Bryn Pica Landfill Site
Surface Water Management

SURFACE WATER MANAGEMENT PLAN

Prepared by

ENCIA CONSULTING LIMITED

AMGEN Cymru

ALTERNATIVE SOLUTIONS IN WASTE MANAGEMENT

Report Ref: AM5456/02
Date: April 2007

SURFACE WATER MANAGEMENT PLAN
for
BRYN PICA LANDFILL SITE

Prepared for

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Project Quality Assurance
Information Sheet

Surface Water Management Plan Bryn Pica Landfill Site
AMGEN CYMRU

Report Number	:	AM5456/02	**Report Status**	:	Final
Report Date	:	April 2007			

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SURFACE WATER MANAGEMENT PLAN FOR
BRYN PICA LANDFILL SITE

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SUMMARY

This document represents the report requested under Item 5 of Table S1.3 in Schedule 1 to PPC Permit DP3732SQ ("the Permit"), which authorises the operation of the Bryn Pica Landfill site ("the Installation"), wherein the following is stated:

> *'The operator shall submit to the Agency a surface water management plan. The plan shall include, bit not be limited to, the following:*
>
> - *Drawings of the design and specification of all current surface water management drainage systems employed at the site (e.g. drainage ditches, lagoons etc).*
> - *Details of phasing of future works;*
> - *Details of all surface water treatment methods;*
> - *Demonstration by the use of rainfall and other meteorological data that surface water drainage system is designed to cope with storm events including details of the volume of surface water to be controlled;*
> - *Measures to ensure rainwater running off areas outside the landfill is intercepted and channeled away from construction, operational and post-closure phases;*
> - *Maintenance and repair of drainage channels and lagoons.*
> - *Review of the location and number of monitoring points.*
> - *Review of monitoring suite using all available monitoring data.*
> - *The setting/review of control and trigger levels for surface water management monitoring points where appropriate.*
> - *Timetable detailing any relevant works to be completed.*
>
> *The operator shall implement any improvements or measures as agreed in writing with the Environment Agency.'*

The date for compliance with the above, which forms part of the Improvement Plan for the Installation of the said Permit, is the 1st of May 2007.

Surface Water Management Plan

1. INTRODUCTION

Amgen Cymru commissioned **Encia Consulting Ltd.** to undertake the preparation of the Surface Water Management Plan at **Bryn Pica Landfill Site**. The Surface Water Management Plan has been prepared in relation to PPC PERMIT No. DP3732SQ Improvement Condition 7, and in line with the ongoing development of the Site and takes into account the proposed phased infilling of the Site.

It is considered that the purpose of this plan is to minimise, as far as practicably possible the risk associated with surface water contamination from the landfill site and associated activities, and shall include the following:

1. Details and design drawings of all current surface water management drainage systems employed at Bryn Pica.
2. Details of all future phasing and works.
3. Evidence that the surface water management system in operation at Bryn Pica can cope with storm events including volumes to be analysed for.
4. Review of the location and number of monitoring points.
5. Review of monitoring suites using all available monitoring data.

Operational areas have temporary surface water drainage to prevent surface water entering the waste disposal area. In each case, they convey surface water to the balancing ponds at the southern end of the site, which allow for the regulation of the surface water discharge from the site, made under Discharge Consent ref AN033510101, at National Grid Reference (NGR) SO 01242 04417.

Where potential improvements in landfill operations are identified any such remedial measures and associated timescales will be agreed in writing with the Environment Agency.

2. EXISTING SURFACE WATER DRAINAGE

The existing surface water drainage is summarised as detailed below. The drainage consists of a combination of lined and unlined ditches with piped road crossing points.

2.1 Temporary Drainage

2.1.1 The existing temporary drainage consists of the following:-

a) Drainage ditch to the east of the “low level” Haul Road, draining the eastern side slopes between the Site boundary and the “low level” Haul Road and eventually draining to the Southern Surface Water Lagoons;

b) Drainage ditch in the basal formation, draining the western side slopes of the “low level” Haul Road, the basal formation of the Landfill, and run-off from the temporary capped side slopes of phase 2 to the north of the Leachate Lagoons, eventually draining through to the Southern Surface Water Lagoons;

c) Drainage ditch to the south of the “low level” Haul Road, draining the haul roads in the southern part of the Landfill eventually draining through to the Southern Surface Water Lagoons.

2.1.2 These temporary drains connect to the main drainage ditch that feeds in the settlement lagoons located in the south-east corner of the Landfill Site.

2.2 Permanent Drainage

2.2.2 The existing permanent drainage consists of the following:-

a) Drainage ditches on the western slopes of Phase 1, draining to the Western Surface Water Lagoon;

b) Drainage ditches on the western flank of the Site, draining to the western boundary of the Site. These drains bypass the Western Surface Water Lagoon;

2.3 Surface Water Lagoons

2.3.1 The existing surface water lagoons consist of the following:-

a) Lagoon on the western side of the Site, commonly known as the Western Surface Water Lagoon. The lagoon discharges to an existing ditch on the western boundary of the Site.

b) Lagoons on the southern side of the Site, commonly known as the Southern Surface Water Lagoons. These Lagoons originally operated in parallel and discharge to the Perimeter Ditch on the southern boundary of the Site.

c) The addition of a Southern Surface Water Settlement Lagoon provided a greater settlement capacity in this area of the Site. This lagoon was constructed to the east of the current lagoons with alterations to the operation of the lagoons such that all three lagoons now operate in series not in parallel. The lagoons become primary, secondary and tertiary settlement and improve the water quality at the discharge location, and discharge to the Perimeter Ditch on the southern boundary of the Site.

2.4 External Drainage

2.4.1 The existing external intercepting drainage consists of the following:-

a) Perimeter drainage ditch to the eastern flank to the Site, primarily draining the upper slopes to the east of the Site.

3. PROPOSED SURFACE WATER DRAINAGE

The proposed surface water drainage has been designed on the basis of the proposed infilling of the Landfill. The phasing of the Site is detailed on the Existing Layout drawing No. AM5456/2/02a. The alterations proposed to the existing scheme are summarised below.

3.1 Temporary Drainage

3.1.1 The existing drainage ditch to the east of the “low level” Haul Road will be retained during the operation of Phase 2 and 3A. As Phase 3B is developed the upper sections of the drainage ditch will be removed to accommodate the cell construction. This procedure will not remove the drainage ability of the system as slopes previously drained will be consumed into the landfill construction and, will therefore, no longer require surface water drainage.

The same procedure will be adopted as Phase 4 and 5 are developed, ensuring the exposed slopes between the Perimeter Drainage Ditch and the “low level” Haul Road are continually drained.

3.1.2 The existing drainage ditch in the basal formation will be retained during the operation of Phase 2 and 3, however modifications to the ditch will be required as the footprint of the various cells in Phase 4 overlays the existing drainage ditch.

As Phase 4 and 5 are developed the modified drainage ditch adjacent to Phase 2 will be removed to accommodate the cell construction.

3.1.3 The existing drainage ditch to the south of the “low level” Haul Road will be retained throughout the operation of Phase 3, 4, 5A,5B, 5C, and 5D. The drain will be removed as the cell construction within Phase 5E is undertaken.

3.2 Permanent Drainage

3.2.1 No alterations will be made to the existing drainage ditches on the western slopes of Phase 1. As further capping works in Phase 2 are undertaken these drains will be extended in line with the design ability of the current system.

3.2.2 The majority of the existing drainage ditches on the western flank of the Site will be unaltered. The bypass section of the drain will be removed and the drain discharged into the Western Surface Water Lagoon. This alteration will ensure any sediments being transported by the drain are adequately dealt with.

3.3 Surface Water Lagoons

3.3.1 No alterations will be made to the Western Surface Water Lagoon. Subject to changes in the design of the permanent drainage, further lagoons may be constructed to achieve the required capacity in this area of the Site.

3.3.2 No alterations will be made to the Southern Surface Water Lagoon. Subject to changes in the design of the permanent drainage, further lagoons may be constructed to achieve the required capacity in this area of the Site.

3.3.3 As the landfill develops, a greater volume of the surface water will be drained from the permanent capped areas and therefore the performance criteria for the lagoons may change. The size and function of the lagoons will be modified to suit the site conditions.

3.3.4 During the development of Phase 5 the Southern Surface Water Lagoons will be replaced with suitable lagoons constructed outside of the footprint of the landfill. These lagoons are likely to be located adjacent to the Leachate Compound.

3.4 External Drainage

3.4.1 No alterations will be made to the existing Perimeter drainage ditch to the eastern flank to the Site.

3.5 Detailed Design of Drainage System

3.5.1 The lagoon sizing and drainage calculations have been carried out using the Micro-drainage software package. The surface water drainage scheme has been designed for a 1 in 100 year storm event.

3.5.2 The maximum level of suspended solids has been modelled to ensure the lagoon can adequately remove suspended solids throughout its design life and under all conditions. The relevant detailed drainage calculations are contained in Appendix B.

3.6 Maintenance and Repair of Drainage Channels and Lagoons

3.6.1 Maintenance and repair of drainage channels on site is carried out as and when required. All drainage channels are checked at least once a month for damage or blockages and any maintenance required reported and actioned.

3.6.2 Maintenance and repair of lagoons is also carried out when required, although the lagoons are dredged at least once a year to prevent blockage / build up of sludge in the base of the lagoons.

4. SURFACE WATER MONITORING PROCEDURES

4.1 Monthly Surface Water Monitoring

4.1.1 Amgen Cymru carries out monthly surface water quality monitoring inline with the requirements of the sites PPC Permit. Several points, both up and down dip of the landfill site are sampled with samples taken for laboratory analysis as well as in-situ readings.

4.1.2 Amgen Cymru's surface water monitoring regime consists of 7 fixed monitoring points situated around the site. A description of the surface water monitoring regime is provided below, according to each relevant surface water course. The location of these monitoring points in relation to the landfill is illustrated in Drawing. No. AM5456/2/003.

4.1.3 The surface water monitoring points along the Nant-y-Derlwyn stream are as follows:

- **SW1** (Upper Nant-y-Derlwyn) - Background surface water quality in the Nant-y-Derlwyn stream is monitored at SW1, which is located at NGR SO 0123 0575, approximately 550m north of the Installation. From this location, the stream flows down towards the site access road, at the northern end of the Installation.

- **SW 3** (Downstream of the old BPW landfill) – From the site access road, the stream is culverted beneath the old BPW landfill, for a distance of approximately 500m. Amgen continue to monitor any impact this old landfill has on the quality of surface water in the Nant-y-Derlwyn stream.

- **SW4a** (Lower Nant-y-Derlwyn) – Following its exit from beneath the old Bryn Pica West Landfill , the stream flows in a south westerly direction along the boundary of land owned by Amgen. Previously samples have been taken from SW4, on the downstream side of the abandoned railway line. However, since March 2005 samples have been taken from a point further down the Nant-y-Derlwyn due to health and safety concerns regarding access.

4.1.4 The surface water monitoring points located along the unnamed stream to the south of the Installation Boundary, which feeds the Ysguborwen Stream, are as follows:

- **SW 10** (Upstream of the Installation) – Since 2002 Amgen has carried out surface water monitoring of background surface water quality at a location directly east of the Bryn Pica Installation.

- **SW 11** (Old opencast settlement lagoon) – An old surface water settlement lagoon exists on the site at a location within the control Amgen. Surface water quality is sampled from the 750mm concrete pipe as it enters the lagoon. An unnamed stream to the south of the Installation enters this settlement lagoon, from where the overflow is culverted beneath the disused railway line.

- **SW 12** (tributary of the Ysguborwen Stream) – Over flow from the settlement lagoon described in SW11 above, combines with other small drainage features to form a small tributary to the Ysguborwen Stream. In March 2005, this additional monitoring point was added to gauge the quality of water therein. However, historically the surface water monitoring point identified as SW12 was located on the Nant-y-Wenalt (where it emerges from a culvert running beneath the old dismantled railway line).

4.1.5 Surface water monitoring points located in issues from the opencast backfill:

- **SW8** (Opencast Backfill Issue) – It is considered that the pond and associated unnamed watercourse to the south west of the site, represents perched groundwater issuing from near the base of the opencast backfill. This feature is located approximately 500m south west of the Installation.

4.1.6 Laboratory analysis of a range of water chemistry determinands are required on a monthly frequency, at each of the locations mentioned above, depending on their association with leachate contamination, presence in waste materials deposited at the site, and the logistics involved in accurately quantifying their presence.

4.2 Review of Current Monitoring Regime

4.2.1 Number and Location of Monitoring Points

Amgen Cymru currently utilises 7 surface water monitoring points on and around the landfill site. These points monitor both of the major surface water streams in the area as well as the discharge from the MCM level. In the past Amgen Cymru have previously utilised 8 other surface water monitoring points. Two of which were relocated to current sampling points.

As can be seen from Section 4.1 above there are two main surface water streams in the vicinity of the landfill site. These are each being sampled at three separate locations on the stream, one of which in both cases is up gradient of the landfill site; thus providing a baseline for water quality in the streams.

SW8 monitors a separate surface water pond that does not form part of the flow of either of the two streams previously discussed with water in the pond infiltrating into the ground beneath and subsequently the groundwater system.

There are no further surface water streams in the vicinity that could be incorporated into the surface water monitoring regime and the pond at SW8 represents the only stand alone surface water body within the vicinity of the landfill site.

The Environment Agency's "Guidance on Monitoring of Landfill Leachate, Groundwater and Surface Water" states that sampling of surface water water courses should occur at two monitoring points per water course and that monitoring of surface water ponds should occur at one point per water body. Taking this into account Amgen Cymru currently sample surface water around the site in excess of what is recommended.

4.2.2 Analysis Suites

Amgen Cymru currently take samples for laboratory analysis at each of the 7 surface water monitoring points, in addition to this in-situ analysis of several parameters is also carried out at the 7 monitoring points.

Table 4.1 shows the parameters monitored for monthly at Bryn Pica by both the laboratory and in-situ analysis.

Parameter	**Laboratory**	**In-situ**
pH	•	•
Electrical Conductivity	•	•
Temperature		•
Dissolved Oxygen		•
Chloride	•	
Ammoniacal Nitrogen	•	
Chemical Oxygen Demand	•	
Suspended Solids	•	

Table 4.1 Parameters Monitored for In Surface Water at Bryn Pica Landfill

The Environment Agency's "Guidance on Monitoring of Landfill Leachate, Groundwater and Surface Water" recommends that for a non-hazardous biodegradable landfill site posing a moderate to high risk to water receptors that the following parameters be sampled for in addition to those to above on a regular basis:

a) Total Oxidised Nitrogen
b) Total Organic Carbon
c) Biological Oxygen Demand
d) Dissolved Oxygen (recommended that this be laboratory analysed for)

Due to the lack of these parameters in the Amgen Cymru analysis suites a review of the surface water quality results to date is included below to determine the quality of the surface water around Bryn Pica and the potential requirements for additional monitoring parameters.

4.3 Review of Surface Water Quality Results

4.3.1 Surface Water Quality Results Jan 2004 – Dec 2006

Tables 4.2, 4.3 and 4.4 below detail the surface water quality results for the period Jan 04 – Dec 06 at Bryn Pica. As can be seen from the tables below surface water quality sampled around Bryn Pica is off good quality. There are some exceedances observed in the results, these are discussed further below.

Table 4.2 Surface Water Quality Average Concentrations for 2004

Potential Contaminant	Units	EAL		Surface Water Monitoring Point						
				SW1	**SW3**	**SW4**	**SW8**	**SW10**	**SW11**	**SW12**
Ammoniacal Nitrogen (NH_4 as N)	mg/l	DWS	0.5	**0.53**	0.36	**1.19**	0.41	0.3	**0.62**	**-**
Chloride	mg/l	DWS	250	6.4	14.6	17	7.33	6.033	11.1	-
COD	mg/l	-	-	19.1	21.4	26.4	18.9	19	36.5	-
DO	mg/l	-	-	9.49	9.35	13.15	8.77	8.68	7.44	-
EC @ 20^{o}C	uS/cm	DWS	1500	252	494	976	1307	100	284	-
PH	-	DWS	5.5-9.5	7.64	7.35	8.21	7.5	6.44	7.59	-

Table 4.3 Surface Water Quality Average Concentrations for 2005

Potential Contaminant	Units	EAL		Surface Water Monitoring Point						
				SW1	**SW3**	**SW4**	**SW8**	**SW10**	**SW11**	**SW12**
Ammoniacal Nitrogen (NH_4 as N)	mg/l	DWS	0.5	0.5	**0.7**	**1.1**	**2.4**	**1.0**	**0.9**	**0.8**
Chloride	mg/l	DWS	250	4.3	16.0	17.5	5.8	5.1	7.3	7.4
COD	mg/l	-	-	20.0	21.7	20.0	22.1	20.8	30.0	24.7
DO	mg/l	-	-	15.7	10.5	9.0	14.5	6.8	6.3	5.1
EC @ 20^{o}C	uS/cm	DWS	1500	256	527	1011	1363	111	214	822
PH	-	DWS	5.5-9.5	7.9	7.8	8.4	8.0	7.1	7.7	8.1

Table 4.4 Surface Water Quality Average Concentrations for 2006

Potential Contaminant	Units	EAL		Surface Water Monitoring Point						
				SW1	**SW3**	**SW4**	**SW8**	**SW10**	**SW11**	**SW12**
Ammoniacal Nitrogen (NH_4 as N)	mg/l	DWS	0.5	**0.88**	**0.64**	**0.52**	0.37	0.4	0.48	0.46
Chloride	mg/l	DWS	250	4.33	15.92	14.1	5.0	4.5	9.0	6.33
COD	mg/l	-	-	21.11	21.75	21.8	21.27	20.2	58.83	24
DO	mg/l	-	-	8.97	15.45	9.32	8.64	9.52	8.2	9.0
EC @ 20^{o}C	uS/cm	DWS	1500	249	477	879	1309	101	244	772
PH	-	DWS	5.5-9.5	8.08	7.62	8.47	7.75	6.9	7.72	8.21

4.3.2 Discussion

The surface water quality results for Bryn Pica show that the streams and ponds around the site are of good quality with little evidence of contamination by leachate. It can also be seen that Ammoniacal Nitrogen is the only determinand analysed for that exceeds the relevant drinking water standard of 0.5mg/l.

Exceedances of the drinking water standard for Ammoniacal Nitrogen have also been observed at the sampling points up-gradient of the installation as well as those down gradient; Implying that this is not due to leachate infiltration.

Due to the observed good quality of the surface water at Bryn Pica it is not considered necessary at this time to alter the analysis suite used or the frequency of monitoring carried out on site.

However, it is considered that a separate suite be created for analysis in the event of an accident / emergency on site whereby several further determinands could be analysed for to determine the extent and type of any contamination observed. Recommendations for such a suite are presented in Table 4.5 below.

Parameters to be Analysed For	
Flow Rate (In-situ)	Temperature (In-situ)
pH	Sodium
Electrical Conductivity	Potassium
Dissolved Oxygen	Total Alkalinity
Total Suspended Solids	Sulphate
Total Dissolved Solids	Chloride
Ammoniacal Nitrogen	Iron
Total Oxidised Nitrogen	Manganese
Volatile Fatty Acids	Dissolved Methane
Total Organic Carbon	Arsenic
Chemical Oxygen Demand	Mercury
Biochemical Oxygen Demand	Phenols
Calcium	Mineral Oils
Magnesium	Chlorinated Solvents

Table 4.5 Analysis Suite for Surface Water Following Potential Accident / Emergency On Site

It is anticipated that the above suite would be used once a accident or emergency situation had been identified on site, with the potential to cause detriment to the surface water environment on or around the installation.

In such a situation inspection of all surface water monitoring points will be carried out and at least two samples taken from each water course / body for external laboratory analysis.

4.4 Setting of Control / Trigger Levels for Surface Water

4.4.1 The PPC Permit for Bryn Pica landfill site, in Table S4.3, states that the emission limits and monitoring requirements for point source emissions to water shall be as follows:

a)	Suspended Solids	50mg/l
b)	Mineral Oil	5mg/l
c)	Ammoniacal Nitrogen	5mg/l
d)	COD	30mg/l
e)	pH	Not <6 or 9> pH units

4.4.2 Although these limits are set for surface water discharge from the settlement lagoons it is recommended that these levels be adopted as the sites Trigger Levels for surface water quality. Should surface water samples provide results above any of these levels then further sampling, utilising a more general analysis suite such as that in Table 4.5 above, should be carried out.

4.4.3 Control levels, at which further sampling and a review of site procedures shall be carried out, will be set as the relevant EAL for each monitored determinand. If a control level is breached during routine monitoring a further laboratory analysis or in situ analysis will be conducted as well as a brief review of operations in the area in order to determine of any of the operations on site are causing a detrimental effect on the environment (it is not considered necessary for any review to be completed if up-gradient surface water quality is in breach of the EAL in addition to that down gradient or irrespective of down gradient quality).

5. CONCLUSIONS AND RECOMENDATIONS

5.1 Encia Consulting Ltd. has carried out a review of the surface water management and monitoring system in place at the Bryn Pica Installation, as required by PPC PERMIT No. DP3732SQ Improvement Condition 7.

5.2 The following aspects of the surface water management system at the site have been considered as part of this review and recommendations for improvement in surface water management at the site made.

1. Details and design drawings of all current surface water management drainage systems employed at Bryn Pica.
2. Details of all future phasing and works.
3. Evidence that the surface water management system in operation at Bryn Pica can cope with storm events including volumes to be analysed for.
4. Review of the location and number of monitoring points.
5. Review of monitoring suites using all available monitoring data.

5.3 The current surface water scheme incorporates various lagoons to reduce the quantity of sediment in the surface water at the discharge points. The various surface water drains on the Site will be monitored to establish where the main sediment generators are located. These sediment generators can be addressed as a priority to effect significant improvements in the surface water system.

5.4 It is considered that the site operators current procedures for the management and monitoring of surface water discharged from the Bryn Pica Landfill Site are suitable for the protection of proximal water environments.

5.5 The current surface water control infrastructure is shown to be of an adequate specification for both normal site conditions as wells having sufficient capacity to deal with storm events (designed for up to 1 in 100 year flood).

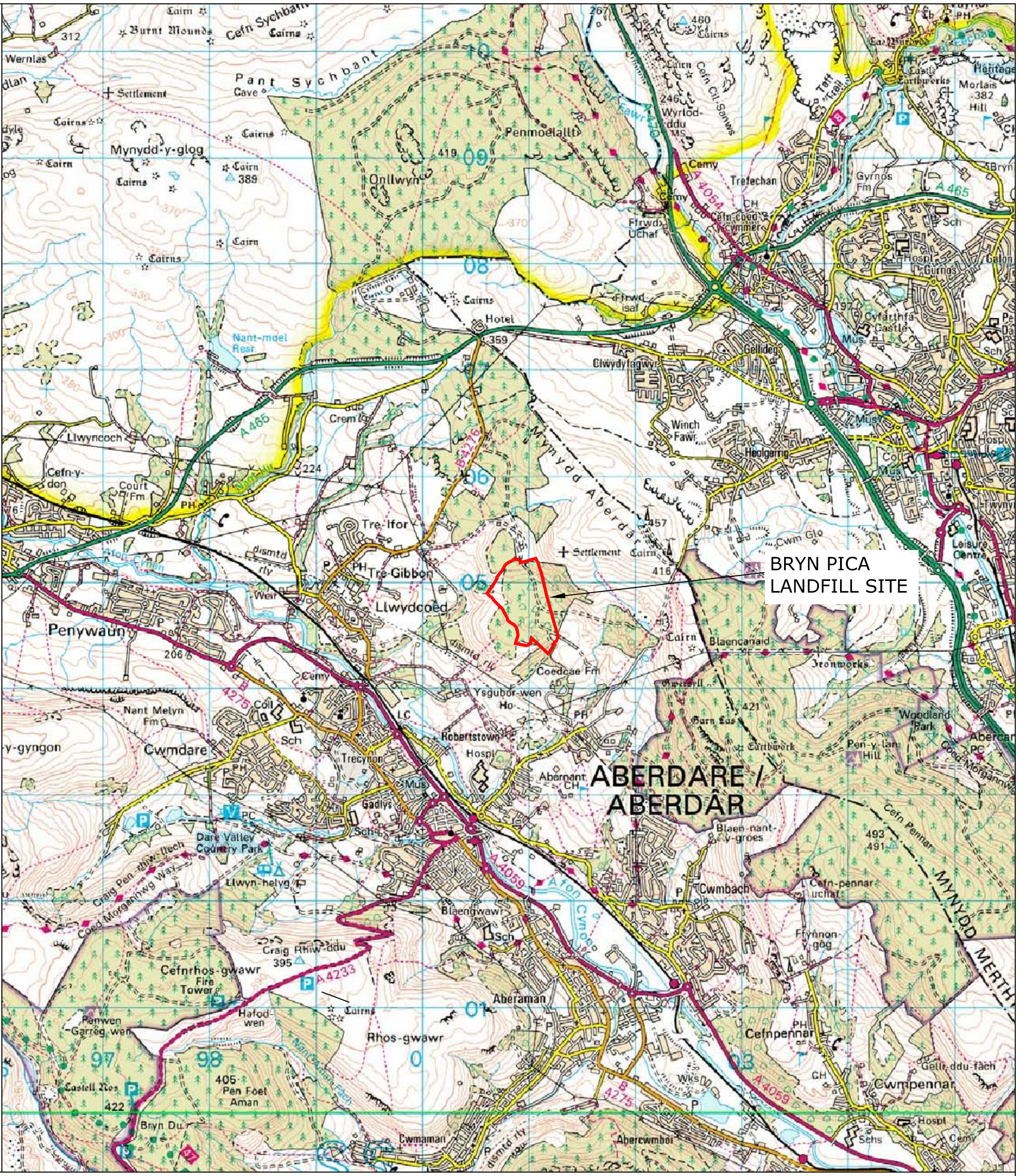
5.6 The following recommendation are made following this review:

a) Hydro-seeding the eastern side slopes between the Site boundary and the “low level” Haul Road to reduce erosion. These slopes are to remain exposed until the completion of Phase 4, and therefore, there is long term benefit to the Site;

b) Continued use of flocculants to control colloidal particles within the lagoons. The benefits of flocculants should be regularly reviewed.

c) It recommended that the operator carryout an annual review of the performance of the surface water management system at the Bryn Pica site and following any significant alteration to the site infrastructure.

