Balancing Surface Water and Groundwater at the Portland Water Bureau

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Portland Water Bureau
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PORTLAND WATER BUREAU
FROM FOREST TO FAUCET

Portland's Water System

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A Tale of Two Sources

- 1st source – Bull Run River
  - A river with two dammed reservoirs in a protected watershed.
  - Developed over 100 years ago.
  - Clean, soft, good-tasting water.
  - Flows by gravity about 25 miles to 1st in-town storage.
  - Peak capacity of treatment & transmission system is about 225 MGD – more than peak day demand

Surface Water

- Water is screened & chlorinated at Headworks
- Ammonia added at a downstream facility to complete chloramination process
- Plenty of CT in conduits
- NaOH added to raise pH slightly
- In winter, most of the Bull Run watershed water ends up in the river

Figure 2-5. Reservoir 1 and Concrete Gravity Arch Dam 1

Dam 1 at Reservoir 1

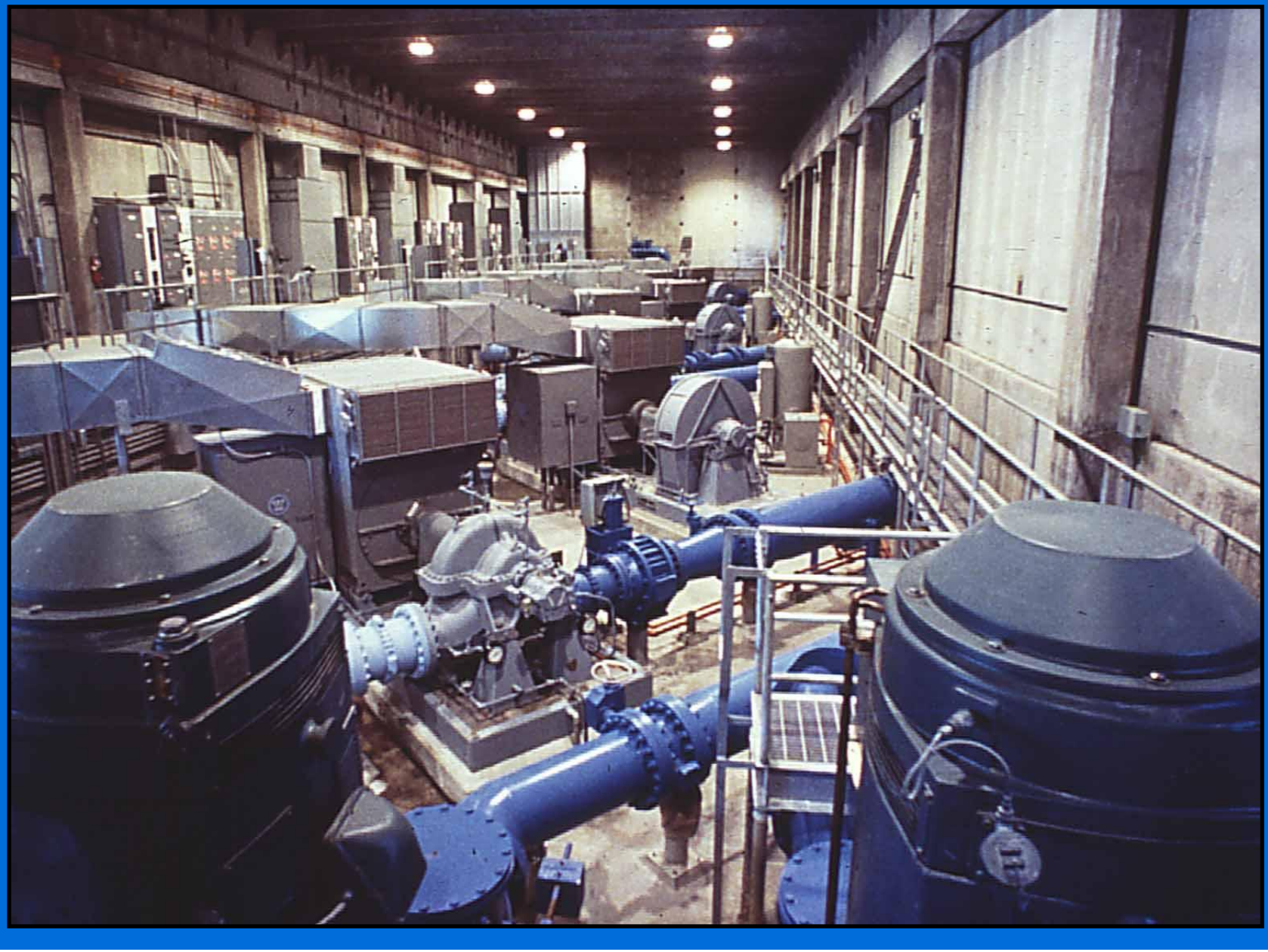
The Upper Reservoir

Groundwater—A Backup and Augmentation Source Closer to Home

- 2nd Source
- PWB explored potential well sites via a pilot well program in late 1970's.
- Purchased land & got easements for the "Columbia South Shore Well Field".
- First 19 wells, Groundwater Storage Tank, Groundwater Pumping Station, and treatment facilities built between 1980 and 1984.

