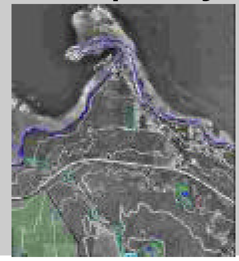
Deep Bay



COMMUNITY TEAM

Deep Bay Waterworks District

March 2005

Drought Management Plan

(C) Community Team

Community Team Approach:

Developing a plan utilizing local professional and technical expertise has the advantage of having a better understanding of local environmental conditions, the local community being served and the current local government policies affecting the area. This team is composed of the following four members:

Community Team:
Bon Thorburn, P.Eng. is a Civil Engineer and manager of Thorconsult Ltd., a municipal engineering consultancy firm that has effectively serviced municipalities and developers throughout British Columbia since 1986. Thorconsult Ltd. has varied experience related to the areas of water supply, environmental sanitation and land development. Such clients as the City of Prince Rupert, City of Surrey, Municipality of Delta and The City of Coquitlam have used Thorconsult engineers to provide traffic, water supply, and sewage treatment design/construction plans and/or investigative studies. He is to conduct the “Infrastructure” section’s activities of the Drought Management Study.

James Hooper B.Sc, M.Sc., Ph.D., Physical Geographer
James is a physical geographer specialized in mapping and interpreting glacial and marine sediments. Early experience was on Baffin Island mapping a 17,000 km² area for the Geological Survey of Canada. Later years included producing terrain stability maps for forest companies in B.C. He will provide the “Aquifer and Watershed Protection Issues” portion.

Richard Wahlgren, B.Sc. (Agriculture), is the owner/manger of Streamside Native Plants. He received a BSc. (Agriculture) from the University of British Columbia in 1979. Currently he is enrolled as a biologist in training (BIT) leading up to a registered professional biologist (RPBio.) designation. Locally, Richard is an active member of the Nile Creek Enhancement Society, and Canadian Coast Guard Auxiliary. He was recently appointed as a member of the Area 'H' parks and open space advisory committee. He will provide the “Conservation Measures for the Homeowner” portion.

Dianne Eddy, B.Sc. (Chemistry), M.Sc. (Computer Science), is retired after more than 15 years as a computer programmer/analyst. This profession required analytical computational abilities. Locally, Dianne is president of the Mapleguard Ratepayers’ Association, elected Trustee of the Deep Bay Waterworks District and member of several other organizations. She will provide the “Regulatory Methods of Reducing Water Demands” portion. She is the team coordinator for this project.

This project was financed by a grant from Land and Water BC to help local government with drought planning.

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Executive Summary

The Water Board of Deep Bay Waterworks District (DBWD) contracted a professional team consisting of Bon Thorburn, P.Eng.(Civil), James Hooper B.Sc, M.Sc., Ph.D.(Geography), Richard Wahlgren, B.Sc. (Agriculture), and Dianne Eddy, B.Sc. (Chemistry), M.Sc. (Computer Science), to produce the drought management plan contained in this report.

This Deep Bay community team reviewed the well history and production records including a survey of the water system's infrastructure. This report suggests improvements to methods and structures, as well as detailing deficiencies. The team reviewed the mapping of the aquifer - the source of water for the Deep Bay area. They also reviewed the available hydrogeological data and recommended methods for monitoring and protecting the aquifer.

As the residents of Deep Bay are the ultimate consumers of the product supplied by the Water Board, the report presents conservation measures at the customer level. The report also presents an implementation plan based on the observations of the team members. This part of the plan details the various stages from 'ALERT' to 'EMERGENCY' that the Water Board can use to protect the water supply as well as continue to serve their customers.

The team remapped the Deep Bay Aquifer from existing data and field checks on sediments exposed along creeks and in road cuts in the general area of the aquifer. This led to a reduction in the mapped extent of the aquifer and a reinterpretation of the aquifer sediments as postglacial deltaic sediments, not Quadra Sand. The team listed anticipated risks to the aquifer during droughts based on an aquifer with no protective confining layer, where the aquifer and recharge area occupy essentially the same map polygon. Immediate risks of aquifer contamination arise mainly from the illegal dumping along back roads in the recharge area. The most serious risk would be a highway accident involving a tanker truck in the vicinity of the well field. The installation of informational signage would inform travelers, trespassers and/or residents of the potential consequences of their pollution.

The team recommends the Water Board improve its baseline data collection capability by collecting climate data from the Bowser Seed Orchard, installing its own weather station or both. Without baseline monitoring of climate and well levels, it will be difficult to estimate the drought return interval, amongst other things.

The team reviewed the existing infrastructure and feel the Water Board should be proud of a well-maintained and operated water system compared to others they have encountered. However, there are still areas for improvements such as organized operation, maintenance and design information placed in the filing system in the Deep Bay offices of the DBWD, a water audit and the drought management plan this report presents.

The team thanks the Water Board for their cooperation and assistance in the preparation of this report.

Drought

1 Preparing for Drought

The need to develop a drought management plan reflects the vulnerability of any water supply system on the east coast of Vancouver Island. The rapid population growth, privatization of Crown Lands, logging and sale of timberlands, all become part of the impact and demands on limited water supplies in the area. Limitations of improvement districts to control or limit growth and protect aquifer watershed areas, highlights the need for actions that can reduce long term water demands due to population increases.

Currently observed changes in weather patterns and extremes of weather events, add to the need for a Drought Management Plan to best utilize and protect limited water supplies. The importance of monitoring and maintaining records will be necessary to implement this plan.

Why Prepare for Drought?

Drought preparedness plans promote a more preventive, risk management approach to drought management. The process seeks to identify data and informational gaps that may exist and make recommendations on what is needed. Ultimately, preparedness plans will improve procedures for monitoring, assessing, and responding to water shortages; information flow to primary users; and efficiency of resource allocation. The goals of these plans are to reduce water shortage impacts, personal hardships, and conflicts between water and other natural resource users. These plans should promote self-reliance by systematically addressing issues of principal concern to the region in question. To be successful, drought preparedness plans must be integrated between levels of government.

What is Drought? (from NDMC)[1]

Operational definitions help define the onset, severity, and end of droughts. No single operational definition of drought works in all circumstances, and this is a big part of why policy makers, resource planners, and others have more trouble recognizing and planning for drought than they do for other natural disasters. In fact, most drought planners now rely on mathematical indices to decide when to start implementing water conservation or drought response measures.

[1] NDMC: National Drought Mitigation Center

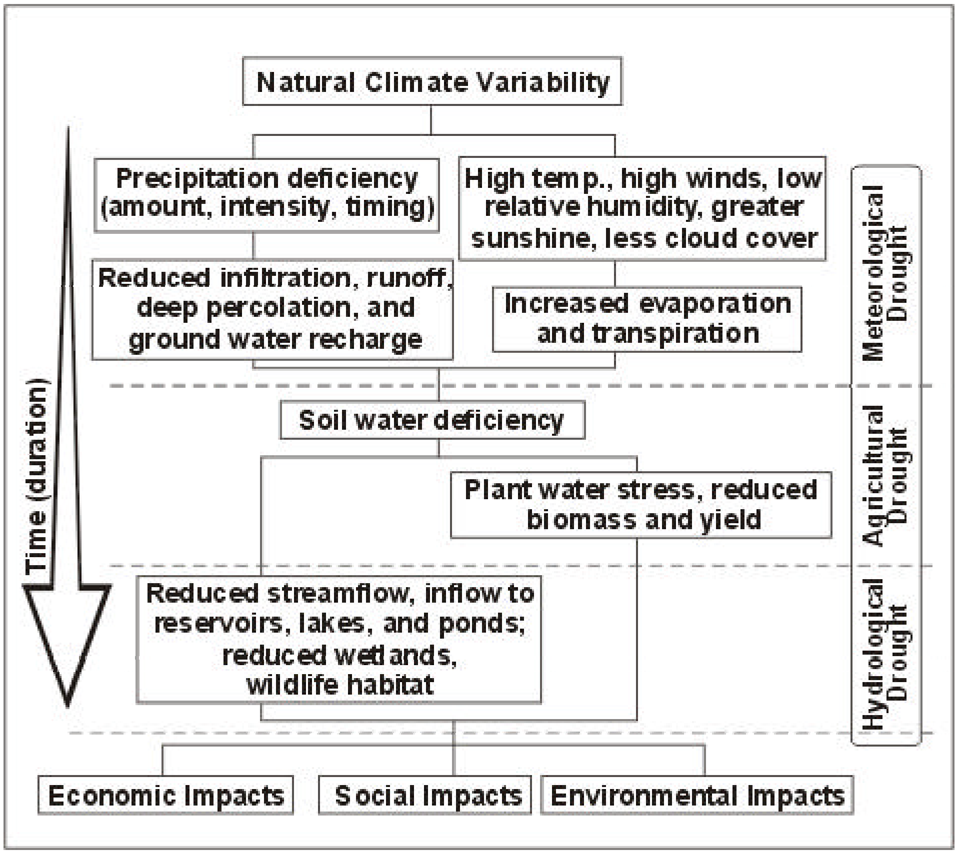

Figure 1.1 Table showing relationships of drought impacts

Meteorological drought is usually an expression of precipitation's departure from normal over some period of time. These definitions are usually region-specific, and presumably based on a thorough understanding of regional climatology.

Agricultural drought occurs when there isn't enough soil moisture to meet the needs of a particular crop at a particular time. Agricultural drought happens after meteorological drought but before hydrological drought. Agriculture is usually the first economic sector to be affected by drought.

Hydrological drought refers to deficiencies in surface and subsurface water supplies. It is measured as streamflow and as lake, reservoir, and groundwater levels. There is a time lag between lack of rain and less water in streams, rivers, lakes, and reservoirs, so hydrological measurements are not the earliest indicators of drought. When precipitation is reduced or deficient over an extended period of time, this shortage will be reflected in declining surface and subsurface water levels.

Hydrological Drought and Land Use

Although climate is a primary contributor to hydrological drought, other factors such as changes in land use (e.g., deforestation), land degradation, and the construction of dams all affect the hydrological characteristics of the basin. Because regions are interconnected by hydrologic systems, the impact of meteorological drought may extend well beyond the borders of the precipitation-deficient area. Changes in land use upstream may alter hydrologic characteristics such as infiltration and runoff rates, resulting in more variable streamflow and a higher incidence of hydrologic drought downstream. Land use change is one of the ways human actions alter the frequency of water shortage even when no change in the frequency of meteorological drought has been observed.

Socioeconomic drought occurs when physical water shortage starts to affect people, individually and collectively. Or, in more abstract terms, most socioeconomic definitions of drought associate it with the supply and demand of an economic good.

Sequence of Drought Impacts

The sequence of impacts associated with meteorological, agricultural, and hydrological drought further emphasizes their differences. When drought begins, the agricultural sector is usually the first to be affected because of its heavy dependence on stored soil water. Soil water can be rapidly depleted during extended dry periods. If precipitation deficiencies continue, then people dependent on other sources of water will begin to feel the effects of the shortage. Those who rely on surface water (i.e., reservoirs and lakes) and subsurface water (i.e., ground water), for example, are usually the last to be affected. A short-term drought that persists for 3 to 6 months may have little impact on these sectors, depending on the characteristics of the hydrologic system and water use requirements. When precipitation returns to normal and meteorological drought conditions have abated, the sequence is repeated for the recovery of surface and subsurface water supplies. Soil water reserves are replenished first, followed by streamflow, reservoirs and lakes, and ground water. Drought impacts may diminish rapidly in the agricultural sector because of its reliance on soil water, but linger for months or even years in other sectors dependent on stored surface or subsurface supplies. Ground water users, often the last to be affected by drought during its onset, may be last to experience a return to normal water levels. The length of the recovery period is a function of the intensity of the drought, its duration, and the quantity of precipitation received as the episode terminates.

2 Information Available From Government

Levels of Responsibility

Drought monitoring has become an integral part of drought planning, preparedness and mitigation efforts at the international, national, provincial, regional and local levels. Drought can develop in all regions of the continent, and its effects can be devastating.

Policy recommendations and legislative action results in one of the essential requirements for all life: water. Without the force of legislation, growth and development will likely outpace water supplies. Currently there is little protection from federal or BC Provincial legislation preventing outright diversion of underground water supplies from a community dependant upon the groundwater supply. As a consequence, drought management becomes not simply an act of watching weather reports, but also an issue of planning sustainable growth. Water supplies can become limited due to the lack of good planning by all levels of government.

Obtaining Drought Information

North American Joint Drought Monitor

* NA-DM Overview
* NA-DM maps
* NA-DM maps (limited access)
* ArcGIS Archive (limited access)
* Drought Monitoring Indices and Data
* Animated Indicator Maps
* Associated Links

The three-way partnership with the U.S., Canada and Mexico, is responding to the need for accurate, centralized drought information by developing a map that summarizes information from numerous drought indices and indicators on a single, easy-to-read color map known as the Drought Monitor (http://www.ncdc.noaa.gov/oa/climate/monitoring/drought/nadm/)

Information from Provincial organizations is often unavailable or difficult to obtain. There seems to be no apparent coordination between Ministries. An example of this is several different agencies collect rain information in the area, but only for their own needs: highways, forestry, and other ministries. There is no attempt to consolidate information.

