East Waterway Anthropogenic Background

Meeting #3 Green River Data

Presented by

East Waterway Group

September 24, 2020

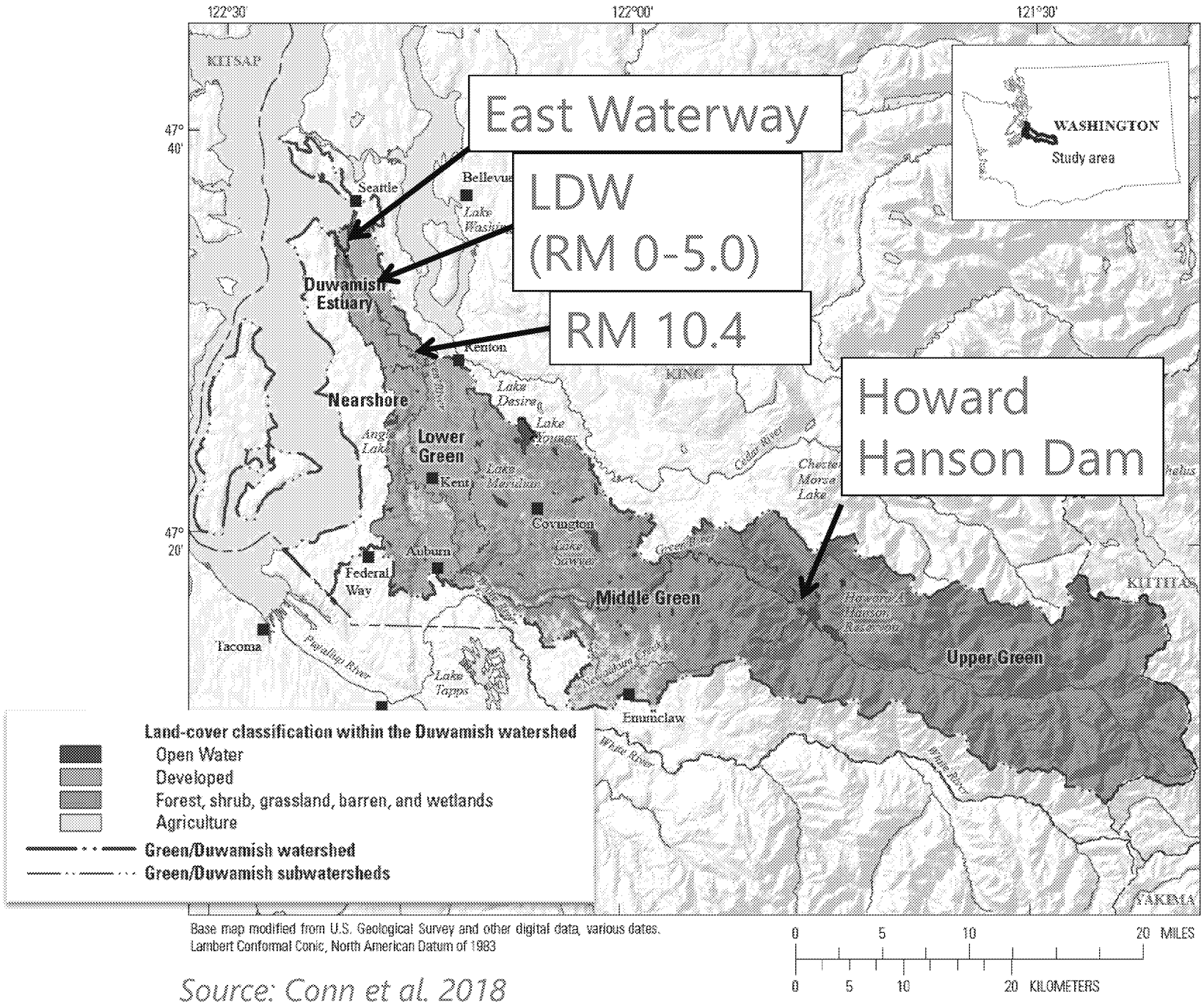
Meeting Agenda

- Green River Datasets
  - Green River Conceptual Site Model (CSM)
  - Sample types
  - Brief summary of each study
  - Summary statistics
  - Questions/ Discussion

Planned Anthropogenic Background Meetings

Meeting No.	Date	Topic
1	9/9/20	State the problem and identify the goals of the evaluation, review the CSM
2	9/15/20	~~Complete CSM discussions (if needed)~~ [Cancelled]
3	**9/24/20**	**Review available Green River data**
4	10/7/20	Review available EW laterals, LDW laterals, and LDW bedded sediment data
5	10/21/20	Data sufficiency evaluation
6	11/4/20	Discuss data analysis approach

Green River Conceptual Site Model



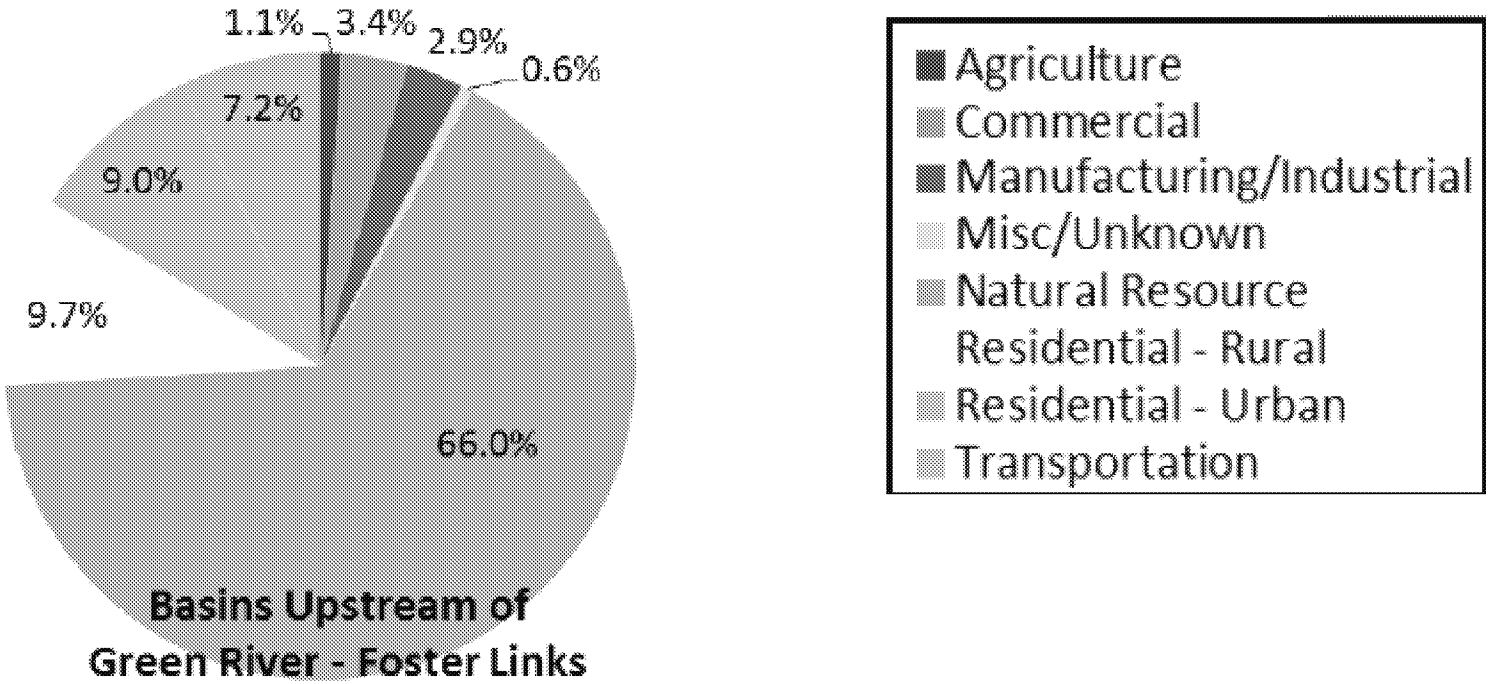
Base map modified from U.S. Geological Survey and other digital data, various dates.
Lambert Conformal Conic, North American Datum of 1983

