Monitoring the Climate of Glacier Bay

2006 Progress Report

Studies Conducted As Part of Research Project: Long-term tidewater and terrestrial glacier dynamics, glacier hydrology, and Holocene and historic glacier activity and climate change in Glacier Bay National Park and Preserve

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Introduction

A major research effort to monitor modern climate change is underway. In 1999, we established 24 sites that are distributed regularly within the interior Glacier Bay watershed for monitoring contemporary climate and sampling of meteoric water as a means of defining its regional, spatial and temporal variability. These data provide the basis for calibrating tree-ring records and interpreting the paleoclimate in terms of climatic indices. These data are also critical to understanding how glaciers and other physical systems are responding to regional and global changes in climate. We will also compare these data to historical records of climate from sites outside Glacier Bay to determine whether those records are representative of the climate within the bay.

Climate is perhaps the single most important factor in controlling the physical, marine and terrestrial environments of Glacier Bay. Climate and its variability in time and space is an overarching driver of the Park ecosystems. Thus, global changes in climate may cause significant impacts to ecosystems and their responses in the near and long-term, an understanding of which will be important considerations to management for utilizing and protecting Park resources while accommodating visitors in the future.

Methods

Climate sites are located along fiord margins, generally at or near sea level (Figure 1). Each site has a minimum of two rain gauges (for redundancy), a temperature gauge, and a bulk precipitation collector for heavy isotope analysis (Lawson *et al* 2004; Finnegan *et al* 2006). The rain gauges (Onset RG-2 Tipping Bucket; Peet Electronic) record rainfall to Hobo event data loggers in 0.01 inch increments (Figure 2). Temperature is measured to 0.1 ° C accuracy at a 20 minute interval using two separate thermistors that are housed

within a solar radiation shield (Figure 2). Snow gauges previously used at three sites are being repaired and upgraded and will be returned to active use in September 2007.

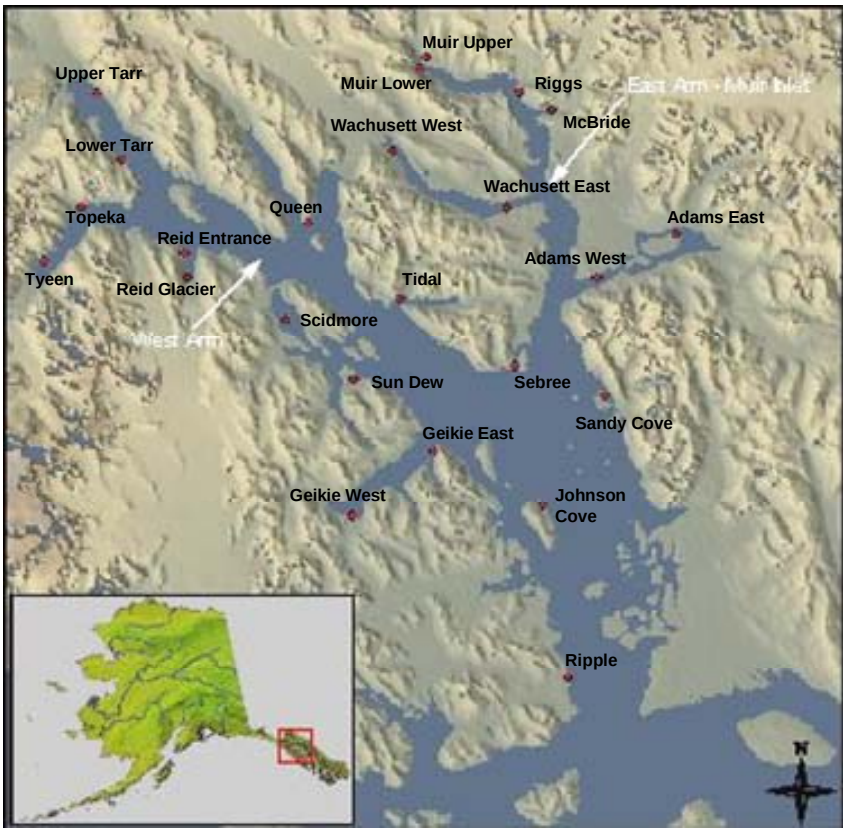

Figure 1. Locations of CRREL climate monitoring locations within the Glacier Bay watershed.

Two sites (Queen Inlet, Tyeen) are utilizing GOES (Geostationary Operational Environmental Satellite) satellite transmitters for year-round, near-real time data transmission to include precipitation, temperature, solar radiation and wind measurements (Figure 3). By using the GOES transmission system, data are collected at regularly timed intervals (15 minutes) and transmitted via the GOES system for processing hourly. Once the data are transmitted, the information is decoded at a central receiving station located at the New England District Corp of Engineers Reservoir Control Center in Concord, MA. These data are quality checked and then pushed to a central database server at CRREL where the information is disseminated via the World Wide Web. The site address is: https://rsgis.crrel.usace.army.mil/ltir/GBweb.GBindex. We plan additional GOES transmitters as funds allow, reducing the need for costly site visits especially in areas where access may be limited by vessel restrictions and providing data in near real time for park managers, staff and researchers. The remote monitoring systems are ultimately expandable to include new instruments as research needs arise,

and allows for collaboration with other researchers who likewise may benefit from near real-time data transmission.

Figure 2. Typical monitoring set up at climate sites. Upper left photo shows white solar radiation shield housing temperature sensors and a tipping bucket rain gauge installed on 1-meter tall post at Muir Glacier. Photo on lower right shows the tipping bucket and electronic rain gauges in steel housings as mounted on the ground at the Riggs site. A post is only used where animals are unlikely to damage rain gauges, but preferred to reduce snow cover effects early in the winter season.

Each climate site is routinely maintained during late spring or early summer and again in late summer or early fall. Typically we require 5 days to complete servicing, download, repair and maintenance of all 24 sites. We record the condition of the site in a field book upon arriving, sometimes photographing more serious problems such as animal or natural destruction of instruments and mounting equipment. The levelness of the rain gauges is measured and any deviation noted as this affects the volume recorded. The data loggers of each instrument are then downloaded to portable recorders and batteries and desiccant are replaced, while clearing the memory of older data and reinitializing loggers to begin a new data collection cycle. Any problems with data loggers or instruments are noted in our field books, and we replace problematic loggers and broken instruments in the field with spares we carry with us to minimize the time required to service each site and insure that we have fully operational equipment for the next period of monitoring. Simple repairs or download issues are addressed on board the vessel used to access the site or back in the office or lodging that night. More serious problems are repaired back at the CRREL Hanover laboratory. Details of each instrument recorded in the field book include condition and operation of the data loggers and any problems noted that may have affected the operation and recording of data (for example leaves or spiders in the rain gauge orifice). If loggers or entire instruments must be replaced, the new serial numbers and time of start up are recorded. Bulk water samples are collected in 60 ml Nalgene bottles and assigned sample numbers recorded in the notes for the particular site. On board the vessel, we download all files on the data recorder to a folder on a laptop

Figure 3. GOES test site in Queen Inlet. GOES satellite transmission system transmits hourly data on precipitation and air temperature, while also storing these data as a backup on Campbell data logger located within the grey box.

computer and as a back up onto a data key. During travel between sites, we prepare spare data loggers and instruments in case they are needed at the next climate site.

Once back at the office, all data files are archived on the CRREL server and its back up, as well as on personal computers being used to process and analyze the climate data. Water samples are logged and then stored pending analysis of their oxygen and hydrogen isotopic composition.

2006 Monitoring Activities

The increased support of the M/V Capelin and Captain Justin Smith in 2006 to service and maintain climate sites allowed us to achieve coverage of the climate sites at both the beginning and end of the summer season. After last season's incomplete coverage due to loss of park vessel Nunatak (Lawson *et al*, 2006), Capelin support resulted in a nearly complete and continuous precipitation and air temperature record for all climate sites from September 2005, when sites were last serviced, through September 2006. Site visits were accomplished from 6 to 9 June, 21 June and 11 to 15 September with transport via the M/V Capelin.

Most sites had complete records of both the air temperature and precipitation for both the 2005 – 2006 winter and 2006 summer periods. Exceptions included the Topeka site where a bear had destroyed the rain gauges and air temperature sensor prior to our visiting the site in June. We were able to recover data off one rain gauge data logger despite extensive damage, but the data logger for the air temperature sensor could not be found and all data were lost for the period September 2005 to June 2006. Also at Tyeen, an avalanche knocked the rain gauges off their stands and buried the temperature gauge in mid-January, disrupting the temperature record at that point. The Tyeen site should be moved to the east beyond a small bedrock knob to avoid future problems due to avalanches, a common occurrence at this site. In addition at Ripple, a curious bear ripped the guts out of both rain gauges and no data were recovered for the summer period, while at Scidmore the summer data were lost due to an eagle perching on the rain gauge and knocking it off level enough that it did not record rainfall.

The raw data as collected from the air temperature data loggers are plotted by site name in Appendix A and from the rainfall gauge loggers in Appendix B. These data have not yet been fully processed and corrected for any problems noted in the field or as the result of instrumentation or data logger problems. This processing will be undertaken by a Dartmouth College student as part of a thesis. The initial processing of the 2005 data was begun this year and will be combined with the 2006 data as part of the thesis.

The raw data presented in the Appendices should NOT be interpreted or used without final processing and corrections for site-specific and other possible problems. We ask that all requests to use the climate data be made directly to CRREL; we will be pleased to share the data. Potential users should provide us a description of how it will be used in their investigations to insure there are no conflicts with our research and publication. Once processed and applied to our research, all data will be open to the general public.

Continuing Work

We plan to visit each climate site over two, 5-day periods in the spring and fall of 2007 to insure that a complete record of the air temperature and precipitation from each site is acquired (barring problems over which we have no control). Additional processing and analysis of the 2005 and 2006 data will be combined with the existing database as part of a planned thesis during 2007 at Dartmouth College. We have recently (July 2006) provided a DVD with all climate data acquired from 1999 through 2005 to Bill Eichenlaub for archiving on the NPS Glacier Bay server. An updated DVD to include the 2006 climate data is being prepared and will be sent to Bill for archiving on the Park server.

Data from the climate monitoring effort will continue to be acquired annually to develop the lengthy record necessary to discern and analyze long-term trends versus short-term variability inherent in natural systems. The six year record we now have is significant, but not yet sufficiently long to analyze for multi-year (like El Nino) and longer (like Pacific Decadal and Arctic Oscillations) influences on climate, but it is approaching a length sufficient to begin to see overall trends related to global warming within the range of normal variability inherent in the regional climate.

We will continue to collaborate with Justin Smith (NPS) and Tom Ainsworth (NWS) to provide a climate station at Bartlett Cove. The current plan is for CRREL to provide a GOES system, precipitation gauge and solar radiometer, while the Weather Service provides the mounting, temperature gauges, barometric pressure gauge and related equipment for local weather download. The Park will provide set up on the dock and electrical power. This climate station will provide current weather conditions for the Park staff at the Visitor Center, while the GOES transmission will provide the Weather Service data hourly via the web from the central database server at CRREL. The climate site will also provide new climate coverage for the lower eastern side of the bay, supplementing the 24 existing CRREL sites. Additional sensors may be added, including a tide gauge, if funding can be acquired.

Acknowledgements

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Lawson, D.E., Finnegan, D. C., Kopczynski, S. and Bigl, S., 2004. Long-term studies of tidewater and terrestrial dynamics, glacier hydrology and Holocene and historic climate activity, Glacier Bay National Park and Preserve, Southeast Alaska. Annual Report; Prepared for Glacier Bay National Park and Preserve, Gustavus, AK (March).

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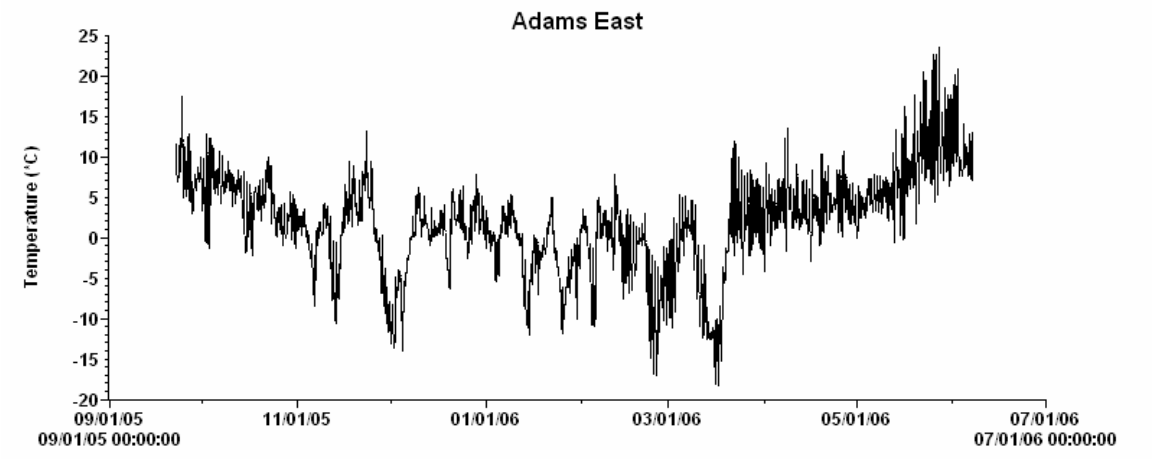
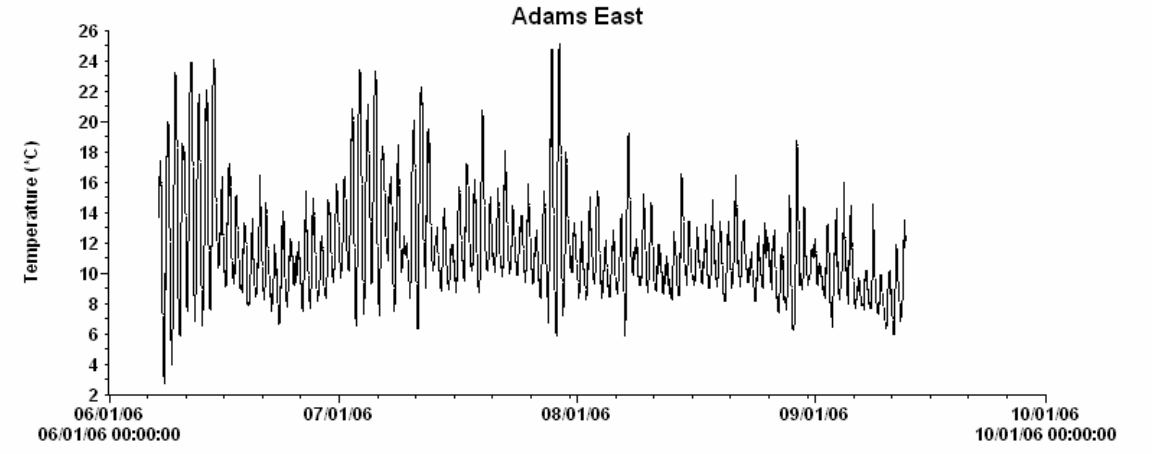
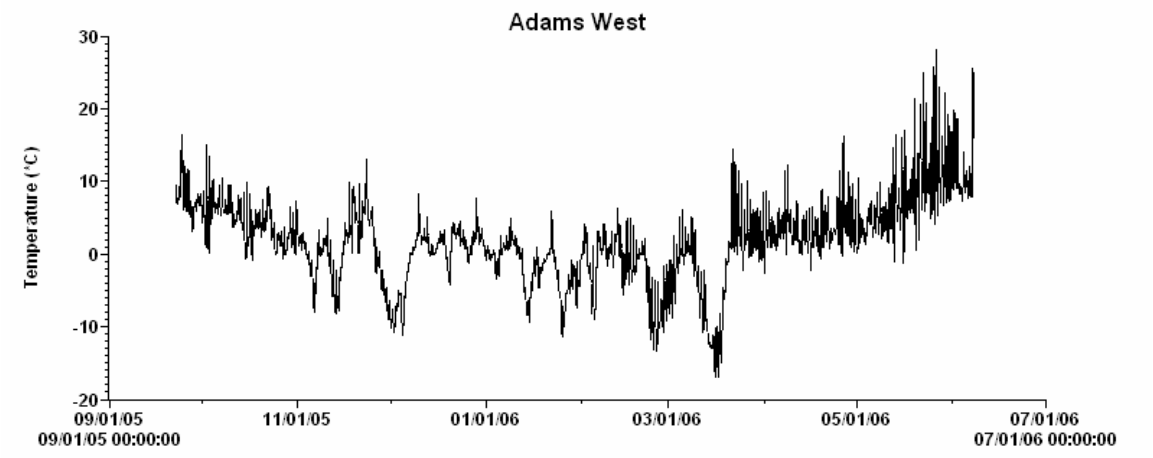
Appendix A.
Raw Temperature Data 2006

The graphs provided in this appendix are listed by site name and illustrate the raw temperature data acquired in 2006 during site visits in June and September. These data are for illustration only and need to be quality checked as well as assessed and corrected for site-specific problems. Combined downloads generally cover the period of September 2005 to September 2006. Missing datasets are described in the text. The line graphs appear different because of the variable lengths of the record and the range in magnitude of the air temperature.



