Summary of North Branch Reservoir Operations

North Branch Advisory Committee

October 29, 2007

Overview

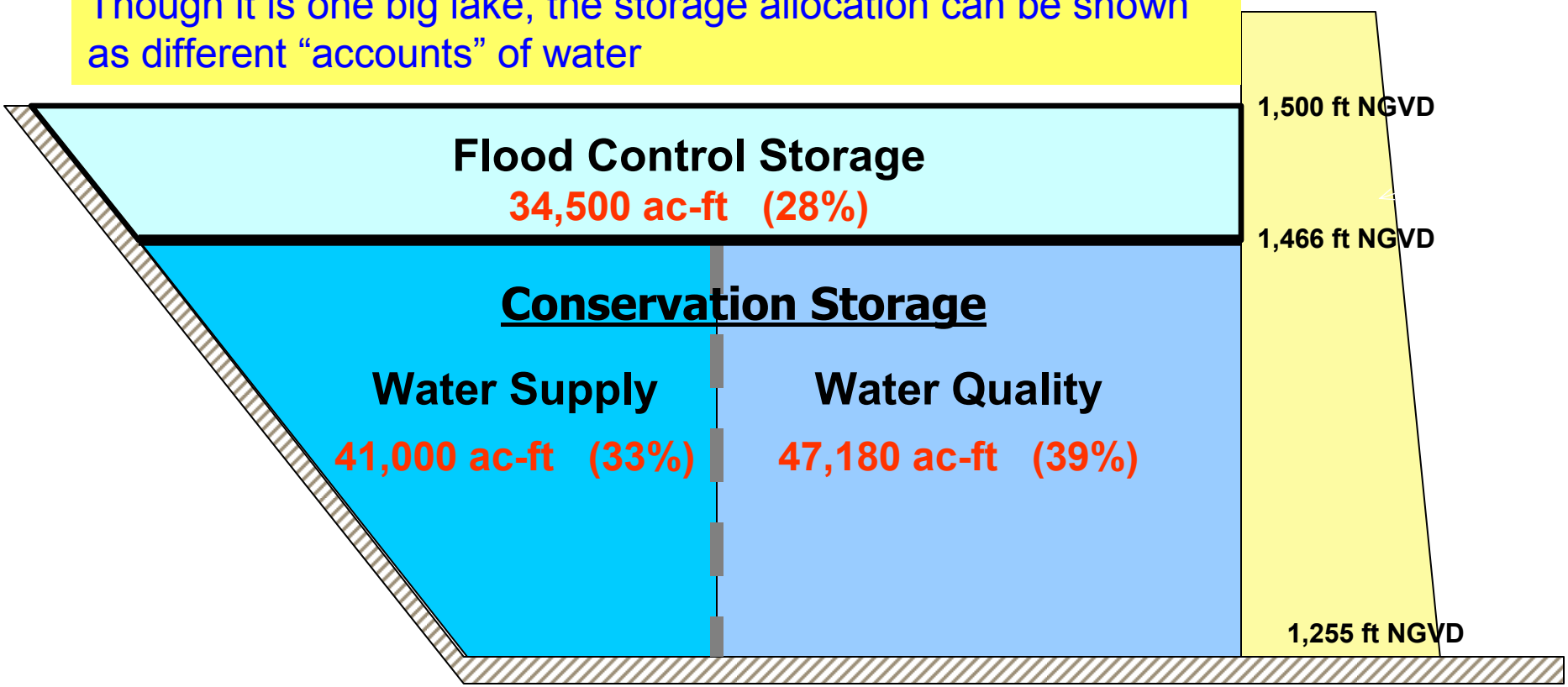
- Reservoir storage allocation
- Water supply operations
- Water quality operations
- PRRISM
- Focused on Jennings Randolph
- Focused on summer/fall operations

Jennings Randolph Reservoir Storage Allocation

- Federal legislation mandates three "accounts" for the storage in Jennings Randolph:
    1. Water Quality
    2. Water Supply
    3. Flood Control
- Accounts are managed separately
- Storage accounting

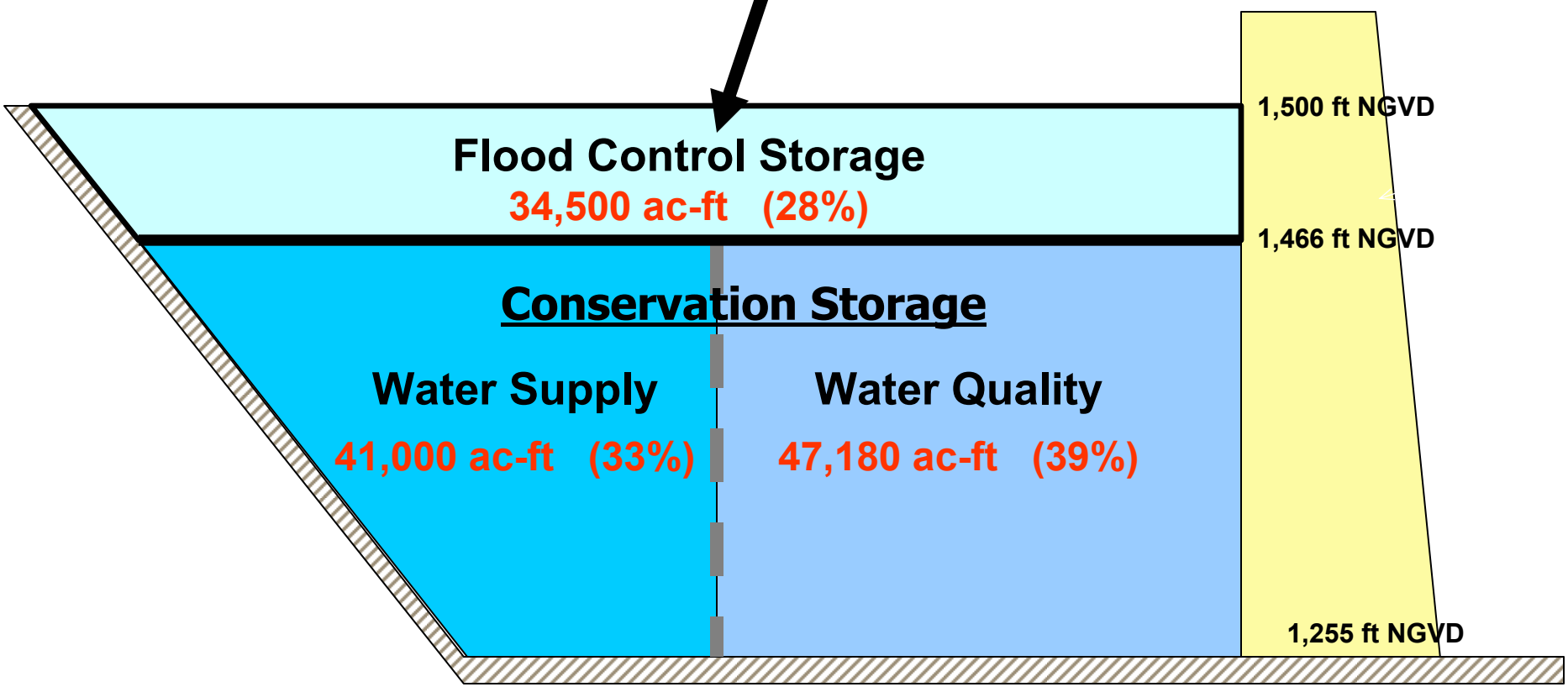
Jennings Randolph Lake Storage Allocation

