[redacted]

From: Michael Turnell [redacted]
Sent: Wednesday, 29 May 2019 11:33 AM
To: Shirvill, Natasha [redacted]
Cc: Pigliardo, Tina [redacted]
Subject: HPE CM: RE: Reports discussed in telephone call [DLM=Sensitive]

Hi Natasha,

As foreshadowed, please find attached report which we requested from Manly Hydraulics Laboratory. In respect to MHL report number 2123, this is a report commissioned by MACE Pty Ltd and one that MI is not privy to. We do not have any concerns however for the ACCC to request release of this report from Manly Hydraulics Laboratory.

Kind regards,

Michael

From: Michael Turnell
Sent: Tuesday, 28 May 2019 9:59 AM
To: Shirvill, Natasha [redacted]
Cc: Pigliardo, Tina [redacted]
Subject: RE: Reports discussed in telephone call [DLM=Sensitive]

Hi Natasha,

Thank you for those details. I have called Manly Hydraulics Lab to request copies of the two documents below. My request has been noted and a contact is due to call me back at some stage today to discuss the release of the reports.

In the meantime, we will undertake a further search to determine whether any additional reports are available, including in relation to our customers' metering complaints (excluding the Complainants).

Kind regards,
Michael

From: Shirvill, Natasha [redacted]
Sent: Monday, 27 May 2019 3:29 PM
To: Michael Turnell [redacted]
Cc: Pigliardo, Tina [redacted]
Subject: Reports discussed in telephone call [DLM=Sensitive]

Hi Michael,

As discussed in this afternoon's telephone call, we are aware of two test reports relating to tests conducted on MI meters that were conducted by the Manly Hydraulics lab in 2002. Our understanding is that one of these test reports was provided to MACE (as MACE was the customer) and that MI was the customer for the other report. If MI has either or both of these reports and would be willing to provide them to the ACCC this would be appreciated (the reference details for these report are below).

As also discussed, if you have any other reports (e.g. in-flow verification checks conducted by MI) relating to MI's meters that would also be appreciated.

The details of the Manly reports are as follows:

MHL Report Number	1215
Title	Murrumbidgee Irrigation Dethridge Meter and Ultrasonic Doppler Meter Testing
Client	MURRUMBIDGEE IRRIGATION - ANDREW KEITH
Date Created	2002-09-11
Status	Release is Subject to Client Consent
Date of Publication	
Author	R Cook & R Kadluczka

MHL Report Number	2123
Title	Intrinsic Error of Indication in Dn300 Pipe Test Report Mace Flopro3 Insertion Meter S/N 3515
Client	MACE PTY LTD
Date Created	2012-02-06
Status	Release is Subject to Client Consent
Date of Publication	
Author	R Cook

The following are links to the report references on the Manly Hydraulics Laboratory website.

Suspicious URL Removed

Suspicious URL Removed

Should you have any queries about this request, please do not hesitate to contact either myself (on [redacted]) or Tina Pigliardo[redacted].

Kind Regards
Natasha Shirvill
Senior Analyst| Insurance, Water and Wireline Markets Branch
Infrastructure Regulation Division
Australian Competition & Consumer Commission
Level 18 | 2 Lonsdale St (Casselden Place) Melbourne Victoria 3000 | http://www.accc.gov.au
[redacted]

Michael Turnell | Legal Advisor | **MI** Murrumbidgee Irrigation
[redacted] | www.mirrigation.com.au
86 Research Station Road, Hanwood NSW 2680 | Locked Bag 6010, Griffith NSW 2680

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computer system. For the purposes of the Spam Act 2003, this email is authorised by the ACCC www.accc.gov.au

MANLY
HYDRAULICS
LABORATORY

NSW Department of
Commerce

Murrumbidgee Irrigation Dethridge Meter and Ultrasonic Flowmeter Laboratory Testing

Report MHL1215
June 2003

MURRUMBIDGEE IRRIGATION

DETHRIDGE METER AND ULTRASONIC FLOWMETER

LABORATORY TESTING

Report No. MHL1215

NSW Department of Commerce
Manly Hydraulics Laboratory

Report No. MHL1215
DPWS Report No. 02069
MHL File No. HS6-00070
First published June 2003

Manly Hydraulics Laboratory is Quality System Certified to AS/NZS ISO 9001:1994.

Foreword

This study was undertaken by the NSW Department of Commerce's Manly Hydraulics Laboratory for Murrumbidgee Irrigation. The Manly Hydraulics Laboratory project manager was Bob Cook. Andrew Keith managed the project on behalf of Murrumbidgee Irrigation and checked the test rig at Manly Hydraulics Laboratory prior to testing. Bob Cook and Roman Kadluczka carried out testing, data analysis and data presentation with assistance from Tim Davies.

Information in this report may only be released by the Principal Engineer, Manly Hydraulics Laboratory, with the permission of the client.

Under the Public Sector Employment and Management (General) Order of 2 April 2003 the Department of Public Works and Services (DPWS) was abolished and its branches transferred to the Department of Commerce

Summary

A Dethridge meter and a MACE AgriFlo ultrasonic flowmeter were calibrated over a flow range of 1.0 to 10.0 ML/day by Manly Hydraulics Laboratory for Murrumbidgee Irrigation in the Know the Flow test facility. The AgriFlo meter was installed in a standard Murrumbidgee Irrigation 450 mm diameter pipe installation downstream of the Dethridge meter. Both meters were tested simultaneously and compared to an ABB MagMaster reference meter.

The Dethridge meter was tested with combinations of two upstream water levels and three tailwater levels at each flowrate. The upstream water levels were 380 mm and 450 mm above the upstream floor of the meter emplacement. Tailwater levels were controlled by slide boards downstream of the emplacement with crest levels 0, 135 mm and 300 mm above the downstream bed level. Data from the AgriFlo meter was logged for all tests resulting in up to six data sets for each flowrate. Each test was conducted for two hours.

The AgriFlo meter showed generally good accuracy over the flow range 1.0 ML/day to 10.0 ML/day with 22 of the 29 average flowrates within ±5% of the MagMaster average flowrate. The majority (18/29) of indicated flowrates were lower than the MagMaster flowrates.

Using the Murrumbidgee Irrigation conversion factor of *Flowrate (ML/day) = Dethridge meter revolutions/minute x 1.3045* the Dethridge meter showed poor accuracy at flowrates below 2.0 ML/day but good accuracy at flowrates from 4.0 to 10.0 ML/day. Over this range 16 of the 17 Dethridge meter average flowrates were within ±5% of the MagMaster average flowrate. The majority (19/29) of indicated flowrates were lower than the MagMaster flowrates.

A separate series of tests was conducted to determine the headloss through the standard Murrumbidgee Irrigation AgriFlo pipe installation. Flow through the test rig and pipe installation was uncontrolled for these tests apart from setting the flowrate in the pipeline supplying the test facility. The standard installation showed low headloss. The water level difference from upstream of the entry sump to within the exit sump ranged from 19 mm at a flowrate of 2.0 ML/day to 65 mm at a flowrate of 10.0 ML/day.

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1. Introduction

This report describes laboratory testing of a Dethridge meter and a MACE AgriFlo ultrasonic flowmeter with an insert head installed in a standard Murrumbidgee Irrigation pipe installation. The testing was carried out by Manly Hydraulics Laboratory (MHL) for Murrumbidgee Irrigation (MI) using the Know the Flow irrigation testing facility. The AgriFlo meter was located downstream of the Dethridge meter allowing simultaneous testing of both meters.

Dethridge meters are currently a common means of metering irrigation water delivery to farms in the Murrumbidgee Irrigation area. MACE AgriFlo ultrasonic meters in standard MI pipe installations (commonly referred to as a Doppler installation) are being installed at new sites and as replacements for Dethridge meters. On occasions an ultrasonic meter is installed downstream of a Dethridge meter to check the Dethridge meter.

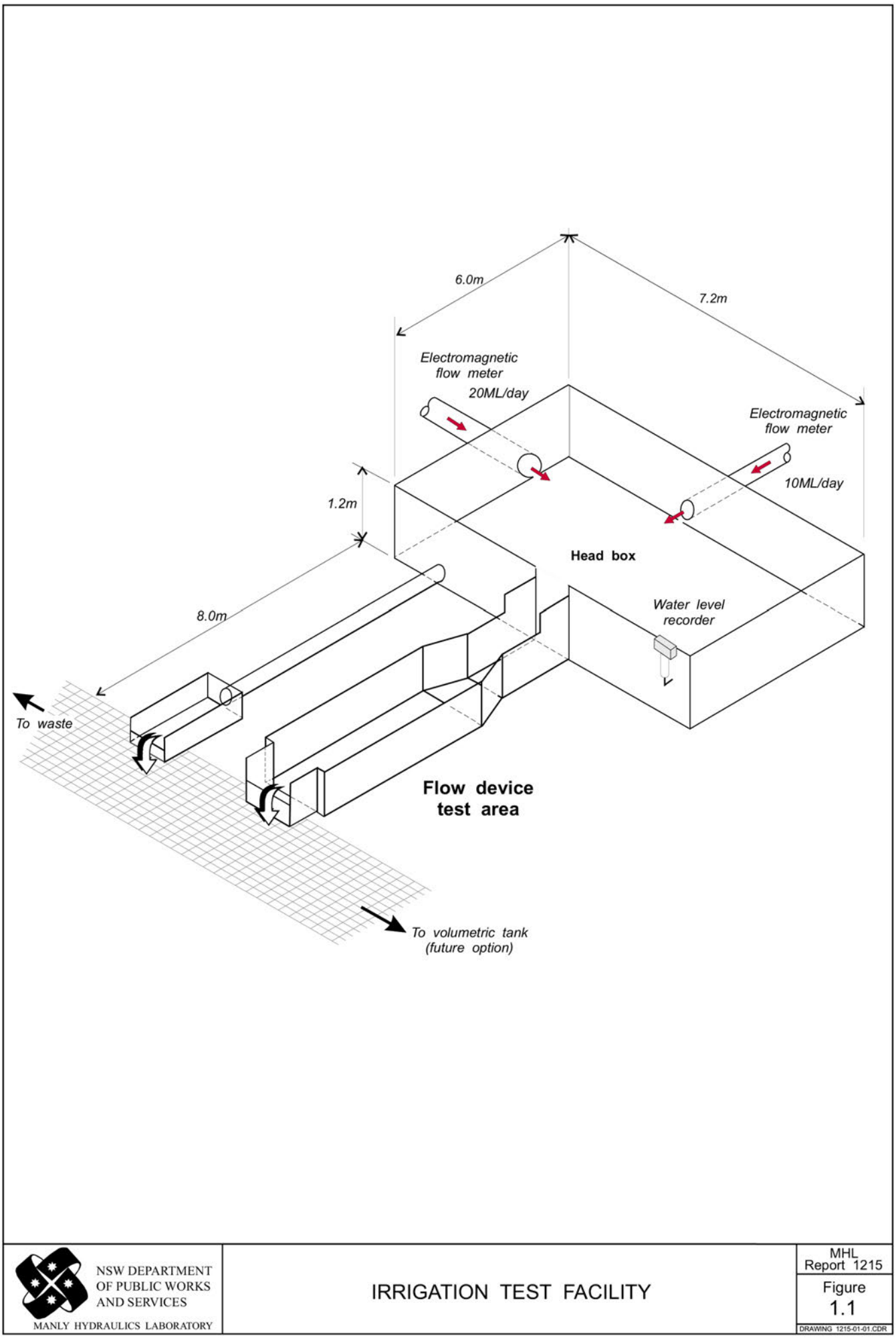
The layout of the Know the Flow test facility is shown in Figure 1.1. Further details of the Know the Flow facility may be found on the MHL website www.mhl.nsw.gov.au. The layout of the test rig for the MI testing is shown in Figure 1.2. The Dethridge emplacement was installed within the head box to accommodate the overall length of the rig in the available space. The connection between the outlet of the emplacement, the head box wall and the entry to the transition sump was carefully sealed to ensure that all water leaving the head box passed through the Dethridge meter and the AgriFlo flowmeter.

The primary objective of testing was to calibrate the Dethridge meter and ultrasonic flowmeter by comparing their performance to the reference MagMaster electromagnetic flowmeter. A secondary objective was to determine the headloss through the Dethridge meter installation and the ultrasonic meter installation. All testing was carried out over the flow range 1-10 ML/day which covers the typical range of flowrates used in the field.

Murrumbidgee Irrigation provided the following equipment for the project:

- a new Dethridge meter emplacement
- a new Dethridge wheel and timber bearings
- a revolution counter
- a prefabricated transition sump and slide boards
- two concrete Doppler sumps
- a 4 m length of 450 FRC pipe with a 2" threaded meter mounting
- a new MACE AgriFlo ultrasonic flowmeter.

The equipment supplied by MI was installed by MHL staff. A false floor, flush with the outlet sill of the Dethridge emplacement, was fitted to the section of the transition sump upstream of the slide boards. A MI engineer set the clearances between the Dethridge wheel and the emplacement and checked the test rig at MHL prior to testing.



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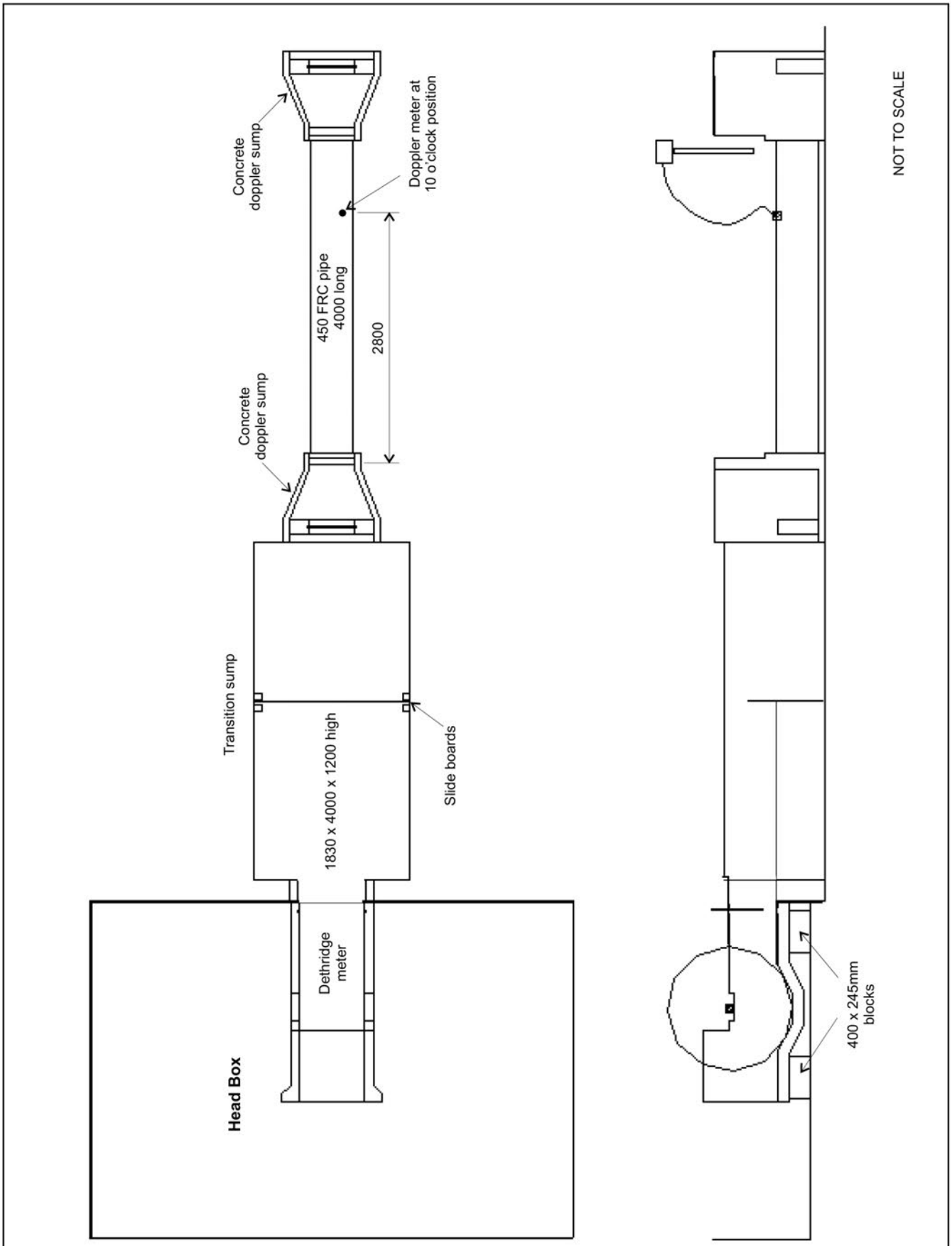
IRRIGATION TEST FACILITY

MHL Report 1215
Figure 1.1
DRAWING 1215-01-01.CDR



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MURRUMBIDGEE IRRIGATION TEST RIG

MHL Report 1215
Figure 1.2
DRAWING 1215-01-02.CDR

2. Testing

2.1 Test Program

The test program comprised seven series of tests. In Series 1 to 6 the performances of both the AgriFlo ultrasonic meter and the Dethridge meter were compared to the MagMaster reference meter for combinations of two water levels upstream of the Dethridge meter, three heights of slide boards in the transition sump downstream of the Dethridge meter and six flowrates.

In Series 7 the headloss through the AgriFlo (Doppler) installation was measured at five flowrates.

The testing program is summarised in Table 2.1.

Table 2.1 Summary of Test Program

Test Series	Target U/S WL Depth Above Entry Sill (mm)	Height of D/S Slide Boards Above False Floor (mm)	Flowrates (ML/day)
1	380	0	1, 2, 4, 6, 8, 10
2	450	0	as above
3	380	135	as above
4	450	135	as above
5	380	300	as above
6	450	300	as above
7	uncontrolled	0	2, 4, 6, 8, 10

In Series 1-6 flow data from the MACE AgriFlo meter, Dethridge meter and MagMaster reference meter and water levels in the Dethridge emplacement, upstream and downstream of the Dethridge wheel, were logged.

In Series 7 water levels at the downstream end of the transition sump, in the upstream Doppler sump and in the downstream Doppler sump and flow data from the MagMaster reference meter were logged.

2.2 Tested Flowmeters

Identification details and configuration settings of the Dethridge meter and MACE ultrasonic meter are shown in Table 2.2.

Table 2.2 Details of Dethridge and MACE Ultrasonic Meters

Flowmeter	Details
Dethridge Meter	**Standard MI 12 ML/day** Wheel clearance: 6 mm Emplacement internal dimensions: 2525 long, 800 wide, 870 deep at entry, 580 deep at outlet Gate: downstream undershot gate
Ultrasonic Meter	**MACE AgriFlo Series II Ultrasonic Flowmeter, 2" insert sensor** MACE Serial Number 11157 Insert Sensor Number 2642 Logging interval for flowrate (L/sec): one minute Integration period: 15 sec Logging interval for volume (L): one hour, on the hour Pipe internal diameter setting: 456 mm Location: 10o'clock position, 2.8 m from entry, 1.2 m from exit

2.3 Test Procedure

Flow into the head box was controlled by a manually operated gate valve permanently installed in the pipeline at a suitable distance upstream of the MagMaster reference meter. A display of the flowrate measured by the MagMaster was located adjacent to the valve to facilitate setting the required flowrate.

Series 1 – 6

Initially the slide boards with the required height for each series were installed in the transition sump, held in place by rods and clamps. The slide boards, mid way along the sump, controlled the water level downstream of the Dethridge meter emplacement. The flowrate into the head box for each flow point set was then set with the gate valve.

The water level in the head box was set by adjusting the undershot gate at the outlet of the Dethridge emplacement until a balance was reached between the flowrate through the head box and the required water level. A lead screw control fitted to the undershot gate allowed the fine adjustment of the gate required to produce an equilibrium water level in the head box that closely matched the target water level.

After the upstream water level had stabilised at a level within ±20 mm of the target water level all data was logged for a minimum of two hours. The water level stabilised relatively quickly at high flowrates but required a considerable time to stabilise at the 1.0 ML/day flowrate.

Series 7

The last series of tests was undertaken to determine the headloss through the standard MI Doppler installation. The Doppler installation can be seen in Figure 2.1. The installation comprises a length of nominal 450 mm diameter FRC pipe fitted between two identical precast concrete sumps. The sumps have a weir entry/exit (540 wide x 740 high x 150 breadth) in their upstream/downstream wall. The crest of the weirs is 25 mm below the obvert level of the pipe which ensures that the pipe flows full in normal use. The sumps have provision for sliding gates to control flow or to isolate the installation.

Tests were carried out with the undershot gate at the outlet of the Dethridge emplacement full open and no slide boards installed. The required flowrate was set and data was logged for a period of approximately 30 minutes for each flow point after the water level in the head box had stabilised.

2.4 Instrumentation

Measuring instrument locations are shown in Figure 2.1. Details of the testing instruments are shown in Table 2.3 below.

