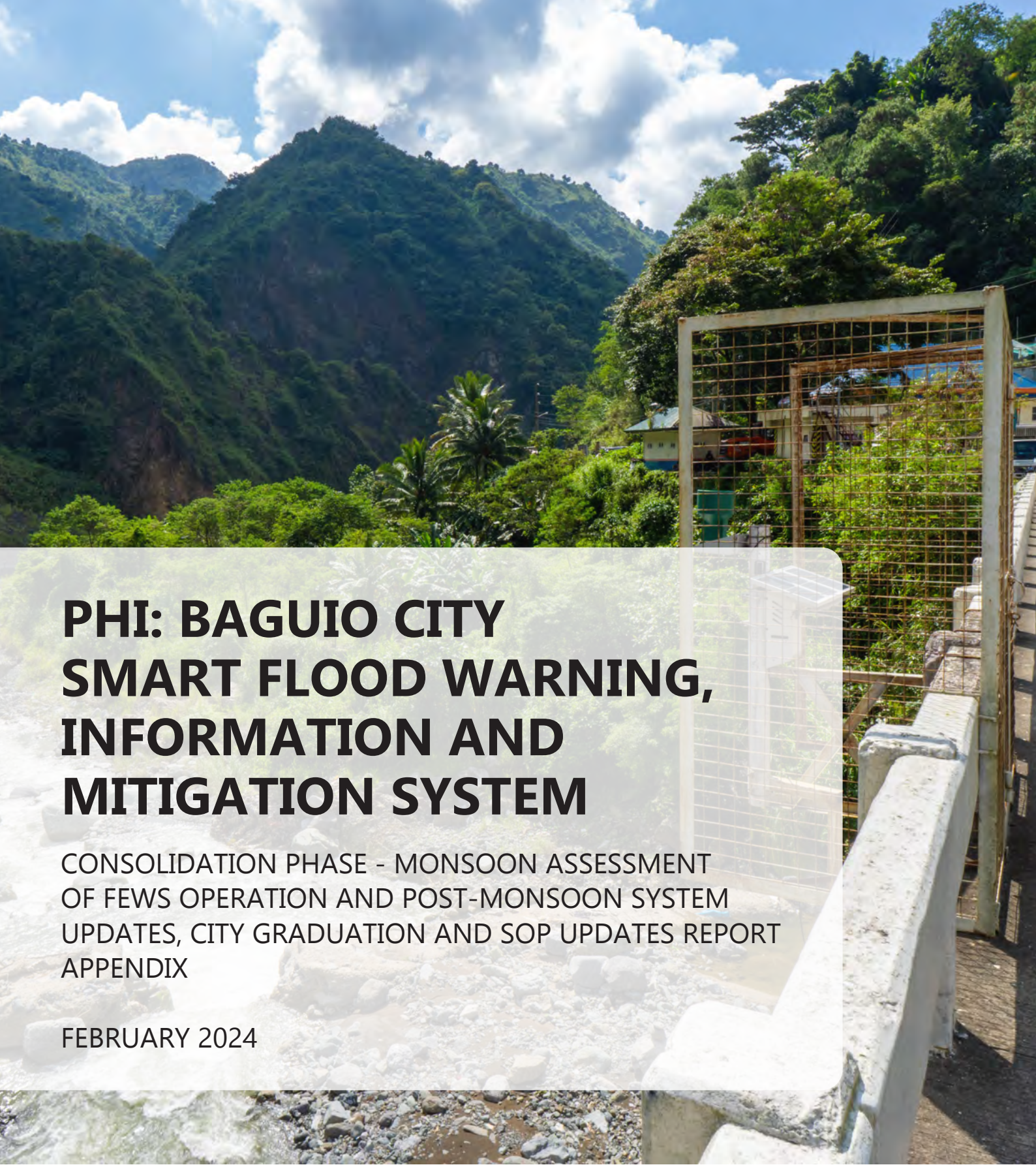

PHI: BAGUIO CITY SMART FLOOD WARNING, INFORMATION AND MITIGATION SYSTEM

CONSOLIDATION PHASE - MONSOON ASSESSMENT OF FEWS OPERATION AND POST-MONSOON SYSTEM UPDATES, CITY GRADUATION AND SOP UPDATES REPORT APPENDIX

FEBRUARY 2024

ASEAN AUSTRALIA SMART CITIES TRUST FUND
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CONTENTS

APPENDIX A
2023 MODEL PERFORMANCE

1 INTRODUCTION

This appendix provides an overview of the evaluation of FEWS (Flood Early Warning System) performance throughout the 2023 monsoon operations. The primary focus of this assessment revolves around two crucial elements:

- Input data
- Model

The subsequent chapters delve into an in-depth analysis of each of these components, scrutinizing their impact on the overall performance of the system. Detailed discussions and findings regarding the assessment of both input data and the model are presented in the following sections, shedding light on their individual contributions to the system's effectiveness during the specified monsoon operations.

2 DATA ASSESSMENT

2.1 REAL-TIME WATER LEVEL DATA ASSESSMENT

The monthly statistics of the observed real-time water level are presented in the Table A2-1. The evaluation of water level data observed during 2023 monsoon led to the following conclusions:

- Sudden jumps or shifts in y-direction i.e., datum were observed at various stations. Few of these stations are presented in Figure A2-1 to Figure A2-3.
- These shifts were majorly introduced during readjustments of the sensor elevations. The sensors position was changed during routine maintenance due to various reasons and the corresponding changes in the backend calculations were not made accurately.
- For all the stations where the issue with the datum shift was caused by manual error, the data has been corrected post-monsoon based upon the new position of the sensors.
- City Camp Lagoon and Eagle Crest stations exhibited sensor issues and has observed erroneous (negative water depths) or no data in the months of June and July.

Table A2-1: Summary of mean monthly and maximum water level observed at the realtime water level monitoring stations

Station	Month	Average	Maximum
City Camp Lagoon	June	1413.28	1422.29
	July	1413.94	1422.29
	August	1411.38	1419.87
	September	1411.32	1411.93
Asin Bridge	June	214.66	216.03
	July	214.79	217.71
	August	214.87	216.64
	September	214.76	215.86
Camp 6 Bridge	June	770.85	771.73
	July	771.16	782.08
	August	770.86	773.31
	September	771.11	772.08
Balili Bridge	June	1303.22	1304.97
	July	1303.32	1307.04
	August	1303.34	1305.52
	September	1303.63	1304.65
Ferguson Bridge	June	1367.73	1369.14
	July	1367.78	1370.13
	August	1367.82	1369.51
	September	1367.84	1369.18
Sadjap Bridge	June	1342.86	1344.56
	July	1342.99	1345.66
	August	1342.98	1344.11
	September	1342.97	1344.76
Brookspoint	June	1405.57	1406.80
	July	1405.67	1407.55
	August	1405.60	1406.64
	September	1405.66	1407.10

Continued on next page

Table A2-1 continued

Station	Month	Average	Maximum
Eagle Crest	June	NA	NA
	July	1311.65	1318.65
	August	1309.57	1317.77
	September	1308.98	1317.77
Camp 7	June	1236.24	1236.90
	July	1236.35	1238.67
	August	1236.40	1240.46
	September	1236.39	1236.89

Source: Ramboll

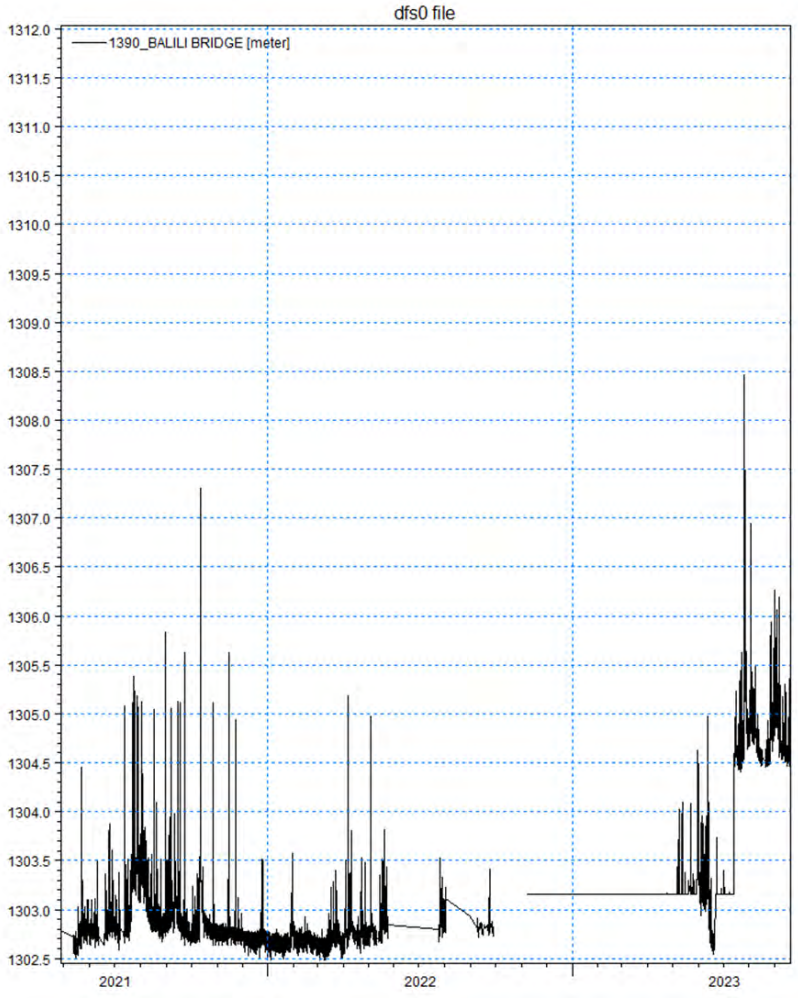


Figure A2-1: Datum shifts observed in water level data at Balili Station
Source: Ramboll

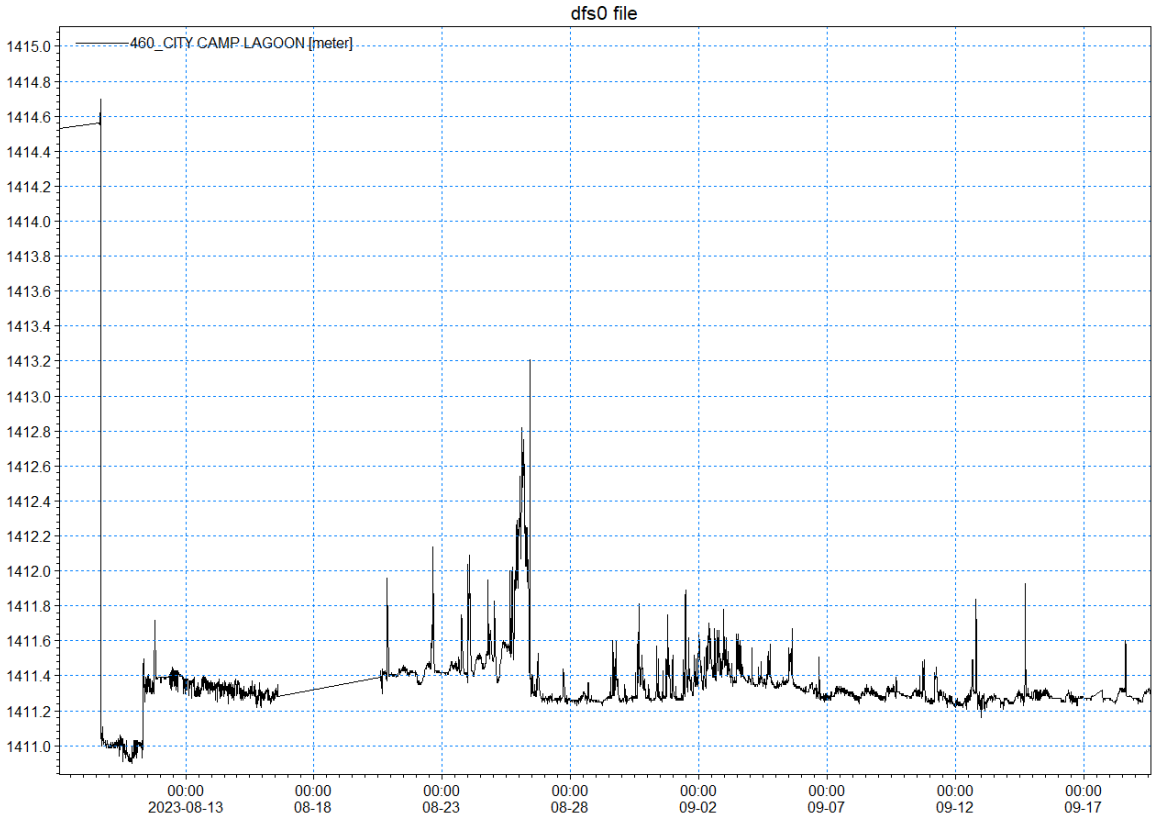


Figure A2-2: Datum shifts observed in water level data at Balili Station
Source: Ramboll

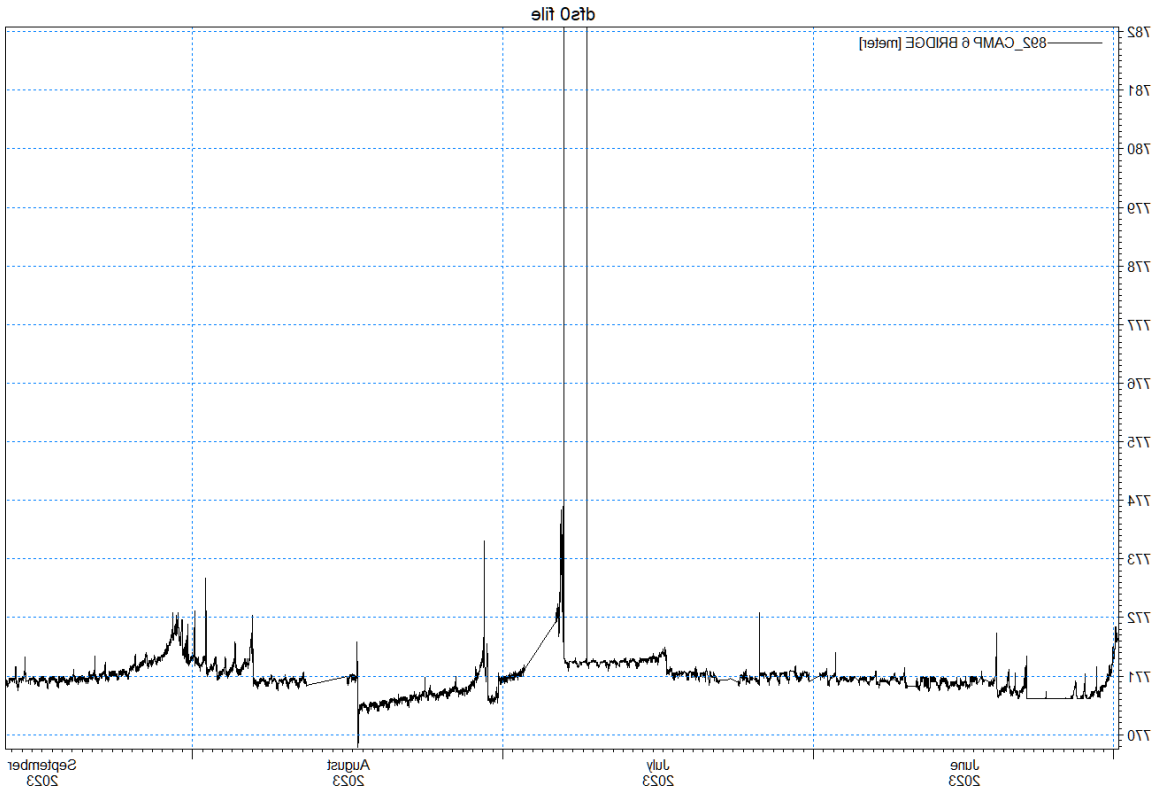


Figure A2-3: Datum shift observed in water level data at Camp 6 Bridge station
Source: Ramboll

2.2 REAL-TIME RAINFALL DATA ASSESSMENT

The daily and monthly statistics of the recorded rainfall for all the real-time monitoring stations are presented in the Table A2-3 to Table A2-8. The assessment of real-time rainfall data observed during 2023 monsoon led to the following conclusions:

- The monthly statistics show higher rainfall in the months of July and August.
- The total precipitation observed by real-time monitoring stations is comparatively lower to the rainfall forecasts from PAGASA's WRF data.
- During investigation it was also found that few large peak events were recorded. It was determined that these were caused due to cleaning and testing of instruments during the routine maintenance. To rectify these erroneous peaks, the data recorded during the periods of maintenance of rainfall stations has been removed from the recorded data during post-monsoon model updates.

Table A2-2: Summary of maximum and total precipitation in each month observed at the real-time rainfall monitoring stations

Station	Month	Total Precipitation (mm)	Maximum Precipitation (mm)
Asin Bridge	June	767.00	16.50
	July	1095.00	20.50
	August	1125.50	18.00
	September	486.00	13.00
Balili Bridge	June	310.39	8.38
	July	637.54	8.89
	August	502.67	5.84
	September	228.60	5.08
City Camp Lagoon	June	397.50	11.00
	July	192.00	5.50
	August	816.50	14.50
	September	463.00	13.50
Camp 6 Bridge	June	118.80	4.80
	July	296.20	6.00
	August	265.00	4.00
	September	170.20	2.60
Camp 6 Bridge	June	343.00	13.00
	July	1233.50	20.00
	August	888.50	10.50
	September	415.50	20.00
Irisan Fire Station	June	808.00	26.00
	July	1991.00	25.00
	August	2349.00	35.00
	September	949.00	19.00

Source: Ramboll

Table A2-3: Daily maximum and total precipitation at Asin Bridge station

Date	Daily Maximum Precipitation (mm)	Total Precipitation (mm)
6/1/2023	9.5	34.5
6/2/2023	0	0
6/3/2023	10	57
6/4/2023	3	11.5
6/5/2023	6.5	17
6/6/2023	5	16
6/7/2023	15.5	101.5
6/8/2023	2	9
6/9/2023	8.5	30.5
6/10/2023	7	23
6/11/2023	5	51
6/12/2023	9	33.5
6/13/2023	2	11
6/14/2023	9.5	22.5
6/15/2023	8	14
6/16/2023	0	0
6/17/2023	0.5	1
6/18/2023	14	31.5
6/19/2023	0	0
6/20/2023	2.5	3.5
6/21/2023	16.5	83
6/22/2023	14	108.5
6/23/2023	5	10.5
6/24/2023	9	22.5
6/25/2023	5.5	5.5

Continued on next page

Table A2-3 continued

Date	Daily Maximum Precipitation (mm)	Total Precipitation (mm)
6/26/2023	0	0
6/27/2023	0	0
6/28/2023	9	27.5
6/29/2023	7.5	41.5
6/30/2023	0	0
7/1/2023	13.5	74.5
7/2/2023	11	38.5
7/3/2023	2	2.5
7/4/2023	0	0
7/5/2023	0	0
7/6/2023	0	0
7/7/2023	4	5
7/8/2023	0	0
7/9/2023	0	0
7/10/2023	0	0
7/11/2023	0.5	0.5
7/12/2023	3	14.5
7/13/2023	3	8.5
7/14/2023	0.5	2
7/15/2023	7	67
7/16/2023	5.5	18
7/17/2023	2	6.5
7/18/2023	0.5	0.5
7/19/2023	5.5	10.5
7/20/2023	4.5	29

Continued on next page

Table A2-3 continued

Date	Daily Maximum Precipitation (mm)	Total Precipitation (mm)
7/21/2023	20.5	66
7/22/2023	3.5	4.5
7/23/2023	1	4.5
7/24/2023	11.5	40
7/25/2023	6.5	59
7/26/2023	13	376
7/27/2023	9.5	160.5
7/28/2023	3	39.5
7/29/2023	7.5	46.5
7/30/2023	2	10
7/31/2023	2.5	11
8/1/2023	1.5	17
8/2/2023	10.5	116.5
8/3/2023	5	53
8/4/2023	1	4
8/5/2023	6	34.5
8/6/2023	4.5	16
8/7/2023	6.5	20
8/8/2023	15.5	76
8/9/2023	3.5	18
8/10/2023	0	0
8/11/2023	16	98.5
8/12/2023	0.5	0.5
8/13/2023	0	0
8/14/2023	3.5	3.5
8/15/2023	3	6.5

Continued on next page

Table A2-3 continued

Date	Daily Maximum Precipitation (mm)	Total Precipitation (mm)
8/16/2023	3.5	7.5
8/17/2023	0	0
8/18/2023	0	0
8/19/2023	0	0
8/20/2023	9.5	19
8/21/2023	1.5	5
8/22/2023	2	12
8/23/2023	9.5	42.5
8/24/2023	7	56
8/25/2023	13	117
8/26/2023	18	137
8/27/2023	6.5	61.5
8/28/2023	0.5	0.5
8/29/2023	8.5	52
8/30/2023	11.5	76
8/31/2023	12	75.5
9/1/2023	7	74.5
9/2/2023	5.5	78
9/3/2023	9	47
9/4/2023	7	44.5
9/5/2023	2	29
9/6/2023	3.5	19
9/7/2023	1	2.5
9/8/2023	0	0
9/9/2023	0.5	0.5
9/10/2023	0	0

Continued on next page

Table A2-3 continued

Date	Daily Maximum Precipitation (mm)	Total Precipitation (mm)
9/11/2023	4.5	18
9/12/2023	2	5
9/13/2023	3.5	6.5
9/14/2023	7	35
9/15/2023	13	52.5
9/16/2023	2.5	14
9/17/2023	1	4
9/18/2023	10.5	39
9/19/2023	5	17
9/20/2023	0	0
9/21/2023	0	0
9/22/2023	0	0
9/23/2023	0	0
9/24/2023	0	0
9/25/2023	0	0
9/26/2023	0	0
9/27/2023	0	0
9/28/2023	0	0
9/29/2023	0	0
9/30/2023	0	0

Source: Ramboll

Table A2-4: Daily maximum and total precipitation at Balili Bridge Station

Date	Daily Maximum Precipitation (mm)	Total Precipitation (mm)
6/1/2023	3.81	32.258
6/2/2023	4.318	12.954
6/3/2023	2.794	8.382
6/4/2023	4.318	11.684
6/5/2023	3.81	7.62
6/6/2023	8.382	38.354
6/7/2023	2.54	9.652
6/8/2023	0.254	0.762
6/9/2023	2.54	19.558
6/10/2023	2.286	9.652
6/11/2023	2.032	20.574
6/12/2023	5.334	30.734
6/13/2023	2.286	14.224
6/14/2023	4.826	20.574
6/15/2023	0	0
6/16/2023	6.858	10.668
6/17/2023	0	0
6/18/2023	0.508	1.27
6/19/2023	0	0
6/20/2023	0	0
6/21/2023	1.27	6.604
6/22/2023	6.858	17.78
6/23/2023	0.254	0.762
6/24/2023	2.54	6.604
6/25/2023	0	0

Continued on next page

Table A2-4 continued

Date	Daily Maximum Precipitation (mm)	Total Precipitation (mm)
6/26/2023	0	0
6/27/2023	0.254	0.254
6/28/2023	6.858	24.892
6/29/2023	0.762	4.572
6/30/2023	0	0
7/1/2023	0.762	1.27
7/2/2023	6.096	10.414
7/3/2023	5.08	6.35
7/4/2023	0	0
7/5/2023	0	0
7/6/2023	0	0
7/7/2023	4.064	6.604
7/8/2023	0	0
7/9/2023	0	0
7/10/2023	0	0
7/11/2023	2.032	3.556
7/12/2023	1.27	7.112
7/13/2023	0.254	0.254
7/14/2023	0.508	2.032
7/15/2023	2.032	29.718
7/16/2023	1.524	5.842
7/17/2023	0.254	2.286
7/18/2023	0.762	1.016
7/19/2023	7.112	12.446
7/20/2023	4.572	12.192
7/21/2023	8.89	20.828

Continued on next page

Table A2-4 continued

Date	Daily Maximum Precipitation (mm)	Total Precipitation (mm)
7/22/2023	2.54	5.842
7/23/2023	5.08	18.796
7/24/2023	2.032	5.08
7/25/2023	6.096	44.958
7/26/2023	6.858	298.704
7/27/2023	5.334	102.362
7/28/2023	1.016	16.51
7/29/2023	3.048	10.414
7/30/2023	1.016	6.604
7/31/2023	0.762	6.35
8/1/2023	2.286	18.542
8/2/2023	5.842	76.2
8/3/2023	3.302	39.116
8/4/2023	1.016	5.842
8/5/2023	2.794	15.494
8/6/2023	2.032	21.336
8/7/2023	1.016	12.192
8/8/2023	3.556	29.464
8/9/2023	0.254	2.032
8/10/2023	0.254	0.254
8/11/2023	1.524	4.572
8/12/2023	0	0
8/13/2023	0	0
8/14/2023	0	0
8/15/2023	0.254	0.254
8/16/2023	0	0

Continued on next page

Table A2-4 continued

Date	Daily Maximum Precipitation (mm)	Total Precipitation (mm)
8/17/2023	0	0
8/18/2023	0	0
8/19/2023	0	0
8/20/2023	0.762	3.81
8/21/2023	0.254	1.016
8/22/2023	1.016	3.302
8/23/2023	1.524	3.556
8/24/2023	1.016	8.128
8/25/2023	1.27	17.018
8/26/2023	3.302	59.944
8/27/2023	5.334	36.068
8/28/2023	0.762	3.048
8/29/2023	5.842	45.212
8/30/2023	4.826	40.894
8/31/2023	4.064	55.372
9/1/2023	2.794	45.212
9/2/2023	2.54	70.358
9/3/2023	3.048	25.4
9/4/2023	2.286	17.018
9/5/2023	1.27	17.526
9/6/2023	5.08	22.352
9/7/2023	0.254	1.27
9/8/2023	0	0
9/9/2023	2.032	6.35
9/10/2023	0.254	0.254
9/11/2023	1.016	6.604

Continued on next page

Table A2-4 continued

Date	Daily Maximum Precipitation (mm)	Total Precipitation (mm)
9/12/2023	4.826	9.906
9/13/2023	0	0
9/14/2023	3.556	6.35
9/15/2023	0	0
9/16/2023	0	0
9/17/2023	0	0
9/18/2023	0	0
9/19/2023	0	0
9/20/2023	0	0
9/21/2023	0	0
9/22/2023	0	0
9/23/2023	0	0
9/24/2023	0	0
9/25/2023	0	0
9/26/2023	0	0
9/27/2023	0	0
9/28/2023	0	0
9/29/2023	0	0
9/30/2023	0	0

Source: Ramboll

Table A2-5 Daily maximum and total precipitation at City Camp Lagoon

Date	Daily Maximum Precipitation (mm)	Total Precipitation (mm)
6/1/2023	10	48
6/2/2023	11	29
6/3/2023	8.5	16
6/4/2023	6.5	26.5
6/5/2023	0	0
6/6/2023	0.5	2
6/7/2023	3.5	11
6/8/2023	0	0
6/9/2023	3	18
6/10/2023	4	17
6/11/2023	3.5	33.5
6/12/2023	10	54
6/13/2023	5.5	22.5
6/14/2023	3	18
6/15/2023	0	0
6/16/2023	2	5
6/17/2023	0	0
6/18/2023	0.5	0.5
6/19/2023	0	0
6/20/2023	0.5	1
6/21/2023	4.5	14.5
6/22/2023	6.5	23.5
6/23/2023	2.5	12
6/24/2023	2.5	7
6/25/2023	0	0

Continued on next page

Table A2-5 continued

Date	Daily Maximum Precipitation (mm)	Total Precipitation (mm)
6/26/2023	0	0
6/27/2023	0	0
6/28/2023	6.5	23
6/29/2023	4	15
6/30/2023	0.5	0.5
7/1/2023	2.5	4
7/2/2023	1	1
7/3/2023	0.5	0.5
7/4/2023	0	0
7/5/2023	0	0
7/6/2023	0	0
7/7/2023	3.5	6.5
7/8/2023	0	0
7/9/2023	0	0
7/10/2023	0.5	0.5
7/11/2023	0	0
7/12/2023	4.5	12
7/13/2023	1	2.5
7/14/2023	2	14.5
7/15/2023	5.5	71
7/16/2023	1.5	14.5
7/17/2023	0.5	6.5
7/18/2023	0.5	1.5
7/19/2023	5	12.5
7/20/2023	1.5	9

Continued on next page

Table A2-5 continued

Date	Daily Maximum Precipitation (mm)	Total Precipitation (mm)
7/21/2023	3.5	20
7/22/2023	4	14
7/23/2023	1	1.5
7/24/2023	0	0
7/25/2023	0	0
7/26/2023	0	0
7/27/2023	0	0
7/28/2023	0	0
7/29/2023	0	0
7/30/2023	0	0
7/31/2023	0	0
8/1/2023	0	0
8/2/2023	0	0
8/3/2023	4	26
8/4/2023	2	13.5
8/5/2023	7.5	53.5
8/6/2023	4	39.5
8/7/2023	2	14
8/8/2023	5	67
8/9/2023	2	17
8/10/2023	1.5	3
8/11/2023	4.5	22.5
8/12/2023	0	0
8/13/2023	0	0
8/14/2023	0	0
8/15/2023	0	0

Continued on next page

Table A2-5 continued

Date	Daily Maximum Precipitation (mm)	Total Precipitation (mm)
8/16/2023	0	0
8/17/2023	0	0
8/18/2023	0	0
8/19/2023	0	0
8/20/2023	3	7.5
8/21/2023	0.5	0.5
8/22/2023	3.5	11
8/23/2023	4	9.5
8/24/2023	2	11.5
8/25/2023	6.5	58.5
8/26/2023	14.5	152.5
8/27/2023	7.5	64.5
8/28/2023	1.5	13
8/29/2023	5	56
8/30/2023	7.5	66.5
8/31/2023	9.5	109.5
9/1/2023	13.5	89.5
9/2/2023	9	148
9/3/2023	3.5	57.5
9/4/2023	2.5	27
9/5/2023	3.5	26
9/6/2023	9	26.5
9/7/2023	2	7
9/8/2023	0	0
9/9/2023	2	3
9/10/2023	3.5	9.5

Continued on next page

Table A2-5 continued

Date	Daily Maximum Precipitation (mm)	Total Precipitation (mm)
9/11/2023	1	10.5
9/12/2023	6	19.5
9/13/2023	0	0
9/14/2023	8.5	16.5
9/15/2023	0.5	0.5
9/16/2023	1.5	3.5
9/17/2023	0.5	2
9/18/2023	5	11.5
9/19/2023	1.5	5
9/20/2023	0	0
9/21/2023	0	0
9/22/2023	0	0
9/23/2023	0	0
9/24/2023	0	0
9/25/2023	0	0
9/26/2023	0	0
9/27/2023	0	0
9/28/2023	0	0
9/29/2023	0	0
9/30/2023	0	0

Source: Ramboll

Table A2-6: Daily maximum and total precipitation at Camp 6 Bridge

Date	Daily Maximum Precipitation (mm)	Total Precipitation (mm)
6/1/2023	1.6	9.8
6/2/2023	0	0
6/3/2023	1.6	5.4
6/4/2023	2	8.2
6/5/2023	1.8	2.4
6/6/2023	0.8	3.2
6/7/2023	0.4	1.2
6/8/2023	0	0
6/9/2023	1.8	10
6/10/2023	1.4	6
6/11/2023	0.8	10.2
6/12/2023	3	10
6/13/2023	0.6	5.2
6/14/2023	0.4	1.8
6/15/2023	0.2	0.4
6/16/2023	1	4
6/17/2023	0.2	0.2
6/18/2023	0	0
6/19/2023	0	0
6/20/2023	1.2	1.2
6/21/2023	0.4	1.4
6/22/2023	2.8	8
6/23/2023	0	0
6/24/2023	0	0
6/25/2023	0	0

Continued on next page

Table A2-6 continued

Date	Daily Maximum Precipitation (mm)	Total Precipitation (mm)
6/26/2023	0	0
6/27/2023	0	0
6/28/2023	2	7
6/29/2023	4.8	23.2
6/30/2023	0	0
7/1/2023	0.2	0.2
7/2/2023	1.8	3.4
7/3/2023	3.6	6.2
7/4/2023	0	0
7/5/2023	0	0
7/6/2023	0	0
7/7/2023	1.8	3
7/8/2023	0	0
7/9/2023	0	0
7/10/2023	0	0
7/11/2023	0.2	0.2
7/12/2023	1.4	5.8
7/13/2023	0.8	1.4
7/14/2023	0.6	8
7/15/2023	1	24
7/16/2023	3.6	9.8
7/17/2023	0.4	3.2
7/18/2023	0.4	0.8
7/19/2023	0.8	1.8
7/20/2023	0.8	2.2
7/21/2023	1	2.8

Continued on next page

Table A2-6 continued

Date	Daily Maximum Precipitation (mm)	Total Precipitation (mm)
7/22/2023	4.8	6
7/23/2023	4.8	11
7/24/2023	2.2	5.4
7/25/2023	4	33.6
7/26/2023	6	152.6
7/27/2023	0	0
7/28/2023	0	0
7/29/2023	0.4	1.6
7/30/2023	0.6	5.4
7/31/2023	0.6	7.8
8/1/2023	1.6	19.2
8/2/2023	4	48.2
8/3/2023	2.2	19.2
8/4/2023	1	7
8/5/2023	1.8	10.2
8/6/2023	0.2	4.4
8/7/2023	0.4	2.6
8/8/2023	1.2	6.2
8/9/2023	0.8	1.4
8/10/2023	0	0
8/11/2023	0.4	1.6
8/12/2023	0	0
8/13/2023	0	0
8/14/2023	0	0
8/15/2023	0	0
8/16/2023	0	0

Continued on next page

Table A2-6 continued

Date	Daily Maximum Precipitation (mm)	Total Precipitation (mm)
8/17/2023	0	0
8/18/2023	0	0
8/19/2023	0	0
8/20/2023	0.8	2
8/21/2023	0.2	0.6
8/22/2023	0	0
8/23/2023	0.4	1.6
8/24/2023	1.2	3
8/25/2023	2.8	15.4
8/26/2023	2.8	28.6
8/27/2023	2.2	11.4
8/28/2023	0.8	4
8/29/2023	1.8	9.6
8/30/2023	4	33
8/31/2023	3.8	35.8
9/1/2023	2.6	40.4
9/2/2023	2	53.8
9/3/2023	1.2	15.8
9/4/2023	2.4	12
9/5/2023	1.2	18.4
9/6/2023	2.6	5.2
9/7/2023	0.6	0.8
9/8/2023	0	0
9/9/2023	0.2	0.6
9/10/2023	0.4	1
9/11/2023	0.2	1.2

Continued on next page

Table A2-6 continued

Date	Daily Maximum Precipitation (mm)	Total Precipitation (mm)
9/12/2023	0.2	1
9/13/2023	0.2	0.2
9/14/2023	0.2	0.6
9/15/2023	0.2	0.8
9/16/2023	1.4	7.6
9/17/2023	2.2	9.8
9/18/2023	0.2	0.2
9/19/2023	0.4	0.8
9/20/2023	0	0
9/21/2023	0	0
9/22/2023	0	0
9/23/2023	0	0
9/24/2023	0	0
9/25/2023	0	0
9/26/2023	0	0
9/27/2023	0	0
9/28/2023	0	0
9/29/2023	0	0
9/30/2023	0	0

Source: Ramboll

Table A2-7: Daily maximum and total precipitation at Brookspoint

Date	Daily Maximum Precipitation (mm)	Total Precipitation (mm)
6/1/2023	11	61
6/2/2023	0.5	1
6/3/2023	13	19.5
6/4/2023	8	29
6/5/2023	10	11
6/6/2023	4	7
6/7/2023	5.5	12.5
6/8/2023	0	0
6/9/2023	2.5	15.5
6/10/2023	4.5	16.5
6/11/2023	2.5	21
6/12/2023	7	32
6/13/2023	6.5	16.5
6/14/2023	3	11.5
6/15/2023	0.5	0.5
6/16/2023	4	9.5
6/17/2023	0	0
6/18/2023	2.5	5
6/19/2023	0.5	0.5
6/20/2023	4	5.5
6/21/2023	5.5	13.5
6/22/2023	4.5	11
6/23/2023	5	15
6/24/2023	1	2.5
6/25/2023	0	0

Continued on next page

Table A2-7 continued

Date	Daily Maximum Precipitation (mm)	Total Precipitation (mm)
6/26/2023	0.5	1
6/27/2023	0	0
6/28/2023	5.5	17
6/29/2023	1.5	8
6/30/2023	0	0
7/1/2023	0	0
7/2/2023	1	1.5
7/3/2023	0.5	0.5
7/4/2023	0	0
7/5/2023	0	0
7/6/2023	0	0
7/7/2023	0.5	0.5
7/8/2023	6	11
7/9/2023	0	0
7/10/2023	1	1
7/11/2023	0	0
7/12/2023	6.5	18
7/13/2023	0.5	2
7/14/2023	1.5	16.5
7/15/2023	3.5	53
7/16/2023	5.5	18
7/17/2023	1.5	8
7/18/2023	1	4
7/19/2023	5.5	16
7/20/2023	5.5	22.5

Continued on next page

Table A2-7 continued

Date	Daily Maximum Precipitation (mm)	Total Precipitation (mm)
7/21/2023	12.5	48.5
7/22/2023	3.5	13.5
7/23/2023	11.5	26
7/24/2023	3	11.5
7/25/2023	11	97.5
7/26/2023	20	586.5
7/27/2023	9	194
7/28/2023	2.5	32
7/29/2023	3.5	27.5
7/30/2023	1.5	14.5
7/31/2023	1	9.5
8/1/2023	3	37
8/2/2023	10.5	141.5
8/3/2023	6.5	63.5
8/4/2023	3	20.5
8/5/2023	5	48.5
8/6/2023	3.5	36.5
8/7/2023	1.5	17.5
8/8/2023	3.5	49.5
8/9/2023	2	7
8/10/2023	0.5	0.5
8/11/2023	1	5.5
8/12/2023	0	0
8/13/2023	0	0
8/14/2023	0	0
8/15/2023	0	0

Continued on next page

Table A2-7 continued

Date	Daily Maximum Precipitation (mm)	Total Precipitation (mm)
8/16/2023	0	0
8/17/2023	0	0
8/18/2023	0	0
8/19/2023	0	0
8/20/2023	0.5	2
8/21/2023	0.5	1
8/22/2023	0.5	1.5
8/23/2023	0.5	2
8/24/2023	1	7
8/25/2023	5.5	36
8/26/2023	5.5	103.5
8/27/2023	9	79
8/28/2023	2	5
8/29/2023	3.5	55.5
8/30/2023	8.5	68
8/31/2023	10	100.5
9/1/2023	7	83.5
9/2/2023	10	133.5
9/3/2023	7	41
9/4/2023	0	0
9/5/2023	0	0
9/6/2023	0.5	0.5
9/7/2023	0	0
9/8/2023	0	0
9/9/2023	0	0
9/10/2023	0	0

Continued on next page

Table A2-7 continued

Date	Daily Maximum Precipitation (mm)	Total Precipitation (mm)
9/11/2023	1.5	10
9/12/2023	4	19
9/13/2023	0.5	0.5
9/14/2023	15.5	34.5
9/15/2023	0.5	1
9/16/2023	0.5	2
9/17/2023	20	58.5
9/18/2023	4.5	10.5
9/19/2023	8	21
9/20/2023	0	0
9/21/2023	0	0
9/22/2023	0	0
9/23/2023	0	0
9/24/2023	0	0
9/25/2023	0	0
9/26/2023	0	0
9/27/2023	0	0
9/28/2023	0	0
9/29/2023	0	0
9/30/2023	0	0

Source: Ramboll

Table A2-8: Daily maximum and total precipitation at Irisan Fire Station

Date	Daily Maximum Precipitation (mm)	Total Precipitation (mm)
6/1/2023	26	97
6/2/2023	5	10
6/3/2023	11	20
6/4/2023	12	27
6/5/2023	10	11
6/6/2023	4	9
6/7/2023	6	19
6/8/2023	4	8
6/9/2023	9	45
6/10/2023	19	49
6/11/2023	14	98
6/12/2023	23	114
6/13/2023	14	39
6/14/2023	12	41
6/15/2023	0	0
6/16/2023	1	3
6/17/2023	0	0
6/18/2023	0	0
6/19/2023	1	1
6/20/2023	8	12
6/21/2023	5	14
6/22/2023	26	109
6/23/2023	6	18
6/24/2023	7	13
6/25/2023	0	0

Continued on next page

Table A2-8 continued

Date	Daily Maximum Precipitation (mm)	Total Precipitation (mm)
6/26/2023	0	0
6/27/2023	0	0
6/28/2023	8	40
6/29/2023	3	11
6/30/2023	0	0
7/1/2023	19	33
7/2/2023	1	4
7/3/2023	1	1
7/4/2023	0	0
7/5/2023	0	0
7/6/2023	0	0
7/7/2023	1	2
7/8/2023	0	0
7/9/2023	0	0
7/10/2023	0	0
7/11/2023	0	0
7/12/2023	4	21
7/13/2023	1	1
7/14/2023	2	16
7/15/2023	8	132
7/16/2023	2	21
7/17/2023	2	9
7/18/2023	1	1
7/19/2023	4	13
7/20/2023	8	18
7/21/2023	12	36

Continued on next page

Table A2-8 continued

Date	Daily Maximum Precipitation (mm)	Total Precipitation (mm)
7/22/2023	1	1
7/23/2023	16	16
7/24/2023	9	9
7/25/2023	9	9
7/26/2023	25	25
7/27/2023	21	21
7/28/2023	6	6
7/29/2023	8	8
7/30/2023	5	5
7/31/2023	3	3
8/1/2023	11	11
8/2/2023	29	29
8/3/2023	6	6
8/4/2023	4	4
8/5/2023	14	14
8/6/2023	12	12
8/7/2023	7	7
8/8/2023	18	18
8/9/2023	8	8
8/10/2023	3	3
8/11/2023	35	35
8/12/2023	1	1
8/13/2023	0	0
8/14/2023	2	2
8/15/2023	1	1
8/16/2023	9	9

Continued on next page

Table A2-8 continued

Date	Daily Maximum Precipitation (mm)	Total Precipitation (mm)
8/17/2023	0	0
8/18/2023	0	0
8/19/2023	0	0
8/20/2023	7	22
8/21/2023	2	4
8/22/2023	8	40
8/23/2023	19	67
8/24/2023	10	72
8/25/2023	13	147
8/26/2023	33	322
8/27/2023	10	108
8/28/2023	11	74
8/29/2023	12	126
8/30/2023	12	120
8/31/2023	15	186
9/1/2023	9	144
9/2/2023	16	267
9/3/2023	18	131
9/4/2023	8	92
9/5/2023	11	63
9/6/2023	19	59
9/7/2023	4	12
9/8/2023	4	7
9/9/2023	1	2
9/10/2023	10	24
9/11/2023	9	40

Continued on next page

Table A2-8 continued

Date	Daily Maximum Precipitation (mm)	Total Precipitation (mm)
9/12/2023	8	37
9/13/2023	0	0
9/14/2023	17	32
9/15/2023	1	1
9/16/2023	2	4
9/17/2023	1	5
9/18/2023	17	29
9/19/2023	0	0
9/20/2023	0	0
9/21/2023	0	0
9/22/2023	0	0
9/23/2023	0	0
9/24/2023	0	0
9/25/2023	0	0
9/26/2023	0	0
9/27/2023	0	0
9/28/2023	0	0
9/29/2023	0	0
9/30/2023	0	0

Source: Ramboll

2.2.1 DOUBLE-MASS CURVE ANALYSIS FOR RAINFALL DATA

The double mass curve to rainfall data provides insights into changes in precipitation patterns and help in understanding trends over time or between different locations. In this section, the cumulative rainfall for each rainfall stations and an average of the cumulative rainfall for all the stations is shown in Figure A2-4. The Figure A2-5 shows the double mass curve i.e., the relation between the cumulative rainfall of all stations and cumulative rainfall at each station.

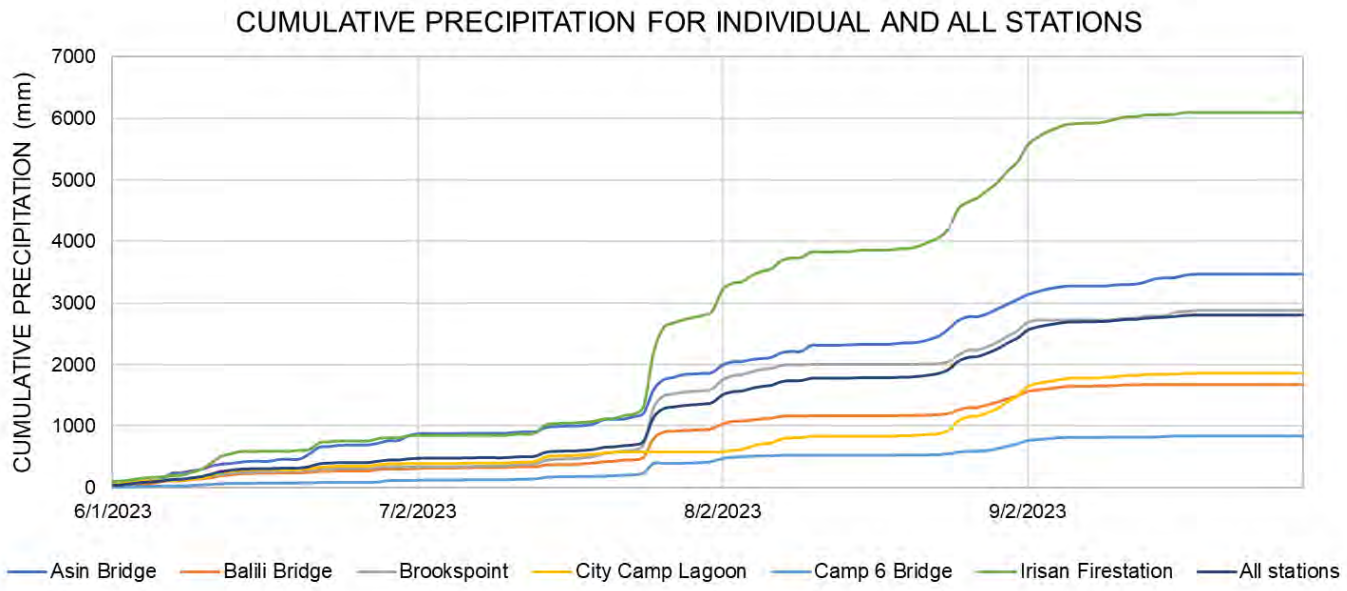


Figure A2-4 Cumulative rainfall observed at all and individual stations
Source: Ramboll

The following inferences can be derived from the graphical analysis:

- The Irisan Fire Station observed comparatively higher rainfall in the Baguio catchment. The average of the cumulative rainfall is therefore, have a strong influence of the Irisan station rainfall. This is also discernible from the double mass curve exhibiting a good fit with the average cumulative, see Figure A2-5.
- Apart from Irisan station, Asin Bridge, Balili Bridge and Camp 6 Bridge stations also follows the trend and pattern of the average cumulative and no breaks are observed. Therefore, showing a good correlation with the overall rainfall pattern behaviour of the combined network system.
- Brookspoint station shows a break in the slope in month of August.
- City Camp Lagoon station does not follow the trend of the average cumulative and shows multiple breaks. However, the station was not operational and was under maintenance for considerable period and therefore, further investigations in the upcoming years to derive any conclusion.

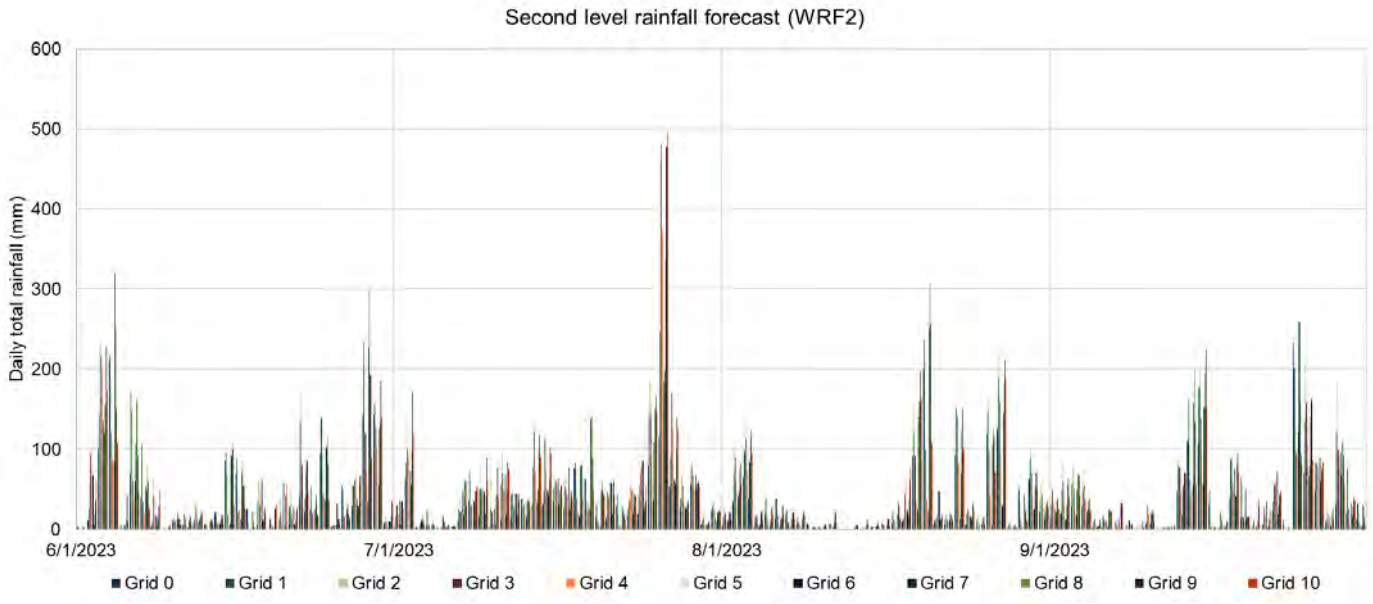


Figure A2-5 Double mass curve for rainfall data for all stations
Source: Ramboll

2.3 WRF DATA ASSESSMENT

WRF gridded data from PAGASA is fetched by FEWS at 48 grid points. In the FEWS, this gridded data is converted to a single timeseries per sub-catchment by direct area weighted formula. Bias correction is performed to these timeseries to correct the rainfall forecast data using observed real-time rainfall station data for each model simulation.

In this section, an assessment of the WRF data prior to bias correction have been presented. The Figure A2-6 to Figure A2-9 presents the total precipitation observed in second to fifth levels of WRF data demonstrating the range and variability in the WRF data. A summary of total precipitation and hourly maximum rainfall in each month for the second level of WRF data is presented in Table A2-9.

The analysis of WRF data led to the following conclusions:

- In general, prior to bias correction, the WRF data shows large from the observed rainfall data in the Balili catchment.
- Cumulative precipitation for individual
- This implying that the application of bias correction to the model successfully rectified the forecasted rainfall values, resulting in a system that provided reliable water level forecasts.
- Also suggesting the non-operability of real-time monitoring stations can significantly impact the flood forecast model results as the bias-correction will not be applied for that period.

