QAPP UPDATE

HSPF GOALS & OBJECTIVES

TOXIC MODELING FRAMEWORK

CALIBRATION APPROACH

APRIL 10, 2019

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STUDY QUESTIONS

- What is the rank of pollutant contribution among point sources and non-point sources?
- What is the contribution of contaminants from groundwater?
- What is the atmospheric contribution of a contaminant to the receiving waterbodies?

- What is the contribution of a contaminant from an Identified point source (or sources) in the watershed?
- What is the contribution of a contaminant from different land uses that are non-point sources?
- What would be the needed reduction of non-point loadings in the watershed to achieve the stated goals?
- What is the contribution of contaminant loadings coming from Howard Hanson Dam versus below?
- What are the different methods of treatment that might be modeled?

HSPF MODELING GOALS

- Leverage past efforts
- Integrate with current complimentary modeling efforts (internal and external to the project)
- Provide the necessary tools to characterize a highly complex physical landscape in a simpler quantifiable way, and
- Be adaptable to allow for future assessments

HSPF OBJECTIVES

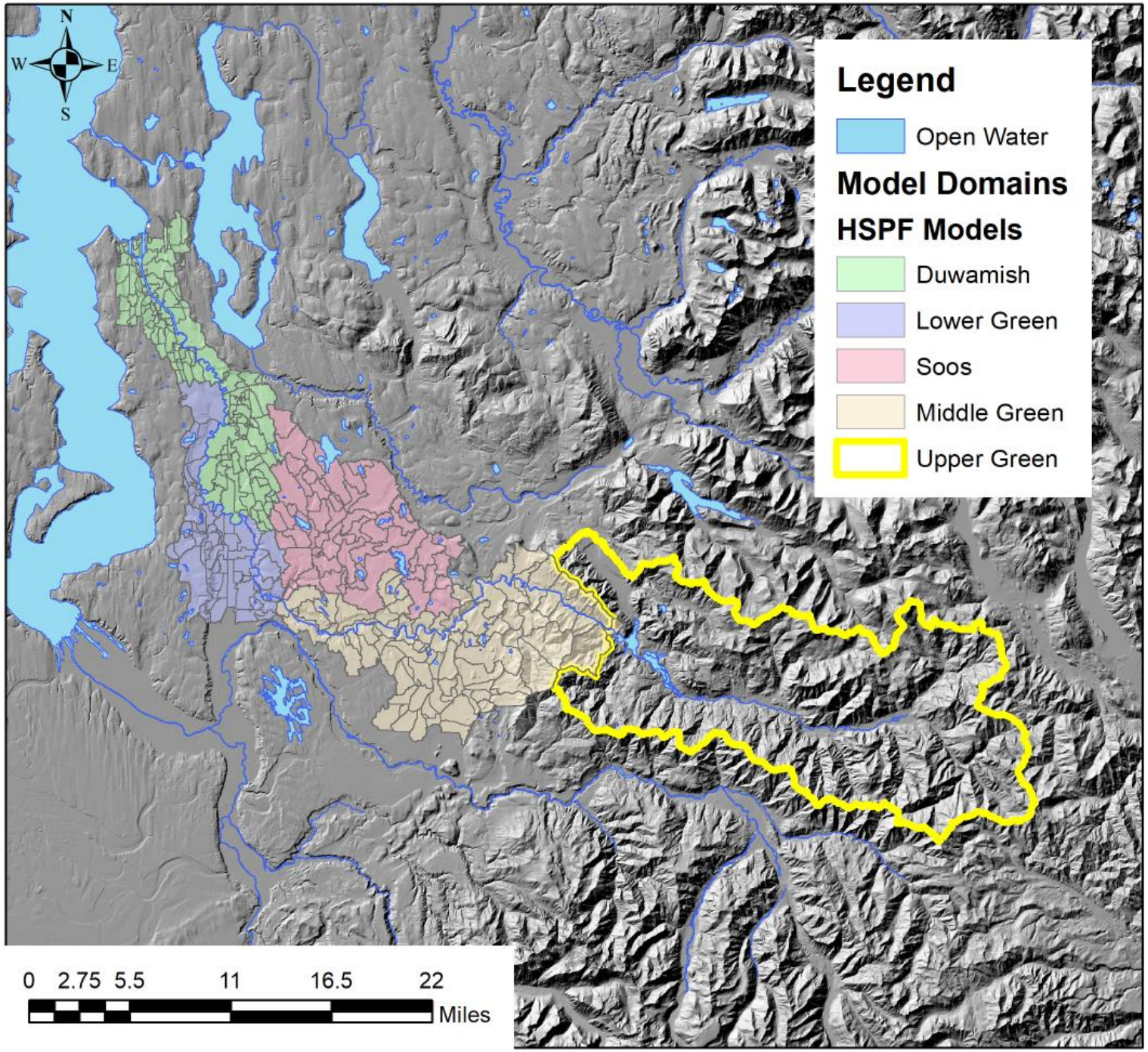
- Provide boundary conditions for the Lower Duwamish Waterway (LDW)
- Characterize the watershed and estimate pollutant pathways and loadings
- Evaluate effectiveness of proposed mitigation strategies