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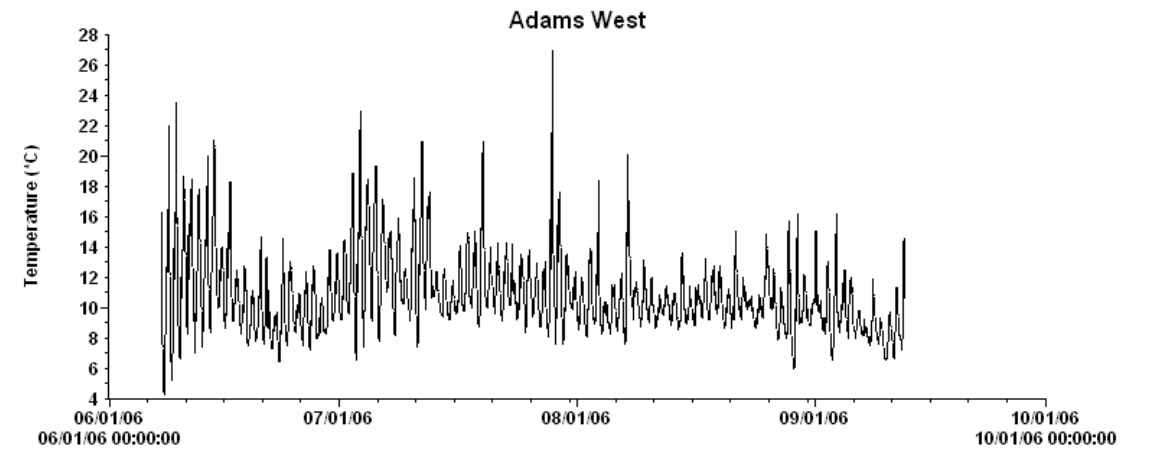
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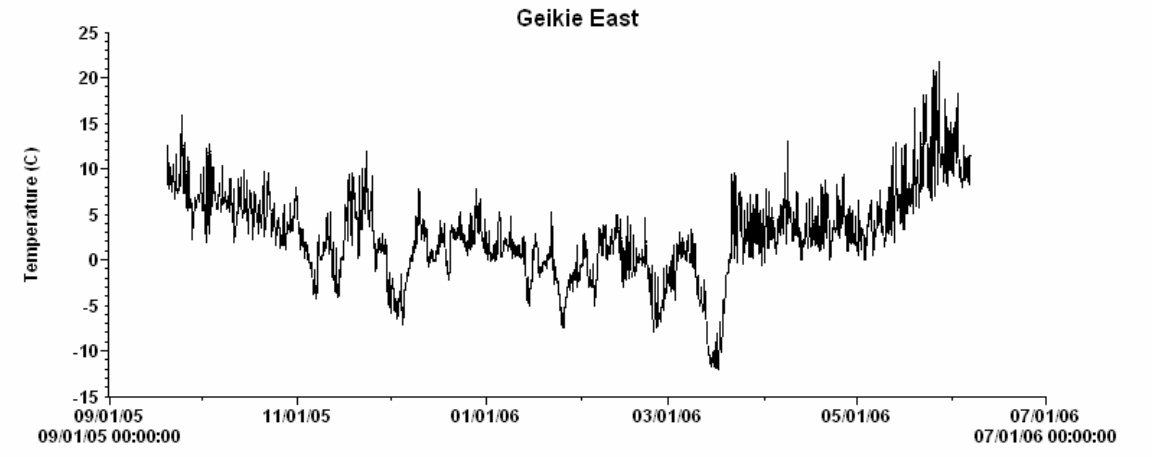
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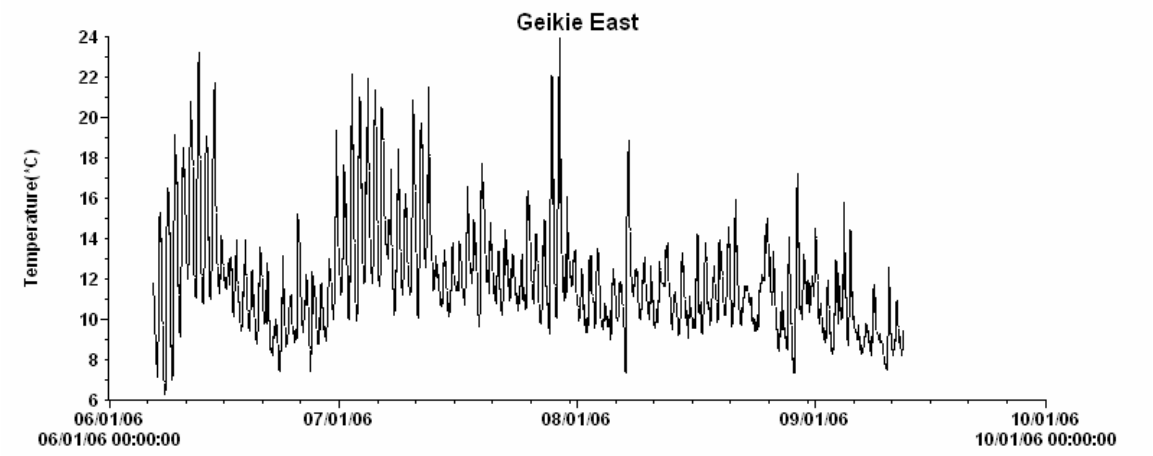
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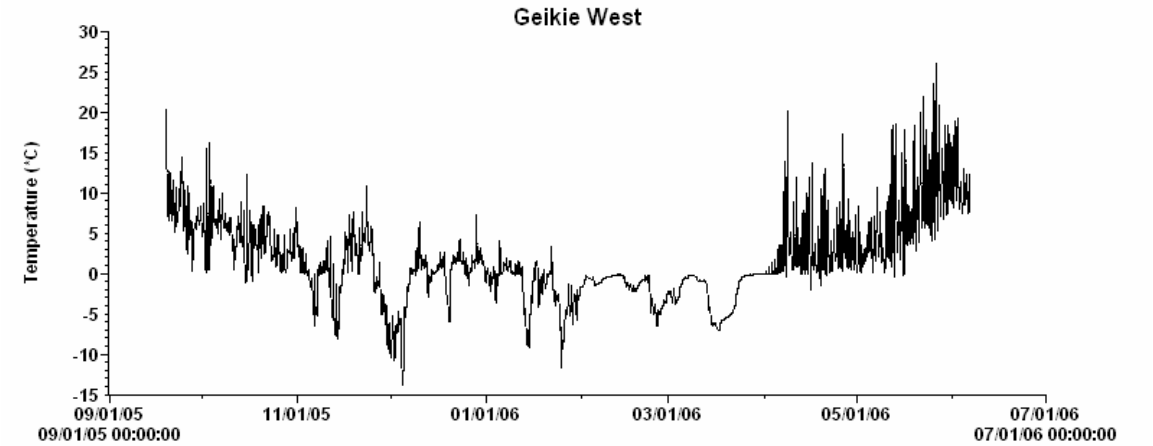
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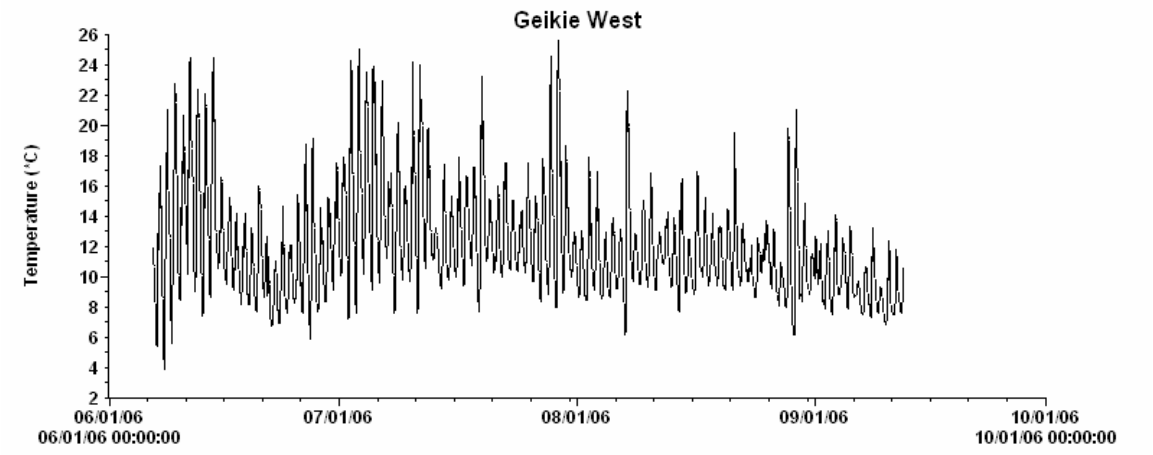
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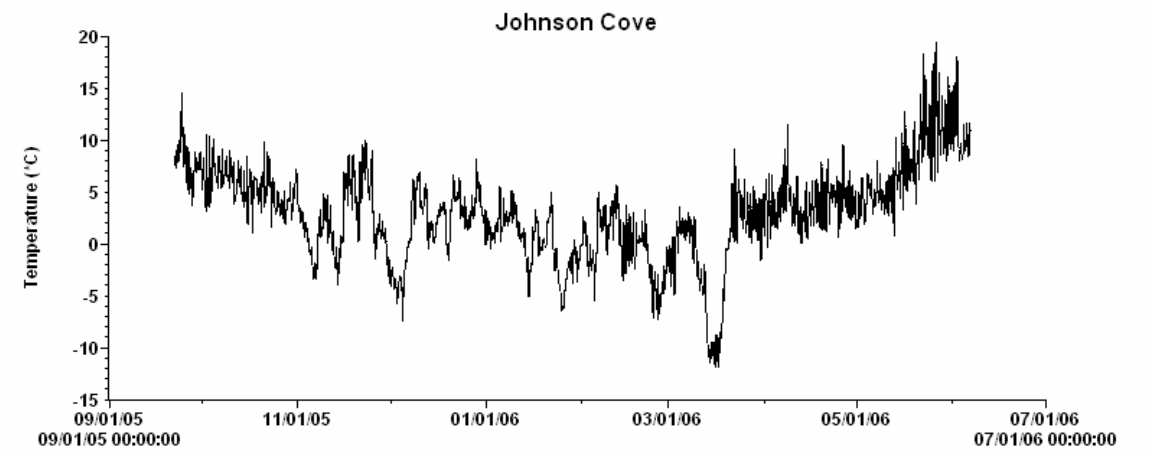
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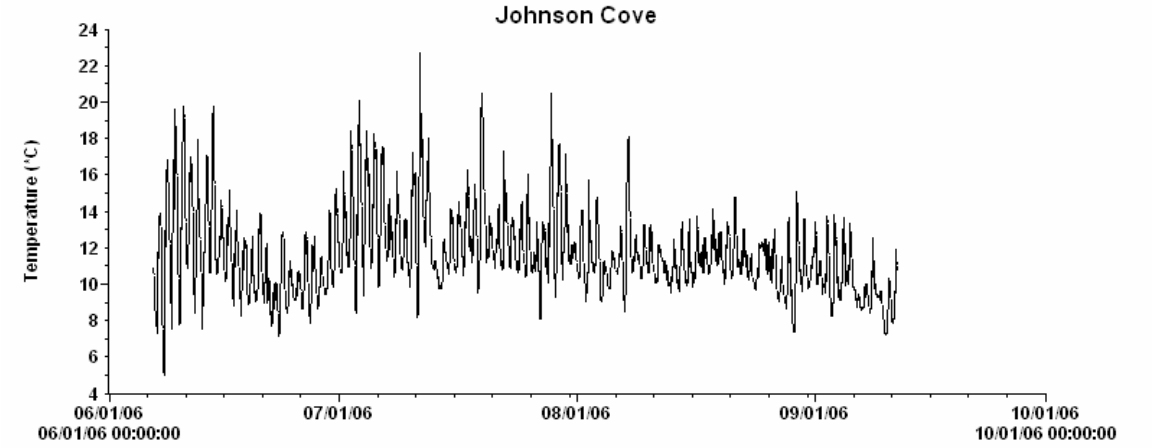
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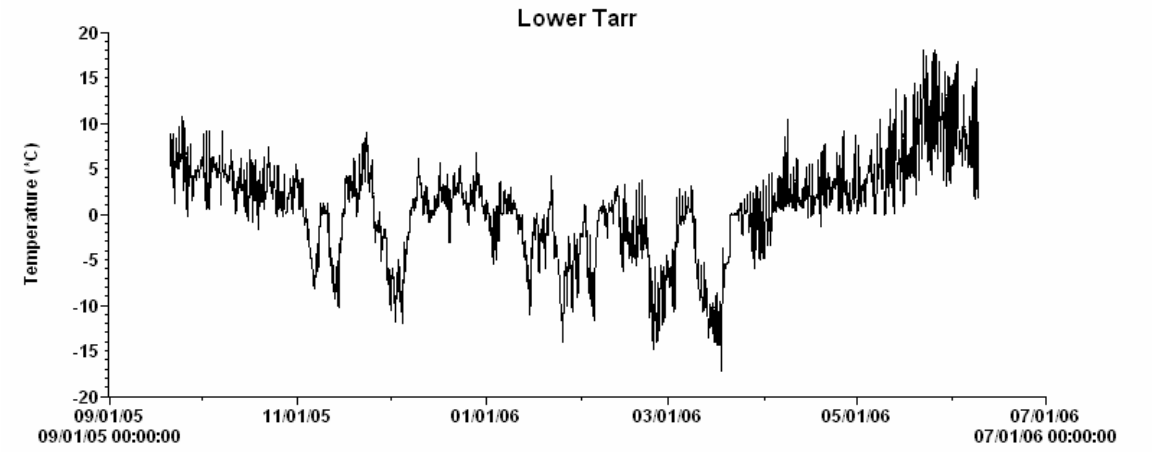
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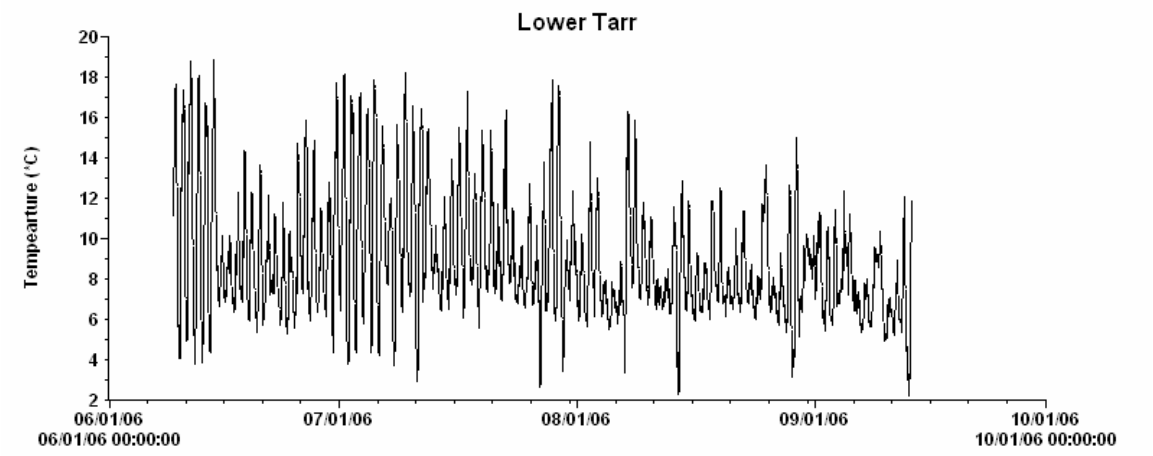
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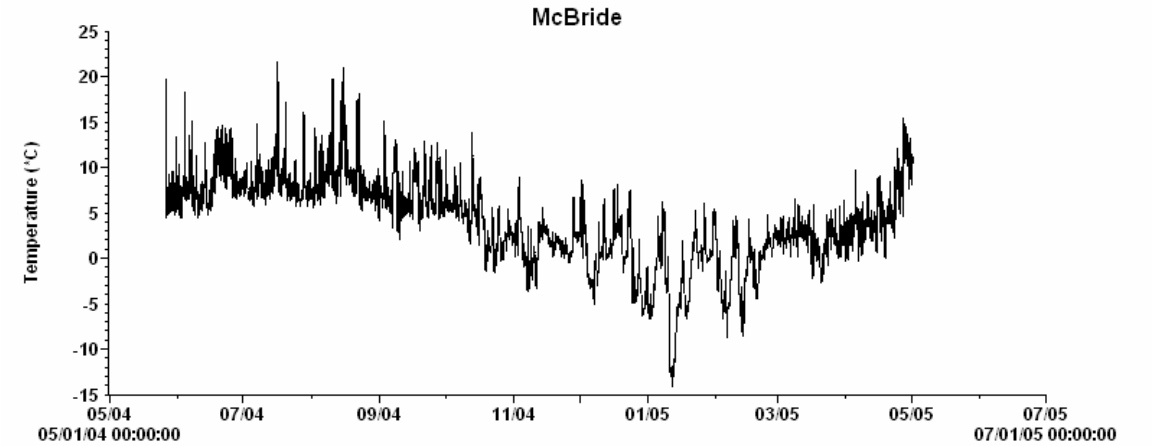
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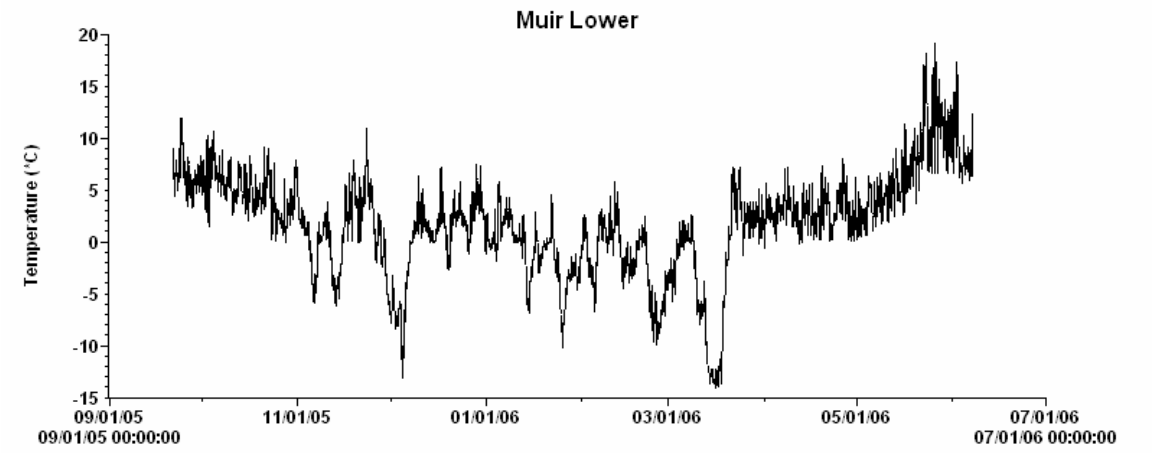
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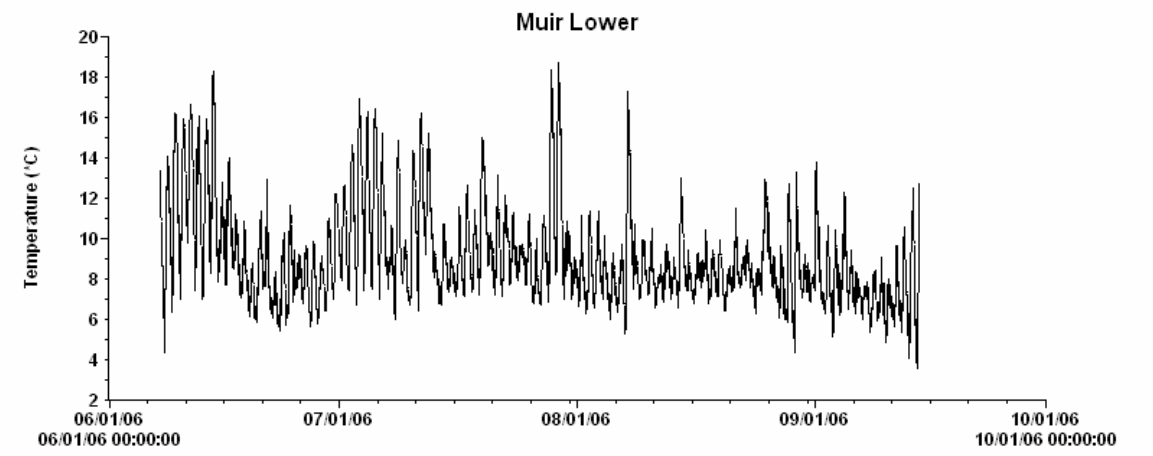
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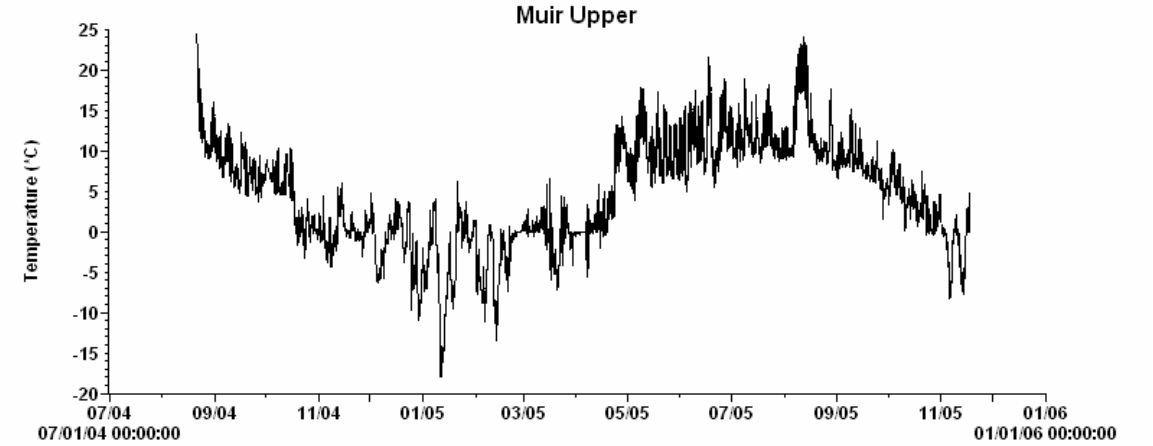
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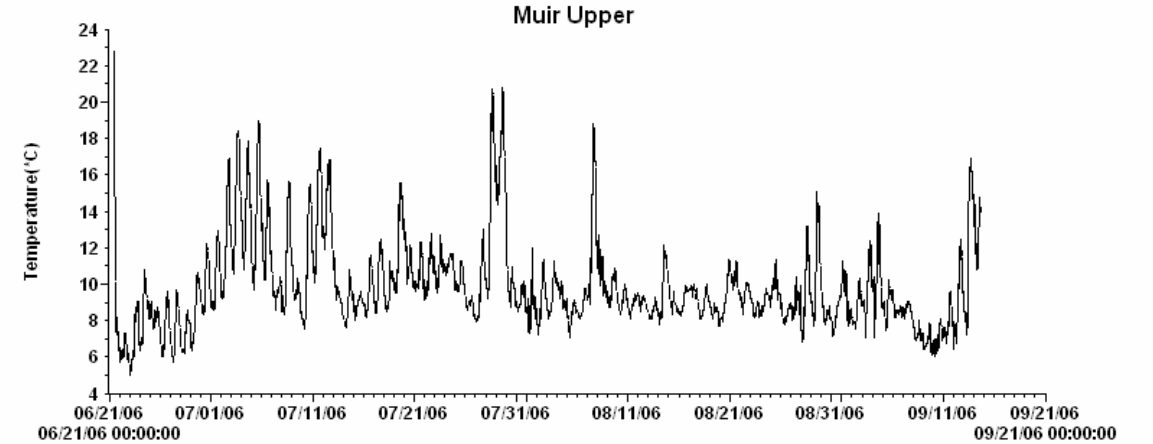
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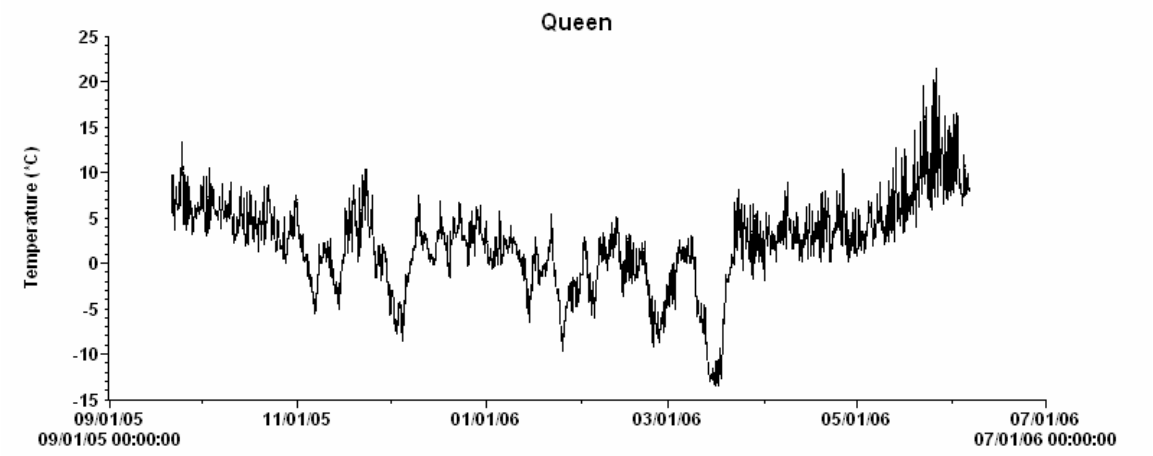
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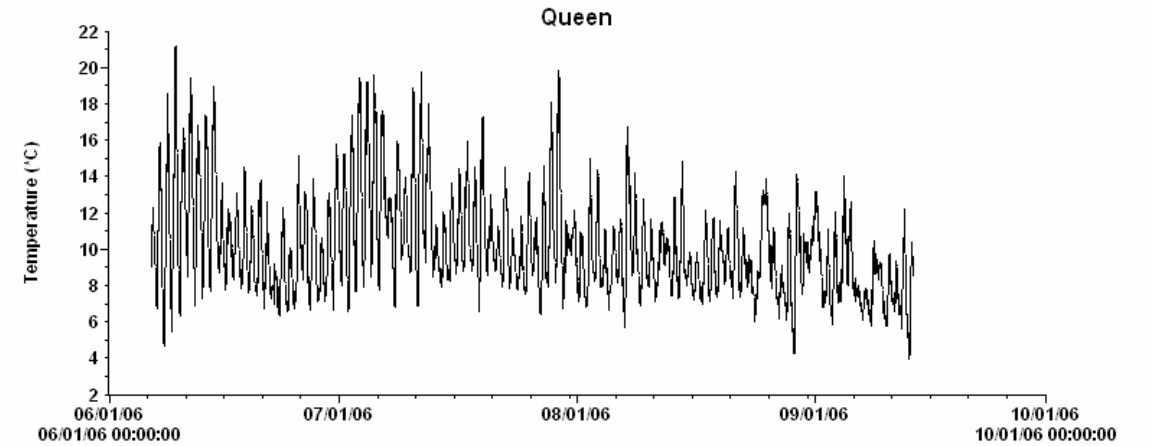
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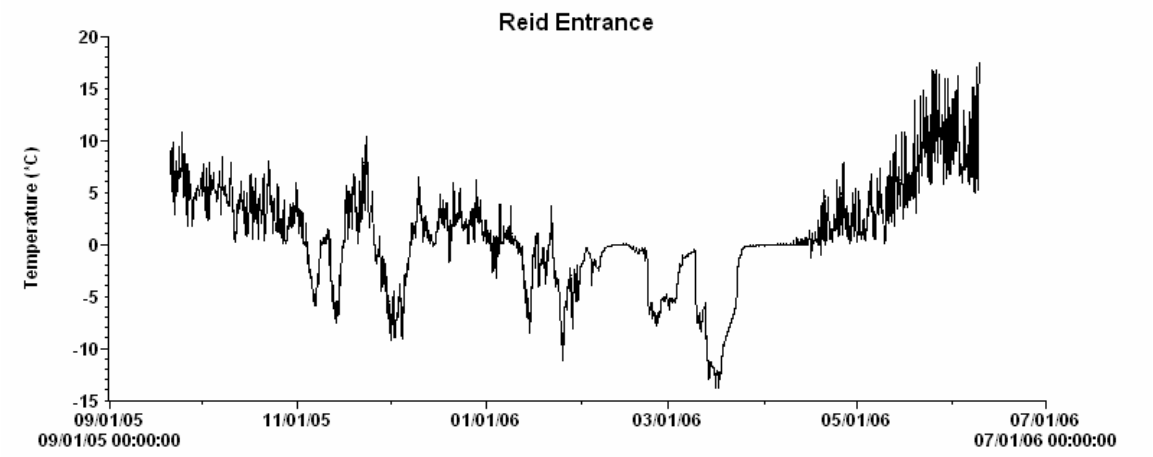
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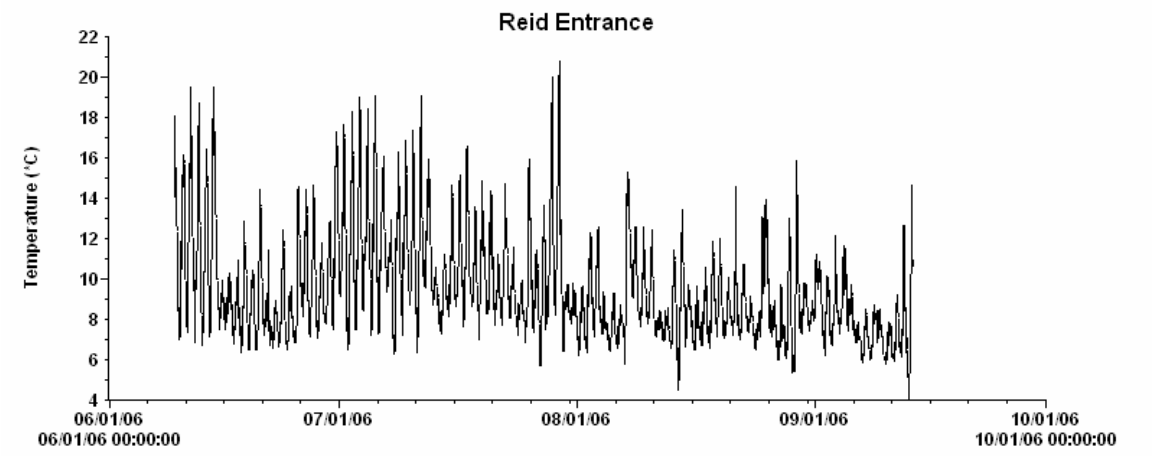
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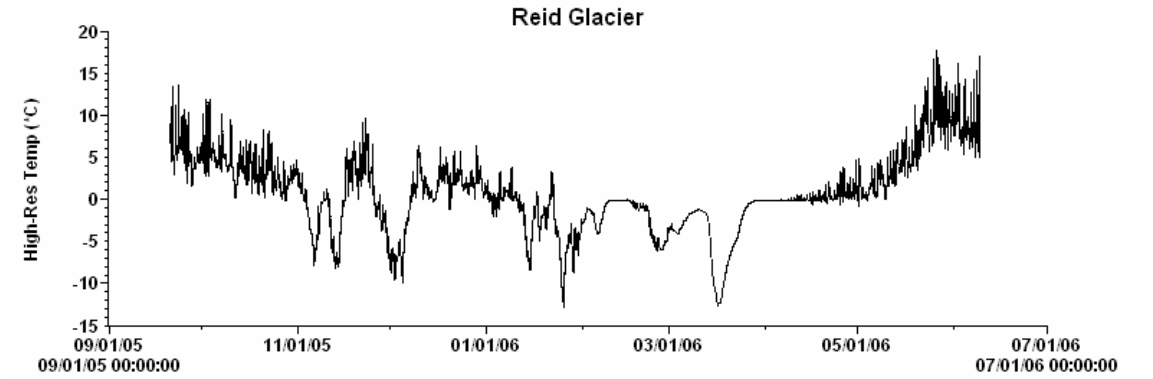
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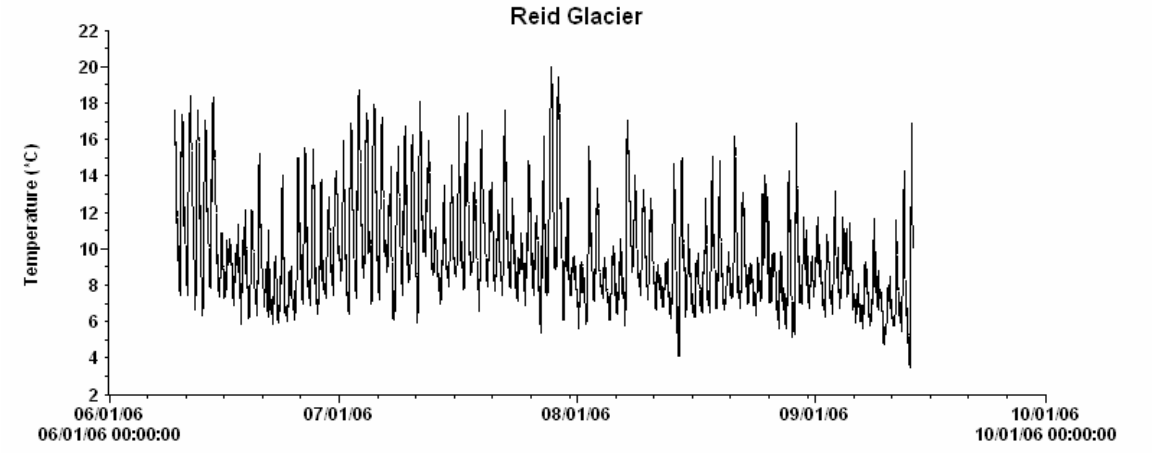
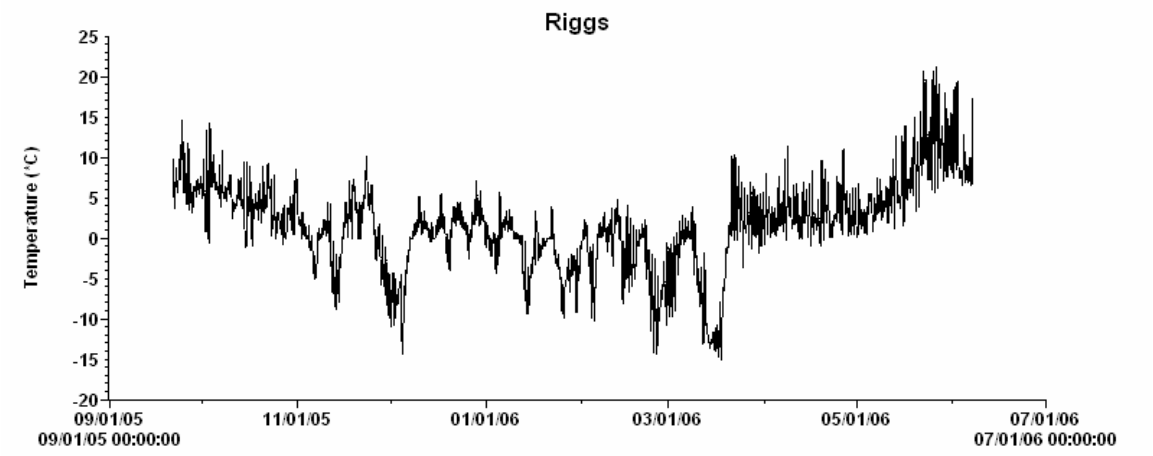
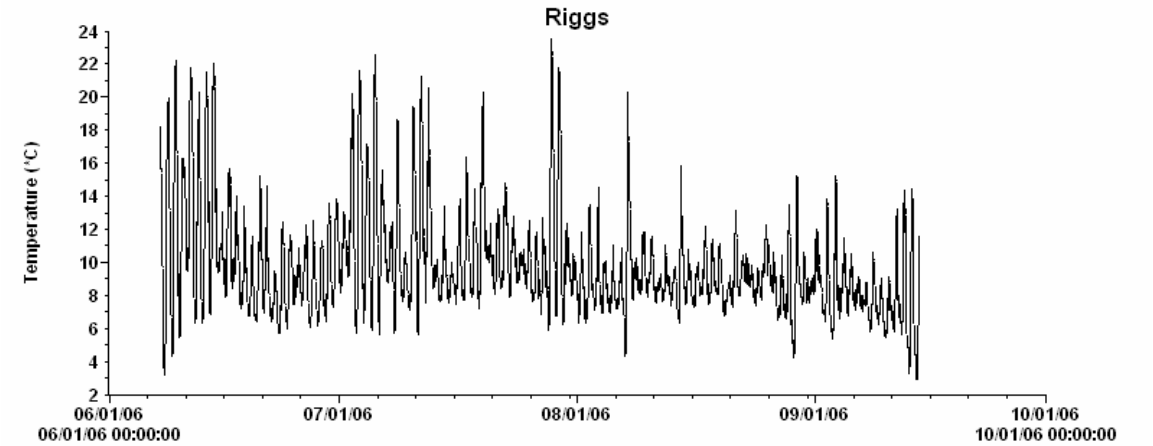
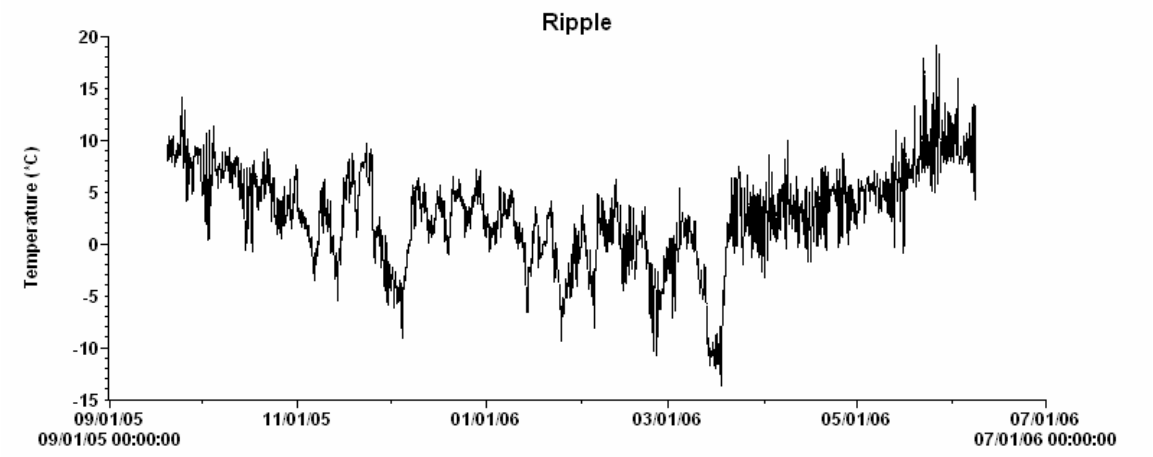
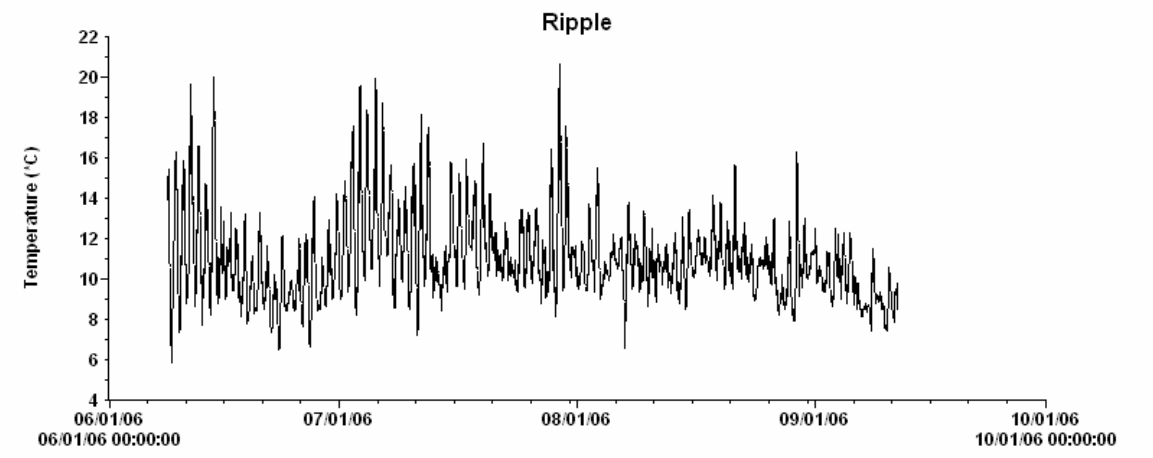
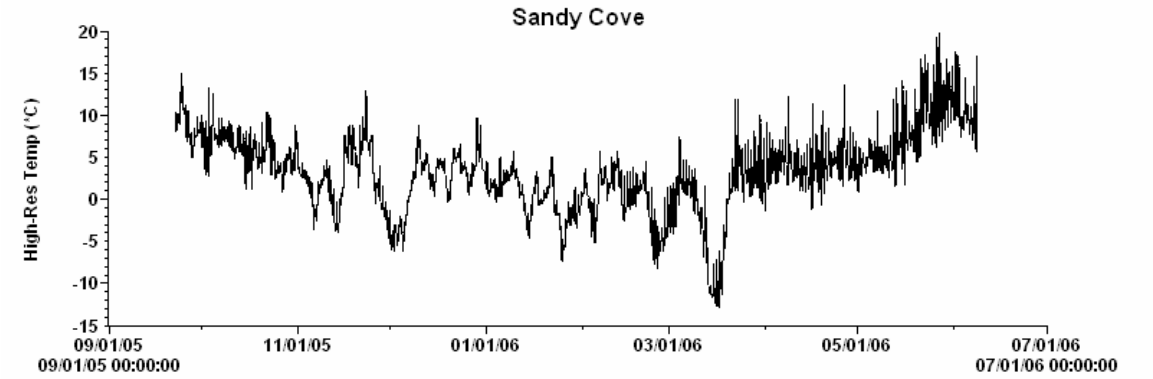

