# Crediting Stream Restoration for Phosphorus Reductions

February 4, 2020

VERMONT DEPARTMENT OF ENVIRONMENTAL CONSERVATION
WATERSHED MANAGEMENT DIVISION
RIVERS PROGRAM

VERMONT DEPARTMENT OF ENVIRONMENTAL CONSERVATION
WATERSHED MANAGEMENT DIVISION
STORMWATER PROGRAM

# TMDL review

**Wasteload Allocation**

- Wastewater discharge
- Stormwater from developed lands
- Treated CSOs (Burlington Main facility)
- Agriculture production areas (farmsteads)

**Load Allocation**

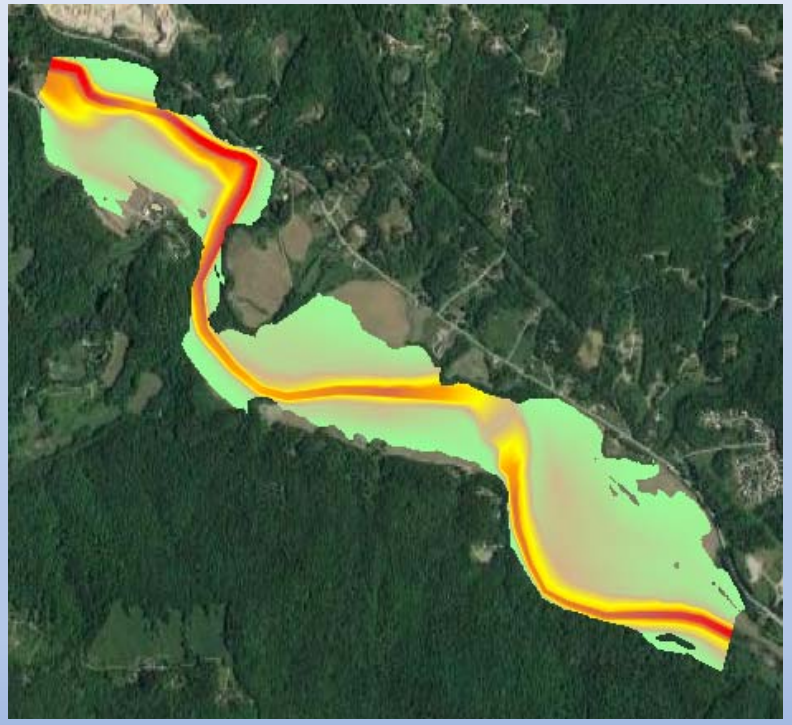
- Forested land
- Agricultural land
- Stream channel instability/erosion

Phosphorus load from **BOTH** need to be reduced to meet the TMDL

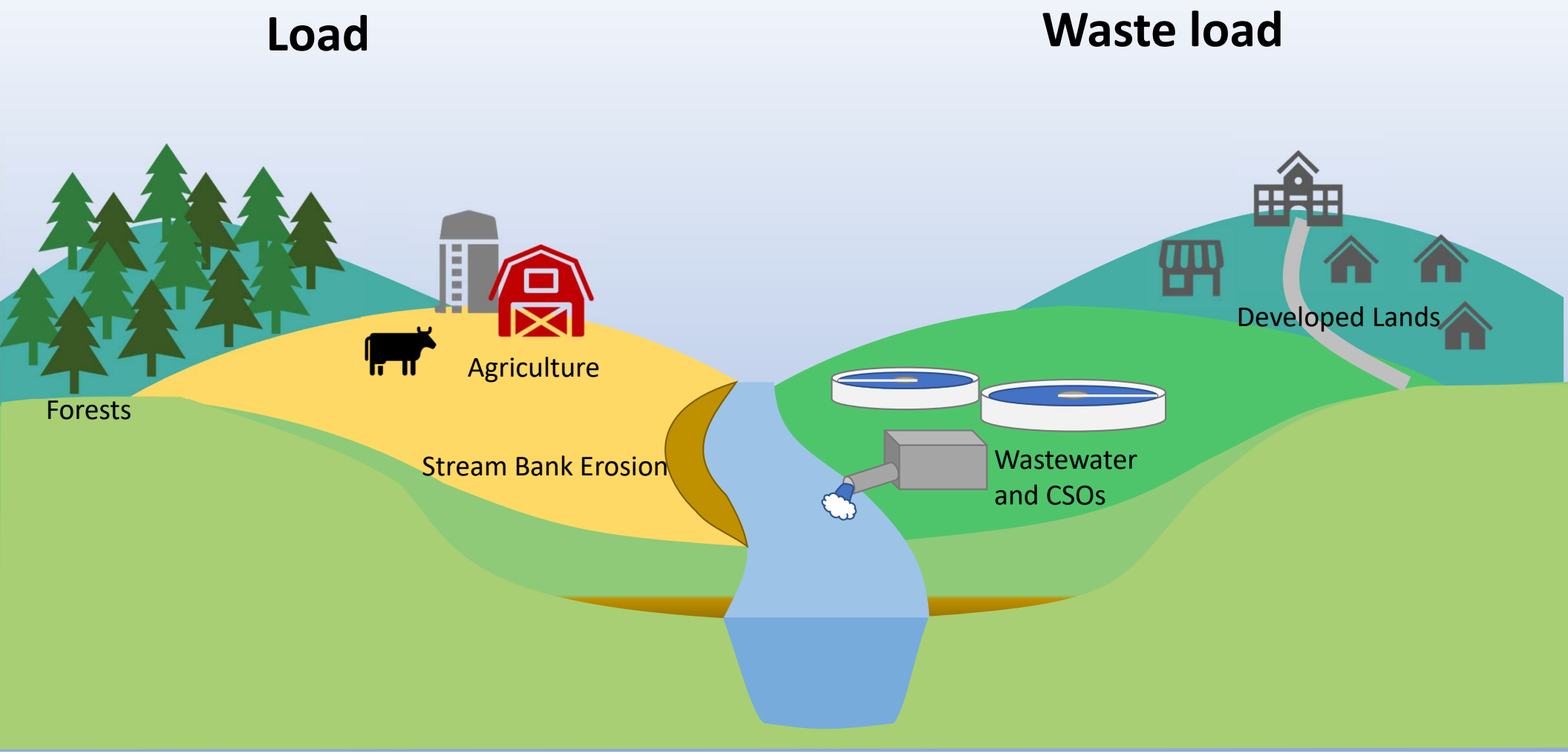
# Crediting Stream Projects

- ~~Stream Bank Erosion~~ → Reductions included in the Load Allocation
- Floodplain Reconnection:

  Increase deposition and adsorption of phosphorus by increasing floodplain storage.

