REPUBLIC OF VANUATU

WATER RESOURCES MANAGEMENT ACT [CAP 281]

Design and Construction Standards for Rural Water Supply Order No. 50 of 2019

In exercise of the powers conferred on me by paragraphs 37(2)(e) and (h) of the Water Resources Management Act [CAP 281], I, the Honourable ALFRED MAOH, Minister of Lands and Natural Resources, make the following Regulation.

1 Design and Construction Standards for Rural Water Supply

The Design and Construction Standards for Rural Water Supply is set out in the Schedule.

2 Commencement

This Regulation commences on the day on which it is made.

Made at Port Vila this 13th day of May, 2019.

Honourable ALFRED MAOH
Minister of Lands and Natural Resources

MINISTER OF LANDS AND NATURAL RESOURCES REPUBLIC OF VANUATU MINISTRE DES TERRES ET DES RESSOURCES NATURELLES

SCHEDULE

DESIGN AND CONSTRUCTION STANDARDS FOR RURAL WATER SUPPLY

DoWR

RURAL WATER SUPPLY

DESIGN AND CONSTRUCTION STANDARDS FOR RURAL WATER SUPPLY IN VANUATU

MESSAGE FROM THE DIRECTOR

Every Ni-Vanuatu citizen should have access to safe water in sufficient quantities to meet basic needs, including drinking, cooking and sanitation. The relatively abundant supply of fresh water in Vanuatu should further increase livelihoods opportunities and be fully harnessed to improve the overall economic standing of the country, both now and in the future.

As Vanuatu's population grows, demands on existing water sources will increase. These demands when combined with the increasing risk of pollution and climate-related changes could be expected to limit the future availability of potable water, constrain its productive use and impact negatively on Vanuatu's most precious resource, its pristine natural environment.

The National Water Strategy aims to address these issues by overcoming constraints that limit sustainable development of the water sector including factors related to finances, human resources, institutions and operations. In doing so, it gives effect to certain directives of the Ni-Vanuatu Government such as for Physical Planning Areas requiring detailed strategies and plans for all Government Departments.

The mission of the Department of Water Resources is to develop and manage the nation's water resources for the social and economic wellbeing of the people of Vanuatu with a vision to make sure 'sustainable and equitable access to safe water for the people of Vanuatu to support improved public health and promote social and economic development'.

The purpose of standard is to provide guidance and direction on the technical aspects of implementation of water supply systems for rural Vanuatu. There are many sponsors and providers of water supply and sanitation, and I hope that you will rally behind this standard to develop a consistent approach that is appropriate for Vanuatu. Over time, I hope to create supporting resources, including standard drawings, specifications and training notes that will complement these standards which will be freely available to all stakeholders, including community operators, builders, Provincial Government, donor partners and NGOs.

I wish to sincerely thank Piter Visser who assisted the Department with creating the first edition this document. This standard will be updated from time to time with the issue of new editions. My staff and I welcome your feedback on any improvements or suggestions that you may have.

Erickson Sammy
Director, Department of Water Resources

MESEJ BLONG DAREKTA

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INTRODUCTION

The DoWR aims to ensure adequate safe, appropriate and environmentally sustainable water supplies to all citizens of Vanuatu to improve the health and living standards of its population. It does so by providing technical, financial and institutional support to rural communities and managing water assets and contracts in urban areas.

In rural settings, the DoWR is not the only actor with various non-governmental organizations (NGOs), church organizations, the private sector, community-based organizations (CBOs), and individuals also involved. With a variety of actors comes a variety of design and construction standards as well. Though much good work has been done, there is at times a disparity between the intended and actual outcome. In part, this is caused by the absence of proper design and construction standards.

In 2001, the then called Department of Rural Water Supply (RWS) issued the 'Vanuatu Rural Water Supply Technical Standards Manual'. The manual primarily focused on presenting the standard designs as used and developed by RWS. Though useful to a certain extent, this manual was updated significantly in 2010 to:

1. Provide a workable and enforceable set of design and construction standards
2. Focus more on 'design standards' rather than 'standard designs';
3. Incorporate expected consequences of *climate change*.

The aim of the 2010 standard was to provide the reader with the information needed to design and construct appropriate, durable and sustainable water supply infrastructure.

The 2010 standard has been reviewed in 2019 to improve the document based on feedback from and consultation with various users of the existing document. Potential amendments and improvements have been collected since April 2019. A workshop was held in November 2019 to consult with WASH Sector stakeholders to seek feedback on the on the current standards and proposed amendments.

The 2019 revised standard is set up as follows:

- PART I: GENERAL INFORMATION
  Part I provides brief, relevant background information on Vanuatu (both geographical and socio-economic aspects), and the legal framework for the WASH sector.
- PART II: WATER SUPPLY
  Part II deals with the design standards for water supply infrastructure. It includes information on appropriate systems for rural Vanuatu, system selection, design standards for each type of system, and water quality standards.

Though the DoWR has standard design drawings, these are not included in this design standard. They can be obtained at the DoWR offices or on their website. Whilst this standard must be met to gain DoWR approval, the DoWR drawings are typical arrangements only, being DoWR's interpretation of how to apply this standard. Design should ensure that local conditions and available products are taken into account to produce project specific drawings meeting DoWR standards contained within this document.

As with the 2010 revision, this design standard is primarily written for trained professionals involved in the design and construction of rural water supply infrastructure. It is proposed that this document have a periodic review at least every two years, but can be amended at any time as improvements are identified.

Brie Jowett.
December 2019

LIST OF ABREVIATIONS/DEFINITIONS

ADD	Average Daily Demand
CAP	Community Action Plan
CBO	Community-Based Organization
CDT	Community Development Training (course)
DoH	Department of Health
DoWR	Department of Water Resources
DGF	Direct Gravity Fed
DWSSP	Drinking Water Safety and Security Plan
EIA	Environmental Impact Assessment
F/C	Ferro-cement
GI	Galvanized Iron
GPS	Global Positioning System
NBC	National Building Code
NGO	Non-Government Organization
MHD	Maximum Hourly Demand
O&M	Operations and Maintenance
HDPE	High Density Poly-Ethylene /PE 100
l/c	liters per capita per day
IGF	Indirect Gravity Fed
PVC	Polyvinyl Chloride
PWD	Public Works Department
RWS	Rural Water Supply (Department of)
VPT	Village Plumber Training (course)
VLOM	Village Level Operation & Maintenance
WASH	Water, Sanitation and Hygiene
WCT	Water Committee Training (course)
WHO	World Health Organisation

LEGAL NOTICE

This manual is a direction under the Water Resources Management Act. Failure to comply with the standards set herein is punishable upon conviction according to the penalties set forth in the Acts of the Government of Vanuatu.

Water Resources Management Act [CAP 281]: requires the Director of Water Resources to declare water protection zones and issue waterworks / wateruse permits for the non-customary use of water resources. The Act enables the Director to set standards and penalize compliance failures. This Act empowers the Director to transfer schemes to Rural Water Committees (RWC) that meet certain standards (i.e. undertaken a drinking water safety and security plan, at least 40% women representation, registered with the Provinces). The Act establishes National and Provincial Water Resources Advisory Committees (NWRAC & PWRACs) to strengthen coordination with other sectors.

Water Supply Act [CAP 24]: empowers the Minister of Lands and Natural Resources (with the approval of the Council of Ministers) to let water supply concession contracts of public owned water assets to the private sector. The Act requires concessionaires to have drinking water safety plans audited by the Department of Water Resources and empowers the Minister in consultation with the Director from the Ministry of Health to issue drinking water quality standards and penalize compliance failures.

Public Health Act [CAP 234]: establishes the responsibility of provincial councils to ensure and municipal councils to enforce sufficient access to safe water for all. The Act requires all owners and/or occupiers of premises that design and construct water supply systems to comply with public health standards. The Act provides for water quality sampling by environmental health officers and the imposition of penalties or closure of polluted water outlets / sources. The Act also assigns the responsibility for maintaining the safety of water for drinking to the occupier of premises.

Decentralization Act [CAP 230]: empowers Provincial Councils to pass (and notify sub-committees to draft) by-laws for water supply and public health services to be gazetted into law by the Minister of Internal Affairs after a suitable complaint redressal period. The Act empowers Provincial Councils to issue licenses, contracts & set rates for water service delivery.

Environmental Conservation Act [CAP 283]: refers to all surface water (flowing or situated), groundwater (including geothermal) and estuarine / coastal seawater and therefore does not pertain to water contained in works. All projects, proposals and activities that cause or are likely to cause significant environmental, social and/or custom impacts are required to undergo an Environmental Impact Assessment (EIA).

Physical Planning Act [CAP 193]: enables any Municipal or Local Government Council to declare any area within its jurisdiction a Physical Planning Area with the preparation of a physical (zoning) plan and then gazetting by the Minister for Internal Affairs. No person shall carry on development in a Physical Planning Area without the approval of the Council.

Building Act [No. 36 of 2013]: Empowers the Minister of Infrastructure and Public Works Utilities to prescribe a Building Code for the construction of buildings in any municipality or Physical Planning area or any building owned or partly owned by the State. No person may construct a building without first obtaining a building permit from the Authority.

Utilities Regulatory Authority Act [No. 11 of 2007]: Establishes the Utilities Regulatory Authority (URA) to promote consumers long-term interest in access to safe, reliable and affordable water services. The URA approves tariffs for water services for state-owned public water enterprises and private providers under concession contracts.

Custom Land Management Act [No. 33 of 2013]: provides for the determination of custom owners and the resolution of disputes over ownership of custom land by customary institutions. **Land Reform Act [CAP 123]:** vests all state land and all public roads at the day of Independence with the Government of Vanuatu. **Land Acquisition Act [CAP 215]:** provides for the acquisition of land and easements in the public interest including systems for determining appropriate compensation, appeal and resolution. **Land Lease Act [CAP 163]:** provides for the registration of the rights and responsibilities of a lessee (Individual or body corporate) to land, water and air and the development of those resources.

Business License Act [CAP 249]: requires any “Water Works, Distribution and Supply Companies and Providers” for the “collection purification distribution, supply and sale of water to household, industrial and commercial users” to obtain a license from the Minister or Local Council. **Vanuatu Qualifications Authority Act [No. 1 of 2014]:** establishes the Vanuatu Qualifications Authority to strengthen the post-school education skills training (i.e. plumbing), regulate the issuing of qualifications and ensure the maintenance of quality standards in associated trades.

PART 1: GENERAL INFORMATION

1. VANUATU

1.1 Location & population

The Republic of Vanuatu lies between latitudes 13°S and 21°S and longitudes 165°E and 170°E. It is a Y-shaped archipelago stretching over approximately 1300km. The Vanuatu territory, including its marginal seas, covers about 700,000 km^2. Vanuatu has 83 islands of which 65 are inhabited. The total land surface area is 12,190 km^2.

The rural population of Vanuatu, which totals 75% of the total population, leads a subsistence lifestyle with very little cash income. Most live in coastal communities though with increasing population pressures there is movement back inland. Vanuatu ranks at position 138 of the Human Development Index (2017).

Most of the population lives on 16 of the main islands. The less populated outer islands consequently enjoy less service, particularly in terms of transport. Only few communities have proper wharves, many lack proper road access. The large distances combined with poor transport facilities make logistics very costly.

Figure 1 – Map of Vanuatu

The key population data are as follows:

Table 1 – Population Data

Summary of main indicators, Vanuatu: 2016

Indicator	Vanuatu	Urban	Rural	Torba	Sanma[a]	Penama	Malampa	Shefa[a]	Tafea
Population Count									
Total population[b]	272,459	67,749	204,710	10,161	54,184	32,534	40,928	97,602	37,050
Males	138,265	34,506	103,759	5,153	27,901	16,549	20,689	49,541	18,432
Females	134,194	33,243	100,951	5,008	26,283	15,985	20,239	48,061	18,618
Total population (Private households)	266,555	66,809	199,746	9,875	52,145	31,334	39,997	96,405	36,799
Males	134,937	33,876	101,061	4,983	26,714	15,907	20,180	48,848	18,305
Females	131,618	32,933	98,685	4,892	25,431	15,427	19,817	47,557	18,494

Source: 2016 Post Pam Mini Census Report, Vol 1

1.2 Geography

Vanuatu is very young in geological terms with the oldest islands (Torres group, Santo and Malekula) having formed only 22 million years ago. An estimated 20% of the land surface was formed within the last 200,000 years. The main island building force is plate tectonics. Vanuatu lies on the Pacific Plate with the subduction zone to its west. The geology is still very active with numerous earthquakes and tremors, and volcanic activity.

The second origin of island building is coral formation. Large limestone formations can be found in Vanuatu, which often provide good water bearing layers. Thick capping of soil and loosely consolidated (volcanic) deposits may result in surface waters significantly reducing in flow or even disappear during dry periods.

Vanuatu is mostly mountainous with natural forests covering its surface. Approximately half of the land surface area (6000 km^2) is estimated to be arable of which about one sixth is used at the moment. The highest mountain is on Santo, standing 1800 meters tall.

1.3 Climate

Vanuatu has a fairly uniform temperature. The slightly hotter period is from November to April. Daytime temperatures are around 30^oC. The cooler period is from May to October with average daytime temperatures of approximately 26^oC.

The hot season corresponds with the wet season as well, with March as the wettest month of the year. Average annual rainfall for Vanuatu is 2360mm, though there is considerable difference between the regions. The Banks islands get around 4000mm per year. The predominant wind direction is south-east, affecting the rainfall patterns as well. On the bigger islands, the windward sides receive almost twice as much rain than the north-western leeward sides.

Several cyclones may come about during the wet season, bringing strong wind and torrential rains. In particular roof structures must take cyclones into account.

The effects of *climate change* may not be accurately predicted at this time, though considerable work is being carried out for Vanuatu and the Pacific islands states. Changing rainfall patterns, increased radiation levels (increased temperatures), rising sea level, as well as more frequent and/or intense extreme weather events may occur. Subsequent effects such as landslides and salt water intrusion may occur more frequently or pronounced.

