Introduction

This document is to be used as a reference for all monitoring data that the NDSU hydrologic modeling group of CRCS has collected over the course of the project funded by the NSF EPSCoR award IIA-1355466. All information, including, where the data were collected, how the data were collected, types of data, how to download the data, and other details can be found in this document. This document is divided into 3 sections based on the types of the collected data: (1) Precipitation data, (2) Temporal pothole depth data, and (3) Spatially distributed pothole depth data.

Monitoring Data

1. Precipitation Data

Locations

Ten precipitation stations were set up to collect precipitation data (including rainfall/snowfall and snow depth measurements) across 6 USGS HUC10 watersheds. The locations of the precipitation stations are shown in Table 1.

Table 1: Precipitation stations and their locations

Watershed	Site Name	Latitude	Longitude	Location
Baldhill Creek	BH1	47.18324	-98.06959	Valley City, ND
Baldhill Creek	BH2	47.39027	-98.32696	Valley City, ND
Maple	Cass1	46.87780	-97.23489	Casselton, ND
Bois De Sioux	Fairmount	46.00858	-96.59895	Fairmount, ND
Pipestem	PPR1	47.09725	-99.09342	Jamestown, ND
Pipestem	PPR2	47.10080	-99.09614	Jamestown, ND
Pipestem	PPR3	47.09984	-99.10107	Jamestown, ND
Sandhill-Wilson	Grand Forks	47.87550	-97.20775	Grand Forks, ND
Devils Lake	DL1	48.17428	-98.95309	Devils Lake, ND
Devils Lake	DL2	48.38896	-98.75739	Devils Lake, ND

Data Collection

The heated tipping bucket rain gauge was utilized to obtain precipitation measurements at each station. The heating mechanism engaged when temperatures were below freezing and thawed frozen precipitation to acquire measurements year-round (Heated Tipping Bucket Rain Gauge, Hydrological Services America). Data accuracy is within +/- 3% even with high rainfall intensities due to the integrated syphon mechanism which controls the release of precipitation into the tipping bucket (TB3 Tipping Bucket Rain Gauge, Hydrological Services America). Data were originally collected at a 1-minute time interval, which was changed to a 5-minute time interval in June 2016; however, not all data are continuous at this point. Table 2 shows the complete range of the collected date for the 1-minute and 5-minute intervals. Small gaps in the collected data (e.g., 1-2 hours) were interpolated, whereas large gaps in the data were not corrected, as highlighted in Table 2.

Table 2. Precipitation data time periods and time intervals.

Site Name	1-minute Interval	5-minute Interval
BH1	7/29/15 9:01– 6/13/16 15:00	6/13/16 15:00 – 7/10/17 7:00
BH2	11/1/15 0:00 – 6/13/16 15:00	6/27/16 22:05 – 7/10/17 9:00
Cass1	8/5/15 15:01 – 6/14/16 16:00	6/27/16 22:05 – 7/7/17 10:00
Fairmount	7/28/15 12:32 – 6/13/16 15:00	6/27/16 22:05 – 7/7/17 12:00
PPR1	7/30/15 12:17 – 6/13/16 15:00	6/27/16 22:05 – 7/10/17 11:00
PPR2	7/30/15 12:29 – 6/14/16 16:00	6/27/16 22:05 – 7/10/17 11:00
PPR3	7/28/15 0:41 – 6/13/16 15:00	6/27/16 22:05 – 7/10/17 10:00
Grand Forks	11/2/15 17:56 – 6/13/16 15:00	6/13/16 15:00 – 7/11/17 8:00
DL1	6/10/16 10:05 – 6/13/16 15:00	6/27/16 23:05 – 7/11/17 11:00
DL2	6/16/16 10:57 – 6/28/16 16:00	6/28/16 16:00 – 7/11/17 10:00

Data Download

The data collected from the 10 stations were telemetrically transferred to the Global Data Network (https://www.hyquestsolutions.com/global-data-network-gdn/) where the original, unprocessed data can be downloaded. Login: EPSCoR Password: EPSCoR

