ABERDEEN WEST PERIPHERAL ROUTE (AWPR) MONITORING PROJECT

MONITORING REPORT

ERS Ref: 0962-003

release the value of your land

site investigation, assessment and remediation

ABERDEEN WEST PERIPHERAL ROUTE (AWPR) MONITORING PROJECT

MONITORING REPORT

Prepared for:
AWPR CJV
Craibstone Offices
Craibstone Estate
Bucksburn
Aberdeenshire, AB21 9YA

Prepared by:
ERS
Westerhill Road
Bishopbriggs
Glasgow, G64 2QH

Date of Issue: **11 March 2021**
ERS Project No: **0962-003**
Report No: **01**
Issue: **01**

1. INTRODUCTION

In July 2013 Aberdeen City Council commissioned ERS to undertake Hydrogeological and Hydrological Monitoring for the 'Aberdeen West Peripheral Route/Balmedie-Tipperty scheme' for a number of Private Water Supplies (PWS) and Sensitive Environmental Sites (SES), prior to the construction of the Aberdeen West Peripheral Route. This consisted of the supply and installation of monitoring equipment, and subsequent monitoring and sampling at each site for between the period July 2013 and December 2014.

Subsequent to the above, in April 2019, following the completion of the Aberdeen West Peripheral Route, the Aberdeen West Peripheral Route Construction Joint Venture (AWPR CJV) commissioned ERS to undertake further monitoring at a number of PWS and SES. This consisted of monitoring and sampling at each site for a period of 12 months (April 2019 to March 2020). In February 2020, ERS were commissioned to extend the monitoring period for an additional 7 months, to October 2020.

In January 2021, ERS was commissioned by AWPR CJV to prepare a report, detailing "*all monitoring undertaken, any variances to pre-construction conditions, and any changes to conditions monitored in advance of construction for both PWS and SES locations*".

2. MONITORING AND SAMPLING UNDERTAKEN

2.1 'Pre-Construction' August 2013 – December 2014 by ERS

'Pre-construction' monitoring was undertaken, on a monthly basis, by ERS between July / August 2013 (Baseline monitoring) and December 2014 (MR15) for 22no. private water supply sites (PWS) and 20no. sensitive environmental sites (SES), prior to the construction of the AWPR. This consisted of the supply and installation of monitoring equipment (pressure transducers, flowmeters, rain gauges, sampling taps, level boards), and subsequent monitoring and sampling at each PWS and SES.

2.1.1 Private Water Supplies

PWS were monitored for water flow and water quality. Several PWS were also monitored for water level. The scope of monitoring is summarised in Table 1 below.

The PWS water quality laboratory testing requirements were provided by Aberdeen City Council, based on the usage of the PWS at the time. There were 5no. suites for water quality testing (Suites A – E) and each PWS was assigned a suite, which varied for monthly, quarterly and six-monthly testing. The PWS and their analytical suites are provided in Table 1 below; Table 2 provides each suites water quality parameter and frequency of analysis.

Table 1: PWS Sites and Suites - Pre-Construction

PWS Sites	Monitoring	Water Quality Analytical Suite
F2	Flow	
F14a	Flow, level	Suite C
F43	Flow, level	Suite B
N11b	N/A	Suite B
N21a	Flow	Suite C
N21b	Flow	Suite A
N21c	N/A	Suite D
N22a	Flow, level	Suite C
N5b	N/A	Suite D
N9	Flow	Suite A
S4	Flow	Suite C
S11	Flow	Suite C
S40	N/A	Suite C
S44/46-Q1	Flow	Suite A
S44/46-Q2	Flow	Suite A
S44/46-Q3	Flow	Suite A
S45	Flow	Suite C
S49a	Level	Suite C
S51a	Flow	Suite C
S59	Flow	Suite D
S66	Flow	Suite E

Table 2: PWS Water Quality Parameters – Pre-Construction

Water Quality Parameter	Suite	Frequency - Monthly (M) / Quarterly (Q) / 6-monthly
Temperature	A B C D E	M
Electrical Conductivity	A B C D E	M
pH	A B C D E	M
Redox	A B C D E	M
Dissolved oxygen	A B C D E	M
Calcium	A B C D E	M (Suite E-Q)
Sodium	A B C D E	M (Suite E-Q)
Potassium	A B C D E	M (Suite E-Q)
Magnesium	A B C D E	M (Suite E-Q)
Aluminium	A B C D E	M (Suite E-Q)
Iron	A B C D E	M
Copper	A B C D E	M (Suite E-Q)
Lead	A B C D E	M (Suite E-Q)
Zinc	A B C D E	M (Suite E-Q)
Bromide	A B C D E	M (Suite E-Q)
Chloride	A B C D E	M (Suite E-Q)
Sulphate	A B C D E	M (Suite E-Q)
Soluble Nitrate	A B C D E	M (Suite E-Q)
Total Dissolved Solids	A B C D E	M (Suite E-Q)
Total Nitrogen	A B C D E	M (Suite E-Q)
Enterococci	A C	M
Escherichia coli (E. coli)	A B C D	M (Suites B and D-Q)
Coliform bacteria	A C	M
Cryptosporidium	A C	M
Giardia lamblia	A C	M
Cadmium	A B C D E	Q (Suite E-6-monthly)
Nickel	A B C D E	Q (Suite E-6-monthly)
Polyaromatic hydrocarbons	A B C D E	Q (Suite E-6-monthly)
Pesticides	A B C D E	Q (Suite E-6-monthly)
Ammoniacal nitrogen	A B C D	Q
Total petroleum hydrocarbons	C D E	Q (Suite E-6-monthly)

2.1.2 Sensitive Environmental Sites (SES)

SES were monitored for water level and water quality at a number of locations comprising rivers, lochs and boreholes. A rain gauge was also installed on each SES. The scope of monitoring is summarised in Table 3 below.

The SES water quality laboratory testing requirements were provided by Aberdeen City Council; there were separate suites depending on whether the sample was ‘surface water’ or ‘groundwater’; both sample types had a ‘monthly’ and ‘quarterly’ testing suite. The SES sites and their sample types are provided in Table 3 below; Table 4 provides the water quality parameters for each water type and frequency of analysis.

