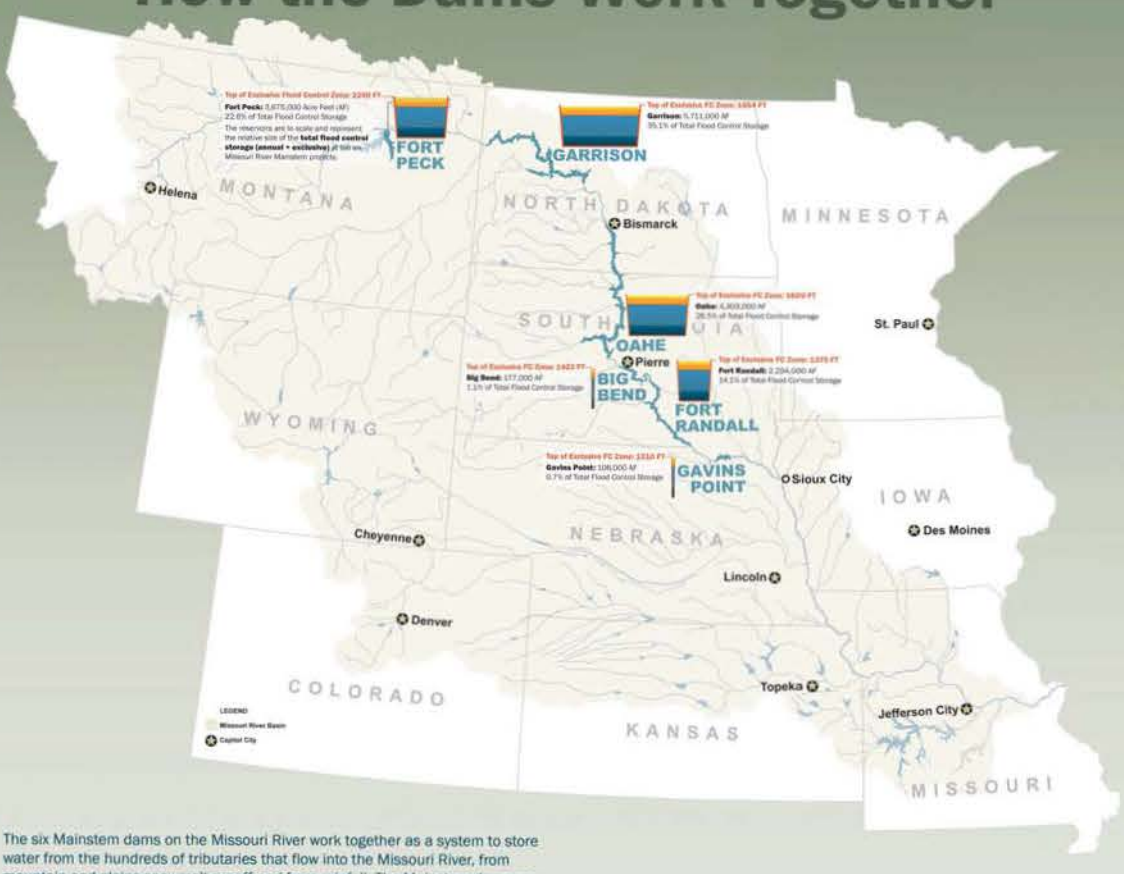
US Army Corps of Engineers
BUILDING STRONG

Missouri River
Mainstem Reservoir System

Capacity & Purpose
How the Dams Work Together



The six Mainstem dams on the Missouri River work together as a system to store water from the hundreds of tributaries that flow into the Missouri River, from mountain and plains snowmelt runoff and from rainfall. The Mainstem dams vary greatly in their storage capacity. Above you can see the dams' size relative to one another and their location in the Missouri River Basin.

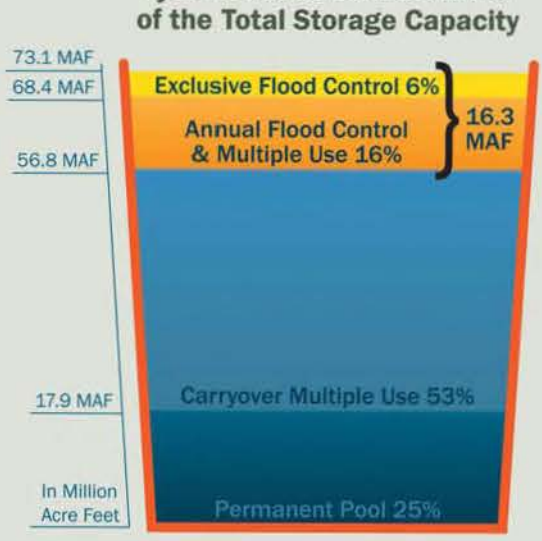
The six Mainstem dams, working together as a system, are Congressionally authorized to store water for eight purposes. Storage in the reservoir system is divided into four operating zones. As a whole system, the six Mainstem dams can hold 73.1 million acre feet of water.