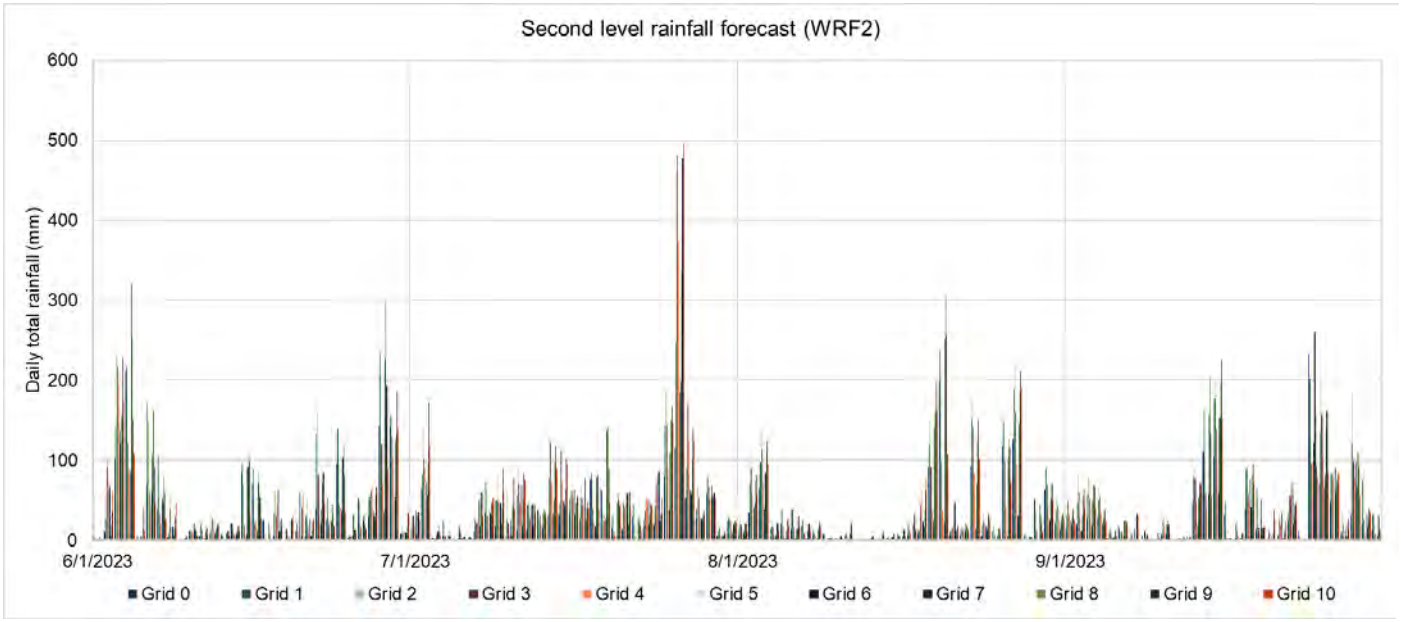


Figure A2-6 Daily total precipitation of second level of WRF (3-5 hours)
Source: Ramboll

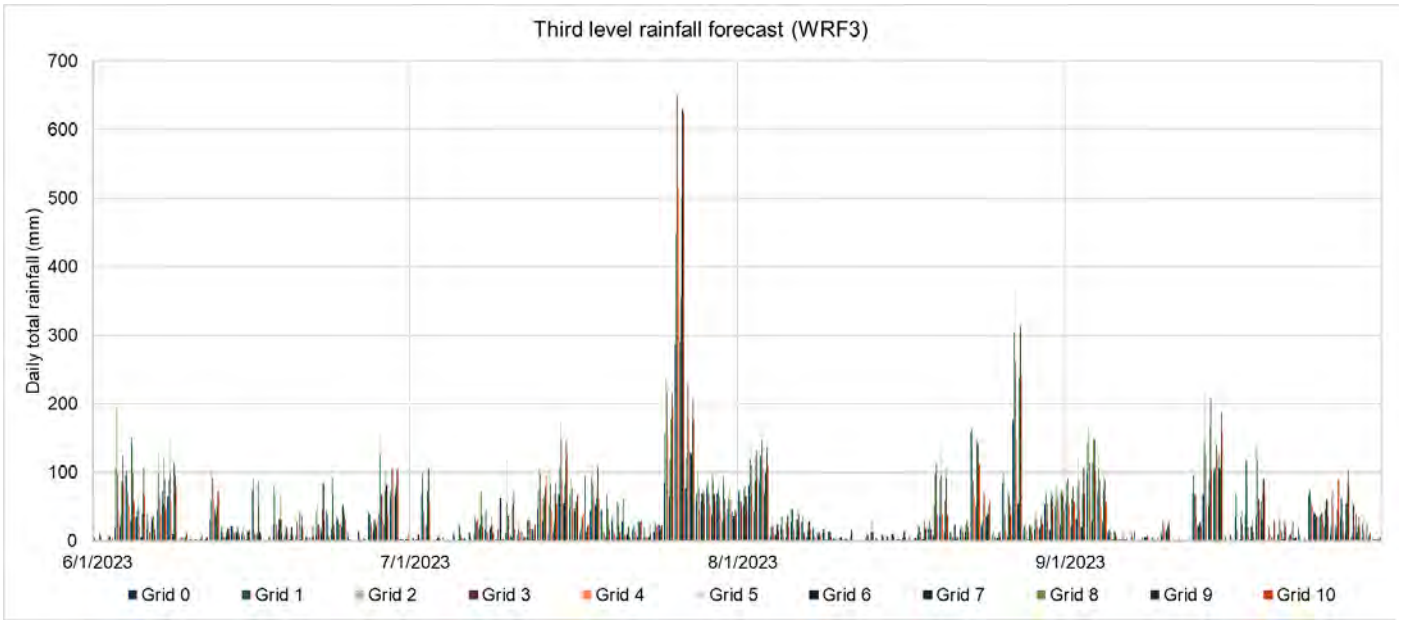


Figure A2-7 Daily total precipitation of third level of WRF (6-8 hours)
Source: Ramboll

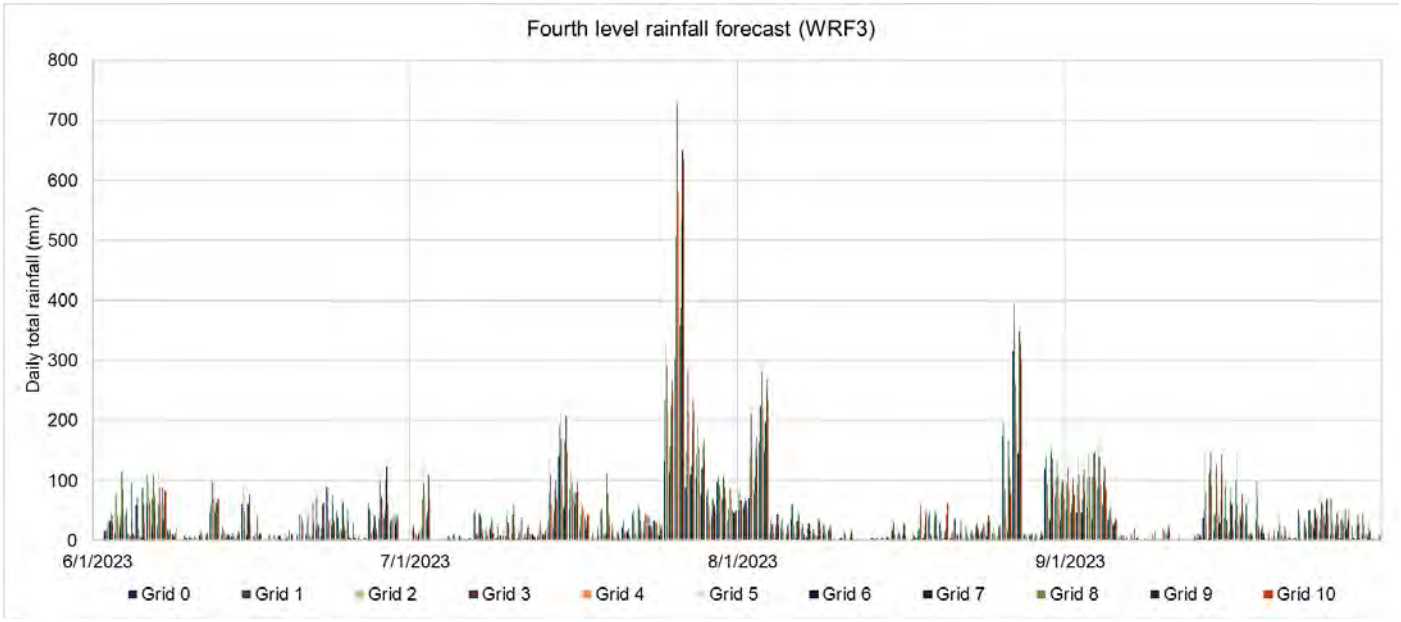


Figure A2-8 Daily total precipitation of fourth level of WRF (9-11 hours)
Source: Ramboll

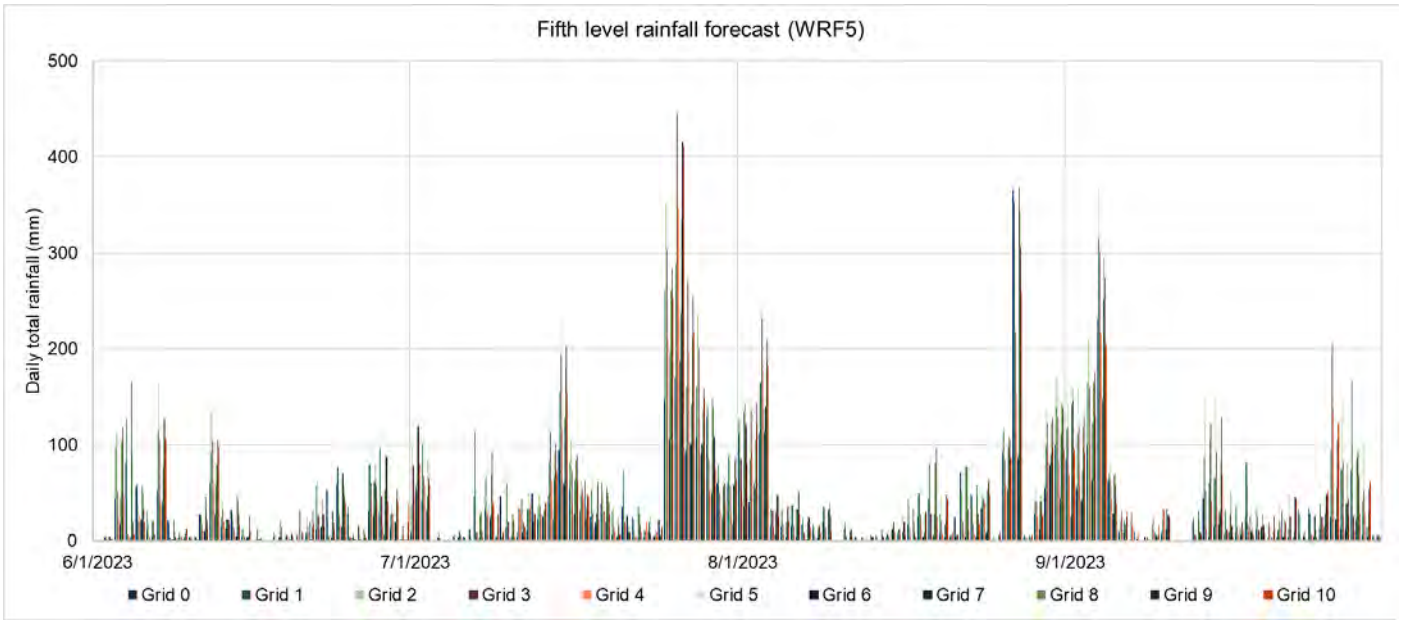


Figure A2-9 Daily total precipitation of fifth level of WRF (12-14 hours)
Source: Ramboll

Table A2-9: Summary of total and hourly maximum rainfall in each month for the second level WRF

WRF2 Grid	Monthly total precipitation (mm)				Hourly maximum rainfall (mm)			
	June	July	August	September	June	July	August	September
Grid 0	1220.9	927.1	983.2	924.4	78.3	39.2	74.2	51.1
Grid 1	1869.8	1651.1	1453.5	1570.8	81.6	41.6	69.0	58.9
Grid 2	1951.5	2321.9	1706.2	1778.6	73.2	70.1	64.4	63.0
Grid 3	1242.9	1915.8	1142.6	1230.7	72.9	52.5	54.8	62.1
Grid 4	952.9	1489.8	654.6	869.2	51.2	43.0	36.8	58.3
Grid 5	895.3	1338.9	417.5	830.3	48.9	44.1	25.6	51.6
Grid 6	885.4	1262.7	336.3	922.7	39.9	57.7	18.8	43.4
Grid 7	1510.8	1220.2	1145.4	1145.0	71.7	64.1	74.7	59.2
Grid 8	1814.2	1876.0	1562.3	1436.2	72.8	71.5	87.4	62.8
Grid 9	1690.4	2284.1	1648.4	1462.1	72.3	67.2	120.7	99.2
Grid 10	1163.7	1911.8	1139.2	1037.6	67.4	68.5	101.6	76.9
Grid 11	917.3	1619.0	638.0	831.8	58.9	58.9	37.0	44.3
Grid 12	789.9	1410.6	365.1	797.2	48.4	47.2	18.8	45.1
Grid 13	758.7	1233.9	279.3	880.9	43.0	50.5	22.9	51.8
Grid 14	1471.2	1306.9	955.5	923.5	53.0	58.6	50.0	59.7
Grid 15	1320.6	1697.0	1101.0	1023.6	65.5	65.6	63.2	50.5
Grid 16	1321.8	2101.7	1152.8	1139.9	70.3	69.0	90.6	83.6
Grid 17	1159.4	2106.3	1003.3	1168.6	78.0	65.3	77.2	65.5
Grid 18	1027.9	1913.0	652.4	1094.3	55.2	65.2	41.1	63.1
Grid 19	859.6	1589.7	405.9	995.7	53.2	52.9	23.9	76.3
Grid 20	790.6	1352.7	337.6	1040.2	53.8	51.0	33.7	72.6
Grid 21	1260.6	1237.6	795.7	745.1	44.7	51.1	45.4	86.7
Grid 22	1333.5	1685.1	880.0	879.4	50.1	55.4	45.5	56.4
Grid 23	1498.2	2395.4	1058.5	1133.1	72.5	72.2	74.2	55.2
Grid 24	1605.1	2564.5	997.5	1385.3	77.7	55.2	57.3	53.2

Table A2-9 continued

WRF2 Grid	Monthly total precipitation (mm)				Hourly maximum rainfall (mm)			
	June	July	August	September	June	July	August	September
Grid 25	1598.0	2311.5	736.0	1361.7	86.9	74.3	41.9	50.0
Grid 26	1337.3	1883.8	504.5	1156.6	64.5	58.8	27.0	52.9
Grid 27	1140.6	1512.2	421.6	1052.5	54.0	48.7	37.7	56.6
Grid 28	1464.8	1403.5	850.2	788.9	61.3	51.6	40.8	67.2
Grid 29	1782.9	1989.4	1016.7	1109.7	74.6	56.7	63.4	84.5
Grid 30	1967.1	2723.1	1162.3	1461.6	59.3	72.0	58.7	84.7
Grid 31	2032.2	2744.7	1017.4	1556.8	88.5	68.6	49.2	47.5
Grid 32	1919.5	2341.3	767.0	1443.4	83.5	88.3	31.1	53.6
Grid 33	1496.9	1881.1	524.6	1136.3	64.5	75.3	24.4	59.2
Grid 34	1212.7	1483.0	400.4	913.5	52.3	39.5	23.8	43.7
Grid 35	1713.5	1502.4	932.4	980.1	95.1	58.3	47.0	76.5
Grid 36	1858.4	1934.5	1093.3	1229.1	96.1	70.9	55.4	96.8
Grid 37	1907.3	2247.0	1117.2	1399.3	60.6	69.3	62.9	89.2
Grid 38	1929.2	2262.6	926.7	1310.3	68.1	66.7	39.3	68.0
Grid 39	1740.0	2089.8	713.2	1141.3	74.7	72.2	31.1	57.8
Grid 40	1482.5	1951.0	593.2	1088.7	62.3	82.6	26.9	48.3
Grid 41	1338.7	1819.6	542.6	1107.0	63.4	61.4	23.8	70.2
Grid 42	1711.8	1530.1	822.2	898.5	85.1	67.8	34.6	70.3
Grid 43	1720.4	1670.9	945.0	969.9	81.0	74.0	56.4	79.5
Grid 44	1636.7	1718.6	970.5	1048.8	60.5	74.7	60.8	82.4
Grid 45	1647.5	1829.0	869.2	1055.0	63.1	73.6	72.3	75.3
Grid 46	1787.6	1956.5	756.6	1065.9	67.7	70.6	57.9	61.8
Grid 47	1927.1	2175.0	728.4	1250.8	66.5	66.9	35.7	57.2
Grid 48	1849.8	2181.2	754.8	1420.4	92.3	78.8	26.5	68.8

Source: Ramboll

3 MODEL ASSESSMENT

During the 2023 real-time FEWS operations, the model performed satisfactorily in terms of model stability and accuracy. In this section, assessment of the model results has been presented. The model results have been assessed for first four levels of forecasts i.e., for initial 12 hours from time of forecasts. Root Mean Square Error (RMSE) and R-squared (coefficient of determination) metrics are used to define model accuracy. The model performance metrics for the various level of forecasts at Balili, Sadjap Bridge, Brookspoint and Ferguson Bridge stations are presented in Table A3-1 to Table A3-4. Figure A3-1 to Figure A3-8 presents the forecasted vs observed water levels at all four stations in Balili catchment for first four levels of forecasts.

Based on the assessment of model results, the following inferences are derived:

- The model performed considerably well at Balili Bridge station for which 2023 model has been calibrated.
- At Balili Bridge station, the model demonstrated satisfactory performance, achieving R^2 values exceeding 0.6 for the initial 12 hours of the forecast and surpassing 0.8 for the initial 3 hours of the forecast.
- At Sadjap Bridge and Brookspoint stations, though the scores of model performance are low. A good match of peaks and variability can be observed in months of July and August. In the month of September, the station maintenance caused few erroneous peaks.
- Due to real-time data errors, the model faced inaccuracies that occasionally resulted in false peaks. This impacted the model's precision, necessitating careful operation of FEWS during real-time operations. However, the procedures to address this issue have been incorporated into the Monsoon SOPs for resolution.

3.1 MODEL PERFORMANCE AT BALILI BRIDGE STATION

Table A3-1 Baguio FEWS model performance in real time during 2023 monsoon at Balili Station

Level of Forecast	Time of forecast	RMSE	R^2
First	0-2 hours	0.357	0.86
Second	3-5 hours	0.640	0.67
Third	6-8 hours	0.689	0.62
Fourth	9-11 hours	0.65	0.63

Source: Ramboll

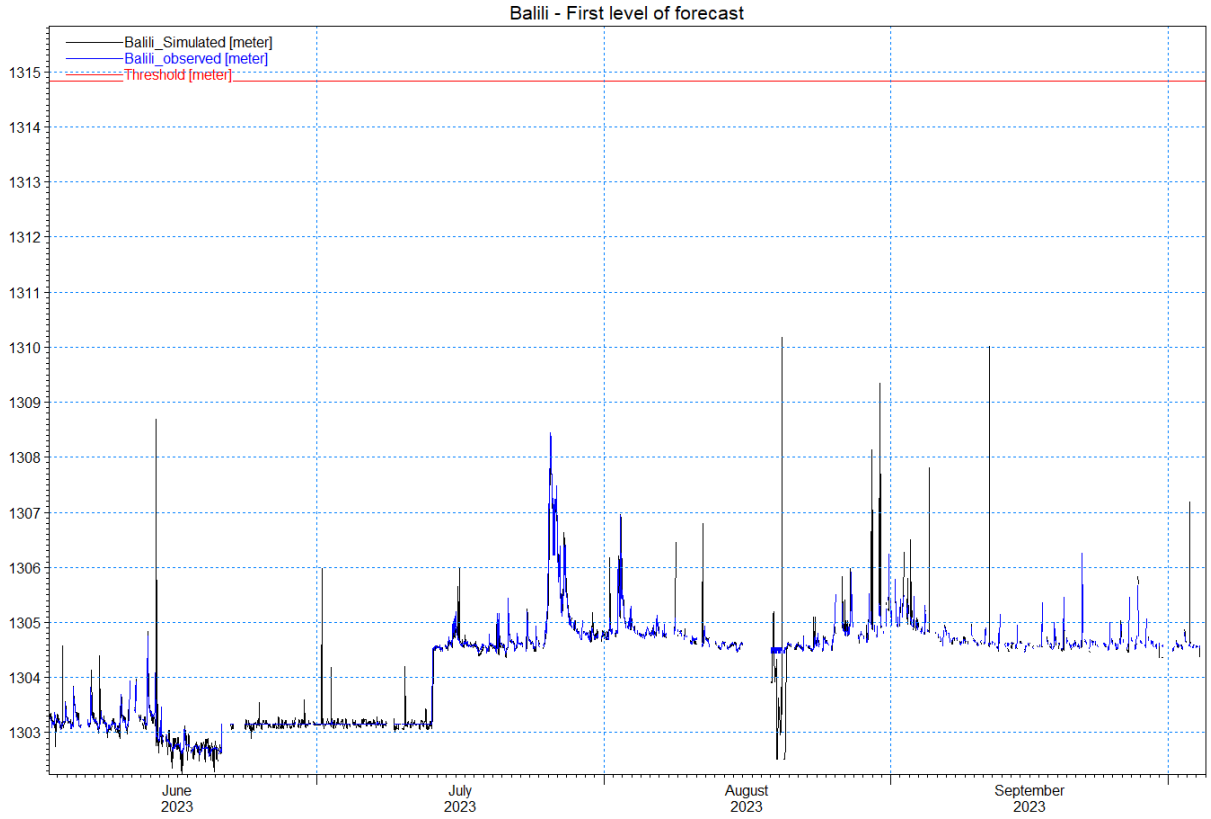


Figure A3-1 Simulated vs observed water levels for first level of forecasts at Balili Station
Source: Ramboll

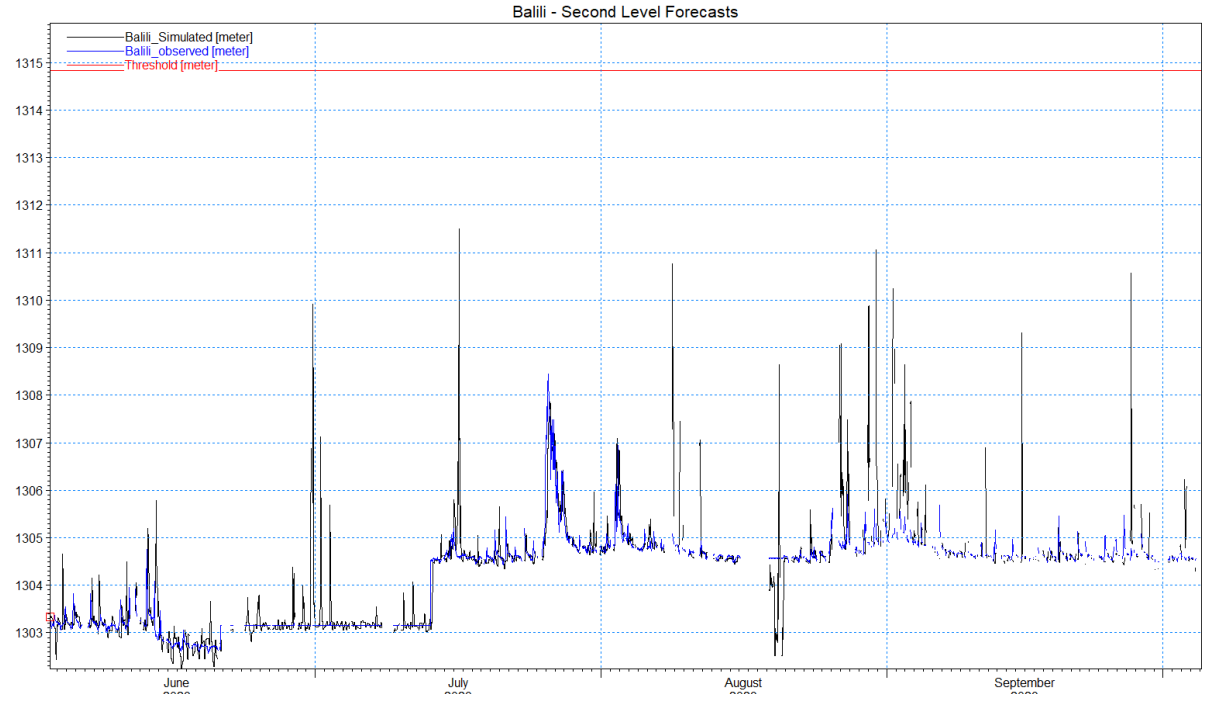


Figure A3-2 Simulated vs observed water levels for second level of forecasts at Balili Station
Source: Ramboll

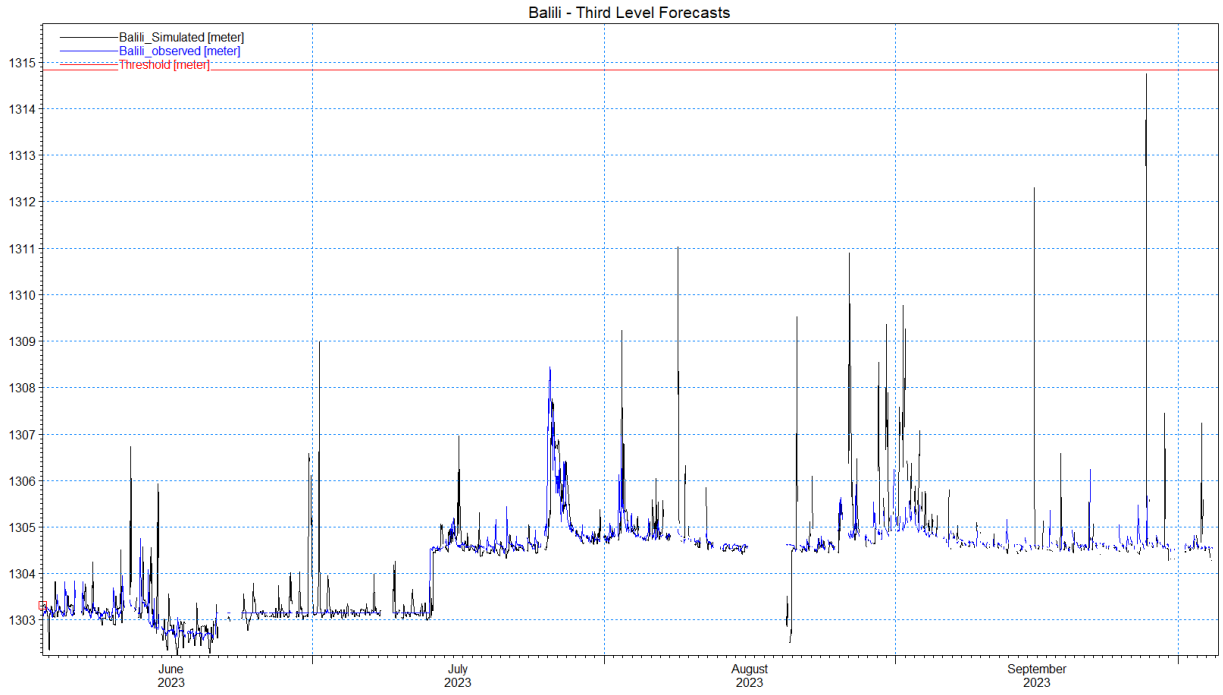


Figure A3-3 Simulated vs observed water levels for third level of forecasts at Balili Station
Source: Ramboll

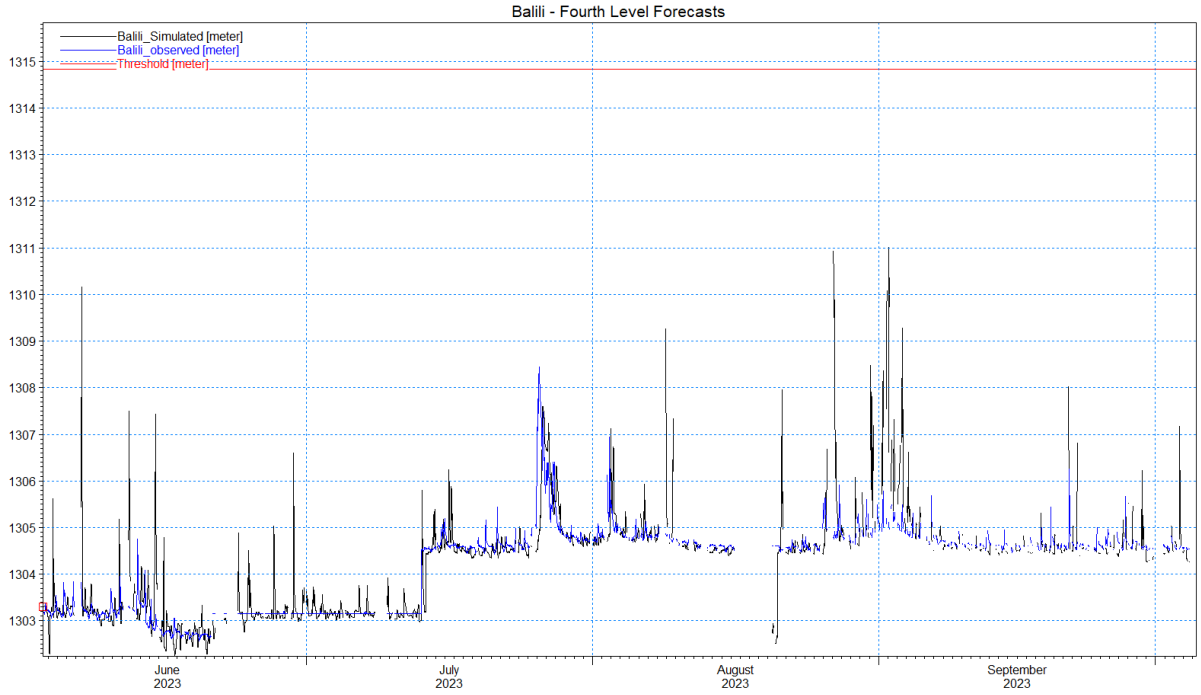


Figure A3-4 Simulated vs observed water levels for fourth level of forecasts at Balili Station
Source: Ramboll

3.2 MODEL PERFORMANCE AT SADJAP BRIDGE STATION

Table A3-2 Baguio FEWS model performance in real time during 2023 monsoon at Sadjap Bridge Station

Level of Forecast	Time of forecast	RMSE	R^2
First	0-2 hours	0.8	0.15
Second	3-5 hours	0.91	0.11
Third	6-8 hours	0.84	0.09
Fourth	9-11 hours	0.84	0.07

Source: Ramboll

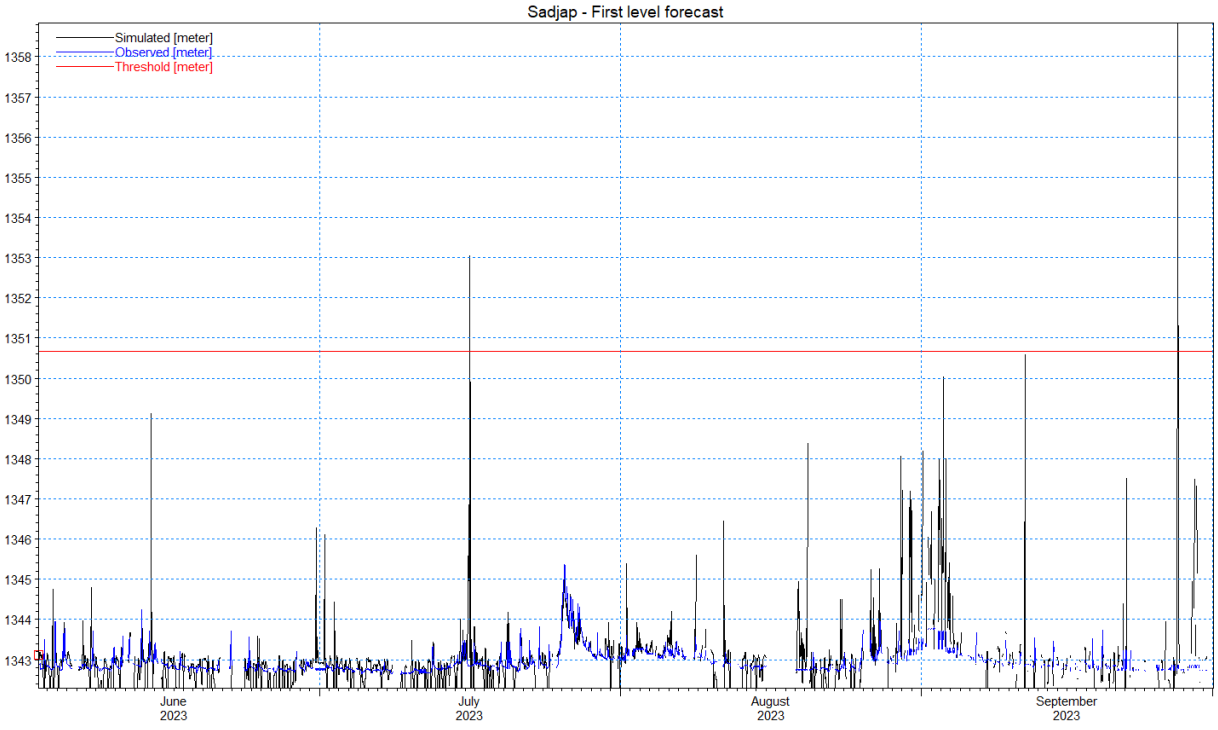


Figure A3-5 Simulated vs observed water levels for first level of forecasts at Sadjap Bridge Station
Source: Ramboll

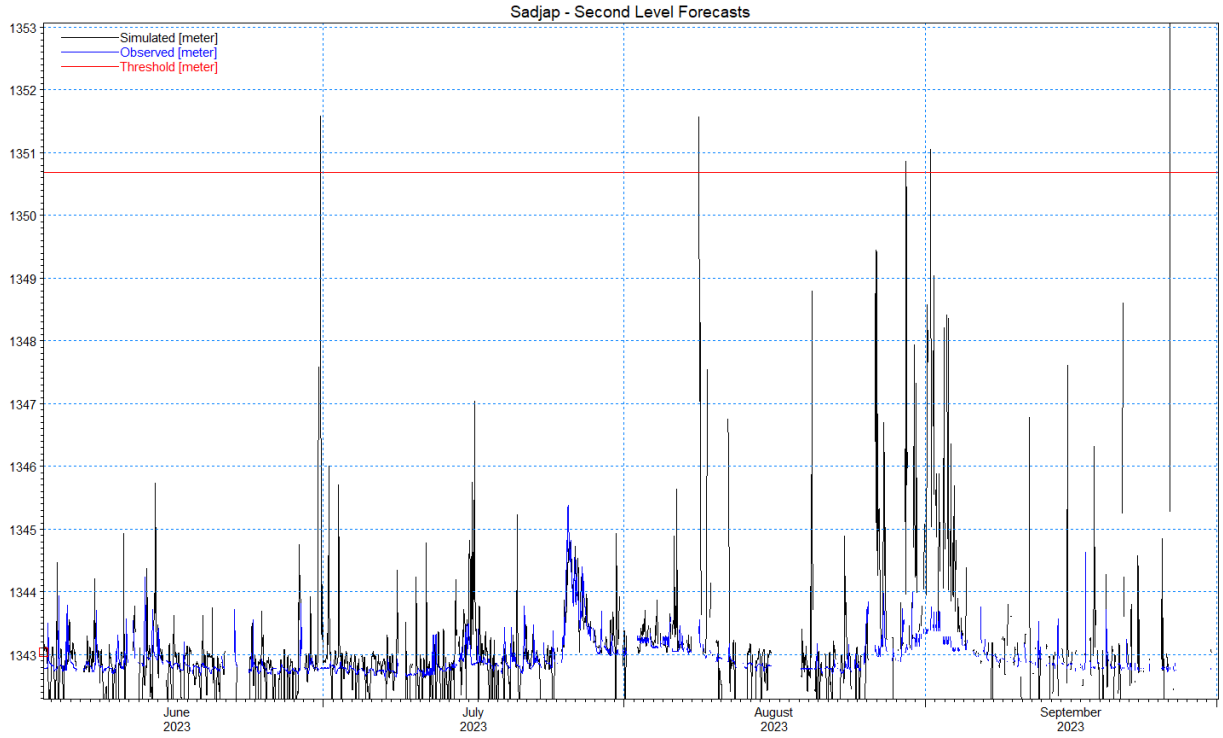


Figure A3-6 Simulated vs observed water levels for second level of forecasts at Sadjap Bridge Station
Source: Ramboll

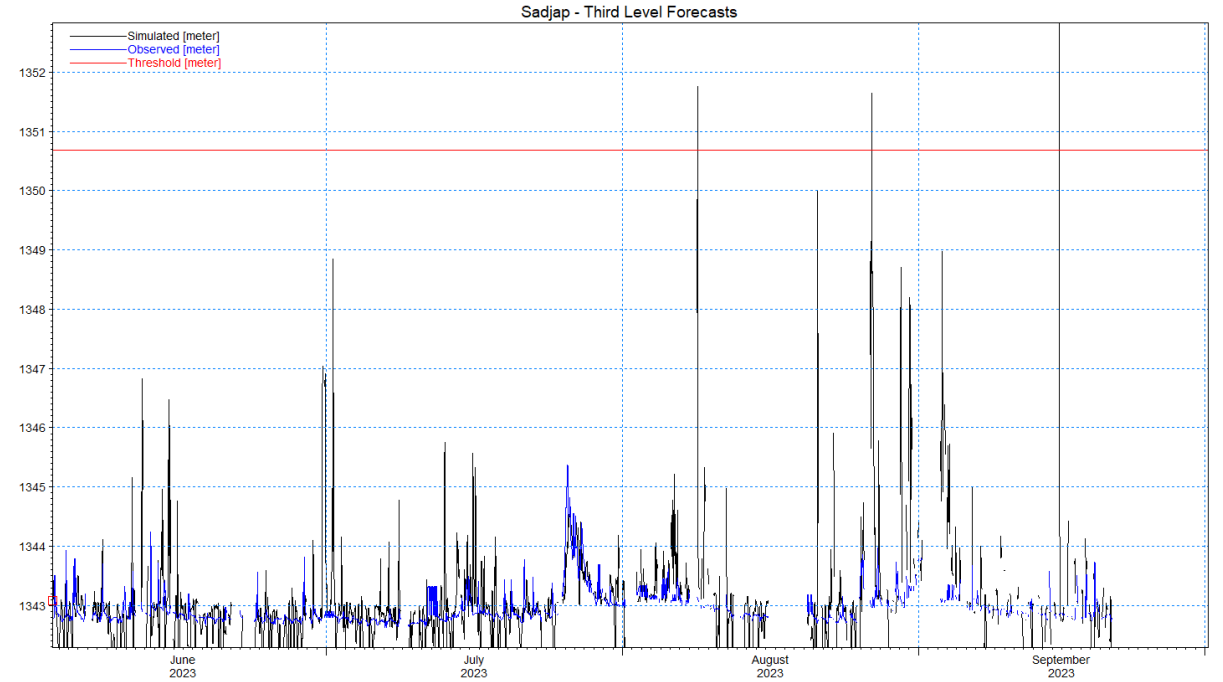


Figure A3-7 Simulated vs observed water levels for third level of forecasts at Sadjap Bridge Station
Source: Ramboll

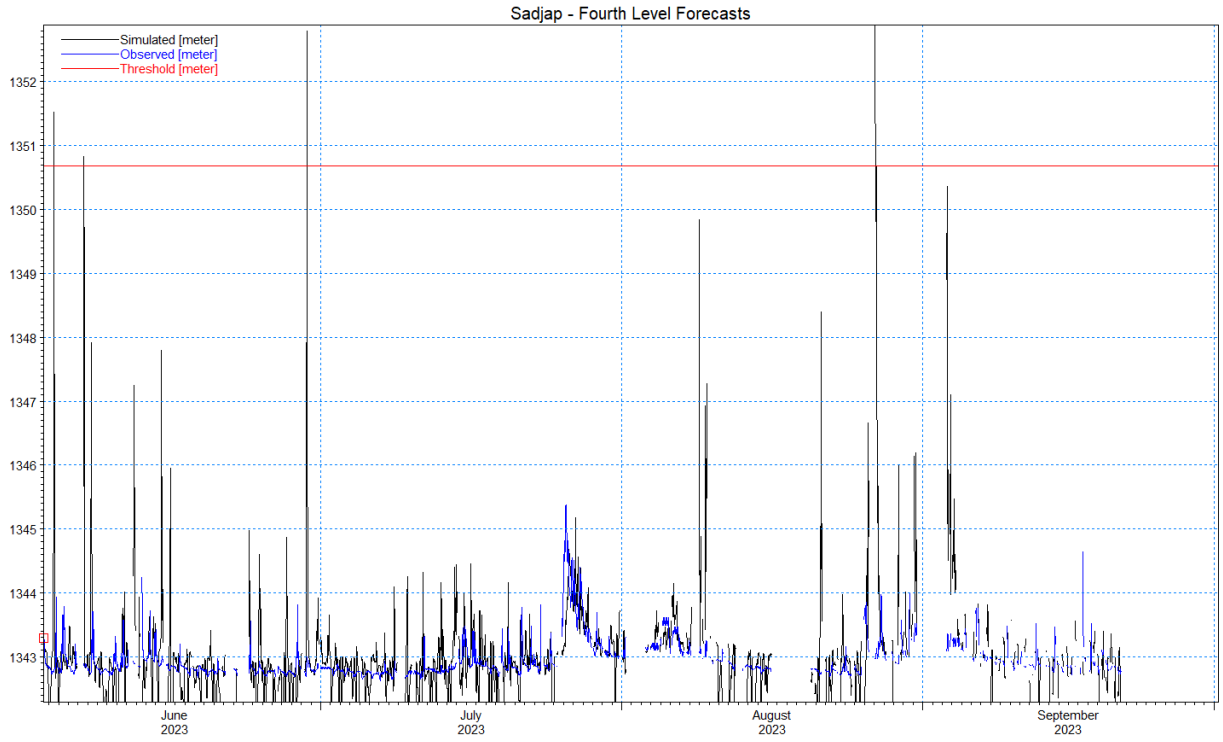


Figure A3-8 Simulated vs observed water levels for fourth level of forecasts at Sadjap Bridge Station
Source: Ramboll

3.3 MODEL PERFORMANCE AT BROOKSPOINT STATION

Table A3-3 Baguio FEWS model performance in real time during 2023 monsoon at Brookspoint Station

Level of Forecast	Time of forecast	RMSE	R^2
First	0-2 hours	0.3	0.1
Second	3-5 hours	0.53	0.1
Third	6-8 hours	0.59	0.05
Fourth	9-11 hours	0.55	0.05

Source: Ramboll

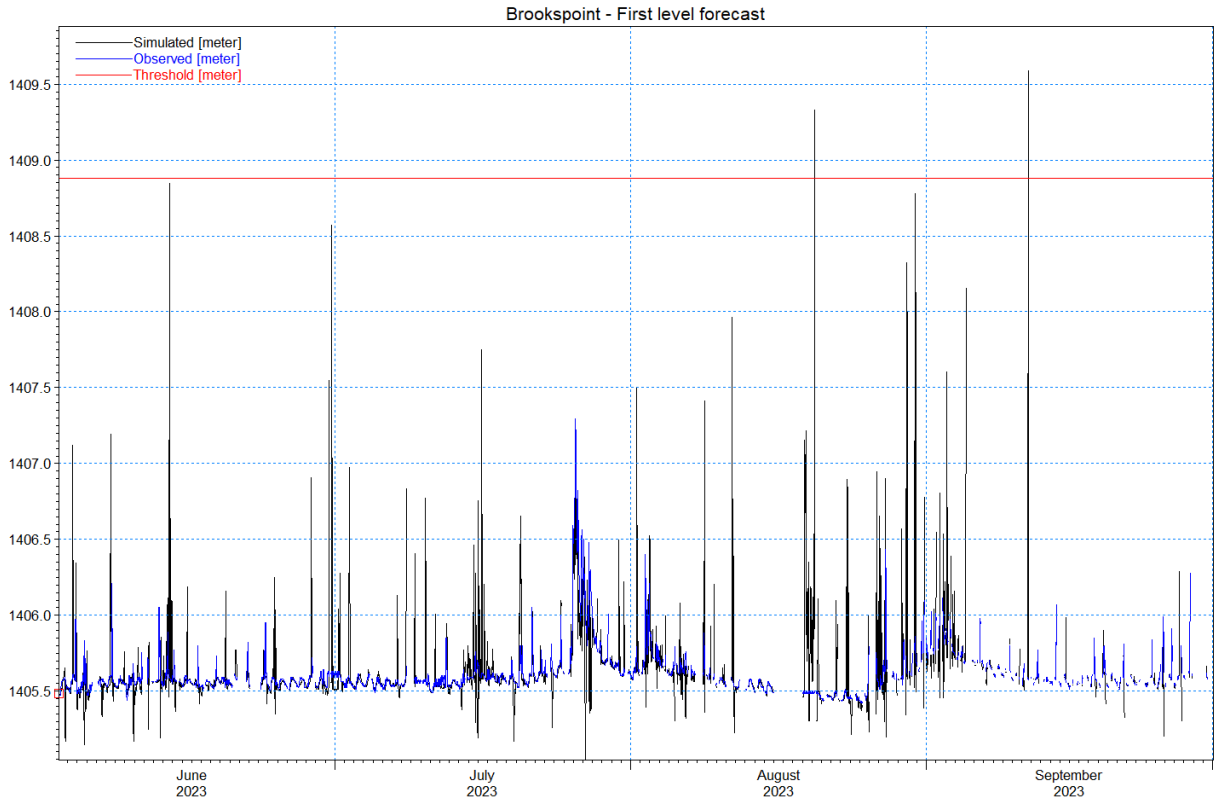


Figure A3-9 Simulated vs observed water levels for first level of forecasts at Brookspoint Station
Source: Ramboll

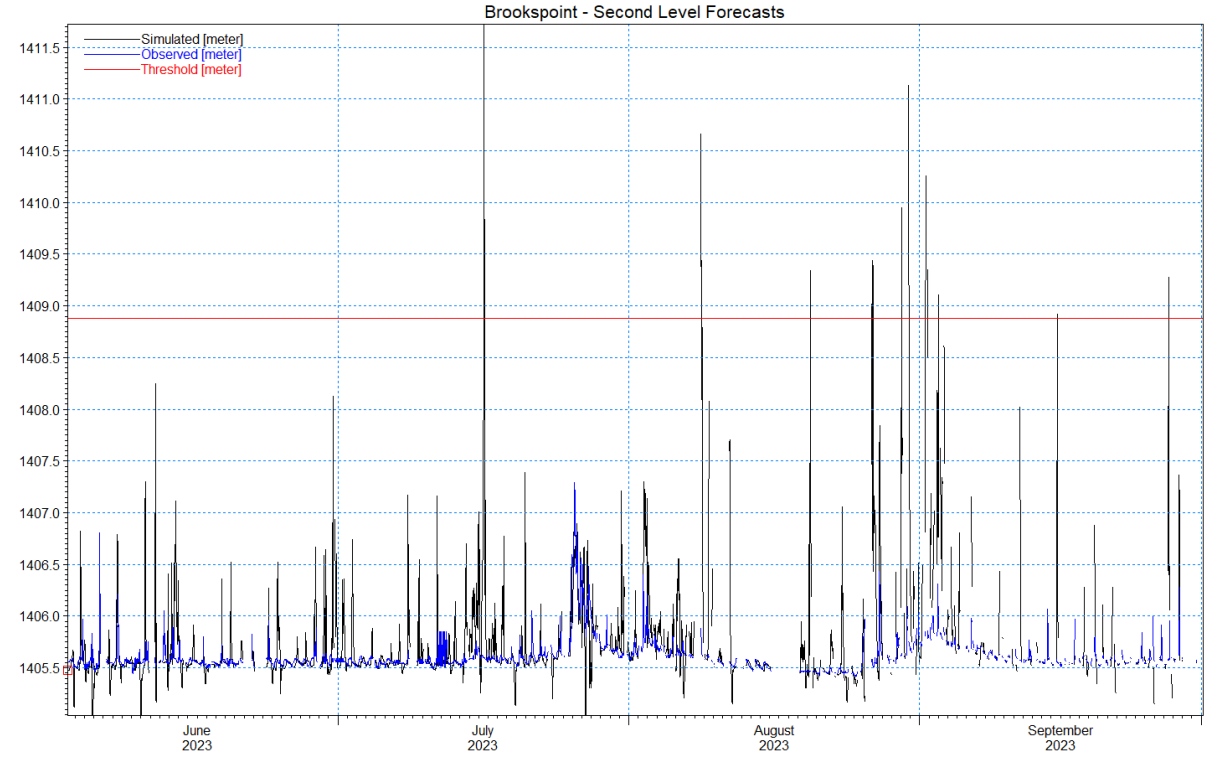


Figure A3-10 Simulated vs observed water levels for second level of forecasts at Brookspoint Station
Source: Ramboll

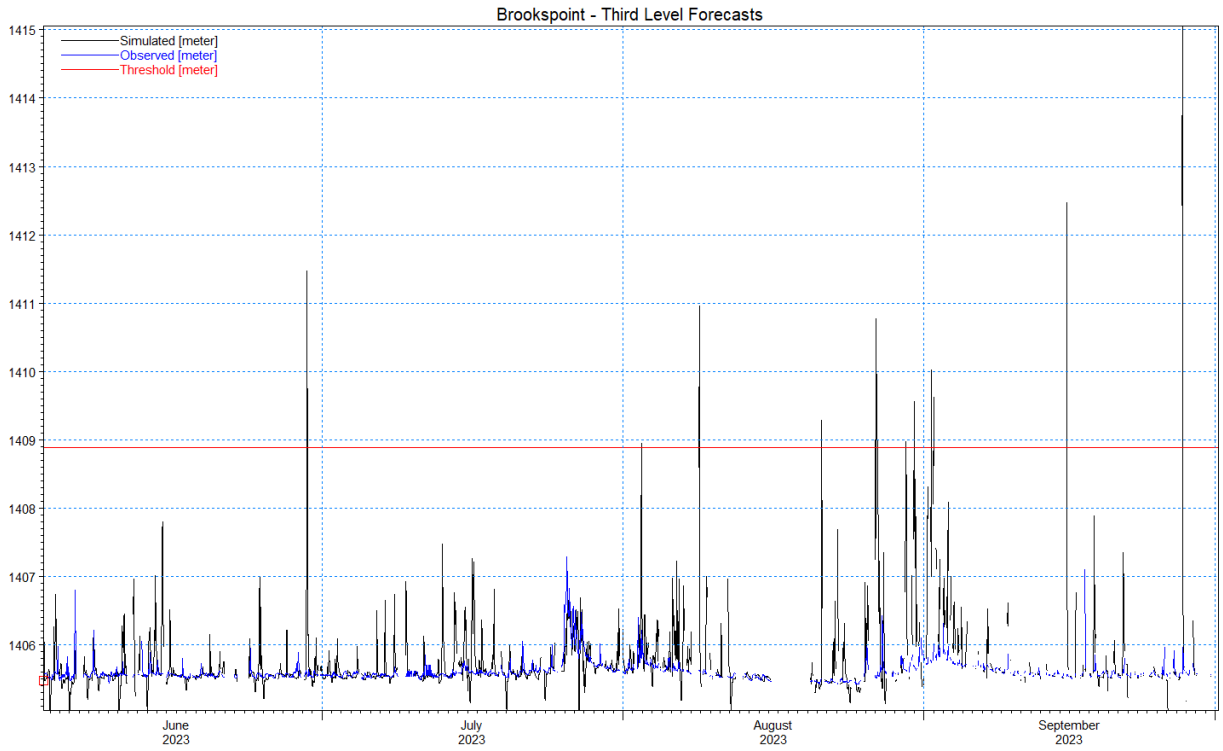


Figure A3-11 Simulated vs observed water levels for third level of forecasts at Brookspoint Station
Source: Ramboll