APPENDIX A
DRAWINGS



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JOB TITLE

BRYN PICA LANDFILL SITE
SURFACE WATER MANAGEMENT

REV.	DESCRIPTION	DATE

CLIENT

AMGEN CYMRU
BRYN PICA
LLWYDCOED
ABERDARE
CF44 OBX

AMGEN Cymru

DRAWING TITLE

LOCATION PLAN

DRAWN	SIGNATURE	DATE	STATUS
A.W.		11/03/07	FOR COMMENT ☐
			FOR APPROVAL ☐
APPROVED	SIGNATURE	DATE	DRAFT ☐
D.J.B.		11/03/07	FINAL ☑

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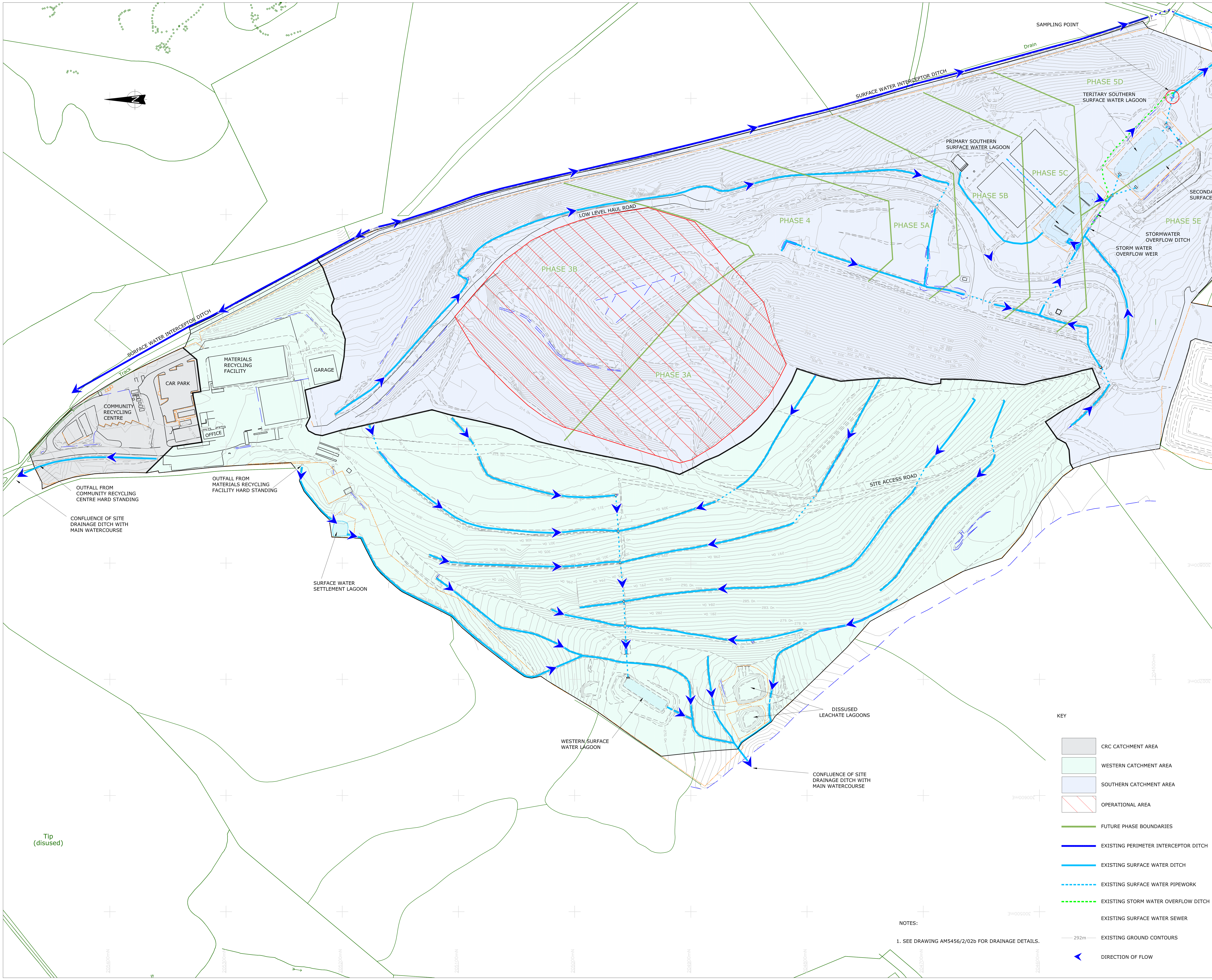

NOTES:

1. SEE DRAWING AM5456/2/02b FOR DRAINAGE DETAILS.

KEY

- CRC CATCHMENT AREA
- WESTERN CATCHMENT AREA
- SOUTHERN CATCHMENT AREA
- OPERATIONAL AREA
- FUTURE PHASE BOUNDARIES
- EXISTING PERIMETER INTERCEPTOR DITCH
- EXISTING SURFACE WATER DITCH
- EXISTING SURFACE WATER PIPEWORK
- EXISTING STORM WATER OVERFLOW DITCH
- EXISTING SURFACE WATER SEWER
- 292m EXISTING GROUND CONTOURS
- DIRECTION OF FLOW

NOTES

REV	DESCRIPTION	DATE	BY

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JOB TITLE

BRYN PICA
LANDFILL SITE
SURFACE WATER MANAGEMENT

DRAWING TITLE

EXISTING ARRANGEMENT

DRAWN	SIGNATURE	DATE	STATUS
A.W.		11/03/07	FOR COMMENT ☐ FOR APPROVAL ☐
APPROVED	SIGNATURE	DATE	
R.H.		11/03/07	DRAFT ☐ FINAL ☑

SCALE	SHEET	DRAWING NO.	REVISION
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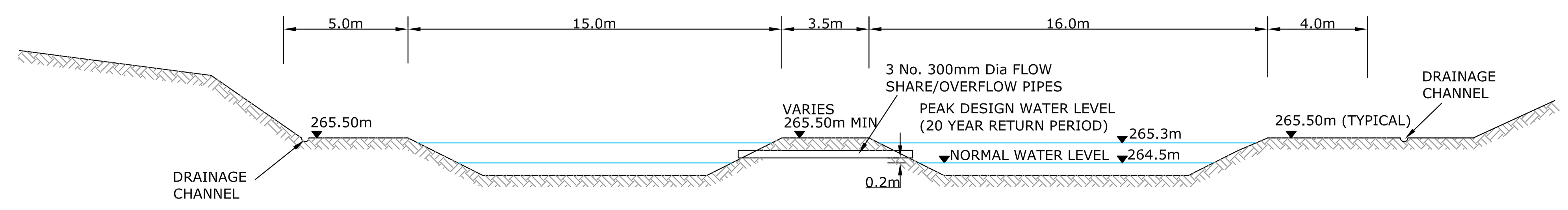

CROSS SECTION THROUGH SECONDARY SOUTHERN SETTLEMENT LAGOON
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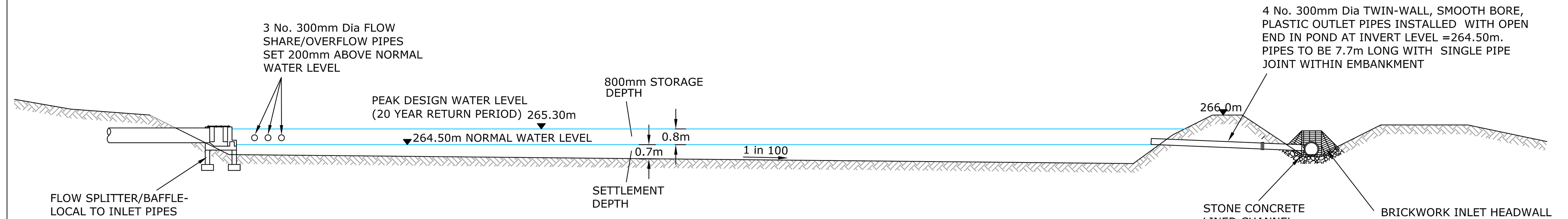
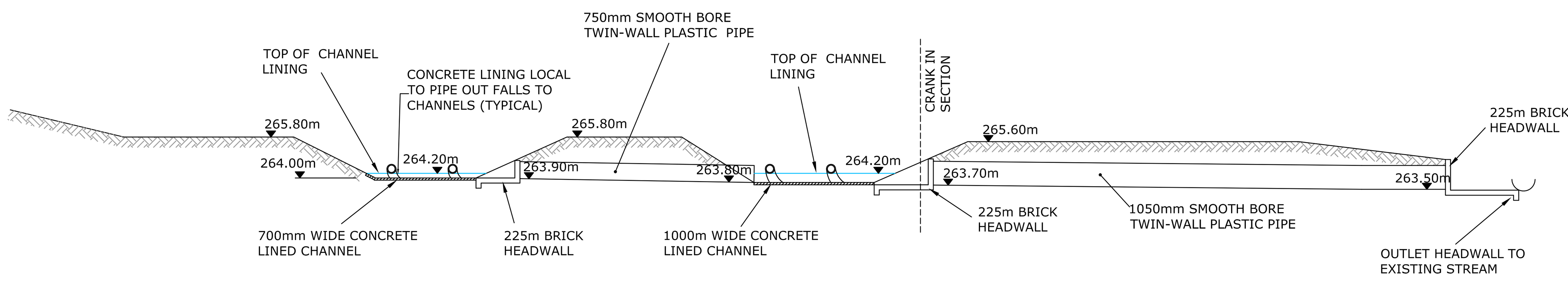
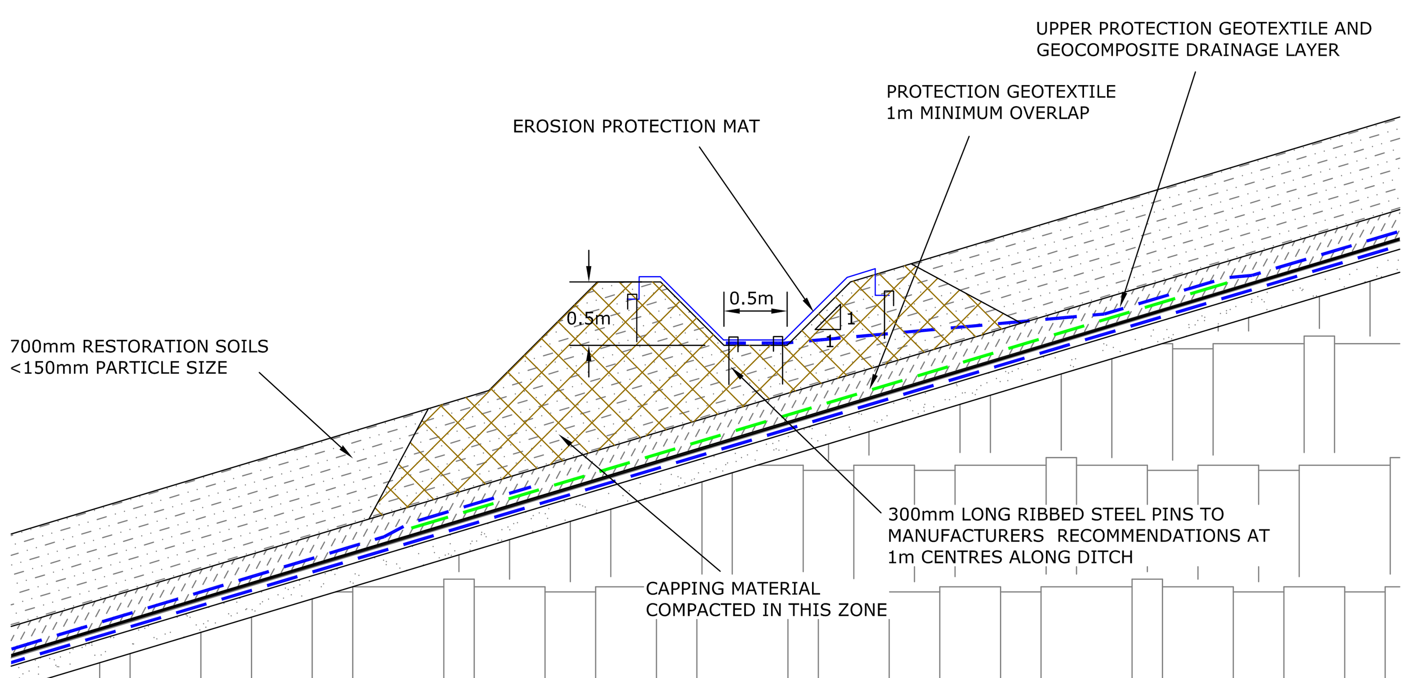


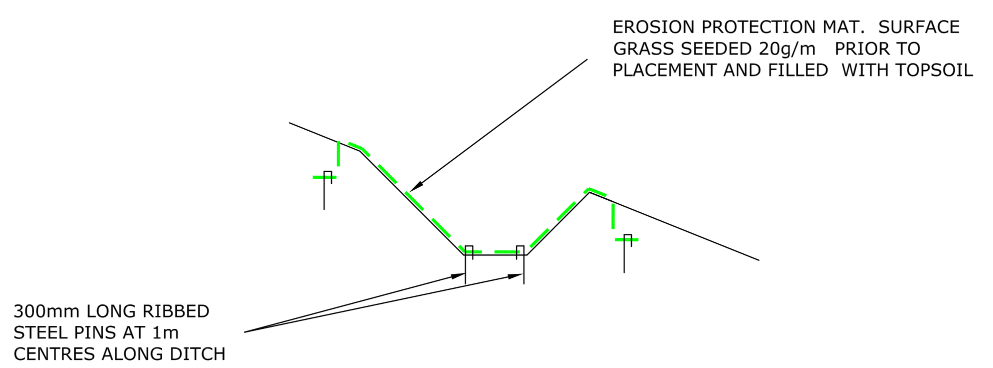
LONG SECTION THROUGH SECONDARY SOUTHERN SETTLEMENT LAGOON
Scale 1:200



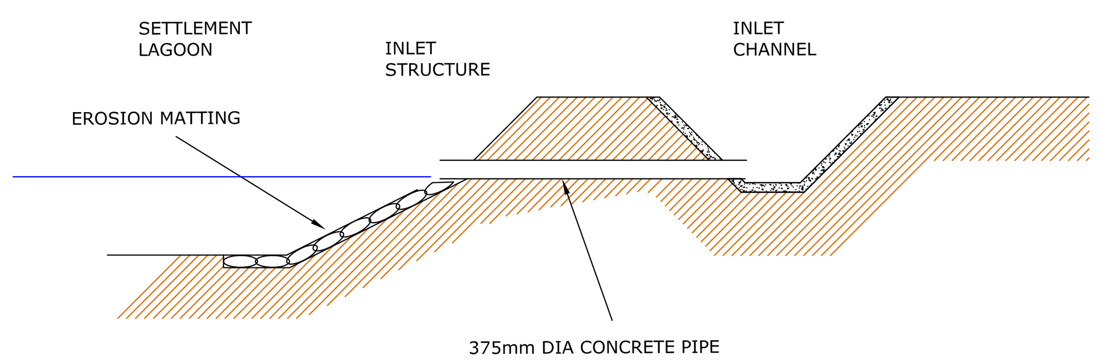
LONG SECTION THROUGH SECONDARY SOUTHERN SETTLEMENT LAGOON(CRANKED ON OUTFALL PIPE) THROUGH OUTLET CHANNEL
Scale 1:200



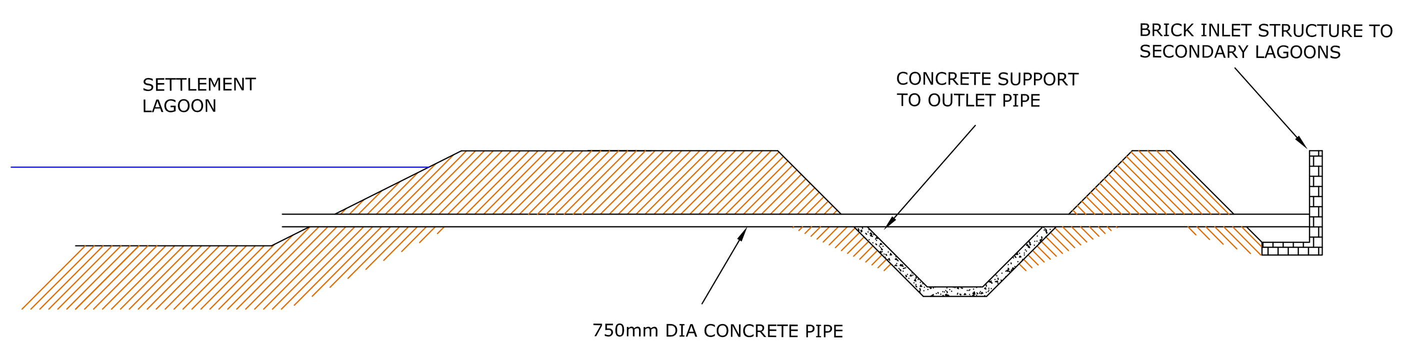
TYPICAL DETAIL OF PHASE 2 SURFACE WATER COLLECTION DITCH
(SCALE 1:50)



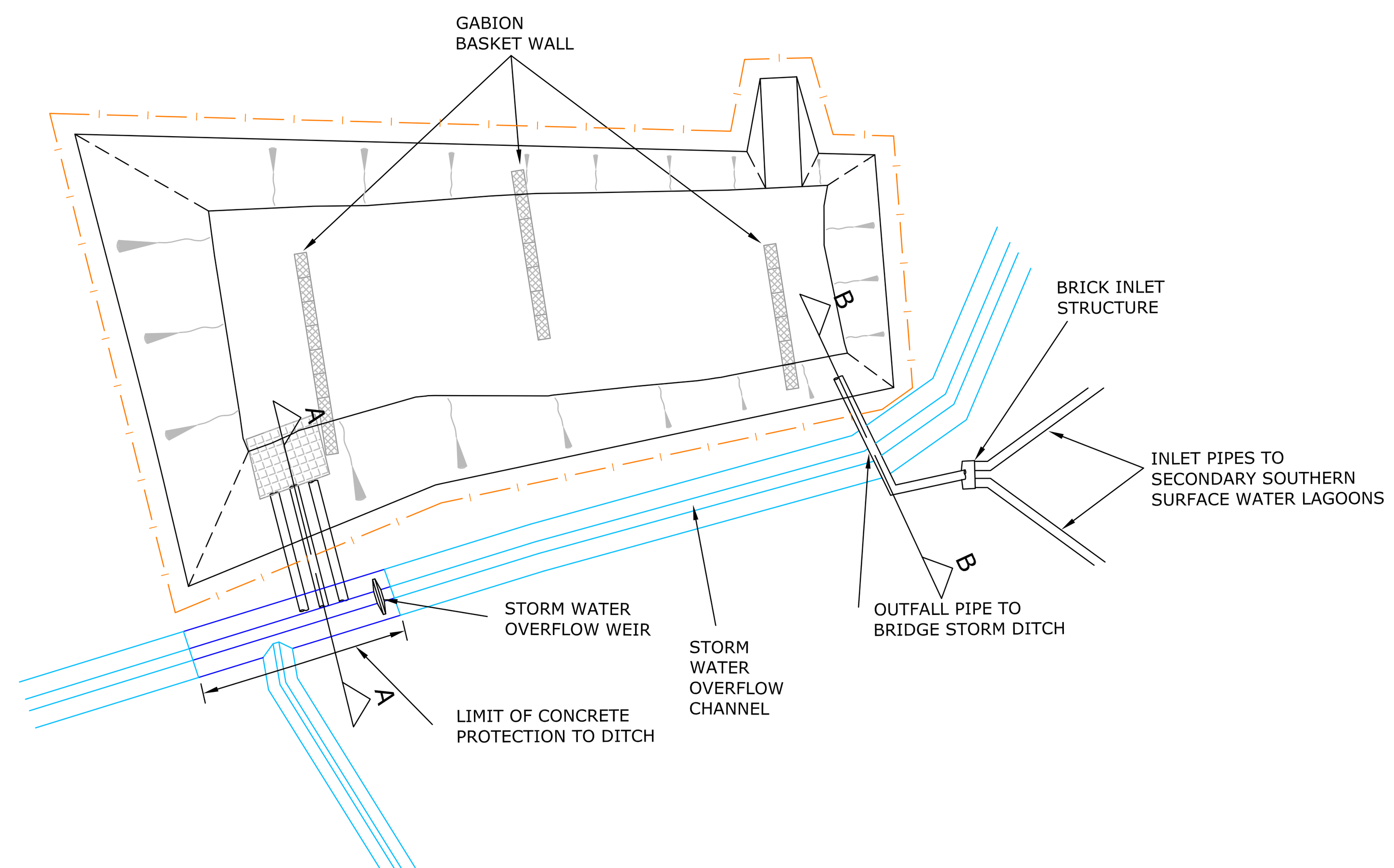
SECTIONAL DETAIL OF EROSION PROTECTION MEASURES TO DITCHES ON LANDFILL CAP
Scale 1:50



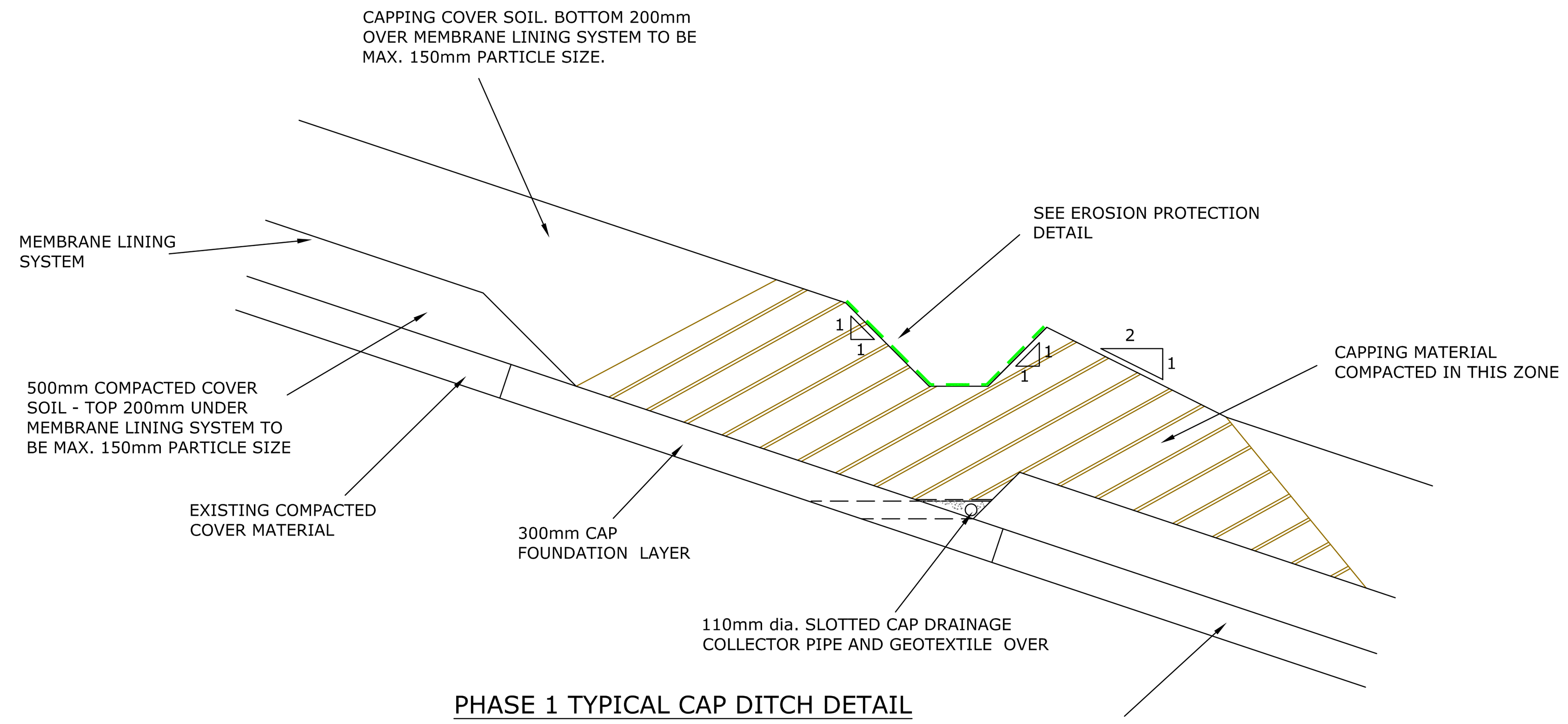
SECTION A-A
SCALE 1 : 100



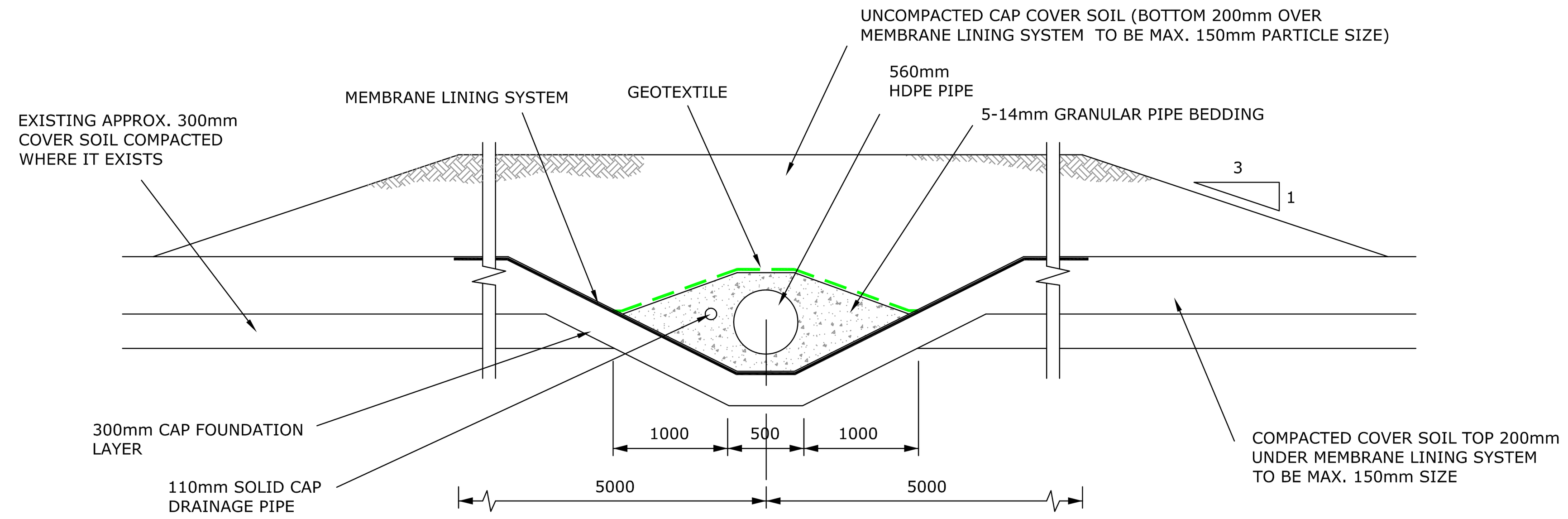
SECTION B-B
SCALE 1 : 100



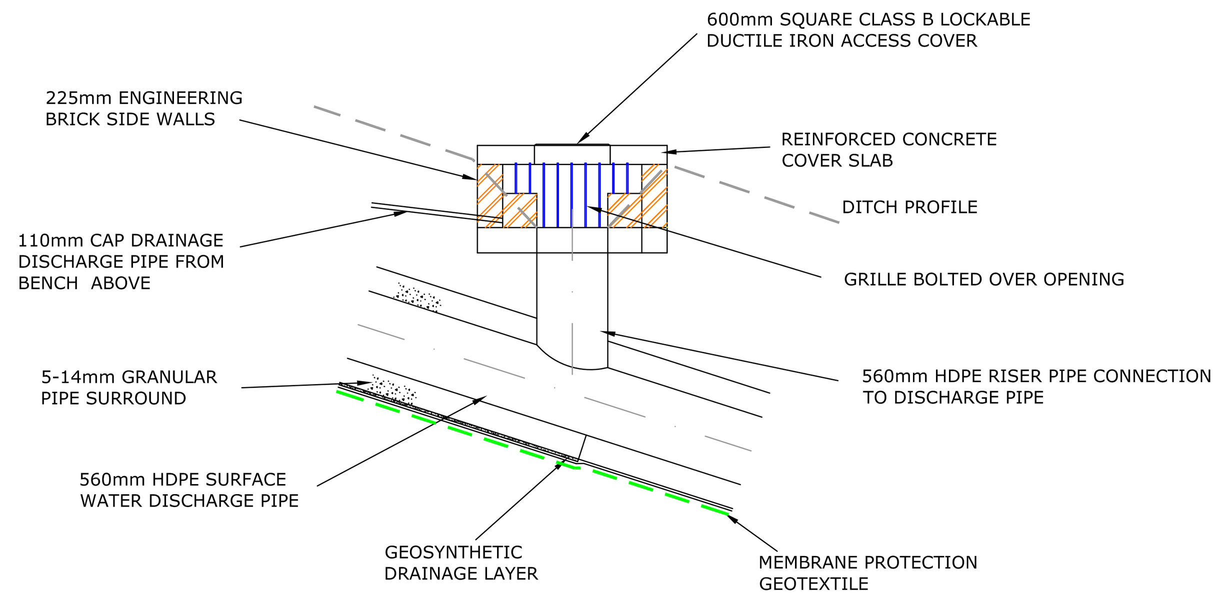
PRIMARY SURFACE WATER SETTLEMENT LAGOON
SCALE 1 : 500