Table 3: SES Sites and Suites - Pre-Construction

SES Sites	Monitoring	Quality Analytical Suite
SES1-Site1	River Level	Surface Water
SES1-BHB	Groundwater Level	Groundwater
SES1-BHHM002	Groundwater Level	Groundwater
SES1-BHHM003	Groundwater Level	Groundwater
SES1-BHHM004	Groundwater Level	Groundwater
SES2- Site 1	River Level	Surface Water
SES2- Site 2	River Level	Surface Water
SES2- FLBH053A	Groundwater Level	Groundwater
SES2- FLBH053B	Groundwater Level	Groundwater
SES2- FLBH053C	Groundwater Level	Groundwater
SES2- FLBH053D	Groundwater Level	Groundwater
SES2- FLBH053E	Groundwater Level	Groundwater
SES3- DK175	Groundwater Level	Groundwater
SES3- DK176	Groundwater Level	Groundwater
SES3- DK177	Groundwater Level	Groundwater
SES3- Site 1	River Level	Surface Water
SES3- Site 2	Loch Level	Surface Water
SES3- Site 3	River Level	Surface Water
SES3- Site 4	Loch Level	Surface Water
SES3- BHA	Groundwater Level	Groundwater

Table 4: SES Water Quality Parameters – Pre-Construction

Water Quality Parameter	Suite - Surface Water (SW) or Groundwater (GW)	Frequency - Monthly / Quarterly / 6-monthly
Temperature	SW GW	M
Electrical Conductivity	SW GW	M
pH	SW GW	M
Redox	SW GW	M
Dissolved oxygen	SW GW	M
Calcium	SW GW	M
Sodium	SW GW	M
Potassium	SW GW	M
Magnesium	SW GW	M
Aluminium	SW GW	M
Iron	SW GW	M
Copper	SW GW	M
Lead	SW GW	M
Zinc	SW GW	M
Bromide	SW GW	M
Chloride	SW GW	M
Sulphate	SW GW	M
BOD	SW GW	M
COD	SW	M
Suspended solids	SW	M
Carbonate	SW GW	Q
Bicarbonate	SW GW	Q
Arsenic	SW GW	Q
Cadmium	SW GW	Q
Chromium	SW GW	Q
Nickel	SW GW	Q
Selenium	SW GW	Q
Vanadium	SW GW	Q

Water Quality Parameter	Suite - Surface Water (SW) or Groundwater (GW)	Frequency - Monthly / Quarterly / 6-monthly
Total petroleum hydrocarbons	SW GW	Q
Polyaromatic hydrocarbons	SW GW	Q
Ammoniacal nitrogen	SW GW	Q

2.2 During-Construction

2.3 'Post-Construction' April 2019 –October 2020

'Post-construction' monitoring and sampling was undertaken, on a monthly basis, by ERS between April 2019 (MR1) and October 2020 (MR17) for 16no. private water supply sites (PWS) and 15no. sensitive environmental sites (SES), following completion of the AWPR. This consisted of monitoring and sampling at each site for a period of 17 months. It should be noted that there was a 2-month gap in the dataset (April and May 2020) when monitoring and sampling was not possible due to travel restrictions related to Covid-19.

2.3.1 Private Water Supplies

The PWS water quality laboratory testing requirements were provided by AWPR CJV. Each PWS was tested for the same suite, which varied for monthly and quarterly testing. The list of PWS monitored is provided in Table 5; Table 6 details the monthly and quarterly testing suite and their respective drinking water standards, where available.

Table 5: PWS Sites Monitored Post-Construction

PWS Sites	Note on Water Supply
F14a	Existing concrete tank
F43	New supply (borehole)
N21a	Existing concrete tank
N21b	Existing concrete tank
N9*	N/A *
N9-449	New supply (borehole)
S4	Existing supply
S11	Existing plastic tank
S40	New supply (borehole)
S44a	New supply (borehole)**
S44b	New supply (borehole)
S44d	New supply (borehole)
S45	Existing supply
S46	New supply (borehole)
S51	New supply (borehole)
S35***	Existing supply

* No access was granted by the landowner to the treatment shed for N9; therefore, no monitoring and sampling was undertaken from this site during post-construction monitoring.

** ERS understand that the new supply was subsequently modified by the landowner to allow both the new borehole and a pre-existing spring to supply the property. It is not known what supply was sampled during each monitoring round.

*** This site was not monitored during pre-construction monitoring.

Table 6: PWS Water Quality Parameters – Post Construction

Water Quality Parameter	Frequency - Monthly (M) / Quarterly (Q)	Drinking Water Standards
Temperature	M	NA
Electrical Conductivity	M	2,500µS/cm*
pH	M	NA
Redox	M	NA
Dissolved oxygen	M	NA
Calcium	M	NA
Sodium	M	200mg/l*
Potassium	M	NA
Magnesium	M	NA
Aluminium	M	0.2mg/l*
Iron	M	0.2mg/l*
Copper	M	2,000µg/l*
Lead	M	10µg/l*
Zinc	M	5,000µg/l**
Bromide	M	NA
Chloride	M	250mg/l*
Sulphate	M	250mg/l*
Soluble Nitrate	M	11.3mg/l***
Total Dissolved Solids	M	NA
Total Nitrogen	M	NA
Enterococci	M	0 cfu/100ml*
Escherichia coli (E. coli)	M	0 cfu/100ml*
Coliform bacteria	M	0 cfu/100ml*
Cryptosporidium	M	0 oocysts/10L
Giardia lamblia	M	NA
Cadmium	Q	5µg/l*
Nickel	Q	20µg/l*
Polyaromatic hydrocarbons	Q	Benzo(a)pyrene 0.01µg/l* ∑4PAH 0.1µg/l*
Pesticides	Q	0.5µg/l (Total)*
Ammoniacal nitrogen	Q	0.39mg/l***
Total petroleum hydrocarbons	Q	0.01mg/l****

Source of Drinking Water Standards:

*The Public Water Supplies (Scotland) Regulations 2014.