The processed data can be downloaded here. All data is organized into different zip files by the site name/location (see Figure 1 and Table 1). Precipitation data are organized into Excel files by year (i.e., 2015, 2016, and 2017). The precipitation Excel files are indicated by a "P" followed by the start date (yyyy-mm-dd) and the end date (yyyy-mm-dd). For example, the file titled "P_2016-01-01_2016-12-31" includes the 2016 precipitation data. Within each Excel file, different sheets hold the monthly data in the specified year. For example, the Excel file titled "P_2016-01-01_2016-12-31" includes an Excel sheet titled 11-1-2016_11-30-2016 which includes all the precipitation data collected for November 2016. Small data gaps which were interpolated are highlighted within each sheet while large data gaps were not interpolated, but are indicated in Table 2. The precipitation data were recorded in inches, but all data were converted to cm and both units are included in each Excel sheet.

Publications

Chu, X. (2015). "Delineation of Pothole-Dominated Wetlands and Modeling of Their Threshold Behaviors." *Journal of Hydrologic Engineering*, American Society of Civil Engineers, D5015003.

Habtezion, N., Tahmasebi Nasab, M., and Chu, X. (2016). “How does DEM resolution affect microtopographic characteristics, hydrologic connectivity, and modelling of hydrologic processes?” *Hydrological Processes*, 30(25), 4870–4892.

Tahmasebi Nasab, M., Jia, X., and Chu, X. (2016). “Modeling of Subsurface Drainage under Varying Microtopographic, Soil and Rainfall Conditions.” *10th International Drainage Symposium*, J. Strock, ed., American Society of Agricultural and Biological Engineers, Minneapolis, MN, 133–138.

Tahmasebi Nasab, M., Grimm, K., Wang, N., and Chu, X. (2017). “Scale Analysis for Depression-Dominated Areas: How Does Threshold Resolution Represent a Surface?” *World Environmental and Water Resources Congress 2017*, American Society of Civil Engineers, Reston, VA, 164–174.

2. Snow Depth Data

Locations

Ten precipitation stations were set up to collect precipitation data (including rainfall/snowfall and snow depth measurements) across 6 USGS HUC10 watersheds. The locations of the precipitation stations are shown in Table 1.

Data Collection

The ultrasonic snow depth sensor was utilized to obtain continuous and non-contact snow depth measurements (Ultra Sonic Snow Depth Sensor (USH-8), Hydrological Services America). Data accuracy is within 0.1% due to the integrated temperature compensation and filtering of snow and rainfall using intelligent spectrumanalysis. However, the sensor does pick up any vegetation beneath the sensor. Therefore, the snow depth data were processed. The start and end dates for snow in each year are indicated in the datasets, as well as in Table 3. The snow start/end dates were determined by using local weather data and ambient temperature data recorded at each station. Any recorded “snow” depths before the snow start date and after the snow end date were changed to zero. Any missing data within the snow period were interpolated. All data were recorded at a 5-minute time intervals.

Table 3. Snow periods for each year.

Site Name	Snow Period 2015 - 2016	Snow Period 2016 - 2017
BH1	11/30/15 17:25 – 3/19/16 11:45	11/26/16 21:40 – 3/22/17 6:15
BH2	7/29/15 16:35 – 6/13/16 15:00	6/27/16 22:05 – 7/10/17 9:00
Cass1	8/5/15 15:01 – 6/14/16 16:00	6/27/16 22:05 – 7/7/17 10:00
Fairmount	7/28/15 12:32 – 6/13/16 15:00	6/27/16 22:05 – 7/7/17 12:00
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Data Download

The data collected from the 10 stations were telemetrically transferred to the Global Data Network (https://www.hyquestsolutions.com/global-data-network-gdn/) where the original, unprocessed data can be downloaded. Login: EPSCoR Password: EPSCoR