PHASE 1 TYPICAL CAP DITCH DETAIL
Scale 1:50



SECTION THROUGH PHASE 1 SURFACE WATER DISCHARGE PIPE
Scale 1:50



PHASE 1 SURFACE WATER ENTRY CHAMBER SECTIONAL ELEVATION
Scale 1:20

NOTES

1. SEE DRAWING AM5456/2/02a FOR PLAN LAYOUT OF EXISTING SURFACE WATER SYSTEM.

REV	DESCRIPTION	DATE	BY

ENCIA CONSULTING LIMITED
ENCIA HOUSE, AUDBY LANE
WETHERBY, WEST YORKSHIRE
TEL: 01937 589955 FAX: 01937 544760
WEBSITE: WWW.ENCIAGROUP.CO.UK
EMAIL: INFO@ENCIAGROUP.CO.UK

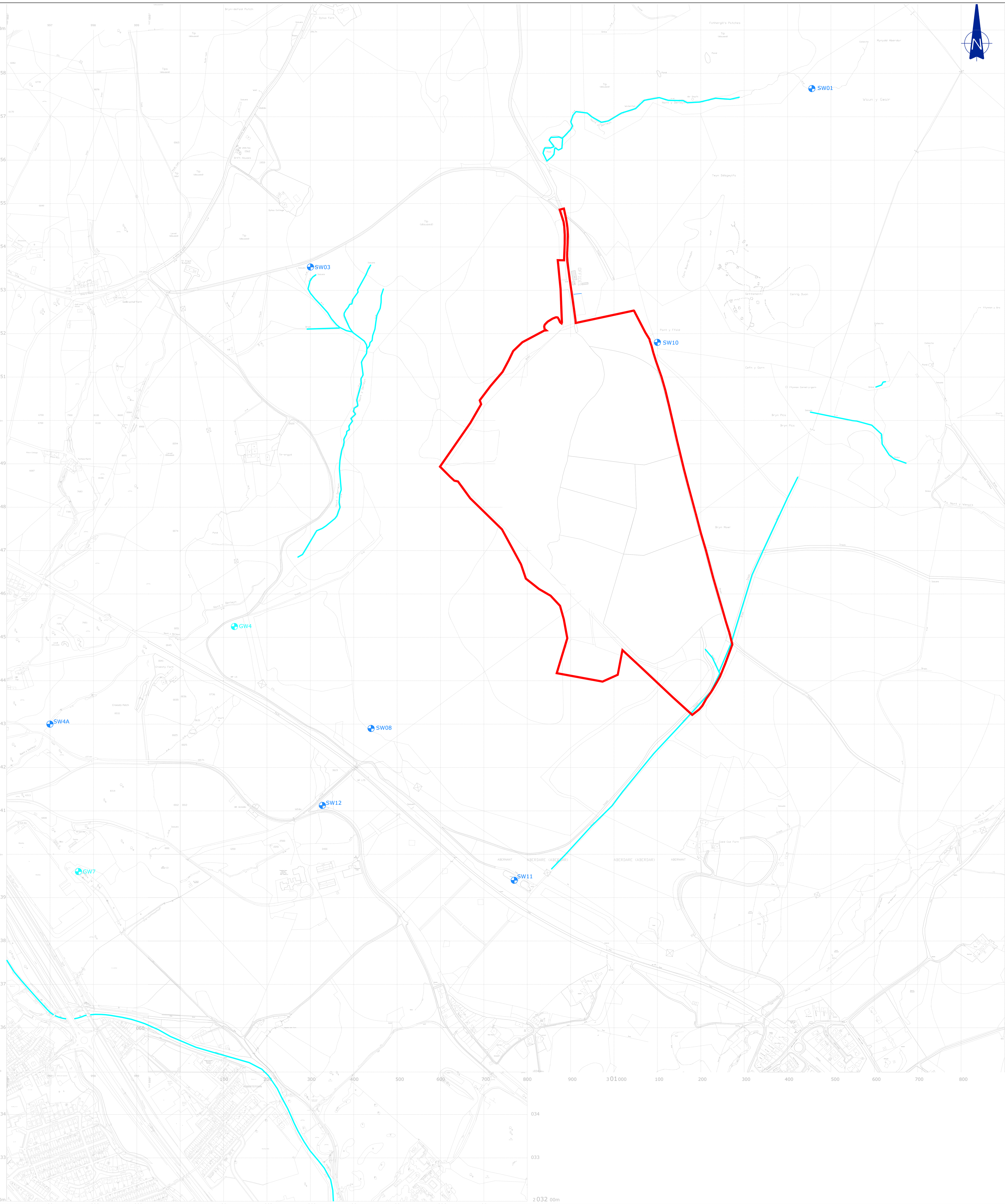
CLIENT
AMGEN CYMRU
BRYN PICA
LLWYDCOED
ABERDARE
CF44 OBX
TEL: 01685 870770
FAX: 01685 874684

JOB TITLE
BRYN PICA
LANDFILL SITE
SURFACE WATER MANAGEMENT

DRAWING TITLE
EXISTING DETAILS

DRAWN	SIGNATURE	DATE	STATUS
A.W.		11/03/07	FOR COMMENT ☐ FOR APPROVAL ☐
APPROVED	SIGNATURE	DATE	DRAFT ☐
R.H.		11/03/07	FINAL ☑

SCALE	SHEET	DRAWING NO.	REVISION
AS SHOWN	A1	AM5456/2/02b	0



NOTES

1. REPRODUCED FROM THE ORDNANCE SURVEY 1:50,000 MAP WITH THE PERMISSION OF THE CONTROLLER OF HER MAJESTY'S STATIONERY OFFICE. © CROWN COPYRIGHT, LICENCE NUMBER AL50604A.

LEGEND

INSTALLATION BOUNDARY

SURFACE WATER MONITORING POINTS

REV.	DESCRIPTION	DATE

ENCIA

ENCIA CONSULTING LIMITED
ENCIA HOUSE, AUDBY LANE
WETHERBY, WEST YORKSHIRE
TEL: - 01937 589955 FAX: - 01937 589944

CLIENT

AMGEN Cymru
ALTERNATIVE SOLUTIONS IN WASTE MANAGEMENT

AMGEN CYMRU
BRYN PICA
LLWYDCOED
ABERDARE
CF44 OBX

TEL:01685 870770
FAX: 01685 874684

JOB TITLE

BRYN PICA LANDFILL
SURFACE WATER
MANAGEMENT PLAN

DRAWING TITLE

LOCATION OF SURFACE
WATER MONITORING POINTS

DRAWN	SIGNATURE	DATE	STATUS
L.F.		25/04/07	FOR COMMENT ☐ FOR APPROVAL ☐
APPROVED A.W.		25/04/07	DRAFT ☐ FINAL ☑

SCALE	SHEET	DRAWING NO.	REVISION
1:5000	A1	AM5456/2/03	-

A1 TITLE BLOCK 801mm x 564mm

APPENDIX B
DRAINAGE CALCULATIONS

OAP20

ARUP **Ove Arup & Partners**
Calculation Sheet

Job No.	Sheet No.	Rev.
56767		

Member/Location

Job Title

Drg. Ref.

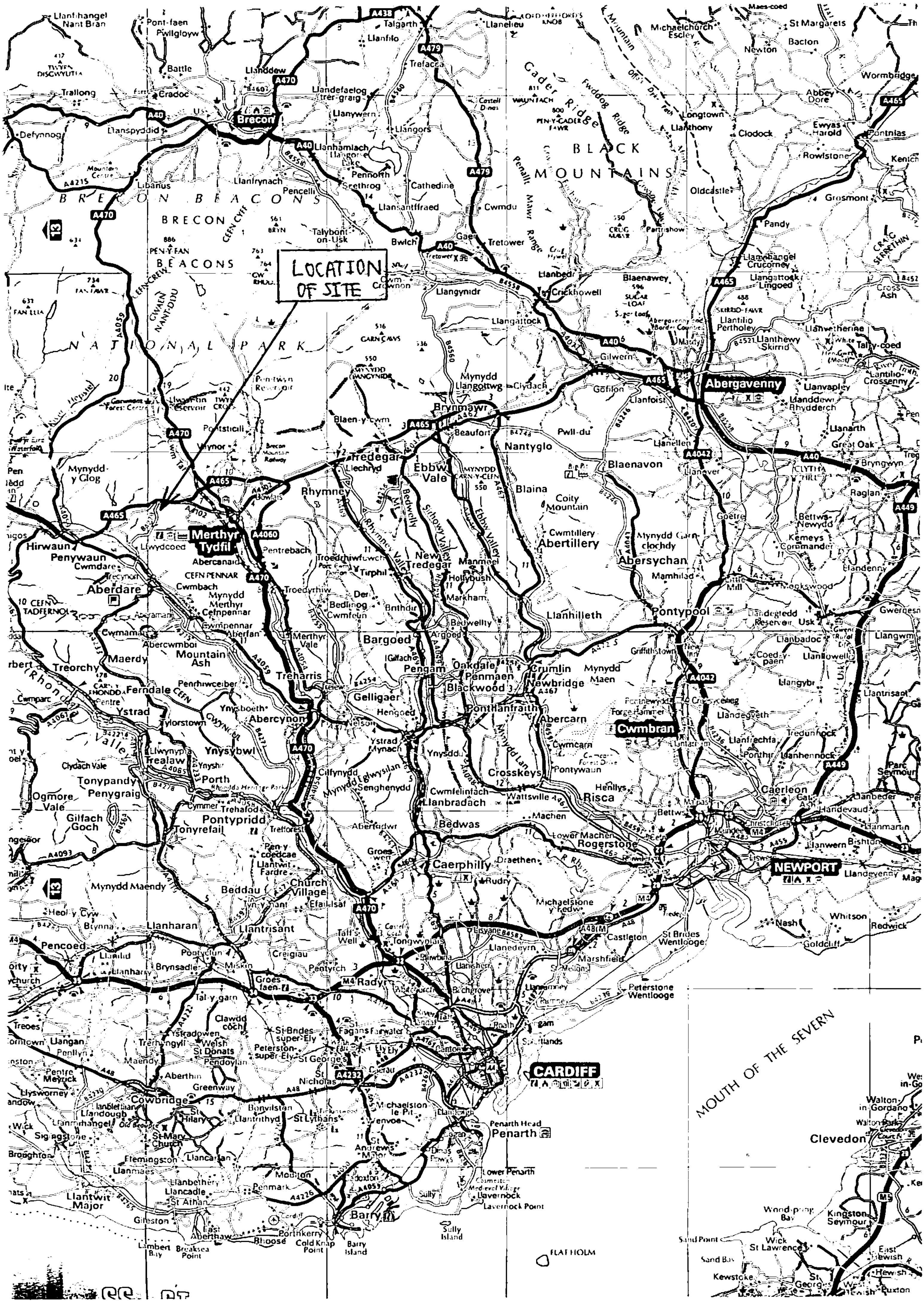
Made by SPK Date 5/7/99 Chd. LP 7/7/99

SITE LOCATION / RAINFALL CHARACTERISTICS.

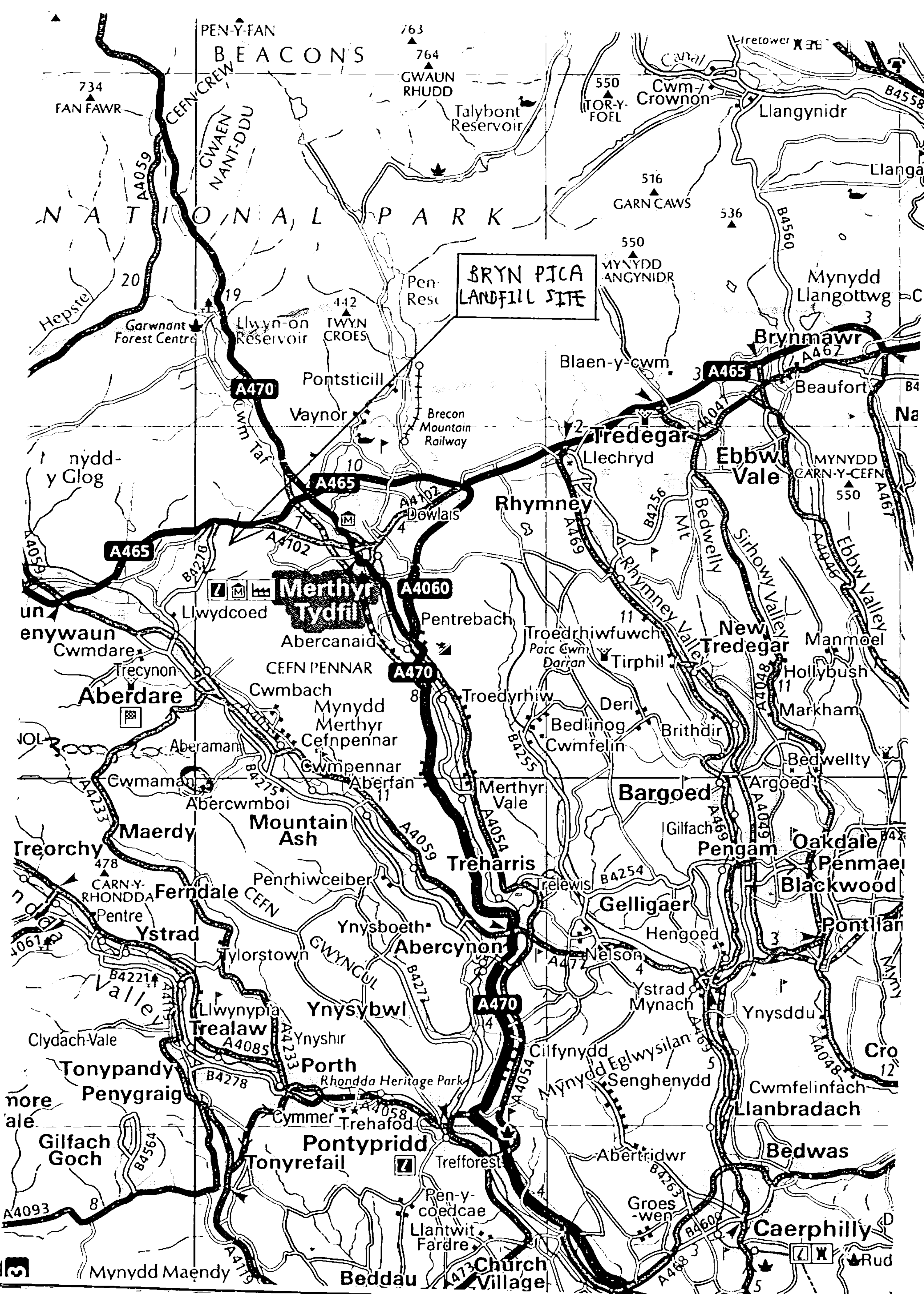
Summary

$r = 0.20$

$M5\text{-}60 = 20mm$



LOCATION OF SITE
BRECON BEACONS
NATIONAL PARK
BLACK MOUNTAINS
MOUTH OF THE SEVERN
Brecon
Merthyr Tydfil
Abergavenny
Cwmbran
NEWPORT
CARDIFF
Hirwaun
Aberdare
Mountain Ash
Tredegar
Ebbw Vale
Rhymney
Brynmawr
Nantyglo
Blaenavon
Blaina
Abertillery
Abersychan
Pontypool
Bargoed
Blackwood
Crumlin
Newbridge
Abercarn
Crosskeys
Risca
Caerphilly
Pontypridd
Porth
Tonypandy
Treorchy
Llantrisant
Cowbridge
Barry
Penarth
Llantwit Major
Crickhowell
Talgarth
Caerleon
Raglan
Usk
Clevedon
Kingston Seymour



BRYN PICA LANDFILL SITE
PEN-Y-FAN
BEACONS
NATIONAL PARK
734 FAN FAWR
CEFN CREW
GWAEN NANT-DDU
764 GWAUN RHUDD
Talybont Reservoir
550 TOR-Y-FOEL
Cwm-Crownon
Llangynidr
Canal
516 GARN CAWS
536
550 MYNYDD LLANGYNIDR
Mynydd Llangottwg
Hepste
Garwnant Forest Centre
Llwyn-on Reservoir
442 TWYN CROES
Pen-Resr
Pontsticill
Vaynor
Brecon Mountain Railway
Cwm Taf
Blaen-y-cwm
Brynmawr
Beaufort
Tredegar
Llechryd
Ebbw Vale
MYNYDD CARN-Y-CEFN 550
Mynydd-y Glog
Dowlais
Rhymney
Rhymney Valley
Bedwelly Mt
Sirhowy Valley
Ebbw Valley
Merthyr Tydfil
Llwydcoed
Cwmdare
Trecynon
Aberdare
Pentrebach
Abercanaid
CEFN PENNAR
Troedrhiwfuwch
Parc Cwm Darran
Tirphil
New Tredegar
Manmoel
Hollybush
Markham
Cwmbach
Mynydd Merthyr
Cefnpennar
Aberaman
Troedyrhiw
Deri
Bedlinog
Cwmfelin
Brithdir
Bedwellty
Cwmaman
Cwmpennar
Aberfan
Merthyr Vale
Bargoed
Argoed
Abercwmboi
Maerdy
Treorchy
Mountain Ash
Gilfach
Pengam
Oakdale
Penmaen
Treharris
Trelewis
Blackwood
478 CARN-Y-RHONDDA
Ferndale
CEFN
Penrhiwceiber
Gelligaer
Pentre
Ystrad
Ynysboeth
Hengoed
Pontllanfraith
Abercynon
Nelson
Tylorstown
GWYNCUL
Ystrad Mynach
Valley
Llwynypia
Ynysybwl
Ynysddu
Trealaw
Ynyshir
Cilfynydd
Clydach Vale
Mynydd Eglwysilan
Tonypandy
Porth
Rhondda Heritage Park
Senghenydd
Cwmfelinfach
Penygraig
Cymmer
Trehafod
Llanbradach
Gilfach Goch
Pontypridd
Tonyrefail
Treforest
Abertridwr
Bedwas
Pen-y-coedcae
Groes-wen
Caerphilly
Llantwit Fardre
Church Village
Beddau
Mynydd Maendy
A470
A465
A4060
A4102
A4059
A4054
A4233
A4058
A4085
A4093
A469
A4048
A4049
A467
A4047
A472
B4560
B4558
B4256
B4255
B4254
B4275
B4276
B4273
B4221
B4278
B4564
B4263
B4600

OAP20

ARUP Ove Arup & Partners
Calculation Sheet

Job No.	Sheet No.	Rev.
56767	04	

Member/Location

Job Title

Drg. Ref.

Made by | Date | Chd.

BRYN-PICA LANDFILL

SETTLEMENT POND DESIGN CALCULATIONS

OAP20

ARUP Ove Arup & Partners Calculation Sheet

Job No.	Sheet No.	Rev.
56767	1	

Member/Location

Job Title BRYN PICA LANDFILL SITE

Drg. Ref.

Made by AR Date 25/06/99 Chd LP 7/7/99

DETERMINATION OF FLOOD ESTIMATION FOR SITE

FROM ORDNANCE SURVEY MAP SITE LOCATED WEST OF MERTHYR TYDFIL OF THE B4728.

FROM INSTITUTE OF HYDROLOGY'S METHODS OF FLOOD ESTIMATION: A GUIDE TO THE FLOOD STUDIES REPORT AND ASSOCIATED MAPS DETERMINE SITE'S CHARACTERISTICS — SEE SEPARATE SHEETS

FIG I.4.20	HYDROMETRIC AREA NUMBER = 57
FIG. 4.19	EFFECTIVE MEAN SOIL MOISTURE DEFICIT = 3.5mm
FIG. 3.4	25 DAY M5 RAINFALL = 21.5% (PERCENTAGE OF 1941-70 RAINFALL)
FIG. 4.18	WINTER RAIN ACCEPTANCE POTENTIAL = CLASS 3 - MODERATE
FIG. 4.1	ESTIMATED MAXIMUM 2-HOUR RAINFALL = 163mm
FIG. 4.2	ESTIMATED MAXIMUM 24-HOUR RAINFALL = 350mm
FIG. 3.1	AVERAGE ANNUAL RAINFALL (1941-1970) = 1700mm
FIG. 3.3	2-DAY M5 RAINFALL = 6% (PERCENTAGE OF 1941-70 RAINFALL)
FIG. 3.5	1-HOUR M5 AS PERCENTAGE OF 2-DAY M5, r = 20%
FIG. 3.2	2 DAY M5 RAINFALL = 100mm

CATCHMENT AREA

FROM DAP DRAWING WSK11 THE CATCHMENT AREA OF BRYN PICA LANDFILL SITE = 151130m²

ASSUME PERMEABILITY = 50%.

