4.2.10 Operational Requirements

At the design stage, the DSC requires designers to specifically outline all designer requirements for operation and response actions that must be met to ensure the ongoing safety of the dam. Criteria for mechanical and electrical works (including pumps) should also be specified and align with the considerations set out in the DSC's Guidance Sheet on *General Dam Safety Considerations - DSC3G*. Designers' operational requirements are to be highlighted in the Operation and Maintenance Manual prepared for each tailings dam.

4.2.11 Upstream / Centre Lift Tailings Dams

While upstream tailings dams can be the cheapest method of construction, they require the highest level of operator skill and owner diligence in order to maintain their stability. They also need to be subject to strict design and operational constraints to ensure their ongoing safety. The DSC has identified several particularly critical issues, which require an appropriate minimum standard of design (and operation) to satisfy the DSC's requirements for this type of dam, as follows:

- A separate geotechnical report should be prepared;
- Results of a flownet analysis, detailing all assumptions, should be undertaken;
- Operating pond levels and trigger levels, which signal "unsafe" phreatic surfaces, should be determined and documented;
- Tailings discharge requirements for safe operation of the dam should be established;
- A planned, and safe maximum, rate of rise of the dam should be determined;
- Design parameters, values and requirements for seepage control, should be assessed and documented;
- Specifications for surveillance (including monitoring instrumentation) should be determined and outlined; and
- A conceptual rehabilitation plan should be prepared.

New dams should have either a suitably permeable foundation or an upstream drainage blanket. If this requirement is not met for existing dams then the Operational Pond Limit should be determined by flownet analyses based on measured permeability values. In the absence of a flownet analysis, or underdrainage system, the DSC will require that the operational pond not approach closer to the embankment than a distance which is 10 times the height of the embankment.

Flood handling capabilities of these types of tailings dams are particularly crucial for their long term safe operation and they should meet the criteria specified in Table 3.

The rate of rise of an upstream or centre-lift dam should not exceed 5 m per year. Proposals to exceed this rate should consider a total stress stability analysis and must incorporate additional monitoring aimed at fully understanding the pore pressures being developed in the dam.

4.3 Construction

Owners of all prescribed tailings dams are required to comply with the provisions of the pertinent chapters of the ANCOLD *Guidelines on Dam Safety Management – August 2003*, and ANCOLD Guidelines on *Tailings Dam Design, Construction and Operation – 1999* which have been adopted by the DSC.

The DSC requires dam designers to be integrally involved during the construction of tailings dams and to approve any design changes made during construction. This involvement is to be signed off formally by the Owner's representative in a Construction Certificate to be provided to the DSC at the end of each stage, and conclusion, of construction. Work-As-Executed Drawings and a Construction Report are to be provided to the DSC at the same time (refer pertinent sections of DSC Guidance Sheets DSC2A, DSC2B and DSC3G for details).

4.4 Operation, Maintenance and Emergency Management

Owners of all prescribed tailings dams are generally required to meet, in full, the provisions of the DSC's Guidance Sheets DSC2F, DSC2G and DSC3G. These requirements are in line with the pertinent chapters of the ANCOLD *Guidelines on Dams Safety Management – August 2003*, and ANCOLD Guidelines on *Tailings Dam Design, Construction and Operation – 1999* which have been adopted by the DSC, subject to the following qualifications:

- Since operational rules are important for the ongoing safety of tailings dams, an Operation and Maintenance (O&M) Manual is to be compiled, normally prior to commissioning of a tailings dam. The exception to this requirement is for upstream and centre lift construction tailings dams where, as a minimum, the Operational Management Section of the Manual is to be forwarded at the design stage for DSC consideration. This action is required for these types of dams as design operational rules are crucial to their ongoing safety;
- Operational Management Plans within the O&M Manual should specifically highlight all designer requirements for operation and response actions that must be met to ensure the ongoing safety of the dam. The O&M Manual should specify all requirements for operators and the minimum level of operator training with alternatives (e.g. consultant assistance) whenever these levels are not available;
- Operation and Maintenance Manuals for tailings dams are to be updated at least every two years with the updated copies forwarded to the DSC for its information;
- The DSC requires a Dam Safety Emergency Plan (DSEP) to be prepared for prescribed tailings dams where non-itinerant persons could be at risk. The DSEP is to include an appropriate dambreak study with the conservative assumption of liquid tailings flow in the event of dam failure (refer DSC2G for details);
- The DSC requires a modified DSEP to be prepared for all other prescribed tailings dams (refer DSC2G for details);

- DSEPs are to emphasise planning and strategies to minimise dam failure impacts on the surrounding environment. DSEPs are to be forwarded to the DSC for its consideration before commissioning of tailings dams. DSEPs are to be updated annually with pertinent update sections forwarded to the DSC for its information.

4.5 Surveillance

Owners of all prescribed dams are required to meet in full the provisions of the DSC's Guidance Sheet on *Surveillance Reports for Dams - DSC2C*. These requirements are in line with the pertinent chapters of the ANCOLD *Guidelines on Dam Safety Management - August 2003*, which have been adopted by the DSC. They recommend that dam owners undertake comprehensive inspections on initial dam filling, and thence on a five yearly basis, with intermediate inspections undertaken usually on an annual basis. Routine inspection and monitoring of the dam is to be undertaken by trained staff, with overall DSC surveillance requirements as set out in Table 4, which is adapted from the ANCOLD *Dam Safety Management Guidelines - 2003*.

TABLE 4 - TAILINGS DAM SURVEILLANCE CRITERIA

Sunny Day Consequence Category	Low	Significant	High C	High B	High A / Extreme
Comprehensive Inspections	5yr	5yr	5yr	5yr	5yr
Intermediate Inspections	2yr	Annual	Annual	Annual	Annual
Routine Inspections	Monthly	Weekly	Tri- weekly	Daily to Tri-weekly	Daily
Rainfall	Monthly	Weekly	Tri- weekly	Daily to Tri-weekly	Daily
Pond Level	Monthly	Weekly	Tri- weekly	Daily to Tri-weekly	Daily
Seepage – rate	Monthly	Weekly	Tri- weekly	Daily to Tri-weekly	Daily
Seepage - chemistry analysis		Consider	Annual	Annual	Annual
Pore Pressure	Consider	3 Monthly	Monthly	Monthly	Monthly
Surface Survey[1]	Consider	2yr	Annual	Annual	Annual

Note 1 *For compacted dams on solid foundations - (more frequent survey required for lightly compacted dams and dams on compressible foundations).*

The DSC requires all prescribed dam owners to submit the results of their comprehensive inspections in Surveillance Reports to the DSC (refer DSC2C for details). For water supply dams, the DSC does not require the submission of intermediate reports and they are usually incorporated into the normal Surveillance Reports for dams. However, due to the normally dynamic nature of tailings dams, the DSC requires the owners of tailings dams to submit the results of their intermediate inspections in reports for the DSC's consideration.

For dams requiring Type 1 and 2 Surveillance Reports, these intermediate reports should be prepared by a suitably qualified engineer, and cover the same surveillance issues addressed in five yearly Surveillance Reports, including updates on operations and programming, but need not be as detailed (e.g. not include a long-term review of surveillance data) as the review requirements for

Surveillance Reports (see attached DSC Form D19 for report checklist). Owners of other prescribed tailings dams are to submit their intermediate inspection reports in the format of Type 3 Surveillance Reports.

The following specific issues should be considered and reported to the DSC, where appropriate:

- Groundwater monitoring with special emphasis on the environmental impacts of the tailings dam on groundwater;
- Seepage monitoring, both visual observations and seepage measurement is required as a minimum; and
- Chemical analysis of seepage water with reference to changing chemical and
- physical characteristics of the flow.

In view of the short term nature of mining operations, it is essential that dam owners conform to the report process and the required deadlines for submissions. Failure to do so could result in delays of approvals to proceed with construction and operational activities, with consequent interruptions to the mining operation.

In ensuring effective surveillance of tailings dams, the owners are required to select suitable operational staff and arrange for their training in the areas of dam safety management with regular refresher courses to keep operators up to date with current practices. As part of that training, operators should be capable of recognising abnormal conditions and circumstances that could affect the safety of their dams and be able to institute appropriate actions including when to call for more expert assistance.

Incident Reports of any events threatening dam safety, including their inspection, assessment and remedial action / control details, are to be forwarded at the earliest opportunity for the DSC's consideration (refer DSC2A for details).

4.6 Decommissioning

The decommissioning of tailings dams raises issues that are not faced in the decommissioning of other dams. The DSC notes that it is often necessary to undertake site rehabilitation and long term monitoring of decommissioned dams. Dam owners are required to advise the DSC of their strategies in this regard at the initial design stage for the dam to enable assessment of the long term feasibility of design options. Dam owners are also required to submit their final decommissioning proposal for the DSC's consideration prior to implementing their decommissioning processes.

In particular, the DSC requires, as a minimum, consideration of the following issues in decommissioning a tailings dam:

- Protection of its long term stability;
- The potential for erosion of an embankment, especially if it has been an upstream construction with a low quality material on the exposed face;

- Its flood capacity with consideration of provision for changes in future standards and the long term loss of holding capacity;
- Advice on its ongoing effects on the surrounding environment and long term controls to minimise these effects;
- Advice on the proposal for its long term monitoring and the role of the Department of Primary Industries in this respect; and
- Advice on when the dam can be de-prescribed, in the owner's opinion.

Dam owners are advised that the DSC will maintain prescription of any dam, and place its normal dam safety obligations on the dam owner, until such stage that the decommissioning process has guaranteed that the dam imposes minimal safety risks to life and the surrounding environment, whereupon the DSC will deprescribe the dam.

5.0 DOCUMENTATION

The DSC's normal requirements as to the substance and timing of information required by the DSC, and the responses to be expected from the DSC, are set out in the DSC's Guidance Sheet on *Documentation and Information Flow over Dam Life Cycle - DSC2B*. These requirements apply for all tailings dams with the following qualifications:

- Incident Reports of any events threatening dam safety, including their inspection, assessment and remedial action / control details, are to be forwarded at the earliest opportunity for the DSC's consideration (refer DSC2A for details);
- Due to the usually dynamic nature of tailings dams, the DSC requires the owners of these dams to submit the results of their intermediate inspections in reports for the DSC's consideration. These reports should cover the same surveillance issues addressed in five yearly Surveillance Reports, and include updates on operations and programming, but need not be as detailed as Surveillance Reports (refer sub-section 4.5 and Form D19 checklist). They should also include an updated DSC D8 Form to update the DSC on pertinent owner contact details;
- The DSC also has some concerns about the issue of ownership of tailings dams. Submissions should state clearly "Who is the owner?" and "What is their relationship to the land owner or leaseholder?" In this context, the term "owner" has its usual legal sense, and does not have the meaning defined in the *Dams Safety Act 1978*. There should also be advice on the corporate structure clearly outlining the responsibilities for the management of the dams. Any changes in the detail of these arrangements should be advised to the DSC immediately;
- Rehabilitation Strategy Plans are to be submitted at the design stage to enable determination of the long term feasibility of design options;

- Management Plans are to be submitted at the design stage for upstream or centre lift construction tailings dams to ensure designer requirements are appropriately incorporated for these types of dams; and
- Operational Management Plans are to be included in the Operations and Maintenance Manual for the dam.

6.0 REFERENCES

- ANCOLD (Australian National Committee on Large Dams), 1998, *Guidelines for Design of Dams for Earthquake*, August.
- *ANCOLD, 1999, Guidelines on Tailings Dam Design, Construction and Operation*, October.
- ANCOLD, 2000, *Guidelines on Selection of Acceptable Flood Capacity for Dams,* March.
- ANCOLD, 2000, *Guidelines on Assessment of the Consequences of Dam Failure,* May.
- ANCOLD, 2003, *Guidelines on Dam Safety Management*, August.
- ANCOLD, 2003, *Guidelines on Risk Assessment*, October.
- DMEWA (Western Australian Department of Minerals and Energy), 1998, *Guidelines on the Development of an Operating Manual for Tailings Storage.*
- DMEWA, 1999, *Guidelines on the Safe Design and Operating Standards for Tailings Storage.*
- EPA, 1995, *Best Practice Environmental Management In Mining,* 1995
- Fell, MacGregor, and Stapledon, 2004, *Geotechnical Engineering of Dams,* GEED
- ICOLD (International Commission on Large Dams) Bulletin 97, 1994, *Tailings Dams-Design of Drainage-Review and Recommendations.*
- ICOLD Bulletin 98, 1995, *Tailings Dams and Seismicity-Review and Recommendations.*
- ICOLD Bulletin 104, 1996, *Monitoring of Tailings Dams-Review and Recommendations.*
- ICOLD Bulletin 106, 1996, *A Guide to Tailings Dams and Impoundments-Design, Construction, Use and Rehabilitation*.
- ICOLD Bulletin 121: *Tailings Dams Risk of Dangerous Occurrences Lessons learnt from Practical Experiences*
- Mining Association of Canada, 1998, *A Guide to the Management of Tailings Facilities,* September.
- UNEP, 1996, *Environmental and Safety Incidents Concerning Tailings Dams at Mines.*
- Vick, Steven, 1990, *Planning Design and Analysis of Tailings Dams* BiTech Publishers.
- WMC (Western Mining Corporation) *Guidelines for the Design of Tailings Storage Facilities- GL68,* undated.

New South Wales Government
Dams Safety Committee
D19 Form

TAILINGS DAM – INTERMEDIATE REPORT REQUIREMENTS

Checklist for owners and consultants preparing Reports

Please return this form completed with Report

The following checklist covers the minimum items to be included in Intermediate Reports. Please tick against each item to indicate completion of the item in the Report, and enclose the signed D19 Form with the copy of the Report submitted to the Dams Safety Committee. Please note that Reports which do not address all relevant items may not be accepted.

- ❑ Owner to provide cover letter indicating that the owner accepts the report and containing a program to carry out recommendations
- ❑ Conclusions (in point form)
- ❑ Recommendations (in point form), separate from the Conclusions
- ❑ Basic Dam Details – location, type of dam, height, crest length, storage volume, consequence categories, outlet works, spillway type and hydrology, etc
- ❑ Inspection
  - Details of inspection – names of inspection team, date, weather conditions, storage level
  - Condition of dam, e.g. evidence of slips, erosion, cracks, sink holes, piping, subsidence, seepage, settlement, movement, misalignment, etc. & history (old, recent or continuing)
  - Condition of Abutments & Foundations – seepages related to the storage, slips, erosion, piping, etc. & history
  - Condition of Spillways – stability, erosion, blockages, movement, etc. & history
  - Condition of Storage Basin & Downstream Areas
  - Condition & operability of inlet & outlet works, spillway works and other mechanical & electrical equipment
- ❑ Monitoring
  - Type of instrumentation and frequency of monitoring
  - Comment on monitoring measurements since the previous Report – seepage (rates & quality), pore pressures, groundwater, deformation surveys, rainfall, storage level, etc.
- ❑ Comment on compliance of inspection and monitoring procedures with the ANCOLD "Guidelines on Dam Safety Management - 2003".
- ❑ Comment on status of O & M Manual and Dam Safety Emergency Plan (DSEP)
- ❑ Findings of any reports produced since the previous Report
- ❑ Incidents which have occurred since the previous Report and actions taken
- ❑ Changes to the dam, operating procedures, developments, management or operating staff since the previous Report and their effect on dam safety.
- ❑ Comparison to the previous Report, action taken as a result of that Report's recommendations and any recommendations not carried out.
- ❑ Provide information on mining activities close to the dam or storage
- ❑ An opinion as to whether the dam is safe in terms of the Committee's requirements
- ❑ Signatures of Report writers
- ❑ Appendices
  - Dam data sheets - D1 & D8
  - Drawings, e.g. Site, General Arrangement, Cross-Section, Spillway, Outlet Works, etc.
  - Photographs of main aspects of dam taken during the inspection, particularly areas commented on in the Report
  - Monitoring data summary sheets
  - An IBM compatible CD, or equivalent, containing a Microsoft Word format file of the text and a PDF of the entire report including drawings and photos.

Checklist completed by: ....

This Guidance Sheet is one of a series available from our Website at:

http://www.damsafety.nsw.gov.au

In order to read this file you need a Portable Document Format (PDF) reader. A free PDF reader is available from http://www.adobe.com/

For any further information please contact:

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ISSN 1039-821X

APPENDIX B

Embankment Water Breach Output Files

Knight Piésold CONSULTING	Subject: Cortona Resources	Made by: AMJ	Job No.: PE801-00139
	Dargues Reef Gold	Checked: TML	Date: 08/11/2011
	TSF Spillway Design: Stage / Storage	Approved	

Spillway Design: Outflow Rating Table for Dargues Reef TSF Pond (5 m spillway)

The following information was developed for use in hydrologic routing of the proposed channel spillway, which operates under broad-crested weir control ($Q = C * L * H^{1.5}$), with coefficient "C" taken from: *Brater, E.F. & King, H.W. (1996) "Handbook of Hydraulics, Seventh Edition"*, New York, N.Y: McGraw-Hill.

The channel spillway rating information is taken from a hydraulic model developed using HEC-RAS software.

Dam crest length is: 467.0 m
Dam crest breadth is: 6.0 m
Dam crest invert elevation is: 712.0 m

Elevation	Water Storage	Channel Spillway Outflow		Crest Overflow		Combined
	Volume	Weir	HEC-RAS	Weir	{Weir Eqn.}	Total
(m)	(m^3)	Coefficient	(m^3/s)	Coefficient	(m^3/s)	(m^3/s)
706.0	0.0	#N/A	0.0	#N/A	#N/A	0.0
706.1	58.8	#N/A	0.0	#N/A	#N/A	0.0
706.2	117.6	#N/A	0.0	#N/A	#N/A	0.0
706.3	176.4	#N/A	0.0	#N/A	#N/A	0.0
706.4	235.2	#N/A	0.0	#N/A	#N/A	0.0
706.5	294.0	#N/A	0.0	#N/A	#N/A	0.0
706.6	352.8	#N/A	0.0	#N/A	#N/A	0.0
706.7	411.6	#N/A	0.0	#N/A	#N/A	0.0
706.8	470.4	#N/A	0.0	#N/A	#N/A	0.0
706.9	529.2	#N/A	0.0	#N/A	#N/A	0.0
707.0	588.0	#N/A	0.0	#N/A	#N/A	0.0
707.1	1,170.4	#N/A	0.0	#N/A	#N/A	0.0
707.2	1,752.8	#N/A	0.0	#N/A	#N/A	0.0
707.3	2,335.2	#N/A	0.0	#N/A	#N/A	0.0
707.4	2,917.6	#N/A	0.0	#N/A	#N/A	0.0
707.5	3,500.0	#N/A	0.0	#N/A	#N/A	0.0
707.6	4,082.4	#N/A	0.0	#N/A	#N/A	0.0
707.7	4,664.8	#N/A	0.0	#N/A	#N/A	0.0
707.8	5,247.2	#N/A	0.0	#N/A	#N/A	0.0
707.9	5,829.6	#N/A	0.0	#N/A	#N/A	0.0
708.0	6,412.0	#N/A	0.0	#N/A	#N/A	0.0
708.1	8,391.0	#N/A	0.0	#N/A	#N/A	0.0
708.2	10,370.0	#N/A	0.0	#N/A	#N/A	0.0
708.3	12,349.0	#N/A	0.0	#N/A	#N/A	0.0
708.4	14,328.0	#N/A	0.0	#N/A	#N/A	0.0
708.5	16,307.0	#N/A	0.0	#N/A	#N/A	0.0
708.6	18,286.0	#N/A	0.0	#N/A	#N/A	0.0
708.7	20,265.0	#N/A	0.0	#N/A	#N/A	0.0
708.8	22,244.0	#N/A	0.0	#N/A	#N/A	0.0
708.9	24,223.0	#N/A	0.0	#N/A	#N/A	0.0
709.0	26,202.0	#N/A	0.0	#N/A	#N/A	0.0
709.1	30,576.5	#N/A	0.0	#N/A	#N/A	0.0
709.2	34,951.0	#N/A	0.0	#N/A	#N/A	0.0
709.3	39,325.5	#N/A	0.0	#N/A	#N/A	0.0
709.4	43,700.0	#N/A	0.0	#N/A	#N/A	0.0
709.5	48,074.5	#N/A	0.0	#N/A	#N/A	0.0
709.6	52,449.0	#N/A	0.0	#N/A	#N/A	0.0
709.7	56,823.5	#N/A	0.0	#N/A	#N/A	0.0
709.8	61,198.0	#N/A	0.0	#N/A	#N/A	0.0
709.9	65,572.5	#N/A	0.0	#N/A	#N/A	0.0
710.0	69,947.0	#N/A	0.0	#N/A	#N/A	0.0
710.1	77,403.1	#N/A	0.0	#N/A	#N/A	0.0
710.2	84,859.2	#N/A	0.0	#N/A	#N/A	0.0
710.3	92,315.3	#N/A	0.0	#N/A	#N/A	0.0
710.4	99,771.4	#N/A	0.0	#N/A	#N/A	0.0

Knight Piésold CONSULTING	Subject Cortona Resources	Made by AMJ	Job No. PE801-00139
	Dargues Reef Gold	Checked TML	Date 08/11/2011
	TSF Spillway Design: Stage / Storage	Approved	

Spillway Design: Outflow Rating Table for Dargues Reef TSF Pond (5 m spillway)

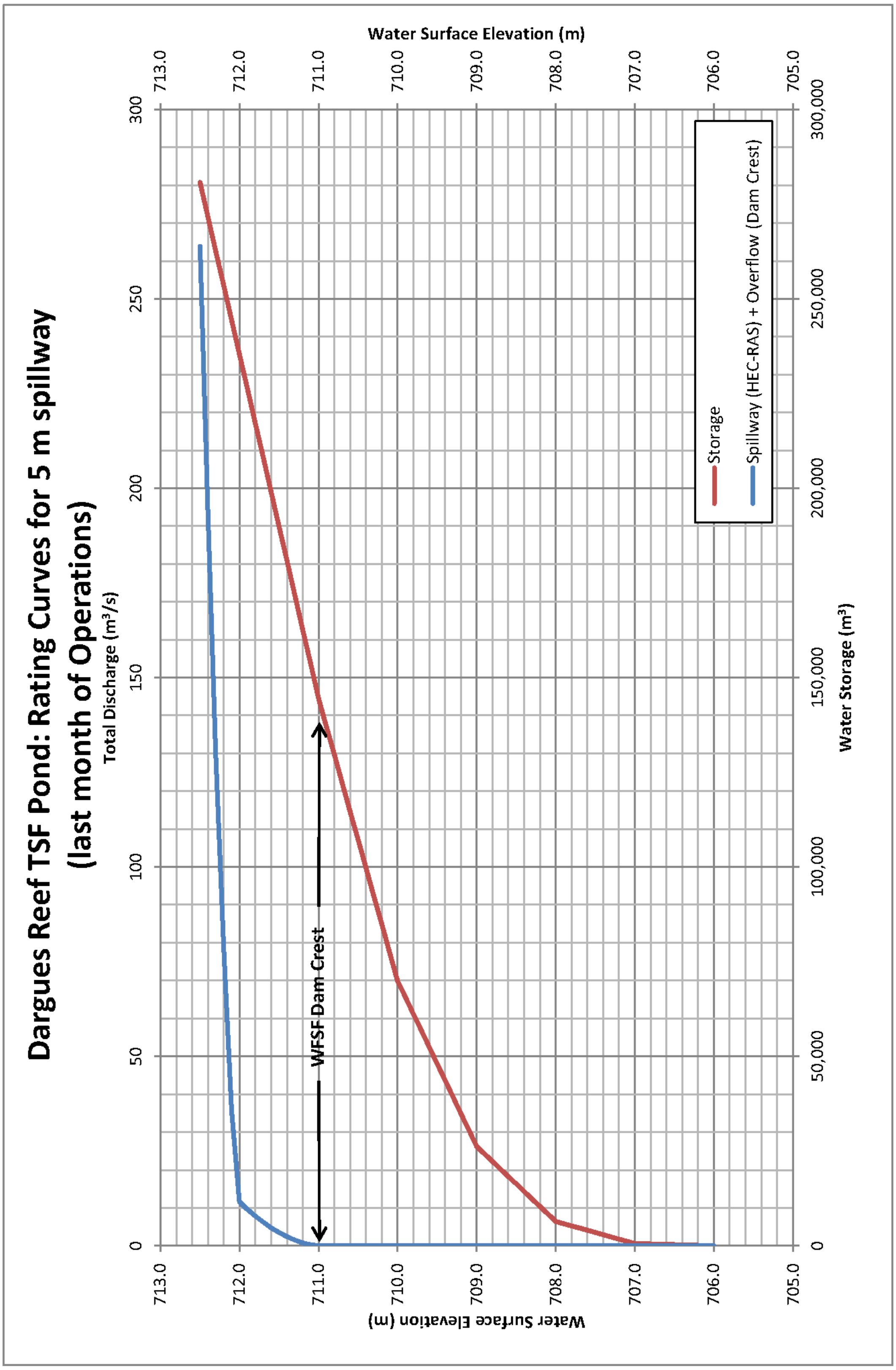
The following information was developed for use in hydrologic routing of the proposed channel spillway, which operates under broad-crested weir control ($Q = C * L * H^{1.5}$), with coefficient "C" taken from: *Brater, E.F. & King, H.W. (1996) "Handbook of Hydraulics, Seventh Edition"*, New York, N.Y: McGraw-Hill.

The channel spillway rating information is taken from a hydraulic model developed using HEC-RAS software.

Dam crest length is: 467.0 m
Dam crest breadth is: 6.0 m
Dam crest invert elevation is: 712.0 m

Elevation (m)	Water Storage Volume (m^3)	Channel Spillway Outflow Weir Coefficient	HEC-RAS (m^3/s)	Crest Overflow Weir Coefficient	{Weir Eqn.} (m^3/s)	Combined Total (m^3/s)	
710.5	107,227.5	#N/A	0.0	#N/A	#N/A	0.0	
710.6	114,683.6	#N/A	0.0	#N/A	#N/A	0.0	
710.7	122,139.7	#N/A	0.0	#N/A	#N/A	0.0	
710.8	129,595.8	#N/A	0.0	#N/A	#N/A	0.0	
710.9	137,051.9	#N/A	0.0	#N/A	#N/A	0.0	
711.0	144,508.0	#N/A	0.0	#N/A	#N/A	0.0	⇦ Spillway invert
711.1	153,595.0	#N/A	0.3	#N/A	#N/A	0.3	
711.2	162,682.0	#N/A	0.8	#N/A	#N/A	0.8	
711.3	171,769.0	#N/A	1.5	#N/A	#N/A	1.5	
711.4	180,856.0	#N/A	2.4	#N/A	#N/A	2.4	
711.5	189,943.0	#N/A	3.5	#N/A	#N/A	3.5	
711.6	199,030.0	#N/A	4.7	#N/A	#N/A	4.7	
711.7	208,117.0	#N/A	6.2	#N/A	#N/A	6.2	
711.8	217,204.0	#N/A	7.8	#N/A	#N/A	7.8	
711.9	226,291.0	#N/A	9.6	#N/A	#N/A	9.6	
712.0	235,378.0	#N/A	11.6	1.490	0.0	11.6	⇦ Dam crest
712.1	244,465.0	#N/A	13.8	1.490	22.0	35.8	
712.2	253,552.0	#N/A	16.2	1.490	62.2	78.4	
712.3	262,639.0	#N/A	18.7	1.450	111.3	130.0	
712.4	271,726.0	#N/A	21.5	1.460	172.5	194.0	
712.5	280,813.0	#N/A	24.5	1.450	239.4	263.9	

Note: storage information shown pertains to the last month of operations.