The Regional District of Nanaimo is currently working on sustainable growth. However, zoning seems to have limited effect on protecting sensitive areas in the long term. The need is for stronger Provincial legislation to provide local government with ways of protecting groundwater resources.

3 Drought Management Awareness

Recommendations from the U.S. Environmental Protection Agency

1. Define the available resources: Water may be available from several sources to meet demands in time of drought
2. Define the demand: The quantity, quality, and location requirements of all users must be defined
3. Describe possible shortfalls in supply: Managing the resources to best accommodate the shortfall in meeting demand under a given drought event calls for sound preparation
4. Describe the management measures for potential events: Define the adopted measures necessary in response to projected shortfalls for various drought events
5. User and public involvement: it has been repeatedly proven that the success of drought management depends most on the understanding and support of the users and the public
6. Securing legislation agreements, rules, and procedures: Any water management under conditions of shortage usually calls for new authority, rules, and procedures; for example, new legislation and specific legal agreements
7. Drought management event plan: Any drought requires a specific set of management actions tailored to the specific event and a mechanism to forecast event dates

Recommendation from the Community Team

1. Monitor current and long-term weather forecasts; keep track of snow pack surveys; know precipitation levels in the area for the last 12 months.
2. Map the change above or below normal groundwater for given dates.
3. Compare the current weekly average flows from the well heads with median flows, and 5 and 20 year return period low flows, over the historic record of the wells
4. Know and promote water conservation issues; examine water use efficiency in the district; have adequate water storage.
5. Consider effective drought-related management decisions both long-term and day-to-day as a drought progressively worsens.
6. Know federal and provincial governmental support programs that may provide financial - support during a drought (if they exist)
7. Have strategies that deal with water inventory, allocation, protection and conservation. Have long-term reasonable options for water conservation and riparian management for the watershed and aquifer.

4 Weather History and Well Production

Past Weather Events

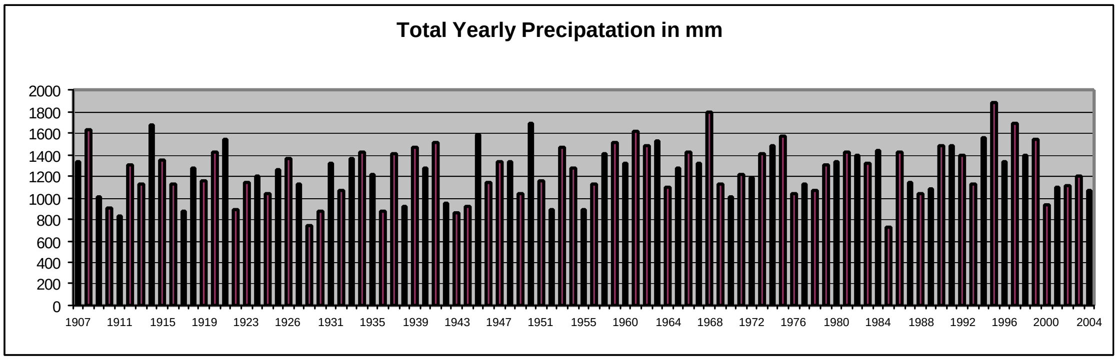

Figure 4.1 Annual rainfall since 1907

A chart showing rainfall figures from the area indicates the yearly variation of rainfall over the past century. Those years with less than 1000 mm would indicate the beginning of a dry period or drought.

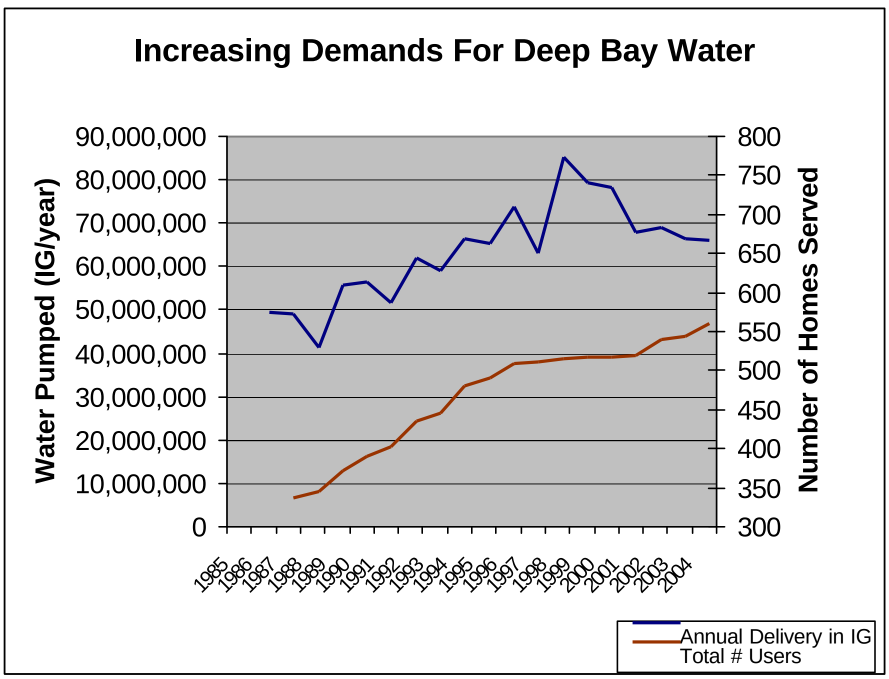

Figure 4.2 Water Demands by Year

Records for water pumped by the Deep Bay wells date back to about 1985. Population increases show a fairly steady growth pattern over this time period.

Maintaining records for weather and water demand provides an indication of increasing water demands on the water resources of Deep Bay. Such events as leak detection and watering restrictions have resulted in a decline in demand while the number of homes being served has increased. This is an important indication that residents are willing to voluntarily support water restrictions and that leak detection programs reduces overall demand. (*from History of Deep Bay file)*

Observation Well

Observation well information provided by monthly observations and government records indicate the fluctuation of water levels in the aquifer. The lowest recorded drop was in 2001 showing a poor recovery during the preceding and following years (2000 and 2002). Recovery to the higher levels seen between 1991 to 1999 have not occurred. *(from OBSW310 1990 to)*

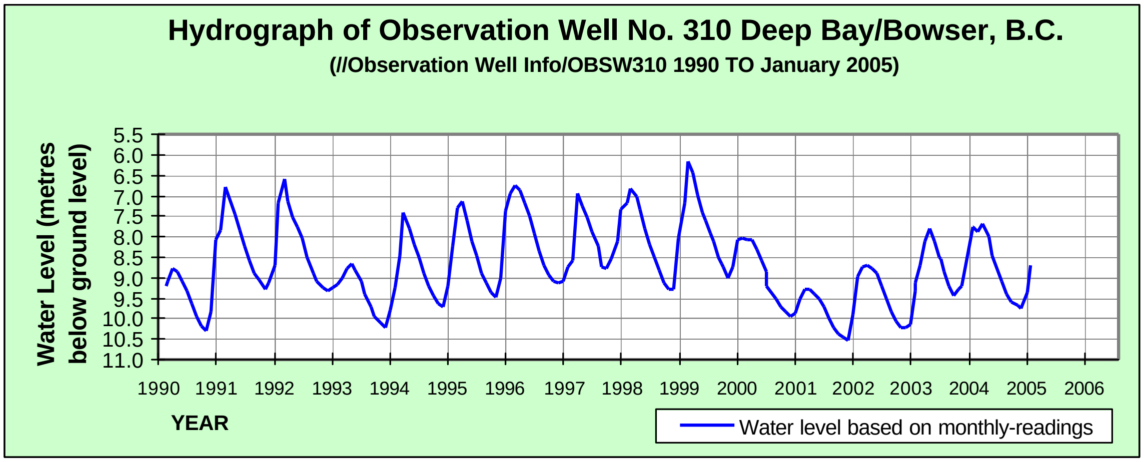

Figure 4.3 Observation well information from 1990 to current readings

The normal fluctuation in the water table varies considerable from year to year. High levels of the aquifer generally occur in February or March with the lowest levels observed in October or November. *(OBSW310 1990 to July 03)*

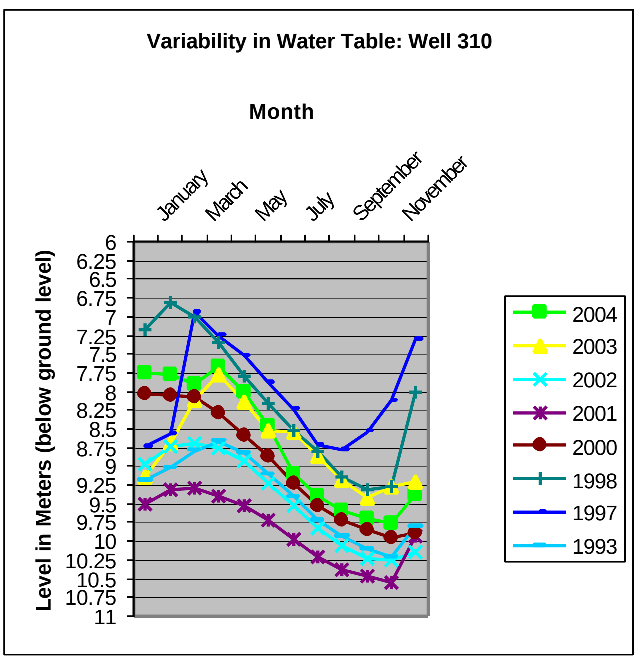

Figure 4.4 Yearly variations in water table

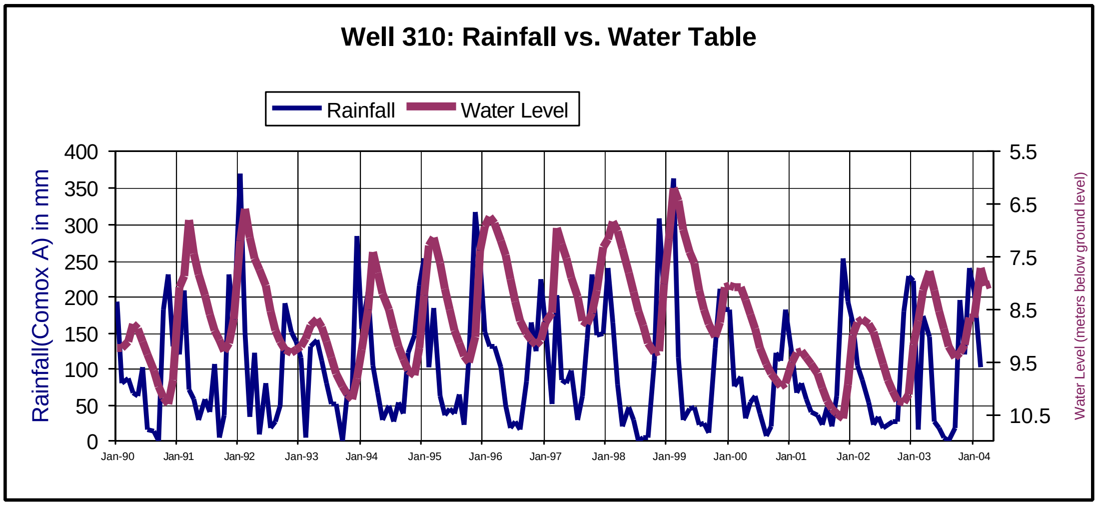

Figure 4.5 Fluctuations in the water table (Observation Well 310) in response to rainfall and drawdown

Blending rainfall records with water table records for the same time period, the correlation between the two is apparent. Reaction to rainfall is nearly always between the time frame of January to February following a low water table. Also from this graph, reaction to rainfall following the drought of 2001 did not result in the immediate recovery. *(OBSW310 to July 2003 with rainfall)*

Monitoring Drought

Because there is no single definition for drought, its onset and termination are difficult to determine. We can, however, identify various indicators of drought, and tracking these indicators provides us with a crucial means of monitoring drought. Determining which indicators to use poses more difficulties for planners: should they rely on data collected for specific parameters (such as streamflow and snowpack), or should they select one or more indices, which incorporate and weigh various types of data in various combinations? Equally important in choosing these indicators is a consideration of the type or types of water shortage facing the planner—an index or parameters well suited to agricultural concerns are of limited use to urban planners.

In order to plan for droughts, more information needs to be gathered on the aquifer/recharge zone, including its extent, forest cover, and climate and the available data needs to be organized. The aquifer is an unconfined or partially confined system developed in sands but the actual extent of the aquifer is unknown. Recharge occurs within a period of weeks to months and the residence time of water in the aquifer is unknown but appears to be relatively short.

