Government of Samoa

SAMOA
FLOOD MANAGEMENT
ACTION PLAN
2007-2012

WITH SPECIFIC REFERENCE TO VAISIGANO RIVER

Prepared by:

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in collaboration with

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Acknowledgement

The development of the Flood Management Action Plan was attained upon the invaluable support and knowledge of Assistant Chief Executive Officers of the Ministry of Natural Resources and Environment Mr Mulipola Ausetalia Titimaea, Meteorology Division; Mr Suluimalo Amataga Penaia, Water Resources Division; and Mr Tagaloa Jude Kohlhase, Planning Urban Management Agency.

SOPAC under the EDF8 Project and HR Wallingford Ltd. provided technical assistance in the development of the Plan in collaboration with the Government of Samoa.

Further acknowledgement to other key government agencies, private sectors, NGOs and relevant national donor funded projects such as WaSSP and ADB TA on Drainage and Sanitation for their immense contribution to the formulation of the Plan.

Foreword

[to be completed by Water Resource Division (MNRE)]

Table of Contents

List of Tables

List of Figures

Abbreviations and Acronyms

The following abbreviations and/or acronyms are used throughout this Plan.

Abbreviation/Acronym	Description
ACP	Asia, Caribbean and Pacific
AG	Attorney General
CHARM	Comprehensive Hazard and Risk Management
CSD	Corporate Services Division
DAC	Disaster Advisory Committee
DMO	Disaster Management Office
DTMs	Digital Terrain Models
EDF	European Development Fund
EIA	Environmental Impact Assessment
EPC	Electric Power Corporation
EU	European Union
FD	Forestry Division
FMAP	Flood Management Action Plan
GIS	Geographic Information Systems
ICT	Information and Communication Technology
IPES	Institute of Professional Engineers of Samoa
LMD	Land Management Division
MESC	Ministry of Education, Sports and Culture
MNRE	Ministry of Natural Resources and Environment
MOA	Ministry of Agriculture and Fisheries
MWCSD	Ministry of Women, Community and Social Development
MWTI	Ministry of Works, Transport and Infrastructure
NDMP	National Disaster Management Plan
NGOs	Non Government Organisations
NUS	National University of Samoa
NWS	National Water Strategy
PUMA	Planning and Urban Management Agency
SNDMP	Samoa's National Disaster Management Plan
SIAM	Samoa Integrated Asset Management Project
SLMNAP	Sustainable Land Management National Action Plan
SOPAC	Pacific Islands Applied Geoscience Commission
STA	Samoa Tourism Authority
SWA	Samoa Water Authority
TIN	Triangulated Irregular Network
TSD	Technical Services Division
WaSSP	Water Sector Support Programme
WRD	Water Resources Division

1. Introduction

This Flood Management Action Plan (FMAP) was developed in response to the Government of Samoa's request for flood management assistance on particularly in the urban areas surrounding the capital of Apia. The need for flood management was first identified in Samoa's work plan for the EDF 8 project in WS 3.4 and 3.5 pertaining to hazard assessment and risk reduction. The Plan has been developed as part of the regional EDF 8 Project Reducing Vulnerabilities in the Pacific ACP States, executed by the Secretariat of the Pacific Islands Applied Geoscience Commission (SOPAC). The implementation of the Plan should also consider the following documents, which had been developed in conjunction:

- *Samoa Floodplain Management: A Guideline for Planning and Development Assessment 2007*
- *Samoa - Capacity Building in Flood Risk Management* – Technical report SOPAC/EDF8 Project No : ER0069a

Samoa's location and characteristics together with its economic and technological capacity contributed to its vulnerability to a number of natural and technological hazards including flooding. A risk analysis carried out for the Disaster Management Plan (NDMP) 2006-2009 indicated that 'floods' as a result of heavy rain were ranked as a 'high risk' event.

The economic cost of the 2001 flood was estimated to be over 11 million Tala. As the number and cost of floods continues to rise, specifically in Apia the centre for many businesses, improving the management of floodplain areas to reduce flood risk becomes even more critical. All too often, after floodwaters have subsided, the emphasis has been placed on rebuilding structures and trying to restore flood victims' lives back to normal as quickly as possible. Unfortunately, these flood victims have often rebuilt their structures in their previous "at risk" conditions. The Government of Samoa is now seeking to integrate numerous programmes to address Apia's flood problems and reduce future flood risks and costs.

1.1. Scope

The flood management process is countrywide, with particular focus on the lower Vaisigano watershed and coastal area (Figure 1.1). The central administrative level of the national government underpins the scope of this Plan applicable countrywide, which mean that the non-structural actions such as policy recommendation, capacity building, information management and communication, flood forecasting and warning and community awareness and education apply to other river catchments in Samoa. The plan discusses various structural measures to mitigate flood in the lower Vaisigano. The methods by which the structural mitigation options have been identified could also be applied to other river catchments across Samoa. The FMAP has two main components:

Component 1 – Flood Risk Reduction
Flood risk reduction or mitigation includes prevention, protection and / or adaptation. However, floods cannot be totally prevented or mitigated by structural means. Hence, integrated flood management is important combining structural and non-structural measures, such as adopting to flood risks and implementing development control in flood prone areas.

Component 2 – Flood Emergency Management
Flood emergency management addresses preparedness (including flood forecasting

and warning), response (moving to higher grounds) and recovery (cleaning and rebuilding after floods) before, during and after flood events.

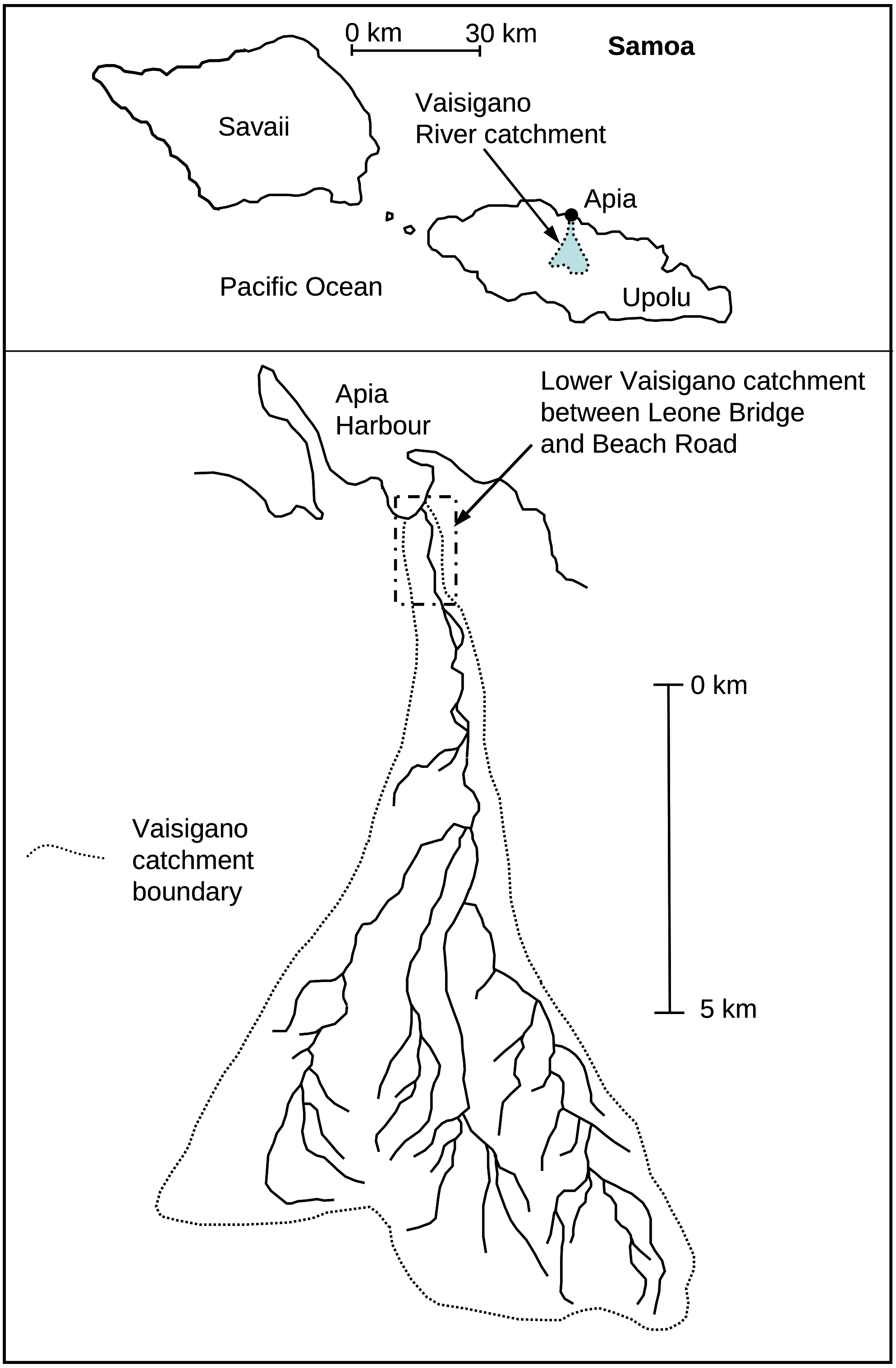

Figure 1-1: Map of Samoa showing the location of the Vaisigano River catchment

1.2. Purpose

The purpose of the Plan is to assist Samoa in attaining its sustainable development goal of *"improving quality of life for all"*[1] through developing a sustained level, integrated and coordinated flood risk management plan. Special emphasis is on the lower Vaisigano River catchment as a pilot area and specific actions are recommended to be in line with the overarching goal. This Plan identifies actions for Government agencies, the private sector, NGOs and communities responsible for flood and floodplain management that can assist in reducing flood risks to the Samoan people and their property, as well as improving public safety and enhancing the environment.

1.2.1. Goals and Objectives

The overall goal of the Action Plan is to reduce social, economic and environmental impacts of floods on the people of Apia thereby facilitating the achievement of national development goals. Table 1-1 sets out six goals of the Action Plan.

Table 1-1: Flood Management Action Plan Goals

Goal 1	Flood Risk Reduction
Goal 2	Flood Preparedness and Early Warning
Goal 3	Capacity Building
Goal 4	Technological Information Management
Goal 5	Sustainable Watershed Management
Goal 6	Flood Governance

Specific objectives of the Plan are to:

- Identify and map the flood hazard within the lower Vaisigano River catchment
- Identify flood risk management options and indicate how these may be assessed in more detail
- Strengthen a nationally coordinated flood forecasting and warning systems
- Support public outreach and educations activities to improve awareness of flood risk and hazard and promote recommended preparedness actions communities can take to reduce risks to themselves and to others
- Manage activities in floodplains in a manner compatible with multiple and competing uses, including existing and proposed urban development within Apia.
- Strengthen capacity of the Ministry of Natural Resources and Environment, in particular Water Resources Division, PUMA, Meteorology Division and DMO and other relevant agencies to provide consistency in flood risk management
- Incorporate flood risk management in the national planning and budgetary processes

[1] 2005-2007 Strategy for Development of Samoa

- Update the Action Plan regularly and employ adaptive management strategies in order to take full advantage of scientific and technological advances, and to use the best available floodplain management practices, principles and information

1.3. Guiding Principles

The guiding principles are based on integrated watershed management approach and technical understanding of the characteristics of floodplain in Samoa. They serve as a reference point for the evaluation of flood risks, identifying the range of management alternatives and developing appropriate actions.

The key guiding principles include:

- Flooding is a development issue
- Flood management requires a whole of government/country approach, involving partnership between and amongst government agencies, donors, communities/land owners and the private sector
- Adopting a programmatic and integrated approach covering all aspects of Flood Management from risk reduction[2] to preparedness, response and recovery
- Flooding is a natural process

Flooding is a natural process that provides many benefits, but severe floods also have disastrous impacts on people, livelihoods, infrastructure and ecosystems. Flooding poses a risk when people and property occupy areas that are subject to inundation, bank erosion or channel migration. Risk can most effectively be reduced through comprehensive and integrated flood management actions that employ both structural and non-structural approaches to create a safe, effective and sustainable means for conveying floodwaters and that are consistent with other uses that rely on natural river processes.

- Flood damage creates financial costs for both the public and private sectors. Effective flood management can reduce long-term damage costs
- Actions in the upland portions of watersheds impacts flooding and channel migration within the river corridor

Factors that lead to flooding begin upland of the rivers and streams. The conversion of forested land to grass or impervious surface increases the speed and quantity of stormwater runoff. In addition, forest loss and grading that changes the natural topography of the landscape can alter the location at which water leaves a site. Flood (stormwater) design standards should be applied to upland development to minimise flood impacts at lower elevations.

- Good governance, policy context and legislative backing clarifying roles and accountabilities for flood management activities recognising interconnectivity and interactions between and amongst government agencies, sectors, and communities

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[2] This includes prevention, mitigation and adaptation

1.4. Frameworks that Encompass the FMAP

1.4.1. The Regional Context

Samoa and other Pacific Leaders acknowledges the vulnerability of the Pacific to disaster, and the need for a shift towards treating disaster as a development issue to an integrated approach on disaster risk management. The following regional frameworks endorsed this shift in focus:

- 2005 the regional Disaster Risk Reduction and Disaster Management (DRR & DM) Framework for Action, 2006-2015 which mirrors the *Hyogo Framework for Action 2005-2015: Building the Resilience of Nations and Communities to Disasters,* and which draws on the guidance set by the Yokohama Strategy for a Safer World (1994) and the International Strategy for Disaster Reduction (ISDR)[3].
- UN Framework on Climate Change Convention (UNFCCC)
- The Forum Economic Ministers and the Forum Leaders have also acknowledged disaster as a development issue in 2003.

The Kalibobo Road Map produced by the Forum Leaders Meeting in 2005, also called for the operationalisation of these regional frameworks at the national level. In addition, member countries will strengthen national capacity on preventative measures, as well as effective and timely post disaster response and rehabilitation.

1.4.2. The National Context

This Action Plan is in line with the Samoa Disaster Risk Management National Action Plan and links to other relevant key sector plans, national development plans and budgetary process must be articulated. This Plan also compliments sections 2.1.1.8 and 2.1.1.9 of the existing Samoa's National Action Plan for combating desertification by providing the flood management issues that was lacking in the sustainable land management NAP.

Figure 1-2 illustrates the linkages between this Action Plan and National Development Plans and budgetary process, Disaster and Sector Plans and the need to incorporate the FMAP into key agencies corporate/business plans.

[3] ISDR, when mentioned alone, refers to the Strategy. References to the system, the secretariat and platforms are specifically indicated.