Reid Glacier
Temperature (°C)
22
20
18
16
14
12
10
8
6
4
2
06/01/06
06/01/06 00:00:00
07/01/06
08/01/06
09/01/06
10/01/06
10/01/06 00:00:00

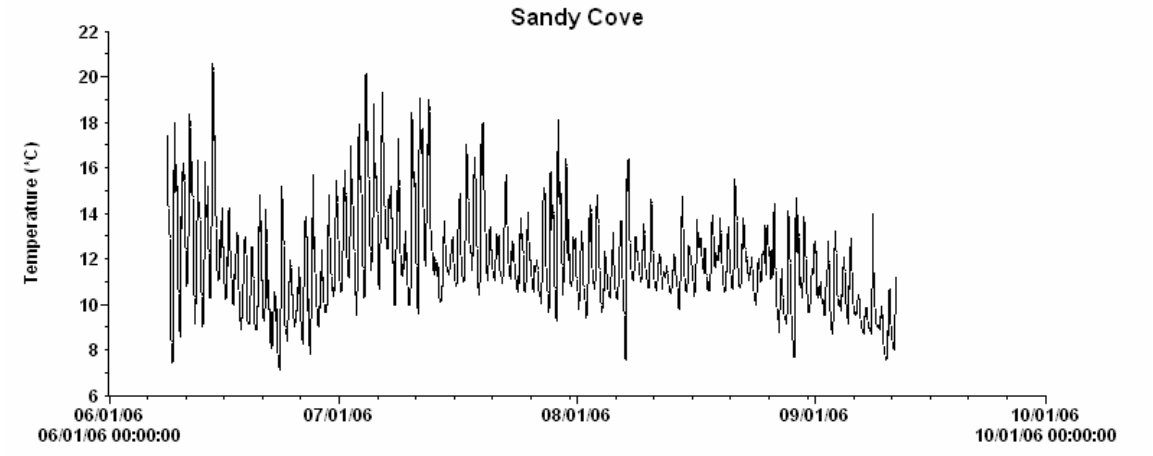

Riggs
Temperature (°C)
25
20
15
10
5
0
-5
-10
-15
-20
09/01/05
09/01/05 00:00:00
11/01/05
01/01/06
03/01/06
05/01/06
07/01/06
07/01/06 00:00:00

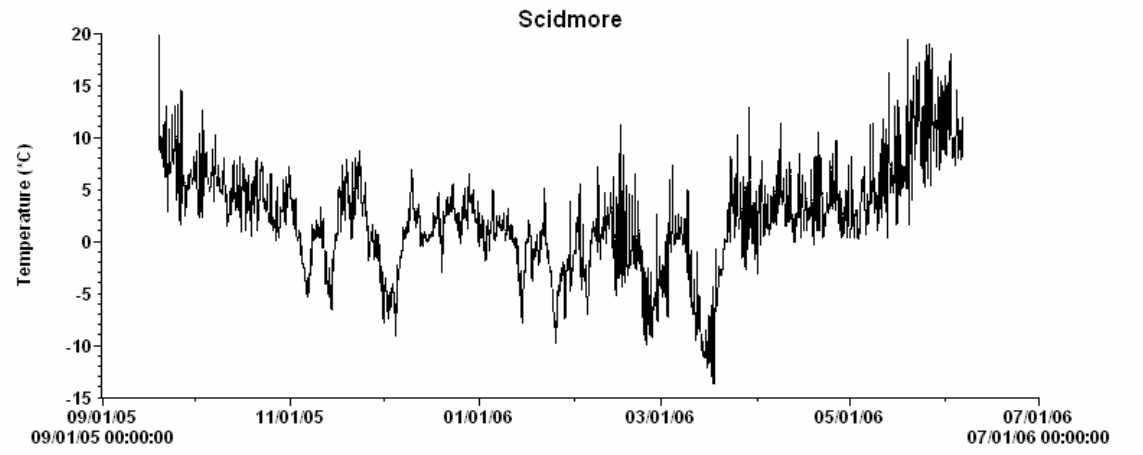

Riggs
Temperature (°C)
24
22
20
18
16
14
12
10
8
6
4
2
06/01/06
06/01/06 00:00:00
07/01/06
08/01/06
09/01/06
10/01/06
10/01/06 00:00:00