Table 2.3 Testing Instruments Information

Instrument	Details
Reference Flowmeter	**ABB Water and Waste MagMaster, 250mm** Serial Number: V/31122/35/1 Original calibration: 17/02/99 - see Appendix B Last calibration verification: 04/09/02 - see Appendix B Measurement of Uncertainty: ± 0.25% of measured quantity or ± 60 L, whichever is greater. Reading interval (flowrate and cumulative volume): one second Logging interval ((average one minute flowrate (L/s) and one minute volume (L)): one minute Logger: PC via Maglog software, DataTaker DT50
Water Level Loggers	**Greenspan PS310** Resolution: 1 mm Accuracy: ± 2 mm Gauge zero: u/s entry sill of Dethridge meter emplacement Damping: none Reading interval: one sec Logging interval: one minute Gauge locations: For Flowmeter Tests (see Figure 2.1) 1. at u/s entry of Dethridge emplacement (100 mm from u/s edge) 2. in emplacement d/s of Dethridge wheel (150 mm from d/s edge) **Piezometer Tappings and Water Manometer** Resolution: 1 mm Gauge zero: u/s entry sill of u/s Doppler sump Gauge locations: For Headloss Tests (See Figure 2.1) 3. 500 mm from d/s end of transition sump 4. midpoint of u/s Doppler sump 5. midpoint of d/s Doppler sump
Logger Status Monitoring (at start and end of each test session)	**Mechanical Point Gauge** Gauge Location: at entry to Dethridge emplacement Gauge zero: u/s sill of Dethridge emplacement Resolution: 0.1 mm
Dethridge Meter Revolutions Logging	**Micro Switch Pulses** (two separately logged switches for redundancy) Logging interval: one minute Pulses per revolution: 4 Logger: DataTaker DT50

2.5 Data Logging

Experimental data was logged every minute on the minute throughout each test. All data was date/time stamped to allow time alignment of data. Internal clocks in all loggers and an auxiliary PC were synchronised with the main PC at the commencement of each data logging session. Data was downloaded from the loggers to the main PC at the conclusion of each logging session.

MagMaster Reference Meter

One-second instantaneous flowrates were transmitted direct to the main PC and the one-minute average of the instantaneous flowrates for the previous minute logged directly by the PC. The MagMaster also transmits a pulse for each litre of water passing through the meter. These pulses were logged by a DT50 DataTaker logger as one-minute volumes.

AgriFlo Ultrasonic Meter

Average flowrate was logged by the AgriFlo meter each minute. The AgriFlo also has the capability to log the volume of water passing through the meter each hour, 12-hour or 24-hour period. During testing the one hour volume was logged each hour on the hour.

Dethridge Meter

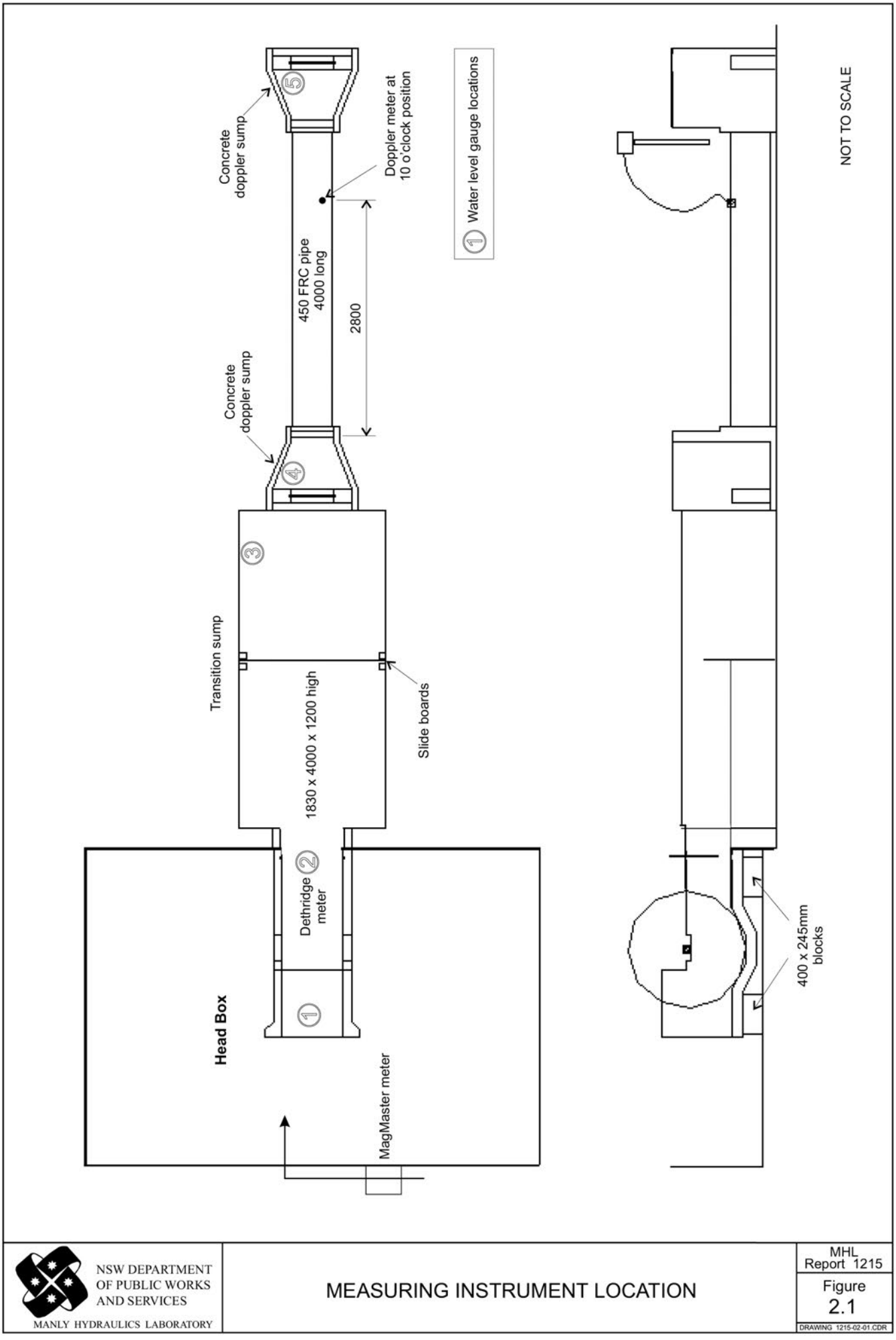
Initially the Dethridge meter revolutions were logged using a series of small rare earth magnets around the perimeter to generate pulses via a reed switch. This method was abandoned after 'double pulses' were detected in a number of instances. All data logged to that point was discarded. Subsequently revolutions were logged via micro switches generating four pulses per revolution. Two separate micro switches were installed and logged to provide redundancy and a means of checking pulse measurements. The micro switch pulses were logged each minute by the DataTaker logger via two separate channels.

Greenspan Water Level Gauges

Water levels in the Dethridge emplacement upstream and downstream of the wheel were logged each minute via Greenspan water level gauges. These were initialised via a PC at the commencement of each logging session and then logged water levels in their on-board loggers. The datum for water levels was set at the start of each logging session and verified at the end of each session using the mechanical water level probe at the entry to the Dethridge emplacement to measure the still water level with no flow. The Greenspan water level gauges were completely undamped during testing and readings were therefore affected by waves generated by the Dethridge wheel.

2.6 Data Processing

At the completion of each logging session data was downloaded from the loggers to the main PC and data combined in a computer data processing/presentation package using the one-minute time stamps for time alignment. Continuous plots of all parameters versus time were then generated for the logging period. Quality control was carried out by examining the plots on screen for anomalies. Two-hour periods of good quality data with constant upstream water level were selected from the continuous plots and further processed to generate the results presented in this report.



View from downstream

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PHOTOGRAPH OF TEST RIG

MHL Report 1215

Figure 2.2

DRAWING 1215-02-02.CDR

View from upstream

View of instruments

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PHOTOGRAPHS OF TEST RIG

MHL Report 1215

Figure 2.3

DRAWING 1215-02-03.CDR

3. Test Results

3.1 Flowmeter Test Results

One-minute test data for a period of two hours for each test are shown as time series plots in Appendix A. Each figure shows:

- plots of MagMaster and AgriFlo flowrate versus time
- a plot of Dethridge meter counts/minute versus time (four counts/revolution)
- plots of water levels upstream and downstream of the Dethridge wheel versus time.

Test statistics for the test are tabulated on each figure. Statistics comprise minimum, maximum and average values for each parameter over the two-hour period and the total volume logged by the MagMaster and AgriFlo meters over the two-hour period.

The figure numbers are summarised in Table 3.1. An asterix indicates that the test was not conducted because the upstream water level for the flow condition exceeded the target water level with the gate in the Dethridge emplacement fully open.

Table 3.1 Data Plot Figure Numbers

Test Series	Target Upstream WL (mm)	Height of Downstream Slide Boards (mm)	Flowrate (ML/day)					
			1	2	4	6	8	10
1	380	0	A1	A2	A3	A4	A5	*
2	450	0	A7	A8	A9	A10	A11	A12
3	380	135	A13	A14	A15	A16	A17	*
4	450	135	A19	A20	A21	A22	A23	A24
5	380	300	A25	A26	*	*	*	*
6	450	300	A31	A32	A33	A34	A35	*

* Indicates test not conducted as target water level and flow conditions not compatible.

Raw flowmeter data for the Dethridge meter and AgriFlo meter for all tests are shown on Figure 3.1. The equations to fit the data to the MagMaster data are also shown. The Dethridge and AgriFlo data fitted using the equations are shown in Figures 3.2 and 3.3 respectively. Dethridge meter data fitted to the MagMaster data using both the derived equation and the MI flowrate conversion factor of 1.3045 (revolutions/minute x 1.3045 = ML/day) is shown on Figure 3.4.

A summary of the total volumes and flowrates logged by the Dethridge meter and AgriFlo meter compared to the MagMaster are shown for all tests in Tables 3.2 and 3.3 respectively.

Table 3.2 AgriFlo Test Results Summary

Test*	MACE AgriFlo					MagMaster					% of Reference Flow
	Cum. Volume ML	Average Flow ML/day	Max Flow ML/day	Min Flow ML/day	Std.Dev. Flow ML/day	Cum. Volume ML	Average Flow ML/day	Max Flow ML/day	Min Flow ML/day	Std.Dev. Flow ML/day	
1.1	0.081413	0.977	1.210	0.691	0.102	0.081878	0.983	0.999	0.971	0.005	99.43%
1.2	0.167286	2.007	2.333	1.555	0.130	0.168590	2.023	2.034	2.011	0.004	99.23%
1.4	0.341403	4.097	4.406	3.715	0.156	0.331339	3.976	3.990	3.862	0.022	103.04%
1.6	0.496140	5.954	6.221	5.616	0.144	0.498625	5.984	5.999	5.936	0.010	99.50%
1.8	0.633783	7.605	7.949	7.171	0.145	0.671118	8.053	8.067	8.039	0.005	94.44%
2.1	0.084415	1.013	1.210	0.778	0.090	0.083818	1.006	1.024	0.987	0.005	100.71%
2.2	0.174960	2.100	2.333	1.728	0.115	0.167848	2.014	2.030	1.976	0.008	104.24%
2.4	0.339242	4.071	4.406	3.629	0.162	0.330633	3.968	3.979	3.952	0.005	102.60%
2.6	0.508137	6.098	6.480	5.789	0.142	0.500647	6.008	6.023	5.994	0.005	101.50%
2.8	0.647157	7.766	8.208	7.258	0.137	0.668119	8.017	8.035	8.003	0.006	96.86%
2.10	0.774060	9.289	9.763	8.899	0.165	0.833271	9.999	10.019	9.963	0.008	92.89%
3.1	0.077278	0.927	1.210	0.691	0.111	0.081901	0.983	0.969	0.970	0.005	94.36%
3.2	0.169020	2.028	2.419	1.642	0.164	0.166360	1.996	2.019	1.984	0.005	101.60%
3.4	0.332396	3.989	4.320	3.715	0.124	0.332526	3.990	4.016	3.948	0.014	99.96%
3.6	0.499017	5.988	6.307	5.530	0.179	0.501346	6.016	6.032	6.005	0.006	99.54%
3.8	0.644824	7.738	8.208	7.344	0.185	0.667409	8.009	8.024	7.990	0.006	96.62%
4.1	0.082795	0.994	1.210	0.691	0.111	0.083820	1.006	1.017	0.995	0.004	98.78%
4.2	0.164941	1.979	2.419	1.469	0.179	0.165880	1.991	2.009	1.968	0.005	99.43%
4.4	0.337676	4.052	4.493	3.715	0.173	0.333169	3.998	4.018	3.974	0.007	101.35%
4.6	0.505860	6.070	6.480	5.789	0.150	0.499024	5.988	5.998	5.971	0.005	101.37%
4.8	0.635345	7.624	8.035	7.085	0.172	0.665562	7.987	7.998	7.972	0.005	95.46%
4.10	0.789239	9.471	10.022	8.986	0.182	0.836262	10.035	10.047	10.022	0.006	94.38%
5.1	0.090785	1.089	1.469	0.778	0.120	0.084520	1.014	1.023	1.004	0.004	107.41%
5.2	0.167101	2.005	2.333	1.642	0.138	0.166215	1.995	2.005	1.983	0.004	100.53%
6.1	0.083044	0.997	1.296	0.605	0.168	0.084088	1.009	1.017	1.000	0.004	98.76%
6.2	0.169501	2.034	2.333	1.728	0.126	0.165533	1.986	2.000	1.976	0.004	102.40%
6.4	0.331559	3.979	4.579	3.542	0.195	0.332786	3.993	4.016	3.981	0.004	99.63%
6.6	0.470339	5.644	6.048	5.270	0.154	0.501902	6.023	6.037	6.013	0.005	93.71%
6.8	0.631019	7.572	7.949	7.085	0.170	0.667397	8.009	8.027	7.988	0.007	94.55%

* Test Series . Flowrate (ML/day)
**(AgriFlo Average Flow/MagMaster Average Flow) x 100

Table 3.3 Dethridge Meter Test Results Summary

(Flowrate (ML/day) = Dethridge meter revolutions/minute x 1.3045)

Test*	Dethridge Meter					MagMaster					% of Reference Flow
	Cum. Volume ML	Average Flow ML/day	Max Flow ML/day	Min Flow ML/day	Std.Dev. Flow ML/day	Cum. Volume ML	Average Flow ML/day	Max Flow ML/day	Min Flow ML/day	Std.Dev. Flow ML/day	
1.1	0.044625	0.535	0.652	0.326	0.157	0.081878	0.983	0.999	0.971	0.005	54.50%
1.2	0.142462	1.710	1.957	1.631	0.140	0.168590	2.023	2.034	2.011	0.004	84.50%
1.4	0.321586	3.859	3.914	3.587	0.122	0.331339	3.976	3.990	3.862	0.022	97.06%
1.6	0.508211	6.099	6.523	5.870	0.156	0.498625	5.984	5.999	5.936	0.010	101.92%
1.8	0.697554	8.371	8.479	8.153	0.154	0.671118	8.053	8.067	8.039	0.005	103.94%
2.1	0.046418	0.557	0.652	0.326	0.149	0.083818	1.006	1.024	0.987	0.005	55.38%
2.2	0.138603	1.663	1.957	1.305	0.107	0.167848	2.014	2.030	1.976	0.008	82.58%
2.4	0.307998	3.696	3.914	3.587	0.154	0.330633	3.968	3.979	3.952	0.005	93.15%
2.6	0.490329	5.884	6.196	5.544	0.078	0.500647	6.008	6.023	5.994	0.005	97.94%
2.8	0.676030	8.112	8.153	7.827	0.108	0.668119	8.017	8.035	8.003	0.006	101.18%
2.10	0.853822	10.246	10.436	10.110	0.161	0.833271	9.999	10.019	9.963	0.008	102.47%
3.1	0.044842	0.538	0.652	0.326	0.156	0.081901	0.983	0.969	0.970	0.005	54.75%
3.2	0.147218	1.767	1.957	1.631	0.161	0.166360	1.996	2.019	1.984	0.005	88.49%
3.4	0.327946	3.935	4.240	3.914	0.082	0.332526	3.990	4.016	3.948	0.014	98.62%
3.6	0.516147	6.194	6.523	5.870	0.116	0.501346	6.016	6.032	6.005	0.006	102.95%
3.8	0.693912	8.327	8.479	8.153	0.163	0.667409	8.009	8.024	7.990	0.006	103.97%
4.1	0.045522	0.546	0.652	0.326	0.153	0.083820	1.006	1.017	0.995	0.004	54.31%
4.2	0.143142	1.718	1.957	1.631	0.145	0.165880	1.991	2.009	1.968	0.005	86.29%
4.4	0.324304	3.892	4.240	3.587	0.092	0.333169	3.998	4.018	3.974	0.007	97.34%
4.6	0.500520	6.006	6.196	5.870	0.161	0.499024	5.988	5.998	5.971	0.005	100.30%
4.8	0.678965	8.148	8.479	7.827	0.084	0.665562	7.987	7.998	7.972	0.005	102.01%
4.10	0.851784	10.221	10.436	9.784	0.161	0.836262	10.035	10.047	10.022	0.006	101.86%
5.1	0.048919	0.587	0.978	0.326	0.138	0.084520	1.014	1.023	1.004	0.004	57.88%
5.2	0.146974	1.764	1.957	1.631	0.161	0.166215	1.995	2.005	1.983	0.004	88.42%
6.1	0.045304	0.544	0.652	0.326	0.154	0.084088	1.009	1.017	1.000	0.004	53.88%
6.2	0.142218	1.707	1.957	1.631	0.139	0.165533	1.986	2.000	1.976	0.004	85.92%
6.4	0.320228	3.843	3.914	3.587	0.135	0.332786	3.993	4.016	3.981	0.004	96.23%
6.6	0.501200	6.014	6.196	5.544	0.168	0.501902	6.023	6.037	6.013	0.005	99.86%
6.8	0.668339	8.020	8.153	7.827	0.161	0.667397	8.009	8.027	7.988	0.007	100.14%

* Test Series . Flowrate (ML/day)

**(Dethridge Average Flow/MagMaster Average Flow) x 100

3.2 AgriFlo Installation Headloss Test Results

Results for the headloss testing are shown in Table 3.4. The locations of the piezometer tapping points are as shown in Figure 2.1.

Table 3.4 Water Level Readings for AgriFlo Installation

Flowrate ML/day	WL 3 mm	WL 4 mm	WL 5 mm	Δ_{3-4} mm	Δ_{4-5} mm	Δ_{3-5} mm
2.0	104	85	85	19	0	19
4.0	195	160	159	35	1	36
6.0	221	180	178	41	2	43
8.0	277	229	222	48	9	57
10.0	320	271	255	49	16	65

Notes: Water levels are relative to the crest levels of the sump weirs. Both crests were at the same level.

3.3 Assessment of Uncertainty

The uncertainty of the AgriFlo and Dethridge meter data was determined using AS3778.2.4 – 2001. From this standard the potential sources of error in the testing considered were random, systematic and spurious.

Random Error – often referred to as precision errors and expressed as the standard deviation of the sample. The standard deviations for flowrate for the MagMaster, AgriFlo and Dethridge meters are shown in Tables 3.2 and 3.3 respectively.

Systematic Error – often referred to as biases, can only be determined when compared with the true value of the quantity measured which is rarely possible. The flow from the MagMaster was adopted as the reference flow. The calibration certificate shown in Appendix B gives a maximum error of ±0.25% of measured quantity which is considered a reasonably accurate basis for determination of the systematic error. The systematic uncertainty (B) was determined as the difference between the MagMaster flow and the AgriFlo or Dethridge meter flow readings. The results of the systematic uncertainty (Tables 3.5 and 3.6) may indicate that it is an unsymmetrical uncertainty (e.g. giving mostly positive values with the AgriFlo or Dethridge meter giving lower flow data than the MagMaster, or vice versa).

Indications of the direction of the systematic uncertainty (B) of individual tests are shown in Tables 3.7 and 3.8 for the AgriFlo and Dethridge meters respectively. The number of tests do not justify estimation of error as unsymmetrical for any individual flow rate. Therefore the calculation of uncertainty is presented (Tables 3.5 and 3.6) assuming that the systematic error is symmetrical.

Spurious Error - no spurious errors were detected from the measurement procedure based on the results in Tables 3.2 and 3.3 and Figures A1-A35.

Calculation of Uncertainty - the random and systematic errors were combined to determine the uncertainty of measurement for each test. According to AS3778.2.4 'for simplicity of presentation a single number, U, is needed to express a reasonable limit of error. The single number must have a simple interpretation (e.g. the largest error reasonably expected), and be useful without complex explanation.' Further, 'there is no way of combining systematic and random uncertainties to produce a single uncertainty figure with a statistically rigorous confidence level.' The standard states two possible ways of determining U, either by linear addition or root-sum-square combination of errors. For this study U_{RSS} has been chosen as the standard considers this value to have a coverage of approximately 95% confidence. URSS is defined as:

$$U_{RSS} = \sqrt{B^2 + (t_{95} s_x)^2}$$

where $t_{95} s_x$ = standard deviation

U_{RSS} was calculated for each individual test. A single uncertainty value was not calculated for all the tests combined as the flow rate would need to be normalised throughout the calculations to eliminate the effect of the flow on the error.