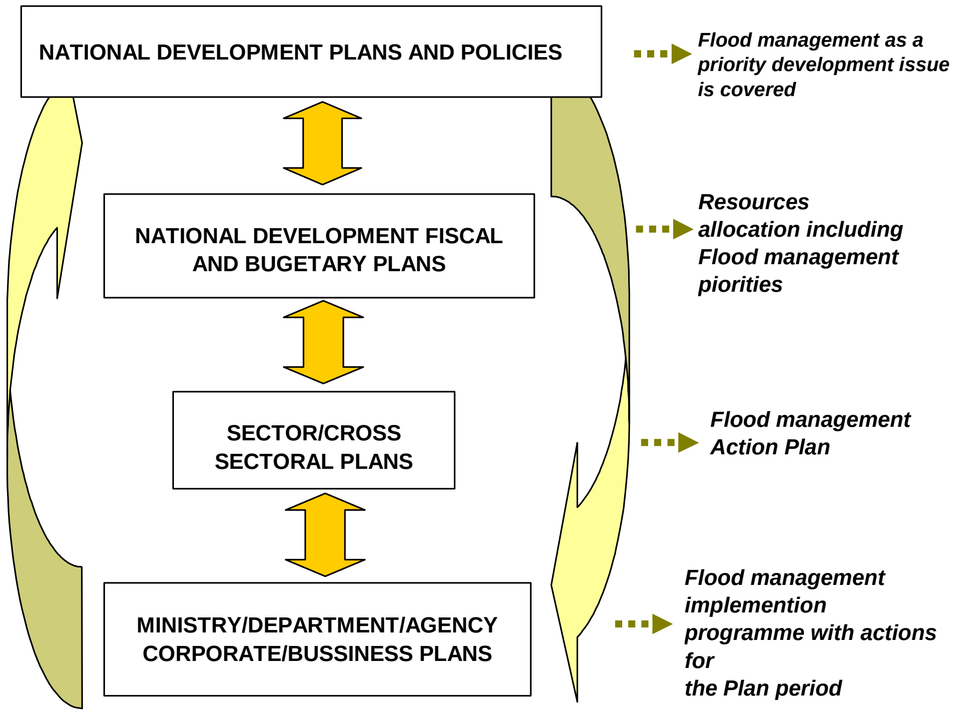


Figure 1-2: Links between National Development Planning, Budgetary Process and Flood Management

1.4.3. Issues to be addressed

The key issues identified during various consultations, and in past assessment, reports on disaster and flood risk management are:

- Flooding is a severe and frequent risk to major parts of Apia
- Traditional Focus on Response and recovery from disasters
    - Lack of appropriate incentives
    - Short term costs versus long-term payoff
    - Relying on assistance at times of disaster (dependency)
- Lack of town planning in Apia - many commercial and residential properties are developed on floodplain
- Relevant government policy, organisational structures and legislative framework reflecting connectivity and linkages in flood risk management are still evolving such as the recent restructure this year (2006) of the MNRE to include PUMA, Forestry, and Meteorology.
- Inadequate coordination and integrated planning among agencies that have some responsibilities for flood risk reduction.
- Insufficient human resources and capacity (both in the number of staff and in the skill required) to sustain the effectiveness of the Plan
- Constraints in budgetary allocation to mitigation activities
- Weak monitoring and early warnings to communities at risk
- Hydro-meteorological data is sparse with a high degree of uncertainty (lack of, or inadequate, quality information)

1.4.4. Existing Policies and Legislation that Provide for Flood Management

Although, existing policy or legislation do not explicitly addresses flood management as the sole responsibility of a single agency; the following if integrated could assist in flood management:

- Planning and Urban Management Act 2004
- EIA regulations 1998
- Watershed Protection and Management Regulations 1991
- Disaster and Emergency Management Act 2006
- Code of Environmental Practice 2001
- Draft Housing Guidelines 2003
- Draft Building Regulations 1992
- National Building Code
- Water Act 1965

1.4.5. Linkages with other National Projects

Four relevant national projects are currently implementing in Samoa. These are:

- The Asian Development Bank (ADB) funded project entitled “Samoa Sanitation and Drainage Project (SSDP)”;
- The ADB Technical Assistance (TA) project “Institutional Strengthening for Drainage and Wastewater Management” (4229-SAM);
- The EU funded Water Sector Support Programme (WaSSP).
- The World Bank funded Samoa Integrated Asset Management Project (SIAM)

Efforts were made by the SOPAC project as well as these three other projects to ensure complementarities and synergies through consultation and meetings. The Apia sanitation and drainage project address flooding in specific low-lying areas of Apia. Outputs from the drainage phase of the project will include:

- Improvement to floodways;
- Rehabilitation of existing drains;
- Installation of water gauges to for flood monitoring.

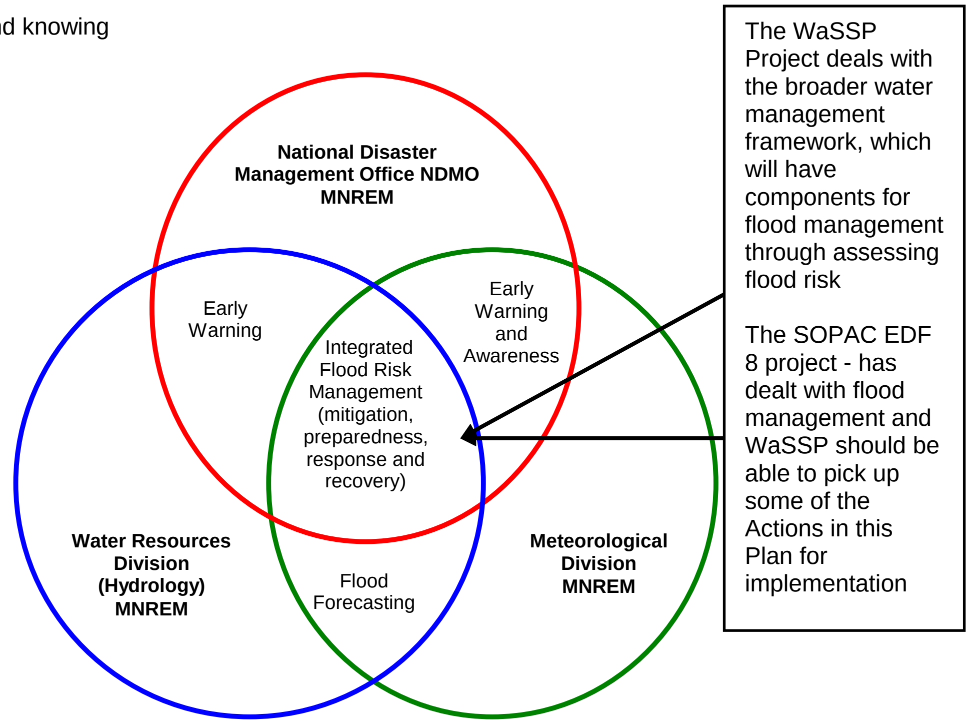
The ADB TA on institutional strengthening for drainage and wastewater management provides technical assistance in terms of capacity building to key agencies involved including the SWA, MWTI and MNRE

The purpose of the EU funded Water Sector Support Programme (WaSSP) is to accelerate achievement of water sector policy goals and objectives and more specifically to improve the quality of public health through improved water services and the sustainable management of water resources. Expected outcomes of this project are as follows:

- Establish an effective and skilled Water Resources Division;
- Develop a Water Resources Management Strategy;
- Environmentally sensitive development of water resources;
- Improved conservation and protection of water catchment areas and water resources;
- Improved assessment and monitoring of water resources.

Figure 1-3 shows the links between donor funded projects and responsibilities of government agencies in various aspects of flood management in Samoa.
Step 1.

Identifying and knowing Flood risk



Step two:

Users of flood risk information – infrastructure designs and development process

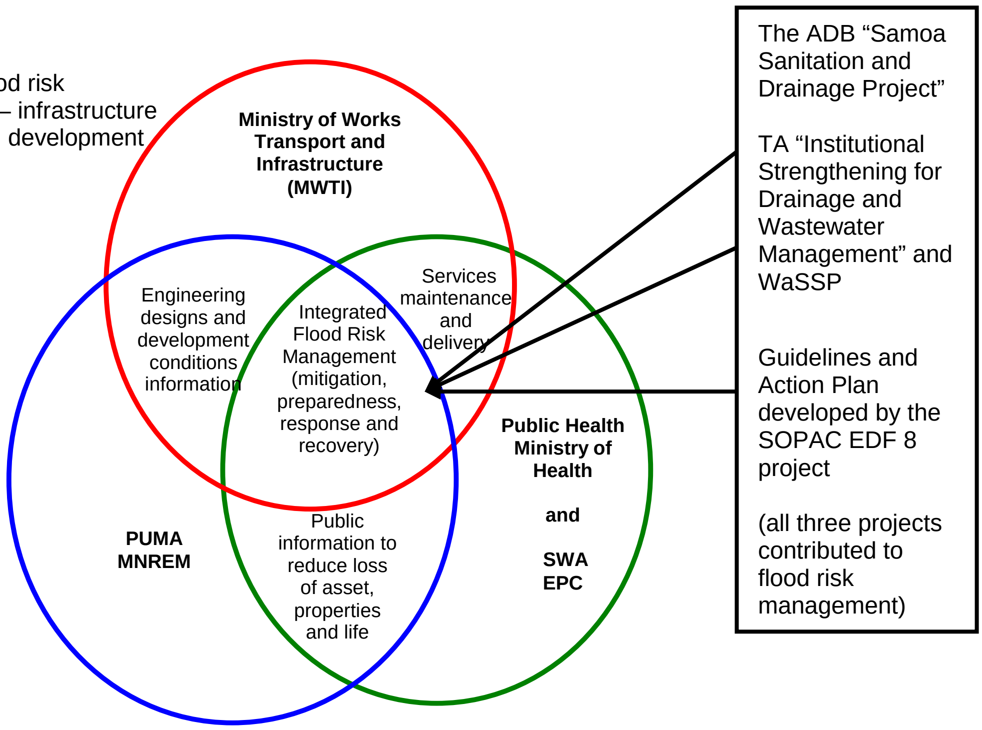


Figure 1-3: The responsibilities of key sectors for flood risk management are crosscutting with particular functions identified in the FMAP

1.5. Implementation Strategy

The Plan has identified key strategies and actions to improve flood mitigation, flood forecasting and flood warning; and provide for effective emergency management of floods.

The implementation of the Plan requires commitments from the Government of Samoa and support from key sectors at the national levels. Active involvement of communities and private sector stakeholders in the process and in taking action to reduce their vulnerabilities is also essential to the successful implementation of the Plan. A detailed implementation plan will be developed subsequent to the formal endorsement of the Plan.

1.5.1. Implementing Agencies

Key ministries involved in flood risk management are the MNRE, MWTI and the MAF. Lack of coordination and collaboration among these three ministries and among the divisions within a ministry need to be addressed to maximise the use of resources and skills available either nationally or through donor funded projects.

The Disaster Advisory Committee has the overall responsibility to coordinate preparedness measures for any hazard. Currently, it seems that the Meteorology is responsible for forecasting flood and giving flood warning to three bodies, the media, Disaster Management Office and Disaster Advisory Committee (NDMP 2006). It is not clear however, on who is responsible for the level of flood warning given to the public.

The responsibility for the collection and management of hydrological data lies with the Water Resources Division, MNRE. Although the Division does not undertake and implement flood management programmes there is a regular flow gauging on Vaisigano river at Alaoa East station. In addition the Hydrology Section carryout fortnightly flow gauging at two operating weir stations, spot flow gauging at selected sites as requested by SWA; and data analysis and estimation of flow. There is presently no overall strategy in place for the systematic and prioritised collection, storage and analysis of water resources and watershed data, for its use in water resources and watershed management decision making.

1.5.2. Coordinated In-country Implementation, Monitoring and Evaluation Programme

The following are required for a co-ordinated in country implementation, monitoring and evaluation programme.

- Development of a detailed implementation plan for each of the Actions of the FMAP identifying the responsible agency, completion time, and resources requirements.
- Incorporating the relevant implementation programme into each ministerial and sectoral corporate/bussiness plans for implementation.
- Identifying capacity development needs of government agencies, private sector, NGOs and communities for the implementation of the FRMAP.
- Undertaking annual review of progress against the Plan and its effectiveness and adjust as necessary involving in-country participants and Samoa's Development

Partners.

- MNRE is committed to lead and coordinate the implementation of the plan

Annex 1 summarises the process undertaken to develop the FRMAP, Annex 2 contains definitions key words and concepts used in this Plan, Annex 3 is the list of workshop participants for the development of the guideline and Action Plan and Annex 4 is a Consolidation of existing statutory and non-statutory flood risk activities in Samoa.

2. Background to flood management in the Vaisigano River catchment and Apia

2.1. Introduction

The Vaisigano River catchment drains an area of approximately 34 km^2. The length of the main river is approximately 12.5 km and the catchment is 5 km wide at its widest section. The Vaisigano River flows north, bisecting the capital city of Apia where it discharges into the sea. The gradient of its lower reaches means that it is tidal for a maximum of approximately 500 m upstream from the river mouth. The tidal range at the mouth of the river typical varies between from about to 0.6 m to 1.0 m above mean sea level to 0.25 m to 1.5 m above mean sea level. The Vaisigano River is one of the main sources of water supply for Apia. The river also feeds two hydropower stations that supply most of Apia’s electricity.

Detailed historical data on the frequency and extent of flooding is limited. A recent SOPAC study records a long history of flooding in Apia (Yeo 2001). Severe floods were reported in 1939, 1974, 1975, 1982, 1990, 1991 and 2001. More recently flooding of Apia occurred in February 2006, which was the result of surface water ponding and poor drainage rather than fluvial flooding from the Vaisigano River. The 2001 flood was particularly severe, with estimated 1,300 buildings damaged exceeding Samoan Tala 11 million of direct damage.

There appears to have been much speculation that tidal levels have a significant effect on peak flood water levels in the lower Vaisigano River. The highest recorded tide level in Apia Harbour in the past 12 years was approximately 1.67 m above mean sea level. Owing to the size of the peak flow at the downstream end of the Vaisigano River the tidal water level has no impact on upstream flood water levels even for a 1 in 2 year flood event.

2.2. Hydrological monitoring in the Vaisigano River catchment

This section gives a brief overview of the hydrological monitoring that is carried out in the Vaisigano catchment. It should be noted that there is requirement for long-term, sustainable investment not only in improving and maintaining the hydro-meteorological network but also in increasing the capacity of Water Resources and Meteorology Divisions not only in data collection, but in also in archiving and backing up precious past records and providing a degree of quality control over the data collected.

2.2.1. Rainfall stations

There are a number of rainfall stations in or adjacent to the Vaisigano River catchment. These are listed in Table 2-1.

Table 2-1: Rainfall gauges in the Vaisigano catchment

Station	Elevation (m above mean sea level)	Period of record
Afiamulu	720	1903-07, 1947-
Alaoa Pond	260	1958-
Apia	2	1890-
Moamoa	100	1906-1908, 1913-1914, 1962-
Nafanua	150	1965-

Owing to the size of the Vaisigano catchment and the intensity of the rainfall in Samoa rainfall intensity data is required to generate flood hydrographs using rainfall – runoff models. An analysis of daily rainfall is not particularly useful when it comes to flood modelling for the Vaisigano. Of the above rainfall stations only two, Apia and Afiamulu record rainfall intensity.

2.2.2. Flow monitoring stations

The Alaoa East gauging station is the only functioning gauging station in the Vaisigano catchment. For details of other, now defunct gauging stations, Reference ** should be referred to. At Alaoa East water levels are recorded continuously via a chart and pen recorder linked to a stilling well upstream of the abandoned water supply intake which comprises a broad crested weir which is silted up. It has been estimated that a catchment area of approximately 17.3 km^2 drains to this gauge.

Flow gauging is undertaken regularly at Alaoa East. However, although the station is unlikely to be by-passed at high flows, the stage versus discharge curve at the site (i.e. the relationship between water level and discharge) is questionable, especially for estimating flood flows. The station has approximately 22 years of flow data available.

2.3. Elements at risk of flooding in the lower Vaisigano floodplain

There are numerous elements at risk in the lower Vaisigano floodplain. Using the flood extent maps produced as part of this action plan, the affected number of people and buildings could be identified as shown in Table 2.2.

Table 2-2: Number of people and buildings at risk in the lower Vaisigano floodplain

Return period (years)	Number of people at risk	Number of buildings at risk
1 in 2	1139	244
1 in 5	1382	296
1 in 20	1536	329
1 in 50	1596	342
1 in 100	1634	350

The hydraulic modelling of the lower reach of the Vaisigano River has indicated that during rare flood events it is possible that Lelata, Leone and the Vaisigano Bridge will overtop causing them damage. The amount of damage that these structures would incur is difficult to quantify.

2.4. Previous flood risk management studies and measures

There have been limited studies into flooding of Apia and Vaisigano River catchment. The most relevant recent studies include:

- Flood study of the occurrence 15 to 16 April 2001 flooding areas of the Apia township by Apia Management Services carried out in 2001.
- A review of flooding in Apia, Samoa, April 2001 by Dr Yeo produced for the South Pacific Applied Geoscience Commission (SOPAC) in July 2001.
- A report by Kammer for the Samoan Hydrological Services produced in 1975 on the storm and floods of 16 to 18 November 1974 in Western Samoa.

