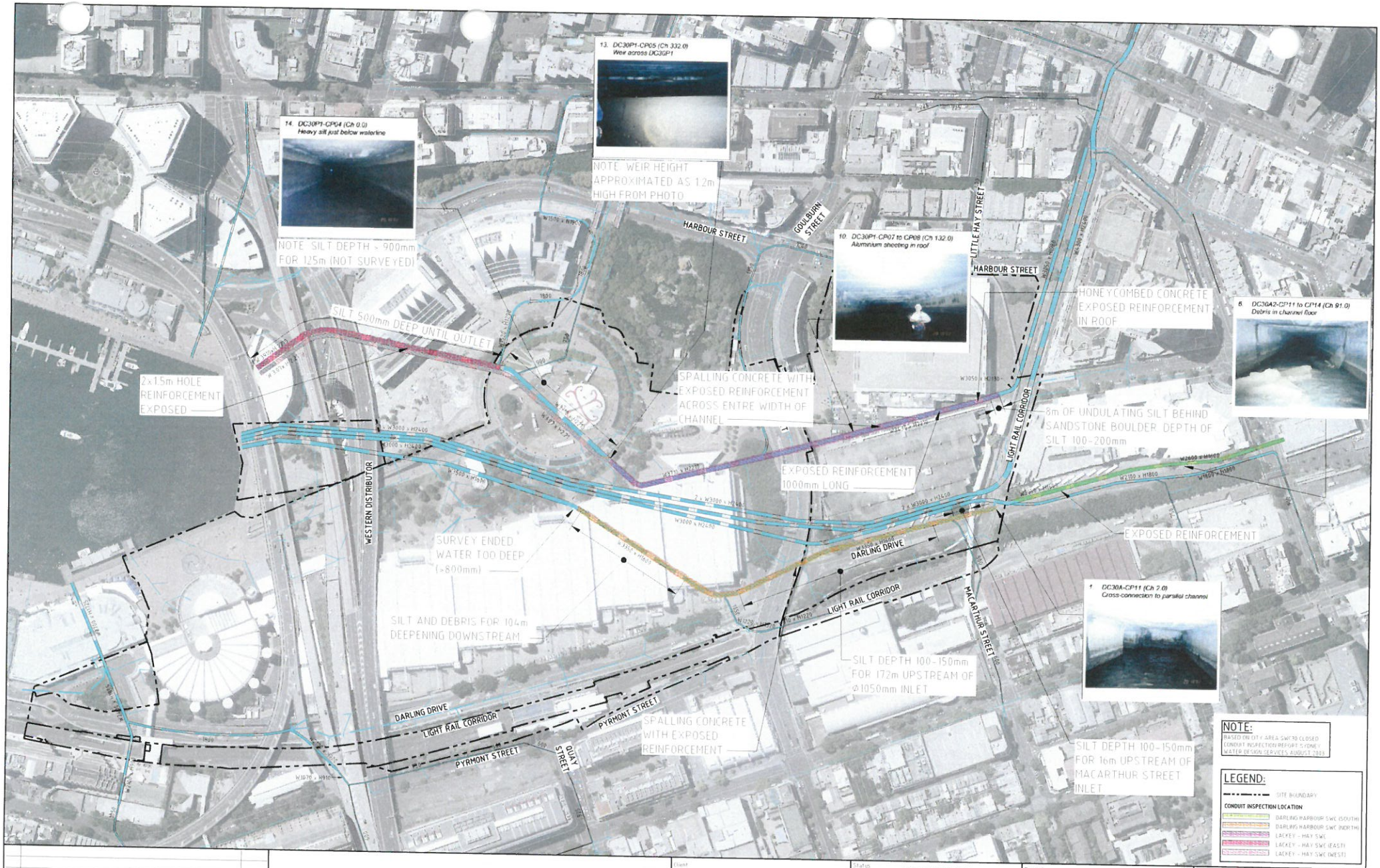


Issue	Description	Date
P1	ISSUE FOR INFORMATION	xx/02/13

0 30 60 90 120 150m
1 : 1500

Client: Lend Lease

Status: PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION

Scales	1:1500	Current Issue Signatures
Original Size	A1	Designed
Height Datum	AHD	Checked
Grid		Approved
Filename		

Project: SICEEP
DARLING HARBOUR
PROJECT PRECINCT

Title: SUMMARY OF CLOSED CONDUIT INSPECTION REPORT

HYDER CONSULTING PTY LTD
ABN 76 104 485 289
Level 5, 141 Walker St
North Sydney NSW 2060
Australia
Tel: +61 (0)2 8907 9000
Fax: +61 (0)2 8907 9001
www.hyderconsulting.com

Drawing No.	Project No.	Issue
SKC264	AA004399	P1

Date Plotted: 26 Feb 2013 - 04:26PM File Name: I:\AA004399\Reports\Stormwater\Appendices\Flooding Appendices\Appendix D\SKC264-AA004399-P01-x-05-SummaryOfClosedConduitInspectionReportSydneyWater03.dwg

APPENDIX E

SYDNEY HARBOUR DESIGN LEVELS AND SEA LEVEL RISE

Sea Level Change Table

ARI Years	2008[1] Design Still Water Levels (m AHD)	Sea Level Rise[3] Scenerio	2050[1] (m AHD)	2100[1] (m AHD)
1	1.235	Low	1.275	1.395
		Medium	1.445	1.765
		High	1.615	2.125
2	1.275	Low	1.315	1.435
		Medium	1.485	1.805
		High	1.655	2.165
5	1.315	Low	1.355	1.475
		Medium	1.525	1.845
		High	1.695	2.205
10	1.345	Low	1.385	1.505
		Medium	1.555	1.875
		High	1.725	2.235
20	1.375	Low	1.415	1.535
		Medium	1.585	1.905
		High	1.755	2.265
50	1.415	Low	1.455	1.575
		Medium	1.625	1.945
		High	1.795	2.305
100	1.435	Low	1.475	1.595
		Medium	1.645	1.965
		High	1.815	2.325
PMF[4]	1.8	Low	1.84	1.96
		Medium	2.01	2.33
		High	2.18	2.69

Notes

1. Levels taken from Table 6.3 Fort Denison Sea Level Rise Vulnerablity Study (DECC, 2008)
2. Levels assume a linear increase rounded to the nearest 5mm
3. Low, Medium, High refer to climate change projections outlined in the table below
4. PMF calculated by taking the highest astronomical tide of 1.175m AHD plus a surge component of 0.6m and then rounded to 1.8m

Table 6.2 Fort Denison Sea Level Rise Vulnerability Study (DECC, 2008)

Sea Level Rise Scenario	Year 2050 (cm)	Year 2100 (cm)
Lower Bound Estimate (**LOW**)	4 [1]	16 [3]
Medium Estimate (**MED**) [5]	21	53
Upper Bound Estimate (**HIGH**)	38 [2]	89 [4]

Notes

1. SLR estimate derived from Figure 11.12 (IPCC, 2001) corrected for application from 2008.
2. SLR estimates derived from Figure 11.12 (IPCC, 2001) corrected for application from 2008 (26cm) with the addition of 12 cm to account for the upper bound regional increase in SLR above the global average (CSIRO, 2007).
3. SLR estimate from Table SPM.3 (IPCC, 2007) using the 18cm advised, corrected for application from 2008 assuming average increase in MSL of 1.8mm/year from 1999.
4. SLR estimate from Table SPM.3 (IPCC, 2007) using the 59cm advised, corrected for application from 2008 assuming average increase in MSL of 1.8mm/year from 1999. An additional 20cm has been added to account for the possibility of ice sheet flow rates increasing linearly with increased temperature for upper bound projections as advised by IPCC (2007). A further 12cm has been added to account for the upper bound regional increase in SLR above the global average (CSIRO, 2007).
5. Medium position between "lower" and "upper" bound derived estimates rounded up to nearest cm.

APPENDIX F

RAINFALL, COCKLE BAY WATER LEVEL AND CATCHMENT RUNOFF COINCIDENCE

20 Worst Rainfall Events from 1914-2012

Event	Recorded Rainfall Observatory Hill			Approximate ARIs from Bureau of Meteorology			Approximate Timing of Events		Recorded Water Levels Fort Denison			Calculated From Predicted Tide	
Date	25min (mm/hr)	60min (mm/hr)	Daily Rainfall (mm)	25min ARI	60min ARI	24hr ARI	Start of Severe 25min	Peak Runoff	Peak Tide (m AHD)	Tide ARI	Approx Tide at Peak Runoff	Peak Anomaly (m)	Anomaly ARI
10/05/25	36.6	27.8	178.5	1yr	<1yr	5yr - 10yr	11:11 AM	11:33 AM	1.01	<1 month	0.211	0.01	< 1 yr
18/04/27	75.2	33.4	101.0	2-5yr	1yr	1yr	07:35 PM	07:57 PM	1.04	<1 month	0.801	0.37	5 yr
6/07/31	46.5	16.0	197.8	<1yr	<1yr	10yr - 20yr	07:11 AM	07:33 AM	1.01	<1 month	-0.035	0.49	20 yr
31/01/38	75.4	67.0	174.7	2-5yr	10yr - 20yr	5yr - 10yr	06:31 AM	06:53 AM	0.79	<1 month	0.629	0.04	< 1 yr
27/03/42	66.0	41.4	241.7	2yr	2yr	20yr-50yr	11:23 PM	11:45 PM	0.77	<1 month	-0.076	0.18	< 1 yr
23/01/55	47.5	47.5	173.5	<1yr	2yr - 5yr	5yr - 10yr	05:07 AM	05:29 AM	0.73	<1 month	0.251	-0.04	< 1 yr
10/02/56	34.7	23.3	192.5	<1yr	<1yr	10yr	06:41 AM	07:03 AM	0.94	<1 month	0.776	0.25	< 1 yr
10/03/58	37.1	31.1	199.2	<1yr	1yr	10yr - 20yr	04:05 PM	04:27 PM	1.10	1 month	-0.052	0.37	5 yr
27/04/66	36.8	28.0	194.7	<1yr	<1yr	10yr - 20yr	11:23 AM	11:45 AM	0.88	<1 month	0.161	0.20	< 1 yr
21/08/71	105.5	73.6	132.9	10-20yr	20yr	2yr	04:59 PM	05:21 PM	0.70	<1 month	-0.02	0.04	< 1 yr
8/01/73	62.2	62.2	174.2	2yr	10yr	5yr - 10yr	12:49 AM	01:11 AM	0.78	<1 month	-0.125	0.14	< 1 yr
10/03/75	87.7	87.7	175.2	5yr	50yr - 100yr	5yr - 10yr	09:25 AM	09:47 AM	0.58	<1 month	0.157	0.03	< 1 yr
8/11/84	199.8	119.4	240.4	>100yr	>100yr	20yr-50yr	09:59 PM	10:21 PM	0.69	<1 month	0.169	0.09	< 1 yr
5/08/86	57.9	44.0	309.7	1yr	2yr - 5yr	>100yr	01:59 PM	02:21 PM	1.01	<1 month	-0.293	0.34	3 yr
17/01/88	33.6	33.2	166.1	<1yr	1yr	5yr	04:17 AM	04:39 AM	0.98	<1 month	0.465	0.04	< 1 yr
30/04/88	53.3	37.7	192.5	1yr	1yr - 2yr	10yr	03:11 AM	03:33 AM	0.78	<1 month	-0.125	0.10	< 1 yr
6/01/89	104.5	42.2	46.8	10-20yr	2yr	<1yr	02:23 PM	02:45 PM	0.91	<1 month	-0.389	0.12	< 1 yr
10/06/91	63.5	44.1	169.7	2yr	2yr - 5yr	5yr	10:29 PM	10:51 PM	0.69	<1 month	-0.36	-0.07	< 1 yr
10/04/98	87.8	67.2	209.4	5yr	10yr - 20yr	10yr - 20yr	09:53 AM	10:15 AM	0.71	<1 month	0.304	0.13	< 1 yr
7/08/98	42.6	31.6	175.8	<1yr	1yr	5yr - 10yr	07:35 PM	07:57 PM	1.23	1 yr	1.2	0.34	3 yr

