Susitna-Watana Hydroelectric Project
(FERC No. 14241)

Ice Processes in the Susitna River Study (7.6)

2014 Study Implementation Report (SIR)

Appendix A
Alternate Visualizations of Freeze-up Progression
And Open Leads

Prepared for

Alaska Energy Authority

SUSITNA-WATANA HYDRO

Clean, reliable energy for the next 100 years.

Prepared by

HDR Alaska, Inc.

September 2015

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1.0 Background

The overall goals of the Ice Processes in the Susitna River Study (Study 7.6) as described in the Revised Study Plan (AEA 2012) are to understand the existing ice processes on the Susitna River and to be able to predict what changes might occur to these processes with the construction and operation of the proposed project. Specific objectives included gathering data on the freeze-up progression of the river, how the ice cover changed during the mid-winter period, and where breakup and jamming occurred. As part of these observations and data gathering, a comparison was also made with the observations of the previous efforts that occurred in the 1980's.

The observational data was also provided to the Fluvial Geomorphology Modeling below Watana Dam Study (Study 6.6), Groundwater Study (7.5), Instream Flow Studies (Studies 8.5-8.6), Fish and Aquatics Study (Studies 9.12), Riparian Vegetation Study Downstream of the Proposed Susitna-Watana Dam (Study 11.6), Recreation and Aesthetics Studies (12.5-12.7), and Socioeconomic and Transportation Study (Study 15.7) for use in their analyses. Descriptions of the freeze-up processes and plots of the ice cover progression were provided in the Study 7.6 ISR Part A filed in June 2014 (HDR 2014a) and in the Technical Memorandum filed in September 2014 (HDR 2014b). Stakeholders and the other studies, however, requested that the plotted progression data be presented in in a more visual fashion. A base map of the Susitna River basin was developed upon which the progression of the ice cover formation was mapped for each day when observations occurred. These figures present a sequential series of observations of how and where the ice cover forms and progresses throughout the freeze-up period.

2.0 Freeze-up Progression

Freeze-up on the Susitna River begins as air and water temperatures drop in the fall and the formation of frazil ice begins on the Upper River. Frazil ice is carried downstream and will eventually bridge across the river surface at locations of reduced ice transport capacity. Overall, freeze-up is characterized by ice progression from downstream to upstream with only a few ice cover bridging locations. Frazil ice is first seen flowing on the river surface as early as mid-October or as late as early December. Typically the earliest ice bridges are short, thick frazil ice accumulations in Devils Canyon, which do not progress very far upstream. Bridging which results in the formation of the ice cover on the Lower River generally occurs in the lowest 5 miles of the river. Once bridging takes place in this tidal region, the ice cover progresses steadily to approximately PRM 100 and then slows as it progressed farther upstream. There are some locations (notably near PRM 188) where another cover forms and progresses upstream but these covers are often overtaken by the cover progressing from downstream. The rate of progression of the main cover as well as the likelihood of formation of other bridging locations is highly dependent on the air temperature and the river discharge. Warmer years may see stalled progression or significant open reaches. For example, the 2013 freeze-up saw no cover formation between Devils Canyon and the Dam Site until much later in the winter.

3.0 Open Lead Survey Information

The Ice Processes in the Susitna River Study conducted specific open lead surveys on March 12, 2013 and February 20-21 and April 2, 2014. During these open lead observations, open leads were systematically mapped using a GPS enabled iOS mapping application for use with the Apple iPad. Both downstream and upstream waypoints were collected for longer open leads, while for leads less than about 100 feet in length only a center point was located. Georeferenced photographs were taken of most leads mapped, as well as continuous video. Each lead was classified as thermal or velocity in origin.

Thermal leads were generally found in marginal areas outside of the main channel flow. These include bank toes, which may accumulate groundwater from the surrounding floodplain, the margins of gravel bars, side channels, and side sloughs where shallow upwelling water may occur. Thermal leads were distinguished by very shallow depth (often bare gravel), discoloration and staining of water (occasional), and uneven, rounded and beaded appearance of the ice edges. In addition, throughout the winter, thermal leads tended to remain open, but may shrink or even cover over during very cold periods.

Velocity leads tended to be in the thalweg of the main channel, have visible current, deeper water, occasionally broken ice accumulated along edges or at the downstream end, and the margins were smoother and aligned with current. During very cold periods, flowing frazil would accumulate at the downstream ends of velocity leads but they would generally remain open.

4.0 Discussion

The freeze-up progression of the Susitna River was monitored from the initial appearance of frazil ice until the end of December in 2012 and 2013. These observations documented the river from the mouth to PRM 235 near the confluence of the Oshetna River. The 1980’s studies provided a significant amount of data on the ice processes on the Susitna River including the progression of the ice cover. While the 1980’s studies covered different reaches of the river each year and may have been limited in some areas, those data generally agree with the freeze-up observations from 2012 and 2013. The 1980’s data also includes 1981 and 1985, the years chosen from the historic record that correspond to a warmer/wetter winter and an average winter, respectively.

The freeze-up progression maps are presented as a series of figures with up to three different dates on each figure. It can be seen from the figures that the first ice covers form in Devils Canyon and the Upper River, followed by the main cover initiated near the mouth. Some shorter covers grow slowly or are overtaken by the main cover moving upstream. Each series of freeze-up progression figures are followed by a figure that shows the discharge hydrograph at the USGS Gold Creek gage (PRM 140) for the period of October 1 through December 31 along with the hourly air temperature recorded at the Talkeetna Airport weather station. For example, Figures 1-5 show the series of ice cover progression maps for the 2012 freeze-up with Figure 6 showing the Gold Creek discharge hydrograph, air temperature at Talkeetna and the dates when the observations in Figures in 1-5 were made. This provides additional data to further inform the cover progression; the cover progresses rapidly during very cold air temperatures and the discharge also can drop during cold spells.

The open lead survey data also shows a strong correlation between the 2013-2014 observations and those from the 1980's. Figures 37-40 show the locations of open leads, designated as thermal or velocity leads. For clarification in the figures, when there were leads located closer together than 1/4 mile, only a single point was plotted. Figure 40, which shows the data from 1982 and 1983, does not separate the leads by thermal or velocity nor does it separate them by date or year. Overall, however, the locations and numbers of the open leads are generally the same between the 1980's and the more recent observations.

The freeze-up progression and open lead observations show that there has not been any significant change (in terms of ice processes) in the river between the 1980's and the present time. Velocity lead locations indicate reaches where the flow is concentrated and too fast to allow an ice cover to form (outside of tight bends, rapids, etc). Many of the reaches identified during the 1980's studies as important spawning and rearing areas were also similarly identified in the present studies as those where upwelling of groundwater maintained stable conditions during the winter. These reaches are where the thermal leads are most prevalent.

5.0 References

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Table 1. List of Freeze-up Records.

Year	Observation Date Range	Area of River Observed	Figures
2012	October 22 - December 19	PRM 0 - 235	Figures 1 - 6
2013	November 6 – December 23	PRM 0 - 235	Figures 7 - 11
1980	October 31 – December 30	PRM 9 - 212	Figures 12 - 16
1981	November 2 – March 10	PRM 3 - 166	Figures 17 - 19
1982	October 12 – January 27	PRM 3 - 166	Figures 20 - 24
1983	October 26 – December 28	PRM 14 - 134	Figures 25 - 33
1984	October 27 – December 20	PRM 9 - 140	Figures 34 - 39
1985	October 22 – December 5	PRM 0 - 187	Figures 40 - 44

Table 2. List of Open Lead Data.

Date	Reach of River Observed	Velocity Leads	Thermal leads	Figures
3/12/13	PRM 0 - 235	100	44	Figure 45
2/20-21/14	PRM 0 - 235	89	20	Figure 46
4/2/14	PRM 0 - 235	79	29	Figure 47
1982-83[1]	PRM 88 - 154	112[1]	-	Figure 48