Source: Conn et al. 2018

Green River Watershed

- Size
  - 300,000-acre watershed (1,200 km2)
  - 93 river miles (150 km)
- Predominant Land Use (Forest, Developed, Agriculture [from USGS report])
  - Upper watershed: 95% forest
  - Middle watershed: 57% forest, 33% developed, 10% agriculture
  - Lower watershed: 85% developed
  - Lower Duwamish: 91% developed
- Four major tributaries to Green River
  - Newaukum, Soos, Mill, Black/Springbrook

Predominant Land Use Above River Mile 10.4 (King County Report)



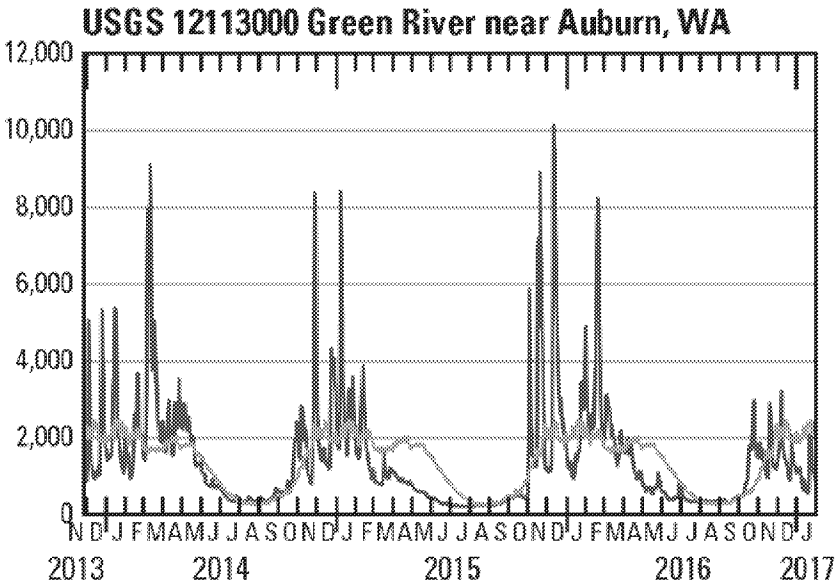
**Land use categories were designated based on King County Assessor data from May, 2013. Residential land was split into urban and rural based on the Urban Growth Area Line for 2013. Parcels with over 50% cultivated land cover, based on 2007 Landsat Landcover classification, were designated as agricultural land.*

Green River Discharge

Foster Links Golf Course

RM10.4 (RKM16.7)

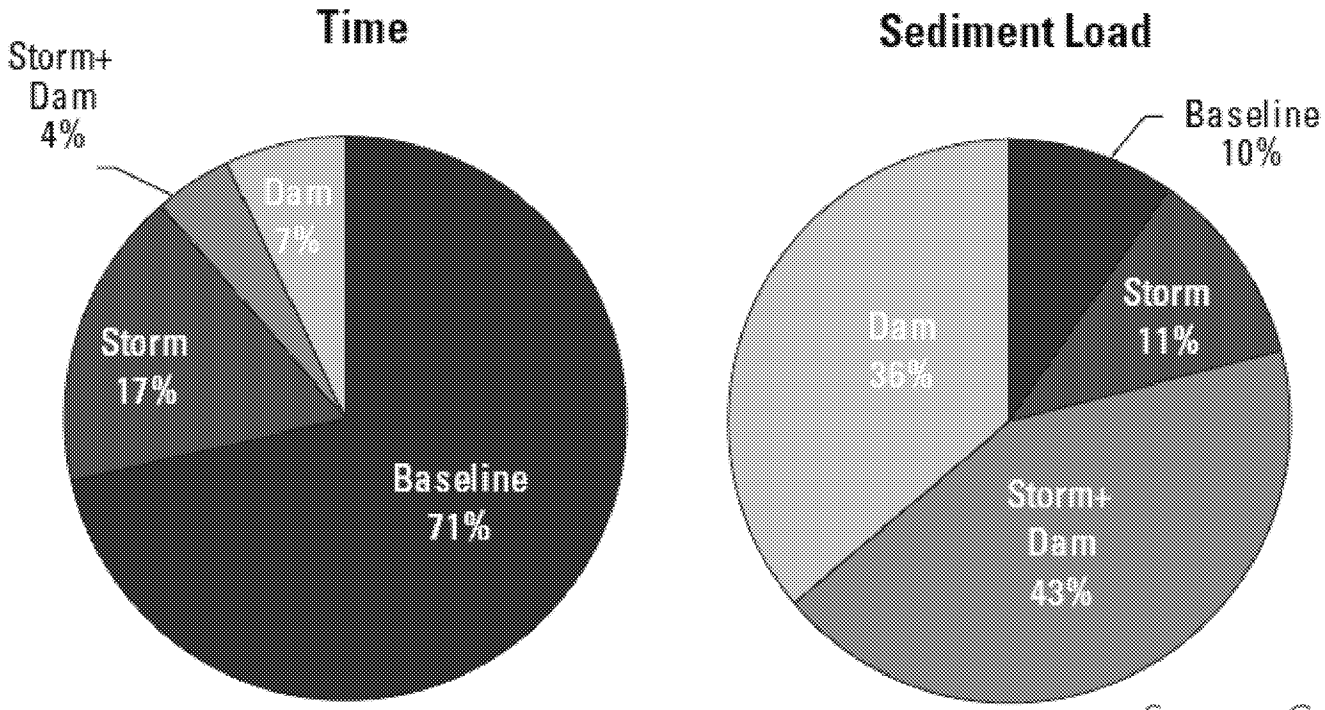
2013 – 2017



Source: Conn et al. 2018

- Average: 1,600 ft^3/s
- Max: 11,000 ft^3/s
- The river flow is regulated by the Howard Hanson Dam discharge that is maintained between ~300 and 12,000 ft^3/s
- Significant Dam Releases = 32 – 50 days/year (>2,000 ft^3/s at the base of the Howard Hanson Dam)

Sediment Transport (2013-2015)



Source: Conn et al. 2018

- Based on the flow categories in the USGS study
- Dam = significant release >2,000 ft^3/s at base of Dam
- Storm = >1 cm in 48 hours

Green River Watershed CSM Take-Aways

- Green is the main source of sediment to the LDW
  - 117,000 tons (106,000 metric tons) / year
  - 86,200 tons (78,200 metric tons) / year fines fraction
- Howard Hanson Dam regulates flows at RM 63
- Suspended sediment loads and contaminant concentrations vary with the four major flow regimes:
  - Base flow
  - Storm flow
  - Significant dam releases
  - Storm & large dam release
- Streamflow and suspended-sediment concentrations are highest from ~October 16 to April 15 of each year
- Over 90% of the sediment load (storm and/or significant dam) comes from flows during 30% of the time (based on data from USGS study)

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Green River Data Sets

Overview of Sample Types

- Suspended solids
  - Sediment traps
    - Deploy ~3 months
    - Jar & baffle traps anchored directly on riverbed
  - Filtered solids
    - Deploy ~24 (storm); ~ 24-48 hours (baseflow)
    - Pump to a filtration unit
    - Intake near riverbank, depth varies based on tidal condition
  - Centrifuged solids
    - Deploy ~hours to days
    - Pump to centrifuge unit
    - Intake center channel, ~0.6 times river depth

Overview of Sample Types (cont.)