To prepare for the next runoff season, the Corps must evacuate water from the flood control zones of all six dams by the end of the previous year. This means that water stored in the Fort Peck reservoir will eventually travel the length of the system, be released from Gavins Point and continue to St. Louis where the Missouri River meets the Mississippi River.

Congressionally Authorized Purposes of the Missouri River Mainstem System

Flood Control
Navigation
Irrigation
Hydropower
Water Quality Control
Water Supply
Recreation
Fish and Wildlife

System Zones & Allocations of the Total Storage Capacity



Types of Missouri River Basin Runoff: What Adds Water to the System?

Plains Snowmelt
(March to April)

Mountain Snowmelt
(May to July)

Rainfall
(March to October)

Fort Peck

Garrison

Oahe

Big Bend

Fort Randall

Gavins Point

US Army Corps of Engineers
BUILDING STRONG

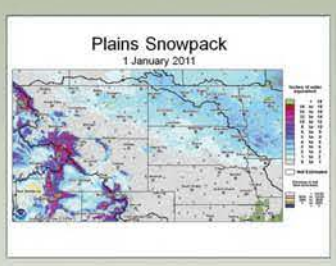
Missouri River
Mainstem Reservoir System

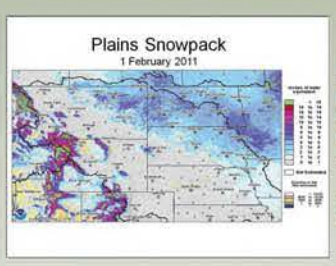
Winter: Jan/Feb 2011
Long-Term Climate Outlook

How the Corps Assesses Its Long-Term Climate Forecast

The Corps uses climate forecast information from the National Oceanic and Atmospheric Administration (NOAA). The Three-Month Outlook is updated monthly and forecasts the probability of precipitation in an area. The precipitation probability levels are: Above Normal (A), shown in shades of green; Below Normal (B) shown in shades of brown; and Equal Chances (EC), equal chance of (A) and (B), shown in white.

In both January and February, the three-month precipitation forecast called for Below Normal (B) precipitation in the lower Missouri River basin and Equal Chances (EC) for the upper Missouri River basin.

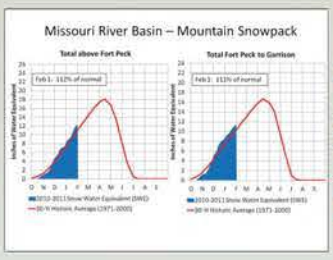




Plains Snowpack

The National Operational Hydrologic Remote Sensing Center (NOHRSC) produces plains snow assessments. These are estimates of snow water equivalent (SWE). The assessments are determined using modeled and observed snow information, airborne snow data, satellite snow cover and historic snow data.

2011 was the third consecutive year of significant plains snowpack.



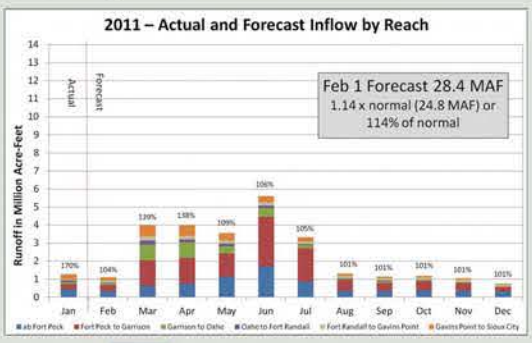
Mountain Snowpack

Runoff from mountain snowpack enters the system above the Fort Peck and Garrison reservoirs. Mountain snowpack normally peaks on or about April 15. The amount of SWE in the mountain snowpack above these two projects is determined from approximately 100 remote sensing stations.

The mountain SWE above Fort Peck and from Fort Peck to Garrison was slightly above normal when measured in January and February.

Corps' Runoff Forecast

Reach-by-Reach Runoff Forecast

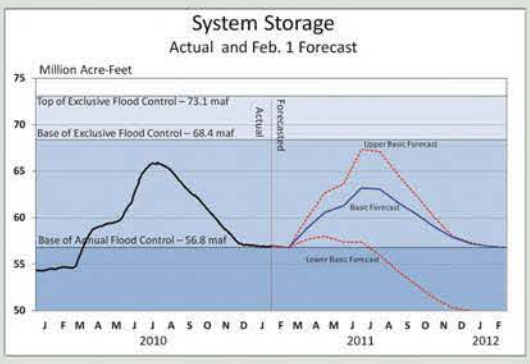


The Corps uses information from plains snowpack, mountain snowpack and the long-term climate forecast to develop a monthly runoff forecast.