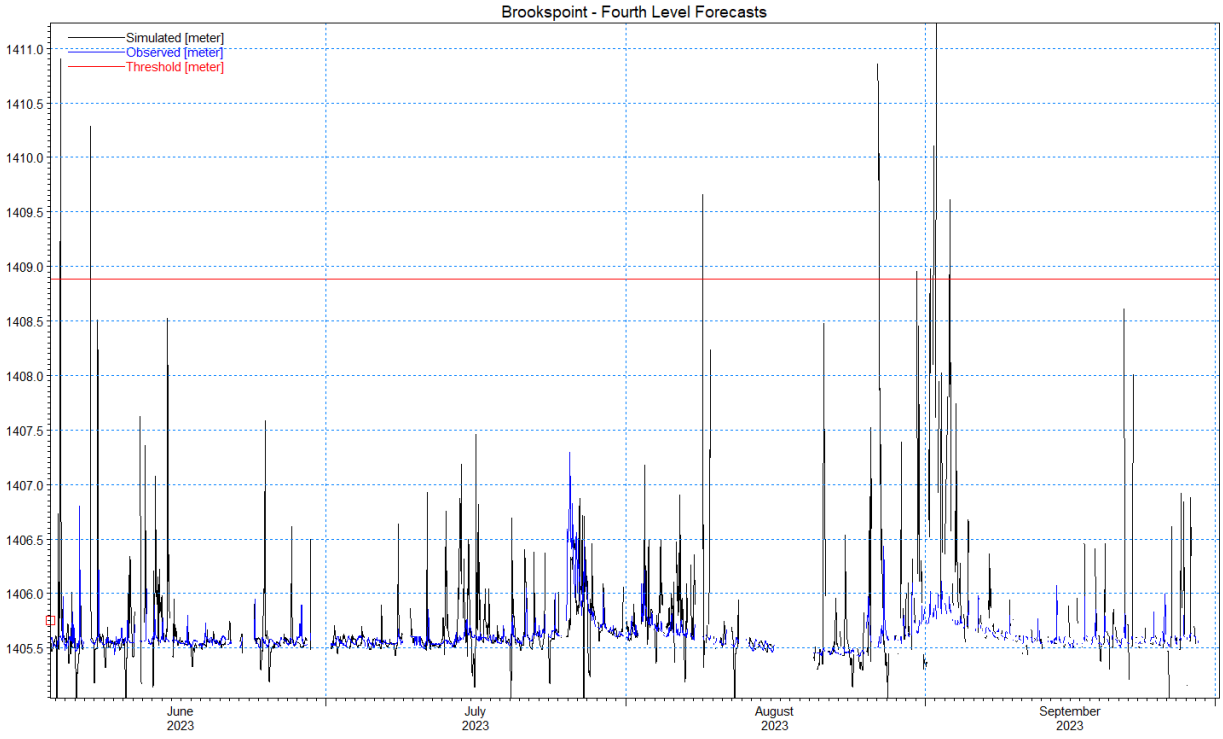


Figure A3-12 Simulated vs observed water levels for fourth level of forecasts at Brookspoint Station
Source: Ramboll

3.4 MODEL PERFORMANCE AT FERGUSON BRIDGE STATION

Table A3-4 Baguio FEWS model performance in real time during 2023 monsoon at Ferguson Bridge Station

Level of Forecast	Time of forecast	RMSE	R^2
First	0-2 hours	0.84	0.004
Second	3-5 hours	1.31	0.025
Third	6-8 hours	1.36	0.021
Fourth	9-11 hours	1.41	0.025

Source: Ramboll

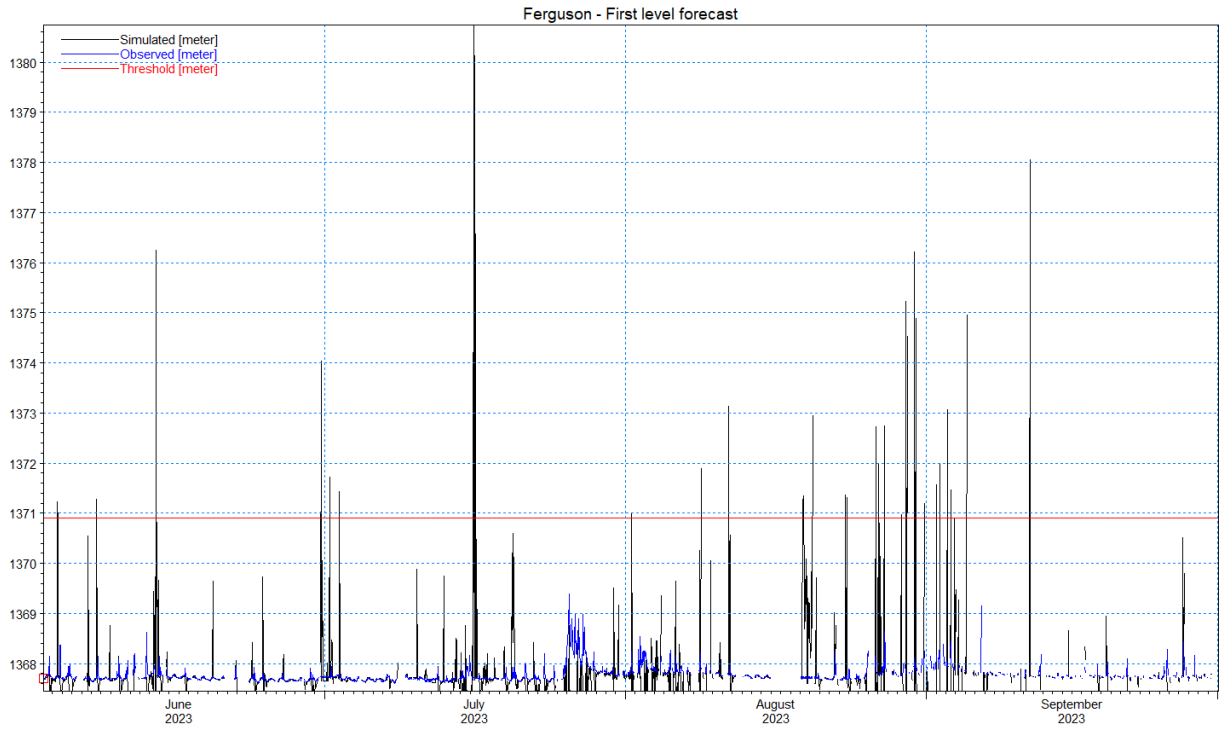


Figure A3-13 Simulated vs observed water levels for first level of forecasts at Ferguson Bridge Station
Source: Ramboll

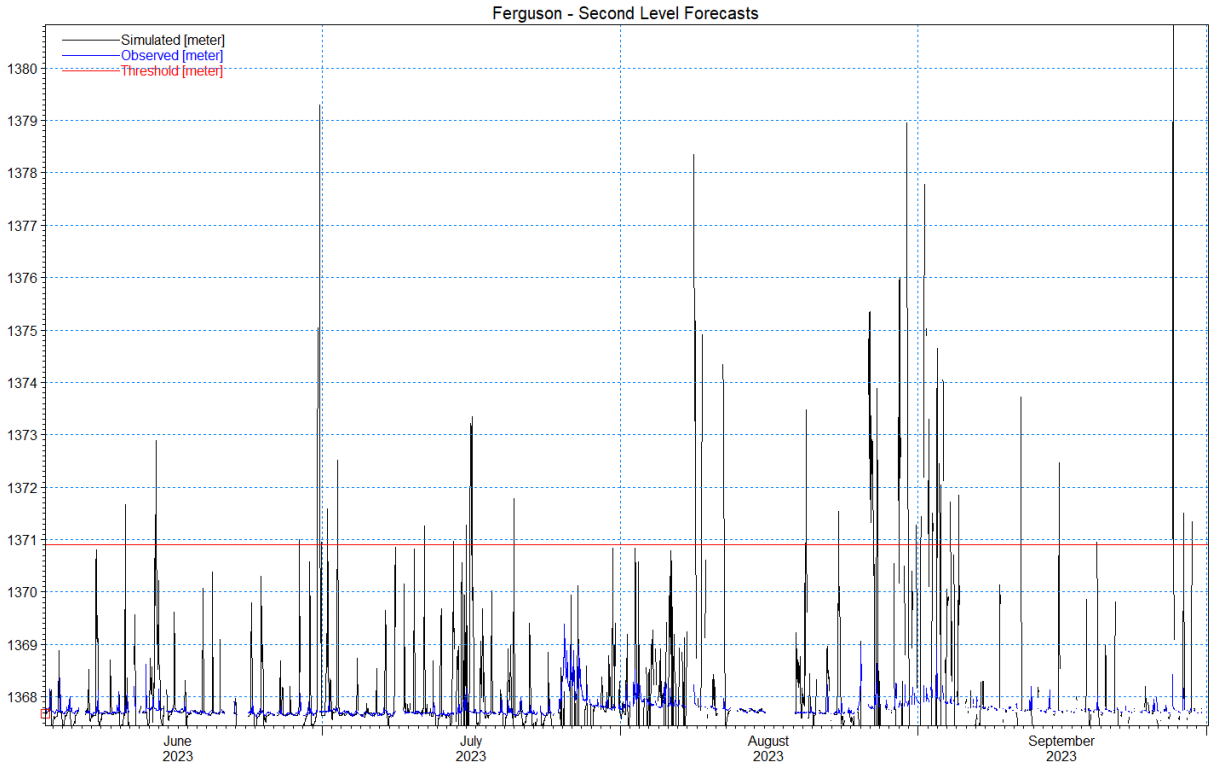


Figure A3-14 Simulated vs observed water levels for second level of forecasts at Ferguson Bridge Station
Source: Ramboll

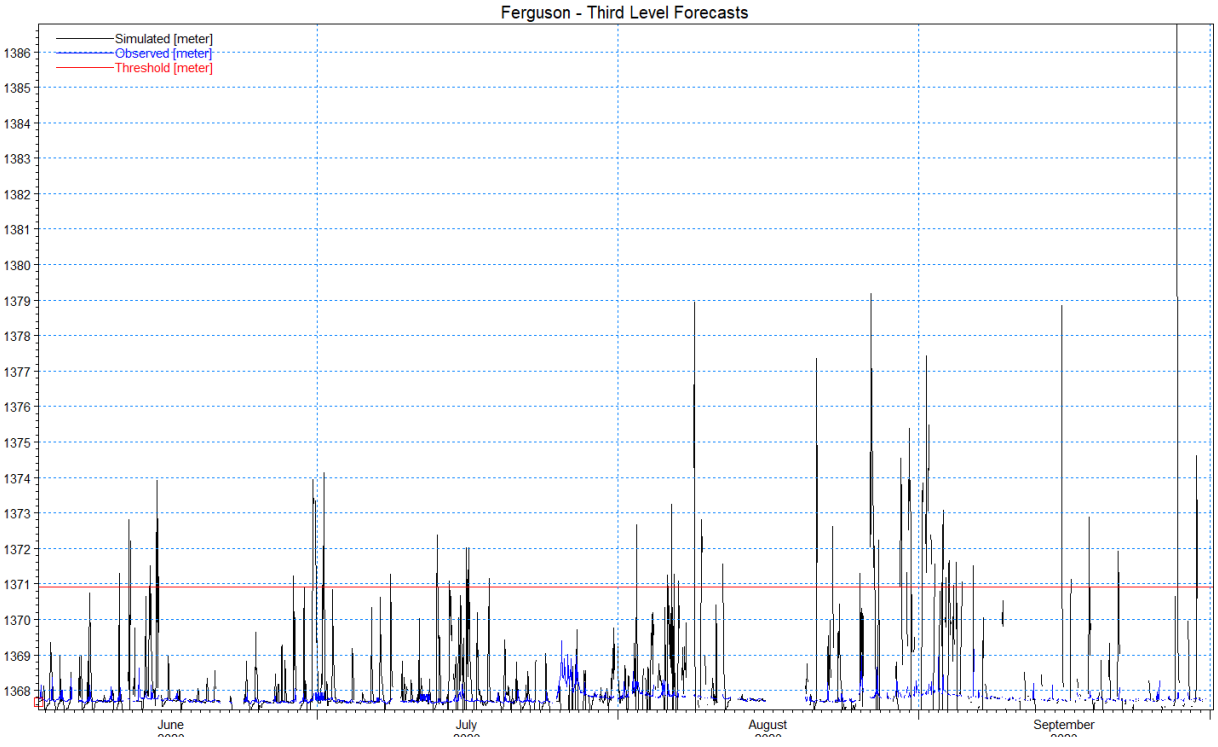


Figure A3-15 Simulated vs observed water levels for third level of forecasts at Ferguson Bridge Station
Source: Ramboll

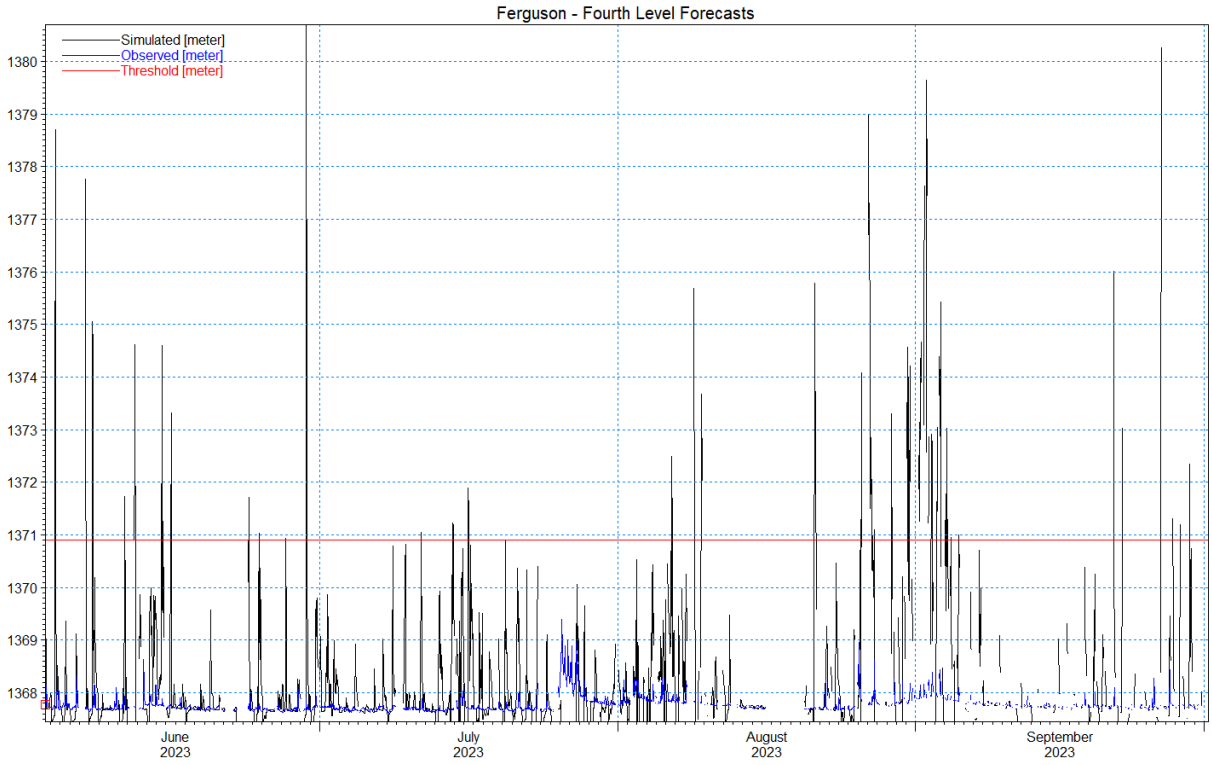


Figure A3-16 Simulated vs observed water levels for fourth level of forecasts at Ferguson Bridge Station
Source: Ramboll

Source: Baguio City Disaster Risk Reduction and Management Office

APPENDIX B
POST-MONSOON MODEL UPDATES

1 POST-MONSOON MODEL UPDATES

Model 1, which has been updated and finetuned in pre-monsoon 2023 for the Balili river, has been operated and run in 2023 monsoon in real time in the FEWS setup. Data for the new water level and rainfall stations has been collected for 2023. Using this additional data, the model has been recalibrated in the post-monsoon phase.

During the post-monsoon assessment of the model performance, it has been noted that the system generated false overtopping warnings based on forecasted water levels. As the model had been calibrated against station data and the WRF forecasted rain data is significantly larger than the observed rainfall data, it was a preliminary deduction that that the bias correction was unable to correct the WRF data to the extent required, thus causing the overpredictions.

Upon deeper assessment, it was seen that the spikes in water level data triggering the false overtopping warnings almost always occurred immediately after the time of forecast and the spikes were not predicted for the same time in the prior simulations and that the system corrected itself in the next simulation. This redirected the deduction that the false warnings were being generated due to the bias correction process not working as intended, to the conclusion that the DA process has been introducing the false initial condition of water level. This also indicated that there have been instances of sudden jumps in the observed water levels (outliers) that were not filtered by the FEWS setup. The outliers get overwritten by the scripts for the download and processing of real time data and the data corrects itself for the next simulations. SOPs have been updated to check for such outliers during the real time operation and maintenance.

Although the WRF data is seen to be giving satisfactory forecasts with the help of bias correction process and DA, the forecasts can be further improved by applying correction to WRF data prior to the same. During the recalibration of the model in the post-monsoon period, data from the new stations as well as the corrected WRF data for level 2 to 4 have been used as input rain in separate scenarios such that the model parameters remain the same while giving the best possible correlations between the modelled and simulated water-levels in all cases.

The recalibrated model performs very well with the observed rain as input and also the corrected forecasted rainfall as input indicating that the forecasted water levels can be expected to be further improved for 3 levels of forecast (up to 9 hours after time of forecast). The performance of the recalibrated model is further described in the subsections below.

To compare performance of the model calibrations, the processes of bias correction and DA are assessed separately.

1.1 Updates to NAM and HD parameters

The NAM parameters of all scenarios are indicated in table below.

Table B1-1 Recalibrated NAM parameters for the Balili sub-catchments

Name	Area	Umax	LMAX	CQOF	CKIF	CKI	CK2	TOF	TIG	TG
Catchment 1	2.4503	10	50	0.95	50	0.1	5	0	0	0
Catchment 2	2.5585	350	4700	0.2	500	1	0.1	0	0.5	0
Catchment 3	8.6313	5	300	0.4	700	0	10	0	0.5	0
Catchment 4	16.155	1	300	0.99	300	1	10	0	0	0

Source: Ramboll

The resistance numbers Manning's M is indicated in table below.

Table B1-2 Manning's M per branch

Branch Name	Chainage	Manning's M
Balili_Branch2	0	28
Balili_Branch2	5000	28
Balili_Branch2	6000	40
Balili_Branch2	9000	40
Balili_Branch1	0	25
Balili_Branch1	499	25

Source: Ramboll

1.2 Calibration results

1.2.1 Ferguson Station

The Ferguson Station is at chainage zero of the tributary defined in the Balili river model setup. Figure B1-1 shows the calibration plot when the model is run with only observed rainfall data. Figure B1-2 and Figure B1-7 show how the correlation between the observed data and simulated data improves when corrected forecast rainfall is used in place of the uncorrected forecast rainfall.

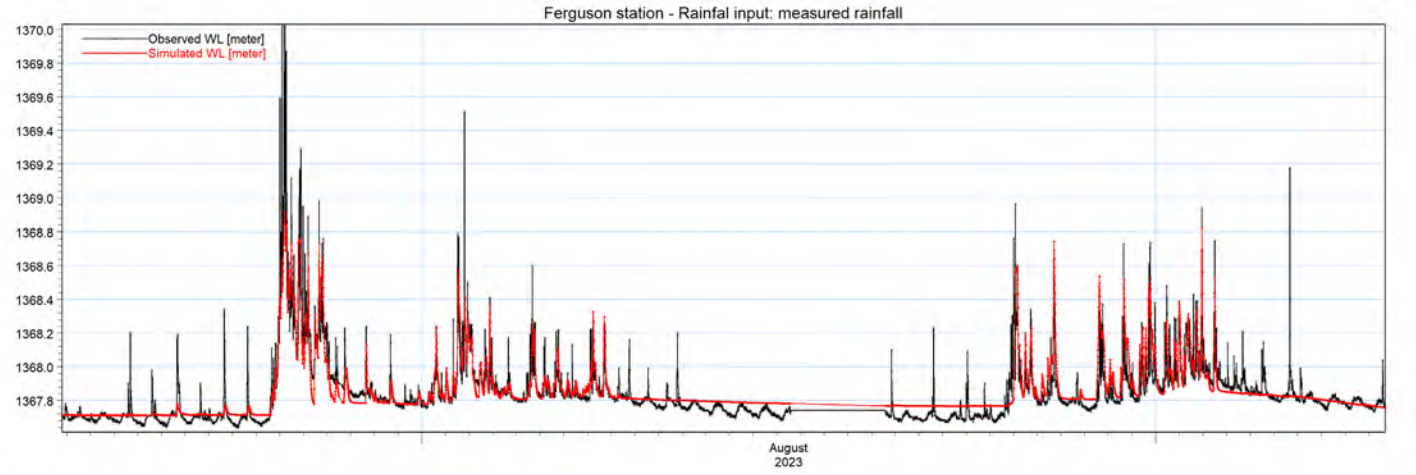


Figure B1-1 Ferguson station plot: measured rainfall as input
Source: Ramboll

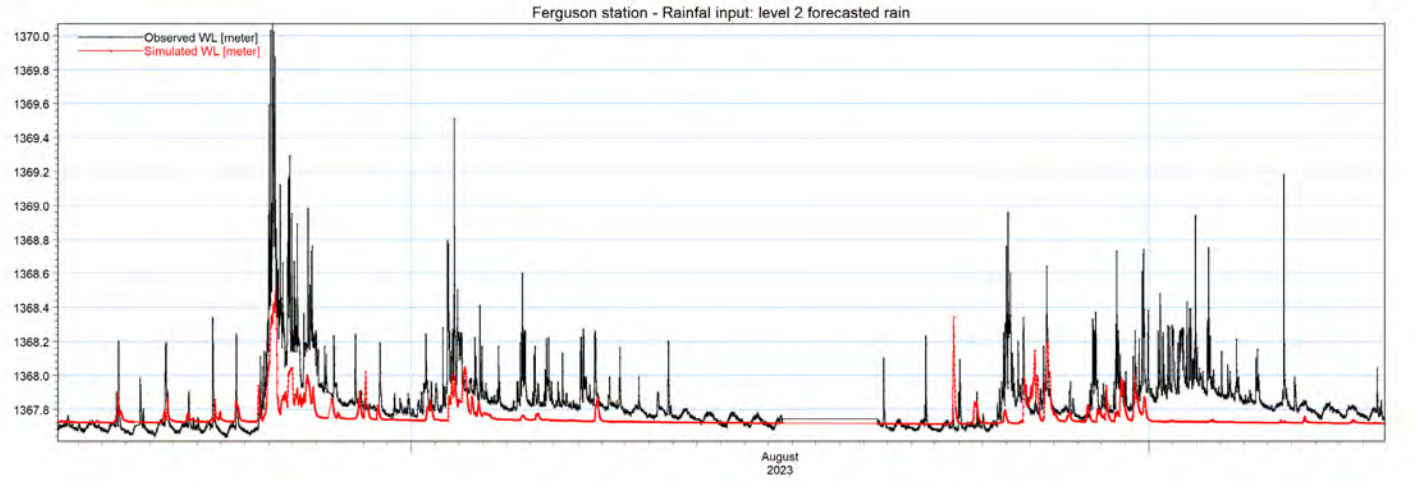


Figure B1-2 Ferguson station plot: level 2 forecasted rainfall as input
Source: Ramboll

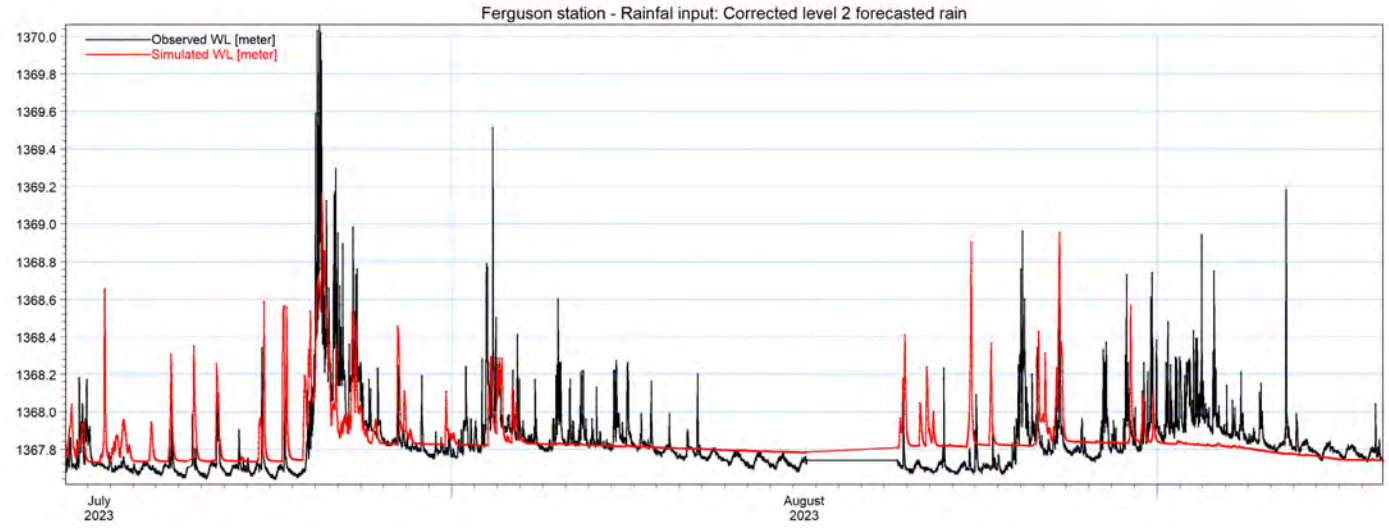


Figure B1-3 Ferguson station plot: level 2 corrected forecasted rainfall as input
Source: Ramboll

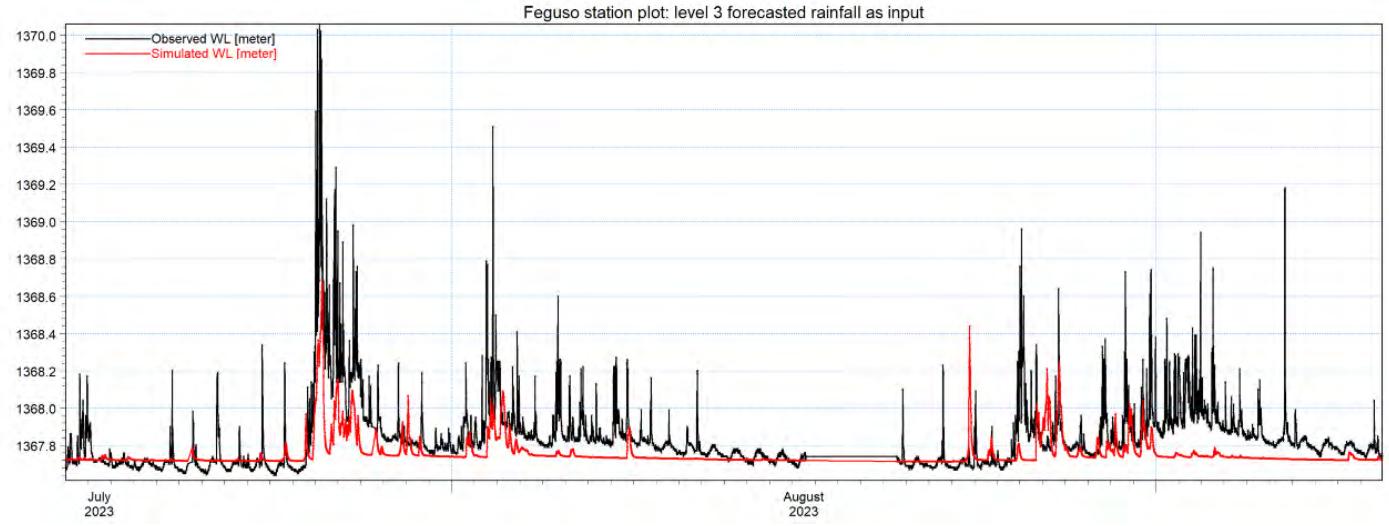


Figure B1-4 Ferguson station plot: level 3 forecasted rainfall as input
Source: Ramboll

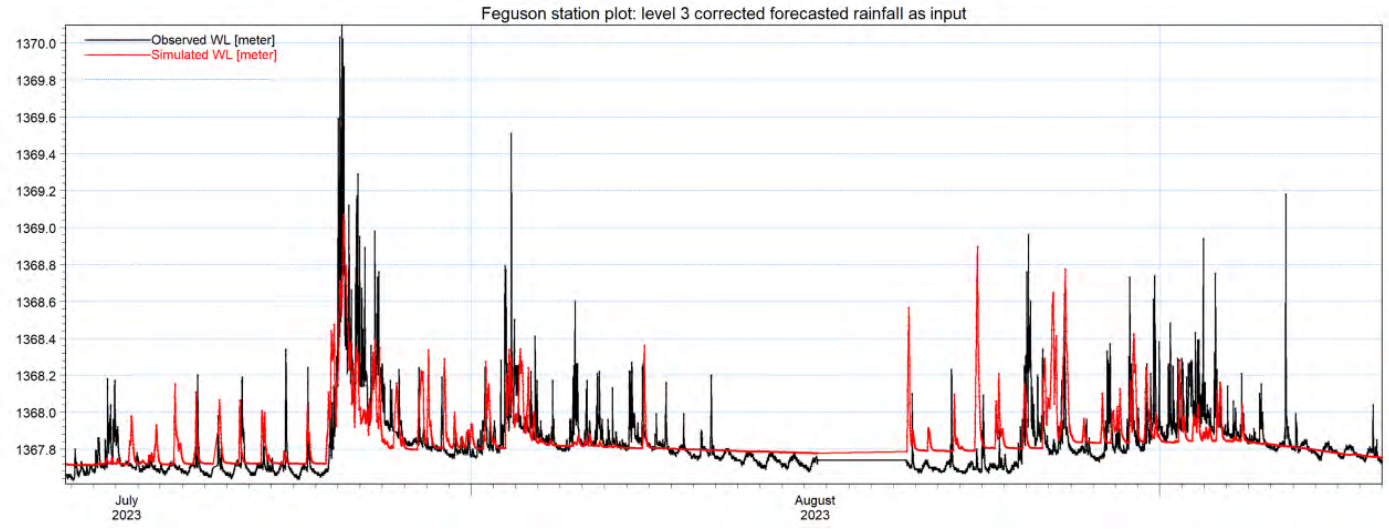


Figure B1-5 Ferguson station plot: level 3 corrected forecasted rainfall as input
Source: Ramboll

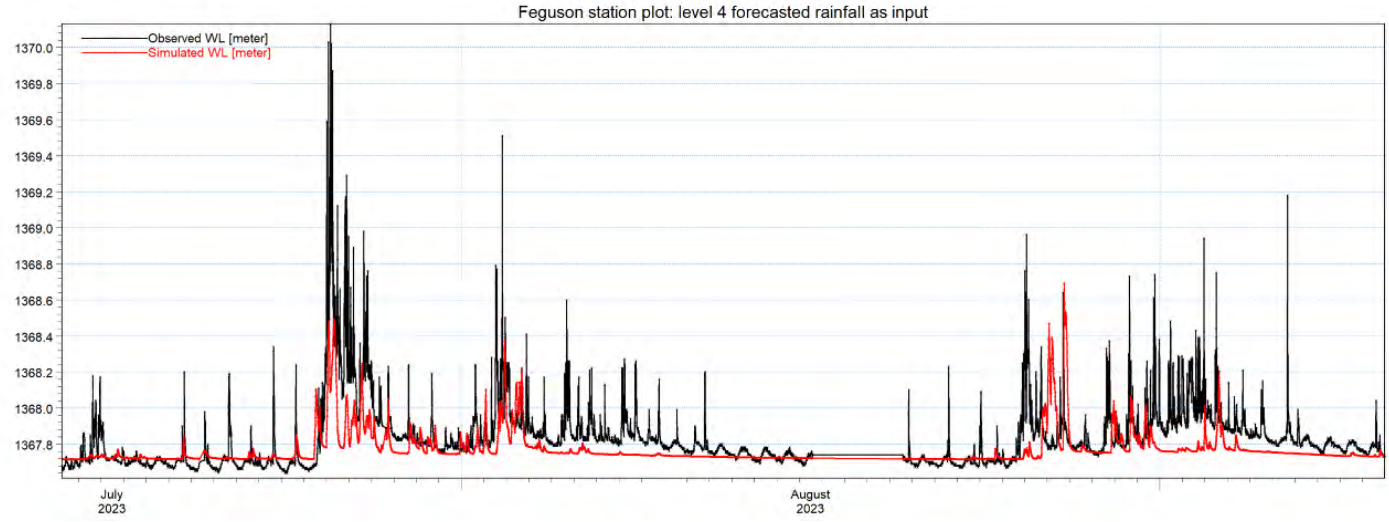


Figure B1-6 Ferguson station plot: level 4 forecasted rainfall as input
Source: Ramboll

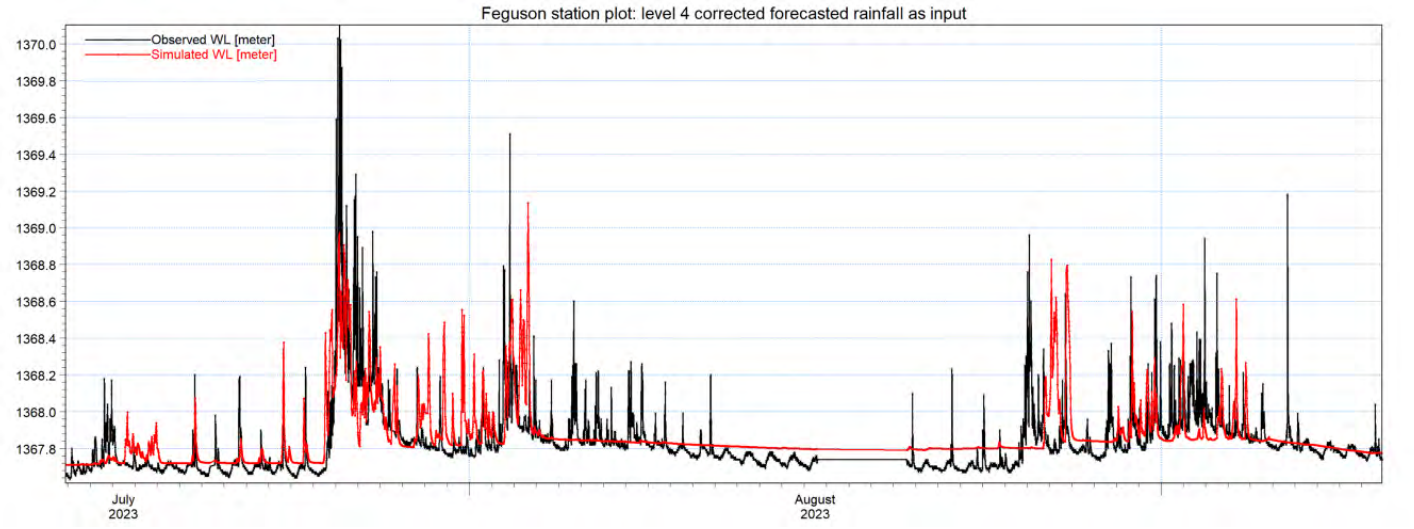


Figure B1-7 Ferguson station plot: level 4 corrected forecasted rainfall as input
Source: Ramboll

Table B1-3 Ferguson station: comparison of correlation for various rainfall inputs

Rainfall input	Root Mean Square Error	Coefficient of Determination	Index of Agreement
Stations observed rain	0.09	0.73	0.92
Level 2 forecasted rain	0.15	0.33	0.58
Corrected level 2 forecasted rain	0.14	0.33	0.73
Level 3 forecasted rain	0.15	0.36	0.61
Corrected level 3 forecasted rain	0.14	0.39	0.77
Level 4 forecasted rain	0.15	0.28	0.62
Corrected level 4 forecasted rain	0.15	0.37	0.75

Source: Ramboll

1.2.2 Brookspoint station

The Brookspoint station is at chainage zero of the main Balili river in the model setup. The Figure B1-8 is the calibration plot when the model is run with only observed rainfall data. Figure B1-9 to Figure B1-10 show how the correlation between the observed data and simulated data improves when corrected forecast rainfall is used in place of the uncorrected forecast rainfall.

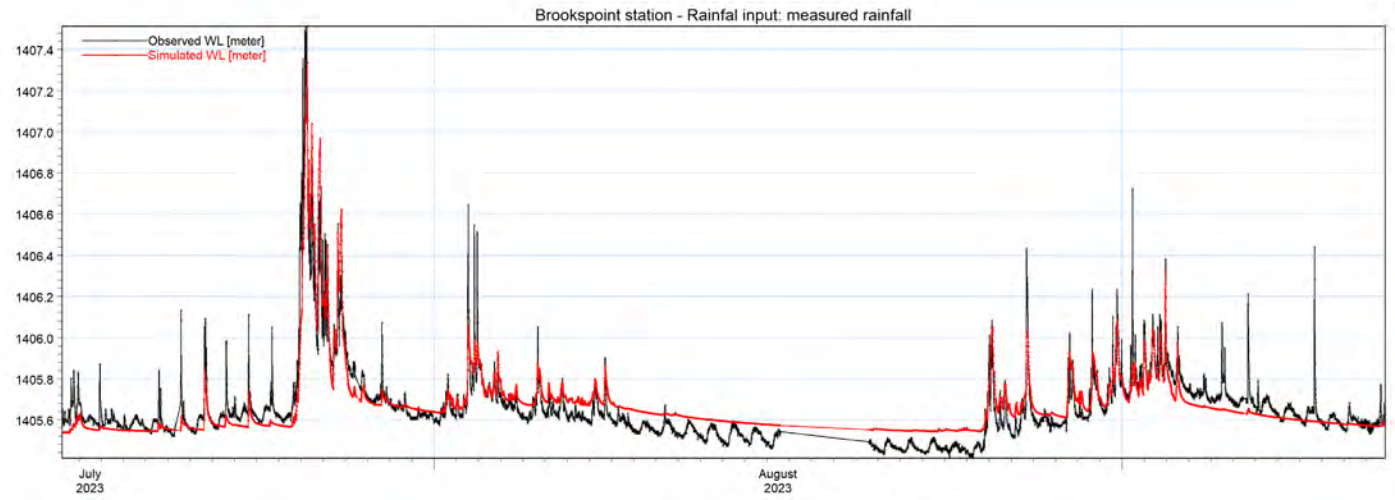


Figure B1-8 Brookspoint station plot: measured rainfall as input
Source: Ramboll

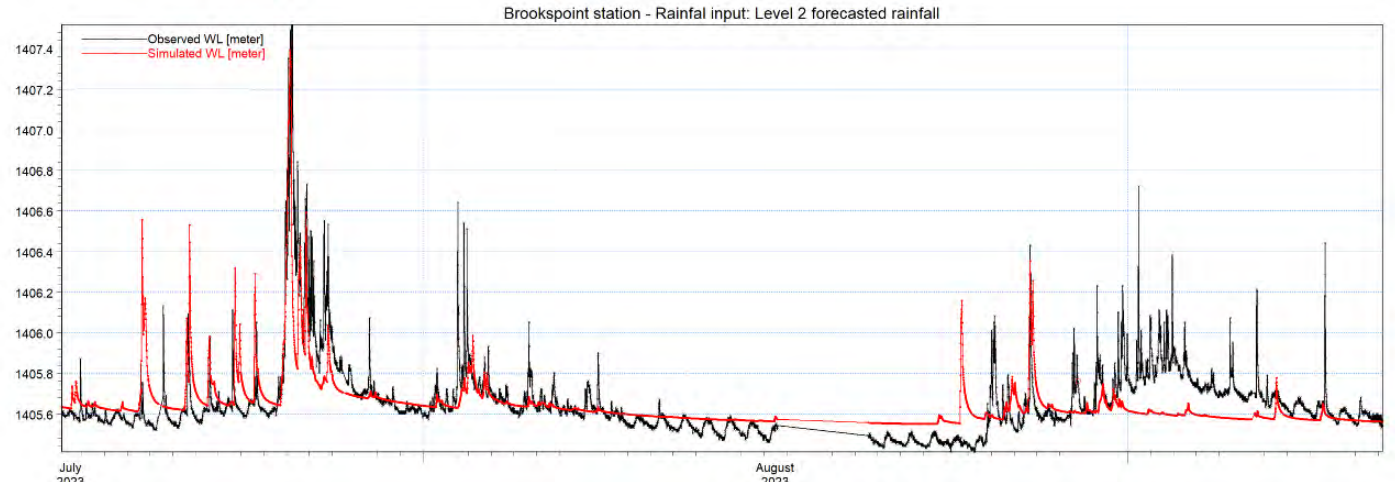


Figure B1-9 Brookspoint station plot: level 2 forecasted rainfall as input
Source: Ramboll

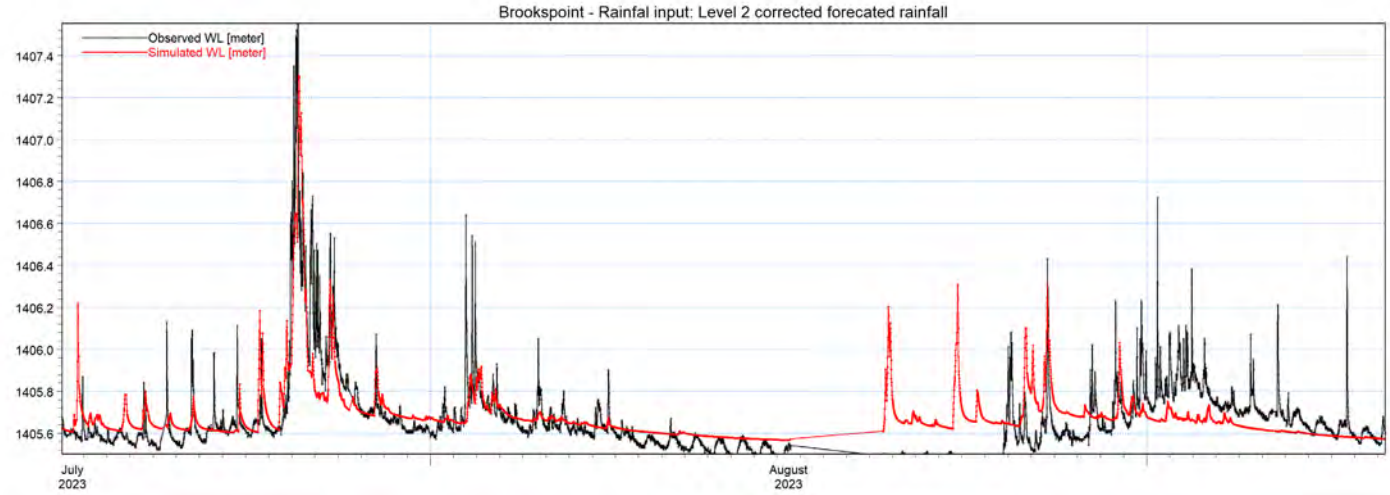


Figure B1-10 Brookspoint station plot: level 2 corrected forecasted rainfall as input
Source: Ramboll

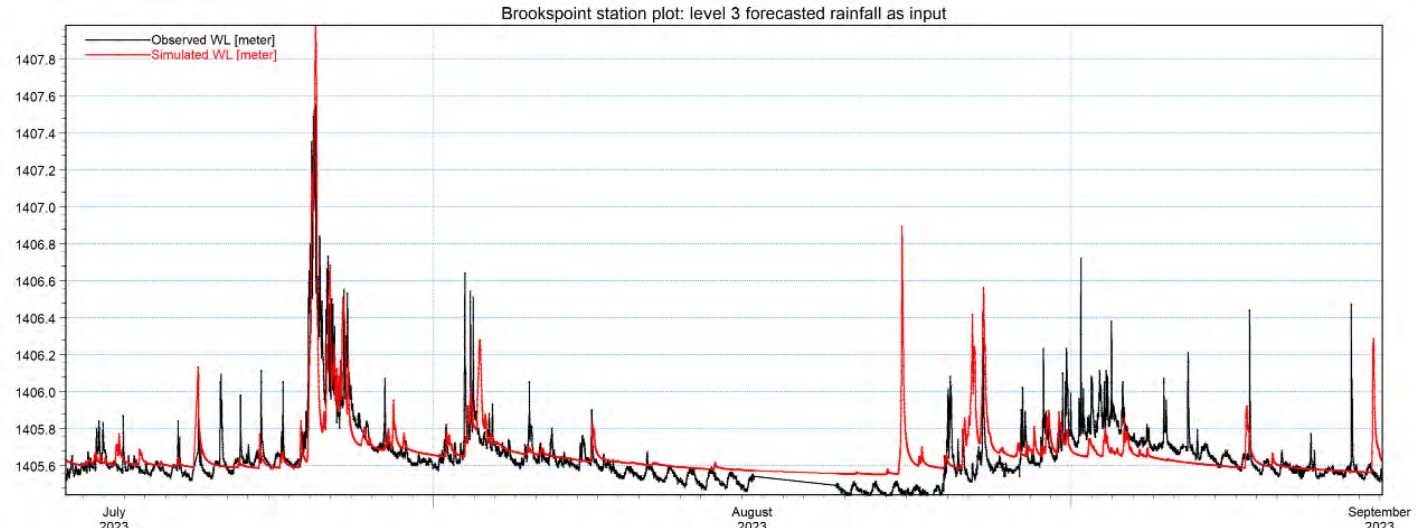


Figure B1-11 Brookspoint station plot: level 3 forecasted rainfall as input
Source: Ramboll

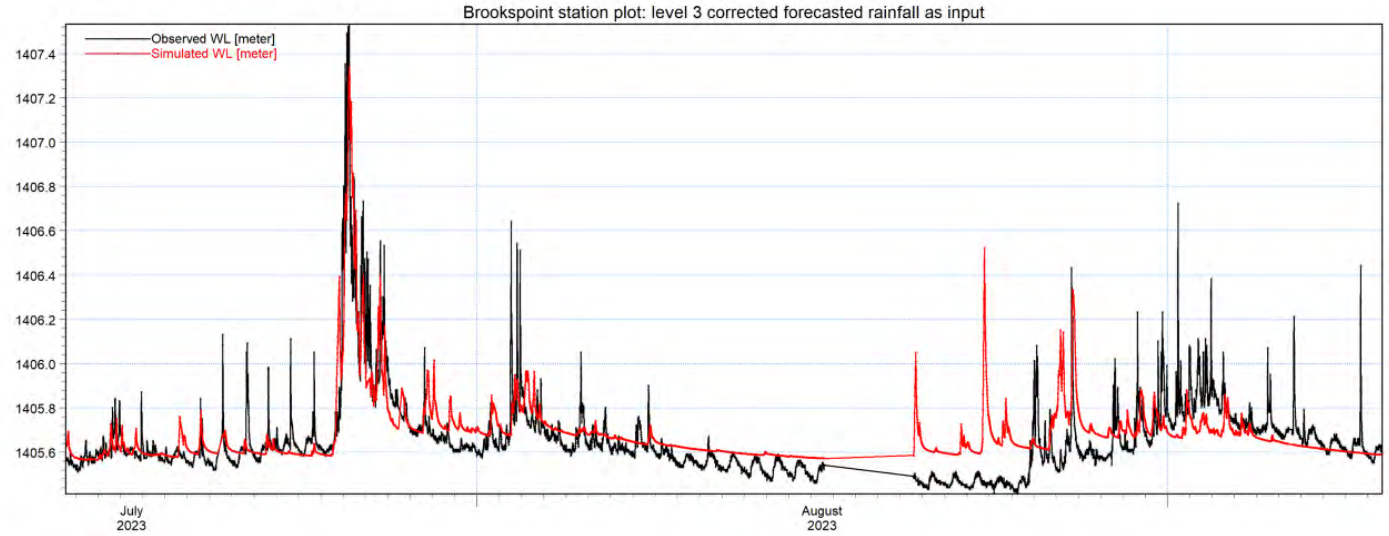


Figure B1-12 Brookspoint station plot: level 3 corrected forecasted rainfall as input

Source: Ramboll

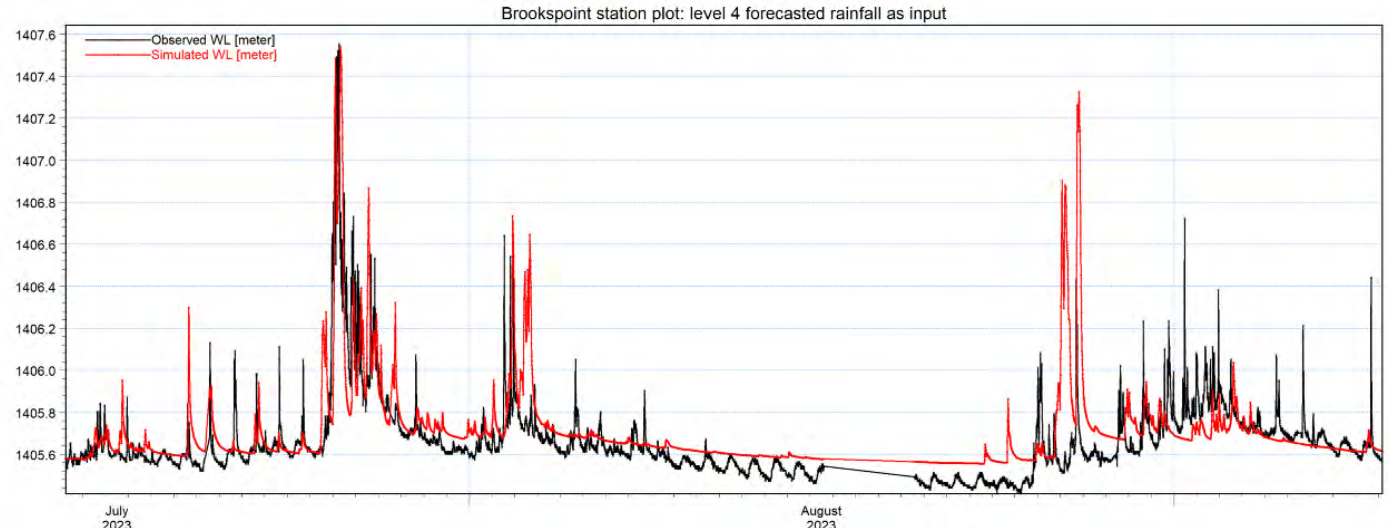


Figure B1-13 Brookspoint station plot: level 4 forecasted rainfall as input

Source: Ramboll

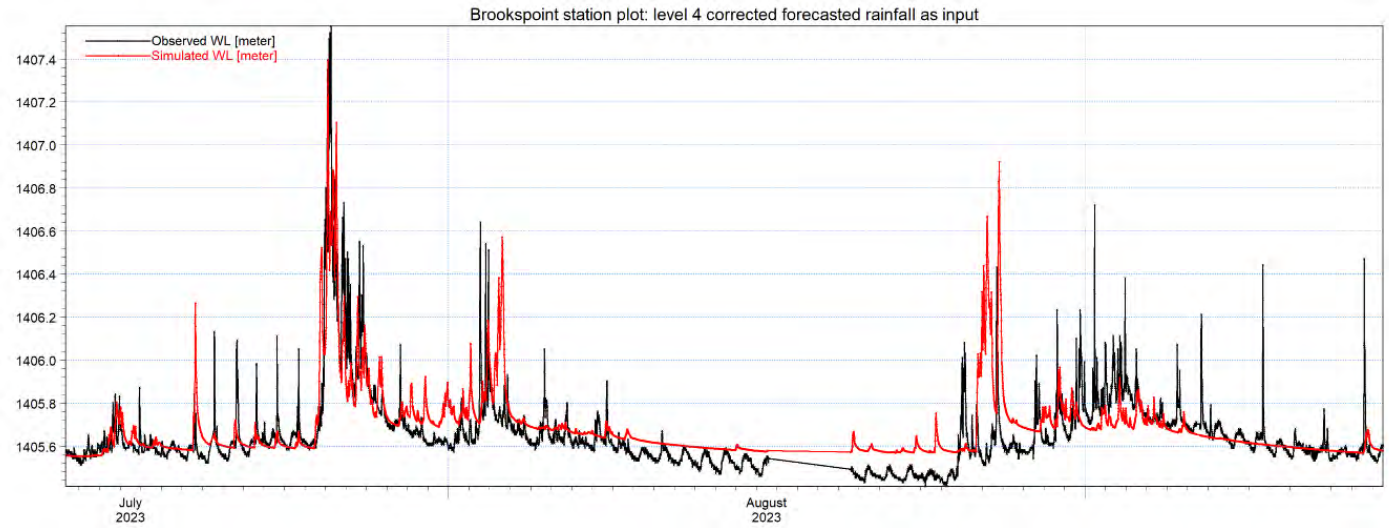


Figure B1-14 Brookspoint station plot: level 4 corrected forecasted rainfall as input
Source: Ramboll

Table B1-4 Brookspoint station: comparison of correlation for various rainfall inputs

Rainfall input	Root Mean Square Error	Coefficient of Determination	Index of Agreement
Stations observed rain	0.08	0.76	0.93
Level 2 forecasted rain	0.17	0.23	0.67
Corrected level 2 forecasted rain	0.14	0.40	0.77
Level 3 forecasted rain	0.14	0.43	0.80
Corrected level 3 forecasted rain	0.12	0.53	0.84
Level 4 forecasted rain	0.18	0.34	0.73
Corrected level 4 forecasted rain	0.14	0.43	0.79

Source: Ramboll

1.2.3 Sadjap station

Sadjap station is located a little downstream of the confluence point of the main Balili river. The Figure B1-15 is the calibration plot when the model is run with only observed rainfall data. Figure B1-16 and Figure B1-21 show how the correlation between the observed data and simulated data improves when corrected forecast rainfall is used in place of the uncorrected forecast rainfall.

