

ICE JAMS ON NORTH DAKOTA RIVERS

Predicting when, where and how ice jams form is challenging. Ice jams are most likely to occur during freeze up or breakup but can occur anytime during the winter season. Ice jams cause increases in upstream water levels, and may, at the same time, cause downstream water levels to drop. If the increase in upstream water levels is large enough flooding will result. The threat from freeze up ice jams is primarily on the Missouri River; other rivers in ND typically don't have increased water levels leading to flooding during freeze up. Once a stable ice cover has formed, the threat from ice caused flooding diminishes until breakup. Ice jams have been recorded on all the rivers in the state during breakup; however, breakup ice jams are most prevalent on the Missouri, Little Missouri and Red Rivers. In general, breakup ice jams tend to form at sharp bends, river confluences, and at obstructions, such as bridges and low-head dams.

HISTORICAL ICE JAMS

One of the first measures in assessing the ice jam threat to a particular community is to review past history of ice jam flooding. This review can lead to a general idea of the frequency of flooding and the most likely location of ice jams within a specific area. Local residents may be the best source of information to provide specific ice jam locations and associated flood damages. A second means of evaluating the potential ice jam threat is to review peak stages and flows from past flood events. One good source for locating ice jam information is the Cold Regions Research and Engineering Laboratory's (CRREL) Ice Jam Database (IJDB) at <https://rsgisias.crrel.usace.army.mil/icejam/>. Although not a comprehensive list, the ice jam database contains information on a large number of known ice jams and ice-affected events as well as a map of historical ice jams.

POTENTIAL ICE JAM MITIGATION METHODS

Note: Many of the following methods were identified in the USACE's "Assessment of 2011 North Dakota Ice Jam Threat and Potential Mitigation Measures".

PERMANENT MEASURES

The following permanent measures are a local jurisdictional responsibility. Permanent measures are often the most expensive (and often most politically challenging) means of mitigating ice jams, but may prove to be the most cost-effective over a long period of time. Detailed studies and analysis are often required prior to implementation of any of these measures, as solutions are often site-specific.

FLOODPLAIN MANAGEMENT

- The most effective flood prevention technique is floodplain management. Floodplain management is the operation of a community program of corrective and preventative measures for reducing flood damage (<http://www.fema.gov/national-flood-insurance-program-1>). It is crucial that cities and counties implement floodplain management through zoning ordinances, acquisition/relocation and other means. Keeping people and property from encroaching into the floodplain, as well as voluntarily removing those who are there, will prevent flood related losses. The floodplain is normally delineated by floodplain mapping performed for the National Flood Insurance Program. However, this mapping is often based on open water conditions and should be considered the minimum area

necessary. In areas where ice jams have historically occurred larger floodplains should be considered if ice jams were not considered in the floodplain delineation. Floodplain mapping has been performed and completed for many North Dakota cities and counties. A listing can be obtained from floodplain management staff of the ND State Water Commission (SWC) at (701) 328-2752.

PERMANENT LEVEES

- Levees create a barrier between the river and the protected property. Levees allow river stages to rise above bank full without damaging the property along the river banks. Levees protect river bank property from ice jams and open water floods, up to the levees design floods. If a storm event or ice jam occurs that exceeds the levee's design capacity, the property protected by the levee may be damaged and lead to a life safety issue. Levees can be constructed along most any stream with the necessary space but construction can be expensive and levees require long-term maintenance. A detailed engineering design would be needed to assess which communities could benefit from levees.

CHANNEL MODIFICATION (I.E. DREDGING, RESHAPING)

- River channels can be modified to move ice downstream more efficiently by removing snags, bars, and other constrictions that impede ice passage and cause jams. A flood diversion channel can be constructed to route flow around an ice jam, decreasing upstream flooding. These options are not as useful in braided river channels or channels with high sediment loads (i.e. Missouri River) where constant maintenance would be required to preserve the modifications.
- The channel and overbank areas can also be modified to slow the flow of ice and increase ice storage. Shaping the channel and overbank areas can allow ice to leave the channel during breakup. This reduces the volume of ice available to form ice jams downstream. Changing the bank slope, removing trees and creating berms in specific locations can utilize the available floodplain and reduce the risk of damage downstream. These modifications methods are useful when a large floodplain is present.
- Both of these options require site-specific detailed analysis to determine the most effective means of mitigating the ice jam hazard, or if it's even possible to accomplish this type of mitigation at the site. It is likely that both of these options would require some type of permit.