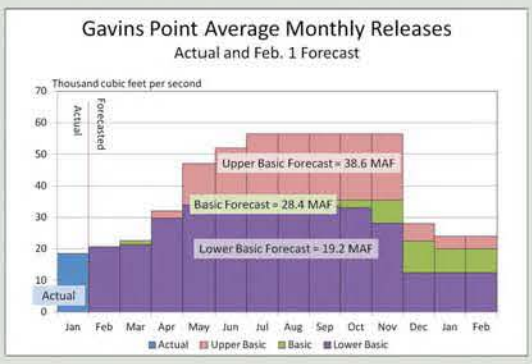
Reservoir Computer Model

After developing the monthly reach-by-reach forecast for the basin, the Corps enters this information into a reservoir model to develop the reach-by-reach expected storage and reservoir release levels.

Storage and Releases



The Corps started the 2011 runoff season with the full capacity of its 16.3 million acre feet of flood control storage available. During the 2010 runoff season, storage in the system peaked July 23, 2010, when the Corps was storing more than 9 million acre feet of floodwaters. Evacuation of those floodwaters continued from July 23, 2010 through Jan. 28, 2011, when the Corps fully evacuated all of the 2010 floodwaters and was prepared for the 2011 runoff season.



The graphic at left shows actual storage for 2010 and projected storage for 2011. The graphic at right shows projected Gavins Point releases for 2011. The Corps develops a basic forecast which assumes expected precipitation (snow and rain). The Corps also develops two contingency forecasts that set a plan for reservoir storage and release rates in the event of above and below expected precipitation.

US Army Corps of Engineers
BUILDING STRONG

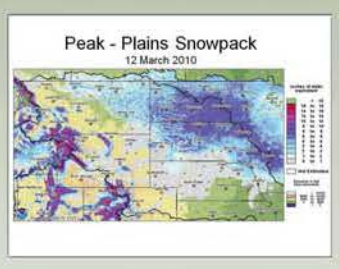
Missouri River
Mainstem Reservoir System

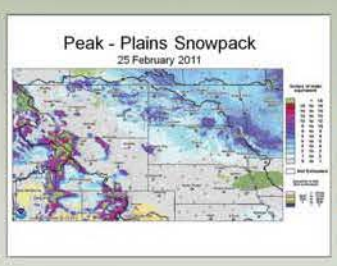
Spring 2011: March/April
Flood Season Begins

How the Corps Assesses Its Long-Term Climate Forecast

The precipitation probability levels are: Above Normal (A), shown in shades of green; Below Normal (B) shown in shades of brown; and Equal Chances (EC), equal chance of (A) and (B), shown in white.

In March, the three-month outlook was for Below Normal (B) precipitation in the lower Missouri River basin and Equal Chances (EC) precipitation in the upper Missouri River basin. In April, the outlook was Equal Chance (EC) for precipitation in most of the Missouri River basin and Above Normal (A) in North Dakota and eastern Montana.

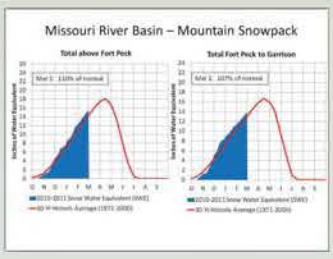


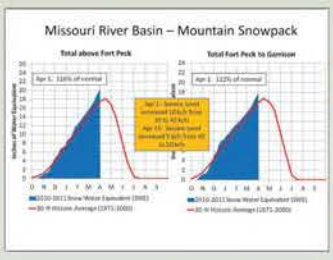


Plains Snowpack

Runoff from plains snowpack occurs throughout the Missouri River basin, including above all six Mainstem projects. That snowpack is measured in terms of Snow Water Equivalent (SWE), e.g. how many inches of water the snow equals when melted.

The plains snowpack peaked about Feb. 25, 2011. In general, the plains snowpack in 2011 was "heavy" - similar to 2010, and "very heavy" in some areas of the upper basin.





Mountain Snowpack

The Corps began evacuating floodwaters from the upper reservoirs even before the large May storms. During high water years, the rate at which floodwater is evacuated is calculated monthly, or more frequently if needed, to facilitate a smooth transition in releases.

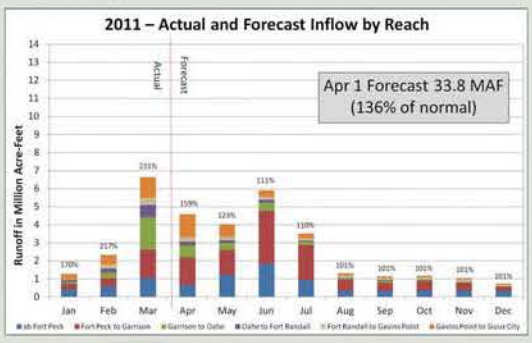
Because the ability to evacuate water is severely restricted during the winter months, most floodwater evacuation is accomplished during the navigation season (April 1 to Dec. 1). Thus, floodwater evacuation rates are defined as an increment of release above navigation flows.

