1.　　Introduction and Scope

This method describes the processes for setting up, calibrating, installing, downloading, maintaining and storing data from temperature dataloggers. The primary purpose of these datalogger deployments is to improve understanding of river temperature variability, underlying processes and to allow the prediction of current and future river temperatures.

2.　　Principle

Two temperature dataloggers will be externally calibrated against a known international standard to ascertain their bias and estimate the uncertainty associated with the measurements. These will then be designated "Reference Loggers". The reference loggers will then be used to cross calibrate the dataloggers that will be deployed. These will subsequently be known as "Field loggers". A calibration will be obtained between the "Reference Loggers" and the "Field loggers", and the "Reference Loggers" and the international standard to obtain corrected temperature measurements reflecting uncertainty in both calibration procedures. Note that historic temperature dataloggers are recorded in section 5 as it is proposed to retrospectively correct historic data with contemporary calibration to the "Reference Loggers" where possible.

All non-controlled documentation associated with this method is held at:

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3.　　Reference Materials

Externally calibrated "Reference Loggers". Tinytag Aquatic 2 (Cal 2) and Tinytag Aquatic 2 (Cal 3).Serial numbers:

1. 733784 (Named Cal 2)

2. 865626 (Named Cal 3)

4.　　Reagents

N/A

5. Major Equipment

Water bath EN1983
Water bath EN2111
Computer with access to FLEObs database with Tinytag Explorer software version 4.8 or higher installed
Tinytag Aquatic 2 dataloggers
Inductive download pad ACS 3030
Tinytag Plus 2 Calibration datalogger
Tinytag Aquatic 2 Calibration datalogger
Tinytag serial cable CAB-0007
OTT Orpheus mini + HYDRAS3pocket software
Campbell Scientific Models: CR1000, CR3000, CR23X, CR510 and CR10X + Software PC200W 4.1
Campbell Scientific Sensors: Campbell Scientific 107-L and Rotronic HC2-S3
Divers + Software: Van Essen Instruments EnvironMon
Thermometer T267
Angle Iron
Dexion
MR-88 anchor system
Hand held drive steel HDR-88
Iron chain links (weighting)
5mm wire
White Plastic shielding pipe
Identification labels
10mm and 13mm spanners
Stainless steel bolts and locking nuts M6 x 80mm, M8 x 30mm
Penny washers M6 and M8, M8 spring washers
Sledge hammer,
Pinch bar
Eye protection and gloves
Camera for site photos
CR2450N, 3 volt button cell battery
Tinytag Aquatic 2seal (1320.1017)
SGM 494 silicone grease (or similar)
Vice
Screwdriver (able to fit through the hole on top of the logger)

5.1 Historic Datalogging Equipment

Grant Squirrel SQ8-2U-2V (-10/+40 $^{\circ}$C), SQ2-4U (-10/+40 $^{\circ}$C),   + software SQLOT
Minilog + software: Vemco minilog V3.09
Tinytalk I + software: Tinytalk Host version 1.1 or Gemini Data Logger OTLM version1.5

Note: the following dataloggers can all be accessed using Tinytag Explorer software version 4.8. Names in brackets are for external identification only.

Tinytalk II -40/+75 (125) $^{\circ}$C
Tag Instrument -40/+85 $^{\circ}$C (Induction)
Tinytag Plus -30/+50 $^{\circ}$C
Tinytag Plus -40/+85 $^{\circ}$C
Tinytag +12 -40/+85 $^{\circ}$C (Tingtag plus)
Tinytag PLUS2 -40/+85 $^{\circ}$C (Tingtag plus2)
TGP-4017 (Tingtag plus2)

Note that the software Tinytag Explorer 4.8 can be used with the above historic loggers apart from Grant Squirrel, Minilog and Tinytalk 1.

6. Environmental Control

The analyses are carried out in a climate controlled laboratory. The temperature is set at 20°C, variation is as per the manufacturers specification.

7. Interferences

Not relevant.

