QUEENSLAND FLOODS
COMMISSION OF INQUIRY

STATEMENT OF PETER HUGH ALLEN

I, **PETER HUGH ALLEN**, of c/- 41 George Street Brisbane in the State of Queensland, Project Director (Dam Safety), Office of the Water Supply Regulator ("OWSR"), Department of Environment and Resource Management ("DERM"), state on oath:

Requirement from Queensland Floods Commission of Inquiry

1. I have seen a copy of a letter dated 2 September 2011 from the Commissioner, Queensland Floods Commission of Inquiry ("the Commission") to me requiring a written statement under oath or affirmation, which is attachment **PHA-31** ("Requirement") and which details the topics my statement should cover.

2. I initially provided a statement to the Commission dated 4 April 2011, an addendum to it dated 11 April 2011 and a supplementary statement dated 13 May 2011.

3. I have also provided a second statement to the Commission dated 12 September 2011.

Role

4. My role is relevantly described in my statement dated 12 September 2011.

Background

5. As far as I understand, there are two systems of detention basins within central Toowoomba with about 11 basins of various sizes on East Creek and 17 basins on West Creek. Both these creeks flow from southern Toowoomba roughly north to the Toowoomba CBD. They meet just to the north of the CBD and form Gowrie Creek which is part of the upper reaches of the Condamine River. The catchment areas of East Creek and West Creek are about 14 km^2 and 16 km^2 respectively. The detention basins are all owned by the Toowoomba Regional Council. The original owner was the Toowoomba City Council which was merged with nearby councils to form the Regional Council in March 2008.

6. A good general description of the catchments and the basins is given in the Commission's Exhibit 75.

Regulatory Background

7. Dam safety is regulated under the provisions of the *Water Supply (Safety and Reliability) Act 2008* (the Act).

8. Dam safety is primarily a dam owner responsibility. If an incremental population at risk (PAR) of 2 or more is identified, the Dam Safety Regulator will apply dam safety conditions to ensure that the dam owner develops and implements a dam safety management framework for the dam to reduce the risk of failure of the dam to tolerable levels.

9. Under the provisions of the Act, a Failure Impact Assessment is required to identify PAR. Prior to the commencement of the dam safety provisions of the *Water Act 2000* in April 2002, whether a dam was referable or not primarily relied on the size of the dam. This applied irrespective of where the dam was and what development was downstream of the dam.

10. Failure Impact Assessments (FIAs) are used to determine whether a dam should be referable or not. Such assessments therefore need to be sufficiently accurate to reliably assign a Category 1 or a Category 2 failure impact rating or to accurately determine if a dam should not be assigned such a rating. If it is not given a failure impact rating it is not subject to regulation under the dam safety provisions of the Act.

11. OWSR work procedure DS 1.1 covers this activity. The current version is attached as **PHA-32.**

Using the Failure Impact Assessment Guidelines

12. Failure impact assessments should be undertaken in accordance with the Failure Impact Assessment (FIA) Guidelines approved in accordance with section 342 of the Act. These guidelines detail the process for undertaking and certiying a Failure Impact Assessment.

13. The FIA guidelines were originally developed in 2001/2002 ready for the commencement of the dam safety provisions of the *Water Act 2000* which commenced in April 2002. The guidelines were formally approved in May 2002 by Bob Reilly as delegate. In 2008, the dam safety provisions of the Water Act were transferred virtually unchanged to the *Water Supply (Safety and Reliability) Act 2008* (the Act) and the guidelines were updated to reflect this change. A copy of the FIA guidelines are attachment **PHA-33**.

14. A dam is assigned a Category 1 failure impact rating if the incremental population at risk as a result of dam failure (PAR) is in the range of 2 or more persons but not greater than 100 persons. A Category 2 failure impact rating is assigned if the PAR is more than 100. People are considered to be at risk as a result of dam failure if there is an increase in water level at their residence or business of 300 mm or more.

15. The aim is that only sufficient is analysis done to ensure the category of dam is satisfactorily determined. If the PAR is on the cusp of say 'non-referable' and category 1 or category 1 and category 2 then further work might be warranted to determine which category is to be assigned to the dam. For example, a dam such as Wivenhoe Dam is obviously referable with a PAR many times the '100' PAR lower limit of category 2 and does not require any analysis (indeed such dams were deemed to be category 2 in the Water Regulation 2002). Similarly, many dams in regional Queensland have no one living for 40 or 50 km downstream of them and are obviously non-referable. Such dams virtually just need a statement to that effect by the certifying Registered Professional Engineer Queensland. However, for determining whether a Failure Impact Assessment notice is to be issued, it is all about determining whether it is 'non-referable' or 'category 1'.

Item 1: Any investigation since 2004 (all relevant reports, briefing notes and memoranda should be attached to the statement) into whether any detention basin, water storage or water course within central Toowoomba is or should be

(a) A referable dam, or

16. In order to be a referable dam there must be a Failure Impact Assessment conducted and submitted to the chief executive. If the chief executive accepts it then becomes a referable dam. There are no referable dams in East or West Creeks catchment areas. As to Failure Impact Assessments I refer to my answer in paragraphs 17 to 19 below.

(b) Required to have a failure impact assessment under the Water Supply (Safety and Reliability) Act 2008 (Qld)

17. It is important to note that in the 2011 event, none of the Toowoomba detention basins failed, so that the flood levels in the Toowoomba CBD were not aggravated by the failure of any detention basin.

18. The actions DERM has taken since the beginning of 2004 on the Toowoomba Detention Basins are summarised in **PHA-34**.

19. However, given the events of January 2011, Dam Safety, OWSR has re-commenced the analysis and Russ McConnell, a Dam Safety engineer has inspected the basins following the January 2011 event and prepared a report on the inspection. It is contained in **PHA-34**. The Dam Safety analysis is not expected to be completed before 1 December 2011 at the earliest as the Dam Safety unit has competing priorities on approximately twenty other analyses.

I make this solemn statement on oath conscientiously believing the same to be true, and by virtue of the provisions of the *Oaths Act 1867*.

Signed . [redacted]

Peter Hugh Allen

Taken and declared before me, at Brisbane this 16th day of September 2011

[redacted]

~~Peace/Commissioner for Declarations~~

Our ref: Doc 1684454

2 September 2011

[redacted]
Assistant Crown Solicitor
Crown Law
GPO Box 5221
BRISBANE QLD 4001

Dear [redacted]

Please find enclosed a Requirement to Provide Statement addressed to Mr Peter Allen, Dam Safety Regulator, Department of Environment and Resource Management.

This requirement is additional to Requirement number 1674479 dated 23 August 2011. If it is convenient, one statement covering the topics listed on each requirement may be prepared.

The return date for both Requirements is 5 pm, Friday, 9 September 2011.

If you require further information or assistance, please contact Ms [redacted] Hedge on telephone [redacted]

We thank you for your assistance.

Yours sincerely

[redacted]
Jane Moynihan
Executive Director

Encl.

400 George Street Brisbane
GPO Box 1738 Brisbane
Queensland 4001 Australia
Telephone **1300 309 634**
Facsimile **+61 7 3405 9750**
www.floodcommission.qld.gov.au
ABN 82 696 762 534

Our ref: Doc 1684437

2 September 2011

Mr Peter Allen
Dam Safety Regulator
Department of Environment and Resource Management
GPO Box 2454
BRISBANE QLD 4001

REQUIREMENT TO PROVIDE STATEMENT TO COMMISSION OF INQUIRY

I, Justice Catherine E Holmes, Commissioner of Inquiry, pursuant to section 5(1)(d) of the *Commissions of Inquiry Act 1950* (Qld), require Mr Peter Allen to provide a written statement, under oath or affirmation, to the Queensland Floods Commission of Inquiry, in which the said Mr Allen gives an account of:

1. any investigation since 2004 (all relevant reports, briefing notes and memoranda should be attached to the statement) into whether any detention basin, water storage or water course within central Toowoomba is or should be:

    a. a referable dam, or

    b. required to have a failure impact assessment under the *Water Supply (Safety and Reliability) Act 2008* (Qld)

In addressing these matters, Mr Allen is to:

- provide all information in his possession and identify the source or sources of that information;
- make commentary and provide opinions he is qualified to give as to the appropriateness of particular actions or decisions and the basis of that commentary or opinion.

Mr Allen may also address other topics relevant to the Terms of Reference of the Commission in the statement, if he wishes.

The statement is to be provided to the Queensland Floods Commission of Inquiry by 5 pm, Friday 9 September 2011.

400 George Street Brisbane
GPO Box 1738 Brisbane
Queensland 4001 Australia
Telephone **1300 309 634**
Facsimile **+61 7 3405 9750**
www.floodcommission.qld.gov.au
ABN 82 696 762 534

The statement can be provided by post, email or by arranging delivery to the Commission by emailing info@floodcommission.qld.gov.au.

C. Holmes

Commissioner
Justice C E Holmes

Department of **Environment and Resource Management**

DS 1.1 Requiring a dam to be failure impact assessed

WIR/2002/1027 – Version 1

Endorsed 02/07/2002
by Peter Allen, Director, Dam Safety (Water Supply) Office of the Water Supply Regulator

Queensland Government

Table of Contents

Version history

Version	Date	Comment
1	02/07/2002	Endorsed
1.1	11/05/2005	Conversion Project- New WORD/XML Template
1.2	24/02/2011	Under review - internet access removed

Purpose

Provide a framework for deciding whether a dam should be required to be failure impact assessed under section 343(5) of the *Water Supply (Safety and Reliability) Act 2008*.

Provide a format to use for the above notice.

Rationale

Section 343(5) of the *Water Supply (Safety and Reliability) Act 2008* (the Act) gives the chief executive the power to require a dam to have a failure impact assessment (FIA) carried out. The chief executive exercises this power by giving the owner of the dam a written notice (s. 343(5) notice).

When deciding whether a dam should be required to be failure impact assessed under s. 343(5), the chief executive is subject to certain requirements and limitations imposed by the Act.

A section 343(5) notice may be given only for an existing dam or a dam being constructed, whether or not the dam meets or will meet the s. 343(1) size criteria. A section 343(5) notice may not be given for a proposed dam (i.e. a dam where construction has not yet commenced) (however, under s. 343(1) a failure impact assessment must be prepared for the proposed dam if the dam meets the height and volume criteria in s. 343(1)(a) or (b)).

Section 343(6) provides that a s. 343(5) notice may be given only if the chief executive reasonably believes the dam would have a category 1 or category 2 failure impact rating (i.e. the dam would be a referable dam). It is not mandatory for the chief executive to give a s. 343(5) notice after forming such a belief.

If a section 343(5) notice is issued, it must:

- be given to the owner/s of the dam
- advise the dam owner/s that he or she is required to have the dam failure impact assessed and
- state a reasonable time for the failure impact assessment to be completed and given to the chief executive.

The chief executive must pay the reasonable cost of preparing and certifying the failure impact assessment (s. 348(2)(a)), if:

- a failure impact assessment is completed for a dam because of a s. 343(5) notice
- the assessment is accepted by the chief executive under s. 349(1)
- the assessment does not give the dam a failure impact rating (i.e. the dam is found to not be a referable dam) and
- the dam or proposed dam, does not meet the s. 343(1) size criteria.

Under s. 348(3), this cost includes the cost of any review of the assessment that occurs under s. 351. In any other case, the dam owner must pay the cost of preparing and certifying the assessment (s. 348(2)(b)).

A decision requiring a dam to be failure impact assessed is not subject to the review and appeal process under Chapter 7 of the Act. However, decision makers need to be aware that if the decision is not lawful (e.g. the requirements of the Act are not complied with) it is possible the person required to complete the failure impact assessment could apply to the Supreme Court for a statutory order of review under the *Judicial Review Act 1991*.

Procedure

A flow chart for this procedure can be found in Attachment A <attachments/ds1_1_flowchart_a.pdf> .

Step 1 - Identify if a failure impact assessment should be prepared for a dam

Note: Section 343(6) provides that a s. 343(5) notice may be given only if the chief executive reasonably believes the dam would have a category 1 or category 2 failure impact rating (i.e. the dam would be a referable dam). For a dam to be referable there must be a population at risk in the event of failure of the dam, of at least two persons.

Examples of when a failure impact assessment could be required include:

- a complaint is received from the public about the potential consequences of the failure of the dam
- an issue about the safety of the dam is raised by a local government, or other government agency
- an ongoing review of dams reveals the need to make a decision about requiring a failure impact assessment for the dam under s. 343(5).

Step 2 - Decision maker allocates the matter to an action officer for further processing

The decision maker:

- allocates the matter to an action officer for further processing. A decision maker can nominate him/herself as the action officer
- sets a time frame for the action officer to conduct a review of the available data on the dam and report back to the decision maker (see steps 3 and 4).

Step 3 - Action officer conducts searches and reviews the available data about the dam

This step should be completed by the date set by the decision maker in step 2.

The action officer:

- conducts a search of the referable dam register (RDR) and local office records to obtain details of relevant file/s concerning the dam, decides which file/s are required for the purposes of this procedure and obtains those files. Officers need to be aware that relevant files could be held in a number of locations, for example at a local office, regional office and CHQ (Head Office – Brisbane).
- conducts searches of SMIS, ATS and mining leases to identify all persons/entities which are considered 'owners' under the definition of 'owner' in the Act
- begins to review the available information about the dam including a preliminary failure impact assessment for the dam (if available) to the point where the action officer is confident that there is or is not likely to be a population at risk in the event of failure of the dam. The action officer should complete relevant sections of the assessment and decision form as this review and model development progresses (see Attachment B <attachments/ds1_1_a_d_form_b.pdf> for the template for the assessment and decision form).
- updates RDR, as appropriate.

Relevant available information could include, but will not necessarily be limited to:

- available design information for the dam
- available topographic and photogrammetric data and hydrographic information
- past failure impact assessments
- complaint records
- compliance information
- preliminary failure impact assessment
- investigation reports
- Google images.

If there is no existing file for the dam, the action officer must ensure a file is created for the dam, in accordance with local office processes and relevant departmental standards. The creation of a file will require the allocation of a referable dam register number to the dam. If the department has previously received a “complaint” about the dam, a file may already have been created.

The purpose of the assessment is to determine whether there is enough information available for the action officer to make a recommendation to the decision maker about whether a failure impact assessment should be required for the dam, under s. 343(5).

Action officers need to be aware that the decision maker is not obliged to require a failure impact assessment for the dam even if the decision maker reasonably believes the dam would have a category 1 or 2 failure impact rating. Reasons for not requiring a FIA might include (but will not necessarily be limited to) the following:

- the dam owner is taking action to remove the population at risk (PAR) rating
- a FIA is being prepared for the dam as part of a wider range of engineering studies being undertaken for the dam (e.g. acceptable flood capacity assessment).

When conducting the assessment, it is essential that action officers refer to the full text of the Act to determine the precise details of the requirements imposed by the Act with respect to requiring a FIA for a dam under s. 343(5). The assessment and decision form should not be used as a substitute for referring to the Act. However, action officers are expected to conduct their review having regard to the issues listed in the assessment and decision form and the notes to that form.

Action officers need to be aware that the information and documents kept on departmental file/s may later need to be made available to the decision maker, or other people, for independent consideration or inspection.

Step 4 - Action officer briefs decision maker about the amount of available information concerning the dam

This step should be completed by the date set by the decision maker in step 2. The action officer briefs the decision maker on the following issues:

- the information concerning the dam that has been located to date
- the extent and outcomes of any modelling undertaken
- the need for further information and how it might assist or be required for the making of a recommendation or decision about requiring a failure impact assessment for the dam under s. 343(5)
- the likelihood of there being a population at risk in the event of dam failure and the uncertainty associated with this assessment.

Step 5 - Decision maker decides if there is enough available information about the dam for a decision to be made

The decision maker:

- considers the briefing by the action officer under step 4
- decides whether additional information about the dam is required before a decision is made about requiring a failure impact assessment for the dam under s. 343(5).
- Decision makers are expected to assess the adequacy of available information about the dam, having regard to the issues listed in the assessment and decision form and the notes to that form.

It is essential that decision makers refer to the full text of the Act to determine the precise details of the requirements imposed by the Act with respect to requiring failure impact assessments for dams under s. 343(5). The assessment and decision form should not be used as a substitute for referring to the Act.

Decision makers also need to be aware that the information and documents kept on departmental file/s may later need to be made available to other people, for independent consideration or inspection.

If the decision maker decides no further information or investigations are required to make a decision, the decision maker:

- records, on the assessment and decision form, a time frame for the review of the dam to be finalised by the action officer. Go to step 7.

If the decision maker decides further information or investigation is required, the decision maker:

- records, on the assessment and decision form
  - further information that needs to be obtained before a decision can be made about requiring a failure impact assessment for the dam under s. 343(5)
  - the methods proposed or agreed to be used to obtain the relevant information
  - a time frame for obtaining the relevant information

- returns the assessment and decision form to the action officer.

Methods of obtaining further information could include, but will not necessarily be limited to:

- enquiries with local governments
- enquiries with persons in places of occupation downstream of the dam
- enquiries with the owner of the dam
- site inspections under s. 411(1) of the Act.

It should be noted that s. 343 does not give the chief executive the power to formally require, from a dam owner, information that will assist the chief executive in considering whether a failure impact assessment should be required. This means while it is possible for a written request for information in this regard to be sent to the dam owner, if the request is not complied with it cannot be enforced under s. 343. Accordingly, if necessary information is requested from the dam owner, but that information is not supplied to the department, consideration may need to be given to the department using other methods of obtaining the information. The “authorised officer” powers in chapter 5 of the Act may be a suitable method.

Before any of these powers are exercised, the decision maker should assess and decide:

- whether the information is really required in order to be able to make a decision about whether a failure impact assessment should be required for the dam under s. 343(5)
- the need for the ‘authorised officer’ powers in chapter 5 of the Act to be exercised to obtain the information
- which powers need to be exercised? Authorised officers have a range of powers under chapter 5 of the Act. For example, under s. 411(1), an authorised officer may, at any reasonable time, enter land to:
  - inspect a dam or a referable dam on the land or
  - inspect any records about a referable dam or
  - ascertain the impact a failure of the dam or referable dam would have or
  - ascertain if there are factors that are likely to cause the dam or referable dam to fail or
  - ascertain if a failure impact assessment of the dam or referable dam should be requested.

- Who should exercise the relevant powers. In this regard, note that 'authorised officers' are persons appointed as authorised officers under s. 402 of the Act. The powers of individual authorised officers may be limited pursuant to s. 400, for example by conditions attached to the document appointing the person as an authorised officer. Therefore, it is prudent to confirm the officer chosen to obtain the information is able to exercise the relevant powers to obtain that information.

Step 6 - Action officer arranges for the required further information to be obtained

The action officer may need to communicate with the owner of the dam, or other people, for the purposes of this step in the procedure. Accurate and written records of any communications, including verbal communications, must be kept and retained on the relevant departmental file. These records should indicate who was contacted or consulted about particular issues, when this occurred and the advice that was given. It may also be appropriate for the action officer to make some reference to these communications in the assessment and decision form itself (for example, in the response column for the appropriate item/s in the assessment and decision form checklist).

Action officers need to be aware that the information and documents kept on departmental file/s may later need to be made available to the decision maker, or other people, for independent consideration or inspection.

Authorised officers who obtain information for decision makers pursuant to the provisions in chapter 5 of the Act must comply with:

- all relevant statutory requirements regarding the exercise of their powers. It is essential that authorised officers refer to the full text of the Act to determine the precise details of the requirements imposed by the Act with respect to the exercise of their powers, and the options that may be available to them when obtaining information.
- any directions from their appointer, regarding how they are to exercise their powers (see s. 401).

Step 7 - Action officer finalises the review of the dam

This step should be completed by the date set by the decision maker in step 5 (if no further information or investigations were required for a decision to be made), or step 6 or 9 (if the decision maker formed the view that further information or investigations were required for a decision to be made).

The action officer:

- completes and signs the relevant sections of the assessment and decision form (Attachment B <attachments/ds1_1_a_d_form_b.pdf>). In cases where additional information has been obtained or further investigations have been conducted, the action officer may complete an entirely new assessment and decision form if this is considered more appropriate. In completing the assessment and decision form, the action officer should
  - address the issues outlined in step 4 and
  - make recommendations about the appropriate action to take, having regard to the matters outlined in the assessment and decision form and the notes to that form

- gives the assessment and decision form to the decision maker.

When completing the assessment and decision form, it is essential that action officers refer to the full text of the Act to determine the precise details of the requirements imposed by the Act with respect to requiring failure impact assessments for dams under s. 343(5). The assessment and decision form should not be used as a substitute for referring to the Act. However, action officers are expected to conduct their review, and complete the assessment and decision form, having regard to the issues listed in the form and the notes to

that form.

Action officers need to be aware that the decision maker is not obliged to require a failure impact assessment for a dam, even if the decision maker reasonably believes that the dam would have a category 1 or 2 failure impact rating.

Action officers also need to be aware that the information and documents kept on Departmental file/s may later need to be made available to the decision maker, or other people, for independent consideration or inspection.

Step 8 - Decision maker decides on action to take with respect to the dam

The decision maker:

- decides what action should be taken with respect to the dam. Decision makers are expected to assess the appropriate action to take having regard to the matters outlined in the assessment and decision form and the notes to that form.
- completes and signs the assessment and decision form
- gives the completed assessment and decision form to the action officer.

Depending on the situation, available options could be to:

- require a failure impact assessment for the dam, under s. 343(5)
- not require a failure impact assessment for the dam, even though the decision maker considers the dam is likely to have a category 1 or 2 failure impact rating
- decide that s. 343(5) does not apply to the dam (i.e. the dam is not likely to be given a failure impact rating)
- seek further information before making a decision about the action to be taken in relation to the dam.

It is essential that decision makers refer to the full text of the Act to determine the precise details of the requirements imposed by the Act with respect to requiring a failure impact assessment under s. 343(5). The assessment and decision form should not be used as a substitute for referring to the Act.

Decision makers need to be aware that they are not obliged to require a failure impact assessment for the dam, even if they reasonably believe that the dam would have a category 1 or 2 failure impact rating.

Decision makers also need to be aware that a decision requiring a dam to be failure impact assessed is not subject to the internal review and appeal process under chapter 7 of the Act. However, if a decision is made to require a failure impact assessment and that decision is not lawful (e.g. the requirements of the Act are not complied with) it is possible the person required to complete the failure impact assessment could apply to the Supreme Court for a statutory order of review under the *Judicial Review Act 1991*. Therefore, decision makers must ensure that any decisions made to require failure impact assessments under s. 343(5) are lawful and comply with the requirements of the Act. The decision maker should also be satisfied that the reasons for the decision are properly presented and are sufficient to justify the decision made.

Note: Information and documents kept on departmental file/s may later need to be made available to other people, for independent consideration or inspection.

Step 9 - Action officer actions decision

The action officer:

- places the completed assessment and decision form on the relevant departmental file/s. This action can

be done electronically by scanning the signed document/s and saving it in Keeper. Note: It is not necessary to place a hard copy on the Keeper file if it has been scanned and saved electronically in Keeper.
- updates the Referable Dam Register, as appropriate.

If the decision made is to obtain further information before making a final decision, return to step 6.

If the decision made is to not require a failure impact assessment for the dam, or that s. 343(5) does not apply to the dam, go to step 13.

If the decision made is to require a failure impact assessment under s. 343(5), prepare a draft 343 notice and covering letter. A suggested format for a draft s. 343(5) notice and letter to the dam owner can be found at Attachment C <attachments/ds1_1_require_fia_c.pdf> . See Attachment D <attachments/ds1_1_req_fia_mort_d.pdf> for a format for a letter and notice to a mortgagee.

The s. 343(5) notice must:

- be prepared on the basis of the information contained in the completed assessment and decision form
- be given to all confirmed owner/s of the dam (see issue 4 in the checklist in the assessment and decision form)
- advise the dam owner that he or she is required to have the dam failure impact assessed and
- state a reasonable time for the failure impact assessment to be completed and given to the chief executive.

Step 10 - Decision maker checks and signs the notice requiring a FIA and accompanying letter

Before signing the notice and letter, the decision maker must be satisfied that the case for requiring a failure impact assessment is reasonable and is properly documented.

The action officer, if necessary, makes changes to the draft documents, in accordance with the decision maker's instructions, and then arranges for:

- the signed letter and notice requiring a failure impact assessment to be sent to the dam owner, on the day of signing, by registered mail or some other method where the date of delivery can be confirmed
- copies of the signed documents to be placed on the relevant departmental file/s. This action can be done electronically by scanning the signed document and saving it in Keeper.
- the documents to be registered in Keeper, in accordance with local office processes and relevant departmental standards. **Note:** It is not necessary to place a hard copy on the Keeper file if it has been scanned and saved electronically in Keeper.
- update to the Referable Dam Register, as appropriate.

Step 11 - Action officer follows up, as appropriate, on the notice

The action officer may need to communicate with the owner/s of the dam, or other people, for this step in the procedure. Accurate and written records of any communications, including verbal communications, must be kept and retained on the relevant departmental file/s. These records should indicate who was contacted or consulted about particular issues, when this occurred and the advice that was given.

Any postage receipts or other documents received showing that the notice requiring a review has been received are to be placed on the appropriate departmental file.

If the department does not receive a failure impact assessment from the dam owner/s in response to the s.

343(5) notice, the action officer must discuss appropriate action to take with the decision maker. The Act requires the dam owner to ensure the failure impact assessment is completed and given to the chief executive within the reasonable time stated in the s. 343(5) notice (s. 344(2)). In order to obtain the failure impact assessment, it may eventually be necessary to commence some form of non-compliance action under the Act (see work practice OWSR 3.2 Issuing a compliance notice).

If the department receives a failure impact assessment in response to the s. 343(5) notice, see work practice DS 1.2 Processing a failure impact assessment.

Step 12 - Action officer takes appropriate action with respect to the file and departmental records, to complete this procedure

The action officer:

- conducts a final check to ensure all relevant data has been entered into the Referable Dam Register
- checks documents created or received during the course of this procedure have been placed on the appropriate departmental file/s. For documents created during this procedure this action can be done electronically by scanning the signed document/s and saving it/them in Keeper. **Note:** It is not necessary to place a hard copy on the Keeper file if it has been scanned and saved electronically in Keeper.
- determines appropriate action to take in relation to the departmental file (e.g. storage, closure) and arranges for this to occur.

End of work practice.

Responsibilities

Section 343 gives the chief executive the power to issue a s. 343(5) notice. The chief executive can delegate this power to an appropriately qualified public service officer or employee, using s. 582 of the *Water Supply (Safety and Reliability) Act 2008* (the Act). However, delegation does not prevent the chief executive from exercising the power to issue a s. 343(5) notice.

As at the time of writing, the *Water Supply (Chief Executive) Delegation (No. 1) 2010* was in force. Under that instrument of delegation, the powers of the chief executive under the Act to issue a s. 343(5) notice were delegated to the following positions:

- General Manager, Office of the Water Supply Regulator
- Director, Water Industry Asset Management & Standards, Office of the Water Supply Regulator
- Director, Dam Safety (Water Supply), Office of the Water Supply Regulator.

Decision makers must ensure they have, at the time of making their decision, a current delegation allowing them to make the decision. This is important as instruments of delegation can be revoked and replaced from time to time.

Definitions

"the Act" – means the *Water Supply (Safety and Reliability) Act 2008* and references to sections means sections of the Act.

"assessment and decision form" – means the assessment and decision form to decide if a section 343(5) notice should be issued to a dam owner.

"category 1 failure impact rating" – a category of referable dam under the Act. The population at risk from failure of the dam has been determined as between two and 100 persons inclusive.

"category 2 failure impact rating" – a category of referable dam under the Act. The population at risk from failure of the dam has been determined as greater than 100 persons.

"chief executive" – the Director-General, Department of Environment and Resource Management.

"dam" –

1. *Dam* means–
   - Works that include a barrier, whether permanent or temporary, that does or could impound water; and
   - The storage area created by the works.

2. The term includes an embankment or other structure that controls the flow of water and is incidental to works mentioned in paragraph (1) above.
3. The term does not include the following:
   - A rainwater tank;
   - A water tank constructed of steel or concrete or a combination of steel and concrete;
   - A water tank constructed of fibreglass, plastic or similar material.

"decision maker" – the person making the decision on whether to issue a s. 343(5) notice, under this work practice.

"department" – the Department of Environment and Resource Management.

"failure" – of a referable dam, means–

- The physical collapse of all or part of the dam; or
- The uncontrolled release of any of its contents.

"failure impact assessment" – an assessment certified by a registered professional engineer under s. 342 of the Act.

"failure impact rating" – an indication of the population at risk from failure of a dam. Dams with a category 1 or category 2 failure impact rating are referable dams under the Act.

"guidelines" – the Guidelines for Failure Impact Assessment of Water Dams, issued by the chief executive.

"hazardous waste dam" means–

1. hazardous waste dam means a dam containing, or that after its construction will contain–
   a. a substance, whether liquid, solid or gaseous, derived by, or resulting from, the processing of minerals that tends to destroy life or impair or endanger health or
   b. ash resulting from the process of power generation.

2. The term includes a dam that is used, or after its construction will be used, to prevent contamination of

the environment by storing waste or a contaminant within the meaning of the *Environmental Protection Act 1994*.

