# Engineering Assessment of 2006 Floods

## Final Report

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# Engineering Assessment of 2006 floods

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# Executive Summary

**Scope**

Upon the request of the Government of Guyana and in consultation with the Resident Coordinator of the United Nations Development Programme (UNDP) the United Disaster Assessment and Coordination (UNDAC) team invited two teams of specialists for assistance in making both a socio-economic assessment of damages and losses (ECLAC Team) and a technical assessment of damages and losses to infrastructure (Engineering Team).

This report presents the findings of the Engineering Team as a technical assessment of the causes of the floods of December 2005 and January 2006 and assessment of potential measures to reduce future flood risk. It focuses on regions 2 and 5 where the most severe flooding occurred this year but also considers national scale issues. It should be noted that the scope and detail of the report is relatively limited due to the short mission duration (12 day input by team members).

**Continued Flood Risk**

The Guyana floods of 2005 and 2006 showed that the drainage system is insufficient to discharge all the water in case of excessive rainfall. Emergency works have provided a temporary respite. However there remain serious deficiencies in the flood control and drainage systems and in disaster preparation and management that demand an urgent response from government and donors alike.

The state of emergency is not over yet as the ground is likely to remain saturated until the next rainy season, increasing the risk of flooding. Government agencies should be aware of this risk and carry out necessary pre-rainy season planning for disaster mitigation and preparedness.

The question has been asked – what has been achieved since the end of the Emergency Works in 2005? There is no doubt that government organisations have learnt lessons from last year, there have been some improvements in pre-rainy season preparedness and monitoring of the conservancies along with emergency works carried out during the 2006 floods. However of grave concern is the lack of progress that has been made since July last year on implementing larger scale urgent works, to take one example - improvements to the East Demerara Conservancy. In July 2005 the Task Force for Infrastructure Rehabilitation set out a programme of urgent measures covering the short and medium term to reduce the risk of flooding. This programme has not progressed since then. Unfortunately the momentum and cooperation that was generated between the different donors and with the government following the 2005 floods and the Emergency Works was not carried forward into further action.

As a consequence there remains an urgent need for action. Government departments remain under-resourced and over-stretched dealing with day-to-day management and maintenance and emergency response. This is making it difficult to move beyond a reactive approach to floods to the development of a coherent and integrated action plan for improving flood management and disaster response nationally. We consider that a proactive donor response is urgently required to assist in planning and programme development leading to implementation.

**Infrastructure Improvements to Reduce Flood Risk**

Based on information from NDIA and brief review and site visits by the Engineering Team the following works have been identified as priority works. These works concentrate on Regions 2 and 5 though high priority works for other regions are also identified. A programme for developing and undertaking the priority works is required as soon as possible.

| **Short Term/High Priority** | | |
|---|---|---|
| Region | Work | Costs |
| 2 | Drainage works at Cozier/Pomeroon area | G$ 123 M |
| | Drainage works at Charity | G$ 31.5 M |
| | Rehabilitation of Ituribisi Conservancy Embankment | G$ 20 M |
| | Drainage works at Sommerset and Berks | G$ 22 M |
| | (Test) Dredge in the Pomeroon river mouth | G$ 50 M |
| | Raising of dams along the Pomeroon River | G$ 100 M |
| 5 | Trafalgar Pump station – pump rehabilitation | G$ 175 M |
| | Bara Bara Flood Control Embankment - New flood control between the Mahaica and Mahaicony | G$ 334 M |
| 3 | Boerasirie Conservancy Flood Management Project, Phase 1 and Phase 2 | G$ 200 M initial phase |
| 4 | EDWC Flood Management Project, Phase 1 and Phase 2 | G$ 1055 M |
| | Region 4 Priority Works | G$ 295 M |
| Total costs | | G$ 2405.5 M |
| | | US$ 12 M |

The following works are considered as medium- and long-term works:

| **Medium Term/Medium Priority** | | |
|---|---|---|
| Region | Work | Costs |
| 2 | Various small scale drainage works in north/east | G$ 53.5 M |
| | Improvement of drainage infrastructure along the Pomeroon River | P.M. |
| 5 | MMA Drainage Improvement Works | G$ 125 M |
| | Region 5 Drainage Improvement works | G$ 242 M |
| 4 | Drainage Improvement Works | G$ 75 M |
| Total costs | | G$ 495.5 M |
| | | US$ 2.5 M |
| **Long Term/Low Priority** | | |
| Region | Work | Costs |
| 5 | Dredging Investigation on Mahaica River | G$ 580 M |
| Total costs | | G$ 580 M |
| | | US$ 2.9 M |

## Key recommendations

### 1. National Flood Management Strategy

Future floods are inevitable and the investment available for reducing the impacts of flooding is both finite and limited. It is therefore recommended that a National Flood Management Strategy (NFMS) be developed as soon as possible to better target investment on a planned and rational basis for reducing the impacts of floods. The Strategy needs to move beyond a list of drainage infrastructure rehabilitation projects (though drainage rehabilitation/improvements will form significant projects under the drainage component of the strategy). Instead it needs to integrate all the tools available for managing and reducing the impacts of floods both in the short and longer term, including disaster preparedness, mitigation, management, post-disaster recovery and longer term regulation, policy and social change with respect to floods and drainage. Such a holistic approach will encourage wise and well planned investment.

The Strategy should be live and updatable rather than a report that is "left on the shelf" (and forgotten). As such it will be an action plan for an integrated programme of measures for improved flood management.

The strategy may identify new requirements needed for agriculture, environment and higher drainage standards for settlements and in line with, for example, expected sea level rise will result in the need for an upgrade of the drainage infrastructure. Within this Flood Management Strategy policy and institutional reforms may be required e.g. using a Water Board Model at a regional level under the supervision of a national Ministry.

A more detailed scope and terms of reference for the NFMS need to be developed.

### 2. Disaster Preparedness and Management

As new rains are only a few months away and knowing that the soils are still saturated and new storage capacity is hardly available a quick-scan of the present situation is necessary. The government should be aware of the situation and the relevant government departments (NDIA, CDC etc) need to ensure disaster management plans are in place now to prepare for the risk of flooding during the next rainy season, both to reduce the risk (e.g. by carrying our pre-rains maintenance) and to be prepared if it does occur again (disaster management).

In the longer term this type of quick-scan should be part of a Flood Risk Management Plan based on planned drainage infrastructure and the vulnerability of reduction measures and linked to disaster preparedness. Well-trained people of the relevant government departments should be planning for the next rainy season.

Additional measurements regarding the discharge of water particularly on the Mahaica and Mahaicony Rivers seem to be necessary whilst river levels are high and natural discharge based on gravity is slow.

## 3. East Demerara Water Conservancy Dam and Relief Improvements

Major works to the EDWC (dam strengthening/replacement and a major new relief structure) remains one of the most urgent and highest priorities. The scale and nature of the proposed works will require proper investigation and design. Options need to be examined, more detailed costings developed and works designed to suitable engineering standards. This can only be done following further topographic survey, hydraulic analysis, geotechnical investigations and geotechnical analysis.

The situation of the dams of the conservancies is both complex and critical. Raising the dams may lead to a failure of the dam, which may cause a huge impact. Therefore it is recommended to carry out soil survey at various places along the dam as part of the project for EDWC dam improvements. This survey will provide information for a sound design of the dam.

Designs and construction works to the EDWC are relatively independent of the outcome of a National Flood Management Strategy. Data collection and analysis could be started as soon as funds are available and could run concurrently with development of the NFMS.

## 4. Integrated response from donors

Funds from donors for emergency drainage works often require a short timescale for implementation. The nature of the flood events mean that the drainage and irrigation system tends not to suffer major damages (unless there are major breaches of conservancy dams) but extensive works have to be carried out in an attempt to control and alleviate the extent of the flooding in the different communities. Considerable losses were experienced to drainage infrastructure in the 2006 flood (of the order of G$ 500 M). Thus there is considerable value in emergency funds to compensate for losses incurred to drainage infrastructure and to carry out small scale/simple works in preparation for the next rainy season.

However this leaves the risk that larger scale emergency works are left out as they have a longer lead time, because they require data collection, planning and design (as well as a longer construction period). These larger scale emergency works then rely on implementation of a loan programme, which has a long period to completion (e.g. 5 years plus).

**It is therefore strongly recommended that donors consider how such emergency funds can be mobilised for larger scale emergency works. The flood events in Guyana ask not only an immediate but also a well-founded response. Sound technical investigation and design will benefit the sustainability of these works but requires flexibility in how emergency funds are disbursed.**

**In addition we recommend that donors consider how they can proactively provide practical assistance to government departments in the development of programmes and projects, such as those outlined in this report. This is urgently needed to kick-start the process.**

## Other recommendations

### Survey and test dredge in Pomeroon River

Sedimentation in the mouth of the rivers may cause constriction and higher water levels. As the feasibility of dredging up to now not can be proven a test dredge is recommended. It is recommended to start this test dredge in the mouth of the Pomeroon River as if results are positive there will be benefit to a large number of small farmers living along the Pomeroon riverside. Doing a test dredge needs an accurate survey- and monitoring programme. Arrangements should be discussed with Sea Defence whereby the investigation is tied into its ongoing coastal management and capacity building programme, which includes ongoing training in coastal process modelling. Sea defence also have appropriate equipment for bathymetric survey.

### Capacity building – Survey - Modelling

Appropriate data is the basis for future management of the hydraulic infrastructure in the coastal areas. An upgrading of the hydrological information system (including extension of the observations network, surveying, stage and flow measurements, data collection, processing and analysis, storage and dissemination carried out by trained staff) is a necessity. Modelling capacity should be developed to create a sound basis for design of the hydraulic infrastructure. Education and training of employees, equipment and facilities are necessary for accurate water management.

### Alternatives and Communication

Environmental aspects will influence the designs for hydraulic infrastructure. An overview of the hydraulic infrastructure as a system is necessary to understand the consequences of designer's solutions. Alternatives can be considered. Pro-active communication with people concerned is necessary to get design options accepted and optimised.

### Timescales

A suggested timescale for implementation is indicated in the following table.

| Activity | Programme | Time scale (months) | Costs |
|---|---|---|---|
| Drainage Works design and implementation | Short Term<br>Medium Term<br>Long Term | 0 - 24<br>12 - 36<br>> 24 | G$ 2405.5 M<br>G$ 495.5 M<br>G$ 580 M |
| National Flood Management Strategy | Short Term | 0 - 8 | G$ 100 M |
| Communication with farmers, local people etc. | On going | Continuously | P.M. |

# 1 Introduction

In addition to the situation in January 2005 large parts of the coastal area of Guyana were hit by another period of excessive rainfall and related flooding in the period December 2005/January 2006.

Upon the request of the Government of Guyana and in consultation with the Resident Coordinator of the United Nations Development Programme (UNDP) the United Disaster Assessment and Coordination (UNDAC) team invited two teams of specialists for assistance in making both a socio-economic assessment of damages and losses (ECLAC Team) and a technical assessment of damages and losses to infrastructure (Engineering Team).

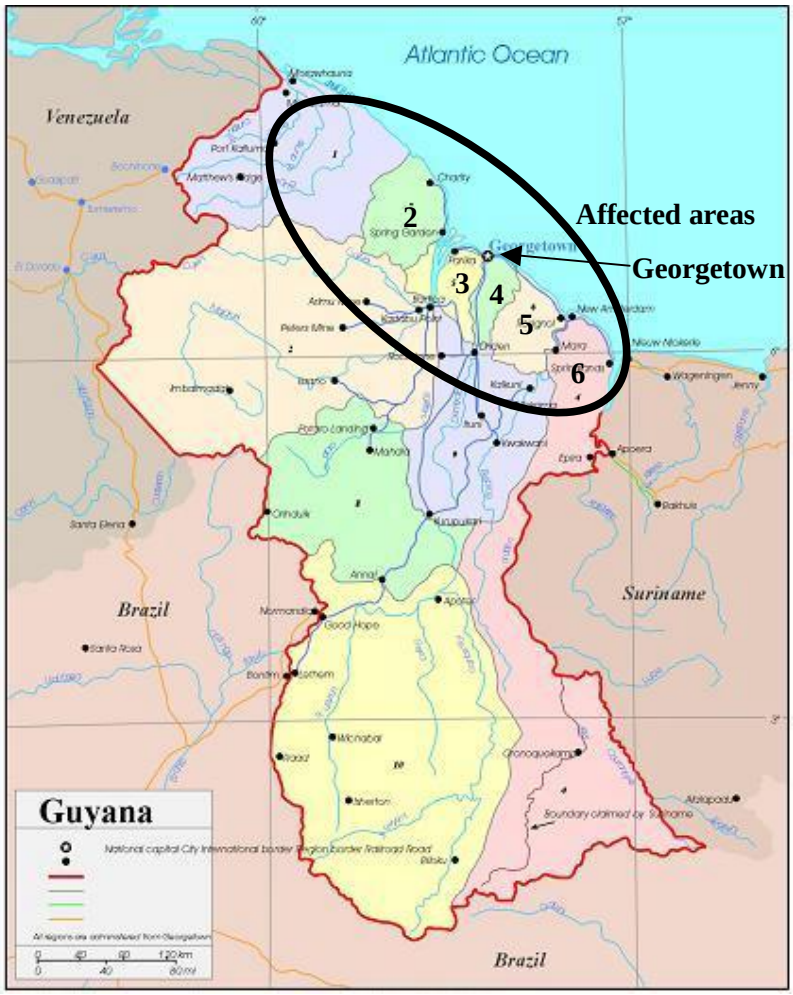


***Figure 1-1:** Map of Guyana*

This report presents the findings of the Engineering Team as a technical assessment of damages and losses to infrastructure caused by the floods of December 2005 and January 2006.

