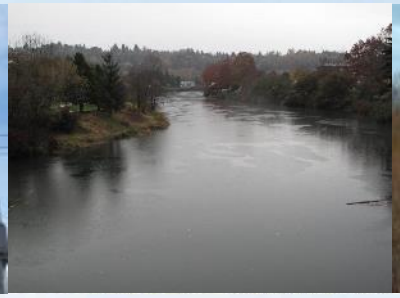
Green/Duwamish River Watershed



Pollutant Loading Assessment: LSPC Watershed Model for Flow

Interested Parties Meeting
March 15, 2017

DEPARTMENT OF ECOLOGY
State of Washington

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

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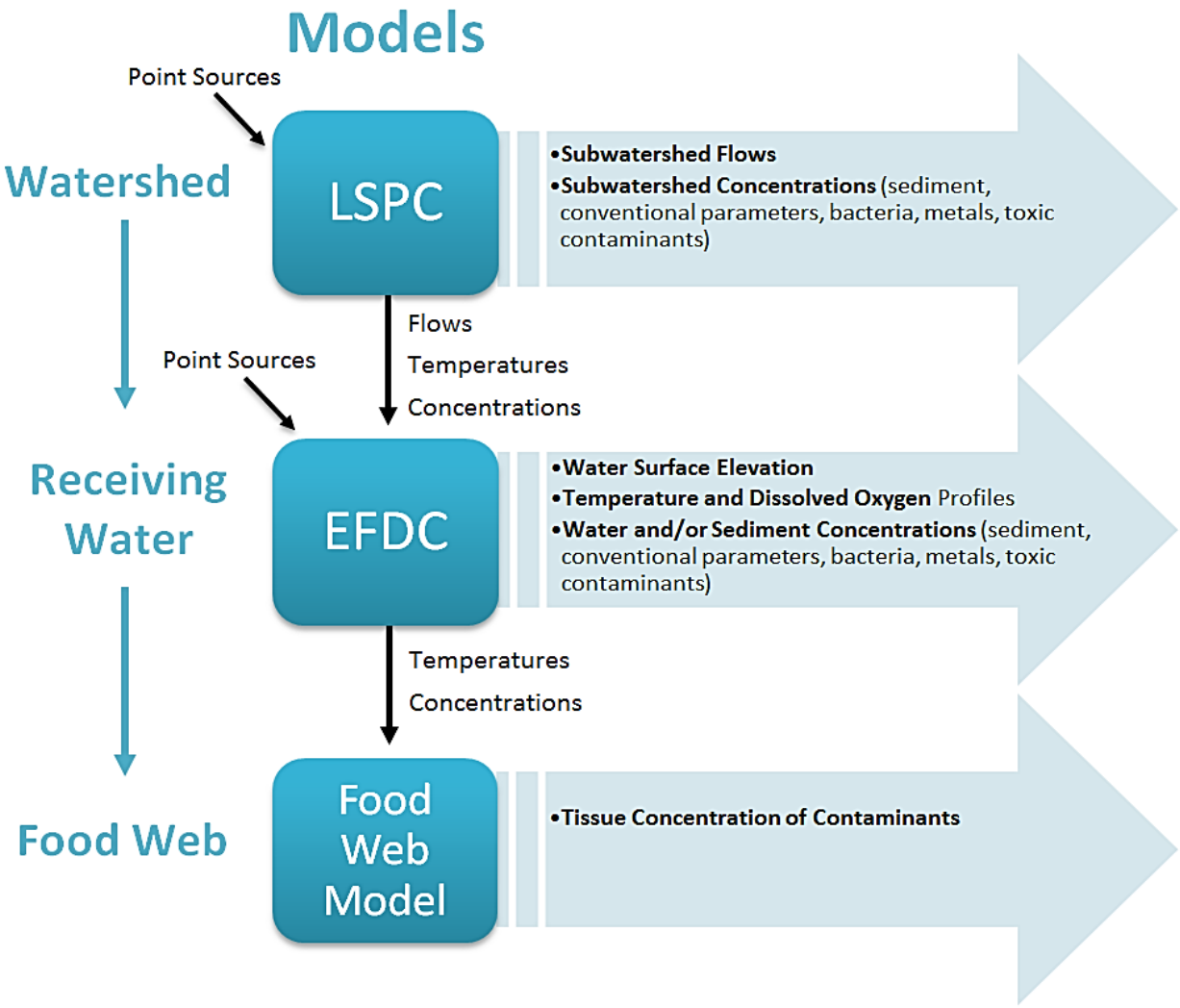
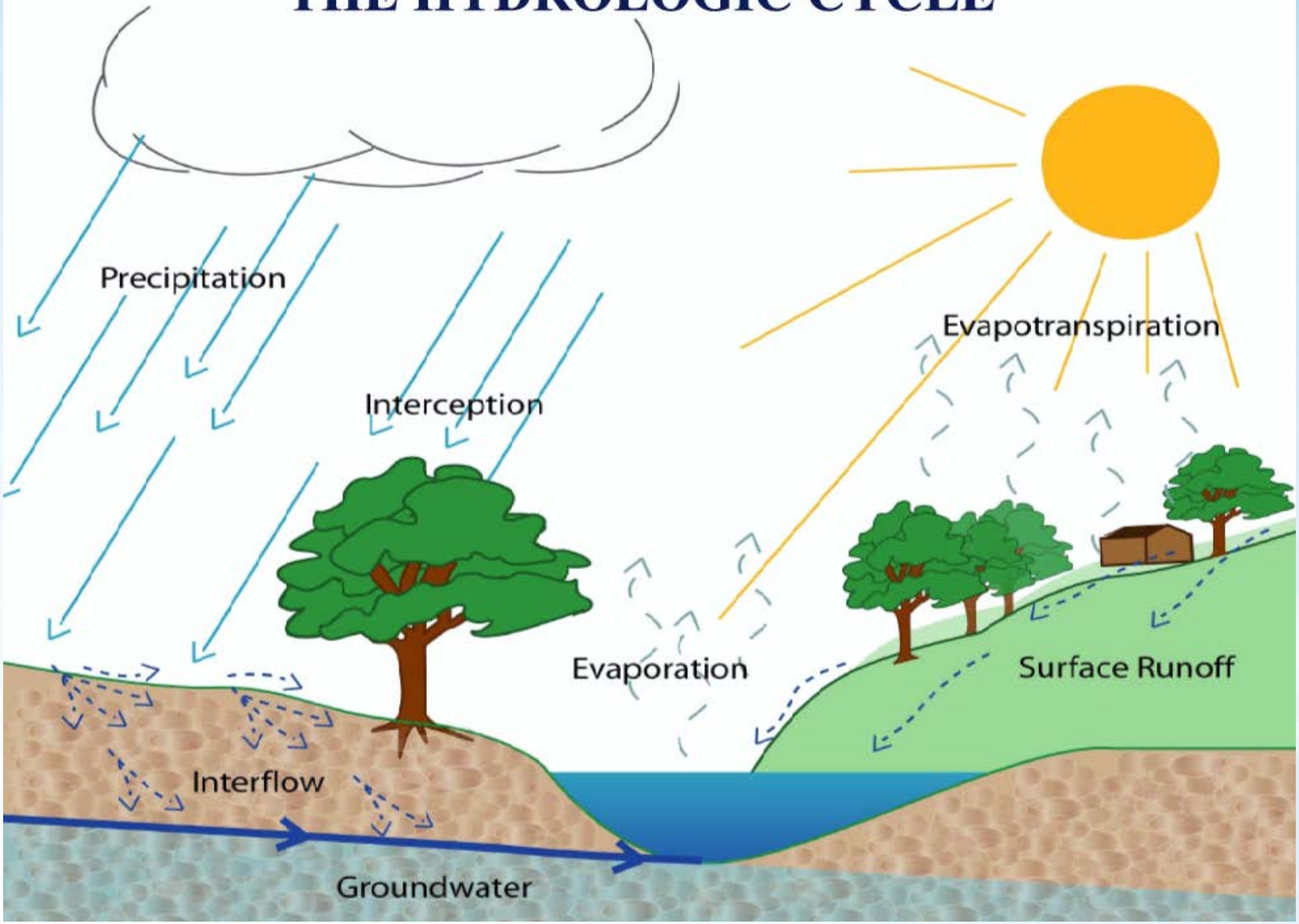
Green/Duwamish Modeling System



