Portland Water System & PUMA

Lorna Stickel & David Evonuk
Resource Protection & Engineering
Work Groups

PORTLAND WATER BUREAU
FROM FOREST TO FAUCET

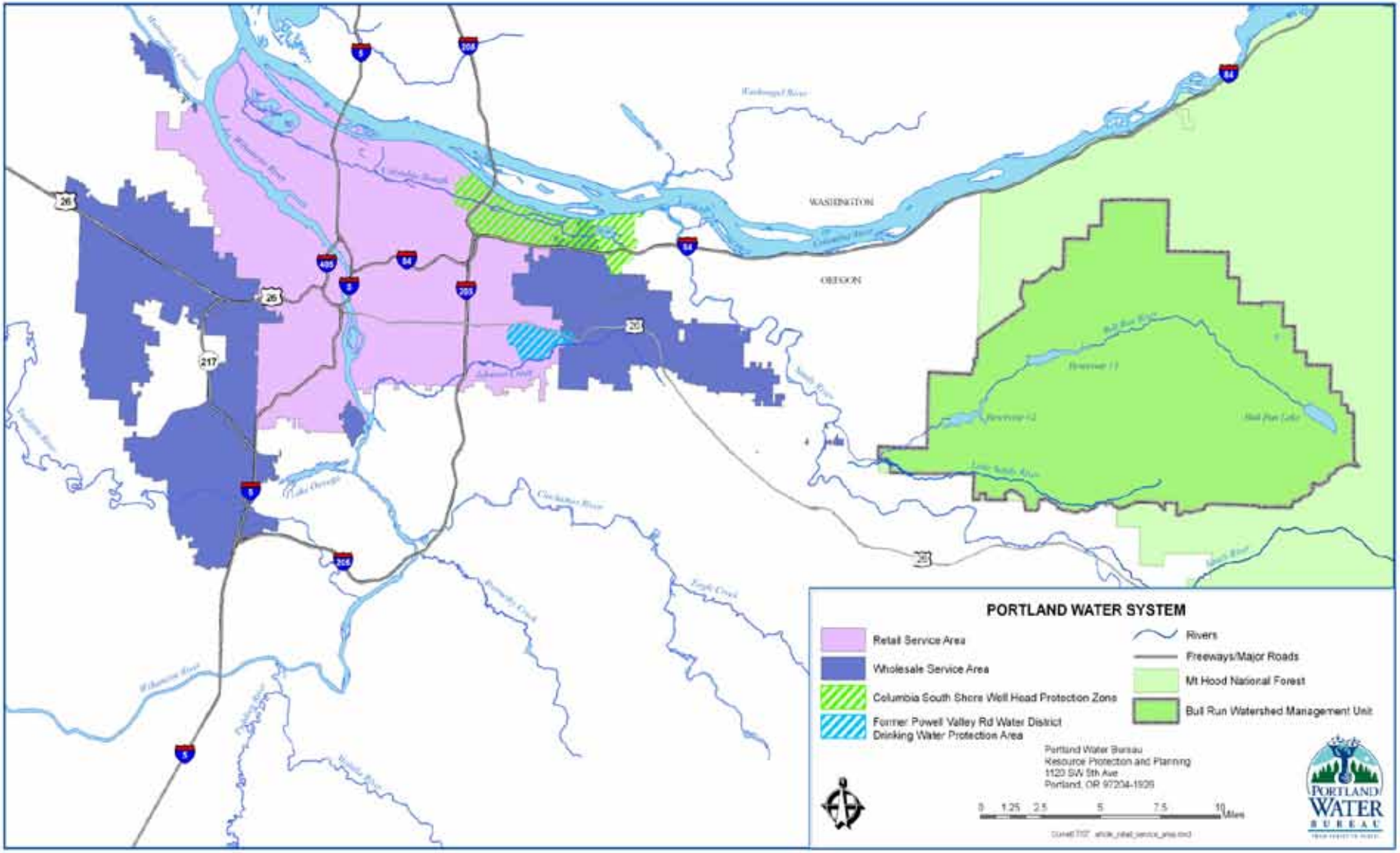
CITY OF PORTLAND, OREGON 1851

Presentation Overview

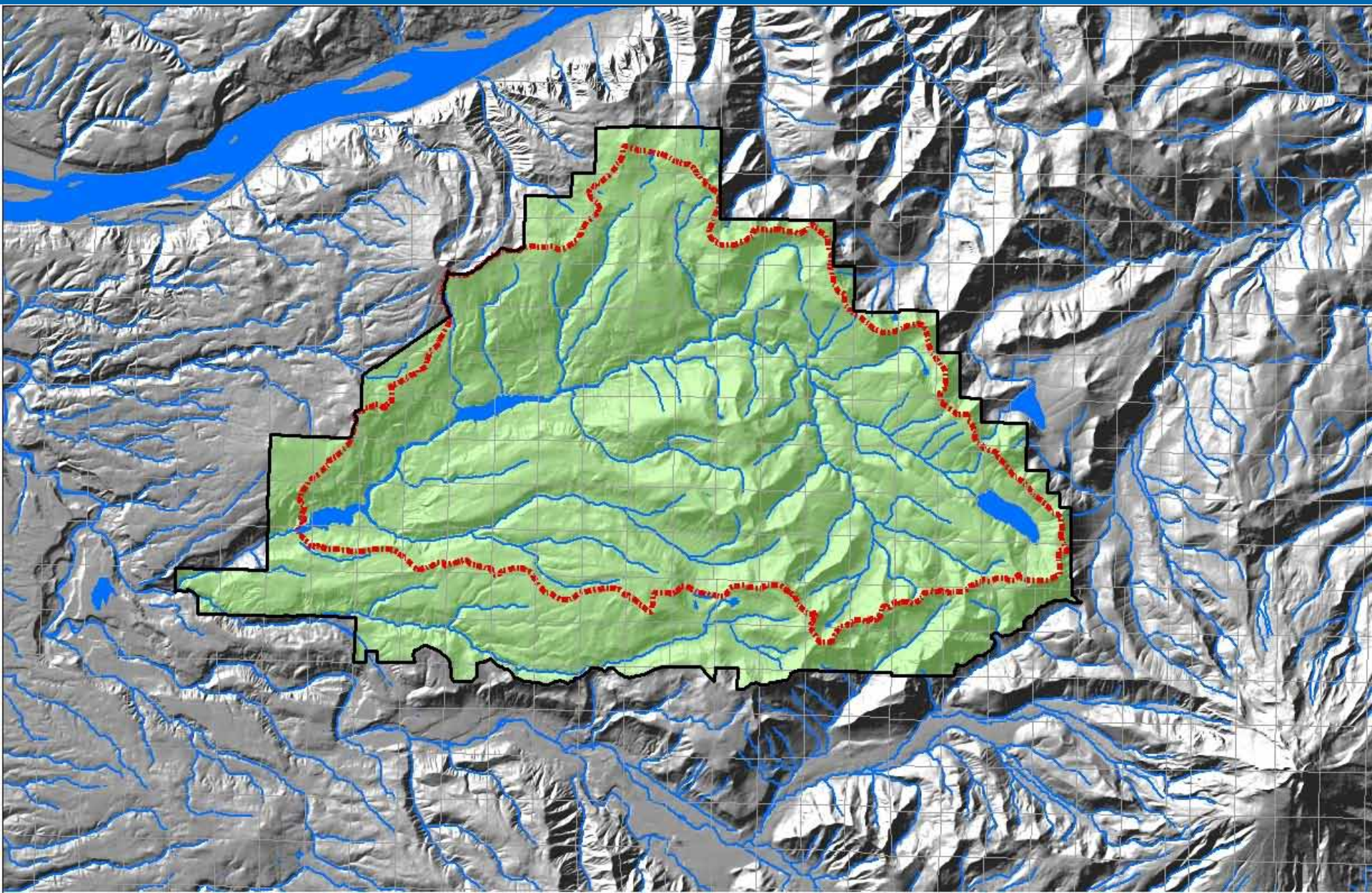
1. Background on Portland System
2. Hydrologic tools used to model our water system
3. Past climate change study & recent modeling by State of Oregon
4. Opportunities, challenges & questions for future climate change analysis on the Portland water system

Portland Water System

- Population served 850,000
- Two supply sources:
  - Bull Run surface supply – treated but unfiltered
  - Columbia South Shore Well Field – emergency and peak season supply
- Wholesale water under 19 contracts
- Water Demand
  - 103 MGD Average - 160 MGD Peak


PORTLAND WATER SYSTEM
Retail Service Area
Wholesale Service Area
Columbia South Shore Well Head Protection Zone
Former Powell Valley Rd Water District Drinking Water Protection Area
Rivers
Freeways/Major Roads
Mt Hood National Forest
Bull Run Watershed Management Unit
Portland Water Bureau
Resource Protection and Planning
1120 SW 5th Ave
Portland, OR 97204-1926
0 1.25 2.5 5 7.5 10 Miles
WASHINGTON
OREGON
PORTLAND WATER BUREAU

