# EDI Metadata Template (2019)[[1]](#footnote-1)

Data should be in csv text file. If starting with an Excel spreadsheet, please make sure it does not contain any formulas and comments on cells. If you need comments put them in their own column. If data were used in a database and major table linking is necessary to analyze, please de-normalize into a flat file, not just database table exports.

## Dataset Title

Methane ebullition and diffusion rates, turbulence, water temperature, and water depth data from Falling Creek Reservoir in the ice-free period of 2017

## Short name or nickname you use to refer to this dataset:

Falling Creek Reservoir methane efflux and driver data

## Abstract

Weekly and subweekly data of methane ebullition and diffusion rates collected from March through November in 2016, 2017, 2018, and 2019 in Falling Creek Reservoir (FCR), a drinking water reservoir owned and managed by the Western Virginia Water Authority and located in Vinton, Virginia, USA. In 2016, ebullition rates were measured at four near-shore locations along a longitudinal gradient in FCR that included four sites each, for a total of 16 sites. In 2017, methane emission rates and five different driver variables were measured at five longitudinal transects that included four sites each, for a total of 20 sites. In 2018, ebullition was measured at five longitudinal transects that included two sites each, for a total of 10 sites. In 2019, ebullition was meausred from the upmost transect in the reservoir that included four sites. The dataset consists of 1) weekly methane ebullition and diffusion rates and the water depths at each of the 24 sites; 2) 10-minute resolution sediment water interface and surface water temperatures from 16 sites in 2017; 3) weekly sediment water interface and surface turbulence from the four transects in 2017; and 4) geographical coordinates of each of the 24 sites in the reservoir. In 2017, We used time series modeling to quantify how the drivers of ebullition and diffusion rates varied among transects along a longitudinal gradient.

## Investigators

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
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|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |

## License

(Select a license for release of your data. We have 2 recommendations: [CCO – most accommodating of data reuse](https://creativecommons.org/publicdomain/zero/1.0/), & [CCBY – requires attribution](https://creativecommons.org/licenses/by/4.0/))

## Keywords

Carey Lab, greenhouse gas emissions, reservoir, depth, water temperature, turbulence, ebullition, methane, diffusion, diffusive flux, Si3D model, Virginia Tech, Stream Team, lake, Western Virginia Water Authority, Falling Creek Reservoir

## Funding of this work:

Add rows to table if several grants were involved, list only the main PI, start with main grant first:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| PI First Name | PI Middle Initial | PI Last Name | PI ORCID ID (optional) | Title of Grant | Funding Agency | Funding Identification Number |
| Cayelan | C. | Carey | 0000-0001-8835-4476 | Collaborative Research: Consequences of changing oxygen availability for carbon cycling in freshwater ecosystems | National Science Foundation | DEB-1753639 |
| Cayelan | C. | Carey | 0000-0001-8835-4476 | SCC-IRG Track 2: Resilient Water Systems: Integrating Environmental Sensor Networks and Real-Time Forecasting to Adaptively Manage Drinking Water Quality and Build Social Trust | National Science Foundation | CNS-1737424 |
| Cayelan | C. | Carey | 0000-0001-8835-4476 | MSB-ECA: A macrosystems science training program: developing undergraduates' simulation modeling, distributed computing, and collaborative skills | National Science Foundation | EF-1702506 |
| Ryan | M. | McClure | 0000-0001-6370-3852 | Dynamic responses of greenhouse gases to whole ecosystem manipulations under future climate conditions in reservoirs | Virginia Tech Graduate Research Development Program | 117105 |

## Timeframe

* Begin date: 2017-05-15 (Begin Sampling)
* End date: 2017-11-06 (Final analyses and data collation)
* Data collection ongoing/completed: Completed

## Geographic location

Falling Creek Reservoir

* Verbal description: Falling Creek Reservoir is located in Vinton, Virginia, USA
* North bounding coordinates (decimals): 37.309589
* South bounding coordinates (decimals): 37.302660
* East bounding coordinates (decimals): -79.836009
* West bounding coordinates (decimals): -79.839249