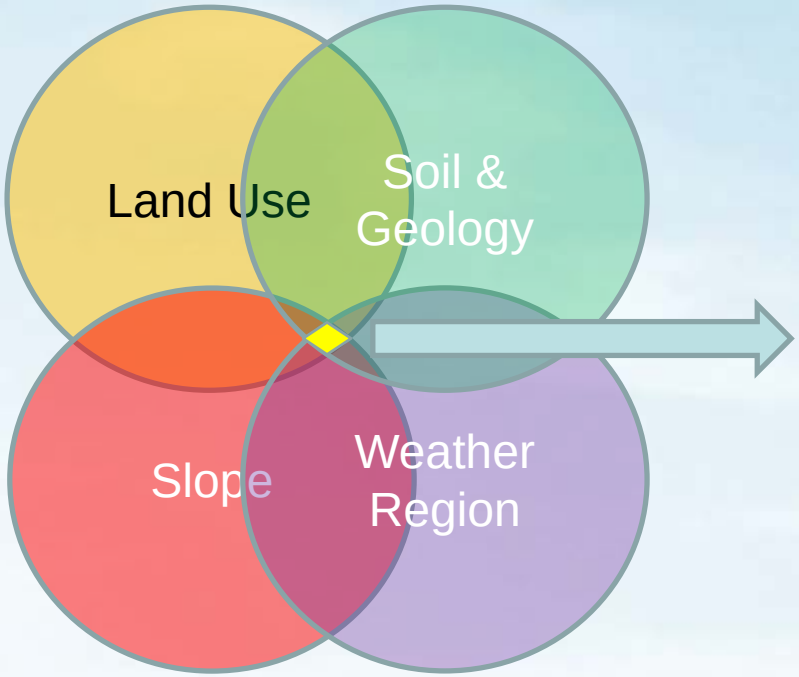
THE HYDROLOGIC CYCLE



Setup of the Watershed Model

- Using LSPC – a C++ implementation of the algorithms in Hydrologic Simulation Program – FORTRAN (HSPF)
  - EPA supported – stable, widely used code
  - Selected as appropriate tool in the QAPP process
- Watershed model
  - Builds upon existing King Co. WRIA9 models
  - Rebuilt with new land use, impervious surface, and reach information
  - Extends models in time through Dec. 2015
  - Extends models in space to cover entire drainage area, including Seattle drainages
- Model implemented on an hourly time step
- Spatial resolution of 30 m