Though it is one big lake, the storage allocation can be shown as different "accounts" of water



*NGVD = National Geodetic Vertical Datum, so 1,500 ft NGVD means 1,500 feet above NGVD

Flood control storage is usually kept **empty** in order to capture large storm event flows and prevent them from flooding towns downstream



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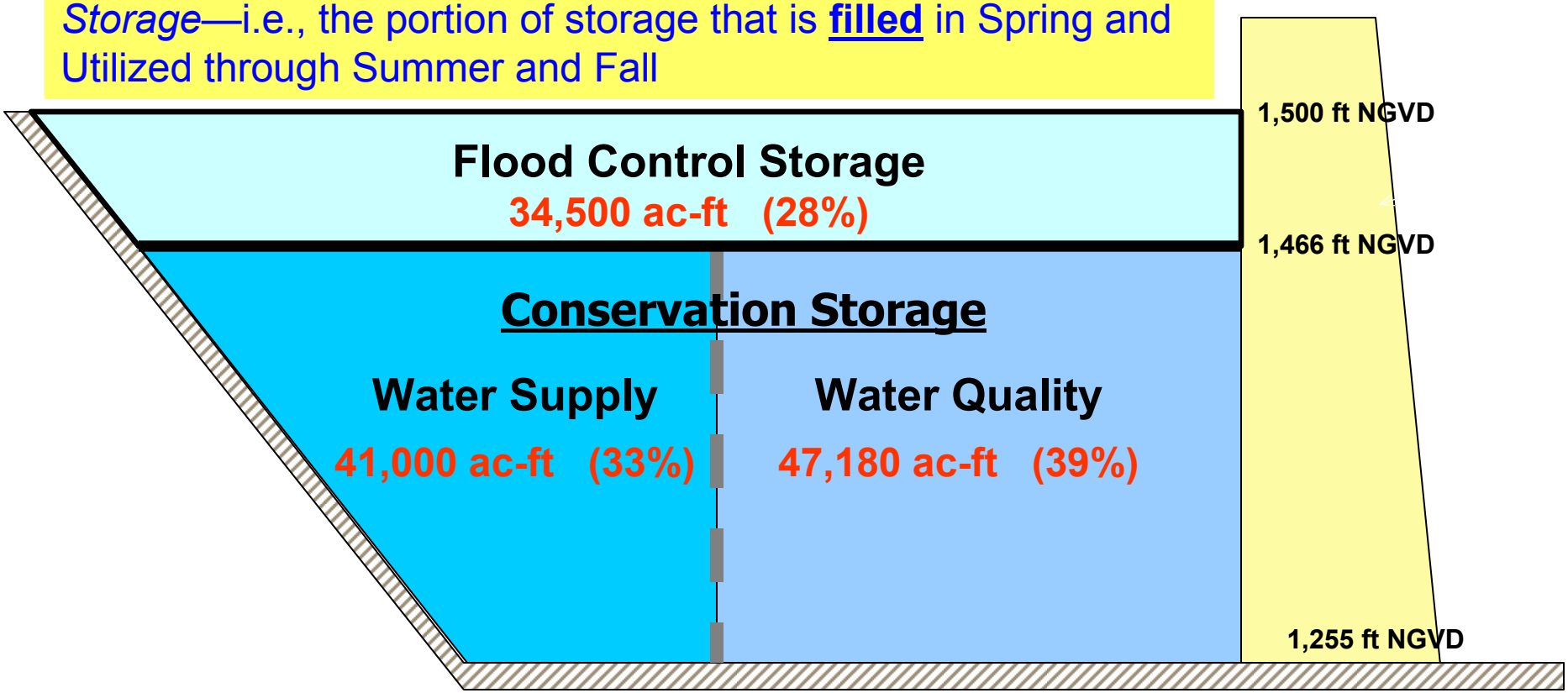
Jennings Randolph Lake Storage Allocation

Water Supply and Water Quality Make up the *Conservation Storage*—i.e., the portion of storage that is **filled** in Spring and Utilized through Summer and Fall



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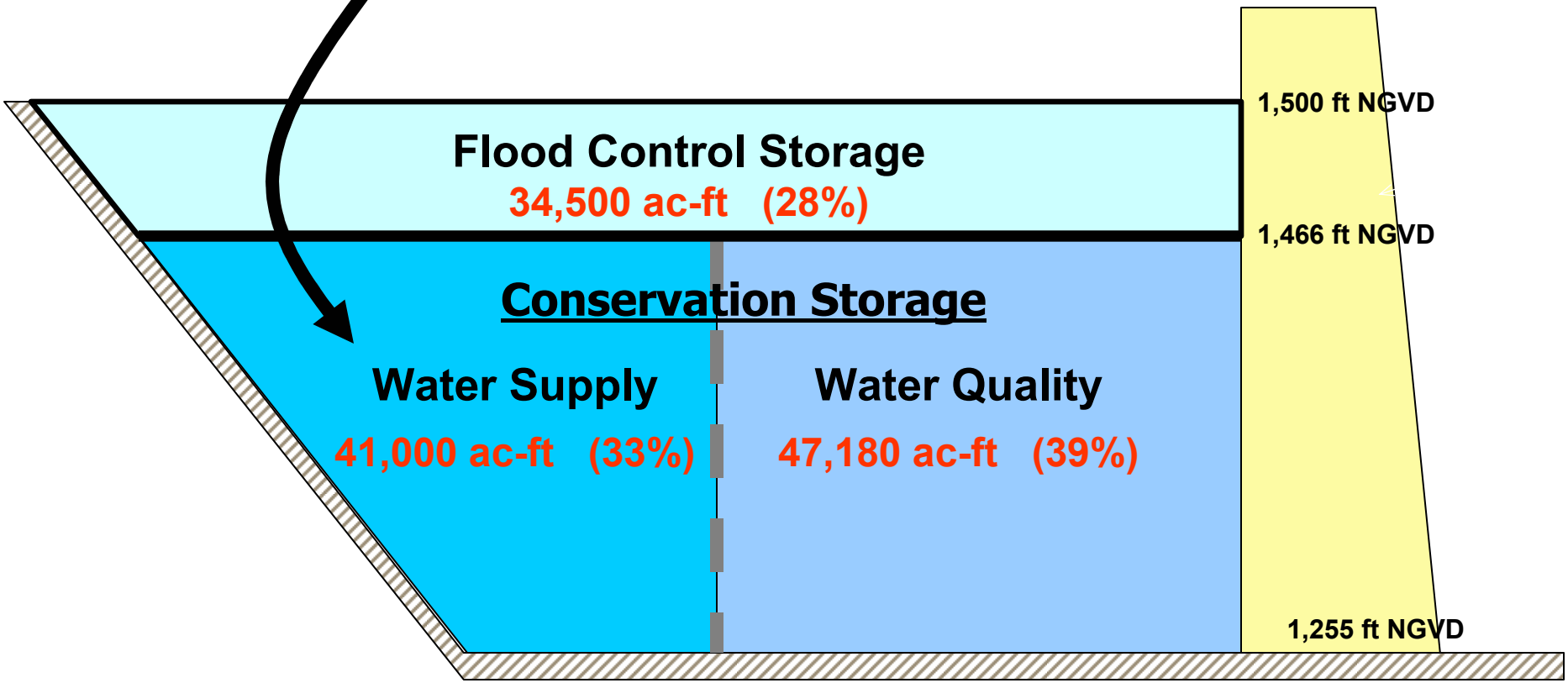
Water supply storage is used by D.C. area water suppliers to ensure reliable water supply for the D.C. area residents and businesses. It is kept full most years and is needed in only severe droughts. ICPRB works with the water suppliers to manage this storage.