## Taxonomic species or groups

N/A

## Methods

We sampled methane ebullition rates using passive ebullition traps (Keller & Stallard, 1994). Each 0.26-meters squared ebullition trap was placed 0.5 m below the water surface to capture methane bubbles that were released from the sediments underneath the trap. A sealed tube extended from the bottom of the funnel to 0.1 m above the water surface through a foam float that kept the trap in place. The top of the inverted funnel’s tubing was fitted with a 25-mm plastic threaded ball valve that was sealed with a rubber septum stopper (Suba-Seal Septa, MilliporeSigma, St. Louis, MO, USA). The valve and the septum prevented ebullition gas from escaping out of the top of the funnel. When rising methane bubbles were caught in the funnel trap, the siphoned water at the top of the tube was displaced with gas, which stayed in the top of the tube until the gas was sampled weekly. We collected ebullition gas from every trap each week during the monitoring period. Up to 10 mL of gas was injected into a 12-mL crimp top glass vial that was pre-filled with salt brine solution. A secondary exit syringe extracted the salt brine solution as the sample was injected to generate 10 mL of gas headspace in the vial. If enough gas sample was available, two replicates were collected from each trap. The vials were stored upside down until analysis, so the remaining 2 mL of salt brine solution acted as a barrier to prevent any gas from escaping. We extracted any remaining gas in the trap using a 30 mL syringe and summed the total volume of gas collected each week. The gas samples were analyzed using a gas chromatograph coupled with a flame ionization detector (GC-FID) within 24 hours of collection (following McClure et al., 2018). We calculated the daily ebullition rate separately for each trap every week and then averaged the rates from the four traps within each transect to determine a mean daily transect ebullition rate for each week.

Methane diffusion rates were collected using the floating chamber method (Galfalk et al., 2013). The chamber was constructed using an inverted opaque bucket with a volume of 0.02 meters cubed and an area of 0.15 meters squared. The trap was fitted with foam so that the lip of the chamber sat approximately 3 cm below the water surface to seal the inside of the chamber from the surrounding air. We prevented internal heating within the chamber while it was deployed by wrapping the outside of the chamber with reflective aluminum tape. Two air-tight gas ports were fitted at the top of the chamber and connected to two separate three-meter sections of 0.635-cm Tygon PVC tubing, which were in turn connected to the inlet and waste valves of a Los Gatos ultraportable GHG analyzer (UGGA; Los Gatos Research Inc., San Jose, CA, USA). The UGGA circulated air through the chamber at approximately 405 mL per minute and recorded moisture-corrected methane (ppm) on 10-second intervals. We allowed the chamber to float freely on the water surface and collect data for five minutes at each site before it was vented to the atmosphere. We used a short incubation time because we were interested in instantaneous diffusion rates and did not intend to parse out ebullition from diffusion. If ebullition bubbles were observed when the chamber was deployed, we removed the chamber from the water surface, held it open to the atmosphere, and waited one minute to allow any methane from the ebullition bubble to circulate out of the chamber before placing it back onto the surface.

In 2017, 2018, and 2019 the depth of each site was determined using a Portable Water Depth Sounder Gauge (Cole – Parmer, Vernon Hills, IL, USA). We first determined the depth of all the sites along the longitudinal gradient (n = 20). We then determined the mean depth of each transect by adding up the total depth (m) of the traps in each transect and then divided by the number of traps (n = 4 traps) across the transect. In 2016, each ebulliiton trap was deployed 1 meter above the sediments.

Sediment and surface water temperature data was collected each ebullition trap during the monitoring period. Two temperature loggers (HOBO Pendant Temperature/Light Data Logger, Bourne, MA, USA) were deployed at each ebullition trap during the monitoring period and recorded data on 10-minute intervals. One logger was sunk using a stainless-steel weight and a nylon string to sit approximately 10 cm above the sediment-water interface to determine the near-sediment temperature. The surface water temperatures logger was attached to the underside of each trap, just below the water’s surface.

Sediment and surface water turbulence was estimated as turbulent kinetic energy (TKE) at the transects using a calibrated three-dimensional (3-D) hydrodynamic model (Si3D). Si3D is a semi-implicit 3-D computational fluid dynamics code that adopts a finite-difference method for numerically solving the Reynolds-averaged Navier-Stokes equations for momentum, transport equations for temperature, and equations that relate water temperature to density (Rueda & Schladow, 2003; Rueda & Schladow, 2009). Si3D provides output velocities that are highly resolved over space and time and allows a user to analyze physical processes of lake circulation (Rueda & Schladow, 2003). A detailed description of the Si3D model is provided by Rueda & Schladow (2003). Driver data for Si3D includes shortwave radiation (Watts per meter squared), air temperature (degrees celsius), atmospheric pressure (Pa), relative humidity (percent), cloud cover (percent), and the zonal and meridional wind speeds (meters per second), which were all measured by the meteorological station located on the dam (Carey et al., 2019), and the discharge from the primary inflow into the reservoir (Carey et al., 2018). We developed a three-dimensional numerical grid using 5 m by 5 m by 0.3 m (L by W by H) cells was generated for the entire reservoir based on the bathymetry. The Si3D calibration for was validated by Chen et al. (2017, 2018), who reported good consistency between the field and numerical results for reservoir mixing. The sediment and surface turbulence at each of the sites was determined by running Si3D for one-week intervals at five second timesteps, which generated model output of instantaneous velocity in the x, y, and z-axes for each grid cell. First, we determined the perturbation velocity (in centimeters per second), which is the difference between the instantaneous velocity at each timestep and the mean velocity in all three axes in each grid cell over the week-long time interval (Garratt, 1994). Next, we used the mean perturbation velocities to calculate near-sediment turbulence for each ebullition trap. Finally, we calculated the mean transect-level sediment and surface turbulence by averaging the turbulence for all sites in each transect between weekly samplings.

