of each threat varies from district to district and is greatly influenced by the dominant land-use activities as well as on the level of direct dependence on natural resources. (Masundire, et al, 1998)

Table 11.1 Wetlands Coverage by District

District	Wetlands covered per district (%)	Total land area covered by wetlands (%)
South-east	17.5	3.8
South-west	12.0	1.5
North-east	24.2	6.8
North-west	46.3	8.5

Source: Inventory of wetlands in Botswana

The country comprises parts of four major (regional) catchments; the Limpopo basin (20 percent) along the eastern fringe, the Orange basin (20 percent) along the southern fringe, the Okavango-Makgadikgadi basin (60 percent) in the north-centre. Along with the regional catchments, water from rainfall causes a number of ephemeral streams to flow in the hardveld and stands intermittently in fossil valleys and pans in the sandveld. Rainwater also periodically collects in a variety of different depressions throughout the country. (Masundire, et al, 1998)

Low rainfall combined with flat topography and deep sandy soils result in low rates of surface run-off and low rates of groundwater recharge especially in the sandveld. Streamflow, more common in the hardveld, is not continuous even during the wet season with ephemeral hardveld streams only flowing for 10-75 days per year on average. There is no surface run-off in the sandveld, and groundwater is channelled into a series of fossil valleys and pans. The estimated mean annual run-off from Botswana rivers is given in Table 11.2. (Government of Botswana 1991)

The Okavango river enters Botswana through Angola. It has a mean discharge of about 320 000 m^3/s but is largely dissipated in the Okavango Delta, an area of about 11 000 km^2 of permanent and seasonal swamps. The outflow from the delta is only about 14 m^3/s or 4 percent of the inflow. Most of the loss is by evaporation.
The Zambezi has a large flow (41 000 $x10^6$ m^3 at Victoria Falls) but only about 20 km of this flow through Botswana. The Kwando-Linyanti-Chobe River drains into the Zambezi at Kasane. It has an estimated runoff of 1 310 $x10^6$ m^3.
Limpopo River at the junction with the Shashe has an estimated runoff of 620 x 10^6 m^3. A few large dams exist, notably the Gaborone Dam (capacity 144 x 10^6 m^3), the Mopipi dam (90 x 10^6 m^3, now mainly dry), the Shashe Dam (85 x 10^6 m^3), Bokaa Dam (35 x 10^6 m^3) and the recently completed Letsibogo Dam (100 x 10^6 m^3). According to NDP7 only 17% runoff in eastern Botwana is stored in dams. (Masundire, et al, 1998)

Table 11.2 Estimated Mean Annual Run-offs for Internal Botswana Rivers (Government of Botswana, 1991).

River Basin	Area (km^2)	Est. Mean Annual Runoff
		10^6 m^3*
A. Limpopo drainage		
Shashe	11,430	270
Motloutse	18,319	125
Lotsane	15,790	70
Mahalapye	5,740	40
Bonwapitse	11,000	15
Notwane	17,620	85
B. Makgadigkadi Pans drainage		
Mosope and Mosetse	9 500	55
Nata**	6 500	45
C. Orange drainage		
Molopo	71 000	No enough data
D.Total for Botswana	582,000	705

* Figures rounded to the nearest 10^6 m^3
** Botswana section of the catchment only.
Source: Government of Botswana, 1991

***Surface runoff** is the water flow which occurs when soil is infiltrated to full capacity and excess water, from rain, snowmelt, or other sources flows over the land.*

The mean annual runoff for Shashe is estimated at 270 Mm^3 and this normally happens during rainy season. The table above shows Bonwapitse as having the least water flow as it is a small river and normally dry most of the season. There was no data for Molopo as the river is mainly on the South African side of the border. (See Table 11.2)

12.0 LEGISLATION

According to the 1968 Water Act, the State owns all water resources. The state has delegated water user and development rights to various stakeholders:

- ***The Water Utilities Corporation*** **(WUC)** has the duty to provide safe drinking water to urban areas in so-called water works areas. WUC has monopoly in these areas; others are, for example, not allowed to drill boreholes in these areas. Since the late 1990s, WUC has assumed responsibility for the operation of the NSWC, which supplies urban areas and some large villages;

- ***The Department of Water Affairs*** **(DWA)** is charged with the establishment of reticulated water supply systems in rural villages. In addition, it operates and maintains the systems in seventeen large villages. Where these villages are supplied by the NSWC, DWA purchases the water from WUC;

- ***The District Councils*** **(DC)** operate and maintain the water supply systems in all other rural villages, usually through the Water and Sanitation Division;

- ***Self-providers****,* including livestock owners, arable farmers and mining companies that operate outside villages and settlements. Self-providers apply for surface or groundwater rights to the Water Apportionment Board. The WAB grant such rights with an abstraction ceiling and the duty to return as much water as possible of the original quality. Details of boreholes (e.g. yields, depth, water quality etc) are recorded in the National Borehole Registry. Monitoring of abstraction of the self-providers is difficult and in practice inadequate. This is major gap in the country's water management system, as self-providers account for the bulk of the abstraction.

12.1 Waterworks Act, 1962

This Act provides for the establishment of water authorities who are given powers and duties to acquire rights to existing waterworks, and to construct and manage waterworks for supplying water to the public. It is an offence to pollute or cause risks of pollution to such water. According to the Act, waterworks include reservoirs, dams, wells, boreholes, tanks and all other structures for storing, purifying and distributing water.

12.2 Water Act, 1968

The Act defines water use rights, including water servitudes. The Act establishes a regime over public water with widely defined classes of water comprising all surface and ground water. The Act prohibits the privatization of public water and establishes the right of public access to public water for a number of essential purposes. The Act also has some provisions governing the use of water for industrial and other purposes. Every water right granted under the Act carries an implied condition that such water would not be polluted with any matter derived from its use that is likely to cause direct or indirect injury to the public, flora and fauna. The holder of a water right is also obligated to take precautions to prevent accumulations in water courses of waste and other substances that are likely to affect, injuriously the use of such water.

13. 0 INTERNATIONAL AND REGIONAL WATER RELATED INSTRUMENTS TO WHICH BOTSWANA IS A PARTY

13.1 Convention on Wetlands (RAMSAR Convention 1971)

The RAMSAR Convention is concerned with the conservation and sustainable utilization of wetlands, especially as water fowl habitats. Botswana ratified the convention in 1997. It aims at stemming the progressive encroachment on and loss of wetlands now and in the future, recognizing the fundamental ecological functions of wetlands and their economic, cultural, scientific and recreational value. The Okavango River System has been listed as a Ramsar Site.

The Convention does not dictate policy but it serves as a forum for fostering objective discussion on sustainable utilization of the resourced base of a wetland. One of the advantages to Botswana as a party to this convention is the privilege of participating in the global environmental debate on the conservation and wise use of wetlands and the access it has to international research funding and advice from experts on wetland conservation.

13.2 Agreement of the Action Plan for the Environmentally Sound Management of the Common Zambezi River System, (ZACPLAN, 1987)

This is a regional treaty that was ratified by Botswana in 1987. Its objective is to coordinate the efforts of parties in the sound management of the water resources and the environment of the common Zambezi River System. The system is shared with eight other countries and therefore requires multilateral cooperation.