5 Infrastructure

This team member spent the weeks of February 13-26, 2005, reviewing the existing infrastructure and documentation at the Deep Bay Water District's wells and the Deep Bay Waterworks Office in Deep Bay B.C. The observations and recommendations are noted in the following paragraphs.

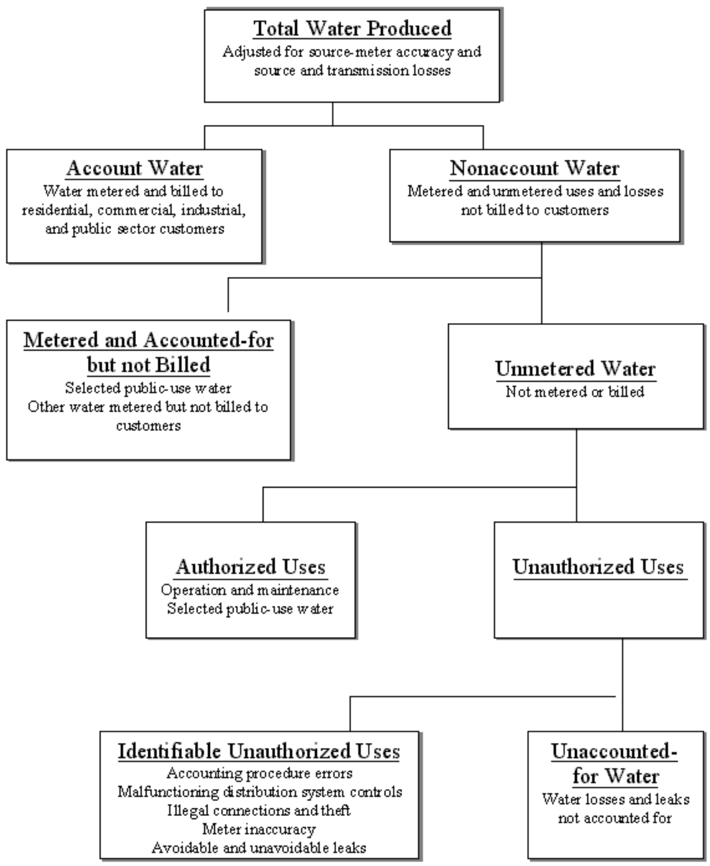

Figure 5.1 Water Accounting System

Current trends in conservation of water

Water pumped or gravity fed into a distribution system can be either authorized consumption or water loss. That authorized water consumption can be metered/un-metered or billed/un-billed. Water loss can be either apparent loss due to water meter inaccuracies or unauthorized consumption or real loss due to leakage at water service lines or breaks on mains and hydrants/laterals or its pumping and storage facilities.

Utility managers and their supervisory water boards must fully understand all elements of their water systems and properly account for the water supplied to their users. This will allow the water board to make informed decisions on operations, maintenance, and capital investment for expansion or upgrading and customer service programs.

Review of existing infrastructure

DBWD's Operation Coordinator, Jim Dennison, accompanied this team member on a field review of the DBWD infrastructure. We visited most well, distribution and storage facilities. The condition of these facilities was considered above normal with regard to appearance, security, maintenance and operation, as compared to the many water systems I observed over my professional years. Of course, there is always room for improvement, but generally, the Water Board should be very proud of their well-maintained and operated water system. For reference to the various systems' components, please refer to Drawing #'s D24-16-1, 2 & 3 in Appendix A.

Well sites: We visited all well sites, including the observation sites 7-96, 310 and the swamp. Well 5-85 was in the process of pump testing as DBWD Operations changed this pump after many years of useful service. The installation of an easily read static water level in well 5-85 is an improvement over the other well sites. All the well sites were easily accessible, well secured and maintained. There was a lack of informational signage at all sites for the public to denote the well site and the need for diligence with regards to possible pollution of the surrounding aquifer area. Due to the planned overflow of the DBWD's storage facility for the testing of well 5-85, all other pumps were not in operation at the time of visit.

Storage facility: The storage tanks were secure and well maintained. The tanks were overflowing at the time and there was some leakage at an upper valve and the lower ditch exit pipe for the overflow needed screening. There was some visible leaching in the corners of the concrete tanks. It was not determined if these were aged filled stress cracks or a natural process. This team member did not view the top or the interior of the tanks. Again there was inadequate signage on this facility for public awareness.

Office and distribution system: From the general appearance of the office, maintenance shop and the overall distribution system were functional, well operated and maintained. The fire hydrants and terminal standpipes were visibly well maintained and accessible. Access to the 6" AC pipeline from Well 2-73 to the 4" AC pipe on Hembrough Road was hampered due to a possible leak along the ROW that caused swampy conditions. The Operations Department was active in investigating and possibly correcting this problem.

Maintenance, well head and office records

Under the assistance of DBWD's Chair, Ron Baldry, Maintenance/Operation Member, George Dussault, and Office Administrator, Tracy Stefani, this team member reviewed the non-accounting file system for plans and documents. It took a full morning for the cursory review due to the need for file re-organization. Mr. Dussault agreed to organize this future task. There was a system of filing that kept the files in some semblance of order. This will be improved with installation of planned file holders and organization of the files. Some out-dated file contents could go into the long-term file storage in the maintenance shop.

The review of the water system's drawings and design information was also cursory. This team member found a partial and incomplete list of the water system's design drawings (See Appendix B) mostly held elsewhere than the office in Deep Bay. There was a lack of adequate elevation and location information on most of the drawings especially on the Drawings D24-16, 1, 2 & 3. This team member found some drawings with offset information for the water services to each lot. This would be quite useful for the location of these services for maintenance or the installation of water meters. There is a lack of any information on the depth of water mains and services.

The location and depth of services can be obtained and documented when new water meters are installed. The Operation/Maintenance Board Member created an adequate format (See Appendix C for Sample) for this operation and adherence to adequate collecting and documenting of this information would assist future effective operations/maintenance.

The Water Board should obtain all drawings and documentation noted on the list of the water system's design drawings for storage at its office in Deep Bay. They should also retrieve and store in Deep Bay's office any further technical maintenance/operation documentation and design information that could assist any reviews or future engineering designs of extensions or up-grades to the water system.

All well sites housed operation and maintenance record books for the past year. The Operation Coordinator was diligent in keeping well site records. These records noted the operating hours and quantities of flow from the wells. The Operation Coordinator could improve the record keeping if this data was periodically typed into the computer at the office. Then board members or others could review, analyze and assess this information.

If drawings and design information was entered into the computer in a digital format, it could also assist board members or others to easily review, analyze, assess or further design the system in an effective and efficient manner.

A brief review of the 2003 Report on DBWD Water System has several recommendations. Some recommendations need serious attention as the DBWD Board could be held liable if storage and the looping of mains, such as, those in the Jamieson Road and Henry Morgan Drive areas, are not planned and undertaken. This team member also questions whether the restricted size of the mains from the pump stations, such as, Well # 8-97 and 5-85, are impeding the efficiency of these pumps. There is a deficiency of data or analyses calculations, such as, in section *12.0 HYDRAULIC ANALYSES*. There are only definitive statements in this report, such as, *"The existing distribution network in Buccaneer Beach (D.L. 40) is not capable of providing the required fire flow…"*.

In order for a professional determination of possible shortfalls in the supply of water, it would be cost effective and efficient to have such analyses and supporting data, especially elevation or profile data, on file in Deep Bay. Due to the incompleteness of the plans and data in the Deep

Bay files at this time, it was not possible for this team member to do even a preliminary analysis of the water system to determine shortfalls.

A brief review of the November 1997 Pacific Hydrology Consultants Ltd.'s report on Well 8-97 noted that the well was rated "*…based on the usual assumption of a 30% factor of safety on the drawdown, including allowances for a small amount of mutual well interference and with the available drawdown decreased to reflect a lower static water level at the time of minimum groundwater conditions in a drought year.*" They also note that the wells should be tested in a drought situation in order to assess the optimum or critical drawdown rates for each well to avoid damage when the drawdown reaches the screen level in a drought situation. The pump would suck air at this time and could cause damage to the pump.

It is perplexing to this community team member how Section 13.0 of the 2003 water report conflicts with the 1997 hydrology report. The hydrology report rated well 8-97 with a 30% factor of safety, yet the 2003 report notes "*Owing to the recurring seasonally summer decline in water levels in the aquifer, the District currently reduces the summer production rates of wells 1-6 inclusive by an average of 18%. It is assumed that this reduction will also be applied to the recently constructed Well 8.*" Does this mean that DBWD Well # 8 is running at 48% (30+18) of its rated capacity? The DBWD should also have the data on file to determine quantitatively whether and when "*the existing 150 mm (6-inch) pumping main serving Wells 4, 5. 6 and 8 is at the limit of its capacity.*"

An effective leak-detection program

After the review of the existing maintenance system, it was evident that the maintenance system employed by the DBWD is quite sophisticated and conducted in such a manner that obvious leaks are dealt with on a priority basis. Individual lots that DBWD service with meters are tested for obvious leaking and monitored until the lot owner corrects the leak.

However, if DBWD does not conduct an audit of the water system, there is no way anyone can guess that all the system's leaks are repaired. Not until the system is totally metered will the DBWD Board will be able to perform an accurate audit. The other option is to do a total system leakage investigation. Due to the cost, this investigation is not warranted, unless major increases in demands indicates a major leakage.

In-line metering of mains to the various developments in Deep Bay is an option before the installation of individual lot meters. At an estimated magnitude of cost of $8-12,000 for each in-line nodal metering station (due to the necessity of installing manhole stations), it is considered to be not a cost effective water conservation option.

Individual lot and system nodal water meters and water depth indicators

To promote conservation of Deep Bay's priceless water resource, it must be a priority of the DBWD Board to install a completely metered water system. With the present rate of meter installation by local forces, it could take 10 years to complete the program in Deep Bay. If the DBWD Board tenders the construction of this program, it could obtain effective control of the system at a much earlier date. It would also possibly be more cost effective. A tender call does not obligate in actual construction. A board review of tenders could decide that only all, 50%, or none of the meters are contracted in one year.

This team member makes the following suggestions for reduction of water losses:

* Calculate the value of water losses to help communicate the value of additional investigations.
* Understand the system's demand characteristics by monitoring pump quantity and hour usage meters at all pumps.
* On a monthly basis, compare usage with the same month of previous years to identify unusual demands or losses/leakages.
* Hire an experienced consultant to conduct the first water audit and then the water board can follow up with annual audits thereafter.
* Assess other water loss reduction strategies (e.g. pressure management, restrictive uses, increased rates for high usage, etc.) for the best approach of the water board.
* Develop an accurate, clear and detailed record-keeping program to register leak or break history, location and type of previous leaks and flow readings.
* Enforce good operation and maintenance practices to prevent or minimize further leaks or loss of service and conduct all necessary system repairs.
* Communicate the results of the water board's program to their users.

Annual water supply audit

To effectively account for DBWD's water, the board should conduct annual water balances or water audits. This would enable the water board to determine the quantity of water delivered, consumed, and lost in their distribution system. They can then calculate what that 'lost' water costs. A water audit ideally should be conducted annually using a water distribution flowchart that identifies water supplied to the system and water used and lost within the system. Strategies to reduce 'lost' water include:

* Leak detection and repair
* Consumption metering
* On-line source water metering
* Valve maintenance
* Water efficiency/conservation
* Pressure management
* Infrastructure upgrading
* Pricing (water rates and development cost charges)
* Speed and quality of maintenance
* Bylaw enforcement
* System inspection
* Zone metering

Deciding which strategies to use will depend on the condition of DBWD's infrastructure and the areas where loss is occurring.

As noted in the *Deterioration and Inspection of Water Distribution Systems: A Best Practice by the National Guide to Sustainable Municipal Infrastructure,* "Water distribution systems should be designed, constructed, operated and maintained to deliver an adequate supply of water in a safe, cost-effective and reliable manner." To that end, we must develop a clear understanding of water main deterioration processes, such as, reduced hydraulic capacity, high leakage or frequent breakage, that will allow DBWD to implement mitigation measures in a timely manner so as to extend the useful service life of the systems. This would minimize the overall economic, social and environmental costs of the water system operation using a two-phase approach.

<u>Phase I:</u> preliminarily assessment of the structural condition, hydraulic capacity, seismic capacity or resistance, leakage and water quality on a system-wide basis using data collected by DBWD staff and government personnel on a regular basis and professional consultant review. This would include assessment of water main breaks, customer complaints, meter losses through water audits, and data on a routine sampling by staff. This would clearly identify both trends and the need for more detailed investigations.

The DBWD Water Board already conducts this approach to identify trends and sanction further investigations but possibly without clear assessments due to the lack of organized data and the informed interpretation of that data.

<u>Phase II:</u> DBWD Water Board should authorize the needed detailed investigations of specific problems based on evaluations of the level of service, economics, risk and benefits. The board can then make informed decisions on how to effectively and efficiently account for DBWD's water, based on the results of those investigations.

