

LEWIS AND CLARK - WEATHER AND CLIMATE DATA FROM THE EXPEDITION JOURNALS (1803-1806)

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1. INTRODUCTION

The first scientific records of weather, water and climate in the western United States were collected during the Lewis and Clark Expedition of 1803 to 1806 as the "Corps of Discovery" traversed the vast uncharted region between St. Louis, Missouri and the Pacific Ocean. Inspired by years of planning under President Thomas Jefferson, their journey established a foundation of commerce, science and knowledge of what would become the expanding domain of the United States of America. (Ambrose 1996, 68-79; Appleman 1975; Hayes 2001; Ronda 2001, p. viii, 1-16; Wheeler 1904, Vol 1) "In its scope and achievements, the expedition towers among the major explorations of the North American Continent and the world." (Appleman 1975, p. 3) This Expedition vastly increased the knowledge of flora, fauna, geography, geology, native peoples, commerce trade possibilities and routes.

Observations made during the journey were recorded in various journals and diaries. Of these entries, systematic climatological, hydrological and meteorological observations were recorded in narrative style as well as in table format. The written observations contained in the Narrative Journals by the Expedition members as well as the Lewis and Clark's "Weather Diary" were recently published by the author through the American Meteorological Society as a Historical Monogram (Preston 2006). A brief overview of this research effort will be presented.

2. HISTORY OF THE EXPEDITION JOURNALS

The journals of Meriwether Lewis, William Clark, and Expedition members are many and varied. As Donald Jackson (1978, Vol 1, p. vii) has noted, Lewis and Clark were "the writingest explorers of their time. They wrote constantly and abundantly, afloat and ashore, legibly and illegibly, and always with an urgent sense of purpose." They recorded data into daily narrative diaries, made rough Field Notes which were translated at the end of each day by Clark, and several other documents and booklets containing, astronomy, botany, ethnology, geography, military orders, mineralogy, zoology, thermometrical and weather observations. Clark produced numerous sketches and maps. Both wrote numerous letters before, during and after the expedition. (Cutright 1976)

President Thomas Jefferson did not order the keeping of journals by anyone other than the captains. In his final instructions to Lewis, however, he did suggest that "several copies of these as well as of your other notes should be made at leisure times, & put into the care of the most trust-worthy of your attendants, to guard, by multiplying them, against the accidental losses to which they will be exposed." (Jackson 1978, Vol 1, p. 62; Moulton 1996: Vol 10, p. xi) Four additional journals are currently in existence, with previously unknown written materials from the Expedition discovered as recently as the 1960s. There may be an additional one to three journals that have never been found. Lewis gives credence to this in his last communication to Jefferson from Fort Mandan on April 7, 1805, as he wrote: "We have encouraged our men to keep journals, and seven of them do so, to whom in this respect we give every assistance in our power." (Jackson 1978, Vol 1, p. 232)

The Journals of Lewis and Clark have been reproduced only a few times in the past two hundred years. The first issuance was under the guidance of Clark, who after the untimely death of Lewis, took control of the known journals. Nicholas Biddle (1814) produced the first edition, a two volume set, in 1814 using a general narrative paraphrase without much scientific content. However, Biddle turned the manuscript over to Paul Allen, for final revision, who's name appears on the title page. Biddle may have followed a literary custom of the time, which mandated that a gentleman did not publish under his own name. (Ambrose 1996, 469-470; Moulton 1986, Vol 2, p. 37) Elliott Coues produced the next edition of the journals in 1893 introducing never before published scientific discoveries made by the Expedition. It is believed that it was Coues who rekindled the nation's interest in Lewis and Clark. (Moulton 1986, Vol 2, p. 39) Yet Coues only produced a small subset of the full journal writings. The first full edition of known journal writings was published for the Expedition's Centennial by Ruben Gold Thwaites. Through extensive research he discovered a number of new documents that greatly enhanced his edition. Thwaites' (1904) eight-volume edition including copies of Clark's cartography in a special Atlas and was made available in 1904. For the first time in history, the bulk of the Lewis and Clark journal writings were available to the public.