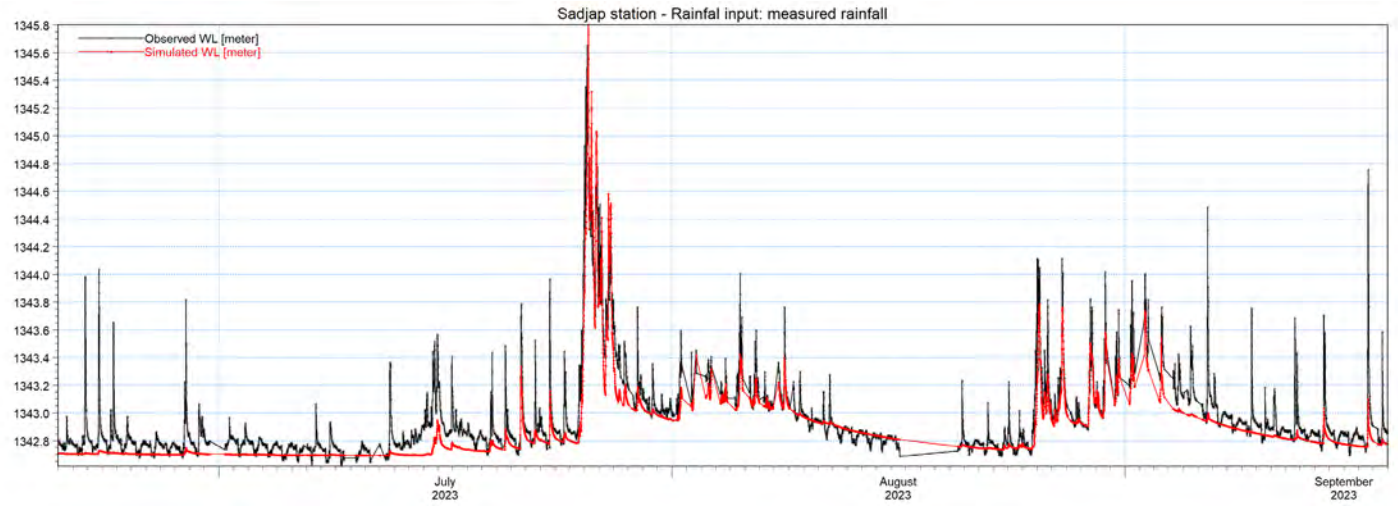


Figure B1-15 Sadjap station plot: measured rainfall as input
Source: Ramboll

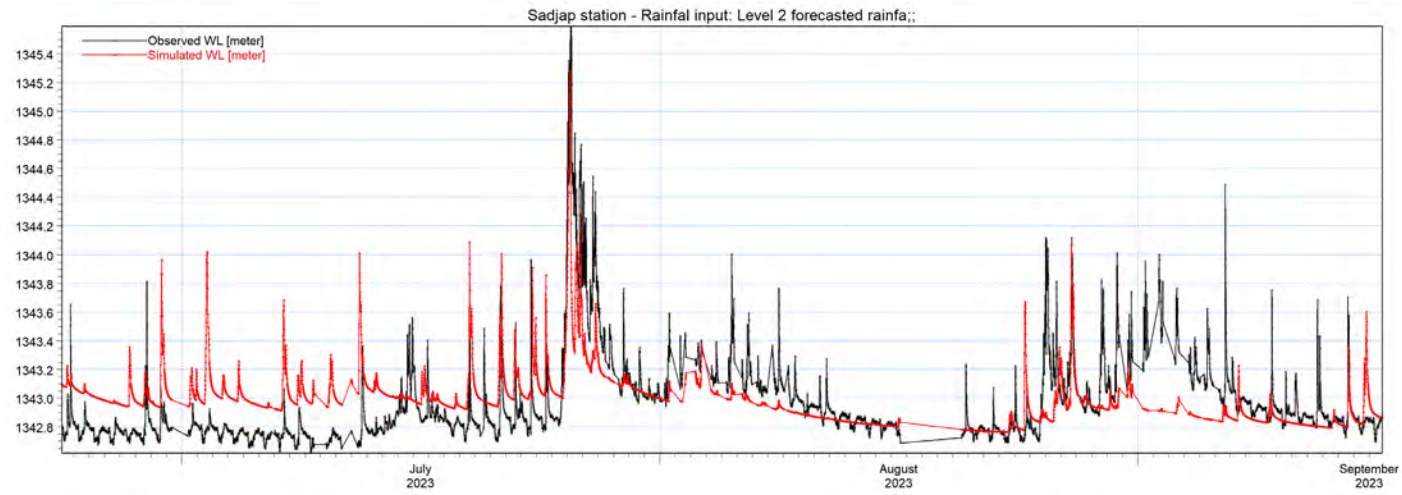


Figure B1-16 Sadjap station plot: level 2 forecasted rainfall as input
Source: Ramboll

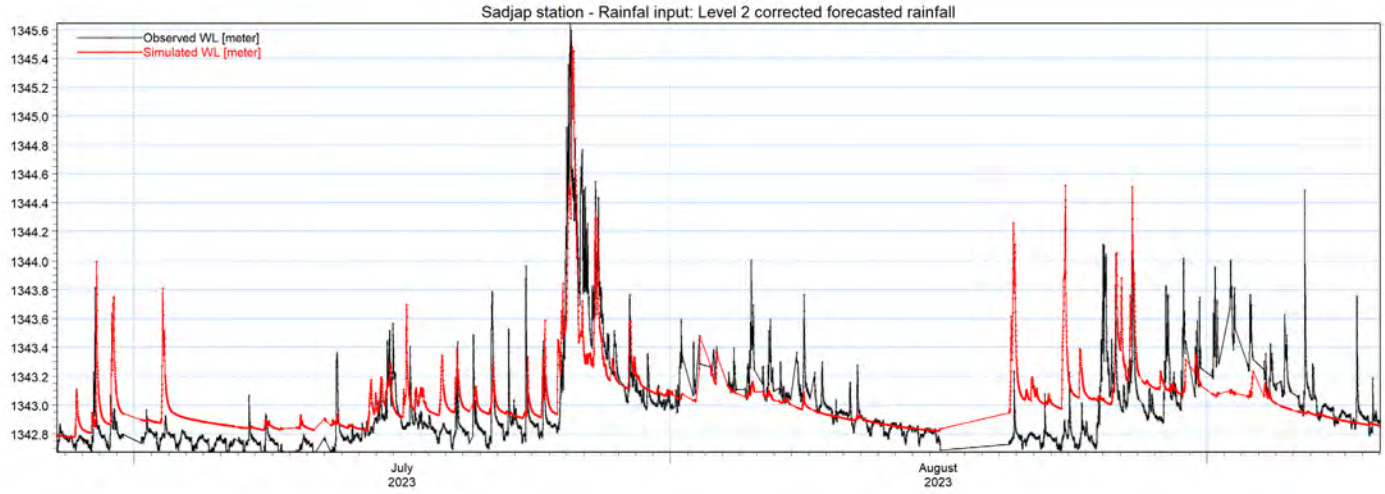


Figure B1-17 Sadjap station plot: level 2 corrected forecasted rainfall as input
Source: Ramboll

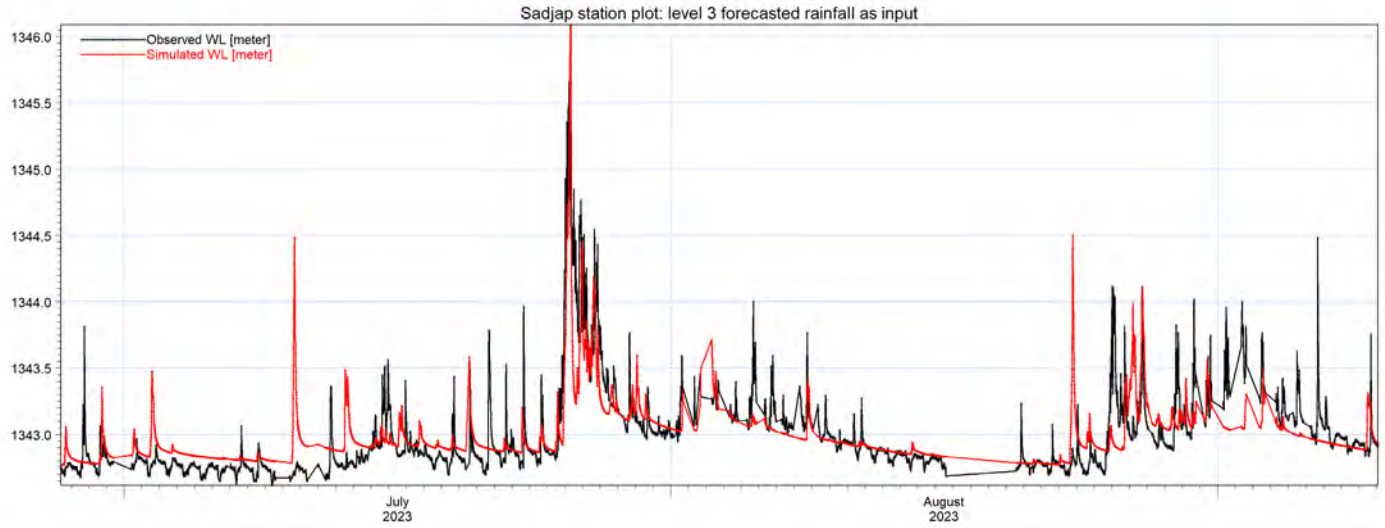


Figure B1-18 Sadjap station plot: level 3 forecasted rainfall as input
Source: Ramboll

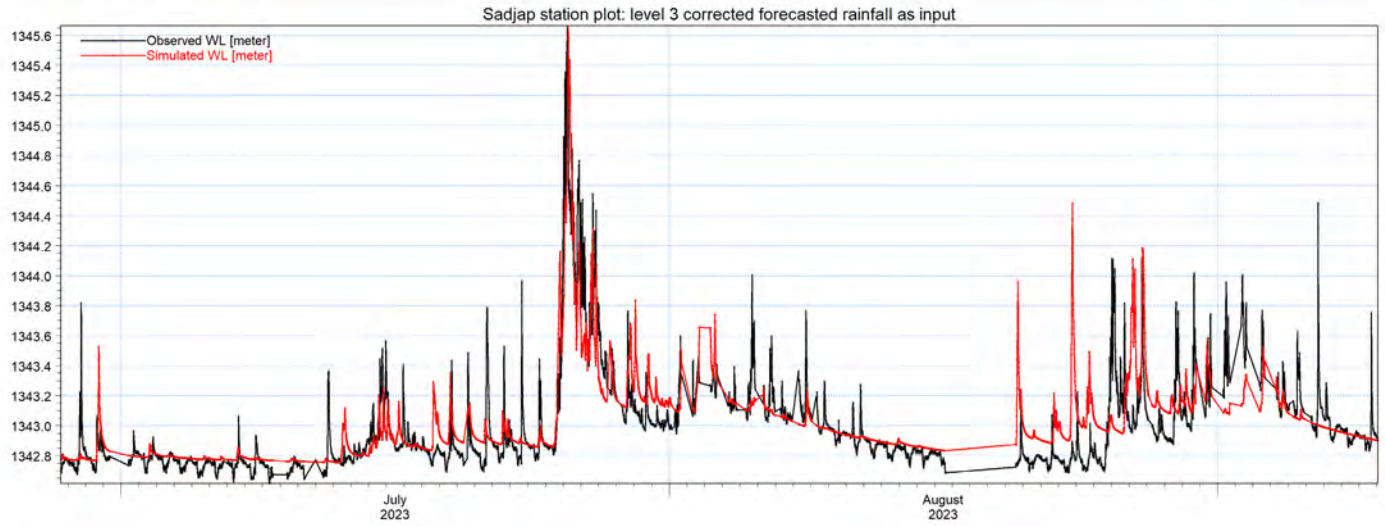


Figure B1-19 Sadjap station plot: level 3 corrected forecasted rainfall as input
Source: Ramboll

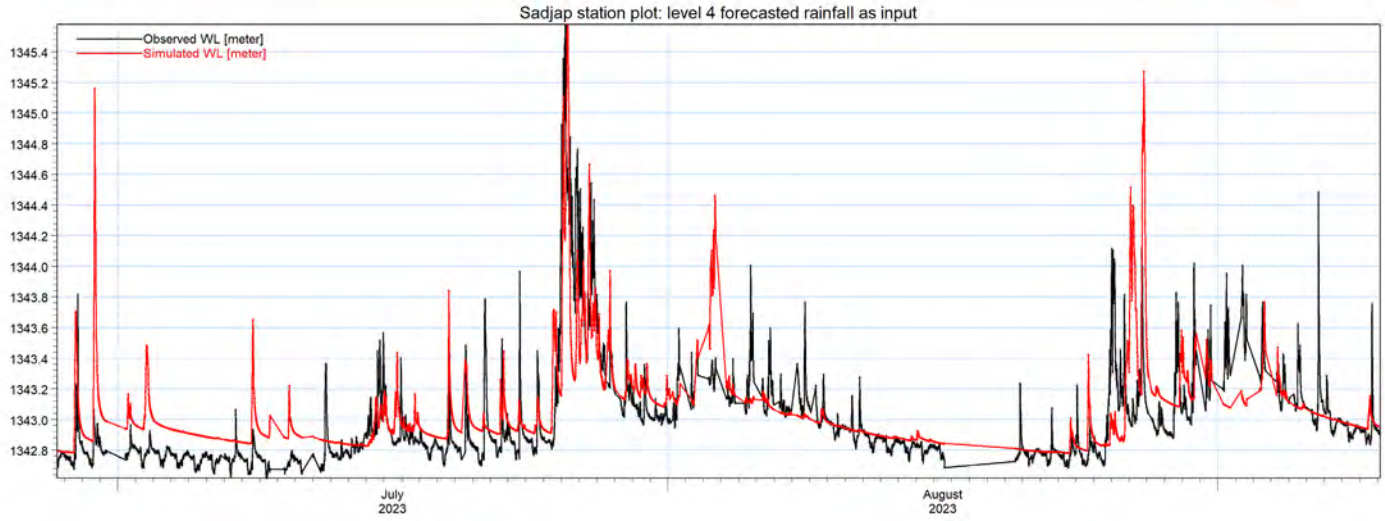


Figure B1-20 Sadjap station plot: level 4 forecasted rainfall as input
Source: Ramboll

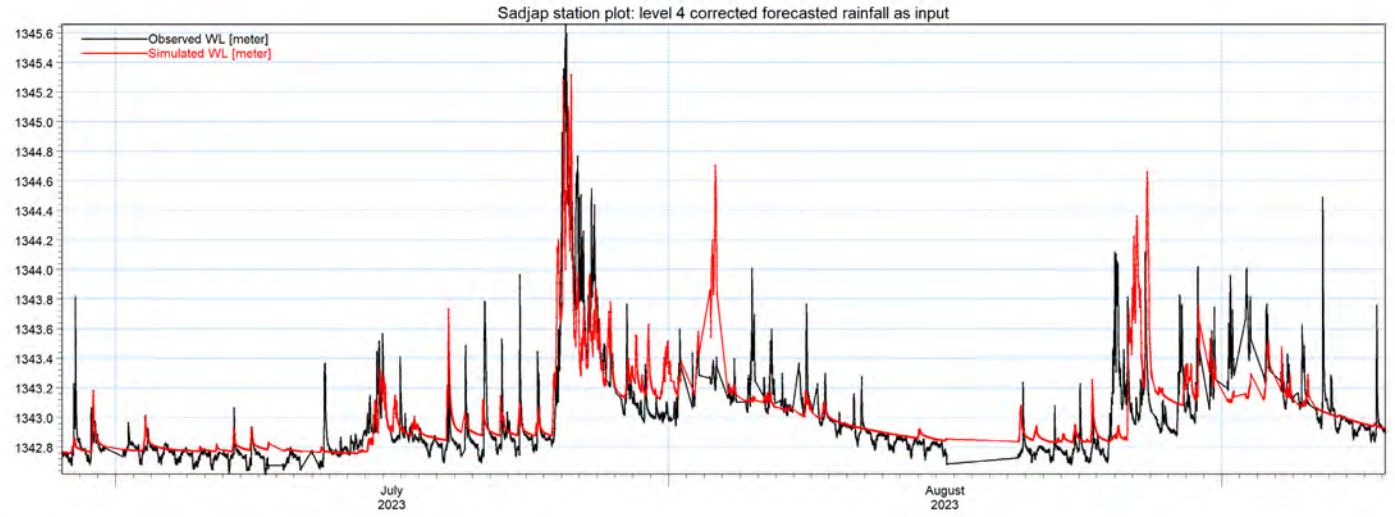


Figure B1-21 Sadjap station plot: level 4 corrected forecasted rainfall as input
Source: Ramboll

Table B1-5 Sadjap station: comparison of correlation for various rainfall inputs

Rainfall input	Root Mean Square Error	Coefficient of Determination	Index of Agreement
Stations observed rain	0.15	0.83	0.93
Level 2 forecasted rain	0.28	0.23	0.66
Corrected level 2 forecasted rain	0.24	0.45	0.80
Level 3 forecasted rain	0.22	0.50	0.82
Corrected level 3 forecasted rain	0.20	0.58	0.86
Level 4 forecasted rain	0.25	0.43	0.79
Corrected level 4 forecasted rain	0.22	0.55	0.85

Source: Ramboll

1.2.4 Balili Bridge station

Balili Bridge Station is located in La Trinidad, a little after of the main Balili river exits Baguio City. The Figure 1-22 is the calibration plot when the model is run with only observed rainfall data. Figure 1-23 and Figure 1-28 show how the correlation between the observed data and simulated data improves when corrected forecast rainfall is used in place of the uncorrected forecast rainfall.

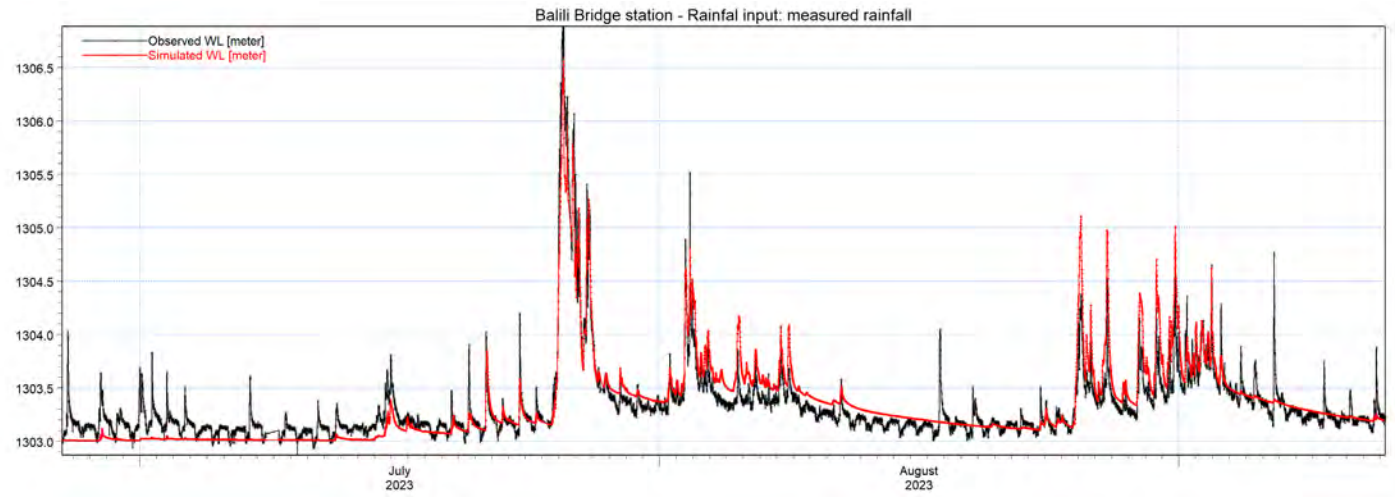


Figure B1-22 Balili bridge station plot: measured rainfall as input
Source: Ramboll

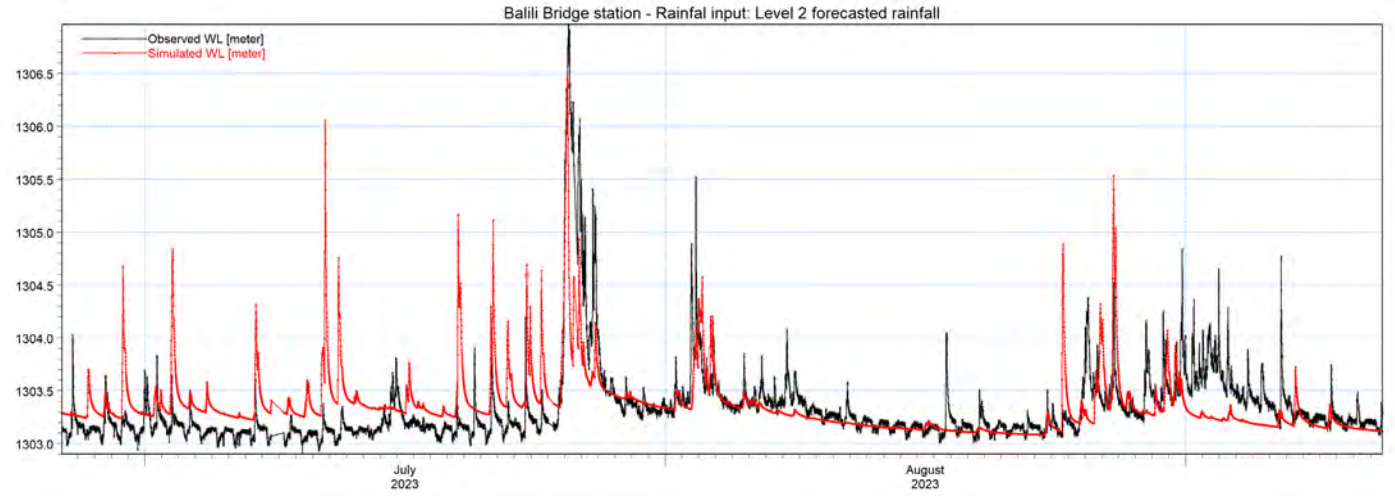


Figure B1-23 Balili bridge station plot: level 2 forecasted rainfall as input
Source: Ramboll

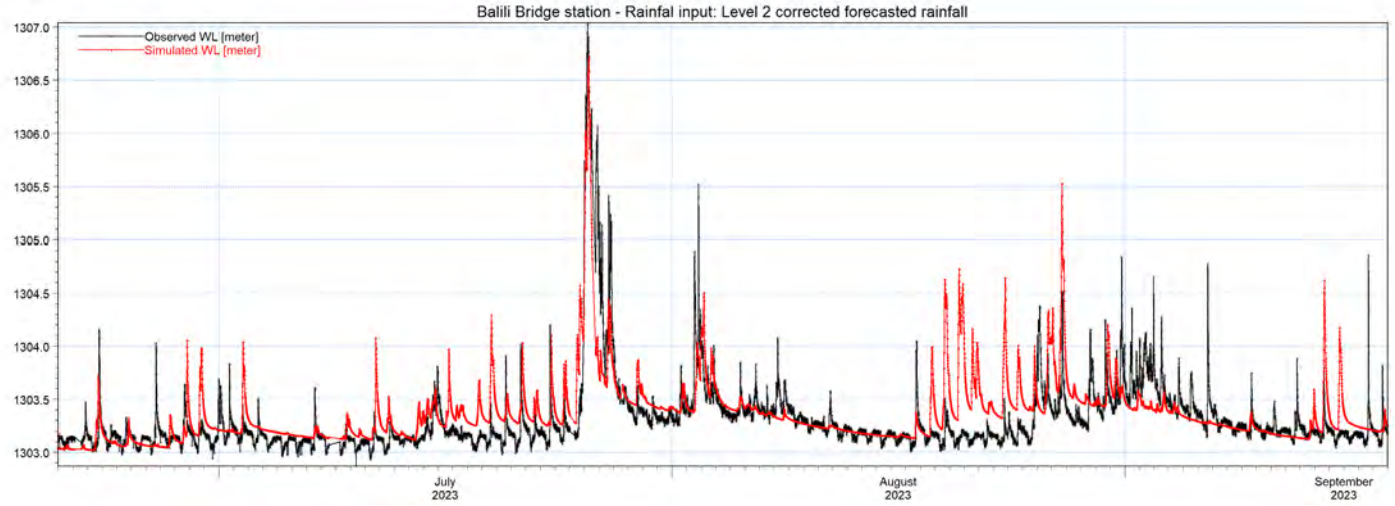


Figure B1-24 Balili bridge station plot: level 2 corrected forecasted rainfall as input
Source: Ramboll

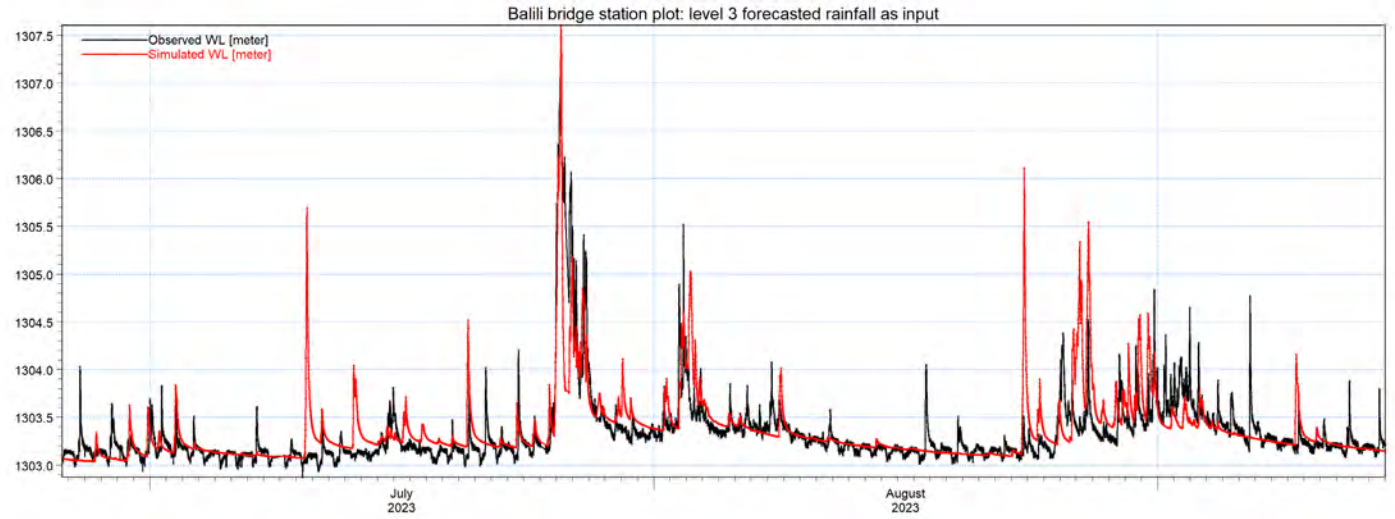


Figure B1-25 Balili bridge station plot: level 3 forecasted rainfall as input
Source: Ramboll

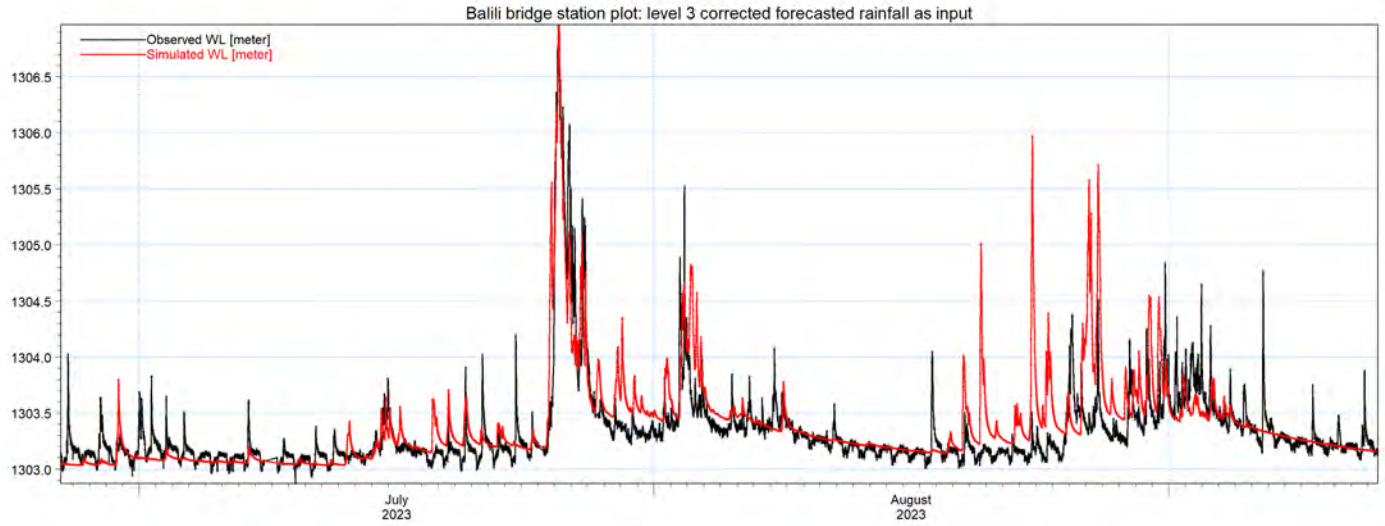


Figure B1-26 Balili bridge station plot: level 3 corrected forecasted rainfall as input
Source: Ramboll

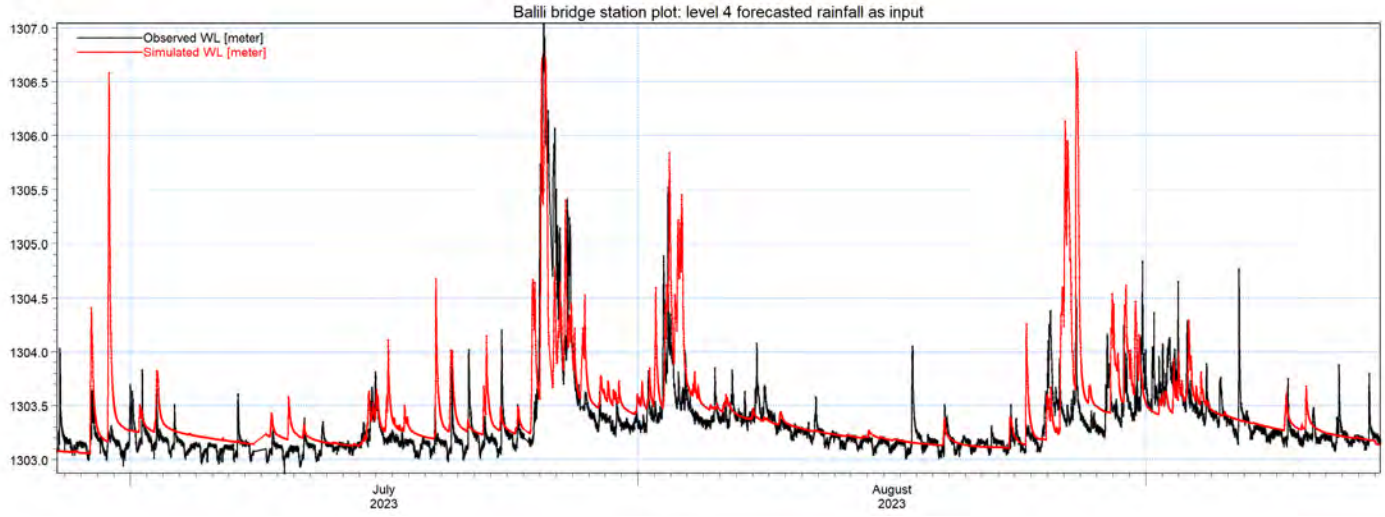


Figure B1-27 Balili bridge station plot: level 4 forecasted rainfall as input
Source: Ramboll

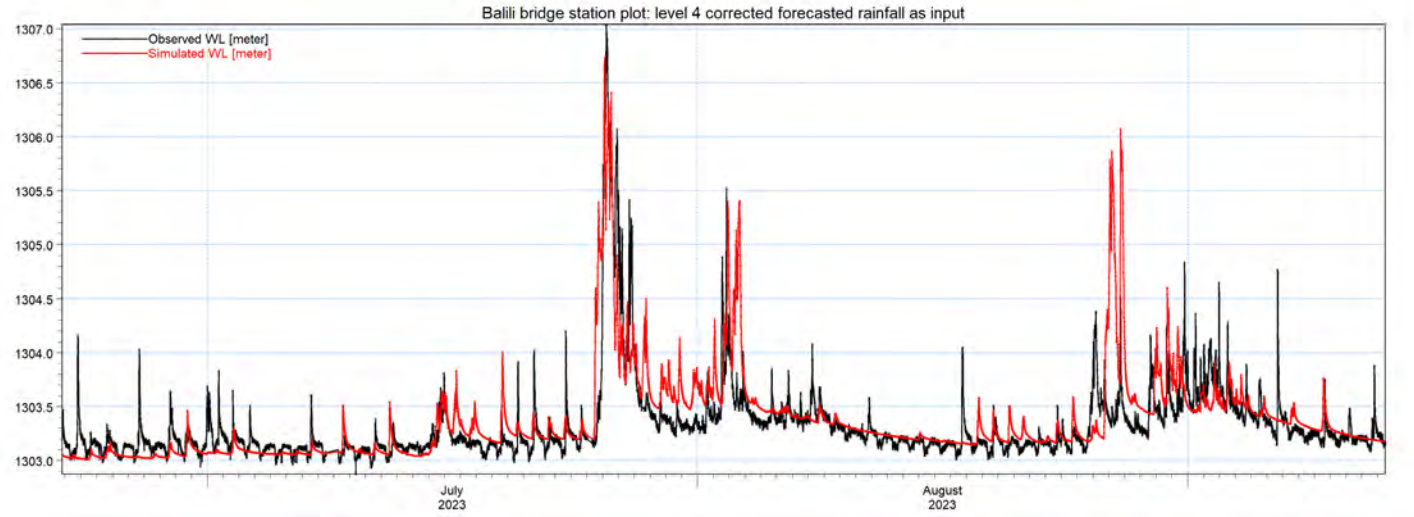


Figure B1-28 Balili bridge station plot: level 4 corrected forecasted rainfall as input
Source: Ramboll

Table B1-6 Balili bridge station: comparison of correlation for various rainfall inputs

Rainfall input	Root Mean Square Error	Coefficient of Determination	Index of Agreement
Stations observed rain	0.17	0.81	0.95
Level 2 forecasted rain	0.34	0.23	0.67
Corrected level 2 forecasted rain	0.28	0.46	0.81
Level 3 forecasted rain	0.28	0.50	0.83
Corrected level 3 forecasted rain	0.28	0.55	0.85
Level 4 forecasted rain	0.34	0.42	0.77
Corrected level 4 forecasted rain	0.30	0.48	0.82

Source: Ramboll

Source: Baguio City Disaster Risk Reduction and Management Office

APPENDIX C
STANDARD OPERATING PROCEDURES

1 INTRODUCTION

The Flood Early Warning System (FEWS) for Baguio has been developed using historical data collected from real-time gauging stations. It is required that the system is operated and tested in the coming monsoon seasons and maintained henceforth. It is also required that, as the network of real-time monitoring stations for the basins grow and develop, the system is updated accordingly to produce better forecasts and timely warnings.

To ensure the effective operation of the FEWS, Standard Operating Procedures (SOPs) have been prepared to guide the FEWS Operation and Maintenance team (O&M team). The purpose of a SOP is to carry out operations correctly and always in the same manner. SOPs can be defined as a written document with step-by-step instructions on how to perform a designated activity to obtain a desired outcome. Clearly defined SOPs are crucial to ensuring consistent operation of the FEWS. The benefits of effective SOPs for the FEWS include:

- Effective operation of the FEWS
- Consistency in operation
- Assigning responsibility and accountability of tasks to smaller teams
- Ensuring dynamic upgrades of the FEWS
- Creating a safe work environment
- Saving time and money

Thus, the SOPs contribute to enhancing long-term sustainability by outlining specific activities and tasks to be undertaken by the O&M team and serving as a guide for the team throughout the different operation and maintenance phases. At the same time, the SOPs contribute to achieving efficiency, quality output, and uniformity of performance, while reducing miscommunication and failure to comply with standards.

The activities and tasks related to the operation and maintenance of the FEWS can be divided into three phases as seen in Figure C1-1:

- **Preparation phase: Pre-monsoon period (April)**
  - This phase includes preparation of the FEWS for operation in the monsoon season. The pre-monsoon system maintenance for a season will essentially be the outcome of the post-monsoon analysis of the previous monsoon.
- **Application phase: Monsoon period (May – October)**
  - This phase includes operation and maintenance of the FEWS during the monsoon.
- **Assessment phase: Post-monsoon period (November – March)**
  - This phase includes assessment and updating of the FEWS post-monsoon. In this phase the existing system needs to be assessed to evaluate its performance in the recent monsoon season; this assessment primarily is to be carried out in two areas:
  - Assessment of real-time monitoring station performance- which work well, which malfunction, which are consistent, which have very intermittent data, overpredicting/underpredicting, addition of any new stations in the network etc.
  - Updating the FEWS by inclusion/removal of input data based upon above assessment and readjustment of the models to accommodate any changes.

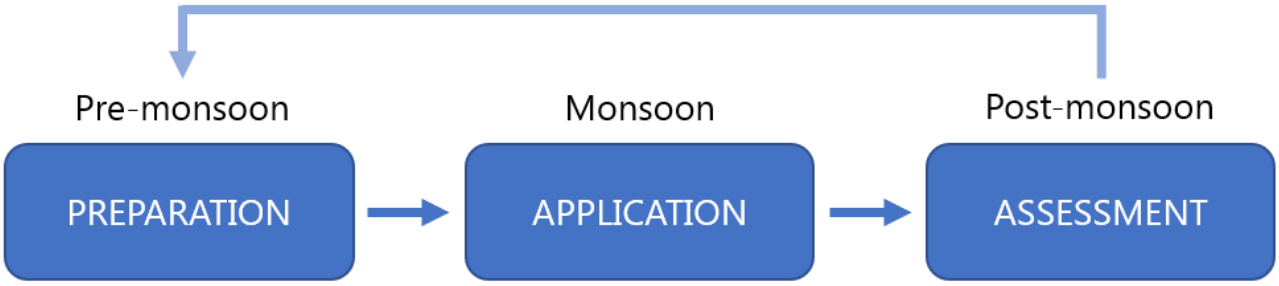


Figure C1-1 Operation and maintenance phases of the FEWS
Source: Ramboll

This document presents the SOPs during the three operation phases. The SOPs are specified for each phase providing a clear overview of tasks and procedures to be performed by the O&M team.

2 FEWS OPERATION AND MAINTENANCE TEAM COMPOSITION

To ensure effective operation and maintenance of the FEWS for Baguio, an FEWS Operation and Maintenance Team has been formed. The roles and responsibilities of the team members have been defined. The ownership of the FEWS is anchored at the Local Government Unit (LGU) and thus, the O&M core team consists of LGU staff with support from a peer team of representatives from academia and selected relevant agencies (i.e., PAGASA, DOST-CAR). To ensure the long-term sustainability of the FEWS, the LGU should continuously ensure that the O&M team members are available to perform the required tasks. It is crucial that the O&M team is institutionalized and that team members have the mandate to prioritize the required tasks.

The structure and roles of the O&M team can be seen in Figure C2-1. The O&M team is subdivided in three smaller teams: the modelling team, the instrument team, and the IT team. Each team has a team lead and two core team specialists from the LGU. Peer support is defined for each team. The responsibility for a defined SOP will be assigned to one of the three teams.

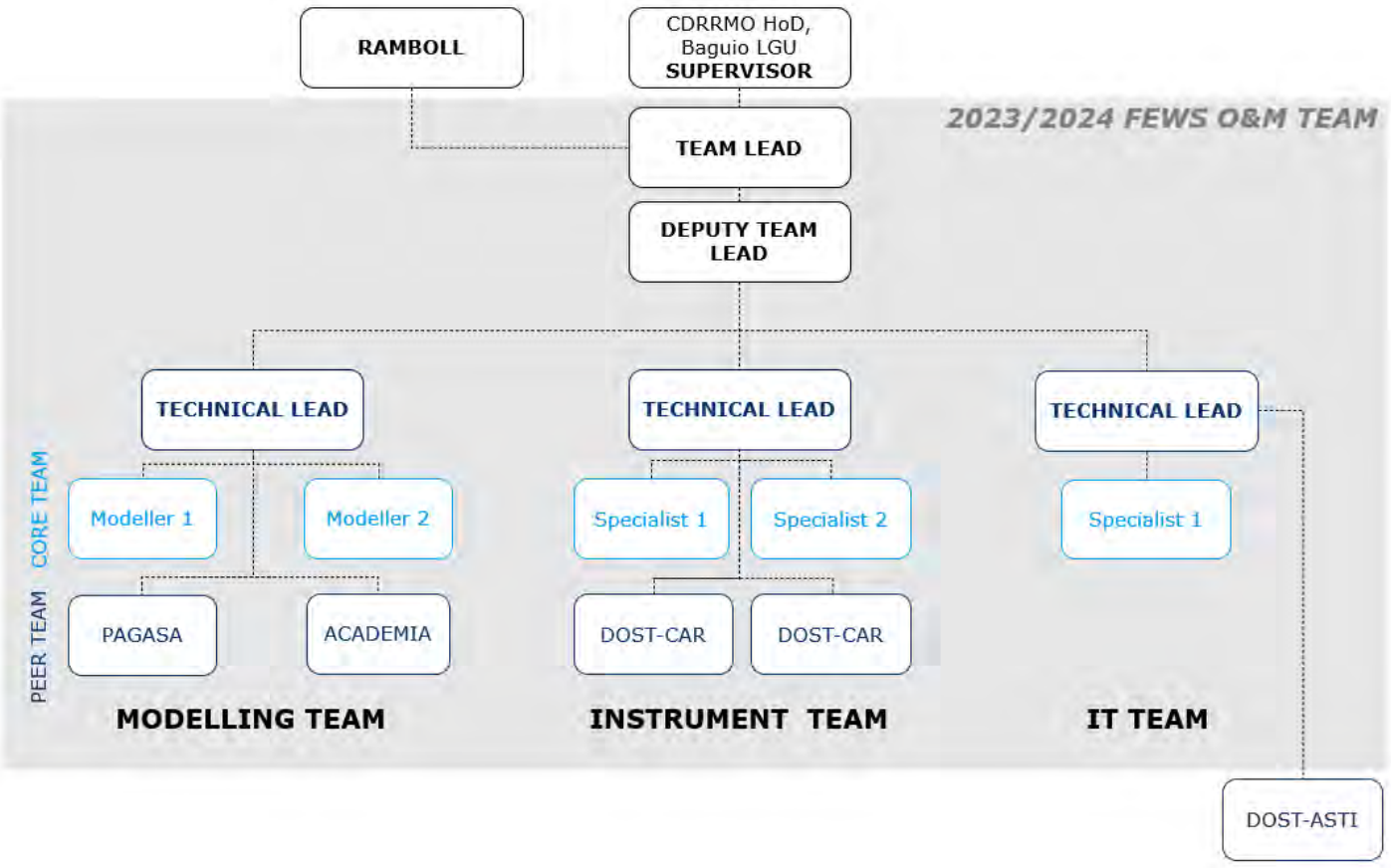


Figure C2-1 The structure of the FEWS Operation and Maintenance (O&M) team

Source: Ramboll

3 INTERNAL OPERATION AND MAINTENANCE COMMUNICATION

The O&M team should communicate closely for the effective operation of the FEWS, especially during the monsoon. To ensure fast communication, an internal team communication channel is needed. A WhatsApp group has been created for the team for internal communication. Furthermore, the Team Leader should ensure the facilitation of weekly team meetings with all team members and additional coordination meetings as needed.

Furthermore, the FEWS is sending automatic WhatsApp messages to the O&M team in case of e.g., real-time monitoring station failure. This allows the O&M team to easily monitor the status of the FEWS and receive real-time status messages immediately.

4 STANDARD OPERATING PROCEDURES (SOPS)

An overview of the Standard Operating Procedures for the Baguio FEWS is shown in Figure C4-1. For each SOP the following is described:

- **Phase:** The operation phase in which the SOP should be carried out
- **Frequency:** The number of times a task should be completed within a given time period.
- **Responsible:** The team responsible for performing the SOP
- **Section:** The number of the sections in which the SOP is described step-by-step
- **SOP:** The title of the SOP

The following sub-sections describe the SOPs step-by-step for each operation phase.

Phase	Frequency	Responsible	Section	Standard Operating Procedure
Monsoon	Daily	IT	4.1.1	Operate system, check IT system, connectivity and create backup
	Daily	TL DL M IT IN	4.1.2	Daily review of jobs
	Daily	IT IN	4.1.3	Daily review of data logs
	Daily	IT	4.1.4	Daily report on job and script performance
	Daily	M	4.1.5	Daily report on model performance
	As needed/as scheduled	IN	4.1.6	Real-time station maintenance and weekly report on station performance
	Weekly	M	4.1.7	Weekly report on quality of model input data
	As needed	M IN	4.1.8	Flood warning and flood occurence
Post-monsoon	Post-monsoon	IN	4.2.1	Station assessment
	Post-monsoon	M	4.2.2	Model input data assessment
	Post-monsoon	M	4.2.3	Catchment assessment
	Post-monsoon	M	4.2.4	NAM-model assessment
	Post-monsoon	M	4.2.5	Hydrodynamic (HD) model assessment
	Post-monsoon	M	4.2.6	Data assimilation (DA) assessment
	Post-monsoon	IT	4.2.7	Update Mike Operations (MO) back-end
	Post-monsoon	IT	4.2.8	Update MO front-end
	Post-monsoon	M IT	4.2.9	Update reports
	Post-monsoon	TL DL M IT IN	4.2.10	Update SOPs
Pre-monsoon	Pre-monsoon	TL	4.3.1	Ensure completion of post-monsoon SOPs
	Pre-monsoon	TL	4.3.2	Coordinate with stakeholder organizations
	Pre-monsoon	TL	4.3.3	Plan O&M activities
	Pre-monsoon	TL	4.3.4	Assemble O&M team
	Pre-monsoon	IN	4.3.5	Ensure real-time stations are operational

TL Team leader DL Deputy team leader M Modelling team IT IT team IN Instrument team

Figure C4-1 Standard Operating Procedures for the Baguio FEWS

Source: Ramboll

4.1 MONSOON SOPS

The SOPs for the Baguio FEWS to be completed during the monsoon are outlined in Table C4-1. The SOPs should be followed from June to October i.e., for the entire duration of the monsoon.

Table C4-1 Standard Operating Procedures for the Baguio FEWS during the monsoon (i.e. application phase)

Section	Standard Operating Procedure	Responsible	Frequency
4.1.1	Operate system, check IT system and connectivity and create backup	IT team	Daily
4.1.2	Daily review of system logs and jobs	Team lead Deputy team lead Modelling team IT team Instrument Team	Daily
4.1.3	Daily review of data logs	IT team Instrument Team	Daily
4.1.4	Daily report on job and script performance	IT team	Daily
4.1.5	Daily report on model performance	Modelling team	Daily
4.1.6	Real-time station maintenance and weekly report on station performance	Instrument team	As needed/as scheduled
4.1.7	Weekly report on quality of model input data	Modelling team	Weekly
4.1.8	Flood warning and flood occurrence	Modelling team Instrument team	As needed

Source: Ramboll

4.1.1 Operate system, check IT system, connectivity and create backup

The system should be operated, the IT system and connectivity checks carried out:

1. The servers hosting the website, the FEWS platform and the back-up should be kept "ON" at all times throughout the monsoon period, from beginning of May up to end of October.
2. The servers should always have an active and good internet connection.
3. There should be sufficient space available on the servers to ensure the upload of data and smooth operation of the FEWS
4. The FEWS should be checked daily. The FEWS will run automatically, but it is necessary to check its continuous effective operation. The system sends an auto-generated response summarizing the daily status of the jobs. The status of the FEWS should be examined by checking the email log daily and should be verified by connecting to the FEWS server. The check on the FEWS server can be done by completing the following steps:
   a. Connect to the FEWS platform server. To access the server (anchored at MITD) you will be required FortiClient VPN. Please refer to the VPN installation and configuration guide, provided by the MITD. Once VPN is installed and configured, you can use the Windows remote desktop application to connect to the server.
   Open the remote desktop connection and type the IP: 192.168.90.3
   Username: not published
   Password: not published

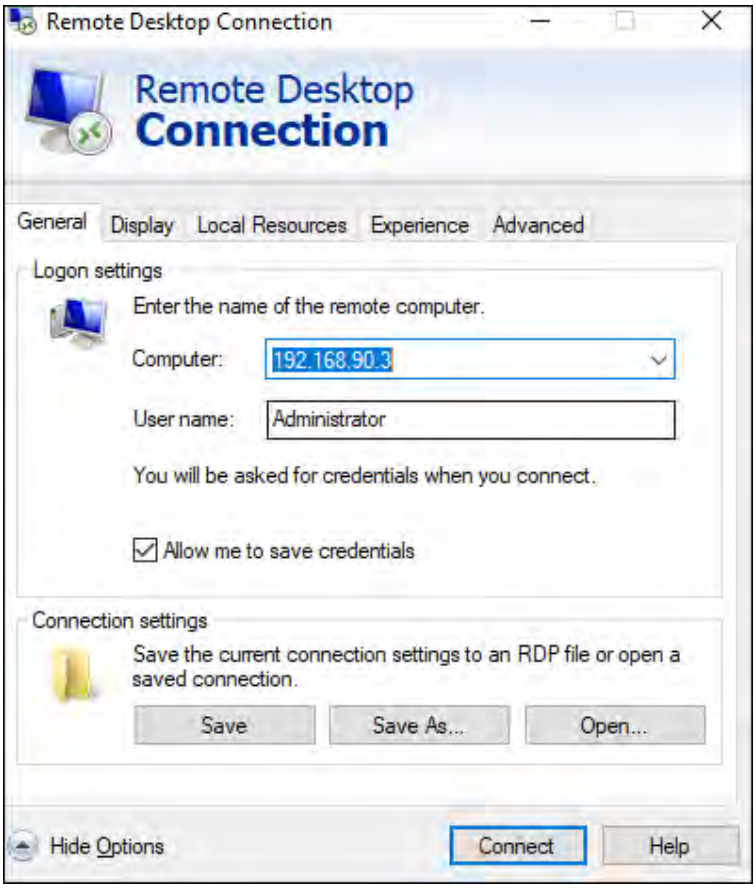


Figure C4-2 Remote desktop connection to the FEWS platform server
Source: Ramboll

b. The DHI license should be connected at all times. The license is managed through the DHI License Management.
Internet License Server
Username: not published
Password: not published

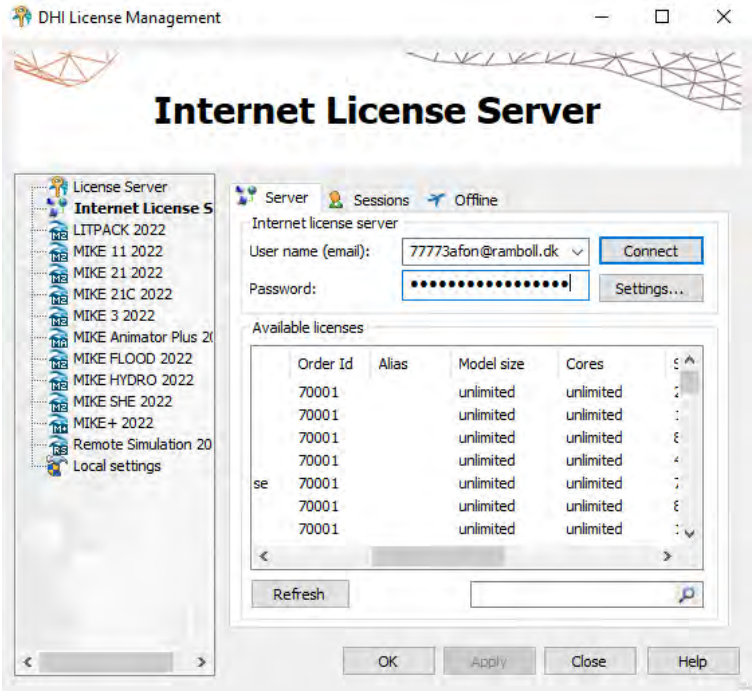


Figure C4-3 DHI license management. Connection to internet license server
Source: Ramboll

Jobs may fail due to failure of license connection. In case of license failure:

i. Check internet connection.
ii. Check firewall restrictions.
iii. Restart the server and reconnect to the license.
iv. Check the DHI License service at https://license.mikepoweredbydhi.com/internetlicense/Status
v. If (i)-(iv) does not resolve the license failure, contact DHI at mike@dhigroup.com (visit https://www.mikepoweredbydhi.com/support for more information).