"owner" means –

1. An owner of land is any of the following, and includes the occupier of the land-
   - The registered proprietor of the land under the *Land Titles Act 1994*;
   - The lessee or licensee under the *Land Act 1994* of the land;
   - The holder of a mineral development license or mining lease over the land under the *Mineral Resources Act 1989*;
   - The person or body of persons who, for the time being, has lawful control of the land, on trust or otherwise;
   - The person who is entitled to receive the rents and profits of the land.

2. An owner of a referable dam is the owner of land on which the referable dam is constructed or is to be constructed.

"population at risk" – means the number of persons, calculated under the failure impact assessment guidelines, whose safety will be at risk if the dam, or proposed dam after its construction, fails.

"reasonable belief" – a reasonable belief does not have to be one that is completely without doubt, but it must also not rely on mere speculation, suspicion, guesses or assumptions that have been made without any foundation.

A reasonable belief is, generally, a belief based on information:

- reasonably believed to be reliable and accurate; and
- available to the decision maker.

"referable dam" – means

1. dam, or a proposed dam after its construction, for which–
   a. A failure impact assessment of the dam, or the proposed dam, is required to be carried out under Part 1 of Chapter 4 of the Act
   b. The assessment states the dam has, or the proposed dam after its construction will have, a category 1 or category 2 failure impact rating; and
   c. The chief executive has, under s 349 of the Act, accepted the assessment.

2. The following are not referable dams–
   a. A hazardous waste dam
   b. A weir, unless the weir has a variable flow control structure on the crest of the weir.

"registered professional engineer" – means a registered professional engineer, a registered professional engineering company or a registered professional engineering unit as defined under the *Professional Engineers Act 2002*.

References

The following documents should be referenced in conjunction with this work practice:-

- *Water Supply (Safety and Reliability) Act 2008*
- Queensland Dam Safety Management Guidelines
- Guidelines for Failure Impact Assessment of Water Dams

Officers involved in this work practice should also be familiar with, and comply with, requirements of the following departmental standards:

- Departmental policy RKP/2006/2907 – Recordkeeping overarching policy
- Departmental policy RKP/2006/2899 – Recordkeeping email policy
- Departmental standard IMP/2005/2253 – Procedures for using electronic mail
- Departmental standard ADM/2005/941 – Paper-Based document management
- Departmental standard ADM/2002/965 – Decision making and requests for statements of reasons under the Judicial Review Act 1991
- Departmental standard ADM/2003/1402 – Information privacy.

Legislation

Water Supply (Safety and Reliability) Act 2008

Professional Engineers Act 2002

Judicial Review Act 1991

Mineral Resources Act 1989

Land Titles Act 1994

Land Act 1994

Attachments

Attachment A - Flow chart for processing a FIA <attachments/ds1_1_flowchart_a.pdf>

Attachment B - Assessment and Decision Form <attachments/ds1_1_a_d_form_b.pdf>

Attachment C - Notice to dam owner to have dam failure impact assessed <attachments/ds1_1_require_fia_c.pdf>

Attachment D – Notice to mortgagee to have a dam failure impact assessed <attachments/ds1_1_req_fia_mort_d.pdf>

Department of Environment
and Resource Management

Guidelines for Failure Impact Assessment of Water Dams

June 2010

Prepared by:

Office of the Water Supply Regulator

Department of Environment and Resource Management

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#29384

Contents

1. Introduction

There is community concern regarding the potential for medium to large dams, including ring tanks and some weirs, to fail and threaten lives. In the past dam safety has been regulated by the *Water Resources Act 1989* and then superseded by the *Water Act 2000*.

New legislation, the *Water Supply (Safety and Reliability) Act 2008* (the Act), which supersedes provisions of the Water Act, received assent on 21 May 2008. The dam safety provisions of the Act commenced on 1 July 2008.

The Act details the provisions for referable dams and the process for determining whether a dam is referable or not. Dam owners need to check whether their dam is subject to this legislation. The Act requires owners of particular dams to assess the impacts of dam failure on the safety of people living downstream of the dam, by way of a dam failure impact assessment, to determine whether the dam is a referable dam. The new legislation also provides for regular ongoing assessment of the potential threat to people from unexpected flooding caused by a failure of one of these dams.

These guidelines are prepared pursuant to s. 342 of the Act for failure impact assessment of water storage dams and issued by the chief executive of the Department of Environment and Resource Management (DERM). The Act can be accessed on the internet at <www.legislation.qld.gov.au>.

This version of the guidelines are a simple update of the April 2002 guidelines updating the name of the department and the new legislation references. There are no fundamental changes to the basic failure impact assessment process methodology in this updated version of the guidelines.

1.1 Dam safety

Under the Act, the chief executive of DERM is responsible for the regulation of referable dams in Queensland.

The chief executive becomes involved in the assessment of applications for development permits that seek approvals to:

- build new referable dams or
- carry out operational works on existing referable dams that will increase the storage capacity of those dams by more than 10 per cent.

The chief executive has the power under the *Sustainable Planning Act 2009* (s. 244) to impose conditions relating to dam safety on development permits which approve the above dams and works. The development permit is attached to the land where the referable dam is located and binds the owner, future purchasers and any occupier of the land.

The chief executive also has the power under the Act to impose safety conditions on existing referable dams. The chief executive can modify these conditions if the chief executive believes that the changes are in the interests of dam safety. Safety conditions are taken to form part of a development permit for the dam and can be imposed regardless of whether the dam owner already has a development permit for the dam. They attach to the land where the dam is located and bind the owner, future purchasers and any occupier of the land.

The chief executive can also give directions to take stated action to an owner or operator of a referable dam by issuing a written notice. Such a notice will only be issued if:

- there is a danger of the dam failing and
- action is necessary to prevent or minimise the impact of the failure.

These notices also attach to the land where the referable dam is located, binding the owner of the land at the time it is issued and any future owners.

1.2 Guidelines—aims

The Guidelines for Failure Impact Assessment of Water Dams and the Queensland Dam Safety Management Guidelines for referable dams have been developed to help owners comply with the Act and dam safety conditions for referable dams (these include both conditions relating to dam safety imposed on development permits and safety conditions imposed under the Act).

The Guidelines for Failure Impact Assessment of Water Dams provide information about:

- referable dams
- failure impact ratings
- failure impact assessment and how it is done
- certification of a failure impact assessment

- lodging a failure impact assessment for an existing dam
- lodging a failure impact assessment for a new or proposed dam
- lodging a failure impact assessment for works on an existing dam
- timing requirements for undertaking failure impact assessments
- processes for accepting, rejecting or reviewing a dam failure impact assessment
- responsibilities, penalties and provisions for appeals.

More information on changes to the legislation and dam safety generally can be found in the Queensland Dam Safety Management Guidelines.

For further information on this guideline or the information outlined above, please contact:

Dam Safety
Office of the Water Supply Regulator
Department of Environment and Resource Management

Ph: (07) 3224 7215

<www.derm.qld.gov.au>

2. Overview—Requirements of the legislation

2.1 What is a dam failure?

A dam is considered to have failed when:

- a part or all of the dam physically collapses, for example, when:
    - the earth wall slumps
    - part of the wall erodes when overtopped
    - foundation weakness removes a section of a concrete dam wall.

or

- there is an uncontrolled release of any of the contents from the dam, for example, when:
    - a gate or valve fails
    - an outlet pipe breaks.

2.2 What is a failure impact assessment?

A failure impact assessment of a water storage dam is the process used under the Act to determine the number of people whose safety could be at risk should a dam fail (population at risk). The results of the assessment are used to determine:

- whether a dam is referable and
- the failure impact rating of a dam.

2.3 What is a failure impact rating?

A failure impact rating is a measure of the population at risk should a dam fail. There are two categories:

- Category 1— between two to 100 people at risk by the dam failing. All category 1 dams are referable dams under the Act.
- Category 2—more than 100 people at risk by the dam failing. All category 2 dams are referable dams under the Act.

If less than two people are at risk by the dam failing then the dam is not given a failure impact rating and is not referable under the Act.

The chief executive imposes dam safety conditions on referable dams based partly on the failure impact rating. Dam safety conditions can be imposed either when a development permit relating to a referable dam is granted or, after the dam has been constructed (as safety conditions under the Act, which are taken to form part of a development permit for the dam).

2.4 Who certifies a failure impact assessment as complete and accurate?

A failure impact assessment must be certified by a registered professional engineer, which is a person, company or unit registered under the *Professional Engineers Act 2002*. He or she is responsible for certifying, as specified in these guidelines, the:

- accuracy and content of a dam failure impact assessment
- adequacy and accuracy of the modelling used to calculate the population at risk
- accuracy of the assessed population at risk and other matters.

An assessment cannot be certified by an engineer who is:

- the owner of the dam being assessed or
- an employee of the owner of the dam or
- the operator of the dam or
- an employee of the operator of the dam.

2.5 How do you failure impact assess a dam?

An assessment can be done using one of the following methods:

2.5.1 Simplified assessment

This might typically be used when the flow of water proceeds down well-defined channels and when there is little doubt regarding the level of population at risk. For example, it might be used when:

- the dam is large and located upstream from a major urban population and where it is clear that more than 100 people would suffer the impact of dam failure (that is, the dam would have a category 2 failure impact rating) or
- the dam is small and there are no people at risk should the dam fail (that is, the dam would not be a referable dam).

2.5.2 Comprehensive assessment

This might be used when the flow of water proceeds down well-defined channels and when there is some uncertainty in estimates of the population at risk.

This is a detailed assessment and must include a dam break analysis for a range of dam failure scenarios such as overtopping, sabotage, seeping and piping failure.

A dam owner may choose to commission a comprehensive assessment even though a simplified assessment could be acceptable under these guidelines. However, the owner must undertake a comprehensive assessment if the registered professional engineer is:

- uncertain that the dam will have a category 1 or 2 failure impact rating and the owner wishes to justify the lower category 1 failure impact rating or
- uncertain that the dam will have a category 1 failure impact rating, or it is not a referable dam, and the owner wishes to justify the dam not being referable.

2.5.3 Tw o-dimensional flow analysis

This form of assessment might need to be used if the population at risk is situated close to a possible dam breach(es) location(s) and there is a risk that the population will be inundated by water from the dam before it concentrates in downstream channels. This method is likely to be needed for ring tanks.

2.6 Do I need to undertake a failure impact assessment to obtain a failure impact rating?

See Chart 1 (page 9).

Yes, if you are the owner of a dam that is not already assigned a category 2 failure impact rating and the dam:

- exceeds, or will after its construction, exceed the height and storage criteria specified in the Act (refer to 2.7) or
- is under notice from the chief executive to undertake a failure impact assessment of the dam (s. 343(5) of the Act). Notices will only be issued if the chief executive reasonably believes the dam will be given a category 1 or category 2 failure impact rating.

The failure impact assessment will be due:

- if the dam exceeds, or will after its construction, exceed the height and storage criteria specified in the Act:
    - if the dam has not already been assigned a category rating, it is due now
    - if the dam has already been assigned a category 1 rating, it will be due within the period stated in the notice of the acceptance of the previous failure impact assessment.
- If the dam is subject to a notice from the chief executive to undertake a failure impact assessment, by the due date stated in the notice.

2.7 Does my dam exceed the height and storage criteria specified in the Act?

Yes, if your dam is, or after construction will be:

- more than eight metres in height with a storage capacity of more than 500 megalitres or

- more than eight metres in height with a storage capacity of more than 250 megalitres and a catchment area that is, more than three times its maximum surface area at full supply level.

2.8 Do all dams that exceed the height and storage criteria specified in the Act require a failure impact assessment?

See Chart 1 (page 9).

Yes, unless it is:

- a dam which has already been assigned a category 2 failure impact rating or
- a dam which contains hazardous waste or
- a proposed dam which will contain hazardous waste or
- a weir that does not have a variable flow control structure on its crest.

2.9 Do I need to undertake a failure impact assessment if I want to increase the storage capacity of my dam?

Yes, if either:

- you are the owner of an existing referable dam and
- you want to carry out operational work that will increase the storage capacity of that dam by more than 10 per cent and
- your existing development permit for the dam does not authorise the carrying out of those works

or if:

- the dam did not previously exceed the height and storage criteria specified in the Act (refer section 2.7) and the increase in dam size means that the dam will exceed the criteria.

2.10 What if I receive a notice from the chief executive to undertake a failure impact assessment?

You must comply with the notice.

The chief executive can issue a notice requiring the owner of an existing dam, or a dam being constructed, to undertake a failure impact assessment (s. 343(5)). Notices will only be issued:

- for dams that do not meet the height and storage criteria specified in the Act (refer section 2.7) if the chief executive reasonably believes the dam will be given a category 1 or category 2 failure impact rating
- for dams that meet the height and storage criteria specified in the Act (refer section 2.7) if the chief executive reasonably believes the dam will be given a different rating category to that it was previously given and the reassessment under s. 345 of the Act is not yet due.

2.11 Who pays for the failure impact assessments?

See also Responsibilities 3.1

The owner of the dam must pay the cost of the failure impact assessment unless:

- the dam does not meet the size criteria in s. 343(1) of the Act and
- the assessment is undertaken in response to a notice(s. 343(5) of the Act) from the chief executive and
- the resultant assessment is accepted by the chief executive and
- in that assessment the dam is not given a failure impact rating and is therefore not a referable dam.

If applicable the chief executive will pay the reasonable costs of:

- preparing the assessment
- certifying the assessment
- any review of the assessment that occurs under s. 351 of the Act.

2.12 Who submits the failure impact assessment?

See Chart 1 (page 9) and Chart 2 (page 10)

The owner of the dam.

The owner must submit a failure impact assessment that has been certified by a registered professional engineer. The failure impact assessment must be carried out in accordance with these guidelines and clearly detail how the assessment was undertaken and justify the conclusion.

The failure impact assessment is then submitted to the chief executive of DERM for acceptance.

2.13 When must I submit my failure impact assessment if I plan to construct a new dam that exceeds the height and storage criteria specified in the Act?

See Chart 1 (page 9) and Responsibilities 3.4.

Prior to a development permit being submitted for approval.

You must ensure the failure impact assessment is completed, and accepted by the chief executive, before the development application is submitted to the assessment manager. The development application must be accompanied by a copy of the information notice accepting the failure impact assessment.

2.14 When must I submit my failure impact assessment if I plan to carry out works that will increase the storage capacity of my referable dam by more than 10 per cent?

- You must ensure the failure impact assessment is completed, and accepted by the chief executive, before work begins.
- You must also obtain a development permit approving the works before commencing, and supply evidence of the accepted failure impact assessment with the application for the development permit.
- In some cases, the Act will also require the chief executive to give written consent (as the water manager under the Act) to the development application being made. Consent will be required in cases where a water entitlement is required to operate the dam. The entitlement could be a water allocation, an interim water allocation or a water licence.

2.15 How often do I need to undertake a failure impact assessment once I have my failure impact rating?

See Chart 1 (page 9).

The notice issued by the chief executive accepting the FIA will state the period within which the owner must have another failure impact assessment carried out. The period must be at least five years if your dam:

- has a category 1 failure impact rating or
- is not given a failure impact rating in a dam failure impact assessment accepted by the chief executive, but your dam exceeds the specified height and storage criteria outlined in the Act (refer to 2.7).

Each five-year period runs from the date the last assessment was accepted by the chief executive.

For dams deemed to have a failure impact rating of Category 1 under the Water Regulation 2002, the first reassessment of the failure impact assessment was due on 20 April 2007.

A further dam failure impact assessment will also be required if your dam is a referable dam and you want to carry out operational work that will increase the storage capacity of the dam by more than 10 per cent and the existing development permit for the dam does not authorise the carrying out of those works. This further assessment is required because of the application for the development permit for the works to be carried out must be supported by evidence the chief executive has accepted a dam failure impact assessment for the dam.

A further dam failure impact assessment will also be required if you are given a notice by the chief executive to have your dam failure impact assessed (s. 343(5)).

Further dam failure impact assessments are not required if:

- your dam has a category 2 failure impact rating as it is considered unlikely that such a dam would be given a lower rating if reassessed

- the chief executive issued you with a notice under s. 343(5) to have your dam failure impact assessed, the dam failure impact assessment is accepted by the chief executive, the dam is assessed as not having a category 1 or category 2 failure impact rating (that is, it is not a referable dam), and the dam does not meet the specified height and storage criteria outlined in the Act.

2.16 When must I submit my failure impact assessment if I receive a notice from the chief executive requiring me to undertake a dam failure impact assessment?

The notice you receive will state the date when the failure impact assessment must be submitted.

2.17 What details must be included in the written failure impact assessment?

See Section 5 on page 35 for a complete list.

However in general the assessment must include:

- general information (for example, name of owner, operator, address, geographical location etc.)
- catchment area details
- dam description
- data and analysis
- results of failure impact assessment (include detailed discussion)
- registered professional engineer's written certification.

2.18 What happens to my failure impact assessment once it is submitted?

See Chart 2 (page 10) and Responsibilities 3.3.

The chief executive of DERM can:

- accept a failure impact assessment or
- reject a failure impact assessment or
- require a review of a failure impact assessment.

A failure impact assessment may be rejected or a review of it may be required if it is:

- not completed in accordance with these guidelines
- incomplete in a material particular (for example, the assessment is not certified by a registered professional engineer)
- incorrect in a material particular (for example, the assessment did not take into account downstream residential development).

The owner of the dam will be given written notice of the chief executive's decision.

Before requiring a review of, or rejecting an assessment, the chief executive can request additional information about the assessment.

If a failure impact assessment is not initially accepted and is then reviewed, corrected or completed, it will need to be recertified and resubmitted.

Details of the process for accepting, rejecting or reviewing a failure impact assessment are presented in Chart 2 on page 10 (including the appeals process against the chief executive's decision).

2.19 What happens if I don't do a dam failure impact assessment as required?

See responsibilities 3.1 and 3.2.

A dam owner may be prosecuted for failing to comply with the Act if he or she fails to carry out and submit a failure impact assessment as required. Penalties may also apply if a person gives information which is false or misleading to the registered professional engineer certifying the dam failure impact assessment or if the registered professional engineer certifies a dam failure impact assessment the engineer knows is false or misleading.

2.20 What happens to my waterworks licence issued under the *Water Resources Act 1989*?

For dams which are no longer referable

Owners may find that their dam, which was referable under the *Water Resources Act 1989* and had a waterworks licence, is not referable under the *Water Act 2000* and subsequently the *Water Supply (Safety and Reliability) Act 2008*. The Water Act transitioned existing hazardous waste dams licensed under the repealed Water Resources Act as licensed environmentally relevant activities with dam safety conditions being deemed to be conditions of the dam's environmental authority or development approval.

However, take note that there may be certain waterworks licence conditions which still apply. For example:

- If your dam was licenced under the *Water Resources Act 1989* and is no longer considered to be a referable dam, conditions on the waterworks licence other than dam safety conditions may still continue to apply (for example, conditions dealing with the interference with the flow of water in a watercourse continue to apply).

For dams which are still referable

If your dam was licenced under the *Water Resources Act 1989* and is still a referable dam under the Act, the licence for that dam will be taken to be a development permit approving the dam. Any safety conditions issued as part of the existing waterworks licence continue to apply and form part of the development permit.

Chart 1: How to determine if your dam is referable and when a dam failure impact assessment is required

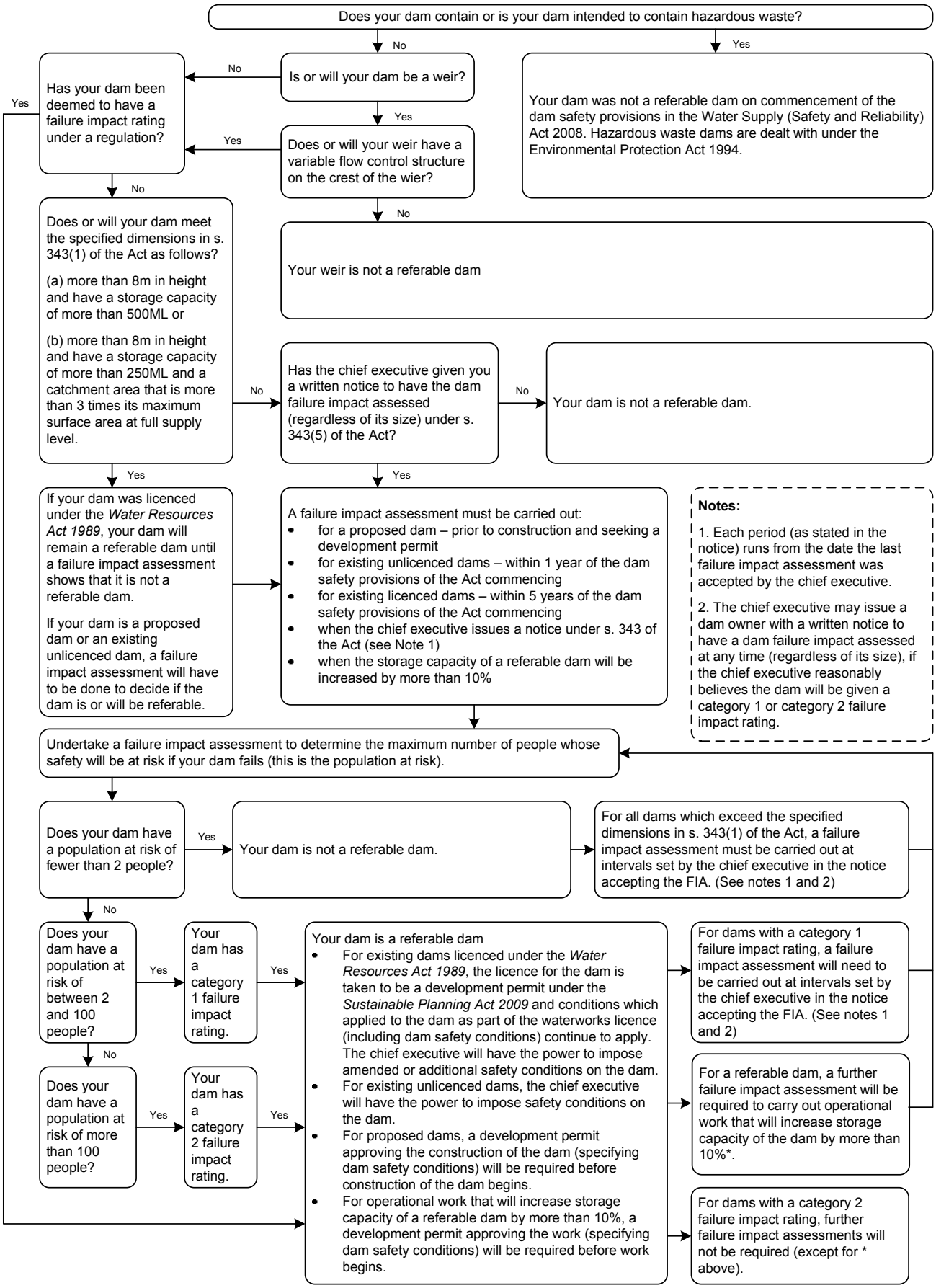
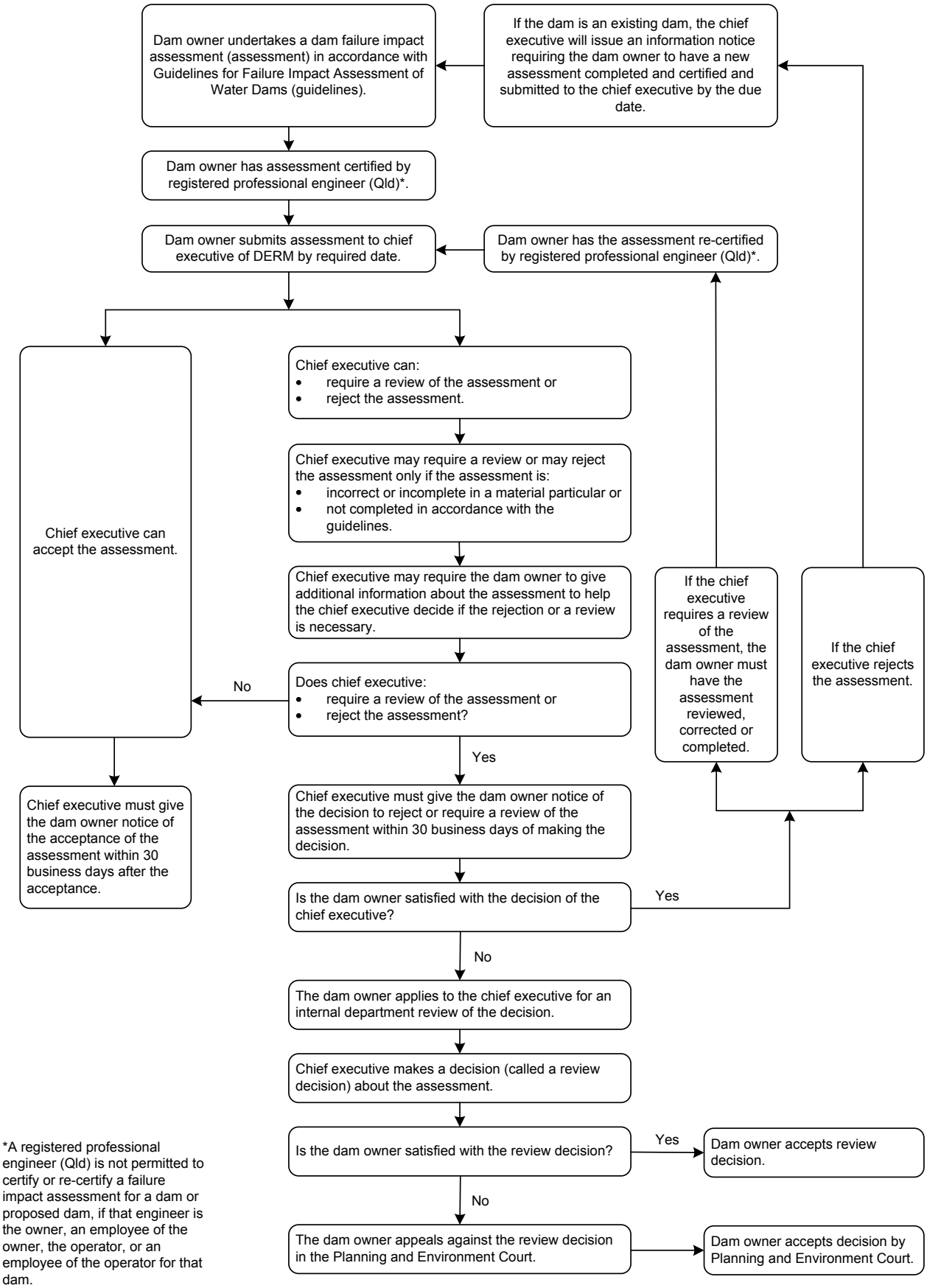


Chart 2: Process for accepting, rejecting or reviewing dam failure impact assessments



*A registered professional engineer (Qld) is not permitted to certify or re-certify a failure impact assessment for a dam or proposed dam, if that engineer is the owner, an employee of the owner, the operator, or an employee of the operator for that dam.

3. Responsibilities

3.1 Responsibility of the owner

A failure impact assessment must be undertaken by a dam owner if the dam is not deemed to have a failure impact rating under a regulation and:

- the dam exceeds the specified height and storage criteria outlined in the Act (refer to 2.7) or
- the dam owner is issued with a notice by the chief executive of DERM under s. 343(5) of the Act.

Section 343(2) of the Act requires the owner of a dam that is not referable to have the dam failure impact assessed if, because of any works proposed to be carried out in relation to the dam, the dam will meet the height and capacity criteria in s. 343(1) after the works are carried out.

If works are proposed that would increase the capacity of a non-referable dam (which meets the height and capacity criteria in s. 343(1) of the Act) by 10 per cent then the owner of the dam must have the dam failure impact assessed (s. 343(3) of the Water Supply Act),

The owner of a referable dam must have the dam failure impact assessed if the storage capacity of the dam will increase by more than 10 per cent after proposed works are carried out (s. 343(4) of the Water Supply Act).

The Act sets out timing requirements for dam failure impact assessments (see Chart 1, page 9).

The chief executive sets the timeframe when further failure impact assessments are required (see Chart 1, page 9). The owner must ensure another assessment of the dam is completed and given to the chief executive within the period set by the chief executive after the last assessment was accepted by the chief executive. The timeframe for further failure impact assessments must be no less than five years (s. 345(2)). Such assessment must be undertaken by a dam owner if:

- the dam is given a category 1 failure impact rating in an assessment accepted by the chief executive, or
- the dam is not given a failure impact rating in an assessment accepted by the chief executive, but the dam exceeds the height and storage criteria specified in the Act or
- the dam owner is given a notice to have the dam failure impact assessed under s. 343(5) or
- the dam is given a category 1 or category 2 failure impact rating in an assessment accepted by the chief executive, and the owner wants to carry out operational work that will increase the storage capacity of the dam by more than 10 per cent and those works are not authorized by the existing development permit for the dam.

A further failure impact assessment does not apply to the owner of:

- a dam given a category 2 failure impact rating under the last assessment of the dam, or
- an existing dam, or a dam being constructed that was issued a notice by the chief executive to have the dam failure impact assessed, where it was not given a category 1 or category 2 failure impact rating, or
- the dam does not meet the criteria of more than eight metres in height and have a storage capacity of more than 500ML, or a storage capacity of more than 250ML and a catchment area that is more than three times its maximum surface area at full supply level.