In terms of controlling development in flood prone areas, in September 2006, the Planning and Urban Management Agency (PUMA) of the MNRE produced a document entitled “Draft guidelines for the development of land adjoining rivers, streams and on flood prone land and priority actions for mitigating drainage impacts in the catchments of urban Apia”. These state the following:

Development within flood prone land shall be designed to minimise the impact of the passage of water through drainage channels and floodways. In assessing a development application, PUMA shall take into account:

- *Whether or not the development will adversely affect flood behavior resulting in detrimental increases in the flood prone land, or on adjoining development or properties outside the flood prone lands.*
- *Whether or not the development will alter local flow distributions and velocities to the detriment of other properties or the environment in the flood prone lands.*
- *Whether the development will enable safe occupation of the flood prone lands.*
- *Whether or not the development will detrimentally affect the role of rivers and streams as a floodway including avoidable erosion, siltation, destruction of vegetation or a reduction in the stability of the banks of the rivers and streams.*
- *Whether or not the development is compatible with the function of the affected rivers or streams including drainage channels and floodways.*

In the case of development involving the excavation or filing of land, whether or not the development:

- *Will detrimentally affect the existing drainage patterns and soil stability in the local area.*
- *Will significantly impact on the likely future use or redevelopment of the land*
- *Will adversely impact on the existing and likely amenity of adjoining properties.*

Will adversely affect any river or stream or environmentally sensitive areas including mangroves.

- *Habitable floors rooms in any development (including septic tanks) are to have floor levels of 300 mm above the estimated flood level resulting from a 1 in a 100 year flood.*

- *For works considered as significant by PUMA, a drainage and stormwater plan including drainage plans for physical works shall be prepared by a qualified person (that is, a person who is a member of the Samoan Institute of Engineers), such drainage and stormwater assessment plan to include at a minimum:*

- *An existing flood assessment (including existing flood levels and existing drainage), and*
- *A future flood assessment (including future flood levels, future drainage system and design and mitigation options to minimise impacts).*

The onsite drainage system shall be designed to ensure that downstream flows are restricted to pre development levels unless otherwise approved by the responsible authority."

There as been little in the way of mitigation measures implemented in the lower Vaisigano River catchment. The only structural measures of note are a flood wall between one and two metres high constructed to protect Aggie Greys hotel, shown in Figure 2-1, and a flood wall built on a tributary of the Vaisigano built to protect a commercial development. This is shown in Figure 2-2.

Figure 2-1: Flood wall at Aggie Greys Hotel at the mouth of the Vaisigano

Figure 2-2: Flood wall and bank protection for commercial property on a tributary of the Vaisigano River

3. Flood mitigation measures

3.1. Introduction

There is a wide range of possible measures for managing floods. These cover such items as structural measures which generally involve some type of construction (for example, flood defence embankments and walls) and non-structural measures such as flood warning, land use planning, development control and building control.

This chapter details the various floodplain mitigation measures considered, in particular for the lower Vaisigano River catchment including their advantages and potential disadvantages. The actions required to investigate the various mitigation measures in more detail are also outlined.

Structural measures considered include:

- Flood walls and embankments.
- Upstream flood storage.
- The use of a by-pass channel.
- Increasing the channel conveyance.
- Improving the channel maintenance.
- Pumping.
- Flood proofing of new and existing buildings and other assets.

Non-structural measures considered include:

- Development control, which includes the avoidance of developments on floodplains or the protection of new developments.
- Flood forecasting and warning.
- Floodplain zoning, to link land use with the flooding function of different parts of the floodplain.
- Flood insurance.
- Raising the awareness of flood risk and preparedness of individuals and organisations to respond to a flood emergency. This includes the floodplain population, floodplain managers and the emergency services.
- Land use change.

A preliminary assessment of a number of these measures has been made for the Vaisigano River catchment using the results of the HEC-HMS hydrological model and a one dimensional HEC-RAS hydraulic model.

Mainly due to a lack of data, the various measures have been described in isolation. However, a fundamental principle of effective flood management is that management measures should not be considered in isolation. Rather, they need to be considered collectively on a integrated risk management basis in order to provide the best combination of measures for managing flood risk on floodplains taking account of the following:

- Their interactions.
- Their suitability and effectiveness.
- Economic effectiveness.
- Social impacts.
- Environmental impacts.

A hydrological and a one dimensional hydraulic model of the Vaisigano River has been set up using the HEC-HMS and HEC-RAS software produced by the US Army Corps of Engineers.

The hydrological model has been used to assess the following:

- o Flood flow hydrograph shapes.
- o Estimate peak flood flows.
- o The time it takes water to travel from the upper part of the catchment to the lower part.

The hydraulic model covers the lower Vaisigano River from the Vaisigano Bridge at Beach Road to just upstream of Lelata Bridge a distance of approximately 2 km. The model was based on 32 surveyed cross-sections. Further details of the hydrological and hydraulic model consult the EU EDF 8 – SOPAC Project Report No : ER0069a

It is important to recognise that there is a vary high degree of uncertainty in carrying out hydrological estimates in Samoa, not just for flood management, but also for water quality assessments, water resources management, sanitation and water supply projects.

The work carried out by SOPAC/EU project in July 2006 indicated that the 1 in 100 year flood flow for the Vaisigano River at Apia is likely to be between 400 m^3/s and 600 m^3/s. For consistency the flood flows that have been used to asses the various structural flood mitigation options are those produced by Kellogg, Brown and Root for the Asian Development Bank Technical Assistance (TA) project 4229-SAM: Institutional Strengthening for Drainage and Wastewater Management which is being implemented by the Planning and Urban Management Authority (PUMA).

The design flood flows adopted for this plan for the lower Vaisigano River at Apia are detailed in Table 3-1.

Table 3-1: Design flood flows for the Lower Vaisigano at Apia

Return period (years)	Annual probability of occurrence (%)	Design flood flows for the lower Vaisigano River at Apia (m^3/s)
1 in 2	50	174
1 in 5	20	283
1 in 20	5	418
1 in 50	2	470
1 in 100	1	550

Note: There is a high degree of uncertainty in these flood flow estimates

3.2. Structural mitigation measures

This section details a range of structural mitigation options and the actions that are required to take these forward. Before many of these structural mitigation options can be prioritised it is important to:

(i) Improve the quality of data (e.g. hydrological, topographical).
(ii) Assess the cost and benefits for each of the options.

3.2.1. Flood embankments and walls

Flood embankments and walls can provide an effective way to protect existing development in flood-prone areas. The height or crest level of the flood walls or embankment is determined by factors that include:

- Flood levels.
- Required standard of protection.
- Economics. This is defined by the way in which the project is appraised, for example this is usually carried out via a cost-benefit analysis.
- Physical limitations of the site. Flood walls are normally used in restricted locations.

The difference between a flood wall and a flood embankment is shown in Figure 2-2 and Figure 3-1

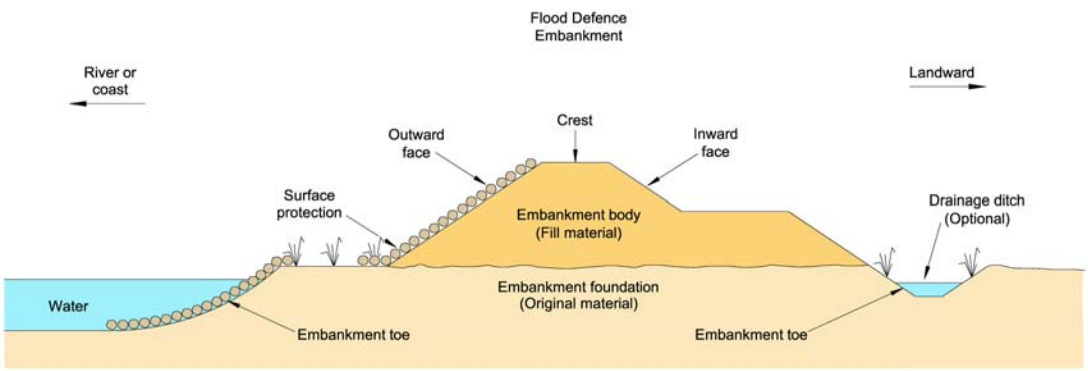


Figure 3-1: Example of a cross-section through a typical flood defence embankment

There is a risk that embankments and walls may fail, and there is an ongoing need for maintenance and repair. In addition, embankments and walls will be overtopped during events exceeding their design standard.

Using the hydraulic model for the Lower Vaisigano River an initial estimate of the height of a flood embankment/wall for various return period floods in the downstream reach of the lower Vaisigano has been considered. The construction of flood embankments/walls has been considered in the reach between the Leone and Vaisigano (Beach Road) Bridges, a reach of approximately 900 m. This is because this reach of the Vaisigano River has the highest number of elements at risk in terms of people and properties. The proposed location of the flood embankments is shown in Figure 3-2.

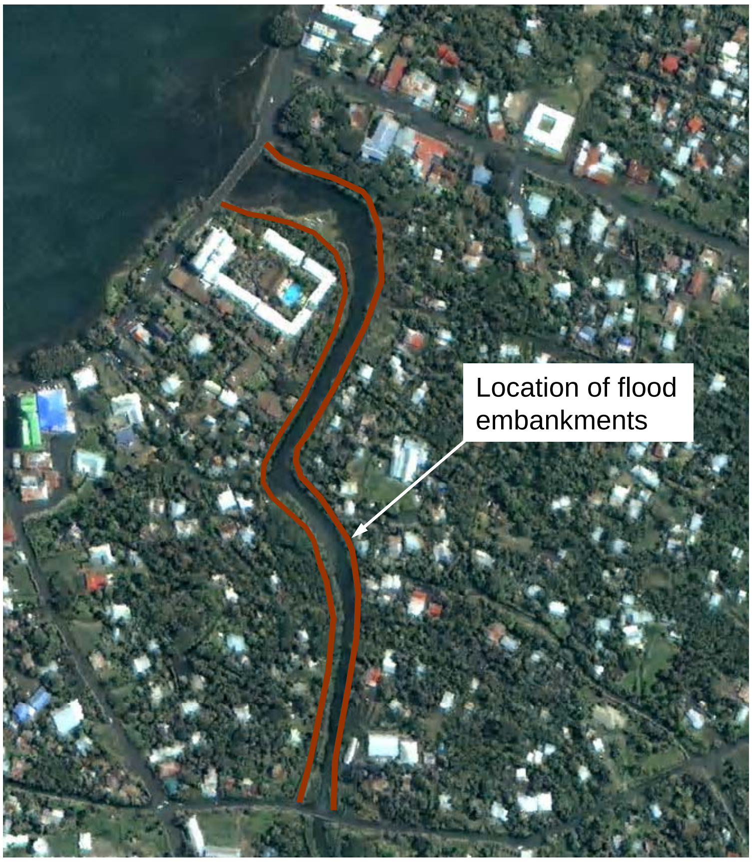


Figure 3-2: Location of flood embankments for the lower Vaisigano River downstream of Leone Bridge

The height of the flood embankment has been estimated using the steady state HEC-RAS hydraulic model of the lower Vaisigano River. It should be noted that the height of the embankment/flood wall will vary depending on the height of the left and right bank of the river. Table 3-2 provides details of the average height of the flood embankment/walls and the maximum height of the flood wall for the left and the right banks of the river.

Table 3-2 does not contain any allowance for "freeboard". Freeboard is the height above a defined flood level typically used to provide "a factor of safety" for setting embankment crest levels. This "factor of safety" is used to take account of uncertainties in the hydrological and hydraulic calculations and other factors such as settlement. To protect the lower portion of the catchment against the 1 in 100 year flood the average height of the left bank and right bank embankments would have to be 3.24 m and 2.81 m respectively.

Table 3-2: Summary of embankment/wall heights

Return period (years)	Average height of the embankment (m)		Maximum height of embankment (m)	
	Left bank	**Right bank**	**Left bank**	**Right bank**
1 in 2	0.96	0.61	1.72	1.37
1 in 5	1.72	1.35	2.60	2.18
1 in 20	2.54	2.13	3.51	2.97
1 in 50	2.83	2.40	3.82	3.23
1 in 100	3.24	2.81	4.29	3.62

Note: There is no allowance for freeboard in these figures

Table 3-3 provides an initial estimate of the amount of material required to construct the flood embankments has been made. It has been assumed that the crest width of the embankments would be 2 m and that they would have 1 in 2 side slopes. A cross-section through the embankments is shown in Figure 3-3. To construct flood embankments to protect the lower reaches of the Vaisigano floodplain against the 1 in 100-year flood approximately 26,400 m^3 of material would be required. This volume of fill does not take into account any allowance for freeboard.

Table 3-3: Summary of the preliminary volume of fill material required for the flood embankments in the lower Vaisigano River

Return period (years)	Amount of fill material required (m^3)		
	Left bank	**Right bank**	**Total**
1 in 2	2,650	1,500	4,150
1 in 5	5,800	4,050	9,850
1 in 20	10,150	7,750	17,900
1 in 50	11,900	9,250	21,150
1 in 100	14,700	11,700	26,400

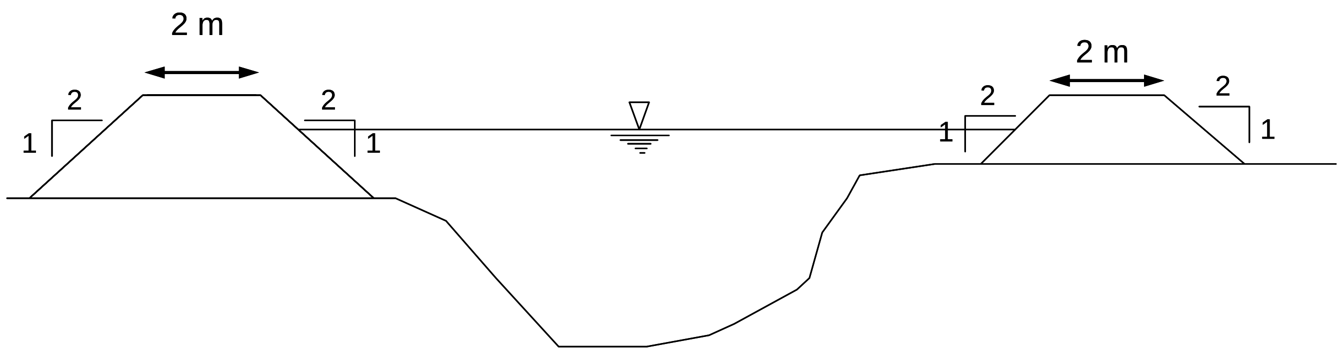


Figure 3-3: Cross-section through the flood embankments for the Lower Vaisigano downstream of Leone Bridge

Table 3-4 provides an estimate of the number of buildings and people that could be protected by the construction of an embankment or wall between Leone and the Vaisigano Bridges.

Table 3-4: Number of people and properties protected by building an embankment or wall between the Leone and Vaisigano Bridges

Return period (years)	Number of people protected	Number of buildings protected
1 in 2	1125	241
1 in 5	1270	272
1 in 20	1330	285
1 in 50	1330	285
1 in 100	1363	292

Recommended Actions:
To further investigate the feasibility of flood embankments/walls as a flood mitigation option it is recommended that the following actions should be carried out:

- Improve the accuracy of the topographic and hydrological data available for the lower Vaisigano River and its floodplain in order to reduce the uncertainty in the design flood levels.
- Establish the availability of material to construct such an embankment/wall and also the need for a "cut-off" to prevent seepage underneath the protection.
- Make a preliminary assessment of the costs of constructing and maintaining flood walls/embankments.
- Quantify the economic benefits that are derived by building a flood embankment/wall for a number of return periods.
- Establish if the bridge across the Vaisigano River at Beach Road would have to be modified to allow flood flows to pass under it without any damage occurring.
- Assess land ownership issues in the Lower Vaisigano and establish whether there is sufficient space to construct a flood wall/embankment along the banks of the river.
- Make an assessment of the local runoff that may collect behind the flood walls/embankments. This needs to be taken into account. Pumps may be required to remove this water during a flood event. If these pumps fail then local flooding behind the flood walls embankments may still occur in the protected area.
- Establish the views of the local communities along the length of the river.
- Make a preliminary assessment of the environmental impacts including the visual impacts of constructing this option.