1 No distinction made for date of observations or if velocity or thermal in nature. Indicates location only.

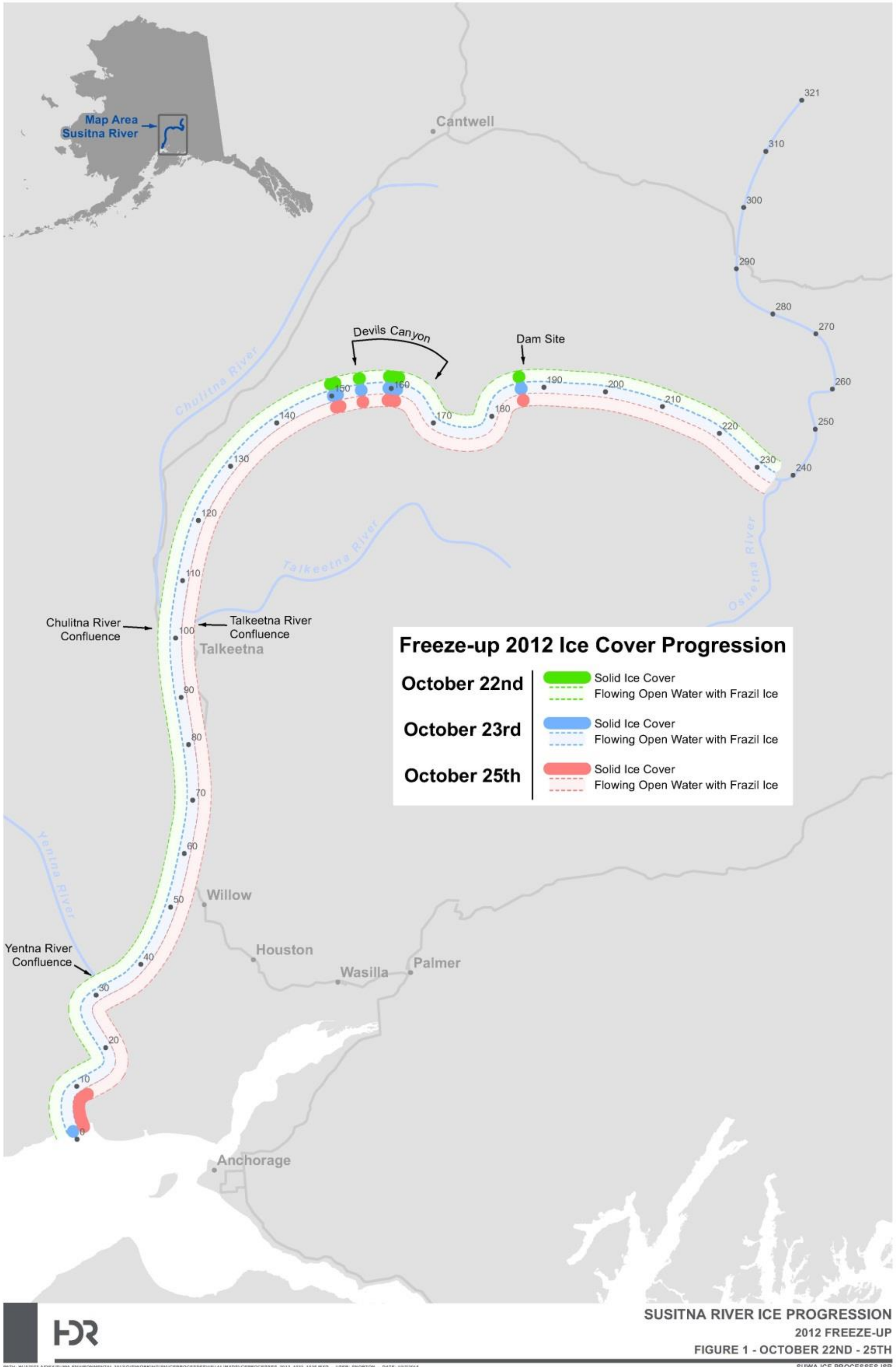


Figure 1. 2012 Freeze-up Progression - October 22, 23, and 25, 2012

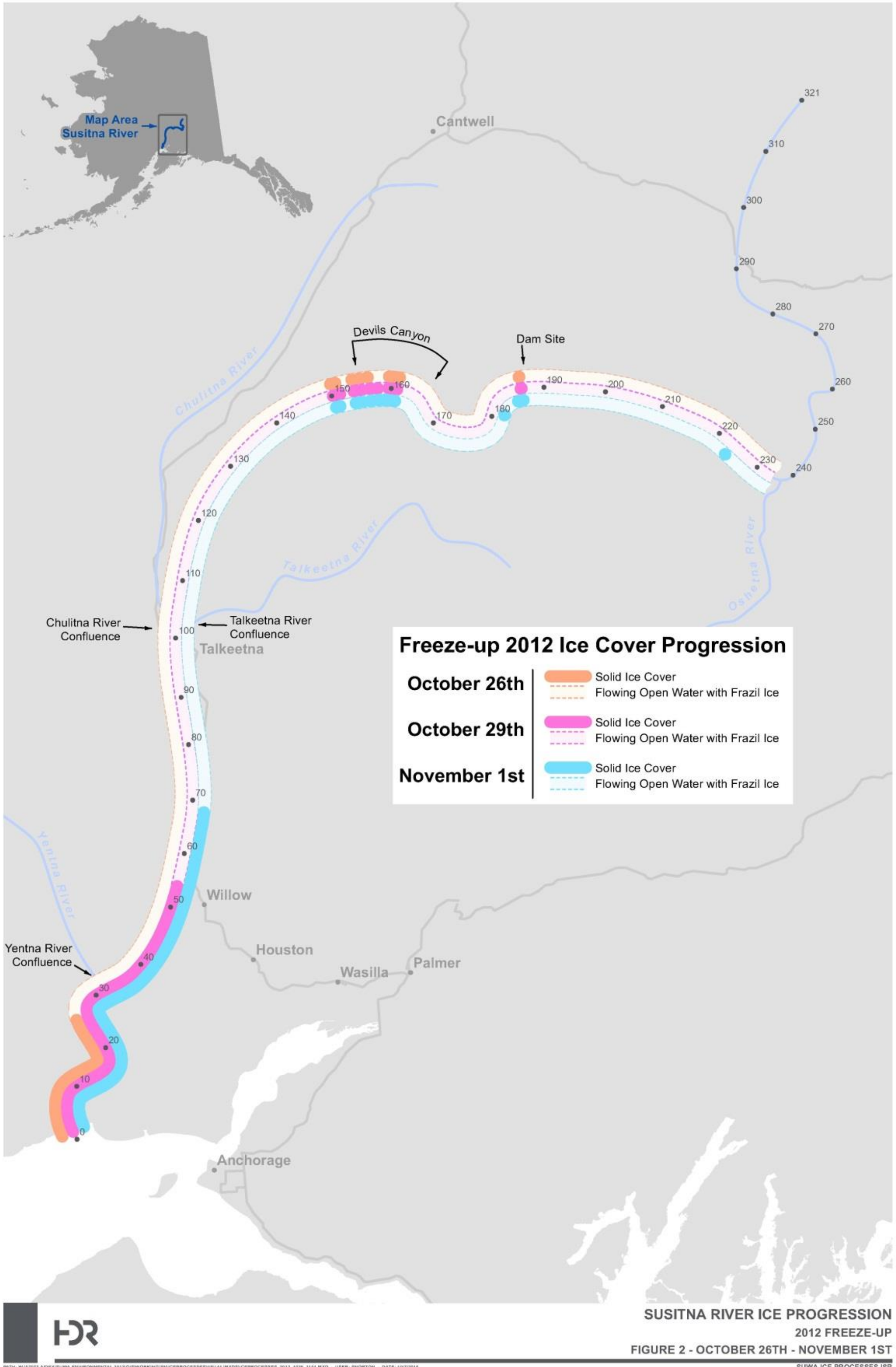


Figure 2. 2012 Freeze-up Progression - October 26, 29, and November 1, 2012

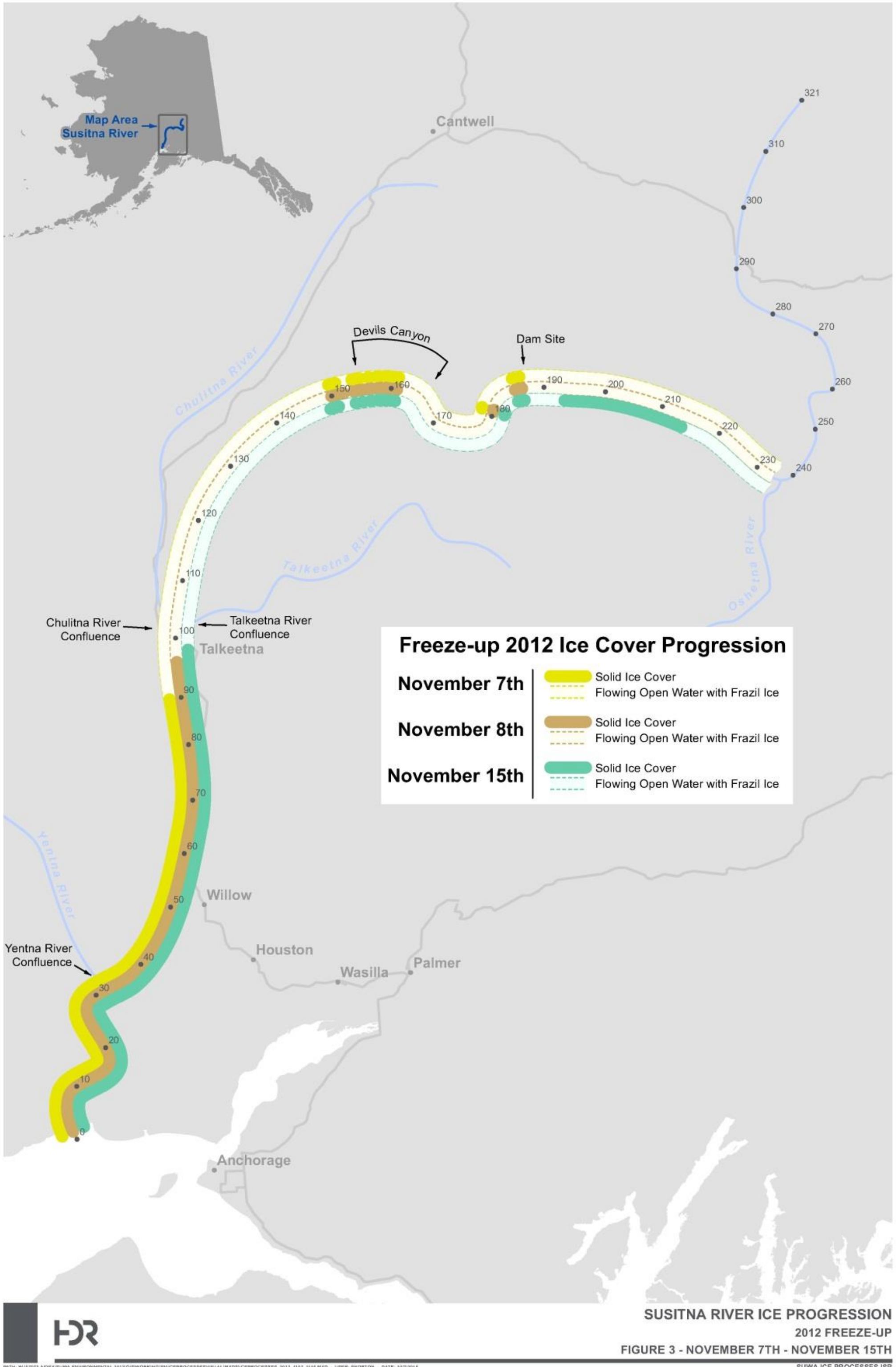


Figure 3. 2012 Freeze-up Progression - November 7, 8, and 15, 2012

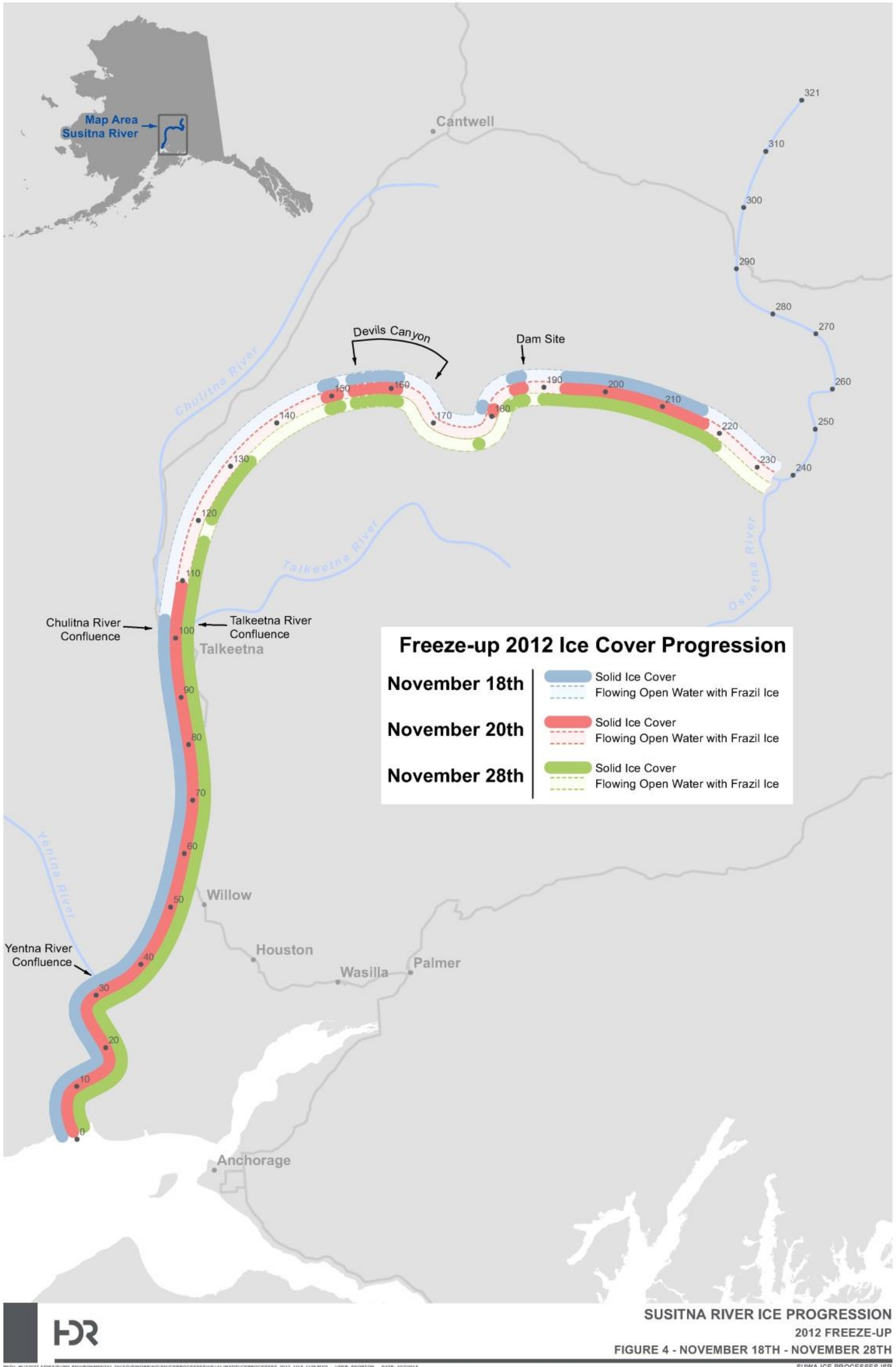


Figure 4. 2012 Freeze-up Progression – November 18, 20, and 28, 2012

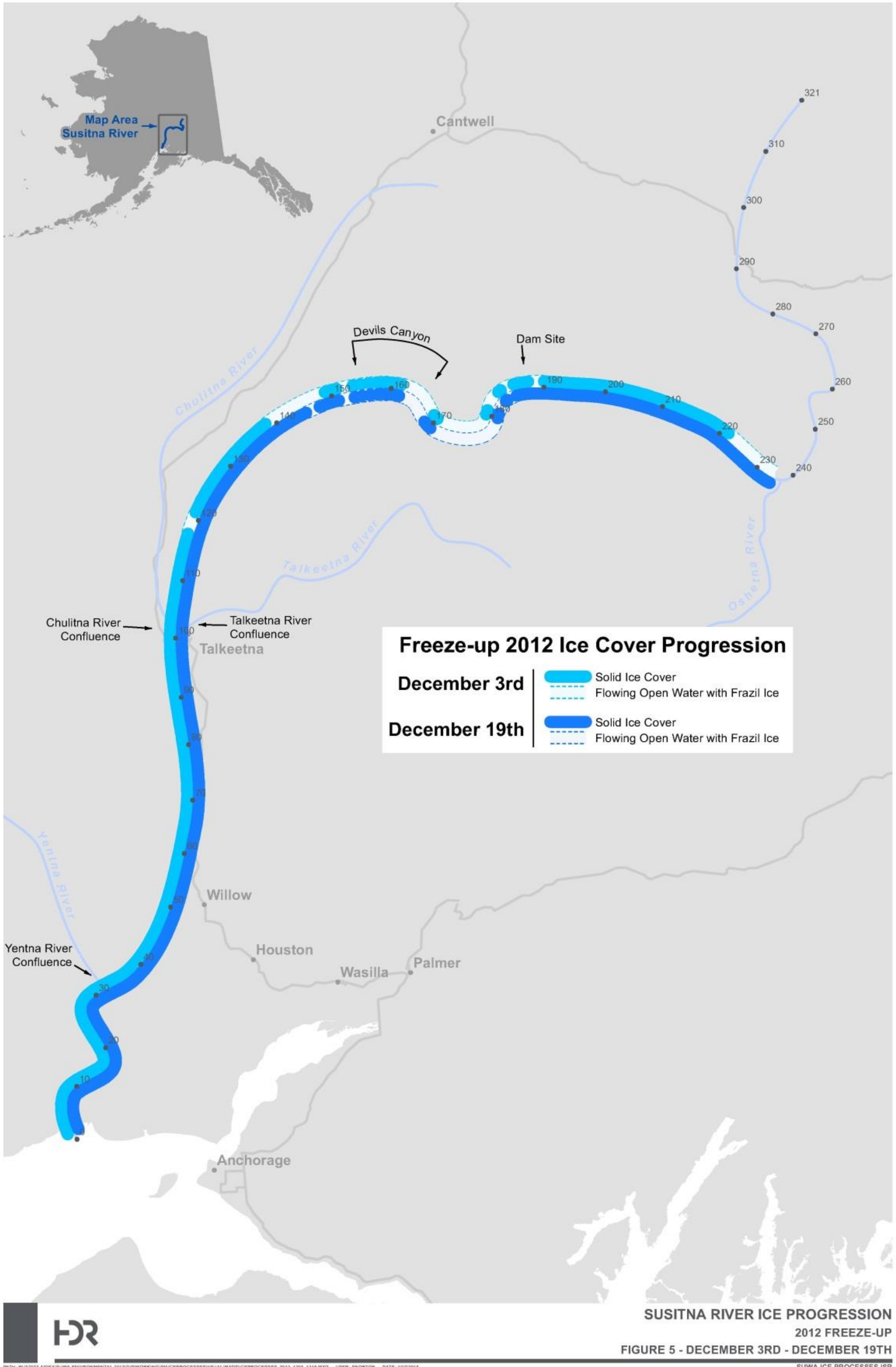


Figure 5. 2012 Freeze-up Progression - December 3 and 19, 2012

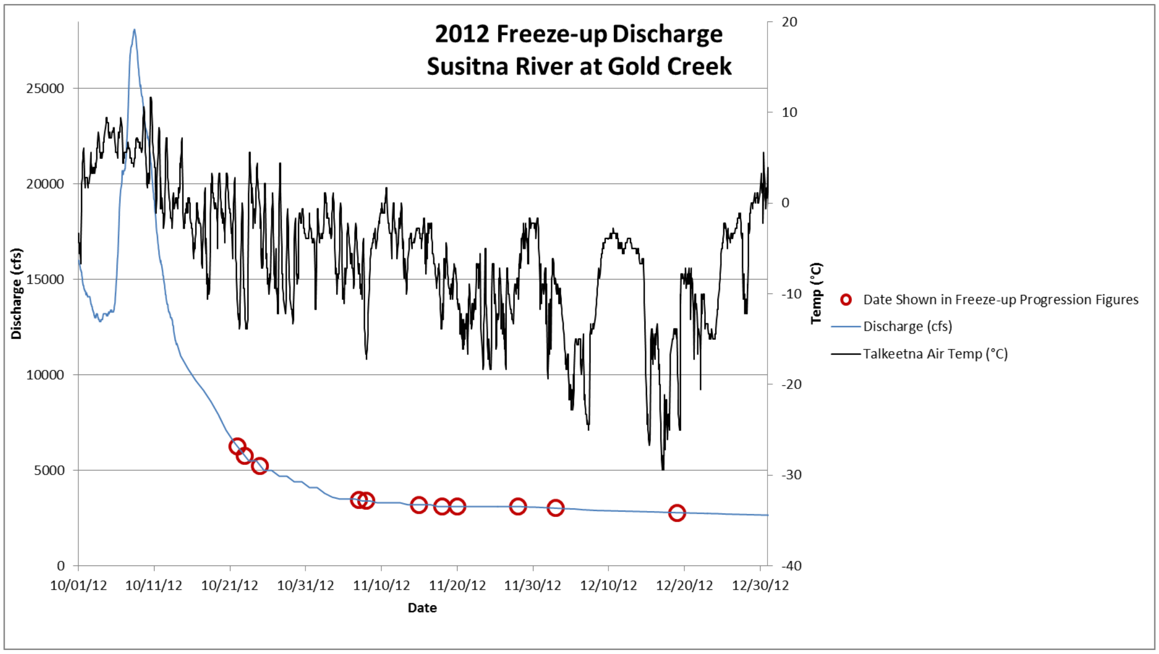


Figure 6. Gold Creek discharge hydrograph, Talkeetna air temperature, and dates of observations for Freeze-up 2012

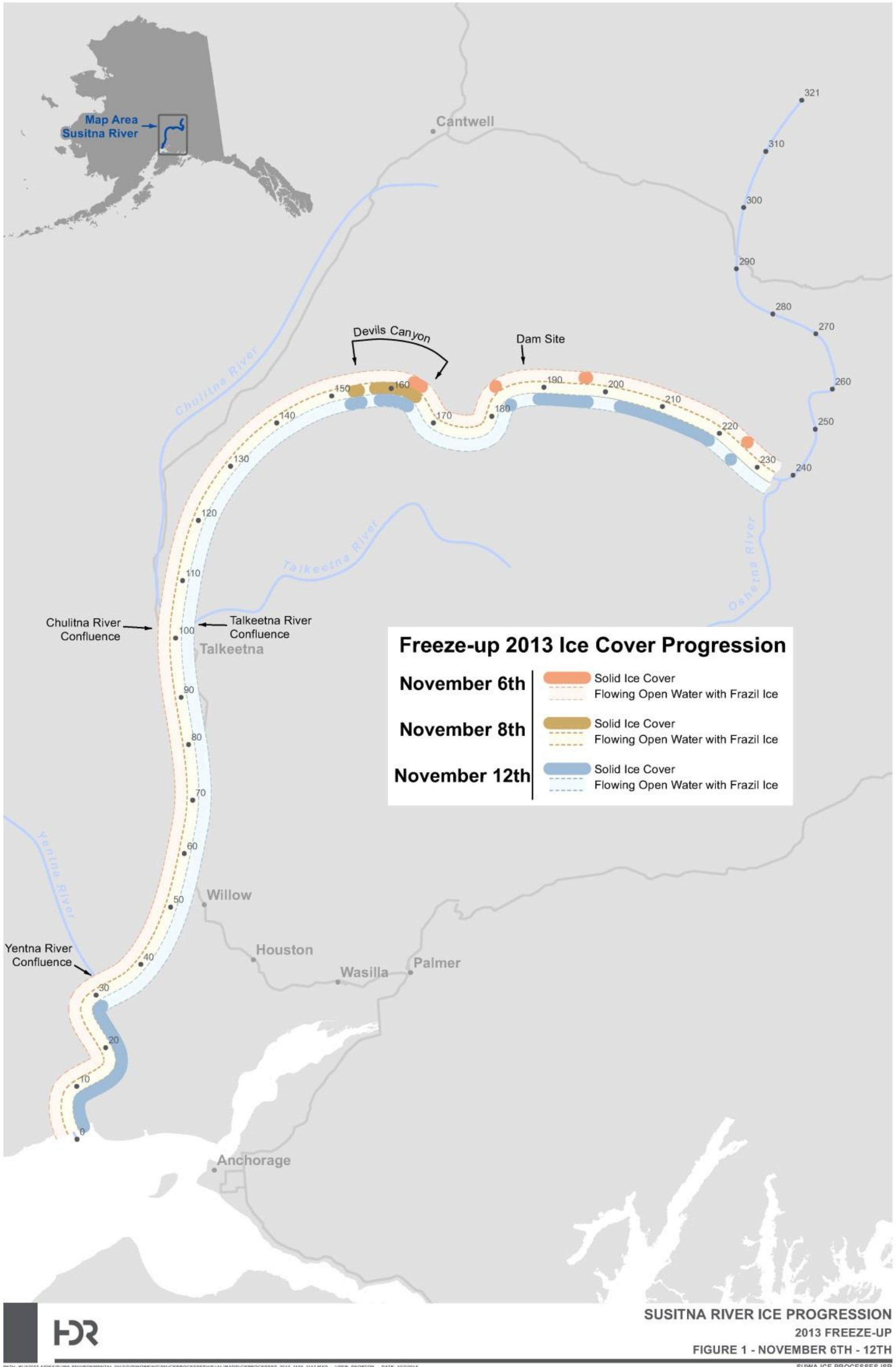


Figure 7. 2013 Freeze-up Progression - November 6, 8, and 12, 2013

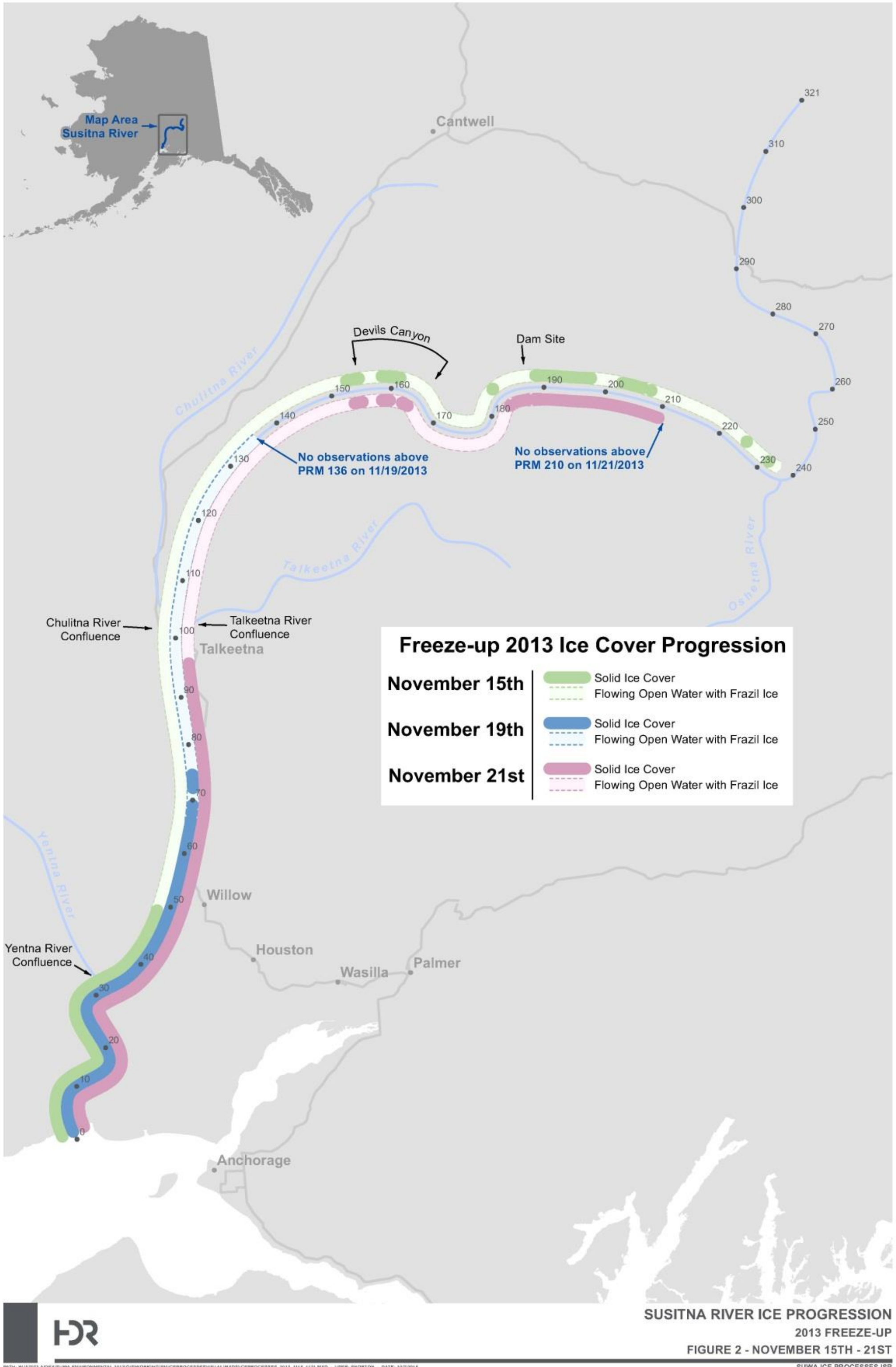


Figure 8. 2013 Freeze-up Progression - November 15, 19, and 21, 2013

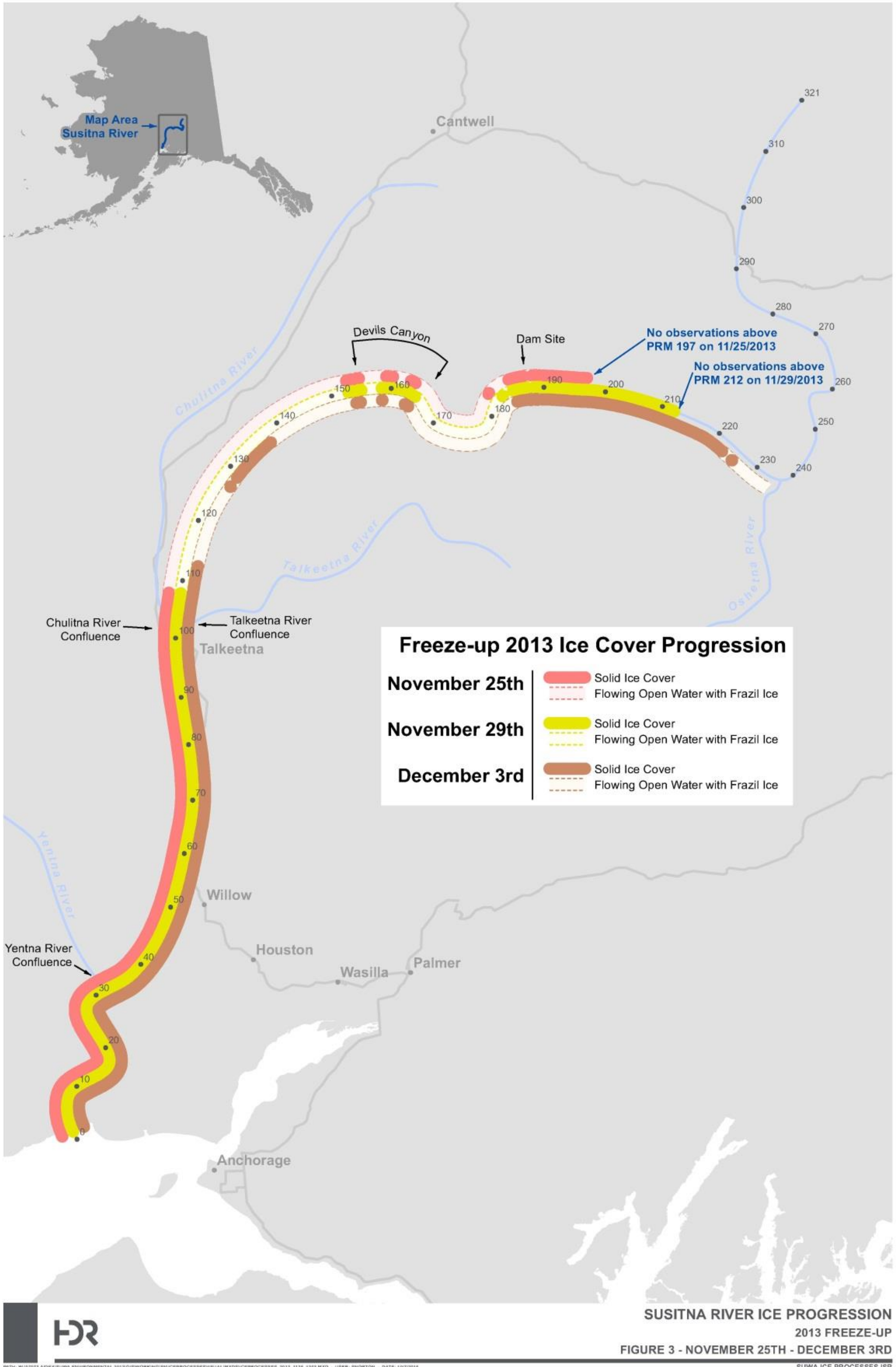


Figure 9. 2013 Freeze-up Progression - November 25, 29, and December 3, 2013

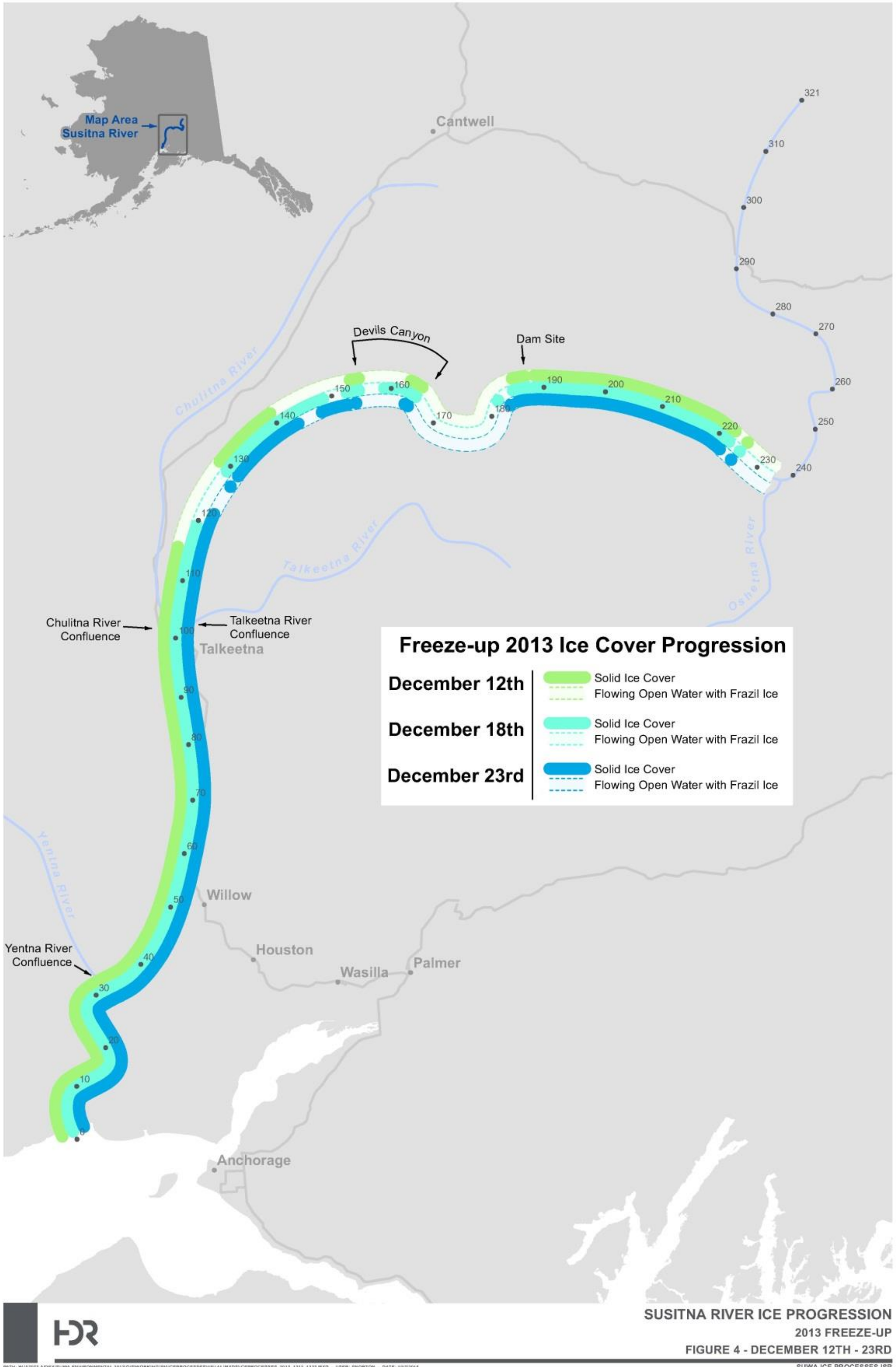


Figure 10. 2013 Freeze-up Progression - December 12, 18, and 23, 2013

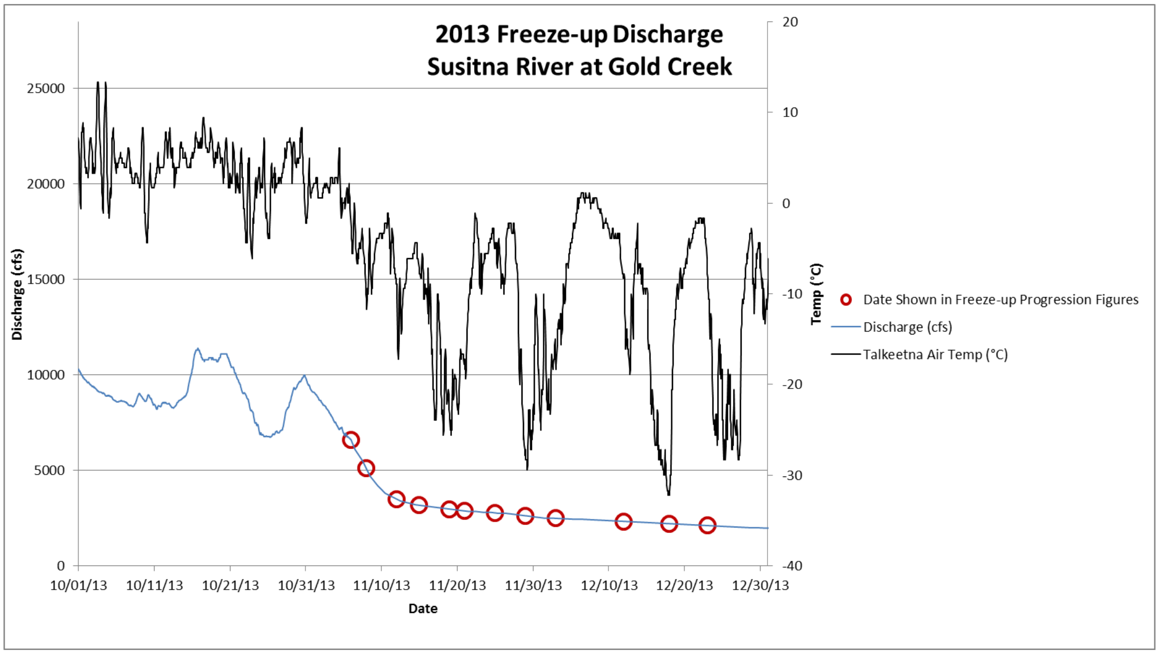


Figure 11. Gold Creek discharge hydrograph, Talkeetna air temperature, and dates of observations for Freeze-up 2013