The floodwater evacuation rate is based on a computation of water supply that considers the volume of water already stored in the mainstem and tributary reservoirs and the forecast runoff for the remainder of the year. The goal is to evacuate floodwater at the lowest rate possible over a long period of time to provide flood damage reduction for downstream communities.

On April 1, the rate of flood water evacuation was set at 10,000 cfs above full service navigation flows. As the mountain snowpack continued to climb during late April, the evacuation rate was increased to 15,000 cfs above navigation levels on April 15, and to 25,000 cfs on May 1.

Corps' Runoff Forecast

Reach-by-Reach Runoff Forecast



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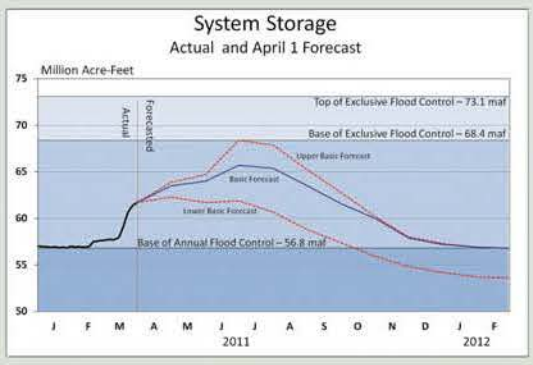
Storage and Releases



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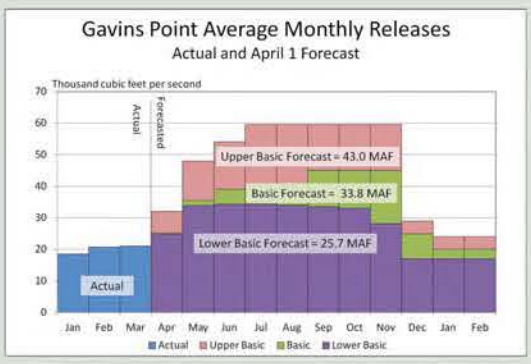


The graphic at left shows actual storage for 2010 and projected storage for 2011. The graphic at right shows projected Gavins Point releases for 2011.

US Army Corps of Engineers
BUILDING STRONG

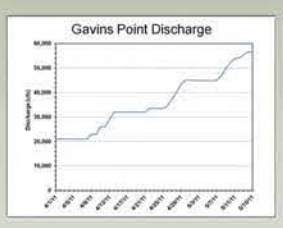
Missouri River
Mainstem Reservoir System

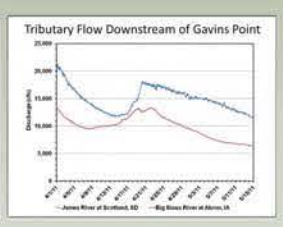
Spring 2011: May 1-20
Climate Outlook

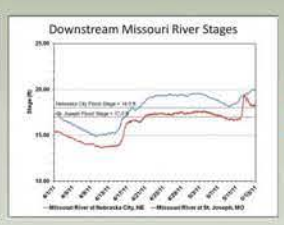
How the Corps Assesses Its Climate Forecast

The precipitation probability levels are: Above Normal (A), shown in shades of green; Below Normal (B) shown in shades of brown; and Equal Chances (EC), equal chance of (A) and (B), shown in white.

On May 1, the one-month outlook was Above Normal (A) in the northern Plains and Rockies, Equal Chances (EC) in the midsection of the basin and Below Normal (B) in the lower basin. The three-month outlook was for a mix of Above Normal (A) and Equal Chances (EC) precipitation in the upper and lower Missouri River basin. The Above Normal (A) outlook was mainly for eastern Montana, North Dakota, Missouri and Iowa.

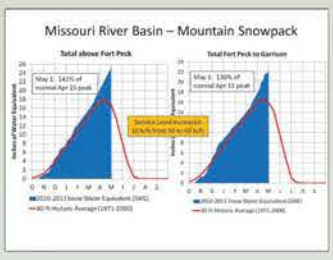


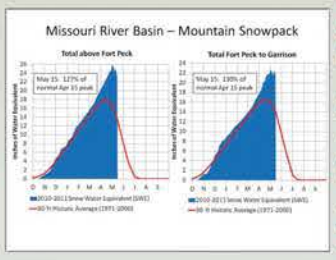




Gavins Point Releases

The Corps held Gavins Point releases at 45,000 cfs in early May due to high tributary flows entering the river below Gavins Point and downstream flooding.