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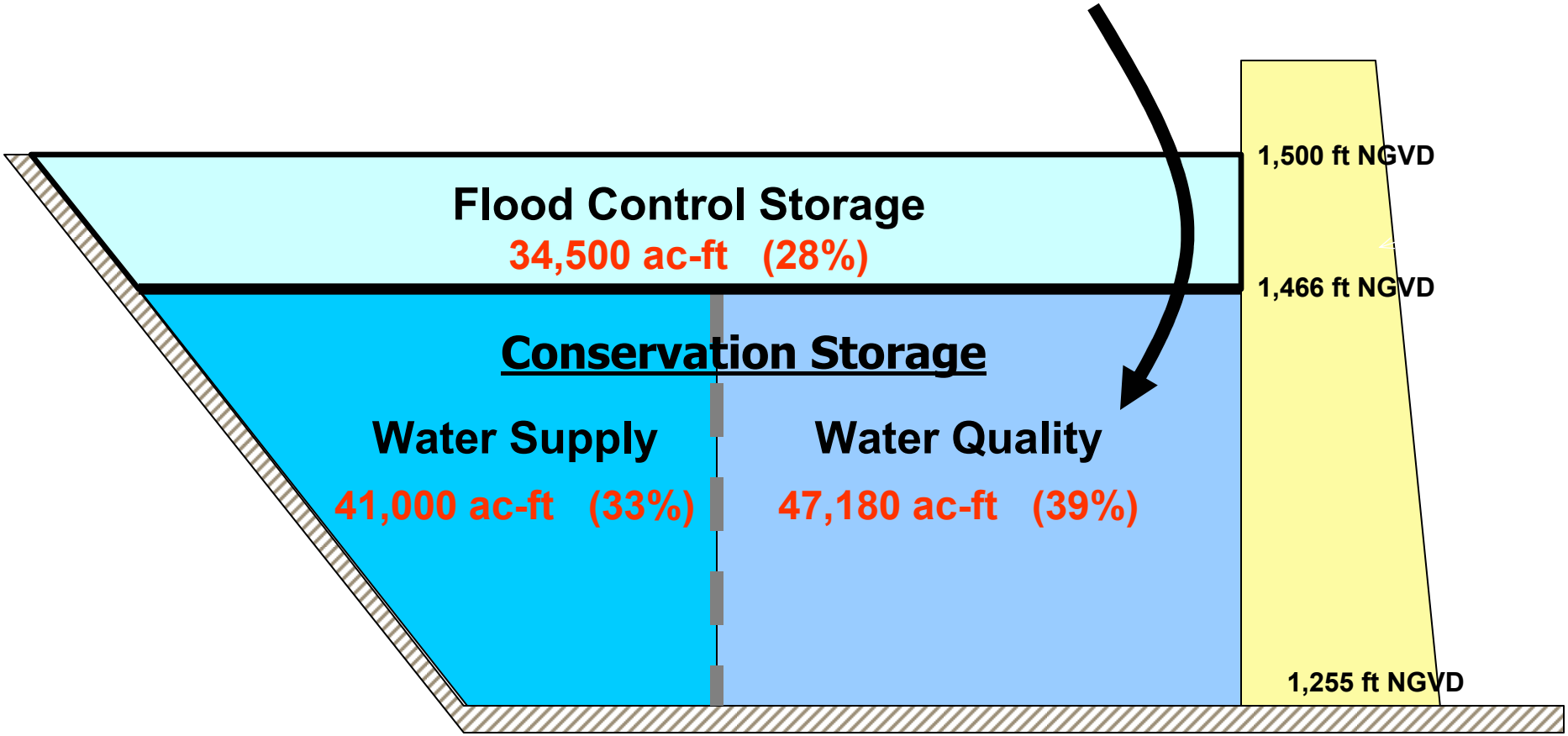
Water quality storage is used by the Corps to augment summer low flows in order to improve water quality in the North Branch. It is used every year through the Summer and Fall, and usually refilled by early Spring.