13.3 Permanent Okavango River Basin Commission (OKACOM) Angola, Botswana and Namibia, 1994

This agreement was signed in 1994 to advice the three river basin countries on matters relating to the conservation, development and utilization of the Okavango Water resources. Among other things, the commission will advise on the long term safe yield of the water available from all potential water resources of the Okavango River Basin, and on the equitable allocation and sustainable utilization of Water Resources in the Okavango Delta. This includes pollution and aquatic weeds control within the basin.

13.4 Bilateral Water commission, 1994

This was established by an n agreement between Governments of Botswana and Zimbabwe. The objectives of the commission are to act as a technical advisor to the parties on matters relating to the conservation, development and utilization of the water resources of common interest. The agreement centers on the following River Basins:

- Ramokgwebana and Shashe Rivers
- Nata River
- Zambezi-Chobe River System

13.5 Limpopo River Basin Committees

The water resources of the Limpopo River are shared between Botswana, the Republic of South Africa, Mozambique and Zimbabwe. To ensure both mutual benefit and the sustainable use of these water resources, the four countries have to agree on all plans for the utilization of the Limpopo River. In this regard, two committees have been established:

- The joint Permanent Technical Committee: it was established between the Governments of Botswana and South Africa in 1983. It deals with water rights applications along the upper Limpopo Basin which forms part of the boarder between the two countries.
- The Limpopo Basin Technical Committee: It was established between the four basin countries in 1984.

13.6 SADC Protocol on Shared Watercourse System, 1995

This Protocol was ratified by Botswana and other SADC Heads of States in August 1995. Among other things, the Protocol aims to promote measures for the protection of the environment and the prevention of all forms of environmental degradation that arise from the utilization of the resources of the shared water system. To this end, the Protocol requires member states within a shared watercourse system to exchange available information and data regarding the hydrological, water quality, meteorological and ecological condition of such watercourse system. This Protocol does not derogate existing agreements entered into between two or more Member States or a Member State and a State that is not a Member State concerning the utilization of a shared watercourse system.

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APPENDIX-1: Population and Water Production for the 17 Major Villages

Table 2.2 Total Population for the 17 major villages by Year

VILLAGES	1998	1999	2000	2001*	2002	2003	2004	2005	2006	2007	2008
Kanye	35,515	36,189	36,877	40,628	38,170	38,857	39,557	40,269	41,051	41,790	42,542
Ramotswa	25,458	26,731	27,933	20,680	30,498	32,023	33,624	35,305	37,423	38,546	39,702
Maun	30,287	31,104	31,260	43,776	32,397	33,207	33,373	33,473	34,206	34,753	35,310
Tlokweng	17,920	18,816	19,870	21,133	21,712	22,385	23,079	23,841	24,270	25,046	25,848
Tsabong	4,014	4,114	4,217	6,591	4,440	4,551	4,665	4,781	4,889	4,996	5,106
Moshupa	13,081	13,690	14,005	16,922	14,681	15,019	15,364	15,718	16,076	16,430	16,791
Tonota	11,963	12,203	12,203	15,617	12,618	12,770	12,923	13,078	13,209	13,341	13,475
Ghanzi	7,123	7,330	7,542	9,934	7,995	8,226	8,465	8,710	8,974	9,198	9,428
Mahalapye	31,333	31,865	32,407	39,719	33,563	34,100	34,645	35,200	35,809	36,346	36,892
Palapye	20,261	20,747	21,245	26,293	22,194	22,682	23,181	23,691	24,215	24,699	25,193
Kasane	6,292	6,632	6,990	7,638	7,729	8,123	8,537	8,973	9,437	9,824	10,226
Mochudi	29,422	30,040	30,671	36,962	31,600	31,948	32,299	32,655	33,080	33,675	34,281
Molepolole	44,564	45,811	47,094	54,561	49,701	51,042	52,421	53,836	55,384	56,768	58,187
Serowe	32,549	32,940	33,335	42,334	34,181	34,557	34,937	35,321	35,784	36,142	36,504
Thamaga	15,327	15,695	16,072	18,117	16,884	17,289	17,704	18,129	18,549	18,957	19,374
Letlhakane	11,673	12,175	12,698	14,962	13,756	14,306	14,878	15,473	16,059	16,637	17,236
Mogoditshane	19,994	20,901	21,905	32,843	23,990	25,069	26,198	27,376	28,636	29,810	31,033
Total	**356,776**	**366,983**	**376,324**	**448,710**	**396,109**	**406,154**	**415,850**	**425,829**	**437,051**	**446,958**	**457,128**

Source: Central Statistics Office Population Projections 1991-2021
*NB: *2001 Population and Housing Census figures*

Table 3.5 Water Production in Major Villages (m^3)

VILLAGES	1997/98	1998/99	1999/00	2000/01	2001/02	2002/03	2003/04	2004/05	2005/06	2006/07	2007/08
Kanye	1,528,754	1,479,189	1,657,291	2,187,351	2,381,510	2,568,447	2,662,739	2,904,969	2,762,456	3,317,585	2,919,454
Ramotswa	508,473	1,082,763	1,287,890	1,414,015	1,362,367	1,559,617	1,483,556	1,344,002	1,275,156	1,610,900	1,713,900
Maun	1,146,090	1,186,971	1,218,520	1,157,234	1,610,332	1,295,582	1,188,079	1,435,451	1,682,822	1,697,088	2,135,624
Tlokweng	776,084	1,008,915	1,367,845	1,338,680	1,538,932	1,608,990	1,721,059	1,593,460	1,151,740	1,523,160	1,619,960
Tsabong	162,078	195,740	224,245	289,508	284,748	280,786	320,498	343,266	380,672	348,905	385,051
Moshupa	265,656	281,761	336,063	345,872	386,240	466,551	496,096	539,560	458,793	539,650	523,950
Tonota	576,326	937,566	701,715	779,191	889,464	971,525	867,792	1,001,592	929,608	942,606	995,564
Ghanzi	379,848	379,848	363,381	481,852	496,137	531,681	596,695	601,643	533,126	586,146	602,235
Mahalapye	1,304,354	1,886,845	2,031,558	1,871,462	1,950,003	2,152,691	2,182,230	2,172,161	2,203,623	2,305,873	2,438,675
Palapye	826,412	1,030,555	1,098,006	1,168,767	1,328,934	1,402,109	1,330,101	1,492,069	1,315,525	1,379,232	1,207,100
Kasane	550,483	571,228	604,343	614,750	662,069	619,794	639,725	752,275	862,220	916,840	1,052,257
Mochudi	743,836	1,174,383	1,111,861	1,229,400	1,331,558	1,675,594	1,812,310	1,949,026	1,610,411	1,836,933	1,833,636
Molepolole	1,054,996	1,282,401	1,509,807	1,701,137	1,960,554	2,160,437	2,147,724	2,519,631	2,501,041	2,672,986	1,592,827
Serowe	1,223,478	1,366,472	1,306,311	1,466,165	1,612,092	1,707,837	1,987,130	2,266,422	2,405,806	2,585,802	2,391,128
Thamaga	362,021	421,199	338,551	428,537	428,537	460,789	512,795	486,308	550,968	621,320	750,921
Letlhakane	391,820	425,675	426,999	440,900	490,588	535,453	555,219	594,511	580,188	648,864	668,447
Mogoditshane	2,377,257	2,635,653	2,578,354	2,807,003	2,992,678	2,999,841	3,179,371	3,179,844	3,219,685	3,244,685	3,191,000
Total	**14,177,966**	**17,347,164**	**18,162,740**	**19,721,824**	**21,706,743**	**22,997,724**	**23,683,119**	**25,176,190**	**24,423,840**	**26,778,575**	**26,021,729**

