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Cardiff Urban Geo-Observatory

Groundwater Temperature Data 2014 – 2018 Metadata Report

BRITISH GEOLOGICAL SURVEY

UK GEOENERGY OBSERVATORY PROGRAMME

OPEN REPORT OR/19/053

Cardiff Urban Geo-Observatory

GROUNDWATER TEMPERATURE DATA 2014 – 2018 METADATA REPORT

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BRITISH GEOLOGICAL SURVEY

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Summary

This report provides the metadata to accompany the first open source data release of groundwater temperature time series measurements from the **'Cardiff Urban Geo-Observatory'** project.

Groundwater temperatures were measured in 53 boreholes at a sampling frequency of 30 minutes between 2014 to 2018. The dataset comprises over 3.5 million temperature measurements. Boreholes are located within the urban area of the City of Cardiff, Wales, UK. The majority of temperature sensors were installed within boreholes that monitor a shallow (maximum ~30m thickness) Quaternary aged sand and gravel aquifer, which is the target aquifer for the Cardiff Urban Geo-Observatory project. Representative groundwater temperature data from the Made Ground and the Triassic Mercia Mudstone are also reported.

We hope that by releasing this open-source data we can provide an evidence base to support the public, developers, planners, regulators, utility companies and policy makers that have an interest in the urban subsurface. We also hope to engage with other researchers and welcome collaborative research and innovation projects using this publically funded data.

The open access data can be downloaded from:

http://bgsintranet/resources/data/accessions/index.html?simpleText=ukgeos#item130165

Contributions to this report and the data acquired are as follows:

- Gareth Farr: project management, project design, fieldwork & data QA
- Ashley Patton: fieldwork & data QA
- David James: fieldwork, access to borehole infrastructure
- David Boon: project design and project management
- Lynn Coppell: database design
- Laura James: fieldwork

1 Introduction

This report provides the accompanying metadata for open access release of groundwater temperature monitoring data collected at the 'Cardiff Urban Geo-Observatory' project between 2014 and 2018.

1.1 THE 'CARDIFF URBAN GEO-OBSERVAOTRY'

The Cardiff Urban Geo-Observatory was established in 2014 as a platform for urban subsurface research. The objective is to provide city-scale environmental data (including groundwater temperatures), supporting a better understanding of urban subsurface processes. Groundwater temperature data provides an evidence base for renewable technologies, including ground source heat and recovery, as we move towards a low carbon future.

Developed in close partnership with Cardiff Council and Cardiff Harbour Authority the project has already realised city scale mapping of groundwater temperatures (Farr et al., 2017) the installation and successful operation of a shallow open loop ground source heating scheme (Boon et al., 2019) and creation of a 3D geological model (Kendall et al., in prep). This report describes the metadata associated with the time series groundwater temperature data measured between 2014 and 2018.

1.2 FUNDING

The Cardiff Urban Geo-Observatory has been mainly funded directly by the British Geological Survey's National Capability science budget since 2014. Cardiff Council and Cardiff Harbour Authority have provided significant support, providing access to their monitoring boreholes and installation of temperature sensors and data collection. Data collection was also supported by InnovateUK via TSB Energy Catalyst – Early-stage award – Technical feasibility – Round 3 (grant number 102214: April 2015 – March 2016) (Boon et al., 2016) and fieldwork in 2018 was supported by EU H2020 GeoERA MUSE project (Managing Urban Shallow Geothermal Energy: 2018-2021).

2 Borehole Network

2.1 BOREHOLE LOCATIONS

The location of the boreholes are listed in Table 1 and plotted on Figure 1 below. The map also illustrates the location of the pilot ground source heat pump (GSHP) scheme and several active groundwater control zones used by the City of Cardiff Council / Cardiff Harbour Authority to dewater the made ground and sand and gravel aquifer, as part of the Groundwater Protection Scheme under Schedule 7 of the Cardiff Bay Barrage Act (1993).