THEREFORE SOIL ABSORBS THE REMAINING 50% OF THE RUNOFF THUS AREA ANALYSED = 75000m²

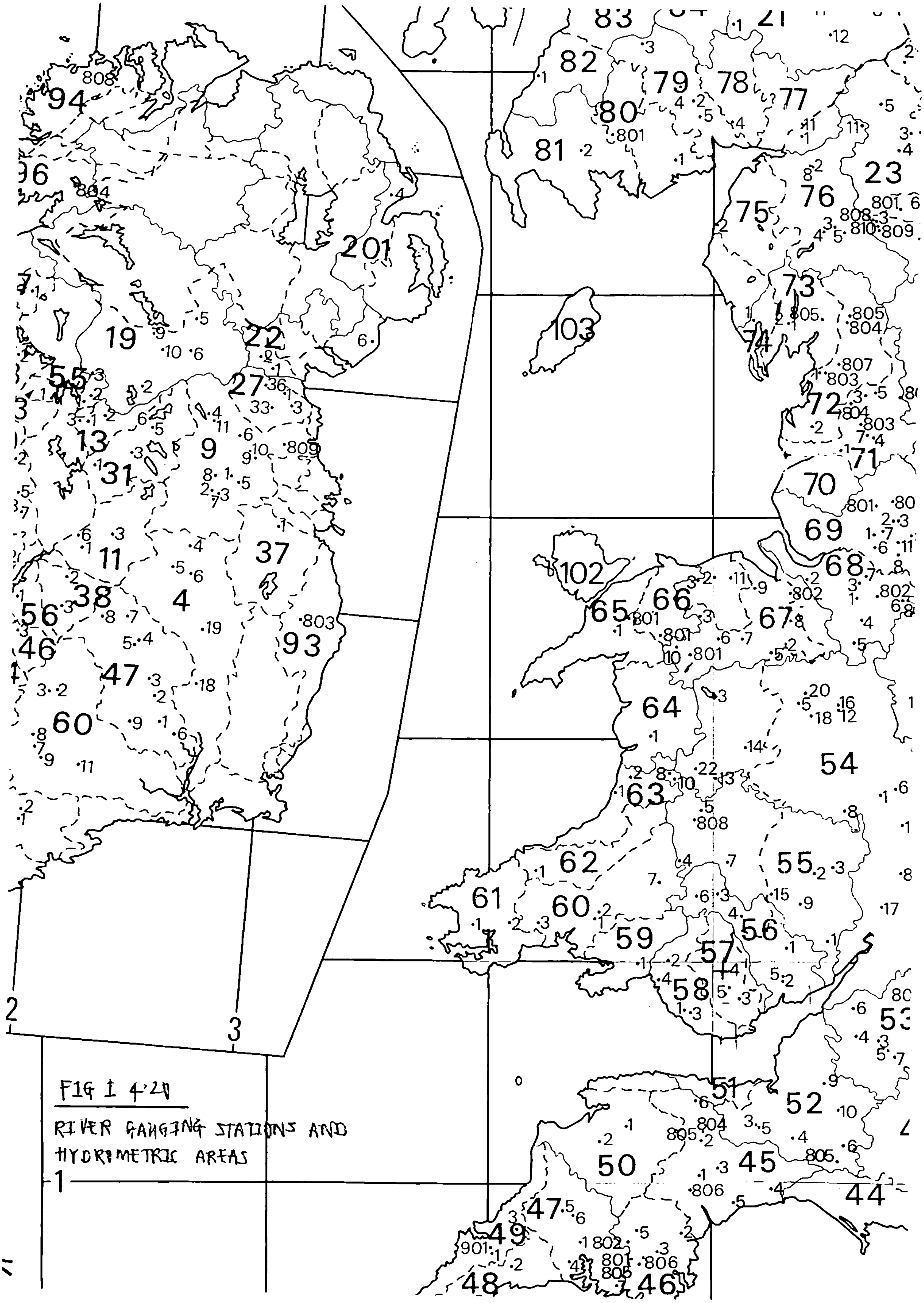


FIG I 4.20

RIVER GAUGING STATIONS AND HYDROMETRIC AREAS

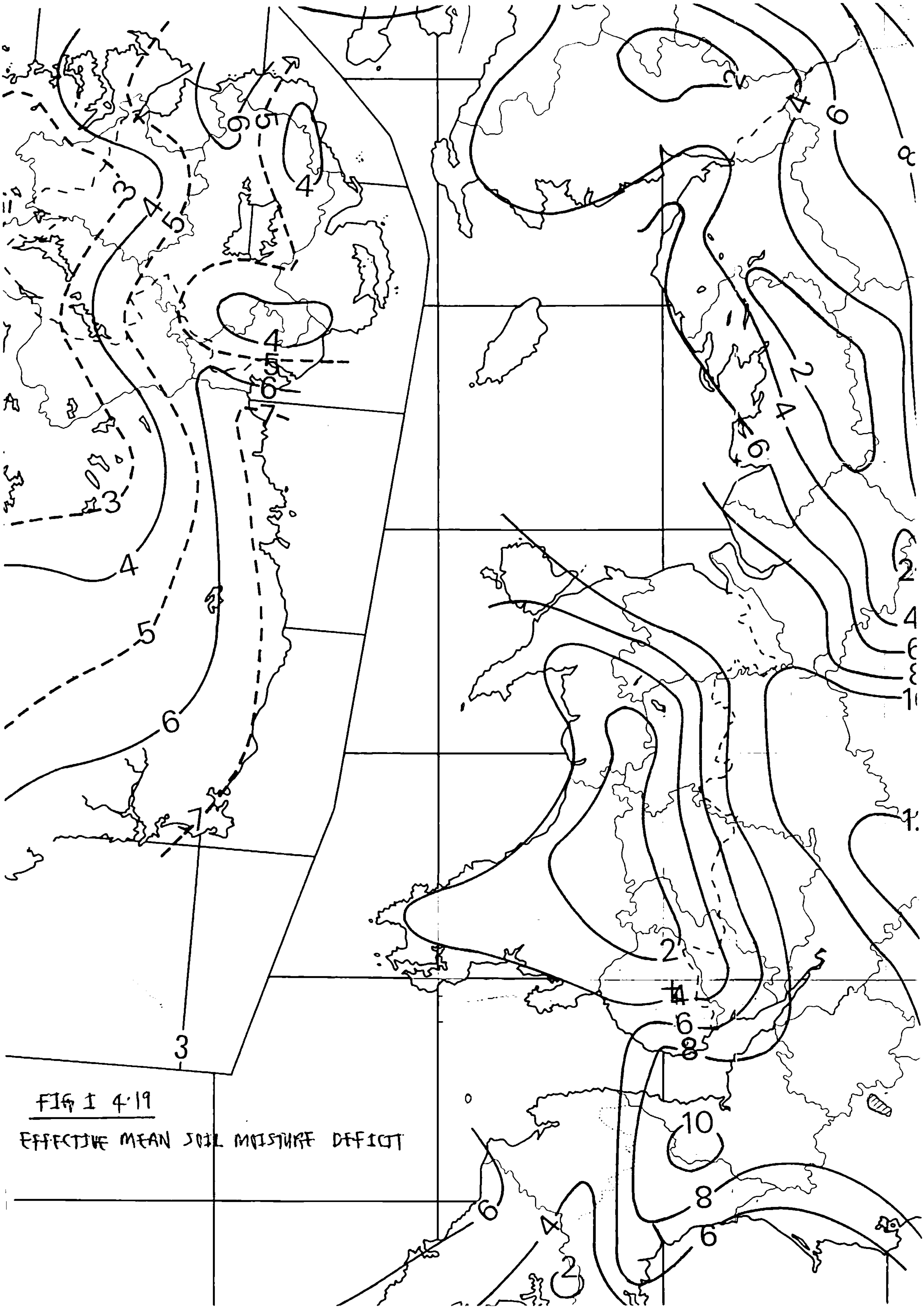


FIG I 4·19

EFFECTIVE MEAN SOIL MOISTURE DEFICIT

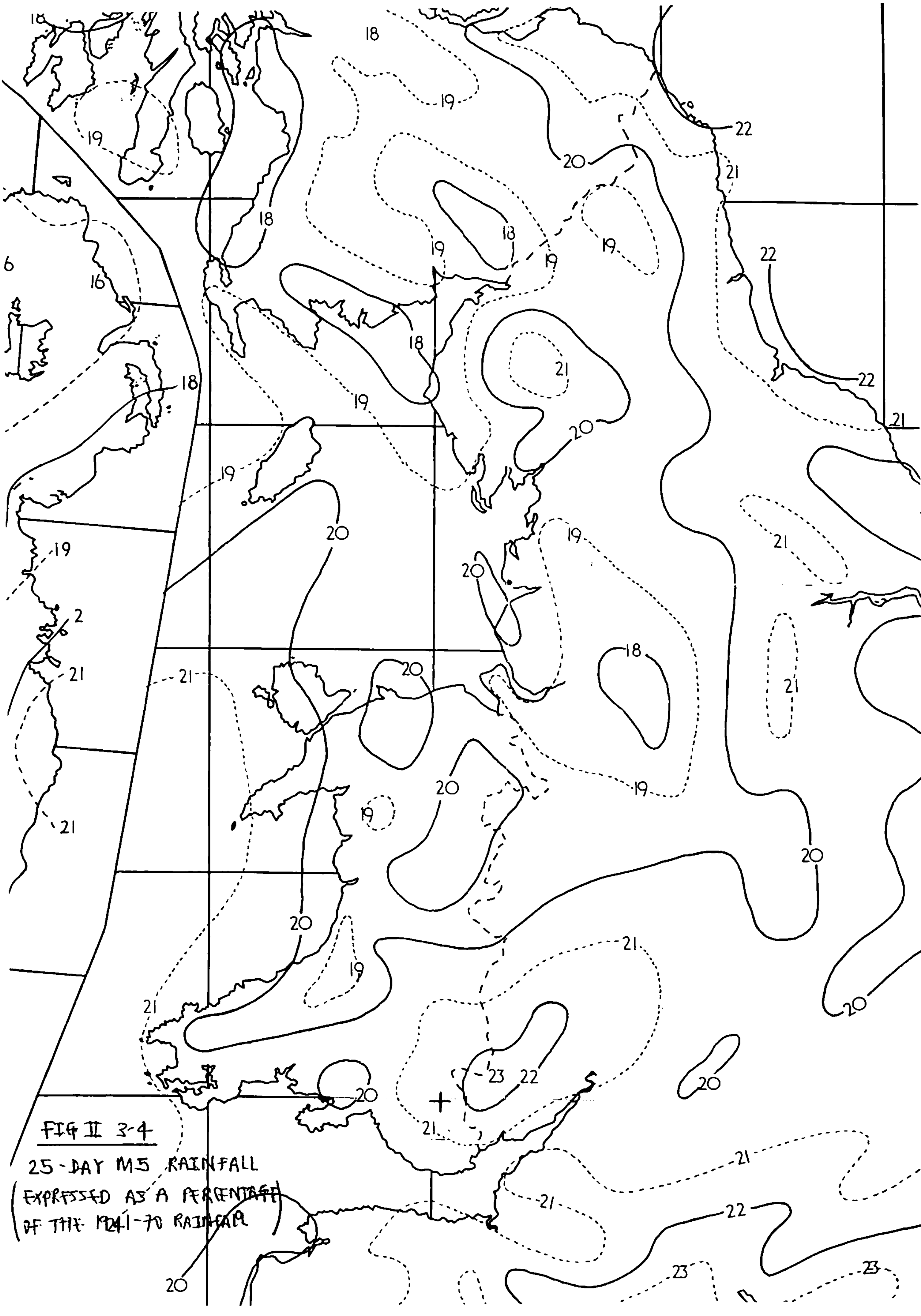


FIG II 3-4

25-DAY M5 RAINFALL
(EXPRESSED AS A PERCENTAGE
OF THE 1941-70 RAINFALL)

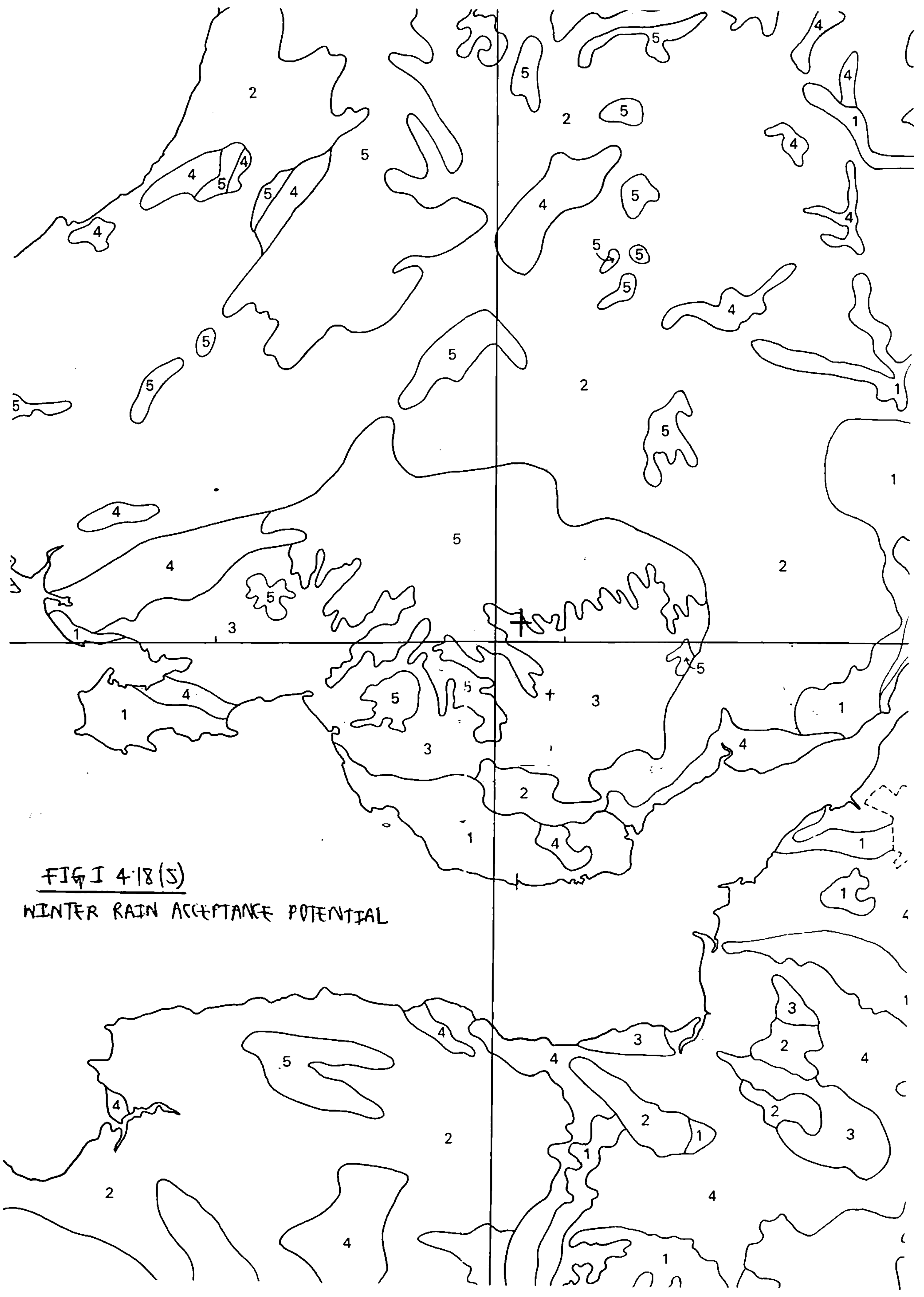


FIG I 4·18 (S)

WINTER RAIN ACCEPTANCE POTENTIAL

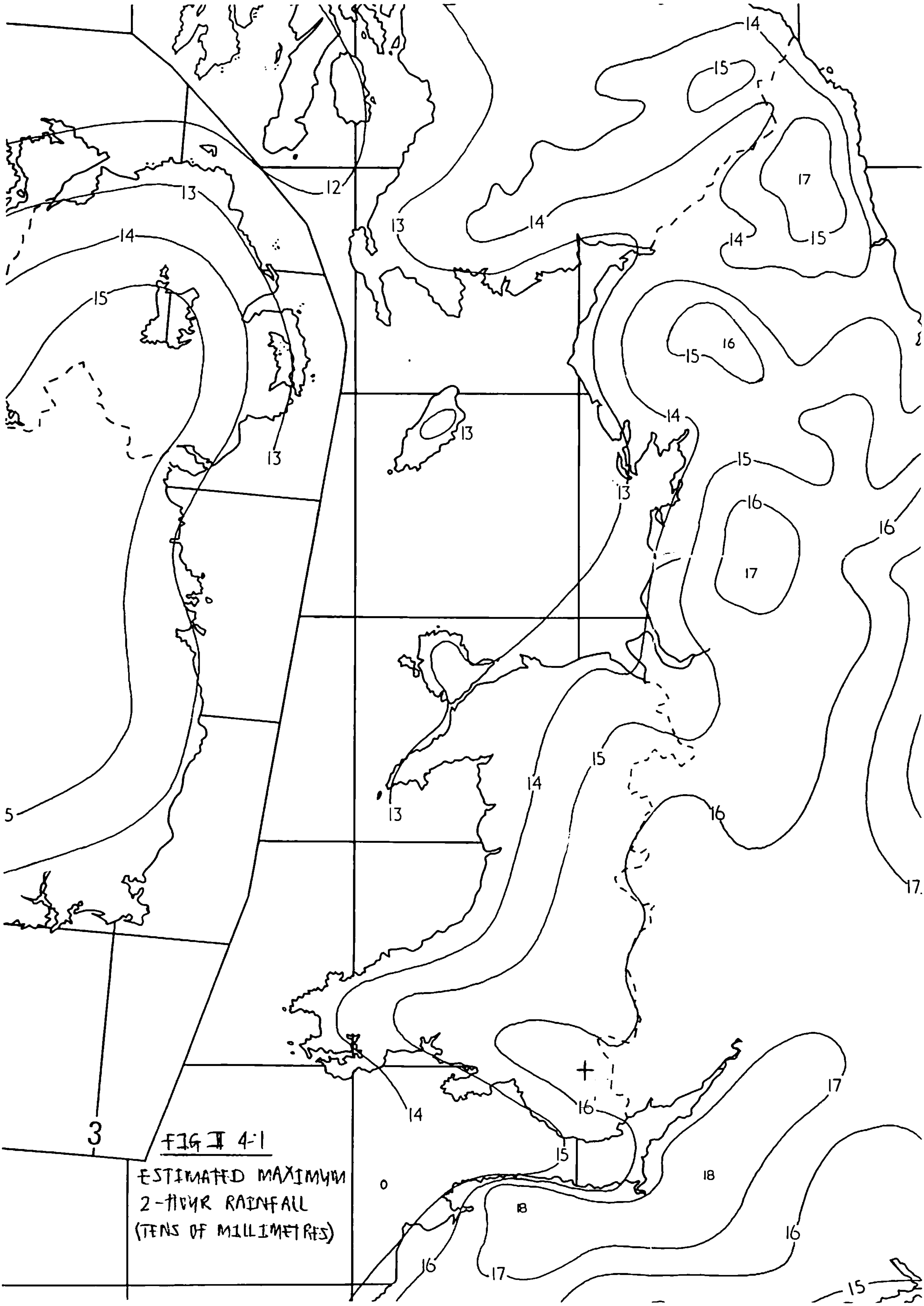


FIG II 4·1

ESTIMATED MAXIMUM 2-HOUR RAINFALL (TENS OF MILLIMETRES)

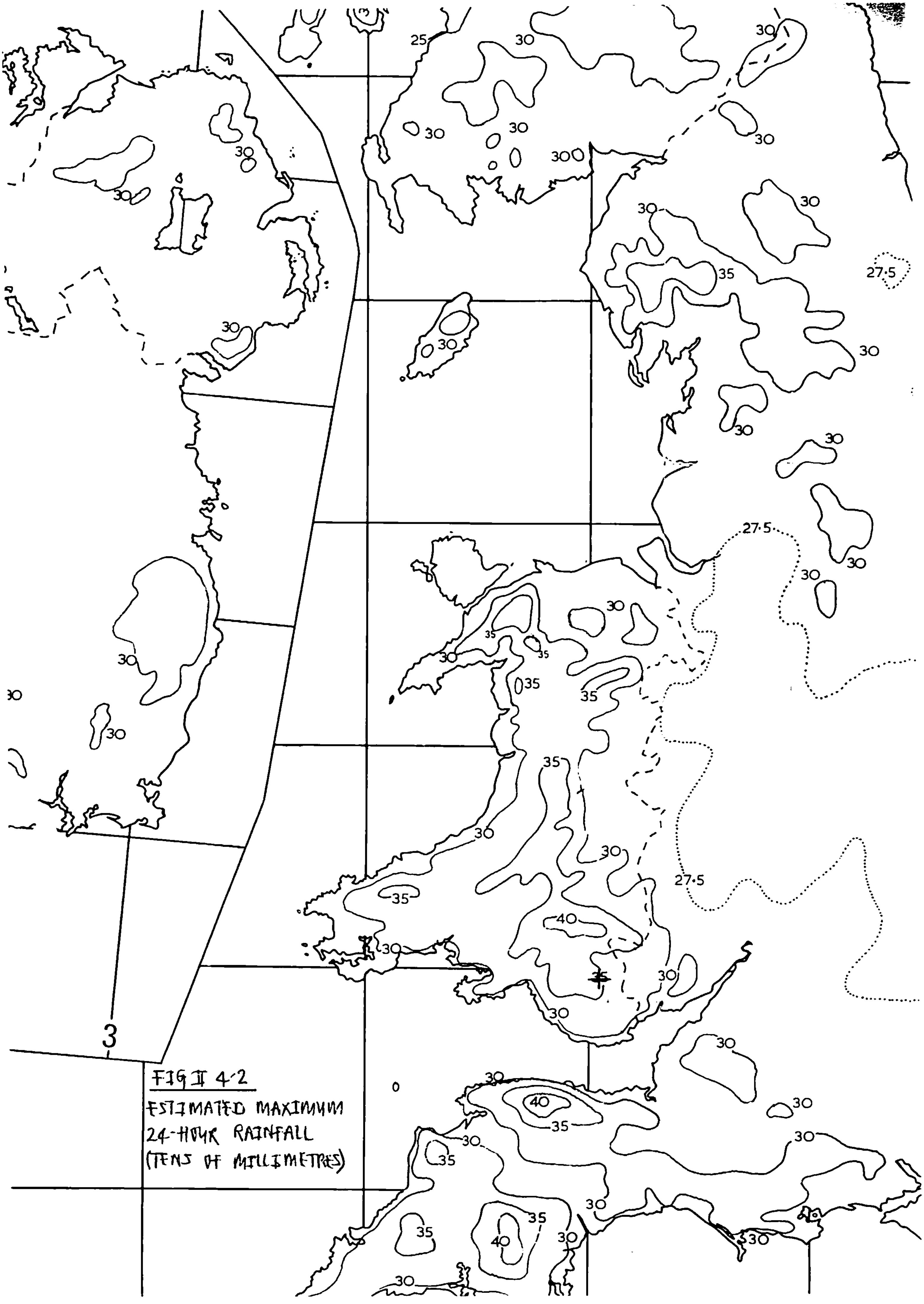


FIG II 4·2
ESTIMATED MAXIMUM
24-HOUR RAINFALL
(TENS OF MILLIMETRES)

FIG II 3·1(S)

AVERAGE ANNUAL RAINFALL 1941-1970
(HUNDREDS OF MILLIMETRES)

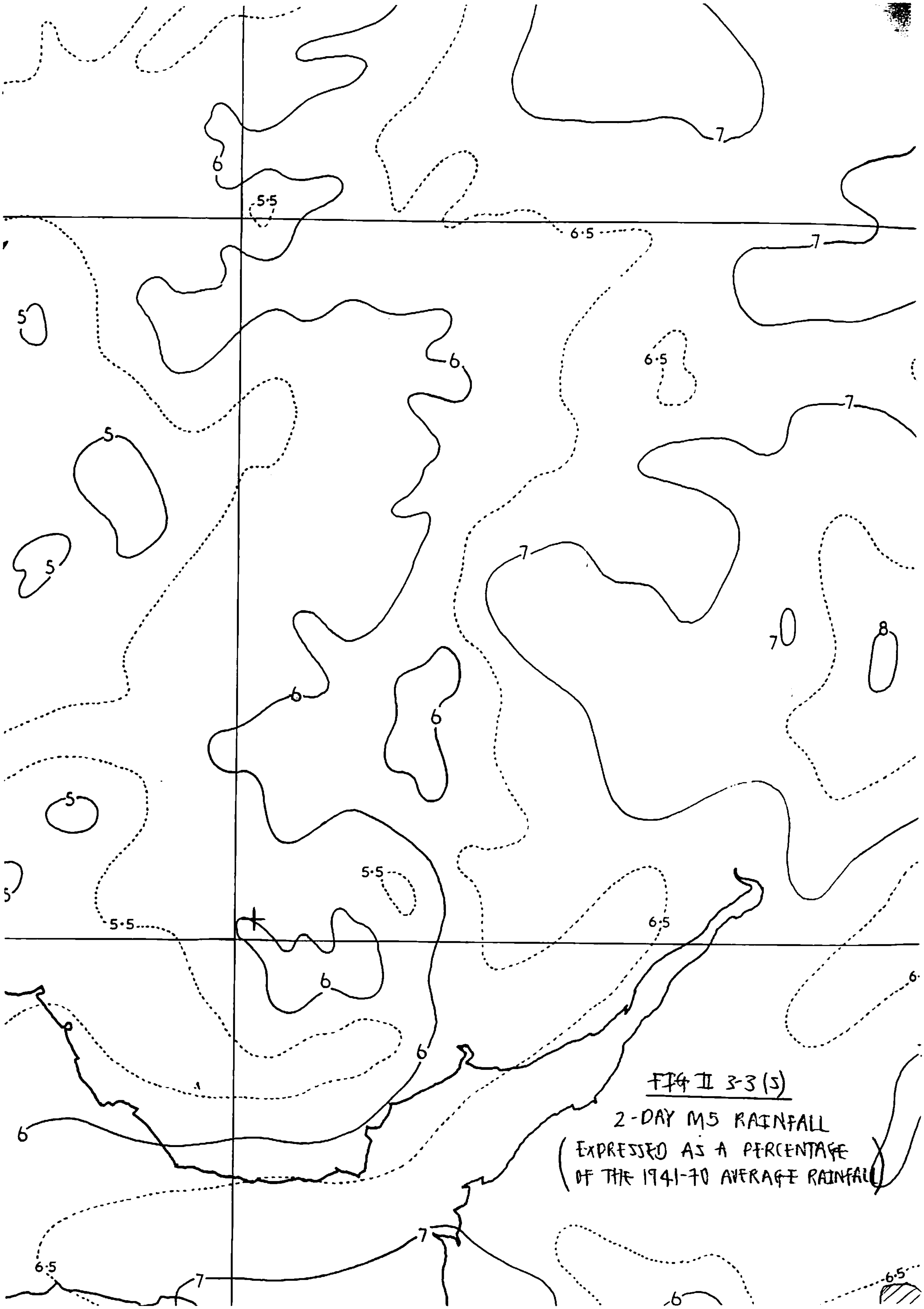


FIG II 3-3 (S)

2-DAY M5 RAINFALL
(EXPRESSED AS A PERCENTAGE
OF THE 1941-70 AVERAGE RAINFALL)