Table 3.6 Water Consumption in Major Villages (m^3)

Villages	1997/98	1998/99	1999/00	2000/01	2001/02	2002/03	2003/04	2004/05	2005/06	2006/07	2007/08
Kanye	1,084,853	1,014,326	1,003,560	1,606,587	1,687,783	1,864,072	1,614,093	1,813,722	1,581,445	1,895,692	1,634,626
Ramotswa	310,883	698,638	759,507	670,336	643,349	750,890	631,636	954,068	942,884	310,883	962,244
Maun	1,019,172	1,029,465	980,972	908,380	1,124,519	970,020	948,483	1,065,138	1,181,793	1,305,158	1,657,445
Tlokweng	508,811	804,757	1,100,702	1,149,080	1,090,678	1,221,293	1,436,306	1,192,356	931,422	1,169,138	1,259,986
Tsabong	139,023	162,377	185,730	221,960	218,687	232,421	250,969	260,821	277,436	249,570	229,061
Moshupa	190,615	229,645	262,766	249,663	277,157	332,407	316,391	319,310	311,505	393,952	345,059
Tonota	479,924	688,949	600,332	638,294	748,189	838,638	768,868	823,000	781,621	843,563	824,438
Ghanzi	321,804	321,804	289,298	396,035	458,043	408,604	432,246	521,676	508,950	526,813	526,148
Mahalapye	1,150,680	1,466,681	1,453,765	1,341,124	1,593,636	1,513,492	1,708,877	1,794,003	1,725,982	1,794,011	1,679,606
Palapye	676,698	894,574	1,006,158	858,149	1,017,968	1,040,322	1,031,515	1,063,193	978,418	1,005,579	984,128
Kasane	451,793	454,075	489,206	495,282	539,933	536,101	551,662	669,824	584,968	604,249	847,675
Mochudi	724,699	863,519	940,230	1,047,943	1,152,689	1,436,692	1,466,006	1,495,320	1,349,522	1,522,301	1,533,575
Molepolole	613,072	863,108	1,113,144	1,127,229	1,072,241	1,471,880	1,566,305	1,638,659	1,827,218	1,904,696	1,866,237
Serowe	1,022,511	978,208	991,800	1,108,774	1,404,451	1,330,606	1,099,942	869,277	1,334,792	1,527,471	1,506,812
Thamaga	282,722	322,622	247,229	290,893	326,915	354,821	354,821	431,791	445,819	579,689	540,063
Letlhakane	353,195	373,277	356,069	401,457	448,154	478,864	523,414	543,393	516,972	565,263	565,263
Mogoditshane	2,069,804	2,105,340	2,493,733	2,599,537	2,605,017	2,609,277	2,795,915	2,702,596	2,662,468	2,590,842	2,590,842
Total	**11,400,259**	**13,271,365**	**14,274,201**	**15,110,723**	**16,409,409**	**17,390,400**	**17,497,449**	**18,158,147**	**17,943,215**	**18,788,870**	**19,553,208**

Table 3.8 Water Losses for the Major Villages (m^3)

Villages	1997/98	1998/99	1999/00	2000/01	2001/02	2002/03	2003/04	2004/05	2005/06	2006/07	2007/08
Kanye	443,901	464,863	653,731	580,764	693,727	704,375	1,048,646	1,091,247	1,181,011	1,421,893	349,373
Ramotswa	197,590	384,125	528,383	743,679	719,018	808,727	851,920	389,934	332,272	721,850	751,656
Maun	126,918	157,506	237,548	248,854	485,813	325,562	239,596	370,313	501,029	391,930	478,179
Tlokweng	267,273	267,208	267,143	189,600	448,254	387,697	284,753	401,104	220,318	354,022	359,974
Tsabong	23,661	33,363	38,515	67,548	66,061	48,365	69,529	82,445	103,236	99,335	155,990
Moshupa	75,041	52,116	73,297	96,209	109,083	134,144	179,705	220,250	147,288	145,698	178,891
Tonota	96,402	248,617	101,383	140,897	141,275	132,887	98,924	178,592	147,987	99,043	171,126
Ghanzi	58,044	58,044	74,083	85,817	38,094	123,083	164,449	79,967	24,176	59,333	76,086
Mahalapye	153,674	420,164	577,793	530,338	364,367	639,199	473,353	378,158	477,641	511,862	759,069
Palapye	149,714	135,981	91,848	310,618	310,966	361,787	298,586	428,876	337,107	373,653	222,972
Kasane	98,690	117,153	115,137	119,468	122,136	83,693	88,063	82,451	277,252	312,591	204,582
Mochudi	19,137	310,864	171,631	181,457	178,869	238,902	346,304	453,706	260,889	314,632	300,061
Molepolole	441,924	419,293	396,663	573,908	888,313	688,557	581,419	880,972	673,823	768,290	726,590
Serowe	200,967	388,264	314,511	357,391	207,641	377,231	887,188	1,397,145	1,071,014	1,058,331	884,316
Thamaga	79,299	98,577	91,322	137,644	101,622	105,968	157,974	54,517	105,149	118,823	210,858
Letlhakane	38,625	52,398	70,930	39,443	42,434	56,589	31,805	51,118	63,216	69,175	103,184
Mogoditshane	307,453	530,313	84,621	207,467	387,661	390,564	383,456	477,248	557,217	552,121	600,158

Source: Department of Water Affairs

Table 3.9 Percentages of Water Losses for Each Major Villages (m^3)

Villages	1997/98	1998/99	1999/00	2000/01	2001/02	2002/03	2003/04	2004/05	2005/06	2006/07	2007/08
Kanye	29.0	31.4	39.5	26.5	29.1	27.4	39.4	37.6	42.8	42.9	12.0
Ramotswa	38.9	35.5	41.0	52.6	52.8	51.9	57.4	29.0	26.1	44.8	43.9
Maun	11.1	13.3	19.5	21.5	30.2	25.1	20.2	25.8	30.0	23.0	22.4
Tlokweng	34.4	26.5	19.5	14.2	29.1	24.1	16.6	25.2	19.1	23.2	22.2
Tsabong	14.5	17.0	17.2	23.3	23.2	17.2	21.7	24.0	27.1	28.5	40.5
Moshupa	28.3	18.5	21.8	27.8	28.2	28.8	36.2	40.8	32.1	27.0	34.1
Tonota	16.7	26.5	14.5	18.1	15.9	13.7	11.4	17.8	15.9	10.5	17.2
Ghanzi	15.3	15.3	20.4	17.8	7.7	23.2	27.6	13.3	4.5	10.1	12.6
Mahalapye	11.8	22.3	28.4	28.3	18.6	29.7	21.7	17.4	21.7	22.2	31.2
Palapye	18.1	13.2	8.4	26.6	23.4	25.8	22.5	28.7	25.6	27.1	18.5
Kasane	17.9	20.5	19.1	19.4	18.5	13.5	13.8	11.0	32.2	34.1	19.4
Mochudi	25.7	26.5	15.4	14.8	13.4	14.3	19.1	23.3	16.2	14.2	16.4
Molepolole	41.8	32.7	26.3	33.7	45.3	31.9	27.1	35.0	26.9	28.7	45.6
Serowe	16.4	28.4	24.1	24.4	12.9	22.1	44.6	61.6	44.5	40.9	37.0
Thamaga	21.9	23.4	27.0	32.1	23.7	23.0	30.8	11.2	19.1	19.1	28.1
Letlhakane	9.8	12.3	16.6	8.9	8.6	10.6	10.2	8.6	10.9	9.7	15.4
Mogoditshane	12.9	20.1	3.2	7.4	6.9	13.0	12.1	15.0	17.3	17.0	18.8