- Bedded sediment
  - Fine-grained upstream sediment
    - Composite samples, sieved
    - Point samples
  - Turning basin
    - Composite Cores
- Unfiltered water
  - Sample ~1 to 24 hours
  - Composite and grab sampler
  - Target depth varied depending on study; typically 0.5 m above riverbed

Relevant Studies and Source Documents

- **USGS Green River Loading Study.** 2013 to 2017. RM 10.4 (Foster Link Golf Course).
  - Suspended solids (centrifuge)
  - surface water
  - fine-grained-bedded sediment
  - flow and suspended sediment characteristics
  - (Conn and Black 2014; Conn et. al. 2015, 2018a, 2018b, Senter et. al. 2018)
- **King County Suspended Sediment Study**. 2013 to 2015. RM 10.4.
  - suspended solids (filtered)
  - sediment traps (baffle and jar)
  - (King County 2016).
- **Ecology Contaminant Loading from Suspended Sediment.** 2008 – 2009. RM 6.8 (Footbridge).
  - Suspended solids (centrifuge)
  - (Gries and Sloan 2009)

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Relevant Studies and Source Documents (cont.)

- **Ecology Source Control Sediment Sampling.** 2008 - 2009. RM 4.9 to RM 7.4.
  - Surface sediment samples
  - (Ecology and Environment 2009)
- **USACE Turning Basin Sediment Core Sampling.** 2008 – 2017. RM 4.3 to RM 4.75.
  - Sediment core composites collected at the Turning Basin for dredge material characterization by USACE
  - (summarized in Windward 2020)
- **LDWG and King County Whole Water Data.** 2001 – 2015.
  - Concentrations associated with suspended solids in the Green/Duwamish River inflow
  - (Windward 2020, King County 2018 and AECOM 2012).

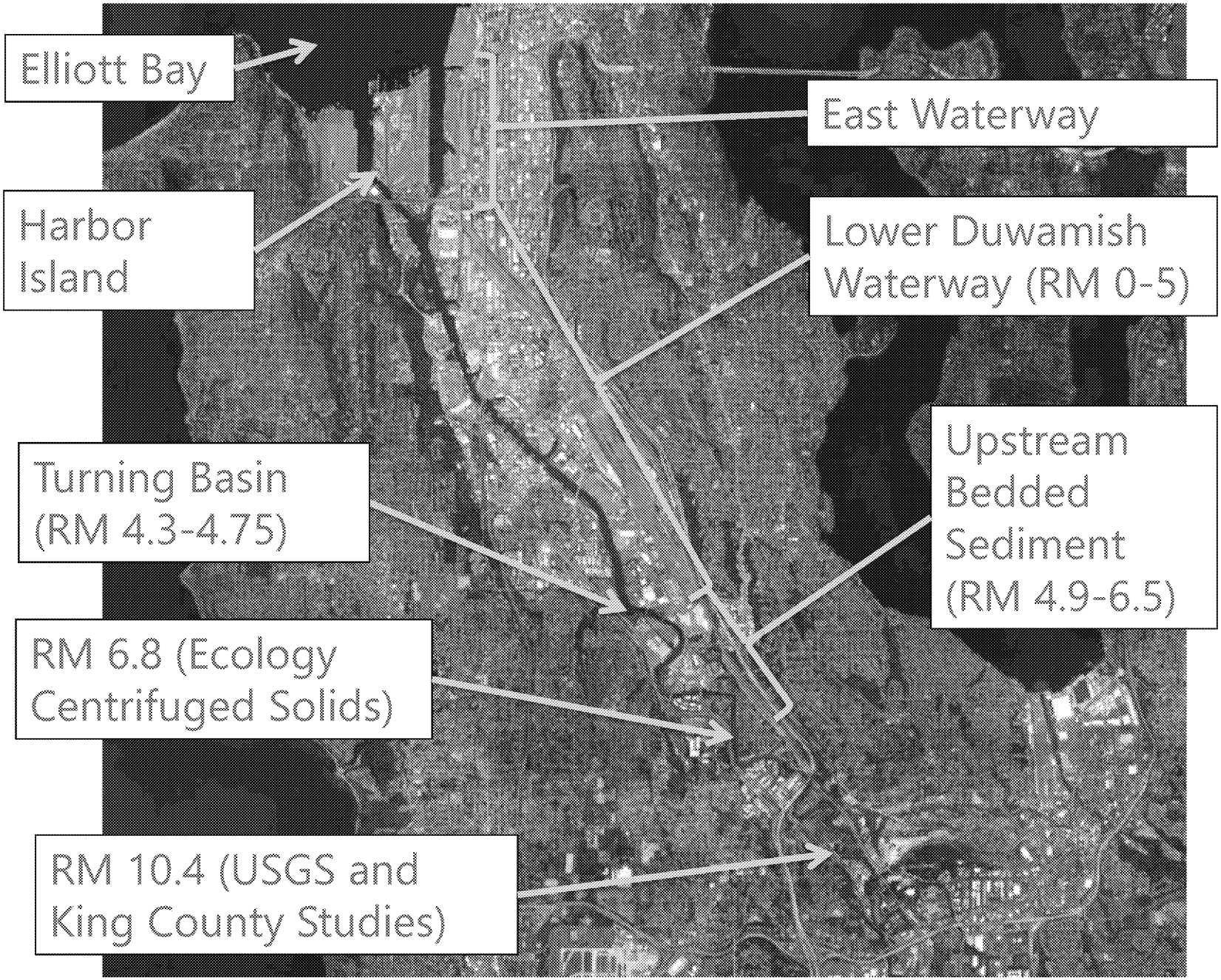


Image: Google Earth

USGS Loading Study

- 2013 - 2017
- RM 10.4
- 42 discrete sampling periods targeting a variety of flow conditions
- Suspended sediment centrifuge (39 samples)
- Fine-grained sediment composites (7 samples)
- Whole water (39 samples)

