Spokane County Water Demand Forecast Model

IWAC & CAMP Joint Meeting

March 11, 2014

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Water Resources Specialist
Spokane County Resources

Presentation Overview

- Project Overview
- Overall Model Structure
- Model Development
- Forecast Results
- Comparison to Idaho Future Water Demand Study
- Potential Application in Idaho

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Water Resources

Water Demand Project Overview

- Initial Model Developed ***(Model 1.0)***
  - January 2010 to June 2010
  - Project managed by Spokane County with technical consultants CDM & Tetra Tech. Included advisory committee.

- Model Refinement, Calibration, & Verification ***(Model 2.0)***
  - June 2010-January 2011
  - Developed new single family & multi family models
  - Calibrated & verified the model, using water system data
  - Developed forecast & wrote report

- Forecast update, Consumptive/Non-consumptive separation, & return flow routing ***(Model 3.0)***
  - Used updated housing & employment data that was based on new census data, new economic forecast
  - Separated consumptive & non-consumptive use, and routed return flow

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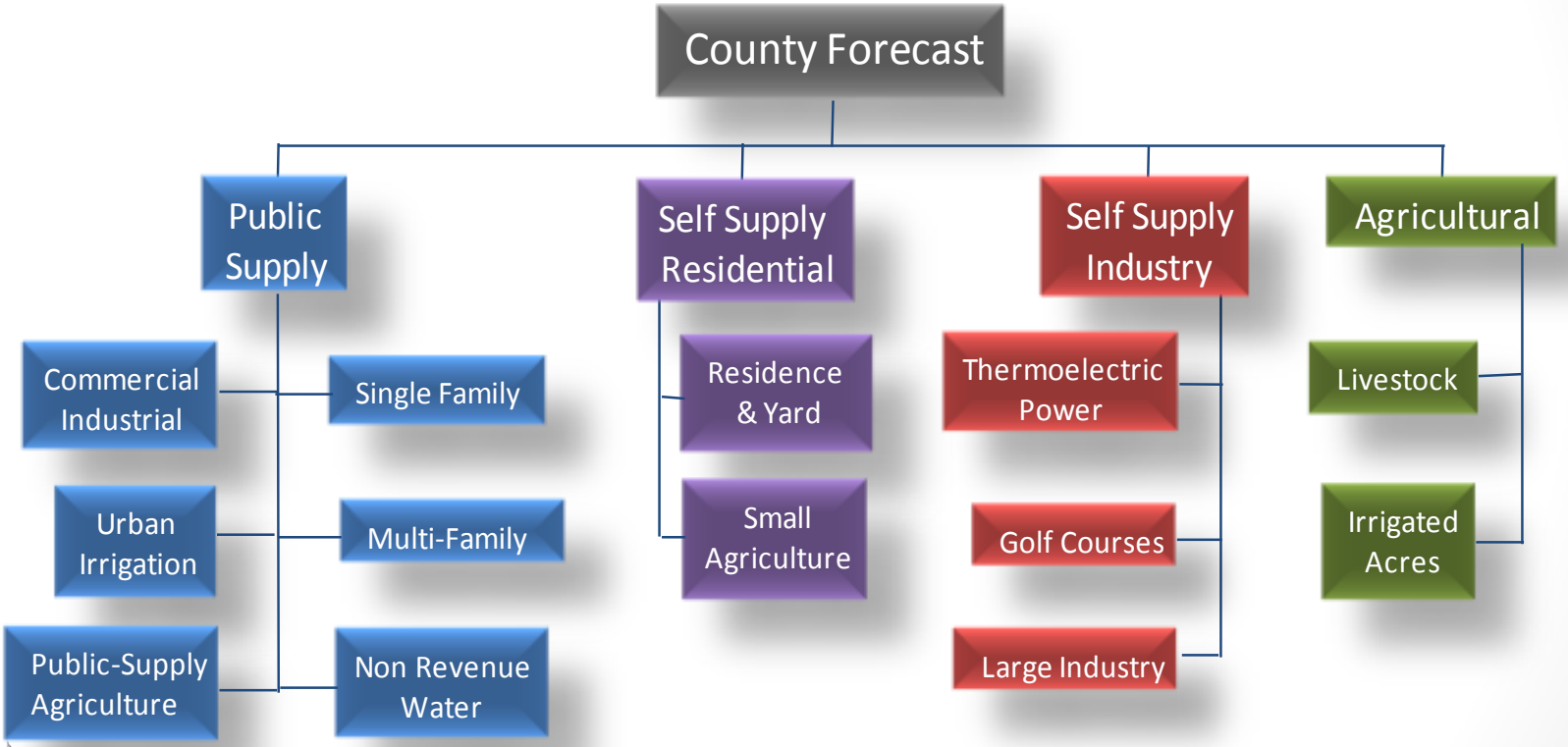
Overall Model Structure

- Segregated by Water Use Sector



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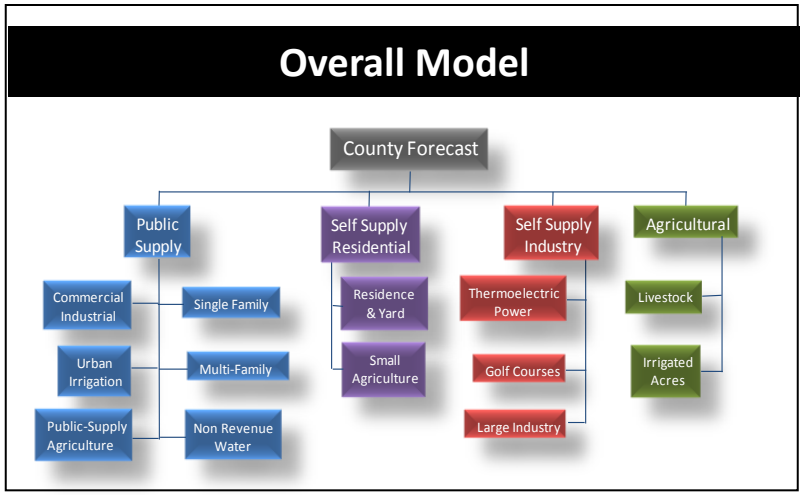
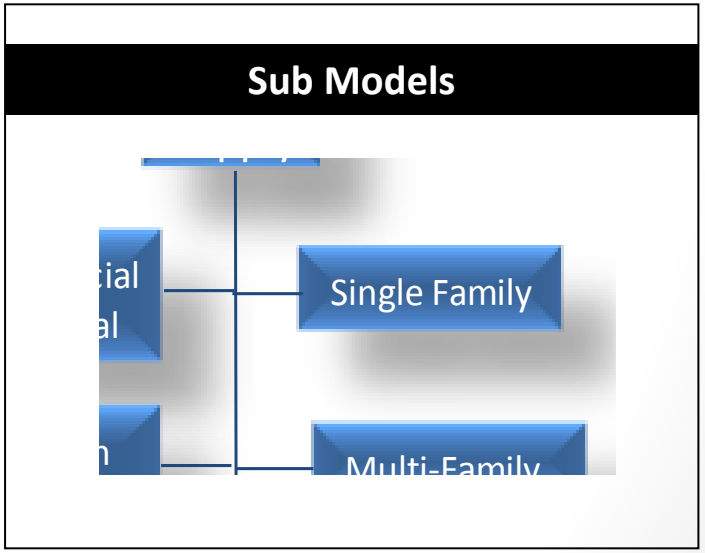
Overall Model Structure



Forecast model is comprised of sub models that vary in complexity from unit use (simple) to econometric (complex).



- Unit Use:
  - gallons per day per household
  - gallons per day per acre
  - gallons per day per employee
- Modified Unit Use
  - Seasonal adjustments
- Econometric:
  - Water use is a function of variables
    - Income, home value, lot size, weather, etc.
  - Statistically derived equation

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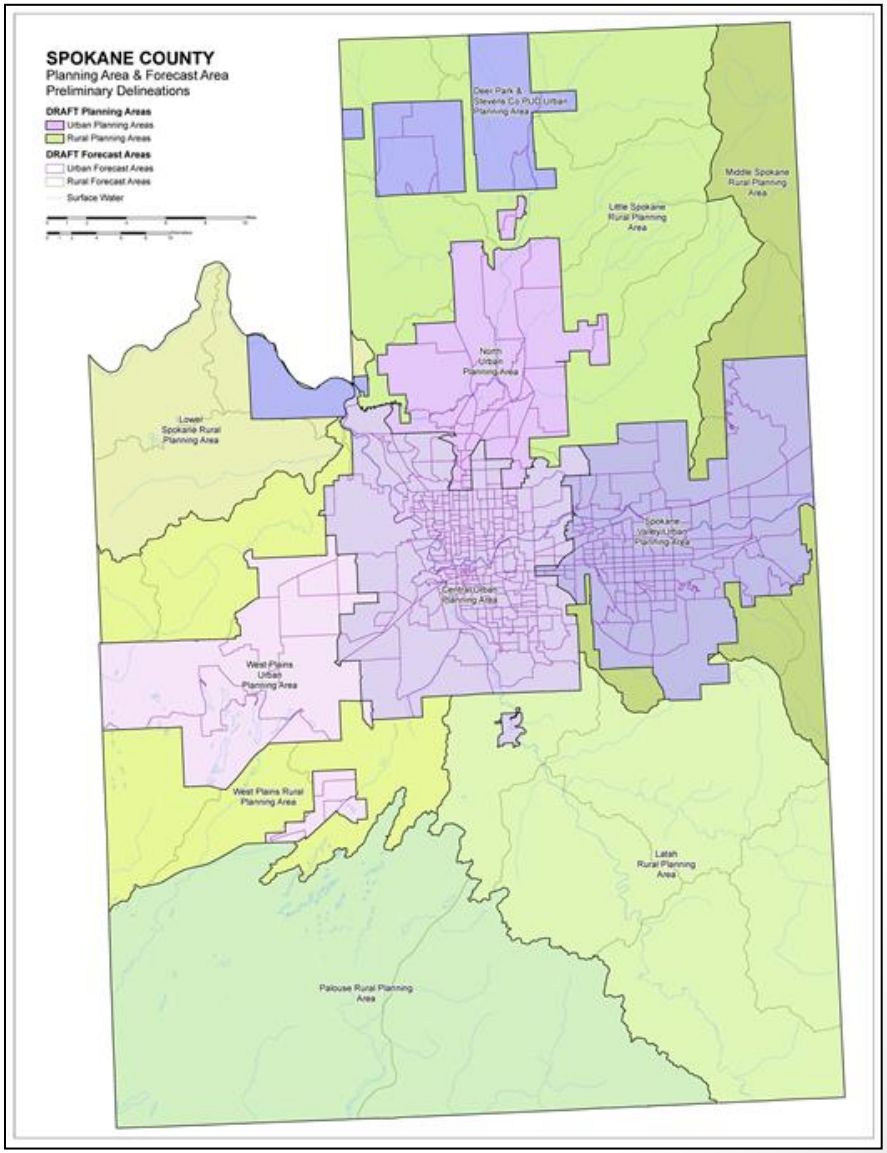
Overall Model Structure

- Segregated Spatially
  - 513 separate forecast units
  - A unique water demand calculation is done for each forecast unit
  - Can evaluate different areas of interest
    - Areas over the SVRP aquifer for groundwater return flow
    - Areas served by aquifer for SVRP groundwater withdrawals