Upland Representation: Hydrologic Response Units

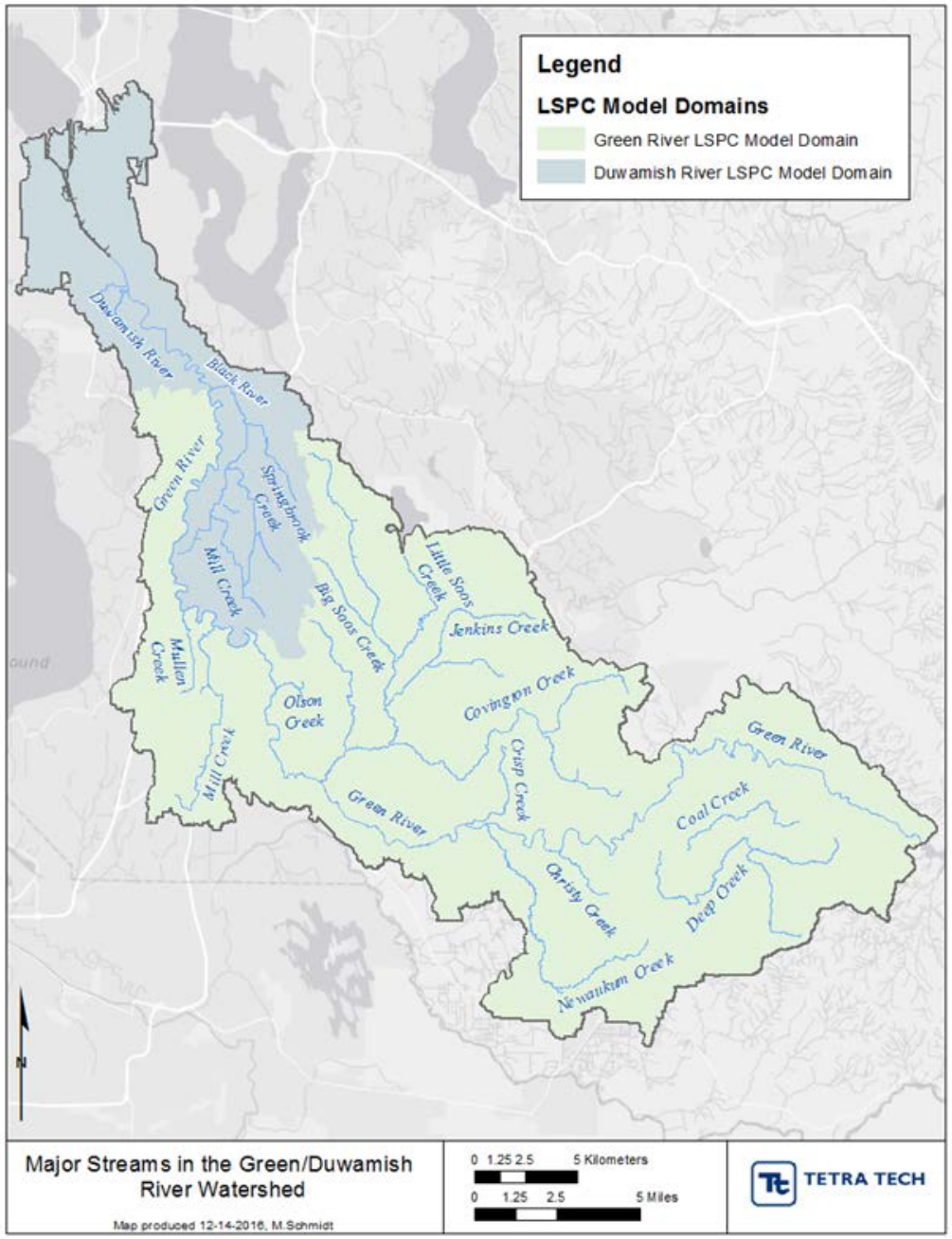


Source areas, classified by land use, soil & geology, slope, and weather region

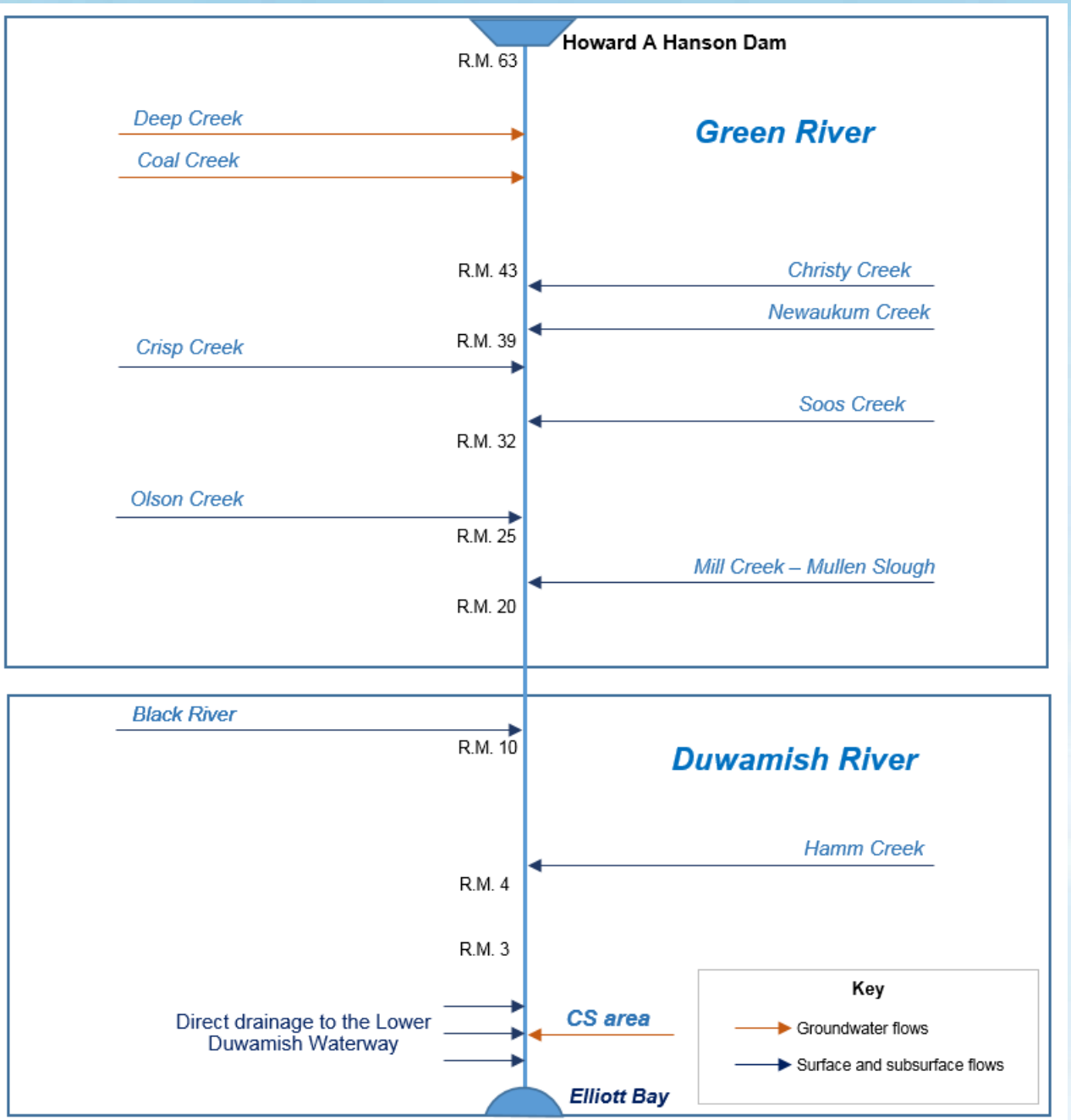
10 pervious land use classes, 4 impervious surface classes, 3 geological types (outwash, till, saturated), 64 weather regions

Model Domain

- From Howard A. Hanson Dam (protected watershed) to mouth of LDW at Elliott Bay in Seattle
- Two linked LSPC models