15 Worst Tide Events from 1914-2012

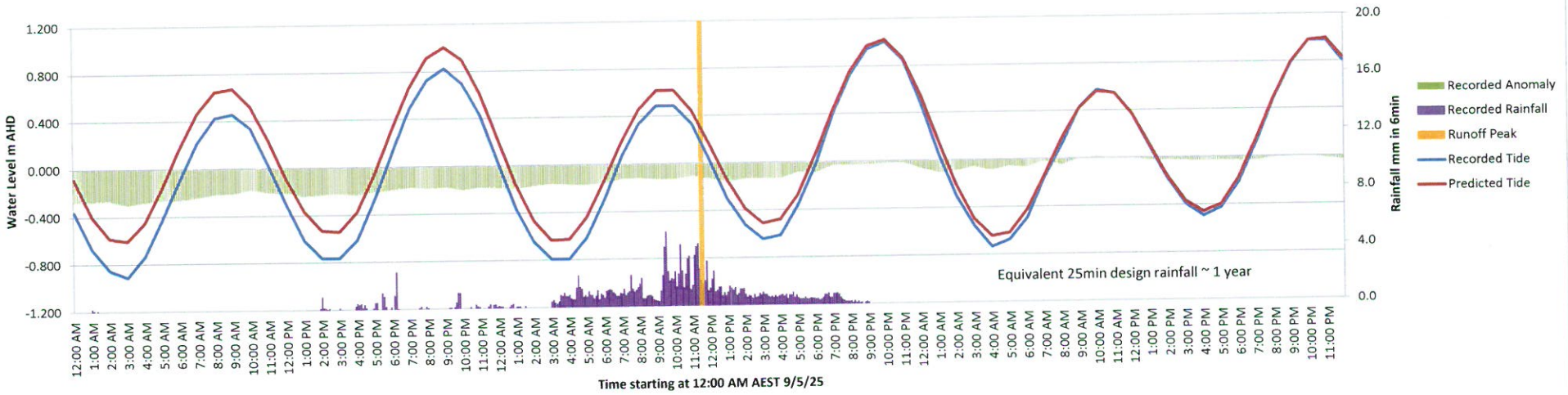
Event	Recorded Water Levels Fort Denison		Calculated From Predicted Tide		Recorded Rainfall Observatory Hill	
Date	Peak Tide (m AHD)	Tide ARI	Peak Anomaly (m)	Anomaly ARI	Daily Rainfall (mm)	24hr ARI
3/8/21	1.31	2yr-5yr	0.29	1 yr	1.0	<1yr
19/6/47	1.29	2yr-5yr	0.20	< 1 yr	0.0	<1yr
12/12/50	1.30	2yr-5yr	0.26	< 1 yr	0.8	<1yr
10/6/56	1.40	20yr - 50yr	0.30	1 yr	18.8	<1yr
10/7/64	1.34	5yr - 10yr	0.29	1 yr	0.0	<1yr
2/6/73	1.28	2yr	0.16	< 1 yr	0.0	<1yr
25/5/74	1.48	>100yr	0.62	> 100 yr	82.6	<1yr
22/7/78	1.32	5yr	0.32	1 yr	2.8	<1yr
30/6/84	1.35	10yr	0.36	5 yr	0.0	<1yr
27/4/90	1.43	50yr - 100yr	0.37	5 yr	0.0	<1yr
13/6/99	1.29	2yr - 5yr	0.17	< 1 yr	0.0	<1yr
19/8/01	1.34	10yr	0.31	1 yr	0.0	<1yr
1/1/02	1.26	1yr - 2yr	0.28	<1 yr	0.0	<1yr
15/6/03	1.26	1yr - 2yr	0.18	< 1 yr	0.4	<1yr
14/6/07	1.32	5yr	0.27	< 1 yr	0.0	<1yr

Notes

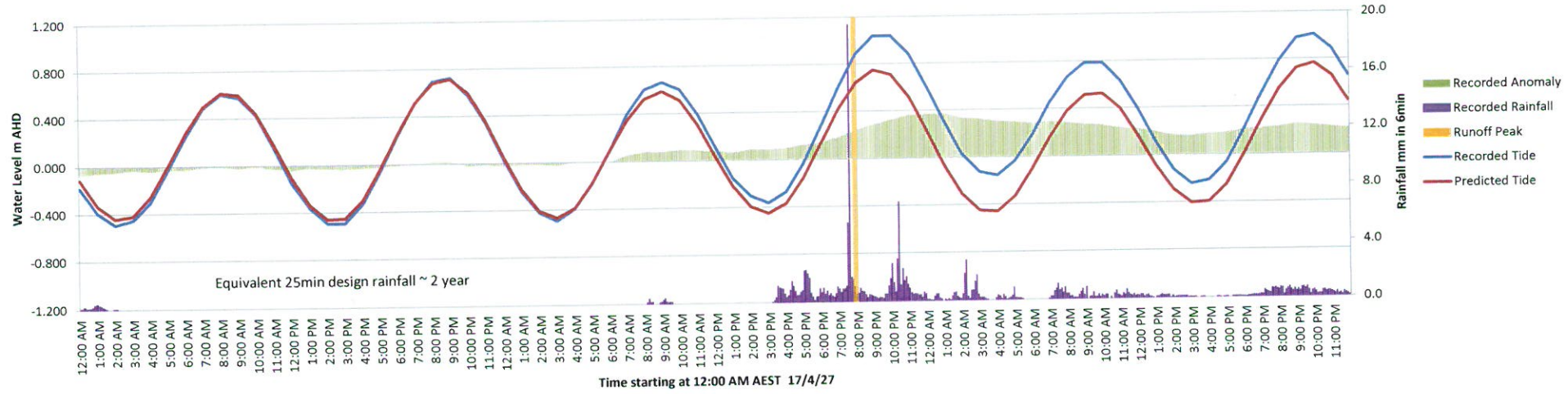
Rainfall data supplied by the Bureau of Meteorology
Tidal recordings and predictions supplied by Sydney Ports Corportation
Anomaly ARIs approximated using NSW Ocean Water Levels, MHL, 2011
Anomally refers to the water level recorded above the predicted.

Peak runoff times to Cockle Bay estimated based on catchment hydrology
Tide ARIs approximated using the Fort Denison Sea Level Rise Vulnerability Study, DECC, 2008
Each event is monitored for 3 days with peaks refering to peaks which occur at anytime during this period
Anomallies are mainly caused by meteorlogical effects above the tidal recorder

Severe Rainfall Event 10/5/25



Severe Rainfall Event 18/4/27



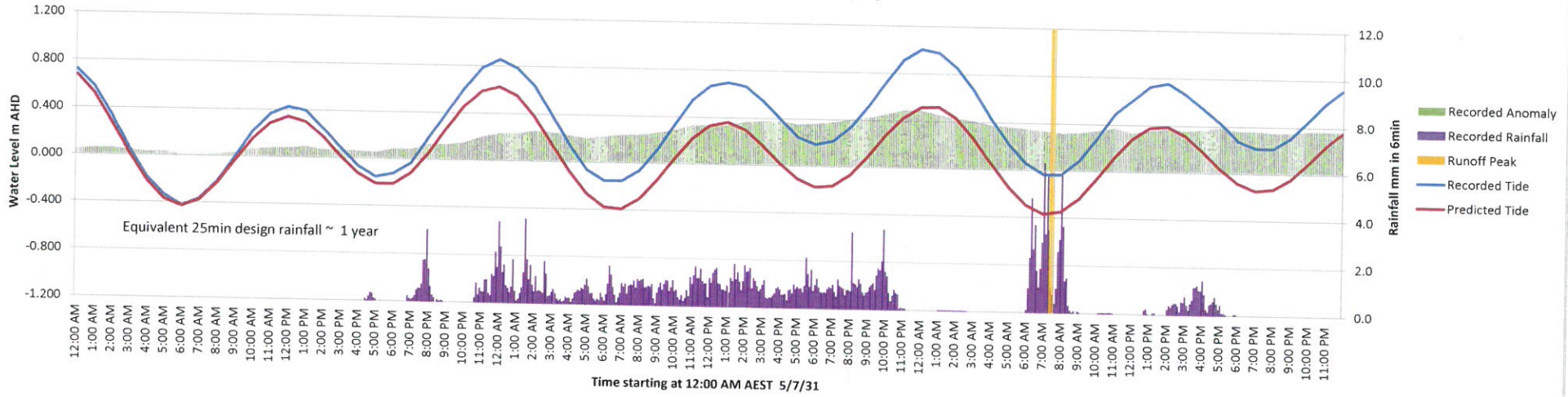
Notes

Rainfall data recorded at Observatory Hill Sydı Anomallies are mainly caused by meteorlogica Runoff Peak refers to the estimated time at which maximum flow reached Cockle Bay

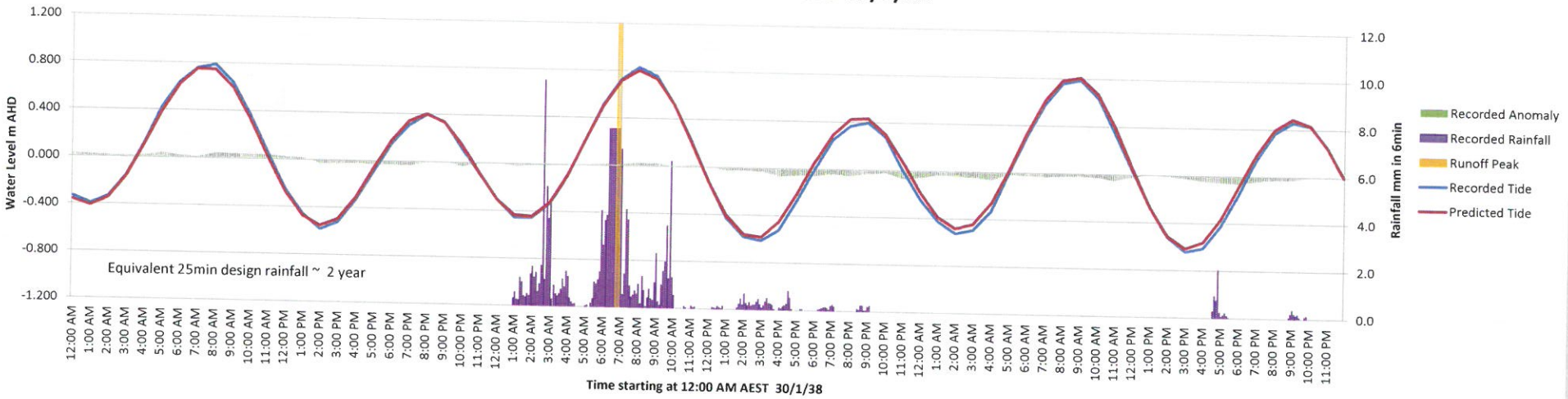
Tide data recorded at Fort Denison

Tide data and predicted tide data supplied by the Sydney Ports Corporation

Severe Rainfall Event 6/7/31



Severe Rainfall Event 31/1/38



Notes

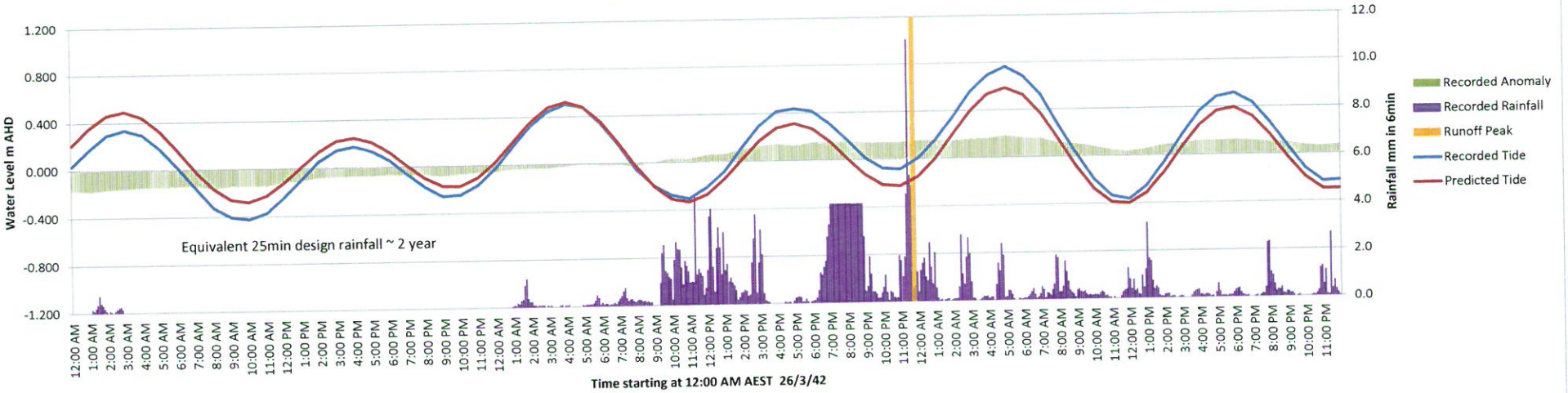
Rainfall data recorded at Observatory Hill Sydney, Station number 66062