Bull Run Boundary & Watershed

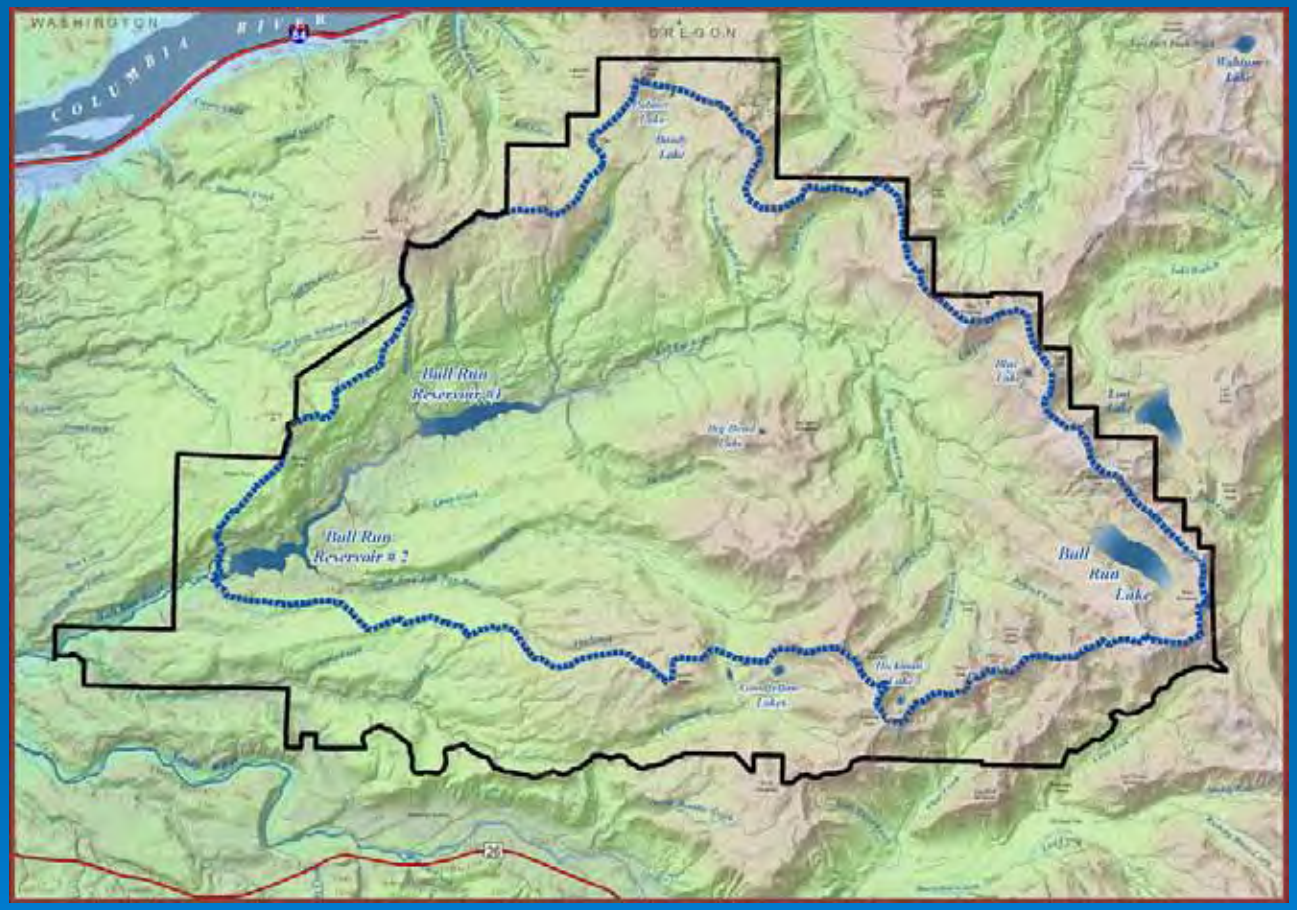


Bull Run Lake in Upper Watershed

Dam 2 - Headworks

Dam 1 – upstream of Dam 2

Geology, Topography and Climate



- 750'– 4,500' elev.
- 135" annual precip, rain-dominated system
- Basalt and andesite underlying geology
- 90% owned by US Forest Service
- Physical watershed 65,500 Acres

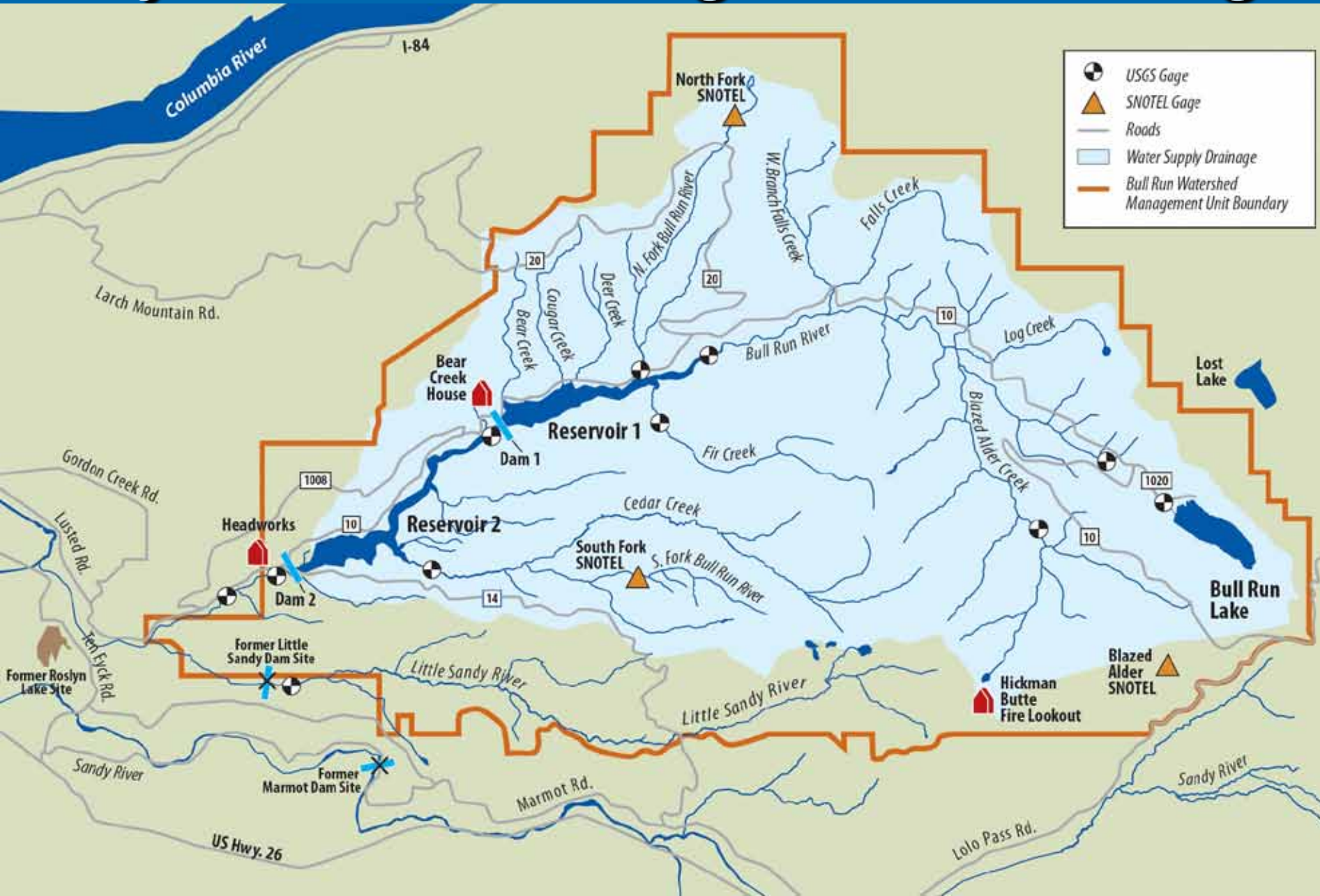
Hydrological Observation System

- 6 Stream gages inside the watershed – well distributed. Various periods of record 1966-present.
- 2 Stream gages below the watershed diversion point & 1 gage in adjacent watershed used to extend the streamflow record in Bull Run back to 1940 (70 years of daily streamflows).
- 3 SNOTEL sites inside the watershed – period of record 1980-present
- 3 Staff gages on dam reservoirs & BR lake

Weather Observation System

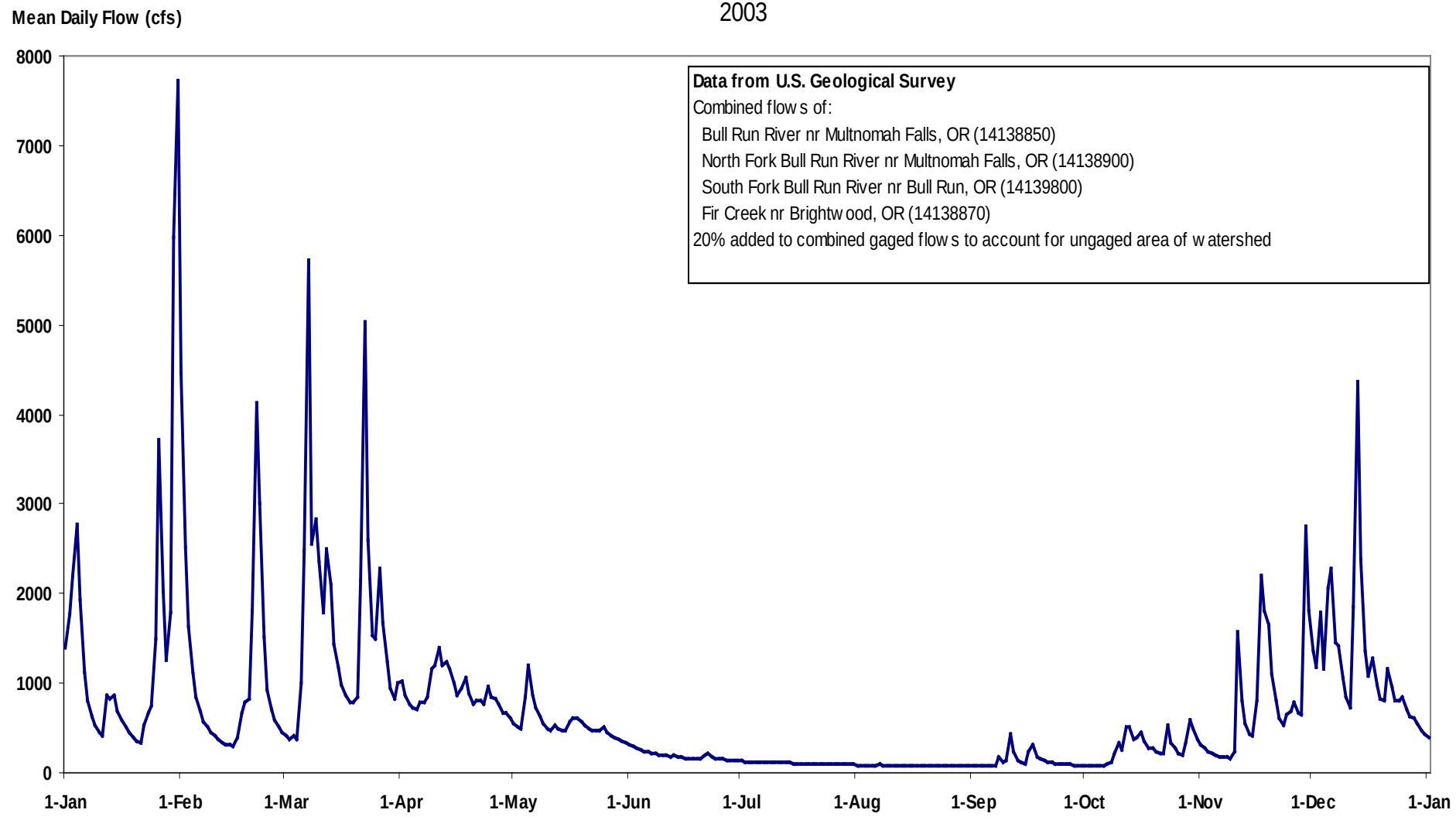
- Primary NWS site at the Portland Airport 1928-present
- Headworks in Bull Run – Daily (Manual Recording) back to 1899
  - Precipitation
  - T-max & T-min
- Top of Dam 2 – Hourly archive (2000)
  - Air Temperature
  - Relative humidity
  - Solar radiation
  - Wind speed and direction