4.1.2 Daily review of jobs

The FEWS will run automatically, but it is necessary to check its continuous effective operation by daily checks of the operation logs and execution of jobs.

1. The IT team should keep track of failures in various jobs by checking the automated job status alerts.
2. The IT team should ensure through daily checks that all jobs that enable the automation of the various elements and processes of the FEWS run without failures. In case any failures are identified, relevant troubleshooting must be carried out to identify and rectify the issues.

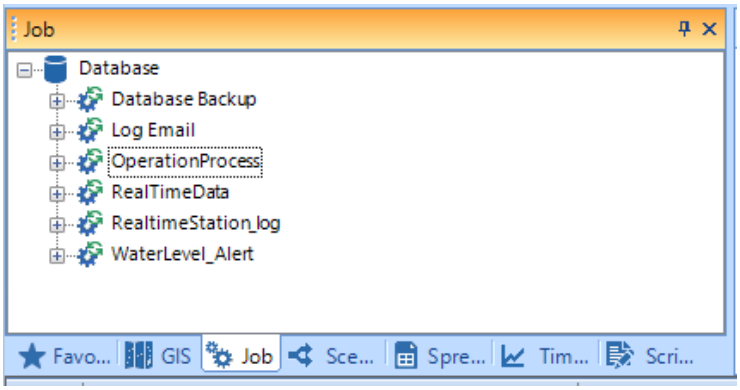


Figure C4-4 All Jobs in Baguio FEWS
Source:Ramboll

a. In MIKE Workbench, "Jobs" have been created. Each job is essentially a sequence of targets. Each job is scheduled to run automatically in real-time which triggers the targets to run one by one, thus ensuring the right flow of tasks with each run.

   Check jobs from the previous day. Ensure that all jobs have run successfully. Job/target run failure can be identified within MIKE Workbench. An indication of the failure of a model run can be seen in the Jobs Manager:

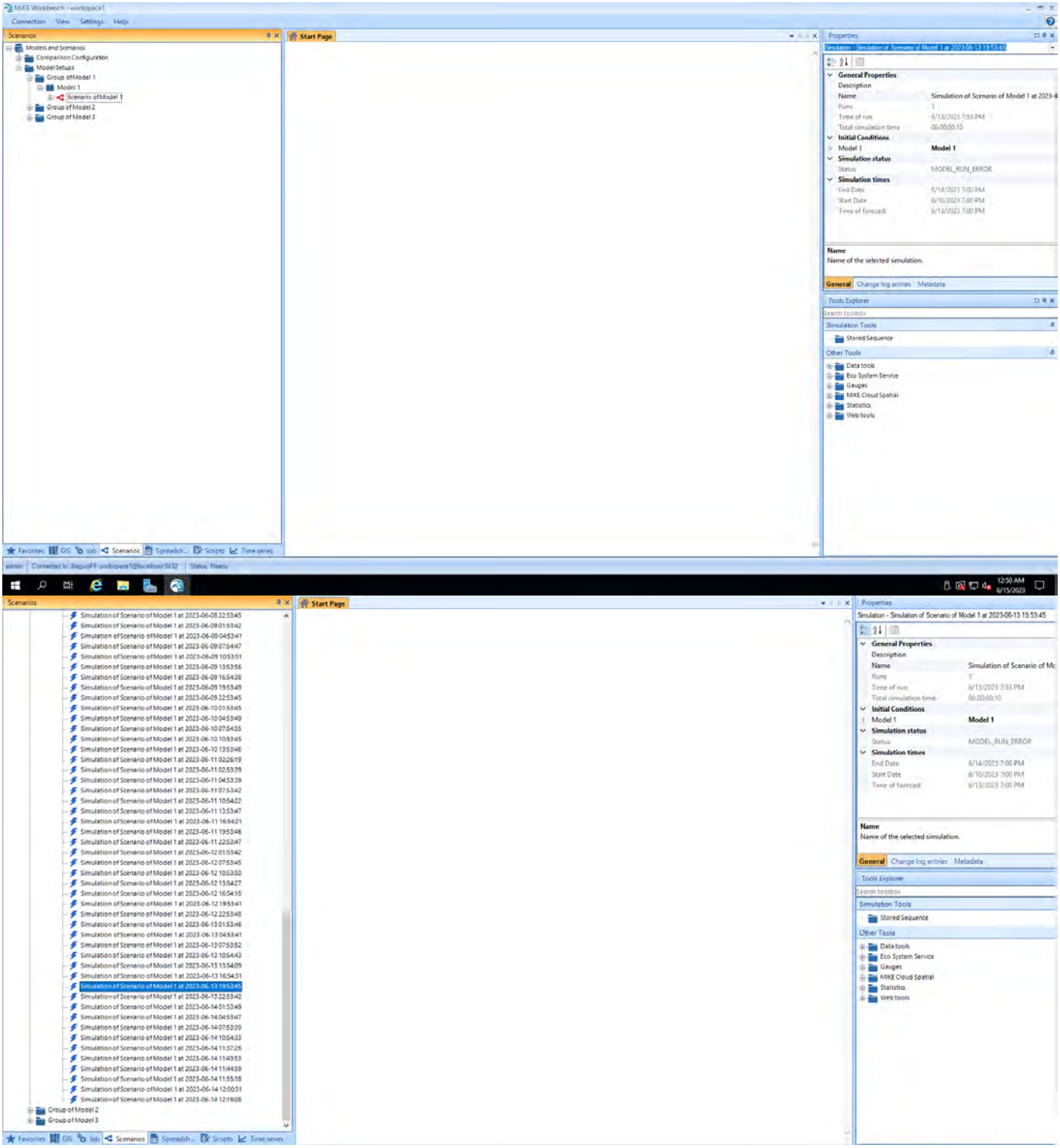
   ii. Navigate to the Job Manager. Job instances will show a 'red percentage mark' to indicate that a script has failed to complete its run.

   iii. Next, open that failed jobs instance and expand the log. The log will show the details of the error. The job may fail due to various targets. These targets need to be identified and rectified.

   iv. If more information on the job is required, please refer to the Flood Early Warning System Report, Appendix C, 'Technical Note FEWS setup in MIKE OPERATIONS'

b. If the job has failed at the model run target, the setup of the failed model will need to be checked and the problem causing the model failure identified and rectified.

   iii. To check the model setup, go to C:\Temp\ModelX. This folder will contain the last run model. Otherwise open the Scenario manager in MIKE Workbench. Expand the Scenario of ModelX and selected the failed simulation, right click on selected simulation, and export the failed model as shown in Figure C4-5 into desired location for further investigation.


Scenarios
Start Page
Properties
Tools Explorer
Simulation Tools
Other Tools
Stored Sequence
Data tools
Eco System Service
Gauges
MIKE Cloud Spatial
Statistics
Web tools
General Properties
Initial Conditions
Simulation status
Simulation times
Name
Name of the selected simulation.
General
Change log entries
Metadata
Group of Model 2
Group of Model 3

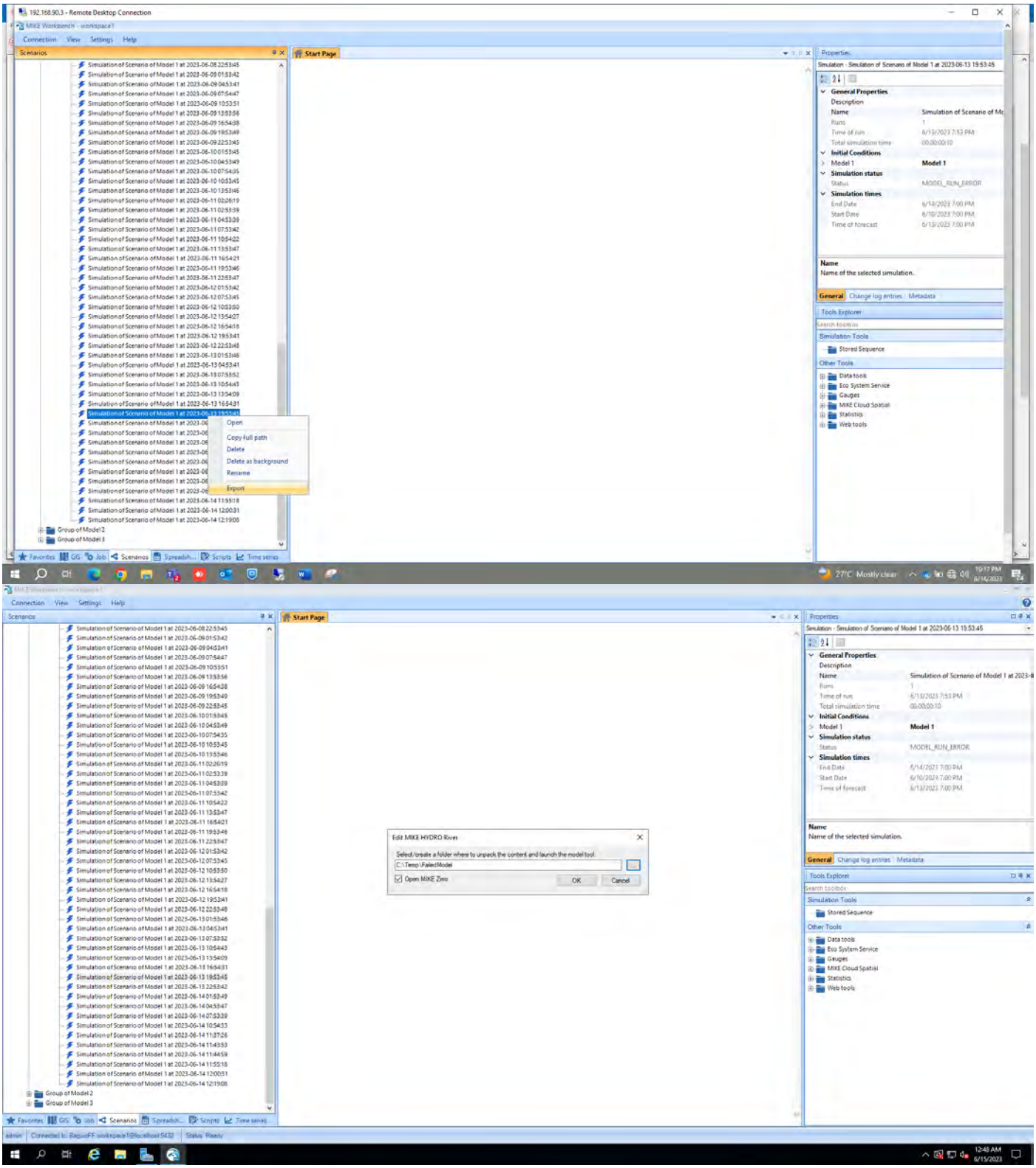


Figure C4-5 Step for failed simulation identification

Source: Ramboll

ii. Once the failed model run has been exported, open the setup in MIKE Hydro Software and check the time series used by the model. Common problems with input time series include missing or erroneous data. If the model run fails within MO for greater than 72 hours, issues may arise due to the "hotstart" file not having data up to the Time-Of-Forecast for the next run.

iii. If needed, run the setup to check on the error message again. In the model folder, open the file with the extension ".Log" to review the error message. IT team would need support from the modeling team in this process.

In case the different logs being produced indicate systemic issues with gauging stations or assessment of job runs indicate any, relevant follow-up and measures for the rectification of the issues must be initiated. In such a situation, the information must reach the team lead as and when the problem is noticed and immediate coordination by the team lead between teams to take decisions on actions, as needed.

4.1.3 Daily review of data logs

The FEWS will run automatically, but it is necessary to check its continuous effective operation by daily checks of the operation logs and execution of jobs.

1. The IT team and instrument team should keep track of failures in the reception of input data from gauging stations and the forecasted rainfall input for the models by checking the automated job status alerts and the daily performance logs for the input data received via email. This email summarizes the working hours for the station in the past 24 hours, along with the accumulated rainfall data over the same period for rainfall stations.
2. The Instrument Team is responsible for managing sensors, while the IT Team oversees the storage of data in the database.
3. In case there is discrepancy in the accumulated rainfall, the data must be verified from Philsensors. In case the different logs being produced indicate systemic issues with gauging stations, relevant follow-up and measures for the rectification of the issues must be initiated. In such a situation, the information must reach the team lead as and when the problem is noticed and immediate coordination by the team lead between teams to take decisions on actions, as needed.
4. A detailed description of the cause of failure and rectification method must be given. A summary report to be created if sensor adjustments are done. The station adjustments must be reported to the entire O&M team.
5. Google Forms has been created to log automize the daily reports: not published.

The daily report forms contain information about:

- Sensor type
- Station ID and location
- Identified issue/purpose
- Other details of the identified issue/remarks
- Date and time of inspection
- Team member responsible
- Trouble-shooting process applied
- Date for rectification of the issue
- Control number

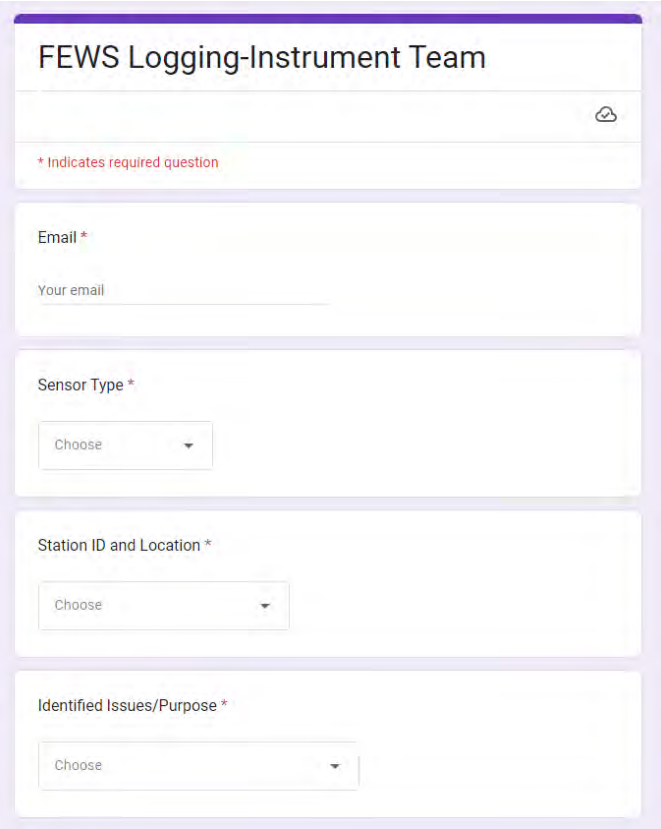


Figure C4-6 Report for logging station issues
Source: Ramboll

4.1.4 Daily report on job and script performance

Based upon the assessment and tasks carried out as described in sections 4.1.1 and 4.1.2, data, as indicated below, should be tabulated by the IT team daily and collected in a weekly report on job and script performance: (not published)

Table C4-2 Template for daily report on job and script performance

Number	Name of Job failed	Date of job failed	Identified cause of job failure	Troubleshooting process applied	Date of Action	Assigned to:	Date of rectification of issue

Source: Ramboll

By using the online form prepared, the reports are automatically stored for documentation and can easily be extracted. These reports will later be used during the post-monsoon assessment to study the frequency of the different types of failures and help in identifying and prioritizing the improvements that would be required in the system automation for the next monsoon.

4.1.5 DAILY REPORT ON MODEL PERFORMANCE

Throughout the monsoon, the Modelling team should periodically monitor the model performance using the model performance email log which is automatically send to the team from the system. This email log consists of Excel documents as indicated for each real time WL station included in the model. The Modelling Team is dedicated to evaluating and assessing the performance of the model, which includes:

- Maintaining the daily reports of the tabulated logs and review the model performance. These reports will later be used during the post-monsoon assessment to study the overall model performance and help in identifying and prioritizing the improvements that would be required in the models and overall FEWS for the next monsoon.
- The report should also contain any observations and remarks on issues encountered in relation to identified outliers in model inputs and/or outputs.
- If a prolonged issue is seen with the quality of input data for the model which consistently influences the model performance, a mid-monsoon fine tuning of the model calibration would be required. This should also be documented in the reports whenever the updates are made. If a mid-monsoon update to the models is made, support would be required from the IT team to re-register the models in MO and make the necessary alterations to the time series connections and automation processes, as required.
- Accessing the Baguio FEWS dashboard and reviewing the observed and forecasted water levels. In case of exceedance of forecasted water levels above flood threshold, follow 'Flood warning and flood occurrence' SOP.

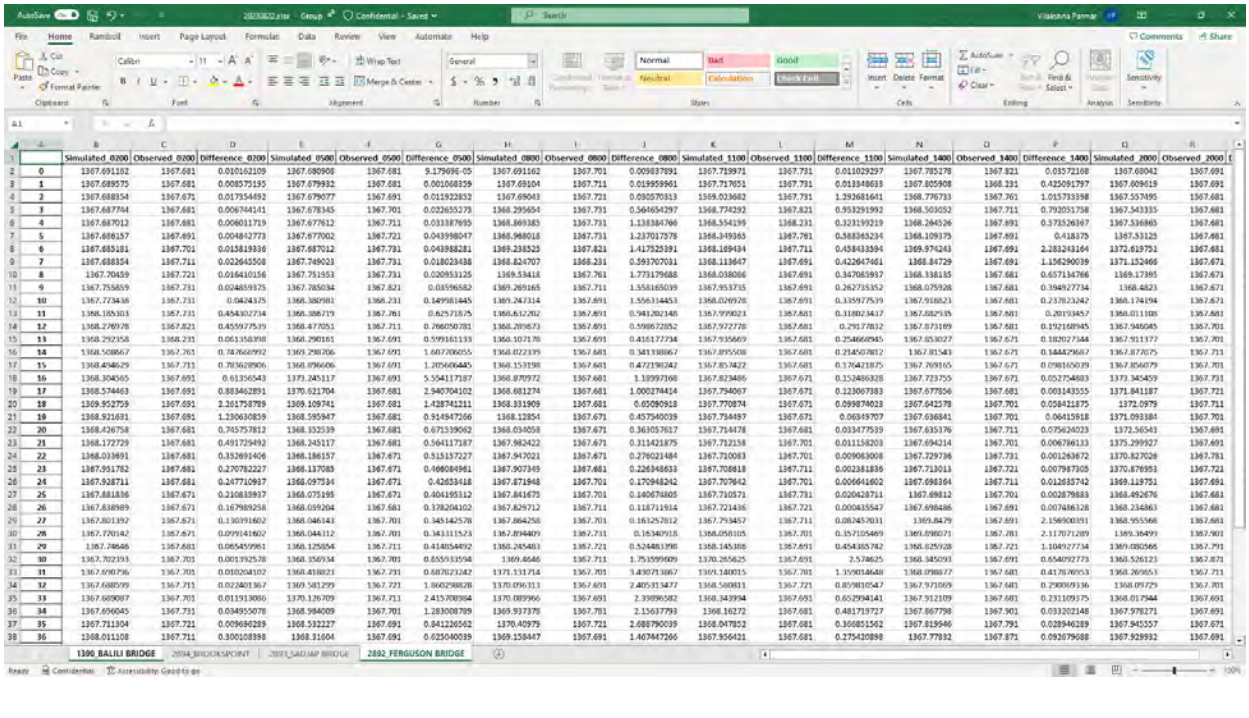


Figure C4-7 Snapshot of model results log received in email alerts
Source: Ramboll

Table C4-3 Template for Daily report on model performance

Date of forecast	dd/mm/yyyy																							
Time of forecast	8:00			11:00			14:00			17:00			20:00			23:00			2:00			5:00		
	Forecasted WL	Observed WL	Difference	Forecasted WL	Observed WL	Difference	Forecasted WL	Observed WL	Difference	Forecasted WL	Observed WL	Difference	Forecasted WL	Observed WL	Difference	Forecasted WL	Observed WL	Difference	Forecasted WL	Observed WL	Difference	Forecasted WL	Observed WL	Difference
tof + 0																								
tof + 1																								
tof + 2																								
.....																								
.....																								
.....																								
.....																								
tof + 72																								

Source: Ramboll

4.1.6 REAL-TIME STATION MAINTENANCE AND WEEKLY REPORT ON STATION PERFORMANCE

The network of real-time monitoring stations needs to be operational at all times. The instrument team should closely follow the operational status of the real-time monitoring stations through daily checks of the system logs and automatic messages sent to the O&M WhatsApp group. Furthermore, the Instrument team should complete scheduled regular inspections of all monitoring stations. There are two types of maintenances performed by the instrument team:

1. Preventive Maintenance
2. Corrective Maintenance

4.1.6.1 Preventive Maintenance

Preventive maintenance is performed to prevent equipment or system failures before they occur. It involves regular, scheduled inspections, servicing, and repairs to keep equipment in optimal working condition and prevent breakdowns:

1. Follow the manual for maintenance of real-time monitoring stations by DOST-ASTI. Steps in conducting inspection and maintenance:
   b. Check the overall physical condition of the station
   c. Check the sensors
   d. Check battery health using multi-meter
   e. Check data logger (ARQ)
   f. Check wiring connections
   g. Check the solar panel
   h. Cleaning of the station
2. Conduct preventive maintenance at least once a month.
3. Complete Maintenance of the stations throughout the monsoon and fill up the log template of Preventive Maintenance.
   a. Logs to be maintained as tabulated with clear indication of date and time of inspection, duration, findings, action taken and recommendation.
2. Conduct maintenance and troubleshooting and fill up the log template of Corrective Maintenance, if needed.
3. Report the O&M team when the maintenance is performed. Any adjustments made to the sensors must be carefully recorded and reported to the entire O&M team and DOST-ASTI.

Table C4-4 Template for Preventive Maintenance

Station ID	Station Name	Sensor type	Date of Inspection	Purpose/Action taken	Findings	Remarks/Recommendations	Repair No.	Actioned by:
460	City Camp Lagoon	Tandem	7/10/2023	Cleaning and Preventive Maintenance	N/A	Need Padlock for the gate		CDRRMO, MITD
892	Camp 6 Bridge	Tandem	7/10/2023	Cleaning and Preventive Maintenance	N/A	Need Padlock for the gate		CDRRMO, MITD
463	Nangalisan, Asin	Tandem	7/10/2023	Cleaning and Preventive Maintenance	N/A	Need Padlock for the gate		CDRRMO, MITD
2892	Ferguson Bridge	Water level	7/10/2023	Cleaning and Preventive Maintenance	N/A	N/A		CDRRMO, MITD
2893	Sadjap Bridge, Km3	Water level	7/10/2023	Cleaning and Preventive Maintenance	N/A	N/A		CDRRMO, MITD
2894	Brookspoint	Tandem	7/10/2023	Cleaning and Preventive Maintenance	N/A	N/A		CDRRMO, MITD
2896	Woodsgate, Camp 7	Water level	7/10/2023	Cleaning and Preventive Maintenance	N/A	N/A		CDRRMO, MITD
3028	Irisan Fire Station	Rain gauge	7/10/2023	Cleaning and Preventive Maintenance	N/A	Need Padlock for the gate		CDRRMO, MITD
892	Balili Bridge, Km6	Tandem	7/10/2023	Cleaning and Preventive Maintenance	Negative Values read by the WL Sensor	Operational BUT with negative values; Waiting for ASTI to update the sensor height on their server	BB-0002	CDRRMO, MITD, DO
892	Camp 6 Bridge	Tandem	8/14/2023	Cleaning and Preventive Maintenance	Negative Values read by the WL Sensor	Operational BUT with negative values; Waiting for ASTI to update the sensor height on their server(Need padlock for Cage and arg and battery enclosure)		CDRRMO, MITD
463	Nangalisan, Asin	Tandem	8/14/2023	Cleaning and Preventive Maintenance	N/A	Need Padlock for the gate and Data logger/Battery enclosure		CDRRMO, MITD
3028	Irisan Fire Station	Rain gauge	8/14/2023	Cleaning and Preventive Maintenance	N/A	Need Padlock for the gate and Data logger/Battery enclosure		CDRRMO, MITD
2896	Woodsgate, Camp 7	Water level	8/14/2023	Cleaning and Preventive Maintenance	N/A	Need pestiside to prevent manifestation of ants		CDRRMO, MITD

Source: Ramboll

4.1.6.2 Corrective Maintenance

Corrective maintenance is performed to troubleshoot and rectify the equipment or system failures once they occur. It involves inspections, servicing, and repairs to bring instrument to working condition.

1. Monitor email/WhatsApp messages from FEWS.
   b. Take necessary actions and complete troubleshooting, if necessary
      iii. Complete physical inspection of the station, if necessary.
4. Check the status of real-time monitoring stations on the PhilSensor website for validation (philsensors.asti.dost.gov.ph/).
   a. Contact DOST-ASTI for troubleshooting, if necessary.
      ii. Complete physical inspection of the station, if necessary.
3. Follow the manual for maintenance of real-time monitoring stations by DOST-ASTI.
4. Conduct maintenance and troubleshooting as necessary.
5. Complete Corrective Maintenance of the stations throughout the monsoon and fill up the log template of Corrective Maintenance (not published).
6. Coordinate with IT and Modelling teams, DOST-CAR, PAGASA and DOST-ASTI when corrections are performed.

Table C4-5 Template for Corrective Maintenance

Station ID	Station Name	Sensor type	Date	Action Taken	Remarks/Recommendations	Repair No	Date accomplished	Actioned by:
2895	Eagle Crest, Bakakeng	Water level	6/9/2023	Recalibrated Sensor Height	Need to extend arm of water level sensor	EC-0001		CDRRMO, MITD, DOST
2895	Eagle Crest, Bakakeng	Water level	6/28/2023	Arm extension of water level sensor	Non-Operational; Need to extend wirings of water level sensor	EC-0001		CEO
2895	Eagle Crest, Bakakeng	Water level	6/30/2023	Online Validation - Philsensors	ERR data	EC-0001		MITD
2895	Eagle Crest, Bakakeng	Water level	7/3/2023	Extended the Wiring of water level sensor	Still ERR data For validation. Need to check if the water sensor is working; Need to lower the arm of water level sensor; Need to replace sensors if necessary;	EC-0001		CDRRMO,MITD
2895	Eagle Crest, Bakakeng	Water level	7/4/2023	Validation of the cause of ERR data	Tested 2 sensors simultaneously; Both the 2 sensors cannot read the 12.45m height of the riverbed; Endorsed to CEO to lower the arm of the water level sensor	EC-0001		CDRRMO,MITD
2895	Eagle Crest, Bakakeng	Water level	7/5/2023	Station Inspection conducted by CEO	Recommendation to do the following: - renovation of the arm (lowering the sensor 1-2meters down) - additional stability bracket (to ensure it remains firm with various weather conditions)	EC-0001		CEO, CDRRMO,MITD
3028	Irisan Fire Station	Rain gauge	7/8/2023	Error on philsensors, no data received	Non-Operational;	IS-0001		MITD
1390	Balili Bridge, Km6	Tandem	7/8/2023	Error on philsensors, no data received	Non-Operational;	BB-0001		MITD
463	Nangalisan, Asin	Tandem	7/8/2023	Error on philsensors, no data received	Non-Operational;	NS-0001		MITD
460	City Camp Lagoon	Tandem	7/8/2023	Error on philsensors, no data received	Non-Operational;	CC-0001		MITD

Source: Ramboll

4.1.6.3 Down Time Log

Down time log is to be maintained to monitor and log occurrences of equipment or system unavailability. It is a critical instrument for overseeing and controlling maintenance tasks, recognizing trends in malfunctions, and enhancing overall operational effectiveness.

1. Monitor email/WhatsApp messages from FEWS.
   b. Take necessary actions and complete troubleshooting, if necessary.
      iii. Complete physical inspection of the station, if necessary.
4. Check status of real-time monitoring stations on the PhilSensor website for validation (philsensors.asti.dost.gov.ph/)
5. Conduct maintenance and troubleshooting and fill up the log template of Corrective Maintenance, if necessary
6. Fill up the log template of Down TIme (not published).
7. Coordinate with DOST-CAR, PAGASA and DOST-ASTI as needed.

Table C4-6 Template for station down time log

Date Started (Down Time)	Time Started (Down Time)	Station Name	Date Resumed (Operating)	Time Resumed (Operating)	Remarks / Recommendations
9/21/2023	15:30	Sadjap Bridge, Km3	10/27/23	10:00 AM	Reoccuring Issue; Sending data but not 24hrs; SJ-0001;

Source: Ramboll

These reports will later be used during the post-monsoon assessment to study the frequency of the different types of failures and help in identifying and prioritizing the improvements that would be required for the different stations before the next monsoon.

4.1.7 Weekly report on quality of model input data

The modelling team should periodically evaluate the quality of input data for the models throughout the monsoon and prepare the weekly reports on data from the gauging stations and WRF models to include the following.

1. Review data collected at all real-time stations
   b. Collect all data for real-time stations from IT team.
   c. Create the time series of the rainfall and water level data.
   d. Check for outliers, negative values, unrealistic values, gaps and jumps.
   e. Take necessary actions and complete troubleshooting, if necessary.
   f. Compare water level data to rainfall data.
   g. Do the measured water levels seem realistic? Complete troubleshooting and coordinate with the instrument team for maintenance, if necessary.
2. Review input rainfall forecast data
   c. Collect rainfall forecast data from IT team.
   d. Create the time series of the data.
   e. Check for gaps and assess and document the reason for the gaps by following up if needed with PAGASA
   f. Compare forecast rainfall with observed rainfall data and record your observations

Reference material for data analysis:

7. Excel analysis: not published
8. Session 2 and session 3 of available training session material: not published

4.1.8 Flood warning and flood occurrence

During the monsoon season, floods can be forecasted with a warning from the FEWS, but they can also occur without any prior notification from FEWS. In both situations, the O&M team is responsible for gathering additional field data to assess the performance of the system. They must also collect field data when floods happen unexpectedly in rivers without any warning from the FEWS. In both scenarios, the O&M team should undertake the following tasks:

1. The modelling team should closely monitor the results published on the dashboard at least twice a day.
2. In case, the forecasts are above thresholds at the monitoring stations. The entire log of the simulation and graph shown on the dashboard should be saved in a Flood logs folder, in a sub-folder titled “station name_ddmmyyyy”.
3. The modelling team should confirm the forecasted water levels with measured water level and rainfall data from real-time monitoring stations on the PhilSensor website (philsensors.asti.dost.gov.ph/).

   a. Do the forecasted and measured water levels seem realistic? Complete troubleshooting and coordinate with instrument team for maintenance, if necessary.

4. In case of flood occurrence, the modelling team should record the water level observed in the neighbouring station, first level forecasts given by FEWS for that station, observed and forecasted rainfall.
5. Modelling team should identify the locations for field investigation by the Instrument team for both flood warning ad flood occurrence condition.
6. Instrument team to inspect the flooding locations and gather detailed field data to assess the situation and evaluate the performance of the flood warning system. This should include:
   a. Flood extent
   b. Flood depth
   c. Site photographs with geolocations and time stamp
7. In case field survey is not feasible due to inaccessibility the news clippings must be recorded for validation.
8. Instrument team should analyse and report the collected field data in the same folder.
9. Modelling team should compare the survey log with the FEWS warnings or lack and assess the model's performance.

Table C4-7 Template for flood warning and flood event log

No.	Warning/occurrence/both	Date & time of record	Simulation date & time	Event date & time	Location coordinates	Station Name	Forecasted wl (m)	Observed wl (m)	Observed rainfall* (Mm)	Flood extent (Barangays)	Flood extent (Barangays)	Site photographs	Remarks
* Observed data to be taken from the PhilSensor website (link: https://philsensors.asti.dost.gov.ph/).													

Source: Ramboll

4.2 POST-MONSOON SOPs

The SOPs for the Baguio FEWS to be completed post-monsoon are outlined in Table C4-8 below. The SOPs should be implemented from November to March and can be started as soon as the monsoon ends. The tasks should be completed before the next monsoon begins.

Table C4-8 Standard Operating Procedures for the Baguio FEWS post-monsoon (Assessment Phase)

Section	Standard Operating Procedures	Responsible	Frequency
4.2.1	Station assessment	Instrument team	Post-monsoon
4.2.2	Model input data assessment	Modeling team	Post-monsoon
4.2.3	Catchment assessment	Modeling team	Post-monsoon
4.2.4	NAM-model assessment	Modeling team	Post-monsoon
4.2.5	Hydrodynamic (HD) model assessment	Modeling team	Post-monsoon
4.2.6	Data Assimilation (DA) assessment	Modeling team	Post-monsoon
4.2.7	Update Mike Operations (MO) back-end	IT team	Post-monsoon
4.2.8	Update Mike Operations (MO) front-end	IT team	Post-monsoon
4.2.9	Update reports	Modeling team	Post-monsoon
4.2.10	Update SOPs	Team lead Deputy team lead Modelling team IT team Instrument Team	Post-monsoon

Source: Ramboll

4.2.1 Station assessment

An assessment of all stations needs to be completed post-monsoon by the instrument team. Reports prepared during the monsoon would need to be assessed to study the frequency of the different types of failures and help in identifying and prioritizing the improvements that would be required for the different stations before the next monsoon.

1. Post-monsoon physical inspection of all stations following the manual for maintenance of real-time monitoring stations by DOST-ASTI.
2. Coordinate with DOST-CAR, PAGASA and DOST-ASTI as needed based upon the findings from the station performance reports to plan and apply required improvements to the stations.
3. Update required maintenance documentation in line with the maintenance manual.
4. Inform the modelling team and IT team of the assessment results and any updates made to the stations.

4.2.2 Model input data assessment

An assessment of the real-time data needs to be completed post-monsoon. This includes:

1. Individual assessment of performance of each real-time monitoring station.
   a. Assess data consistency and identify periods of data gaps.
   b. Assess data quality: identify outliers, negative values, unrealistic values.
   c. Follow up/coordinate with the IT team for stations or data that needs to be corrected/filtered.
2. Assessment of WRF data.
   a. Assess data consistency and identify periods of data gaps.
      i. Follow up/coordinate with the Numerical Modeling Section at PAGASA Central Office, as needed.
   b. Assess if there is a modification required in the error correction process for the WRF and communicate to the IT team about the subsequent changes to any scripts that would be needed to reflect the same.
3. If new stations are constructed and data has been collected during the monsoon, the data from these stations needs to be assessed following the steps outlined in Step 1 above.
4. Using the conclusions step 1, decisions to include/exclude real-time stations or change station weights in the NAM models should be made with each station being assessed separately.

4.2.3 Catchment assessment

Depending on the conclusions of 4.2.2 Real-time data assessment, re-delineation of catchments for the hydrological model domain may be necessary, if a decision to include/exclude a water level station has been made. Hence, this step should only be completed if new water level stations need to be included/ excluded in the back-end models.

1. Import updated point shapefile with stations to model.
2. Re-delineate catchments for all stations to be included in the model. Ensure that catchments for excluded stations are deleted.
3. Share new catchment shapefile and coordinate with IT team. Ensure that IT team implements updates to scripts based on the re-delineated catchments. For more information, refer to the *Flood Early Warning System Report*, Appendix C, 'Technical Note FEWS setup in MIKE OPERATIONS'.

4.2.4 NAM-model assessment

An assessment of the NAM-model needs to be completed post-monsoon. If no new water level stations have been included/excluded in the models, fine-tuning the NAM-model parameters is necessary based on the additional station data collected during the monsoon for the stations in the model:

1. If it has been decided to include new rainfall stations in the model, add the stations to the model and adjust the station weightages.
2. Finetune NAM parameters based on sub-catchments against the derived Q at the water level station locations. Repeat step 1 and step 2 until results are satisfactory.

If new water level stations have been included/excluded in the models and sufficient data is captured for the same, re-calibration of the models will be required based on the new sub-catchments delineated for the system in 4.2.3 Catchment assessment:

1. Develop QH relationship for new stations based on which derived Q is to be calculated
   a. Make a temporary copy of the model for this calculation alone
   b. Ensure cross-section data at the new station location is included in the MH model
   c. Add a standard boundary condition at this chainage in the model as a QH relationship
   d. Use the inbuilt tool in MIKE Hydro for QH calculation based on critical flow assumption at this location
   e. Copy the populated q-H table from the model to MS-Excel and generate a best fit "trendline". Use online reference[1] material, if required.
   f. Copy the formula for the trendline (with maximum possible decimal values for accuracy). This formula can then be used to generate Q from the observed WL for the station. Use online reference[2] material, if required.
2. If new rainfall stations should be included in the model, add the stations to the model and adjust the station weightages.
3. Calibrate NAM-model parameters based on new sub-catchments against the derived Q. Repeat step 2 and step 3 until results are satisfactory.

4.2.5 Hydrodynamic (HD) model assessment

An assessment and update of the HD model needs to be completed post-monsoon.

1. If new cross sections have been surveyed or there are updates to existing cross-section data, the cross-section file in the model should be updated accordingly.
2. If any changes have been made to the sub-catchments, enable both RR (NAM) and HD modules simultaneously in the model and update the river links to fit the new sub-catchments.
3. Update the roughness coefficient for calibration of the HD model while adjusting NAM-model parameters and station weightages again, if required, to obtain satisfactory results.
4. Repeat step 3 until satisfactory calibration results are obtained.

4.2.6 Data Assimilation (DA) assessment

Updates to the Data Assimilation (DA) module are based on an assessment and identification of well-functioning stations. Data Assimilation is applied to water-level data in the MIKE Hydro Model.
The error in the data is computed based on a period before the time of forecast by comparing the forecasted data and simulated data and then applied to the forecasted data in a way that at the time of forecast the error correction applied is 100% and then reduces over a few timesteps after the time of forecast, to 0.

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1 An example of online reference material from Microsoft: https://support.microsoft.com/en-us/office/choosing-the-best-trendline-for-your-data-1bb3c9e7-0280-45b5-9ab0-d0c93161daa8#:~:text=A%20polynomial%20trendline%20is%20a,valleys)%20appear%20in%20the%20curve.

2 An example of open-source reference material from Excellent: https://www.excell-en.com/blog/2019/4/20/using-trendline-equation-in-excel#:~:text=Right%20click%20on%20the%20trendline%20equation%2C%20%E2%80%9CFormat%20Trendline%20Label%E2%80%9D,you%20feel%20it%20is%20required.&text=-Copy%20this%20to%20an%20Excel,and%20ctrl%20v%20to%20paste.

The period for which this error is calculated and then applied makes a difference to how the forecasts improve. To determine this appropriate "period" at each location/station where DA is applied, repeated simulations with multiple assumed periods must be carried out, the difference in accuracy of the forecasted WL recorded for each simulation and compared.

DA should be assessed and updated every year, post-monsoon, to continuously improve forecasts through application of real time error calculations. Also, if any station which is used in DA has not been performing well (based upon 4.2.2), it is also required to take a call on removing it from the DA process altogether. If any new stations are added, they should also be included in DA for the next monsoon.

4.2.7 Update MIKE OPERATIONS (MO) back-end

The IT Team and the Modelling Team should collaborate on updating the MO workbench to make any necessary updates and changes to the FEWS setup. This would include Model re-registration, timeseries mapping, updating scripts, jobs etc.

4.2.8 Update MO front-end

The IT Team and the Modelling Team should together update the MIKE Operation dashboard to include updates to front-end visualizations based on the post-monsoon assessment and the updates to Dissemination and Outreach Plan and activities as these are tested and validated.

4.2.9 Update Reports

The model documentation should be updated following the assessment, finetuning and re-calibration of the system. The reports describe the current setup of the FEWS and should be revised based on post-monsoon system updates. The modelling team and IT team are responsible for preparing/updating the reports and should obtain input from the instrument team and stakeholder organizations as required.

4.2.10 Update SOPs

Following the post-monsoon assessment, the SOPs may need to be updated as new information becomes available and data, tasks and responsibilities for the operation and maintenance of the Baguio FEWS are validated. All procedures should be reviewed and, if necessary, adjusted or expanded to ensure lessons learned from the monsoon season are incorporated. The task is to be led by the Team Lead but requires input from all teams.

4.3 PRE-MONSOON SOPs

The SOPs for the Baguio FEWS to be completed pre-monsoon are outlined in Table C4-9 below. The SOPs should be implemented in April to ensure that the organizational and model set-up is ready for the monsoon. It is required that all tasks are completed before the monsoon begins.

Table C4-9 Standard Operating Procedures for the Baguio FEWS pre-monsoon (i.e. assessment phase).

Section	Standard Operating Procedures	Responsible	Frequency
4.3.1	Ensure completion of post-monsoon SOPs	Team Lead	Pre-monsoon
4.3.2	Coordinate with stakeholder organizations	Team Lead	Pre-monsoon
4.3.3	Plan O&M activities	Team Lead	Pre-monsoon
4.3.4	Assemble O&M team	Team Lead	Pre-monsoon
4.3.5	Ensure real-time stations are operational	Instrument team	Pre-monsoon

Source: Ramboll

4.3.1 Ensure completion of post-monsoon SOPs

The team lead should ensure that all post-monsoon SOPs are completed. It is crucial that available data and lessons learned from the past monsoon are incorporated in the FEWS ahead of the monsoon to ensure that timely and accurate warnings are produced. It is the team lead's responsibility to ensure that all teams complete their assigned SOPs.

4.3.2 Coordinate with stakeholder organizations

Coordination with stakeholder organizations involved in the operation and maintenance of the FEWS should take place ahead of the monsoon season to ensure that all communication lines are open, and staff are ready to assist in troubleshooting, if needed.

The team lead needs to reach out to contact persons from DOST-ASTI, DOST-CAR, and PAGASA to ensure that their staff are ready to support during the monsoon and that the system is fully operational from their side.

4.3.3 Plan O&M activities

The team lead should lead the planning of O&M activities for the coming monsoon.

1. Schedule regular O&M team meetings throughout the monsoon. A weekly meeting is recommended as a minimum, but more frequent meetings may be necessary.
2. Ensure that the technical leads have planned regular status meetings with their teams and have distributed tasks within their team.
3. Schedule monthly status meetings with stakeholder organizations including PAGASA, DOST-ASTI, and DOST-CAR to ensure that communications line stay open and that staff are available to assist in troubleshooting.
4. Assess the need for and plan training sessions to ensure the O&M team is fully prepared for the monsoon operation of the system.
5. Plan and schedule any other activities that are deemed necessary for the operation of the system throughout the monsoon.

4.3.4 Assemble O&M team

During the pre-monsoon preparation, the team lead should ensure that the O&M team is assembled and briefed on their responsibilities and tasks for the upcoming monsoon season:

1. Assemble all team members for a pre-monsoon meeting.
2. Ensure availability of all O&M team members to perform required tasks throughout the monsoon.
3. Go through the planned O&M activities for the monsoon.
4. Go through all SOPs for the monsoon as these may have been updated and ensure that all team members understand their required tasks and expected responsibilities.
5. Ensure all internal communication lines are open and well-established.

4.3.5 Ensure real-time stations are operational

An assessment of all stations needs to be completed pre-monsoon by the instrument team to ensure that all stations are operational ahead of the monsoon season.

1. Complete physical inspection of all stations following the manual for maintenance of real-time monitoring stations by DOST-ASTI.
2. Coordinate with DOST-CAR, PAGASA and DOST-ASTI as needed.
3. Update required maintenance documentation in line with the maintenance manual.
4. Ensure that SIM card subscriptions are continuedly paid and that payment plans are maintained. A post-paid plan subscription is recommended.

5 IMPLEMENTATION OF SOPs

Implementation of the SOPs is a responsibility shared by all members of the O&M team. To foster long-term sustainability of the FEWS, it is key to ensure continuous maintenance of the system as well as availability and capacity of resources. The City of Baguio needs to continuously prioritize physical maintenance of the system equipment and operation of the system by providing funding for required repairs and training of staff.

Proper coordination and understanding among different stakeholders are a prerequisite for sustainability of the FEWS. The SOPs provide the foundation for the operation and maintenance of the FEWS, but the implementation of these is highly dependent on well-established partnerships between the City of Baguio and stakeholders. The MOAs with relevant stakeholders enable collaboration, but it is ultimately up to the City of Baguio and stakeholders to take the responsibility required.

To ensure long-term sustainability of the FEWS it is therefore crucial that the LGU prioritizes:

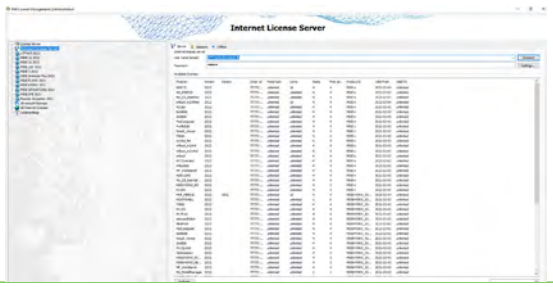
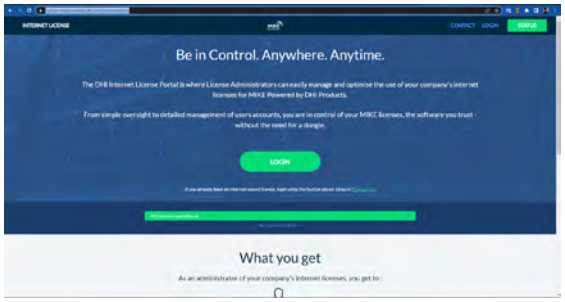
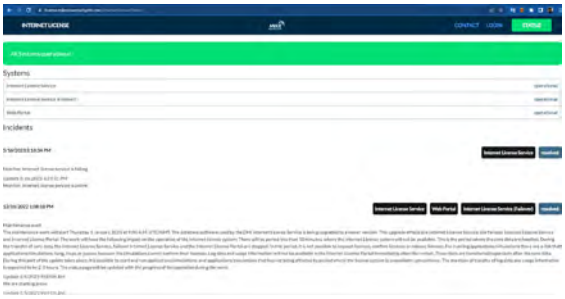
- Allocation of adequate financial resources
- Motivated, available, and trained human resources
- Well-established partnerships and proper coordination with stakeholder organizations
- Research and knowledge-sharing on FEWS
- Annual assessment of external technical support required

The FEWS is a dynamic system that should be adapted as additional data and knowledge is gained and lessons learned are incorporated in the system to enhance the system's resiliency, sustainability and value for the citizens of the City of Baguio.

6 TROUBLESHOOTING

In the operation processes, the jobs can fail due to multiple causes. These failures can be broadly classified based on the type of job failed. A few important failures and their rectification processes are presented in Table C6-1.