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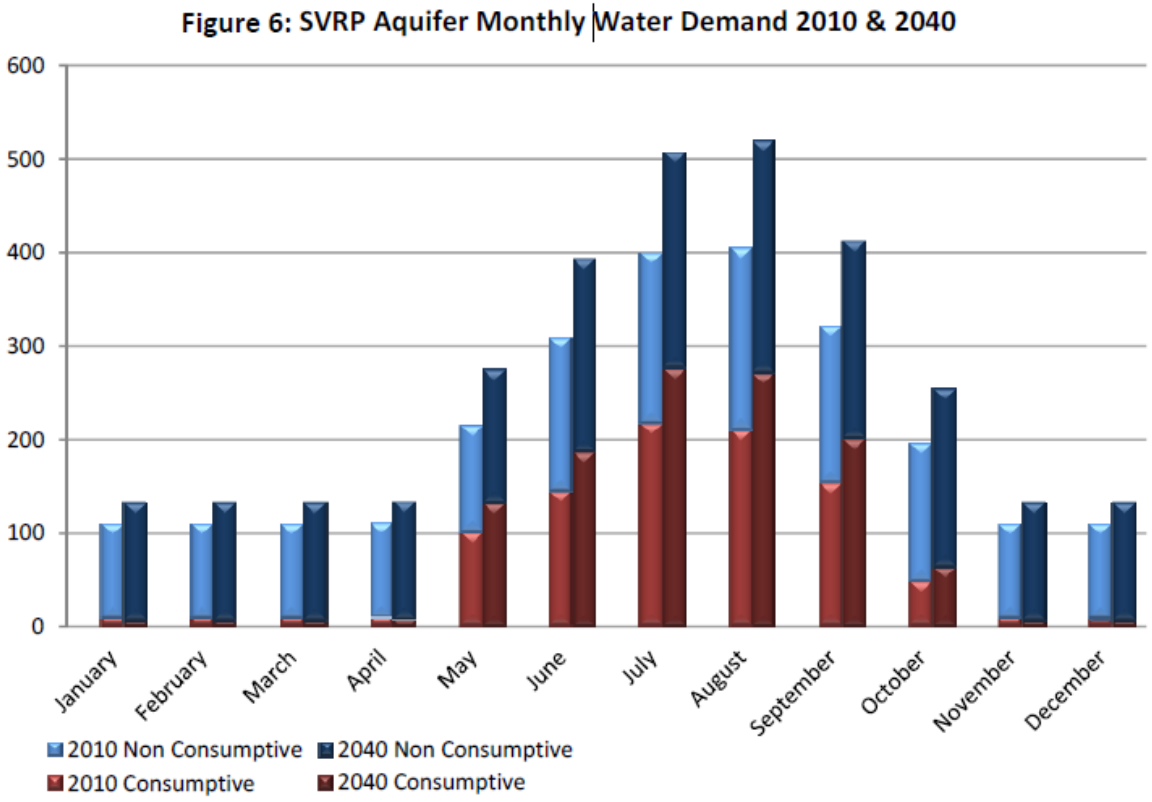
Overall Model Structure

- Segregated in monthly increments



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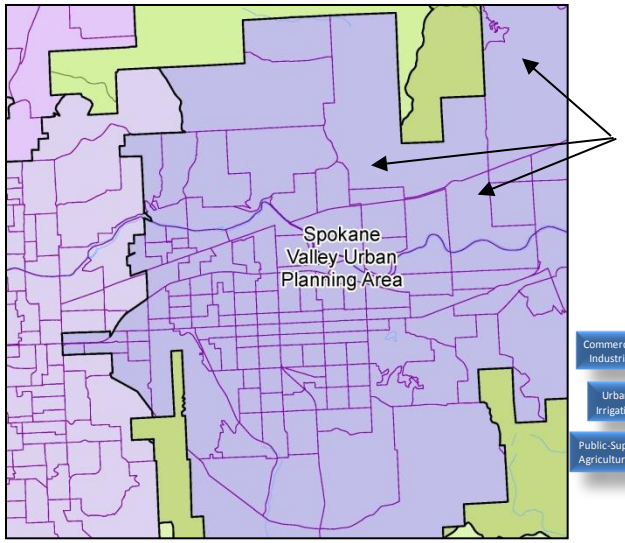
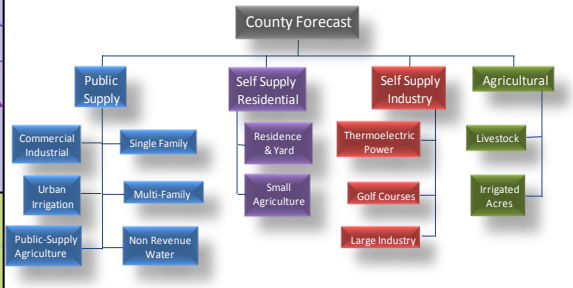
Water Demand Model Overview

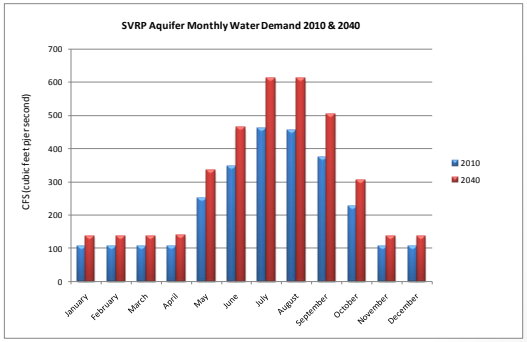
- Model is highly disaggregated which allows for many types of analysis, for example:
  - Water use from SVRP
  - Self supplied water use in Little Spokane River Basin



Each forecast unit can have different inputs into each sub model



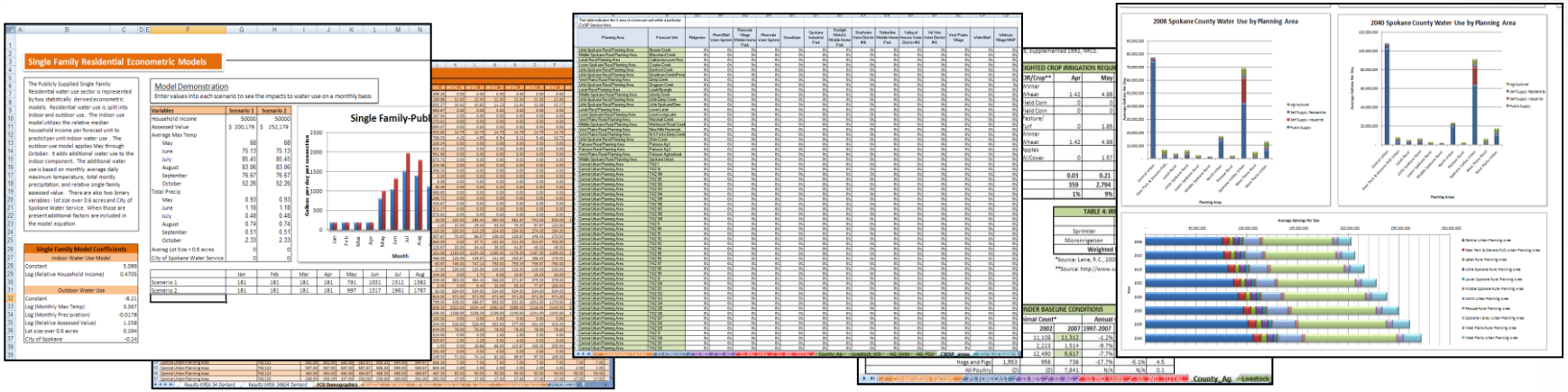
Water demand calculation for each month



Spokane County Water Resources

Water Demand Model Overview

- Developed and runs in Excel




```
=$B5+(1-'Conservation Factors'!$D66)*IF(ISERROR(EXP('SF Model'!$C$32+(LN(Weather!$G$12)*'SF Model'!$C$33)+(LN(Weather!$H$12)*'SF Model'!
$C$34)+(LN('FCU Demographics'!$CO5)*'SF Model'!$C$35)+('SF Model'!$C$36*'FCU Demographics'!$CI5)+('SF Model'!$C$37*'FCU Demographics'!$CJ5))
),0,EXP('SF Model'!$C$32+(LN(Weather!$G$12)*'SF Model'!$C$33)+(LN(Weather!$H$12)*'SF Model'!$C$34)+(LN('FCU Demographics'!$CO5)*'SF Model'!
$C$35)+('SF Model'!$C$36*'FCU Demographics'!$CI5)+('SF Model'!$C$37*'FCU Demographics'!$CJ5)))
```

```
=IF(($AA10*IF(ISERROR(('MF Model'!$C$19)+('MF Model'!$C$22*Weather!$G$11)+(LN('FCU Demographics'!$CO10)*'MF Model'!$C$23)*(1-
'Conservation Factors'!$C$10)),0,(('MF Model'!$C$19)+('MF Model'!$C$22*Weather!$G$11)+(LN('FCU Demographics'!$CO10)*'MF Model'!$C$23)*(1-
'Conservation Factors'!$C$10))))<150,$AA10,($AA10*IF(ISERROR(('MF Model'!$C$19)+('MF Model'!$C$22*Weather!$G$11)+(LN('FCU Demographics'!
$CO10)*'MF Model'!$C$23)*(1-'Conservation Factors'!$C$10)),0,(('MF Model'!$C$19)+('MF Model'!$C$22*Weather!$G$11)+(LN('FCU Demographics'!
$CO10)*'MF Model'!$C$23)*(1-'Conservation Factors'!$C$10)))))
```

- Series of interconnected spreadsheet and formulas

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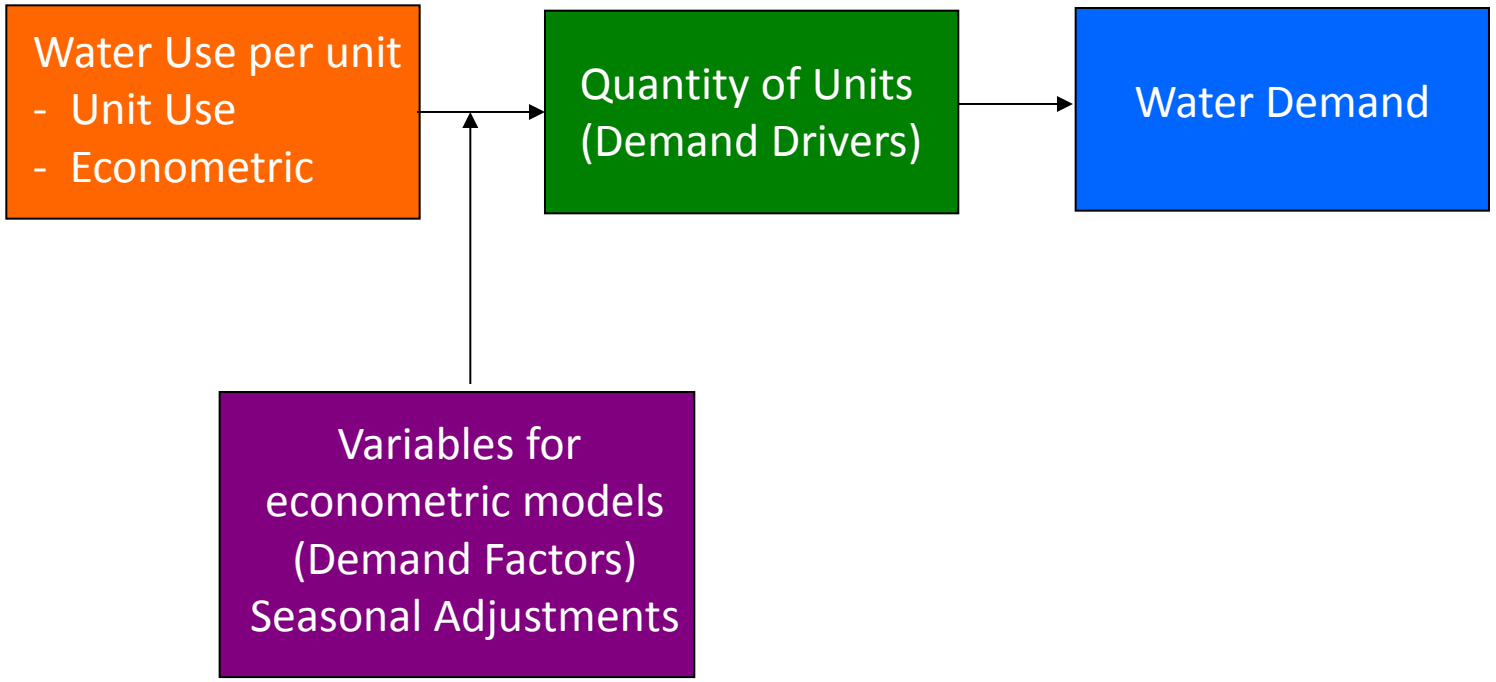
Model Development