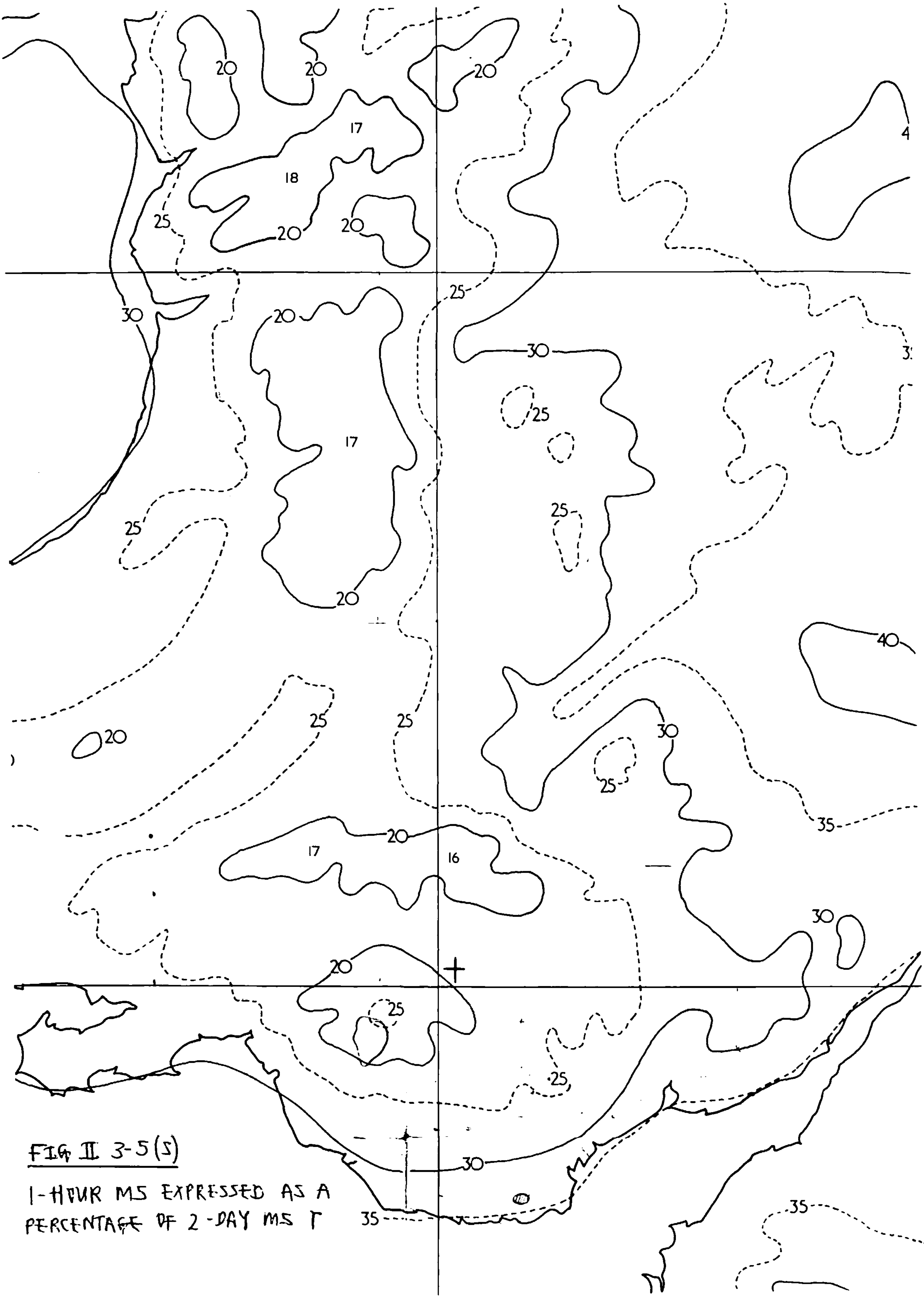


FIG II 3-5 (S)

1-HOUR MS EXPRESSED AS A PERCENTAGE OF 2-DAY MS T

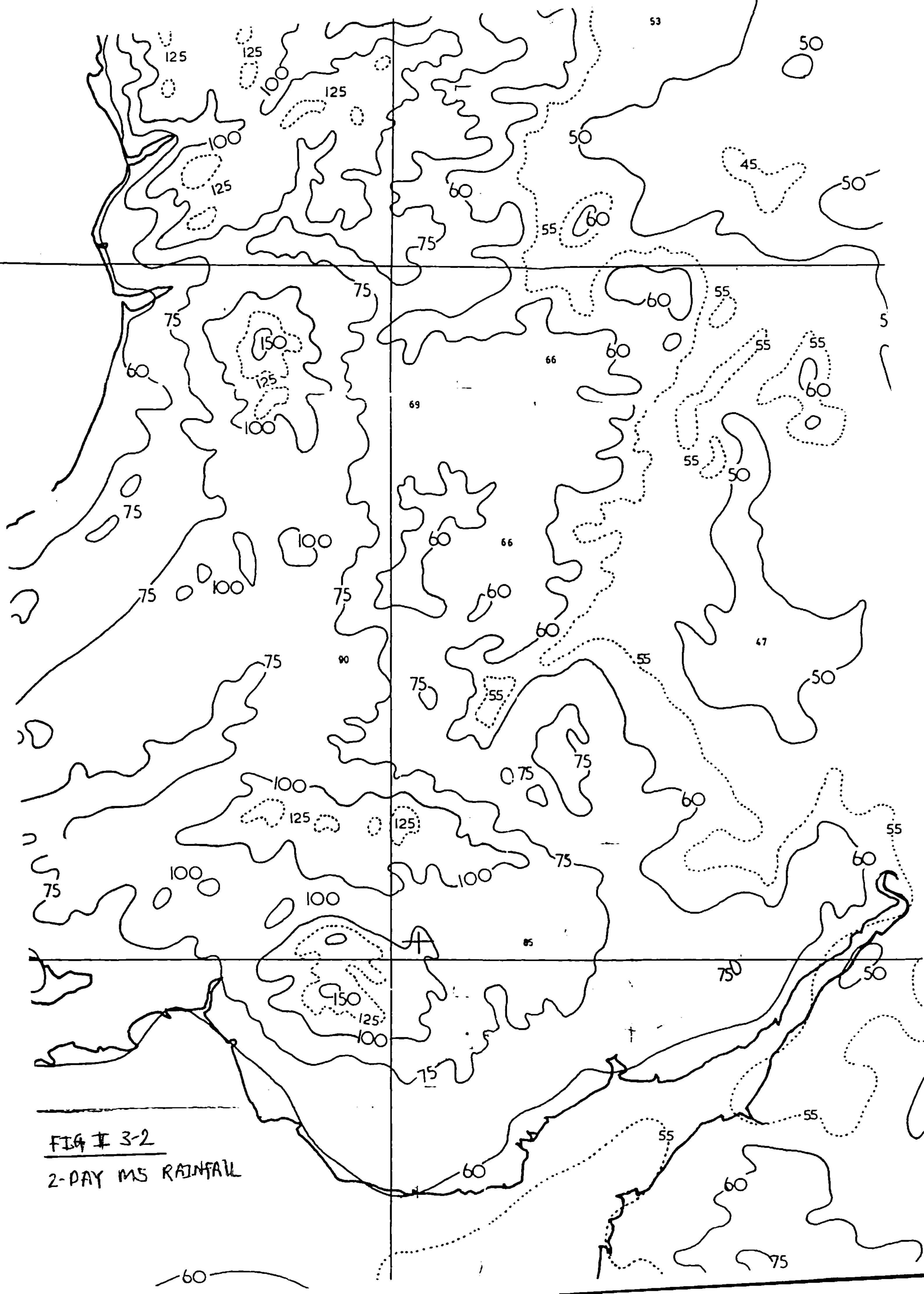


FIG II 3-2

2-DAY MS RAINFALL

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Calculation Sheet

Job No.	Sheet No.	Rev.

Member/Location

Job Title

Drg. Ref.

Made by | Date | Chd.

POND ATTENUATION DESIGN

SUMMARY OF RESULTS

- PEAK INFLOW = 1500 l/s.
- PEAK OUTFLOW = 500 l/s.
- STORAGE DEPTH = 705mm (i.e. W/L = 265.21)
- OUTFLOW CONTROL VIA 4 No 300φ OPEN-ENDED PIPES.

0AP20

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Calculation Sheet

Job No.	Sheet No.	Rev.
56164		

Member/Location

Job Title

Drg. Ref.

Made by SRD Date 6/7/99 Chd. LP 7/7/99

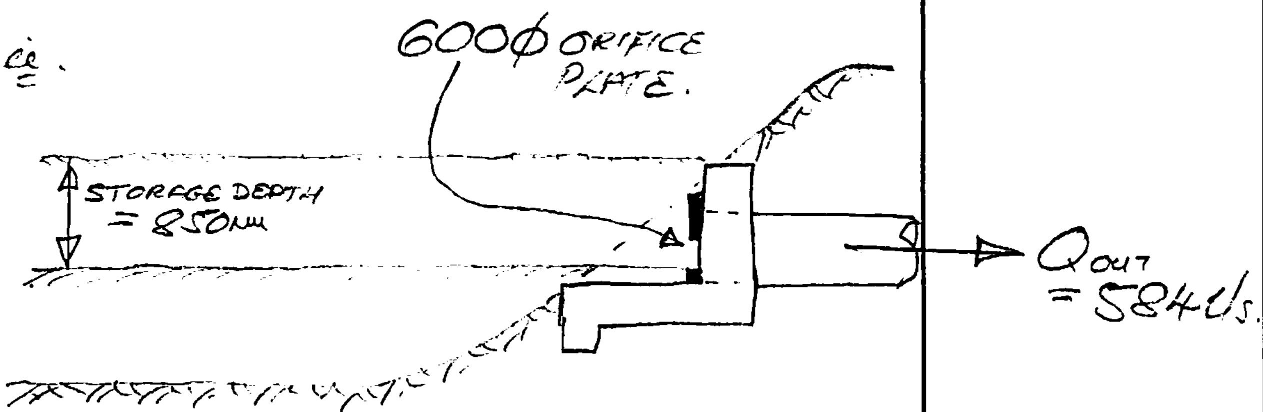
Design of Outlet Control ("Throttle") pipes

- From Micro-Drainage model, outflow is limited to :-

584 l/s for 120min duration storm.

This requires a storage depth of 848mm, with the control in the computer model provided by a 600mm ϕ orifice plate, with an invert level @ the base of the storage depth.

i.e.

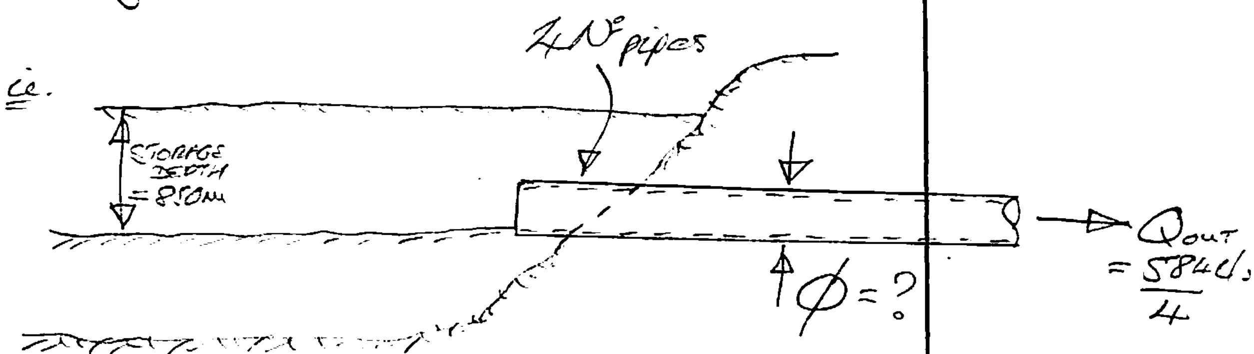


- Orifice plate coeff. taken as 0.63 in model.

- In practice, an orifice plate will not be used.

Instead, 4 No throttle pipes will be used, terminated with a projecting open end into the lagoon.

i.e.



Determine suitably sized pipes!

OAP20

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Calculation Sheet

Job No.	Sheet No.	Rev.
56767		

Member/Location

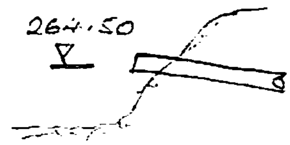
Job Title

Drg. Ref.

Made by SRU   Date 7/7/97   Chd. LP 7/7/99

① DERIVE HEAD DISCHARGE RELATIONSHIP FOR 300 φ PIPE.

NB – Use projecting pipe conditions
(NO H/WALL !).



LAGOON WATER LEVEL	φ	Hw	Hw/D	Q /pipe	Q (4 PIPES)	Q (6 PIPES)	POND PLAN AREA
264.55	0.3	0.05	0.1667				1082 m²
							1110
264.65	0.3	0.15	0.50	0.017	0.068	0.102	1140
264.70	0.3	0.20	0.667	0.030	0.120	0.180	1170
264.75	0.3	0.25	0.833	0.042	0.168	0.252	1200
264.80	0.3	0.3	1.008	0.055	0.220	0.330	1230
264.85	0.3	0.35	1.167	0.065	0.260	0.390	1260
264.90	0.3	0.40	1.333	0.080	0.320	0.480	1290
264.95	0.3	0.45	1.50	0.089	0.356	0.534	1320
265.00	0.3	0.5	1.667	0.097	0.388	0.582	1340 m²
265.05	0.3	0.55	1.833	0.104	0.416	0.624	1370
265.10	0.3	0.60	2.000	0.112	0.448	0.672	1400
265.15	0.3	0.65	2.167	0.118	0.472	0.708	1430
265.20	0.3	0.70	2.333	0.120	0.480	0.720	1460
265.25	0.3	0.75	2.500	0.130	0.520	0.780	1490
265.30	0.3	0.80	2.667	0.132	0.528	0.792	1520
265.35	0.3	0.85	2.833	0.145	0.580	0.870	1550
265.40	0.3	0.9	3.0	0.148	0.592	0.888	1580
265.45	0.3	0.95	3.167	0.150	0.600	0.900	1590
265.50	0.3	1.00	3.333	0.155	0.620	0.930	1600 m²

HEAD/DISCHARGE RELATIONSHIPS FOR 4 OR 6 OUTFALL PIPES.

Cambrian Buildings
Mount Stuart Square
Cardiff CF1 6QP

BRYN-PICA LANDFILL SITE
SURFACE WATER
SETTLEMENT LAGOON

Date Jun-99
Disk File BRINPIC2.pnd

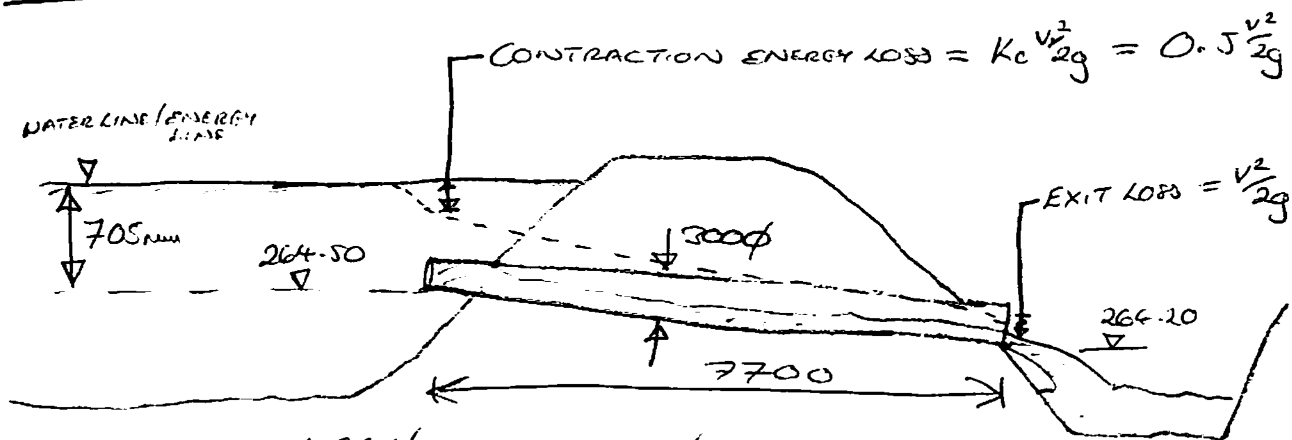
Designed by srb
Checked by

Integer Storage Design W.6.1b (c)1982-1997 APC Millerick

SUMMARY OF RESULTS FOR 20 YEAR RETURN PERIOD

Storm Duration (mins)	Rain (mm/hr)	Time-Peak (mins)	Overflow (m3/s)	Maximum Outflow (m3/s)	Maximum Depth (m)	Maximum Volume (m3)
15	55.25	24	0.000	0.373	0.478	572
30	40.11	33	0.000	0.447	0.598	736
60	28.10	50	0.000	0.483	0.688	864
120	19.06	84	0.000	0.490	0.705	889
180	14.97	114	0.000	0.476	0.669	836
240	12.60	144	0.000	0.459	0.628	778
360	9.86	204	0.000	0.419	0.551	670
480	8.26	272	0.000	0.386	0.496	596
600	7.20	320	0.000	0.353	0.448	532
720	6.43	384	0.000	0.332	0.417	491
960	5.37	512	0.000	0.290	0.370	432
1440	4.16	768	0.000	0.231	0.311	359

Check using Energy Principles



- Flow in pipe $= \frac{490 \, l/s}{4} = 122.5 \, l/s$
- Area of pipe $= \pi r^2 = 0.0707 m^2$

$\Rightarrow$ Velocity $= 1.73 m/s$

$\Rightarrow$ Exit loss $= \frac{V^2}{2g} = 0.153m$

Entry loss $= \frac{0.5V^2}{2g} = 0.076m$

$\Rightarrow$ Hydraulic gradient $= \frac{(264.50+0.705) - 0.076 - 0.153 - (264.20+0.3)}{7.7}$

$= 0.476/7.7 = 1:16$

300φ @ 1:16 $\Rightarrow$ Capacity $= 280 \, l/s > 122.5$ OK

RAINFALL DATA

Region	ENG+WAL	Return Period (years)	20
M5-60 (mm)	20	Ratio R	0.200
Volumetric Runoff Coef	0.750		
Shortest Storm Duration	15	Longest Storm Duration	1440

TIME / AREA

Time (mins) from:	to:	Area (HA)
4	8	1.500
8	12	4.000
12	16	2.000
Total Area =		7.500

(based on 50% impermeability from 15ha total site area).

TANK / POND DETAILS

Pond / Tank Invert (m).....264.500

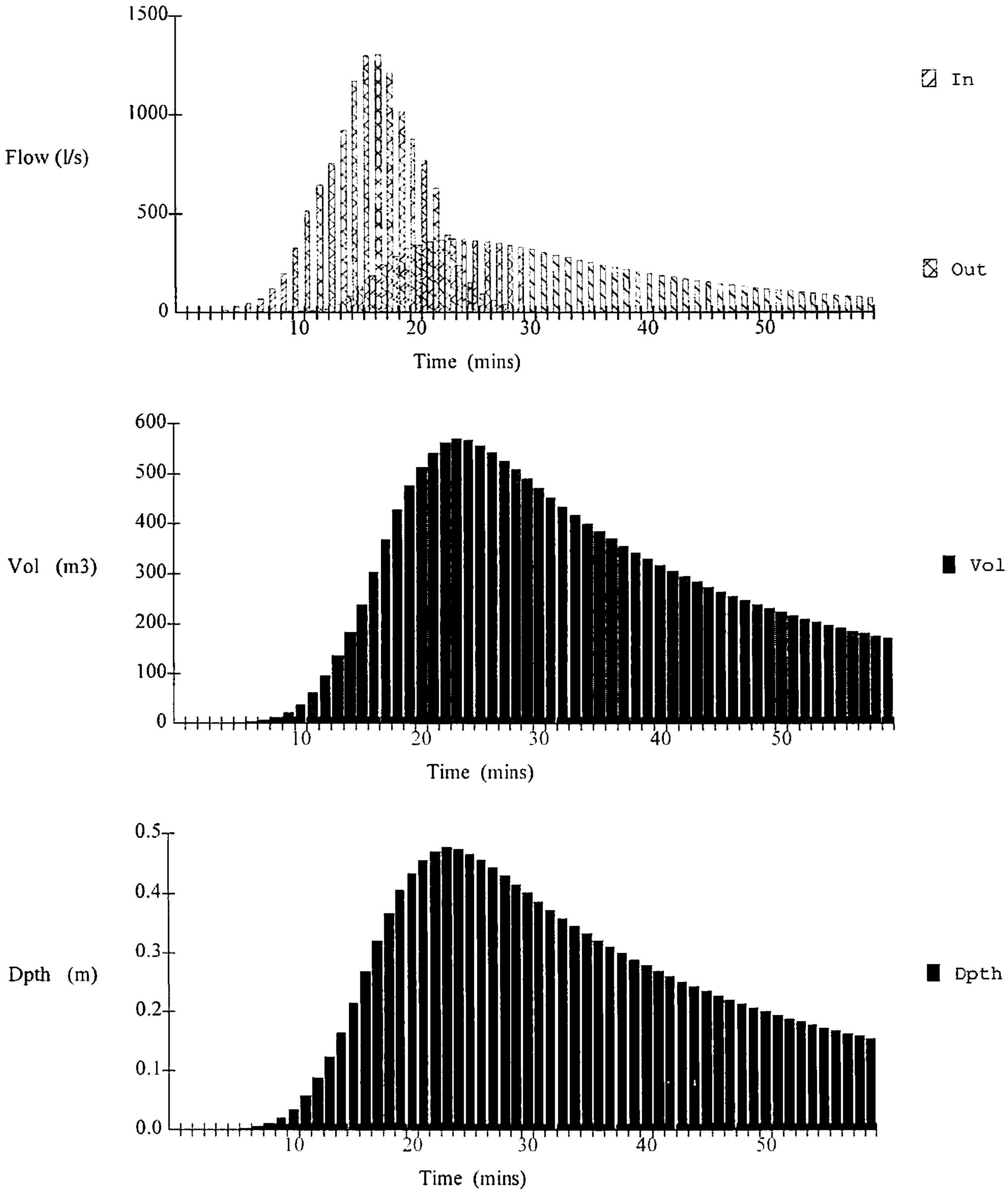
Depth (m)	Area (m2)	Depth (m)	Area (m2)
0.00	1080.00	1.30	1600.00
0.10	1110.00	1.40	1600.00
0.20	1170.00	1.50	1600.00
0.30	1230.00	1.60	1600.00
0.40	1290.00	1.70	1600.00
0.50	1340.00	1.80	1600.00
0.60	1400.00	1.90	1600.00
0.70	1460.00	2.00	1600.00
0.80	1520.00	2.10	1600.00
0.90	1580.00	2.20	1600.00
1.00	1600.00	2.30	1600.00
1.10	1600.00	2.40	1600.00
1.20	1600.00	2.50	1600.00

DEPTH / FLOW OUTFLOW CONTROL

Invert of Control (m)......264.500

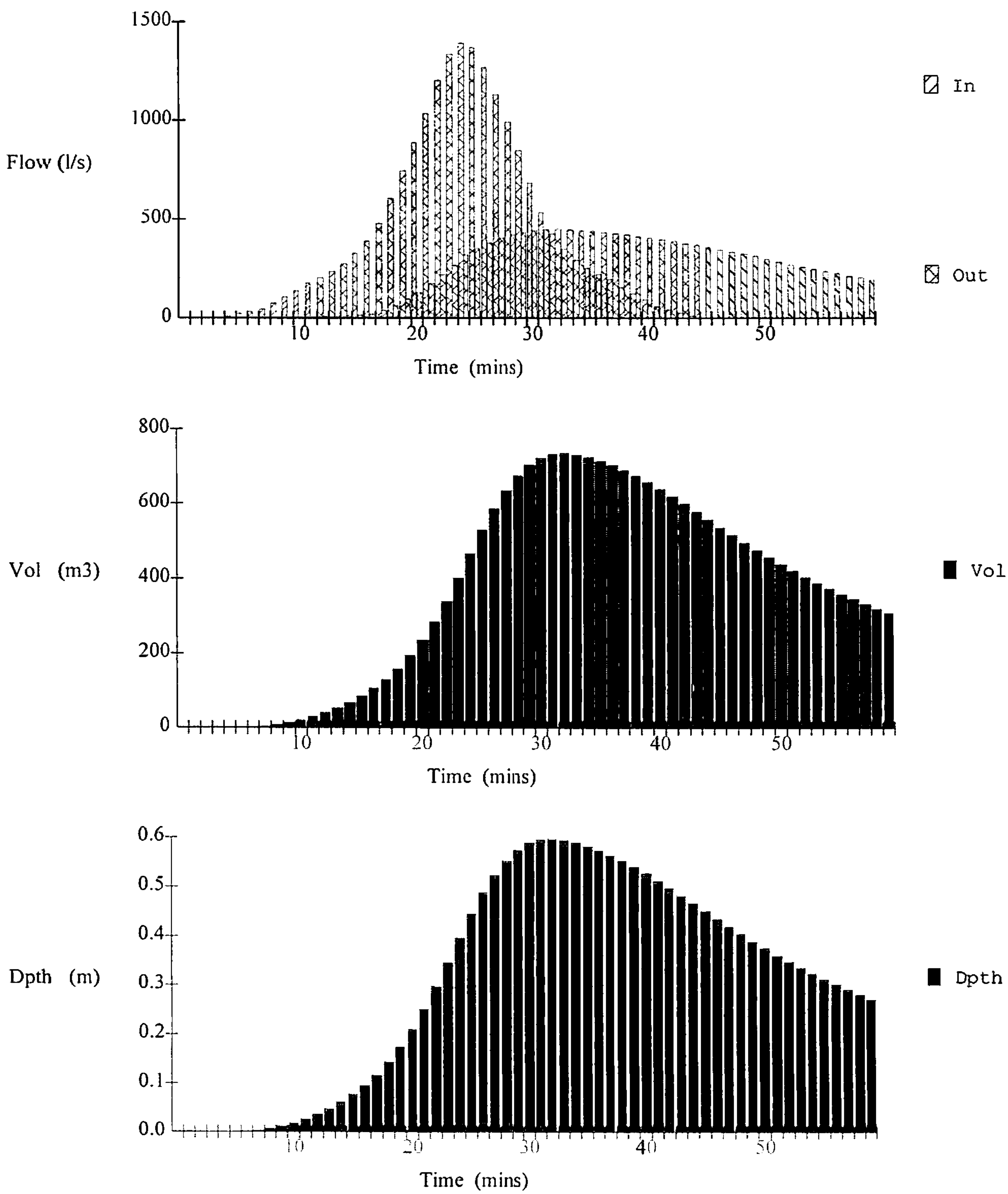
Depth (m)	Flow (m/s)	Depth (m)	Flow (m/s)
0.1	0.0200	2.60	0.8200
0.2	0.1200	3.00	0.8200
0.3	0.2200	3.50	0.8200
0.4	0.3200	4.00	0.8200
0.5	0.3880	4.50	0.8200
0.6	0.4480	5.00	0.8200
0.8	0.5280	5.50	0.8200
1.0	0.6200	6.00	0.8200
1.2	0.7200	6.50	0.8200
1.4	0.8200	7.00	0.8200
1.6	0.8200	7.50	0.8200
1.8	0.8200	8.00	0.8200
2.0	0.8200	8.50	0.8200
2.2	0.8200	9.00	0.8200
2.4	0.8200	9.50	0.8200