Hydro-meteorological Monitoring



Bull Run River Flow at Headworks

2003



Operational Forecast Modeling Summer Supply

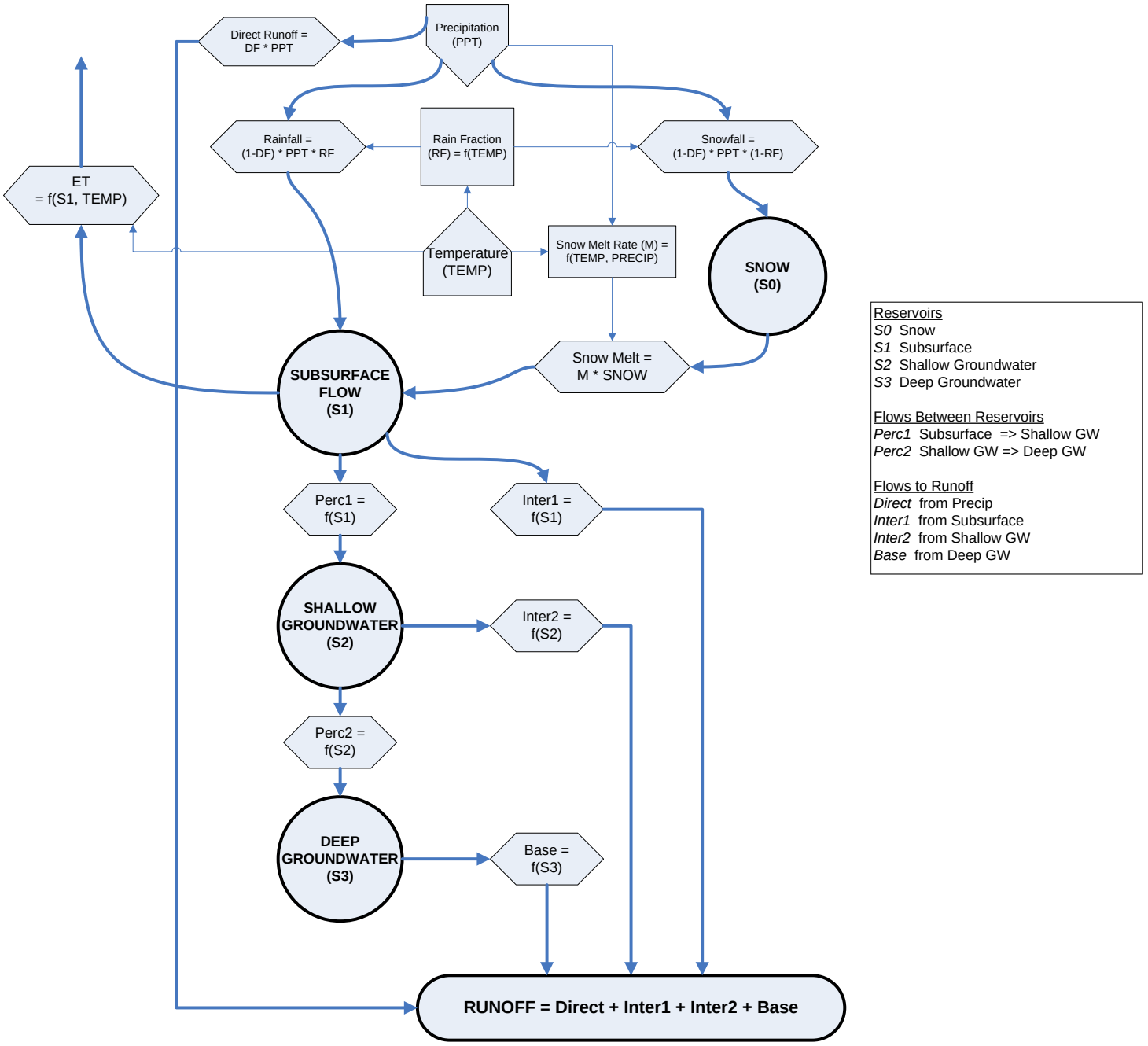
- Based on three weather forecast scenarios:
  - Median (most likely)
  - Cool & Wet
  - Warm & Dry
- 90-day forecasts of daily temperature & precipitation.
- Forecasts are input to spreadsheet models
  - Precip-Runoff Model => Streamflow projections
  - Demand Model => Water use projections

Beyond the Weather Forecast

- Forecast accuracy approaches climatology at about 90 days.
- Weather data since 1940
- Run weather data through demand model to create suite of demand scenarios – historical weather with current population.
- Streamflow data since 1940
- Combine demand scenarios with streamflow from each corresponding year.

→ Suite of 60+ potential reservoir drawdown scenarios

Bull Run Precipitation – Runoff Model

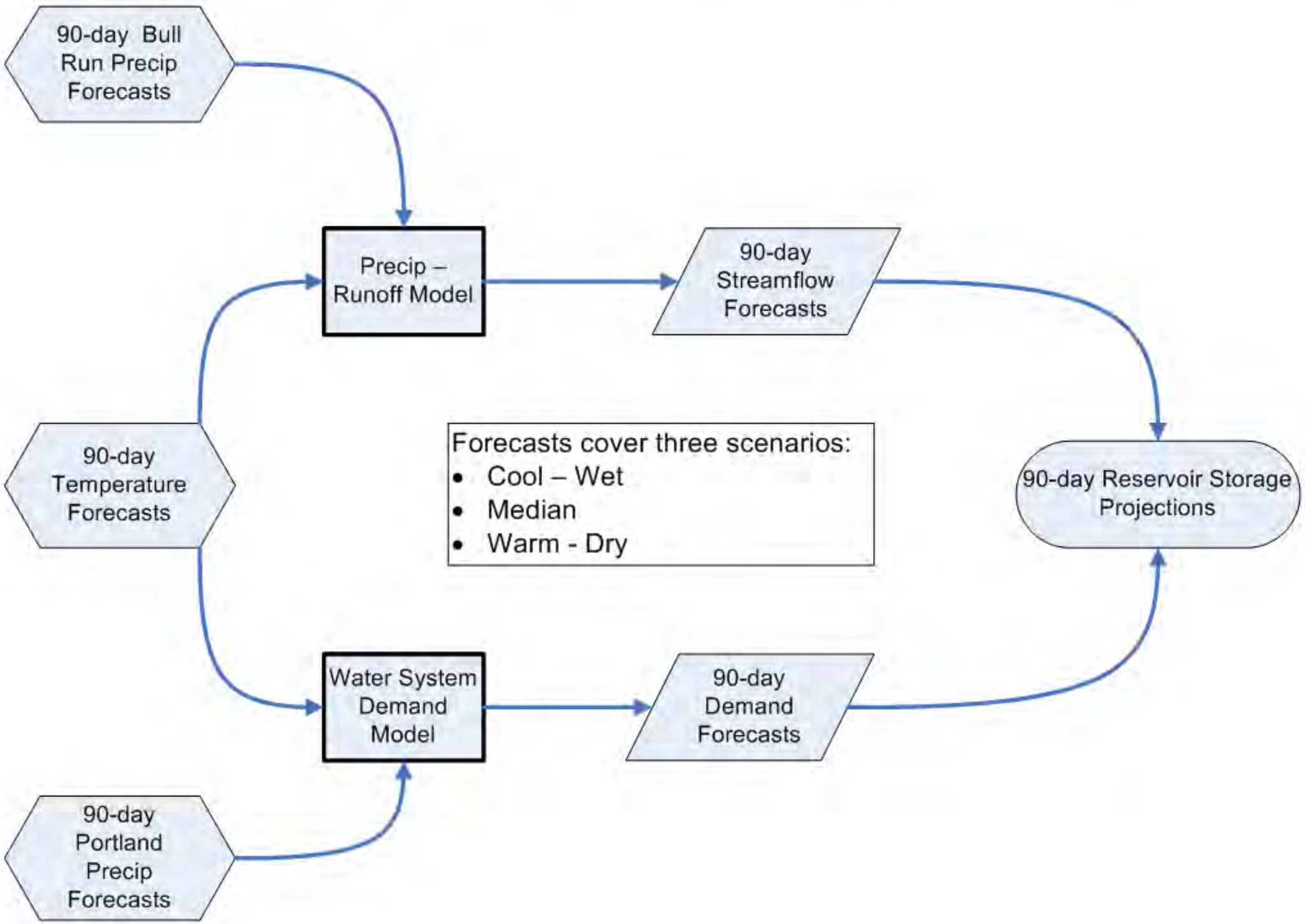


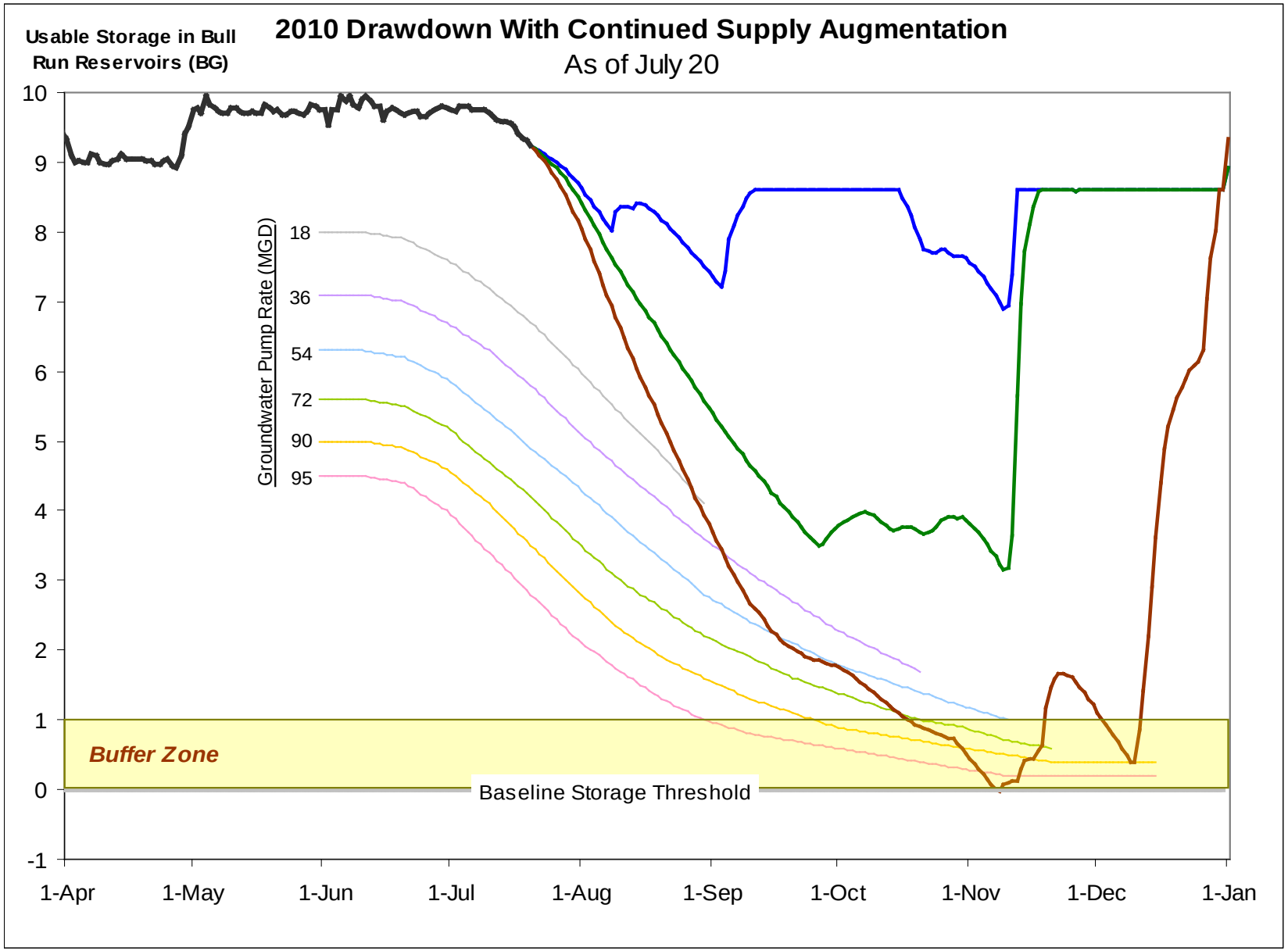
Reservoirs
S0 Snow
S1 Subsurface
S2 Shallow Groundwater
S3 Deep Groundwater