3.2.2. Flood storage

A flood storage basin is an artificial reservoir specifically designed for the temporary storage of excess floodwater, thus limiting the flow that passes downstream. Floodwater is released gradually after the flood has passed. A flood storage reservoir requires controls to limit the amount of water passing downstream. Flood storage basins may be classified as "on-line", where the river channel passes through the storage area, and "off-line", where the river channel bypasses the storage area.

In the Vaisigano River catchment the amount of space in the floodplain for off-line storage is very limited owing to the topography and nature of the river's floodplain. However, there is a possibility of providing on-line storage in the upstream part of the catchment. The approximate location for the storage is shown in Figure 3-4. The provision of on-line flood storage would require the construction of an embankment dam. A typical section through an earth embankment dam is shown in Figure 3-5. Using the flood flow hydrographs developed for the Lower Vaisigano River a preliminary estimate of the minimum storage volume required for such a structure have been made.

Using the one-dimensional hydraulic model of the Vaisigano River the bankfull capacity of the lower reaches of the Vaisigano River has been estimated to be approximately 100 m^3/s. The bankfull capacity of river is the flow that it can carry without the water level exceeding the levels of the bank. Hence in order to reduce fluvial flooding from the Vaisigano in Apia the on-line storage should be sized such that the peak of the flood flow hydrograph is attenuated to 100 m^3/s. The minimum storage volumes required to attenuate a three hour duration hydrograph to 100 m^3/s for different return periods is given in Table 3-5. The assumptions made in these calculations are shown illustratively in Figure 3-6.

Table 3-5: Preliminary storage volumes and heights required for an on-line storage dams for flood storage[4]

Return period (years)	Volume of flood storage (million m^3)	Indicative height of a flood storage dam (m)
1 in 2	0.4	18
1 in 5	1.2	26
1 in 20	2.3	32
1 in 50	2.8	35
1 in 100	3.4	37

An initial estimate has been made of the minimum height of the dam required. It should be noted that there was insufficient topographic data available in the upper catchment to estimate the dam height accurately. The dam heights for the various return periods have been assessed from a simple geometric relationship between reservoir volume and river slope. As a consequence the heights in Table 3-5 are very preliminary and have a high degree of uncertainty attached to them.

For this option to be cost effective it is likely that the flood storage reservoir would have to fulfil a number of purposes. For example it could also be used as a source of water supply and hydropower. It is important to note that the figures provided in Table 3-5 are only indicative and only include the volume required from a flood storage point of view. Should a multipurpose reservoir be considered, the volume of storage required would need to be increased to cater for these other functions. The number of people and properties that would be protected by the construction of an earth embankment dam is given in Table 3-6.

[4] Note: These values are preliminary. They are based on a three hour duration hydrograph and that the bankfull flow of the lower Vaisigano River is approximately 100 m^3/s. There was no detailed topographic data available in this area.

Table 3-6: Number of people and properties protected by building an embankment dam in the upstream reaches of the catchment[5]

Return period (years)	Number of people protected	Number of buildings protected
1 in 2	1139	244
1 in 5	1382	296
1 in 20	1536	329
1 in 50	1596	342
1 in 100	1634	350

The following should be noted with respect to this option:

- A flood storage reservoir would require a substantial area of land to achieve the necessary storage. However, the area where the storage reservoir is located is not densely populated and is understood to be a Government reserve
- Long duration or multi-peak storms, where the reservoir is partly or completely filled from a previous flood peak, can reduce the effectiveness of this mitigation option. Once the reservoir is full, attenuation of the flood discharge is small.
- When the reservoir is full, overtopping will occur and if the storage dam is not designed correctly there is a risk of breaching and this resulting in significant downstream hazard.
- The flood storage basins may trap sediment, and require regular maintenance for sediment removal. There may also be adverse impacts downstream associated with this loss of sediment.

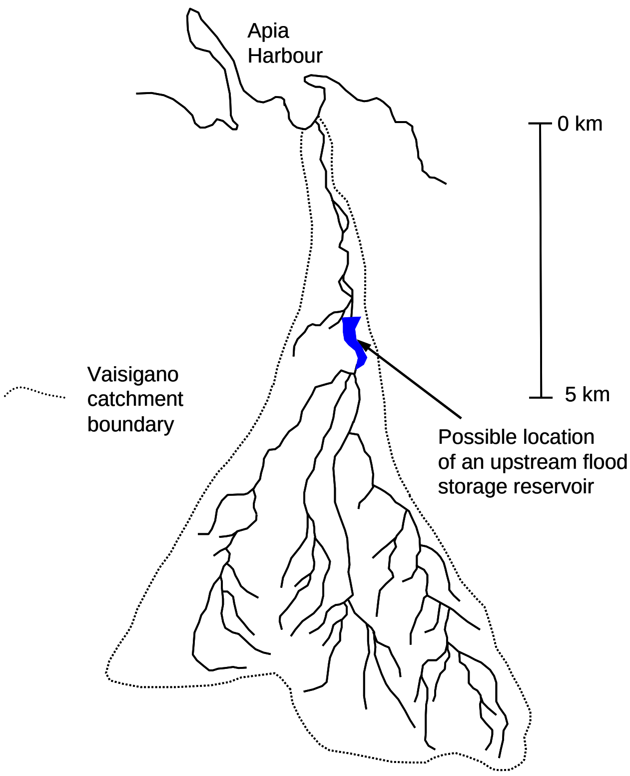


Figure 3-4: Indicative location for upstream flood storage

[5] Note: These numbers are an underestimate of the total number of people and property protected because it does not take account of the elements at risk upstream of Lelata Bridge. This is because there is no flood hazard mapping available for the catchment upstream of this point.

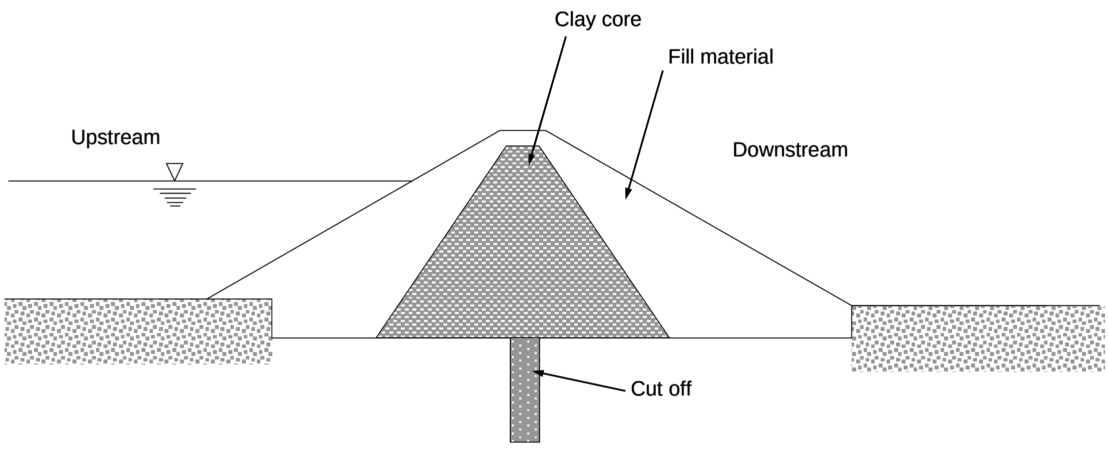


Figure 3-5: Cross-section through a typical earth embankment dam

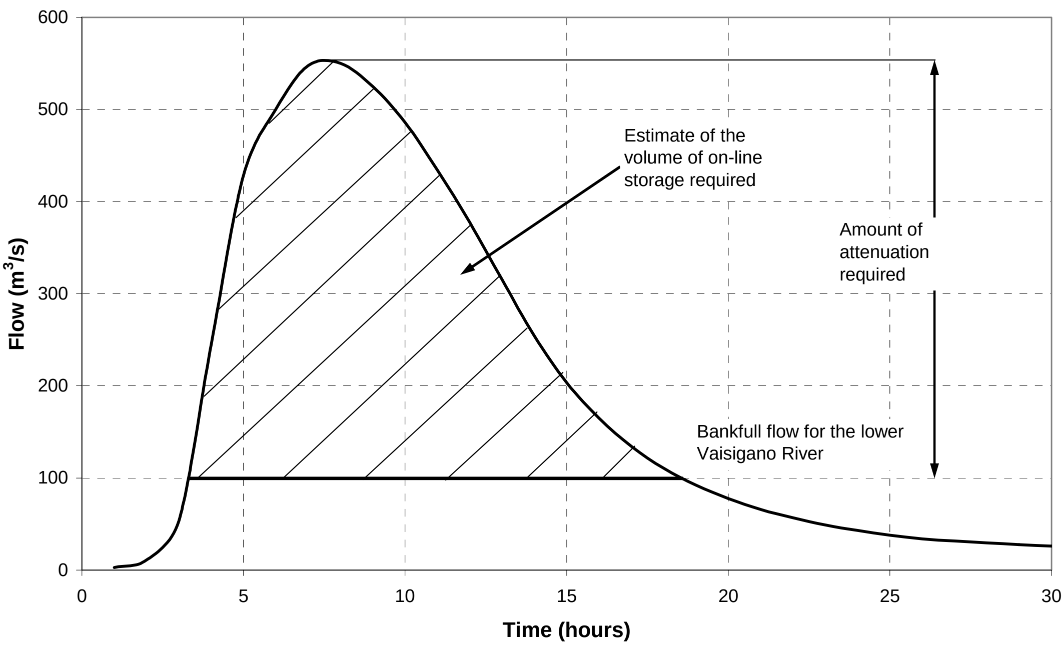


Figure 3-6: Illustration of the estimation of flood storage for the 1 in 100 year flood hydrograph

Recommended actions:

To further investigate the feasibility of constructing an on-line flood mitigation options it is recommended that the following actions should be carried out:

- Improve the accuracy of the topographic and hydrological data available for the lower Vaisigano River and also in the area where the on-line flood storage could be constructed. This is the key to establishing the volume of the flood storage reservoir and the height of the dam required.
- Assess the probable maximum flood for the flood storage reservoir and produce an estimate of the required spillway capacity.

- Estimate the volume of the fill required to construct an embankment dam.
- Make a preliminary assessment of the costs of constructing and maintaining flood storage.
- Quantify the economic benefits that are derived by constructing a storage dam for a number of return periods.
- Assess land ownership issues in the area where the reservoir would be constructed.
- Make a preliminary assessment of the environmental impacts including the visual impacts of constructing this option
- A preliminary assessment of the effect of a dam breach on the population living downstream of the storage should be made.

3.2.3. By-pass or diversion channel

Bypass or diversion channels redirect a portion of flood flow away from areas at risk, and reduce flood levels along the channel downstream of the diversion off take. Opportunities for the construction of diversion channels are often limited by the topography of the area, ecological considerations and the availability of land. A possible route for a flood diversion channel is shown in Figure 3-7. The off take for the diversion channel would be located in the vicinity of Lelata Bridge. The channel would run in a north-easterly direction before joining an existing river channel to the south of the Apia Park sports stadium. The length of the channel would be between 1.5 km and 2 km depending on the route that was taken. The construction of such a channel would entail the construction of one new road crossing and the increase in capacity of another crossing on the main road to the east of the Apia Park sports stadium.

A very preliminary estimate of the size of the channel has been made using the HEC-RAS modelling software. It has been assumed that the channel would be trapezoidal in shape with a bed width of 30 m and 1 in 2 side slopes. The bankfull capacity of the Vaisigano River has been estimated to be some 100 m^3/s. It has been assumed that all flows greater than this are diverted into the bypass channel. A cross-section for the assumed by-pass channel is shown in Figure 3-8. Table 3-7 provides details of the channels dimensions for a number of design period flood flows. It should be noted in the low lying area to the west of Apia Park stadium there may need to be flood defence embankments along the side of the channel to avoid the water spilling out of the channel and exacerbating flooding in this area.

Recommended actions:
To further investigate the feasibility of constructing an on-line flood mitigation options it is recommended that the following actions should be carried out:

- Improve the accuracy of the topographic and hydrological data available for the lower Vaisigano River and for the route of the diversion channel. This is the key to establishing the route of the channel and the amount of material that would to be removed.
- Assess the nature of the off take structure for the channel (e.g. gate, side spill weir).
- Estimate volume of material that would need to be dredged from the existing drainage channel that the by-pass channel would join.
- Make a preliminary assessment of the costs of constructing and maintaining the diversion channel.
- Quantify the economic benefits that are derived by constructing a diversion channel for a number of return periods.
- Assess land ownership issues in the area where the reservoir would be

constructed.

o Make a preliminary assessment of the environmental impacts including the visual impacts and health and safety of constructing this option.

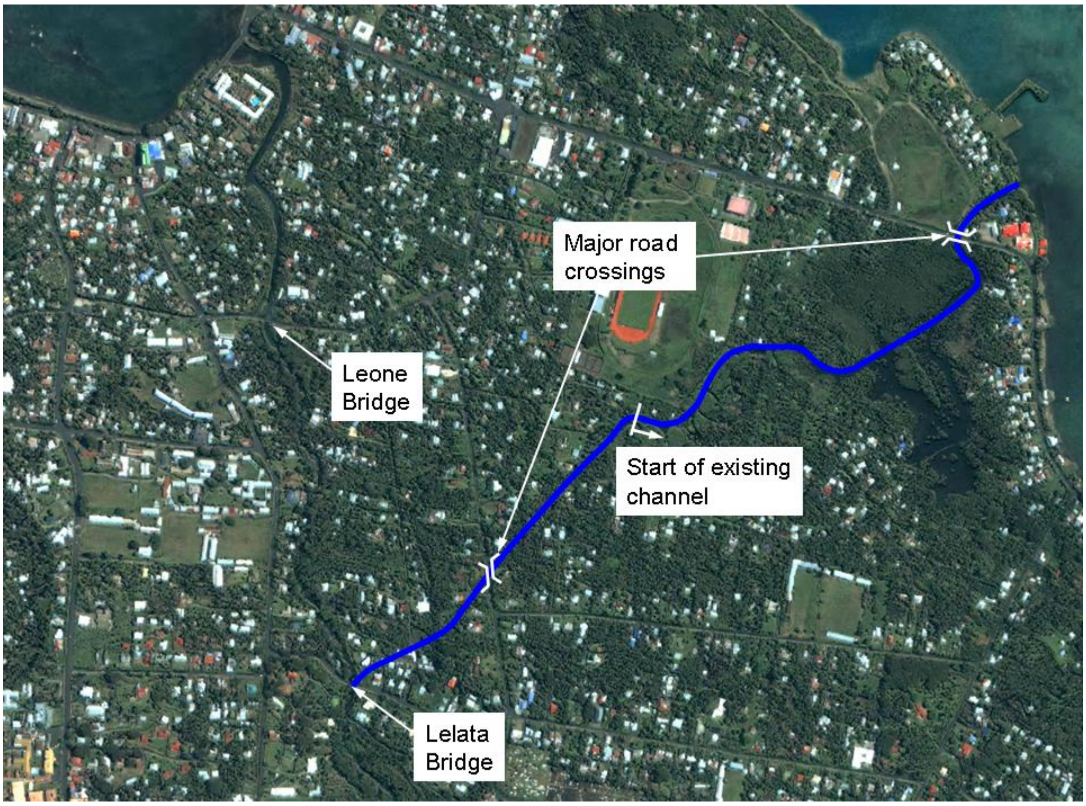


Figure 3-7: Possible route for a flood diversion channel

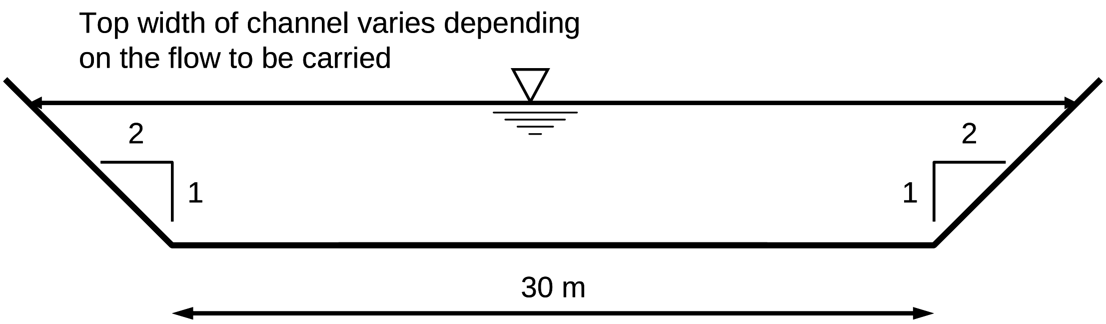


Figure 3-8: Cross-section of a possible flood diversion channel for the lower Vaisigano River

Table 3-7: Preliminary dimensions of a flood diversion channel for the Lower Vaisigano[6]

Return period (years)	Capacity of the channel (m^3/s)	Depth of channel (m)	Top width of channel (m)
1 in 2	74	0.9	33.6
1 in 5	183	2.0	38.0
1 in 20	318	2.1	38.4
1 in 50	370	2.4	39.6
1 in 100	450	2.7	40.8

3.2.4. Increasing channel conveyance

The capacity of a river channel to discharge floodwater can be increased by widening, deepening or realigning the channel, and by clearing the channel banks and bed of obstructions to flow. Such "improvements" can increase the velocity and possibly the depth of flow. A particular example of a method of increasing the conveyance capacity providing enhancement opportunities is the creation of a "two stage" channel. In this case the existing river channel is retained for low and medium flows, and floodplains are created parallel to the river channel to accommodate flood flows.