Drought Management Implementation

Although there are no known published methods of determining critical ground water levels, the State of New York in its publication *Guidelines for an Emergency Plan for Community Water Supplies* suggests steps to determine critical groundwater levels:

1. Research the water system well data and determine the depth of each pump intake and type of aquifer.
2. Determine the highest static water level during non-pumping conditions.
3. Calculate the maximum safe available draw-down (distance from the static level to the pump intake)
4. Monitor the well's static water level before pumping and during pumping. Calculate the present overall draw-down by subtracting the maximum static water level from the present water pumping level.
5. Divide the present overall draw-down by the maximum safe available draw-down. If this ratio is between 0.7 and 0.8, you should go to a Level I or II stage of Drought Management.

6. If the ratio rises to 0.8 to 0.95, a Level III emergency exists.
7. A ratio greater than 0.95 could be indicative of an immediate loss of pumping ability and thus presents a potential disaster. If at any time, the observed water pumping level falls within 5.0 feet of the pump's intake, the report suggests that a Level III be declared

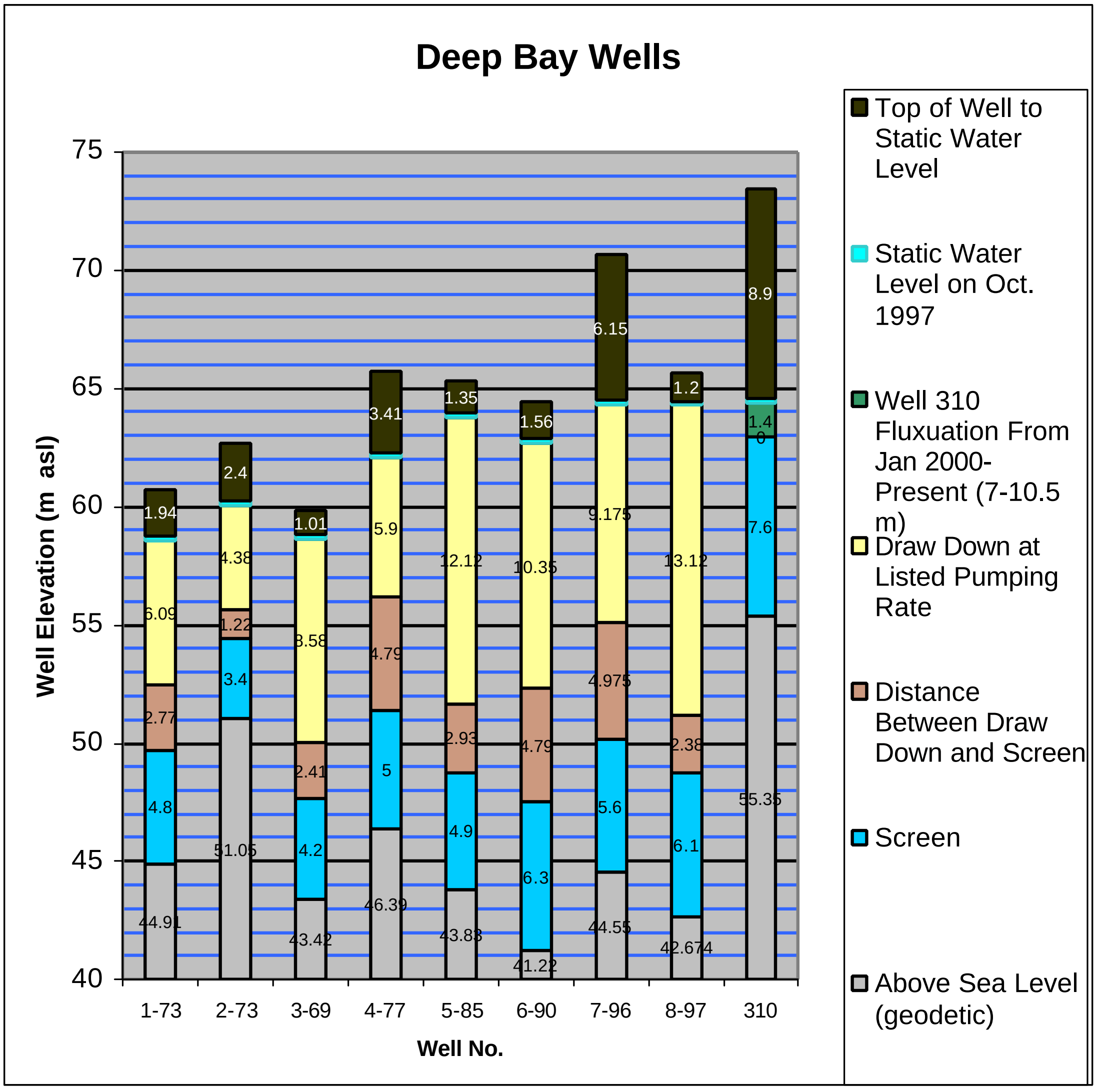

Figure 5.2 Deep Bay Waterworks Well Elevations above sea level (asl). Well information from Pacific Hydrology reports details the elevations of wells. This information provides some indication of capacity. It should be noted the railway crossing at Jamieson is 42 meters above sea level. This is also the approximate elevation of many springs flowing from the aquifer in the Deep Bay area.

The DBWD should concern itself with the management of its groundwater resources. The major concerns are the annual changes in the water table and the nature of the recharging of the aquifer. The recharge of the aquifer and subsequent changes in the water table usually follow specific timings and patterns. Charting of information from reliable sources can show these patterns.

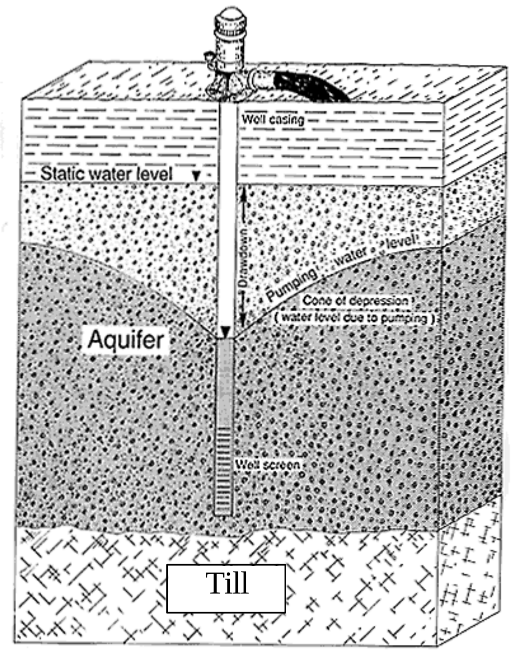

Figure 5.3 Pumping effect on the aquifer: "Cone of Depression"

The aquifer tests conducted by Pacific Hydrology Consultants Ltd. in October 1996 and again in November 1997 on Well # 8 showed that the wells are generally trouble free and the draw downs measured proved that specific capacities of the wells were close to those measured at the times of the various well installations. However, as a possible drought nears and the water demand continues to rise and the wells pump continuously for longer periods, the monitoring of those wells becomes quite effective in determining:

- Reduced Pump or Well Performance
- Depletion of the Aquifer Resource
- Over usage of the Water Resources by the Users

In Memorandum 03-1 from MGE Consultants Ltd to LWBC, it notes that the Deep Bay area may contain zones where the Vashon Till may not exist and the more recent Capilano Sediments (Marine gravel, sand, silt and clay) directly overlie the Quadra Sands and are of a permeable nature. They also note that where this happens, the Quadra Sand aquifer is more vulnerable to surface source contamination. They note that an ***Unconfined Aquifer*** *is an aquifer where the water table is exposed to the atmosphere through openings in the overlying materials.*

This unconfined aquifer seems to be the case after review of the well logs for the DBWD wells alongside of the Old Island Highway. The groundwater even flows within the deep ditches alongside of the highway in the wet season. A possible future accident involving a fuel supply truck and the consequent dumping of any fuel (it only takes a small amount) into the exposed groundwater or the unconfined areas could be a long-term pollution disaster for our now pristine aquifer. Informational signage on the crossing of Deep Bay's aquifer should be posted in both directions to warn the public of this danger.

In the *Drinking Water Review Panel's Final Report* in 2002, it noted that *"… the Panel became increasingly aware of the risks to drinking water sources and systems in B.C.: e.g., source protection is not adequate and may result in expensive water treatment infrastructure improvements, the province has the highest rate of disease outbreaks in Canada and the second oldest water system infrastructure….*" The Panel learned from the Walkerton tragedy that the human and economic costs of disease outbreaks can be horrific. It has become clear to the Panel that these risks cannot be ignored."

6 Aquifer Mapping, Monitoring and Protection

Mapping

The Deep Bay Aquifer was (re)mapped based on a the new hydrogeology study by Thurber Engineering (2004a) and field checks of sediments along Thames, Chef and Nile Creeks as well as local roadcuts. The extent of the aquifer shown here at approximately 625 ha (Figure 1) is smaller than previously reported.

Deposits of the last glaciation in this part of Vancouver Island are collectively referred to as the Vashon Drift. The Vashon Drift includes a lower sand unit, the Quadra Sand, a middle unit, here referred to as the Vashon Till, and an upper unit, here referred to as the Vashon Sands and Gravels. The Quadra Sands were deposited at the onset of the last glaciation and were subsequently overriden by the ice sheet that deposited the Vashon Till. Later, as the ice sheet melted, rivers of meltwater deposited the Vashon Sands and Gravels burying the underlying till with a series of large, partly coalescent deltas. The tops of these deltas are now perched about 120 m above present sea level. This is because sea level in the area has fallen about 120 m over the last 11,000 years. A whole series of raised deltas can be seen along this part of eastern Vancouver Island, where they are the main source of aggregate. The hill at Bowser Seed Orchard is one such delta, though not the largest one. Its summit is at or a little above 120 m asl (metres above sea level) and marks the maximum height of the sea that existed at that time (the Holocene Marine Limit). Figure 6-2 shows the arrangement of the various units, their composition and approximate ages.

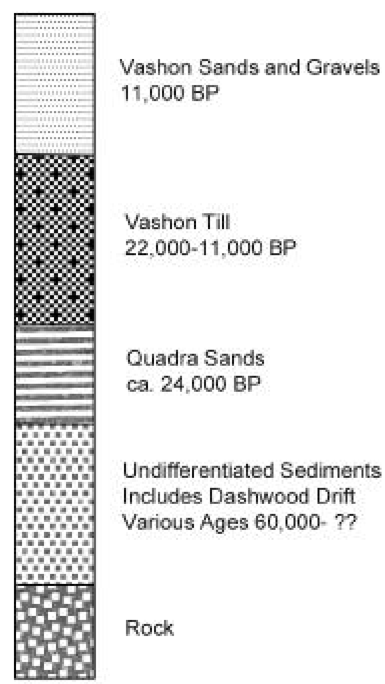

Figure 6-2. Stratigraphic Column for the Deep Bay area. Shows the relative position of units known and presumed to exist in the area and their approximate ages. The lower two units above bedrock, undifferentiated and Quadra Sand were not encountered during field checking.

Field checks on sediments exposed along the creeks and in roadcuts in the vicinity of the Deep Bay Aquifer revealed only two main stratigraphic units. Figure 6-3 is a schematic diagram showing the arrangement of these units in the aquifer area. The lower unit is a gray compact stony till with a matrix of clay-rich sandy silt. This is the regional till sheet from the last glaciation, the Vashon Till, and was deposited between 20,000 and 11,000 BP (Before Present). Far more common in the area were sections in the Vashon Sands and Gravels. These are typically well sorted light yellowish brown pebbly sands. No exposures of Quadra Sands were found and none of the twenty sections examined had sands overlain by till.