Source: Derived from Table 3.8

Table 3.7 Water Consumption in Major Villages Categorized by Activities (m^3)

Village	Domestic								Institution							
	00/01	01/02	02/03	03/04	04/05	05/06	06/07	07/08	00/01	01/02	02/03	03/04	04/05	05/06	06/07	07/08
Kanye	795,486	854,182	909,496	443,495	741,418	694,611	1,224,953	736,548	72,579	63,154	66,260	77,006	171,946	189,360	156,325	192,529
Ramotswa	139,802	99,441	116,671	171,906	121,437	143,467	567,229	566,351	139,802	99,441	116,671	171,906	121,437	143,467	159,829	163,811
Maun	519,025	640,649	619,813	-	-	405,208	918,737	1,220,282	208,133	308,520	206,349	-	-	67,695	232,337	231,960
Tlokweng	790,366	883,050	970,063	744,292	838,644	715,343	905,089	992,216	92,419	88,648	117,460	123,106	124,837	98,516	112,034	120,926
Tsabomg	118,439	109,923	141,277	113,010	147,237	171,534	157,982	163,943	73,874	49,789	588,783	77,687	92,673	85,891	68,815	40,562
Moshupa	140,149	230,701	255,490	230,861	199,029	218,252	243,823	240,567	69,326	29,373	87,068	60,176	74,058	74,892	76,123	74,930
Tonota	311,606	374,011	414,762	386,284	410,054	383,539	434,999	435,516	281,546	260,906	26,101	265,093	252,520	227,963	180,469	184,692
Ghantsi	168,042	217,930	229,682	205,629	237,164	243,157	262,552	276,680	133,522	187,974	145,455	125,864	235,133	222,430	233,626	189,557
Mahalapye	636,554	666,161	724,358	801,794	880,243	783,058	798,472	776,060	339,158	423,478	346,094	381,410	408,731	389,747	423,765	376,362
Palapye	599,166	497,265	323,616	677,228	643,319	595,164	700,691	700,691	98,576	109,490	46,787	142,443	117,845	145,891	143,278	38,166
Kasane	256,112	307,553	329,959	300,032	321,345	342,360	363,609	352,570	90,971	125,421	121,859	128,698	153,269	141,614	124,136	124,136
Mochudi	643,907	748,031	855,280	869,483	869,019	755,523	882,669	903,761	167,623	186,989	259,483	226,253	283,515	265,817	237,527	237,527
Molepolole	632,084	411,650	291,243	748,743	835,077	969,878	936,867	851,601	214,244	137,211	92,077	256,980	255,685	309,271	355,379	334,594
Serowe	542,543	470,940	793,854	320,600	924,497	894,277	1,051,091	997,433	291,261	190,294	323,862	115,637	470,449	328,299	359,074	348,389
Thamaga	215,566	197,699	236,737	244,568	257,876	296,045	472,354	381,149	46,129	46,106	45,598	40,770	45,035	47,288	54,943	63,256
Letlhakane	146,048	213,740	229,643	237,419	303,920	304,901	344,846	356,264	156,817	290,280	161,061	158,396	171,654	162,503	214,969	214,969
Mogoditshane	576,235	1,059,265	812,248	945,279	634,421	866,417	920,015	1,093,419	657,139	589,279	514,365	742,595	697,710	542,563	668,347	580,796

Table 3.7 Water Consumption in Major Villages Categorized by Activities (m^3) continued

Village	Commercial								Industrial							
	00/01	01/02	02/03	03/04	04/05	05/06	06/07	07/08	00/01	01/02	02/03	03/04	04/05	05/06	06/07	07/08
Kanye	638,101	384,880	331,102	114,493	169,500	164,963	162,651	151,279	1,768	1,737	3,723	4,549	7,287	11,165	9,075	8,271
Ramotswa	125,614	105,608	111,015	109,903	60,766	96,343	87,628	105,034	7,954	5,153	5,783	6,329	3,033	4,446	6,972	22,852
Maun	146,842	364,203	13,9954	-	-	65,257	164,396	188,897	6,650	3,073	3,964	-	-	2,960	6,210	16,711
Tlokweng	135,876	197,527	206,345	77,532	76,442	77,388	90,620	96,955	28,110	16,363	25,963	32,302	32,192	36,469	40,870	50,577
Tsabomg	26,529	12,078	14,420	30,421	30,443	1,596	25,933	29,213	1,153	492	905	523	399	467	421	1,334
Moshupa	12,240	15,391	21,762	19,162	17,780	16,376	18,060	25,432	795	1,477	993	1,224	1,007	1,529	2,931	1,908
Tonota	187,873	320,840	510,667	538,397	623,813	491,866	523,056	562,932	9,685	13,258	13,412	12,392	12,206	7,424	8,190	8,009
Ghantsi	18,729	34,332	29,297	27,920	44,012	40,336	42,012	39,754	4,154	2,624	4,249	2,666	4,393	3,106	5,393	4,061
Mahalpye	153,973	423,864	316,263	500,606	547,060	667,845	470,860	462,604	7,723	8,405	9,080	8,721	6,263	7,484	7,870	9,691
Palapye	137,775	102,132	74,296	102,711	111,801	134,079	139,640	139,640	8,915	7,580	5,281	12,583	11,174	5,472	3,621	3,621
Kasane	108,979	128,861	135,692	150,316	136,071	154,155	196,985	166,410	985	2,448	2,944	4,054	5,552	4,755	70,443	2,657
Mochudi	68,098	190,925	291,208	234,908	331,554	283,732	362,745	362,745	14,295	16,441	15,349	12,455	13,869	13,190	12,916	14,177
Molepolole	140,148	62,970	34,122	97,653	90,551	114,431	127,598	93,087	3,314	2,094	1,424	4,549	8,556	5,095	3,669	577,206
Serowe	62,397	42,526	86,512	30,398	107,872	105,608	109,337	150,508	6,199	4,971	9,377	3,659	8,637	7,810	7,108	8,714
Thamaga	56,401	90,376	119,961	132,850	107,243	126,837	144,920	161,050	3,610	4,506	6,094	7,842	8,541	7,063	6,852	6,509
Letlhakane	32,760	40,938	39,413	48,094	65,446	44,372	46,195	53,361	4,111	3,846	5,852	5,162	4,577	6,025	5,441	5,481
Mogoditshane	323,310	135,903	531,009	790,530	881,063	977,332	769,708	846,729	11,742	7,313	12,759	13,824	13,216	11,557	19,541	19,190