Three experts in drainage, flood control, geotechnics, hydraulics, sea and river defence and construction works were deployed to the UNDP team, from February 7th till February 23rd.

The objective of the mission is presented in the Terms of Reference (TOR) enclosed as Appendix No 1. The key tasks for the Engineering Team were:

- Conduct a hydraulic assessment of the sources and causes of flooding in the flood-affected areas of Regions 2 and 5.
- Make recommendations on the rehabilitation and improvement of the drainage infrastructure including consideration of dredging of the estuaries of the Pomeroon, Mahaica, Mahaicony and Abary rivers.
- Make recommendations for the development of a comprehensive approach and plan to address national drainage and irrigation.

The assessment concentrates on Regions 2 and 5 as the worst affected regions this year but also considers Regions 3, 4, 6 and Georgetown in the overall strategy. It should be noted that Region 1 has also been affected by flooding, however it has not been possible within the time available for this mission to cover that Region.

The Engineering Team was a joint cooperation between experts of:

- Engineering Consultants Mott MacDonald, England
- Ministry of Transport, Public Works and Water Management, the Netherlands
- WL|delft hydraulics, the Netherlands

The Team consisted of the following members:

- Mr. Andrew Kirby (Mott MacDonald)
- Mr. Peter Meesen (Ministry of Transport, public Works and Water Management)
- Mr. Henk Ogink (WL|delft hydraulics)

# 2 Background

## 2.1 The 2005 floods and the donor response

Between 15th and 22nd January 2005 the coastal regions of Guyana, in particular Region 4[1] (including Georgetown), and to a lesser extent Regions 3 and 5, received extremely heavy and prolonged rainfall, (in the order of 800mm), which led to widespread flooding. The East Demerara Water Conservancy Dam (EDWC) overtopped leading to increased flooding of the Region 4 coastal area. The drainage structures and channels discharging into the Demerara River had insufficient capacity to deal with the massive inflow into the EDWC. To save the EDWC Dam excess waters were released through the Lama Sluices which resulted in severe flooding in the Mahaica area (east Region 4, west Region 5), with extensive loss of the rice crop.

Upon the request of the Government of Guyana, a United Nations Disaster Assessment and Coordination (UNDAC) team was deployed by OCHA on 23 January 2005. Based on initial assessments of the situation, the UNDAC team alerted the Joint UNEP/OCHA Environment Unit (Joint Unit) about a potential collapse of the EDWC dam, which would result in further and more extensive flooding.

Two experts of the Ministry of Transport, Public Works and Water Management of The Netherlands were deployed to assist the UNDAC team, from 2 to 11 February 2005.

The UNDAC mission to Guyana in February 2005 prepared an Action Plan for the Emergency Works needed to be carried out prior to the May/June 2005 rains.

The Plan[2] envisaged the following:

1. Restore the drainage channels from the Conservancy dam to the coast.
2. Open up the outlets in the conservancy dam that are currently out of order.
3. Repair or construct temporary fixtures to facilitate drainage of dysfunctional outlets in the sea defence
4. Equip the Repair force for the conservancy dam.
5. Draw up a Disaster Management Plan (DMP)

An immediate response to the Government's request for help was made by DfID and CIDA in Grant Aid with the monies being administered by the UNDP, the UNDP being the contracting party on behalf of the Government of Guyana and the Donor Group.

For Emergency Drainage & Irrigation (D&I) repairs DfID provided £950,000 and CIDA C$1.870 million, whilst for international consultants DfID provided £217,056 and CIDA C$0.362 million.

The Donors agreed to fast-track their procedures. The Government of Guyana agreed to fast-track her administrative procedures, including tendering procedures, to enable immediate start of the works.

[1] See Location Map in Figure 1-1 for the location of Regions 2, 3, 4 and 5

[2] UNDAC Mission to Guyana 2005 – Geotechnical and hydraulic assessment of flooding damage caused by the East Demerara Water Conservancy Dam, Nisa Nurmahomed and Olaf van Duin, February 2005

## 2.2 Emergency Works and the Task Force for Infrastructure Recovery

A Task Force for Infrastructure Recovery (TFIR) headed by Mr. Ravi Naraine of the Ministry of Agriculture – National Drainage and Irrigation Board, was put in charge of the contracting of the measures identified in the Action Plan and engaged with supervision, investigations, payment, coordination and management of the whole programme until the coming rainy season of May-June 2005.

The donors, through UNDP agreed to engage a Special Advisor (SA) and a small support team to liaise between the donors and the Government, and to help and support the TFIR in ensuring adequate progress and supervision of the quality of works, and ensure accountability, notwithstanding the use of fast-tracking procedures to minimise procurement delays. The TFIR separately engaged local consulting engineers to provide on-the-ground engineering staff and clerks of works to oversee contractors.

Mr. Olaf van Duin, one of the earlier engineers of the UNDAC team was made available from 04th to 25th March 2005 as the SA to further detail and initiate the Emergency Works Action Plan. Subsequently Mott MacDonald Ltd (MM) was appointed to provide a Special Advisor (SA) and small support team to further these tasks. Members of the MM Team were in Guyana between 20th March and 16th July 2005.

The original UNDAC Action Plan envisaged a Budget of G$930M. The Government approved a Budget of G$800 M for Emergency Works and the works carried out are summarised in Appendix No. 8. The Emergency Works were carried out between March 2005 and August 2005 under this budget. Details of the contracts let and the scope of works carried out can be found in the Final Report of the Special Advisor to the TFIR (July 2005).

A Strategic Emergency Engineering Committee was established as a sub-committee to the TFIR tasked with the development of a plan to improve the management of water levels in the East Demerara Water Conservancy (EDWC). A water level management manual was prepared setting out amongst other things roles and responsibilities, actions in the event of emergencies, and operating rules for the opening of relief sluices.

Under the TFIR water management models were also developed of the East Demerara Conservancy and the Boerasirie conservancy. The models were used to develop the operating rules for the EDWC relief sluices for the Water Level Management Plan, to assess the capacity of the conservancies and relief structures for different flood events and to identify the shortfall in flood relief capacity. The models provided, for the first time, a sound technical basis for management and operation of the relief sluices as well as a technical basis for identifying the scope of improvements to relief required for the future. Staff in NDIA, Hydromet, Sea Defence and from local consultants were trained in the use of the model. The models are intended as a future management tool. However their use for flood forecasting is limited due to the short lead times between rainfall and response.

In addition, a programme of future works was developed under the TFIR (Infrastructure Rehabilitation Short to Medium Term Plan, July 2005), which focused on infrastructure rehabilitation and improvements rather than disaster preparedness. The plan was developed within a very tight timescale (2 weeks) and was not therefore a detailed strategy for the future. Instead its purpose was to highlight the need for continued action after the Emergency and to identify the scope, cost and timescale of the rehabilitation programme needed.

A programme of 15 packages were identified. The rehabilitation programme suggested was divided into three phases to give an overall programme duration of 5 years:

**Short Term**: next 8 months leading up to and into the next rainy season (July 2005 to February 2006)

**Medium Term**: the subsequent 22 months leading up to the December 2007 rainy season (March 2006 to December 2007)

**Long Term**: a period of 2 ½ years following on from the Medium Term (January 2008 to June 2010)

This report draws from the work carried out for this Medium Term Plan and updates it to reflect the outcome of the 2005/2006 floods.

## 2.3 Post-emergency response - 2005

As a follow on from the Emergency Works a further G$150M was requested from the GoG by NDIA for Immediate Works to be carried out before December 2005. A budget was allocated for these works and the works were carried out after the end of the TFIR. This brought the amount spent in the Emergency and Immediate Works to G$ 952 M. The works carried out under the Immediate and Emergency Works is summarised in Appendix No. 8.

The D&I budget for 2005 was originally set at G$ 540 M. This was subsequently increased by G$ 423 M to G$ 963 M for the procurement of 15 excavators for emergency works.

**The D&I budget for 2006 has been set at G$ 780 M which represents over a 40 % increase on the basic budget for 2005.**

## 2.4 2005 – 2006 Floods

Flooding began in the Mahaicony area in December and since then has become widespread, overwhelming drainage and flood control mechanisms. Thousands of residents of riverain areas have suffered and endured disruption and loss of their livelihoods.

On Saturday 28 January 2006, the President declared Regions 2 and 5 disaster areas. It was stated that the Government hoped to acquire financing for the disaster prevention and mitigation, including rehabilitation of livelihoods and drainage infrastructure. Further details by Region are contained in Section 5.

*Flooded area in Section 5 (February 15th 2006)*

# 3 Methodology

The findings and recommendations in this report are based on:

- Reports and databases out of previous studies (see Appendix No.5).
- Site observations in the field (see Appendix 2)
- Interviews with representatives of relevant UN Agencies, Government officials and Guyanese experts. In particular, the experts met with the Ministries of Agriculture and Public Works.

After collecting information the experts made analyses needed for a general view on the flooding problems and needed for prioritising the works proposed for the different Regions. The criteria for prioritisation were developed from consultations with the ECLAC Team.

The sources and causes of flooding are analysed Region by Region in more detail and this leads to a list of proposed works along with their priority.

After reporting on the assessment of proposed works an implementation strategy for flood management is suggested based on management aspects.

The overall results of the assessment are the conclusions and recommendations, which can be used as a starting point for government and donors to develop and prioritise a programme and source funding.

The experts have discussed their preliminary conclusions and recommendations with the UNDP ECLAC Team, the Government and Donors in meetings on 17th February.

# 4 Limitations

The assessment is based on a combination of information out of existing reports, existing data, estimations, site visits, interviews and experience of the engineering team. Not all the works in the proposed Programme of Works (see Appendix No. 7) have been visited during the site visits due to lack of time.

Detailed information about canals, rivers, coastal area, sluices and other constructions was hardly available. Notwithstanding this lack of information, the engineering team is convinced that the conclusions and recommendations made in this report will help all the concerned parties to make the right decisions in relation to the flood risk reduction needs of the people in the coastal areas of Guyana.

# 5 Technical Assessment

## 5.1 General

Wherever water flows naturally, floods can occur, an event that can have disastrous consequences for inhabited areas. The coastal area of Guyana has experienced these consequences in both 2005 and 2006. The flooding in the coastal areas of Guyana occurred by a combination of high intensity rainfall and high water levels on the rivers. The capacity within the system of drains, sluices and conservancies is too small too discharge all this water effectively.

### 5.1.1 Sources and causes of flooding

The flooding in December 2005 – January 2006 is mainly caused by the long period of excessive rainfall. After one month of excessive rainfall the ground becomes saturated and natural storage areas are full. When raining continuously for more than one month large scale flooding will occur. Also the maximum storage capacity of the water Conservancies becomes exceeded and starts running over and extra water will be discharged in to the overburden areas. Small scale flooding also occurs after a short period of extreme intense rainfall when drainage infrastructure is not able to discharge the water quickly enough. Insufficient management of the complex water based infrastructure increases the probability of flooding problems. Pro-active actions may reduce the risks of flooding.

### 5.1.2 Assessment of the Works

The emergency works and the works that have been realised under the Task Force for Infrastructure Recovery will have improved the drainage situation in the coastal area, especially in Region 4. However, the recent flooding in 2006 showed that still a lot has to be done, especially in Region 2 and Region 5, the 2006 Disaster Areas.

The Ministry of Agriculture – National Drainage and Irrigation Authority (NDIA), produced a list of projects intending to improve the drainage system in all the regions by rehabilitation and enlargement of the system capacity, see Appendix No. 7. The Engineering Team used this list of works as a basis for the technical assessment. In addition assessment was based on the Infrastructure Rehabilitation Short to Medium Term Plan prepared in July 2005.

