DEPARTMENT OF WATER AFFAIRS AND FORESTRY

TECHNICAL GUIDELINES FOR THE DEVELOPMENT OF WATER AND SANITATION INFRASTRUCTURE

SECOND EDITION: 2004

PREFACE

The first version of these Guidelines was issued in 1999. The original guidelines were specifically developed to give technical guidance to engineering and other experts who were responsible for developing RDP type water supply projects on behalf of the Department of Water Affairs and Forestry.

There have however been a number of fundamental changes since 1999, which prompted the Department to update the guidelines.

Firstly, a greater emphasis has been placed on the provision of basic sanitation services, necessitating the inclusion of guidelines on basic sanitation infrastructure.

Secondly, Government funding for water services is now channelled directly to Local Government through the Municipal Infrastructure Grant. With few exceptions, municipalities will in future be the main developers of basic services infrastructure.

Thirdly, much experience has in the interim been gained in the development of water services infrastructure and these lessons needed to be captured in the guidelines.

Finally, the adoption of the Strategic Framework for Water Services has impacted on the definition of basic services and on the approach to developing these services.

The purpose of this updated 2004 version of the guidelines is primarily to pass on the experience of national government in the development of water and sanitation services, and especially the planning and design of water and sanitation infrastructure, to local government. It is believed that this document will accelerate the learning process of those in local government who are taking full responsibility for water services development for the first time. It is also believed that these guidelines will be just as useful to those who wish to refine their existing knowledge.

While these guidelines are mainly technical in nature, the wider issues such as the social aspects and the operation and maintenance of water services infrastructure will be addressed in other documents.

A large number of experts from the Department of Water Affairs and Forestry and other organisations have selflessly contributed their experience towards the development of these guidelines. It is acknowledged that these guidelines would not have been possible without their contribution.

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COMMONLY USED ABBREVIATIONS

CD	Compact disk
DBSA	Development Bank of Southern Africa
IDP	Integrated development plan
DPLG	Department of Provincial and Local Government
DWAF	Department of Water Affairs and Forestry
LG	Local government
MIU	Municipal Infrastructure Unit
SANS	South African National Standards
SABS	South African Bureau of Standards
SFWS	Strategic Framework for Water Services
WSA	Water services authority
WSDP	Water services development plan
WSP	Water services provider

1 INTRODUCTION

Municipalities have a Constitutional responsibility for providing sustainable and viable water services to the communities within their areas of jurisdiction.

The purpose of these guidelines is to assist municipalities undertake the development of water and sanitation infrastructure, with a focus on the design aspects of development.

Further guidelines are in the process of being developed for Water Services Development Plans, social aspects and operation and maintenance of water services projects.

1.1 Purpose of guidelines

It is important to note that these guidelines:

- ARE MERELY INTENDED TO GIVE GUIDANCE TO MUNICIPAL OFFICIALS, PLANNERS AND DESIGNERS.

- Are not intended to replace professional expertise and engineering judgement.

- Provide overarching guidance and cannot be used as a replacement for specifications.

- Must be used together with recognised standards, codes, and acts such as those of the South African Bureau of Standards (SANS Codes), the Water Services Act, the National Water Act, and the Occupational Health and Safety Act.

These guidelines are made available through two media:

- A CD has been distributed which contains this document as well as a number of useful folders. The contents of the folders are listed at the end of this document.
- A downloadable version of the document is also accessible from the web page of the Department of Water Affairs and Forestry. The DWAF web page also contains the same folders that are included on the CD.

1.2 Definitions of minimum norms and standards

The aim of Water Services projects funded out of government grants is primarily to provide a basic level of water services.

Section 6 of the "Strategic Framework for Water Services" provides the minimum technical norms and standards for water services. The Strategic Framework is included in the ***Legislation and Policy Folder***.

The following definitions and minimum standards are given in the Strategic Framework:

Basic water supply facility is:
The infrastructure necessary to supply 25 litres of potable water per person per day supplied within 200 metres of a household and with a minimum flow of 10 litres per minute (in the case of communal water points) or 6 000 litres of potable water supplied per formal connection per month (in the case of yard or house connections).

Basic water supply service is:
The provision of a basic water supply facility, the sustainable operation of the facility (available for at least 350 days per year and not interrupted for more than 48 consecutive hours per incident) and the communication of good water-use, hygiene and related practices.

Basic sanitation facility is:
The infrastructure necessary to provide a sanitation facility which is safe, reliable, private, protected from the weather and ventilated, keeps smells to the minimum, is easy to keep clean, minimises the risk of the spread of sanitation-related diseases by facilitating the appropriate control of disease carrying flies and pests, and enables safe and appropriate treatment and/or removal of human waste and wastewater in an environmentally sound manner.

Basic sanitation service is:
The provision of a basic sanitation facility which is easily accessible to a household, the sustainable operation of the facility, including the safe removal of human waste and wastewater from the premises where this is appropriate and necessary, and the communication of good sanitation, hygiene and related practices.

Potable water quality is:
Water supplied by water services providers intended to be used for drinking or domestic purposes (potable water) must be of a quality consistent with SANS 241 (Specifications for Drinking Water), as may be amended from time to time.

Metering and flow control:
All unrestricted water connections must be metered or controlled to a basic level. Where appropriate, water services providers should consider the benefits of offering households controlled flow connections (for example, yard tanks) that can provide a basic supply of water cost-effectively. Where pre-payment meters are installed, these must take into account the free basic water services policy and allow for access to a basic amount of water at zero tariff.

Eradication of bucket toilets:
The bucket system is an unsuitable and inappropriate level of service. All water services authorities must identify and implement programmes for the eradication of all bucket systems by 2006.

1.3 Project development life cycle

A typical project development life cycle consists of the following phases:

Establishment of institutional arrangements

The designated municipality is the water services authority and is responsible for water services provision. The water services authority either contracts with a water services provider or fulfils that function itself.

Planning phase

The municipality:

- prepares a Water Services Development Plan (WSDP) as part of its Integrated Development Plan (IDP) for the area of jurisdiction of the Water Services Authority (WSA);
- undertakes Feasibility Studies for each water or sanitation project identified in the WSDP.

DWAF integrates all WSDPs into a National Reference Framework.

Design phase

The municipality procures the design consultant who designs the works and prepares the tender documentation or the municipality does it in house.

Tender stage

Advertising, site inspection, adjudication of tenders received and award of contract.

Construction phase

Execution of the works in accordance with the tender documentation under supervision

Operations and maintenance

The Water Services Provider operates and maintains the works (with or without the assistance of contractors) and collects the revenue.

The Water Services Authority (WSA) monitors the Water Services Provider (WSP) and manages the contract that it has with the WSP.

The WSA undertakes an annual water services audit and reports to DWAF who performs the function of Regulator.

2 LEGISLATION AND POLICY

A number of important statutes and policy documents govern the development and operation of community water supply schemes. Legislation affects all phases of development, and for example stipulates requirements for taking water from the resource, for the planning of water services, how to determine institutional arrangements, and the requirements for financial and other reporting.

The most important legislation and policy documents governing the development and operation of water services are:

- Constitution of the Republic of South Africa, 1996 (Act 108 of 1996)
- Water Services Act, 1997 (Act 108 of 1997)
- National Water Act, 1998 (Act 36 of 1998)
- Municipal Systems Act, 2000 (Act 32 of 2000)
- Municipal Structures Act, 2000 (Act 33 of 2000)
- Public Finance Management Act, 1999 (Act 1 of 1999)
- Local Government Municipal Finance Management Act, 2003 (Act 56 of 2003)
- Division of Revenue Act-Enacted Annually
- Strategic Framework for Water Services, September 2003
- White Paper on Sanitation, September 2001
- Regulations under S9 of the Water Services Act, 1997
- Regulations under S10 of the Water Services Act, 1997
- Regulations under S 19 of the Water Services Act, 1997
- Model Water Services Bylaws. Section 21(1) of the Water Services Act, 1997
- Guidelines For Human Settlements Planning and Design (Red Book). Obtainable from the CSIR.

The full text of these documents, with the exception of the Red Book, are included in the ***Legislation and Policy folder*** of the guidelines CD. Most of these documents must be read with Acrobat Reader which is available on the Web

Specific sections of these documents will also be highlighted in the different sections of the Guidelines.

3 INSTITUTIONAL ARRANGEMENTS

3.1 Introduction

The following institutions are responsible for the supply of water and sanitation services:

- The Water Services Authority;
- The Water Services Provider (Sometimes a Water Board or bulk water provider); and
- The Department of Water Affairs and Forestry as regulator.

Other National Government Departments also fulfil important roles. For example DPLG manages the Municipal Infrastructure Grant and the Equitable Share and the Department of Health has an important function regarding health and hygiene and sanitation.

A Water Services Authority (WSA) is the municipality that has been designated responsibility for ensuring access to water services. The WSA is both the owner of the works and is the elected representative of the customers.

A water services provider (WSP) is the person or organization that actually provides water services to consumers or to another water services institution. The WSA can either appoint a WSP, for example another municipality, a water board or a private contractor, or can fulfil the function itself.

3.2 Deciding on and contracting with a water services provider

The WSA should follow the procedure set out in S78 of the Municipal Systems Act when deciding whether it should fulfil the WSP function itself or whether it should contract with a separate WSP. A model Terms of Reference for a S78 Assessment has been developed by the Municipal Infrastructure Unit (MIU) which is associated with DBSA. This model Terms of Reference is included in the Institutional Folder.

S19 of the Water Services Act sets out requirements that must be complied with when a WSA contracts with a WSP. The Minister has promulgated regulations under S19 of the Water Services Act which sets out the minimum requirements with which a contract between a WSA and a WSP must comply. These regulations are included in the ***Legislation and Policy Folder***.

Even if the WSA fulfils the WSP function itself, it should account separately for water services, i.e. it should:

- keep separate financial accounts of how much was spent on or invested in water services during each financial year;
- the revenue it received from the sale of water services;
- funds received from National Government and other sources that were allocated to water services etc.

Water Services includes both water supply and sanitation services.

3.3 Bylaws and other requirements

S21 of the Water Services Act requires that WSAs must make bylaws which contain conditions for water services. Model Bylaws that comply with the requirements of S21 of the Water Services Act are included in the ***Legislative and Policy Folder***.

4 PLANNING

4.1 Introduction

Water and sanitation projects are essentially planned at three levels:

- At the national level the Department of Water Affairs and Forestry (DWAF) maintains a national reference framework;
- At a municipal level each Water Services Authority (WSA) compiles and regularly updates a Water Services Development Plan (WSDP); and
- At a project level each WSA undertakes a feasibility study for each project and compiles a technical report.

This hierarchy of plans are discussed below:

4.2 National reference plan

The Department of Water Affairs and Forestry is required to comment on the Water Services Development Plans (WSDP) of each WSA and to ensure that all current and projected activities are compatible with the national strategies. To enable a common framework for assessing WSDPs, a National Reference Plan is being developed which will capture the essence of each WSDP in one common structure that relates water services planning to the National Water Resource Strategy, Catchment Management Strategies (together with water allocations and licensing), Provincial Strategies and IDPs.

The reference framework will cover the following topics:

- General (Locality map and Demographics);
- Physical & Socio-Economic Development;
- Water resource availability, allocation and licensing;
- Service Level Development;
- Water Resource Development;
- Water Conservation & Demand Management;
- Water Services Infrastructure;
- Water Services Authority Institutional Arrangement;
- Customer Services;
- Financial Profile; and
- Project Development.

Municipalities will need to cross reference their plans to the National Reference Framework in order to integrate their own planning with other developments being undertaken in surrounding areas.

4.3 Water services development plan

Sections 12 to 18 of the Water Services Act, 1997 requires a Water Services Authority to prepare a Water Services Development Plan. These sections describe how to develop and adopt a WSDP and sets out the contents of the WSDP.

The Water Services Act, 1997 is included in the ***Legislation and Policy Folder***.

Whilst the WSDP is a legal requirement, the real value of preparing a WSDP lies in the development of a plan whereby the key municipal water services targets are set for a five year period.

The WSDP forms a subset of, and must be aligned to, the municipality's Integrated Development Plan (IDP).

The Department of Water Affairs and Forestry has prepared a set of Guidelines for preparing a WSDP. These Guidelines provide basic information about the WSDP, as well as specific information on how to prepare the WSDP.

The DWAF WSDP guidelines are included in the ***Planning Folder***.

4.4 Feasibility studies and technical reports

The aim of Water Services projects funded by municipalities out of government grants is primarily to provide a basic level of services to the poorer residents of the municipality.

Previously, project level business plans were compiled by municipalities for purposes of project approval and allocation of funds by national government. Under the Municipal Infrastructure Grant (MIG) it is no longer necessary for municipalities to submit business plans to National Government for approval. However municipalities are still required to plan for projects (feasibility studies) and to submit a Water Services Project Technical Report to the appropriate DWAF Office for recommendation before releasing funds for water services projects. It is recommended that the same approach be followed for all Water Services projects.

Essentially the Water Services Project Technical Report (Technical Report) comprises a description of the following elements of the project:

- Population
- Water consumption
- Existing works
- Water source
- Proposed works
- Supply pipelines and pump systems

- Service reservoirs
- Water purification works
- Distribution network
- Estimated cost of integral parts
- Unit cost of water
- Viability, acceptability and sustainability of proposed project
- Legal requirements

The format of the "Water Services Project Technical Report" is shown in the table below:

FORMAT OF WATER SERVICES PROJECT TECHNICAL REPORT

1.1	Introduction	(a) Name the engineering reports from which the report was compiled. Relevant letters or notes should be enclosed. (b) General A good concise description of the location of the local community or supply area based on its geographical location and main routes serving the area. The socio-economic activities of the community with much emphasis on the development prospects that can be realistically expected of the area as well as the climatic factors and their influence on the water consumption. (c) General nature and extent of the problem with regard to the water supply.
1.2	Existing works	A concise description of the existing works in which the relevant storage capacities, yield capacities, distances and heights are reflected and preferably it should be further illustrated by means of a site map or a diagrammatic sketch plan. In respect of the particular component of the works that has to be improved, more detail should be included, whereas more general detail on the remaining elements will suffice although the extent, condition and effectiveness thereof should be indicated. Briefly, the extent of the works is as follows:
1.2.1	Existing Water source	(a) From own sources, e.g. boreholes, reservoirs and/or abstraction from public

		streams. General detail, relative location, method of abstraction or supply, existing yield capacity, water rights, etc. (b) From other sources, e.g. Government water works, common works, or supply by water boards.
1.2.2	Existing Supply pipelines and pump systems	A general description, diameter, length and yield capacity of pipelines and pump units and, where applicable, number of pump units, pump heads, etc.
1.2.3	Existing Service reservoirs	Location, volume, condition and expected useful life and adequacy.
1.2.4	Existing Water purification works	General dimensions, type of treatment, yield capacity and adequacy.
1.2.5	Existing Distribution network	• General dimensions, condition and adequacy. • Is total use being metered? • Is every point of supply equipped with a meter? • Is the bulk supply to the different communities being metered? • How is water supplied to the different communities? • Stand-up taps or indoors? • Is there a water-borne sewerage system in these communities? • Are such improvements being planned for the future and, if so, for when? • How much is the unaccounted water?
1.3	Population	An estimate of the population growth over the next 25 years in stages of five years, showing the population to be provided out of the existing works and the population to be provided out of the proposed works. This estimate should be approached cautiously taking into account all pertinent factors, in comparison with the historical growth and accompanying socio-economic circumstances. Unless there are specific circumstances demanding elucidation, any estimate of the population growth is assumed to link up with the available census information.

		Where available the official information for the past 25 years for the supply area of the water scheme should be provided. If the supply area varies from the census area or if the census returns do not correspond with the area's own surveys, the latter figures should also be provided. If no figures are available a judicial estimate should be made of the present population, based on known items such as number of houses, etc.
1.4	Water consumption	The conditions and particulars of the water consumption over at least the preceding five years should be provided. In some areas records covering longer periods are available and it is useful to provide this information in such instances. The projection of the expected water needs should be compiled from various parameters that have an effect on the water consumption, e.g.: (a) Historical water consumption; (b) the unit consumption; (c) population projection; (d) water consumption of the business centre; (e) water consumption of the industrial area; (f) schools, hostels, old age homes, army complex, etc.; (g) municipal consumption, e.g. irrigation of sports grounds, parks, etc.; (h) unmetered use; (i) losses. If the losses in a system are higher than say 10%, an accurate loss analysis ought to be done on the system; and (j) climatic factors. In item (b) attention should also be given to the expected increase in unit consumption taking place as a result of the improvement in living standards. The estimates of the future water needs should be calculated in stages of five years over the next 25 years, and where applicable the expected peak consumption should also be shown. An example of a table that can be used in calculating the projected future water consumptions is given below.
1.5	Water source	A general description of the source, in addition to the description given in paragraph 1.2.1 above, indicating the adequacy of the source to meet the

		expected future water consumption. If the source is a storage dam or if one is being developed, the basic data of the dam should be furnished, i.e. the assured yield, mean annual runoff, size of catchment area and storage capacity of the dam basin. If available, information on the silting up should be included. In respect of boreholes the dependable yield of the various sources should be provided and for existing boreholes their performance during dry periods should be mentioned. Where water sources are shared with other consumers, the apportionment, water rights, agreements, permits, water court orders, servitudes, tariffs, etc. should be fully set out. Where the water source is being further developed, proper hydrological and/or geohydrological reports should be compiled. For new schemes the necessary permits, water court orders, servitudes etc. should be obtained. The quality of the water should be given as well as any process that will be used to treat the water should be commented on.
1.6	Proposed works	In the introductory paragraph a concise explanation should be given of the reasons for deciding on the water scheme or works in question. Where applicable it should be done on the basis of information obtained from an economic study or evaluation of alternatives weighed up against each other. The reader should be convinced that the proposed works represent the most favourable alternative and that works must indeed now be constructed. Further phases (say for the next 10 to 20 years) should be stated briefly so that a complete view of the future planning may be formed. Further, the individual components of the scheme should be described to provide at least the following information: (i) Description and dimensions: Volume, yield capacity, diameter, length, pumping head, pump yield

		capacity, pump drive requirement. (ii) Serviceability of proposed components in respect of the required rendering of service, i.e. to what extent future demands will be met. (iii) In respect of water feeder systems the peak capacities of the feeder pipes and water purification works should be mentioned. As regards distribution systems the maximum and minimum pressures in the network during zero and peak consumption should be furnished.
1.7	Integral parts and estimated cost	In this paragraph the engineer should give a capital cost estimate of the proposed scheme as accurately as possible. The term "integral parts" relates to those components of the scheme that can function independently, e.g. pipelines, pumping station, reservoirs, purification works, powerlines, dams, pressure towers, etc.
1.8	Operation and maintenance arrangement	It is important that arrangements for the operation and management of the works are dealt with before the project is completed. The designer of the project should provide the operating authority with an operating manual, in advance, in order for it to train or appoint qualified personnel to operate and maintain the project.
1.9	Viability	Calculations to show that the operations and maintenance are financially sustainable through a mix of tariff revenue and equitable share and other allocations.
1.10	Legal Requirements	Legal requirements that need to be complied with including water use licensing and Environmental Impact Assessments.