POSSIBLE POINTS OF ANALYSIS

- Four modeling domains
- 329 catchments
- 991 HRUs (max allowed is 999)

Combinations of:

Land Use & Cover
Geology
Slope
Rainfall



LEVERAGING PAST & CURRENT STUDIES

- LDW – Bulk atmospheric deposition report (2015)
- PCB *max* potential atmospheric loading (K. Schock 2019)
- WQA Present-Day Contaminant Loadings (2017)
- The 2015 CSO Water Quality Study (2015)
- Western Washington NPDES Phase 1 Stormwater Permit: Final Data Characterization 2009-2013
- King County WTD current modeling
- King County Clean Water Plan update
  - Water Quality Benefit Evaluation (WQBE)
- The Nature Conservancy (Heat Map, Phase I & II)
- Seattle Public Utilities (SPU) Integrated Plan (2015)
  - SPU updated PLM modeling effort?
- WA Ecology Stormwater Action Monitoring (SAMs)

KEEPING IT SIMPLE (WATERSHED MODELING)

- Build-up & Wash-off
- Adsorption & Desorption
- Deposition & Resuspension
- Point Sources

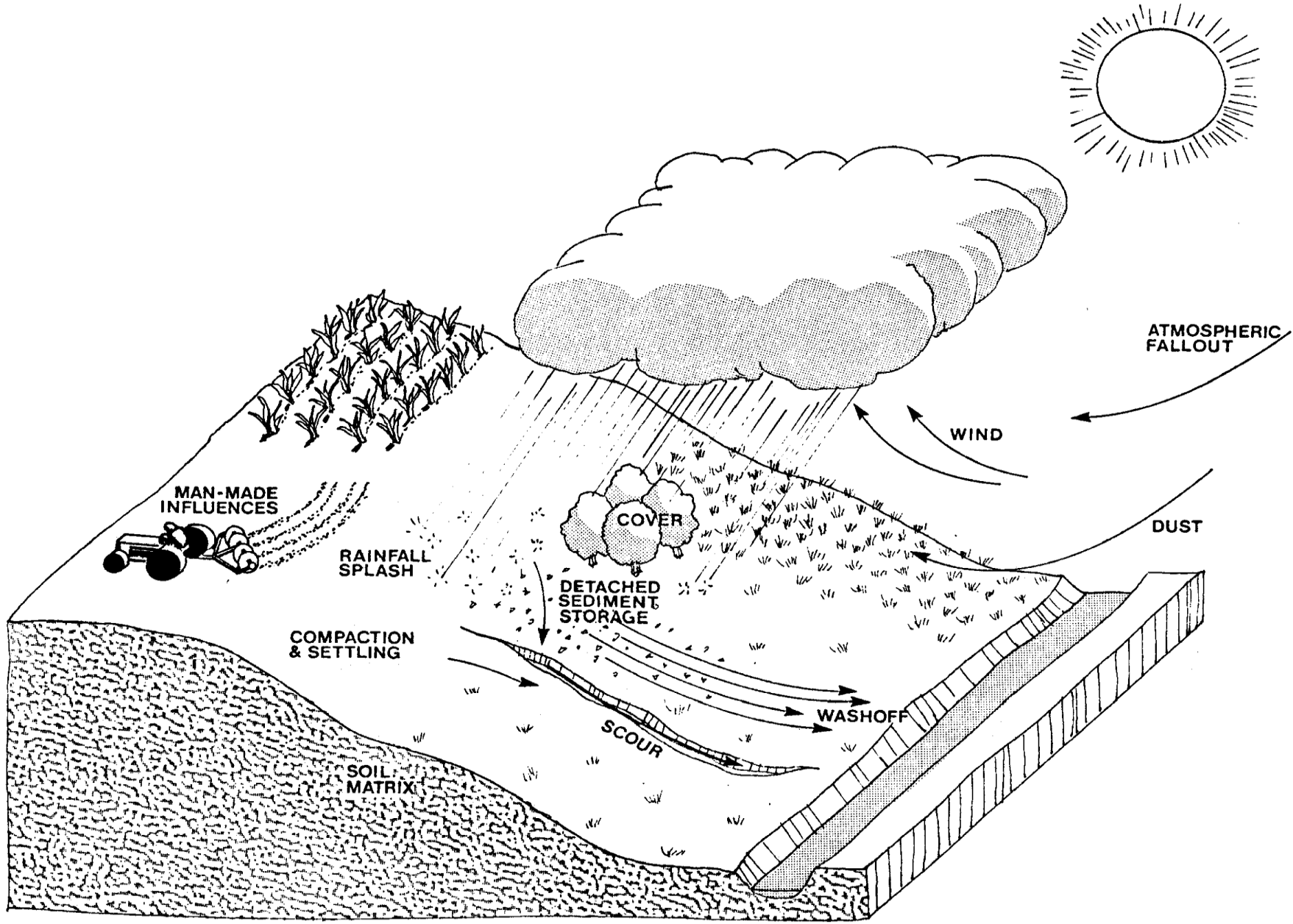
$$-\tfrac{1}{2}\partial_\nu g^a_\mu \partial_\nu g^a_\mu - g_s f^{abc}\partial_\mu g^a_\nu g^b_\mu g^c_\nu - \tfrac{1}{4}g_s^2 f^{abc}f^{ade}g^b_\mu g^c_\nu g^d_\mu g^e_\nu + \tfrac{1}{2}ig_s^2(q^\sigma_i\gamma^\mu q^\sigma_j)g^a_\mu + \bar{G}^a\partial^2 G^a + g_s f^{abc}\partial_\mu \bar{G}^a G^b g^c_\mu - \partial_\nu W^+_\mu \partial_\nu W^-_\mu -$$