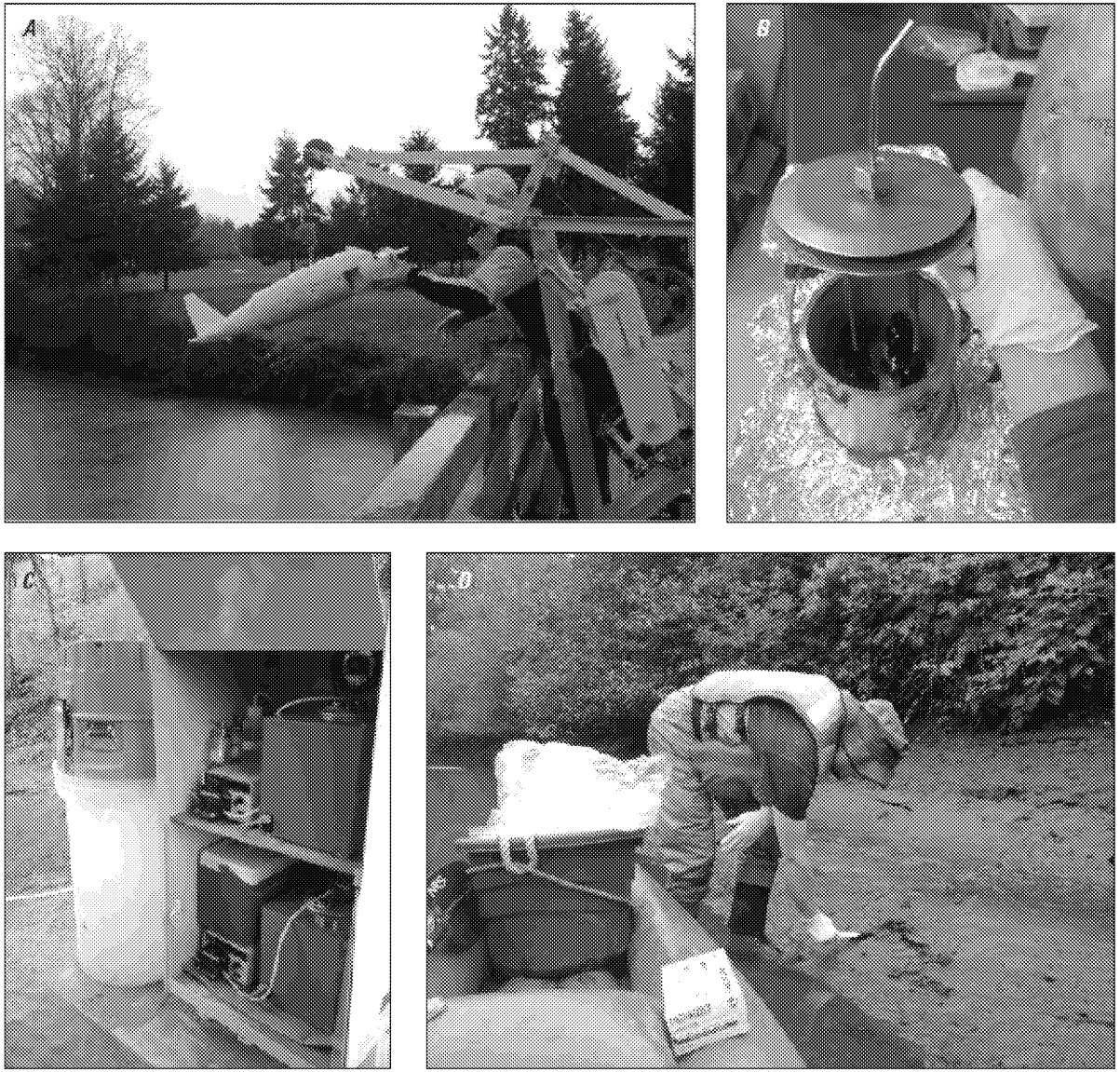
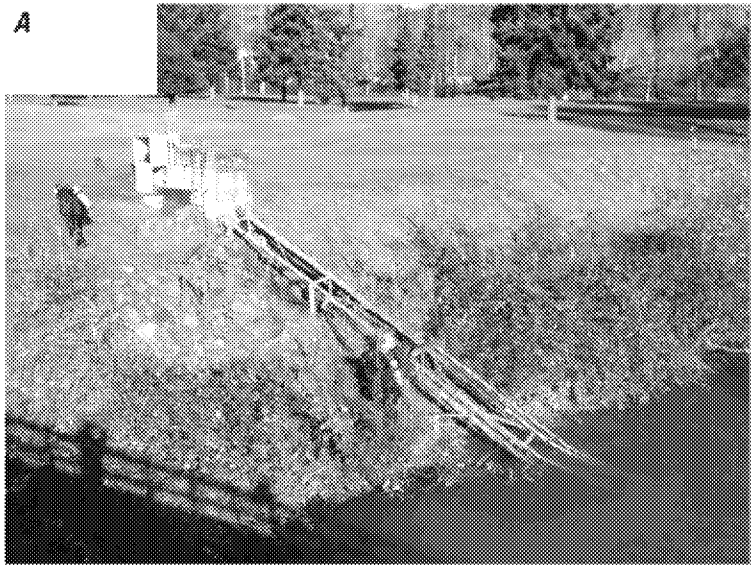


Figure 4. (*A*) US D-96 sampler for water chemistry and suspended-sediment physical parameters, (*B*) volatile organic compound sampler, (*C*) continuous-flow centrifuges for suspended-sediment chemistry, and (*D*) Teflon™ spatula from an inflatable kayak used for bed-sediment sampling at Duwamish River at Golf Course at Tukwila, Washington. Photographs taken by Kathleen Conn on (*A*) January 11, 2014, (*B*) May 26, 2015, (*C*) April 15, 2014, and (*D*) September 17, 2014.

Source: Conn et. al. 2015

USGS Loading Study

- Continuous measurement of discharge and turbidity
- Correlation of suspended sediment concentration with turbidity
- Other gauges and locations used to determine:
  - Base Flow
  - Storm
  - Dam
  - Storm + Dam

