Upper Mississippi River Basin Association
Water Level Management Workshop

April 4-5, 2017
Grand River Center — Dubuque, Iowa

Workshop Purpose

Upper Mississippi federal and state natural resource agencies and non-governmental partners have been debating for decades about how to best manage the pool water levels to ensure a reliable 9-foot navigation channel and a healthy river ecosystem, including whether the benefits of holding down the river level merited the resource needs. Over time, various policies appeared to limit the feasibility of implementing water level management on a routine basis even within the operating band. Observations from the St. Louis District's water level management efforts over the past few years have shown tremendous ecological responses while, at the same time, the St. Paul District appeared stymied with obstacles to implementing a planned drawdown. The Upper Mississippi River Restoration's (UMRR's) effort to quantify the river's ecological resilience linked water level management to several key drivers impacting fish and wildlife habitat. Together, this highlighted a need for a comprehensive dialogue among the resource agencies regarding objectives for potentially operationalizing routine, systemic, large-scale water level management – what that would look like, the challenges to doing so, and recommendations for moving forward. The workshop's purposes are two-fold: 1) reaching a common understanding of implementation mechanics and stakeholder perspectives and 2) reaching consensus on a suite of recommendations.

Partner Recommendations

Through facilitated exercises, participants identified and prioritized recommendations for the UMRBA Board and broad UMRS partnership to consider. In addition to the highest ranking actions (listed below), the need for public outreach and education and increased communication and coordination among partners and Districts was evident in nearly all discussed recommendations.

1) *Employ water level management opportunistically* – seize opportunities to manage pool levels at the lower end of the existing operating band to generate ecological benefits within the existing funding, staffing, and policy construct
2) *Perform a cost-benefit analysis to determine merit* – define and quantify the trade-offs to implementing water level management associated with the spectrum of effort
3) *Address various policy and program implementation issues* – gain a comprehensive understanding of the policy and programmatic constraints impeding implementation of water level management and determine the best ways to resolve them
4) *Implement drawdowns in Pools 13 and* 18 – execute drawdowns (below the standard operating band) and more routine water level management (within the operating band) in these pools, which have a high potential for implementation success and for generating substantial ecological benefits as well as learning opportunities (Pool 13 is an UMRR LTRM study reach and there has been substantial monitoring in Pool 18)
5) *Seek and secure necessary funding* – identify means to cover the costs of additional dredging and material placement (or river training structures), increase efficiencies and reduce unnecessary costs, and generate public support for investment
6) *Gain a better understanding of how hydrology and hydraulics affect river management* – research and develop models to better predict river flows and water levels and identify the appropriate conditions to trigger water level management (perhaps integrate with the UMRS watershed study)

Day 1 – April 4

Opening Remarks/Setting the Stage

Partner Perspectives

Representatives from each of the Upper Mississippi federal and state agencies and non-governmental partners present shared their perspectives on the opportunities and challenges surrounding the potential for managing pool water levels in ways that benefit the ecosystem and what they hope will be achieved during the workshop. Representatives who spoke include B.J. Murray, Levi Solomon, Mike Griffin, Megan Moore, Jim Fischer, Jessica Brooks, Sabrina Chandler, Tim Schlagenhaft, Olivia Dorothy, Gretchen Benjamin, Paul Rohde, Kevin Landwehr, Brian Johnson, and Steve Clark. Shared objectives included learning, reaching consensus surrounding recommendations, and fostering interagency, interdisciplinary relationships.

Multi-Purpose Management

Dru Buntin provided a historical context of the Corps' dual purpose management of the river – the agreements that led to the Corps operating the dams (and pool water levels) to ensure a reliable 9-foot navigation system as well as a healthy ecosystem that supports fish and wildlife habitat. The states strongly hold that balanced management of the river allows for maximizing the broad suite of river uses and ensuring that the navigation system and ecosystem are sustained for future generations.

Ecosystem Resilience

Jeff Houser provided an overview of UMRR's effort to define and quantify the resilience of the Upper Mississippi ecosystem – i.e., its capacity to absorb disturbances and sustain its fundamental ecological characteristics to support abundant and diverse habitat – and how water level management directly or indirectly affects various controlling variables to ecosystem health. These controlling variables include water depth and velocity, substrate, total suspended solids, hydraulic connectivity among aquatic areas, water level fluctuations, and flood inundation. Conceptual models of lentic, lotic, and floodplain forest subsystems within the UMRS ecosystem illustrate the influence of individual and cumulative relationships among watershed and in-river drivers. Next steps include identifying thresholds among these relationships when an ecosystem is likely to move to a different state – e.g., floods lasting about 40 percent of the growing season suffocate many of the hardwood tress and present understory from establishing and growing, resulting in uniformly low species diversity and a degraded floodplain forest state.

District Pool Operations

Each of the three UMRS Districts presented on the operational realities of managing pool water levels. [Note: Slides of these presentations are included at the end of this summary.]

St. Louis District (MVS)

Joan Stemler presented on the operations of MVS's hinge-point control pools and the District's ability to manage the pools in ways that benefit the ecosystem. Four of the five MVS locks are controlled by a hinge-point, which is very challenging to manage. The pools' water level limits change with flows ranges and can require over a five-foot pool change in a 24-hour timeframe. The District issues instructions to lock personnel at least once per day and gate changes are made as necessary. Stemler showed visualizations illustrating the hinge-point operations and discussed the District's dredging operations as well as rock pinnacle removal necessary to maintain the nine-foot navigation channel. Stemler discussed the District's approaches to forecasts river flows in order to make daily adjustments to pool levels.

In 1988, resource managers began asking the Corps to lower pool water levels during the growing season to improve ecological conditions. They began by asking for 3-foot drawdowns for 120 days, which the Corps was unwilling to do. It was in 1994 that resource managers changed the request to a half-foot drawdown for at least 30 days; 10 more days than the Corps was already holding water levels down half a foot. With successful communication and collaboration between the Corps and resource managers in the field, it was found that managing water levels is feasible when tried. Since 1994, MVS has achieved environmental benefits annually through successful water level management.

In particular, 2016 was a very successful year for MVS's environmental pool management (EPM). In February 2015, the Corps formed an interagency project delivery team for EPM that defined a suite of parameters for successful water level management. This includes initiating EPM around April 1 every year, continuing EPM from May 1 for at least 90 days or until hydrologic conditions require routine dam operations, and ending EPM with raising water levels less than 0.3 foot per day to allow vegetation to survive and continue to grow. In 2016, the Corps was able to hold water levels at L&D 24 for at least half a foot for 148 days, 1 foot for 97 days, and 2 feet for 30 days. At L&D 25, water levels were held at 1.5 feet for 143 days and 2.5 feet for 61 days. At Mel Price, water levels were held at 1 foot for 224 days and 2 feet for 110 days. Stemler explained that the Corps only actively managed the pools for 10-20 days within the entire season. Stemler provided an overview of the biological response, which included increased species richness including emergent perennials and structural diversity. The response included all native species, with no infestations by invasive species. Stemler also explained how the Corps' outreach efforts helped to increase public understanding and support for its efforts to hold water levels low.

Rock Island District (MVR)

Kevin Landwehr presented MVR's pool characteristics and water level management capabilities given its ability to manage the dams. MVR has operational control of L&Ds 11-14, 16-18, and 20-22; L&D 15 is operated by lock staff; and L&D 19 is privately-held and controlled by Ameren UE. All of MVR's L&Ds are operated under dam point control, except for L&Ds 16 and 20, which are operated under primary-secondary-tertiary control where regulation occurs at multiple points along the length of the pool. Landwehr explained how the Corps manages the dam point and primary-secondary-tertiary L&Ds, including the operating limits and different gate settings. Ameren operates L&D 19 for the purposes of maximizing hydropower energy output. That has significant implications for Pools 20-22, making it virtually impossible to implement drawdowns in those pools.

During the non-navigation season (winter), the Corps historically employed drawdowns to maintain minimum desired depth at St. Louis. The Anti-Drawdown Law of 1934 and amended in 1946 and 1948 requires the Corps to operate and maintain the pools as though the navigation season was open year-round, limiting drawdowns north of L&D 15. However, Pools 16-18 were drawn down as needed to maintain depth at St. Louis. From 1970 to 1987, drawdowns were limited to one foot at all dams and, since 1988, the dams have been operated for a year-round navigation season.

Landwehr explained the Pool 13 drawdown event in 1998, which showed that a drawdown of 30 days or more could be accomplished once every three years. The Navigation and Ecosystem Sustainability Program's 2004 Water Level Management Report included a suite of prioritized recommendations for implementing water level management. In MVR, Pools 11 and 13 are found to be most suitable to water level management with Pools 16 and 18 as secondary priorities. Landwehr asserted that drawdowns in hinge-point pools have less recreational impacts and less associated dredging requirements.

Landwehr recalled that MVR attempted to implement a drawndown in Pool 13 again in 2000-2003, but conditions did not make it feasible. Partners quit asking the District to implement a drawdown, and therefore the Corps has not attempted once since then.

Hank DeHaan provided a handout of graphs showing dredging volume trends since 1997 in all Mississippi River pools within MVR, acknowledging that volumes have been decreasing. Illinois pools have experienced stable dredging volume needs.

St. Paul District (MVP)

Steve Clark explained that MVP employed deeper drawdowns in the 1930s than today due to several factors, including concerns regarding impacts to commercial navigation, riverfront property, and conservation. The 1948 Anti-Drawdown Act targeted winter operations, requiring that dams be held to levels required for navigation. And, changes in channel maintenance practices in the early 1970s required reduced frequency of dredging. In 1995, the Corps adopted the water level management task force's (WLMTF's) recommendation to maintain winter operations on the high side of the operating band.

Dan Fasching explained that MVP operates L&Ds 2-6 and 8-9 under hinge point control, L&D 7 under primary-secondary control, and L&D 10 under primary-secondary-tertiary control. Fasching explained the day-to-day dam operations, including how gate instructions are issued and the relationship among dams as well as the challenges association with wind, power generation, shift changes, math and human error and so forth that affect daily fluctuations.

Jon Hendrickson explained MVP's channel maintenance management requires, including dredging depth requirements and material placement. All dredged material must be placed in uplands except in emergency situations, increasing the cost and limiting the volume that can be accommodated from each dredge job. Hendrickson said factors affecting success of drawdowns include timeframe, duration, and depth of exposed areas. While in the 1990s partners sought optimum drawdown conditions targeting a 1.5 foot depth, more recent discussions have concluded that opportunistic drawdowns of shorter duration could have ecological benefits. Hendrickson explained the drawdown events that occurred in Pool 8 in 2001-2002 and then in Pool 5 in 2005-2006, including the biological responses measured and the associated channel maintenance. According to Hendrickson, planning for future drawdowns should consider constraints associated with additional dredging costs and recreational boating as well as opportunistic factors such as deferred dredging reaches, high tailwater at some dams, short-term change sin channel conditions, and risk of groundings. One consideration may be the construction of river training structures to reduce dredging needs.

Facilitated Exercise

Participants identified three opportunities and three challenges to water level management on sticky notes and placed them on the wall for a Day Two facilitation exercise – see below.

Day 2 – April 5

Partner Perspectives

Each participant provided an observation for the presentations on Day One and a desired outcome of Day Two's discussion. Observations included:

- There are no show-stoppers, but rather each challenge can be overcome with an opportunity
- We can work better together to integrate water level management in annual dam operations
- Water level management presents a great opportunity for dialogue with the public
- There are policy constraints limiting the ability to employ water level management – identify and address the most pressing constraints
- The ecological impacts/trade-offs need to be better understood

- There exist opportunities to be opportunistic – identify triggers for employing and maintaining water level drawdowns on an annual basis; identify and prioritize opportunities
- Federal funds are silo-ed preventing available funds being used for water level management – secure adequate funding through appropriate channels and explore ways to work cross-programmatically
- In addition to maintaining lower water levels, water level management should consider restoring annual fluctuations
- Hold annual meetings to track progress and exchange information
- Hydrology in the river is changing and that will affect water level management – need to get a better understanding of watershed influences and acknowledge changing conditions
- Opportunities to automate gates with a hard-wired control located within the lock house may create substantial efficiencies and better enable water level management
- Consistent understandings of water level management terminology – low control pool, operating band, etc. – would be helpful to ensuring that all partners are on the same page
- There seems to be difference perspectives between Districts regarding hydraulics and how that affects water level management

Facilitated Exercise

Participants grouped the sticky notes of opportunities and challenges in similar thematic groups. Small groups formed to consider a series of questions that would ultimately result in recommendations for action. The instructions

- Define the opportunity or constraint (what)
- Explain why it is important (why)
- List actions that can be taken to address (how)
- Name who can take those actions (who)
- Identify what they would need in order to act (how)
- Explain whether UMRBA should do anything to support these actions (UMRBA)

A spokesperson for each small group presented on the results, which then all participants voted on their respective priorities. The recommended actions and their associated priorities are described below.

<u>Opportunities</u>

Opportunistic Management (28 votes)

- **What**: Employ water level management opportunistically with existing/readily available funding sources, policy framework, and working conditions
- **Why**: There are ecological benefits to managing water levels for ecological purposes that are feasible and at relatively low cost (partners are learning how to optimize)
- **How**: (1) Be ready

  (2) Continue to monitoring biological responses and collect data on operations when employing water level management

  (3) Plan for opportunities following dredge operations; seek extended dredging activities if needed/feasible

(4) Allow for opportunistic allowances in dam operating manuals

(5) Partners continue to ask the Corps to operate the pool levels on an opportunistic basis; Corps staff discuss internally to instill the willingness

(6) Engage public to increase awareness, understanding, and buy-in

(7) Identify, own, and share the risk

- **Who**: Federal and state agencies, river teams, non-governmental organizations
- **UMRBA:** (1) Engage agency leadership

  (2) Facilitate the development of a UMRS environmental pool management manual

Costs-Benefit Analysis (20 votes)

- **What**: Define and quantify the benefits and costs associated with various levels of water level management
- **Why**: To rationalize the additional effort involved in managing pool water levels for the purposes of improving ecological health
- **How**: (1) Complete a meta-analysis of information known

  (2) Define the scope of a cost-benefit analysis

  (3) Employ any additional studies necessary to accurately portray the costs and benefits associated with various scales of water level management
- **Who**: River teams, federal and state agencies, non-governmental organizations, universities, contractors (e.g., Earth Economics), Congress
- **UMRBA**: (1) Support and facilitate the development of a cost-benefit analysis

  (2) Pursue any necessary and desired legislative changes

Pools 13 and 18 (17 votes)

- **What**: Employ more routine, opportunistic water level management and drawdowns (below the standard operating band) in Pools 13 and 18
- **Why**: (1) The pools represent feasible options to employ water level management that have a high potential to result in substantial ecological benefits

  (2) These pools would "fill the gap" within MVR, creating a systemic link between MVS and MVP

  (3) These pools offer tremendous learning opportunities given that Pool 13 is an LTRM study reach and there has been substantial monitoring in Pool 18
- **How**: (1) Just do it! Ask for it!

  (2) Determine whether NESP recommendations for water level management in these pools are still appropriate and feasible

  (3) Inform the public through an outreach campaign

  (4) Prepare the navigation channels (i.e., advanced dredging if needed)
- **Who**: Corps and federal and state resource managers
- **UMRBA**: (1) Facilitate partners' request for water level management in Pools 13 and 18

  (2) Lead or support the public outreach campaign

Monitoring/Modeling/Learning (8 votes)

- **What**: Generate an information gradient associated with the range of water level management options
- **Why**: To obtain a better understanding of the biological responses to repeated implementation, benefits to natural resources more comprehensively, impacts to other river users, and implementation approaches – e.g., optimal depth and duration
- **How**: (1) Immediate: continue learning from water level management in Pools 24-26

  (2) Define and implement a desired monitoring protocol

  (3) Prioritize learning needs

  (4) Secure necessary resources – funding and staff – to make learning a priority
- **Who**: "Funded" or experienced staff at federal and state agencies and universities as well as other knowledgeable partners, with an appropriate mix of agencies and expertise
- **UMRBA**: Seek and secure necessary funding sources

Enabling Methodologies (7 votes)

- **What**: Determine ways to better manage sediment in the UMRS to make routine water level management more feasible– e.g., use of river training structures
- **Why**: To provide mechanisms by which Districts can operationalize water level management
- **How**: (1) Evaluate the use of river training structures to minimize dredging costs

  (2) Explore any new ways to handle dredge material that are more cost-effective, environmentally-acceptable

  (3) Develop models to better manage sediment – e.g., 2-dimensional, Applied River Engineering Center models

  (4) Acquire new, or increase capacity at existing, disposal sites for future drawdowns; integrate dredge needs with habitat restoration projects for disposal opportunities
- **Who**: Corps and federal and state resource agencies
- **UMRBA**: (1) Seek and secure funding sources

  (2) Pursue any necessary and desired policy and/or legislative changes

Improving Habitat (6 votes)

- **What/why**: Improve habitat for fish and wildlife through more routine, systemic water level management
- **How**: (1) Educate policy makers, public, and key stakeholders within the basin about the potential of water level management for improving habitat; broaden support

  (2) Quantify the benefits

  (3) Implement pool-scale water level drawdowns through UMRR

  (4) Explore all available authorities
- **Who**: Corps, federal and state resource agencies, and non-governmental partners

Generic Opportunity (4 votes)

- **What**: Follow through on the recommendations from today's workshop
- **Why**: To ease constraints, operationalize, and realize benefits
- **How**: (1) Annual in-person meetings and other conference calls as needed
  (2) Enhance consistency and communication among partners
- **Who**: Corps, federal and state resource agencies, and non-governmental partners
- **UMRBA**: Provide accountability and momentum within the partnership

Public Outreach (1 vote)

- **What**: Outreach to the public to increase awareness and understanding
- **Why**: To gain support and ease concerns in advance of water level management events to dampen negative reactions
- **How**: (1) Hold public meetings
  (2) Install informative kiosks at boat landings
  (3) Distribute fliers at libraries, marinas, and other targeted locations
  (4) Employ a social media presence
  (5) Create consistent messages that are reviewed and accepted among the partnership
  (6) Task a communications specialist to create a strategy and materials
- **Who**: Federal and state resource agencies, non-governmental partners, water level management task force
- **UMRBA**: Provide leadership, facilitate logistics

<u>Constraints</u>

Policy (26 votes)

- **What**: Lack of a complete awareness/shared understanding of relevant policies and how they might be constraining (or facilitating) of water level management actions
- **Why**: Seemingly, existing policies are impeding routine water level management within and beyond the operating band whether they be perceived or real
- **How**: (1) Gain a comprehensive understanding of those policy constraints and determine the best ways to resolve them
  (2) Increase shared knowledge of the various authorities affecting water level management individually and cumulatively
- **Who**: Corps and federal and state resource managers
- **UMRBA**: Facilitate dialogue among partners about the policy issues and any action to resolve them

Funding (15 votes)

- **What**: Costs associated with water level management are expensive – dredging, material placement, monitoring, river training structures

- **Why**: Costs are an impeding factor
- **How**: (1) Seek and secure necessary funding, including potential flexible funding sources within the Corps

  (2) Advocate for desired policy changes to reduce unnecessary costs and increase efficiencies where possible

  (3) Quantify ecological benefits and cost savings (over dredging for future years) to explain that costs are essentially off-set

  (4) Generate public support for investment
- **Who**: Federal and state resource agencies, non-governmental partners, UMRBA
- **UMRBA**: Facilitate discussion about potential policy solutions and ways to minimize associated costs

Hydrology & Hydraulics (10 votes)

- **What**: The hydrology and hydraulics (H&H) of the river system are changing in ways that may be constraining
- **Why**: Successful implementation of water level management for environmental purposes is dependent on the H&H conditions – need to have a better understanding of how H&H affect drawdown implementation, including identifying the optimum conditions
- **How**: (1) Pursue studies of sediment and water flow from the watershed, floodplain, and within the channel

  (2) Update models to better predict H&H

  (3) Integrate existing information from multiple sources

  (4) Determine desired water level management effort to base results

  (5) Secure public and agency support, funding, and expertise

  (6) Define objectives and strategy to scope studies
- **Who**: Partners determine objectives; Corps, USGS, and other H&H technical experts develop the models and studies
- **UMRBA**: (1) Obtain political support

  (2) Facilitate collaboration and distribution of information

Perceptions (8 votes)

- **What**: There is a perception among some stakeholders that environmental pool management or drawdowns are not good/valuable
- **Why**: This becomes a impeding factor to being opportunistic or initiating plans for a larger drawdown
- **How**: (1) Engage both the general public and targeted constituency groups such as Ducks Unlimited, etc.

  (2) Define "triggering criteria" for the Corps to begin facilitating a planning process (to be opportunistic)
- **Who**: All partners have a roll

Risk (3 votes)

- **What**: There is concern about associated risk – e.g., costs outweighing benefits, allocating risk for planning when not feasible, negative public reaction
- **Why**: Understanding risk is important for either accepting or mitigating and ultimately deciding whether to implement
- **How**: (1) Identify risk and its certainty, impact, and options for addressing

  (2) Communicate among partners the various risks involved in water level management and which are perceived and can be overcome immediately
- **Who**: UMRS regional partnership and public
- **UMRBA**: (1) Facilitate public outreach and education

  (2) Encourage forward movement

Operational (2 votes)

- **What**: The Corps 9-foot navigation channel authority cannot be impacted
- **Why**: Recognizing this authority allows planners to set boundaries and may require additional dredging to ensure the authority is met
- **How**: (1) Define success

  (2) Explore options for changing dredge operations and policies, including river training structures and automating gates

  (3) Pursue any necessary federal and state policy changes

  (4) Revise dam operations manuals and develop a water level management plan, enhancing consistency among Districts to the extent possible

  (5) Make a shared commitment to invest in water level management

  (6) Prioritize pools to employ water level management based on likelihood of success – implementation and desired biological responses

  (7) Generate regional support – among agencies and the public – and funding
- **Who**: Federal and state agencies, non-governmental organizations, Congress
- **UMRBA**: (1) Facilitate public outreach and education

  (2) Encourage forward movement

Ecological Impact (0 votes)

- **What**: There are known negative impacts on mussel and fish populations that creates concern among some resource practitioners
- **Why**: Water level management may impact threatened and endangered species of mussels and fish
- **How**: (1) Survey and assess mussel communities and relocate mussels from exposed areas

  (2) Mitigate (or propagate) for mussel mortality

  (3) Gradually alter water levels

  (4) Only employ drawdowns within the operating band

  (5) Time drawdowns to avoid spawning and rearing events
- **Who**: Corps and federal and state resource managers and scientists
- **UMRBA**: Facilitate multi-agency leadership in determining solutions to potential resources impacts

Partner Perspectives

Each participant provided an observation of the workshop discussion and outcomes, including:

- There was a lack of information in the Corps' presentations about narrowing of the operating bands over time and just in-time dredging – would like to determine if the issues were perceived or whether future discussion is warranted about addressing those management issues
  - If the operating band was widened, there would be greater flexibility to be opportunistic
  - Environmental communities requested the Corps manage for a narrower operating band at higher levels to minimize dredging needs; it may be time to revisit that decision as it would require dredging deeper and increased associated costs or constructing river training structures
  - The tradeoff is that increased dredging may have a greater impact on the ecosystem than the benefit from doing water level management
- There might still be some misconception surrounding L&D operations
- The intent of the MVP WLMTF is to address these issues and prepare for a feasibility study
- Water level management presents a great opportunity for dialogue with the public
- The 9-foot navigation channel is the most significant constraint and the wide range of options for managing the system should be on the table
- In WRDA 2016, Congress asks the Corps to identify beneficial use projects that would disregard the federal low cost standard – the UMRS partnership could propose a project that includes dredging, a habitat restoration project (island), and a drawdown
- MVD has given the Districts a clear directive that an independent funding source is needed outside of O&M budget for any major drawdown beyond the operating band
- It may be worthwhile to do a modeling exercise to illustrate extent of exposed areas from various levels of drawdowns

Upper Mississippi River System
2017 Water Level Management Workshop

Attendance List

Levi Solomon	Illinois Natural History Survey
B.J. Murray	Illinois Department of Transportation
Kyle Bales	Iowa Department of Natural Resources
Mike Griffin	Iowa Department of Natural Resources
Kirk Hansen	Iowa Department of Natural Resources
Dan Dieterman	Minnesota Department of Natural Resources
Megan Moore	Minnesota Department of Natural Resources
Brian Stenquist	Minnesota Department of Natural Resources
Matt Vitello	Missouri Department of Conservation
Deanne Drake	Wisconsin Department of Natural Resources
Jim Fischer	Wisconsin Department of Natural Resources
Brenda Kelly	Wisconsin Department of Natural Resources
Jim Killian	Wisconsin Department of Natural Resources
Kurt Rasmussen	Wisconsin Department of Natural Resources
Jessica Brooks	National Weather Service
Dave Busse	U.S. Army Corps of Engineers
Steve Clark	U.S. Army Corps of Engineers
Dan Cottrell	U.S. Army Corps of Engineers
Hank DeHaan	U.S. Army Corps of Engineers
Tim Eagan	U.S. Army Corps of Engineers
Russell Errett	U.S. Army Corps of Engineers
Dan Fasching	U.S. Army Corps of Engineers
Jon Hendrickson	U.S. Army Corps of Engineers
Toby Hunemuller	U.S. Army Corps of Engineers
Shahin Khazrajafari	U.S. Army Corps of Engineers
Brian Johnson	U.S. Army Corps of Engineers
Kevin Landwehr	U.S. Army Corps of Engineers
Ben McGuire	U.S. Army Corps of Engineers
Davi Michl	U.S. Army Corps of Engineers
Bre Popkin	U.S. Army Corps of Engineers
Lane Richter	U.S. Army Corps of Engineers
Joan Stemler	U.S. Army Corps of Engineers
Chuck Theiling	U.S. Army Corps of Engineers
Steve Tapp	U.S. Army Corps of Engineers
Randy Urich	U.S. Army Corps of Engineers
Sabrina Chandler	U.S. Fish and Wildlife Service
Brandon Jones	U.S. Fish and Wildlife Service
Mary Stefanski	U.S. Fish and Wildlife Service
Tim Yager	U.S. Fish and Wildlife Service
Jeff Houser	U.S. Geological Survey
Kevin Kenow	U.S. Geological Survey
Olivia Dorothy	American Rivers
Tim Schlagenhaft	Audubon
Gretchen Benjamin	The Nature Conservancy
Doug Blodgett	The Nature Conservancy
Paul Rohde	Waterways Council, Inc.
Dru Buntin	Upper Mississippi River Basin Association
Kirsten Mickelsen	Upper Mississippi River Basin Association