The summary of the sources of elemental error are shown in Tables 3.5 and 3.6.

Table 3.5 Elemental Error Sources AgriFlo Meter

Test No.*	MagMaster Flow ML/day	MagMaster St. Dev. (ML/day)	AgriFlo Average Flow (ML/day)	AgriFlo Flow St. Dev. (ML/day)	Systematic uncertainty (B)[1]	U_{RSS}[1]	U_{RSS}% (U_{RSS}/MagMaster Flow* 100)
1.1	0.983	0.005	0.977	0.102	0.006	0.10	10.39
1.2	2.023	0.004	2.007	0.130	0.016	0.13	6.47
1.4	3.976	0.022	4.097	0.156	-0.121	0.20	4.97
1.6	5.984	0.010	5.954	0.144	0.03	0.15	2.46
1.8	8.053	0.005	7.605	0.145	0.448	0.47	5.85
2.1	1.006	0.005	1.013	0.090	-0.007	0.09	8.97
2.2	2.014	0.008	2.100	0.115	-0.086	0.14	7.13
2.4	3.968	0.005	4.071	0.162	-0.103	0.19	4.84
2.6	6.008	0.005	6.098	0.142	-0.09	0.17	2.80
2.8	8.017	0.006	7.766	0.137	0.251	0.29	3.57
2.10	9.999	0.008	9.289	0.165	0.71	0.73	7.29
3.1	0.983	0.005	0.927	0.111	0.056	0.12	12.65
3.2	1.996	0.005	2.028	0.164	-0.032	0.17	8.37
3.4	3.990	0.014	3.989	0.124	0.001	0.12	3.11
3.6	6.016	0.006	5.988	0.179	0.028	0.18	3.01
3.8	8.009	0.006	7.738	0.185	0.271	0.33	4.10
4.1	1.006	0.004	0.994	0.111	0.012	0.11	11.10
4.2	1.991	0.005	1.979	0.179	0.012	0.18	9.01
4.4	3.998	0.007	4.052	0.173	-0.054	0.18	4.53
4.6	5.988	0.005	6.070	0.150	-0.082	0.17	2.85
4.8	7.987	0.005	7.624	0.172	0.363	0.40	5.03
4.10	10.035	0.006	9.471	0.182	0.564	0.59	5.91
5.1	1.014	0.004	1.089	0.120	-0.075	0.14	13.96
5.2	1.995	0.004	2.005	0.138	-0.01	0.14	6.94
6.1	1.009	0.004	0.997	0.168	0.012	0.17	16.69
6.2	1.986	0.004	2.034	0.126	-0.048	0.13	6.79
6.4	3.993	0.004	3.979	0.195	0.014	0.20	4.90
6.6	6.023	0.005	5.644	0.154	0.379	0.41	6.79
6.8	8.009	0.007	7.572	0.170	0.437	0.47	5.85

* Test Series . Flowrate (ML/day)
[1] – explanation of uncertainty described in Section 3.3.

Table 3.6 Elemental Error Sources Dethridge Meter

Test No.	MagMaster Flow ML/day	MagMaster St. Dev. (ML/day)	Dethridge Average Flow (ML/day)	Dethridge Flow St. Dev. (ML/day)	Systematic uncertainty (B)[1]	U_{RSS}[1]	U_{RSS}% (U_{RSS}/MagMaster Flow* 100)
1.1	0.983	0.005	0.535	0.157	0.448	0.47	48.29
1.2	2.023	0.004	1.710	0.140	0.313	0.34	16.95
1.4	3.976	0.022	3.859	0.122	0.117	0.17	4.25
1.6	5.984	0.010	6.099	0.156	-0.115	0.19	3.24
1.8	8.053	0.005	8.371	0.154	-0.318	0.35	4.39
2.1	1.006	0.005	0.557	0.149	0.449	0.47	47.03
2.2	2.014	0.008	1.663	0.107	0.351	0.37	18.22
2.4	3.968	0.005	3.696	0.154	0.272	0.31	7.88
2.6	6.008	0.005	5.884	0.078	0.124	0.15	2.44
2.8	8.017	0.006	8.112	0.108	-0.095	0.14	1.79
2.10	9.999	0.008	10.246	0.161	-0.247	0.29	2.95
3.1	0.983	0.005	0.538	0.156	0.445	0.47	47.97
3.2	1.996	0.005	1.767	0.161	0.229	0.28	14.02
3.4	3.990	0.014	3.935	0.082	0.055	0.10	2.47
3.6	6.016	0.006	6.194	0.116	-0.178	0.21	3.53
3.8	8.009	0.006	8.327	0.163	-0.318	0.36	4.46
4.1	1.006	0.004	0.546	0.153	0.46	0.48	48.19
4.2	1.991	0.005	1.718	0.145	0.273	0.31	15.53
4.4	3.998	0.007	3.892	0.092	0.106	0.14	3.51
4.6	5.988	0.005	6.006	0.161	-0.018	0.16	2.71
4.8	7.987	0.005	8.148	0.084	-0.161	0.18	2.27
4.10	10.035	0.006	10.221	0.161	-0.186	0.25	2.45
5.1	1.014	0.004	0.587	0.138	0.427	0.45	44.26
5.2	1.995	0.004	1.764	0.161	0.231	0.28	14.11
6.1	1.009	0.004	0.544	0.154	0.465	0.49	48.55
6.2	1.986	0.004	1.707	0.139	0.279	0.31	15.70
6.4	3.993	0.004	3.843	0.135	0.15	0.20	5.05
6.6	6.023	0.005	6.014	0.168	0.009	0.17	2.79
6.8	8.009	0.007	8.020	0.161	-0.011	0.16	2.01

* Test Series . Flowrate (ML/day)
[1] – explanation of uncertainty described in Section 3.3.

Table 3.7 Direction of Systematic Uncertainty for AgriFlo Meter

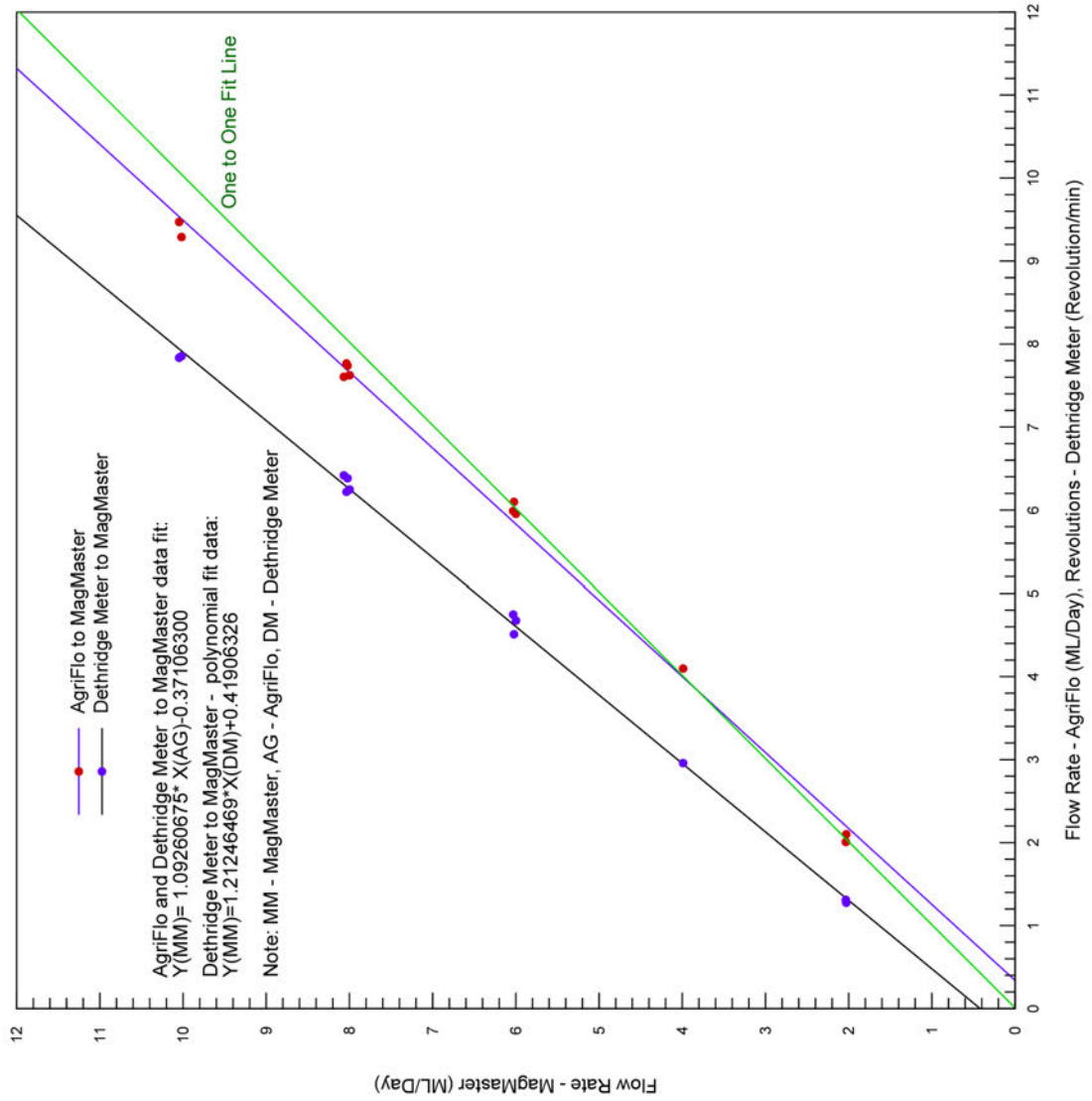
Test Series	Target Upstream WL (mm)	Height of Downstream Slide Boards (mm)	Flowrate (ML/day)					
			1	2	4	6	8	10
1	380	0	A1	A2	A3	A4	A5	*
2	450	0	A7	A8	A9	A10	A11	A12
3	380	135	A13	A14	A15	A16	A17	*
4	450	135	A19	A20	A21	A22	A23	A24
5	380	300	A25	A26	*	*	*	*
6	450	300	A31	A32	A33	A34	A35	*

Shaded boxes indicate positive uncertainty (i.e. AgriFlo values lower than reference meter).
Boxes show data plot figure numbers.
* indicates test not conducted.

Table 3.8 Direction of Systematic Uncertainty for Dethridge Meter

Test Series	Target Upstream WL (mm)	Height of Downstream Slide Boards (mm)	Flowrate (ML/day)					
			1	2	4	6	8	10
1	380	0	A1	A2	A3	A4	A5	*
2	450	0	A7	A8	A9	A10	A11	A12
3	380	135	A13	A14	A15	A16	A17	*
4	450	135	A19	A20	A21	A22	A23	A24
5	380	300	A25	A26	*	*	*	*
6	450	300	A31	A32	A33	A34	A35	*

Shaded boxes indicate positive uncertainty (i.e. Dethridge values lower than reference meter).
Boxes show data plot figure numbers.
* indicates test not conducted.



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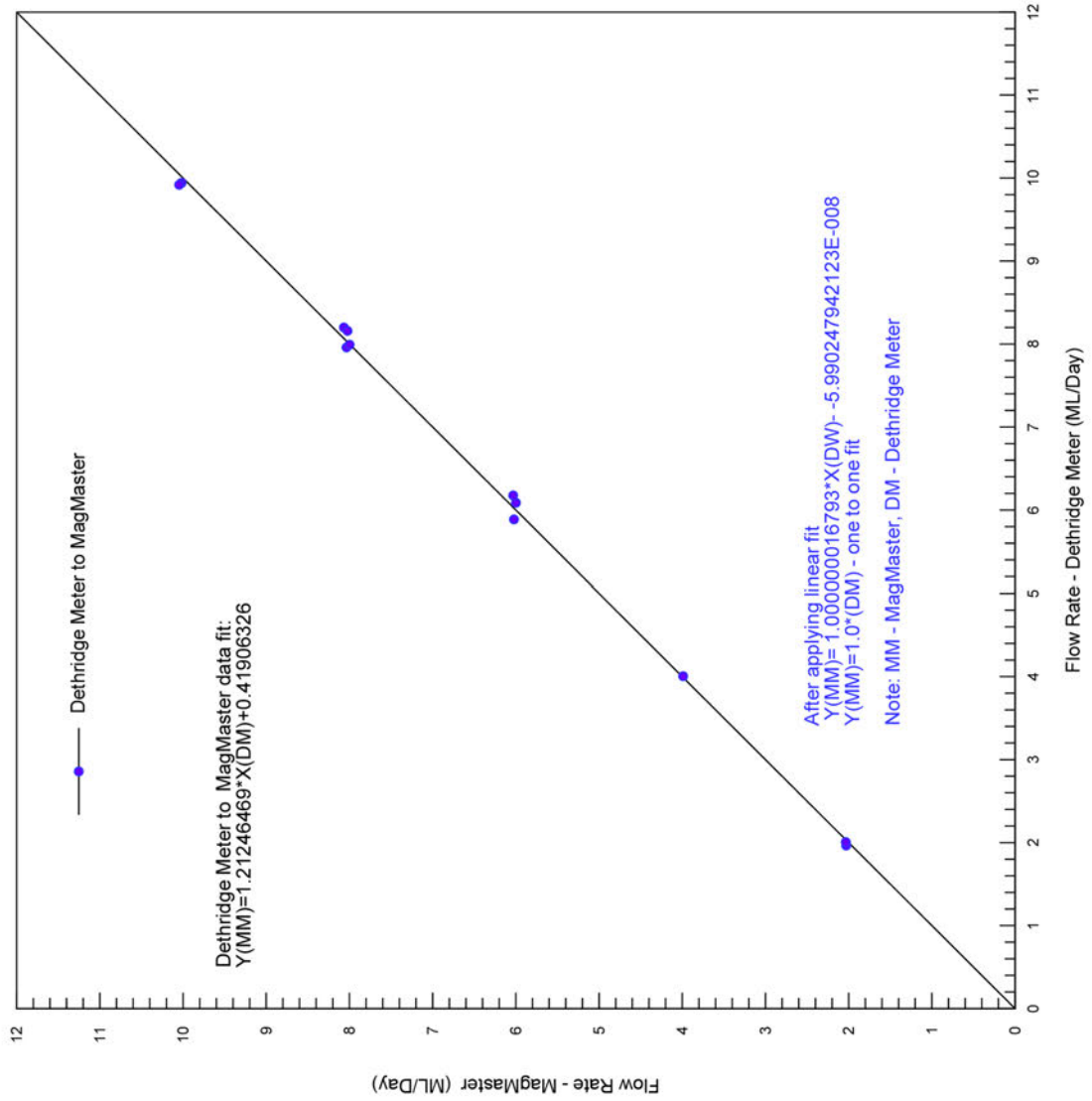
AGRIFLO AND DETHRIDGE DATA FIT TO MAGMASTER
UPSTREAM WATER LEVEL - 380 and 450
HEIGHT OF DOWNSTREAM BOARD - 0, 135, 300 mm

MHL Report 1215
Figure 3.1
DRAWING 1215_031.BPS



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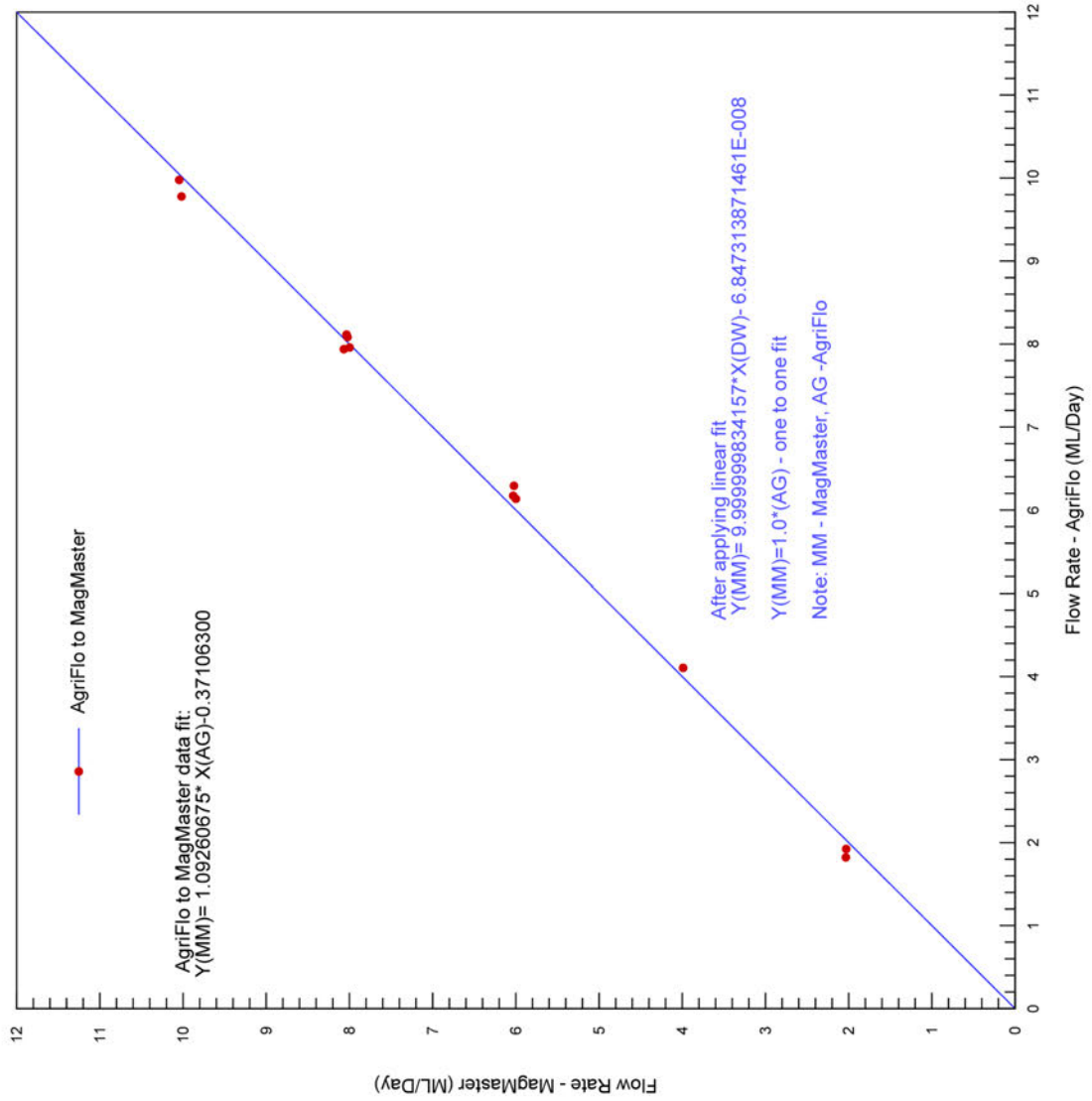
DETHRIDGE DATA FIT TO MAGMASTER
UPSTREAM WATER LEVEL - 380 and 450
HEIGHT OF DOWNSTREAM BOARD - 0, 135, 300 mm

MHL Report 1215
Figure 3.2
DRAWING 1215_032.BPS



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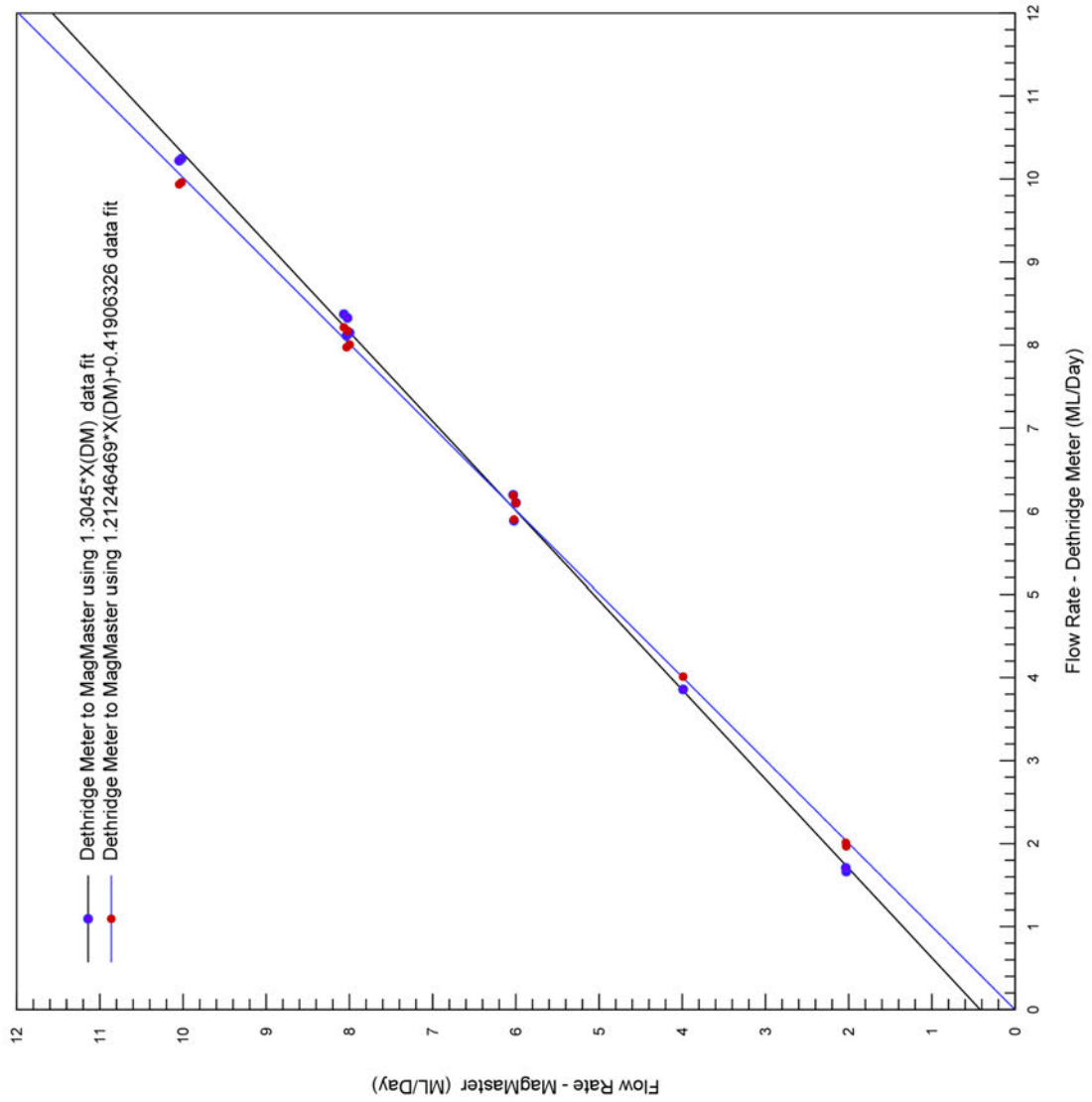
AGRIFLO DATA FIT TO MAGMASTER
UPSTREAM WATER LEVEL - 380 and 450
HEIGHT OF DOWNSTREAM BOARD - 0, 135, 300 mm

MHL Report 1215
Figure 3.3
DRAWING 1215_033.BPS



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COMPARISON OF DATA FITS
1.3045 FACTOR
1.21246469*X+0.41906326

MHL Report 1215
Figure 3.4
DRAWING 1215_034.BPS

4. Conclusions

The Dethridge meter and MACE AgriFlo were forwarded to MHL for testing as new meters which had not been previously used in the field. Both meters performed reliably throughout the testing and showed a linear relationship with the MagMaster reference meter which had exhibited a high level of accuracy when calibrated in a NATA-endorsed calibration facility.