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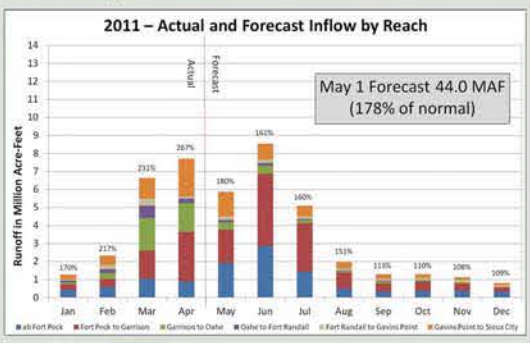
Reach-by-Reach Runoff Forecast



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Reservoir Computer Model

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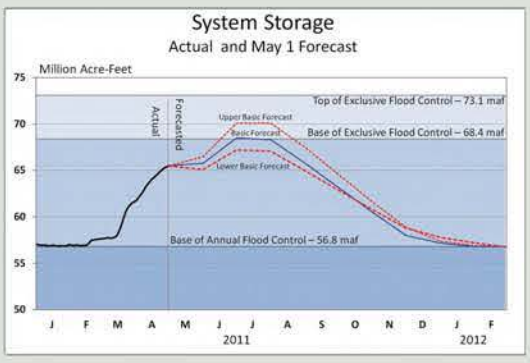
Storage and Releases



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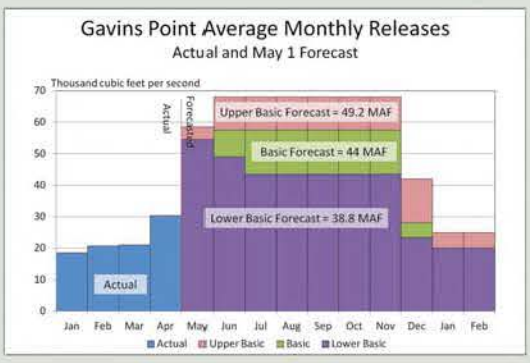


The graphic at left shows actual storage for 2010 and projected storage for 2011. The graphic at right shows projected Gavins Point releases for 2011.

US Army Corps of Engineers
BUILDING STRONG

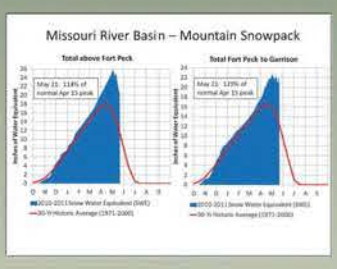
Missouri River
Mainstem Reservoir System

Spring 2011: May 21-31
Montana Rains: The Game Changer

Leading Up to the Flood

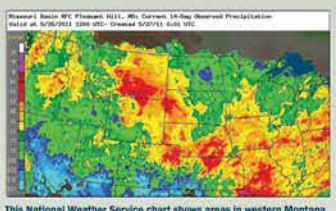
May 1: The Corps forecasts the annual runoff to be 44 million acre feet (MAF), considering already melted plains snow, still accumulating mountain snowpack and observed and forecasted above normal precipitation in the upper basin. The runoff total would be the 2nd highest runoff in 114 years, exceeded only in 1997 (49 MAF). Reservoir models indicate that the maximum releases out of Garrison Dam will hover near 49,000 cubic feet per second (cfs); for Gavins Point Dam, maximum releases are expected to be roughly 57,500 cfs.

May 10-11: Significant rain falls in eastern Montana with the total precipitation ranging from 2.5 to 3.5 inches.



Decision Timeline for Making Historic Releases

May 20-22 — Between 5 and 8 inches of rain falls across the regions of eastern Montana, western South Dakota and northern Wyoming covering an area of 50 million acres.



This National Weather Service chart shows areas in western Montana, Wyoming and parts of Nebraska that received high precipitation over a 14 day span (May 12-26). Some parts of Montana received more than 15 inches of rain.

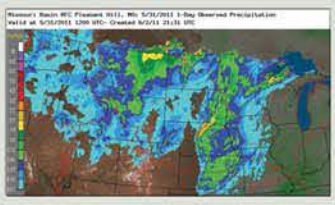
May 24 — More field data (precipitation and river stages/flows) becomes available to the Corps from the National Weather Service (NWS) and U.S. Geological Survey, following the heavy rain on May 20-22. Soils previously saturated over the last several weeks contribute to record inflows of runoff entering the reservoir system. The Corps holds a teleconference call and issues a press release warning the public that releases out of Garrison Dam, Oahe and Gavins Point Dam will increase to 85,000 cfs.

This chart from the National Weather Service shows the departure from normal precipitation during the 14 day span (May 12-26). Areas in Montana, Wyoming, Nebraska, Colorado and Kansas received more than 8 inches above normal rainfall.

May 27 — The NWS precipitation forecast indicates that more heavy rain (including 2 to 3 inches over the eastern half of Montana) is expected May 30-31.

The Corps hosts a teleconference call and issues a press release informing the public that reservoir releases from the lower five Mainstem dams will increase to 150,000 cfs; releases from Fort Peck will increase to 50,000 cfs.