The results of the field checking program indicate that the Deep Bay Aquifer is developed entirely in the Vashon

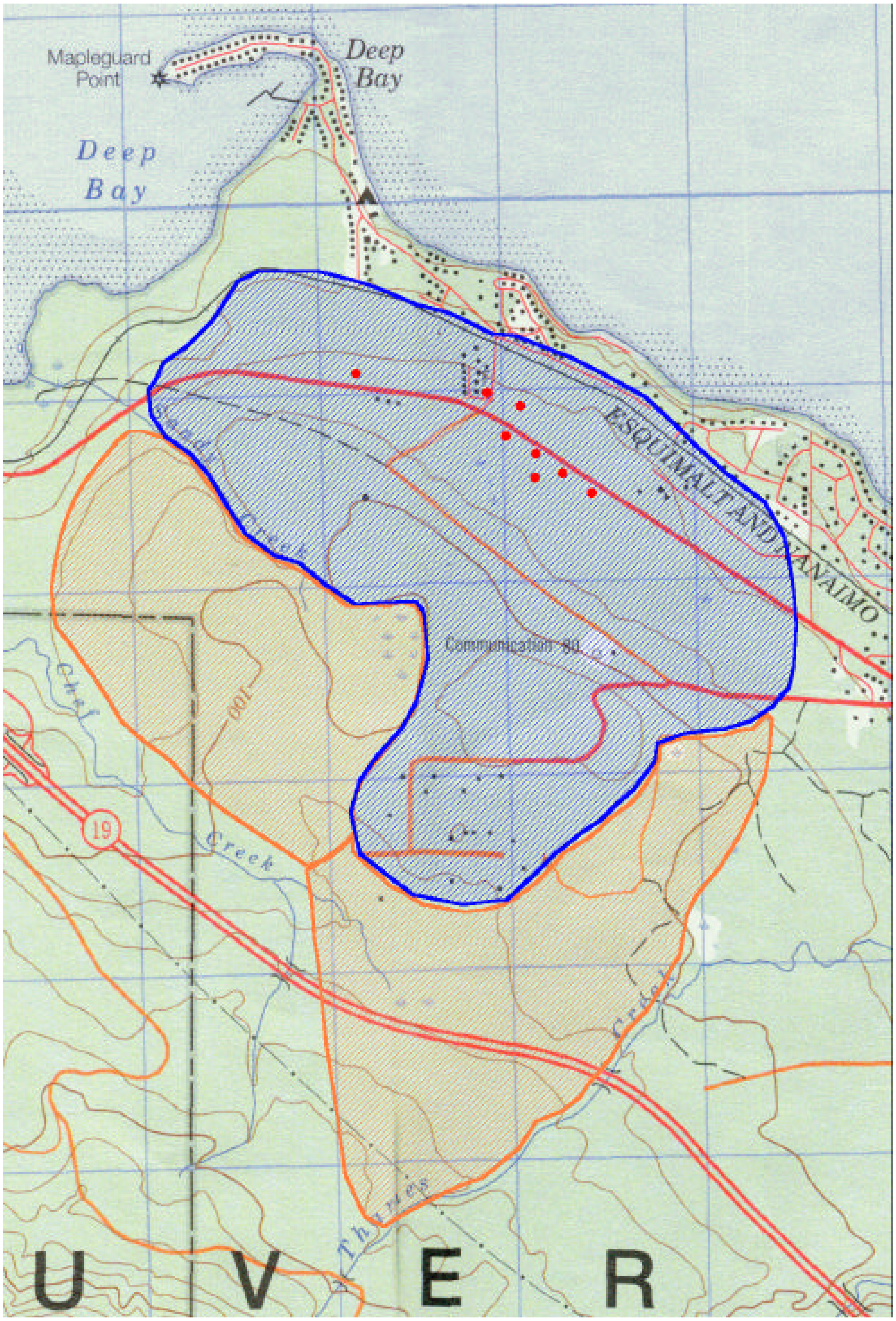

Figure 6-1. Location of the Deep Bay Aquifer. The blue shaded area shows the location of the Deep Bay Aquifer, which is functionally identical to the recharge zone, based on the distribution of the contiguous, unconfined deposit of Capilano sands. The orange shaded areas are potential areas of related smaller aquifers based on the MLWAP mapping and field observations. The red dots are the Deep Bay Waterworks Production Wells. Basemap: National Topographic Map 92F/07, 1:50,000.

Sands and Gravels, and are not in the Quadra Sands at all, nor do they receive water from that unit. These results indicate that the aquifer is developed in a surficial deposit which is almost entirely unconfined. Also, because it is a surficial deposit, the recharge area is essentially the same map polygon as the aquifer.

The main reason for this reinterpretation is that none of the sands examined were overlain by till. Presumably, the last glaciation ice sheet would have left a regional till sheet but in no case was a till found on top of the water bearing sands that form the Deep Bay Aquifer. However, there are numerous exposures of last glacial till in the area and all of them are located stratigraphically below the sands. The lower part of the Thames Creek valley is entirely incised in this material which is at least 20 m thick. Secondly, an important diagnostic feature of the Quadra Sand is their light color but the well logs from the area consistently report that the wells were drilled in brown sand and rarely grayish brown sand, colours typical of the Vashon Sands and Gravels. Thirdly, the possibility that there had been a younger till sheet over the water bearing sands which was subsequently eroded is irrelevant. This possibility, which is essential if the sands are to be interpreted as Quadra Sand, is not discussed in the reports and no evidence was found for an erosional episode because delta surfaces graded to the Holocene marine limit are well preserved in the vicinity of upper Nile Creek and elsewhere. If a till had been stripped from these surfaces one would expect that there would be remnants of till but none of the sites examined had till on top of the water-bearing sand, nor is there any plausible erosional mechanism for removing a regional till sheet without leaving other evidence.

The lowermost unit which was not found in the course of this study, but which does occur in the vicinity, is the preglacial Quadra Sand deposited approximately 24,000 BP (Before Present). The closest known exposure of the Quadra Sand in the area is the Mapleguard Section located just above sea level southeast of Deep Bay. This anomalous low elevation deposit is the type section of the Quadra Sands for this part of Vancouver Island. Other sediments of preglacial age may eventually be found in the area, probably in protected valley bottom locations where they had the best chance of surviving erosion during the last glaciation (see Figure 6-2).

The Deep Bay Aquifer is developed in a surficial sand and gravel deposit sitting on top of the till. Essentially, this deposit is a large delta, and its surface morphology is still visible although it has been eroded somewhat by marine action and surface streams. The top of the delta is the hilltop near the Bowser Seed Orchard. Since it was deposited against the edge of the ice sheet, hence the term “ice-contact delta”. There is no valley connecting to it and all trace of the meltwater stream which deposited it disappeared when ice retreated towards the north at the end of the last glaciation.

During rains, water falls on this relict delta and sinks readily into the outwash sands south of the well field until it encounters the relatively impermeable till below. It then flows along the till/sand contact until it reaches the land surface where it forms a spring or seepage zone. In this unconfined setting the groundwater flow regime follows a hydrostatic pressure gradient determined by the force of gravity. The springs are the source of Deep Bay, Tremaine, Domey, and Jamieson Creeks, as well as several other small, unnamed creeks. Assumptions involving underground lakes and streams, large bodies of groundwater in preglacial sediments or recharge over long distances, for example from the mountains, are unwarranted and completely unsupported by the available data. No transference of water in these sands can occur across creeks whose channels are incised in the till that underlies the surface sands, i.e. the sands the wells are tapping (Figure 6.3). The subtill sand, if it exists, would have to occur below the till, in order to form a conduit for groundwater to cross creeks incised in the till. If the till in this area is underlain by rock, as much of it probably is, then such conduits simply do not exist and even if they did, they would not have been tapped by the existing well field that collects water from a few metres above the sand / till contact. (This explains why it was possible to use creeks incised in the till as boundaries for mapping the aquifer where water bearing sediments are located above the till.)

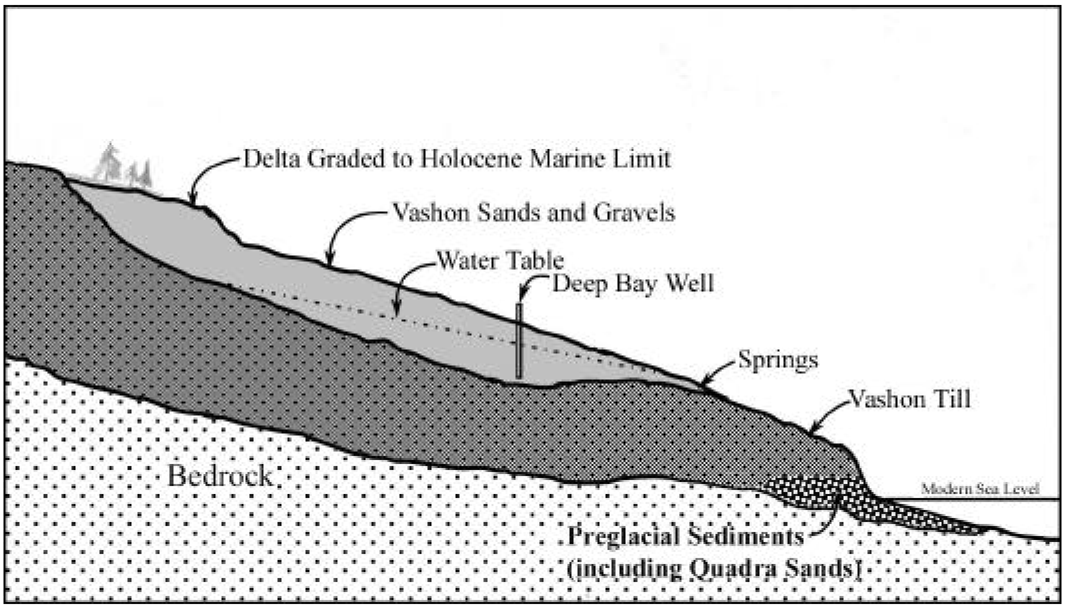

Figure 6-3. Schematic diagram of the stratigraphy of the Deep Bay Area showing the source deposit for the Deep Bay water supply. Rainwater drains rapidly through the permeable Capilano sands and collects on top of the nearly impermeable Vashon till below. It then drains along the top of the till until it reaches a spring or seepage zone at the surface. Not to scale.

The northern boundary of the aquifer (Figure 6-1) is based on a line of bogs and seepage zones that roughly parallels the railroad. The seepage zones mark the contact between the water bearing sands and the underlying relatively impermeable till. The revised extent of the aquifer is approximately 625 hectares. Two other zones were identified that could contain groundwater but it is unknown whether they connect to the Deep Bay Aquifer or function as independent aquifers. These include an area south of Sandy Creek and an area between Cowley Road and Highway 19 (Figure 6-1). The sand deposit on the south side of Sandy Creek is known to be water bearing because there is a spring that empties into Sandy Creek, just southeast of where it crosses Highway 19A. These are areas that warrant further investigation and possibly need protection as potential groundwater reserves for the future.

The reinterpretation of the aquifer sediments as Vashon Sands and Gravels rather than Quadra Sands means there is no regional aquifer that might provide large reserves of water during drought. It also means that there is no confining layer of till which would protect the aquifer from contamination. Because it is an unconfined aquifer in a surficial deposit, the residence time of water in the system is short, with a recharge interval of only a few years rather than decades or centuries. Untapped reserves of water in the aquifer are not expected to be large and will be more likely to be depleted during dry years which will also be the years of lowest recharge.

Land Use Conditions in the Aquifer/Recharge Zone

Using the new delimitation of the aquifer in combination with a 1998 Landsat image (orthorectified 1:50,000 scale) of the area it is possible to estimate the proportion of the aquifer under various land uses. However, new logging and other land use changes have occurred in the area since 1998. The values below are estimates for demonstration purposes only. For minimal additional cost, an updated and more accurate land use map could be generated from 1:20,000 colour air photographs (approximately 2-4 airphotos at $10 each plus shipping). Land use mapping is useful for aquifer management because land use affects the "peakedness" of stream hydrographs and the infiltration rate, and can also be used to estimate the risk of contamination.

Land Use	**Proportion of Aquifer (%)**
Second Growth Forest	64
Residential Subdivisions	18
Logged areas	14
Wetlands	3
Bowser Seed Orchard	1

Aquifer Protection

With the exception of logging, the subdivision at Cowley Road, and the development along Highway 19A, the aquifer land is undeveloped. Several roads cross the aquifer including, Crosley and Cowley Roads, Highway 19A and the old highway right-of-way (dirt road). Bowser Seed Orchard is also on the aquifer. The roads allow uncontrolled public access to the recharge area. The main risk is of contamination from spilled oil, fuels and possibly fertilizers and herbicides.

Because there is no control on road access, the main problem that exists presently is illegal dumping along the backroads. Minimal contamination risk is expected from ordinary yard waste, but yard waste frequently ends up being mixed with other materials, including "agricultural" waste, household garbage and other waste such as old appliances and abandoned vehicles. The situation needs to be monitored, eliminated if possible, and the existing piles of debris cleaned up. A high priority should be placed on preventing the dumping of additional waste, such as household garbage and wastes containing paint, pesticides, used oil, hydraulic fluid, chemicals and metals, because these can contaminate large volumes of water. One way to do this would be to restrict road access to the old highway, where a lot of dumping occurs. Additional enforcement of the existing laws is another solution but due to the remoteness of the area and the short time that it takes to dump materials there, a lot of additional enforcement could be conducted without having any noticeable effect on the problem. In the future, technological improvements may allow for new solutions to the problem such as remotely photographing the license plates of illegal dumpers or similar measures. Roadside dumping is a major environmental problem along many of the backroads that connect to Highway 19A and the aquifer area is cleaner than most. Signage in the area has already been improved somewhat. Recreational use of the area should be encouraged because, to the best of our knowledge, such activity leads to reporting of unlawful dumpsites and a public attitude of environmental responsibility.

The worst contamination risk, and one that is very difficult to mitigate against, is that of a tanker truck spill on the highway in the vicinity of the well field. Such an event could shut down the system completely. In such an eventuality, there needs to be a coordinated response between the various agencies, with a view to limiting the damage if at all possible. Complete interruption of the water supply to protect public health could very well be required.

