SUMMIT
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OKANAGAN BASIN WATER SUPPLY & DEMAND PROJECT

HYDROLOGY STUDY & HYDROLOGICAL MODELLING FOR WATER RESOURCE PLANNING

Presented by:

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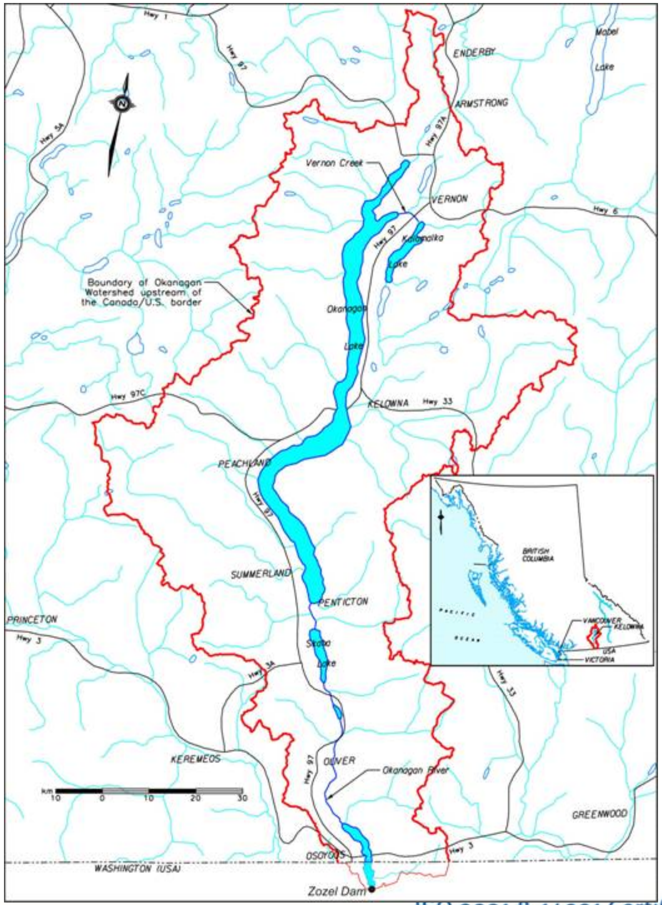
OUTLINE:

- Background – Okanagan Basin Water Supply & Demand Project; **Will we have enough water?**
- Study objectives
- Surface Water - "State of the Basin"
- Hydrology Model Development – Mike SHE
- Model calibration
- Future scenarios – climate, population growth

PROJECT AREA

- Okanagan Basin
- Valley bottom is semi-arid
- Growing population
- Agriculture still critically important
- Lakes = lifestyle



OKANAGAN WATER SUPPLY & DEMAND PROJECT (OWSDP)

Purpose:

- science for sustainable water management in the Okanagan
- to aid land use planning
- to support water allocation

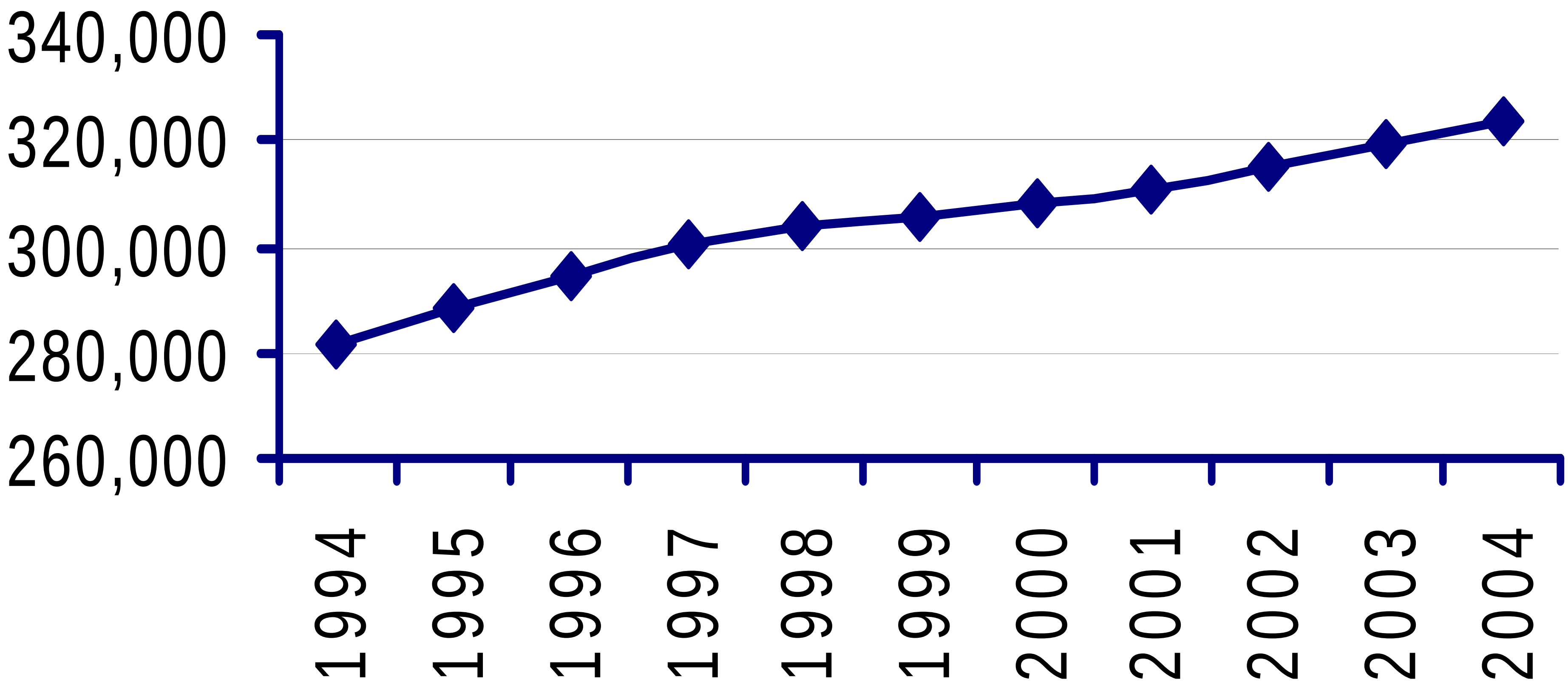
Objectives:

- update knowledge of water supply and need
- evaluate demand alternatives and future climate effects

Context

- 1974 Okanagan Basin Agreement - a comprehensive evaluation of water resources
- Population has increased beyond the greatest projections of the 1970s – and growth continues
- New concern over climate change – will supplies decrease and demand go up in the future?
- Recognition of First Nations' development potential
- Need for Basin-wide approach

Okanagan Population Growth (1994 - 2004)



Initial predictions of climate change effects on Okanagan Streams

	% REDUCTION IN FLOW	
	mid-2020s	mid-2050s
Lambly	11	30
McDougall	11	36
Powers	17	34
Trepanier	20	39
Peachland	18	34
AVERAGE	*15*	*35*

OWSDP COMPONENTS

Supply

- Hydrology & Hydrological Model (this presentation)
- Groundwater
- Lake Evaporation
- Climate Scenarios

Demand

- Actual Water Use
- Irrigation Demand
- Instream Flow Needs
- Climate Scenarios

Okanagan Water Accounting Model ties it together

HYDROLOGY STUDY – "State of the Basin"

- Compilation of streamflow data (WSC & others) & previous reports
- Determine natural flows in tributaries
- Surface water storage & diversion is very common – streams rated as "regulated"
- To determine natural flows from regulated records, must remove human management – *naturalization*
- Use data – Water Management & Use Study (WMU)

NODES

- 81 “Nodes” or points of interest
- Naturalized flow developed for 72 (not major lakes)
- 11-year standard period (1996-2006)
- 35 WSC stations of use (>150 have existed)