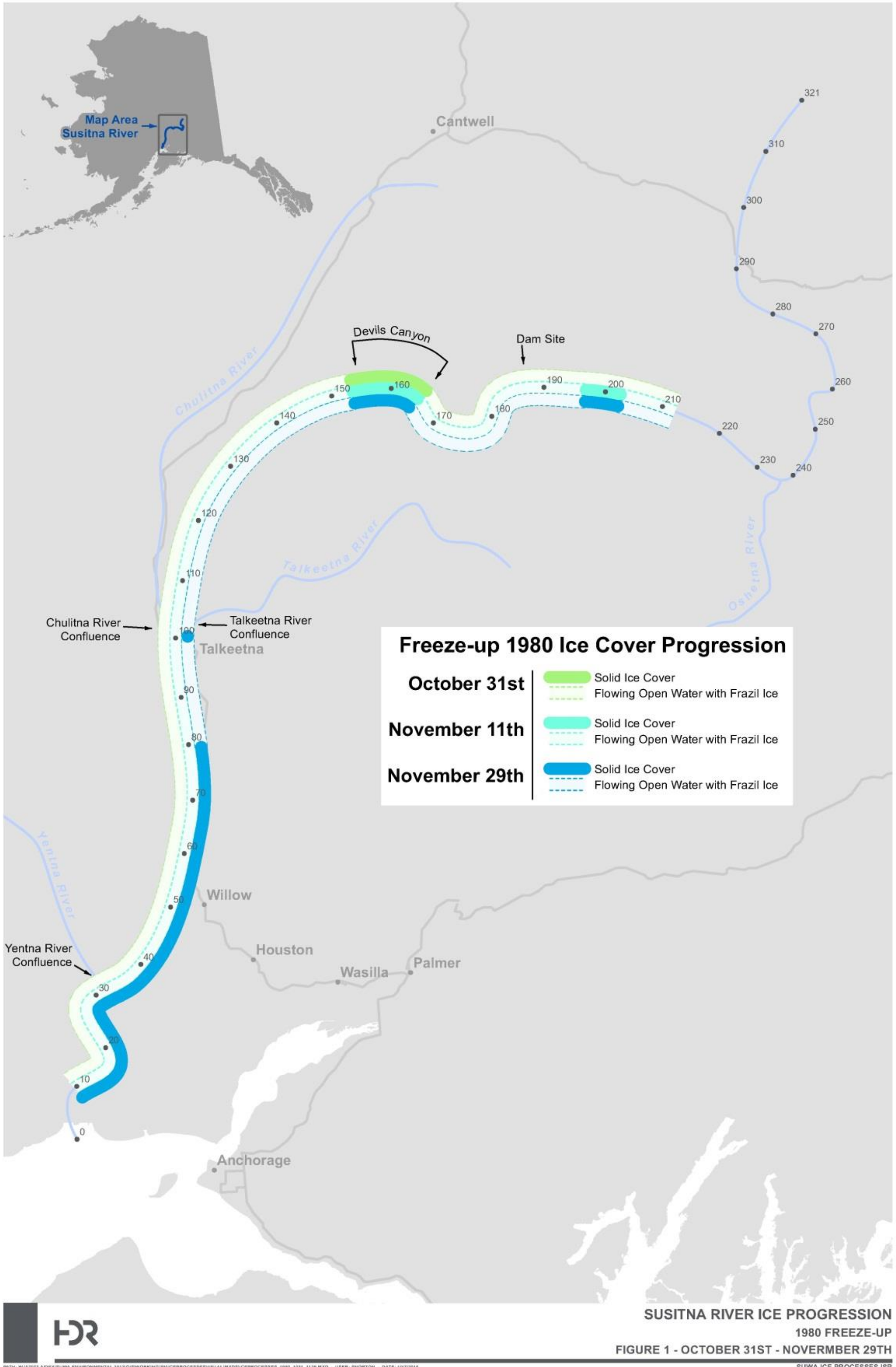


Figure 12. 1980 Freeze-up Progression – October 31, November 11, and 29, 1980

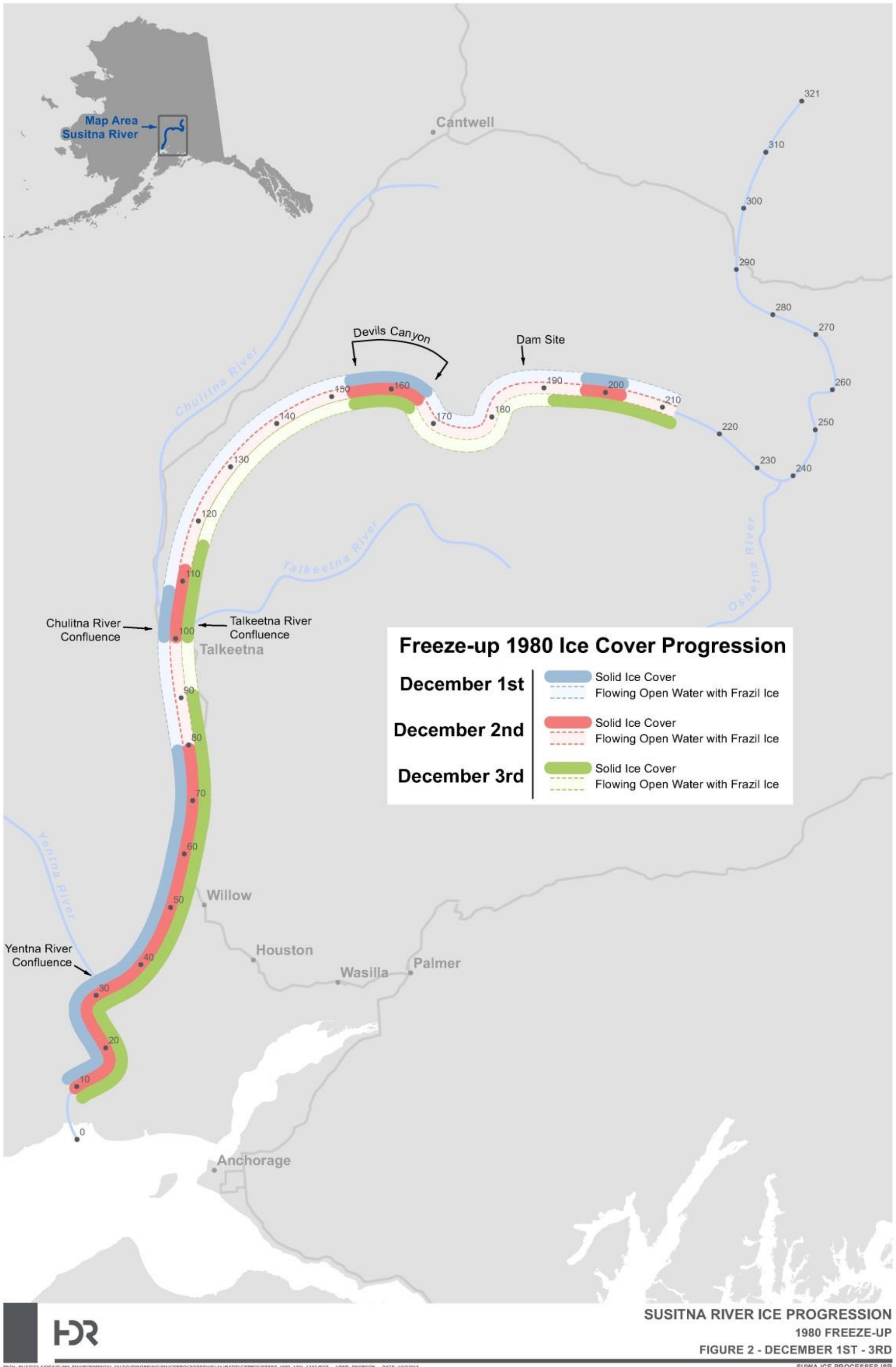


Figure 13. 1980 Freeze-up Progression – December 1, 2, and 3, 1980

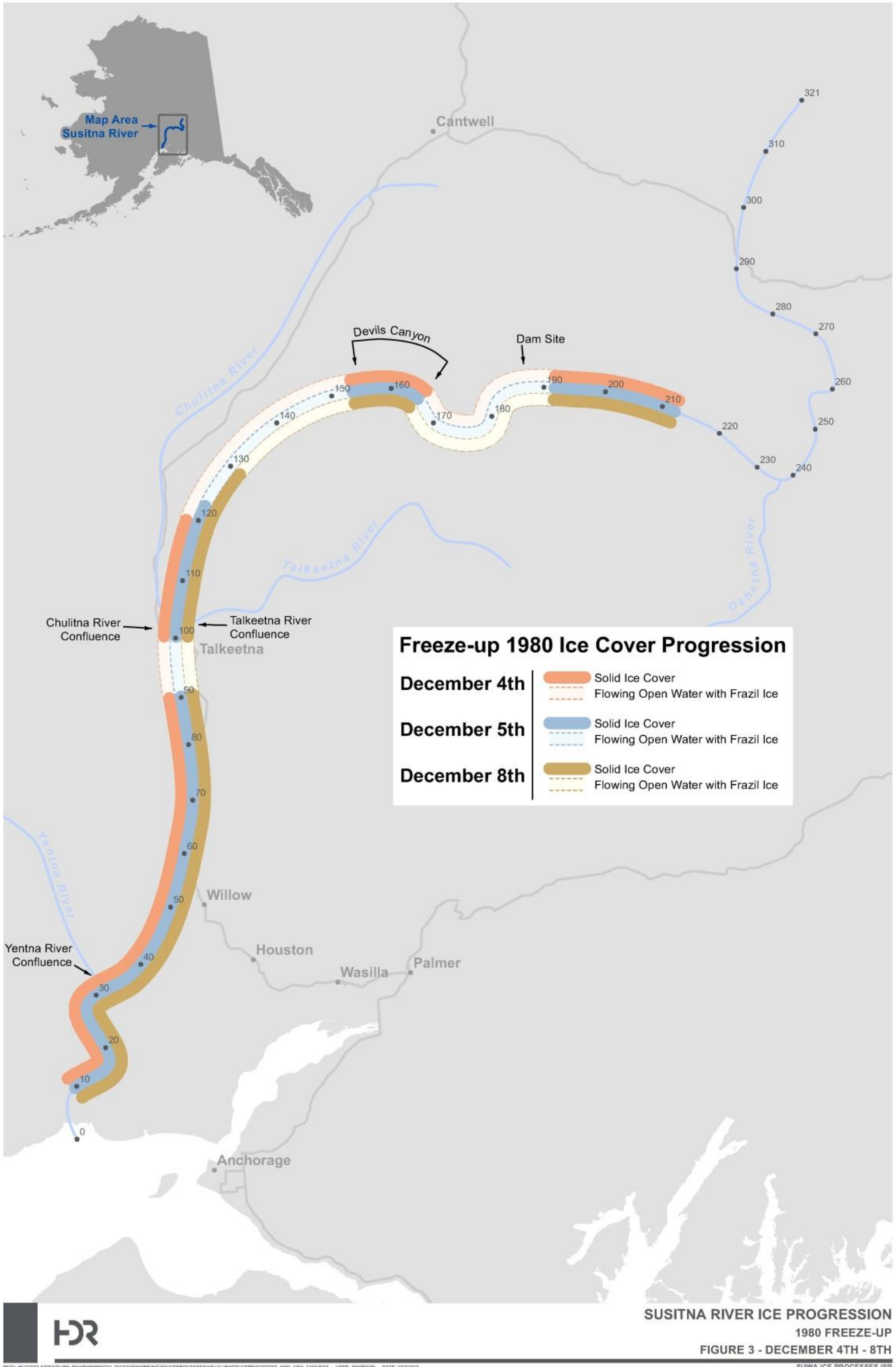


Figure 14. 1980 Freeze-up Progression – December 4, 5, and 8, 1980

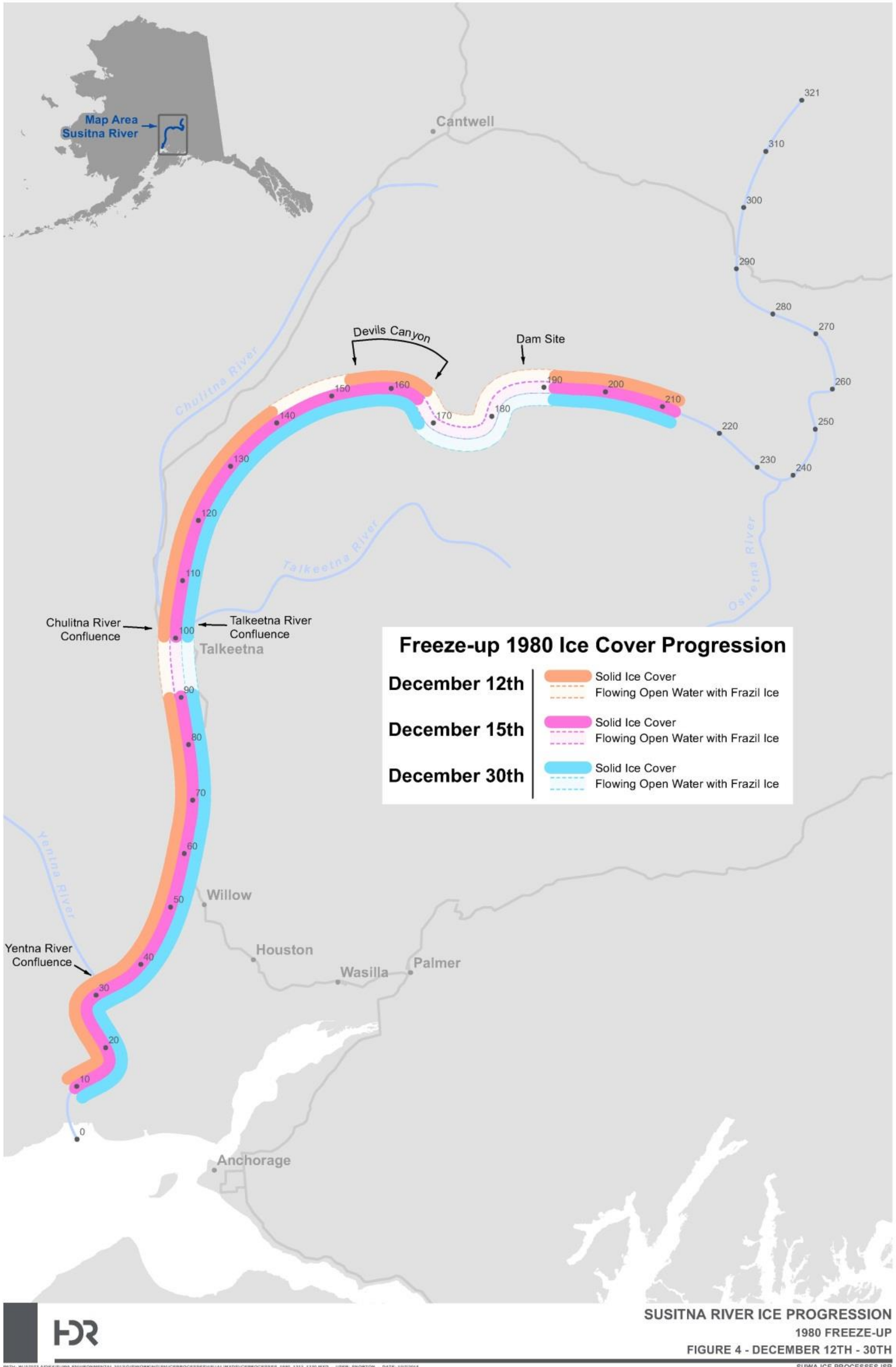


Figure 15. 1980 Freeze-up Progression – December 12, 15, and 30, 1980

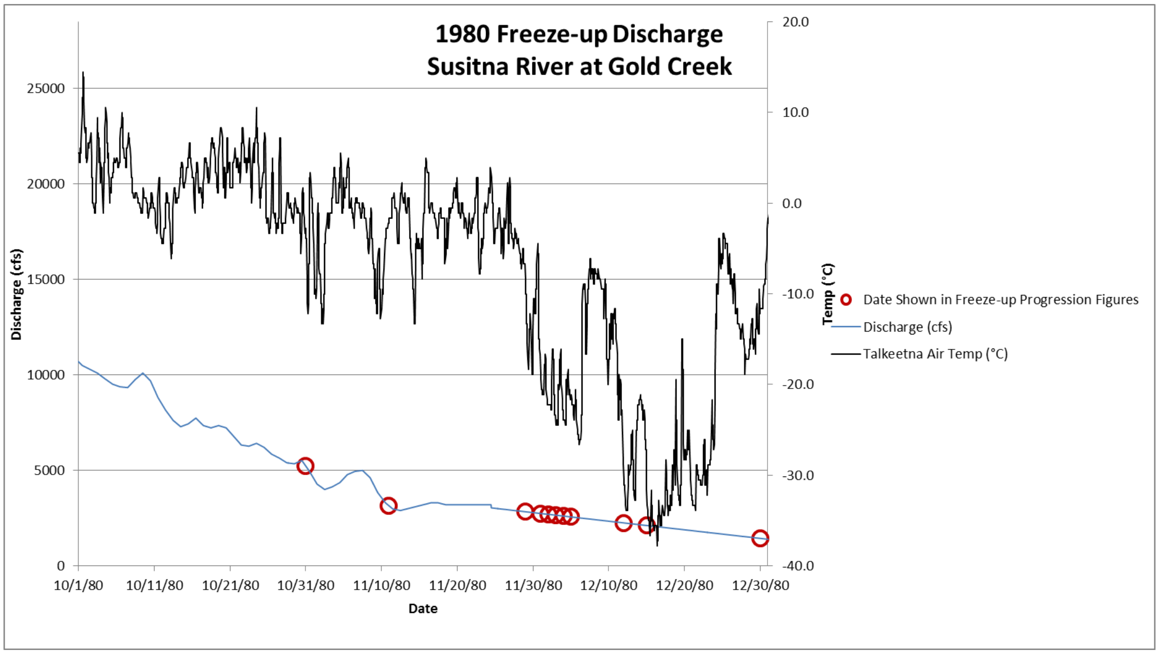


Figure 16. Gold Creek discharge hydrograph, Talkeetna air temperature, and dates of observations for Freeze-up 1980