The AgriFlo meter showed generally good accuracy over the flow range 1.0 ML/day to 10.0 ML/day with 22 of the 29 average flowrates within ±5% of the MagMaster average flowrate. The majority (18/29) of indicated flowrates were lower than the MagMaster flowrates. The accuracy of the AgriFlo meter could be further improved, for the pipe installation tested, by applying a linear correction.

Using the Murrumbidgee Irrigation conversion factor (*Flowrate (ML/day) = Dethridge meter revolutions/minute x 1.304)5* the Dethridge meter showed poor accuracy at flowrates below 2.0 ML/day but good accuracy at flowrates from 4.0 to 10.0 ML/day. Over this higher range 16 of the 17 Dethridge meter average flowrates were within ±5% of the MagMaster average flowrate. The majority (19/29) of indicated flowrates were lower than the MagMaster flowrates. The testing indicated that the accuracy of the Dethridge meter could be improved by applying a modified conversion factor to readings.

The AgriFlo pipe installation showed low headloss for the flow range tested. The head difference, as indicated by the difference in water level from upstream of the entry sump to within the downstream sump, ranged from 19 mm at 2.0 ML/day to 65 mm at 10.0 ML/day.

5. References and Bibliography

ABB Kent-Taylor 1995, *MagMaster Electromagnetic Flowmeters Instruction Manual, Books 1 - 7*, ABB Kent-Taylor Pty Ltd, Caringbah, NSW.

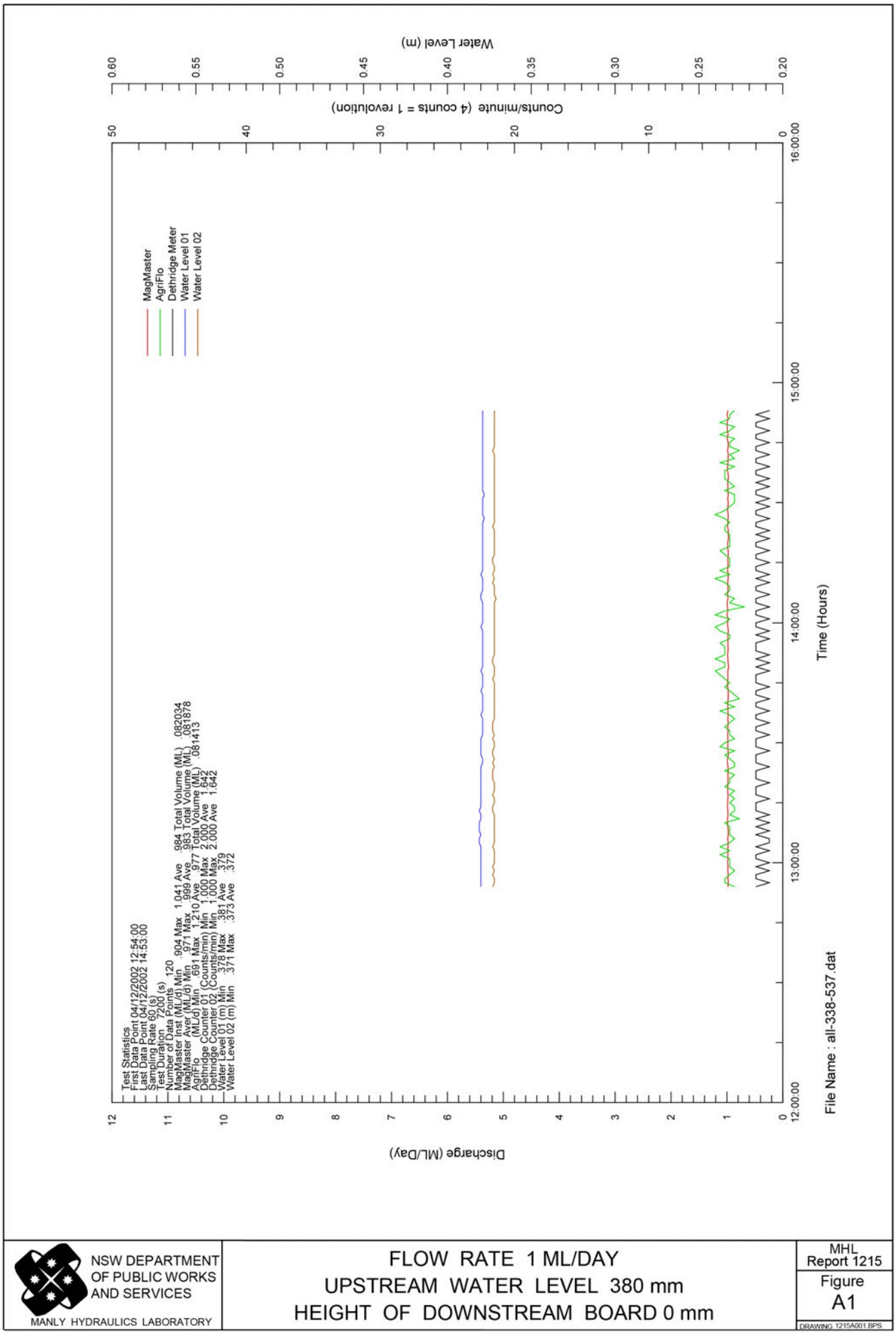
Australian Standard AS3778 2001, *Measurement of water flow in open channels, Part 2.4 General – Estimation of uncertainty of a flow-rate measurement*, AS3778.2.4, Standards Australia.

ISO/TR 5168:1998, *Measurement of fluid flow - Evaluation of uncertainties.*

MACE 2002, *AgriFlo/FloPro Users Guide*, Measurement and Control Equipment Pty Ltd, www.macequip.com.au.

Appendix A

Experimental Results Meter Readings vs Time



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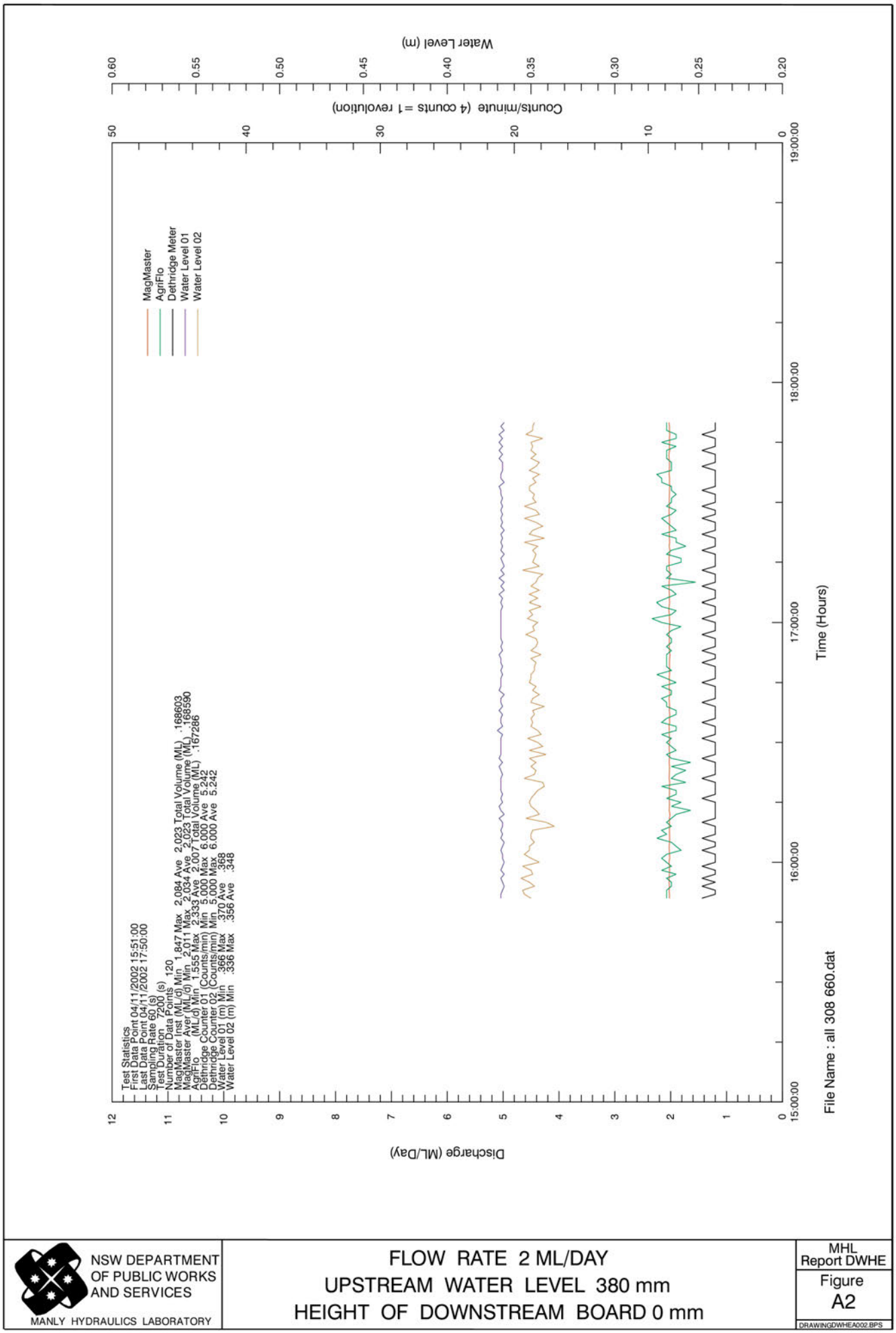
FLOW RATE 1 ML/DAY
UPSTREAM WATER LEVEL 380 mm
HEIGHT OF DOWNSTREAM BOARD 0 mm

MHL Report 1215
Figure A1
DRAWING 1215A001.BPS



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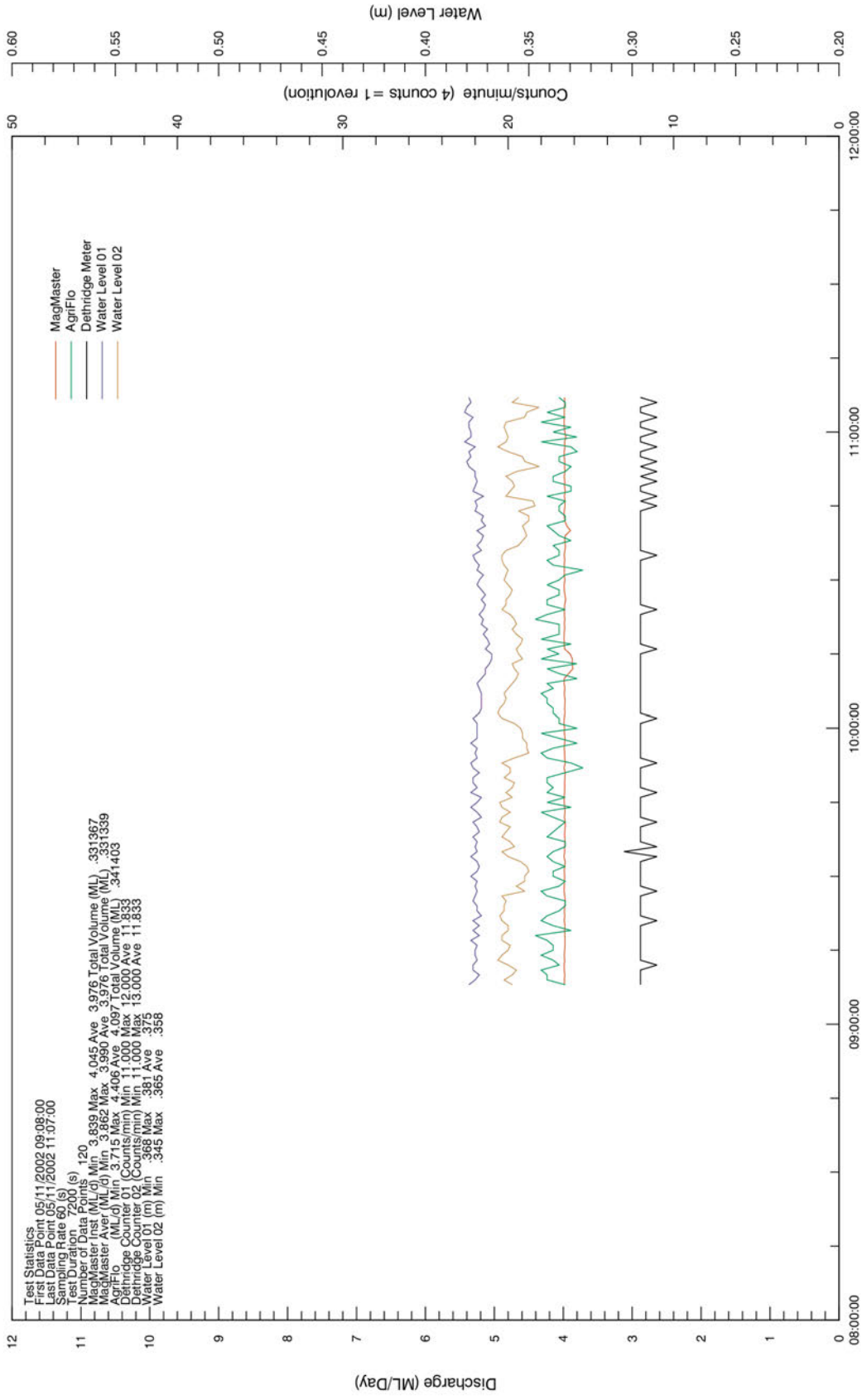
FLOW RATE 2 ML/DAY
UPSTREAM WATER LEVEL 380 mm
HEIGHT OF DOWNSTREAM BOARD 0 mm

MHL Report DWHE
Figure A2
DRAWINGDWHEA002.BPS



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FLOW RATE 4 ML/day
UPSTREAM WATER LEVEL 380 mm
HEIGHT OF DOWNSTREAM BOARD 0 mm

MHL Report DWHE
Figure A3
DRAWING DWHEA003.BPS

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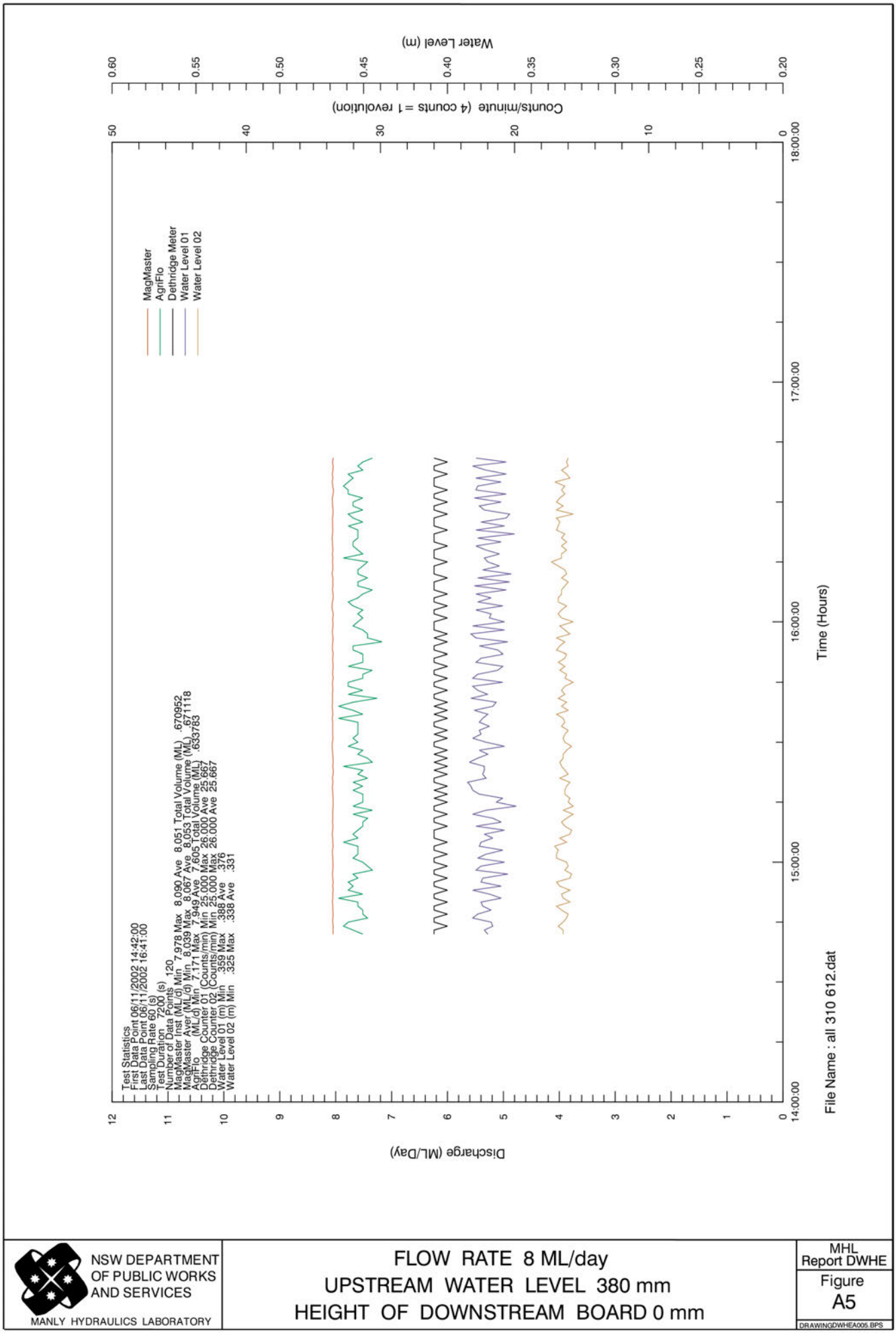
FLOW RATE 6 ML/day
UPSTREAM WATER LEVEL 380 mm
HEIGHT OF DOWNSTREAM BOARD 0 mm