Ideally, there would be no alterations of the supply area from its natural condition but since there have already been significant modifications to it, including a rural residential subdivision, this is no longer possible. It is possible to restrict development over the aquifer itself and to restrict the areal extent of clearcutting or other alterations that could be done in a given period. For instance limits could be set on the percentage of the area that could be logged each year. Restricting such changes to small areas in a given year would allow the water board to monitor changes in the system and react accordingly before the impact on water quality and/or availability becomes too severe. Any activity that involves removal of the vegetative cover or rearrangement of the natural drainage can reasonably be expected to alter the runoff regime in the recharge area. Human alterations typically result in more rapid runoff (more peaked stream hydrographs) and this limits the time available for water from a rainfall event to saturate the overlying sand and reach the water table. Mature forest cover also intercepts a great deal of precipitation which is then returned to the atmosphere through evapotranspiration, so in some circumstances, during dry conditions, climax vegetation (i.e. mature or old growh forest) might actually retard groundwater recharge.

Presently, parkland zoning is in effect for much of the aquifer, however parts of the recharge area that exist southwest of the height of land near the Bowser Seed Orchard are not protected under the current zoning (see Appendix D for a map of current zoning in the aquifer area). The flow of groundwater does not always parallel the surface drainage even in an unconfined setting. Surficial deposits are not as difficult to map as underground strata, so it should be possible to construct an improved map that will allow protection of the recharge zone which at this juncture would only involve readjusting the present zoning boundary with a view to protecting the entirety of the water bearing sand and gravel deposit.

Aquifer vulnerability according to the BC Aquifer Classification is Level A (Berardinucci, 2002). The aquifer does have very localized confining conditions where silts and clays floor a few natural depressions such as the bottom of Gainsberg Swamp. In the Deep Bay Aquifer, such confining sediments are thin and highly localized. Such wetlands cover only about 3% of the aquifer area (see above) so the level of confinement and contaminant protection is severely limited. The aquifer is not protected by a discontinuous cover of till as was previously suggested. In addition, during high water conditions water overflows these natural basins onto the completely unprotected sand surface where it sinks rapidly to the water table. The result is that even if contaminants are trapped in the wetlands, it is very likely they will find their way into aquifer during the next high water event.

Aquifer Monitoring

Data is currently being collected on observation wells and there are two functioning weather stations in the recharge zone, both run by the Ministry of Forests, however the DBWB could very economically collect these data. For example, weather records are maintained for the hundreds of seed trees at Bowser Seed Orchard, but the possibility of collecting weather data for Deep Bay Aquifer, upon which thousands of people rely, has not been evaluated. It is recommended that the DBWB consider either obtaining the data from the seed orchard, which at the present time can be obtained free, on condition that it not be sold, or install their own weather station. Several off-the-shelf weather stations are available that include dataloggers and software and which record weather observations automatically every 30 minutes. After the system is installed, only minimal staffing would be required because the system is almost completely automated. The cost of this equipment is approximately $1800. To avoid the risk of vandalism, the DBWB Office is probably the best site to locate a new weather station, even if it is not the optimal site from a climatological perspective. It would also be worth obtaining the 3.5 years of detailed data already collected at the seed orchard as well as annual data from them for comparison purposes. Installing and operating a weather station, or simply collecting and utilizing the available local data, avoids the endless quandaries that could arise as to whether the Comox data is really providing an adequate representation of the weather in the recharge area.

The data from weather records can be combined with well level monitoring to answer various questions about the overall operation of the aquifer:

1) The amount of rain that needs to fall, within a specified timeframe, before the aquifer is being recharged.
2) The duration of recharge.
3) The duration that the system can continue operating under drought conditions.
4) The level at which the system is essentially "full" such that continued rain falling on the recharge area does not cause any further increase in well levels.
5) Other questions about the system which may arise in future.

This information would be very useful for deciding how to best manage the system in time of drought or limited supply. For example, it is quite likely that during the dry period, when the soils in the recharge area are dry and well levels are low, that rainfall amounts below a certain threshold level will not contribute to recharging the aquifer because they are being completely intercepted by dry soils and vegetation whereas the same precipitation event in winter would cause a measurable increase in well levels. Better monitoring would also help answer questions about the natural loss presumed to occur during the dry season as water seeps out of the aquifer into the creeks. The contribution of the aquifer to creeks, which maintains water levels during the dry season, has important consequences for the maintenance of fish habitat.

Considering the importance of the water supply, it is recommended that the board not operate in a vacuum without collecting baseline data on the aquifer. This includes weather data however it is collected, well monitoring data, stream gauging and other information they can collect about land use, the extent of the aquifer, hydrogeological studies in adjoining areas etc. Without the benefit of baseline data it will always be impossible to rationally assess the effect of proposed changes to the recharge area. Once changes are made, such as logging or development, there needs to be a retrospective assessment made as to how these things have affected the water system. In the absence of baseline data from the time preceding the change, rational analysis will be forever beyond the reach of the Board. From the perspective of drought management, without accurate climate data and well logs it will be impossible to measure the drought return interval which is very important for future planning that normally uses return intervals for droughts, floods etc. Considering the levels of expenditure on infrastructure and maintenance, the cost of baseline data collection seems a very prudent measure when they provide the basis to plan effectively for the future.

7 Conservation Measures for the Homeowner

> "*We have had a few years now of obviously drier weather, though I can't say if global warming was behind the trend. What I do know is people are going to have to be more conscious of how they utilize water. Do they want to keep their grass green or to have a bath?*" John Finnie, General Manager of Environmental Services, Regional District of Nanaimo, Feb. 2005

Statistics show that community water is used as follows:

2%	Cooking/Drinking
13%	Dishes/Laundry
23%	Baths/Showers
26%	Toilets
36%	Outdoor watering

Source: Greater Victoria Water District

Residents of British Columbia have the highest rate of water consumption in Canada. An average of 440 litres per day per person, or more than 160,000 litres of water per year per person is consumed. It is interesting to note that very little water is actually consumed. Most water is used for some type of cleaning, disposal or irrigation.

The two major factors that contribute to water shortages are the area's population growth and increasing per capita water demand.

The quickest and least costly method to reduce water consumption is to educate users about water conservation. When water meters are used to charge for consumption, installing water-conserving appliances, low-flow toilets and low-volume irrigation systems will make economic sense to residents. Water meters will help accelerate behavior changes in users that think the water supply is endless and water just comes out of a faucet.

As Deep Bay is an Improvement District, non-regulatory methods of reducing water consumption are needed. Public education and 'buy-in' are critical factors to successfully reduce water demand. The Water Board and Water District employees as well as community volunteers are essential for the implementation of water efficiency measures. The Water Board should sanction a committee to oversee water conservation.

The following discussion is a list of conservation measures. Even if relatively few measures are adopted, it will have a huge effect on water consumption for the district. Small changes in attitude can achieve tremendous savings in water consumption when multiplied over the entire Deep Bay population.

Examples of brochures that can be used to disseminate the information are available in the appendix.

Water Efficiency Measures for Landscaping

How does outdoor watering contribute to the problem?

The average household water demand can more than double during the summer with approximately 36% of the total water being used for lawn sprinkling. The high rate of consumption occurs at a period of time when the recharge rate of the aquifer is at its lowest. This can put a tremendous strain on the system. Outdoor watering regulations that are in place at present will not remedy problems associated with population growth and changes in the world's climate.

> To put the problem in perspective, an 8 metre x 12 metre lawn needs approximately 38,000 litres of water during the summer to stay green.

Xeriscaping

Xeriscape landscaping, by definition, is landscaping designed specifically for areas that are susceptible to drought or for properties where water conservation is practiced. Derived from the Greek *xeros* meaning "dry," the term, xeriscape means literally "dry landscape."

Plant specimens are selected that once established would require no watering. These plants can be a combination of natives and exotics.

Rain barrels

Rain barrels are useful for outdoor watering. A program in Delta Municipality estimated that rain barrels can save up to 4500 litres of water per year. A subsidized rain barrel program, as with community compost box programs, will involve more people if there is a rebate. Like the blue recycling box, the rain barrel is a constant reminder to conserve water.

Irrigation

Many systems are available to irrigate lawns and gardens. The homeowner can install some simple systems. Irrigation companies such as the Pump House in Courtenay install systems that are more complex.

* Drip systems
* Micro-spray systems
* Hose timers
* Rain sensors
* Trigger shut off valves on hoses
* Irrigation system moisture detectors
* Electronic timer irrigation controls

Outdoor watering restrictions

Without meters

* Alternate days for odd and even number houses
* Restricted hours for watering
* Allow watering only two days per week

With meters

* Alternate days for odd and even number houses
* Restricted hours for watering
* Allow watering only two days per week
* Surcharge for watering above community average

Lawns

Since lawns consume the greatest percentage of water, they should be designed to be as small as possible to meet the function that the homeowner needs. Drought tolerant grass mixtures should be incorporated. Fescues and perennial ryegrasses are easily seeded and are drought tolerant. This hard wearing mix can remain green all year. During a long hot summer, the grass may go dormant. The lawn retains more moisture if it is mowed to about 5 cm (2") in length, instead of shorter.

Plant placement

Proper placement of plants (wet, dry, sun, shade according to soil preference) will result in plants that require less water with less care and attention.

Watering

* Watering deeply and infrequently encourages deep root systems. Plants, when watered frequently develop shallow root systems and are more susceptible to drought.
* A lawn only needs about one inch of water per week; that is about one hour of sprinkling. Most lawns need about 25 mm (1 inch) of water per week, including rainfall, which can be easily applied on just one sprinkling day.
* Watering early in the morning or early in the evening is best as water evaporates quickly during the heat of the day and watering late at night sometimes causes problems with mold and fungus.
* A good way to see if the lawn needs water is to step on the grass. If the grass springs back up when you move, it does not need water.
* If an automatic irrigation system is installed, make sure it is set to sprinkle within the allowable times.
* Avoid sprinkling paved areas such as sidewalks and driveways

Composting

Organic soils help retain moisture and supplies nutrients to plants

Mulching

Put a layer of mulch around trees and shrubs to reduce evaporation and preserve soil moisture.

Gray water

New construction may be able to incorporate gray water collection in the design. For existing homes, converting plumbing so that gray water can be collected and used for irrigation would not be cost effective.

Other Ways to Conserve Water Outdoors

A garden hose delivers an average of 27 litres of water per minute. It is a quick calculation that leaving the hose on for 15 minutes while washing a car will consume over 400 litres of water.

* When washing your car, make sure that you use a spring-loaded nozzle so that water is not wasted while you are not using the hose.
* Use a broom, not a hose, to clean driveways and sidewalks.

Hard-surfaces

Consider changing a portion of the lawn area to a paving stone patio.

Rebates

Rebate programs may be useful to encourage quicker change in water use. The rebate will be awarded upon proof of purchase and installation by the homeowner.

Examples are:

* Upon installation of 365 day irrigation controller receive a rebate
* Re-seed lawns with drought tolerant grass species receive a rebate

Inside Water Efficiency Measures for Residences

These measures are can range in cost from a few cents for a hose washer to thousands of dollars to refit a house with new appliances. Not everyone can afford the latest water and energy efficient appliances but even modest expenditure can save a lot of water.

Bathroom

* New showerhead - Older model showerheads use 18 to 30 litres of water per minute. New showerheads use 9.5 litre or less per minute.
* Install shower flow restrictor
* Reduce time in shower - Every minute less spent in the shower can save up to 11,000 litres of water per year.
* Faucet Aerator
* Water displacement device
* Dual flush toilets
* 6 litre toilets

The Province of British Columbia recently introduced new regulations requiring the installation of low-flow toilets in all new construction and renovations in the Capital Region effective January 1, 2005. New toilets must use six litres of water or less, per flush. A conventional toilet uses 13 to 25 litres per flush. Low flow toilets can reduce consumption by 20%. Translated for a family of 4 this is an 80,000 litre saving per year. The saving will become significant when meters are installed. Changing older model toilets to low flow toilets should be advertised and encouraged.

Kitchen

* Faucet aerator
* Insulate hot water pipes
* Efficient dishwasher - Dishwashers use approximately 60 litres of water per load. Make sure dishwasher is full before use. Efficient use of the dishwasher will reduce energy costs.

Laundry Room

* Faucet aerator
* Efficient washing machine - Washing machines can use between 100 to 200 litres of water. Make sure water level is set appropriately for the load size. Efficient use of the washing machine will reduce energy costs.

Leaks

The two main sources of water waste are leaks and over watering of lawns.

Leaking toilets - A toilet that continues to run after being flushed can waste from 20 to 40 litres of water per hour. Small leaks in a toilet can be difficult to detect. These are mainly caused by misalignment or worn parts. A dye tablet can be used to see if a toilet is leaking.