Example of a table for cost estimation:

ITEM	DESCRIPTION	COST (R)
1.	Concrete reservoir 1 000 m^3	....
2.	Pumping station	....
2.1	Pumping gear 2 x 55 kW x 35 l/s @ 65 m	....
2.2	Pump house (50 m^2)	....
2.3	Electricity supply KVA x L meter	....
3.	Main supply pipeline (35 l/s)	....
3.1	8 000 m x 250 mm dia	....
3.2	4 000 m x 200 mm dia	....
	Subtotal	____________________
	10% contingencies	....
	Professional fees and supervision	....
	Subtotal	
	Total estimated cost	____________________
	VAT	....
	Total cost of scheme	____________________

2. UNIT COST OF WATER

The total annual expenditure on completed scheme must be calculated in terms of the present cost.

An example on calculating the unit cost is given below.

EXAMPLE OF A TABLE THAT CAN BE USED IN CALCULATING THE PROJECTED FUTURE WATER CONSUMPTION

YEAR	HOUSEHOLD			INDUS-TRIAL	INSTITUTION SCHOOLS HOSP. ECT.	MUNICIPAL AND LOSSES	TOTAL CONSUMPTION		AVERAGE DAILY PEAK DEMAND	GROWTH RATE
	NUMBER	AVERAGE DAILY CONSUMPTION					DAY	YEAR		
		1/c	m^3/d	m^3/d	m^3/d	m^3/d	m^3/d	m^3/d	m^3/d	%/a

A. PRECEDING WATER CONSUMPTION (A record of at least the preceding 5 years ought to be provided.)

The actual annual water consumption for the previous 5 years should be shown to provide an indication of the historical growth rate. Sometimes these particulars are simply not available. A grouping of available data of actual water consumption according to group consumption and the determination of actual unit consumption of the various population groups, present the possibility to do more accurate projections of future water consumption. If bulk water meters are not available, summation of sales can be integrated with the general monthly bookkeeping. With modern accounting equipment it can probably be readily integrated.

B. PROJECTION OF FUTURE WATER CONSUMPTION

The method of calculation and assumptions on expected consumption should be motivated and should be compatible with the WSDP. The Departmental standards indicate the minimum standard to which consumption for institutions, etc., should be added. Some estimates assume larger unit consumptions per capita, whether as a result of gardening, high living standards, climatic conditions or because a separate estimate is not included for schools, hospitals and businesses etc.

The format of this example allows for gradual adjustment of unit consumption which mainly applies where improved services and exalted living standards eg. as a result of future indoors water supply and sewerage. Rainfall and climate information, nature of population composition and the economic activities (e.g. wet industries) of the community therefore should be elucidated in the report.

EXAMPLE OF A TABLE TO CALCULATE THE ANNUAL COST:

ITEM	DESCRIPTION	COST (R)
1.	Interest and redemption	
1.1	Existing works	
1.2	Proposed works R x A% p.a. for 25 years	
2.	Maintenance cost	
2.1	Existing works	
2.2	Proposed works	
2.2.1	4% on mechanical equipment to the value of	
2.2.2	1% on pipelines and powerlines to the value of	
2.2.3	0,5% on civil works to the value of	
3.	Electricity cost E kWh @ B c/kWh	
4.	Chemicals Z m3 @ C c/m3	
5.	Salaries and wages of operating staff required i.t.o. section 12A of the Water Act	
6.	Administrative costs @ RD per point of connection	
	TOTAL ANNUAL COST	
	Based on the estimated annual water consumption the unit of water is	x c/m3

NOTES:

(A) Interest rate at time of application for funds.

(B) Cost of electricity per unit.

(C) Cost of chemicals per m3 (kl).

(D) The actual estimated administrative cost.

(E) Total units estimated to be used.

(Z) Estimated water consumption plus losses.

5 DESIGN CRITERIA

5.1 Introduction

These planning/design criteria have been determined to provide a basic level of water supply with some provision has been made for the future upgrading of the supply to higher levels of service. For higher levels of service the Red Book should be used.

Not withstanding the guidelines given in this document, the professional responsibility for selecting appropriate planning/design criteria for the specific circumstances remains with the planner or design engineer.

5.2 Summary of design and planning criteria

Recommended planning/design criteria are summarised in the following table:

GENERAL SUMMARY OF BASIC PLANNING AND DESIGN CRITERIA

1	Design Horizon:	10 Years from commissioning for pipelines and reticulation. 5 - 10 years for all above ground civil works and mechanical and electrical equipment.
2	Population:	For Design Horizon as above.
3	House occupancy:	6 persons (unless evidence exists to prove otherwise).
4	Growth Rate: (up to Design Horizon)	As projected in WSDP or otherwise proved. Could be as low as 0% in some areas.
5	Design Water Usage:	60 lcd for all infrastructure components In cases of restricted groundwater sources, a minimum water usage of 25 lcd is acceptable for pumps, pumping mains and elevated tanks only. Even in cases of restricted groundwater sources reticulation is to be designed for 60 lcd.
6	Design Loss Factors (LF):	i) Water treatment works, LF_w = 10% ii) Total conveyance losses, LF_r = 10%
7	Gross Average Annual Daily Demand (GAADD):	GAADD = (1 + LF_r) * AADD
8	Summer Peak Factor:	SPF = 1,2 minimum to 1,5 maximum
9	Summer Daily Demand, WATER TREATMENT WORKS AND	SDD_{ww} = SPF * GAADD * (1 + LF_w) Design Pumping Period = 20 hrs/day

	RAW WATER AND CLEAN WATER PUMPS, (SDD_{ww}):	
10	Summer Daily Demand, BULK SUPPLY PIPELINES, (SDD_{pl}):	SDD_{pl} = SPF * GAADD
11	Summer Daily Demand, BOREHOLE PUMPS, (SDD_{pu})	SDD_{pu} = SPF * GAADD Design Pumping Period – See below
12	Storage Reservoirs: (Total Storage, i.e. Regional and Village Reservoirs combined, but excluding elevated tank volume)	48 Hrs * AADD Pumped from One Source 36 Hrs * AADD Pumped from Multiple Sources 24 Hrs * AADD Gravity Source Recommended to split volumes roughly equal between Regional and Village storage's for new reservoirs. A maximum of 24 hours and a minimum of 16 hours is required at Village storage. Reinforced concrete structures only acceptable. Exceptions apply for a groundwater source supply where a ground level storage is inappropriate. In this case an elevated tank with 16hrs (for 2 or more powered borehole pumps) to 24hrs * AADD (one powered pump only) for 25 lcd is acceptable.
13	Elevated Tank/Tower: (Only required to provide reticulation pressures)	4 Hrs * AADD (only for area to be served by tank) Max. 6 x 10 kl for polyethylene tanks on stands. From 75 kl and greater size use pressed sectional steel tanks on stand.
14	Design for pipeline flow between Main Storage and Elevated Tank:	2 * GAADD (Gravity) 2 * GAADD (Pumped: 20hrs/day)
15	Design Peak Factor (for Reticulations):	DPF = 2 to 3
16	Design Peak Flow Rate (DPFR for Reticulation):	DPFR = DPF * GAADD Primary reticulation designed to supply 60 lcd for all erven, but only standpipes and existing erf connections to be provided against project costs. New erf connection piping to be paid for by the new consumer.
17	Standpipe design: Flow Rate	DPFR divided by No. of standpipes, subject to a minimum of 10 1/min (0,17l/s) per tap Note: Standpipe with two taps – flow rate 20 l/min
18	Standpipe design: Spacing	Each household must be within a 200m radius of a Standpipe Note: Additional standpipes should be provided if a

		physical barrier, such as a river, main highway, railway or long housing block unduly lengthens the walking distance to standpipes.
19	Residual Pressures (above GL):	10 m minimum at point of delivery, where possible. *Flow limiters must be installed on stand pipes when Residual Pressure are greater than 25 m above GL.*

5.3 Water availability

A common cause of scheme failure is the overestimation of the availability of water. Care must be taken that the underlying assumptions of water source availability are proven, especially in the case of ground water and where river abstraction is not controlled by significant upstream storage.

5.4 Power availability and alternative pump drives

It is also important that the availability of a power supply for the project is properly investigated. Installation of long power lines may prove to be very expensive. Dedicated transformer supply points are preferred.

In some instances an economic Eskom power supply may not be available, in which case alternative power sources for driving pumps must be considered. There are many factors to be considered in these instances and it will be up to the engineer to investigate these factors. Some of the factors to be considered are:

- Amount of power required.
- Can this be provided by solar means - usually for small power requirements.
- Can the pumps be directly driven by a diesel engine.
- Can a diesel generator be provided in anticipation of later conversion to Eskom power supply.
- Are facilities for operation and maintenance of diesel engines available,
- The comparable cost of each solution.

5.5 Guidelines for economic optimisation of pump - pipeline sizing

Two or three of the preferred layouts should be compared in terms of cost, technical feasibility, economic viability, social and environmental impacts.

5.5.1 *Economic analyses*

At the preliminary design stage, economic analyses will normally only be undertaken for surface water pumping mains. The purpose is to optimise the pump and pipeline sizes by comparing the net present value of alternative configurations.

These analyses are not usually relevant for small village pumping mains from localised boreholes.

Usually the analysis compares net present values over a planning horizon of 30 years.

The recommended criteria to be used for economic analysis of water supply infrastructure are as follows:

(i) Infrastructure Lifetime:

Small pumps and motors	15 years
Electric installation	15 years
Structures and buildings	30 years
Pipelines	30 years

(ii) Power Costs: Eskom Tariff A

(iii) Operation and Maintenance Costs:

Pump station:	0,5 % per annum (p.a.) of total pipeline costs
	0,25 % p.a. of pump station civil costs
	4 % p.a. of pump station mechanical and electrical costs
Pipeline:	0,5 % p.a. of total costs
Civil Works:	0.25 % p.a. of total costs

(iv) Discount Rates:

8% p.a. or the official Government discount rate as revised from time to time (but sensitivity analysis also done to test for 6 % and 10 %)

5.5.2 *Pump and pipe sizing for small borehole schemes*

In most cases the boreholes for small schemes have yields of less then 5l/sec and only require a pumping main of one to two kilometres to the village storage or reticulation.

Typically, pipe diameters are less than 100mm. Pumps for borehole schemes are also usually small, typically less than 10 kW.

Sizing of pipes, and therefore pumps, can normally be made using simple engineering calculations without the need for undertaking optimisation analyses.

Simple guidelines for this type of scheme are:

(i) Pipeline velocities of between 0,8 and 1,0 m/s generally result in optimised pump and pipeline size.

(ii) For diesel engine powered pumps the optimum pump and pipeline should be governed by the option with the lowest recurrent diesel fuel consumption.

6 DESIGN REPORT, DRAWINGS AND SPECIFICATIONS

6.1 Introduction

This section deals with the design report and the design drawings.

A typical water supply scheme comprises the following components:

- A source, which could be boreholes or a dam or a weir;
- A water treatment plans;
- A pumps station;
- Pipelines;
- Reservoirs; and
- Consumer connections.

The design of all of these components are discussed in following sections.

A section has also been included on VIP Pit Latrines.

6.2 Design report

Design reports should generally contain the following information:

- Cover page (Region/Province's name, District Council/Water Services Authority, Consultant's name, Scheme name, CWSS No. Locality number, File No., Date, and report's status, i.e. draft 1, draft 2 etc.).
- Index/Contents page.
- Executive summary.
- Description of the project. Refer to locality and scheme layout plans, preferably in A3 size.
- Historical background – for existing supply.
- Statistical data.
- Design philosophy.
- Water source - to be correctly and thoroughly described as described below.
- Design assumptions.
- Sizing of components/infrastructure (litres per second or m^3) - clearly indicate how sized. Peak factors should be motivated.
- Discussion of alternatives and choice of preferred solution.
- Design standards – SANS, BS, etc. standards used to design each component.

- Special problems and their solution.
- Methods of analysis.
- Geology.
- Foundation treatment.
- Diversion.
- Instrumentation/ Scheme's control system.
- Quantities.
- Costs including fees, contingencies and VAT and indicate schemes budgeted amount.
- Programme – bar chart in weeks/months.
- Recommendations.
- References - White papers, feasibility reports, previous and / or other phases design reports, etc.
- Annexures - not greater than A3 size containing a locality plan.

Usually 5 copies of each report will be required.

An expanded framework for the design report is included in the design folder.

6.3 Sustainability

Sustainability must be designed into the development process. At least the following should be confirmed (preferably in the Design Report) before going out to tender:

- Name of the identified WSP;
- Budgeted Operation and Maintenance costs;
- Amount allocated for basic water supply;
- Cost recovery mechanisms and expected revenue;
- Other sources of operating funds (such as Equitable share).

6.4 Drawings

Drawings should generally comply with the following standards:

- All drawing work shall be done on A1, or smaller size sheets with the client's standard title block. All electrical drawings to be A3.
- The drawings remain the property of the Client.
- The minimum letter size is 3mm.
- All drawings shall be signed by the employer or his representative.
- Alterations to drawings may only be authorised by the employer or his representative.
- Index drawing sheets of the complete scheme or part thereof as per type drawing, must be drawn up giving a list of all drawings with their description and must be subsidised in sections with appropriate section headings. Reference must be made on all drawings to these index drawing numbers.

- Every project shall have a compilation/ property diagram drawing(s), showing the required expropriation and/or servitude requirements for bulk water pipelines up to the revenue flow meter and associated dimensions.
- Cross sections on drawings shall be consecutively numbered for each part of the project. The number and section as well as the sheet number where the section is shown must be indicated on the drawing where the position of the section is shown, i.e. 49 section number 12 sheet number
- Pipeline drawings shall contain a summarised complete profile drawing(s) indicating the pipeline profile, design and field test pressure lines, pipeline and valves' major characteristics.
- Detailed profile drawings shall contain a plan view showing major topographical features, property boundaries and all other items as per DWS 1110 clause 4.1 (See Design Folder for Standard Specifications).
- Drawings prepared by the Consulting Engineer must bear a partners or directors signature.
- Drawings prepared by the Contractor must be thoroughly checked by the Consulting Engineer with particular regard to compatibility with proposed, adjoining or existing works.
- Manufacturers' drawings shall be supplied as specified in mechanical contracts and wiring and circuit diagrams shall be supplied as specified in electrical contracts.
- Where civil works are based on plant layout drawings prepared by the mechanical/electrical contractor, the drawings shall be formally approved by the mechanical/electrical representative of the employer, after which the layout may not be altered without repeating the procedure.
- On completion of the works the original drawings must be updated to the "AS BUILT" condition, clearly marked "AS BUILT" and all drawings returned to the employer or his representative for safekeeping in a format as specified. The original will be returned to the Consulting Engineer for his records. Submitted not later than 3 months after completion of the project.

Approval of the specification or drawing shall not absolve the Consulting Engineer of any responsibility.

6.5 Standard drawings

A number of standard drawings are included in the ***Drawings Folder***. CAD software is required to read these drawings.

6.6 Special drawing requirements and operating and maintenance manuals

Special requirements for drawings for tendering, manufacturing, and construction of a mechanical/electrical nature and special requirements for mechanical and electrical operating and maintenance manuals are included in the ***Design Folder***.

6.7 Design specifications

The following DWAF specifications are relevant to the design of Community Water Supply Schemes and are included in the ***Specifications Folder***. DWAF gives its approval to any municipality or water board to use or adapt, for their own purposes, any of these specifications:

NUMBER	DESCRIPTION
DWS 0510	Drilling and grouting
DWS 0750	Water retaining concrete
DWS 1110	Construction of pipelines
DWS 1130	Design, manufacture and supply of steel pipes
DWS 1131	Lining and coating of steel pipes and specials
DWS 1140	Design, manufacture and supply of asbestos-cement pressure pipes and joints
DWS 1150	Glass reinforced plastics (GRP) pipes and joints for use for water supply
DWS1160	Design, manufacture, supply, and installation of Polyvinyl Chloride (PVC) Pressure Pipes and fittings
DWS 1710	Bricklaying
DWS 1720	Plasterer, tiler, and floorer
DWS 1730	Glazing and painting
DWS 1740	Plumbing
DWS 1810	Specialist services
DWS 1910	Supply, delivery, installation and commissioning of mechanical and electrical equipment for a bio-filter plant
DWS 1930	Supply, installation and commissioning of water treatment plant equipment
DWS 1940	Design, manufacture, supply, delivery, installation and commissioning of package water treatment plant
DWS 1950	Supply, installation and commissioning of a reverse osmosis unit for the desalination of mineralised water
DWS 2010	Boundary fencing
DWS 2410	Landscaping
DWS 2510	Valves (set of specifications)
DWS 9900	Corrosion protection (set of specifications)
DWS GTE	General Technical Specifications (Electrical)

7 BOREHOLES

7.1 Borehole development steps

The establishment of potable groundwater sources for community water supply entails hydrogeological related investigations and the drilling and test pumping of existing and new boreholes.

It is a requirement that the establishment of potable groundwater sources should be executed under the controlled supervision of qualified and suitably experienced hydrogeologists, (geologists, geophysicists and hydrogeological technicians).

The hydrogeological services required during project implementation are as follows:

- **Assessment of existing groundwater sources.** This may require the test pumping of existing boreholes, rehabilitation or re-drilling of boreholes, chemical analysis of water samples from existing boreholes and an examination of documentation relating to the reliability and sustained discharge rate of existing boreholes.

- **Groundwater quality assessment.** In areas with marginal water quality, testing of newly drilled boreholes or equipped existing boreholes should not commence prior to availability of chemical analysis results of TDS, NO_3 and F.

- **Borehole siting.** The hydrogeologist is responsible for ensuring that appropriate scientifically based methods are used to identify suitable drilling targets (sites) in accordance with hydrogeological conditions for exploration drilling. In order to ensure safe working conditions and to limit the risk of pollution entering the groundwater abstraction facility, borehole sites are also affected by the existence of manmade structures such as roads, pipelines, cemetries, sewage plants, overhead powerlines, buildings, etc.

- **Supervision of borehole drilling and administration of drilling contracts.** The hydrogeologist is responsible to ensure that boreholes are drilled, designed and constructed to the required standards by controlled and on site supervision of drilling rigs. One supervisor is to supervise at least two drilling rigs up to a maximum of three drilling rigs.

- **Supervision of borehole test pumping and administration of testing contracts**. The hydrogeologist is responsible to ensure that the required and appropriate calibration, multi-rate draw-down, constant discharge, and related recovery tests are conducted to the required standards by on site and controlled supervision of testing contractors.