Lowering the pump/motor assembly through the wellhouse into the well

Groundwater Booster Pump Gallery



Groundwater System Overview

- 27 Active Supply Wells
- 600 to 8,000 GPM each
- Capacity: 100 MGD (million gallons/day) at start-up
- Capacity is >winter demand, <summer demand
- About 75 MGD after 90 days of pumping
- Other Groundwater Infrastructure:
  Groundwater pump station
  - Six 2350 HP pumps
  - Two 500 HP "jockey" pumps
  - By far PWB's biggest pump station, with a 12.5 MW electrical sub-station

Groundwater System Overview

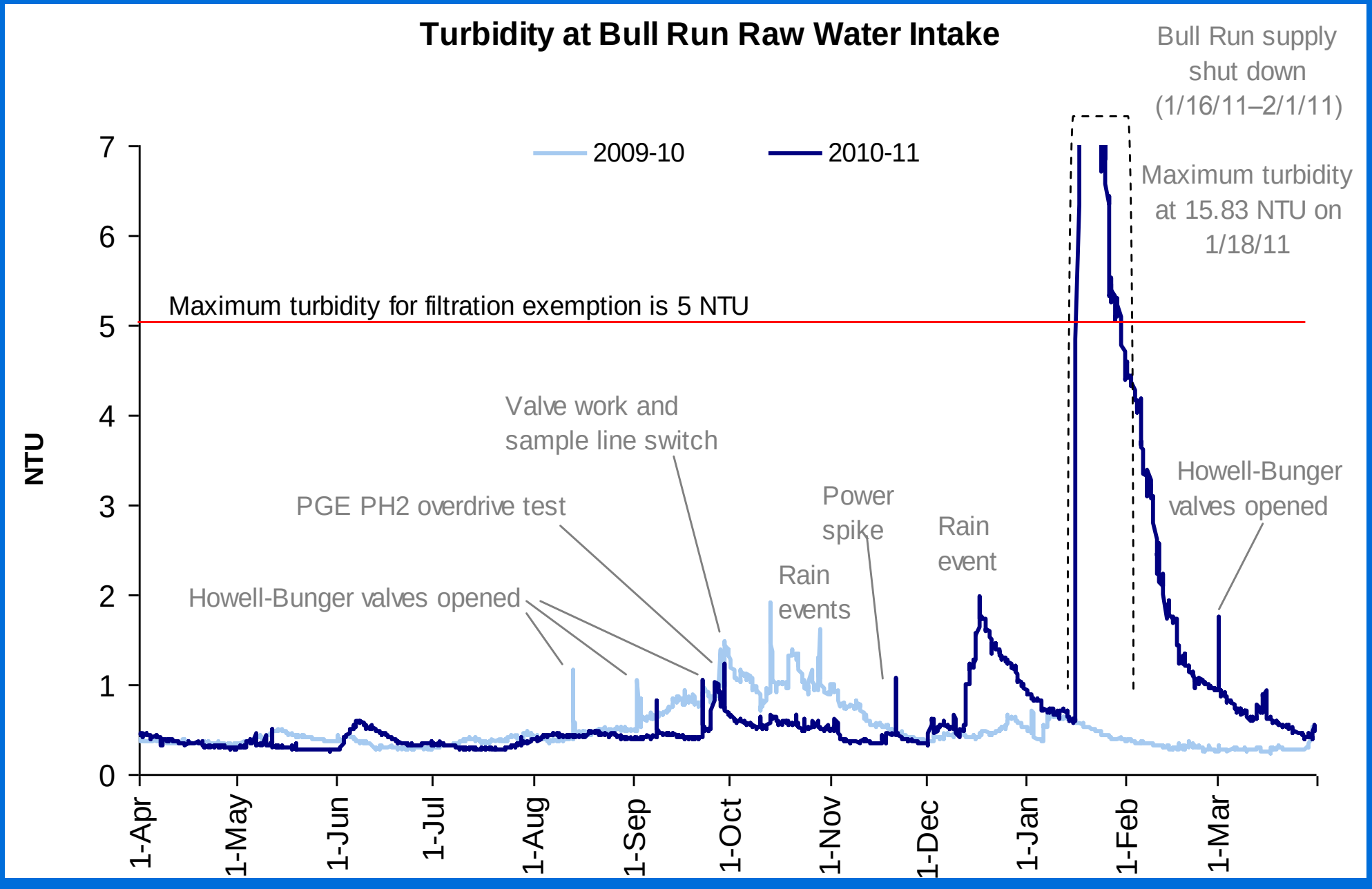
- 2 MG GW storage tank
- New improved treatment system
  - Chlorine added before tank, ammonia after
  - pH adjustment with NaOH if needed

Primary Uses of Groundwater System

1. To replace surface water when turbidity approaches 5 NTU – this generally only occurs in late fall, winter, or early spring, when demand is (fortunately) low.

   Decision-making for this use is straight-forward.

   Note that both because the SW source is normally high-quality, and because we have GW as a back-up, the need for SW filtration is reduced.