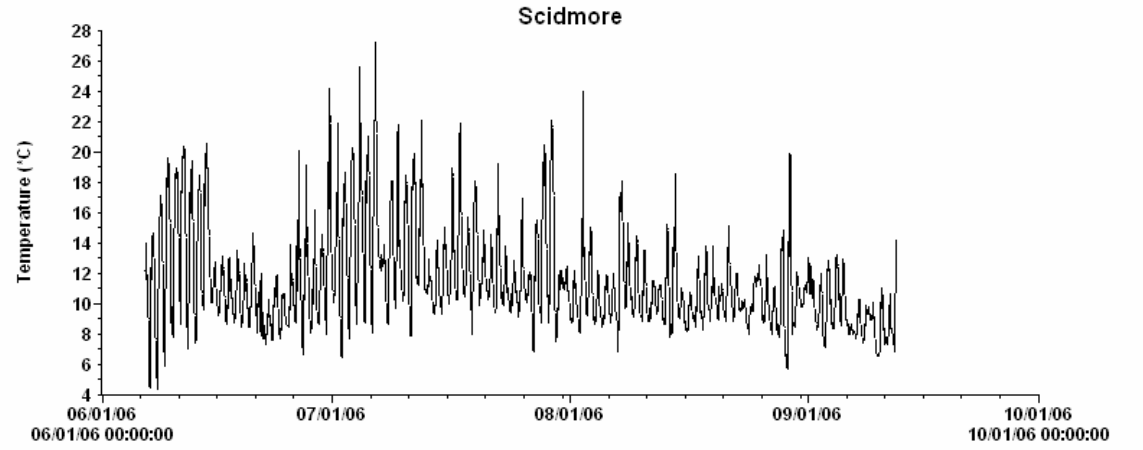

Ripple
Temperature (°C)
20
15
10
5
0
-5
-10
-15
09/01/05
09/01/05 00:00:00
11/01/05
01/01/06
03/01/06
05/01/06
07/01/06
07/01/06 00:00:00

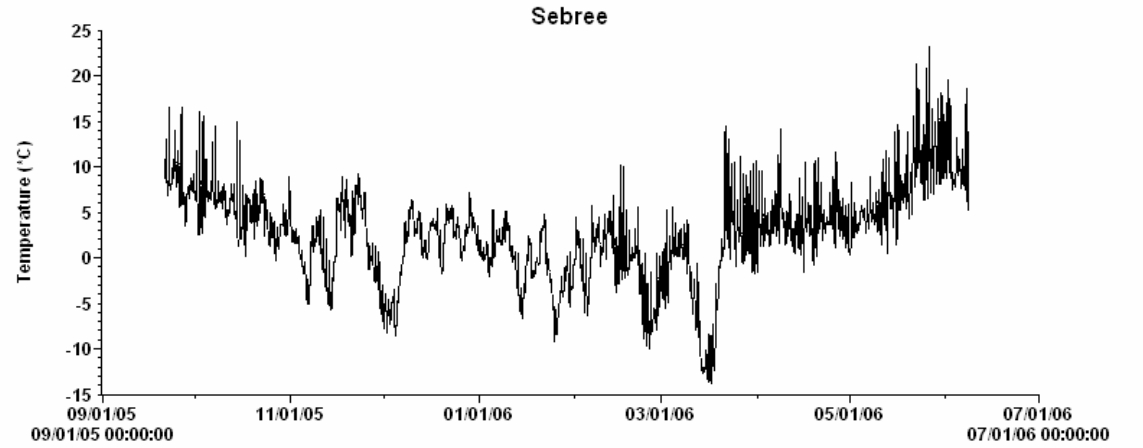

Ripple
Temperature (°C)
22
20
18
16
14
12
10
8
6
4
06/01/06
06/01/06 00:00:00
07/01/06
08/01/06
09/01/06
10/01/06
10/01/06 00:00:00

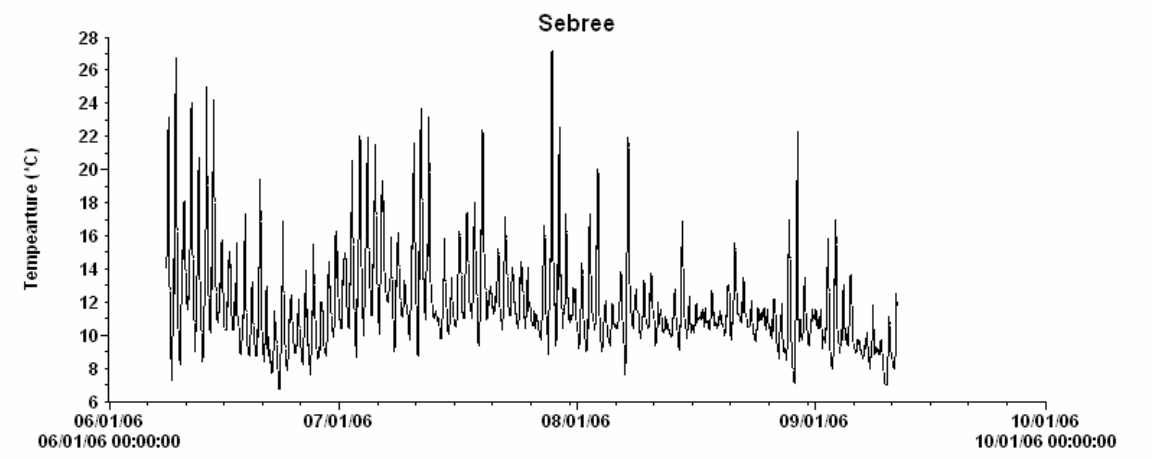

Sandy Cove
High-Res Temp (°C)
20
15
10
5
0
-5
-10
-15
09/01/05
09/01/05 00:00:00
11/01/05
01/01/06
03/01/06
05/01/06
07/01/06
07/01/06 00:00:00

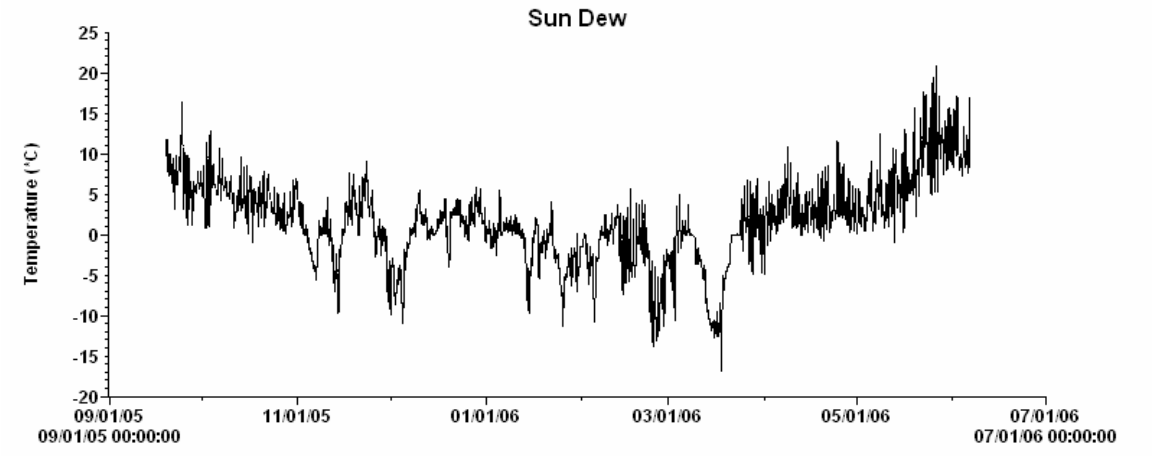

Sandy Cove
Temperature (°C)
22
20
18
16
14
12
10
8
6
06/01/06
06/01/06 00:00:00
07/01/06
08/01/06
09/01/06
10/01/06
10/01/06 00:00:00

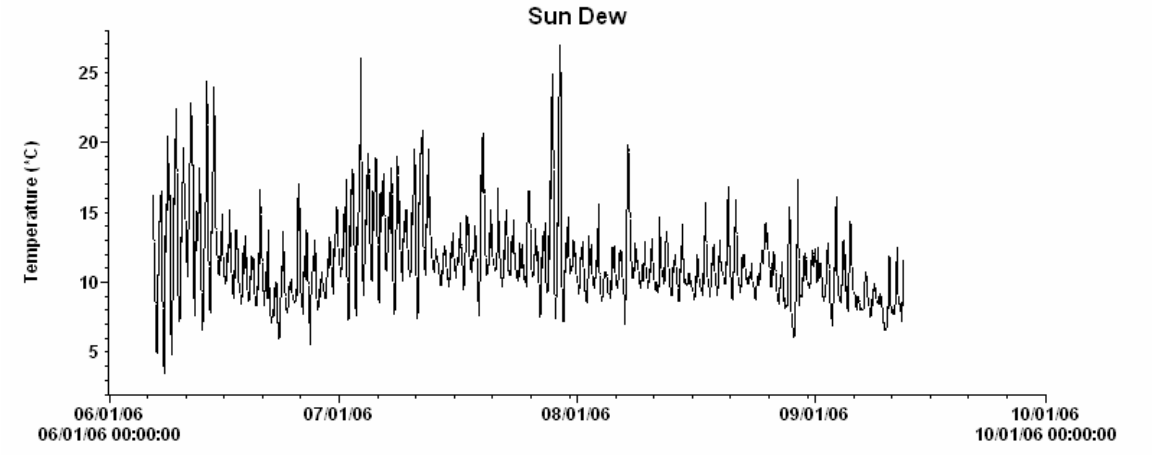

Scidmore
Temperature (°C)
20
15
10
5
0
-5
-10
-15
09/01/05
09/01/05 00:00:00
11/01/05
01/01/06
03/01/06
05/01/06
07/01/06
07/01/06 00:00:00

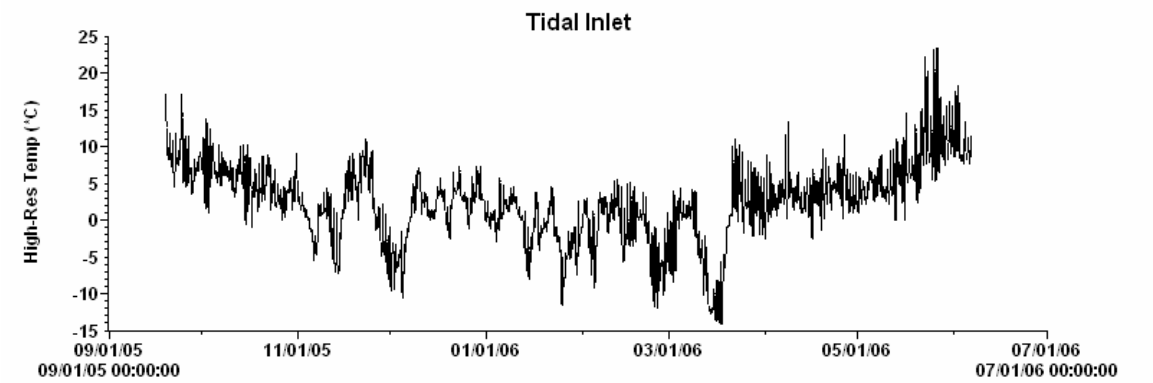

Scidmore
Temperature (°C)
28
26
24
22
20
18
16
14
12
10
8
6
4
06/01/06
06/01/06 00:00:00
07/01/06
08/01/06
09/01/06
10/01/06
10/01/06 00:00:00

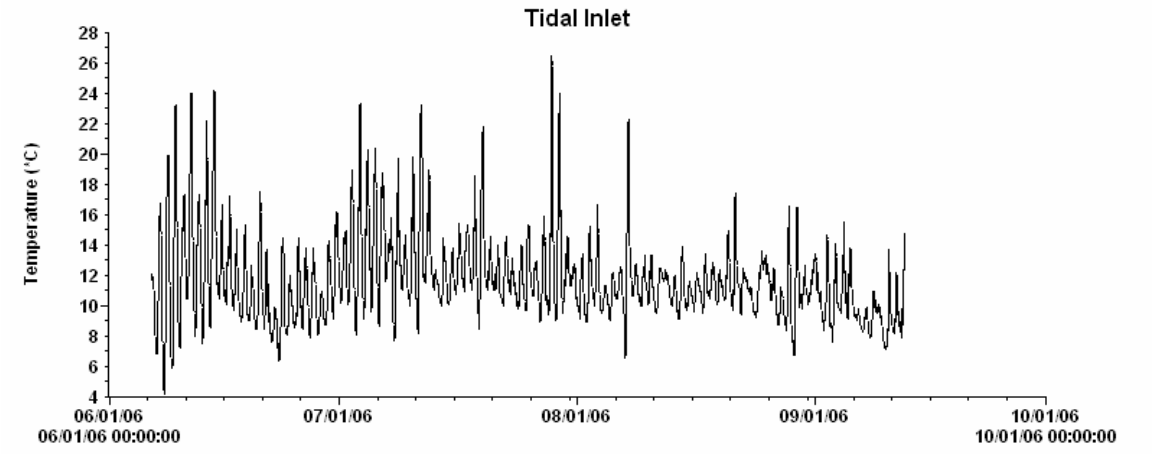

Sebree
Temperature (°C)
25
20
15
10
5
0
-5
-10
-15
09/01/05
09/01/05 00:00:00
11/01/05
01/01/06
03/01/06
05/01/06
07/01/06
07/01/06 00:00:00

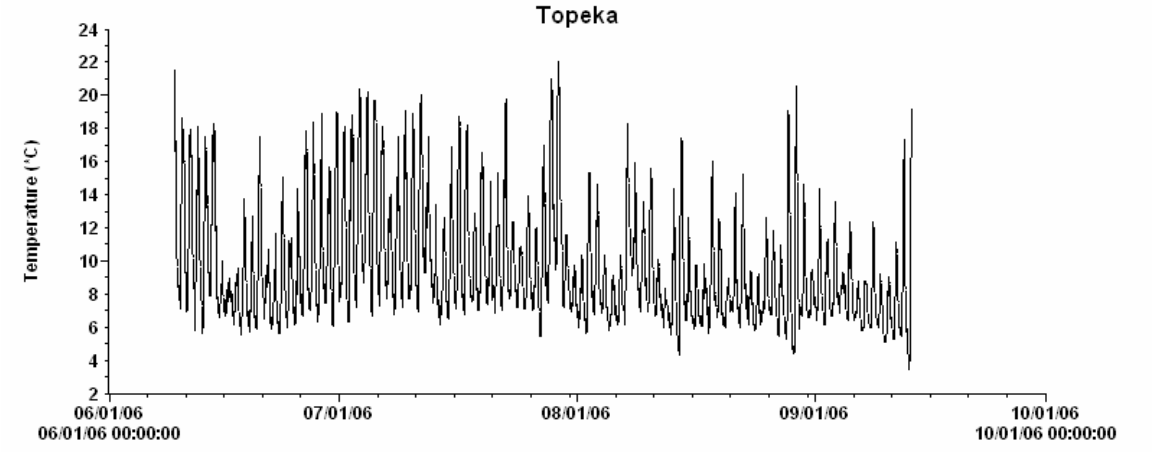

Sebree
Tempearture (°C)
28
26
24
22
20
18
16
14
12
10
8
6
06/01/06
06/01/06 00:00:00
07/01/06
08/01/06
09/01/06
10/01/06
10/01/06 00:00:00

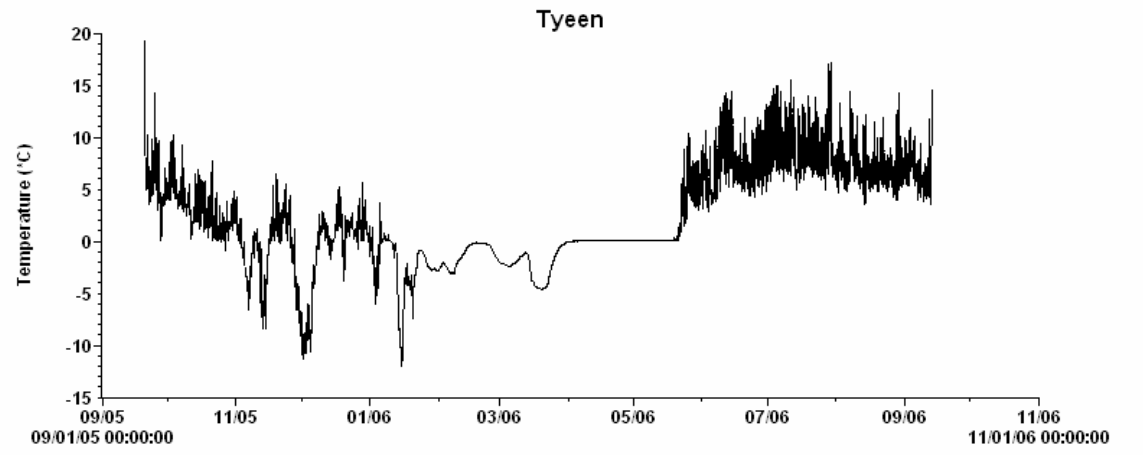

Sun Dew
Temperature (°C)
25
20
15
10
5
0
-5
-10
-15
-20
09/01/05
09/01/05 00:00:00
11/01/05
01/01/06
03/01/06
05/01/06
07/01/06
07/01/06 00:00:00

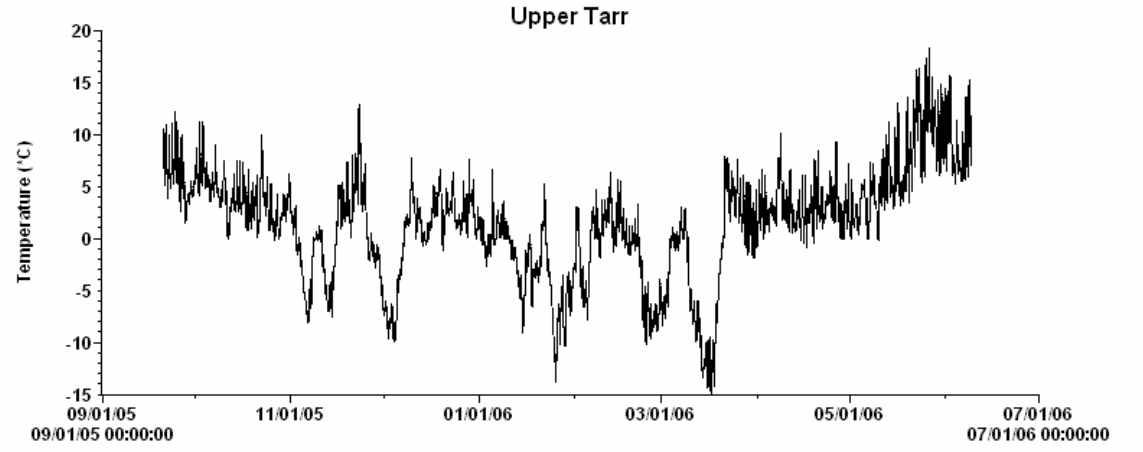

Sun Dew
Temperature (°C)
25
20
15
10
5
06/01/06
06/01/06 00:00:00
07/01/06
08/01/06
09/01/06
10/01/06
10/01/06 00:00:00

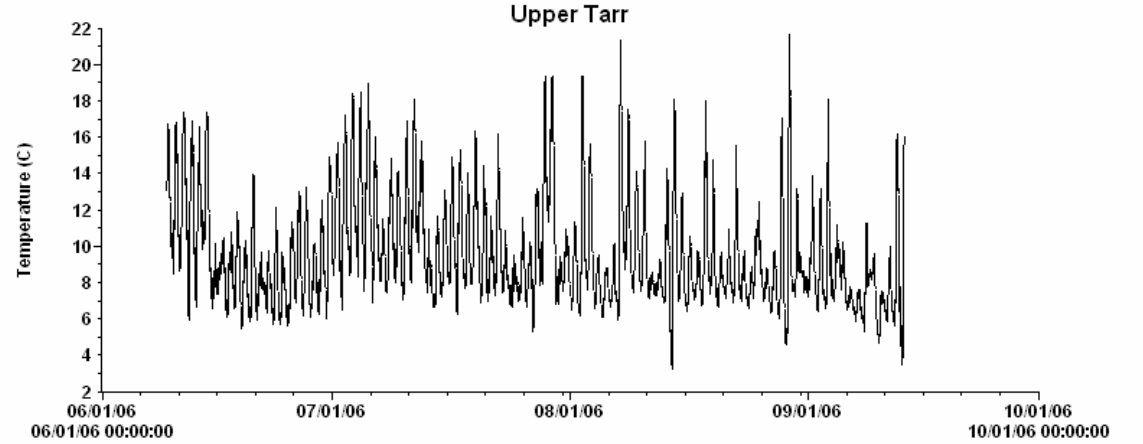

Tidal Inlet
High-Res Temp (°C)
25
20
15
10
5
0
-5
-10
-15
09/01/05
09/01/05 00:00:00
11/01/05
01/01/06
03/01/06
05/01/06
07/01/06
07/01/06 00:00:00