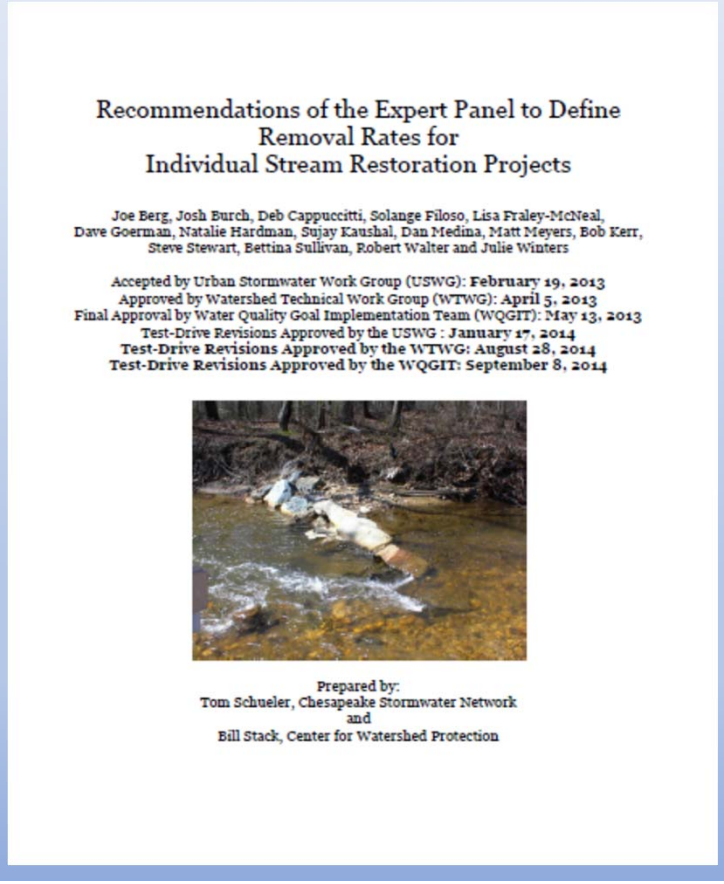


Stream power lbs/ft/s


Load
Waste load
Forests
Agriculture
Stream Bank Erosion
Developed Lands
Wastewater
and CSOs

# Proposed Method for Crediting Floodplain Reconnection

## Expert panel formed to define removal rates for stream restoration



Recommendations of the Expert Panel to Define
Removal Rates for
Individual Stream Restoration Projects

Joe Berg, Josh Burch, Deb Cappuccitti, Solange Filoso, Lisa Fraley-McNeal, Dave Goerman, Natalie Hardman, Sujay Kaushal, Dan Medina, Matt Meyers, Bob Kerr, Steve Stewart, Bettina Sullivan, Robert Walter and Julie Winters

Accepted by Urban Stormwater Work Group (USWG): **February 19, 2013**
Approved by Watershed Technical Work Group (WTWG): **April 5, 2013**
Final Approval by Water Quality Goal Implementation Team (WQGIT): **May 13, 2013**
Test-Drive Revisions Approved by the USWG : **January 17, 2014**
**Test-Drive Revisions Approved by the WTWG: August 28, 2014**
**Test-Drive Revisions Approved by the WQGIT: September 8, 2014**



Prepared by:
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and
Bill Stack, Center for Watershed Protection

# Credit for floodplain reconnection volume

- Calculate volume of runoff that accesses the floodplain on an annual basis before and after reconnection
- Estimate load of TP in reconnected volume by multiplying total pollutant load times the ratio of floodplain runoff to total runoff
- Compute percent of floodplain load that is removed by deposition

$$TP_{removed} = (Q_{AfterReconnect} - Q_{BeforeRonnect}) \times TP_{export} \times TP_{efficiency}$$

$TP_{removed}$ = Phosphorus removed annually due to floodplain reconnection (kg/yr)

$$Q_{AfterReconnect} = \frac{Annual\ peak\ flow\ volume\ that\ accesses\ floodplain\ \boldsymbol{after}\ reconnection}{Total\ annual\ peak\ flow\ volume}$$ (dimensionless)

$$Q_{BeforeReconnect} = \frac{Annual\ peak\ flow\ volume\ that\ accesses floodplain\ \boldsymbol{before}\ reconnection}{Total\ annual\ peak\ flow\ volume}$$ (dimensionless)

$TP_{export}$ = Annual TP export from one or more sources (kg/yr)

$TP_{efficiency}$ = TP removal efficiency for floodplain (dimensionless)