WLM IN THE CONTEXT OF ECOLOGICAL RESILIENCE

Jeff Houser
USGS Upper Midwest Environmental Sciences Center
Water Level Management Workshop
4-5 April 2017

Resilience Acknowledgements/Contributors

Resilience Working Group
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- Dave Bierman (IDNR)
- Dave Herzog (MDC)
- Jeff Houser (USGS)
- Jon Hendrickson (USACE)
- Kirsten Mickelsen (UMRBA)
- Kristen Bouska (USGS)
- Marvin Hubbell (USACE)
- Nate De Jager (USGS)
- Nate Richards* (USACE)
- Ken Barr* (USACE)
- Mark Cornish (USACE)
- Shawn Giblin (WDNR)
- Steve Winter (FWS)

*former members

Additional Workshop attendees
- Yao Yin (USGS)
- Brian Ickes (USGS)
- Jim Rogala (USGS)
- Bob Clevenstine, (FWS
- Sarah Schmuecker (FWS)
- Melinda Knutson (FWS)
- Dru Buntin (UMRBA)
- Kevin Stauffer (MDNR)
- Lance Gundersen (Emory U.)
- Allyson Quinlan (Resilience Alliance)

- UMRR LTRM 2016 Science Meeting Participants
- Informal survey respondents
- Manuscript reviewers

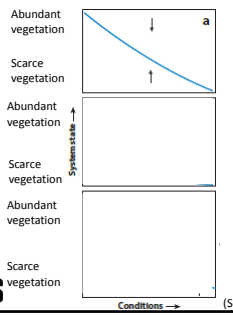
Ecological resilience

- "…capacity of a system to **absorb disturbance and…still retain essentially the same function, structure, identity and feedbacks** (Holling 1973, Walker et al. 2004)"
- In other words – the ability of the system to cope with unexpected disturbances without losing its fundamental characteristics or identity

Resilience: main concepts

- Multiple states may be possible
- Thresholds small changes in some variables can lead to large, rapid changes in others
- Controlling variables of the ecosystem can interact resulting in positive or negative feedbacks
- Processes occurring at different scales interact

System changes: gradual, threshold, & hysteresis



gradual

threshold

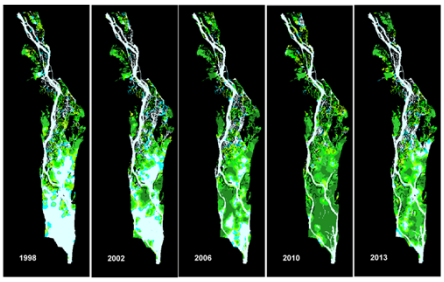
Hysteresis (alternate states)

(Scheffer et al. 2015. Annu. Rev. Ecol. Evol. Syst. 46:145–67)

Aquatic vegetation as example of resilience, lack of resilience, and why resilience isn't always good.

Upper Reaches:
- Vegetation crash and return

Lower reaches:
- No return
- Resilient, scarce veg. state?
  - Herbivory?
  - Lack of propagules?
  - Sediment characteristics?
  - Water level dynamics?

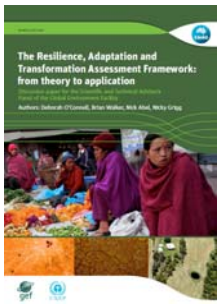


http://www.umesc.usgs.gov/data_library/vegetation/graphical/distribution_query.shtml

Resilience assessment of the UMRS

What can we infer about the resilience of the UMRS from existing data?

- Describe the system
- Assess the system
  - General resilience: Capacity of a system to absorb disturbances of all kinds, including novel, unforeseen ones, so that all parts of the system keep functioning as they have in the past
  - Specified resilience: Resilience of some specified part of the system to a particular kind of disturbance
- Management implications



O'Connell et al. 2015. The resilience adaptation and transformation assessment framework: from theory to application. CSIRO, Australia

USGS

General Resilience

- Maintain diversity and redundancy
  - Geomorphic diversity
  - Biodiversity
- Manage connectivity
  - Off-channel areas
  - Floodplain
- Manage slow variables and feedbacks
  - Sediment/nutrient accumulation
  - Sediment characteristics
  - Changes in FP forest
  - Spread of invasive species

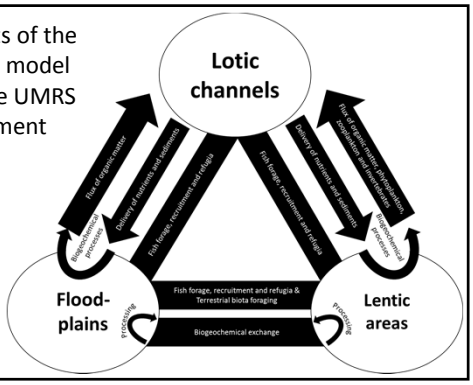
(John Sullivan)

Biggs et al. 2015. Principles for Building Resilience. Cambridge University Press.

System Description

- Purpose:
  - Develop an agreed upon (*more or less*) simplification of the UMRS that clearly identifies the fundamental characteristics of the system.
  - *Briefly* describe the history of how the UMRS came to be what it is today.
  - **Simplify a complex system to its most fundamental controlling variables**.
    - Valued uses & ecosystem services
    - Major ecological resources needed to support those uses & services
    - Major controlling variables that affect those major resources
- Bouska, K.L., J.N. Houser, N. R. De Jager. Developing a shared understanding of the Upper Mississippi River: the foundation of a resilience assessment. *Submitted manuscript.*

Three components of the UMRS conceptual model created during the UMRS Resilience Assessment

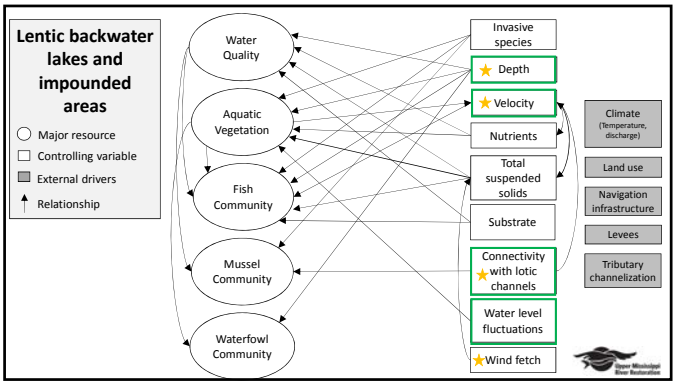


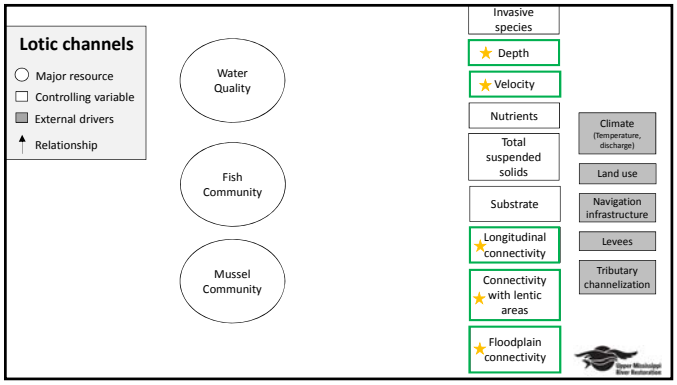
Major ecological resources identified during the UMRS resilience assessment

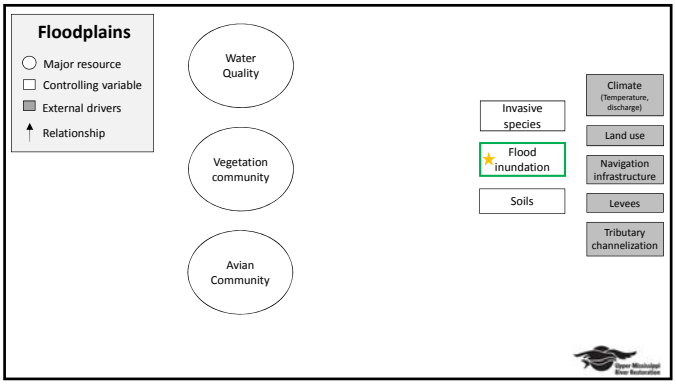
Valued use or ecosystem service
- Aesthetics, photography & sight-seeing
- Biodiversity
- Bird-watching
- Boating, swimming & camping
- Cultural identity
- Drainage
- Flood risk reduction and storage
- Floodplain agriculture
- Hunting and trapping
- Hydropower
- Navigation
- Nutrient and sediment processing
- Recreational and commercial fishing
- Water supply

→

Major ecological resources
- Aquatic vegetation
- Birds
- Floodplain vegetation
- Native fish
- Native mussels
- Waterfowl
- Water quality





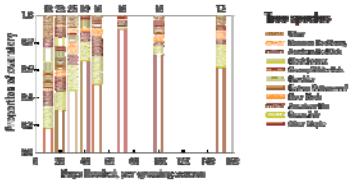


Controlling variables that may be **directly** or **indirectly** affected by WLM

	Lotic	Lentic	Floodplain	
Depth	■	■		Water surface elevation - bed elevation= depth
Velocity	■	■		Complex effects on velocity depending on geomorphology
Substrate		■		Sediment drying/compaction can affect substrate characteristics
Total suspended solids		■		Sediment drying/compaction of exposed sediment may reduce resuspension when subsequently inundated
Connectivity b/t channels and OCAs	■	■		Hydrologic connectivity among aquatic areas is affected by water surface elevation
Water level fluctuations	■	■		Water surface elevation and its variability directly determined by WLM
Flood inundation			■	Duration and extent of floodplain inundation directly determined by WLM.

Potential thresholds relevant to WLM

- Inundation duration / frequency
  - Floodplain vegetation
- Duration/frequency of sediment exposure
  - Sediment compaction
  - Emergent plant germination/establishment



(De Jager et al. 2012)

Summary

- Resilience perspective emphasizes:
  - ability of an ecosystem to cope with unexpected disturbances without losing its fundamental characteristics or identity
  - slowly changing variables and potential thresholds
  - Interactions among processes occurring at multiple scales
- Several of the controlling variables identified in the Resilience Assessment conceptual models can be directly or indirectly affected by WLM and a variety of other management and restoration actions (e.g., island construction, dredging, closing dam modifications…)

Questions?

Water Level Management Workshop

Joan Stemler

April 2017

Overview

- St. Louis District Overview/Background
- Lock & Dam Operations
- Dredging Operations
- Environmental Pool Management
- Questions

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St. Louis District

District Overview

- 5 Flood Control Reservoirs Projects
  - ►Lake Shelbyville, Carlyle Lake, Rend Lake, Mark Twain Lake, and Wappapello Lake
- 5 Lock and Dam Projects
  - ►L&D 24, L&D 25, Mel Price L&D, L&D 27, and Kaskaskia L&D
- 9 Watersheds draining into the Mississippi River within the St. Louis District
  - ►Salt, Cuivre, Lower Missouri, Meramec, Upper St. Francis, Castor, Lower Illinois, Kaskaskia, and Big Muddy Rivers

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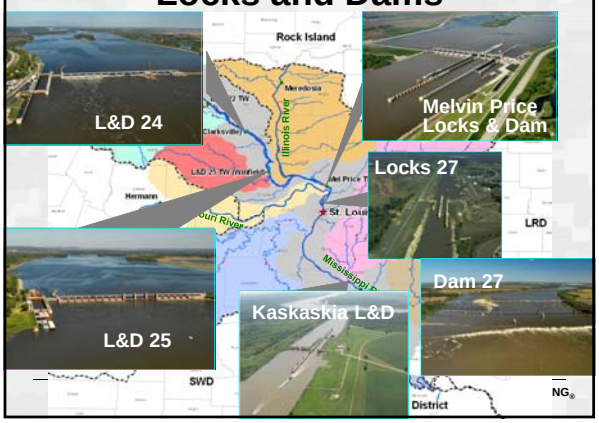
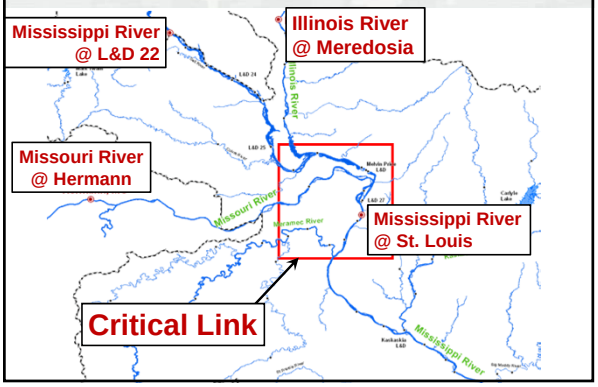
Locks and Dams



Critical Link



HISTORY OF THE ST. LOUIS GAGE

- Lowest recorded stage = -6.2 feet (1940)
- Highest recorded stage = 49.6 feet (1993)
  Over a 55 foot range
- Average stage (11.3 feet)
- 2012-2013
  Low ~ -4.6 (JAN 2013)
  High ~ 40.5 (JUN 2013)
- Range in flows
  -3.2' (LWRP) approx. 6,300/foot
  30.0' (Flood) approx. 22,000/foot

Coordination

- **USACE**
  - ►Mississippi Valley Division
    - St. Paul District
    - Rock Island District
    - Memphis District
  - ►Northwestern Division
  - ►Lakes and River Division
- **NWS River Forecast Centers**
  - ►North Central RFC (handoff at Chester, IL)
  - ►Missouri Basin RFC (handoff at Hermann, MO)
  - ►Lower Mississippi RFC (starting at Cape Girardeau, MO)

Coordination

- **USGS**
  - ►Illinois
  - ►Missouri
- **Coast Guard**
  - ►Sector Upper Mississippi River
    - Upper Mississippi down to UMR mile 109.9 (Chester, IL)
  - ►Sector Lower Mississippi River
    - Lower Mississippi starting at UMR mile 109.9 (Chester, IL)
- **River Industry Action Committee (RIAC)**

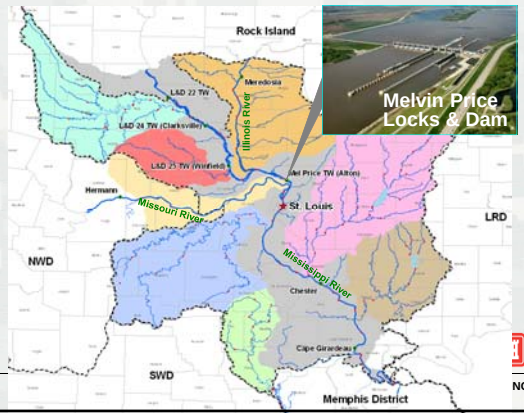
Hinge Point Operation

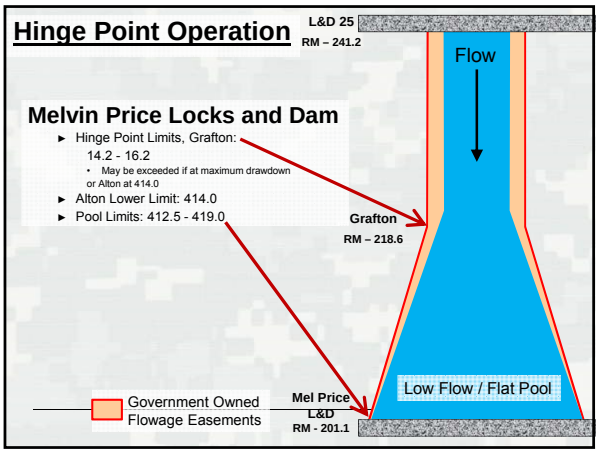
- Difficult!! Operate by using two control points. One at dam and one mid-point in pool
- Range limits change with flow ranges
- Change in flows can require over a 5 ft pool change in a 24-hour timeframe
- Pool elevation instructions are issued to lock personnel (minimum daily) and gate changes are made as necessary
- Daily instructions +/- tenth

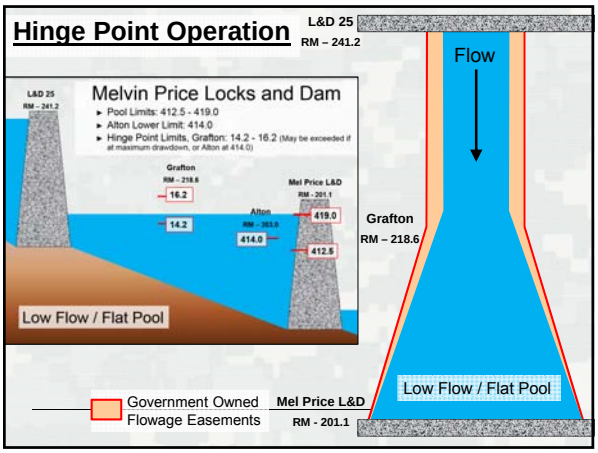
Hinge Point Operation

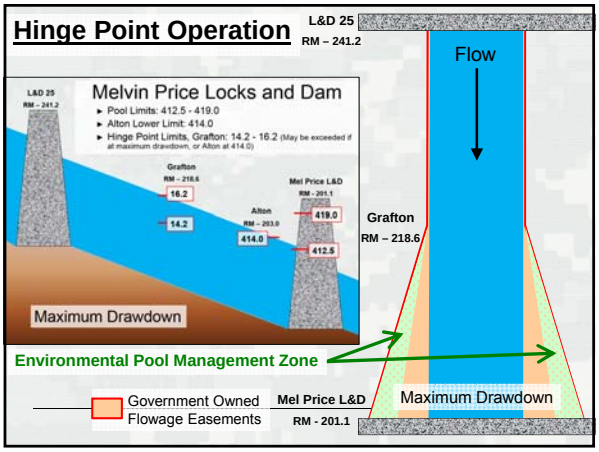
- Lock and Dam 24
  - ► Pool Limits: 445.5 - 449.0
  - ► Hinge Point Limits, Louisiana: 11.5 - 12.2 (May be exceeded if at maximum drawdown)
- Lock and Dam 25
  - ► Pool Limits: 429.7 - 434.0
  - ► Hinge Point Limits, Mosier Landing: 434.0 - 437.0 (May be exceeded if at maximum drawdown)
- Melvin Price Locks and Dam
  - ► Pool Limits: 412.5 - 419.0 Alton Lower Limit: 414.0
  - ► Hinge Point Limits, Grafton: 14.2 - 16.2 (May be exceeded if at maximum drawdown, or Alton at 414.0)
- Kaskaskia Lock and Dam
  - ► Pool Limits: 363.0 - 368.8
  - ► Hinge Point, Red Bud: 368.0 - 370.0

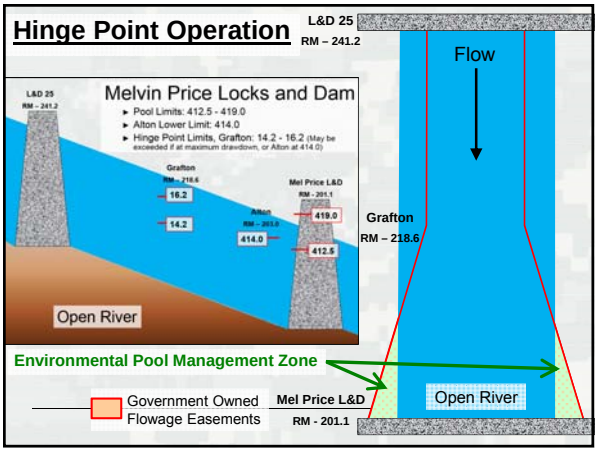
Locks and Dams

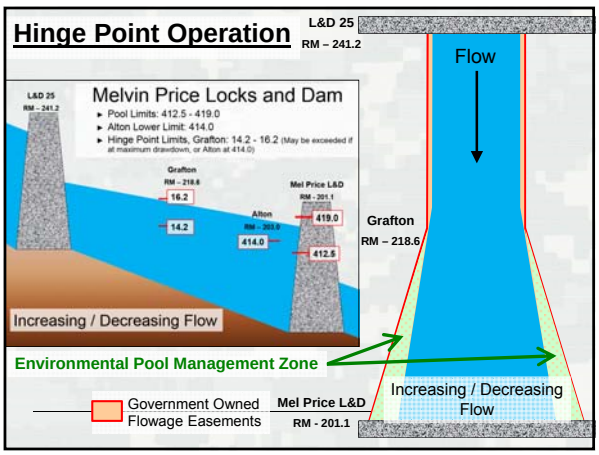












Visualizing L&D Hinge Point Operating Limits

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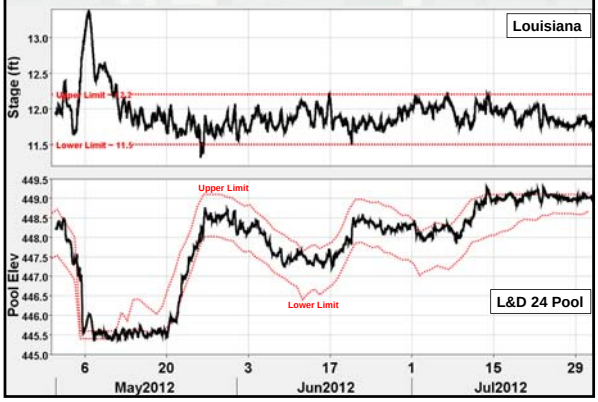
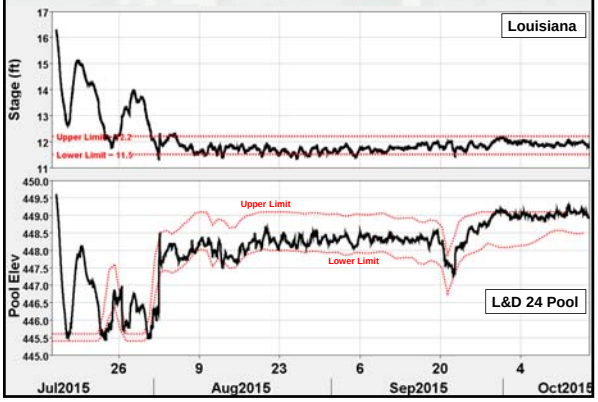
L&D 24 Operating Limits (2012)



L&D 24 Operating Limits (2015)



Dredging Operations

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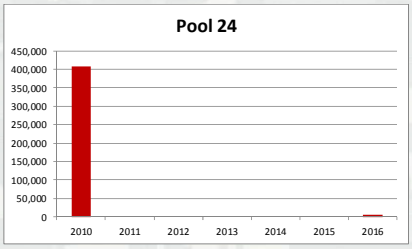
Pool 24

Jobs: 1
CY: 5k

Mile 289
MVR – Mech
11 - 13 Jul 2016



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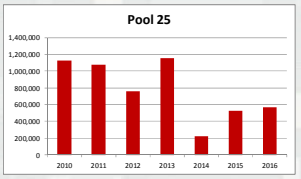
Pool 25

Jobs: 8
CY: 565,829

Dredge Potter
10-23 Jun
Lock 25 Upper, 242.0
Westport Island, 255.6
Coon Island, 266.0
Coon Island, 266.0
Carroll Island, 270.0
Carroll Island, 270.3

11-20 Aug
Lock 25 Upper, 243.0
Lock 25 Upper, 242.2



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Pool 26, UMR

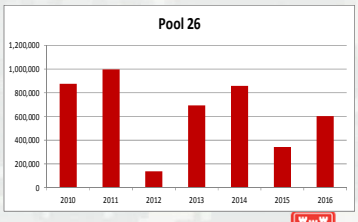
Jobs: 11
CY: 599,797

Dredge Potter

6-12 June
Sherwood, 219.0
Bolter Island, 227.0
Lock 25 Lower, 241.0

23 Jun – 1 Jul
Bolter Island, 227.0
Thomas Landing, 229.0
Peruque Island, 233.0
Martin Towhead, 234.0
Squaw Island, 221.0
Alton, 203.0

9-11 Aug
Royal Landing, 223.5



6-9 Dec
Lock 25 Lower, 241.0

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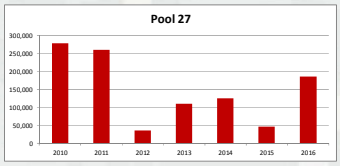
Pool 27, UMR

Jobs: 3
CY: 185,499

Dredge Potter, 146k CY
1-5 Jul
Mel Price Lower, 200.3
Mobile Island, 196.0



Dredge Goetz, 39.5k CY
17-22 Oct
Upper Chain of Rocks Canal, 194.0

Standby High Water – 15 days

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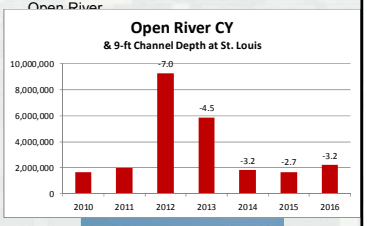
Open River

Jobs: 11
CY: 2,155 MCY

Dredge Potter
20 Aug – 28 Dec 2016
Riverway, 173.0
*Cliff Cave,167.0
*Notre Dame,171.0
*Reidy, 175.0
*Lower Canal, 184.0
Riverway, 173.0
Cliff cave, 167.0
JB Lower, 168.3
Vancill Towhead, 67.0
Manskers, 103.0
Service Base, 177.0



Standby High Water – 82 days
6 Jul – 8 Aug
1 – 8 Sep
13 Sep – 22 Oct

* Flex Pipe

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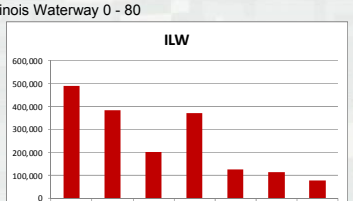
Illinois Waterway 0 - 80

Jobs: 8
CY: 77,377

Dredge Goetz

25 Aug – 30 Sep
Wing Island, 40.0
Old La Grange Lock Lower, 77.0
Old La Grange Lock, 77.5
Moores Island, 76.7 & 76.4
Old La Grange Lock Upper, 78.0
Indian Creek, 78.8
Kamp Creek, 74.0
Mauvaise Terre, 63.0



Standby High Water - 19.5 days

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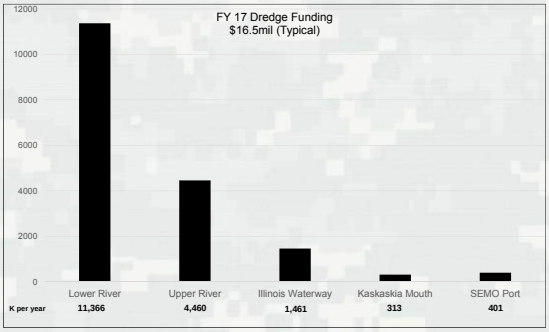

We have had at times reprogram from Lower to Upper to meet needs or receive supplemental funds to help out like during the drought of 2012.