- **Borehole yield recommendations.** Motorized borehole pumps are generally warranted only in instances where a discharge rate in excess of 0,5l/s can be maintained for a continuous pumping period of eight hours or more per day. Borehole yields must always be determined on the basis of 24 hour per day pumping.

- **Reporting.** A technical report documenting all data and information is required on completion of investigations. The project hydrogeologist is required to ensure that data requirements from the hydrogeologist and contractors are documented on appropriate data recording forms and submitted to DWAF.

- **Borehole development.** This comprises the removal of drilling fines from the aquifer pores, removal of drilling foam/mud and establishing a reverse filter around the borehole aquifer interface. Duration of development can vary from a couple of hours (formation stabilizer, hard rock formations) to several days (unconsolidated fine sandy aquifers). Boreholes must also be disinfected or sterilized of any bacteria, and particularly coliform bacteria, intruded into the borehole during drilling operations.

- **Borehole Protection and Marking**. The borehole is protected from foreign material by means of a lockable cap fitted to the borehole collar. The borehole should be marked with a pole (5 meters to the north of the borehole) of approximately 2,0 m high with a number plate, showing the borehole identification number.

- **Borehole pump testing.** The pump testing contractor is required to test newly drilled boreholes which have not yet been equipped and existing boreholes which may or may not already be equipped with pumping installations. The type of borehole test methods required include:
  Slug Test
  Calibration Discharge Test
  Stepped Discharge Test
  Constant Discharge Test
  Recovery Test

- **Monitoring the resource.** The geohydrologist must develop a monitoring system for at least one full hydrological year to evaluate the resource response to the safe yield abstraction rate. After this period the monitoring program should be re-assessed and planned according to prevailing climatic conditions.

7.2 Borehole pumps

The pump specified must not be capable of exceeding the safe yield of the borehole when utilized over a 24 hour period.

The rest and pumping water levels in a borehole may vary considerably during drought and above average rainfall sequences. Choice of type of borehole pumping plant must take this into account.

The selection of the particular pumping unit must also take into account the following factors:

- The static head between the lowest drawdown level anticipated in the borehole and the delivery point at the borehole top.
- The friction generated in this length of rising main given due attention to the presence of any operating rods within the rising main.
- The static and friction heads from the top of the borehole to the top water level of the delivery point.
- The ability of the pumping plant to commence operation under the full static head conditions of the pump unit.
- The ability of the pump to start operation with the riser pipe empty.
- The level at which the pumping unit has to be placed in the borehole must be as specified by the hydrogeologist or based on reliable information known to the engineer should a hydrogeologist not be available.

Borehole pumps can be powered by means of line supply electricity, solar power, or diesel power. It is generally not acceptable to provide motorised borehole pumps in boreholes yielding less that 0,5 litres per second.

7.3 Borehole monitoring and other equipment

All boreholes and borehole pumping plant must be provided with equipment to monitor pump, borehole and aquifer performance. The main components required are:

- Water meters
- Hour meters
- Water level depth measuring devices –a conduit pipe (20-25mm diameter) next to the riser in the borehole through which a measuring cable can be lowered is preferred, however an electrical transducer or pressure pipe is an alternative.
- Operational equipment

The following operational equipment is required:

- Non return valve, to prevent backflow into borehole.
- Isolating valve, to prevent backflow into the borehole. Only allowed for positive displacement pumps if a pressure relief valve is installed upstream of the valve.
- Scour valve.
- Valves placed to enable removal/replacement of meter in exceptional circumstances.
- Pressure release valve upstream of all isolating valves.

- Pressure cut out switch with manual control and pressure cut out switch with 1 to 2 hour timed reset in auto control (if electrically operated).
- Delivery pressure gauge.
- Low water level in borehole cut out relay with manual control and low water level in borehole cut out relay with 1 to 2 hr. timed reset in auto control (if electrically operated).

8 DAMS AND WEIRS

8.1 Dams

In some cases dams will be required to store surface runoff and to provide the bulk water supply source.

The size of the dam is dependent on the water demand, the required assurance of delivery, the hydrological characteristics of the river, and the characteristics of the dam basin.

The type of dam to be constructed will, amongst others, depend on site configuration (topography), foundation conditions and the availability of suitable construction materials.

8.2 Weirs

Where a dam is used for bulk water storage, and the water is released down the river, it may be necessary to construct a weir at the point of abstraction. The purpose of the weir is usually to provide limited balancing storage for the bulk releases from the dam.

Weirs can also be constructed to store limited amounts of runoff, or even, by allowing the basin to be filled with alluvial material, to create a reservoir within the alluvial sand from which water can be abstracted.

In the case of weirs, siltation is a far greater problem than in the case of large or medium sized dams. The outlet works and abstraction points of weirs need to be kept free of silt.

Weirs, generally being of a limited height and capacity, will also be overtopped by (large) floods. They will therefore need to be constructed of concrete or other non-erodable material.

A site for a weir, where both the riverbed and the abutments consist of good quality rock is an ideal situation. More usually the weir is founded on rock in the river section and one or both of the abutments will comprise of soft river-bank materials. In this case special measures are required to prevent outflanking of the structure by (large) floods.

8.3 Approved professional engineer

Dams are site specific. The Dam Safety Regulations may require that an Approved Professional Engineer (APE) assume responsibility for the design depending on the site, capacity, and hazard potential of the dam. The classification of a proposed dam is done by the Dam Safety Office of DWAF upon submission of an application listing the pertinent data.

Dams can be categorized into the following categories:

- Category I,
- Category II, and
- Category III.

The design of weirs should also be undertaken, or supervised, by competent engineers who are conversant with the particular problems associated with these structures.

8.4 Outlet works of dams and weirs

The outlet works of a typical dam comprises the following components:

- Outlet works;
- Outlet pipe systems
- Intake entrance
- Control valves for outlet works
- Isolating valves
- Control valves
- Intake isolating gates
- Under water wall mounted sluice gates
- Maintenance cranes
- Screening of intake works

The requirements for the outlet works of a typical Class I Dam is described below:

8.4.1 Depth of water draw off

Water drawn from the dam directly to the water treatment works should come from the upper 1,2m layer of the dam.

8.4.2 Outlet pipe systems

Dual system outlets should be provided in order to ensure continuous outlet from the water sources during repair or maintenance of the main outlet.

At the most upstream point of the outlet pipe system, an emergency closure by means of an underwater wall type spindle driven sluice gates operated by manual actuators may be employed only if the size of the outlet is in excess of 600 mm diameter.

8.4.3 Intake entrance

The most upstream exit from the dam/reservoir should consist of a bellmouth. Maintenance of bellmouths is practically impossible due to leakage through the isolating gate seals (if gates are employed) and limited working space downstream of such gates. Intake bellmouths and adjacent pipework should thus be fabricated from stainless steel up to the downstream isolating valve.

Should the pipework downstream of the isolating valve be built into concrete or buried in earth, this pipework should also be fabricated from stainless steel.

Accessible pipework in any outlet system i.e. pipes which are exposed and are removable, may be fabricated from mild steel and corrosion protected.

HDPE pipework is acceptable for small dams. Reducers and pipework directly adjacent to valves should be of fabricated steel.

The coupling of built-in steel or HDPE pipework should be SABS or BSS 4504 flanges only and should be rated according to the hydrostatic pressure of the outlet works. Flanges should normally be used to join built-in pipes. HDPE pipe may not be joined with friction grip couplings. Friction grip couplings are unacceptable in other cases as well except where construction joints occur.

Air supply pipes should be fitted to the outlet bellmouth top and extended to above the high flood level of the dam. The air pipe should be at least 1/6 th of the diameter of the outlet pipe.

8.4.4 Control valves for outlet works

8.4.4.1 Isolating valves

Pipe outlets should be provided with a valve downstream of the pipe entrance to facilitate maintenance of the control valves and downstream pipework. Pipe outlets up to 300 mm in diameter should be provided with open port resilient seal valve (RSV) type gate valves.

Rising and non-rising spindles are acceptable. Pipe outlets exceeding 300 mm diameter should be fitted with butterfly valves double flanged or wafer type having horizontal spindles only so as not to be affected by silt build-up on the bottom of the pipe. For small dams and weirs, manual actuation can be specified for all isolating valves. Manual operation is to be provided as far as possible due to the low cost and lower maintenance. Larger valves may be fitted with manually operated gearboxes to limit operating forces on the hand wheels or levers to 100 kN.

Isolating valves should all be situated in fully accessible boxed-out chambers having suitable drainage facilities.

Valves situated in chambers less than 1,8 m deep should be provided with extension spindles, which are operable from the deck of the chamber.

Valves in chambers more than 1,8m deep should be accessible via vertically mounted access ladders.

All isolating valves should be removable by means of either approved flange adapters or in line pipe couplings situated directly downstream of such valves.

Supports should be provided under pipework at either side of dismantling couplings, excepting in cases where such couplings are converted to thrust absorbing couplings by means of studs and thrust collars.

8.4.4.2 Control valves

Control valves are to be situated at the end of outlet works pipelines to facilitate controlled flow outlet from the dam.

resilient seal valve (RSV) type gate valves are acceptable control valves for small dams and shall as far as possible be manually operated.

In cases of free discharge into rivers, adequate protection must be given to the environment in the immediate vicinity of the valve to prevent erosion.

8.4.4.3 Control valves - needle type

Only in extreme instances where low head loss is important should in-line needle valves be used for controlled water outlet from the dam or weir.

Since needle valves are mounted in the pipeline, their energy dissipating qualities are not as effective as sleeve valves. It is thus advisable to either provide the pipe exit downstream of the valve with a flared disperser, which is to be shaped to cause a hydraulic jump or alternatively the exit should disperse into a stilling chamber.

Needle valves should be operated manually in the case of low head dams (12 meters maximum). It is essential to have a mechanical position indication in 10% increments on the handwheel headstock in order to facilitate accurate water outlet control in accordance with the flow chart provided with the valve.

Acceptable needle valves are more fully described in Standard Specification DWS 2510 - 1996.

8.4.4.4 Intake isolating gates

Dam outlet works having maintainable horizontally placed outlet pipework may be provided with emergency closure gates i.e., gates which are capable of closing under fully unbalanced condition and against high flood conditions (HFL).

Emergency closure is required for unforeseen simultaneous failure of the isolating valve and control valve or a failure in the pipework or pipe couplings downstream of the outlet entrance.

The construction and functioning of wall mounted sluice gates, which have positive spindle drives, are more fully described below.

Dam outlet works having vertically placed outlets may be isolated by means of a rubber lined steel sphere or tapered plug. These however only serve as service closure mechanisms i.e. to isolate pipe entrances under balanced hydrostatic conditions.

8.4.4.5 Under water wall mounted sluice gates

These gates are generally spindle driven units which are secured in a sealing frame where sufficient movement is provided upwards for the gate to clear the inlet fully open and for the downward stroke to seal off the opening completely.

These gates are primarily proprietary items provided by private concerns and are provided with either metal to metal sealing qualities or alternatively with rubber to metal seals. Departmental designs for such gates for operation under low head conditions are also available i.e. for water heads in the order of maximum of 6 meters. Wall mounted sluice gates are spindle driven units where the spindle is supported against buckling by means of wall mounted brackets, spaced to suit the design criteria.

Since these gates are permanently submerged all materials used should be of stainless steel. Exposed sealing frame components built into concrete should be stainless steel grade 316 or 316 L. The gate body should be of at least stainless steel 304 and 304 L. All fasteners should be of stainless steel.

Drive spindles should consist of stainless steel 304 or 304 L as well as submerged wall mounted spindle guide brackets. Wall bracket spindle guide sleeves should be of vescolene PP, ultrablack, or vesconite and should be split to facilitate removal of the gate spindle without having to remove the wall bracket in the process.

All fasteners for under water fixing of components to concrete should be of stainless steel.

All fasteners used on the assembly of the gate and sealing frame should similarly be of stainless steel.

Operating gear for wall mounted sluice gates should as far as possible be manually operated. The screwed spindle shall be stainless steel and should be driven through a brass nut by means of a handwheel mounted on a headstock. The headstock, which is to be mounted on the concrete deck of the outlet works, may be of mild steel fabrication (galvanised).

Rising spindle designs are essential since experience has proven that submerged drive nuts used on non-rising spindle designs renders the gate inoperable due to algae and other debri suspended in the water which enters the drive nut thread.

Rising spindle drives should be provided with position indicator in 10% increments from the fully open to fully closed stroke of the gate.

The indicator arrow should be driven by the spindle either within a slot in the headstock or in a column mounted on top of the headstock over the rising spindle. The manual operating force on the handwheel or cranking lever should not exceed 100 kN. Gearboxes may be employed to reduce operating forces to within the given limit. Handwheel diameters should not exceed 600 mm and lever arm radii should not exceed 400 mm.

8.4.5 Maintenance cranes

Affordable maintenance cranes in the form of slewing jib type, A-frame structures or monorail hoist structures should be provided for the handling i.e. installation and removal, of accessible mechanical components forming part of the outlet works of the dam such as valves and pipework. Removable manually operated hoist units should be employed as far as possible, which includes geared chain hoists, pneumatic chain hoists or winches. All hoist structures should be designed in accordance with BSS 2573, BSS 466 and should comply with the requirements of the Occupational Health and Safety Act.

Crane structures should provide sufficient approach to enable an operator to offload the equipment from a truck and to install such equipment with ease and visa versa. The structures should be of simple, affordable basic design and fabricated from galvanised mild steel.

Fasteners having key functions in the structural strength and stability of the structures should without exception, especially in respect of supporting carriage beams, monorails etc. be of stainless steel. Geared trolleys having manual drive chains to facilitate long or cross travel should be fitted to the carriage rails/beams. All crawl beams should have removable end stops to prevent over-travel of the trolleys and hoist units. To prevent deterioration of the hoist units due to outdoor exposure, they should be removed directly after each use and suitably stored for future use as may be required.

To prevent overloading of cranes, the safe working loads should be clearly displayed on the travel beams, hoist trolley as well as on the hoist or winch unit, example 1,5t SWL. Hoist units and winches as well as travelling trolleys are proprietary items.

Structures especially those of slewing jib cranes should be designed to ensure that minimum maintenance will be required and should incorporate self lubricating bronze or plastic bushing and sealed roller ball or thrust bearings. It is however essential to provide sufficient lubricating nipples at all strategic points of moving components.

8.4.6 Screening of intake works

In order to prevent debris from entering the outlet pipes of the dam from the upstream side and thus forming blockage of the isolating and especially the control valves, removable fine screens having clear openings between slats of 20 mm (min) to 25 mm (max) are to be provided and placed at a distance of 1,5 X pipe outlet diameter (minimum) from the intake pipe entrance. These screens are to be placed upstream of the emergency gate or wall sluice gate in all instances and should either be individually lowered in guides, one on top of the other by use of either an automatic grapple or by inter-linking the screen elements in cases where more frequent removal is required.

The screen size should be such that the water velocity through the slats does not exceed 2m per second.

The total height of the stacked screen units should extend from the very bottom outlet pipe up to at least 500mm above the high flood level (HFL) of the dam or weir.

9 WATER TREATMENT WORKS

9.1 General

As with dams, the design of the water treatment process is a specialist field of expertise and should be done by a suitably trained professional engineer.

Certain broad guidelines can however be given for planning purposes.

9.2 Potable water quality

Potable water should comply with SANS 241.

9.3 Selection of appropriate treatment process

The selection of an appropriate treatment process is essentially determined by:

- The raw water quality (physical and chemical).
- The prescribed final water quality.

9.4 Recommended loading rates and design parameters for water treatment process units

The following loading rates and design parameters can be given as guidelines only and should be tested against actual circumstances:

- Rapid mixing: at least 500mm head loss (mixing in G values, G = 2000^{-5}).
- Floculation: 10 min. Retention with a total head loss of about 150mm and G = $50s^{-5}$ $(40 - 80)^{-5}$
- Horizontal flow settling tanks (in lieu of other flow types) are recommended for turbid raw waters > 200NTUs with manual sludge or hydraulic sludge withdrawal and a maximum loading rate of $1m^3/m^2$.h.
- Direct gravity filtration as secondary solid/liquid phase separation step: filtration rate 5m/h with upstream flow control.

- Upflow-downflow (series) filtration: only to be constructed when the raw water turbidity rarely exceeds 100NTU (say 5% of the time). Recommended filtration rates are:
    - Upflow: 5m/h
    - Downflow: 10m/h
- Flotation: recirculation rate of 10% and a loading rate of $6m^3/m^2.h$.
- Sludge and wash handling facilities: for design purposes assume that the sludge will thicken to a 10% concentration. The sludge dam should be large enough for a planning horizon of 6 to 8 years and space should be available for a second dam.
- Production losses through water plant: allow 3% to 5%.
- Chlorine contact time: 6% of flow capacity. 6% x 24 = 1,5 hours.
- Clear water sump for high lift pumps: 2% of flow capacity.
- Sludge disposal to sludge dams.
- Design flow capacity of plant to be based on the average daily summer demand plus 5% for production losses.

The sludge from settling (sedimentation) tanks should at least flow to sludge lagoons from where only the supernatant flows to rivers. Reclamation can be considered where water is scarce and supernatant can be used.

9.5 Automation

If a water treatment plant has more than 4 rapid gravity sand filters, the filter backwashing sequence may be automated. Other operations, for example chemical dosing and sludge withdrawal will only be automated in plants bigger than 50 000m3/d (579 litres per second).

Automation shall be motivated and not governed by hard and fast rules.

9.6 Structural considerations

It is recommended that all reinforced concrete water retaining structures should be designed to a 0,2mm crack width using 30MPa concrete in accordance with BS8007.

9.7 Accessibility

All units should be easily accessible, and easily removed for repairs. Walkways should be provided to give safe access to all points requiring inspection and to provide logical progression to operators doing inspections. Ease of handling chemicals should receive special attention.

9.8 Specifications

The following specifications are relevant for the design, manufacture, supply, construction, and commissioning of water treatment plants.

Departmental Specification	Description
DWS 1930	Supply, installation and commissioning of water treatment plant equipment.
DWS 1940	Design, manufacture, supply, delivery, installation, and commissioning of package water treatment plant.
DWS 1950	Supply, installation, and commissioning of a reverse osmosis unit for the desalination of mineralised water.

These specifications are included in the ***Specifications Folder***.

10 PUMP STATIONS

10.1 Introduction

Community water supply schemes are likely to involve the pumping of relatively small quantities of water. Pump stations are often be sited at small purification works or as booster pump stations along pipelines.

Normally the electrical power supply will be provided by Eskom or the local authority.