THERMAL CONTROL

- Warm water can be used to thin an ice cover or melt ice jams. Warm water is a relative term because all water that is above freezing (32°F) carries enough heat that can melt ice. Heat can be added to a stream by applying wastewater treatment effluent, ground water or power plant cooling water. Cities could utilize all these sources of warm water by developing the outfalls of these facilities upstream of ice jam problem locations. However, most cities prefer to locate the outfall facilities downstream of the city because of water quality concerns. Often water with temperature greater than 32°F is located below the surface of large water storage reservoirs. Air bubblers or pumps can be used to bring this water to the surface and melt ice. Reservoirs can release this warmer water and melt ice downstream.

FLOODPROOFING

- Floodproofing involves minimizing the impact of a flood on a structure. There are four types of floodproofing; raising or moving a structure, building a barrier, dry floodproofing and wet floodproofing. Floodproofing is an attractive option for historic buildings built in the floodplain or when residents refuse buyout programs. Raising a structure involves building up the foundation to a level where floodable features are above the expected flood elevation. The new foundation must be designed to handle forces caused by flowing water and ice as well as the loads from the building.
- Barriers and floodwalls can be alternative to raising the foundation. A floodwall is simply built to keep water out of a building. All openings in a floodwall should be easily closed with the proper material. Groundwater seepage and water flow through sewer and water lines should be considered in the design.
- Dry proofing requires the outside of a building become watertight. This would allow the building to be flooded up to three feet without major flood damage. Dry proofing above a few feet is discouraged because the building walls can collapse under higher water pressure.
- Wet proofing assumes flood water will flow through the structure, up to a designed elevation. Building design below the expected flood elevation will minimize the damages and losses during flooding. HVAC, electrical and fiber optics cables will be located above expected flood levels. Wet proofing is often the least attractive option.

ICE CONTROL STRUCTURES

- Ice control structures (ICS) are structures that are designed and installed specifically to control ice and prevent or reduce ice jam flooding. Structures built to control flooding from freeze up jam formation include floating booms and low head weirs. Structures built to control breakup jam flooding are designed to arrest an ice run in a safe location and allow flow around the accumulation to reduce upstream water levels. Breakup structures include a series of piers across the river channel to retain ice and a bypass channel to pass water around the jam. A detailed engineering design would be needed to assess which communities could benefit from ICS.

ADVANCE MEASURES (PREPAREDNESS AND EARLY RESPONSE)

If the meteorological and river conditions indicate that ice jam flooding may occur, attempts can be made to reduce the risk of ice jam flooding. Methods explained below have all been successful factors in preventing ice jam flooding. But the methods have also been executed without stopping ice jam flooding. It is difficult to analyze the effectiveness of these actions because of the vast number of uncertainties contributing to ice jam flooding.

MONITOR CONDITIONS

- Monitoring weather conditions can guide advance measures decisions. Cold winters, especially those with below normal temperatures in late January and February, may justify advance measures. Above normal temperatures forecasted during ice breakup may also validate the need for advance measures. Measuring ice thicknesses can provide ice strength and ice volume information. Ice motion detectors can alert local officials when ice movement begins. Stage-only stream gages help locate ice jams by showing the rapid

stage increases caused by ice jams; however, many ice jams form in areas without stream gages.