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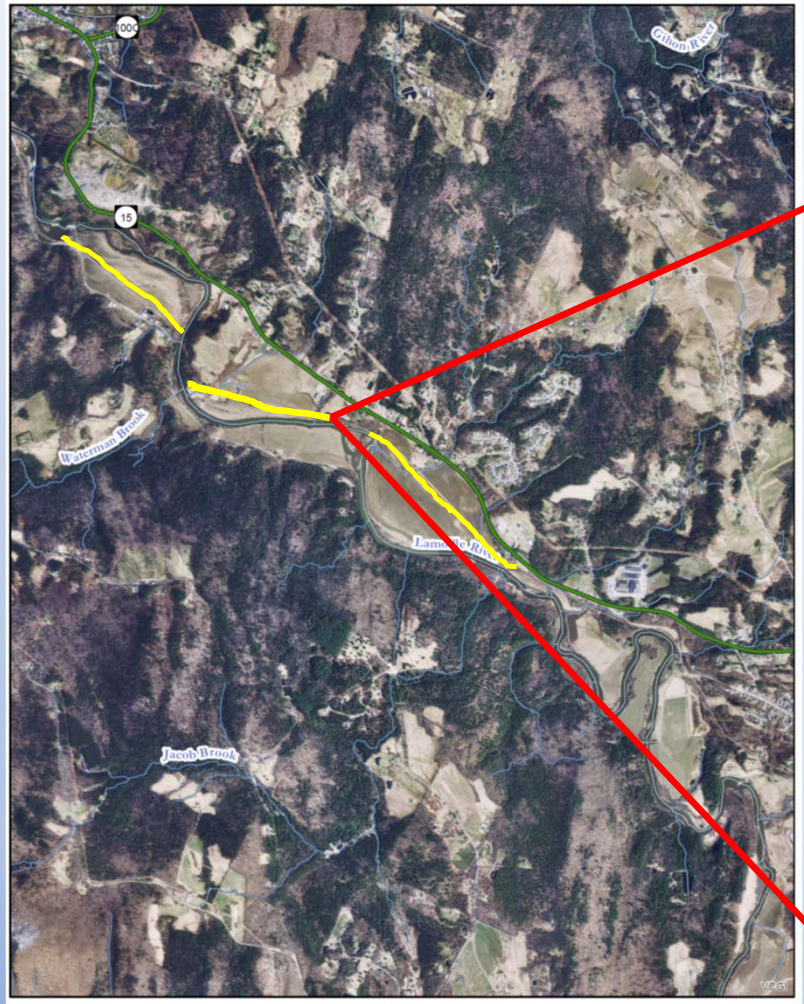
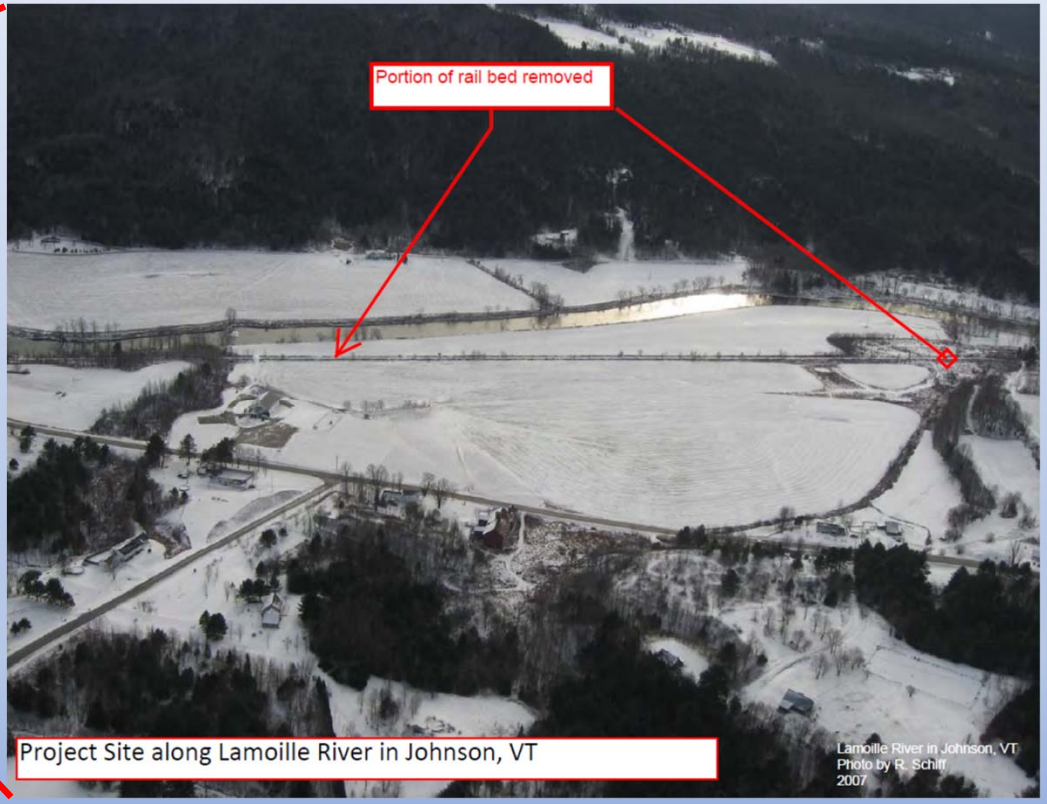
# Required data and sources

| Inputs | Data source |
| --- | --- |
| Flow data | Streamstats |
| Topographic data | LiDAR |
| Estimate of surface roughness | Professional judgement/literature |
| Land cover | Existing GIS layers |
| Export Coefficients | TMDL Modeling |
| Floodplain efficiency | Default Chesapeake Bay value/best available data |