**For more information, we refer users to the publications listed below.**

Carey C. C., B. J. Bookout, M. E. Lofton, R. P. McClure. 2019. Time series of high-frequency meteorological data at Falling Creek Reservoir, Virginia, USA 2015-2018. Environmental Data Initiative. https://doi.org/10.6073/pasta/037384d2d5ae16cdc7450bf7a72792e3. Dataset accessed 10/07/2019.

Carey C. C., A. B. Gerling, R. P. McClure, M. E. Lofton, B. J. Bookout. (2018). Discharge time series for the primary inflow tributary entering Falling Creek Reservoir, Vinton, Virginia, USA 2013-2018. Environmental Data Initiative. https://doi.org/10.6073/pasta/64ff214b987da2997f5c823b156b3334. Dataset accessed 10/07/2019.

Chen, S., Lei, C., Carey, C. C., Gantzer, P. A., & Little, J. C. (2017). A coupled three‐dimensional hydrodynamic model for predicting hypolimnetic oxygenation and epilimnetic mixing in a shallow eutrophic reservoir. Water Resour. Res., 53(1), 470-484. doi:10.1002/2016WR019279

Chen, S., Carey, C. C., Little, J. C., Lofton, M. E., McClure, R. P., & Lei, C. (2018). Effectiveness of a bubble-plume mixing system for managing phytoplankton in lakes and reservoirs. Ecol. Eng., 113, 43-51. https://doi.org/10.1016/j.ecoleng.2018.01.002

Galfalk, M., Bastviken, D., Fredriksson, S., & Arneborg, L. (2013). Determination of the piston velocity for water‐air interfaces using flux chambers, acoustic Doppler velocimetry, and IR imaging of the water surface. J. Geophys. Res. Biogeosci., 118(2), 770-782. https://doi.org/10.1002/jgrg.20064

Garratt, J. R. (1994). The atmospheric boundary layer. Earth-Sci. Rev., 37(1-2), 89-134. https://doi.org/10.1016/0012-8252(94)90026-4

Keller, M., & Stallard, R. F. (1994). Methane emission by bubbling from Gatun Lake, Panama. J. Geophys. Res., 99(D4), 8307-8319. https://doi.org/10.1029/92JD02170

McClure, R. P., Hamre, K. D., Niederlehner, B. R., Munger, Z. W., Chen, S., Lofton, M. E., et al. (2018). Metalimnetic oxygen minima alter the vertical profiles of carbon dioxide and methane in a managed freshwater reservoir. Sci. Total Environ., 636, 610-620. https://doi.org/10.1016/j.scitotenv.2018.04.255

Rueda, F. J., & Schladow, S. G. (2003). Dynamics of Large Polymictic Lake. II: Numerical Simulations. J. Hydraul. Eng-Asce., 129(2), 92-101. https://doi.org/10.1061/(ASCE)0733-9429(2003)129:2(92)

Rueda, F., & Schladow, G. (2009). Mixing and stratification in lakes of varying horizontal length scales: Scaling arguments and energy partitioning. Limnol. Oceanogr., 54(6), 2003-2017. https://doi.org/10.4319/lo.2009.54.6.2003