These charts from the National Weather Service shows areas in western Montana, Wyoming and parts of Nebraska that received precipitation on May 30 and 31.



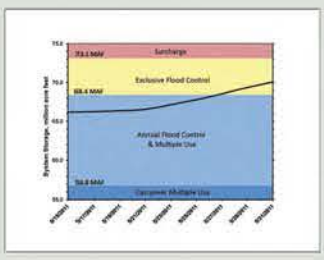
May 20 — The Corps issues a press release to notify the public that reservoir releases out of Garrison will go to 60,000 cfs the following week and to 65,000 cfs by early June.

NEWS RELEASE

May 23 — The Corps continues to assess the impact from the May 20-22 rain. River and reservoir models dictate a need to increase releases from all projects. Press release issues notice to the public that releases out of Garrison Dam will increase to 75,000 cfs and releases from Gavins Point Dam will go to 75,000 cfs in June, which is 5,000 cfs above the previous record release of 70,000 cfs during the 1997 flood.

NEWS RELEASE

May 25 — An additional 1.5 to 2 inches of rain falls in eastern Montana.

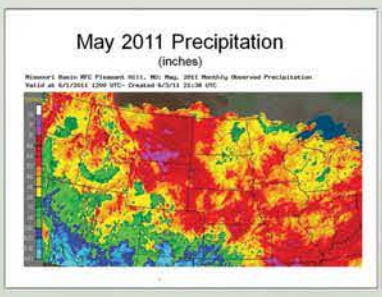


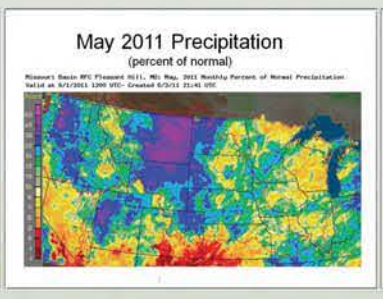
May 26 — More runoff enters the system from the May 25 rains. The runoff from the additional rain forces the Corps to increase releases from 85,000. The Corps assesses the additional impact to the reservoirs and holds another call announcing that reservoir releases will reach 110,000 to 120,000 cfs at the lower five Mainstem dams. Releases out of Fort Peck, Mont. are projected to increase to 50,000 cfs. At right, water flows through the Fort Peck spillway June 4 at a rate of 30,000 cfs.

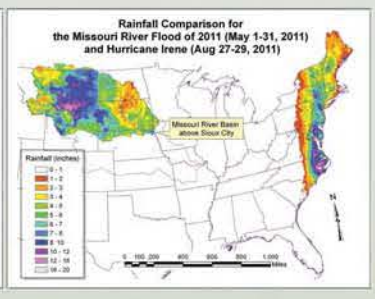
May 30 — On May 30, the Corps establishes the Missouri River Joint Information Center (MRJIC). The goal is to organize a central communications hub for basin communities to contact for accurate and timely information about the Corps' reservoir control and emergency response operations.

May 30-31 — An additional 2 to 4 inches of rain falls in Montana.