$$M^2 W^+_\mu W^-_\mu - \tfrac{1}{2}\partial_\nu Z^0_\mu \partial_\nu Z^0_\mu - \tfrac{1}{2c_w^2}M^2 Z^0_\mu Z^0_\mu - \tfrac{1}{2}\partial_\mu A_\nu \partial_\mu A_\nu - \tfrac{1}{2}\partial_\mu H \partial_\mu H - \tfrac{1}{2}m_h^2 H^2 - \partial_\mu \phi^+ \partial_\mu \phi^- - M^2\phi^+\phi^- - \tfrac{1}{2}\partial_\mu \phi^0 \partial_\mu \phi^0 - \tfrac{1}{2c_w^2}M\phi^0\phi^0 - \beta_h[\tfrac{2M^2}{g^2} + \tfrac{2M}{g}H + \tfrac{1}{2}(H^2+\phi^0\phi^0+2\phi^+\phi^-)] + \tfrac{2M^4}{g^2}\alpha_h - igc_w[\partial_\nu Z^0_\mu(W^+_\mu W^-_\nu - W^+_\nu W^-_\mu) - Z^0_\nu(W^+_\mu \partial_\nu W^-_\mu - W^-_\mu \partial_\nu W^+_\mu) + Z^0_\mu(W^+_\nu \partial_\nu W^-_\mu - W^-_\nu \partial_\nu W^+_\mu)] - igs_w[\partial_\nu A_\mu(W^+_\mu W^-_\nu - W^+_\nu W^-_\mu) - A_\nu(W^+_\mu \partial_\nu W^-_\mu - W^-_\mu \partial_\nu W^+_\mu) + A_\mu(W^+_\nu \partial_\nu W^-_\mu - W^-_\nu \partial_\nu W^+_\mu)] - \tfrac{1}{2}g^2 W^+_\mu W^-_\mu W^+_\nu W^-_\nu + \tfrac{1}{2}g^2 W^+_\mu W^-_\nu W^+_\mu W^-_\nu + g^2 c_w^2(Z^0_\mu W^+_\mu Z^0_\nu W^-_\nu - Z^0_\mu Z^0_\mu W^+_\nu W^-_\nu) + g^2 s_w^2(A_\mu W^+_\mu A_\nu W^-_\nu - A_\mu A_\mu W^+_\nu W^-_\nu) + g^2 s_w c_w[A_\mu Z^0_\nu(W^+_\mu W^-_\nu - W^+_\nu W^-_\mu) - 2A_\mu Z^0_\mu W^+_\nu W^-_\nu] - g\alpha[H^3 + H\phi^0\phi^0 + 2H\phi^+\phi^-] - \tfrac{1}{8}g^2\alpha_h[H^4 + (\phi^0)^4 + 4(\phi^+\phi^-)^2 + 4(\phi^0)^2\phi^+\phi^- + 4H^2\phi^+\phi^- + 2(\phi^0)^2H^2] - gMW^+_\mu W^-_\mu H - \tfrac{1}{2}g\tfrac{M}{c_w^2}Z^0_\mu Z^0_\mu H - \tfrac{1}{2}ig[W^+_\mu(\phi^0\partial_\mu\phi^- - \phi^-\partial_\mu\phi^0) - W^-_\mu(\phi^0\partial_\mu\phi^+ - \phi^+\partial_\mu\phi^0)] + \tfrac{1}{2}g[W^+_\mu(H\partial_\mu\phi^- - \phi^-\partial_\mu H) - W^-_\mu(H\partial_\mu\phi^+ - \phi^+\partial_\mu H)] + \tfrac{1}{2}g\tfrac{1}{c_w}(Z^0_\mu(H\partial_\mu\phi^0 - \phi^0\partial_\mu H) - ig\tfrac{s_w^2}{c_w}MZ^0_\mu(W^+_\mu\phi^- - W^-_\mu\phi^+) + igs_w MA_\mu(W^+_\mu\phi^- - W^-_\mu\phi^+) - ig\tfrac{1-2c_w^2}{2c_w}Z^0_\mu(\phi^+\partial_\mu\phi^- - \phi^-\partial_\mu\phi^+) + igs_w A_\mu(\phi^+\partial_\mu\phi^- - \phi^-\partial_\mu\phi^+) - \tfrac{1}{4}g^2W^+_\mu W^-_\mu[H^2 + (\phi^0)^2 + 2\phi^+\phi^-] - \tfrac{1}{4}g^2\tfrac{1}{c_w^2}Z^0_\mu Z^0_\mu[H^2 + (\phi^0)^2 + 2(2s_w^2-1)^2\phi^+\phi^-] - \tfrac{1}{2}g^2\tfrac{s_w^2}{c_w}Z^0_\mu\phi^0(W^+_\mu\phi^- + W^-_\mu\phi^+) - \tfrac{1}{2}ig^2\tfrac{s_w^2}{c_w}Z^0_\mu H(W^+_\mu\phi^- - W^-_\mu\phi^+) + \tfrac{1}{2}g^2 s_w A_\mu\phi^0(W^+_\mu\phi^- + W^-_\mu\phi^+) + \tfrac{1}{2}ig^2 s_w A_\mu H(W^+_\mu\phi^- - W^-_\mu\phi^+) - g^2\tfrac{s_w}{c_w}(2c_w^2-1)Z^0_\mu A_\mu\phi^+\phi^- - g^1 s_w^2 A_\mu A_\mu\phi^+\phi^-$$