Rainfall data can be found in APPENDIX 1: VANUATU RAINFALL DATA.

1.4 Key community aspects

1.4.1 Village setup

Vanuatu communities are often nucleated rather than dispersed. Most facilities such as health posts, boarding schools and churches are often located between villages to allow easy access from several communities. Gardens are generally located in the hinterland.

Communal water supply facilities are spread out in a community, but sanitary facilities generally are not. Though some communities still use areas for open defecation, 53% of Vanuatu has improved facilities. The spreading of toilets throughout a village requires careful positioning of any groundwater abstraction infrastructure.

1.4.2 Religion

Vanuatu is a predominantly Christian country. An estimated 32% is Presbyterian, 13% Anglican, 13% Catholic and 11% Seventh-Day Adventists. The remainder is a mix of Christian churches including Assemblies of God, Church of Christ, Church of the Later-Day Saints and others. The plethora of churches may affect water supply projects, as communal facilities must be accessible to all religious groups within a community.

1.4.3 Land issues

Land is the principal economic resource to indigenous Pacific Islanders, which has the highest rate of customary land ownership in the world. Very little land in Vanuatu is not claimed by custom owners. With Melanesian society based more on oral tradition rather than written, many disputes arise over who is the owner of a certain piece of land. This can affect infrastructure projects which cross several land boundaries, such as for example piped water supplies. Clear agreement and consensus is required prior to commencing a project though it is not a guarantee that a water supply system will not encounter any land disputes in the future and care should be taken in designing projects to limit operational risk

1.4.4 Social structures

Any negotiations with a community must take into account the social structures within a Vanuatu community. Communities are led by a (head) chief, whom with fellow chiefs and village elders makes decisions on issues affecting the community.

Women in Vanuatu generally play a subservient role to men and it can be challenging to involve them in the project process. As women are responsible for the collection of water, cooking and cleaning, women are the main users of water and thus involving them in the project is essential. Water Committees must be formed with a minimum of 40% female representation.

2. LEGISLATION

2.1 Introduction

This chapter provides information on the legislative basis for rural water supply in Vanuatu. Key aspects of the most relevant acts are presented here with. Full copies are available on the Vanuatu Government website (http://www.paclii.org/countries/vu.html). The most relevant acts are:

1. Water Resources Management Act (2002);
2. Environmental Management and Conservation Act (2002);
3. The Public Health Act (1994).
4. The Water Supply Act (1993)
5. The Building Act (2013)

2.2 Water Resources Management Act

The Water Resources Management Act commenced in March 2003. It states that the responsibility for protection, management and use of water lies with the Minister responsible for water resources.

Water in the Act means all surface water (flowing or situated), groundwater, estuarine & coastal seawater, and water contained in works. The latter therefore includes rainwater stored in tanks.

Key sections:

Section (3): subject to the Act, water may be used for any purpose.

Section (4): Customary rights and rights of occupiers are regulated as follows:

1. Every person may use water if no other customary users of the same water resource are adversely affected, and the use of that water is for customary use. Customary use means use recognized by the landowners of an area, and includes non-commercial irrigation.
2. An occupier of any land can use water on, adjacent to or under that land for domestic and stock purposes, if no other lawful users are adversely affected.
3. If any lease is made under the Land Leases Act, the lessee may use any water on, adjacent to, or under that land in accordance to subsection (1) and (2); must apply to the Director for use of other purposes.

Section (5): Existing works and uses lawfully undertaken prior to the commencement of the Act are deemed lawful under the Act.

Section (6): A person must apply to the Director for the right to use water for any purpose that does not comply with *Section 4* and *Section 5*, unless water is supplied from a work authorized under the Act. Similarly,

Section (7): a person must apply to the Director for the right to construct, maintain, or operate works not complying with *Section 4* and *Section 5*. The existence of any work does not confer any rights to that land on the part of the owner of the works; or to the work on the part of the landowner.

Section (19): A landowner or group of landowners can establish a water management committee for any water resource on or under the land for the purpose of implementing water supply conservation measures or a water management scheme. Local water management committees are required to register with the Department.

Section (32): Any person

a. contravening a regulation, order, declaration, direction or term of condition of an approval under the Act; or
b. hinders, obstructs or fails to give reasonable assistance to any officer or person empowered to carry out any function or duty under the Act; or
c. provides false or misleading information under any requirement of the Act; or

d. obstructs someone lawfully entitled to use water; or

e. without authorization, interferes or encourages others to interfere with the means of supply of water, including any works; or

f. without authorization, pollutes any water commits an offence punishable upon conviction. If convicted, the fine for individuals is a maximum of Vt 1,000,000; and/or a maximum imprisonment of 2 years. The fine for any other cases is a maximum of Vt 5,000,000.

Disputes within or between communities often leads to damage done to the water supply scheme. This is punishable under the Act (bullet point *e* in the above list).

Amendments passed in December 2016 specify the approval requirements as follows:

Water use permit (Division 2): Requires all non-custom users of water to obtain a water use permit (Section 5) by way of application on a prescribed format (Section 6) to be determined by the Director of DoWR (Section 7) within limits set by the Director (Section 8).

Water works permit (Division 3): Requires any non-custom construction, operation or maintenance of works affecting water resources to obtain a water works permit (Section 9) on a prescribed format (Section 10) to be determined by the Director of DoWR (Section 11).

The DoWR will support water works and water use permit holders in:
- the assessment, conservation, protection or management of water resources
- training on water safety and security planning processes
- bacterial and chemical water quality testing and analysis

The Act further regulates the planning, development & monitoring of national water resources; and the cross-sectoral coordination linked to water resource management. These are not discussed here.

In essence, the above implies that water is not owned by any individual but by the state/the people. Landowners on whose land exist water resources may use but not claim the water resource as his/her own. A landowner can therefore not prohibit the use of a source, though he can of course object to pipes or infrastructure to be on his/her land.

2.3 Environmental Management and Conservation Act

The Environmental Management and Conservation Act provides for the conservation, sustainable development and management of the environment of Vanuatu, and the regulation of related activities.

The act applies throughout Vanuatu, including its lands, air, and waters.

Key aspects:

Section (2):

Environment means the components of the earth and includes all or any of the following: land & water; layers of the atmosphere; all organic and inorganic matter and all living organisms; the interacting natural, cultural and human systems that include the mentioned components.

Water in the Act means all surface water (flowing or situated), groundwater including geothermal water), and estuarine & coastal seawater. Water contained in works therefore does not fall under this act.

Section (12): Subject to the Environmental Impacts Assessment (EIA) provisions in this Act are all projects, proposals and activities that cause or are likely to cause significant environmental, social and/or custom impacts. More specifically, all projects, proposal or activities that:

- affect coastal dynamics or cause coastal erosion;
- results in pollution of water resources;
- affect any protected, rare, threatened or endangered species, its habitat or nesting grounds;
- result in the contamination of the land;
- endanger public health;
- affect important custom resources;

- affect protected proposed protected areas;
- affect air quality;
- result in unsustainable use of renewable resources;
- result in the introduction of foreign organisms and species;
- result in any other activity prescribed by regulation.

Section (14): A preliminary impact assessment[1] is required to determine whether the proposal, project or development activity is likely to cause any environmental, social or custom impact and the significance of the identified impact. Based on the preliminary EIA, the Director decides whether a full EIA is required.

Section (24): Any activity undertaken subject to an EIA without prior approval or when approval has been refused is an offence punishable upon conviction to a maximum fine or Vt1, 000,000, a maximum of 2 years imprisonment or both.

Unless a water supply project is planned in a protected area, an EIA will not be necessary for most rural water supply projects.

2.4 Public Health Act

The 1994 Public Health Act details the regulations of many aspects of public health. Those regulations concerning water supply, sanitation and hygiene are summarized here:

Section (1): A nuisance is anything that injures or is likely to injure health. A local authority officer or environmental health officer will serve an abatement notice on the author of the nuisance. Failure to comply with the abatement notice, a complaint will be made before the court, which will decide on a suitable fine upon conviction.

Section (31): All collections of water, waste, rubbish, etc. in or around any dwelling that permit or facilitate the transmission of disease carrying factors are labeled as nuisances and dealt with accordingly.

Section (33): Any water holding receptacle (tank, barrel, bucket, etc.) must be covered with a lid or screen to prevent mosquitoes from entering. Failure to do so is punishable upon conviction by a maximum fine of Vt50, 000, 12 month imprisonment or both.

Section (35): Cesspools, cesspits, septic tanks, or soakaways must be properly screened by the owner or occupier of the premises to which such structures are upon or attached to.

Section (43): Every local government council shall take all necessary steps to ensure that all inhabitants of the rural area under its jurisdiction have access to proper and sufficient supplies of potable water.

Section (45): An environmental health officer may enter upon any land or premises at any time of the day to collect water samples at any water source or supply.

Section (46): A local authority, based on the findings of an environmental health officer, may order the temporary or permanent closure or cutting off of any water source or supply if the water is found detrimental of the public health, or restrict its use.

Section (47): Any receptacle for collecting or storing water for human domestic use must be kept clean and protected from contamination.

Section (50): Every local government council shall take all necessary steps to ensure that all inhabitants of a rural area have access to proper and adequate sanitation systems.

Section (53): All hotels, restaurants or similar places must have and maintain a proper sanitation system with sufficient number of toilets for those visiting the premises. Failure to comply may result in the closure of the premises *(Section (55))*.

Section (54): An environmental health officer may enter any premises at any reasonable time for the purpose of ensuring the sanitation system is proper and adequate for the occupant of the premises.

[1] *Preliminary EIA forms can be found here: www.mol.gov.vu/env_app_forms.html.*

Section (56): All sanitation systems must be kept clean by the occupier of the premises to the satisfaction of the environmental health officer, so as not to become a nuisance.

Section (57): Any person causing or permitting to cause a sanitation system to become a nuisance or dangerous to health, by willfully destroying or damaging the sanitation system or its (water supply) components is guilty to an offence and liable upon conviction to a fine not exceeding Vt 50,000, 12 month imprisonment or both.

Section (58): In every urban area, the municipal council provide and maintain in proper and convenient situations sufficient toilets for public use.

Section (62): Any sanitary convenience used in common by two or more premises or by other people, must be kept clean and maintained in a proper state so as to avoid becoming a nuisance. Failure to do so is an offence and liable upon conviction to a fine not exceeding Vt 50,000, 12 month imprisonment or both.

Section (63): No person shall erect or cause to be erected any toilet within 30m of any well, dam, reservoir, river, creek, stream, water course, aquifer or groundwater which is used for domestic supply. Failure to comply is an offence and liable upon conviction to a fine not exceeding Vt 1,000,000, a maximum of 5 years imprisonment or both.

Though the Act refers to owners and/or occupiers of premises with regards to the regulations, any organization designing and implementing the construction of water supply and sanitation systems must comply as well. Hence, water supply and sanitation infrastructure must be designed and constructed in such a manner so as not to become a nuisance.

2.5 Water Supply Act

The Water Supply Act (commencement 1955, revised 1993) stipulates the regulations regarding connections to public water mains as managed by the Public Works Department (PWD) or its concessionaire effectively focusing on metered, urban water supplies.

Applicant wishing to be connected to the public mains must apply to the Director of Public Works. The cost for any extension to the applicant premises will be paid by the applicant. However, the infrastructure up to the premises' boundary is the property of PWD. Liability for the (payment of) connection in the case of change of ownership of the premises, remains with the applicant until the new owner, in writing, accepts the liability for the connection.

The government is responsible for maintenance for the entire infrastructure up to and including the meter, but is not liable to any person for failure to supply water from any cause. This includes temporary interruptions of water supply for maintenance purposes.

The Minister, with the approval of the Council of Ministers, may enter into an agreement or contract with any legal entity granting that entity the sole concession for the provision, development, management and maintenance of water supply to the public within the area of concession. The 'area of concession' is identified as Port Vila Municipality and any part of the Efate Local Government Council region prescribed by the Minister by order.

Any damage caused to water mains through negligence or willful intent, obstruction or assault of an authorized officer in the exercise of any powers conferred or execution of any works for the PWD or the concessionaire, is upon conviction punishable by maximum fine of Vt30, 000, a maximum of 3 months imprisonment or both. Any person wasting or diverting water supplied by the concessionaire is punishable by a maximum fine of Vt30, 000.

Amendments to the Act in December 2016 requires concessionaires to have drinking water safety plans audited by the Department of Water Resources. The amendments also empowers the Minister in consultation with the Director from the Ministry of Health to issue drinking water quality standards and penalize compliance failures.

2.6 Building Act

The Building Act [No. 36 of 2013] empowers the Minister of Infrastructure and Public Works Utilities to prescribe a Building Code for the construction of buildings in any municipality or Physical Planning area or any building owned or partly owned by the State. This requires that no person may construct a building without first obtaining a building permit from the Authority. No building or any part of a building may be occupied or reoccupied unless the Authority has issued a fitness to occupy certificate (based on an inspection against the terms of the building permit). Any such construction must comply with the requirements of the national building code.

- Vanuatu National Building Code (2000): Specifies compliance with AS 3500 Plumbing and Drainage Code and AS 2179/80 Metal Rainwater Goods Standard (Specification, Selection & Installation). The code includes plumbing and rainwater specifications for any buildings (DF5 & DF7), public buildings (NF5 & NF7) including fire mains (NE 1.2).