May 2011 Precipitation



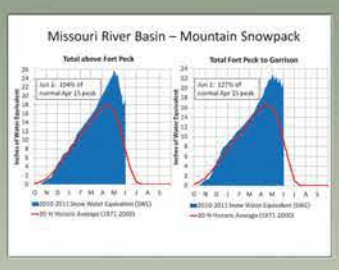


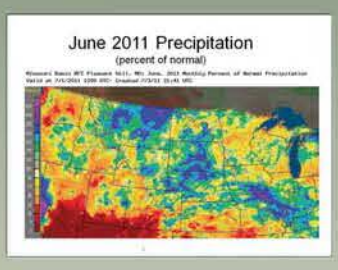


US Army Corps of Engineers
BUILDING STRONG

Missouri River
Mainstem Reservoir System

Summer 2011: June - August
Historic Runoff and Releases





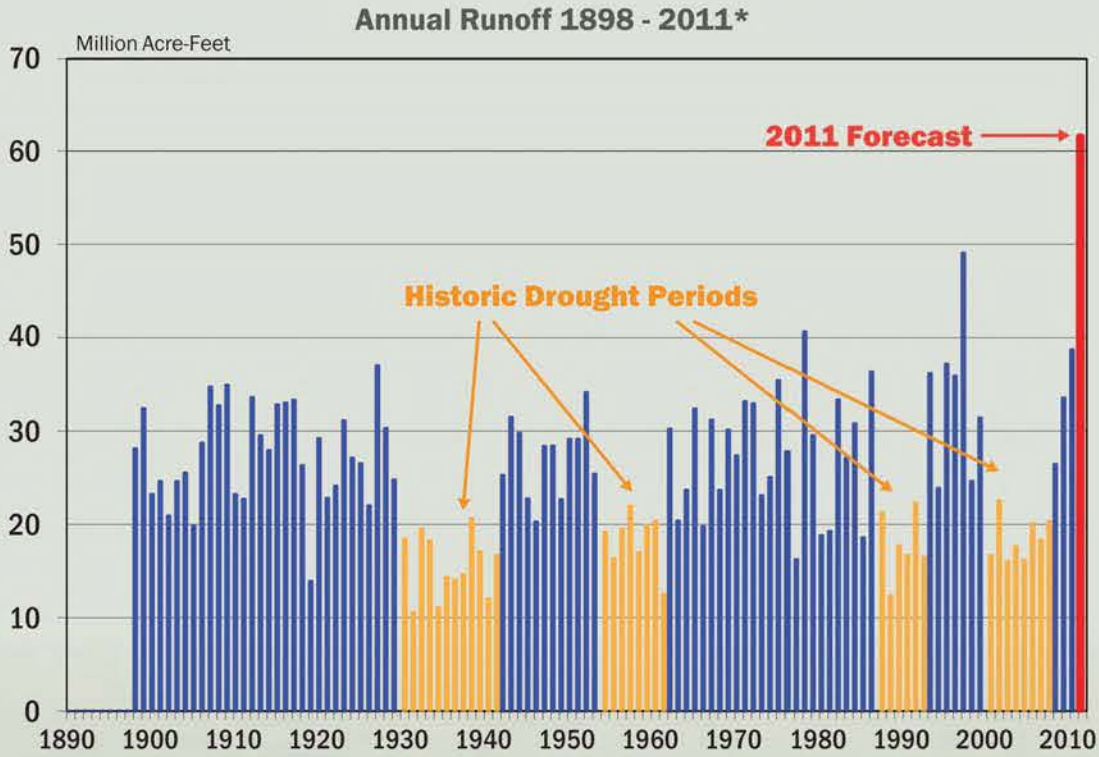
1368 Months of Record Keeping
(114 years x 12 months)

Wettest Months: Highest to Lowest

1. June 2011
2. April 1952
3. May 2011
4. June 1909
5. July 2011

Missouri River
Mainstem Reservoir System

Annual Runoff 1898 - 2011*



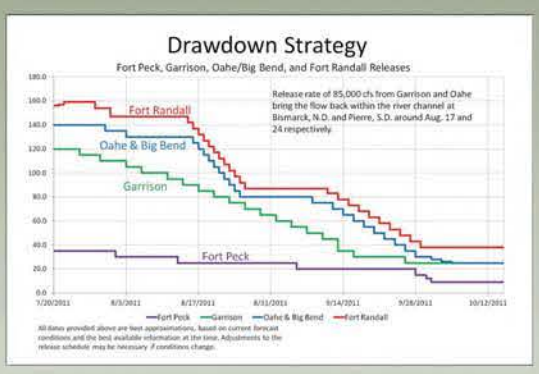
*Above Sioux City, IA

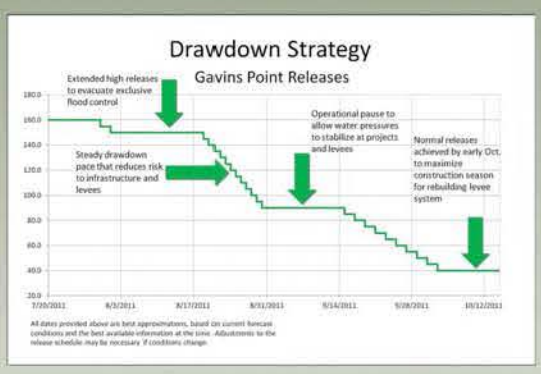
US Army Corps of Engineers
BUILDING STRONG

Missouri River
Mainstem Reservoir System

Fall 2011 and Beyond
Moving Forward

Drawdown Strategy





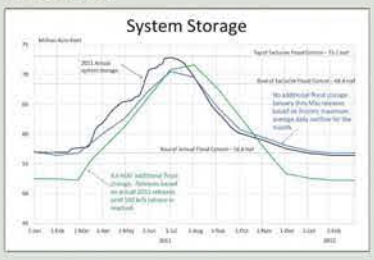
Key Engineering Considerations

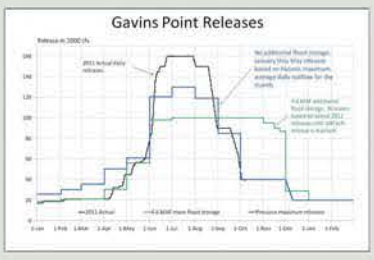
- Evacuate exclusive flood control zones of all reservoirs as soon as possible — gain back our flexibility.
- Ensure fall releases are low enough to facilitate damage assessment and repair of infrastructure and levees (<40,000 cfs).
- Ensure winter releases are low enough to permit winter construction and minimize the risk of ice jam flooding (<20,000 cfs).
- Ensure rates of change in releases and reservoir levels are acceptable.
- Consider releases that take water off critical infrastructure.
- Consider releases that avoid continued use of various project features such as spillways and outlet tunnels.
- Consider releases that allow temporary measures to be removed.