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Page 2 of 2

Knight Piésold Pty. Ltd.
P:\PE801-00139 Dargues\Technical\Hydrology\Spillway Sizing\Spillway Sizing - SO (5m HEC-RAS - for Dam Breach Assessment).xlsm

November 2011

Knight Piésold CONSULTING	Subject: Cortona Resources	Made by: TML	Job No.: PE801-00139
	Dargues Reef Gold	Checked	Date: 07/11/2011
	PMP Estimation (Summer): Impact Analysis	Approved	Sheet No.: 1 of 14

Estimation of Probable Maximum Precipitation in Australia: GSDM For Short Duration PMP (Depth)

Estimation of short duration Probable Maximum Precipitation (PMP) in Australia is performed using procedures taken from the following publication of the Australian Bureau of Meteorology (BOM):

- "The Estimation of Probable Maximum Precipitation in Australia", June 2003 ⇦ (GSDM) for short (≤6 h) duration PMP only.

Location Information								
Catchment ID	Catchment Area (km^2)	Located in Aus. State	Catchment Latitude (°)	Catchment Longitude (°)	PMP Duration Limit (h)	Smooth (S) Portion of Catchment	Rough (R) Portion of Catchment	Consider Monthly PMP?
Majors Creek	19.593	NSW	-35.5475	149.7482	6.0	0.00	1.00	Yes

Computation of Adjustment Factors				
Catchment ID	Mean Catchment Elevation (m)	Adustment for Elevation	Elevation Adjustment Factor EAF	Moisture Adjustment Factor MAF
Majors Creek	721	0.00	1.00	0.640

The Annual Exceedance Probability (AEP) associated with a PMP storm is estimated based on the area of the catchment it occurs within; see ARR 1999 - Volume 1, Book 6, Section 3.6, Figure 6.

Estimation of Depth-Duration PMP (Short Duration)				
Duration (h)	Initial PMP Depth Smooth, D_S (mm)	Initial PMP Depth Rough, D_R (mm)	Catchment PMP Estimate (mm)	Rounded PMP Estimate (mm)
0.25	202.0	202.0	129.4	130
0.50	297.0	297.0	190.2	190
0.75	377.0	377.0	241.4	240
1.0	443.0	443.0	283.7	280
1.5	506.0	567.0	363.1	360
2.0	567.0	663.0	424.6	420
2.5	605.0	733.0	469.4	470
3.0	634.0	799.0	511.7	510
4.0	704.0	912.0	584.0	580
5.0	756.0	1,001.0	641.0	640
6.0	802.0	1,067.0	683.3	680

PMP Frequency	
AEP	ARI (1 in X yr)
1.0E-07	10000000

If the overall catchment area exceeds 1 km^2 and the required level of calculations warrant the effort, estimated PMP rainfall may be varied spatially using the procedures given in GSDM, Section 6 and GSDM, Figure 6. However, spatially-distributing PMP is generally not required unless the contributing catchment area exceeds 5 km^2. **(Spatially-distributed PMP is considered for Impact Analysis.)**

In addition, for Australian catchments south of 30° S with catchments smaller than 500 km^2, annual PMP values may be converted to monthly PMP values using the information given in GSDM, Figure 7 as illustrated below. (Values are rounded to the nearest 10 mm.)

Seasonal Variation: Monthly PMP for Southern Australian Catchments (mm)											
Duration (h)	0.25	0.50	0.75	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
Annual	129.4	190.2	241.4	283.7	363.1	424.6	469.4	511.7	584.0	641.0	683.3
January	130	190	240	280	360	420	470	510	580	640	680
February	130	190	240	280	360	420	470	510	580	640	680
March	130	190	240	280	360	420	470	510	580	640	680
April	110	160	210	240	310	360	400	430	500	540	580
May	90	140	180	210	270	310	340	370	430	470	500
June	80	120	150	180	230	260	290	320	360	400	420
July	80	110	140	160	210	250	270	300	340	370	400
August	70	110	140	160	200	240	260	290	330	360	380
September	80	120	150	170	220	260	290	310	360	390	420
October	90	140	170	200	260	310	340	370	420	460	490
November	110	160	200	230	300	350	380	420	480	530	560
December	130	190	240	280	360	420	470	510	580	640	680

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Estimation of Probable Maximum Precipitation in Australia: GSDM For Short Duration PMP (Spatial Distribution)

If the size of the catchment of interest and/or required level of calculations warrant the effort, PMP rainfall is distributed using the procedure given in GSDM, Section 6 as follows:

Step 1 Position the spatial distribution diagram
Overlay the set of 10 concentric ellipses (labeled A - J) from GSDM Figure 6 over the boundary of the catchment of interest. The ellipses have been digitised in AutoCAD file: GSDM - Figure 6.dwg. Copy the set of ellipses into the AutoCAD file containing your site topography and position them to obtain the best fit by the smallest possible ellipse. (This ellipse is now the outermost ellipse of the spatial distribution.)

Step 2 Determine the catchment area between successive ellipses
Determine the area of the catchment lying *between* successive ellipses, ($CBtn_i$, where i = selected ellipse A, B, ... J) to the outermost ellipse from Step 1. Where the catchment completely fills both the inner and outer ellipses on a given interval, the value $CBtn_i$ is simply the area between the areas enclosed by each ellipse as given below. (When the catchment only partially fills the area between ellipses, use AutoCAD (or planimetering) to determine this area.)

Step 3 Determine the catchment area enclosed by each ellipse
The area of catchment *enclosed* by each ellipse ($CEnc_i$) is simply the sum of all $CBtn_i$ values from the innermost ellipse A to the selected ellipse i: $CEnc_i = \sum_{k=A}^{i} CBtn_k$
(The area of the catchment enclosed by the outermost ellipse will equal the total area of the catchment.)

Step 4 Determine initial mean rainfall depth enclosed by each ellipse
Step 4a The initial mean rainfall depths ($IMRD_i$) for each of the areas enclosed by successive ellipses ($CEnc_i$ from Step 3) are determined (for each duration) from **Table 1** (below). When the catchment only partially fills an ellipse ($CEnc_i$ < $Area_i$), the x-hour initial mean rainfall depth for that area is to be obtained from the appropriate Depth-Duration-Area (DDA) curve from GSDM, Figure 4. (Note that DDA initial mean rainfall depths from GSDM, Figure 4 are not to be extrapolated for areas greater than 1000 km^2!)
Step 4b The composite initial mean rainfall depths are computed as a weighted average of SMOOTH and ROUGH values: $IMRD_i = (IMRD_{Si} \cdot S + IMRD_{Ri} \cdot R)$ using the predetermined fractions S and R; see GSDM, Section 4.2.

Step 5 Determine adjusted mean rainfall depth enclosed by each ellipse
The initial mean rainfall depths ($IMRD_i$) for each of the areas enclosed by successive ellipses ($CEnc_i$ from Step 3) are adjusted by multiplying by both predetermined Moisture Adjustment and Elevation Adjustment Factors (MAF and EAF): $AMRD_i = IMRD_i \cdot MAF \cdot EAF$.
The adjusted mean rainfall depth (AMRD) for the area enclosed by the outermost ellipse will equal the (unrounded) PMP estimate for the whole catchment; see GSDM, Section 4.5.

Step 6 Determine the volume of rain enclosed by each ellipse
The volumes of rainfall ($VEnc_i$) for each of the successive ellipses are determined by multiplying the corresponding adjusted mean rainfall depths ($AMRD_i$ from Step 5) and the enclosed catchment areas ($CEnc_i$ from Step 3): $VEnc_i = AMRD_i \cdot CEnc_i$

Step 7 Determine the volume of rain between successive ellipses
The volumes of rainfall between successive ellipses ($VBtn_i$) are determined by succesive subtraction of the volumes from Step 6: $VBtn_i = VEnc_i - VEnc_{i-1}$.
The volume of rainfall within Ellipse A was determined in Step 6: $VBtn_A = VEnc_A$.

Step 8 Determine mean rainfall depths between successive ellipses
The mean rainfall depths (MRDi) over the catchment between successive ellipses are given by dividing the volumes of rainfall between ellipses ($VBtn_i$ from Step 7) by the catchment areas between ellipses ($CBtn_i$ from Step 2): $MRD_i = VBtn_i / CBtn_i$.

Step 9 Other PMP durations
Repeat Steps 4 to 8 for the other PMP durations.

Table 1: Initial mean rainfall depth data taken from GSDM Table 2

Ellipse			Initial Mean Rainfall Depth (mm) for SMOOTH elements: $IMRD_{Si}$ where the catchment completely fills the ellipse ($CEnc_i$ = $Area_i$) for Duration (hours)											Initial Mean Rainfall Depth (mm) for ROUGH elements: $IMRD_{Ri}$ where the catchment completely fills the ellipse ($CEnc_i$ = $Area_i$) for Duration (hours)										
Label	Area Enc. (km^2)	Area Btn. (km^2)	0.25	0.50	0.75	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0	0.25	0.50	0.75	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
A	2.6	2.6	232	336	425	493	563	628	669	705	771	832	879	232	336	425	493	636	744	821	901	1030	1135	1200
B	16.0	13.4	204	301	383	449	513	575	612	642	711	765	811	204	301	383	449	575	672	742	810	926	1018	1084
C	65.0	49.0	177	260	330	397	453	511	546	576	643	695	737	177	260	330	397	511	590	663	717	811	890	950
D																								
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Estimation of Probable Maximum Precipitation in Australia: GSDM For Short Duration PMP (Spatial Distribution)

Steps 2 and 3			Step 4a: Determine $IMRD_{Si}$ values. Initial Mean Rainfall Depth (mm) for SMOOTH elements: $IMRD_{Si}$ of given catchment areas enclosed by ellipse i ($CEnc_i$) for Duration (hours)											Step 4a: Determine $IMRD_{Ri}$ values. Initial Mean Rainfall Depth (mm) for ROUGH elements: $IMRD_{Ri}$ of given catchment areas enclosed by ellipse i ($CEnc_i$) for Duration (hours)										
Ellipse Label	Catchment Area Btn. $CBtn_i$ (km²)	Enc. $CEnc_i$ (km²)	0.25	0.50	0.75	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0	0.25	0.50	0.75	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
A	2.6	2.6	232	336	425	493	563	628	669	705	771	832	879	232	336	425	493	636	744	821	901	1030	1135	1200
B	12.5	15.1	205	303	385	451	515	577	615	645	714	767	814	205	303	385	451	577	675	745	814	930	1022	1087
C	4.5	19.6	202	297	377	443	506	567	605	634	704	756	802	202	297	377	443	567	663	733	799	912	1001	1067
D																								
E																								
F																								
G																								
H																								
I																								
J																								

Computational Factors for Catchment		for Adjustment	
Smooth S	Rough R	Elevation EAF	Moisture MAF
0.00	1.00	1.00	0.640

Designated Sub-Areas			Step 4b: Determine $IMRD_i = (IMRD_{Si} \cdot S + IMRD_{Ri} \cdot R)$ values. Initial Mean Rainfall Depth (mm) for elements: $IMRD_i$ of given catchment areas enclosed by ellipse i ($CEnc_i$) for Duration (hours)											Step 5: Determine $AMRD_i = (IMRD_i \cdot EAF \cdot MAF)$ values. Adjusted Mean Rainfall Depth (mm) for elements: $AMRD_i$ of given catchment areas enclosed by ellipse i ($CEnc_i$) for Duration (hours)										
Ellipse Label	Catchment Area Btn. $CBtn_i$ (km²)	Enc. $CEnc_i$ (km²)	0.25	0.50	0.75	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0	0.25	0.50	0.75	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
A	2.6	2.6	232	336	425	493	636	744	821	901	1030	1135	1200	149	215	272	316	407	476	526	577	660	727	768
B	12.5	15.1	205	303	385	451	577	675	745	814	930	1022	1087	131	194	247	289	370	432	477	521	596	654	696
C	4.5	19.6	202	297	377	443	567	663	733	799	912	1001	1067	129	190	241	284	363	425	469	512	584	641	683
D																								
E																								
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Designated Sub-Areas			Step 6: Determine $VEnc_i = (AMRD_i \cdot CEnc_i)$ values. Volumes of Adjusted Mean Rainfall Depth (mm · km²): $VEnc_i$ enclosed by ellipse i ($CEnc_i$) for Duration (hours)											Step 7: Determine $VBtn_i = (VEnc_i - VEnc_{i-1})$ values. Volumes of Adjusted Mean Rainfall Depth (mm · km²): $VBtn_i$ between successive ellipses i and i - 1 for Duration (hours)										
Ellipse Label	Catchment Area Btn. $CBtn_i$ (km²)	Enc. $CEnc_i$ (km²)	0.25	0.50	0.75	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0	0.25	0.50	0.75	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
A	2.6	2.6	386	559	708	821	1059	1239	1367	1500	1715	1890	1998	386	559	708	821	1059	1239	1367	1500	1715	1890	1998
B	12.5	15.1	1981	2928	3721	4359	5577	6524	7200	7867	8988	9878	10506	1595	2369	3013	3538	4518	5285	5833	6367	7273	7988	8508
C	4.5	19.6	2533	3725	4728	5556	7111	8315	9193	10020	11437	12553	13381	552	796	1007	1197	1534	1791	1992	2153	2449	2676	2875
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Estimation of Probable Maximum Precipitation in Australia: GSDM For Short Duration PMP (Spatial Distribution)

Designated Sub-Areas			Step 8: Determine MRD$_i$ = (VBtn$_i$ / CBtn$_i$) values Mean Rainfall Depth (mm): MRD$_i$ between successive ellipses i and i - 1 for Duration (hours)										
Ellipse Label	Catchment Area Btn. CBtn$_i$ (km^2)	Catchment Area Enc. CEnc$_i$ (km^2)	0.25	0.50	0.75	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
A	2.6	2.6	149	215	272	316	407	476	526	577	660	727	768
B	12.5	15.1	128	190	241	283	362	423	467	510	582	639	681
C	4.5	19.6	123	177	224	266	342	399	444	479	545	596	640
D													
E													
F													
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If monthly variation of PMP is employed, then the MRD$_i$ values from Step 8 (which correspond to annual or 100% values) need to be adjusted using the following factors taken from GSDM, Figure 7:

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Factor	100%	100%	100%	85%	73%	62%	58%	56%	61%	72%	82%	100%

Designated Sub-Areas			January - March (inclusive) seasonal values of Mean Rainfall Depth (mm): MRDi between successive ellipses i and i - 1 for Duration (hours)											April seasonal values of Mean Rainfall Depth (mm): MRD$_i$ between successive ellipses i and i - 1 for Duration (hours)										
Ellipse Label	Catchment Area Btn. CBtn$_i$ (km^2)	Catchment Area Enc. CEnc$_i$ (km^2)	0.25	0.50	0.75	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0	0.25	0.50	0.75	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
A	2.6	2.6	149	215	272	316	407	476	526	577	660	727	768	126	183	231	268	346	405	447	490	561	618	653
B	12.5	15.1	128	190	241	283	362	423	467	510	582	639	681	109	161	205	241	307	360	397	433	495	543	579
C	4.5	19.6	123	177	224	266	342	399	444	479	545	596	640	104	151	191	227	290	339	377	407	463	506	544
D																								
E																								
F																								
G																								
H																								
I																								
J																								

Designated Sub-Areas			May seasonal values of Mean Rainfall Depth (mm): MRD$_i$ between successive ellipses i and i - 1 for Duration (hours)											June seasonal values of Mean Rainfall Depth (mm): MRD$_i$ between successive ellipses i and i - 1 for Duration (hours)										
Ellipse Label	Catchment Area Btn. CBtn$_i$ (km^2)	Catchment Area Enc. CEnc$_i$ (km^2)	0.25	0.50	0.75	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0	0.25	0.50	0.75	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
A	2.6	2.6	108	157	199	230	297	348	384	421	482	531	561	92	133	169	196	253	295	326	358	409	451	476
B	12.5	15.1	93	138	176	207	264	309	341	372	425	467	497	79	118	150	176	224	262	290	316	361	396	422
C	4.5	19.6	90	129	164	195	249	291	324	350	398	435	467	76	110	139	165	212	247	275	297	338	369	397
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	Dargues Reef Gold	Checked	Date: 07/11/2011
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Estimation of Probable Maximum Precipitation in Australia: GSDM For Short Duration PMP (Spatial Distribution)

Designated Sub-Areas			July seasonal values of Mean Rainfall Depth (mm): MRD_i between successive ellipses i and i - 1 for Duration (hours)										
Ellipse Label	Catchment Area: Btn. $CBtn_i$ (km^2)	Enc. $CEnc_i$ (km^2)	0.25	0.50	0.75	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
A	2.6	2.6	86	125	158	183	236	276	305	335	383	422	446
B	12.5	15.1	74	110	140	164	210	245	271	296	338	371	395
C	4.5	19.6	71	103	130	155	198	231	257	278	316	346	371
D													
E													
F													
G													
H													
I													
J													

	August seasonal values of Mean Rainfall Depth (mm): MRD_i between successive ellipses i and i - 1 for Duration (hours)										
Ellipse Label	0.25	0.50	0.75	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
A	83	120	152	177	228	267	294	323	369	407	430
B	72	106	135	159	203	237	261	285	326	358	381
C	69	99	126	149	191	223	248	268	305	334	359
D											
E											
F											
G											
H											
I											
J											

Designated Sub-Areas			September seasonal values of Mean Rainfall Depth (mm): MRD_i between successive ellipses i and i - 1 for Duration (hours)										
Ellipse Label	Catchment Area: Btn. $CBtn_i$ (km^2)	Enc. $CEnc_i$ (km^2)	0.25	0.50	0.75	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
A	2.6	2.6	91	131	166	193	248	291	321	352	402	443	469
B	12.5	15.1	78	116	147	173	221	258	285	311	355	390	415
C	4.5	19.6	75	108	137	163	208	243	271	292	333	363	391
D													
E													
F													
G													
H													
I													
J													

	October seasonal values of Mean Rainfall Depth (mm): MRD_i between successive ellipses i and i - 1 for Duration (hours)										
Ellipse Label	0.25	0.50	0.75	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
A	107	155	196	227	293	343	379	415	475	523	553
B	92	137	174	204	260	305	336	367	419	460	490
C	88	128	161	192	246	287	319	345	393	429	461
D											
E											
F											
G											
H											
I											
J											

Designated Sub-Areas			November seasonal values of Mean Rainfall Depth (mm): MRD_i between successive ellipses i and i - 1 for Duration (hours)										
Ellipse Label	Catchment Area: Btn. $CBtn_i$ (km^2)	Enc. $CEnc_i$ (km^2)	0.25	0.50	0.75	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
A	2.6	2.6	122	176	223	259	334	391	431	473	541	596	630
B	12.5	15.1	105	156	198	232	297	347	383	418	477	524	558
C	4.5	19.6	101	145	184	219	280	327	364	393	447	489	525
D													
E													
F													
G													
H													
I													
J													

	December seasonal values of Mean Rainfall Depth (mm): MRDi between successive ellipses i and i - 1 for Duration (hours)										
Ellipse Label	0.25	0.50	0.75	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
A	149	215	272	316	407	476	526	577	660	727	768
B	128	190	241	283	362	423	467	510	582	639	681
C	123	177	224	266	342	399	444	479	545	596	640
D											
E											
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Estimation of Probable Maximum Precipitation in Australia: GSDM For Short Duration PMP (Temporal Distribution): Spatial Ellipse A

Estimated PMP values for various durations (duplicated below) are distributed into hyetographs using the design temporal distribution for short duration PMP given in GSDM, Table 1. PMP values for all durations are taken from an envelope curve fitted to the computed PMP values. (Input values are rounded to the nearest 10 mm.) If spatial or season variation (or both) are employed, a copy of this worksheet will be necessary for each combination (season / spatial region) used, with different input PMP depths.

Storm Duration (h) =	0.250	0.333	0.417	0.5	0.75	1.0	1.5	2.0	2.5	3.0	4.0	4.5	5.0	6.0
PMP Depth (mm) =	149	173	195	215	272	316	407	476	526	577	660	694	727	768

Storm Duration (h)		0.250	Storm Duration (h)		0.333	Storm Duration (h)		0.417	Storm Duration (h)		0.50	Storm Duration (h)		0.75	Storm Duration (h)		1.0	Storm Duration (h)		1.5
Elapsed	Rainfall Depth		Elapsed	Rainfall Depth		Elapsed	Rainfall Depth		Elapsed	Rainfall Depth		Elapsed	Rainfall Depth		Elapsed	Rainfall Depth		Elapsed	Rainfall Depth	
Time (min)	Instant. (mm)	Cum. (mm)	Time (min)	Instant. (mm)	Cum. (mm)	Time (min)	Instant. (mm)	Cum. (mm)	Time (min)	Instant. (mm)	Cum. (mm)	Time (min)	Instant. (mm)	Cum. (mm)	Time (min)	Instant. (mm)	Cum. (mm)	Time (min)	Instant. (mm)	Cum. (mm)
0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
5	64.9	64.9	5	55.4	55.4	5	48.8	48.8	5	43.8	43.8	5	32.1	32.1	5	25.3	25.3	5	19.0	19.0
10	56.5	121.3	10	55.4	110.9	10	52.7	101.5	10	50.2	94.0	10	44.5	76.5	10	38.9	64.2	10	29.0	48.0
15	27.2	148.6	15	43.3	154.2	15	44.9	146.4	15	43.8	137.7	15	42.3	118.8	15	36.8	101.0	15	34.8	82.8
			20	19.1	173.3	20	33.2	179.6	20	38.0	175.7	20	39.6	158.5	20	36.8	137.9	20	31.7	114.5
						25	15.6	195.2	25	26.5	202.3	25	33.6	192.0	25	33.7	171.5	25	31.7	146.2
									30	12.9	215.2	30	30.2	222.3	30	30.5	202.1	30	31.7	177.8
												35	24.5	246.8	35	29.5	231.5	35	28.5	206.4
												40	16.0	262.8	40	26.3	257.8	40	30.8	237.1
												45	9.4	272.2	45	23.2	281.0	45	23.5	260.7
															50	15.8	296.8	50	26.7	287.4
															55	11.6	308.3	55	22.6	310.0
															60	7.4	315.7	60	22.6	332.6
																		65	20.8	353.4
																		70	15.8	369.3
																		75	13.6	382.8
																		80	10.4	393.3
																		85	9.1	402.3
																		90	5.0	407.3

Short Duration PMP (≤ 6-h)			
Position i		*Position i+1*	
Fraction of Storm Duration	Fraction of Storm PMP	Fraction of Storm Duration	Fraction of Storm PMP
0%	0%	5%	4%
5%	4%	10%	10%
10%	10%	15%	18%
15%	18%	20%	25%
20%	25%	25%	32%
25%	32%	30%	39%
30%	39%	35%	46%
35%	46%	40%	52%
40%	52%	45%	59%
45%	59%	50%	64%
50%	64%	55%	70%
55%	70%	60%	75%
60%	75%	65%	80%
65%	80%	70%	85%
70%	85%	75%	89%
75%	89%	80%	92%
80%	92%	85%	95%
85%	95%	90%	97%
90%	97%	95%	99%
95%	99%	100%	100%
100%	100%		

Storm Duration (h)		2.0	Storm Duration (h)		2.5	Storm Duration (h)		3.0	Storm Duration (h)		4.0	Storm Duration (h)		4.5	Storm Duration (h)		5.0	Storm Duration (h)		6.0
Elapsed	Rainfall Depth		Elapsed	Rainfall Depth		Elapsed	Rainfall Depth		Elapsed	Rainfall Depth		Elapsed	Rainfall Depth		Elapsed	Rainfall Depth		Elapsed	Rainfall Depth	
Time (min)	Instant. (mm)	Cum. (mm)	Time (h)	Instant. (mm)	Cum. (mm)	Time (h)	Instant. (mm)	Cum. (mm)	Time (h)	Instant. (mm)	Cum. (mm)	Time (h)	Instant. (mm)	Cum. (mm)	Time (h)	Instant. (mm)	Cum. (mm)	Time (h)	Instant. (mm)	Cum. (mm)
0	0.0	0.0	0.00	0.0	0.0	0.00	0.0	0.0	0.00	0.0	0.0	0.00	0.0	0.0	0.00	0.0	0.0	0.00	0.0	0.0
5	15.9	15.9	0.25	52.6	52.6	0.25	46.2	46.2	0.25	36.3	36.3	0.25	32.4	32.4	0.25	29.1	29.1	0.25	25.6	25.6
10	22.2	38.1	0.50	78.9	131.4	0.50	71.2	117.3	0.50	56.1	92.3	0.50	49.4	81.8	0.50	43.6	72.7	0.50	35.9	61.5
15	28.6	66.7	0.75	73.6	205.0	0.75	67.3	184.6	0.75	61.0	153.4	0.75	59.4	141.2	0.75	58.1	130.8	0.75	46.1	107.6
20	30.2	96.9	1.00	68.3	273.4	1.00	67.3	252.0	1.00	57.7	211.1	1.00	54.0	195.2	1.00	50.9	181.7	1.00	48.7	156.3
25	27.8	124.7	1.25	63.1	336.5	1.25	61.5	313.5	1.25	57.7	268.8	1.25	54.0	249.2	1.25	50.9	232.6	1.25	44.8	201.1
30	27.8	152.5	1.50	57.8	394.3	1.50	55.8	369.3	1.50	54.4	323.2	1.50	54.0	303.2	1.50	50.9	283.5	1.50	44.8	245.9
35	27.8	180.3	1.75	52.6	446.9	1.75	53.9	423.1	1.75	54.4	377.6	1.75	48.6	351.8	1.75	50.9	334.3	1.75	44.8	290.7
40	27.8	208.0	2.00	36.8	483.7	2.00	48.1	471.2	2.00	44.5	422.1	2.00	52.5	404.2	2.00	43.6	378.0	2.00	44.8	335.6
45	25.4	233.5	2.25	26.3	510.0	2.25	42.3	513.5	2.25	47.8	470.0	2.25	40.1	444.3	2.25	50.9	428.8	2.25	41.0	376.5
50	25.4	258.9	2.50	15.8	525.8	2.50	28.8	542.4	2.50	41.2	511.2	2.50	45.5	489.8	2.50	36.3	465.2	2.50	41.0	417.5
55	26.2	285.1				2.75	21.2	563.5	2.75	41.2	552.4	2.75	38.6	528.4	2.75	43.6	508.8	2.75	42.3	459.8
60	19.9	304.9				3.00	13.5	577.0	3.00	34.6	587.0	3.00	38.6	567.0	3.00	36.3	545.1	3.00	32.0	491.8
65	23.8	328.7							3.25	24.7	611.8	3.25	35.5	602.5	3.25	36.3	581.5	3.25	38.4	530.2
70	20.6	349.4							3.50	21.4	633.2	3.50	27.0	629.5	3.50	36.3	617.8	3.50	33.3	563.5
75	19.9	369.2							3.75	16.5	649.7	3.75	23.1	652.6	3.75	29.1	646.9	3.75	32.0	595.6
80	19.9	389.1							4.00	9.9	659.6	4.00	17.7	670.4	4.00	21.8	668.7	4.00	32.0	627.6
85	19.1	408.2										4.25	15.4	685.8	4.25	21.8	690.5	4.25	30.7	658.3
90	15.9	424.0										4.50	8.5	694.3	4.50	14.5	705.0	4.50	25.6	683.9
95	11.9	435.9													4.75	14.5	719.6	4.75	19.2	703.1
100	11.9	447.9													5.00	7.3	726.8	5.00	19.2	722.4
105	9.5	457.4																5.25	15.4	737.7
110	7.9	465.3																5.50	12.8	750.5
115	7.1	472.5																5.75	11.5	762.1
120	4.0	476.4																6.00	6.4	768.5

Knight Piésold CONSULTING	Subject: Cortona Resources	Made by: TML	Job No.: PE801-00139
	Dargues Reef Gold	Checked	Date: 07/11/2011
	PMP Estimation (Summer): Impact Analysis	Approved	Sheet No.: 7 of 14

Estimation of Probable Maximum Precipitation in Australia: GSDM For Short Duration PMP (Temporal Distribution): Spatial Ellipse B

Estimated PMP values for various durations (duplicated below) are distributed into hyetographs using the design temporal distribution for short duration PMP given in GSDM, Table 1. PMP values for all durations are taken from an envelope curve fitted to the computed PMP values. (Input values are rounded to the nearest 10 mm.) If spatial or season variation (or both) are employed, a copy of this worksheet will be necessary for each combination (season / spatial region) used, with different input PMP depths.