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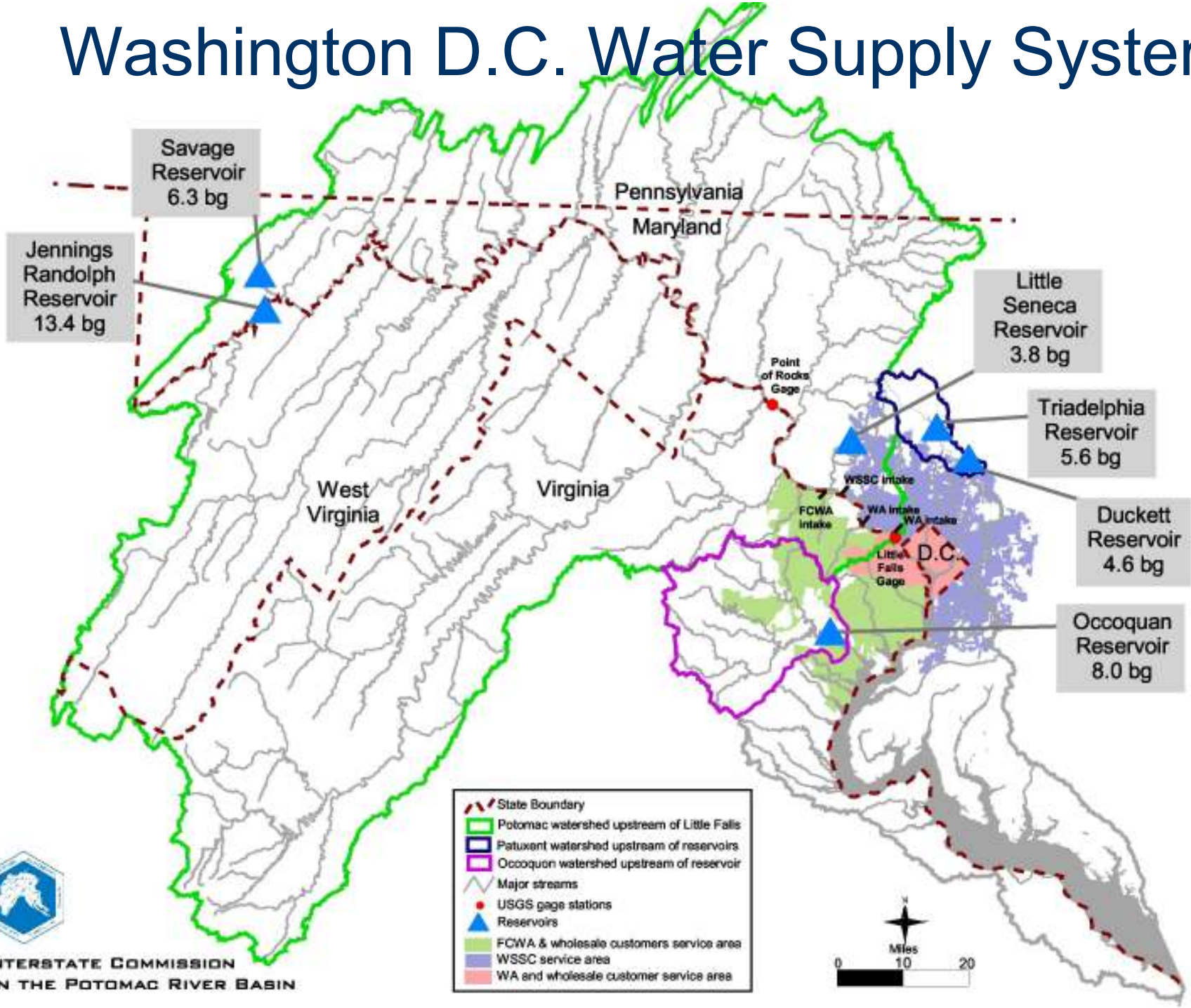
Water Supply Storage

- ICPRB calls upon water supply storage in drought
  - When flow cannot meet demand + flow-by, water supply releases are requested
- Water supply releases in 1999 and 2002
- A release takes about 9 days to reach Washington, D.C., so we have to make this decision with about 9 days lead time
- This means we have to forecast river flow (without a release) and water demands 9 days out

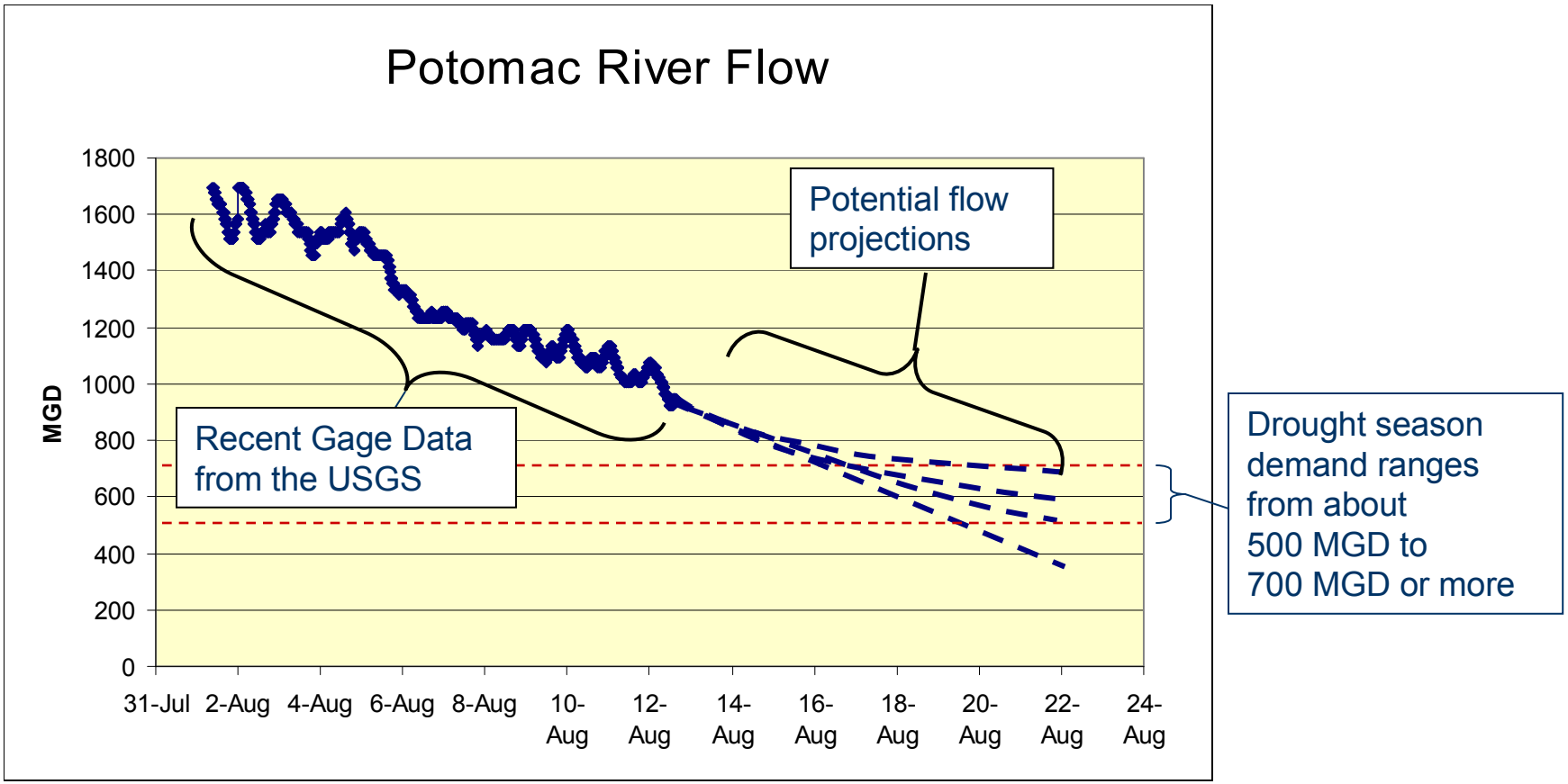
Washington D.C. Water Supply System



INTERSTATE COMMISSION ON THE POTOMAC RIVER BASIN

Water Supply Operations Example

(these are hypothetical numbers for demonstration purposes)



Water Quality Storage

- The Corps manages water quality storage at Jennings Randolph.
- Objective is to augment summer and fall low flows to improve water quality conditions.
- The Corps makes release decisions based on predictions of inflow and remaining storage
- The Corps' aims to use about 75% water quality through the summer and fall.