Table C6-1: Overview of failures and rectification processes

Type 1		
Problem Description	Failure of DHI MIKE License • Can cause an issue in data transfer • Running of daily Jobs	
Responsibility	IT Team	
Steps for investigations	1. Open DHI License Management 2. Check Available license is showing modules, or it is blank. 3. If blank restart the computer. 4. If restarting of computer doesn't solve the problem, follow the steps below	
Resolution Steps	1. Open https://license.mikepoweredbydhi.com/internetlicense 2. Click on Status button	
	3. Check whether there is any news of license service failing information. 4. If yes, then wait for DHI to fix the service. 5. Otherwise go to next step	
	1. Email to DHI	mikebydhi@dhigroup.com

Continued on next page

Table C6-1 continued

<table>
<tr><th>Type 2</th><th colspan="2"></th></tr>
<tr><td>Problem Description</td><td colspan="2">Check weather station data is receiving.
If stations are not working for 24 hours, it is important to investigate the following potential causes:
1. License failure
2. Problem with the latest data API/GSM card low balance
3. Failure of job</td></tr>
<tr><td>Responsibility</td><td colspan="2">IT Team and Instrument Team</td></tr>
<tr><td>Steps for investigations</td><td>Case 1: Due to license failure
In this scenario, the jobs were not executed, and therefore the data fetching from the Philsesensors website remains incomplete. Consequently, it is expected that the data available on the Philsesensors website will not be visible in MIKE Workbench.</td><td>
<table>
<tr><th>StationID</th><th>Station Name</th><th>Date</th><th>Station working(Hours)</th></tr>
<tr><td>2893</td><td>SADJAP BRIDGE</td><td>2023/05/11</td><td>19</td></tr>
<tr><td>460</td><td>CITY CAMP LAGOON</td><td>2023/05/11</td><td>19</td></tr>
<tr><td>2896</td><td>CAMP 7</td><td>2023/05/11</td><td>19</td></tr>
<tr><td>463</td><td>ASIN BRIDGE</td><td>2023/05/11</td><td>19</td></tr>
<tr><td>1728</td><td>CABARITAN BRIDGE</td><td>2023/05/11</td><td>0</td></tr>
<tr><td>2894</td><td>BROOKSPOINT</td><td>2023/05/11</td><td>19</td></tr>
<tr><td>460_old</td><td>CITY CAMP LAGOON - old</td><td>2023/05/11</td><td>0</td></tr>
<tr><td>1730</td><td>ARINGAY BRIDGE</td><td>2023/05/11</td><td>0</td></tr>
<tr><td>892</td><td>CAMP 6 BRIDGE</td><td>2023/05/11</td><td>19</td></tr>
<tr><td>2895</td><td>EAGLE CREST</td><td>2023/05/11</td><td>19</td></tr>
<tr><td>1390</td><td>BALILI BRIDGE</td><td>2023/05/11</td><td>19</td></tr>
<tr><td>1069</td><td>MAMAT-ING BRIDGE</td><td>2023/05/11</td><td>0</td></tr>
<tr><td>2892</td><td>FERGUSON BRIDGE</td><td>2023/05/11</td><td>19</td></tr>
</table>
</td></tr>
<tr><td>Resolution Steps</td><td>Case 2: In this scenario, despite executing the data fetching jobs, no data was received for several hours. This could be attributed to either a problem with the latest data API or a low balance on the GSM card.
Consequently, during the timeframe in which no data was obtained in MIKE Workbench, it is expected that the same hours will also exhibit a lack of data on the Philsesensors website. The absence of data in both platforms suggests a potential issue with the data source or connectivity, causing the data to be unavailable in both locations.</td><td>
<table>
<tr><th>StationID</th><th>Station Name</th><th>Date</th><th>Station working(Hours)</th><th>Accumulated Rainfall(mm)</th></tr>
<tr><td>764</td><td>BANGAR GYM</td><td>2023/05/21</td><td>0</td><td>0</td></tr>
<tr><td>453</td><td>KAPANGAN HEALTH CENTER</td><td>2023/05/21</td><td>0</td><td>0</td></tr>
<tr><td>1069</td><td>MAMAT-ING BRIDGE</td><td>2023/05/21</td><td>0</td><td>0</td></tr>
<tr><td>892</td><td>CAMP 6 BRIDGE</td><td>2023/05/21</td><td>0</td><td>0</td></tr>
<tr><td>450</td><td>BAKUN MUNICIPAL HALL</td><td>2023/05/21</td><td>0</td><td>0</td></tr>
<tr><td>478</td><td>ITOGON MUNICIPAL HALL</td><td>2023/05/21</td><td>0</td><td>0</td></tr>
<tr><td>1383</td><td>TOCMO</td><td>2023/05/21</td><td>0</td><td>0</td></tr>
<tr><td>460</td><td>CITY CAMP LAGOON</td><td>2023/05/21</td><td>0</td><td>0</td></tr>
<tr><td>463</td><td>ASIN BRIDGE</td><td>2023/05/21</td><td>0</td><td>0</td></tr>
<tr><td>2894</td><td>BROOKSPOINT</td><td>2023/05/21</td><td>24</td><td>4.5</td></tr>
<tr><td>1150</td><td>KABAYAN MUNICIPAL HALL</td><td>2023/05/21</td><td>0</td><td>0</td></tr>
<tr><td>460_old</td><td>CITY CAMP LAGOON - old</td><td>2023/05/21</td><td>0</td><td>0</td></tr>
<tr><td>454</td><td>BARANGAY HALL</td><td>2023/05/21</td><td>0</td><td>0</td></tr>
<tr><td>1969</td><td>ALNO</td><td>2023/05/21</td><td>0</td><td>0</td></tr>
<tr><td>2341</td><td>MANGAAN ELEMENTARY SCHOOL</td><td>2023/05/21</td><td>0</td><td>0</td></tr>
<tr><td>1379</td><td>BARANGAY HALL</td><td>2023/05/21</td><td>0</td><td>0</td></tr>
<tr><td>1729</td><td>LIBBO ELEMENTARY SCHOOL</td><td>2023/05/21</td><td>0</td><td>0</td></tr>
<tr><td>1381</td><td>SAGPAT ELEMENTARY SCHOOL</td><td>2023/05/21</td><td>0</td><td>0</td></tr>
<tr><td>1390</td><td>BALILI BRIDGE</td><td>2023/05/21</td><td>0</td><td>0</td></tr>
<tr><td>850</td><td>POBLACION EAST-Rosario LU</td><td>2023/05/21</td><td>0</td><td>0</td></tr>
<tr><td>468</td><td>MANKAYAN MUNICIPAL HALL</td><td>2023/05/21</td><td>0</td><td>0</td></tr>
<tr><td>452</td><td>TUBA MUNICIPAL HALL</td><td>2023/05/21</td><td>0</td><td>0</td></tr>
<tr><td>3028</td><td>IRISAN FIRE STATION</td><td>2023/05/21</td><td>0</td><td>0</td></tr>
</table>
</td></tr>
</table>

Continued on next page

Table C6-1 continued

<table>
<tr><th>Type 2</th><th colspan="2"></th></tr>
<tr><td>Steps for investigations</td><td>Case 3: Due to failure of the Job for many hours

Occasional failures of the real-time data download job, happening once or twice a day, should not be a cause for alarm as long as the job resumes its normal functioning.

It is not uncommon for such intermittent failures to occur due to factors like temporary connectivity issues, server glitches, or inconsistencies in the data source. However, if the job successfully retrieves and delivers the expected data after the initial failure(s), there is typically no need to worry.

But it might be possible that job is failing for many hours</td><td>
<table>
<tr><th>StationID</th><th>Station Name</th><th>Date</th><th>Station working(Hours)</th></tr>
<tr><td>2893</td><td>SADJAP BRIDGE</td><td>2023/05/11</td><td>19</td></tr>
<tr><td>460</td><td>CITY CAMP LAGOON</td><td>2023/05/11</td><td>19</td></tr>
<tr><td>2896</td><td>CAMP 7</td><td>2023/05/11</td><td>19</td></tr>
<tr><td>463</td><td>ASIN BRIDGE</td><td>2023/05/11</td><td>19</td></tr>
<tr><td>1728</td><td>CABARITAN BRIDGE</td><td>2023/05/11</td><td>0</td></tr>
<tr><td>2894</td><td>BROOKSPOINT</td><td>2023/05/11</td><td>19</td></tr>
<tr><td>460_old</td><td>CITY CAMP LAGOON - old</td><td>2023/05/11</td><td>0</td></tr>
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<tr><td>892</td><td>CAMP 6 BRIDGE</td><td>2023/05/11</td><td>19</td></tr>
<tr><td>2895</td><td>EAGLE CREST</td><td>2023/05/11</td><td>19</td></tr>
<tr><td>1390</td><td>BALILI BRIDGE</td><td>2023/05/11</td><td>19</td></tr>
<tr><td>1069</td><td>MAMAT-ING BRIDGE</td><td>2023/05/11</td><td>0</td></tr>
<tr><td>2892</td><td>FERGUSON BRIDGE</td><td>2023/05/11</td><td>19</td></tr>
</table>
</td></tr>
<tr><td>Resolution Steps</td><td>Log in to MIKE Workbench, the software platform used for managing and analyzing data in DHI applications.

Access the Jobs Manager within MIKE Workbench to check the status of the RealTimeData job. Look for any gaps or interruptions in the job's execution.

Case 1: If you find that the job is not running continuously and there are significant gaps of several hours or more in the job run, it suggests that the job has failed due to MIKE license issues.

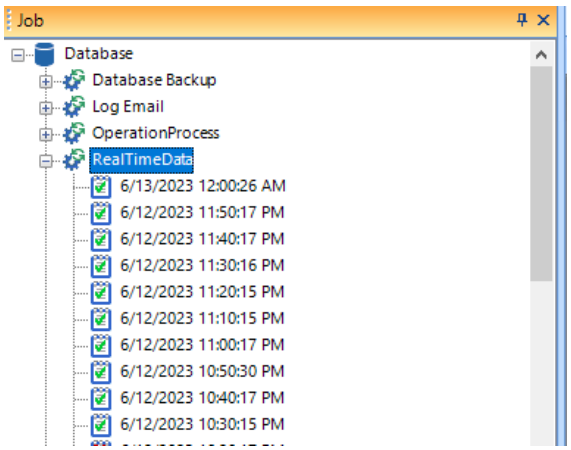
Case 2: However, if the job has been running fine without interruptions, but the daily report indicates fewer working hours for the stations than expected, it indicates a different issue. This could be a case of Case 2, where the stations are not working as expected despite the job running successfully.</td><td> 
</td></tr>
</table>

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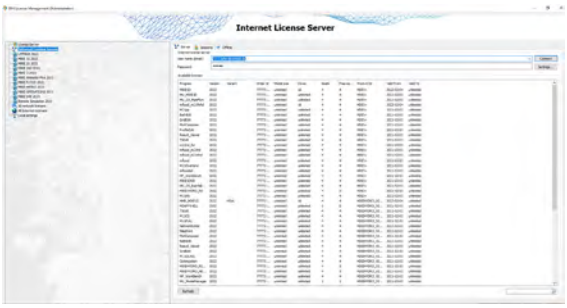
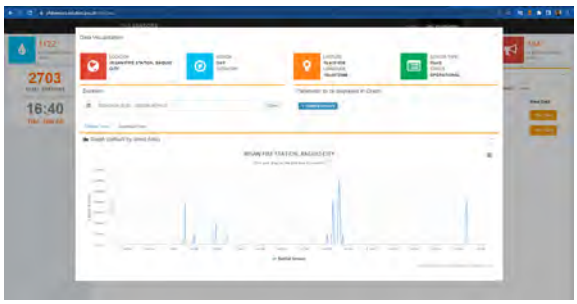
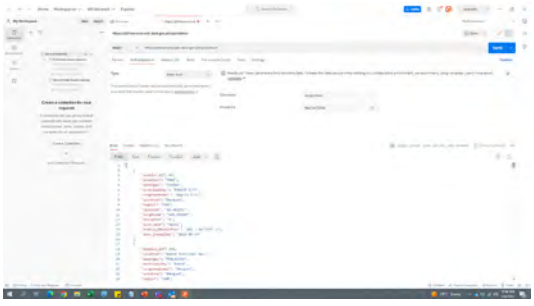
Table C6-1 continued

Type 2		
Steps for investigations	**Case 3:** If the RealTimeData job is failing continuously, regardless of the station's working hours, it implies a persistent problem. In this case, additional troubleshooting steps should be taken to identify and resolve the underlying cause of the job failure. Review job logs, error messages information to pinpoint the issue.	
	Case 1: Open the DHI License Manager, which is the software used to manage licenses for DHI software products. Check the status of the MIKE License in the License Manager. If the license is not working or is expired, it needs to be addressed according to the Standard Operating Procedure (SOP1) specifically designed for such situations. Refer to SOP1 for instructions on how to handle license failures and proceed accordingly to resolve the issue. If the MIKE License is working and valid in the License Manager, you can proceed to the next step of troubleshooting.	
	Case 2: Open MIKE Workbench and check for which hours data is not available. Verify missing data hours on https://philsensors.asti.dost.gov.ph/site/data If data is available on above website and not it MIKE OPERATIONS then check the API is working properly or not	
	Check API using Postman software.	

Continued on next page

Table C6-1 continued

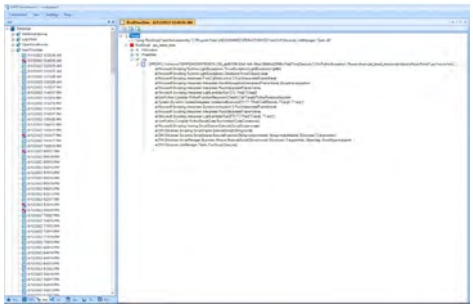
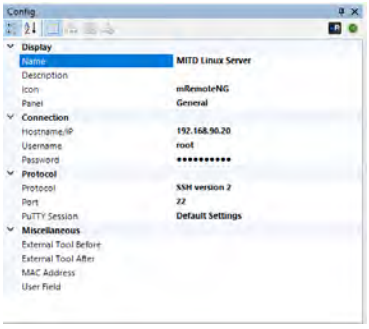
Type 2		
Steps for investigations	**Case 3:** Open the Job Manager and check the log of the failed Job. RealTimeData job trigger following script. Debug and check the script for details. **Script Path:** /RealTime/get_latest_data	
Type 3	**WRF data failure**	
Problem Description	**WRF data is not received** • Can cause issue in data transfer • Running of daily Jobs PAGAS team upload WRF data into MITD server (Server – FEWS Backup and Data server) every 3-hour interval. PAGASA upload WRF data in folder with name – YYYYMMDD_hhmm. Inside this folder there must b two folders d01 and d02. d01 folder contains 144 files and d02 contains 48 files. File format must be **baguio_fews_postwrf_d0x_yyyymmdd_init_fhhhhh.gr2** • dxx - domain 01 for 12km, 02 for 3km • yyyymmdd - year, month, date • init - initialization times (0000, 0300, 0600, 0900, 1200, 1500, 1800, 2100) • fhhhhh - forecast hour (example: f09900 -> 99th forecast hour ,f10000 -> 100th forecast hour)	
Responsibility	IT Team	
	We want to check weather data uploaded on MITD server matches with the data in FEWS machine	
Steps for investigations	Login 192.168.90.20 User name: not published Password: not published Protocol: SSH version 2 Port: 22 It is a Linux machine, so you need mRemoteNG software to login this machine	

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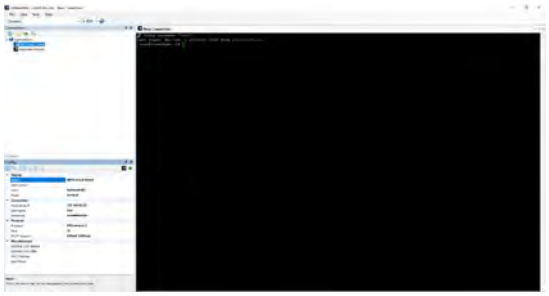
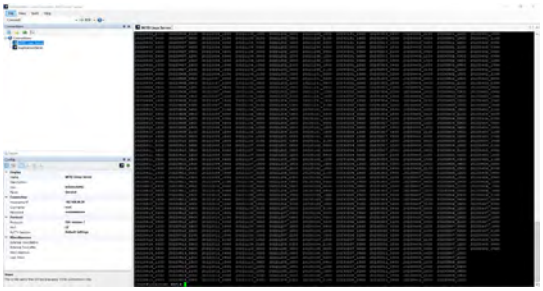
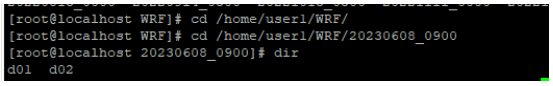
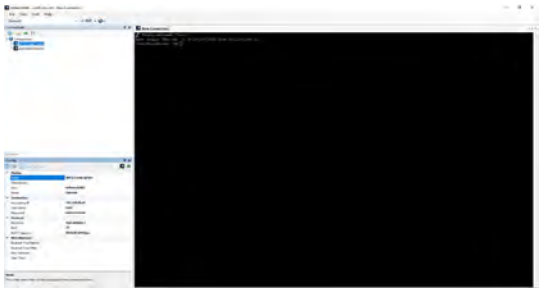
Table C6-1 continued

Type 3	WRF data failure	
	Once it will be connected it will look like	
	Run command cd /home/user1/WRF and press enter Then run command dir This will show the available directories in WRF folder	
	Run command cd /home/user1/WRF/ YYYYMMDD_hhmm YYYYMMDD_hhmm is the folder name which you want to investigate Again run dir commad for all available directories in this folder	
	Example of failure. In this uploaded folder has only d01 folder and d02 folder is not available	
Resolution Steps	Wait for next upload from PAGASA and inform about the wrong upload to PAGASA team	

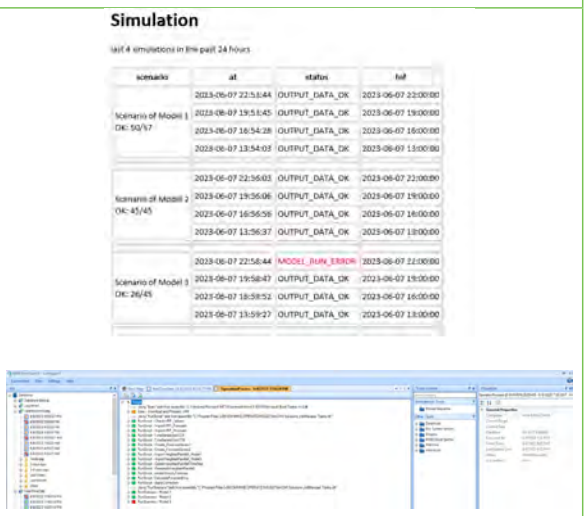
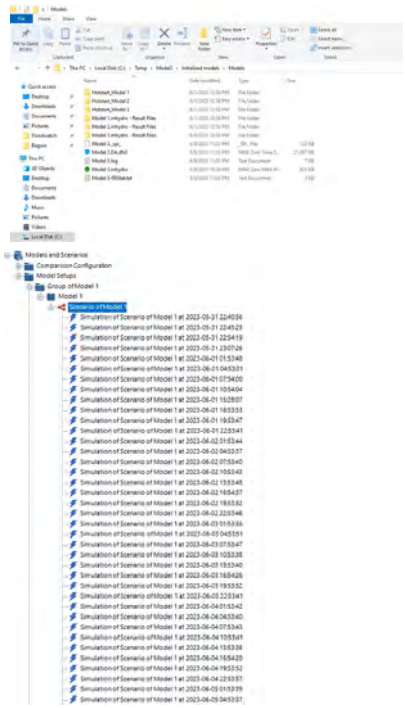
Continued on next page

Table C6-1 continued

Type 4	Data preprocessing failure	
Problem Description	Failure of Bias Correction scripts • Issue in development of Cx_resampled file	
Responsibility	IT Team and Modelling Team	
Steps for investigations	Check the Cx_resampled files Then, check the catchments MAW files named as Cx files	
	Check the status of real time station data Follow steps of investigation for "Station data failure".	
	Check the status of WRF data Follow steps of investigation for "WRF data failure".	
Resolution Steps	Replace the Cx_file for the simulation period with blank data	
	Case 1: Failure due to station data Follow resolution steps for "Station data failure".	
	Case 2: Failure due to WRF data Follow resolution steps for "WRF data failure".	

Continued on next page

Table C6-1 continued

Type 5	Data preprocessing failure	
Problem Description	• Simulation Failure	
Responsibility	Modelling Team and IT team	
Steps for investigations	Check the email simulation log or job manager to identify: a. Model b. Simulation time	
Resolution Steps	1. Run the model saved in C:\Temp\Model1 if Model1 fail and C:\Temp\Model3 if Model3 fail as these are Checkout location for the models. If the simulation failed is of earlier time step, extract the model for the time step at which model failed.	
	2. Troubleshoot and re-run the model	

Continued on next page

Table C6-1 continued

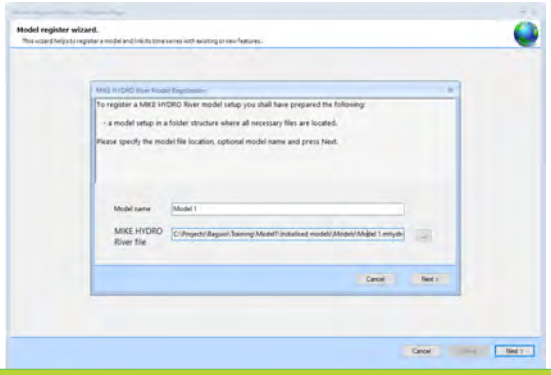
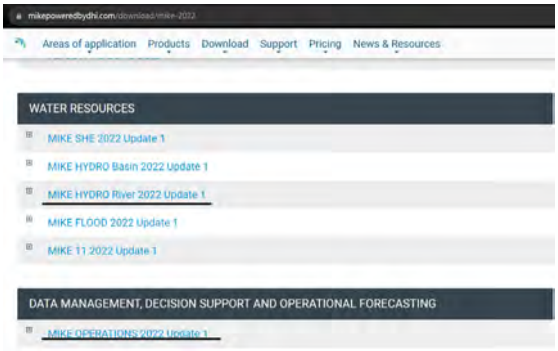
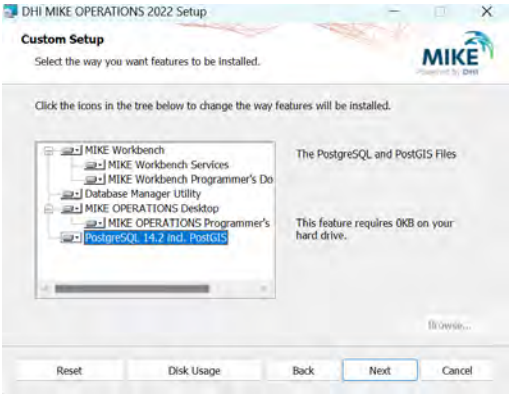
Type 5	**Data preprocessing failure**	
	3. Re-register the updated model with the same name	
Type 6	**System wipe-out/Server Re-installation**	
Problem Description	If the main server has received damage or is unable to function and needs to be re-installed or transferred to a new location or system.	
Responsibility	IT Team	
Steps	1. Re-install the MIKE Zero (MIKE Hydro River and MIKE Operations) Software to the new system	Download the installer from: https://www.mikepoweredbydhi.com/download/mike-2022
		
	1.1 Make sure that all of these features are checked for MIKE Operations	

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Table C6-1 continued

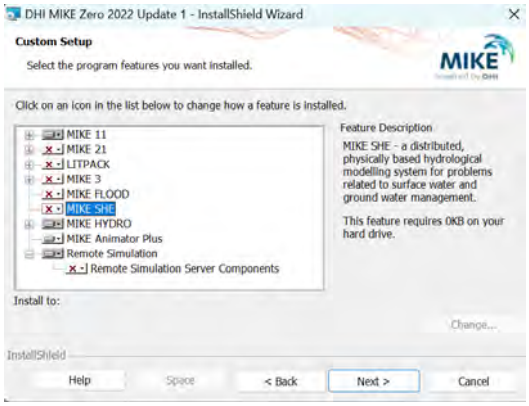
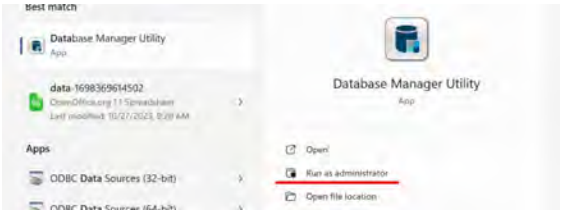
Type 6	System wipe-out/Server Re-installation	
	1.2 Most options would be on default but the password will be required and set-up properly	
	1.3 For MIKE Zero Installation follow the image on the right which features to install and the rest would be the default options.	
	2. Copy the database from Back-up	File is located at "C:/DatabaseBackup/ BaguioFF_pgAdmin_2023_10_27.backup" *May have a different filename according to the latest date the backup was created*
	3. Store the data base back up into new machine	Use Database Manager Utility and run as an administrator 

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Table C6-1 continued

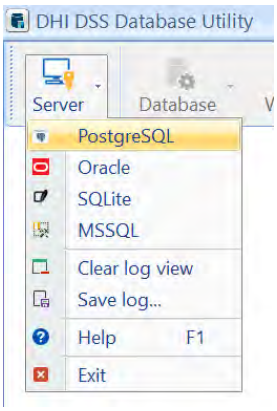
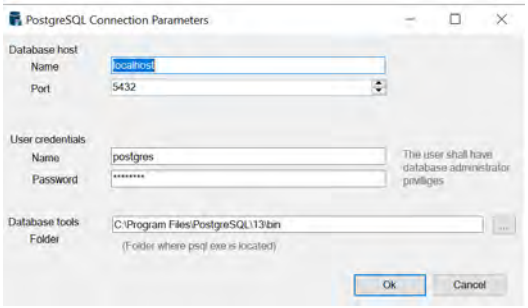
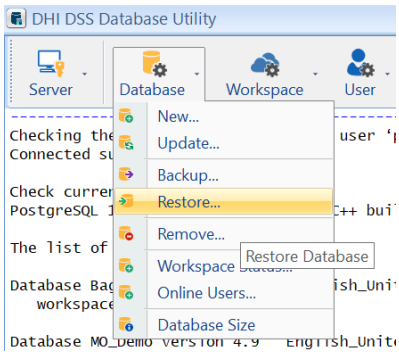
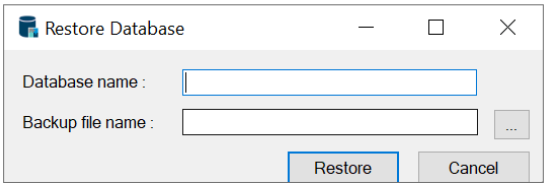
Type 6	System wipe-out/Server Re-installation	
	3.1 Select "PostgreSQL"	
	3.2 Password will be the one from the previous installation at 1.2	
	3.3 Go to Menu>Database and select "Restore"	
	3.4 Input any data base name and select the back-up file and click "Restore"	

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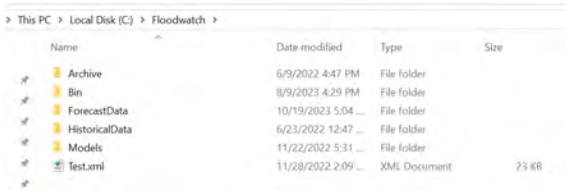
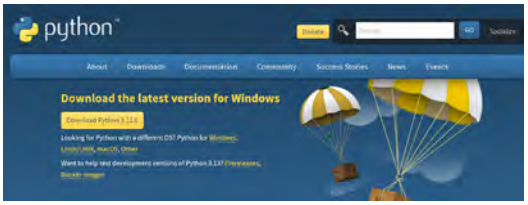
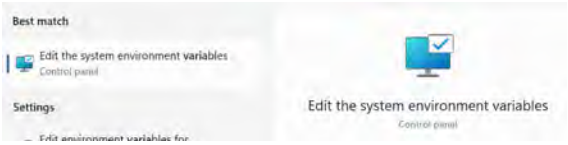
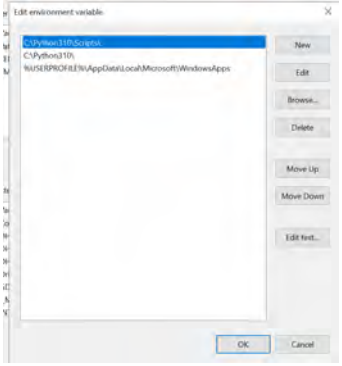
Table C6-1 continued

Type 6	System wipe-out/Server Re-installation	
	3.5 Copy "Floodwatch" folder from the backup and transfer it to the new Machine at the same folder	
	4. Download and Install Python	
	4.1 PIP Install these libraries	https://drive.google.com/file/d/1bzhVdq7Y-fjKir_SksLlOP0xIUgfz79Mu/view?usp=drive_link
	5. Add environmental variable for Python	  

Source: Ramboll

7 FEWS SOPS VERSION HISTORY

Table C7-1: Version history of the FEWS Standard Operating Procedures

Version	Publishing Date	Description	Responsible	Frequency
V1.1	June 2023	Updated version ahead of 2023 Monsoon based on learnings through OTJ training. Version used for O&M during the 2023 Monsoon.	FEWS O&M team	Stine Dybkjær
V2.0	January 2024	Updated version based on learnings from 2023 monsoon O&M	FEWS O&M team, Vilakshna Parmar, Amit Garg	Stine Dybkjær

Source: Ramboll

Source: Ramboll

APPENDIX D
SUSTAINMENT PLAN

1 SUSTAINMENT PLAN

1.1 PURPOSE OF THE SUSTAINMENT PLAN

The sustainment plan describes strategies to maintain the operational capabilities of the Baguio Flood Early Warning System (FEWS) and to continue to develop the system and the technical capacity of the FEWS Operations and Maintenance (O&M) team, building upon the successes and the lessons learned throughout the project. The sustainment plan addresses the ongoing needs for capacity building, governance, system enhancements and adaptation, and resource allocation. The goal is to ensure that the FEWS remains a viable and reliable system and that it continues to add value to the citizens of Baguio as an active risk mitigation instrument. In essence, this sustainment plan sets the stage for continuous improvement and long-term viability of the FEWS.

Significant strides were made in implementing and operationalizing the FEWS since the inception of the project. Several steps for enhancement of long-term sustainability have already been taken including the establishment of the FEWS O&M team, implementation of targeted capacity building and training programs, preparation of standard operating procedures (SOPs), establishment of Memorandums of Agreement (MOAs) with partner organizations, and development of an implementation plan which outlines actions and responsibilities for a Gender Transformative FEWS in Baguio.

Building on these efforts, actions to further enhance the foundation for effective operation and maintenance were identified at the end of the pilot project, and support to the Baguio Local Government Unit (LGU) towards achieving these actions has been prioritized in the Consolidation Phase in 2023. The sustainment plan combines the activities already in progress with recommendations for next steps from 2024 onwards.

The City of Baguio's ambition is to ultimately achieve a Gender Transformative and people-centric FEWS, specifically to ensure appropriate, applicable, and timely early warning reaching the last mile, including the most vulnerable, recognizing that an effective FEWS is people-centric. While this sustainment plan has a core focus on strategies to maintain the operational capabilities of the FEWS and continue to develop the system and technical capacity, it recognizes and references throughout the ongoing centrality of the Gender Transformative Implementation Plan in the context of overall sustainment of the FEWS.

1.2 STRUCTURE OF THE PLAN

The sustainment plan combines four critical lenses (human resources, institutional, technical, and financial) to form a comprehensive roadmap of activities that ensure the LGU and FEWS O&M team can effectively operate, adapt, and evolve the FEWS in the long term.

- **Human resources sustainment**
  Considering the pivotal role of the O&M team in the successful functioning and continual improvement of the FEWS, the first part of the plan will focus on maintaining and enhancing the pool of available and well-trained staff. The chapter will outline both actions to enhance the human resources sustainability that have already taken place (such as the establishment of the O&M team, formulation of SOPs, and the implementation of capacity building and training programs), as well as recommendations for further actions needed in terms of training and on-the-job technical support.
- **Institutional sustainment**
  The second part of the plan addresses anchoring of the FEWS within the existing institutional setup in Baguio. It outlines the proposed structure of ownership and governance of the system, monitoring stations, and data. The successful operations of the FEWS depend on defining clear roles and responsibilities between partner organisations in and outside Baguio, and establishing formal partnerships between key stakeholders through MOAs – both those already signed, and those recommended to be established in 2024 and beyond.
- **Technical sustainment**
  This chapter outlines activities enhancing and sustaining the technical components of the system, covering the maintenance schedules for stations and ITC equipment, software update schedules and data security, as well as identifying stakeholders responsible for this maintenance in line with SOPs. It delves into future system enhancements, including model calibration, additional features and functionalities, as well as expanding the network of monitoring stations. The chapter will close with a plan for data dissemination and outreach activities, including the development of warning messages, essential testing phases, and awareness-raising. The FEWS is a dynamic system that should be adapted and finetuned as additional data and knowledge is gained and lessons learned are incorporated in the system.
- **Financial sustainment**
  A well-defined budget and stable sources of funding for operations and maintenance of the FEWS are instrumental to ensuring the long-term sustainability of the system and opportunity for growth and continual enhancements. The financial sustainment chapter will provide an overview of all expected costs associated with the O&M of the system and identify the departments or institutions responsible for covering them. The chapter will break down key costs involved in the operation and maintenance of the Baguio FEWS, including salaries, hardware and software costs, and costs related to additional training, workshops, and meetings. Furthermore, it will suggest potential new funding sources that could be explored as part of the development of the system.

Finally, the plan will close with an overview of risks identified by the O&M team during the October 2023 sustainment workshop and actions to mitigate the risks in each of the four focus areas.

1.3 WORKSHOP ON SYSTEM SUSTAINMENT

A workshop on system sustainment for the O&M team members was held on 25 October 2023, with the primary aim to agree on components that should be included in the sustainment plan, collect inputs for the plan, and bring the team's attention to sustainment activities, further strengthening the sense of local ownership of the FEWS. The outcomes of the workshop highlight that the team demonstrates very good knowledge of the system and the efforts required to sustain it. The full results of the workshop can be found in Additional material A.

The workshop included four group exercises:

1. Sustainment plan components and risks exercise
The participants were divided into four groups and provided with posters for each of the four sustainment areas (human resources, institutional, technical, and financial). They were asked to come up with topics that should be covered in the plan under each area. They were also asked to identify potential risks or challenges that could arise and propose actions to mitigate these risks.

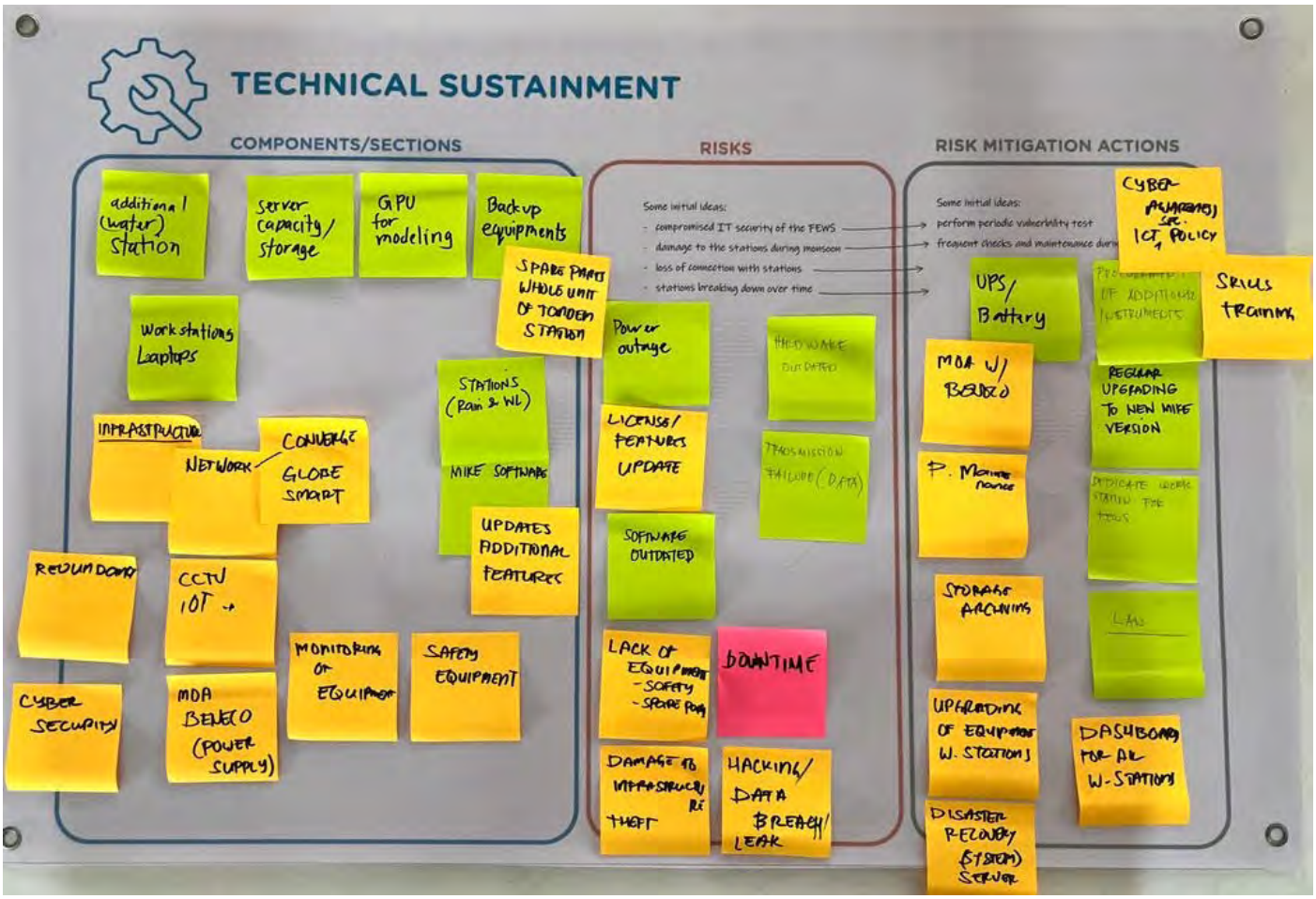


Figure D1-1 Output from the sustainment workshop: suggestions for technical components in the sustainment plan
Source: Ramboll

In 10-minute intervals, groups were asked to switch to another board and repeat the exercise on a different area by continuing the work on the other board, until all groups had a chance to address all four topics. The exercise design aimed to minimize the effort of starting the idea generation process from scratch and allowed participants to build upon the ideas of their colleagues, or to try to propose mitigation actions to risks proposed by others. The participants representing different teams (IT, modelling, instrument) were purposefully split up into different groups to enhance the diversity of ideas during the brainstorming.

2. Planning the FEWS year exercise

Workshop participants were divided into the three teams (IT, modelling, instrument) and were provided with posters with a wheel representing one year. They were tasked to list cyclical activities and place them into the corresponding months. The activities included both the teams' assigned tasks according to the SOPs, as well as external cyclical events that can influence the timing of activities (such as the approval of the LGU's annual budget). The exercise aimed to bring more detail into activities included in the FEWS SOPs, especially those that take place in the post-monsoon phase, which don't specify the month of completion. The exercise also aimed to help the O&M team members to visualize activities connected to the FEWS in a cyclical manner, which could be used for planning tasks in the future.

Figure D1-2 Output from the sustainment workshop: annual IT activities

Source: Ramboll

3. SOP confidence exercise
The primary aim of this exercise was to evaluate the overall confidence levels associated with carrying out each SOP. Participants were asked to grade how confident they are as a team in implementing each SOP on a scale from 1 to 10. If the rating fell below 7 on any of the SOPs, they were also asked to provide a detailed description of activities they would require more support on. This exercise provided input on the needs for training and technical support, which are listed in section 2.3 of this plan.

4. Budget preparation
The exercise aimed to create an estimated budget for O&M, including compensation, hardware and software costs, training costs and other (further outlined in chapter 6 of this plan). Due to time constraints, this exercise was carried out online after the workshop.

2 HUMAN RESOURCES SUSTAINMENT

A plan for sustainment of available and well-trained human resources is crucial for ensuring correct operations and maintenance of the FEWS in the long term. A significant effort in training, teambuilding, and guiding the designated local resources for the FEWS project was made and continued in 2023 during the Consolidation Phase. There is still a need for continuously developing the team's knowledge and skills, to ensure seamless functionality and adapting the FEWS to changing conditions and continual system enhancements.

This chapter outlines the project achievements to ensure long-term sustainment in terms of setting up the O&M team, training and capacity building and defining the SOPs. Furthermore, it lists key actions necessary to enhance the capacity and resiliency of the O&M team following the completion of the Consolidation Phase, to address the further training and technical support needs.

2.1 O&M TEAM STRUCTURE, ROLES AND RESPONSIBILITIES

To enable effective operation and maintenance of the FEWS for Baguio, the FEWS O&M Team has been formed. The ownership of the FEWS is anchored at the Local Government Unit (LGU). Thus, the O&M team consists of a core team of seven (7) LGU staff and a peer team of five (5) representatives from academia (i.e., Saint Louis University, University of Cordilleras) and selected relevant agencies (i.e., PAGASA, DOST-CAR). The team is tasked with the responsibility of operating and maintaining the FEWS. To ensure long-term operations of the FEWS, the LGU should continuously ensure that the O&M team members are available and have the mandate to prioritize and perform the required tasks.

Overall supervision of the FEWS O&M team lies with the head of CDRRMO, who has the mandate to coordinate directly with high-ranking government officials and guide decision-making. The team is sub-divided in three smaller teams: the modelling team, the instrument team, and the IT team. The structure of the O&M team can be seen in Figure D2-1. A well-defined organigram provides guidance to all team members by outlining the official reporting relationships that govern the workflow of the team and enhances the foundation for efficient operation and communication.

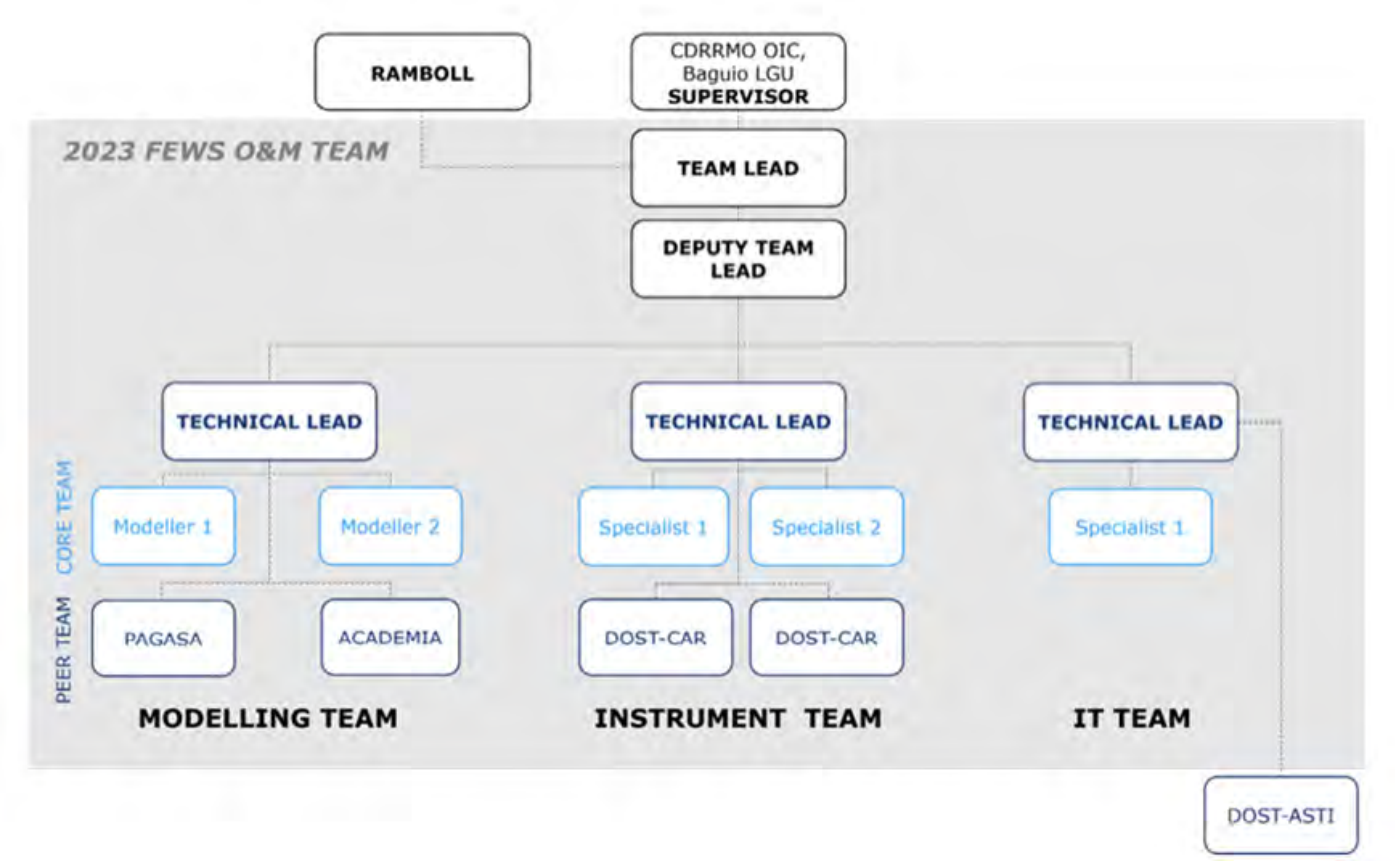


Figure D2-1 O&M Team structure
Source: Ramboll

The responsibilities of each of the O&M team roles are further detailed in the *Flood Early Warning System Report*[1].

Ensuring that the O&M team members are available to perform their assignments is a key concern in ensuring the continuity of FEWS operations. The possibility of staff being promoted, transferring to other offices, or retiring has been identified by LGU as a significant human resources risk during the sustainment workshop and is addressed further in chapter 6 – risk mitigation. It is recommended that the LGU identifies team members who can take over vacant positions in case of staff changes. Cross-training of staff members to handle multiple roles could also minimize knowledge loss.

The time and resources required to operate and maintain the FEWS will change throughout the operation phases. The resources required are expected to be highest in the application phase, where the system is actively used as a decision-making tool. Table D-1 outlines the expected time requirements for the staff of the O&M team. The number of hours indicated therein are to serve as guidance which may vary depending on actual system performance.

The LGU and partner organizations shall ensure that all O&M team staff are available to support the operation and maintenance of the FEWS as required. In case of unforeseen circumstances, it is required that the LGU be flexible and can readily adapt workflows to meet increased demands for resources to e.g. complete troubleshooting.

1 Flood Early Warning System Report Phi: Baguio City Smart Flood Warning, Information And Mitigation System, AASCTF, April 2022

Over the course of the project, it has been observed that the O&M team members have many work commitment and high workloads. Even though LGU staff shows very high commitment and sense of ownership over the FEWS, this is a risk to the long-term program sustainability, as the LGU staff may not have the time required to maintain and operate the FEWS due to limited resource availability. Hiring additional staff is strongly recommended to ensure sustainable workloads for the team, especially in highly intensive periods like the monsoon phase.

The LGU is currently undergoing organizational development where City Disaster Risk Reduction and Management Office (CDRRMO) is one of the offices being considered as a separate department within the LGU. This is being led by the City Human Resources and Management Office (CHRMO). As a department, the CDRRMO has proposed the creation of additional plantilla positions, including those positions that will handle the maintenance of the weather station facilities that the LGU owns, notwithstanding the established collaboration of the FEWS O&M.

CDRRMO proposed organizational restructuring based on the approved CDRRMO Ordinance . In the restructuring, the office proposed expansion of the number of personnel in all three sections, especially under the Operations and Warning Section/Division. The O&M team will closely collaborate with this division as this will be part of their Core Function.

Table D2-1 Number of hours required for roles in the FEWS O&M team

Role	Time allocation (hours/week)		
	Monsoon	Post-monsoon	Pre-monsoon
Team Lead	12	12	12
Deputy Team Lead	8	8	8
Technical Lead	12	12	12
Modelling Team (core team)	16*	12*	8*
IT Team (core team)	16*	8*	12*
Instrument Team (core team)	16*	8*	8*
Peer Staff	4	2	2
Support	2	2	2
*Note: The (*) marks hours stated as team hours which implies the total hours that are needed from the team as a whole. Based on availability of team members for tasks, the total hours would be divided between them.			

Source: Ramboll

The list of staff on the FEWS O&M Team as of 2023 can be found in Additional material B.

To further enhance the capacities of the FEWS O&M team, a technician with experience in operation and maintenance of monitoring stations has been hired in the MITD in early 2023. The technician has become an active part of the FEWS O&M team serving as technical lead of the instrument team. The addition of a technician to the team has enhanced the effectiveness of troubleshooting and maintenance as well as increased effective communication with partner organizations including DOST-CAR, DOST-ASTI, and PAGASA.

2.1.1 GEDSI recommendations for the team

An Implementation Plan outlining actions and responsibilities for a Gender Transformative FEWS in Baguio has been developed and shared with LGU as a working document to support key FEWS stakeholders on the journey towards realising a gender transformative FEWS (shared with Baguio FEWS stakeholders in November 2021). The Implementation Plan is based on the *Baguio City Gender and Inclusion Study*[2], and the subsequent *Policy and Practice Recommendations Brief*[3].

Developed in consultation and collaboration with the CDRRMO, the City Social Welfare and Development Office (CSWDO), and the Public Information Office (PIO), the actions delineated in the Implementation Plan were designed for the initial purpose of informing the Smart Flood Early Warning, Information and Mitigation System project and project stakeholders. By implementing the actions specifically aligned to each recommendation, the FEWS will take a gender transformative approach to the design and implementation of the FEWS to ensure that the system is effective for everyone who needs it, leaves no one behind, and supports equitable and inclusive risk reduction and resilience.

The Implementation Plan actions are a starting point and will evolve as the FEWS evolves - the plan identifies what is possible with current resources (immediate actions), what might be possible with further resources (later actions). The actions can (and have already) form the basis for implementation plans, SOPs for the FEWS, and guidance for future iterations and evolutions of the FEWS. The actions should be refined and revised later as the system evolves. The actions should also be integrated into plans, procedures, and policies for DRM and EWS stakeholders, rather than standing alone in isolation. In this way, gender and social inclusion will be considered and addressed across all areas of the FEWS, rather than as a separate list of gender-specific "add-ons".

The Implementation Plan provides the actions to be taken under the eight overarching recommendations for a gender transformative FEWS, including: 1) Gender and inequality informed EWS; 2) Improve understanding of risk; 3) Preparedness for safe evacuation; 4) Development of forecasts, alerts, and warnings; 5) Dissemination (of forecasts, alerts, and warnings); Communication (of forecasts, alerts, and warnings); 7) Person-centred evacuation; 8) Safety and dignity in temporary shelter.

Significant progress on implementing Gender Transformative actions in the Implementation Plan has been made in addressing actions linked to gender and inequality informed EWS, and recommendations for the dissemination testing phases. However, the implementation of many of the gender transformative actions needed to be slowed or postponed accommodating the significant technical and consolidation activities underway as part of setting up and testing the FEWS.

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2 Mixed Methods Gender and Inclusion Study Report. PHI: Gender Transformative Approach for Strengthened Development, Application, and Replication of the Baguio City Smart Flood Early Warning. AASCTF. August 2021.

3 Policy and Practice Recommendations: Towards a Gender Transformative Flood Early Warning System in Baguio City PHI: Gender Transformative Approach for Strengthened Development, Application, and Replication of the Baguio City Smart Flood Early Warning. AASCTF. September 2021

To progress and sustain momentum on the actions, there is a need to ensure continuation of the GEDSI focal point and GEDSI capacity within the CDRRMO, including the support by the required institutional stakeholders beyond CDRRMO that are mandated and resourced to assist or lead the actions assigned to them in the Implementation Plan (e.g. CSWDO, PIO, Barangays, OPCEN, Gender and Development (GAD) Focal Points, and Civil Society Actors). These HR requirements, responsibilities, and capacities are delineated in the Implementation Plan and not located directly in the O&M team and activities. That being said, the importance of the link between the O&M team and the gender focal points in CDRRMO and beyond cannot be overstated. The link between O&M activities and gender transformative actions is particularly strong in relation to formulating the SOPs for dissemination and outreach in future testing phases.

2.2 SOPs

To ensure effective operations of the FEWS, Standard Operating Procedures (SOPs) were formulated. They are designed to ensure that all procedures are performed consistently and efficiently across all team members and over time.

SOPs can be defined as a written document with step-by-step instructions on how to perform a designated activity to obtain a desired outcome. Clearly defined SOPs are crucial to ensuring consistent operation of the FEWS. The benefits of effective SOPs for the FEWS include:

- Effective operation of the FEWS
- Consistency in operation
- Assigning responsibility and accountability of tasks to smaller teams
- Ensuring dynamic upgrades of the FEWS
- Creating a safe work environment
- Saving time and money

Thus, the SOPs contribute to enhancing long-term sustainability by outlining specific activities and tasks to be undertaken by the O&M team and serving as a guide for the team throughout the different operation and maintenance phases. At the same time the SOPs contribute to achieving efficiency, quality output and uniformity of performance, while reducing miscommunication and failure to comply with standards.