MHL Report DWHE
Figure A4
DRAWING DWHEA004.BPS



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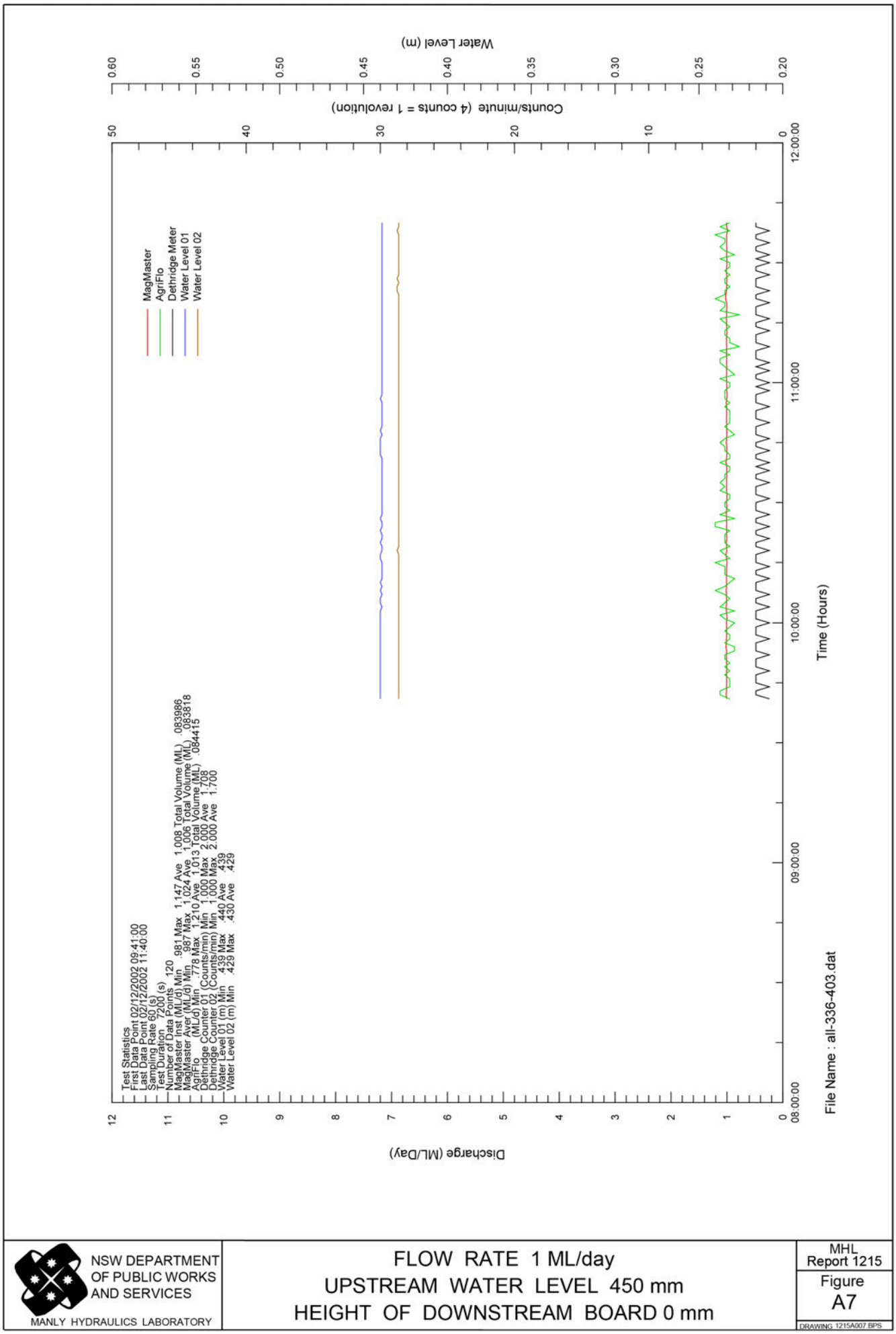
FLOW RATE 8 ML/day
UPSTREAM WATER LEVEL 380 mm
HEIGHT OF DOWNSTREAM BOARD 0 mm

MHL Report DWHE
Figure A5
DRAWING:DWHEA005.BPS



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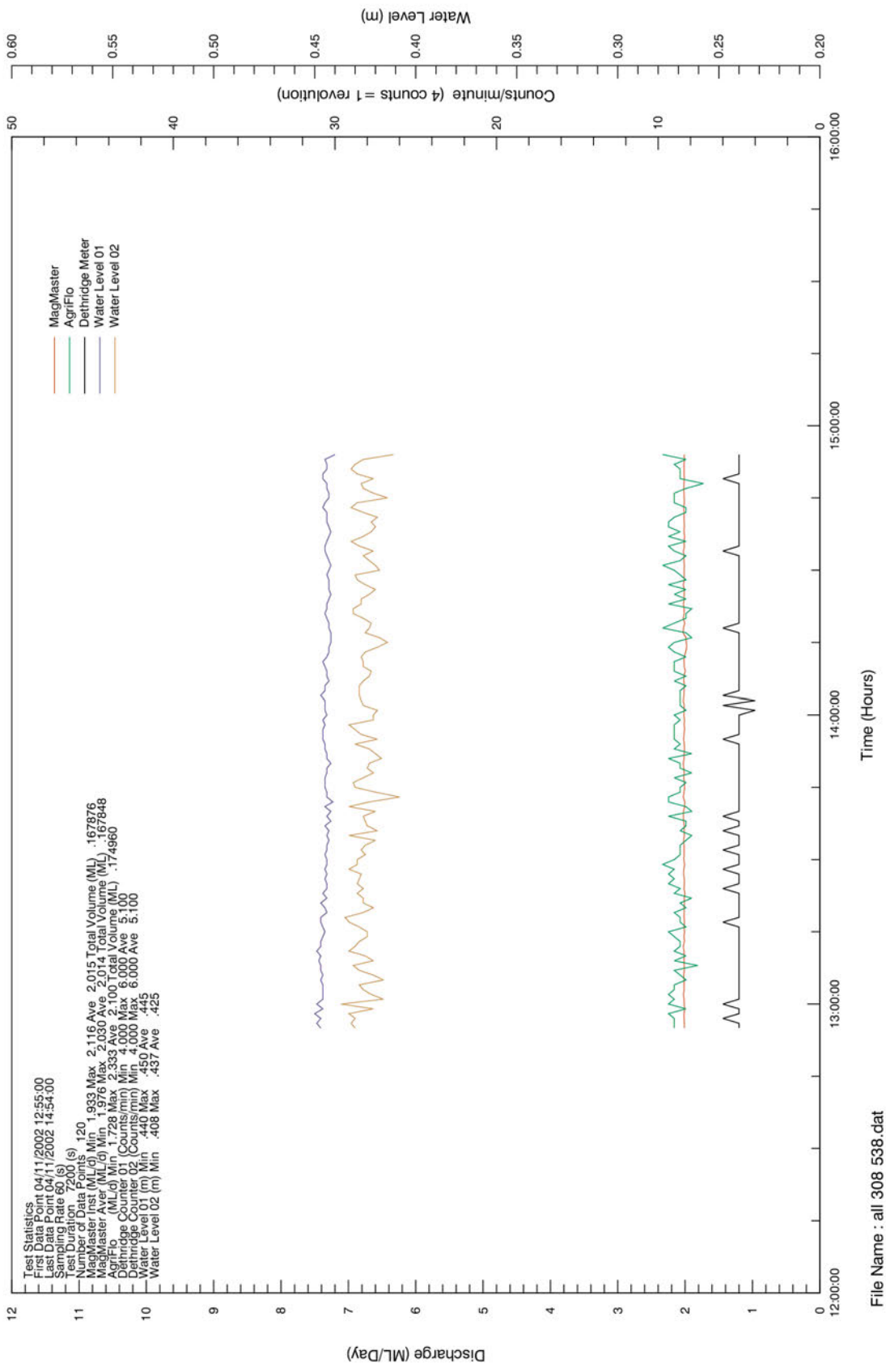
FLOW RATE 1 ML/day
UPSTREAM WATER LEVEL 450 mm
HEIGHT OF DOWNSTREAM BOARD 0 mm

MHL Report 1215
Figure A7
DRAWING 1215A007.BPS



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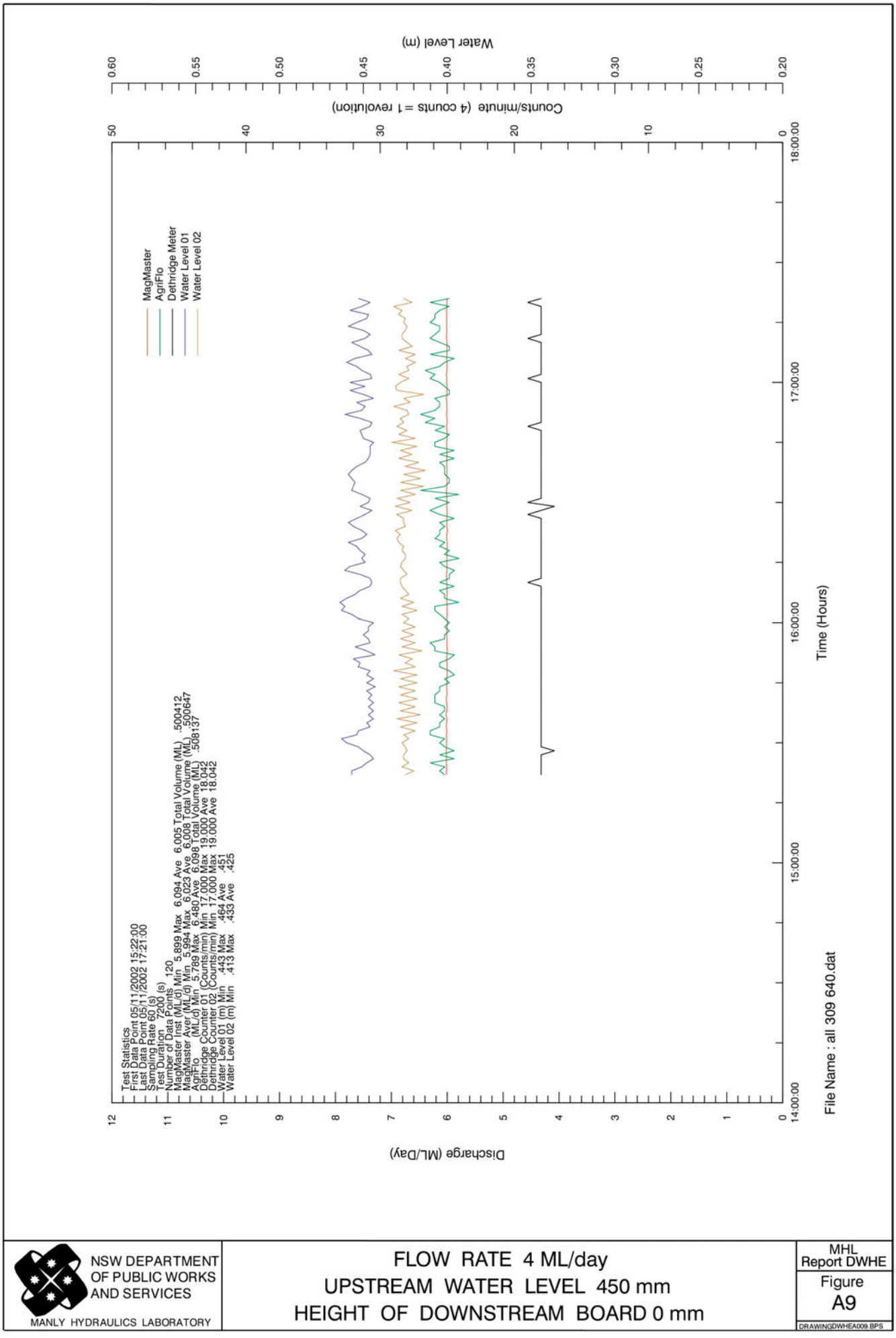
FLOW RATE 2 ML/day
UPSTREAM WATER LEVEL 450 mm
HEIGHT OF DOWNSTREAM BOARD 0 mm

MHL Report DWHE
Figure A8
DRAWING DWHEA008.BPS



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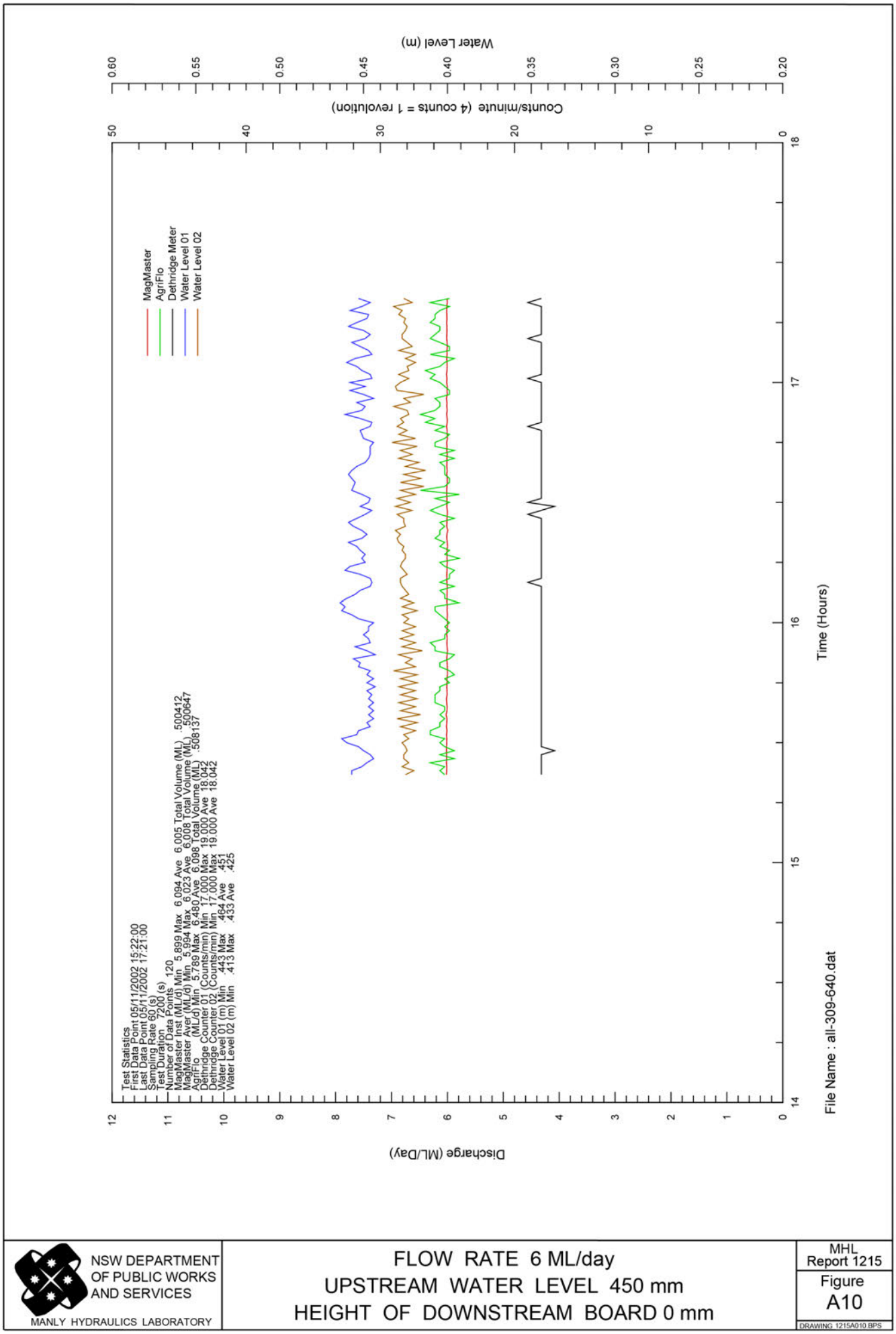
FLOW RATE 4 ML/day
UPSTREAM WATER LEVEL 450 mm
HEIGHT OF DOWNSTREAM BOARD 0 mm

MHL Report DWHE
Figure A9
DRAWINGDWHEA009.BPS



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MANLY HYDRAULICS LABORATORY

FLOW RATE 6 ML/day
UPSTREAM WATER LEVEL 450 mm
HEIGHT OF DOWNSTREAM BOARD 0 mm

MHL Report 1215
Figure A10
DRAWING 1215A010.BPS

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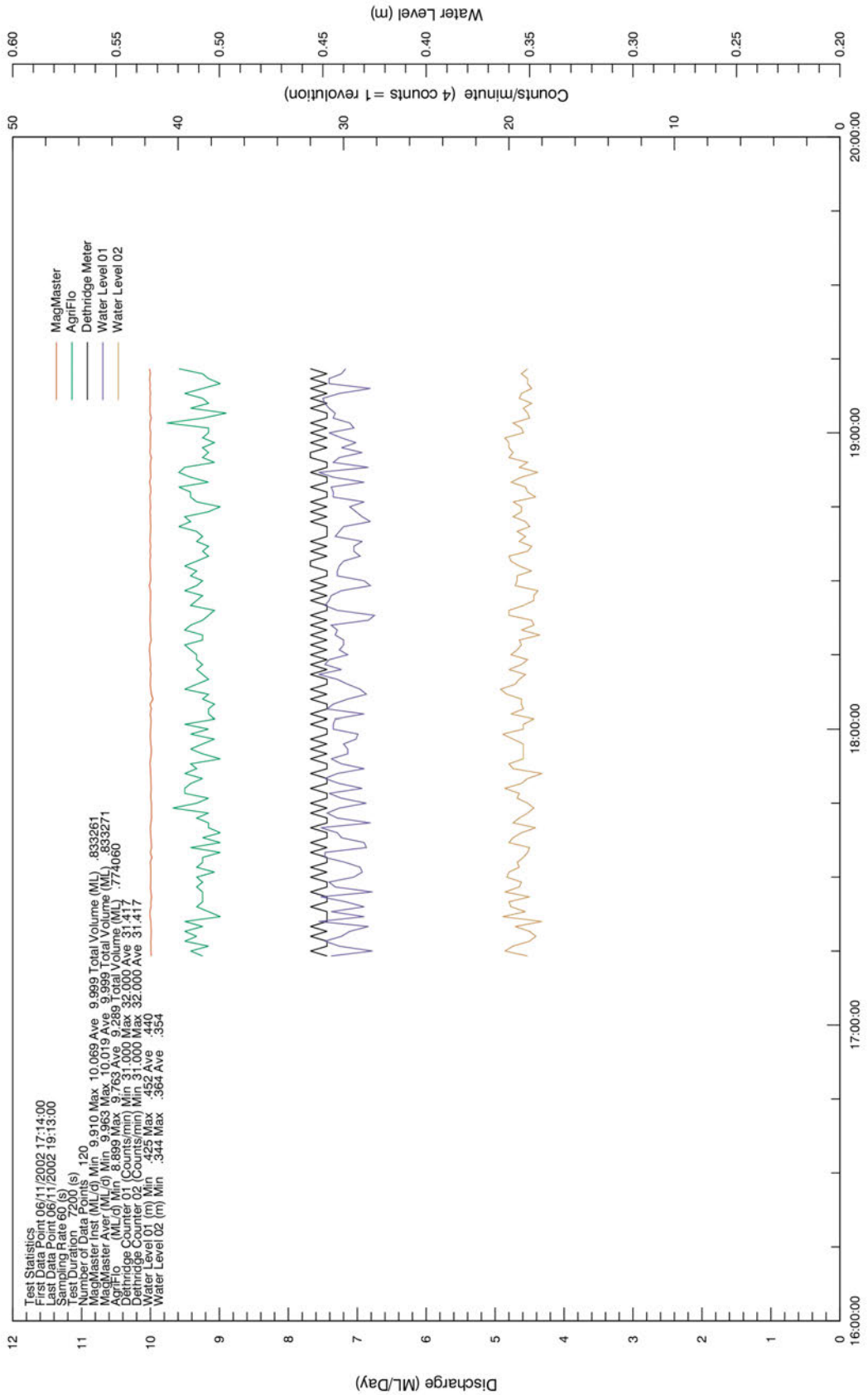
FLOW RATE 8 ML/day
UPSTREAM WATER LEVEL 450 mm
HEIGHT OF DOWNSTREAM BOARD 0 mm