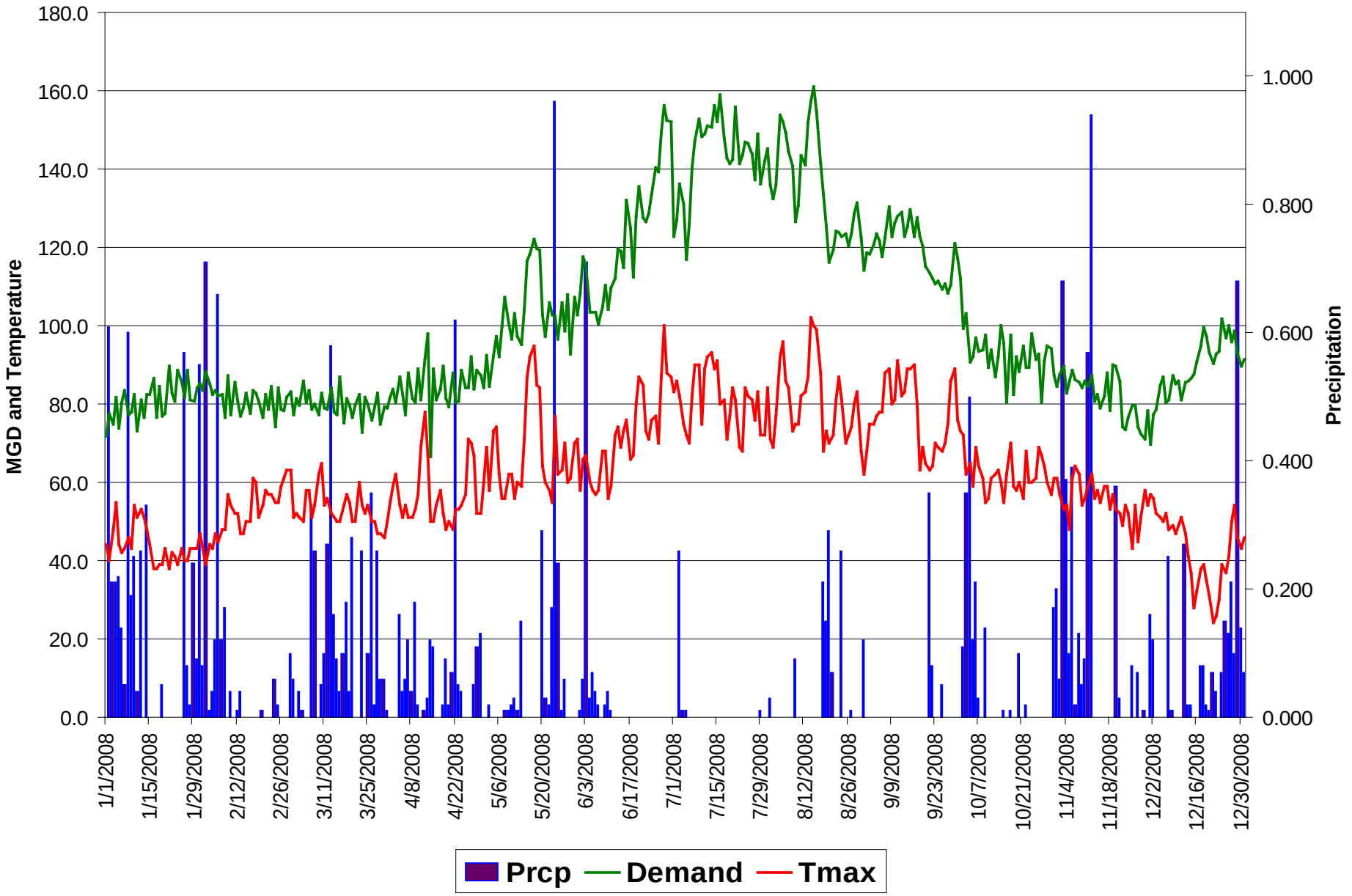
Flows Between Reservoirs
Perc1 Subsurface => Shallow GW
Perc2 Shallow GW => Deep GW

Flows to Runoff
Direct from Precip
Inter1 from Subsurface
Inter2 from Shallow GW
Base from Deep GW

Combining Streamflow and Demand Forecasts




2010 Drawdown With Continued Supply Augmentation
As of July 20
Usable Storage in Bull Run Reservoirs (BG)
Groundwater Pump Rate (MGD)
18
36
54
72
90
95
Buffer Zone
Baseline Storage Threshold
10
9
8
7
6
5
4
3
2
1
0
-1
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
1-Jan


Portland Water Supply System 2008
Daily Demand, Maximum Temperature, and Precipitation
MGD and Temperature
Precipitation
180.0
160.0
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
1.000
0.800
0.600
0.400
0.200
0.000
1/1/2008
1/15/2008
1/29/2008
2/12/2008
2/26/2008
3/11/2008
3/25/2008
4/8/2008
4/22/2008
5/6/2008
5/20/2008
6/3/2008
6/17/2008
7/1/2008
7/15/2008
7/29/2008
8/12/2008
8/26/2008
9/9/2008
9/23/2008
10/7/2008
10/21/2008
11/4/2008
11/18/2008
12/2/2008
12/16/2008
12/30/2008
Prcp
Demand
Tmax

Planning Model Tools

- CEQUAL-W-2
  - Reservoir operation system model for temperature management
  - Utilized for fish flow monitoring & building a multiple level intake in Dam 2
- Storage & Transmission Model (STM)
- Water Evaluation and Planning (WEAP)

Storage & Transmission Model (STM)

- University of Washington, Dept. of Civil Engineering – late 1990s
- Dr. Richard Palmer & Margaret Ayles
- PWB staff involved
- Built in STELLA and Excel as part of PWB's Infrastructure Master Plan
- Evaluated numerous supply & demand scenarios to determine deficiencies in supply, storage, and transmission capacity

Main Menu

Demand Year

2020

About Portland Water Works

To Control Panel

Summary Output

Portland M&I Metrics

Dam Metrics

Supply Metrics

Groundwater Metrics

Bull Run River Metrics

Hydropower Metrics

Transmission Metrics

Start Dates for Model Runs

Node Descriptions

Status Quo

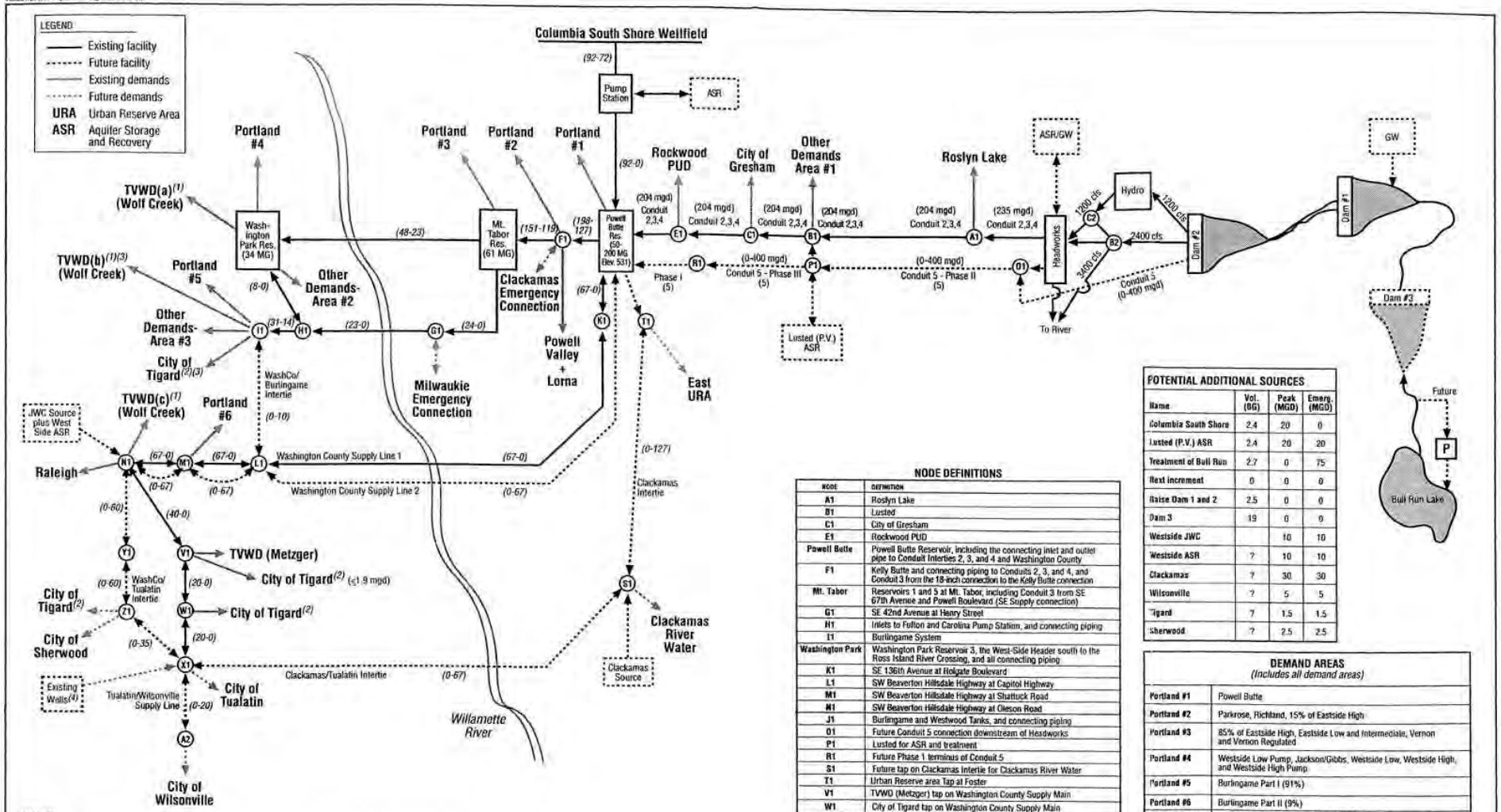
To Title Page

To Work in Progress Screen

To Drawdown Metrics Screen

Top: Photograph of Bull Run Dam 1 and Power House

Bottom: Photgraph of Bull Run Dam 2 and Power House



NOTES:

(1) TVWD (Wolf Creek) can be fed from three taps. The total demand must be met by the sum of the flows from these three taps.
(2) For City of Tigard, serve demand first from I1, then V1, then W1, finally Z1.
(3) At Node I1, the sum of TVWD(b) and City of Tigard cannot exceed 8mgd.
(4) Existing wells at Wilsonville, Tigard, and Sherwood.
(5) The increase in peak day capacity from construction of Conduit 5 is 23 mgd from Phase I, 33 mgd from Phase II, and 194-244 mgd from Phase III.