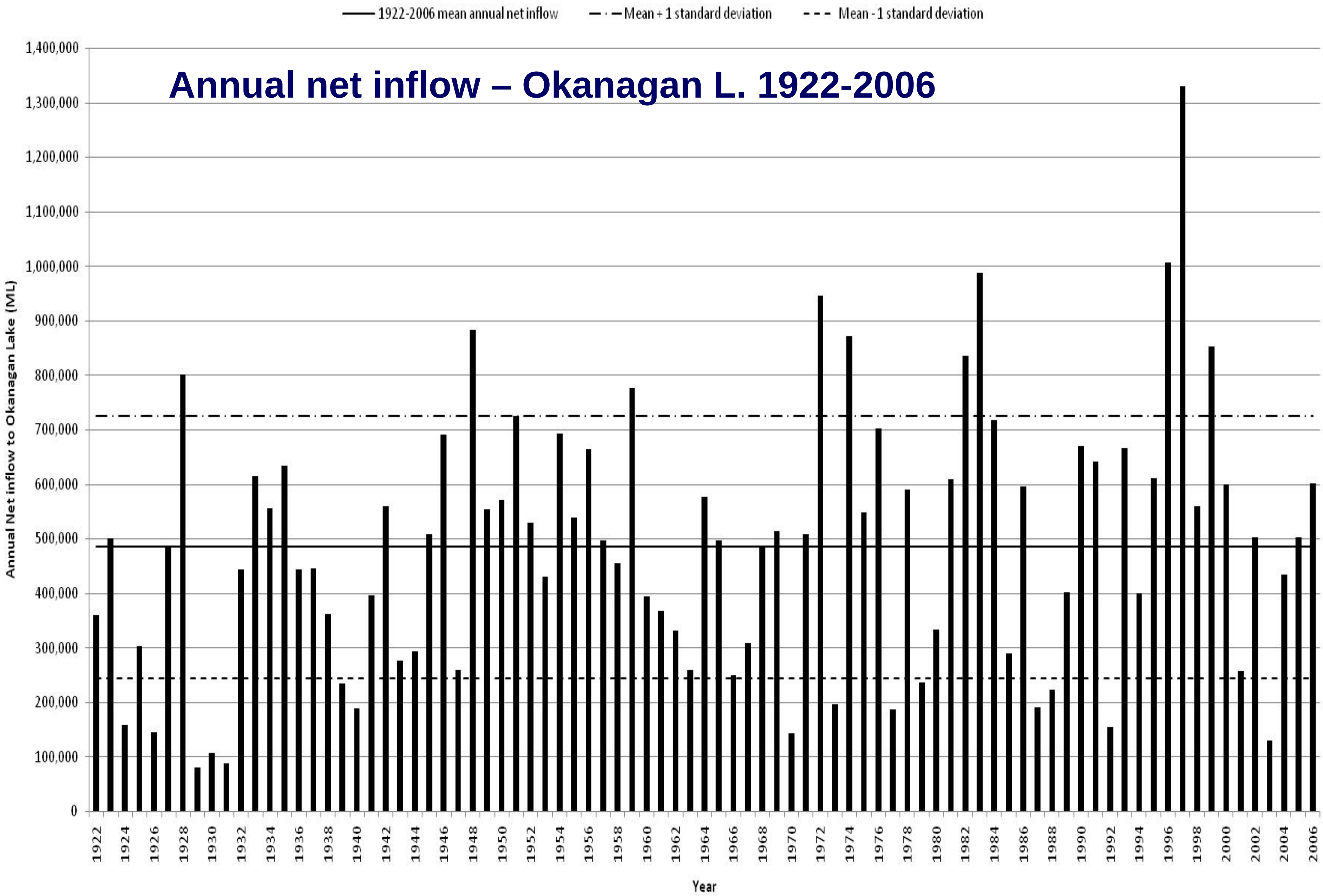
METHODS

- GIS – node drainage areas, median elevation
- Update MOE (Obedkoff 1998) regional relationships with data from up to 2008
- Screen data & fill in gaps (local comparisons)
- Few nodes are at stations – only one had 1996-2006 natural data; only 5 natural stations in total had 30+ years
- Naturalize – remove water use effect
- Data set – 72 nodes x 11 years x 52 weeks
- Data Quality checking & uncertainty ratings

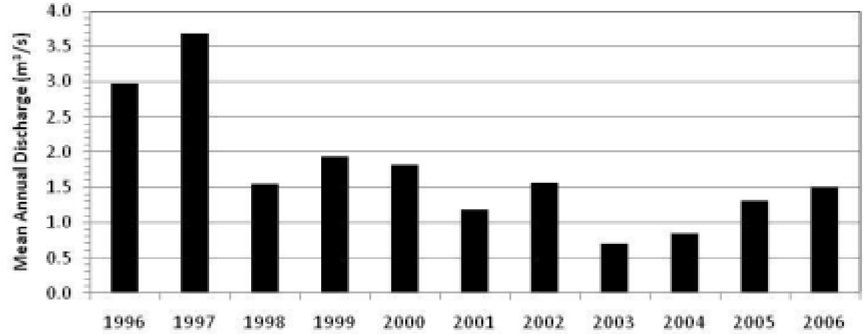
RUNOFF PATTERNS

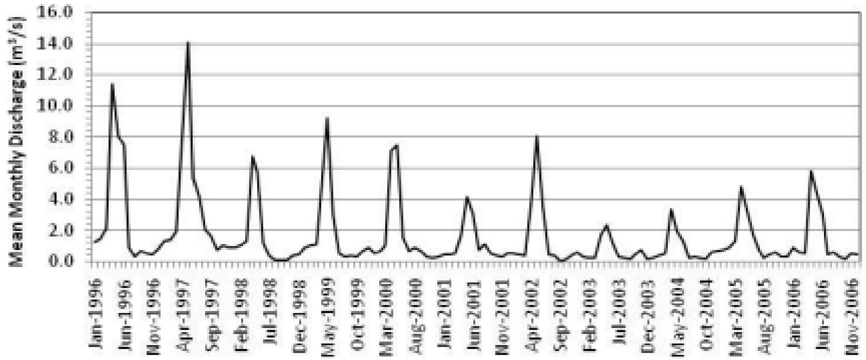
- Snowmelt Apr-July is 75% of annual flow – peak May/June
- Mean annual runoff – 100 m in south to 200 mm in north (average 117 mm)
- 884,000 ML/yr – 83% to Okanagan Lake; 17% to Okanagan River & mainstem lakes south of “big lake”
- East side 34% runoff higher than west side
- Mission Creek 28%, Vernon 7%, Trout 7%
- Residual areas: 17% of area, only 5% of runoff (high AET)

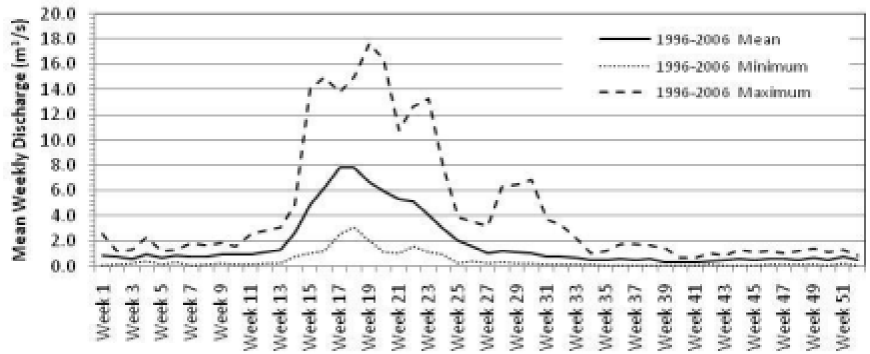
Annual net inflow – Okanagan L. 1922-2006