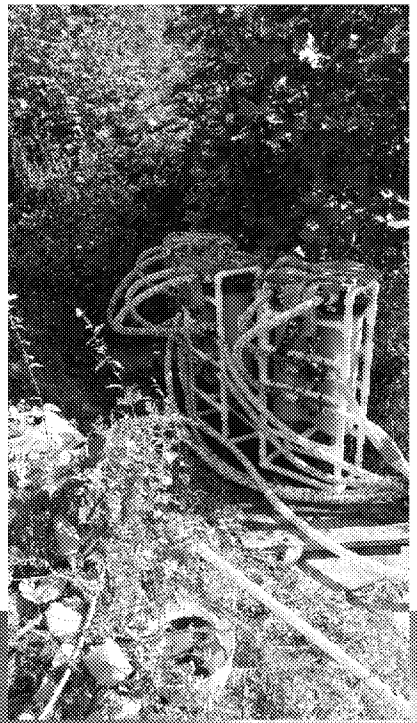


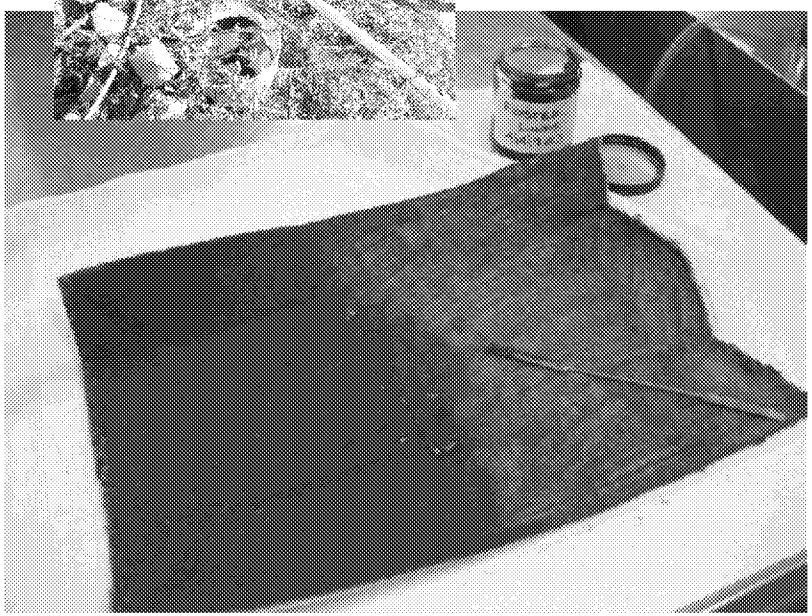
Source: Senter et. al, 2018

King County Suspended Solids Study (2013-2015) Filter Solids

- 12 sample events from RM 10.4
- Sampling device from Ecology
- Pump water through 5 µm polypropylene filter to capture suspended solids
- Deploy for ~ 24 hours
- Sampled during baseflow and storm with and without significant dam release conditions

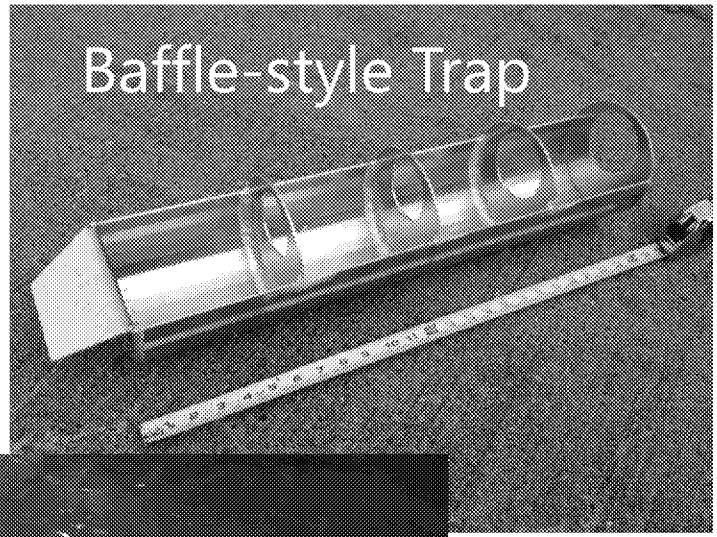
Source: King County 2016

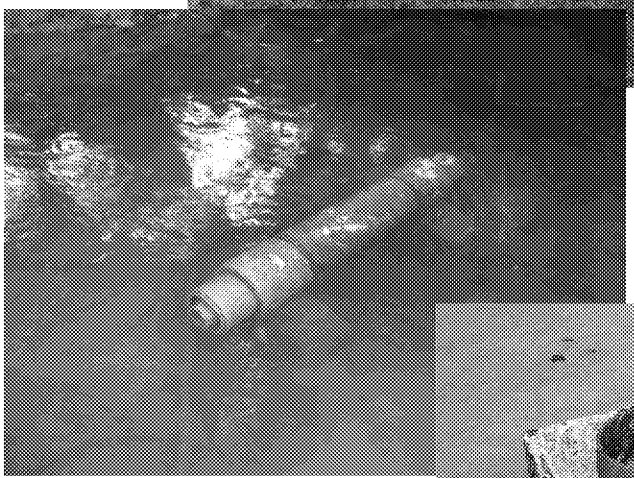




King County Suspended Solids Study (2013-2015) Sediment Traps

- 5 sample events from RM 10.4
- Deployed for ~ 3 months
  - Oct 2012-Feb 2013
  - Feb – May 2013
  - July – Sept 2013
  - Oct 2013 – Jan 2014
  - July -Sept 2015
- Used both baffle and jar style sediment traps