Tide data recorded at Fort Denison

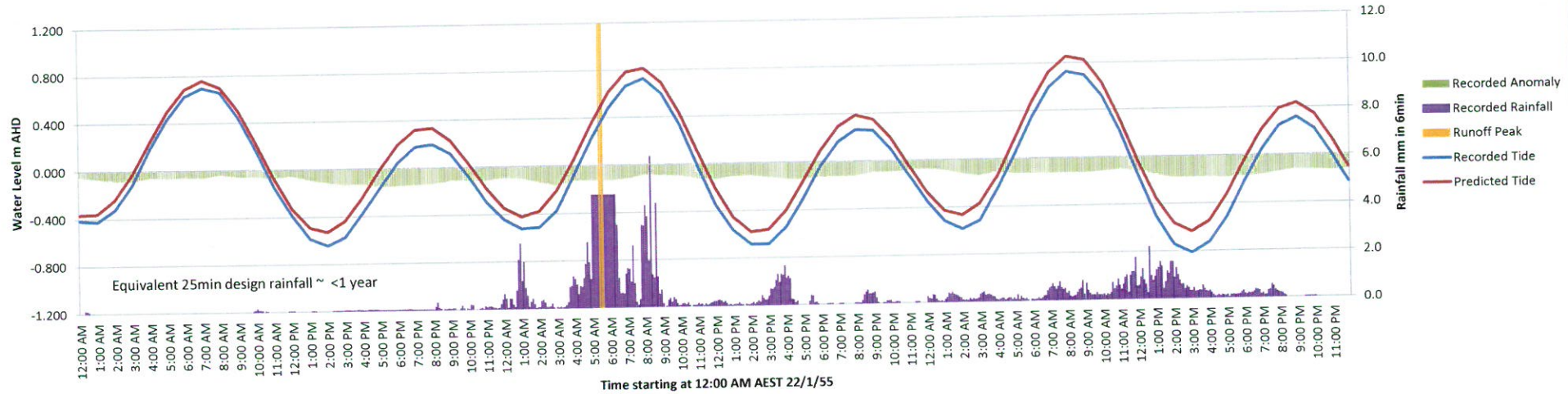
Tide data and predicted tide data supplied by the Sydney Ports Corporation

Runoff Peak refers to the estimated time at which maximum flow reached Cockle Bay

Severe Rainfall Event 27/3/42



Severe Rainfall Event 23/1/55



Notes

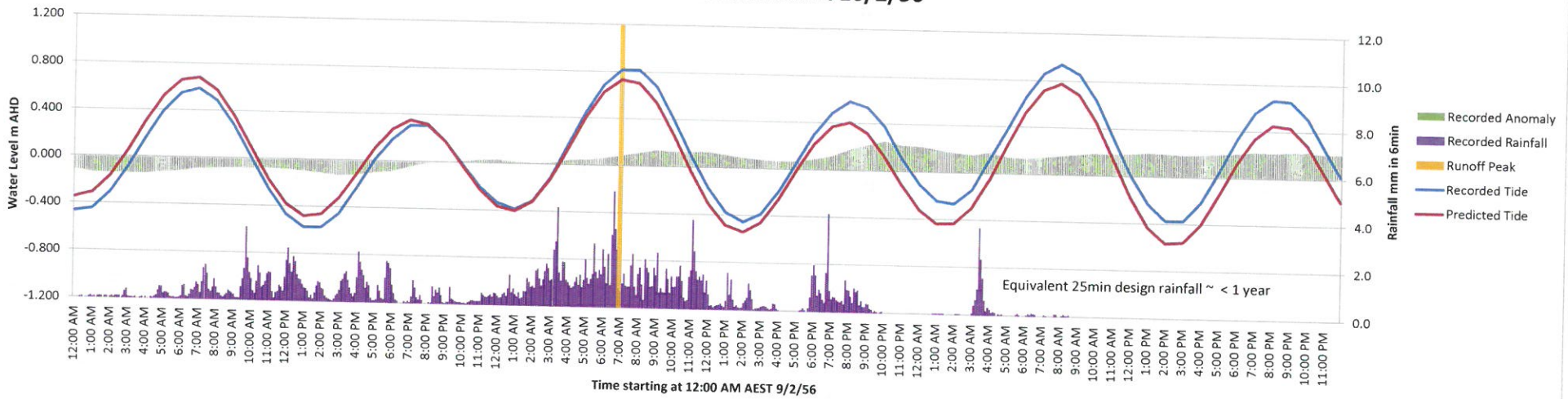
Rainfall data recorded at Observatory Hill Sydney, Station number 66062

Tide data recorded at Fort Denison

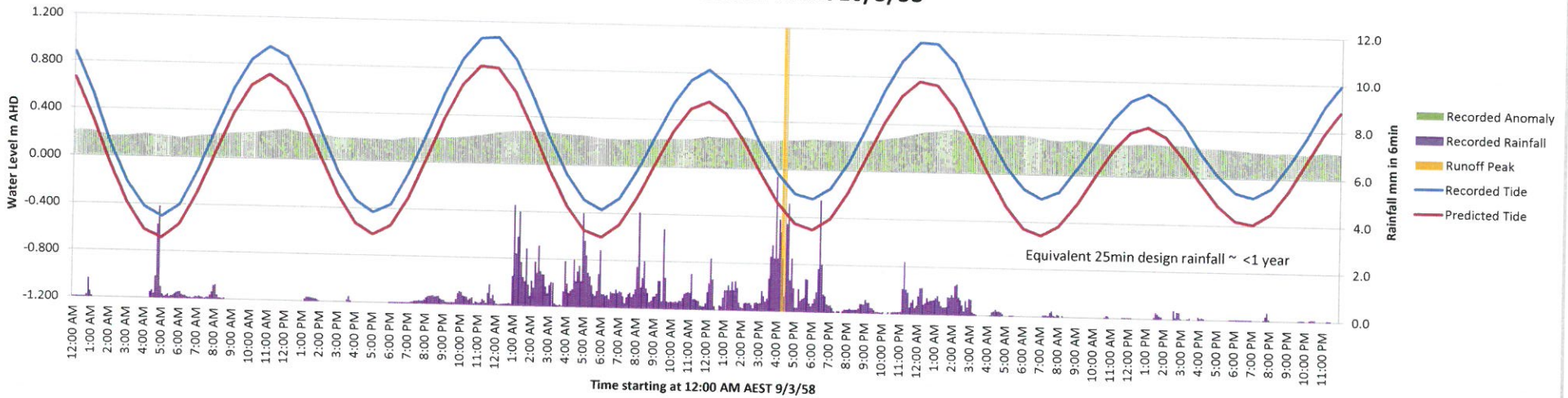
Tide data and predicted tide data supplied by the Sydney Ports Corporation

Runoff Peak refers to the estimated time at which maximum flow reached Cockle Bay

Severe Rainfall Event 10/2/56



Severe Rainfall Event 10/3/58



Notes

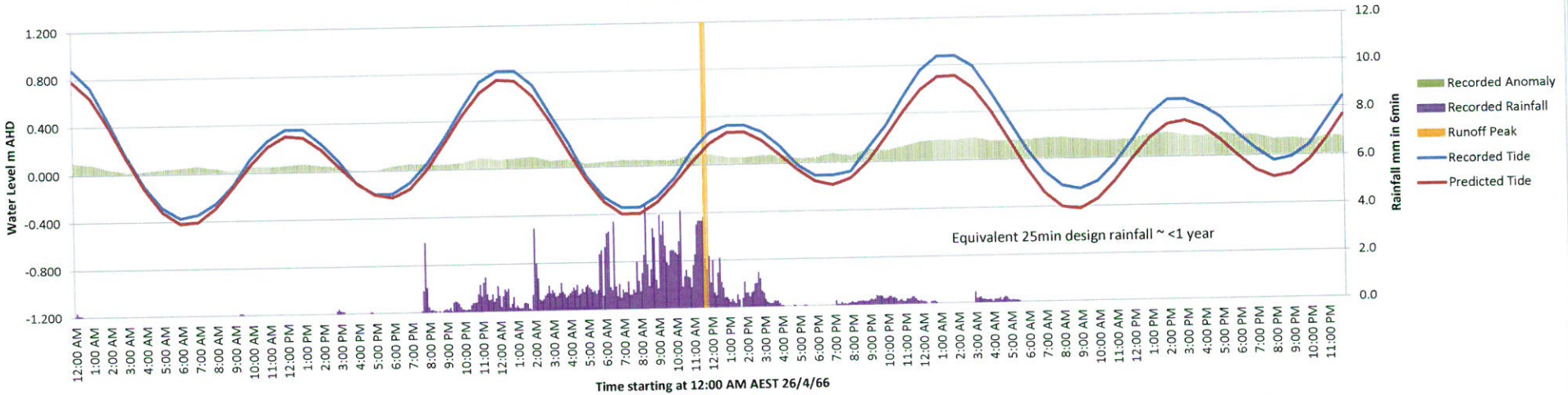
Rainfall data recorded at Observatory Hill Sydney, Station number 66062

Tide data recorded at Fort Denison

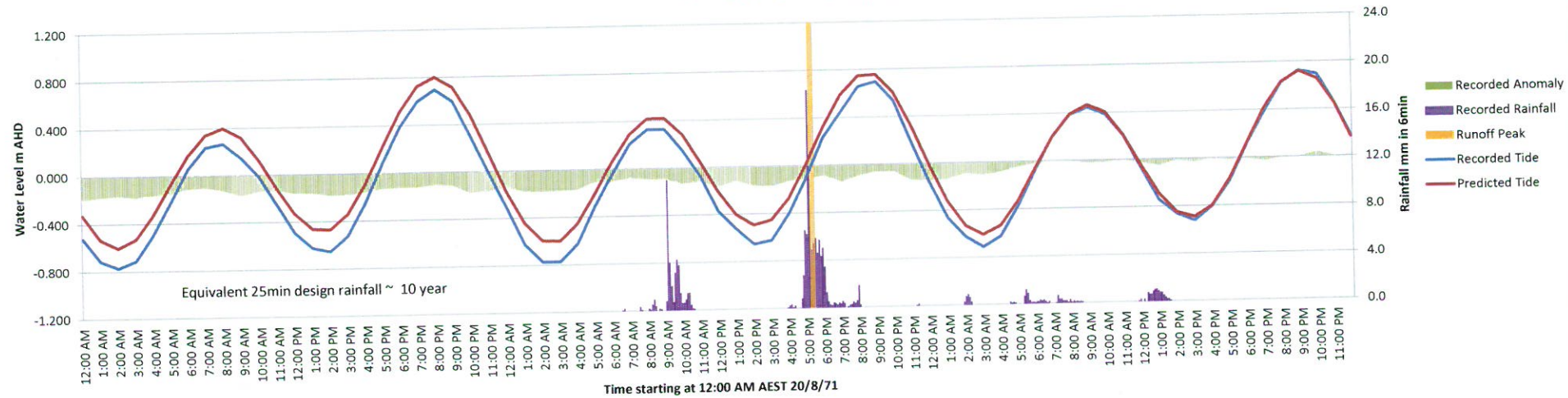
Tide data and predicted tide data supplied by the Sydney Ports Corporation

Runoff Peak refers to the estimated time at which maximum flow reached Cockle Bay