3. National Implementation Plan and Capital Assistance Programme Process

3.1 Introduction

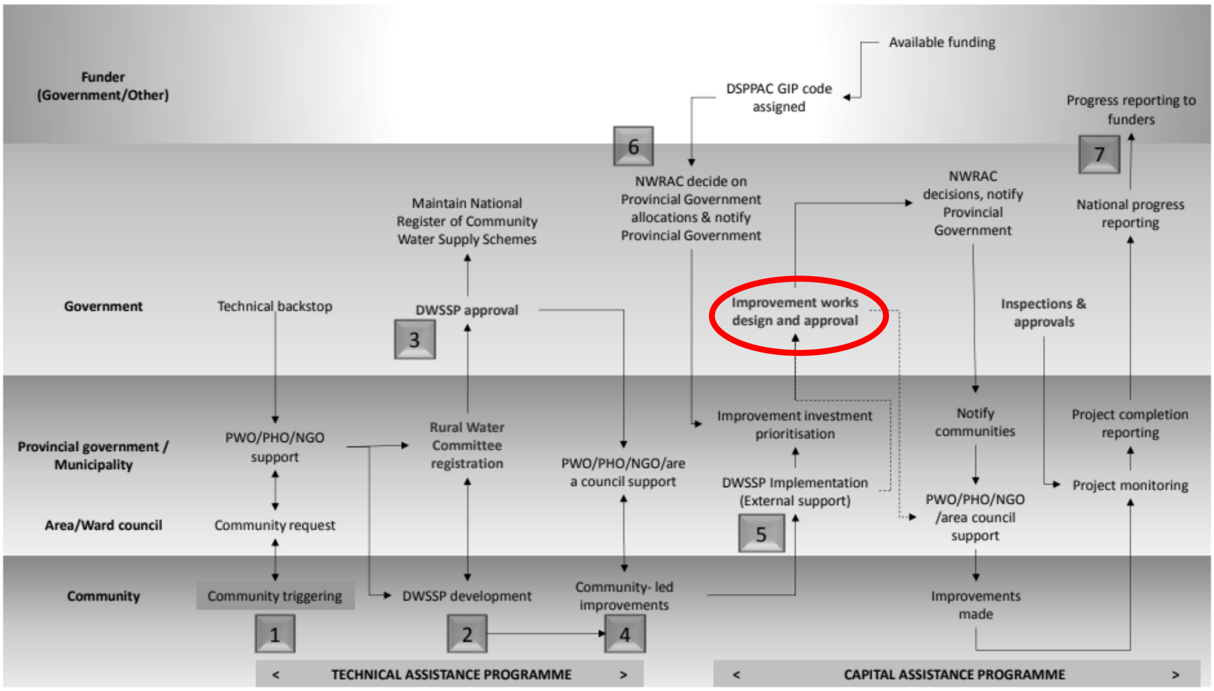
The Department of Water Resources has established the *National Implementation Plan for Safe and Secure Community Drinking Water*. A guide on the program can be found on the Department of Water Resources website. The program coordinates support to Vanuatu communities across all six provinces. Central government, provincial government, area councils and communities are all involved.

A community's improvement plan needs to be based on an assessment of the water supply for threats to its quality and quantity, its safety and security. An approach called Drinking Water Safety and Security Planning (DWSSP) has been adopted in Vanuatu. Developing a DWSSP is a facilitated community activity. DoWR assigns a facilitator to assist the community.

Communities will learn to identify what makes their water supply unsafe, and will learn what needs to be done to improve this. Some things can be done immediately and by the community at low cost. Other improvements will need technical and financial assistance. The program includes a process for applying for funds (Capital Assistance Programme) for major improvements.

A flowchart of the process is shown below:

Figure 2 – Process Flowchart – National Implementation Plan



Whilst this document may support or inform the Technical Assistance Programme in some ways, the primary purpose of this document is to provide standards to those involved in the Capital Assistance Programme and the broader water sector for major capital works. It is required to be used in the 'Improvement Works Design and Approvals' stage of the process as circled in red within the process flowchart above.

PART 2: WATER SUPPLY

4. SURVEY & DESIGN

STANDARD 1: PROJECT DESIGN

Projects are designed to provide optimum level of service while keeping operation and maintenance requirements to a minimum.

4.1 Indicators

- Projects have detailed design reports, as per standard format in section 4.5.9 of this document, including hydraulic design details;
- Projects are not overly large or technically complex and assets are able to be operated, maintained and repaired using local labor and parts readily available in Vanuatu (where possible)
- All designs for water supply schemes should be done by an approved engineer, e.g.:
    - Professional engineer with a qualification in civil engineering, or other relevant engineering degree;
    - Professional civil engineering consultant approved to practice in Vanuatu.
    - Any individual trained to perform the duties of a water engineer, as recognized by the Government of Vanuatu.

4.2 Guidance notes:

With a lack of qualified engineers working in the rural water supply sector, many projects are not properly designed. Instead, fieldworkers or other staffs guess what materials are required for water supply systems without any (hydraulic) calculations being done. As a result, many systems function poorly and often are poorly constructed. Adequate design reports are not available either.

It is important therefore that qualified person do the designing of systems, in particular where hydraulic calculations are required. It is recognized that there are individuals who are capable of doing hydraulic design but do not have any formal qualifications. These individuals may still carry out design work if recognized and approved by the Vanuatu Government.

A key criterion for water supply projects is ease of operation and maintenance. Low-tech facilities and low operation costs are essential for the sustainability of projects. High-tech systems must be avoided in community settings as much as possible. Where a gravity-fed supply is not possible, but a pumped supply is, the designer must be convinced that the community is capable of bearing both the cost of operation (including replacements of parts) and has the skills to maintain the system. The community must therefore be made aware of the consequences of pumped supplies.

A second key criterion is the size of piped water supply systems: the larger, the higher the risk of poor management and (land) disputes. Breaking up a potentially large system into several smaller ones (using different water sources) should always be investigated and be the preferred option.

'Level of service' primarily refers to the quantity of water provided per person per day, and to a lesser degree the ease of access to water and its quality. An 'optimum' level of service means as much water is provided as possible, but without sacrificing ease of operation and maintenance. For example: a combination of wells and rainwater harvesting may be preferred over a mechanically pumped water supply system.

4.3 Engineering Standards Overview:

The overall engineering standards are summarized in the following table:

Table 2 – Engineering Standards Overview

ELEMENT	STANDARD TO BE APPLIED	DESCRIPTION
Survey and Design	Projects shall be properly surveyed and designed to ensure basic access to water, sanitation and hygiene, whilst keeping operation and maintenance requirements within the capacity of the community	Survey must have sufficient accuracy and record key information to enable design to be completed to an acceptable standard. The Design shall optimize the Level or service to be achieved with requirements of operation and maintenance of the system. Where possible, simple basic systems shall be selected over high technology systems that would require skilled maintenance workforces and parts which are more difficult to source. In rural communities, Operations and Maintenance activities will need to be undertaken by the community. The design shall where possible be localized to single communities to minimize risks of disputes and enable communities to better manage the infrastructure within a community water committee structure. Where systems must service multiple communities, the design shall ensure an equitable distribution of water and level of service is achieved in each recipient community. The design shall also consider the appropriate management structure for the ongoing operations and maintenance of the system and work with the community to enact this management structure.
Water Supply	Basic Access is available at all times to a sufficient quantity of water for drinking, food preparation, hygiene, cleaning and laundry. Water is safe for its intended use	Refer Sections 5.1.2 and 5.1.3
Sanitation	Communities have access to improved, functional and private sanitation facilities appropriate to their resources and environment	Refer Sanitation Guidelines Appendix 1 – Tools 3 to 10 for guidance and standards about rural household sanitation.
Persons Living with a Disability (PLWD)	PLWD are provided with appropriate access to water supply and sanitation facilities on the household compound	
Health Facilities	Health facilities are provided with basic access to water supply, sanitation, hand hygiene and waste disposal facilities.	Refer to the Department of Health Standards

ELEMENT	STANDARD TO BE APPLIED	DESCRIPTION
Schools	Schools are provided with basic access to water supply, sanitation, hand hygiene and waste disposal facilities.	Refer Table 5.1.2 Refer Sanitation Guidelines – Appendix 3

4.4 Survey requirements

The survey requirements of this standard relate to the survey undertaken for design and approval of improvement works. This will be undertaken after the DWSSP surveys and DWSSP approval as outlined in the National Implementation Plan and Capital Assistance Programme Process summarised in Section 3.

Some design survey information may have been collected in the DWSSP survey. This information must always be verified by the designer prior to use. Good design is only possible if based on a good survey. The following elements are discussed:

- Community information and current situation;
- Source inspections and flow measurements
- Detailed survey of pipe alignments and structure locations;
- Sanitation (for the purposes of designing the water system improvement works);
- Prior to starting the survey, a rough sketch of the proposed system must be made, including population figures, land use, alternative sources, and main topographical features (rivers, gorges etc.).

4.4.1 – Community Information including but not limited to the following:

- Household Survey including coordinates and elevation of households, self-identified community, number of occupants per household, and Persons Living with a Disability (PLWD) impacting their access to water and sanitation.
- Schools – number and type of schools, current and future student and staff numbers, coordinates and elevation.
- Clinics – outpatients, inpatients, number of beds, typical occupancy, staff numbers, coordinates and elevation.
- Logistics and Location –Coordinates and elevation of key aspects of community and infrastructure. Information regarding access by land, air, sea and foot.
- Existing community rainwater harvesting infrastructure – including roof sizes (connected and potential), storage volumes and conditions.
- Past water supply systems including status, reasons for disuse, salvagable components, size/length/condition of pipes and coordinates and elevation of infrastructure.
- Current sanitation facilities and use in the village;

Notes: The designer shall in consultation with the community or communities associated with a water supply system define the boundaries of the community or community cluster.

Definition of a Disability: The WHO defines a disabled person as someone who has a physical or mental impairment that has a substantial and long-term adverse effect on his or her ability to carry out normal day-to-day activities. Information in relation to disabilities of persons impacting their ability to access water and sanitation activities shall be collected to suitably inform the design to assist these people as much as practical (for example, in locating tap stands)

4.4.2 – Source information:

- A clear description, sketch, photo or video of the source(s),
- Source categorization (ie. Undeveloped surface water, developed spring, undeveloped pool etc)
- Ownership information (ie. Customary owner, Government land)
- Flow rate measurements (refer section 4.5.3)
- Water quality testing (Refer to the Vanuatu National Drinking Water Quality Standards)
- Source catchment land use and mapping of potential contaminants
- Pump tests to confirm safe yield of groundwater sources.
- For RWH systems, existing roofs should be measured and an assessment of the infrastructure and condition recorded (such as guttering, fascia boards etc). Careful consideration and community consultation should be used if proposing private roofs be used for communal rain water harvesting.
- Solar irradiance data For Solar pump systems.

4.4.3 – Detailed survey of pipe alignments, structure coordinates and elevations:

- Topographic surveys using specialized survey equipment are considered the standard approach for confirming coordinates and elevation to design water supply systems. At all times it is the responsibility of the designer to ensure that the accuracy of the elevation measurements are within the allowable tolerances of the design. Handheld GPS-derived elevations are usually not considered accurate within the design tolerances for most water supply systems in Vanuatu.
- Distance and elevation readings at regular intervals (not merely major points such as junctions, tank site, village site etc.) to obtain good topographical data;
- If GPS are used, elevations should be measured with a barometric altimeter and GPS together (not just a GPS) and preferably with a two altimeter method such that changes in atmospheric can be accounted for. Designers shall use closing methods and calibration methods to reduce as far as practical measurement errors.
- Potential coordinates and elevations for infrastructure such as distribution tanks, break pressure tanks, creek crossings must be identified
- Coordinates and elevations of existing infrastructure
- Length and coordinates of suspended crossings, elevation variance between proposed columns and required type of crossing;
- Coordinates and elevations of possible high points (air traps) and low points (scours/washouts)
- Soil conditions and whether pipes can be buried or not;
- Factors impacting infrastructure sustainability such as sub-surface road crossings, location in a corrosive environment, potential for vandalism or damage by livestock etc.
- Village layout

4.4.4 – Sanitation Survey Requirements:

Sanitation requirements are detailed in the Sanitation Guidelines (Department of Health). The sanitation survey requirements mentioned in this standard are those deemed necessary for the design of water system improvements only, rather than sanitation improvements.

- Record the availability and reliability of any water sources (refer section 4.4.2) to determine if water-based sanitation is feasible;
- Record the following if necessary to avoid undue pollution of the water source (Refer Sections 5.3.8 to 5.3.10):
    - Location, type and use of sanitation points, including depth of any pits
    - Record likely soil type (below top soil) and water table levels if relevant
    - Collect information to determine if possible the direction of flow of groundwater. Ground water flow direction typically related to slope as groundwater, like surface water, flows downhill from high points to low points.
- Record flood prone areas if any;

4.5 Water Supply Design requirements

4.5.1 Design period

The design period for all communal water supply systems shall be not less than 15 years.

4.5.2 Demand and Population growth

The Average Daily Demand (ADD) is the total daily water demand of the population, at the end of the design period (15 years) including health clinics and schools calculated in accordance with section 5.1.2

Current Population data should be obtained as part of the Community Information Survey (Refer Section 4.4.1)

All designs shall incorporate a population increase as per the relevant growth rate shown in Table below.

Table 3: Provincial growth rate

Province	Avg. ANNUAL POPULATION GROWTH RATE (%)	Population GROWTH FACTOR over 15yrs design period
TORBA	1.2	1.20
SANMA	2.6	1.47
PENAMA	0.8	1.13
MALAMPA	1.6	1.27
SHEFA	3.4	1.56*
TAFEA	2.0	1.35

(SOURCE: 2016 Post Pam Mini Census Report, Vol 1);
* Figures for SHEFA are high because of urban drift to the respective rural centers. The growth factor over 15 years has been adjusted to 3% annual growth.

The calculation for Design Population is as follows:

Population Future = Current Population x ((1+Annual Population Growth Rate %)/100)^15

or

Population Future = Current Population x Growth Factor

Where projects target individual household systems (e.g. RWC projects on islands without any alternative water source) the current population is to be used, as installing facilities for households that are not there yet, is not advisable.

Population figures should be based on *average* and *realistic* situations:

- Outpatient numbers shall not be based on figures at times of a disease outbreak;
- Community figures shall not include the number of people coming back merely for the holidays, but may include some additional numbers for those returning to the village now that a water system is in place;
- Schools may expand but care must be taken with accepting (wishful) figures from school staff.

Verification should be sought from the relevant department. It is up to the discretion of the engineer what figures to use.