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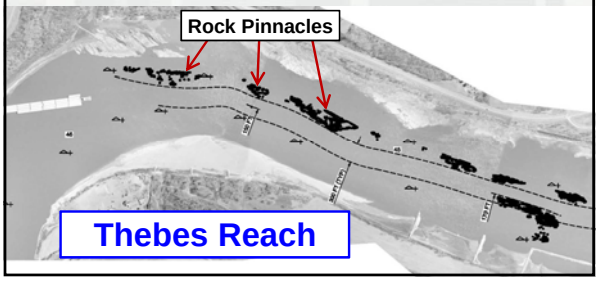
Rock Removal

- **Remnants of the 1988-1989 rock removal**
  - ▸**Grand Tower Reach (RM 78.9 to 80.0)**
  - ▸**Thebes Reach (RM 38.5 to 46.0)**



Bumpings/Groundings

- In our pools we generally have may a few bumpings, say 3 to 5 per season, but generally those issues are related to buoys off station or if it is an area that is shoaling. We can delay dredging by pulling buoys in with the Pathfinder
- We have also temporarily re-aligned the channel to avoid shallow water until a dredge is available
- We also provide survey data to industry to help them find the best available water
- Hard groundings per year, hopefully none that are directly in the channel

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Extended River Forecast

(issued late November)

- **Currently St. Louis is at -0.7 ft**
  - ►7,000 cfs/ft
- **Upper Mississippi River Flow Forecast**
  - ►Currently ~ 39,200 cfs
  - ►28 days ~ 21,500 cfs (-17,700 cfs)
- **Missouri River Flow Forecast**
  - ►Currently ~ 48,700 cfs
  - ►28 days ~ 24,000 cfs (-24,700 cfs)
- **St. Louis 28 day Forecast**
  - ►Loss of 42,400 cfs ~ loss of 6 ft ~ -6.7 ft at St. Louis

Accounting for Forecast Errors

- **Assuming St. Louis Low of -5.1 ft** (*i.e. no Mel Price operation*)
  - ►6,000 cfs/ft
- **Upper Mississippi River Flow Forecast**
  - ►Error ~ -1,140 cfs
- **Illinois River**
  - ►Error ~ -3,000 to -6,000 cfs
- **Missouri River Flow Forecast**
  - ►Error ~ -3,300 cfs
- **St. Louis Low:**
  - ►Loss of 7,440 to 10,440 cfs ~ -6.3 ft to -6.8 ft

Environmental Pool Management In St. Louis District

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Environmental Pool Management is Adaptive Management

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EPM – The Beginning

Agency request (~1988)- "We want a 3 foot drawdown for 120 days!"

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Corps response -"Nope!" "It will impact navigation, dredging, we don't have the mission, it costs too much, blah, blah, blah……"

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EPM – The Beginning

- 1989, 1990, 1991, 1992 - same request, same "**Nope**"
- 1994 NR agencies – "Can you at least give us a 1/2 ft for at least 30 days?"
- Corps "Yea we will try it."
  - Reality was the Corps was doing it for ~ 20 days already, so really only talking 10 days or so
  - Environmental benefit was hard for the Corps to see, but we went along
- Corps "If we do it, you need to tell us if it worked."
  - They did, and it turns out it worked…..

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Environmental Pool Management

- Adaptively managing pools within the St. Louis District since 1994!
- Optimize water levels to maximize environmental benefits

1994 Annual Spring Coordination Meeting

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Environmental Pool Management

- Since 1994 we have been able to achieve yearly environmental benefits
- There have been a few years when the process was abbreviated due to channel conditions (2008, 2010, 2013)
- 2014 River Resources Action Team (RRAT) TNC and USACE met after a 2014 EPM results presentation

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Creation of Environmental Pool Management PDT

- Feb 2015 - Initial face-to-face meeting with multiple stakeholders/agencies to discuss current operations and development of PDT.
  - Reviewed team members
  - Seasonal bi-weekly/weekly conference calls
  - Annual face-to-face meeting to review current year operations

"Can you do 90 days?"

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Environmental Pool Management Imperative

Continue to provide a safe and dependable navigation channel.

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Environmental Pool Management Goals

Utilize the following parameters as general guidelines:

- Begin EPM around April 1st
  - Before the majority of fish spawn begins
  - Reduces likelihood of fish being stranded.
- Continue EPM from May 1st for at least 90 days or until hydrologic conditions require routine dam operations
  - the period most suitable for vegetative growth and seed production.
- At the end of EPM, allow the pool to rise at a rate <0.3 foot per day or a rate recommended by the EPM Coordination Team
  - Slow rise allows vegetation to survive and continue to grow

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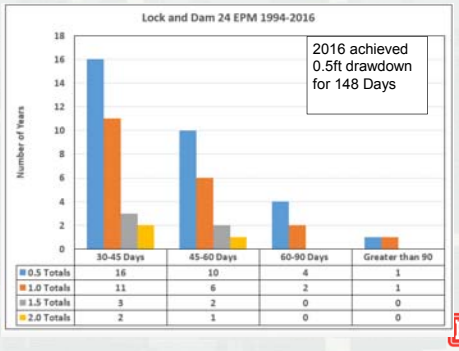
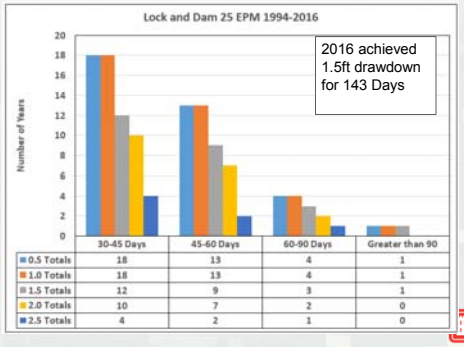
Environmental Pool Management Requirement

Close coordination with resource managers in the field

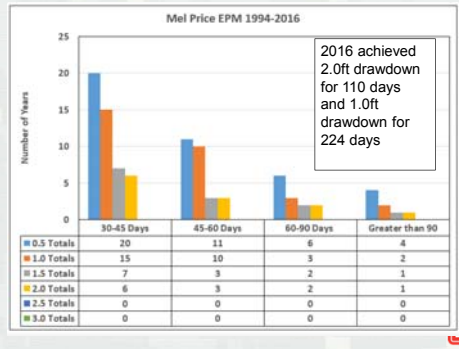
- Environmental conditions will vary from year to year
  - Time of year, temp, and precipitation all have an effect
- Field managers provide valuable insight into actual conditions
- Provide significant suggestions relative to needed adjustments.



	30-45 Days	45-60 Days	60-90 Days	Greater than 90
0.5 Totals	16	10	4	1
1.0 Totals	11	6	2	1
1.5 Totals	3	2	0	0
2.0 Totals	2	1	0	0



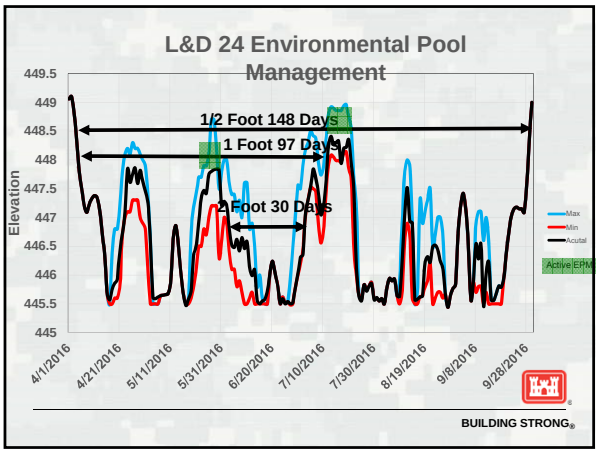
	30-45 Days	45-60 Days	60-90 Days	Greater than 90
0.5 Totals	18	13	4	1
1.0 Totals	18	13	4	1
1.5 Totals	12	9	3	1
2.0 Totals	10	7	2	0
2.5 Totals	4	2	1	0



	30-45 Days	45-60 Days	60-90 Days	Greater than 90
0.5 Totals	20	11	6	4
1.0 Totals	15	10	3	2
1.5 Totals	7	3	2	1
2.0 Totals	6	3	2	1
2.5 Totals	0	0	0	0
3.0 Totals	0	0	0	0

Environmental Pool Management 2016 Operations

Lock & Dam 24



Lock & Dam 25

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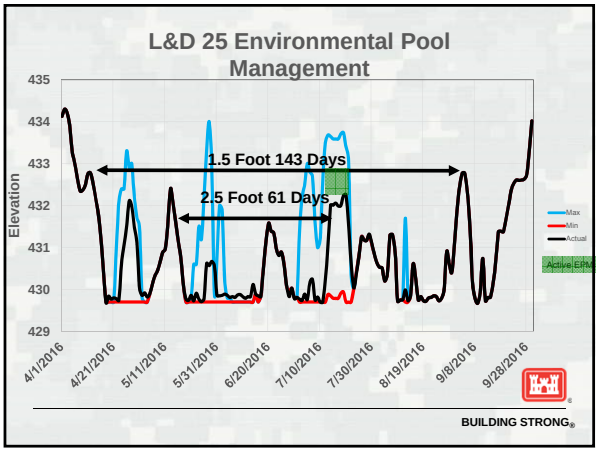

Mel Price Lock & Dam

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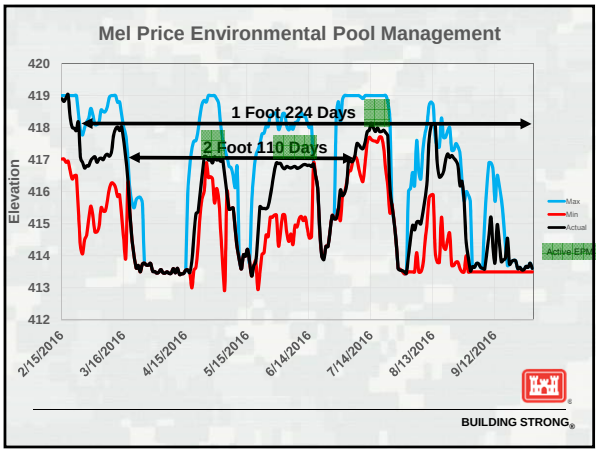

Biological Response to EPM

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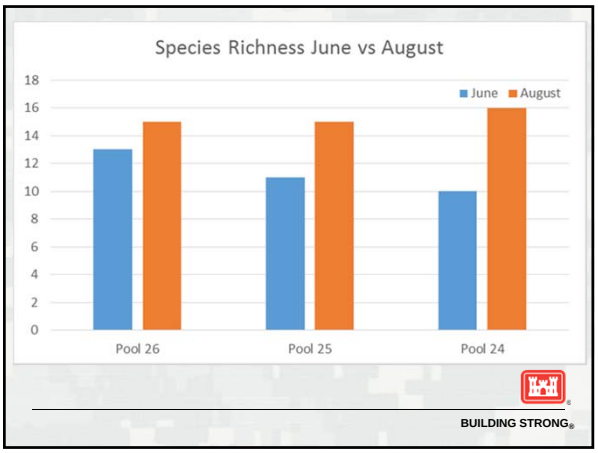
August 26 – Pool 24, Gosline Island


Species Richness June vs August
18
16
14
12
10
8
6
4
2
0
June
August
Pool 26
Pool 25
Pool 24
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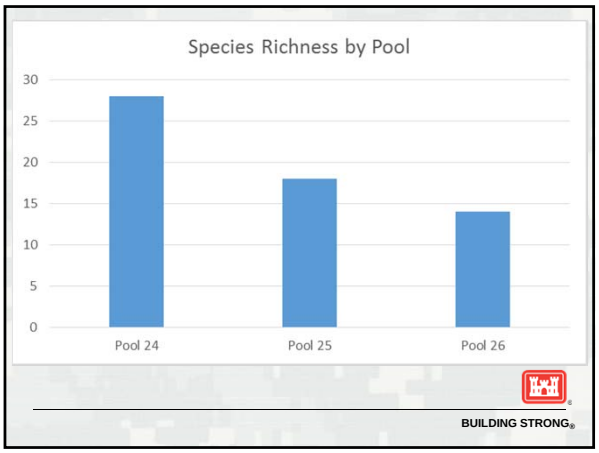
June 8 – Pool 24, Middleton Island L&D HW 446.65


June 8 – Pool 24, Middleton Island L&D HW 446.65


June 8 – Pool 24, Middleton Island L&D HW 446.65


June 8 – Pool 24, Middleton Island L&D HW 446.65


Species Richness by Pool
30
25
20
15
10
5
0
Pool 24
Pool 25
Pool 26
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? ? ? Questions ? ? ?

Rock Island District – Water Control

Kevin Landwehr, P.E., D.WRE
Chief, Hydrology and Hydraulics Branch
Rock Island District, USACE

US Army Corps of Engineers
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Rock Island District Water Management

- 78,000 sq. mi. Drainage Area
- 20 Navigation Locks and Dams
- 3 Multi-Purpose Flood Control Reservoirs
- Centralized 24/7 System Operation
- Daily coordination with the USGS and NWS

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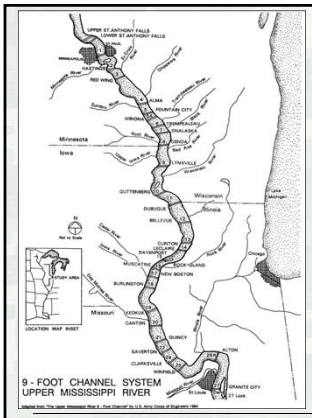

Mississippi River

- Rock Island District operates and maintains 314 miles of the Upper Mississippi River: Dam 10 tailwater to Dam 22 tailwater.
- MVR Water Control regulates Dams 11-14, 16-18, and 20-22.
- Dam 15 normally operated by L&D personnel. (Dam 14 instructions and pool limits are emailed)
- Dam 19 Hydroelectric Plant in Keokuk, IA is operated by Ameren UE. (Dam 18 three day forecast is called in daily)
- The Dams are regulated as a system.
- Each L&D is provided with daily operation instructions.
- Daily flow forecasts are provided to the NCRFC, MVS, MVP, MVD, and other MVR internal stakeholders.

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Mississippi River Pool Regulation

- Types of Pool Regulation
  - ► Dam Point Control – The pool is regulated based on a target pool stage located at the dam itself.
    - Dams 11 – 15, 17 – 19, and 21 - 22
  - ► Primary-Secondary-Tertiary Control – pool is regulated based on control stages at multiple points along the length of the pool.
    - Dams 16 and 20

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Mississippi River Pool Regulation

- Why differences?
  - ► 1930s pool operation studies
  - ► In MVR, all were originally P-S-T, however, MVR petitioned for authority to acquire additional real estate interests to allow for dam point control.
    - Higher Cost vs. ease of operation
    - Pools 16 and 20 remained P-S-T for site specific reasons
      - ▷ Pool 16 – perceived impacts to infrastructure???, land required???
      - ▷ Pool 20 – power generation at Dam 19

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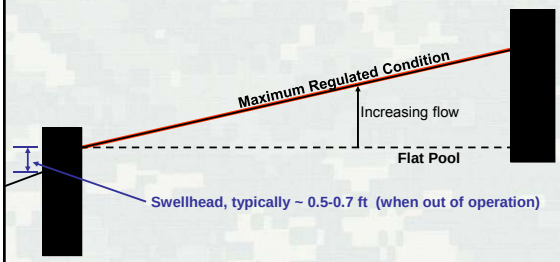
Pool Regulation – Dam Point Control



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Mississippi River Pool Regulation

Dam Point Control – Operating Limits

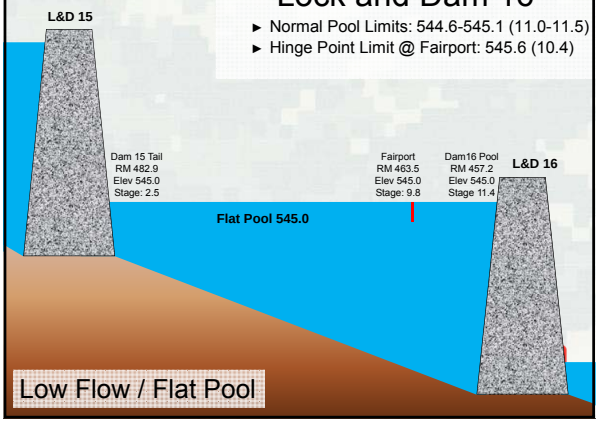
- To smooth out the system we will occasionally deviate from these limits but will avoid running water over spillways. Dams 12, 13, 17, 18, 21 & 22 have non-overflow spillways that are 0.2 - 0.5 above flat pool.
- Winter (non-navigation) operating limits expand to one foot, however at request from USFWS, the pools are regulated as if navigation continues year round.

Primary-Secondary-Tertiary Control

- Utilizes multiple control points
- Active control point at any time is a function of river stage/flow

Lock and Dam 16

- Normal Pool Limits: 544.6-545.1 (11.0-11.5)
- Hinge Point Limit @ Fairport: 545.6 (10.4)



Lock and Dam 16

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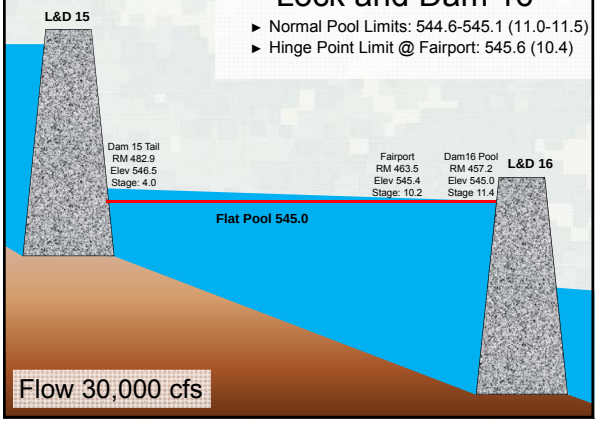

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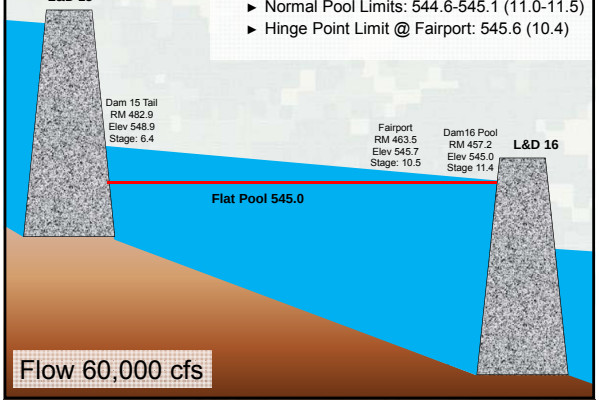

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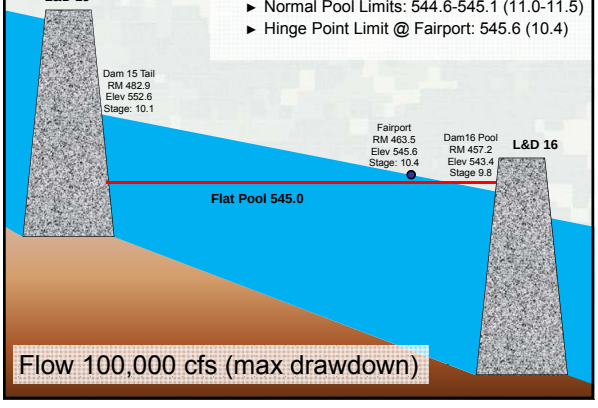
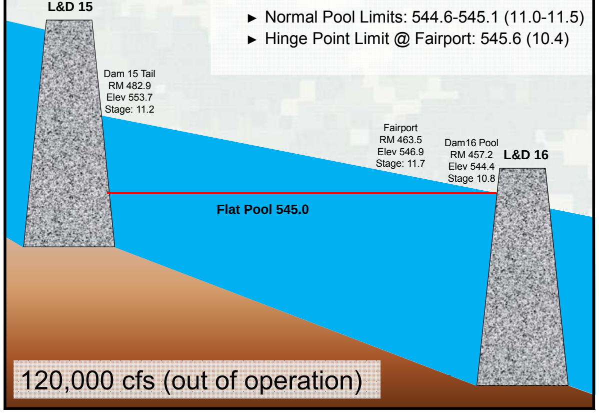


Lock and Dam 16



Lock and Dam 20

- Utilizes 3 control points depending upon flow conditions.
  - ► Low flows – maintain minimum stage of 2.6 feet at LD19 tailwater, until
  - ► Gregory Landing stage falls to 6.3 feet, then maintain this stage, at a minimum, until
  - ► Maximum drawdown at Lock and Dam 20 occurs (7.0 feet), maintain this as minimum pool stage until open river conditions exist.