10.2 Pump selection

The following steps should be followed to select the correct pump duty:

- The system curve, relating to the hydraulic head lost in the system for different flows, is calculated and plotted as a graph above the required static head. Pump Station losses, including those of all valves in the pumpline, should be included in the calculation of the system curve.
- The pump performance curves are then plotted on the same graph. If more than one pump is required then these are added either in series or in parallel, as required. The pump curves will intercept the system curve at the station duty point.
- An ideal pump selection will result in each Pump Duty Point falling at or very near to the pump Best Efficiency Point (BEP).
- When only one pump in a multi-pump arrangement is operating, the intercept with the system curve will be at a point of reduced head and increased flow with regard to the chosen Pump Duty Point. Care should be taken that the motor is not overloaded under the one pump condition, and that a margin of at least 15% in excess of what the pump will demand is ensured under the worst possible operating condition.

10.3 Pump standby capacity

For Surface Water Pump Stations:

- 100% standby capacity for single pumps
- 33% minimum standby acceptable for larger pump sets.

For Borehole Pump Stations:

- No standby pump capacity is required, but a minimum of 2 boreholes must be equipped for a village.

10.4 Power requirements for pumps

The power supplied to a pump must equal the total power required for the duty as calculated above with an allowance for pump and motor efficiency, and in addition the following factors must be added:
For Motors > 25 kW: Add 10% to power requirement
For Motors < 25 kW: Add 25% to power requirement

10.5 Pump control

Centrifugal pumps should be started and stopped against a closed valve.

All controls should be designed to operate "fail safe".

All pumps should be provided with emergency stops adjacent to the pump.

Pumps may be controlled manually, by means of downstream pressure (reservoir pressure) or by means of telemetry. The following rules apply:

MANUAL Pump Control:

- Top Open Inlet to Storage or Combined Bottom Inlet/Outlet.
- Manual or Timer Control for starting and stopping of pumps.
- Manual override switch for starting and stopping of pumps.

PRESSURE Pump Control:

- Top or Bottom inlet to storage.
- Float Level Control.
- High Pressure Cut-Out switch for pumps – must always switch off pumps, even when on manual.
- Time delay restart for pumps (minimum 30 mins.)
- Manual override switch for starting and stopping of pumps.

TELEMETRY Pump Control:

- Top Open Inlet to Storage or Combined Bottom Inlet/Outlet
- Automatic Telemetry Cut-In and Cut-Out Level Control for pumps.
- Settings for Cut-In levels:
  Reservoirs: 4 hr x GAADD below TWL
  Elev. Tanks: 1 hr x GAADD below TWL
- Minimum distance of 150 mm, in all cases, between cut-in and cut-out levels.
- Manual override switch for starting and stopping of pumps.

10.6 Pump station building

The suggested requirements for a pump station building are as follows:

- Pump station floor level: determined in conjunction with the minimum N.P.S.H. (net positive suction height) of the pumps. The effect of surge in the suction pipeline and manifold should also be checked for pump start-up and trip conditions.
- Top of the pump well should not be below the 1:50 year flood level for pump stations built along a river. This can be raised to say 1:100 year flood level if the pump station is downstream of a dam wall. If the pump station is built upstream of a dam wall then the motor floor must at least be 2,0 m above the 1:100 year or the high flood level, whichever is the greater.
- The pump station should be accessible during all weather conditions.
- The protective fencing must be designed in accordance with the protection requirements of the area, usually barbed wire spaced at 100mm intervals with razor-cut flat coils fencing materials.
- Stormwater to be drained away from the pump station during the construction and operation phase.
- Corrosivity of the soils surrounding the pump station concrete structure should be investigated.
- Pump wells should be anchored to prevent flotation.
- Light fittings must be vandal proof. Light bulbs must be easily changed. Fluorescent lighting is acceptable. Security lighting to be provided with daylight switches. High masts to be furnished with lightning down conductors.
- Generally no external windows will be allowed. Fixed and sturdy ventilated louvers with insect screens must be provided instead.
- Facilities (crawl beam and loading bay) for the safe removal of the pumps and motors should be provided where the weight of the equipment is such that it cannot be manhandled.
- The loading bay entrance doors should preferably be of the roller shutter type (rugged design).
- Normally steel roofs should be used. Reinforced concrete roofs could be three times as expensive as steel roofs. Timber should not be used.
- The following stair dimensions are suggested:

Risers: 160 to 178 mm high
Treads:265 to 300 mm long

- Off shutter concrete finished areas i.e. pump well walls, concrete columns, etc., should generally not be painted.
- Hot dip galvanised treatment
  All internal handrails, steel cat ladders, steel stairways and eggrate flooring.
  Steel windows, doors and door farms.
  Roller shutter doors.
- Structural steelwork to be protected and painted as per SANS 1200 HC.
- Generally vinyl tiles on floors except loading bay, workshops, store rooms and very low traffic areas around and in pump well which should be concrete wood screed.

NOTE: Many of the pump station guidelines are also applicable to the design of water treatment work structures and reservoirs.

10.7 Pumpline components

10.7.1 Baseplates

Pumpset baseplates should be machined and must be adequately anchored and grouted to robust concrete plinths. Pumpset and pipework out-of-balance thrust loads must be adequately restrained by concrete or steel supports and pipework must be supported to the floor or walls within the pump station.

Pumps and motors should be located by dowels, once aligned.

10.7.2 Pumps

Suitable pumps are:

- single stage end-suction or horizontal split,
- multi stage, horizontal, for treated water (not recommended for raw water owing to excessive wear on balancing disc),
- single or multi stage vertical in raw water wet-well application (product-lubricated with thrust bearing outside the flow tube), or
- progressive cavity pumps.

10.7.3 Pump coupling

Belt drives are unacceptable for electrically driven pumps.

10.7.4 Pump components

Impellers or rotors should be either a zinc-free bronze or stainless steel.
Cast iron impellers are not acceptable.
Impellers and pump casings should be fitted with renewable bronze or stainless steel wearing neck-rings.

Pump testing should be to BS 5316 part 2 class B undertaken at an acceptable test facility, e.g. SABS or at the pump manufacturer if test facilities meet with the standards.

10.7.5 Motors

Limited to motors of 185kW (400V).

Motors should be (TEFC.) Totally Enclosed Fan Cooled(1C 0141) with cast iron body and should be 3 phase 400V induction type.

10.7.6 Pumpset speed

Pumpset speed should not be greater than 1 480 rpm (4 - pole).
2-pole motors ± 2 800 rpm are only acceptable under exceptional circumstances.

10.7.7 Switchgear enclosures:

All switchgear and control panel enclosures should be rated IP54.

10.7.8 Valves

See **DWS Standard 2510 in *Specifications Folder*.**

<u>Isolating valves:</u>

Double flange gate valves should be specified (resilient seal valves up to 1,6Mpa).

Isolating valves at both pump suction and pump delivery should be hand operated and double-flanged to permit stripping of the pump or control valve. A wafer type valve will not permit this and is therefore unacceptable.

The upstream (suction) isolating valve should have the same pressure rating as the delivery isolating valve.

Control valves

Flow and pressure control valves are not acceptable. In order to reduce excessive surges, double flanged reflux valves are preferred. Alternatively surge tanks should be provided or an alternative form of surge control.

Mounting of butterfly valves
(or valves with adjustable seals with specific reference to their use in or relating to pump stations)

The seal should always be accessible from the side of the valve "facing the pump".

The direction in which the valve is to be placed, should be specified by the supplier.

Butterfly valves should be supported and not fixed.

10.7.9 Instrumentation and protection

All instrumentation must be mounted on vibration free surfaces.

Temperature sensors (pump thermal protection) should be fitted in the pump casing to protect the pump against closed valve conditions.

RTDs (Resistance Temperature Detectors) are preferred for motors greater than 50kW and should be embedded in the motor windings, two per phase providing one set spare.

In typical community water supply size of pump station, motor or pump bearings as well as pump glands need not be monitored.

Pressure sensors

A low suction pressure sensor should be provided and located between the suction isolating valve and the pump suction flange. This device should monitor and ensure that the pump does not operate under conditions that will result in cavitation within the pump.

A pump delivery pressure sensor should be located between the pump delivery flange and the reflux or other control valve. This device should monitor two conditions:

(1) on start-up, that the pump is generating full pressure and it is safe to open the delivery isolating valve, and
(2) in operation, that when the level controlled valve at the receiving reservoir located at the upper end of the rising main is closed, the ensuing increase in pump delivery pressure should be employed to stop the pump. The delivery isolating valve should then be re-closed before restarting the pump.

Pressure gauges

Each pumpline should be equipped with two pressure gauges. One should display the pressure at the pump suction flange, the other, the pressure at the pump delivery flange.

In addition, one pressure gauge should be installed to measure the pressure in the station delivery manifold itself.

Pressure gauges should be glycerine filled and be calibrated in metres head of water. The range of operation should be from zero to 50% in excess of the pump "closed valve" pressure.

All pressure gauges should be supplied with isolating and drain cocks, piping, and fitted with a pulsation damper.

Flow meters

Usually ultrasonic flowmeters should be used where electronic type metering is required. Where this type of meter is not justified mechanical type meter are acceptable.

10.7.10 Control panel

All panels should have a test button to test all lamps. For indication lamps use only cluster type LED with coloured lens caps (blue LED's are not available).

The pumpline control panel (whether combined with the motor starting switchgear, or separate) should contain the following displays:

- Green lamp - "pump running".
- Red lamp "pump stopped".
- White lamp "pump tripped".
- Blue lamp "pump available".

The blue "pump available" lamp should be illuminated only when all safety conditions being monitored are healthy, i.e.:

- motor winding temperature sensors, and
- suction pressure sensor healthy.

In addition electric power should be available.

Should any one of these safety sensors indicate an "unhealthy" or faulty condition the pump should be tripped and the white "pump tripped" lamp should be illuminated. In addition, the station panel alarm should sound.

Audible alarm devices should be time controlled (3 minutes) as these devices are sometimes sabotaged by nearby residents.

Also mounted on the control panel should be the following push buttons:

- pump start - green
- pump stop - red
- emergency stop - red mushroom (lockable)
- alarm accept (to silence station alarm) - black.
- trip cancel (to cancel white lamp after fault is rectified) - black.
- Auto/manual switch if remote auto controls are used, such as level devices or telemetry. When in manual mode warning devices must still be operative.

11 LOW VOLTAGE ELECTRICAL EQUIPMENT

11.1 General guidelines

The DWAF General Technical Specifications (Electrical) (GTSE) are included in the ***Specifications Folder***.

SANS 0142 and other standard specifications as set out in the GTSE as well as regulations of Eskom and local authorities must be followed where applicable.

The Occupational Health and Safety Act (Act 85 of 1993) applies in all instances.

11.2 Design report

The design report must include the results of a quality investigation of the electrical supply. This could determine the starting methods to be used by the various electric motors. Direct on line starting is always preferred if possible.

11.3 Important aspects to consider

Cognisance should be taken of the following aspects:

- Environmental;
- Aesthetics;
- Safety to equipment and personnel;
- Spares cost & availability;
- Ease of operation;
- Future extensions;
- Maintainability;
- Availability;
- Serviceability;
- Technology improvements;
- Quality of equipment;
- Energy conservation;
- Quality of electrical supply; and
- Economics.

11.4 Maximum voltage

No voltage higher than 400V should be used. Higher voltages must remain the responsibility of the electricity supply authority.

11.5 Metering points

A dedicated transformer should be negotiated with the relevant supply authority for each metering point to avoid quality of supply problems originating from the supply authorities 400 volt system.

The total cost of the supply point is important and should be determined before final designs are submitted.

11.6 Motors

Motors must meet the necessary pump requirements.

11.7 Power cables

Power cables must be suitable for short circuit and environmental conditions.

11.8 LV switchboards and motor control

11.8.1 Construction

The following requirements are recommended for switchboards:

- IP54 enclosure;
- Free standing;
- Extensible;
- Flush tiers front and rear;
- Accessible front and rear with hinged doors in front and removable panels at the rear;
- Door locking and safety lockout systems are required;
- Steel construction (2mm);
- Colour white internal and lighter electric orange external;
- Provide ventilation slots on face panels and doors with vermin screens behind slots;

- Ensure that all panels are totally vermin proof; and
- Use substantial gland plates at bottom of panels (3mm thickness).

11.9 Switchgear

11.9.1 Circuit breakers

The following requirements for circuit breakers are recommended:

- The incoming circuit breaker of the main LT switch board, which receives the supply from the supply authority or transformer, must be equipped with adjustable earth leakage protection as well as an adjustable time delay facility to create the necessary discriminating between this breaker and other earth leakage protectors further down the line.
- Selective tripping between incoming and outgoing circuits must be provided.
- Protection grading must be effective for all operating conditions.
- Where circuit breakers are used to protect contactors, motor protection circuit breakers equipped with shunt trips to trip the circuit breaker in the event of short circuit or earth faults should be used. The contactor should not be required to clear these types of faults.
- Fast acting circuit breakers should be used in all instances.
- Motor circuit breakers should allow for long duration (up to 10 second) start ups.
- HRC fuses should not be used as these tend to get tampered with and are not always readily available.
- All circuit breakers must be selected to handle the maximum possible fault current taking into consideration possible future extensions involving and increase in the available fault current.

11.9.2 Isolators

Isolators should be load breaking \ fault making type.
Isolator should be lockable in the OPEN position.

11.9.3 Contactors

Contactor should comply with IEC 158-1 for Class AC3 unless the specific duty requires a higher rating.
De-rate contactors should be used in areas where ambient temperatures exceed 35^0C.

11.9.4 Switch gear general

No bypass facilities on protection equipment, level relays, etc. are allowed.
All power, signal and control cables must be numbered on site and on drawings.

11.10 Motor protection

The following requirements for motor protection are recommended:

- Comprehensive motor protection is required where the requirements are such that the normal thermal overload protection will not be adequate. A versatile, multifunction motor protection unit or relay is therefore to be used.
- For motors below 15kW thermal overload protection may be used provided single phase, phase reversal, and under load protection is provided. For under load protection, phase angle type relays may be used.
- Trip mechanisms should be settable with front panel mounted buttons and trip conditions should have indicator lamps on the front panel.
- Under and over voltage protection must be provided to disable the motor starter control circuits excluding the remainder of the pump station.
- Automatic re-start must be prevented when trips occurred due to over/under current conditions. In such instances make use of an alarm plus a manual restart.
- Provide adequate motor, pump, and pipe earthing.

11.11 Indication and instrumentation

The following instrumentation is required:

- Combined thermal demand and instantaneous ammeters on all incomers, and transformer feeders.
- One ammeter per phase.
- Motor starter panels one ammeter.
- Voltmeter with selector switch on each incoming panel.
- Maximum demand/kWh combination meters will normally be required on the incoming sections.
- Power factor indicating instrument where warranted.

Other indication will include:

- Run lamp;
- Emergency Stop lamp;
- Ready lamp (not applicable in the case of boreholes and small pumpstations);
- Overload lamp;
- Motor winding lamp (over-temperature) where motor winding temperature sensors are available in motors;

- Supply Voltage lamp; and
- Running hour meter.

Other requirements for indication are:

- Where necessary for safety reasons a control voltage should be 24v.
- All alarm indication must be latched and reset by a reset button.
- Only mercury bulbs or 3 wire level relays should be used for level controls in reservoirs. Ultra sonic level sensing is not acceptable.
- Borehole level sensing should be done with equipment using normal wires.
- To assist operators, three "cable live" neon indication lamps should be provided on incoming supplies.

11.12 Control

11.12.1 General

Easily maintainable systems using relays, etc. must be used.
PLC's are only to be used where warranted.

If PLC's are used (see above) full lighting protection must be provided for all inputs, outputs, and power supplies.

11.12.2 Local control

Local control should consist of pushbuttons as follows:

- Start;
- Stop;
- Emergency Stop (At motor starting cubicle and at motor);
- Reset; and
- Lamp test.

11.13 Power factor correction

Power factor correction must only be provided where it can be proved before-hand that it is economically justified.
Power factor correction equipment, if provided, should preferably be mounted directly on the motor.
Automatic power factor equipment should be avoided.

11.14 Earthing

The following requirements for earthing are recommended:

- Earthing may consist of an earth mat, trench earth, electrode earth, or a trench and electrode combination scheme.
- An earthing survey must be carried out by a specialist where necessary.
- All earthing must be connected to a common earth bar at the lowest possible point where separate systems are provided for instrumentation, LV and MV.
- All exposed earthing must be PVC insulated copper conductors. All other must be bare copper conductors.
- Maximum resistance to earth is 1Ω for LV systems and 2Ω for MV systems.
- The supply authority's requirements regarding earthing must be taken into consideration.
- One drawing showing the overall arrangements must be provided.

11.15 Lightning protection

The requirements for lightning protection are:

- Lightning protection must be provided for safety purposes as well as for the protection of equipment and instrumentation.
- Surge arrestors must be of the metal oxide type in accordance with SANS 172.
- Guard against the use of long control cables between eg. reservoirs and pump stations to minimise damage due to lightning.
- Use MOV (5 - 10kA) surge arrestors on both ends of control cables between eg. level sensing equipment and motor controls.
- Provide lightning protection for instrument supply cables.
- Provide lightning protection for panel incomers.

11.16 Conduit wire ways and conduit

11.16.1 Conduit

All conduits must be galvanised steel conduit in accordance with SANS 1665 and should be surface mounted.

11.16.2 Wire ways (conduit and trunking)

Separate wire ways must be used for normal power and lighting, emergency power and lighting, standby power and lighting, control wiring, and extra low voltage wiring.

11.16.3 Cable ways

The requirements for cable ways are:

- Cable routes should be specified. This should be in trenches, in floors, or cable ladders against walls.
- Floor trenches should be filled with sand and screeded over after completion of the installation. Provision should be made for draining of cable trenches. Gland drip water should be piped into a no-fines opening into the trench, next to the pump set in this case, to keep the sand wet.
- Heavy duty galvanised beehive type racks supported at least every 750mm on galvanised angle iron brackets should be used to support aerial and vertical cables.
- Stainless steel straps should be used to attach cables to cable racks, masts, etc.
- Pipes must not be used for cable ways for motor cables. Channel iron or other protection and support that allows sufficient ventilation should be used.

11.16.4 Switches and socket outlets

Light switches should be placed in galvanised steel box in accordance with SANS 1065, 1,2m above finished floor level.

16A Switched socket outlets should be placed in 100mm x 100mm boxes.

Three phase welding sockets with built in earth leakage should be provided.

11.16.5 Wiring

One circuit per conduit wire way is allowed. All un-armoured conductors should be installed in conduit or wire ways. All cables and conductors must be protected by suitably rated switch or fuse gear.

Conductors originating from different switchboards may not be installed in the same wire way.

Minimum conductor sizes are:

- Lighting circuits 1,5mm^2 power and 2,5mm^2 earth conductors
- Socket outlets 2,5mm^2 power and 2,5mm^2 earth conductors
- Stove circuits 10mm^2 power and 6mm^2 earth conductors
- Bell circuits 1,5mm^2
- Clock circuits 1,5mm^2

11.17 Lighting, luminaires and masts

11.17.1 Lighting

Task lighting of 160 lux is required for each pump.