The processed snow depth data can be downloaded here. All data are organized into zip files by the site name/location (see Figure 1 and Table 1). The snow depth data are organized into Excel files by year (e.g., 2015, 2016, and 2017). The snow depth data Excel files are indicated by "S" followed by the start date (yyyy-mm-dd) and the end date (yyyy-mm-dd). For example, the file titled "S_2016-01-01_2016-12-31" is the Excel file which includes the 2016 snow depth data. Within each Excel file, different sheets hold the monthly data in the specified year. For example, the Excel file titled "S_2016-01-01_2016-12-31" includes an Excel sheet titled "11-1-2016_11-30-2016" which includes all the snow depth data collected for November 2016. However, the sheets which contain start snow data include an "(S)" at the end of the sheet title like "11-1-2016_11-30-2016 (S)," and sheets which contain the end snow data include an "(E)" at the end of the sheet title like "2017-03-01_2017-03-31 (E)." Any sheet which contains missing data was corrected and indicated by a "(G)". Small data gaps which were interpolated are highlighted within each sheet while large data gaps were not interpolated, but are indicated in Table 2. The processed snow depth data are highlighted in blue (mostly in the summer and fall months). The snow depth data were recorded in mm.

3. Temporal Pothole Depth Data

Location

Figure 1 shows the locations of our pressure transducers in the Cottonwood Lake Study Area (CLSA) of the USGS Northern Prairie Wildlife Research Center (NPWRC). The GPS coordinates for each pressure transducer are shown in Table 4 along with the ID name which refers to the potholes they were placed in.

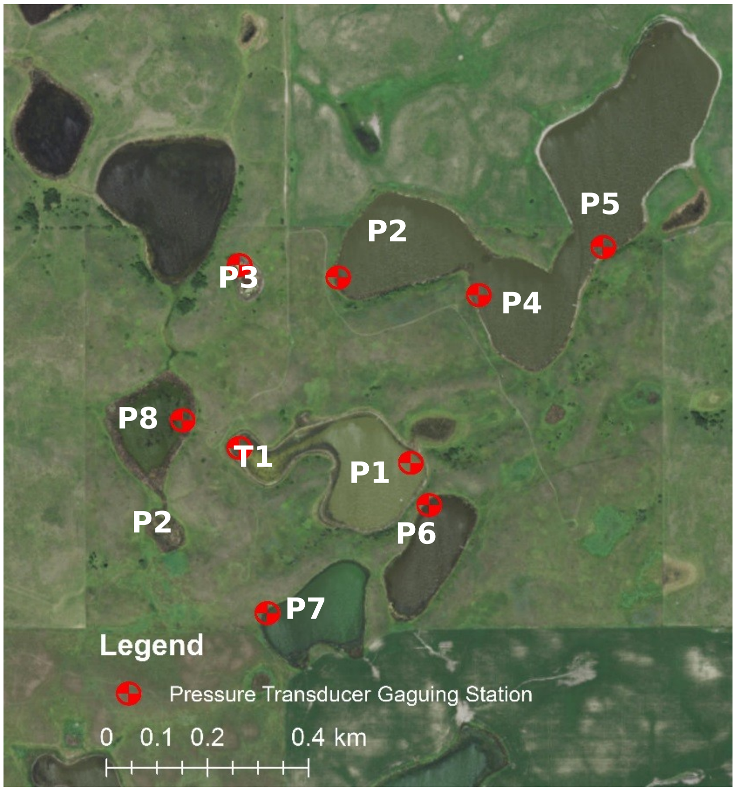

Figure 1. Locations of pressure transducers and names of pothole lakes

Table 4. Coordinates of pressure transducers.