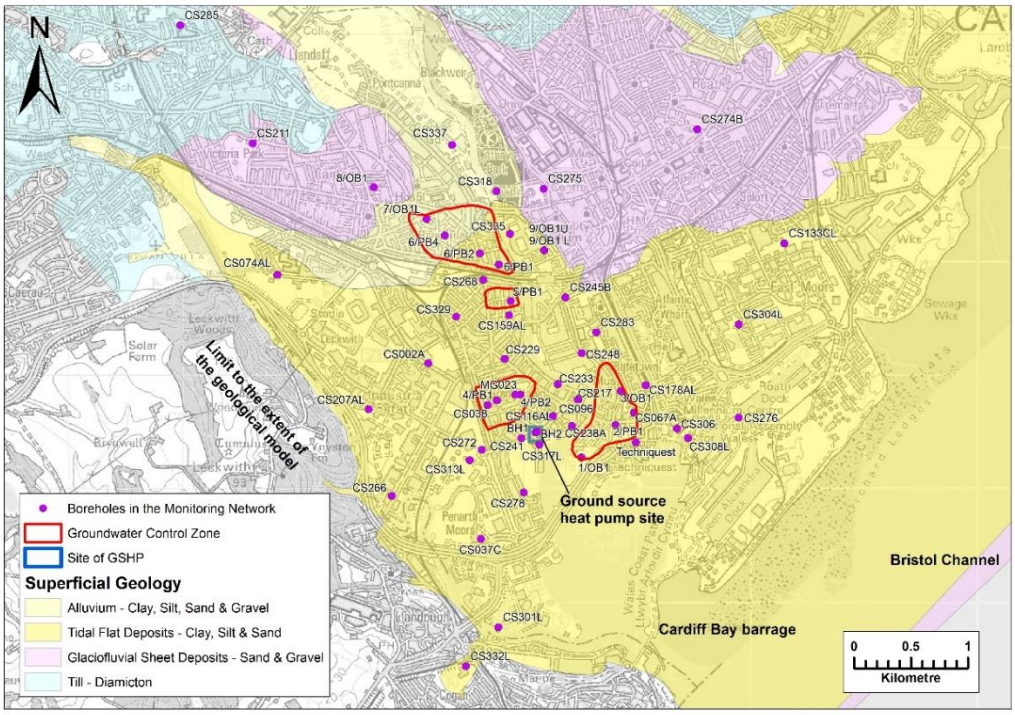

Figure 1 Location of boreholes

2.2 BOREHOLE LOGS

The borehole logs are registered on the BGS 'SOBI' database and can be viewed using the online 'Onshore GeoIndex' http://www.bgs.ac.uk/GeoIndex/ to locate a borehole log, first use the easting and northing data in Table 1 to navigate to the required location, or search using the borehole name. The borehole logs are all unrestricted and can be downloaded free of charge.

2.3 BOREHOLE OWNERSHIP

The majority of the boreholes within the observatory were drilled and are owned by Cardiff Council. Installed as part of the groundwater level monitoring network required by the Cardiff Bay Barrage Act, 1993, in response to the construction of Cardiff Bay Barrage. Techniquest Science Museum have also kindly provided access and facilitated temperature monitoring within a borehole on their property.