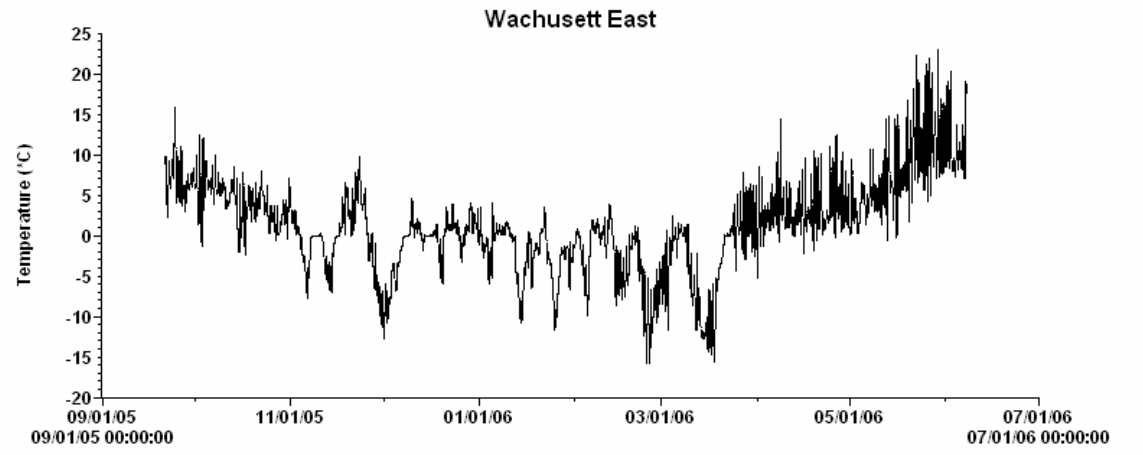

Tidal Inlet
Temperature (°C)
28
26
24
22
20
18
16
14
12
10
8
6
4
06/01/06
06/01/06 00:00:00
07/01/06
08/01/06
09/01/06
10/01/06
10/01/06 00:00:00

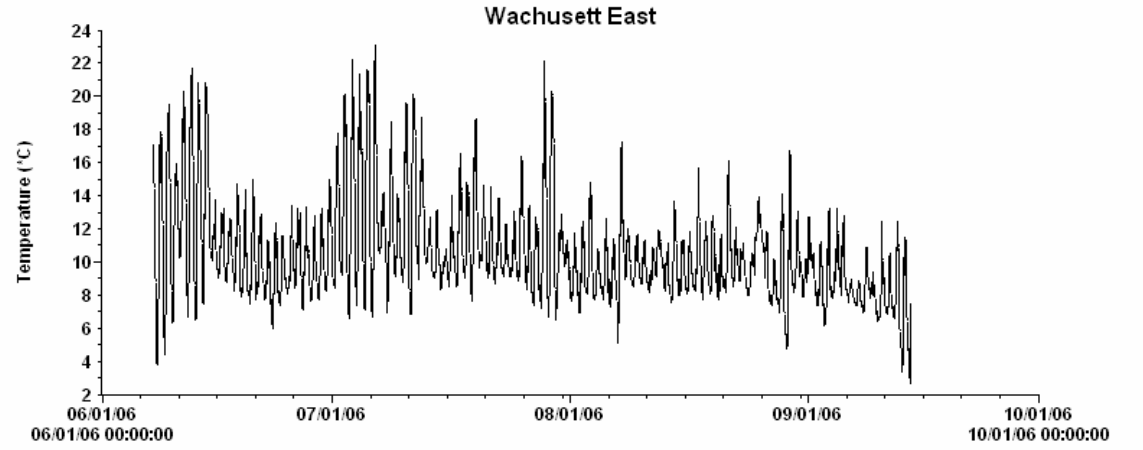

Topeka
Temperature (°C)
24
22
20
18
16
14
12
10
8
6
4
2
06/01/06
06/01/06 00:00:00
07/01/06
08/01/06
09/01/06
10/01/06
10/01/06 00:00:00

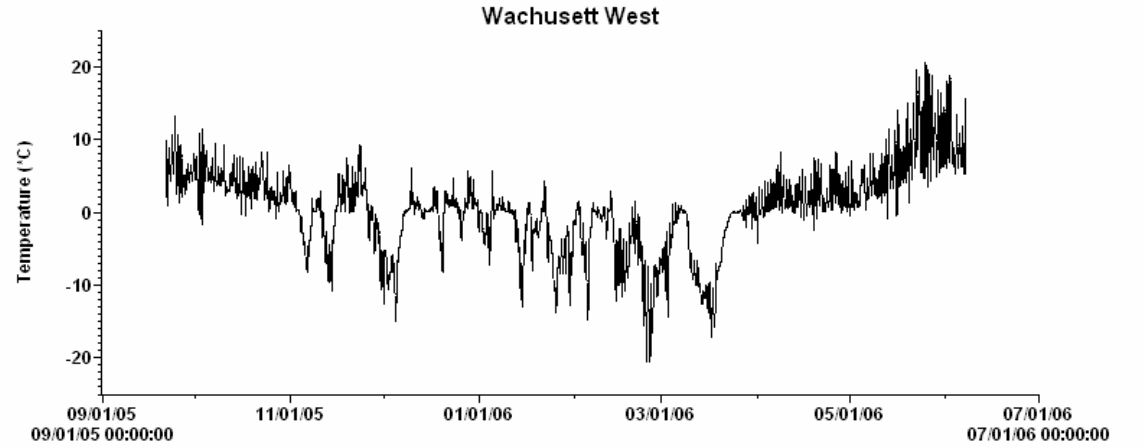

Tyeen
Temperature (°C)
20
15
10
5
0
-5
-10
-15
09/05
09/01/05 00:00:00
11/05
01/06
03/06
05/06
07/06
09/06
11/06
11/01/06 00:00:00

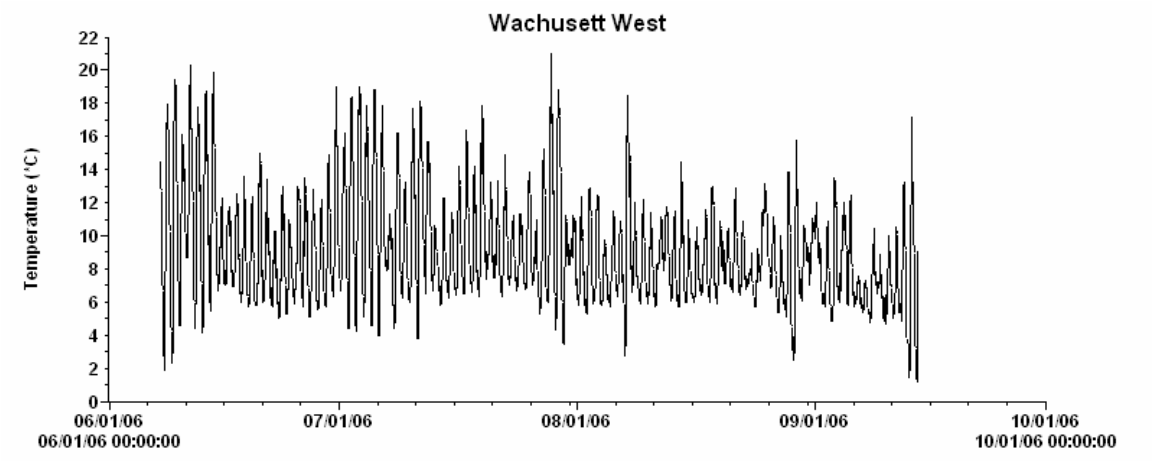

Upper Tarr
Temperature (°C)
20
15
10
5
0
-5
-10
-15
09/01/05
09/01/05 00:00:00
11/01/05
01/01/06
03/01/06
05/01/06
07/01/06
07/01/06 00:00:00


Upper Tarr
Temperature (C)
22
20
18
16
14
12
10
8
6
4
2
06/01/06
06/01/06 00:00:00
07/01/06
08/01/06
09/01/06
10/01/06
10/01/06 00:00:00


Wachusett East
Temperature (°C)
25
20
15
10
5
0
-5
-10
-15
-20
09/01/05
09/01/05 00:00:00
11/01/05
01/01/06
03/01/06
05/01/06
07/01/06
07/01/06 00:00:00

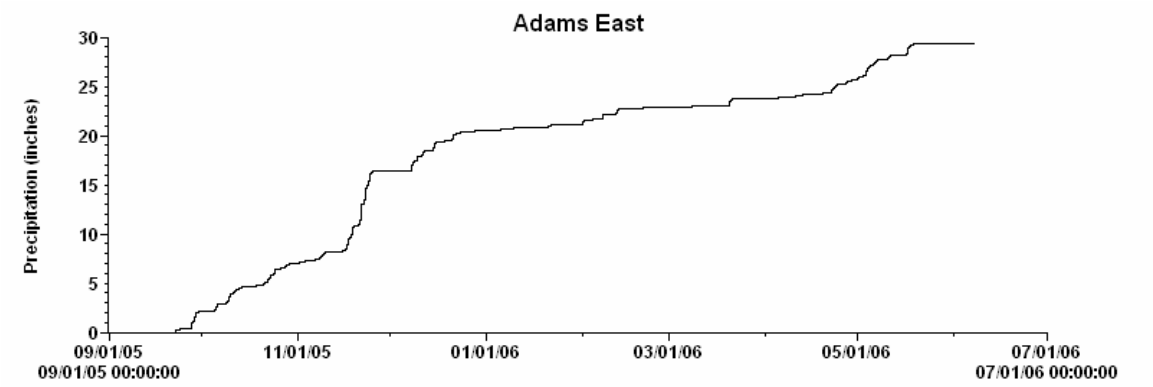

Wachusett East
Temperature (°C)
24
22
20
18
16
14
12
10
8
6
4
2
06/01/06
06/01/06 00:00:00
07/01/06
08/01/06
09/01/06
10/01/06
10/01/06 00:00:00

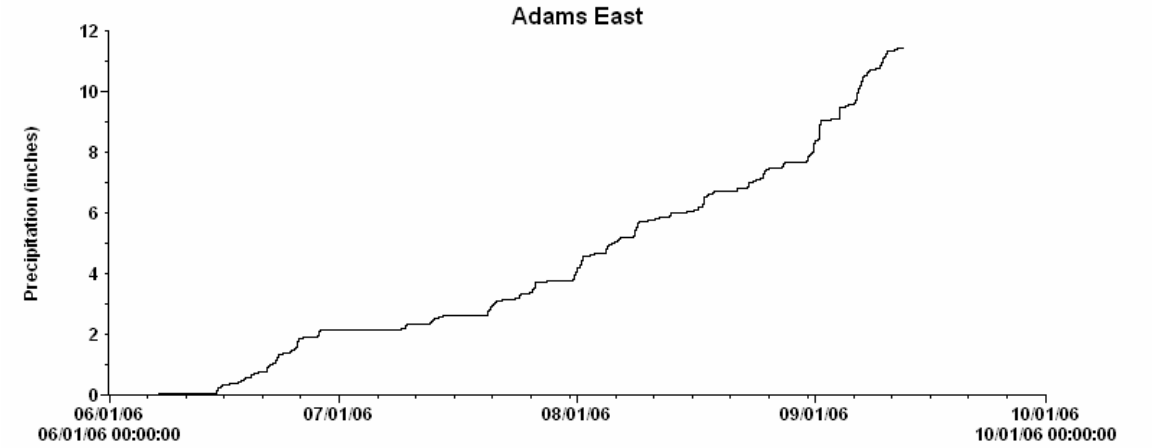

Wachusett West
Temperature (°C)
20
10
0
-10
-20
09/01/05
09/01/05 00:00:00
11/01/05
01/01/06
03/01/06
05/01/06
07/01/06
07/01/06 00:00:00

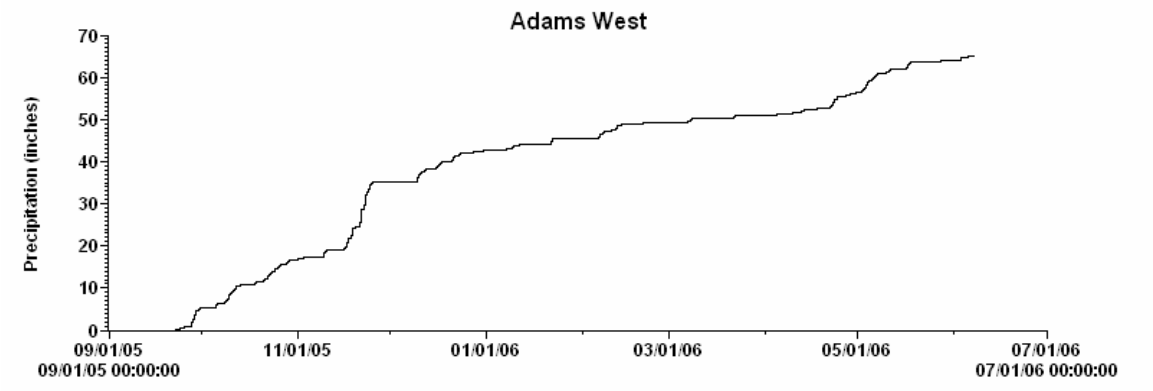

Wachusett West
Temperature (°C)
22
20
18
16
14
12
10
8
6
4
2
0
06/01/06
06/01/06 00:00:00
07/01/06
08/01/06
09/01/06
10/01/06
10/01/06 00:00:00

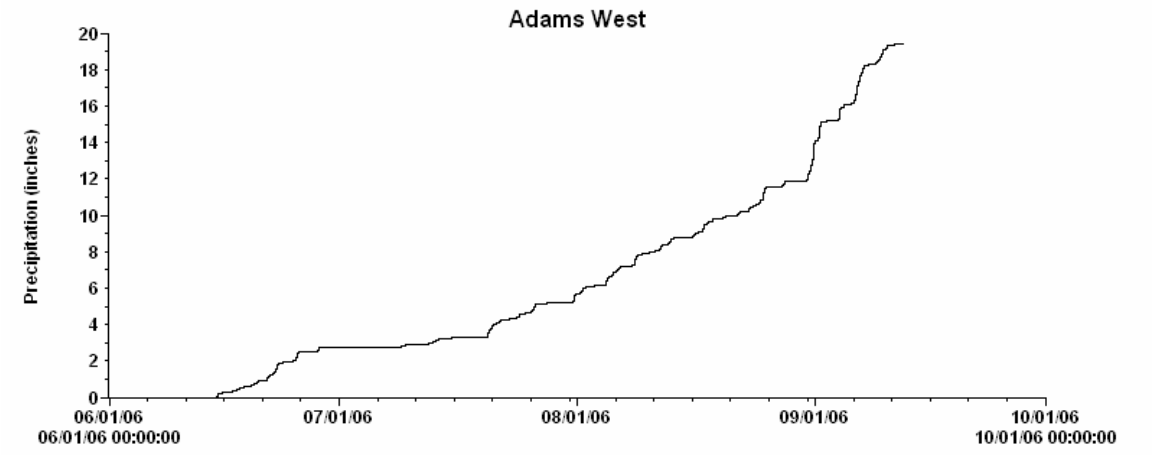
Appendix B.
Raw Precipitation Data 2006

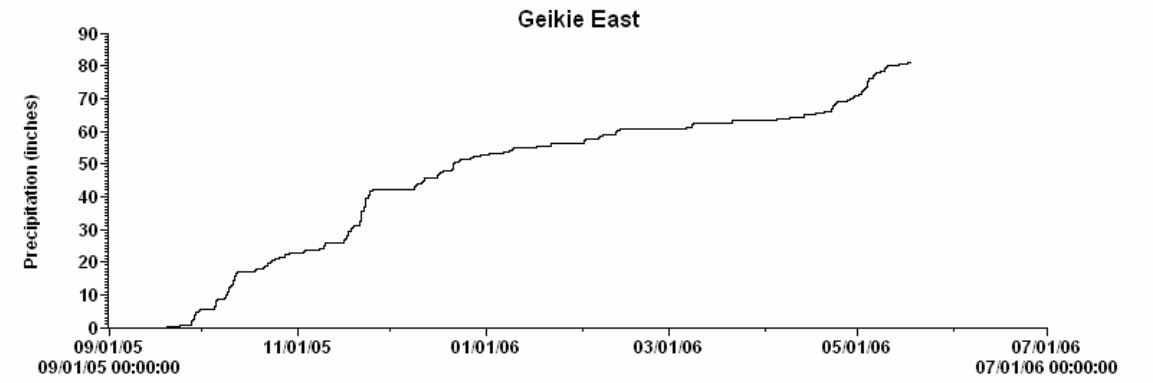
The graphs provided in this appendix illustrate the raw precipitation data acquired in 2006 during site visits in June and September. These data are for illustration only and need to be quality checked as well as assessed and corrected for site-specific problems. Combined downloads generally cover the period of September 2005 to September 2006. Missing datasets are described in the text.

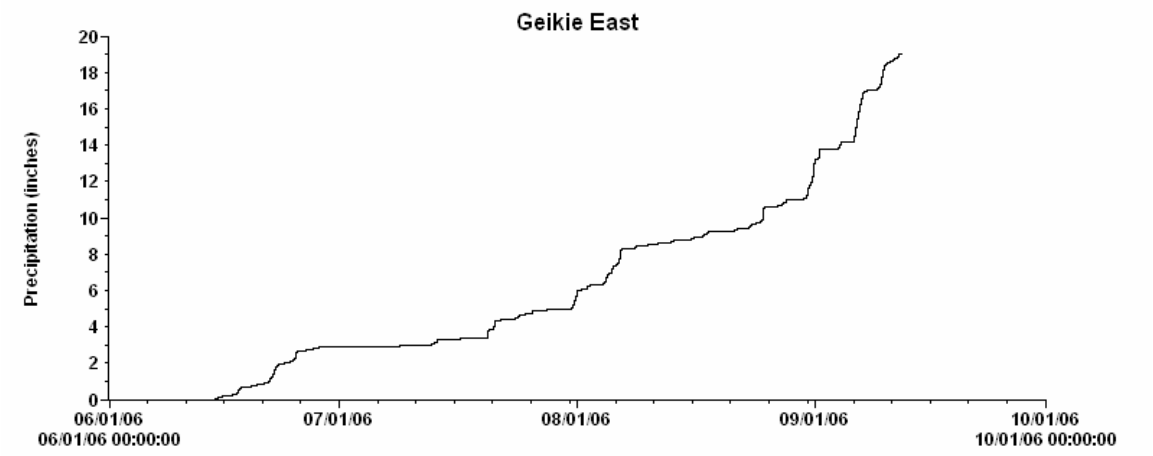


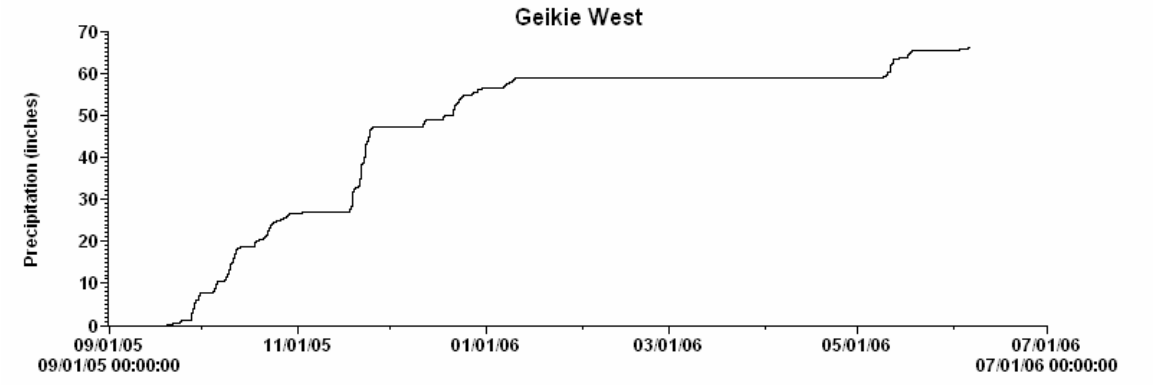


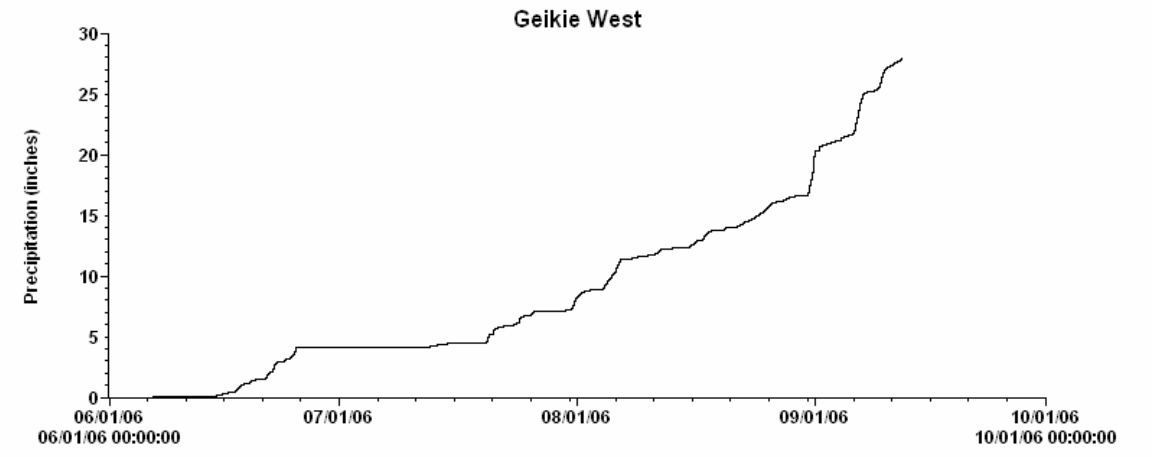

Adams West
Precipitation (inches)
70
60
50
40
30
20
10
0
09/01/05
09/01/05 00:00:00
11/01/05
01/01/06
03/01/06
05/01/06
07/01/06
07/01/06 00:00:00