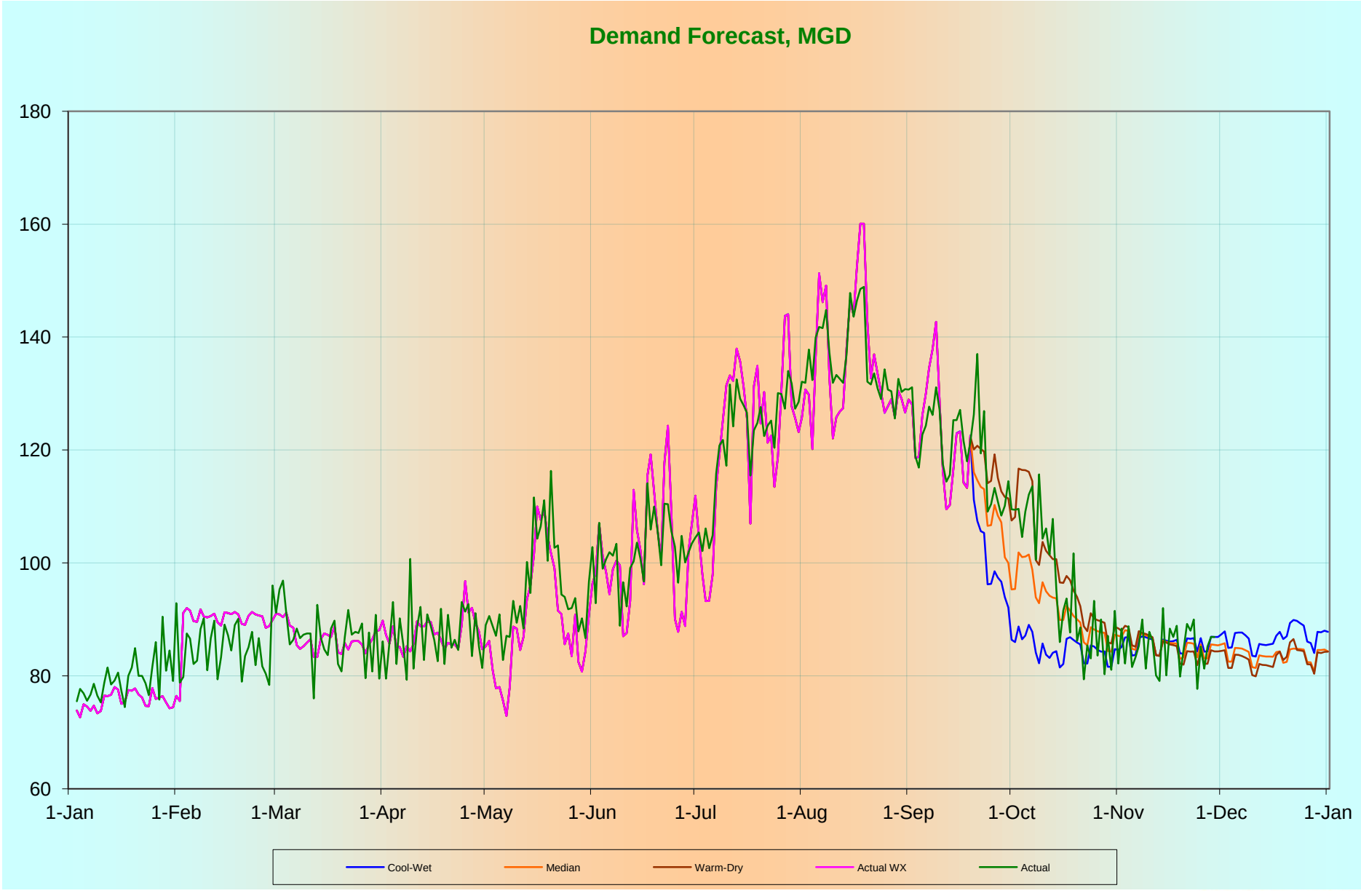
High turbidity triggered GW use in 2011

Primary Uses of GW, cont'd

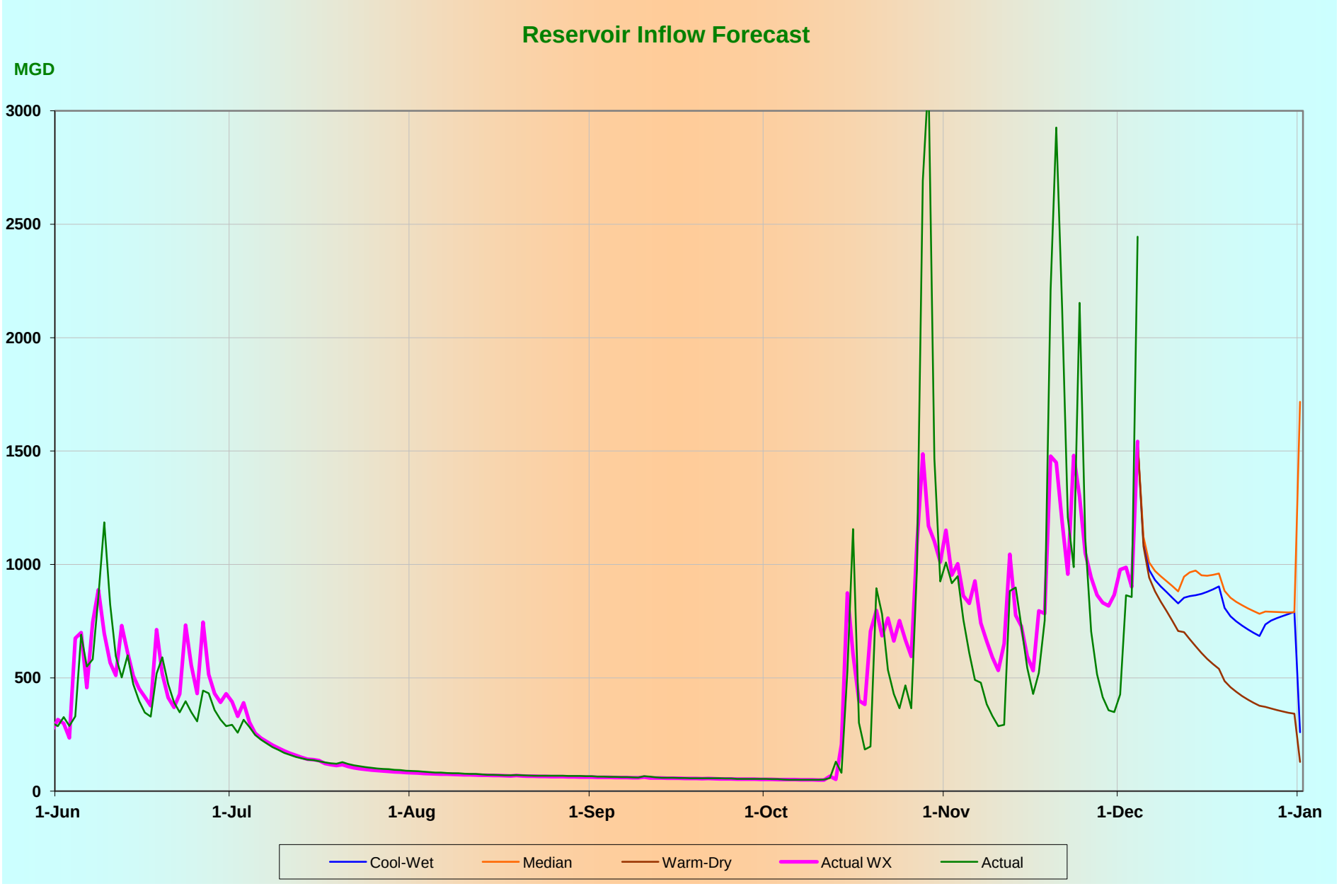
2. To augment Bull Run surface water during a summer when demand is expected to deplete storage in Bull Run reservoirs.

- Annual flow in the Bull Run River vastly exceeds annual demand
- So why do we need groundwater for augmentation?