Severe Rainfall Event 27/4/66



Severe Rainfall Event 21/8/71



Notes

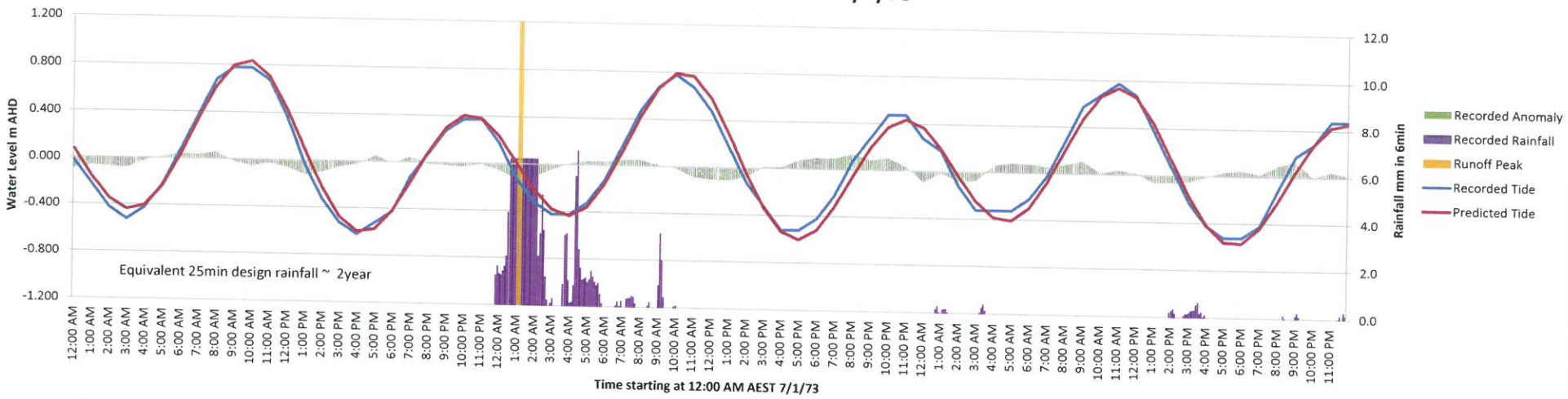
Rainfall data recorded at Observatory Hill Sydney, Station number 66062

Tide data recorded at Fort Denison

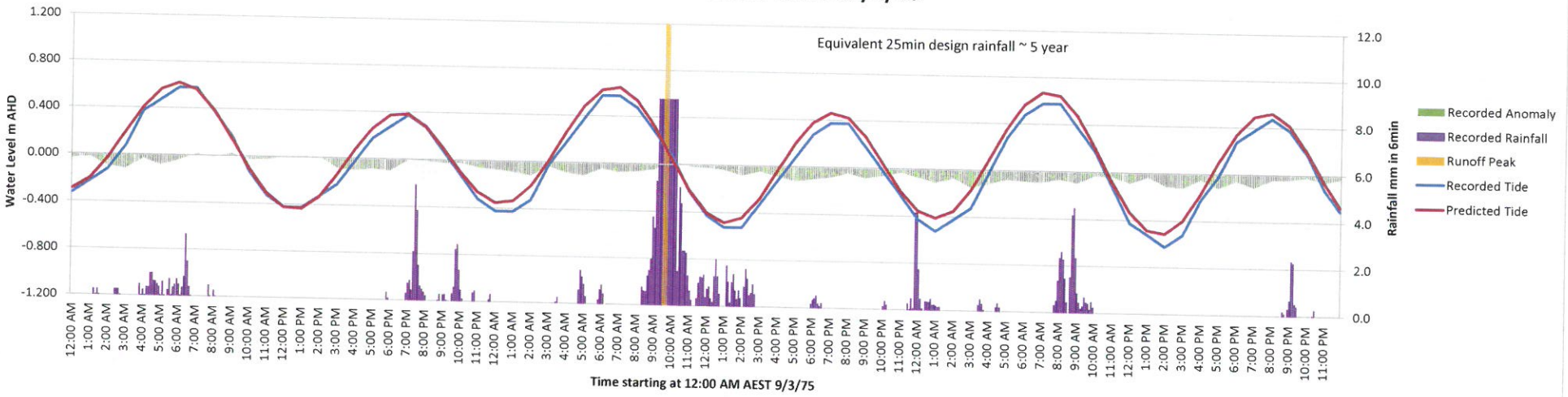
Tide data and predicted tide data supplied by the Sydney Ports Corporation

Runoff Peak refers to the estimated time at which maximum flow reached Cockle Bay

Severe Rainfall Event 8/1/73



Severe Rainfall Event 10/3/75



Notes

Rainfall data recorded at Observatory Hill Sydney, Station number 66062

Tide data recorded at Fort Denison

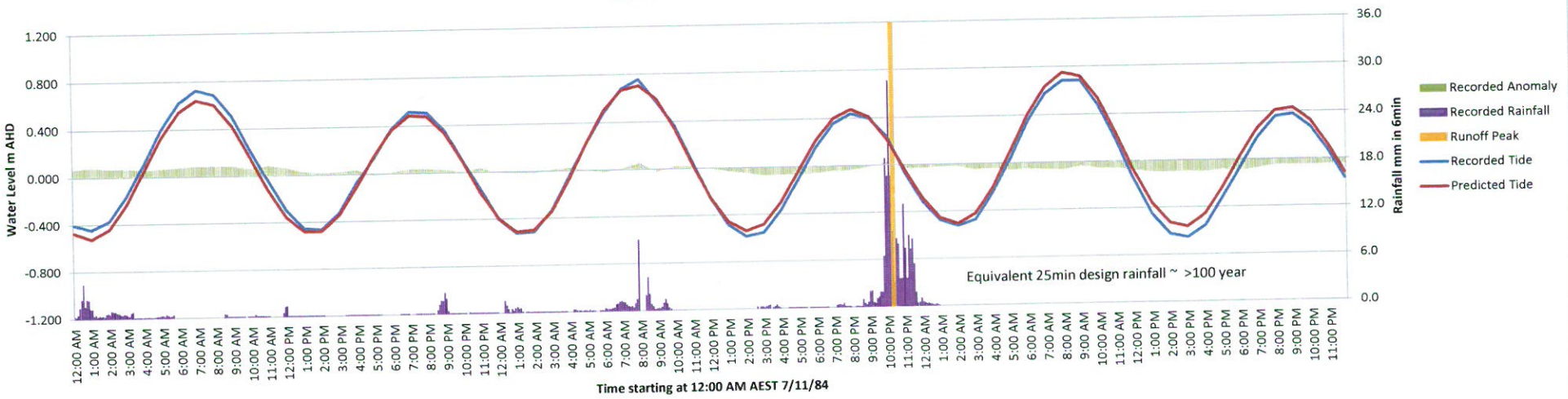
Tide data and predicted tide data supplied by the Sydney Ports Corporation

Tide recordings from this time (1972-1976) were rounded to the nearest 100mm.

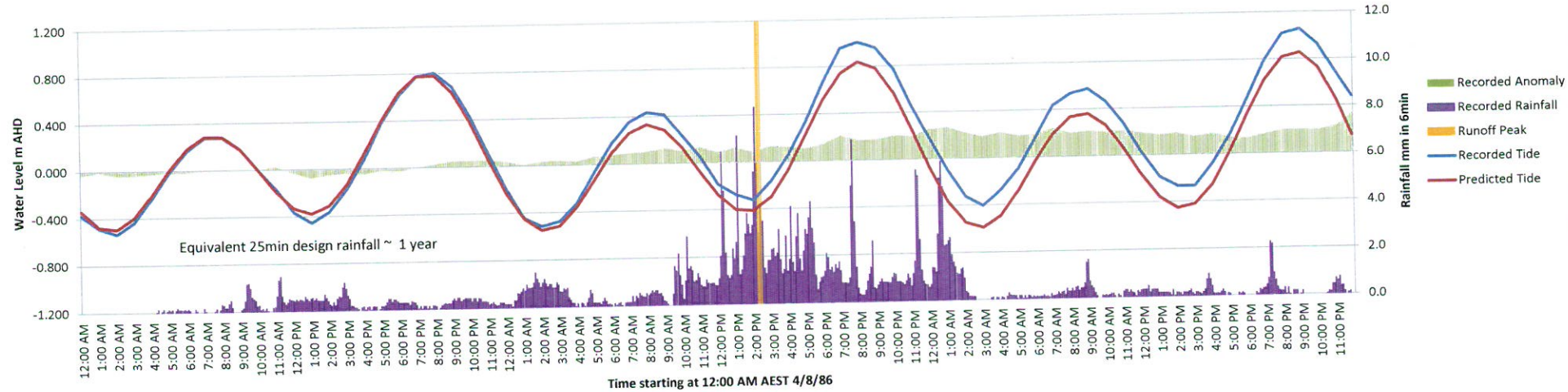
Therefore anomalies of the order of +/- 100mm are likely due to rounding error.

Runoff Peak refers to the estimated time at which maximum flow reached Cockle Bay

Severe Rainfall Event 8/11/84



Severe Rainfall Event 5/8/86



Notes

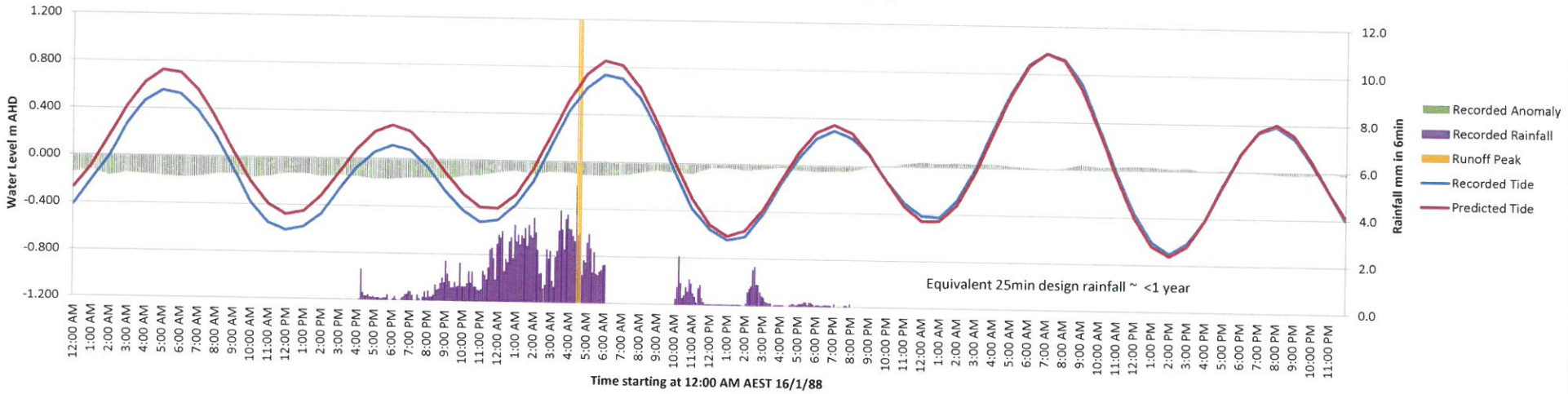
Rainfall data recorded at Observatory Hill Sydney, Station number 66062

Tide data recorded at Fort Denison

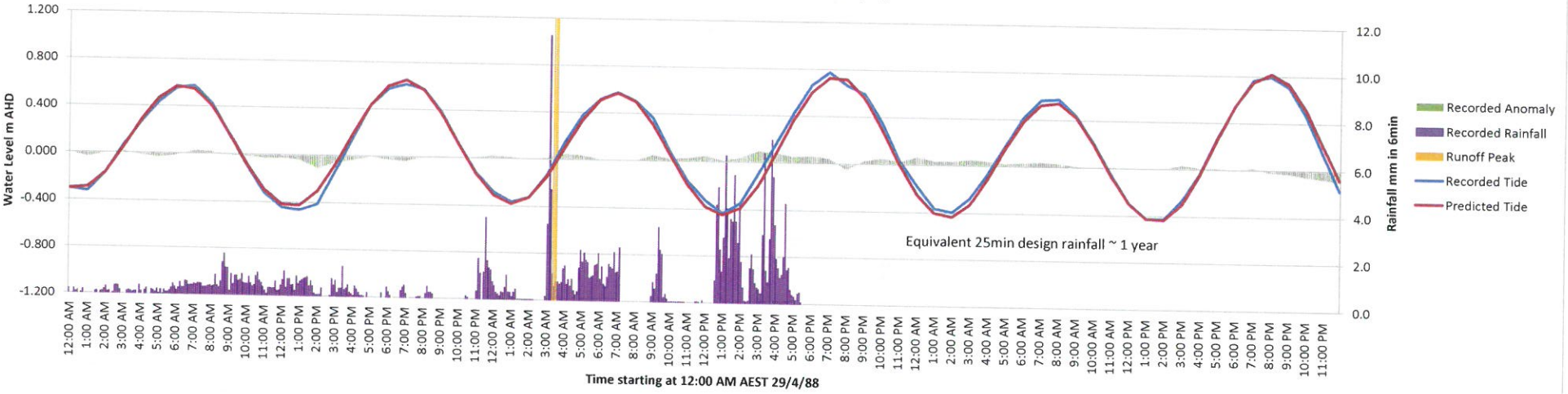
Tide data and predicted tide data supplied by the Sydney Ports Corporation