Increasing the channel conveyance capacity can, like diversion channels, reduce flood attenuation and increase the flood risk downstream. Other disadvantages include the cost of maintenance of oversized channels, where sediment deposition may occur.

A preliminary investigation into increasing of the channel capacity has indicated that the Vaisigano River would have to be widened by some 70 m at the downstream end with the bed level dredged to -1 m below mean sea level. At the upstream end near Leone Bridge the channel needs to be widened by 50 m to prevent flooding during the 1 in 100 year flood. The widening and dredging of the channel upstream of Leone Bridge has not been considered because this part of the Vaisigano River is constrained by bed rock meaning that the costs of channel widening and dredging are likely to be prohibitive.

The key disadvantages of the increase in channel conveyance for the lower Vaisigano are as follows:

- The issue of land tenure and the socio-economic cost and impacts of relocating communities that live adjacent to the Vaisigano between Leone and Vaisigano Bridges.
- The cost of maintenance of the oversized channels, where sediment deposition is likely to occur.
- The destruction of riparian habitat and the visual impact of replacing naturally varying channel sections with a section of more uniform geometry.

[6] Note: The channel is assumed to be trapezoidal with 1 in 2 side slopes and a bottom width of 30 m
No allowance for freeboard has been made when estimating the depth of the channel

Recommended actions:
If increasing the channel conveyance of the lower Vaisigano River was to be considered in more detail then the following actions would be required:

- Improve the accuracy of the topographic and hydrological data available for the lower Vaisigano River and its floodplain in order to reduce the uncertainty in the design flood levels.
- Establish the quantity of cut that would need to removed to widen and deepen the Lower Vaisigano to prevent flooding for a number of design return periods.
- Make a preliminary assessment of the costs of increasing the conveyance of the lower Vaisigano.
- Quantify the economic benefits that are derived by increasing the conveyance of the lower Vaisigano for a number of return periods.
- Assess land ownership issues in the Lower Vaisigano and establish the cost of relocation of communities adjacent to the river.
- Assess the sediment load in the river and quantify the amount of material that would have to be dredged from the river in order to maintain the new channel profile and cross-section.
- Make a preliminary assessment of the environmental impacts including the visual impacts of constructing this option

3.2.5. Pumping

Pumping is an effective flood mitigation measure for relatively small catchments (e.g. in Samoa this probably means less than 1 km^2) where the flood volumes are not too great. However, in the case of the Lower Vaisigano where the flows are high (e.g. the 1 in 2 year flow is 174 m^3/s), pumping is not a practical option owing to the size of pumps required to lift such large volumes of water. The capital, and operation and maintenance costs of pumps would be prohibitively high.

3.2.6. River maintenance

River maintenance is used to reduce flood risk by a number of measures including:

- Dredging.
- Vegetation cutting.
- Bank clearance.
- Removal of obstructions and rubbish that may block structures such as bridges.

The HEC-RAS hydraulic model of the Vaisigano River has shown that dredging the lower reaches of the river downstream of Leone Bridge by up to 2 m would only have a minimal effect on the depth of water in the floodplain. The same is true of cutting vegetation and bank clearance. The Manning's n roughness coefficient is currently set at 0.035 in the hydraulic model. Assuming that the weed cutting and bank clearance reduces this roughness coefficient to 0.025 then the 1 in 100 year flood water level in the lower Vaisigano will only drop by some 0.22 m. This will provide a minimal amount of benefit to the elements at risk from flooding. In practice it is unlikely that the cutting vegetation and clearing the banks will reduce the roughness coefficient to 0.025. The removal of obstacles and rubbish that may block bridges would be a useful exercise but again is unlikely to have a significant effect on peak flood water levels.

Recommended actions:

- o A detailed assessment as to whether incentives can be found for riverside communities to carry out the maintenance of the river side vegetation.
- o An assessment of the tangible effects of carrying out improved maintenance along the lower Vaisigano River.

3.2.7. Flood proofing of buildings

Flood proofing refers to:

- o The design and construction of buildings with appropriate water-resistant materials such that flood damage to the structure of the building and contents is minimised when the building is flooded.
- o Increased ground floor levels.
- o The use of temporary barriers and other measures to reduce flood damage when a flood actually occurs.

Flood proofing may be applied to both new construction and existing buildings. In areas of the Lower Vaisigano River catchment that flood regularly where residents are aware of the impacts, some buildings are already “flood proofed” using such measures as stone and concrete floors and walls, raised floors and raised electricity supply. The decision to adopt flood proofing as a formal mitigation measure is best made within the framework of a building control policy and land use plans. Furthermore, the Government of Samoa should raise awareness on pay-offs of flood proofing and create incentives to owners of existing buildings. Although flood proofing can reduce damage to flood-affected buildings, the occupiers still suffer the social disruption of flooding. In areas of the lower Vaisigano River where the flood depths are high (i.e. greater than 1 m) it should be ensured that the residents can be evacuated from their property safely.

Issues to consider in flood proofing the structure of a building include:

- o Raising floor levels above a recommended design flood level.
- o Design to withstand water immersion, differential water pressure on walls, debris and flotation forces.
- o Use of methods of construction and certain types of materials which are better able to withstand immersion than others. For example bricks and plastics are much better than many other materials and can withstand immersion without damage and only require cleaning when the flood subsides.
- o Impact of polluted water, particularly by sewage from urban flooding.

The most effective flood proofing measure is to raise the floor level above flood level. However, this involves additional cost in raising ground levels which can be very significant, particularly for large commercial buildings. Raised floor levels can also reduce the amount of available flood plain storage as water which would otherwise flood buildings is now unable to do so. This must be taken into account in the overall assessment of the impact of the development on flooding. One method to preserve the floodplain storage is construct buildings on stilts. However, if this approach is adopted then it is important that the storage under buildings is not used for storage or filled with rubbish.

Recommended actions:
- o Develop control measures for new developments. For example with regards to a minimum floor level a decision has to made by the Government of Samoa concerning what return period (annual probability) flood above which floors should be raised and the amount floors should be raised above this level. For example a development control policy may be to have the minimum floor levels of new buildings to be a minimum of 300 mm above the 1 in 50 year flood level.
- o Provide advice on flood resistant construction materials.
- o Provide a mechanism by which the above measures are implemented in the consenting procedure for new developments.
- o Provide advocacy on long-term pay-offs of flood proofing and create incentives for owners to invest in these proactive measures

3.3. Non-structural mitigation measure options

This section details a range of non-structural mitigation options and the actions that are required to take these forward.

3.3.1. Development control

Development control is concerned with whether or not developments should be constructed in flood risk areas and, where developments are permitted, the conditions attached to the development. Such controls are aimed at reducing the risk of buildings and other assets being flooded, reducing the resulting damage when above floor flooding occurs, and avoiding increases in flood risk elsewhere.

Typical development control requirements include for example, identification of the parts of a site where building may and may not be permitted, and minimum floor levels. Careful and creative strategic site planning can reduce hazard and facilitate evacuation when required.

It is recommended that PUMA and the Water Resources Division should state specific requirements related to developments in flood prone areas and the type of additional data and analysis that might be required before developments are allowed in the floodplain. These requirements may include:

- o The assessment of the impacts of the development on flood levels elsewhere.
- o Specific comments on the proposed development to minimise the impact of floods.
- o Identification of suitable evacuation routes.
- o Environmental requirements.

The safety of people during a flood event is of fundamental importance in the development of flood risk areas. Evacuation can be very hazardous if safe evacuation routes are not available. It is recommended that new developments in the lower Vaisigano River floodplain should either include safe locations for people, for example in the upper floors of buildings, and/or safe evacuation routes. Provisions for the safety of people during floods should be agreed with the Disaster Management Office and emergency services such as the police and the fire service.

Flood maps have been produced showing the flood depth for the Lower Vaisigano for a number of return periods. The 1 in 20 and 1in 100 year maps showing the depth of flooding for these design floods are shown in Figure 3-9 and Figure 3-10 respectively.

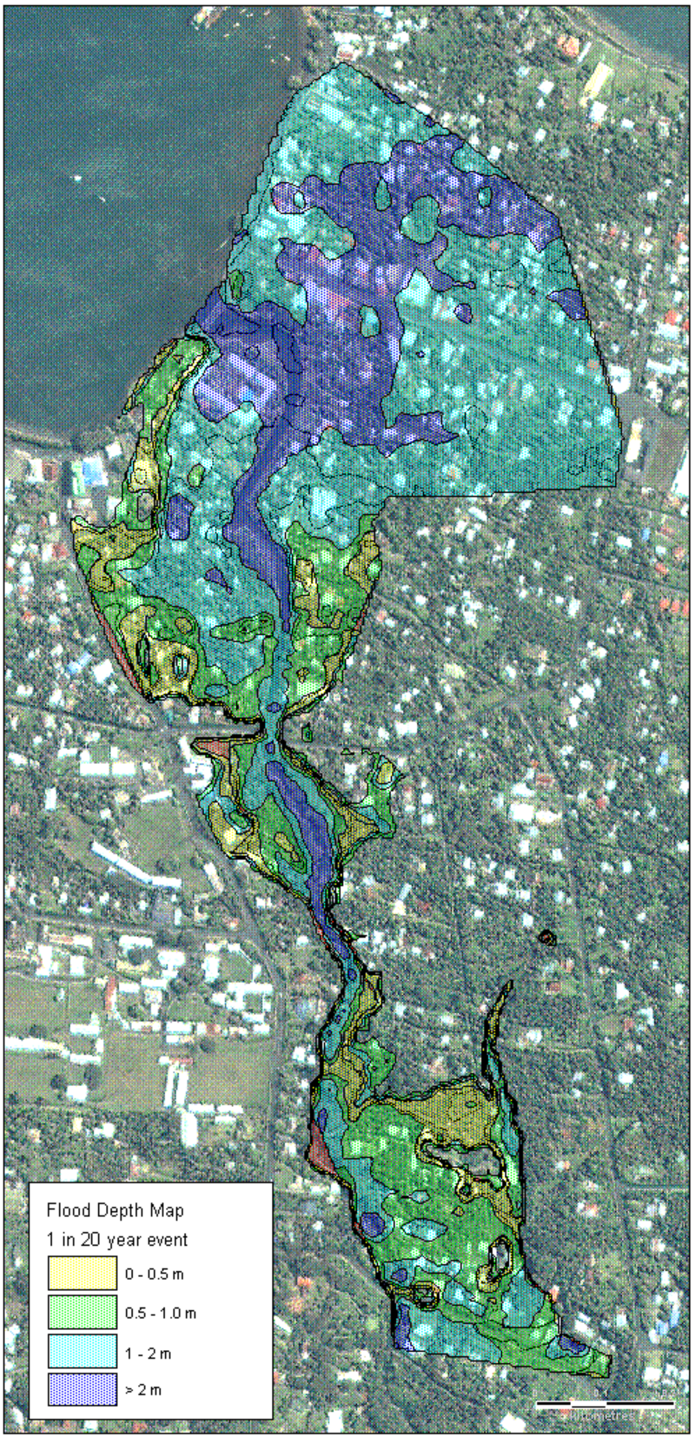


Figure 3-9: Flood depth map for the 1 in 20 year flood for the lower Vaisigano

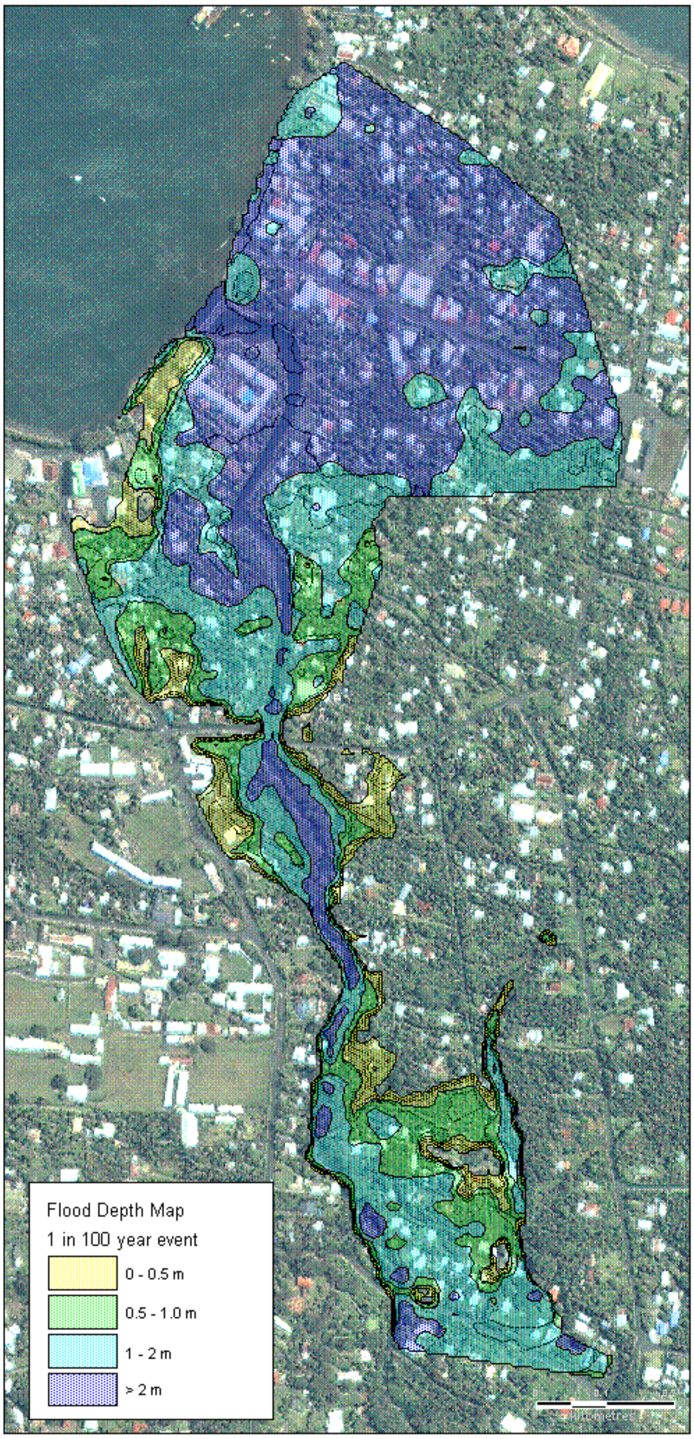


Figure 3-10: Flood depth map for the 1 in 100 year flood for the lower Vaisigano

Flood hazard varies significantly across the lower Vaisigano floodplain mainly because of topography. For example in the higher areas further away from the river the depth of flooding is generally lower than closer to the river as are flow velocities. By locating buildings in the higher parts of the site, their effect on flooding will be reduced, potential flood damage will be lessened and risks to people will be less.