Walkways, footpaths, staircases, general movement areas etc. must be lighted according to SANS 10098.

Maintained emergency lighting must be provided where applicable.

11.17.2 Luminaires

For ease of maintenance, light fittings should be mounted against walls at a maximum height of 3,5m.

Depending on the application and the required lighting levels fluorescent, incandescent or HPS luminaires may be used.
Exterior luminaires are to be rated to IP65.
Luminaires manufactured from sheet steel or aluminium may not be used.

Highmast luminaires must be 250W HPS.

ES Screw in lamps incandescent fittings should be used.

11.17.3 High masts

Streetlights should be mounted on 8m standard poles with a 2m outreach.

High masts should be of the 12m hinged type with removable hand winch.

11.18 Standby generators

Where standby generators are provided, the change-over switches between standby and normal electricity must be both mechanically and electrically interlocked and conform to the supply authorities requirements.

Batteries for standby generators should be charged from the mains supply.
Fuel tank level and battery voltage sensors should be provided (for possible use with telemetry systems).

12 TELEMETRY

12.1 Maintenance

It is normally recommended that telemetry be maintained by maintenance contractors.

12.2 General guidelines

Telemetry will normally be required where there is a need to exchange data and information between two or more distant or remote installations or sites, e.g. between a remote reservoir and a pump station or control room.

The design engineer should take consideration of the following:

- Environmental impact;
- Safety to equipment and personnel;
- Affordability;
- Ease of operation;
- Maintainability;
- Serviceability;
- Compatibility with existing systems;
- Quality;
- Aesthetics;
- Best practice;
- Spares costs and availability;
- Future extensions;
- Availability; and
- Technology improvements.

12.3 Typical system configuration

A typical system may consist of a master station and a number of outstations. Depending on the distance and terrain, repeater stations may be required. Typical data or information that may be transmitted is for example:

- valve position;
- reservoir level;
- pump status, e.g. running, stopped, tripped etc;
- start/stop commands; and

- camera images.

The telemetry installation consists of the following elements:
- transducers and field instrumentation;
- cabling;
- communication system; and
- control systems.

To protect and enable the above to operate two ancillary systems are required, namely:
- power supplies; and
- lightning protection and earthing.

12.4 Transducers and field instrumentation

12.4.1 General

In most cases the instrumentation, transducers and sensors will be supplied and installed by the various other Contractors, e.g. electrical or pump contractor. However situations may arise where no other Contractors are employed and in these cases the supply and installation of the instrumentation equipment must form part of the telemetry installation.

12.4.2 Technical requirements

In general all transducers/sensors must comply with the following -

• analogue outputs	4 - 20 mA
• supply voltage	24 V DC (nominal)
• accuracy	± 0,3 %
• reliability	+ 5 000 hours
• housing	suitable for environment.

12.4.3 Back up requirements

Where valves are controlled, limit and back up switches must be provided.
Level transducers must be backed up by float switches.

12.4.4 Compatibility

Cognisance must be taken of compatibility with existing equipment.

12.5 Cabling

12.5.1 Power cables

The installation of these cables are covered in the Department's Specifications on Electrical Installations included in the ***Specifications Folder***.

12.5.2 Data cables

For correct performance of cables for data transmission, the correct type and size cable must be selected for the application e.g. data transmission speed, noise, distance, type of data (analogue or discrete) etc.

As a general rule, the following should apply:

- Low data transfer rates: Low frequency type cables e.g. twisted pair;
- High data transfer rates: High frequency type cables e.g. co-axial cables, optic fibre or special type of twisted pair;
- High noise and lightning environment: Shielded cable or optic fibre cable.

The number of cables or pairs must make allowance for future extensions. Cables must be suitably protected against damage.

12.6 Communication system

The communication system consists of the following sub-systems:

- Radio equipment – Transmitters and receivers;
- Antennas and Masts;
- RF cabling;
- Power supply system; and
- Lightning protection and earthing.

12.6.1 Transmitter and receivers

The Transmitters and Receivers should comply with the requirements of SANS 300086.

The specification should address the following :

- RF output power — Normally 2 - 30 W
- Modulation — Phase or frequency
- Frequency stability — 3 - 5 ppm

- Allowable audio distention less than 5%
- Maximum spurious radiation and harmonics < 70 dB
- Channel spacing 12,5 kHz.
- Number of channels 4 minimum
- Frequency bands VHF (68 - 88 MHz),
- VHF (146 - 174 MHz) and UHF (450 - 470 mHz)
- Microwave (2,4GHZ; 10GHZ)
- GSM (HSCO; GPRS; SMS)
- Input impedance 50 ohm.

12.6.2 Masts and antennas

a) <u>Masts</u>

Construction of masts should be metallic self supporting lattice or sectional pole.
Steel is preferred above 4m.
12m and above must have stay wires.
The finish should be galvanised steel.
The design load, including antenna, is a wind load of 160 km/h (and snow load where applicable).

b) <u>Antennas</u>

Gain:	6 dB depending on signal
Type:	Omni-directional or directional where applicable
Nominal impedance:	50 ohm
Material:	Aluminium.

c) <u>RF cabling</u>

All RF cabling must be low loss coaxial cable suitable for outdoor use.
Suitable protection must be provided to the cable where exposed to damage.
Minimum bending radius must be specified.

12.7 Control systems

12.7.1 Control modes

Local and remote control modes are required, i.e.. it must be possible to switch between local and remote control.
Both control modes can be either automatic or manual.
Distributed control should be employed with override and monitoring by the telemetry system.

Failure of the telemetry system should not affect the local control.
Telemetry must not be able to start or stop in local control.

12.7.2 Man machine interface

Computers must be specified as follows:

- 17 inch monitor;
- Pentium IV 2GHZ or higher
- 40G Hard Drive
- At least 512 MB memory.

A display unit must be provided or the existing display upgraded or reprogrammed at the master control panel to display all the data and control parameters from the out stations, including all alarms, equipment status, valve positions, levels, etc.
All controls should be effected from this interface, either automatically or by the operator when selected.
Sufficient data storage capability must be provided for backup and data storage.

12.8 Power supplies

Suitable power supplies with adequate battery back up facilities must be provided.

The batteries may be charged from one of the following sources:

- AC main supply with rectifier and protective equipment
- Solar cells
- WIVA chargers.

Solar cells will be used where no mains power is available.

Alarm signals should include the following:

- Low battery voltage;
- Mains failure (if applicable);
- Solar panel (if applicable);
- Intruder alarm;
- Communication failure.

In general the power supplies must conform to the following:

- Output voltage: 12 Volt for normal use or 24 Volt for transducers;
- Protection: Overcharging, under voltage, cut out, power surges, reverse polarity.

Rating:

- Data transmission only: 30%Transmit/Receiver 70% standby for 48 hours;
- Data and Voice transmission: 50% Transmit/Receiver 50% standby for 48 hours.

12.9 Lightning protection and earthing

Suitable protection must be provided to protect equipment, including:

a) Earth Electrode System

- Maximum resistance 5 ohms. 1 ohm if possible;
- Test points are to be provided;
- SANS 10199 is applicable;
- Concealed joints and interconnections brazed or welded.

b) Bonding all exposed steelwork and other steelwork that may become "live" due to equipment faults, static build up or lightning strikes are to be bonded.

c) Lightning Protection

All equipment should be considered exposed to lightning strikes and suitable protection must be provided.

All instrument boxes should be earthed by a 70 mm copper earth wire.

12.10 Documentation and training

Complete maintenance and operating manuals must form part of the scope of supply.

As-built documentation must be provided and must include:

- Control logic;
- Cabling; and
- Physical layout.

Operating and Maintenance manual must also be provided.

12.11 Spares

A full set of spares must be included with the manuals.

13 PIPELINES

13.1 General

Water supply is delivered under pressure either by gravity or by pumping.

Water supply pipelines are generally designed to convey water free of suspended matter and generally of potable quality.

Laying and jointing are important operations that contribute to the life of a pipeline and to the level of service provided. These can constitute a significant factor in pipe selection, especially where labour based construction methods are utilized.

The prime function of any pipe and pipe material is that, for the expected life of the pipeline, there is adequate resistance and strength to withstand all forces that can be expected to be imposed on the pipe. These forces and requirements include:

- Internal forces including internal pressure and pressure surges;
- External forces including earth pressure and superimposed loads;
- Water tightness; and
- Corrosion.

Generally refer to **DWS 1110 Clause 4** (included in the ***Specifications Folder)*** for the design and setting out of pipelines.

13.2 Design capacity

See Planning and Design Parameters in the Preliminary Design Section.

13.3 Pipeline materials

The pipeline material that provides the lowest life cycle cost should be selected. The selection procedure as proposed in **Section 3 of Darling and Hodgson's "Pipe Selection Manual, 1996"** is recommended.

Suitable pipeline materials are tabulated below:

Pipe Materials, Classes and Acceptable Sizes:	**DWAF DWS Specification**	**Class (bar)**	**Sizes (mm)**
Minimum pipe size for reticulation: 50mm nominal diameter			
HDPE (SANS 533)	None	Min. Class 6	15 - 75
uPVC (SANS 966 or ISO 4422)	DWS 1160	Min. Class 6	50 - 250
Note: 125 and 140 mm sizes are not recommended for uPVC pipes, due to the lack of standard fittings.			
21GRP	DWS 1150	Min. Class 6, Max. 25 bar	Min. 150
Galvanised Mild Steel (SANS 62)	None	Medium Duty	15 – 150
Steel (> 150mm)	DWS 1130	Min. API 5L Grade A Min. wall thick. t = 4,5 mm Slenderness, D/t < 120	Min. 200
	Max. Press. incl. surge (m) = 120*t/D, where S = Yield Point Stress (MPa) and D = Outside Dia (mm). Formula assumes max. of 60% of yield stress mobilised.		
Protection to steel pipes (> 150 mm):	Generally bitumen fibre wrap coating with cement mortar lining or epoxy lining and cathodic protection – see DWS 1131.		

13.4 Pipeline velocities

The following maximum and minimum pipeline velocities are recommended:

- Minimum Raw water: 0,6 m/s,
- Minimum Treated water: 0,3 m/s,
- Maximum DPFR for Reticulations: 1,5 m/s,
- Maximum Pump suction inside station: 2,0 m/s,
- Maximum Design flow in Bulk Supply: 3,0 m/s,
- Maximum Scour flow in Pipelines: 5,0 m/s,

13.5 Pipe friction factors

Only Colebrook-White or Darcy-Weisbach formulae (with friction factor, Δ, determined using Moody diagram or equivalent formula); or Hazen-Williams formula, with C factor equivalent to k_s for pipe diameter and velocity, are acceptable for design.

Pipe friction factors are provided in the table below:

Pipe Friction Factors (Absolute Roughness, k_s, mm)

	Pipelines; (excl. fittings losses)	**Reticulation** (incl. fittings losses)**;**
uPVC or GRP	0,06 mm	0,10 mm
Steel (cement mortar lined)	0,20 mm	0,26 mm

13.6 Depth of pipe cover

The minimum depth of cover to main pipelines are:

- Generally: 600mm
- Under cultivated land: 900mm
- Road/Railway crossings: 1000mm

Additional protection should be provided to pipes under roads or railways where required.

13.7 Vacuum pressures

Vacuum pressures in Bulk Supply Pipelines during shutdown and scouring of pipes are generally unacceptable, but 3 m maximum is acceptable to economise on Double Orifice Air Valve installations.

13.8 Cover

750mm minimum cover with 1000mm cover required under road crossings.

13.9 Trench width

Allow for at least the pipe diameter plus 150mm on both sides for small diameter pipelines to ensure that backfilling is effectively rammed. The minimum trench width should be 500mm.

13.10 Bedding and backfill (including material)

According to SANS 1200 and DWS 1110 (see ***Specification Folder***) where applicable.

13.11 Slope

A slope of steeper than 0,3% is required to avoid air pockets.

13.12 Meters

Schemes should be provided with bulk metering from the water source.

The supply to each local authority should be separately metered.

All stand pipes should be measured.

Where house or yard connections are provided, the consumption of each individual household should be measured.

13.13 Delivery point

For a basic level of service in rural communities the delivery point should be the stand pipe or a yard tank.

13.14 Pipe markers

Refer to DWS 1110 in ***Specifications Folder.***

Pipe markers are required at a minimum spacing of 500m unless the pipeline follows a road.

All bends should be marked.

13.15 Air release and air intake valves

Air valves should be provided on summits of main lines.

Air intake valves are required upstream and downstream of isolation valves on ascending and descending pipeline slopes respectively.

The minimum distance between air valves should be 500m.

Separate isolating valves are required on each air valve branch for maintenance purposes.

Refer to **Messrs Mulric Hydro Projects' catalogue No. RBX 0001** for the selection and positioning of air valves.

Diameter of branch below air valve should be as follows:

- Pipeline =< 200 mm NB: Install an equal T piece below air valve.
- Pipeline > 200mm NB: The branch pipe must be as large as practically possible with a maximum diameter of 600mm NB for all pipelines > 600mm NB.

13.16 Scour valves

Should be provided at all low points.

Scour valves should be so sized that the pipe can be drained between the isolating valves within 2 hours.

The diameter of the drainpipe should be 0,4 times the diameter of the main pipe but should be an equal T for pipelines =< 200mm NB.

13.17 Isolating valves

Should be placed:

- At all pipeline intersections in the branch and main line.
- At an approximate distance of 1,5km, preferably at the lowest points.
- Start of every rising main with arrow pointing towards the pumping station.
- At the end of every gravity main with arrow on valve pointing in flow direction.

Isolating valves should be mounted with flange adapters to aid in removal.

13.18 Valve chambers

Valve chambers of robust construction should be provided for all valves.

Valve chambers must be properly ventilated with vermin proof fixed GMS or 3CR12 louvered ventilators.

Sufficient access should be provided in valve chambers for the removal of bolts.

The cover should be 700mm above ground level and should be of a hinged and non-removable type.

A sump should be provided for dewatering.

The chamber should be secure against vandalism.

13.19 Pressure control valves

Pressure control valves are not favoured and their use should be minimised.

Break pressure tanks should be used for pressure reduction where possible, but the correct placing of reservoirs is preferred.

13.20 Thrust blocks and anchors

Coupled pipelines must be anchored at:

- All changes of direction greater than 10 degrees.
- At changes in pipe size.
- At slopes greater that 1:6.
- At blank ends.

The anchor blocks must be large enough to:

- Provide sufficient friction and bearing forces between the anchor block and soil to balance the thrust force in any direction; and
- Balance upward forces through the mass of the block.

The pipe should be imbedded at least up to the centre line at bends.
A flexible membrane should be inserted between the pipe and anchor block to prevent damage to pipes subject to chafing.

13.21 Structural design

Pipelines should be designed for internal and external pressure including surge pressure.

The structural load bearing capacity of the pipe is specified by the manufacturer and care should be taken not to expose the pipe to loading conditions other than that intended by the manufacturer.

13.22 Corrosion protection

Refer to DWS 1131 in ***Specifications Folder***.

13.23 Couplings

Two major categories are generally used, namely rigid and flexible joints.

Flexible joints are defined as those joints that allow some telescopic movement or angular flexure of the adjoining pipes.

13.23.1 Rigid couplings/joints

13.23.1.1 Flanges

Flanges should be attached to pipes by metal-arc welding, the weld preparation being in accordance with the requirements of **BS806 Type 6** unless otherwise specified.

A slip-on welded flange is suitable for all design pressure conditions covered by BS flange tables up to and including **Table J** and design temperatures not exceeding 425^{o}C, with pipes 80 mm and over.

Flanges should be in accordance with **BS 4504**.

13.23.1.2 Welded butt joints

Butt joints welded by the metal-arc process should be in accordance with the requirements of **DWS 1130 and DWS 1110**.

13.23.1.3 Screwed couplings

Pipes should be screwed taper and sockets parallel thread according to SANS 1109 or ISO 7/1.

Galvanized pipes may be threaded after galvanizing.

The use of parallel threads on light pipes are not recommended.

13.23.2 Flexible couplings

All flexible coupling should be able to withstand an internal pressure equal to or greater than the design working pressure of the pipe.

The couplings should be able to withstand any external pressure due to installation conditions without the presence of an internal pressure.

Spigot and socket joints utilizing a rubber ring as a seal should be watertight under working pressure with a shear force equal to the expected external load applied to the coupling.

Rubber O-rings used for sealing should not elongate more than 25% of the original length when stretched over the spigot end of a pipe. See BS 2494.

Rubber o-rings should not be exposed to ultra-violet radiation or ozone for periods longer than the time required for installation.

Where a pipeline is likely to be subjected to any abnormally corrosive condition, the pipe manufacturer should be contacted in advance so that they may advise on the suitability of their joints for the purpose, or alternatively in collaboration with their rubber supplier, provide rings that will meet the requirements of the situation.

Sleeve type joints using a flexible plastic sleeve must conform to the misalignment test according to the relevant SANS standard for that specific type of pipe utilizing the coupling.

The draw and slew movement of the coupling will be in accordance with the requirements of the relevant SANS standard for that specific type of pipe utilizing the coupling.

13.24 Fittings

13.24.1 Reducers / diffusers and inlets

The range of angle of deflection for concentric or eccentric diffusers (enlarging diameter) should be between 2,5 – 30 degrees.

Where available NPSH is a problem, rounded inlets should provide better flow characteristics and less friction losses.

13.24.2 Bends

Refer to **DWS 1130**.

Elbows should not have a bending radius smaller than the outside diameter of the pipe.

Medium and long radius bends should not have a radius larger than seven times the outside diameter of the pipe. Long radius bends normally have a radius of approximately three times the outside diameter of the pipe.

Standard angles of elbows are: 90, 45 and 22,5 degrees.

13.24.3 Dividers

All flow dividers will cause change in flow direction and should therefore be properly anchored.

Standard angles of deviation from the main pipe are: 90, 60, 45, 22.5 and 11 degrees.

13.24.4 Puddle or thrust flanges

Puddle or thrust flanges should be provided where a pipe passes through a water retaining structure or chamber.

A thrust flange will assist in the transfer of axial pipe forces due to water hammer or surges.
The flange should be designed structurally to withstand the shear forces it will experience.

Steel pipelines should be insulated with paint where they pass through concrete.

13.24.5 Reinforced specials

The procedures developed H.S. Swanson et al have been incorporated **into AWWA M11 - Steel pipe - A guide for design and installation**, and are generally used in the design of reinforced specials.

13.25 Pipeline specifications

The following DWAF specifications are applicable to pipelines and are included in the ***Specifications Folder***.