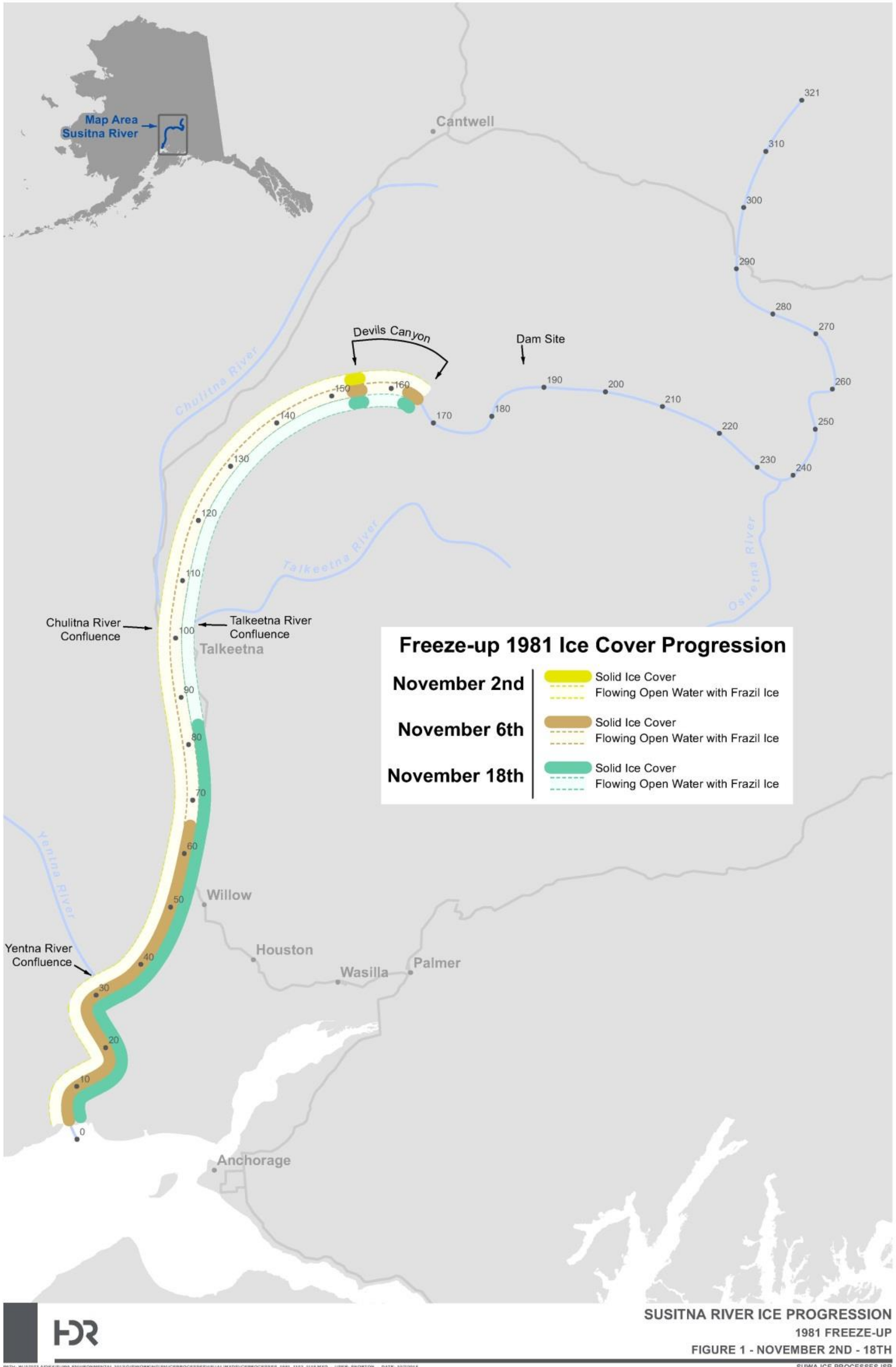


Figure 17. 1981 Freeze-up Progression – November 2, 6, and 18, 1981

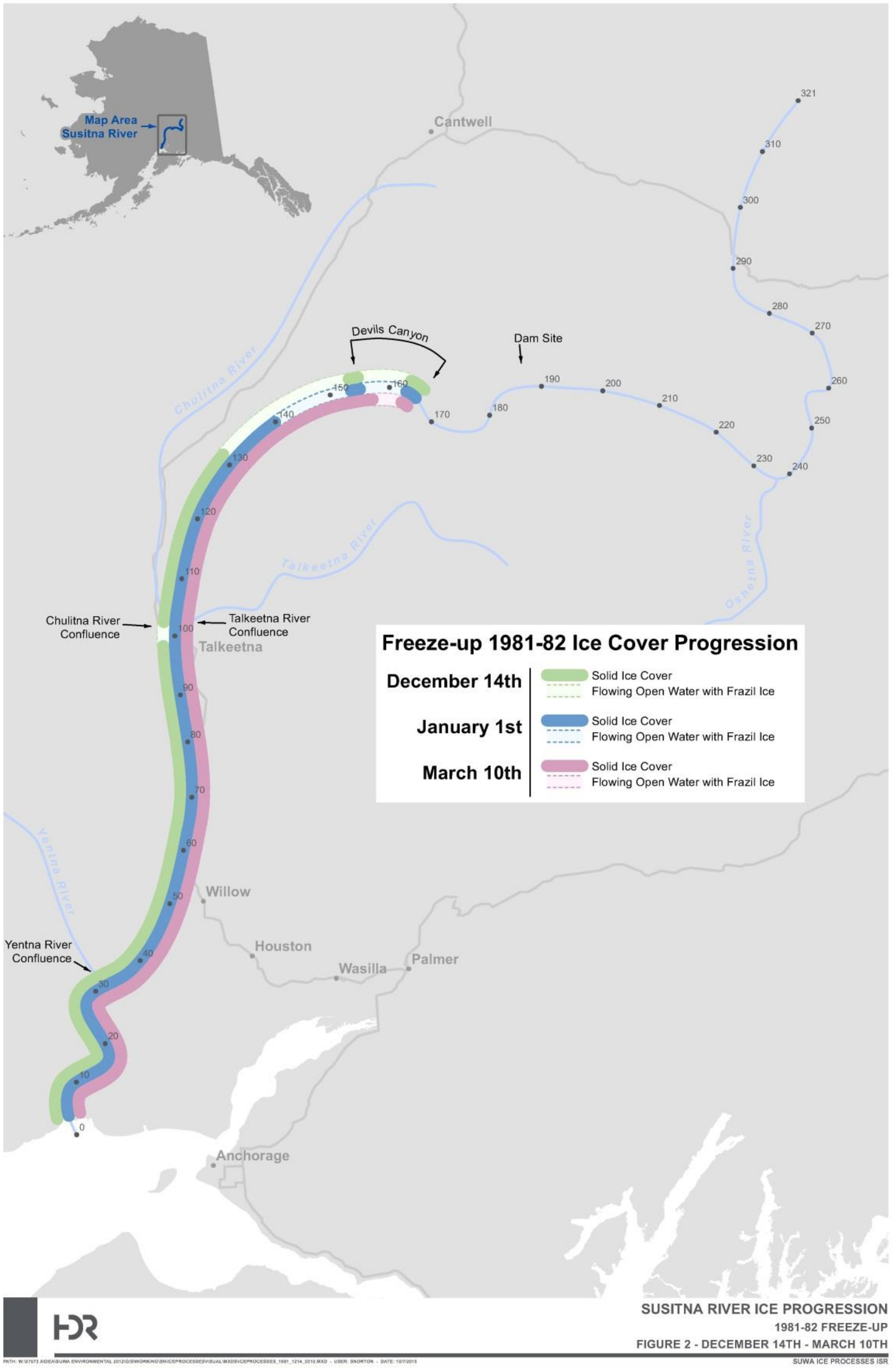


Figure 18. 1981 Freeze-up Progression – December 14, 1981, January 1 and March 10, 1982

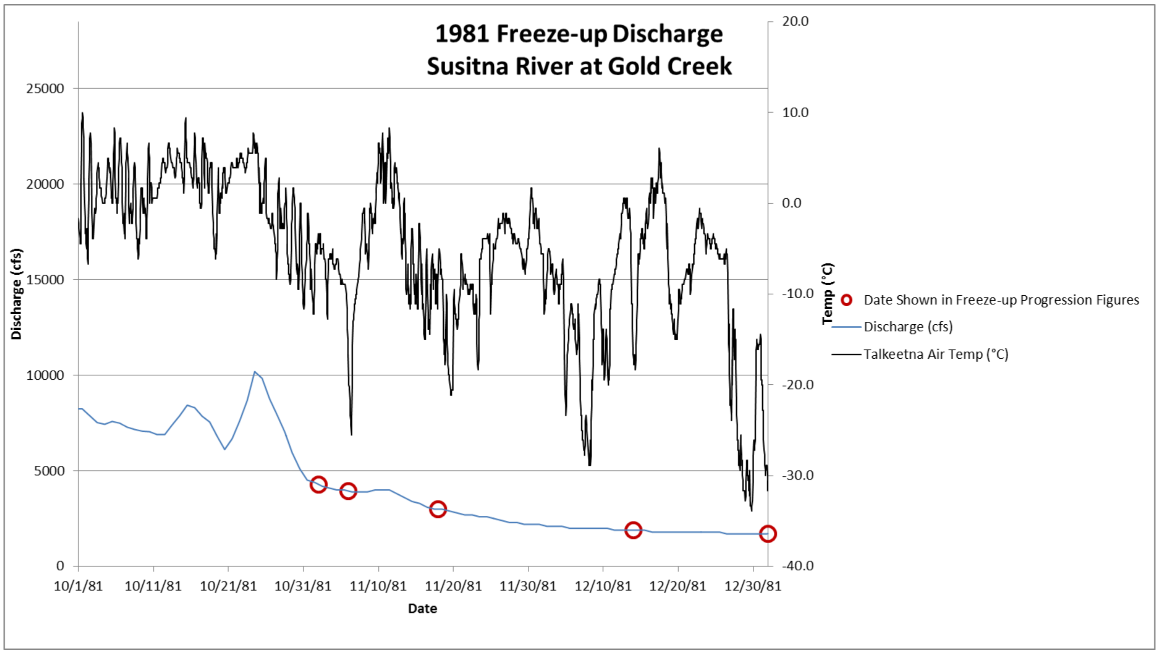


Figure 19. Gold Creek discharge hydrograph, Talkeetna air temperature, and dates of observations for Freeze-up 1981

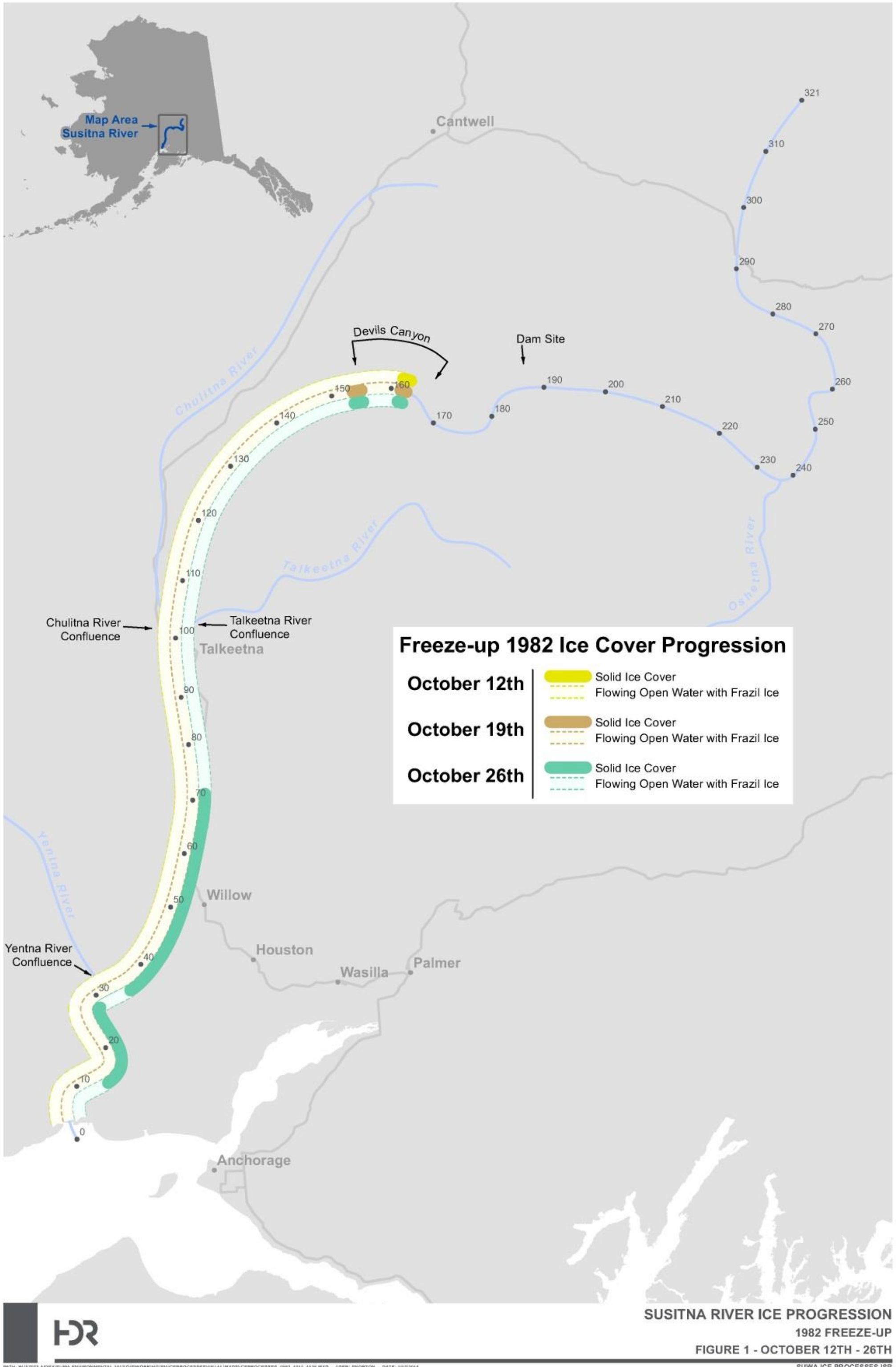


Figure 20. 1982 Freeze-up Progression – October 12, 19, and 26, 1982

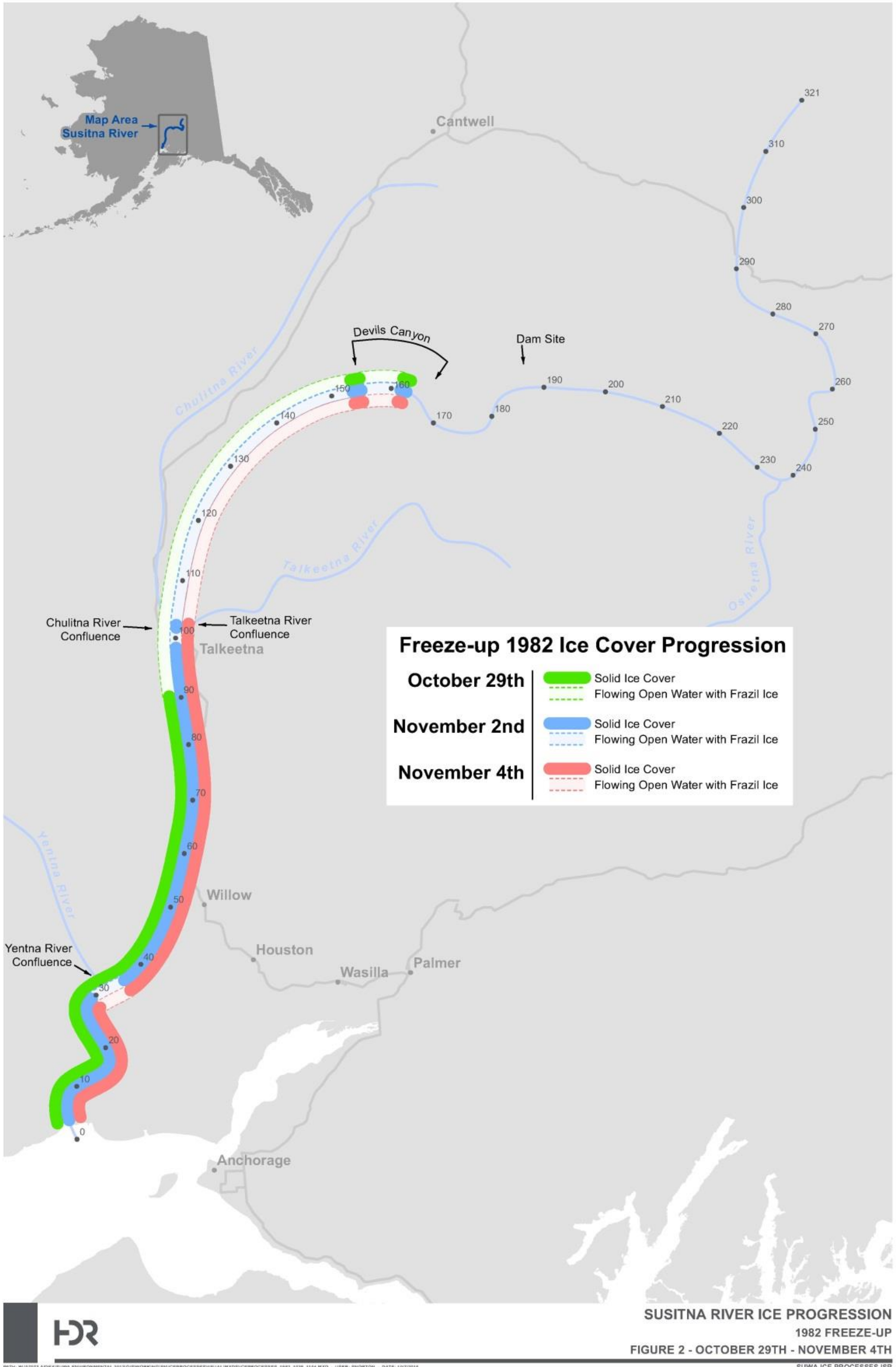


Figure 21. 1982 Freeze-up Progression – October 29, November 2, and 4, 1982

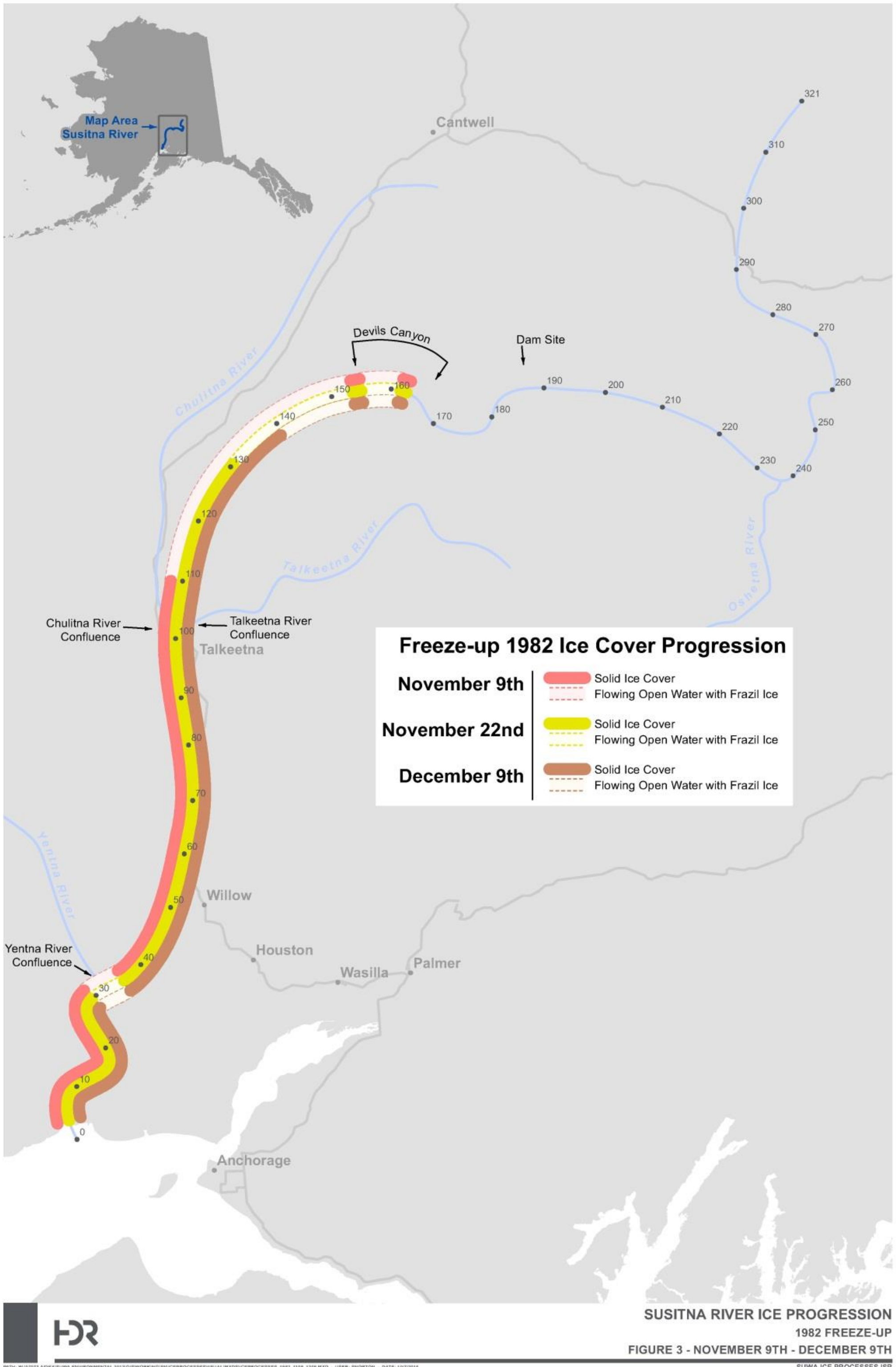


Figure 22. 1982 Freeze-up Progression – November 9, 22, and December 9, 1982

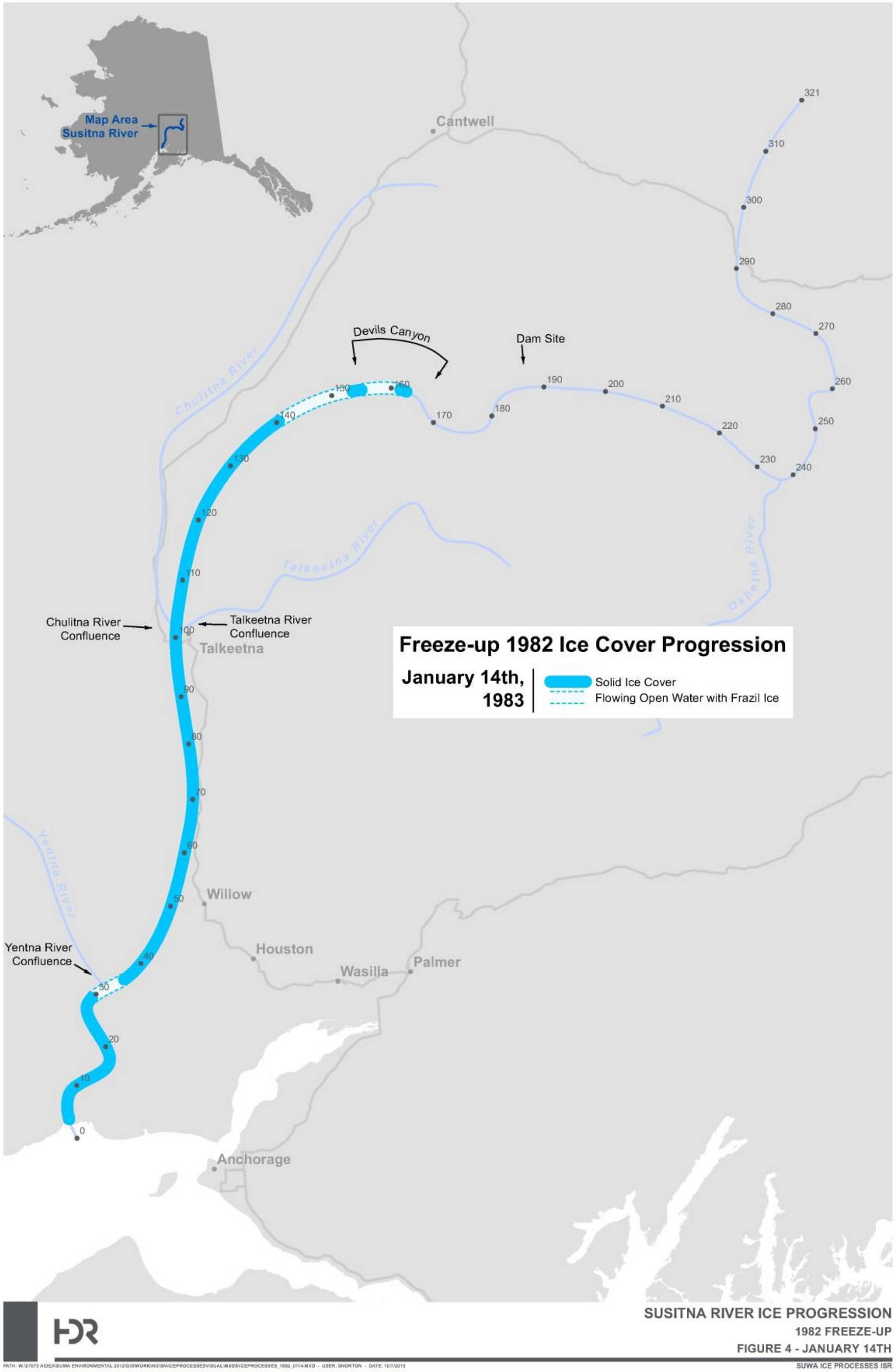


Figure 23. 1982 Freeze-up Progression – January 14, 1983

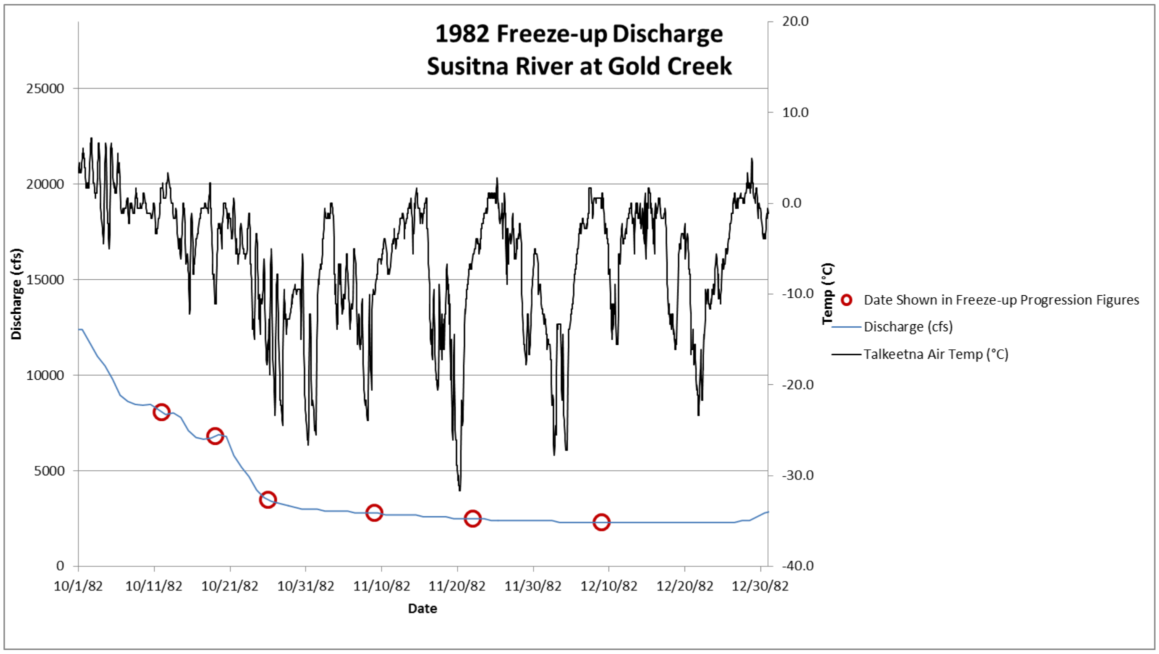


Figure 24. Gold Creek discharge hydrograph, Talkeetna air temperature, and dates of observations for Freeze-up 1982