- Fundamental components of the model



- Model complexity from the adaptation of this approach to each water use sector and subsector

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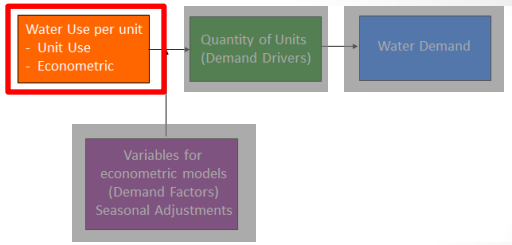
Model Development



- Water Use Per Unit Data
  - Public Supply Model
    - Monthly water use data per connection by sector for multiple years from Water Purveyors
      - Single family
      - multi-family
      - commercial industrial
      - Irrigation
    - Wastewater data
    - Commercial/Industrial water use data by employee
  - Agricultural
    - Washington State Irrigation Guide
  - Self Supplied Residential
    - Residential Water Use Survey
  - Self Supplied Industrial
    - NPDES Discharge Monitoring Reports, BiState aquifer study, Watershed Planning Data Assessments

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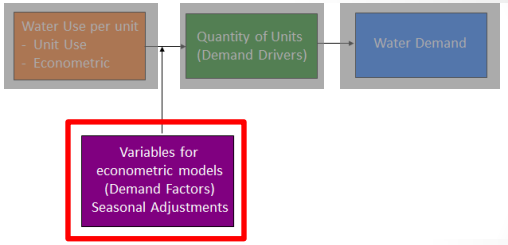
Model Development



- Demand Factors Data
  - Weather – NOAA, Agrimet
    - Temperature
    - Precipitation
    - ET Estimates
  - Census Data
    - Household size
    - Family size
    - Household income
  - Assessor Data
    - Single family residential assessed value
    - Lot size
  - GIS Spatial Analysis of Well Yield
    - Water availability limitations
  - USGS Land Cover Data
    - Rural residential setting

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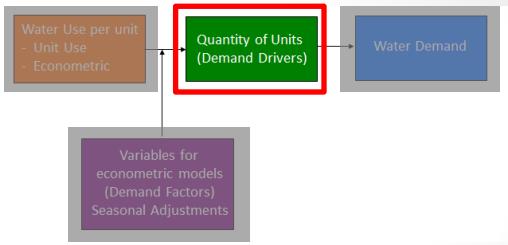
Model Development



- Demand Drivers Data
  - SRTC TAZ Data
    - Single family residential housing units
    - Multi family residential housing units
    - Commercial & industrial employment
  - Acres of urban irrigation
    - Digitized from Aerial Photo
  - Acres of crop irrigation
    - Agricultural Census,
    - Digitized from Aerial Photo
  - Number of livestock
    - Agricultural Census
  - Large self supplied commercial/industrial use
    - Bistate aquifer study, Watershed Planning Assessments

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Model Development

- Consumptive Use & Return Flow
- water demand for each sector/subsector is separated into consumptive use and non-consumptive use and routing the return flow of non-consumptive use.

Model Before Update

Total Water Demand

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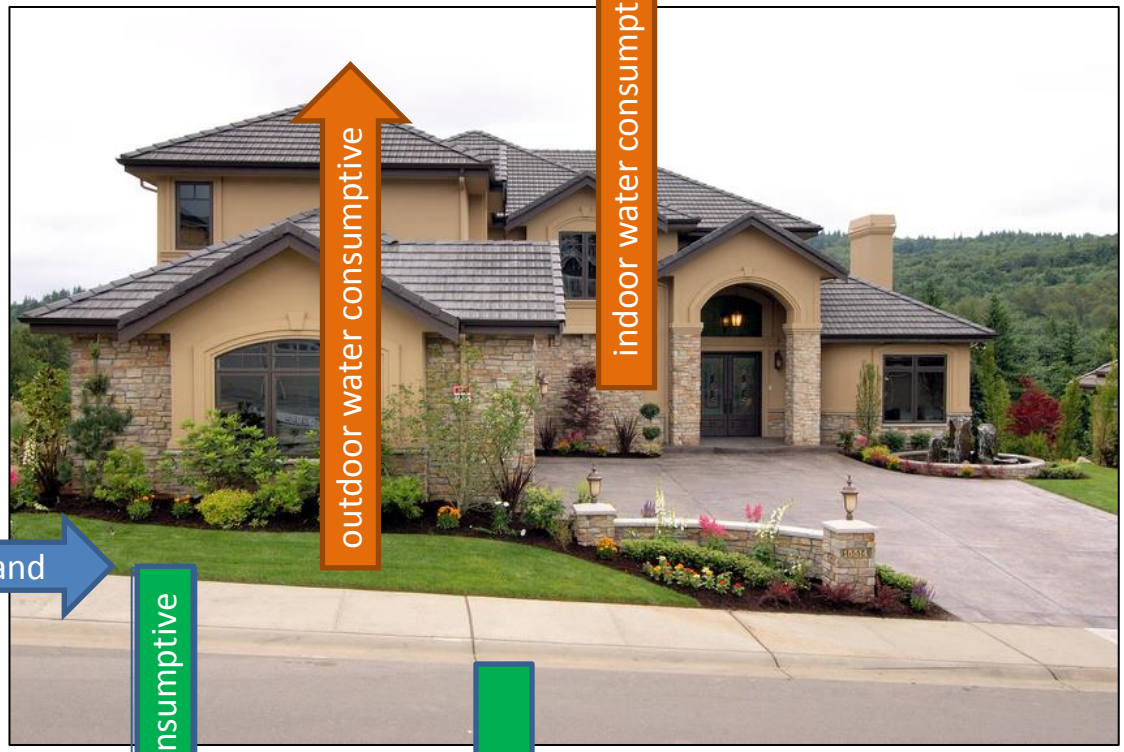
Water Resources

Model Development



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Model Development

- Calibration & Verification

Water System	# of Residential Connections	Annual Average GPD per connection		RPD
		Modeled	Reported	
Airway Heights	1,484	364	343	6%
City of Spokane	74,325	464	425	9%
Whitworth WD	9,954	801	785	2%
East Spokane WD	1,700	433	539	-22%
Irvin WD	1,597	421	791	-61%
Model ID	2,513	615	805	-27%
Modern Water Co.	7,424	467	599	-25%
North Spokane ID	703	495	895	-58%
SCWD #3- 1	2,211	551	535	3%
SCWD #3- 2	4,575	707	721	-2%
SCWD #3-3A	1,462	521	516	1%
SCWD #3- 3B	1,475	657	616	6%

Water System	# of Residential Connections	Annual Average GPD per connection		RPD
		Modeled	Reported	
Trentwood ID	1,727	553	421	27%
Carnhope ID	495	328	433	-28%
Cheney	4,143	448	554	-21%
City of Deer Park	1,448	488	440	10%
Consolidated ID	4,984	614	500	20%
Four Lakes WD	159	564	450	22%
Hutchinson ID	872	385	685	-56%
Liberty Lake	3,488	964	643	40%
Medical Lake	1,974	505	342	39%
Moab ID	718	855	877	-2%
Orchard Avenue ID	1,255	426	731	-53%
Pasadena Park ID	2,304	825	736	11%
Pioneer Water Co	152	950	820	15%
Vera ID	9,195	731	834	-13%
			Average RPD	-6%
			Weighted Average RPD	2%

Spokane County
Water Resources

Model Development

- Calibration & Verification

Annual Public Water System Use: Modeled vs. Reported

Sector	Modeled	Reported	RPD
Total Production	41,895	41,530	0.88 %
Single Family Residential	15,920	15,617	1.92%
Multi Family Residential	3,996	4,102	-2.62%
Total Residential	19,916	19,719	0.99%
Commercial/Industrial	9,528	9,798	-2.79%
Total Non Residential	10,758	10,118	6.13%
Non Revenue	3,433	3,500	-1.92%

Reported in millions of gallons per year

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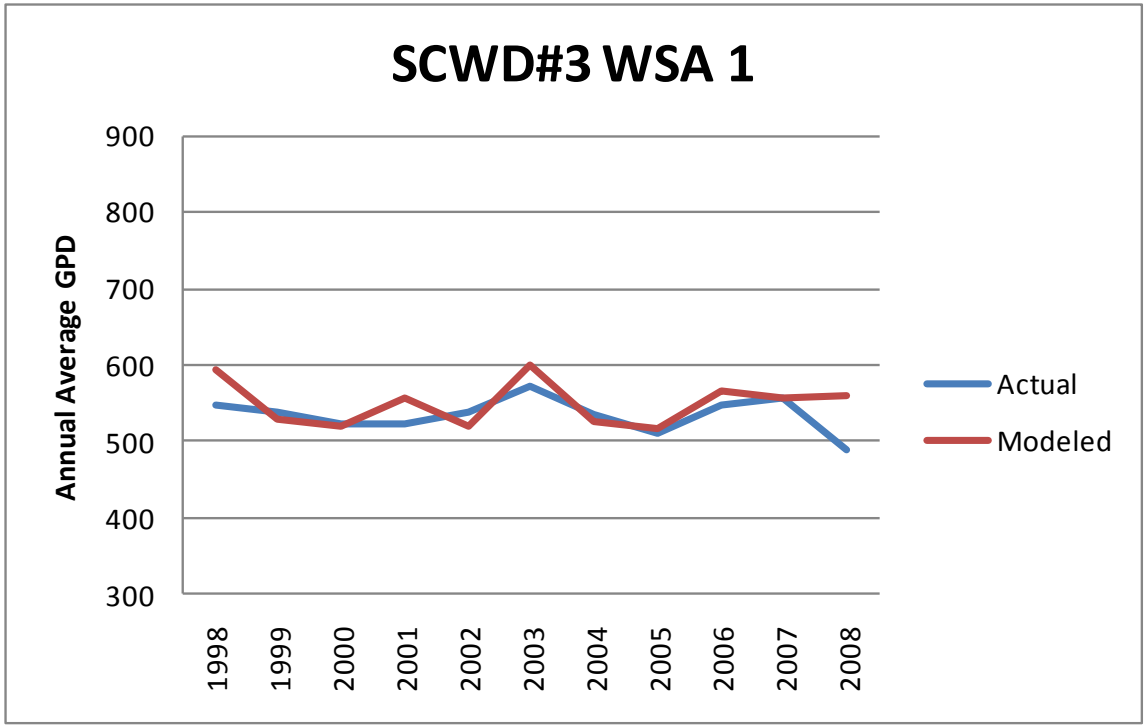
Model Development

- Impact of weather on water use – compared actual use to modeled use with each year's weather data for model input