Other valuable but small renderings were made by Milo Quaife (1916) and Earnest Osgood (1964) and concise, abridged editions like John Bakeless (1947) and Bernard DeVoto's (1953) have been published after 1904 as new materials became available. New historic finds of missing journals and letters were compiled and published between 1986 and 2001 by University of Nebraska professor, Dr. Gary Moulton, resulting in 13 volumes

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including an atlas and journals by Lewis and Clark, Sergeants Floyd, Gass, Ordway, and Private Whitehouse. Donald Jackson (1978) produced a two volume set which complemented the Moulton edition and contained letters that were written before, during and after the Expedition. For further history about the journals the reader is referred to the following source documents: (Coues 1893, Vol 1, cvii-cxxxii; Cutright 1976; Jackson 1978; Moulton 1986, Vol 2, 8-48, 530-567; Thwaites 1904, Vol 1, xvii-xciii)

3. WEATHER, WATER & CLIMATE JOURNAL WRITINGS

Weather was a major influence for the Lewis and Clark Expedition. During their trip they experienced sweltering summer heat in Missouri and Nebraska and extreme cold and dangerous wind chills at Fort Mandan in the Dakotas. They were pelted by "pigeon egg" sized hail in Montana, and near continuous rains at Fort Clatsop on the mouth of the Columbia River which perpetuated sickness and spoilage of dwindling food supplies. Numerous Pacific Coast storms during the 1805-06 winter produced an extreme snowpack in the Bitterroot Range of Idaho and delayed their return trip to St. Louis. Flash floods in Montana nearly swept away Clark, Sacagawea, her son and other Expedition members. Snowmelt and spring river flooding caused a dilemma on which river channel to follow. They were surprised by snowfall in June and frost in July. Members viewed the ravages of a derecho or tornado in twisted and blown down trees north of present-day Omaha which Clark called a "*Dreadfull hurican*." Strong prairie wind storms tipped their canoes and almost sunk their keel boat and peppered them with sand and dust.

Journalists recorded seasonal changes in vegetation and migrating habits of animals and birds and even changing air masses as Lewis and Clark both commented on a drier climate as their ink wells were hard to keep moist and wood writing tables split. Winter ice jams on the Missouri nearly crushed their boats and they recorded tidal changes as they proceeded from Beacon Rock, one-hundred miles inland, to the Pacific Ocean. Immense ocean waves pinned the Expedition just miles from their goal while Clark exclaimed their relief at completing their journey with the summation "*Ocian in view! O! the joy*." A thousand more weather stories are revealed within the pages of the journals.

Several scientifically based books have been written describing the flora and fauna and geology of the expedition (Allen 1975; Bergon 1989; Blume 1999; Botkin 1995; Burroughs 1995; Cutright 1976; Moulton 1999, Vol 12; Patient 2003; Wells and Anzinger 2001). Other publications describe the advance in the fields of geography and cartography (Allen 1975; Cohen 2002; Moulton 1986, Vol 1; Plamondon II, 2000-2001; Schmidt 1999) and medical needs. (Chuinard 1998; Paton 2001; Peck 2002) The first of it's kind Lewis and Clark weather and climate book was printed through the American Meteorological Society Historical Monograph series in 2006 (Preston 2006) showing the scientific achievements of the Expedition in relationship to the systematic daily

observations of climate, water and weather elements. Their daily observations were taken when only a handful of scientists were noting weather patterns. In fact regular observations were not recorded on a daily basis until the late 1600's with the development of instruments such as the thermometer, barometer and hygrometer. (Frisinger 1983)

Scientists have used the small record of historical diaries which included basic meteorological observations to reconstruct climate patterns. (Baron 1995; Bradley and Jones 1993; Catchpole 1995; Druckenbrod 2003; Glaser 1999; Ingram 1978; Ludlam 1966; Pfister 1995; Quinn and Neal 1995) Diaries containing instrument based data were very uncommon in the United States during the late eighteenth century. Thomas Jefferson and James Madison in Virginia, John Winthrop in Massachusetts, Dr. John Lining and others in South Carolina are documented as having taken daily observations during this era. (Druckenbrod 2003, p. 62) No daily science based observations were conducted across the North American Continent during the Lewis and Clark Expedition.