Storm Duration (h) =	0.250	0.333	0.417	0.5	0.75	1.0	1.5	2.0	2.5	3.0	4.0	4.5	5.0	6.0
PMP Depth (mm) =	128	150	171	190	241	283	362	423	467	510	582	612	639	681

Storm Duration (h)		0.250	Storm Duration (h)		0.333	Storm Duration (h)		0.417	Storm Duration (h)		0.50	Storm Duration (h)		0.75	Storm Duration (h)		1.0	Storm Duration (h)		1.5
Elapsed	Rainfall Depth		Elapsed	Rainfall Depth		Elapsed	Rainfall Depth		Elapsed	Rainfall Depth		Elapsed	Rainfall Depth		Elapsed	Rainfall Depth		Elapsed	Rainfall Depth	
Time (min)	Instant. (mm)	Cum. (mm)	Time (min)	Instant. (mm)	Cum. (mm)	Time (min)	Instant. (mm)	Cum. (mm)	Time (min)	Instant. (mm)	Cum. (mm)	Time (min)	Instant. (mm)	Cum. (mm)	Time (min)	Instant. (mm)	Cum. (mm)	Time (min)	Instant. (mm)	Cum. (mm)
0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
5	55.8	55.8	5	48.1	48.1	5	42.7	42.7	5	38.6	38.6	5	28.4	28.4	5	22.7	22.7	5	16.9	16.9
10	48.5	104.3	10	48.1	96.3	10	46.1	88.9	10	44.2	82.8	10	39.4	67.8	10	34.9	57.6	10	25.7	42.6
15	23.4	127.7	15	37.6	133.9	15	39.3	128.2	15	38.6	121.4	15	37.5	105.3	15	33.0	90.6	15	30.9	73.5
			20	16.6	150.5	20	29.1	157.2	20	33.5	154.9	20	35.1	140.4	20	33.0	123.7	20	28.1	101.7
						25	13.7	170.9	25	23.4	178.3	25	29.7	170.2	25	30.2	153.9	25	28.1	129.8
									30	11.4	189.6	30	26.8	197.0	30	27.4	181.3	30	28.1	157.9
												35	21.7	218.7	35	26.4	207.7	35	25.3	183.2
												40	14.2	232.9	40	23.6	231.3	40	27.3	210.6
												45	8.3	241.2	45	20.8	252.1	45	20.9	231.4
															50	14.2	266.2	50	23.7	255.2
															55	10.4	276.6	55	20.1	275.2
															60	6.6	283.2	60	20.1	295.3
																		65	18.5	313.8
																		70	14.1	327.9
																		75	12.1	339.9
																		80	9.2	349.2
																		85	8.0	357.2
																		90	4.4	361.6

Short Duration PMP (≤ 6-h)			
Position i		*Position i+1*	
Fraction of Storm Duration	Fraction of Storm PMP	Fraction of Storm Duration	Fraction of Storm PMP
0%	0%	5%	4%
5%	4%	10%	10%
10%	10%	15%	18%
15%	18%	20%	25%
20%	25%	25%	32%
25%	32%	30%	39%
30%	39%	35%	46%
35%	46%	40%	52%
40%	52%	45%	59%
45%	59%	50%	64%
50%	64%	55%	70%
55%	70%	60%	75%
60%	75%	65%	80%
65%	80%	70%	85%
70%	85%	75%	89%
75%	89%	80%	92%
80%	92%	85%	95%
85%	95%	90%	97%
90%	97%	95%	99%
95%	99%	100%	100%
100%	100%		

Storm Duration (h)		2.0	Storm Duration (h)		2.5	Storm Duration (h)		3.0	Storm Duration (h)		4.0	Storm Duration (h)		4.5	Storm Duration (h)		5.0	Storm Duration (h)		6.0
Elapsed	Rainfall Depth		Elapsed	Rainfall Depth		Elapsed	Rainfall Depth		Elapsed	Rainfall Depth		Elapsed	Rainfall Depth		Elapsed	Rainfall Depth		Elapsed	Rainfall Depth	
Time (min)	Instant. (mm)	Cum. (mm)	Time (h)	Instant. (mm)	Cum. (mm)	Time (h)	Instant. (mm)	Cum. (mm)	Time (h)	Instant. (mm)	Cum. (mm)	Time (h)	Instant. (mm)	Cum. (mm)	Time (h)	Instant. (mm)	Cum. (mm)	Time (h)	Instant. (mm)	Cum. (mm)
0	0.0	0.0	0.00	0.0	0.0	0.00	0.0	0.0	0.00	0.0	0.0	0.00	0.0	0.0	0.00	0.0	0.0	0.00	0.0	0.0
5	14.1	14.1	0.25	46.7	46.7	0.25	40.8	40.8	0.25	32.0	32.0	0.25	28.5	28.5	0.25	25.6	25.6	0.25	22.7	22.7
10	19.7	33.8	0.50	70.0	116.7	0.50	62.9	103.6	0.50	49.5	81.5	0.50	43.5	72.0	0.50	38.4	63.9	0.50	31.8	54.5
15	25.4	59.2	0.75	65.4	182.1	0.75	59.5	163.1	0.75	53.9	135.4	0.75	52.3	124.4	0.75	51.2	115.1	0.75	40.9	95.3
20	26.8	86.0	1.00	60.7	242.8	1.00	59.5	222.6	1.00	50.9	186.3	1.00	47.6	172.0	1.00	44.8	159.9	1.00	43.1	138.5
25	24.7	110.7	1.25	56.0	298.9	1.25	54.4	276.9	1.25	50.9	237.3	1.25	47.6	219.5	1.25	44.8	204.6	1.25	39.7	178.2
30	24.7	135.4	1.50	51.4	350.2	1.50	49.3	326.2	1.50	48.0	285.3	1.50	47.6	267.1	1.50	44.8	249.4	1.50	39.7	217.9
35	24.7	160.1	1.75	46.7	396.9	1.75	47.6	373.8	1.75	48.0	333.3	1.75	42.8	309.9	1.75	44.8	294.1	1.75	39.7	257.7
40	24.7	184.7	2.00	32.7	429.6	2.00	42.5	416.2	2.00	39.3	372.6	2.00	46.2	356.2	2.00	38.4	332.5	2.00	39.7	297.4
45	22.6	207.3	2.25	23.3	452.9	2.25	37.4	453.6	2.25	42.2	414.8	2.25	35.3	391.5	2.25	44.8	377.3	2.25	36.3	333.7
50	22.6	229.9	2.50	14.0	467.0	2.50	25.5	479.1	2.50	36.4	451.2	2.50	40.1	431.6	2.50	32.0	409.2	2.50	36.3	370.0
55	23.3	253.1				2.75	18.7	497.8	2.75	36.4	487.6	2.75	34.0	465.6	2.75	38.4	447.6	2.75	37.5	407.5
60	17.6	270.8				3.00	11.9	509.7	3.00	30.6	518.2	3.00	34.0	499.6	3.00	32.0	479.6	3.00	28.4	435.9
65	21.2	291.9							3.25	21.8	540.0	3.25	31.3	530.9	3.25	32.0	511.5	3.25	34.1	469.9
70	18.3	310.2							3.50	18.9	558.9	3.50	23.8	554.6	3.50	32.0	543.5	3.50	29.5	499.4
75	17.6	327.9							3.75	14.6	573.5	3.75	20.4	575.0	3.75	25.6	569.1	3.75	28.4	527.8
80	17.6	345.5							4.00	8.7	582.2	4.00	15.6	590.7	4.00	19.2	588.3	4.00	28.4	556.2
85	16.9	362.4										4.25	13.6	604.3	4.25	19.2	607.4	4.25	27.2	583.4
90	14.1	376.5										4.50	7.5	611.7	4.50	12.8	620.2	4.50	22.7	606.1
95	10.6	387.1													4.75	12.8	633.0	4.75	17.0	623.1
100	10.6	397.7													5.00	6.4	639.4	5.00	17.0	640.2
105	8.5	406.1																5.25	13.6	653.8
110	7.1	413.2																5.50	11.4	665.1
115	6.3	419.5																5.75	10.2	675.4
120	3.5	423.1																6.00	5.7	681.0

Knight Piésold CONSULTING	Subject: Cortona Resources	Made by: TML	Job No. PE801-00139
	Dargues Reef Gold	Checked	Date: 07/11/2011
	PMP Estimation (Summer): Impact Analysis	Approved	Sheet No. 8 of 14

Estimation of Probable Maximum Precipitation in Australia: GSDM For Short Duration PMP (Temporal Distribution): Spatial Ellipse C

Estimated PMP values for various durations (duplicated below) are distributed into hyetographs using the design temporal distribution for short duration PMP given in GSDM, Table 1. PMP values for all durations are taken from an envelope curve fitted to the computed PMP values. (Input values are rounded to the nearest 10 mm.) If spatial or season variation (or both) are employed, a copy of this worksheet will be necessary for each combination (season / spatial region) used, with different input PMP depths.

Storm Duration (h) =	0.250	0.333	0.417	0.5	0.75	1.0	1.5	2.0	2.5	3.0	4.0	4.5	5.0	6.0
PMP Depth (mm) =	123	143	161	177	224	266	342	399	444	479	545	571	596	640

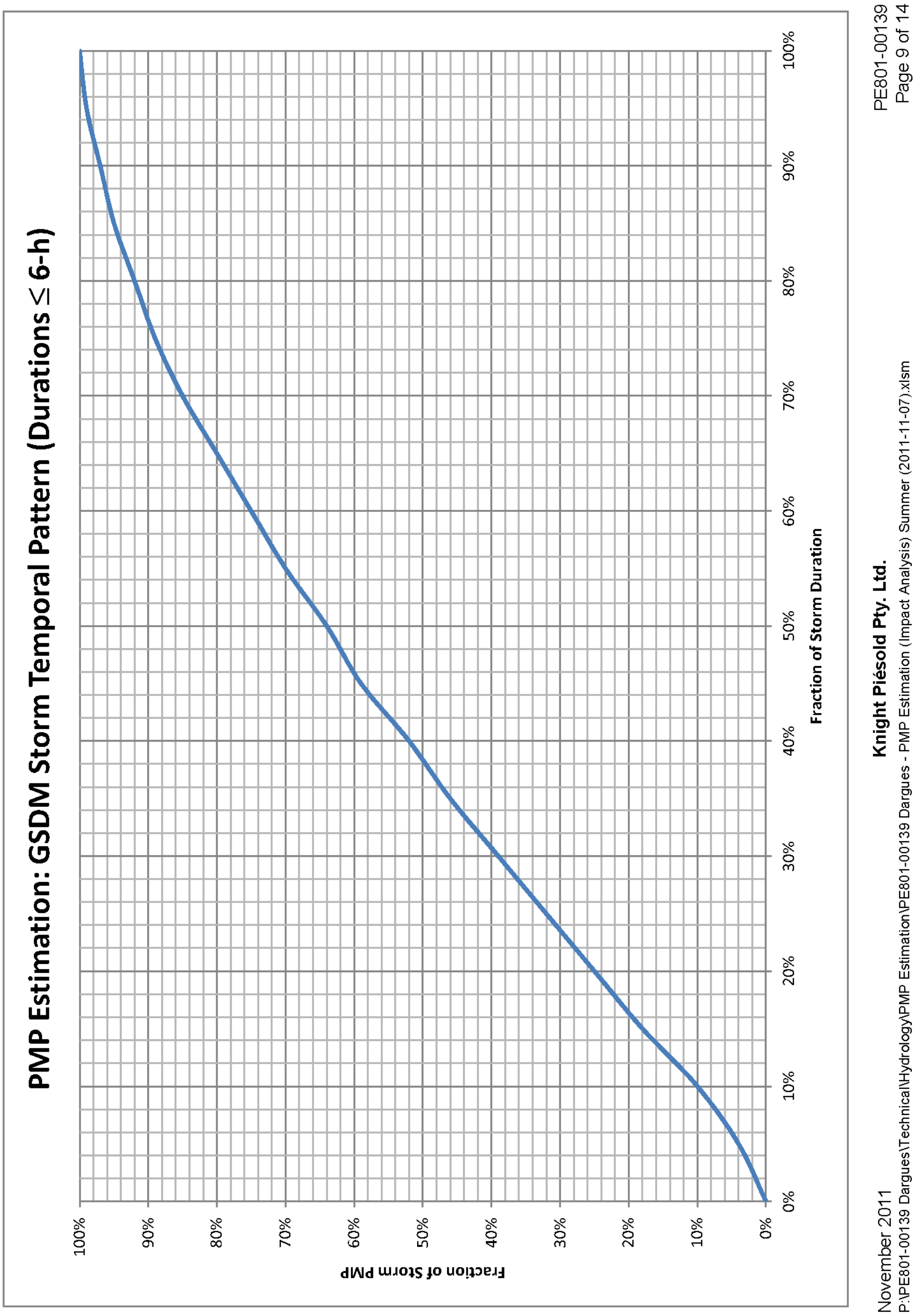
Storm Duration (h)		0.250	Storm Duration (h)		0.333	Storm Duration (h)		0.417	Storm Duration (h)		0.50
Elapsed	Rainfall Depth		Elapsed	Rainfall Depth		Elapsed	Rainfall Depth		Elapsed	Rainfall Depth	
Time (min)	Instant. (mm)	Cum. (mm)	Time (min)	Instant. (mm)	Cum. (mm)	Time (min)	Instant. (mm)	Cum. (mm)	Time (min)	Instant. (mm)	Cum. (mm)
0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
5	53.7	53.7	5	45.8	45.8	5	40.2	40.2	5	36.0	36.0
10	46.7	100.4	10	45.8	91.6	10	43.5	83.7	10	41.4	77.4
15	22.5	122.9	15	35.8	127.3	15	37.0	120.7	15	36.0	113.5
			20	15.7	143.1	20	27.4	148.1	20	31.3	144.8
						25	12.9	161.0	25	21.9	166.6
									30	10.6	177.3

Storm Duration (h)		0.75	Storm Duration (h)		1.0	Storm Duration (h)		1.5
Elapsed	Rainfall Depth		Elapsed	Rainfall Depth		Elapsed	Rainfall Depth	
Time (min)	Instant. (mm)	Cum. (mm)	Time (min)	Instant. (mm)	Cum. (mm)	Time (min)	Instant. (mm)	Cum. (mm)
0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
5	26.4	26.4	5	21.3	21.3	5	15.9	15.9
10	36.6	63.0	10	32.9	54.2	10	24.3	40.2
15	34.9	97.9	15	31.1	85.3	15	29.2	69.5
20	32.6	130.5	20	31.1	116.4	20	26.6	96.0
25	27.7	158.2	25	28.4	144.8	25	26.6	122.6
30	24.9	183.1	30	25.8	170.5	30	26.6	149.2
35	20.2	203.3	35	24.9	195.4	35	23.9	173.1
40	13.2	216.5	40	22.2	217.6	40	25.8	198.9
45	7.7	224.2	45	19.5	237.2	45	19.7	218.6
			50	13.3	250.5	50	22.4	241.0
			55	9.8	260.3	55	19.0	260.0
			60	6.2	266.5	60	19.0	279.0
						65	17.5	296.4
						70	13.3	309.7
						75	11.4	321.1
						80	8.7	329.8
						85	7.6	337.4
						90	4.2	341.6

Short Duration PMP (≤ 6-h)			
Position i		*Position i+1*	
Fraction of Storm Duration	Fraction of Storm PMP	Fraction of Storm Duration	Fraction of Storm PMP
0%	0%	5%	4%
5%	4%	10%	10%
10%	10%	15%	18%
15%	18%	20%	25%
20%	25%	25%	32%
25%	32%	30%	39%
30%	39%	35%	46%
35%	46%	40%	52%
40%	52%	45%	59%
45%	59%	50%	64%
50%	64%	55%	70%
55%	70%	60%	75%
60%	75%	65%	80%
65%	80%	70%	85%
70%	85%	75%	89%
75%	89%	80%	92%
80%	92%	85%	95%
85%	95%	90%	97%
90%	97%	95%	99%
95%	99%	100%	100%
100%	100%		

Storm Duration (h)		2.0	Storm Duration (h)		2.5	Storm Duration (h)		3.0	Storm Duration (h)		4.0
Elapsed	Rainfall Depth		Elapsed	Rainfall Depth		Elapsed	Rainfall Depth		Elapsed	Rainfall Depth	
Time (min)	Instant. (mm)	Cum. (mm)	Time (h)	Instant. (mm)	Cum. (mm)	Time (h)	Instant. (mm)	Cum. (mm)	Time (h)	Instant. (mm)	Cum. (mm)
0	0.0	0.0	0.00	0.0	0.0	0.00	0.0	0.0	0.00	0.0	0.0
5	13.3	13.3	0.25	44.4	44.4	0.25	38.4	38.4	0.25	30.0	30.0
10	18.6	31.9	0.50	66.5	110.9	0.50	59.1	97.5	0.50	46.3	76.3
15	23.9	55.8	0.75	62.1	173.0	0.75	55.9	153.4	0.75	50.4	126.8
20	25.3	81.1	1.00	57.7	230.7	1.00	55.9	209.3	1.00	47.7	174.5
25	23.3	104.3	1.25	53.2	283.9	1.25	51.1	260.5	1.25	47.7	222.2
30	23.3	127.6	1.50	48.8	332.7	1.50	46.3	306.8	1.50	45.0	267.2
35	23.3	150.9	1.75	44.4	377.0	1.75	44.7	351.5	1.75	45.0	312.2
40	23.3	174.1	2.00	31.1	408.1	2.00	39.9	391.5	2.00	36.8	349.0
45	21.3	195.4	2.25	22.2	430.3	2.25	35.2	426.7	2.25	39.5	388.5
50	21.3	216.7	2.50	13.3	443.6	2.50	24.0	450.6	2.50	34.1	422.6
55	21.9	238.6				2.75	17.6	468.2	2.75	34.1	456.7
60	16.6	255.2				3.00	11.2	479.4	3.00	28.6	485.3
65	19.9	275.1							3.25	20.4	505.8
70	17.3	292.4							3.50	17.7	523.5
75	16.6	309.0							3.75	13.6	537.1
80	16.6	325.6							4.00	8.2	545.3
85	16.0	341.6									
90	13.3	354.9									
95	10.0	364.9									
100	10.0	374.8									
105	8.0	382.8									
110	6.6	389.4									
115	6.0	395.4									
120	3.3	398.8									

Storm Duration (h)		4.5	Storm Duration (h)		5.0	Storm Duration (h)		6.0
Elapsed	Rainfall Depth		Elapsed	Rainfall Depth		Elapsed	Rainfall Depth	
Time (h)	Instant. (mm)	Cum. (mm)	Time (h)	Instant. (mm)	Cum. (mm)	Time (h)	Instant. (mm)	Cum. (mm)
0.00	0.0	0.0	0.00	0.0	0.0	0.00	0.0	0.0
0.25	26.7	26.7	0.25	23.8	23.8	0.25	21.3	21.3
0.50	40.6	67.3	0.50	35.7	59.6	0.50	29.9	51.2
0.75	48.9	116.2	0.75	47.7	107.2	0.75	38.4	89.6
1.00	44.4	160.6	1.00	41.7	149.0	1.00	40.5	130.2
1.25	44.4	205.1	1.25	41.7	190.7	1.25	37.3	167.5
1.50	44.4	249.5	1.50	41.7	232.4	1.50	37.3	204.9
1.75	40.0	289.5	1.75	41.7	274.1	1.75	37.3	242.2
2.00	43.2	332.7	2.00	35.7	309.8	2.00	37.3	279.6
2.25	33.0	365.7	2.25	41.7	351.5	2.25	34.1	313.7
2.50	37.5	403.2	2.50	29.8	381.3	2.50	34.1	347.9
2.75	31.7	434.9	2.75	35.7	417.1	2.75	35.2	383.1
3.00	31.7	466.7	3.00	29.8	446.9	3.00	26.7	409.8
3.25	29.2	495.9	3.25	29.8	476.7	3.25	32.0	441.8
3.50	22.2	518.1	3.50	29.8	506.5	3.50	27.7	469.5
3.75	19.0	537.1	3.75	23.8	530.3	3.75	26.7	496.2
4.00	14.6	551.7	4.00	17.9	548.2	4.00	26.7	522.9
4.25	12.7	564.4	4.25	17.9	566.0	4.25	25.6	548.5
4.50	7.0	571.4	4.50	11.9	578.0	4.50	21.3	569.8
			4.75	11.9	589.9	4.75	16.0	585.8
			5.00	6.0	595.8	5.00	16.0	601.8
						5.25	12.8	614.6
						5.50	10.7	625.3
						5.75	9.6	634.9
						6.00	5.3	640.2


PMP Estimation: GSDM Storm Temporal Pattern (Durations ≤ 6-h)
Fraction of Storm PMP
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Fraction of Storm Duration
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
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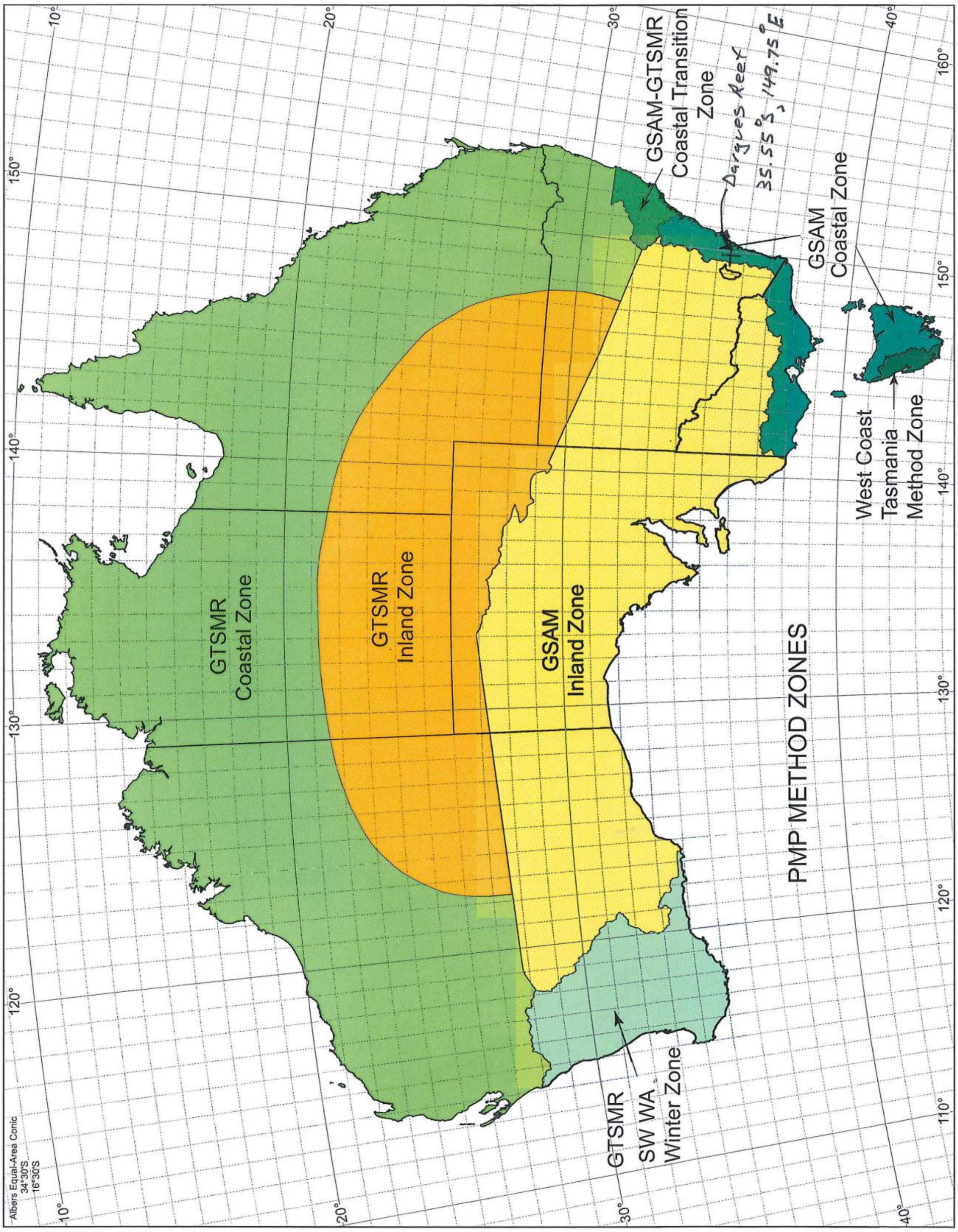
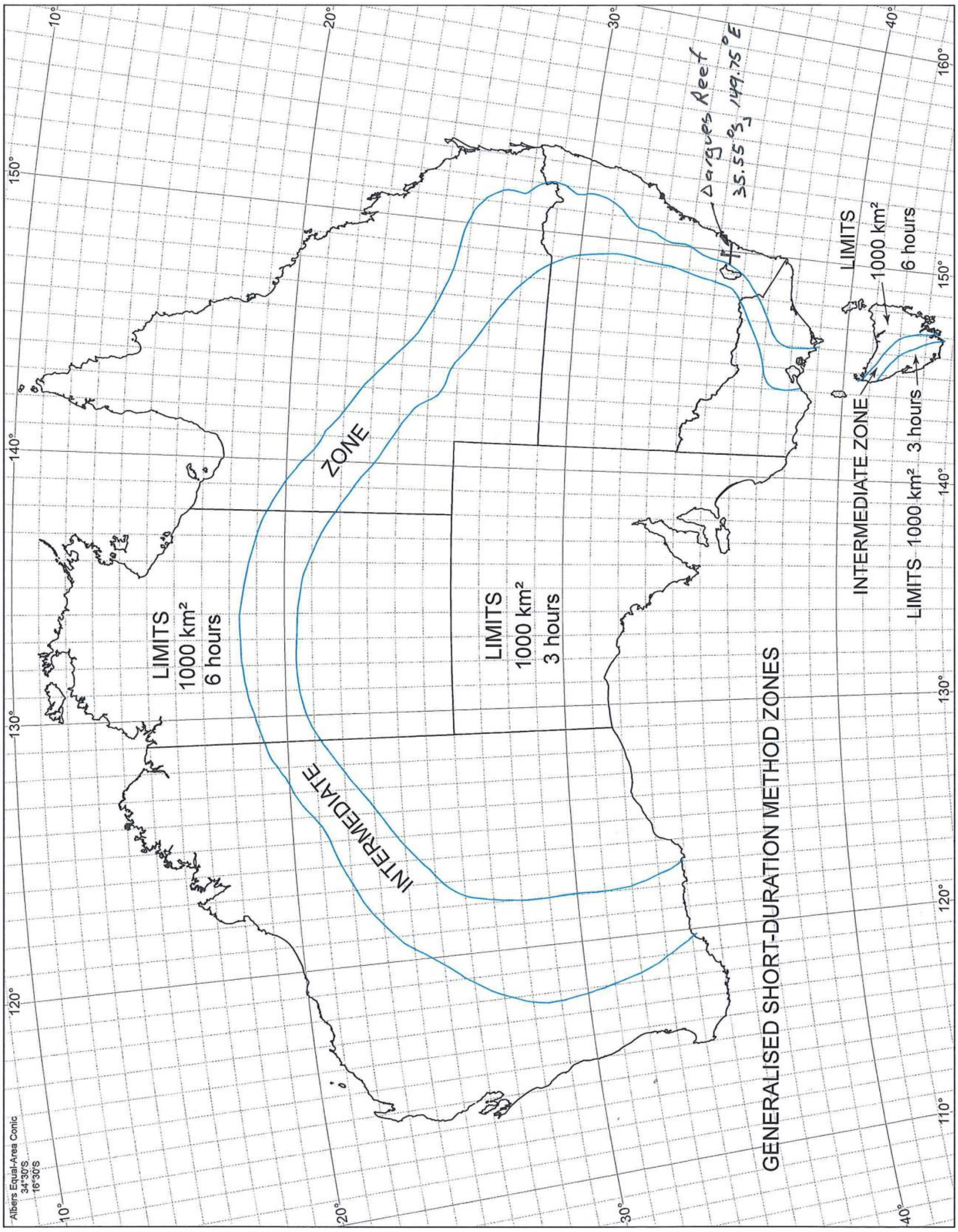
Knight Piésold Pty. Ltd.
November 2011
P:\PE801-00139 Dargues\Technical\Hydrology\PMP Estimation\PE801-00139 Dargues - PMP Estimation (Impact Analysis) Summer (2011-11-07).xlsm