APPENDIX –2: Water Supply by District Councils

Table 4.2 Ghanzi District Council: Water Supply and Demand

Village	Population	Supply (m^3/d)	Demand (m^3/d)
kacgae	282	48	38
Bere	385	60	48
E-hanahai	405	120	50
West hanahai	560	53	52
Kgoesakene	930	160	130
D'kar	943	48	40
Kuke	466	48	39
Grootlaagte	483	49	49
Qabo	401	48	43
Total	**4,855**	**634**	**489**

Table 4.3 Charleshill Sub-District: Water Supply and Demand

Village	Population	Supply (m^3/d)	Demand (m^3/d)
Charleshill	1,859	274	75
Makunda	331	10	13
Kole	741	89	30
Ncojane	1,439	192	58
Metsimantle	60	10	4
Metsimantsho	152	26	6
Kalkfotein	1,397	108	56
New Xanahas	540	58	22
Ranyane	94	56	30
Chobokwane	484	84	20
Karakubis	785	160	32
Xanahas	540	24	-
Mamuno	40	24	4
Total	**7828**	**1105**	**320**

Table 4.4 Central District Council-Serowe/Palapye Sub-district: Water Supply and Demand

Village	Population	Supply (m^3/d)	Demand (m^3/d)
Dimajwe	694	39	34
Mabeleapodi	961	61	40
Paje	1,579	216	127
Malatswae	484	60	23
Mmashoro	1,288	168	92
Serule	2,556	454	200
Moreomabele	2,870	30	13
Topisi	857	79	43
Gojwane	1,011	62	32
Tshimologo	861	76	40
Mogome	327	17	17
Mokgware	152	22	10
Radisele	1,807	216	142
Moiyabana	1,995	216	88
Mabuo	424	37	16
Motshegaletau	716	73	34
Sehunou	150	11	10
Thabala	1,740	138	49
Mogorosi	1,258	112	80
Lecheng	1,363	475	240
Goo-Tau	1277	95	60
Goo-Sekgweng	534	15	21
Ratholo	1,105	186	108
Lerala	4,923	568	350
Majwaneng	994	99	90
Mokokwana	395	30	62
Mosweu	512	27	30
Maunatlala	2,914	378	210
Lesenepole	1,478	172	94
Moremi	330	30	30
Kgagodi	1,263	125	90
Mogapinyana	1,208	87	57
Mogapi	1,609	146	103
Diloro	463	26	-
Tamasane	818	61	48
Malaka	474	54	30
Mokungwana	249	34	30
Manaledi	312	20	10
Seolwane	1,371	80	51
Matlhakola	844	89	27
Total	**46,166**	**4,884**	**2,801**

Table 4.5 Bobirwa Sub-District: Water Supply and Demand

Village	Population	Supply (m^3/d)	Demand (m^3/d)
Damchojenaa	760	37	30
Gobojango	1,631	156	93
Semolale	1,145	43	70
Mabolwe	735	155	50
Lepokole	505	47	30
Robelela	471	51	15
Tshokwe	897	20	20
Tobane	1,788	54	60
Lentswe le Moriti	262	39	20
Mathathane	1,845	202	100
Motlhabaneng	1,276	68	50
Molalatau	1,788	178	167
Tsetsebjwe	3,457	136	140
Moledji	50	68	4
Moletemane	1,367	55	60
Sefophe	3,821	124	148
Mmadinare	10,918	989	670
Bobonong	14,622	1340	1750
Total	**47,338**	**3,762**	**3,477**

Table 4.6 Boteti Sub- District: Water Supply and Demand

Village	Population	Supply (m^3/d)	Demand (m^3/d)
Khwee	279	50	38
Kedia	1,091	64	64
Mopipi	2,844	256	213
Mokoboxane	790	61	53
Mmatshumo	1,036	97	66
Mosu	670	92	68
Nthane	281	108	5
Mokubilo	826	72	71
Mmea	367	33	30
Khumaga	566	110	42
Mmadikola	811	88	48
Moreomaoto	303	200	24
Motopi	999	111	92
Makalamabedi	1,313	83	122
Rakops	3,853	315	367
Toromoja	520	35	14
Xhumo	1,466	80	94
Xere	300	20	20
Total	**18,315**	**1,875**	**1,431**

Table 4.7 Mahalapye Sub –District: Water Supply and Demand

Village	Population	Supply (m^3/d)	Demand (m^3/d)
Chadibe/Borotsi	3,545	182	239
Sefhare	4,195	407	283
Machaneng	2,050	358	138
Makwate	1,591	95	104
Mokobeng	1,746	325	146
Ngwapa	424	325	146
Taupye	402	178	37
Pilikwe	1,318	223	79
Ramokgonami	3,527	947	238
Tumasera	4,305	291	291
Maape	1,222	51	82
Mhalapitsa	828	149	56
Moshopha	1,409	92	95
Shakwe	856	149	58
Mookane	2,297	61	155
Kudumatse	1,339	349	90
Mokoswana	362	111	24
Dovedale	706	150	48
Mmaphashalala	1,027	123	69
Dibete	1,002	190	68
Palla-road	1,053	108	71
Poloka	420	109	38
Shoshong	7,490	-	506
Kalamare	2,241	-	151
Mmutlane	841	-	57
Mosolotshane	1,798	79	139
Moralane	446	35	30
Ikongwe	471	40	32
Kodibeleng	1,206	99	81
Otse	973	413	66
Mokgenene	513	65	35
Bonwapitse	544	-	37
Tobela	243	49	9
Matlhako	679	119	46
Total	**53,069**	**5,872**	**3,744**

Table 4.8 Kgatleng District Council: Water Supply and Demand

Village	Population	Supply (m^3/d)	Demand (m^3/d)
Artesia	2,589	140	137
Bodungwane	109	11	10
Dikgonnye	360	30	27
Dikwididi	591	6	35
Kgomodiatshaba	508	35	31
Khurutse	52	8	8
Leshibitse	653	41	38
Malotwana	504	76	31
Olifants Drift	758	46	45
Ramotlabaki	640	40	38
Mabalane	895	55	50
Malolwane	3,084	164	163
Mathubudukwane	2,124	158	150
Ramonaka	518	43	41
Sikwane	1,516	470	104
Matebele	1,458	87	80
Oodi	3,550	195	186
Modipane	2,508	140	133
Rasesa	2,986	160	158
Bokaa	4,456	235	233
Total	**29,859**	**2,140**	**1,698**

Table 4.9 South East Sub-District: Water Supply and Demand

Village	Population	Supply (m^3/d)	Demand (m^3/d)
Otse	5,192	493	447
Mogobane	2,053	217	382
Metsimaswaana	174	4	7
Total	**7,419**	**714**	**836**