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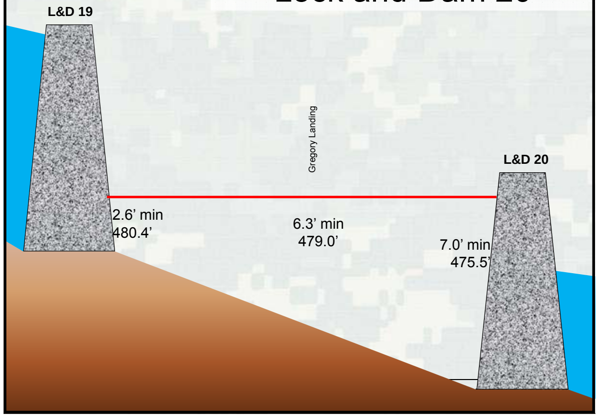
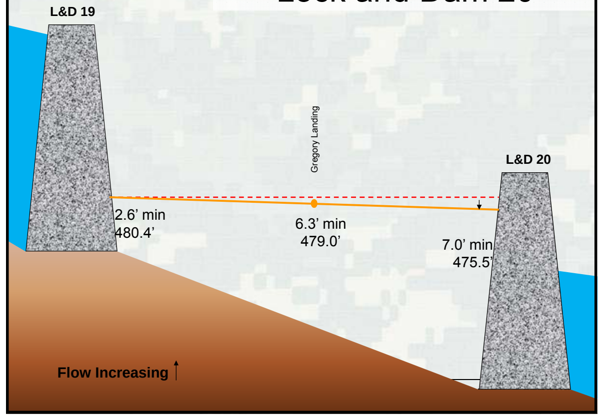
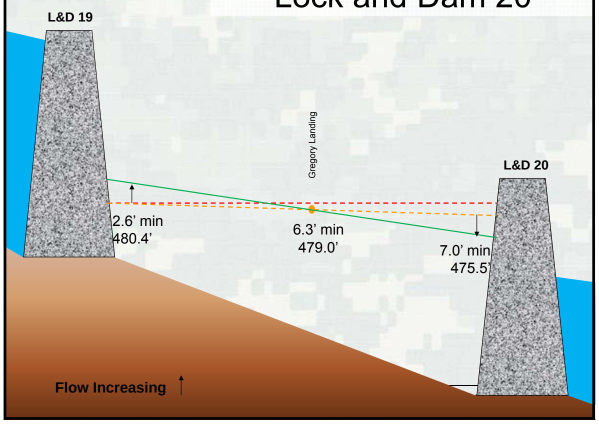
Lock and Dam 20



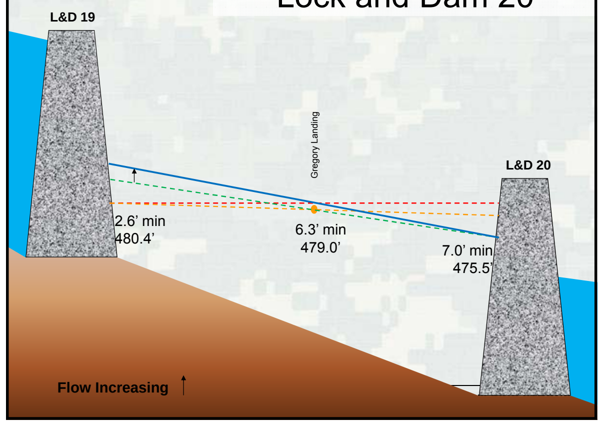
Lock and Dam 20



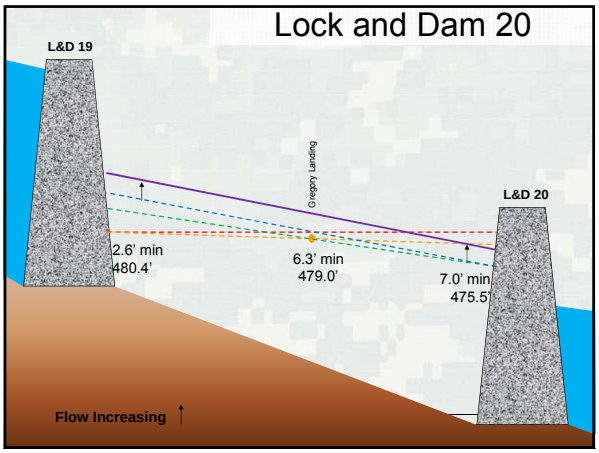
Lock and Dam 20



Lock and Dam 20



Lock and Dam 20



Nuances

- LD 14 and 15 drawdown as go to open river
- Ice Effects
- Positive vs. negative gate settings
  - Not all sites have submersible gates
- Hydropower
  - LD15
  - LD19

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Dam 15 Hydropower

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Mississippi River – Forecasting Challenges – Dam 19

Mississippi River – Forecasting Challenges – Dam 19

- Run-of-the-river structure, 38 feet of head (2nd highest on the Upper Mississippi).
- 15 turbines and 119 crest gates.
- When inflow is at or above 62,000 cfs, water is passed through the turbines with crest gates being opened as necessary to maintain authorized pool.

- At inflows below 62,000 cfs, pool and tailwater fluctuate diurnally (cycling) as turbine units are brought on and off-line to achieve most economical operation of the power plant.
- During cycling, outflows can vary as much as 40,000 cfs.
- Dam 20 is authorized to operate within a sliding band of pool limits to dampen the effects of the fluctuations induced by the hydropower generation and provide sufficient depth below Dam 19.

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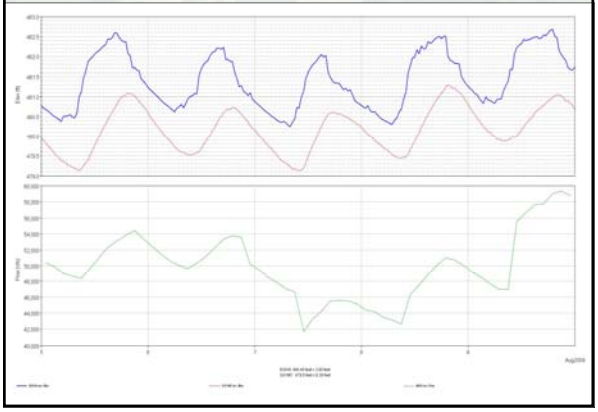
Mississippi River – Forecasting Challenges – Dam 19



Mississippi River – Forecasting Challenges – Dam 19

- USACE has oversight authority related to maintenance of the navigation channel.
- Unscheduled gate operations performed by Ameren without knowledge of the duty forecaster.
- A recent development is unexpected transmission or generation outages and heavy wind power production causing power grid congestion. This can cause negative pricing and unscheduled flow changes. During these scenarios Ameren will avoid operating the crest gates during inclement weather due to personnel safety concerns.
- Pools 20-22 have very little storage area, as a result travel times are extremely short (six hours from Dam 19 to Dam 22).

Regulation Changes Over Time

Navigation Season – No major changes

Non-Navigation Season

- Historical changes to limits
  - World War II – complete drawdowns of pools (as high as LD 2) to maintain minimum desired depth at St. Louis.
  - Post World War II – mid 1950s – drawdowns of pool 16-18 as need to maintain depth at St. Louis; above LD15, drawdowns limited by law***.
  - Mid 1950s-late 1960s – limited drawdown of pools 16-18 to 3-4 feet.
  - 1970-1987 – limited drawdown to 1 foot at all dams.
  - Since 1988 – operated during winter as if navigation continued year-round.

***"Anti-Drawdown Law." Dated March 10, 1934, and as amended by Public Law 732 on August 14, 1946, and again by Public Law 697 on June 19, 1948.

The law directs that the Corps shall generally operate and maintain pool levels as though navigation were carried on throughout the year.

Daily Operations

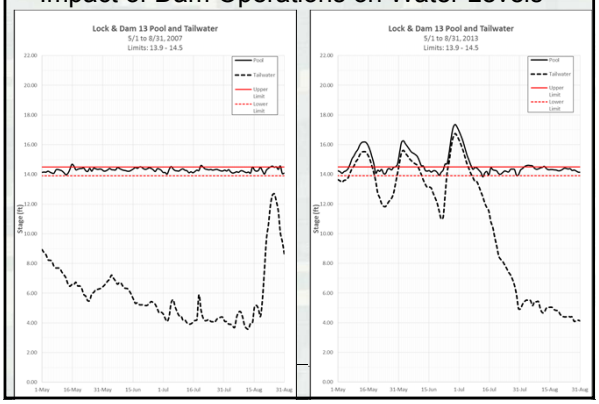
- Daily gate instructions are sent to each project, typically one setting per day but more if needed. Some restrictions in winter/holidays on timing.
- Specifies gate openings to be set at the dam – Total feet of Tainter and roller gate openings.
- Specifies pool limits.

- If operating band limits are exceeded, the project contacts the forecaster on duty for new gate setting.

Project Regulation - Mississippi River

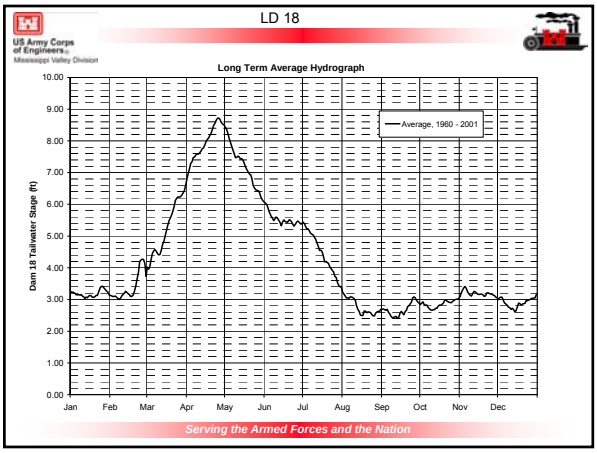
- **Gate changes are a function of:**
  - **Rising or falling pool**
  - **Location in operating band**
  - **Upstream changes in flow**
  - **Local tributary flow changes**
  - **Wind**
  - **Ice**

Impact of Dam Operations on Water Levels

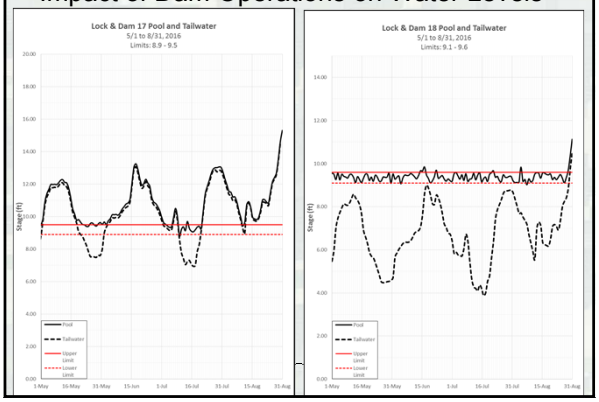


LD 18

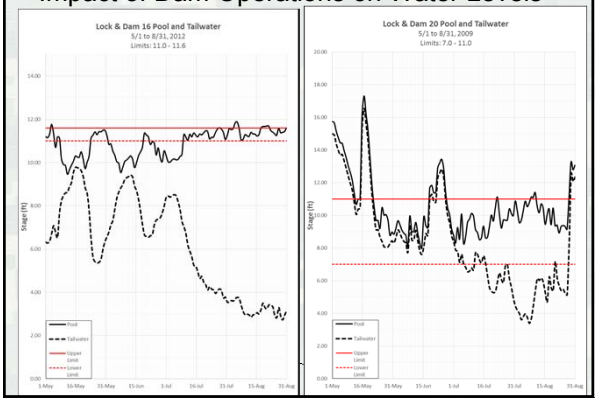
US Army Corps of Engineers
Mississippi Valley Division



Impact of Dam Operations on Water Levels



Impact of Dam Operations on Water Levels



Previous Drawdowns in MVR

- ►Lock and Dam 13 (1998)
- ►NESP Water Level Management Opportunities Report
- ►Lock and Dam 18 Planning under NESP

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1998 Pool 13 Drawdown

- Goal was to conduct a 1 foot drawdown to elevation 582.0, occurring between June 15 and August 15
- The drawdown would be a drawdown of opportunity occurring any time during the period that the flow is within and forecast to remain within the specified flow constraints (50,000 to 110,000 cfs).

Based on the available hydrologic record it appeared that a drawdown of 30 days or more could be accomplished, on average, once every 3 years.

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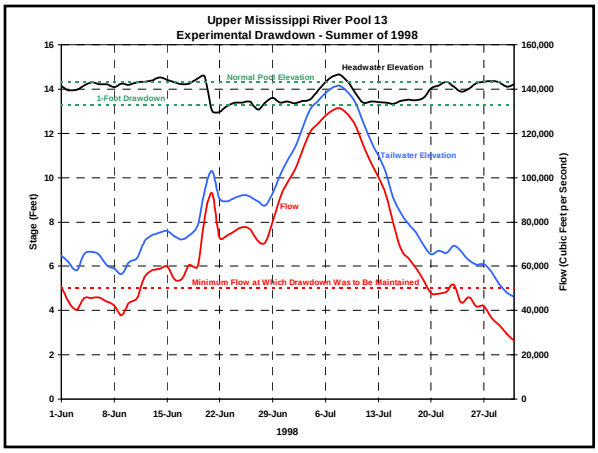

NESP Water Level Management Report (Environmental Report 53)

- Each District prioritized actions – Appendices B-D
- MVR prioritization of pool-wide drawdowns based on screening of pools considering benefits potential and conflicts/impacts.
  - Most suitable – Pools 11 and 13
  - Second tier – Pools 16 and 18

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Mississippi Valley Division

Navigation and Ecosystem Sustainability Program (NESP)

Pool 18 Water Level Management – Seasonal Drawdown

• Buffalo Slough, Pool 18

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Mississippi Valley Division

Where we've been:

2005
- **Aquatic Veg Survey**
- **Data Collection**
- **Existing Conditions**
- **Public Scoping Meetings**

2006
- **Alternative Formulation and Analysis**
- **Coordination on Recreational Access**
- **Shallow-Water Mussel Recon**

2007
- **Coordination of Shallow-Water Mussel Recon**
- **Coordination of potential thalweg disposal sites**
- **Mussel survey for population estimate and site-specific impacts**

2008
- **Coordination of potential mussel impacts**
- **Shallow-Water Mussel Survey**

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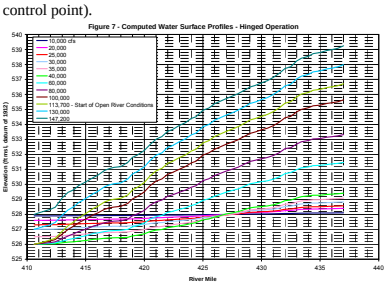
2-Foot Hinged Alternative

2-Foot drawdown at the dam, with secondary control point at Keithsburg of 528.0 ft
- Allows for full drawdown of 2 feet at the dam (primary control point) if flow is greater than ~ 40,000 cfs. Below 40,000 cfs, maintain elevation at Keithsburg of 528.0 (secondary control point).



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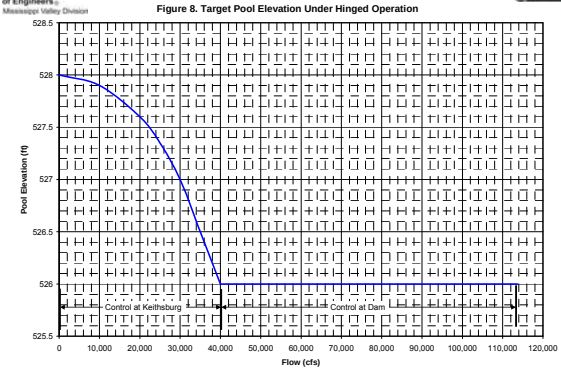

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Lower Pool 18 Existing Bathymetry

•Vegetation response during 2005 low water, Credit Island, Pool 16

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Benefits of "Hinged" Drawdown

- Provides majority of benefits of "full" drawdown
- Reduced recreational impacts
- Reduced dredging requirements (cost)

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Mississippi Valley Division

Where we've been:

2005
- **Aquatic Veg Survey**
- **Data Collection**
- **Existing Conditions**
- **Public Scoping Meetings**

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Mississippi Valley Division

Questions?

Buffalo Slough
August 16, 2005

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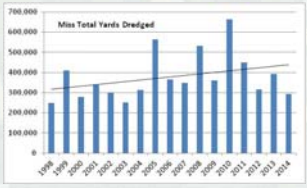
MVR- Mississippi River Dredging



Dredging Volume over Time (Pools 11-24)

Downward Trend Over Last 50 Years

Upward Trend Since 1998

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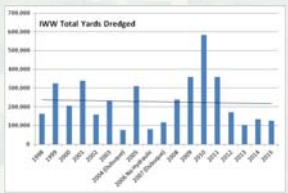
MVR – Illinois Waterway Dredging



Dredging Volume over Time

Slight Downward Trend Since 1998

Slight Upward trend Over Last 50 Years

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Number of Vessel Groundings – Miss.

Rock Island District

5-yr Reported Groundings by Pool -Mississippi River

Pool	2012	2013	2014	2015	2016	5-yr Total
11		1	1		2	4
12				1		1
13	2			1	1	4
14		1				1
15			1			1
16	9	1				10
17						0
18	2					2
19	1					1
20		2		1		3
21	1			2		3
22		1		1		2
Total by Year	15	6	2	6	3	32

*Critical and Non-Critical Groundings reported directly to Channel Maintence Section

CRITICAL - When a vessel is aground or was aground and the channel is restricted so that other vessels cannot safely pass. This does not include groundings where the tow gets under way again in a relatively short time period and traffic resumes without further incident.

NON-CRITICAL - When a vessel was aground or is aground but the channel is not restricted and other vessels can safely pass. This category includes a temporary restriction caused by the vessel maneuvering to free itself.

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Number of Vessel Groundings – IWW

Rock Island District

5-yr Reported Groundings by Pool - Illinois Waterway

Pool	2012	2013	2014	2015	2016	5-yr Total
LaGrange	2					2
Peoria						0
Starved Rock	2	2				4
Marseilles						0
Dresden						0
Brandon						0
Lockport						0
Total By Year	4	2	0	0	0	6

*Critical and Non-Critical Groundings reported directly to Channel Maintence Section

CRITICAL - When a vessel is aground or was aground and the channel is restricted so that other vessels cannot safely pass. This does not include groundings where the tow gets under way again in a relatively short time period and traffic resumes without further incident.

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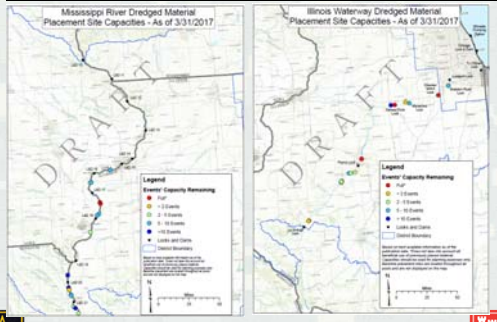
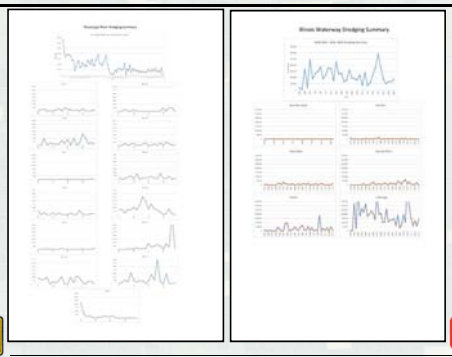
MVR - Available Dredging Placement



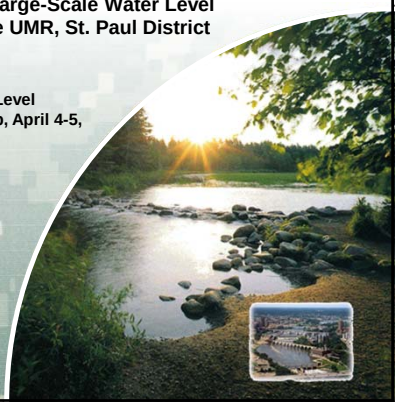
Dredging Volumes by Pool



Questions?

Nuts and Bolts of Large-Scale Water Level Management on the UMR, St. Paul District

For the UMRBA Water Level Management Workshop, April 4-5, Dubuque IA



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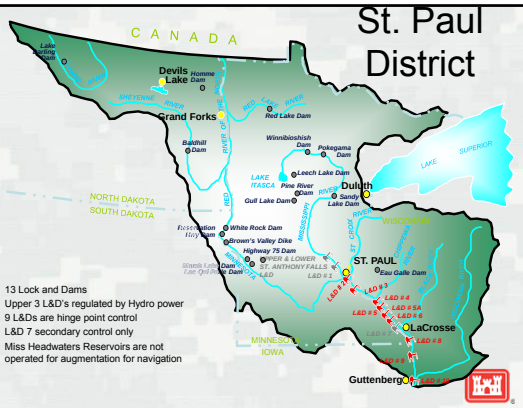
St. Paul District



- 13 Lock and Dams
- Upper 3 L&D's regulated by Hydro power
- 9 L&Ds are hinge point control
- L&D 7 secondary control only
- Miss Headwaters Reservoirs are not operated for augmentation for navigation

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Stakeholders

- Wisconsin DNR
- Minnesota DNR and PCA
- Iowa DNR
- U.S. Fish and Wildlife Service
- National Park Service
- U.S. Geological Survey
- TNC, Audubon, other NGO's
- General Public

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General Dam Operation

- General Control-Point operation explanation
- Operating Limits according to their Water Control Plans
- Have these changed over time and if so, how and why?

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Lock and Dam		Proj. Pool Elev.		Original Drawdown		Interim Changes with Year Approved				Present Drawdown
2		687.2		3.2				2		0.7
				(1938)				(1960)		(1970)
3		675		2						1
				(1939)						(1971)
4		667.0		4.0		2.5		1.5		0.5
				(1941)		(1943)		(1960)		(1971)
5		660.0		2.5				1.5		0.5
				(1936)				(1960)		(1970)
5A		651.0		2.5						1.0
				(1936)						(1959)
6		645.5		2.5						1.0
				(1935)						(1959)
7		639.0								
				none						none
8		631.0		3.5		2.0		1.5		1.0
				(1936)		(1941)		(1963)		(1971)
9		620.0		2.5						1.0
				(1937)						(1971)
10		611.0		2.0						1.0
				(1936)						(1971)

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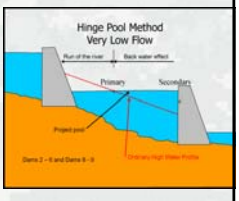
Lock & Dam Regulation

- Three Types of Regulation
  - ► Hinge Point
    - Dams 2 – 6 and Dams 8 – 9
    - Primary control (mid pool)
    - Secondary control at the Dam
    - Less flowage easements
  - ► Control at the Dam
    - Lock and Dam 7 Only
    - Secondary Only (Primary control point would be in the structure of Lock 6)
  - ► Primary @ Dam – Secondary mid pool – Tertiary @ Dam
    - Lock and Dam 10 Only (Designed by MVR)



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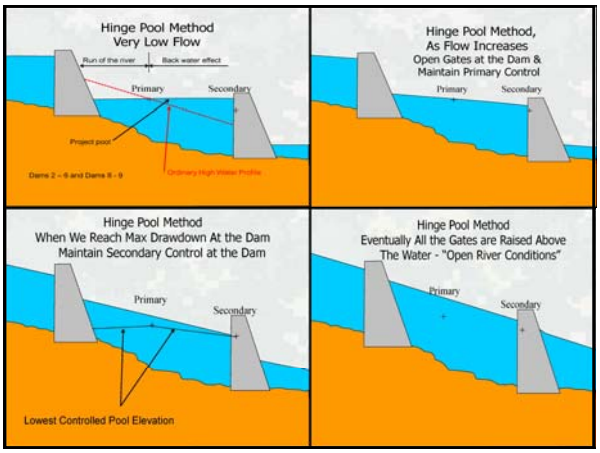

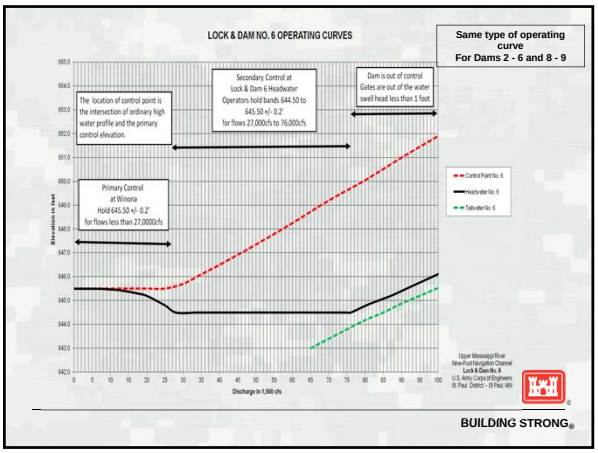

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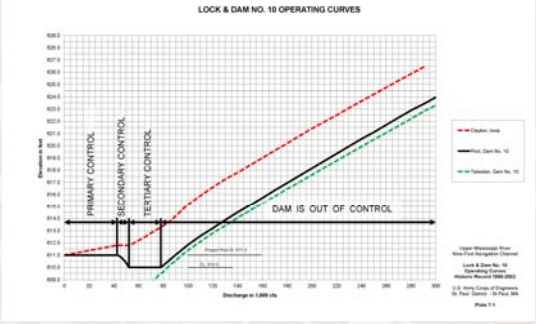

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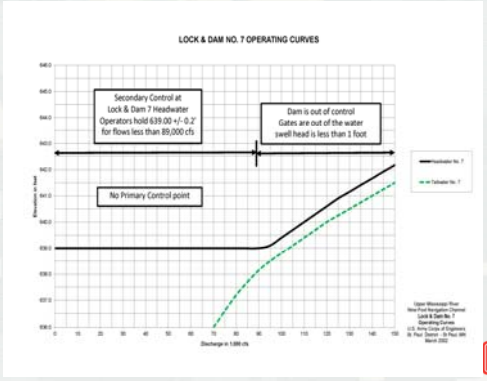

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	Primary Control	Secondary Control	Gates Out	Primary Control name	River Mile of Primary Control
Lock & Dam 2	flow < 13,000 hold elevation = 687.20 @ SSPM5	flow 13,000 to 61,000 hold elevation = 686.50 @ Dam 2	flow > 61,000	South St. Paul	833.7
Lock & Dam 3	flow < 15,000 hold elevation = 675.00 @ PREW3	flow 15,000 to 36,000 hold elevation = 674.00 @ Dam 3	flow > 36,000	Prescott	811.4
Lock & Dam 4	flow < 20,000 hold elevation = 667.00 @ WABM5	flow 20,000 to 89,000 hold elevation = 666.50 @ Dam 4	flow > 89,000	Wabasha	760.45
Lock & Dam 5	flow < 30,000 hold elevation = 660.00 @ AMAW3	flow 30,000 to 116,000 hold elevation = 659.50 @ Dam 5	flow > 116,000	Alma	749.2
Lock & Dam 5A	flow < 25,000 hold elevation = 651.00 @ L&D 5 tailwater	flow 25,000 to 57,000 hold elevation = 650.00 @ Dam 5A	flow > 57,000	L&D 5 tailwater	738.1
Lock & Dam 6	flow < 27,000 hold elevation = 645.50 @ WNAM5	flow 27,000 to 76,000 hold elevation = 644.50 @ Dam 6	flow > 76,000	Winona	725.5
Lock & Dam 7	flow < 89,000 hold elevation = 639.00 @ Dam 7		flow > 89,000		
Lock & Dam 8	flow < 24,000 hold elevation = 631.00 @ LACW3	flow 24,000 to 96,000 hold elevation = 630.00 @ Dam 8	flow > 96,000	La Crosse	696.9
Lock & Dam 9	flow < 33,000 hold elevation = 620.00 @ LNSI4	flow 33,000 to 64,000 hold elevation = 619.00 @ Dam 9	flow > 64,000	Lansing	663.0
Lock & Dam 10	flow < 42,000, hold elevation 611.00 @ Dam 10 flow 42,000 to 52,000, hold elevation 611.80 @ CLAI4 flow 52,000 to 73,000, hold elevation 610.00 @ Dam 10		flow > 73,000	Clayton	624.8

note #1 : Bands are +/- 0.2' during the navigation season, and +/- 0.3' during non navigation season
note # 2: Gates are usually pulled when the head is less than a foot at the dam, then the tailwater rating curve is used to calculate discharge.
note # 3 : Bands given in the orders are what the L&D Operators hold at the pool gage at the dam to maintain either primary or secondary control.
note # 4 : water surface elevations held at the L&D's are flow dependent and can range any where between the secondary elevation up to the primary elevation