The owner of the dam must pay for a dam failure impact assessment, unless the chief executive requires the owner to carry out a dam failure impact assessment (under s. 343(5) of the Act) on a dam that does not meet the size criteria in s. 343(1) and subsequently the assessment is accepted by the chief executive and the dam is assessed as not being referable. In these circumstances, the chief executive must pay the reasonable cost of preparing and certifying the dam failure impact assessment.

A development permit may be required as per section 3.4 of these guidelines.

Please note that the provisions of the Act relating to referable dams and flood mitigation do not affect the liability of a dam owner or operator for any loss or damage caused by the failure of a dam or the escape of water from a dam.

3.2 Responsibility of the certifying engineer

A registered professional engineer must certify each failure impact assessment. Penalties apply if a registered professional engineer certifies a failure impact assessment that contains information that the engineer knows is false or misleading and does not disclose this.

The written certification must state:

- that the assessment has been prepared in accordance with these guidelines and that it is not based on information that the registered professional engineer knows is false or misleading
- that the certifying registered professional engineer is not the owner, an employee of the owner, the operator, or an employee of the operator of the dam being assessed
- that it is an accurate estimate of the population at risk and that the estimate is consistent with:
    - the detail and accuracy of the modelling used
    - the extent of the failure impact zone
- the certifier's judgment of the appropriateness and accuracy of the information included in the assessment
- the certifier's view of the veracity of the information included in the assessment, as well as specifying the information on which the assessment was made
- that the certifier is satisfied that the inspection of the site has accounted for sufficient points of impact, covering the failure impact zone as a minimum, to justify the failure impact rating
- that the certifier is satisfied with the locations of cross-sections and the intervals between those cross-sections for each individual numerical model generated for the dam failure impact assessment.

For failure impact assessments completed following an initial assessment accepted by the chief executive (that is, the second and subsequent assessments), it may be permissible to use the same inundation data used in the previous assessment of the population at risk. However, the registered professional engineer's certification must include justification of this approach in the reassessment (refer to section 4.8 for details).

3.3 Responsibility of the chief executive

See Chart 2 (page 10).

The chief executive may accept, reject, or require a review of a failure impact assessment. If a failure impact assessment is accepted and the dam is referable (that is, it has a category 1 or a category 2 failure impact rating), the chief executive may impose dam safety conditions on the dam. Dam safety conditions can be imposed either when the development permit for the dam or for works proposed to be undertaken on the dam is granted (as development permit conditions), or after the dam has been built (as safety conditions).

The chief executive may reject or require a review of a failure impact assessment if the assessment:

- has not been completed in accordance with these guidelines or
- is incomplete in a material particular (for example, the assessment is not certified by a registered professional engineer) or
- is incorrect in a material particular (for example, the assessment did not take account of downstream residential development)[1]

The chief executive may require the dam owner to supply additional information to assist in the decision to reject or require a review of the assessment.

The owner of the dam will be given written notice within 30 business days of a decision being made to accept, reject or require a review of the failure impact assessment.

If the chief executive requires a review of the assessment, the dam owner must review, correct or complete the failure impact assessment, have it re-certified by a registered professional engineer and resubmit the assessment by the date specified in the information notice.

[1] The chief executive reserves the right to check the accuracy of an assessment, although the certifying registered professional engineer retains responsibility for the accuracy of the assessment.

If the chief executive rejects an assessment relating to an existing dam, the dam owner must prepare a new failure impact assessment, have it certified by a registered professional engineer and submit the assessment by the date specified in the information notice.

If the chief executive rejects an assessment relating to a proposed dam, the dam owner will not be required to complete a new assessment by a specified date. However, if the proposed dam meets the height and storage criterion outlined in the Act (refer section 2.7), it will still be necessary for the dam owner to obtain an accepted failure impact assessment before-

a. a properly made application for a development permit is made, and

b. before construction of the dam begins

A dam owner may apply to the chief executive for an internal review of the decision, if the chief executive requires a review of, or rejects, a dam failure impact assessment. The chief executive will then review the failure impact assessment and make a review decision (see Chapter 7 of the Act).

If a dam owner is not satisfied with the review decision, the appeal provisions of the Act allow the owner to appeal this decision in the Planning and Environment Court (see Chapter 7 of the Act).

3.4 Responsibilities under the *Sustainable Planning Act 2009*

A development permit must be obtained if a person wants to carry out operational work, that is, the construction of a new referable dam or that will increase the storage capacity of a referable dam by more than 10 per cent. A development permit is an approval under the *Sustainable Planning Act 2009*, which allows particular development (for example, construction of a new referable dam) to occur. A development permit may impose conditions (for example, safety conditions) on the approved development.

A development permit is only issued after a development application has been assessed and approved using the Integrated Development Assessment System (IDAS) under the Sustainable Planning Act.

A development application for the construction of a new referable dam or for carrying out operational work that will increase the storage capacity of a referable dam by more than 10 per cent must be lodged with an assessment manager, who is then responsible for administering the assessment and approval process[2]. The development application must be supported by evidence the chief executive has accepted a failure impact assessment for the dam (refer to s. 561 of the Act). Additionally, if a water entitlement is required under the Act to operate the dam (for example, the proposed dam is on a watercourse) the development application must be accompanied by the chief executive's written consent (as the water manager under the Act) to the application being made.

The assessment manager for a development application for construction of a new referable dam or for operational works that will increase the storage capacity of a referable dam by more than 10 per cent will generally be the local government if its planning scheme makes the construction of the new dam, or the carrying out of the operational works, assessable development. If the local government does not make the dams' construction, or the operational works assessable development under its planning scheme, a regulation under the Sustainable Planning Act may make the chief executive the assessment manager. Even in those cases where the chief executive is not the assessment manager, the chief executive will have the power to require dam safety conditions to be imposed on the development permit.

In some cases, a dam may become referable after it is constructed (for example, if the chief executive issues a s. 343(5) notice to have the dam failure impact assessed and the dam is assessed as having a category 1 or category 2 failure impact rating). In these cases, the chief executive has the power to impose safety conditions on the dam under the Act and these are taken to be part of a development permit for the dam. However, as the dam was not a referable dam prior to its construction, there is no requirement for the dam owner to apply for a new development permit under the Sustainable Planning Act.

[2] The appeal provisions of the Sustainable Planning Act allow appeals in the Planning and Environment Court against the decision made about the development application.

4. Methodology

4.1 Introduct ion

The owner needs to undertake (possibly in conjunction with a registered professional engineer) the following activities when preparing a failure impact assessment:

- the dam site needs to be inspected at least once
- data needs to be collected and its appropriateness and accuracy assessed
- the dam failure zone must be identified and an assessment of the population at risk calculated
- finally, the failure impact assessment needs to be certified by a registered professional engineer and submitted to the chief executive.

4.2 Dam site inspection

Site inspections are mandatory. These ensure that the information upon which the failure impact assessment is based is correct and up to date, and also enable an appreciation of the characteristics of the site. The date(s) and name(s) of the personnel involved in the site inspection must be included in the failure impact assessment.

Site inspections must include areas that could be affected by dam failure both upstream and downstream of the dam. Site inspections are needed to:

- verify the accuracy of all mapping/aerial photogrammetry or satellite imagery that is, used in the assessment
- verify the existence of buildings and other places of occupation to justify the failure impact rating identified in the assessment
- identify other storages on the same waterway
- identify buildings and other places of occupation along waterways, which may house population at risk (for example, camping facilities)
- identify catchment modification works (for example, diversion drains and levee banks).

The registered professional engineer certifying the failure impact assessment must be satisfied that the inspection of the site has accounted for sufficient points of impact, covering the failure impact zone as a minimum, to justify the failure impact rating. The registered professional engineer must include a statement to this effect in the certification.

Less rigour will be required for a failure impact assessment where a dam obviously has a category 2 failure impact rating (as this is the highest rating applicable) than if a dam is either on the border of not being referable or on the border of having a category 1 failure impact rating[3] and the owner wishes to justify the adoption of the lower failure impact rating.

4.3 Data collection

The registered professional engineer certifying the failure impact assessment must judge the appropriateness and accuracy of the information included in the assessment and indicates in the certification, the engineer's views on the assessment information.

A wide array of information needs to be collected to determine the effects of a dam failure as detailed below.

4.3.1 General information

Floods due to dam failure are generally significantly larger than natural floods. They can rise very rapidly, form steep wave fronts and carry large amounts of debris and sediment.

Flood information can be used in the assessment including:

- available historic flood levels
- hydrographic data

[3] Note: A detailed inundation map may still have to be produced as part of the preparation of an Emergency Action Plan for the dam.

- rainfall/runoff model results
- dam break flood model results under sunny day and incremental conditions.

4.3.2 Dam and storage information

Information should be gathered which outlines the dam's physical dimensions used to determine potential breach characteristics and incremental flooding effects (for example, stability of slopes, earthquake effects, condition of components, materials and spillway capacity). Such information should include:

- type of dam and location (including latitude and longitude)
- spillway type and adequacy (including flood control facilities such as gates and secondary spillways)
- dimensions such as height and length of embankments and the width of the crest
- storage capacity to full supply level and to the crest of the dam (stage capacity curve)
- use of dam including contents of the storage area
- possible causes and modes of failure
- comments on design, foundations and any unusual conditions
- design studies or reports.

4.3.3 Topographic information

Topographic information can be sourced from a number of areas, with the decision as to which data is used being based on issues such as the availability, relevancy and accuracy of the information. Sufficient topographic information must be obtained to accurately determine:

- the shape and slope of the valley downstream of all potential failure locations
- controls on the downstream flow, such as culverts, vegetation, weirs, bridges, embankments, surface roughness and temporary storage on the flood plains
- location of major downstream tributaries.

If regional maps do not provide sufficient detail for a failure impact assessment, further information may need to be obtained from sources such as:

- road maps
- orthographic, topographic, military and cadastral plans
- surveyed cross-sections
- aerial photographs
- satellite imagery
- local residents.

Orthographic maps, if they exist, are generally very useful for failure impact assessments as they combine contour information with images of buildings, roads etc. Contours can be used as flood level indicators.

It is important to note that mapping or aerial photogrammetry may not contain recent developments, for example, houses or other places of occupation (refer to Appendix A). Information contained in photogrammetry that plays an integral role in the assessment must be verified by site inspections.

For dam break models where the need for precision is not great, model cross-sections may be based on existing survey information such as stream strips, cross sections, and the most reliable topographic maps available. It may also be possible to extend survey cross sections by using contours from maps etc.

Cross sections may need to be taken at locations where there are buildings or other places of occupation as well as at sufficient other locations, including hydraulic controls such as bridges, weirs, waterfalls, to allow reasonable dam break models to be established.

As a guide to cover the inundation area, the cross sections should extend for at least half the vertical height of the dam above the stream bed at each location. This height of the cross-sections may be able to be decreased at greater distances downstream of the dam.

Where extreme precision is required, extensive, detailed surveys of the downstream valley may be necessary. In such circumstances, surveys may also be required to locate and determine natural surface levels at all buildings or other places of occupation that are thought to be at risk.

4.3.4 Hydrograp hic data

The inflow hydrograph into a storage during a flood event can affect the results of a dam break analysis. Its impact will depend on a number of parameters such as:

- the size of the available flood storage
- the height of the dam
- the size and capacity of its spillway
- the shape of the valley downstream of the dam.

For lower accuracy analyses, only one roughness coefficient might be sufficient in representing the whole floodplain at each cross-section. In such analyses, it might also be appropriate to adjust roughness coefficients using text book allowances.

To obtain an indication of model sensitivity to variation of the assumed roughness the model must be run with values of Manning's 'n'[4] varying either side of the adopted roughness coefficient.

Some of the potential errors in hydrographic data include:

- extrapolation of existing flood data to predict a much larger, deeper and faster flood
- short circuiting of the much higher flows at loops in a watercourse resulting in a shorter effective flow length
- selecting channel cross-sections that do not accurately represent a watercourse channel
- excluding the effects of the flood wave on the storage in the tributary creeks and other near stream storages
- excluding distributory flows.

Where previous flood records exist in the river or stream reach under consideration, the hydraulic model should be calibrated to match the available flood inundation data so that the numerical dam break model can be demonstrated to approximate actual flow conditions. If these records are not available, or are available for a limited range of flows, some assessment must be made of the potential impact on the accuracy of the modelled results. All modelling must be subjected to sensitivity analyses to test sensitivity to model assumptions.

Hydrographic characteristics of each study reach must be assessed and validated using aerial photography (where available) and site inspections.

4.3.5 Hy drologic data

Downstream tributary inflows may impact on the dam break flood, particularly if population centres are some distance downstream of the dam. Simpler analyses on smaller dams would not normally consider inflows from tributaries downstream of the dams. Concurrent rainfall to produce downstream tributary flows should be based on the lesser of the following rainfalls over the tributary catchments (see Table 1 below).

Table 1

Annual exceedance probability (AEP) of dam break flood rainfall	Annual exceedance probability of concurrent rainfall
1.0 e^{-3} or greater	Does not need to be considered
1.0 e^{-3} to 1.0 e^{-5}	AEP of dam break flood rainfall multiplied by 1000
1.0 e^{-5} or less	0.01

[4] Manning 'n' is a roughness parameter used to model energy losses in streams. Unless reasonable discharge and water level calibration is available, reference should be made to standard hydraulic engineering texts for appropriate values of Manning's 'n'.

4.3.6 Downstream community information

Downstream community information must include the location, number and nature of buildings and other places of occupation (for details see Appendix A) and approved camping and recreational areas in the failure impact zone.

This information may be obtained from maps, persons with local knowledge and emergency action plans for the dam. Recent aerial photogrammetry also provides useful information on the location of downstream structures. As stated above, site inspections must be undertaken to verify downstream community information to ensure the information is up to date and identifies buildings and other places of occupation obscured by trees.

4.4 Determination of failure impact zone (see also analytical techniques)

The failure impact zone is the area affected by flooding as a result of the failure of the dam. The magnitude of the flood impact is determined by the difference between the flood impacts associated with a particular event with dam failure and the same event without dam failure. Failure impact zones must be determined for all:

- failure events specified within the analytical technique used for the failure impact assessment (refer to Box 1) and
- for all other failure events relevant to the dam.

The failure impact zone ends when the:

- flood caused by a dam failure is retained within the bed and banks and no more people (including people on boats) are at risk downstream or upstream or
- difference between the flooding effect with dam failure and the flooding effect without dam failure (that is, the incremental effect of the dam failure on the impacted zone) is less than 300 millimetres.

It should be noted that:

- While the dam failure impact zone is generally located downstream, areas upstream can also be affected and should be included where relevant (for example, an upstream area may be affected by the abnormal operation of discharge control devices such as gates or inflatable bags).
- Where people work in a mine pit, excavation or local depression below the dam that would fill after dam failure to the point it would inundate the people, they would be considered to be in the failure impact zone unless there was a prepared path of escape that would not be blocked by inflows.
- In some circumstances (for example, during a ring tank failure) a dam breach may discharge onto a flood plain before the flow concentrates into a downstream channel. In such a situation there may be areas where the incremental flooding is more than 300 mm, separated by areas where the incremental flooding is less than 300 mm. When determining the failure impact zone, all areas where the incremental effect is 300 mm or higher must be included.
- Where a dam has multiple segments such as a main embankment and one or more saddle dams, failure of each of these segments must be considered for its effect on the failure impact zone. The case producing the maximum population at risk must be used to determine the failure impact rating.

A map showing the extent of the failure impact zones must be included in the written assessment.

4.5 Population at risk

People are considered part of the population at risk if:

- they occupy buildings or other places of occupation that lie within the failure impact zone and
- any part of the ground where these buildings or other places of occupation are located would be covered by 300 mm or more of water.

When the failure impact zone is being determined, the number, location and nature of buildings and other places of occupation must be identified. A particular population at risk is determined by allocating default populations to each such site depending on its nature. (See Appendix A for default populations). For example, a detached house has a default population of 2.9 people. If 10 detached houses were inundated by 300 mm or more of water (and there was no natural flooding at the time) and these were the only buildings or other places of occupation located in the failure impact zone, the population at risk for that dam failure event is 29 people.

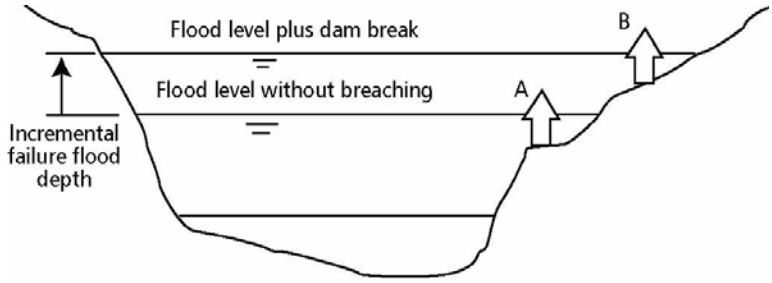
Note: The written assessment must state the nature of the site and justify the populations used for those places of occupation not listed in Appendix A.

The population at risk is the difference between the population at risk for a specific dam failure and the population at risk for the same flood had dam failure not occurred (that is, the incremental population at risk). The failure impact rating is determined using the highest incremental population at risk from a range of failure events relevant to the dam.

For example:

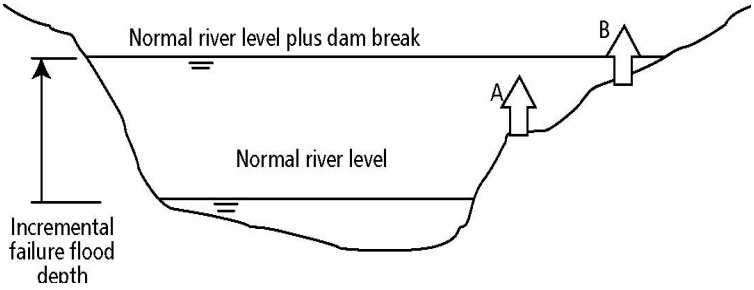
- Dam failure during a flood: 170 people are at risk from a dam failure, and 20 of those people are at risk from the natural flooding even if dam failure does not occur; it follows that 150 people are at risk if the dam fails (that is, 170 people minus 20 people). In the diagram below, house A is not included in the population at risk assessment for this event as it is inundated by natural floodwater. House B is included in the assessment of population at risk if the ground on which the house is located is inundated by at least 300 mm.

Figure 1—Dam failure during a flood



- A sunny day dam failure (when flooding is due to dam failure only): if 40 people are at risk from a dam failure, the population at risk is 40 people as nobody is at risk if the dam does not fail. In the diagram below, houses A and B are included in the assessment of population at risk if any part of the ground on which the houses are located is inundated by at least 300 mm.

Figure 2—Sunny day dam failure



4.6 Accuracy of population at risk calculations

A variety of factors may affect the accuracy of population at risk calculations. These must be considered to ensure the reliability of population at risk calculations. Factors include:

- the accuracy of cross-sections used in the analysis
- the locations of cross-sections used in the analysis
- the accuracy of the hydraulic modelling
- availability and accuracy/reliability of calibration data and the degree of extrapolation required to model dam break flows
- assumed hydraulic roughness parameters
- assumed breach development times
- locations, numbers and elevations of buildings and other places of occupation.

Sensitivity analyses or sensitivity tests assess the potential impact of some factors on the size of the population at risk and are normal practice for dam failure impact assessments. For example:

- What if the elevations of buildings or other places of occupation are at the lower bounds of the accuracy of the available survey information (for example, the accuracy of contours used to assess flood inundation is 2 metres)?
- What is the population at risk if all buildings or other places of occupation were 2 metres lower than assumed in the analysis?

- Does the population at risk change if conservatively short breach formation times are used?
- Does the population at risk change if conservatively high stream channel roughness parameters are used?

The degree of conservativeness should reflect the amount of calibration data available to determine stream channel roughness for the watercourse reaches in question.

The written dam failure impact assessment should include a statement on the range of the estimate of population at risk for the critical case. Such an assessment should indicate values for the upper limit of population at risk that could reasonably be expected as a result of the analysis and a similarly derived lower limit of population at risk.

4.7 Analy tical techniques

4.7.1 Introduction

Three analytical techniques may be used in preparing dam failure impact assessments. These are two-dimensional flow analysis, simplified assessment techniques and comprehensive assessment techniques. These techniques may be used alone or in combination. Certifying registered professional engineers need to be satisfied that the techniques selected and the accuracy of the models developed are reasonable for the situations under consideration (see Box 1 and refer to section 2.5).

4.7.2 Tw o-dimensional flow analysis

This analysis will typically need to be used downstream of ring tanks and gully dams where embankments are close to buildings or other places of occupations that may be inundated by dam failure. This analysis calculates the extent of inundation on a local scale prior to the flow entering the main watercourse. This typically occurs on flood plains where there are few or no defined gullies for dam break floodwater to follow. Additionally this technique may be used close to gully dam abutments where failure may inundate buildings and other places of occupation immediately downstream of the dam.

Two-dimensional flow analysis takes curvilinear flow paths into account as flow discharges from the breach and spreads out downstream. Models used in such analyses need to be able to simulate the dynamic behaviour of overland flow over complex geometries. There are a number of models that are capable of being used to determine these local effects. These include those based on the shallow water wave equations such as those discussed in Wang et al (2000) and Zoppou and Roberts (1999). A number of standard commercial software packages are also capable of determining inundated areas for two-dimensional flow (for example, MIKE21—Danish Hydraulic Institute, DELFT-FLS—Delft Hydraulics).

Details on dam breach mechanisms for two-dimensional flow analyses are detailed in section 4.7.5.

Box 1 Minimum failure events which must be considered in the failure impact assessment

Two dimensional flow analysis and comprehensive analysis

- sunny day dam failure where the failure occurs at the full supply level and there is no concurrent flooding
- if the probable maximum flood (or lesser flood event) overtops the dam, assume the dam fails with the water level at the crest of the non-overflow section of the dam embankment. Where there is no defined non-overflow section, failure levels up to the headwater level produced by the Acceptable Flood Capacity headwater level is to be considered (refer to DERM, 2010).
- if the probable maximum flood does not overtop the dam, assume the dam fails with the water at the level of the probable maximum flood
- if the dam is filled through pumping, assume failure at the crest level occurs (from pumping alone) when the pumps fail to stop pumping
- failure due to the maloperation or malfunction of flow control structures. If the dam has the capability to significantly vary flood discharges through crest gates, sluices or some other type of variable flow control structures, the possibility of either failure or malfunction of these structures must be considered
- where there are premises between the sunny day impact zone and the highest natural flood levels, intermediate flood events are to be considered when the no failure flood levels falls just below buildings and other places of occupation that would be inundated with dam failure.

Simplified assessment

- sunny day dam failure where the failure flood occurs with the storage at full supply level and there is no other concurrent flooding
- dam crest flood when failure occurs during a flood event or during pump filling with the water level at the crest of the non-overflow section of the dam embankment
- where there are premises between the sunny day impact zone and the highest natural flood level, intermediate events are to be considered when the no failure flood levels fall just below buildings and other places of occupation that would then be inundated with dam failure.

4.7.3 Simplified assessment

A simplified failure impact assessment technique may be justified where there is little doubt as to the population at risk and the cost of a comprehensive assessment is anticipated to be high relative to the potential benefits. It involves the conservative use of topographic and hydrographic data and an empirically determined breach discharge.

This is an approximate technique, which uses the normal depth at a section to estimate maximum flood levels at a point for a given discharge. As such this technique does not take any backwater effects into account. It must not be used where backwater effects are expected to be significant in terms of the affected population at risk. Aside from the backwater effects, the principal areas of uncertainty are the accuracy of the stream slopes, the cross-sections, and the locations and levels of the impacted buildings.

Unless more accurate techniques are used which result in the breach size indicated in section 4.7.5, the maximum breach discharge from a dam during a breaching event, QBREACH must be determined using Equation 1. The empirical discharge relationship is based on the failure of a typical homogeneous earthfill embankment.

Equation 1 $Q_{BREACH} = 2.5\ F\ V^{0.76} H^{0.1}\ m^3/sec$

where:

F = 1.3 a factor to account for the simplified nature of the assessment

V = total volume of water released (in megalitres)

H = maximum depth of water in the storage (in metres)

Where a case for assessing population at risk includes flow through dam spillways or other discharge points, an additional flow Q_{DCF} must be added to the breach discharge. This additional flow will include the total discharge through any dam spillways with the appropriate storage level for the failure event.

If alternative techniques are applied to determining the dam discharge, the factor F must still be applied to the breach discharge.

For embankments exceeding 12 metres in height or embankments made up of non-cohesive materials such as gravels or ash, the breach characteristics may differ and the expected peak discharge must be adjusted accordingly.

A survey of the cross-sections at buildings or other places of occupation that could be affected is normally required. Survey data may be relative to the creek bed at the cross section under consideration. The distance of the sections downstream of the dam should also be determined using aerial photography or available maps.

The water level at any particular cross-section resulting from the discharge from a dam breach should be consistent with the normal depth for the section using the maximum breach discharge and Equation 2:

Equation 2 $$Q = \frac{R^{2/3}\ S^{1/2}}{n} A$$

where:

R = hydraulic radius = A/P (metres)

S = stream slope (metres/metre)

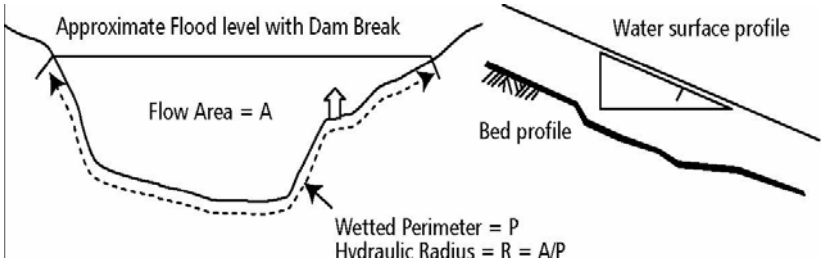
A = flow cross-sectional area (square metres)

P = wetted perimeter of cross-section (metres)

n = Manning's number[5]

[5] Manning 'n' is a roughness parameter used to model energy losses in streams. Unless reasonable discharge and water level calibration is available, reference should be made to standard hydraulic engineering texts for appropriate values of Manning's 'n'.

Figure 3—Parameters for water level determinations for simplified assessment



When sufficient depths at downstream sections have been determined the results should be plotted on a map. Interpolation between calculated points should be based on the accuracy of prevailing topography and contours.

4.7.4 Comprehensive assessment

If a simplified assessment is not accurate enough to adequately calculate the population at risk, then a comprehensive dam break analysis may be required. A comprehensive assessment is a detailed assessment of the failure impact zone and the population at risk if the dam fails. Dam break analyses must be undertaken for a range of dam failure scenarios (refer to Box 1) and use current hydraulic modelling practice and suitably documented and validated numerical models. Software capable of being used to carry out dam break analysis includes:

- BOSS FLOODWAV—International NWS DAMBRK (Version 3.0)
- Danish Hydraulics Institute—MIKE FLOOD
- RUBICON

Some estimate of the accuracy of each model must be made and this accuracy must be taken into account in assessing potential population at risk as indicated in section 4.6. The impact on population at risk will be greatest in areas with higher populations (for example, towns), and it may be justified to selectively improve accuracy in these areas.

Initially, cross-sections should be taken at or near the intervals shown in Table 2. However, the registered professional engineer certifying the assessment must be satisfied with the locations of cross-sections and the intervals between these cross-sections for each individual numerical model generated for the failure impact assessment.

Table 2

Storage (megalitres)	Indicative intervals between cross-sections	Indicative total distance downstream
20,000	1 kilometre	Up to 60 kilometres
2000	0.5 to 1 kilometre	Up to 20 kilometres
200	Not greater than 0.5 kilometre	Up to 5 kilometres

The total distances downstream in Table 2 are based on actual dam break studies indicating the distances downstream where the incremental effects of the dam break flood become relatively small.

Care should be taken to treat each case as site specific, particularly where the downstream valley is confined and narrow for great distances. In these cases, the dam break flood may not dissipate quickly and greater distances downstream may need to be considered, especially where there are buildings and other places of occupation at risk.

When carrying out dam break studies, other factors that must be included are:

- downstream hydraulic roughness
- other significant downstream hydraulic coefficients such as expansion and contraction coefficients
- dam break characteristics including breach base width, breach side slopes, breach depth, time for completion of breach
- spillway discharge rating curve
- storage versus height curves

- inflow hydrograph
- downstream tributary inflows.

The output from a dam break analysis must include:

- hydrograph at each section (flow versus time)
- depths at each section at appropriate time intervals
- velocities at each section at time intervals
- flood peak arrival times at each section
- the first rise in water level at each section
- recession time of the dam break flood.

This information needs to be summarised in tables and plotted on a map. The preferred map scale is 1 in 5000 with contours at maximum two metre intervals. However this can be varied depending on the scale of the inundated area.

It is expected that a detailed dam break analysis will provide results that are at best accurate to +/– 1m vertically. However, it should be noted that most dam break models are based on two-dimensional cross sections. Real life effects such as run-up around bends, the effects of rolling wave fronts and the effects of debris building up into secondary dams and then breaking may not be catered for in such models.