Table 4.10 Tutume Sub-District: Water Supply and Demand

Village	Population	Supply (m^3/d)	Demand (m^3/d)
Maitengwe	5,302	305	300
Dagwi	1,512	77	82
Nkange/Senete	6,099	94	329
Changate	938	26	80
Goswe	1,156	838	62
Sebina	2,878	178	156
Nswazwi	1,741	87	94
Marobela	1,320	155	-
Matobo	1,314	92	71
Nshakashogwe	1,718	124	133
Marapong	1,579	123	85
Semitwe	537	37	29
Natale	1,117	610	50
Mathangwane	3,962	1,100	214
Chadibe	1,192	219	64
Borolong	3,003	137	162
Makobo	939	110	51
S/Mooke	2,143	46	116
Matsitama	1,030	83	56
Mabesekwa	886	62	47
Tshokotshaa	-	112	22
Gweta	4,055	350	219
Dzoroga	948	106	51
Dukwi	1,901	-	103
Nata	4,150	-	224
Maposa/Manxotai	409	-	22
Sepako	627	17	34
Lepashe	-	22	14
Mosetse	1,661	90	90
Kutamogoree	763	20	32
Tutume	13,735	1,034	1,000
Moigapi	1,609	75	103
Diloro	463	50	-
Tamasane	818	75	48
Malaka	474	10	30
Mokungwana	249	30	30
Manaledi	312	10	10
Seolwane	1,371	75	51
Matlhakola	844	75	27
Total	**74,825**	**6,654**	**4,291**

Table 4.11 Southern District-Kanye/Moshupa Sub-District Water Supply and Demand

Village	Population	Supply (m^3/d)	Demand (m^3/d)
Betesankwe	209	20	10
Bikwe	210	10	-
Diabo	532	16	150
Dipotsna	249	7	-
Gamoswaana	487	-	-
Gasita	717	123	20
Kgomokasitwa	1,673	87	35
Lekgolobotlo	1,111	72	30
Lorolwane	809	65	85
Lotlhakane East	3,298	282	235
Lotlhakane West	1,277	72	77
Magotlhwane	1,431	86	-
Maisane	404	37	-
Manyana	3,541	191	112
Mmathethe	4,044	402	235
Mogonye	699	32	20
Mogojogojo	564	115	55
Molapowabojang	2,820	292	-
Moshaneng	1,484	80	140
Ntlhantlhe	2,167	105	110
Pitseng	610	51	50
Polokwe	450	17	40
Ralekgetlho	152	19	38
Ranaka	3,318	187	125
Segwagwa	840	43	58
Seherelela	326	32	40
Selokolela	1,080	71	42
Sese	1,269	88	-
Sesung	856	26	50
Tswaane	451	12	26
Tsonyane	685	37	110
Total	**37,763**	**2,677**	**1,893**

Table 4.12 Goodhope Sub-District: Water Supply and Demand

Village	Population	Supply (m^3/d)	Demand (m^3/d)
Bethel	495	-	26
Borobadilepe	526	55	60
Digawana	2,824	162	180
Dikhukhung	479	38	60
Dinatshana	526	46	-
Ditlharapa	386	48	90
Gamajaalela	1,058	62	-
Gathwane	1,266	79	-
Goodhope	2,297	-	405
Gopong	704	55	-
Hebron	1,003		104
Kanngwe	482	40	60
Kgoro	1,024	285	464
Lejwana	509	-	78
Leporung	787	-	60
Lorwana	1,176	97	-
Mabule	1,963	-	55
Madingwana	455	43	50
Magoriapits	702	39	42
Malokaganyane	516	28	40
Metlobo	1,187	110	90
Metlojane	596	112	130
Mmakgori	582	48	50
Sedibeng	455	260	18
Phitshane-Molopo	1,937	154	91
Mokatako	1,289	65	52
Tswaaneng	601	56	24
Pitsane	3,119	-	156
Potlokwe	1,169	-	47
Tlhareseleele	1,005	45	40
Rakhuna	1,631	203	82
Papatlo	605	150	24
Ramatlabama	1,622	-	65
Mogwalale	333	30	13
Total	**35,309**	**2,310**	**2,656**

Table 4.13 Mabutsane Sub-District: Water Supply and Demand

Village	Population	Supply (m^3/d)	Demand (m^3/d)
Itholoke	156	16	20
Kanaku	-	62	40
Keng	625	68	55
Khakhea	1,750	123	110
Khonkhwa	225	18	25
Kokong	651	62	40
Mabutsane	1,032	89	75
Mahutshwane	354	45	14
Morwamosu	508	60	-
Sekoma	599	-	60
Total	**5,900**	**543**	**439**

Table 4.14 Kweneng East Sub-District: Water Supply And Demand

Village	Population	Supply (m^3/d)	Demand (m^3/d)
Gakgatla	554	13	52
Mmanoko	763	46	48
Gamodubu	861	60	47
Losilakgokong	294	-	40
Kubung	615	37	52
Kumakwane	3,139	188	-
Mmankgodi	4,997	299	410
Gabane	10,399	-	430
Mmokolodi	584	50	68
Metsimotlhabe	4,056	-	150
Mmopane	3,512	-	120
Gakuto	1,156	69	-
Kopong	5,571	334	-
Lentsweletau	4,025	242	200
Kgope	507	20	25
Kweneng	415	25	30
Ditshukudu	89	5	18
Mahetlwe	591	35	40
Mogonono	201	12	16
Hatsalatladi	609	36.54	25
Boatlaname	770	46	50
Sojwe	2,056	123	110
Lephephe	742	45	65
Shashadi	666	40	32
Total	**47,172**	**1,726**	**2,028**

Table 4.15 Kweneng West District-Letlhakane Sub-District Water Supply and Demand

Village	Population	Supply (m^3/d)	Demand (m^3/d)
Botlhopatlou	915	40	40
Diphuduhudu	559	20	43
Ditshegwane	1,766	105	136
Kaudwane	551	53	16
Khekhenye	339	42	12
Kotolaname	278	37	36
Kudumelapye	1,837	48	117
Maboane	813	125	52
Malwelwe	930	40	77
Mantshwabisi	464	234	35
Maratswane	12	2	-
Masope	90	19	-
Metsibotlhoko	355	32	-
Monwane	375	38	29
Motokwe	1,479	41	129
Ngware	573	17	47
Salajwe	1,705	65	101
Serinane	450	20	17
Sesung	1,281	35	75
Sorilatholo	472	23	18
Takatokwane	1,590	114	138
Dutlwe	1,017	114	74
Tshwaane/Khong	341	72	28
Tsetseng	395	37	36
Total	**18,587**	**1,373**	**1,256**

Table 4.16 Kgalagadi District: Water Supply and Demand

Village	Population	Supply (m^3/d)	Demand (m^3/d)
Bogogobo	341	29	28
Bray/Hereford	899	-	54
Bokspits	899	101	37
Gachibana	797	34	53
Hukuntsi	4,131	135	315
Huhunkwe	579	49	36
Inalegolo	558	-	38
Kang	4,124	-	532
Khisa	545	-	37
Khuis	851	44	56
Khawa	623	20	42
Kokotsha	1,333	32	85
Kolonkwaneng	762	46	49
Lehututu	1,778	52	122
Lokgwabe	1,435	40	94
Make	366	50	25
Makopong	1,635	75	105
Maleshe	455	26	32
Maralaleng	487	16	34
Maubelo	453	45	30
Middlepits	657	105	105
Monong	172	10	12
Ncaang	175	39	13
Ngwatle	206	-	13
Omaweneno	1,134	75	74
Phepheng	998	68	-
Phuduhudu	621	43	41
Rapplespan	458	29	30
Struzendam	313	33	21
Tsabong	6,591	-	-
Tshane	858	74	63
Ukwi	454	38	32
Vaalhoek	346	33	25
Werda	2,237	189	189
Zutshwa	525	-	36
Draihoek	998	52	66
Total	**24,261**	**948**	**1,947**