Only a few other select writings on the Lewis and Clark expedition weather, water or climate have been published. These writings include snow conditions along the Lolo Trail (Ambrose 1978); the inclement weather at the mouth of the Columbia River (Lange 1979); general weather observations at select dates along the trail (Large 1986); scientific instruments used on the expedition (Plamondon II 1991); a master thesis on the weather conditions at Fort Mandan, ND and Fort Clatsop, OR (Burnette 2002); a pioneering look at meteorological observations by Lewis and Clark (Solomon and Daniel 2004); climate conditions of the Lewis and Clark expedition (Knapp 2004); and the weather at Fort Clatsop, OR (Miller 2004) .

Two types of data are available from the journals. The first are the "Daily Narrative Journals" which contain general descriptions of what happened each day. Lewis and Clark kept separate entries as well as other expedition members. Many times, they would copy passages from each other to preserve the record. A second set of data was entered into scientific log books which contain information on meteorology, celestial readings, flora and fauna, geology and expenses.

Lewis' writing style was that of an educated man with excellent prose and fine alliteration. Clark had a frontier writing style with numerous spelling and punctuation challenges. Lewis' journal entries begin in a field book started on the day he left Pittsburgh, August 31, 1803. His first meteorological entry was a discussion about a "*thick fogg on the face of the water that no object was visible 40 paces*." Clark's first known travel entries were in some of his field notes taken near the confluence of the Ohio and Mississippi Rivers. Clark's first meteorological reference was written on November 28, 1803 "*This morning being verry Smokey prevents my being as acurate as I Could wish—*." The same day he noted "*The horozon became darkened that I could not see*

across the River, which appeared to windened, the Current much Swifter than usial.”

In order to preserve the record, at Fort Mandan and again at Fort Clatsop, duplicate journals were made by Lewis and Clark. At other times, Clark would write two versions of his daily entries. The first entries were in his field notes, and a cleaner second version for the final bound journals. As for Lewis, his journal writing entries are much more sporadic. Many scholars have researched why Lewis' journal entries have large gaps in them. Some believe it was from fits of depression, others believe the journals may have been lost, destroyed, or misplaced. (Ambrose 1996; Appleman 1975; Cutright 1976; Moulton 1986, Vol 2) The only known reason was due to injuries he suffered from an accidental gunshot wound on August 11, 1806. Meeting Clark and the rest of the party the next day, Lewis decided he would relinquish his journal entries to Clark as wrote his last words in the journals, "*I shall desist untill I recover and leave to my frind Capt. C. the continuation of our journal...This cherry...is now ripe...I have never seen it in blume.*" Clark's last reference was, "*a fine morning we commenced wrightin &c,*" entered on September 26, 1806, three days after their arrival back in St. Louis.

Journal writings are also available from three Sergeants and one Private. Sergeant Charles Floyd's entries are the shortest as he passed away near present-day Sioux City, Iowa on August 20, 1804. Floyd was the only member of the expedition to die during the journey. His entries provided a more conscientious look at daily happenings. As Moulton (1995, Vol 9, p. xviii) notes, "Floyd apparently had an eye for such details, which makes us regret all the more that he did not live to complete a record of the whole journey." He kept entries until two days before his death. Sergeants Patrick Gass and John Ordway wrote their journals from the day they left Camp Dubois, on May 14th, 1803 through September 23rd, 1806, their arrival back in St. Louis.

Sergeant Gass' rough journal entries were edited by David McKeehan in 1807 (Gass 1807) and was the first full account of the expedition published, against the wishes of Lewis. Gass, a carpenter, paid particular attention to physical details other journalist did not.

Sergeant Ordway's refined entries are in his own hand and provide a substantial amount of meteorological data which fills gaps left by other writers. With the exception of Clark's journal and the Weather Diary, Ordway's journal provides the most useful information on weather, water and climate.

The final known journalist is Private Joseph Whitehouse. As with Gass, Whitehouse had an original version which was very rough and provides some distinct language about certain incidents. It dates from May 14th, 1804 to November 6th, 1805. A paraphrased journal found in 1966 in a bookstore in Philadelphia, PA, provides entries from May 14th, 1804 to March 23rd, 1806. There is speculation that he may have kept a journal through the end of the journey, but nothing has been found. (Cutright

1976)

Spelling was a challenge to all journal writers and their creativity in using phonics is widely dispersed in the journals. The most diligent and faithful journal keeper was Ordway who did not miss a single entry for the 863 days of the journey. Clark was a close second with missing entries only while he was on a hunting trip between February 3-12, 1805. Although he did summarize the hunting trip experiences when he returned. (Cutright 1976)

