

Endocrine Disrupting Chemicals in King County Surface Waters – Survey Results

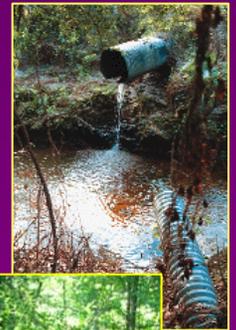
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King County Department of Natural Resources and Parks



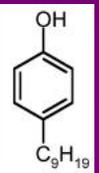
King County

Department of
Natural Resources and Parks



Overview

- Overview of EDC issue and associated challenges
- Purpose of Survey
- Survey Design and Methods
- Results
- Conclusions and Discussion



Endocrine Disrupting Chemical - Definition

- “An external compound that interferes with or mimics natural hormones in the body that are responsible for the maintenance, reproduction, development and/or behavior of an organism” (EPA 1997)

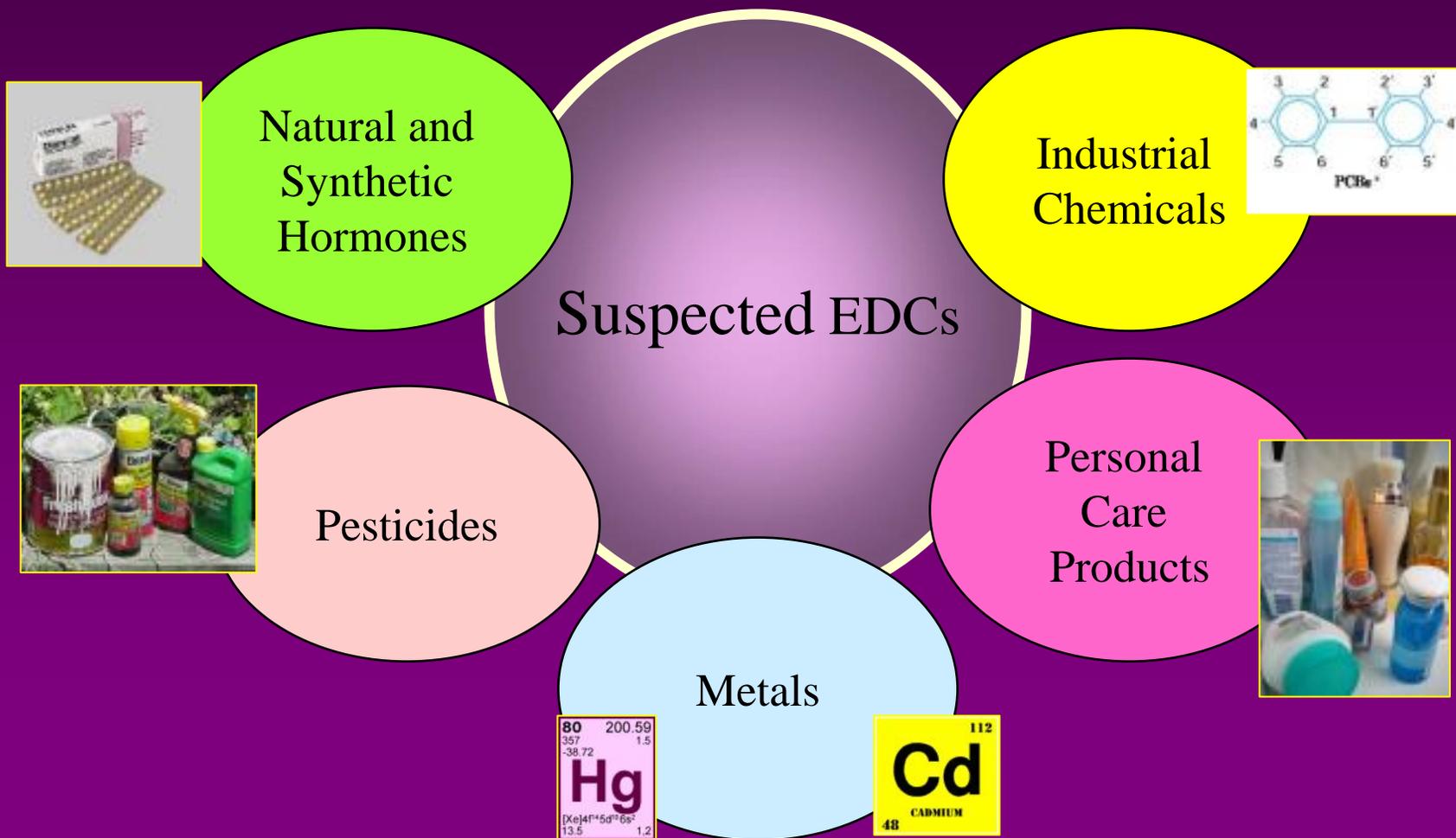


EDC's - Why the increased concern?

- 1996 publication of “Our Stolen Future” - increased public awareness;
- Reports of feminization/altered reproduction of fish downstream of STPs in Europe and US;
- 2002 USGS survey detected EDCs or pharmaceuticals in 80% of nationwide surface waters tested;
- Increasing scientific literature linking EDCs with effects on fish, other aquatic life, and humans;
- Altered reproductive status of English Sole observed in Elliott Bay (NOAA and WDFW).



EDCs represent wide variety of household and industrial compounds



Examples of Some EDCs

Industrial/Household Chemicals

- 4-Nonylphenol
- Bisphenol-A
- PBDEs
- PCBs, Dioxins
- Phthalates
- Parabens

Sex and Steroidal Hormones

- Natural and synthetic hormones (e.g., estrogen, ethinylestradiol)

Pesticides

- Atrazine
- Carbofuran
- Vinclozolin
- Endosulfan, Lindane
- DDT, DDE
- Aldicarb

Metals

- Hg, Cd, Pb, As, Tributyltin



Pharmaceuticals and Personal Care Products vs. EDCs

- PPCPs and EDCs not synonymous;
- Subset of PPCPs are known EDCs (synthetic hormones);
- Primary sources - municipal and hospital effluent;
- Examples of PPCPs include:
 - human and veterinary drugs, diagnostic agents
 - antibacterial compounds, surfactants, other compounds in soap and shampoo and consumer products



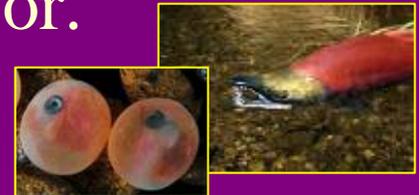
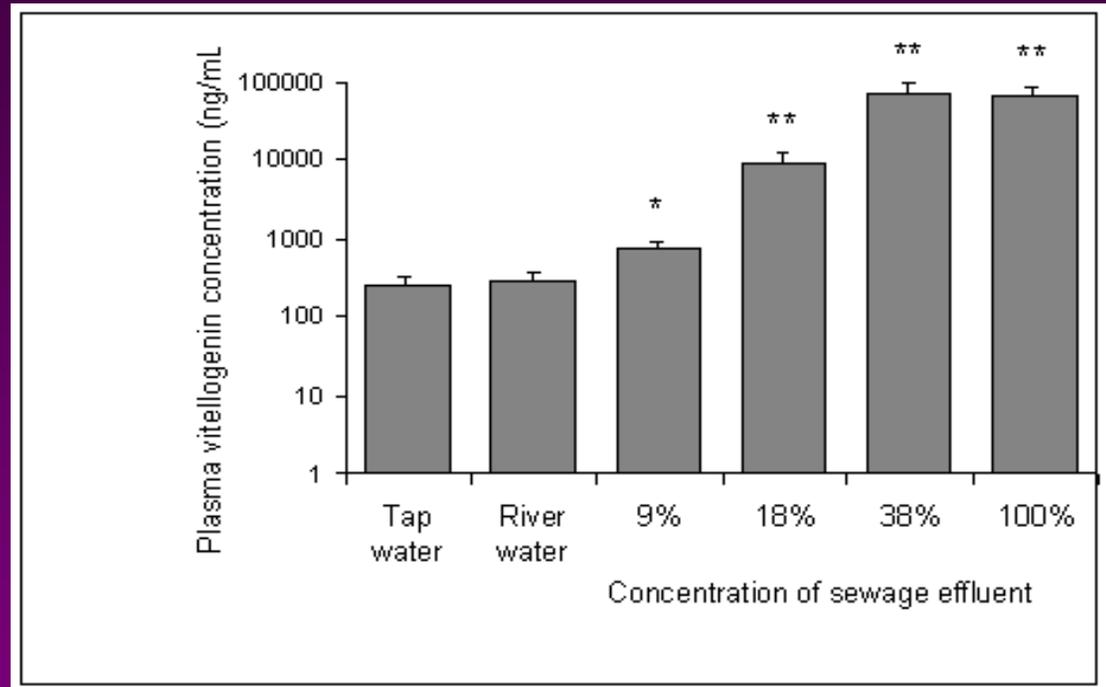
EDCs - Potential Ecological Effects