### 5.1.3 Prioritising and Criteria

The Mission Team carried out an initial prioritisation of the proposed works out of the NDIA list (Appendix No. 7) based on the following criteria:

**Effect of the works in relation to people and area affected**

It will be positive when the works benefit more people and/or a larger area. A larger area means that more farmers benefit from the improved drainage/protection. Also, it will be positive when works may stimulate local people in a quick restart of their agricultural activities.

**Effect of the works in relation to benefits for overall hydraulic infrastructure/agriculture**

Every single work is related to this complex total hydraulic infrastructure. It will be positive when works or packages of works also benefit the rest of the related infrastructure. Also, it will be positive when the works or the package of works fits within a medium or long-term solution in dealing with the flooding problems. Also it will be positive when the proposed works immediately will improve the local situation in relation to flooding.

The given criteria are discussed with the ECLAC Team. Due to a lack of data the scores based on the given criteria are mainly based on a qualitative expert judgement.

When works of the list are strongly technically related to each other than they are assessed together.

The scores are based on a ranking scale of 0 - 5:

- 0 means hardly any positive effect
- +5 means a maximum positive effect

The weight of the criteria will be handled as given in the following table.

| No. | Criteria | Weight factor |
|---|---|---|
| 1 | Effect in relation to people and area affected | 2 |
| 2 | Effect in relation to benefits for overall hydraulic infrastructure/agriculture | 4 |

The weight factor for Criteria No. 2 is higher based on the assumption that works, which fulfil this criterion, will be more sustainable.

For prioritising see Appendix No. 6

## 5.2 Region 2

### 5.2.1 Sources and causes of flooding

In December 2005 and January 2006 Region 2 experienced the most severe rainfall on record; the December total was twice the normal amount, whereas in January the Region received 5.5 times the normal amount, see Figure 5.1. Though the January 2006 rainfall was only slightly higher than in the year before, this time it was preceded by a wet December month. These heavy December rains saturated ground within the catchment and filled natural storage creating the conditions for the Pomeroon to flood following the excessive rainfall in January. As a consequence, the river embankments along the lower Pomeroon were overtopped and the flood water caused severe damage to diverse crops and fruit trees. The low height river embankments protect the low lying cultivated land from the tidal influence within the river and to some extent from high fluvial river levels. This flooding from the Pomeroon extended the duration of flooding which had started already in December due to local rainfall and insufficient drainage capacity combined with runoff from the back lands. Though the rainfall in the 2005-2006 rainy season was the highest observed, the Region has experienced 4 more events of a similar nature since 1940. Therefore, the recurrence interval of flooding can be estimated at 10 to 15 years, with a higher probability of occurrence in the November-January rainy season compared with the May/June rainy season. Further details can be found in Appendix No. 4

Sedimentation in the mouth of the Pomeroon negatively affected the discharge capacity of the river. However, the scale of it and its effect on the flood levels is difficult to assess as neither hydrographic surveys nor hydrologic monitoring data are available. However, in the lower reach of the Pomeroon River the January 2006 flood level exceeded the spring tide level only by about one foot as reported by locals.

Furthermore, the flood levels in the Pomeroon are increased by drainage of the Coizer/Pomeroon area, which used to drain directly to the Atlantic Ocean, and by drainage of a swamp in the Wakapau area, whose outlet now joins the Pomeroon further upstream. The sizes of these areas are however small compared to the basin area and their effects on the flood levels are likely to be very small.

It was further reported that in January 2006 the dam of the Ituribisi Conservancy was overtopped and that the area adjacent to its outlet downstream of the Conservancy dam was flooded, caused by lack of drainage capacity.

Flooding was also reported in the Charity area. No reports of significant flooding were received from areas in the rest of the coastal zone.

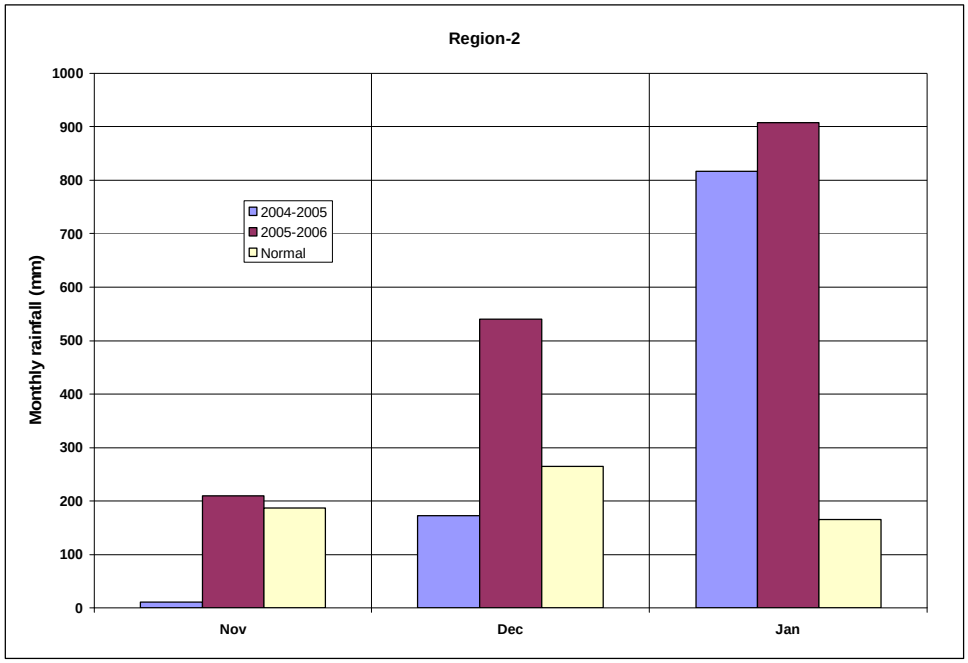


***Figure 5.1:*** *November to January rainfall 2004-2005, 2005-2006 compared to normals*

### 5.2.2 Emergency works carried out

In 2005 no Emergency Works were carried out in Region 2 under the TFIR due to lack of time but works were carried out under the budget of 'Immediate Works' to a value of about G$ 19.9 M (US$ 0.1 M). These works can be summarised as:

- Good Hope Main Drain, construction of flood relief structure
- Plantation Andrews, desilting of outfall channel
- Somerset & Berks, desilting of outfall channel
- Lima outfall channel, rehabilitation

The following D&I sub-projects were completed in 2005/ongoing in Region 2 by PRCSSP to a value of about G$ 85.1 M (US$ 0.4 M):

- Supernaam, construction of 26'x34'Wharf
- Little Tri-Best, Macedonia, Lower Pomeroon, rehabilitation and excavation of channels
- New Road North, Somerset & Berks, de-silting of canals and construction of structures
- Middlesex/Pomona, excavation of channels, construction of water control structures
- Fairfield/Vilvoorden, excavation of channels, construction of water control structures
- Mainstay/Whyaka, cleaning, de-silting of channels

### 5.2.3 Future planned works

No areas in Region 2 were selected for rehabilitation under the ASP loan. The rehabilitation of the Dawa pump station, the construction of a drainage sluice at Golden Fleece and the construction of the West Burry sluice were realised under EU/IFAD loans. The 2006 D&I budget contains some G$ 66.6 M of maintenance and rehabilitation works in Region 2, a relatively small proportion of the total budget of G$ 780 M. This comprises a range of works including:

- Johanna Cecilia/Zorg, rehabilitation of channels and structures and improving access to dams
- Fear Not, rehabilitation of channels and structures and improving access to dams

- Riverstown/Onderneeming, rehabilitation of channels and structures and improving access to dams
- Zorg, Golden Fleece, rehabilitation of channels and structures
- Bethany, rehabilitation of channels and structures
- Abram Zuil/Annadale, rehabilitation of channels and structures and improving access to dams
- Colombia/Aberdeen, rehabilitation of channels and structures and improving access to dams
- Three Friends/Land of Plently, rehabilitation of channels and structures and improving access to dams
- Sparta, rehabilitation of channels and structures and improving access to dams
- Maria's Deight, rehabilitation of channels and structures and improving access to dams
- Onderneeming/Johanna Cecilia, rehabilitation of channels and structures and improving access to dams
- Bremen/Perseverance, rehabilitation of structures and improving access to dams
- Walton Hall, rehabilitation of channels and structures and improving access to dams
- Windsor Castle, rehabilitation of structures and improving access to dams

### 5.2.4 Proposals for Region 2

**General**

Over and above the D&I budget for 2006 the NDIA has recommended the need for a programme of emergency works at a cost of G$ 250 M for areas in Region 2. This includes:

- Drainage works at Cozier/Pomeroon area (G$ 123 M)
- Drainage works at Charity (G$ 31.5 M - G$ 35 M)
- Rehabilitation of Ituribisi Conservancy Embankment (G$ 20 M)
- Drainage works at Sommerset and Berks (G$ 22 M)
- A series of small works up to G$ 14 M in size for cleaning and rehabilitation of drains and dams (G$ 53.5 M)

In addition a dredging operation in the Pomeroon River Mouth has been suggested at a cost of (G$ 220 M).

Another project, which would reduce the risk of flooding, especially in the western part of Region 2, is raising the river embankments along properties near the Pomeroon River.

**Drainage works at Cozier/Pomeroon area**

A total package of works at the Cozier/Pomeroon area will increase the capacity for water discharge from an area of about 8000 acres. The package of works consists of:

- Desilting of Cozier outfall
- Desilting of drainage canals
- Rehabilitation of Cozier pump station/Pomeroon
- Rehabilitation of Cozier/Pomeroon Sea Sluice

The Mission team visited the canal: Cozier (or Hope & Success). It was reported that the Cozier/Pomeroon Sea Sluice is not functioning well due to siltation. This results in a situation that water in this area has to be discharged mainly into the Pomeroon River. Together with the fact that the Cozier pump station is not functioning well, water in this area cannot be discharged quickly enough and flooding occurs in case of excessive rainfall. Excavation of Cozier outfall, repair of the pump station and clearing the drainage canals may result in better drainage infrastructure.

The costs of this package of works is estimated in the order of G$ 123 M. Most of these costs are related to the rehabilitation of the pump station (G$ 100 M).

Attention should be paid to the small sluices within the hydraulic infrastructure of this area. Not all of these sluices are functioning well and form obstacles in canal flow when discharge is needed.

**Drainage works at Charity**

Drainage of a housing area of about 2,000 households (300 acres) is restricted by the small size and dilapidated condition of its outfall sluices to the Pomeroon river. In case of excessive rainfall this discharge capacity is insufficient and flooding occurs. Additional outfall capacity into the Pomeroon River is needed. The following package of works are proposed to benefit the drainage infrastructure at Charity:

- Construction of a Drainage Sluice
- Desilting of the Canal at Charity

The Mission team visited the potential locations, both for the Drainage sluice and the Charity canal. It seems obvious that siltation and overgrowth in the canal are decreasing the discharge capacity and that the outfall capacity is insufficient to adequately drain the housing area particularly during high river levels. The potential location for an additional sluice is alongside the Pomeroon River.

The costs of this package of works is estimated in the order of G$ 31 M up to G$ 35 M. Most of these costs are related to the construction of the new sluice (G$ 30 M).

**Rehabilitation of Ituribisi Conservancy Embankment**

The Ituribisi Conservancy Embankment was not visited by the Mission team. It is said that the embankment and the relief channel were overtopped and rehabilitation of parts of the embankment is necessary. Works on the conservancy embankment were identified as a need in 2005.

The costs of these works are estimated in the order of G$ 20 M.

**Drainage works at Sommerset and Berks**

Water in this area cannot be discharged quickly enough due to the insufficient capacity of the outfall sluice. Siltation in the outfall channel also reduces the water discharge capacity of the infrastructure. This package of works consists of:

- Widening of relief structure at Somerset and Berks
- Construction of Timber revetment

The Mission Team did not visit the relief structure.

The costs of this package of works is estimated in the order of G$ 22 M. Most of these costs are related to the construction of the timber revetment G$ 14 M.

**Various small-scale drainage works in northern/eastern part of region 2**

This area consists of about 35,000 acres of coastal land divided by several canals. All of the different works are related to a small part of this area. The package of works consists of:

- Widening of relief channel at Good Hope to Pomeroon Supernaam River
- Construction of Relief structure and desilting of relief channel at Riverstown

- Raising of northern embankment at Unu Creek Relief Channel
- Desilting of Relief Channel at Unu Creek
- Construction of Timber Revetment at Unu Creek Outfall
- Construction of relief structure at mainstay Main Canal
- Construction of relief structure and raise embankment of relief channel at Capoey Main Canal
- Construction of timber revetment at Plantation Andrews outfall.
- Desilting of relief channel at Mainstay
- Desilting of canal at L'Union

These proposed works were not inspected. The estimate of works would need to be developed into a targeted programme. This should be carried out leading on from a coherent Drainage and Flood Management strategy for Regions 2 through 6.