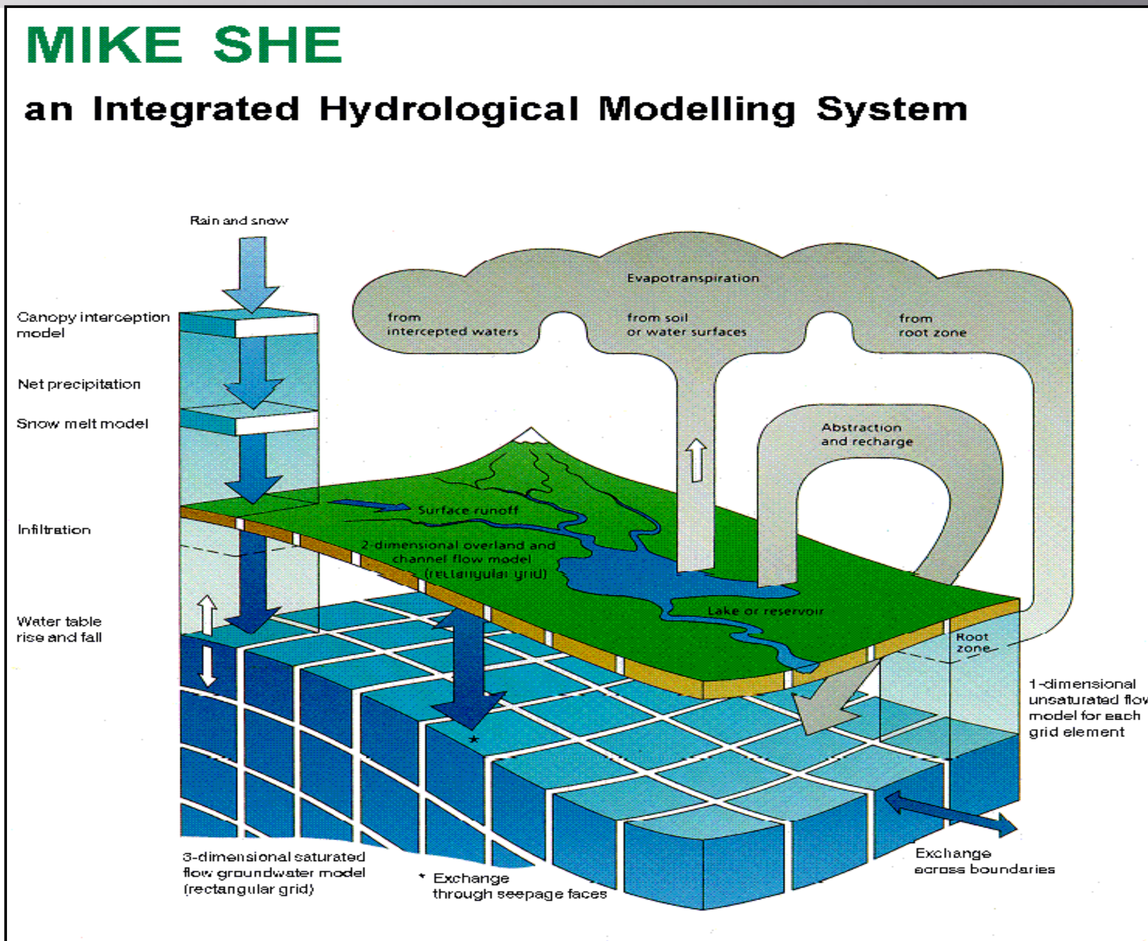
SAMPLE OUTPUT – VERNON CK. @ KALAMALKA LAKE







MODEL OVERVIEW



Model components

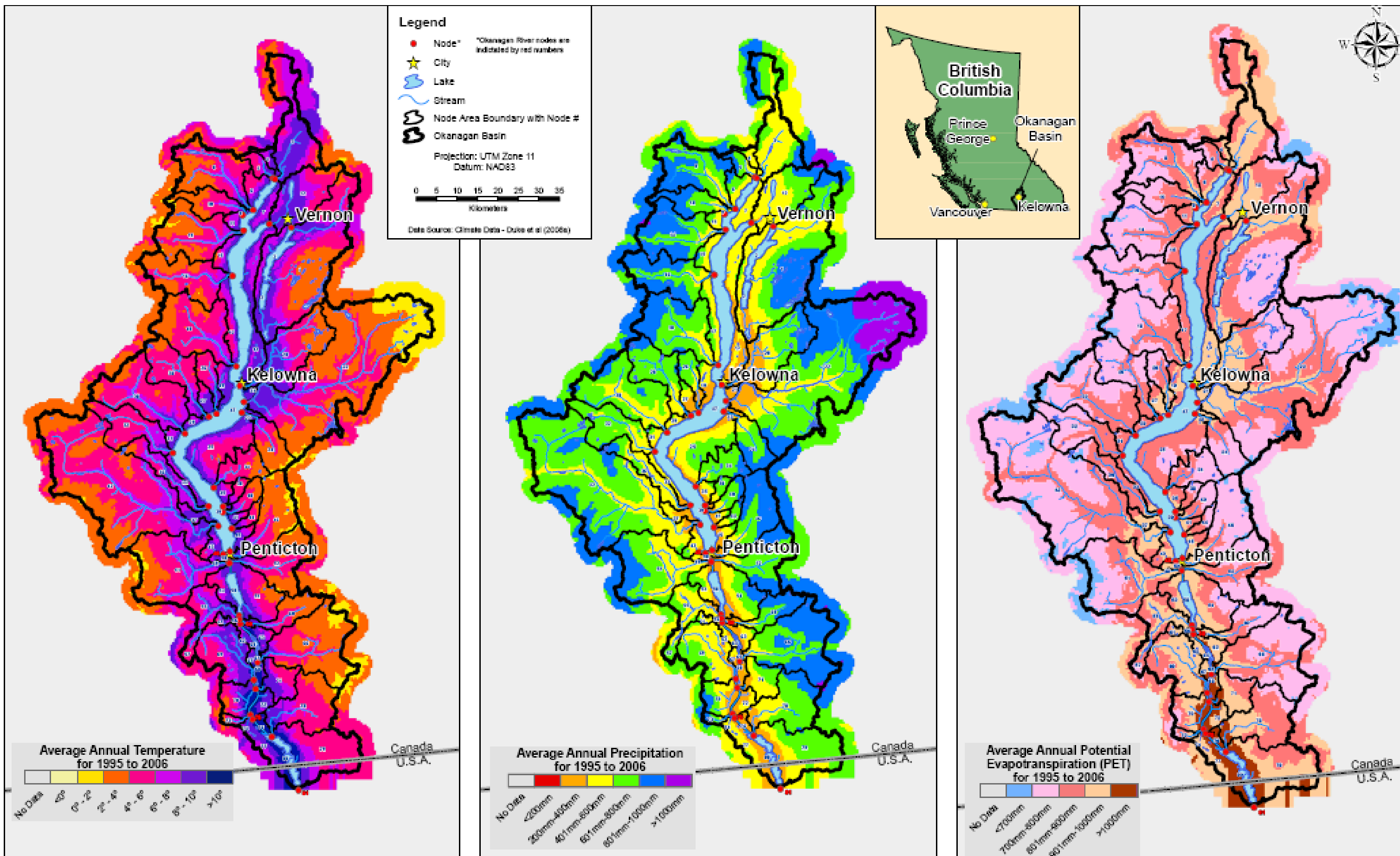
Model Component	Processes Simulated	Methodology
MIKE SHE OL	Overland sheet flow. water depths, depression storage	Two-dimensional diffusive wave approximation of the St. Venant equations
MIKE SHE Snowmelt	Snowmelt	Modified degree-day method
MIKE 11	River and lake hydraulics, flows and water-levels for fully dynamic reaches and flows for kinematic reaches	Fully dynamic wave approximation for lakes and valley-bottom reaches, kinematic routing for tributaries
MIKE SHE UZ and ET	Flow and water content in the unsaturated zone, ET, infiltration, groundwater recharge	Two-layer water balance method
MIKE SHE SZ	Groundwater flow, interflow, baseflow	Linear reservoir method

Model Inputs

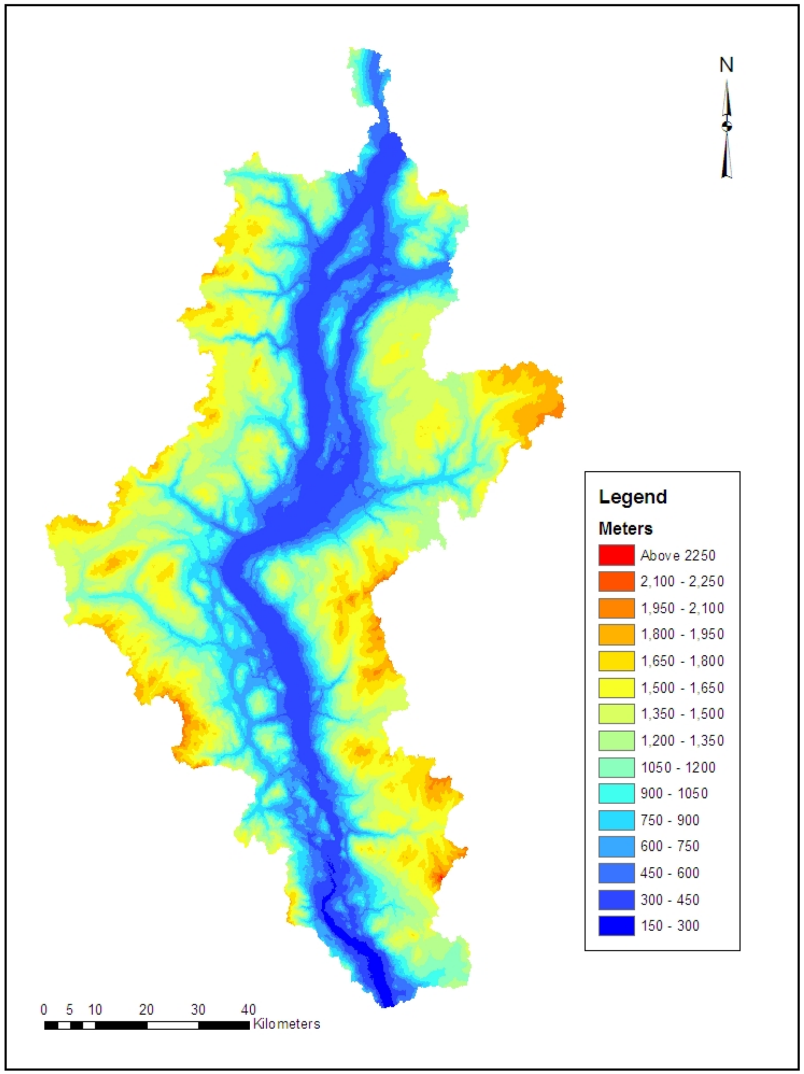
Model Component	Required Input Data
Precipitation	Distribution of precipitation rates
MIKE SHE OL	Topographic map, land use map, distribution of Manning's roughness coefficients, distribution of detention storage, initial water depths
MIKE SHE Snowmelt	Distribution of temperature, reference temperature, degree-day coefficient, minimum snow storage, maximum wet snow fraction, initial total snow storage, initial wet snow storage
MIKE 11	Channel network, cross-section geometries, structure geometries and operational rules, Manning's roughness coefficients, boundary conditions, initial conditions
MIKE SHE UZ and ET	Distribution and rates of potential ET, groundwater table map, soil map, saturated hydraulic conductivities, soil moisture contents at saturation, field capacity, and wilting point, leaf area index, rooting depth
MIKE SHE SZ	Subcatchment boundaries, linear reservoir and baseflow reservoir delineations, reservoir depths, time constants, specific yield