- Reproductive,
- Developmental,
- Abnormalities,
- Immune response,
- Behavior, etc.

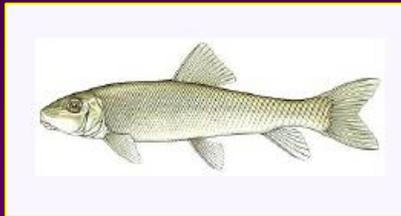


EDC Effects- Vitellogenin Induction

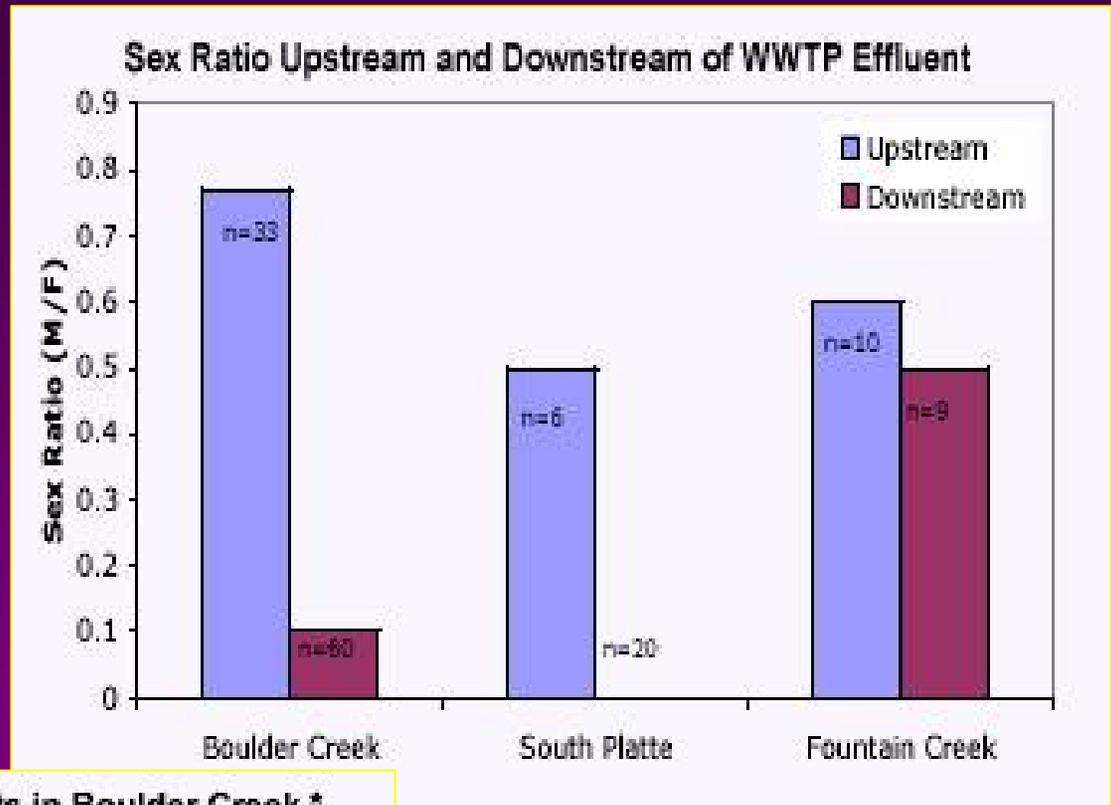
- VTG - protein precursor to egg production in **female** fish;
- EDC exposure induces VTG in **male** fish;
- Depressed VTG in female fish exposed to EDCs;
- Ecological relevance unclear; potential stressor.



EDC Effects – Skewed Sex Ratio



White Sucker



Endocrine-Active Wastewater Constituents in Boulder Creek *

Compound	Concentration	Endocrine Activity
17 β -Estradiol	2.4 ng/L	Estrogenic
17 α -Estradiol	24 ng/L	Estrogenic
Estriol	3.1 ng/L	Estrogenic
Bisphenol A	5.8 ng/L	Estrogenic
4-Nonylphenol	240 ng/L	Estrogenic
Total Nonylphenolethoxycarboxylates	200 μ g/L	

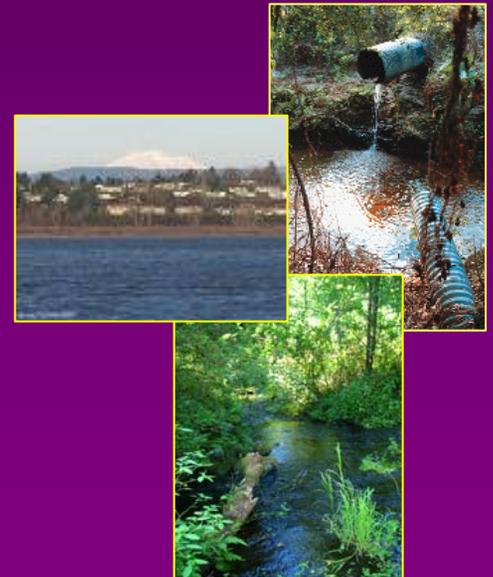
* Murphy et al. 2003 and Larry Barber, pers.comm.

Challenge of Evaluating EDCs

- Variety of chemical classes,
- “Standard” analyses not developed for some compounds,
- Low analytical detection limits required,
- Chemical potencies vary significantly,
- Complexity of hormonal effects,
- Evidence of synergism.



King County EDC Surface Water Survey



Purpose of Surface Water Survey

- Determine if EDC's present in KC surface waters;
- Better understand issue and magnitude of any potential problem;
- If detected, determine general spatial distribution –
Is there an obvious area/chemical of concern?
- Need for KCEL to develop capability to analyze these compounds;
- Use data to guide future monitoring.
- Not intended to provide a comprehensive assessment of EDCs in surface waters.