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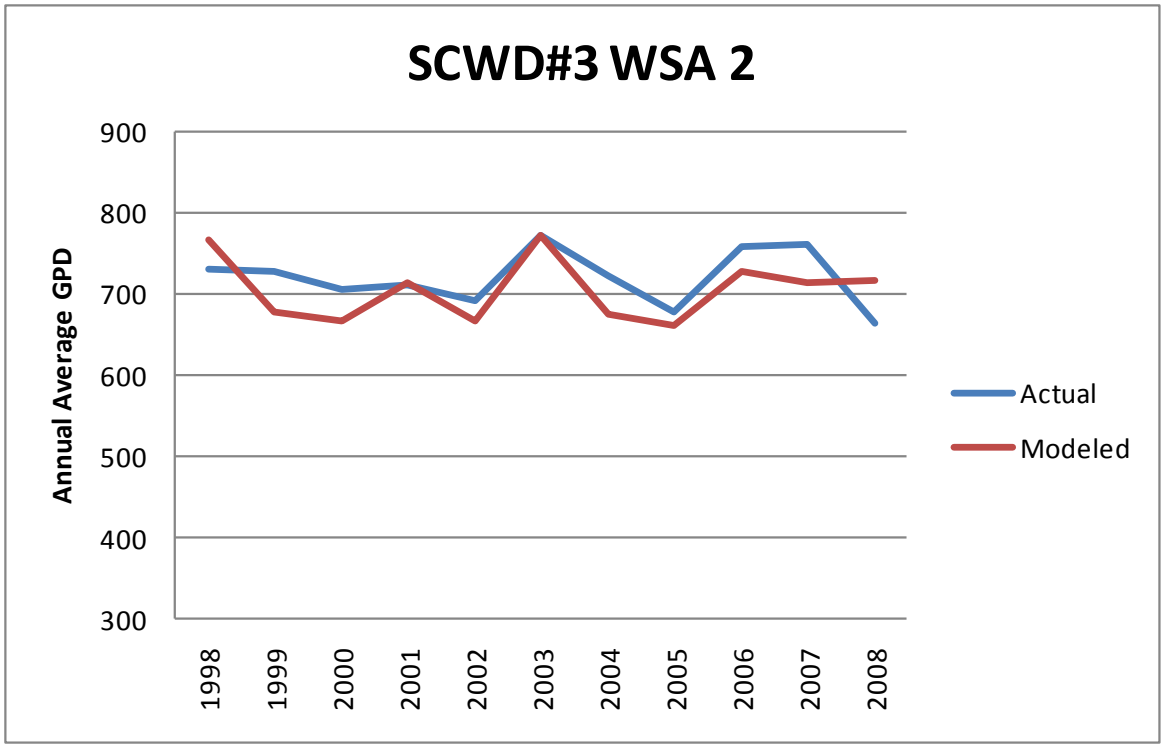

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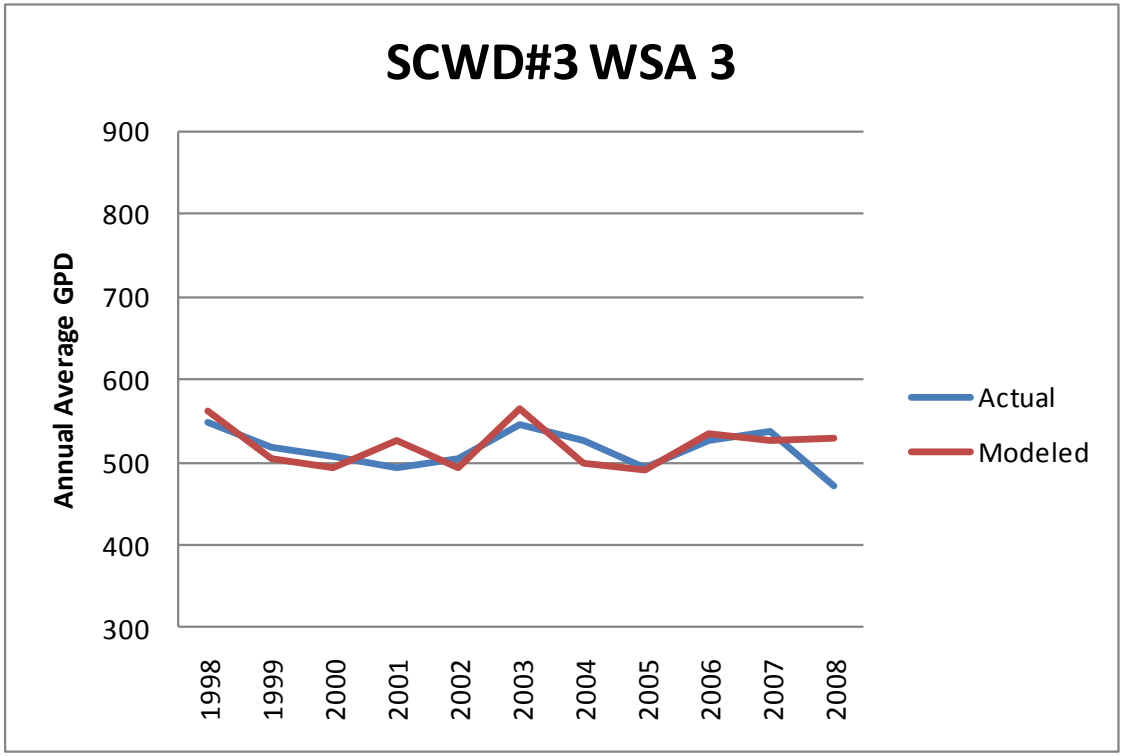

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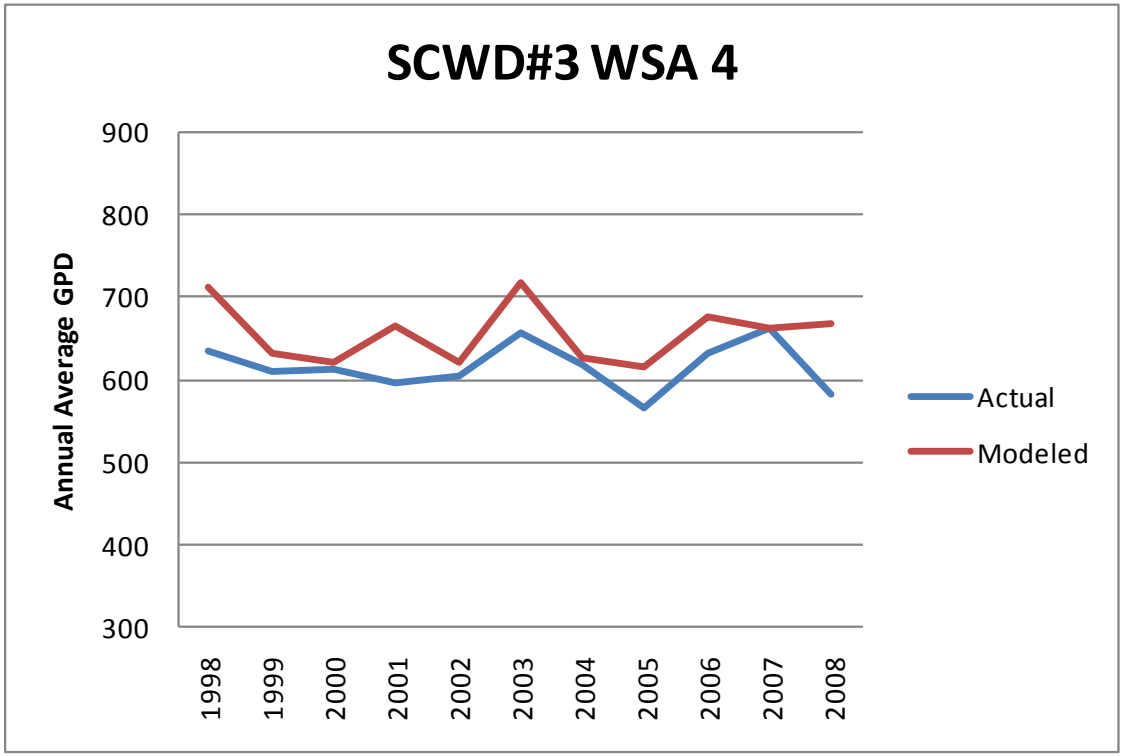

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Water Resources

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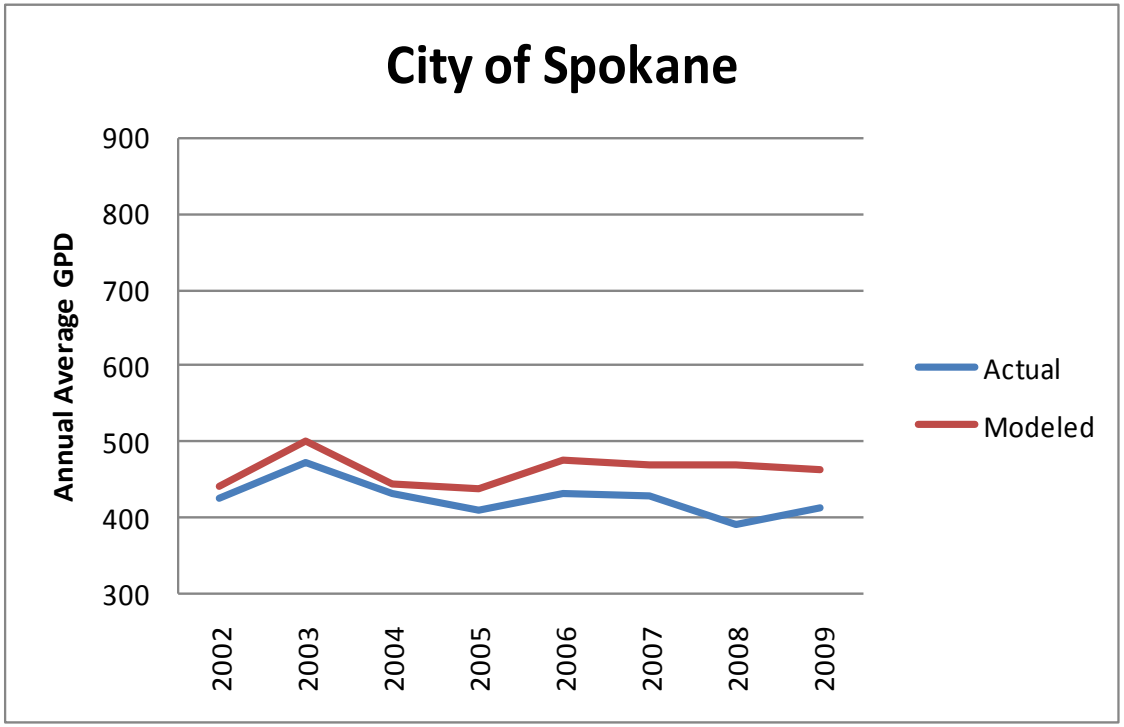