## Data Tables

**Table 1: Methane ebullition, diffusion, and depth**

|  |  |  |  |
| --- | --- | --- | --- |
| **Column name** | **Description** | **Unit or**  **code explanation or date format** | **Empty value code** |
| **Reservoir** | Three-letter code corresponding to sampled reservoir | FCR=Falling Creek Reservoir | NA |
| **Site** | Sampling ebullition site within Falling Creek Reservoir | T1e1=Transect 1 ebullition trap 1,  T1e2=Transect 1 ebullition trap 2,  T1e3=Transect 1 ebullition trap 3,  T1e4=Transect 1 ebullition trap 4,  T2e1=Transect 2 ebullition trap 1,  T2e2=Transect 2 ebullition trap 2,  T2e3=Transect 2 ebullition trap 3,  T2e4=Transect 2 ebullition trap 4,  T3e1=Transect 3 ebullition trap 1,  T3e2=Transect 3 ebullition trap 2,  T3e3=Transect 3 ebullition trap 3,  T3e4=Transect 3 ebullition trap 4,  T4e1=Transect 4 ebullition trap 1,  T4e2=Transect 4 ebullition trap 2,  T4e3=Transect 4 ebullition trap 3,  T4e4=Transect 4 ebullition trap 4 | NA |
| **Transect** | Sampling transect within Falling Creek Reservoir | T1=Transect 1,  T2=Transect 2,  T3=Transect 3,  T4=Transect 4 | NA |
| **DateTime** | Date and time of sampling. All data were collected in the eastern time zone of the U.S.A., with daylight savings time observed | YYYY-MM-DD | NA |
| **Depth\_m** | Site depth | meter | NA |
| **Ebu\_rate** | Ebullition rate | milligramPerMeterSquaredPerSecond | NA |
| **Diff\_rate** | Diffusion rate | milligramPerMeterSquaredPerSecond | NA |
| **Flag\_depth** | Data flag for site depths | 0=Not suspect, 1=Sample not taken, 2=Instrument malfunction, 3=Sample below detection, 4=Negative value set to 0, 5=demonic intrusion due to otter attack of equipment | NA |
| **Flag\_ebu** | Data flag for ebullition rates | 0=Not suspect, 1=Sample not taken, 2=Instrument malfunction, 3=Sample below detection, 4=Negative value set to 0, 5=demonic intrusion due to otter attack of equipment | NA |
| **Flag\_diff** | Data flag for diffusion rates | 0=Not suspect, 1=Sample not taken, 2=Instrument malfunction, 3=Sample below detection, 4=Negative value set to 0, 5=demonic intrusion due to otter attack of equipment | NA |

**Table 2: Water Temperature**

|  |  |  |  |
| --- | --- | --- | --- |
| **Column name** | **Description** | **Unit or**  **code explanation or date format** | **Empty value code** |
| **Reservoir** | Three-letter code corresponding to sampled reservoir | FCR=Falling Creek Reservoir | NA |
| **Site** | Sampling ebullition site within Falling Creek Reservoir | T1e1=Transect 1 ebullition trap 1,  T1e2=Transect 1 ebullition trap 2,  T1e3=Transect 1 ebullition trap 3,  T1e4=Transect 1 ebullition trap 4,  T2e1=Transect 2 ebullition trap 1,  T2e2=Transect 2 ebullition trap 2,  T2e3=Transect 2 ebullition trap 3,  T2e4=Transect 2 ebullition trap 4,  T3e1=Transect 3 ebullition trap 1,  T3e2=Transect 3 ebullition trap 2,  T3e3=Transect 3 ebullition trap 3,  T3e4=Transect 3 ebullition trap 4,  T4e1=Transect 4 ebullition trap 1,  T4e2=Transect 4 ebullition trap 2,  T4e3=Transect 4 ebullition trap 3,  T4e4=Transect 4 ebullition trap 4 | NA |
| **DateTime** | Date and time of sampling. All data were collected in the eastern standard time zone of the U.S.A., with daylight savings time not observed | YYYY-MM-DD HH:MM:SS | NA |
| **Sed\_temp** | Water temperature | celsius | NA |
| **Surf\_temp** | Water temperature | celsius | NA |
| **Flag\_sed\_temp** | Data flag for sediment water temperature | 0=Not suspect, 1=Sample not taken, 2=Instrument malfunction, 3=Sample below detection, 4=Negative value set to 0, 5=demonic intrusion due to otter attack of equipment | NA |
| **Flag\_surf\_temp** | Data flag for surface water temperature | 0=Not suspect, 1=Sample not taken, 2=Instrument malfunction, 3=Sample below detection, 4=Negative value set to 0, 5=demonic intrusion due to otter attack of equipment | NA |