The costs of this package of works is estimated in the order of G$ 53.5 M.

**Dredging the Pomeroon river mouth**

The mouth of the Pomeroon River was inspected by boat.The Pomeroon River enters the Atlantic Ocean along a north-easterly alignment. A significant sand bank is evident running from the east towards the west. At low-tide the water is very shallow and sand/mudbanks stand clear. There is no bathymetric survey of the Pomeroon River mouth.

Locals report that a dredging operation was carried out in the early 1970s using a dredger the "Steve N". It is reported that there were problems with dredging due to the quantity of coconut shell in the sand banks that had been washed down to the sand banks from copra production on the Pomeroon river banks. It is indeed conceivable that such shells may have affected the operation of a cutter suction dredger. It was reported that sand banks returned rapidly after the dredge – within six months. No written records of this dredge were found therefore the anecdotal evidence could not be confirmed.

Dredging the mouth may provide some reduction in flood levels. However it is not possible with the information currently available to determine by how much flood levels would reduce or how frequently dredging operations would need to be carried out. Sustainability in the face of the known movement of sediment along the coast is of key concern. Investigations would be required to prove the benefits and sustainability of dredging. Such investigations would take in excess of a year.

It is suggested that an initial investigation be carried out into the benefits and sustainability of a dredging solution. Arrangements should be discussed with Sea Defence whereby the investigation is tied into its ongoing coastal management and capacity building programme which includes ongoing training in coastal process modelling using DELFT-3D. There is an invaluable opportunity to strengthen their training with practical investigation. However a decision on this would be needed rapidly as further training is planned shortly (end of February). It is suggested that one river mouth is chosen for the investigation. Either the Pomeroon or the Mahaica is suggested as an example as sedimentation appears more pronounced at these two. The investigation will require bathymetric survey – which could be carried out using Sea Defence's echo sounding equipment. A trial dredge could be carried out and post-dredge surveys undertaken to investigate the rate of sedimentation. Morphological modelling could be carried out to investigate the coastal processes. A hydraulic model of the river will also be required to assess the impact of dredging on river levels. Detailed terms of reference will need to be developed.

It should be noted that other works at the river mouths such as river training may also be part of a solution.

**Raising of dams along the Pomeroon River**

The Pomeroon River was inspected by boat. About 550 small farmers are living along the Pomeroon River. The mean landholding is about 1 to 1.5 Acres. These farmers produce for both their own consumption and markets. In January most of the river embankment dams were overtopped and the farms were flooded. Crops and fruits like coconut and avocado were affected. It should be noted that unlike rice such crops take a long period to mature and crop and therefore represent a long term investment for people.

It is suggested that small scale operations, helping farmers to raise the dams along their properties would benefit these people a lot. Not only by preventing them from being flooded again, but also by providing some income in the short term. The costs of such an operation is estimated at G$ 100 M.

**Improvement of drainage infrastructure along the Pomeroon River**

During the site visit in the areas along the Pomeroon River is was noticed that maintenance of the drainage infrastructure was poor. Especially in times of high water levels open canals are necessary for a rapid discharge of water. Such an operation can be combined with the raising of the dams in the Pomeroon area.

### 5.2.5 Region 2 Proposals in summary

The table below summarises the proposed projects. See Appendix No. 6 for prioritising.

| **Drainage works at Cozier/Pomeroon area** | | | |
|---|---|---|---|
| Ranking: 1 | Cost: G$ 123 M | Priority: High | Timescale: Short Term |

| **Drainage works at Charity** | | | |
|---|---|---|---|
| Ranking: 4 | Cost: G$ 31.5 M | Priority: High | Timescale: Short Term |

| **Rehabilitation of Ituribisi Conservancy Embankment** | | | |
|---|---|---|---|
| Ranking: 4 | Cost: G$ 20 M | Priority: High | Timescale: Short Term |

| **Drainage works at Sommerset and Berks** | | | |
|---|---|---|---|
| Ranking: 2 | Cost: G$ 22 M | Priority: High | Timescale: Short Term |

| Various small scale drainage works in northern/eastern part of region 2 | | | |
|---|---|---|---|
| Ranking: 7 | Cost: G$ 53.5 M | Priority: Medium | Timescale: Medium Term |

| Data collection, analysis and test dredge in the Pomeroon river mouth | | | |
|---|---|---|---|
| Ranking: 7 | Cost: G$ 220 M | Priority: Medium | Timescale: Short term |

| Raising of dams along the Pomeroon River | | | |
|---|---|---|---|
| Ranking: 3 | Cost: G$ 100 M | Priority: High | Timescale: Short Term |

| Improvement of drainage infrastructure along the Pomeroon River | | | |
|---|---|---|---|
| Ranking: 6 | Cost: P.M. | Priority: Medium | Timescale: Medium Term |

## 5.3 Region 5

### 5.3.1 Sources and causes of flooding

Excessive rainfall in the 2005-2006 rainy season in Region 5 for two consecutive months caused widespread flooding in the catchments of the Mahaica, Mahaicony and Abary rivers. The observed rainfalls in December 2005 and January 2006 were 2.5 to 3 times as large as their monthly normals (see Figure 5.2) and the season total was 700 mm higher than in the year before. Though the December-January rainfall is the largest on record, 5 times more a similar amount has been observed in consecutive months since 1974, which would indicate that on average every 5 years flooding could be expected.

Generally, the drainage capacity of the hydraulic infrastructure in Region 5 is insufficient, which leads to a slow recession of the flood. This leads to excessive damage to the crop and loss of cattle. Farmers to alleviate the flooding of their land, thereby shifting the problems further downstream, illegally cut embankments.

Flooding along the Mahaica river worsened by opening of relief sluices on EDWC on 16 January 2006, though the land was already underwater. The amount discharged from the EDWC to the Mahaica was about 20 to 30 % of the conveyance capacity of river.

Furthermore, the outflow to the sea is hampered by sedimentation in the river mouths. For the Abary the sedimentation may have been aggravated by the control of the headwaters in the Abary Conservancy, reducing the flow to the lower Abary, though according to the MMA this is compensated for by flows from the MMA scheme.

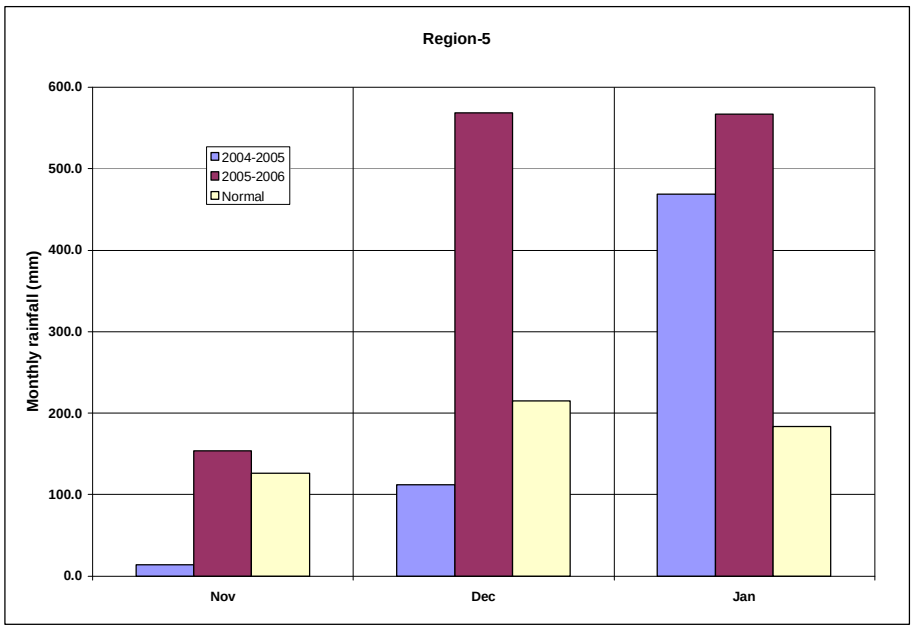


***Figure 5.2:*** *November to January rainfall 2004-2005, 2005-2006 compared to monthly normals*

There have been suggestions that water from the MMA conservancy bypassed the flanks of the MMA dam where it ties into high ground and therefore contributed to flooding outside MMA.. Whilst it is difficult to conclusively prove that this was not the case without survey, no evidence was found to support the theory. Water level records for the MMA conservancy at Copeman for December 2005 to February 2006 were examined. The maximum recorded water level was 64.5 ftGD compared with a design high flood level of 64.8 ftGD (19.8 mGD) suggesting that water levels were below design levels. Recent topographic survey of the dam crest have been carried out by the MMA authority, and was inspected, which do not show significantly low dam crest levels. The area was flown over on 15th February but no conclusions could be drawn. There remains a possibility that there is a water path from the conservancy through the higher ground but even if it exists it may not be a major flood route.

### 5.3.2 Emergency works carried out

In 2005 Emergency Works were carried out to in Region 5 to a value of about G$ 60.2 M (US$ 301,000). These works can be summarised as:

- Rehabilitation of channels – 53 miles
- Construction of flood embankments - 13 miles
- Construction of canal embankments – 3 miles
- Construction of large diameter pipe culverts – 4 No.

### 5.3.3 Future planned works

No areas in Region 5 were selected for rehabilitation under the ASP loan. The 2006 D&I budget contains some G$ 42.4 M of maintenance and rehabilitation works in Region 5, a relatively small proportion of the total budget of G$ 780 M.

### 5.3.4 Proposals for Region 5

**General**

Over and above the D&I budget for 2006 the NDIA has recommended the need for a programme of urgent works at a cost of G$ 300 M in the MMA area and G$ 630 M for other areas in Region 5. This includes:

- Refurbishment of four pumps at Trafalgar Pump Station in MMA (G$ 175 M)
- Various cleaning and rehabilitation of drains in MMA (G$ 125 M)
- Flood control dam and associated river embankments and structures between the Mahaica and Mahaicony Rivers at Bara Bara (G$ 334 M)
- Widening and dam construction on the main façade drain (the Bellamy canal) between the Mahaica and Mahaicony Rivers (G$ 54 M)
- A series of small works up to G$ 16 M in size for cleaning and rehabilitation of drains and dams (G$ 242 M)

In addition to this a dredging programme has been suggested for the mouths of the Abary, Mahaica and Mahaicony rivers at a cost of G$ 580 M.

The other high priority project that would reduce the risk of flooding in Region 5 is additional relief to the EDWC to reduce the use of the Lama and Maduni sluices. This is discussed further in Section 5.5.4.

**Trafalgar Pump Station**

The Trafalgar pump station was visited. It forms part of the drainage outfall system for the MMA scheme along with three outfall sluices (one each to the Mahaica and Mahaicony rivers and another at Trafalgar to the Atlantic coast). This electric pump station was constructed under the MMA scheme in the early 1980s to a similar design to the electric pump stations along the coast in Region 4 e.g. at Liliendaal. It had a large capacity of 2 nr x 200 cusec (5.7 $m^3/s$) and 2 nr x 150 cusec (4.2 $m^3/s$) pumps – 700 cusecs (19.8 $m^3/s$) in total. However the pumps, pipework and switchgear need significant replacement and refurbishment. At the moment two temporary pumps have been installed providing a capacity of only 40 cusec (1.1 $m^3/s$) capacity each, i.e. about 10 % of the original design capacity.

Restoring the design capacity will allow drainage during tide locked periods. It is therefore judged to provide significant benefits and is recommended as a high priority project.

**Various cleaning in MMA**

The condition of the drainage in the MMA scheme was not inspected other than as part of the fly over. The estimate of works would need to be developed into a targeted programme.

**Bara Bara Flood Control Embankment**

Currently between the Mahaica and Mahaicony Rivers there are no flood control embankments to prevent water from the upper reaches of these rivers overtopping their banks and combining with runoff from the land between from flowing from the south into the rice growing areas. The only embankment is alongside the Baiboo Canal, which was visited during the mission. This canal is approximately the southern boundary of the main rice growing area. The embankment alongside the canal is very low and therefore does not provide significant flood control. In addition it is reported that cattle farmers cut the embankment to alleviate flooding on their lands to the south.

If security of the Baiboo Canal embankment could be assured then an option would be to raise that embankment to provide better flood protection. However, this cannot be assured and also provides no benefit to cattle farmers to the south. The solution suggested by NDIA is therefore a new flood embankment some kilometres further to the south, which would run between the Mahaica and Mahaicony Rivers at a place called Bara Bara. This would provide protection to both cattle grazing and rice lands. The NDIA Engineer for Region 5 has carried out investigations into the potential alignments of the flood control embankment. The proposed alignment was visited by the mission team and seems to have been thought through. The alignment was chosen to run along a reef of higher ground, which would minimise the height of the embankment, would provide suitable borrow material for embankment construction and would avoid as far as possible deep pegasse soils.