STORM DURATION 15 Mins

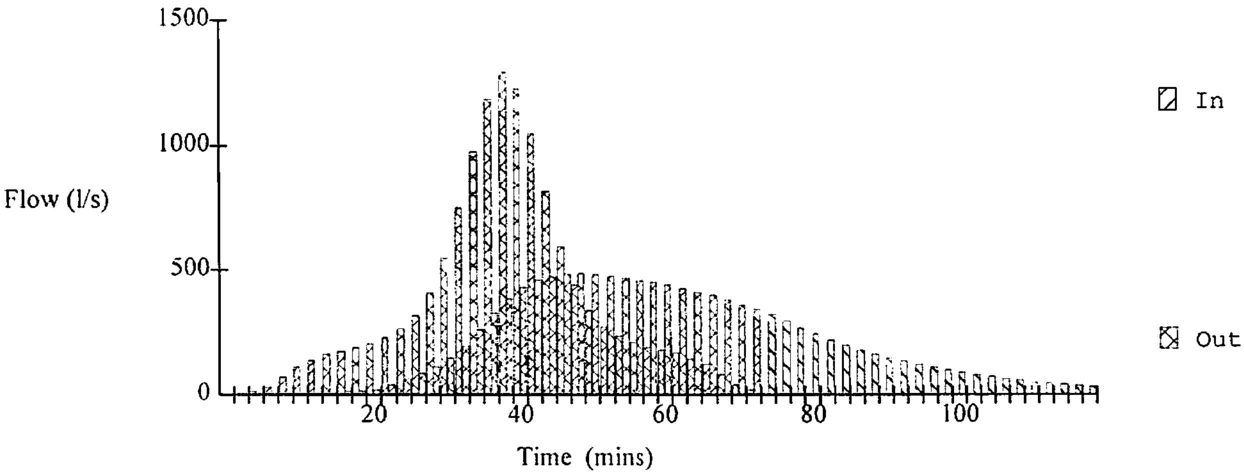


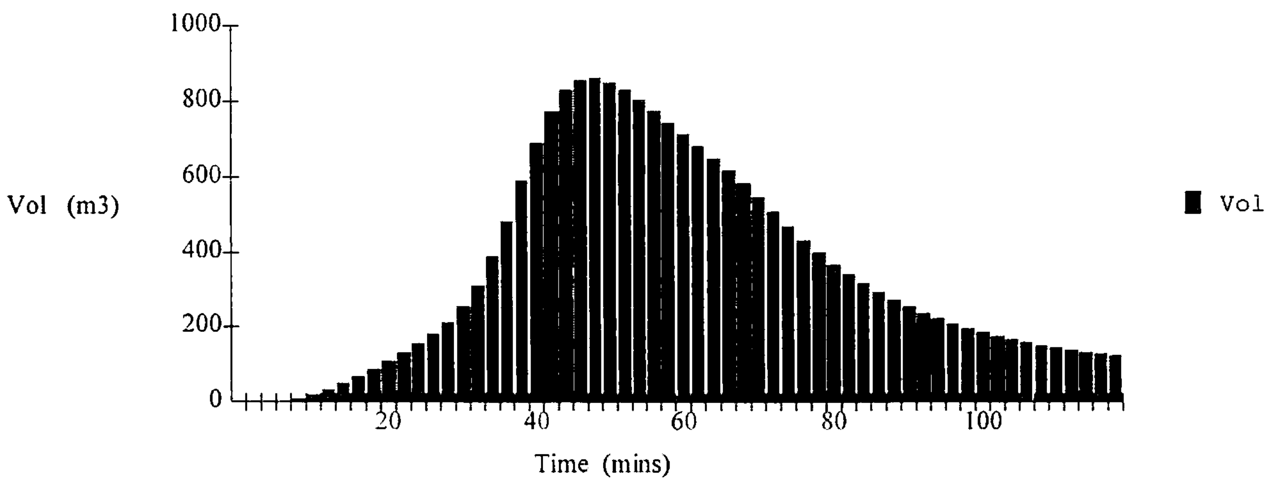
Cambrian Buildings Mount Stuart Square Cardiff CF1 6QP	BRYN-PICA LANDFILL SITE SURFACE WATER SETTLEMENT LAGOON	Micro Drainage®
Date Jun-99 Disk File BRINPIC2.pnd	Designed by srb Checked by	
Integer	Storage Design W.6.1b (c)1982-1997 APC Millerick	

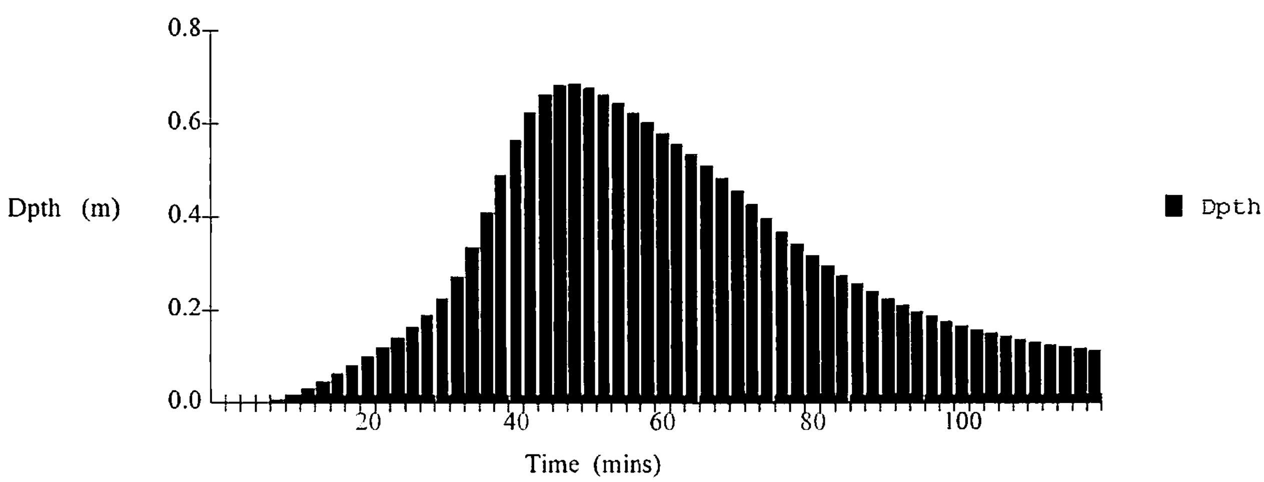
STORM DURATION 30 Mins



STORM DURATION 60 Mins







Cambrian Buildings Mount Stuart Square Cardiff CF1 6QP	BRYN-PICA LANDFILL SITE SURFACE WATER SETTLEMENT LAGOON	Micro Drainage
Date Jun-99 Disk File BRINPIC2.pnd	Designed by srb Checked by	

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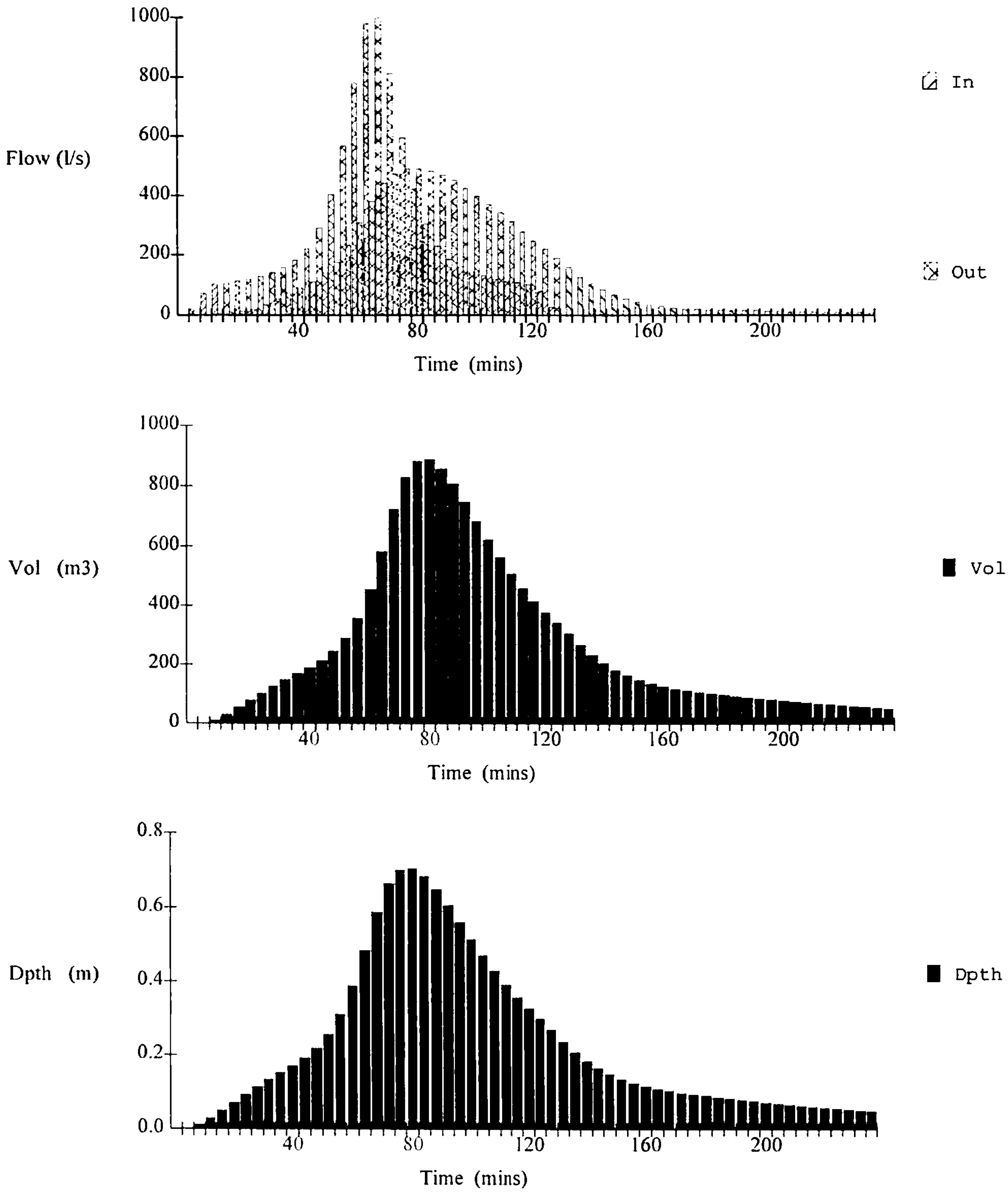
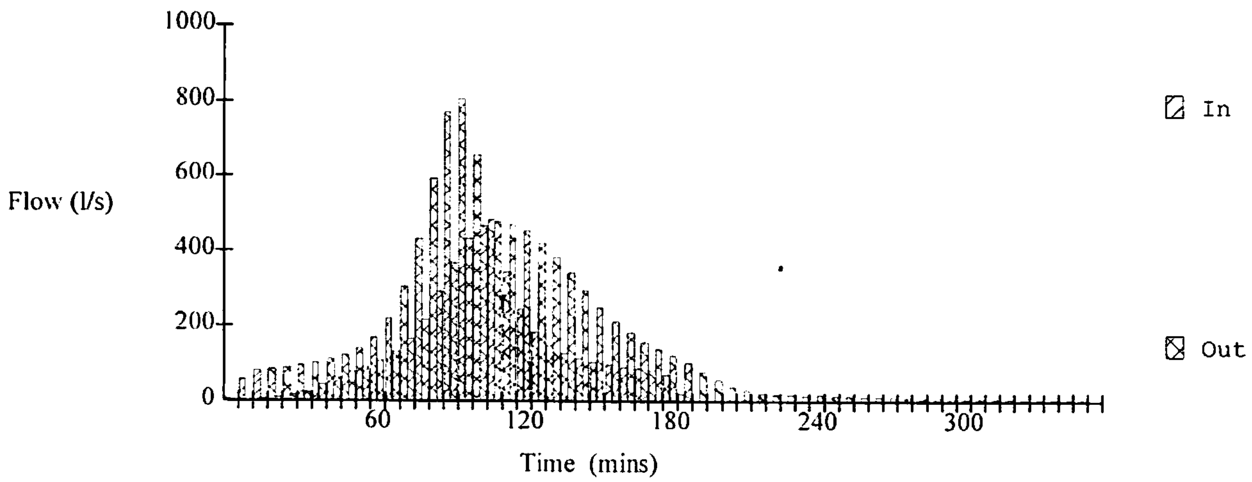
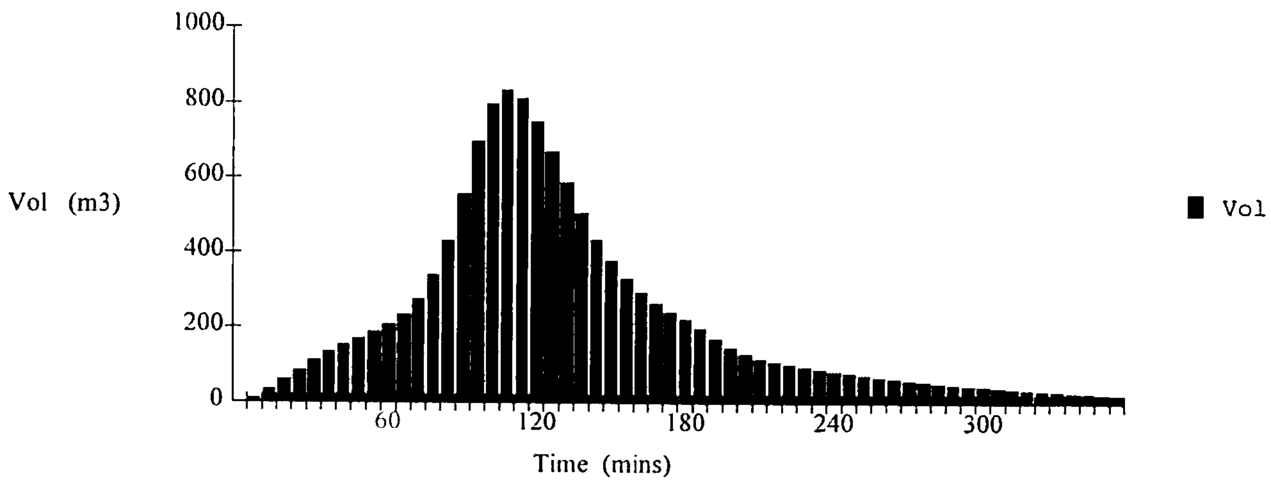
STORM DURATION 120 Mins

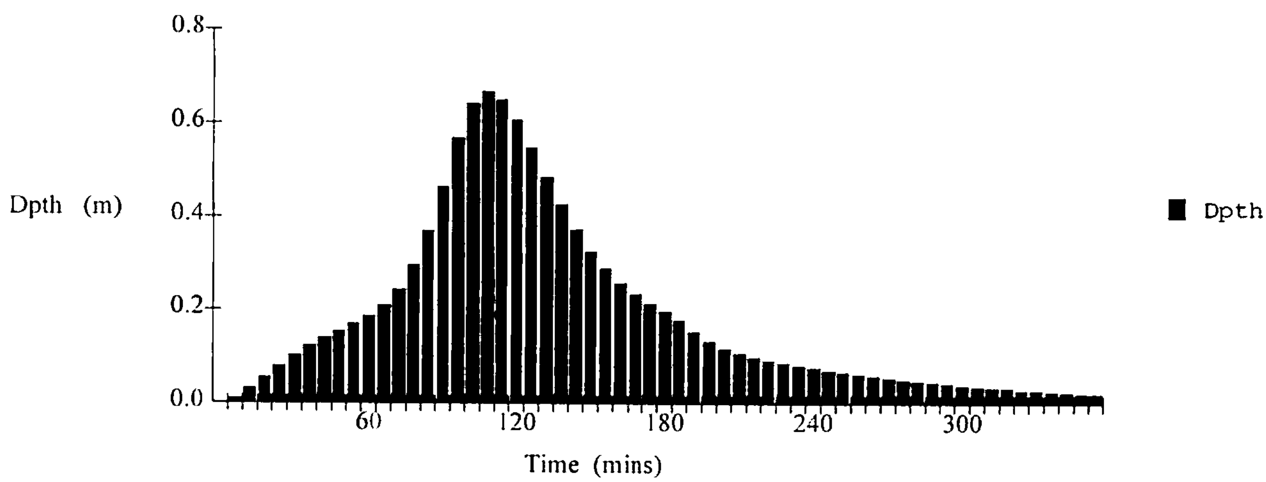


Cambrian Buildings Mount Stuart Square Cardiff CF1 6QP	BRYN-PICA LANDFILL SITE SURFACE WATER SETTLEMENT LAGOON	Micro Drainage
Date Jun-99 Disk File BRINPIC2.pnd	Designed by srb Checked by	
Integer	Storage Design W.6.1b (c)1982-1997 APC Millerick	

STORM DURATION 180 Mins







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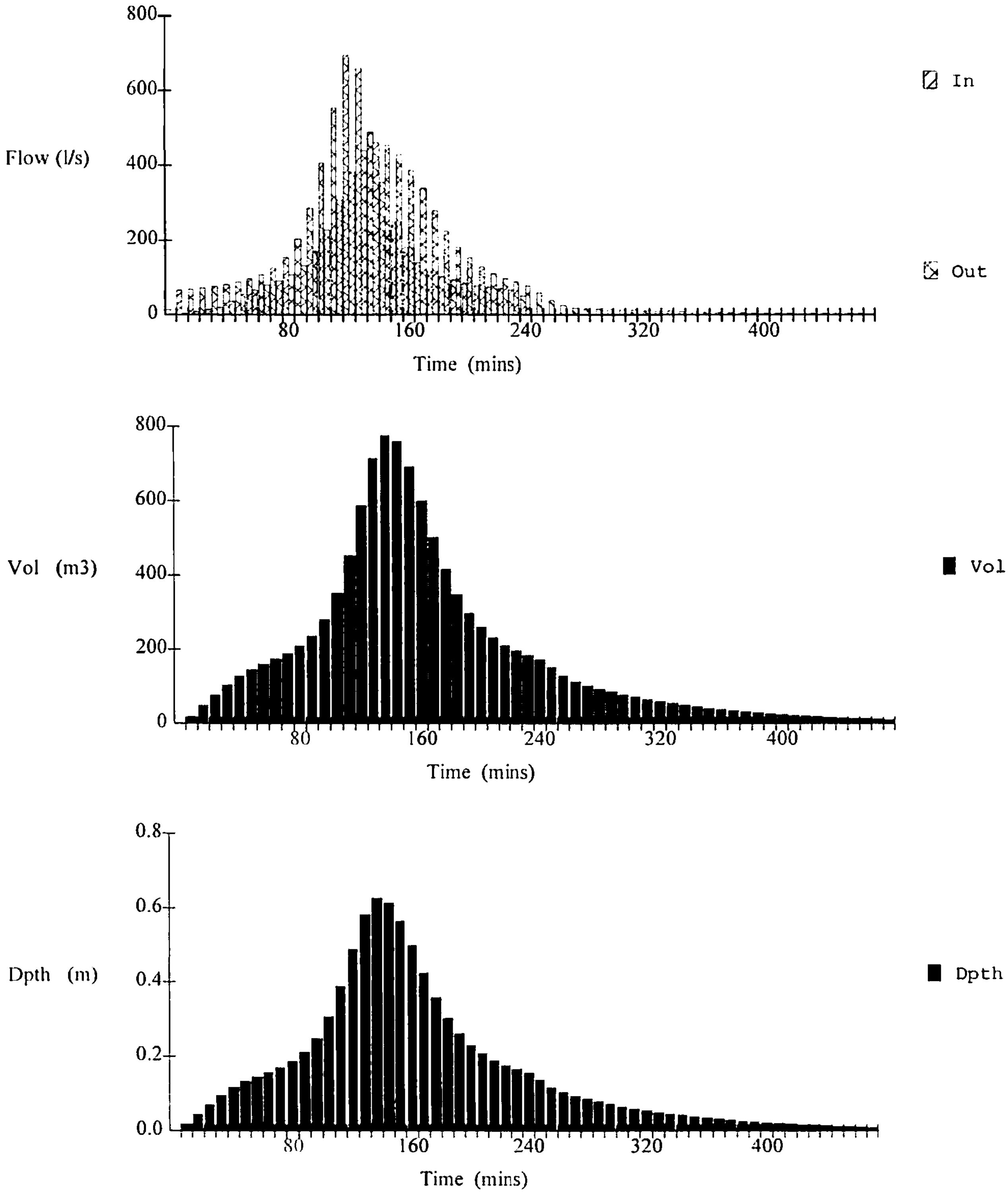
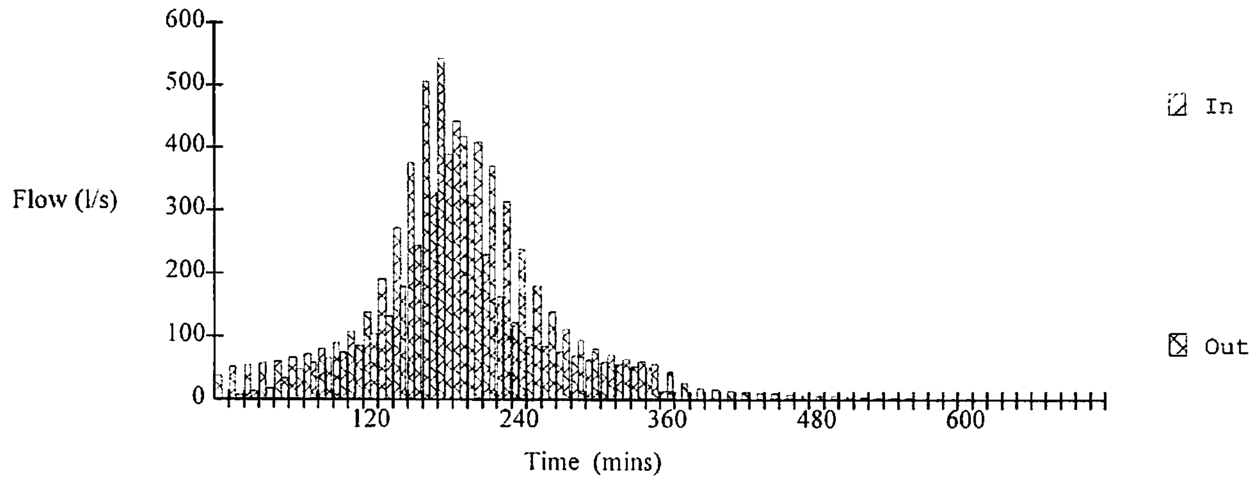
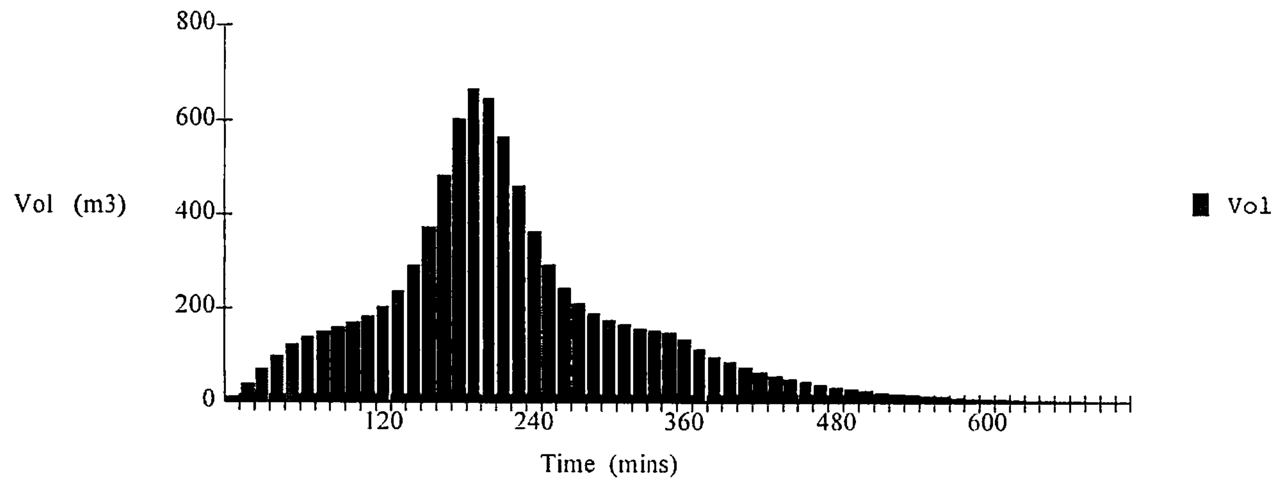
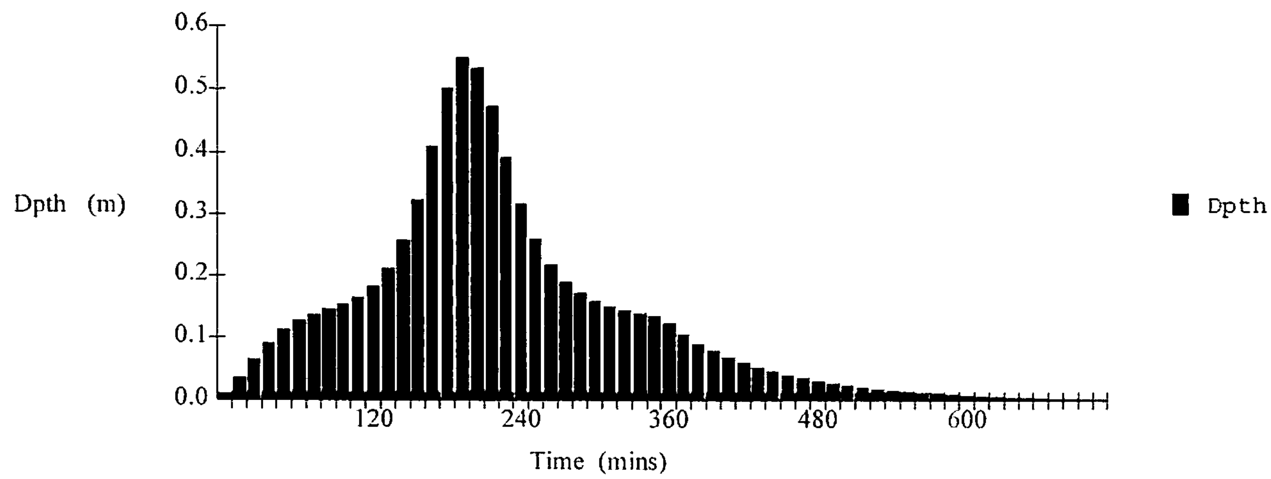