** USEPA - National Primary Drinking Water Regulations and National Secondary Drinking Water Regulations.

***Calculation to allow comparison to DWS provided in Section 4 of Appendix 1.

****Limit of detection.

2.3.2 Sensitive Environmental Sites (SES)

The SES were monitored for water level (groundwater, river or loch) and sampled for water quality. The scope of monitoring is provided in Table 7 below.

The SES water quality laboratory testing requirements were provided by AWPR CJV. Each SES had the same monthly suite, quarterly suite and 6-monthly suite. The list of SES monitored is provided in Table 7; Table 8 details Suites 1 - 3 and the respective environmental quality standards, where available.

Table 7: SES Sites Monitored Post-Construction

SES Sites	Monitoring	Surface Water Sample or Borehole
SES1-Site1	River Level	Surface Water
SES1-BHB	Groundwater Level	Borehole
SES1-BHHM002	Groundwater Level	Borehole
SES1-BHHM003	Groundwater Level	Borehole
SES2- Site 1	River Level	Surface Water
SES2- Site 2	River Level	Surface Water
SES2- FLBH053A	Groundwater Level	Borehole
SES2- FLBH053B	Groundwater Level	Borehole
SES2- FLBH053D	Groundwater Level	Borehole
SES2- FLBH053E	Groundwater Level	Borehole
SES3- Site 1	River Level	Surface Water
SES3- Site 2	Loch Level	Surface Water
SES3- Site 3	River Level	Surface Water
SES3- Site 4	Loch Level	Surface Water
SES3- BHA	Groundwater Level	Borehole

Table 8: SES Water Quality Parameters – Post-Construction

Water Quality Parameter	Frequency - Monthly (M) / Quarterly (Q) / 6-monthly	Environmental Quality Standards
Temperature	M	NA
Electrical Conductivity	M	NA
pH	M	NA
Redox	M	NA
Dissolved oxygen	M	NA
Calcium	M	NA
Sodium	M	NA
Potassium	M	NA
Magnesium	M	NA
Aluminium	M	0.015mg/l*
Iron	M	1mg/l*
Copper	M	1µg/l***
Lead	M	1.2µg/l*
Zinc	M	10.9µg/l*
Bromide	M	NA
Chloride	M	250mg/l*
Sulphate	M	400mg/l*
BOD	Q	NA
COD	Q	NA

Water Quality Parameter	Frequency - Monthly (M) / Quarterly (Q) / 6-monthly	Environmental Quality Standards
Suspended solids	Q	NA
Carbonate	6-monthly	NA
Bicarbonate	6-monthly	NA
Arsenic	6-monthly	50µg/l*
Cadmium	6-monthly	0.08µg/l*
Chromium	6-monthly	4.7µg/l*
Nickel	6-monthly	4µg/l*
Selenium	6-monthly	NA
Vanadium	6-monthly	20µg/l*
Total petroleum hydrocarbons	6-monthly	0.01mg/l**
Polyaromatic hydrocarbons	6-monthly	Anthracene 0.1µg/l* Benzo(a)pyrene 0.00017µg/l* Fluoranthene 0.0063µg/l* Naphthalene 2µg/l*
Ammoniacal nitrogen	6-monthly	NA

Source of Environmental Quality Standards:

* WAT-SG-53 (v7.1 2020) Environmental Quality Standards and Standards for Discharges to Surface Waters

** Limit of detection

***Recent EQS is for bioavailable copper, which has not been assessed for this dataset; therefore, compared Cu (total) to EQS, which is a conservative assessment.

3. INTERPRETATION – WATER QUALITY

3.1 Methodology

Section 2 provides the detail of the PWS and SES sites that were monitored and sampled; in total, there are 14no. PWS sites and 15no. SES sites that have both pre- and post-construction data. Therefore, these are the sites for which an assessment of "*any variances to pre-construction conditions*" can be undertaken.

To allow an assessment of any variances for each PWS and SES, the 'pre-construction' dataset for each monthly, quarterly and 6-monthly determinand was compared to the 'post-construction' dataset. To enable this, the results for each monitoring round had to be combined into one dataset for each monitoring period. Given the timeframe over which monitoring was undertaken, which included a total of 36 sets of monthly data spanning 7 years and from three separate laboratories, some dataset manipulation was required in order to be able to compare the results across both monitoring periods. The details of the dataset manipulations are summarised in Appendix 1.

To enable comparison between datasets by time series, each monitoring period (pre-and post-construction) was considered as a 24-month time series (Month 1 – 24) as monitoring for each dataset was initiated on a different month, and for a varying number of months, as illustrated in Table 9 below; this approach would also potentially indicate any obvious seasonal patterns.

Table 9: Pre- and Post-Construction Time Series

Month	Pre-Construction	Post-Construction
1	January 2013	January 2019
2	February 2013	February 2019
3	March 2013	March 2019
4	April 2013	April 2019
5	May 2013	May 2019
6	June 2013	June 2019
7	July 2013	July 2019
8	August 2013	August 2019
9	September 2013	September 2019
10	October 2013	October 2019
11	November 2013	November 2019
12	December 2013	December 2019
13	January 2014	January 2020
14	February 2014	February 2020
15	March 2014	March 2020
16	April 2014	April 2020
17	May 2014	May 2020
18	June 2014	June 2020
19	July 2014	July 2020
20	August 2014	August 2020

Month	Pre-Construction	Post-Construction
21	September 2014	September 2020
22	October 2014	October 2020
23	November 2014	November 2020
24	December 2014	December 2020

Red font indicates the monitoring period for each dataset.

The time series, box plots and statistics for each PWS are provided in Appendices 2 - 15; where available, the data was compared to the drinking water standards (DWS) provided in Section 2. The time series, box plots and statistics for each SES are provided in Appendix 16 - 30; where available, the data was compared to the environmental quality standards (EQS) provided in Section 2.

3.2 Comparison of Pre- and Post-monitoring Water Quality Data

The summary sheets in Appendices 2 - 30 provide a comparison of the water quality data between the pre- and post-construction monitoring datasets at each PWS and SES monitoring location, and for each determinand analysed for at the laboratory.

There is no clear, consistent, trend in the data which would allow a brief summary of the differences in water quality to be provided for each PWS or SES between the pre- and post-construction monitoring datasets. Therefore, the reader is invited to scrutinise the summary sheets in each Appendix where each determinand is discussed individually.