“New” Compounds Evaluated

Hormones

- Estrone (E1), Ethynylestradiol (EE2), Estradiol (E2), Methyltestosterone, Progesterone and Testosterone;

Plasticizers

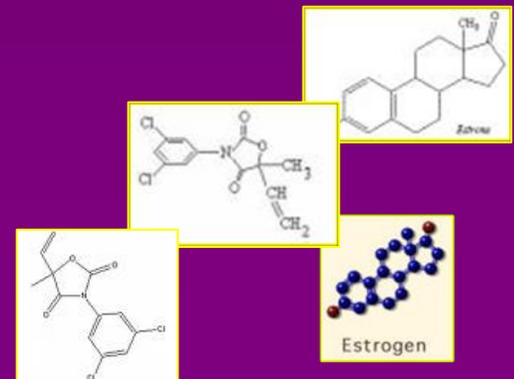
- Phthalates (7), Bisphenol A (BPA);

Surfactants

- Total 4-Nonylphenol (NP);

Pesticide

- Vinclozolin.

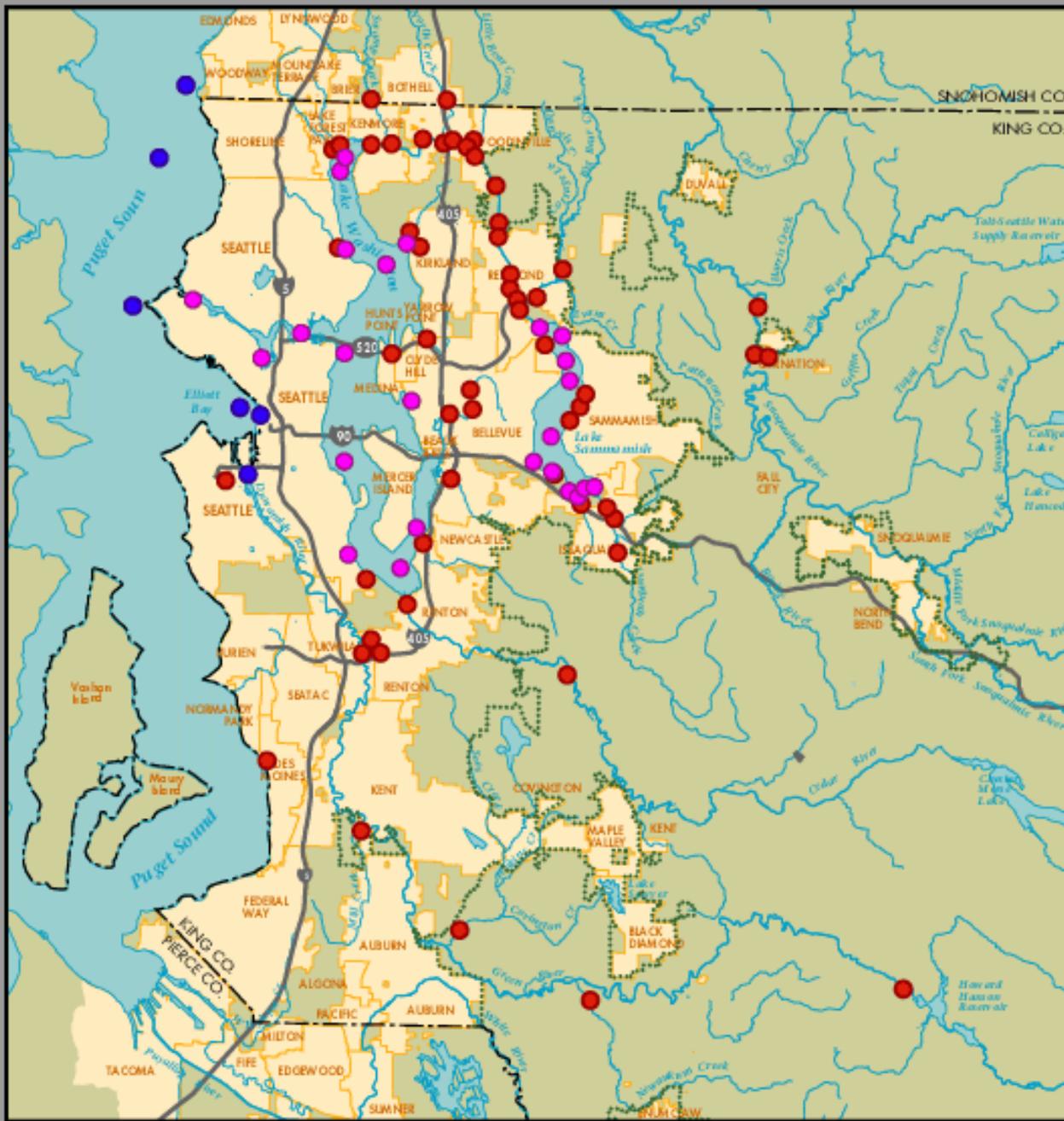


Surface Water Sampling Locations

- **Stream locations** – 63 (42)
- **Lake locations** – 25
 - Lake Union - 3
 - Lake Washington - 11
 - Lake Sammamish - 11
- **Marine locations** - 5
 - Multiple depths
- In general, samples collected quarterly
- Additional EDC data associated with other studies also included (Sammamish River, Snoqualmie River and smaller streams)



ENDOCRINE DISRUPTER SAMPLING LOCATIONS



- Lake Sampling Site
- Marine Sampling Site
- Stream Sampling Site
- Urban Growth Area Line
- River/Stream
- King County Boundary
- Incorporated Area
- Lake

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October 2004



King County
Department of Natural Resources and Parks
Water and Land Resources Division

Storm Water Samples

- Limited samples collected as part of 2 separate efforts;
 - Evergreen Point Floating Bridge (SR 520)
(3 downspouts);
 - 4 discharges into Sammamish River (Redmond area);
- All samples 100% storm water – not mixed with surface waters.



Results – General Overview

- Of 16 compounds analyzed, 11 detected at least once; 5 never detected (estrone, progesterone, testosterone, methyltestosterone and vinclozolin);
- Concentrations of most compounds highest in stormwater;
- Highest frequency of detection (FOD) and levels of BPA, NP, EE2 and E2 detected in streams/rivers.
- Blank contamination problem for phthalates, BPA and NP; limited data availability;



Weather Influence?

- Some compounds detected in streams at higher levels and greater FOD during wet and dry conditions:
 - Wet - NP, BPA
 - Dry - E2, EE2
- However - Sample size for wet/dry not balanced, greater number of samples collected during dry weather.



Surface Water– Frequency of Detection

Parameter	Marine	Lakes	Streams
Bisphenol A	*0% (n=6)	*8.4% (n=47)	* 26% (n=98)
Total 4-Nonylphenol	*3.2% (n=31)	*5.6% (n=71)	* 16.2% (n=130)
Ethinylestradiol	0% (n=48)	22% (n=83)	26% (n=183)
Estradiol	16.7% (n=48)	11% (n=83)	35.9% (n=184)
Bis(2-ethylhexyl) Phthalate	*100% (n=1)	*100% (n=3)	*100% (n=19)

* Blank qualified data not included in summary statistics

Surface Water- Max Concentrations

Parameter	Marine	Lakes	Streams
Bisphenol A (µg/L)	ND (MDL 0.095) (n=6*)	0.046 (n=47*)	0.934 (n=98)
Total 4-Nonylphenol (µg/L)	0.25 (n=31*)	0.149 (n=71*)	0.836 (n=130)
Ethinylestradiol (ng/L)	ND (MDL 0.3) (n=48)	0.9 (n=83)	4.0 (n=183)
Estradiol (ng/L)	ND (MDL 0.2) (n=48)	0.6 (n=83)	1.1 (13) (n=184)
Bis(2-ethylhexyl) Phthalate (µg/L)	40.5 (n=1*)	13.1 (n=3*)	15.8 (n=19*)

ND – Not detected above the method detection limit (MDL)