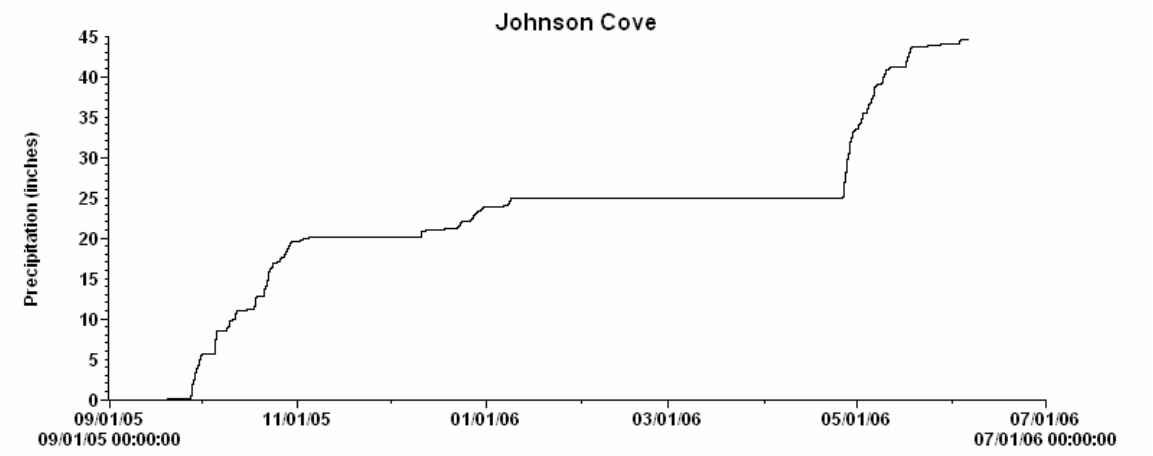

Adams West
Precipitation (inches)
20
18
16
14
12
10
8
6
4
2
0
06/01/06
06/01/06 00:00:00
07/01/06
08/01/06
09/01/06
10/01/06
10/01/06 00:00:00

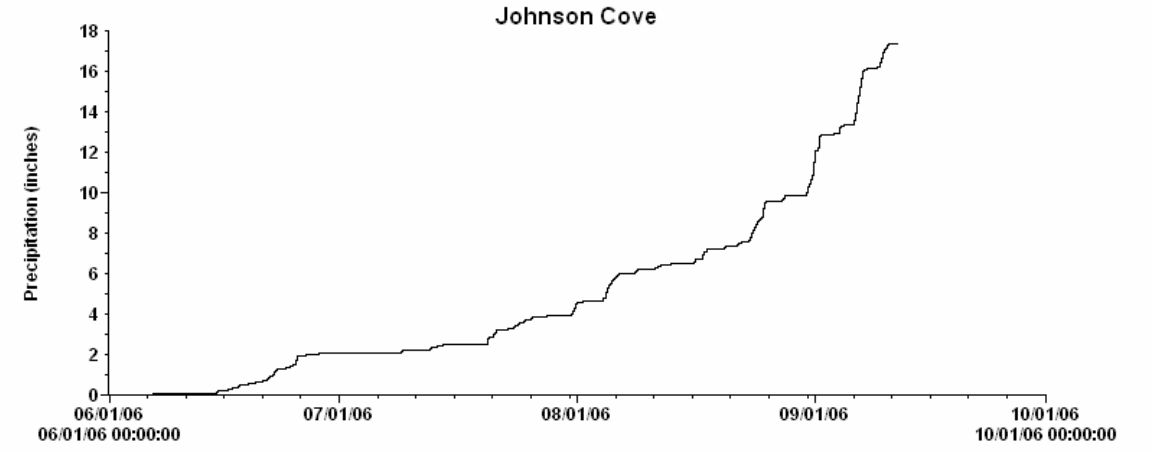

Geikie East
Precipitation (inches)
90
80
70
60
50
40
30
20
10
0
09/01/05
09/01/05 00:00:00
11/01/05
01/01/06
03/01/06
05/01/06
07/01/06
07/01/06 00:00:00

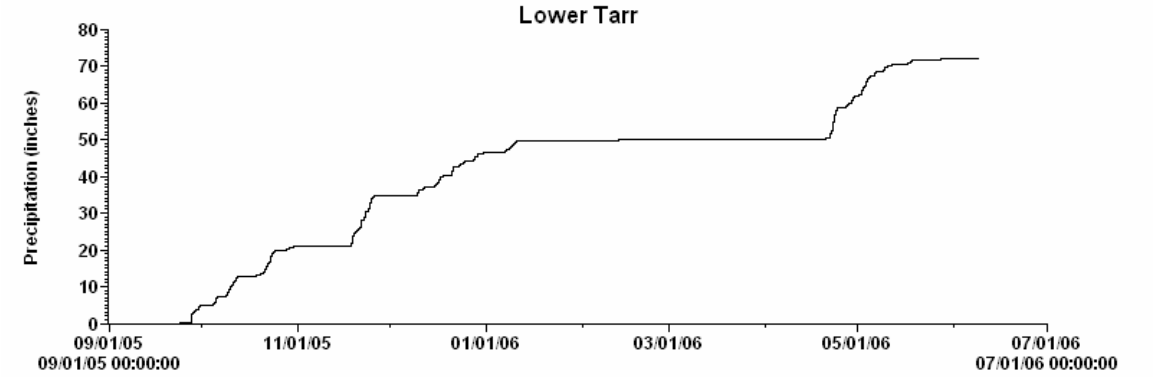

Geikie East
Precipitation (inches)
0
2
4
6
8
10
12
14
16
18
20
06/01/06
06/01/06 00:00:00
07/01/06
08/01/06
09/01/06
10/01/06
10/01/06 00:00:00

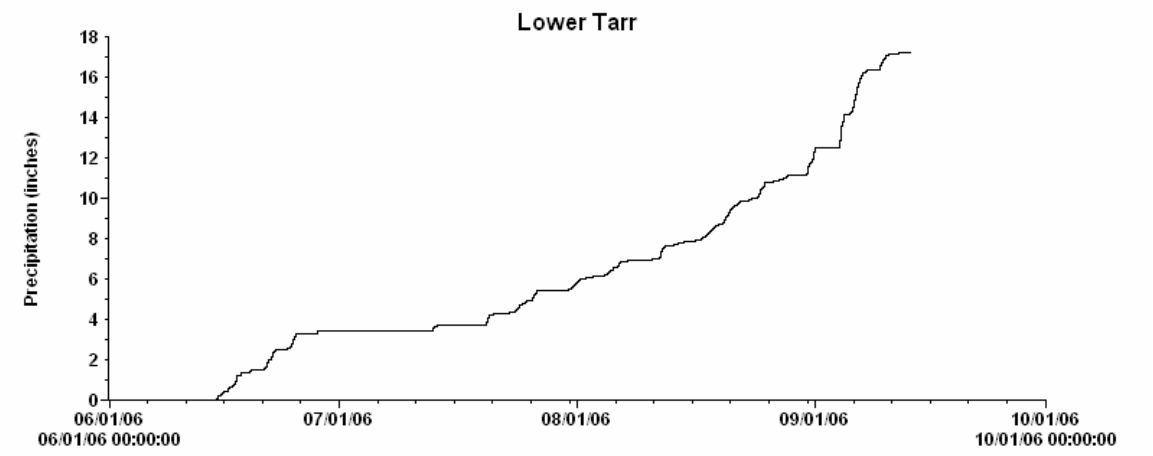

Geikie West
Precipitation (inches)
0
10
20
30
40
50
60
70
09/01/05
09/01/05 00:00:00
11/01/05
01/01/06
03/01/06
05/01/06
07/01/06
07/01/06 00:00:00

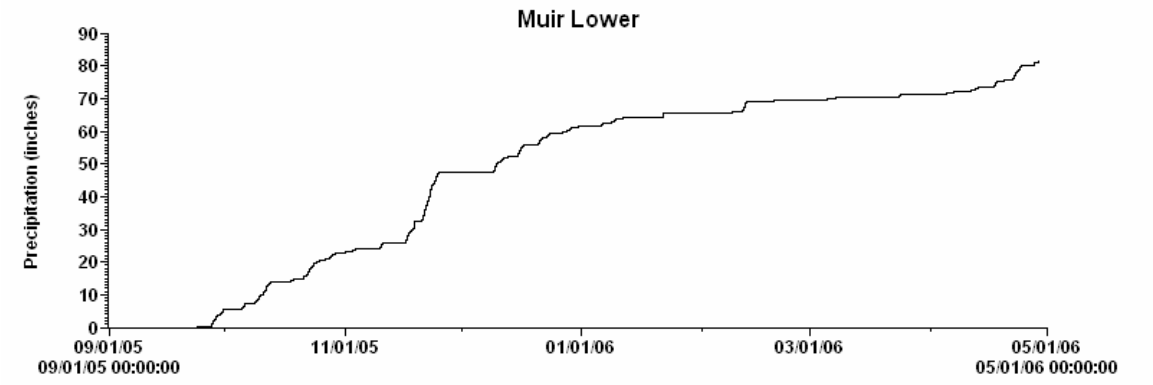

Geikie West
Precipitation (inches)
0
5
10
15
20
25
30
06/01/06
06/01/06 00:00:00
07/01/06
08/01/06
09/01/06
10/01/06
10/01/06 00:00:00

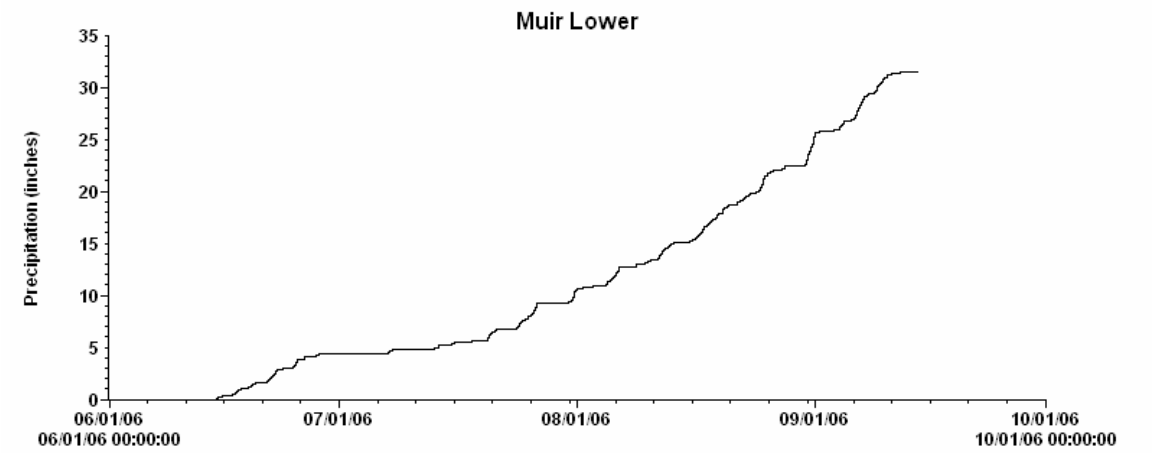

Johnson Cove
Precipitation (inches)
0
5
10
15
20
25
30
35
40
45
09/01/05
09/01/05 00:00:00
11/01/05
01/01/06
03/01/06
05/01/06
07/01/06
07/01/06 00:00:00

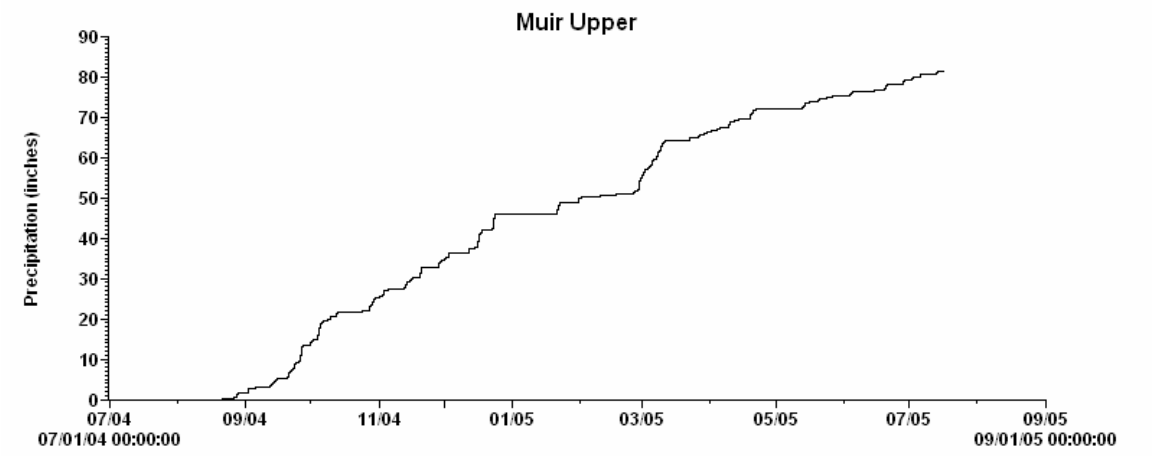

Johnson Cove
Precipitation (inches)
0
2
4
6
8
10
12
14
16
18
06/01/06
06/01/06 00:00:00
07/01/06
08/01/06
09/01/06
10/01/06
10/01/06 00:00:00

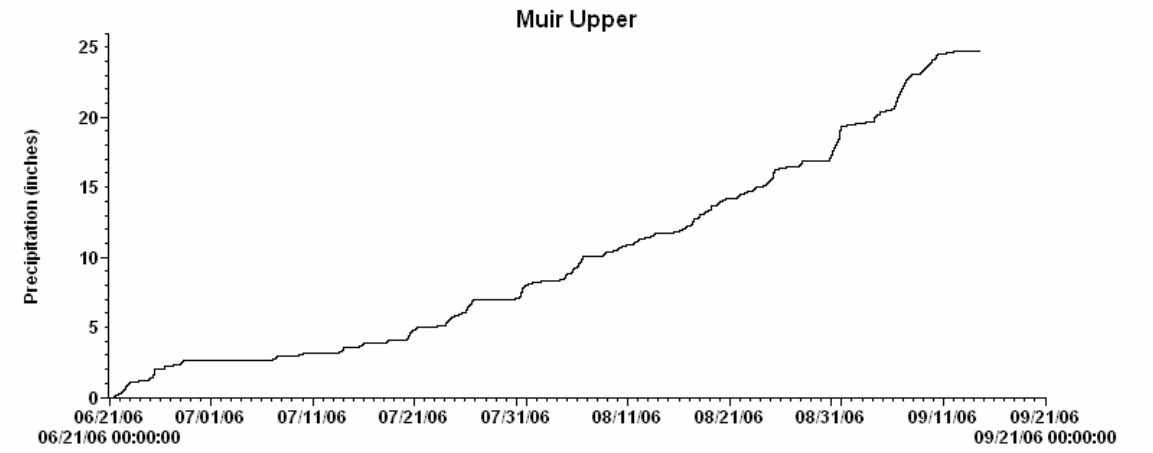

Lower Tarr
Precipitation (inches)
0
10
20
30
40
50
60
70
80
09/01/05
09/01/05 00:00:00
11/01/05
01/01/06
03/01/06
05/01/06
07/01/06
07/01/06 00:00:00

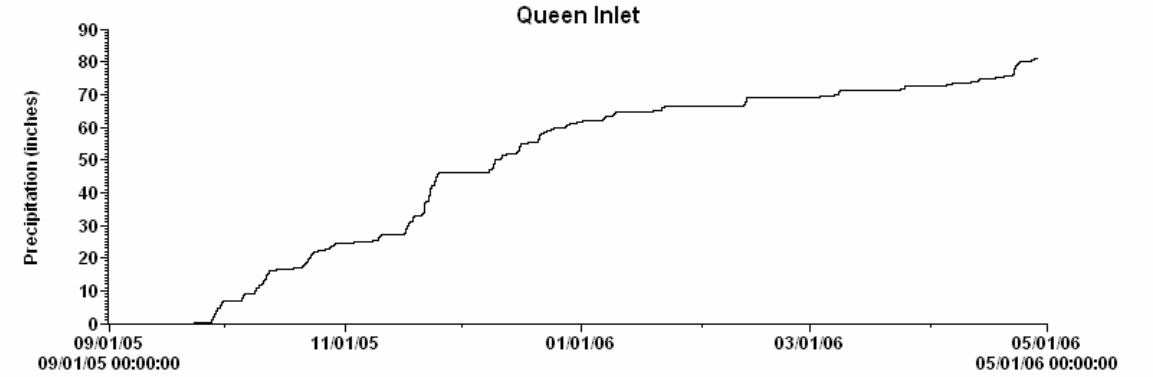

Lower Tarr
Precipitation (inches)
0
2
4
6
8
10
12
14
16
18
06/01/06
06/01/06 00:00:00
07/01/06
08/01/06
09/01/06
10/01/06
10/01/06 00:00:00

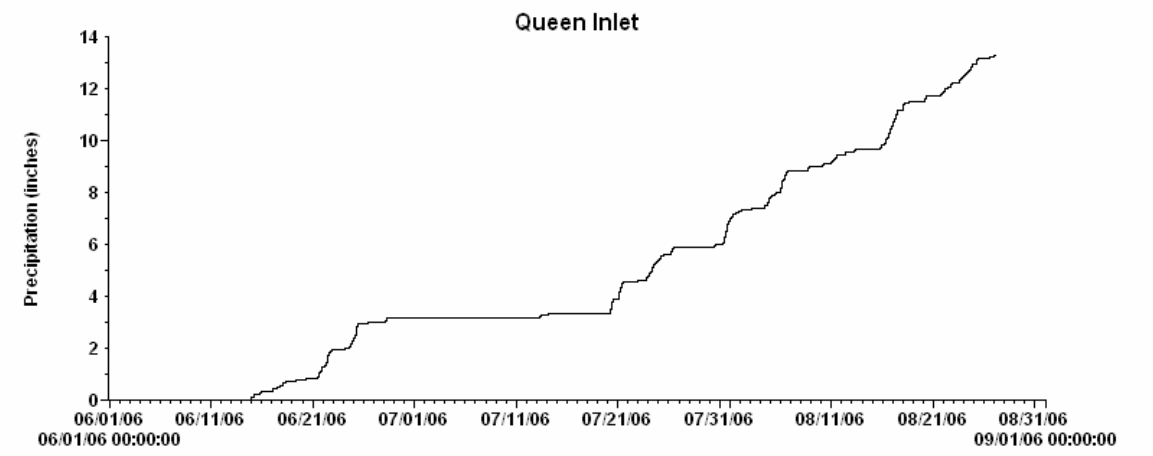

Muir Lower
Precipitation (inches)
0
10
20
30
40
50
60
70
80
90
09/01/05
09/01/05 00:00:00
11/01/05
01/01/06
03/01/06
05/01/06
05/01/06 00:00:00

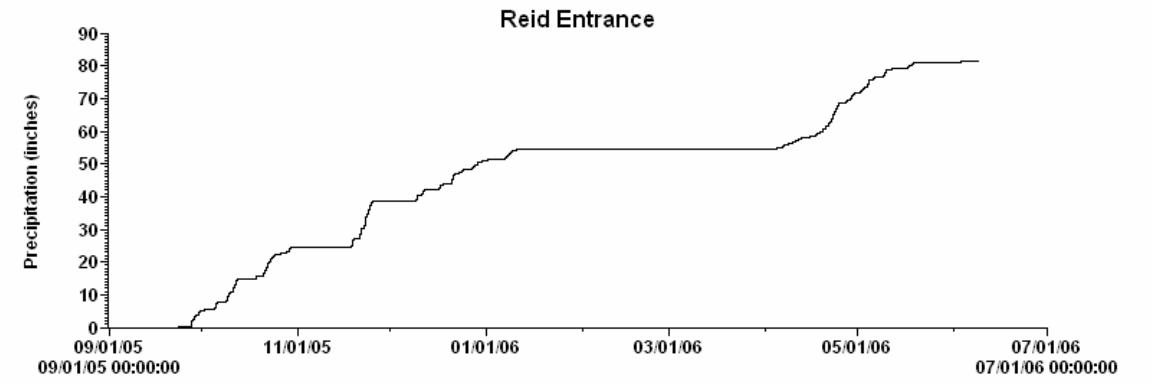

Muir Lower
Precipitation (inches)
0
5
10
15
20
25
30
35
06/01/06
06/01/06 00:00:00
07/01/06
08/01/06
09/01/06
10/01/06
10/01/06 00:00:00