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Travel times for Moderate flows

L & D's 2 to 3	8 -12 hours
L & D's 3 to 4	at least a day
L & D's 4 to 5	6-8 hours
L & D's 5 to 5A	4-6 hours
L & D's 5A to 6	4-6 hours
L & D's 6 to 7	6 – 8 hours
L & D's 7 to 8	12 hours
L & D's 8 to 9	16 -20 hours
L & D's 9 to 10	8 - 12 hours

Change in flow for 24 hours to change the pool 0.1 foot

Pool 2 - 1200cfs
Pool3 - 900cfs
Pool 4 – 2000cfs
Pool 5 – 600cfs
Pool 5A – 400cfs
Pool 6 – 300cfs
Pool 7 – 700cfs
Pool 8 – 1200cfs
Pool 9 – 1600cfs
Pool 10 – 1000cfs

L & D's and control points

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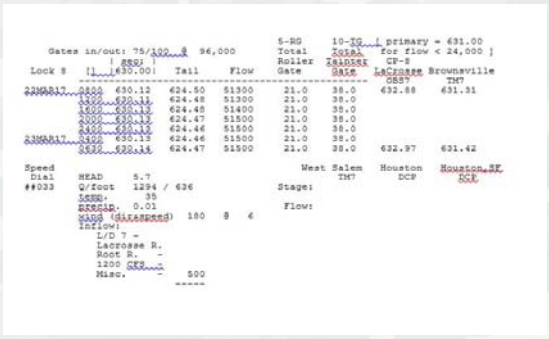
Daily Dam Operation

- How are gate instructions issued?
  - Water on the ground
  - Upstream Inflow
  - Gate balance
  - Conditions at the Dam (wind, maintenance)
- Gate change frequency
  - Usually once per day, at higher flows more regulation is needed

Daily Regulation Sheet



Gates in/out: 75/100 @ 96,000

Lock 8	[1	630.00]	Tail	Flow	S-RG Total Roller Gate	10-TG [primary = 631.00 Total 25TBA for flow < 24,000] Radial CF-8 Gate	LaCrosse OBS?	Brownsville TM?
23MAR17	0800	630.12	624.50	51300	21.0	38.0	632.88	631.31
	1000	630.11	624.48	51300	21.0	38.0		
	1200	630.13	624.48	51400	21.0	38.0		
	1400	630.13	624.47	51500	21.0	38.0		
	1600	630.13	624.46	51500	21.0	38.0		
24MAR17	0400	630.13	624.46	51500	21.0	38.0		
	0600	630.14	624.47	51500	21.0	38.0	632.97	631.42

Speed Dial ##033

HEAD 5.7
Q/foot 1294 / 636
35
Precip. 0.01
Q100 (discharged) 180 8 4
Inflow:
L/D 7 -
Lacrosse R. -
Root R. -
1200 CFS -
Misc. - 500

West Salem TM? | Houston DCP | Houston,SF DCP

Stage:
Flow:

CWMS

Sending the Orders

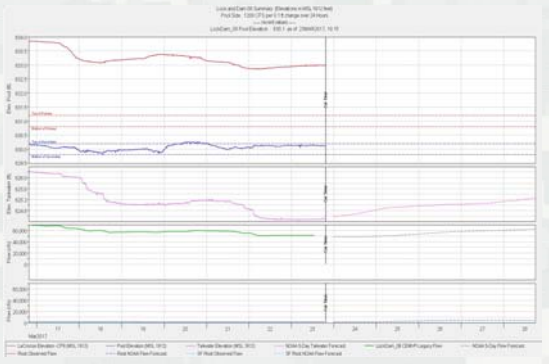
From: Daniel Fasching
To: Lock and Dam 6
Transmitted: March 23, 2017 at 07:18:08
Subject: Regulation orders for Lock and Dam 6

Current flow is 46500.
No change in flow at present.
Maintain pool band from 644.3 to 644.7.
Target elevation is 644.5, plus or minus 0.2 foot.
*** Later today when the pool falls to 44.5 cut 2' on RG
***

Regulation Frequency

- Orders routinely sent before 8 AM
- Afternoon orders are needed when
  - ▸Greater flows
  - ▸Significant rain events
  - ▸Minor adjustments can also be made
- Lock and Dam Operators can make a 20% change in flow without orders

Fluctuations occur and the Math isn't Perfect

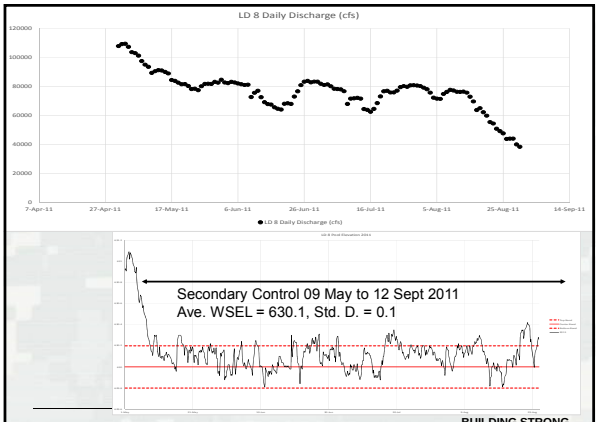


Daily Fluctuations

- Wind - can change the pool 0.1 ft per 10mph
- Power generation – WI River, LD 2
- Shift changes and staffing
- Math and human error

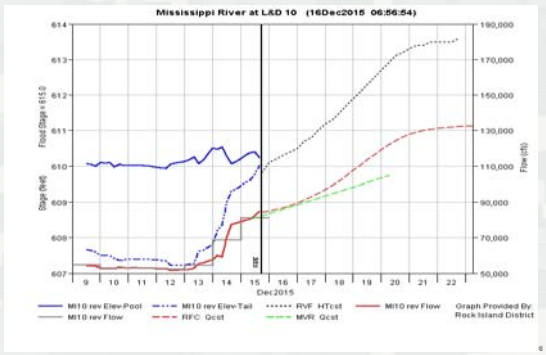
Dam Operation Effects on Water Levels

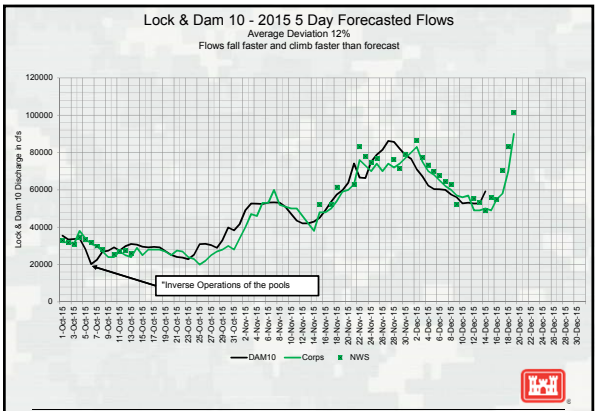
- Typical fluctuations and ranges during the growing season (not open river conditions)
- Graphics depicting 10 years of daily water levels May-August for select dams

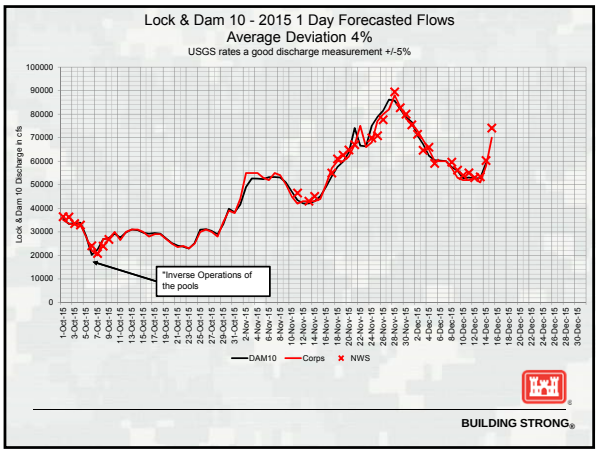


LD 8 Year	Ave WSEL During Growing Season when in Secondary Control	Std. D.
2006	630.09	0.1
2007	630.16	0.1
2008	630.14	0.2
2009	630.15	0.1
2010	630.15	0.2
2011	630.15	0.1
2012	630.07	0.1
2013	630.20	0.2
2014	630.06	0.1
2015	630.13	0.1
2016	630.13	0.1
	Primary 22%	Secondary 71%	Out of Control 7%

Lock & Dam forecast
http://155.76.213.69/docs/mvd2.html







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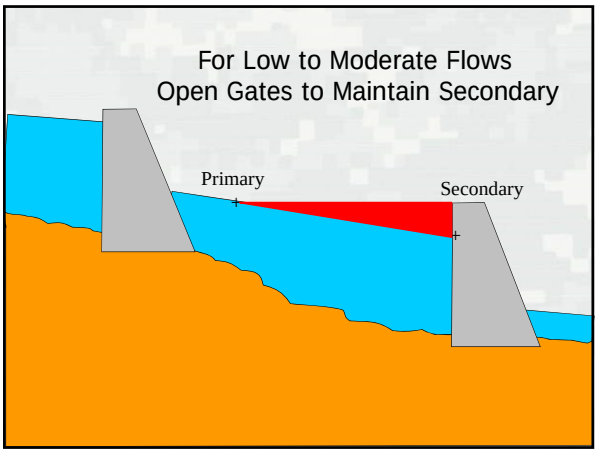

Channel Maintenance

- Dredging depths
  - St. Paul District dredges to 12' below LCP with the goal of maintaining a > 9' channel until the next navigation season.
  - Dredge material placement: All placement in the St. Paul District is upland except in Emergency situations – this increases cost and limits volume that can be accommodated from every dredge job.

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Channel Maintenance (Cont.)

Annual Dredging Per Pool 1985 - 2016

Pool	Cubic Yards
2	112,935
3	48,229
4	281,328
5	111,484
5A	47,288
6	25,791
7	52,463
8	75,706
9	55,852
10	24,190
Total	835,266

MN River, Pool 1, USAF, harbors not included

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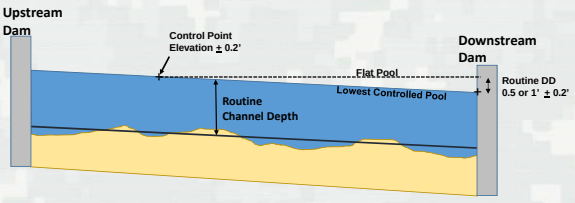
ROUTINE POOL MANAGEMENT, HINGE POOL



- Routine Dredging Conducted to lowest controlled pool elevation
- Low Pool level tolerance at MVP dams very small (± 0.2 ft)
- Low tolerance minimizes overall dredging needs, but doesn't support routine drawdowns

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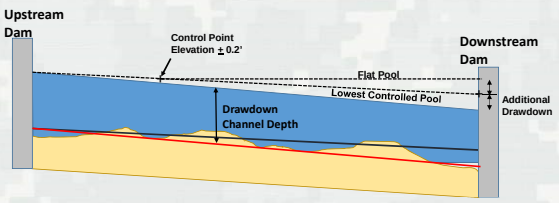
DRAWDOWNS, HINGE POOL



- DRAWDOWN COST = Additional dredging prior to drawdown to maintain adequate depth for navigation
- This deeper dredging can result in reduced dredging needs for several years.
- The sediment trap efficiency is increased, which has resulted in overall increased dredging associated with drawdowns.

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Channel Performance

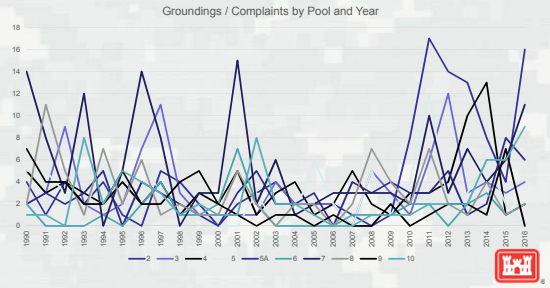
- Number of groundings/complaints per year per pool

Groundings/Complaints Pools 2 - 10

Pool	2	3	4	5	5A	6	7	8	9	10	Total Per Yr
1990	4	2	5	5	2	2	14	2	7	1	44
1991	1	3	3	5	3	0	8	11	4	1	39
1992	4	9	4	3	2	0	3	5	4	0	34
1993	2	2	3	1	3	0	12	1	2	8	34
1994	4	1	2	6	5	1	0	7	2	2	30
1995	1	2	4	2	0	0	5	2	5	5	26
1996	0	7	2	6	4	2	14	6	2	4	47
1997	5	11	4	3	3	4	8	1	2	3	44
1998	4	3	1	1	2	1	0	2	4	1	19
1999	2	1	3	1	1	1	3	1	5	2	20
2000	0	1	2	0	0	2	3	1	2	1	12
2001	2	1	5	0	3	7	15	5	1	1	40
2002	3	1	1	3	5	2	2	2	0	8	27
2003	4	4	3	0	2	0	6	0	1	2	22
2004	2	2	4	1	2	0	1	2	1	2	17
2005	2	2	1	6	3	0	2	2	0	1	19
2006	2	2	2	2	0	0	3	0	1	0	12
2007	1	0	5	0	4	1	3	2	0	0	16
2008	0	5	2	5	3	1	3	7	0	1	27
2009	1	3	1	1	4	1	3	4	2	1	21
2010	8	1	3	4	3	2	2	2	0	1	26
2011	17	6	3	12	3	2	10	7	1	2	63
2012	14	12	4	2	5	0	3	2	2	2	46
2013	13	3	10	3	1	2	7	1	2	2	44
2014	8	4	13	6	2	3	4	4	1	6	51
2015	4	3	1	2	0	1	6	1	7	6	30
2016	16	4	2	0	6	2	11	2	0	9	52
Totals	124	95	93	80	79	37	151	82	58	72	871
Avg. Yr	4.6	3.5	3.4	3.0	2.9	1.4	5.6	3.0	2.1	2.7	

Channel Performance

- Number of groundings/complaints per year per pool



Drawdowns – Defining Success

- Time frame
- Duration
- Depth of exposed acres

Early documents (1990s) – "The probability of having optimum drawdown conditions was defined as the probability for river discharge to allow a drawdown to the target depth (1.5') during the June through September growing season, with no more than two re-flooding events of less than one week duration."

Recent Discussions (2016 – 2017) – Opportunistic shorter duration smaller drawdowns could have ecological benefits.

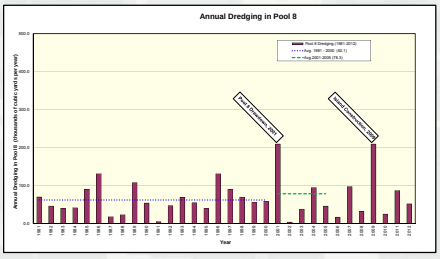
Past Drawdown Examples

	Pool 8	Pool 5
Years	2001-2002	2005-2006
Drawdown Initiated	June 16, 2001 June 15, 2002	June 13, 2005 June 12, 2006
Maximum DD Duration	1.5' (06 July – 14 Aug 2001) 1.5' (03 July – 16 Sep 2002)	1.5' (29 Jun – 31 Jul 2005) 1.5' (26 Jun – 29 Jun 2006)
Acres Exposed	1950 (Both years)	1000 (in 2005)

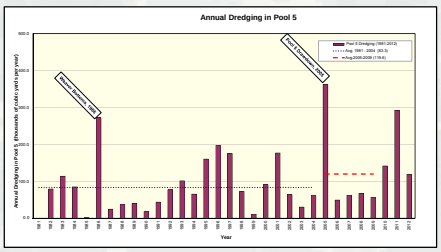
Past Drawdown Examples

	Pool 8	Pool 5
Years	2001-2002	2005-2006
Vegetation Response	Shift from annuals to perennials from 1st to 2nd year. Increase in emergent and submersed veg. But…veg has been increasing in other pools.	
Fish	No measurable effect? Potential for stranding and adverse effects to spawning areas. Positive impacts from increased vegetation.	
Mussels		At least 28% of mussels died in shallow water areas in Pool 5. The mussel population in Pool 5 was estimated at 189 million

Past Drawdown Examples



- 209,000 cubic yards dredged in 2001
- Reduced dredging for several years after this
- 26% increase in dredging for the 5 year time period 2001 – 2005 compared to the 1981 to 2000 time period



- 362,000 cubic yards dredged in 2005
- Reduced dredging for several years after this
- 44% increase in dredging for the 5 year time period 2005 – 2009 compared to the 1981 to 2004 time period
- Note – Additional dredging was done for island construction in 2005

	Pool 8	Pool 5
Pre-Drawdown Dredging (yd3/year)	62,000	83,000
5-year Drawdown Dredging Average (yd3/year)	78,000 (+26-percent)	120,000 (+44-percent)
Reference Reach Dredging Ratio	0.93	0.80
Average Annual Discharge Ratio	1.0	0.77

Future Drawdowns

- Constraints – Additional dredging costs, recreational boating
- Opportunistic DD factors:
  - Deferred (marginal) dredging reaches
  - High tailwater at some dams
  - Short-term changes in channel conditions (ie. what condition is first cut in, when final cut is finished)
  - Risk of groundings

Questions?

Water Level Management Workshop

Joan Stemler

April 2017

Overview

- St. Louis District Overview/Background
- Lock & Dam Operations
- Dredging Operations
- Environmental Pool Management
- Questions

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St. Louis District

District Overview

- 5 Flood Control Reservoirs Projects
  - ►Lake Shelbyville, Carlyle Lake, Rend Lake, Mark Twain Lake, and Wappapello Lake
- 5 Lock and Dam Projects
  - ►L&D 24, L&D 25, Mel Price L&D, L&D 27, and Kaskaskia L&D
- 9 Watersheds draining into the Mississippi River within the St. Louis District
  - ►Salt, Cuivre, Lower Missouri, Meramec, Upper St. Francis, Castor, Lower Illinois, Kaskaskia, and Big Muddy Rivers

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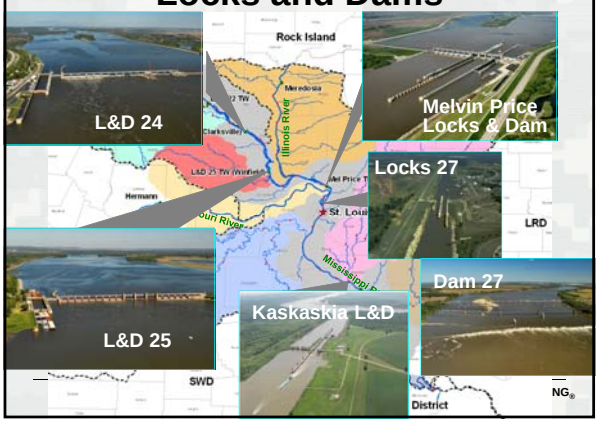
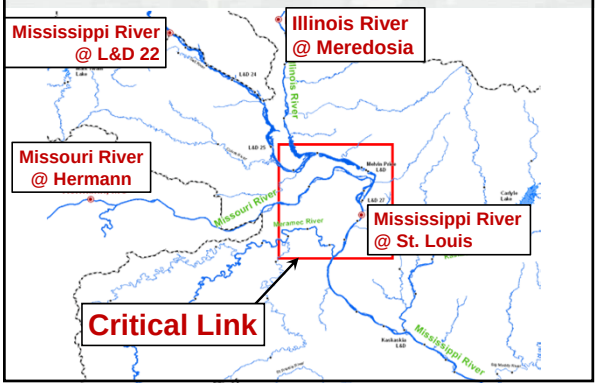
Locks and Dams



Critical Link



HISTORY OF THE ST. LOUIS GAGE

- Lowest recorded stage = -6.2 feet (1940)
- Highest recorded stage = 49.6 feet (1993)
  Over a 55 foot range
- Average stage (11.3 feet)
- 2012-2013
  Low ~ -4.6 (JAN 2013)
  High ~ 40.5 (JUN 2013)
- Range in flows
  -3.2' (LWRP) approx. 6,300/foot
  30.0' (Flood) approx. 22,000/foot

Coordination

- **USACE**
  - ►Mississippi Valley Division
    - St. Paul District
    - Rock Island District
    - Memphis District
  - ►Northwestern Division
  - ►Lakes and River Division
- **NWS River Forecast Centers**
  - ►North Central RFC (handoff at Chester, IL)
  - ►Missouri Basin RFC (handoff at Hermann, MO)
  - ►Lower Mississippi RFC (starting at Cape Girardeau, MO)

Coordination

- **USGS**
  - ►Illinois
  - ►Missouri
- **Coast Guard**
  - ►Sector Upper Mississippi River
    - Upper Mississippi down to UMR mile 109.9 (Chester, IL)
  - ►Sector Lower Mississippi River
    - Lower Mississippi starting at UMR mile 109.9 (Chester, IL)
- **River Industry Action Committee (RIAC)**

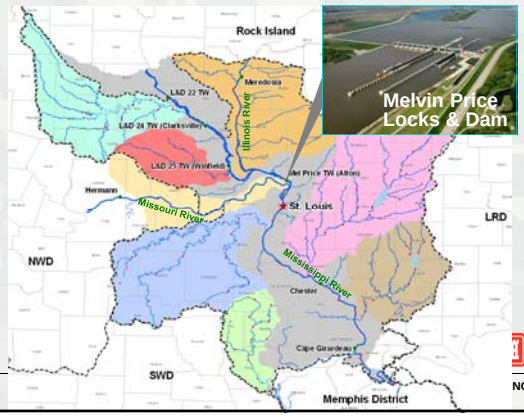
Hinge Point Operation

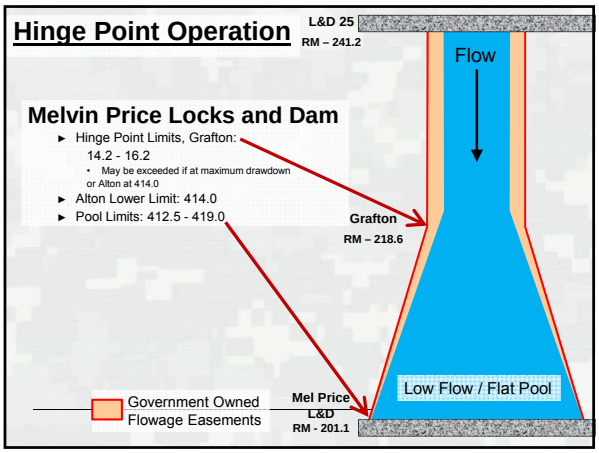
- Difficult!! Operate by using two control points. One at dam and one mid-point in pool
- Range limits change with flow ranges
- Change in flows can require over a 5 ft pool change in a 24-hour timeframe
- Pool elevation instructions are issued to lock personnel (minimum daily) and gate changes are made as necessary
- Daily instructions +/- tenth

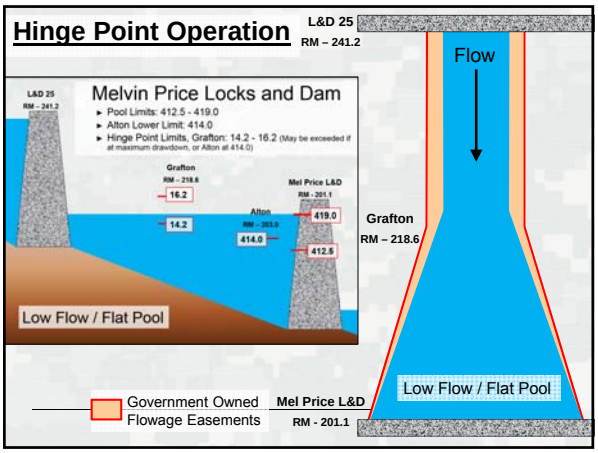
Hinge Point Operation

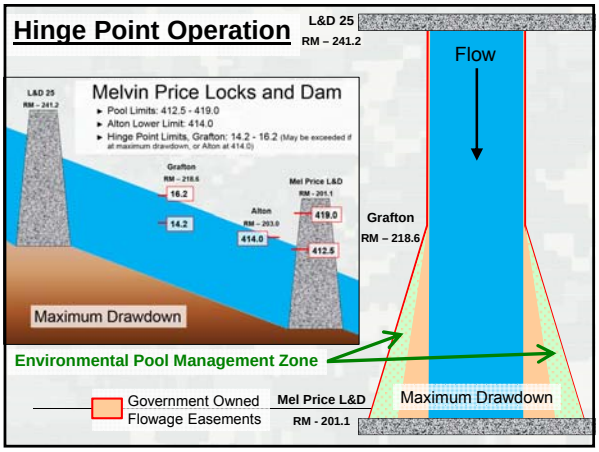
- Lock and Dam 24
  - ► Pool Limits: 445.5 - 449.0
  - ► Hinge Point Limits, Louisiana: 11.5 - 12.2 (May be exceeded if at maximum drawdown)
- Lock and Dam 25
  - ► Pool Limits: 429.7 - 434.0
  - ► Hinge Point Limits, Mosier Landing: 434.0 - 437.0 (May be exceeded if at maximum drawdown)
- Melvin Price Locks and Dam
  - ► Pool Limits: 412.5 - 419.0 Alton Lower Limit: 414.0
  - ► Hinge Point Limits, Grafton: 14.2 - 16.2 (May be exceeded if at maximum drawdown, or Alton at 414.0)
- Kaskaskia Lock and Dam
  - ► Pool Limits: 363.0 - 368.8
  - ► Hinge Point, Red Bud: 368.0 - 370.0