Releases from Water Quality Storage are Determined from Two Parts

Part 1: Water currently available in water quality storage

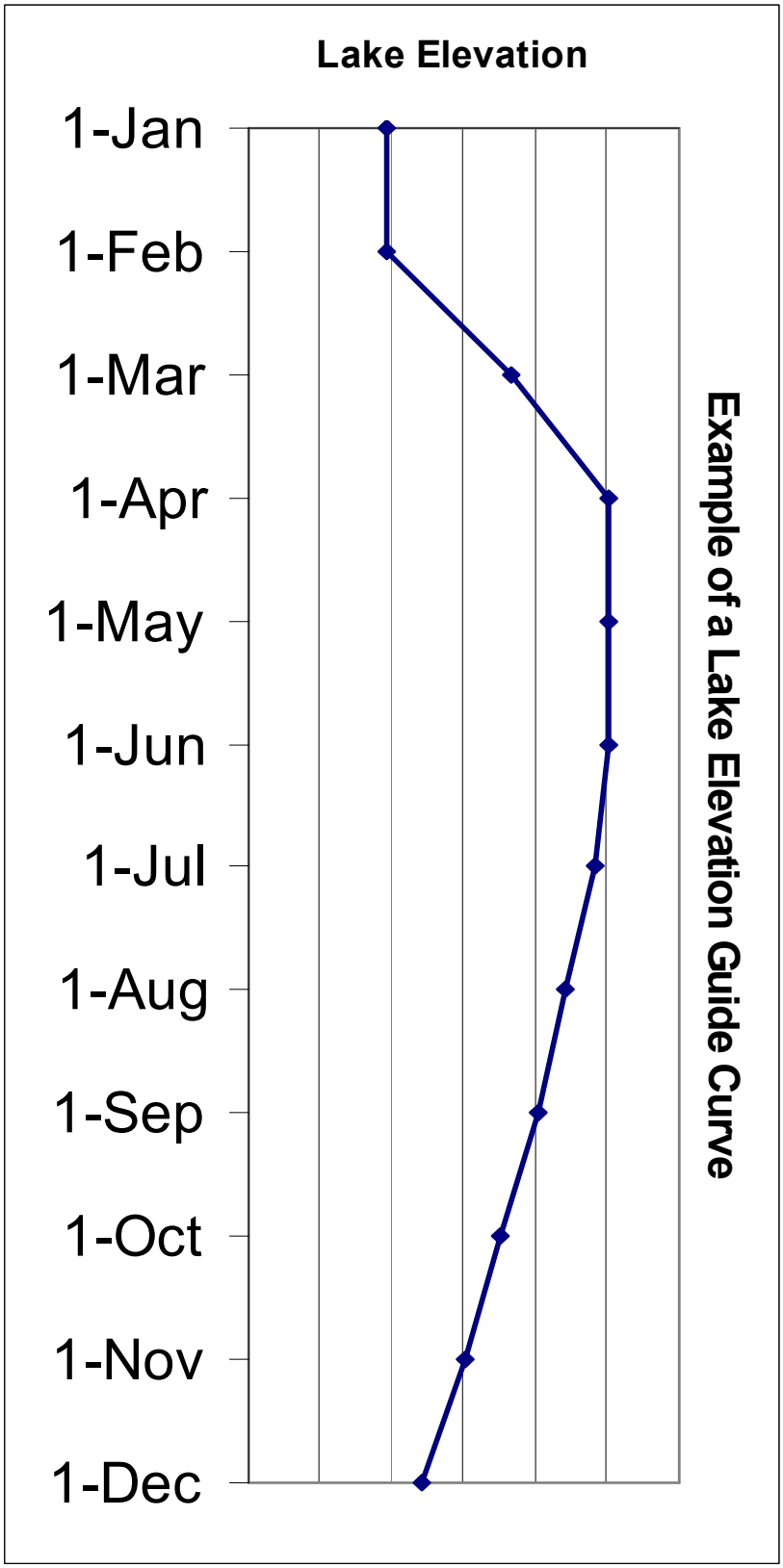
Part 2: Expected inflow to the reservoir over the next several weeks or months

- A release rate is calculated based on Parts 1 and 2, which is covered on the next several slides.
- The Corps may increase or decrease the calculated release if water quality conditions downstream warrant.

Lake Elevation Guide Curves

- The Corps has guide curves that define target lake elevations through the year
- Water above a future target level is available for making releases
- Target elevations are goals not rules—water quality is a higher priority

Example Guide Curve



Critical Lake Elevations from the Guide Curve

The Corps strives to keep the facilities open through the dates shown

- *Early Date Goals=minimum acceptable times for keeping facility open*
- *Late Date Goals=desired times for keeping the facility open*

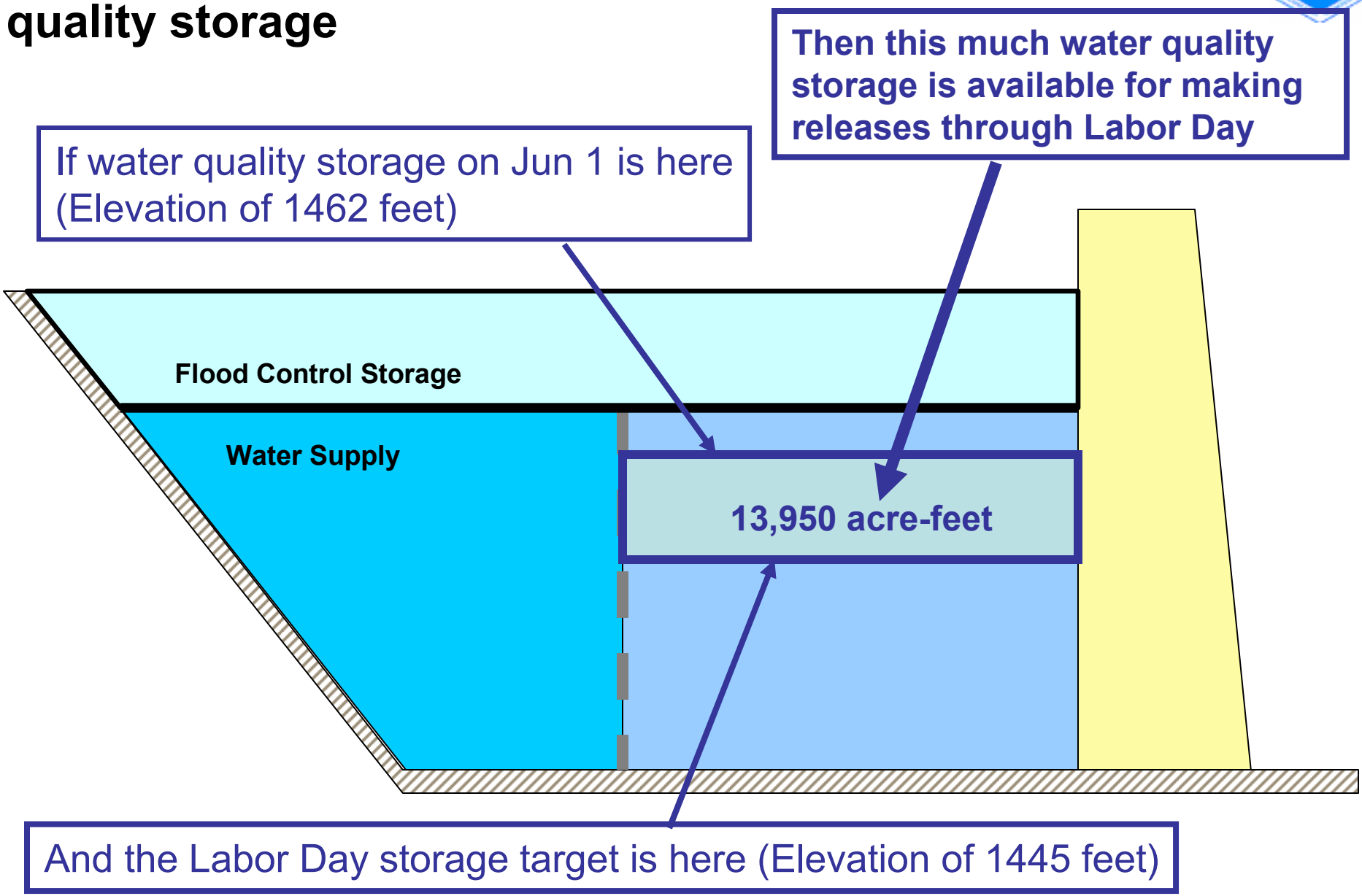
Facility	Critical Elevation	Corresponding Storage	Early Date Goal	Late Date Goal
Beach	1455 feet	78,694 acre-feet	Mid August	Early September
WV Boat Ramp	1445 feet	70,661 acre-feet	Early September	Early December
MD Boat Ramp	1420 feet	52,898 acre-feet	Late September	Early December