4. WEATHER DIARY

Lewis and Clark began keeping a "Weather Diary," or as written on the first day's observation "Thermometrical Observations" on January 1, 1804 while the Corps was at Camp Dubois near St. Louis, Missouri. The Weather Diary recorded systematic daily observations at sunrise and 4 p.m. which included the following meteorological data: temperature, wind, weather conditions and river levels. **Figure 1** shows entries from the Month of May, 1805. In addition to the raw data, remarks were recorded on various weather phenomena, seasonal and climate changes, and changes in flora and fauna. **Figure 2** shows various remarks entered in the Weather Diary for the month of May, 1805.

Data was kept in the Diary on a daily basis until May 14, 1804. After this date, gaps appear in data until September 19, 1804. Between September 19, 1804 and September 30, 1806 the two-a-day observations and remarks resumed with few interruptions. When the two parties split at Travelers Rest on their return trip, both Captains kept separate daily logs for July and portions of August. The weather notes indicate a substantial scientific record of atmospheric and hydrologic conditions for portions of the western United States that would not have systematic daily observations for over 60 years after their trip was completed.

The only known meteorological instrument the Corps of Discovery used was a thermometer. Historians postulate Lewis purchased three thermometers in Philadelphia, PA during the Spring of 1803 as documented on a packing list. It is believed that the thermometers were made in Philadelphia, (Moulton 1986, Vol 2, p. 69) and Clark makes mention of a particular company that made a thermometer in his January 3rd, 1804 entry: "John Donegan (or Denegan) and Joseph Donegany (Donegani) were making thermometers in Philadelphia in 1785." (Moulton 1986, Vol 2, 145-146)

"Although thermometers are among Lewis' list of requirements for the trip, there is no direct evidence that any were purchased." Moulton (1986 Vol 2, p. 146) Other stories abound as to their origin. Historian Donald Jackson (1978, Vol 1, p. 75) notes that "an undocumented family tradition, first related by Dye and renewed by Meany, declares that St. Louis physician, Antoine Saugrain, made thermometers for Lewis and Clark by scraping the mercury off the back of his wife's mirror. Saugrain had social contacts with the explorers before

and after the Expedition, but it is not likely that he made thermometers for them.”

Lewis kept temperature records on his way down the Ohio in the fall of 1803. Clark continued the practice at the Wood River (Dubois) Camp in the early months of 1804, and this lends credence to the theory that thermometers were obtained in Philadelphia and used for these observations. The last one was broken on September 3, 1805 when it was accidentally struck against a tree. (Moulton 1988, Vol 5, p. 186) The instruments must have been similar to that described by Jefferson in a request on June 5, 1804 to Isaac Briggs for two thermometers: “The kind preferred is that on a lackered plate slid into a mahogany case with a glass sliding cover, these being best exposed on exposure to the weather.” (Jackson 1978, Vol 1, p. 75) Based on notes in the Weather Diary as well as experiments conducted by Clark at Camp Dubois it is believed the thermometers were in the Fahrenheit scale.

Most observations were taken by visual means. To determine wind direction, they would stand facing the wind with a compass to determine a direction. For rise and fall of the river water, various marks were made on the bank and measured later with marked sticks, poles or chains which used the English scale of inches and feet.

5. SUMMARY

Only a few papers and books have been published describing the weather, water and climate during the Lewis and Clark Expedition. A publication from the American Meteorological Society - Historical Monograph Series contains a complete listing of all weather, water and climate entries from the journals of the Lewis and Clark Expedition. The book provides a meteorological synopsis of the Expedition; various scientific instruments used during the expedition; a discussion on the expedition journals; all excerpts related to weather, water and climate from the journals; a pictorial tour; and supporting pre and post journey letters. An example of this collected data is in **Figure 3**. In future work, the author plans to research and produce a compilation of weather journal entries from various expeditions who came after the landmark Lewis and Clark journey.

Author's Note: Quoted text italicized in manuscript from Lewis and Clark Expedition journals from Moulton (1986-2001).

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me to continue my pursuit of the meteorological history along the trail of the Lewis and Clark Expedition.