NUMBER	DESCRIPTION
DWS 1110	Construction of pipelines
DWS 1130	Design, manufacture and supply of steel pipes
DWS 1131	Lining and coating of steel pipes and specials
DWS 1140	Design, manufacture and supply of asbestos-cement pressure pipes and joints
DWS 1150	Glass reinforced plastics (GRP) pipes and joints for use for water supply
DWS1160	Design, manufacture, supply, and installation of Polyvinyl Chloride (PVC) Pressure Pipes and fittings
DWS 2510	Supply of valves

14 RESERVOIRS

14.1 Storage

Reservoirs should be designed for the following storage capacities:

- Elevated storage capacity should be designed for 2 hours of peak daily demand for the area served by the elevated storage.
- Ground level reservoirs that are gravity fed: 24 hours of annual average daily demand.
- Ground level reservoirs that are pump fed from one source without a standby power supply or pump: 48 hours of annual average daily demand (all storage inclusive).
- Storage based on 60 litres per capita per day demand.

14.2 Storage for small ground water schemes

If ground level storage can be located close to the village and provide the required residual head for the reticulation, then 36 hours or 48 hours storage at 60 lcd should be provided according to the number of boreholes utilised.

However, if achieving the minimum residual pressure requires an elevated tank, then it is recommended to omit the ground level storage.
The elevated tank should only be sized for 16 to 24 hours of 25 lcd (10 years design horizon), and the borehole pumps should pump directly into the tank.

An elevated tank so sized will be adequate in the short term and will be a suitable investment for use as an elevated tank in conjunction with ground level storage at a future date.

14.3 Design

It is recommended that all reinforced concrete water-retaining structures be designed to a 0,2mm crack width using 30MPa concrete in accordance with **BS8007**.

Potable water tanks must have roofs.

Storage must be provided for sludge accumulation and a scour valve must be provided. The scour pipe should be separate from the inlet or the outlet pipe.

Submerged valves and fittings must be avoided if possible.

Pipework below the reservoir floor should be minimized.

A screen should be provided at the outlet.

14.4 Materials

The selection of materials is dictated by durability and life cycle costs.

14.5 Metering

Bulk metering is essential.

Whether the meter should be placed at the inlet or the outlet depends on the institutional or contractual arrangements.

14.6 Level control and indication

The reservoir must not be capable of spilling under normal operating conditions.

A water level indicator should be provided.

14.7 Position

The reservoir should be provided close to consumers to avoid long pipelines having to cater for the instantaneous peak demand.

14.8 Break pressure tanks

Correctly placed reservoirs are preferred in place Break Pressure Tanks, but when this is not practical, the following guidelines are applicable to break pressure tanks:

Tanks to have a partition with duplicate pipework and control valves etc.

The minimum volume per partition:

- Gravity inflow and outflow – 5 minutes
- Pumped inflow and/or outflow – 30 minutes

Inlet control:

- Gravity – Float Level Control

- Pumped – as per pump control

Control Valves are not preferred, but if required, then provision must be made for adequate maintenance.

15 STAND PIPES, YARD TANKS AND OTHER CONSUMER CONNECTIONS

15.1 Stand pipes

A concrete plinth should be provided which allows the water to drain into a soak-away (sump with crushed stone).

The tap should be high enough for a container to fit underneath. Preferably a stand should be provided for the container to stand on, with a higher tap.

The tap should preferably be of the push button or self-closing type.

Consumer off-takes directly on pumping mains are not acceptable.

15.2 Yard tanks

The yard tanks should be approximately 200 litres in size to provide adequate storage for daily supply. The flow into the yard tank must be regulated by means of a flow constraint mechanism to maintain supply at approximately 200 litres.

The level of the outlet must be high enough to ensure a 25-litre container can fit easily for filling.

As in standpipes, a concrete plinth should be provided below the outlet to allow waste to drain into a soak-away (Sump with crushed stones).

Sunlight entry into the tank should be prevented to prevent algae growth.

15.3 Valves

An isolating valve should be provided at each standpipe.

15.4 Pressure

The minimum pressure at the hydraulically highest tap under a dynamic loading of 80% of the stand pipes being open should not be less than 6m.

The maximum static pressure should be 90m.

15.5 Minimum flow

The flow rate from the outlet of a standpipe should not be less than 10 litres per minute. For yard tanks it should be a maximum of 6000 litres per household per month.

15.6 Coverage

A maximum of 25 households or 100 people per stand pipe.

15.7 Walking distance

A maximum of 200m where feasible.

16 VENTILATED IMPROVED TOILETS

16.1 Introduction

Providing adequate sanitation facilities for residents is a major challenge in all developing countries. Those who have inadequate sanitation may be using a bucket system, unimproved pit toilets or the veld or any toilet which is not properly operated and maintained.

When a sanitation system fails, or is inadequate, the impact on the health of the community and the negative impact on the environment can be extremely serious. Outbreaks of diarrhoea and of cholera could occur.

The VIP toilet has a number of advantages over other toilet systems. The capital and operation and maintenance costs of a VIP are low, standard designs are available, only semi-skilled labour is required for their construction and the availability of a constant supply of water is not a factor.

The purpose of this standard is primarily to assist authorities and funding agencies in settting acceptable minimum standards for the design and construction of VIP toilets.

Individual households often copy the VIP toilets constructed by nearby formal programmes. It is hoped that this standard will create an expanded sphere of influence in that the VIP toilets constructed in accordance with this standard should stand as examples for surrounding communities who wish to build their own.

16.2 DefinitionS

Ventilated Improved Pit Toilet (VIP toilet) is a toilet which comprises:

- a pit into which the excreta falls and from which the liquid fraction seeps into the surrounding soil;
- a slab which covers the pit and which has two holes, one for the excreta to fall through and one for the vent pipe;
- a superstructure which provides privacy and which prevents light from entering the pit;
- a vent pipe which removes odour from the pit;
- a fly screen at the top of the vent pipe which prevents flies from entering the pit and which also prevents flies that have entered the pit from leaving through the vent pipe.

The Strategic Framework provides various definitions relating to a basic sanitation facility, a basic sanitation service and the eradication of the bucket system, as follows:

Basic sanitation facility is:
The infrastructure necessary to provide a sanitation facility which is safe, reliable, private, protected from the weather and ventilated, keeps smells to the minimum, is easy to keep clean, minimises the risk of the spread of sanitation-related diseases by facilitating the appropriate control of disease carrying flies and pests, and enables safe and appropriate treatment and/or removal of human waste and wastewater in an environmentally sound manner.

Basic sanitation service is:
The provision of a basic sanitation facility which is easily accessible to a household, the sustainable operation of the facility, including the safe removal of human waste and wastewater from the premises where this is appropriate and necessary, and the communication of good sanitation, hygiene and related practices.

[A Ventilated Improved Pit toilet (VIP) complies with both the old and revised definitions of a basic sanitation facility.]

Eradication of bucket toilets:
The bucket system is an unsuitable and inappropriate level of service. All water services authorities must identify and implement programmes for the eradication of all bucket systems by 2006.

The social, economic and cultural circumstances in the community,the geographical location and the technical characteristices of the different sanitation facilities all play major roles in the choice of the most appropriate sanitation system. In most situations, however, the ventilated improved pit (VIP) toilet together with good domestic health and hygiene practices will meet the requirements of a basic minimum level of service.

16.3 Operating principles

No water is needed to operate a VIP toilet (i.e. there is no flushing).

The pit should retain sufficient moisture for biological decomposition to occur, as the faecal matter will not break down if the pit is too dry and as a result the pit will fill up rapidly.

The egress of water from the pit should be adequate to prevent the pit being filled up rapidly with faeces and urine.

Provision should be made to access the pit of a VIP toilet through the slab in order to empty it manually or per vacuum action when required. Alternatively it should be possible for the VIP toilet to be moved when the pit is full.

Odour is removed from the pit through the action of wind blowing across the vent pipe and to a lesser extent by the air heating up on the inside of the vent pipe.

Flies, which are attracted into the pit by the smell, are trapped by the fly screen at the top of the vent pipe as they try to escape to the light.

16.4 Material

16.4.1 Concrete

The concrete should be capable of coping with the exposure conditions expected. Where necessary this will dictate cement and aggregate selection.

Recommended volumetric mix proportions are given in table 1.

Table 1 — Volumetric mix proportions for concrete and mortar

1	2	3	4
Purpose for use	**Cement** Wheelbarrow[a)]	**Sand** Wheelbarrow[b)]	**Stone** Wheelbarrow
Mortar for plastering	1	6	-
Mortar for bricklaying	1	6	-
Concrete for foundations and floors	1	3	4
Cover slab	1	2	2

[a)] The volume of 2 packets of cement is equal to the volume of 1 wheelbarrow of cement
[b)] The type of sand should comply with the purpose, i.e. plaster sand for plastering, building sand for bricklaying and river or crusher sand for concrete

16.4.2 Cover slab

The cover slab should generally be made of concrete or cement-mortar

16.4.3 Pedestal

The pedestal can be commercially fabricated with ceramic, polyethylene, glass reinforced plastic (GRP) and PVC or can be fabricated on site with wood, concrete, mortar or bricks.

16.4.4 Superstructure

The walls and roof can be constructed from a variety of local or prefabricated materials that are durable and weatherproof.

All hinges. Locks and handles should be of robust construction and resistant to corrosion.

16.4.5 Vent pipe

The vent pipe should be manufactured from uPVC pipe, brick, fibre cement pipe or cast iron.

16.4.6 Fly screen

The flyscreen should be resistant to damage from UV light, rain water and the gases emanating from the pit.

16.5 Design and construction of a VIP toilet

16.5.1 Pit

The recommended pit storage volume for a typical household (excluding the freeboard) is as given in Table 2.

NOTE A method for determining the pit storage volume as a function of the number of people using the pit, the solid accumulation rate and the desired life span of the pit is described in the publication *Building VIPs: Guidelines for the design and construction of domestic ventilated improved pit toilets*.

Freeboard height above the storage volume should be as given in Table 2 and Figure 1.

A pit can be round or rectangular. A round pit is more stable and is recommended in less cohesive soils.

For maximum efficiency, a pit should be large and deep. Round pits with diameter 1 m to 1,5 m and square pits with a width of 1 m to 1,5 m are the norm. Longer and shallower pits are acceptable in the case of rocky areas or areas with a high water table.

If the pit depth cannot be achieved due to rock or groundwater, an alternative such as a urine diversion toilet should be considered.

The size of the pit and the porosity of the soil surrounding it should be such that water will percolate faster out of the pit than liquids entering the pit.

A pit should not penetrate the water table

Only faecal matter, urine and cleansing water should be allowed to enter the pit.

Separate provision should be made for the disposal of grey-water and other household waste.

A drawing of a typical VIP toilet is shown in figure 1.

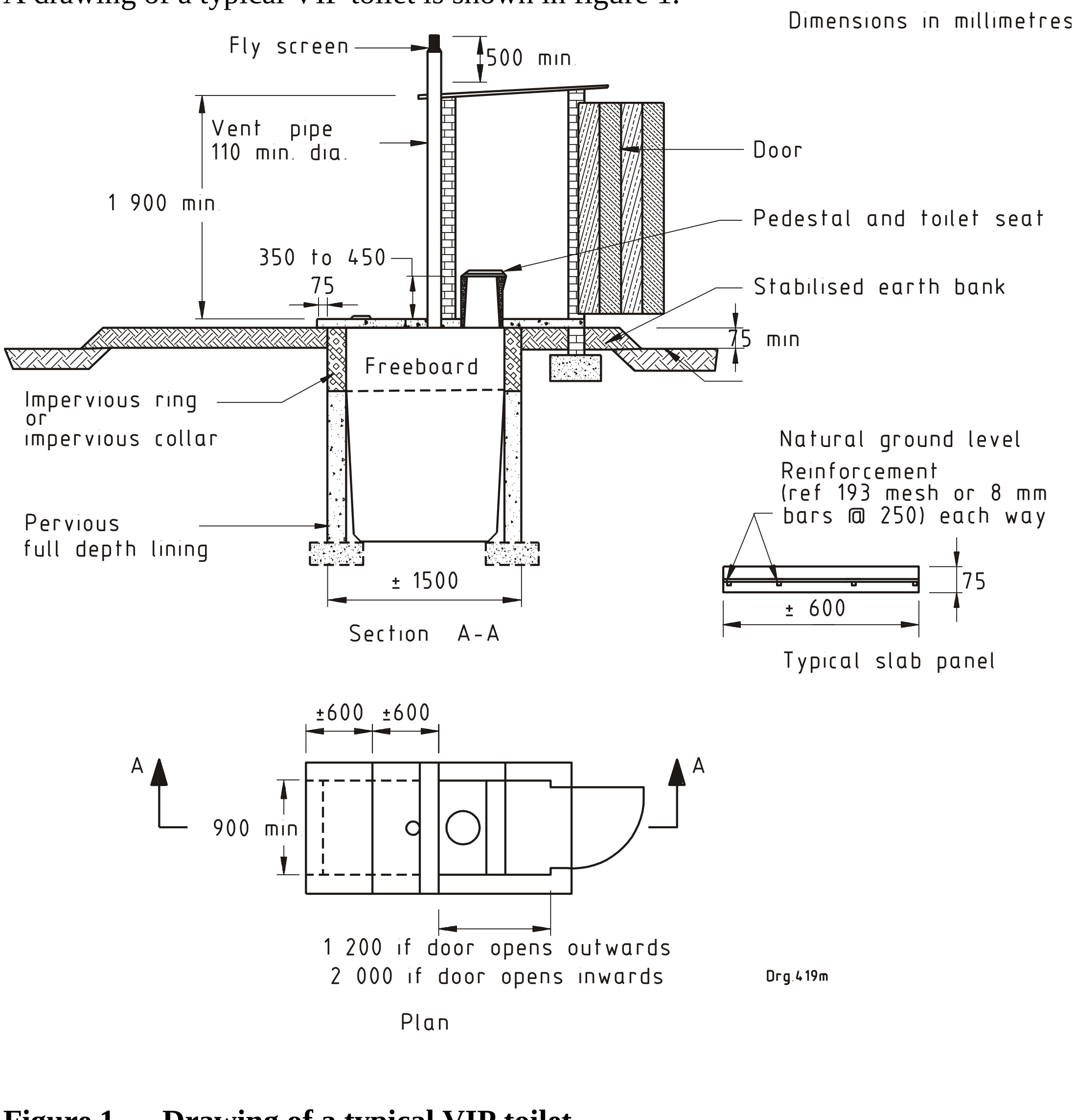


Figure 1 — Drawing of a typical VIP toilet

16.5.2 Location

The toilet should be situated downhill and at least 30 m from a borehole or a well (see SANS 10252-2).

The toilet should be near the house but so sited as not to endanger the structure of any building or any services on the site or on the border of the site.

The toilet should afford privacy of use by facing towards the house

If practical, more than one potential suitable location should be identified per stand where there is no pit emptying service.

Where the pit will be emptied by a vacuum tanker the toilet should be situated such that a vacuum tanker can approach to within 30 m of the toilet and not more than 2 m above the pit.

The toilet should not be built under or near trees.

16.5.3 Lining

Pits in stable soil which will be emptied by hand or pits moved when full need not be lined.

Pits in unstable soils and those that will be emptied by vacuum tanker should be lined.

The lining and soil should be sufficiently porous to allow water to seep out.

The lining can be constructed from concrete blocks, bricks, cement-stabilised soil blocks, stones or mesh-reinforced soil-cement.

16.5.4 Collar

A collar should be installed in all pits to:

a) prevent surface water or soil fines running into the pit;
b) support the cover slab and the mass of the users; and
c) support the mass of the superstructure if it rests on the slab.

A collar should be impervious and extend to at least 500 mm below the top of the pit and at least 75 mm above ground level.

A collar should be surrounded by a cement-stabilised earth bank or a shaped earth drain.

The same material that would be used for a lining is suitable for a collar.

16.5.5 Cover slab

The cover slab should generally be made of concrete.

The minimum thickness of the slab panel should be as given in Table 2. The mass of the slab should not exceed 150kg (to allow it to be moved by hand).

The reinforcing should be as given in Table 2.

Reinforcing have to be designed for a flat slab exceeding 1,5 m in span.

A cover slab should have two holes to accommodate the pedestal and the vent pipe. The shapes and sizes of the holes should correspond with the shapes and sizes of the pedestal and the vent pipe.

It can be circular or rectangular.

A cover slab should be properly supported by the pit lining or pit collar by allowing an overlap of at least 75 mm on each side.

Separate panels should be sealed against each other with a weak mortar mixture or window putty to obtain a fly-proof joint.

16.5.6 Pedestal and toilet seat

Some groups may require a squatting plate and not a pedestal.

The pedestal should have a smooth inside surface and be impervious to the penetration of water.

Pedestals can be commercially fabricated with ceramic, polyethylene, glass reinforced plastics (GRP) and uPVC or can be fabricated on site withconcrete, mortar or bricks.

Concrete or mortar pedestals should be painted with a waterproof paint.

The inside walls should be vertical or splayed slightly outwards from top to bottom (to minimize fouling).

The inside walls should be located directly over the pit. A side chute is not recommended.

The pedestal height should be between 350 mm and 450 mm.

A toilet seat should be installed. The minimum internal dimensions of an oval seat are 310 mm and 250 mm and for a round seat the diameter is 250 mm.

The opening in the seat should be smaller than the opening in the pedestal with an overlap of at least 10 mm at the front end side and at least 70 mm at the back.

The surfaces of the toilet seat and lid should be smooth and free of obstructions.

The hinges of the seat and lid should be corrosion-resistant.

A gap should be provided between the seat and lid for ventilation purposes.

16.5.7 Superstructure

The superstructure can be rectangular shaped, circular or spiral with or without a privacy wall (a screen wall makes a door unnecessary).

The design of the superstructure should ensure privacy, comfort and protection against the weather.

The design of the superstructure should allow for emptying the pit, if required. (manually or by vacuum).

To reduce load on the cover slab, pit collar or lining, the superstructure can be offset. Any part of a wall that extends beyond the edge of the cover slab should be supported by a foundation.

The vent pipe may be situated inside or outside of the superstructure.

While the superstructure should allow indirect light to enter, the pit should be kept dark.

The superstructure should be adequately fastened to the cover slab or the foundation.

The roof should be waterproof and adequately fastened to the walls.

The vent pipe should be adequately fastened to the superstructure.

If the door opens outwards it is more prone to wind damage but the interior floor area can be decreased, thus reducing building costs.

The minimum dimensions of a superstructure should be as given in table 2.

The walls and roof can be constructed from a variety of local or prefabricated materials that are durable and weatherproof.

16.6 Ventilation

16.6.1 General

Moving air should be allowed to enter the superstructure through the vent holes through the walls and above the door, through the gap between the lid and seat, through the pedestal into the pit and out through the vent pipe.

Ventilation openings should be provided and positioned high up in the walls or above the door (see Figure 2).

The total ventilation opening areas for incoming air should be at least three times the cross-sectional area of the vent pipe.

16.6.2 Vent pipe

Wind shear across the vent pipe is the main cause of ventilation in the system.

The vent pipe should have a diameter of at least 110 mm.