PMP METHOD ZONES
GTSMR Coastal Zone
GTSMR Inland Zone
GSAM Inland Zone
GSAM-GTSMR Coastal Transition Zone
Dargues Reef 35.55°S, 149.75°E
GSAM Coastal Zone
West Coast Tasmania Method Zone
GTSMR SW WA Winter Zone
Albers Equal-Area Conic


GENERALISED SHORT-DURATION METHOD ZONES
LIMITS
1000 km²
6 hours
LIMITS
1000 km²
3 hours
INTERMEDIATE
ZONE
INTERMEDIATE ZONE
LIMITS 1000 km² 3 hours
LIMITS
1000 km²
6 hours
Dargues Reef
35.55°S, 149.75°E
Albers Equal-Area Conic
34°30'S
16°30'S

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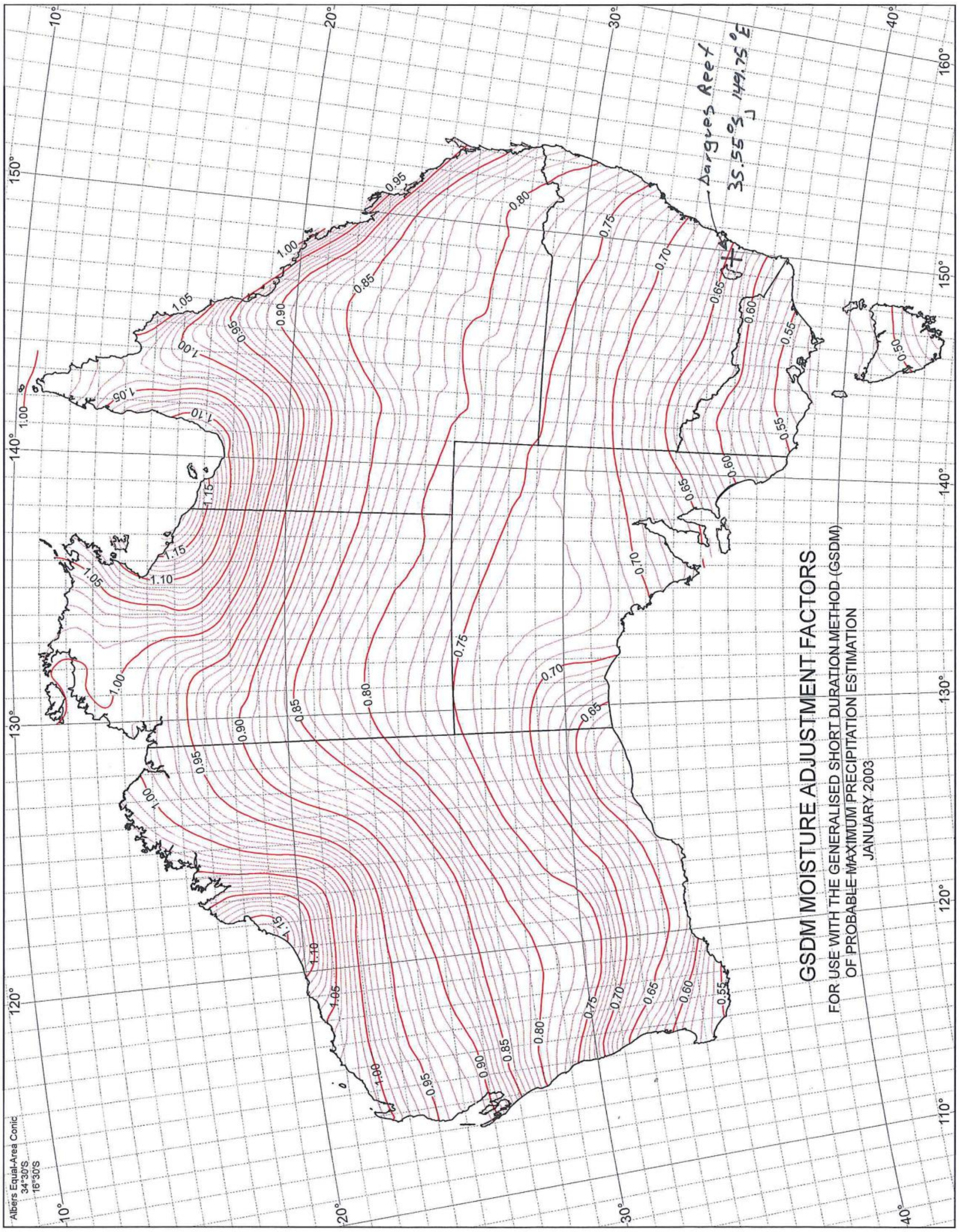
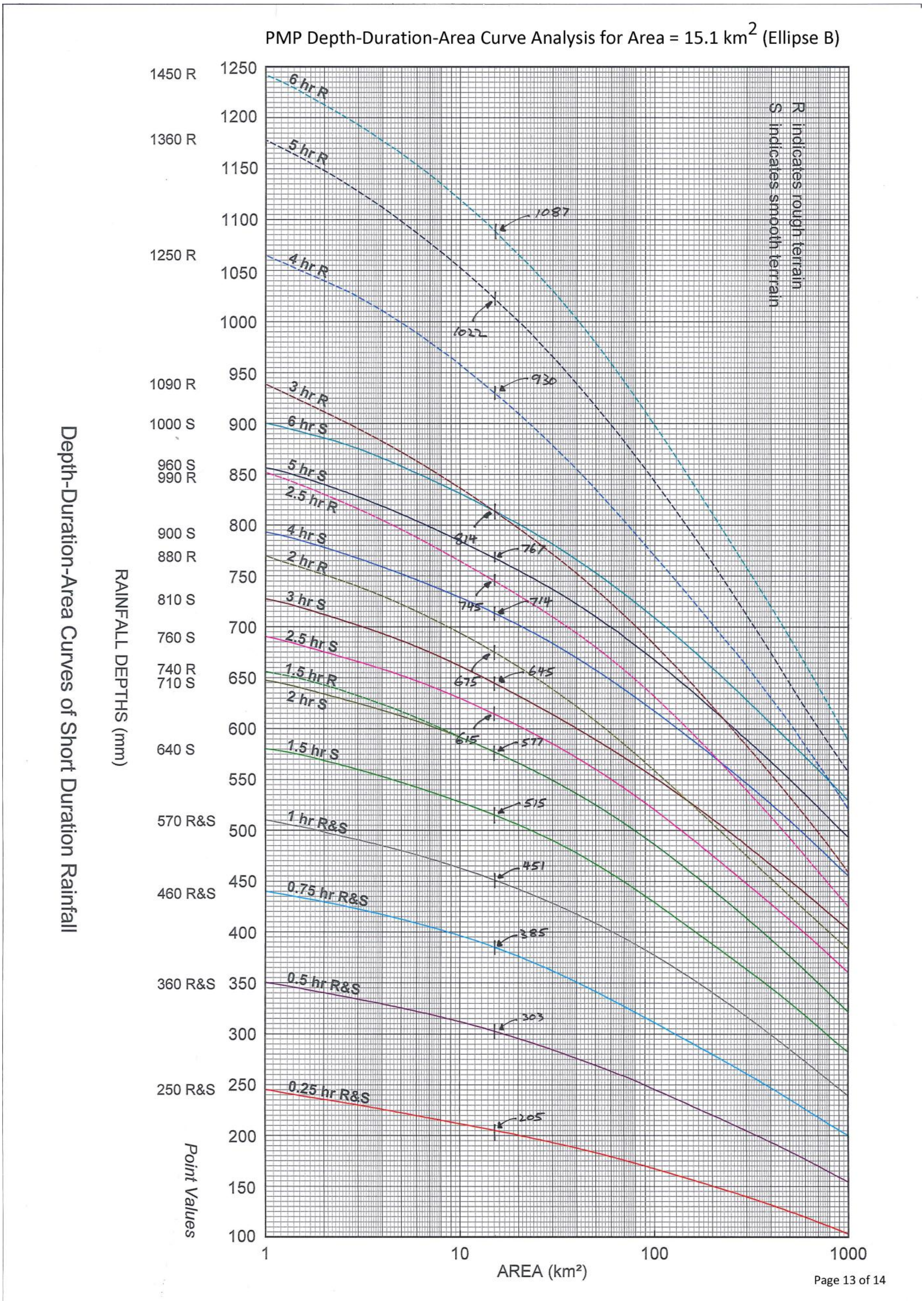
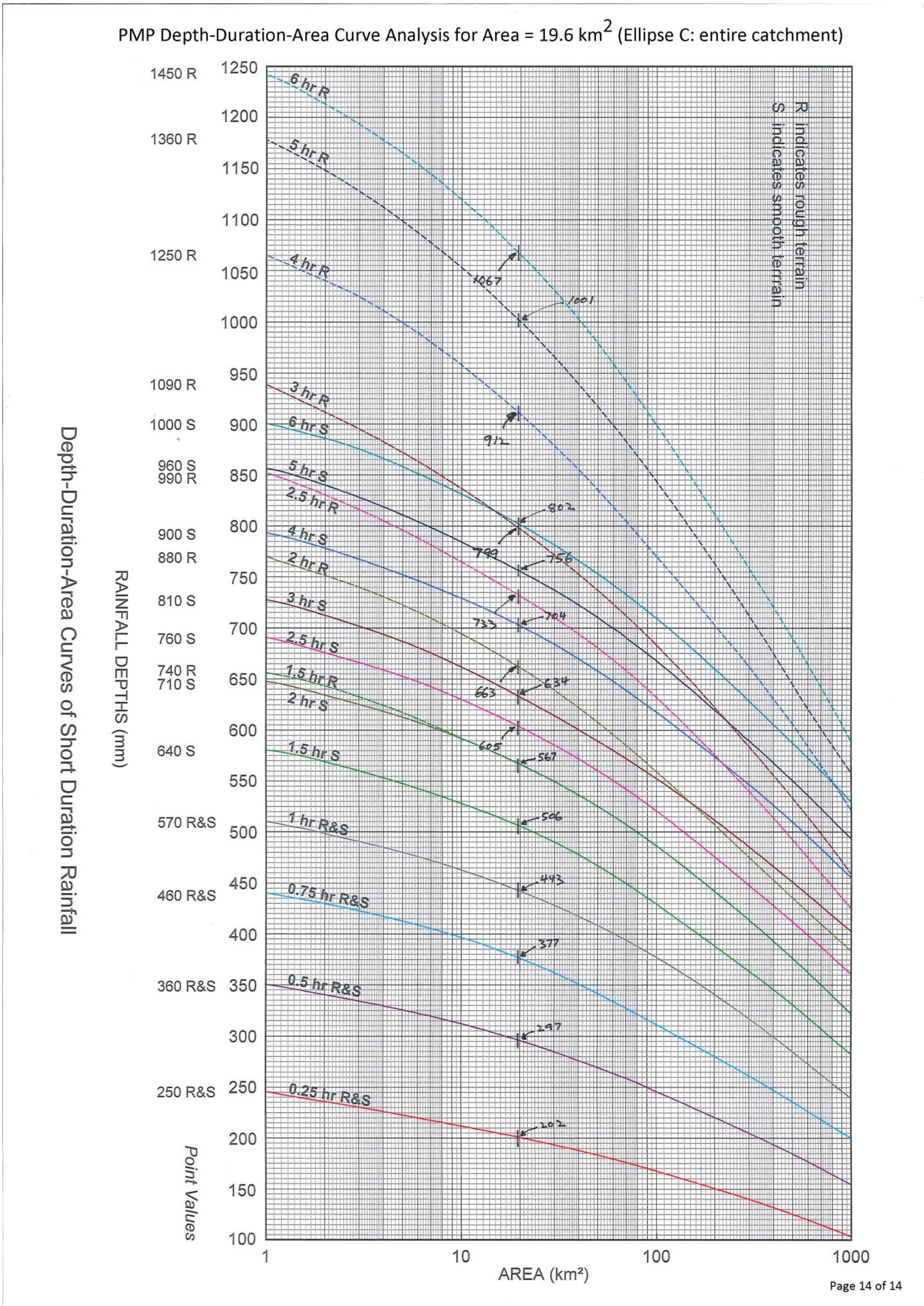

GSDM MOISTURE ADJUSTMENT FACTORS
FOR USE WITH THE GENERALISED SHORT DURATION METHOD (GSDM)
OF PROBABLE MAXIMUM PRECIPITATION ESTIMATION
JANUARY 2003
Dargues Reef
35.55°S 149.75°E
Albers Equal-Area Conic
34°30'S
16°30'S


PMP Depth-Duration-Area Curve Analysis for Area = 15.1 km² (Ellipse B)
Depth-Duration-Area Curves of Short Duration Rainfall
RAINFALL DEPTHS (mm)
Point Values
AREA (km²)
R indicates rough terrain
S indicates smooth terrain
1450 R
1360 R
1250 R
1090 R
1000 S
960 S
990 R
900 S
880 R
810 S
760 S
740 R
710 S
640 S
570 R&S
460 R&S
360 R&S
250 R&S
6 hr R
5 hr R
4 hr R
3 hr R
6 hr S
5 hr S
2.5 hr R
4 hr S
2 hr R
3 hr S
2.5 hr S
1.5 hr R
2 hr S
1.5 hr S
1 hr R&S
0.75 hr R&S
0.5 hr R&S
0.25 hr R&S
1087
1022
930
814
767
745
714
675
645
615
577
515
451
385
303
205
Page 13 of 14


PMP Depth-Duration-Area Curve Analysis for Area = 19.6 km2 (Ellipse C: entire catchment)
Depth-Duration-Area Curves of Short Duration Rainfall
RAINFALL DEPTHS (mm)
Point Values
1450 R
1360 R
1250 R
1090 R
1000 S
960 S
990 R
900 S
880 R
810 S
760 S
740 R
710 S
640 S
570 R&S
460 R&S
360 R&S
250 R&S
1250
1200
1150
1100
1050
1000
950
900
850
800
750
700
650
600
550
500
450
400
350
300
250
200
150
100
6 hr R
5 hr R
4 hr R
3 hr R
6 hr S
5 hr S
2.5 hr R
4 hr S
2 hr R
3 hr S
2.5 hr S
1.5 hr R
2 hr S
1.5 hr S
1 hr R&S
0.75 hr R&S
0.5 hr R&S
0.25 hr R&S
R indicates rough terrain
S indicates smooth terrain
1067
1001
912
802
799
756
733
704
663
634
605
567
506
443
377
297
202
1
10
100
1000
AREA (km²)
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Knight Piésold CONSULTING	Subject Cortona Res.	Made by TML	Job No. PE801-00139
	Dargues Reef Gold	Checked	Date 07/11/2011
	PMP Est. (Summer) for I.A.	Approved	Sheet No. 1 of 5

Estimation of Probable Maximum Precipitation in Australia: GSAM For Long Duration PMP (Depth)

Estimation of long duration Probable Maximum Precipitation (PMP) in Australia is performed using procedures taken from the following publications of the Australian Bureau of Meteorology (BOM):

- "Development of the Generalised Southeast Australia Method for Estimating Probable Maximum Precipitation, HRS Report No.4", August 1996 ⇐ (GSAM) for long (> 24 hr) duration PMP.
- "Guidebook to the Estimation of Probable Maximum Precipitation, GENERALISED SOUTHEAST AUSTRALIA METHOD", October 2006

Location Information								
Catchment ID	Catchment Area (km^2)	Located in Aus. State	Catchment Latitude (°)	Catchment Longitude (°)	PMP Convergence Application Zone	Consider Seasons?	Summer (S) or Autumn (A) Storm?	Mean Catchment Elevation (m)
Majors Creek	19.593	NSW	-35.5475	149.7482	CAZ	Yes	S	721

Computation of Convergence PMP Adjustment Factors			
Extreme Std. Precipitable Water EPW_{std} (mm)	Extreme Cat. Precipitable Water EPW_{catch} (mm)	Moisture Adjustment Factor MAF	Topographic Adjustment Factor TAF
80.8	66.920	0.828	1.770

Estimation of Depth-Duration PMP (Long Duration)			
Duration (h)	Base Convergence PMP (mm)	Catchment PMP Estimate (mm)	Rounded PMP Estimate (mm)
24	858.3	1,258.2	1,260
36	960.5	1,408.1	1,410
48	1,012.0	1,483.6	1,480
72	1,057.9	1,550.8	1,550
96	1,093.8	1,603.5	1,600

If the overall catchment area exceeds 1 km^2 and the required level of calculations warrant the effort, estimated PMP rainfall may be varied spatially using the procedures given in GSAM CD 2006 Guidebook, Section 3. However, spatially-distributing PMP is generally not required unless the contributing catchment area exceeds 5 km^2.

To spatially-distribute PMP, it is necessary to multiply each of the "Catchment PMP Estimate" values by the ratio of area-averaged TAF values: **(Spatially-distributed PMP is considered for TSF design. Sub-catchment specific PMP estimates are made for each sub-catchment at a selected duration: TSF Spillway Critical Duration.)**

$PMP_{sc,d} = PMP_{c,d} \times (TAF_{sc} / TAF_c)$

where:

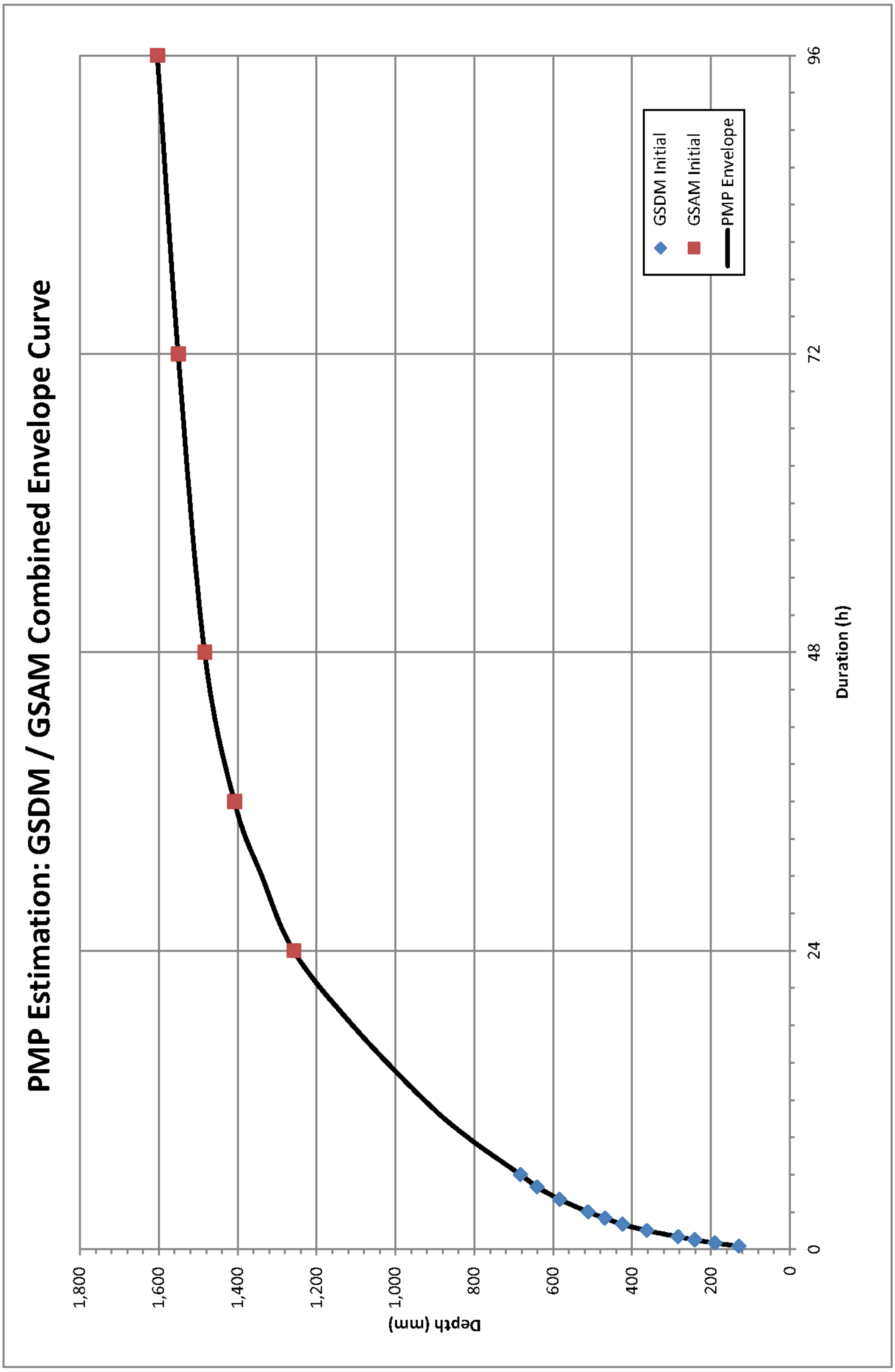
$PMP_{c,d}$ = catchment (c) average PMP for duration (d);
$PMP_{sc,d}$ = sub-catchment (sc) average PMP for duration (d);
TAF_c = areal-average topographic adjustment factor for catchment (c); and
TAF_{sc} = areal-average topographic adjustment factor for sub-catchment (sc).

Estimation of Depth-Duration PMP (Combined Curve)			
PMP Estimation Procedure	Duration (h)	Catchment PMP Estimate (mm)	Rounded Final PMP Depth (mm)
GSDM	0.250	129.4	130
	0.333	#N/A	150
	0.417	#N/A	170
	0.500	190.2	190
	0.750	241.4	240
	1.0	283.7	280
	1.5	363.1	360
	2.0	424.6	420
	2.5	469.4	470
	3.0	511.7	510
	4.0	584.0	580
	4.5	#N/A	610
	5.0	641.0	640
	6.0	683.3	680
Interpolated from Final Envelope	9.0	#N/A	820
	12.0	#N/A	930
	18.0	#N/A	1,110
GSAM	24.0	1,258.2	1,260
	30.0	#N/A	1,340
	36.0	1,408.1	1,410
	48.0	1,483.6	1,480
	72.0	1,550.8	1,550
	96.0	1,603.5	1,600

Once the scaled "Catchment PMP Estimate" values are derived for the sub-catchment, a smooth envelope curve is drawn and the final PMP depths (rounded to the nearest 10 mm) are extracted.

The Annual Exceedance Probability (AEP) associated with a PMP storm is estimated based on the area of the catchment it occurs within; see ARR 1999 - Volume 1, Book 6, Section 3.6, Figure 6.

PMP Frequency	
AEP	ARI (1 in X yr)
1.0E-07	10000000



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Knight Piésold Pty. Ltd.

November 2011
P:\PE801-00139 Dargues\Technical\Hydrology\PMP Estimation\PE801-00139 Dargues - PMP Estimation (Impact Analysis) Summer (2011-11-07).xlsm

Knight Piésold CONSULTING	Subject: Cortona Resources	Made by: TML	Job No.: PE801-00139
	Dargues Reef Gold	Checked	Date: 07/11/2011
	PMP Estimation (Summer): Impact Analysis	Approved	

Estimation of Probable Maximum Precipitation in Australia: GSAM For Long Duration PMP (Temporal Distribution)

Estimated PMP values for various durations (duplicated below) are distributed into hyetographs using the design temporal distributions for long duration PMP given in GSAM CD 2006 Guidebook. PMP values for all durations are taken from an envelope curve fitted to the computed PMP values.
(PMP depths are rounded to the nearest 10 mm.) The temporal distribution for 30-h PMP is estimated via interpolation between bounding distributions (24-h and 36-h). Temporal distributions for PMP rainfall between 6-h and 24-h are not available; see note below for a procedure to use with this scenario: 9-, 12- and 18-h PMP.