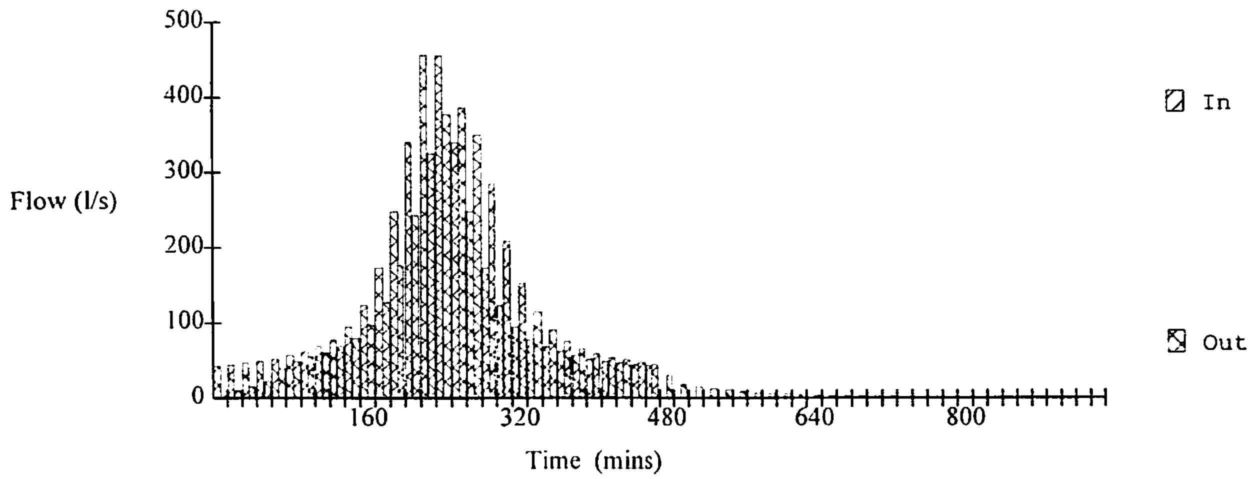
STORM DURATION 360 Mins

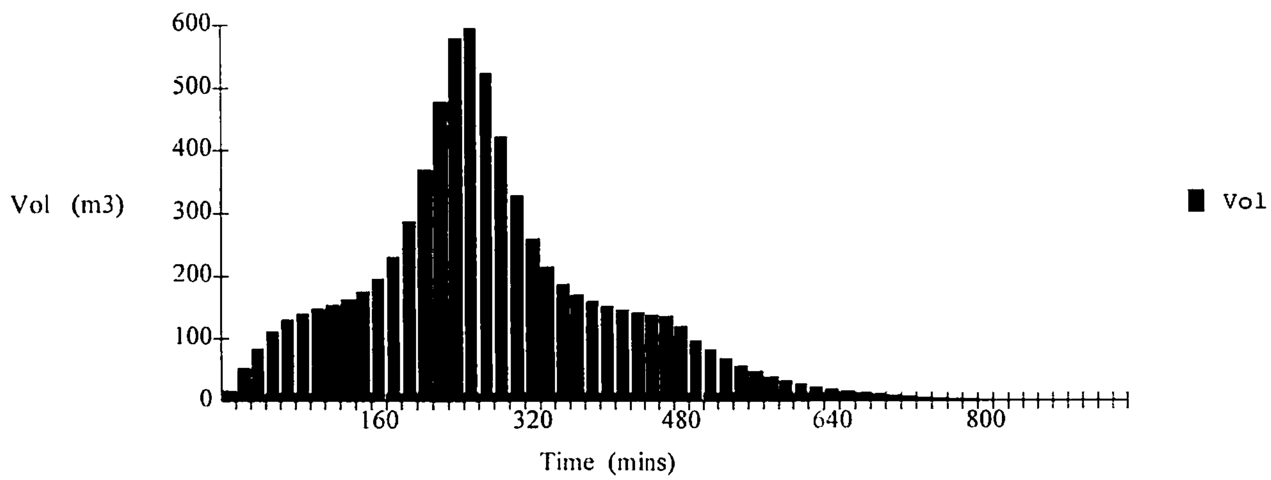


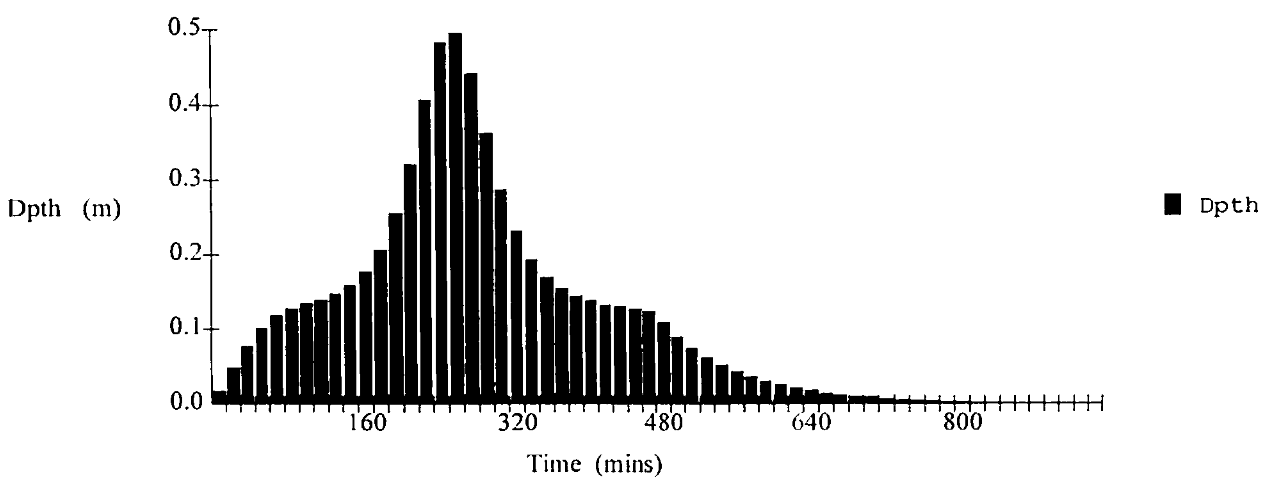




STORM DURATION 480 Mins

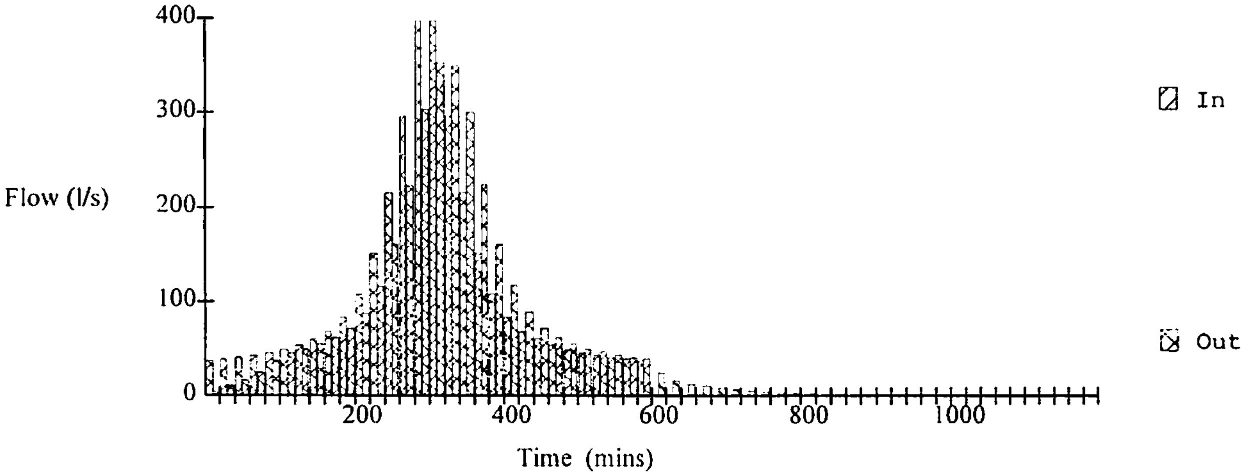


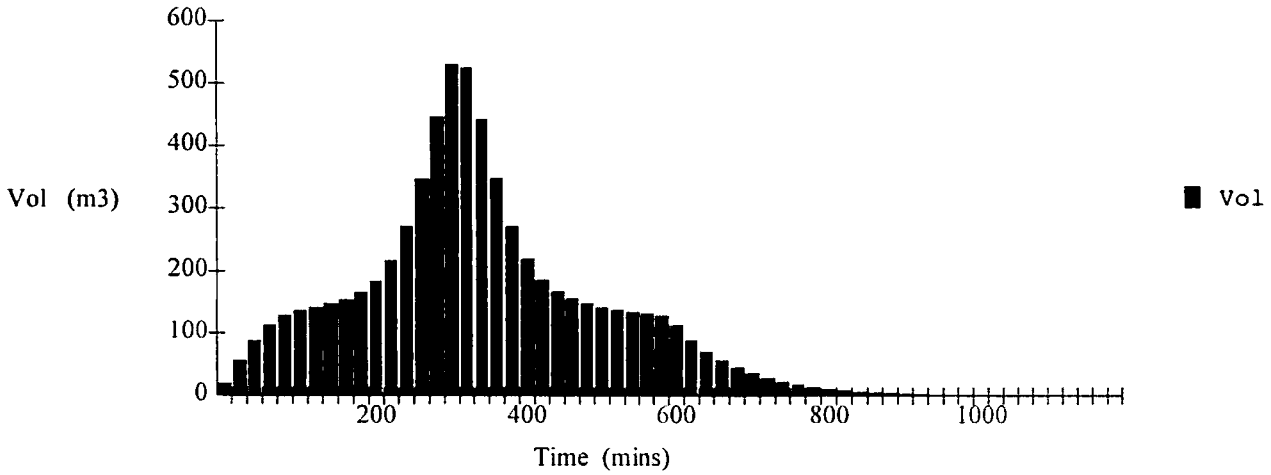


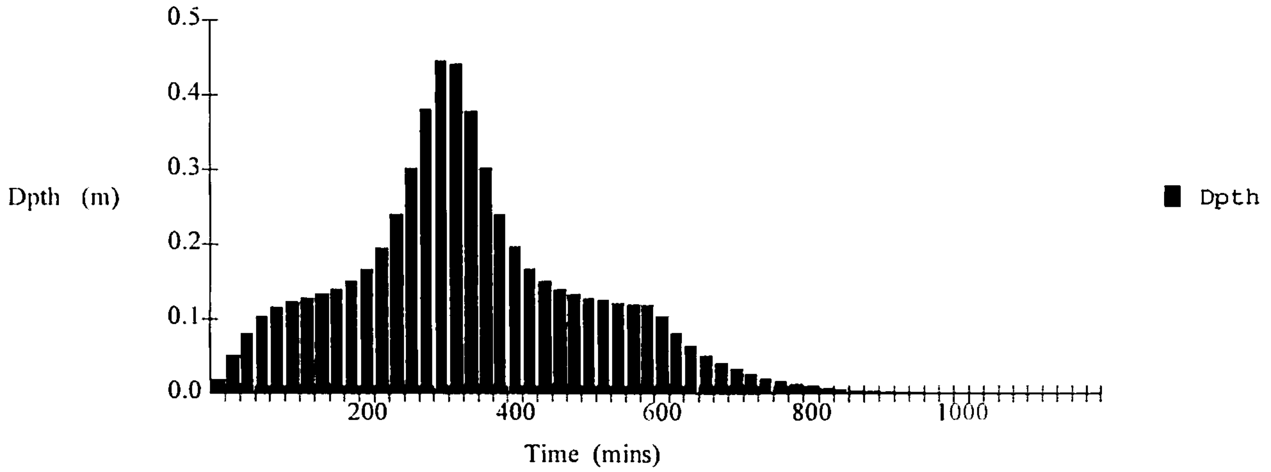


Ove Arup & Partners Cardiff		Page 12
Cambrian Buildings Mount Stuart Square Cardiff CF1 6QP	BRYN-PICA LANDFILL SITE SURFACE WATER SETTLEMENT LAGOON	Micro Drainage
Date Jun-99 Disk File BRINPIC2.pnd	Designed by srb Checked by	
Integer	Storage Design W.6.1b (c)1982-1997 APC Millerick	

STORM DURATION 600 Mins







Cambrian Buildings
Mount Stuart Square
Cardiff CF1 6QP

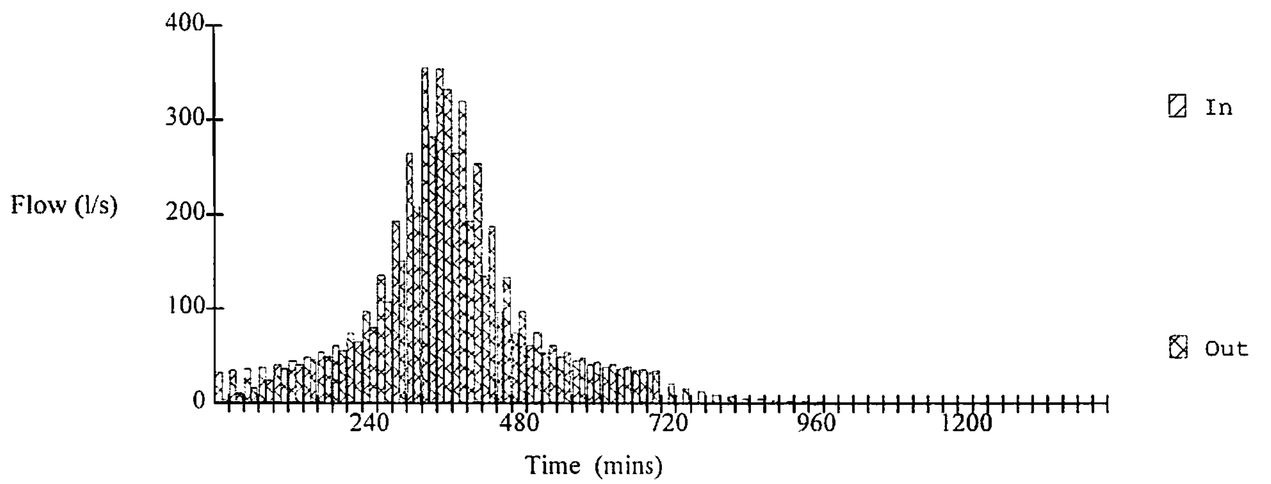
BRYN-PICA LANDFILL SITE
SURFACE WATER
SETTLEMENT LAGOON

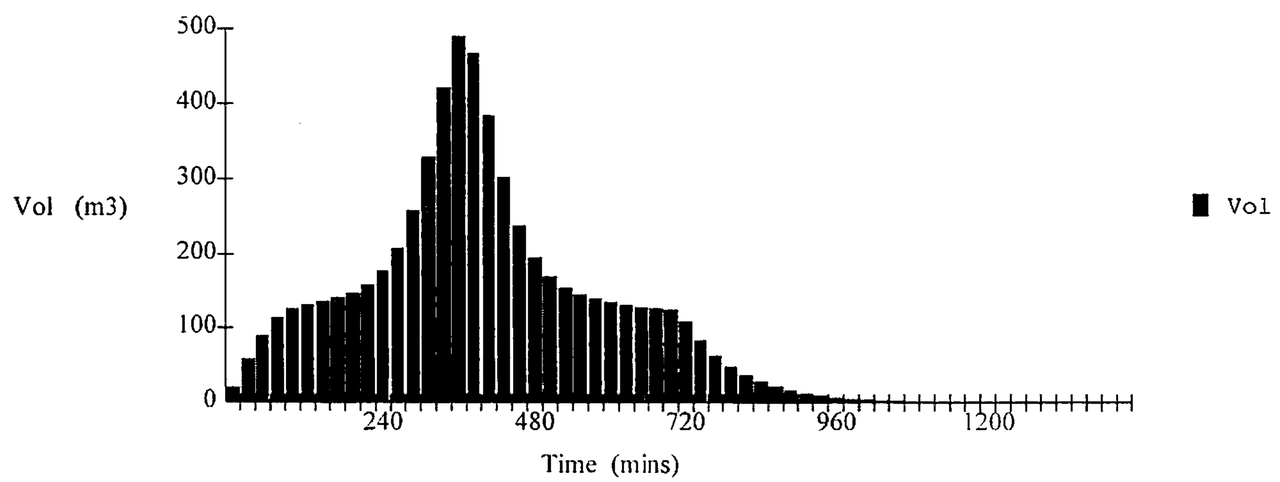
Date Jun-99
Disk File BRINPIC2.pnd

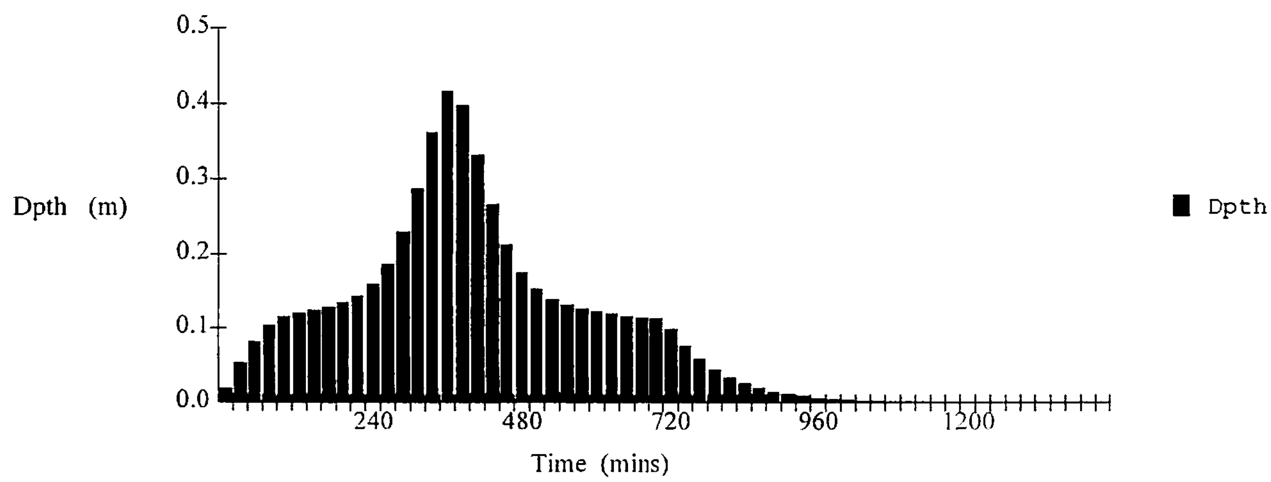
Designed by srb
Checked by

Integer Storage Design W.6.1b (c)1982-1997 APC Millerick

STORM DURATION 720 Mins



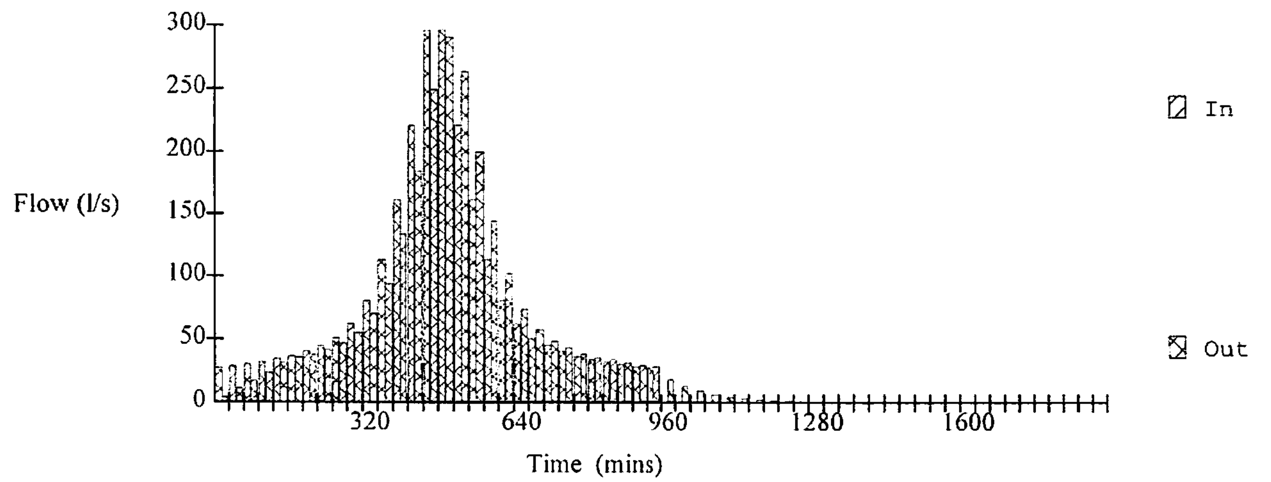


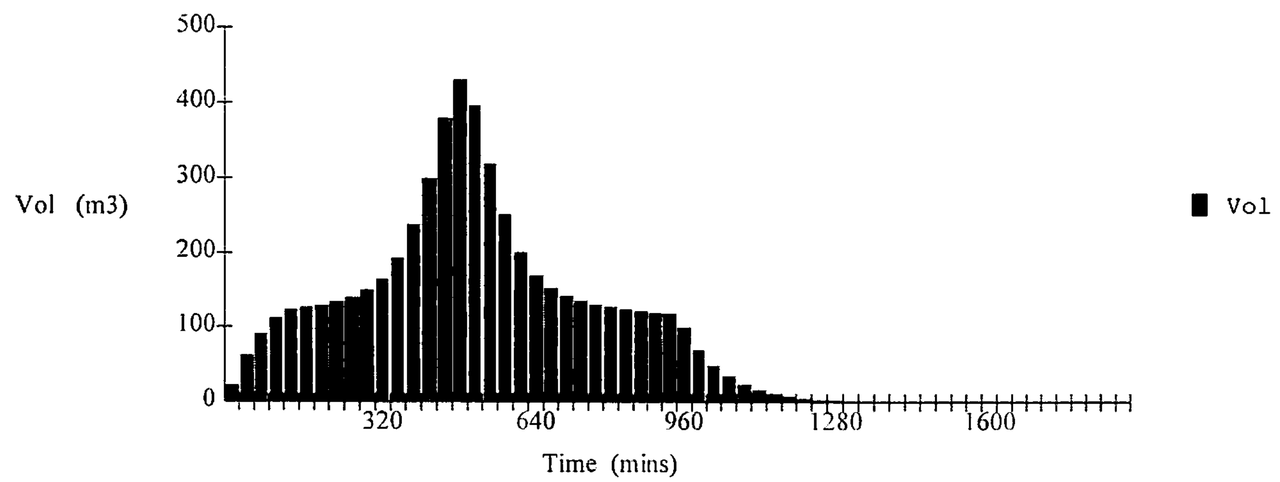


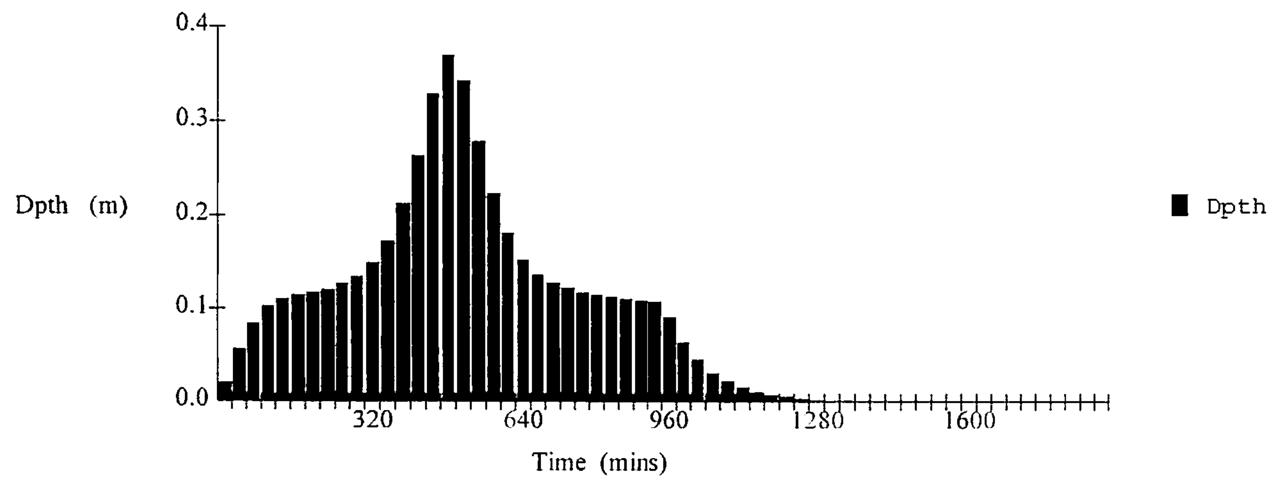
Cambrian Buildings Mount Stuart Square Cardiff CF1 6QP	BRYN-PICA LANDFILL SITE SURFACE WATER SETTLEMENT LAGOON
Date Jun-99 Disk File BRINPIC2.pnd	Designed by srb Checked by