8. Sample Preparation

N/A

9. Analytical Procedure (See FCFL 1001)

Logger sensors will be added to FLEObs database prior to calibration see SOPFL 1010 and SOPFL 1020

9.1 External Calibration of Reference loggers.

Two dataloggers are held as reference loggers and sent for external calibration to a laboratory with UKAS accreditation to ISO/IEC 17025:2005 for temperature calibration of dataloggers. (Currently ETI Ltd, UKAS Lab No: 0601). See SOPFL 1010

9.2 Internal Calibration of Field Loggers.

Before first use all new field loggers will be cross calibrated with one of the reference loggers in accordance with SOPFL 1020. Subsequent cross calibrations will be carried out at not more than 3 years intervals to check for instrument drift and to allow for logger rotation.

9.3 Calculation of Calibration Coefficients from internal and External calibration.

Instructions for obtaining calibration coefficients (bias corrections) for temperature dataloggers can be found in SOPFL 1025. These calibration coefficients relate the 'recorded' temperature to the 'true' temperature for each datalogger and provide an estimate of uncertainty in the resulting data. These refer to Gemini TinyTag dataloggers and the TinyTag Explorer software but alternative loggers could be used assuming that the required input data structures can be generated.

9.4 Datalogger and Weather Station Setup for Field deployment.

Dataloggers and weather stations must have their sensors and details logged in FLEObs database prior to deployment as in SOPFL 1020. The physical deployment of the loggers and logger set up are covered in SOPFL 1030.

9.5 Datalogger Download, Data Transfer and Storage.

Loggers will be downloaded within 11 months of being launched (note that at the recommended resolution of 15 minutes the dataloggers will only run for 339 days before the memory is full). This will usually be carried out in the field to allow site/logger continuity. Data will therefore be stored on a mobile device before being returned to the lab for storage in FLEObs. These procedures are covered in SOPFL 1040.

Raw data will be held on the server at:

Data sheets will be held on the server at:

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Site photos will be held on the server at:

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9.6   Temperature Database Information Retrieval.

Business objects will be the primary method for data retrieval by experienced staff. Basic reports from single sites (for data checking) will be possible through user reports from FLEObs. These procedures are covered in SOPFL 1050.

10.   Calculation of results

Measured field temperatures will be corrected using queries from the FLEObs database using the calculated bias and uncertainty estimates from the combined internal and external calibrations (See SOPFL 1025.)

11.   Method Validation

Raw internal calibration data and results of the calibration calculations (equations correcting for bias and describing uncertainty) will be held on the server at:

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Calibration and uncertainty data will be held in the FLEObs database as equations that describe the relationship between field loggers and "true temperatures" for the length of time that the calibration applies to the field logger i.e. time between internal calibrations.

12.   Reports

Temperature Database Information Retrieval.

This procedure is covered in SOPFL 1050

13.   Safety

RAFL 02, RAFL 05, RAFL 06, RAFL 09, FE/R/63

14. Literature references

N/A

15. Measurement uncertainty:

Uncertainty values are maintained in the FLEObs database

- Instrument effects: Individual differences between field loggers are accounted for in the cross calibration process with the reference loggers. Uncertainty accounted for in calibration data
- Time: Not applicable
- Computational Effects: Manual check of calculation has been carried out and is acceptable – negligible contribution to uncertainty.
- Environment conditions: The instruments are calibrated across 0 to 30 °C in a stirred water bath, reflecting the expected environmental range. Room air conditioned to 20+/- 2 °C. Uncertainty is accounted for in the reported data output.
- Operator Effects: Only trained personnel may perform method unsupervised. Variations between operators are accounted for by calibration data. Uncertainty accounted for in reported data output.
- Matrix Effects: All loggers are placed in stream water and shaded from the sun by a plastic radiation shield.
- Random effects: These will be accounted for by calibration.
- Instrument Maintenance: The instrument is maintained as per SOPFL 1020. Minimal ability to affect maintenance other than routine battery change and resealing of the unit. Instruments are checked at download, any debris is removed and noted on the field data sheet. Uncertainty is accounted for in the internal and external calibration procedure.