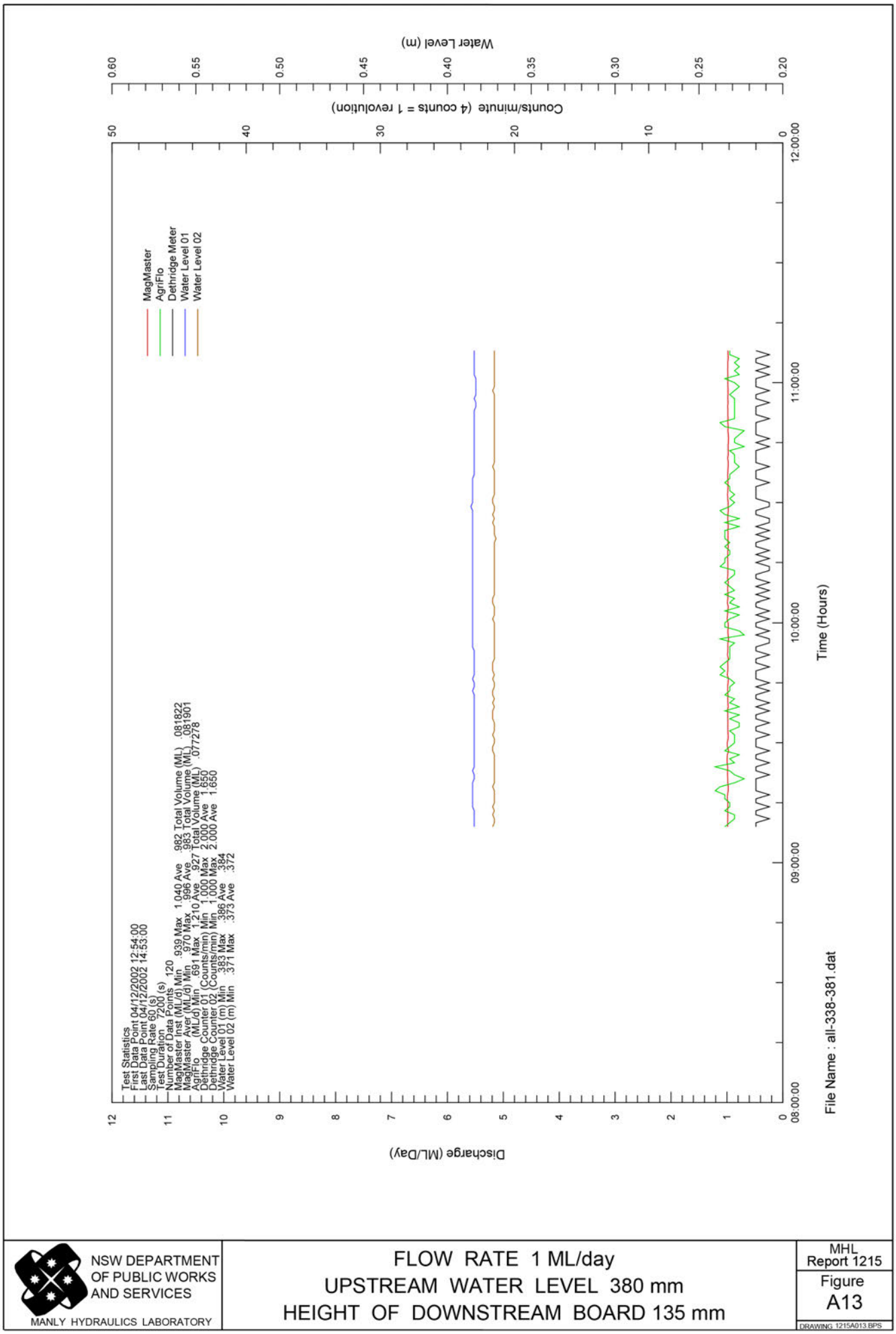
MHL Report 1215
Figure A11
DRAWING 1215A011.BPS



NSW DEPARTMENT OF PUBLIC WORKS AND SERVICES
MANLY HYDRAULICS LABORATORY

FLOW RATE 10 ML/day
UPSTREAM WATER LEVEL 450 mm
HEIGHT OF DOWNSTREAM BOARD 0 mm

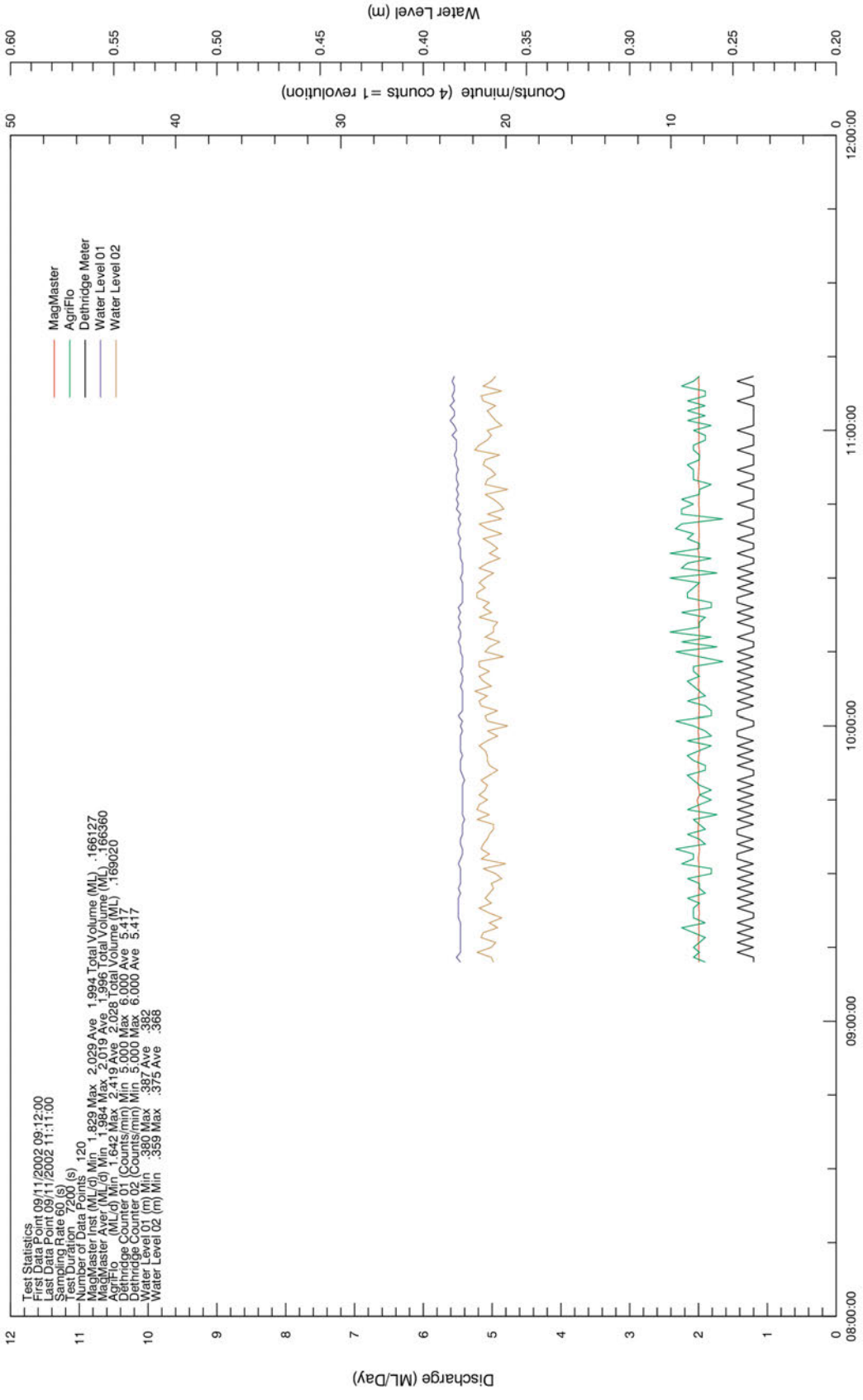
MHL Report DWHE
Figure A12
DRAWINGDWHEA012.BPS



NSW DEPARTMENT OF PUBLIC WORKS AND SERVICES
MANLY HYDRAULICS LABORATORY

FLOW RATE 1 ML/day
UPSTREAM WATER LEVEL 380 mm
HEIGHT OF DOWNSTREAM BOARD 135 mm

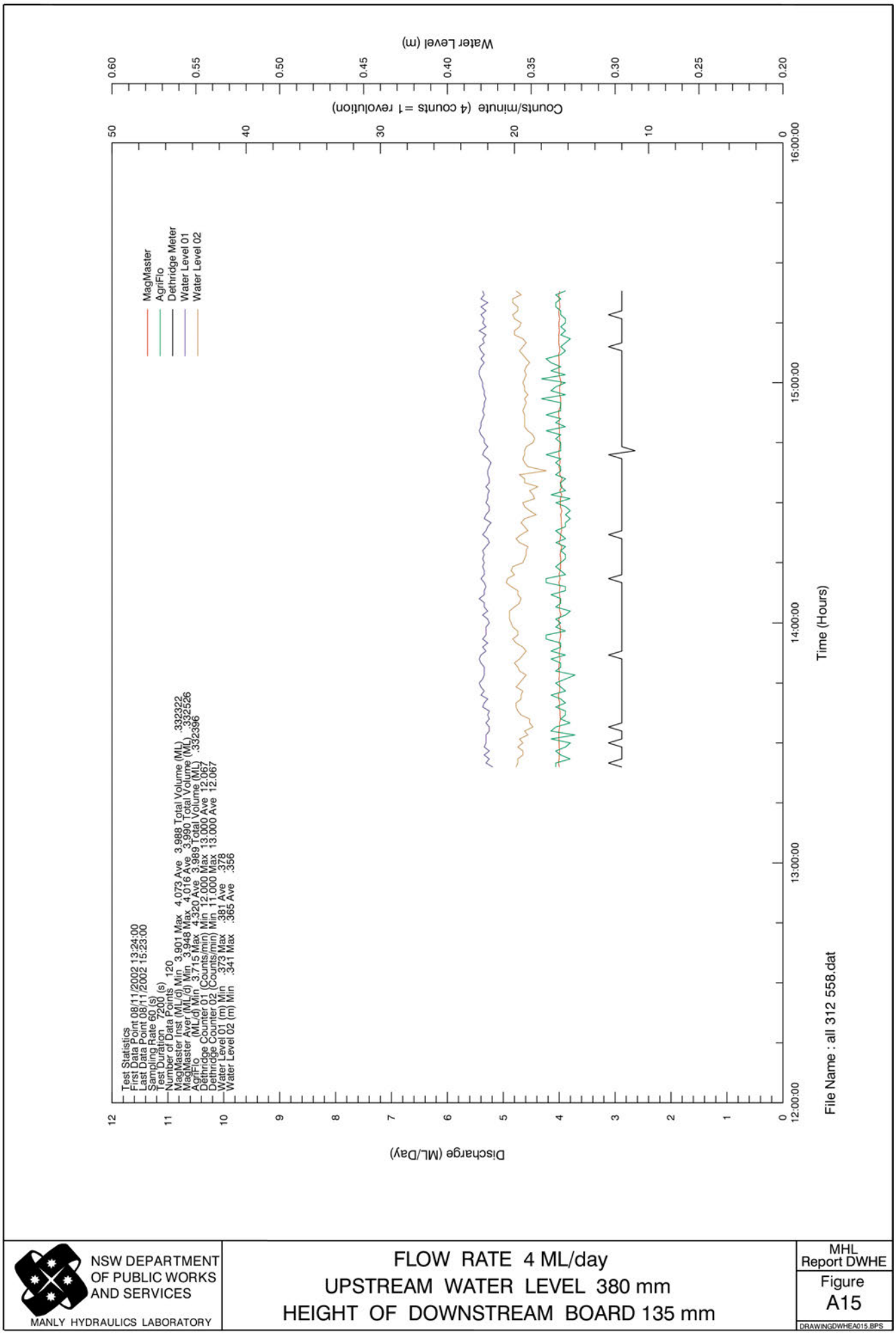
MHL Report 1215
Figure A13
DRAWING 1215A013.BPS



NSW DEPARTMENT OF PUBLIC WORKS AND SERVICES
MANLY HYDRAULICS LABORATORY

FLOW RATE 2 ML/day
UPSTREAM WATER LEVEL 380 mm
HEIGHT OF DOWNSTREAM BOARD 135 mm

MHL Report DWHE
Figure A14
DRAWING DWHEA014.BPS



NSW DEPARTMENT OF PUBLIC WORKS AND SERVICES
MANLY HYDRAULICS LABORATORY

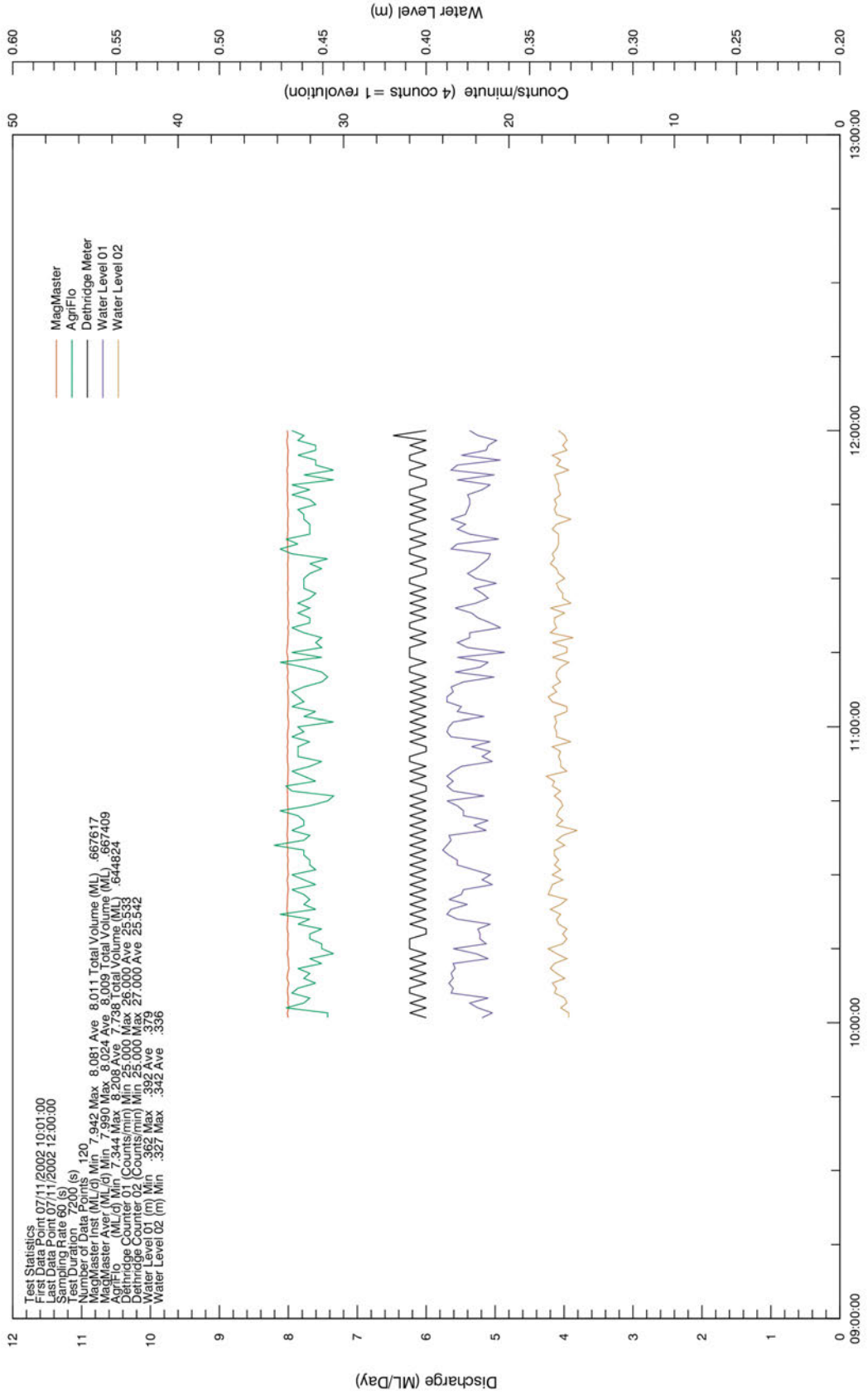
FLOW RATE 4 ML/day
UPSTREAM WATER LEVEL 380 mm
HEIGHT OF DOWNSTREAM BOARD 135 mm

MHL Report DWHE
Figure A15
DRAWINGDWHEA015.BPS

NSW DEPARTMENT OF PUBLIC WORKS AND SERVICES
MANLY HYDRAULICS LABORATORY

FLOW RATE 6 ML/day
UPSTREAM WATER LEVEL 380 mm
HEIGHT OF DOWNSTREAM BOARD 135 mm

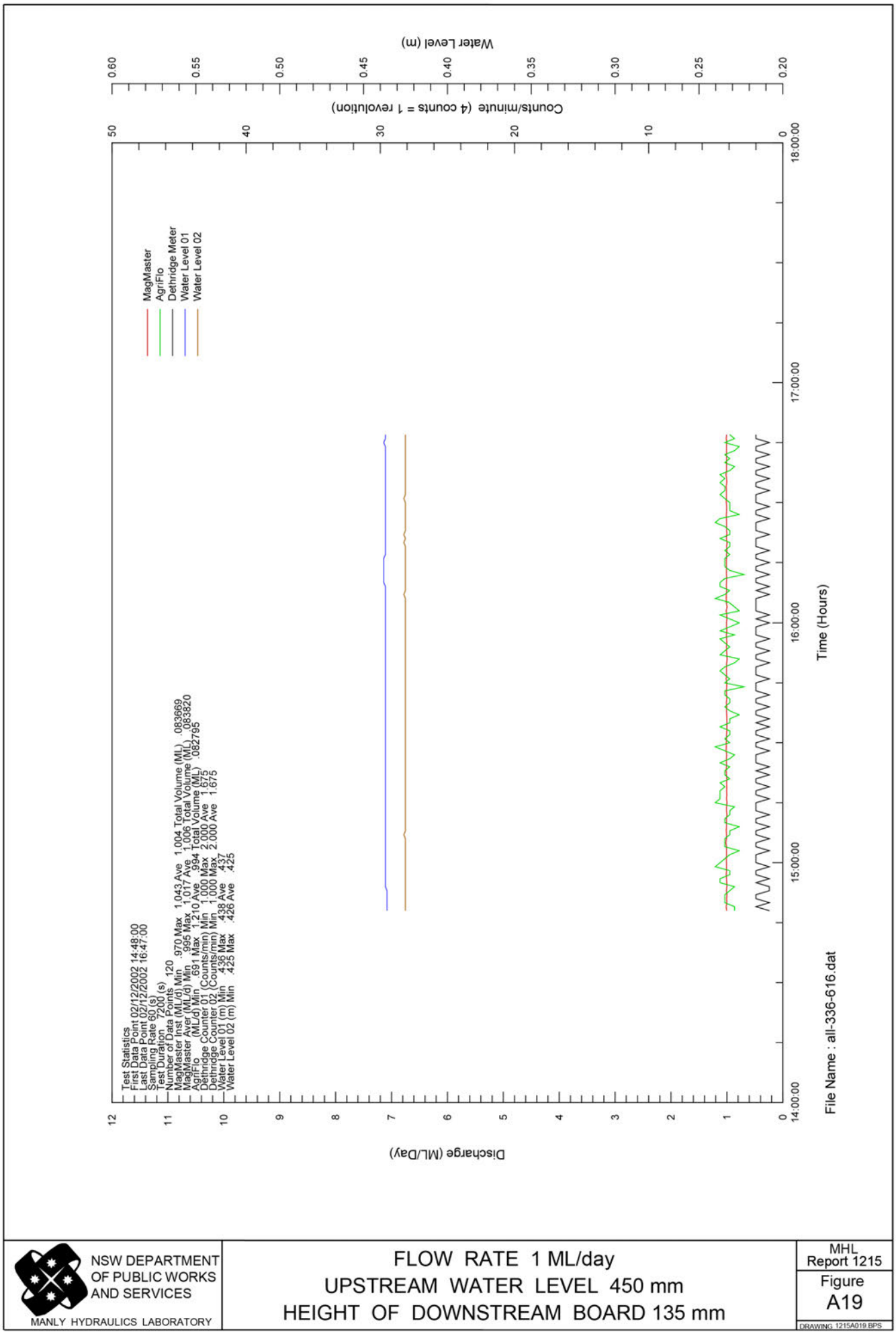
MHL Report DWHE
Figure A16
DRAWING\DWHEA016.BPS