Details on dam breach mechanisms for comprehensive assessments are described in section 4.7.5.

4.7.5 Dam breach mechanisms for two-dimensional flow analyses and comprehensive assessments

Assumptions made of dam breach parameters can significantly affect the results of dam break analyses. The most significant parameters are the dimensions of the fully developed breach and the time it takes for the breach to develop.

Breach analyses must include sensitivity tests using assumed breach parameters to gauge their impact on the overall analysis.

The following procedure must be used for determining the magnitude of any potential dam breaches (Allen 1994). The same procedure is to be used for determining the ultimate size of the breach for both overtopping failures and for sunny day failures. In piping failures, it is to be assumed that the breach is initiated at the level which produces the maximum discharge from the breach. Unless special provisions are made, overtopping failures should be initiated as soon as the embankment is overtopped.

1. Examine the structure, or proposed structure, of the dam and obtain any available service histories, design reports or design reviews which may indicate likely modes and/or locations of breaches for that type of structure.
2. Consider all possible breach mechanisms, with a view to selecting the critical mechanism after running dam break inundation models for each alternative breach.

Then for embankment dams:

3. Calculate Breach Formation Factor for the assumed failure condition:

   $BFF = V_w * h$

   where

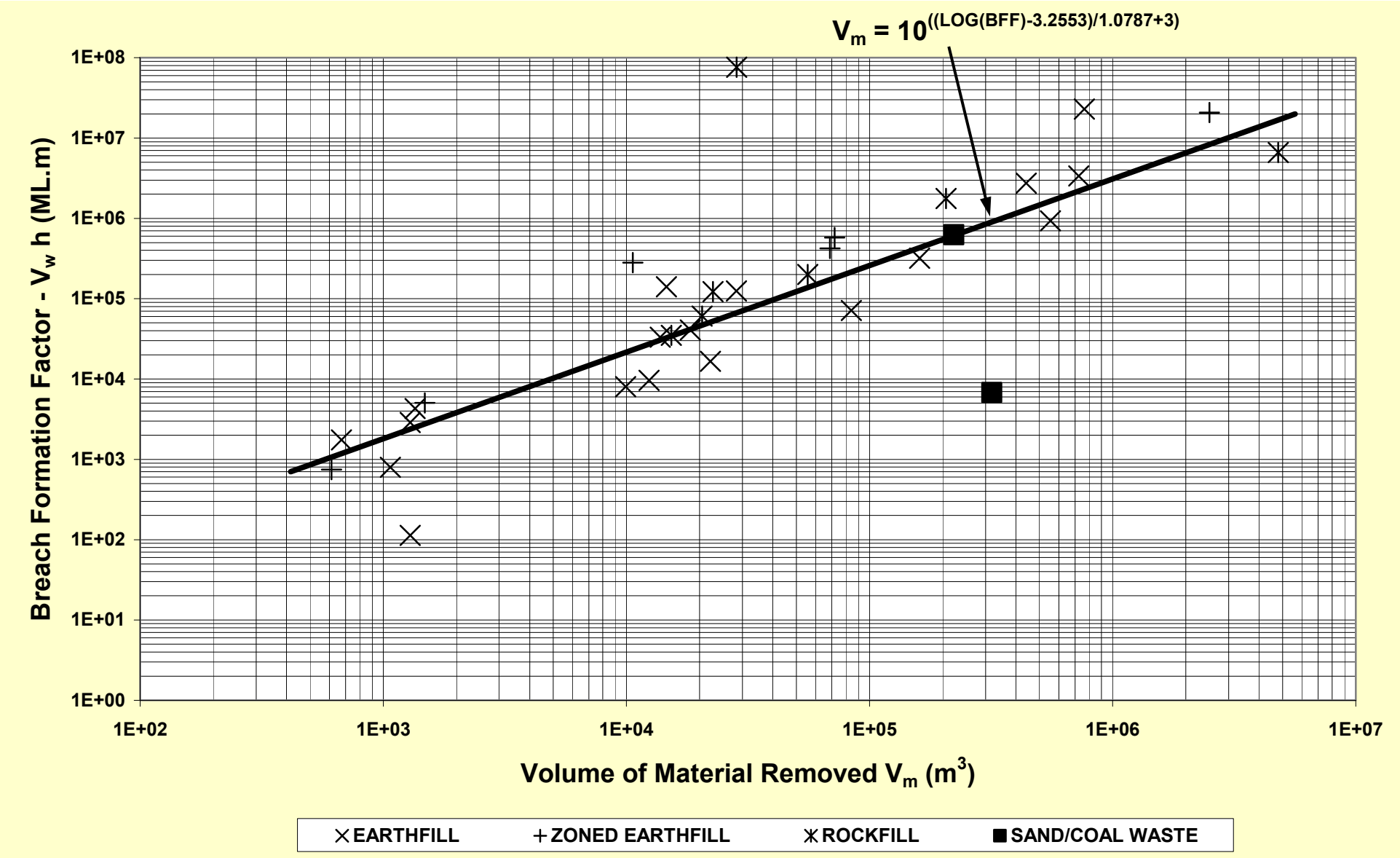
   BFF = Breach Formation Factor

   V_w = Total volume of water to flow through the breach (megalitres)

   h = Height differential between headwater and tailwater levels (metres)

4. Use Figure 4 to determine the volume of material expected to be removed during the formation of the breach V_m (cubic metres).

Figure 4—Outflow characteristics as a function of breach size



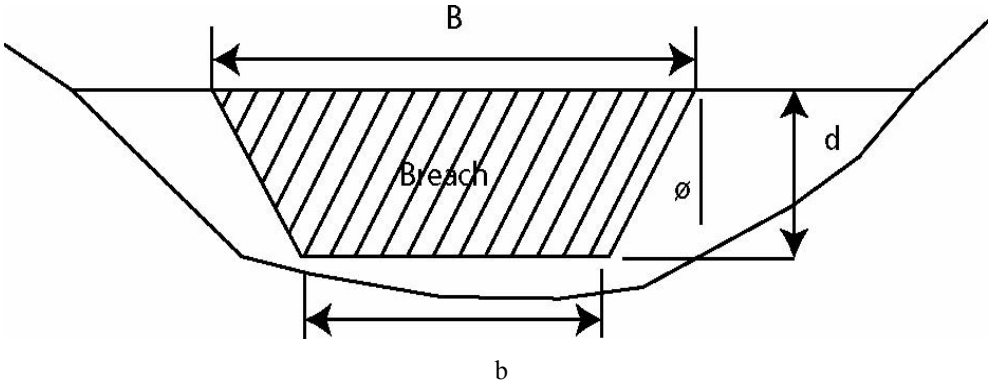
5. Determine the size of breach that corresponds to V_m assuming a trapezoidal breach with side slopes of between IH: IV and IH:2V. Note: If V_m is more than the volume of material available in the embankment, assume the embankment is effectively removed and replace V_m with this volume.
6. Unless special circumstances prevail (such as a very high embankment being required to store a relatively small volume of water), check to see that the breach size is within the following range of parameters (refer to Figure 5 below). That is,-

   $1.06 < B/b < 1.74$ with a mean of 1.29 and a standard deviation of 0.18

   $0.84 < B/d < 10.93$ with a mean of 3 and a standard deviation of 2.62

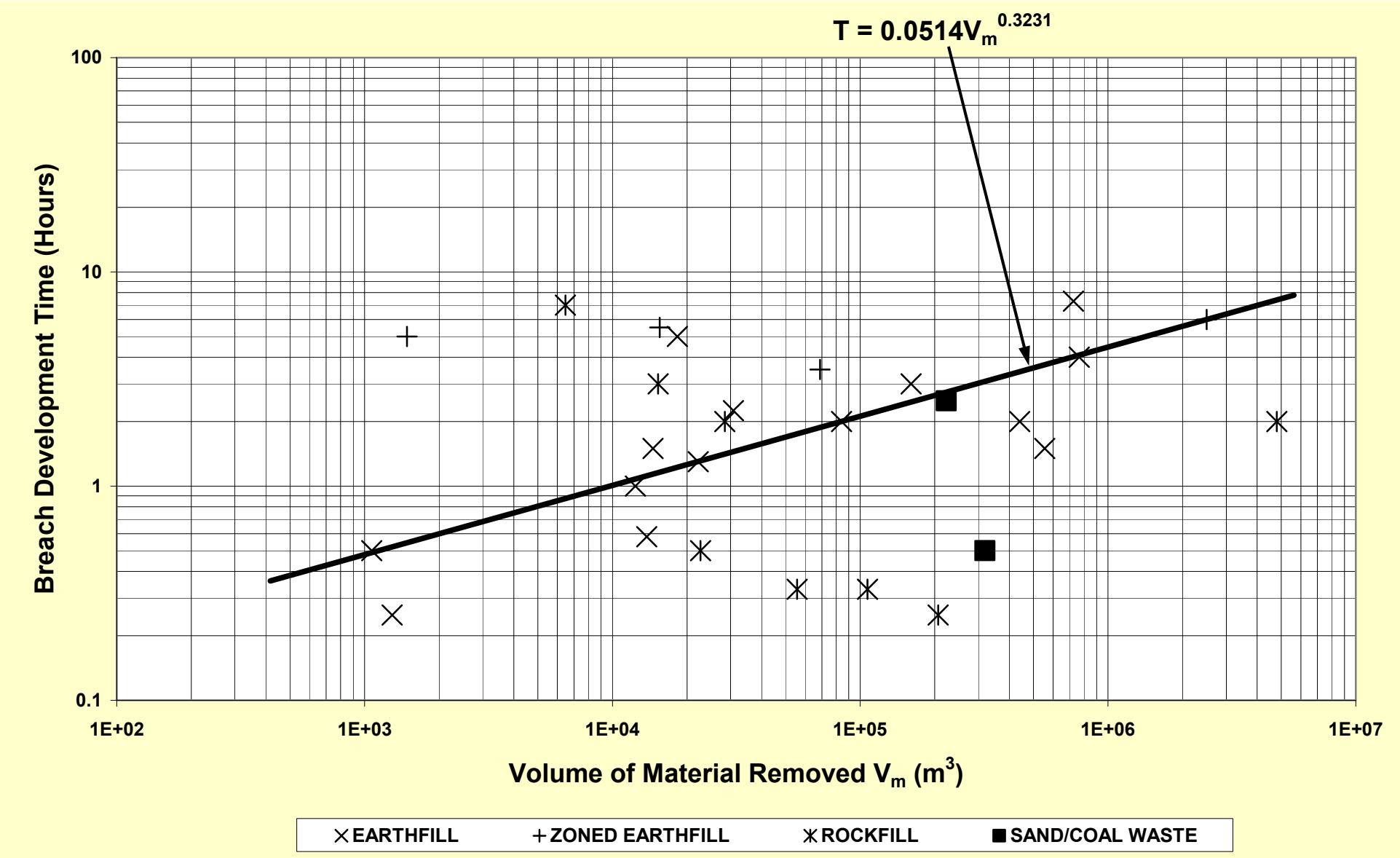
   side slope ø in the range 10° to 50° off vertical.

Figure 5—Notation for breach parameters



7. Use figure 6 to determine the breach development time.

Figure 6—Breach development time as a function of material removed



8. Run the dam break model and examine the hydraulic conditions occurring in the breach throughout the discharge and qualitatively modify the parameters accordingly. For example, if the breach outflow is heavily affected by tailwater, increase the breach development time or reduce the size of the breach to reflect the reduced erosive capacity of the flow. If the discharge continues at high levels long after the breach has been fully developed, increase the size of the breach.

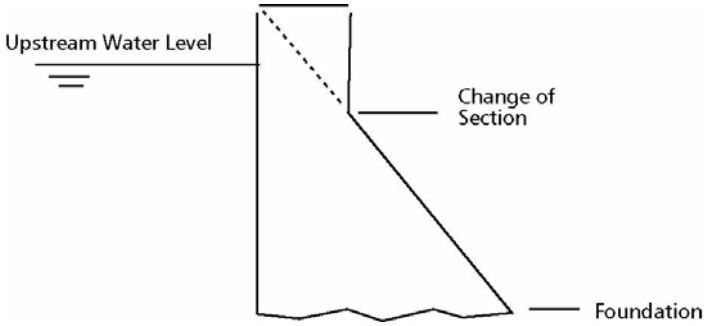
Note: Saddle dams are likely to fail relatively quicker and more completely than main embankment dams because they store more water for a given embankment volume.

9. Conduct a sensitivity analysis on the adopted parameters with due regard to the composition of the embankment.

And for Concrete dams:

10. Determine the storage level at which failure is likely to occur. If no design information is available, assume removal of the top of the non-overflow section above the change of section and the dam foundation. However, this assumption should be checked during model analysis, and, if a more critical case is identified, this should be adopted.
11. Assume that at least 30 per cent of the monoliths in the main section of a mass gravity structure are instantaneously removed at either the change of section or the dam foundation (refer to Figure 7 below).

Figure 7—Typical mass concrete dam cross-section



12. Assume complete removal of any arch dam or multiple arch dam as rapidly as the model will allow.
13. Conduct a sensitivity analysis on the adopted parameters.

4.7.6 Two or more dams on the same watercourse

Sometimes, two or more dams occur on the same watercourse. In such circumstances, it must be assumed that the failure of an upstream dam may trigger the failure of downstream dams. If the downstream dam cannot store the contents of the upstream dam without failure, the combined effect of multiple dam failures must be considered when determining the incremental population at risk for the upper dam for failure events. Similarly, if failure of a downstream dam could contribute to the failure of an upstream dam (such as through a rapid drawdown failure if headwaters of the downstream dam back up against the upstream dam), the potential failure of the upper dam must be considered when determining the incremental population at risk of the lower dam for failure events. The dam failure case producing the highest incremental population at risk must be used to determine the failure impact rating for the dam.

4.7.7 Other failure events

If the registered professional engineer considers that other failure events could result in a higher incremental population at risk, these failure conditions must be considered and described in the failure impact assessment. These failures may include:

- storage rim instability
- factors such as deterioration, old age, design or construction faults and poor maintenance
- damage due to fire, wind (for example, causing beaching leading to a breach) and escape of water into mining tunnels/shafts beneath reservoirs
- vandalism.

4.8 Periodic re-assessment of failure impact rating

Provided that:

- the records of the previous failure impact assessment still exist and
- there have not been substantial changes in:
    - the stream channel cross-sections and roughness
    - the embankment and spillway geometry and
    - the magnitude of the design floods

it is permissible for each consequential re-assessment of a failure impact rating (after the last failure impact rating has been accepted by the chief executive) to use the same inundation data as used in the previous analysis for assessment of the population at risk.

However, the population at risk must be re-calculated as part of each re-assessment of the failure impact rating.

In all other cases, reassessment will require a complete analysis following procedures outlined in these guidelines.

The registered professional engineer's certification must include justification of the approach adopted in the re-assessment.

5. Summary of failure impact assessment requirements

The following information is to be included in a written failure impact assessment:

Executive summary/introduction

A general description of the dam and a summary of the results of the failure impact assessment including:

- type of dam
- general location of the dam
- height and storage capacity of the dam
- the maximum population at risk
- a description of the critical failure event producing the maximum population at risk
- the recommended failure impact assessment category for the dam.

General information

- name of dam
- owner of dam (that is, individual or company)
- dam owner contact details (that is, postal address, street address, phone number, facsimile, email)
- status of dam (that is, existing or proposed dam or proposed work)
- property description of dam (for main part of dam wall including portion, parish, county and locality)
- location of dam (that is, longitude and latitude)
- date dam construction completed to current arrangement
- licence or development permit number (if any)
- date last failure impact assessment accepted by the chief executive
- date last failure impact assessment submitted to the chief executive
- attach relevant maps (including map number, scale, map date and height accuracy). Copies of inundation maps in electronic format are also desirable.
- attach copies of relevant aerial photographs (if any) (including photographic series name, film number, run number, approximate scale, date flown, photograph number(s))
- attach other topographic or cadastral source data (for example, detailed survey plans, orthographic maps, property boundary details)
- name of watercourse or offstream storage (including adopted middle thread distance (AMTD) measured in kilometres).

Catchment details

- catchment area (hectares)
- catchment general description
- percentage of catchment which has-
  - bare ground, rock, pavements, roofs, city areas (fully built)
  - rocky, clayey or non-absorbent soil with scanty herbage
  - open forest or grassed land, cereal crops
  - average grassed timberland of medium soil texture
  - heavily timbered country, closely cultivated land and pasture
  - sand
- average catchment slope.

Dam description

- type (that is, homogenous earthfill dam, zoned earth and rockfill dam, concrete dam or other)
- height (that is, the measurement of the difference in level between the natural bed of the watercourse at the downstream toe of the dam or, if the dam is not across a watercourse, between the lowest elevation of the outside limit of the dam and the top of the dam)
- total length of main dam (that is, metres from end of left abutment to end of right abutment)
- total length and brief description of other dam components (for example, saddle dams)
- saddle dam details
- purpose of storage (for example, water supply for irrigation)
- dam capacity to full supply level (in megalitres)
- dam surface area at Full Supply Level
- details of the storage capacity curve used in the analysis.

Spillway description

- type of spillway
- dimensions of spillway.

Data

- summary of the data collected for the analysis and an assessment of the appropriateness and accuracy of the data
- summary of the findings/verification of the site including details of who undertook the inspection and inspection date(s)
- spillway rating curve used in the analysis
- details of the critical flood used in the analysis and a summary of the methodology used to derive it.

Results and discussion

- analytical technique used (that is, two-dimensional flow analysis, simplified assessment or comprehensive assessment or a combination of these) and justification for use
- details of modelling used including-
  - model or models used in the analysis
  - breach parameters adopted and the basis for their adoption
  - hydrological inputs used
  - statement of calibration data used to validate the models generated
  - degree of extrapolation adopted
  - cross-sections used and roughness parameters adopted
  - predicted accuracy of the modelling, both in terms of flood levels and the population at risk
  - statement on the sensitivity of the model results to the various adopted parameters with supporting evidence drawn from the modelling undertaken.
- failure events considered
- reasonable upper and lower limits of population at risk as a result of the analysis
- recommended failure impact rating (that is, category 1 or 2 failure impact rating or not referable) and the critical dam failure condition determining this rating
- failure impact zone accounting for sufficient points of impact for all relevant failure events including map showing the extent of the failure impact zones (hard copy mandatory and electronic format desirable)
- incremental population at risk for all relevant failure events (including the nature of the site and justification for the populations used for places of occupation not listed in Appendix A)
- statement on the range of population at risk that can be reasonably expected for the critical case as a result of the analyses.
- detailed summary of the buildings and other places of occupation containing population at risk, and the location of this population
- details of dam break analyses
- commentary on sensitivity analyses.

Certifying registered professional engineer

- name
- registration number
- contact details (including postal address, street address, telephone number, facsimile, email as appropriate)
- statement that he or she is not the owner or operator, an employee of the owner or operator
- statement of certification (refer to section 3.2 for details of what is required in this statement)
- signature
- date.

6. Bibliography

6.1 References

[redacted] (1994), Dam Break Breach Mechanisms, ANCOLD Bulletin No.97, August.

[redacted] (2000), Finite Difference TVD Scheme for Computation of Dam Break Problems, Journal of Hydraulics Division ASCE, Volume 126 (4), April.

[redacted] (1999), Catastrophic Collapse of Water Supply Reservoirs in Urban Areas 1999, Journal of Hydraulics Division ASCE, Volume 125 (7), July.

Department of Environment and Resource Management (DERM) (2010), Guidelines on Acceptable Flood Capacity for Dams

6.2 Software

Standard commercial packages capable of determining inundated areas for two-dimensional flow include:

- MIKE 21—Danish Hydraulic Institute
- DELFT-FLS—Delft Hydraulics.

Standard commercial packages useful for dam break analysis include:

- BOSS FLOODWAV, NWS DAMBRK (Version 3.0)—International
- MIKE 11—Danish Hydraulics Institute
- RUBICON.

7. Appendices

7.1 Appendix A—Default populations

Nature of buildings or other places of occupation	Equivalent population
Detached housing [1] 2.	9 per house
Semi-detached, row or terrace housing [1] 2.	0 per house
Multi-unit buildings [1] 1.	7 per unit
Blocks of flats [1] 1.	7 per flat
House or flat attached to a shop, office, etc. [1]	2.5 per house or flat
Approved caravan parks [1,16]	1.8 per caravan site
Approved camping grounds [2,16]	0.45 per camping site
Hotel/motel accommodation [3] 1.	0 per bedroom
Child care centres [4]	0.4 per child and staff member
Kindergartens, pre-schools [5]	0.25 per student and staff member
Primary schools (day) [5]	0.25 per student and staff member
High schools (day) [6]	0.3 per student and staff member
Tertiary education centres Lectures—day Lectures—evening	 0.35 per student and staff member attending during the day 0.15 per student and staff member attending during the night
Offices [8] 0.	4 per employee
Restaurants [9]	0.3 per member of staff and diners' places
Medical centres [10]	1.7 per member of staff
Mines	Total of all personnel working in inundated area where the path to escape the inundation will be cut-off by the incoming flows.
Tavern/hotel bars [11]	0.15 per m^2 of patrons' area
Shops, shopping centres [12]	2.0 per 100 m^2 of gross area
Hospitals [13]	1.0 per bed plus 0.33 times the total number of staff
Institutional accommodation [14]	1.0 per bed plus 0.33 times the total number of staff
Service stations [15]	0.4 times the total number of staff
Industrial buildings and other non-residential sites	0.4 times the total number of staff
Department of Transport and Main Roads moorings	2.0 per mooring

Notes:

1. The occupancies for these dwellings are derived from the overall Queensland figures for persons, by dwelling structure and occupied dwelling structures, by tenure type (private dwellings) in the 1996 census.
2. This occupancy comes from an analysis of 1999 figures for the number of permits issued, the numbers of campers per permit and the duration of each permit for 20 camping grounds under the control of the Department. The average number of campers per permit was 3.0 and the average site occupancy rate was 14.5 per cent. Therefore an average occupancy value of 0.45 campers per site has been adopted.
3. This occupancy assumes that a hotel/motel bedroom will typically accommodate two people, who will be present for half of any one day, and that number of staff will compensate for the fact that generally not all rooms will be (fully) occupied.
4. This occupancy is based on a typical 9.5 hour day (8:00-5:30).
5. These occupancies are based on a typical 6 hour day (9:00-3:00).
6. This occupancy is based on a typical 7 hour day (8:30-3:30).
7. These occupancies are based on a typical 8 hour day (9:00-5:00) for day lectures and a typical 3 hour day (6:00-9:00) for evening lectures.
8. This occupancy is based on a typical 9 hour day (8:30-5:30).
9. This occupancy is based on the following assumed patronage:
    a. 10 per cent full—9:00 am—noon, 2:00 pm—6:30 pm
    b. full-noon—2:00 pm, 6:30 pm—10:30 pm
    c. staff numbers are 10 per cent of number of places.
10. This occupancy is based on a 10 hour day (8:00-6:00) and assumes 3 patients at the location for each doctor and other staff member.
11. This occupancy is based on the following assumed breakdown of daily patronage:
    a. 10 per cent of daily peak—10:00 am—noon
    b. daily peak—noon—2:00 pm
    c. 15 per cent of daily peak—2:00 pm—5:00 pm
    d. daily peak—5:00 pm—7:00 pm
    e. 50 per cent of daily peak—7:00 pm—8:00 pm
    f. 25 per cent of daily peak—8:00 pm—10:00 pm.

    The Liquor Licensing Division of the Department of Employment, Economic Development and Innovation cited maximum numbers of patrons as $2/m^2$ standing and $1/m^2$ dining. The occupancy rate is therefore based on an assumed annual average for the daily peak patronage of $0.6/m^2$ plus a 10 per cent allowance to cover staff.
12. This occupancy rate is an estimate based on information from the former Appendix B of Volume 1 of the Guidelines for Planning and Design of Sewerage schemes (issued by Department of Natural Resources) which has now been superceded by the DERM Planning Guidelines for Water Supply and Sewerage.
13. The occupancy rate of 1.0 per bed assumes that the number of visitors will compensate for the fact that generally not all beds will be occupied. The staff factor applies to the sum of the numbers of staff on different shifts.
14. These occupancies are identical to those for hospitals. It has been assumed that lower visitor numbers will offset the higher bed occupancy ratio for institutions.
15. This occupancy rate applies to the sum of the numbers of staff on different shifts. It contains a 20 per cent allowance to cover customers.
16. Only camping areas and caravan parks approved by government agencies (local, state or federal) or included in local authority planning schemes should be included. Because of the difficulties associated with determining the number of sites, and their permanence, of non-approved camping grounds and caravan parks, they are excluded from assessment.

7.2 Appendi x B—Definitions

AMTD is adopted middle thread distance

Annual exceedance probability is the probability that a particular flood value will be exceeded in any one year.

Bed and banks for a watercourse or lake is the land over which the water within the watercourse or lake normally flows or the land normally covered by that water, whether permanently or intermittently. This does not include land adjoining or adjacent to the bed or banks that is, from time to time covered by floodwater.

Dam means:

1. (a) works that include a barrier, whether permanent or temporary, that does or could impound water; and
   (b) the storage area created by the works.
2. The term includes an embankment or other structure that controls the flow of water and is incidental to works mentioned in item 1(a).
3. The term does not include the following:
   (a) a rainwater tank
   (b) a water tank constructed of steel or concrete or a combination of steel and concrete
   (c) a water tank constructed of fibreglass, plastic or similar material.

Dam break flood is the flood event produced by a dam failure.

Dam crest flood is the flood event which, when routed through the storage with the storage initially at full supply level, results in a still water level in the storage, excluding wind and wave effects which:

- for an embankment dam, is the lowest point of the embankment crest
- for a concrete dam, is the level of the non-overflow section of the dam, excluding handrails and parapets if they do not store water against them
- for a concrete faced rockfill dam, is the lowest point of the crest structure.

Dam failure is the physical collapse of all or part of a dam or the uncontrolled release of any of its contents.

Development has the meaning given by the *Sustainable Planning Act 2009*, section 7. Development is any of the following–

a. carrying out building work
b. carrying out plumbing or drainage work
c. carrying out operational work
d. reconfiguring a lot
e. making a material change of use of premises.

Development permit is a development permit as defined under the *Sustainable Planning Act 2009*. A development permit authorises assessable development to take place:

a. to the extent stated in the permit; and
b. subject to:
   i. the conditions of the permit; and
   ii. any preliminary approval relating to the development the permit authorises, including any conditions of the preliminary approval.

Failure impact assessment is an assessment about the safety of a dam or proposed dam certified:

a. by a registered professional engineer who is not, for the dam, or the proposed dam
   i. the owner or
   ii. an employee of the owner or
   iii. the operator or
   iv. an employee of the operator and
b. in accordance with the Guidelines for Failure Impact Assessment of Water Dams issued by the chief executive.

Failure impact zone is the area affected by the failure of the dam. The zone is limited to the area where the incremental effect of a dam break flood is 300 mm or higher.

Full supply level is the level of the water surface of the dam when the water storage is at maximum operating level when not affected by flood.

Hazardous waste is any substance, whether liquid, solid or gaseous, derived by, or resulting from, the processing of minerals that tends to destroy life or impair or endanger health; or ash resulting from the process of power generation.

Height for a dam, the measurement of the difference in level between the natural bed of the watercourse at the downstream toe of the barrier or, if the barrier is not across a watercourse, between the lowest elevation of the outside limit of the barrier of the dam and the top of the barrier.

Height for a weir, barrage or dam, means the measurement of the difference in level between the natural bed of the watercourse at the downstream toe of the barrier or, if the barrier is not across a watercourse, between the lowest elevation of the outside limit of the barrier and the top of the barrier.

Incremental effect is the difference between flood impact that what would occur under a given set of conditions with no dam break and the flood impact under the same set of conditions with a dam failure.

Information notice is a formal notice of a decision made under the Act. The Act states when information notices must be sent. Information notices must state:

- the decision (Act requirement)
- the decision maker's findings on material questions of fact (section 27B *Acts Interpretation Act 1954* requirement)
- the evidence on which those findings were based (section 27B *Acts Interpretation Act 1954* requirement)
- the reasons for the decision (Act requirement)
- the name and address of any other person who was given the notice (Act requirement)
- that the person to whom the notice is given may appeal for an internal review of the decision within 30 business days after the notice is given (Act requirement)
- how to apply for an internal review (Act requirement).

Owner of land means any of the following, and includes the occupier of the land:

a. the registered proprietor of the land under the *Land Title Act 1994*

b. the lessee or licensee under the *Land Act 1994* of the land

c. the holder of a mineral development licence or mining lease over the land under the *Mineral Resources Act 1989*

d. the person or body of persons who, for the time being, has lawful control of the land, on trust or otherwise

e. the person who is entitled to receive the rents and profits of the land.

Owner of a referable dam means the owner of land on which the referable dam is constructed, or is to be constructed.

Population at risk is the number of persons, calculated using these guidelines, whose safety will be at risk if the dam, or the proposed dam after its construction, fails. For the purposes of this guideline, persons are considered to be at risk if they are within the failure impact zone.

Probable maximum flood is the flood resulting from probable maximum precipitation, and where applicable snow melt, coupled with the worst conditions that can be realistically expected in the prevailing meteorological conditions.