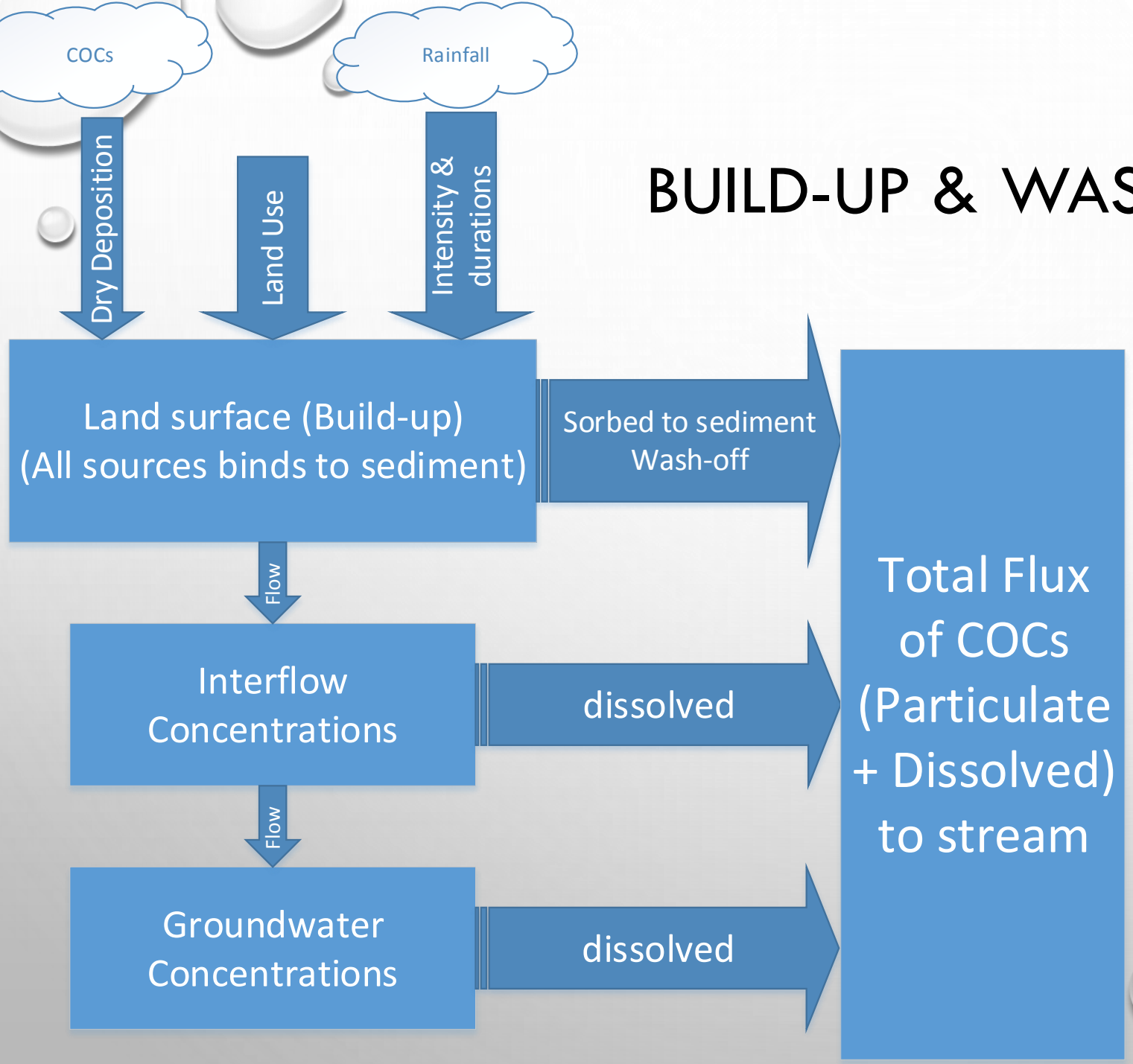
$$-\bar{e}^\lambda(\gamma\partial + m^\lambda_e)e^\lambda - \bar{\nu}^\lambda\gamma\partial\nu^\lambda - \bar{u}^\lambda_j(\gamma\partial + m^\lambda_u)u^\lambda_j - \bar{d}^\lambda_j(\gamma\partial + m^\lambda_d)d^\lambda_j + igs_w A_\mu[-(\bar{e}^\lambda\gamma^\mu e^\lambda) + \tfrac{2}{3}(\bar{u}^\lambda_j\gamma^\mu u^\lambda_j) - \tfrac{1}{3}(\bar{d}^\lambda_j\gamma^\mu d^\lambda_j)] + \tfrac{ig}{4c_w}Z^0_\mu[(\bar{\nu}^\lambda\gamma^\mu(1+\gamma^5)\nu^\lambda) + (\bar{e}^\lambda\gamma^\mu(4s_w^2 - 1 - \gamma^5)e^\lambda) + (\bar{u}^\lambda_j\gamma^\mu(\tfrac{4}{3}s_w^2 - 1 - \gamma^5)u^\lambda_j) + (\bar{d}^\lambda_j\gamma^\mu(1 - \tfrac{8}{3}s_w^2 - \gamma^5)d^\lambda_j)] + \tfrac{ig}{2\sqrt{2}}W^+_\mu[(\bar{\nu}^\lambda\gamma^\mu(1+\gamma^5)e^\lambda) + (\bar{u}^\lambda_j\gamma^\mu(1+\gamma^5)C_{\lambda\kappa}d^\kappa_j)] + \tfrac{ig}{2\sqrt{2}}W^-_\mu[(\bar{e}^\lambda\gamma^\mu(1+\gamma^5)\nu^\lambda) + (\bar{d}^\kappa_j C^\dagger_{\lambda\kappa}\gamma^\mu(1+\gamma^5)u^\lambda_j)] + \tfrac{ig}{2\sqrt{2}}\tfrac{m^\lambda_e}{M}[-\phi^+(\bar{\nu}^\lambda(1-\gamma^5)e^\lambda) + \phi^-(\bar{e}^\lambda(1+\gamma^5)\nu^\lambda)] -$$