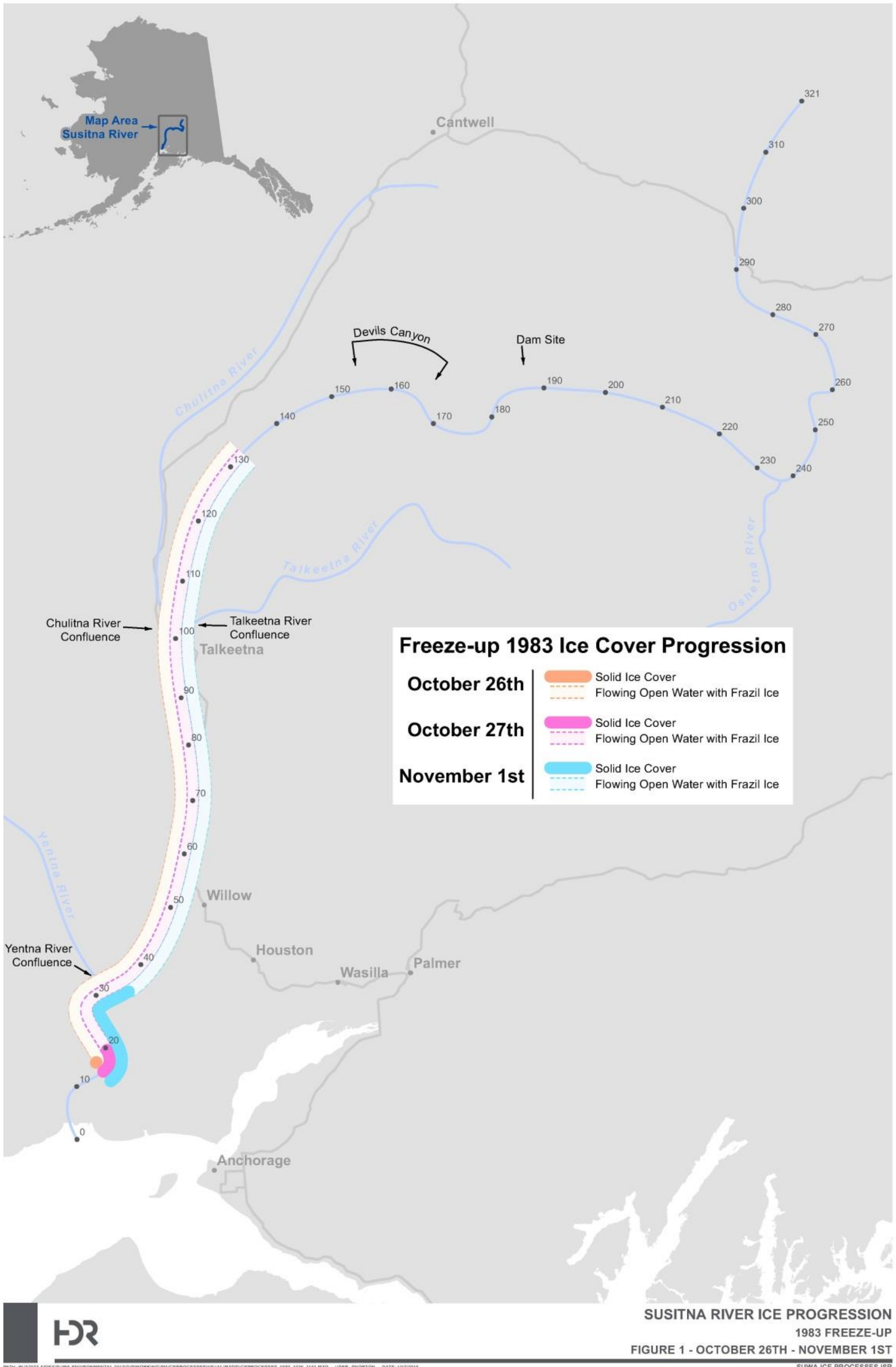


Figure 25. 1983 Freeze-up Progression – October 26, 27, and November 1, 1983

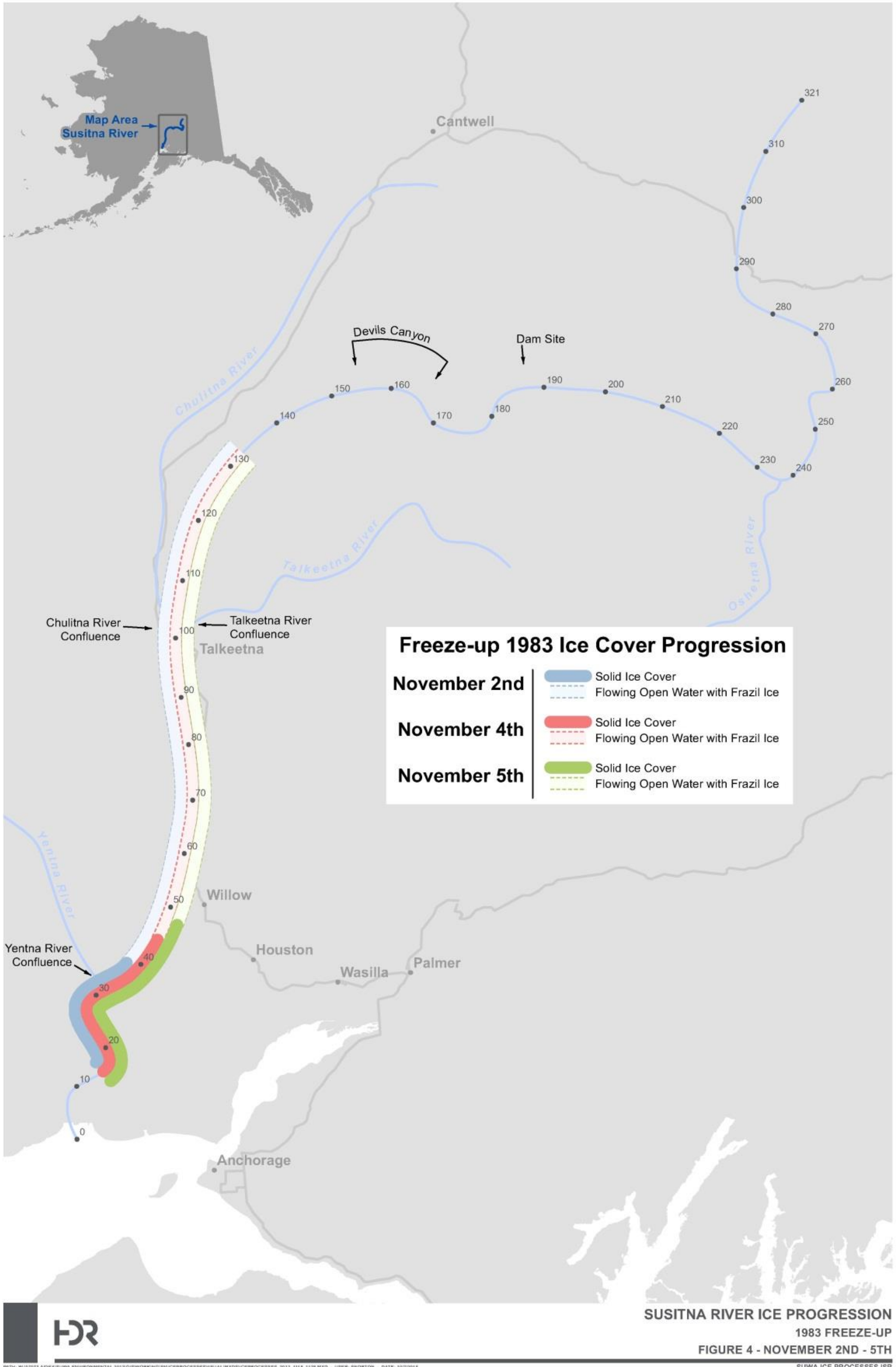


Figure 26. 1983 Freeze-up Progression – November 2, 4, and 5, 1983

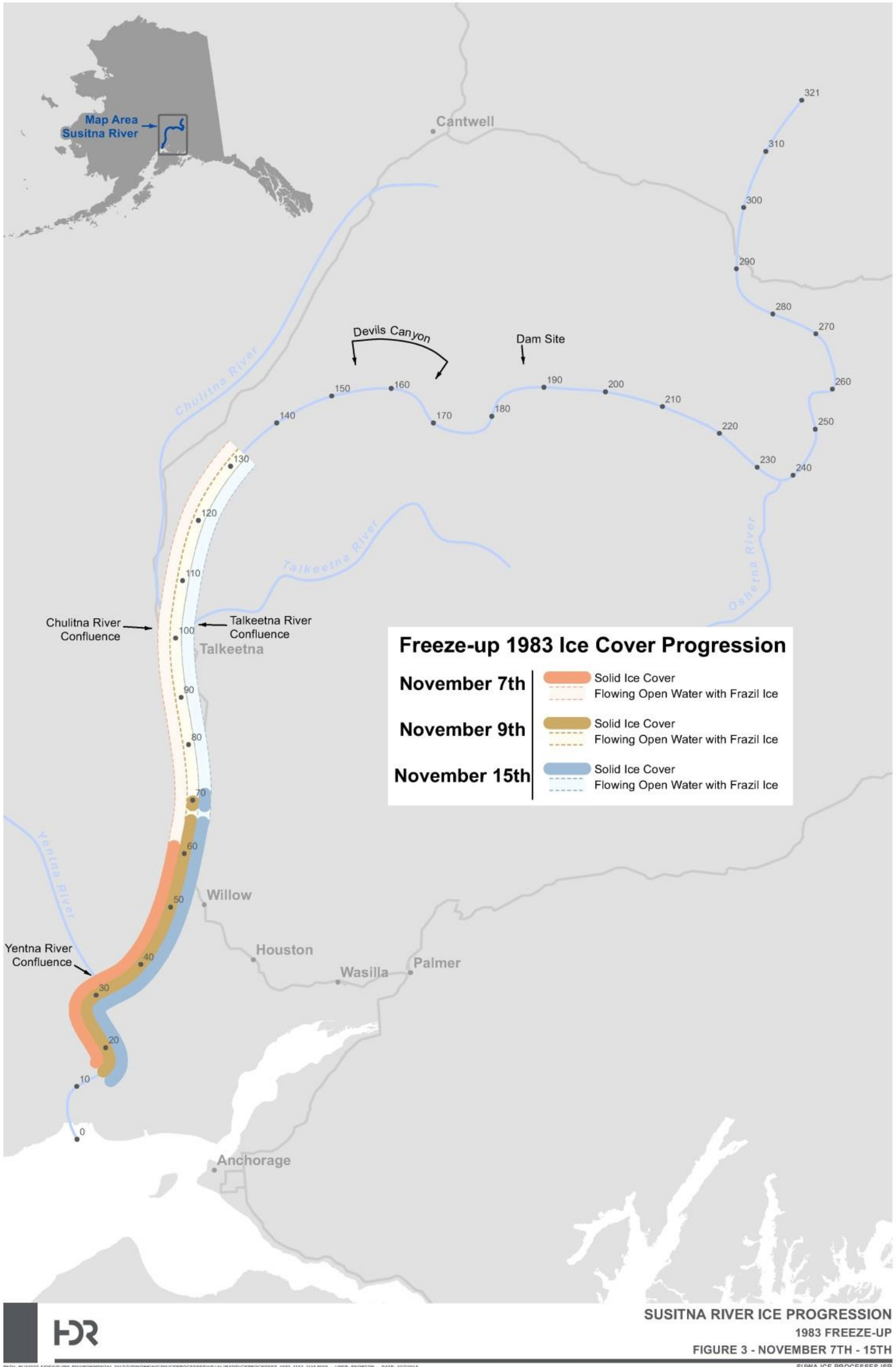
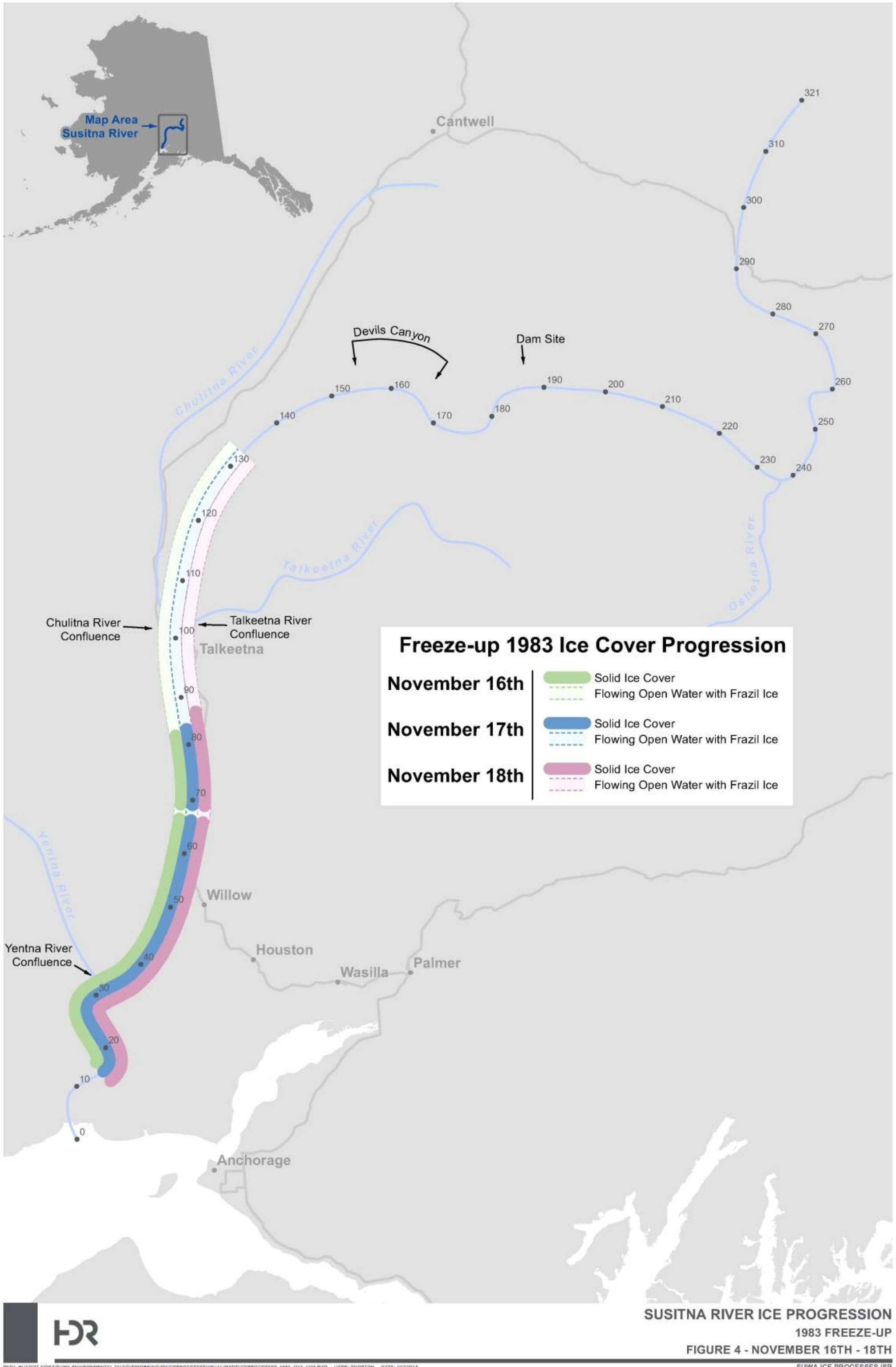


Figure 27. 1983 Freeze-up Progression – November 7, 9, and 15, 1983



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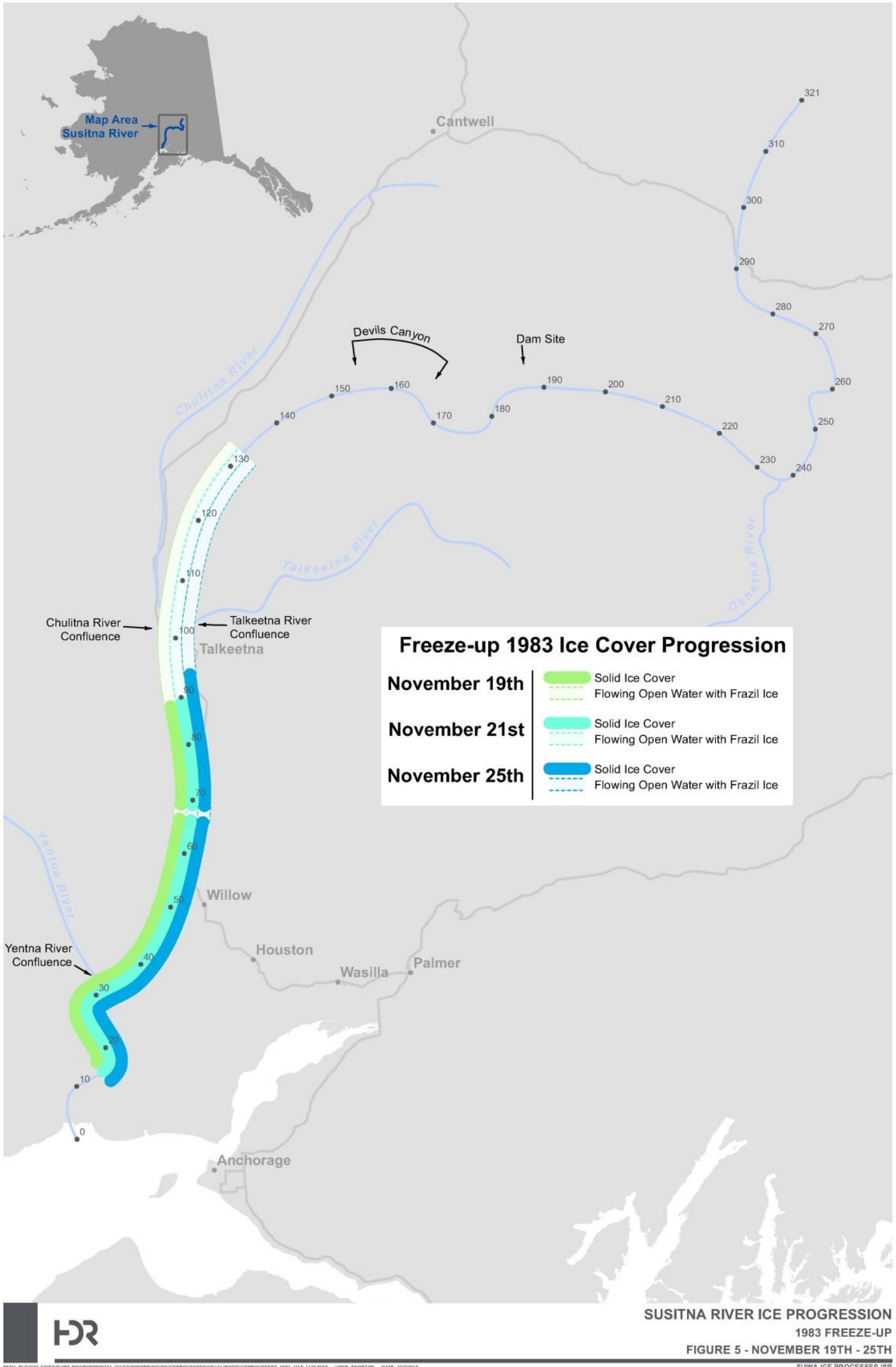