Revised: August 6, 1998

NODE DEFINITIONS

NODE	DEFINITION
A1	Roslyn Lake
B1	Lusted
C1	City of Gresham
E1	Rockwood PUD
Powell Butte	Powell Butte Reservoir, including the connecting inlet and outlet pipe to Conduit Interties 2, 3, and 4 and Washington County
F1	Kelly Butte and connecting piping to Conduits 2, 3, and 4, and Conduit 3 from the 18-inch connection to the Kelly Butte connection
Mt. Tabor	Reservoirs 1 and 5 at Mt. Tabor, including Conduit 3 from SE 67th Avenue and Powell Boulevard (SE Supply connection)
G1	SE 42nd Avenue at Henry Street
H1	Inlets to Fulton and Carolina Pump Station, and connecting piping
I1	Burlingame System
Washington Park	Washington Park Reservoir 3, the West-Side Header south to the Ross Island River Crossing, and all connecting piping
K1	SE 136th Avenue at Holgate Boulevard
L1	SW Beaverton Hillsdale Highway at Capitol Highway
M1	SW Beaverton Hillsdale Highway at Shattuck Road
N1	SW Beaverton Hillsdale Highway at Oleson Road
J1	Burlingame and Westwood Tanks, and connecting piping
D1	Future Conduit 5 connection downstream of Headworks
P1	Lusted for ASR and treatment
R1	Future Phase 1 terminus of Conduit 5
S1	Future tap on Clackamas Intertie for Clackamas River Water
T1	Urban Reserve area Tap at Foster
V1	TVWD (Metzger) tap on Washington County Supply Main
W1	City of Tigard tap on Washington County Supply Main
X1	City Tualatin tap on Washington County Supply Main
Z1	Future City of Tualatin and City of Sherwood taps on future Wash Co/Tualatin Intertie at Tigard
A2	Future City of Wilsonville tap on Tualatin/Wilsonville Supply Line at ?
B2	?
C2	?

POTENTIAL ADDITIONAL SOURCES

Name	Vol. (BG)	Peak (MGD)	Emerg. (MGD)
Columbia South Shore	2.4	20	0
Lusted (P.V.) ASR	2.4	20	20
Treatment of Bull Run	2.7	0	75
Next increment	0	0	0
Raise Dam 1 and 2	2.5	0	0
Dam 3	19	0	0
Westside JWC		10	10
Westside ASR	?	10	10
Clackamas	?	30	30
Wilsonville	?	5	5
Tigard	?	1.5	1.5
Sherwood	?	2.5	2.5

DEMAND AREAS
(Includes all demand areas)

Portland #1	Powell Butte
Portland #2	Parkrose, Richland, 15% of Eastside High
Portland #3	85% of Eastside High, Eastside Low and Intermediate, Vernon and Vernon Regulated
Portland #4	Westside Low Pump, Jackson/Gibbs, Westside Low, Westside High, and Westside High Pump
Portland #5	Burlingame Part I (91%)
Portland #6	Burlingame Part II (9%)
Other Demands Area #1	GNR Corporation, Green Valley Water Company, Hideaway Hills Water Company, Lusted Water District, Pleasant Home Water District, Skyview Acres Water Company
Other Demands Area #2	Burlington Water District, Palatine Hill Water District, West Slope, and Valley View
Other Demands Area #3	Lake Grove Water District, City of Beaverton

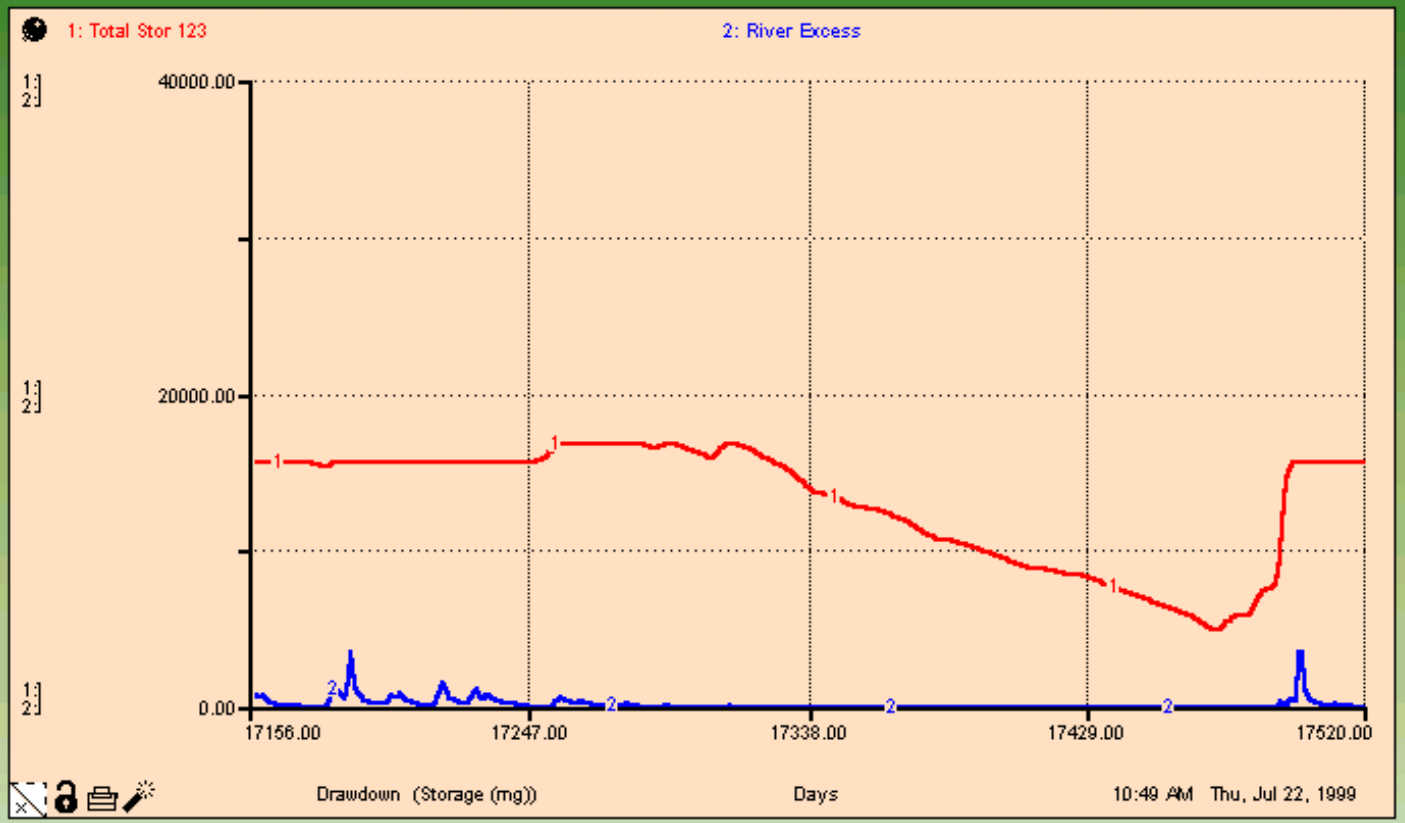
Figure 1-1
Portland's Current "Backbone" Supply, Transmission, and Storage System

Storage & Transmission Model (STM)

- Large number of input parameters:
  - Demand projections from 2000-2060
  - Wholesale demand scenarios
  - Programmatic water conservation
  - Groundwater supply
  - Later: Fish flow release scenarios for Habitat Conservation Plan

Drawdown Metrics

Drawdown Data Table



DD Inflow	0
DD Alternate	0
DD Gmd	0
Storage Used	11944
Max Storage123	16799
Min Stor I23	4855
Min Storage Remaining	607
DD Fish	0
DD Demand	0
Max Day Demand	308
Max 3 Day	291
Peak WCSL	68
Days of Gmd	126
Max Gmd Pumping	90
Average Gmd Pumped	0
Max GW Ratio	0.7
Average GW Ratio	0
Supply Reliability	100.0
Supply Shortfall Vol	0.0
Transmission Shortfall	0.0
Drawdown Start	15146
Drawdown Finish	15226