$$\tfrac{g}{2}\tfrac{m^\lambda_e}{M}[H(\bar{e}^\lambda e^\lambda) + i\phi^0(\bar{e}^\lambda\gamma^5 e^\lambda)] + \tfrac{ig}{2M\sqrt{2}}\phi^+[-m^\kappa_d(\bar{u}^\lambda_j C_{\lambda\kappa}(1-\gamma^5)d^\kappa_j) + m^\lambda_u(\bar{u}^\lambda_j C_{\lambda\kappa}(1+\gamma^5)d^\kappa_j] + \tfrac{ig}{2M\sqrt{2}}\phi^-[m^\lambda_d(\bar{d}^\lambda_j C^\dagger_{\lambda\kappa}(1+\gamma^5)u^\kappa_j) - m^\kappa_u(\bar{d}^\lambda_j C^\dagger_{\lambda\kappa}(1-\gamma^5)u^\kappa_j] - \tfrac{g}{2}\tfrac{m^\lambda_u}{M}H(\bar{u}^\lambda_j u^\lambda_j) - \tfrac{g}{2}\tfrac{m^\lambda_d}{M}H(\bar{d}^\lambda_j d^\lambda_j) + \tfrac{ig}{2}\tfrac{m^\lambda_u}{M}\phi^0(\bar{u}^\lambda_j\gamma^5 u^\lambda_j) - \tfrac{ig}{2}\tfrac{m^\lambda_d}{M}\phi^0(\bar{d}^\lambda_j\gamma^5 d^\lambda_j) + \bar{X}^+(\partial^2 - M^2)X^+ + \bar{X}^-(\partial^2 - M^2)X^- + \bar{X}^0(\partial^2 - \tfrac{M^2}{c_w^2})X^0 + \bar{Y}\partial^2 Y + igc_w W^+_\mu(\partial_\mu\bar{X}^0X^- - \partial_\mu\bar{X}^+X^0) + igs_w W^+_\mu(\partial_\mu\bar{Y}X^- - \partial_\mu\bar{X}^+Y) + igc_w W^-_\mu(\partial_\mu\bar{X}^-X^0 - \partial_\mu\bar{X}^0X^+) + igs_w W^-_\mu(\partial_\mu\bar{X}^-Y - \partial_\mu\bar{Y}X^+) + igc_w Z^0_\mu(\partial_\mu\bar{X}^+X^+ - \partial_\mu\bar{X}^-X^-) + igs_w A_\mu(\partial_\mu\bar{X}^+X^+ - \partial_\mu\bar{X}^-X^-) - \tfrac{1}{2}gM[\bar{X}^+X^+H + \bar{X}^-X^-H + \tfrac{1}{c_w^2}\bar{X}^0X^0H] + \tfrac{1-2c_w^2}{2c_w}igM[\bar{X}^+X^0\phi^+ - \bar{X}^-X^0\phi^-] + \tfrac{1}{2c_w}igM[\bar{X}^0X^-\phi^+ - \bar{X}^0X^+\phi^-] + igMs_w[\bar{X}^0X^-\phi^+ - \bar{X}^0X^+\phi^-] + \tfrac{1}{2}igM[\bar{X}^+X^+\phi^0 - \bar{X}^-X^-\phi^0]$$