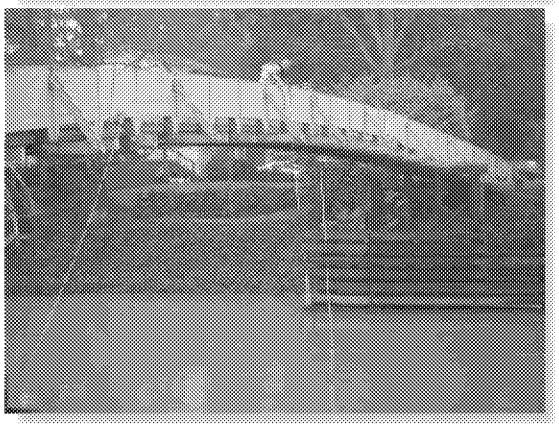


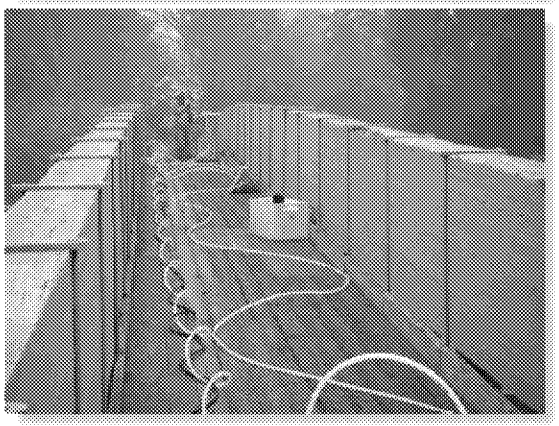


Source: King County 2016

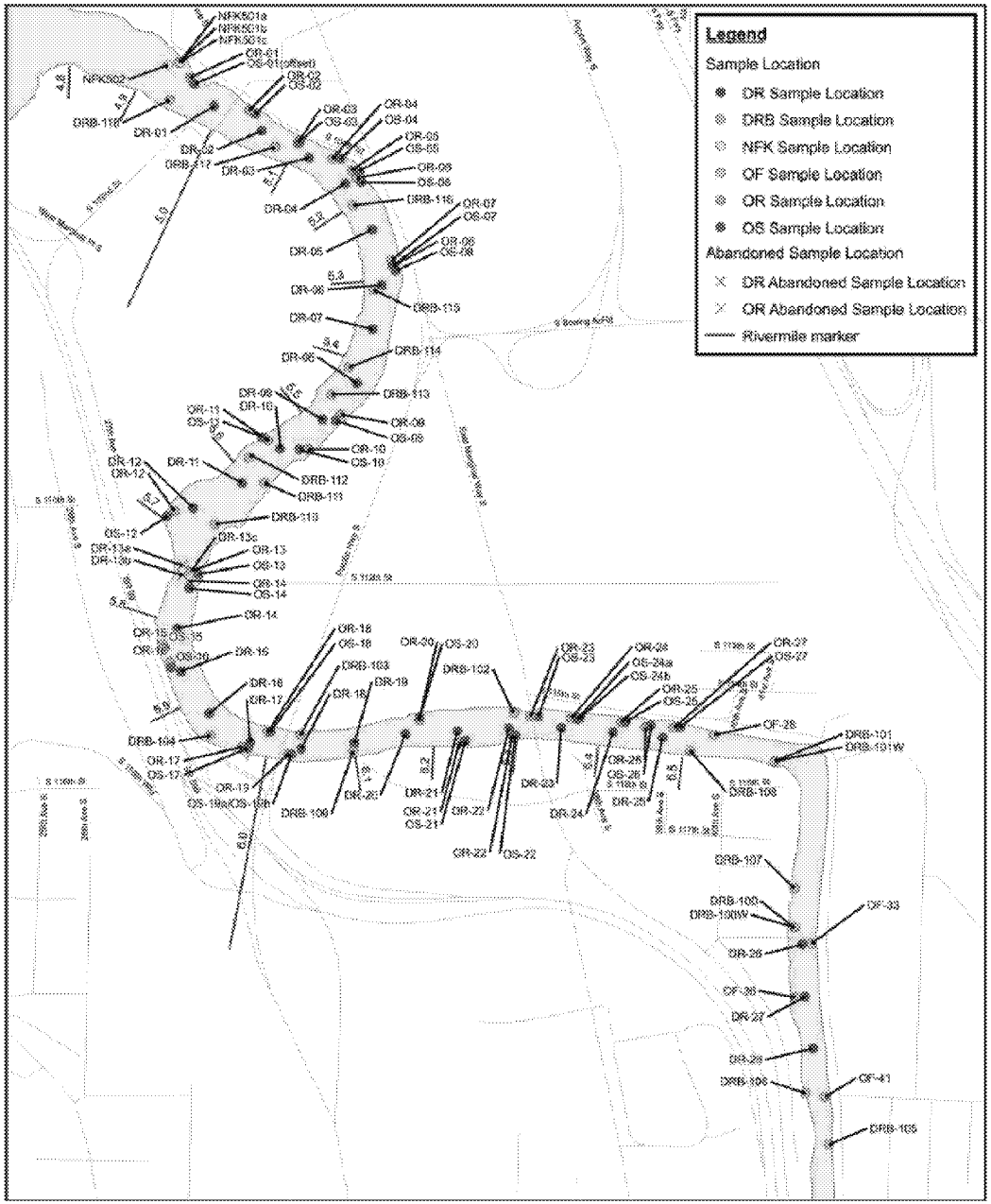
Ecology Loading Study (2008-2009)

- July 2008 to January 2009
- RM 6.8
- 7 sample events – 7 to 10 samples
- Centrifuged suspended solids
  - Occasionally within salt wedge
  - River stage – TSS relationship
- Precursor to USGS and King County studies





Source: Greis and Sloan 2009



Source: Ecology and Environment 2009

Ecology Source Control Sediment Sampling (2008)

- RM 4.9 to RM 6.5
- 104 sample locations
- Only samples with fines > 30% selected for model input evaluation (Summarized in the LDW FS App B Part 3B (AECOM 2012))
- Sample codes:
  - DR: Duwamish River channel
  - OS, OF: locations near the discharge points of outfalls
  - OR: locations approximately 15 meters (m) downstream of outfall discharge points
  - NFK: locations near the Norfolk combined sewer
  - DRB: banks of the Duwamish River at locations that appeared to be depositional environments

USACE LDW Turning Basin Samples

- LDW turning basin traps sediment that requires dredging every ~2-3 years
- Dredge material management characterization data is available for multiple years
- Data based on core composites within dredge material management units RM 4.3 – 4.75
- Data from 2008, 2009, 2011, and 2017 summarized in the LDW Data Evaluation Report (Windward 2020)
- Samples from 1990 through 2009 were summarized in the LDW FS (AECOM 2012)

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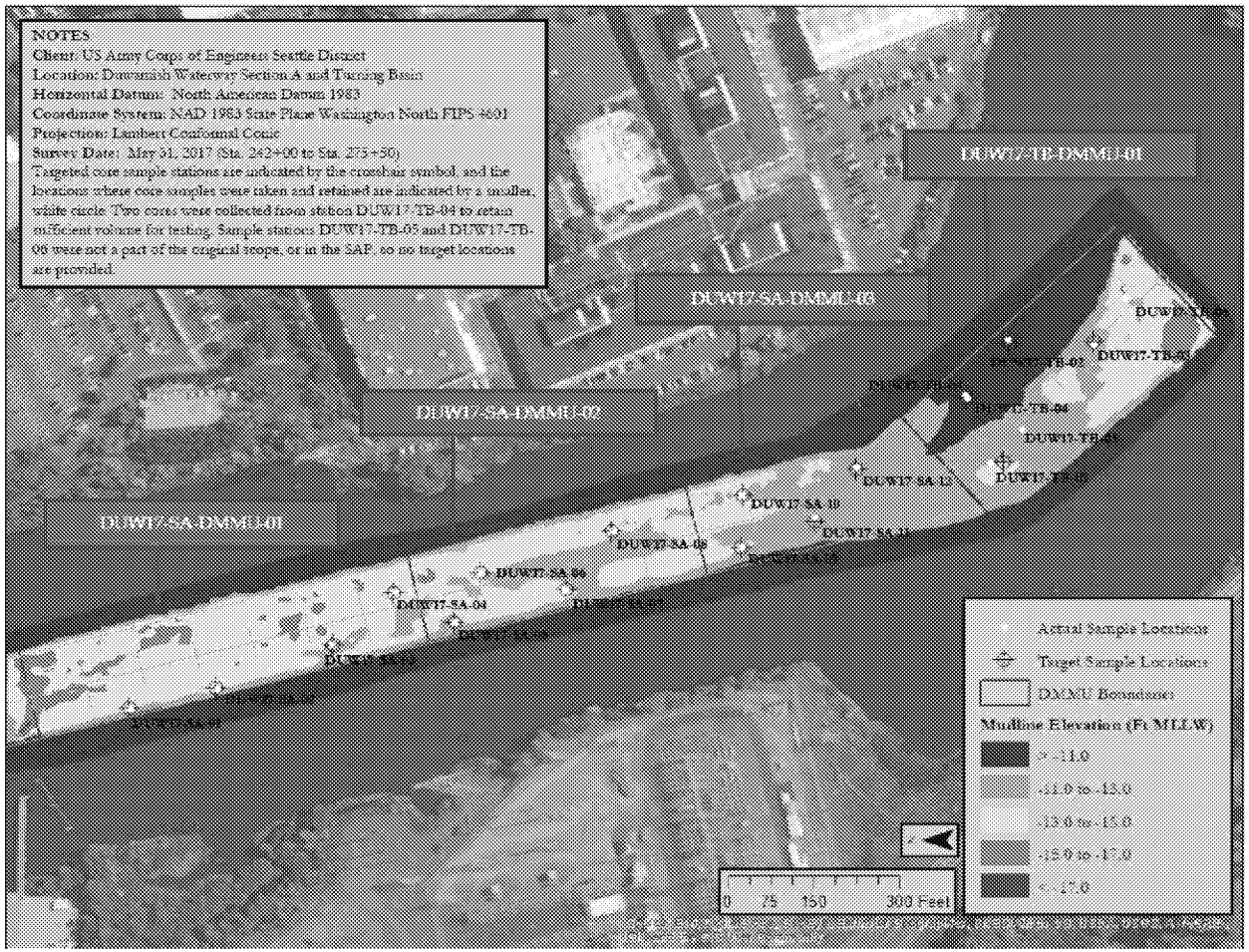
USACE LDW Turning Basin