Table 1: Location, depth and data period of temperature sensors

Borehole Sensor Name	Easting	Northing	Depth (mbgl)	Reading Count	Start	End
1OB1L	318511	174275	14	67,394	06/02/2015 10:00	11/12/2018 12:00
2PB1	318809	174561	6	80,017	07/04/2014 11:45	30/11/2018 14:30
3OB1	318857	174859	18	60,295	23/06/2015 10:30	30/11/2018 14:30
4PB1 Shallow	317766	174778	7	66,221	31/10/2014 15:00	15/11/2018 14:00
4PB1 Deep	317766	174778	11	66,208	31/10/2014 14:30	15/11/2018 14:00
4PB2 Shallow	317973	174828	8	65,776	31/10/2014 14:00	15/11/2018 14:30
4PB2 Deep	317973	174828	12	65,817	31/10/2014 13:30	15/11/2018 14:30
5PB1 Shallow	317886	175652	7	65,588	03/11/2014 11:00	15/11/2018 12:30
5PB1 Deep	317886	175652	10.5	65,610	03/11/2014 11:00	15/11/2018 13:00
6PB1	317783	175973	6.7	60,049	24/06/2015 11:30	26/11/2018 12:00
6PB2	317616	176069	10	66,669	06/02/2015 11:30	26/11/2018 10:30
6PB4	317307	176228	6.3	60,047	24/06/2015 12:00	26/11/2018 11:30
7OB1L	317147	176374	5	54,486	24/06/2015 12:30	02/08/2018 15:00
8OB1	316683	176653	7	37,156	19/06/2015 09:30	01/08/2017 12:00
9OB1L	318181	176098	6.2	67,395	06/02/2015 13:00	11/12/2018 15:30
9OB1U	318181	176098	13	36,670	25/06/2015 14:30	28/07/2017 13:00
BGS OBS1	318066	174436	10	12,095	14/12/2016 12:00	23/08/2017 12:00
BGS OBS2	318008	174384	10	12,094	14/12/2016 12:00	23/08/2017 12:00
CS002A	317162	175103	7.9	60,097	24/06/2015 15:00	27/11/2018 16:00
CS037C	317624	173558	14.5	60,089	24/06/2015 16:00	27/11/2018 12:30
CS038	317685	174736	6	66,831	31/10/2014 15:00	27/11/2018 14:00
CS067A	318972	174669	13.2	60,186	25/06/2015 17:00	30/11/2018 14:00
CS074AL	315834	175882	6	60,230	24/06/2015 13:30	30/11/2018 11:00
CS096	318483	174789	6.5	71,412	31/10/2014 16:30	27/11/2018 11:30
CS116AL	318258	174638	12.5	60,135	23/06/2015 13:30	27/11/2018 11:00
CS133CL	320293	176158	10.3	60,768	24/06/2015 10:00	11/12/2018 10:00
CS159AL	317873	175526	1.5	59,567	23/06/2015 13:00	15/11/2018 13:00
CS178AL	319076	174911	8.8	60,296	23/06/2015 09:30	30/11/2018 15:30
CS207AL	316639	174699	8	46,729	22/07/2015 12:30	11/12/2018 14:00
CS211	315617	177038	3.95	81,355	31/03/2014 13:15	26/11/2018 10:30
CS217 Shallow	318478	174785	7.5	61,391	31/10/2014 15:30	03/08/2018 13:30
CS217 Deep	318478	174785	11.5	61,433	31/10/2014 15:30	03/08/2018 13:30
CS229	317833	175143	7	43,247	31/10/2014 16:30	19/04/2017 15:30
CS233 Shallow	318300	174920	7	71,414	31/10/2014 16:00	27/11/2018 11:30
CS233 Deep	318300	174920	11	71,413	31/10/2014 16:00	27/11/2018 11:30