Demand Peaks in Summer



Reservoir Inflow Pattern



A Big Mismatch Between Demand and Reservoir Inflow

- Like most of western Oregon and Washington, our highest demand is when streamflow is lowest.
- So how do we ensure that we meet peak demands in the season when we have the least reservoir inflow?
- 9.9 Billions gallons of dammed storage, that's how.

And –

- We prepare and implement the Summer Supply Plan.
- Excerpts from this year's Plan:
  - Population supplied by Portland Water Bureau (PWB) system for the 2013 peak season is about 940,000, including retail and wholesale customers (welcome, Sandy!) and accounting for wholesale customer offloads.
  - Peak season ave. water demand is about 120 MGD

Supply Planning - Goals

- The bureau strives to supply water that has a better water quality than required by regulations.
- Supply reliability is ensured by carefully managing the use of primary water resources, employing conservation strategies, and preparing for the potential use of contingency resources.

Fish Play a Role in Managing the Bull Run System

- At times many years ago, the summer flow in the Bull Run River below Water Bureau's Headworks was very low.
- The Water Bureau needs to comply with the Endangered Species Act and Clean Water Act for its water supply operations.
- Therefore, PWB releases flows into the lower Bull Run River to improve habitat conditions for fish, pursuant to the regulations and the PWB Bull Run Water Supply Habitat Conservation Plan.

As part of ESA compliance, the bureau monitors listed fish species in streams.

Fish in the Bull Run River

- State and federal rules also require meeting temperature objectives designed to protect aquatic habitat. So we monitor and manage temperature to aid recovery of ESA-listed steelhead, coho, and Chinook.

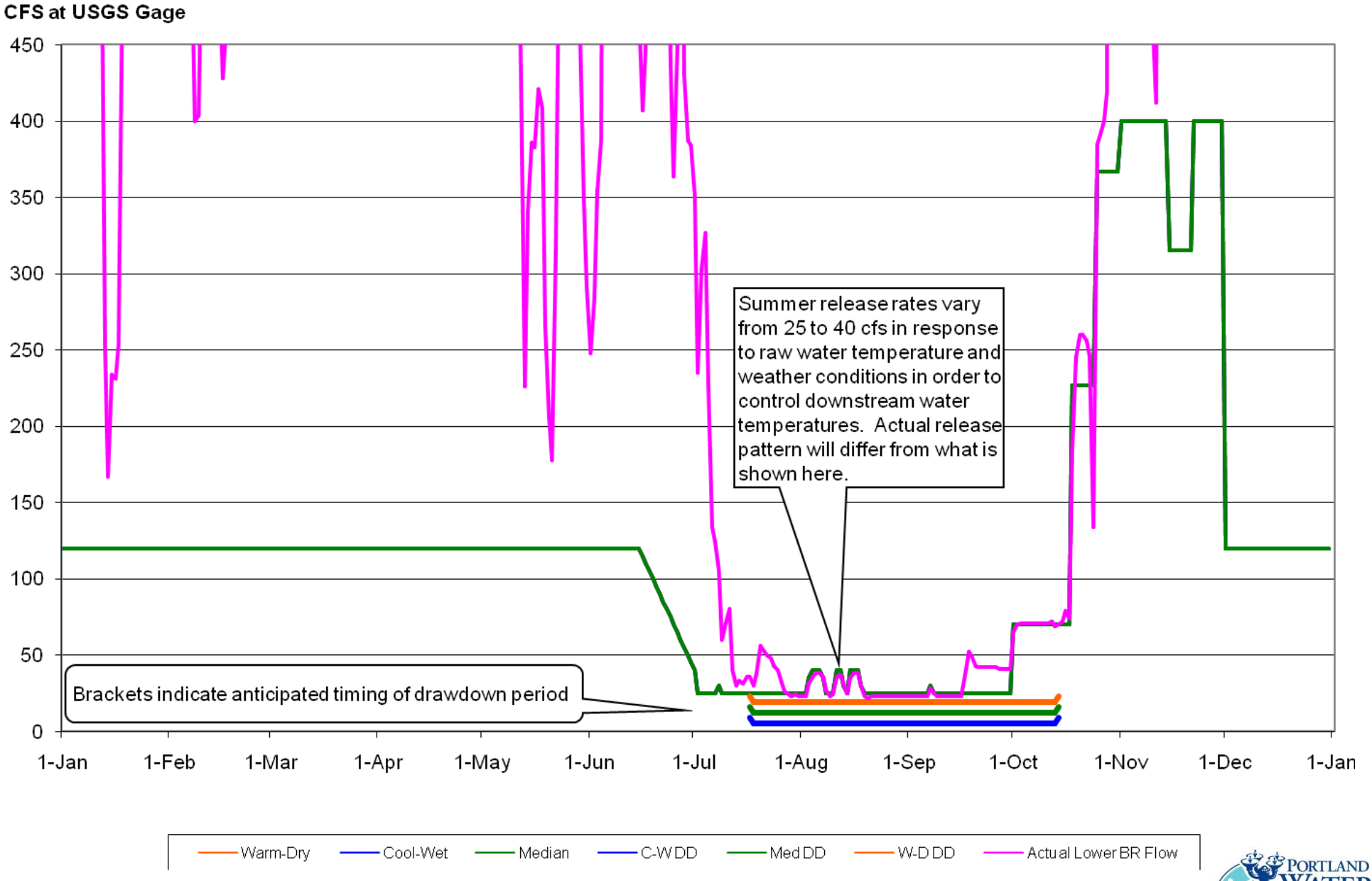
- We also have a fish-related capital project underway: Dam 2 Tower Improvements

  Vertical sliding gates allow selective-depth withdrawal of water from a large reservoir.

  This will provide for better water temperature management, and "banking" of cool water that can be released for fish in the summer.