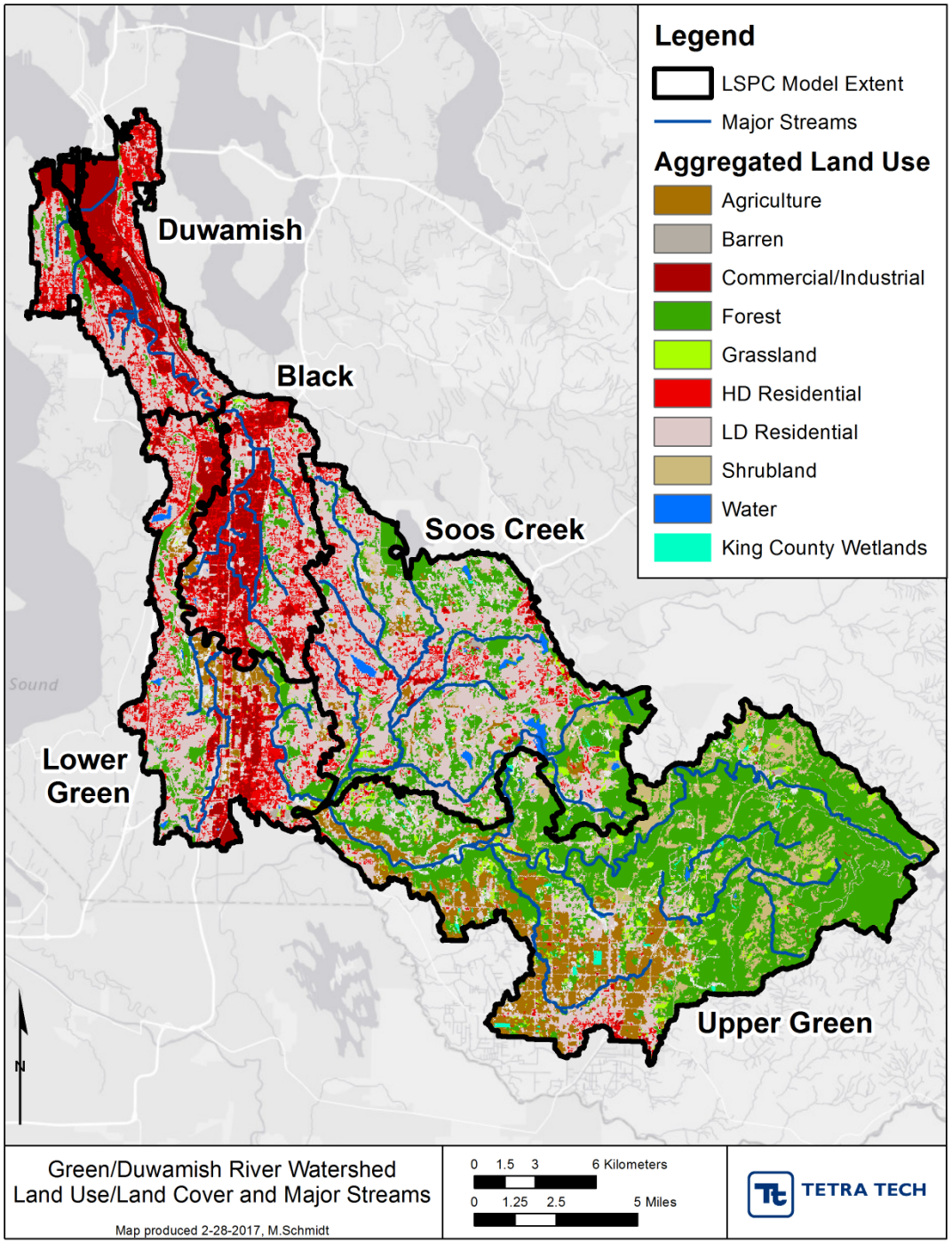


Linked Models



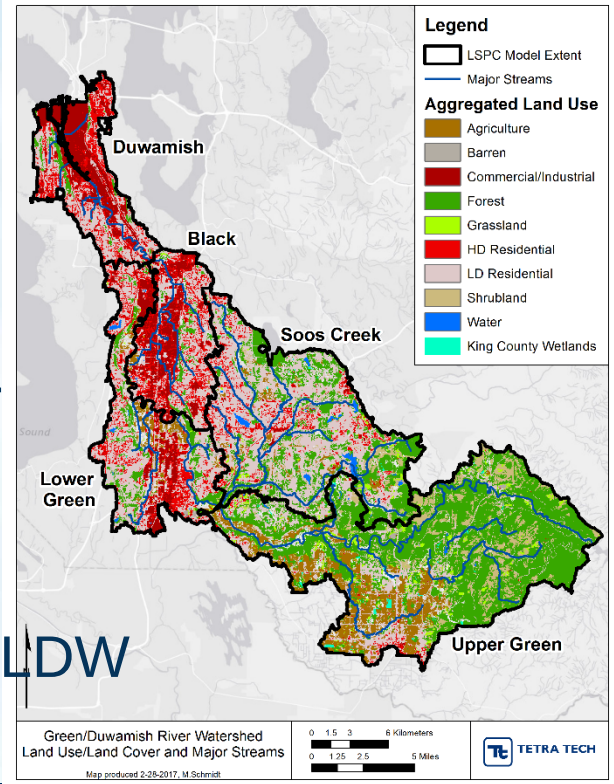
Notes: Not to scale. River Mile zero is defined at the southern tip of Harbor Island