Part 1 – release based on available water quality storage

THE PROCESS:

1. Determine target storage using guide curve.
2. Subtract target storage from current storage to determine available volume for operations.
3. Available volume is divided by the number of days until storage target date to determine available daily release rate based on available storage.
4. Example follows.

Part 1 – release based on available water quality storage



Part 1 – flow released from storage

Example continued:

84,611 AF ← Total storage on June 1

-70,661 AF ← Target storage on Sep 1

=13,950 AF

The storage available for making a release is 13,950 acre-feet

Part 1 – flow released from storage

Example continued:

$$\begin{array}{r} 84{,}611 \text{ AF} \\ \underline{-70{,}661 \text{ AF}} \\ =13{,}950 \text{ AF} \end{array}$$

The Corps takes the available storage, divides by the number of days until Sep 1 and then converts to cubic feet per second (cfs)

$$\frac{13{,}950 \text{ AF}}{92 \text{ days}} = \textbf{151.6 acre-feet per day} = \textbf{76 cubic feet per second (cfs)}$$

Summary of Part 1 of the Water Quality Release for this Example

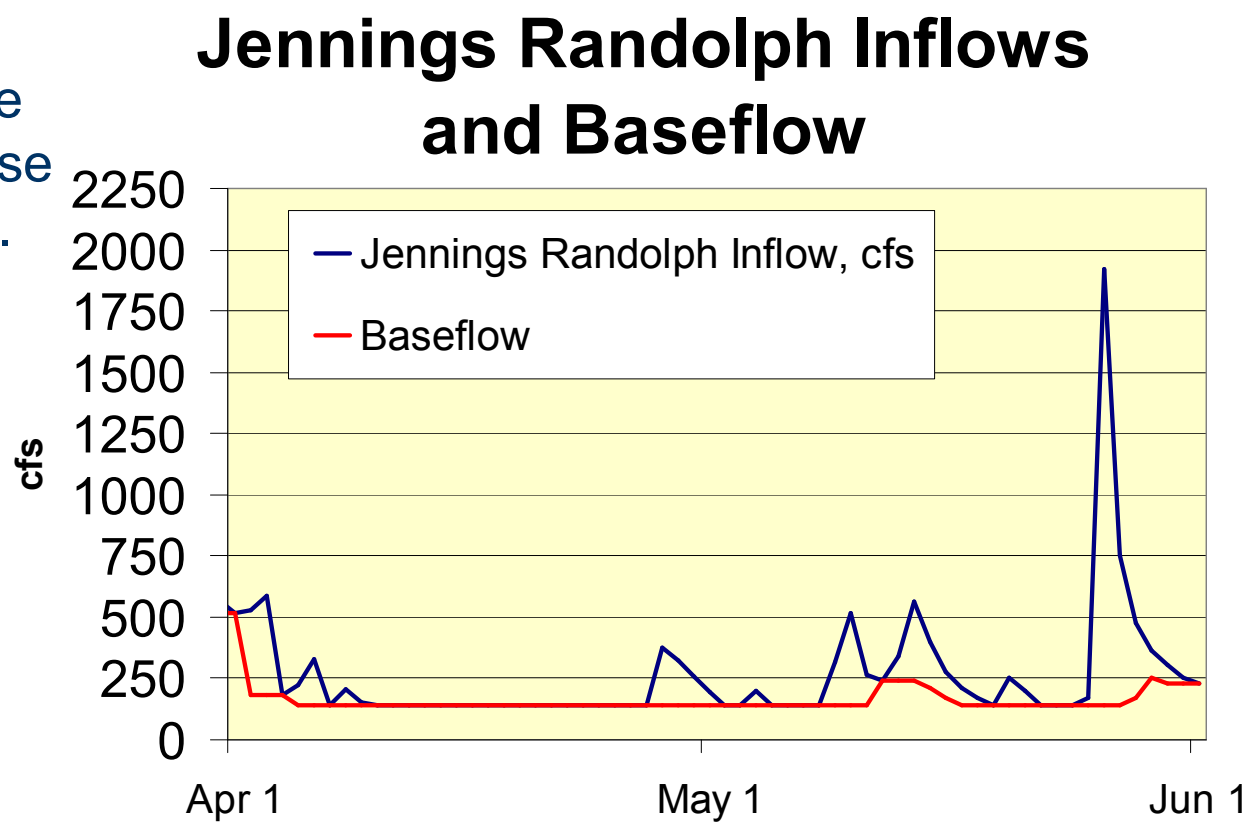
- 13,950 AF of storage is currently available for making a release
- The storage target is 92 days away, so the 13,950 AF will be used equally for the next 92 days.
- That means 76 cfs is the portion of the release that will come from available storage
- Additional water will be released based on expected inflows—this is covered next

Part 2 – flow based on expected reservoir inflows

- The Corps forecasts expected inflow based on recent conditions:
  - If conditions have been dry, they are expected to remain dry.
  - If it has been wet, it is expected to remain wet
- In dry conditions→more conservative approach
- Uncertainty and flexibility