The degree of flood hazard to people has been evaluated by assessing the product of the floodwater depth and water velocity, (i.e. water depth x water velocity). The degree of hazard is based on research related to the risk to people in floodwater. Table 3-8 shows the guidance on the degree of flood hazard for the lower Vaisigano. Flood hazard maps have been produced for the lower Vaisiagano. Figure 3-11 and Figure 3-12 show the flood hazard map for the 1 in 20and 1 in 100 year floods for the Vaisigano respectively based on the degree of flood hazard shown in Table 4.8.

Table 3-8: Guidance on the degree of flood hazard

Floodwater depth (m) x water velocity (m/s) (m^2/s)	Degree of flood hazard	Description
Less than 0.75	Low	**Caution** Flood zone with shallow flowing water or deep standing water
0.75 to 1.25	Moderate	**Dangerous for some (i.e. children)** Danger: Flood zone with deep or fast flowing water
1.25 to 2.5	Significant	**Dangerous for most people** Danger: Flood zone with deep fast flowing water
Greater than 2.5	Extreme	**Dangerous for all** Extreme danger: Flood zone with deep fast flowing water

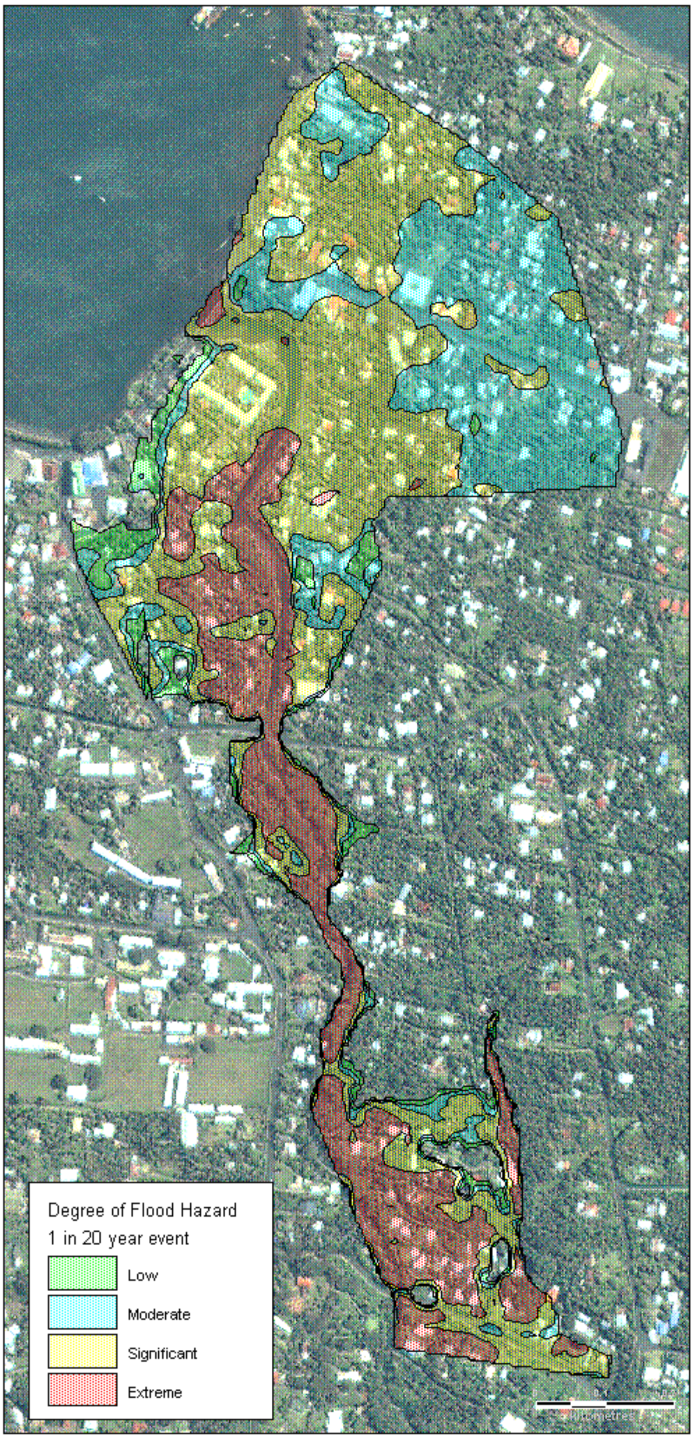


Figure 3-11: Flood hazard map for the 1 in 20 year flood for the lower Vaisigano

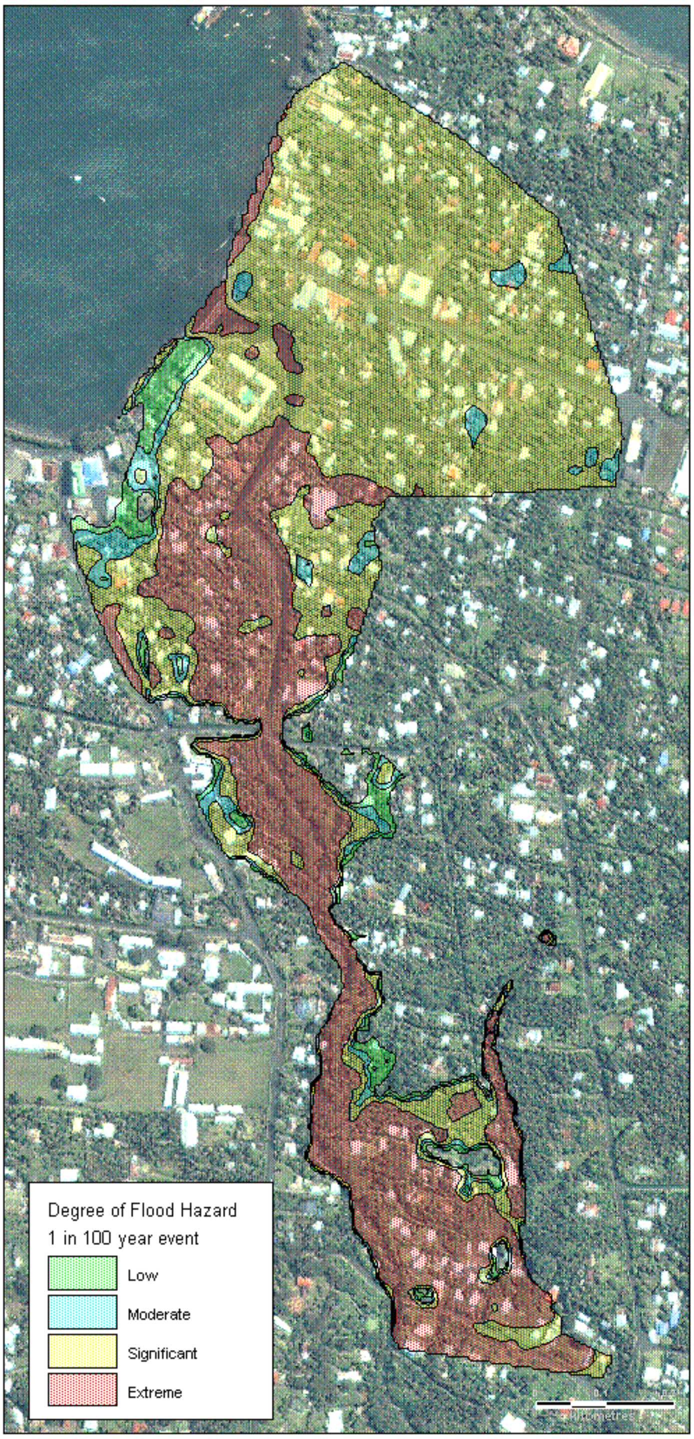


Figure 3-12: Flood hazard map for the 1 in 100 year flood for the lower Vaisigano

The flood depth and flood hazard maps presented in Figure 3-9 to Figure 3-12 are based on the results of the one-dimensional hydraulic model of the lower Vaisigano. It should be noted that there is a high degree of uncertainty in the flood water depths and hazard zones for the following reasons:

- o There is a high degree of uncertainty in the design flood flows owing to the lack of hydrological data.
- o There was limited calibration of the hydraulic model as the result of limited information on historical floodwater levels and flows.
- o The HEC-RAS hydraulic model of the Vaisigano is only one dimensional meaning that only an average value of velocity in the floodplain can be estimated at each cross-section.
- o There is an uncertainty in the vertical resolution of the digital terrain model of the lower Vaisigano that was used to estimate the flood extents and the flood depths.

Recommended actions:
The following actions should be carried out with regards to the flood extent and hazard maps:

- o Improve the accuracy of the topographic and hydrological data available for the lower Vaisigano River and its floodplain in order to reduce the uncertainty in the design flood levels.
- o Regularly update the hydraulic model using additional survey data, especially areas of the model where surveyed data is sparse.
- o Re-run the model every time flood flows are re-estimated.
- o Re-evaluate the flood extents and flood hazard for the design return periods.

With regards to new developments the following actions should be undertaken:

- o Incorporate minimum floor level requirements in policy, regulations (e.g. building codes) and legislation.
- o Enforce minimum floor level requirements for new development.
- o Produce floodplain risk reduction guidelines.

3.3.2. Flood forecasting

Forecasting flood water levels several hours in advance is difficult in Samoa. This is because the catchments are steep, relatively small and rainfall events intense. As a result floodplains can flood in a matter of hours. The flooding that occurs in the lower Vaisigano floodplain can be defined as flash flooding. Flash flooding is sudden and unexpected flooding caused by local heavy rainfall or rainfall in another area. Flash floods are difficult to forecast accurately. However, it may be possible to issue flash flood warnings based on flash flood guidance estimates. These estimates are indices of the volume of rainfall of a given duration over the Vaisigano catchment that is just enough to cause minor flooding at the downstream end of the river, which in this case is a flow of around 100 m^3/s to 150 m^3/s. These indices would be used with estimated or forecast precipitation over the Vaisigano catchment to arrive at flash flood threat indices that form the basis of decisions regarding the dissemination of warnings. The dominant source of uncertainty in these decisions is the precipitation.

In order to set up such a forecasting system the first step is for forecast precipitation data to be available for the whole of the Vaisigano River catchment. We understand that the there is an Australian forecasting model available that can forecast hourly rainfall up to six hours in advance. In order to validate the flood forecasting guidance there would also be a need to install more rainfall intensity gauges in the catchment with which to validate the model to understand the uncertainty in the forecast rainfall. There is also a need to validate the existing hydrological model so that it can be used to assess what rainfall intensity pattern triggers flooding in the lower Vaisigano floodplain.

Recommended actions:
The following actions are required to set a flood forecasting system for the lower Vaisigano:

- o Investigate the availability and cost of obtaining forecast six hourly precipitation data six hours in advance.
- o Assess the cost of installing three additional rainfall intensity gauges in the Vaisigano catchment.
- o Calibrate the hydrological data using hydrological data collected over the next three years to reduce the uncertainty in the rainfall intensity that triggers flooding.
- o Collect data to reduce the errors in issuing false flood forecasts.
- o Assess how the flood forecasting process would be organised with the MNRE.
- o Assessing the benefits of setting up a flood forecasting system.

It is recommended that Meteorology Division takes ownership of any flood forecasting model.

3.3.3. Flood warnings

It is important that there is a method for disseminating flood warnings and that there are different levels of flood warning that are well understood by the communities that live in flood prone areas. It is recommended that a method for disseminating the flood warning, other than just alerting the media, is set. The different levels of flood warnings that are set up could be along the lines of the following:

- o **Flood Watch**: Flooding possible. Be aware! Be prepared! Watch out!
- o **Flood Warning**: Flooding expected affecting homes, businesses and main roads. Act now!
- o **Severe Flood Warning**: Severe flooding expected. Imminent danger to life and property. Act now!

It should be noted that warning levels based on colours (e.g. green, yellow, red) are often confusing for local communities.

Recommended actions:
The actions related to flood warning include:

- o Establishing a process for communities in flood prone areas receiving flood warnings especially if a flood occurs in the middle of the night.
- o Develop a series of staged flood warnings.
- o Establish a process (e.g. an advertising campaign in the media) to ensure that communities understand what each different warning means.

3.3.4. Flood insurance

From our consultation with a private insurance company in Samoa we understand that it is unlikely that residents and businesses in flood prone areas will be offered insurance against flooding. It is recommended that the insurance industry has a greater involvement in flood management in Samoa.

Recommended actions:

- o Being consulted on guidelines for floodplain risk reduction.
- o Being consulted on major developments and working with local communities, the

Samoan Government and developers to develop schemes where the flood risk is acceptable to insurers.

3.3.5. Improving flood preparedness and response

Recommended actions:
Measures to increase the flood preparedness in flood prone areas should include:

- Develop flood response plans
- Raising awareness of flood risk.
- Flood warning arrangements and advice to communities, businesses and other stakeholders on how they should respond.
- Preparatory measures by communities and businesses to protect properties and contents.
- Arrangements for public safety including evacuation plans where required.

These measures will reduce both the intangible as well as the tangible costs of flooding. One challenge is to maintain an adequate level of flood awareness during extended periods when moderate to severe flooding does not occur. A continuing awareness programme must be put in place to inform new residents, maintain the level of awareness of old residents and to cater to changing circumstances of, for example, flood behaviour and new developments should be put in place.

The flood-prone communities must be made aware and remain aware of their role in the overall floodplain management strategy for their area, including the evacuation of themselves (and possibly personal goods and possessions). Sustaining an appropriate level of flood awareness will involves a continuous effort by various Samoan Government Departments, community groups and the emergency services. The cost of maintaining a level of awareness should be budgeted for. It should be noted that irrespective of the available warning time, generally there is widespread variation in flood awareness, both between households and communities.

3.3.6. Land use change

Rural land use change

Rural land use change (e.g. the afforestation of catchments) is often put forward as a method of reducing flood flows. The upper Vaisigano catchment, which forms the majority of the drainage area, remains largely covered in trees. Forests intercept precipitation, and this has sometimes led to the misconception that forests can "absorb" floods, acting like a sponge. In the case of a flood-producing rainstorm over the Vaisigano catchment, only a limited amount of rainfall (typically up to 5 mm to 10 mm) is intercepted which will not in itself have a significant mitigating impact on reducing flood flows. It can thus be concluded that adjusting the rural land use will not have a significant effect on reducing downstream flood risk[7].

Increasing urbanisation of the catchment

With respect to urban land use change, the development of houses and businesses in the catchment will increase the impervious area and will often result in a local increase in flood flows. It is recommended that PUMA puts in place in its consenting

[7] Forest has very minimum impact on flood control

process guidance through which the runoff from new developments is controlled so that it does not increase the downstream flood risk.