* Blank qualified data not included in summary statistics

Stormwater- Frequency of Detection

Parameter	520 Bridge Runoff	Sammamish Stormwater
Bisphenol A	100% (n=11)	*100% (n=6)
Total 4-Nonylphenol	73% (n=11)	50% (n=16)
Ethynylestradiol	Not Measured**	100% (n=16)
Estradiol	Not Measured**	81% (n=16)
Bis(2-ethylhexyl) Phthalate	*100% (n=7)	*0% (n=0)

* Blank qualified data not included in summary statistics

** Matrix interference, not analyzed

Stormwater- Max Concentrations

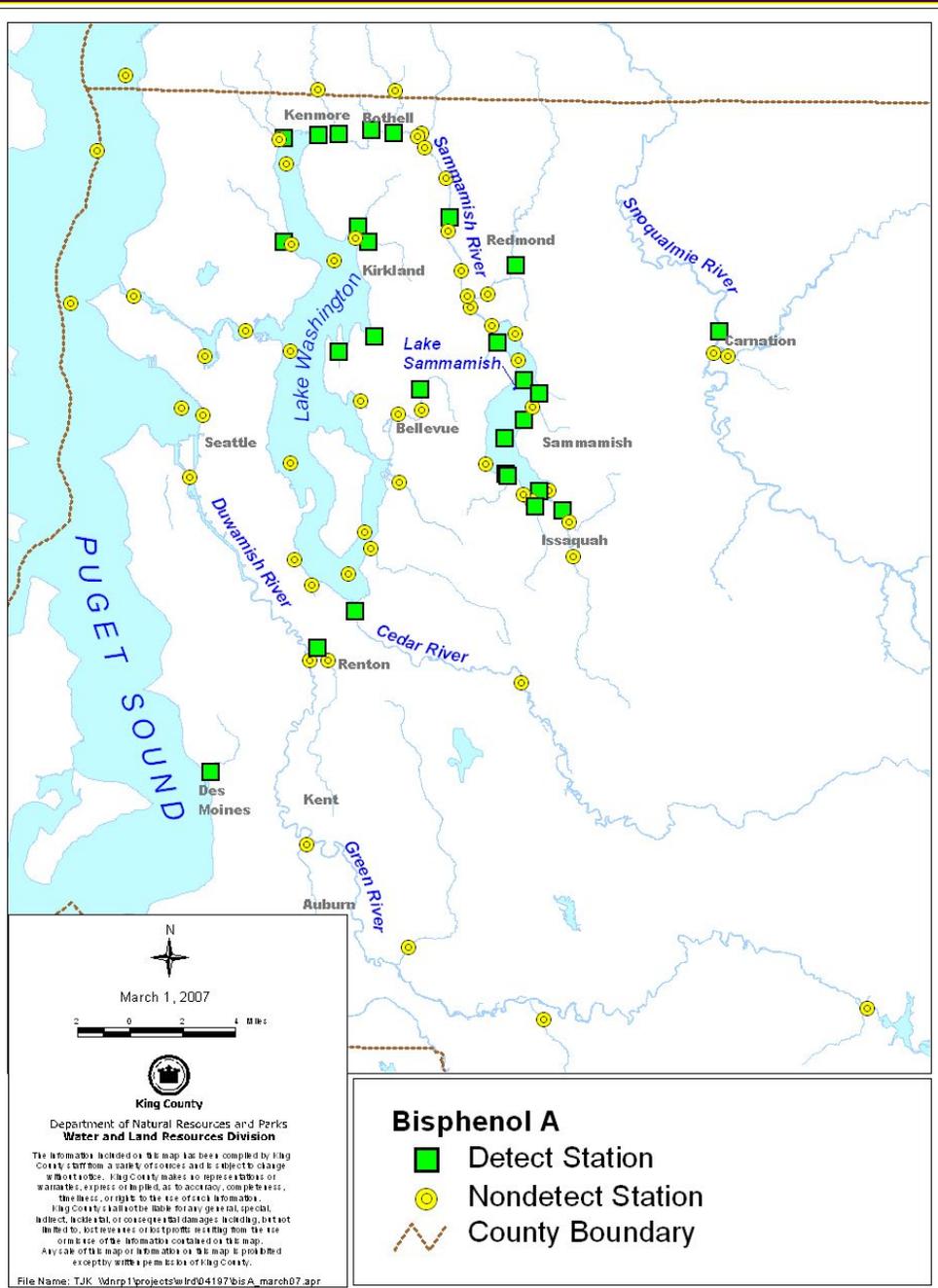
Parameter	520 Bridge Runoff	Sammamish Stormwater
Bisphenol A ($\mu\text{g/L}$)	9.14 (n=11)	1.57 (n=6)*
Total 4-Nonylphenol ($\mu\text{g/L}$)	44.2 (n=11)	8.9 (n=16)
Ethynylestradiol (ng/L)	Not Measured**	5.9 (n=16)
Estradiol (ng/L)	Not Measured**	1.2 (n=16)
Bis(2-ethylhexyl) Phthalate ($\mu\text{g/L}$)	20.3 (n=7)*	*ND (n=0)***

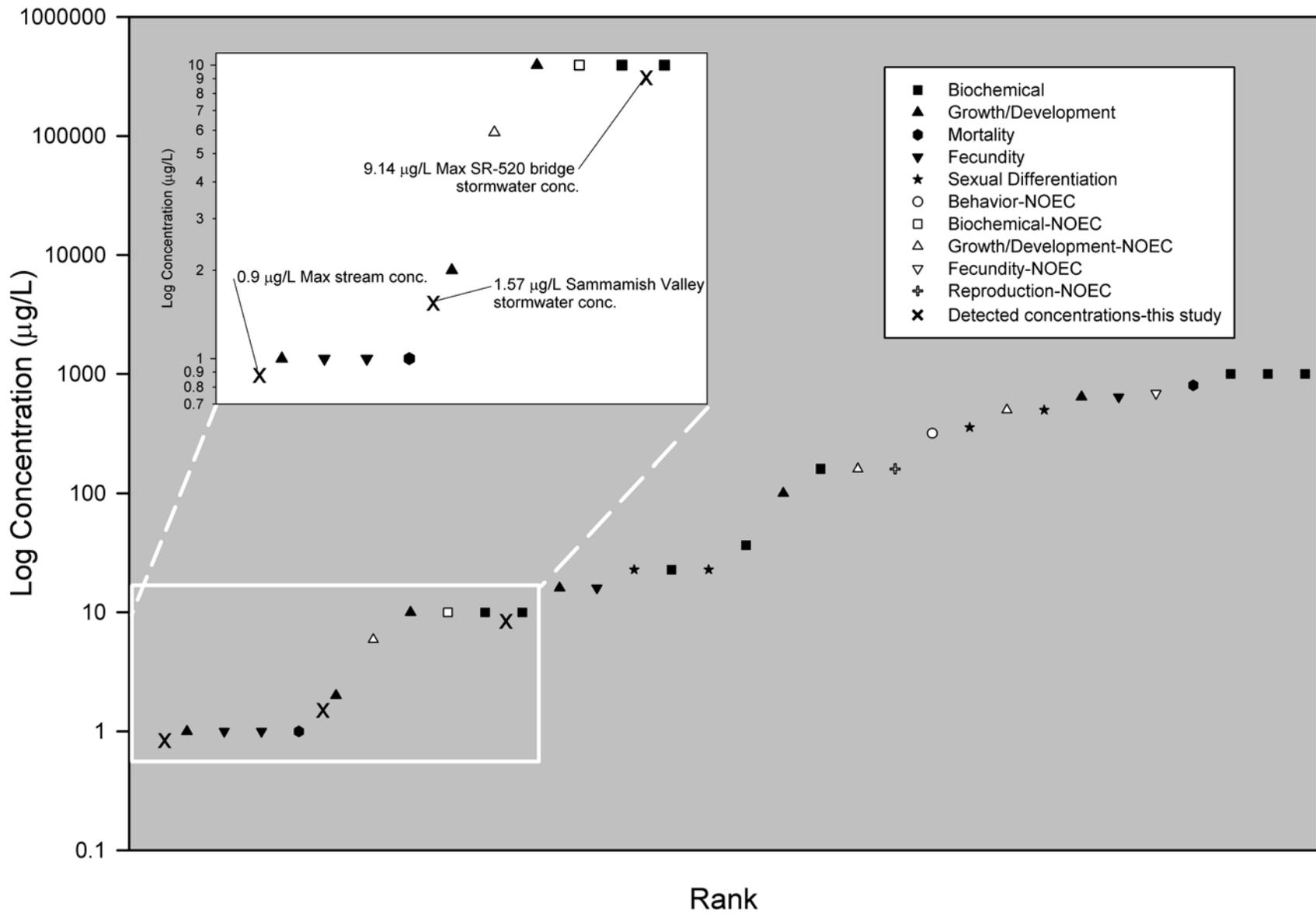
* Blank qualified data not included in summary statistics