Muir Upper
Precipitation (inches)
0
10
20
30
40
50
60
70
80
90
07/04
09/04
11/04
01/05
03/05
05/05
07/05
09/05
07/01/04 00:00:00
09/01/05 00:00:00


Muir Upper
Precipitation (inches)
0
5
10
15
20
25
06/21/06
07/01/06
07/11/06
07/21/06
07/31/06
08/11/06
08/21/06
08/31/06
09/11/06
09/21/06
06/21/06 00:00:00
09/21/06 00:00:00


Queen Inlet
Precipitation (inches)
0
10
20
30
40
50
60
70
80
90
09/01/05
11/01/05
01/01/06
03/01/06
05/01/06
09/01/05 00:00:00
05/01/06 00:00:00


Queen Inlet
Precipitation (inches)
0
2
4
6
8
10
12
14
06/01/06
06/01/06 00:00:00
06/11/06
06/21/06
07/01/06
07/11/06
07/21/06
07/31/06
08/11/06
08/21/06
08/31/06
09/01/06 00:00:00


Reid Entrance
Precipitation (inches)
0
10
20
30
40
50
60
70
80
90
09/01/05
09/01/05 00:00:00
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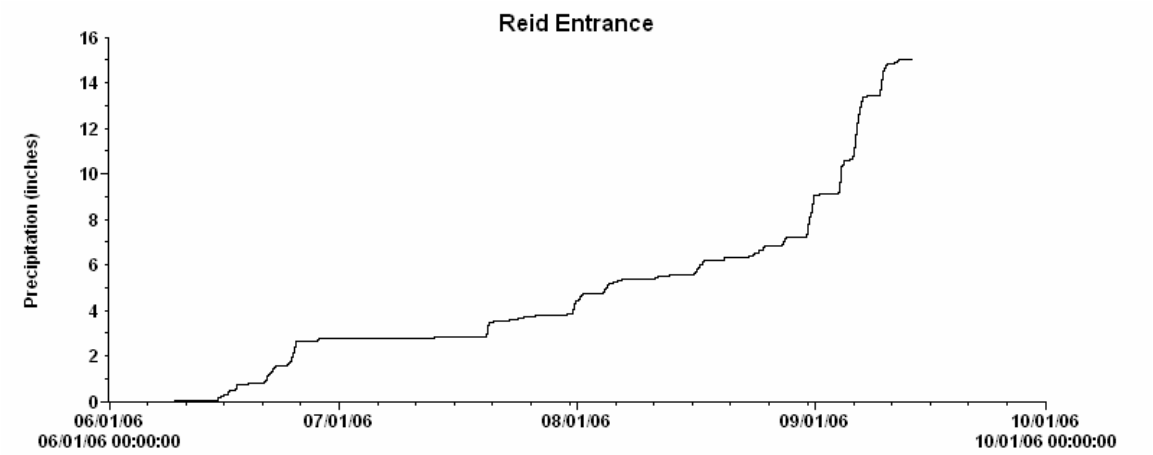
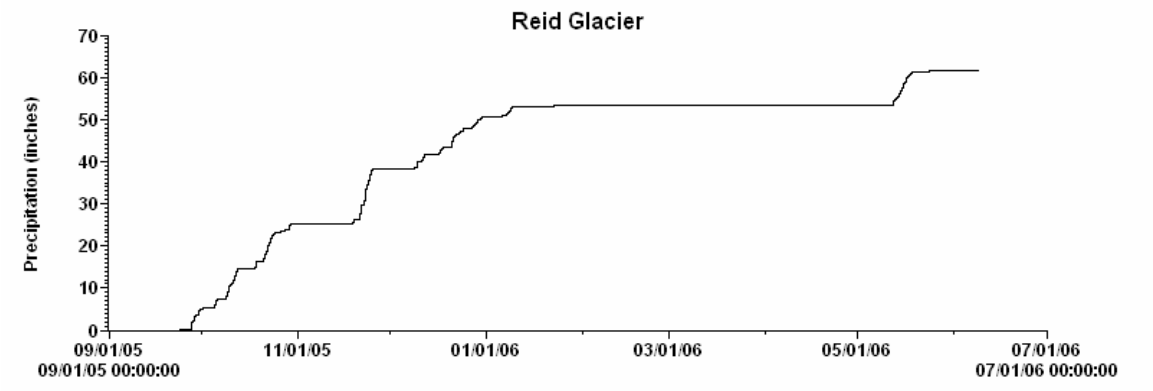
05/01/06
07/01/06
07/01/06 00:00:00


Reid Entrance
Precipitation (inches)
0
2
4
6
8
10
12
14
16
06/01/06
06/01/06 00:00:00
07/01/06
08/01/06
09/01/06
10/01/06
10/01/06 00:00:00


Reid Glacier
Precipitation (inches)
70
60
50
40
30
20
10
0
09/01/05
09/01/05 00:00:00
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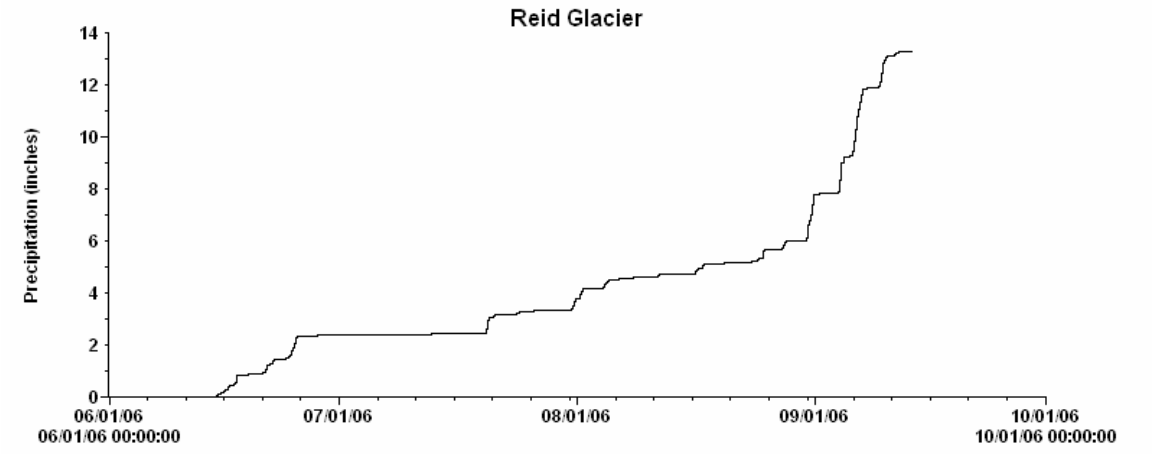
05/01/06
07/01/06
07/01/06 00:00:00


Reid Glacier
Precipitation (inches)
14
12
10
8
6
4
2
0
06/01/06
06/01/06 00:00:00
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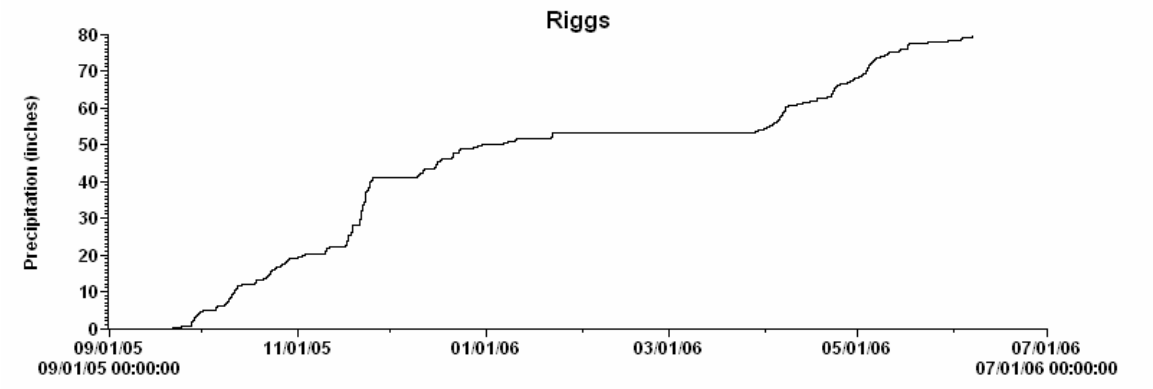
09/01/06
10/01/06
10/01/06 00:00:00


Riggs
Precipitation (inches)
80
70
60
50
40
30
20
10
0
09/01/05
09/01/05 00:00:00
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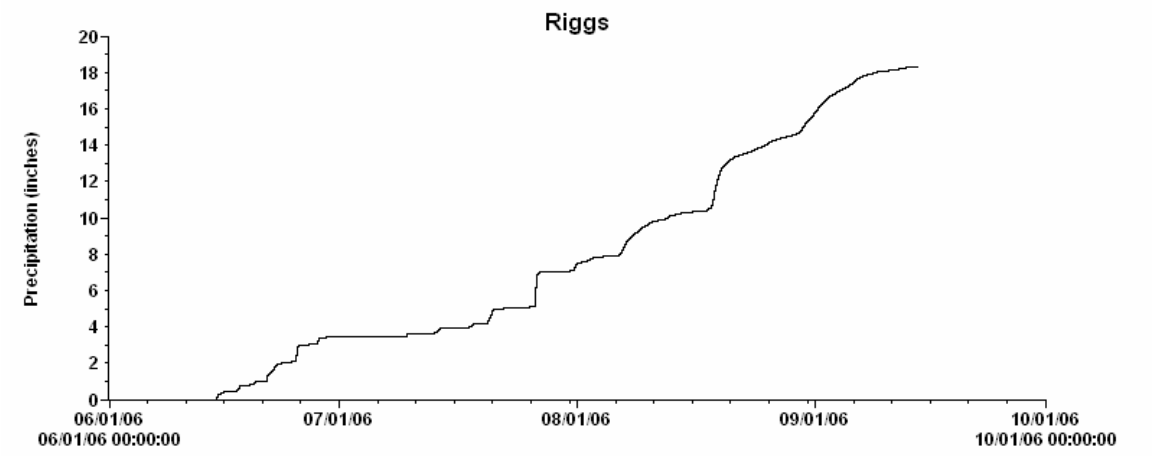
05/01/06
07/01/06
07/01/06 00:00:00


Riggs
Precipitation (inches)
0
2
4
6
8
10
12
14
16
18
20
06/01/06
06/01/06 00:00:00
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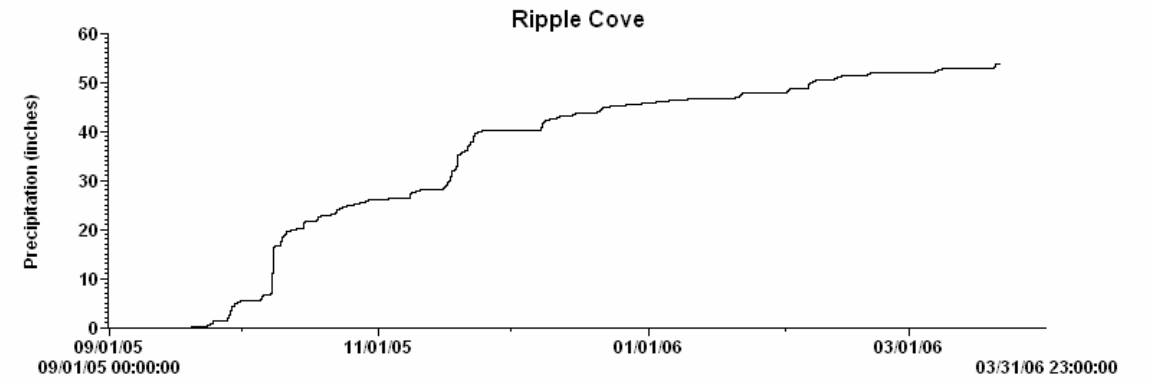
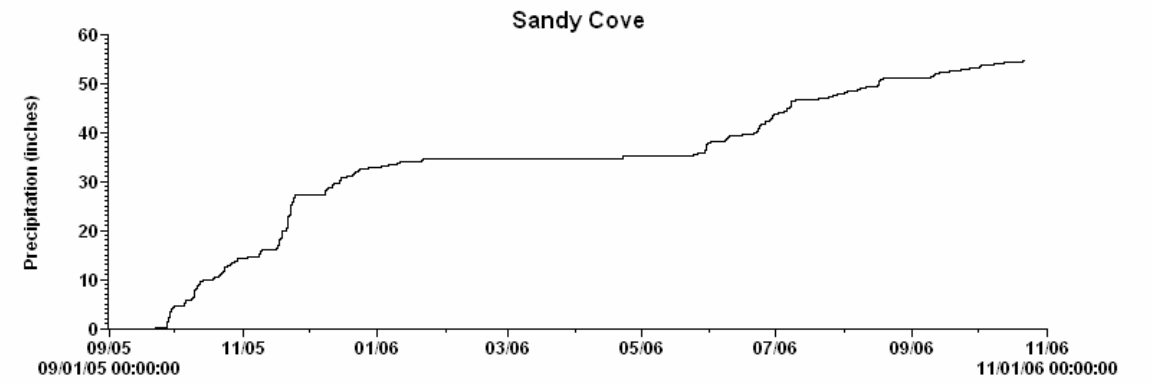
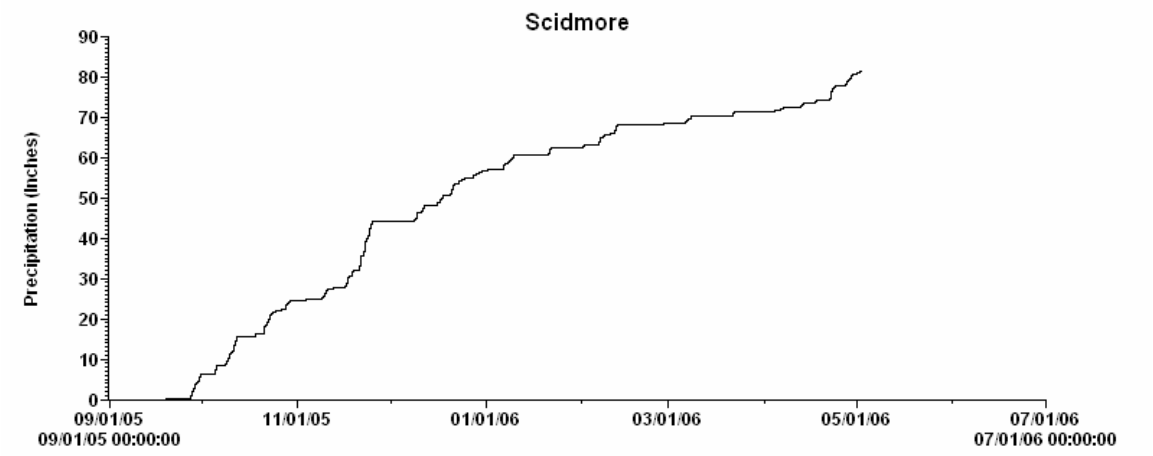
09/01/06
10/01/06
10/01/06 00:00:00


Ripple Cove
Precipitation (inches)
0
10
20
30
40
50
60
09/01/05
09/01/05 00:00:00
11/01/05
01/01/06
03/01/06
03/31/06 23:00:00


Sandy Cove
Precipitation (inches)
0
10
20
30
40
50
60
09/05
09/01/05 00:00:00
11/05
01/06
03/06
05/06
07/06
09/06
11/06
11/01/06 00:00:00


Scidmore
Precipitation (Inches)
0
10
20
30
40
50
60
70
80
90
09/01/05
09/01/05 00:00:00
11/01/05
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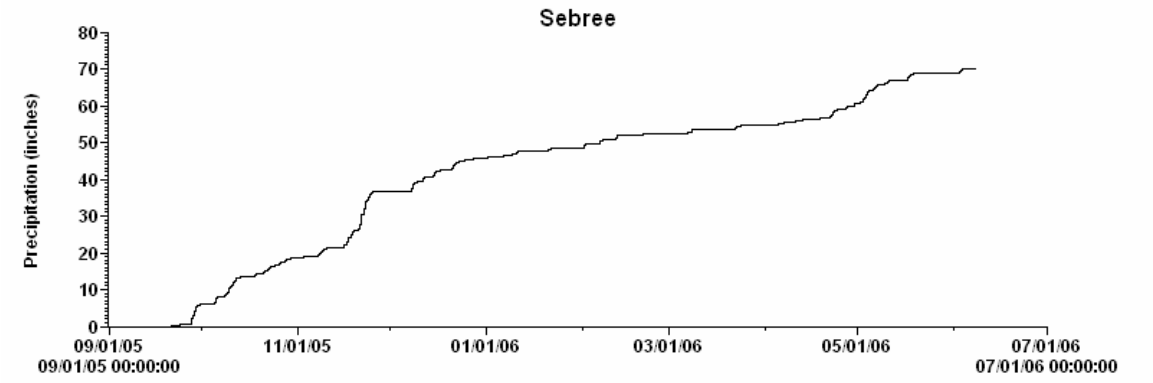
03/01/06
05/01/06
07/01/06
07/01/06 00:00:00


Sebree
Precipitation (inches)
0
10
20
30
40
50
60
70
80
09/01/05
09/01/05 00:00:00
11/01/05
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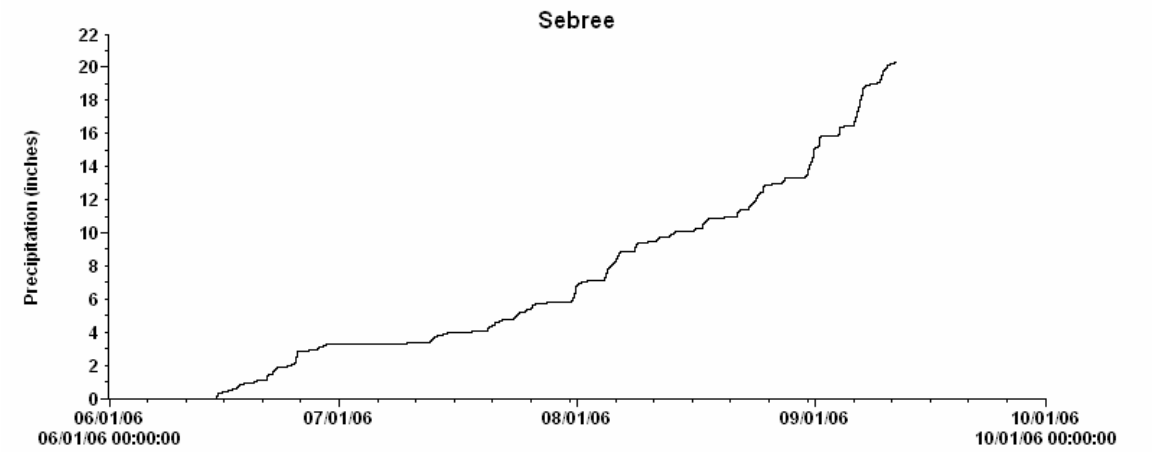
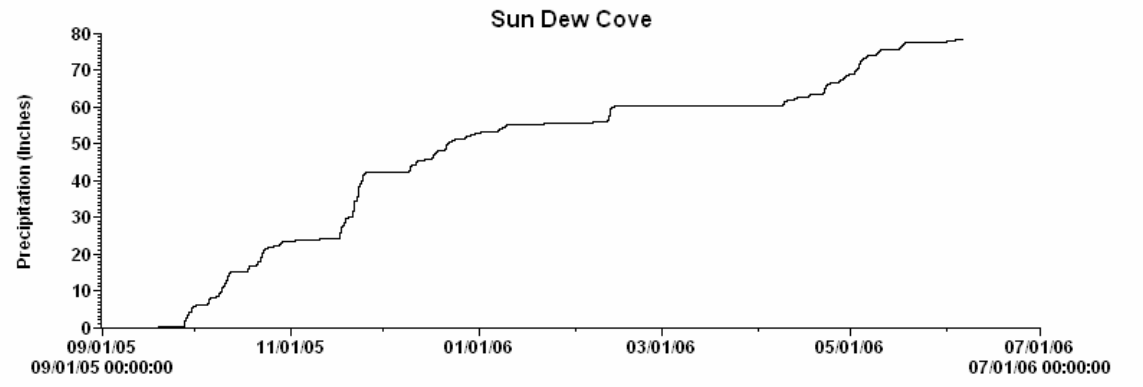
03/01/06
05/01/06
07/01/06
07/01/06 00:00:00


Sebree
Precipitation (inches)
0
2
4
6
8
10
12
14
16
18
20
22
06/01/06
06/01/06 00:00:00
07/01/06
08/01/06
09/01/06
10/01/06
10/01/06 00:00:00