Runoff Peak refers to the estimated time at which maximum flow reached Cockle Bay

Severe Rainfall Event 17/1/88



Severe Rainfall Event 30/4/88



Notes

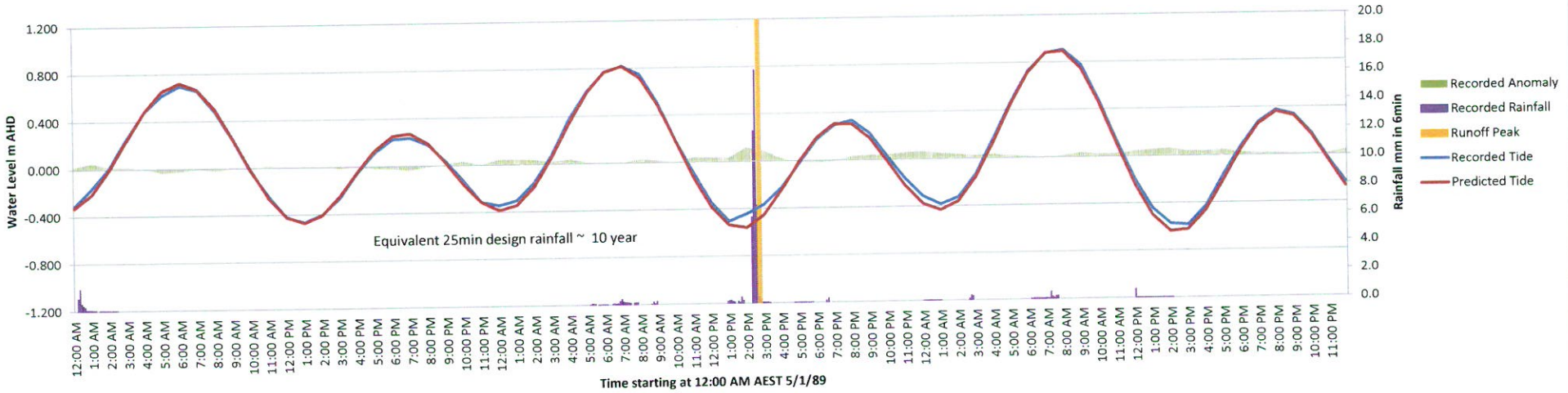
Rainfall data recorded at Observatory Hill Sydney, Station number 66062

Tide data recorded at Fort Denison

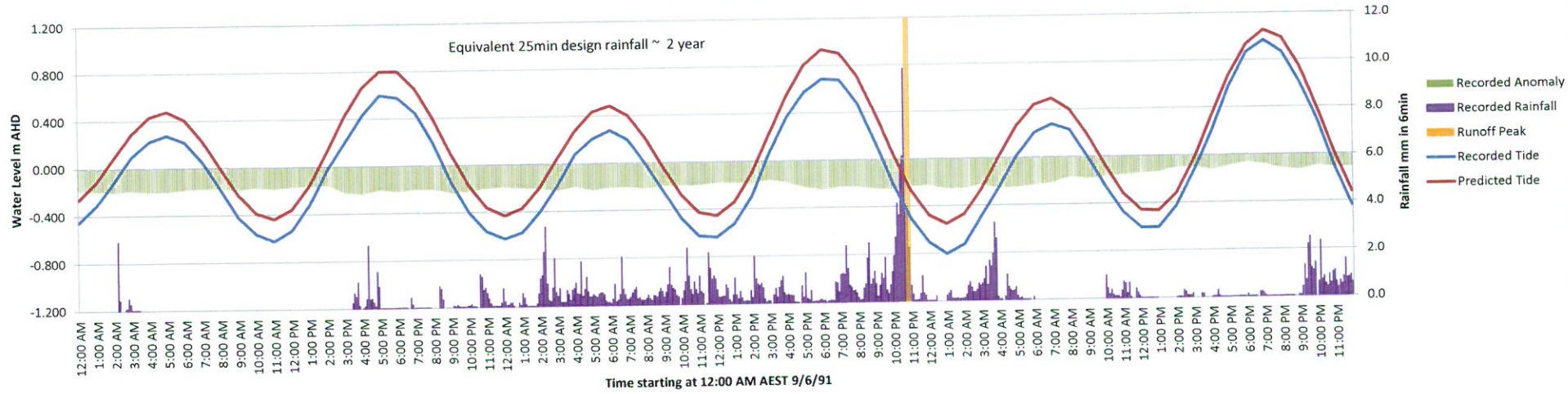
Tide data and predicted tide data supplied by the Sydney Ports Corporation

Runoff Peak refers to the estimated time at which maximum flow reached Cockle Bay

Severe Rainfall Event 6/1/89



Severe Rainfall Event 10/6/91



Notes

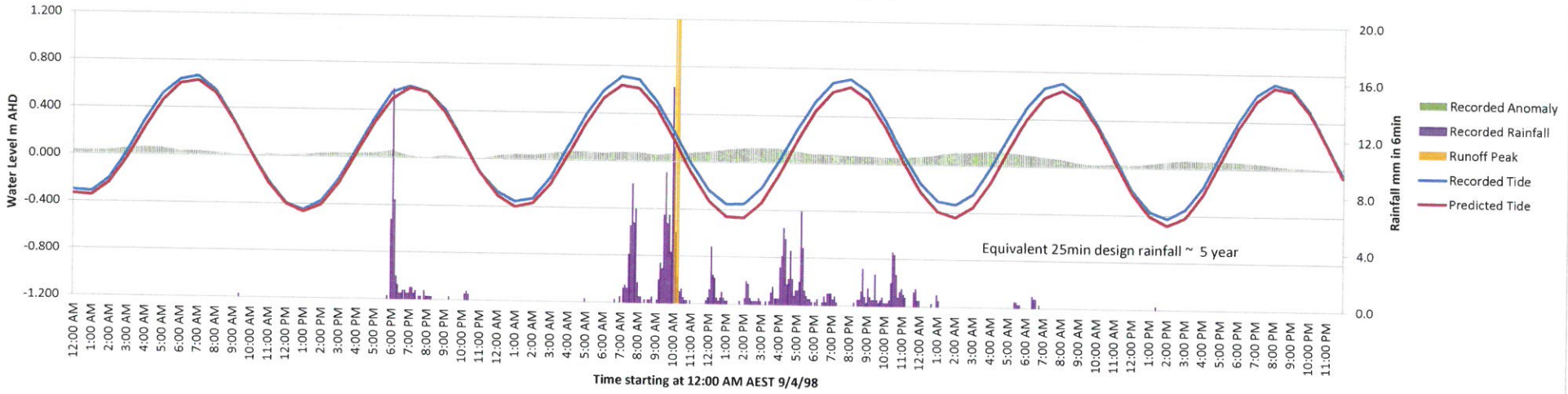
Rainfall data recorded at Observatory Hill Sydney, Station number 66062

Tide data recorded at Fort Denison

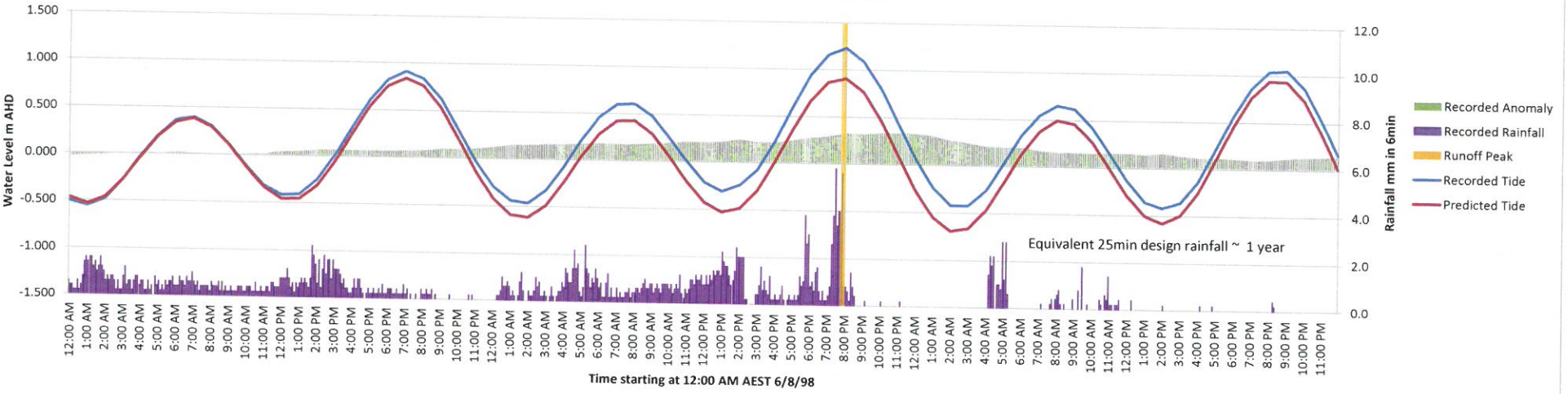
Tide data and predicted tide data supplied by the Sydney Ports Corporation

Runoff Peak refers to the estimated time at which maximum flow reached Cockle Bay

Severe Rainfall Event 10/4/98



Severe Rainfall Event 7/8/98



Notes

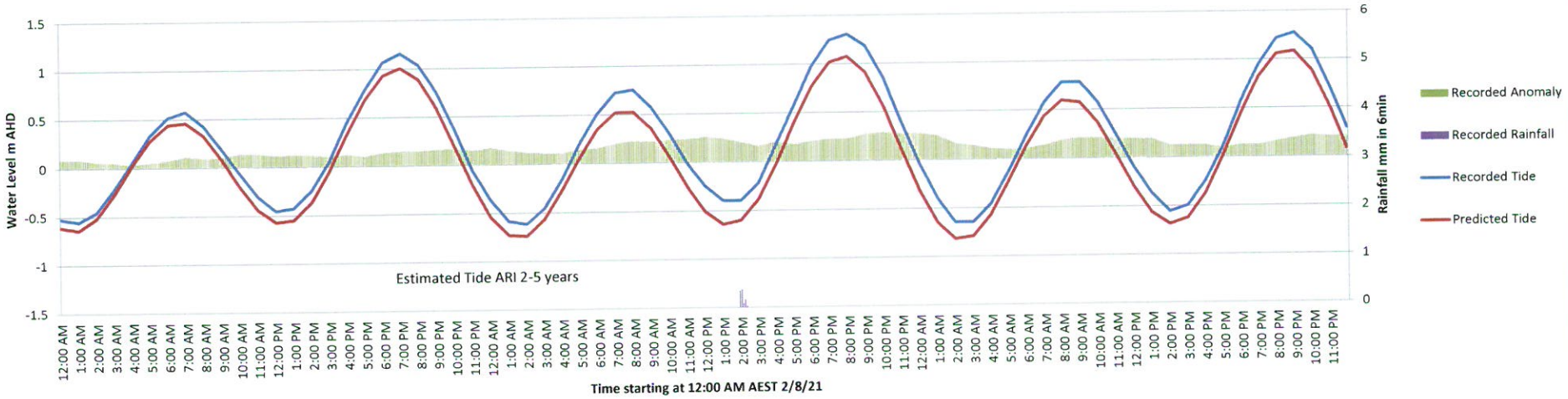
Rainfall data recorded at Observatory Hill Sydney, Station number 66062