Integer Storage Design W.6.1b (c)1982-1997 APC Millerick

STORM DURATION 960 Mins







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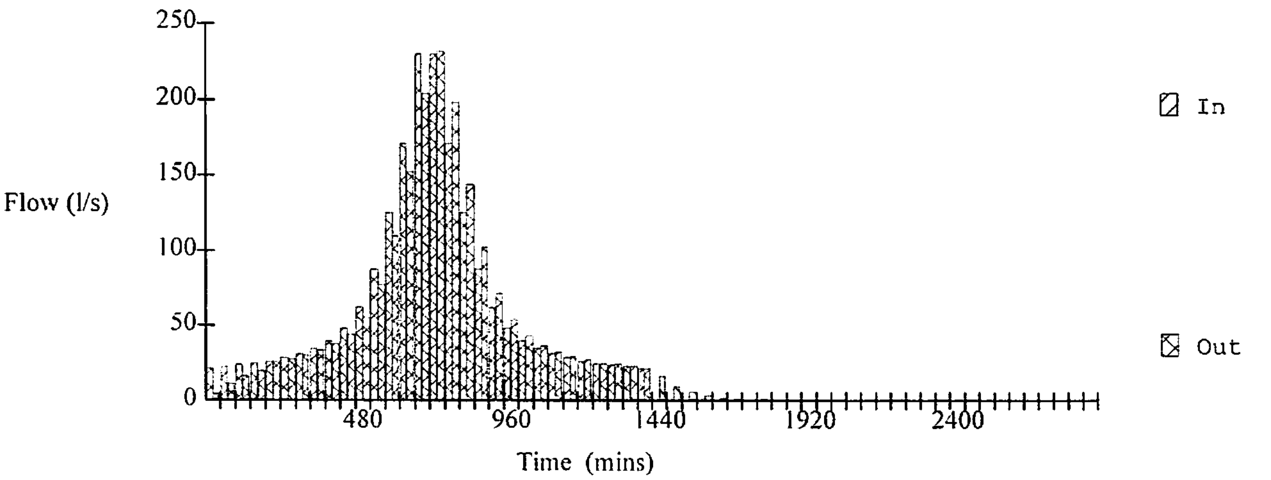

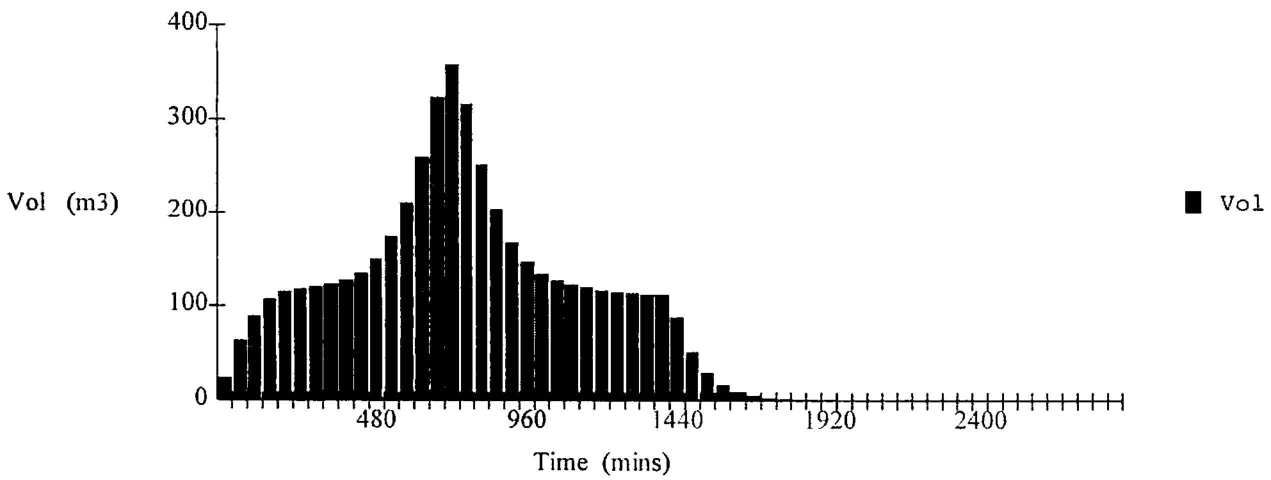

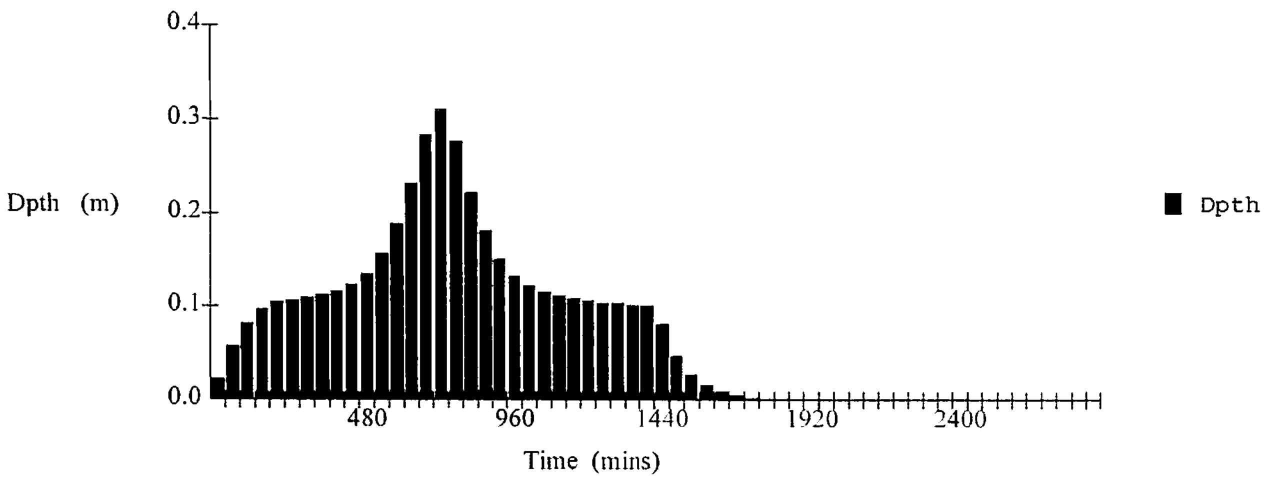

OAP20

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Calculation Sheet

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Job Title

Drg. Ref.

Made by | Date | Chd.

POND SETTLING CAPACITY

OAP20

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Calculation Sheet

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56767		

Member/Location

Job Title

Drg. Ref.

Made by SRR. Date 28/6/99 Chd. 7/7/99. LP

Estimate Capacity of Existing Settling Capacity

Existing Pond Size

- Length = 50m
- Width = 19m (average).

Use design equation : $Lb = Q/V_s$

- To determine V_s, assume particle size.

Particle ϕ	Typical Description	Settling Velocity
0.1mm	Fine Sand	1.0×10^{-2} m/s
0.01mm	Silt	1.0×10^{-4} m/s
0.0001mm	Large Colloid	1.0×10^{-8} m/s.

$\Rightarrow Q = Lb V_s$

$Q = 50\times19\times V_s$.

Particle Settled	Peak Flow, Q
FINE SAND	9.5 m³/s.
SILT	0.095 m³/s.
LARGE COLLOID	RIDICULOUS.

} ENORMOUS VARIATION

Try Different "Silt"

BS definition of silt = 0.002mm to 0.06mm particle size.

$\Rightarrow$ Average size = $\underline{0.031\text{mm}}$

$\Rightarrow$ Settling Velocity = $\frac{0.031^2}{0.01^2}\times1.0\times10^{-4} = \underline{9.6\times10^{-4}\text{ m/s}}$.

$\Rightarrow$ Peak flow = $\underline{0.91\text{ m}^3/\text{s}}$

0.01 = 100 l/s.

0.03 = 900 l/s.

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HYDRAULIC DESIGN OF CULVERTS & CHANNEL SECTIONS.

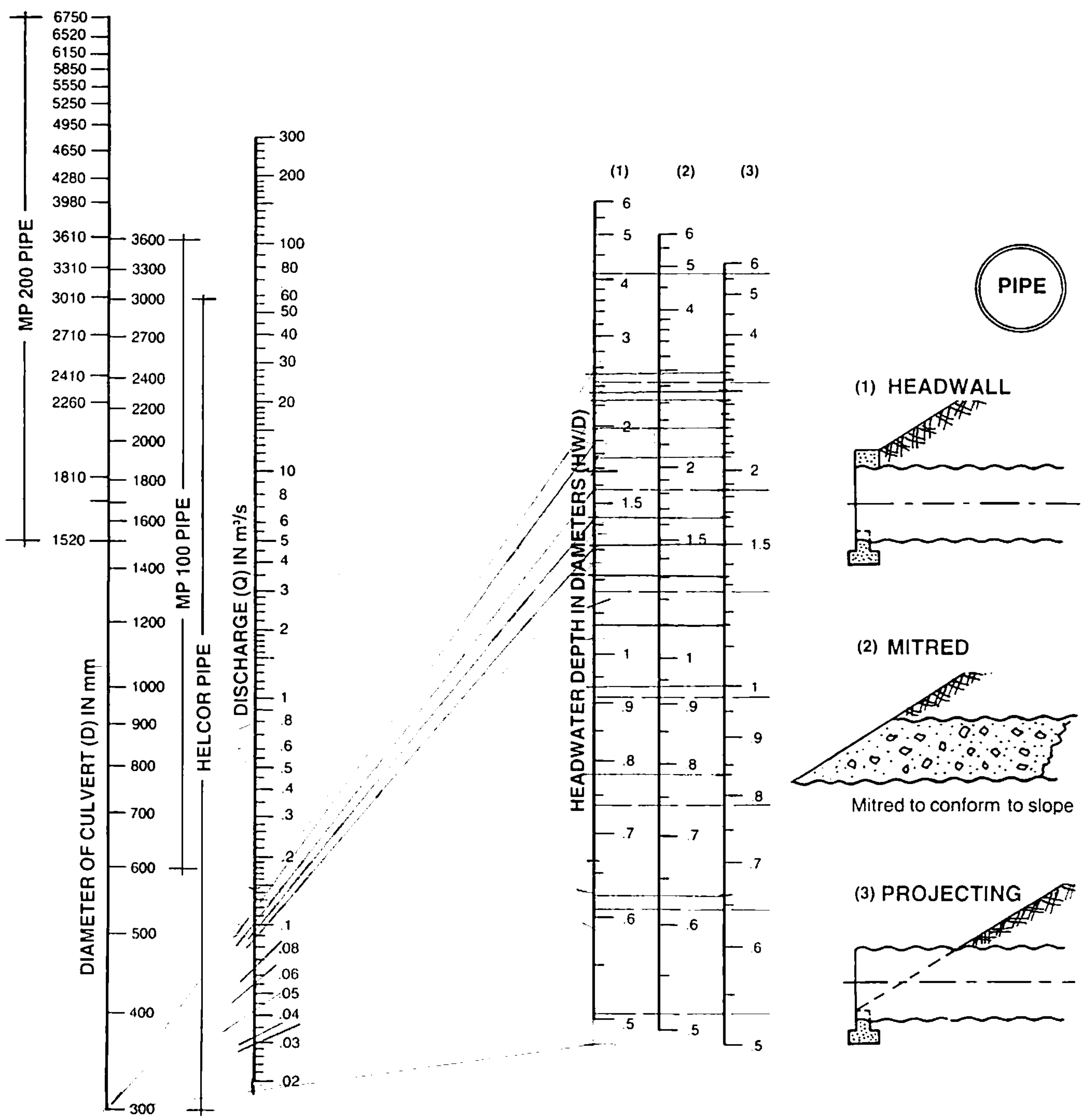
2:2 MP200

HYDRAULICS

NOMOGRAPH No.1

INLET CONTROL HEADWATER DEPTH ROUND HELCOR & MULTIPLATE PIPE

Inlet control nomograph for corrugated steel pipe culverts. We recommend keeping HW/D to a maximum of 1.5 and preferably to no more than 1.0. Data is derived from nomographs published by the Bureau of Public Roads.



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Calculation Sheet

Job No.	Sheet No.	Rev.
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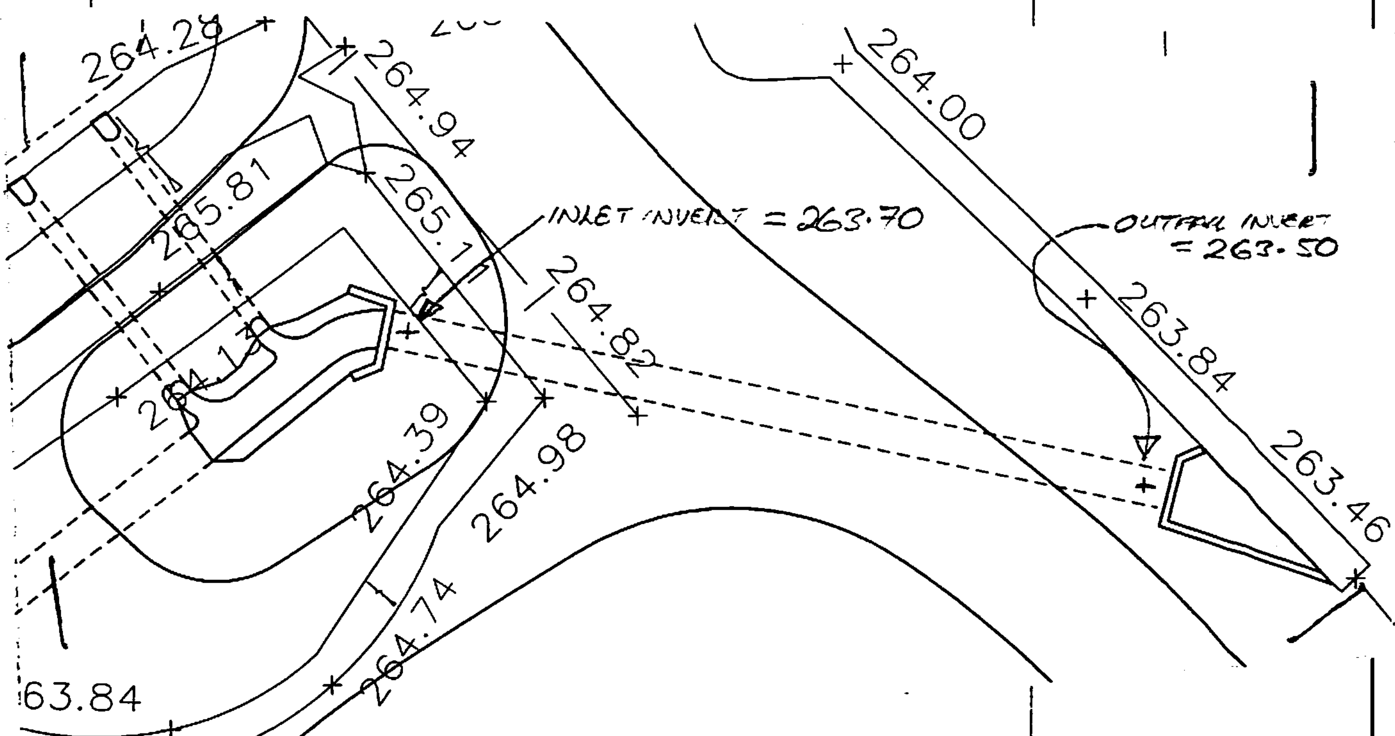
	Member/Location
Job Title Bryn Pica Settlement Lagoon	Drg. Ref.
	Made by SPL. Date 5/7/99 Chd. LP 7/7/99

Design of Culvert/Pipe Sizes

1) OUTLET CULVERT TO STREAM

- Design for peak stream inflow (ie $1.5m^3/s$) instead of actual attenuated outflow ($0.5m^3/s$). This will cater for possible future modification of the pond & the possible removal of its storage function.

- $Q = 1.5m^3/s$



Check Pipe Flow

- Pipe gradient $= \frac{0.2m}{21m} = 1:105$
- for $k_s = 0.60$ @ 1:105

$\Rightarrow$ Suitable pipe size = 825mm ($Q = 1.54m^3/s$)

- by comparison, $900\phi = 1.94m^3/s$
  $975\phi = 2.4m^3/s$
  $1050\phi - 2.9m^3/s$

Check Inlet Condition

- This is likely to be more critical than pipe flow capacity.

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Calculation Sheet

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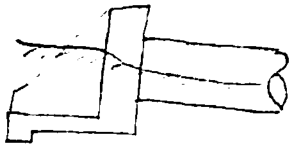
Member/Location

Job Title [illegible] | Drg. Ref.

Made by [illegible] Date [illegible]/99. Chd. LP 7/7/99

(1).

• Headwall type

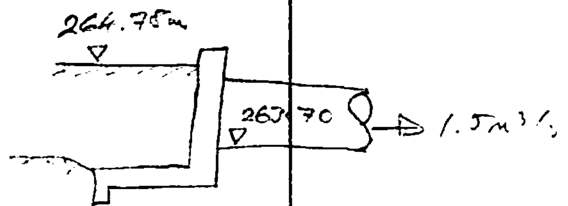


• Try 1050ϕ pipe (largest in [illegible] practice range)

• from Inlet condition chart ⇒ for $Q = 1.5 m^3/s$

$$H_w/_D = 1.03.$$

$$\Rightarrow \text{Depth} = 1.03 \times 1.05 = \underline{1080mm}$$



∴ for culvert invert = 263.70
⇒ u/s w/l = $\underline{264.78m}$

• Hence the pond will be partially flooded by downstream water level, although this will be acceptable as the [illegible] water level in the pond will be 264.50 + 800mm (storage depth)

= 265.30 > 264.78 ∴ OK

$$\boxed{\therefore \text{ PROVIDE } 1050\phi \text{ OUTFALL PIPE @ IL} = 263.70.}$$

Check Depth for Actual Max Outflow, ie. 600l/s

With 1050ϕ pipe, & $Q = 0.6m^3/s$ ⇒ $\frac{H_w}{D} = 0.59$

⇒ $H_w = 0.59 \times 1.05 = 0.62m$

ie. u/s w/l = 263.70 + 0.62
= $\underline{264.32m}$

w/l = 264.32m

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Design of Pipe-line Linking open channels

- Pipe serves one lagoon only, ∴ peak flow = ½ × TOTAL

∴ Design for Q_{PEAK} = 0.75 m³/s

Check pipe flow

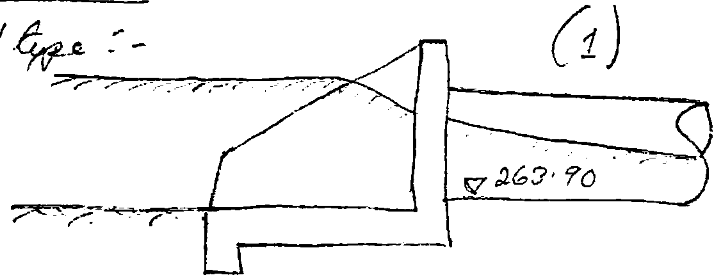
- Gradient = $\frac{0.1m}{11.5m}$ = 1:115.

600 ϕ 1:115 ⇒ Q = 0.75 m³/s ∴ OK

for comparison, 700 ϕ 1:115, Q = 1.19 m³/s
750 ϕ 1:115, Q = 1.42 m³/s

Check Inlet Condition

- Headwall type :-



- Try 750 ϕ pipe
- For Q = 0.75 m³/s,

Hw/D = 1.15 ⇒ Hw = 1.15 × 0.75
= 0.862 m

⇒ u/s w/l = 264·76 m

OK

∴ Use 750 mm pipe between channels

Check Water level for actual Max ①

Qactual = 600 l/s / 2 = 300 l/s

⇒ for 750 ϕ headwall ⇒ Hw/D = 0·63

⇒ u/s w/l = 0·63 × 0·75 = 0·47 m

⇒ W/L = 263·9 + 0·47 = 264·37 m

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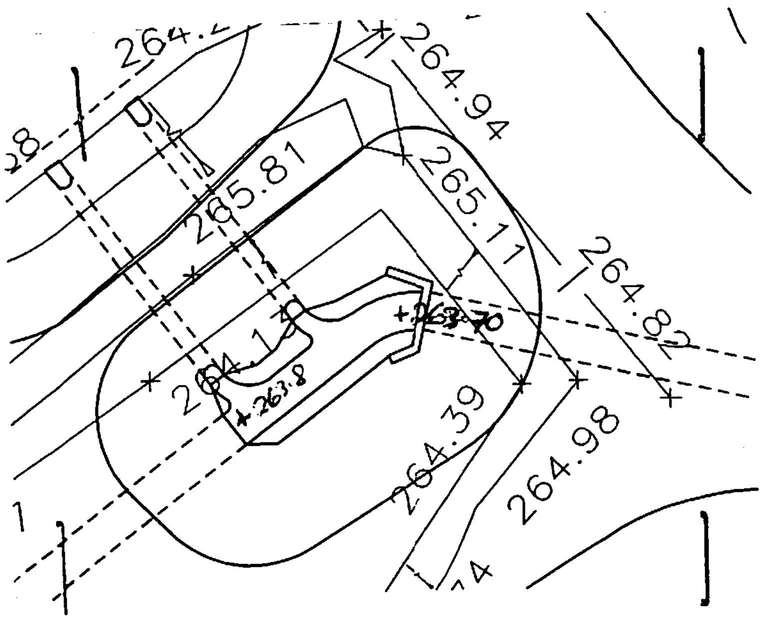
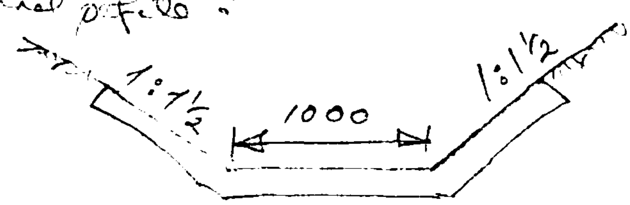
Design of Open Channel Section

- Worst case = end channel adjacent to exit of pipe on steep gradient.
- Design for $Q_{peak} = 1.5\,m^3/s$ (neglect attenuation) - as culvert.
- Channel gradient $= \frac{0.1m}{5.8m} = \underline{1:58}$



Channel profile :



$$Q = \frac{AR^{2/3}S_o^{1/2}}{n}$$

- Concrete lined ∴ take $n = 0.02$ (conservative).

$$S_o^{1/2} = \sqrt{1/58} = 0.131$$

Try 1000mm channel

- assume depth = 0.5m ⇒ $A = 0.875m^2$, $P = 2.80m$

⇒ $R = 0.3125$

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Calculation Sheet

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$$\Rightarrow Q = \frac{0.875 \times 0.325^{2/3} \times 0.131}{0.02}$$

$$= \underline{2.64\,m^3/s} \quad > 1.5\,m^3/s.$$

i.e. for channel width = 1m, ⇒ flow depth < 0.3m ∴ OK

$\boxed{\text{∴ USE 1m WIDE CHANNEL IN LOWER SECTION}}$

Design of Upper Channel

• This channel only serves one lagoon,

∴ Design for ½ peak flow.

i.e. $Q_{PEAK} = \frac{1.5}{2} = \underline{0.75\,m^3/s}$

Try 500 wd. channel

• assume depth = 300mm

$\Rightarrow A = 0.285\,m^2$
$P = 1.582\,m$

$\Rightarrow R = 0.180$

$$\Rightarrow Q = \frac{0.285 \times 0.18^{2/3} \times 0.131}{0.02}$$

$Q = 0.595\,m^3/s < 0.75$

∴ Try 600wd. channel

• assume depth = 300mm

$\Rightarrow A = 0.315\,m^2$
$P = 1.682\,m$

$\Rightarrow R = 0.187$

$$\Rightarrow Q = \frac{0.315 \times 0.187^{2/3} \times 0.131}{0.02} = \underline{0.683\,m^3/s}$$

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Try 700wd. channel

@ assuming depth = 300mm

$\Rightarrow A = 0.345 m^2 \quad \Rightarrow R = 0.1936$
$P = 1.782 m$

$$\Rightarrow Q = \frac{0.345 \times 0.1936^{2/3} \times [illegible]}{0.02} = 0.757 \, m^3/s$$

> 0.75

$\boxed{\therefore \text{ Use 700wd. channel for upper section @ depth} \leq 300mm}$

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Calculation Sheet

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Made by | Date | Chd. L.P 7/2/99

Design of Inlet Pipework

- 2 No. pipelines provided from inlet chamber.
- each pipe-line will convey ½ peak inflow.

$\therefore$ $Q_{PEAK} = \frac{1.5\,m^3/s}{2} = \underline{0.75\,m^3/s}$ — $Q_{peak} = 0.75\,m^3/s$.

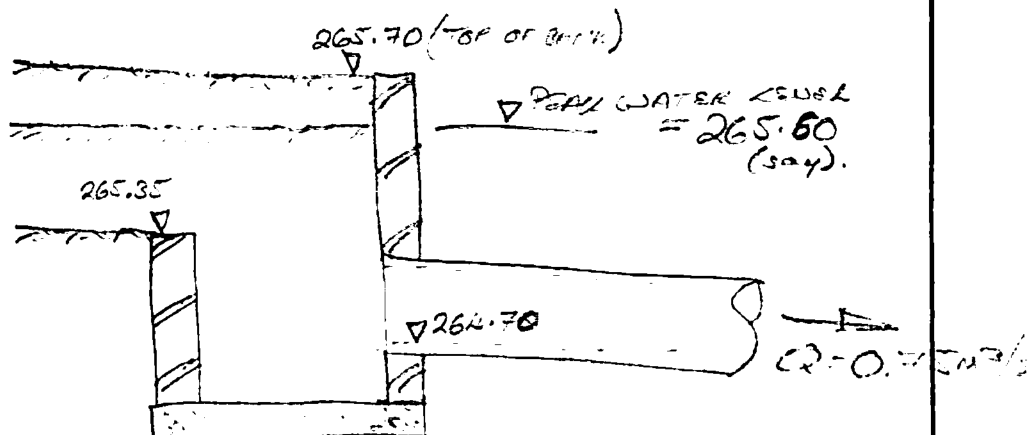
Design of pipeline for "Sewer" flow

- Pipe gradient $= \frac{0.10\,m}{20\,m} = 1:200$

$\Rightarrow$ 600ϕ 1:200, Q = 0.55 m³/s.
700ϕ 1:200, Q = 0.88 m³/s.
750ϕ 1:200, Q = 1.06 m³/s

$\therefore$ 700ϕ pipe seems reasonable providing some heading-up @ inlet permitted.

Check Inlet Condition



- Allow heading-up @ inlet to w/l = 265.60 m. (just within banks).

$\Rightarrow$ for 600ϕ pipe, $H_w/D = \frac{0.90}{0.60} = 1.50$

$Q = 0.58\,m^3/s < 0.75$ ∴ 700 sewer

- for 750ϕ pipe, $H_w/D = \frac{0.90}{0.75} = 1.2$

$\Rightarrow Q = 0.8\,m^3/s > 0.75$ OK

Use 2 x 750ϕ INLET PIPES