Figure 29. 1983 Freeze-up Progression – November 19, 21, and 25, 1983

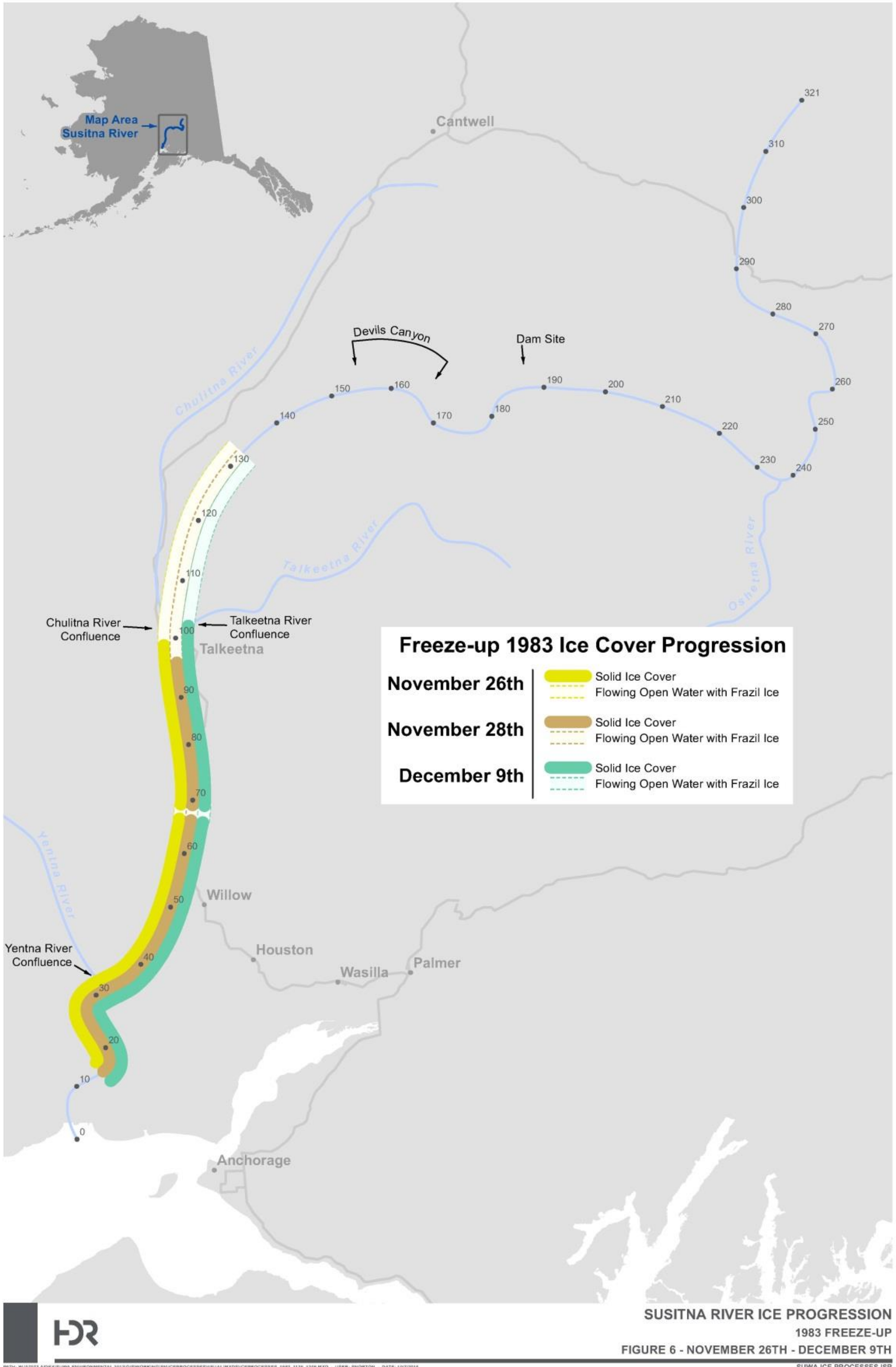

Figure 30. 1983 Freeze-up Progression – November 26, 28, and December 9, 1983

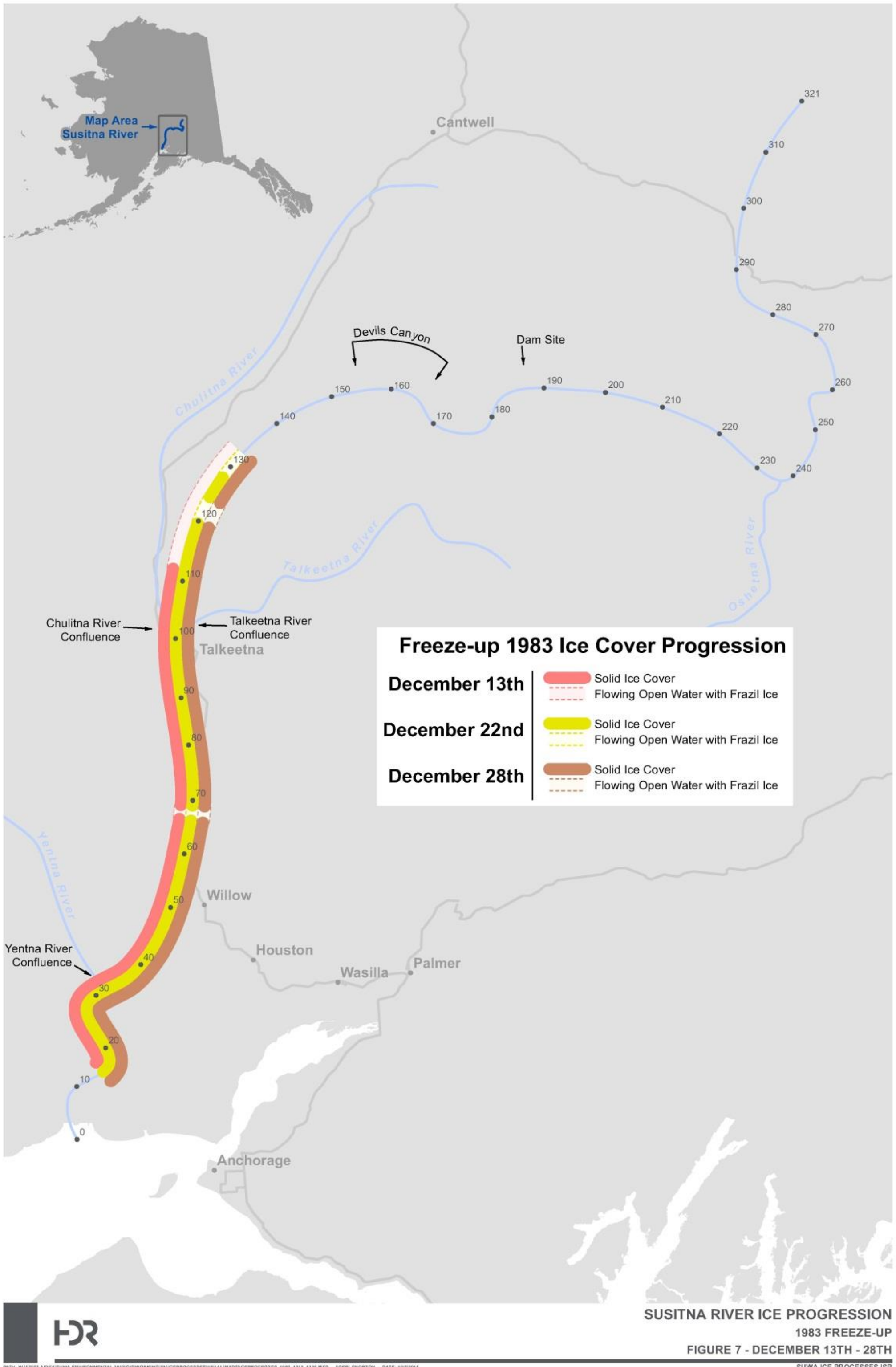

Figure 31. 1983 Freeze-up Progression – December 13, 22, and 28, 1983

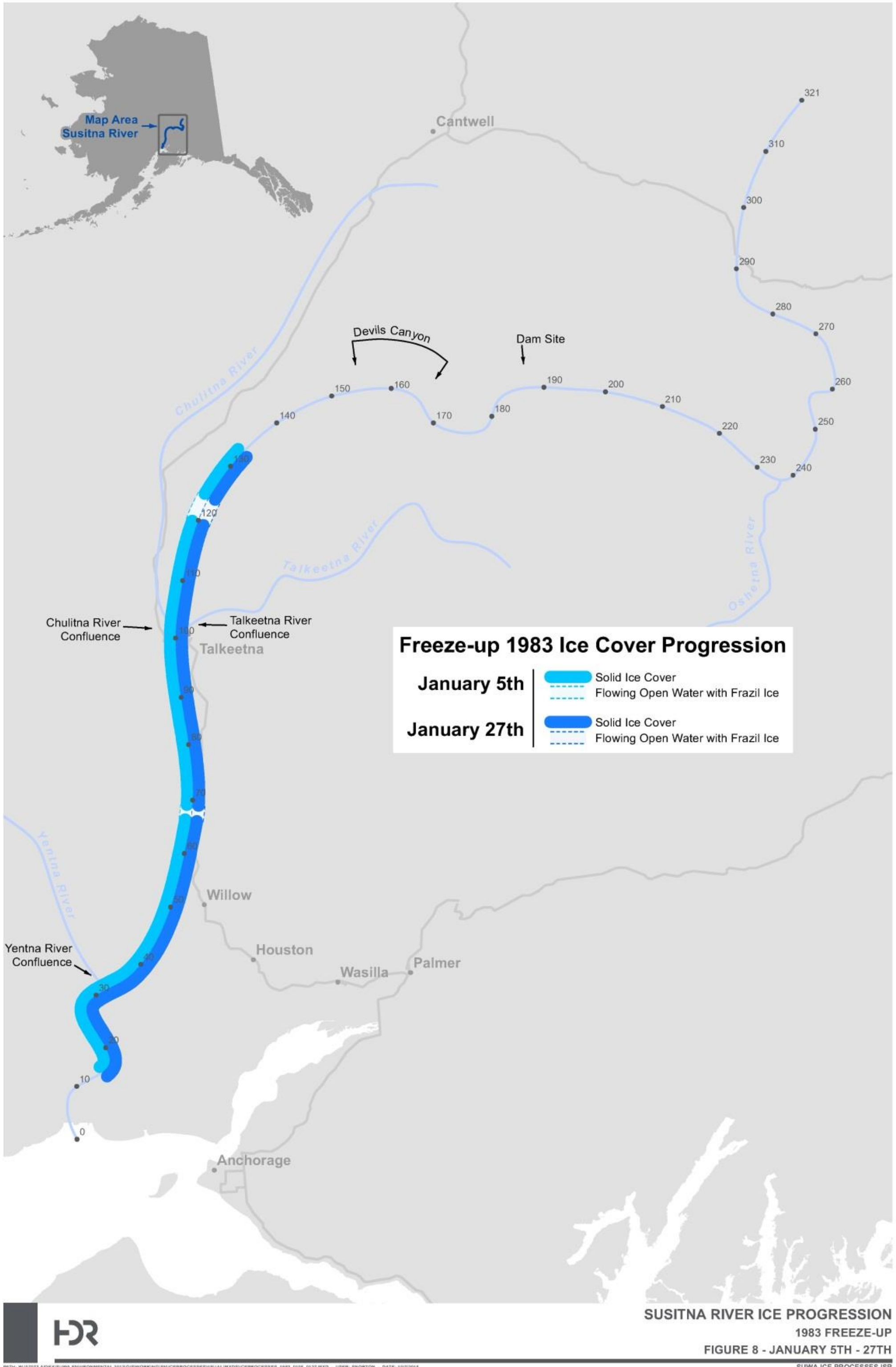

Figure 32. 1983 Freeze-up Progression – January 5 and 27, 1984

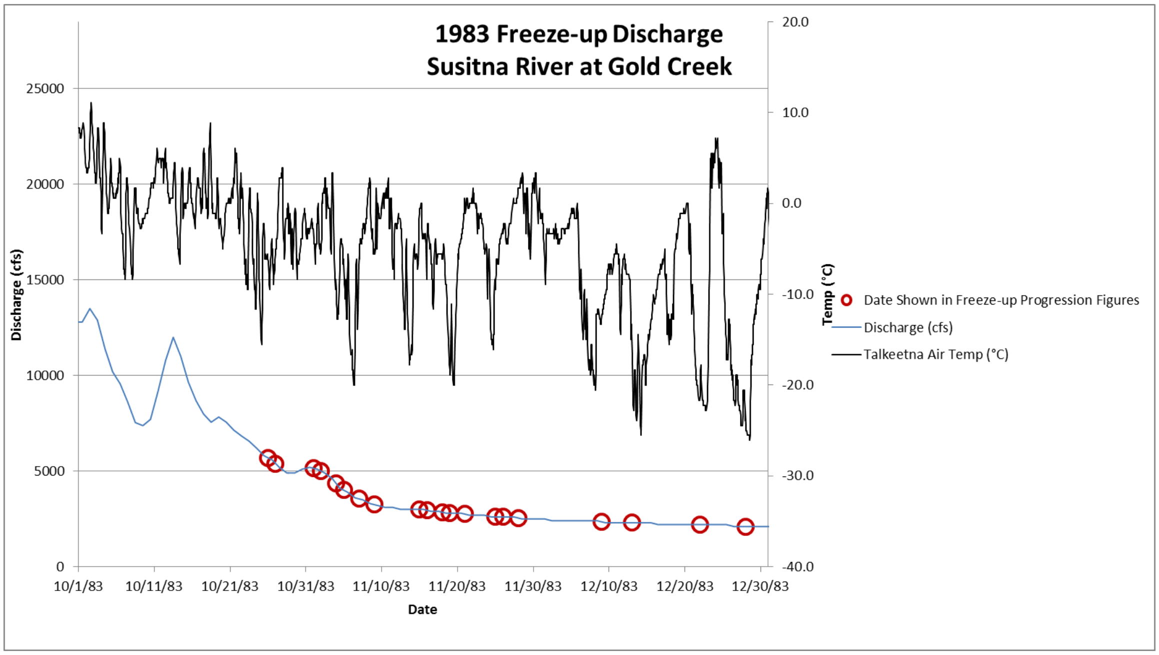

Figure 33. Gold Creek discharge hydrograph, Talkeetna air temperature, and dates of observations for Freeze-up 1983