** Matrix interference, not analyzed

*** All samples blank qualified

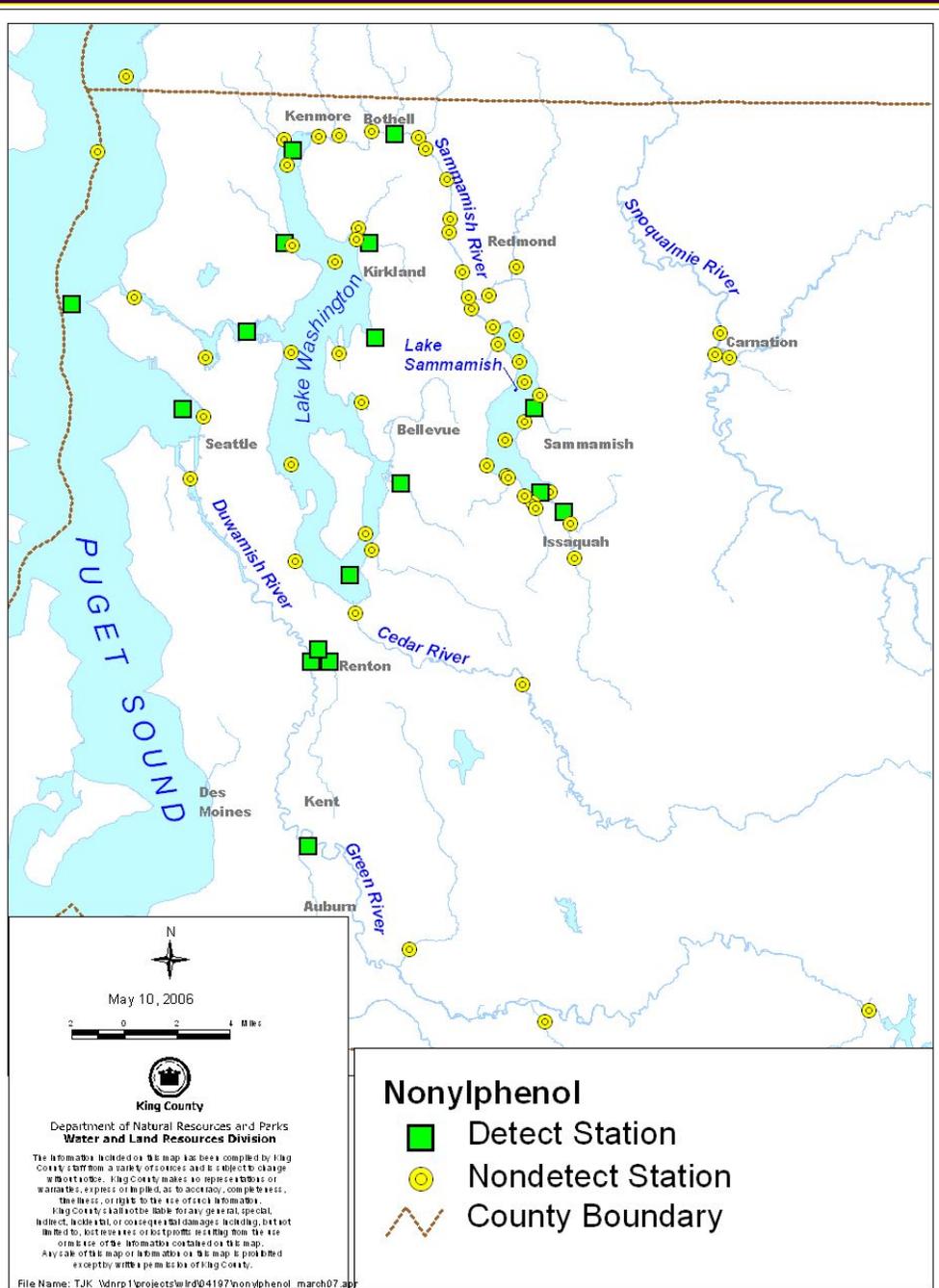
Locations Where Bisphenol A Detected in Surface Waters