  Cost: about $35 million

2012 Downstream Releases for Fish Habitat



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Balancing the Cost of Surface Water and Groundwater

- From the surface water source, the water flows by gravity to storage in east Portland (Powell Butte).
- In contrast, groundwater is intercepted lower in the hydrologic cycle. It must be pumped twice – once from the well to the Groundwater Storage Tank, and from there to the 50 MG Powell Butte tank. The typical electrical cost of pumping groundwater is about $400 – $500 per million gallons, or roughly $0.33 per CCF.
- Bottom line: groundwater involves greater energy costs.

Balancing the Cost of Surface Water and Groundwater

- Also: the different water quality (e. g. hardness) of groundwater triggers higher operational costs of some industrial or HVAC water systems.
- Note that surface water also has substantial costs for continued compliance with regulations, but because surface water is the primary source, these are fixed costs.
- Therefore: the Bureau strives to balance use of groundwater and other augmentation sources to be cost-effective while meeting all other objectives.

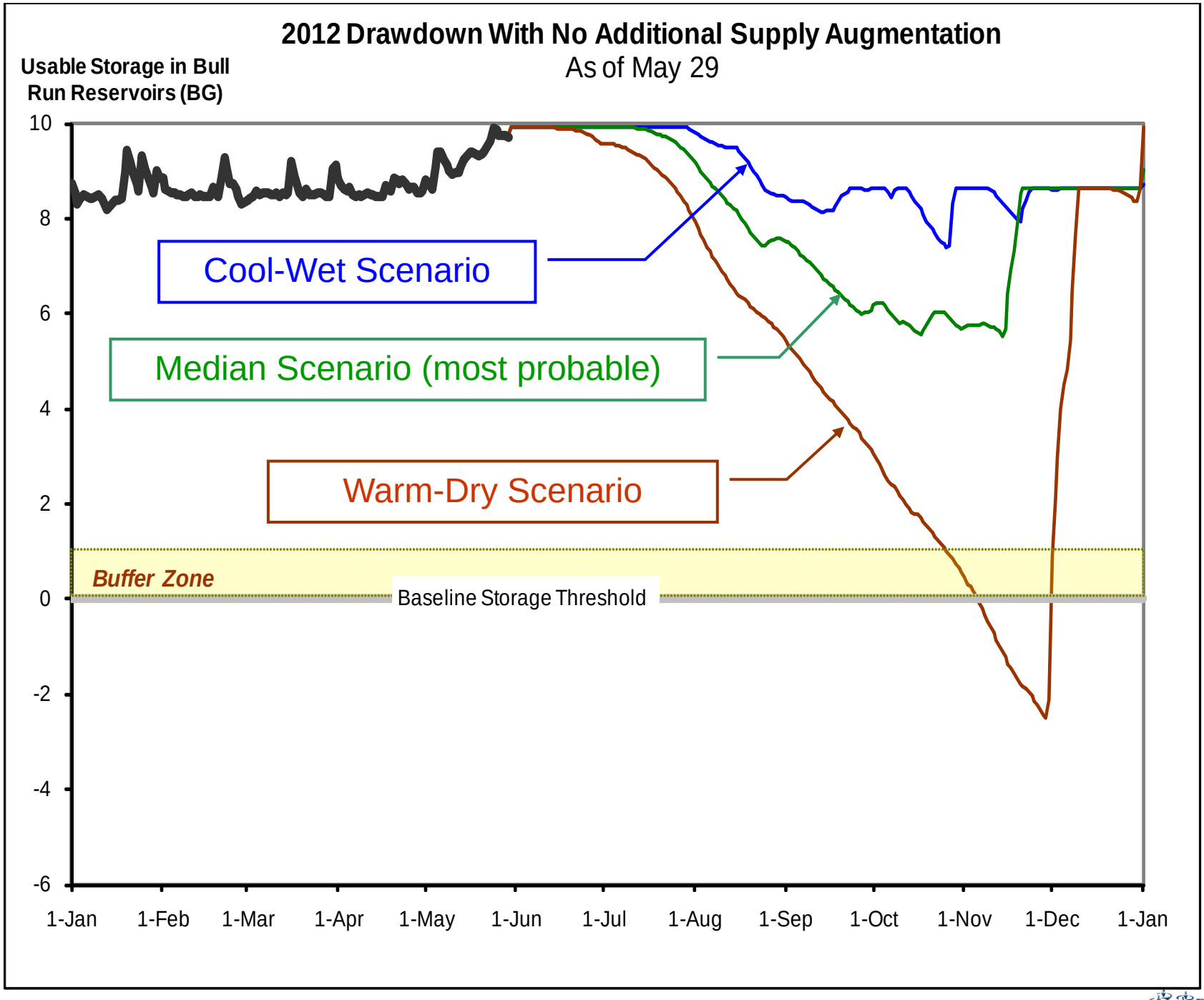
- This balance can be difficult to budget for – in any given year, we won't know whether we'll need groundwater for augmentation, or turbidity, or neither.
- We budget for an average year's electrical costs.
- So: the incremental cost of power for groundwater is a budgetary concern.

Summer Supply Planning – Implementation

- Every year, starting in the spring, staff updates the Summer Supply Plan, and we have a series of meetings to monitor demand, storage, fish habitat and flow, operational readiness, and other constraints.
- Management, with input from stakeholders, makes decisions about dam operations, reservoir level targets, fish flow, and whether to run the groundwater system.
- We've developed two analytical tools to help decide when to turn on groundwater.