Table 4.17 North East District: Water Supply and Demand

Village	Population	Supply (m^3/d)	Demand (m^3/d)
Botalaote	182	50	13
Butale	513	38	29
Ditladi	1,156	38	51
Gambule	716	38	41
Gulubane	878	47	39
Gungwe	387	-	17
Jackalas1	1,172	86	108
Jackalas2	1,144	67	50
Kalakamati	925	40	50
Kgari	581	-	31
Letsholathebe	674	40	30
Mabudzane	318	-	21
Makaleng	1,121	170	108
Mambo	561	118	35
Mapoka	1,540	138	103
Masingwaneng	548	29	31
Masukwane	886	27	47
Masunga	3,110	800	850
Matenge	451	35	31
Matopi	247	14	18
Matshelagabedi	1,874	139	97
Matsiloje	2,910	216	200
Mbalambi	984	56	44
Moroka	1,747	235	84
Mosojane	1,035	44	47
Mowana	428	-	20
Mulambakwena	1,132	56	60
Nlapkhwane	1,938	57	71
Pole	318	24	15
Ramokgwebana	1,479	90	81
Sechele	668	40	34
Sekakangwe	751	163	68
Senyawe	1,530	62	70
Shashe-Bridge	795	67	125
Siviya	1,285	202	61
Tati-Siding	4,432	639	326
Themashanga	1,576	71	73
Toteng	337	-	12
Tsamaya	1,694	115	116
Tshesebe	1,519	346	155
Vukwi	263	17	16
Zwenshambe	1,468	151	100
Total	**47,273**	**4,565**	**3,578**

Table 4.18 Tonota Sub-District: Water Supply and Demand

Village	Population	Supply (m^3/d)	Demand (m^3/d)
*Serule	4,684		328
*Gojwane	1,542		108
*Moreomabele	1,250	612	62
*Topisi	1,585		801
Mabesekwa	2,396	223	168
*Borolong	3,801		266
*Chadibe	1,957	687	137
*Shashe-Mooke	4,008		281
Natale	1,572	-	110
Foley	545	60	38
Total	**23,340**	**15,582**	**2,299**

Table 4.19 North West District: Ngami Sub-District Water Supply and Demand

Village	Population	Supply (m^3/d)	Demand (m^3/d)
Sexaxa	534	60	70
Matlapana	1,169	90	100
Shorobe	955	50	60
Sankoyo	372	39	33
Chanoga	381	65	40
Phuduhudu	563	65	32
Sehithwa	1,473	60	410
Bothatogo	467	68	60
Bodibeng	472	50	65
Toteng	509	46	45
Kareng	599	40	60
Legothwane	361	-	-
Semboyo	246	60	65
Makakung	84	-	50
Tsau	1,073	-	130
Mababe	157	-	31
Komana	186	68	-
Makalamabedi	310	45	58
Somelo	481	32	30
Total	**10,392**	**838**	**1,339**

Table 4.20 Chobe Sub-District: Water Supply and Demand

Village	Population	Supply (m^3/d)	Demand (m^3/d)
Pandamatenga	1,545	182	69
Pandamatenga No.7	524	-	56
Lesoma	405	73	25
Mabele	792	83	36
Kavimba	519	73	40
Kachikau	881	182	74
Satau	730	93	40
Parakarungu	806	94	46
Total	**6,202**	**780**	**386**

Table 4.21 Okavango Sub-District Water Supply and Demand

Village	Population	Supply (m^3/d)	Demand (m^3/d)
Nokaneng	1,590	100	120
Qooshe	69	12	10
Qangwa	337	20	27
Gumare	6,067	361	400
Tubu	392	22	31
Etsha 12 &13	1,975	88	90
Sepopa	1,519	62	137
Ikoga	699	-	-
Nxamasere	1,328	60	39
Shakawe	4,389	225	240
Ngarange	948	47	37
Seronga	1,641	66	56
Gani	480	-	7
Beeetsha	760	23	30
Mogotho	6	10	10
Xakao	1,049	60	210
Mohembo East	580	33	-
Kauxwi	859	24	30
Sekondomboro	655	28	-
Xaixai	-	20	17
Nxauxau	50	-	22
Gudigwa	616	-	32
Gunitsoga	506	17	29
Etsha 6	2,629	112	150
Total	**29,144**	**1,390**	**1,724**

Source: Ministry of Local Government and District Councils

APPENDIX –3: Water Supply by Water Utilities Corporation

Table 6.3 The situation of the Water Utilities Corporation dams as at March 31 from 2005/6 to 2007/08

Dam	Gaborone			Nnywane			Shashe			Bokaa			Letsibogo		
F.S.C	**141.4 Mm^3**			**2.3 Mm^3**			**85.3 Mm^3**			**18.5 Mm^3**			**100 Mm^3**		
F.S.L	**(998.05m)**			**(1134.03m)**			**(971.46m)**			**(954m)**			**(848.8m)**		
Financial year	07/08	06/07	05/06	07/08	06/07	05/06	07/08	06/07	05/06	07/08	06/07	05/06	07/08	06/07	05/06
Cumulative rainfall (mm)	369	3	521	352	47	745	127	108	204	159	0	591	117	843	329
Impoundment (Mm^3)	101.6	79.6	118.1	2.27	1.21	2.3	83.4	71.6	85.3	18.4	7.2	18.5	90.5	76.0	98.4
Percentage full %	71.9	56.3	83.5	98.5	41.1	100	98.9	84.9	100.8	99.0	38.9	100	87.3	73.2	98.4

Source: Water Utilities Corporation Annual Reports

Note: MCM denotes million cubic meters
mm denotes millimeters
FSC denotes full Supply Capacity
FSL denotes Full Supply Level

Table 6.4 Water Production and Losses (ML)