However, given the amount of data available, the following two sections provide a summary of the number of exceedances of water quality standards at each PWS and each SES.

3.2.1 DWS Exceedances

The following table 10 lists exceedances of the Drinking Water Standard in the PWS dataset pre- and post-construction. It is important to note that the sampling points are not necessarily at a drinking water tap but can be located upstream of the treatment system.

Time series, statistics and comparisons between pre- and post-construction datasets for all determinands are provided in Appendices 2 to 15 and the DWS is indicated on the charts, when relevant.

Overall, there are a number of exceedances of the DWS post-construction which have not been recorded pre-construction. For the most part, these exceedances are limited to a single occurrence and, therefore, are unlikely to be a significant concern and not considered further.

This leaves a small number of PWS (N21a, N21b, S11 and S45) at which a number of exceedances of DWS were recorded several times for microbiological indicators (cryptosporidium, enterococci and total coliforms) and metals (aluminium, iron, lead) during post-construction monitoring. However, we are unable to conclude the cause of these exceedances for these parameters alone.

It is noted that all PWS with a new supply installed as part of the AWPR construction works record a lower number of exceedances of the DWS post-construction than pre-construction.

3.2.2 EQS Exceedances

The following table 11 lists exceedances of the Environmental Quality Standard in the SES dataset pre- and post-construction.

Timeseries, statistics and comparisons between pre- and post-construction datasets for all determinands are provided in Appendices 16 to 30. The EQS is indicated on the charts, when relevant.

Table 11: SES Exceedances

SES	Pre-Construction Exceedances	Post-Construction Exceedances
SES1-Site 1	Aluminium (16/16) Copper (16/16) Iron (11/16) Lead (7/16) Zinc (9/16) Cadmium (1/6) **Chromium (1/6)** **Nickel (2/6)** PAH (1/6) **TPH (2/7)**	Aluminium (17/17) Copper (17/17) **Iron (12/17)** **Lead (8/17)** **Zinc (16/17)** Cadmium (1/2) PAH (1/2)
SES1-BHB	Aluminium (13/16) **Copper (16/16)** Iron (16/16) **Lead (7/16)** **Zinc (11/16)** **Chromium (3/6)** **Nickel (6/6)** **TPH (2/7)**	**Aluminium (17/17)** Copper (13/17) Iron (17/17) Lead (2/17) Zinc (10/17)
SES1-BHHM002	Aluminium (16/16) Copper (16/16) Iron (16/16) Lead (15/16) Zinc (16/16)	Aluminium (17/17) Copper (17/17) Iron (17/17) **Lead (17/17)** Zinc (17/17)

SES	Pre-Construction Exceedances	Post-Construction Exceedances
	Cadmium (6/6) Chromium (3/6) Nickel (1/6) **TPH (3/7)** **Vanadium (2/6)**	Chromium (1/2) Nickel (1/2) **PAH (1/2)**
SES1-BHHM003	Aluminium (16/16) Copper (16/16) Iron (16/16) **Lead (13/16)** Zinc (12/16) **Chromium (1/6)** **Nickel (1/6)** **TPH (4/7)**	Aluminium (17/17) Copper (16/17) Iron (17/17) Lead (2/17) **Zinc (15/17)** **Cadmium (1/2)** **PAH (1/2)**
SES2-Site 1	Aluminium (15/16) Copper (16/16) **Iron (15/16)** **Lead (14/16)** Zinc (14/16) **Arsenic (3/6)** **Cadmium (6/6)** **Chromium (2/6)** Nickel (4/6) **TPH (2/6)** **Vanadium (2/6)**	**Aluminium (17/17)** Copper (17/17) Iron (14/17) Lead (8/17) **Zinc (16/17)** Nickel (1/2) **PAH (1/2)**
SES2-Site 2	Aluminium (16/16) Copper (16/16) Iron (15/16) Lead (16/16) Zinc (16/16) **Arsenic (1/6)** **Cadmium (6/6)** **Chromium (3/6)** Nickel (5/6) **TPH (3/6)** Vanadium (3/6)	Aluminium (17/17) Copper (17/17) **Iron (16/17)** Lead (17/17) Zinc (17/17) Cadmium (1/2) Nickel (2/2) **PAH (1/2)** Vanadium (1/2)
SES2-FLBH053A	Aluminium (16/16) Copper (16/16) Iron (12/16) Lead (9/16) Zinc (8/16) Cadmium (6/6) **Chromium (2/6)** Nickel (6/6) **TPH (2/6)** **Vanadium (1/6)**	Aluminium (17/17) Copper (17/17) **Iron (16/17)** **Lead (16/17)** **Zinc (16/17)** Cadmium (2/2) Nickel (2/2) **PAH (1/2)**
SES2-FLBH053B	Aluminium (12/16) Copper (8/16) Iron (16/16) Lead (4/16) Zinc (4/16) Arsenic (4/6) **Cadmium (1/6)** **Chromium (3/6)**	**Aluminium (17/17)** **Copper (14/17)** Iron (16/17) **Lead (5/17)** **Zinc (12/17)** Arsenic (1/2)