- Ice jam mitigation and monitoring programs have been developed in Nebraska and Manitoba. These programs could be used as templates in development of local and statewide ice jam mitigation efforts. Questions regarding the Manitoba program can be directed to Darrell Kupchik, Selkirk Emergency Coordinator, at 204-785-4945 or emo@cityofselkirk.com. For questions regarding the Nebraska program, please contact Laura Ackerman, ND SWC, at 701-328-4868 or lcackerman@nd.gov.
- **CAPABILITIES/RESPONSIBILITIES**
 - The thickness of river ice covers can vary extensively with distance and time. The state does not have an ice sampling or measuring program and therefore relies heavily on local observation reports from public works, emergency management, law enforcement and the public to provide situational awareness in the field.
 - SWC has the ability to deploy field staff to verify local observation and obtain data as needed.
 - SWC staff monitors USGS river gages throughout the state as needed, particularly during freeze and thaw periods. The SWC, USGS and USACE coordinate closely regarding river levels, gage data, reservoir releases and critical situations that arise.
 - If conditions warrant, the state has the ability to leverage field personnel and aerial assets for both air and ground reconnaissance to monitor ice conditions, ice breakup, ice jams, etc.
- **CONSIDERATIONS**
 - Ice monitoring that includes personnel on the river ice cover is always hazardous and should only be done by those with appropriate training. Appropriate safety measures must be taken.
- **COORDINATION**
 - State Water Commission (SWC), US Army Corps of Engineers (USACE), US Geological Survey (USGS), National Weather Service (NWS), Local Emergency Managers (EMs), ND Department of Emergency Services (NDDDES)
 - NDDDES will coordinate with other state and federal agencies as necessary, i.e. Civil Air Patrol (CAP), National Guard (NG), etc.

ICE CUTTING

- Ice cutting weakens the ice cover. Cutting can influence where ice sheets break providing more control over how and when the ice moves out. Ice cutting is primarily used to move the location of ice jams downstream and out of reaches where damaging ice jam flooding occurs. Ice can be cut in the direction of flow to create a flow channel for ice and water during breakup, decreasing ice jam probability. Cuts can be made manually with a trenching machine, chainsaw or repeated auger bores. Warm water and melting chemicals can also make cuts in the ice.
- **CAPABILITIES/RESPONSIBILITIES**
 - The state does not have capabilities to perform ice cutting. However, specialized ice cutting equipment is available from commercial vendors.

- **CONSIDERATIONS**
 - Ice cutting could potentially be hazardous.
 - Safety measures should be taken.
 - Timing of ice cutting is crucial, i.e. ice cuts can refreeze, if done too early.
 - Local jurisdictions must coordinate with the SWC and other appropriate agencies prior to implementing any control measures.
- **COORDINATION**
 - SWC, USACE, USGS, NWS, Local EMs, NDDDES (will coordinate with other state and federal agencies as necessary)

AQUATIC EXCAVATORS

- An aquatic excavator, like the Amphibex, is a floating vessel equipped with an excavating arm capable of breaking and removing ice from a channel. The Amphibex is 35' long by 11-1/2' wide, which is longer and wider than a semi-truck. Aquatic excavators can break up ice sheets downstream of a major jam or excavate small ice jams.
- **CAPABILITIES/RESPONSIBILITIES**
 - The state does not own aquatic excavators. However, specialized equipment is available from commercial vendors.
- **CONSIDERATIONS**
 - They are not capable of removing large, heavy ice jams or if the ice thickness exceeds two feet.
 - The Amphibex would be limited to channels large enough to accommodate the excavator and to those sites with ice thicknesses less than two feet.
 - Safety measures must be taken.
 - Local jurisdictions must coordinate with the SWC and other appropriate agencies prior to implementing any control measures.
- **COORDINATION**
 - SWC, USACE, USGS, NWS, Local EMs, NDDDES (will coordinate with other state and federal agencies as necessary)

DUSTING

- Dusting typically uses aircraft or other means to apply a thin layer of dark material on the ice cover. The dark material can be soil, sand, fly ash or any other dark material that spreads evenly and absorbs energy more rapidly than snow and ice. The material is applied to decrease the albedo of the ice cover. Albedo is the ratio of reflected sunlight to downwelling sunlight. An albedo of 1 means all the sunlight is reflected. Dusting reduces the albedo allowing the ice cover to absorb the energy of sunlight and melt. The lower albedo absorbs more energy from the sun, melting and weakening the ice. There have been some instances of dusting river ice with leaf mulch, or other organic material, in order to deteriorate the ice cover.
- **CAPABILITIES/RESPONSIBILITIES**
 - Ice dusting should be initiated and implemented at the local level.
 - Technical assistance and implementation assistance can be requested if needed.
 - The SWC and NDDoH can provide technical assistance in determining appropriate permits, type and quantity of material; as well as timing and placement.