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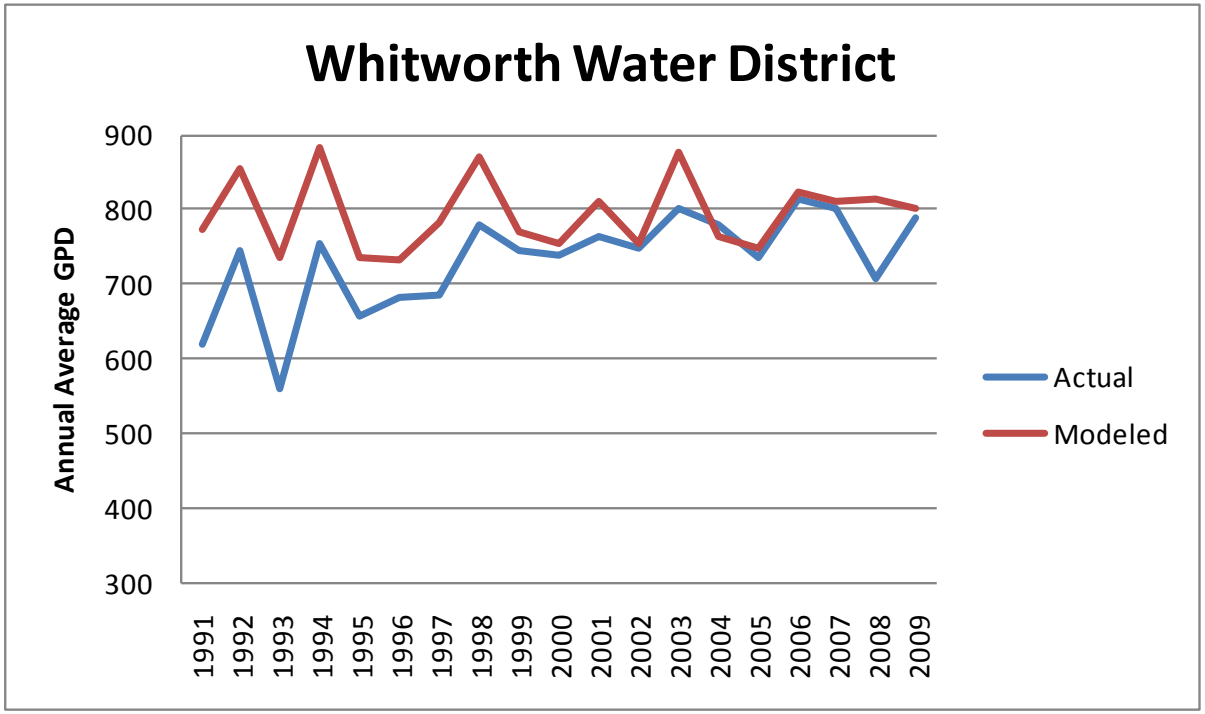

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Model Development

- Assessment of return flow quantity and routing

Table 7: 2010 Total Public Supply Indoor Use Return Flow Modeled vs. Reported

System Name	Modeled	Reported
Total Flow to City of Spokane Facility	26.31	27.1
City of Spokane	24.41	-
Spokane County - North System	1.9	1.72
Spokane County - Valley	8.05	6.8
Liberty Lake Sewer & Water District	1.06	0.73
City of Cheney	0.86	1.17
City of Airway Heights	0.51	0.6
City of Deer Park	0.3	0.27
City of Medical Lake	0.43	0.4
Latah Creek WWTP	0.05	0.04
Septic	5	-
Self Supplied Septic	3.7	

values in million gallons per day

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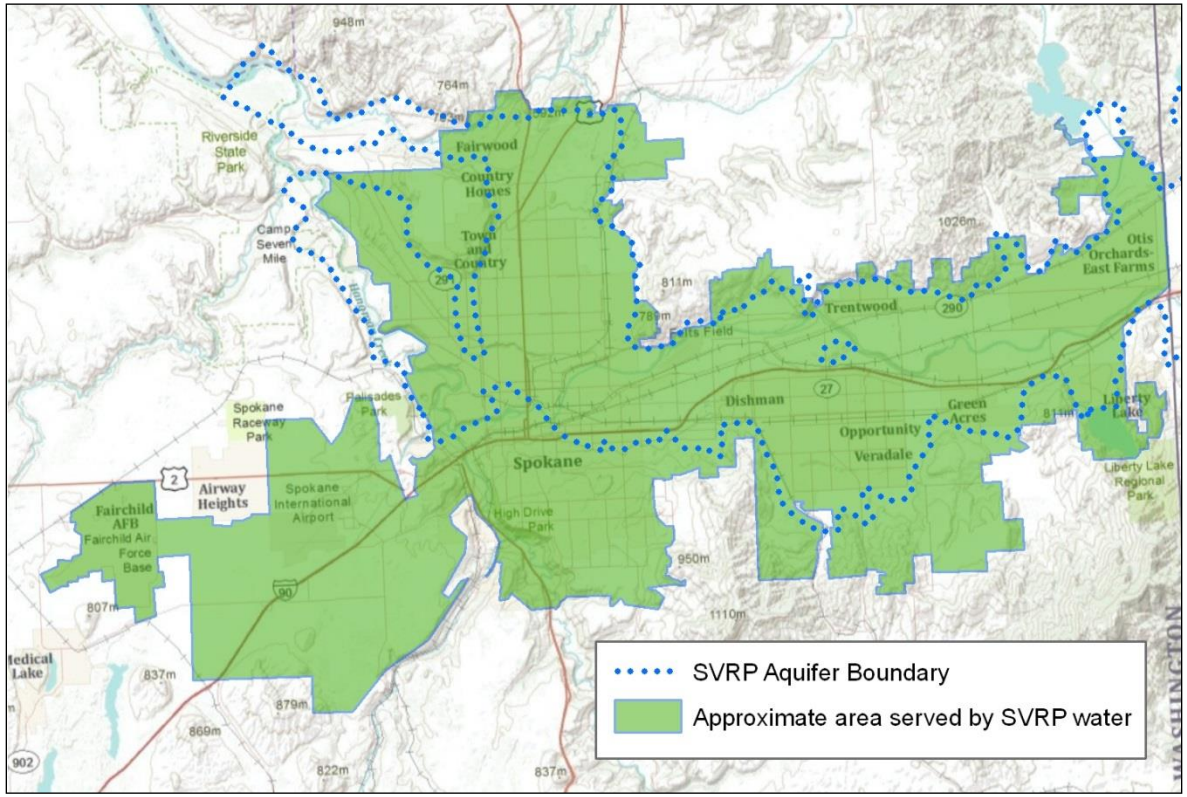
Water Demand Forecast

- SVRP is a subset of the Spokane County Water Demand Forecast Model



Spokane County Water Resources

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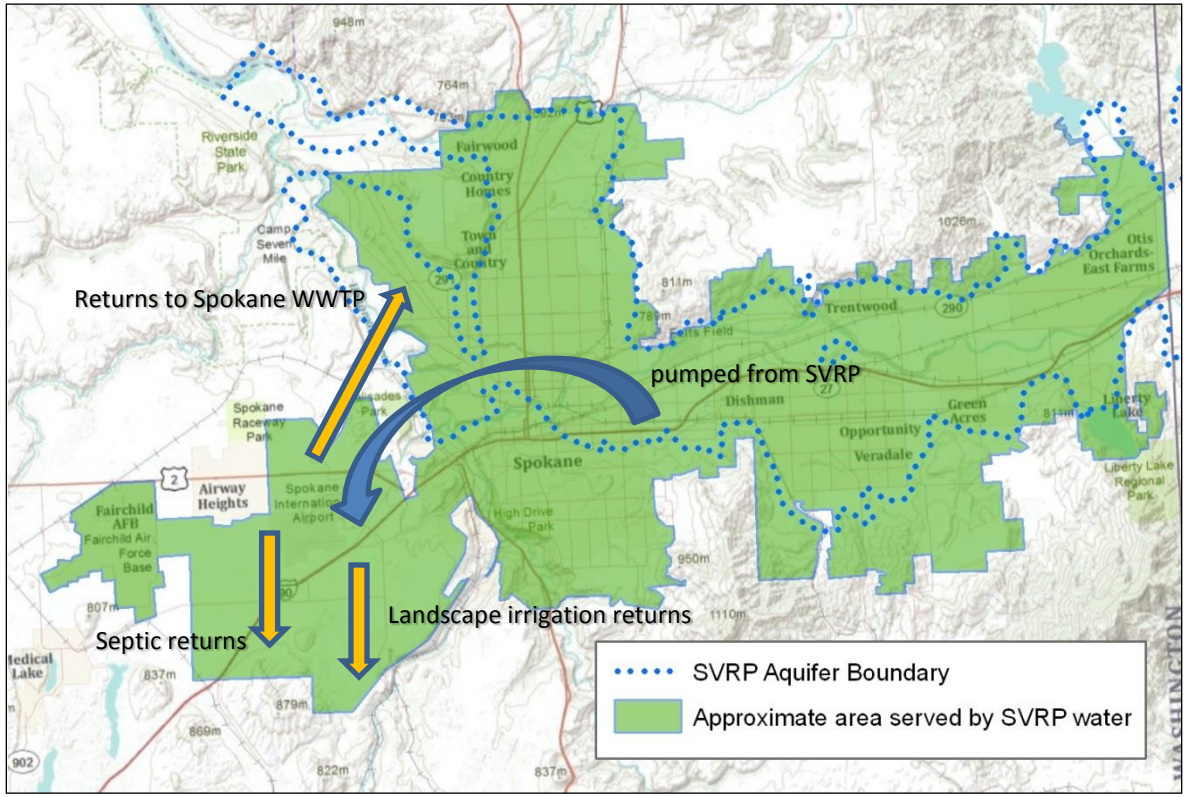

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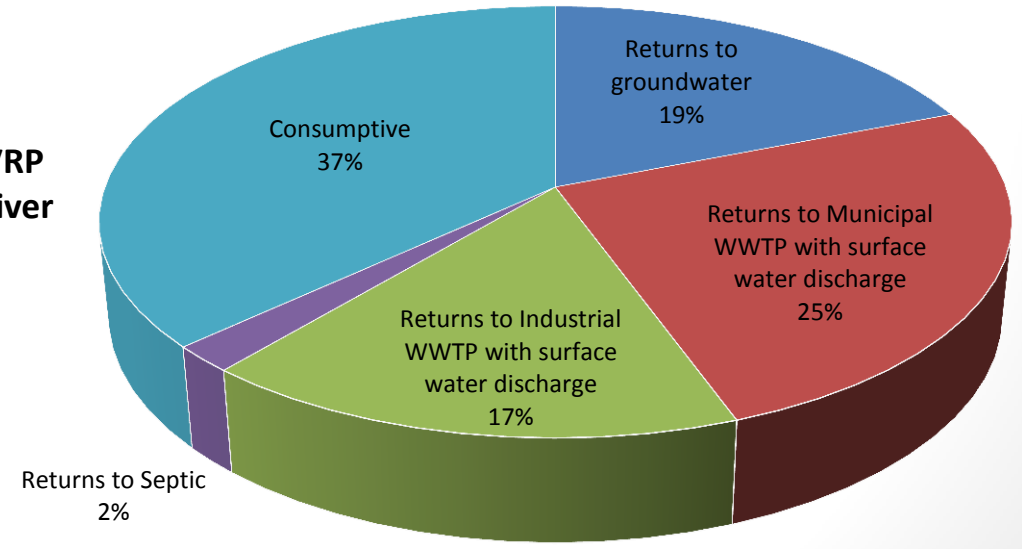
Water Demand Forecast

- Total Water Demand from SVRP = 151,586 AF/year
  - Consumptive Demand = 55,857 AF/year
  - Non-Consumptive Demand = 95,730 AF/year
    - Return to ground from outdoor irrigation = 28,838 AF/ year
    - Return to municipal WWTP = 38,554 AF/year (53 cfs)
    - Return to industrial WWTP = 25,315 AF/year (34 cfs)
    - Return to septic = 3,023 AF/year

42% of water withdrawn from the SVRP Aquifer is returned to the Spokane River via surface water discharge.