SES	Pre-Construction Exceedances	Post-Construction Exceedances
	Nickel (2/6) **TPH (1/6)** **Vanadium (1/6)**	**PAH (1/2)**
SES2-FLBH053D	Aluminium (16/16) Copper (16/16) **Iron (16/16)** Lead (4/16) Zinc (4/16) **Cadmium (6/6)** **Chromium (3/6)** **Nickel (6/6)** TPH (1/6) **Vanadium (1/6)**	Aluminium (17/17) Copper (17/17) **Lead (8/17)** **Zinc (17/17)** Cadmium (1/2) Nickel (1/2) **PAH (1/2)** TPH (1/2)
SES2-FLBH053E	Aluminium (16/16) Copper (16/16) Iron (16/16) **Lead (16/16)** Zinc (6/16) **Cadmium (6/6)** **Chromium (4/6)** Nickel (6/6) **TPH (1/6)** **Vanadium (1/6)**	Aluminium (17/17) Copper (17/17) Iron (17/17) Lead (15/17) **Zinc (13/17)** Cadmium (1/2) Nickel (2/2) **PAH (1/2)**
SES3-Site 1	Aluminium (15/16) **Copper (16/16)** **Iron (15/16)** **Lead (11/16)** **Zinc (15/16)** **Cadmium (1/6)** **Nickel (3/6)** **TPH (5/6)** **Vanadium (1/6)**	**Aluminium (16/16)** Copper (15/16) Iron (8/16) Lead (3/16) Zinc (14/16) **PAH (1/2)**
SES3-Site 2	Aluminium (14/16) Copper (16/16) **Iron (10/16)** **Lead (4/16)** Zinc (6/16) **Cadmium (1/6)** **Nickel (1/6)** **TPH (3/6)**	**Aluminium (16/16)** Copper (16/16) Iron (6/16) Lead (3/16) **Zinc (12/16)** **PAH (1/2)**
SES3-Site 3	Aluminium (16/16) Copper (16/16) Iron (10/16) Lead (9/16) Zinc (12/16) Cadmium (3/6) Chromium (2/6) Nickel (4/6) PAH (1/6) **TPH (2/6)** Vanadium (3/6)	Aluminium (17/17) Copper (17/17) **Iron (12/17)** **Lead (14/17)** **Zinc (17/17)** Cadmium (2/2) Chromium (1/2) Nickel (2/2) PAH (1/2) Vanadium (1/2)
SES3-Site 4	Aluminium (16/16) Copper (16/16) Iron (10/16)	Aluminium (17/17) Copper (17/17) Iron (10/17)

SES	Pre-Construction Exceedances	Post-Construction Exceedances
	Lead (14/16) Zinc (13/16) Cadmium (3/6) Nickel (1/6) **TPH (4/6)** Vanadium (1/6)	**Lead (15/17)** **Zinc (17/17)** Cadmium (2/2) **Chromium (1/2)** Nickel (1/2) **PAH (1/2)** Vanadium (1/2)
SES3-BHA	Aluminium (15/16) Copper (16/16) Iron (16/16) **Lead (15/16)** Zinc (10/16) Cadmium (3/6) Chromium (2/6) **Nickel (6/6)** **TPH (4/6)**	**Aluminium (17/17)** Copper (17/17) Iron (17/17) Lead (14/17) **Zinc (15/17)** Cadmium (1/2) Chromium (1/2) Nickel (1/2) **PAH (1/2)**

Bold font indicates a higher number of exceedances in the dataset.

Red font indicates an exceedance limited to the post-monitoring dataset.

Table 11 shows that, largely, exceedances in the post-construction dataset mirror exceedances pre-construction. The exceptions are:

- PAH at most sites. Exceedances are limited to June 2019 and repeat sampling in June 2020 showed no exceedances of the PAH EQS.
- Cadmium (SES1-BHHM003 only) was detected above the EQS only once in June 2020 with a concentration marginally above the EQS (0.09 µg/l vs 0.08 µg/l).
- Chromium (SES3-Site 4 only) was detected above the EQS only once in June 2019. Repeat sampling in June 2020 showed no exceedances of the chromium EQS.

Overall, based on the number of exceedances in table 11 above, there is no evidence that the water quality at the SES is significantly different post-construction.

4. INTERPRETATION – WATER LEVELS

4.1 Methodology

Section 2 provides the detail of 15 no. SES sites at which water level was monitored pre- and post-construction. However, the weir plates, stilling wells and pressure transducers which had been installed pre-construction at the Corby Inflow (SES3-Site1) and redacted 11(2) were not present during the post-construction monitoring period and, therefore, no post-construction water level data is available for these two sites. This leaves a total of 13no. SES sites for which pre- and post-construction water level data can be used in order to undertake an assessment of "*any variances to pre-construction conditions*".

To enable comparisons between the pre- and post-construction datasets using time series, each monitoring period (pre-and post-construction) was considered as a 24-month time series (Month 1 – 24) and plotted on the same chart as described in the previous section on water quality. This approach would also potentially indicate any obvious seasonal patterns.

In order to allow a comparison between the two datasets, the data for each SES was charted as time series and summarised with statistics reported as a 'box plot' and summary table. The time series, box plots and statistics for each SES are provided in Appendix 31 – 33.

Due to the amount of data available from the pressure transducers which recorded the water levels continuously during the monitoring periods, the water level data was first down-sampled to hourly, prior to calculation of the summary statistics and charting.

Furthermore, at borehole sites, the collection of groundwater samples depressed the groundwater level in the borehole standpipes and, at some locations, took several days to recover. In order to remove this effect as far as practicable from the dataset, one- or two-days' worth of data were removed for each monitoring event. This was kept consistent for the whole dataset and is clearly indicated on the summary sheets in Appendices 31 - 33.

4.2 Comparison of Pre- and Post-monitoring Water Level data

The summary sheets in Appendices 31 - 33 provide a comparison between the pre- and post-construction monitoring datasets at each monitoring location. Unlike the water quality data, it is possible to summarise general trends in water level at each SES.

Overall, ERS consider that the differences between the two datasets are likely to be mostly weather-related, with a drier spring in the post-construction dataset impacting the post-construction groundwater level.

The reason for the difference between pre- and post-construction groundwater level in FLBH053D is unknown but, given that similar trends are shown compared to the other three boreholes, may be due to a change in datum.

4.2.3 SES3 – Corby and Lily Loch

The data from the two loch level gauges (SES3-Site 2 Corby Loch, SES3-Site 4 Lily Loch) shows that the water level at the Corby and Lily Loch SES was lower during the post-construction monitoring period than pre-construction with an average difference of 15-17 cm in loch level.

The two loch level datasets are in very good agreement with each other with the mean water levels between the lochs within 2 cm of each other on average and similar trends showing a lower water level in the Spring during the post-construction monitoring.

The data from the borehole (SES3-BHA) shows that the groundwater level at the Corby and Lily Loch SES was lower during the post construction monitoring period than pre-construction with an average difference of 16 cm in groundwater level. Although the average difference between pre- and post-construction groundwater level data is similar to the loch gauges, the trends are very different with the pre-construction dataset recording a much more stable groundwater level than the post-construction dataset.