Model Construction – Climate

- Okanagan Climate Data Interpolator (Duke et al., 2008)
- 500 x 500-m grid resolution, daily time scale

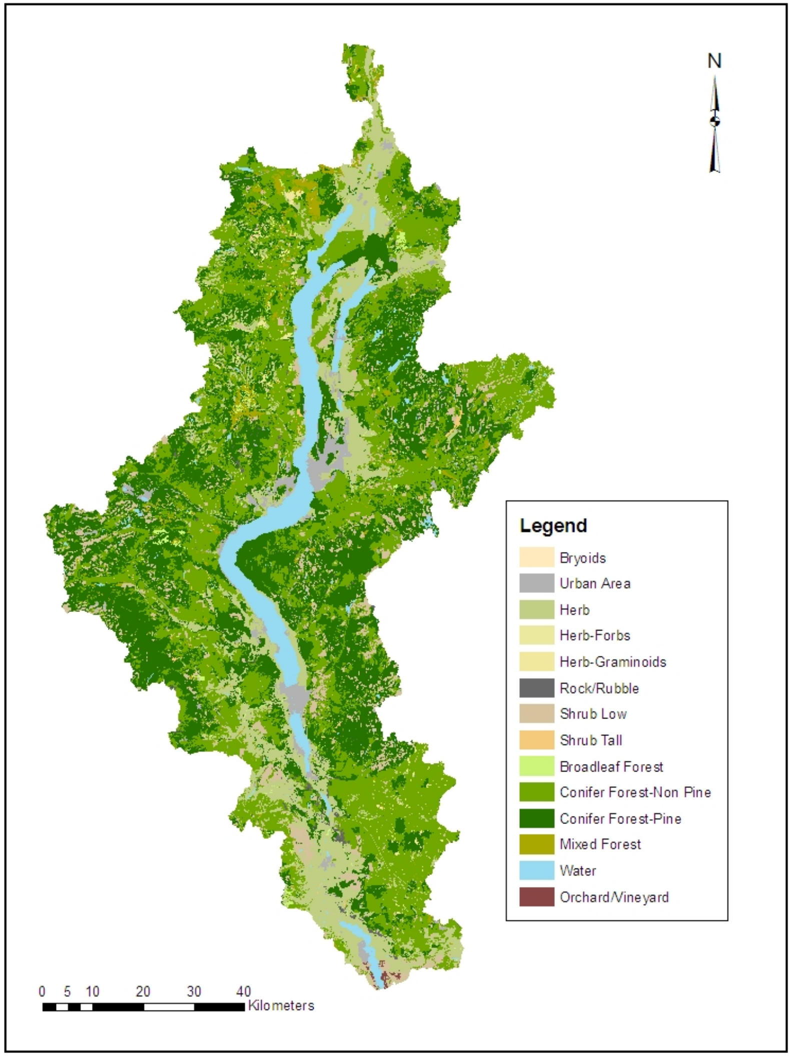


Model Construction - Topography



- Drives the overland flow component of the model
- 30-m resolution Canadian DEM and US DEM merged and re-sampled to 500-m resolution

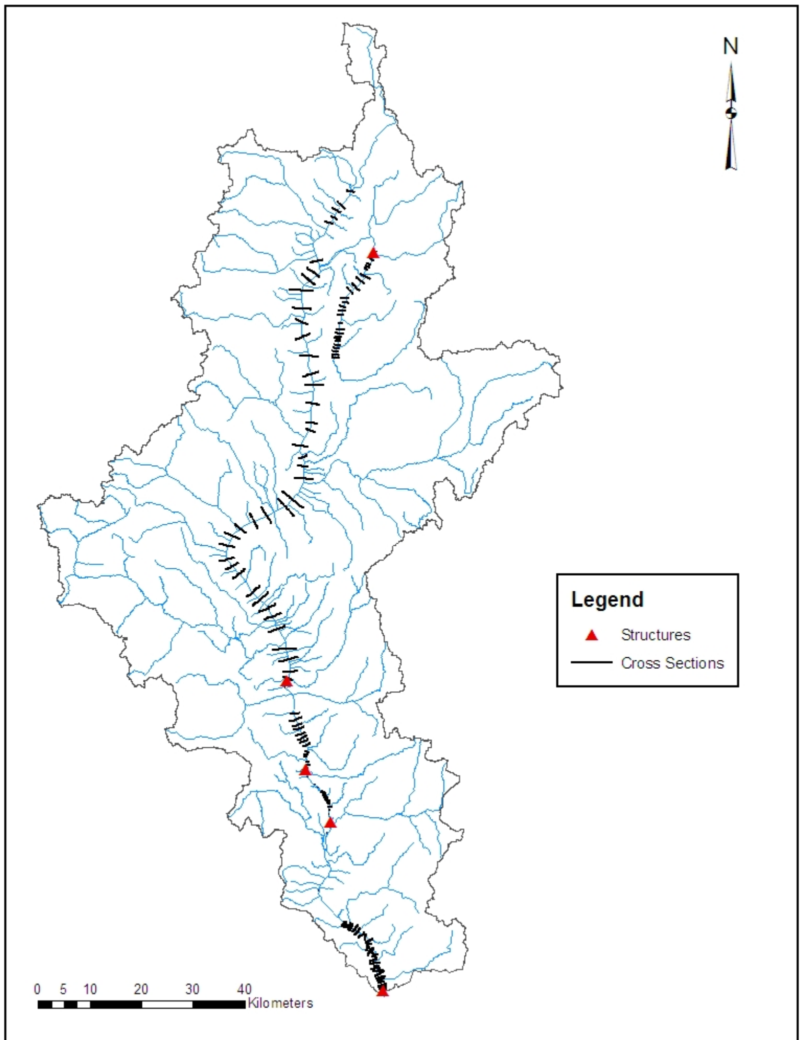
Model Construction – Land Cover



- Used to distribute vegetation properties (ET component) and roughness and detention storage values (overland flow component)