Year 1987

Month 1

1988

1

RUN | STOP | PAUSE | RESET | TIME SPECS

To Control Panel

To Main Menu

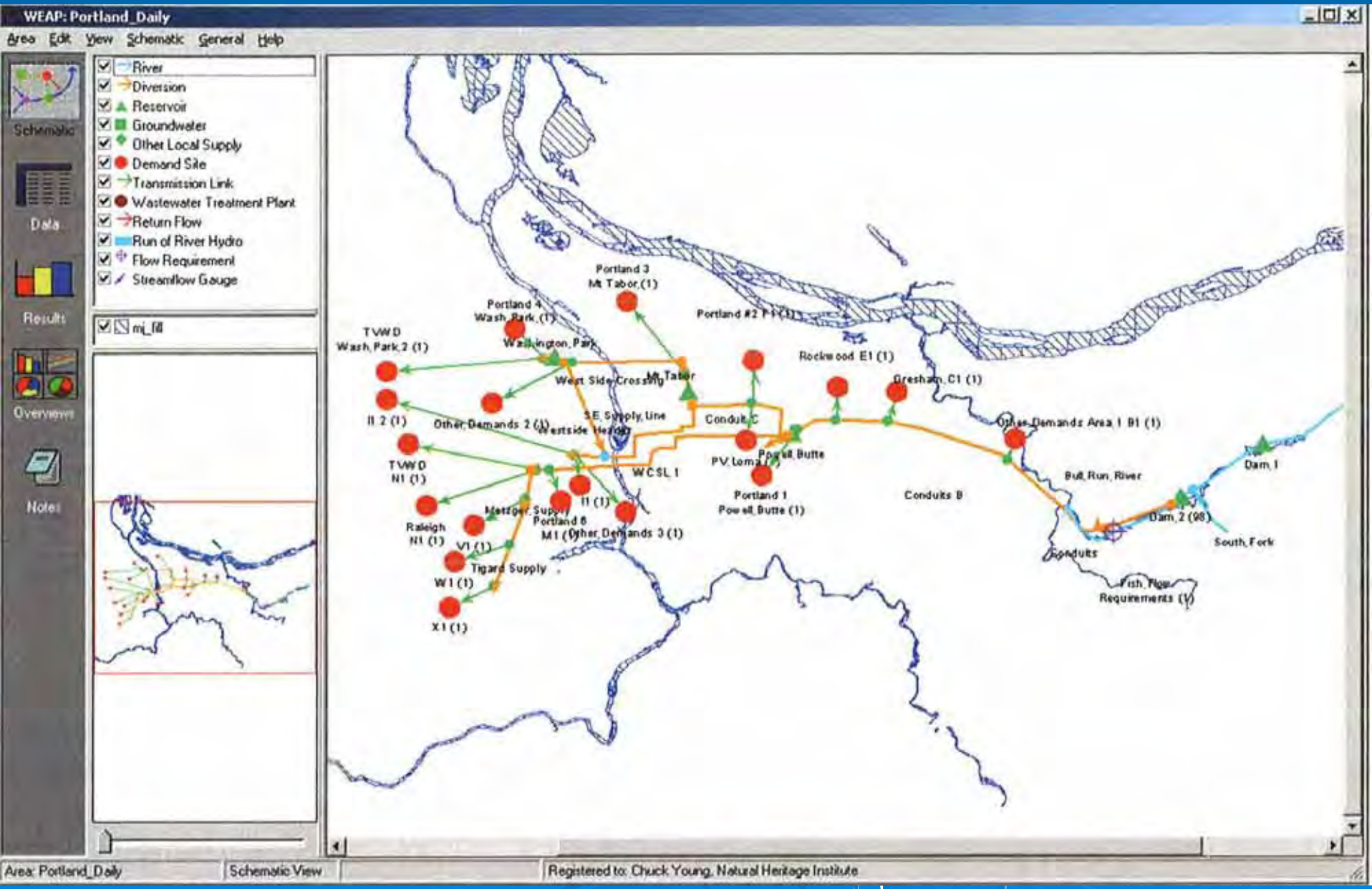
Summary Output

Storage & Transmission Model (STM)

- Model notes
  - Built to analyze a specific set of scenarios
  - Very successful in accomplishing project goals
  - Provides much more information than just supply and drawdown characteristics
  - Somewhat difficult to extract data
  - Difficult to modify model for evaluating future questions (fish flow scenarios)
  - Unable to generate a routine for estimating required Groundwater supply augmentation

Water Evaluation and Planning (WEAP)

- Stockholm Environment Institute (SEI)
- “User Friendly” graphical model building interface
- 2005 - AwwaRF project: Decision Support System for Sustainable Water Supply Planning
- Replicated a portion of the STM model, ran a series of wholesale demand scenarios in WEAP and STM, compared results


WEAP: Portland_Daily
Area Edit View Schematic General Help
Schematic
Data
Results
Overviews
Notes
River
Diversion
Reservoir
Groundwater
Other Local Supply
Demand Site
Transmission Link
Wastewater Treatment Plant
Return Flow
Run of River Hydro
Flow Requirement
Streamflow Gauge
mi_fill
Portland 3
Mt Tabor (1)
Portland 4
Wash_Park (1)
Washington_Park
TWD
Wash_Park_2 (1)
West Side Crossing
Mt Tabor
Rockwood E1 (1)
Gresham_C1 (1)
I1 2 (1)
Other Demands 2 (1)
SE Supply Line
Westside Heading
Conduit C
Other Demands Area 1 B1 (1)
TWD
N1 (1)
WCSL 1
PV Loma
Powell Butte
Portland 1
Powell Butte (1)
Conduits B
Bull Run River
Dam 1
Dam 2 (98)
South Fork
I1 (1)
Raleigh
N1 (1)
Metzger Supply
Portland 6
M1 (1)
Other Demands 3 (1)
V1 (1)
Tigard Supply
W1 (1)
X1 (1)
Conduits
Fish Flow
Requirements (1)
Area: Portland_Daily
Schematic View
Registered to: Chuck Young, Natural Heritage Institute

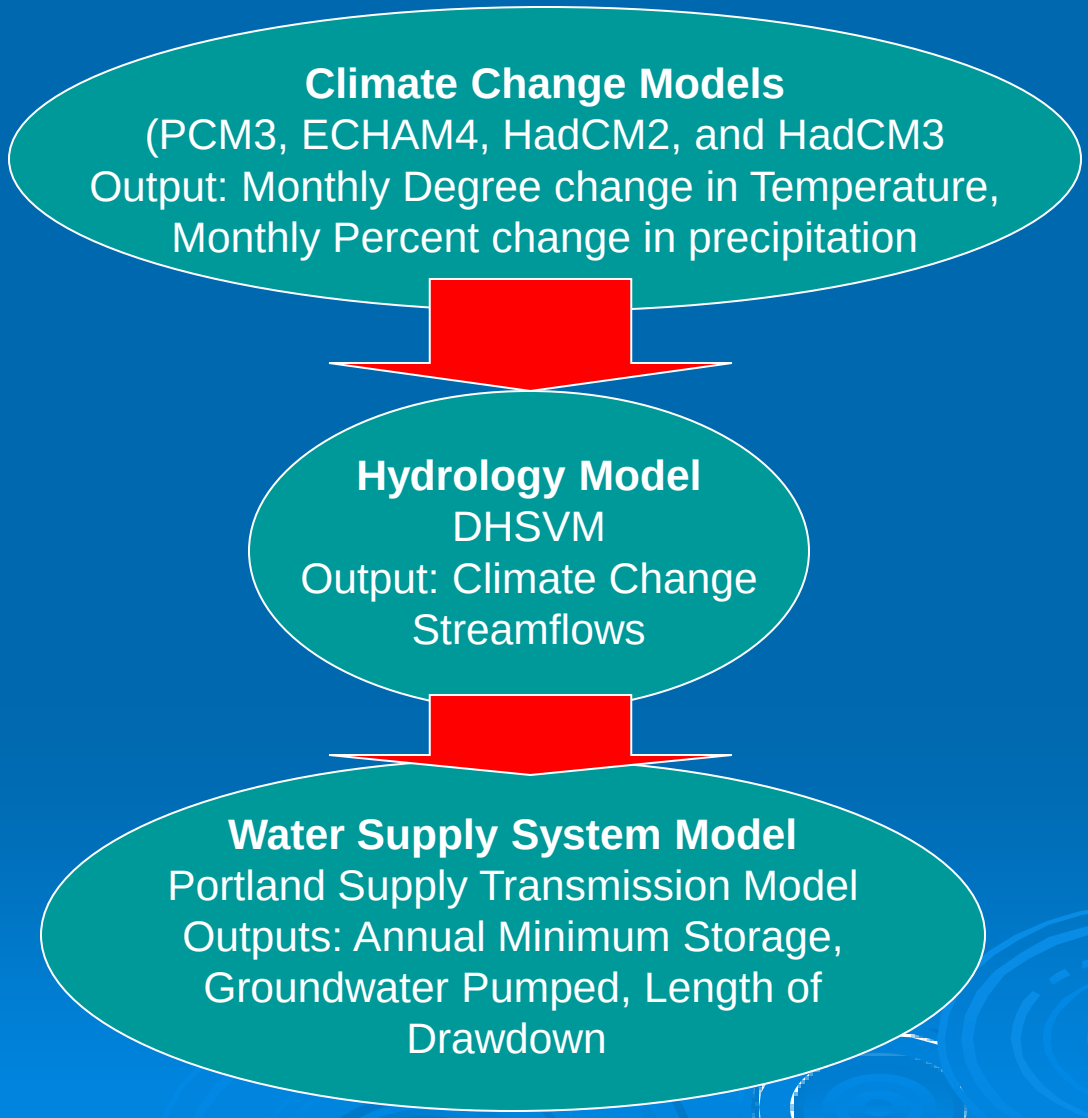
Water Evaluation and Planning (WEAP)

- Project was successful in duplicating STM results in WEAP
- Model building and results export relatively easy
- Since 2005 evaluations have focused on supply availability rather than transmission capacity
- Models have been built in Excel rather than STM and WEAP

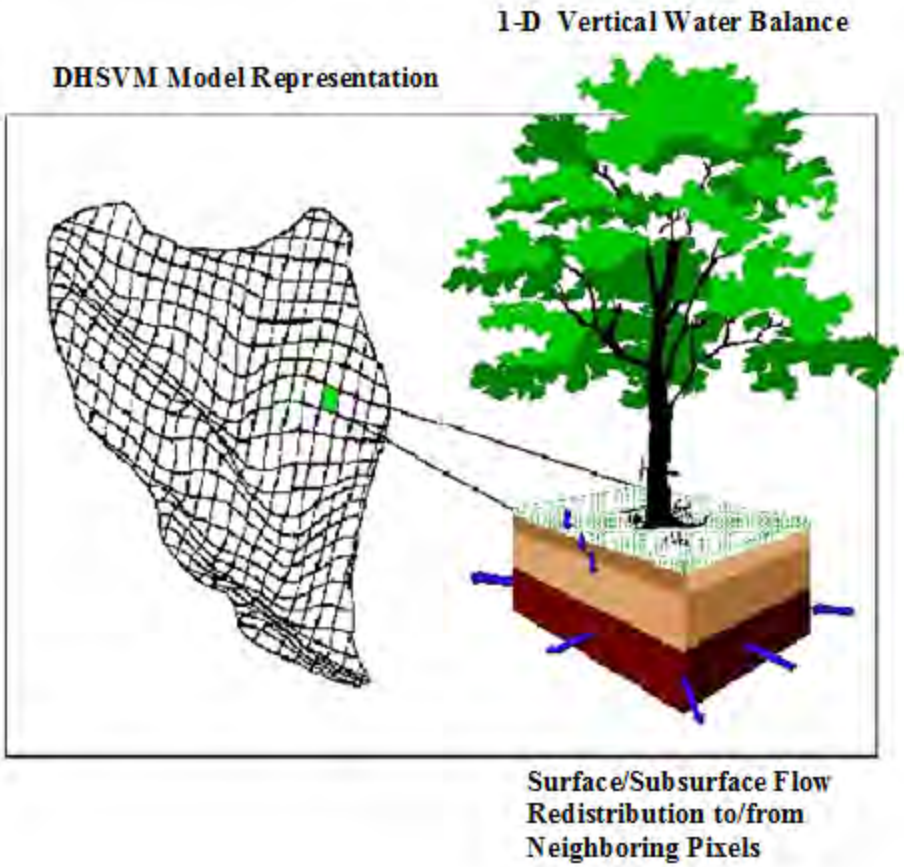
Portland Climate Change Study

- University of Washington, Dept. of Civil Engineering & CIG
- Completed as part of PWB's Integrated Management Plan in 2002
- Dr. Richard Palmer & Margret Ayles
- PWB staff involved
- Evaluated impacts of 4 GCM's on Bull Run watershed with PWB Demand Forecasts with CC signals within the STM