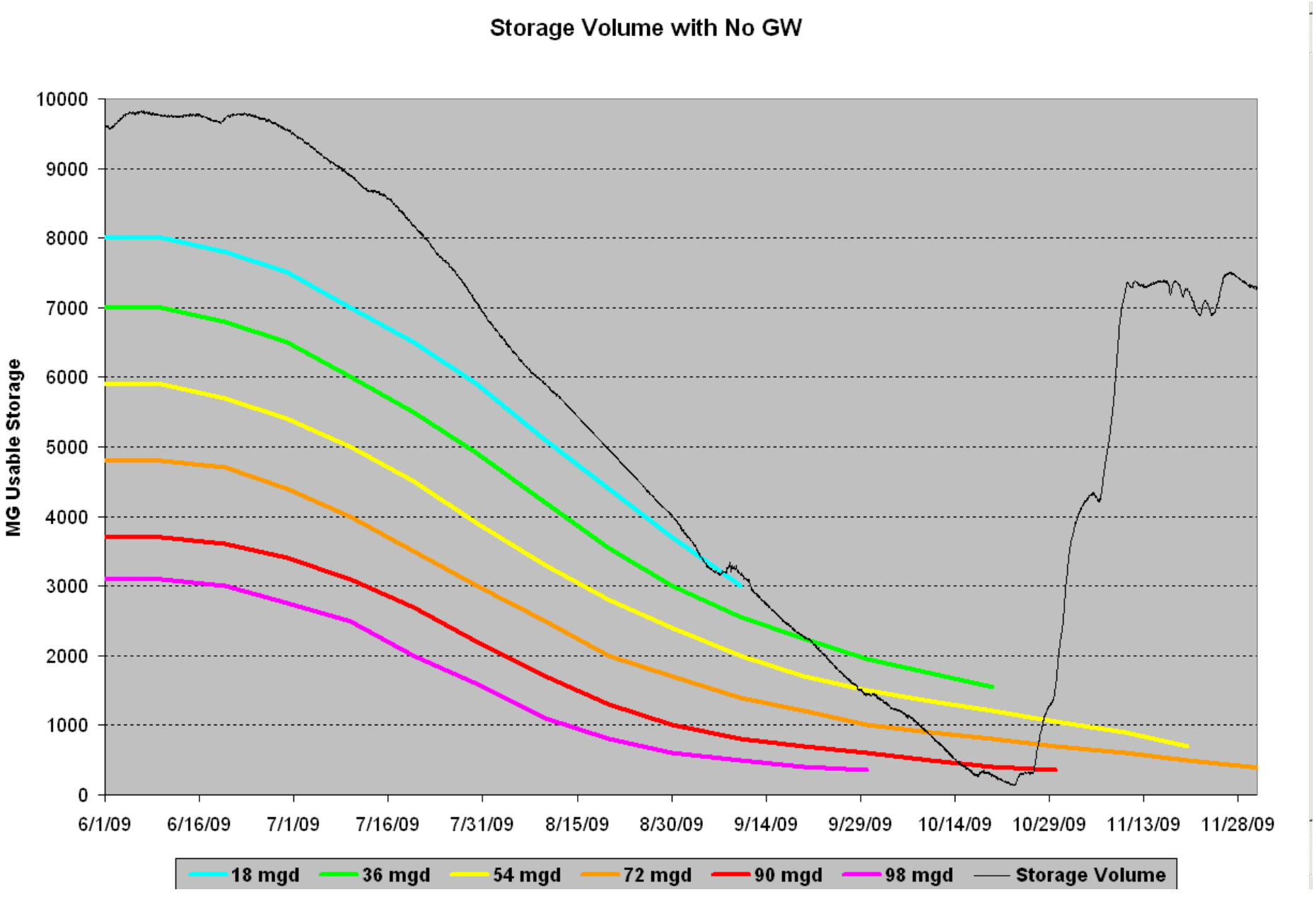
Bull Run Precipitation–Runoff Model

- Uses weather forecasts and models the effect of precipitation and temperatures on streamflows.
- Demands are forecast based on temperature forecasts, and population & historical trends.
- Uses 73 years of actual weather and streamflow data to make probabilistic projections beyond the weather forecast.
- Served us well for many years.


2012 Drawdown With No Additional Supply Augmentation
As of May 29
Usable Storage in Bull Run Reservoirs (BG)
10
8
6
4
2
0
-2
-4
-6
Cool-Wet Scenario
Median Scenario (most probable)
Warm-Dry Scenario
Buffer Zone
Baseline Storage Threshold
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
1-Jan

Groundwater Use Model

- PWB is transitioning to this new model.
- Uses 73 years of past daily data and estimated demand, but not weather forecasts.
- Actual streamflow is combined with rule-based fish flow releases, and estimated current year demand, to develop a drawdown curve for past years.
- Based on this, on any day during drawdown, knowing the actual drawdown, the spreadsheet predicts the ave. GW rate needed to avoid dropping below baseline storage.
- We attempt to avoid pumping in years when no GW is needed, and start pumping soon enough to avoid running out in worst-case years.