The data from the Lily Inflow river gauge (SES3-Site 3) suggests a higher water level post-construction, by 7 cm on average. The installation of the weir plate in July 2014 is clearly visible on the pre-construction dataset. The timeseries chart suggests that the installation of the plate probably explains a large part of the difference; indeed, only the final few months of the pre-construction monitoring but the whole of the post-construction monitoring would have had a slightly higher water level due to the presence of the plate.

Overall, ERS consider that the differences between the two datasets for the Corby and Lily Loch SES are likely to be weather related, with a drier spring in the post-construction dataset.

5. CONCLUSIONS

Water Quality Monitoring

A comparison of the pre- and post-construction water quality monitoring has indicated that there is no clear, consistent, trend in the overall data which would allow a conclusion to be drawn on whether there are "*any variances to pre-construction conditions*".

For the PWS, there are a number of exceedances of the drinking water standards (DWS) post-construction which have not been recorded pre-construction. However, for the most part, these exceedances are limited to a single occurrence and, therefore, are unlikely to be a significant concern and not considered further.

This leaves a small number of PWS (N21a, N21b, S11 and S45) at which a number of exceedances of DWS were recorded several times for microbiological indicators (cryptosporidium, enterococci and total coliforms) and metals (aluminium, iron, lead) during post-construction monitoring. However, we are unable to conclude the cause of these exceedances for these parameters alone.

It is noted that all PWS with a new supply installed as part of the AWPR construction works record a lower number of exceedances of the DWS post-construction than pre-construction.

For the SES it is shown that exceedances in the post-construction dataset largely mirror exceedances pre-construction. Therefore, it is concluded that, based on the number of exceedances, there is no evidence that the water quality at the SES is significantly different post-construction.

Water Level Monitoring

The data from the boreholes at all the SES shows that the groundwater levels were slightly lower during the post-construction monitoring period than during pre-construction. However, ERS consider that the differences between the pre- and post-monitoring datasets are likely to be mostly weather-related, with a drier spring in the post-construction dataset impacting the post-construction groundwater level.

APPENDICES

Appendix 33 – SES 3 (Corby and Lily Loch) Water Level Charts

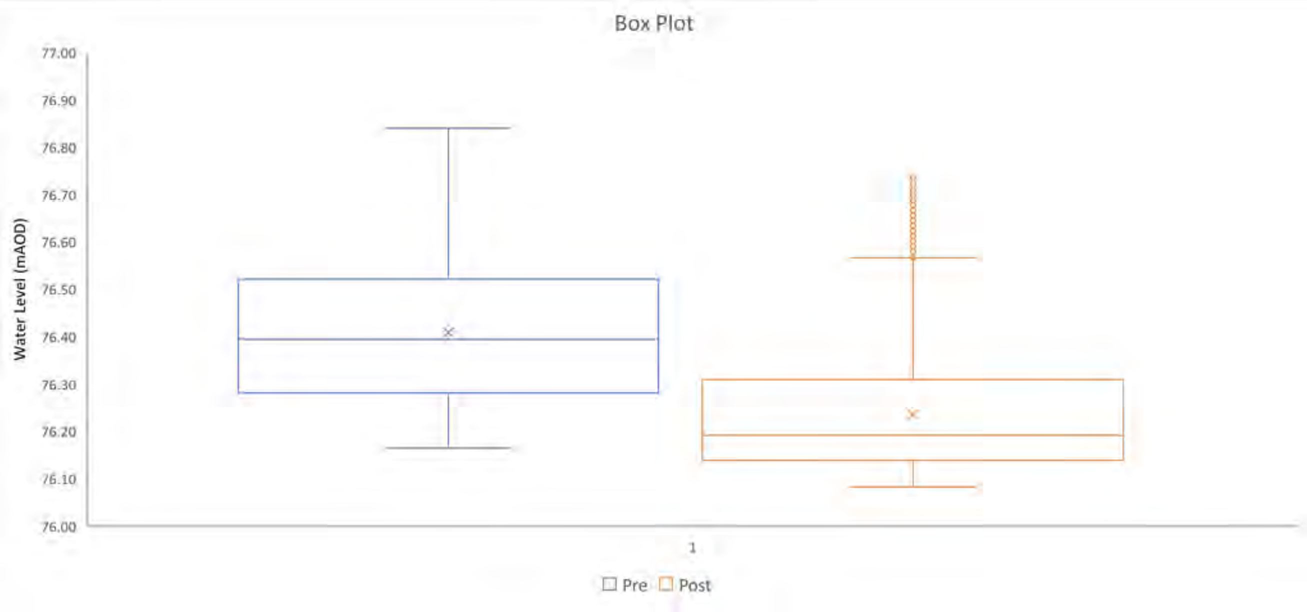


Table of statistics

Water Level (mAOD)	Pre	Post
Max	76.85	76.80
75th percentile	76.50	76.32
Mean	76.41	76.26
Median	76.40	76.22
25th percentile	76.30	76.17
Min	76.17	76.06

Data Set Time	Pre	Post
From	26-Aug-13	02-Apr-19
To	17-Dec-14	26-Oct-20
No. of data points	11467	13744