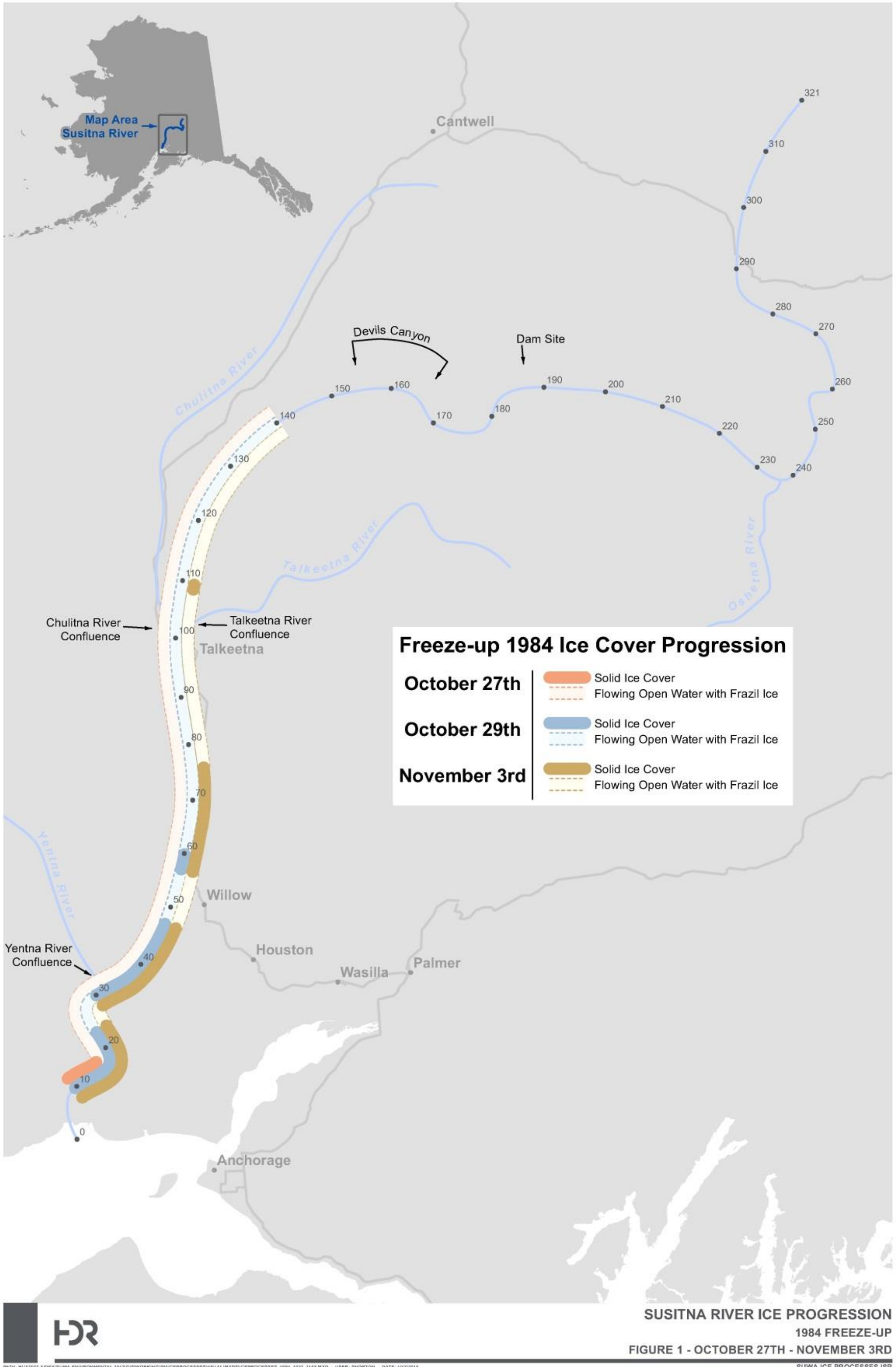

Figure 34. 1984 Freeze-up Progression – October 27, 29, and November 3, 1984

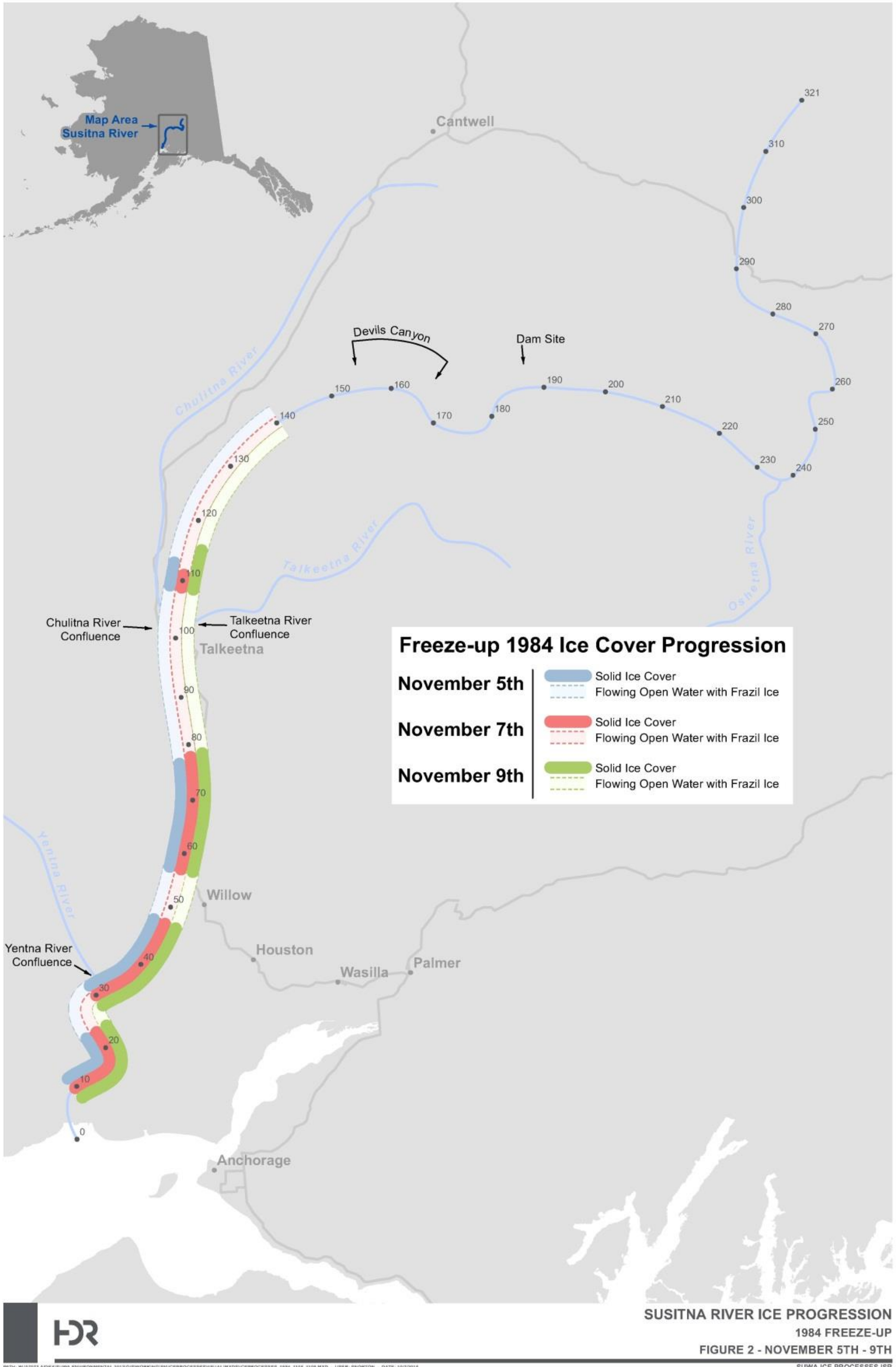

Figure 35. 1984 Freeze-up Progression – November 5, 7, and 9, 1984

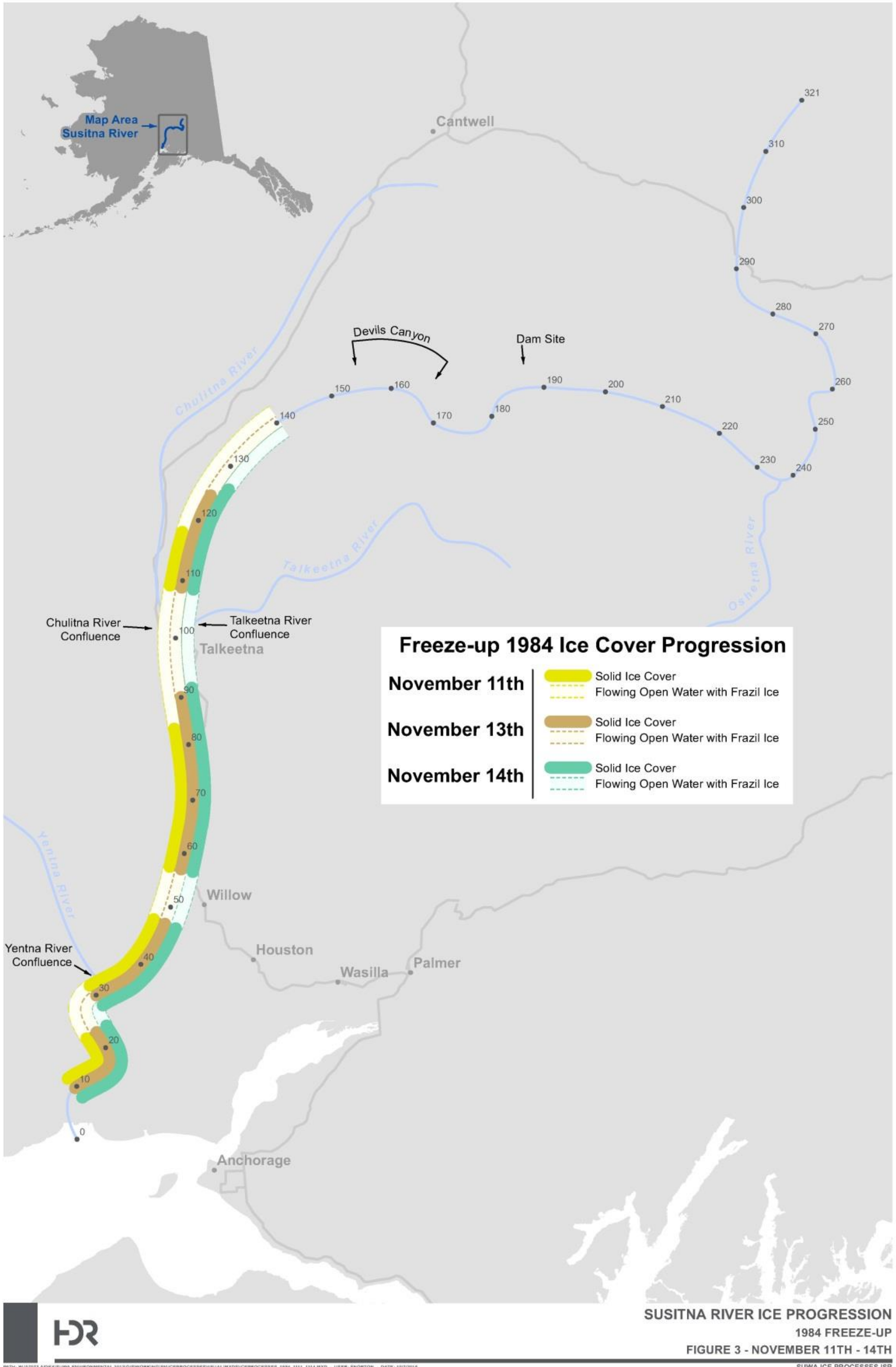

Figure 36. 1984 Freeze-up Progression – November 11, 13, and 14, 1984

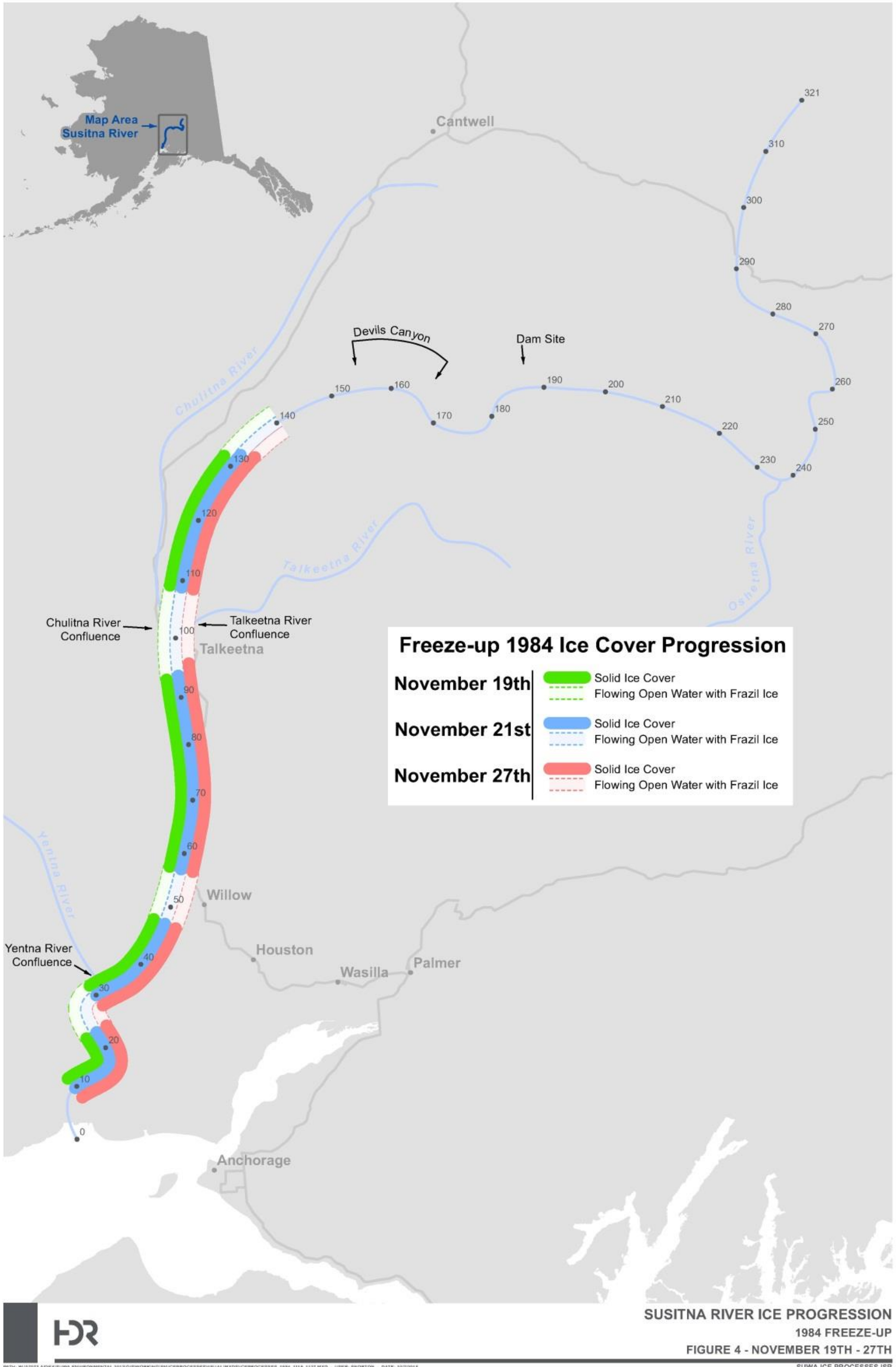

Figure 37. 1984 Freeze-up Progression – November 19, 21, and 27, 1984

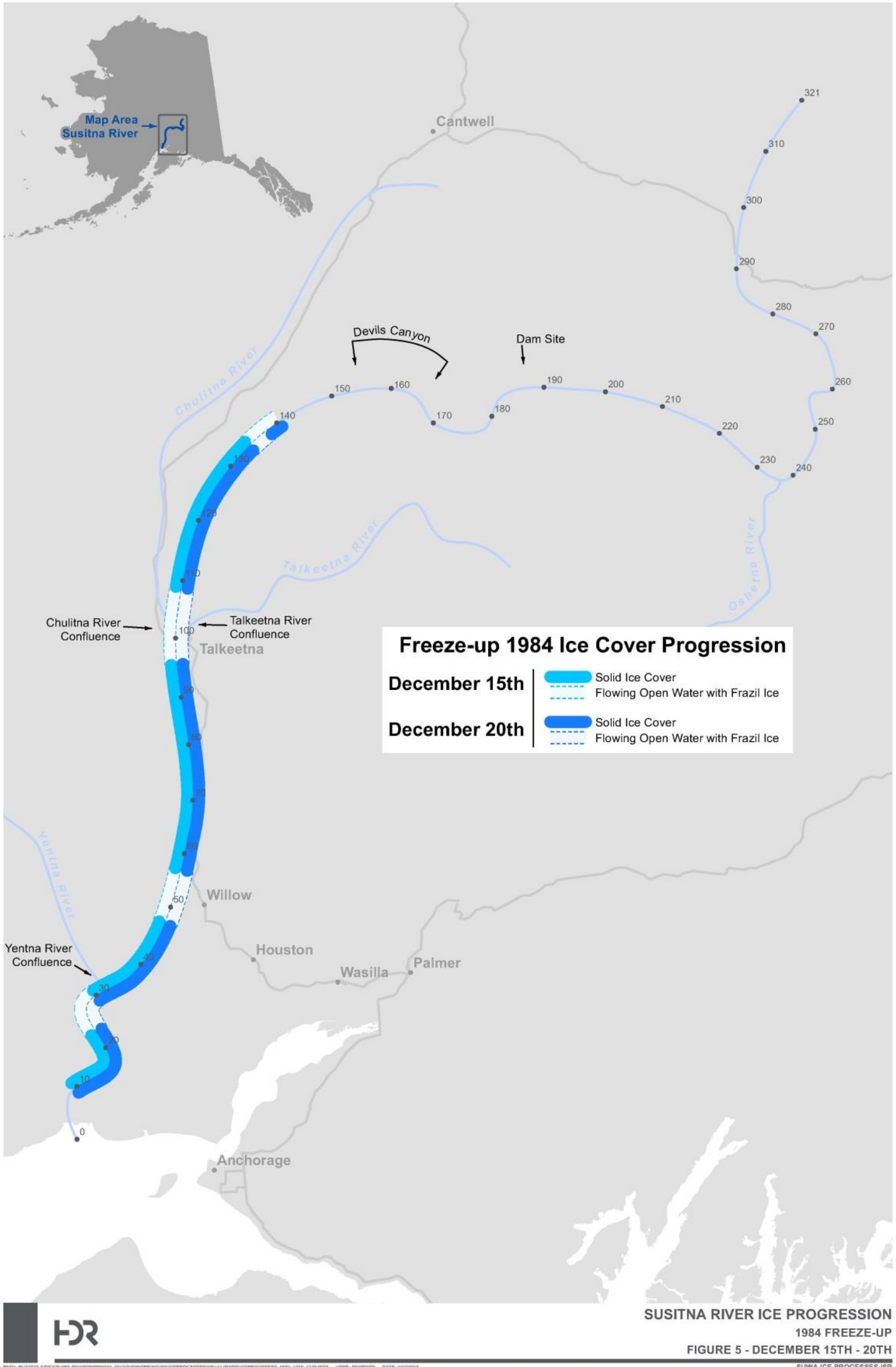

Figure 38. 1984 Freeze-up Progression – December 15 and 20, 1984

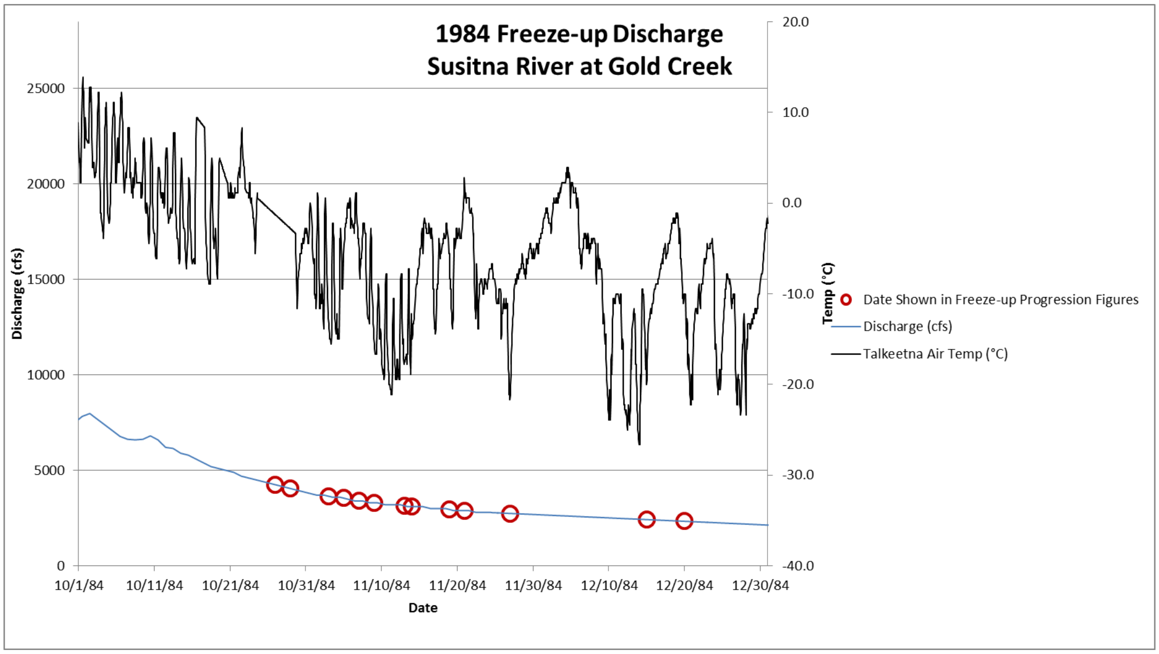

Figure 39. Gold Creek discharge hydrograph, Talkeetna air temperature, and dates of observations for Freeze-up 1984