Table 1 continued

Borehole Sensor Name	Easting	Northing	Depth (mbgl)	Reading Count	Start	End
CS238A	318427	174553	15.5	60,095	23/06/2015 14:00	26/11/2018 15:30
CS241	317980	174445	11.5	61,333	31/10/2014 13:30	02/08/2018 13:00
CS245B	318368	175683	8	60,298	23/06/2015 11:30	30/11/2018 16:00
CS248	318510	175193	7.8	60,484	30/06/2015 12:00	11/12/2018 14:30
CS266	316841	173938	11.4	54,525	24/06/2015 15:30	03/08/2018 14:00
CS268	317646	175838	7	60,295	23/06/2015 12:00	30/11/2018 15:30
CS272 Shallow	317632	174343	7	66,026	03/11/2014 11:30	15/11/2018 15:30
CS272 Deep	317632	174343	11	61,154	03/11/2014 00:00	03/08/2018 11:00
CS274B	319527	177162	5.2	60,143	23/06/2015 15:30	27/11/2018 15:00
CS275	318177	176639	5	32,968	19/06/2015 11:00	26/11/2018 14:00
CS276	319891	174627	4.7	37,193	17/06/2015 14:00	01/08/2017 10:00
CS278	318002	173967	18.9	54,517	23/06/2015 14:00	02/08/2018 11:30
CS283	318639	175375	7.7	36,726	30/06/2015 09:30	03/08/2017 12:00
CS285	317928	174829	3.2	60,190	25/06/2015 11:30	30/11/2018 10:30
CS304L	319892	175445	13.7	54,526	24/06/2015 10:30	03/08/2018 10:00
CS306	319349	174529	10.2	58,613	28/07/2015 10:00	30/11/2018 13:00
CS307L	319251	174489	14.15	60,711	25/06/2015 16:00	11/12/2018 11:30
CS308L	317928	174829	18.1	60,709	25/06/2015 15:30	11/12/2018 11:00
CS313L	317526	174252	11	60,048	25/06/2015 12:30	27/11/2018 13:30
CS317L	318139	174388	12.4	50,543	14/09/2015 10:00	02/08/2018 11:30
CS318	317761	176618	3	49,472	21/05/2014 12:00	27/07/2017 14:00
CS329	317408	175515	6.5	60,148	23/06/2015 12:30	27/11/2018 14:30
CS332L	317494	172439	6	59,999	25/06/2015 13:00	26/11/2018 12:30
CS335	317880	176242	4	50,998	19/06/2015 10:30	26/11/2018 14:00
CS337	317372	177025	5.5	36,960	19/06/2015 12:00	28/07/2017 11:30
+ MG023C	317928	174829	1.5	66,245	01/10/2014 13:30	15/11/2018 14:30
Techniquest Shallow	318987	174408	10	25,819	04/02/2016 12:00	26/07/2017 09:00
++Techniquest Deep	318987	174408	120	36,994	16/06/2015 18:00	26/07/2017 10:30

+ MG023 (made ground)

++Techniquest Deep (Triassic Mercia Mudstone)

3 Monitoring and Data

3.1 AQUIFERS

The majority of temperature sensors were installed within boreholes that monitor a Quaternary aged sand and gravel aquifer, which is the target aquifer for this study. Groundwater temperature data representative of the underlying Triassic Mercia Mudstone bedrock (e.g. Techniquest borehole) and the made ground (MG023) are also included (Table 1).

3.2 DATA COVERAGE

In this data release, groundwater temperatures from 53 boreholes and 63 temperature sensors are included. The dataset comprises of just over 3.5 million temperature measurements made between March 2014 and November 2018.

3.3 DATA FREQUENCY AND SENSOR DEPTH

Groundwater temperatures were measured every 30 minutes between 2014 to 2018. A 30 minute frequency was chosen as it was the same as the pre-existing groundwater level monitoring network in Cardiff managed by Cardiff Council. The sensors were installed across a range of depths which were dictated by the 'response zone' which is the slotted area along the borehole casing where groundwater is allowed to ingress into the borehole. Sensors are downloaded bi-annually.

3.4 SENSOR TYPE

A mixture of temperature sensors were used in the monitoring period from 2014-2018. Sensors included; Hobo® ProV2 with a resolution of 0.02°C and an accuracy of ±0.21°C, Solinst Levelloggers with a resolution of 0.003°C and an accuracy of ± 0.5°C and OTT sensors with a resolution of ± 0.1°C and an accuracy of ± 0.5°C. Since 2018 the network has been harmonised and the majority of boreholes are now instrumented with Solinst Levelloggers, that measure both water pressure and temperature.

3.5 DATA ACCESS

The data that accompanies this report can be downloaded from www.UKGEOS.ac.uk. Upon downloading the data, the users will be prompted to agree to agree with the BGS terms and conditions of use.

3.6 CITING THIS DATA

The data should be cited as;

- Farr, G., Patton, A.M., Boon, D., James, D., Coppell, L & James., L. 2019. Cardiff Urban Geo-Observatory, Groundwater Temperature Data 2014-2018. British Geological Survey. (Dataset). https://dx.doi.org/10.5285/bf150dd6-7b28-49ca-b66f-8b543a33a5c0

The metadata report should be cited as;

- Farr, G., Patton, A.M., Boon, D., James, D., Coppell, L & James., L. 2019. Cardiff Urban Geo-Observatory, Groundwater Temperature Data 2014-2018 metadata report. UK Geoenergy Observatory Programme Open Report OR/19/053.