- State aviation assets can be leveraged to conduct ice dusting operations if required.
- **CONSIDERATIONS**
 - The longer the dust is on the ice, the more effective the dust will be. Application two weeks ahead of ice breakup is recommended for maximum effectiveness.
 - If dusting is performed too early, the dust can be covered by a new layer of snow, and become ineffective.
 - Some materials may be deemed environmentally unacceptable, while others may require significant lead time in obtaining necessary approvals. The ND Department of Health (NDDoH) should be involved in early discussion in order to address water quality issues/concerns and necessary permits.
 - Local jurisdictions must coordinate with the SWC and USACE for all permitting requirements prior to implementing any control measures.
 - Safety measures should be taken.
 - Dusting is most effective on flat sheets of ice. It has minimal effect on jagged or jumbled ice sheets.
 - Too light of an application of material significantly reduces the ability of the material to absorb enough energy to effectively weaken the ice, while too heavy of an application of material reduces effectiveness by insulating the ice surface.
- **COORDINATION**
 - SWC, USACE, Local EMs, NDDoH, NDDDES (will coordinate with other state and federal agencies as necessary, i.e. NG)

EMERGENCY OPERATIONS (RESPONSE)

Sometimes, in spite of existing measures in place, or implementation of advance measures, ice jams can still form and cause significant damage. In such cases, it is often desirable to undertake emergency measures to remove the ice jam; however, it is often difficult and expensive to do so. The methods below are the most commonly undertaken. Other measures not shown below (e.g. deployment of materials to deflect or divert flows) that are commonly used in normal flood-fighting may also be practical under emergency conditions.

PUBLIC WARNING

- Reverse 911 systems, phone or personal notification, media, EAS, NWS, etc can be leveraged to disseminate emergency information to threatened residents.

FLOOD PROTECTIVE MEASURES

- All activities that are performed during open water flood fighting can be undertaken to fight ice jam floods. These include temporary levee construction, sandbagging, flood barriers (i.e. Hesco, big bags, etc), blocking of culverts, pumping, evacuations, etc.
- **CAPABILITIES/RESPONSIBILITIES**
 - Local jurisdictions are expected to procure necessary flood fighting resources, to include material, equipment and volunteer support, based on anticipated need and not rely on state and federal resources.
 - NDDDES has a limited cache of flood fighting resources to include sandbags, Hesco, big bags, trap bags, one ton sandbags and rapid deployable floodwall.
 - The SWC can provide technical assistance as needed.

- **CONSIDERATIONS**
 - State owned resources, including NDDDES and National Guard, may be made available to local jurisdictions responding to incidents or emergencies when local, mutual aid and private sector resources have been exhausted, or are unavailable or cannot be deployed in time.
 - Assets are allocated on a priority basis depending upon the extent and duration of need, lack of local availability and delivery time.
- **COORDINATION**
 - SWC, USACE, Local EMs, NDDDES (will coordinate with other state and federal agencies as necessary, i.e. NG, NDDOT)

MECHANICAL REMOVAL

- Ice jams can be removed from river using construction equipment like excavators, drag lines, and bulldozers. Equipment can sometimes be located in the stream, but equipment is often operated from the bank. Wrecking balls or other heavy objects can be dropped onto an ice cover to break the ice and assist passage of ice jams around obstacles and bridges.
- **CAPABILITIES/RESPONSIBILITIES**
 - Local jurisdictions are expected to utilize local resources, to include mutual aid and private contractors and not rely on state and federal resources.
 - The SWC can provide technical assistance as necessary.
 - The SWC, NDDOT and NG have equipment that is capable of removing ice from bridges and shorelines; pending access and river width.
- **CONSIDERATIONS**
 - Mechanical removal is often only viable on small streams with low flows; safety concerns deter mechanical removal on wide or deep rivers.
 - Mechanical removal can be a slow, expensive process.
 - Access, location, river width and landowner permission must be taken into account.
 - Ice jam removal can be extremely dangerous.
 - Safety measures should be taken.
 - Local jurisdictions must coordinate with the SWC and USACE for all permitting requirements prior to implementing any control measures.
- **COORDINATION**
 - SWC, USACE, USGS, NWS, Local EMs, Local Landowner, NDDDES (will coordinate with other state and federal agencies as necessary; i.e. NG, NDDOT)