Tide data recorded at Fort Denison

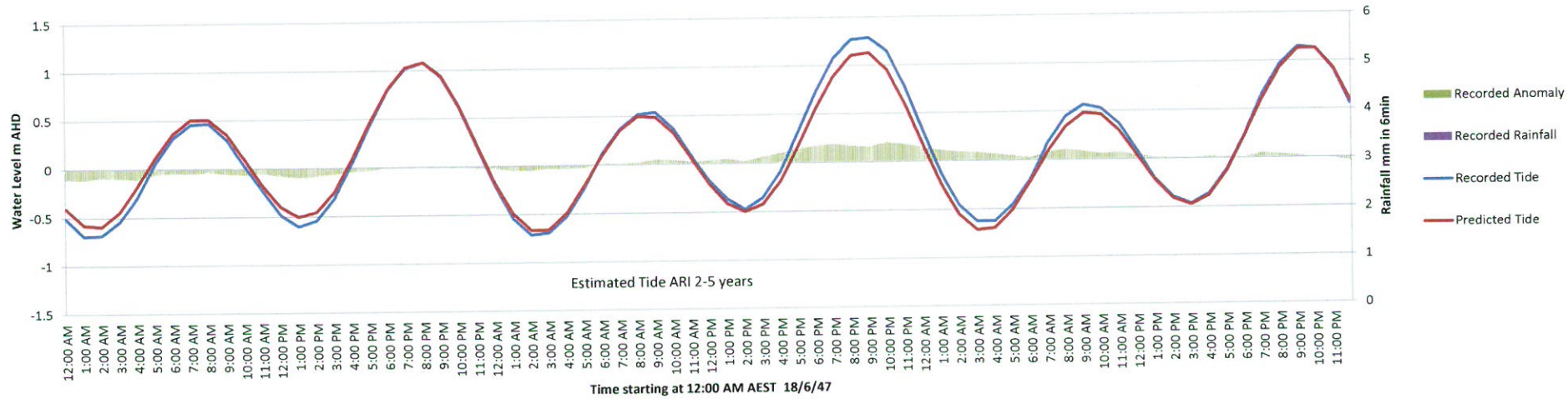
Tide data and predicted tide data supplied by the Sydney Ports Corporation

Runoff Peak refers to the estimated time at which maximum flow reached Cockle Bay

Severe Tide Event 3/8/21



Severe Tide Event 19/6/47



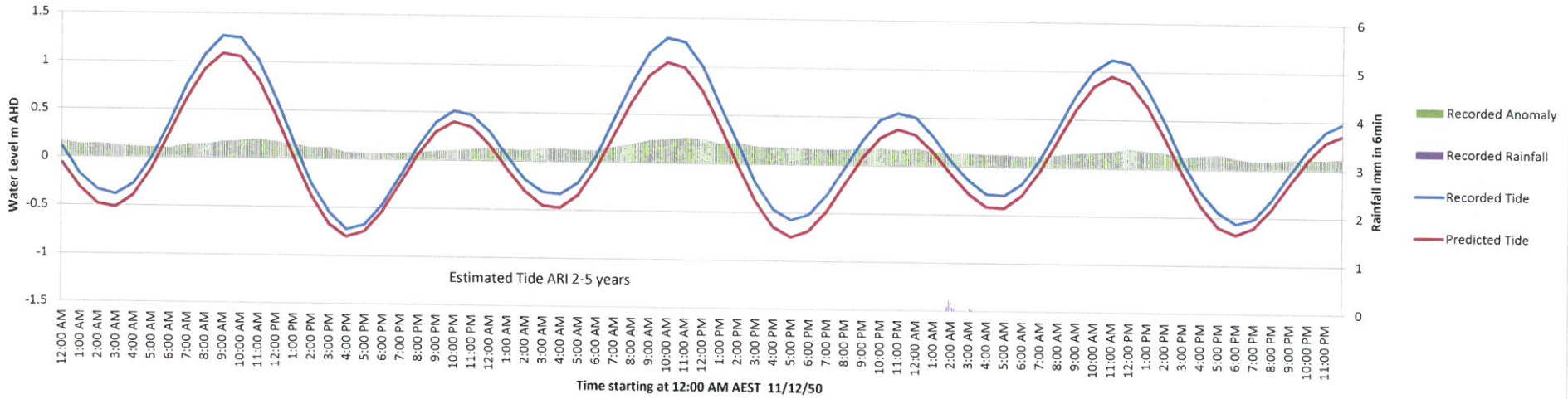
Notes

Rainfall data recorded at Observatory Hill Sydı Anomallies are mainly caused by meteorlogical effects abı Tide ARI estimations made using Fort Denison Seal Level Rise Vulnerablility Study, DECC 2008

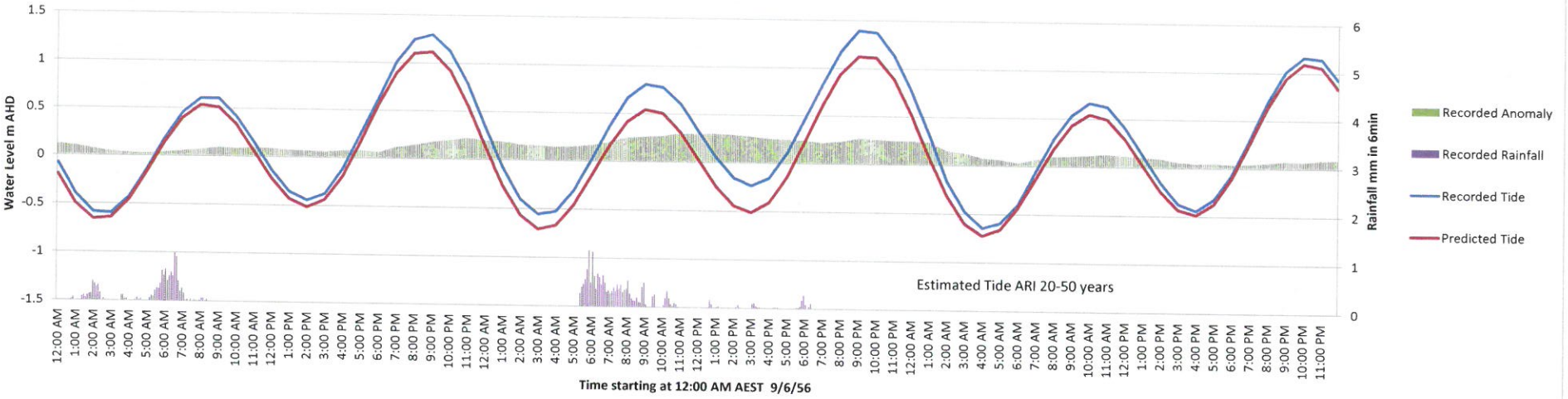
Tide data recorded at Fort Denison

Tide data and predicted tide data supplied by the Sydney Ports Corporation

Severe Tide Event 12/12/50



Severe Tide Event 10/6/56



Notes

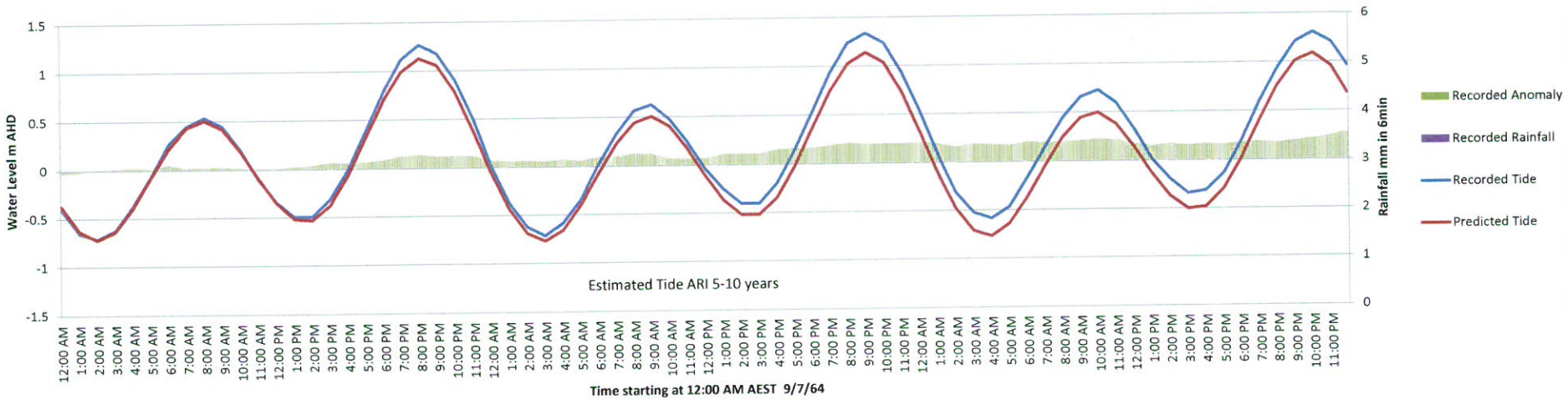
Rainfall data recorded at Observatory Hill Sydney, Station number 66062

Tide data recorded at Fort Denison

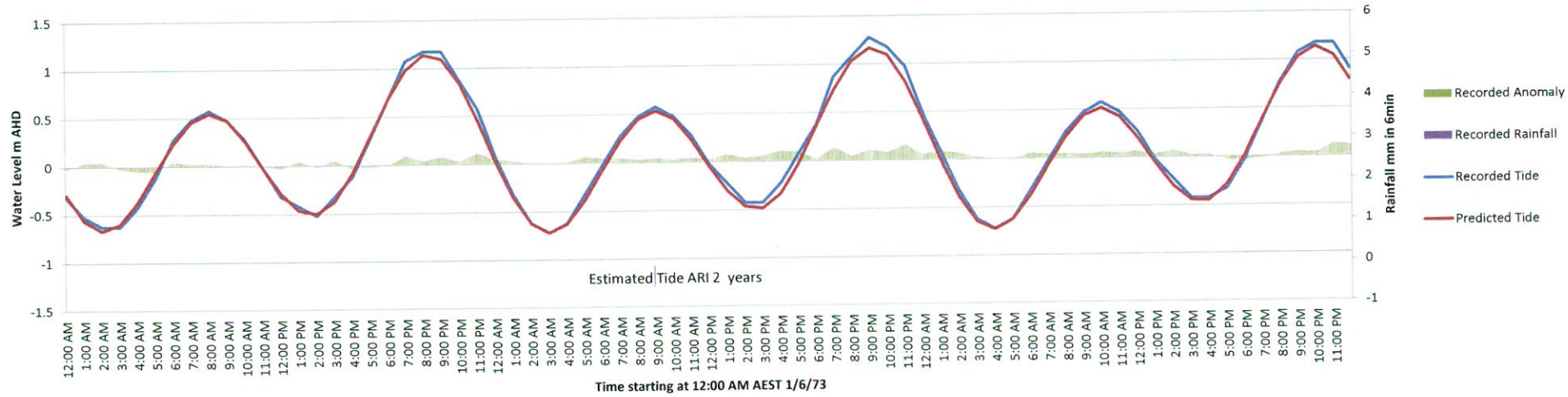
Tide data and predicted tide data supplied by the Sydney Ports Corporation

Tide ARI estimations made using Fort Denison Seal Level Rise Vulnerablility Study, DECC 2008

Severe Tide Event 10/7/64



Severe Tide Event 2/6/73



Notes

Rainfall data recorded at Observatory Hill Sydney, Station number 66062

Tide data recorded at Fort Denison

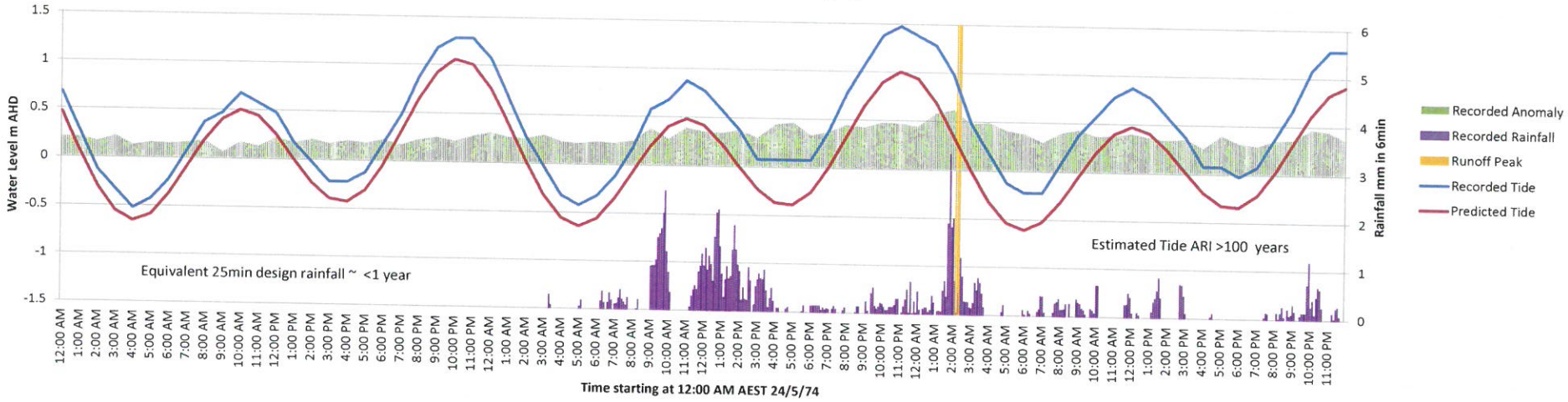
Tide data and predicted tide data supplied by the Sydney Ports Corporation

Tide recordings from this time (1972-1976) were rounded to the nearest 100mm.