4 Results

4.1 SUMMARY STATISTICS

We have provided a simple statistical data summary for each of the sensors (Table 2) although we do not offer any interpretation within this metadata report and the data should be treated as raw data. Depth refers to the depth of the temperature sensor and not the depth of the borehole.

Table 2 Summary of groundwater data

Borehole Sensor Name	Easting	Northing	Depth (mbgl)	Reading Count	Min Temp °C	Max Temp °C	Mrean Temp °C	Range Temp °C	Standard Deviation
1OB1L	318511	174275	14	67394	3.17	12.36	12.2	9.2	0.09
2PB1	318809	174561	6	80017	12.15	13.38	12.7	1.23	0.29
3OB1	318857	174859	18	60295	12.61	12.99	12.9	0.39	0.03
4PB1 Shallow	317766	174778	7	66221	12.99	14.24	13.8	1.25	0.25
4PB1 Deep	317766	174778	11	66208	13.45	14	13.8	0.55	0.13
4PB2 Shallow	317973	174828	8	65776	12.97	15.18	13.4	2.21	0.09
4PB2 Deep	317973	174828	12	65817	13.26	13.5	13.4	0.24	0.06
5PB1 Shallow	317886	175652	7	65588	13.21	15.89	14	2.68	0.7
5PB1 Deep	317886	175652	10.5	65610	13.45	15.87	14	2.42	0.66
6PB1	317783	175973	6.7	60049	12.49	13.93	13.2	1.45	0.36
6PB2	317616	176069	10	66669	12.9	13.8	13.4	0.9	0.24
6PB4	317307	176228	6.3	60047	12.36	15.18	13.9	2.81	0.86
7OB1L	317147	176374	5	54486	11.64	15.2	13.6	3.56	1.13
8OB1	316683	176653	7	37156	10.8	14.8	13.5	4	0.65
9OB1L	318181	176098	6.2	67395	11.69	15.01	13.4	3.32	0.72
9OB1U	318181	176098	13	36670	10.2	17.77	14.3	7.57	2.28
BGS OBS1	318066	174436	10	12095	12.9	13.02	13	0.12	0.03
BGS OBS2	318008	174384	10	12094	12.8	13	12.9	0.2	0.05
CS002A	317162	175103	7.9	60097	10.05	13.93	13.6	3.88	0.11
CS037C	317624	173558	14.5	60089	12.82	13.23	13.1	0.41	0.01
CS038	317685	174736	6	66831	13.4	14.89	14.2	1.49	0.39
CS067A	318972	174669	13.2	60186	12.99	13.38	13.2	0.39	0.1
CS074AL	315834	175882	6	60230	11.83	13.14	12.6	1.31	0.2
CS096	318483	174789	6.5	71412	6.48	14.65	14.1	8.17	0.26
CS116AL	318258	174638	12.5	60135	13.21	13.45	13.4	0.24	0.05
CS133CL	320293	176158	10.3	60768	12.15	12.32	12.2	0.17	0.03
CS159AL	317873	175526	1.5	59567	7.02	19.53	13.6	12.5	3.48
CS178AL	319076	174911	8.8	60296	10.12	12.63	12.4	2.51	0.08
CS207AL	316639	174699	8	46729	13.09	13.67	13.3	0.58	0.15
CS211	315617	177038	3.95	81355	8.92	14.55	12.2	5.64	1.53
CS217 Shallow	318478	174785	7.5	61391	7.27	14.82	14.1	7.55	0.15
CS217 Deep	318478	174785	11.5	61433	6.46	15.18	13.9	8.72	0.1
CS229	317833	175143	7	43247	10.47	13.95	13.7	3.49	0.11
CS233 Shallow	318300	174920	7	71414	6.18	14.34	12.8	8.16	0.43
CS233 Deep	318300	174920	11	71413	6.2	13.52	12.7	7.32	0.34

Table 2 continued:

Borehole Sensor Name	Easting	Northing	Depth (mbgl)	Reading Count	Min Temp °C	Max Temp °C	Mrean Temp °C	Range Temp °C	Standard Deviation
CS238A	318427	174553	15.5	60095	11.22	12.68	12.1	1.45	0.34
CS241	317980	174445	11.5	61333	7.27	13.23	13	5.96	0.07
CS245B	318368	175683	8	60298	11.98	13.35	12.5	1.38	0.16
CS248	318510	175193	7.8	60484	12.68	13.33	13	0.65	0.18
CS266	316841	173938	11.4	54525	12.97	13.28	13	0.31	0.04
CS268	317646	175838	7	60295	12.2	13.69	12.9	1.5	0.37
CS272 Shallow	317632	174343	7	66026	12.1	13.21	12.8	1.11	0.16
CS272 Deep	317632	174343	11	61154	6.48	23.42	12.9	16.9	0.13
CS274B	319527	177162	5.2	60143	10.05	16.8	13.7	6.75	1.81
CS275	318177	176639	5	32968	7.5	32.3	13.1	24.8	1.03
CS276	319891	174627	4.7	37193	11.7	14.1	12.9	2.4	0.8
CS278	318002	173967	18.9	54517	3.96	14.29	14.2	10.3	0.05
CS283	318639	175375	7.7	36726	12.61	13.26	12.9	0.65	0.21
CS285	317928	174829	3.2	60190	8.59	15.1	12.6	6.51	1.7
CS304L	319892	175445	13.7	54526	13.09	13.43	13.2	0.34	0.04
CS306	319349	174529	10.2	58613	13.4	14.55	14.1	1.15	0.24
CS307L	319251	174489	14.15	60711	4.66	14.72	14.3	10.1	0.07
CS308L	317928	174829	18.1	60709	12.27	12.94	12.7	0.68	0.06
CS313L	317526	174252	11	60048	12.39	13.62	13.4	1.23	0.09
CS317L	318139	174388	12.4	50543	12.63	12.99	12.8	0.36	0.07
CS318	317761	176618	3	49472	9.6	15.15	12.3	5.55	1.74
CS329	317408	175515	6.5	60148	4.48	14.51	13.3	10	0.56
CS332L	317494	172439	6	59999	10.76	15.39	12.9	4.63	0.35
CS335	317880	176242	4	50998	4.25	15.8	12.5	11.6	1.26
CS337	317372	177025	5.5	36960	10.4	15.2	12.8	4.8	1.46
+ MG023C	317928	174829	1.5	66245	9.41	20.08	14.5	10.7	2.93
Techniquest Shallow	318987	174408	10	25819	13.43	13.71	13.6	0.29	0.09
++Techniquest Deep	318987	174408	120	36994	12.8	13.62	13.5	0.82	0.01

+ MG023 (made ground)

++Techniquest Deep (Triassic Mercia Mudstone)

n.b Depth = depth in meters below ground of temperature sensor within the borehole

Acknowledgments

We would like to thank our partners the City of Cardiff Council and Cardiff Harbour Authority. We thank staff at Techniquest, Cardiff for access to their borehole. Funding for this work has been supplemented by InnovateUK (project number TSB Energy Catalyst grant 102214; 2015) and the GeoERA 'MUSE' Managing Urban Shallow geothermal Energy project (European Union Horizon 2020). Many staff at BGS have contributed to the 'Cardiff Urban Geo–Observatory' project including; David Schofield, Alan Holden, Rhian Kendall, Stephen Thorpe, Corinna Abesser, Johanna Schidegger, Debbie White, Carl Watson, Christina Chapman and Craig Woodward. Kirsty Shorter is thanked for review of this metadata report. Cardiff Urban Geo-Observatory is a registered EPOS (European Plate Observing System) Geoenergy Test bed.

References

British Geological Survey holds most of the references listed below, and copies may be obtained via the library service subject to copyright legislation (contact libuser@bgs.ac.uk for details). The library catalogue is available at: https://envirolib.apps.nerc.ac.uk/olibcgi.

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