Five Sections of the Watershed



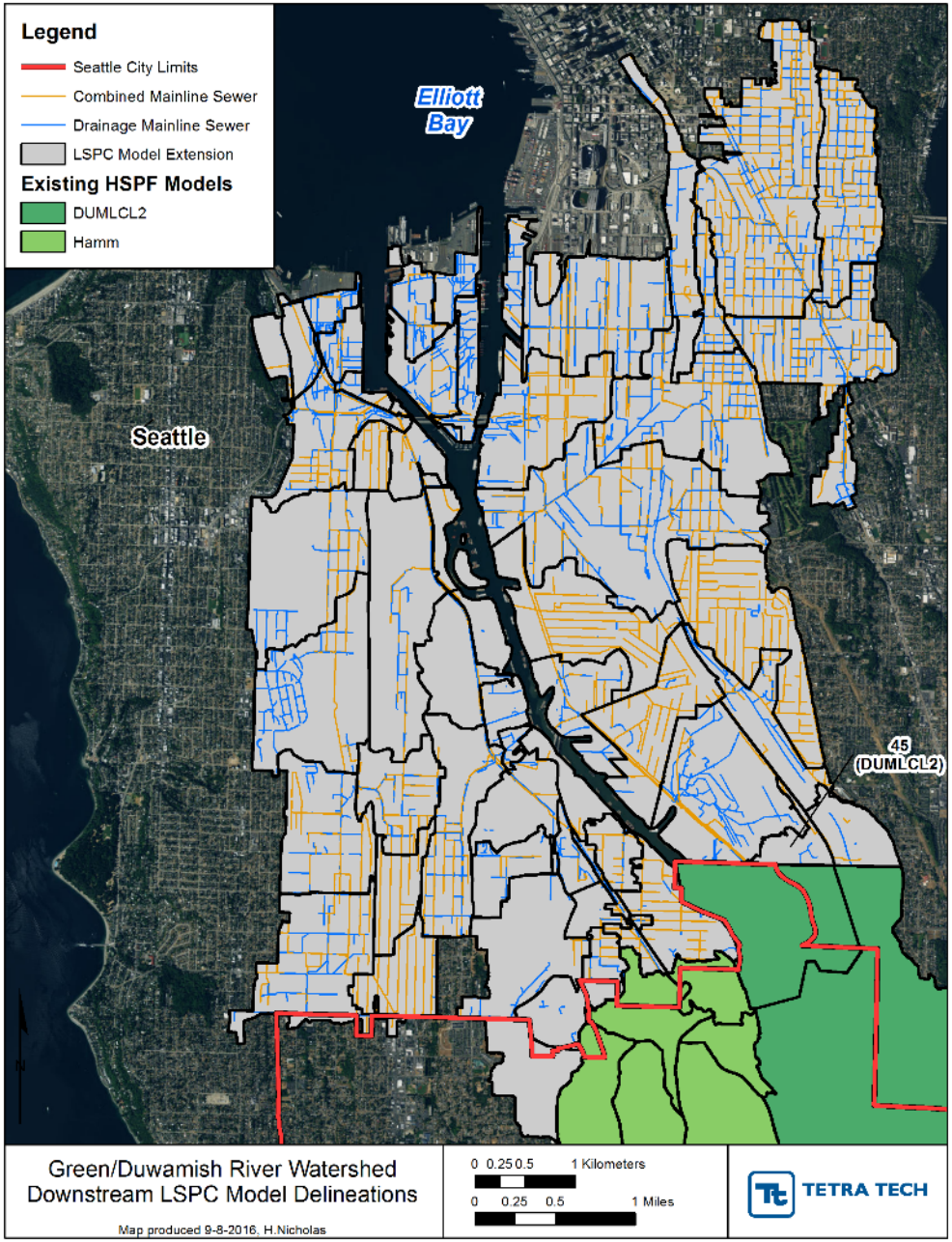
Five Sections of Watershed

1. Upper Green River, Howard Hanson Dam to Soos Crk
   - Largely rural (steep forest, ag near Newaukum)
   - Tacoma diversion
   - Disconnected drainages
2. Soos Creek
   - Low density residential and rural
   - Extensive groundwater interactions
3. Lower Green and 4. Black River
   - High density development on valley floor
   - Cities of Auburn and Kent
5. Duwamish River
   - Grading to ultra-urban in Seattle around LDW
   - Combined storm-sewer areas



Seattle Drainage

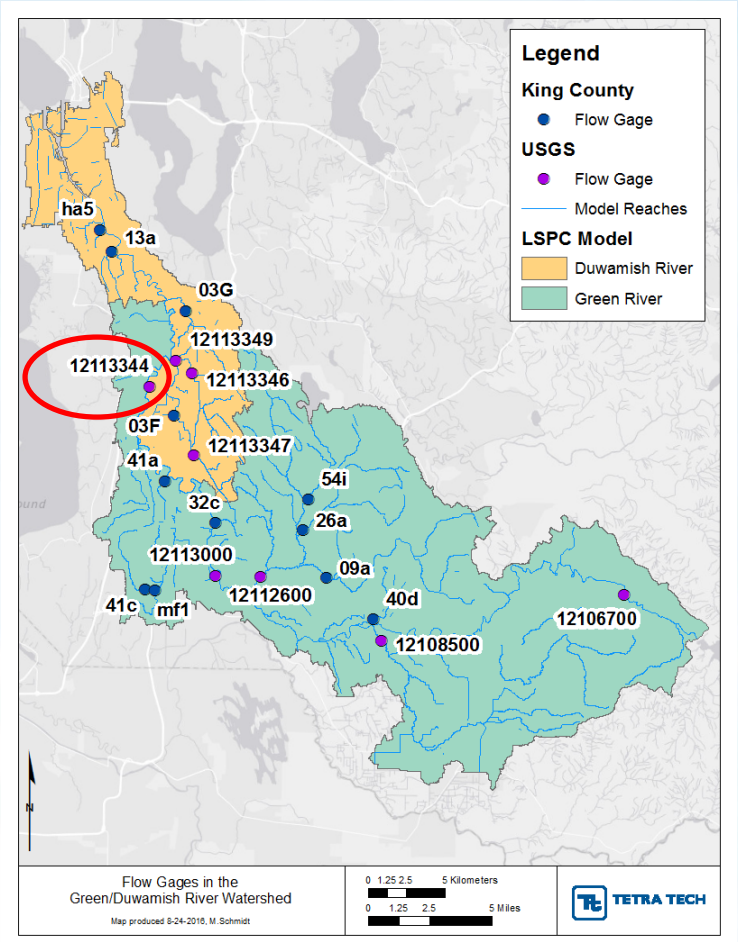
- Not in previous models
- Use SPU drainage basins, sewer lines and SWMM models
- Includes combined sewer areas, as they may contribute groundwater flow to LDW
- Surface runoff in combined area only contributes to LDW during CSO events



LSPC Calibration Strategy

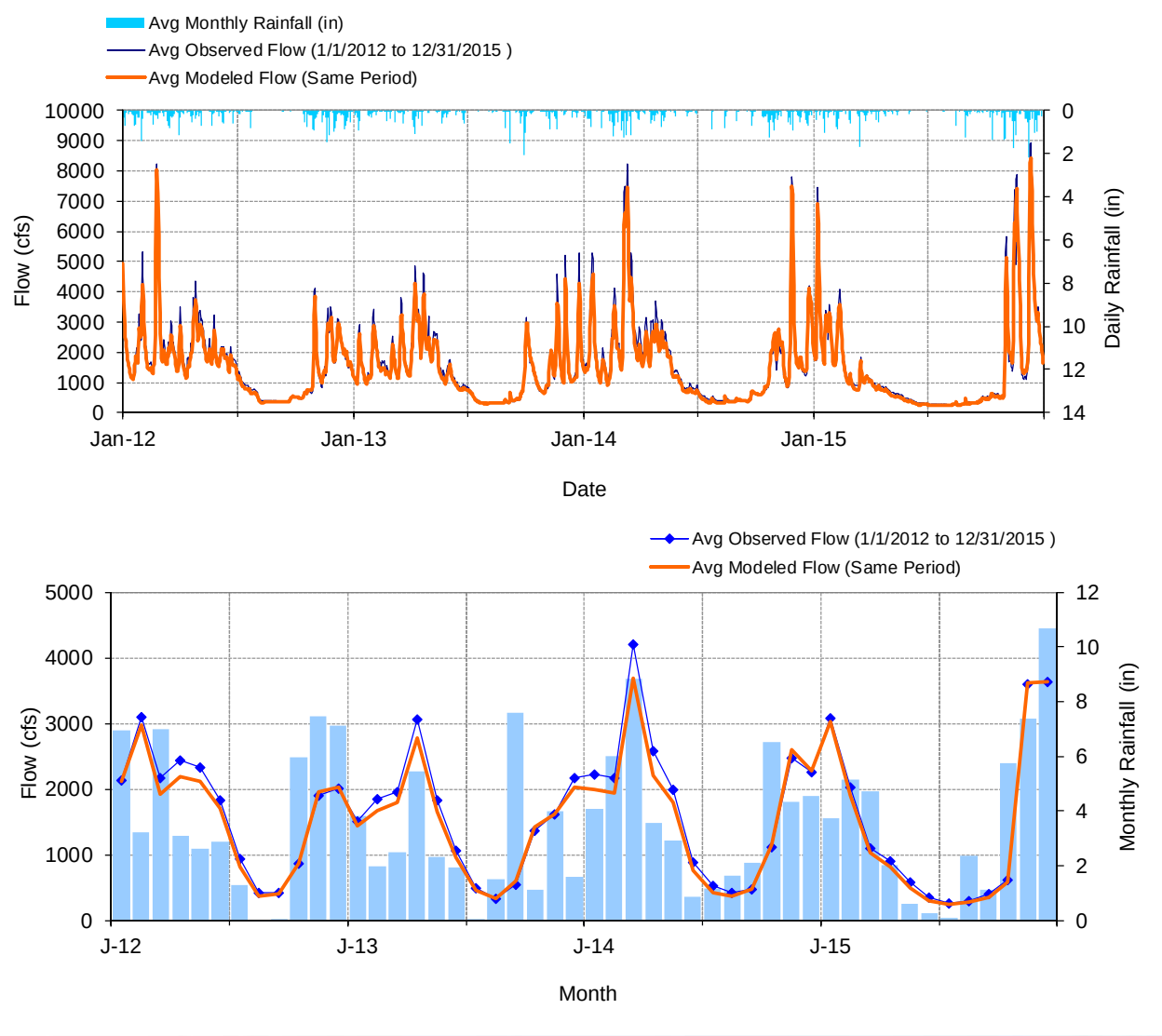
- Start from King Co. WRIA9 HSPF model parameters – adjust within recommended ranges
- Strive for consistent set of upland parameters that vary according to soils and land use/cover (avoid over fitting)
- Calibrate to multiple objectives to ensure robust fit
  - Overall water balance
  - Replicate satellite-based evapotranspiration estimates
  - Calibrate to flow gaging
    - Fit to multiple gages simultaneously
    - Evaluate statistics on annual and seasonal volume error
    - Evaluate fit to flow distribution (high, low)
    - Evaluate fit to flow pattern