Commentary

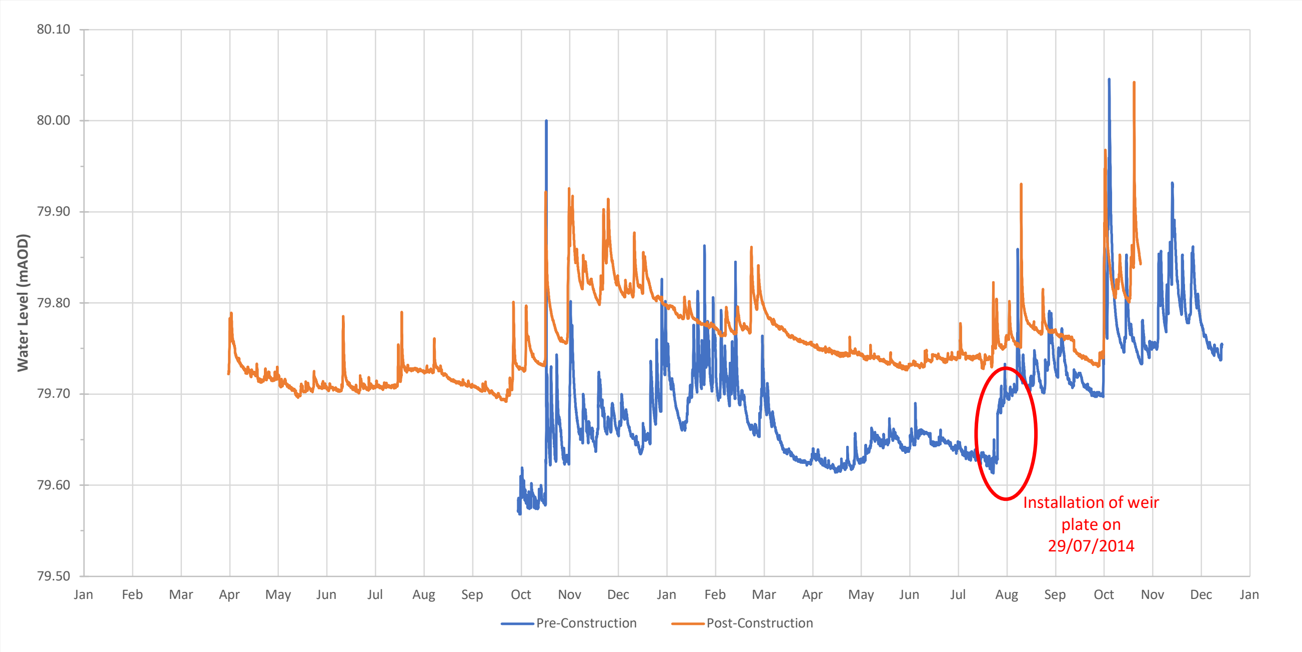
The water level at Corby Loch has been lower during the post -construction monitoring than during pre-construction monitoring, on average by 15cm.

The time series chart shows that this is largely due to December 2013 -May 2014 recording a higher loch level than December 2019 -May 2020. The rest of the dataset is similar.

Caveat

All data was down-sampled to one data point per hour before statical analysis and plotting was carried out.

SES3 Site 3 - Lily Loch Inflow Water Level



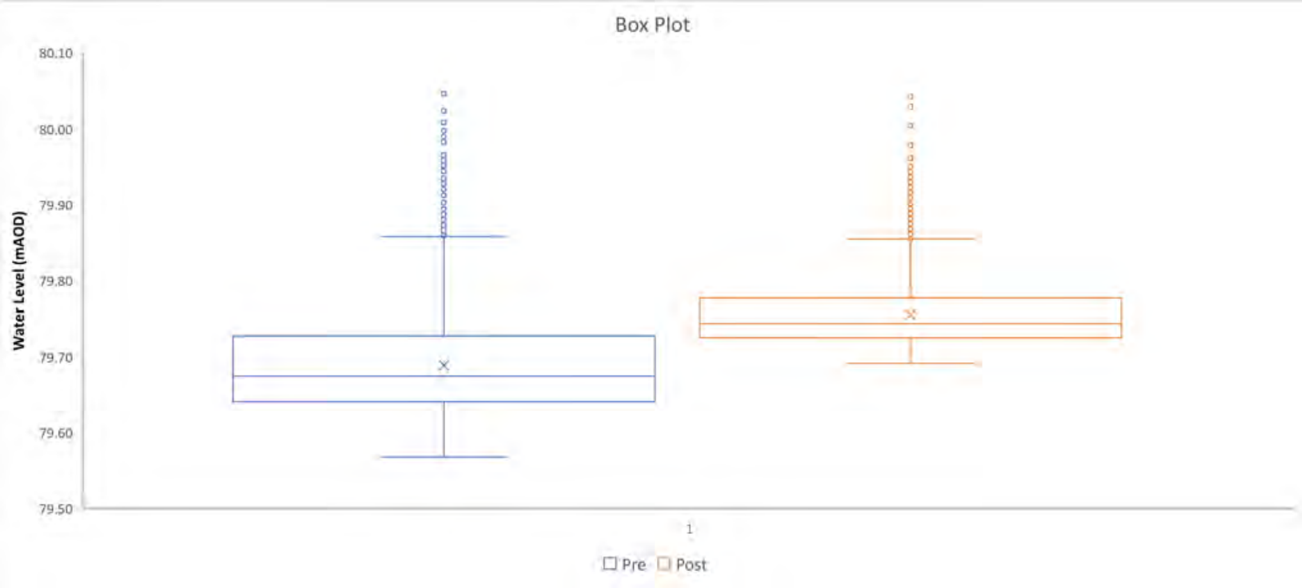


Table of statistics

Water Level (mAOD)	Pre	Post
Max	80.05	80.04
75th percentile	79.73	79.78
Mean	79.69	79.76
Median	79.68	79.74
25th percentile	79.64	79.73
Min	79.57	79.69

Data Set Time Scales	Pre	Post
To	01-Oct-13	02-Apr-19
From	17-Dec-14	26-Oct-20
No. of data points	10607	13746