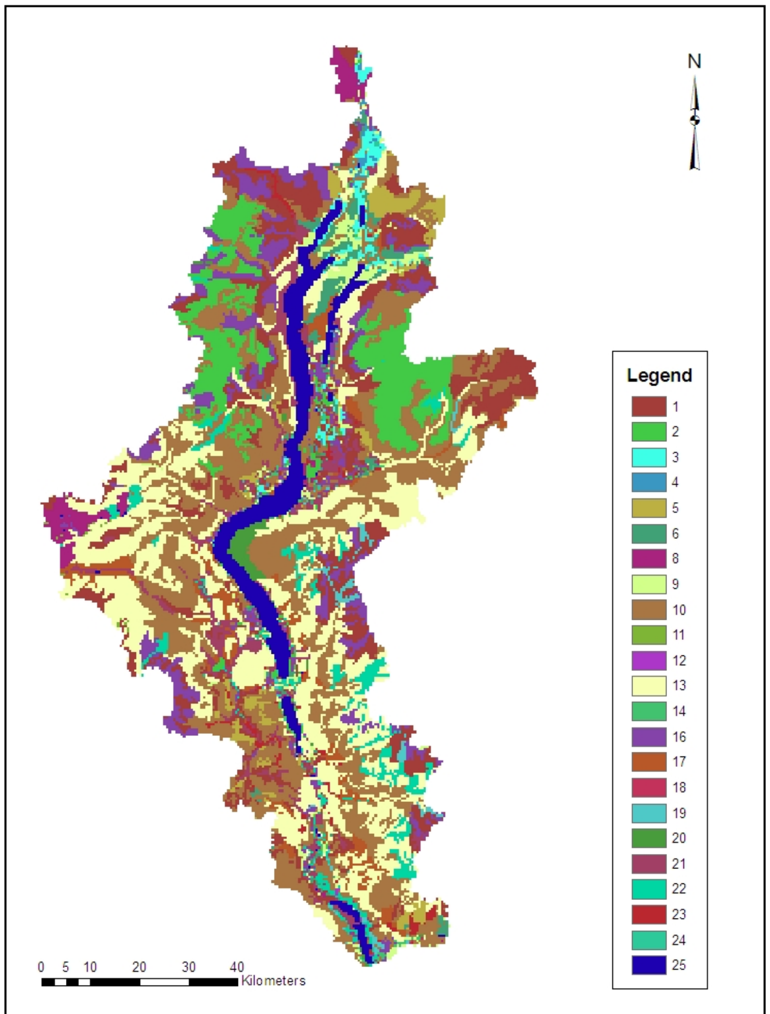
- Combination of data sources:
  - Base land cover maps (14)
  - Biogeoclimatic zones (4)
  - Disturbance areas (4)
  - Total of 67 zones

Model Construction – Streams and Lakes

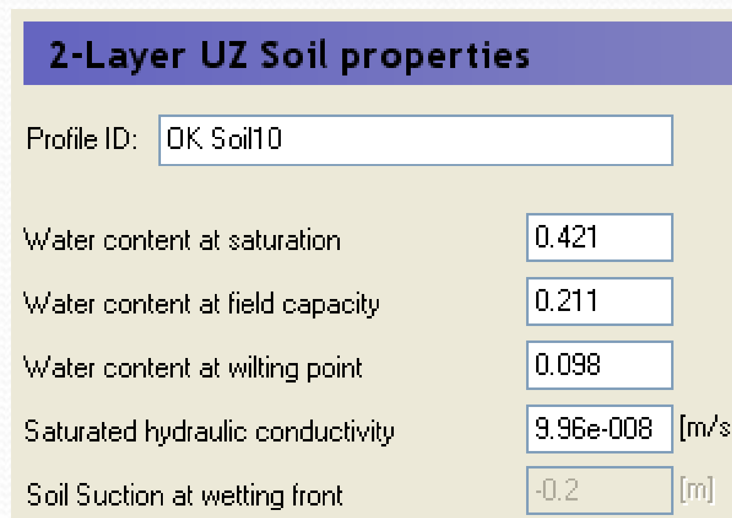


- 187 river branches
- 146 cross sections (lake bathymetry surveys, flood control surveys for Okanagan River)
- 5 control structures (lake operations)

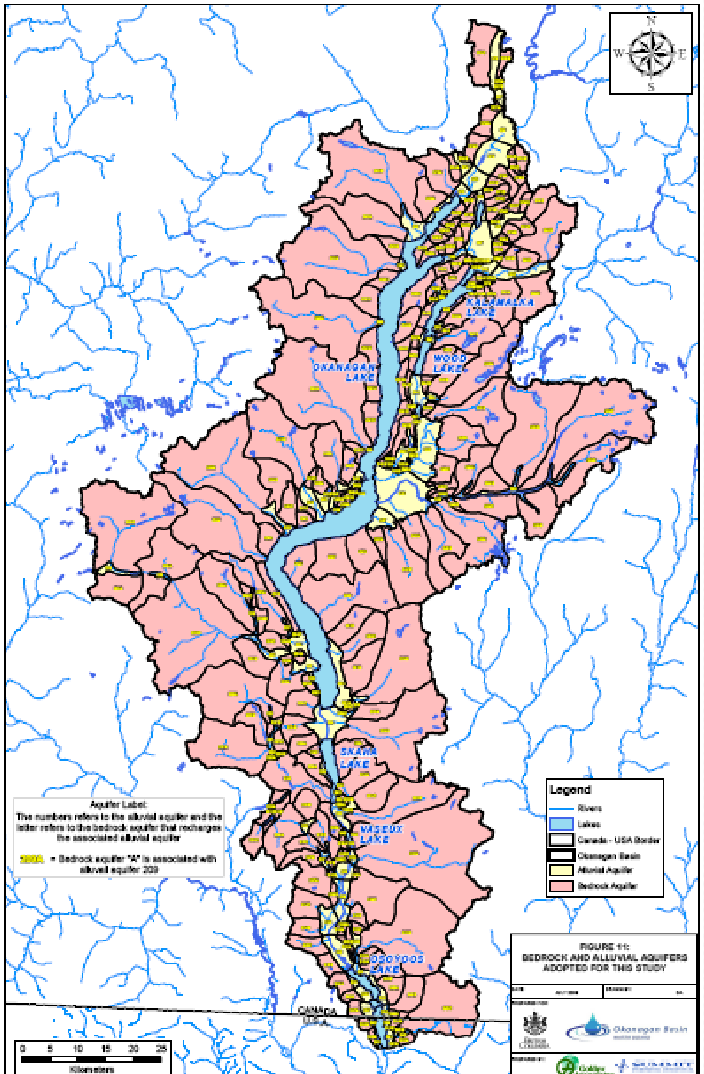
Model Construction – Soils



- Used to distribute soil properties (unsaturated flow and ET components)
- Four soil maps were merged and aggregated into 25 classes