NSW DEPARTMENT OF PUBLIC WORKS AND SERVICES
MANLY HYDRAULICS LABORATORY

FLOW RATE 8 ML/day
UPSTREAM WATER LEVEL 380 mm
HEIGHT OF DOWNSTREAM BOARD 135 mm

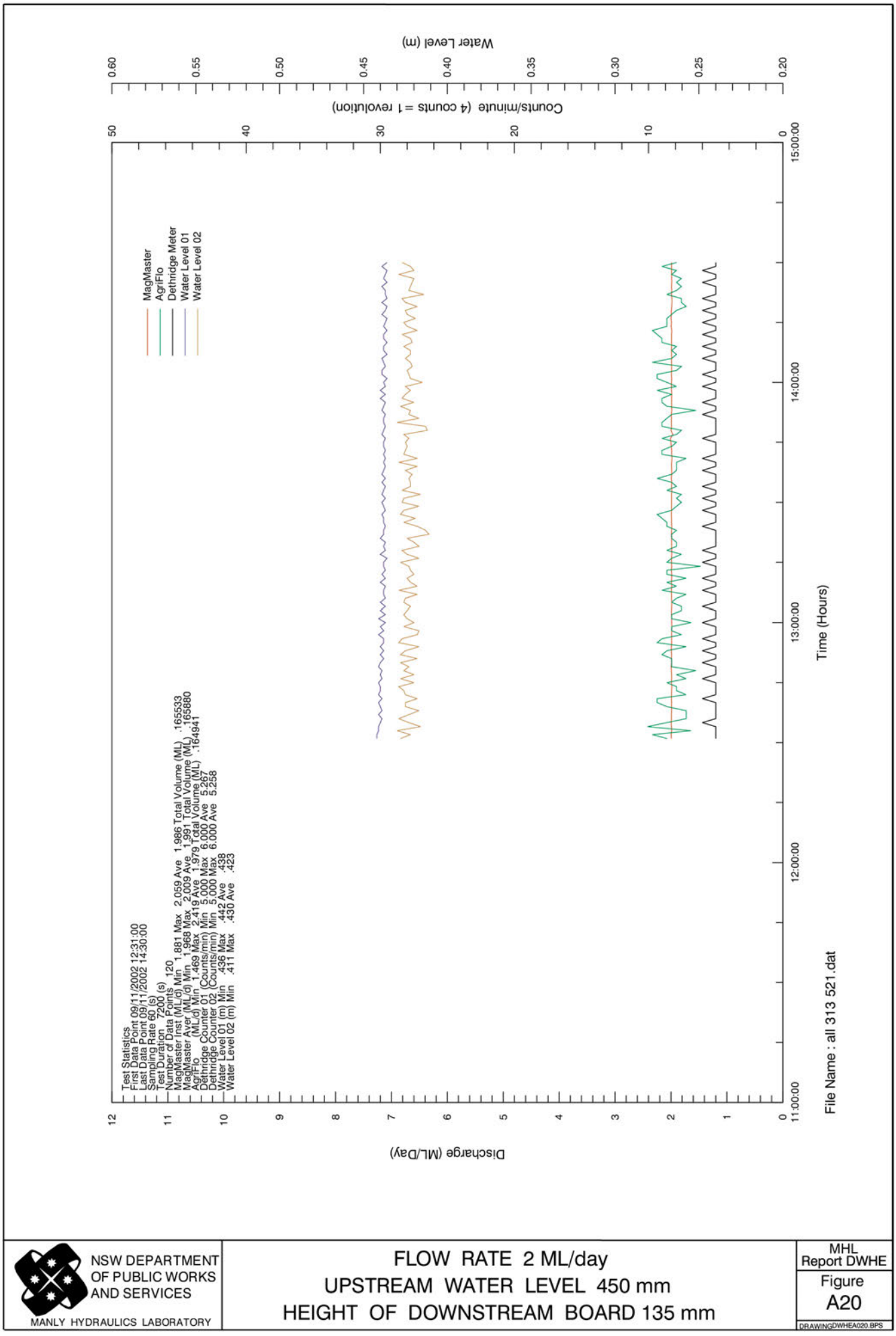
MHL Report DWHE
Figure A17
DRAWINGDWHEA017.BPS



NSW DEPARTMENT OF PUBLIC WORKS AND SERVICES
MANLY HYDRAULICS LABORATORY

FLOW RATE 1 ML/day
UPSTREAM WATER LEVEL 450 mm
HEIGHT OF DOWNSTREAM BOARD 135 mm

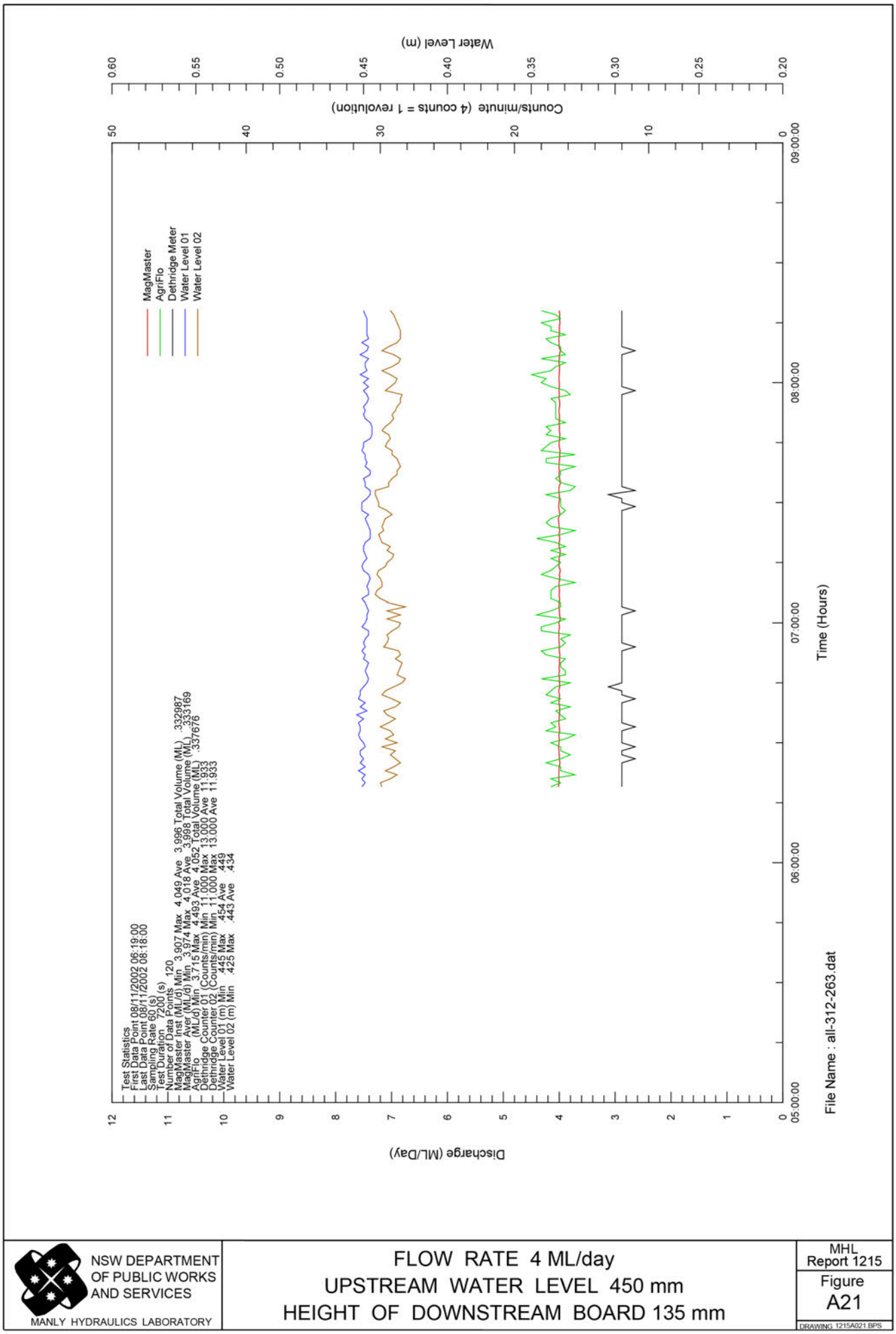
MHL Report 1215
Figure A19
DRAWING 1215A019.BPS



NSW DEPARTMENT OF PUBLIC WORKS AND SERVICES
MANLY HYDRAULICS LABORATORY

FLOW RATE 2 ML/day
UPSTREAM WATER LEVEL 450 mm
HEIGHT OF DOWNSTREAM BOARD 135 mm

MHL Report DWHE
Figure A20
DRAWING DWHEA020.BPS



NSW DEPARTMENT OF PUBLIC WORKS AND SERVICES
MANLY HYDRAULICS LABORATORY

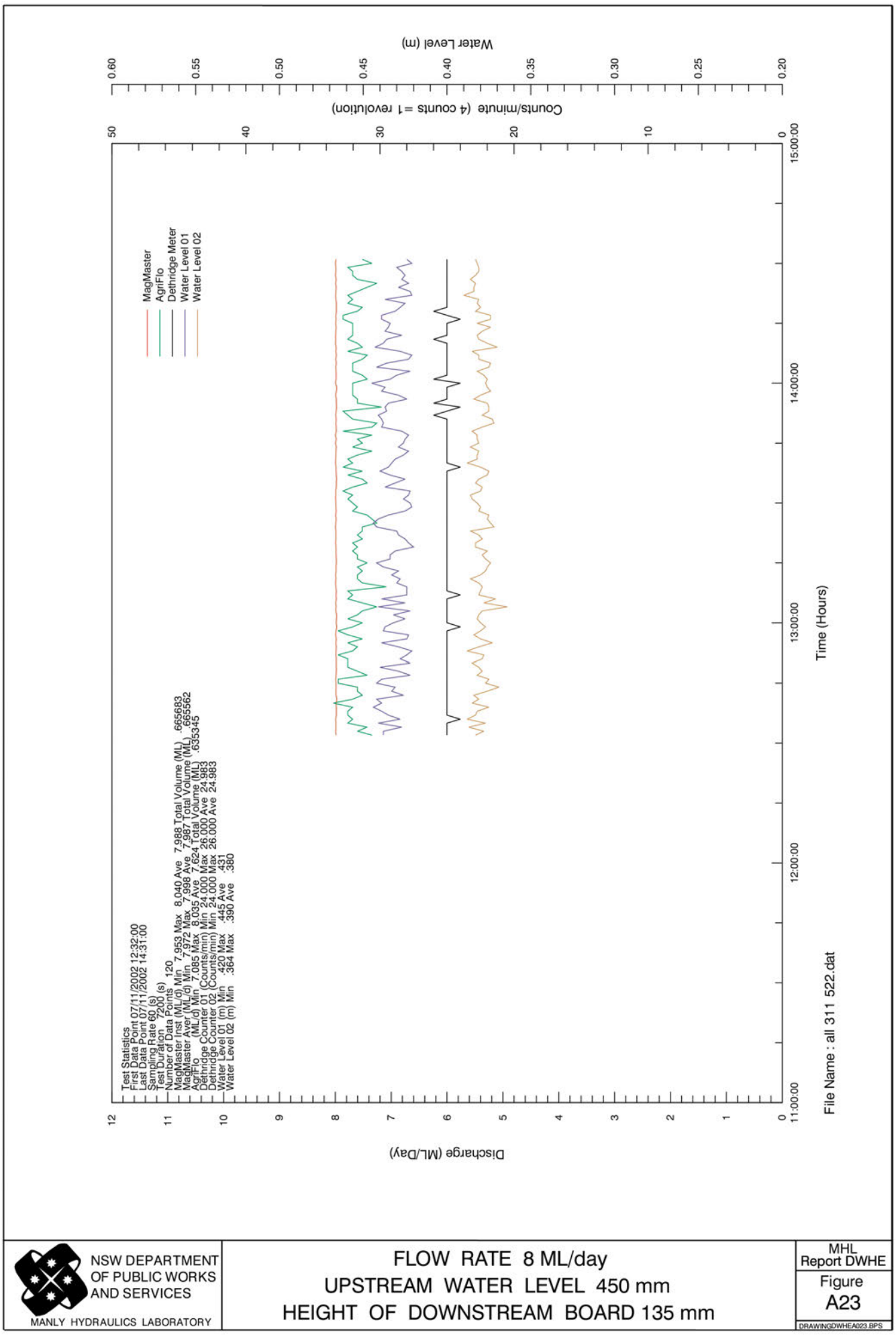
FLOW RATE 4 ML/day
UPSTREAM WATER LEVEL 450 mm
HEIGHT OF DOWNSTREAM BOARD 135 mm

MHL Report 1215
Figure A21
DRAWING 1215A021.BPS

NSW DEPARTMENT OF PUBLIC WORKS AND SERVICES
MANLY HYDRAULICS LABORATORY

FLOW RATE 6 ML/day
UPSTREAM WATER LEVEL 450 mm
HEIGHT OF DOWNSTREAM BOARD 135 mm

MHL Report DWHE
Figure A22
DRAWING DWHEA022.BPS



NSW DEPARTMENT OF PUBLIC WORKS AND SERVICES
MANLY HYDRAULICS LABORATORY

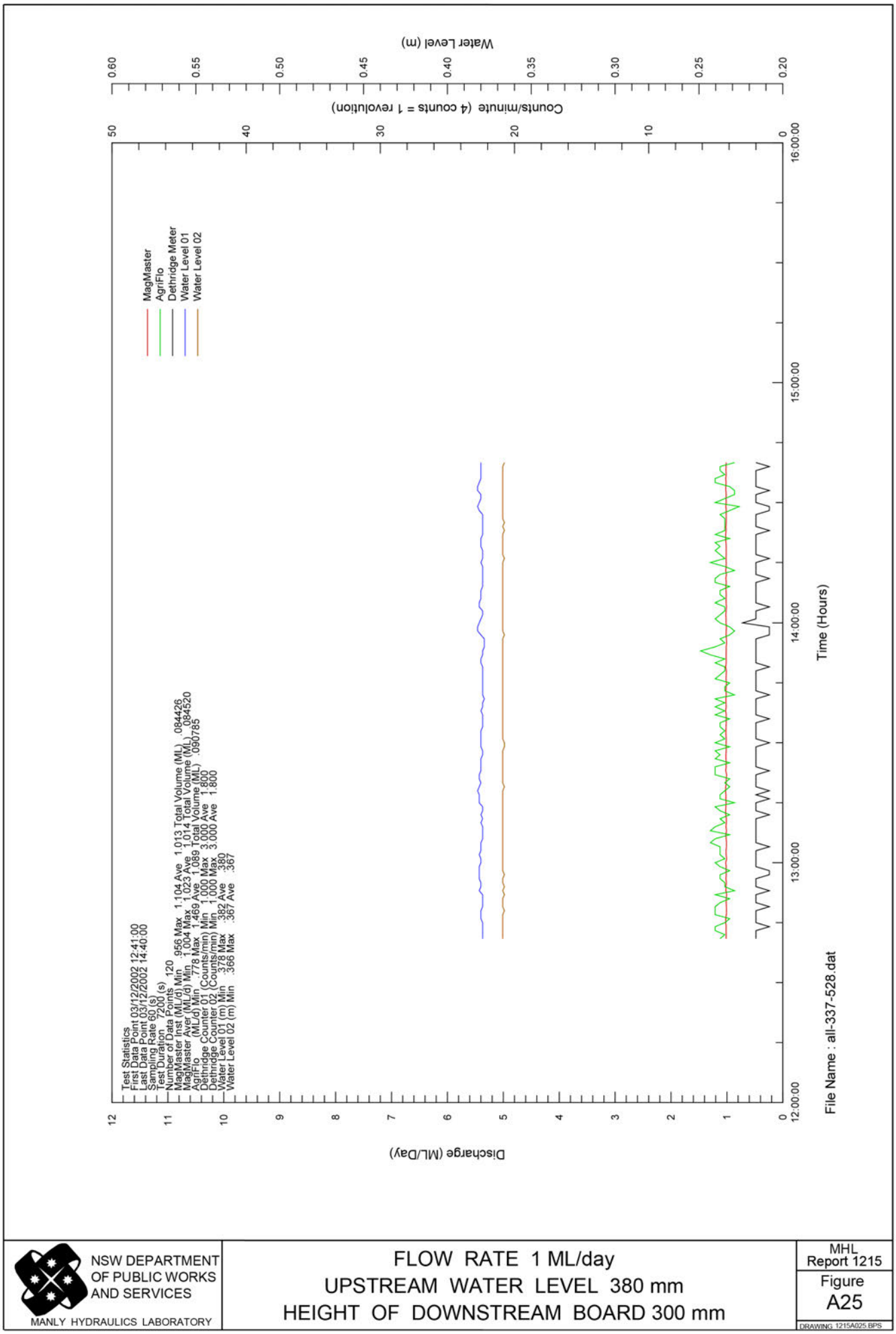
FLOW RATE 8 ML/day
UPSTREAM WATER LEVEL 450 mm
HEIGHT OF DOWNSTREAM BOARD 135 mm

MHL Report DWHE
Figure A23
DRAWINGDWHEA023.BPS

NSW DEPARTMENT OF PUBLIC WORKS AND SERVICES
MANLY HYDRAULICS LABORATORY

FLOW RATE 10 ML/day
UPSTREAM WATER LEVEL 450 mm
HEIGHT OF DOWNSTREAM BOARD 135 mm

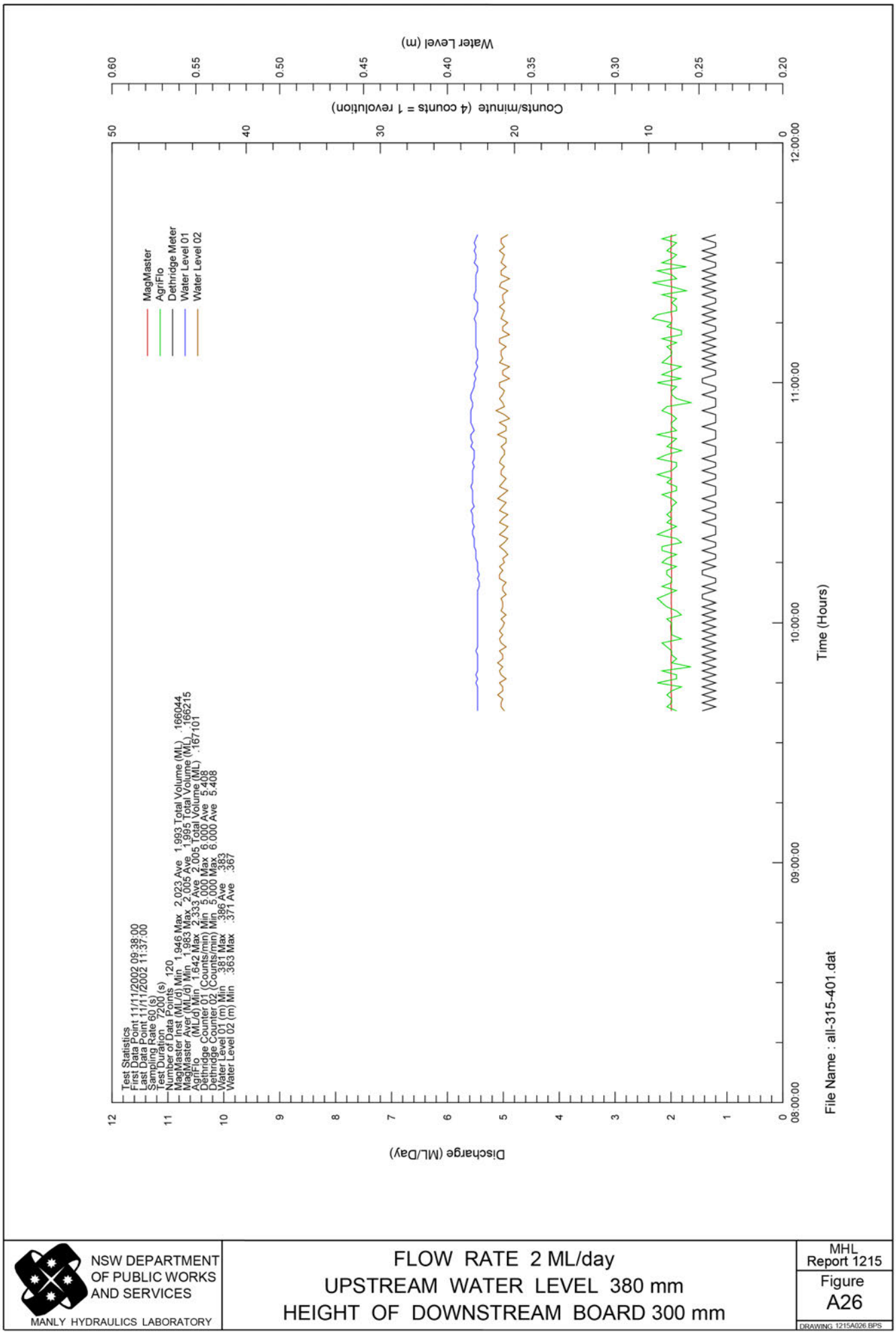
MHL Report DWHE
Figure A24
DRAWINGDWHEA024.BPS