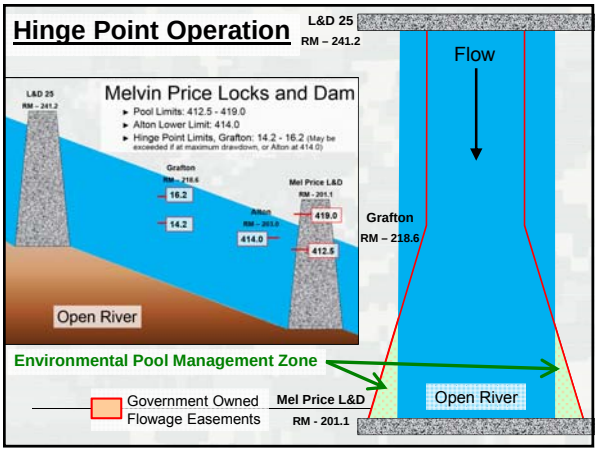
Locks and Dams

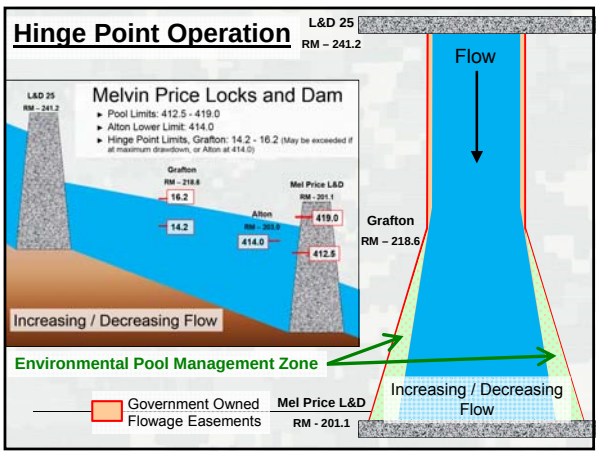












Visualizing L&D Hinge Point Operating Limits

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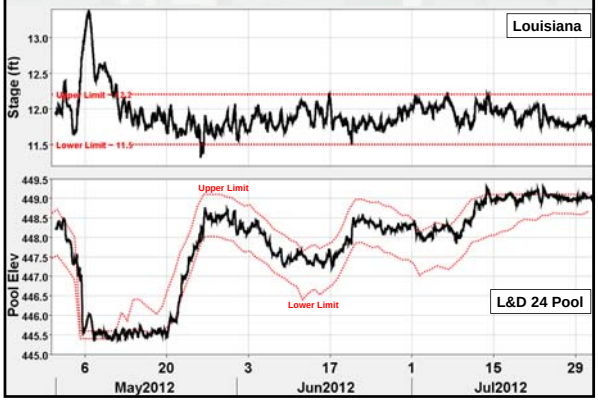
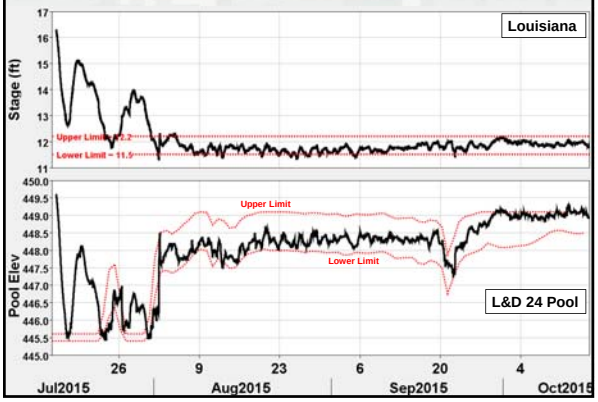
L&D 24 Operating Limits (2012)



L&D 24 Operating Limits (2015)



Dredging Operations

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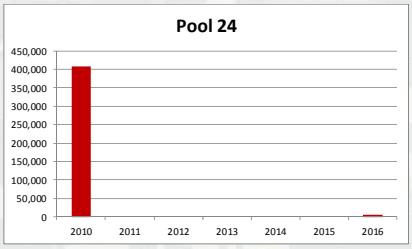
Pool 24

Jobs: 1
CY: 5k

Mile 289
MVR – Mech
11 - 13 Jul 2016



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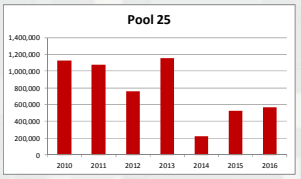
Pool 25

Jobs: 8
CY: 565,829

Dredge Potter
10-23 Jun
Lock 25 Upper, 242.0
Westport Island, 255.6
Coon Island, 266.0
Coon Island, 266.0
Carroll Island, 270.0
Carroll Island, 270.3

11-20 Aug
Lock 25 Upper, 243.0
Lock 25 Upper, 242.2



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Pool 26, UMR

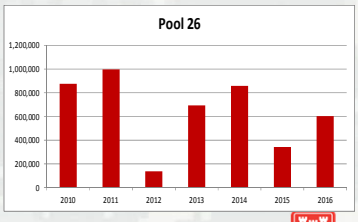
Jobs: 11
CY: 599,797

Dredge Potter

6-12 June
Sherwood, 219.0
Bolter Island, 227.0
Lock 25 Lower, 241.0

23 Jun – 1 Jul
Bolter Island, 227.0
Thomas Landing, 229.0
Peruque Island, 233.0
Martin Towhead, 234.0
Squaw Island, 221.0
Alton, 203.0

9-11 Aug
Royal Landing, 223.5



6-9 Dec
Lock 25 Lower, 241.0

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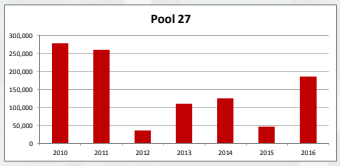
Pool 27, UMR

Jobs: 3
CY: 185,499

Dredge Potter, 146k CY
1-5 Jul
Mel Price Lower, 200.3
Mobile Island, 196.0



Dredge Goetz, 39.5k CY
17-22 Oct
Upper Chain of Rocks Canal, 194.0

Standby High Water – 15 days

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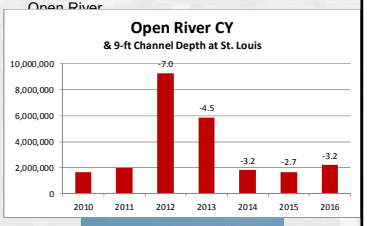
Open River

Jobs: 11
CY: 2,155 MCY

Dredge Potter
20 Aug – 28 Dec 2016
Riverway, 173.0
*Cliff Cave,167.0
*Notre Dame,171.0
*Reidy, 175.0
*Lower Canal, 184.0
Riverway, 173.0
Cliff cave, 167.0
JB Lower, 168.3
Vancill Towhead, 67.0
Manskers, 103.0
Service Base, 177.0



Standby High Water – 82 days
6 Jul – 8 Aug
1 – 8 Sep
13 Sep – 22 Oct

* Flex Pipe

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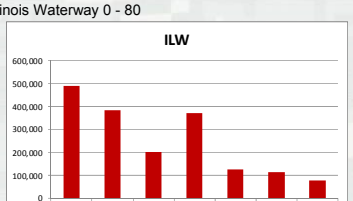
Illinois Waterway 0 - 80

Jobs: 8
CY: 77,377

Dredge Goetz

25 Aug – 30 Sep
Wing Island, 40.0
Old La Grange Lock Lower, 77.0
Old La Grange Lock, 77.5
Moores Island, 76.7 & 76.4
Old La Grange Lock Upper, 78.0
Indian Creek, 78.8
Kamp Creek, 74.0
Mauvaise Terre, 63.0



Standby High Water - 19.5 days

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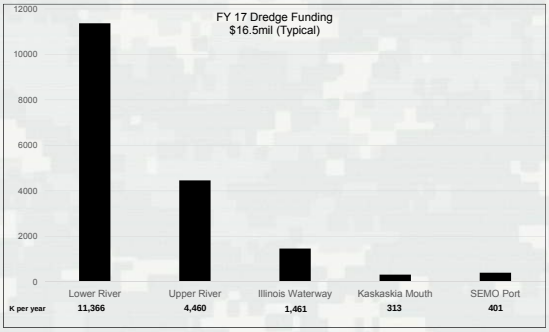

We have had at times reprogram from Lower to Upper to meet needs or receive supplemental funds to help out like during the drought of 2012.

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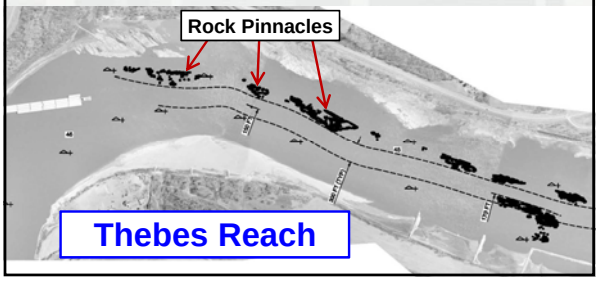
Rock Removal

- **Remnants of the 1988-1989 rock removal**
  - ▸**Grand Tower Reach (RM 78.9 to 80.0)**
  - ▸**Thebes Reach (RM 38.5 to 46.0)**



Bumpings/Groundings

- In our pools we generally have may a few bumpings, say 3 to 5 per season, but generally those issues are related to buoys off station or if it is an area that is shoaling. We can delay dredging by pulling buoys in with the Pathfinder
- We have also temporarily re-aligned the channel to avoid shallow water until a dredge is available
- We also provide survey data to industry to help them find the best available water
- Hard groundings per year, hopefully none that are directly in the channel

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Extended River Forecast

(issued late November)

- **Currently St. Louis is at -0.7 ft**
  - ►7,000 cfs/ft
- **Upper Mississippi River Flow Forecast**
  - ►Currently ~ 39,200 cfs
  - ►28 days ~ 21,500 cfs (-17,700 cfs)
- **Missouri River Flow Forecast**
  - ►Currently ~ 48,700 cfs
  - ►28 days ~ 24,000 cfs (-24,700 cfs)
- **St. Louis 28 day Forecast**
  - ►Loss of 42,400 cfs ~ loss of 6 ft ~ -6.7 ft at St. Louis

Accounting for Forecast Errors

- **Assuming St. Louis Low of -5.1 ft** (*i.e. no Mel Price operation*)
  - ►6,000 cfs/ft
- **Upper Mississippi River Flow Forecast**
  - ►Error ~ -1,140 cfs
- **Illinois River**
  - ►Error ~ -3,000 to -6,000 cfs
- **Missouri River Flow Forecast**
  - ►Error ~ -3,300 cfs
- **St. Louis Low:**
  - ►Loss of 7,440 to 10,440 cfs ~ -6.3 ft to -6.8 ft

Environmental Pool Management In St. Louis District

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Environmental Pool Management is Adaptive Management

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EPM – The Beginning

Agency request (~1988)- "We want a 3 foot drawdown for 120 days!"

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Corps response -"Nope!" "It will impact navigation, dredging, we don't have the mission, it costs too much, blah, blah, blah……"

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EPM – The Beginning

- 1989, 1990, 1991, 1992 - same request, same "**Nope**"
- 1994 NR agencies – "Can you at least give us a 1/2 ft for at least 30 days?"
- Corps "Yea we will try it."
  - Reality was the Corps was doing it for ~ 20 days already, so really only talking 10 days or so
  - Environmental benefit was hard for the Corps to see, but we went along
- Corps "If we do it, you need to tell us if it worked."
  - They did, and it turns out it worked…..

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Environmental Pool Management

- Adaptively managing pools within the St. Louis District since 1994!
- Optimize water levels to maximize environmental benefits

1994 Annual Spring Coordination Meeting

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Environmental Pool Management

- Since 1994 we have been able to achieve yearly environmental benefits
- There have been a few years when the process was abbreviated due to channel conditions (2008, 2010, 2013)
- 2014 River Resources Action Team (RRAT) TNC and USACE met after a 2014 EPM results presentation

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Creation of Environmental Pool Management PDT

- Feb 2015 - Initial face-to-face meeting with multiple stakeholders/agencies to discuss current operations and development of PDT.
  - Reviewed team members
  - Seasonal bi-weekly/weekly conference calls
  - Annual face-to-face meeting to review current year operations

"Can you do 90 days?"

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Environmental Pool Management Imperative

Continue to provide a safe and dependable navigation channel.

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Environmental Pool Management Goals

Utilize the following parameters as general guidelines:

- Begin EPM around April 1st
  - Before the majority of fish spawn begins
  - Reduces likelihood of fish being stranded.
- Continue EPM from May 1st for at least 90 days or until hydrologic conditions require routine dam operations
  - the period most suitable for vegetative growth and seed production.
- At the end of EPM, allow the pool to rise at a rate <0.3 foot per day or a rate recommended by the EPM Coordination Team
  - Slow rise allows vegetation to survive and continue to grow

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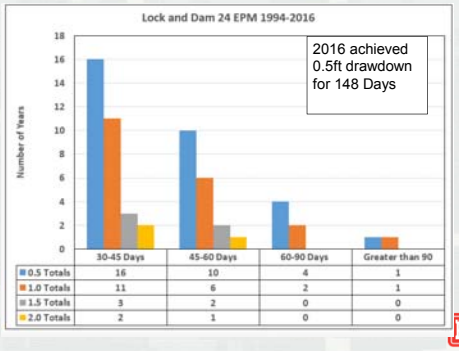
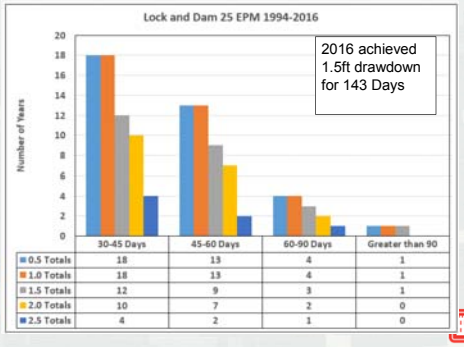
Environmental Pool Management Requirement

Close coordination with resource managers in the field

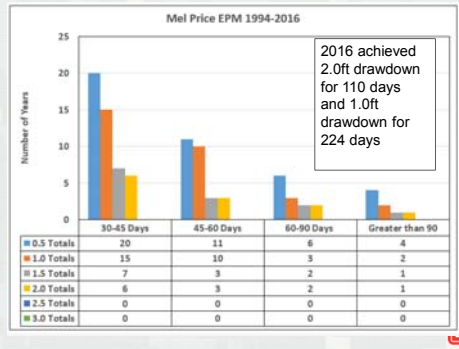
- Environmental conditions will vary from year to year
  - Time of year, temp, and precipitation all have an effect
- Field managers provide valuable insight into actual conditions
- Provide significant suggestions relative to needed adjustments.



	30-45 Days	45-60 Days	60-90 Days	Greater than 90
0.5 Totals	16	10	4	1
1.0 Totals	11	6	2	1
1.5 Totals	3	2	0	0
2.0 Totals	2	1	0	0



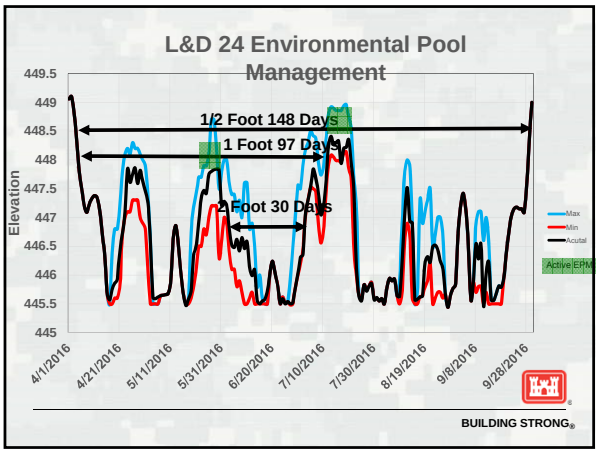
	30-45 Days	45-60 Days	60-90 Days	Greater than 90
0.5 Totals	18	13	4	1
1.0 Totals	18	13	4	1
1.5 Totals	12	9	3	1
2.0 Totals	10	7	2	0
2.5 Totals	4	2	1	0



	30-45 Days	45-60 Days	60-90 Days	Greater than 90
0.5 Totals	20	11	6	4
1.0 Totals	15	10	3	2
1.5 Totals	7	3	2	1
2.0 Totals	6	3	2	1
2.5 Totals	0	0	0	0
3.0 Totals	0	0	0	0

Environmental Pool Management 2016 Operations

Lock & Dam 24



Lock & Dam 25

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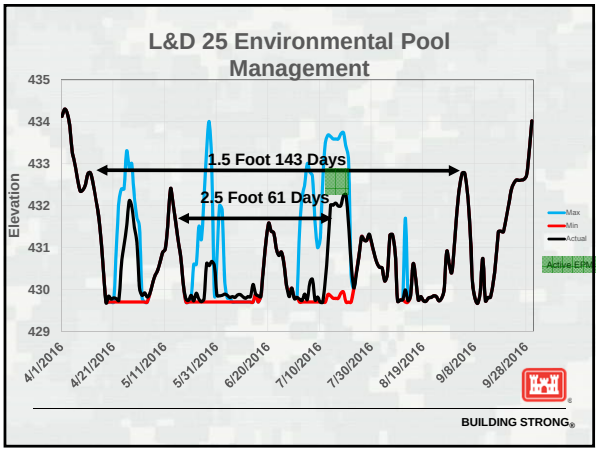

Mel Price Lock & Dam

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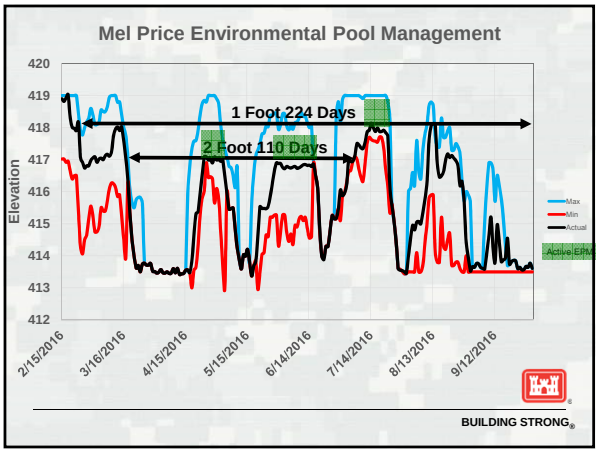

Biological Response to EPM

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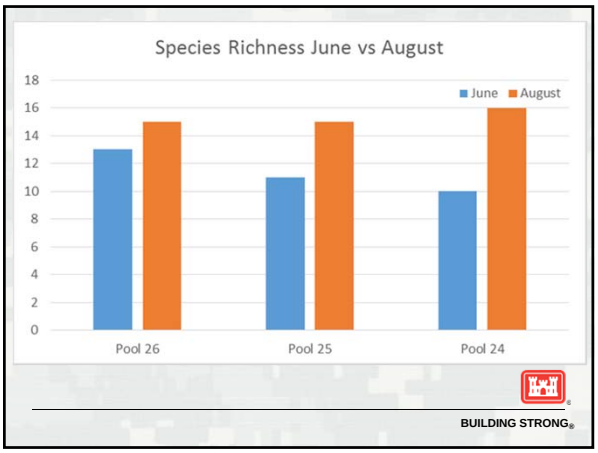
August 26 – Pool 24, Gosline Island


Species Richness June vs August
18
16
14
12
10
8
6
4
2
0
June
August
Pool 26
Pool 25
Pool 24
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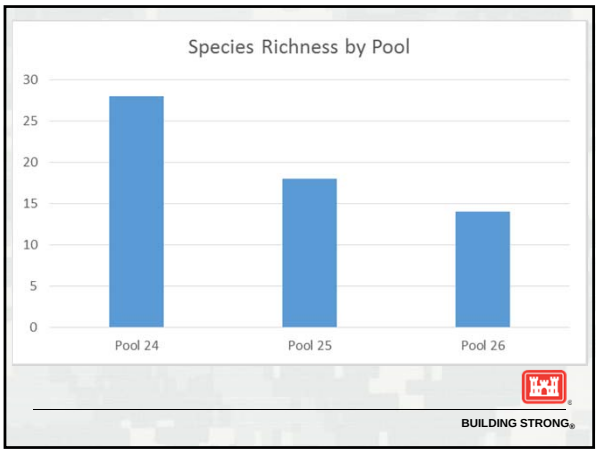
June 8 – Pool 24, Middleton Island L&D HW 446.65


June 8 – Pool 24, Middleton Island L&D HW 446.65


June 8 – Pool 24, Middleton Island L&D HW 446.65


June 8 – Pool 24, Middleton Island L&D HW 446.65


Species Richness by Pool
30
25
20
15
10
5
0
Pool 24
Pool 25
Pool 26
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? ? ? Questions ? ? ?

Rock Island District – Water Control

Kevin Landwehr, P.E., D.WRE
Chief, Hydrology and Hydraulics Branch
Rock Island District, USACE

US Army Corps of Engineers
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Rock Island District Water Management

- 78,000 sq. mi. Drainage Area
- 20 Navigation Locks and Dams
- 3 Multi-Purpose Flood Control Reservoirs
- Centralized 24/7 System Operation
- Daily coordination with the USGS and NWS

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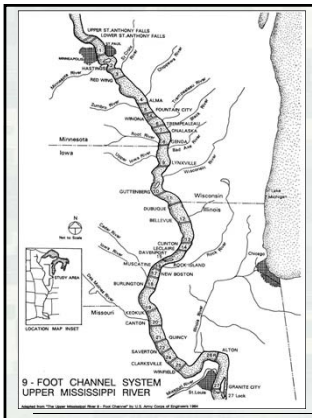

Mississippi River

- Rock Island District operates and maintains 314 miles of the Upper Mississippi River: Dam 10 tailwater to Dam 22 tailwater.
- MVR Water Control regulates Dams 11-14, 16-18, and 20-22.
- Dam 15 normally operated by L&D personnel. (Dam 14 instructions and pool limits are emailed)
- Dam 19 Hydroelectric Plant in Keokuk, IA is operated by Ameren UE. (Dam 18 three day forecast is called in daily)
- The Dams are regulated as a system.
- Each L&D is provided with daily operation instructions.
- Daily flow forecasts are provided to the NCRFC, MVS, MVP, MVD, and other MVR internal stakeholders.

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Mississippi River Pool Regulation

- Types of Pool Regulation
  - ► Dam Point Control – The pool is regulated based on a target pool stage located at the dam itself.
    - Dams 11 – 15, 17 – 19, and 21 - 22
  - ► Primary-Secondary-Tertiary Control – pool is regulated based on control stages at multiple points along the length of the pool.
    - Dams 16 and 20

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Mississippi River Pool Regulation

- Why differences?
  - ► 1930s pool operation studies
  - ► In MVR, all were originally P-S-T, however, MVR petitioned for authority to acquire additional real estate interests to allow for dam point control.
    - Higher Cost vs. ease of operation
    - Pools 16 and 20 remained P-S-T for site specific reasons
      - ▷ Pool 16 – perceived impacts to infrastructure???, land required???
      - ▷ Pool 20 – power generation at Dam 19

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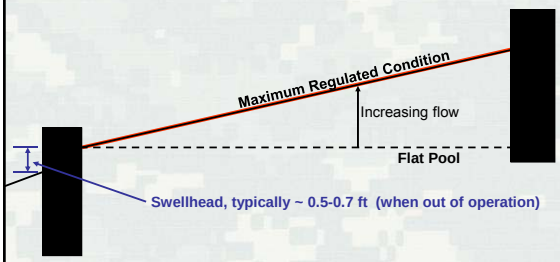
Pool Regulation – Dam Point Control



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Mississippi River Pool Regulation

Dam Point Control – Operating Limits

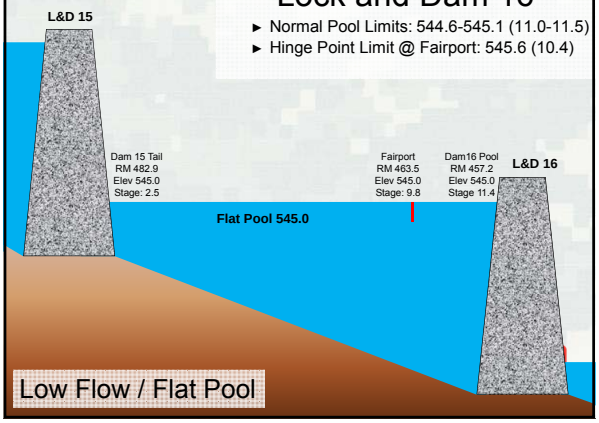
- To smooth out the system we will occasionally deviate from these limits but will avoid running water over spillways. Dams 12, 13, 17, 18, 21 & 22 have non-overflow spillways that are 0.2 - 0.5 above flat pool.
- Winter (non-navigation) operating limits expand to one foot, however at request from USFWS, the pools are regulated as if navigation continues year round.