4.5.3 Flow measurement

Flow measurements shall:

- Always be carried out at the source. Even for rehabilitation or extension of existing projects, flow measurements are only taken at the source to avoid inaccurate data caused by leaks, blockages etc.;
- Be done a minimum of 3 times to ensure statistical relevance and an average taken;
- Be carried out by a trained person to ensure accuracy of the measurements;
- Be done using either of the following methods:
    - Collection of water in a receptacle of <u>known</u> volume (e.g.: bucket) – Requires a bucket and something to record time (stop watch or phone). This is the most common method used.
    - Water level increase over time in the intake box where the dimension of the intake box are know;
    - Use of a weir in small streams.
- Ideally be taken monthly by a trained person(s) on the water committee, but at a minimum seasonally (end of each dry and wet season) to confirm source variability
- Allow for the flow to stabilize completely where the source has been disturbed in order to capture its flow (ie. Ensure a box has drained completely if measuring from a box);

4.5.4 Safe yield

Safe yield (SY) of surface water and spring sources shall be:

- Be 80% of the measured flow where:
    - most, if not all of the water was captured during measurement;
    - little or no decrease in flow seasonally is recorded or reported by the local villagers;
    - no significantly adverse land use is present near the source or in the catchment area (logging, gardens, etc.);
- Be less than 80% of the measured flow, the precise value at the discrepancy of the surveyor, where flow is reported to reduce during the dry season;
- Be 0% of the measured flow where logging activities are in the upstream surface catchment of the source. Effectively this prohibits the source from being used, as the source will be seriously affected both in terms of quality as quantity in the near future;

- Allow for residual flow to continue its natural course where possible. Where the yield is critically low to meet the demand, damming and using the entire flow away from its natural cause may be done after consultation with the community;

Safe yield (SY) of groundwater sources shall be confirmed using pump testing.

4.5.5 Design flow

The design flow (DF) used in the system will be based on the following:

- When the Safe Yield (SY) is larger than the MHD (refer below), the design flow is equal to the MHD.
- When the Average Daily demand (ADD) is less than the SY, but the SY is less than the MHD, the design flow should be 1.2 times ADD from the source or tank to tank (allowing for 20% leakage) and then MHD from the tank to the taps.
- When the SY is less than the ADD, the design flow should typically be the SY. The designer shall consider the variability in the source and maximize the potential for water to be harvested when available.

The maximum hourly demand (MHD), usually occurs at the first few hours in the morning and at a few hours at the end of the afternoon/early evening.

Two traditional methods used in Vanuatu of calculating MHD are:

1. 70% method: using the assumption of 70% of all the taps being open at the same time during the peak hours. This assumption requires fixed flow rates at the taps/showers (and these water points must be throttled using valves to achieve this);
2. MHD method: Maximum Hourly Demand, which is the Average Daily Demand (ADD, the total demand over 24 hours) multiplied by a factor. This does not require throttling of taps, as a determined flow enters a village, regardless of the number of water points.

Experience indicates that both methods are very similar in results (e.g. pipe sizes) for flows up to 3 l/s. For larger flows, the MHD reduces overall mainline pipe sizes and therefore the cost of the system.

However, the reliance on throttling the taps with the 70% method allows for greater risk of tampering with flow rates at taps. Also, increasing the number of tap stands in a project (as the population grows) requires careful setting and adjusting the flow rate of the newly installed taps.

Design flow shall:

1. Be calculated using the MHD method;
2. MHD = 3 x ADD;

The recommended velocity is between 0.7m/s to 3.0m/s.

4.5.6 Storage tanks

Community Storage tanks (excluding storage tanks for solar pump systems) shall:

- Be used where the safe hourly yield is lower than the peak hour flow (MHD),
- Be used where it is clearly more economical to include a storage tank (thus allowing for a smaller diameter pipe to the tank);

- Have their volume calculated as follows:

Period	% total daily demand used
2 hours	30%
8 hours	40%
2 hours	30%

The shortage between supply and demand represents the required storage volume.

An example is shown below:

Situation 1:

Total Daily Demand (ADD) = 24,000 L per day

Spring Source – Safe Yeild = 1150L/h

PERIOD	**DEMAND**	**SUPPLY**	**DIFFERENCE**
2hrs 30%	7,200 L	2,300 L	-4,900
8hrs 40%	9,600 L	9,200 L	-400
2hrs 30%	7,200 L	2,300 L	-4,900
		STORAGE REQUIRED **(Positive sum of the difference)**	**10,200 L**

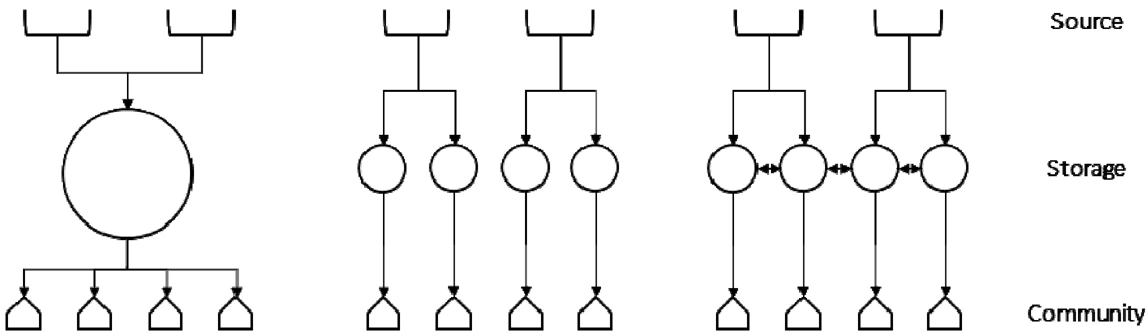
Sizing of storages with pumped supplies shall consider the hours of operation of the pump and complete an hourly water balance model over 24 hours and 7 days. This model should use a demand profile generated for the community.

Sizing of storage tanks for Solar pump systems with no power or generator backup, require consideration of the availability of solar radiation, peak sunlight hours and the Equivalent number of NO-SUN or black days in a month for the particular location. Typically, storage tanks shall be sized with a minimum of 2 days supply at 50L/p/d

The designer should consider any community circumstances requiring additional water storage in addition to the minimum storage requirements.

When designing storage configurations in multi-community systems, consideration should be given to the likelihood and impact of operational failures. Routine operational failures such as leakages are chronic problems in rural Vanuatu often remaining unfixed for long periods of time while funds are raised for replacement parts and they are procured, freighted and fitted. Likewise, disputes can be an occurrence in some areas with pipe cutting sometimes used as a resolution method. Splitting flow prior to distribution tanks (creating separate pressure zones) can be a design approach to limit the impact of failure to the respective zone, building resilience into the system and allowing time for committees to procure new fittings. Figure 3 below illustrates possible configurations that can achieve lower operational risk and/or a more resilient distribution system in multi-community systems.

Figure 3 – Tank Configurations for Operations Risk



High Operational Risk	Medium Operational Risk	Low Operational Risk
Sources are combined and a large shared storage serves all users.	*Sources are separate and further split, feeding smaller storages serving communities.*	*Sources are separate, split and storages are further connected below the overflow level.*
• Leaks in a single line drain the system affecting all users • Recurrent maintenance is costly as large distribution pipes require large, difficult to source fittings • Difficult to diagnose problems caused by leaks or air-lock. May require a specialist. • Discourages accountability as users behaving in their own interest affect can affect all system users	• Leaks only drain a single tank affecting individual communities • Recurrent maintenance is cheaper and easier as smaller distribution pipes require smaller fittings • Allows diagnosis of problems by village plumber as they are isolated to a single zone • Promotes accountability through existing social structures as communities are responsible for their own zone	• Interconnected storages allow tanks to 'top-up' other zones if leaks develop providing the storage is full (i.e. at night) • Leaks may go unnoticed as the system 'self-corrects'

4.5.7 Residual head

Residual head/water pressure shall at Tap Stands:

Table 4 – Standard residual head at tapstands

Absolute Minimum Dynamic	5 m
Desired Minimum Dynamic	10 m
Ideal	15 m
Desired Maximum Dynamic	20 m
Absolute Maximum Static	50 m

- Ideally be within a range of 10-20m in peak flow (dynamic) conditions;
- Never exceed 50m water head at tap stands in static conditions;
- Never be below 5m head at tap stands and shower stands in peak flow (dynamic) conditions;

If the terrain is very flat,

- Where the available pressure is below 5m water head, showers may not be constructed.
- Where below 2m water head, tap stands may not be constructed. Instead small storage tanks fitted with taps may be used;

Residual head/water pressure in pipelines shall:

- Never exceed 90m for PN10 rated mains anywhere in the system in static conditions;

Note: If you receive more than 18-20L per minute at a tap, you are typically receiving 15m water pressure or more at that tap

Break-pressure tanks or boxes are to be used and suitably located to ensure static pressure cannot exceed 50m at any tap stand and 90m in any PN10 pipeline. Hydraulic grade line plots are to be provided with pipeline profiles in design reports (see section 4.5.9) to confirm maximum static pressure and minimum dynamic pressures are within the above limits.

4.5.8 Hydraulic Analysis and Software

4.5.8.1 Hydraulic Calculations and Pipe Sizing

Pipe sizes shall be determined using suitable hydraulic friction loss calculations. The commonly used formulas for computation of head loss due to friction (also called friction loss) are the:

- Darcy-Weisbach formula
- Hazen-Williams formula
- Mannings formula
- Combined Darcy-Weisback and Colebrook-White equation.

The Department of Water Resources (DoWR) recommends the use of Hazen Williams among the formulas. This formula is the most widely used, relates the velocity of the flow, hydraulic mean radius and hydraulic gradient. In terms of head loss due to friction, *Equation 1* is used below:

$$V = \mathrm{k}\,\mathrm{C}\left(\frac{D}{4}\right)^{0.63} S^{0.54} \qquad (1)$$

And *Equation 2 and 3* below:

$$S = \frac{h_f}{L} \qquad (2)$$

$$Q = \mathrm{V}\frac{\pi D^2}{4} \qquad (3)$$

Where:

V	Velocity (m/s)
S	Slope of Energy Line (m/m)
K	Unit Conversion Factor
	k = 1.318 for English units (feet and seconds)
	k = 0.85 for SI units (meters and seconds)
C	Hazen-Williams Coefficient
D	Pipe internal diameter
h_f	Head Loss due to friction (m)
L	Length of pipe (m)

The C-value is a carrying capacity factor that is sometimes referred to as the roughness coefficient, which varies depending on the pipe material being considered. Coefficients of Friction shall allow for an aged condition of the pipe (15 years design life). The following C values are recommended:

- Polyethylene (PE) Pipe C = 140
- Galvanised Iron (GI) Pipe C = 120

Pipes transferring water from a box or tank open to atmosphere to a another tank open to atmosphere via gravity, shall be designed to ensure that the pipe size is suitable to transfer the amount of water required within the 24hour period, but to minimize the overflow of the receiving tank if the float valve (or inlet control valve) is to fail open.

Pipes distributing water from an open atmosphere tank to the distribution and reticulation network via gravity, shall be designed to ensure the dynamic water pressure during Peak Hour Demand (MHD) provides the required residual head (refer section 3.4.7) throughout the system.

In pumped systems, the rising main size shall be optimized with the pump selection to achieve the lowest cost over the design life of the system (15 years).

Pipe sizes shall be specified in nominal diameters that are standard for pipe suppliers in Vanuatu. It is preferred that pipe sizes not exceed DN90 if possible, as mechanical couplings for repairs are typically only available up to DN90 size. Pipe pressure ratings shall be PN10 (100m grade) as standard. This is the minimum size for durability in pipe handling. Approval of higher pressure rating pipes (such as PN12 and PN16) may be considered for some applications where there is a clear cost-benefit demonstrated.

Hydraulic Grade Lines (HGL) for the proposed pipes shall be produced by the designer. The HGL for the maximum possible flow rate for the pipeline should always lie above the top of pipeline through the entire length of the system.

4.5.8.2 Designing for Air in Pipes

Air in pipelines is a significant issue in many water supply systems in Vanuatu. It is very common in DGF systems with uncertain or variable output from the source. It is a requirement that the system is designed to operate smoothly with limited entrained air both when draining/filling and when in normal operation. This will require the designer to calculate the supercritical and subcritical flowrates for pipe runs under assumed (dry season) low flow conditions and when draining/filling.

Note: Guidance on Air in Water Pipes can be found in the *AGUA PARA LA VIDA – A Manual for Designers of Spring Supplied Gravity Driven Water Rural Delivery Systems (2004)*.

4.5.8.3 Software

The use of software for pipe size calculations must be done with extreme caution. The software must incorporate friction loss figures relevant to the available pipes in Vanuatu or must be verified with manual calculation using relevant friction loss table or charts.

Any designs and calculations done using software must be presented in the design report in such a manner that manual verification is possible (ie presented in HGL plots or tables). Software used must be able to save model files in suitable file formats that can be access for assessment using available software packages, free of charge, by the Department of Water Resources. EPANet is currently a program available to the DoWR suitable for assessment of water supply networks.

4.5.9 Detailed Design Reports

The following content is to be included in a standard design report:

- Introduction, clearly defining the scope with general information regarding the location and community
- Summary of Field Assessment Survey Data including Household and Infrastructure Surveys
- Summary of any asset condition assessments completed
- Summary of Design including but not limited to:
    - Design Standards used and explanations for any variation to the Vanuatu standard (this document)
    - Population census methodology and summary by community cluster
    - Hydraulic design methodology, including coefficients
    - Air in pipes design methodology
    - Design Demand
    - Source Information (Flow measurements, calculated safe yield and water quality) and proposed source collection infrastructure and protection measures.
    - Elevation measurements of key existing and proposed assets including method used.
    - System Schematic and Geographical Layout Plans/Maps
    - Pipe Selection (including pipe type, size, pressure rating, resultant velocities and static/dynamic pressures)
    - Resultant Hydraulic Grade Lines (HGLs)
    - Tank selection (including type, size, elevation)
    - Requirements for air valves and washouts
    - Designs of creek crossings (including methodology) and road crossings.