Storm Duration (h) =	24.0	30.0	36.0	48.0	72.0	96.0
PMP Depth (mm) =	1260	1340	1410	1480	1550	1600

Standard Project Area = 100 km^2 **PMP Convergence Application Zone =** CAZ

Storm Duration (h)	24.0		Storm Duration (h)	30.0		Storm Duration (h)	36.0		Storm Duration (h)	48.0	
Elapsed	Rainfall Depth		Elapsed	Rainfall Depth		Elapsed	Rainfall Depth		Elapsed	Rainfall Depth	
Time (h)	Instant. (mm)	Cum. (mm)	Time (min)	Instant. (mm)	Cum. (mm)	Time (h)	Instant. (mm)	Cum. (mm)	Time (h)	Instant. (mm)	Cum. (mm)
0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
1	23.9	23.9	2	36.4	36.4	2	26.3	26.3	2	14.8	14.8
2	23.9	47.9	4	46.0	82.4	4	36.7	63.0	4	22.2	37.0
3	23.9	71.8	6	63.0	145.4	6	47.0	110.0	6	29.6	66.6
4	37.0	108.8	8	77.9	223.3	8	68.6	178.6	8	38.5	105.1
5	37.0	145.7	10	100.4	323.7	10	77.6	256.2	10	46.9	151.9
6	37.0	182.7	12	109.6	433.4	12	86.5	342.6	12	55.3	207.2
7	59.6	242.3	14	120.9	554.3	14	90.2	432.9	14	85.8	293.0
8	59.6	302.0	16	113.3	667.5	16	87.9	520.8	16	95.2	388.3
9	59.6	361.6	18	114.6	782.2	18	85.5	606.3	18	104.6	492.8
10	84.0	445.6	20	132.5	914.7	20	79.9	686.2	20	137.1	630.0
11	84.0	529.6	22	120.4	1035.1	22	109.0	795.2	22	114.9	744.9
12	84.0	613.6	24	93.8	1129.0	24	138.2	933.4	24	92.7	837.7
13	71.4	685.0	26	88.0	1216.9	26	113.7	1047.2	26	65.1	902.8
14	71.4	756.4	28	73.3	1290.2	28	97.3	1144.5	28	64.1	966.9
15	71.4	827.8	30	49.8	1340.0	30	80.8	1225.3	30	63.1	1030.1
16	62.6	890.4				32	93.1	1318.4	32	79.9	1110.0
17	62.6	953.0				34	61.6	1379.9	34	77.9	1187.9
18	62.6	1015.6				36	30.1	1410.0	36	76.0	1263.9
19	46.6	1062.2							38	53.3	1317.2
20	46.6	1108.8							40	49.3	1366.5
21	46.6	1155.4							42	45.4	1411.9
22	34.9	1190.3							44	33.5	1445.5
23	34.9	1225.1							46	22.7	1468.2
24	34.9	1260.0							48	11.8	1480.0

24-h Duration PMP				30-h Duration PMP				36-h Duration PMP				48-h Duration PMP			
Position i		*Position i+1*		*Position i*		*Position i+1*		*Position i*		*Position i+1*		*Position i*		*Position i+1*	
Fraction of Storm Duration	Fraction of Storm PMP	Fraction of Storm Duration	Fraction of Storm PMP	Fraction of Storm Duration	Fraction of Storm PMP	Fraction of Storm Duration	Fraction of Storm PMP	Fraction of Storm Duration	Fraction of Storm PMP	Fraction of Storm Duration	Fraction of Storm PMP	Fraction of Storm Duration	Fraction of Storm PMP	Fraction of Storm Duration	Fraction of Storm PMP
0.00%	0.00%	12.50%	5.70%	0.00%	0.00%	5.00%	1.98%	0.00%	0.00%	8.33%	2.80%	0.00%	0.00%	6.25%	1.50%
12.50%	5.70%	25.00%	14.50%	5.00%	1.98%	10.00%	4.18%	8.33%	2.80%	16.67%	7.80%	6.25%	1.50%	12.50%	4.50%
25.00%	14.50%	37.50%	28.70%	10.00%	4.18%	15.00%	7.13%	16.67%	7.80%	25.00%	15.10%	12.50%	4.50%	18.75%	8.40%
37.50%	28.70%	50.00%	48.70%	15.00%	7.13%	20.00%	10.85%	25.00%	15.10%	33.33%	24.30%	18.75%	8.40%	25.00%	14.00%
50.00%	48.70%	62.50%	65.70%	20.00%	10.85%	25.00%	14.80%	33.33%	24.30%	41.67%	33.90%	25.00%	14.00%	31.25%	22.70%
62.50%	65.70%	75.00%	80.60%	25.00%	14.80%	30.00%	20.40%	41.67%	33.90%	50.00%	43.00%	31.25%	22.70%	37.50%	33.30%
75.00%	80.60%	87.50%	91.70%	30.00%	20.40%	35.00%	26.04%	50.00%	43.00%	58.33%	51.50%	37.50%	33.30%	43.75%	47.20%
87.50%	91.70%	100.00%	100.00%	35.00%	26.04%	40.00%	32.34%	58.33%	51.50%	66.67%	66.20%	43.75%	47.20%	50.00%	56.60%
100.00%	100.00%			40.00%	32.34%	45.00%	39.12%	66.67%	66.20%	75.00%	78.30%	50.00%	56.60%	56.25%	63.20%
				45.00%	39.12%	50.00%	45.85%	75.00%	78.30%	83.33%	86.90%	56.25%	63.20%	62.50%	69.60%
				50.00%	45.85%	55.00%	51.80%	83.33%	86.90%	91.67%	96.80%	62.50%	69.60%	68.75%	77.70%
				55.00%	51.80%	60.00%	58.37%	91.67%	96.80%	100.00%	100.00%	68.75%	77.70%	75.00%	85.40%
				60.00%	58.37%	65.00%	65.97%	100.00%	100.00%			75.00%	85.40%	81.25%	90.80%
				65.00%	65.97%	70.00%	72.84%					81.25%	90.80%	87.50%	95.40%
				70.00%	72.84%	75.00%	79.45%					87.50%	95.40%	93.75%	98.80%
				75.00%	79.45%	80.00%	84.25%					93.75%	98.80%	100.00%	100.00%
				80.00%	84.25%	85.00%	89.18%					100.00%	100.00%		
				85.00%	89.18%	90.00%	94.09%								
				90.00%	94.09%	95.00%	97.38%								
				95.00%	97.38%	100.00%	100.00%								
				100.00%	100.00%										

In order to determine peak outflow for durations between 6-h and 24-h, the following procedure, as given in Australian Rainfall and Runoff 1999, Volume 1, Book 6, Section 3.9.2 is employed:

1) Employ rainfall / runoff model to estimate the hydrographs resulting from 6-h PMP (GSDM) and from 24-h PMP (GSAM).
2) Determine the peak flow for both of these hydrographs: Qp_6 and Qp_{24}.
3) Estimate peak flows for intermediate durations: Qp_9, Qp_{12} and Qp_{18} using a weighted average (i.e. with linear interpolation) as shown below:

$$Qp_D = Qp_6 + (Qp_{24} - Qp_6) * (D - 6) / (24 - 6)$$

where:
Qp_D = peak flow rate for intermediate duration PMP design flood (m^3/s);
Qp_6 = peak flow rate for 6-h duration PMP design flood (m^3/s);
Qp_{24} = peak flow rate for 24-h duration PMP design flood (m^3/s); and
D = intermediate duration (6-h < D < 24-h).

WARNING: "Weighting of all ordinates of the hydrograph is not recommended as the resulting hydrograph may exhibit a lower peak than either of the individual hydrographs."

Knight Piésold CONSULTING	Subject: Cortona Resources	Made by: TML	Job No.: PE801-00139
	Dargues Reef Gold	Checked:	Date: 07/11/2011
	PMP Estimation (Summer): Impact Analysis	Approved:	

Estimation of Probable Maximum Precipitation in Australia: GSAM For Long Duration PMP (Temporal Distribution)

Estimated PMP values for various durations (duplicated below) are distributed into hyetographs using the design temporal distributions for long duration PMP given in GSAM CD 2006 Guidebook. PMP values for all durations are taken from an envelope curve fitted to the computed PMP values.
(PMP depths are rounded to the nearest 10 mm.) The temporal distribution for 30-h PMP is estimated via interpolation between bounding distributions (24-h and 36-h). Temporal distributions for PMP rainfall between 6-h and 24-h are not available; see note below for a procedure to use with this scenario: 9-, 12- and 18-h PMP.

Storm Duration (h) =	24.0	30.0	36.0	48.0	72.0	96.0
PMP Depth (mm) =	1260	1340	1410	1480	1550	1600

Standard Project Area = 100 km^2

PMP Convergence Application Zone = CAZ

Storm Duration (h)	72.0		Storm Duration (h)	96.0	
Elapsed Time (h)	Rainfall Depth Instant. (mm)	Rainfall Depth Cum. (mm)	Elapsed Time (h)	Rainfall Depth Instant. (mm)	Rainfall Depth Cum. (mm)
0	0.0	0.0	0	0.0	0.0
3	14.0	14.0	3	12.8	12.8
6	24.8	38.8	6	14.4	27.2
9	43.4	82.2	9	17.6	44.8
12	46.5	128.7	12	24.0	68.8
15	34.1	162.8	15	27.2	96.0
18	57.4	220.1	18	17.6	113.6
21	83.7	303.8	21	14.4	128.0
24	102.3	406.1	24	32.0	160.0
27	144.2	550.3	27	62.3	222.3
30	178.3	728.5	30	80.1	302.4
33	122.5	851.0	33	108.6	411.0
36	108.5	959.5	36	112.2	523.2
39	105.4	1064.9	39	102.2	625.4
42	71.3	1136.2	42	85.0	710.4
45	68.2	1204.4	45	67.1	777.5
48	80.6	1285.0	48	75.3	852.8
51	63.6	1348.5	51	84.7	937.5
54	45.0	1393.5	54	78.5	1016.0
57	34.1	1427.6	57	67.1	1083.1
60	27.9	1455.5	60	75.3	1158.4
63	23.3	1478.7	63	92.7	1251.1
66	27.9	1506.6	66	81.7	1332.8
69	27.9	1534.5	69	55.9	1388.7
72	15.5	1550.0	72	44.9	1433.6
			75	36.7	1470.3
			78	25.7	1496.0
			81	14.4	1510.4
			84	8.0	1518.4
			87	19.2	1537.6
			90	24.0	1561.6
			93	22.4	1584.0
			96	16.0	1600.0

72-h Duration PMP				96-h Duration PMP			
Position i		*Position i+1*		*Position i*		*Position i+1*	
Fraction of Storm Duration	Fraction of Storm PMP	Fraction of Storm Duration	Fraction of Storm PMP	Fraction of Storm Duration	Fraction of Storm PMP	Fraction of Storm Duration	Fraction of Storm PMP
0.00%	0.00%	4.17%	0.90%	0.00%	0.00%	3.13%	0.80%
4.17%	0.90%	8.33%	2.50%	3.13%	0.80%	6.25%	1.70%
8.33%	2.50%	12.50%	5.30%	6.25%	1.70%	9.38%	2.80%
12.50%	5.30%	16.67%	8.30%	9.38%	2.80%	12.50%	4.30%
16.67%	8.30%	20.83%	10.50%	12.50%	4.30%	15.63%	6.00%
20.83%	10.50%	25.00%	14.20%	15.63%	6.00%	18.75%	7.10%
25.00%	14.20%	29.17%	19.60%	18.75%	7.10%	21.88%	8.00%
29.17%	19.60%	33.33%	26.20%	21.88%	8.00%	25.00%	10.00%
33.33%	26.20%	37.50%	35.50%	25.00%	10.00%	28.13%	13.90%
37.50%	35.50%	41.67%	47.00%	28.13%	13.90%	31.25%	18.90%
41.67%	47.00%	45.83%	54.90%	31.25%	18.90%	34.38%	25.70%
45.83%	54.90%	50.00%	61.90%	34.38%	25.70%	37.50%	32.70%
50.00%	61.90%	54.17%	68.70%	37.50%	32.70%	40.63%	39.10%
54.17%	68.70%	58.33%	73.30%	40.63%	39.10%	43.75%	44.40%
58.33%	73.30%	62.50%	77.70%	43.75%	44.40%	46.88%	48.60%
62.50%	77.70%	66.67%	82.90%	46.88%	48.60%	50.00%	53.30%
66.67%	82.90%	70.83%	87.00%	50.00%	53.30%	53.13%	58.60%
70.83%	87.00%	75.00%	89.90%	53.13%	58.60%	56.25%	63.50%
75.00%	89.90%	79.17%	92.10%	56.25%	63.50%	59.38%	67.70%
79.17%	92.10%	83.33%	93.90%	59.38%	67.70%	62.50%	72.40%
83.33%	93.90%	87.50%	95.40%	62.50%	72.40%	65.63%	78.20%
87.50%	95.40%	91.67%	97.20%	65.63%	78.20%	68.75%	83.30%
91.67%	97.20%	95.83%	99.00%	68.75%	83.30%	71.88%	86.80%
95.83%	99.00%	100.00%	100.00%	71.88%	86.80%	75.00%	89.60%
100.00%	100.00%			75.00%	89.60%	78.13%	91.90%
				78.13%	91.90%	81.25%	93.50%
				81.25%	93.50%	84.38%	94.40%
				84.38%	94.40%	87.50%	94.90%
				87.50%	94.90%	90.63%	96.10%
				90.63%	96.10%	93.75%	97.60%
				93.75%	97.60%	96.88%	99.00%
				96.88%	99.00%	100.00%	100.00%
				100.00%	100.00%		

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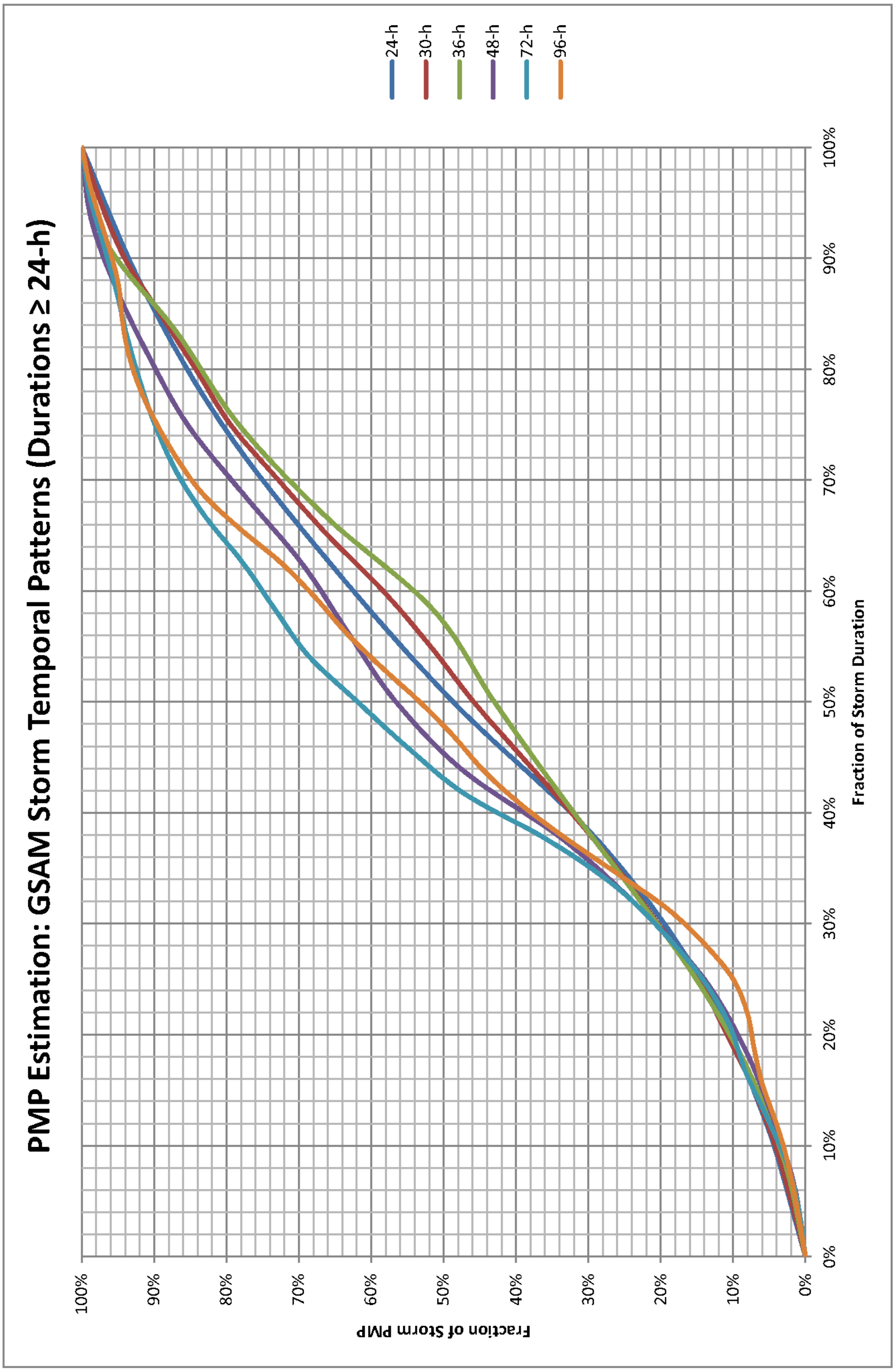

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Dam Breach Modelling – Empirical Methods (Froehlich)

Froehlich (1995a, 2008) empirical methods for estimating breach width, breach side-slope ratio, breach formation time and peak breach outflow are reproduced below:

(1) $\bar{B} = 0.27 \cdot k_o \cdot V_w^{0.32} \cdot H_b^{0.04}$

where:

$\bar{B}$ = average ultimate breach width (m);
k_o = failure mode parameter (1.3 for overtopping failures, 1.0 for other modes);
V_w = water volume about the ultimate breach invert at start of dam failure (m^3); and
H_b = ultimate breach height (m).

(2) z = breach side-slope ratio (1.0 H:1V for overtopping failures, 0.7 H:1V for other failure modes).

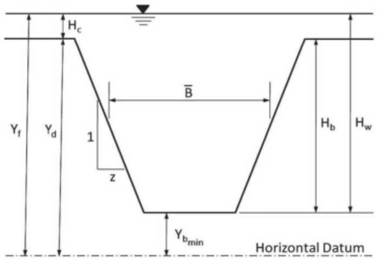

Figure 1. Typical Breach Cross Section

(3) $t_f = 63.2 \cdot (V_w / (g \cdot H_b^2))^{0.5}$

where:

t_f = breach formation time (s) and
g = gravitational acceleration (9.81 m/s^2)

(4) $Q_p = 0.607 \cdot (V_w^{0.295} \cdot H_w^{1.24})$

where:

Q_p = peak dam breach discharge at the dam (m^3/s) and
H_w = height of water over ultimate breach invert at initiation (m).

Table 1. Froehlich (1995a, 2008) Empirical Breach Parameter Estimation Results

Selected Failure Mechanism	Dam Failure Initiating Event	Ultimate Breach Height H_b (m)	Initial Water Height H_w (m)	Initial Water Volume V_w (m^3)	Failure Mode Parameter k_o	Average Breach Width $\bar{B}$ (m)	Breach Side-Slope z (H:1V)	Breach Formation Time t_f (s)	Breach Formation Time t_f (h)	Peak Breach Outflow Q_p (m^3/s)
Overtopping	PMPDF	6.0	5.4	180,856	1.3	18.1	1.0	1,430.4	0.4	174.7
Overtopping	SD	6.0	5.0	144,508	1.3	16.9	1.0	1,278.6	0.4	148.6
Piping	PMPDF	6.0	5.4	180,856	1	14.0	0.7	1,430.4	0.4	174.7
Piping	SD	6.0	5.0	144,508	1	13.0	0.7	1,278.6	0.4	148.6

Sources:

Froehlich, D.C. (1995a). *Peak Outflow from Breached Embankment Dam*, Journal of Water Resources Planning and Management, Vol. 121, No. 1, January/February, pages 90-97.

Froehlich, D.C. (2008). *Embankment Dam Breach Parameters and Their Uncertainties*, ASCE Journal of Hydraulic Engineering, Vol. 134, No. 12, May, pages 1708-1720.

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Dam Breach Modelling – Empirical Methods (Von Thun and Gillette)

Von Thun and Gillette (1990) empirical methods for estimating breach width, breach side-slope ratio, and breach formation time are reproduced below:

(1) $\bar{B} = 2.5 \cdot H_w + C_b$

where:

$\bar{B}$ = average ultimate breach width (ft);
H_w = height of water over ultimate breach invert at initiation (ft);
C_b = breach width factor (ft), which varies according to V_w (see Table 1); and
V_w = water volume about the ultimate breach invert at start of dam failure (acre·ft).

(2) z = breach side-slope ratio (1.0 H:1V for non-cohesive dams, 0.33 H:1V for cohesive dams).

(3) $t_f = \bar{B} / (4 \cdot H_w + c_t)$

where:

t_f = breach formation time (h) and
C_t = breach time factor (200 ft for easily eroded dams, 0 ft for erosion resistant dams)

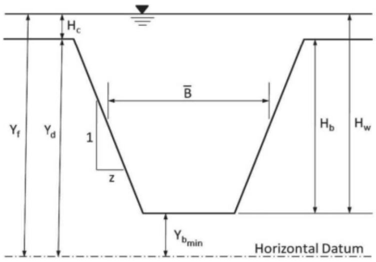

Figure 1. Typical Breach Cross Section

Table 1. Breach Width Factor

V_w (acre·ft)	C_b (ft)
< 1,000	20
1,000 - 5,000	60
5,000 - 10,000	140
> 10,000	180

Table 2. Von Thun and Gillette (1990) Empirical Breach Parameter Estimation Results

Dam Failure Initiating Event	Selected Dam Shell Material	Selected Dam Fill Material	Initial Water Height H_w (ft)	Initial Water Volume V_w (acre·ft)	Breach Width Factor C_b	Average Breach Width $\bar{B}$ (ft)	Breach Side-Slope z (H:1V)	Breach Time Factor C_t (ft)	Breach Formation Time t_f (h)
PMPDF	Non-cohesive	Erosion resistant	17.7	146.6	20	64.3	1.00	0	0.9
SD	Non-cohesive	Erosion resistant	16.4	117.2	20	61.0	1.00	0	0.9

Source:
Von Thun, J.L., and Gillette, A.M. (1990). *Guidance on Breach Parameters,* Unpublished internal document, U.S. Bureau of Reclamation, Denver, Colorado, March 13, 1990.

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Dam Breach Modelling – Empirical Methods (USBR)

USBR (1982, 1988) empirical methods for estimating breach width, breach formation time and peak breach outflow are reproduced below:

(1) $\bar{B} = 3 \cdot H_w$

where:

$\bar{B}$ = average ultimate breach width (m);

H_w = height of water over ultimate breach invert at initiation (m).

(2) z = breach side-slope ratio (undefined with USBR methods.)

(3) $t_f = 0.011 \cdot \bar{B}$

where:

t_f = breach formation time (h)

(4) $Q_p = 75 \cdot H_w^{1.85}$

where:

Q_p = peak dam breach discharge at the dam (ft^3/s) and

H_w = height of water over ultimate breach invert at initiation (ft).

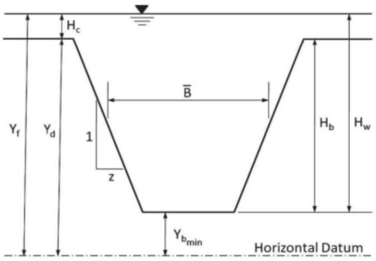

Figure 1. Typical Breach Cross Section

Emprical routing of the resulting peak breach outflow may be estimated (at the Screening level) with:

(5) $Q_r = 10^{(\log(Qp) - 0.01X)}$

where:

X = distance downstream of the dam along the flood plain (mi);

Q_r = peak attenuated dam breach discharge at distance X (ft^3/s); and

Q_p = peak dam breach discharge at the dam (ft^3/s).

Table 1. USBR (1982, 1988) Empirical Breach Parameter Estimation Results

Dam Failure Initiating Event	Initial Water Height H_w		Average Breach Width $\bar{B}$	Breach Formation Time t_f	Peak Breach Outflow Q_p		Distance Downstream of Dam X		Peak Attenuated Downstream Breach Outflow Q_r	
	(m)	(ft)	(m)	(h)	(m^3/s)	(ft^3/s)	(km)	(mi)	(m^3/s)	(ft^3/s)
PMPDF	5.4	17.7	16.2	0.2	433.1	15,295	6.3	3.9	395.9	13,983
SD	5.0	16.4	15.0	0.2	375.6	13,266	6.3	3.9	343.4	12,127

Sources:

United States Bureau of Reclamation (USBR). (1982). *Guidelines for defining inundated areas downstream from Bureau of Reclamation dams*, Reclamation Planning Instruction No. 82-11, U.S. Department of the Interior, Bureau of Reclamation, Denver, Colorado. (25 pages).

United States Bureau of Reclamation (USBR). (1988). *Downstream hazard classification guidelines,* ACER Technical Memorandum, Report No. 11, U.S. Department of the Interior, Bureau of Reclamation, Denver, Colorado. (57 pages).

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Dam Breach Modelling – Empirical Methods (MacDonald and Langridge - Monopolis)

MacDonald and Langridge - Monopolis (1984) empirical methods for estimating breach volume (and consequently width), breach side-slope ratio, breach formation time and peak breach outflow are reproduced below:

(1) $V_{er} = K_c \cdot (V_w \cdot H_w)^{K_e}$

where:
V_{er} = final volume of embankment eroded by breach (m^3);
K_c = dam type coefficient (0.02610 for earthfill dams, 0.00348 for non-earthfill dams);
V_w = water volume about the ultimate breach invert at start of dam failure (m^3);
H_w = height of water over ultimate breach invert at initiation (m); and
K_e = dam type exponent (0.769 for earthfill dams, 0.852 for non-earthfill dams).

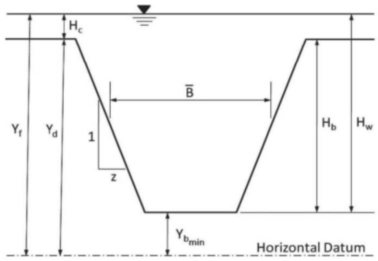

Figure 1. Typical Breach Cross Section

(2) z = breach side-slope ratio (0.5 H:1V)

(3) $t_f = 0.0179 \cdot V_{er}^{0.364}$

where:
t_f = breach formation time (h).

(4) $Q_p = 1.154 \cdot (V_w \cdot H_w)^{0.412}$

where:
Q_p = peak dam breach discharge at the dam (m^3/s).

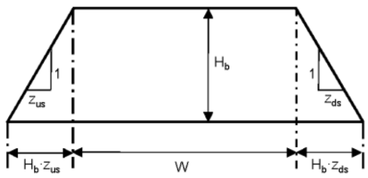

Figure 2. Typical Breach Long Section

The average breach width employed in other empirical methods can determined using the geometry of the final breach through the given embankment. The following equations show how this may be done for the breach geometry shown in Figures 1 and 2.

(5) $V_{er} = ((B + z \cdot H_b) \cdot H_b) \cdot ((H_b \cdot z_{us})/2 + W + (H_b \cdot z_{ds})/2)$

where:
B = ultimate breach bottom width (m);
H_b = ultimate breach height (m);
z_{us} = upstream embankment slope (H:1V); and
z_{ds} = downstream embankment slope (H:1V).

Equation (5) may be algebraically manipulated to yield the following expression for directly calculating the ultimate breach bottom width:

(6) $B = (V_{er} / ((z_{us} + z_{ds}) \cdot (H_b^2)/2 + W \cdot H_b)) - (z \cdot H_b)$

Which then gives the average ultimate breach width through Equation (7):

(7) $\bar{B} = B + z \cdot H_b$

Table 1. MacDonald and Langridge - Monopolis (1984) Empirical Breach Parameter Estimation Results

Dam Failure Initiating Event	Selected Dam Type	Dam Type Coefficient K_c	Dam Type Exponent K_e	Initial Water Volume V_w (m^3)	Initial Water Height H_w (m)	Final Eroded Volume V_{er} (m^3)	Breach Side-Slope z (H:1V)	Breach Formation Time t_f (h)	Peak Breach Outflow Q_p (m^3/s)
PMPDF	Non-earthfill	0.00348	0.852	180,856	5.4	441	0.5	0.2	338.8
SD	Non-earthfill	0.00348	0.852	144,508	5.0	341	0.5	0.1	299.3

At first, the assumed ultimate breach height from the tailings run-out analysis is used to compute the bottom breach width that will satisfy the estimated final eroded volume. If the resulting bottom breach width estimate is negative (not possible), it is necessary to determine the ultimate breach height that will yield a bottom breach width of 0.0 m, thereby satisfying the other relationships.

Such a scenario was found for the Dargues Reef TSF embankment. The ultimate breach height predicted by the tailings run-out analysis is greater than that indicated by the final eroded volume predicted by this methodology for the SD scenario.

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Dam Breach Modelling – Empirical Methods (MacDonald and Langridge - Monopolis)

Table 1. (continued)

Dam Failure Initiating Event	Ultimate Breach Height H_b (m)	Embk. Crest Length W (m)	US Embk. Slope z_{us} (H:1V)	DS Embk. Slope z_{ds} (H:1V)	Bottom Breach Width B (m)	Average Breach Width $\bar{B}$ (m)
PMPDF	6.0	6.0	3.0	3.0	0.1	3.1
SD	5.5	6.0	3.0	3.0	0.0	2.8

Source:
MacDonald, T.C., and Langridge-Monopolis, J. (1984). *Breaching Characteristics of Dam Failures,* ASCE Journal of Hydraulic Engineering, Vol. 110, No. 5, May, pages 567-586.

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Dam Breach Modelling – Empirical Methods Summary

Wahl (2004) studied the uncertainty of predictions of embankment breach parameters. Through statistical analysis of a comprehensive database of dam failures and various empirical breach parameter estimation methods, Wahl formulated a means for computing an approximate 95% confidence interval about the estimated breach parameters with:

(1) $CL_L = \hat{X}\cdot 10^{(-\bar{e} - 2Se)}$ and $CL_U = \hat{X}\cdot 10^{(-\bar{e} + 2Se)}$

where:
CL_L = Lower 95% confidence interval limit about $\hat{X}$;
CL_U = Upper 95% confidence interval limit about $\hat{X}$;
$\hat{X}$ = Predicted value ($\bar{B}$, V_{er}, t_f or Q_p)
$\bar{e}$ = Mean of prediction errors; and
S_e = Standard deviation of prediction errors:

As given in Wahl (2004), the uncertainty in the four selected empirical methods are given in Table 1. A summary of results are given in Table 2.

Table 1. Wahl (2004) Empirical Breach Parameter Prediction Uncertainty Parameters

Breach Parameter Type	Empirical Breach Parameter Estimation Method	Mean of Prediction Errors $\bar{e}$ (log cycles)	Std. Dev of Prediction Errors S_e (log cycles)	Width of Uncertainty Band $\pm 2S_e$ (log cycles)
V_{er} (Eroded Volume)	MacDonald et. al (1984)	-0.01	0.410	±0.82
$\bar{B}$ (Average Width)	Froehlich (2008)	0.01	0.195	±0.39
	Von Thun and Gillette (1990)	0.09	0.175	±0.35
	USBR (1988)	-0.09	0.215	±0.43
t_f (Breach Formation Time)	Froehlich (2008)	-0.22	0.320	±0.64
	Von Thun and Gillette (1990)	-0.38	0.420	±0.84
	USBR (1988)	-0.40	0.510	±1.02
	MacDonald et. al (1984)	-0.21	0.415	±0.83
Q_p (Peak Breach Outflow)	Froehlich (1995a)	-0.04	0.160	±0.32
	USBR (1982)	0.19	0.250	±0.50
	MacDonald et. al (1984)	0.13	0.350	±0.70

Note: uncertainty parameters from Froehlich (1995b) were assumed to apply (as an approximation) to the improved methods in Froehlich (2008).