An overview of the Standard Operating Procedures for the Baguio FEWS is shown in Figure D2-2. For each SOP the following is described:

- Phase: The operation phase in which the SOP should be carried out (pre-monsoon, monsoon, post-monsoon)
- Frequency: The number of times a task should be completed within a given time period
- Responsible: The team responsible for performing the SOP
- Section: The number of the section in which the SOP described step-by-step
- SOP: The title of the SOP

Phase	Frequency	Responsible	Section	Standard Operating Procedure
Monsoon	Daily	IT	4.1.1	Operate system, check IT system, connectivity and create backup
	Daily	TL DL M IT IN	4.1.2	Daily review of jobs
	Daily	IT IN	4.1.3	Daily review of data logs
	Daily	IT	4.1.4	Daily report on job and script performance
	Daily	M	4.1.5	Daily report on model performance
	As needed/as scheduled	IN	4.1.6	Real-time station maintenance and weekly report on station performance
	Weekly	M	4.1.7	Weekly report on quality of model input data
	As needed	M IN	4.1.8	Flood warning and flood occurence
Post-monsoon	Post-monsoon	IN	4.2.1	Station assessment
	Post-monsoon	M	4.2.2	Model input data assessment
	Post-monsoon	M	4.2.3	Catchment assessment
	Post-monsoon	M	4.2.4	NAM-model assessment
	Post-monsoon	M	4.2.5	Hydrodynamic (HD) model assessment
	Post-monsoon	M	4.2.6	Data assimilation (DA) assessment
	Post-monsoon	IT	4.2.7	Update Mike Operations (MO) back-end
	Post-monsoon	IT	4.2.8	Update MO front-end
	Post-monsoon	M IT	4.2.9	Update reports
	Post-monsoon	TL DL M IT IN	4.2.10	Update SOPs
Pre-monsoon	Pre-monsoon	TL	4.3.1	Ensure completion of post-monsoon SOPs
	Pre-monsoon	TL	4.3.2	Coordinate with stakeholder organizations
	Pre-monsoon	TL	4.3.3	Plan O&M activities
	Pre-monsoon	TL	4.3.4	Assemble O&M team
	Pre-monsoon	IN	4.3.5	Ensure real-time stations are operational

TL Team leader DL Deputy team leader M Modelling team IT IT team IN Instrument team

Figure D2-2 Standard Operating Procedures for the Baguio FEWS
Source: Ramboll

Proper coordination and understanding among different stakeholders are a prerequisite for sustainability of the FEWS. The SOPs provide the foundation for the operation and maintenance of the FEWS, but the implementation of these is highly dependent on well-established partnerships between the City of Baguio and stakeholder organizations.

2.2.1 Cyclical activities per team

It is vital that the SOPs are updated regularly to closely reflect the current situation as the system develops and the O&M team gains new competences and responsibilities. During the workshop on system sustainment conducted in October 2023, the team identified activities and milestones which take place yearly in a cyclical manner to gain a more detailed understanding to how SOPs should be carried out. This included not only the specific month in which each SOP should be carried out, but also external factors that could influence the team's ability to fulfil their responsibilities, such as holiday periods or closing of the city budget.

Specifying a clear timeline of activities was particularly applicable for the post-monsoon phase, as the current SOPs only list which actions need to be completed in this period, but not in which month exactly. It was important for the project team to facilitate a collaborative workshop environment for the O&M team members to plan the activities. This collaborative approach aimed to foster a sense of shared responsibility and ownership of the activities among the O&M team, as well as make use of the team's hands-on experience with the city context. During the workshop, the team showed considerable dedication and sense of ownership over their assigned tasks. The inclusion of social events in the cyclical activities also reveals that a positive and engaging team environment has been created in the O&M team.

The timeline of cyclical yearly activities for each of the sub-teams developed during the Sustainment Workshop can be found in Additional material A.

2.3 TRAINING AND CAPACITY BUILDING

The main objective of the targeted capacity building program was to ensure long-term sustainability for the established FEWS by securing the required local capacity for operating and utilising the FEWS as an active risk mitigation instrument beyond the timeframe of the pilot project.

Towards the end of the pilot project in 2022 it was apparent that there was a need for improved capacity of Baguio City to better utilize the established FEWS to facilitate appropriate, applicable, and timely early warning through completion of necessary finetuning, troubleshooting, and testing of the system and enhancement of FEWS governance. The capacity building activities of the consolidation phase builds on the completed Targeted Capacity Building Program to Enhance the sustainable delivery of FEWS and OTJ training completed in 2022.

The purpose of the 2023 Baguio FEWS Training Program implemented under the Baguio FEWS Consolidation Phase was therefore to strengthen local capacity for independent operation and maintenance of the FEWS in parallel with implementing, testing, and refining the system. The goal was to increase the confidence level within the locally established FEWS Operation and Maintenance (O&M) Team in operating and maintaining the FEWS.

The program consisted of the following training modes (Figure D2-3):

1. **Instructor-led online training sessions**: These sessions took place during the pre-monsoon phase and focused on giving the participants a recap of modelling, data, and instruments (from the 2022 program).
2. **On-site OTJ training**: These sessions took place during the pre- and post-monsoon phases. The focus of the first session was preparation for real-time operation, understanding SOPs and roles and responsibilities throughout the monsoon, and the second session focused on post-monsoon SOPs, system assessment and updates, and planning for system sustainment.
3. **Real-time operation of the FEWS**: This took place during the monsoon season where the O&M team operated and maintained the system in real-time with support from the technical project team. This training aiming at enhancing the teams' experience in FEWS operation and troubleshooting and ability to apply their technical skills acquired.

The training program sessions were tailored to the three O&M sub-teams to ensure that the content presented is relevant for the individual participant's responsibility as part of the team. Thus, the participants of the different teams covered different topics throughout the program.

Furthermore, it was important that the knowledge base of materials used during the targeted capacity building program was handed over to the trainees to access at any time after the training. These resources, which include videos, text, exercises, and downloadable materials, are hosted on the dedicated e-learning platform. Additionally, presentations, data, and exercises are available for access and download in a shared Google Drive folder. These materials can be used by all trainees as a refresher of what they have learned during the training, as well as used when developing new trainings for future members of the team.

Another fundamental component of the training design was the use of knowledge assessment surveys throughout the 2023 training program. Data from these surveys enabled an ongoing alignment with and adjustment to the changing needs of the participants.

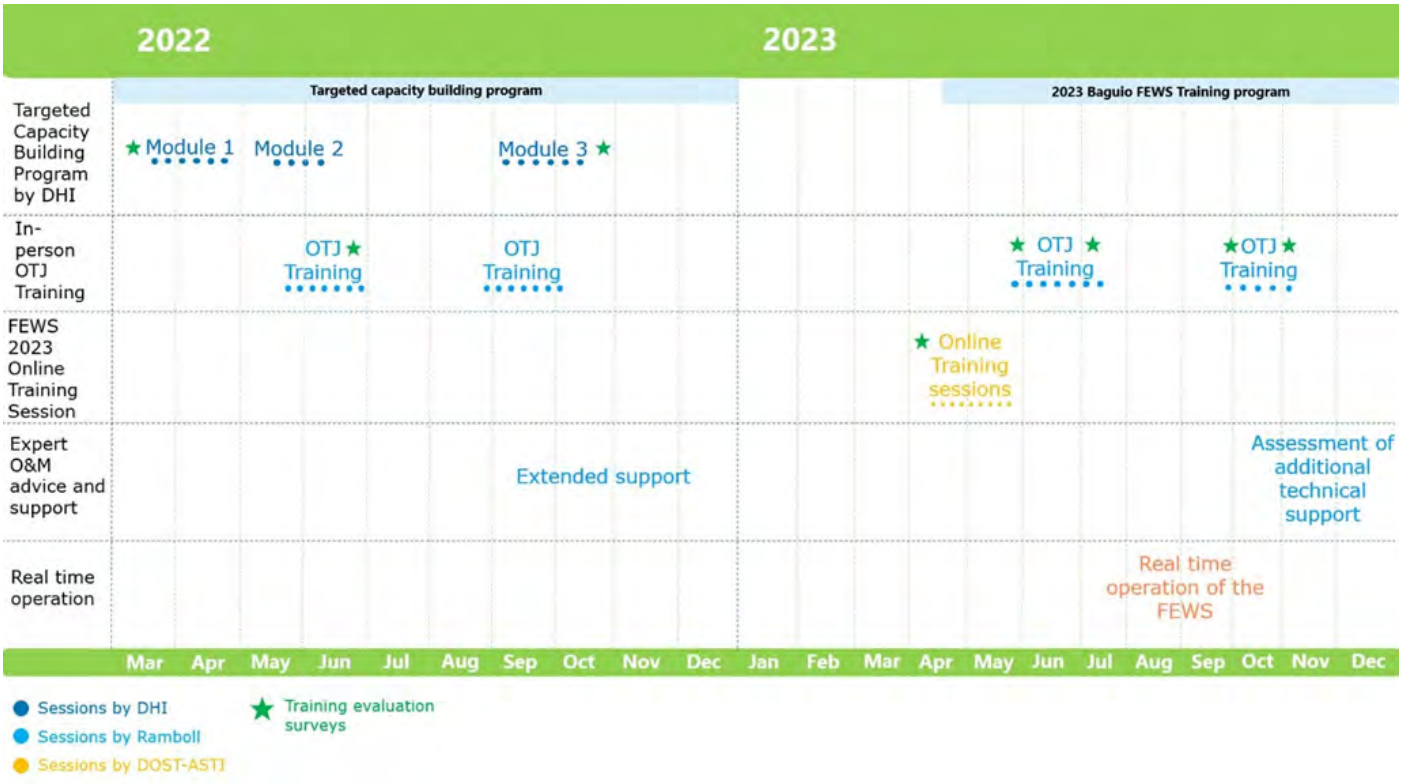

Figure D2-3 Timeline of the 2022-2023 training activities
Source: Ramboll

2.3.1 Summary of 2023 training activities and FEWS real-time operation

The training activities of the consolidation phase were aligned with the operational phases of the FEWS to ensure alignment with the full-scale test of the system including the real-time operation and maintenance tasks.

The O&M team oversee operation and maintenance of the FEWS throughout all operation phases (Figure D-6):

- Preparation phase: Pre-monsoon period (April - July)
- Application phase: Monsoon period (August - September)
- Assessment phase: Post-monsoon period (October – December)

The aim of the pre-monsoon training was to prepare the O&M team for operating the FEWS through the full-scale real-time test of the system with expert guidance and support from the technical project team. The training focused on the enhancement of technical capacity, improved understanding of SOPs, and improved understanding of role and responsibility. The program included nine online training sessions, revisiting subjects from the 2022 capacity building program to refresh participants' knowledge and skills before the practical On-the-Job (OTJ) training. Additionally, there were on-site OTJ sessions, encompassing presentations, live demonstrations, Q&A discussions, peer-to-peer presentations, live testing of SOPs, and hands-on exercises utilizing Baguio models and data.

Following the pre-monsoon OTJ training, the O&M team operated and maintained the FEWS for the first time during the 2023 monsoon season (June 30, 2023 – September 30, 2023). Throughout this period, support was given to the sub-teams within the FEWS O&M team in carrying out their respective monsoon SOPs. Finally, the last part of the 2023 training program kicked off in October during the post-monsoon phase with five on-site OTJ training sessions. The aim of the post-monsoon training was to enhance the FEWS O&M team's understanding of system performance assessments and the resulting required system updates as well as the components of system sustainment. In response to feedback from previous training sessions, these training sessions placed a strong emphasis on hands-on learning and centred on learning-by-doing tasks on updating the 2023 system.

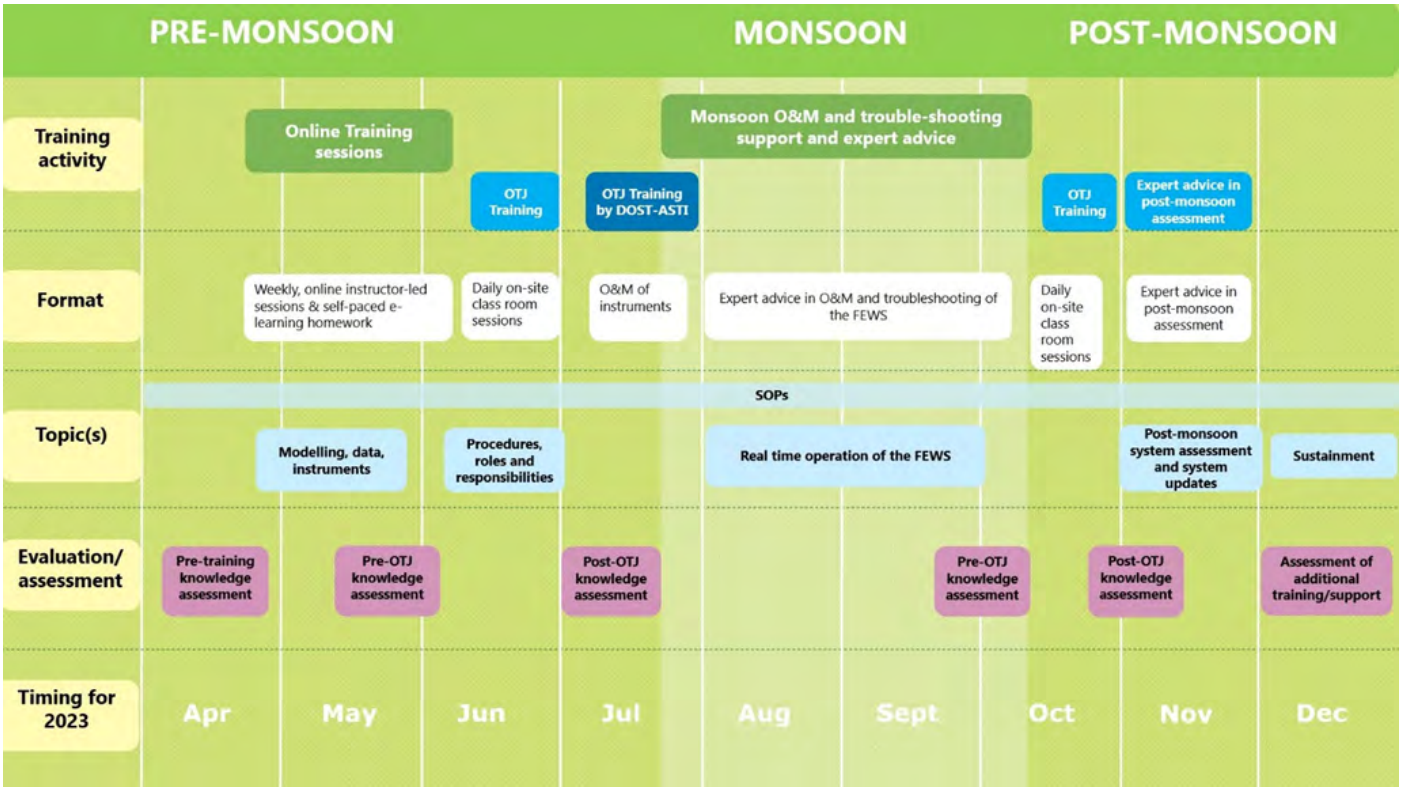

Figure D2-4 Overview of the 2023 Baguio FEWS Training Program
Source: Ramboll

2.3.2 Identified training and technical support needs

There is a need to test the FEWS throughout multiple monsoon seasons to trouble-shoot, adjust and calibrate the system, which requires experience and expertise in FEWS. During feedback sessions in the OTJ training, the O&M team has expressed concerns about being unable to meet expectations and are anxious to be independently responsible for the FEWS without technical support beyond 2023. In the evaluation of the post-monsoon training, it has become clear that the team can fully undertake most of the SOPs but need technical sparring for quality assurance and complex trouble shooting. Furthermore, the team also need experience in planning and executing the various activities throughout the operational phases.
The results from the baseline knowledge assessment (May 2023), indicate a very high level of participant satisfaction, signalling the well-received nature of the training (Figure D2-5). The knowledge acquired during the 2022 FEWS training has been moderately applied, however there has been a significant increase in the application of this knowledge during the pre- and post-monsoon trainings. Participants also express agreement regarding the training's relevance, understanding its objectives, and recognizing the significance of topics covered in the OTJ sessions in relation to their roles.

Participants were also encouraged to provide written feedback, and many pointed out that the training greatly improved their understanding of the project, allowing them to concentrate more effectively on their individual responsibilities. They also stressed the invaluable role of hands-on experience in facilitating the learning process. The practical and experiential nature of the training was instrumental in strengthening their comprehension and skill development.

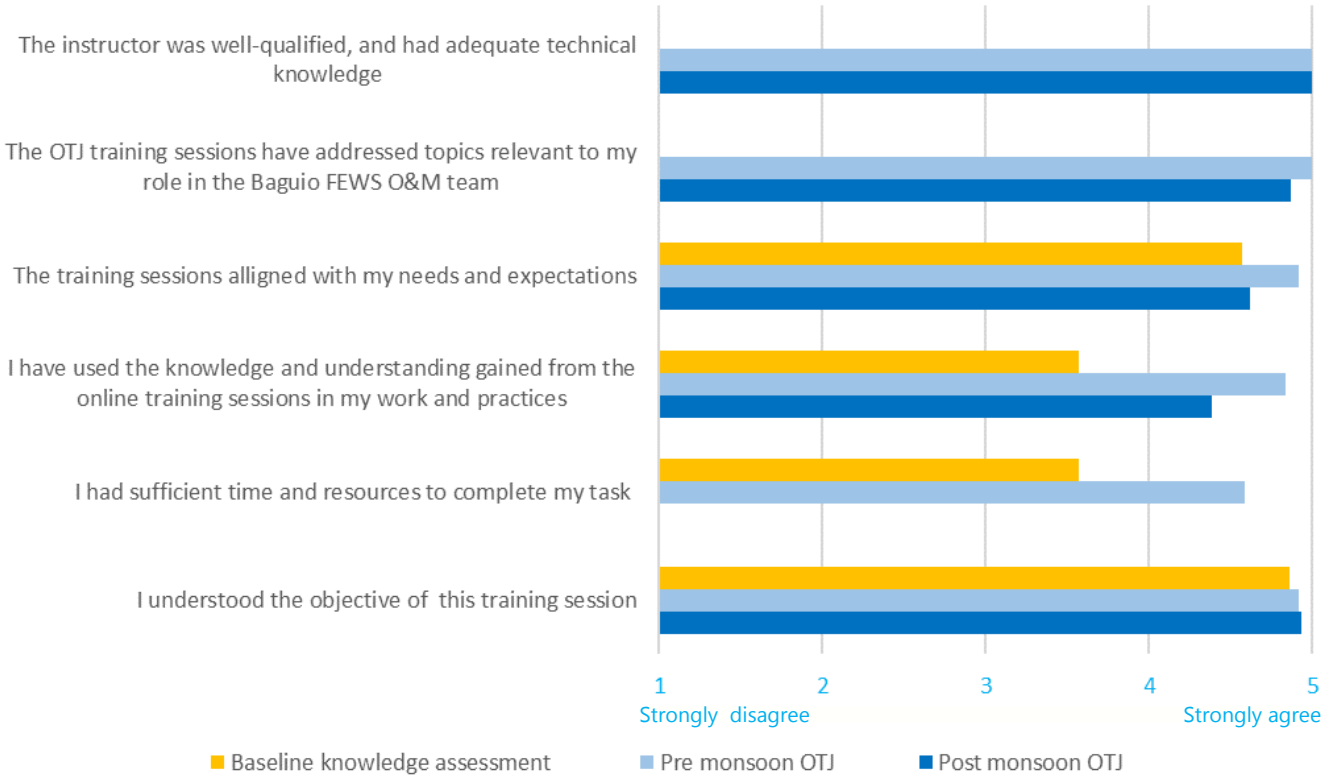

Figure D2-5 Assessment of participants satisfaction and expectations before and after the pre-monsoon OTJ
1= strongly disagree, 2= disagree, 3= neutral, 4= agree, 5= strongly agree.
Source: Ramboll

In addition to the general improvement in knowledge and confidence levels, all teams acknowledge the significance of ongoing external support from the project team. When asked about how the technical experts from the project team can best assist and support them during the monsoon phase, their responses emphasized the importance of receiving assistance during this critical period for multiple monsoon seasons. They also expressed the need for continuous guidance and training to ensure optimal performance and to maintain the FEWS in the future.

During the sustainment workshop in October 2023, the team was asked to assess their confidence in carrying out SOPs. Figure 8-Figure 10 present the self-reported level of confidence in each SOP, with 0 meaning 'we are not confident at all that we can carry out this SOP without outside assistance', and 10 meaning 'we are very confident we can carry out this SOP without any assistance'. For any SOPs rated at lower than 7 (indicated by an orange dashed line in Figures D2-6 to D2-8), the teams were asked to describe in detail the needs for support in performing the tasks.

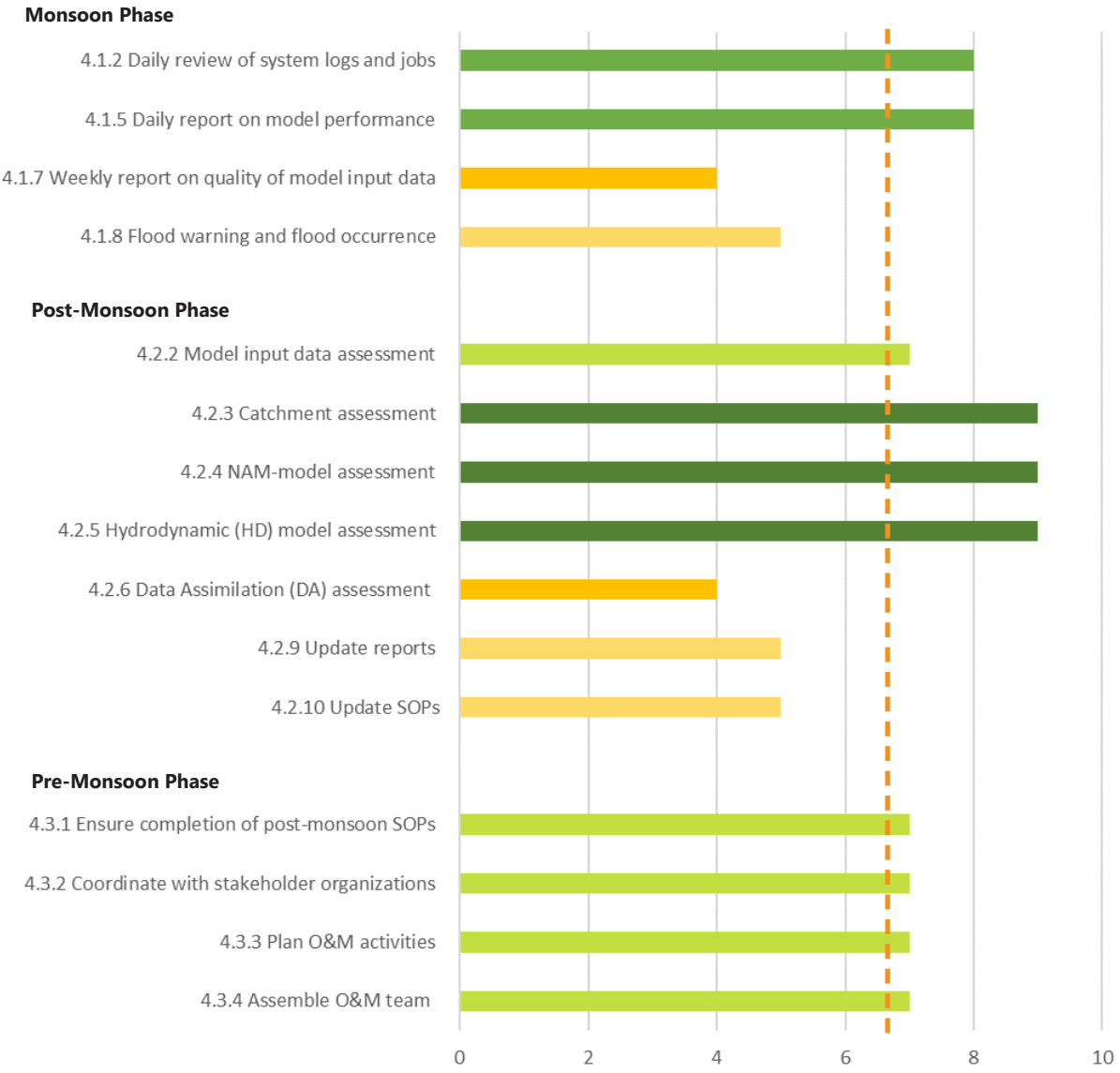

Figure D2-6 Modelling team - Self-reported confidence level in carrying out SOPs
Source: Ramboll

The modelling team identified the following activities that they need support with:

- The team needs to develop a framework for performing the weekly assessment of the quality of model input data
- To perform the model input data assessment (SOP 4.2.2), the team lacks a detailed course of action and experience
- More training is needed in data assimilation (DA) to correctly perform DA assessment
- The team identified that they would need external support with updating the SOPs annually.

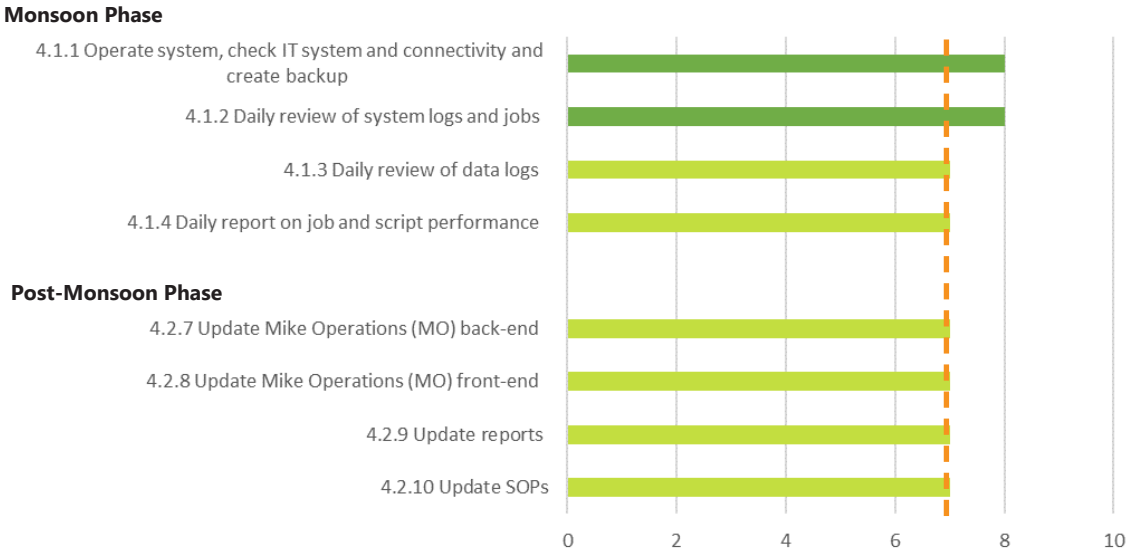

Figure D2-7 IT team - Self-reported confidence level in carrying out SOPs
Source: Ramboll

The IT team requires further support with the following:

- Understanding the reasons for why scripts fail in the daily review of system logs and jobs, and in the daily report on job and script performance
- More time and experience is required for the team to familiarize themselves with Mike Operations
- More time spent on coordination of activities with the modelling team

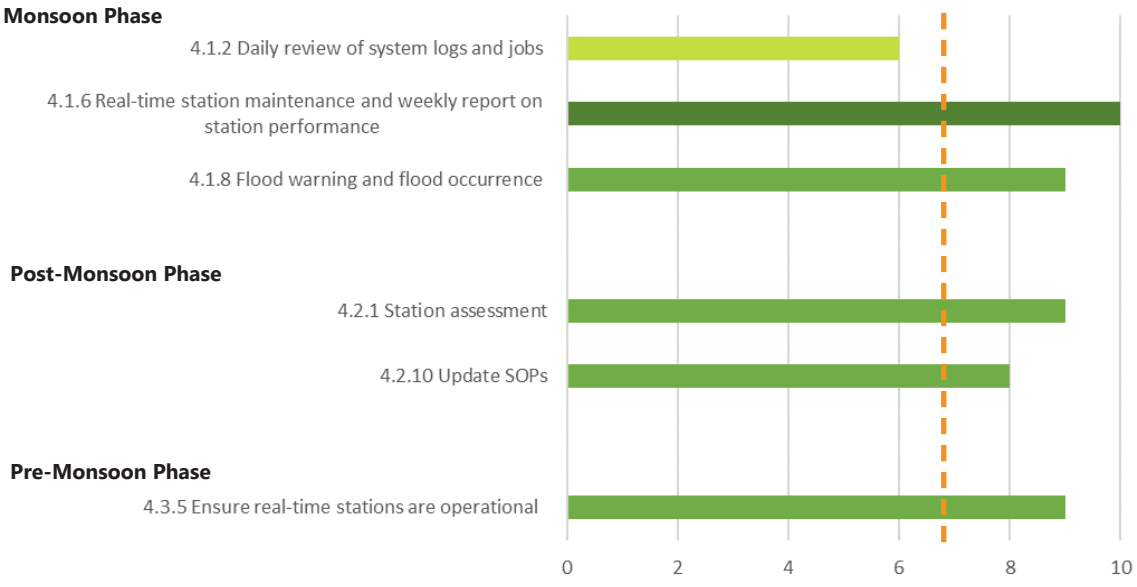

Figure D2-8 Instrument team - Self-reported confidence level in carrying out SOPs
Source: Ramboll

The instrument team needs more support in performing the daily review of system logs and jobs and requires more information on how the system generates logs, detects errors, and what specific scripts are used to run jobs.

2.3.3 Organization of future training

There is high potential for the system to be sustained and the team is starting to work well together. However, the team does not yet have the experience to independently operate and maintain the FEWS. The team can fully undertake most of the SOPs but needs sparring for quality assurance and complex troubleshooting. Furthermore, the team also needs experience in planning and executing the various activities throughout the operational activities. Thus, further technical support for finetuning, testing, and operating the system will be needed beyond 2023.

The following annual training activities are recommended for 2024-2025:

- **Pre-monsoon**: Experts co-leading with the team leads in completion of pre-monsoon SOPs and pre-monsoon in-person OTJ training to ensure proper initiation of real-time monsoon operation
- **Monsoon**: Experts co-leading with the team leads in real-time operation, maintenance and troubleshooting of the FEWS
- **Post-monsoon**: Experts co-leading with the team leads in completion of post-monsoon SOPs and post-monsoon in-person OTJ training to ensure proper assessment of system performance and implementation of post-monsoon SOPs.

It is furthermore recommended that:

- CDRRMO identifies staff responsible for planning training activities for the O&M team in 2024 and beyond and identifies external experts with experience in operating FEWS to support the team.
- The focus of the training in 2024 should less on traditional classroom trainings and designed to inculcate independent problem-solving capacities in the O&M team. The training activities will need to be planned such that the technical leads for the modelling team, IT team and instrument team coordinate and lead the activities with guidance and shepherding from experts. One way of achieving the required outcome would be temporarily integrating the experts in the O&M team structure. The goal would be to shift from the experts carrying out the troubleshooting and updates in silos and later training the team to the experts prompting the technical resolutions required during the operation and maintenance which would be carried out mainly by the core team.
- Potential partnerships with academic organisations are explored in order to conduct training and knowledge exchange activities.
- Once the current O&M team has the experience to independently operate and maintain the FEWS, additional trainees and students are added to the O&M team to ensure continuity in the team in case of staffing changes.
- After the FEWS has been tested for multiple monsoon seasons and the current O&M team is confident in independently operating and maintaining the FEWS, the O&M team can identify internal staff that can serve as trainers and technical support for new staff.

All training materials used in the targeted capacity building program are available for the team to access and download on the e-learning platform and a shared folder on Google Drive. It is recommended that this procedure is followed for all future trainings organised – the team should create and keep a repository of training material that is continually updated and expanded, so it can be used for training new additions to the team if needed. The contents should be reviewed annually to ensure that training materials are up to date and relevant. The repository can serve as an opportunity for the team to look back on what they have learned and used as reference when updating the SOPs.

3 INSTITUTIONAL SUSTAINMENT

The chapter explores the fundamental role of sustaining the institutional setting supporting the Baguio City FEWS. It is essential for long-term viability that the system is built into the existing institutional framework, with clearly outlined roles and responsibilities between departments within the LGU and in the partner organizations, both within Baguio City and beyond.

There is also a need to consider institutional sustainment aspects associated with the gender transformative actions. High-level support (e.g., mayoral level) has thus far played an important role in advancing the gender transformative actions. Vocal and active leadership, both for the overall project and for the implementation of key actions, has helped legitimize the actions beyond the CDRRMO to other institutional actors and agencies, and underscore their importance. This has also worked to help the CDRRMO to build coalitions for actions within related agencies, with high level endorsement setting the expectations for contribution and involvement of stakeholders in the FEWS. Closely linked to leadership are the broadly supportive institutional structures emerging in Baguio that prioritize gender equality, disability and social inclusion efforts in the context of DRRM.

3.1 OWNERSHIP OF THE FEWS

Ownership of the system is understood as bearing responsibility for the operational management, maintenance, and long-term adaptation of the FEWS, as well as decision-making authority and responsibility for the system's performance. Defining the ownership of the system helps avoid uncertainty about roles and responsibilities and ensures that the O&M team has the mandate to fulfil their tasks and continue to work on improving the system and adapting it to changing conditions.

The ownership of the FEWS lies with the Baguio City LGU. Within LGU, the system is anchored between three bodies: City Disaster Risk Reduction and Management Office (CDRRMO), Management Information Technology Division (MITD), and Baguio Smart City Command Center (SCCC). Placing the FEWS into the already established organisational structure was instrumental in the sustainability of the system through leveraging the LGU staff's familiarity with the city's administrative processes, the connections between LGU staff and peer organisations, and outlining clear responsibilities between organisations or departments.

3.2 OWNERSHIP OF MONITORING STATIONS

The FEWS collects real-time data from five hydrometeorological monitoring stations that were set up by PAGASA:

- Irisan Baguio Fire Station (Baguio)
- City Camp Lagoon (Baguio)
- Asin Bridge (Tuba)
- Camp 6 Bridge (Tuba)
- Balili Bridge (La Trinidad)

The LGUs of Baguio, Tuba and La Trinidad have successfully applied to PAGASA for a formal transfer of ownership of the stations to the respective LGUs.

Ahead of the transfer, issues related to reliability of the existing stations were widely experienced due to lack of proper maintenance and operation. Transferring the ownership of monitoring stations contributes to the sustainability of the system by ensuring that the Baguio LGU has full control of the continuous operations and maintenance of the stations and can include the maintenance of stations in the FEWS budget. Following the approval of the transfer of ownership, the stations were replaced, and new monitoring equipment was installed.

In addition to the five existing stations, five new stations, one tandem station (i.e., monitoring rainfall and water level) and four water level stations have been procured and installed as part of the project. The new stations are owned by the Baguio LGU and ensure greater spatial real-time data coverage of the river basins in Baguio.

3.3 FEWS GOVERNANCE

Since the pilot project, it has been discussed with the Mayor and LGU staff that there is a need to properly anchor and institutionalize the FEWS O&M team in the LGU. In October 2023, the Mayor signed an Executive Order (see: Additional material C), officially establishing the FEWS O&M team and outlining thatresponsibilities for operation and maintenance are shared between the CDRRMO and MITD.

3.3.1 Data governance

The data of the FEWS is managed by the LGU and processed in collaboration with partners. The IT team in the O&M team is in charge of FEWS data management. The Advanced Science and Technology Institute under the Department of Science and Technology (DOST-ASTI) is a crucial stakeholder in the Baguio FEWS, as they are in charge of processing, storing, and publishing the real-time data from the network of monitoring stations which is accessed by the Baguio LGU trough an API provided by DOST-ASTI. Enhancing the collaboration with DOST-ASTI has been a key focus in the efforts of enhancing system governance. An in-person meeting with the Director of DOST-ASTI Mr. Franz A. de Leon was held on June 23, 2023 to discuss the partnership on the FEWS project, expectations to roles and responsibilities of DOST-ASTI in the FEWS project, and the coordination mechanism going forward. The communication with DOST-ASTI has greatly improved in the past months and a direct link to the technical team at DOST-ASTI has been established. The Director of DOST-ASTI has expressed the commitment of DOST-ASTI to support the FEWS O&M team in relation to data management.

3.3.2 Recommendations for enhancement of governance

The following considerations are recommended to strengthen the institutional sustainability of the FEWS:

- A council resolution further supporting the executive order signed in October 2023 would ensure the ownership of the FEWS is firmly anchored within the team and CDRRMO and increase the resilience of the FEWS in the event of changes in the LGU.
- While the recognition of the FEWS operation and maintenance as part of the LGU responsibilities through the executive order is a great step forward for system sustainment, further details on delineation of responsibilities are necessary in an officially approved order or resolution to further strengthen effective system operation.

In addition to the above, Baguio has demonstrated progress towards a gender transformative FEWS, underpinned by a supportive institutional framework, the presence of local champions and leadership endorsement. A core challenge has been trying to overcome the siloed nature of institutional and DRRM governance in the Philippines generally. The Gender and Development Focal Point System (GFPS) is core to City Planning and Development with representatives from other city department. In the RA 10121 or the Philippine DRRM Act, GAD/GFPS focal or representative is required to be a member of the local DRRM councils. The Baguio City LGU noted that it is through the gender transformative FEWS that the CDRRMO became more informed and guided in mainstreaming GAD/GEDSI in all aspects of DRRM as appropriate.

Yet, a hurdle faced in implementing the actions towards a gender transformative FEWS has been in coordination between departments which further complicate the assimilation and uptake of actions within the GAD FPS. This type of collaboration required to progress the actions requires stakeholders to move beyond the usual planning formats and to further integrate the gender transformative actions within the GAD framework, aligning them with existing forms, templates and processes to bridge the gap. This will increase the likelihood that these actions are further embraced and executed by the various stakeholders in DRRM. Leveraging the GAD focal point system is a key strategy to mainstream actions, as the GAD FPS is already integral to the DRRM system. Moreover, linking into the existing GAD systems and DRM processes is essential, recognizing that DRRM transcends the CDRRMO's jurisdiction, impacting all sectors.

3.4 PARTNERSHIPS

Strong stakeholder partnerships are essential in ensuring success and sustainability of the FEWS. Through stakeholder partnerships with public and private organizations as well as academia, the LGU can gain knowledge, experience and innovation improving the overall impact and usefulness of the FEWS for the City of Baguio. The *Flood Early Warning System Report*[4] provides an overview of stakeholders relevant in operating the FEWS, while the *Data Dissemination and Outreach Plan*[5] describes stakeholders involved in warning and information dissemination/outreach activities, as well as the chain of communications before, during and after a hazard event.

4 Footnote 1

5 Data Dissemination and Outreach Plan, Phi: Baguio City Smart Flood Warning, Information And Mitigation System, AASCTF, December 2022.

3.4.1 Established MOAs

Formalization of stakeholder partnerships through a Memorandum of Agreement (MOA) contributes to enhancing collaboration to ensure the foundation for effective operation and maintenance of the system. Important MOAs have been signed with DOST-CAR and PAGASA, outlining the key roles and responsibilities of each partner and the LGU.

DOST-CAR
The MOA between the LGU and DOST-CAR outlines the commitment by both agencies to collaborate on the operation and maintenance of the FEWS. According to its terms, Baguio City LGU is responsible for owning, operating, and managing the FEWS (including bearing the costs for O&M), as well as collecting, managing, and owning the data collected through the stations. They furthermore agreed to coordinate with DOST-CAR regarding technical issues, and share the data with DOST-ASTI, if necessary.

DOST-CAR will provide technical assistance related to the gauging stations, including installation of stations, preparing the O&M plan, and training in operation and maintenance of the stations. Furthermore, DOST-CAR will communicate and coordinate with DOST-ASTI on all technical issues related to the equipment and data management concerns which are included in the services of the DOST-ASTI.

PAGASA
The MOA between the LGU and PAGASA enables collaboration between the agencies and provides the foundation for data-sharing. The MOA outlines the responsibilities of both the LGU and PAGASA in the maintenance of the FEWS, and the commitment by both agencies to work together to continuously improve the FEWS.

In addition to owning and managing the FEWS and the collected data, and shouldering the responsibility and costs of O&M (as outlined in the previous section), Baguio City LGU agreed to provide PAGASA with access to data collected through the new stations through a dedicated server. Furthermore, LGU will coordinate with DOST-CAR regarding technical concerns on the deployed stations and advise PAGASA in case of any inconsistencies with the data co-owned and used in the system.

PAGASA shall share real-time WRF data with LGU through a dedicated MITD server. They will also share QPF (forecast) data calculated from radar data, if available. PAGASA will be responsible for the annual recalibration of the new rain gauges. The data from newly installed rain gauge stations shall be co-owned by Baguio LGU and PAGASA.

PAGASA will assist in replication of all the automated data upload processes to new servers when the FEWS is transfered to the Smart City Command Center. They agree to inform LGU prior to any anticipated changes to data processing or any downtime in the system. PAGASA recognized the importance of real-time data in the operations of the system, and agrees to resolve any downtime as a priority.

La Trinidad and Tuba

During the Consolidation Phase, the project team has furthermore facilitated the establishment of two Memoranda of Agreements with La Trinidad and Tuba, which were signed in a ceremonial signing event. The Mayors from the City of Baguio, La Trinidad, and Tuba, Hon. Benjamin Magalong, Hon. Romeo Salda, and Hon. Clarita P. Sal-ongan attended the ceremony and signed Memoranda of Agreement on 23 June 2023, establishing a partnership in support of the Baguio FEWS Project. The MOAs formalize the collaboration on maintenance of the network of monitoring stations and knowledge and data-sharing on the Baguio FEWS between the three municipalities. The signing event demonstrated the good partnership that has been established between the municipalities on disaster preparedness and provided an opportunity for all partners to meet in-person.

Baguio LGU agreed to facilitate the transfer of stations to the neighbouring municipalities and replace outdated stations, as well as include the other LGUs in FEWS activities as necessary. They will also share the FEWS data and dashboard once fully operational and tested. La Trinidad and Tuba LGUs agreed to facilitate the transfer of ownership of stations and take responsibility of the O&M of stations within their jurisdiction. They will coordinate with Baguio LGU and CDRRMO regarding any technical concerns.

The above MOAs took several months to get formulated and signed, and represent an important achievement as they ensure ownership, delineate expectations across organizations and set the foundation for long-term sustainability of the system, anchored at the LGU.

3.4.2 Recommended MOAs

In addition to the MOAs achieved during the project, it is recommended to formalize partnerships with SLU and UC and other relevant partners, to delineate expectations across organizations and set the foundation for long-term sustainability of the system anchored at the LGU. The MOA with SLU has been drafted and is currently undergoing review at the Mayor's Office.

Under the proposed MOA, Baguio LGU will be responsible for preparing the terms of reference, inviting SLU support team members to training related to FEWS, and engaging them for an agreed number of hours to work on the FEWS. They will also accommodate SLU students for possible internships or apprenticeships. SLU will be included as a member of the City Disaster Risk Reduction and Management Council (CDRRMC). SLU shall be responsible for providing technical advice to the LGU, designating support team members and ensuring their availability for training and critical activities in operating the FEWS. They will recommend students for internships, as well as utilize the data from FEWS for possible research outputs that may be translated into policies if applicable.

Furthermore, following the signing of MOAs with the municipalities of Tuba and La Trinidad, formal partnerships with other BLISTT municipalities (Itogon, Sablan, and Tublay) should be considered. Strengthening the relationships with neighbouring municipalities contributes to raising the resilience of the entire area through expanding the network of monitoring stations and data sharing.

During the sustainment workshop in October 2023, an idea was raised that the FEWS could benefit from a formal agreement with BENECO (Benguet Electric Cooperative) in an effort to secure a stable energy supply to the system.

4 TECHNICAL SUSTAINMENT

A detailed plan for the sustainment of the technical components of the system, such as monitoring stations, ITC equipment, and software is crucial to ensuring that the FEWS remains operational and up to date in the long term.

This chapter will outline the hardware and software that makes up the FEWS, the schedule of maintenance of the components, as well as future enhancements to the system – model calibration, testing in upcoming monsoon seasons, new functionalities, as well as the development of warning messages and testing phases for dissemination and outreach. The focus on future improvements to the system ensures that maintenance activities are not only reactive, but aim to perfect the system, adapt it to changing conditions, and incorporate new knowledge and lessons learned on a continual basis.

4.1 HARDWARE INVENTORY

Stations

There are nine water level monitoring stations in the system, listed in Table D4-1. Out of these nine stations, five are tandem stations which record both water level and rainfall, and remaining four stations are water level stations.

Table D4-1 Real-time water level monitoring stations used in Baguio FEWS

S. No.	Station ID	Station Name	Type	Year	City/location
1	892	Camp 6 Bridge	Tandem	2023	Tuba
2	460	City Camp Lagoon	Tandem	2023	Baguio City
3	463	Asin Bridge	Tandem	2023	Tuba
4	2894	Brookspoint	Tandem	2022	Baguio City
5	1390	Balili Bridge	Tandem	2023	La Trinidad
6	2893	Sadjap Bridge	Water Level	2022	La Trinidad
7	2896	Camp 7	Water Level	2022	Baguio City
8	2892	Ferguson Bridge	Water Level	2022	Baguio City
9	2895	Eagle Crest	Water Level	2022	Baguio City

Source: Ramboll

Servers

The FEWS servers are located at the MITD and comprises three key servers:

- MIKE Operations Web Server Hardware Information
- MIKE Operations Platform Server Hardware Information
- Backup Server.

The server specifications are seen in the tables below.

Table D4-2 MIKE Operations Web Server Hardware Information

CPU	2.70 Ghz and 8 cores	Ethernet	1x10 Gb
RAM	128 GB DDR4 RAM	Raid Support	High availability
HDD	1.8 TB of disk storage with SAS SSD (15k) in RAID-1 configuration	Options	VMware
OS	Windows Server 2019 64 bit	Power	Hot swap redundant power supply 750 watts

Source: Ramboll

Table D4-3 MIKE Operations Platform Server Hardware Information

CPU	2.70 Ghz and 8 cores	Ethernet	1x10 Gb
RAM	128 GB DDR4 RAM	Raid Support	High availability
HDD	1.8 TB of disk storage with SAS SSD (15k) in RAID-5 configuration+ 8X2.5 TB of SSD, all hot swappable	Options	VMware
OS	Windows Server 2019 64 bit	Power	Hot swap redundant power supply 750 watts

Source: Ramboll

Table D4-4 MIKE Operations Backup Server Hardware Information

CPU	2.70 Ghz and 8 cores	Ethernet	1x10 Gb
RAM	32 GB	Raid Support	High availability
HDD	2 tb (scalable if needed)	Options	VMware
OS	Windows Server 2019 Standard	Power	Hot swap redundant power supply 750 watts

Source: Ramboll

Server hardware typically lasts between 3 to 5 years, although this can vary. Critical components such as hard drives, power supplies, and cooling systems may need replacement or upgrades during this time frame. Regular maintenance, including software updates, security patches, and hardware checks, can extend the lifespan of a server. Neglecting maintenance may result in a shorter operational life. Presently, FEWS employs a physical dongle (USB Key) to ensure uninterrupted MIKE license service. Due to the absence of a USB port on the current server, a temporary workaround involves connecting a basic computer to establish a network license, allowing for the insertion of the USB key. However, this makeshift solution is not sustainable, as the machine hosting the MIKE License lacks robustness and is susceptible to potential failures at any time. Budget has been allocated to purchase a USB over IP component for the supplication server, aiming to eliminate the need for the current temporary arrangement.

Workstations
It is recommended to establish a workstation dedicated to the FEWS O&M team. A computer and screen are already available at the LGU but would have to be set up in a permanent location. It is recommended that the workstation is prepared as part of the departmentalization of the CDRRMO and ahead of the monsoon season. It is crucial, that the workstation is available 24/7 during the monsoon phase. The workstation would also be used by the team for the system preparation during the pre-monsoon phase and for post-monsoon system performance assessment and updates. Most of the O&M team members also have MIKE software on their work/personal computers, which can be used for training purposes.

CCTV equipment
CCTV equipment is recommended to be installed at each of the stations to deter theft and vandalism, as well as to provide real-time updates on any damages (e.g. weather-related) to the stations. Funds should be allocated in the FEWS budget for CCTV equipment to enhance the safety of the stations.

Hardware maintenance schedule
The maintenance schedule of stations and ITC equipment has been prepared as part of the SOPs. For each activity connected with hardware maintenance, the SOPs specify the person, team or institution responsible, as well as the frequency or timing of the maintenance. The frequency of maintenance of physical infrastructure varies throughout the year based on the phase (pre-monsoon, monsoon, and post-monsoon). This approach ensures safe operations during the monsoon period when the equipment needs to be operational at all times and is more likely to be damaged, a thorough assessment at the end of the monsoon period, and less frequent check-ups during the rest of the year.

As mentioned in the human resources sustainment chapter, to further ensure the proper maintenance of the hardware, a technician has been hired in the MITD and has since became a valuable member of the instrument team.

4.2 SOFTWARE

Software Specification

FEWS comprises various components, with a significant emphasis on modelling software and automation tools to facilitate the seamless operation of the entire system without requiring user intervention. Currently, the FEWS system utilizes MIKE Hydro River, a component of MIKE Zero, for modelling purposes, and MIKE OPERATIONS is employed for constructing the FEWS system and executing it through automation. The data storage aspect of MIKE OPERATIONS relies on PostgreSQL. Additionally, FEWS incorporates Python scripts for analysing raw data. The table below provides information on the version and licensing availability for all the essential software components.

Table D4-5 FEWS software specifications

Software	Version	License
DHI MIKE Zero Update 1	2021	Perpetual
DHI MIKE OPERATIONS	2021	Perpetual
PostgreSQL	13	Free
Python	3.10	Free

Source: Ramboll

Schedule of FEWS Update

Presently, FEWS operates on MIKE Suite 2021, and its functionality will persist for several years (5 – 10 years) due to the client's possession of a perpetual license (until 2050). The FEWS system will continue to run smoothly without necessitating updates to the MIKE software. However, if the client desires access to new features and updates within the MIKE software, a comprehensive system update may be required. This update process would involve fine-tuning the model in the new version and ensuring synchronization with the updated MIKE OPERATIONS.

An update to FEWS becomes necessary in case PAGASA alters the method of sharing forecast data or modifies the format of WRF data. Additionally, updates are recommended in response to significant changes in real-time data APIs.

For optimal performance during each monsoon season, it is advisable for the client to follow a proactive approach. This involves cloning the previous year's database, eliminating all simulations, and initiating a fresh start at the commencement of each monsoon. This practice ensures the continued efficacy and reliability of the system.

Cybersecurity

The IT team is responsible for maintaining the security of the system and data, in coordination with relevant stakeholders. A number of measures to enhance the cybersecurity of the FEWS have already been implemented, including setting up the server dedicated only to the FEWS to which a very limited group has access, as well as signing a data responsibility agreement with all people involved.

4.3 CONTINUAL SYSTEM ENHANCEMENTS

The FEWS should be updated and finetuned as more data becomes available. The system should continuously be enhanced to improve system performance and ensure adaptation to changing conditions.

4.3.1 Improvement of stage-discharge relationship

The stage-discharge relationships currently applied to derive the calculated discharge are generated using the inbuilt tool in MIKE Hydro. These should be revised based on simultaneous measurements of water levels and flow data, but this requires further development. Measurements should be taken in the next few monsoons and non-monsoon seasons to have sufficient data to apply this system improvement.

4.3.2 Expanding the network of stations

Expanding the network of stations will ensure greater spatial real-time data coverage of the river basins in Baguio. The addition of rainfall stations could ensure that the spatial rainfall variability of Baguio City is captured better. However, it is recommended that the system performance is evaluated through a few monsoon seasons before significant investments in new stations are made.

4.3.3 Additional features and functionalities

The FEWS can be continuously updated with new features. One feature to add to further enhance the system, is the development of barangay-level warnings. WRF data, which have been bias-corrected against station rainfall data, will be compared to rain intensities for various return periods (as per existing IDF curves developed by PAGASA) and based on this comparison, flood warnings will be triggered by the FEWS for the various at-risk barangays. This will allow the FEWS to benefit areas in the city which experience flooding not just due to the riverine flooding but also due to other issues such as insufficient or blocked urban drainage infrastructure. For identifying the at-risk barangays with greater reliability, flood maps will need to be prepared for more return periods as required and the ones prepared already will need to be prepared again based upon new rain data analysis using only most appropriate station data. The same stations would be used for the bias correction of the WRF data to ensure proper correlation.

4.4 DATA DISSEMINATION AND OUTREACH

To avoid sending flawed warnings to the wrong recipients at a wrong time, the FEWS in Baguio needs to be tested and the quality of the messages need to be validated in several steps, before sending messages to the end-recipients, the affected residents of Baguio. Dissemination and outreach is a key area under which the gender transformative actions are being taken forward, with associated SOP integrating the actions from the gender transformative Implementation Plan on the topic.