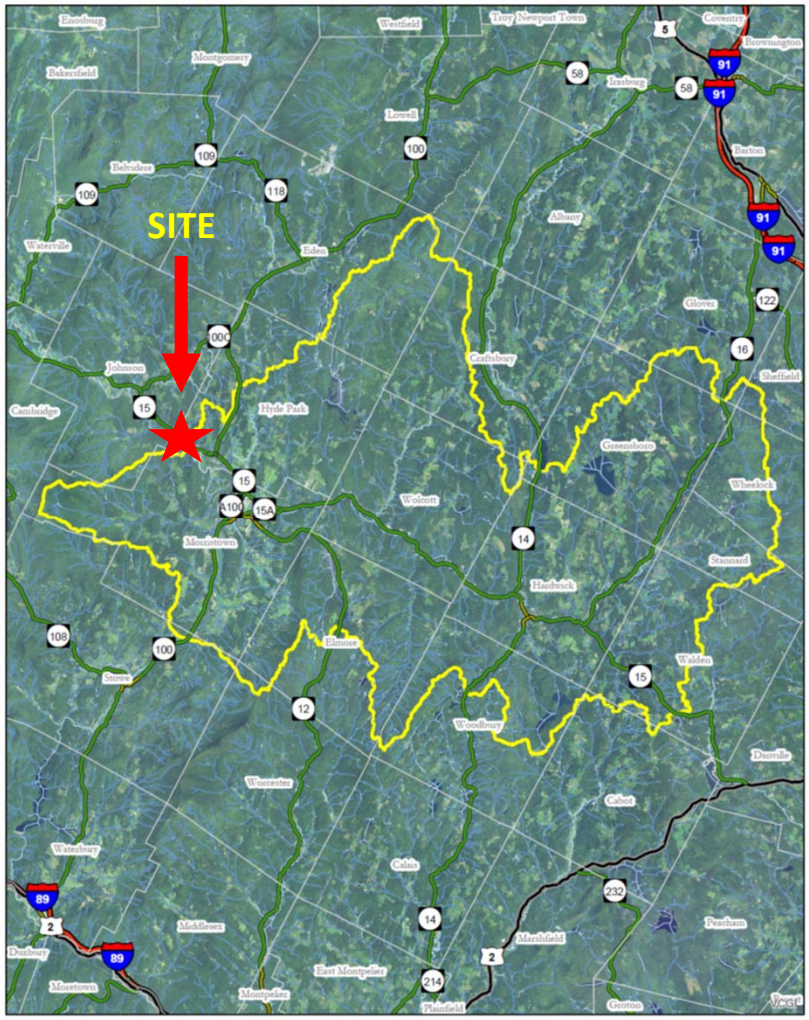
# Site Location: Lamoille River, Johnson VT