In addition to this main embankment a flanking embankment will be required on the Mahaica River side to tie back into the existing river embankment, which currently finishes at Grass Hook. A number of sluice control structures would also be required to regulate water levels. The largest would be across the Perth-Baiboo Canal, which is the main canal to the rice area. It takes water from swamps to the south of the area. The canal is currently closed each rainy season by constructing a temporary earth dam across it. This stops floodwater from the south passing down the canal. A more permanent structure is recommended.

The proposed project appears to be a suitable solution. One concern is that the project will reduce flood storage between Baiboo and Bara Bara which will lead to increased flow in the Mahaica and Mahaicony Rivers. This could increase river flood levels further downstream where low river embankments may be overtopped.

Further survey, site investigations, hydraulic analysis and design needs to be carried out to confirm the feasibility of the proposals and to prepare proper designs. This project will be significantly more successful if it is carried out in conjunction with reducing the use of the Lama and Maduni sluices through construction of a new relief structure for the EDWC (see section 5.5.4).

This project was proposed in 2005 and was included in the Short to Medium Term Plan.

It is judged to provide significant benefits and is recommended as a high priority project.

**Bellamy Canal widening**

The Bellamy canal outfall sluice to the Mahaica river was visited by the mission team. Problems of drainage capacity were reported combined with the lack of an embankment between the drain and housing areas. The feasibility of these works could not be confirmed. Between the outfall sluice and the Mahaica river is a short (75 m) section of silted channel. Excavation of this channel prior to the rainy season would be beneficial. Potential work here has been combined with small-scale works below.

**Various small scale works in Region 5**

The proposed works were not inspected. The estimate of works would need to be developed into a targeted programme. This should be carried out leading on from a coherent Drainage and Flood Management Strategy for Regions 2 through to 6. Expanded and amended proposals for this are described in Section 8.1.

**Dredging the Mahaica, Mahaicony and Abary river mouths**

The mouths of the Mahaica and Mahaicony rivers were inspected by boat. Unfortunately it was not possible in the short time available to visit them over a low tide. For this reason and due to lack of time the Abary River mouth was not visited, other than during the over-fly.

**The Mahaica River** enters the Atlantic along a north-westerly alignment with the main outfall channel running along the Region 4 coast. Significant sand bank was evident running from the east (Region 5 bank) towards the west. Even at mid-tide the water was shallow with sediment disturbed by the boat propeller and the extent of shallow water evident by a line of sticks. At low tide it is reported that only a very small channel exists. There are verbal reports that river levels are higher than previously - attributed to constriction at the mouth. The operator of the nearby Bellamy sluice noted that the river levels are higher than they used to be which reduces the time available between tides for gravity drainage. He reported that the situation has become worse over the nearly 20 years of his experience.

There is no known bathymetric survey of the Mahaica River mouth. No record of previous dredging has been found and locals did not know of any within the previous 50 years. The only data found on the Mahaica River mouth is aerial photography from the 1970s and recent satellite imagery, though not to a very fine resolution. Few conclusions can be drawn from this data, other than confirming the general alignment of the river channel. Comparison of the two images suggests that a breakwater has been constructed since the 1970s on the Region 4 coast near Lancaster. This appears to have pushed the channel alignment away from the coast. It can be speculated that this might be one cause of increased sedimentation at the mouth. Further analysis would be required to investigate this.

**The Mahaicony River** also enters the Atlantic along a north-westerly alignment with a similar sand bank to the Mahaica evident running east to west. There is no known bathymetric survey of the Mahaicony River mouth. No record of previous dredging has been found. No firm conclusions can therefore be made on the benefits of dredging this river.

The **Abary River** mouth was not visited. Some limited survey of the mouth was made available by the MMA authority. This indicates a position of the low water channel with an alignment moving between northern and western direction. The risk of sedimentation of the river after construction of MMA Stage 1 was investigated by Hydraulics Research (UK) at the time of its design. The report on this was not available during the mission, though extracts have been quoted by the MMA Chairman indicating that the reduction in normal flows due to damming the river would to some extent be compensated by flows from the MMA scheme and that significant sedimentation was not expected. Camacho also carried out a review some years after construction.

Sea Defence (Ministry of Public Works) has an ongoing programme of coastal management and capacity building. One element of this programme has been bathymetric survey along the coast using echo sounding. Unfortunately the survey extends from Charity (Region 2) to Haslington (Region 4) and therefore does not cover any of the river mouths being considered within this report.

Dredging the mouths may provide some reduction in flood levels. However it is not possible with the information currently available to determine by how much flood levels would reduce or how frequently dredging operations would need to be carried out. Sustainability in the face of the known movement of sediment along the coast is a key concern. Investigations would be required to prove the benefits and sustainability of dredging. Such investigations would take in excess of a year.

It is suggested that an initial investigation be carried out into the benefits and sustainability of a dredging solution. Arrangements should be discussed with Sea Defence whereby the investigation is tied into its ongoing coastal management and capacity building programme, which includes ongoing training in coastal process modelling. There is an invaluable opportunity to strengthen their training with practical investigation. However a decision on this would be needed rapidly as further training is planned shortly (end of February). It is suggested that one river mouth is chosen for the investigation. Either the Pomeroon or the Mahaica is suggested as an example as sedimentation appears more pronounced at these two. The investigation will require bathymetric survey – which could be carried out using Sea Defence's echo sounding equipment. A trial dredge could be carried out and post-dredge surveys undertaken to investigate the rate of sedimentation. Morphological modelling could be carried out to investigate the coastal processes. A hydraulic model of the river will also be required to assess the impact of dredging on river levels. Detailed terms of reference will need to be developed.

It should be noted that other works at the river mouths such as river training might also be part of a solution.

### 5.3.5 Region 5 Proposals in summary

The table below summarises the proposed projects:

| | | | |
|---|---|---|---|
| **Trafalgar Pump station** – pump rehabilitation | | | |
| Ranking: 1 | Cost: G$ 175 M | Priority: High | Timescale: Short Term |

| | | | |
|---|---|---|---|
| **MMA Drainage Improvement Works** Improvement of the drainage system in MMA 5, by planned and targeted interventions of priority works | | | |
| Ranking: 5 | Cost: G$ 125 M | Priority: Medium | Timescale: Medium Term |

| | | | |
|---|---|---|---|
| **Dredging Investigation on Mahaica** - Investigation into the feasibility of dredging river mouths to reduce flooding. | | | |
| Ranking: 4 | Cost: G$ 580 M | Priority: Low | Timescale: Long Term |
| Priority for a test dredge on Pomeroon River (Region 2). Figures may be useful for Mahaica | | | |

| | | | |
|---|---|---|---|
| **Bara Bara Flood Control Embankment** - New flood control between the Mahaica and Mahaicony | | | |
| Ranking: 3 | Cost: G$ 334 M | Priority: High | Timescale: Short Term |

| | | | |
|---|---|---|---|
| **Region 5 Drainage Improvement Works -** Improvement of the drainage system in Region 5, by planned and targeted interventions of priority works based on the outcome of a Drainage and Flood Management Strategy (see Section 8.1). | | | |
| Ranking: 5 | Cost: G$ 242 M | Priority: Medium | Timescale: Medium Term |

Project profiles are contained in Appendix No. 7.

## 5.4 Region 3

### 5.4.1 Sources and causes of flooding

Unlike 2005, the January 2006 floods did not cause widespread flooding, though there was severe flooding in some areas of Canals Polder. This area is acknowledged to be particularly susceptible to flooding. The rainfall in Region 3 in the 2004-2005 and 2005-2006 rainy seasons compared to the monthly normals are displayed in Figure 5.3. It is observed that the January 2006 was less than in the previous year, but the December 2005 rainfall was significantly higher than in 2004. The season totals were practically the same. The difference though is in the short duration rainfalls; whereas e.g the 7 day total in January 2005 reached a return period level between 20 to locally over 500 years, in the last season nowhere even the 5 year return period was attained. The difference in the daily rainfall pattern may be observed from Figure 5.4, where the January 2005 and 2006 rainfall is presented. And particularly the short duration rainfalls determine the extent of flooding in the cultivated lands and create problems in the low capacity conservancies.

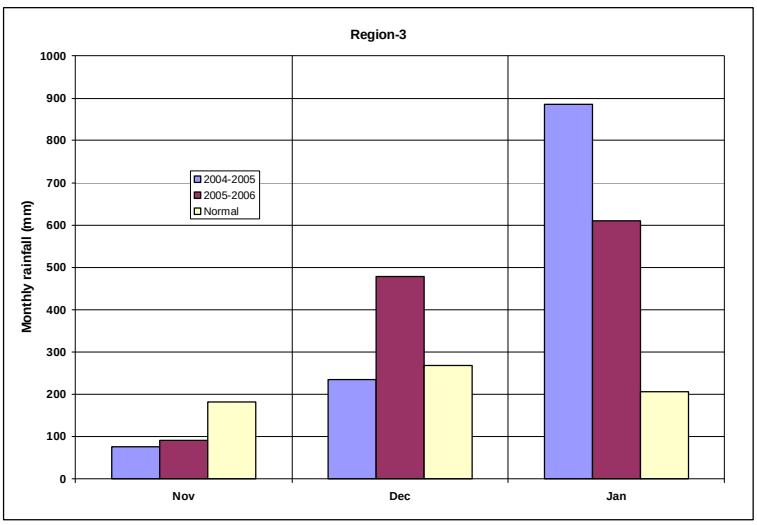


***Figure 5.3:*** *November to January rainfall 2004-2005, 2005-2006 compared to the normals in Region 3*

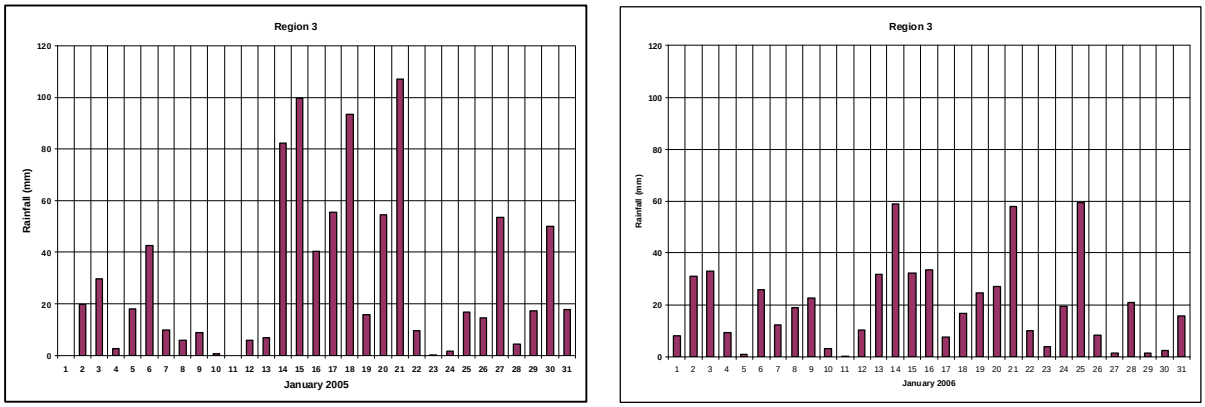


***Figure 5.4:*** *Daily rainfall in Region 3 in January 2005 and 2006*

Consequently, in 2005 there was more widespread flooding reflecting higher rainfall intensities in 2005. The Boerasirie conservancy dam then was overtopped though was not breached. The dam crest level is known to be low in relation to the crest level of its relief structures (in places the dam crest is only 60 mm above the crest level of the main relief structure, the 8,000 foot weir). The investigations by the TFIR and in particular the water level management modelling that was undertaken identified three key issues:

- Low dam crest elevation
- The need to widen waterways within the conservancy to improve flow across the conservancy to the main relief structures (the 8,000 foot weir and Waramia sluice on the western side of the conservancy
- The need to improve hydraulic conditions at the 8,000 foot weir to make full use of its potential capacity, which is currently being reduced by significant vegetation growth
- The need for an additional relief structure to reduce the risk of overtopping

Elsewhere within Region 3 flooding occurs primarily from lack of capacity in the drainage system within villages and the agricultural backlands. There is not currently a major problem with outfalls being blocked by coastal sedimentation, though regular clearance is required. As elsewhere along the coast, drains from agricultural areas frequently pass through housing areas prior to outfall into the Atlantic, exacerbating flooding in housing areas. The causes of lack of drainage capacity are common to the other coastal regions:

- Drainage has been designed for low agricultural drainage rates (e.g. 1 ½ inches/day – 38 mm/day being common)
- Urban expansion with no consequent expansion of the drainage system
- A backlog of maintenance throughout the D&I system including macro-drainage in the housing areas
- Drainage obstruction through filling in drains and rubbish dumping

These are over and above the natural disadvantages that prevent good drainage in the coastal region i.e. very flat low-lying land.