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Dam Breach Modelling – Empirical Methods Summary

Table 2. Summary of Empirical Breach Parameter Predictions with 95% Confidence Interval

Breach Parameter Type	Empirical Breach Parameter Estimation Method along with Dam Failure Initiating Event and Selected Failure Mechanism (if applicable)	Predicted Breach Parameter $\hat{X}$	Lower 95% Confidence Limit CL_L	Upper 95% Confidence Limit CL_U
		(m^3, m, h or m^3/s)		
V_{er} (Eroded Volume)	MacDonald et. al (1984) - PMPDF	441	68	2,984
	MacDonald et. al (1984) - SD	341	53	2,308
$\bar{B}$ (Average Width)	Froehlich (2008) - PMPDF, Overtopping	18.1	7.2	43.5
	Froehlich (2008) - PMPDF, Piping	16.9	6.7	40.5
	Froehlich (2008) - SD, Overtopping	14.0	5.6	33.5
	Froehlich (2008) - SD, Piping	13.0	5.2	31.2
	Von Thun and Gillette (1990) - PMPDF	19.6	7.1	35.7
	Von Thun and Gillette (1990) - SD	18.6	6.8	33.8
	USBR (1988) - PMPDF	16.2	7.4	53.6
	USBR (1988) - SD	15.0	6.9	49.7
	MacDonald et. al (1984) - PMPDF	3.1	2.8	24.1 ⇦ derived from V_{er} values
	MacDonald et. al (1984) - SD	2.8	2.8	18.6
t_f (Breach Formation Time)	Froehlich (2008) - PMPDF, Overtopping	0.4	0.2	2.9
	Froehlich (2008) - PMPDF, Piping	0.4	0.1	2.6
	Froehlich (2008) - SD, Overtopping	0.4	0.2	2.9
	Froehlich (2008) - SD, Piping	0.4	0.1	2.6
	Von Thun and Gillette (1990) - PMPDF	0.9	0.3	15.1
	Von Thun and Gillette (1990) - SD	0.9	0.3	15.4
	USBR (1988) - PMPDF	0.2	0.0	4.7
	USBR (1988) - SD	0.2	0.0	4.3
	MacDonald et. al (1984) - PMPDF	0.2	0.0	1.8
	MacDonald et. al (1984) - SD	0.1	0.0	1.6
Q_p (Peak Breach Outflow)	Froehlich (2008) - PMPDF, Overtopping	174.7	91.7	400.2
	Froehlich (2008) - PMPDF, Piping	148.6	78.0	340.5
	Froehlich (2008) - SD, Overtopping	174.7	91.7	400.2
	Froehlich (2008) - SD, Piping	148.6	78.0	340.5
	Von Thun and Gillette (1990)	#N/A	#N/A	#N/A
	USBR (1982) - PMPDF	433.1	88.4	884.3
	USBR (1982) - SD	375.6	76.7	1,395.6
	MacDonald et. al (1984) - PMPDF	338.8	50.1	1,258.8
	MacDonald et. al (1984) - SD	299.3	44.3	1,111.9

A simulation testing grid, consisting of the Expected values (as predicted) of average breach width and breach formation time will be formulated and employed for assessing potential dam breach failures under both PMPDF and SD initiating conditions and for both Overtopping (OT) and Piping (PI) failure modes.

Source:
Wahl, T.L. (2004). *Uncertainty of Predictions of Embankment Dam Breach Parameters,* ASCE Journal of Hydraulic Engineering, Vol. 130, No. 5, May, pages 389-397.

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Dam Breach Modelling – Testing Grid (Failure and Non-Failure Scenarios)

There are five primary variables which may be varied in setting up a testing grid:

1) Dam Failure Initiating Event: Probable Maximum Precipitation Design Flood (PMPDF) or Sunny Day (SD)
2) Failure Mechanism: Overtopping (OT) or Piping (PI)
3) Parameter Estimation Method: Froehlich (2008), Von Thun and Gillette (1990), USBR (1988) or MacDonald et. al (1984)
4) Failure Parameters Combination: Expected, Best-case and Worst-case (combinations of breach width, $\bar{B}$ and breach formation time, t_f). For this analysis, the only combination of parameters that will be employed is the Expected scenario.
   a) Expected failure scenarios employ breach widths, $\bar{B}$ and formation times, t_f as given by each parameter estimation method.
   b) Best-case failure scenarios employ the lower 95% confidence limit breach widths, $\bar{B}_{L95}$ and the upper 95% confidence limit formation times, t_{f-U95} as given by each parameter estimation method.
   c) Worst-case failure scenarios employ the upper 95% confidence limit breach widths, $\bar{B}_{U95}$ and the lower 95% confidence limit formation times, t_{f-L95} as given by each parameter estimation method.
5) Breach Progression: Linear or Sine-wave. For this analysis, the only breach progression model that will be employed is the Linear model.

These variable combinations, along with the necessary inputs to the HEC-HMS breach model are given in the following test matrix:

Simulation ID	Dam Failure Initiating Event	Selected Failure Mode	Parameter Estimation Method	Failure Parameters Combination	Breach Progression	Breach Development Parameters (for HEC-HMS): Top Elevation $Yb_{min} + H_b$ (m)	Bottom Elevation Yb_{min} (m)	Average Width $\bar{B}$ (m)	Bottom Width B_{Yb} (m)	Left Side Slope z_L (H:1V)	Right Side Slope z_R (H:1V)	Piping Elevation Yp (m)	Piping Coefficient	Failure Trigger Elevation (m)	Formation Time t_f (h)	Key Breach Routing Results (from HEC-HMS): at CP05 (4+528.5) Peak Flow Q_{MAX} (m^3/s)	at CP05 Time t_{Q-MAX} (h)	at CP01 (0+000.0) Peak Flow Q_{MAX} (m^3/s)	at CP01 Time t_{Q-MAX} (h)
NF	PMPDF	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	208.99	12.27	431.47	12.43
F01	PMPDF	OT	Froehlich (2008)	Expected	Linear	712.0	706.0	18.1	12.1	1.0	1.0	#N/A	#N/A	711.4	0.4	369.05	16.93	515.83	17.07
F02	SD	OT	Froehlich (2008)	Expected	Linear	712.0	706.0	14.0	8.0	1.0	1.0	#N/A	#N/A	711.0	0.4	147.88	0.47	112.21	0.70
F03	PMPDF	OT	Von Thun and Gillette (1990)	Expected	Linear	712.0	706.0	19.6	13.6	1.0	1.0	#N/A	#N/A	711.4	0.9	285.58	17.30	458.30	17.47
F04	SD	OT	Von Thun and Gillette (1990)	Expected	Linear	712.0	706.0	18.6	12.6	1.0	1.0	#N/A	#N/A	711.0	0.9	98.79	0.88	90.75	1.08
F05	PMPDF	OT	USBR (1988)	Expected	Linear	712.0	706.0	16.2	10.2	1.0	1.0	#N/A	#N/A	711.4	0.2	391.55	16.73	522.81	16.90
F06	SD	OT	USBR (1988)	Expected	Linear	712.0	706.0	15.0	9.0	1.0	1.0	#N/A	#N/A	711.0	0.2	183.20	0.28	122.07	0.52
F07	PMPDF	OT	MacDonald et. al (1984)	Expected	Linear	712.0	706.0	3.1	0.1	0.5	0.5	#N/A	#N/A	711.4	0.2	212.49	16.78	431.47	12.43
F08	SD	OT	MacDonald et. al (1984)	Expected	Linear	712.0	706.5	2.8	0.0	0.5	0.5	#N/A	#N/A	711.0	0.1	27.43	0.25	21.79	0.85
F09	PMPDF	PI	Froehlich (2008)	Expected	Linear	712.0	706.0	16.9	12.7	0.7	0.7	706.0	0.6	711.4	0.4	351.07	16.80	502.01	16.98
F10	SD	PI	Froehlich (2008)	Expected	Linear	712.0	706.0	13.0	8.8	0.7	0.7	706.0	0.6	711.0	0.4	124.71	0.35	102.95	0.65
F11	PMPDF	PI	Von Thun and Gillette (1990)	Expected	Linear	712.0	706.0	19.6	13.6	1.0	1.0	706.0	0.6	711.4	0.9	317.11	17.08	475.93	17.20
F12	SD	PI	Von Thun and Gillette (1990)	Expected	Linear	712.0	706.0	18.6	12.6	1.0	1.0	706.0	0.6	711.0	0.9	121.17	0.58	96.45	0.80
F13	PMPDF	PI	USBR (1988)	Expected	Linear	712.0	706.0	16.2	12.0	0.7	0.7	706.0	0.6	711.4	0.2	379.71	16.73	525.31	16.88
F14	SD	PI	USBR (1988)	Expected	Linear	712.0	706.0	15.0	10.8	0.7	0.7	706.0	0.6	711.0	0.2	172.46	0.23	125.81	0.48
F15	PMPDF	PI	MacDonald et. al (1984)	Expected	Linear	712.0	706.0	3.1	0.1	0.5	0.5	706.0	0.6	711.4	0.2	213.82	16.80	431.47	12.43
F16	SD	PI	MacDonald et. al (1984)	Expected	Linear	712.0	706.5	2.8	0.0	0.5	0.5	706.5	0.6	711.0	0.1	27.64	0.27	21.94	0.87

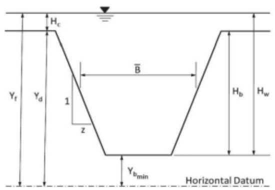

Figure 1. Typical Breach Cross Section

After inspection of these results, the Froehlich (2008) empirical breach parameter estimation methodology was selected as representative for the Dargues Reef TSF. The highlighted Failure (F) scenarios for PMPDF and SD initiating events (for the OT failure mode) along with the Non-Failure (NF) scenario are selected for detailed hydraulic modelling (HEC-RAS).

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Runoff Estimation: 1.0E-07 AEP, Breach Impact Analysis (Rainfall / Runoff Model Input - 1)

Peak runoff for the PMP storm (having an Annual Exceedance Probability, AEP of 1.0E-07) is estimated for a portion of the Majors Creek catchment (including the proposed Dargues Reef Gold WFSF) for purposes of breach impact assessment.

a) PMP (Probable Maximum Precipitation) rainfall depths for various durations at the Dargues Reef site are determined by using procedures discussed in "The Estimation of Probable Maximum Precipitation in Australia", June 2003 (GSDM) and "Development of the Generalised Southeast Australia Method for Estimating Probable Maximum Precipitation, HRS Report No.4", August 1996 (GSAM). This step results in the creation of a *depth-duration-frequency* (DDF) curve for the PMP frequency, which was estimated as 1.0E-07 (1 in 10,000,000) AEP for the Majors Creek Catchment (including the Project site) to the downstream point of analysis.

b) The rainfall depth for a critical duration (2 hours for short-duration PMP, 24 hours for long-duration PMP) at a 1.0E-07 AEP frequency is used with a template pattern derived from GSDM and GSAM to derive a time distributions of rainfall (*hyetograph*). This potential design storm is the primary hydrologic input to outflow estimation. Depths are spatially-varied to reflect expected changes in intensity over the area of the design storm.

c) *Rainfall excess* is estimated in HEC-HMS software for the Dargues Reef Diversion channel sizing using the Initial Loss / Constant Loss (IL/CL) model as discussed in Book 2, Section 3 and Book 6, Section 4 of Australian Rainfall and Runoff (ARR), 1999. Specific values for NSW are calculated from Book 2, Table 3.2.

AEP =	1.0E-07
IL (mm) =	0.1
CL (mm/h) =	1

⇦ assigned for PMP over the Majors Creek catchment of 19.6 km²

d) Rainfall excess is transformed to *runoff hydrographs* using the Clark synthetic unit hydrograph method. As formulated in the HEC-HMS model, the two primary inputs for this method are the time of concentration (t_c) and a basin storage coefficient (K). For Eastern New South Wales, times of concentration may be estimated using the following relationship, taken from ARR 1999, Volume 1, Book 4, Section 1.4.1:

$$t_c = 0.76 \cdot A^{0.38}$$

where: t_c = time of concentration (h) and
A = catchment area (km²).

The basin storage coefficient may be estimated using the following relationship, taken from ARR 1999, Volume 1, Book 5, Section 2.6.2:

$$K = 0.7 \cdot L^{0.57}$$

where: K = storage coefficient (h) and
L = main stream length (km).

e) The assembled data is then used to compute the estimated outflow hydrographs at various locations for the selected storm duration and frequency (in this case, AEP = 1.0E-07).

The various catchment configuration parameters used for constructing the HEC-HMS model are given below:

Sub-Catchment ID	Sub-Cat. Area A (km²)	Spatial-Distribution of PMP Rainfall for Short-Duration Storms % of Sub-Catchment in Ellipse: A	B	C	Sub-Cat. Topo. Adj. Factor TAF_{sc}	Sub-Cat. Length L (km)	Time of Concentration t_c (h)	Storage Coefficient K (h)
SC01	2.9997	0.00%	60.92%	39.08%	1.800	3.5358	1.1537	1.4379
SC02	3.2088	19.30%	62.12%	18.57%	1.790	3.0708	1.1836	1.3269
SC03	3.4216	30.59%	52.23%	17.18%	1.770	3.4913	1.2129	1.4276
SC04	0.3963	83.44%	16.56%	0.00%	1.770	0.9727	0.5346	0.6890
SC05	0.7246	11.85%	86.25%	1.90%	1.760	2.3504	0.6724	1.1393
SC06	0.9020	0.00%	100.00%	0.00%	1.750	1.5565	0.7308	0.9008
SC07	0.3094	0.00%	100.00%	0.00%	1.740	1.0514	0.4867	0.7203
SC08	0.8528	0.00%	32.47%	67.53%	1.730	1.3028	0.7154	0.8139
SC09_DC001	0.0564	0.00%	100.00%	0.00%	1.740	0.1744	0.2549	0.2587
SC09_DC002	0.0587	0.00%	100.00%	0.00%	1.750	0.2789	0.2588	0.3380
SC09_POND	0.0851	0.00%	100.00%	0.00%	1.750	0.2691	0.2980	0.3312
SC10	0.1197	68.86%	31.14%	0.00%	1.770	0.7424	0.3392	0.5907
SC11	2.0705	2.01%	87.76%	10.23%	1.750	2.7317	1.0021	1.2413
SC12	1.7703	22.37%	77.63%	0.00%	1.770	2.3487	0.9442	1.1389
SC13	2.0847	0.00%	39.38%	60.62%	1.770	2.3168	1.0047	1.1300
SC14	0.5318	0.00%	86.73%	13.27%	1.760	1.5601	0.5978	0.9020

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Runoff Estimation: 1.0E-07 AEP, Breach Impact Analysis (Rainfall / Runoff Model Input - 2): GSDM For Short Duration PMP, Temporal Distributions for Spatially-Distributed Rainfall

Estimated PMP values for various durations are distributed into hyetographs using the design temporal distribution for short duration PMP given in GSDM, Table 1. PMP values for all durations are taken from an envelope curve fitted to the computed PMP values.

Show hyetographs for: Ellipse A

Storm Duration (h)		0.250	0.333	0.417	0.5	0.75	1.0	1.5	2.0	2.5	3.0	4.0	4.5	5.0	6.0
PMP Depth (mm)	Ellipse A	149	173	195	215	272	316	407	476	526	577	660	694	727	768
	Ellipse B	128	150	171	190	241	283	362	423	467	510	582	612	639	681
	Ellipse C	123	143	161	177	224	266	342	399	444	479	545	571	596	640

Storm Duration (h) 0.250		
Elapsed Time (min)	Rainfall Depth Instant. (mm)	Rainfall Depth Cum. (mm)
0	0.0	0.0
5	64.9	64.9
10	56.5	121.3
15	27.2	148.6

Storm Duration (h) 0.333		
Elapsed Time (min)	Rainfall Depth Instant. (mm)	Rainfall Depth Cum. (mm)
0	0.0	0.0
5	55.4	55.4
10	55.4	110.9
15	43.3	154.2
20	19.1	173.3

Storm Duration (h) 0.417		
Elapsed Time (min)	Rainfall Depth Instant. (mm)	Rainfall Depth Cum. (mm)
0	0.0	0.0
5	48.8	48.8
10	52.7	101.5
15	44.9	146.4
20	33.2	179.6
25	15.6	195.2

Storm Duration (h) 0.50		
Elapsed Time (min)	Rainfall Depth Instant. (mm)	Rainfall Depth Cum. (mm)
0	0.0	0.0
5	43.8	43.8
10	50.2	94.0
15	43.8	137.7
20	38.0	175.7
25	26.5	202.3
30	12.9	215.2

Storm Duration (h) 0.75		
Elapsed Time (min)	Rainfall Depth Instant. (mm)	Rainfall Depth Cum. (mm)
0	0.0	0.0
5	32.1	32.1
10	44.5	76.5
15	42.3	118.8
20	39.6	158.5
25	33.6	192.0
30	30.2	222.3
35	24.5	246.8
40	16.0	262.8
45	9.4	272.2

Storm Duration (h) 1.0		
Elapsed Time (min)	Rainfall Depth Instant. (mm)	Rainfall Depth Cum. (mm)
0	0.0	0.0
5	25.3	25.3
10	38.9	64.2
15	36.8	101.0
20	36.8	137.9
25	33.7	171.5
30	30.5	202.1
35	29.5	231.5
40	26.3	257.8
45	23.2	281.0
50	15.8	296.8
55	11.6	308.3
60	7.4	315.7

Storm Duration (h) 1.5		
Elapsed Time (min)	Rainfall Depth Instant. (mm)	Rainfall Depth Cum. (mm)
0	0.0	0.0
5	19.0	19.0
10	29.0	48.0
15	34.8	82.8
20	31.7	114.5
25	31.7	146.2
30	31.7	177.8
35	28.5	206.4
40	30.8	237.1
45	23.5	260.7
50	26.7	287.4
55	22.6	310.0
60	22.6	332.6
65	20.8	353.4
70	15.8	369.3
75	13.6	382.8
80	10.4	393.3
85	9.1	402.3
90	5.0	407.3

Short Duration PMP (≤6-h)			
Position i		*Position i+1*	
Fraction of Storm Duration	Fraction of Storm PMP	Fraction of Storm Duration	Fraction of Storm PMP
0%	0%	5%	4%
5%	4%	10%	10%
10%	10%	15%	18%
15%	18%	20%	25%
20%	25%	25%	32%
25%	32%	30%	39%
30%	39%	35%	46%
35%	46%	40%	52%
40%	52%	45%	59%
45%	59%	50%	64%
50%	64%	55%	70%
55%	70%	60%	75%
60%	75%	65%	80%
65%	80%	70%	85%
70%	85%	75%	89%
75%	89%	80%	92%
80%	92%	85%	95%
85%	95%	90%	97%
90%	97%	95%	99%
95%	99%	100%	100%
100%	100%		

Storm Duration (h) 2.0		
Elapsed Time (min)	Rainfall Depth Instant. (mm)	Rainfall Depth Cum. (mm)
0	0.0	0.0
5	15.9	15.9
10	22.2	38.1
15	28.6	66.7
20	30.2	96.9
25	27.8	124.7
30	27.8	152.5
35	27.8	180.3
40	27.8	208.0
45	25.4	233.5
50	25.4	258.9
55	26.2	285.1
60	19.9	304.9
65	23.8	328.7
70	20.6	349.4
75	19.9	369.2
80	19.9	389.1
85	19.1	408.2
90	15.9	424.0
95	11.9	435.9
100	11.9	447.9
105	9.5	457.4
110	7.9	465.3
115	7.1	472.5
120	4.0	476.4

Storm Duration (h) 2.5		
Elapsed Time (h)	Rainfall Depth Instant. (mm)	Rainfall Depth Cum. (mm)
0.00	0.0	0.0
0.25	52.6	52.6
0.50	78.9	131.4
0.75	73.6	205.0
1.00	68.3	273.4
1.25	63.1	336.5
1.50	57.8	394.3
1.75	52.6	446.9
2.00	36.8	483.7
2.25	26.3	510.0
2.50	15.8	525.8

Storm Duration (h) 3.0		
Elapsed Time (h)	Rainfall Depth Instant. (mm)	Rainfall Depth Cum. (mm)
0.00	0.0	0.0
0.25	46.2	46.2
0.50	71.2	117.3
0.75	67.3	184.6
1.00	67.3	252.0
1.25	61.5	313.5
1.50	55.8	369.3
1.75	53.9	423.1
2.00	48.1	471.2
2.25	42.3	513.5
2.50	28.8	542.4
2.75	21.2	563.5
3.00	13.5	577.0

Storm Duration (h) 4.0		
Elapsed Time (h)	Rainfall Depth Instant. (mm)	Rainfall Depth Cum. (mm)
0.00	0.0	0.0
0.25	36.3	36.3
0.50	56.1	92.3
0.75	61.0	153.4
1.00	57.7	211.1
1.25	57.7	268.8
1.50	54.4	323.2
1.75	54.4	377.6
2.00	44.5	422.1
2.25	47.8	470.0
2.50	41.2	511.2
2.75	41.2	552.4
3.00	34.6	587.0
3.25	24.7	611.8
3.50	21.4	633.2
3.75	16.5	649.7
4.00	9.9	659.6

Storm Duration (h) 4.5		
Elapsed Time (h)	Rainfall Depth Instant. (mm)	Rainfall Depth Cum. (mm)
0.00	0.0	0.0
0.25	32.4	32.4
0.50	49.4	81.8
0.75	59.4	141.2
1.00	54.0	195.2
1.25	54.0	249.2
1.50	54.0	303.2
1.75	48.6	351.8
2.00	52.5	404.2
2.25	40.1	444.3
2.50	45.5	489.8
2.75	38.6	528.4
3.00	38.6	567.0
3.25	35.5	602.5
3.50	27.0	629.5
3.75	23.1	652.6
4.00	17.7	670.4
4.25	15.4	685.8
4.50	8.5	694.3

Storm Duration (h) 5.0		
Elapsed Time (h)	Rainfall Depth Instant. (mm)	Rainfall Depth Cum. (mm)
0.00	0.0	0.0
0.25	29.1	29.1
0.50	43.6	72.7
0.75	58.1	130.8
1.00	50.9	181.7
1.25	50.9	232.6
1.50	50.9	283.5
1.75	50.9	334.3
2.00	43.6	378.0
2.25	50.9	428.8
2.50	36.3	465.2
2.75	43.6	508.8
3.00	36.3	545.1
3.25	36.3	581.5
3.50	36.3	617.8
3.75	29.1	646.9
4.00	21.8	668.7
4.25	21.8	690.5
4.50	14.5	705.0
4.75	14.5	719.6
5.00	7.3	726.8

Storm Duration (h) 6.0		
Elapsed Time (h)	Rainfall Depth Instant. (mm)	Rainfall Depth Cum. (mm)
0.00	0.0	0.0
0.25	25.6	25.6
0.50	35.9	61.5
0.75	46.1	107.6
1.00	48.7	156.3
1.25	44.8	201.1
1.50	44.8	245.9
1.75	44.8	290.7
2.00	44.8	335.6
2.25	41.0	376.5
2.50	41.0	417.5
2.75	42.3	459.8
3.00	32.0	491.8
3.25	38.4	530.2
3.50	33.3	563.5
3.75	32.0	595.6
4.00	32.0	627.6
4.25	30.7	658.3
4.50	25.6	683.9
4.75	19.2	703.1
5.00	19.2	722.4
5.25	15.4	737.7
5.50	12.8	750.5
5.75	11.5	762.1
6.00	6.4	768.5

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	TSF Breach Impact Analysis	Approved	

Runoff Estimation: 1.0E-07 AEP, Breach Impact Analysis (Rainfall / Runoff Model Input - 2): GSDM For Short Duration PMP, Temporal Distributions for Spatially-Distributed Rainfall

Estimated PMP values for various durations are distributed into hyetographs using the design temporal distribution for short duration PMP given in GSDM, Table 1. PMP values for all durations are taken from an envelope curve fitted to the computed PMP values.

Design X-hour duration (2-h shown) hyetographs for PMP are then formulated for each sub-catchment by computing areal-weighted averages of the their respective total PMP rainfall. The previously-computed areal averages are employed.
The total sub-catchment specific rainfall depths are then temporally distributed using the design temporal distribution for short duration PMP given in GSDM, Table 1.