Probable maximum precipitation is the theoretical greatest depth of precipitation for a given duration that is, physically possible over a particular catchment area, based on generalised methods.

Referable dam is a dam or a proposed dam:

a. which must have a dam failure impact assessment carried out under the Act

b. for which the assessment states that the dam, or the proposed dam after its construction will have a category 1 or category 2 failure impact rating

c. for which the chief executive has, under section 349, accepted the assessment.

The following are not referable dams:

a. a hazardous waste dam

b. a weir, unless the weir has a variable flow control structure on the crest of the weir.

The following are not dams and cannot therefore be referable dams:

a. a rainwater tank

b. a water tank constructed of steel or concrete or a combination of steel and concrete

c. a water tank constructed of fibreglass, plastic or similar material.

Registered professional engineer is a registered professional engineer, a registered professional engineering company or a registered professional engineering unit as defined under the *Professional Engineers Act 2002*.

Ring tank is a dam that has a catchment area, that is, less than three times its maximum surface area at full supply.

Storage capacity means the capacity of water ordinarily stored in a thing.

Top of the barrier for a weir, barrage or dam, means the level of the top of the barrier exclusive of any parapet or ancillary structure or, if the barrier includes a spillway, the level of the top of the abutment walls adjoining the spillway exclusive of any parapet or ancillary structure.

Water means:

a. water in a watercourse, lake or spring

b. underground water

c. overland flow water

d. water that has been collected in a dam

e. includes any other liquid or a mixture that includes water or any other liquid or suspended solid.

Weir means a barrier constructed across a watercourse below the banks of the watercourse that hinders or obstructs the flow of water in the watercourse.

NATURAL RESOURCES AND MINES

PRELIMINARY DAM FAILURE IMPACT ASSESSMENT, STAGE 2 FLOOD DETENTION BASINS ALONG WEST CREEK (2001), TOOWOOMBA

WSDJ00310/03-K (2001)

24 May 2004

Coffey

WSDJ00310/03-K (2001)
24 May 2004

Natural Resources and Mines
GPO Box 2454
BRISBANE QLD 4001

Attention: [redacted]

Dear Sir,

RE: PRELIMINARY DAM FAILURE IMPACT ASSESSMENT, STAGE 2
FLOOD DETENTION BASINS ALONG WEST CREEK (2001)
TOOWOOMBA

Please find attached a copy of the Preliminary Dam Failure Impact Assessment, Stage 2 for the four Flood Detention Basins along West Creek in Toowoomba (No. 2001), prepared by [redacted] (RPEQ No. [redacted]).

Please do not hesitate to contact the undersigned if you have any queries.

For and on behalf of
WATER STUDIES PTY LTD

[redacted]

Manager, Northern Region

Attachment: A - Preliminary Failure Impact Assessment, Stage 2
Flood Detention Basins Along West Creek, Toowoomba (No. 2001)

Water Studies Pty Ltd ACN: 090 062 294
A member of the Coffey Group of companies

53B Fairlawn Street, Nathan
QLD 4111 Australia
PO Box 108 Salisbury
QLD 4107 Australia
Telephone +61 3274 4411
Facsimile +61 7 3274 4977
Email brisbane@waterstudies.com.au

2. METHODOLOGY

This preliminary failure impact assessment has been prepared generally in accordance with the 'Brief for performance of preliminary FIA's for suspect Dams' issued by the Queensland Department of Natural Resources and Mines. Analyses undertaken in Stage 1 were updated where necessary with additional data and information gathered during the site visit, and from Toowoomba City Council. Further, sensitivity analyses were undertaken to assess the surety of the assessment made. General information concerning the detention basins, as well as details of refined calculations used in determination of the PAR, are summarised in Tables 1 to 6 below, and in Appendices 1 to 4.

3. SITE VISIT

The four detention basins and the potential properties at risk if these basins failed were inspected on 11 November 2003. The tasks undertaken during the site visit included:

- Confirm the information and data given in the preliminary inspection report;
- Verify available aerial photographs or topographic maps used to identify the PAR;
- Assess the potential flood behaviour at the location of the PAR;
- Meet with Toowoomba City Council officers to explain the scope of the current investigation and obtain relevant data and information to assist the preliminary FIA.

4. INFORMATION AVAILABLE FROM PREVIOUS STUDIES

Toowoomba City Council has undertaken a number of flood and catchment management studies of West Creek in the past. These studies have used hydrologic and hydraulic models to investigate West Creek flooding behaviour and design the current detention basins. From these studies, the following data and information were supplied by Toowoomba City Council.

- Gowrie Creek Catchment Management Study – Main Report (November 1998);
- Gowrie Creek Catchment Management Study – Technical Appendix (August 1998);
- Detailed design drawings for Spring to Stenner Street Basins #1 and #2, and Stenner to Alderley Street Basin;
- Layout drawings for Spring Street Basin;
- West Creek cross-section data;
- Aerial photo of West Creek reserve with cross-section locations;
- HEC-RAS model results; and
- RAFTS model results for model runs with detentions basins in place.

It is noted that there are some inconsistencies in the data available from the model files and the detailed drawings and reports. In addition, information and data available for the Spring Street basin was insufficient. Therefore, some assumptions were made and discretion used when interpreting and using the available data. The findings of this report, however, are not affected by these issues. The data used for the estimation of dam breach discharges are shown in Appendices 1 to 4.

Tables 1 and 2 provide general information on the detention basins and the West Creek catchment. Details of calculations undertaken for the four detention basins are given in Tables 1 to 7 in Appendices 1 to 4.

TABLE 1. GENERAL INFORMATION

Name of Dam	Toowoomba Flood Detention Basins (No. 2001)
Dam Owner	Toowoomba City Council
Contact Details	Herries Street Toowoomba Qld 4350 Ph: 07 4688 6111 F: 07 4638 3830 Email: council@toowoomba.qld.gov.au
Status	Existing – 4 basins along West Creek - year completed varies from 1999 to 2001, further basins proposed in the future (time table unknown)
Property Description	West Creek Reserve, Kearneys Spring, Toowoomba
Latitude	27° 35' 30" S
Longitude	151° 56' 30" E
Current Licence No.	n/a
Regional Drainage Characteristics	The series of flood detention basins is located in West Creek Reserve within the Gowrie Creek Catchment, Toowoomba. The Gowrie Creek catchment forms part of the Condamine River catchment.
Available Topographic Data	1:25:000 topographic map 9242-11 Toowoomba
Available Aerial Photographs	1:37500 flown 17/6/1999 (QAP58790 Run 3 – 32 and Run 4 - 117)

TABLE 2. CATCHMENT DETAILS

Catchment Characteristics	The West Creek catchment drains in a northerly direction into Gowrie Creek. The four flood detention basins investigated in this study are in the West Creek Reserve between Alderley Street and Spring Street. Based on 2001 aerial photography, the upstream catchment is urban and upstream of Spring Street is rural residential.
Catchment Area (ha)	• 1578 to confluence with East Creek (from Gowrie Creek Flood Management Study report) • 660 to Alderley Street (from Councils hydrologic model files)
Average Catchment Slope (to Stenner to Alderley Street basin)	Approximately 4% (from Councils hydrologic model files)
Methodology for Inflow Estimate	Flood Study Report (Ref 3 and 4)
100 Year ARI inflow (m^3/s)	See Tables 3, 4 and 5 below

The results of relevance to this report obtained from previous studies are presented below.

Table 3 shows estimated 1 year, 2 year and 100 year ARI West Creek design discharges at the confluence with East Creek for existing (pre-basin), ultimate development (without basins) and ultimate development (with all proposed detention basins) catchment conditions. It is noted that not all basins proposed along West Creek have been constructed to date. Also note that the West Creek catchment areas contributing to the four detention basins investigated in this report are much smaller than the total catchment area at its confluence with East Creek (1578 ha).

TABLE 3: 1 YEAR, 2 YEAR AND 100 YEAR ARI WEST CREEK DESIGN DISHCARGES AT CONFLUENCE WITH EAST CREEK FOR EXISTING (PRE-BASIN), ULTIMATE DEVELOPMENT (WITHOUT BASINS) AND ULTIMATE DEVELOPMENT (WITH ALL PROPOSED BASINS) CONDITIONS.

ARI (years)	Discharge (m^3/s)		
	Existing (without basins)	Ultimate Development (without basins)	Ultimate Development (with all basins)
1	35.7	43.8	21.7
2	48.6	57.7	28.3
100	104.2	131.9	56.2

Table 4 shows the approximate design discharges at the Stenner to Alderley Street Basin, which is the most downstream of the current basins, based on the ratio of catchment areas, for 1 year, 2 year and 100 year ARI design events for existing (pre-basin) and ultimate development (without basins) conditions.

TABLE 4: APPROXIMATE 1 YEAR, 2 YEAR AND 100 YEAR ARI WEST CREEK DESIGN DISHCARGES AT STENNER TO ALDERLEY STREET DETENTION BASIN FOR EXISTING (PRE-BASIN) AND ULTIMATE DEVELOPMENT (WITHOUT BASINS) CONDITIONS.

ARI (years)	Discharge (m^3/s)	
	Existing (without basins)	Ultimate Development (without basins)
1	15.0	18.4
2	20.4	24.2
100	43.8	55.4

cf 48.4 m^3/sec outflow for Ultimate development all basins installed

Table 5 shows the catchment areas draining to each basin and the estimated 100 year ARI design inflows to and outflows from each basin.

TABLE 5: CONTRIBUTING CATCHMENT AREAS AND 100 YEAR ARI DESIGN INFLOW AND OUTFLOW ESTIMATES, WEST CREEK DETENTION BASINS.

Basin	Catchment Area (ha)	Inflow (m^3/s)	Outflow (m^3/s)
Spring Street	182	40.1	36.2
Spring to Stenner Street #1	319	45.0	41.0
Spring to Stenner Street #2	357	48.5	46.0
Stenner to Alderley Street	660	63.2	48.4

Information supplied by the council indicates that flooding problems existed along West Creek at a number of locations prior to the construction of basins, and that the major area of flooding concern extended from Herries Street to the confluence with East Creek. Flooding problems, including property inundation, in this reach commenced when floods exceeded 5 year to 10 year ARI magnitudes (Ref 3). Therefore, on the basis of discharge values given in Tables 1 and 2, flooding problems along West Creek commence at discharges ranging approximately between 26 m^3/s and 30 m^3/s at Alderley Street, and between 62 m^3/s and 72 m^3/s at the confluence with East Creek.

5. FINDINGS

Assessment of the failure impacts of the Toowoomba detention basins is quite complex due to a number of reasons:

- The detention basins will only fail during a flood event as they are dry basins;
- A failure is likely to be due to a Dam Crest Failure Flood (DCFF);
- Downstream detention basins would attenuate the resulting flood; and
- Cascading basin failure is a real possibility.

Table 6 shows a summary of the estimated dam break discharges due to DCFF for the four West Creek detention basins. Sunny Day failure estimates were not made for these basins because such failure is unlikely for detention basins with low level pipe outlets.

TABLE 6: BREACH DEVELOPMENT DISCHARGE SUMMARY

Discharge Estimation Method	Breach Discharge (m^3/s)			
	Spring St Basin	Spring to Stenner St Basin #1	Spring to Stenner St Basin #2	Stenner to Alderley St Basin
NRM Dam Break Routing Spreadsheet[1]	24.2	28.0	22.6	76.6
Equation 1 NRM FIA Guideles (Ref 2)	92.2	95.1	86.2	260.0

Do they take cascade failure into account?

NOTES

1. See Tables 1 to 7 of Appendices 1 to 4 for adopted parameters

The DCF inflow to the most downstream detention basin (Stenner to Alderley Street basin) is estimated to be about 50 m^3/s (see Table 7, Appendix 4). This discharge is approximately equal to the 100 year ARI design outflow from this basin (see Table 3). Based on council flood study results, PAR for this outflow is zero.

Results in Table 6 show that the dam break discharge for the Stenner to Alderley Street basin alone is significantly greater than the magnitude of flood discharge required to cause flooding problems and inundation along West Creek downstream of Herries Street. The FIA guideline (Equation 1) estimate is about 2.7 times the pre-basin 100 year ARI design discharge for West Creek at its confluence with East Creek.

Given that the current basins have reduced the 100 year ARI flood levels downstream of the basins to just below the lowest property floor level, and that the dam breach discharge from the Stenner to Alderley Street basin alone is significantly larger than the 100 year ARI post basin design discharge, the PAR for this dam alone is likely to be greater than 2.9.

In view of the above finding, the downstream flooding impacts of the other three basins have not been investigated in detail. Further, cascade failure of two or more basins in the system has also not been investigated.

The actual PAR locations have not been assessed as part of this study. These locations have been identified in previous studies undertaken by council.

6. CONCLUSIONS AND RECOMMENDATIONS

Available data indicate that one or more of the four flood detention basins along West Creek in Toowoomba (No. 2001) are likely to be at least Category 1 referable dams under the Water Act (2000). Although these detention basins do not exceed the height and volume criteria specified in the Water Act (2000), preliminary investigations indicate that the estimated population at risk (PAR) associated with the Stenner to Alderley Street detention basin alone at dam crest flow is likely to be greater than 2.9.

Further hydrologic and hydraulic modelling investigations are recommended for the West Creek detention basins to confirm their referable status. For these investigations, it will be necessary to obtain 'as constructed' configurations of the four detention basins and ground levels at potential PAR locations. The other data required for hydrologic and hydraulic modelling are likely to be available from Toowoomba City Council's previous studies for the Gowrie Creek catchment. These basins also may have to be investigated as a 'system' of basins, with failure occurring individually or in series with others.

7. REFERENCES

1. 'Preliminary Dam Failure Impact Assessment, Stage 1 – Toowoomba Flood Detention Basins (No. 2001), Toowoomba.
2. 'Guidelines for Failure Impact Assessment of Water Dams', Queensland Government Natural Resources and Mines, April 2002.
3. Gowrie Creek Catchment Management Strategy, Report prepared by WBM Oceanics Australia and Hassell for Toowoomba City Council, November 1998.
4. Gowrie Creek Catchment Management Strategy Technical Appendix, WBM Oceanics Australia, 31 August 1998.
5. West Creek Flood Mitigation Works, Spring to Stenner Street Detention Basins 1 and 2, Design Drawing Series 30755 1 to 39, Toowoomba City Council, 2001.
6. West Creek Flood Mitigation Works, Stenner to Alderley Street Detention Basin, Design Drawing Series 30783 1 to 47, Toowoomba City Council, 2000.

7. West Creek Flood Mitigation Works, Spring Street Detention Basin, Design Drawing Series 30736 1 to 4, Toowoomba City Council, 2000.

APPENDIX 1 – DETAILS OF SPRING STREET DETENTION BASIN CALCULATIONS

TABLE 1: DAM DESCRIPTION

Parameter	Units	Value	Reference
Type		Earthfill	Ref 7
Maximum Height	m	2.5	Estimate
Length	m	50	Estimate
Crest Width	m	3.0	Estimate
Purpose of Storage		Flood Detention Basin	
Dam Capacity to FSL	ML	0	Ref 7
Dam Surface Area at FSL	ha	1.5	Ref 7

TABLE 2 . SPILLWAY DESCRIPTION

Parameter	Units	Value	Reference
Spillway Description		Weir	Ref 7
Channel Crest Length	m	20.0	Estimate from TCC RAFTS model results
Spillway Level Below Dam Crest	m	0.8	Estimate
Spillway Capacity (Dam Crest Flood) (including Pipes)	m^3/s	21.5	From TCC RAFTS model results
Available Spillway Flow Data		None available	

RECORD OF CONVERSATION		File: 130/000(2001)
Project:	Toowoomba Detention Basin	
Subject:	Dambreak study	
Date:	10th February 2005 11:00am	
Personnel:	[redacted]	

Content:

DR explained purpose of visit and also apologised for any confusion and lack of communication between NRM and TCC regarding the flood study we were undertaking.

DR however did state that the investigation was one financed and approved by NRM as part of our ongoing investigation into referable dams. NRM did not expect TCC to finance this exercise and we would be reporting to TCC on outcomes from the study.

TCC also claimed they were not aware of any preliminary work undertaken by Coffey or NRM.

TCC also stated they have recently engaged the services of WBM Oceanics to undertake flood studies in the area of the flood detention basins – but unfortunately the project brief does not include any dambreak analyses. Consequently, TCC would be keen to be advised of the outcomes from the study NRM are currently undertaking and also will be happy to provide any maps, survey data etc to ensure we use the latest information in the model.

TCC asked if they could receive a copy of the Coffey Report, DR stated that he had no problem with that but would confirm with Director Dam Safety

Meeting Closed 12:15pm

[redacted]

[redacted]

From: [redacted] [redacted]
Sent: Wednesday, 16 February 2005 11:10 AM
To: [redacted]
Cc: [redacted]
Subject: Re: West Ck Flood Detention Basin Dambreak Study

Hello [redacted]

[redacted] has a few other things on his plate at the moment, so could I please respond on his behalf "that will be fine".

Thank you,

[redacted]

[redacted]
Manager Design and Survey Services
Toowoomba City Council
Tel: 07 [redacted]
Mobile [redacted]
Fax: 07 [redacted]
Email: [redacted]
Web: www.toowoomba.qld.gov.au
Toowoomba: The Garden City

[redacted]
15/02/2005 10:06 AM

To: [redacted]
cc: [redacted]
Subject: West Ck Flood Detention Basin Dambreak Study

[redacted]

Following on from our meeting on 11th February re the dambreak study NRM are undertaking, I have spoken to Peter Allen, Director Dam Safety, who has confirmed that we have no objection to you receiving a copy of the Preliminary Dam Failure Impact Assessment Report prepared by the Coffey group in May 2004.

I can forward a copy of that report to you within 10 working days.

Please advise if that arrangement is not convenient for you.

Regards

[redacted]
Principal Engineer, Dam Safety (Water Supply)
Natural Resources & Mines
Level 12 Mineral House 41 George Street
GPO Box 2454 Brisbane QLD 4001
e: [redacted]
p:
f:
m:

Contents

[redacted] I am happy to base my decision on the Alderley St detention basin on the basis of this report. However, it may be appropriate to examine the cascade failure of the upstream basins before we issue any notices on Toowoomba City Council... This will require using the NR&M spreadsheet to look at the cascade effects.

Peter Allen
21/7/05.

Preliminary Failure Impact Assessment

DAM NO. 2001 – Toowoomba Detention Basins

1.0 Introduction

This report contains a preliminary assessment of the population at risk (PAR) downstream of the flood detention basin located on West Creek, near Alderley Street in Toowoomba.

Only the Alderley Street basin has been assessed for referability in this study. The three upstream structures have not been considered. It will be necessary to perform separate calculations to determine the referable status of the upstream structures including the potential effects of cascade failure. The basins were constructed by the Toowoomba City Council (TCC) between 1999 and 2001 as a flood mitigation measure and service a 660ha catchment that drains in a northerly direction into Gowrie Creek. West Creek flows into Gowrie Creek at the confluence with East Creek. This point is downstream of the boundary of this report.

Therefore, the purpose of this report is to determine if the dam is likely to be referable under the Water Act (2000) and hence if the Chief Executive should issue a notice, under S483(3) of the act, to the dam owners requiring that its failure be impact assessed.

1.1 Scenarios and Method of Analysis

Two scenarios were considered:

1. Outlet Works at Alderley Street Basin are blocked
2. Outlet Works at Alderley Street Basin are fully operational.

For both of these scenarios the model was used to simulate a dam failure flood and no dam failure flood to determine the incremental effects of a dam failure. These findings are presented in section 3.

Two computer programs were used in the preliminary assessment of the Alderley Street Detention Basin for the outlet works blocked scenario.

FLDWAV (version 2.0.2 April 2003) is a generalized flood routing model developed by the National Weather Service of Maryland, USA. FLDWAV is based on an implicit finite difference solution of the complete one-dimensional Saint-Venant equations of unsteady flow.

The FLDWAV documentation describes the special modelling features of the program. Such features include time-dependent dam breaches, multiple levee overtopping, gate controlled flows, bridges and user specified routing techniques

The FLDWAV program modelled the area under investigation adequately until bridges were incorporated in the model. It was subsequently found (and confirmed through the programs 'user forum') that the current metric version of the program is unpredictable when a bridge is added to the model.

In order to overcome the problem of modelling bridges without ignoring them totally, the decision was made to use a second program, HEC RAS.

HEC RAS is a computer program developed by the US Army Corps of Engineers that performs one-dimensional steady and unsteady flow river hydraulics calculations.

Although the program is capable of unsteady flow calculations, version 3.1.2 of HEC RAS does not handle embankment breach calculations adequately.

For scenario 1, the approach adopted was to use the breach hydrograph developed by FLDWAV as the upstream boundary condition for HEC RAS.

For scenario 2, when the outlet works remain operational, a different approach was adopted. The release of an updated version of HEC-RAS (version 3.1.3) in May 2005 incorporating embankment failures allowed for the entire model to be run within this program.

The HEC RAS program does not currently allow for the input of reservoir storage data. To counteract this, the inflow hydrograph was modified to hold the water at full supply level with the outlet works operational before adding to the inflow to cause the dam to fail by overtopping.

The HEC-RAS model provides a comprehensive representation of the channel, including bridges and culverts and delivers a stable and logical result. The water levels provided by this model at key locations have been used to determine the properties at risk of inundation due to a dam failure at the Alderley Street detention basin.

2.0 Base Data

2.1 Dam Characteristics

The dimensions of the Alderley Street Detention Basin used in this model were based on information extracted from the Coffey report of May 2004 (ref 1), TCC design drawings (ref 5), a site inspection and examination of aerial photography and contour plans.

Table 2.1 lists the general dimensions used in the analysis and table 2.3 details the parameters used in the development of the breach.

Table 2.1 – Dimensions of Alderley St Detention Basin

Parameter	**Units**	**Value**
Owner	Toowoomba City Council	
Type	Earthfill	
Purpose of Storage	Flood Detention Basin	
Maximum Height	m	4.1
EL Spillway	m (AHD)	626.91
Width of Spillway	m	20
EL Embankment	m (AHD)	627.2
Length of Embankment	m	190
Upstream Batter Slope	1H:V	0.2
Downstream Batter Slope	1H:V	0.25
Crest Width	m	3

2.2 Storage Curve

The storage curve supplied in the Coffey Report 2004 (ref 1) was adopted for the model.

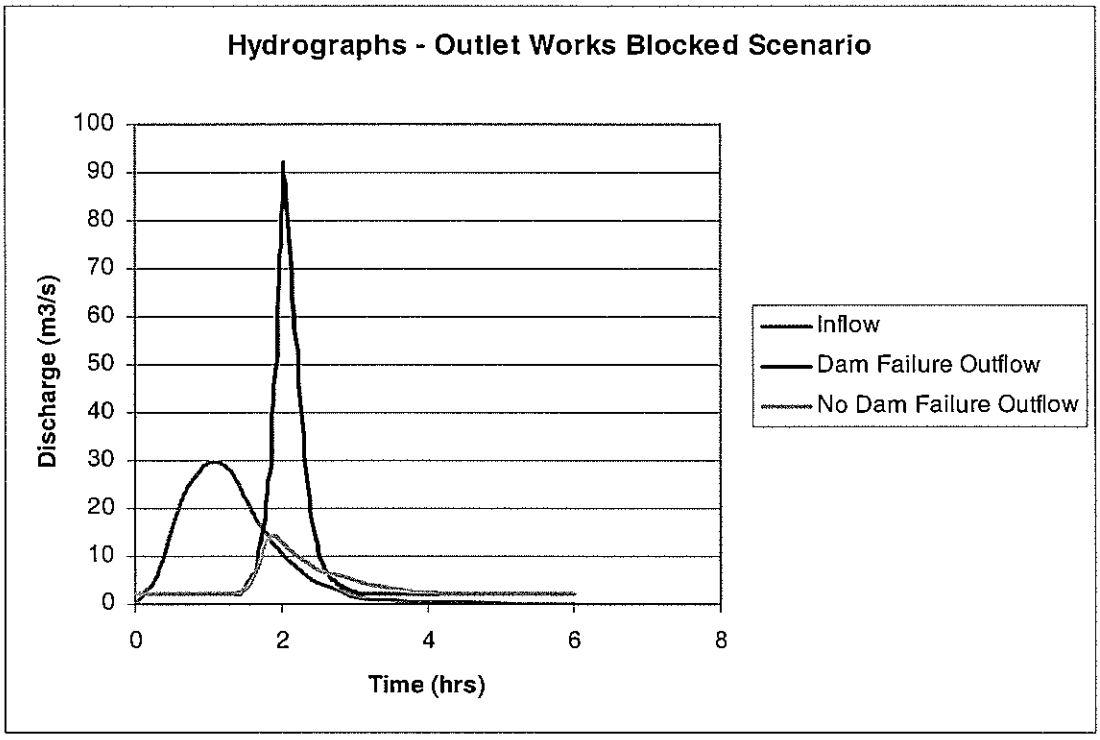
Table 2.2 – Alderley Street Detention Basin Storage Curve

Water Level	**Surface Area**	**Volume**	
(m AHD)	**(ha)**	**(ML)**	
623.1	0.3	0.0	Full Supply Level
624.5	0.9	8.5	
625.5	3.4	30.0	
626.0	4.2	49.0	
626.5	4.6	71.0	
627.0	5.0	95.0	
627.1	5.1	100.1	
627.2	5.2	105.2	Crest Level

2.3 Hydrographs

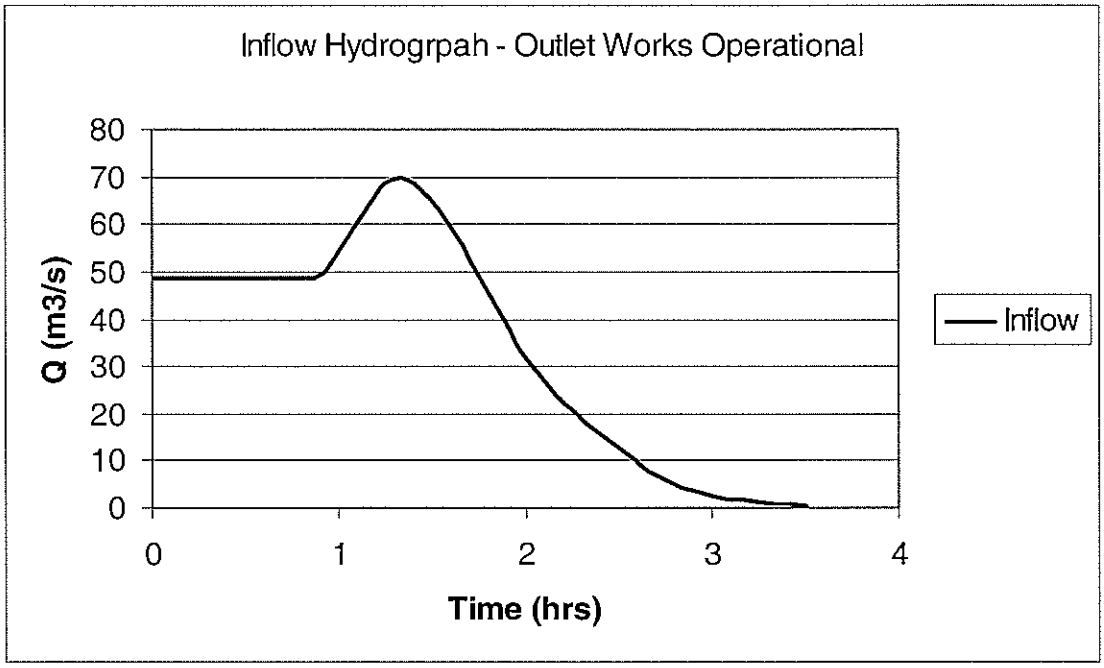
A standardised short duration hydrograph (figure 2.1) was used as the inflow on the FLDWAV model to represent a typical short duration, intense rainfall event. The hydrograph was developed from the NR&M Dam Breach Routing Spreadsheet such that it would cause a minimal flow over the embankment of the structure. At this point the embankment was assumed to fail.

Figure 2.1 –Hydrograph - Alderley Street Detention Basin – Outlet Works Blocked



As described in section 1.1, the program FLDWAV was used to determine the breach characteristics and breach hydrograph for scenario 1. This information was input into the HEC RAS model as the upstream boundary condition. The downstream boundary condition was taken as normal depth calculated by the program, based on a friction slope of 0.015.

Figure 2.2 – Hydrograph Alderley Street Detention Basin – Outlet Works Operational



This model required a significantly larger inflow for scenario 2, firstly to maintain full supply level with the outlet works operational, then to fail the embankment. In the initial stages the hydrograph is level to counteract the water discharging through the outlet works and hold the water level within the detention basin at full supply level. The peak at about 1.5 hours causes the embankment to be overtopped and creates the opportunity to model the dam failing.

2.4 Base Flow

To ensure model stability during the initial stages of the routing procedure a base flow of $2m^3/s$ was used in all simulations.

2.5 Cross sections

The cross sections used in the HEC-RAS model were those supplied by Coffey with their initial report. After a site visit, discussions with the Toowoomba City Council and comparison with the new survey data it was determined that there had been no significant changes in the sections along the channel being modelled and as such it was still appropriate to use these sections.