Why Still 16.3 MAF for Flood Control Storage?

- Risk of levee failure with continued high releases
- Delay of flood recovery
- Low risk of repeat
- 16.3 MAF sufficient for 113 of 114 years

What If?





Historic maximum winter and spring releases for Gavins Point

- 16.3 MAF of flood storage available at the start of the runoff season
- January through May Gavins Point releases based on the historical maximum average daily for each month
- Peak release of 130,000 cfs from early June through late August and then following the actual 2011 comedown schedule
- Total system storage of 56.8 MAF at the end of February 2012

4.6 MAF of additional flood storage

- 20.9 MAF of flood storage available at the start of the runoff season
- Starting pool elevation for upper 3 reservoirs 5.7 feet below the flood control zone
- January through May Gavins Point releases based on actual 2011 releases
- Peak release of 100,000 cfs from early June through end of October. Slowly reduce flows to 20,000 cfs by mid-December
- Total system storage of 52.2 MAF at the end of February 2012

2011-2012 Annual Operating Plan

- 16.3 MAF of flood control storage
- No Gavins Point spring pulse
- Full navigation flow support
- No unbalancing of upper 3 reservoirs

US Army Corps of Engineers
BUILDING STRONG

Missouri River
Mainstem Reservoir System

Post-Flood Assessment Efforts

Missouri River Flood Task Force

The Corps has established a Missouri River Flood Task Force to provide a temporary forum for coordination, collaboration and cooperation among federal officials and designated officers of state, local and Tribal governments within the states of Nebraska, Iowa, South Dakota, Montana, North Dakota, Wyoming, Kansas and Missouri. The mission of the task force is to complete initial repairs to levees and critical infrastructure throughout the basin that has been damaged by the flood. The goal is to complete initial repairs by March 1, 2012 and to enact long-term recovery activities to address floodplain management challenges and comprehensive flood risk reduction throughout the basin.

Water Management Technical Review

The Water Management technical review will include both internal and external components. Both reviews are expected to be complete by December 2011.

Internal Technical Review

An internal post flood technical review of system performance during the Flood of 2011 will be conducted to document the chronology of the event, including a review of the operational decision-making process, with an outlook towards improving system operation and performance.

Independent External Peer Review

The Corps has enlisted the assistance of experts in hydrology and reservoir system operations to review, analyze and assess the Corps' operation of the six Mainstem dams along the Missouri River leading up to and during the Flood of 2011.

Flood Fight Review

The Corps is in the process of reviewing its emergency response efforts during the Flood of 2011. The comprehensive review of flood fight activities and operations will be completed to determine the effectiveness of preparation, collaboration, and execution of the response to the flood event. This review is conducted to improve our future operations, to serve as the consolidated historical record of the disaster and to answer stakeholder questions.

Infrastructure Damage Assessment

The infrastructure damage assessment will focus on Corps-owned dams and levees, and those levees eligible for repairs under Public Law 84-99. This assessment will assess damage to infrastructure and analyze the increased risk posed to public safety, economic and environmental resources. It will identify the highest priority repairs holding life safety risk as paramount. The Corps began its full assessment of damages in early October when reservoir releases were reduced to just slightly above typical fall release rates. Releases out of Gavins Point are currently being maintained at 40,000 cubic feet per second (cfs) and are expected to remain steady through early November when they will be drawn down to a winter release rate of 20,000 cfs. The assessments are expected to be complete by early November. At that time, repairs will be prioritized to receive funding. Due to the limited availability of funding, not all projects will see repairs before the 2012 runoff season begins, but the Corps plans to attend to the most critical repairs first.

Basin Impact Assessment

The 2011 flood event has resulted in extensive regional impacts on public and private infrastructure, regional commerce, regional transportation and environmental resources. As a result, some communities in the basin have been displaced. The basin impact assessment will document the economic, social, cultural, and environmental impacts of the flood. The assessment will be useful in helping with the decision-making processes involving floodplain restoration activities.

Repair and Restore

Preparing the System for the 2012 Runoff Season and Beyond

System repair and restoration involves both emergency repairs and long-term restoration of infrastructure.

The Corps continues to evacuate the remainder of floodwaters stored in the reservoir system. The majority of the floodwaters must be evacuated before winter starts so homeowners, farmers, businesses and agencies have adequate time to inspect, assess and begin recovering from the flood. The goal is to evacuate floodwaters and make emergency repairs in time to be ready for the 2012 runoff season, which begins March 1, 2012.

System Review and Recommendations

A comprehensive review of current flood risk management in the basin will identify opportunities for improvement. The review will also make recommendations for operation and policy changes to reduce threats of future flood events to both life and property within the basin.