Model Construction – Groundwater



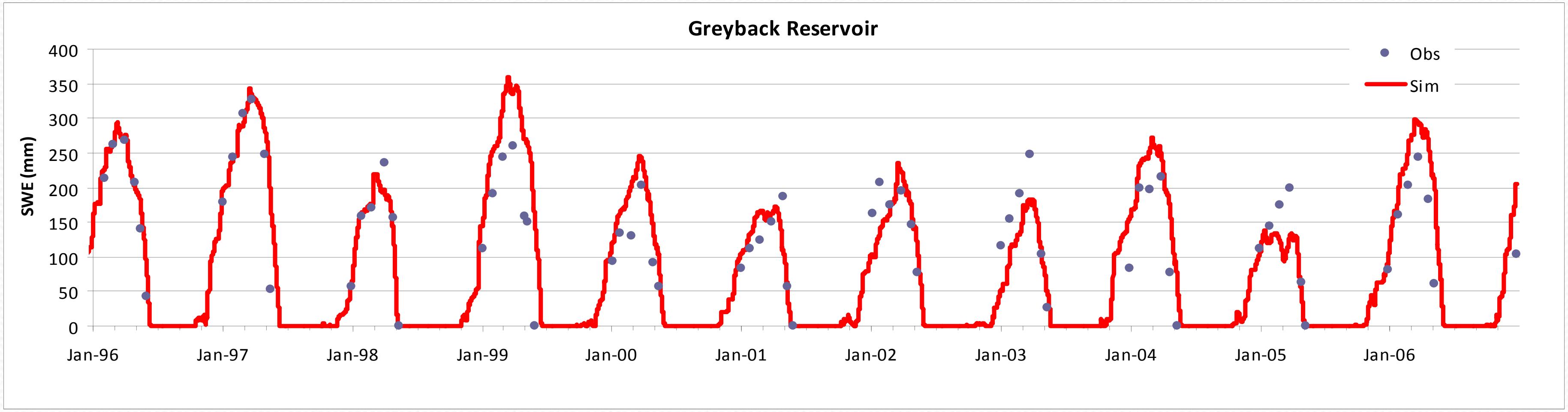
Golder/Summit Groundwater Study

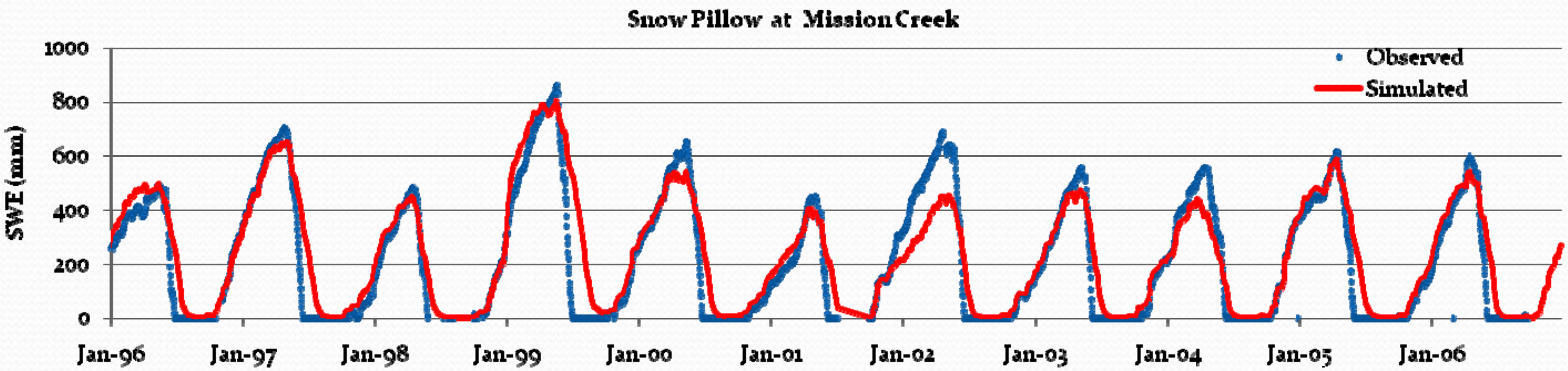
- 324 aquifers (79 alluvial aquifers)
- Recharge occurs primarily in the upland bedrock areas
- The bedrock system consists of a shallow interflow zone and a deeper fractured zone
- ~85% of the upland recharge reports to the shallow interflow zone and flows laterally to recharge down-gradient alluvial aquifers

Hydrology Calibration – Overview

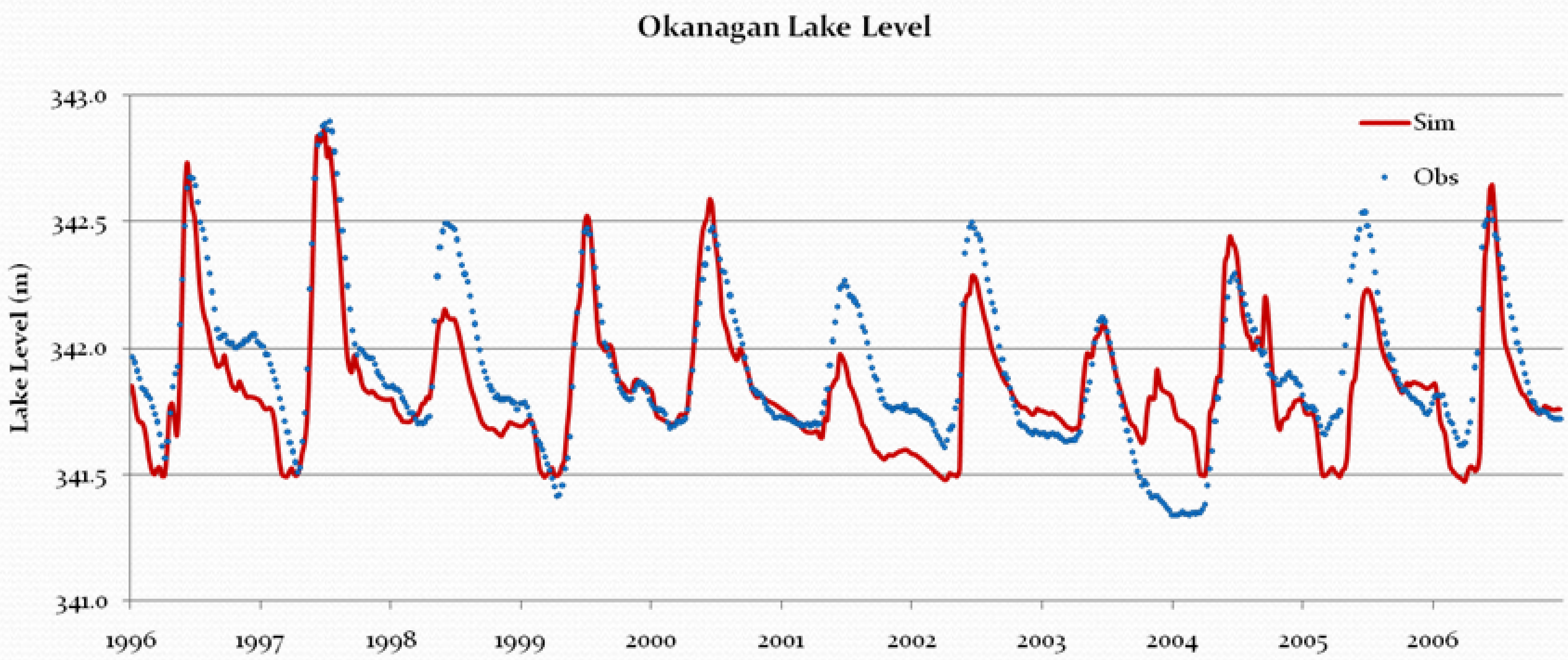
- Overall basin water balance from previous studies
- Snow surveys (19 stations)
- Flow surveys at natural stations (8) and selected regulated stations (5 mainstem stations and 7 tributaries)
- Lake Levels(5 main lakes)