### 5.4.2 Emergency works carried out

In 2005 Emergency Works were carried out to in Region 3 to a value of about G$ 48.7 M (US$ 243,500). These works can be summarised as:

**Boeraserie Water Conservancy**

- Heightening of embankment – 7 miles (primarily between Leonora and Naamryck)
- Improvements to the relief at Potosi though re-excavation of the Patosi relief drain

**Region 3 Channels**

- Rehabilitation of Main drains - 7miles (primarily in Canals Polder)
- Rehabilitation of other channels – 11 miles
- Rehabilitation of structures – 7 No.

Due to lack of time under the Emergency Works dam heightening was halted at Tiger Dam leaving some sections between Leonora and Naamryck un-heightened.

### 5.4.3 Future planned works

Improvements to parts of the main and secondary D&I infrastructure in Region 3 is planned under the IDB Agricultural Sector Program (ASP) loan. The areas covered include Canals Polder, Vreed en Hoop/La Jalousie, Vergenoegen to Bonasika and Den Amstel/Fellowship. It should be noted that the ASP will not cover works to the conservancy dam (other than repairs to irrigation head regulators) nor does it cover drainage works within housing areas. It should also be noted that about G$ 20 M (US$ 100,000) of the works planned in Region 3 under the ASP have been carried out under the Emergency Works.

The 2006 D&I budget contains some G$ 56 M of maintenance and rehabilitation works in Region 3, a relatively small proportion of the total budget of G$ 780 M.

### 5.4.4 Proposals for Region 3

Over and above the D&I budget for 2006 the NDIA have recommended to us the need for a programme of works for the Boerasirie conservancy including rehabilitation of the low embankment sections, cleaning and excavation of relief channels and waterways at a cost of G$ 200 M (US$ 1.0 M).

The TFIR Short and Medium Term Plan identified three Region 3 specific packages. These are along similar lines to the suggested NDIA programme. In addition the Short and Medium Term Plan identified the need for a coherent Drainage and Flood Management Strategy for Regions 2 through to 6. Expanded and amended proposals for this are described in Section 8.1. All these proposals have been reconsidered and updated for this report. The value of these projects has been discussed in the Short and Medium Term Plan (SMTP) and its conclusions remain valid.

The nature of the proposed works proposed means that further data collection, feasibility study and design is required before construction. Without this investment may be wasted.

The table below summarises the proposed projects:

| | | | |
|---|---|---|---|
| 1. **Boerasirie Conservancy Flood Management Project – Phase 1 – Data collection modelling and design:** Analysis and design of flood relief measures to improve flood control on the Boerasirie Conservancy to an acceptable standard. Includes: a) topographic survey of the conservancy dam crest level to identify low areas; b) hydrographic survey of the conservancy and its waterways as data for flood management assessment; c) flood modelling - comprising hydraulic modelling to identify deficiencies in the existing system and to aid design of improvement works; d) design of improved flood control measures, comprising design of basic dam raising/strengthening measures, design of new flood relief sluice or overtopping embankments, design of internal waterways; e) preparation of tender documents for the above works f) supervision of the works.<br><br>2. **Boerasirie Conservancy Flood Management Project – Phase 2 Implementation of Works-** Implementation of flood relief measures to improve flood control on the Boerasirie Conservancy to an acceptable standard based on the outcome of the Boerasirie Conservancy Flood Management Project. Works likely to include: a) widening the waterway between Naamryck and Waramia; b) raising of low sections of embankment c) increasing the capacity of existing relief structures or construction of a new relief | | | |
| Ranking: 1 | Cost: G$ 200 M | Priority: High | Timescale: Short Term |

| | | | |
|---|---|---|---|
| **3. Region 3 Drainage Improvement Works -** Improvement of the drainage system in Region 3, beyond those covered by the ASP programme, by planned and targeted interventions of priority works based on the outcome of a Drainage and Flood Management Strategy (see Section 8). | | | |
| Ranking: 2 | Cost: SMTP | Priority: SMTP | Timescale: SMTP |

Project profiles are contained in Appendix No. 7

## 5.5 Region 4

### 5.5.1 Sources and causes of flooding

Unlike 2005, the January 2006 floods did not cause widespread flooding in Region 4, nevertheless it is understood that there was flooding in some areas.

Like in Region 3 the seasonal rainfall in the rainy season from November to January in 2005-2006 was equal to the previous year, the distribution over the months (see Figure 5.5) and particularly the size of daily rainfall intensities were very different (see Figure 5.6). E.g. in January 2005 the 3 to 7 days rainfall totals in Georgetown exceeded the 1000 year return period level, whereas in January 2006 the totals stayed well below the 5 year return period values.

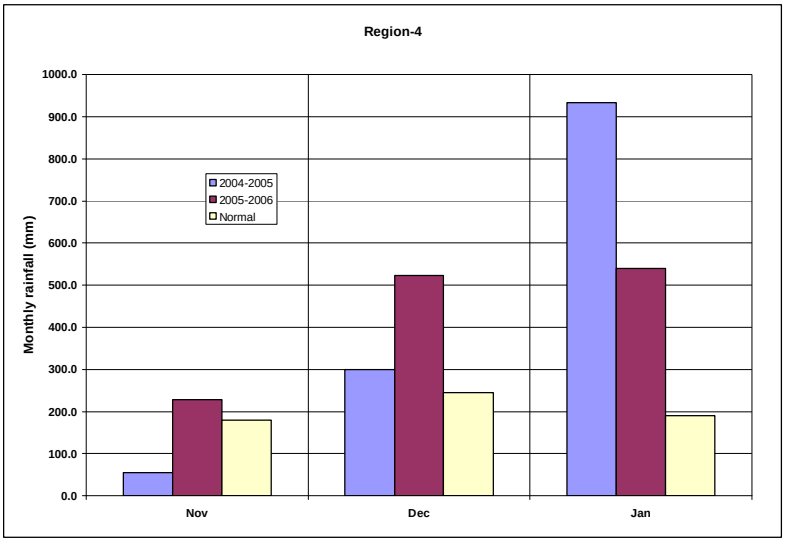


***Figure 5.5:*** *November to January rainfall 2004-2005, 2005-2006 compared to the normals*

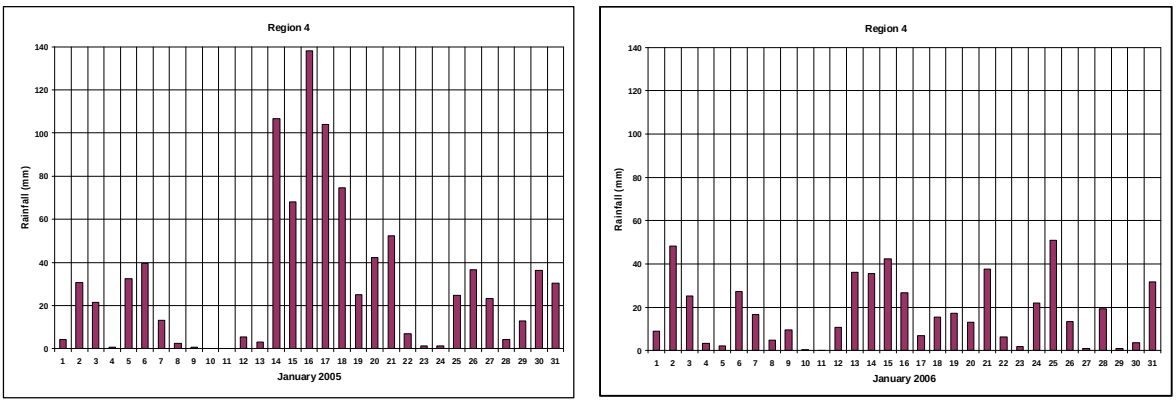


***Figure 5.6****: Daily rainfall in Region 4 in January 2005 and 2006*

Consequently, in 2005 there was much more severe and widespread flooding reflecting higher rainfall intensities in 2005. The EDWC dam was overtopped though was not breached. It is generally acknowledged, supported by technical analysis, that the dam is in a poor condition particularly between Non Pareil and Flagstaff, where excavation for borrow on both sides of the dam has created a very narrow crest with unstable slopes and poor vegetation cover.

It is also widely acknowledged that the conservancy has inadequate relief capacity, which has been confirmed by modelling carried out under the TFIR.

A further major issue is the release of water through the reliefs at Maduni and Lama into the Mahaica which can exacerbate flooding in Region 5. The capacities of the sluices at a EDWC water level of 17.95 m+datum, i.e. the maximum water level in January 2006, (see Figure 5.7) ranges, dependent on the downstream conditions, from 90 to 145 $m^3/s$, which is some 20 to 30 % of the conveyance capacity of the Mahaica.

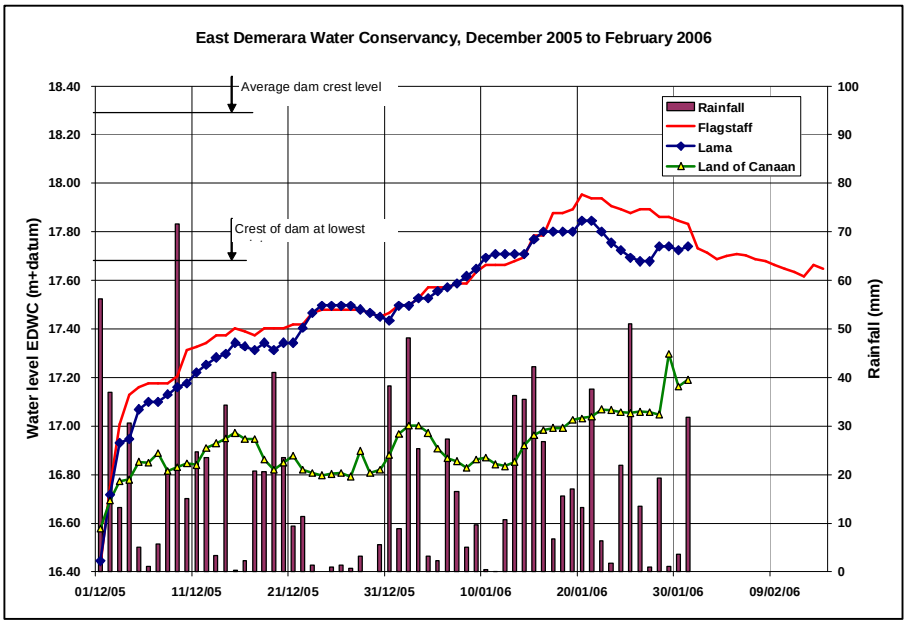


***Figure 5.7:*** *Rainfall and water levels observed in the East Demerara Water Conservancy, Period December 2005 to February 2006*

Thus previous investigations backed up by our own investigations have identified three key issues:

- The urgent need to improve the condition of the dam to reduce the risk of breaches and overtopping
- The urgent need for an additional relief structure to reduce the risk of overtopping
- The urgent need for an additional relief structure to avoid the need to operate Lama and Maduni sluices and so reduce flooding in Region 5.

Elsewhere within Region 4 flooding occurs primarily from lack of capacity in the drainage system within villages and the agricultural backlands. There is also a major problem with outfalls being blocked by coastal sedimentation with gravity drainage by sluices being replaced by pumps or combined pumps and sluices in some areas. As elsewhere along the coast, drains from agricultural areas frequently pass through housing areas prior to outfall into the Atlantic, exacerbating flooding in housing areas. In addition to the problem of blocked outfalls the causes of lack of drainage capacity are common to the other coastal regions:

- Drainage has been designed for low agricultural drainage rates (e.g. 1 ½ inches/day – 38 mm/day being common)
- Urban expansion with no consequent expansion of the drainage system
- A backlog of maintenance throughout the D&I system including macro-drainage in the housing areas
- Drainage obstruction through filling in drains and rubbish dumping

These are over and above the natural disadvantages that prevent good drainage in the coastal region i.e. very flat low-lying land.