3.4. Summary of actions that are required

It can be concluded that the following mitigation measures will not significantly reduce flood levels in the lower Vaisigano River catchment:

- Pumping.
- Rural land use change.
- Improved river maintenance.

Although improved river maintenance has been shown to reduce the 1 in 100 year by some 0.22 m at best it is important that this option is considered in more detail. This is because improved river maintenance may lead to less debris being carried in the river and thus reduce the potential for structures to become blocked. It will also reduce the risk to life by reducing the possibility of people being struck by objects in the floodwater. Hence although improved river maintenance does not significantly reduce the floodwater levels it is important to pursue this action.

The actions that need to be carried out for structural mitigation options are summarised in Table 3-9. The actions that need to be carried out for non-structural mitigation options are summarised in Table 3-10.

Table 3-9: Actions required for structural mitigation measures

Action	Structural mitigation measures that the action applies to
Improve the hydrological and meteorological network, and the collection and archiving of data in the Vaisigano River catchment	Flood walls and embankments Upstream flood storage By-pass channel Increasing the channel conveyance Improving the channel maintenance
Reduce the uncertainty in the flood flow estimates for the lower Vaisigano via the following: Collecting high flow data and rainfall intensity data for the Vaisigano catchment during future floods Using the hydraulic model to	Flood walls and embankments Upstream flood storage By-pass channel Increasing the channel conveyance Improving the channel maintenance
Reduce the uncertainty in the hydraulic model of the lower Vaisigano River by the following: o Calibrating using flow data and water level data collected during future floods o Introducing more surveyed cross-sections into the model especially in areas where topographic data is sparse	Flood walls and embankments Upstream flood storage By-pass channel Increasing the channel conveyance
Collect detailed topographic data at the location(s) where the mitigations are to be employed	Flood walls and embankments Upstream flood storage By-pass channel
Assess land ownership issues	Flood walls and embankments Upstream flood storage By-pass channel Increasing the channel conveyance
Assess capital, operation and maintenance costs	Flood walls and embankments Upstream flood storage By-pass channel Increasing the channel conveyance Improving the channel maintenance
Establish the geo-morphological impacts	Flood walls and embankments Upstream flood storage By-pass channel Increasing the channel conveyance
Assess the environmental impacts of the mitigation measures	Flood walls and embankments Upstream flood storage By-pass channel Increasing the channel conveyance
Assess the direct economic and social benefits of the measure of a range of return periods to assess the average annual damage and benefits	Flood walls and embankments Upstream flood storage By-pass channel
Provide advice on flood resistant construction materials Provide a mechanism by which the above flood resistant materials are implemented via the consenting procedure for new developments	Flood proofing of new buildings

Table 3-10: Actions required for non-structural mitigation measures

Action	Non-structural mitigation measures that the action applies to
• Improve the accuracy of the topographic and hydrological data available for the lower Vaisigano River and its floodplain in order to reduce the uncertainty in the design flood levels. • Regularly update the hydraulic model using additional survey data, especially areas of the model where surveyed data is sparse. • Re-run the model every time flood flows are re-estimated • Re-evaluate the flood extents and flood hazard for the design return periods	Flood extent, flood depth and flood hazard maps for the lower Vaisigano floodplain
• Incorporate minimum floor level requirements in policy, regulations (e.g. building codes) and legislation • Enforce minimum floor level requirements for new development • Produce floodplain risk reduction guidelines	Development control procedures
• Investigate the availability and cost of obtaining forecast six hourly precipitation data six hours in advance • Assess the cost of installing three additional rainfall intensity gauges in the Vaisigano catchment • Calibrate the hydrological data using hydrological data collected over the next three years to reduce the uncertainty in the rainfall intensity that triggers flooding • Collect data to reduce the errors in issuing false flood forecasts • Assessing the benefits of setting up a flood forecasting system	Flood forecasting for the lower Vaisigano catchment
• Establishing a process for communities in the lower Vaisigano River catchment receiving flood warnings especially if a flood occurs in the middle of the night • Develop a series of staged flood warnings • Establish a process (e.g. an advertising campaign in the media) to ensure that communities understand what each different warning means	Flood warning for the lower Vaisigano catchment
• Maintain the awareness of flooding via awareness campaigns in the media and education within the schooling system	Flood preparedness

4. Flood Management Action Plan Matrix

GOAL 1: FLOOD RISK REDUCTION

OBJECTIVE	KEY ACTIONS	EXPECTED RESULTS	INDICATORS	STARTING DATE	RESPONSIBLE AGENCIES[8] • TARGET [9] AGENCIES
1. Appropriate structural mitigation options based on social, economic and environmental factors	Define a effective and clear planning process for determining the most appropriate flood mitigation options	Informed decision making on which are the most appropriate options to reduce flood risk	Range of appropriate flood mitigation options identified	2007	MNRE-WRD MNRE-PUMA Infrastructure Division (MWTI) • DMO • Environment and Conservation • Land Management Division
	Assess and implement prioritised structural mitigation options to reduce flood height related to each return period and hazard zone	Structural mitigation prioritised and implemented	Number of structural mitigation priorities planned and constructed and flood risk reduced	2007- 08 for assessing and prioritising to be followed by construction when funds are secured by 2010.	Asset management Roads Division (MWTI) • MNRE-PUMA • MNRE-WRD • Insurance • MWCSD • MOF
	Draft and apply maintenance plan for implemented structural mitigation measures			Draft 2007-08 Application Ongoing	

[8] Responsible agency or agencies refer to the organization(s) responsible for initiating and making sure that the *'actions'* are carried out/implemented.

[9] Target agency or agencies are the agencies that should be consulted and involved in the planning and implementation of the *'action'*

OBJECTIVE	KEY ACTIONS	EXPECTED RESULTS	INDICATORS	STARTING DATE	RESPONSIBLE AGENCIES[8] • TARGET [9] AGENCIES
2. Improve development control to address flood risk reduction	Incorporate minimum floor level requirements for development control based on water levels modelled for specified return period and for each floodplain and	Agreed requirements for minimum floor level above specified return period (annual probability of flooding) incorporated into development control process for all new development	Enforced development guidelines and building code amended	2007	MNRE-WRD MNRE-PUMA MWTI-Building Division • Developers
	Develop a guideline for development control in floodplain	Effective and clear process for development approval in floodplains	Guideline endorsed by Cabinet	End of 2007	MNRE-PUMA • Developers
	Create awareness programmes on necessity of minimum floor levels and development control in flood prone areas	Relevant stakeholders, e.g. developers and urban communities are aware of flood development control and its benefits and act accordingly	Number of new/existing development constructed/ retrofitted with minimum floor levels	Start 2007, ongoing	MNRE-PUMA MNRE-WRD MNRE-DMO MWTI-Building division NGOs • Private Sector
	Produce a flood-return design standard for infrastructural development	Developers and communities implement the approved flood-return design standards for infrastructural and urban drainage development	Flood design standard approved	2009	MWTI MNRE-PUMA MNRE-WRD • SWA • EPC • Developers • Other utilities

OBJECTIVE	KEY ACTIONS	EXPECTED RESULTS	INDICATORS	STARTING DATE	RESPONSIBLE AGENCIES[8] • TARGET [9] AGENCIES
3. Amend existing Building Code to address flood risk reduction	Review and incorporate minimum floor level requirements into building code for new development in flood prone areas	Minimum floor level requirements for buildings constructed used by developers	Revised building code incorporating minimum floor level requirements available and used	2007-08	MWTI-Building Division MNRE-PUMA • Developers • IPES
4. Improvement of existing Infrastructure to reduce flood risk	Assess and upgrade existing urban drainage and infrastructural capacity	Capacity of urban drainage, roads, bridges and utilities upgrading plan to cope with flood-return design standard approved	Project concept and proposal document for the upgrading of urban drainage, roads, bridges and utilities completed and implemented	2012	MWTI-Road Division MNRE-PUMA • MNRE-WRD • EPC • SWA • Other utilities
5. Strengthen communities and/or households capacity in flood risk reduction	Advocate suitable mitigation options for communities/ household at risk	Increased resilience of communities and households to flooding	Reduced losses to life, livelihood and property and less people affected by flood	Ongoing	MNRE-DMO MNRE-WRD MNRE-PUMA MWCSD NGOs Private sector • community
	Improve community programme[10] to include channel maintenance	Proactive community participation in channel maintenance	Level of community response/involvement supported by relevant agencies	Ongoing	STA MNRE-WRD NGOs MWCSD (Village Mayor) Asset management (MWTI) • community

[10] Community programmes such as the Samoa Tourism Authority Programmes and Environment Week

OBJECTIVE	KEY ACTIONS	EXPECTED RESULTS	INDICATORS	STARTING DATE	RESPONSIBLE AGENCIES[8] • TARGET [9] AGENCIES
	Encourage/promote public-private sector partnership to develop financing schemes for flood management and create incentives for flood proofing of buildings	Financial mechanisms available for flood risk reduction	Number of funded schemes to reduce flood risk	Ongoing	MWCSD MOF (small scheme financing) MNRE-DMO NGOs Financing institutes Private sector • community

GOAL 2 : FLOOD PREPAREDNESS AND EARLY WARNING

OBJECTIVE	KEY ACTIONS	EXPECTED RESULTS	INDICATORS	STARTING DATE	RESPONSIBLE AGENCIES • TARGET AGENCIES
6. Improved awareness and knowledge of flood risk management and related flood issues	Develop appropriate community flood awareness programmes[11]	Funded awareness programme implemented and relevant material produced and disseminated	Increased level of flood awareness	Start developing the programme and material in 2007 and for the awareness programme to be ongoing	MNRE-DMO MNRE-WRD MNRE-PUMA MNRE-Meteorology MNRE-TSD NGOs Private sector • community
	Develop and incorporate flood risk management into school curricula	Students level of knowledge and awareness of flood related issues increased	Flood risk management taught in schools	Start consulting with the Ministry of Education early 2007	MNRE-WRD MNRE-DMO MNRE-PUMA MESC
7. Strengthen flood forecasting	Strengthen technical capacity for developing and managing a flood forecasting system	Capacity to accurately forecast and release predicted water level to official contact points as required by the Samoa National Disaster Master Plan	Achieved minimum lead time	2007-2008	MNRE-Meteorology MNRE-WRD • MNRE-DMO • Media
	Review the requirements and benefits rainfall/runoff forecasting models	Rainfall and flow prediction models produced and updated from hourly rainfall data	River flows at Apia forecast on an hourly basis	2007 review	MNRE-Meteorology MNRE-WRD

[11] Through active community participation and media – radio, TV advertisements; Posters/ Billboards; Printed documents; Games; Internet – flood maps on the MapServer maps.meteorology.gov.ws; www.meterology.gov.ws; www.mnre.gov.ws; Use of flood marks on buildings; Disaster awareness week (national week)

OBJECTIVE	KEY ACTIONS	EXPECTED RESULTS	INDICATORS	STARTING DATE	RESPONSIBLE AGENCIES • TARGET AGENCIES
	Review and strengthen organisational arrangements for the operation of the flood forecasting system	Flood forecasting system operational 24/7	Effective process for flood forecasting	2007	MNRE-WRD MNRE-Meteorology MNRE-DMO
	Install telemetric water levels and rainfall data gauges within the relevant catchment	Availability of real-time data for the flood forecasting system	Number of telemetric stations and gauges installed	Installing to start in 2007	MNRE-WRD MNRE-Meteorology
8. Improve Flood Warning	Review and strengthen existing early warning system to take into account short lead time of less than 2 hours	Coordinated (flood forecasting and flood warning) process in issuing accurate and timely warning	Number of people and community emergency services receiving and responding to warning	Ongoing	MNRE-Meteorology MNRE-WRD MNRE-DMO Media • Community
	Develop a multi-staged warning system for the public	Effective Multi-staged warning available to agencies and communities	Warning system understood	2008	MNRE-Meteorology MNRE-DMO • MNRE-WRD • Media
	Conduct public awareness on the response to the multi-staged flood warning	Increased awareness on what each stage of warning means and how to respond	Number of community awareness programmes and mock exercises completed	Ongoing	MNRE-DMO Fire and emergency services Media • Community • Other response agencies • NGOs • MOH • Red Cross

GOAL 3 : CAPACITY BUILDING IN FLOOD MANAGEMENT

OBJECTIVE	KEY ACTIONS	EXPECTED RESULTS	INDICATORS	STARTING DATE	RESPONSIBLE AGENCIES • TARGET AGENCIES
9. To strengthen Organisational Capacity in flood management	Assess and implement training needs for flood risk management	Key Government agencies, emergencies services, private sectors and NGOs training needs for flood risk reduction and flood management identified	Key capacity needs identified and a training programme plan available	Training needs assessment of start in 2007 and for training opportunity to be available for suitable candidates for the next 5 years.	MNRE-Meteorology MNRE-WRD MNRE-PUMA SWA MWTI-Building Division MWTI-Road Division MOH Utilities
	Provide targeted formal training in hydrology, hydraulics, water resource management and meteorology	Certified staff with appropriate skills	Number of staff trained	Ongoing	MNRE-Meteorology MNRE-WRD • SWA • MWTI • MNRE-PUMA
	Institutionalise flood modelling and mapping training	Courses delivered by training institutes	Flood modelling and mapping course delivered	Ongoing	USP, NUS • MNRE/TSD
	On the job training or attachment with institute carrying out flood modelling	Analytical skills to manage and interpret data available	Number of attachment opportunities and training programmes available	Ongoing	MNRE-Meteorology MNRE-WRD • MNRE-PUMA
	Utilise the professional volunteer scheme[12] for a water engineer specialising in flood risk management	Technical expertise available	Volunteer scheme identified suitable expert	2008	MNRE-WRD

[12] Professional volunteers schemes such as the JICA, Australia Youth Ambassador Programmes, UN Volunteers, Peace Corps and others considered appropriate by the Government of Samoa

OBJECTIVE	KEY ACTIONS	EXPECTED RESULTS	INDICATORS	STARTING DATE	RESPONSIBLE AGENCIES • TARGET AGENCIES
	Procure computers, software - GIS, rainfall prediction model	Equipment purchased and utilisied	Improved capacity and number of up to date hardware and software	2008 – upgrades ongoing	MNRE-WRD MNRE-Meteorology MNRE-PUMA MNRE-TSD

GOAL 4 : TECHNOLOGICAL INFORMATION MANAGEMENT

OBJECTIVE	KEY ACTIONS	EXPECTED RESULTS	INDICATORS	STARTING DATE	RESPONSIBLE AGENCY • TARGET AGENCIES
10. Improve data collection and information management systems to guide and support flood management at the catchment's level	Collect and manage flood risk information that is used to direct flood mitigation actions such as: • flow • rainfall intensity • watershed hydrology and river channel hydraulics	More reliable data available for modelling: • Topographic surveys including increased cross sections across flood plains and critical sections • New flow data incorporated into hydrological model	Reduced uncertainty in the flood model	Ongoing	MNRE-WRD MNRE-Meteorology MNRE-TSD • SWA
	Improve and update precipitation, hydrological and hydraulic model of the catchment	Updated flood flows and levels	Number of key sectors and agencies effectively applying same results to derive management options	Ongoing	MNRE-WRD MNRE-Meteorology MNRE-TSD • MNRE-PUMA • MWTI-Building Divisions • MWTI-Roads
	Update flood risk maps through periodic revision of the need for flood studies updates	Updated maps available	Updated maps available	2007 – upgrade ongoing	MNRE-WRD MNRE-Meteorology MNRE-TSD