Name	Location	GPS Coordinates
PT_P7	PPR, P7	N 47.09578 W 099.10143
PT_P8	PPR, P8	N 47.09921 W 099.10365
PT_T1	PPR, T1	N 47.09872 W 099.10217
PT_P2	PPR, P2	N 47.10176 W 099.09959
PT_P4	PPR, P4	N 47.10145 W099.09592
PT_P5	PPR, P5	N 47.10231 W 099.09267
PT_P1	PPR, P1	N 47.09846 W 099.09769
PT_P6	PPR, P6	N 47.09771 W 099.09721
PT_P3	PPR, P3	N 47.10198 W 099.10217

Data Collection

The HOBO pressure transducers (HOBO Pressure Transducer) used in this hydrologic monitoring study are wireless water level loggers with Bluetooth capabilities for data download. These sensors have a 3-point NIST-traceable calibration certificate from ONSET. They were self-calibrated/lab tested by our NDSU hydrologic modeling group. The measured water level accuracy is ± 0.05 – 0.1%. The sensors were installed in the summers of 2016 and 2017 and removed in late September or early October of each year, respectively. The water level data are unprocessed data, so any missing data have not been corrected or interpolated at this time. The recorded data have a 15-minute time interval.

Data Download

The temporal pothole depth data are organized into 2 zip files by year (i.e., 2016 and 2017). Each zip file includes various text files. The text file name refers to the pothole in which the pressure transducer was located (see Figure 2) followed by the sensor identification number. The text file is organized into 8 columns: Date Time (military time), Diff Press (kPa), Abs Press (kPa), Temp (Celsius), Water Level (m), Baro Press (kPa), Host Connect (if Logged= missing data), and EOF (if Logged= end of collection).

Publications

Tahmasebi Nasab, M., Jia, X., and Chu, X. (2016). "Modeling of Subsurface Drainage under Varying Microtopographic, Soil and Rainfall Conditions." *10th International Drainage Symposium*, J. Strock, ed., American Society of Agricultural and Biological Engineers, Minneapolis, MN, 133–138.

4. Spatially Distributed Pothole Depth Data

Location

Figure 1 shows the locations of the surveyed potholes in the Cottonwood Lake Study Area (CLSA) of the USGS Northern Prairie Wildlife Research Center (NPWRC). The name of each pothole in Figure 1 refers to the data download name.

Data Collection

RiverSurveyor M9 by SonTec (RiverSurveyor M9) was utilized to obtain spatially distributed pothole depth data. This way a modified DEM was created which reflected the pothole bathymetry rather than the water surface elevations. The M9 records water depths using multi-band multiple acoustic frequencies from the vertical beam which "pings" the pothole bed while simultaneously collecting the GPS coordinates of each "ping". High ping rates ensure robust data collection and high resolution. The vertical beam can measure a depth range from 0.2 to 80m, depth accuracy of 1%, and depth resolution of 0.001 m. Two types of data were collected: pothole shapefile (boundary) data and inside pothole data. To create the pothole boundary, the M9 was walked around the water line of the entire pothole in a backpack so all depth measurements read 0 m. The inside pothole data were obtained by attaching the RiverSurveyor M9 to a floatable platform and the floatable platform was attached to a small row boat. The RiverSurveyor was then paddled around the pothole and through the pothole along many vertical and horizontal transects in order to get a good coverage of the pothole bathymetry.

Data Download

The spatially-distributed pothole depth data are organized into 7 zip files. The file name corresponds to the pothole name listed in Figure 3. Each zip file includes text files, again indicating the pothole name and then the data type: shapefile data (see data collection) or inside pothole data (see data collection). Each text file includes 23 columns: Step, Sample, Time, Track, DMG, Depth, # Pings, # Cells, Satellites, GPS Quality, Mean Speed, Boat Speed, Left Q, Right Q, Total Q, Loop Corrected, Total Q, Latitude, Longitude, UTM X, UTM Y, VB Depth, D(BT)/D(GPS), and GpsGeoid. Note that the columns needed for the bathymetry data include: Latitude (degree) and Longitude (degree) or UTM X (m) and UTM Y (m), and VB Depth (m) which refers to the vertical beam (see data collection).

Publications

Grimm K. and Tahmasebi Nasab M. (2017) “TWI computations and topographic analysis of depression-dominated surfaces.” *Water.* (Submitted)

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