AERIAL BREAKUP

- Aerial assets can be used to break up thin ice in areas where access is limited or non-existent.
- **CAPABILITIES/RESPONSIBILITIES**
 - Private contractors can be leveraged by local or state agencies.
 - National Guard blackhawks have limited capability.
 - Skycrane Helicopter companies can also be contracted.
- **CONSIDERATIONS**
 - Environmental considerations need to be taken into account.
 - Safety measures should be taken.

- Local jurisdictions must coordinate with the SWC and USACE for all permitting requirements prior to implementing any control measures.
- **COORDINATION**
 - SWC, USACE, NWS, Local EMs, NDDoH, NDDDES (will coordinate with other state and federal agencies as necessary; i.e. NG)

BLASTING

- Blasting is a popular method of ice removal in emergency operations situations. Blasting is used primarily to dislodge ice jams that are already in place. Explosive charges are strategically placed to dislodge the jam or reroute the flow of water.
- **CAPABILITIES/RESPONSIBILITIES**
 - The state of North Dakota considers this emergency response method to be of last resort. If deemed absolutely necessary, the NG does have a limited capability to perform this mission. However, they do not have any hydro/ice jam experts and would require technical assistance.
- **CONSIDERATIONS**
 - Blasting requires adequate flow and open water downstream of the ice jam to carry the ice downstream. If these requirements are not met, the jam will likely reform downstream.
 - If explosive charges are not imbedded into or placed under the ice, their effectiveness will be reduced; however, placement of personnel on an ice jam is never recommended, as it is far too dangerous.
 - Blasting of an ice jam is extremely dangerous and should not be undertaken without properly trained or certified demolition experts and the proper approvals. Another consideration may be legal liability associated with damages caused by such an operation.
 - Safety measures must be taken.
 - Local jurisdictions must coordinate with the SWC and USACE for all permitting requirements prior to implementing any control measures.
- **COORDINATION**
 - SWC, USACE, NWS, Local EMs, Contractors, NDDoH, NDDDES (will coordinate with other state and federal agencies as necessary; i.e. NG)