Chain of Models Methodology

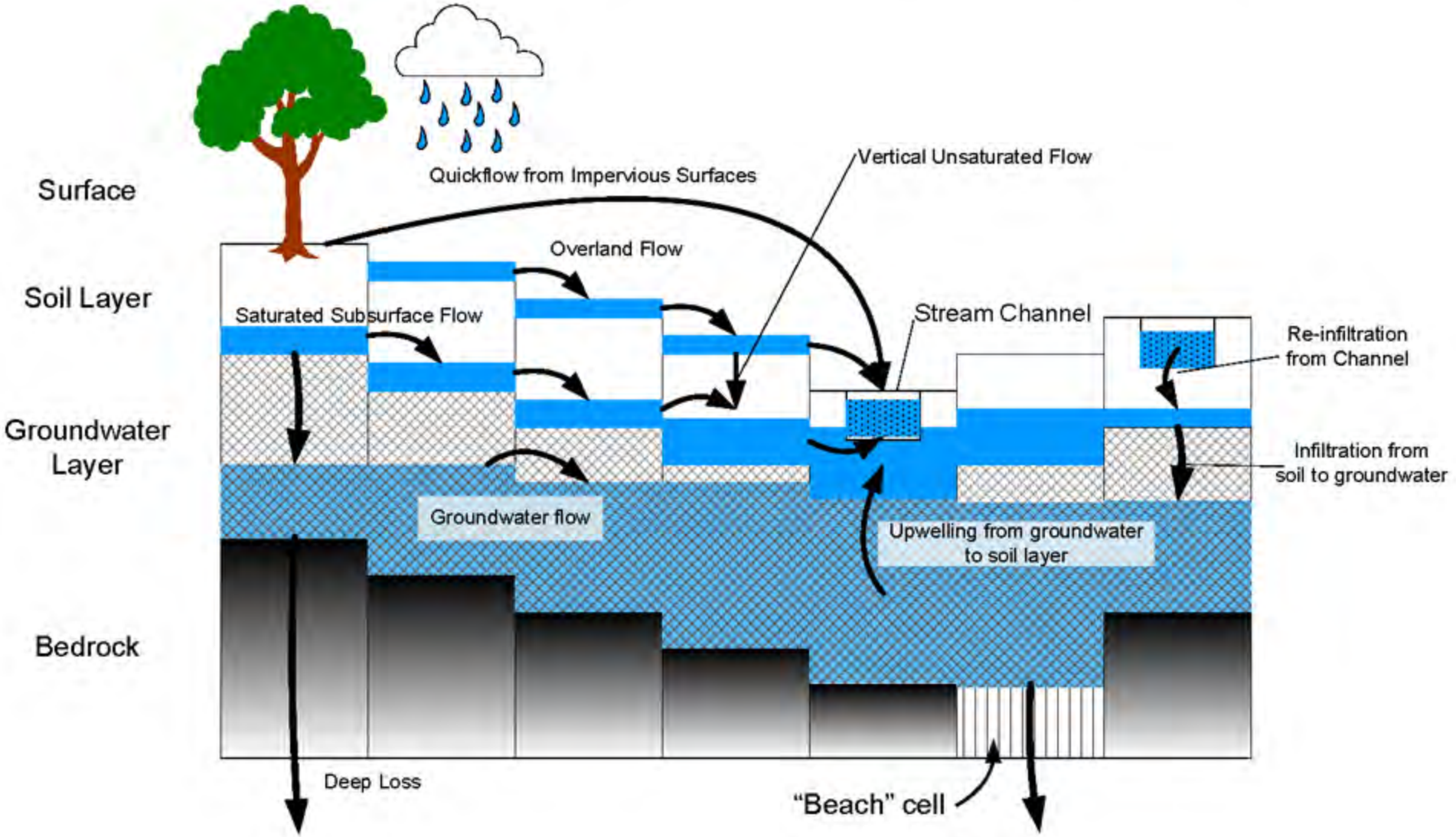


Distributed hydrology-soil-vegetation model (DHSVM)



- Physically based hydrologic model that represents the effects of
  - Topography
  - Soil
  - Vegetation
- Solves the energy and water balance at each grid cell at each timestep

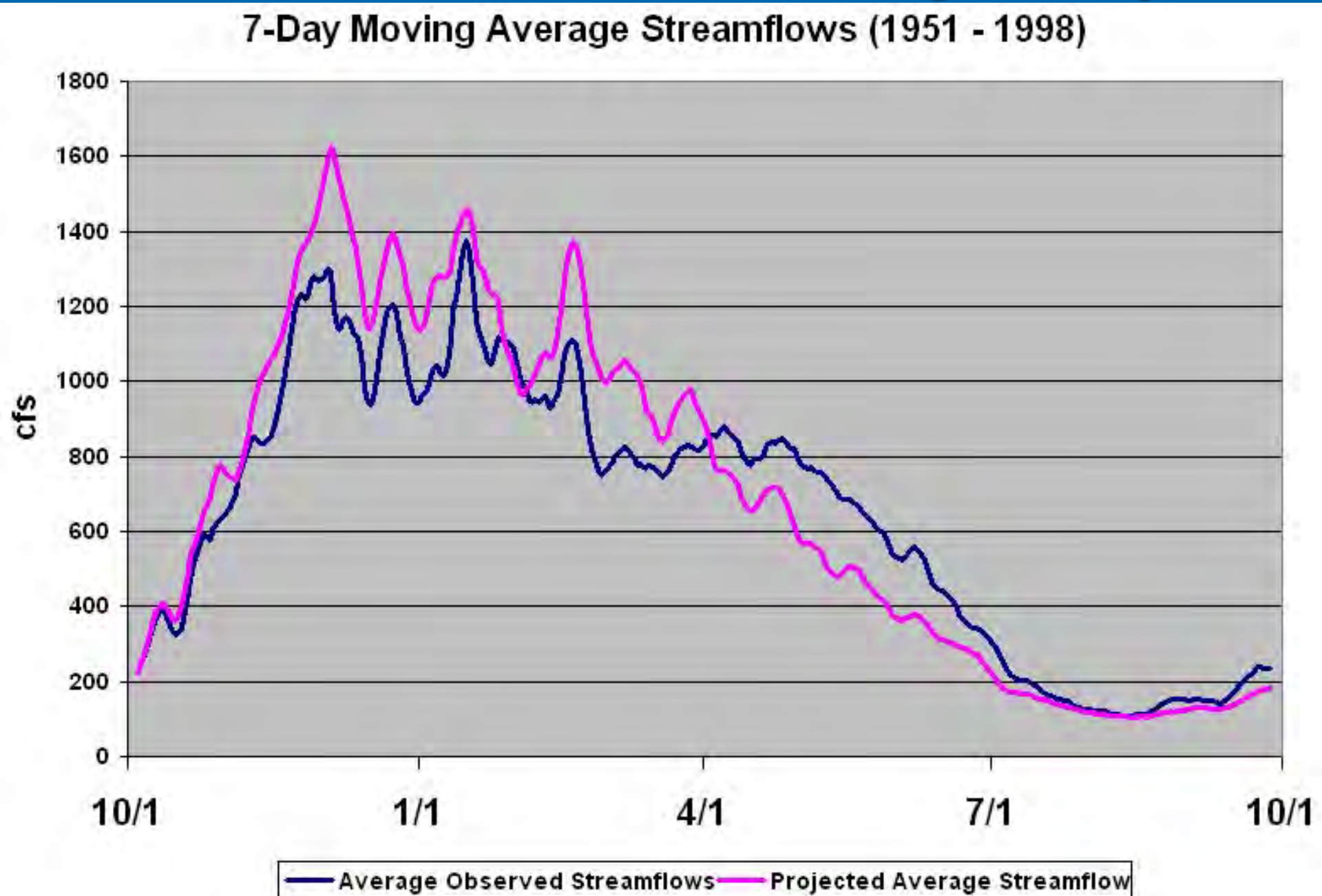
DHSVM Processes - water movement



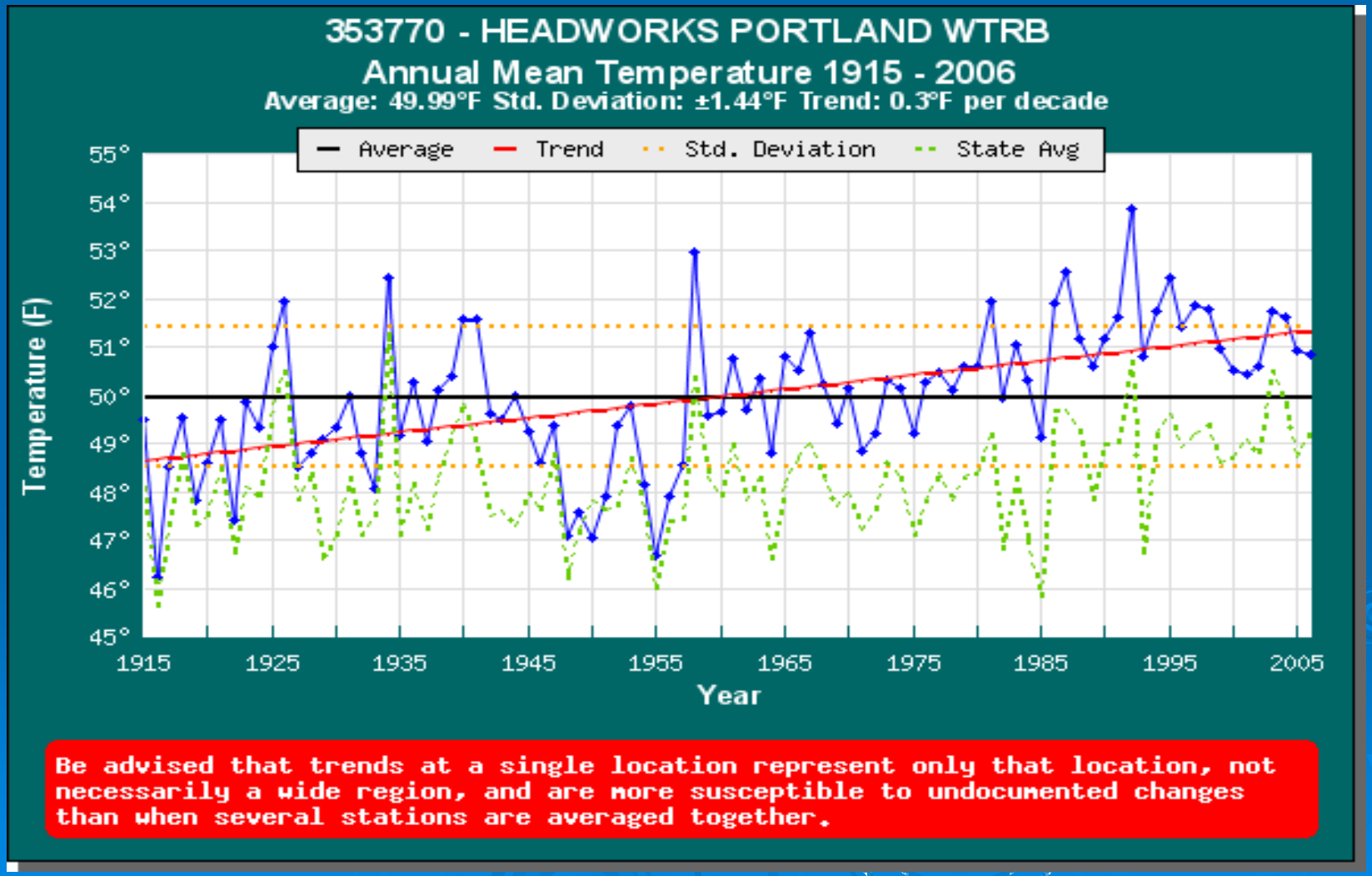
Results of the Portland Climate Change Study 2002