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Lewis and Clark Weather Diary

Lewis and Clark Combined Entries

May 1805

Day of the Month	Temp. at Sunrise	Weather at Sunrise	Wind at Sunrise	Temp. at 4 PM	Weather at 4 PM	Wind at 4 PM	Rise or Fall	Feet ' Inches ''
1	36a	c	E	46a	c a f	NE	F	1 ½"
2	28a	s	NE	34a	c a s	NW	F	1"
3	26a	f	W	46a	c	W	F	¼"
4	38a	c	W	48a	f a c	W	-	-
5	38a	f	NW	62a	f a r	SE	R	1"
6	48a	f	E	61a	c a r	SE	R	2"
7	42a	c	S	60a	f	NE	R	1 ½"
8	41a	c	E	52a	c a r	E	F	¼"
9	38a	f	E	58a	f	W	R	¾"
10	38a	f a c	WNW	62a	c a r	NW	F	¾"
11	44a	f	NE	60a	c	SW	-	-
12	52a	f	SE	54a	c a r	NW	R	2"
13	52a	c a r	NW	54a	f a c	NW	F	2 ¼"
14	32a	f	SW	52a	c	SW	F	1 ¾"
15	48	c a r	SW	54a	c	NW	F	¾"
16	48	c	SW	67a	f	SW	-	-
17	60a	f	NE	68a	f	SW	-	-
18	58a	f	W	46a	c a r	NW	F	1"
19	38a	f	E	68a	f a c	SW	-	-
20	52a	f	NE	76a	f	E	F	1"
21	50a	f	SW	76a	f	NW	-	-
22	46a	c	NW	48a	c	NW	F	½"
23	32a	f	SW	54a	f	SW	F	½"
24	32a	f	NW	68a	f	SE	R	3 ½"
25	46a	f	SW	82a	f	SW	R	2"
26	58a	f	SW	80a	f	SW	R	½"
27	62a	f	SW	82a	f	SW	-	-
28	62a	c	SW	72a	c & r	SW	R	½"
29	62a	c a r	SW	67a	r	SW	R	1"
30	56a	c a r	SW	50a	r	SW	R	5"
31	48a	c a r	W	53a	c a r	SW	R	1 ½"

FIGURE 1

Compiled by Vernon L. Preston from the Lewis and Clark Journals (Coues 1893, Vol 3, p. 1272, 1288-1289; Moulton 1987, Vol 4, 234-238; Thwaites 1904, Vol 6, Part 2, 189-191)

May 1805 Remarks

- 1st wind violent from 12 OC. to 6 pm
- 2nd snow 1 inch deep the wind continued so high from 12 o'clock yesterday, until 5 this evening that we were unable to proceed. The snow which fell last night and this morning one inch deep has not yet disappeared.— it forms a singular contrast with the trees which are now in leaf.—
- 3rd hard frost last night. At four PM the snow has not yet entirely disappeared.— the new horns of Elk being to appear.
- 4th the black martin makes its appearance. The snow has disappeared. Saw the first grasshoppers today.— there are great quantities of a small blue beetle feeding on the willows.—
- 5th a few drops of rain only
- 6th rain very inconsiderable as usual
- 8th rain inconsiderable a mere sprinkle the bald Eagle, of which there are great numbers, now have their young. The turtledove appears.
- 9th The choke Cherry is now in bloom.
- 10th rain but slight a few drops
- 11th frost this morning
- 12th rain but slight
- 13th do. do. do.
- 14th white frost this morning
- 15th slight shower
- 17th the Gees have their young; the Elk being to produce their young, the Antelope and deer as yet have not.— the small species of Goatsucker or whiperwill begin to cry— the blackbirds both small and large have appeared. We have had scarcely any thunder and lightning. The clouds are generally white and accompanied with wind only
- 18th a good shower saw the wild rose blume the brown thrush or mocking bird has appeared.— had a good shower of rain today, it continued about 2 hours; this is the first shower that deserves the appellation of rain, which we have seen since we left Fort Mandan.— no thunder or lightning
- 19th heavy fog this morning on the river
- 22nd the wind excessively hard all night— saw some particles of snow fall today it did not lye in sufficient quantity on the ground to be perceptible.—
- 23rd hard frost last night; ice in the eddy water along the shore, and the water friezed on the oars this morning. Strawburies in bloom. Saw the first king fisher.
- 24th frost last night ice 1/8 of an inch thick
- 25th saw the kingbird, or bee martin; the grouse disappear. Killed three of the bighorned antelopes.
- 26th The last night was much the warmest we have experienced, found the covering of one blanket sufficient. The air is extremely dry and pure.
- 27th wind so hard we were unable to proceed in the early part of the day
- 28th a slight thundershower; the air was turbid in the forenoon and appeared to be filled with smoke; we supposed it to proceed from the burning of the plains, which we are informed are frequently set on fire by the Snake Indians to compell the antelopes to resort to the woody and mountainous country which they inhabit.— saw a small white and black woodpecker with a red head; the same which is common to the Atlantic states.—
- 29th rained by little, some dew this morning.
- 30th the rain commenced about 4 O'clock in the evening, and continued moderately through the course of the night; more rain has now fallen than we have experienced since the 15th of September last.
- 31st but little rain. The Antelope now bring forth their young. from the size of the young of the bighorned Antelope I suppose they bring forth their young as early at least at the Elk.