NOTIFICATION PROCEDURES

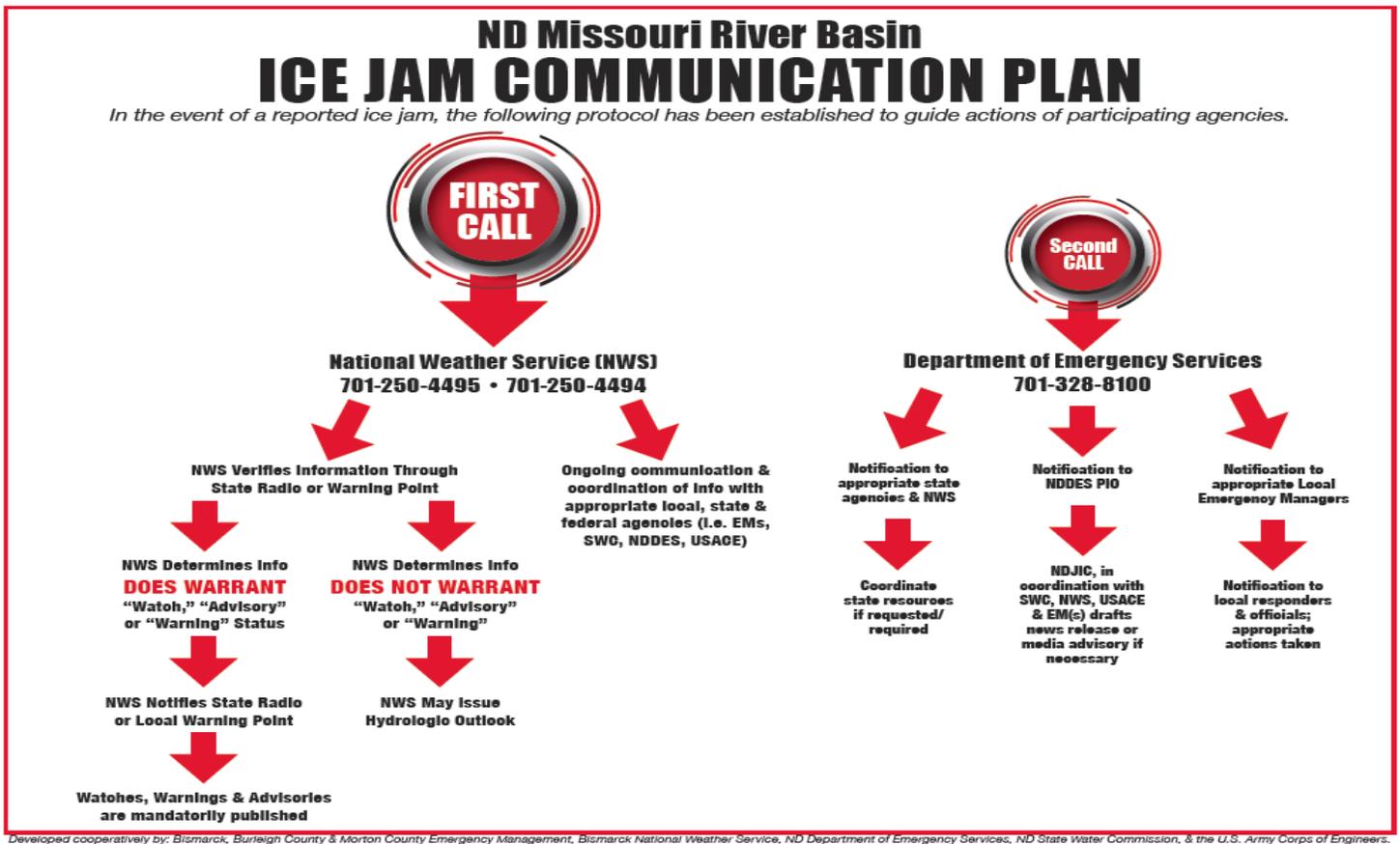
The expectation is for local emergency management to report ice data (i.e. ice thickness) and information (i.e. ice breakup, flooding, impacts, ice jams occurrence, etc) to the National Weather Service (NWS) and the ND Department of Emergency Services Duty Officer. The NWS will issue necessary watches, warnings and advisories based on the situation. The NDDDES will share information with appropriate state agencies and emergency managers and coordinate state resources if requested/required.

REQUEST PROCEDURES

The normal emergency management process should be followed to request state and federal assistance as outlined in the NDDDES Resource Handbook (2012 Edition).

PUBLIC INFORMATION

Local emergency management officials are responsible for dissemination of emergency public information. If an ice jam is suspected or occurs, local observers should notify the National Weather Service (NWS) who will validate the information and determine if issuance of a WATCH, WARNING, ADVISORY and/or PUBLIC INFORMATION STATEMENT is warranted. In addition, notifications should be made to appropriate local and state emergency management officials. In instances where issuance of NWS products are not warranted, the ND Joint Information Center (NDJIC) will take a lead role in coordinating necessary messaging with federal, state and local emergency management officials under some circumstances if needed. Federal, state, and local officials should coordinate messaging between impacted cities and counties as well as pertinent state and federal agencies. Any form of public information should be coordinated with the NWS for possible inclusion into public information statements, watches, warnings and/or advisories.



NDDes encourages local emergency management officials to develop and maintain relationships during non-emergency times with USACE, USGS, NWS, as well as SWC and NDDes to facilitate message development and dissemination during emergency incidents. NDDes is available to support local efforts to develop and disseminate emergency messaging, either through coordination or message dissemination through the NDJIC or <http://nddisasterinfo.com/>.

REQUEST PROCEDURES

The normal emergency management process should be followed to request state and federal assistance as outlined in the NDES Resource Handbook (2012 Edition).

FURTHER INFORMATION

For questions or further information please contact one of the following:

- ND State Water Commission (SWC)
 - Laura Ackerman, Water Resource Engineer
 - 701-328-4868
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- US Army Corps of Engineers (USACE)
 - John Remus, Chief, Hydrologic Engineering Branch
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