The vent pipe should extend at least 500 mm above the highest point of the roof.

16.6.3 Fly screen

The vent pipe should be covered with a mesh to prevent flies entering or leaving the pit.

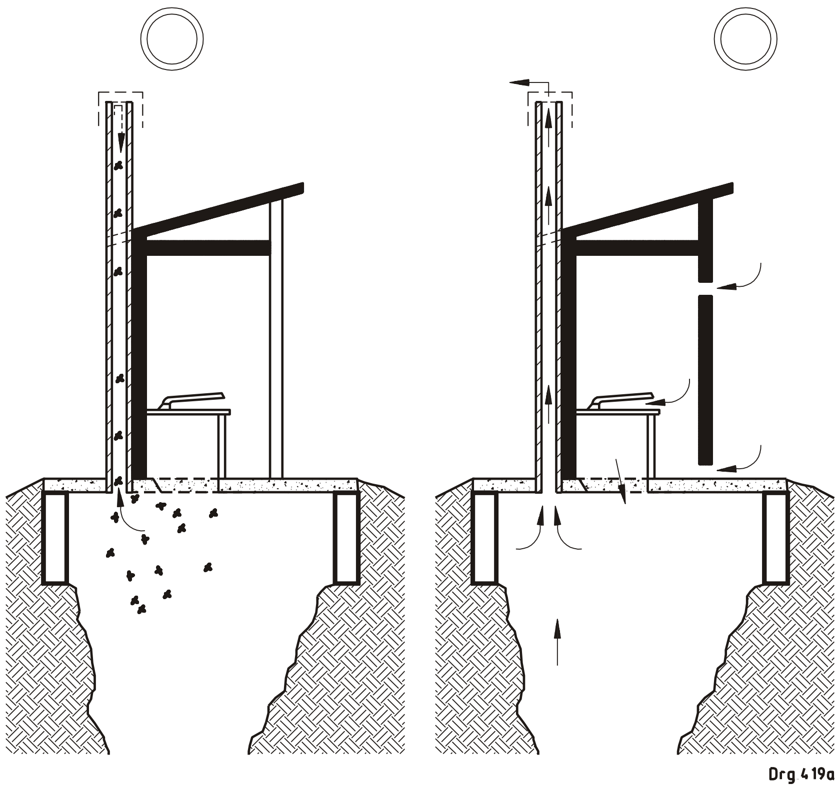
The mesh should be secured horizontally over the top of the vent pipe.

The openings in the mesh should have a maximum size of 1 mm x 1 mm. Smaller openings will cause resistance to free air flow and larger openings allow insects to pass through to the pit.

The mesh should be located in such a position that leaves will not accumulate on it.

The mesh should be made of aluminium, stainless steel, glass fibre or other material resistant to corrosion from uv light, rust and the gases emanating from the pit.

Cowls should not be used over the vent pipe as they obstruct the light and induce turbulence, thereby reducing wind shear at the top of the vent pipe.



a) Fly control **b) Ventilation**

The ventilation systems

16.6.4 Hand-wash facility

Where a water stand pipe is not available nearby a small water tank should be provided.

16.7 Ground water contamination risk associated with a VIP toilet

Unless lined with an impervious lining, on-site sanitation systems, such as the VIP Toilet, dispose of human waste directly into the ground.

In order to minimise the risk of contaminating ground water sources the guidelines provided in the DWAF Ground Water Protocol must be followed.

The DWAF Ground Water Protocol is included in the ***Ground Water Folder***.

TABLE 2: SUMMARY OF RECOMMENDED MINIMUM DIMENSIONS

Component	Recommended minimum dimensions	
Pit	Storage volume: Pit to be emptied Toilet to be moved Freeboard:	 2,0 m^3 3,0 m^3 0,5 m
Collar	Depth: Projection above ground level: Slab support width:	500 mm 75 mm 75 mm
Slab	Thickness: Overlap on collar: Reinforcement if span is < 1,5 m: In underside of slab Concrete cover over reinforcement Type: 8 mm bars, 250 c/c each way, or Ref 193 steel mesh, or 4 mm roofing wire, 150 c/c	75 mm 75 mm 25 mm
Pedestal	Height from floor:	350 mm to 450 mm
Seat opening[b)]	Round Oval	250 mm diameter 310 mm X 250 mm
Superstructure[c)] (on site constructed)	Internal height: Internal width: Internal length, door opening outwards: Internal length, door opening inwards: Dimension between pedestal and door opening outwards	1,9 m 0,9 m 1,2 m 2,0 m 0,6 m
Door	Height: Width:	1,5 m 0,7 m
Vent pipe	Diameter: Extending above roof:	110 mm 500 mm
Fly screen	Openings:	1 mm x 1 mm

17 STAFF, HOUSING, LABORATORIES, AND OTHER FACILITIES

17.1 Staff requirements for water supply schemes

Once a scheme has been planned and the basic designs of the various components are known, a staffing structure must be developed. This will depend on the nature of the works (i.e. water or sewage) and on the components which are to be operated and maintained. Staff within the operating organisation who have spare capacity must be kept in mind so as not to burden the organisation unnecessarily.

The components for which staff must be considered are:

- The raw water source, i.e. borehole(s), dam, river pump station, and pipelines.
- The treatment works.
- The main distribution system and reservoirs.
- Reticulation**.**
- Laboratory.
- Stores.
- Administration.
- Meter reading, billing and collecting revenue.

Where a borehole, fitted with a hand pump or a windmill, is provided and user ownership resides in the community, individual members of the community will have to operate the pump as they require water. In the case of the windmill a few people can be responsible for monitoring tank levels and releasing or applying the brake when necessary. Someone within the community needs to be trained to service the pumps/windmill at regular intervals or these services should be provided from outside.

Where one or more boreholes equipped with an engine are involved a permanent "operator" is required to monitor reservoir levels, start and stop the engine, check fuel, oil and water levels, generally ensure the well-being of the engine, procure the fuel and call for specialised maintenance when needed.

In a case similar to the above where chlorination is applied the operator should receive additional training in controlling the chlorination system.

Where water is abstracted from a river, chlorinated and pumped to a reservoir from where it is reticulated to the community an operator will be necessary with appropriate training in pumps diesel/petrol engines or electric motors. Depending on the length of pipelines and extent of the reticulation, number of standpipes etc. an additional person may be needed to help with maintenance.

Any water supply scheme/or sewage disposal system where a treatment works as defined in the Water Act forms part of the system will fall under Regulation R2834 of 1985 and such works will have to be registered with DWAF and will have to employ operators of the requisite grading. These regulations are included in the ***Legislation and Policy Folder***. These regulations only stipulate the minimum number of operators needed to meet the law. In every case this minimum must be compared with the number of operators physically required to man the works at all times during its operation. Where any works is to operate continuously, for example, at least 4 operators will be required to allow for days off and sick and vacational leave. Besides the operating staff for the treatment process, additional operating staff for dams and pump stations etc., as well as maintenance staff may be required. Depending on the overall length and diameters of the pipelines involved the number and size of maintenance teams will need to be decided. It is recommended that there be at least 1 team per 10 km of pipeline with the size of teams as follows:

DIAMETER OF PIPE	**SIZE OF TEAM**
<75mm	2
75 - 100mm	3
100 - 300mm	4
300 - 800mm	5
>800mm	6

The amount and type of equipment installed will dictate whether full time mechanical and electrical artisans need to be employed or whether such services can be contracted out.

The extent of the buildings and structured will determine the number of civil maintenance staff needed and the number of cleaners needed.

The size of the treatment plant and complexity of the process employed will determine whether full time laboratory staff are required. Usually they would only be necessary on a Class "B" or higher works.

As the size of a treatment plant and/or the major pipelines and reticulation increases, so does the number of supporting staff. Stores are of major importance and a Class "C" or higher works should be provided with a storeman.

Where billing and tariff collection is to be the responsibility of the scheme itself, provision must be made for meter readers (when meters are installed) and for clerks and a cashier.

Financial arrangements need to be made with the WSA to facilitate payments for fuel or electricity and chemicals.

17.2 Housing requirement for water supply schemes

The necessity of providing housing for a scheme will depend on the following:

- Location of works and distance from town.
- Type of storage, water care and pumping facilities and whether they require constant attention.
- Existing staff of service provider and where they are housed.

At the smaller water supply schemes, i.e. those involving boreholes, pumps and chlorination only, and where the level of skill required for the operation and maintenance can be found within the community, housing associated with the scheme should not be necessary.

At larger schemes, where skills required cannot be found within the community to be served and where skills must therefore be procured from elsewhere, consideration must be given to providing housing for the staff required to perform certain duties such as process control, skilled electrical and mechanical maintenance and computerized billing systems.

The houses will need to be similar in size and finish to the standards expected by persons of the relevant post grading. Generally, however, it is preferable to minimize the different types of housing. This reduces housing related problems when personnel are transferred or promoted.

Where housing is provided, problems may arise in cases where it is necessary to terminate the services of employees.

Geographical aspects can be a reason to provide housing for all staff members, such cases arise where a scheme may be located in an isolated area in order to be near a large dam and where transport infrastructure is minimal.

In all cases where housing is provided, the economies of providing the houses against providing a transport allowance should be considered in conjunction with the inconvenience factors which arise. While providing on site housing is convenient for staff, problems arise in providing schooling for children etc.

A charge is normally levied where housing is provided and should this be regarded as too high it is likely that staff may choose lower standards of housing at cheaper rates, privately.

There may be tax implications (perks tax) for employers who receive free housing.

Providing a subsidy for workers to own their own housing should be seen as preferable as this builds stability in communities.

Consideration should be given to the following:

- The installation of security fencing around the housing.
- The provision of security lighting like street lighting or high-mast lighting.
- The provision of an electricity meter for each house.
- The provision of one or more communal telephones.

17.3 Laboratories, offices and other facilities

Laboratory or on-site analysis of water may be performed as a means of plant and system control or adjustment and as a periodic check on water quality. Routine testing of water is designed to establish that the water is aesthetically acceptable and hygienic. These tests may be carried out with relatively simple equipment, titrations, colour comparison or simple robust instrumentation such as pH measurement.

Any water supply scheme such as a borehole or a river pump station where chlorine is added to the water should be provided with a chlorine test kit and the necessary reagents. The recommended equipment is a Lovibond comparator with a chlorine disc B/40A and DPD tablets.

On a small scheme where lime is added a test kit such as that for chlorine, but with a pH disc and reagents should be provided. Alternatively a simple robust PH meter may be used.

Suitable testing equipment and testing frequency for a small water treatment plant that produces <1M1/d are indicated in the table below:

PARAMETERS	EQUIPMENT	FREQUENCY	REMARKS
PH	PH meter	Daily	If lime is added
Turbidity	Turbidity meter	Daily	If flocculants are added
Colour	Colour comparator	Daily	
Chlorine: Total residual Free residual	 Chlorine comparator	Once a day At least twice a day	When gas chlorine is used. When chlorine tablets or solutions are used.
Flocculation	Laboratory jar stirrer	When necessary	When replacing flocculant with a new one or when the nature of the raw water changes

Conductivity TDS E-coli Total hardness Calcium hardness Magnesium hardness Total alkalinity Sulphates Chlorides Fluorides Nitrates Iron Manganese	These tests can be contracted out or performed by a nearby larger facility.	In accordance with the water quality monitoring schedule.	Alternatively when there is pollution or suspicion of pollution in the area.

Note: Potable water should comply with SANS 241. See Chapter 9 for Water Treatment plants.

Suitable testing equipment and testing frequency for a water treatment plant which produces between 1M1/d and 5Ml/d s are listed in the table below:

PARAMETER	**EQUIPMENT**	**FREQUENCY**	**REMARKS**
PH	PH meter	Daily	
Turbidity	Turbidity meter	Daily	
Colour	Colour comparator	Daily	
Chlorine: Total residual Free residual	Chlorine comparator	Once a day At least twice a day	When gas chlorine is used. When chlorine tablets or solutions are used.
E-coli	Incubator	Weekly	
Conductivity	Conductivity meter	Daily	
TDS	Weighing Balance/Calculations	Weekly	
Total hardness Calcium hardness Magnesium hardness Total alkalinity	Titrations:Burettes	Daily	
Stability test	Calculations	Daily	
Flocculation test	Laboratory jar stirrer	When necessary	When replacing flocculant with a new one or when the nature of the raw water changes.

Sulphate Chlorides Fluorides Nitrates Iron Manganese	These tests can be contracted out or performed by a nearby facility.	Once a month or every two months.	Iron and Manganese may be analysed for on a frequent basis, where these are known to occur. Other specific metals may need to be determined when there are industrial or mining activities in the vicinity.

A complete laboratory as per list below should be provided for a water treatment plant which produces >5M1/d. Support laboratory equipment such as weighing balance, hot plates, filters, vacuum pumps, stirrers and burners will also be required.

PARAMETERS	**METHOD/ EQUIPMENT**	**FREQUENCY**	**REMARKS**
PH	PH meter	Daily	
Turbidity	Turbidity meter	Daily	
Colour	Colour comparator	Daily	
Chlorine Total residual: Free residual	Chlorine comparator	Once a day At least twice a day	When gas chlorine is used. When chlorine tablets or solutions are used.
E-coli	Incubator	Daily	
Conductivity	Conductivity meter	Daily	
TDS	Weighing balance/ Calculations	Weekly	
Total hardness Calcium hardness Magnesium hardness Total alkalinity	Titrations	Daily	
Flocculation test	Laboratory jar stirrer	When necessary	When replacing flocculant with a new one or when the nature of the raw water changes.
Stability test	Calculations	Daily	

Sulphates Chlorides Fluorides Nitrates Iron Manganese	Turbidity/ Gravimetric Titration Spectrometry Spectrometry Spectrometry Spectrometry	Weekly	Iron and Manganese may be analysed for on a frequent basis, where these are known to occur. Other specific metals may need to be determined when there are industrial or mining activities in the vicinity..

Laboratories, workshops and other facilities should be available at the time of scheme commissioning. Sufficient funds should be allowed in the project budget for the start up costs of these facilities.

17.4 Non-fixed assets

Non-fixed assets such as loose tools, laboratory fittings, and workshop equipment should be provided as part of the implementation cost.

The number of vehicles needs to be determined carefully according to the requirement and sharing possibilities.

18 TENDER PROCEDURES

Each Municipality must have their own Tender Procedures. However DWAF Tender Procedures are provided here as a guideline.

18.1 Limitations

This section applies mainly to Civil Contracts, and is only applicable to tenders for new schemes being controlled by the Department of Water Affairs and Forestry.

For Mechanical/Electrical Contracts the Mechanical/Electrical Engineering Directorate must be consulted.

Where State Funds are involved, the Departmental Tender Procedures as prescribed in the Accounting Officer's Procurement Procedures must be used.

18.2 Steps in the tendering process

The tendering process comprise the following steps:

- Approval of Business Plan.
- Detailed survey work starts.
- Detailed design work starts.
- Conceptual Design Report submitted to DWAF Pretoria.
- Design Meeting: consultants meet with DWAF Pretoria design team.
- Update on Conceptual Design Report.
- Draft Tender documents with drawings (3 copies prepared and forwarded to DWAF Pretoria).
- Update Tender Documents: 13 copies plus marked up draft sent to DWAF Pretoria.
- Approval: Original Tender Documents sent around to relevant officials of DWAF Pretoria for signature.
- Original copy plus 12 other copies sent to Departmental Control Committee for approval.
- Call for tender advertised in Government Tender Bulletin (Friday). Advertisement period should be 28 days.
- Tenderers obtain Tender Documents from Tender Office situated at the entrance of zwaMadaka Building.
- Compulsory site visit.
- Contractors calculate prices, fees and total cost of their bid for constructing the project.

- Sealed tenders submitted before due date. Tenders up to an unlimited amount close at the Department.
- Tender box closed at specific time (Wednesday at 11h00).
- Tender box opened in public and details of tenders received recorded.

Adjudication of tenders by consultant.
Submission of Adjudication Report to RDP coordinator.
Adjudication Report accepted and contractor assigned to project.
Contractor starts work.

18.3 Pre- tender stage

The pre-tender stage includes all work up to the submission of the tender documents for approval by the Regional Tender Committee or the Departmental Control Committee, as appropriate.

This stage includes:

- Preliminary proposals (dealt with under Section C: Civil Design).
- Design Reports (dealt with under Section C: Civil Design).
- Draft Tender Documents.
- Final Tender Document.
- Drawings (dealt with under Section C: Civil Design).
- Tender Procedures.
- All reviewed and approved by Directorates: Civil Design and Mechanical/Electrical Engineering as appropriate.

18.4 Draft tender documents

18.4.1 Compilation of draft tender document

All tender documents must be prepared in English.

It is recommended that Consultants familiarize themselves with the general requirements of the General Conditions of Tender, Contract and Order.

On completion of the designs, unless otherwise specified, two draft copies of the tender document, based on the standard DWAF format for either:

- supply/ or installation only, or
- supply, installation and commissioning of mechanical/electrical/civil plants,
- are to be submitted to the Director: Civil Design or M/E Engineering for his comments and approval.

The General Conditions of Contract as amended from time to time are applicable. Civil Design and Mechanical/Electrical Engineering must be consulted to determine which general conditions are applicable.

Various standard forms and specifications as indicated in the standard DWAF format, are to be included in the tender documents, i.e.:

- Special conditions of contract which should not be altered or modified by the Consulting Engineer without the approval of the Department.
- Preference should be given to the use of South African National Standards (SANS) as drawn up by the South African Bureau of Standards.
- Penalties or damages must be determined as described in the General Conditions of Contract and or Clause 32.5.2 of the General Conditions of Tender, Contract and Order. For smaller contracts the formula gives and insignificant amount and the penalty must be determined in collaboration with the Director: Civil Design or M/E Engineering and Sub-directorate: Contract Administration. When valves for example are supplied under a separate contract for a pipeline, reservoir, etc., late deliveries can have a significant influence on the construction and completion of the contract. If the late completion of the contract may result in claims from other Contractors against the Department, this must be taken into consideration when determining the penalty.