There is therefore a general need to have an overall strategy for reducing flood risk along the East Bank and East Coast Demerara to provide a consistent standard throughout by means of assessment of current standards, identification and design of improvement/remedial works and targeted investment. This is described in Section 7.2

### 5.5.2 Emergency works carried out

In 2005 Emergency Works were carried out to in Region 4 to a value of about G$ 619 M (US$ 3.1 M). These works can be summarised as:

- Re-opening relief sluices (Khofi and Cunha) and clearing internal waterways for improvements to the EDWC (G$ 350M)
- Clearing and repair of outfall sluices (G$ 25M)
- Drainage works under the TFIR - drain de-silting, repairs to structures etc (G$15M)
- Drainage works under the RDC/NDCs – drain de-silting, repairs to structures etc (G$ 177M)
- Miscellaneous works e.g. access roads, sandbags etc (G$ 52M)

### 5.5.3 Future Planned Works

Improvements to a few areas of the main and secondary D&I infrastructure in Region 4 are planned under the IDB Agricultural Sector Program (ASP) loan. The areas covered include Cane Grove and Golden Grove to Victoria. It should be noted that the ASP will not cover works to the conservancy dam (other than repairs to irrigation head regulators) nor does it cover drainage works within housing areas. It should also be noted that about G$ 98 M (US$ 490,000) of the works planned in Region 4 under the ASP have been carried out under the Emergency Works.

The 2006 D&I budget contains some G$ 580 M of maintenance and rehabilitation works in Region 4, out of total budget of G$ 780 M. This includes G$ 95 M for emergency and repair works to the EDWC embankment.

### 5.5.4 Proposals for Region 4

**East Demerara Water Conservancy**

Over and above the D&I budget for 2006 the NDIA has recommended the need for a programme of works for the East Demerara Water Conservancy at a cost of G$ 1055 M including

- Rehabilitation of the EDWC dam (G$ 700 M)
- Works to the Cunia and Kofi reliefs (G$285 M)
- Other repairs (G$ 70 M)

The urgent need for works to the EDWC cannot be over-emphasised. Studies under the TFIR have confirmed the technical basis of what is already widely acknowledged nationally.

**The Dam**

The cost of major repair or replacement of the worst sections of dam will be considerable. NDIA have indicated above the cost of this might be of the order of G$ 790 M (G$ 700 M plus G$ 90 M from the 2006 budget) for repairs to the dam. A preliminary estimate in the Short and Medium Term Plan suggested of the order of G$ 2,200 M (US$ 11 M) for replacement of a section from Non Pareil to Flagstaff. Considerable sand bagging was carried out in both 2005 and 2006 to shore up the dam. However these can only be considered to be temporary or emergency works and are not a long-term solution.

The scale and nature of the proposed works will require proper investigation and design. Options need to be examined, more detailed costings developed and works designed to suitable engineering standards. This can only be done following further topographic survey, site investigations and geotechnical analysis.

**Additional Relief**

The Ministry of Agriculture states the need for a major additional relief structure. The Short and Medium Term Plan indicated at least a 30 m wide structure (slightly larger than the Land of Canaan sluice) would be needed if the Lama and Maduni Sluices are operated as at present. With a new relief structure also designed to pass the flows currently passing through the Lama and Maduni Sluices would need a considerably wider structure – of the order of 50 m.

The aim of providing additional relief is twofold:

- Reduce the risk of overtopping and breaching
- Avoid the need to operate Lama and Maduni sluices

Additional flood relief will provide major flood risk reduction benefits in Region 4 including Georgetown.

Also with additional relief the operating rules for the EDWC can be amended so that the Lama and Maduni sluices to the Mahaica river will only need to be opened in the event of a "national scale catastrophe" – e.g. failure of the EDWC dam. There will be direct benefits in reducing flooding to those most severely affected by the floods this year in Region 5 - between the Mahaica and Mahaicony Rivers (and probably beyond into the Mahaicony-Abary area).

The location and design of such a major structure will need further investigation. It may even take the form of two structures. Locations for the structure(s) should be considered along both the west (to the Demerara) and the north (to the coast). Though an existing main drain may form the basis for a new relief channel there is no doubt that the new channel will be larger than any existing drain. Therefore land take will be required for the relief channel footprint. There are a number of advantages of a relief to the Demerara:

- the risk of sediment problems at the outfall are avoided,
- the length of relief channel will be less,
- the route is slightly less urbanised
- water from the upper catchment can be diverted before reaching the northern dam providing that a relief channel is excavated across the conservancy

However there are also advantages of a relief to the coast:

- If provides rapid removal of water stored along the northern part of the EDWC (Non-Pariel to Flagstaff) and would keep water levels there lower than a similar relief to the Demerara
- It avoids the need to excavate large internal waterways within the conservancy.

In clarification of the advantages of the relief to the coast: water level records of the 2005 and the 2006 floods show that during floods there is a difference in water surface elevation between Flagstaff and Land of Canaan (of nearly one metre). This indicates that the conservancy does not act as a "level pool" i.e. a large single body of water but instead that there is a hydraulic gradient between the two locations. This suggests that the internal waterways of the conservancy limit flows towards the west which keep water levels along the northern dam high. Inspection of the conservancy during the fly-over of 15th February generally confirms this supposition as the northern area of the conservancy is lower and swampier than some of the higher areas near the Land of Canaan, these higher areas could reduce conveyance to a new western relief.

Options need to be examined, more detailed costings developed and works designed to suitable engineering standards. This can only be done following further topographic/bathymetric survey, modelling and hydraulic analysis.

The additional relief should not mean that the Maduni and Lama sluices are abandoned. Instead they should become a backstop in the event of an EDWC dam breach or a "Noahs ark" rainfall event.

The Short and Medium Term Plan indicated a cost of a 30 m wide structure and a short outfall at about G$ 110 M ($550,000). This is likely to be an underestimate, as it did not include excavation of new internal waterways in the conservancy, new culverts under the public road and other accommodation works. The cost of a new wider relief structure and outfall channel has been re-estimated and is likely to be of the order of US$ 1.5-2 M.

**General - Region 4**

The NDIA has also recommended the need for a programme of urgent works in Region 4 to mitigate future flooding at a cost of G$ 220 M including:

- Five mobile pumps each of 120 cusec (3.4 $m^3/s$) capacity (G$ 150 M)
- Three new outfall sluices – though two of these are also included in the 2006 budget (G$ 145 M)
- Other drainage works (G$ 75 M)

Investment in pumps has advantages and disadvantages over investment in civil drainage infrastructure. Disadvantages include:

- High recurrent operation and maintenance costs

However a key advantage is mobility. The location of drainage problems varies from year to year and mobile pumps allow a response to be targeted at specific problems when and where needed. There is also a level of public reassurance that efforts are being made to alleviate flooding. Another key advantage is that it can be used over high tides to release water during tide lock periods.

Opening/reopening of a number of outfall sluices along the Atlantic coast after the 2005 floods proved reasonably successful in alleviating flooding in the 2006 floods, e.g.

The location of drainage works proposed was not visited and therefore their efficacy could not be confirmed.

The proposals appear appropriate and a project is recommended.

**In Summary**

Major works to the EDWC (dam strengthening/replacement and a major new relief structure) remains one of the most urgent and highest priorities.

The nature of the proposed works proposed means that further data collection, feasibility study and design is required before construction. Without this, investment may be wasted.

In addition the Short and Medium Term Plan identified the need for a coherent Drainage and Flood Management Strategy for Regions 2 through to 6. Expanded and amended proposals for this are described in Section 8.1

The table below summarises the proposed Region 4 projects:

| | | | |
|---|---|---|---|
| **EDWC Flood Management Project – Phase 1 – Data collection modelling and design:** Investigations and design of dam improvements and flood relief measures to improve flood control on the East Demerara Conservancy to an acceptable standard. Services will include: a) topographic survey; b) site investigation; c) hydrographic survey; d) flood modelling; e) feasibility study of options; f) detailed design and supervision.<br><br>**EDWC Flood Management Project – Phase 2 Implementation of Works-** Implementation of dam improvements and flood relief measures to improve flood control on the East Demerara Conservancy to an acceptable standard commensurate with the risk of loss of life and major economic consequences were it to fail. Works will include: a) repair/replacement of the dam between Non Pareil and Flagstaff; b) construction of major additional flood relief structure; c) improvements to other section of the dam where its condition and stability is less than acceptable. | | | |
| Ranking: 1 | Cost: G$ 1055 M | Priority: High | Timescale: Short Term |

| | | | |
|---|---|---|---|
| **Region 4 Drainage Improvement Works -** Improvement of the drainage system in Region 4, beyond those covered by the ASP programme, by planned and targeted interventions of priority works based on the outcome of a Drainage and Flood Management Strategy (see Section 8). | | | |
| Ranking: 3 | Cost: G$ 75 M | Priority: Medium | Timescale: Medium Term |

| | | | |
|---|---|---|---|
| **Region 4 Priority Works –** Undertake targeted priority works identified by NDIA for mobile pumps, new outfall sluices and other works | | | |
| Ranking: 2 | Cost: G$ 295 M | Priority: High | Timescale: Short Term |

## 5.6 Region 6

In the 2006 flood (as well as in 2005) Region 6 escaped widespread flooding. A significant exception to this was in Black Bush Polder where again rice farmers suffered severe flooding. This appears to be a function of particularly low ground levels and silted outfalls constricting gravity drainage. There are also issues about dams being cut and not reinstated before the rainy season. Improvements to Black Bush Polder (and Lots 52-74) are planned under the ASP loan. Since the engineering team was tasked with primarily considering Regions 2 and 5 the problems of Region 6 have not been considered in detail in this report.

The Short and Medium Term Plan identified the need for a coherent Drainage and Flood Management Strategy for Regions 2 through to 6. Expanded and amended proposals for this are described in Section 8.1

There were no works carried out in 2005 under the TFIR in Region 6. The 2006 D&I budget does not include any works in Region 6 and no works were drawn to our attention by NDIA for this Region. Nevertheless emergency works have been carried out this year with an estimated cost of G$ 118 M. About G$ 33.5 M was expended on excavating silted outfall channels with the remainder spread between drain cleaning, dam repairs and other works in both NDC areas and D&I areas.

## 5.7 Georgetown

In the 2006 flood Georgetown did not suffer anything like the extent or severity of flooding experienced in 2005. There was nevertheless some localised flooding. Since the engineering team was tasked with primarily considering Regions 2 and 5 the problems of Georgetown drainage have not been considered in detail in this report. It is reported that drain and sluice maintenance and pre-rainy season preparedness was better than last year. It is reported that pumping was better at Lillinedaal and Kitty than last year.

However underlying capacity issues remain. These issues include:

- Urban planning - rapid urban expansion without similar expansion of the drainage system. Georgetown has expanded considerably over the last 50 years but without little corresponding increase in capacity of the drainage system, exceptions being construction of the Kitty pump station in 1968 and the East Georgetown Flood Alleviation Scheme in 1978
- Solid waste disposal – significant quantities of rubbish are dumped in drains
- Building control and regulation – drains are encroached on and filled in, accesses for maintenance are squatted on etc
- Backlog of maintenance of drains and sluices
- Original design capacity, even if well maintained, is not high

The condition of the drainage system was examined as part of a masterplan in 1995 (The Drainage Masterplan Georgetown Water and Sewerage Masterplan by Halcrow for Guyana Water Authority, March 1995). This indicated that the potential capacity of the existing system if rehabilitated could cope with a storm of 2 year return period (defined as 88 mm in 12 hours) though its capacity at the time of the masterplan was considerably less than that. To increase its capacity beyond a storm of 2 year return period would require new infrastructure. This suggests that flooding can be expected on a regular basis.

The Short and Medium Term Plan recommended a programme that included:

- Drainage Improvement Works - to undertake a strategic programme of rehabilitation and improvement works in the short, medium and long term focussing on drain cleaning, removal of bottlenecks in the system , rehabilitation of sluices and pump stations and long term improvement works
- Strategy development and Design including Condition Inspection and Surveys, Feasibility Study for Long-Term Improvements, Strategy for Short/Medium Term, Institutional Strengthening, Designs, Tender Documents and Supervision

It is considered that the findings of that report probably remain valid.

The programme of works will need to be integrated into a wider long-term programme to improve urban planning and control and solid waste management.