Example Sampling Plan



Source: Windward 2020

Whole Water LDW and EW FS Data Set

- Unfiltered water sample concentrations normalized to total suspended solids to approximate particulate concentrations.
- Arsenic based on (Total – Dissolved)/ TSS

- King County surface water samples were collected at Ft. Dent (RM 10.9) and at Marginal Way (RM 6.3)
  - PCBs, 2005-2008, n = 22
  - As 2001-2008, n = 100
  - LDW FS Table 5-1a,b; FS App C Part 3b Table 1

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Whole Water Post-FS Data Sets (River Mile 10.4)

- LDWG AOC 3 2018
  - PCBs, n = 8, (2 wet baseflow, 2 dry baseflow, 4 storm)
  - DF, n = 3, (1 dry baseflow, 2 storm)
  - As, n/a (inorganic and dissolved arsenic were analyzed)
- USGS 2013 – 2017
  - PCBs, n = 37 (11 baseflow, 18 storm, 7 dam, 1 storm+dam)
  - DF, n = 37 (11 baseflow, 18 storm, 7 dam, 1 storm+dam)
  - As, n = 32 (9 baseflow, 17 storm, 5 dam, 1 storm+dam)

Whole Water Post-FS Data Sets (cont.)

- King County 2011-2012 (King County 2018a); 2015 – 2017 (King County 2018b)
  - PCBs, n = 23 (9 baseflow, 14 storm)
  - Arsenic, n = 21 (9 baseflow, 12 storm)
- Data has not been summarized

Summary Statistics

Studies and Sample Counts

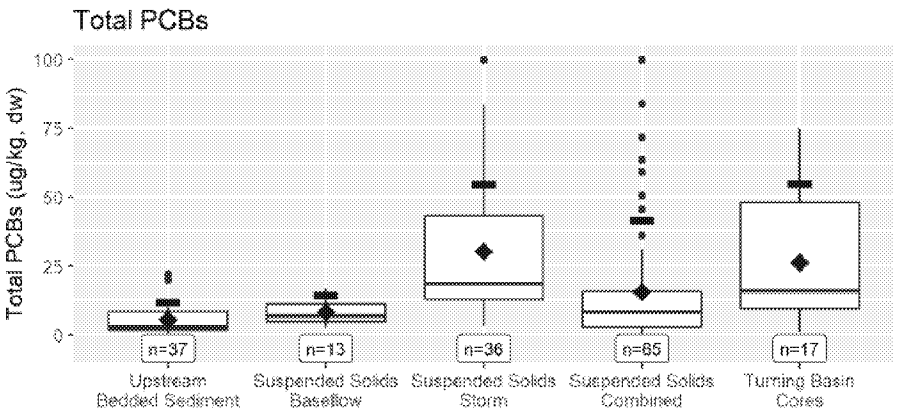
COC	King County Filtered Solids	King County Sediment Traps	USGS Centrifuged Solids	USGS Bedded Sediment	Ecology Centrifuged Solids	Ecology Upstream Bedded Sediment	USACE Turning Basin Cores			
	2013–2015	2013–2015	2013–2017	2013–2015	2008–2009	2008	2008	2009	2011	2017
PCBs	12	9	37	7	7	30	2	2	8	5
Dioxin/furan TEQ	10	5	38	7	6	31	2	0	5	5
Arsenic	10	7	35	7	7	31	2	2	9	5

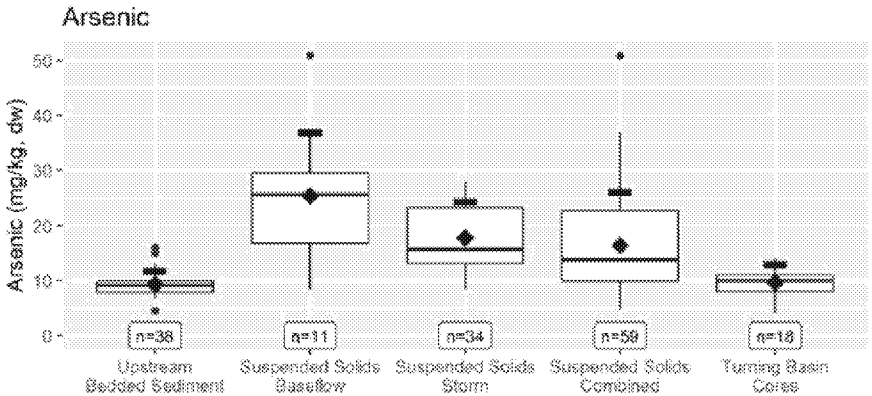
Source: Windward 2020

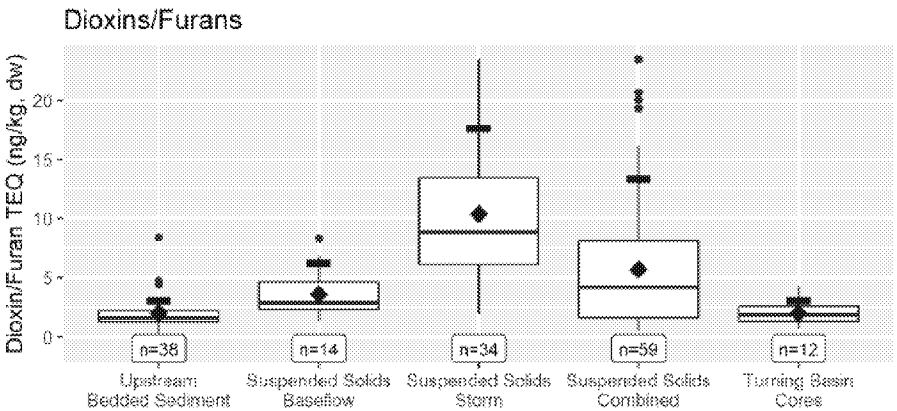
COC	Suspended Sediments Data			Bedded Sediment Data	
	Flow Categorized (King County Filter, USGS Centrifuged)		All suspended solids: Ecology, King County, USGS	Upstream Surface Sediment (Ecology, USGS)	Turning Basin Cores (USACE)
	Baseflow	Storms	All Conditions	All Conditions	RM 4.3–RM 4.75
PCBs (µg/kg)	n = 13 7 (median) 8 (mean) 11 (95UCL) 14 (90th pctile)	n = 36 12 (median) 20 (mean) 29 (95UCL) 55 (90th pctile)	n = 65 8 (median) 16 (mean) 20 (95UCL) 42 (90th pctile)	n = 37 3 (median) 6 (mean) 8 (95UCL) 12 (90th pctile)	n = 17 16 (median) 26 (mean) 41 (95UCL) 55 (90th pctile)
Arsenic (mg/kg)	n = 11 26 (median) 25 (mean) 32 (95UCL) 37 (90th pctile)	n = 34 13 (median) 15 (mean) 17 (95UCL) 24 (90th pctile)	n = 59 14 (median) 16 (mean) 18 (95UCL) 26 (90th pctile)	n = 38 9 (median) 9 (mean) 10 (95UCL) 12 (90th pctile)	n = 18 10 (median) 10 (mean) 11 (95UCL) 13 (90th pctile)
Dioxin/ furan TEQ (ng/kg)	n = 14 3 (median) 4 (mean) 5 (95UCL) 6 (90th pctile)	n = 34 6 (median) 7 (mean) 10 (95UCL) 18 (90th pctile)	n = 59 4 (median) 6 (mean) 7 (95UCL) 13 (90th pctile)	n = 38 2 (median) 2 (mean) 2 (95UCL) 3 (90th pctile)	n = 12 2 (median) 2 (mean) 3 (95UCL) 3 (90th pctile)