18.4.2 Standard format of a DWAF tender document

The standard format of a Departmental tender document is provided below. The consultant may rearrange the format:

- DWAF Tender Front page (DW 106)
- Invitation to Tender (C2)
- Tax Clearance Certificate (C3)
- Locality Plan
- Notice of Site Inspection
- Site Inspection Certificate
- Instructions to Tenderers
- Form of Tender
- Appendix
- Important Conditions: Miscellaneous Requirements (C 6)
- Tender Commitment form (C4)
- Form Preference Points Claim: General Conditions and Definitions (C9) **Compulsory**
- Form Preference Points System: (C9.1, C9.2)
- Form Preference Points System: Equity Ownership by HDI’s (C9.6) **Compulsory**
- Form Preference Points System: Procuring Locally Manufactured Products (C9.7)

- Form Preference Points System: The Promotion of Small Businesses (C9.8)
- Declaration of Interest (C10)
- Questionnaire (C8)
- Credit Order Instruction (C11)
- Agreement
- Deed of Suretyship
- Schedule of Similar Work Undertaken by Tenderer
- Schedule of Proposed Sub-Contractors
- Special Conditions of Contract
- Alterations by Tenderer
- Project Specification (Including Project Manufacture and Installation Schedule)
- Particular Specifications
- Schedule of Quantities
- Daywork Schedule
- List of provisional amounts, for example allowances for escalation.
- The National Industrial Participation Programme (NIPP) [where appropriate for large import content contracts]

18.4.3 Departmental tender and contract forms (C-forms)

The following Departmental Tender and Contract Forms should be included in the tender document:

- Form C2: Invitation to Tender.
- Form C3: Tax Clearance Certificate.
- Form C6: Important Conditions: Miscellaneous requirements.
- Form C4: Tender Commitment Form.
- Form C8: Questionnaire.
- Form Preference Points Claim: General Conditions and Definitions (C9) **Compulsory**
- Form Preference Points System: (C9.1, C9.2)
- Form Preference Points System: Equity Ownership by HDI's (C9.6) **Compulsory**
- Form Preference Points System: Procuring Locally Manufactured Products (C9.7)
- Form Preference Points System: The Promotion of Small Businesses (C9.8)
- Form C10: Declaration of Interest.

Credit Order Instruction (C11)

Original copies of the C forms can be obtained from the Tender Office situated at the entrance of zwaMadaka Building and may not be retyped.

18.4.4 Departmental formats

The following Departmental Formats are available and should be included in the Tender Document:

- Instructions to Tenderers (The Consultant may add additional instructions).
- Special Conditions of Contract and its Appendix.

18.4.5 Standard proformas

The following proformas should be the standard pro forma forms of the “General Conditions of Contract 1990”.

- Alterations by tenderer.
- Tender.
- Agreement.
- Deed of Suretyship.

18.4.6 Other proformas

The following should be included in the contract document:

- Preamble to the Schedule of Quantities.
- Daywork Schedule.
- Schedule of Proposed Sub-Contractors.
- Schedule of Similar Work.

The Consultant may use his own forms or the Standard forms of the Department.

No allowance for price variation or contingencies may be included in the tender.

Amount of Suretyship (Civil Contracts)

The following is recommended:
For contracts with a value in excess of R5 million the amount of suretyship shall be 10%.
For contracts with a value equal to R3 million, but less than R5 million the amount of suretyship shall be as follows:
The greater value of:
Value of fixed charge and value related items in Schedule of Quantities
Or
If value of contract is R150 000 or less: 0%
If value of contract is more than R150 000 but less than R1 million: 2,5%
If value of contract is more than R1 million but less or equal to R3 million: 5%
If the value of the contract is more than R3 million but less than R5 million: 6% - 10%

18.4.7 Final tender document

After incorporation of the comments of the Department into the final document, thirteen copies shall be forwarded to the Tender Office, under cover of a letter which must also give the total estimated cost of the contract, together with expected expenditures for each financial year.

An advertisement, completed on the standard Departmental form, giving the date of advertisement, details of the site inspection, deposit to be paid by the Tenderers for a set of documents, closing date of the tender, etc. must also accompany this letter.

The following deposit structure is recommended:

the invitation of tenders above R150 000, 00 and up to R500 000, 00 a non-refundable deposit will be R50, 00;
between R500 000, 00 and up to R1 million a non-refundable deposit of R100, 00; and
for the invitation of tenders in excess of R1 million a R200, 00 non-refundable deposit.

Please note that no tender deposits are allowed on the invitation of price quotations up to R150 000, 00 per case as well as on the invitation of proposals for professional services.

The date of the site meeting for major civil and building contracts shall be arranged in consultation with the office of the South African Federation of Civil Engineering Contractors or the Master Builders Association in the case of building contracts.

18.5 Tender procedure

Approximately two weeks after the tender document has been approved for publication by the Departmental Control Committee, the tender will be advertised in the Government Tender Bulletin. If required, advertisements can also be placed in the press. Tenders must close at the appropriate DWAF office.

Tender documents will only be issued by the tender section of the Department on payment of the prescribed non-refundable deposit.

18.6 Tender stage

The tender stage includes all work from the advertisement of the tender until the issue of the order.

18.6.1 Site inspection

All information, clarification of clauses in the documents given by the Consultant and questions lodged by any tenderer at the site inspection, together with the answers, shall be recorded and sent to all tenderers as an addendum. It is to be stated clearly that the above will form an integral part of the tender documentation and tenderers must sign acceptance thereof and submit the said addendum together with their tenders. The addendum must be approved and counter signed by the Regional Director before it is distributed to the tenderers. Any other addendums shall be distributed in the same manner and must also be included in the tender. All addendums will be regarded as an integral part of the tender document.

18.6.2 Extension of tender period

Before granting and extension to the tender period it shall be discussed with and approved by the Tender Section, who will then inform the Government Tender Bulletin in writing of the new closing date of the tender. Consulting Engineers shall then advise the tenderers in writing by means of a telex or fax of the new closing date. Clause 12.4 of the General Conditions of Tender, Contract and Order must be adhered to.

18.6.3 Adjudication of tenders

After the closing of the tenders, the Tender Office will forward the tenders to the Regional Director. A duplicate copy of the tenders plus all correspondence shall be collected by hand from the Regional Director by the Consulting Engineer.

Consulting Engineers may not obtain any additional prices or rates from any tenderer during the adjudication period. Communication, except for technical clarification, with the tenderers should be avoided, and then only with the approval of the Regional Director.

The Consulting Engineer must submit a detailed report recommending, with full motivation, the acceptance of a tender as soon as possible, but not later than three weeks after receipt of the tenders from the Department. This recommendation plus all copies of the tenders including the correspondence shall be returned to the Regional Director, by hand.

The report shall include a Schedule of Tenders with comparative prices and a technical summary of the offers received.

18.6.4 Acceptance of a tender

Based on the Consultant's report the Department will check for any discrepancies between the "ORIGINAL" and "DUPLICATE COPY" of the tenders and draw up and submit a recommendation to the appropriate committee for approval. The Departmental Control Committee meets once per week, on a Monday at 12h00. Recommendations and/or specifications which must serve before the DCC must reach the Tender Office not later than a Wednesday at 12h00. When the tender recommendation has been approved, the Tender Office will send a Letter of Acceptance (C17) to the successful Tenderer. The Consulting Engineer will be advised and the official tender order will subsequently be issued by the Regional Director.

The "Tender" becomes a "Contract" with the letter of acceptance.

Rejection of all tenders or cancellation, but before approval by the DCC/RTC

A recommendation to reject all tenders or to cancel the tender must be referred to the relevant Director for approval of the cancellation.

18.6.5 Sureties and insurances

The sureties or guarantees and insurance policies that must be provided by the Contractor in accordance with the General Conditions of Contract and Clause 45 of the General Conditions of Tender, Contract and Order shall on receipt thereof from the Contractor, firstly be checked for correctness, and then sent to the Regional Director.

18.6.6 Signing of the contract

For all major contracts the "Form of Agreement" must be signed in duplicate by the Contractor and relevant Managing Engineer of the Department on behalf of the Employer.

Two documents must be book bound for signature. Only the agreement must be signed. It is not necessary to initial each page.

18.6.7 Award meeting

Immediately after the award of a contract the Consulting Engineer must arrange a meeting between responsible representatives of the Employer, the Consulting Engineer and the Contractor to clarify the scope of the contract and matters of procedure and to hand over the site to the Contractor.

18.7 Mechanical tender preparation guidelines

18.7.1 Document preparation - broad outline

Mechanical tender documents shall comprise the following in broad outline:

General specification relating to components, items and services which generally occur in pump stations, including the crane or hoist.

Project specification describing the specific project first in general terms and then in specific detail.

Technical schedule similar to the Bill of Quantities, but limited to specifying and/or inquiring of the tenderer only the technicalities of the equipment offered.

Form of Guarantee relating to pump, motor and pumpset performance.

Price schedule comprising tender price broken down into just a few major groupings and detailed items as deemed necessary for financial control of the contract.

Note:

The Mechanical engineering component of a pump station contract, unlike its Electrical and Civil engineering counterparts, does not employ a Bill of Quantities because very little of the equipment offered is of a repetitive or "measured" nature. It is not necessary to cost out each little pipe piece or nut, bolt and gasket.

Furthermore, a "payment by progressive measurement" of works completed by month end is not a meaningful control device. A method of payment against measurable goals achieved and relating to specific items of equipment as highlighted in the original document price schedule is employed. Progress payments per item are limited to up to 80% of tender value when delivered to site, with a further 10% making up 90% of both item cost and installation when equipment is ready for commissioning. Successful commissioning initiates the Guarantee Period (either 12 or 24 months). The final 10% of

Contract Value is withheld as retention money and may be released only after the satisfactory completion of the Guarantee Period, signaled by the Final Certificate.

A "Performance Bond" for 10% of the order value, is held until the Final Certificate is issued.

18.7.2 Specific points to be noted

The pump and motor (the pumpset mounted on a single baseplate) are costed in the same schedule and are considered to be a single entity.
The pump duty and station duty are specified as a primary factor in the compilation of the Project Specification - not hidden somewhere in a bill of quantities.
No specific pump manufacturer, pump size or model may be assumed. The specification must therefore clearly define how the motor is to be sized with at least 15% over-capacity safety margin. Pump and motor performance efficiency and power demand shall be guaranteed by the contractor.
Brand names may not be referred to under any circumstances when describing items in the specification. Performance requirements shall be fully specified.
Pump motor, flow meters and any other sensing instrumentation shall be part of the Mechanical Specification.

18.8 Electrical tender

The following must be included in all electrical tender documents issued for CWSS projects.

- No brand names and/or type numbers are allowed.
- The electrical scope and limits of contract must be clearly defined.
- The tenderers must be informed as to how and where the electricity is supplied and metered.
- An electrical and control function analysis must be provided.
- A line diagram of the system must be provided. This must indicate the existing layout as well as that required by the contract.
- One drawing showing the overall electrical earthing system is required.
- The Department's Mechanical and Electrical Engineering Directorate's General Technical Specifications (Electrical) (GTSE) must form part of the document. These are available in printed form as well as on electronic media.
- Transformer and cable sizes must be clearly indicated.
- There must be an electrical project specification that describes the requirements of the tender. This must cover the MV (if any) and LT panels, the motor control center, an earthing system, lighting protection and building power and lights etc. These must be clearly set out to enable the tenderer to select the relevant parts of the GTSE that apply to the contract.
- Only include those sections of the GTSE that applies to the specific project.

18.9 Procurement of a professional team

The latest version of DWAF's Policy for the appointment of Professional Service Providers (PSP's) should be followed. Special attention should be given to the respective fee limitations for competitive bid and tender.

19 CONTRACT ADMINISTRATION

Each Municipality must have their own contract administration systems. DWAF's system is given here as a guide.

19.1 Payment certificates

Payment certificates, certified for payment by the Consultant must be forwarded timeously to the Regional Director who must be consulted beforehand on the payment procedure.

The payment certificate must be structured as set out below and must contain the following information for each item of the schedule of quantities:

- The item number with a short description.
- The unit of measurement.
- The billed quantities.
- The previously measured quantity.
- The quantity for the month.
- The total quantity measured to date.
- The rate of payment.
- The total amount claimed.

All variation orders, day-works claims and extras must be listed and referenced at the end of the certificate.

The certificate must also be accompanied by a summary sheet containing the aggregates of all the individual sections, day-works and variation orders, as well as materials on site, price variation and other miscellaneous items.

An original VAT invoice must accompany all payment certificates.

Actual disbursements should be captured on the Department's Financial Management System. Operating and Capital costs should be recorded separately and not confused with one another.

19.2 Correspondence

Where Consulting Engineers are employed to supervise the construction of works of a civil engineering and building nature or a mechanical/electrical contract executed by a private contractor the following shall apply:

Copies of all correspondence must be forwarded to the Regional Director.
All matters relating to design aspects of the works shall be referred to the Regional Director and copies of correspondence, reports, etc. must be sent to the Regional Director.

19.3 Estimated costs

The following procedure must be followed:

- The estimated cost of the contract together with expected expenditures for each financial year must be submitted to the Department under covering letter with the Final Tender Document.
- After the award of a tender, the Consulting Engineer must submit an estimate of the total value of the contract including all additional costs that can be foreseen at that time, subdivided into annual expenditures if the duration of the contract extends over more than one financial year.
- On larger works where more than one contract is involved, a table setting out the anticipated expenditure for the whole project or works controlled by the Consulting Engineer, must be submitted initially and updated during April of each year. During January of each year an estimate must, after consultation with the Contractors, be made and submitted to the Regional Director, giving the value of the payment certificates for which payment will be required before 31 March of that year.

19.4 Variation orders

For alterations, additions and omissions to the contract the Consulting Engineer shall follow the procedures as set out in the General Conditions of Contract. The following procedures must also be adopted:

The nature and up to what value a variation order may be issued by the Consulting Engineer without prior reference to the Regional Director will be specified in the special conditions of contract. All variation orders must however be referred to the Regional Director for his final approval.

All variation orders involving substantial changes in design or specifications must be referred to the Regional Director. In these instances the Consulting Engineer must obtain a written quotation from the Contractor and determine whether the price is reasonable before reference to the Regional Director. The quotation and recommendation can be dealt with per facsimile if urgent, but must be followed by the Contractor's original signed quotation. The Consulting Engineer shall not instruct the Contractor to proceed until he has obtained approval from the Regional Director.

All variation orders must be submitted on an approved standardised form and consecutively numbered.

Variation orders must be kept up to date and submitted for approval within one month after occurrence of the event.

19.5 Co-ordination

Since most Departmental projects involve more than one contract as well as works executed Departmentally, regular co-ordinating meetings shall be held between the parties involved with the Consulting Engineers responsible represented. The Consulting Engineers will normally be required to minute all meetings with Contractors and must forward copies to all parties involved including the Regional Director.

19.6 Construction reports

The Consulting Engineer will be required to submit a Monthly Construction Report or Progress Report.

Where dams requiring dam safety regulations are involved or for the larger schemes, proposed pro-forma of the construction report is available from the Chief Engineer: Contract Administration. The reports must be in such a format that at the end of the contract the monthly reports must be in bound together with the final covering report to constitute the Final Construction Report. Under certain circumstances (dam safety requirements) the Engineer will be required to submit a separate consolidated Final Construction Report.

19.7 Inspections

19.7.1 Civil works

<u>General</u>

On completion of a contract, but prior to the issuing of the Certificate of Practical Completion, a joint site inspection shall be held. On completion of the list of outstanding items compiled at this inspection the Consultant may issue the Certificate of Practical

Completion in terms of Clause 54 of the General Conditions of Contract to the Contractor.

At the end of the maintenance period the works shall once again be inspected to establish whether any defects have to be corrected by the Contractor.

These inspections shall be attended by the Contractor and the Consulting Engineer and representatives of the following Directorates of this Department:

- Construction
- Civil Design
- Mechanical/Electrical Engineering
- Water Utilisation
- Regional Office

When it has been established that the Contractor has fulfilled all his obligations in terms of the contract, the “FINAL APPROVAL CERTIFICATE” may be issued in terms of Clause 55 of the General Conditions of Contract and the last retention monies released.

Dams

The behaviour of the dam structure and ancillary works shall be monitored during the construction and during the first filling as required by the Director: Civil Design.

Mechanical and electrical works

The following procedure shall be adopted:

While commissioning is in progress, the Contractor in conjunction with the Consulting Engineer will be expected to train the Water Services Provider’s (Water Board or Local Government) staff in the normal operation of the plant installed. The training shall be done with the aid of operation and maintenance manuals which shall be compiled and provided by the Consulting Engineer and/or the Contractor as required by the Director: M/E Engineering.

When commissioning has been satisfactorily achieved, acceptance tests on site will be carried out by the Contractor, in the presence of the Consulting Engineer and representatives of the Water Services Provider (Water Board or Local Government), the Regional Director and of the Mechanical/Electrical Engineering, Civil Design and Water Utilisation Directorates.

The Engineer will subsequently recommend that the plant be taken over from the Contractor, by way of a commissioning certificate whereby the Water Service Provider (Water Board or Local Government) also agrees to be responsible for the operation of the plant. At this time the guarantee period (normally twelve months) commences during which period the Contractor must meet any outstanding obligations.

Prior to the expiry of the guarantee period, an on-site inspection will be held where the Consulting Engineer, the Contractor, the Water Services Provider (Water Board or Local Government) and the Directorates: Mechanical/Electrical Engineering, Civil Design and Water Utilisation and the Regional Office will be represented. When it has been shown that the Contractor has fulfilled all his obligations, the Final Certificate must be issued together with the release of the last retention monies.

20 REPORTING ON OPERATIONS

20.1 Annual scheme audit and water balance

The Regulations prepared in terms of S9 of the Water Services Act require a Water Services Authority to include a water services audit in its annual report on the implementation of its water services development plan. The annual report on the WSDP is required in terms of section 18(1) of the Act.

The Regulations also require a Water Services Authority to undertake an annual water balance every month.

The S9 Regulations are included in the Legislation and Policy Folder.

21 CONTENTS OF FOLDERS

21.1 Legal and policy folder

- Constitution of the Republic of South Africa, 1996(Act 108 of 1996)
- Water Services Act, 1997(Act 108 of 1997)
- National Water Act, 1998(Act 36 of 1998)
- Municipal Systems Act, 2000(Act 32 of 2000)
- Municipal Structures Act, 2000(Act 33 of 2000)
- Public Finance Management Act, 1999(Act 1 of 1999)
- Local Government Municipal Finance Management Act, 2003 (Act 56 of 2003)
- Division of Revenue Act-Enacted Annually
- Strategic Framework for Water Services, September 2003
- White Paper on Sanitation, September 2001
- Regulations under S9 of the Water Services Act, 1997
- Regulations under S10 of the Water Services Act, 1997
- Regulations under S 19 of the Water Services Act, 1997
- Model Water Services Bylaws. Section 21(1) of the Water Services Act, 1997

21.2 Institutional folder

- Terms of reference (TOR) for assessing Water Services Provider options under S78 of the Municipal Systems Act
- Model Water Services Contract between DM and LM

21.3 Planning folder

- WSDP preparation guide

21.4 Design specifications folder

- See Design Specifications Section for full list

21.5 SANS folder

- SANS specification numbering list

21.6 Drawing folder

- BOT Drawings
- Standard Drawings

CAD software is required to read these drawings.

21.7 Procurement folder

- DWAF Policy for the Appointment of Professional Service Providers
- DWAF Accounting Officer's procurement procedures
- Government Procurement: General Conditions of Tender, Contract and Order

21.8 Sanitation folder

- Farm Dweller Sanitation: Guidelines for implementation

21.9 Ground water folder

- Ground water protocol