Sun Dew Cove
Precipitation (inches)
80
70
60
50
40
30
20
10
0
09/01/05
09/01/05 00:00:00
11/01/05
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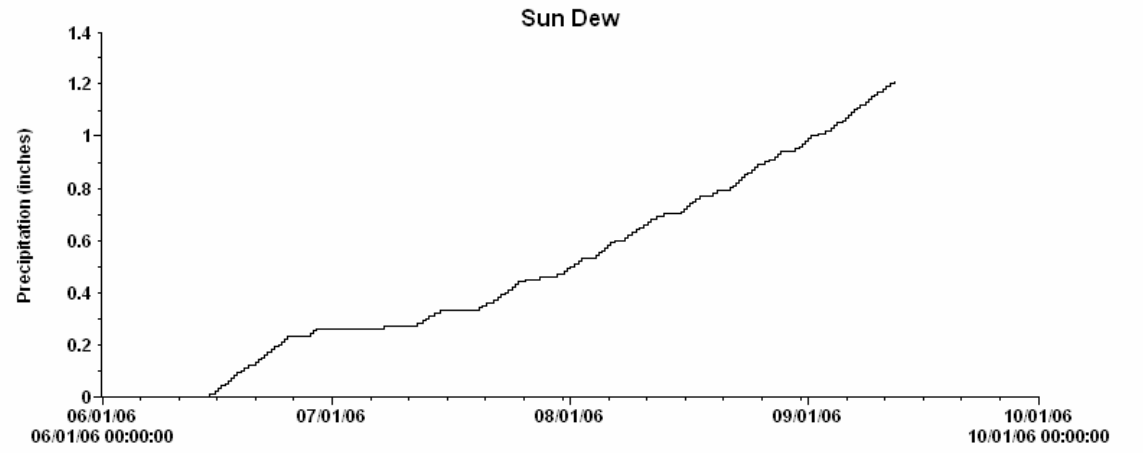
03/01/06
05/01/06
07/01/06
07/01/06 00:00:00


Sun Dew
Precipitation (inches)
1.4
1.2
1
0.8
0.6
0.4
0.2
0
06/01/06
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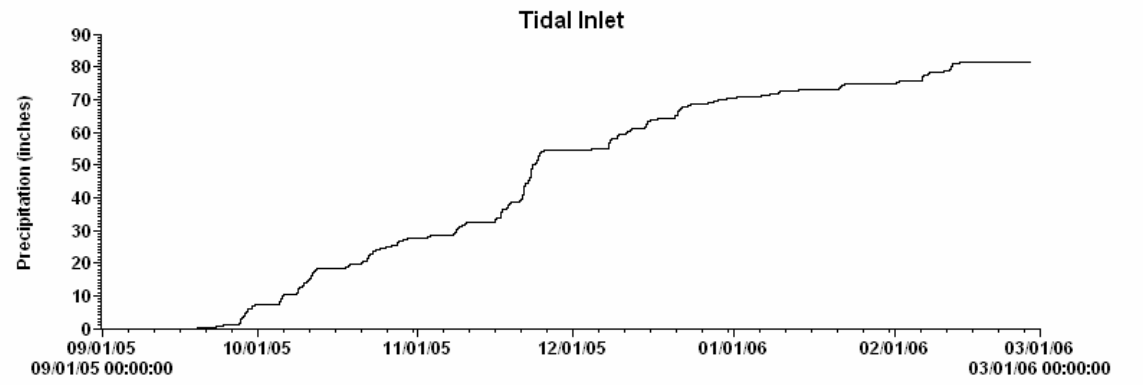
09/01/06
10/01/06
10/01/06 00:00:00


Tidal Inlet
Precipitation (inches)
90
80
70
60
50
40
30
20
10
0
09/01/05
09/01/05 00:00:00
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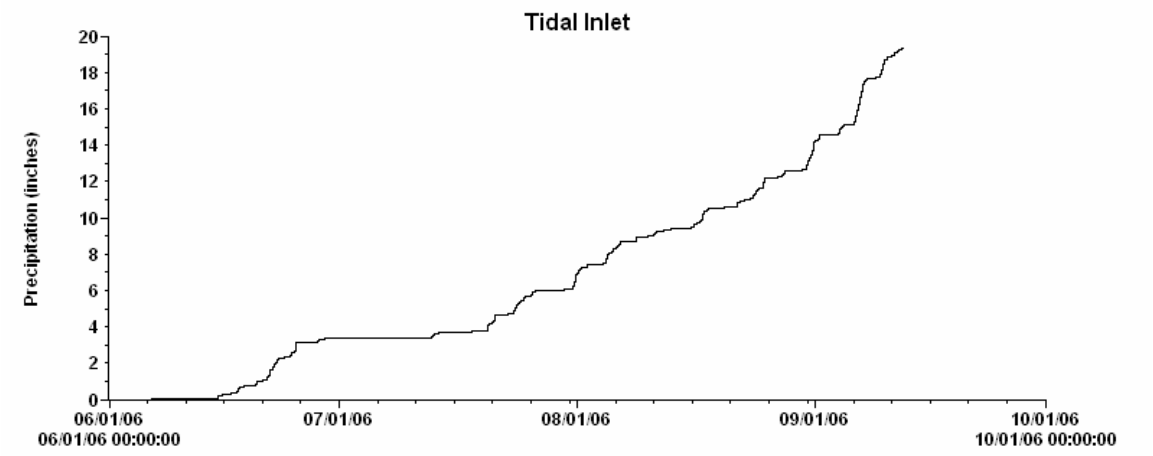
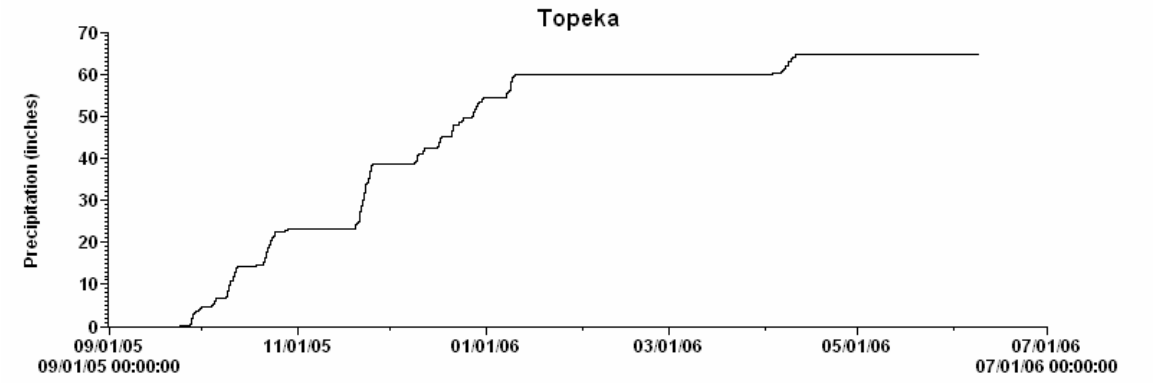
02/01/06
03/01/06
03/01/06 00:00:00


Tidal Inlet
Precipitation (inches)
0
2
4
6
8
10
12
14
16
18
20
06/01/06
06/01/06 00:00:00
07/01/06
08/01/06
09/01/06
10/01/06
10/01/06 00:00:00


Topeka
Precipitation (inches)
0
10
20
30
40
50
60
70
09/01/05
09/01/05 00:00:00
11/01/05
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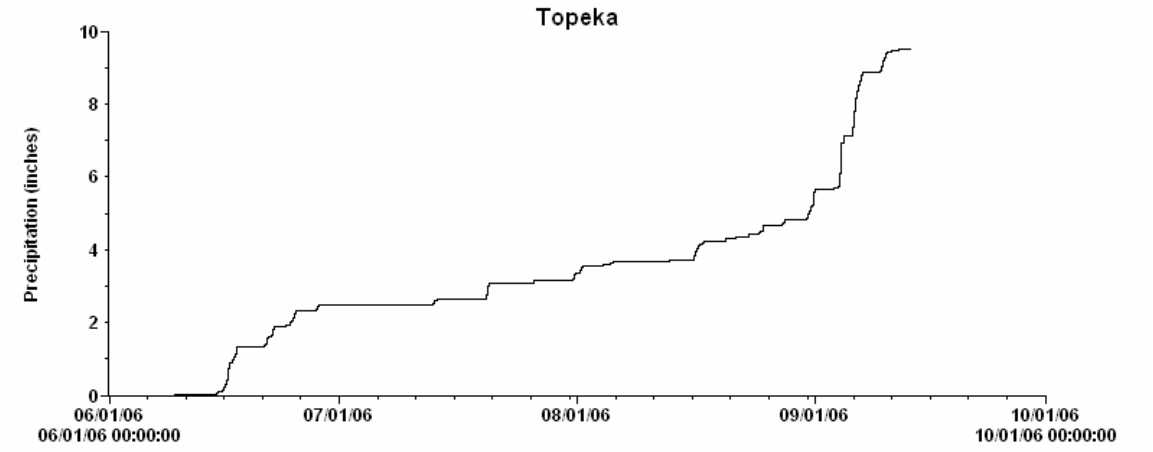
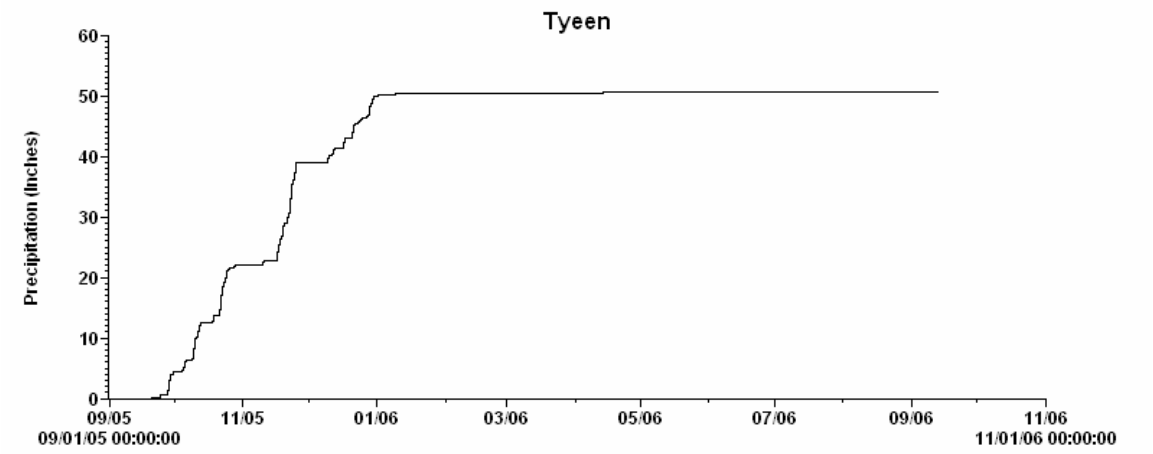
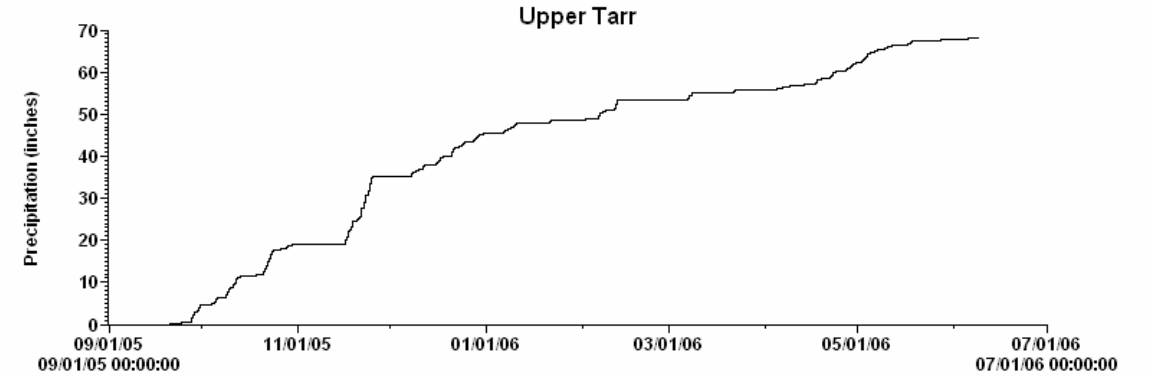
05/01/06
07/01/06
07/01/06 00:00:00


Topeka
Precipitation (inches)
0
2
4
6
8
10
06/01/06
06/01/06 00:00:00
07/01/06
08/01/06
09/01/06
10/01/06
10/01/06 00:00:00


Tyeen
Precipitation (Inches)
60
50
40
30
20
10
0
09/05
09/01/05 00:00:00
11/05
01/06
03/06
05/06
07/06
09/06
11/06
11/01/06 00:00:00


Upper Tarr
Precipitation (inches)
70
60
50
40
30
20
10
0
09/01/05
09/01/05 00:00:00
11/01/05
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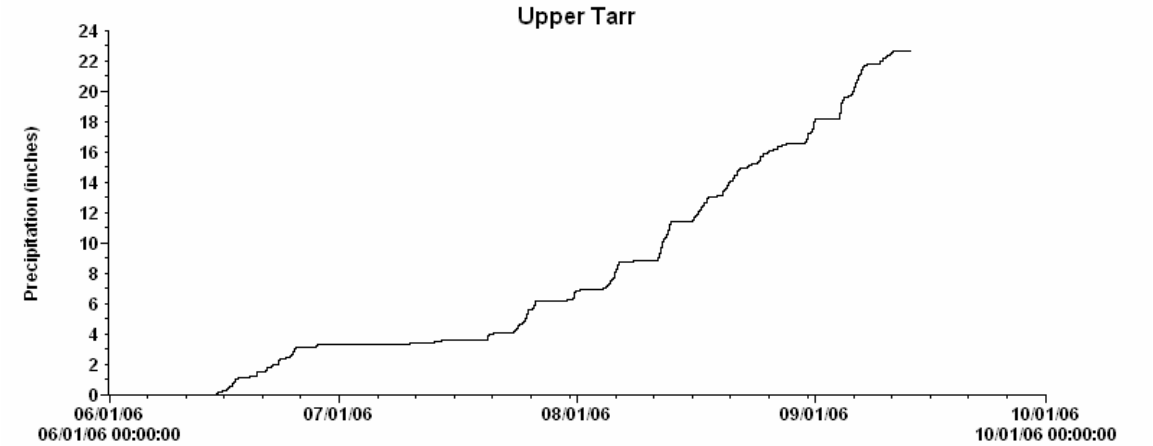
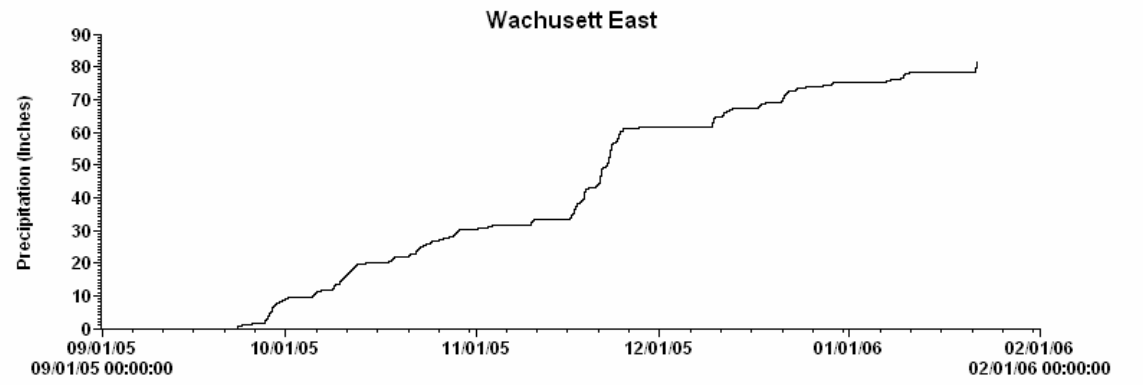
05/01/06
07/01/06
07/01/06 00:00:00


Upper Tarr
Precipitation (inches)
24
22
20
18
16
14
12
10
8
6
4
2
0
06/01/06
06/01/06 00:00:00
07/01/06
08/01/06
09/01/06
10/01/06
10/01/06 00:00:00


Wachusett East
Precipitation (Inches)
0
10
20
30
40
50
60
70
80
90
09/01/05
09/01/05 00:00:00
10/01/05
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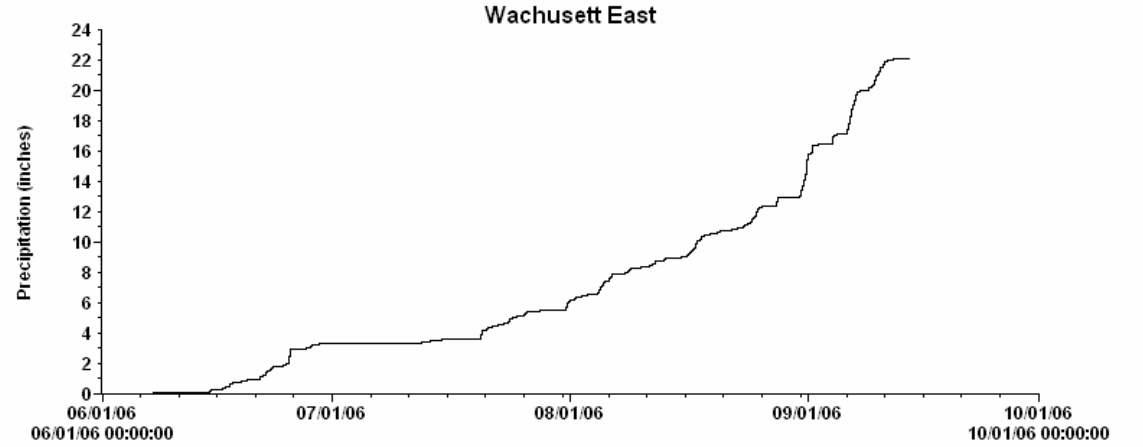
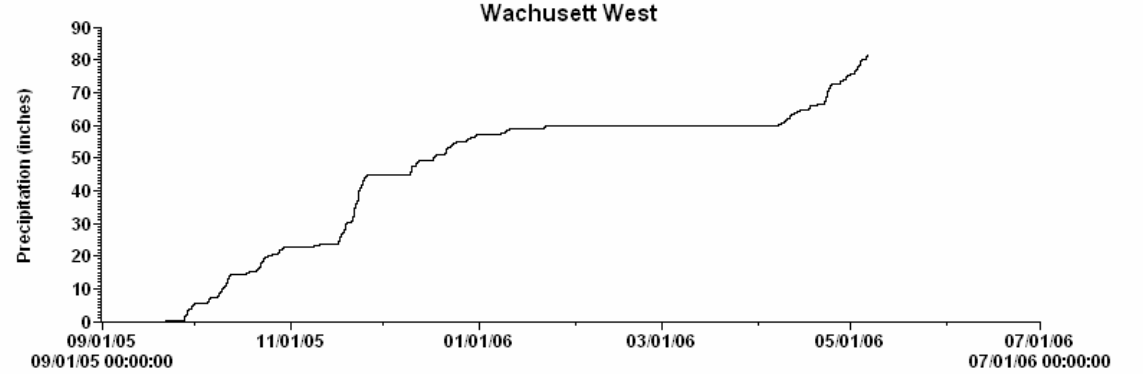
01/01/06
02/01/06
02/01/06 00:00:00


Wachusett East
Precipitation (inches)
0
2
4
6
8
10
12
14
16
18
20
22
24
06/01/06
06/01/06 00:00:00
07/01/06
08/01/06
09/01/06
10/01/06
10/01/06 00:00:00


Wachusett West
Precipitation (inches)
0
10
20
30
40
50
60
70
80
90
09/01/05
09/01/05 00:00:00
11/01/05
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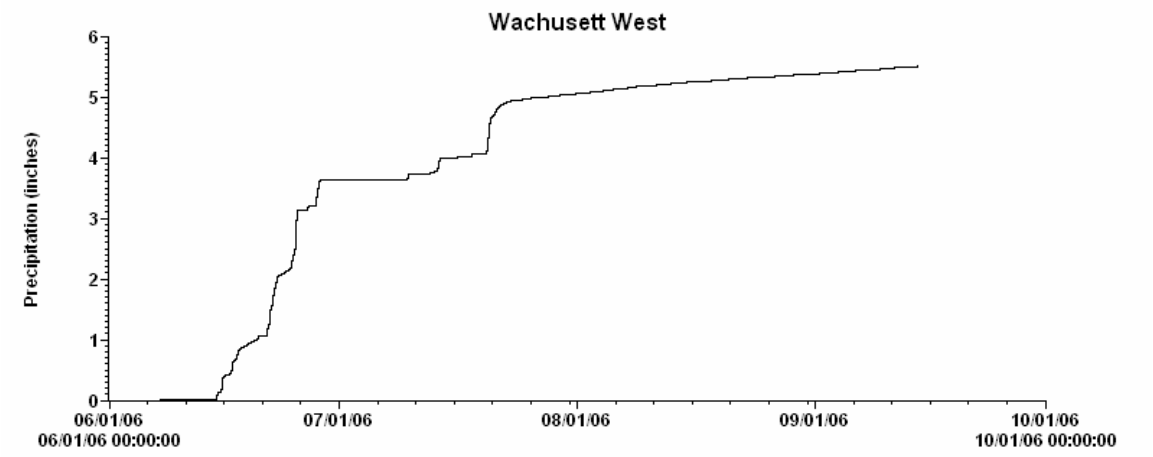
05/01/06
07/01/06
07/01/06 00:00:00


Wachusett West
Precipitation (inches)
0
1
2
3
4
5
6
06/01/06
06/01/06 00:00:00
07/01/06
08/01/06
09/01/06
10/01/06
10/01/06 00:00:00