- Bill of Materials and project cost estimates with suitable contingencies for stage of project and method of implementation.
- Project risks and mitigation measures
- Design drawings (including any DoWR standards proposed to be used)

3. RURAL WATER SUPPLY

STANDARD 2: WATER SUPPLY QUANTITY & QUALITY

Sufficient water is easily accessible and available at all times for drinking, food preparation, personal hygiene, cleaning and laundry, and is safe for the purpose intended.

5.1 Indicators

5.1.1 Water Quality

The Vanuatu National Drinking Water Quality Standards (NDWQS) reflect best practice in drinking water quality processes required to ensure safe water consistent with the World Health Organization's (WHO) *Guidelines for Drinking Water Quality*.

Driven by recognition of the need for different approaches in managing urban and rural supply systems, the NDWQS deals separately with institutional urban and community rural water supply systems. For untreated rural water supply systems, the NDWQS contains standards that relate to water catchment protection, drinking water safety plans, biological / chemical water quality standards and monitoring requirements.

5.1.2 Water Quantity

To ensure that sufficient water is available to all users, the following basic water quantities are to be supplied:

Table 5: Water Demand Quantities

Category	Quantity	Description
Community	5 l/p/d	Minimum for rainwater harvesting projects where rain water is to be used for drinking water and other water sources are available for hygiene. Communities will need to manage daily water consumption to ensure water availability over the longer term.
	20 l/p/d	Absolute minimum quantity of fit for purpose water required for a community to realize minimum essential levels for health and hygiene in accordance with the WHO guidelines. Communities will need to manage daily water consumption to ensure water availability over the longer term.(Note: Pour Flush or Flush Toilets should not be used)
	50 l/p/d	WHO minimum for medium term maintenance of basic levels of health and hygiene including clothes washing and general cleaning. This minimum should only be used when 100L/p/d is not available at the source(s) or there are significant limitations to provision of 100L/p/d. This may be more suitable for pumped systems, including solar pump systems. (Note: Flush Toilets should not be used as they typically require 20-40L per user per day)
	100 l/p/d	**The standard for rural communities. This is based on WHO and UN guidelines for long-term lasting solutions for rural communities.** **This shall be adopted as the minimum daily water supply for Vanuatu unless there are inadequate sources of water or significant limitations in provision of this quantity of water from the available sources.** **This is the minimum amount of water to be supplied to support Flush Toilets in the community)**
Health facility	50 l/bed/d	When rainwater is the only water source available;
	100 l/bed/d	For combined rainwater and other water sources (where the other source is not able to provide 250 l/bed/d;

			For large enough water sources used in a piped water system;
	250	l/bed/d	
	10	l/patient	Out-patients
Day School	5	l/pupil/d	For schools with pit toilets
	15	l/pupil/d	For schools with pour-flush toilets (using a bucket)
	45	l/pupil/d	For schools with flush toilets
Boarding school	50	l/p/d	Boarding school with pit toilets
	85	l/p/d	Boarding school with pour flush toilets (50+35 for flushing)
	130	l/p/d	Boarding school with showers and flush toilets

5.1.3 Access

To ensure easy access to water points, the following applies:

- Service a preferred maximum of 20 users per public tap stand (no more than 5 households)
- Be at a preferred maximum distance of 100m of the users, but no more than 200m; (this should be reduced to less than 30m over an easily accessible path for persons with a disability that impacts their ability to access water)
- Water points are at suitable height for the users for access children, adults and PLWD.
- For Health Facilities the maximum distance to water points and toilets facilities shall be 30m over an easily accessible path.

5.1.4 Key Sanitation design parameters

Sanitation Design Parameters are detailed in the Ministry of Health (MOH) – Sanitation and Hygiene Guideline. The following should be noted in relation to design of water supply systems:

- Toilet types should consider water demand quantity requirements as per table 2 above and the guidance note in section 5.2 below
- Toilets with pits adhere to minimum separation distances to any water extraction point where water is used for domestic use as outlined in Sections 5.3.8 to 5.3.10.

5.2 Guidance notes

Definition:
Water supply is defined here as any facility that provides a source of water. The various types of water supply in rural Vanuatu are:

- *Direct Gravity Fed (DGF)*: a facility where an uphill source is dammed or tapped into and the water is transported using gravity to the users; the preferred option in most cases.
- *Indirect Gravity Fed (IGF):* a facility where a pump is used to pump water to a storage tank from which the water gravity feeds to the users; the least preferred option.
    - *Solar Water Pump Systems (SWPS) are a type of IGF system where solar power is used to operate the pumps*
- *Hand pumps (HP):* a facility where water is manually pumped up from a borehole, a hand-dug well, an underground storage tank or other. Most hand pumps in Vanuatu are used on boreholes;
- *Rainwater Harvesting (RWH):* a facility where rainwater is collected and stored in a tank. In Vanuatu, only roofs should be used as catchment areas.

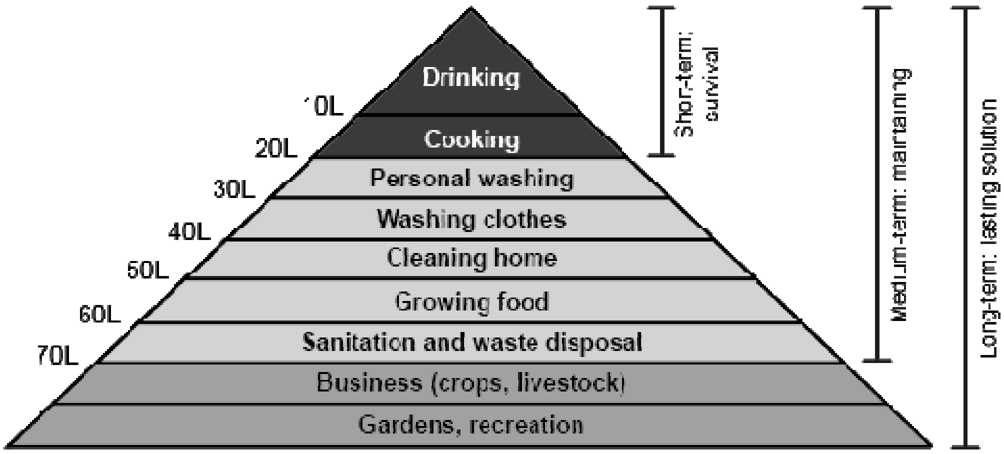
- *Desalination*[2]*:* a facility where saline water, such as sea water, is collected and treated to remove the salts and minerals from the water to produce water suitable for consumption.

Most public water supplies, serving the largest number of people are DGF systems. These systems often use public tap stands - household connections are seldom found. Rainwater harvesting is the second most common water supply; hand pumps the least common.

IGF systems are less common in Vanuatu, as the funds and skills required for operation and maintenance (O&M) are often beyond the capacity of a community. Pumped water supplies are recommended only for public institutions (schools, hospitals etc.), which usually have personnel and funds available for maintenance. Uses of solar pumps (with reduced operation and maintenance burden on the communities) are increasing in number in Vanuatu.

With the new strategy, the water demand design standard for rural communities in Vanuatu is 100 l/p/d. This allows for increased domestic use, as well as water use for small-scale commercial activities (e.g. guesthouses). This is based on the hierarchy of water requirements shown below as documented by the WHO.

Figure 4 – WHO Hierarchy of Water Requirements



Hierarchy of water requirements
(after Maslow's hierarchy of needs)

Typical water use by toilets are:

- 1-2L/user/day for handwashing (all toilet types)
- 3-5L/user/day for pour flush
- 20-40L/user/day for flushing toilets

Climate change

Effects of climate change will be particularly noticed in changes in the water cycle. Increasingly unpredictable rainfall will lead to less predictable surface water and groundwater recharge, and more droughts and floods.

As with sanitation, the potential resilience of water supply technologies can be classified as high, medium or low. Highly resilient technologies should function under most expected climate change conditions, medium resilient under a significant number of climate conditions, and low under a restricted number of conditions.

[2] *Desalination as a solution to water shortages in certain areas, particularly those relying on rainwater or groundwater, is not used or recommended. The high cost (initial investment and energy requirement) and maintenance requirement is deemed unobtainable in rural Vanuatu at this time. Regular maintenance of water supplies is already often lacking.*

The most common type used in Vanuatu, DGF systems, are inherently highly vulnerable to climate change effects due to its size and complexity. Piped supplies are exposed to multiple threats, starting at the source, through treatment systems (if applied) and the distribution network. The network may cross many different environments with significant hazards, and may have numerous joint vulnerable to leakages. Proper design, construction, leakage detection, and choice of materials contribute to the reduction of the vulnerability.

Protected springs (with the exception of artesian springs) have a low-medium resilience to climate change effects, as they cannot be relocated and have limited adaptability in design. Water quality may be adversely affected by increased rainfall, or flow may be reduced in drying environments.

Boreholes are highly resilient to most climate change impacts but are less resilient to saline intrusion from rising sea levels. Drying environment may make boreholes less viable (deepening is not always possible or economically viable), especially where motorized pumping is used.

Hand-dug wells are highly vulnerable to reducing quantity of water and contamination following rainfall (ingress of water along the upper parts of the lining). Securing year-round supply is in many cases already problematic.

Rainwater harvesting rarely provides sufficient water throughout the year presently and increased but less frequent rain or reduced rainfall makes the technology very vulnerable. Often systems are difficult to relocate and have limited adaptability in design.

Boreholes then are the only technology with high resilience to climate change effects. However, they are not universally applicable in Vanuatu and are relatively expensive to construct. Motorized pumping is usually outside the management capacity of the recipient community, leaving hand pumps as the more appropriate solution. Hand pump programs in Vanuatu have seen only limited success. Solar pumps are growing in popularity with reduced operation and maintenance costs, but are still usually outside the management capacity of the recipient community.

To mitigate the effects of climate change, it is recommended to provide a backup water supply next to the primary one. For example, another spring may be protected for use when the primary spring fails. Communal rainwater harvesting may be added to for example a piped water supply or hand-dug well project.

As Vanuatu continues to prepare for climate change, the above approach should be applied in those areas identified as highly prone to climate related hazards.

5.3 Piped water supply system components

5.3.1 Source & Intake

The source shall be:

- Fenced to prevent animal and human activity within the vicinity of the box to prevent the risk of waterborne diseases. Fence design and construction shall be appropriate for the source. The following are guidelines for protection:
    - For spring sources and bores fencing a minimum of 8m radius around the bore/source,
    - For surface water sources, if the entire catchment cannot be fenced (which is likely) and human and animal activity in the catchment cannot be eliminated by other means, water treatment will be required (community level treatment or household treatment).

The intake structure shall:

- Have the intake pipe secured in reinforced concrete, reinforced concrete blocks, stones, masonry or rock piles;
- Be completely enclosed where possible (e.g. at a spring), either with concrete or roofing iron; when a concrete cover is used, suitable access and ventilation must be provided for;
- Use galvanized iron/steel pipes and fittings;
- Be fitted with a control valve (ball valve);
- Have screened inlet piping;

- Be fitted with a washout placed at floor level, and of suitable length to avoid erosion near the intake;
- Include provisions to prevent access to the intake structure by animals (fencing of minimum 8m around the source);
- For a spring source, include surface runoff diversion up slope of the spring box diverting surface runoff away from the source to suitable drainage downstream of the spring box.
- Include flood prevention measures if necessary;
- Include prevention measures for earthquake and landslide were appropriate such as cliff protection and slope stabilization (Chickenwire, Rock Gabion Baskets etc)
- The outlet pipe a minimum of 15cm above the floor of the intake structure;
- Where possible, have the inlet pipe 3 pipe diameters or greater below the static water level;
- Have the crest of the dam, or the overflow, below the height of the natural water level to avoid backflow;
- Provide for sufficient overflow capacity.
- Include a sedimentation and/or filtration facility for water sources with high sediment loads;

5.3.2 Pipes

All pipes shall:

- Made of suitable materials for the application with appropriate pressure ratings, which can be easily maintained in Vanuatu. The pipeline shall conform to the relevant Australian and New Zealand Standard AS/NZS or equivalent ISO standard,
- Be buried at least 300mm from the top of the pipe where possible, in trenches devoid of sharp objects, stones or large quantities of organic material. The trench should allow sufficient space on either side of the pipe;
- Include washout valves at low points in the pipeline, protected by a cover; (Note: Washouts are important at the end of the pipeline networks to flush pipelines. It is recommended that at least one wash out point is provided at a low point at the end of the pipeline system for this purpose)
- Consider the potential of air trapped inside;
- Appropriate pressure rated fittings must be used at all times.
- A union shall be used for every three lengths of GI pipe or less, before t-offs, valves or other types of fittings or where the pipeline changes direction. Universal couplings or Gibault joints may also be used.
- Include a GI union for every GI pipe joint where the water source contains a lot of lime stone. GI pipes should be designed one size larger to allow for possible lime stone growth inside the pipe;
- Have all major branch lines fitted with an isolation valve;
- Incorporate valves of AS 2638.1-2002 or ISO 9001-2000 standard
- Be snaked in their respective trenches during installation to allow ease of maintenance and replacement of fittings

5.3.3 Sedimentation tanks

Sedimentation tanks shall:

- Be constructed for all stream sources and spring water sources which are visibly dirty or cloudy;
- Be of sufficient size and water velocity to enable settling of particles of 80um and larger

- For rectangular basins, the Reynolds number shall be less than 5000 to ensure laminar flow within the basin
- Have an inlet fitted halfway the depth of the water, regulated with a valve, and distribute the flow as evenly as possible (perforated pipe or baffle to stop turbulence);
- Have an outlet designed to collect water from the cleanest layer of the tank, typically well above the floor to avoid sedimentation and slightly below the top of the water to avoid floating debris from entering the outlet.
- Be fitted with a washout (minimum 50mm);

5.3.4 Water holding receptacles

All water holding receptacles shall:

- Be made of plastic, fiber-glass, metal (with or without liner), reinforced masonry, or ferro-cement;
- Poly tanks are the preferred option for tanks up to and including 10,000L. Ferro-Cement tanks are the preferred option for tanks larger than 10,000 L;
- Have a strong and secure cover with a manhole to allow access (this does not always apply to prefab tanks however);
- Be of functional and water tight design;
- Include a system to extract the water without contaminating it;
- have appropriate connections for inlet and outlet fittings;
- have all openings vermin proof;
- use GI fittings or uPVC (pressure) for the inlet and outlet;
- Have float valves for all tanks in a gravity fed system;
- Be fitted with an overflow of sufficient size (not possible for many prefabricated tanks however), min 2x the size of the inlet, allowing excess water to drain away from the immediate tank surroundings (>3m); PVC pipes may be used for the overflow;
- Be placed on a reinforced concrete base slab of sufficient thickness, on a tank stand or other sufficient measure to prevent roots from damaging the tank;
- Incorporate the effects of seismic activity into the design, construction, placement and/or anchoring where applicable
- *Not* have any fittings protruding through the base slab;
- Polyethylene and fiberglass Tanks must have tie downs installed.
- Where there are risks to animal contact and/or security, the tank shall be suitably fenced to prevent animal access or unauthorized access.