2.6 Manning's 'N' Values

A Manning's 'n' value of 0.04 for the concrete channel and 0.05 for the grass banks was adopted as the roughness coefficient of the model. A sensitivity analysis was performed on Manning's 'n' with the following outcomes:

By increasing the roughness coefficient by 0.01 at all points, the maximum water surface elevation increased in the range of +0.05 to +0.25m.

Decreasing the roughness coefficient by 0.01 at all points had the effect of lowering the maximum water surface elevation in the range of -0.05 to -0.35m.

Both of these results are expected. Increasing the roughness coefficient should result in a higher water level and the reducing the 'n' value should lower the water levels.

2.7 Breach Development & Location

The NR&M Dam Breach Routing Spreadsheet was used to determine the time of breach formation and the breach base width. The time of breach formation was 0.42 hours and the breach base width 3.6m. The dam was set to fail by overtopping once the water surface overtopped the dam crest at 627.2m AHD. The ratios of effective top width to depth of breach, B/d and effective top width to effective bottom width, B/b, fall within accepted limits for the outlet blocked scenario, therefore the breach parameters comply with NR&M's FIA guidelines. For the outlet operational scenario the B/b ratio is outside the accepted range. This is due to the large volume of water being released in a short period of time relative to the size of the embankment.

It was assumed that failure would occur through the spillway based on the fact that the downstream face in the area of the spillway is not afforded any additional protection, the embankment is at its maximum height and water would already be over the spillway and may have weakened it. These factors all contribute to making this the most likely point of failure.

Table 2.3 – Breach Parameters

Parameter	Units	Value	Comment
EL Failure	m (AHD)	627.201	Assumed
EL Base of Breach	m (AHD)	623.1	Assumed
Breach Side Slope	1H:V	4	Assumed
Time of Breach Formation	hours	0.26	
Coefficient of Spillway Discharge		1.5	Assumed

3.0 Locations of Potential PAR

Figure 3.1 (attached) shows the flood inundation line and potential PAR locations between Alderley Street and Margaret Street for the outlet works blocked scenario. These levels have been shown as they represent the greater incremental effect of the two possible scenarios.

3.1 Alderley St

The houses to the east of the dam, on the right abutment, are above the maximum flood water level resulting from a dam failure and are therefore not considered at risk.

Downstream of the Alderley Street road crossing the model shows a significant drop off in the maximum water surface elevation of 0.93m. This indicates the for the properties on both sides of the channel there is no threat of inundation.

However, the immediate nature of this reduction is of some concern and may not be a reliable guide to what would occur in reality. For this reason it is considered the properties on the left bank may be under some potential threat despite the findings of the model. This area requires further investigation using accurate survey information to determine exactly what occurs at this location.

3.2 Golf Course

A number of houses to the left of the channel in the section immediately upstream of South Street are borderline cases for inundation. Based on the available contours the maximum water surface will cut across parts of ten properties, creating a potential PAR of 29. Further surveys to determine the exact location of the building footprints and their heights would be required to confirm the exact situation.

Under scenario two, with the outlet works operational, the water level is up to 540mm higher in this section increasing the likelihood that the properties are at risk.

3.3 Downstream of James Street

A number of buildings, possibly commercial or industrial, to the left of the creek downstream of James Street will suffer some inundation in the event of the Alderley Street Detention Basin failing. The maximum water levels taken from the model and compared to contour maps show that the water would cross Prescott Street resulting in a potential population at risk in these buildings.

It is estimated that 5 industrial/commercial type buildings are under threat in this zone. The number of staff working in these buildings is unknown for PAR calculations. Further investigation is required to determine the elevations of these buildings, the extent of inundation and the resultant PAR.

3.4 Railway Bridge (Dent Street)

The railway bridge is a hydraulically significant structure and in large flows it causes the water to pond upstream of the bridge. The flood water can rise to a level such that it spills into Dent Street. The businesses in Dent Street may be under some threat but further survey investigation is required to determine the levels at these buildings.

During a recent site visit, local business owners in Dent Street were asked about their knowledge or experience with local flooding. There was anecdotal evidence to suggest that water has entered some of these premises to a shallow depth during past storm events.

3.5 Water Surface Elevations

The points of potential PAR identified in table 3.1 have been estimated to be under threat based on height data shown on a contour map (ref 1). This approach was taken due to the unavailability of exact elevations at building footprints.

The incremental effect represents the difference between what would occur given a flood event with no dam failure and the same flood when the dam fails. Along the section investigated the incremental effect for scenario one, was greater than 700mm at all points, proving that a dam failure would have a significant effect on inundation levels during a flood.

Figure 3.2 – Water Elevations Along Channel with Outlet Works Blocked

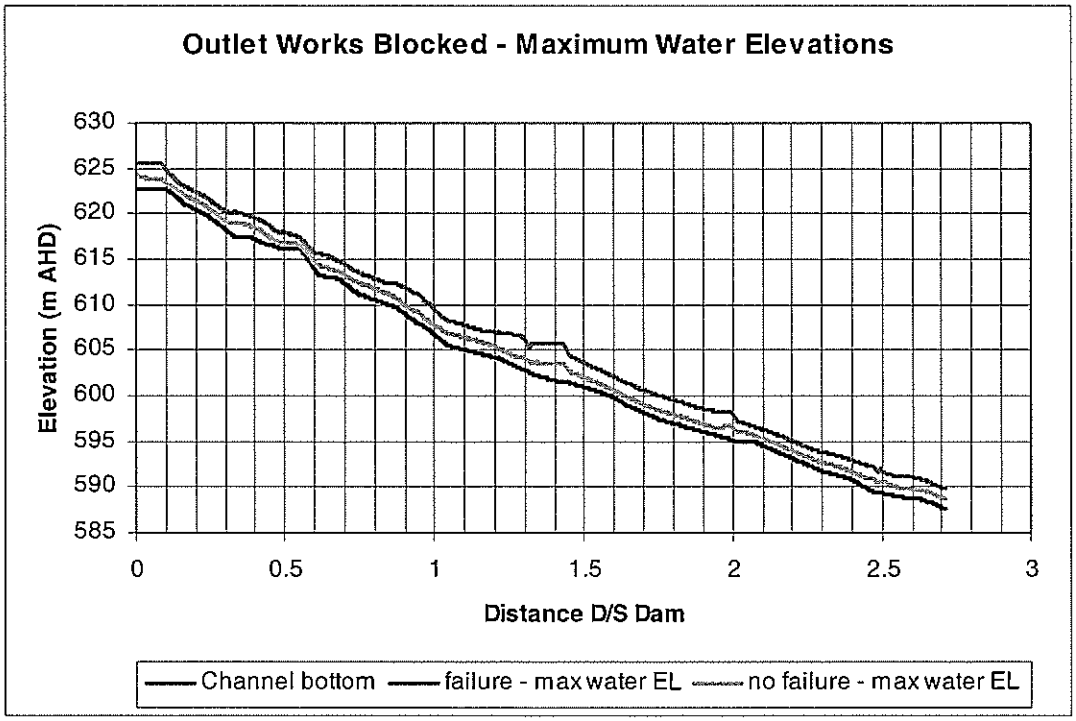


Table 3.1 – Elevations at key points along the channel – Outlet Works Blocked

	Distance Downstream	Channel Elevation	Maximum Water Surface Elevation - Failure	Maximum Water Surface Elevation – No Failure	Incremental Effect	Potential PAR
US Alderley St	0.08	622.78	625.49	623.78	1.71	
DS Alderley St	**0.118**	**622.32**	**624.16**	**622.96**	**1.2**	**Residential Property**
Golf Course Houses	**0.740**	**611.37**	**613.68**	**612.52**	**1.16**	**Residential Property**
US South St	0.932	608.24	611.31	609.27	2.04	
DS South St	0.974	607.41	610.28	608.30	1.98	
US Stephen St	1.418	601.58	605.75	603.62	2.13	
DS Stephen St	1.458	601.35	604.24	602.52	1.72	
@ Centenary Park	1.736	597.62	600.18	598.55	1.63	
US James St	1.984	595.3	598.22	596.59	1.63	
DS James St	2.027	594.96	597.14	596.06	1.08	
Mid James & Herries	**2.122**	**594.26**	**596.05**	**595.02**	**1.03**	**Commercial Property**
	2.216	**592.88**	**594.81**	**593.76**	**1.05**	
US Herries	2.426	590.28	592.61	591.27	1.34	
DS Herries	2.507	589.3	591.59	590.47	1.12	
US Rail Bridge	**2.587**	**588.75**	**591.23**	**589.84**	**1.39**	**Commercial Property**
DS Rail Bridge	2.614	588.77	590.94	589.74	1.2	

The same key points are under threat of inundation due to a dam failure when the outlet works operate in scenario 2, as to when they are blocked. The incremental effects are lower than when the outlet is blocked, but still greater than 300mm at the potential PAR locations.

The maximum water levels are higher after a failure when the outlet operates due to the fact that it takes a significantly larger amount of inflow to fail the dam compared to when the outlet is blocked resulting in a larger flow downstream post failure.

Figure 3.3 - Water Elevations Along Channel with Outlet Works Operational

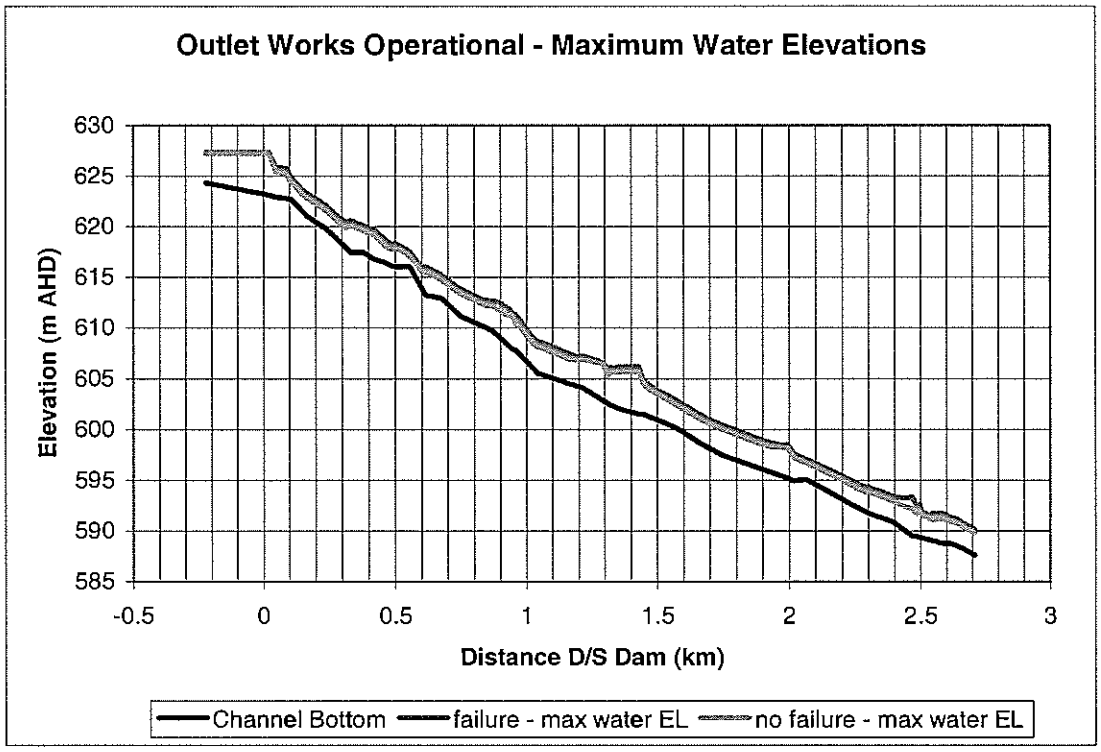


Table 3.2 – Elevations at key points along the channel – Outlet Works Operational

	Distance Downstream	Channel Elevation	Maximum Water Surface Elevation - Failure	Maximum Water Surface Elevation – No Failure	Incremental Effect	Potential PAR
US Alderley St	0.08	622.78	625.78	625.25	0.53	
DS Alderley St	**0.118**	**622.32**	**624.50**	**624.04**	**0.46**	**Residential Property**
Golf Course Houses	**0.740**	**611.37**	**614.00**	**613.55**	**0.45**	**Residential Property**
US South St	0.932	608.24	611.85	611.26	0.59	
DS South St	0.974	607.41	610.84	610.03	0.81	
US Stephen St	1.418	601.58	606.18	605.68	0.50	
DS Stephen St	1.458	601.35	604.60	604.18	0.42	
@ Centenary Park	1.736	597.62	600.55	600.11	0.44	
US James St	1.984	595.3	598.48	598.20	0.28	
DS James St	2.027	594.96	597.49	597.13	0.36	
Mid James & Herries	**2.122**	**594.26**	**596.38**	**596.01**	**0.37**	**Commercial Property**
	2.216	**592.88**	**595.23**	**594.78**	**0.45**	
US Herries	2.426	590.28	593.26	592.57	0.69	
DS Herries	2.507	589.3	591.82	591.58	0.24	
US Rail Bridge	**2.587**	**588.75**	**591.75**	**591.21**	**0.54**	**Commercial Property**
DS Rail Bridge	2.614	588.77	591.36	590.93	0.43	

4.0 Conclusions

This model has identified five points of potential PAR. These locations are highlighted in Tables 3.1 and 3.2 and on Figure 3.1. The sections between James and Herries Streets are the most likely points of inundation as a result of a dam failure at Alderley Street. The other locations are all borderline cases based on the current information for the outlet works blocked scenario, but are under greater threat from a failure when the outlet operates correctly. Based on the currently available information it is estimated that the PAR range will be between 2 and 40, making the Alderley Street Detention Basin a category 1 referable dam under the act. All points require clarification of building levels to ascertain the exact nature and extent of any inundation.

5.0 Recommendations

It is recommended that a full Failure Impact Assessment (FIA) be carried out to determine the extent of the population at risk and hence, if the Alderley Street detention basin is referable. This will require the development of a more sophisticated hydraulic model to ensure an accurate estimate of PAR is obtained. Additional survey work will be required to ascertain the exact location and elevation of buildings potentially at risk. It will also be necessary to determine the number of personnel working in any commercial or industrial buildings. Cascade failure of the detention basins upstream of Alderley Street should also be included in the assessment.

6.0 References

1. [redacted] (May 2004) 'Preliminary Dam Failure Impact Assessment, Stage 2 – Flood Detention Basins Along West Creek (No.2001) Toowoomba' (including digital images & contour maps).

2. National Weather Service (2003), 'NWS FLDWAV Model ver 2.0.2', Maryland, USA

3. Natural Resources and Mines 'Dam Breach Routing Spreadsheet'

4. Natural Resources and Mines (April 2002) 'Guidelines for Failure Impact Assessment of Water Dams'.

5. Toowoomba City Council (2001), 'West Creek Stenner St to Alderley St Detention Basin, Design Drawing Series 30755 1 to 40'.

6. US Army Corps of Engineers (2004), 'HEC RAS ver 3.1.2'

7. US Army Corps of Engineers (2005), 'HEC RAS ver 3.1.3'

Department of Natural Resources and Water

LARGE REFERABLE FARM DAM ASSESSMENT PROGRAM
DESKTOP ASSESSMENT/DRIVE-BY INSPECTION REPORT

(This report has been prepared based on:-
(a) a desktop assessment by Senior Project Officer (FD Identification)
OR
(b) a drive by inspection (no contact made with any property owner)
that has determined that the water body is not a dam of interest for the purpose of dam safety)

RECOMMENDATION: 15.7

1.0	**DETAILS**	
1.1	Object ID	**13933**
1.2	Water body centroid *(from the spreadsheet for the relevant sub-catchment)*	**27º 35' 20.531" S 151º 58' 22.739" E**
1.3	Name of Sub-catchment	**Condamine River Area 1**
1.4	Date of Assessment/Inspection	13/10/09
1.5	Team Members	[redacted]
1.6	This OID is a weir type structure on East Creek in Toowoomba. The feature is made of sheet piles that overtop in a flow event. The pondage area for the weir extends upstream to the downstream batter of 2 smaller dams. These dams will be reported on separately. The site was visited by [redacted] and [redacted] [redacted] advice was the feature had no prospect of failure, was a weir and required no further assessment, PAR unlikely, no contact with owner.	
2.0	**RECOMMENDATION**	
2.1	Recommendation: Water body is not a dam of interest for the purpose of dam safety ☑ No further action required	
3.0	**ENDORSEMENT**	
3.1	I endorse the Recommendation marked in Section 2.0 above. Print Name: [redacted]……. Signature: …SIGNED…… Position Title: Manager, DS(FD), OWSR…. Date: …2/04/2010	

OFFICE USE ONLY – WIR
Date report details:

- validated in the GIS 19/ 08 / 2010 Initials …MEG..

Department of Natural Resources and Water

LARGE REFERABLE FARM DAM ASSESSMENT PROGRAM
DESKTOP ASSESSMENT/DRIVE-BY INSPECTION REPORT

(This report has been prepared based on:-
(a) a desktop assessment by Senior Project Officer (FD Identification)
OR
(b) a drive by inspection (no contact made with any property owner)
that has determined that the water body is not a dam of interest for the purpose of dam safety)

RECOMMENDATION: 15.7(S)

1.0	**DETAILS**	
1.1	Object ID	**OID_92391 (prev Cond01_03)**
1.2	Water body centroid *(from the spreadsheet for the relevant sub-catchment)*	**27º 35' 25.13" S 151º 58' 19.22" E**
1.3	Name of Sub-catchment	**Condamine River Area 1**
1.4	Date of Assessment/Inspection	13/10/09
1.5	Team Members	[redacted]
1.6	This OID is one of 3 dams on East Creek in Toowoomba. The drainage line flows NW through developed parts of Toowoomba. The dam has around 500ha of catchment area, with a large proportion of it being hard. Advice was sought from [redacted] regarding these dams. The advice given was to conduct breach flows on each dam, a cascade failure on both and apply it to a cross section at the first house downstream. Given the small size of the dams, it was assumed that if flow past below plinth of the first house, it is likely to pass plinth of houses further away from the dam. This dam is immediately upstream of a weir type structure (OID_13933), and downstream of a similar type dam. The dam has an embankment 2.1m high storing 5ML. It has a small drop inlet to divert low flows off the bywash. A DCF was carried out on this dam, resulting in 16m3/s. A cascade breach was also carried out resulting in 23m3/s. A cross section was carried out at the first house downstream, approximately 240m from the dam. This section can pass both the DCF and cascade flow well below plinth. On that basis PAR is unlikely, no contact with owner. Crest 80m DOB 90m	
2.0	**RECOMMENDATION**	
2.1	Recommendation: Water body is not a dam of interest for the purpose of dam safety ☑ No further action required	
3.0	**ENDORSEMENT**	
3.1	I endorse the Recommendation marked in Section 2.0 above. Print Name: [redacted]……. Signature: …SIGNED…… Position Title: Manager, DS(FD), OWSR…. Date: …17/08/2010	

OFFICE USE ONLY – WIR
Date report details:

- validated in the GIS 19/ 08 / 2010 Initials …MEG..

Department of Natural Resources and Water

LARGE REFERABLE FARM DAM ASSESSMENT PROGRAM
DESKTOP ASSESSMENT/DRIVE-BY INSPECTION REPORT

(This report has been prepared based on:-
(a) a desktop assessment by Senior Project Officer (FD Identification)
OR
(b) a drive by inspection (no contact made with any property owner)
that has determined that the water body is not a dam of interest for the purpose of dam safety)

RECOMMENDATION: 15.7(S)

1.0	**DETAILS**	
1.1	Object ID	**OID_92392 (prev Cond01_04)**
1.2	Water body centroid *(from the spreadsheet for the relevant sub-catchment)*	**27º 35' 27.13" S 151º 58' 15.85" E**
1.3	Name of Sub-catchment	**Condamine River Area 1**
1.4	Date of Assessment/Inspection	13/10/09
1.5	Team Members	[redacted]
1.6	This OID is one of 3 dams on East Creek in Toowoomba. The drainage line flows NW through developed parts of Toowoomba. The dam has around 500ha of catchment area, with a large proportion of it being hard. Advice was sought from [redacted] regarding these dams. The advice given was to conduct breach flows on each dam, a cascade failure on both and apply it to a cross section at the first house downstream. Given the small size of the dams, it was assumed that if flow past below plinth of the first house, it is likely to pass plinth of houses further away from the dam. This dam is immediately upstream of a similar type dam. The dam has an embankment 2.1m high storing 5ML. It has a small drop inlet to divert low flows off the bywash. A DCF was carried out on this dam, resulting in 20m3/s. A cascade breach was carried out on the downstream dam, resulting in 23m3/s. A cross section was carried out at the first house downstream, approximately 370m from the dam. This section can pass both the DCF and cascade flow well below plinth. On that basis PAR is unlikely, no contact with owner. Crest 80m DOB 90m	

2.0	**RECOMMENDATION**	
2.1	Recommendation: Water body is not a dam of interest for the purpose of dam safety ☑ No further action required	

3.0	**ENDORSEMENT**	
3.1	I endorse the Recommendation marked in Section 2.0 above. Print Name: [redacted]……. Signature: …SIGNED…… Position Title: Manager, DS(FD), OWSR…. Date: …17/08/2010	

OFFICE USE ONLY – WIR

Date report details:

- validated in the GIS 19/ 08 / 2010 Initials …MEG..

Toowoomba Floods
Flood Retention Basins
Inspection Report

Design Philosophy

Toowoomba has a centrally draining storm water system which contains a substantial number of ponds some of which have functions ranging from ornamental to flood mitigation by retention ponds. East Creek and West Creek receive most of the storm drainage from the southern suburbs of Toowoomba. Both these creeks drain to the central business district (CBD) where they join to become Gowrie Creek which drains to the North and then to the West of Toowoomba. Suburban drainage systems are usually designed to manage storms more frequent than a particular AEP. According to the Insurance Council of Australia report on the Toowoomba Flood the piped drainage system is designed for 2 year ARI in the suburbs and up to 5 year ARI in the CBD..

Peak discharges from natural storms can be mitigated by the inclusion of retention basins along the drainage lines. By storing and releasing of runoff the flows in drains will be less but of a longer duration. This also reduces the risk of flooding areas outside of the drains themselves.

Background

On 10/1/2011 a storm cell passed slowly in a South Westerly direction over the Southern suburbs of Toowoomba, dumping up to 120 mm of rainfall in a short period of time (less than 40 minutes). The resultant flows in both East Creek and West Creek exceeded the capacity of culverts and storm drains in the CBD with resultant flooding of property, damage to cars and high risk to persons, including loss of life.

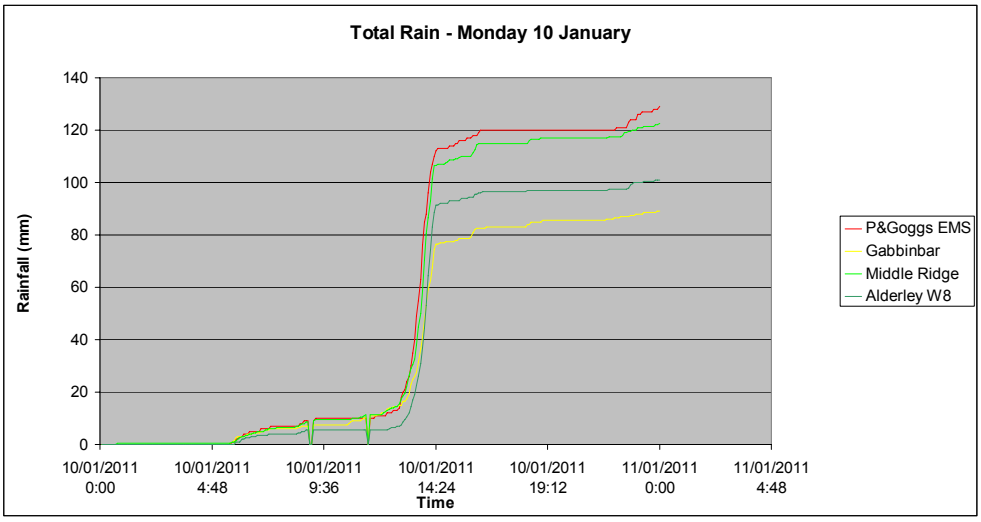


Figure 1 Pluviograph Record of Storm

The flooding was well documented and pictorial records acquired by the Department of Environment and Resource Management (the department) from various sources are contained in Appendix B.

The department was aware that the drainage lines in Toowoomba contained ponds and retention basins of various sizes. While these features can be considered to be dams, none of these features automatically triggered the criteria requiring them to be Failure Impact Assessed. Some preliminary failure impact assessment work was initiated by the department in 2005 which indicated potential population at risk (people in dwellings), however this work was not finalised.

The department is aware that the sudden release of a significant volume of water into an existing flood can cause flood waves to develop. This release could be caused by the collapse of containment embankments of the ponds or retention basins. The mechanisms causing such a collapse could be embankment instability, overtopping and erosion, internal erosion and piping or structural failure of control measures.

The hydraulic behaviour of the flood in the CBD (refer Appendix B) contained standing waves and other hydraulic features associated with high energy flows which are sometimes associated with dam break floods.

Figure 2 Gowrie Creek in Flood

While there had been no reports of damage to the ponds and retention basins along East Creek and West Creek, the department considered that the features needed to be inspected to see if any had failed or otherwise contributed to the behaviour for the flooding.

Inspection 18/1/2011

The inspection team consisted of:

[redacted] Manager Containment Systems;
[redacted] Principal Engineer Containment Systems; and
[redacted] Senior Project Officer.

Access to Toowoomba was restricted by flooding in the Lockyer Valley prior to this date. However it is unlikely that the flood damage situation along the creeks would have changed since the 10/1/2011.

Due to severe delays on the highway to Toowoomba the inspection started at about 1:00 pm.

West Creek was inspected first and then East Creek, starting from the CBD end of both creeks and moving upstream. The inspection of East Creek was cut short because of failing light conditions and storm activity. [redacted] returned on the 20/1/2011 accompanied by Senior Engineer, [redacted]

to systematically examine each pond and retention pond for damage and condition. His description and photographic record is contained in Appendix A.

Observations

None of the containment embankments failed during the storm, thus ruling out the possibility that embankment collapse during the flood could have caused a “dam break flood” within the flood.

Many of the ponds and retention basins had overtopped during the storm with erosion initiating at several containment embankments, usually on the downstream batters (Figures 67, 88, 89 & 99). In some instances crushed rock paving material on the crest walkways had eroded preferentially (Figure 86).

The absence of severe erosion is attributable to the shortness of the period of overtopping and erosion resistant nature of the downstream batters which consisted of flat sloped well grassed batters.

The only control structure to partially fail was the inlet to the Long Street Retention Basin – WC16 (Figures 107 &108). This controlled flow in a formed drain from the pond upstream. It is unlikely that the volume released by the failure of the entrance control would be significant enough to have caused a surge downstream. The flow into the Alderley Retention Pond had overtopped the road over the inlet control.

The outlet to the Long Street Retention Basin – WC14 (Figure 106 & 109) is small and the overtopping of this embankment in particular would probably result in a large increase in flow for a small increase in pond depth. Most of the severe channel erosion occurred downstream of this retention basin. (Figures 118 to 121). The embankment did overtop.

One embankment (Figure 91, 95 &98) had the appearance of severe erosion but later inquiries found that the land form was the result of earthworks carried out by TCC workers the day after the flood.

The trash rack devices on several smaller outlets accumulated debris during the storm event. The restriction of such devices will increase the risk of overtopping the embankments.

Conclusions

On-site inspections by DERM officers revealed that no embankments associated with the ponds and retention basins collapsed during the storm, thus eliminating the possibility that the flood was aggravated by the collapse of a built structure.

The behaviour of the flood was probably the result of the interaction of the storm conditions and the drainage system.

Actions:

Whilst the flood event did not cause the collapse of any pond or retention basin along East Creek or West Creek, but given that there has been further development of ponds / retention basins on these creeks, the department's Dam Safety unit should re-examine whether a failure impact assessment should be completed for one or more of these structures including the impact of cascade failure.

A copy of this report should be forwarded to Toowoomba Regional Council

Report by

[redacted]
Manager Containment System, OWSR
Department of Environment and Resource Management.