Faucets and showerheads - These are usually easy to detect and inexpensive to repair. Worn seats or washers cause these leaks.

Outside hose - Hose connections can often leak and are the result of missing or worn washers. Again, repairs are inexpensive unless the hose needs replacement.

Leaking pipes - These can be more difficult to detect. Clues are damp spots, musty smells or reduced water pressure. Pipe leaks especially on the supply line will be easier to detect when meters are installed.

Irrigation leaks - These can be difficult to detect. Irrigation systems should be checked for excessive wet patches. The irrigation contractor should be called to check the system.

Rebates

As with landscaping, rebate programs may be useful to encourage quicker change in water use. The rebate will be awarded upon proof of purchase and installation by the homeowner.

Examples are:

* With the installation of low-flow toilets receive a rebate
* With the installation of a new low-flow showerhead receive a rebate

Developing Education Programs

All of solutions to conserve water discussed above are voluntary. Therefore, the main objectives of the education programs are to inform residents of ways of how to conserve water. Educating the Deep Bay population is the key to implementing the above water conservation measures.

Funding for workshops and educational programs can be made through interested community organizations. Grants for community projects are available from RDN and other sources.

Watering education programs

* Display at Garden and Artisan show located at the Lighthouse Community Centre
* Display Fall Fair.
* Column in Beacon newspaper with information regarding snow pack, consumption, well levels in addition to other significant information.
* Signage during summer showing water consumption at the top of Jamieson Road and Gainsberg Road.
* Master gardener irrigation training classes.

Workshops

These can be set up with the annual fall fair or spring garden show. Workshops can also be given at Magnolia Court parking lot or at a local business.

* Encourage xeriscape plant gardens
* Soil testing - soil type is important in plant selection and water requirements
* Volunteer gardeners can assess problem gardens and suggest remedies. Streamkeeper groups have successfully used a similar process where fish bearing streams run through residential property.
* School workshops - Teach children about the importance of water conservation.
* 'How to water' workshops
* Introduction to sprinkler systems and design
* Introduction to drip irrigation systems and design
* Landscape design - Encourage reduction in lawn area.
* Encourage historical planting
* Encourage wildlife-friendly planting. Promote the British Columbia Naturescape program.

Build a functioning display garden

* Planned and maintained with volunteer help.
* An ideal location for the display garden is beside the Water District office by the 'Deep Bay' sign.
* Interested nurseries and landscape companies could donate plants and materials.

Flyers

Advertise reasons to conserve water. Many flyers or information pamphlets exist in other jurisdictions. We may be able to use these instead of recreating our own. Flyers can be distributed with the annual water invoice, through an insert in the Beacon or a separate mailing. Savings made by informing the public how to conserve water will outweigh the cost producing and distributing flyers.

Reminders to conserve water

Distribute 'Save Water' fridge magnets. For many residents a constantly visible reminder to conserve water may be helpful.

Awards

Voluntary submissions to the Water District from area builders for a 'Green Builders' award can produce dramatic results in renovations and new construction. Builders can use such an award as positive advertising for their services.

Schools

* Children must learn where their drinking water actually comes from - not a faucet
* Tours of a well, pumping station, aquifer.
* Class room presentations of how our community water system works.

It is important to reiterate that participation at all levels is the key to making water conservation measures work.

These conservation measures will also help residents of Deep Bay prepare for water metering.

8 Regulatory Methods of Reducing Water Demands:

Bylaw Limitations of Improvement Districts

Improvement districts have no control of zoning and population increases. They can, however, require restrictions on water usage. All homeowners can be required to reduce watering by regulations defined by bylaws. Applying the regulations would require the ability to reduce or limit water supply to the homeowner. However, to determine the homeowner is not complying with regulations would probably require meters.

Any water management under conditions of shortage usually calls for new authority, rules, and procedures; for example, new legislation and specific legal agreements. Unfortunately, restrictions on water use are limited to guidelines.

Metering, when available throughout the district, will afford greater control and monitoring of usage. There are many pricing strategies used with metering. The following offers some of those schemes.

About Water Pricing

Prices signal value to consumers and help determine whether consumers use water efficiently. If prices are too low, consumers will use too much water. Economists have long advocated the "user pays" principle.

Full cost pricing is usually interpreted to mean factoring all costs - past and future, operations, maintenance and capital costs - into prices. Full cost pricing can take the form of any of the rate structures below so long as all costs are recovered through prices.

Types of Pricing Structures

Several price structures are available for water providers seeking to encourage conservation.

* **Increasing block rates.** Increasing block rates or tiered pricing reduces water use by increasing the per-unit charges for water as the amount used increases. The first block is charged at one rate, the next block is charged at a higher rate, and so forth.
* **Time of day pricing.** Higher prices are charged during a utility's peak demand periods.
* **Water surcharges.** A higher rate is imposed on "excessive" water use, i.e., water consumption that is considered higher than average.
* **Seasonal rates.** Prices rise and fall according to water demands and weather conditions (with higher prices usually occurring in the summer months).

There are also other rate structures that are currently used by water providers; however, these types of rate structures are not as effective in encouraging conservation.

Uniform rate structures. A uniform rate charges the same price per unit for water usage beyond the fixed customer charge, which covers some fixed costs. The rate sends a price signal to the customer, because the water bill will vary by usage. Uniform rates by class charge the same price per unit for all customers within a customer class (e.g., residential or non-residential).

Flat fee rates. Flat fee rates do not vary by customer characteristics or water usage.

9 Implementing the Drought Management Plan

User and public involvement: it has been repeatedly proven that the success of drought management depends most on the understanding and support of the users and the public

Publicize the Proposed Plan, Solicit Reaction

If there has been good communication with the public throughout the process of establishing a drought plan, there may already be better-than-normal awareness of drought and drought planning by the time the Trustees recommend various drought mitigation and response options.

During drought, the Trustees should keep the public well informed of the current status of water supplies, whether conditions are approaching “trigger points” that will lead to requests for voluntary or mandatory use restrictions. All pertinent information should also be available on the Waterwork’s drought website so that the public can get information directly from the task force without having to rely on mass media.

Drought management event plan:

Any drought requires a specific set of management actions tailored to the specific event and a mechanism to forecast event dates

It is helpful to establish a sequence of descriptive terms for water supply alert levels, such as advisory, alert, emergency, and rationing (as opposed to more generic terms such as phase 1 and phase 2, or sensational terms such as disaster).

Issues related to these descriptive terms would include: loss of potable water; loss of firefighting water; total loss of water.

Establishing Critical Water Levels

The following is a set of instructions provided by the NYRWA for the state water purveyors:

New York Rural Water Association Recommendations

http://www.nyruralwater.org/aquafacts/summer2002/8.shtml

Local Source Water Levels

Establishing critical "trigger" water levels is comparatively easy for surface water sources. Surface water levels can be readily observed and the amount available can be calculated. However, water levels in wells are not as readily measured and the relationship between water level drawdown and well yield is often complex. The remainder of this article focuses on how groundwater systems can establish critical water levels for drought response.

Determining Critical Groundwater Levels

There are no published methods of determining critical groundwater levels for drought stages. As the NYSDOH indicates in the *Guidelines for the Preparation of an Emergency Plan for Community Water Supplies* "there are no simple formulas applicable to every geological condition, hydrological condition, and type of well construction to determine critical water levels…" I have looked into how a groundwater system could derive critical groundwater levels and have formulated a possible methodology that I describe as follows.

The first step in determining the critical groundwater levels that should be used to declare local drought stages is to research your system well data and determine the depth of the pump intake and the type of aquifer. This information is critical. Second, you must determine the maximum static water level for the well. This is the highest water level observed in your well during non-pumping conditions. If you have not been monitoring the water levels, you can initially use the static level on the well completion report completed by the driller. However, this static level is not likely to be the highest static level experienced in the well and this number should only be used until you have been better determined the maximum static level in the well.

Third, you must calculate the maximum safe available drawdown for the well. For unconfined sand and gravel aquifers, this is the difference between the depth of the pump intake and the maximum static level (Figure 3). For confined aquifers, it is the difference between the depth to the top of the confined aquifer and the maximum static level (Figure 4). For bedrock wells it is the difference between the depth of uppermost water-bearing fracture zone and the maximum static level (Figure 5).

Next, begin monitoring pre-pumping (static) and pumping water levels on a daily basis. If necessary install a stilling tube and use an electric water level indicator or have a pressure transducer probe installed in the well. Calculate the present overall drawdown by subtracting the maximum static water level from the present pumping water level.

Finally, divide the present overall drawdown by the maximum safe available drawdown. If this ratio is between 0.7 and 0.8, you should consult the state's regional drought stage and determine if a local watch or warning is in order. A ratio of 0.8 to 0.95 suggests that a drought emergency exists and water restrictions may be in order. A ratio of greater than 0.95 could be indicative of an imminent loss of pumping ability and thus represents a potential disaster. In addition, if at any time the observed pumping level reaches within 5 feet of the pump intake, I would suggest initiating a drought emergency and reduce use of the well. Keep in mind that these numbers are my own invention and should only be used as guidelines.

Based on this system, the study's community team members devised a localized set of drought stages and triggers as noted in the concluding table in this section.

Define the adopted measures necessary in response to projected shortfalls for various drought events

Bylaw 153, passed in February 2002, is used for regulating the distribution and use of water and prescribes penalties for non-compliance with the regulations. It provides for Trustees to introduce regulations when necessary (presumably for drought conditions), but does not describe these regulations.

In establishing water regulations, defining levels of concern for the public to understand the consequences of their actions should they not feel it is necessary to comply. Residents should understand the seriousness of the drought stage to respond appropriately.

Water restrictions have been utilized for the past several years to reduce the strain on the waterworks system during peak days during the summer months. This does have the affect of reducing demand on the aquifer, but has really provided a reduction of demand on pumping resources. The aquifer has always been perceived as having sufficient, if not surplus water to service the community.

Droughts occur in cycles of months to years. Assuming the possibility of an extended drought, plans should be developed for managing resources given the possibility of a severe drought.

One of the difficulties in establishing guidelines is determining how serious the drought may be or could become. Review of rainfall patterns, discussions with past trustees about years with low rainfall, discussions with past maintenance people and the problems seen in the operation of the wells during dryer periods provide some indications of “triggers” for local drought stages. Until we have actually reached lower water table levels, the suggested guidelines are based on recommendations of the Community Team. The Team reviewed the drought indices used by other water purveyors using groundwater from aquifers.

In establishing critical groundwater levels for drought response, response levels are also provided. The definition of five drought stages are given. At level 5, Emergency Stage the highest level established, import of drinking water supplies may be necessary. It basically represents a loss of potable water and loss of firefighting water from the Waterworks service.

The following provides a guideline for implementing water restrictions and expected goals for reducing water demands. Following the more descriptive suggestions, a table is provided establishing critical groundwater levels for drought response. There are five levels of response suggested.

Drought Response Plan

Goal for reducing water demands: 5%

Stage 1:

Watch

Stage 1 is used to prepare for an impending drought. Deep Bay Waterworks will inform customers of the conditions and ask for a voluntary reduction in water usage.

RESPONSE OPTIONS ARE

1. Increased public education.
2. Water suppliers cut back on water use (flushing)
3. Water suppliers fix all leaks and wastes of water and conduct leak survey
4. A voluntary reduction goal of 5% in indoor and outdoor water use

Stage 2 :

Advisory

Goal for reducing water demands: 15%

RESPONSE OPTIONS ARE

All Stage 1 response options remain in effect.

Additionally:

1. Intensify voluntary water conservation measures and prepare the public for mandatory measures
2. Restrict use of water from water system to water lawns, trees, shrubs, gardens, to limited hours of day, alternate days of the week (rotate based on street address)
3. Restaurants are requested to voluntarily discontinue serving water except upon request.
4. Hotels and motels are urged to implement water conservation measures, including the reduction of laundry water usage.
5. Monitor compliance

Any of the above measures may be implemented as warranted.

Stage 3 :

Alert

Goal for reducing water demands: 30%

RESPONSE OPTIONS ARE

All Stage 1 and 2 response options remain in effect.

Additionally:

1. Outdoor watering will be limited to once per week as per the following schedule. Watering will occur before 9:00 a.m. and after 7:00 p.m. and shall be limited to two hours per day. The last number of the street address shall determine watering days.
   Watering Schedule:

Day	Mon	Tue	Wed	Thu	Fri	Sat	Sun
Last # of address	-	0	1,3	2,4	5	6,8	7,9

2. Outdoor watering performed with a permanent drip irrigation system, sub-surface irrigation, or reclaimed water is exempt. Using a bucket to water trees, shrubs and flowers is permitted. Using household gray water is encouraged.
3. Parks and schools served shall water in accordance with a special permit issued by Waterworks and will reduce consumption by a specific amount per month based on reduction targets set by Waterworks to meet basic demand.
4. No new landscaping shall be installed or planted and no new landscape watering permits will be issued except for Xeriscapes which are drip irrigated using a permanent system, use subsurface irrigation, or are irrigated with reclaimed water. New landscaping watering permits shall be granted for a 7-day period for landscaping that incorporates compost in the area at a rate of 5 cubic yards per 1000 square feet of turf.
5. Routine fire hydrant or main flushing and testing shall be curtailed.
6. Existing swimming pools cannot be filled with potable water supplied by the Waterworks after April 1. Single-family residential swimming pools must be covered when not in use. Pools can be topped off to replace water loss by evaporation.
7. Upon a second violation of the Drought and Water Emergency Management Response Plan, the Trustees may order the installation of a restriction device.
8. Impervious surface cleaning with potable water shall be prohibited, except where conducted by order of the Health and Environmental District or the Police and/or Fire Department.
9. A drought surcharge may be added to water rates.