~70 Acres



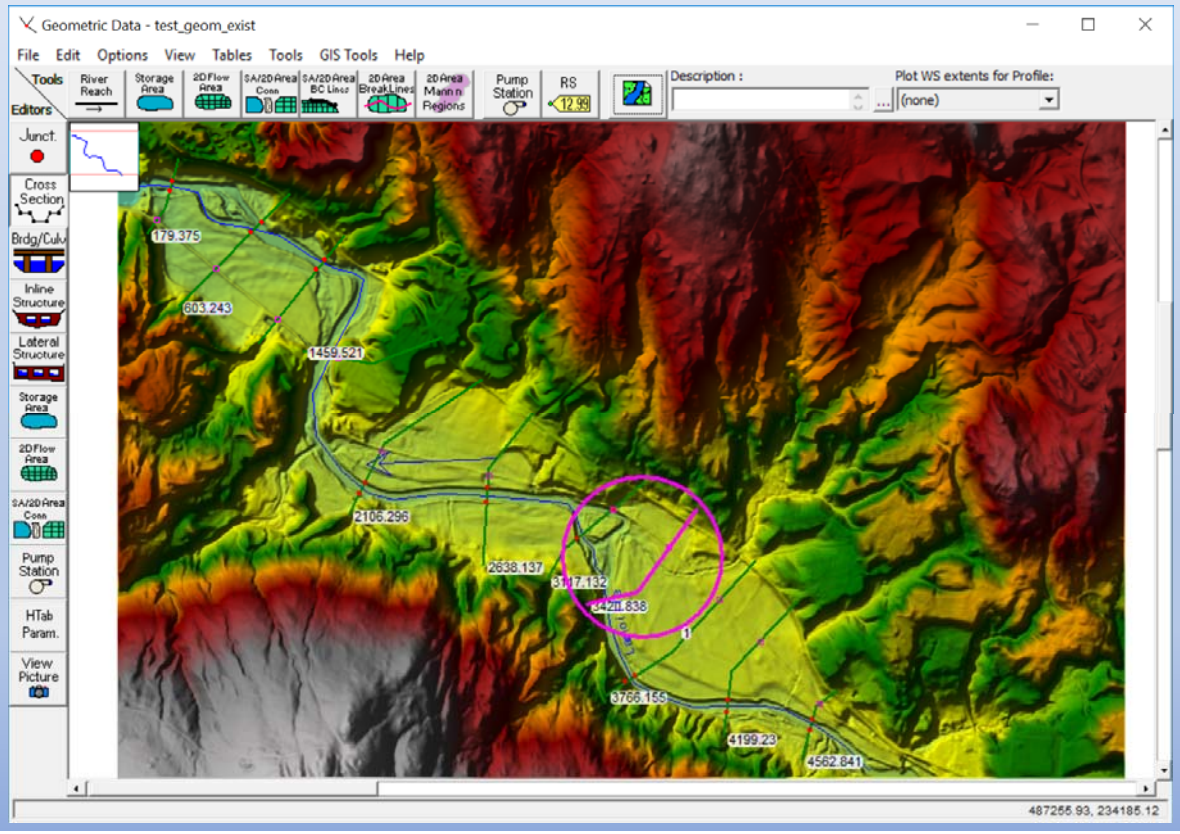
# Contributing Watershed

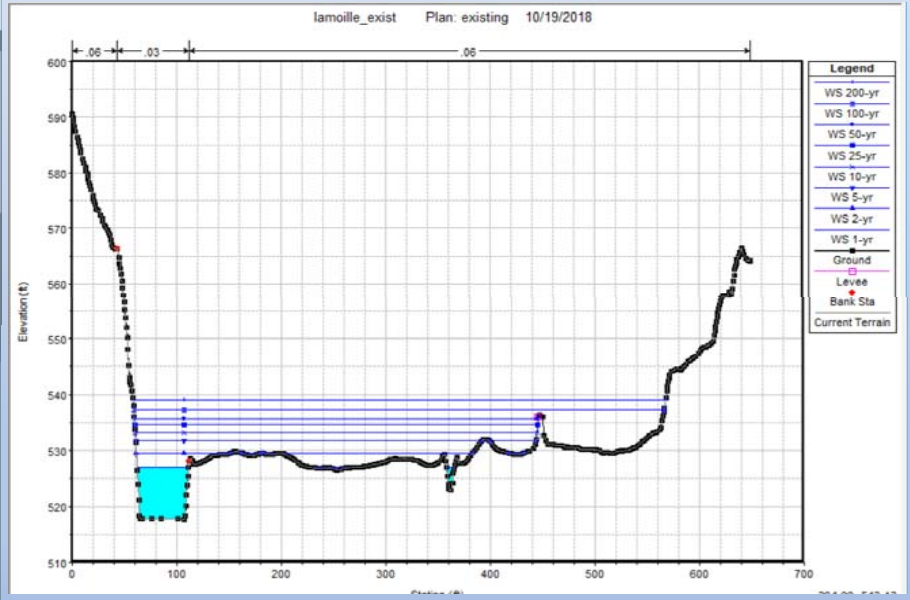



- 190,474 Acres (298 $mi^2$)

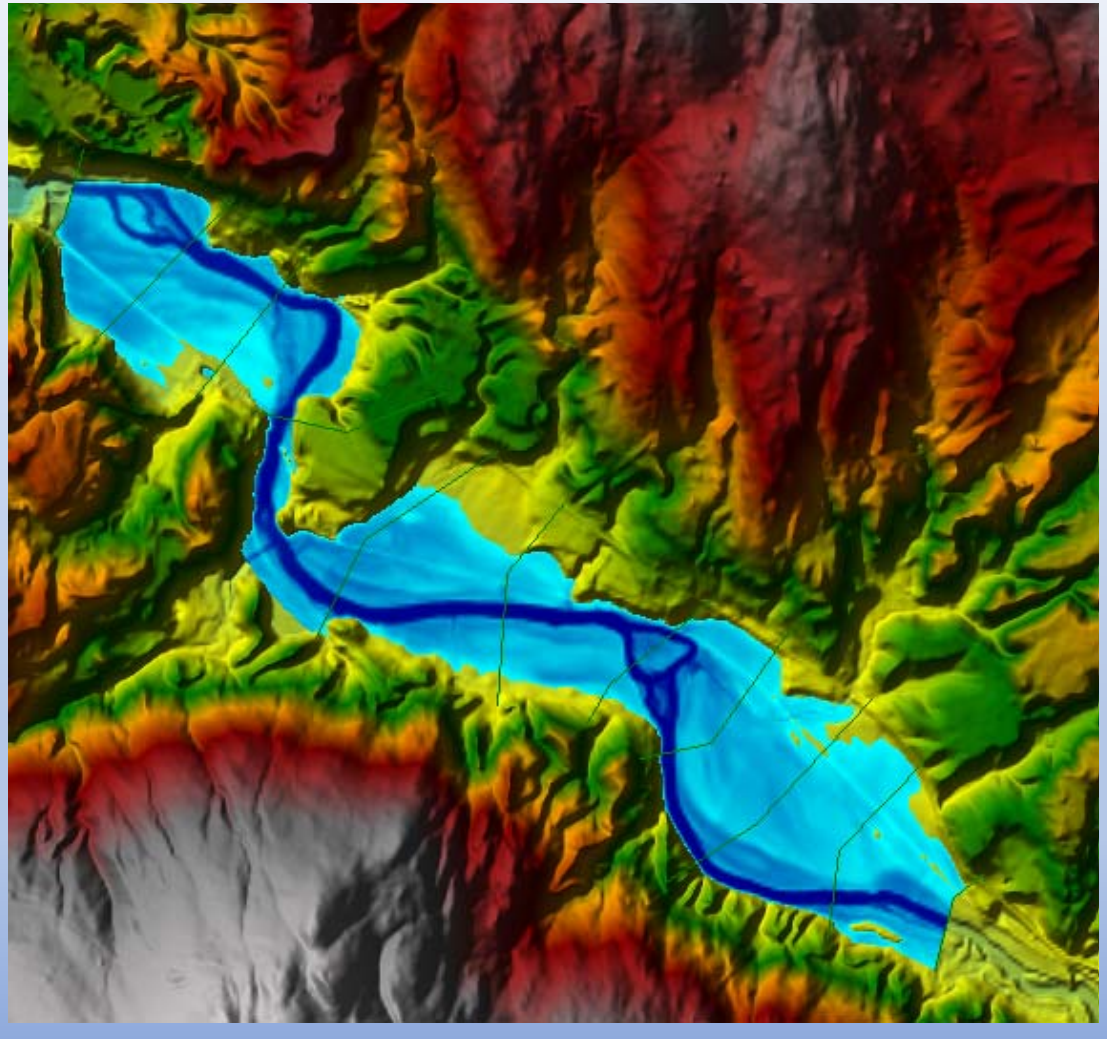
# Modeling

Army Corps of Engineers Hydrologic Engineering Center's (HEC) River Analysis System (RAS)