Each colored line corresponds to one add'l pump-motor "main unit", about 18 MGD

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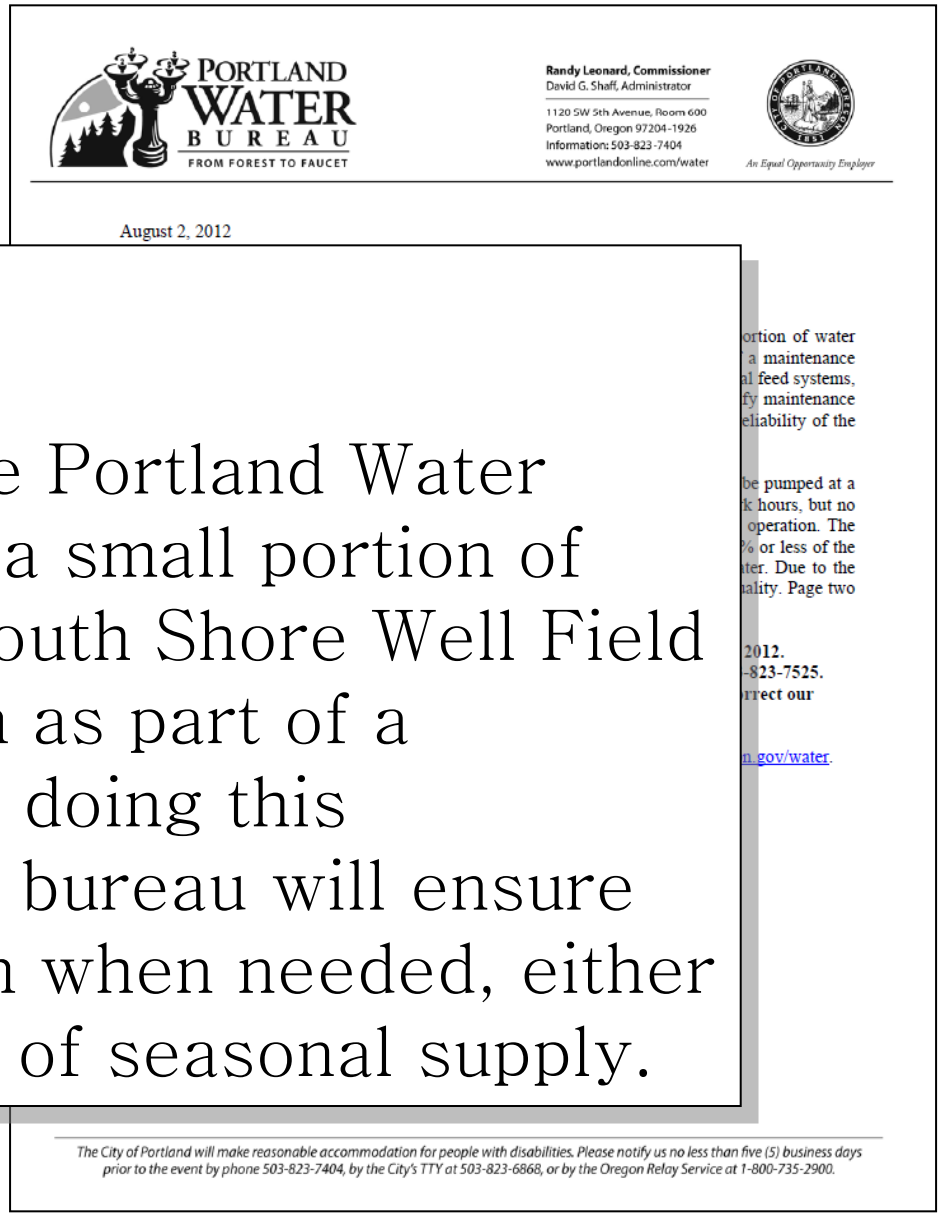
The Decision to Augment with GW

- Once we decide to run groundwater, the Operations team performs checks and readies the treatment system.
- The Public Information group notifies wholesale customers and sends out notifications.
- We also send out notifications when we do an annual, 8-10 day maintenance run of groundwater:



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The City of Portland will make reasonable accommodation for people with disabilities. Please notify us no less than five (5) business days prior to the event by phone 503-823-7404, by the City's TTY at 503-823-6868, or by the Oregon Relay Service at 1-800-735-2900.

Dear Customer,

On Monday, August 6th, the Portland Water Bureau will begin blending a small portion of water from the Columbia South Shore Well Field into the distribution system as part of a maintenance operation...By doing this maintenance operation, the bureau will ensure the reliability of the system when needed, either in an emergency or as part of seasonal supply.

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Blending

- When we use GW for augmentation or during the maintenance run, GW is blended with SW at Powell Butte storage.
- In the last 4-5 years, we've been shifting from starting GW only when we are certain to need it, and sometimes at a high blend ratio, to starting GW sooner and at a lower blend ratio. The models help determine when. We do accept some chance that we'll use GW when it turned out to be unnecessary.
- Advantages of starting early with a lower blend ratio are:
  - Less dramatic changes in water quality and taste
  - Some benefit from reducing extra electrical costs due to lower peak demand

PWB purchased a customized version of RTW WQ software to allow us to simulate blending more than 1 GW source with SW.

We use this tool to check pH and alkalinity.

Portland Water Bureau - RTW Blending Application Package

STEP 1: Press the button to start a new blending scenario

Start a New Scenario

	Units	Water 1	Water 2
Measured TDS	mg/L	79.6	29
Measured temperature	deg C	10	10
Measured pH		8.12	6.7
Measured alk, as CaCO3	mg/L	147	250
Measured Ca, as CaCO3	mg/L	84	210
Measured Cl	mg/L	5	10
Measured SO4	mg/L	16	24
Metal ion concentration	mg/L	5	5
Flowrate	MGD	10	5
Percent Blend of Each	%	66.7%	33.3%
Sum Flowrates:	**15**	**MGD**	

Portland Water Bureau - RTW Blending Application Package

Groundwater (from previous sheet)

Calculated TDS	79.6	mg/L
Calculated Temperature	10	deg C
Calculated pH	7.02	
Calculated alk, as CaCO3	181	mg/L
Calculated Ca, as CaCO3	126	mg/L
Calculated Cl	6.67	mg/L
Calculated SO4	18.67	mg/L
Metal ion concentration	5	mg/L
Flowrate	15	MGD
Percent Blend of Each	15.8%	%

STEP 1: Enter surface water characteristics

Surface Water

Measured TDS	29	mg/L
Measured temperature	10	deg C
Measured pH	6.70	
Measured alk, as CaCO3	8	mg/L
Measured Ca, as CaCO3	6	mg/L
Measured Cl	5	mg/L
Measured SO4	7	mg/L
Metal ion concentration	5	mg/L
Flowrate	80	MGD
Percent Blend of Each	84.2%	%

STEP 2: Enter amount of each chemical

General Water Quality Parameters of Bull Run Source Water

Parameter	Mean	Maximum
Turbidity (NTU)	0.73	15.83*
Fecal Coliform (cfu/100mL)	<1	6
Algae (cells/mL)	271	3,280
Giardia (cysts/L)	ND	0.1
Cryptosporidium (oocysts/L)	ND	ND
Temperature °C	9.1	18.5
pH (standard units)	7.0	7.4
Color, apparent (color units)	12	75
Alkalinity (mg/L CaCO3)	7.8	16

*No water with turbidity > 5 was served to public

General Water Quality Parameters of Bull Run Source Water

Parameter	Mean	Maximum
Hardness (mg/L CaCO3)	7.8	9.1
Specific Conductance (µS/cm)	21	33
Total Dissolved Solids (mg/L)	29	68
Total Organic Carbon (mg/L)	1.1	1.8

Abbreviations: ND–non-detect; mL–milliliters; L–liters; NTU–nephelometric turbidity units; cfu–colony-forming units; MPN–most probable number; µS–microsiemens; mg–milligrams; cm–centimeters.