Primary-Secondary-Tertiary Control

- Utilizes multiple control points
- Active control point at any time is a function of river stage/flow

Lock and Dam 16

- Normal Pool Limits: 544.6-545.1 (11.0-11.5)
- Hinge Point Limit @ Fairport: 545.6 (10.4)



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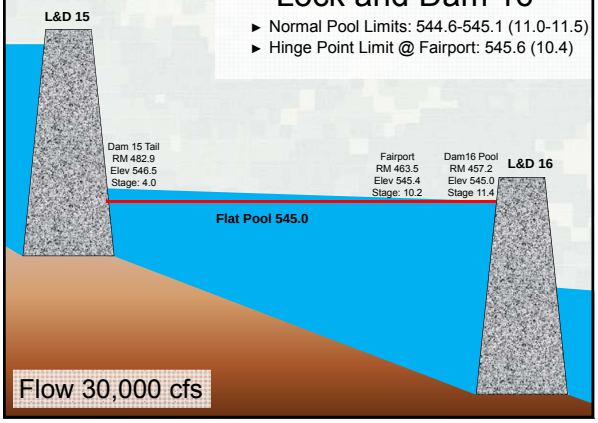

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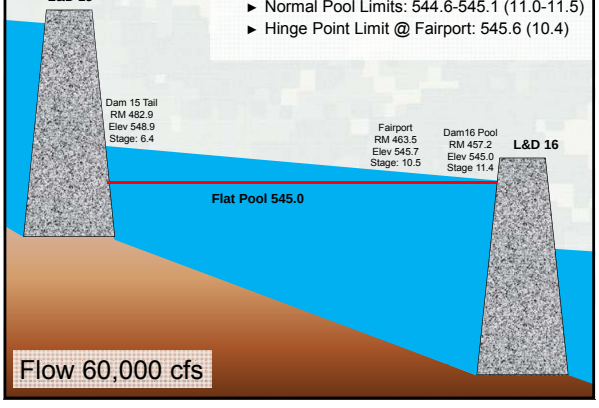

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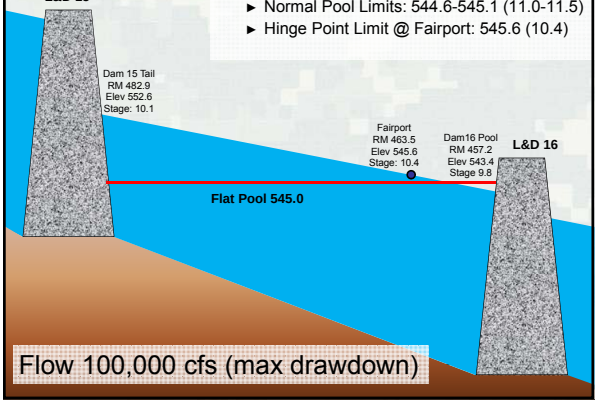

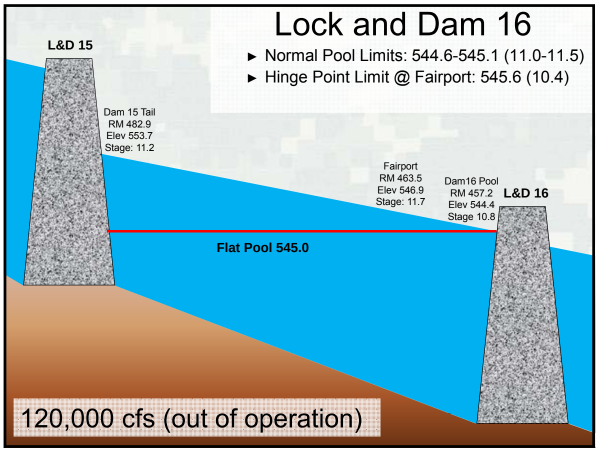

Lock and Dam 20

- Utilizes 3 control points depending upon flow conditions.
  - Low flows – maintain minimum stage of 2.6 feet at LD19 tailwater, until
  - Gregory Landing stage falls to 6.3 feet, then maintain this stage, at a minimum, until
  - Maximum drawdown at Lock and Dam 20 occurs (7.0 feet), maintain this as minimum pool stage until open river conditions exist.

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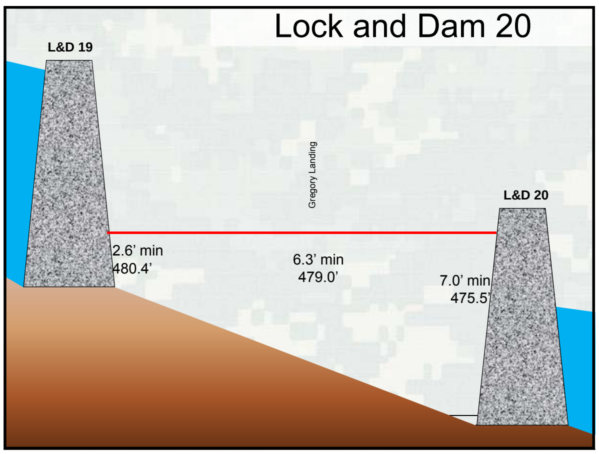
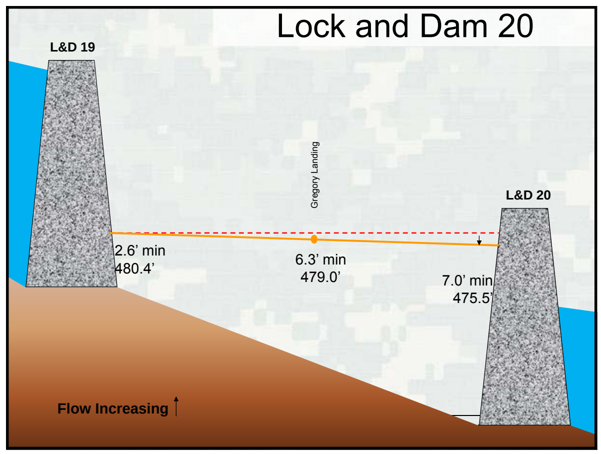
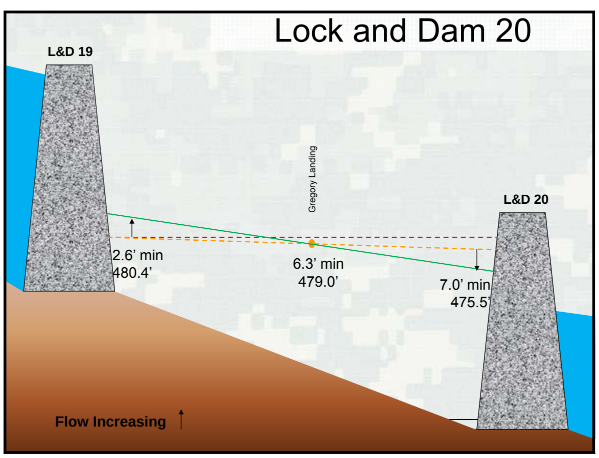
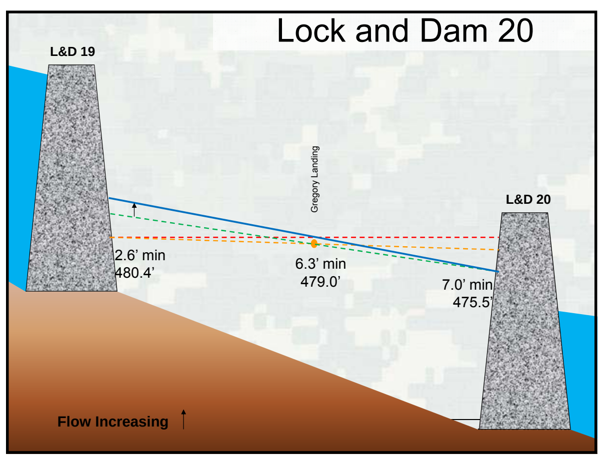
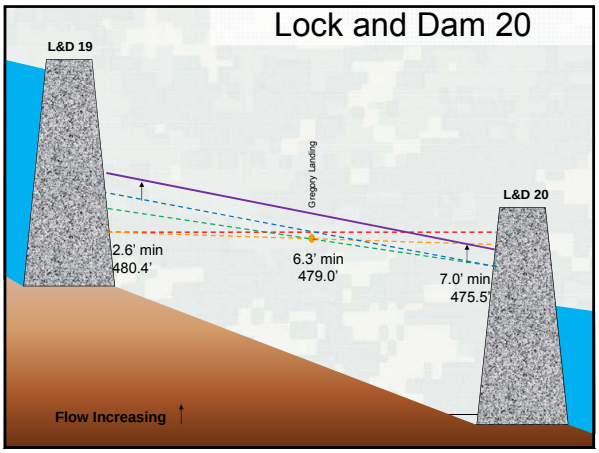








Lock and Dam 20



Nuances

- LD 14 and 15 drawdown as go to open river
- Ice Effects
- Positive vs. negative gate settings
  - Not all sites have submersible gates
- Hydropower
  - LD15
  - LD19

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Dam 15 Hydropower

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Mississippi River – Forecasting Challenges – Dam 19

Mississippi River – Forecasting Challenges – Dam 19

- Run-of-the-river structure, 38 feet of head (2nd highest on the Upper Mississippi).
- 15 turbines and 119 crest gates.
- When inflow is at or above 62,000 cfs, water is passed through the turbines with crest gates being opened as necessary to maintain authorized pool.

- At inflows below 62,000 cfs, pool and tailwater fluctuate diurnally (cycling) as turbine units are brought on and off-line to achieve most economical operation of the power plant.
- During cycling, outflows can vary as much as 40,000 cfs.
- Dam 20 is authorized to operate within a sliding band of pool limits to dampen the effects of the fluctuations induced by the hydropower generation and provide sufficient depth below Dam 19.

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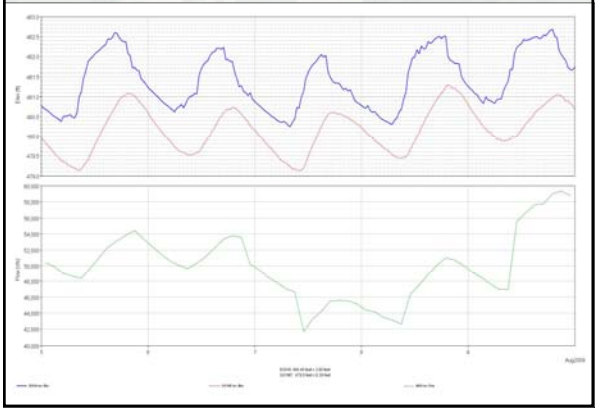
Mississippi River – Forecasting Challenges – Dam 19



Mississippi River – Forecasting Challenges – Dam 19

- USACE has oversight authority related to maintenance of the navigation channel.
- Unscheduled gate operations performed by Ameren without knowledge of the duty forecaster.
- A recent development is unexpected transmission or generation outages and heavy wind power production causing power grid congestion. This can cause negative pricing and unscheduled flow changes. During these scenarios Ameren will avoid operating the crest gates during inclement weather due to personnel safety concerns.
- Pools 20-22 have very little storage area, as a result travel times are extremely short (six hours from Dam 19 to Dam 22).

Regulation Changes Over Time

Navigation Season – No major changes

Non-Navigation Season

- Historical changes to limits
  - World War II – complete drawdowns of pools (as high as LD 2) to maintain minimum desired depth at St. Louis.
  - Post World War II – mid 1950s – drawdowns of pool 16-18 as need to maintain depth at St. Louis; above LD15, drawdowns limited by law***.
  - Mid 1950s-late 1960s – limited drawdown of pools 16-18 to 3-4 feet.
  - 1970-1987 – limited drawdown to 1 foot at all dams.
  - Since 1988 – operated during winter as if navigation continued year-round.

***"Anti-Drawdown Law." Dated March 10, 1934, and as amended by Public Law 732 on August 14, 1946, and again by Public Law 697 on June 19, 1948.

The law directs that the Corps shall generally operate and maintain pool levels as though navigation were carried on throughout the year.

Daily Operations

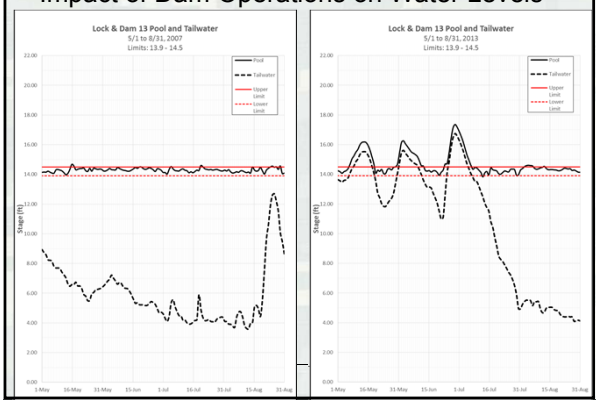
- Daily gate instructions are sent to each project, typically one setting per day but more if needed. Some restrictions in winter/holidays on timing.
- Specifies gate openings to be set at the dam – Total feet of Tainter and roller gate openings.
- Specifies pool limits.

- If operating band limits are exceeded, the project contacts the forecaster on duty for new gate setting.

Project Regulation - Mississippi River

- **Gate changes are a function of:**
  - **Rising or falling pool**
  - **Location in operating band**
  - **Upstream changes in flow**
  - **Local tributary flow changes**
  - **Wind**
  - **Ice**

Impact of Dam Operations on Water Levels



LD 18

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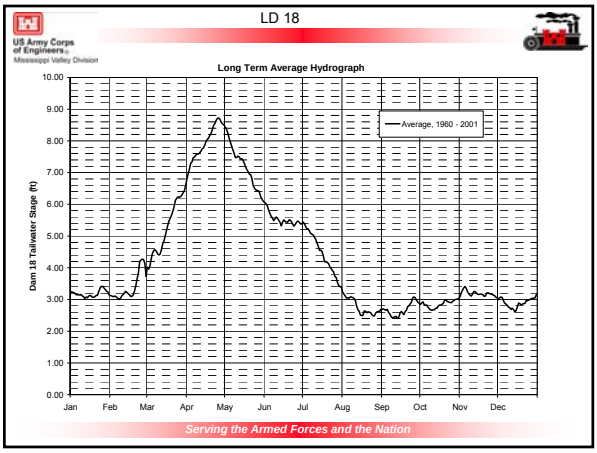
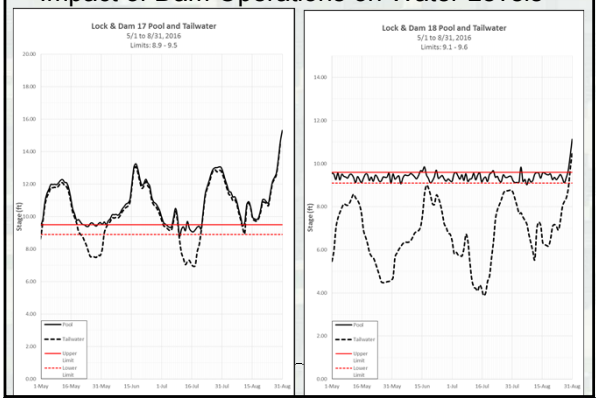
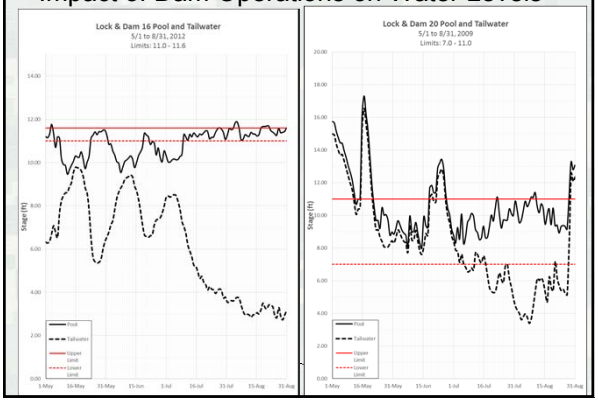
Mississippi Valley Division



Impact of Dam Operations on Water Levels



Impact of Dam Operations on Water Levels



Previous Drawdowns in MVR

- ►Lock and Dam 13 (1998)
- ►NESP Water Level Management Opportunities Report
- ►Lock and Dam 18 Planning under NESP

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1998 Pool 13 Drawdown

- Goal was to conduct a 1 foot drawdown to elevation 582.0, occurring between June 15 and August 15
- The drawdown would be a drawdown of opportunity occurring any time during the period that the flow is within and forecast to remain within the specified flow constraints (50,000 to 110,000 cfs).

Based on the available hydrologic record it appeared that a drawdown of 30 days or more could be accomplished, on average, once every 3 years.

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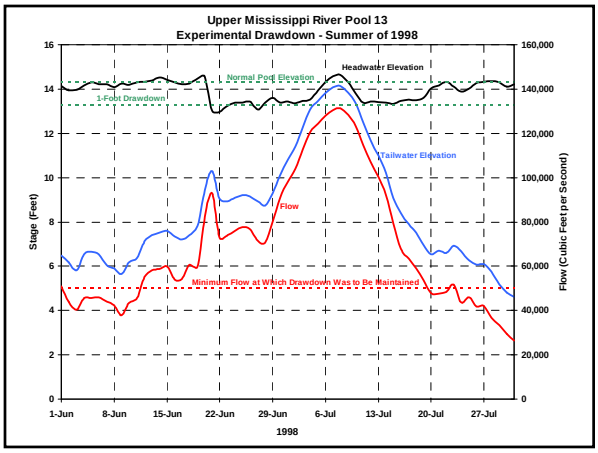

NESP Water Level Management Report (Environmental Report 53)

- Each District prioritized actions – Appendices B-D
- MVR prioritization of pool-wide drawdowns based on screening of pools considering benefits potential and conflicts/impacts.
  - Most suitable – Pools 11 and 13
  - Second tier – Pools 16 and 18

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Mississippi Valley Division

Navigation and Ecosystem Sustainability Program (NESP)

Pool 18 Water Level Management – Seasonal Drawdown

• Buffalo Slough, Pool 18

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Mississippi Valley Division

Where we've been:

2005
- **Aquatic Veg Survey**
- **Data Collection**
- **Existing Conditions**
- **Public Scoping Meetings**

2006
- **Alternative Formulation and Analysis**
- **Coordination on Recreational Access**
- **Shallow-Water Mussel Recon**

2007
- **Coordination of Shallow-Water Mussel Recon**
- **Coordination of potential thalweg disposal sites**
- **Mussel survey for population estimate and site-specific impacts**

2008
- **Coordination of potential mussel impacts**
- **Shallow-Water Mussel Survey**

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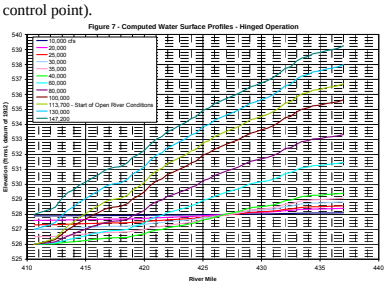
2-Foot Hinged Alternative

2-Foot drawdown at the dam, with secondary control point at Keithsburg of 528.0 ft
- Allows for full drawdown of 2 feet at the dam (primary control point) if flow is greater than ~ 40,000 cfs. Below 40,000 cfs, maintain elevation at Keithsburg of 528.0 (secondary control point).



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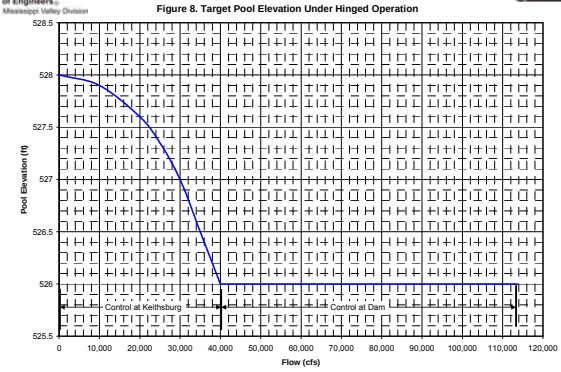

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Lower Pool 18 Existing Bathymetry

•Vegetation response during 2005 low water, Credit Island, Pool 16

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Benefits of "Hinged" Drawdown

- Provides majority of benefits of "full" drawdown
- Reduced recreational impacts
- Reduced dredging requirements (cost)

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Where we've been:

2005
- **Aquatic Veg Survey**
- **Data Collection**
- **Existing Conditions**
- **Public Scoping Meetings**

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- **Shallow-Water Mussel Survey**

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Questions?

Buffalo Slough
August 16, 2005

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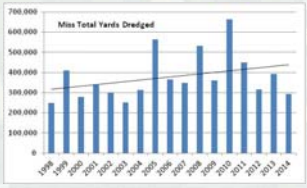
MVR- Mississippi River Dredging



Dredging Volume over Time (Pools 11-24)

Downward Trend Over Last 50 Years

Upward Trend Since 1998

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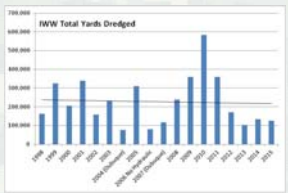
MVR – Illinois Waterway Dredging



Dredging Volume over Time

Slight Downward Trend Since 1998

Slight Upward trend Over Last 50 Years

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Number of Vessel Groundings – Miss.

Rock Island District

5-yr Reported Groundings by Pool -Mississippi River

Pool	2012	2013	2014	2015	2016	5-yr Total
11		1	1		2	4
12				1		1
13	2			1	1	4
14		1				1
15			1			1
16	9	1				10
17						0
18	2					2
19	1					1
20		2		1		3
21	1			2		3
22		1		1		2
Total by Year	15	6	2	6	3	32

*Critical and Non-Critical Groundings reported directly to Channel Maintence Section

CRITICAL - When a vessel is aground or was aground and the channel is restricted so that other vessels cannot safely pass. This does not include groundings where the tow gets under way again in a relatively short time period and traffic resumes without further incident.

NON-CRITICAL - When a vessel was aground or is aground but the channel is not restricted and other vessels can safely pass. This category includes a temporary restriction caused by the vessel maneuvering to free itself.

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Number of Vessel Groundings – IWW

Rock Island District

5-yr Reported Groundings by Pool - Illinois Waterway

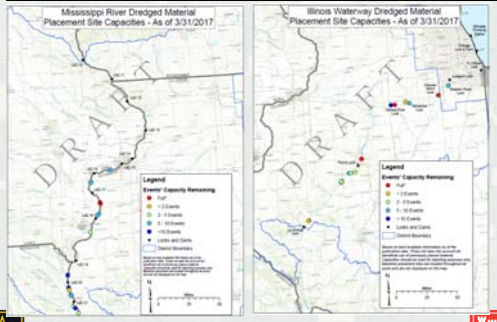
Pool	2012	2013	2014	2015	2016	5-yr Total
LaGrange	2					2
Peoria						0
Starved Rock	2	2				4
Marseilles						0
Dresden						0
Brandon						0
Lockport						0
Total By Year	4	2	0	0	0	6

*Critical and Non-Critical Groundings reported directly to Channel Maintence Section

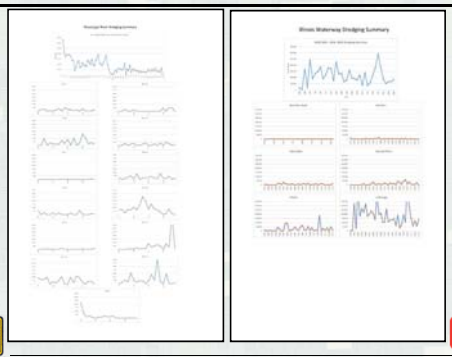
CRITICAL - When a vessel is aground or was aground and the channel is restricted so that other vessels cannot safely pass. This does not include groundings where the tow gets under way again in a relatively short time period and traffic resumes without further incident.

NON-CRITICAL - When a vessel was aground or is aground but the channel is not restricted and other vessels can safely pass. This category includes a temporary restriction caused by the vessel maneuvering to free itself.

MVR - Available Dredging Placement



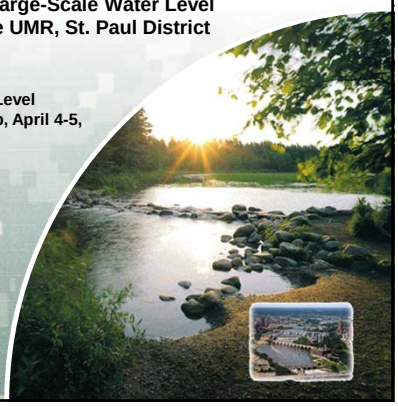
Dredging Volumes by Pool



Questions?