APPENDIX A
Inspection Photographs and Map

Formatted Table

Dam identifier	*Comments*
East Creek 1 (EC1 Most Upstream)	Earth embankment 3.1m high with large capacity pipe (approx 1m) at GL, overtopping spillway 300mm below crest over pipe, no evidence of overtopping
EC2	Earth embankment approx 4m high, 3.7m from FSL to crest level, no evidence of overbank bywash, no overtopping, outlet is piped for 350m and emerges at Daffodil St
EC3	Largely an excavated structure that overtops at or near GL, drop inlet at same level, overtopped by at least 500mm possibly 1m,
EC4	Earth embankment approx 2.0m high, grassed spillway 300mm above drop inlet level with crest 600mm above drop inlet, overtopped crest by approx 200mm.
EC5	Earth embankment approx 2.5m high, on side gully of EC, grassed spillway E end (0.7m below crest) and W end(1.1m below crest), no drop inlet, almost overtopped crest on E end, some bywash erosion
EC6	Earth embankment approx 2.0m high, grassed spillway same level as drop inlet level with crest 400mm above, overtopped crest by approx 300mm.
EC7	Sheet pile weir 300mm above GL, overtopped by at least 1.2m of flow, overtopped side wall on E perimeter as well.
EC8	Weir type structure under Kitchener St crossing, road submerged, erosion to abutments, bridge in pondage area 1.8m above FSL was submerged.
EC9	1.2m high Earth and concrete sill basin, with several drop inlets piped to outlets 480m downstream, Herries St overtopped and is 2.6m above crest of earth embankment
EC10	3 Concrete basins at or below ground level, some erosion ds
EC11	Concrete Weir like structure 1.7m high, Flood level some 3m above bed, flows overtopped Margaret St
West Creek (WC1Most Upstream)	Rock and concrete protected weir type structure overtopped by significant depth of flow, no apparent damage
WC2	Rock and concrete protected weir type structure overtopped by significant depth of flow no apparent damage
WC3	Rock and concrete protected weir type structure overtopped by significant depth of flow, no apparent damage, flows overtopped Spring Street Road crossing immediately ds (pond/excavation ds Spring St LB is off main channel)
WC4	Concrete structure overtopped, some ds erosion, no apparent damage to structure
WC5	Earth embankment approx 4.3m high, grassed spillway 900mm below crest, drop inlet level 2.0m below crest, overtopped crest by approx 200 - 300mm, some erosion on toe of wall
WC6	Earth embankment approx 4.2m high, grassed spillway 600mm below crest, drop inlet level 2.5m below crest, overtopped crest by approx 100 - 200mm.
WC7	Rock and concrete protected weir type structure overtopped by significant depth of flow no apparent damage immediately ups of Stenner St
WC8	Weir or concrete sill forming bed control structure mostly below bed no higher than 300mm, no apparent damage
WC9	Weir type structure approx 1.2m high, no apparent damage.
WC10	Rock and concrete protected weir type structure, approx 2m overtopped by significant depth of flow no apparent damage

WC11	Rock and concrete protected weir type structure with drop inlet for passing low flows overtopped by significant depth of flow no apparent damage, is located to the W of main channel
WC12	Rock and concrete protected weir type structure approx 1.0m high with debris 1.6m above crest
WC13	Earth embankment and rock protected spillway, main channel flows past this storage, inflow predominantly from local RB catchment
WC14	Earth embankment approx 4.0m high, grassed spillway section 100mm below crest, drop inlet level 3.1m below crest, overtopped crest by approx 100 - 200mm, Council breached section of wall after flow event
WC15	Weir type / crossing structure approx 2.8m high, damage to ds batter and RB abutment, crest largely intact, however some undermining is apparent
WC16	Earth embankment approx 1.5m high with large excavated capacity, 4.9m from concrete control to Crest, possible high flow spillway LB 300mm below crest, crest overtopped by 200mm, no apparent damage
WC17	Excavated pond and surrounds off main channel, was inundated by flows out of lined channel to the East, no apparent damage

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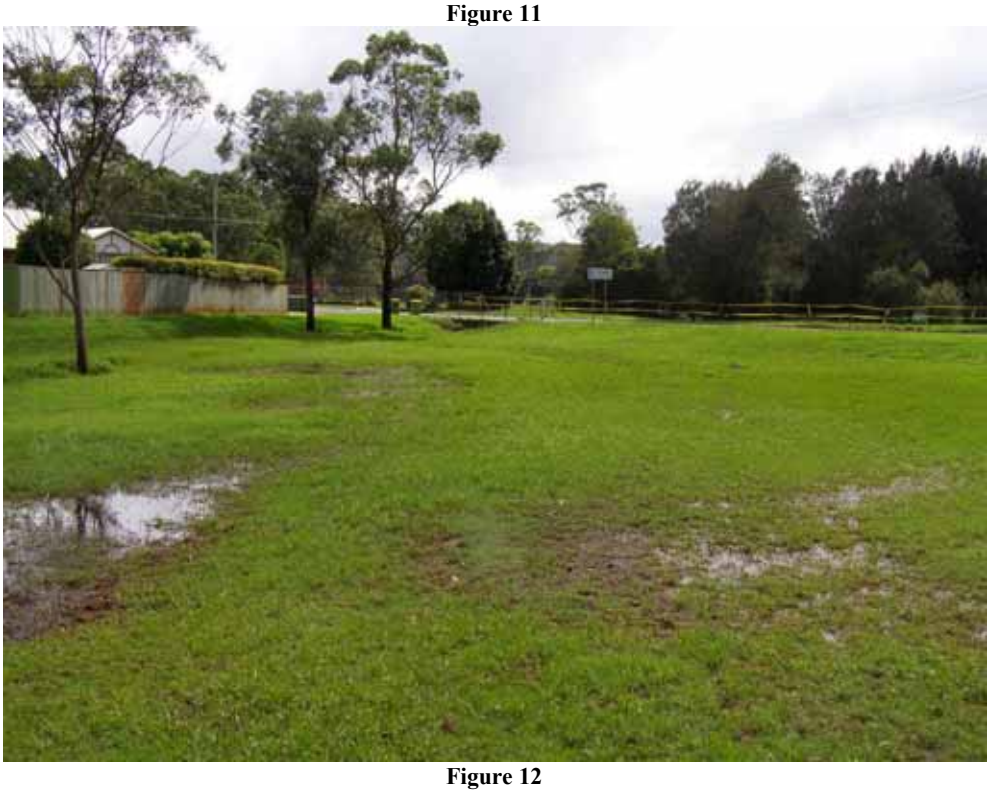

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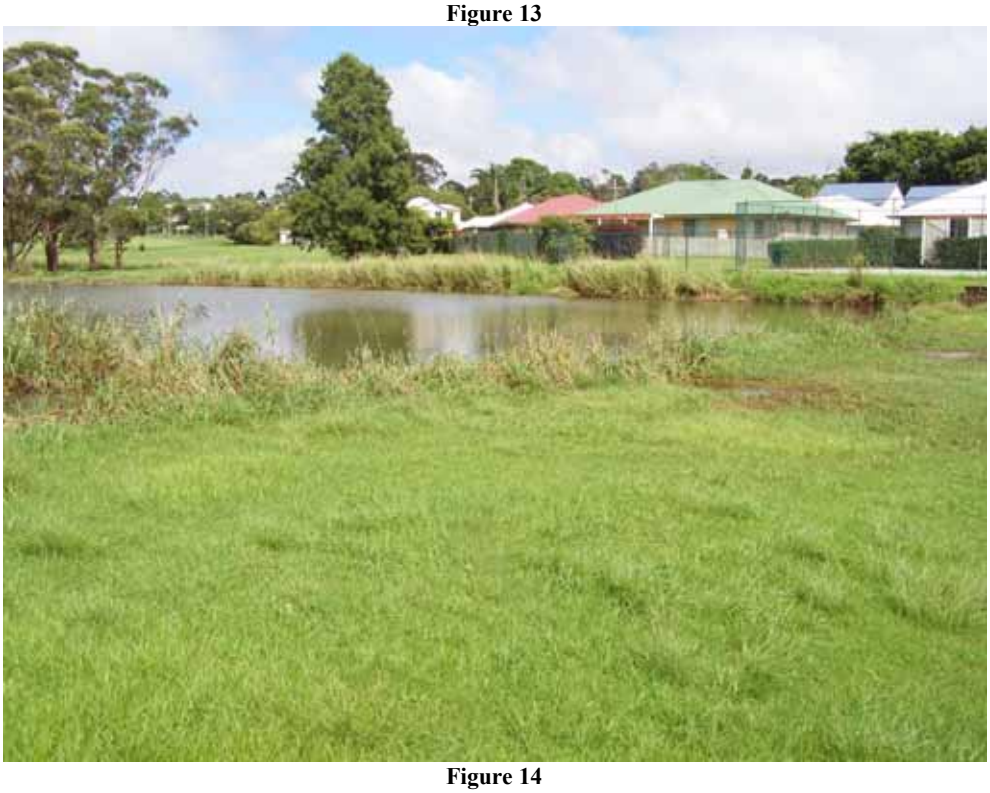

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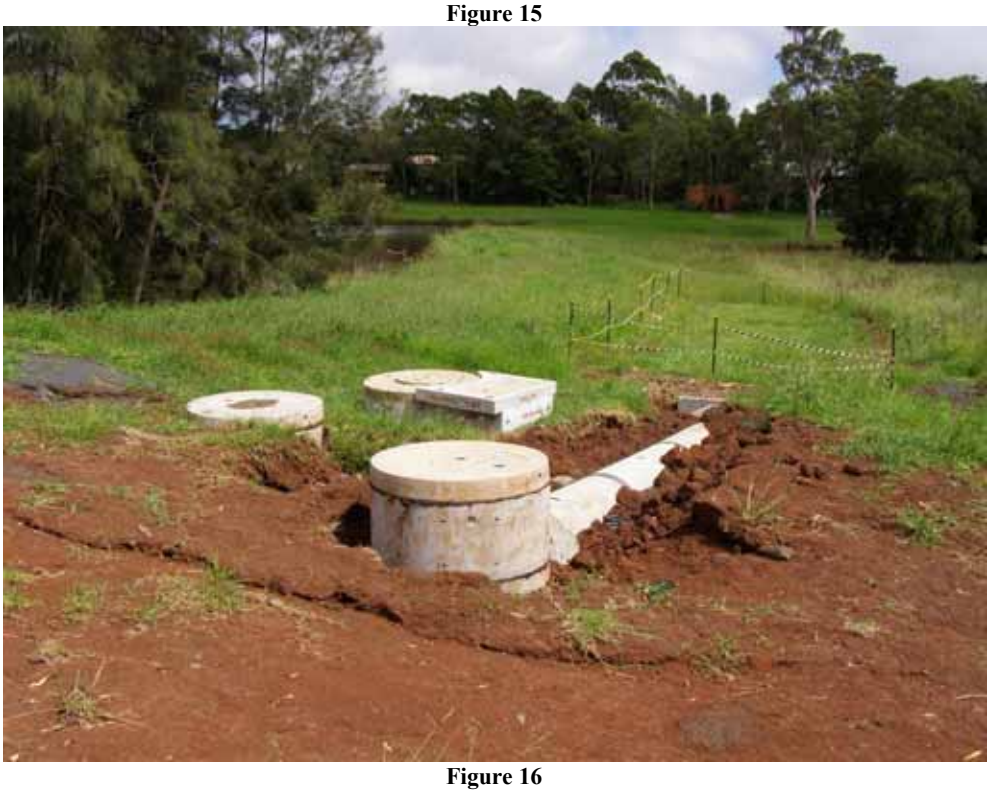

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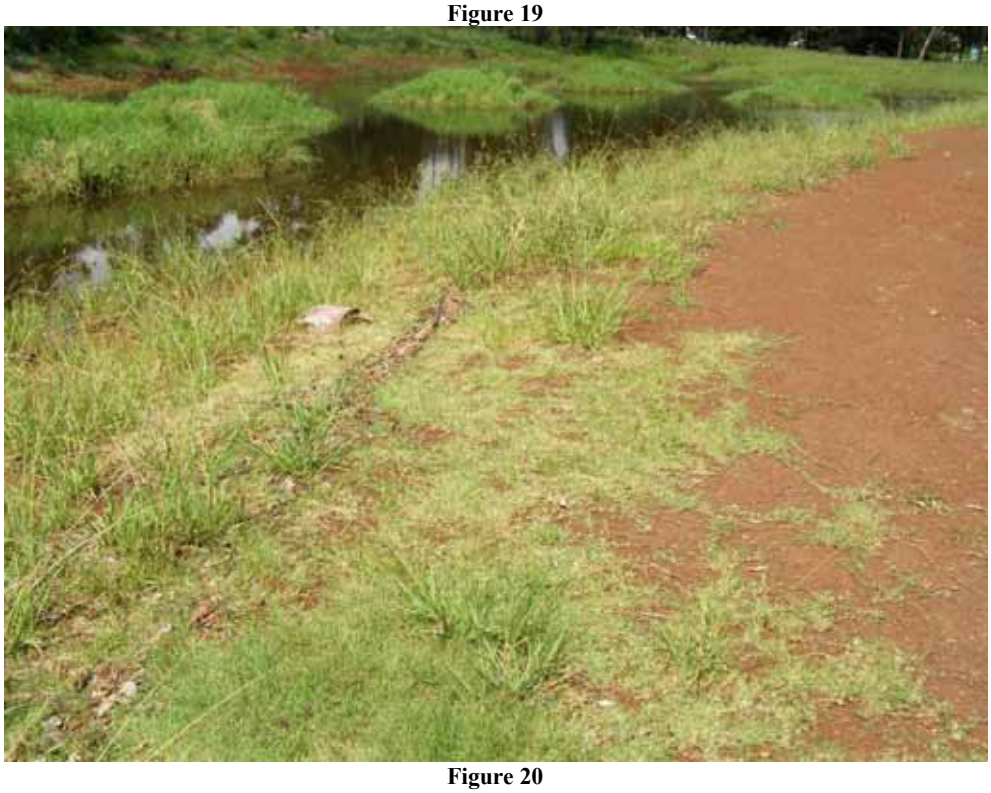

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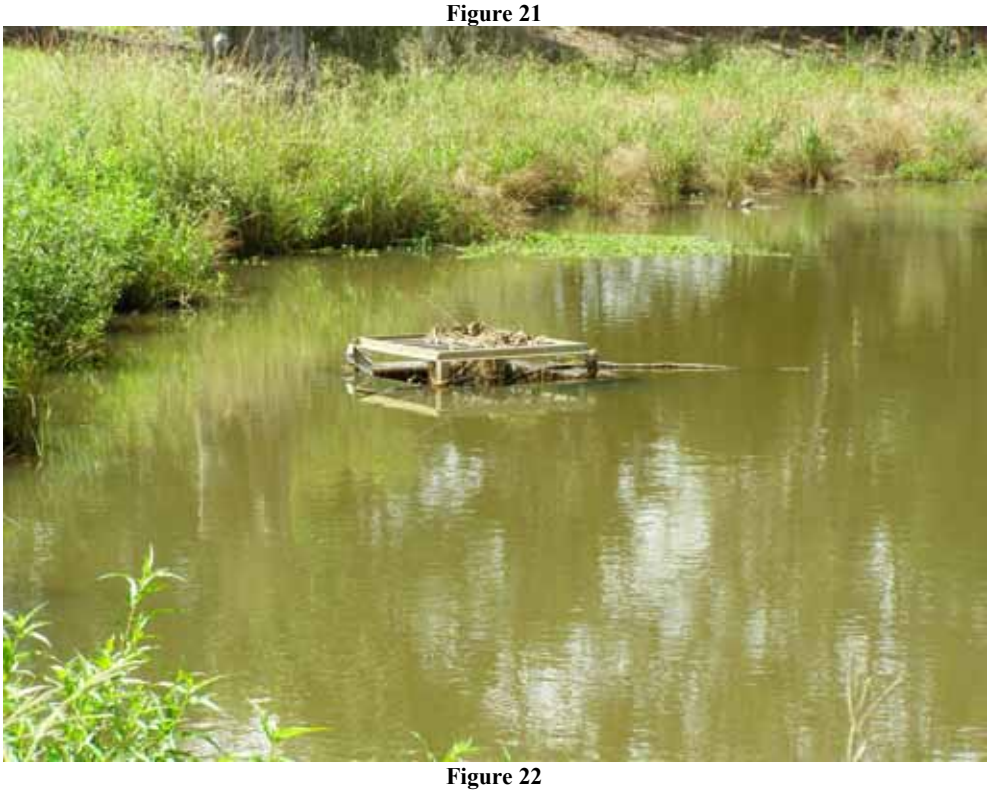

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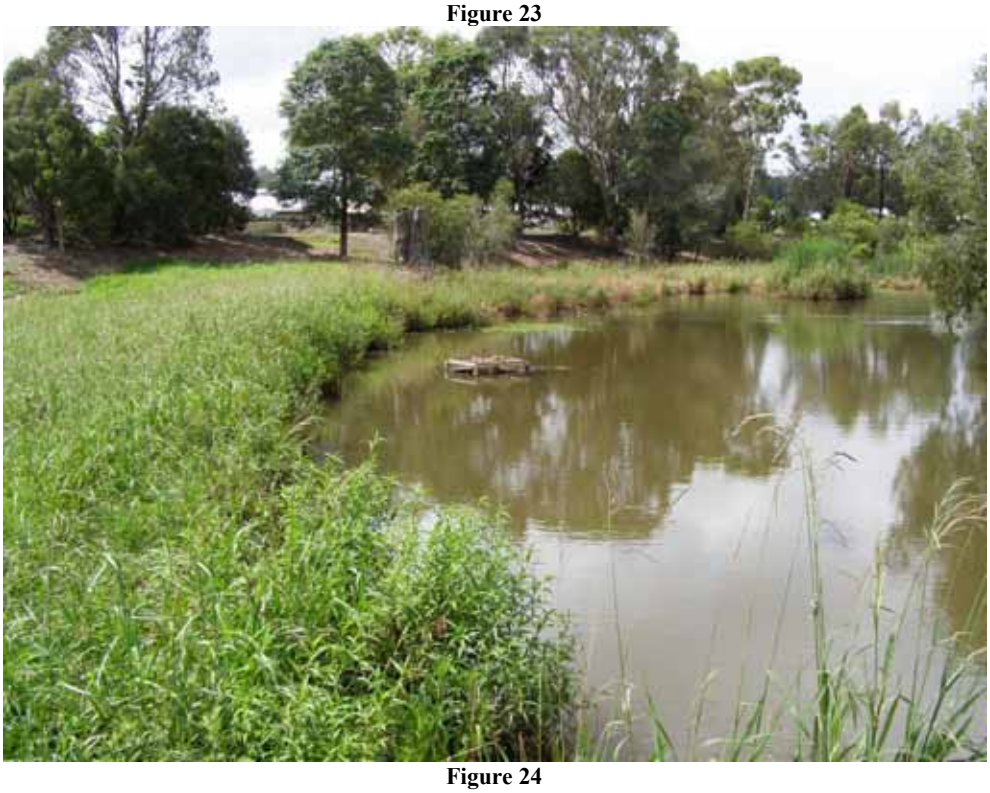

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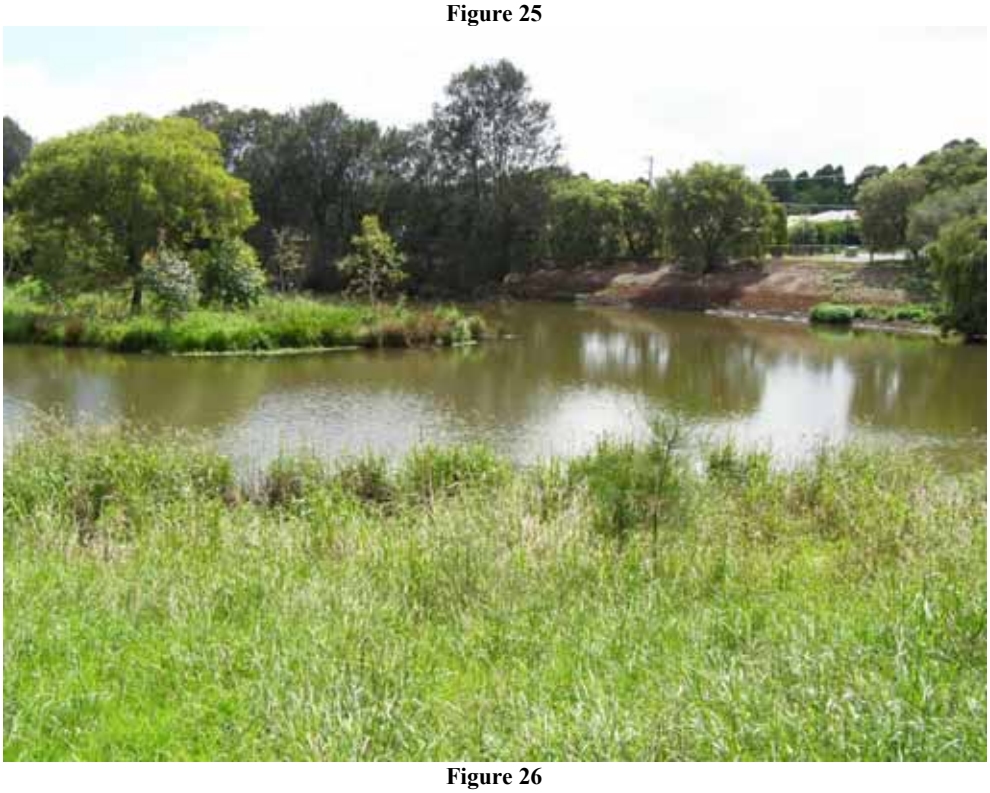

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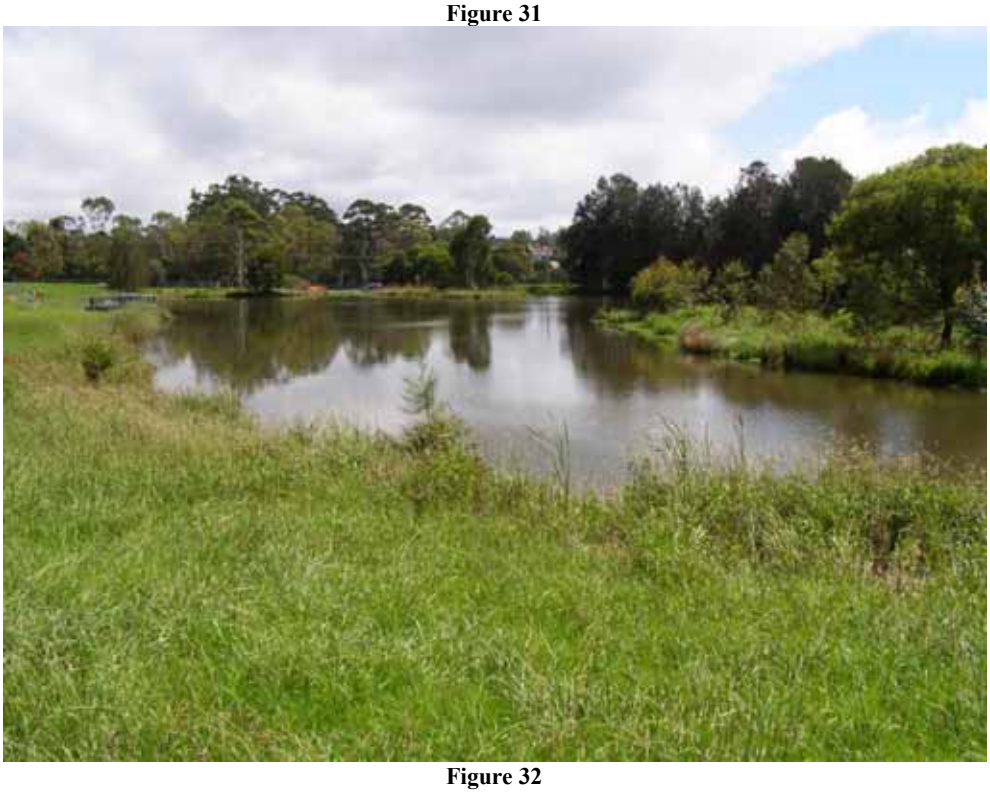

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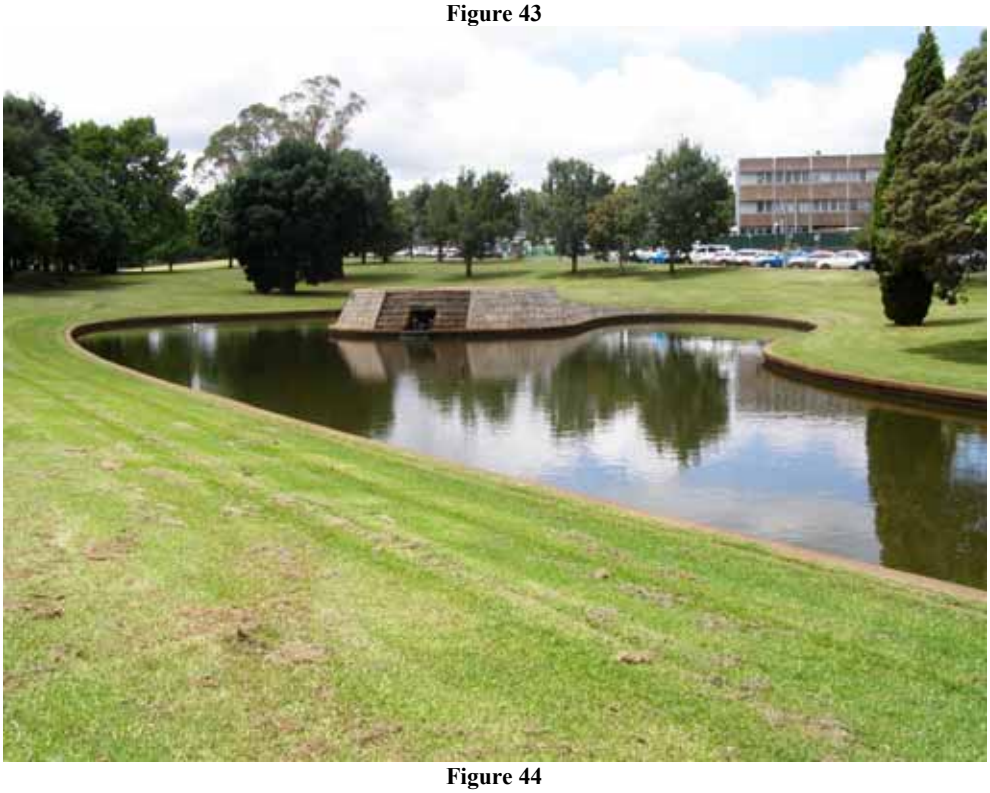

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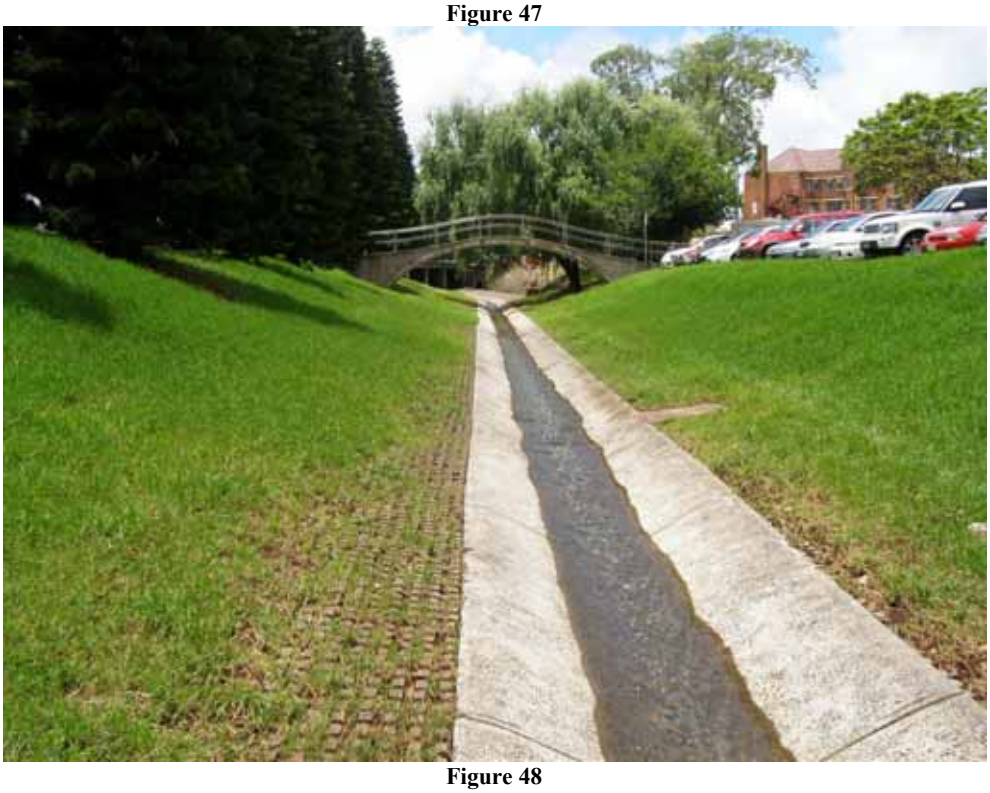