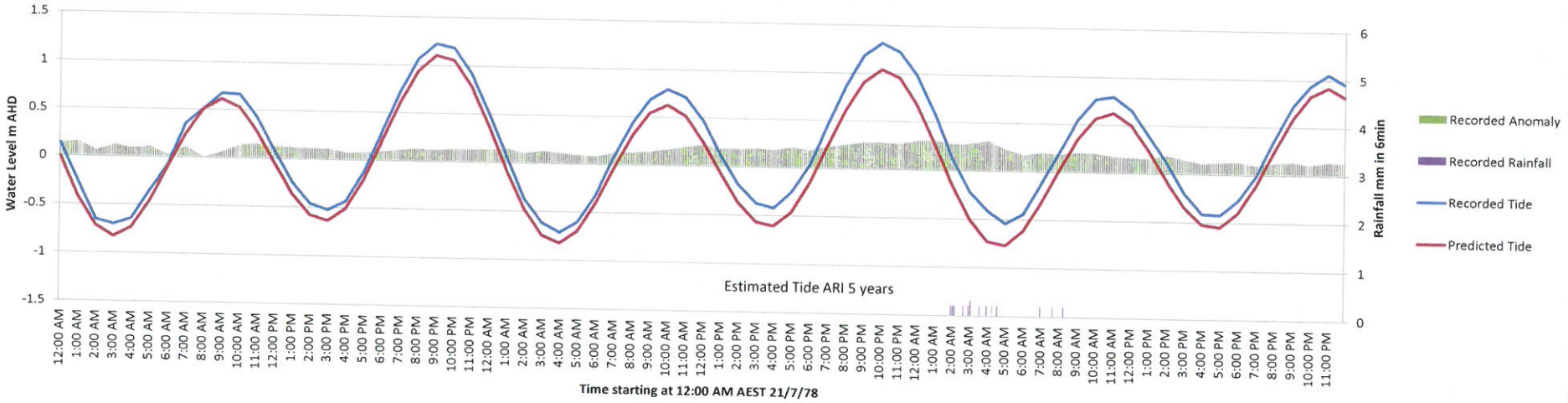
Therefore anomalies of the order of +/- 100mm are likely due to rounding error.

Tide ARI estimations made using Fort Denison Seal Level Rise Vulnerablility Study, DECC 2008

Severe Tide Event 25/5/74



Severe Tide Event 22/7/78



Notes

Rainfall data recorded at Observatory Hill Sydney, Station number 66062

Tide data recorded at Fort Denison

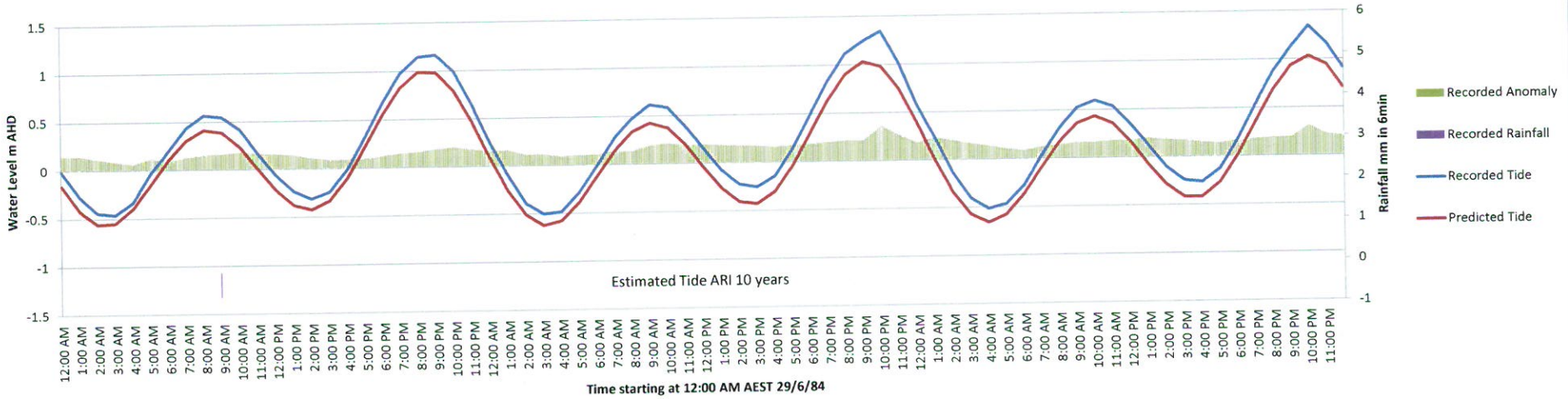
Tide data and predicted tide data supplied by the Sydney Ports Corporation

Tide recordings from this time (1972-1976) were rounded to the nearest 100mm.

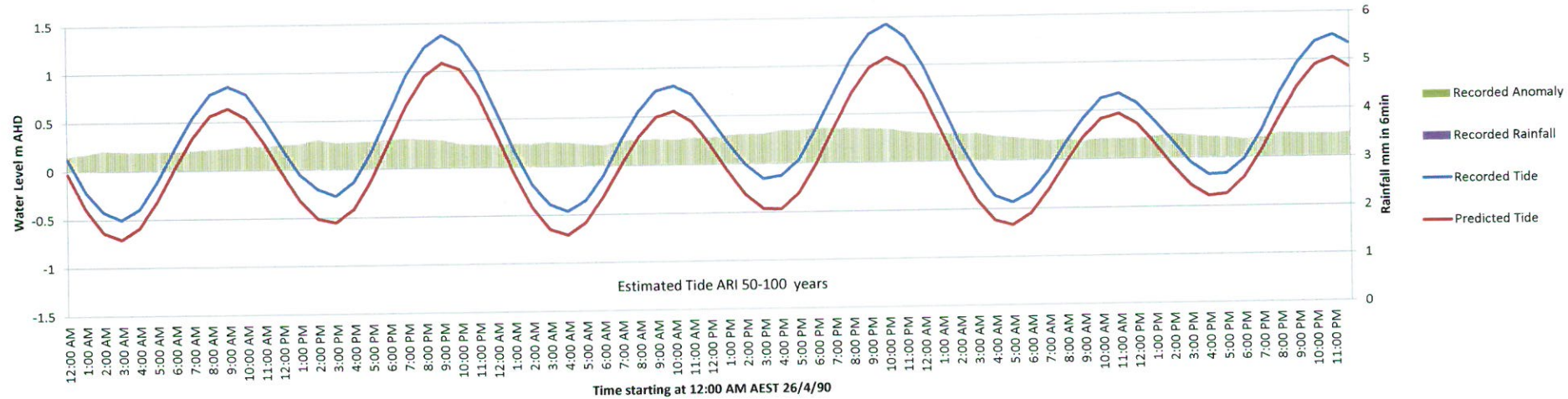
Therefore anomalies of the order of +/- 100mm are likely due to rounding error.

Runoff Peak refers to the estimated time at which maximum flow reached Cockle Bay

Severe Tide Event 30/6/84



Severe Tide Event 27/4/90



Notes

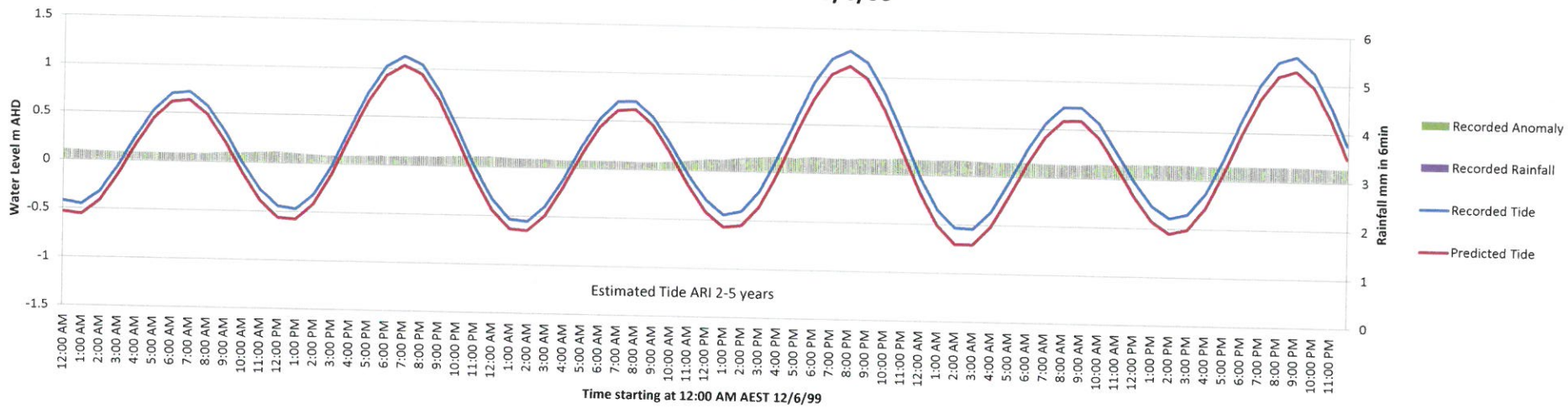
Rainfall data recorded at Observatory Hill Sydney, Station number 66062

Tide data recorded at Fort Denison

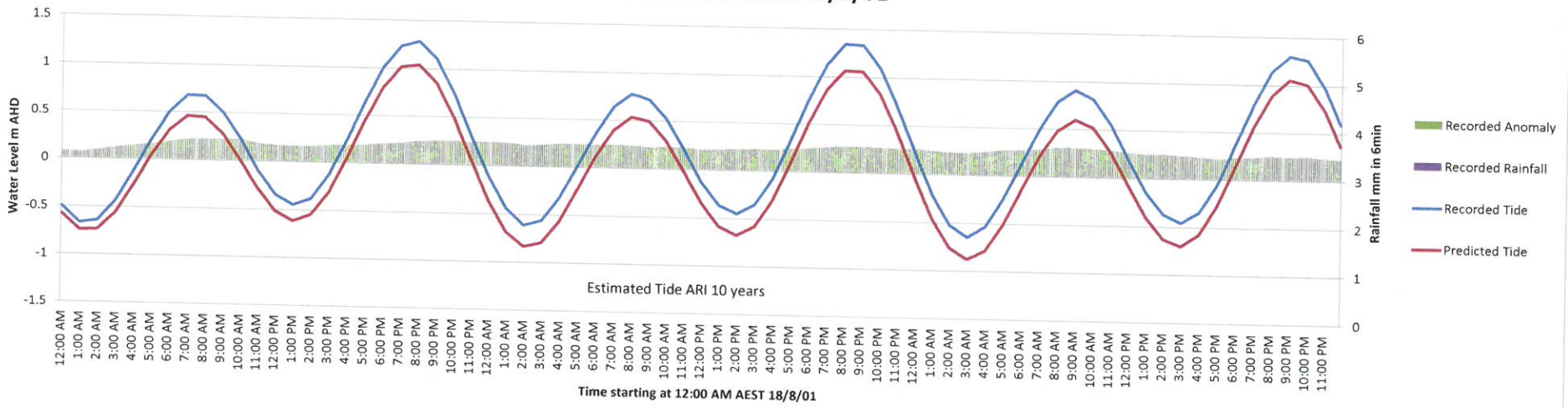
Tide data and predicted tide data supplied by the Sydney Ports Corporation

Tide ARI estimations made using Fort Denison Seal Level Rise Vulnerablility Study, DECC 2008