Source: Windward 2020 Table 8-3

Results Summary by Sample Type / Flow (Excludes Whole Water)







(Source: Windward 2020 Figure 8-2)

Results Summary by Study

COC	Study-specific Data									
	Ecology Centrifuged Solids	King County Filtered Solids	King County Sediment Traps[a]	USGS Centrifuged Solids	Ecology Upstream Bedded Sediment	USGS Bedded Sediment	USACE Turning Basin Cores			
	2008–2009	2013–2015	2013–2015	2013–2017	2008	2013–2015	2008	2009	2011	2017
	All Conditions	Baseflow, Storm, Dam[b]	Baffle, Jar	Baseflow, Storm, Dam[b]	RM 5–RM 7 and >30% fines	RM 10 and < 62.5 µm	RM 4.3 - RM 4.75			
PCBs[c,e] (µg/kg)	n = 7 8 (median) 15 (mean) 67 (95UCL[d])	n = 3, 5, 4 7, 59, 5 (median) 8, 49, 6 (mean) 66 (95UCL[d])	n = 5, 4 1, 9 (median) 5, 13 (mean) 15 (95UCL[d])	n = 10, 17, 10 8, 18, 2 (median) 8, 25,3 (mean) 24 (95UCL[d])	n = 30 2 (median) 5 (mean) 10 (95UCL[d])	n = 7 6 (median) 6 (mean) 9 (95UCL[d])	n = 2 39 (median) 39 (mean)	n = 2 14 (median) 14 (mean)	n = 8 10 (median) 11 (mean)	n = 5 50 (median) 50 (mean)
							41 (95UCL[d] 2008 - 2017); 43 (95UCL[d] 2011, 2017)			
cPAH TEQ[c,f] (µg/kg)	n = 7 53 (median) 136 (mean) 640 (95UCL[d])	n = 2, 3, 4 36, 350, 39 (median) 36, 315, 44 (mean) 415 (95UCL[d])	n = 4, 4 35, 45 (median) 45, 54 (mean) 80 (95UCL[d])	n = 5, 17, 10 33, 141, 14 (median) 53, 156, 28 (mean) 157 (95UCL[d])	n = 31 16 (median) 37 (mean) 72 (95UCL[d])	n = 7 18 (median) 23 (mean) 31 (95UCL[d])	n = 2 75 (median) 75 (mean)	n = 2 17 (median) 17 (mean)	n = 9 20 (median) 25 (mean)	n = 5 28 (median) 27 (mean)
							40 (95UCL[d] 2008 - 2017); 30 (95UCL[d] 2011, 2017)			
Dioxin/furan TEQ[c,f] (ng/kg)	n = 6 3 (median) 6 (mean) 10 (95UCL[d])	n = 3, 3, 4 3, 8, 3 (median) 3, 12, 4 (mean) 11 (95UCL[d])	n = 3, 2 1, 3 (median) 2, 3 (mean) 5 (95UCL[d])	n = 11, 17, 10 3, 9, 1 (median) 4, 10, 2 (mean) 9 (95UCL[d])	n = 31 2 (median) 2 (mean) 2 (95UCL[d])	n = 7 3 (median) 3 (mean) 4 (95UCL[d])	n = 2 3 (median) 3 (mean)	no data	n = 5 1 (median) 1 (mean)	n = 5 3 (median) 3 (mean)
							3 (95UCL[d] 2008 - 2017); 3 (95UCL[d] 2011, 2017)			
Arsenic[c] (mg/kg)	n = 7 14 (median) 17 (mean) 22 (95UCL[d])	n = 3, 3, 4 37, 17, 11 (median) 40, 19 11 (mean) 30 (95UCL[d])	n = 5, 2 5, 13 (median) 9, 13 (mean) 20 (95UCL[d])	n = 8, 17, 10 21, 15, 10 (median) 20, 18, 10 (mean) 20 (95UCL[d])	n = 31 9 (median) 9 (mean) 10 (95UCL[d])	n = 7 10 (median) 10 (mean) 11 (95UCL[d])	n = 2 12 (median) 12 (mean)	n = 2 5 (median) 5 (mean)	n = 9 10 (median) 9 (mean)	n = 5 13 (median) 11 (mean)
							11 (95UCL[d] 2008 - 2017); 11 (95UCL[d] 2011, 2017)			

Windward 2020 Table 8-3

Use of Green River Data in the EW FS

Green River Data Summary for EW and LDW Modeling Roadmap

- LDW Data Evaluation Report (2020) Section 8.2 and Appendix F Bed Composition Model Upstream Data
- EW FS (2019) Section 5.3.1 and Appendix B Part 3B Green River Inputs
- LDW FS (2012) Section 5.2.3.1 and Appendix C Part 3B Datasets Used in Upstream Bed Composition Model Parameters
- Links to individual reports have been provided by email

EW FS Green River Selected Model Inputs and Basis

Analyte	Best Estimate	Low	High	Basis for Input and Sensitivity Values
Total PCBs (µg/kg dw)	**42**	5	80	**Best**: Mean of Ecology centrifuged TSS data and King County whole water data combined (see LDW Table 5-2a). Whole water data were used instead of LDW turning basin data (as used for the LDW FS) to account for finer fractions of sediment settling in the EW. **Low**: Mean of Ecology upstream sediment sample data containing fines >30% (see LDW Table 5-2a). **High**: UCL95 of TSS-normalized King County whole water data (value from LDW Table 5-2a; 82 rounded to 80 µg/kg dw).
Arsenic (mg/kg dw)	9	7	10	**Best**: Mean of Ecology upstream sediment sample data containing fines >30% (see LDW Table 5-2b). **Low**: Mean of LDW RM 4.3 to 4.75 USACE (2001 to 2009) core data (see LDW Table 5-2b). **High**: UCL95 of Ecology upstream sediment sample data containing fines >30% (see LDW Table 5-2b).
Dioxin/ Furan (ng TEQ/kg dw)	**6**	2	8	**Best**: Mean of Ecology centrifuged TSS data (see LDW Table 5-2d). **Low**: Mean of Ecology upstream sediment sample data containing fines >30% (see LDW Table 5-2d). **High**: Midpoint between mean and UCL95 of Ecology centrifuged solids data (see LDW Table 5-1a and LDW Table 5-2d).

Green River Data Next Steps

- Follow up on questions posed today during Meeting #4 or via email
- Future meetings
  - Table summarizing adequacy representativeness of each line of evidence
  - Sufficiency evaluation

Questions/Discussion