Example Flow Calibration: Green River at 200th St., Kent, WA



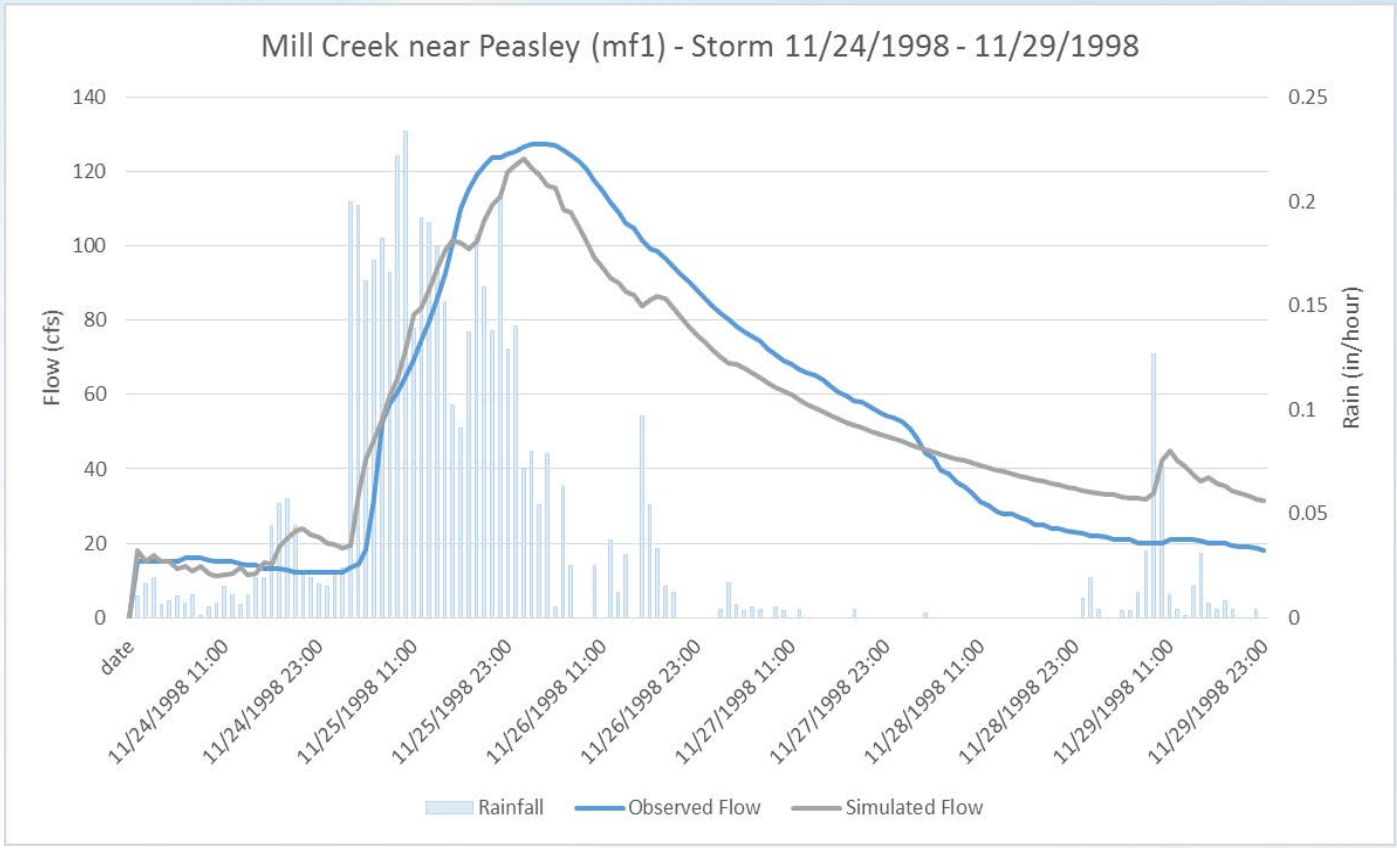
- USGS 12113344
- Established 2012
- Most downstream gage on mainstem
- May be affected by tidal backwater at highest flows