NSW DEPARTMENT OF PUBLIC WORKS AND SERVICES
MANLY HYDRAULICS LABORATORY

FLOW RATE 1 ML/day
UPSTREAM WATER LEVEL 380 mm
HEIGHT OF DOWNSTREAM BOARD 300 mm

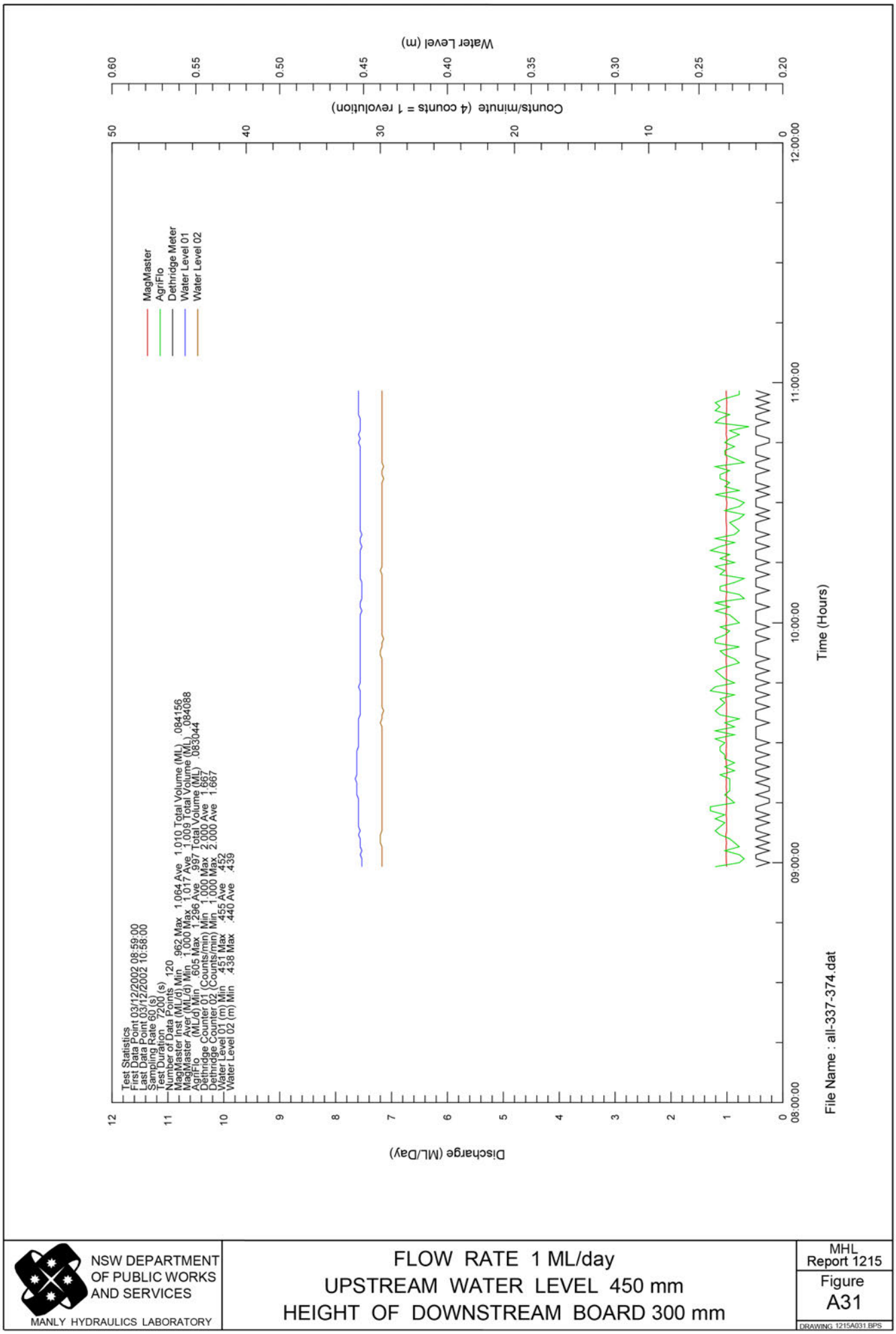
MHL Report 1215
Figure A25
DRAWING 1215A025.BPS



NSW DEPARTMENT OF PUBLIC WORKS AND SERVICES
MANLY HYDRAULICS LABORATORY

FLOW RATE 2 ML/day
UPSTREAM WATER LEVEL 380 mm
HEIGHT OF DOWNSTREAM BOARD 300 mm

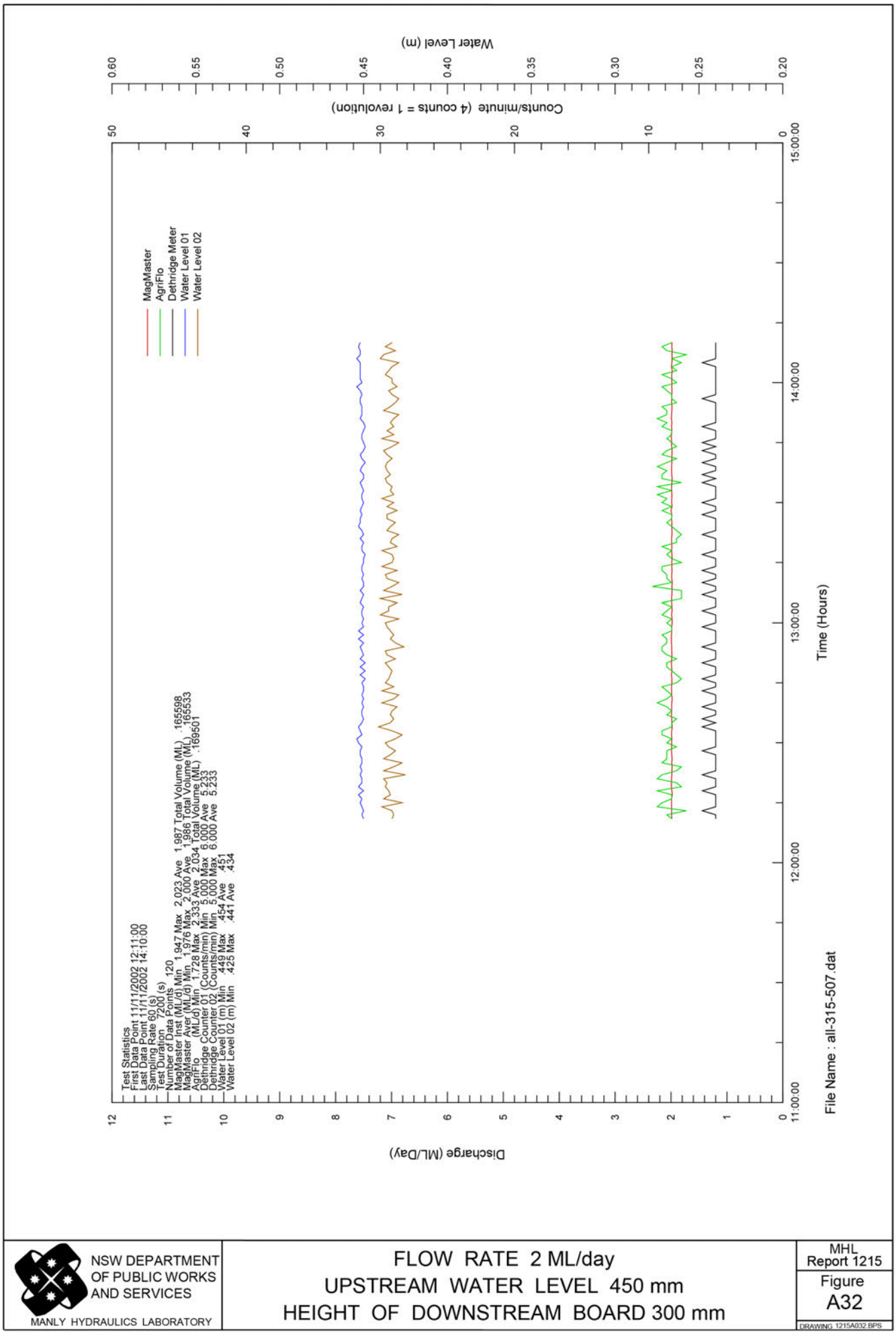
MHL Report 1215
Figure A26
DRAWING 1215A026.BPS



NSW DEPARTMENT OF PUBLIC WORKS AND SERVICES
MANLY HYDRAULICS LABORATORY

FLOW RATE 1 ML/day
UPSTREAM WATER LEVEL 450 mm
HEIGHT OF DOWNSTREAM BOARD 300 mm

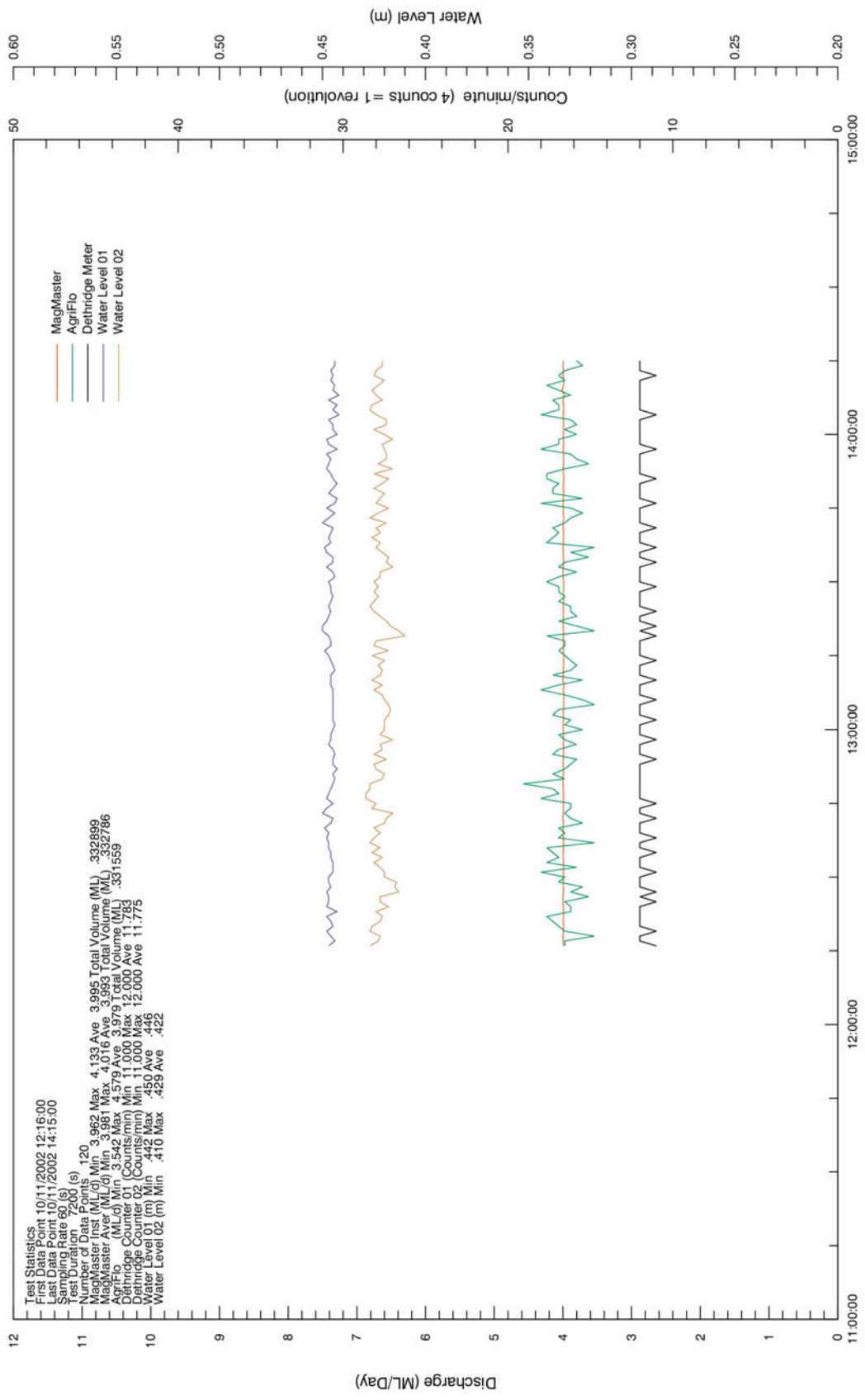
MHL Report 1215
Figure A31
DRAWING 1215A031.BPS



NSW DEPARTMENT OF PUBLIC WORKS AND SERVICES
MANLY HYDRAULICS LABORATORY

FLOW RATE 2 ML/day
UPSTREAM WATER LEVEL 450 mm
HEIGHT OF DOWNSTREAM BOARD 300 mm

MHL Report 1215
Figure A32
DRAWING 1215A032.BPS



NSW DEPARTMENT OF PUBLIC WORKS AND SERVICES
MANLY HYDRAULICS LABORATORY

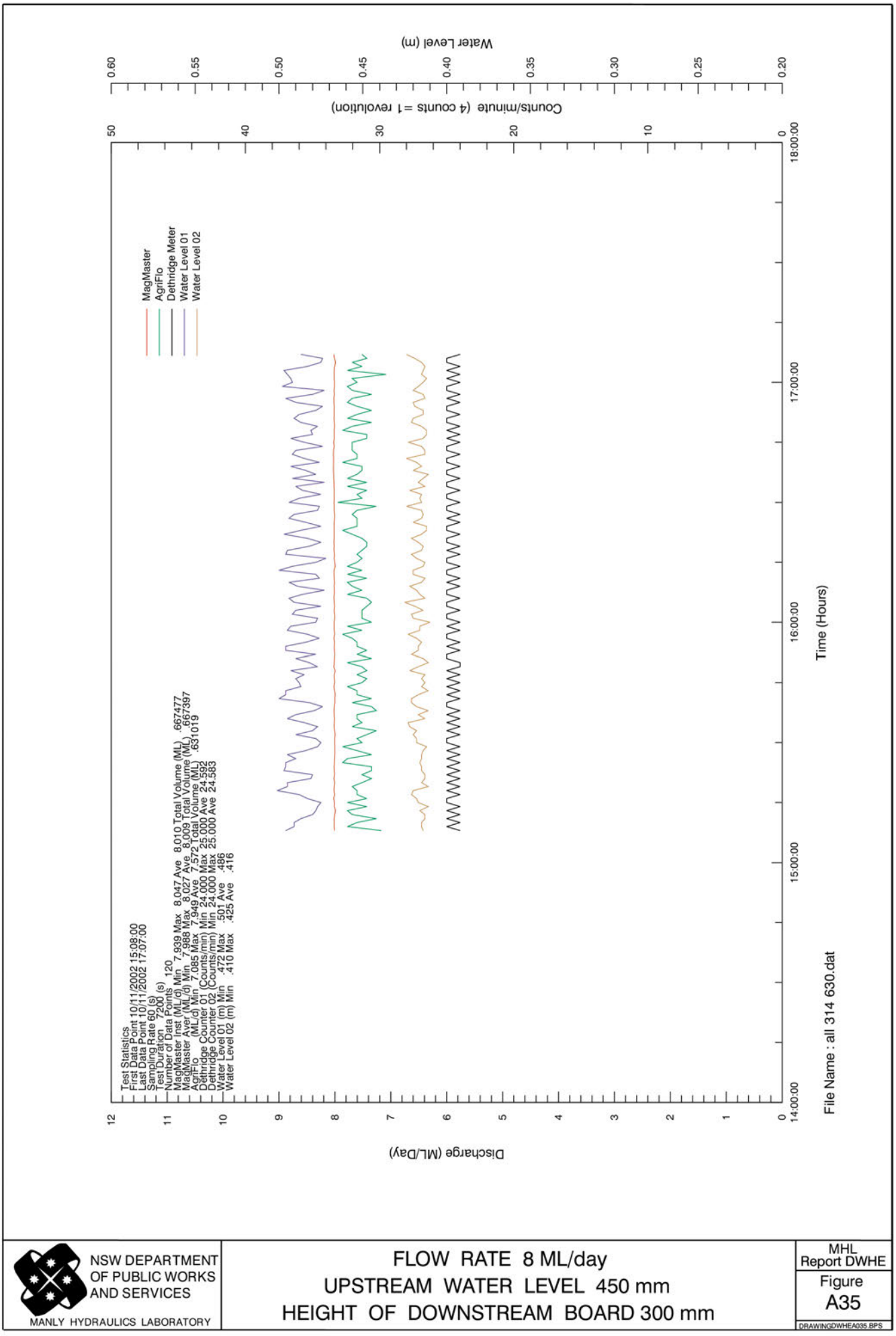
FLOW RATE 4 ML/day
UPSTREAM WATER LEVEL 450 mm
HEIGHT OF DOWNSTREAM BOARD 300 mm

MHL Report DWHE
Figure A33
DRAWING DWHEA033.BPS

NSW DEPARTMENT OF PUBLIC WORKS AND SERVICES
MANLY HYDRAULICS LABORATORY

FLOW RATE 6 ML/day
UPSTREAM WATER LEVEL 450 mm
HEIGHT OF DOWNSTREAM BOARD 300 mm

MHL Report DWHE
Figure A34
DRAWINGDWHEA034.BPS



NSW DEPARTMENT OF PUBLIC WORKS AND SERVICES
MANLY HYDRAULICS LABORATORY

FLOW RATE 8 ML/day
UPSTREAM WATER LEVEL 450 mm
HEIGHT OF DOWNSTREAM BOARD 300 mm

MHL Report DWHE
Figure A35
DRAWINGDWHEA035.BPS

Appendix B

MagMaster Calibration Certificates

Flowmeter Calibration Certificate

ABB Instrumentation Pty Limited
ACN 004 224 953

Head Office
70-78 Box Road Caringbah NSW Australia
PO Box 2083 Taren Point NSW 2229 Australia
Telephone: (02) 9540 0000
Fax: (02) 9540 0001

Quality Endorsed Company

This laboratory is registered by the National Association of Testing Authorities, Australia. The tests reported herein have been performed in accordance with its terms of registration.

W3/4

Customer: NSW Department Of Public Works, Manly **Our Ref:** O115414
Order No: 159627 **Item No:** 1 **Job No:** J47938
Report No: 2677/99 **Test Date:** 15/02/99 **Level:** 0 **Issue No:** 1 **Issue Date:** 17/02/99

FLOWMETER PRIMARY DATA:

Make: ABB **Type:** Electromagnetic **Size:** 250mm
Code/Model No: Water & Waste MagMaster **Serial No:** V/31122/35/1
Specified Flow Range: 200 L/s **Process Connections:** Flanges
Other Details: F1: 1.271 F2: 0 F3: 5 F4: 1.0000

FLOWMETER SECONDARY DATA:

Make: ABB **Type:** Transmitter **Output:** Pulses
Code/Model No: Water & Waste MagMaster **Serial No:** V/31122/35/1

CALIBRATION DATA:

Range of Calibration: 20...200 L/s **Test Rig No:** 2 **Calibration Procedure:** EDM095
Method: Comparison & Volumetric **Water Temp:** 27 **Deg C** **Density:** 996.5 **kg/m³**
Other Details: Tests 1 to 5: using comparison method. Test 6: using volumetric method.

CALIBRATION RESULTS:

Test No	Nominal % Of Maximum Flowrate	Measured Quantity Litres	Indicated Quantity Litres	Error %
1	100	60438	60424	- 0.02
2	80	32472	32481	+ 0.03
3	60	32696	32668	- 0.09
4	50	30948	30901	- 0.15
5	25	21317	21292	- 0.12
6	10	15043	15011	- 0.22

Measurement Uncertainty: ±0.25% of measured quantity or ±60L, whichever is greater.

Calibrated by: G Ashcroft **Certified by:** P J Parsons
Position: Calibrator **Position:** Supervisor

Signature: ..... **Signature:** .....

J47938.doc

Flowmeter Calibration Verification Certificate

Customer	NSW DEPT OF PUBLIC WORKS - MANLY
Date Performed	Wednesday 4 September 2002 09:41
Date Certificate Printed	Wednesday 4 September 2002 14:58

Site Details

Location	NSW
Tag	**********
Operator	Stephen Chan

Results :

Transmitter Zero	Pass
Transmitter Span	Pass
Transmitter Pulse Output	Pass
Transmitter Analogue Output	Pass
Sensor Electrode Integrity	Pass
Sensor Energising Coil Integrity	Pass

Declared "EMPTY" pipe status appears to be EMPTY.

Accuracy :

The above tests and results verify that the flowmeter is functioning within normal working limits, and is within ±1% of original calibration certificate.

Transmitter Settings

Sensor Calibration Factor	1.2710/0/5/1.000
Flow Range	100.0 l/s
Response Time Constant	3 seconds
Probe Factors	ins 1.00000, prof 1.00000
Analogue Output	Not Configured For Use
Second Analogue Range	100.0% (100.0 l/s)
Pulse Output	1.00000 pulses/l
Totaliser Units	milli l

Calmaster Details

Instrument, Serial No.	CM0001, X/10092/01/01
Last Calibrated	Tue 11 Dec 2001
Next Calibration Date	Wed 11 Dec 2002
Firmware Version	CalMaster v1.0 36/96
PC Software Version	v2.10 18/01/2000 (Intn.)
DVM Serial No.	N/A
Resistor Serial No.	N/A

Flowmeter Details

Type	MagMaster, Electromagnetic
Sensor S/No.	V/31122/35/1
Transmitter S/No.	VKE061602
Tag No.	**********
Meter Size	250 mm

CalMaster is fully traceable to National and International Standards.
For details please refer to CalMaster Traceability Documentation.

ABB Instrumentation World Flow Technology Centres

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