Launching a FEWS without proper testing and troubleshooting time can have serious consequences on the credibility of the LGU and ultimately on the confidence in the system itself. The need for testing is not limited to one single monsoon season, as any FEWS requires proper validation before it's publicly launched. A test and validation phase will last several years, depending on the number of flood events, their severity and the feedback loops established to review the messages and channels.

4.4.1 Outline of testing phases

The first full-scale test of the system took place during the 2023 monsoon as the project entered the initial test phase, as seen in Figure D4-1. During the initial test phase, the FEWS was only tested by the FEWS O&M team, and the Mayor's office were informed about the test results on a frequent basis. During the test, the FEWS O&M team completed the SOPs throughout all operational phases with support from the technical project team to validate their effectiveness. Throughout the monsoon, the system is operated daily by the FEWS O&M team in close collaboration with Ramboll's technical team.

It is recommended that the City Disaster Risk Reduction and Management Council (CDRRMC) member organizations and city-level decision makers are included in the upcoming testing phase. Presenting the current status of the system can be used to raise interest in the FEWS and get buy-in from important stakeholders. Thus, the team can continually develop the network of partner organizations and facilitate communication between them.

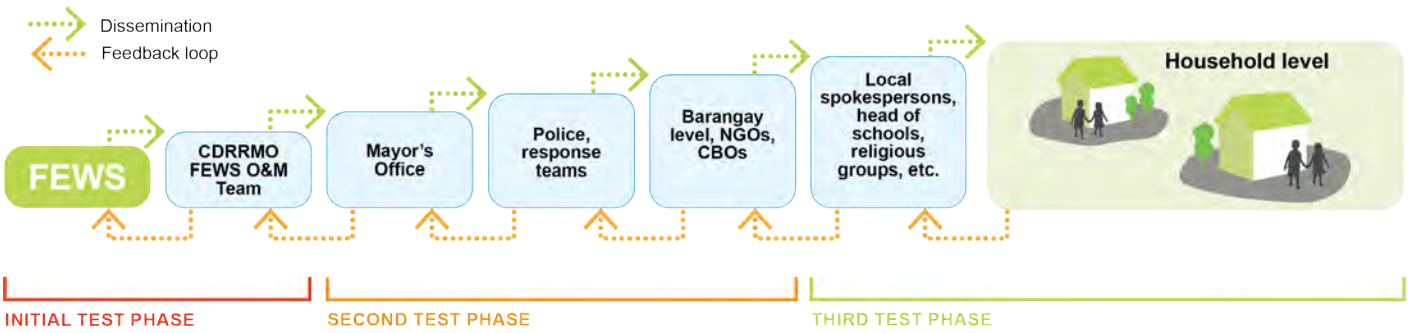

Figure D4-1 Organisational set-up during the expected FEWS test phases
Source: Ramboll

The expected subsequent test phases/years will gradually involve more levels and eventually include the end-users of the information. It will be a political decision when to include the different levels of recipients, as there will always be a risk involved in either disseminating too little or too late information or too broadly and too much information. The real-time operation of the FEWS during the 2023 monsoon period served as a basis to determine the FEWS O&M team's needs for further technical support and the need for further testing. Given the limited historical data available for calibration, the system is expected to need multiple years of fine-tuning, updating, and validation.

Information gathered and the messages and channels tested during the test phase will depend on the readiness of the FEWS system during these phases and the link to the national weather forecast system. The list of channels and messages deployed will gradually be extended over the duration of the test phases.

4.4.2 Plan for development of warning messages

Pre-testing the information and warning messages is crucial to validate whether the information meets people's needs and is well understood. To ensure effectiveness and suitability for different target audiences (specifically those who have specific needs or disabilities), the conduct of a focus group discussion/ workshop or survey is recommended to consult and involve representatives from the different target audiences in the development of these messages and preparedness materials and their format (written text, visual, audio, etc.).

The testing and validation phase should include three distinct phases (Figure 14), followed by the development of SOPs for the different stakeholders involved in getting messages across to the recipients/ end-users. In the third testing phase, awareness and education activities should be developed, as well as media partnerships to ensure the effective delivery of messages. The testing and validation phase is expected to cover multiple monsoon seasons, depending on the frequency of events and resources available to develop the necessary communication tools and channels.

The following are some of the planned actions to be implemented (as outlined in detail in the Implementation Plan for a Gender Transformative FEWS and incorporated into the *Dissemination and Outreach Plan*[6]):

- Test the messages with vulnerable focus groups covering text, audio, visual and different phrases and language, with focus on including people with language, education, literacy and disability-related barriers.
- Communicate with local academia to validate and get feedback on the messaging guide.
- Explore and develop ways to make experience-based knowledge accessible to broader populations, including information on lessons learnt from past floods.
- Develop materials to be disseminated to households/stakeholders with easily digestible information about flooding, how to prepare, and what to do before, during and after a flooding event (With clear examples from previous events of impacts and actions.
- Conduct survey of community leaders/BDRRMO staff helping in disseminating warnings during flooding.

4 Footnote 5

- Conduct survey/research on communication preferences and barriers of migrants, newly-arrived residents (such as students) and other individuals with few local connections.
- Conduct consultations/focus group discussions for testing the content of messages with members of marginalized groups (for example those with linguistic, educational, literacy, disability related barriers to understanding majority targeted content), e.g. the following stakeholders:
  - Local Dept of Social Welfare & Development staff
  - Women's groups, single parents, LGBTQ+ people
  - Dept of Education, public and private schools, universities, vocational institutions
  - Local Dept of Social Welfare & Development staff, organizations representing people with disabilities
  - Local Dept of Social Welfare & Development staff, organizations representing the homeless.

4.4.3 Plan for awareness-raising activities

The following general awareness and education activities are recommended (further detail may be found in the Implementation Plan for Gender Transformative FEWS):

Design general flood warning awareness information campaign to:

- Showcase official flood warning information platforms (such as Baguio City Public Information Office and Baguio CDRRMO official social media) and community-based warning methods (such as siren warnings, sound trucks, and barangay volunteer house-to-house warnings) as reliable sources of flood warning information.
- Educate communities in low-lying, flood prone barangays on the benefits of early preparation and the consequences of responding late or not listening to warnings.
- Educate communities on the importance of proper waste disposal and how it helps to prevent flash floods in the city. Consider involving communities directly through a regular clean-up activity to increase community ownership/commitment.

Enhancement of disaster risk reduction education in schools, in coordination with the Baguio Department of Education and in partnership with educational institutions in the city:

- Design flood risk education modules that can be taught to students throughout the year. Activities can involve games or group activities like role playing to share key messages.
- Conduct regular drills on evacuation/rescue protocol.
- Develop educational materials that students can bring home to their families.
- Give basic first-aid training to students.

Establish media partnerships to ensure effective delivery of messages and alerts:

- Develop public-private partnership with telecom providers such as Globe, Smart, PLDT, etc. to ensure that emergency alerts are delivered to their subscribers in the area.
- Design public service announcements (30-second "ads" on Radio and TV or as a social media campaign) on actions to take during the mitigation, preparation, response, and recovery phase.
- Develop a handbook/toolkit about flooding, how to prepare, what to do before, during, and after events.
- Develop informational campaign - risk knowledge (map of risk areas, connection between rainfall and flood risk, landslides), response capability (what to do, go-bag, numbers/webpages to remember), monitoring and warning (how to read advisories, what to look out for, where to find information), dissemination channels to follow.
- The public service announcements, toolkits, information campaigns and other materials related to preparedness should be developed and tested with members of marginalized groups. This should include people with barriers to understanding majority-targeted content such as language, education, literacy and disabilities.

Establish vulnerability program to easily identify households with special needs so emergency personnel can easily identify these households and prioritize their (early) evacuation:

- Partner with civil society organizations and intermediaries that can help with implementing such a program, and to disseminate information
- Explore use of information from Baguio in my Pocket app, as the app currently asks for information if there is a Person with Disability (PWD) in the household.
- Develop a visual way to "mark" households with special needs so they can be easily identified by rescue/evacuation personnel in the event of a flood event
- Outreach by social welfare officers to homeless residents to ensure they know what to look out for or where to go/evacuate to before flood events.

Enhancement of disaster risk reduction education in the barangay level (for adults and vulnerable individuals in the community):

- Partner with NGOs/volunteer groups who can help with implementing such a program
- Implement regular household-level drills on evacuation/rescue procedure
- Hold regular town hall meetings to address residents' concerns
- Hold regular training for volunteers who want to be part of the disaster response
- Hold first-aid training for families/community.

5 FINANCIAL SUSTAINMENT

A strong financial sustainment plan is crucial for the long-term success and growth of the Baguio FEWS operation and maintenance. Having a clear overview of all costs connected with O&M activities and current sources of funding allows Baguio LGU to effectively allocate resources, anticipate challenges, and plan for future enhancements of the system.

This chapter details the costs related to the operation and maintenance of the system and identifies who is responsible for these costs. These costs include compensation for technical staff, the maintenance and replacement of hardware, software updates, expert technical support, and training. The chapter will also suggest possible new sources of funding to support system development. The importance of a financial sustainment plan goes beyond just managing costs - it's also a tool for ensuring growth and consistent improvements.

5.1 O&M BUDGET

The budget for operation and maintenance should be prepared/reviewed and approved annually. The internal LGU budget approval deadline should be kept in mind and budget preparation and submission should take place well ahead of this.

The budget proposed for calendar year 2024 is outlined in Table D5-1. This has been prepared in close collaboration with the FEWS O&M team.

Table D5-1 FEWS operations and maintenance budget for 2024

All costs are in Philippine peso (PHP). Costs for external technical support from consultants for troubleshooting etc. are not included.

Category	Item	No.	Approx. Costs	Source of funding	Sum	Remarks
O&M team staff	Professional Fee (Non-LGU team members)	2	250,000.00	DRRM General Fund	500,000.00	172,000 Funded under DRRM General Fund 2023
Hardware costs (maintenance of stations, sensors etc.)	Procurement of station components, spare parts etc.	1	500,000.00	LDRRM Fund 2024	500,000.00	Already funded for 2024 and for funding appropriation for the succeeding years
Hardware costs (ICT equipment)	Monthly Electric Bill (server rack)	12	37,000.00	TBD	444,000.00	TBD
	Spare parts, if required	1	100,000.00	TBD	100,000.00	
Software costs	WhatsApp subscription pr. Month (39 USD)	12	2,200.00	TBD	26,400.00	TBD
Costs related to additional training, workshops, meetings	FEWS O& M team quarterly meetings and as needed (snacks, food, materials)	4	5,000.00	DRRM General Fund	20,000.00	For possible funding
	MIKE training licenses for O&M team (estimated cost for 12-month training license)	2	200,000.00	TBD	400,000.00	TBD
System enhancement	Procurement of one (1) USB over IP for the Flood Early Warning System	1	45,000.00	LDRRM Trust Fund	45,000.00	Already Funded, awaiting for SP Resolution
	Enhancement of Flood Early Warning Monitoring System (Installation of CCTVs) in the 10 Stations	10	300,000.00	LDRRM Trust Fund	3,000,000.00	Already Funded, awaiting for SP Resolution
Other	Procurement of tools and equipment for the maintenance of Flood Early warning System Facilities	1	140,000.00	LDRRM Trust Fund	140,000.00	Already Funded, awaiting for SP Resolution
	Loading of simcards (10 stations)	10	7,188.00	DRRM General Fund CY 2023	71,880.00	Already funded and for funding appropriation for the succeeding years
Contingency (10%)				TBD	589,420.00	
Total					6,733,620.00	

Source: Ramboll

Thus, the total budget for FEWS operation and maintenance in 2024 is approx. 6,500,000.00 PHP, excluding consulting fees for technical expert support/advice. The LGU will need expert support for technical trouble shooting and advice in implementation of SOPs but the budget for this should be estimated after preparation of terms of reference.

Beyond 2024, the annual budget is expected to be lower, as lower costs are expected for system enhancements and hardware (monitoring stations).

O&M team staff
Based on the resource workload outlined under the human resources sustainment chapter, budget should be prepared and allocated for all external staff members (excluding permanent LGU personnel). Budget has been prepared for engagement of staff from academia as this will be outlined the proposed MOAs.

Hardware costs
Hardware costs include the procurement and maintenance of monitoring stations, sensors, and as ITC equipment. To ensure that timely maintenance of the physical equipment can be performed as needed, it is recommended that the team maintains an inventory of spare parts and back-up equipment and replaces outdated equipment on a continuous basis.

Software costs
Software costs are understood as including software updates, purchasing additional software, WhatsApp subscription, and server storage.

Costs related to additional training, workshops, meetings
Additional trainings, workshops, meetings, etc. are expected to take place annually to ensure well-trained staff and good coordination among the team members. Costs are related to food, beverages, materials for these events as well as training licenses needed for MIKE software to be shared among team members.

System enhancement
Costs for system enhancements relate to expenses that enhance the system and/or its functionalities. This includes e.g. equipment for sustainment of license connectivity, installation of CCTV to enhance monitoring of stations etc.

Other
Costs that are not listed in other categories are listed under other.

5.2 FUNDING SOURCES

The CDRRMO operational expenses and salaries of CDRRMO staff are to be sourced from the City's General Fund, while DRRM-related programs and activities are to be funded under the Local Disaster Risk Reduction and Management Fund. The local DRRM Fund is expected to be available as a funding source yearly, as long as the programs and activities proposed are DRRM-related. Funding sources should be reconfirmed annually in connection with the preparation of the annual FEWS budget.

The National Government of Philippines is also prioritizing budgeting for DRRM programming, and this is recognized as a key enabler of the progress made on actions. The Philippine DRRM law directs departments and agencies to allocate at least five percent (5%) of the preceding year's annual local revenue for DRRM programs, projects, and activities.

Potential sources of funding to be mobilized
It is recommended to explore funding opportunities beyond the above mentioned to further support system enhancement, partnerships, and dissemination of learnings beyond Baguio City. The opportunity for funding through BLISST and establishment of Public-Private Partnerships (PPP) should be explored as well as opportunities for funding through grants and multi-lateral financing. Close linkages between the FEWS project and the upcoming Baguio Resilient City Tourism Project, an ADB loan project, has been identified with opportunity for co-development to maximize impact, share technical capacity and learnings, and further enhancement of resilience in Baguio.

5.3 GENDER TRANSFORMATIVE BUDGET AND FUNDING SOURCES

The Implementation Plan with the actions for a gender transformative FEWS was developed based on co-assessment of what was considered possible with current resources (immediate actions), what might be possible with further resources (later actions). This approach sought to provide a useful starting point to further evolve the implementation of a gender transformative FEWS in Baguio City. Funding for the actions will require ongoing iterative assessment and specification within the context of existing and planned budgets. This section looks at existing budget arrangement or gender transformative action implementation and considers current and potential sources of funding.

There is a national law (Magna Carta of Women) that directs departments and agencies to allocate a minimum of five percent (5%) of their total annual budgets for gender programs, projects and activities for implementation within the year. The Persons with Disability Affairs Office is also allocated an annual budget to implement programs, projects and activities to meet the needs of persons with disabilities. The office can also tap into the Local DRRM Fund from the CDRRMO to implement DRRM programs/projects that are disability inclusive. The above-mentioned allocations are on top of the regular budget allocated to all departments. Utilization of allocated funds are also monitored annually by third party-oversight agencies.

While funding is available and importantly, funnelled towards DRRM programming and meeting the needs of women, persons with disabilities, and vulnerable members of the community, limitations are apparent in terms of funding sufficiency, timeframes for budget expenditure, and specifications for use. This has posed a challenge to realizing the Implementation Plan actions, as actions tend not to fall neatly within the existing fund use specifications, and many also require a longer term of investment and cross agency approach, impeding the immediate ability to access budget and implement actions.

Some of the ways in which the city is proactively addressing these challenges is through pursuing alternative or supplementary funding modalities and progressing the actions through related donor funded projects that are currently underway or being planned in Baguio. This includes, for example, programming under the United Nations Office for Disaster Risk Reduction (UNDRR) Disaster Resilience Scorecard. The Gender Transformative Action Plan developed under the pilot project has been used to reinforce and guide the work the city is doing on the Disaster Resilience Scorecard, particularly in bringing a focus on disability and inclusion. The city has also partnered with the National Resilience Council towards city resilience efforts. The resilience activities under this program represent a key way in which some of the actions that were identified in the Gender Transformative FEWS may be taken forward and further reinforced (including more broadly beyond FEW). Indeed, the findings and actions from the AASCTF Project were presented by the CDRRMO to the National Resilience Council / UNDRR as core to the city's strategy and vision.

6 RISK MITIGATION

The implementation, operation and maintenance of the Baguio FEWS is invariably exposed to a certain level of risk. These risks could manifest e.g., as technological failures, cost overruns, or data security concerns. A robust risk management plan is necessary to anticipate and mitigate these challenges, serving as a practical guide for the O&M team to navigate any challenges proactively.

The risks are presented in Table D6-1 in the four critical lenses of this sustainment plan - human resources, institutional, technical, and financial. This section is primarily based on the risks identified during the O&M team's workshop in October 2023 and integrates the necessary actions required to overcome those risks identified by the team.

Table D6-1 Risk matrix

Risk Category	Individual Risk	Likelihood (1-5)	Impact (1-5)	Risk Score (Likelihood x Impact)	Mitigation
Human Resources Risks	Lack of available, trained, dedicated staff	4	5	20	Hire additional staff, create a permanent team dedicated to FEWS O&M, hire additional technical staff (hydrology, engineering background)
	Lack of training and experience	3	5	15	Continuous training and technical support, request external staff for training and technical support, creation of a teaching/ training module for new staff, explore research potential using FEWS outputs/ experience
	Top-down changes to the team	3	4	12	Formalize the commitment of dedicated FEWS staff through a council resolution to ensure they have the mandate to perform their tasks and to make the team more resilient to changes in leadership
	Change in O&M Team members (e.g., retirement, promotion of staff to other offices)	4	3	12	Ensure continuous training of staff, leverage students/trainees from partner organizations, and establish a plan for role-specific mentorship Cross-training of staff members to handle multiple roles can minimize knowledge loss when personnel change
Institutional Risks	Change of leadership in LGU / local executive offices	5	3	15	Formalize the FEWS governance through a council resolution to strengthen the Executive Order
	Change of leadership in partner organizations	4	2	8	Continually build and nurture relationships with partner organizations to ensure continuity in communication in case of leadership changes and facilitate smooth knowledge transfer
	Amendment of E.O	4	4	16	Inform top-level decision-makers, share learnings and positive outcomes, inform in case of organizational changes
	Amendment of MOAs	2	4	8	Maintain relationships with partners, share learnings and positive outcomes, inform in case of organizational changes

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Table D6-1 continued

Risk Category	Individual Risk	Likelihood (1-5)	Impact (1-5)	Risk Score (Likelihood x Impact)	Mitigation
Technical Risks	Power outage/ unstable power supply	5	3	15	Backup batteries/power source, signing a MOA with BENECO to prioritize the electricity supply to FEWS during monsoons
	Damage to the infrastructure or theft	4	4	16	Ensure redundancy, check if spare parts and equipment is always available, CCTV in the monitoring stations
	Outdated hardware	3	4	12	Regular maintenance and upgrades to equipment and stations as written in the SOPs, periodic evaluations of the ITC equipment, workstations and servers
	Data transmission failure	4	4	16	Regularly scheduled maintenance and monitoring of the data transmission equipment, redundancy
	Outdated software	5	2	10	Maintain the system, implement updates as needed
	Data breach/ unauthorized access to data	1	4	4	Data security training for all O&M staff, implementing a data backup and recovery plan to recover the data in case of a breach or loss, ensuring that the software is always updated and secured with firewalls and antivirus programs, regular vulnerability assessments and testing
	Cyber attack	1	5	5	Data security training for all O&M staff, implementing a data backup and recovery plan to recover the data in case of a breach or loss, ensuring that the software is always updated and secured with firewalls and antivirus programs, regular vulnerability assessments and testing
	Change to the input data format received from partner organisations	2	5	10	Establish agreements with partner organizations about data format consistency. Agree on coordination processes with partner organizations to receive advanced notice of any unavoidable changes to ensure enough time for the O&M team to prepare/train

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Table D6-1 continued

Risk Category	Individual Risk	Likelihood (1-5)	Impact (1-5)	Risk Score (Likelihood x Impact)	Mitigation
Financial Risks	Lack of funding	3	5	15	Formalize the FEWS in LGU structures to ensure inclusion in yearly budget, diversification of funding sources. Regular Financial Reviews: Routine reviews of project expenditure against budget projections will be carried out to identify potential cost overruns early. Contingency Budget: A portion of the project budget will be set aside as a contingency fund to cover unexpected costs.
	FEWS not prioritized in LGU budget	3	5	15	Formalize the FEWS governance through a council resolution to ensure inclusion in the yearly LGU budget and stability of funding
	No available suppliers	2	3	6	Ensure multiple suppliers of equipment and parts, secure long-term contracts with reliable suppliers to guarantee availability of resources

Source: Ramboll

Developing a robust risk management plan is a crucial step in fostering long-term sustainability of the Baguio City FEWS. Based on the insights gained throughout the project and during the sustainment workshop, key considerations are: securing available, dedicated and well-trained staff to operate and maintain the system, further formalizing the FEWS governance within the LGU to ensure clear responsibilities and stability of funding, as well as clearly defining roles and relationships with partner organizations to build a stable network of support and knowledge exchange around the FEWS. Furthermore, proactive mitigation of technical risks and evaluation of system performance are essential to maintain the continual functionality and growth of the system.

It is recommended that CDRRMO identifies and assigns staff to be responsible for monitoring risks and for implementing each mitigation action to ensure they remain a priority and are not overlooked.

As the FEWS develops over time and potentially grows in complexity, new risks may become apparent – thus, it is recommended that the team performs a periodical risk assessment exercise along all four critical lenses to update the list and identify mitigation actions as needed. This holistic approach in managing risks will not only help to recognize potential challenges early, but also pave the way for the lasting success of the Baguio City FEWS.

ADDITIONAL MATERIAL A – SUSTAINMENT WORKSHOP OUTCOMES

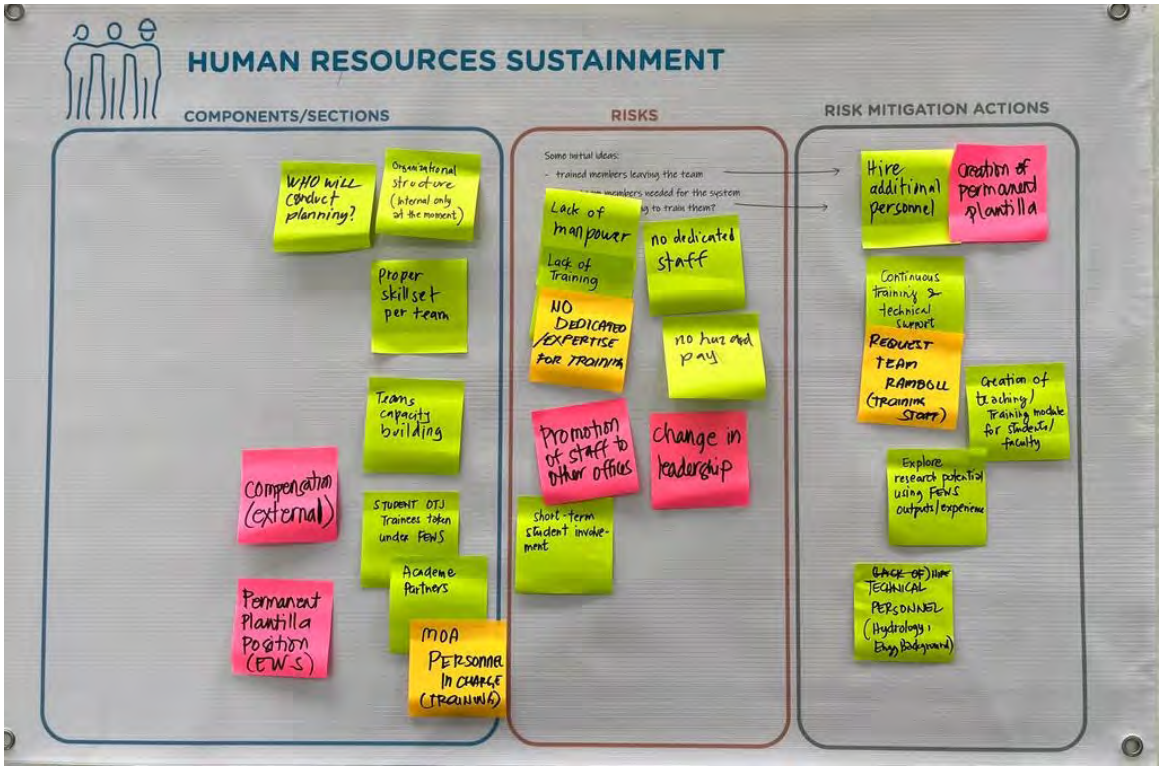

Figure D-1 Sustainment plan components and risks exercise outcome - human resources sustainment
Source: Ramboll

Figure D-2 Sustainment plan components and risks exercise outcome - institutional sustainment
Source: Ramboll

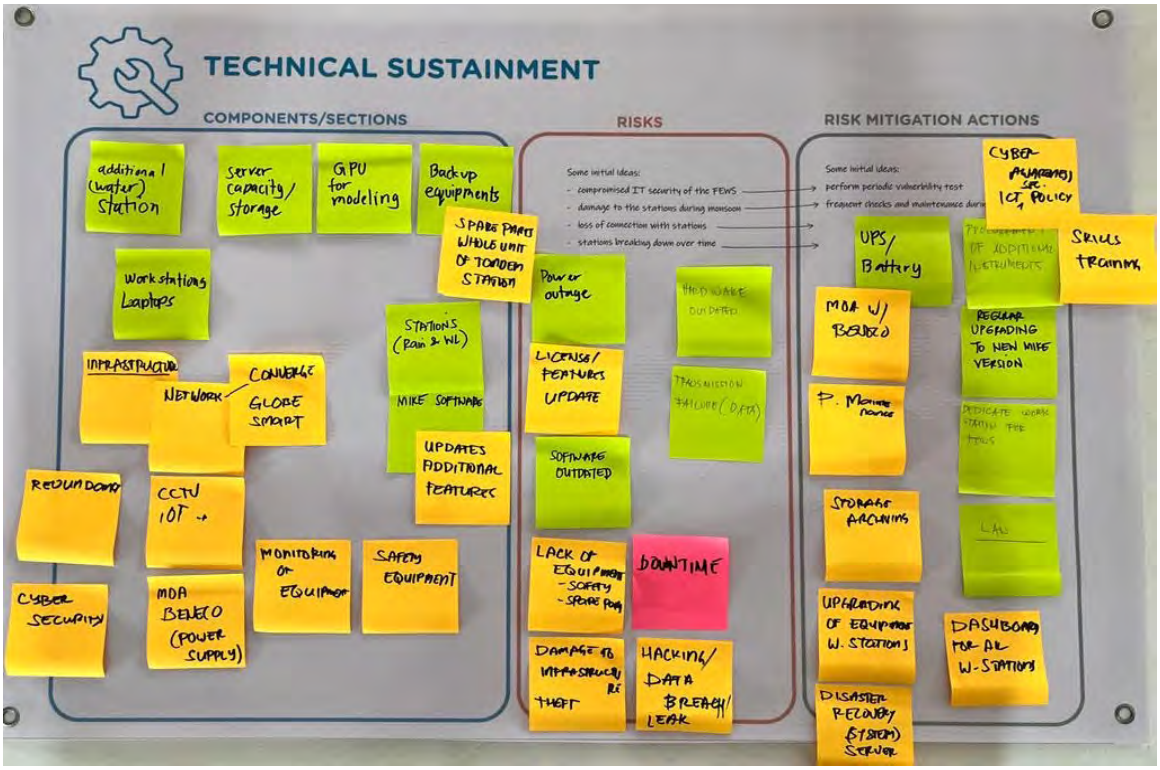

Figure D3 Sustainment plan components and risks exercise outcome - technical sustainment
Source: Ramboll

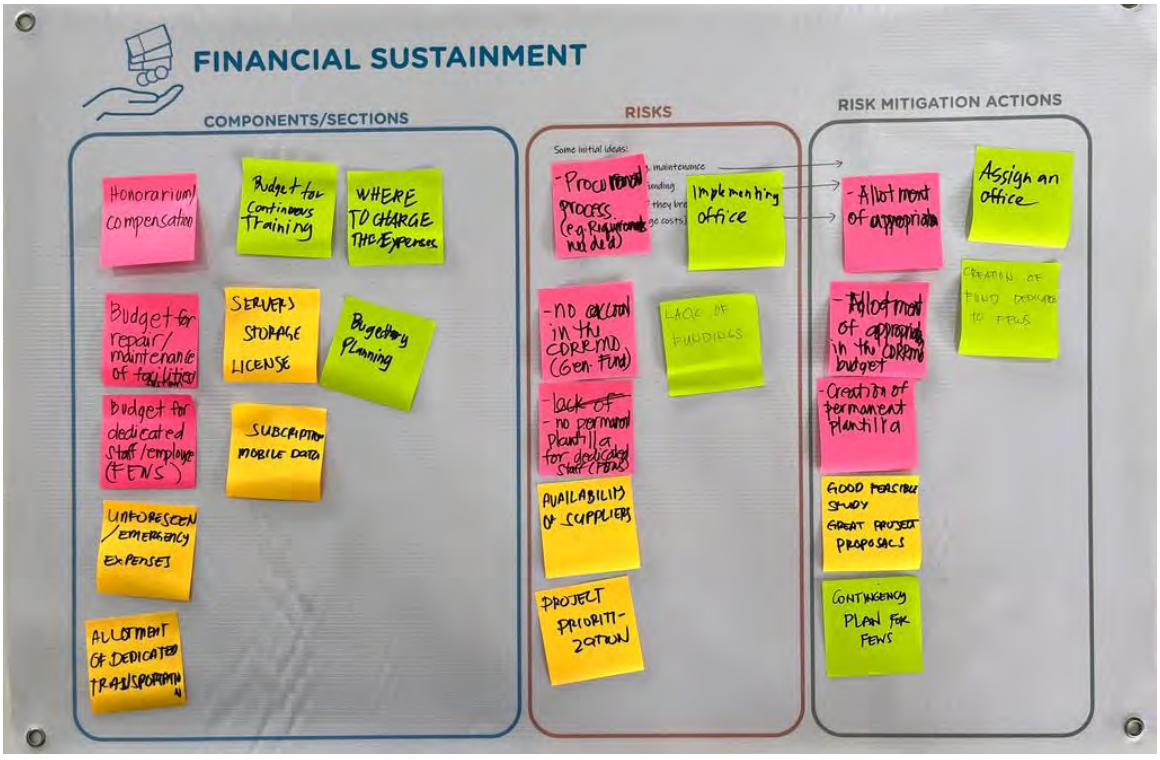

Figure D4 Sustainment plan components and risks exercise outcome - financial sustainment
Source: Ramboll

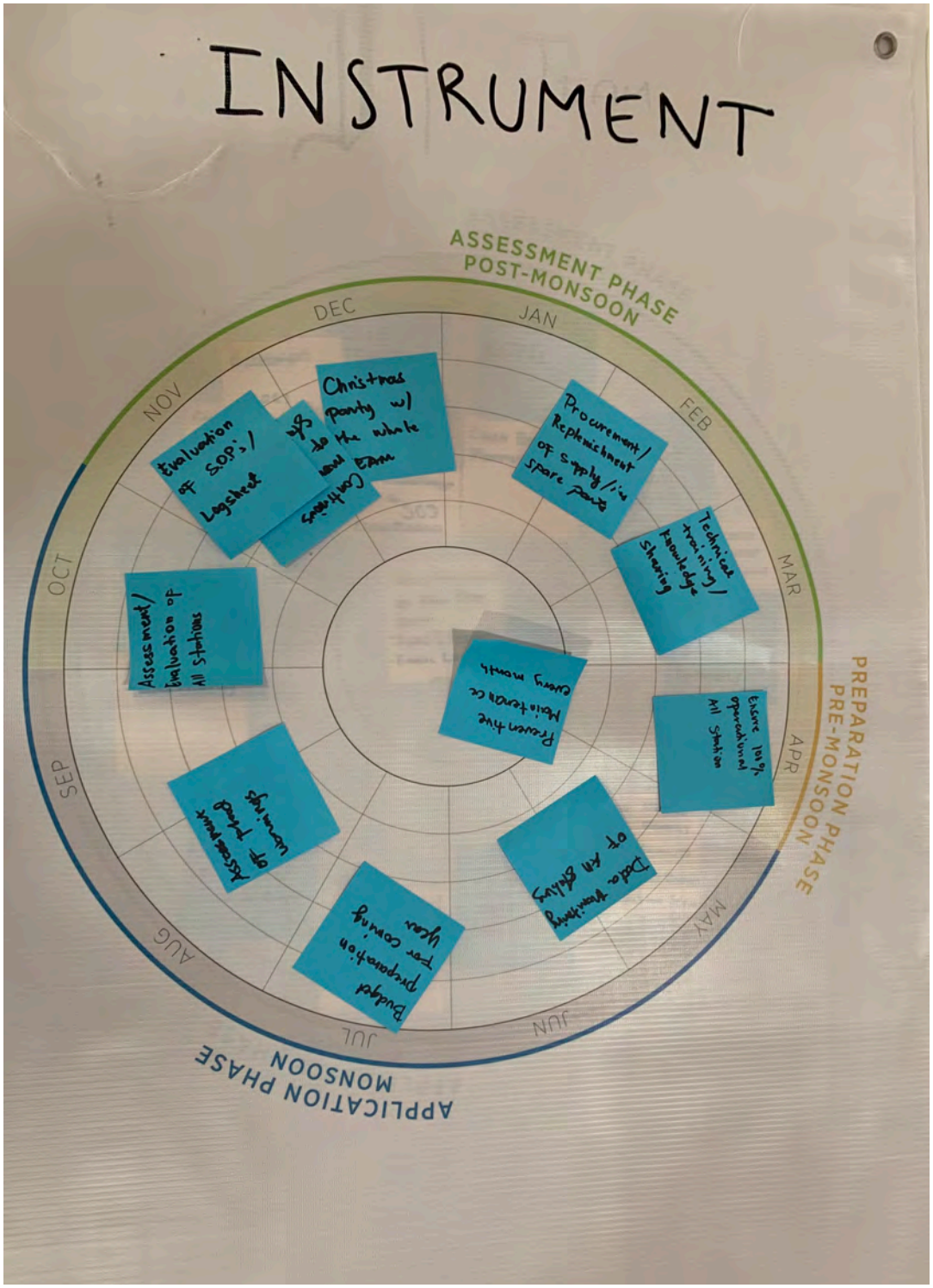

Figure D5 Planning the FEWS year exercise outcome - instrument team
Source: Ramboll

Figure D6 Planning the FEWS year exercise outcome - modelling team
Source: Ramboll

Figure D7 Planning the FEWS year exercise outcome - IT team
Source: Ramboll

ADDITIONAL MATERIAL B – O&M TEAM COMPOSITION

Table D-1 O&M Team composition

verd	Name	Team	Gender	Organization
1.	Carlo Jay S. Valdez	Modelling Team	Male	University of the Cordilleras (UC)
2.	Chester Moling Comicho	Modelling Team	Male	Baguio LGU, City Engineering Office (CEO)
3.	Francis Camarao*	(IT Team)	Male	Baguio LGU, Management Information and Technology Division (MITD)
4.	Hansi Dinumla	Instrument Team	Female	DOST-CAR
5.	Janice Kaye L. Aquino	Modelling Team	Female	Saint Louis University
6.	King B. Gunid	Instrument Team	Male	Baguio LGU, City Disaster Risk Reduction Management Office (CDRRMO)
7.	Mark Jenesis Laory**	Instrument Team	Male	DOST-CAR
8.	Michael Edwin Eugenio	IT Team	Male	Baguio LGU, Management Information and Technology Division (MITD)
9.	Rensz Isaac G. Pinlac	Instrument Team	Male	Baguio LGU, City Disaster Risk Reduction Management Office (CDRRMO)
10.	Shan-ry Roberts	IT Team	Male	Baguio LGU, Management Information and Technology Division (MITD)
11.	Steven Ramirez**	Instrument Team	Male	Baguio LGU, Management Information and Technology Division (MITD)
12.	Stephanie Pinkisan Trinidad	Modelling Team	Female	Baguio LGU, City Disaster Risk Reduction Management Office (CDRRMO)
13.	Larry H. Esperanza	Modelling Team	Male	PAGASA, Baguio Station
14.	Serge Carlo Guevarra Parocha*	-	Male	Department of Public Works and Highways Baguio City District Engineering Office (DPWH-BCDEO)
15.	Nathaniel Vincent Lubrica*	-	Male	University of the Cordilleras (UC)

* Left the capacity building program in 2022, did not participate in the 2023 Baguio FEWS Training Program
** Joined the FEWS O&M team in 2023

Source: Ramboll

ADDITIONAL MATERIAL C – EXECUTIVE ORDER

Not published

Source: Adobe Stock

APPENDIX E
CITY GRADUATION REPORT CARDS

[Please note that each KPI is worth a specific number of points out of a total of 100 points. To graduate from Bronze to Silver and, subsequently, Silver to Gold level, the city should reach a total score of at least 80 points]

Table E-1 City graduation report card - Bronze to Silver

Bronze to Silver					
KPI	**Operationalization[1]**	**Current status[2]**	**Time-bound actions[3]**	**Confidence level[4]**	**Score[5]**
Top-level endorsement of AASCTF objectives and outcome targets *25 points*	The city/provincial government has endorsed a Silver city concept via official letter or formal meeting with Mayor and/ or senior officials, AND	Fully evidenced. Concept Note presented to Baguio LGU/Mayor and endorsed in Q2/Q3 2020.	-	-	25
	The importance of outcome targets is recognized by city/ provincial government and commitment to working to improve conditions for GEDSI groups within the city through AASCTF activities is made	Fully evidenced.	-	-	
Commitment to establish a Project steering committee *15 points*	The city/provincial government has confirmed that a project steering committee will be put in place with mandate to support AASCTF activities	Fully evidenced - Focal points within LGU established from outset, referred to as local project management team vs. project steering committee.	-	-	15
Clear institutional, policy and regulatory framework proposed by the local government *15 points*	The city/provincial government can identify a department or agency responsible for smart city strategies and interventions	Fully evidenced - Baguio has established a Smart City Command Center, where all smart city initiatives are anchored to foster interagency collaboration and integration. The local project management team, sitting within CDRRMO, is collaborating closely with the Smart City Command Center with own staff also dedicated to the Command Center (alongside MITD staff).	-	-	10

Continued on next page

1 Check boxes next to actions/characteristics that the city has delivered/achieved.
2 Describe the status of city according to KPI, including actions taken to achieve KPI and whether the KPI has been met.
3 Outline the planned actions to be taken to meet the KPI, if not met, and/or actions ongoing to maintain/enhance status according to KPI. Indicate the deadline for each action.
4 Confidence the KPI will be met in relation to the time-bound actions expressed as low, medium, or high.
5 Score as all indicates that the KPI has been fully met/evidenced. Partial scoring signals the readiness of the city to meet the KPI but lack of evidence.

Table E-1 continued

Bronze to Silver					
KPI	**Operationalization[1]**	**Current status[2]**	**Time-bound actions[3]**	**Confidence level[4]**	**Score[5]**
	Government policy is in place and guides government decisions relating to smart city strategies and interventions	Not yet fully evidenced. However, with the Smart City Command Center established and fully operational, the LGU is expected to have policies in place that facilitates decisions relating to smart city strategies.	Ramboll have reached out to the Baguio LGU for evidence, awaiting confirmation.	High	
	Government identifies regulation that encourages and establishes framework for planning/funding / implementing smart city initiatives	Not yet fully evidenced. However, with the Smart City Command Center established and fully operational, the local regulation is expected to encourage smart city initiatives.	Ramboll have reached out to the Baguio LGU for evidence, awaiting confirmation.	High	
Smart City Champions and/ or Superuser group nominated, and commitment made with clear responsibilities to support smart city initiatives and AASCTF *15 points*	The city/provincial government has nominated a Smart City Champion as key contact point for coordinating AASCTF activities in the city, AND	Fully evidenced – Antonette Anaban was initially named and acted as the Smart City Champion/key focal point for TO-02/05 activities. Following her departure from the LGU, Stephanie Trinidad has taken over this role as team lead of the established FEWS O&M team.	-	-	15
	The city/provincial government has made a commitment to identify a group of relevant Superusers to participate in silver city (task order) activities under AASCTF	Fully evidenced – 12 superusers (7 within LGU, 5 within peer organizations) have been identified and provided signed commitment letters to take part in targeted capacity building activities as well as long-term O&M of the FEWS as members of the FEWS O&M team.	-	-	
Commitment to taking part in AASCTF e-learning courses by Smart City Champions and Superusers *10 points*	The city/provincial government expresses commitment to completing the AASCTF e-learning courses	Fully evidenced – the AASCTF e-learning courses have been shared with the local project management team and the established FEWS O&M team.	-	-	10
Completion of smart city baseline survey *10 points*	The smart city baseline survey has been completed, AND	Fully evidenced.	-	-	10
	The baseline survey is endorsed by city/ provincial government and commitment is made to update and share the results with AASCTF	Fully evidenced.	-	-	

Continued on next page

Table E-1 continued

Bronze to Silver					
KPI	**Operationalization[1]**	**Current status[2]**	**Time-bound actions[3]**	**Confidence level[4]**	**Score[5]**
Active participation in regional knowledge sharing activities *10 points*	A diverse group (in terms of social and professional identity[6]) of participants take part in the events, AND	Fully evidenced.	-	-	10
	The participants are actively participating in the discussions and bring in their city perspective	Fully evidenced.	-	-	
				Total	**95**
Recommendation: Based on assessment, the City **has met** the criteria to graduate from Bronze to Silver City.					

Source: Ramboll

Table E-2 City graduation report card - Silver to Gold

Silver to Gold					
KPI	**Operationalization[7]**	**Current status[8]**	**Time-bound actions[9]**	**Confidence level[10]**	**Score[11]**
Top-level endorsement of AASCTF pilot project *20 points*	The mayor has endorsed the Silver city pilot project via official letter or formal meeting, which acknowledges what has been achieved and expresses a commitment to working with AASCTF (or another ADB/DFAT program aligned with AASCTF) to explore future smart city initiatives	Not yet fully evidenced, as the City Mayor has not been asked for an official endorsement. The City Mayor is actively participating in project meetings and ceremonies with stakeholder organizations and partners. He has been key to enhancing collaboration with partners through the establishment of multiple Memoranda of Agreements and securing access to data. He is following the project activities closely and has expressed endorsement of project activities in multiple meetings with the project team and ADB. The full score signals the city's readiness, as foreseen, to meet the KPI.	TBD with ADB regarding timing for final receipt of endorsement of Baguio Mayor and alignment with strategies/ plans for future ADB/ DFAT ac.	High	20

6 Social Identity – For example: ethnicity, age, caring responsibilities, cultural background, disability status, gender, religious affiliation, sexual orientation, gender identity, intersex status, and socio-economic background. Professional Identity – For example: profession, education, work experiences, organisational level, functional area, division/department, and location.

7 Check boxes next to actions/characteristics that the city has delivered/achieved.

8 Describe the status of city according to KPI, including actions taken to achieve KPI and whether the KPI has been met.

9 Outline the planned actions to be taken to meet the KPI, if not met, and/or actions ongoing to maintain/enhance status according to KPI. Indicate the deadline for each action.

10 Confidence the KPI will be met in relation to the time-bound actions expressed as low, medium, or high.

11 Score as all indicates that the KPI has been fully met/evidenced or the city's readiness to fully meet the KPI. Partial scoring signals partial readiness of the city to meet the KPI and/or lack of evidence.

Table E-2 continued

Silver to Gold					
KPI	**Operationalization[7]**	**Current status[8]**	**Time-bound actions[9]**	**Confidence level[10]**	**Score[11]**
Effective and sufficiently resources and responsive project organization (steering committee, champions, superusers) *15 points*	The steering committee is active in making decisions and responding to requests for information, AND	Fully evidenced - Extremely responsive/ active local project management team.	-	-	10
	The Change Agents(s) and Superusers are engaged	Fully evidenced - Highly engaged Smart City Champions and Superusers who are actively participating in the capacity building program, On-the-Job Training and FEWS operation and maintenance.			
	The Change Agent(s) and Superusers are sufficiently resourced	Not yet fully evidenced – the staff at the CDRRMO have very high workloads and may lack time to prioritize FEWS O&M. The CDRRMO is currently undergoing organizational restructuring which is expected to improve resource challenges. The sustainment plan prepared outlines the expected workload for all FEWS O&M team members throughout all operational phases.	ADB and Ramboll to work to secure greater resource commitment to both fulfil Sustainment Plan requirements and to engage proactively in Gold Tier activities such as the Change Agent Program.	Medium	
Financially/ technically feasible pilot project with output/tool embedded into regulations/ governance at appropriate levels *15 points*	The pilot project is operationalized, whereby the ability to utilize/ sustain into the future is demonstrated via: • Regulation passed to embed pilot in institutional governance, • Utilization of pilot to inform decision-making, • Adoption of pilot to inform/implement other initiatives, OR • Commitment to explore scaling of pilot	An executive order has been signed by the City Mayor, officially establishing the FEWS O&M team in the LGU. Furthermore, multiple MOAs have been signed to formalize project partnerships and data-sharing.	-	-	15

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Table E-2 continued

Silver to Gold					
KPI	**Operationalization[7]**	**Current status[8]**	**Time-bound actions[9]**	**Confidence level[10]**	**Score[11]**
Mid-term outputs/tools operations budget secured by city *15 points*	The city/provincial government has allocated financial resources to support sustained operations of the pilot project	Partially evidenced – Funding for system operation has been allocated by the LGU for calendar year 2024 and a funding appropriation has been prepared for succeeding years. The budget has been prepared as part of the Sustainment Plan. Funding for expert support and training, including training licenses, is yet to be secured.	TBD - Further funding for expert support to be discussed with ADB	-	10
Meaningful progress toward GEDSI outcomes is demonstrated *15 points*	The city/provincial government is taking a lead to improve understanding and share knowledge that encourages improvements in the conditions for GEDSI groups, AND	Fully evidenced - While there remains work to be done, Baguio stands out in terms of its GEDSI championing within and beyond AASCTF. Baguio's key focal point has confirmed on 15 May 2023 that efforts have been made to breakdown silos within the city and activate other entities to also elevate their work on mainstreaming GEDSI from the earliest stages of data collection/ disaggregation. It was noted in particular that the city in integrating GEDSI strongly into their upcoming urban resilience portfolio of projects and is currently developing a Gender and Development Plan which Baguio LGU are taking efforts to inform and steer vis-à-vis the broader lens of GEDSI. The city has expressed strong leadership support for GEDSI, including the conceptualization and implementation of TO-05 which aspires to a gender transformative FEWS and more broadly a holistically inclusive and resilient smart livable city. The journey towards a transformative FEWS is a process; a process no less which Baguio has clearly identified as having an intent to actively achieve. The city's progress toward implementation of actions (identified under TO-05) to realize GEDSI remains challenged by, among other things, limited resources and capacity, challenges to convene multistakeholder/ institutional engagements, and uncertainty around mechanisms/ dynamics for establishing trusted partnerships with GEDSI representative organizations working at Barangay levels (seen as a key to unlocking the potential to tap into and incorporate the missing voices in Baguio FEWS).	Baguio LGU to continue to pursue implementation of the actions developed for a Gender Transformative FEWS. Ramboll and ADB to explore possibilities for further targeted support to the city/GEDSI champions in order to help overcome the current challenges/ hurdles and unlock the substantial potential within the system and the local knowledge base.	Medium	15

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Table E-2 continued

Silver to Gold					
KPI	**Operationalization[7]**	**Current status[8]**	**Time-bound actions[9]**	**Confidence level[10]**	**Score[11]**
	The city/provincial government is engaging with GEDSI groups and taking the perspectives of GEDSI groups into consideration in decision-making, design, and implementation of measures, AND/OR	Through TO-05, the city has sought to understand the GEDSI context at both micro and macro levels. Accordingly, AASCTF project intervention efforts in Baguio have been accompanied by engagement with GEDSI stakeholders and representatives. Government representatives from multiple departments have been involved in workshops for TO-05. The learnings from TO-05 on GEDSI group needs and preferences have been identified as valuable for broader application in- and across departments and programs within the city. There is a noted "appetite" for GEDSI and ways in which GEDSI may be further mainstreamed through city government service delivery and planning. Capacity (resource availability and depth of practical knowledge) for implementation remains a key challenge in this respect.	As above	Medium	
	The city/provincial government is taking steps towards improving access to and quality of services GEDSI groups (Only relevant for cities where the intervention includes Service delivery), AND/OR	Through TO-05, the city government is taking tangible steps to improve access of GEDSI stakeholders to FEWS and related services. More work and further support to elevate capacities is needed as noted above.	As above	Medium	
	The city/provincial government is working on improving the availability and equality of opportunities to access fiscal and financial services for GEDSI groups (Only relevant for cities where the intervention includes financial management)	N/A			

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Table E-2 continued

Silver to Gold					
KPI	**Operationalization[7]**	**Current status[8]**	**Time-bound actions[9]**	**Confidence level[10]**	**Score[11]**
Engagement in City Twinning activities *10 points*	The city/provincial government has completed the needs assessment and the areas of interest for knowledge sharing have been identified, AND	Fully evidenced.	-	-	10
	The city/provincial government has signed a commitment letter and nominated a City Twinning Coordinator	Fully evidenced.	-	-	
	The city/provincial government has developed an action plan together with the partnering city and has achieved (or is actively working towards achieving) agreed actions	An initial action plan was established however in the end the plan could not move forward due to limited financing availabilities. Baguio remains interested to pursue a similar such plan and had been investigating from their side own possibilities to finance and pursue beyond AASCTF.	TBD with ADB on way forward	Medium	
	The city/provincial government has actively engaged in knowledge sharing outside AASCTF organized events with the partner city	The city has not been asked to actively participate in knowledge sharing with the partner city.	TBD with ADB on way forward	Medium	
Completion of all AASCTF e-learning courses by Smart City Champions and Superusers *5 points*	All AASCTF e-learning courses have been completed by the Smart City Champion(s) and Superusers	Not yet fully evidenced. The Smart City Champion(s) and Superusers have been asked to complete the courses but not all have been able to prioritize this due to high workloads.	-	High	0

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Table E-2 continued

Silver to Gold					
KPI	**Operationalization[7]**	**Current status[8]**	**Time-bound actions[9]**	**Confidence level[10]**	**Score[11]**
Commitment to mentor/ peer support other AASCTF cities *5 points*	The city/provincial government has committed to mentor/peer support other AASCTF cities (via an official letter/ formal meeting)	Not yet fully evidenced – primarily due to the fact that Baguio has yet to be formally asked for such commitment.	TBD with ADB on way forward	High	5
	When/If presented with such opportunities, the city/provincial government responded positively and engaged in next steps	Fully evidenced - Baguio has responded enthusiastically to partaking actively in all such events to which they have been requested to do so, both within and outside of AASCTF (e.g., presenting at the AASCTF 2022 networking days, presenting at various non-AASCTF conferences noted above, taking part in 2x webinars with Makassar – one in more in a listening role and one in a sharing role re. twinning activities).	-	-	
				Total	**85**
Recommendation: Based on assessment the City **has met** the criteria to graduate from Silver to Gold City.					

Source: Ramboll

Source: Ramboll

ABOUT THE ASEAN AUSTRALIA SMART CITIES TRUST FUND

The ASEAN Australia Smart Cities Trust Fund (AASCTF) assists ASEAN cities in enhancing their planning systems, service delivery, and financial management by developing and testing appropriate digital urban solutions and systems. By working with cities, AASCTF facilitates their transformation to become more livable, resilient, and inclusive, while in the process identifying scalable best and next practices to be replicated across cities in Asia and the Pacific.

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