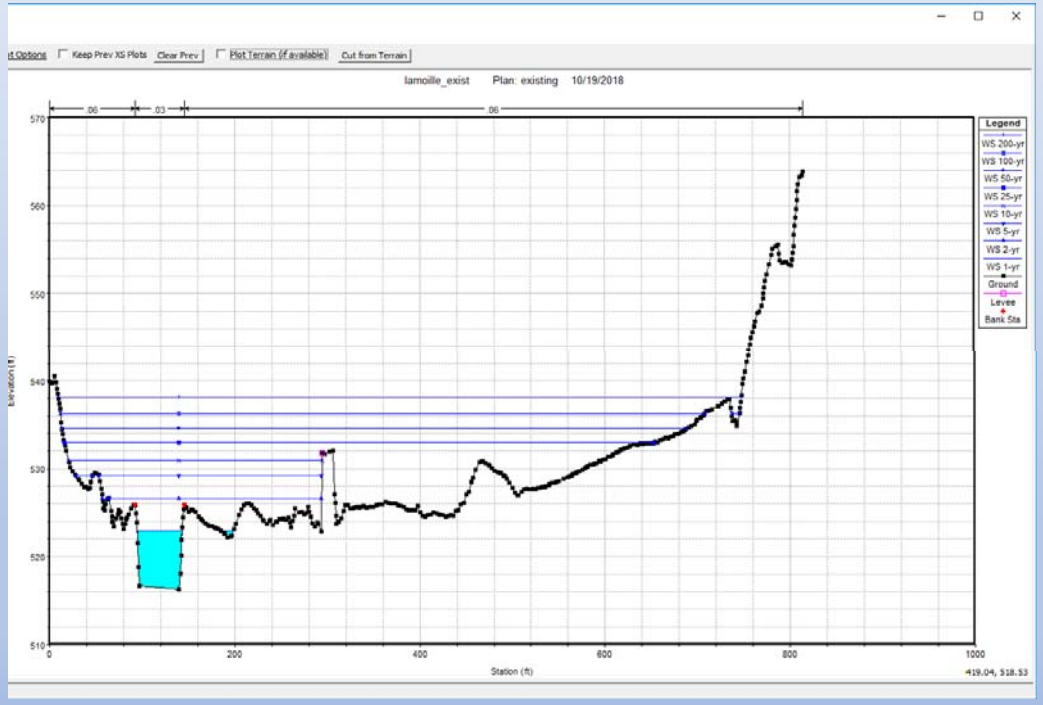
# 10-Year Flood - Proposed



# Hydrologic Data: Lamoille River

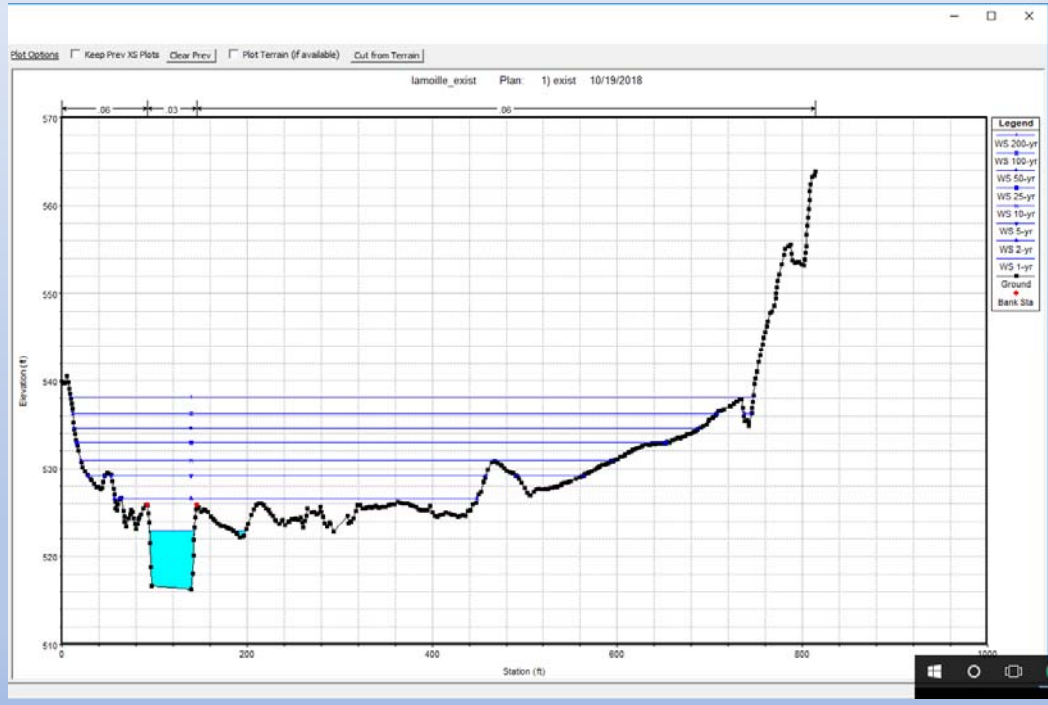
## Existing Condition: Berm

~20-year storm accesses floodplain




## Proposed Conditions: Berm Removed

2-year storm accesses floodplain



# Calculations

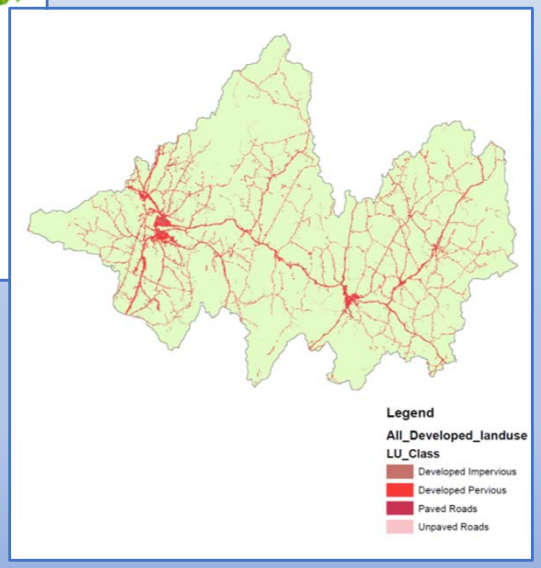
| Credit Calculation | | | | Existing Conditions | | | | Proposed Conditions | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Return Period | Discharge (cfs) | Probability of Event | Integration of Discharge (cfs) | Total Runoff (Ac-ft) | Floodplain Runoff (Ac-ft) | Integration of Total Runoff (Ac-ft) | Integration of Floodplain Runoff (Ac-ft) | Total Runoff (Ac-ft) | Floodplain Runoff (Ac-ft) | Integration of Total Runoff (Ac-ft) | Integration of Floodplain Runoff (Ac-ft) |
| 1 | 480 | 1 | | 47 | 3.64 | | | 47.29 | 3.92 | | |
| 2 | 1,240 | 0.5 | 430.00 | 90.45 | 27.68 | 34.36 | 7.83 | 94.63 | 32.34 | 35.48 | 9.07 |
| 5 | 1,860 | 0.2 | 465.00 | 137.94 | 61.49 | 34.26 | 13.38 | 153.16 | 77.85 | 37.17 | 16.53 |
| 10 | 2,340 | 0.1 | 210.00 | 172.62 | 87.32 | 15.53 | 7.44 | 197.08 | 113.56 | 17.51 | 9.57 |
| 25 | 3,050 | 0.04 | 161.70 | 241.66 | 147.07 | 12.43 | 7.03 | 256.89 | 163.69 | 13.62 | 8.32 |
| 50 | 3,630 | 0.02 | 66.80 | 298.92 | 197.25 | 5.41 | 3.44 | 306.67 | 205.88 | 5.64 | 3.70 |
| 100 | 4,260 | 0.01 | 39.45 | 361.62 | 251.94 | 3.30 | 2.25 | 363.12 | 253.82 | 3.35 | 2.30 |
| 200 | 5,910 | 0.005 | 25.43 | 426.76 | 306.51 | 1.97 | 1.40 | 428.52 | 308.78 | 1.98 | 1.41 |
| | | | 1,398 | | | 107.26 | 42.76 | | | 114.74 | 50.88 |

| | |
|---|---|
| Existing conditions: % of annual flood flow that accesses the floodplain | 39.87% |
| Proposed conditions: % of annual flood flow that accesses the floodplain | 44.34% |
| Percent increase due to reconnection | 4.47% |
| Floodplain Efficiency Data Source: Chesapeake Bay Protocol | 30.00% |
| Reconnected floodplain efficiency | 1.34% |