BUILD-UP & WASH-OFF



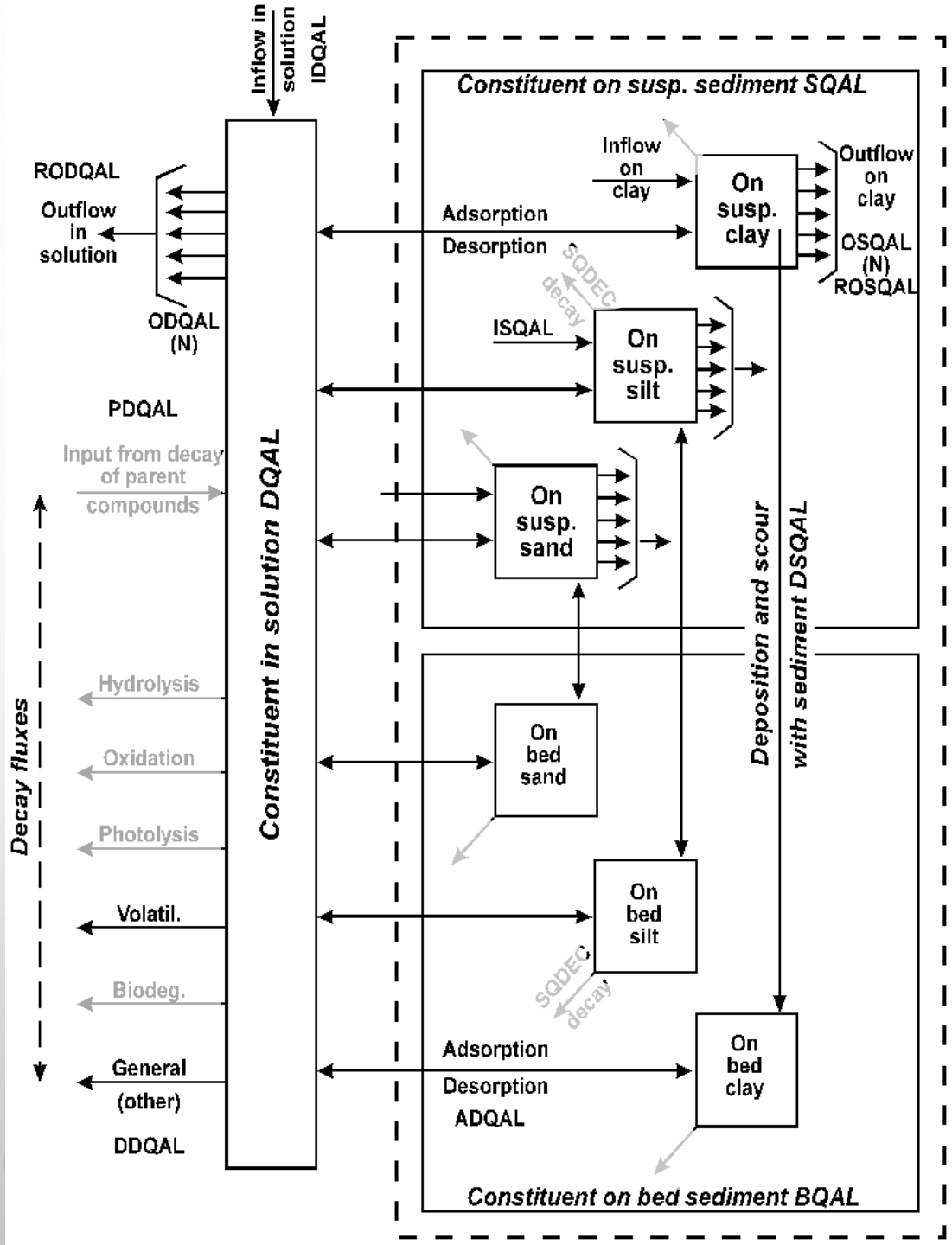
BUILD-UP & WASH-OFF



- Defined by:
  - Wash-off Potency factor of detach sediment
    - Rainfall impacting the land surface detaches sediment building up on the surface
    - The detached sediment has a certain potency (i.e. concentration mass/mass)
  - Subsurface fluxes dissolved only

FATE & TRANSPORT

- Sorped to three grain sizes
  - Sand (non-cohesive)
  - Silt (cohesive)
  - Clay (cohesive)
  - Suspended in water column
  - Deposited in stream, river, lake, wetland
    - Resuspended into the water column
  - Conservation of mass
  - Weighted average partitioning coefficient
  - Adsorption/desorption rate coefficients
    - based on average* organic carbon in TSS and bed sediments
- Dissolved
  - Conservation of mass, or
  - Volatilization (loss), and/or
  - First order decay (loss)