Green River at Kent, Matching Daily and Monthly Flows



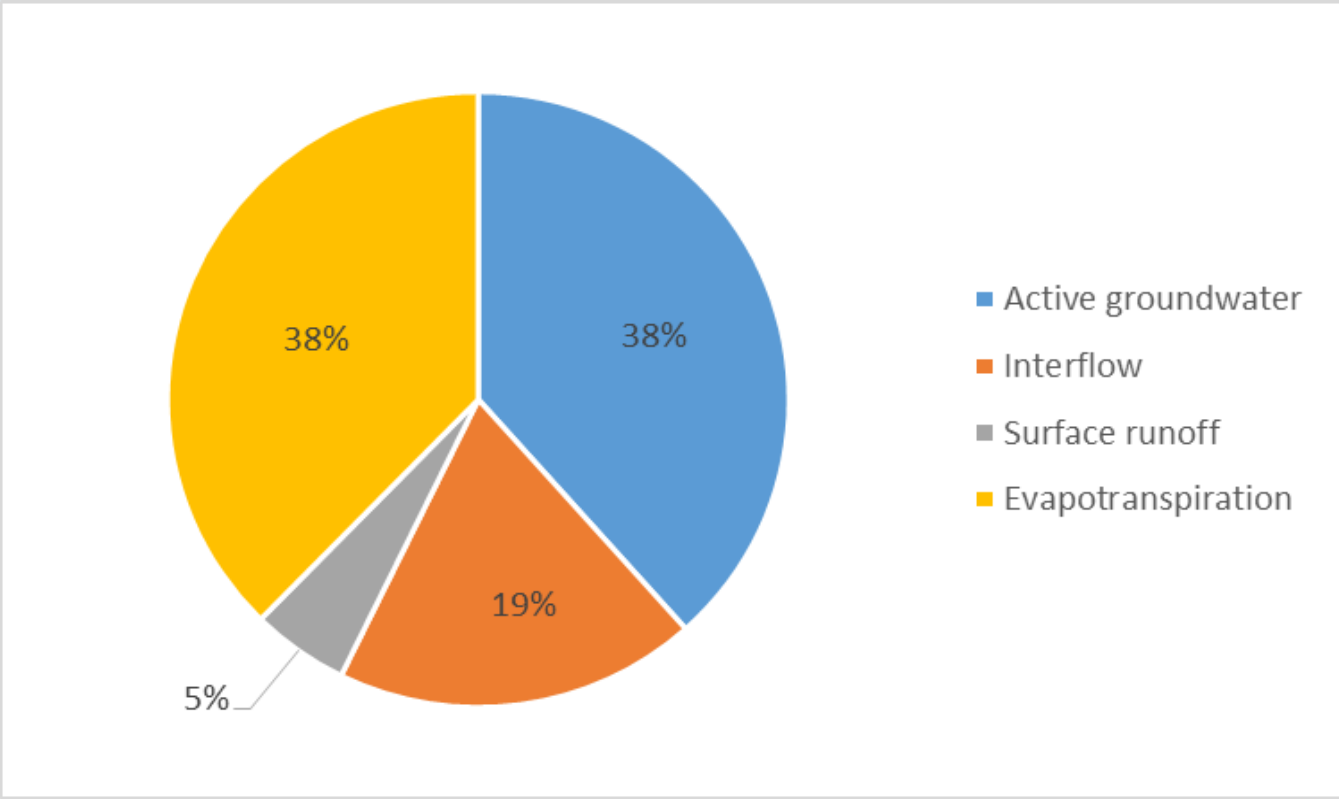
Simulation of Hourly Flows

- Generally reasonable
- Might need additional attention in important source areas



Water Balance and Evapotranspiration – Green River Model

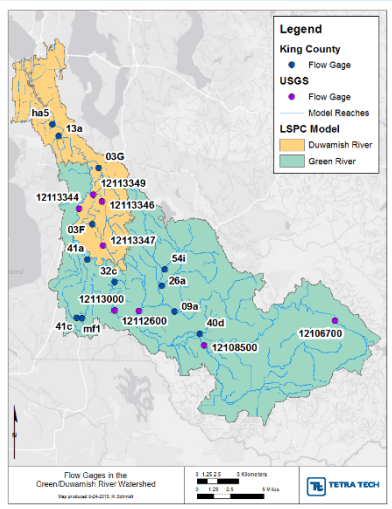
- Matches USGS (Woodward, 1995), *Occurrence and Quality of Groundwater in Southwestern King County*
- Evapotranspiration consistent with MODIS estimates



Overall Model Fit

- Ranked “good” or “very good” for most measures at most gages
- Model is ready to move forward to water quality
- A few situations with poorer fit may be due to complex interactions with ground water and possible issues with some gage records
  - Regional groundwater model has not been developed
  - Gages with poorer fit are small drainage areas, represent only a small fraction of total LDW watershed
- Further refinement could occur (if needed) in conjunction with sediment and toxics transport calibration
  - Should focus on aspects that are significant to the PLA

Overall model fit



Flow Gage Name (Gage Number)	Section	Gage Area as Percent of Total Watershed	Percent Error in Total Volume	Percent Error in 50% Lowest Flow Volumes	Percent Error in 10% Highest Flow Volumes	Daily NSE	Monthly NSE
Mill Creek (Kent) above Diversion (Black R.) (KC 03F)	Black River	1.85%	-5.05%	5.75%	-11.3%	0.860	0.965
Mill Creek at Earthworks Park at Kent, WA (Black R.) (USGS 12113347)		0.96%	2.1%	5.06%	-8.11%	0.766	0.874
Mill Creek near mouth at Orillia (Black R.) (USGS 12113349)		2.16%	-8.93%	-8.23%	-3.93%	0.881	0.930
Springbrook Creek at O'Grady Way (Black R.) (KC 03G)		9.83%	-1.97%	-2.61%	-0.79%	0.863	0.933
Springbrook Creek at Orillia, WA (Black R.) (USGS 12113346)		3.24%	-2.00%	-8.62%	-4.59%	0.722	0.733
Duwamish River Tributary 0003 (KC 13a)	Duwamish	0.21%	16.1%	-7.08%	-6.30%	0.841	0.923
Hamm Creek South Fork (KC ha5)		0.28%	-8.33%	-12.7%	4.50%	0.627	0.639

Model Limitations and Uncertainties

- Many tributaries not gaged or gaged for limited periods
  - *Continue to maintain robust gaging program*
- Hydraulic details for some channels are limited (important for sediment and toxics transport)
  - *Could be further improved through use of local scale HEC-RAS or SWMM stormwater models*
- Shortage of details on extent to which impervious surfaces are connected to the drainage network (outside of Seattle)
  - *Develop/incorporate detailed local studies*

Summary

- Hydrologic calibration is complete
- Team believes model performance is sufficiently good to move ahead with watershed water quality simulation
- Next steps:
  - Set up model to simulate sediment transport
  - Calibrate model to observed suspended sediment and scour/deposition information
- Down the road:
  - Set up and calibrate the watershed model to simulate sources and transport of toxics
  - Link the watershed model to the LDW receiving water model

MODEL DEMONSTRATION

Movie showing model response to high precipitation input of January 2009

- Showing larger reaches only
- Aggregated from 1-hr to 6-hr scale to create manageable animation

Questions and Discussion

EXTRA SLIDES

1D, 2D, or 3D?

Size of Model Domain?

Parameters of Interest?

Time Frame Simulated?

Available Data?