	Gaborone	Mmamashia	Mahalapye	Palapye	Selibe-phikwe	F/town
2002-2003						
Raw Water	27,321,567	5,752,809	1,633,000	1,177,000	5,694,000	9,206,234
Treated Water	24,430,836	5,607,874	1,597,000	1,155,000	5,475,000	8,528,057
Losses	0.11	0.03	0.02	0.02	0.04	0.07
2003-2004						
Raw Water	22,973,641	5,720,554	1,515,000	1,237,420	5,369,942	10,148,787
Treated Water	22,032,737	5,575,619	1,495,600	1,208,860	5,286,944	9,328,578
Losses	4.10	2.53	1.28	2.31	1.55	8.08
2004-2005						
Raw Water	17,812,357	9,902,223	2,013,767	1,548,160	5,695,000	10,431,439
Treated Water	19,771,808	9,140,640	1,987,780	1,469,600	5,585,000	9,659,695
Losses	-11.00	7.69	1.29	5.07	1.93	7.40
2005-2006						
Raw Water	8,001,928	13,753,113	1,482,902	1,094,560	5,471,648	9,987,963
Treated Water	10,422,035	13,141,748	1,455,259	1,027,900	5,406,949	9,563,645
Losses	-30.24	4.45	1.86	6.09	1.18	4.25
2006-2007						
Raw Water	20,524,867	7,894,767	729,009	539,190	5,258,290	10,200,892
Treated Water	31,501,438	7,283,402	732,402	533,100	5,175,231	9,537,409
Losses	-53.48	7.74	-0.47	1.13	1.58	6.50
2007-2008						
Raw Water	22,321,056	7,446,343	310,901	355,360	5,283,651	10,258,000
Treated Water	22,393,858	6,963,130	322,757	342,400	5,186,109	9,678,387
Losses	-0.33	6.49	-3.81	3.65	1.85	5.65

Source: Water Utilities Corporation
NB: ML denotes million litres

Table 6.7 Water Consumption (in kl) for the different towns and the amount of sales collected from the users

Year	Gaborone	Francistown	Lobatse	Jwaneng	Selibe-Phikwe	Sowa Town	North South Carrier	Total in ('000) KL	Sales in Pula
1998	17,289,572	5,131,831	2,134,816	5,521,459	1,398,854	556,892	-	32,027,424	148,012,240
1999	20,061,032	4,098,653	1,684,635	4,420,634	1,045,225	337,067	-	31,647,246	133,164,012
2000	21,307,303	5,374,931	2,432,899	5,889,339	2,404,847	479,107	-	37,888,426	232,887,628
2001	23,975,888	8,132,476	3,032,608	9,896,966	1,876,308	686,945	814,753	48,415,944	387,204,438
2002	23,672,759	6,109,033	1,948,531	5,873,312	1,317,769	456,258	814,753	40,192,415	326,631,106
2003	23,977,709	6,759,856	2,589,689	9,054,474	1,594,425	536,518	2,732,679	47,245,350	430,247,650
2004	24,529,020	7,185,879	2,607,674	8,681,348	1,686,921	463,493	3,338,843	48,493,178	501,353,260
2005	19,643,169	7,715,038	2,168,350	1,635,758	1,635,758	501,959	2,538,200	43,507,553	405,119,463
2006	20,669,603	8,419,012	2,282,253	1,543,636	1,543,636	517,717	1,585,078	43,611,475	421,029,698
2007	23,973,239	8,566,130	2,656,014	1,736,555	1,736,555	441,988	1,007,200	47,287,224	466,665,882
2008	25,657,363	9,269,496	2,968,719	1,578,607	1,578,607	501,895	968,300	50,292,691	502,441,939

Source: Water Utilities Corporation and National Accounts Unit (CSO)

APPENDIX- 4: Standards for Water Quality

Table 8.1 Specification for Drinking Water Quality

VARIABLES (in mg/l where applicable)	WHO	WUC	
	Guideline Values	Recommended Maximum Limit	Maximum Allowable
Physical Requirements			
Turbidity NTU	5	0.5	1
Colour TCU	15	15	20
Taste & Odour	unobjectionable	unobjectionable	unobjectionable
Chemical Requirements			
Chlorine Residual CL_2	0.6	0.3	1
pH value	6.0 - 9.0	6.5 - 8.5	5.5 - 9.0
Total Dissolved Solids TDS	500	500	1000
Total Hardness (as $CaCO_3$)	20 - 200	500.00	1000
Sulphate SO_4	250	250.00	400
Calcium Ca	75	75	200
Nitrite NO_2	3	3	3
Phosphorous PO_4	0.3	0.3	0.3
Chloride CL	250	250	600
Sodium Na	200	200	200
Magnesium Mg	100	100	150
Iron Fe	0.3	0.3	0.7
Manganese Mn	0.1	0.1	0.4
Ammonium NH_4	1.5	1.5	2
Aluminium Al	0.2	0.2	0.2
Copper Cu	1	1	1.5
Zinc Zn	5	5	1.5
Toxic Substances			
Nitrate NO_3	45	45	45
Fluoride F	0.7 - 1.5	1.00	1.50
Lead Pb	0.05	0.05	0.10
Cadmium Cd	0.05	0.01	0.05
Cyanide CN	0.01	0.01	0.20
Microbiological Variables			
Faecal Coliforms / 100 ml	0	0	0
Total Coliforms / 100 ml	0	10	50 - 150
Organic Constituents			
Phenols	0.01	0.002 – 0.01	0.3
Total Organic Carbon TOC	8	8	8
Trihalomethanes THM	100	100	100
Total Pesticides	0.0005	0.0005	0.0005
Poly Aromatic Hydrocarbons	0.001	0.001	0.001
Disinfection by-products	0.6 - 1	0 – 0.5	5
Toluene	0.02 – 0.2	0.02 – 0.2	0.2
Chlorophyll A	0 - 5	0 – 0.5	5

Source: Water Utilities Corporation Water Quality Standards and Botswana Bureau of Standards

Table 10.2 Wastewater standards

Determinant	**Unit**	**Upper lilmiit And range**	**Class 3 potable water**
Colour	TCU	50	50
Temperature	° C	35	
Total Dissolved solids (TDS)	Mg/l	2000	2000
Total suspended solids (TSS)	Mg/l	25	
BOD (max)	Mg/l	30	
Faecal coliform	Counts/100ml	1000	
COD (max)	Mg/l	75 (filtered)	
COD (max)	Mg/l	150 (unfiltered)	
Dissolved oxygen (min)	% sat.	60	
pH value at 25° C		6.0-9.0	5-10
Turbidity	NTU	30	
Chemical requirements macro determinants	Unit		
Free and saline ammonia as N	mg/l	10	2.0
Calcium as Ca	mg/l	500	200
Chloride as Cl	mg/l	600	
Fluoride as F	mg/l	1.5	1.5
Chlorine residual	mg/l	1.0	600
Magnesium as Mg	mg/l		100
Nitrate as N	mg/l	22	
Ortho phosphate or soluble phosphate as P	mg/l	1.5	
Potassium as K	mg/l	100	100
Sodium as Na	mg/l	400	400
Sulphate as SO4	mg/l	400	400
Zinc as Zn	mg/l	5.0	10.0
Chemical requirements-micro determinants	Unit		
Aluminium as Al	µg/l		200
Antimony as Sb	µg/l		5.0
Arsenic as As	µg/l	0.100	10
Boron as B	µg/l	0.50	
Cadmiun	µg/l	0.02	3.0
Chromium VI as Cr	µg/l	0.25	
Chromium as Cr (total)	µg/l	0.5	50
Cobalt as co	µg/l	1.00	1000
Copper as Cu	µg/l	1.00	1000
Cyanide as CN	µg/l	0.100	70
Iron as Fe	µg/l	2.00	2000
Lead as Pb	µg/l	0.05	10
Managanese as Mn	µg/l	0.100	50
Mercury as hg (total)	µg/l	0.01	1.0
Nickel as Ni	µg/l	0.30	20
Selenium as Se	µg/l	0.02	10

Source: Botswana Bureau of Standards BOS 93: 2004