SVRP Aquifer Annual Water Demand & Return Flows

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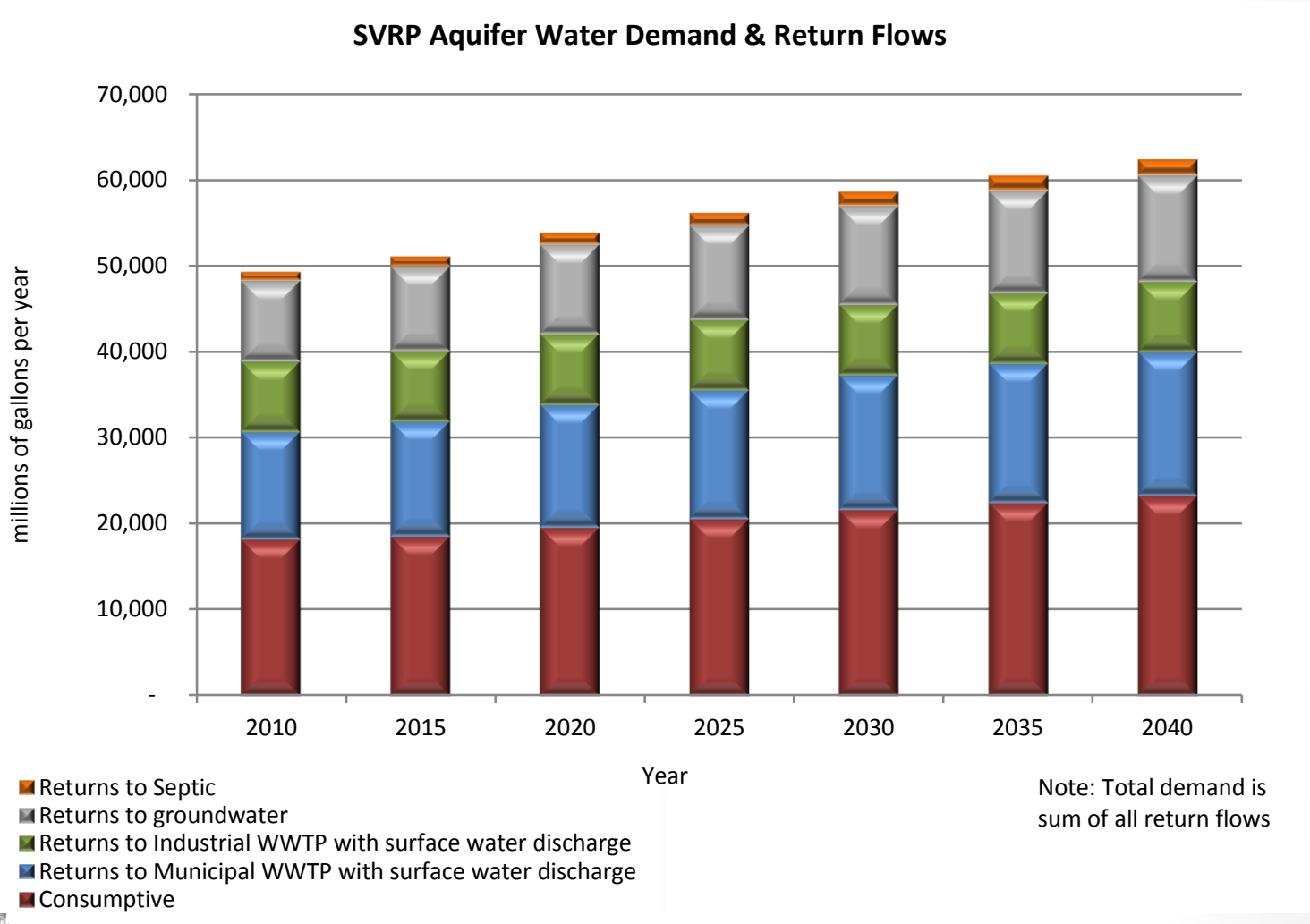
Results & Analysis



26% growth from 2010 to 2040

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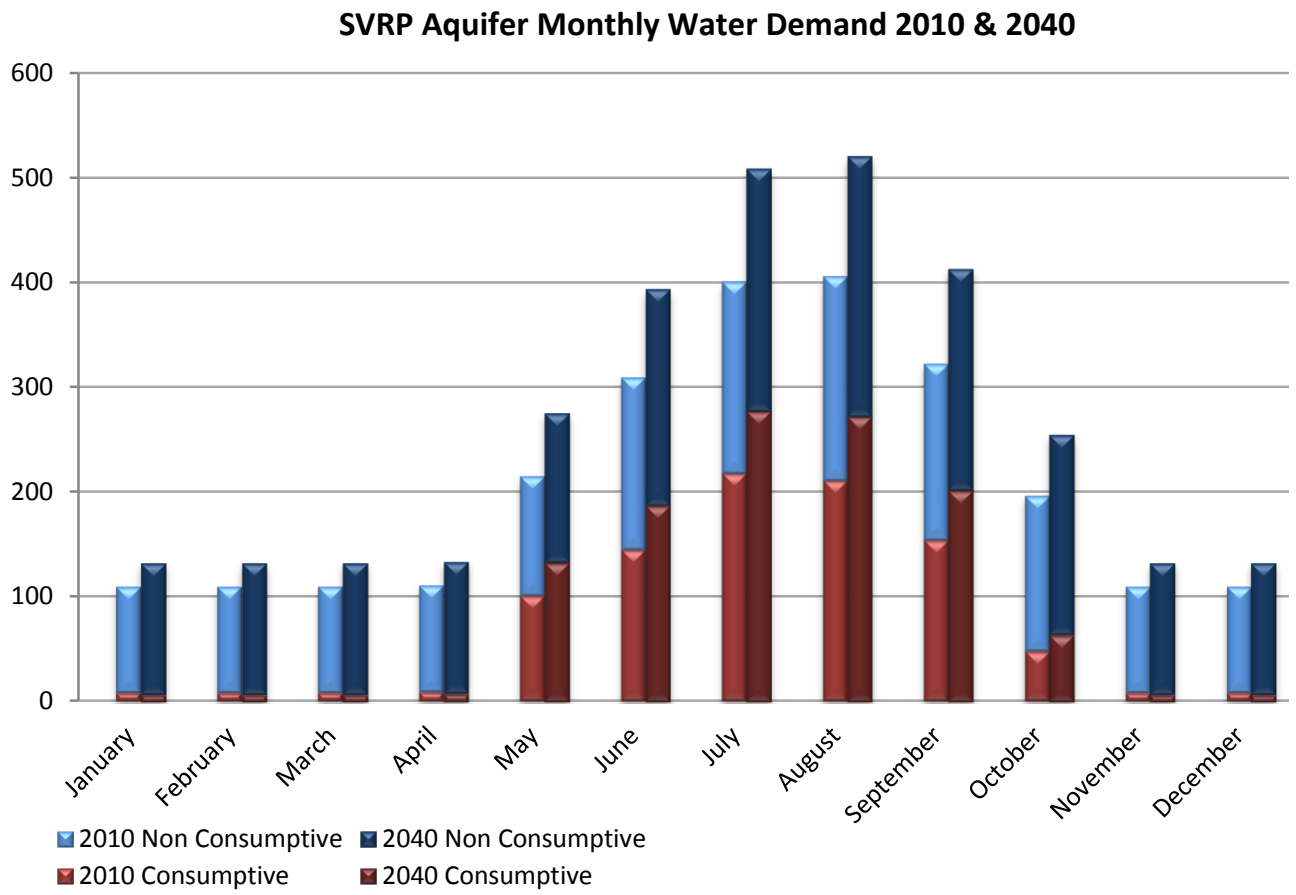
Results & Analysis



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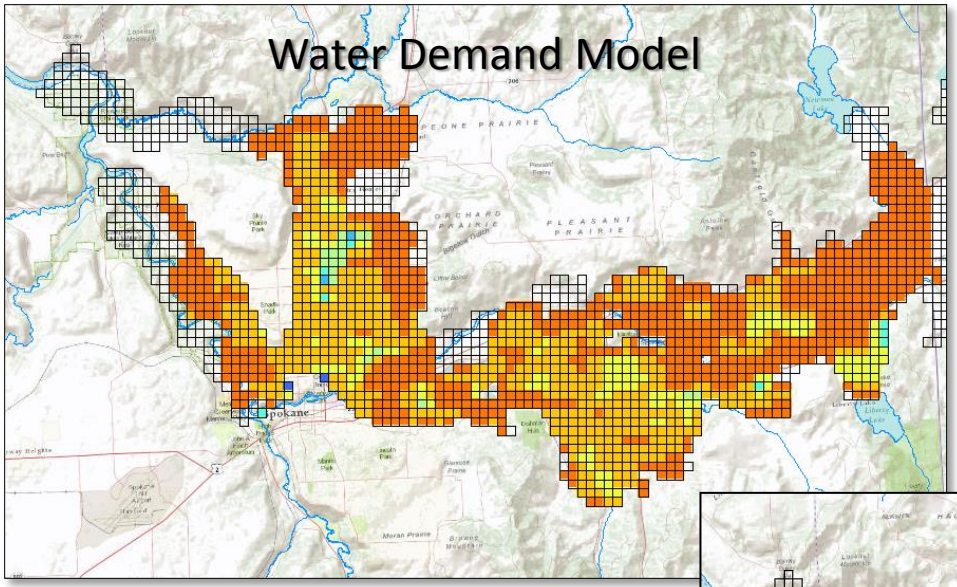
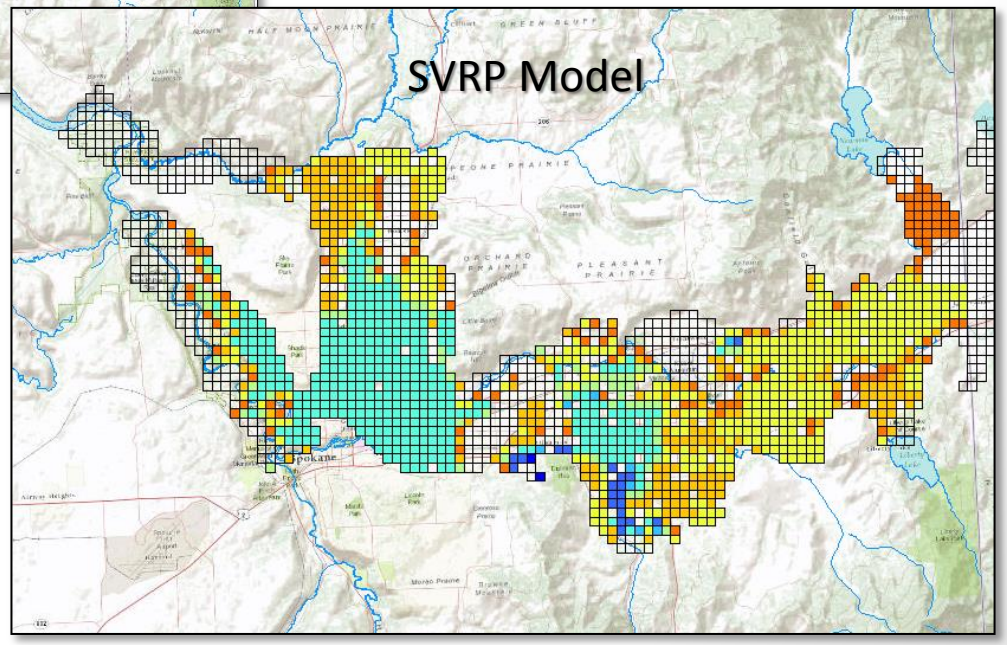
Winter water use growth – 21%

August water use growth – 28%

Results & Analysis



- Comparison of return flow from septic & irrigation in SVRP Model and Water Demand Model



cubic feet per day per model cell

- 1327 - 2946
- 2946 - 4564
- 4564 - 6182
- 6182 - 7800
- 7800 - 9418
- 9418 - 11036
- 11036 - 12654
- 12654 - 14273

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Water Resources

ID & WA Forecast

- Spokane County Water Demand Model and Forecast now separates consumptive and non-consumptive water use

Estimated SVRP Water Use (acre-feet/year)

	Idaho	Washington
Consumptive	39,830	55,857
Non-consumptive	34,320	95,730
Total	74,150	151,587
% consumptive	54%	37%

Spokane County
Water Resources

ID & WA Forecast

- Comparison of water use sectors

Estimated SVRP Water Use (acre feet per year)

	Idaho	Washington
Public Water Systems	34,430	118,752
Self Supplied Domestic	8,800	119
Self Supplied Commercial & Industrial	4,220	26,946
Agriculture	24,700	5,770