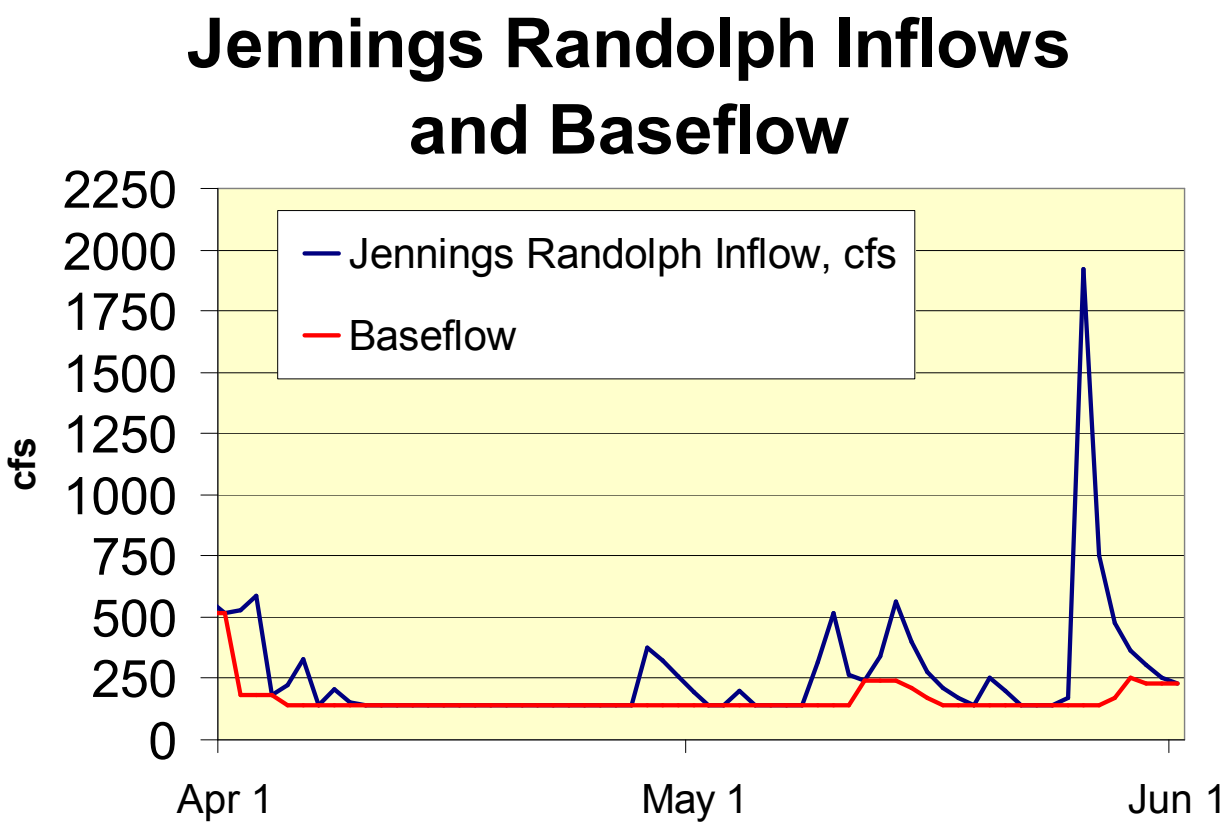
Part 2 – flow based on expected reservoir inflows

First, recent inflows are examined to get a sense of baseflow conditions. In other words, short term rises in flow are usually ignored. The graph shows a hypothetical example.



Part 2 – flow based on expected reservoir inflows

For our example, on June 1, inflow to Jennings Randolph as determined by baseflow is about 250 cfs.



Determining the percentile of recent inflows

- Historical data used to determine percentile of recent inflows
- The data are from 1925-1995
- If recent inflow is similar to the 30th percentile historical flow, then 30th percentile flows are expected to continue in the near future

Determining the percentile of recent observed inflow for the example

	Jennings Randolph Reservoir Inflow Percentile and corresponding inflow by month, units of cfs						
	1%	3%	10%	30%	50%	70%	90%
January	113	119	254	415	576	825	1,061
February	200	214	305	538	772	927	1,201
March	405	[illegible]	[illegible]	[illegible]	[illegible]	[illegible],205	1,513
April	238	[illegible]	[illegible]	[illegible]	[illegible]	992	1,216
May	170	[illegible]	[illegible]	[illegible]	[illegible]	753	967
June	70	[illegible]	[illegible]	[illegible]	[illegible]	442	602
July	32	[illegible]	[illegible]	[illegible]	[illegible]	282	517
August	29	31	53	74	152	218	425
September	23	29	34	62	85	147	345
October	25	28	39	82	119	206	470
November	32	46	101	179	263	360	574
December	71	97	175	395	515	670	924

This table is an ICPRB adaptation of the charts the Corps uses for determining the percentile of recent flows

Determining the percentile of recent observed inflow for the example

We start by finding the row of the current month. It is **June** in our example.

	Jennings Randolph Reservoir Inflow Percentile and corresponding inflow by month, units of cfs						
			10%	30%	50%	70%	90%
			254	415	576	825	1,061
			305	538	772	927	1,201
			588	752	934	1,205	1,513
April	238	350	441	580	815	992	1,216
May	170	187	232	357	664	753	967
June	70	74	99	173	249	442	602
July	32	40	62	97	142	282	517
August	29	31	53	74	152	218	425
September	23	29	34	62	85	147	345
October	25	28	39	82	119	206	470
November	32	46	101	179	263	360	574
December	71	97	175	395	515	670	924

Determining the percentile of recent observed inflow for the example

We then find a flow close to calculated recent inflow in June's row within the table. Our inflow was 250 cfs, pretty close to 249 cfs

	Jennings Randolph Reservoir Inflow Percentile and corresponding inflow by month, units of cfs						
				30%	50%	70%	90%
				15	576	825	1,061
				38	772	927	1,201
				52	934	1,205	1,513
April	238	350	441	580	815	992	1,216
May	170	187	232	357	664	753	967
June	70	74	99	173	249	442	602
July	32	40	62	97	142	282	517
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Determining the percentile of recent observed inflow for the example

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May	170	187	232	357	664	753	967
June	70	74	99	173	249	442	602
July	32	40	62	97	142	282	517
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September	23	29	34	62	85	147	345
October	25	28	39	82	119	206	470
November	32	46	101	179	263	360	574
December	71	97	175	395	515	670	924

Then we work our way up from 249 cfs to find the percentile. 50th percentile in this example.