CALIBRATION APPROACH

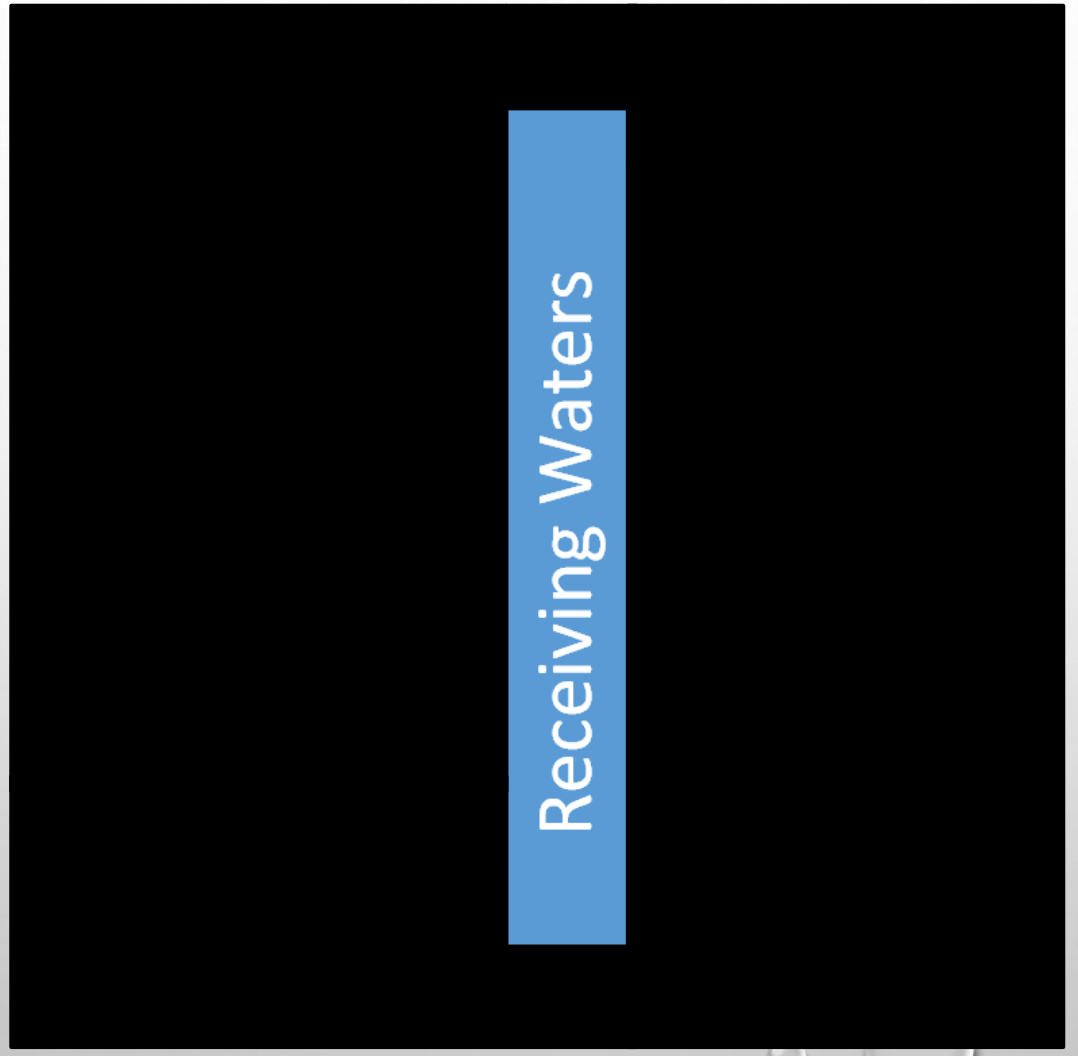
(1) Use *simple/empirical*

- Boundaries
- Atmospheric
- Point Sources
- Groundwater

(2) Use Build-up/Wash-off

- Land Use specific
- Age of structure
- Discriminate known hotspots

(3) Fate & Transport



- Boundaries
  - Regression models
  - Constant concentration
- Atmospheric
  - Constant concentration
  - Three zones
- Point Sources
  - WTD CSO discharge modeling
  - SPU/PLM modeling (possible elements)
  - Leachate rates from previous studies
- Groundwater
  - USGS concentrations
  - NOT land use specific

ANSWERING THE QUESTIONS

What is the rank of pollutant contribution among point sources and non-point sources?

Rank among point sources is dependent on measured data at the source. How the contribution of any particular source ranks in contribution in the receiving water will be based on the fate/transport of the pollutant from the source to the receiving water body. If there are lakes/wetlands/etc. features that may influence transport downstream, can influence the rank of a known point source. Non-point sources can be evaluated down to a catchment scale for contributions of a pollutant. The relative magnitude of non-point source loadings from a land use are specified by the user during the calibration process. The differences will present themselves based on the pathway taken to the receiving water body, but are generally self-described during the calibration process.