Sub-Catchment		SC01	SC02	SC03	SC04	SC05	SC06	SC07	SC08
Storm Duration (h)		2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000
PMP Depth (mm)	Ellipse A	476	476	476	476	476	476	476	476
	Ellipse B	423	423	423	423	423	423	423	423
	Ellipse C	399	399	399	399	399	399	399	399
% of Sub-C. in Ellipse	Ellipse A	0.00%	19.30%	30.59%	83.44%	11.85%	0.00%	0.00%	0.00%
	Ellipse B	60.92%	62.12%	52.23%	16.56%	86.25%	100.00%	100.00%	32.47%
	Ellipse C	39.08%	18.57%	17.18%	0.00%	1.90%	0.00%	0.00%	67.53%
Areal Ave. PMP (mm)		414	429	435	468	429	423	423	407

SC01 Elapsed Time (h)	SC01 Instant. (mm)	SC01 Cum. (mm)	SC02 Elapsed Time (h)	SC02 Instant. (mm)	SC02 Cum. (mm)	SC03 Elapsed Time (h)	SC03 Instant. (mm)	SC03 Cum. (mm)	SC04 Elapsed Time (h)	SC04 Instant. (mm)	SC04 Cum. (mm)
0.000	0.0	0.0	0.000	0.0	0.0	0.000	0.0	0.0	0.000	0.0	0.0
0.083	13.8	13.8	0.083	14.3	14.3	0.083	14.5	14.5	0.083	15.6	15.6
0.167	19.3	33.1	0.167	20.0	34.3	0.167	20.3	34.8	0.167	21.8	37.4
0.250	24.8	57.9	0.250	25.7	60.0	0.250	26.1	60.9	0.250	28.1	65.5
0.333	26.2	84.1	0.333	27.2	87.2	0.333	27.6	88.5	0.333	29.6	95.1
0.417	24.1	108.2	0.417	25.0	112.2	0.417	25.4	113.9	0.417	27.3	122.4
0.500	24.1	132.3	0.500	25.0	137.2	0.500	25.4	139.3	0.500	27.3	149.6
0.583	24.1	156.5	0.583	25.0	162.2	0.583	25.4	164.7	0.583	27.3	176.9
0.667	24.1	180.6	0.667	25.0	187.3	0.667	25.4	190.0	0.667	27.3	204.2
0.750	22.1	202.6	0.750	22.9	210.1	0.750	23.2	213.3	0.750	24.9	229.1
0.833	22.1	224.7	0.833	22.9	233.0	0.833	23.2	236.5	0.833	24.9	254.1
0.917	22.7	247.4	0.917	23.6	256.6	0.917	23.9	260.4	0.917	25.7	279.8
1.000	17.2	264.7	1.000	17.9	274.5	1.000	18.1	278.5	1.000	19.5	299.3
1.083	20.7	285.4	1.083	21.4	295.9	1.083	21.8	300.3	1.083	23.4	322.6
1.167	17.9	303.3	1.167	18.6	314.5	1.167	18.9	319.2	1.167	20.3	342.9
1.250	17.2	320.5	1.250	17.9	332.4	1.250	18.1	337.3	1.250	19.5	362.4
1.333	17.2	337.7	1.333	17.9	350.2	1.333	18.1	355.4	1.333	19.5	381.9
1.417	16.5	354.3	1.417	17.2	367.4	1.417	17.4	372.8	1.417	18.7	400.6
1.500	13.8	368.1	1.500	14.3	381.7	1.500	14.5	387.3	1.500	15.6	416.2
1.583	10.3	378.4	1.583	10.7	392.4	1.583	10.9	398.2	1.583	11.7	427.9
1.667	10.3	388.7	1.667	10.7	403.1	1.667	10.9	409.1	1.667	11.7	439.5
1.750	8.3	397.0	1.750	8.6	411.7	1.750	8.7	417.8	1.750	9.4	448.9
1.833	6.9	403.9	1.833	7.1	418.8	1.833	7.3	425.1	1.833	7.8	456.7
1.917	6.2	410.1	1.917	6.4	425.3	1.917	6.5	431.6	1.917	7.0	463.7
2.000	3.4	413.6	2.000	3.6	428.9	2.000	3.6	435.2	2.000	3.9	467.6

SC05 Elapsed Time (h)	SC05 Instant. (mm)	SC05 Cum. (mm)	SC06 Elapsed Time (h)	SC06 Instant. (mm)	SC06 Cum. (mm)	SC07 Elapsed Time (h)	SC07 Instant. (mm)	SC07 Cum. (mm)	SC08 Elapsed Time (h)	SC08 Instant. (mm)	SC08 Cum. (mm)
0.000	0.0	0.0	0.000	0.0	0.0	0.000	0.0	0.0	0.000	0.0	0.0
0.083	14.3	14.3	0.083	14.1	14.1	0.083	14.1	14.1	0.083	13.6	13.6
0.167	20.0	34.3	0.167	19.7	33.8	0.167	19.7	33.8	0.167	19.0	32.5
0.250	25.7	60.0	0.250	25.4	59.2	0.250	25.4	59.2	0.250	24.4	56.9
0.333	27.2	87.2	0.333	26.8	86.0	0.333	26.8	86.0	0.333	25.8	82.7
0.417	25.0	112.2	0.417	24.7	110.7	0.417	24.7	110.7	0.417	23.7	106.4
0.500	25.0	137.3	0.500	24.7	135.4	0.500	24.7	135.4	0.500	23.7	130.1
0.583	25.0	162.3	0.583	24.7	160.1	0.583	24.7	160.1	0.583	23.7	153.8
0.667	25.0	187.3	0.667	24.7	184.7	0.667	24.7	184.7	0.667	23.7	177.6
0.750	22.9	210.2	0.750	22.6	207.3	0.750	22.6	207.3	0.750	21.7	199.3
0.833	22.9	233.0	0.833	22.6	229.9	0.833	22.6	229.9	0.833	21.7	220.9
0.917	23.6	256.6	0.917	23.3	253.1	0.917	23.3	253.1	0.917	22.4	243.3
1.000	17.9	274.5	1.000	17.6	270.8	1.000	17.6	270.8	1.000	16.9	260.3
1.083	21.4	296.0	1.083	21.2	291.9	1.083	21.2	291.9	1.083	20.3	280.6
1.167	18.6	314.5	1.167	18.3	310.2	1.167	18.3	310.2	1.167	17.6	298.2
1.250	17.9	332.4	1.250	17.6	327.9	1.250	17.6	327.9	1.250	16.9	315.1
1.333	17.9	350.3	1.333	17.6	345.5	1.333	17.6	345.5	1.333	16.9	332.1
1.417	17.2	367.4	1.417	16.9	362.4	1.417	16.9	362.4	1.417	16.3	348.4
1.500	14.3	381.7	1.500	14.1	376.5	1.500	14.1	376.5	1.500	13.6	361.9
1.583	10.7	392.5	1.583	10.6	387.1	1.583	10.6	387.1	1.583	10.2	372.1
1.667	10.7	403.2	1.667	10.6	397.7	1.667	10.6	397.7	1.667	10.2	382.2
1.750	8.6	411.8	1.750	8.5	406.1	1.750	8.5	406.1	1.750	8.1	390.4
1.833	7.1	418.9	1.833	7.1	413.2	1.833	7.1	413.2	1.833	6.8	397.2
1.917	6.4	425.4	1.917	6.3	419.5	1.917	6.3	419.5	1.917	6.1	403.3
2.000	3.6	428.9	2.000	3.5	423.1	2.000	3.5	423.1	2.000	3.4	406.6

Knight Piésold CONSULTING	Subject: Cortona Resources	Made by: TML	Job No.: PE801-00139
	Dargues Reef Gold	Checked	Date: 12/11/2011
	TSF Breach Impact Analysis	Approved	

Runoff Estimation: 1.0E-07 AEP, Breach Impact Analysis (Rainfall / Runoff Model Input - 2): GSDM For Short Duration PMP, Temporal Distributions for Spatially-Distributed Rainfall

Estimated PMP values for various durations are distributed into hyetographs using the design temporal distribution for short duration PMP given in GSDM, Table 1. PMP values for all durations are taken from an envelope curve fitted to the computed PMP values.

Design X-hour duration (2-h shown) hyetographs for PMP are then formulated for each sub-catchment by computing areal-weighted averages of the their respective total PMP rainfall. The previously-computed areal averages are employed.
The total sub-catchment specific rainfall depths are then temporally distributed using the design temporal distribution for short duration PMP given in GSDM, Table 1.

Sub-Catchment		SC09_DC001	SC09_DC002	SC09_POND	SC10	SC11	SC12	SC13	SC14
Storm Duration (h)		2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000
PMP Depth (mm)	Ellipse A	476	476	476	476	476	476	476	476
	Ellipse B	423	423	423	423	423	423	423	423
	Ellipse C	399	399	399	399	399	399	399	399
% of Sub-C. in Ellipse	Ellipse A	0.00%	0.00%	0.00%	68.86%	2.01%	22.37%	0.00%	0.00%
	Ellipse B	100.00%	100.00%	100.00%	31.14%	87.76%	77.63%	39.38%	86.73%
	Ellipse C	0.00%	0.00%	0.00%	0.00%	10.23%	0.00%	60.62%	13.27%
Areal Ave. PMP (mm)		423	423	423	460	422	435	408	420

SC09_DC001 Elapsed Time (h)	Rainfall Depth Instant. (mm)	Rainfall Depth Cum. (mm)	SC09_DC002 Elapsed Time (h)	Rainfall Depth Instant. (mm)	Rainfall Depth Cum. (mm)	SC09_POND Elapsed Time (h)	Rainfall Depth Instant. (mm)	Rainfall Depth Cum. (mm)	SC10 Elapsed Time (h)	Rainfall Depth Instant. (mm)	Rainfall Depth Cum. (mm)
0.000	0.0	0.0	0.000	0.0	0.0	0.000	0.0	0.0	0.000	0.0	0.0
0.083	14.1	14.1	0.083	14.1	14.1	0.083	14.1	14.1	0.083	15.3	15.3
0.167	19.7	33.8	0.167	19.7	33.8	0.167	19.7	33.8	0.167	21.5	36.8
0.250	25.4	59.2	0.250	25.4	59.2	0.250	25.4	59.2	0.250	27.6	64.4
0.333	26.8	86.0	0.333	26.8	86.0	0.333	26.8	86.0	0.333	29.1	93.5
0.417	24.7	110.7	0.417	24.7	110.7	0.417	24.7	110.7	0.417	26.8	120.3
0.500	24.7	135.4	0.500	24.7	135.4	0.500	24.7	135.4	0.500	26.8	147.1
0.583	24.7	160.1	0.583	24.7	160.1	0.583	24.7	160.1	0.583	26.8	174.0
0.667	24.7	184.7	0.667	24.7	184.7	0.667	24.7	184.7	0.667	26.8	200.8
0.750	22.6	207.3	0.750	22.6	207.3	0.750	22.6	207.3	0.750	24.5	225.3
0.833	22.6	229.9	0.833	22.6	229.9	0.833	22.6	229.9	0.833	24.5	249.8
0.917	23.3	253.1	0.917	23.3	253.1	0.917	23.3	253.1	0.917	25.3	275.1
1.000	17.6	270.8	1.000	17.6	270.8	1.000	17.6	270.8	1.000	19.2	294.3
1.083	21.2	291.9	1.083	21.2	291.9	1.083	21.2	291.9	1.083	23.0	317.3
1.167	18.3	310.2	1.167	18.3	310.2	1.167	18.3	310.2	1.167	19.9	337.2
1.250	17.6	327.9	1.250	17.6	327.9	1.250	17.6	327.9	1.250	19.2	356.4
1.333	17.6	345.5	1.333	17.6	345.5	1.333	17.6	345.5	1.333	19.2	375.5
1.417	16.9	362.4	1.417	16.9	362.4	1.417	16.9	362.4	1.417	18.4	393.9
1.500	14.1	376.5	1.500	14.1	376.5	1.500	14.1	376.5	1.500	15.3	409.2
1.583	10.6	387.1	1.583	10.6	387.1	1.583	10.6	387.1	1.583	11.5	420.7
1.667	10.6	397.7	1.667	10.6	397.7	1.667	10.6	397.7	1.667	11.5	432.2
1.750	8.5	406.1	1.750	8.5	406.1	1.750	8.5	406.1	1.750	9.2	441.4
1.833	7.1	413.2	1.833	7.1	413.2	1.833	7.1	413.2	1.833	7.7	449.1
1.917	6.3	419.5	1.917	6.3	419.5	1.917	6.3	419.5	1.917	6.9	456.0
2.000	3.5	423.1	2.000	3.5	423.1	2.000	3.5	423.1	2.000	3.8	459.8

SC11 Elapsed Time (h)	Rainfall Depth Instant. (mm)	Rainfall Depth Cum. (mm)	SC12 Elapsed Time (h)	Rainfall Depth Instant. (mm)	Rainfall Depth Cum. (mm)	SC13 Elapsed Time (h)	Rainfall Depth Instant. (mm)	Rainfall Depth Cum. (mm)	SC14 Elapsed Time (h)	Rainfall Depth Instant. (mm)	Rainfall Depth Cum. (mm)
0.000	0.0	0.0	0.000	0.0	0.0	0.000	0.0	0.0	0.000	0.0	0.0
0.083	14.1	14.1	0.083	14.5	14.5	0.083	13.6	13.6	0.083	14.0	14.0
0.167	19.7	33.7	0.167	20.3	34.8	0.167	19.1	32.7	0.167	19.6	33.6
0.250	25.3	59.0	0.250	26.1	60.9	0.250	24.5	57.2	0.250	25.2	58.8
0.333	26.7	85.7	0.333	27.6	88.5	0.333	25.9	83.0	0.333	26.6	85.4
0.417	24.6	110.3	0.417	25.4	113.8	0.417	23.8	106.8	0.417	24.5	109.9
0.500	24.6	134.9	0.500	25.4	139.2	0.500	23.8	130.7	0.500	24.5	134.3
0.583	24.6	159.5	0.583	25.4	164.6	0.583	23.8	154.5	0.583	24.5	158.8
0.667	24.6	184.1	0.667	25.4	190.0	0.667	23.8	178.3	0.667	24.5	183.3
0.750	22.5	206.6	0.750	23.2	213.2	0.750	21.8	200.1	0.750	22.4	205.7
0.833	22.5	229.1	0.833	23.2	236.4	0.833	21.8	221.9	0.833	22.4	228.1
0.917	23.2	252.3	0.917	23.9	260.3	0.917	22.5	244.3	0.917	23.1	251.2
1.000	17.6	269.9	1.000	18.1	278.4	1.000	17.0	261.3	1.000	17.5	268.7
1.083	21.1	290.9	1.083	21.8	300.2	1.083	20.4	281.7	1.083	21.0	289.7
1.167	18.3	309.2	1.167	18.9	319.0	1.167	17.7	299.4	1.167	18.2	307.9
1.250	17.6	326.8	1.250	18.1	337.1	1.250	17.0	316.5	1.250	17.5	325.4
1.333	17.6	344.3	1.333	18.1	355.3	1.333	17.0	333.5	1.333	17.5	342.9
1.417	16.9	361.2	1.417	17.4	372.7	1.417	16.3	349.8	1.417	16.8	359.7
1.500	14.1	375.3	1.500	14.5	387.2	1.500	13.6	363.4	1.500	14.0	373.7
1.583	10.5	385.8	1.583	10.9	398.0	1.583	10.2	373.6	1.583	10.5	384.1
1.667	10.5	396.3	1.667	10.9	408.9	1.667	10.2	383.8	1.667	10.5	394.6
1.750	8.4	404.8	1.750	8.7	417.6	1.750	8.2	392.0	1.750	8.4	403.0
1.833	7.0	411.8	1.833	7.3	424.9	1.833	6.8	398.8	1.833	7.0	410.0
1.917	6.3	418.1	1.917	6.5	431.4	1.917	6.1	404.9	1.917	6.3	416.3
2.000	3.5	421.6	2.000	3.6	435.0	2.000	3.4	408.3	2.000	3.5	419.8

Knight Piésold CONSULTING	Subject Cortona Resources	Made by TML	Job No. PE801-00139
	Dargues Reef Gold	Checked	Date 12/11/2011
	TSF Breach Impact Analysis	Approved	

Runoff Estimation: 1.0E-07 AEP, Breach Impact Analysis (Rainfall / Runoff Model Input - 3): GSAM For Long Duration PMP, Temporal Distributions for Spatially-Distributed Rainfall

Estimated PMP values for various durations (duplicated below) are distributed into hyetographs using the design temporal distributions for long duration PMP given in GSAM CD 2006 Guidebook. PMP values for all durations are taken from an envelope curve fitted to the computed PMP values.

Storm Duration (h) =	24.0	30.0	36.0	48.0	72.0	96.0
PMP Depth (mm) =	1260	1340	1410	1480	1550	1600

⇦ Note: these are PMP values for the entire catchment, spatially-distributed values are derived below.

Storm Duration (h)	24.0		Storm Duration (h)	30.0		Storm Duration (h)	36.0		Storm Duration (h)	48.0		Storm Duration (h)	72.0		Storm Duration (h)	96.0	
Elapsed	Rainfall Depth		Elapsed	Rainfall Depth		Elapsed	Rainfall Depth		Elapsed	Rainfall Depth		Elapsed	Rainfall Depth		Elapsed	Rainfall Depth	
Time (h)	Instant. (mm)	Cum. (mm)	Time (min)	Instant. (mm)	Cum. (mm)	Time (h)	Instant. (mm)	Cum. (mm)	Time (h)	Instant. (mm)	Cum. (mm)	Time (h)	Instant. (mm)	Cum. (mm)	Time (h)	Instant. (mm)	Cum. (mm)
0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
1	23.9	23.9	2	36.4	36.4	2	26.3	26.3	2	14.8	14.8	3	14.0	14.0	3	12.8	12.8
2	23.9	47.9	4	46.0	82.4	4	36.7	63.0	4	22.2	37.0	6	24.8	38.8	6	14.4	27.2
3	23.9	71.8	6	63.0	145.4	6	47.0	110.0	6	29.6	66.6	9	43.4	82.2	9	17.6	44.8
4	37.0	108.8	8	77.9	223.3	8	68.6	178.6	8	38.5	105.1	12	46.5	128.7	12	24.0	68.8
5	37.0	145.7	10	100.4	323.7	10	77.6	256.2	10	46.9	151.9	15	34.1	162.8	15	27.2	96.0
6	37.0	182.7	12	109.6	433.4	12	86.5	342.6	12	55.3	207.2	18	57.4	220.1	18	17.6	113.6
7	59.6	242.3	14	120.9	554.3	14	90.2	432.9	14	85.8	293.0	21	83.7	303.8	21	14.4	128.0
8	59.6	302.0	16	113.3	667.5	16	87.9	520.8	16	95.2	388.3	24	102.3	406.1	24	32.0	160.0
9	59.6	361.6	18	114.6	782.2	18	85.5	606.3	18	104.6	492.8	27	144.2	550.3	27	62.3	222.3
10	84.0	445.6	20	132.5	914.7	20	79.9	686.2	20	137.1	630.0	30	178.3	728.5	30	80.1	302.4
11	84.0	529.6	22	120.4	1035.1	22	109.0	795.2	22	114.9	744.9	33	122.5	851.0	33	108.6	411.0
12	84.0	613.6	24	93.8	1129.0	24	138.2	933.4	24	92.7	837.7	36	108.5	959.5	36	112.2	523.2
13	71.4	685.0	26	88.0	1216.9	26	113.7	1047.2	26	65.1	902.8	39	105.4	1064.9	39	102.2	625.4
14	71.4	756.4	28	73.3	1290.2	28	97.3	1144.5	28	64.1	966.9	42	71.3	1136.2	42	85.0	710.4
15	71.4	827.8	30	49.8	1340.0	30	80.8	1225.3	30	63.1	1030.1	45	68.2	1204.4	45	67.1	777.5
16	62.6	890.4				32	93.1	1318.4	32	79.9	1110.0	48	80.6	1285.0	48	75.3	852.8
17	62.6	953.0				34	61.6	1379.9	34	77.9	1187.9	51	63.6	1348.5	51	84.7	937.5
18	62.6	1015.6				36	30.1	1410.0	36	76.0	1263.9	54	45.0	1393.5	54	78.5	1016.0
19	46.6	1062.2							38	53.3	1317.2	57	34.1	1427.6	57	67.1	1083.1
20	46.6	1108.8							40	49.3	1366.5	60	27.9	1455.5	60	75.3	1158.4
21	46.6	1155.4							42	45.4	1411.9	63	23.3	1478.7	63	92.7	1251.1
22	34.9	1190.3							44	33.5	1445.5	66	27.9	1506.6	66	81.7	1332.8
23	34.9	1225.1							46	22.7	1468.2	69	27.9	1534.5	69	55.9	1388.7
24	34.9	1260.0							48	11.8	1480.0	72	15.5	1550.0	72	44.9	1433.6
															75	36.7	1470.3
															78	25.7	1496.0
															81	14.4	1510.4
															84	8.0	1518.4
															87	19.2	1537.6
															90	24.0	1561.6
															93	22.4	1584.0
															96	16.0	1600.0

Knight Piésold CONSULTING	Subject: Cortona Resources	Made by: TML	Job No. PE801-00139
	Dargues Reef Gold	Checked	Date: 12/11/2011
	TSF Breach Impact Analysis	Approved	

Runoff Estimation: 1.0E-07 AEP, Breach Impact Analysis (Rainfall / Runoff Model Input - 3): GSAM For Long Duration PMP, Temporal Distributions for Spatially-Distributed Rainfall

Estimated PMP values for various durations (duplicated below) are distributed into hyetographs using the design temporal distributions for long duration PMP given in GSAM CD 2006 Guidebook. PMP values for all durations are taken from an envelope curve fitted to the computed PMP values.

Standard Project Area = 100 km^2 **PMP Convergence Application Zone =** CAZ

24-h Duration PMP			
Position i		*Position i+1*	
Fraction of Storm Duration	Fraction of Storm PMP	Fraction of Storm Duration	Fraction of Storm PMP
0.00%	0.00%	12.50%	5.70%
12.50%	5.70%	25.00%	14.50%
25.00%	14.50%	37.50%	28.70%
37.50%	28.70%	50.00%	48.70%
50.00%	48.70%	62.50%	65.70%
62.50%	65.70%	75.00%	80.60%
75.00%	80.60%	87.50%	91.70%
87.50%	91.70%	100.00%	100.00%
100.00%	100.00%		

30-h Duration PMP			
Position i		*Position i+1*	
Fraction of Storm Duration	Fraction of Storm PMP	Fraction of Storm Duration	Fraction of Storm PMP
0.00%	0.00%	5.00%	1.98%
5.00%	1.98%	10.00%	4.18%
10.00%	4.18%	15.00%	7.13%
15.00%	7.13%	20.00%	10.85%
20.00%	10.85%	25.00%	14.80%
25.00%	14.80%	30.00%	20.40%
30.00%	20.40%	35.00%	26.04%
35.00%	26.04%	40.00%	32.34%
40.00%	32.34%	45.00%	39.12%
45.00%	39.12%	50.00%	45.85%
50.00%	45.85%	55.00%	51.80%
55.00%	51.80%	60.00%	58.37%
60.00%	58.37%	65.00%	65.97%
65.00%	65.97%	70.00%	72.84%
70.00%	72.84%	75.00%	79.45%
75.00%	79.45%	80.00%	84.25%
80.00%	84.25%	85.00%	89.18%
85.00%	89.18%	90.00%	94.09%
90.00%	94.09%	95.00%	97.38%
95.00%	97.38%	100.00%	100.00%
100.00%	100.00%		

36-h Duration PMP			
Position i		*Position i+1*	
Fraction of Storm Duration	Fraction of Storm PMP	Fraction of Storm Duration	Fraction of Storm PMP
0.00%	0.00%	8.33%	2.80%
8.33%	2.80%	16.67%	7.80%
16.67%	7.80%	25.00%	15.10%
25.00%	15.10%	33.33%	24.30%
33.33%	24.30%	41.67%	33.90%
41.67%	33.90%	50.00%	43.00%
50.00%	43.00%	58.33%	51.50%
58.33%	51.50%	66.67%	66.20%
66.67%	66.20%	75.00%	78.30%
75.00%	78.30%	83.33%	86.90%
83.33%	86.90%	91.67%	96.80%
91.67%	96.80%	100.00%	100.00%
100.00%	100.00%		

48-h Duration PMP			
Position i		*Position i+1*	
Fraction of Storm Duration	Fraction of Storm PMP	Fraction of Storm Duration	Fraction of Storm PMP
0.00%	0.00%	6.25%	1.50%
6.25%	1.50%	12.50%	4.50%
12.50%	4.50%	18.75%	8.40%
18.75%	8.40%	25.00%	14.00%
25.00%	14.00%	31.25%	22.70%
31.25%	22.70%	37.50%	33.30%
37.50%	33.30%	43.75%	47.20%
43.75%	47.20%	50.00%	56.60%
50.00%	56.60%	56.25%	63.20%
56.25%	63.20%	62.50%	69.60%
62.50%	69.60%	68.75%	77.70%
68.75%	77.70%	75.00%	85.40%
75.00%	85.40%	81.25%	90.80%
81.25%	90.80%	87.50%	95.40%
87.50%	95.40%	93.75%	98.80%
93.75%	98.80%	100.00%	100.00%
100.00%	100.00%		

72-h Duration PMP			
Position i		*Position i+1*	
Fraction of Storm Duration	Fraction of Storm PMP	Fraction of Storm Duration	Fraction of Storm PMP
0.00%	0.00%	4.17%	0.90%
4.17%	0.90%	8.33%	2.50%
8.33%	2.50%	12.50%	5.30%
12.50%	5.30%	16.67%	8.30%
16.67%	8.30%	20.83%	10.50%
20.83%	10.50%	25.00%	14.20%
25.00%	14.20%	29.17%	19.60%
29.17%	19.60%	33.33%	26.20%
33.33%	26.20%	37.50%	35.50%
37.50%	35.50%	41.67%	47.00%
41.67%	47.00%	45.83%	54.90%
45.83%	54.90%	50.00%	61.90%
50.00%	61.90%	54.17%	68.70%
54.17%	68.70%	58.33%	73.30%
58.33%	73.30%	62.50%	77.70%
62.50%	77.70%	66.67%	82.90%
66.67%	82.90%	70.83%	87.00%
70.83%	87.00%	75.00%	89.90%
75.00%	89.90%	79.17%	92.10%
79.17%	92.10%	83.33%	93.90%
83.33%	93.90%	87.50%	95.40%
87.50%	95.40%	91.67%	97.20%
91.67%	97.20%	95.83%	99.00%
95.83%	99.00%	100.00%	100.00%
100.00%	100.00%		

96-h Duration PMP			
Position i		*Position i+1*	
Fraction of Storm Duration	Fraction of Storm PMP	Fraction of Storm Duration	Fraction of Storm PMP
0.00%	0.00%	3.13%	0.80%
3.13%	0.80%	6.25%	1.70%
6.25%	1.70%	9.38%	2.80%
9.38%	2.80%	12.50%	4.30%
12.50%	4.30%	15.63%	6.00%
15.63%	6.00%	18.75%	7.10%
18.75%	7.10%	21.88%	8.00%
21.88%	8.00%	25.00%	10.00%
25.00%	10.00%	28.13%	13.90%
28.13%	13.90%	31.25%	18.90%
31.25%	18.90%	34.38%	25.70%
34.38%	25.70%	37.50%	32.70%
37.50%	32.70%	40.63%	39.10%
40.63%	39.10%	43.75%	44.40%
43.75%	44.40%	46.88%	48.60%
46.88%	48.60%	50.00%	53.30%
50.00%	53.30%	53.13%	58.60%
53.13%	58.60%	56.25%	63.50%
56.25%	63.50%	59.38%	67.70%
59.38%	67.70%	62.50%	72.40%
62.50%	72.40%	65.63%	78.20%
65.63%	78.20%	68.75%	83.30%
68.75%	83.30%	71.88%	86.80%
71.88%	86.80%	75.00%	89.60%
75.00%	89.60%	78.13%	91.90%
78.13%	91.90%	81.25%	93.50%
81.25%	93.50%	84.38%	94.40%
84.38%	94.40%	87.50%	94.90%
87.50%	94.90%	90.63%	96.10%
90.63%	96.10%	93.75%	97.60%
93.75%	97.60%	96.88%	99.00%
96.88%	99.00%	100.00%	100.00%
100.00%	100.00%		

To spatially-distribute PMP, it is necessary to multiply each of the "Catchment PMP Estimate" values by the ratio of area-averaged TAF values:

$PMP_{sc,d} = PMP_{c,d} \times (TAF_{sc} / TAF_c)$

<u>where</u>:

$PMP_{c,d}$ = catchment (c) average PMP for duration (d);
$PMP_{sc,d}$ = sub-catchment (sc) average PMP for duration (d);
TAF_c = areal-average topographic adjustment factor for catchment (c); and
TAF_{sc} = areal-average topographic adjustment factor for sub-catchment (sc).

Knight Piésold CONSULTING	Subject: Cortona Resources	Made by: TML	Job No. PE801-00139
	Dargues Reef Gold	Checked	Date: 12/11/2011
	TSF Breach Impact Analysis	Approved	

Runoff Estimation: 1.0E-07 AEP, Breach Impact Analysis (Rainfall / Runoff Model Input - 3): GSAM For Long Duration PMP, Temporal Distributions for Spatially-Distributed Rainfall

Estimated PMP values for various durations (duplicated below) are distributed into hyetographs using the design temporal distributions for long duration PMP given in GSAM CD 2006 Guidebook. PMP values for all durations are taken from an envelope curve fitted to the computed PMP values.

Design X-hour duration (24-h shown) hyetographs for PMP are then formulated for each sub-catchment by computing areal-weighted averages of the their respective total PMP rainfall. The previously-computed areal averages are employed.
The total sub-catchment specific rainfall depths are then temporally distributed using the design temporal distribution for short duration PMP given in GSDM, Table 1.