Any of the above measures may be implemented as warranted.

Stage 4: Rationing

Goal for reducing water demands: 50%

RESPONSE OPTIONS ARE

All Stage 1, 2, and 3 drought management response options shall remain in effect.

Additionally:

1. All outdoor watering is prohibited, except when performed with a spring loaded nozzle or permanent drip irrigation system.
2. All car, trailer, truck, and/or boat washings are prohibited.
3. No swimming pools shall be filled.

Any of the above measures may be implemented as warranted.

Stage 5: Emergency

Goal for reducing water demands: Maximum possible

RESPONSE OPTIONS ARE

All Stage 1, 2, 3 and 4 drought management response options shall remain in effect.

Prepare for providing drinking water to residents from alternate sources.

Local Drought Stage*	Water Reduction Goal / Stage Triggers	Actions at Drought Stage
1. Watch	Goal: 5% reduction End of February: Rainfall for current year less than 1,000 mm	DBWD Operations cut back on water use (flushing) DBWD Operations fix all leaks and wastes of water and conduct leak survey DBWD Water Board urges DBWD Users to conserve water
2. Advisory	Goal: 15% reduction Observation Well 310 level > 9 m (below ground level)	All items from Stage 1 plus DBWD Water Board intensifies promotion of voluntary water conservation measures and prepare DBWD Users for mandatory measures DBWD Water Board restrict use of its water for watering lawns, trees, etc., to limited hours of day, alternate days of the week (rotate based on street address)
3. Alert	Goal: 30% reduction Observation Well 310 level > 10.5 m	All items from Stages 1 and 2 plus DBWD Water Board prohibits washing of vehicles using water from the system DBWD Water Board prohibits use of water from its system to wash streets, driveways, etc. DBWD Water Board restricts use of its water for watering lawns, trees, shrubs and/or gardens to limited hours in evenings once a week
4. Rationing	Goal: 50% reduction Observation Well 310 level > 11.5m	All items from Stages 1, 2 and 3 plus DBWD Water Board prohibits all outdoor water use for any purpose DBWD Operations maintain maximum water levels in storage for fire protection
5. Emergency	Goal: Maximum Possible Observation Well 310 level > 12.5m	All items from ALL Stages plus DBWD Water Board prepare for providing alternate drinking water to residents

Figure 9.1 Local Drought Stage Table (see *Notes)

*Notes on Local Drought Stage Table:

- > This study's Community Team set the preliminary **Goals and Triggers** based on available data currently on file and past drought experiences within the DBWD.
- > **Water Reduction Goals** are based on 10-year averages for that time of the year
- > **Alert Level Trigger** is based on the lowest observed level of Well 310 recorded in 2001
- > All **Stage Triggers** can be further adjusted by the DBWD Water Board in the future based on suggested static water levels by a new tendered hydrologist study of all well production in a drought year (as recommended in Pacific Hydrology Consultants Ltd.'s Well 8-97 Report)

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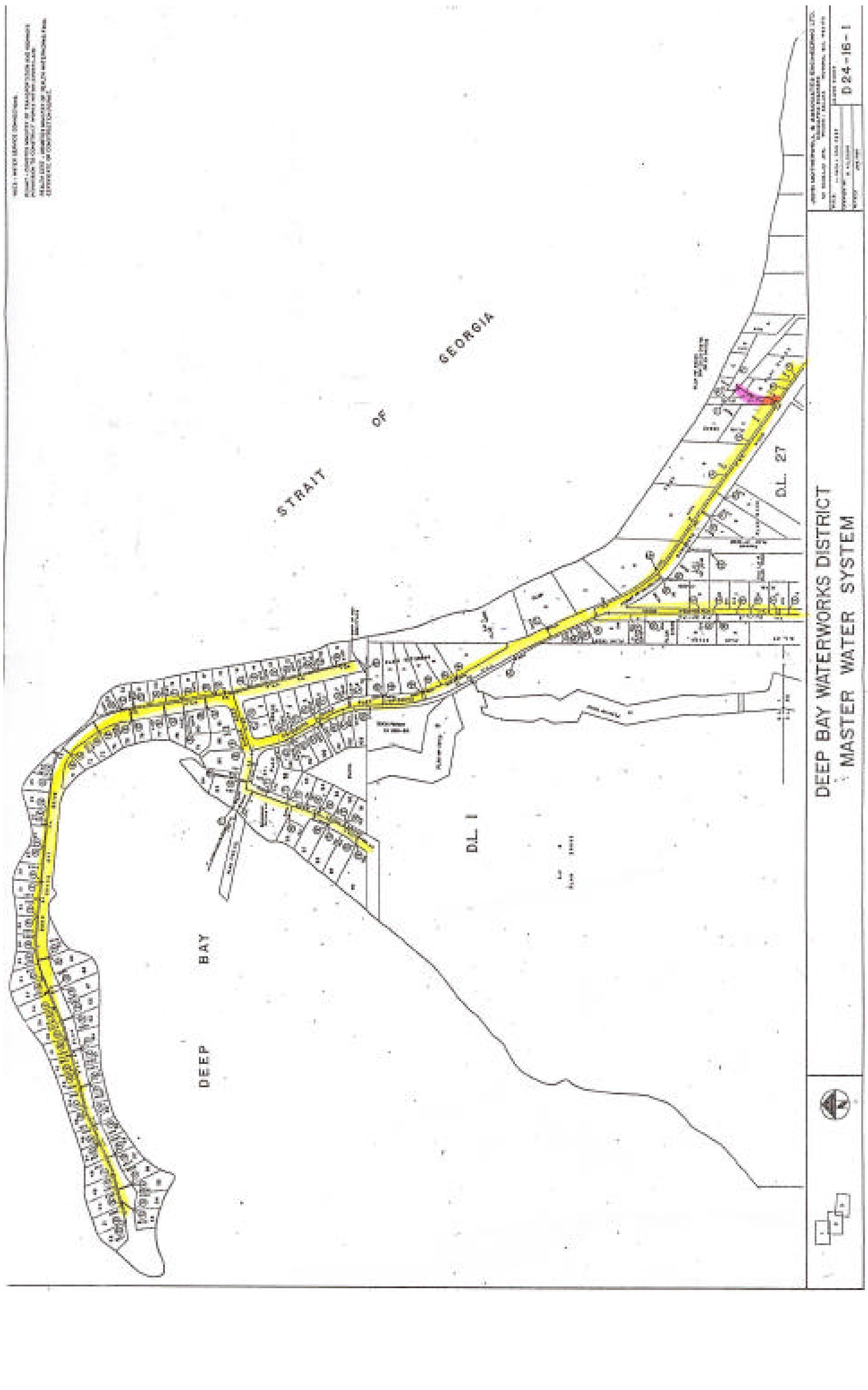
APPENDIX A


STRAIT OF GEORGIA
DEEP BAY
D.L. 27
D.L. 1
DEEP BAY WATERWORKS DISTRICT
MASTER WATER SYSTEM
D24-16-1


DEEP BAY WATERWORKS DISTRICT
MASTER WATER SYSTEM
STRAIT OF GEORGIA
D.L. 28
D.L. 27
D.L. 82
D24-16-2


DEEP BAY WATERWORKS DISTRICT
MASTER WATER SYSTEM
D24-16-3
STRAIT OF GEORGIA
Buccaneer Beach
Lighthouse
D.L. 40
D.L. 82
D.L. 86

APPENDIX B

D-24 Deep Bay Waterworks District

1	Deep Bay	Deep Bay WWD Report (Formerly D-27-1)
2	Deep Bay	Contour Map
3	Deep Bay	1974 - 1975 Water System Project
4	Deep Bay	Kopina Estates Water System
5	Deep Bay	R/W survey for well in D.L. 28 Kopina Estates
6	Deep Bay	Running production S Bdy, D.L. 28 for tank site
7	Deep Bay	Kopina #3 well & 10' pipe connection
8	Deep Bay	R/W Plan in D.L. 28 Newcastle District
9	Deep Bay	Well for DBWD on Gainsburg Road
10	Deep Bay	Proposed 1" water service for Deep Bay
11	Deep Bay	Buccaneer Beach Project
12	Deep Bay	2nd 60.000 IG. Cell for reservoir
13	Deep Bay	#4 Well Project
14	Deep Bay	1978 Water System Project
15	Deep Bay	Sewer Disposal for Trailer Office
16	Deep Bay	Master Water System
17	Deep Bay	Proposed 1979 Buccaneer Pipeline Extension
18	Deep Bay	Fraser Subdivision
19	Deep Bay	Cost Estimate for 1981 Water System project
20	Deep Bay	#2 Well
21	Deep Bay	1981 Buccaneer Pipeline Extension
22	Deep Bay	#4 Well Site Survey
23	Deep Bay	Water Extension for new school (Bowser Elementary)
24	Deep Bay	Cell "C" Reservoir 60,000 ig
25	Deep Bay	Cell "D" Reservoir 60,000 ig
26	Deep Bay	Well #5 Site Project
27	Deep Bay	Update of Master Water System - 1986
28	Deep Bay	Three Phase Power - #4 Well
29	Deep Bay	Proposed #6 Well Site Project
30	Deep Bay	Location of Monitor Well
31	Deep Bay	1989 Alteration to 12" Main
32	Deep Bay	1990 Fire Line Deep Bay Wharf
33	Deep Bay	1990 Pipeline Closings in Buccaneer Beach
34	Deep Bay	#6 Well Construction
35	Deep Bay	1991 Revisions to #6 Well Site Survey
36	Deep Bay	Application for lease of Part of D.L. 28
37	Deep Bay	1992 Sabina Road Cost Estimate
38	Deep Bay	1992 Faye Road Extension
39	Deep Bay	SRW - #2 Pumphouse in Part of Parcel C of 5 DD 70377H
40	Deep Bay	Cut out lines on triangle parcel D.L. 28
41	Deep Bay	1994 Extension on Faye Road
42	Deep Bay	1994 Subdivisions
43	Deep Bay	#7 Well Project
44	Deep Bay	#8 Well Project -
45	Deep Bay	SRW for DL 28 loop (July 97)
46	Deep Bay	No.7 Well Engineering
47	Deep Bay	No.8 Well Engineering
48	Deep Bay	SRW for Pipeline Extension on Maple Guard Drive

DEEP BAY WATERWORKS DISTRICT
WORK ORDER

WORK ORDER #. 0402 **DATE:** ____________

ADDRESS / LOCATION ____

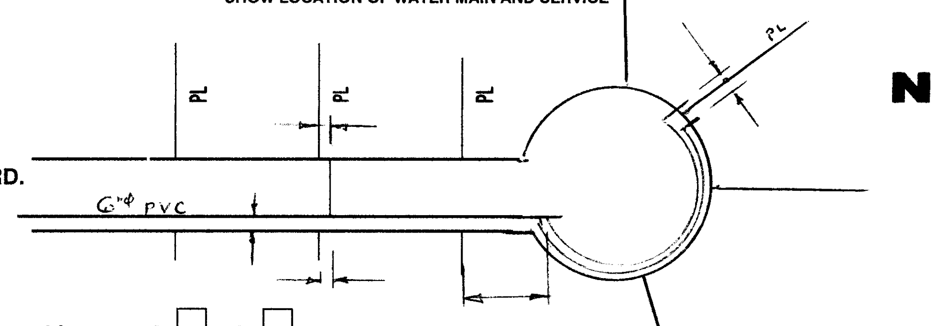
SERVICE REQUIRED ____

____

____

SHOW LOCATION OF WATER MAIN AND SERVICE

SABINE RD.



MATERIAL REQ`D. YES ☐ **NO** ☐ **IF YES, SPECIFY** ____________________

____

____

____

____

EQUIPMENT RENTAL : YES ☐ **NO** ☐ **IF YES SPECIFY**

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____

____

ADDITIONAL LABOUR REQ`D. YES ☐ **NO** ☐ **IF YES SPECIFY**

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ADDITIONAL INFORMATION

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DATE COMPLETED ____________ **MAINTENANCE CONTRACTOR** ____________

APPENDIX D

RDN Zoning (Official Community Plan)

The area marked in green currently has limited protection as Crown Land designated as parkland under the RDN zoning designation.