OBJECTIVE	KEY ACTIONS	EXPECTED RESULTS	INDICATORS	STARTING DATE	RESPONSIBLE AGENCY • TARGET AGENCIES
	Assess water levels for a number of different return periods	Specified flood depths for each of the return periods available to control development	Reduced flood risk for new development	2007	MNRE-WRD MMNRE-Meteorology MNRE-PUMA • Developers
	Install new flow gauging stations upstream of Alaoa East and at other branches of Vaisigano and at other selected sites	Improved flow data records	Flow gauging stations installed Flow database archived	Ongoing	MNRE-WRD MNRE-Meteorology
	Establish a data management procedure to collect, analyse, archive and back-up data	Database in place and data are backed up data including real-time data	Historical flow records accessible	2008	MNRE-Meteorology MNRE-WRD MNRE-ICT
	Digitise historical rainfall data	Historical rainfall records available digitally and archived	All records available digitally and backed-up	Ongoing	MNRE-Meteorology
	Produce a flood hazard map for each of the modelled return periods	Flood hazard zones delineated based on water level and velocity for each return period	Preliminary flood hazard map produced	2006 – ongoing for other rivers	MNRE-WRD MNRE-Meteorology MNRE-TSD MNRE-PUMA
	Identify and collect relevant information (people, property and infrastructure) required to produce a flood risk map	Elements at risk identified – people, property and infrastructure	Required demographic, infrastructural and property data available	2007 – update ongoing	MNRE-TSD MNRE-PUMA MNRE-WRD MNRE-Meteorology • MWTI
	Produce a flood risk map for major river catchments	Map of elements at risk produced	Flood risk map showing number of people and number of buildings affected and potential economic damage and potential loss of life	2007 (Vaisigano) - others ongoing	MNRE-TSD MNRE-DMO MNRE-WRD • Community • Insurance

GOAL 5 : SUSTAINABLE WATERSHED MANAGEMENT

OBJECTIVE	KEY ACTIONS	EXPECTED RESULTS	INDICATORS	STARTING DATE	RESPONSIBLE AGENCY • TARGET AGENCIES
11. Strengthened the SMP for floodplain and watershed development (management)	Review the draft Sustainable Management Plan (SMP) and develop a guideline for floodplain development	Development control and conditions closely linked to catchment status and environment	SMP endorsed and implemented	2007	MNRE-PUMA • Developers
	Establish an inter-agency planning and implementation procedure to reduce flood risk.	Implementation procedures approved	Improved coordination at the planning and the implementation stages	Ongoing	MNRE-WRD MNRE-LMD MNRE-FD MNRE-PUMA
	Review and prioritise appropriate land use zoning for different levels of flood risk in the major water catchments	Recommended sustainable landuse types for different levels of flood risk to reduce potential impacts	Copies of approved and updated Plan available Updated landuse GIS maps available	2008	MNRE-WRD MNRE-LMD MNRE-FD MNRE-PUMA • MAF • Land owners • Communities
	Review and develop regulations to control new or expanded development in flood risk areas	Implementation and enforcement of regulations	Increased number of new development incorporating flood mitigation measures	2009	MNRE-WRD MNRE-PUMA MNRE-TSD • MWTI-Building Divisions • MWTI-Roads

GOAL 6 : FLOOD GOVERNANCE

OBJECTIVE	KEY ACTIONS	EXPECTED RESULTS	INDICATORS	STARTING DATE	RESPONSIBLE AGENCY
12. Strengthen policy, legislative and organisational arrangements for a coordinated and effective flood risk management	Identify social and economic benefits of implementing integrated flood management options (structural and non-structural)	Cost-benefit and appraisal procedures and recommendations completed	Identified sustainable options implemented and promoted	2008	MNRE-WRD MNRE-PUMA MNRE-LMD MWTI SWA • MOF • MNRE-DMO • MWCSD
	Review relevant policy and legislation to provide for flood risk management responsibilities to be explicitly defined	Transparent and accountable organisational management arrangements mandated to control, monitor and provide information on floods mitigation, preparedness, response and recovery	Clear organisational roles and responsibility to be reflected in relevant policy	2009	AG MNRE-WRD MNRE-Meteorology MNRE-PUMA MNRE-Legal services MNRE-DMO
	Incorporate flood management in national macroeconomic policy and fiscal management	Flood management reflected as a priority development agenda and allocated with appropriate level of resources	Percentage of national annual budget allocated to flood management Reflected in SDS	2007-2009	MOF/ACU MNRE-WRD MNRE-DMO
	Incorporated key actions of this Action Plan in relevant agencies annual workplans/business plans	Flood management is a specific budget line item in each Ministerial/Division budget allocation	Percentage of ministerial/division budget allocated to flood management	2007-2009	MNRE-DMO MNRE-TSD MNRE-Meteorology MNRE-WRD MWTI-Building Division

OBJECTIVE	KEY ACTIONS	EXPECTED RESULTS	INDICATORS	STARTING DATE	RESPONSIBLE AGENCY
					MWTI- Road Division MOH SWA
	Develop a detailed implementation programme for this Action Plan linked to annual workplans, relevant national projects and identify potential donors	Action Plan implementation starts	Number of successful actions implemented in a year	2007-2009	MNRE-WRD MNRE-DMO MNRE-TSD MNRE-Meteorology MWTI-Building Division MWTI-Road Division
	Annual review sector/ministerial regulatory and planning processes for flood management	Planning process for flood management being reflected in each agency's work plan and respective goals	Improved Flood risk management	Ongoig	MNRE-WRD MNRE Meteorology MNRE-PUMA MNRE-DMO MNRE-TSD MWTI-Building Divisions MWTI-Road Divisions SWA and all other relevant stakeholders
	Establish a technical advisory committee to review and monitor the implementation progress of this Action Plan	Review process for the progress of the Action Plan in place	Technical advisory committee established to oversee the review process	Mid implementation and at the end in view of review and updating of the Plan	MNRE-WRD MNRE-DMO And a33gencies responsible for flood management in collaboration with provincial and sector agencies and community leaders.

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6. Annexes

Annex 1: The Process carried out in Samoa to develop the Plan

The process contains the following related activities:

- Capacity building in flood hydrology
- Capacity building in river modelling
- Capacity building in floodplain mapping
- The production draft floodplain management guidelines for Samoa to reduce flood risk
- The production of a Flood Risk Management Action Plan for the lower Vaisigano River

The first three initiatives were addressed as phase 1 in July and August 2006 through fieldwork and training in the Vaisigano catchment involving officers from Meteorology, PUMA and Water Resources.

The objective of phase 2 was to develop draft floodplain management guidelines and a flood management action plan based on the information available and other existing initiatives in Samoa and to provide additional training in flood risk management.

The draft guidelines and action plan were developed as follows:

31 October to 17 November (2006)	Further training with a core group that participated in phase one
	Face-to-face consultation, desk reviews, and linking with other relevant projects through consultation
20 to 21 November	Workshop – present preliminary findings of the technical training on mitigation options to reduce flood in Vaisigano
	Introduce guideline and action plan
	Working groups to identify issues to be addressed by the guideline and action plan
22 to 28 November	Guideline and action plan development with the core group
28 to 29 November	Presentation of the first draft of the guideline and Action Plan to key Government Agencies
30 November	Broad circulation of the draft for comments
	Comments are to be received either through the MNRE-WRD or directly to SOPAC for the final incorporation, final editing and printing
1st quarter of 2007	Final guideline and action plan produced and endorsement process to be undertaken by the Samoa Government

Annex 2: Glossary of Definitions

ACCEPTABLE RISK
The level of loss a society or community considers acceptable given existing social, economic, political, cultural, technical and environmental conditions. In engineering terms, acceptable risk is also used to describe structural and non-structural measures undertaken to reduce possible damage at a level, which does not harm people and property, according to codes or "accepted practice" based, among other issues, on a known probability of hazard.

AFFECTED POPULATION
Primary: People requiring immediate assistance during an emergency situation.
Secondary: People who at a certain point will require long-term social and economic assistance as a direct consequence of a disaster situation.

BUILDING CODES
Ordinances and regulations controlling the design, construction, materials, alteration and occupancy of any structure for human safety and welfare. Building codes include both technical and functional standards.

DAMAGE
Unwanted changes or losses resulting from a natural or human-caused event.

DAMAGE ASSESSMENT Identification and qualitative and quantitative recording of the extent, severity and location of the effects of a destructive event.

DECLARATION OF DISASTER
Official declaration by the authorities of a political-management jurisdiction to meet the need for extraordinary action.

DIRECT EFFECTS Those effects having a direct cause and effect relationship with the event.

DIRECT LOSSES Adverse effects caused by a disaster, such as the loss of life, injuries, loss of goods and services, and infrastructure damage.

DISASTER
A serious disruption of the functioning of a community or a society causing widespread human, material, economic or environmental losses which exceed the ability of the affected community or society to cope using its own resources. A disaster is a function of the risk process. It results from the combination of hazards, conditions of vulnerability and insufficient capacity or measures to reduce the potential negative consequences of risk.

DISASTER MANAGEMENT
The organisation and management of resources and responsibilities for dealing with all aspects of emergencies/disasters, in particular preparedness, response and (relief/rehabilitation)

DISASTER RISK MANAGEMENT
The systematic management of administrative decisions, organisation, operational skills and abilities to implement policies, strategies and coping capacities of the society and communities to lessen the impacts of natural hazards and related environmental and technological disasters. This comprises all forms of activities, including structural and non-structural measures to avoid (prevention) or to limit (mitigation and preparedness) adverse effects of hazards.

DISASTER RISK REDUCTION
The conceptual framework of elements considered with the possibilities to minimise vulnerabilities and disaster risks throughout a society, to avoid (prevention) or to limit (mitigation and preparedness) the adverse impacts of hazards, within the broad context of

sustainable development.

DISASTER WARNING SYSTEM
Arrangements and procedures to alert to and warn the community of the possibility of a disaster event and suggest actions that should be taken to reduce its impact.

EARLY WARNING
The provision of timely and effective information, through identified institutions, that allow individuals exposed to a hazard, to take action to avoid or reduce their risk and prepare for effective response. Early warning systems include of three primary elements (i) forecasting of impending events, (ii) processing and dissemination of warnings to political authorities and population, and (iii) undertaking appropriate and timely actions.

EMERGENCY
A situation generated by the real or imminent occurrence of an event that requires immediate attention. A significant or unusual event, requiring the coordinated response of more than one agency.

ENVIRONMENTAL IMPACT ASSESSMENT (EIA)
Study undertaken in order to assess the effect on a specified environment of the introduction of any new factor, which may upset the ecological balance. EIA is a policy making tool that serves to provide evidence and analysis of environmental impacts of activities from conception to decision-making. It is utilised extensively in national programming and for international development assistance projects. An EIA must include a detailed risk assessment and provide alternatives solutions.

FLASH FLOOD A sudden and extreme volume of water that flows rapidly and causes inundation and because of its nature is difficult to forecast.

FLOOD Significant rise of water level in a stream, lake reservoir or a coastal region. A flood is a harmful inundation of property and land utilised by man and may be of two types: slow flood, caused by an increase in the volume of water produced by rain in rivers and lakes over a long period, days or weeks, mainly affecting property such as houses and cattle, and displace the inhabitants from their usual dwelling places. Sudden flood, caused by an increase in the volume of water in rivers and lakes, causing deaths, injuries and violent destruction of property. It may be the result of torrential rain, hurricanes, and structural failures such as the collapse of walls of a reservoir or the embankment of a river proving insufficiently robust to contain the strong flow or water.

FORECAST
Definite statement or statistical estimate of the occurrence of a future event (UNESCO, WMO). This term is used with different meaning in different disciplines.

LEVEL OF RISK
An expression of the severity of a risk derived from consideration of likelihood the event will occur and the potential consequences that may arise.

LIKELIHOOD
How likely is it that a specific hazard will occur within a given time frame.

MITIGATION
The process of implementing measures that reduce the intensity and severity of the impact of potential hazards.

MONITOR
To check, supervise, observe critically, or record the progress of an activity, action or system on a regular basis in order to identify change

NATURAL HAZARDS
Natural processes or phenomena occurring in the biosphere that may constitute a damaging

event. Natural hazards can be classified by origin namely: geological, hydro meteorological or biological.

PREPAREDNESS

The process of implementing measures that are designed to ensure that, should a hazard threaten, communities, resources and services will have the knowledge and understanding to cope with the effects.

PREVENTION

Activities to provide outright avoidance of the adverse impact of hazards and means to minimise related environmental, technological and biological disasters. Depending on social and technical feasibility and cost/benefit considerations, investing in preventive measures is justified in areas frequently affected by disasters. In the context of public awareness and education, related to disaster risk reduction changing attitudes and behaviour contribute to promoting a “culture of prevention”.

RECOVERY

Programming measures that are designed to support affected communities in the reconstruction of the physical infrastructure and restoration of emotional, economic and physical well being.

REHABILITATION

Restoring peoples lives back to normal, as well as essential services, including the beginning of the repair of physical, social and economic damages.

RESPONSE

Programming measures that develop the action to be taken in anticipation of, during and /or immediately after, a hazard impact to ensure its effects are minimised.

RISK

Used to describe the likelihood of harmful consequences, arising from the interaction of hazards, vulnerable elements and the environment.

RISK ASSESSMENT/ANALYSIS

A process to determine the nature and extent of risk by analysing potential hazards and evaluating existing conditions of vulnerability that could pose a potential threat or harm to people, property, livelihoods and the environment on which they depend. The process of conducting a risk assessment is based in a review of both the technical features of hazards such as their location, intensity, frequency and probability; and also the analysis of the physical, social, economic and environmental dimensions of vulnerability, while taking particular account of the coping capabilities pertinent to the risk scenarios.

RISK IDENTIFICATION

The process of determining what can happen, why and how

TREATMENT OPTIONS

Measures contained within mitigation, preparedness, response and recovery programmes that aim to eliminate or drastically reduce the level of risk

VULNERABILITY

Means that element are exposed to specific hazard an have a low level of resilience to cope with the impacts of that hazard (i.e. cyclone) or characteristics of the (i.e. storm surge of flooding)

Annex 3: Stakeholder Consultation Workshop for the FMAP – List of Participants

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Annex 4: Consolidation of existing statutory and non-statutory flood risk reduction activities in Samoa

Agency	Flood risk reduction related activities	Recommendations	Relevant legislative mandates for mitigation
Ministry of Natural Resources, Environment	▪ Samoa Development Planning provisions o Sustainable management plans (SMP) – including a draft guide for housing o Development consents (localities and designs of new developments are assessed where Development Consent may be subject to Conditions. o Environment Impact Assessment o PUMA advice (e.g. to developers on hazard (flood) risk areas and possible adverse and long term ecological and social implications) o Monitoring	Proposal for the development on floodplains or high flood prone areas – conditions could include height of floor, drainage location and design, distance from surface water source etc. Depending on the locality of the proposal – and ensuring that it is clear in the TOR for the scoping phase or for a full EIA to consider impacts of the proposed development on the floodplain and river/streams as well as the impact of the risk of flooding on the development – and to identify appropriate mitigation options Monitoring of conditions given with the development license clearly a function of PUMA. However who should monitor the mitigation measures not attach to development license such as mitigation structures – usually government development projects	Planning and Urban Management Act 2004 EIA guidelines 1998 Code of Environment Practice 2001 Coastal Infrastructure Management Draft Housing guidelines 2003
Ministry of Works, Transport and Infrastructure (MWTI) – Infrastructure Assets – Building	▪ Building regulations ▪ Risk assessments construction and maintenance of public assets ▪ Orders in relation to unsafe buildings	Conditions for building on floodplains and flood risk areas such as Apia should be incorporated into the assessment of building designs Need to consider building that are always flooded and look into options such as relocation, raising of floor level, building a flood wall or improving drainage	Draft building regulations 2003 National Building Code 1992 Ministry of Works Act 2002
MWTI - Infrastructure Assets – Roads	▪ Code of Environment Practice Road Planning, Design, Construction and maintenance ▪ Design specification ▪ Roadwork's specifications ▪ EIAs ▪ Emergency maintenance and Emergency response ▪ Recovery construction	Conditions for infrastructure building on floodplains and flood risk areas	Code of Environment Practice 2001 EIA guidelines 1998 Planning and Urban Management Act 2004 Ministry of Works Act 2002