Tanks may be constructed above or underground according to user preference.

5.3.5 Tap stands

(Public) tap stands shall:

- Be constructed at locations accessible to all community members;
- Service a maximum of 20 people per public tap stand; (no more than 5 typical households)
- Incorporate a reinforced slab apron of sufficient size;
- Be sited in consultation with the users;

- Include appropriate drainage facilities to prevent mosquitoes from breeding In the vicinity of the tap stand and pooling at the tap apron; the tap stand and surround shall have drainage at a minimum of 2% grade towards an appropriate soak away (course coral or stone with no fine materials).
- Be fitted with a high-pressure tap to ensure durability;
- Be constructed using GI pipes of sufficient diameter (3/4" minimum) to withstand daily use, and include concrete or masonry support of the stand pipe;
- Concrete apron shall be broomed or raked (in the direction of the apron fall) prior to curing to provide a non-slip surface
- Where there are risks to animal contact and/or security, the tap stand shall be suitably fenced to prevent animal access or unauthorized access.

5.3.6 Suspended & Vehicular Road Crossings

Suspended crossings shall:

- Be made of GI pipes with the poly pipes running through, if the crossing is less than 6m wide (i.e. One length of GI pipe);
- Where crossings are greater than 6m, the pipe shall be suspended under steel cables.
- Be of sufficient height to allow for high water levels, debris, and traffic to pass safely underneath;
- Use a suspended steel cable of sufficient thickness under which the pipe line is hanging;
- Include sufficient anchoring on either end of the creek;

Vehicular Road crossings shall:

- Have a culvert made of GI pipes, connected with sockets, with the poly pipe line running through.
- If other infrastructure is present (ie brides/culverts) it may be fastened to the downstream side of the structure after receiving approval from the infrastructures owner.
- Be buried as deep as possible with a maximum depth of 1m, and a minimum depth of 300mm under the road crossing
- Extend past the trafficable area on either edge of the road to avoid damage from traffic running off the road;
- Have marker posts and/or signage at the entrance and exit of the road crossing to clearly indicate the location of pipeline crossing.

5.3.7 Pump house (and generator house)

A pump house shall:

- Be suitable for the pump type (Surface or Submersible)
- Where fuel is used, have a reinforced concrete base slab of sufficient thickness, with a very smooth upper surface and raised edges to contain and easily clean up spilled fuels;
- Be weather tight;
- Not be prone to flooding with the floor level 0.3m above the maximum known flood level
- Include locks on all access ways;
- Be of sufficient size to allow both pump and fuel/oil to be placed inside, the fuel separated from the pump by a concrete or masonry wall if applicable;
- Be sufficiently ventilated to prevent hazardous gas built-up;

- Include measures to prevent fuel, oil and/or other hazardous liquids from spilling into the environment, the size equivalent to the volume of fuel used;
- For surface pumps, be located away from any water source, to prevent accidental spillage polluting the source;
- Be of sufficient internal size to allow easy O&M of the pump (enough space around the pump);
- Be constructed at an easily accessible location to allow safe transport of fuel/oil etc. to the site;
- Site selection should include a risk assessment and basic EIA, including noise pollution;
- Where there are risks to animal contact and/or security, the pump house shall be suitably fenced to prevent animal access or unauthorized access.

5.3.8 Manual Extraction (Wells and hand pumps)

Hand-dug wells and boreholes shall:

- Not be constructed or used for human consumption if within located within the following proximity to a waste site, sanitation facility or graveyard;

If the water table is at least 10 meters below the bottom of the latrine, most contamination will be removed before it reaches the groundwater if:

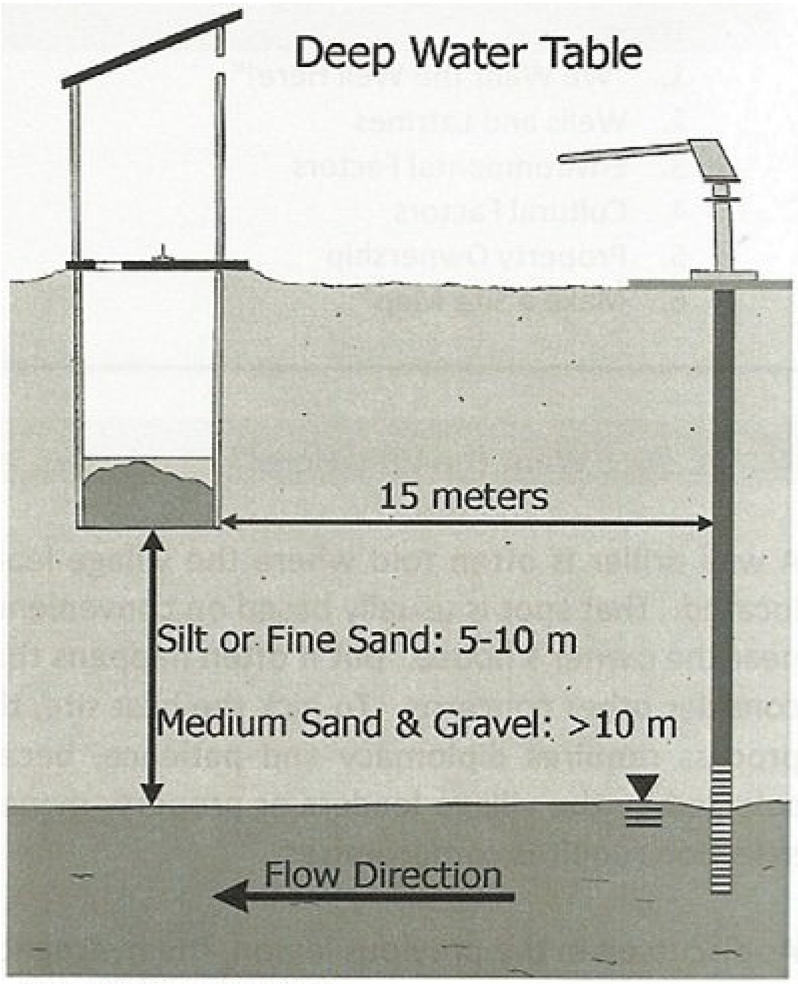
1. There is medium sand or gravel between the bottom of the latrine and the water table.

2. The well is located at least 15 meters from the latrine.

Figure 5 – Deep Water Table Separation

Minimum Safe Separation Distances in a Deep Water Table

Sediment Type	Depth to Water Table	Min. Safe Separation Distance
Clay, silt,or fine sand	5 meters or more	15 meters or more
Medium sand	5 meters or more	15 meters or more
Coarse sand or gravel	10 meters or more	15 meters or more
Fractured rock	10 meters or more	15 meters or more



Source: Lifewater International

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In the Case of a Shallow Water Table

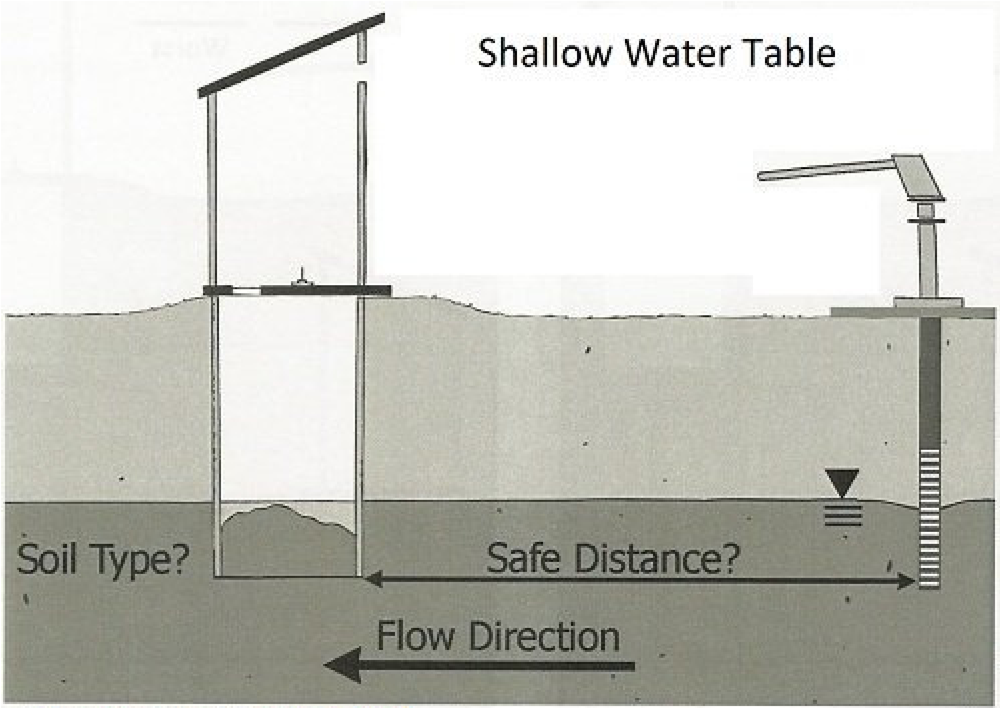
If the bottom of the latrine is at the water table, or close to it, then disease-causing organisms can contaminate groundwater. Finer grain soils, like clay, silt, and fine sand can more easily filter out pathogens than coarse sand or gravel.

As a result, the minimum safe separation distance is shorter for finer soils than it is for coarse soils. In either case, if flow direction is known, it is best to put the well up-gradient from the latrine.

Figure 6 – Shallow Water Table Separation

Minimum Safe Separation Distances in a Shallow Water Table

Sediment Type	Depth to Water Table	Min. Safe Separation Distance
Clay, silt,or fine sand	0 meters (latrine at or near water table)	15 meters
Medium sand	0 meters (latrine at or near water table)	50 meters
Coarse sand or gravel	0 meters (latrine at or near water table)	500 meters
Fractured rock	0 meters (latrine at or near water table)	500meters



Source: Lifewater International

- Where used for human consumption, have the water tested for pH, temperature, salinity, turbidity, fluoride and biological contamination;
- Be fitted with adequate measures to drain excess water at least 6m away from the well/borehole, with the drainage channel having a minimum slope of 5%;
- Be raised 600mm or more above the surrounding ground to avoid surface runoff entering the well or bore;
- Be fitted with a cap/lid to avoid contamination;
- Have a minimum diameter of 800mm (hand-dug wells) to allow access for maintenance;
- Use durable, non-corrodible well lining for hand-dug wells (ferro-cement or prefabricated liners); where concrete liners are stacked, they must be sealed

- Prefer Village Level Operation and Maintenance (VLOM) type hand pumps[3];
- A pump test should be used to determine the maximum number of people who should use the bore. (Bores typically cater for no more than 50 people per facility);
- Be within 200m distance from any household using the facility where this is there only water source;
- For communal facilities, be constructed at locations accessible to all community members;
- Have the area fenced (to prevent animals) and a simple roofing structure constructed (this may use bush material);
- Have a safe place to store well buckets.

5.3.9 Boreholes with Electric Pump

Boreholes with electric pumps shall:

- Not be constructed or used for human consumption if within located within the proximities to a waste site, sanitation facility or graveyard as described in Section 5.3.8 above
- Where used for human consumption, have the water tested for pH, temperature, salinity, turbidity, fluoride and biological contamination;
- Casing be raised 600mm or more above the surrounding cement slab to avoid surface runoff entering the bore;
- Be fitted with a cap to avoid contamination;
- Be a minimum of 6” bore diameter as standard to ensure adequate motor cooling (drilling 4” bores shall only be by approval of the DoWR)
- Have the following (boreholes):
    - Use uPVC or metal casing/screen.
    - Installation of a gravel pack where necessary (rounded material just larger than and no more than 2-3x screen slot size). If no gravel pack required, ensure screen size allows 60% of material to pass through screen during well development.
    - Installation of sanitary seal (above gravel pack) to fill the area between the casing and the borehole (annulus) to fix the casing in place and to stabilize the side of the borehole. If cement grout used, seal top of gravel pack with bentonite clay first.
    - Installation of a minimum of $1m^2$ cement grout top-seal to prevent contamination due to surface infiltration
- Have the area fenced off and a simple roofing structure constructed (this may use bush material);

5.3.10 Wells with Electric Pump

Wells with electric pumps shall:

- Not be constructed or used for human consumption if within located within the proximities to a waste site, sanitation facility or graveyard as described in Section 5.4 above
- Be raised 600mm or more above the surrounding ground to avoid surface runoff entering the well;
- Have a minimum diameter of 800mm to allow access for maintenance;
- Use durable, non-corrodible well lining for wells; where concrete liners are stacked, they must be sealed

[3] *Durable, sustainable, and appropriate hand pumps which can be maintained by village members requiring little special skills or equipment.*

- Have the area fenced off and a simple roofing structure constructed (this may use bush material);
- For communal facilities, be constructed at locations accessible to all community members;

5.4 Rainwater Harvesting Systems

Standards derived from the National Building Code (NBC) are indicated as such.