Commentary

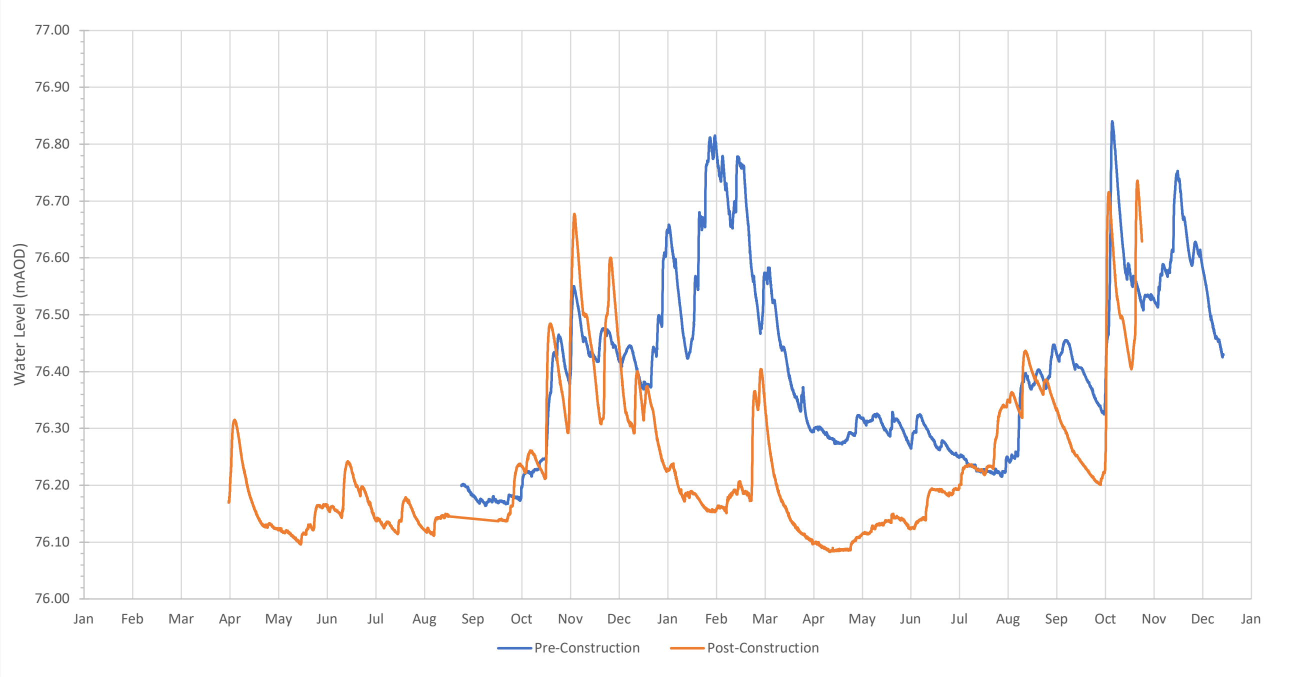
The water level recorded in the inflow to Lily Loch was higher during the post-construction monitoring period, on average by 7cm. Both datasets show that the period February-June has a more consistent water level.

The weir plate at Lily Inflow was installed on 29/07/2014 (clearly visible on the timeseries chart). The plate would have raised the water level slightly for the end of the pre-construction monitoring and the whole post-construction monitoring.

Caveat

All data was down-sampled to one data point per hour before statical analysis and plotting was carried out.

SES3-Site 4 Lily Loch Water Level



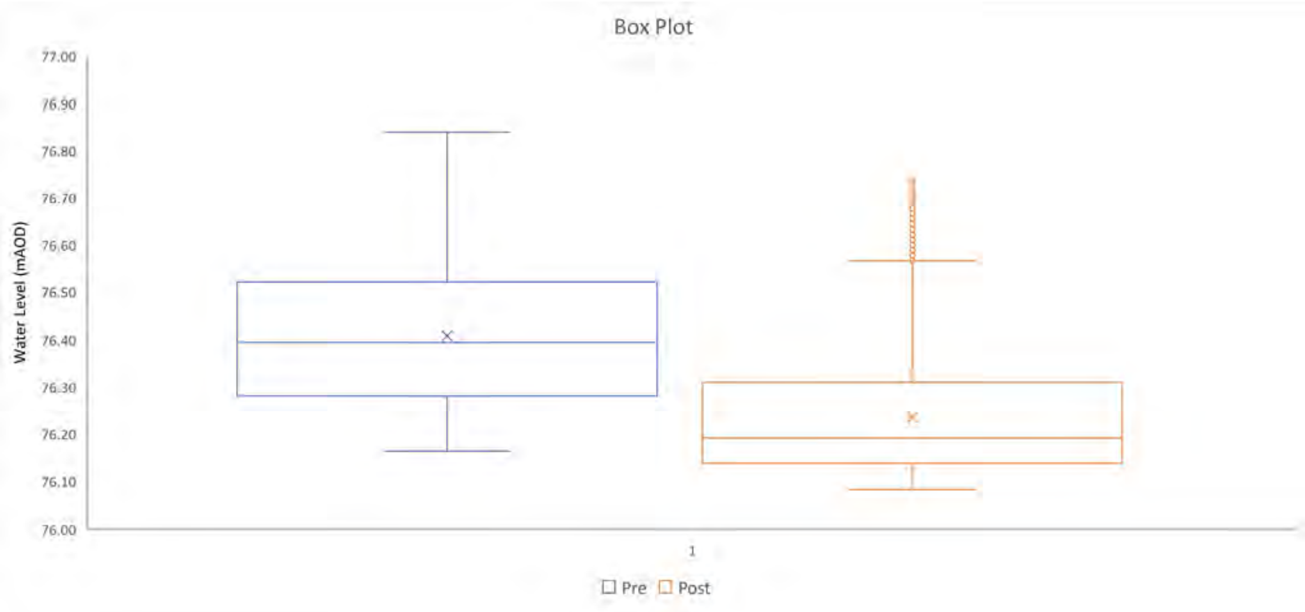


Table of statistics

Water level (mAOD)	Pre	Post
Max	76.84	76.74
75th percentile	76.52	76.31
Mean	76.41	76.24
Median	76.39	76.19
25th percentile	76.28	76.14
Min	76.16	76.08

Data Set Time	Pre	Post
From	26-Aug-13	02-Apr-19
To	17-Dec-14	26-Oct-20
No. of data points	11466	13002

Commentary

The water level at Lily Loch has been lower during the post -construction monitoring than during pre-construction monitoring, on average by 17cm. The time series chart shows that this is largely due to January -June 2014 recording a higher loch level than January-June 2020. The rest of the dataset is similar.

Caveat

All data was down-sampled to one data point per hour before statical analysis and plotting was carried out.

GLASGOW
Westerhill Road,
Glasgow, G64 2QH
0141 772 2789

INVERNESS
23 Henderson Drive
Inverness, IV1 1TR
01463 241 222

EDINBURGH
Midlothian Innovation Centre
Roslin, EH25 9RE
0131 440 8280

info@ersremediation.com

www.ersremediation.com