# 6 Summary proposed works

Based on the assessment carried out by the mission, described in Chapter 5, the following rehabilitation and improvement works are recommended as priority works. The works concentrate on Regions 2 and 5 though high priority works in other regions are also identified. This list should be compared and consolidated with the recommendations of the Short and Medium Term Plan of the TFIR (July 2005), which contains further priority works, and in some cases different costs for works. This review and consolidation should be carried out as part of the National Flood Management Strategy. Overlap between recommendations of the mission and recommendations of the TFIR are indicated below.

| **Short Term/High Priority** | | | |
|---|---|---|---|
| **Region** | **Work** | **Included in TFIR Plan ?** | **Costs** |
| 2 | **Drainage works at Cozier/Pomeroon area** | Y | G$ 123 M |
| | **Drainage works at Charity** | N | G$ 31.5 M |
| | **Rehabilitation of Ituribisi Conservancy Embankment** | Y | G$ 20 M |
| | **Drainage works at Somerset and Berks** | N | G$ 22 M |
| | **Data collection, analysis and test dredge in the Pomeroon river mouth** | N | G$ 50 M |
| | **Raising of dams along the Pomeroon River** | N | G$ 100 M |
| 5 | **Trafalgar Pump station** – pump rehabilitation | N | G$ 175 M |
| | **Bara Bara Flood Control Embankment** - New flood control between the Mahaica and Mahaicony | Y | G$ 334 M |
| 3 | **Boerasirie Conservancy Flood Management Project, Phase 1 and Phase 2** | Y | G$ 200 M initial phase |
| 4 | **EDWC Flood Management Project, Phase 1 and Phase 2** | Y | G$ 1055 M initial estimate |
| | **Region 4 Priority Works** | Y - in outline | G$ 295 M |
| **Total costs** | | | **G$ 2405.5 M** |
| | | | **US$ 12 M** |

| **Medium Term/Medium Priority** | | | |
|---|---|---|---|
| **Region** | **Work** | **Included in TFIR Plan ?** | **Costs** |
| 2 | **Various small scale drainage works in north/east** | N | G$ 53.5 M |
| | **Improvement of drainage infrastructure along the Pomeroon River** | N | P.M. |
| 5 | **MMA Drainage Improvement Works** | N | G$ 125 M |
| | **Region 5 Drainage Improvement works** | Y - in outline | G$ 242 M |
| 4 | **Region 4 Drainage Improvement Works** | Y - in outline | G$ 75 M |
| **Total costs** | | | **G$ 495.5 M** |
| | | | **US$ 2.5 M** |

| **Long Term/Low Priority** | | | |
|---|---|---|---|
| **Region** | **Work** | **Included in TFIR Plan ?** | **Costs** |
| 5 | **Dredging Investigation on Mahaica River** | N | G$ 580 M |
| **Total costs** | | | **G$ 580 M** |
| | | | **US$ 2.9 M** |

# 7 Conclusions and recommendations

## 7.1 Overall Conclusions

Based on the information obtained and the assessment carried out the Mission Team concludes:

**1. Works will improve the standard of the drainage system**

The works for the various regions as proposed in this report will improve the standard of the drainage system and form a basis for a further long-term approach.

**2. Future floods are inevitable**

In spite of the works, which have been done and will be done in line with the proposals in this report, future floods are inevitable bearing in mind that the standard of the drainage system is low relative to the floods experienced recently (e.g. 1 in 5 years or less). In addition because rainfall events vary considerably in severity between Regions (and between the coast and the hinterland) there is an increased annual probability that at a national scale there will be a flood event somewhere in the country, even though a particular Region or area may experience such an event less frequently.

**3. May 2006 rains may cause new flooding, still emergency!!**

During the site visits it was noticed that even by the end of February a large area of land is still flooded, especially in Region 5. Within three months a new rainy season will start and the soil is still saturated leaving the absorption capacity of the basins virtually nil. There is therefore an increased risk that heavy rain during the next rainy season will cause flooding. The government should be aware of this and the relevant government departments (NDIA, CDC etc) need to ensure plans are in place now to prepare for such an eventuality both to reduce the risk (e.g. by carrying our pre-rains maintenance) and to be prepared if it does occur (disaster management).

**4. Constriction in the river mouths**

Rivers and particularly the sea are transporting a lot of sediments along the coast of Guyana. Sand/mud banks may form constrictions in the river mouths, which leads to higher water levels in the rivers.

**5. Substantial contribution to flooding from the water conservancies**

In times of a long period of excessive rainfall the storage capacity of the water conservancies is overloaded and safe discharge of water out of the conservancies is needed. Current discharge from the EDWC to the Mahaica river is substantial and increases the flooding problems in Region 5.

**6. Lack of appropriate data**

Most of the data available is over 40 years old and insufficient for a proper approach to the assessment of the flooding problems.

**7. Environmental aspects**

In times of disaster people will react differently. It has been noticed in Region 5 people are cutting dams/embankments because they understand this will be the best solution for their particular situation. Cutting these dams undermines the drainage infrastructure.

## 7.2 Recommendations

Based on the conclusions as presented in Paragraph 7.1 the following items are recommended:

**1. Start the works as presented in chapter 6 as soon as possible.**

The short-term works as presented in Chapter 6 should be implemented as soon as funds can be made available. These works meet an immediate and clear need and are not generally dependent on the outcomes of the development of an overall strategy.

**2. Start National Flood Management Strategy**

Future floods are inevitable and the investment available for reducing the impacts of flooding is both finite and limited. It is therefore recommended that a National Flood Management Strategy (NFMS) be developed to better target investment on a planned and rational basis for reducing the impacts of floods. The Strategy needs to move beyond a list of drainage infrastructure rehabilitation projects (though drainage rehabilitation/improvements will form significant projects under the drainage component of the strategy). Instead it needs to integrate all the tools available for managing and reducing the impacts of floods both in the short and longer term, including disaster preparedness, mitigation, management, post-disaster recovery and longer term policy and social change with respect to floods and drainage. Such a holistic approach will encourage wise and well planned investment.

The strategy may identify new requirements needed for agriculture, environment and higher drainage standards for settlements and in line with, for example, expected see level rise will result in the need for an upgrade of the drainage infrastructure. See Chapter 8. Within this Flood Management Strategy policy and institutional reforms may be required e.g. using a Water Board Model at a regional level under the supervision of a national Ministry.

**3. Analysis, Flood Risk Management and Disaster Management**

As new rains are only a few months away and knowing that the soils are still saturated and new storage capacity is hardly available a quick-scan of the present situation is necessary. The government should be aware of the situation and the relevant government departments (NDIA, CDC etc) need to ensure disaster management plans are in place now to prepare for the risk of flooding during the next rainy season, both to reduce the risk (e.g. by carrying our pre-rains maintenance) and to be prepared if it does occur (disaster management).

Based on this quick-scan decisions should be made based on both expected evaporation and expected rainfall. Additional measurements regarding the discharge of water seem to be necessary whilst river levels are high and natural discharge based on gravity is slow. This quick-scan should be part of a Flood Risk Management Plan based on planned drainage infrastructure and the vulnerability of reduction measures and linked to disaster preparedness (Disaster Management Plan as recommended by Mr. Olaf van Duin and Ms. Nisa Nurmohamed, Guyana Floods, Geotechnical and Hydraulic assessment on the East Demerara Water Conservancy dam, February 2005). Well-trained people of the relevant government departments should be planning for the next rainy season.

**4. Survey and test dredge in Pomeroon River**

As stated in paragraph 5.2 and paragraph 5.3 sedimentation in the mouth of the rivers may cause constriction and higher water levels. As the feasibility of dredging up to now not can be proven a test dredge is recommended. It is recommended to start this test dredge in the mouth of the Pomeroon River as eventually positive results will benefit a large number of small farmers living along the Pomeroon riverside. Doing a test dredge needs an accurate survey- and monitoring programme. Arrangements should be discussed with Sea Defence whereby the investigation is tied into its ongoing coastal management and capacity building programme, which includes ongoing training in coastal process modelling.

**5. Start works for the improvement of discharge of water out of the conservancies**

The works as presented in the Short and Medium Term Plan and the works as proposed in this report should be implemented as soon as possible.

**6. Capacity building – Survey - Modelling**

Appropriate data is the basis for future management of the hydraulic infrastructure in the coastal areas. An upgrading of the hydrological information system (including extension of the observations network, surveying, stage and flow measurements, data collection, processing and analysis, storage and dissemination carried out by trained staff) is a necessity. Modelling capacity should be developed to create a sound basis for design of the hydraulic infrastructure. Education and training of employees, equipment and facilities are necessary for accurate water management.

**7. Alternatives and Communication**

Environmental aspects will influence the designs for hydraulic infrastructure. An overview of the hydraulic infrastructure as a system is necessary to understand the consequences of designer's solutions (see point 6). Alternatives can be considered. Pro-active communication with people concerned is necessary to get design options accepted and optimised.

## 8. Integrated response from donors

Funds from donors for emergency drainage works often require a short timescale for implementation. The nature of the flood events mean that the drainage and irrigation system tends not to suffer major damages (unless there are major breaches of conservancy dams) but extensive works have to be carried out in an attempt to control and alleviate the extent of the flooding in the different communities. Considerable losses were experienced to drainage infrastructure in the 2006 flood (of the order of G$ 500 M). Thus there is considerable value in emergency funds to compensate for losses incurred to drainage infrastructure and to carry out small scale/simple works in preparation for the next rainy season.

However this leaves the risk that larger scale emergency works are left out as they have a longer lead time, because they require data collection, planning and design (as well as a longer construction period). These larger scale emergency works then rely on implementation of a loan programme which has a long period to completion (e.g. 5 years plus). It is therefore recommended that donors consider how such emergency funds can be mobilised for larger scale emergency works. The flood events in Guyana ask not only an immediate but also a well-founded response. Sound technical investigation and design will benefit the sustainability of these works but requires flexibility in how emergency funds are disbursed.

## 9. Soil survey and design for dams conservancies

As it was stated in the report Geotechnical and hydraulic assessment of the East Demerara Water Conservancy dam (Olaf van Duin/Nisa Nurmohamed, February 2005) the geotechnical situation of the dams of the conservancies is both complex and critical. Raising the dams may lead to a failure of the dam, which may cause a huge impact. Therefore it is recommended to carry out soil survey at various places along the dam as part of the project for EDWC dam improvements. This survey may provide information for a sound design of the dam. However the survey needs to be specified and supervised by the designer of the remedial works.

## 10. EDWC Dam

Major works to the EDWC (dam strengthening/replacement and a major new relief structure) remains one of the most urgent and highest priorities. The scale and nature of the proposed works will require proper investigation and design. Options need to be examined, more detailed costings developed and works designed to suitable engineering standards. This can only be done following further topographic survey, hydraulic analysis, site investigations and geotechnical analysis.

# 8 Implementation Strategy

## 8.1 National Flood Management Strategy

The need for an over-arching National Flood Management Strategy (NFMS) has been discussed in Chapter 7. This needs to be a practical strategy to guide policy development, guide investment decisions and aid the development of action plans for the implementation of projects. The detailed scope and terms of reference for the Strategy needs to be thought through and developed by a multi-disciplinary team. The team needs to cover expertise in at least the following disciplines: flood risk management/drainage engineering, hydrology, disaster management/preparedness, socio-economics, policy development, institutional strengthening, livelihood development. Initial thoughts on the scope are discussed below.

Due to its wide ranging multi-disciplinary scope it may be appropriate for strategy development to be lead by the Office of the President. It is envisaged that the NFMS would be composed of a number of components including:

- Drainage and irrigation improvements, modernising hydraulic infrastructure
- Disaster preparedness
- Forecasting and warning (hydrological)
- Disaster mitigation
- Interaction with economical development (agriculture etc.)
- Policy development, improved regulation, improved social awareness in urban planning, building control, solid waste management
- Restoration of livelihoods (see ECLAC report)

Each component would have an action plan for the implementation of a programme of projects from the short to medium term. The action plans for each component would be lead and implemented by the relevant government department e.g. NDIA for drainage improvements.

All of the components will be important over the longer term to develop an integrated approach. The two components that should deliver "quick wins" in terms of easily realisable and demonstrable benefits are the drainage and flood control improvements component and the disaster management component. It is therefore recommended that these are considered as priority components and that projects are selected and developed under these components to deliver these "quick wins".

The drainage improvements component is likely to comprise the major component in terms of cost. An outline action plan for this component has effectively already been started through the findings of this mission and the Short to Medium Term Plan of the TFIR and can be further developed. The short term works summarised in Chapter 6 are not dependent on the outcome of the NFMS as their need and justification has already been examined.

## 8.2 Time scale for implementation

The suggested timescale for implementation is indicated in the following table.

| Activity | Programme | Time scale (months) | Costs |
|---|---|---|---|
| **Works** | Short Term<br>Medium Term<br>Long Term | 0 – 24<br>12 – 36<br>>24 | G$ 2405.5 M<br>G$ 495.5 M<br>G$ 580 M |
| National Flood Management Strategy | Short Term | 0 - 8 | G$ 100 M (consultant) |
| Analysis, Flood Risk Management and Disaster Management | Short Term | Draft: 3<br>Final: 8 | G$ 20 M (consultant) |
| Capacity building<br>Survey<br>Modelling (all regions) | On going<br>Short Term<br>Medium Term | Continuously<br>8<br>20 | P.M.<br>G$ 50 M (consultant)<br>G$ 20 M (consultant) |
| Communication with farmers, local people etc. | On going | Continuously | P.M. |