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Potential Application of WA model in ID

- Demand Driver Data available
  - Kootenai Metropolitan Planning Organization (KMPO)
    - Housing & Employment
- Need to determine how much data is available from water purveyors – water use by ***connection*** by ***sector*** by ***month***
- Spokane County Model used many ancillary sources of water use data:
  - Spokane County Utilities wastewater
  - Spokane County Parks irrigation use
  - Irrigation use for schools
  - Irrigation use from golf courses
  - NPDES DMR Data
  - Misc. water use data from Watershed Planning Assessments

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- The model Excel file and reports are located at
- http://www.spokanecounty.org/WQMP/content.aspx?c=2761

Or

www.spokanecounty.org >

Water Resources >

Projects >

Water Demand Forecast Model

Spokane County
Water Resources

Single Family Residential

- Separating Single Family Residential into consumptive and non-consumptive use

Total daily water use per single family residence

Econometric model estimated single family water use based on:

- Household Income
- Home Assessed Value
- Monthly Max Temp
- Monthly Precip.
- Lot Size

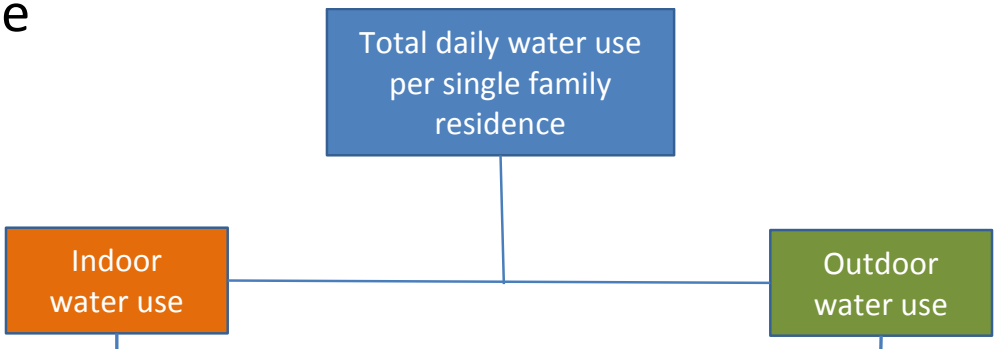
Single family residential model is two separate models:

- Indoor use model based on household income (r^2=0.55)
- Outdoor use model based on monthly average of maximum daily temp., monthly precipitation, assessed value, & lot size (r^2=0.74)

Spokane County Water Resources

Single Family Residential

- Separating Single Family Residential into consumptive and non-consumptive use



Econometric model separated water use between indoor and outdoor components

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Single Family Residential

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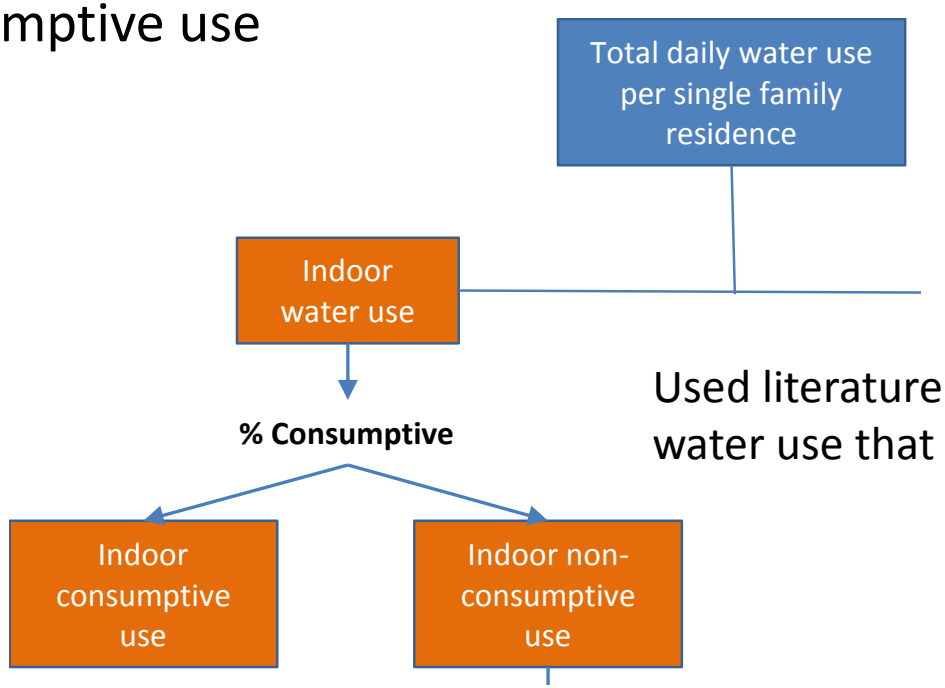

Used literature values for % indoor water use that is consumptive

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Single Family Residential

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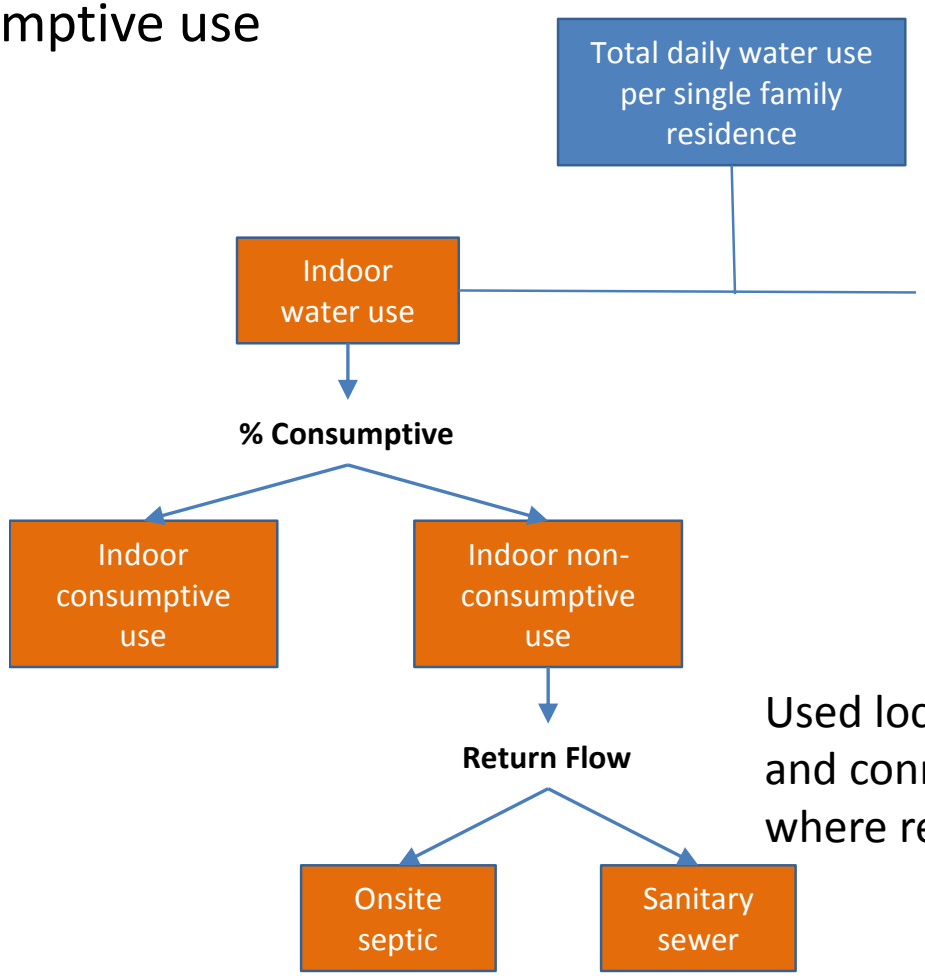

Used location, sewer service areas and connection data to determine where return flow would go

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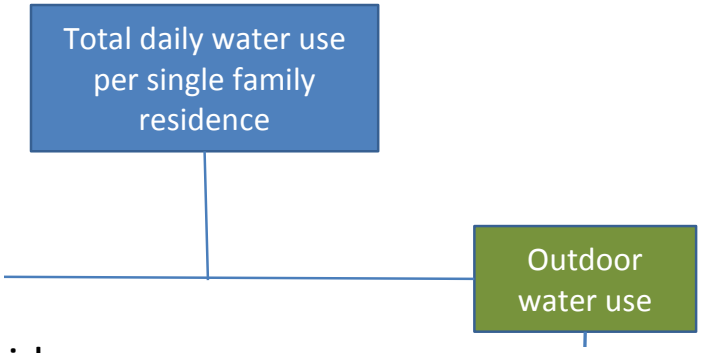
Single Family Residential

- Separating Single Family Residential into consumptive and non-consumptive use



  - Econometric model provide outdoor water use in gallons per day per residence

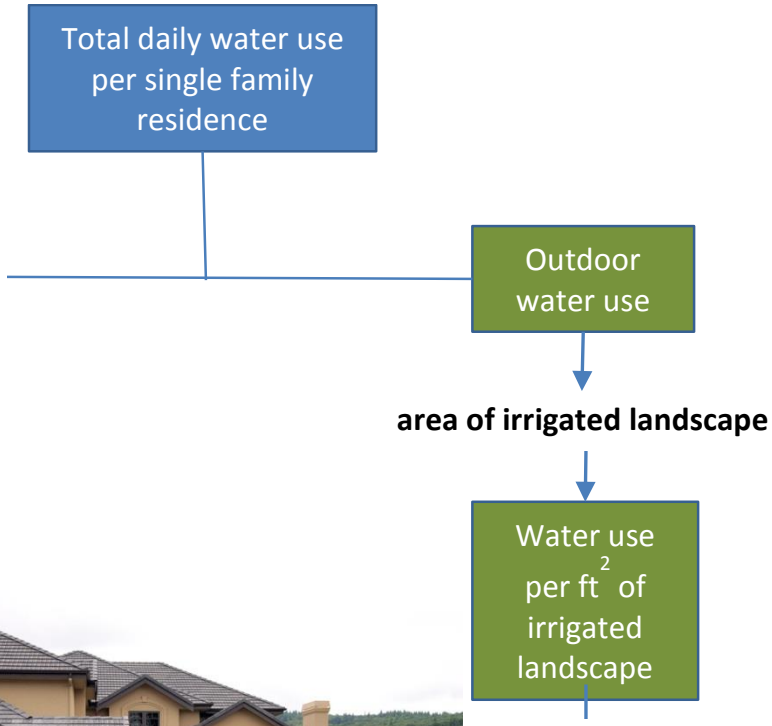
Spokane County
Water Resources

Single Family Residential

- To separate outdoor water use into consumptive and non-consumptive components it is necessary to know how much landscape is irrigated.