Nuts and Bolts of Large-Scale Water Level Management on the UMR, St. Paul District

For the UMRBA Water Level Management Workshop, April 4-5, Dubuque IA



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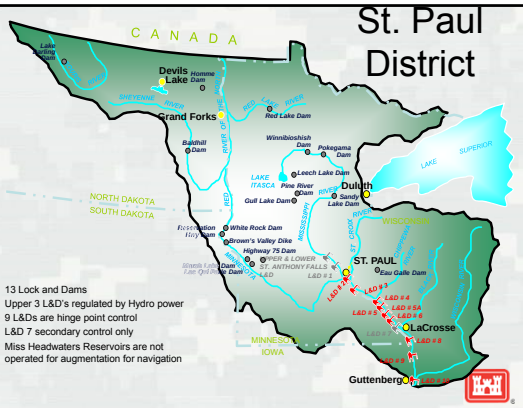
St. Paul District



- 13 Lock and Dams
- Upper 3 L&D's regulated by Hydro power
- 9 L&Ds are hinge point control
- L&D 7 secondary control only
- Miss Headwaters Reservoirs are not operated for augmentation for navigation

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Stakeholders

- Wisconsin DNR
- Minnesota DNR and PCA
- Iowa DNR
- U.S. Fish and Wildlife Service
- National Park Service
- U.S. Geological Survey
- TNC, Audubon, other NGO's
- General Public

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General Dam Operation

- General Control-Point operation explanation
- Operating Limits according to their Water Control Plans
- Have these changed over time and if so, how and why?

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Lock and Dam		Proj. Pool Elev.		Original Drawdown		Interim Changes with Year Approved				Present Drawdown
2		687.2		3.2				2		0.7
				(1938)				(1960)		(1970)
3		675		2						1
				(1939)						(1971)
4		667.0		4.0		2.5		1.5		0.5
				(1941)		(1943)		(1960)		(1971)
5		660.0		2.5				1.5		0.5
				(1936)				(1960)		(1970)
5A		651.0		2.5						1.0
				(1936)						(1959)
6		645.5		2.5						1.0
				(1935)						(1959)
7		639.0								
				none						none
8		631.0		3.5		2.0		1.5		1.0
				(1936)		(1941)		(1963)		(1971)
9		620.0		2.5						1.0
				(1937)						(1971)
10		611.0		2.0						1.0
				(1936)						(1971)

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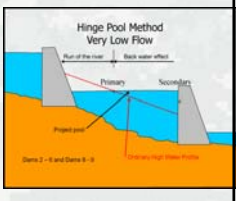
Lock & Dam Regulation

- Three Types of Regulation
  - ► Hinge Point
    - Dams 2 – 6 and Dams 8 – 9
    - Primary control (mid pool)
    - Secondary control at the Dam
    - Less flowage easements
  - ► Control at the Dam
    - Lock and Dam 7 Only
    - Secondary Only (Primary control point would be in the structure of Lock 6)
  - ► Primary @ Dam – Secondary mid pool – Tertiary @ Dam
    - Lock and Dam 10 Only (Designed by MVR)



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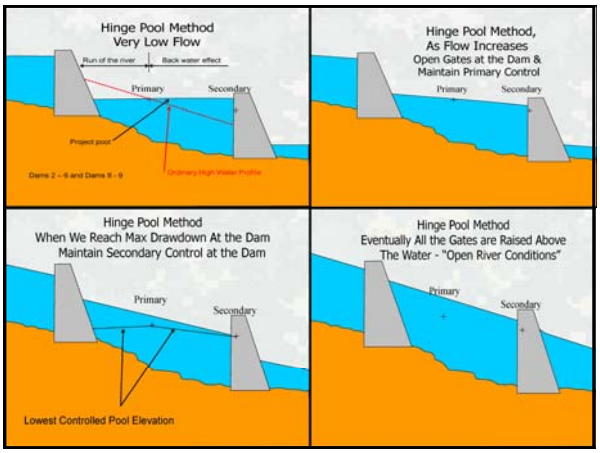

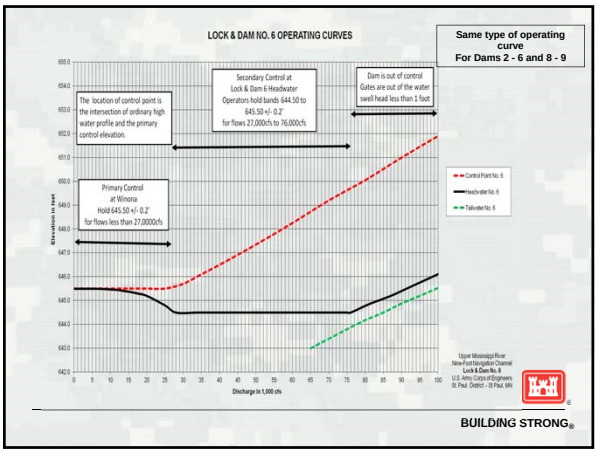

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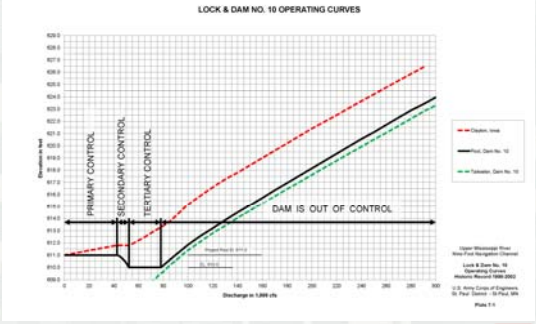

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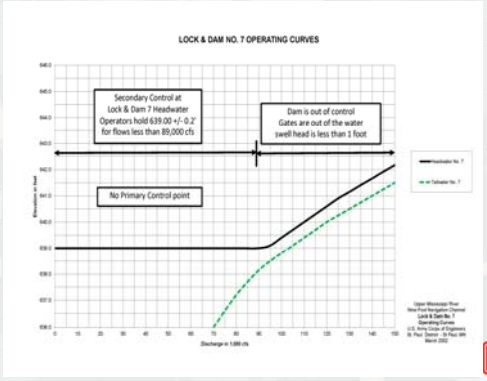

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	Primary Control	Secondary Control	Gates Out	Primary Control name	River Mile of Primary Control
Lock & Dam 2	flow < 13,000 hold elevation = 687.20 @ SSPM5	flow 13,000 to 61,000 hold elevation = 686.50 @ Dam 2	flow > 61,000	South St. Paul	833.7
Lock & Dam 3	flow < 15,000 hold elevation = 675.00 @ PREW3	flow 15,000 to 36,000 hold elevation = 674.00 @ Dam 3	flow > 36,000	Prescott	811.4
Lock & Dam 4	flow < 20,000 hold elevation = 667.00 @ WABM5	flow 20,000 to 89,000 hold elevation = 666.50 @ Dam 4	flow > 89,000	Wabasha	760.45
Lock & Dam 5	flow < 30,000 hold elevation = 660.00 @ AMAW3	flow 30,000 to 116,000 hold elevation = 659.50 @ Dam 5	flow > 116,000	Alma	749.2
Lock & Dam 5A	flow < 25,000 hold elevation = 651.00 @ L&D 5 tailwater	flow 25,000 to 57,000 hold elevation = 650.00 @ Dam 5A	flow > 57,000	L&D 5 tailwater	738.1
Lock & Dam 6	flow < 27,000 hold elevation = 645.50 @ WNAM5	flow 27,000 to 76,000 hold elevation = 644.50 @ Dam 6	flow > 76,000	Winona	725.5
Lock & Dam 7	flow < 89,000 hold elevation = 639.00 @ Dam 7		flow > 89,000		
Lock & Dam 8	flow < 24,000 hold elevation = 631.00 @ LACW3	flow 24,000 to 96,000 hold elevation = 630.00 @ Dam 8	flow > 96,000	La Crosse	696.9
Lock & Dam 9	flow < 33,000 hold elevation = 620.00 @ LNSI4	flow 33,000 to 64,000 hold elevation = 619.00 @ Dam 9	flow > 64,000	Lansing	663.0
Lock & Dam 10	flow < 42,000, hold elevation 611.00 @ Dam 10 flow 42,000 to 52,000, hold elevation 611.80 @ CLAI4 flow 52,000 to 73,000, hold elevation 610.00 @ Dam 10		flow > 73,000	Clayton	624.8

note #1 : Bands are +/- 0.2' during the navigation season, and +/- 0.3' during non navigation season
note # 2: Gates are usually pulled when the head is less than a foot at the dam, then the tailwater rating curve is used to calculate discharge.
note # 3 : Bands given in the orders are what the L&D Operators hold at the pool gage at the dam to maintain either primary or secondary control.
note # 4 : water surface elevations held at the L&D's are flow dependent and can range any where between the secondary elevation up to the primary elevation

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Travel times for Moderate flows

L & D's 2 to 3	8 -12 hours
L & D's 3 to 4	at least a day
L & D's 4 to 5	6-8 hours
L & D's 5 to 5A	4-6 hours
L & D's 5A to 6	4-6 hours
L & D's 6 to 7	6 – 8 hours
L & D's 7 to 8	12 hours
L & D's 8 to 9	16 -20 hours
L & D's 9 to 10	8 - 12 hours

Change in flow for 24 hours to change the pool 0.1 foot

Pool 2 - 1200cfs
Pool3 - 900cfs
Pool 4 – 2000cfs
Pool 5 – 600cfs
Pool 5A – 400cfs
Pool 6 – 300cfs
Pool 7 – 700cfs
Pool 8 – 1200cfs
Pool 9 – 1600cfs
Pool 10 – 1000cfs

L & D's and control points

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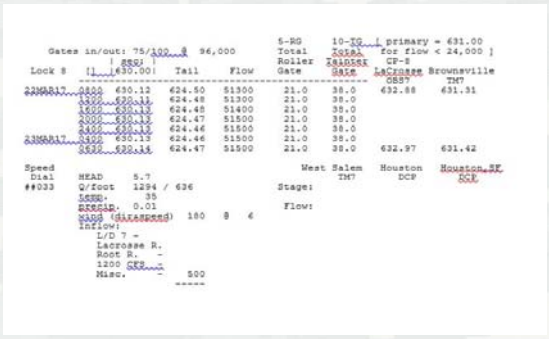
Daily Dam Operation

- How are gate instructions issued?
  - Water on the ground
  - Upstream Inflow
  - Gate balance
  - Conditions at the Dam (wind, maintenance)
- Gate change frequency
  - Usually once per day, at higher flows more regulation is needed

Daily Regulation Sheet



Gates in/out: 75/100 @ 96,000

Lock 8	[1	630.00]	Tail	Flow	S-RG Total Roller Gate	10-TG [primary = 631.00 Total 25TBA for flow < 24,000] Radial CF-8 Gate	LaCrosse OBS?	Brownsville TM?
23MAR17	0800	630.12	624.50	51300	21.0	38.0	632.88	631.31
	1000	630.11	624.48	51300	21.0	38.0		
	1200	630.13	624.48	51400	21.0	38.0		
	1400	630.13	624.47	51500	21.0	38.0		
	1600	630.13	624.46	51500	21.0	38.0		
24MAR17	0400	630.13	624.46	51500	21.0	38.0		
	0600	630.14	624.47	51500	21.0	38.0	632.97	631.42

Speed Dial ##033

HEAD 5.7
Q/foot 1294 / 636
35
Precip. 0.01
Q100 (discharged) 180 8 4
Inflow:
L/D 7 -
Lacrosse R. -
Root R. -
1200 CFS -
Misc. - 500

West Salem TM? | Houston DCP | Houston,SF DCP

Stage:
Flow:

CWMS

Sending the Orders

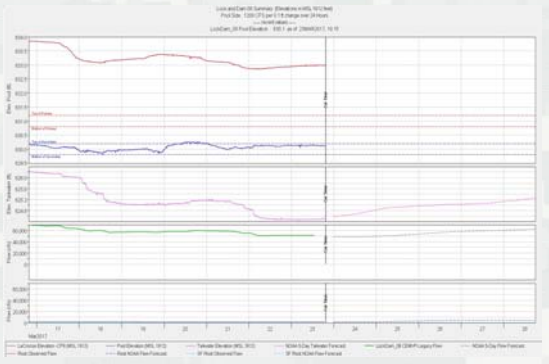
From: Daniel Fasching
To: Lock and Dam 6
Transmitted: March 23, 2017 at 07:18:08
Subject: Regulation orders for Lock and Dam 6

Current flow is 46500.
No change in flow at present.
Maintain pool band from 644.3 to 644.7.
Target elevation is 644.5, plus or minus 0.2 foot.
*** Later today when the pool falls to 44.5 cut 2' on RG
***

Regulation Frequency

- Orders routinely sent before 8 AM
- Afternoon orders are needed when
  - ▸Greater flows
  - ▸Significant rain events
  - ▸Minor adjustments can also be made
- Lock and Dam Operators can make a 20% change in flow without orders

Fluctuations occur and the Math isn't Perfect

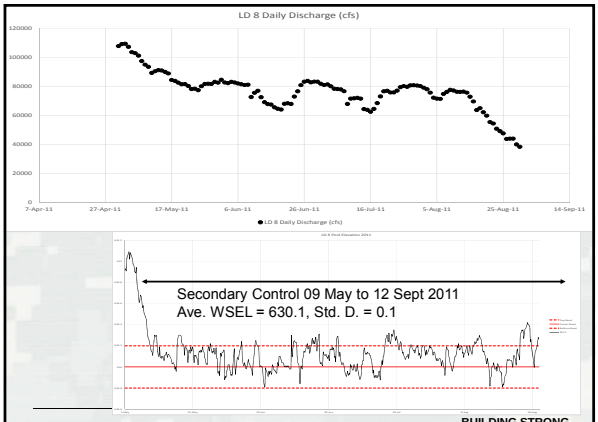


Daily Fluctuations

- Wind - can change the pool 0.1 ft per 10mph
- Power generation – WI River, LD 2
- Shift changes and staffing
- Math and human error

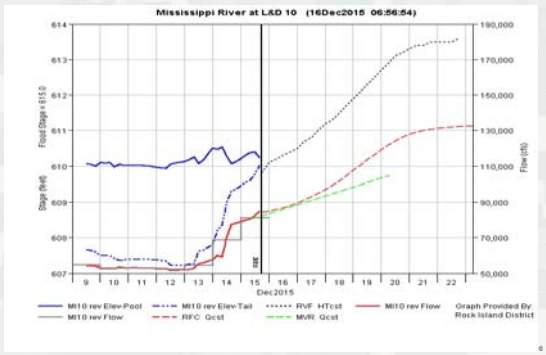
Dam Operation Effects on Water Levels

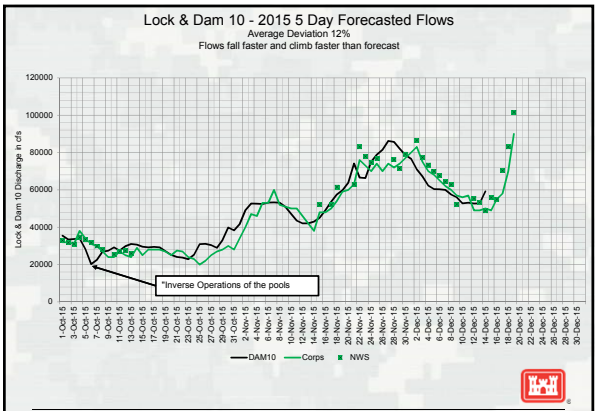
- Typical fluctuations and ranges during the growing season (not open river conditions)
- Graphics depicting 10 years of daily water levels May-August for select dams

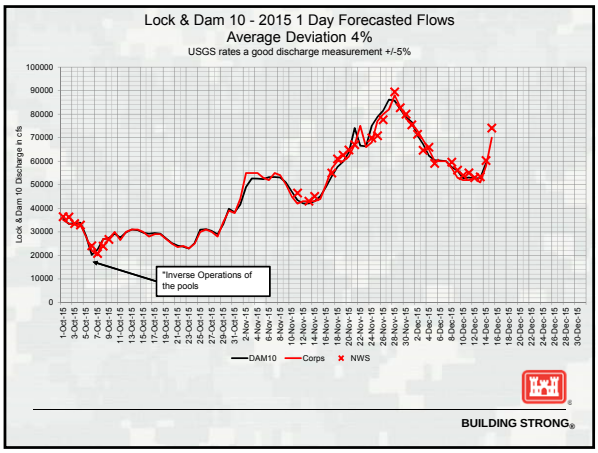


LD 8 Year	Ave WSEL During Growing Season when in Secondary Control	Std. D.
2006	630.09	0.1
2007	630.16	0.1
2008	630.14	0.2
2009	630.15	0.1
2010	630.15	0.2
2011	630.15	0.1
2012	630.07	0.1
2013	630.20	0.2
2014	630.06	0.1
2015	630.13	0.1
2016	630.13	0.1
	Primary 22%	Secondary 71%	Out of Control 7%

Lock & Dam forecast
http://155.76.213.69/docs/mvd2.html







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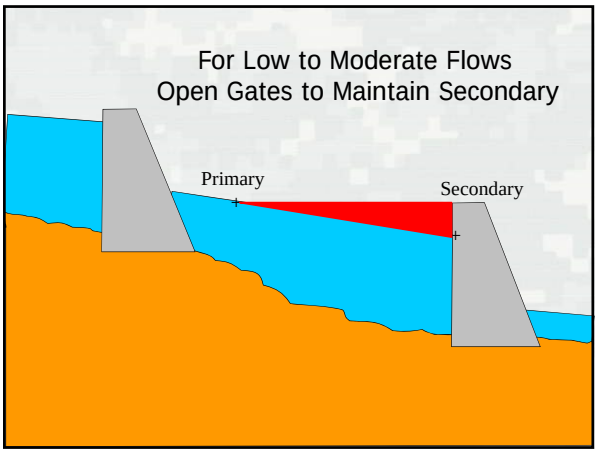

Channel Maintenance

- Dredging depths
  - St. Paul District dredges to 12' below LCP with the goal of maintaining a > 9' channel until the next navigation season.
  - Dredge material placement: All placement in the St. Paul District is upland except in Emergency situations – this increases cost and limits volume that can be accommodated from every dredge job.

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Channel Maintenance (Cont.)

Annual Dredging Per Pool 1985 - 2016

Pool	Cubic Yards
2	112,935
3	48,229
4	281,328
5	111,484
5A	47,288
6	25,791
7	52,463
8	75,706
9	55,852
10	24,190
Total	835,266

MN River, Pool 1, USAF, harbors not included

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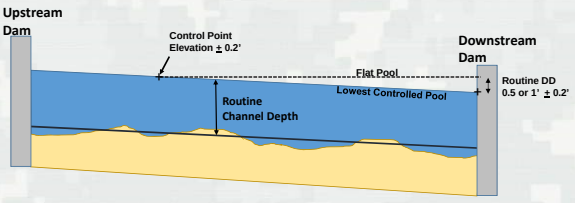
ROUTINE POOL MANAGEMENT, HINGE POOL



- Routine Dredging Conducted to lowest controlled pool elevation
- Low Pool level tolerance at MVP dams very small (± 0.2 ft)
- Low tolerance minimizes overall dredging needs, but doesn't support routine drawdowns

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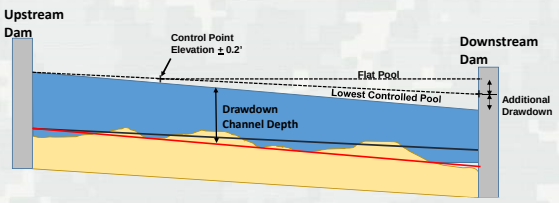
DRAWDOWNS, HINGE POOL



- DRAWDOWN COST = Additional dredging prior to drawdown to maintain adequate depth for navigation
- This deeper dredging can result in reduced dredging needs for several years.
- The sediment trap efficiency is increased, which has resulted in overall increased dredging associated with drawdowns.

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Channel Performance

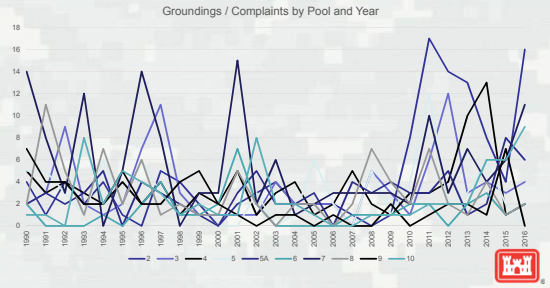
- Number of groundings/complaints per year per pool

Groundings/Complaints Pools 2 - 10

Pool	2	3	4	5	5A	6	7	8	9	10	Total Per Yr
1990	4	2	5	5	2	2	14	2	7	1	44
1991	1	3	3	5	3	0	8	11	4	1	39
1992	4	9	4	3	2	0	3	5	4	0	34
1993	2	2	3	1	3	0	12	1	2	8	34
1994	4	1	2	6	5	1	0	7	2	2	30
1995	1	2	4	2	0	0	5	2	5	5	26
1996	0	7	2	6	4	2	14	6	2	4	47
1997	5	11	4	3	3	4	8	1	2	3	44
1998	4	3	1	1	2	1	0	2	4	1	19
1999	2	1	3	1	1	1	3	1	5	2	20
2000	0	1	2	0	0	2	3	1	2	1	12
2001	2	1	5	0	3	7	15	5	1	1	40
2002	3	1	1	3	5	2	2	2	0	8	27
2003	4	4	3	0	2	0	6	0	1	2	22
2004	2	2	4	1	2	0	1	2	1	2	17
2005	2	2	1	6	3	0	2	2	0	1	19
2006	2	2	2	2	0	0	3	0	1	0	12
2007	1	0	5	0	4	1	3	2	0	0	16
2008	0	5	2	5	3	1	3	7	0	1	27
2009	1	3	1	1	4	1	3	4	2	1	21
2010	8	1	3	4	3	2	2	2	0	1	26
2011	17	6	3	12	3	2	10	7	1	2	63
2012	14	12	4	2	5	0	3	2	2	2	46
2013	13	3	10	3	1	2	7	1	2	2	44
2014	8	4	13	6	2	3	4	4	1	6	51
2015	4	3	1	2	0	1	6	1	7	6	30
2016	16	4	2	0	6	2	11	2	0	9	52
Totals	124	95	93	80	79	37	151	82	58	72	871
Avg. Yr	4.6	3.5	3.4	3.0	2.9	1.4	5.6	3.0	2.1	2.7	

Channel Performance

- Number of groundings/complaints per year per pool



Drawdowns – Defining Success

- Time frame
- Duration
- Depth of exposed acres

Early documents (1990s) – "The probability of having optimum drawdown conditions was defined as the probability for river discharge to allow a drawdown to the target depth (1.5') during the June through September growing season, with no more than two re-flooding events of less than one week duration."

Recent Discussions (2016 – 2017) – Opportunistic shorter duration smaller drawdowns could have ecological benefits.

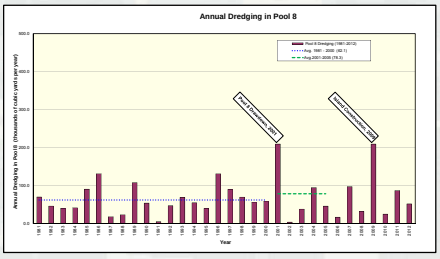
Past Drawdown Examples

	Pool 8	Pool 5
Years	2001-2002	2005-2006
Drawdown Initiated	June 16, 2001 June 15, 2002	June 13, 2005 June 12, 2006
Maximum DD Duration	1.5' (06 July – 14 Aug 2001) 1.5' (03 July – 16 Sep 2002)	1.5' (29 Jun – 31 Jul 2005) 1.5' (26 Jun – 29 Jun 2006)
Acres Exposed	1950 (Both years)	1000 (in 2005)

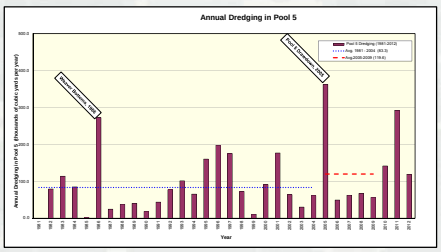
Past Drawdown Examples

	Pool 8	Pool 5
Years	2001-2002	2005-2006
Vegetation Response	Shift from annuals to perennials from 1st to 2nd year. Increase in emergent and submersed veg. But…veg has been increasing in other pools.	
Fish	No measurable effect? Potential for stranding and adverse effects to spawning areas. Positive impacts from increased vegetation.	
Mussels		At least 28% of mussels died in shallow water areas in Pool 5. The mussel population in Pool 5 was estimated at 189 million

Past Drawdown Examples



- 209,000 cubic yards dredged in 2001
- Reduced dredging for several years after this
- 26% increase in dredging for the 5 year time period 2001 – 2005 compared to the 1981 to 2000 time period



- 362,000 cubic yards dredged in 2005
- Reduced dredging for several years after this
- 44% increase in dredging for the 5 year time period 2005 – 2009 compared to the 1981 to 2004 time period
- Note – Additional dredging was done for island construction in 2005

	Pool 8	Pool 5
Pre-Drawdown Dredging (yd3/year)	62,000	83,000
5-year Drawdown Dredging Average (yd3/year)	78,000 (+26-percent)	120,000 (+44-percent)
Reference Reach Dredging Ratio	0.93	0.80
Average Annual Discharge Ratio	1.0	0.77

Future Drawdowns

- Constraints – Additional dredging costs, recreational boating
- Opportunistic DD factors:
  - Deferred (marginal) dredging reaches
  - High tailwater at some dams
  - Short-term changes in channel conditions (ie. what condition is first cut in, when final cut is finished)
  - Risk of groundings

Questions?