**Table 3: Water Turbulence**

|  |  |  |  |
| --- | --- | --- | --- |
| **Column name** | **Description** | **Unit or**  **code explanation or date format** | **Empty value code** |
| **Reservoir** | Three-letter code corresponding to sampled reservoir | FCR=Falling Creek Reservoir | NA |
| **Transect** | Sampling transect within Falling Creek Reservoir | T1=Transect 1,  T2=Transect 2,  T3=Transect 3,  T4=Transect 4 | NA |
| **DateTime** | Date and time of sampling. All data were collected in the eastern standard time zone of the U.S.A., with daylight savings time not observed | YYYY-MM-DD | NA |
| **Sed\_turb** | Sediment turbulence |  | NA |
| **Surf\_turb** | Surface turbulence |  | NA |
| **Flag\_sed\_turb** | Data flag for sediment turbulence | 0=Not suspect, 1=Sample not taken, 2=Instrument malfunction, 3=Sample below detection, 4=Negative value set to 0, 5=demonic intrusion due to otter attack of equipment | NA |
| **Flag\_surf\_turb** | Data flag for surface turbulence | 0=Not suspect, 1=Sample not taken, 2=Instrument malfunction, 3=Sample below detection, 4=Negative value set to 0, 5=demonic intrusion due to otter attack of equipment | NA |

**Table 4: Ebullition site locations**

|  |  |  |  |
| --- | --- | --- | --- |
| **Column name** | **Description** | **Unit or**  **code explanation or date format** | **Empty value code** |
| **Reservoir** | Three-letter code corresponding to sampled reservoir | FCR=Falling Creek Reservoir | NA |
| **Transect** | Sampling transect within Falling Creek Reservoir | T1=Transect 1,  T2=Transect 2,  T3=Transect 3,  T4=Transect 4 | NA |
| **Site** | Sampling ebullition site within Falling Creek Reservoir | T1e1=Transect 1 ebullition trap 1,  T1e2=Transect 1 ebullition trap 2,  T1e3=Transect 1 ebullition trap 3,  T1e4=Transect 1 ebullition trap 4,  T2e1=Transect 2 ebullition trap 1,  T2e2=Transect 2 ebullition trap 2,  T2e3=Transect 2 ebullition trap 3,  T2e4=Transect 2 ebullition trap 4,  T3e1=Transect 3 ebullition trap 1,  T3e2=Transect 3 ebullition trap 2,  T3e3=Transect 3 ebullition trap 3,  T3e4=Transect 3 ebullition trap 4,  T4e1=Transect 4 ebullition trap 1,  T4e2=Transect 4 ebullition trap 2,  T4e3=Transect 4 ebullition trap 3,  T4e4=Transect 4 ebullition trap 4 | NA |
| **Latitude** | Latitude coordinates of each site |  | NA |
| **Longitude** | Longitude coordinates of each site |  | NA |

## Articles

|  |  |  |
| --- | --- | --- |
| Article DOI or URL (DOI is preferred) | Article title | Journal title |
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## Scripts/code (software)

(List any software scripts/code you would like to archive along with your data. These may include processing scripts you wrote to create, clean, or analyze the data.)

|  |  |  |
| --- | --- | --- |
| File name | Description | Scripting language |
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## Notes and Comments

In 2016, 2017, 2018, and 2019, whole-ecosystem manipulations were conducted at Falling Creek Reservoir. These manipulations include intermittent operation of hypolimnetic oxygenation and pulsed epilimnetic mixing engineering systems at the dam. The methane emission sampling sites monitored evaluated were specifically chosen because they were located upstream of any system operation that could affect the data. However, all data represented by "sC" and "t5" represent methane emissions near the hypolimnetic oxygenation and epilimnetic engineered systems. For a detailed description of the hypolimnetic oxygenation engineered system, see Gerling et al. (2014) and for a detailed description of the epilimnetic mixing engineered system, see Chen et al. (2017).

Chen, S., C. Lei, C.C. Carey, P.A. Gantzer, and J.C. Little. 2017. Predicting hypolimnetic oxygenation and epilimnetic mixing in a shallow eutrophic reservoir using a coupled three-dimensional hydrodynamic model. *Water Resources Research.* 53: 470-484. DOI: 10.1002/2016WR019279

Gerling, A.B., Browne, R.G., Gantzer, P.A., Mobley, M.H., Little, J.C., and C.C. Carey. 2014. First report of the successful operation of a side stream supersaturation hypolimnetic oxygenation system in a eutrophic, shallow reservoir.  *Water Research.* 67: 129-143. doi: 10.1016/j.watres.2014.09.002

1. This document liberally borrows from similar documents at SBC and GCE [↑](#footnote-ref-1)