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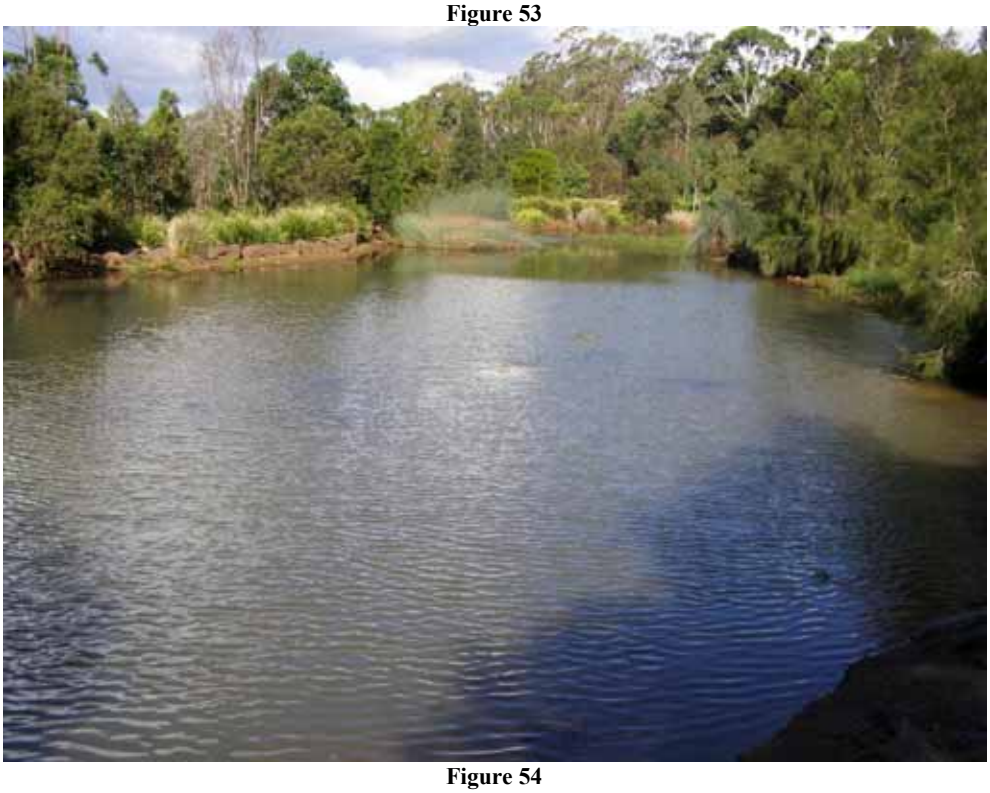

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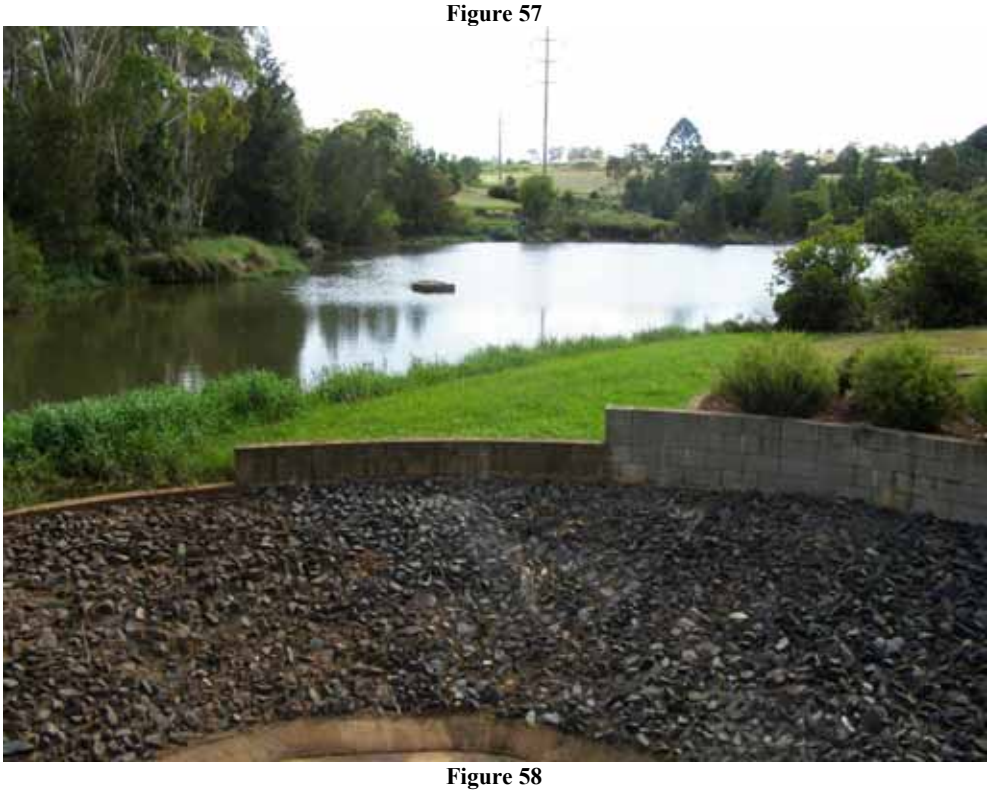

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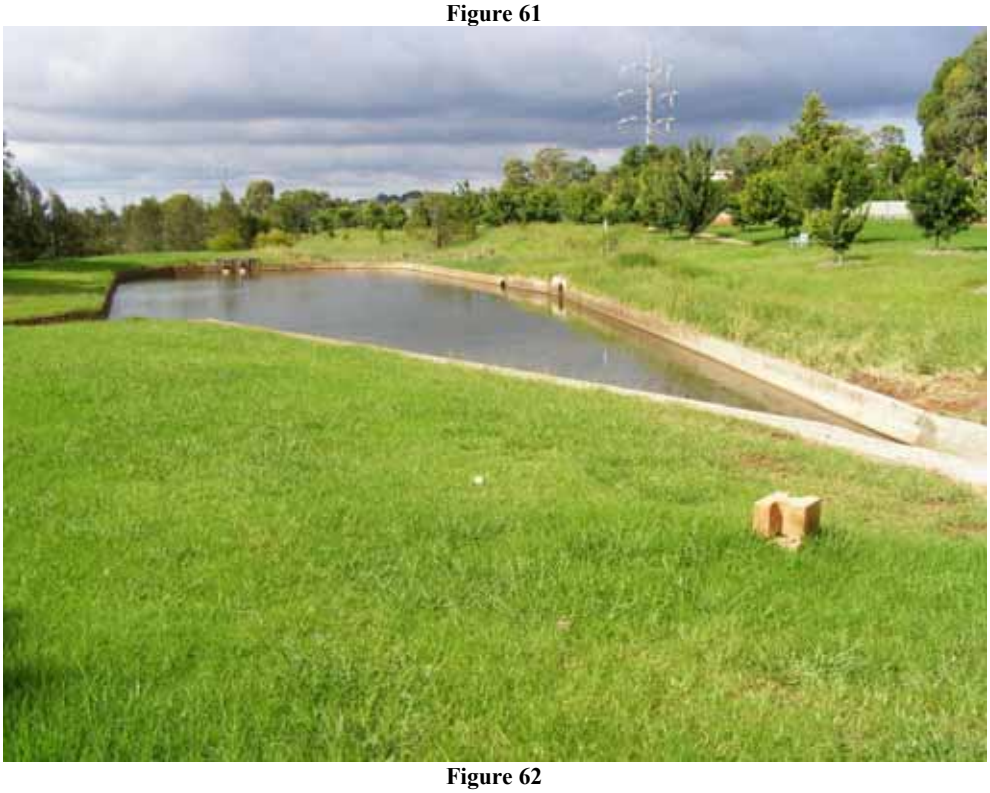

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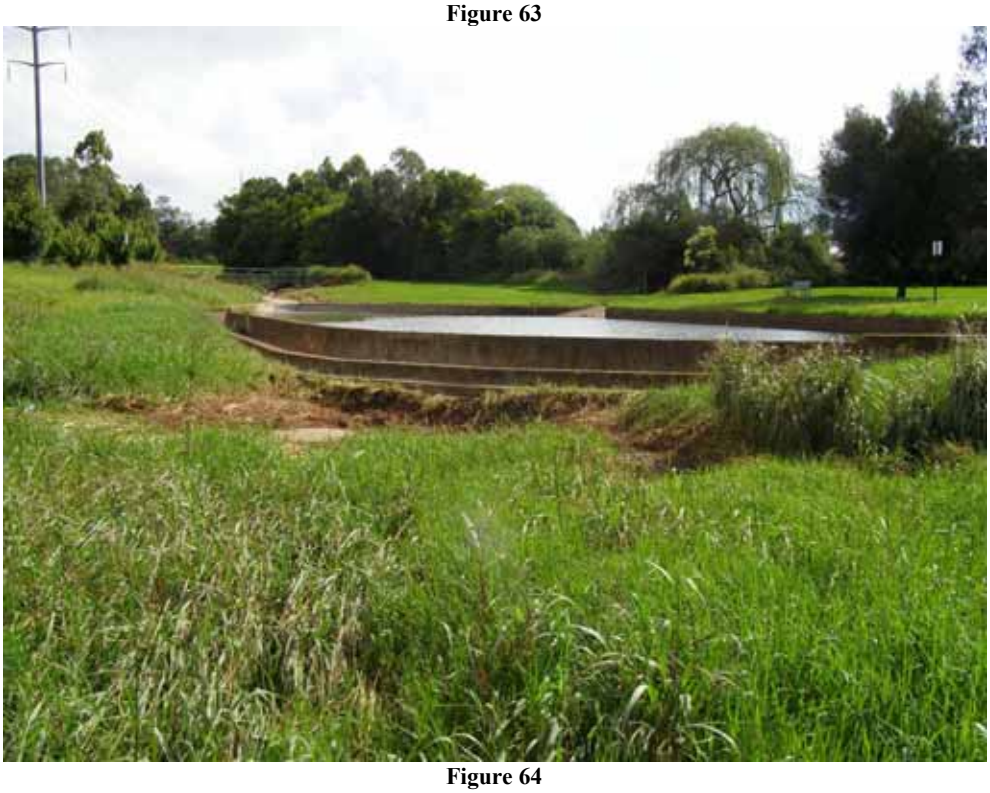

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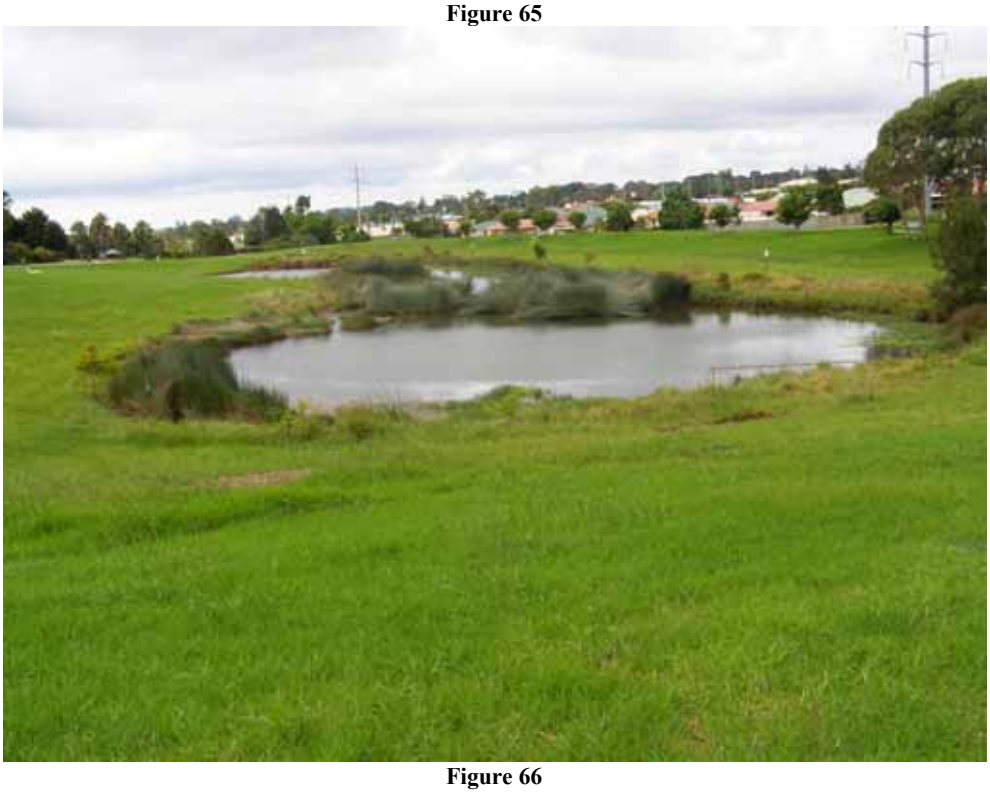

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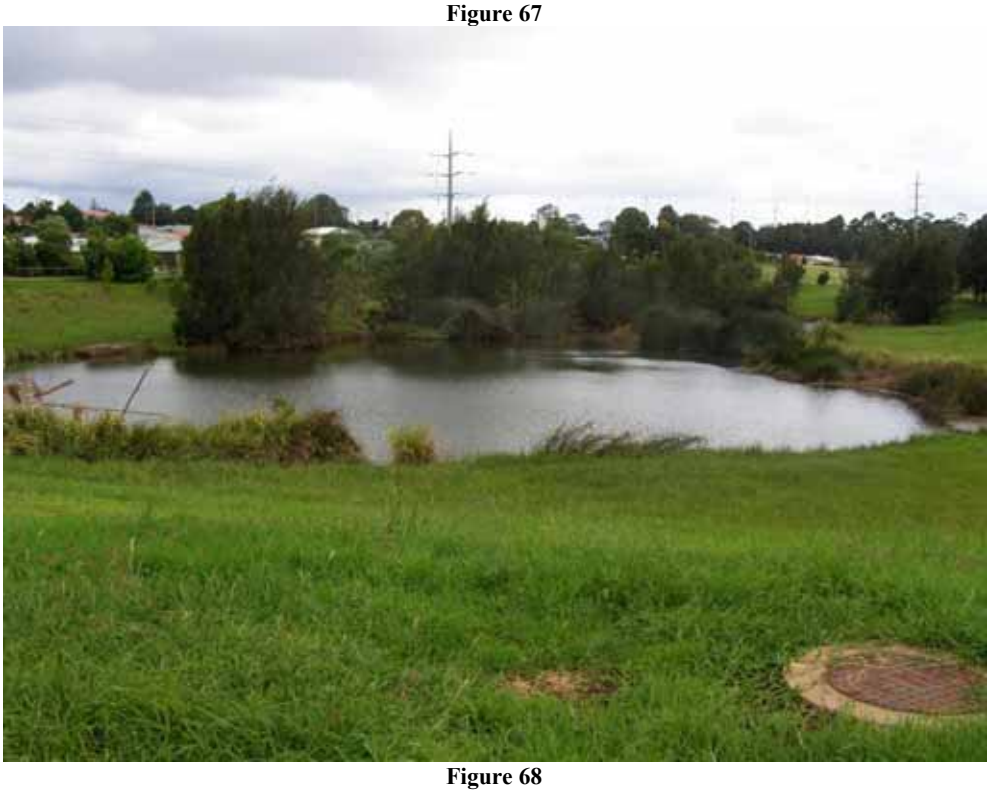

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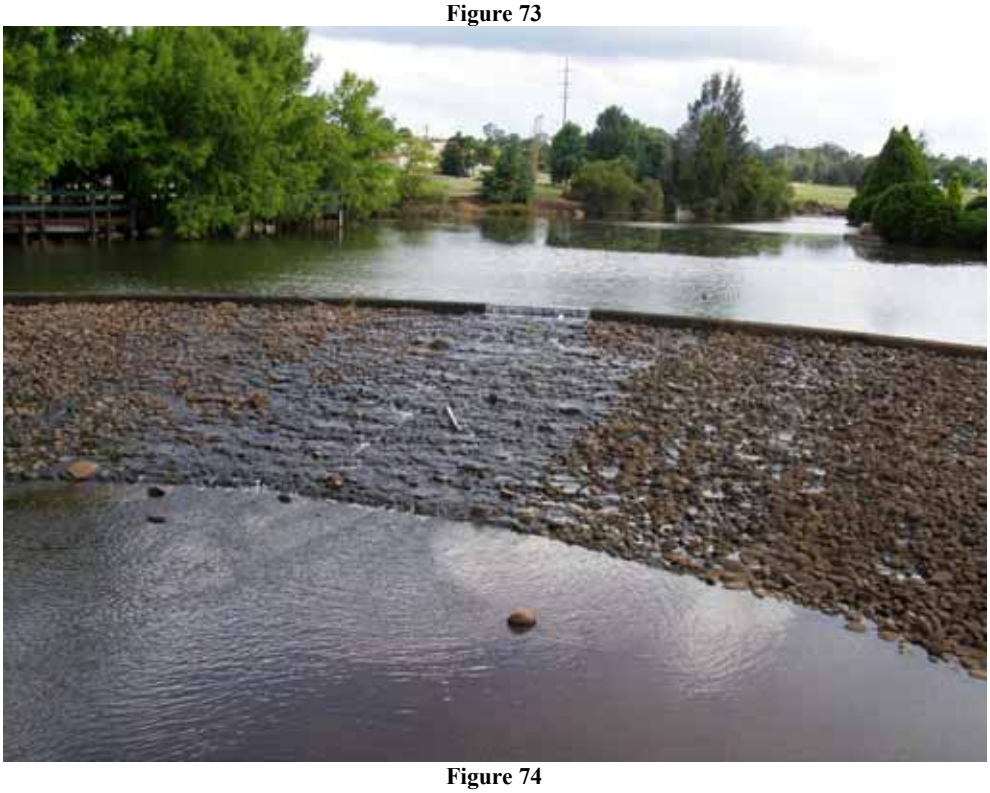

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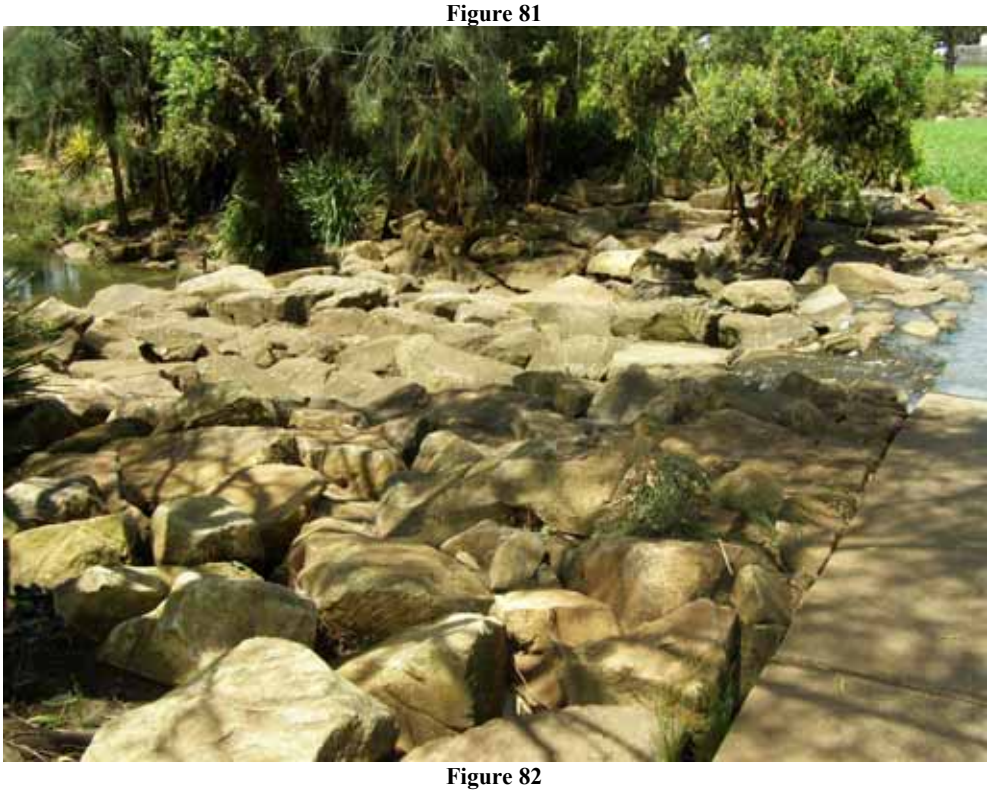

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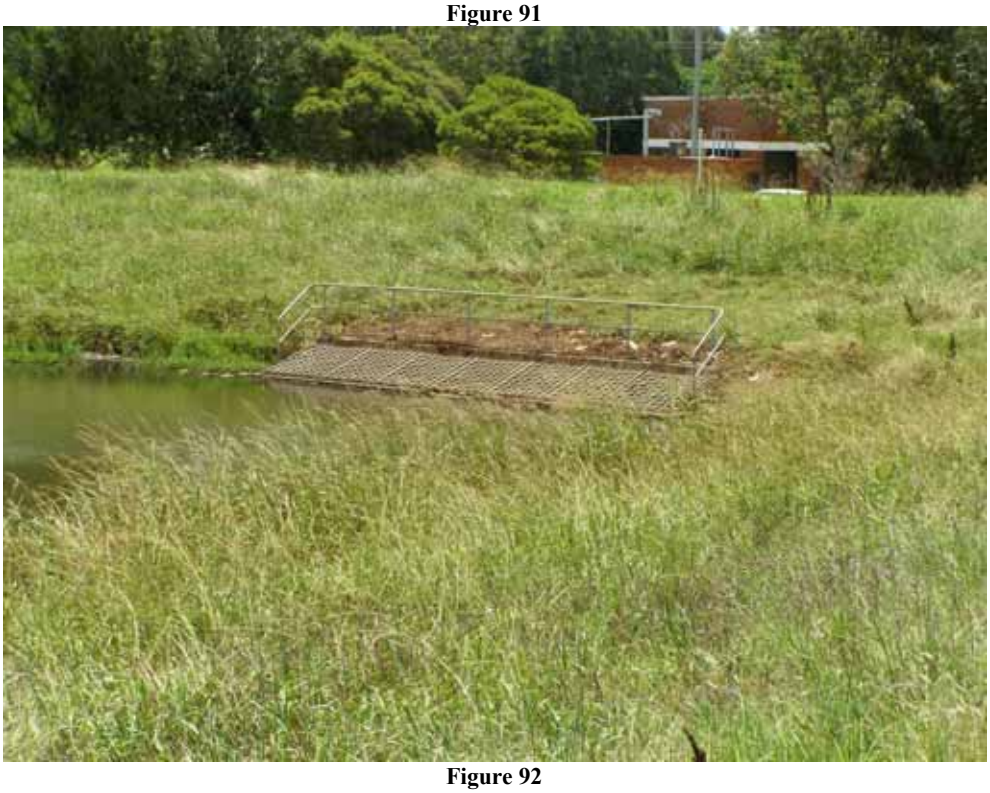

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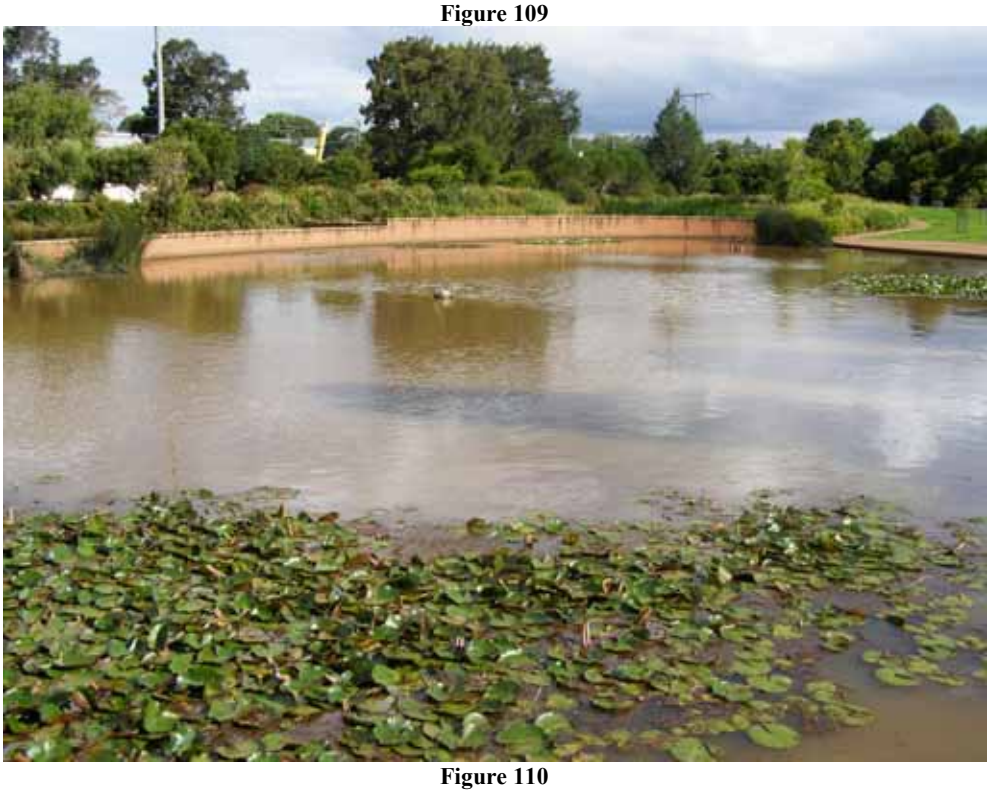

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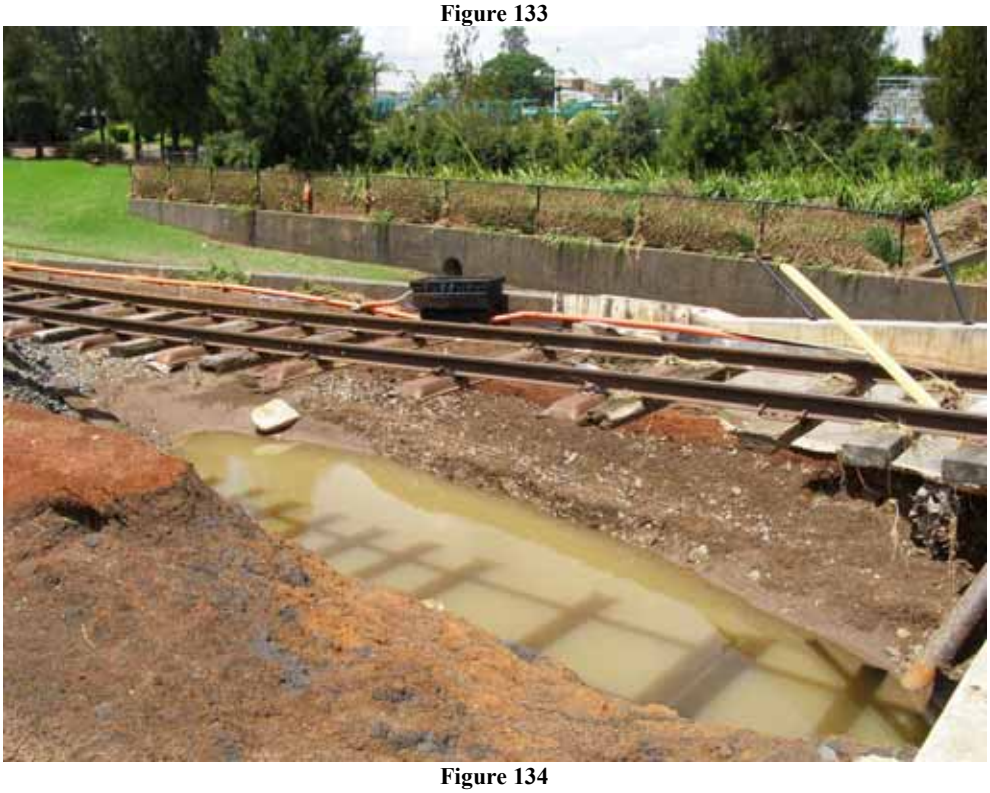

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APPENDIX B
Miscellaneous Photographs

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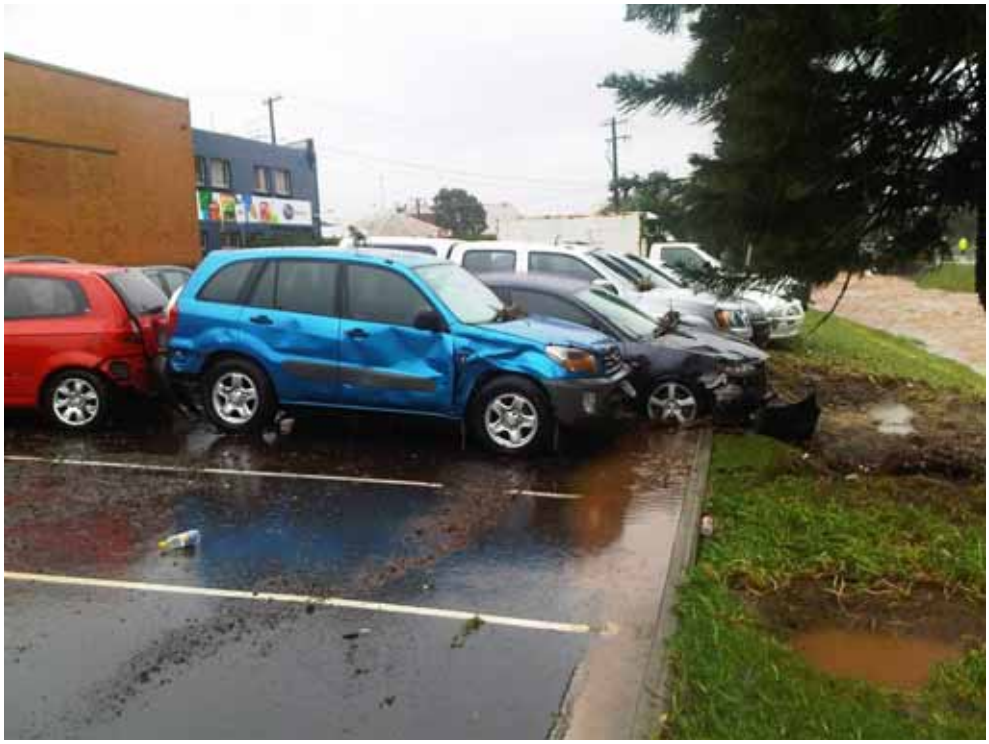

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