What is the contribution of contaminants from groundwater?

Concentrations in groundwater are user specified in HSPF. They can vary by land use and by month. The groundwater pollutant contribution will be based on findings from the USGS study. Hopefully, when using observed data in the receiving waterbodies to calibrate too, the defined concentrations from the USGS study will not need much adjustment– after all, the groundwater loads is a calibration knob to turn in a black box.

What is the atmospheric contribution of a contaminant to the receiving waterbodies?

Atmospheric inputs are specifically defined by the user and assumed to occur continuously at varying rates regardless of rainfall and can be defined for any time scale (e.g., hourly, weekly, monthly, etc.). Background concentrations generated from atmospheric loadings will be compared to point sources and land use activity loadings defined after the calibration process.

HSPF MODEL INPUTS

- Rainfall
- Evapotranspiration
- Atmospheric loadings
- Upstream boundary
  - flow rates
  - mass loadings
- Groundwater
  - Concentrations
- Point Sources
  - CSOs
  - Distributed
    - from landscape
    - generated Instream
- Other modeling efforts
- Channel hydraulics
  - Sources & Sinks
    - Lakes, wetlands,
- Landscape
  - Land use
  - Land cover
  - Surficial geology
  - Slope
  - Development
    - Age
    - Location

QUESTIONS?

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