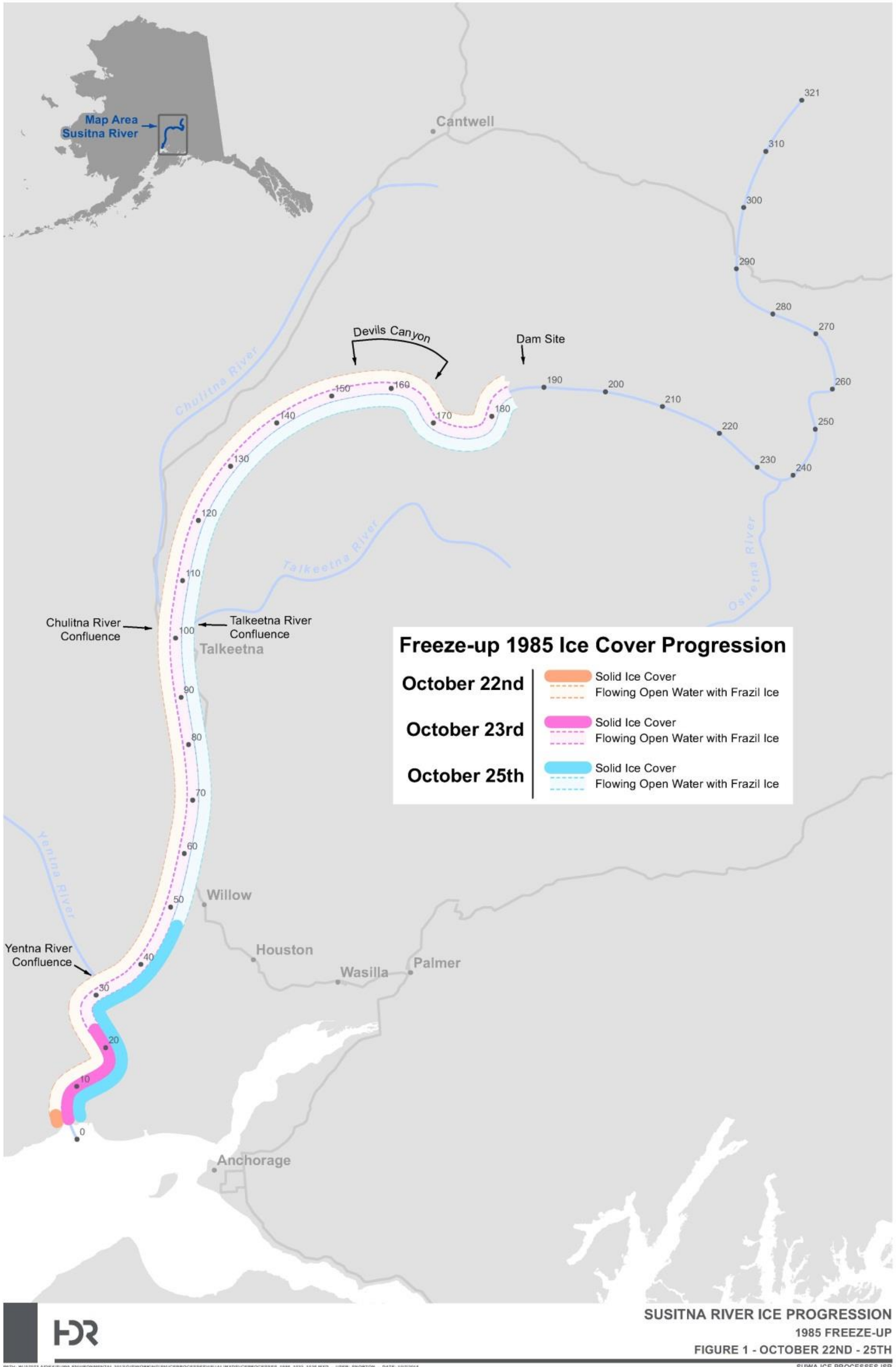

Figure 40. 1985 Freeze-up Progression – October 22, 23, and 25, 1985

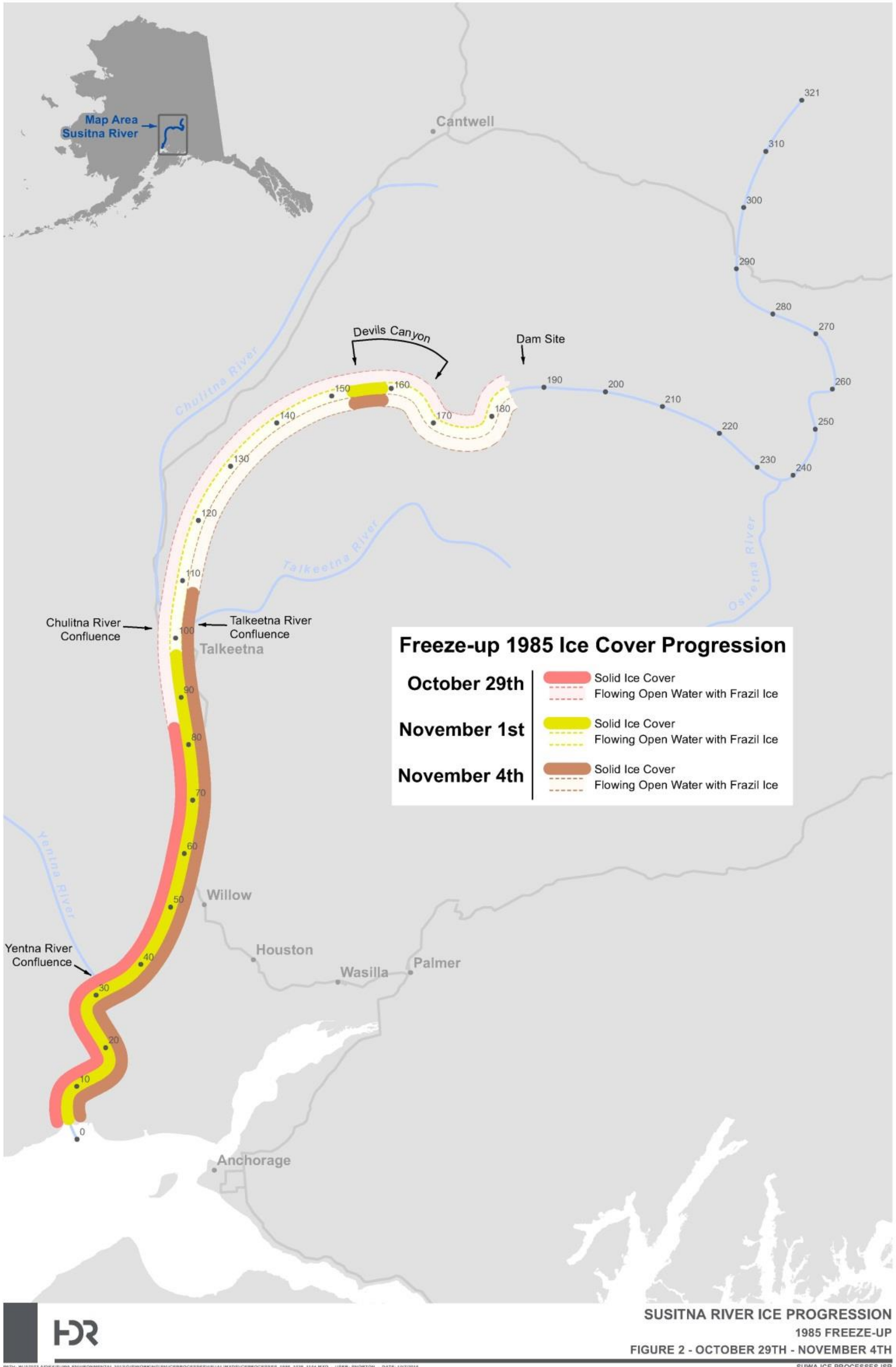

Figure 41. 1985 Freeze-up Progression – October 29, November 1, and 4, 1985

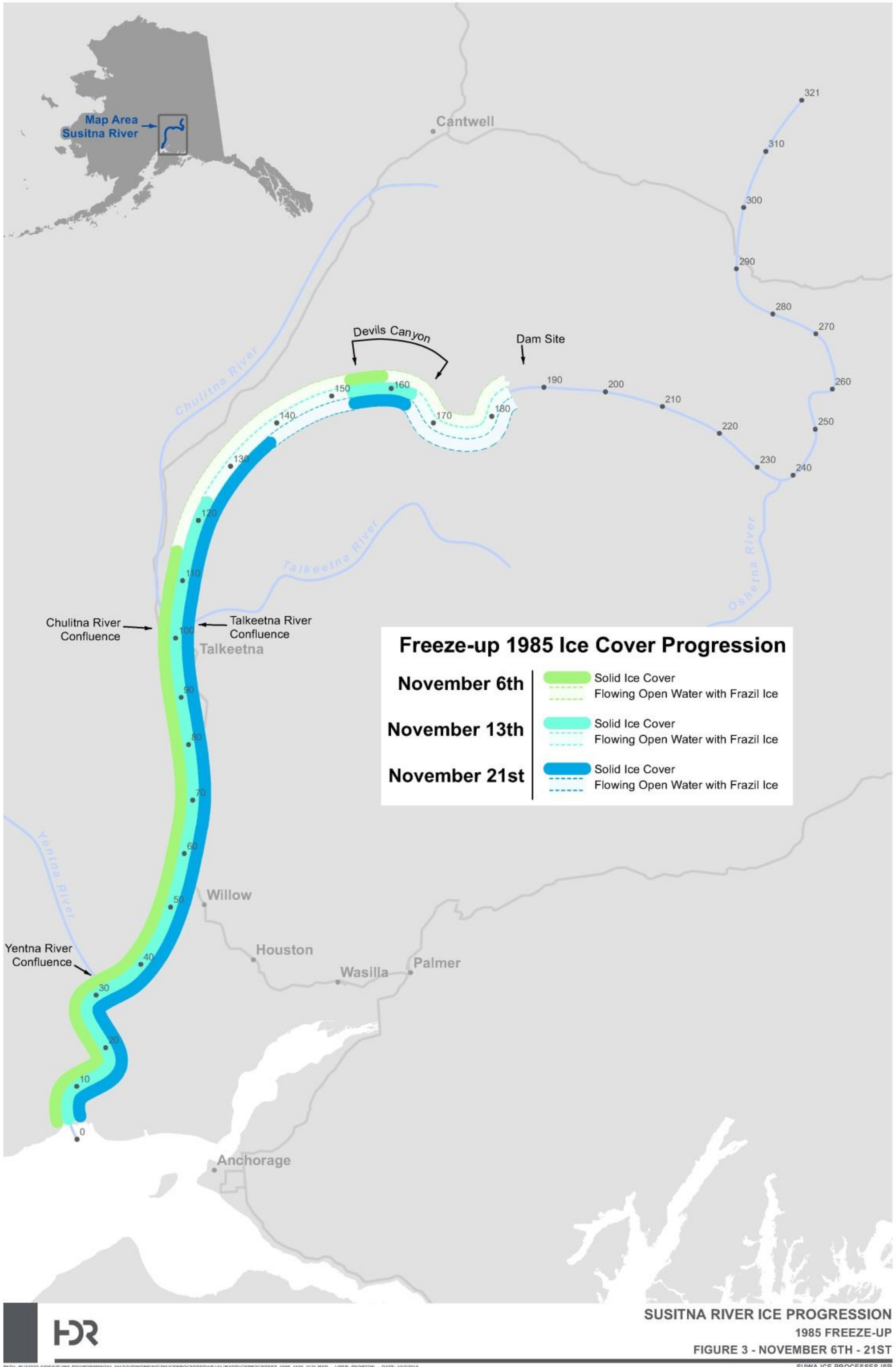

Figure 42. 1985 Freeze-up Progression – November 6, 13, and 21, 1985

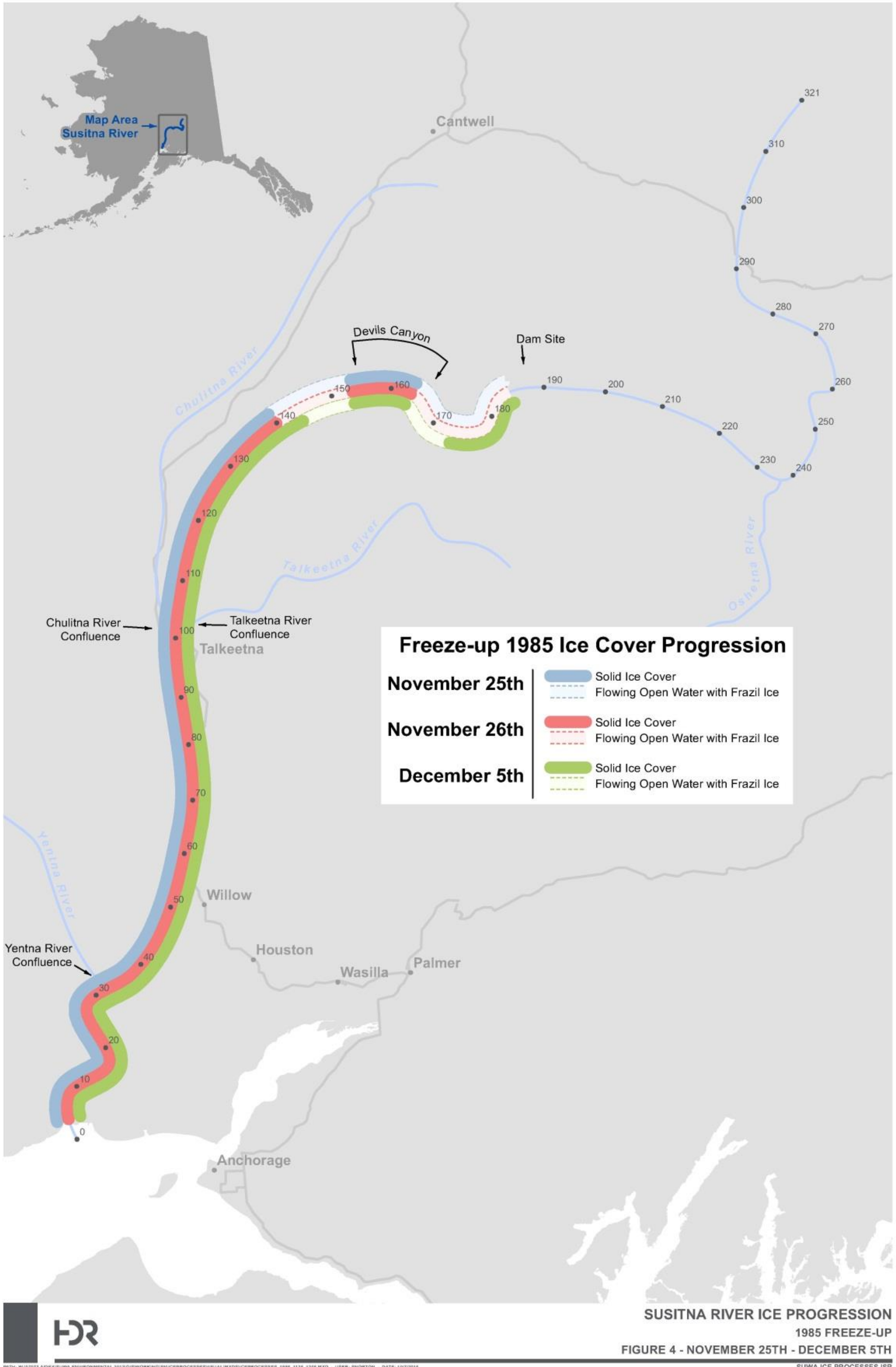

Figure 43. 1985 Freeze-up Progression – November 25, 26, and December 5, 1985

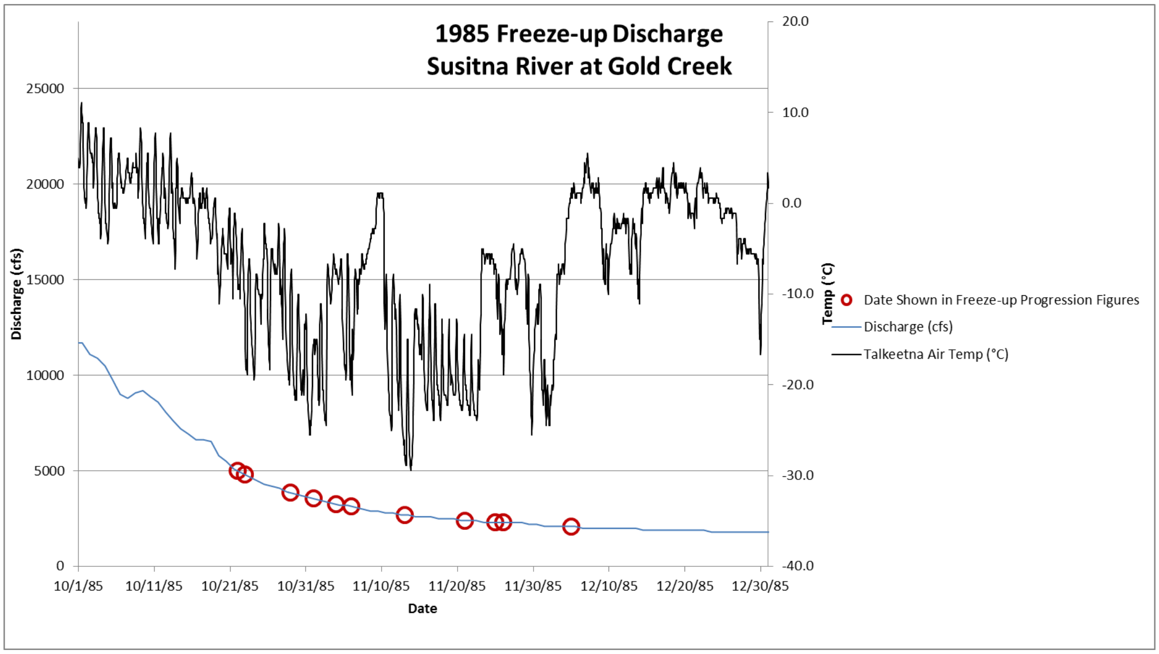

Figure 44. Gold Creek discharge hydrograph, Talkeetna air temperature, and dates of observations for Freeze-up 1985

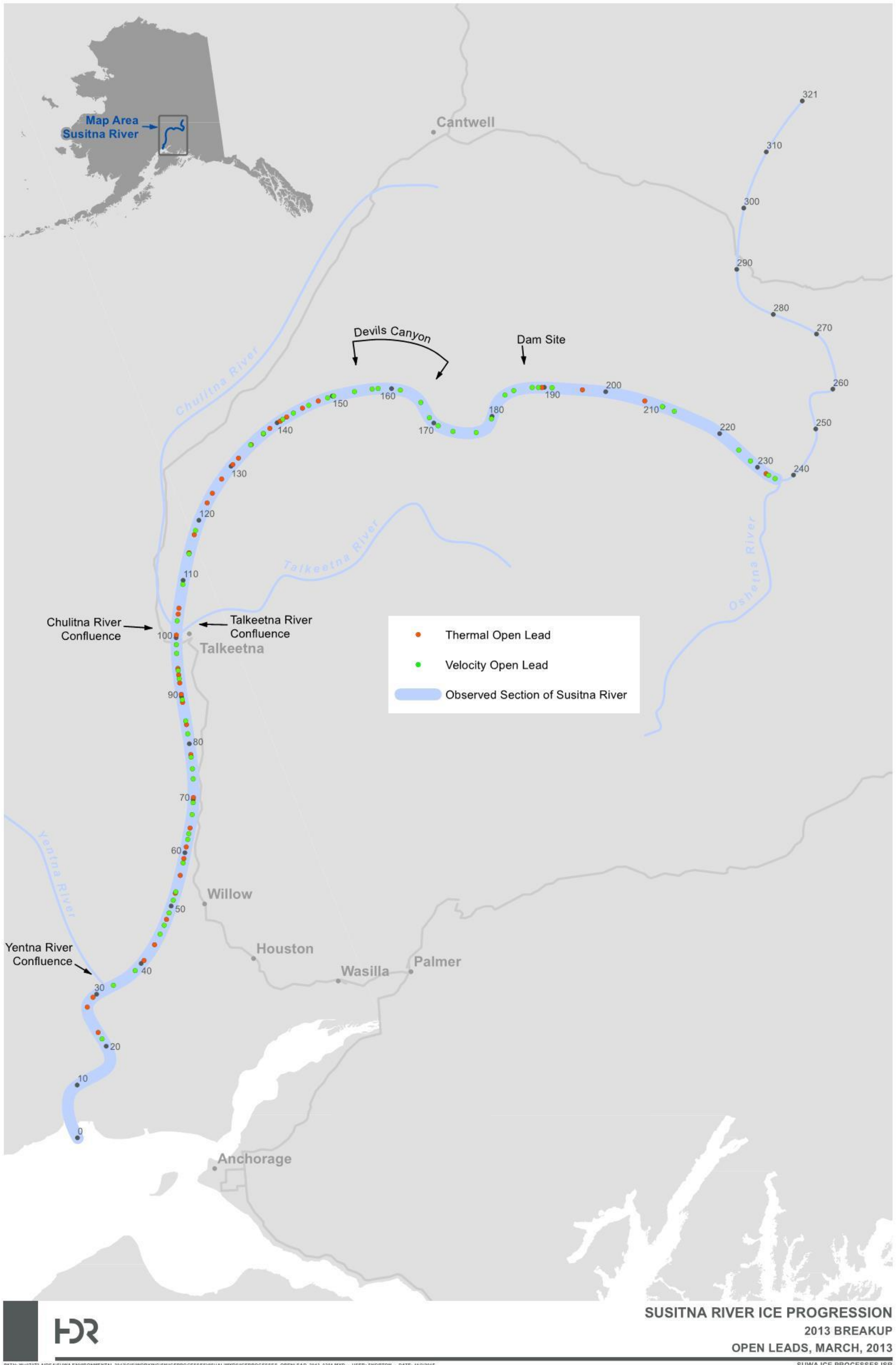

Figure 45. Open Lead Survey March 12, 2013

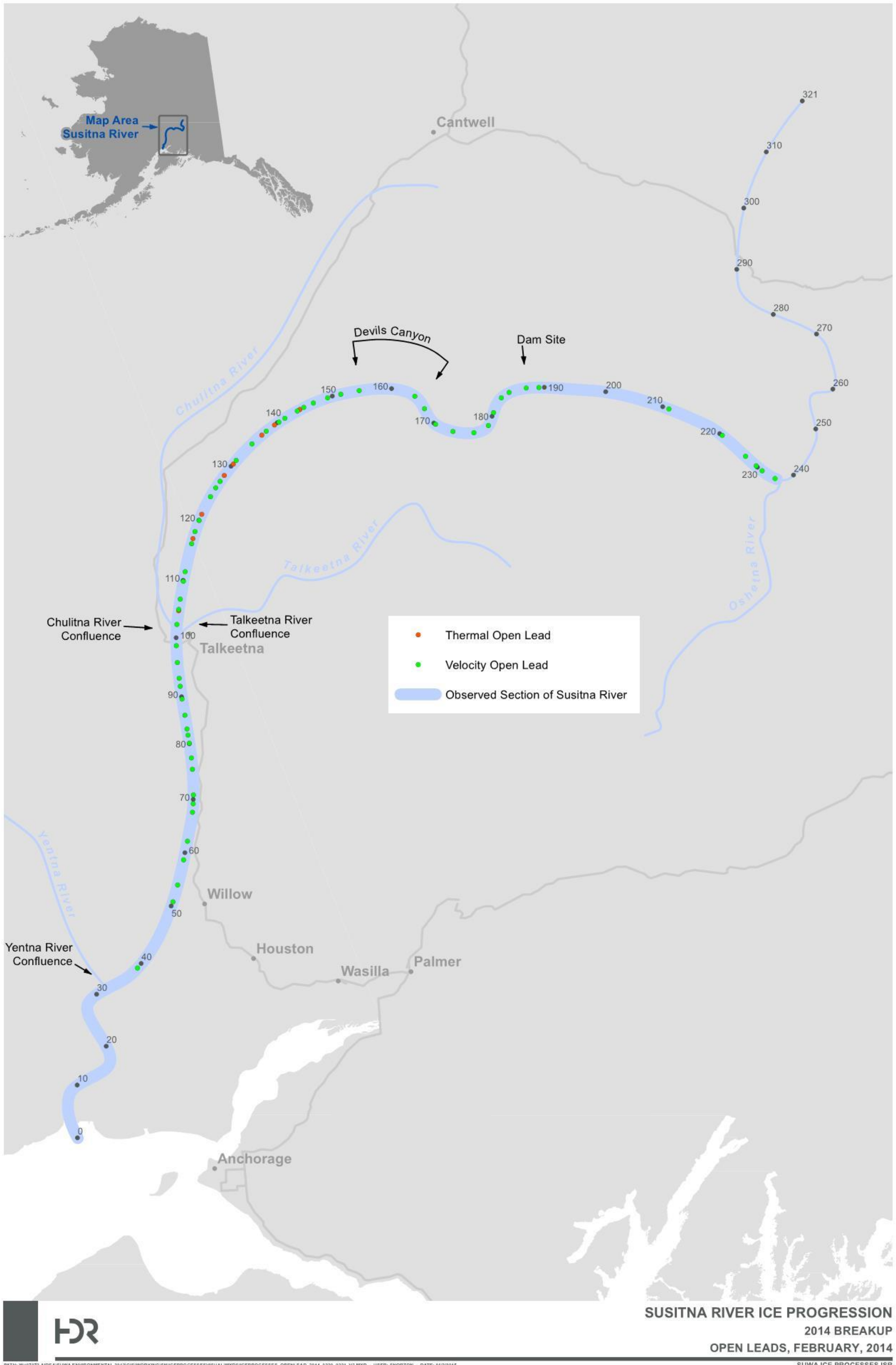

Figure 46. Open Lead Survey February 20-21, 2014

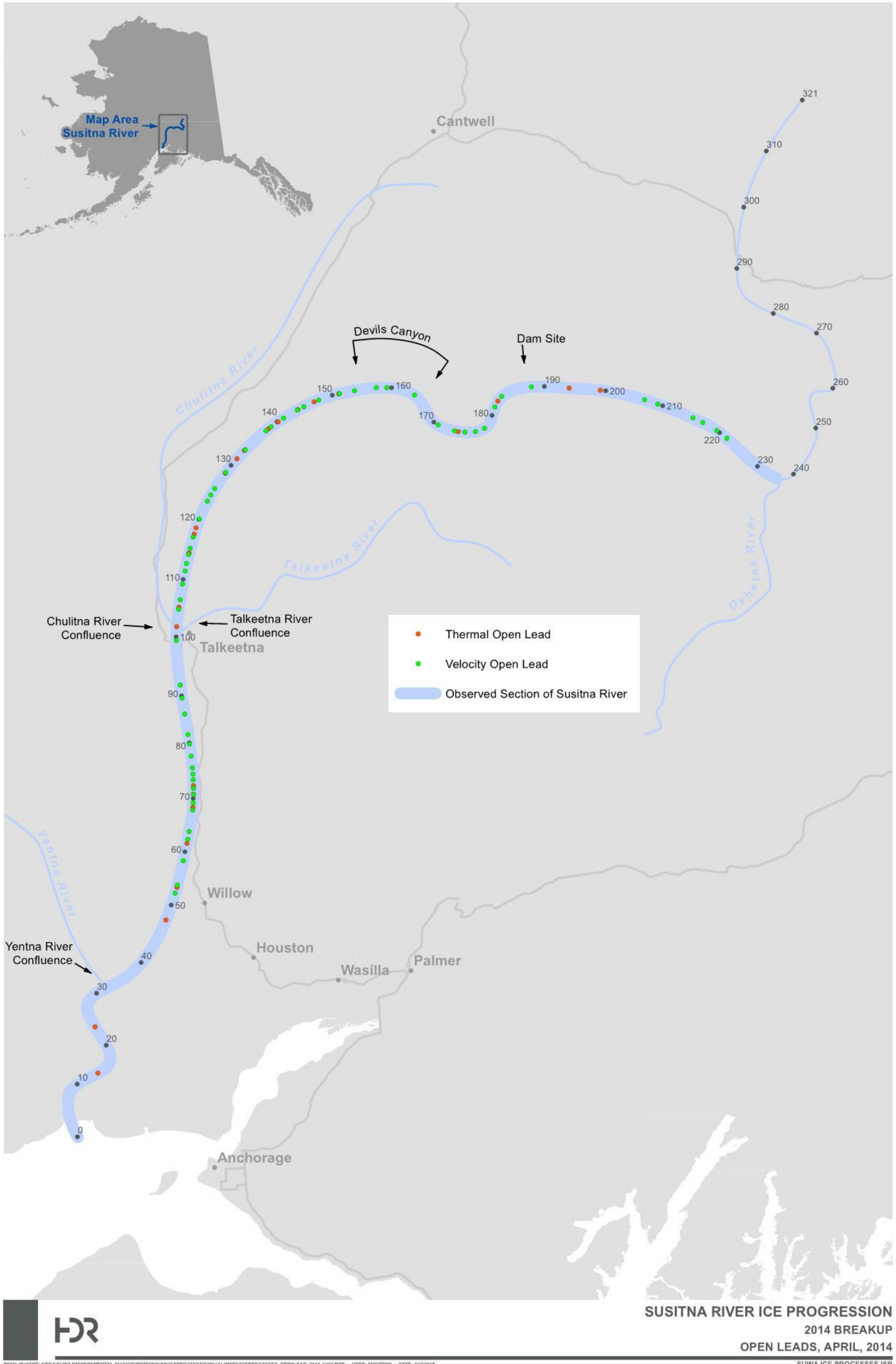

Figure 47. Open Lead Survey April 2, 2014

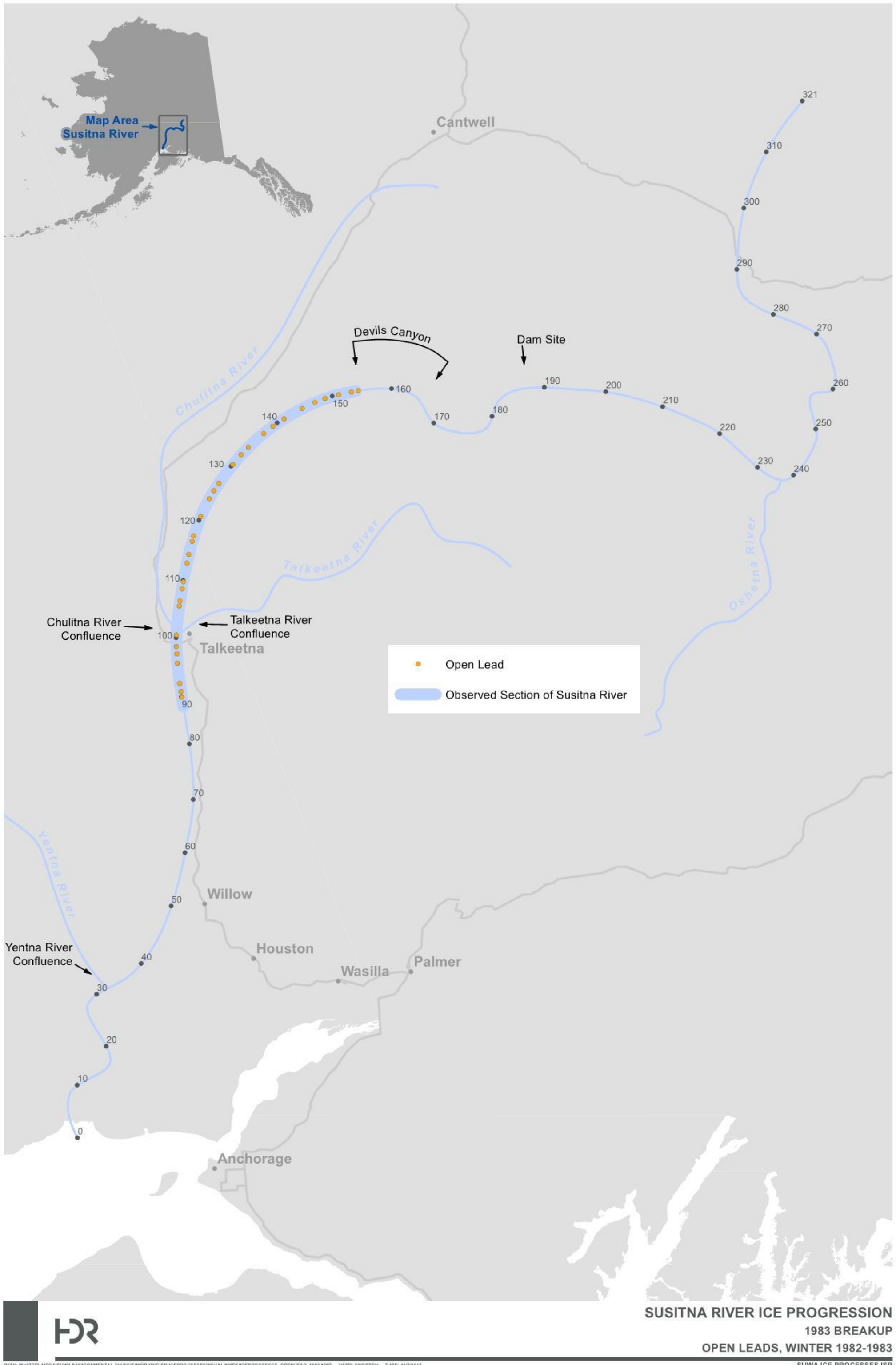

Figure 48. Open Lead Locations in 1982-83