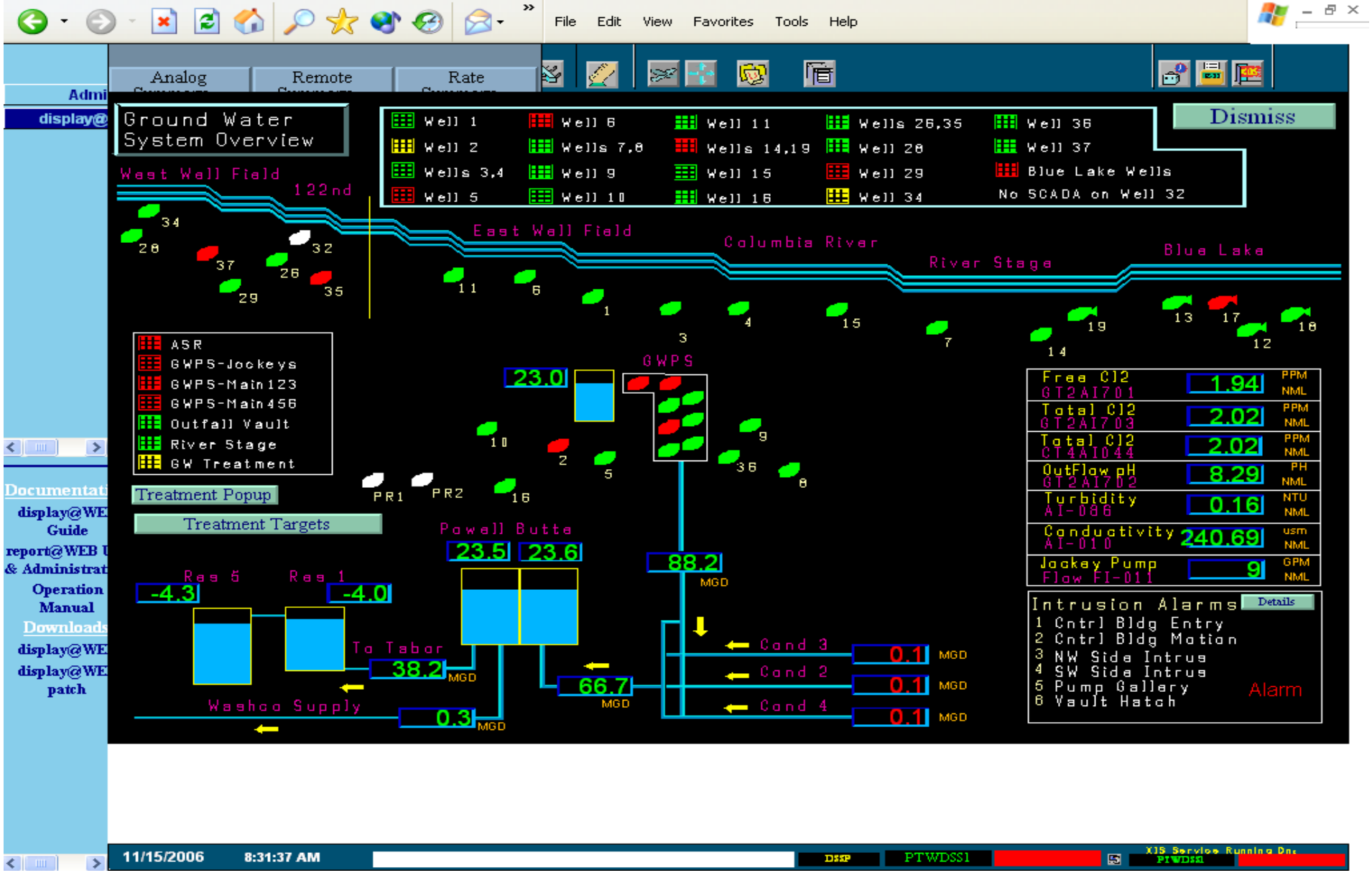
Water Quality Characteristics of Groundwater

- Result of long-term contact and interaction between groundwater and the aquifer matrix materials (closer to equilibrium with sediments)
- Mineral content is variable, and usually higher than surface water
- pH and alkalinity are usually higher than surface water
- Manganese is high in some wells

Groundwater Characteristics

- Temperature is cool (~10 °C to 16 °C) and stable
- Dissolved Inorganic Constituents:
- Major Ions (greater than 5 mg/L): bicarbonate, calcium, chloride, magnesium, silica, sodium, sulfate
- Minor Ions (0.01 to 10 mg/L): carbonate, fluoride, iron, manganese, nitrate, potassium

Real-Time Monitoring of Operations



Two Sources Reduce Vulnerabilities

Both sources have unlikely but different vulnerabilities.
Key elec. power supplies are widely separated.
Same earthquake would not affect both supplies the same due to physical separation.

GW Vulnerabilities

- Severe, highly unlikely Columbia River Flood could damage system (different than BR flood)
- Accidental contamination – unlikely due to Wellhead Protection Program & response capabilities
- Long-term aquifer drawdown is possible

SW Vulnerabilities

- High run-off or landslide-caused turbidity – generally short term
- Landslides can damage conduits – has happened several times
- Large watershed fire could result in ashfall, long-term turbidity

Summing Up

- Having two different types of storage improves overall system reliability and reduces vulnerability to extreme events.
- High-cost improvements to the surface water system, such as filtration, are not as urgent because of the back-up groundwater system.
- Groundwater helps extend the use of large raw reservoir water storage, and meet fish flow obligations.
- An interdisciplinary team of PWB staff, including Operations, Regulatory Compliance, Resource Protection, and upper management successfully plan and manage use of the two sources, especially in the high demand season.

Acknowledgments

Thanks to:

- Doug Bloem
- Dave Evonuk
- Kristin Anderson
- Jessica Letteney
- Randy Albright
- LT2 Variance Team

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More information:

http://www.portlandoregon.gov/water/article/284875

Thanks for listening

Any Questions?