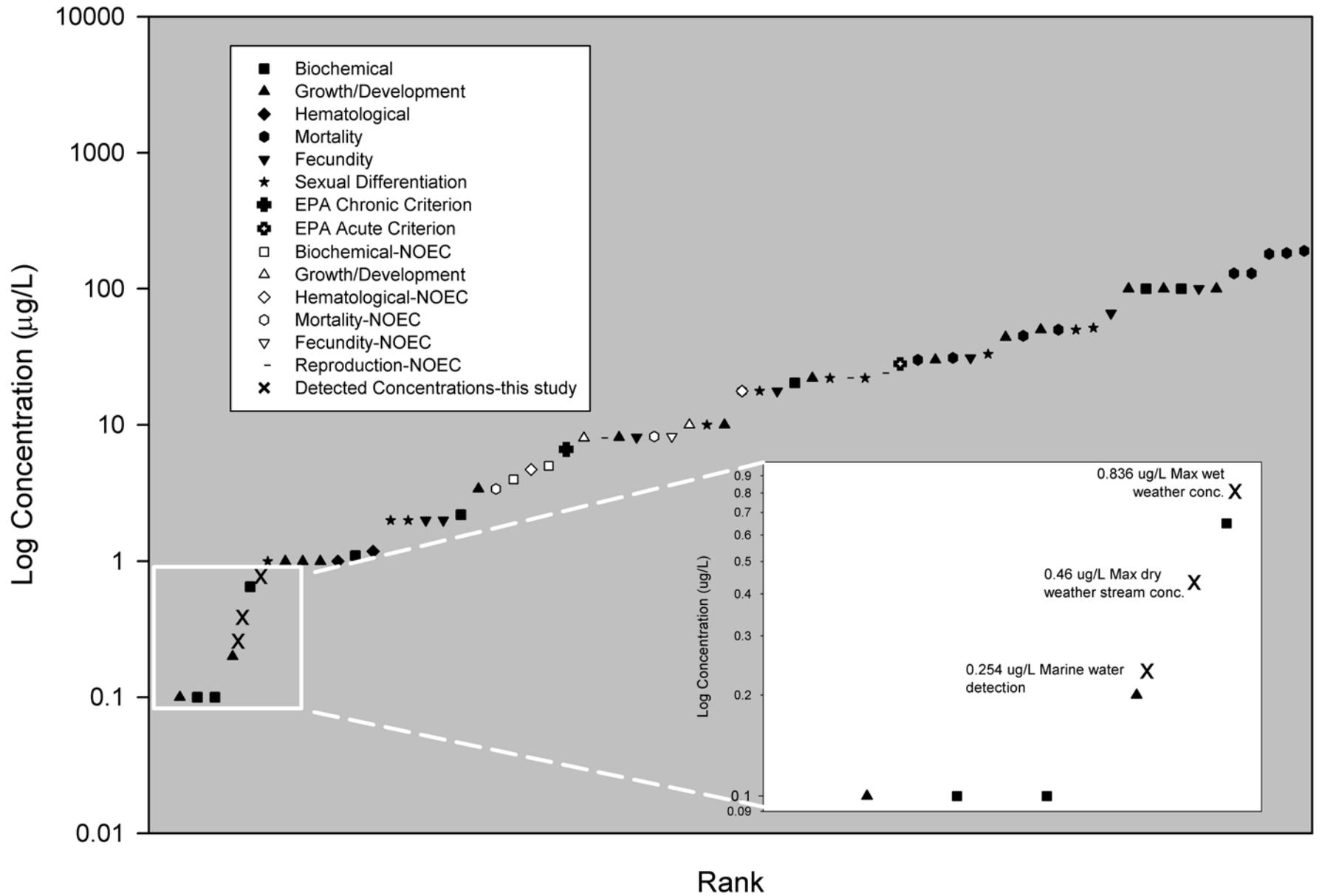




Bisphenol A – Literature Based Effect Values

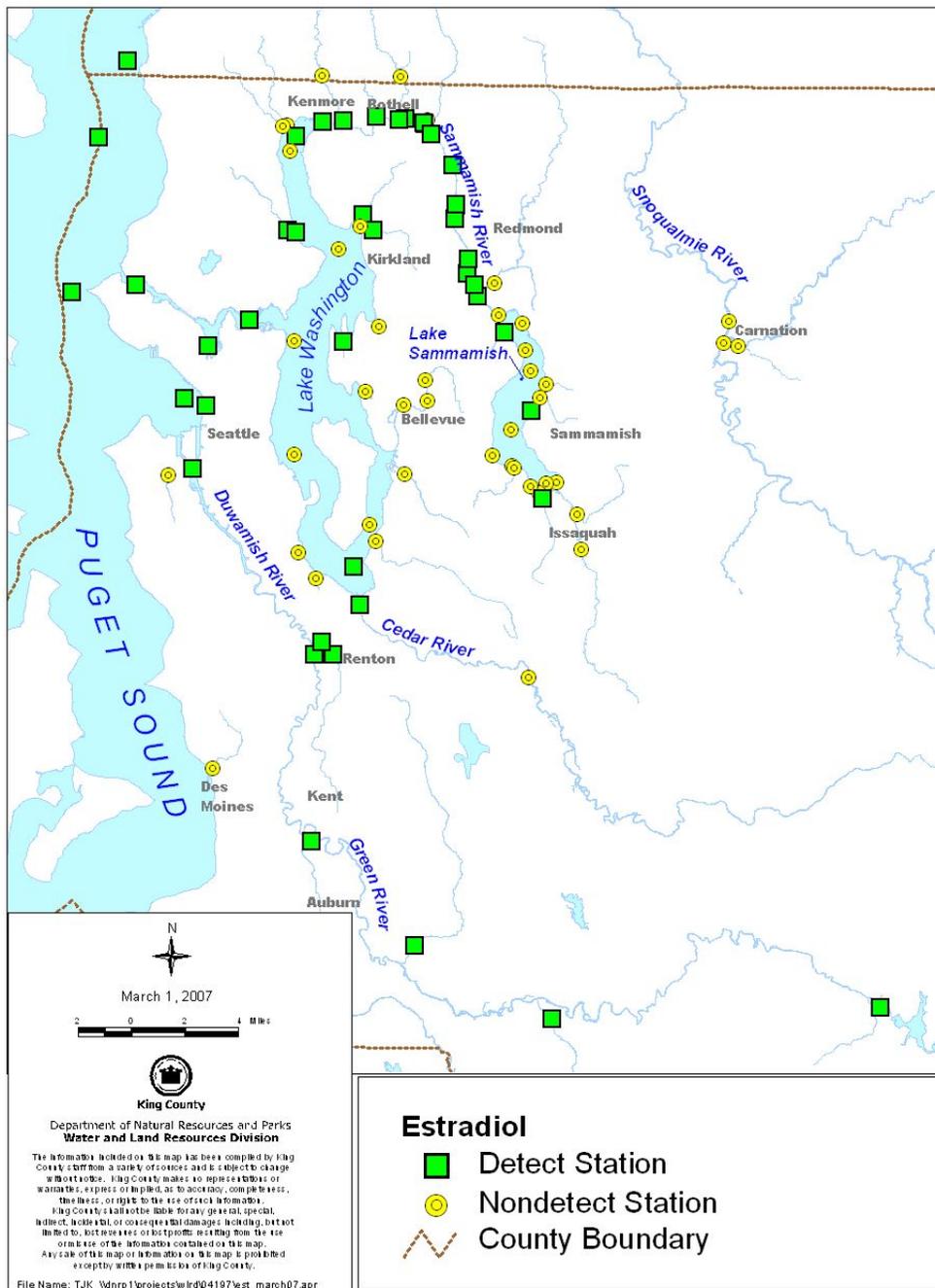
Locations Where Nonylphenol Detected in Surface Waters