- The Bull Run is in a transient watershed where climate change scenarios show more water coming as rain in winter and less snow pack to boost inflows in the Spring and longer Fall dry periods.
- The Bull Run reservoirs will still fill in every year, however, the number of years with longer drawdown periods increases.
- Water supply needs are stressed more by future growth, but climate change compounds that impact requiring more groundwater pumping to make up the amount needed. (Growth assumptions are not the same today)
- This study did not evaluate impacts on groundwater

Bull Run Climate Change Study



Challenges, Opportunities & Questions



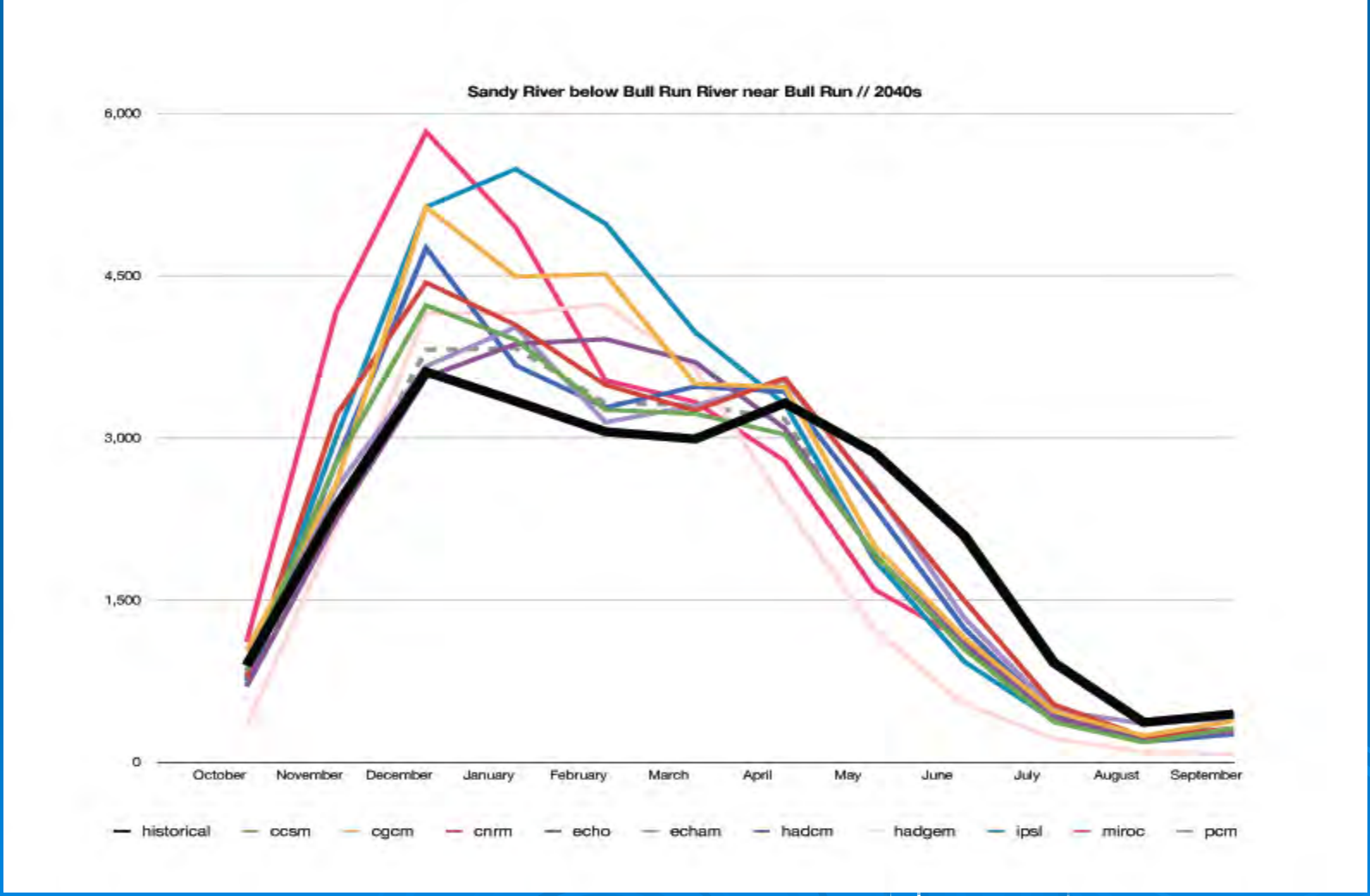
Challenges

- Major future water demand factors are:
  - Growth
  - Wholesale contracting – harder to get a handle on
  - Changes in consumption patterns
    - Constrained growth –higher densities
    - Reduction in per capita demands over last 20 years
    - Pricing impacts of sewer/water costs to meet other regulatory/operational requirements
- Climate change impacts on demands and supply are an added uncertainty on top of these other uncertainties
- Portland does not have a hydrologic model
- The climate change issue is getting a lot more heat but not a lot of additional light in clarifying the uncertainties

Climate Uncertainties

- Portland needs to do a revised look at climate change impacts on Bull Run and on peak season water demands.
- Portland has a robust groundwater source that may have little impact from climate change that is definable.
- More recent GCM downscaled data close to our source shows hydrologic trends, but still within a fairly broad range.

Climate Change Model Forecasts for Streamflow -- Sandy River, 2040



Source: Univ. of Washington/OCCRI 2009 – VIC modeled

Opportunities

- Developing a hydrologic model that will serve multiple purposes.
- Desire to understand the issue better, and to develop and utilize in-house expertise rather than consultants
- Working with other like utilities to get jump start from their experiences
- Working directly with Pacific Northwest Climate Decision Support Consortium -RISA to collaboratively obtain climate data and then apply it. Refine past work, lead on to updated long range planning.
- To develop a platform for future analysis as GCM's get better over time, evaluate extreme events for emergency preparedness and peak demand periods

PUMA Modeling Questions

- How does lack of data from the watershed itself factor into the choice of a hydrologic model?
  - Scale of grid sizes for hydrologic modeling?
  - Boundary conditions from downscaled data from larger to smaller grids?
- We are part of a program to get paleo-records from 500-700 year old trees, would extending the record back further be a substitute?
- Could we obtain what we need from a more simple methodology than downscaled GCMs?
  - Sensitivity analysis based on trends
  - Manipulate the hydrologic record to look at what if scenarios

Title and End Photos by Roman Johnston

QUESTIONS OR COMMENTS?

PORTLAND WATER BUREAU

FROM FOREST TO FAUCET

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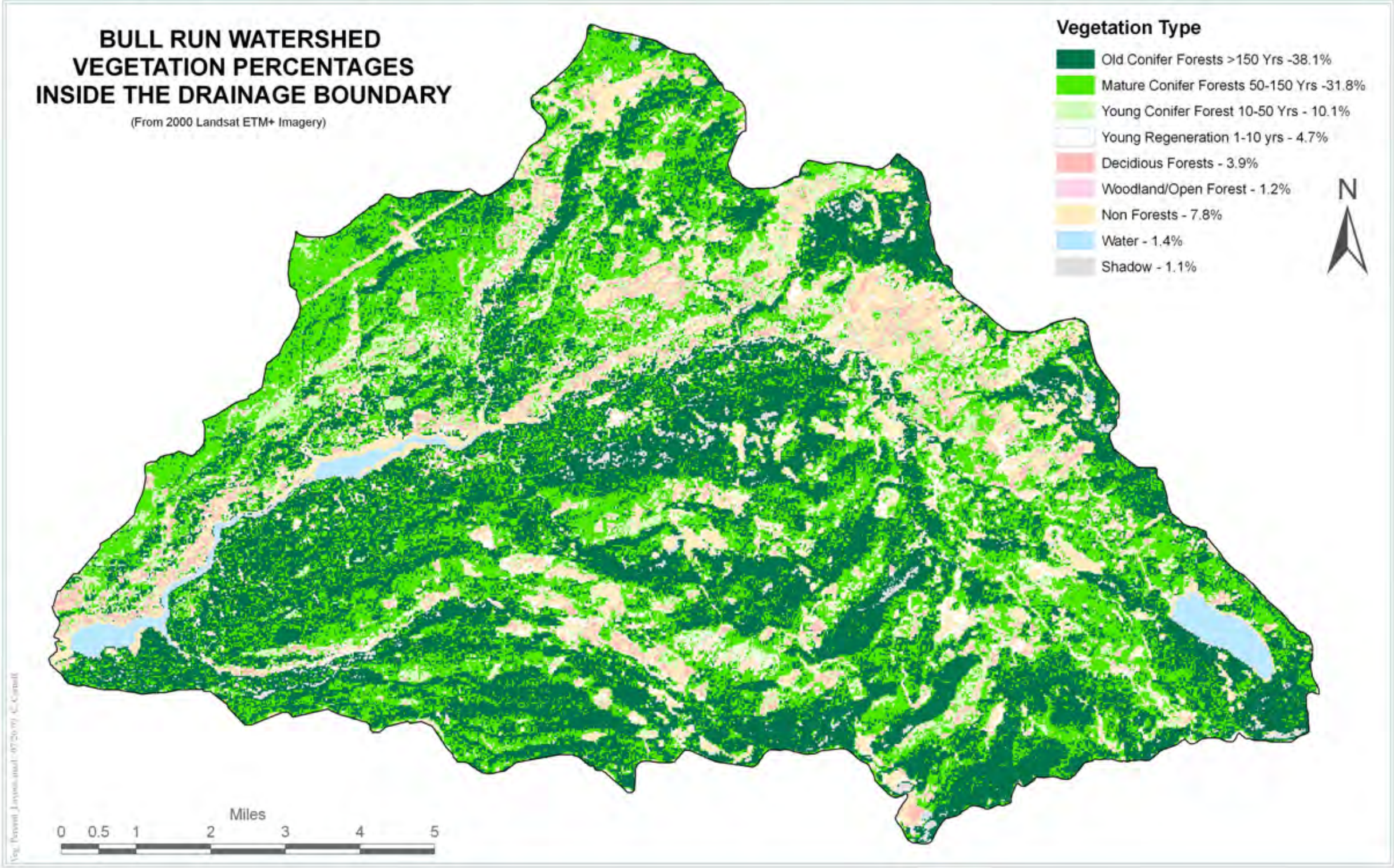
Appendices Slides

Forest Characteristics



Bull Run Watershed – Aerial Photography