Calibration – Snow Surveys

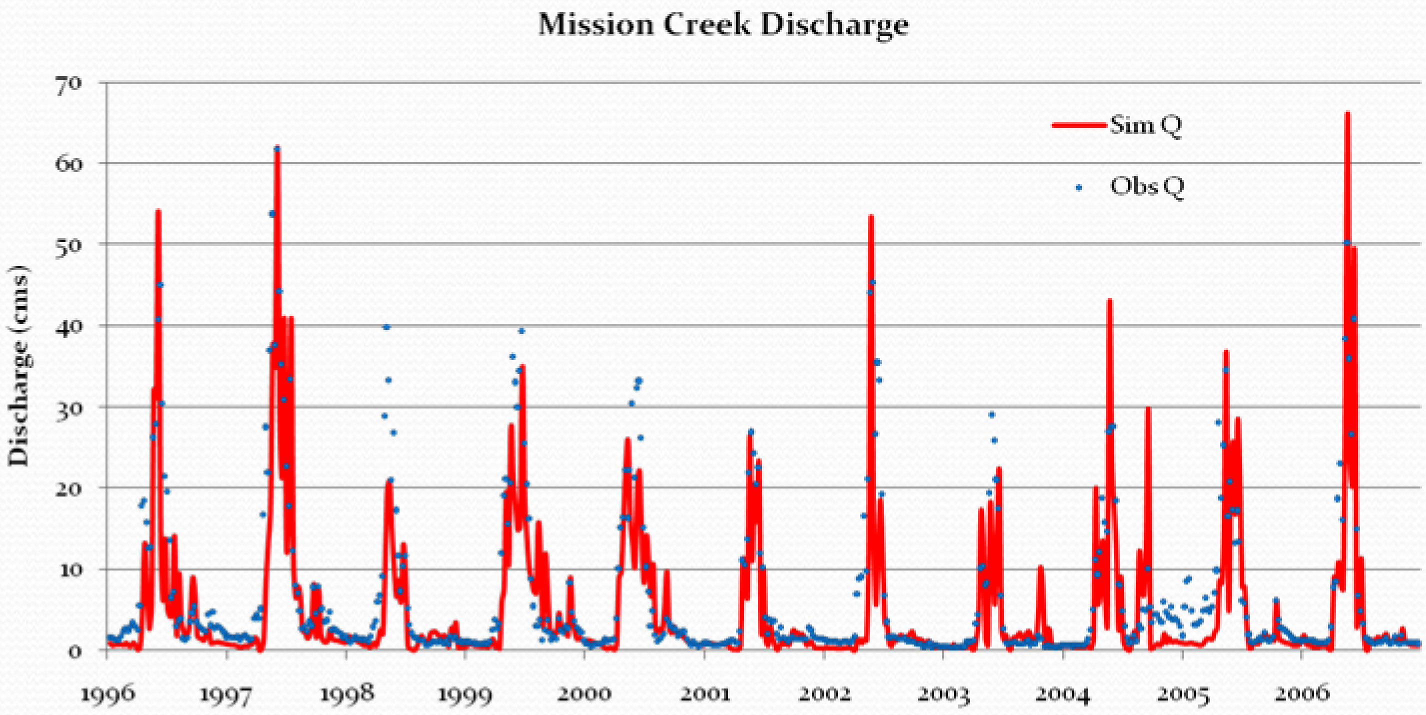




Calibration – Okanagan Lake



Calibration – Mission Creek



Future Scenario Analysis

<u>Supply</u>

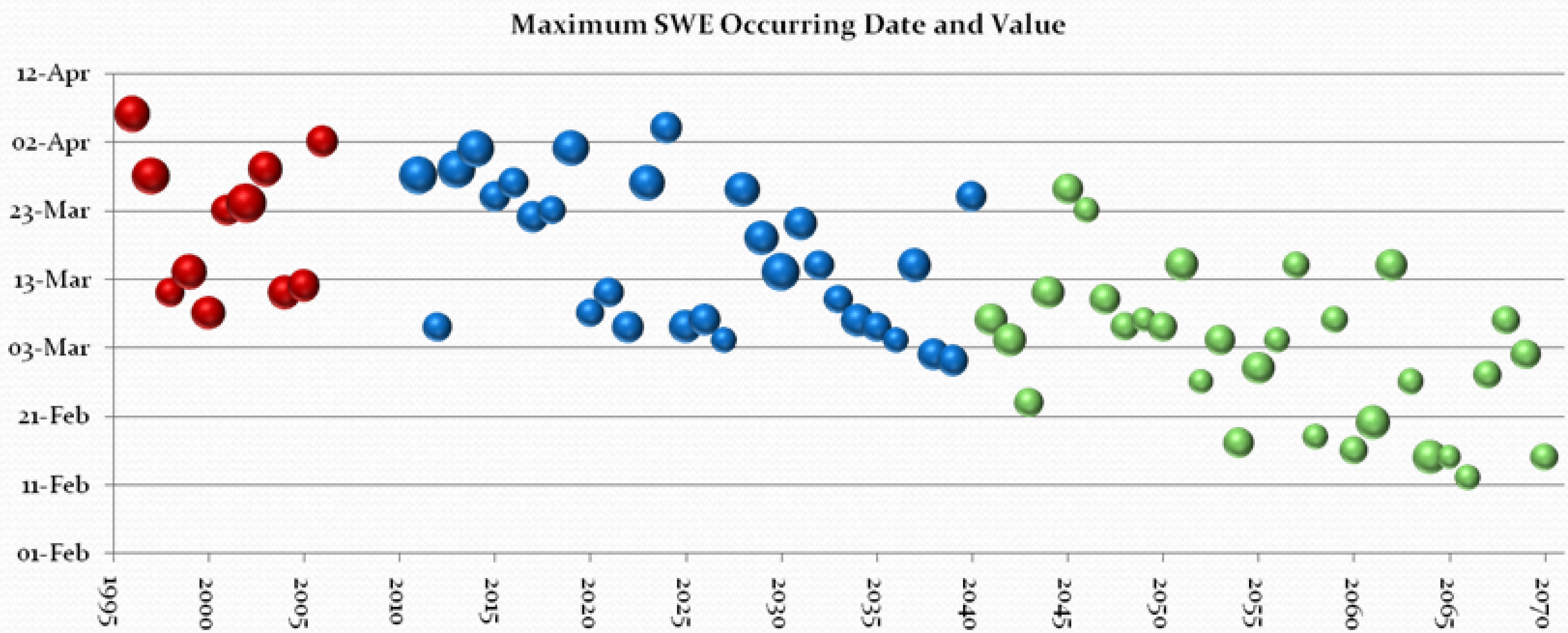
- Impact of climate change on basin hydrology
- Impact of Mountain Pine Beetle (MPB) on basin hydrology

<u>Demand</u>

- Impact of population growth (expected and high)
- Impact of improved water conservation (expected and BC government target of 33%)

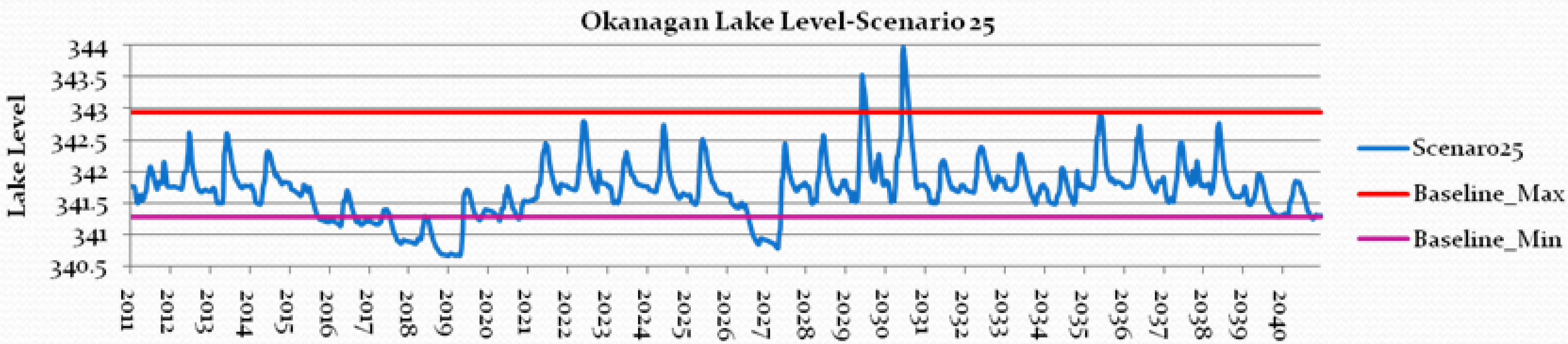
Scenario number	Time Period	CO2 Emission scenario	Mountain Pine Beetle	Efficiency	Agricultural Land Base	Population growth
	T	C	M	E	A	P
1	1. 2011-2040	1. Expected	1. Expected	1. Current use patterns and current trends	1. Present conditions	1. Expected rate
2	1. 2011-2040	1. Expected	1. Expected	1. Current use patterns and current trends	1. Present conditions	2. High rate
3	1. 2011-2040	1. Expected	1. Expected	1. Current use patterns and current trends	2. Irrigate all	1. Expected rate
4	1. 2011-2040	1. Expected	1. Expected	1. Current use patterns and current trends	2. Irrigate all	2. High rate
5	1. 2011-2040	1. Expected	1. Expected	2. 33% Efficiency	1. Present conditions	1. Expected rate
6	1. 2011-2040	1. Expected	1. Expected	2. 33% Efficiency	1. Present conditions	2. High rate
7	1. 2011-2040	1. Expected	1. Expected	2. 33% Efficiency	2. Irrigate all	1. Expected rate
8	1. 2011-2040	1. Expected	1. Expected	2. 33% Efficiency	2. Irrigate all	2. High rate
9	1. 2011-2040	2. Reduced	1. Expected	1. Current use patterns and current trends	1. Present conditions	1. Expected rate
10	1. 2011-2040	2. Reduced	1. Expected	1. Current use patterns and current trends	1. Present conditions	2. High rate
11	1. 2011-2040	2. Reduced	1. Expected	1. Current use patterns and current trends	2. Irrigate all	1. Expected rate
12	1. 2011-2040	2. Reduced	1. Expected	1. Current use patterns and current trends	2. Irrigate all	2. High rate
13	1. 2011-2040	2. Reduced	1. Expected	2. 33% Efficiency	1. Present conditions	1. Expected rate
14	1. 2011-2040	2. Reduced	1. Expected	2. 33% Efficiency	1. Present conditions	2. High rate
15	1. 2011-2040	2. Reduced	1. Expected	2. 33% Efficiency	2. Irrigate all	1. Expected rate
16	1. 2011-2040	2. Reduced	1. Expected	2. 33% Efficiency	2. Irrigate all	2. High rate
17	2. 3 driest years 2011-2100	1. Expected	1. Expected	1. Current use patterns and current trends	1. Present conditions	1. Expected rate
18	2. 3 driest years 2011-2100	1. Expected	1. Expected	1. Current use patterns and current trends	1. Present conditions	2. High rate
19	2. 3 driest years 2011-2100	1. Expected	1. Expected	1. Current use patterns and current trends	2. Irrigate all	1. Expected rate
20	2. 3 driest years 2011-2100	1. Expected	1. Expected	1. Current use patterns and current trends	2. Irrigate all	2. High rate
21	2. 3 driest years 2011-2100	1. Expected	1. Expected	2. 33% Efficiency	1. Present conditions	1. Expected rate
22	2. 3 driest years 2011-2100	1. Expected	1. Expected	2. 33% Efficiency	1. Present conditions	2. High rate
23	2. 3 driest years 2011-2100	1. Expected	1. Expected	2. 33% Efficiency	2. Irrigate all	1. Expected rate
24	2. 3 driest years 2011-2100	1. Expected	1. Expected	2. 33% Efficiency	2. Irrigate all	2. High rate
25	1. 2011-2040	1. Expected	1. Expected	3. Present conditions	1. Present conditions	3. Present conditions
26	3. 2041-2070	1. Expected	1. Expected	3. Present conditions	1. Present conditions	3. Present conditions
27	2. 3 driest years 2011-2100	1. Expected	2. Present	3. Present conditions	1. Present conditions	3. Present conditions