If 500 gallons per day is used on 100 sq. ft. much of it would be non consumptive

If 500 gallons per day is used on 1 acre most of it would be consumed



Spokane County
Water Resources

Single Family Residential

- Estimating area of irrigated landscape

Parcel size

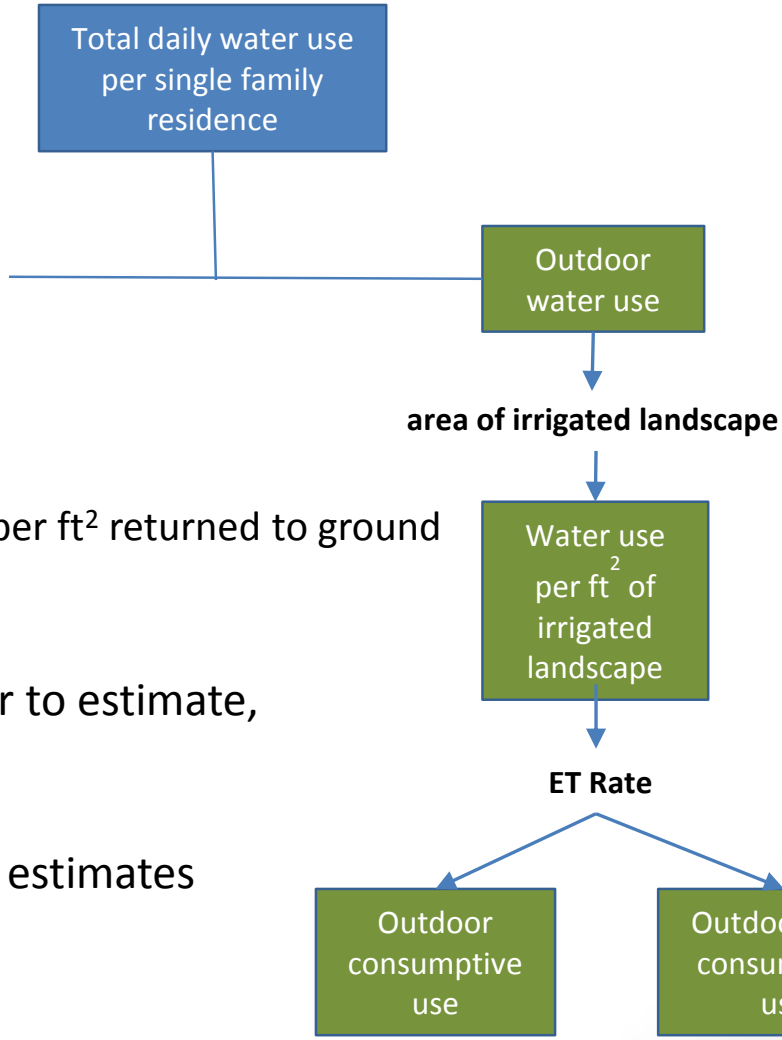
Building footprint

- Need to know how to split remaining portion of lot into landscaped and non-landscaped
- Took a random sample of 284 parcels to estimate percentage

Spokane County
Water Resources

Single Family Residential

- Separating Single Family Residential into consumptive and non-consumptive use



ET rate in inches can be converted to gallons per square foot:

(Total GPD per ft^2)– (ET GPD per ft^2)= GPD per ft^2 returned to ground

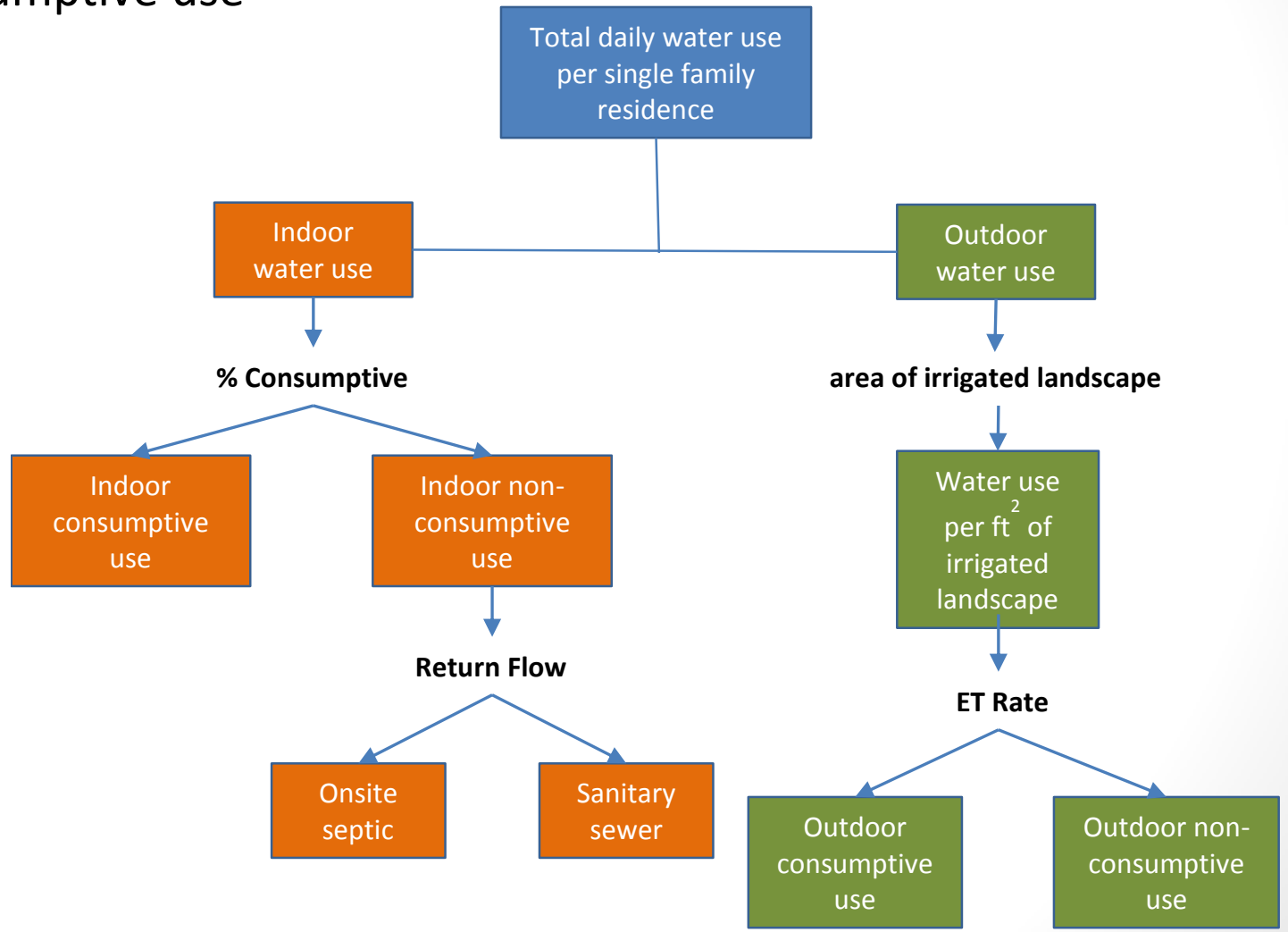
ET is a difficult parameter to estimate, and varies spatially.

Agrimet stations provide estimates

Spokane County Water Resources

Single Family Residential

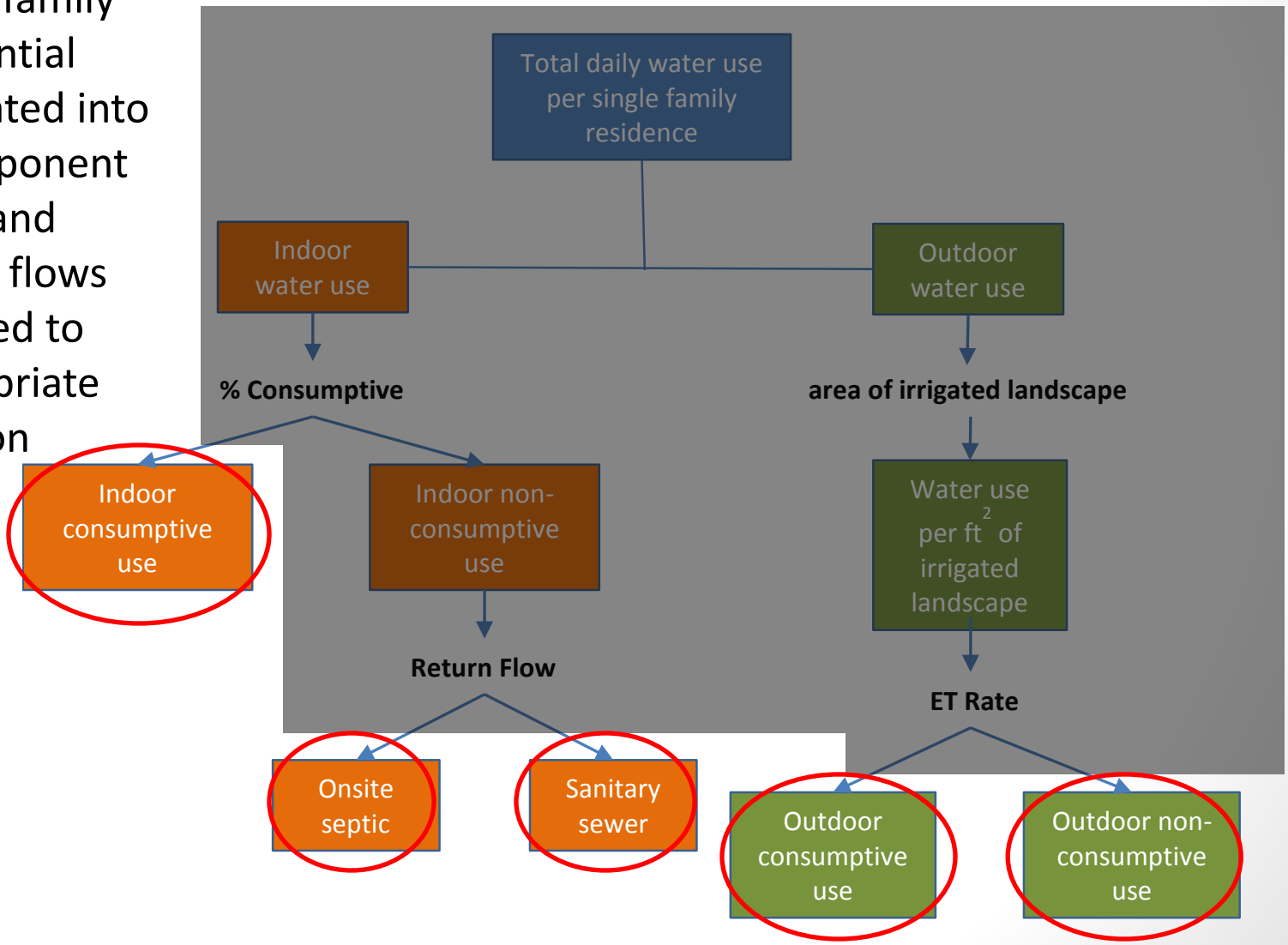
- Separating Single Family Residential into consumptive and non-consumptive use



Spokane County Water Resources

Single Family Residential

- Single family residential separated into 4 component parts and return flows directed to appropriate location



Spokane County Water Resources

Single Family Residential

Table 1—Sample Parcel Data Summary

	Parcel Area	Building Foot Print	Unbuilt Area	Landscape Area	% unbuilt landscaped
Average	13,494	1,816	11,677	5,782	58%
Median	10,031	1,733	8,146	4,571	60%
Max	217,454	5,535	213,549	42,381	100%
Min	4,568	686	3,111	0	0%

284 samples; values given in ft^2

SPOKANE COUNTY
WATER RESOURCES

Table 12: Irrigated Area Comparison

Study City	Average Irrigated Area (ft^2)
Cambridge, ON	6,998
Waterloo, ON	5,951
Seattle, WA	6,058
Tampa, FL	12,361
Lompoc, CA	4,696
Eugene, OR	6,863
Boulder, CO	6,512
San Diego, CA	5,904
Tempe, AZ	7,341
Denver, CO	7,726
Walnut Valley, CA	10,282
Scottsdale, AZ	4,968
Phoenix, AZ	9,075
Las Virgenes, CA	16,306
Spokane, WA	**6,190**

Table 13: Irrigation Application and Return Flow Rates

Month	Application Rate	Net ET	Return Flow Rate
May	0.75	0.86	-14%
June	1.09	0.94	14%
July	1.60	1.41	12%
August	1.60	1.31	19%
September	1.03	0.91	11%
October	0.50	0.00	100%

values in inches per week

Net ET is Lawn ET from the Rathdrum Prairie AgriMet Station less rainfall

SPOKANE COUNTY
WATER RESOURCES