Projecting future inflow based on the percentile of recent inflow

Current month through end of forecast interval	1%	3%	10%	30%	50%	70%	90%
Jan 1 to Feb 1	113	118	257	427	576	823	1086
Feb 1 to Apr 1	478	492	557	746	865	1055	1266
Mar 1 to Apr 1	40					1188	1510
Apr 1 to Jun 1	33					851	990
May 1 to Jun 1	16					747	955
Jun 1 to Sep 1	6					311	477
Jul 1 to Sep 1	40	48	53	101	169	272	452
Aug 1 to Sep 1	29	32	53	74	150	221	415
Sep 1 to Dec 1	28	37	70	122	195	251	506
Oct 1 to Dec 1	28	43	79	136	223	291	679
Nov 1 to Dec 1	32	46	102	178	261	373	574
Dec 1 to Dec 31	71	97	175	395	515	678	950

This is a different table. This one is used for projecting inflow based on the percentile of recent inflow

Projecting future inflow based on the percentile of recent inflow

Current month through end of forecast interval	1%	3%	10%	30%	50%	70%	90%
Jan 1 to Feb 1	113	118	257	427	576	823	1086
Feb 1 to Apr 1	478	492	557	746	865	1055	1266
Mar 1 to Apr 1	401	540	591	760	930	1188	1510
Apr 1 to Jun 1	333	384	415	541	713	851	990
May 1 to Jun 1	169	183	231	374	654	747	955
Jun 1 to Sep 1	63	67	82	145	217	311	477
Jul 1 to Sep 1	40	48	53	101	169	272	452
Aug 1 to Sep 1	29	32	5				5
Sep 1 to Dec 1	28	37	7				6
Oct 1 to Dec 1	28	43	7				9
Nov 1 to Dec 1	32	46	10				4
Dec 1 to Dec 31	71	97	17				0

We start by finding the column for the percentile of recent baseflow. It was 50% from the previous slides

Projecting future inflow based on the percentile of recent inflow

Current month through end of forecast interval	1%	3%	10%	30%	50%	70%	90%
Jan 1 to Feb 1	113	118	257	427	576	823	1086
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Jul 1 to Sep 1	40	48	53	101	169	272	452
Aug 1 to Sep 1	29	32					15
Sep 1 to Dec 1	28	37					06
Oct 1 to Dec 1	28	43					79
Nov 1 to Dec 1	32	46	102	178	261	373	574
Dec 1 to Dec 31	71	97	175	395	515	678	950

Then we find the row of the table that corresponds to our forecast period.

Projecting future inflow based on the percentile of recent inflow

Current month through end of forecast interval	1%	3%	10%	30%	50%	70%	90%
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Jul 1 to Sep 1	40	48	53	101	169	272	452
Aug 1 to Sep 1	29	32					15
Sep 1 to Dec 1	28	37					06
Oct 1 to Dec 1	28	43					79
Nov 1 to Dec 1	32	46	1				74
Dec 1 to Dec 31	71	97	1				50

Then we find the flow where the percentile column and forecast interval row intersect. 217 cfs in this example.

Summary of Part 2 of the Water Quality Release for this Example

- Recent inflow approximately equivalent to the 50th percentile of historical flows.
- So 50th percentile inflows are expected to continue for the forecast interval.
- From Jun 1 to Sep 1 within the historical record, 50th percentile inflows equal about 217 cfs.
- So on average 217 cfs is expected to flow into JRR for the forecast interval, so this amount can be added to the water quality release with minimal risk of an unexpected drop in storage.

The Preliminary release estimate is the sum of part 1 and part 2

- Part 1: Total flow rate available from storage in example is 76 cfs.
- Part 2: The calculated release rate that is available from expected inflow is 217 cfs.
- Total release is 76 cfs + 217 cfs = **293 cfs.**

Additional Considerations

- Downstream recreational activities
- Weather forecasts
- Upcoming events such as fish surveys
- Need for AVFs
- Unusual water quality conditions (e.g., Georges Creek acid mine drainage)
- In lake fish spawning
- Ecological concerns

Determining the Final Release

- Preliminary release is calculated based on Parts 1 and 2 above
- The release may be adjusted based on some of the considerations mentioned on the previous slide
- The release is re-evaluated as needed, at least once a week

Savage Reservoir Operations

- Similar procedures are followed for Savage Reservoir.
- The Corps uses a guide curve that defines target storage levels throughout the year
  - Part of the release is determined from available storage based on future targets
- The Corps also examines inflows and bases part of the release on expected inflow conditions
- These two factors determine a preliminary release
- The Corps may change the preliminary release based on other considerations such as water quality or recreation

Minimum Releases

- The minimum permissible **releases** from Jennings Randolph Reservoir (JRR) and Savage Reservoir Dam (Savage) are set at 50 cfs and 20 cfs, respectively.
- The required minimum flow at Luke is 93 cfs but the reservoirs are normally regulated to provide a minimum of 120 cfs at Luke.
- Since 1982, the lowest daily gaged flow at Luke was 113 cfs occurring in January of 1991 according to the USGS.

Potomac Reservoir and River Simulation Model (PRRISM)

- Simulation model for evaluating water supply reliability for D.C. metro area
- Water quality operations at Jennings Randolph and Savage Reservoir affect Potomac flows all the way down to D.C., so these operations are modeled in detail within PRRISM
- Conducted calibration and verification in 2003
- PRRISM will be modified to support this new study of water quality and water supply operations

PRRISM Overview

- Inputs
  - Historical flows into the reservoirs and at other points throughout the Potomac Basin, data covers 1929 through 2002
  - User-selected alternatives
- Calculations
  - Simulation of Corps water quality operations
  - Simulation of ICPRB water supply operations
  - Simulation of releases and resulting flows on a daily timestep
- Outputs
  - Reservoir storage
  - Reservoir release rates
  - Flow at Luke, Little Falls (Washington, D.C.)
  - Metrics for stakeholder interests

What does PRRISM tell us?

- PRRISM simulates current day operations using historical flow conditions
- *What if tests*
- Historical flows provide a variety of conditions (droughts, average years, wet years all with different patterns) for testing the performance
- *PRRISM tells us what is likely to happen as a result of various operational rules under a wide range of hydrologic conditions*

PRRISM Needs to Cover All Important Issues

- Already measures impacts to water supply
- Add calculations to cover other important issues:
  - Frequency of meeting flow and lake level targets
  - Impacts of flow on temperature profiles
  - Impacts of flow on trout habitat suitability
  - Impacts of operation rules on ability to make whitewater releases and meet recreational fishing targets
  - And more…

How are we going to change PRRISM?

- We will also begin adding features so that we can tweak the operational guidelines and test new ideas
- We are building a Post-Processor for PRRISM. This will be an Excel database with interactive displays of results.

North Branch Viewer

Outputs include:

- Daily JRR releases (WQ, WS and spill)
- Daily savage releases
- Daily JRR and savage elevations
- Daily storage for JRR WQ, WS and Savage
- Daily flows at Luke
- Occurrence of whitewater releases
- Flows and reservoir storage in DC region

Ensuring PRRISM is Accurate

- ICPRB will be working with the Corps to make sure PRRISM accurately represents current operations
- Calibration and validation was done in 2003 (see next several slides), but due to changes in water quality conditions and operations, there is a need to revisit calibration and validation.

THE END