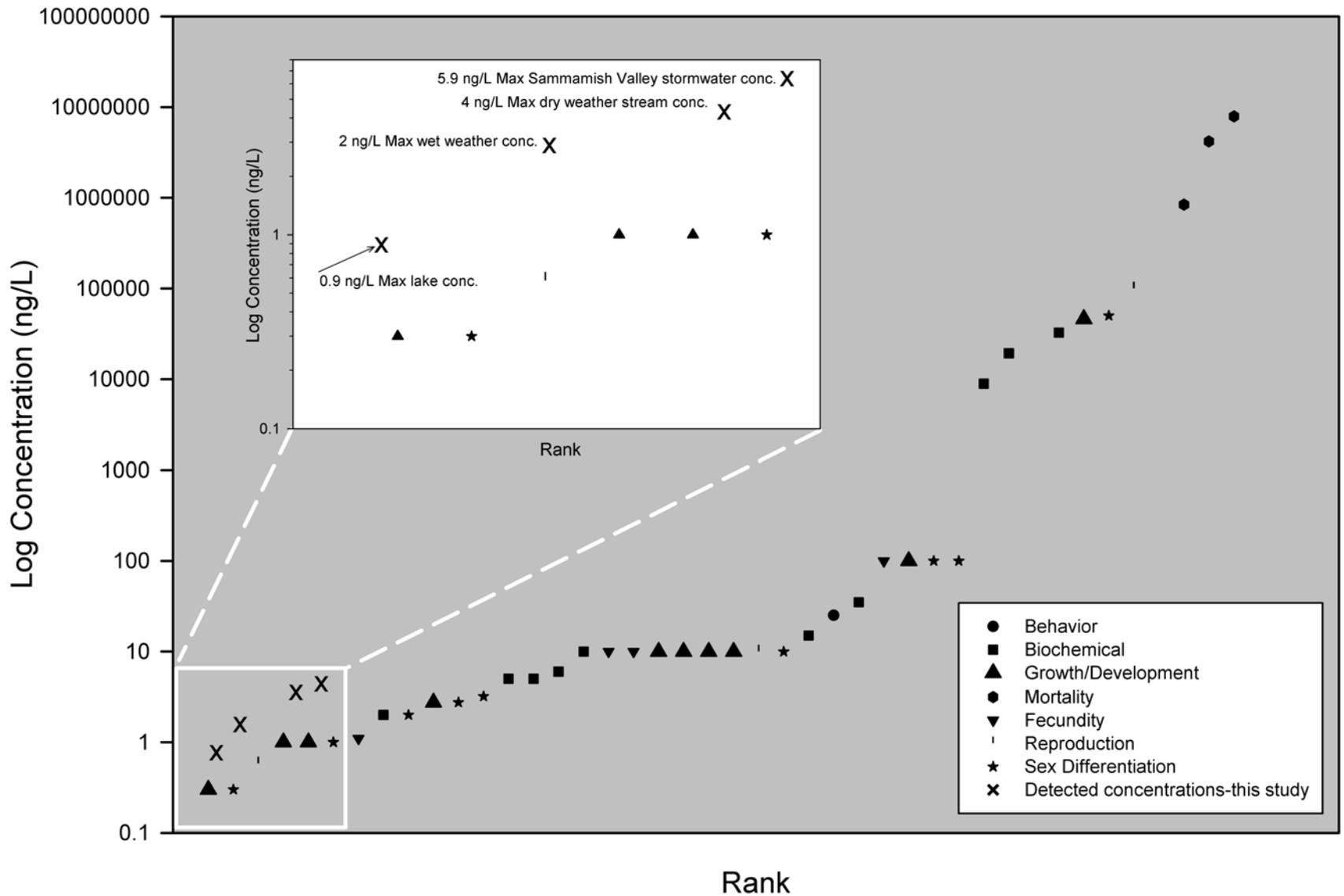




Nonylphenol – Literature Based Effect Values

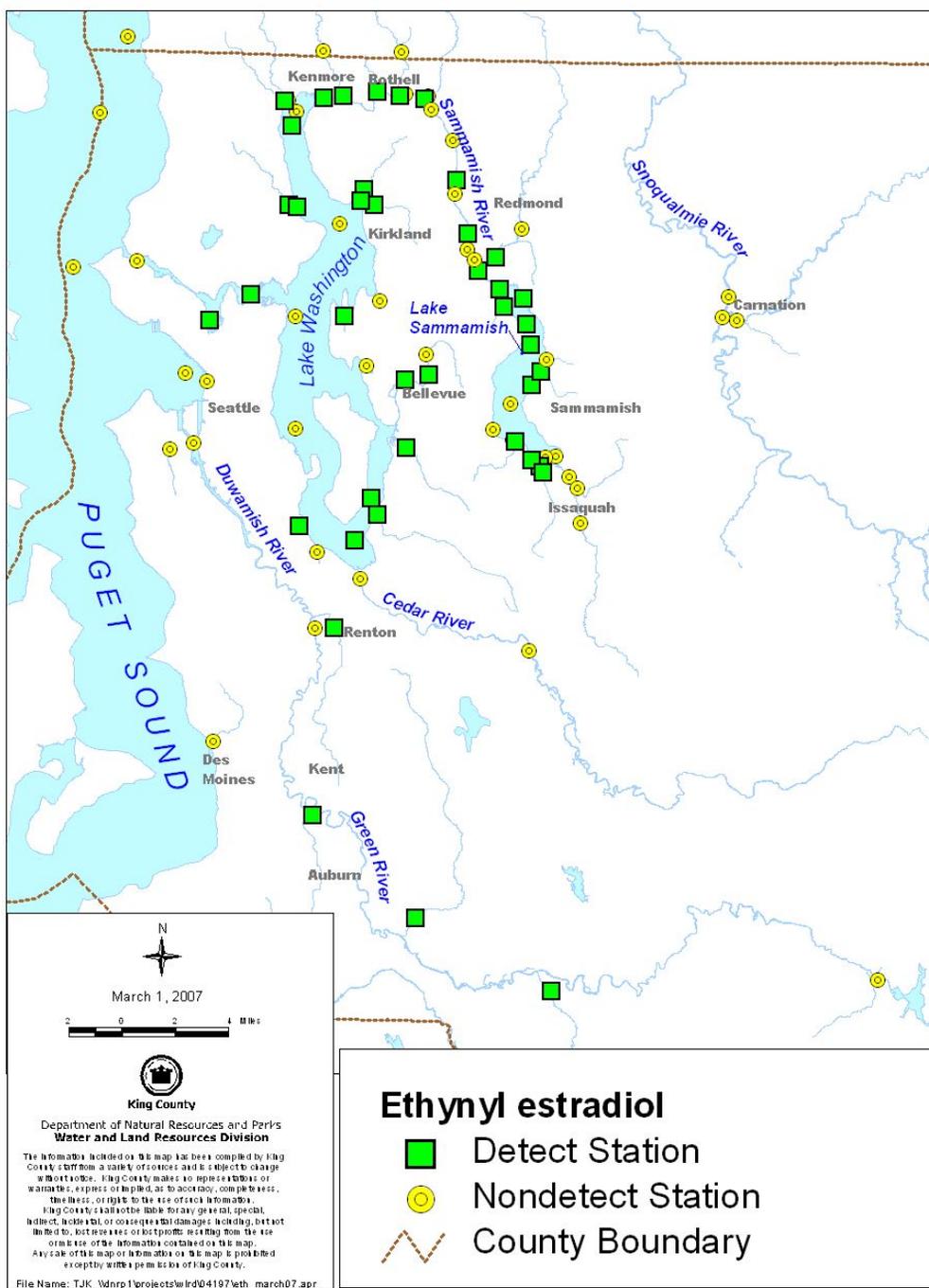
Locations Where Estradiol Detected in Surface Waters