FIGURE 2

Compiled by Vernon L. Preston from the Lewis and Clark Journals (Coues 1893, Vol 3, p. 1272, 1288-1289; Moulton 1987, Vol 4, 234-238; Thwaites 1904, Vol 6, Part 2, 189-191)

Friday, May 31, 1805

Weather Diary

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Sunrise			4 PM			Missouri River		
Temp	Weather	Wind	Temp	Weather	Wind	Rise/Fall	Feet	Inches
48a	c a r	W	53a	c a r	SW	R	-	1 ½

Daily Narrative Journals

Lewis soon after we got under way it began to rain and continued until meridian when it ceased but still remained cloudy through the ballance of the day. The obstructions of rocky points and riffles still continue as yesterday; at those places the men are compelled to be much in the water even to their armpits, and the water is yet very cold, and so frequent are those point that they are one fourth of their time in the water. The hills and river Clifts which we passed today exhibit a most romantic appearance...horizontal stratas of white free-stone, on which the rains or water make nor impression. The water in the course of time in decending from those hills and plains on either side of the river trickled down the soft sand clifts and worn it into a thousand grotesque figures, which with the help of a little immagination and an oblique view at a distance, are made to represent eligant ranges of lofty freestone buildings, haveing their pararpets well stocked with statuary; collumns of various sculpture both grooved and plain, are also seen supporting long galleries in front of those buildings; in other places on a much nearer approach and with the help of less immagination we see the remains or ruins of eligant buildings, some collumns standing and almost entire with their pedestals and capitals. As we passed on it seemed as if those seens of visionary inchantment would never have an end...So perfect indeed are those walls that I should have thought that nature had attempted here to rival the human art of masonry had I not recollected that she had first began her work. The river today has been from 150 to 250 yds. wide.

Clark a cloudy morning. Soon found it verry laborious as the mud Stuck to my mockersons & was verry Slippery. Soon after we got under way it began to rain and continued moderately untill about 12 oClock when it ceased, & Continued Cloudy the ballance of the day. The Hills and river Clifts of this day exhibit a most romantick appearance...in many places this Sand Stone appears like antient ruins some like elegant buildings at a distance, some like Towers &c. &c. Remind us of Some of those large Stone buildings in the United States. As we passed on it Seemed as if those Seens of Visionary enchantment would never have an end; for here it is too that nature present to the view of the traveler vast ranges of walls of tolerable workmanship, so perfect indeed are those falls [walls] that I Should have thought that nature had attempted here to rival the human art of Masonry had I not recollected that She had first began her work. The river rises a little. The water is yet very cold. Little timber on the river to day. River less muddy than it was below.

Gass a cloudy morning. About 11 o'clock it began to rain slowly, and continued raining two hours, when it cleared up. The rocky peaks...appear like the ruins of an ancient city.

Ordway a Cloudy morning. It continued to rain moderately untill about 12 oClock when it ceased & continued cloudy. The Stones on the edges of the river continue to form very considerable rapids. We find them difficult to pass. The River rises a little it is from 150 to 250 yards wide

Whitehouse cloudy weather this morning. About 11 oClock AM it began to rain, and rained moderately for some time. The current of the River rain very strong, the whole of this day. In the Evening, the weather cleared off, and became pleasant.

FIGURE 3
 Combined Entries - Compiled by Vernon L. Preston from the Lewis and Clark Journals (Moulton 1987)