# Contributing Load (kg/yr)

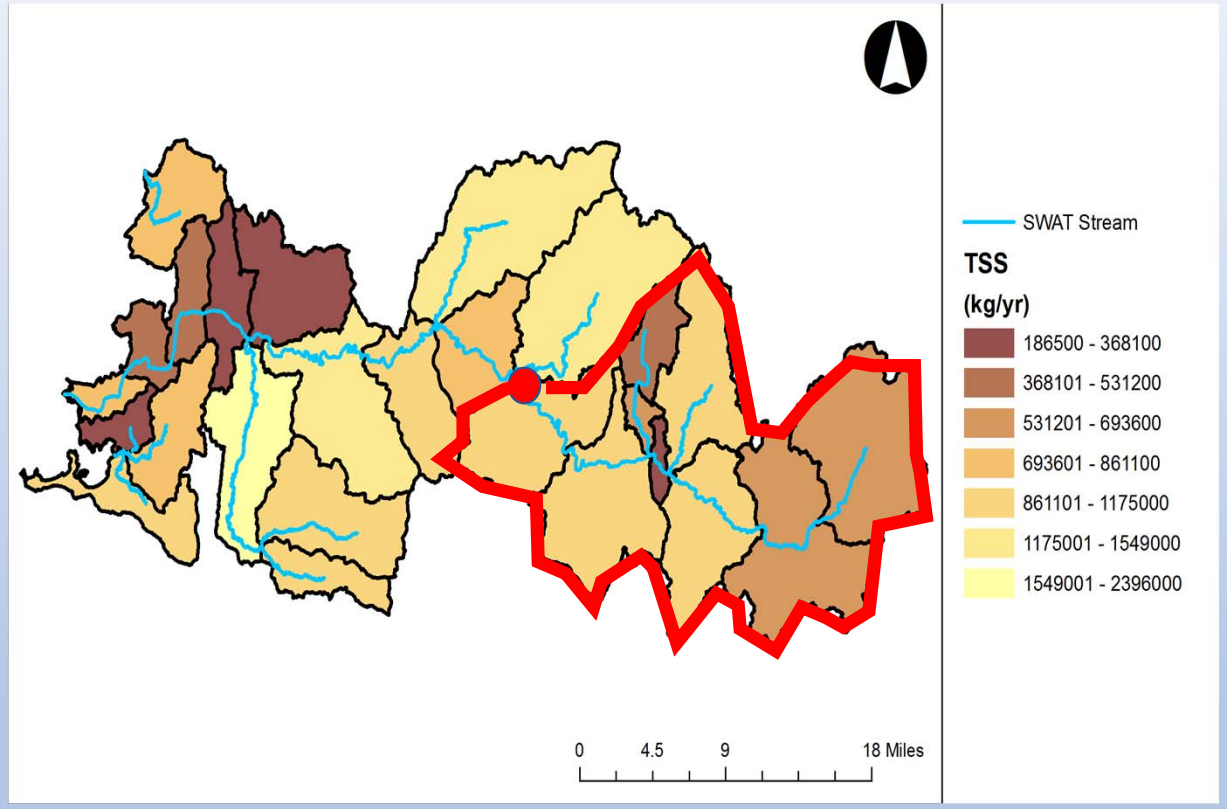
**All Land Uses (SWAT Inputs)**

**Developed Lands**




- Contributing areas from GIS
- Multiply by loading rates from TMDL to get load

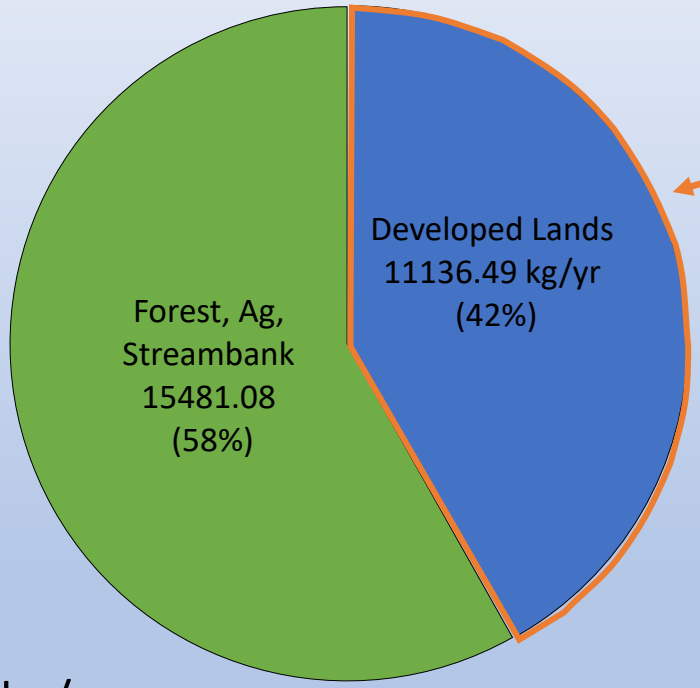
# Streambank Load (kg/yr)




$$\frac{Stream\ km\ upstream\ of\ site\ location}{Total\ stream\ km} * \text{Total Stream Bank Loading} = \text{Stream Bank Load to Project}$$

# TP Loading (kg/yr)

**Loading sources upstream of floodplain reconnection**




Reductions to the developed load is creditable to the MS4

Total Load: 26,617.60 kg/yr

# Results (Total Project)

$$(Q_{AfterReconnect} - Q_{BeforeRonnect}) \times TP_{export} \times TP_{efficiency} = TP_{removed}$$

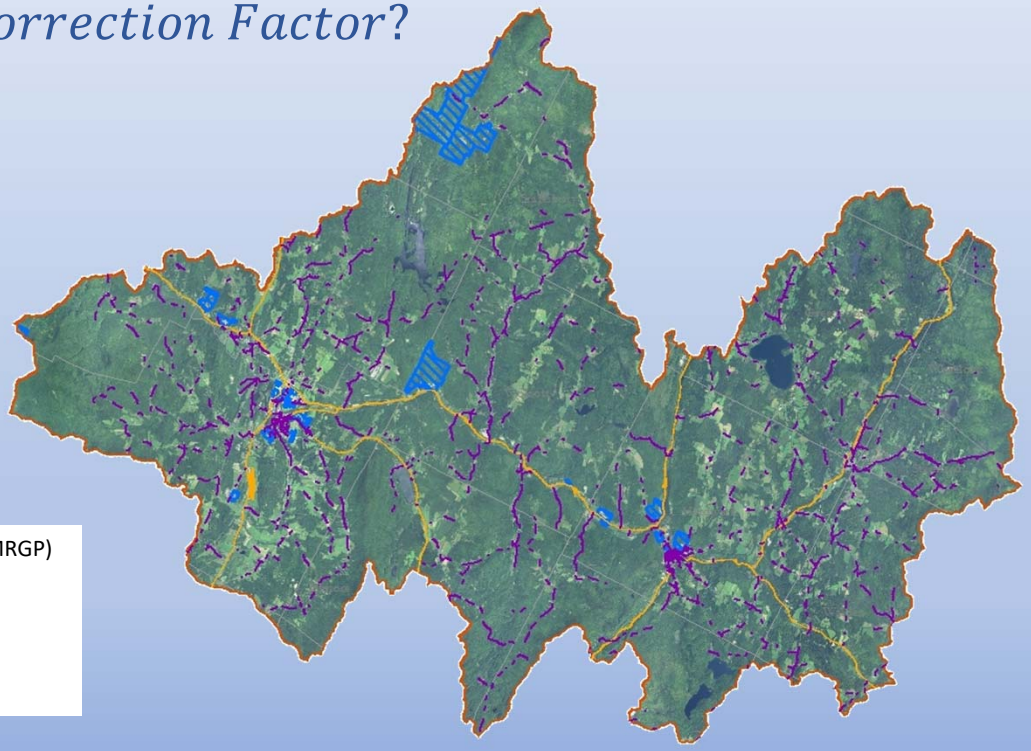
4.47% x 26,617 (kg/yr) x 30% = 357 kg/yr (total removed)

- % Increased annual flood volume: 4.47%
- Assumed Floodplain Efficiency: 30%
- Reconnected floodplain efficiency: 1.34%
- Total TP loading from upstream: 26,617 kgs/yr

# Results (Developed Lands)

$$Total\ P\ Reduction \times \frac{Developed\ Lands\ Load}{Total\ P\ Load} = Developed\ Lands\ Credit$$

$$357\ kg/yr \times 41.9\% = 149.5\ kg/yr \quad \times Correction\ Factor?$$



# Cost Comparison to Stormwater BMPs

Average Stormwater Treatment: $26,000-$95,000 per kg/yr TP

Average Road Erosion Remediation: $14,000 - $67,000 per kg/yr TP

*source: 2019 Vermont Clean Water Performance Report, 25$^{th}$ – 75$^{th}$ Percentile*

Average floodplain reconnection: $321/kg/yr TP

*source: 2007/2008 Lamoille Valley floodplain reconnections*

# Summary

- For a proposed floodplain reconnection site, the methodology quantifies how much of the annual TP load from upstream sources would be captured
    - The reductions can be attributed to specific sources
- Costs/benefits suggest relatively high return on investment (ROI)
    - Not just nutrient retention, also habitat, flood resilience
    - Additional tracking of BMP costs would help support comparisons
- Applicability to Wetlands?