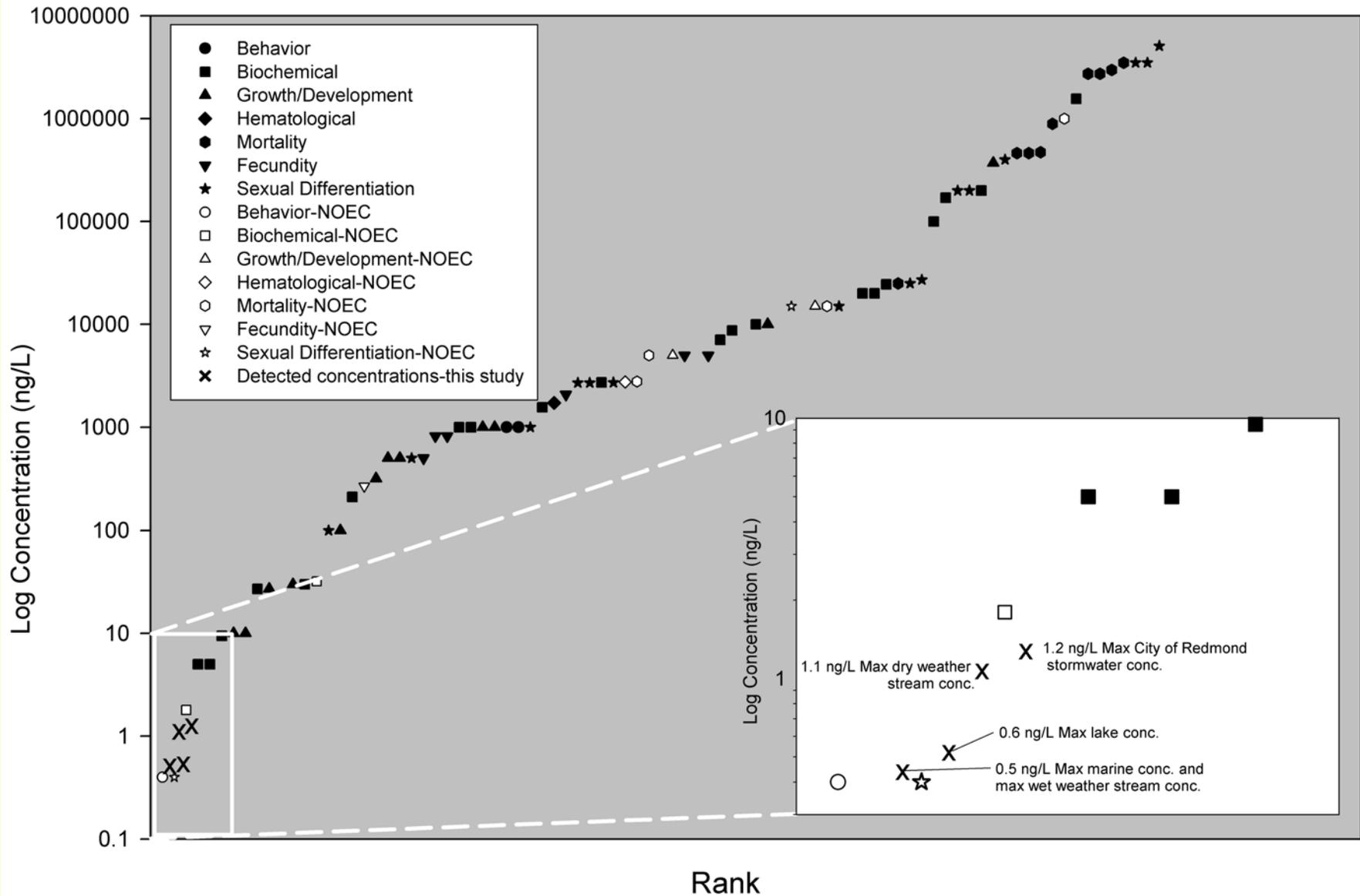




Ethinylestradiol – Literature Based Effect Values

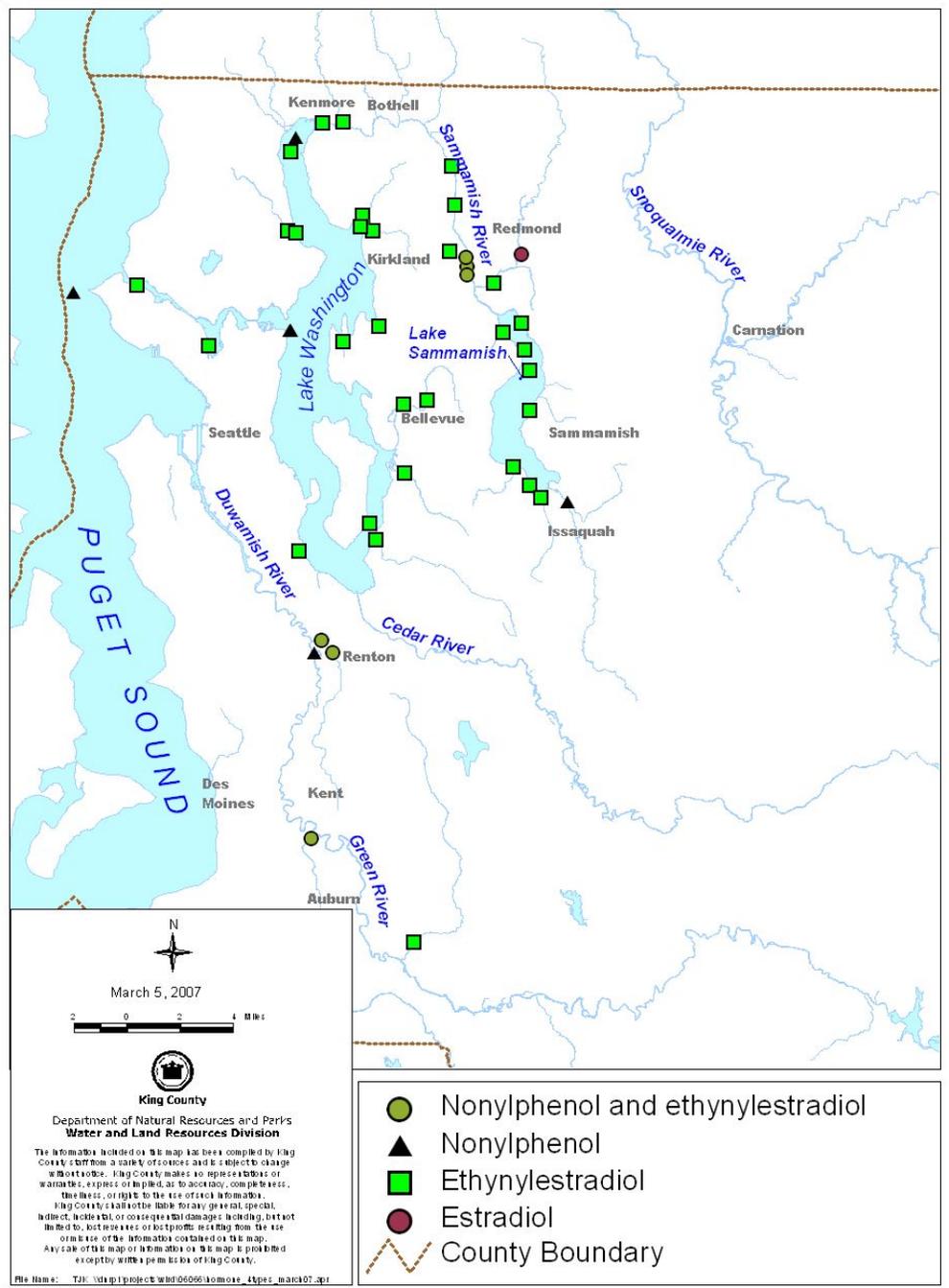
Locations Where Ethynylestradiol Detected in Surface Waters





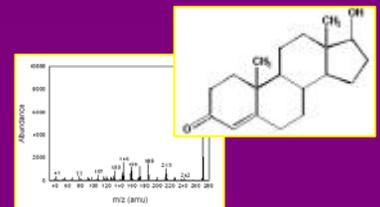
Estradiol – Literature Based Effect Values

Surface water locations where concentrations of at least one of these three chemicals (NP, E2, EE2) may warrant additional investigation



Non-Detected Chemicals

- Analytical detection limits compared to literature based effect values:
 - **Estrone** – all toxicity values below MDLs;
 - **Methyltestosterone** - most toxicity values above, a few below;
 - **Vinclozolin** - all toxicity values above MDLs;
 - **Testosterone** - all toxicity values above MDLs;
 - **Progesterone** - limited toxicity data to evaluate.



Conclusions

- 11 of 16 “new” compounds detected;
- Generally high spatial variability - however, most compounds detected in each water type – suggesting multiple sources;
- Concentrations were relatively low; many below most significant effect levels identified in literature;
- Greatest concern – EE2 and NP in streams.



Conclusions

- Limited detections in vicinity of WW outfall;
- Highest levels of most compounds detected in undiluted stormwater – suggests significant source to surface waters;
- Most concentrations similar to those found by others in North America.



Questions???

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EDCs- How do they reach the environment?

- Natural/synthetic hormones excreted and discharged via wastewater;
- Some household products contain EDCs and are washed down the drain;
- WW treatment not designed to remove some EDCs;
- WW treatment can increase toxicity of some EDCs;
- Pesticides and other EDCs transported to environment via stormwater;
- Wildlife/Agriculture – animals source of hormones to surface waters.