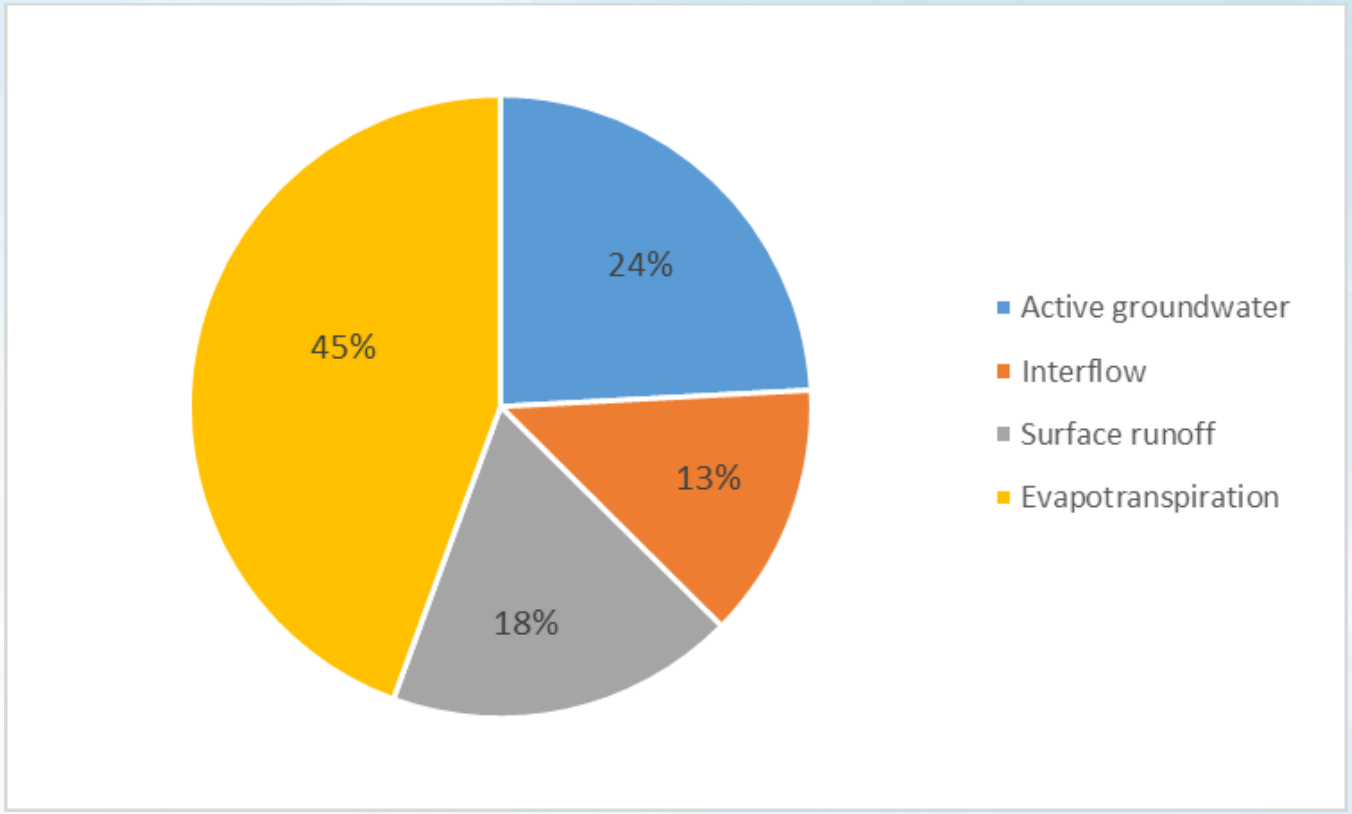
Project Team and Peer Review?

QAPP

AKA “Who, what, how, and when we’re going to build a model”

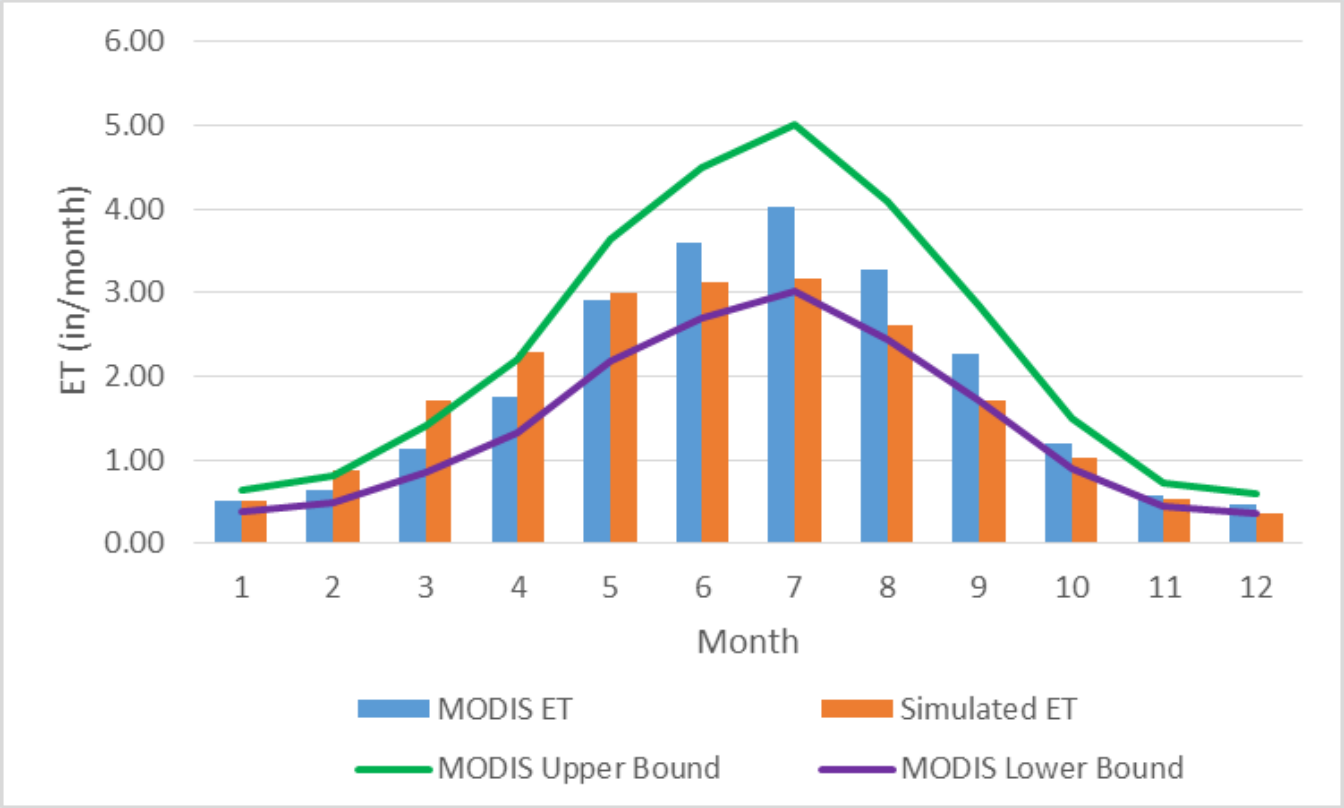
Water Balance – Duwamish Model

- Less Infiltration / more runoff (high imperviousness)



Evapotranspiration

- Consistent with MODIS satellite-based estimates



Flow Gaging

- 20 gages (8 USGS, 12 King Co.)
  - Within 1997-2015 model time frame
  - Periods of record vary
  - Quality of some records questionable (backwaters, shifting channels)