Sub-Catchment		SC01	SC02	SC03	SC04	SC05	SC06	SC07	SC08
Storm Duration (h)		24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0
TAF	TAF_c	1.770	1.770	1.770	1.770	1.770	1.770	1.770	1.770
	TAF_{sc}	1.800	1.790	1.770	1.770	1.760	1.750	1.740	1.730
PMP (mm)	PMP_c	1260	1260	1260	1260	1260	1260	1260	1260
	PMP_{sc}	1281	1274	1260	1260	1253	1246	1239	1232

SC01 Elapsed Time (h)	SC01 Rainfall Depth Instant. (mm)	SC01 Rainfall Depth Cum. (mm)	SC02 Elapsed Time (h)	SC02 Rainfall Depth Instant. (mm)	SC02 Rainfall Depth Cum. (mm)	SC03 Elapsed Time (h)	SC03 Rainfall Depth Instant. (mm)	SC03 Rainfall Depth Cum. (mm)	SC04 Elapsed Time (h)	SC04 Rainfall Depth Instant. (mm)	SC04 Rainfall Depth Cum. (mm)
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0	24.3	24.3	1.0	24.2	24.2	1.0	23.9	23.9	1.0	23.9	23.9
2.0	24.3	48.7	2.0	24.2	48.4	2.0	23.9	47.9	2.0	23.9	47.9
3.0	24.3	73.0	3.0	24.2	72.6	3.0	23.9	71.8	3.0	23.9	71.8
4.0	37.6	110.6	4.0	37.4	110.0	4.0	37.0	108.8	4.0	37.0	108.8
5.0	37.6	148.2	5.0	37.4	147.4	5.0	37.0	145.7	5.0	37.0	145.7
6.0	37.6	185.8	6.0	37.4	184.8	6.0	37.0	182.7	6.0	37.0	182.7
7.0	60.7	246.4	7.0	60.3	245.1	7.0	59.6	242.3	7.0	59.6	242.3
8.0	60.7	307.1	8.0	60.3	305.4	8.0	59.6	302.0	8.0	59.6	302.0
9.0	60.7	367.7	9.0	60.3	365.7	9.0	59.6	361.6	9.0	59.6	361.6
10.0	85.4	453.2	10.0	84.9	450.7	10.0	84.0	445.6	10.0	84.0	445.6
11.0	85.4	538.6	11.0	84.9	535.6	11.0	84.0	529.6	11.0	84.0	529.6
12.0	85.4	624.0	12.0	84.9	620.6	12.0	84.0	613.6	12.0	84.0	613.6
13.0	72.6	696.6	13.0	72.2	692.8	13.0	71.4	685.0	13.0	71.4	685.0
14.0	72.6	769.2	14.0	72.2	765.0	14.0	71.4	756.4	14.0	71.4	756.4
15.0	72.6	841.9	15.0	72.2	837.2	15.0	71.4	827.8	15.0	71.4	827.8
16.0	63.6	905.5	16.0	63.3	900.5	16.0	62.6	890.4	16.0	62.6	890.4
17.0	63.6	969.1	17.0	63.3	963.7	17.0	62.6	953.0	17.0	62.6	953.0
18.0	63.6	1032.8	18.0	63.3	1027.0	18.0	62.6	1015.6	18.0	62.6	1015.6
19.0	47.4	1080.2	19.0	47.1	1074.2	19.0	46.6	1062.2	19.0	46.6	1062.2
20.0	47.4	1127.6	20.0	47.1	1121.3	20.0	46.6	1108.8	20.0	46.6	1108.8
21.0	47.4	1175.0	21.0	47.1	1168.5	21.0	46.6	1155.4	21.0	46.6	1155.4
22.0	35.5	1210.5	22.0	35.3	1203.7	22.0	34.9	1190.3	22.0	34.9	1190.3
23.0	35.5	1245.9	23.0	35.3	1239.0	23.0	34.9	1225.1	23.0	34.9	1225.1
24.0	35.5	1281.4	24.0	35.3	1274.2	24.0	34.9	1260.0	24.0	34.9	1260.0

SC05 Elapsed Time (h)	SC05 Rainfall Depth Instant. (mm)	SC05 Rainfall Depth Cum. (mm)	SC06 Elapsed Time (h)	SC06 Rainfall Depth Instant. (mm)	SC06 Rainfall Depth Cum. (mm)	SC07 Elapsed Time (h)	SC07 Rainfall Depth Instant. (mm)	SC07 Rainfall Depth Cum. (mm)	SC08 Elapsed Time (h)	SC08 Rainfall Depth Instant. (mm)	SC08 Rainfall Depth Cum. (mm)
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0	23.8	23.8	1.0	23.7	23.7	1.0	23.5	23.5	1.0	23.4	23.4
2.0	23.8	47.6	2.0	23.7	47.3	2.0	23.5	47.1	2.0	23.4	46.8
3.0	23.8	71.4	3.0	23.7	71.0	3.0	23.5	70.6	3.0	23.4	70.2
4.0	36.8	108.2	4.0	36.5	107.6	4.0	36.3	106.9	4.0	36.1	106.3
5.0	36.8	144.9	5.0	36.5	144.1	5.0	36.3	143.3	5.0	36.1	142.4
6.0	36.8	181.7	6.0	36.5	180.6	6.0	36.3	179.6	6.0	36.1	178.6
7.0	59.3	241.0	7.0	59.0	239.6	7.0	58.6	238.2	7.0	58.3	236.9
8.0	59.3	300.3	8.0	59.0	298.6	8.0	58.6	296.9	8.0	58.3	295.2
9.0	59.3	359.6	9.0	59.0	357.5	9.0	58.6	355.5	9.0	58.3	353.4
10.0	83.5	443.1	10.0	83.1	440.6	10.0	82.6	438.1	10.0	82.1	435.5
11.0	83.5	526.6	11.0	83.1	523.6	11.0	82.6	520.6	11.0	82.1	517.7
12.0	83.5	610.2	12.0	83.1	606.7	12.0	82.6	603.2	12.0	82.1	599.8
13.0	71.0	681.1	13.0	70.6	677.3	13.0	70.2	673.4	13.0	69.8	669.5
14.0	71.0	752.1	14.0	70.6	747.9	14.0	70.2	743.6	14.0	69.8	739.3
15.0	71.0	823.1	15.0	70.6	818.5	15.0	70.2	813.8	15.0	69.8	809.1
16.0	62.2	885.4	16.0	61.9	880.3	16.0	61.5	875.3	16.0	61.2	870.3
17.0	62.2	947.6	17.0	61.9	942.2	17.0	61.5	936.8	17.0	61.2	931.4
18.0	62.2	1009.8	18.0	61.9	1004.1	18.0	61.5	998.3	18.0	61.2	992.6
19.0	46.4	1056.2	19.0	46.1	1050.2	19.0	45.8	1044.2	19.0	45.6	1038.2
20.0	46.4	1102.5	20.0	46.1	1096.3	20.0	45.8	1090.0	20.0	45.6	1083.7
21.0	46.4	1148.9	21.0	46.1	1142.4	21.0	45.8	1135.8	21.0	45.6	1129.3
22.0	34.7	1183.6	22.0	34.5	1176.8	22.0	34.3	1170.1	22.0	34.1	1163.4
23.0	34.7	1218.2	23.0	34.5	1211.3	23.0	34.3	1204.4	23.0	34.1	1197.5
24.0	34.7	1252.9	24.0	34.5	1245.8	24.0	34.3	1238.6	24.0	34.1	1231.5

Knight Piésold CONSULTING	Subject	Made by	Job No.
	Cortona Resources	TML	PE801-00139
	Dargues Reef Gold	Checked	Date 12/11/2011
	TSF Breach Impact Analysis	Approved	

Runoff Estimation: 1.0E-07 AEP, Breach Impact Analysis (Rainfall / Runoff Model Input - 3): GSAM For Long Duration PMP, Temporal Distributions for Spatially-Distributed Rainfall

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Design X-hour duration (24-h shown) hyetographs for PMP are then formulated for each sub-catchment by computing areal-weighted averages of the their respective total PMP rainfall. The previously-computed areal averages are employed.
The total sub-catchment specific rainfall depths are then temporally distributed using the design temporal distribution for short duration PMP given in GSDM, Table 1.

Sub-Catchment		SC09_DC001	Sub-Catchment		SC09_DC002	Sub-Catchment		SC09_POND	Sub-Catchment		SC10
Storm Duration (h)		24.0	Storm Duration (h)		24.0	Storm Duration (h)		24.0	Storm Duration (h)		24.0
TAF	TAF_c	1.770	TAF	TAF_c	1.770	TAF	TAF_c	1.770	TAF	TAF_c	1.770
	TAF_{sc}	1.740		TAF_{sc}	1.750		TAF_{sc}	1.750		TAF_{sc}	1.770
PMP	PMP_c	1260	PMP	PMP_c	1260	PMP	PMP_c	1260	PMP	PMP_c	1260
(mm)	PMP_{sc}	1239	(mm)	PMP_{sc}	1246	(mm)	PMP_{sc}	1246	(mm)	PMP_{sc}	1260

Sub-Catchment		SC11	Sub-Catchment		SC12	Sub-Catchment		SC13	Sub-Catchment		SC14
Storm Duration (h)		24.0	Storm Duration (h)		24.0	Storm Duration (h)		24.0	Storm Duration (h)		24.0
TAF	TAF_c	1.770	TAF	TAF_c	1.770	TAF	TAF_c	1.770	TAF	TAF_c	1.770
	TAF_{sc}	1.750		TAF_{sc}	1.770		TAF_{sc}	1.770		TAF_{sc}	1.760
PMP	PMP_c	1260	PMP	PMP_c	1260	PMP	PMP_c	1260	PMP	PMP_c	1260
(mm)	PMP_{sc}	1246	(mm)	PMP_{sc}	1260	(mm)	PMP_{sc}	1260	(mm)	PMP_{sc}	1253

Elapsed Time (h)	Rainfall Depth Instant. (mm)	Rainfall Depth Cum. (mm)	Elapsed Time (h)	Rainfall Depth Instant. (mm)	Rainfall Depth Cum. (mm)	Elapsed Time (h)	Rainfall Depth Instant. (mm)	Rainfall Depth Cum. (mm)	Elapsed Time (h)	Rainfall Depth Instant. (mm)	Rainfall Depth Cum. (mm)
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0	23.5	23.5	1.0	23.7	23.7	1.0	23.7	23.7	1.0	23.9	23.9
2.0	23.5	47.1	2.0	23.7	47.3	2.0	23.7	47.3	2.0	23.9	47.9
3.0	23.5	70.6	3.0	23.7	71.0	3.0	23.7	71.0	3.0	23.9	71.8
4.0	36.3	106.9	4.0	36.5	107.6	4.0	36.5	107.6	4.0	37.0	108.8
5.0	36.3	143.3	5.0	36.5	144.1	5.0	36.5	144.1	5.0	37.0	145.7
6.0	36.3	179.6	6.0	36.5	180.6	6.0	36.5	180.6	6.0	37.0	182.7
7.0	58.6	238.2	7.0	59.0	239.6	7.0	59.0	239.6	7.0	59.6	242.3
8.0	58.6	296.9	8.0	59.0	298.6	8.0	59.0	298.6	8.0	59.6	302.0
9.0	58.6	355.5	9.0	59.0	357.5	9.0	59.0	357.5	9.0	59.6	361.6
10.0	82.6	438.1	10.0	83.1	440.6	10.0	83.1	440.6	10.0	84.0	445.6
11.0	82.6	520.6	11.0	83.1	523.6	11.0	83.1	523.6	11.0	84.0	529.6
12.0	82.6	603.2	12.0	83.1	606.7	12.0	83.1	606.7	12.0	84.0	613.6
13.0	70.2	673.4	13.0	70.6	677.3	13.0	70.6	677.3	13.0	71.4	685.0
14.0	70.2	743.6	14.0	70.6	747.9	14.0	70.6	747.9	14.0	71.4	756.4
15.0	70.2	813.8	15.0	70.6	818.5	15.0	70.6	818.5	15.0	71.4	827.8
16.0	61.5	875.3	16.0	61.9	880.3	16.0	61.9	880.3	16.0	62.6	890.4
17.0	61.5	936.8	17.0	61.9	942.2	17.0	61.9	942.2	17.0	62.6	953.0
18.0	61.5	998.3	18.0	61.9	1004.1	18.0	61.9	1004.1	18.0	62.6	1015.6
19.0	45.8	1044.2	19.0	46.1	1050.2	19.0	46.1	1050.2	19.0	46.6	1062.2
20.0	45.8	1090.0	20.0	46.1	1096.3	20.0	46.1	1096.3	20.0	46.6	1108.8
21.0	45.8	1135.8	21.0	46.1	1142.4	21.0	46.1	1142.4	21.0	46.6	1155.4
22.0	34.3	1170.1	22.0	34.5	1176.8	22.0	34.5	1176.8	22.0	34.9	1190.3
23.0	34.3	1204.4	23.0	34.5	1211.3	23.0	34.5	1211.3	23.0	34.9	1225.1
24.0	34.3	1238.6	24.0	34.5	1245.8	24.0	34.5	1245.8	24.0	34.9	1260.0

Elapsed Time (h)	Rainfall Depth Instant. (mm)	Rainfall Depth Cum. (mm)	Elapsed Time (h)	Rainfall Depth Instant. (mm)	Rainfall Depth Cum. (mm)	Elapsed Time (h)	Rainfall Depth Instant. (mm)	Rainfall Depth Cum. (mm)	Elapsed Time (h)	Rainfall Depth Instant. (mm)	Rainfall Depth Cum. (mm)
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0	23.7	23.7	1.0	23.9	23.9	1.0	23.9	23.9	1.0	23.8	23.8
2.0	23.7	47.3	2.0	23.9	47.9	2.0	23.9	47.9	2.0	23.8	47.6
3.0	23.7	71.0	3.0	23.9	71.8	3.0	23.9	71.8	3.0	23.8	71.4
4.0	36.5	107.6	4.0	37.0	108.8	4.0	37.0	108.8	4.0	36.8	108.2
5.0	36.5	144.1	5.0	37.0	145.7	5.0	37.0	145.7	5.0	36.8	144.9
6.0	36.5	180.6	6.0	37.0	182.7	6.0	37.0	182.7	6.0	36.8	181.7
7.0	59.0	239.6	7.0	59.6	242.3	7.0	59.6	242.3	7.0	59.3	241.0
8.0	59.0	298.6	8.0	59.6	302.0	8.0	59.6	302.0	8.0	59.3	300.3
9.0	59.0	357.5	9.0	59.6	361.6	9.0	59.6	361.6	9.0	59.3	359.6
10.0	83.1	440.6	10.0	84.0	445.6	10.0	84.0	445.6	10.0	83.5	443.1
11.0	83.1	523.6	11.0	84.0	529.6	11.0	84.0	529.6	11.0	83.5	526.6
12.0	83.1	606.7	12.0	84.0	613.6	12.0	84.0	613.6	12.0	83.5	610.2
13.0	70.6	677.3	13.0	71.4	685.0	13.0	71.4	685.0	13.0	71.0	681.1
14.0	70.6	747.9	14.0	71.4	756.4	14.0	71.4	756.4	14.0	71.0	752.1
15.0	70.6	818.5	15.0	71.4	827.8	15.0	71.4	827.8	15.0	71.0	823.1
16.0	61.9	880.3	16.0	62.6	890.4	16.0	62.6	890.4	16.0	62.2	885.4
17.0	61.9	942.2	17.0	62.6	953.0	17.0	62.6	953.0	17.0	62.2	947.6
18.0	61.9	1004.1	18.0	62.6	1015.6	18.0	62.6	1015.6	18.0	62.2	1009.8
19.0	46.1	1050.2	19.0	46.6	1062.2	19.0	46.6	1062.2	19.0	46.4	1056.2
20.0	46.1	1096.3	20.0	46.6	1108.8	20.0	46.6	1108.8	20.0	46.4	1102.5
21.0	46.1	1142.4	21.0	46.6	1155.4	21.0	46.6	1155.4	21.0	46.4	1148.9
22.0	34.5	1176.8	22.0	34.9	1190.3	22.0	34.9	1190.3	22.0	34.7	1183.6
23.0	34.5	1211.3	23.0	34.9	1225.1	23.0	34.9	1225.1	23.0	34.7	1218.2
24.0	34.5	1245.8	24.0	34.9	1260.0	24.0	34.9	1260.0	24.0	34.7	1252.9

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Runoff Estimation: Breach Impact Analysis (Rainfall / Runoff Model Output - 4)

A HEC-HMS hydrology model was created to assess the peak runoff and channel attenuation resulting from the various failure (F) and non-failure (NF) scenarios. (An initial screening of tests from the full grid was performed to identify the most representative possibilities under the various initial conditions and dam breach failure modes.) The following are results from those tests:

	Sim ID:	NF_PMPDF		F01_PMPDF_OT		F02_SD_OT	
HEC-HMS ID	HEC-RAS Station (m)	Peak Flow Q_{MAX} (m^3/s)	Time $t_{Q\text{-}MAX}$ (h)	Peak Flow Q_{MAX} (m^3/s)	Time $t_{Q\text{-}MAX}$ (h)	Peak Flow Q_{MAX} (m^3/s)	Time $t_{Q\text{-}MAX}$ (h)
0+230.0	230.0	364.56	12.43	461.12	17.05	112.49	0.68
0+530.0	530.0	364.56	12.42	461.62	17.05	112.74	0.67
0+830.0	830.0	364.56	12.42	462.20	17.03	112.77	0.67
1+130.0	1130.0	364.56	12.40	462.64	17.03	113.07	0.65
1+430.0	1430.0	364.57	12.40	462.96	17.02	113.42	0.63
1+730.0	1730.0	364.57	12.38	463.74	17.02	113.54	0.62
2+330.0	2330.0	292.86	12.37	406.12	17.00	114.15	0.60
2+630.0	2630.0	292.87	12.37	406.51	17.00	114.25	0.60
2+930.0	2930.0	292.87	12.37	406.52	17.00	114.67	0.58
20+750.0	20750.0	46.73	12.40	46.73	12.40	0.00	0.00
21+050.0	21050.0	46.73	12.38	46.73	12.38	0.00	0.00
21+350.0	21350.0	46.74	12.35	46.74	12.35	0.00	0.00
21+650.0	21650.0	46.74	12.32	46.74	12.32	0.00	0.00
3+230.0	3230.0	217.88	12.32	345.59	16.98	115.06	0.57
3+530.0	3530.0	217.89	12.32	346.82	16.97	115.44	0.55
3+830.0	3830.0	217.90	12.30	351.60	16.95	119.64	0.53
30+284.5	30284.5	12.04	12.15	12.04	12.15	0.00	0.00
30+584.5	30584.5	12.04	12.13	12.04	12.13	0.00	0.00
4+280.0	4280.0	208.99	12.28	367.96	16.93	146.11	0.48
4+880.0	4880.0	46.29	12.15	241.25	16.92	148.95	0.45
5+330.0	5330.0	26.01	12.13	229.30	16.90	152.07	0.43
5+630.0	5630.0	26.01	12.12	231.02	16.88	152.87	0.42
6+080.0	6080.0	19.04	12.12	19.04	12.12	0.00	0.00
CP01	0.0	431.47	12.43	515.83	17.07	112.21	0.70
CP02	1986.9	364.57	12.38	463.78	17.00	113.76	0.62
CP03	3146.6	292.87	12.35	407.41	16.98	114.75	0.58
CP04	4091.4	217.91	12.28	356.98	16.95	124.23	0.50
CP05	4528.5	208.99	12.27	369.05	16.93	147.88	0.47
CP06	5119.9	46.29	12.15	242.82	16.90	150.92	0.45
CP07	5903.3	26.01	12.10	232.31	16.88	156.07	0.42
CP08	6365.0	19.04	12.10	19.04	12.10	0.00	0.00
CP09	10250.0	2.93	18.37	220.32	16.87	159.53	0.40
CP10	20207.6	143.95	12.33	143.95	12.33	0.00	0.00
CP11	20431.6	98.39	12.32	98.39	12.32	0.00	0.00
CP12	21950.0	46.74	12.27	46.74	12.27	0.00	0.00
CP13	30884.5	12.04	12.10	12.04	12.10	0.00	0.00

Note: (All storm results taken at a duration of 24 h.) HEC-HMS output was filtered to provide junction output only. In addition, a minimum value of 0.01 m^3/s was enforced.

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	TSF Breach Impact Analysis	Approved	Sheet No.: 1 of 1

Breach Impact Analysis (Inundation Model Results Summary)

A HEC-RAS hydraulics model was created to assess the inundation resulting from the various failure (F) and non-failure (NF) scenarios selected from the HEC-HMS hydrologic routing results of the full testing grid. (Selected scenarios represent the most representative possibilities under the various initial conditions and dam breach failure modes.)

Inundation Analysis Scenario:			NF_PMPDF		F01_PMPDF_OT		F02_SD_OT	
HEC-RAS			Peak Flow	WS Elev.	Peak Flow	WS Elev.	Peak Flow	WS Elev.
River ID	Reach ID	Station (1000 m)	Q_{MAX} (m^3/s)	WSE_{Q-MAX} (m)	Q_{MAX} (m^3/s)	WSE_{Q-MAX} (m)	Q_{MAX} (m^3/s)	WSE_{Q-MAX} (m)
WFSF	MAIN	10.2500	2.93	682.36	220.32	685.13	159.53	681.94
WFSF	MAIN	10.2000	2.93	680.14	220.32	682.08	159.53	679.93
WFSF	MAIN	10.1500	2.93	678.21	220.32	680.88	159.53	677.87
WFSF	MAIN	10.1000	2.93	676.15	220.32	678.48	159.53	675.72
WFSF	MAIN	10.0500	2.93	674.01	220.32	675.93	159.53	673.69
WFSF	MAIN	10.0000	2.93	672.10	220.32	674.50	159.53	671.68
MCWT	MAIN	30.8845	12.04	680.44	12.01	680.44	0.01	680.00
MCWT	MAIN	30.7345	12.04	670.91	12.01	670.91	0.01	670.65
MCWT	MAIN	30.5845	12.04	665.50	12.04	665.50	0.01	665.00
MCWT	MAIN	30.4345	12.04	653.99	12.04	653.99	0.01	653.27
MCWT	MAIN	30.2845	12.04	647.34	12.04	647.34	0.01	646.59
MCWT	MAIN	30.0946	12.04	638.13	12.04	638.13	0.01	635.96
MCWT	MAIN	30.0000	12.04	638.04	12.04	638.04	0.01	633.99
MCW	UPPER	21.9500	46.74	668.40	46.74	668.40	0.01	667.74
MCW	UPPER	21.8000	46.74	665.88	46.74	665.88	0.01	664.73
MCW	UPPER	21.6500	46.74	665.53	46.74	665.53	0.01	664.28
MCW	UPPER	21.5000	46.74	664.77	46.74	664.77	0.01	664.00
MCW	UPPER	21.3500	46.74	660.64	46.74	660.64	0.01	660.01
MCW	UPPER	21.2000	46.74	656.23	46.74	656.23	0.01	655.00
MCW	UPPER	21.0500	46.73	654.43	46.73	654.43	0.01	653.38
MCW	UPPER	20.9000	46.73	646.51	46.73	646.51	0.01	645.44
MCW	UPPER	20.7500	46.73	642.61	46.73	642.61	0.01	642.00
MCW	UPPER	20.6120	46.73	638.27	46.73	638.27	0.01	635.96
MCW	UPPER	20.5070	46.73	637.10	46.73	637.10	0.01	633.99
MCW	LOWER	20.3920	98.39	635.62	98.39	635.62	0.01	633.92
MCW	LOWER	20.3000	98.39	634.76	98.39	634.76	0.01	633.75
MCW	LOWER	20.1500	98.39	633.00	98.39	633.00	0.01	631.91
MCW	LOWER	20.0000	98.39	631.49	98.39	631.49	0.01	629.95
MC	UPPER	6.3650	19.04	680.71	19.04	680.71	0.01	679.99
MC	UPPER	6.2300	19.04	678.55	19.04	678.55	0.01	677.91
MC	UPPER	6.0800	19.04	676.36	19.04	676.36	0.01	675.22
MC	UPPER	6.0100	19.04	672.93	19.04	672.93	0.01	671.87
MC	MID	5.8300	26.01	664.93	232.31	666.61	156.07	663.97
MC	MID	5.7800	26.01	664.09	232.31	665.05	156.07	663.59
MC	MID	5.6300	26.01	660.30	231.02	661.18	152.87	659.72
MC	MID	5.4800	26.01	656.34	231.02	658.43	152.87	655.61
MC	MID	5.3300	26.01	651.49	229.30	652.77	152.07	650.00
MC	MID	5.1800	26.01	648.02	229.30	649.20	152.07	647.22

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Breach Impact Analysis (Inundation Model Results Summary)

A HEC-RAS hydraulics model was created to assess the inundation resulting from the various failure (F) and non-failure (NF) scenarios selected from the HEC-HMS hydrologic routing results of the full testing grid. (Selected scenarios represent the most representative possibilities under the various initial conditions and dam breach failure modes.)

Inundation Analysis Scenario:			NF_PMPDF		F01_PMPDF_OT		F02_SD_OT	
HEC-RAS			Peak Flow	WS Elev.	Peak Flow	WS Elev.	Peak Flow	WS Elev.
River ID	Reach ID	Station (1000 m)	Q_{MAX} (m^3/s)	$WSE_{Q\text{-}MAX}$ (m)	Q_{MAX} (m^3/s)	$WSE_{Q\text{-}MAX}$ (m)	Q_{MAX} (m^3/s)	$WSE_{Q\text{-}MAX}$ (m)
MC	MID	5.0300	46.29	642.98	242.82	644.19	150.92	641.92
MC	MID	4.8800	46.29	636.51	241.25	637.34	148.95	635.90
MC	MID	4.7300	46.29	630.72	241.25	631.66	148.95	629.98
MC	LOWER	4.5200	208.99	628.94	369.05	630.21	147.88	627.52
MC	LOWER	4.4300	208.99	628.66	369.05	630.14	147.88	625.90
MC	LOWER	4.2800	208.99	628.64	367.96	630.12	146.11	623.99
MC	LOWER	4.1300	208.99	628.04	367.96	629.34	146.11	623.91
MC	LOWER	3.9800	217.91	627.36	356.98	628.55	124.23	623.27
MC	LOWER	3.8300	217.90	626.56	351.60	627.56	119.64	622.64
MC	LOWER	3.6800	217.90	626.46	351.60	627.70	119.64	622.00
MC	LOWER	3.5300	217.89	625.17	346.82	626.03	115.44	621.50
MC	LOWER	3.3800	217.89	622.77	346.82	623.13	115.44	621.00
MC	LOWER	3.2300	217.88	619.65	345.59	620.11	115.06	617.66
MC	LOWER	3.0800	292.87	615.31	407.41	615.78	114.75	613.00
MC	LOWER	2.9300	292.87	599.56	406.52	599.78	114.67	598.04
MC	LOWER	2.7800	292.87	574.04	406.52	574.43	114.67	571.29
MC	LOWER	2.6300	292.87	525.76	406.51	525.93	114.25	524.91
MC	LOWER	2.4800	292.87	493.78	406.51	493.97	114.25	492.02
MC	LOWER	2.3300	292.86	479.17	406.12	479.39	114.15	477.43
MC	LOWER	2.1800	292.86	449.68	406.12	449.85	114.15	448.77
MC	LOWER	2.0300	292.86	424.80	406.12	425.10	114.15	423.00
MC	LOWER	1.8800	364.57	418.79	463.78	418.70	113.76	416.37
MC	LOWER	1.7300	364.57	398.17	463.74	398.31	113.54	397.15
MC	LOWER	1.5800	364.57	386.40	463.74	386.53	113.54	385.38
MC	LOWER	1.4300	364.57	374.54	462.96	374.81	113.42	372.44
MC	LOWER	1.2800	364.57	367.00	462.96	367.11	113.42	366.00
MC	LOWER	1.1300	364.56	352.76	462.64	353.00	113.07	350.44
MC	LOWER	0.9800	364.56	348.48	462.64	348.68	113.07	346.41
MC	LOWER	0.8300	364.56	332.74	462.20	332.90	112.77	331.45
MC	LOWER	0.6800	364.56	318.37	462.20	318.63	112.77	316.19
MC	LOWER	0.5300	364.56	311.56	461.62	311.77	112.74	309.00
MC	LOWER	0.3800	364.56	303.62	461.62	303.79	112.74	301.92
MC	LOWER	0.2300	364.56	291.79	461.12	291.95	112.49	290.07
MC	LOWER	0.0800	364.56	288.03	461.12	288.16	112.49	286.72
MC	LOWER	0.0000	431.47	286.03	515.83	286.16	112.21	284.51

Comparison of the results show that the difference between inundation results caused by overtopping and piping (all other assumptions being equal) are minimal. Accordingly, the most conservative values (those for overtopping) were selected for final results analysis for the PMP Design Flood and Sunny Day initiating events (along with the non-failure scenario).

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