Rainwater harvesting facilities shall:

- Be of sufficient size to cater for a regular dry season, based on the minimum water demand of 5 l/p/d in the critical month;
- For communal facilities, be constructed at locations accessible to all community members;
- Include a soak-away to prevent stagnant open water;
- Include a screened inlet & overflow pipe to prevent mosquitoes from entering the storage tank;
- Include an automatic first flush (or *foul* flush) fixture appropriately sized based on the roof area and anticipate pollutant load;
- Include a system to extract the water without contaminating it (tap or pump);
- Include sufficiently sized roof drainage fixtures to withstand peak rainfall intensities: 5-year return intensity for temporary structures, 20-year return intensity for permanent structures (*NBC*);
- Include a 25mm freeboard for eaves gutters and 35mm freeboard for internal box gutters to prevent overflow into buildings (*NBC*);
- A minimum fall of 1 in 500 for eaves gutters;
- Have a maximum bracket spacing of 300mm;
- Include downpipes of sufficient size: 50% of the cross-section of the gutter, or $650mm^2/10m^2$ roof area for eaves gutters and $930mm^2/10m^2$ roof area for internal box gutters (*NBC*);
- Include roof catchments and tanks constructed to withstand cyclones and earthquakes;
- Include roofing made of durable materials;
- Houses to be cross braced in each pane
- Exclude roofing containing toxic materials (such as asbestos, lead-based paint etc.);
- Have a minimum of 400mm spacing under the tap for buckets; If this cannot be achieved a tap stand downhill of the tank should be installed.
- Include measure to prevent animals reaching the faucet such as fencing of the site or tap area if necessary;
- Have the tanks situated to minimize Downpipe length;
- Angles of downpipe fittings shall not exceed 50 degrees such that floats associated with automatic first flush systems are not blocked.
- Tanks are secured to the tank stand/slab to withstand cyclones and earthquakes

Storage and roof catchment requirement for individual households can be calculated using the data in APPENDIX 1: VANUATU RAINFALL DATA.

To easily assess the storage requirement for communal tanks, Vanuatu has been divided in 2 categories, dry and wet. Using 5 l/p/d, a single 5000 gallon/20,000 Litre Ferro Cement tank with 50m^2 roof surface area[4] can typically cater for a maximum of 40 people in 'wet' areas. In 'dry' areas it can typically cater for a maximum of 20 people. Refer to APPENDIX 1: VANUATU RAINFALL DATA

Some areas in Vanuatu rely mainly on rainwater harvesting (for example Aniwa). It is recommended that for such areas, rainwater facilities cater for households rather than communities. Planning for a 15 year design period may be difficult as it is impractical to construct tanks where there are no households yet. The design period standard may in this case be suspended.

5.5 Other

5.5.1 Concrete

Concrete is one of the main construction materials in water supply and sanitation. Vanuatu experiences frequent earth tremors and occasionally strong earthquakes, which consequently places a high demand on the quality and design of concrete works.

Appropriate concrete reinforcement in particular is essential. Correct mixtures and procedures can be found in most text books.

Concrete structures shall:

- Use fresh Portland cement as per AS 3972;
- Use steel reinforcement of 500 MPa unless otherwise specified;
- Not use any other reinforcement material (fiber, pre-mixed reinforced cement, rope, twines, nylon, wood or other);
- For floor slabs, have a total steel surface area of at least 0.225% of the total cross-sectional area;
- For roof slabs, have a total steel surface area of at least 0.3% of the total cross-sectional area;
- For beams, load-bearing walls and load-bearing suspended slabs, have a total steel surface area of at least 0.5% of the total cross-sectional area;
- Use the following mixtures:

Type of sand	Dry mix	Water proof mix
Black sand	1½:2:4	2½:3:6
White sand	1:2:4	2:3:6

- Ensure proper curing practices;
- All sand and aggregate to be free from dust, dirt, salt and other foreign or organic matter. All sand and aggregate must be thoroughly washed if sourced close to the sea.
- Aggregate to be well graded, hard broken stone or coral with a stone size of 20mm or less in which 95-100% is retained on a 4.75mm sieve.

[4] *DoWR's standard RWC unit.*

- Coarse white/black sand shall consist of hard sharp and angular grains with 95-100% passing a 4.75mm sieve.
- Minimum concrete cover of 30mm except when a structure is placed in a corrosive environment (ie shoreline, volcano, aggressive soils) the minimum cover must be increased to 45mm
- Curing will occur by ensuring concrete is kept damp for 24 hours after it has begun to harden (approx 2hrs after mixing).

APPENDICES

APPENDIX 1: VANUATU RAINFALL DATA

Table 6: Sola (Banks) monthly rainfall data (35yrs)

Month	Monthly rainfall (mm)
Jan	394.7
Feb	332.1
March	397.1
April	457.3
May	381
June	334.2
July	248.9
August	243.6
Sept	240.7
Oct	322.7
Nov	392.5
Dec	369.8

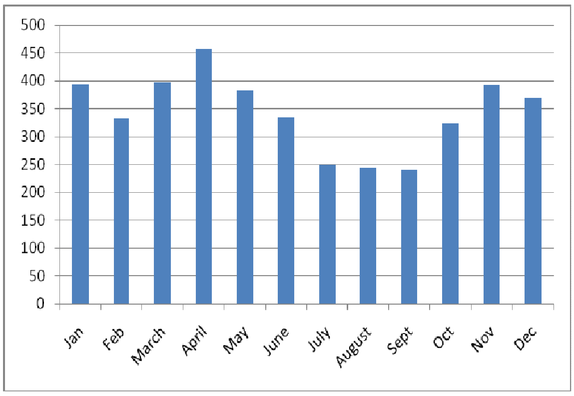


Figure 1: Sola rainfall data

Table 71: Pekoa (Santo) rainfall data (32yrs)

Month	Monthly rainfall (mm)
Jan	297.8
Feb	306.9
March	266.3
April	271.3
May	186.6
June	197.7
July	108.5
August	106.9
Sept	103
Oct	156.9
Nov	191.8
Dec	205.1

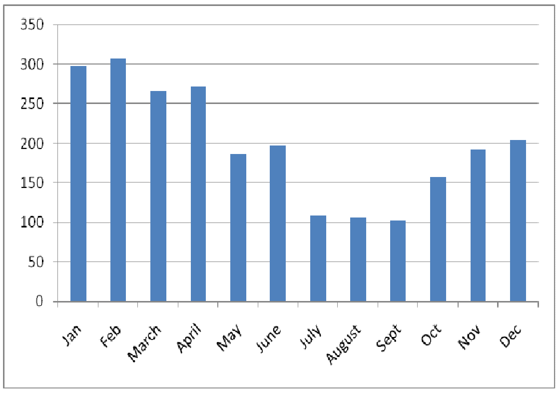


Figure 2: Pekoa (Santo) rainfall data

Table 8: Lamap (Malekula) rainfall data (47yrs)

Month	Monthly rainfall (mm)
Jan	253.8
Feb	245.8
March	277.4
April	219.2
May	160.2
June	141.7
July	118.1
August	83.7
Sept	86.5
Oct	142.2
Nov	129.5
Dec	144

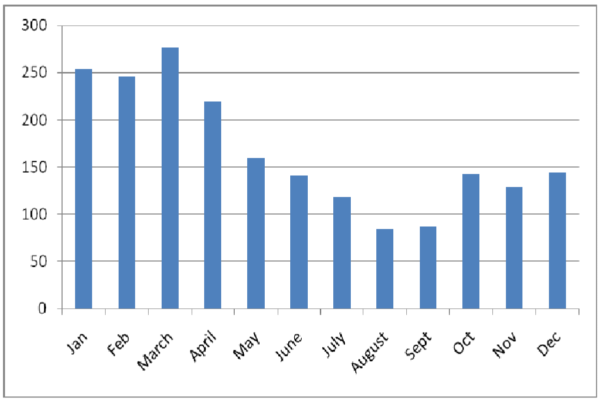


Figure 3: Lamap (Malekula) rainfall data

Table 9: Bauerfeld (Efate) monthly rainfall (36 yrs average)

Month	Monthly rainfall (mm)
Jan	291.3
Feb	324.5
March	320.7
April	231.7
May	185.4
June	182
July	82.8
August	84.7
Sept	88.3
Oct	113.1
Nov	148
Dec	169.6

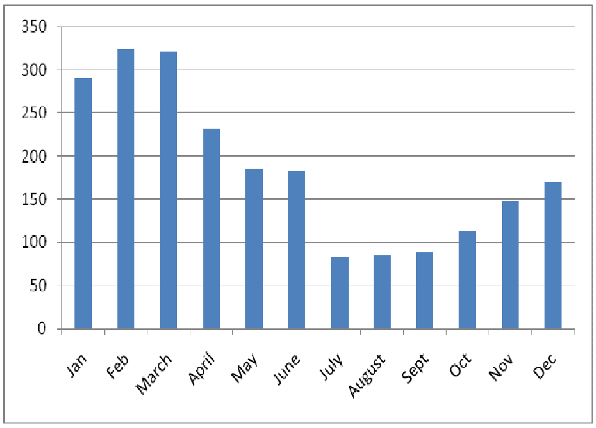


Figure 4: Bauerfeld (Efate) monthly rainfall

Table 10: Burtonfield (Tanna) monthly rainfall data (30 yrs average)

Month	Monthly rainfall (mm)
Jan	176.2
Feb	213.1
March	220.7
April	100.2
May	81.1
June	96.5
July	60.5
August	53.1
Sept	63.4
Oct	52.1
Nov	71.3
Dec	89.5

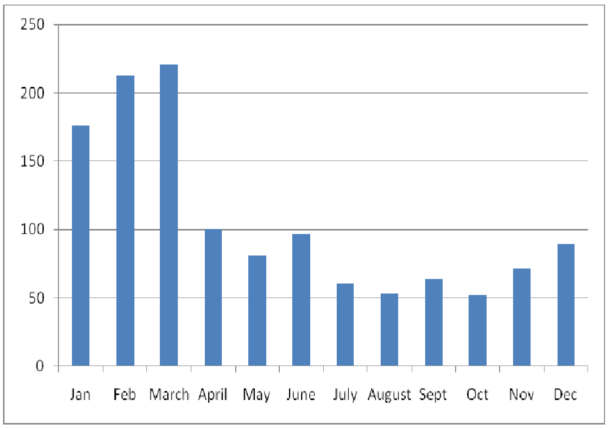


Figure 5: Burtonfield (Tanna) monthly rainfall data

Table 11: Aneitium monthly rainfall data (30yrs)

Month	Monthly rainfall (mm)
Jan	284.7
Feb	310.8
March	380.8
April	219.3
May	167.7
June	173.5
July	124.7
August	108.8
Sept	111.4
Oct	108.1
Nov	134.8
Dec	188

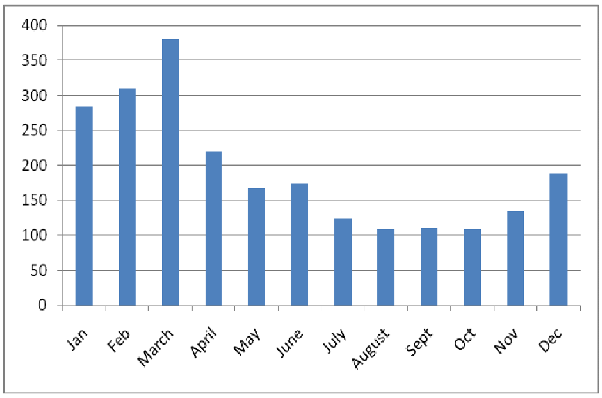


Figure 6: Aneitium monthly rainfall

APPENDIX 2: DRY AND WET AREAS IN VANUATU

To easily assess the storage requirement for communal tanks, Vanuatu has been divided in 2 categories: dry and wet. Using 5 l/p/d, a single 5000 gallon F/C tank with 50m² roof surface area can cater for a maximum of 40 people in 'wet' areas. In 'dry' areas it can cater for a maximum of 20 people. Using the maps below, target communities are in either area (when in doubt, designate them to be in a 'dry' area).

The dark areas on the maps are 'wet', the white areas on the maps are 'dry'.

TORBA PROVINCE:

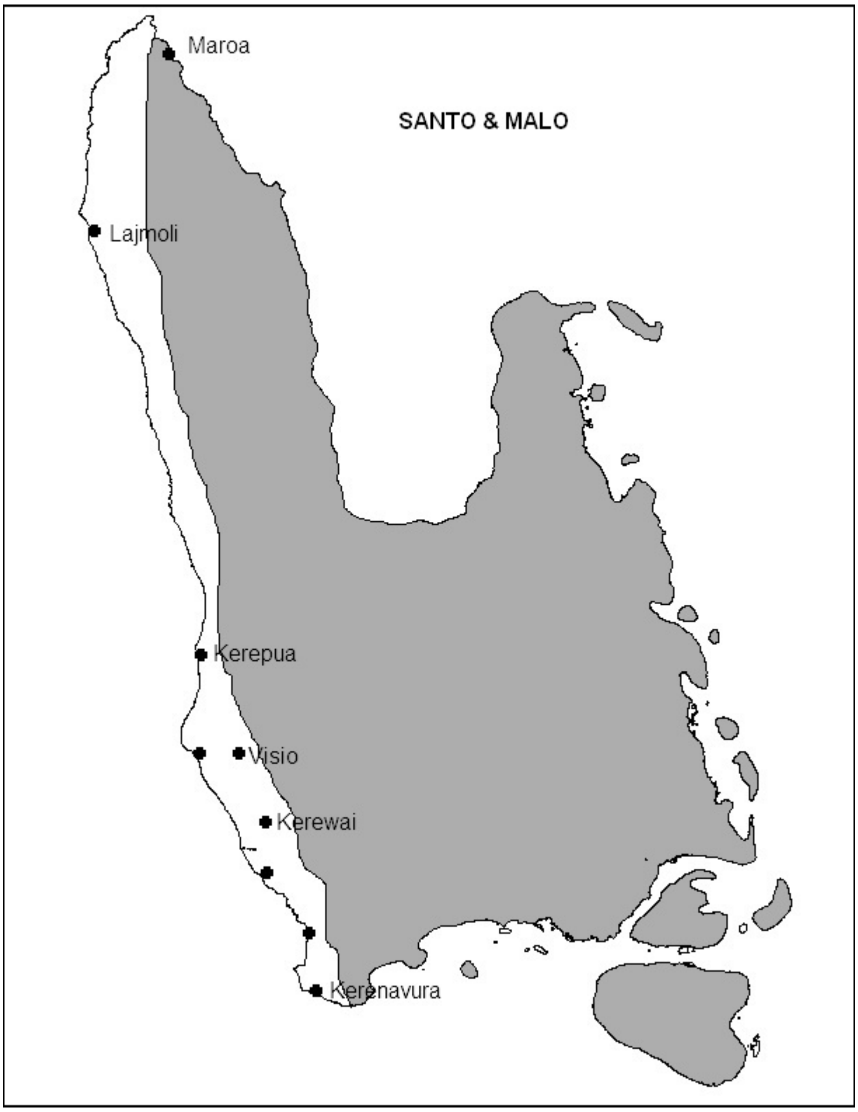
All islands of the Torres and Banks group are wet areas.