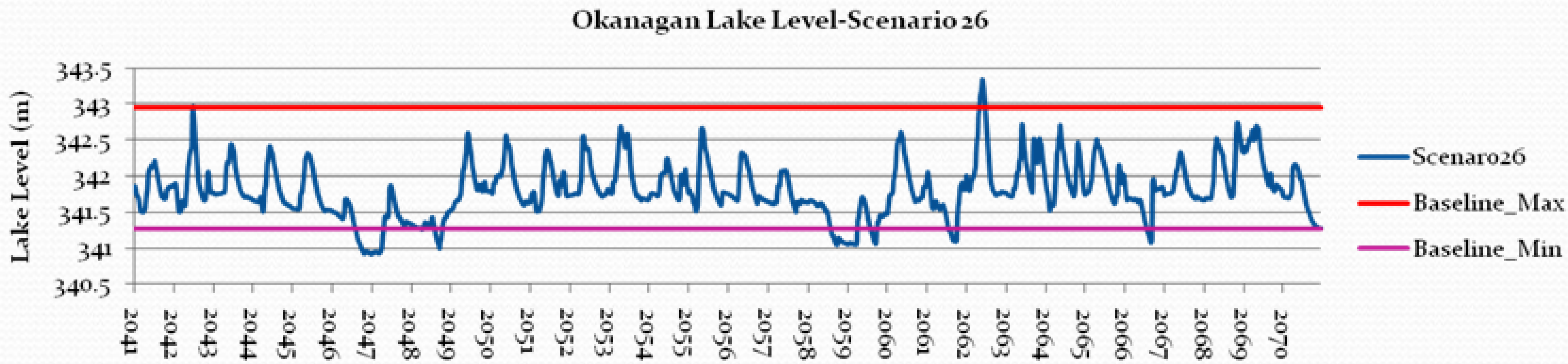
Impact of Climate change on Snow Condition

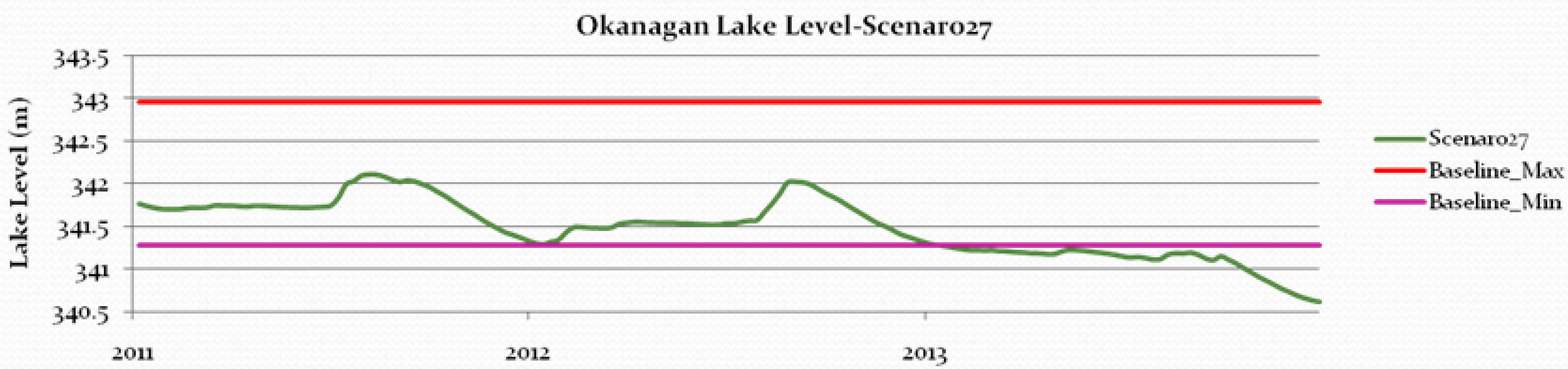


- SWE tends to decrease
- Snow tends to melt earlier

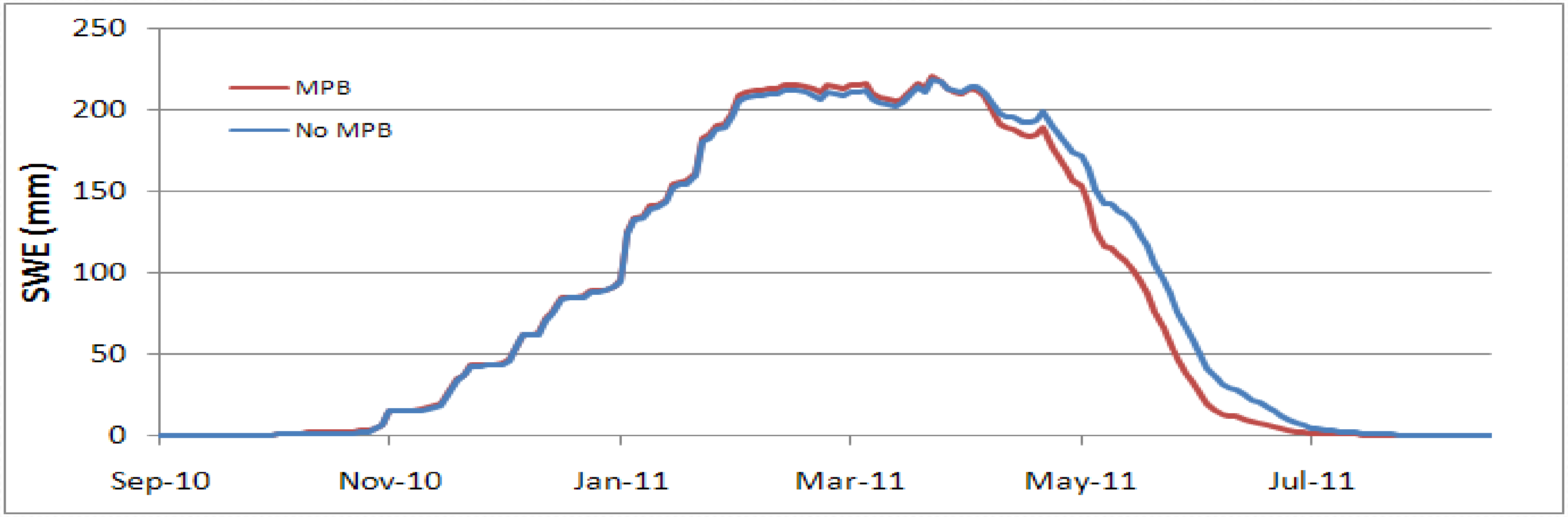
Okanagan Lake Level







MPB Impacts



- Slight increase in peak SWE
- Maximum 12-day earlier melt

SCENARIO PROJECTIONS:

- If we assume that only climate changes, and everything else stays the same, we would use on average 9% more water over the 2011–2040 period than we do now, and 18% more over 2041–2070.
- If climate and population both change as expected, and all reasonably irrigable land is developed (2011-2040), annual water use would average 19% higher over that period than now, even if we continue to introduce water use efficiencies at the same rate we are doing today.
- If we follow the BC Provincial guideline of achieving 33% improvements in water use efficiency by 2020, use would still increase by 12%

PROJECTIONS (continued):

- Climate models show negligible change in total annual precipitation, but air temperatures expected to increase
- More winter precipitation will fall as rain & high elevation snowpack will melt sooner; ~1 week over 2011-2040 period and 2-3 weeks over 2041-2070 period
- Climate change alone or in combination with increased irrigation and population growth is not expected to significantly affect average annual streamflows
- However, between June and September, streamflows Would decrease by roughly 1/3 over the 2011-2040 period, and 2/3 over 2041-2070 (relative to current conditions)
- These reductions balanced by increased streamflows in fall and winter

SUMMARY:

- Okanagan Basin Water Supply & Demand Project: Phase 2 now complete
- Have much better understanding of natural streamflows & factors that affect variability
- Better, but still rough, understanding of groundwater-surface water interaction
- Lake evaporation estimates rely on models, which produce highly variable results
- A working model (using Mike SHE) in place that allows water managers to assess how supply is affected by natural factors (incl. climate change) and by demand
- Phase 3 – Policy & planning changes; refine models