Severe Tide Event 13/6/99



Severe Tide Event 19/8/01



Notes

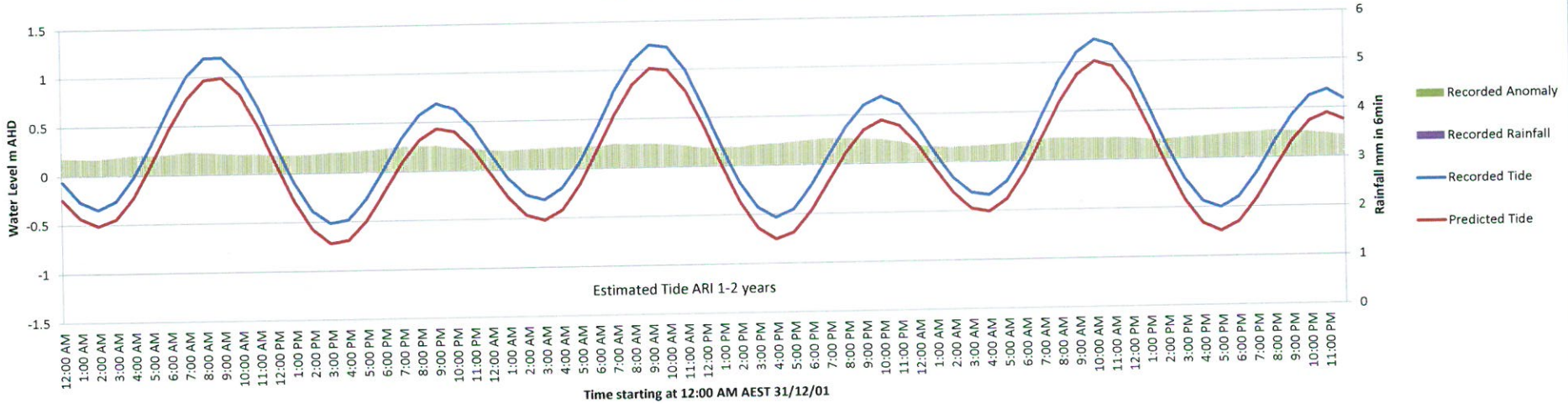
Rainfall data recorded at Observatory Hill Sydney, Station number 66062

Tide data recorded at Fort Denison

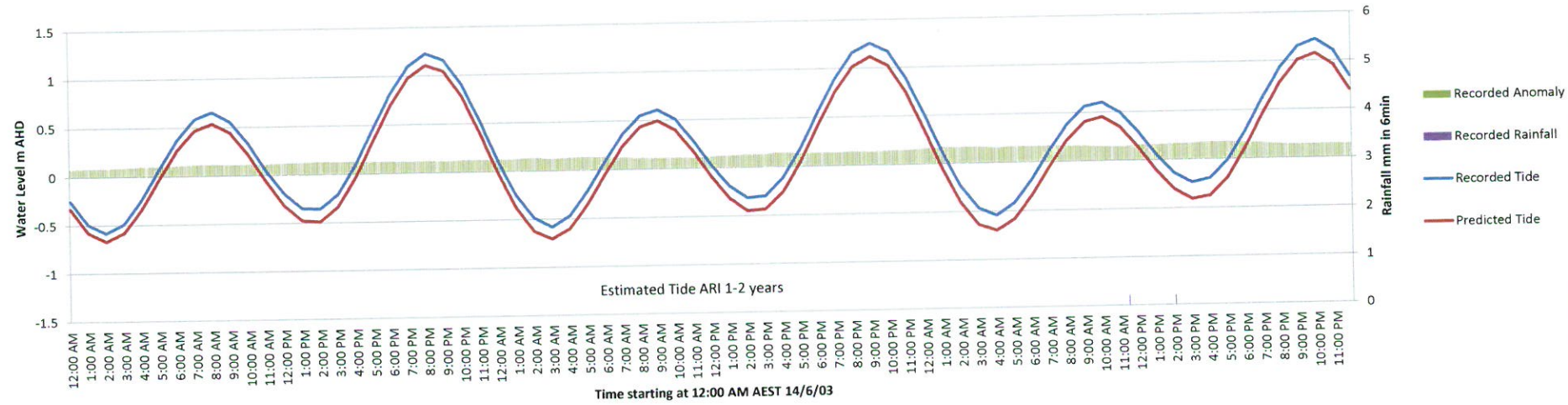
Tide data and predicted tide data supplied by the Sydney Ports Corporation

Tide ARI estimations made using Fort Denison Seal Level Rise Vulnerablility Study, DECC 2008

Severe Tide Event 1/1/02



Severe Tide Event 15/6/03



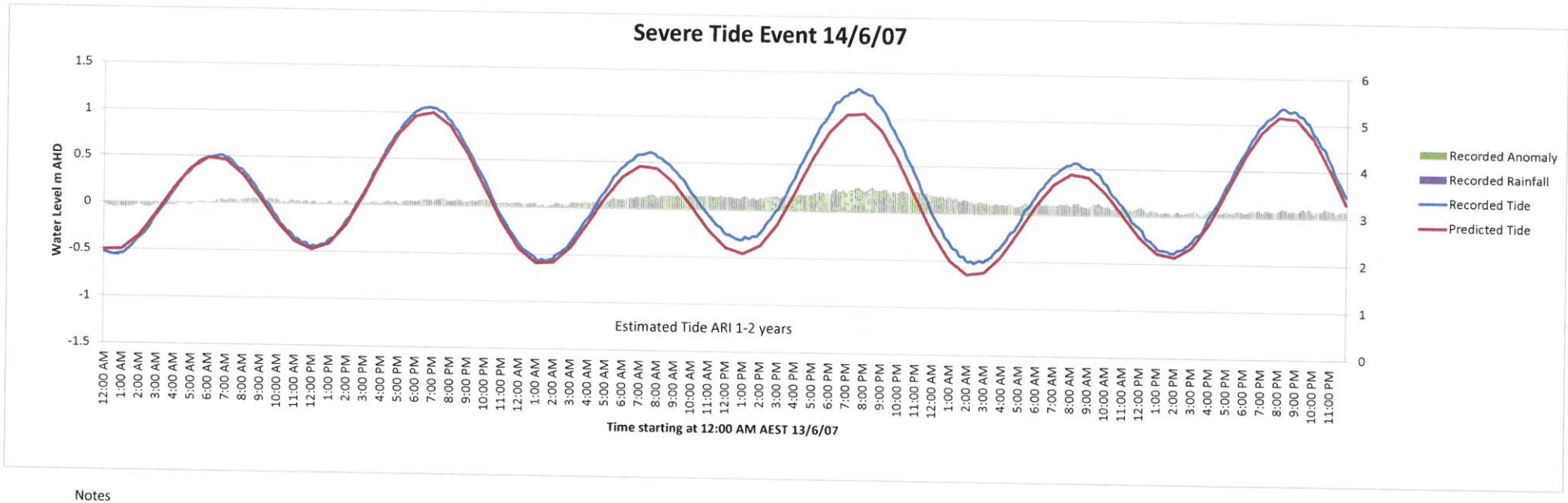
Notes

Rainfall data recorded at Observatory Hill Sydney, Station number 66062

Tide data recorded at Fort Denison

Tide data and predicted tide data supplied by the Sydney Ports Corporation

Tide ARI estimations made using Fort Denison Seal Level Rise Vulnerablility Study, DECC 2008



Notes

Rainfall data recorded at Observatory Hill Sydney, Station number 66062

Tide data recorded at Fort Denison

Tide data and predicted tide data supplied by the Sydney Ports Corporation

Tide ARI estimations made using Fort Denison Seal Level Rise Vulnerablility Study, DECC 2008

APPENDIX G

EXISTING CONDITIONS FLOW REGIMES

1 EXISTING CONDITIONS FLOOD ASSESSMENT

Hyder Consulting has carried out this flood assessment of the SICEEP site for existing development conditions. The assessment is to enable the demonstration of potential flood impacts as a result of the SICEEP re-development, and that the development is in compliance with the Director General (DG) requirement that the proposed development will not adversely impact on flooding of neighbouring properties.

1.1 ASSESSMENT METHODOLOGY

The existing conditions DRAINS and TUFLOW model parameters and assumptions remained unchanged to those of the proposed modelling – the adjustments where simply limited to within the SICCEP site area where local sub-catchment areas, levels, flow paths and associated local inlets and stormwater conduits to represent existing conditions, replaced those of the design conditions. The existing conditions catchment sub-areas and local stormwater systems are shown in Appendix G2 along with the DRAINS model input information.

As per the proposed development modelling, the existing conditions DRAINS output hydrographs from each sub-catchment area (for the various storm events) have been put into the TUFLOW model to quantify existing conditions site flow regimes. Figure G1 and the associated photos (see Appendix G1) indicate various gates located along overland flow paths and a surface inlet pit under Pier Street have the potential to block. However, for the purpose of comparing potential flood impacts on upstream neighbouring property in Hay Street and Harbour Street, 0% blockage has been adopted in the TUFLOW modelling.

1.1.1 HISTORIC INFORMATION

To provide confidence in the model representation of existing condition flow regimes an investigation of historic information has been carried out involving the following.

City of Sydney Report (2012)

Flood hot spots have been identified in a report prepared for City of Sydney Council 'Decentralised Water Master Plan WSUD & Stormwater Infrastructure Report' by GHD (7 June 2012). Significantly, it indicates no major reported flooding at the Entertainment Centre or downstream within the Darling Harbour site.

Design Information (1980s)

While no stormwater design report has been found available for the Darling Harbour development carried out in the mid-1980s, the following design information has been.

- A record of major drainage amplification works carried out by Sydney Water in preparation for the mid-1980s Darling Harbour development. A summary figure of the Sydney Water drainage assets is included in Appendix D (of the main report) and identifies the major culvert amplifications.
- A design drawing of the Entertainment Centre Carpark Floodway Design dated June 1988 (see Appendix G3), which indicates an approximate 20 year flood flow depth of 0.3m through the ground floor driveway and discharging into the Sydney Water culvert amplification via a large (~70m^2) grated stormwater pit located just to the north of the carpark under Pier Street (see Photos 7 and 8) within the SHFA works area.
- The existing Entertainment Centre ground floor level has been surveyed and found to be at RL3.36mAHD.

Recorded Rainfall and Flood Observations (November 1984)

Recorded rainfall data was obtained from Observatory Hill (Station 66062) during the course of this study. Intensities for the twenty most significant events between 1914 and 2012 have been summarised in Appendix F. Of those events, the most intense 25 minute and 60 minute rainfall on 8 November 1984 approximated as greater than 100 year design event, two other more recent events on 6 January 1989 and 10 April 1998 approximated 5 to 10 year design rainfalls.

Hyder interviewed John Dedousis, the Sydney Entertainment Centre Operations Supervisor, who had been working there since its opening in May 1983. Mr Dedousis recalled the largest flood event having occurred there during his time was on the night of 8 November 1984 at about 10pm. At the time he was at the 'local pub' just north-western of the Entertainment Centre building when he observed a massive storm. With respect to flooding, he recalled the water entering the north western loading dock bay (pavement level surveyed as RL2.68mAHD) and ponding up against the wall of the dock (dock height of 0.7m) to just below floor level. It is therefore estimated that the flood water level peaked at about 3.2 to 3.3mAHD.

Mr Dedousis also commented that the nearby stormwater pits had their lids 'pop' off from the water upwelling, and that the flood waters dissipated very quickly as the rain stopped. Furthermore he commented that even though he had experienced some other flood events during his time at the Entertainment Centre, there was nowhere near as much flooding.

The recorded rainfall for the 10 April 1998 event was modelled in DRAINS with the peak flow, in the Hay Street SWCP Main Channel, found to approximate that of a 5 ARI design event.

The event on 8 November 1984 was modelled in both DRAINS and TUFLOW. However:

- the Sydney Water WAE design drawings indicate that the box culvert amplifications were not operational in the 1984 event. As such a 'pre-culvert amplification' TUFLOW model was developed to represent the November 1984 event; and
- the surrounding landform and development at that time is uncertain, but probably less confining of overland flows to the south of Hay Street and the west of the Entertainment Centre (since the car park was not there).

Furthermore, the November 1984 event was also run in TUFLOW under existing conditions (i.e. with the culvert amplifications of the mid 1980s).

1.2 RESULTS AND COMMENT

DRAINS model output information is included in Appendix G2.

TUFLOW model flow regimes figures for existing conditions are included in Appendix C (of the main report) as are the potential flood impacts of the proposed SICEEP development, with discussion of potential flood impacts provided in Section 3 of the main report.

The TUFLOW figures indicate:

- for the November 1984 event;
  - under pre-culvert amplification conditions, the flood level at the south east corner of the building (near the Hay Street and Harbour Street intersection) is 4.0mAHD, and at western loading dock area 3.9mAHD. This is some 0.7m higher than observed, and would have flooded the Entertainment Centre above floor level. Since this was not observed, then the most likely explanation for the inconsistency is that the overland flow paths surrounding the Entertainment Centre in the 1984 event where more substantial than under existing conditions (which has been modelled).
  - under post-culvert amplification conditions, the water levels adjacent to the south-east corner Entertainment Centre are seen to be approximately 3.4mAHD (i.e.