PENAMA PROVINCE:

Pentecost, Ambae and Maewo are all wet areas.

SANMA PROVINCE:

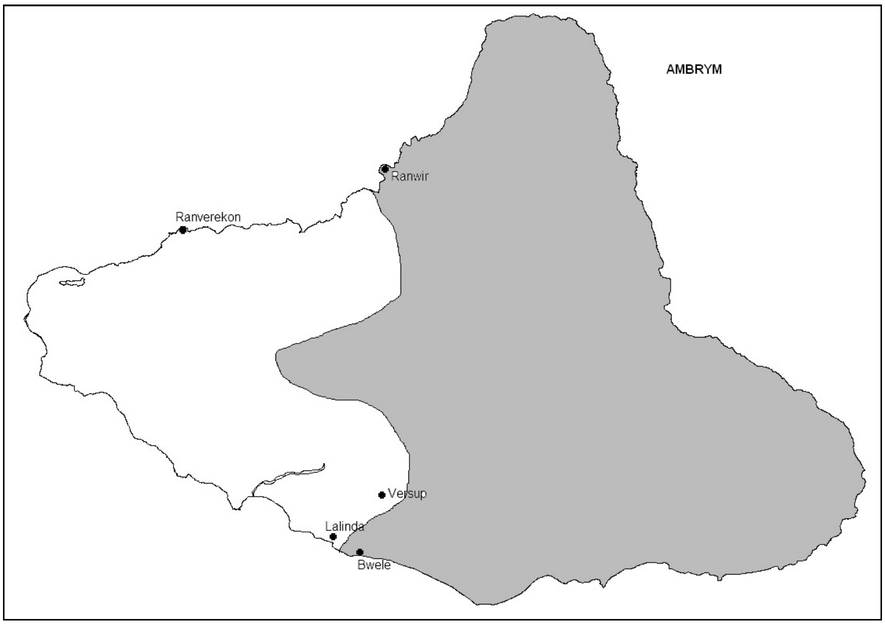
Malo Island is considered wet. The west coast of Santo is dry, the rest wet:


Maroa
SANTO & MALO
Lajmoli
Kerepua
Visio
Kerewai
Kerenavura

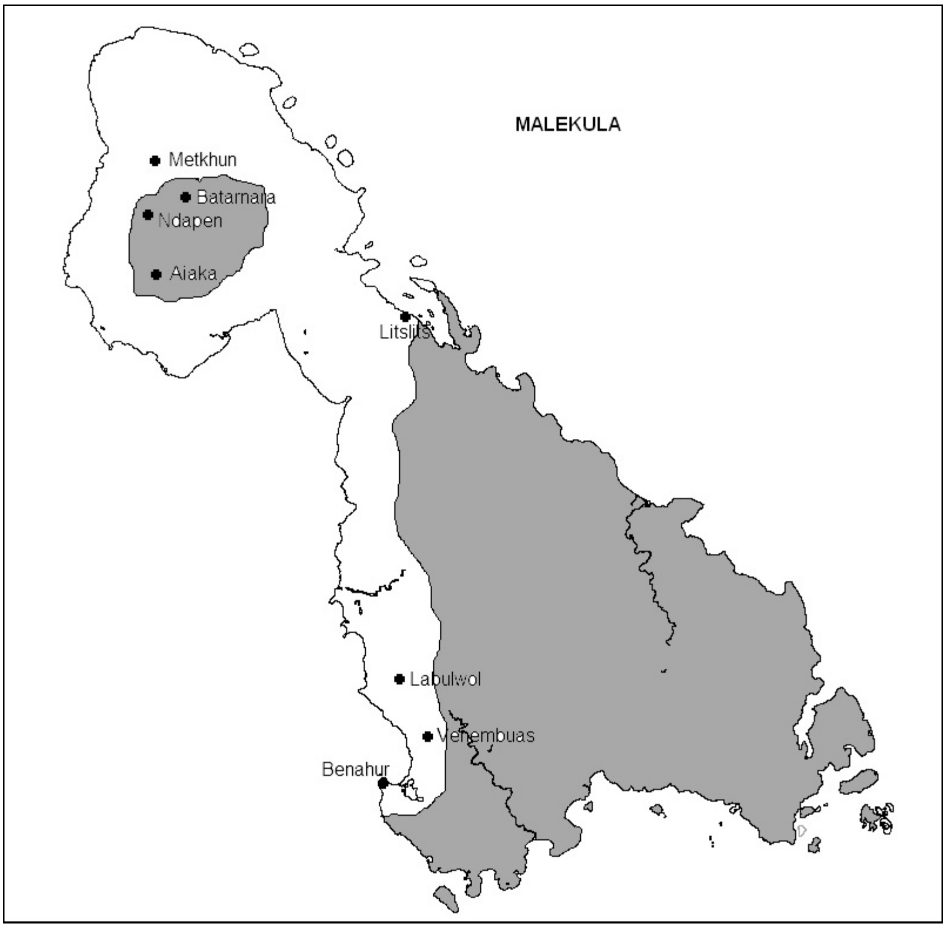
MALAMPA PROVINCE:

Paama Island is a wet area;

The western part of Ambrym is dry:



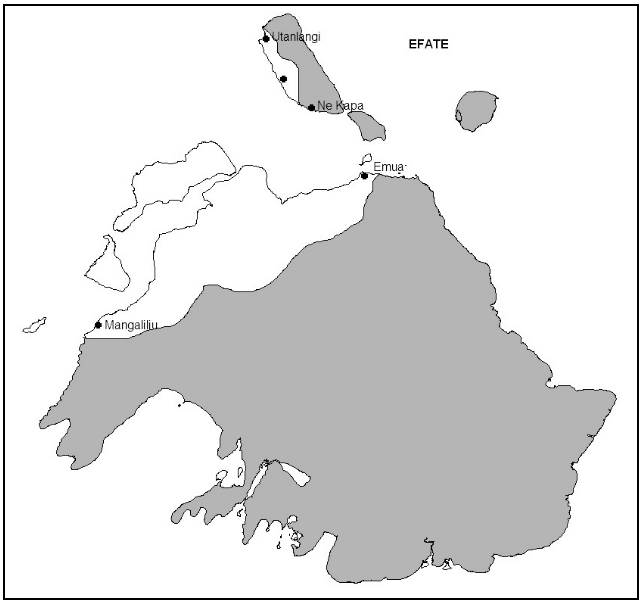
Malekula has large dry areas on the west side of the island, with a wet enclave in the north-west:



SHEFA PROVINCE:

The Sheperd Islands are "wet" areas;

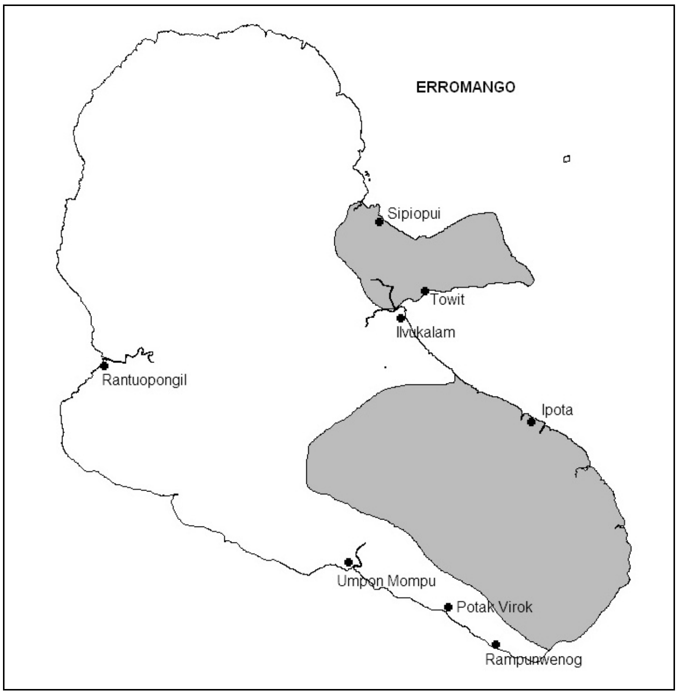
Efate has a dry north-west, as is the western part of Nguna Island, and the islands of Moso and Lelepa:



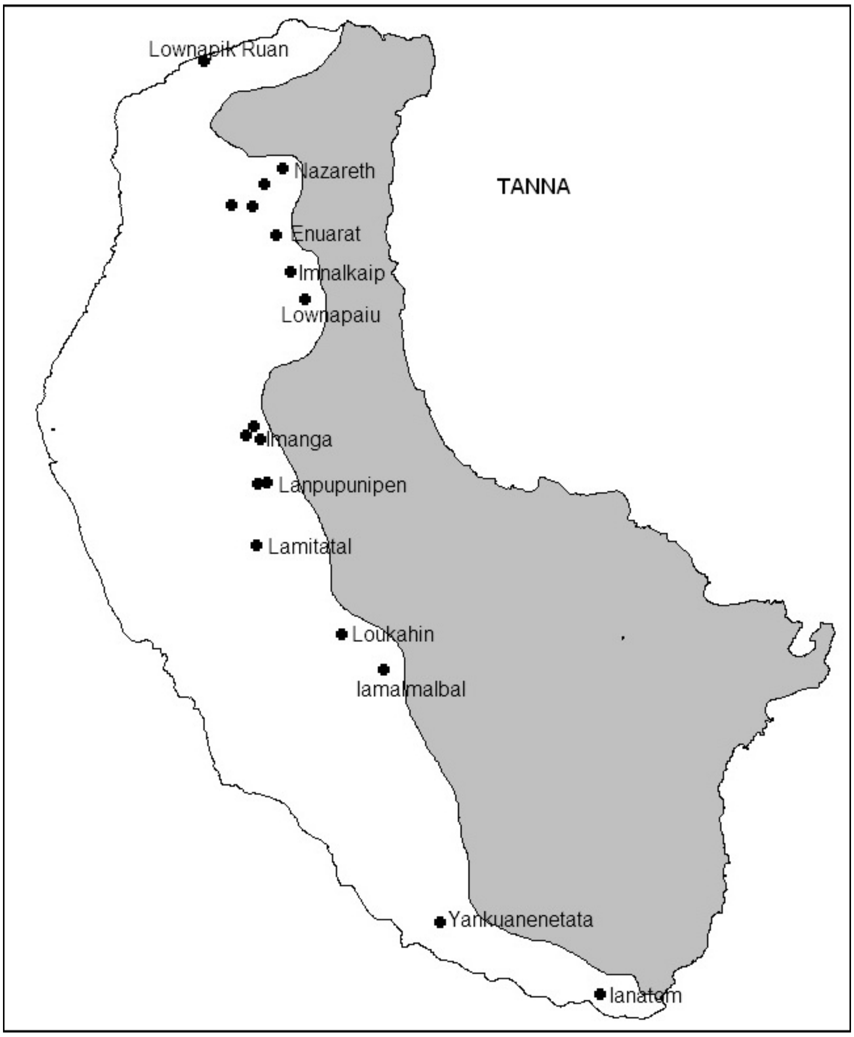
TAFEA PROVINCE:

The islands of Aniwa and Futuna are wet. It should be noted however that Aniwa is a small, relatively flat island with no surface water. It relies on a thin fresh groundwater layer and rainwater. *Rainwater projects should consider providing rainwater tanks at household level, rather than communal tanks.*

Erromango is largely dry, with some wet areas in the east and south-east:



Tanna has a dry western area:



Aneitium has a dry northern part of the island:

APPENDIX 3: TOOL SETS

The below table contains recommended minimum tool sets for different projects. A full tool set for contractors is also included.

Table 2: Tool sets

#	Tool	Supervisor /contractor	Piped supply	Hand Pump/ pumped supply	Rainwater harvesting
1	Hand saw, 22”	1	1		1
2	Hack saw, 12” + blades	1	1	1	
3	Claw hammer, 16oz.	1	1	1	1
4	Shifting spanner (300mm)	1	1	1	1
5	Level (600mm)	1			1
6	Tape measure (3m)	1	1	1	1
7	Pipe wrench, ½”	1			
8	Pipe wrench, 1”	1			
9	Pipe wrench, 1½”	1	1		
10	Pipe wrench, 2”	1			
11	Pipe wrench, 3”	1	1		
12	Pipe wrench, 4”	1			
13	Open spanner set	1		1	
14	Screw driver, Flat head, set	1	1		
15	Screw driver, star, set	1	1		
16	Trowel	2	2	1	1
17	Wooden floater	1	1	1	1
18	Steel floater	1	1	1	1
19	Pliers, side cutter, 180mm	1	1		1
20	Pliers, end cutter, 300mm	1	1		1
21	Bolt cutter, 900mm	1	1		
22	Brush (for white wash)	1	1		1
23	Line level	1			1
24	Profile string (20m)	1			1
25	Carpenters pencil	1			1
26	Cold chisel	1	1		1
27	Combination square	1			1
28	Tin snip	1			1
29	Tool box (lockable) w/lock	1	1	1	1
30	Hex key set	1			
31	Mattock	1			
32	Reseating tool	1	1		1