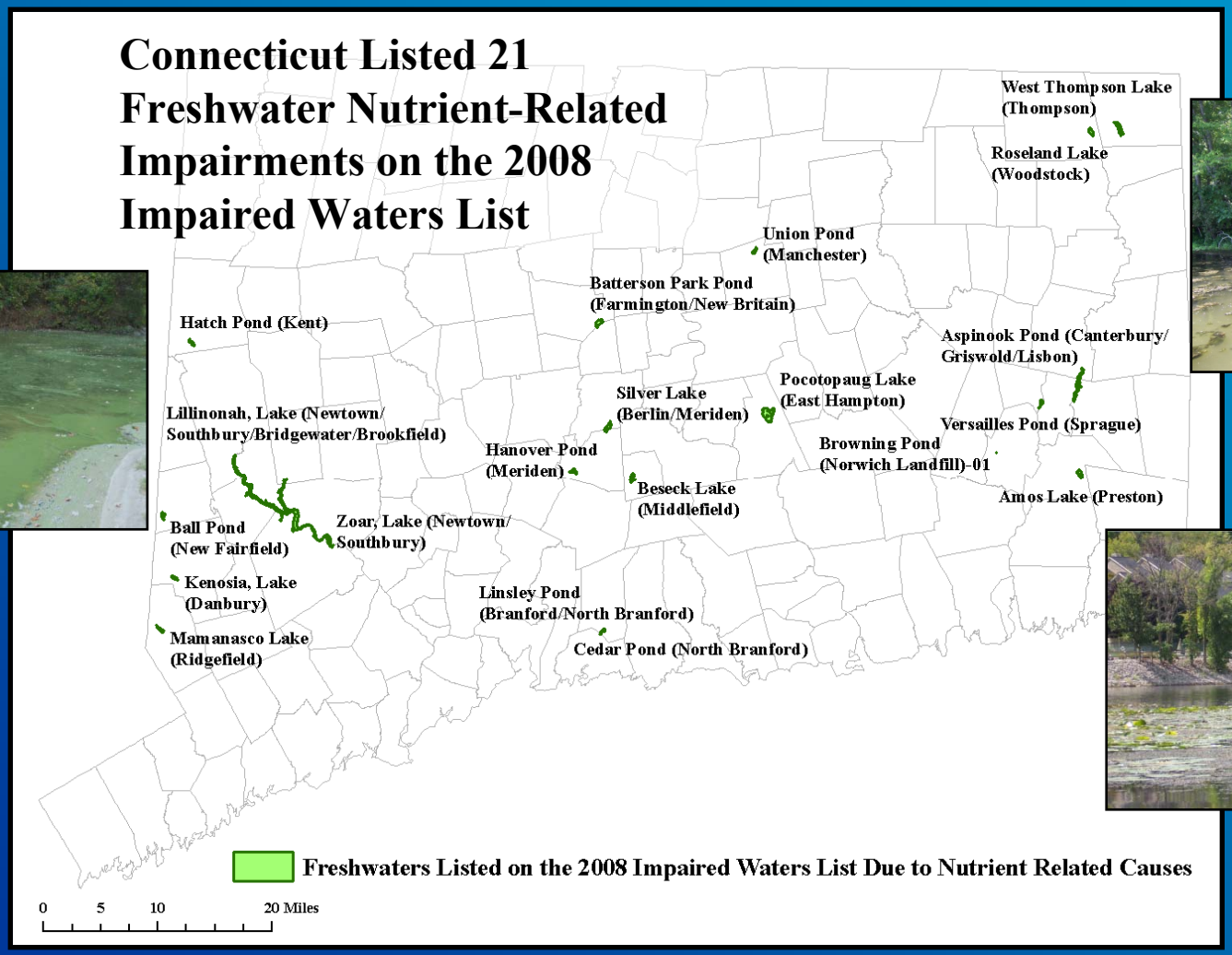
# CT METHODOLOGY FOR FRESHWATER NUTRIENT CRITERIA DEVELOPMENT

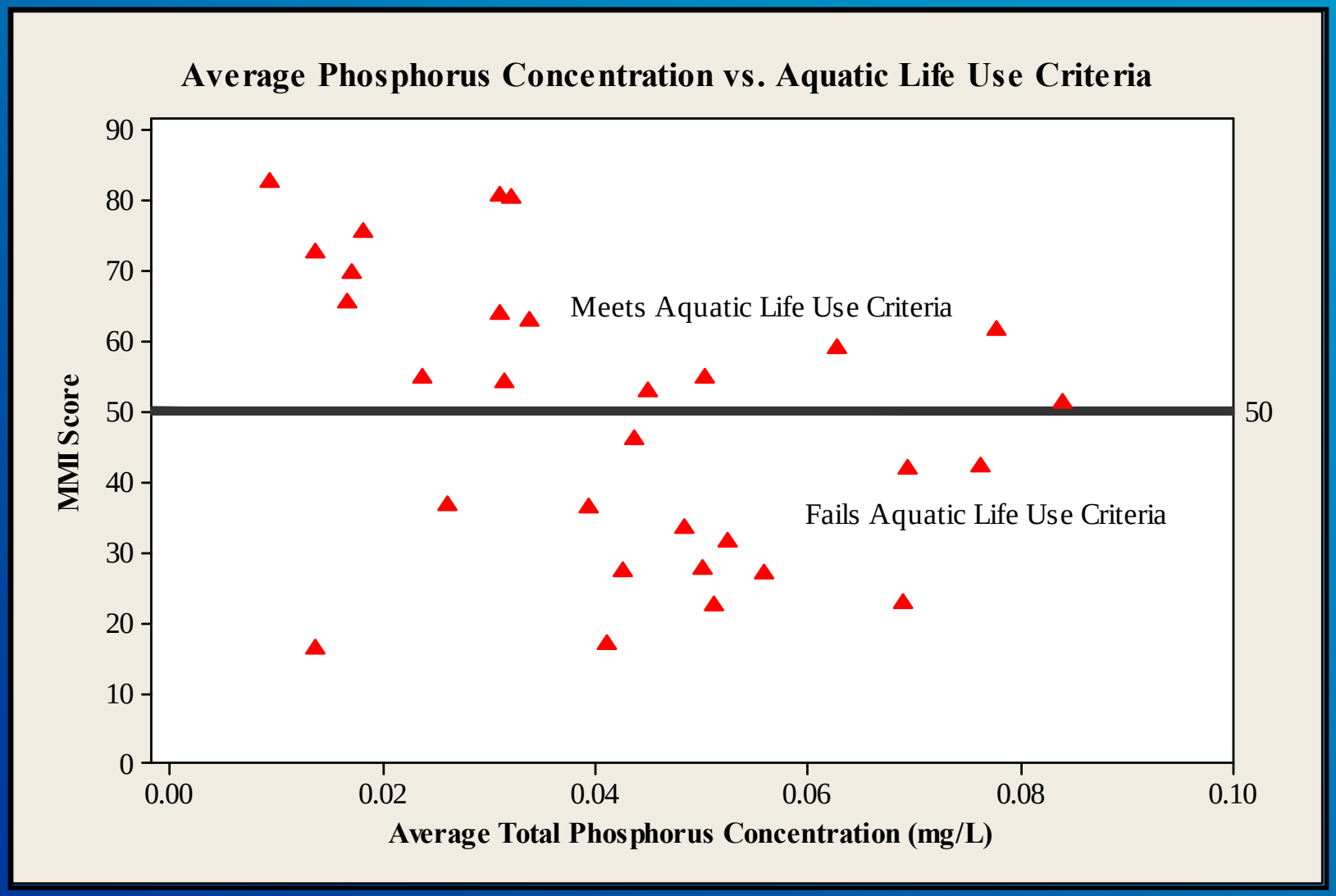

# NUTRIENT IMPAIRMENTS

**EPA cites nutrients (nitrogen and phosphorus) as one of the leading causes of water quality impairment in our Nation's rivers, lakes and estuaries and has required States to develop State-wide numeric criteria**

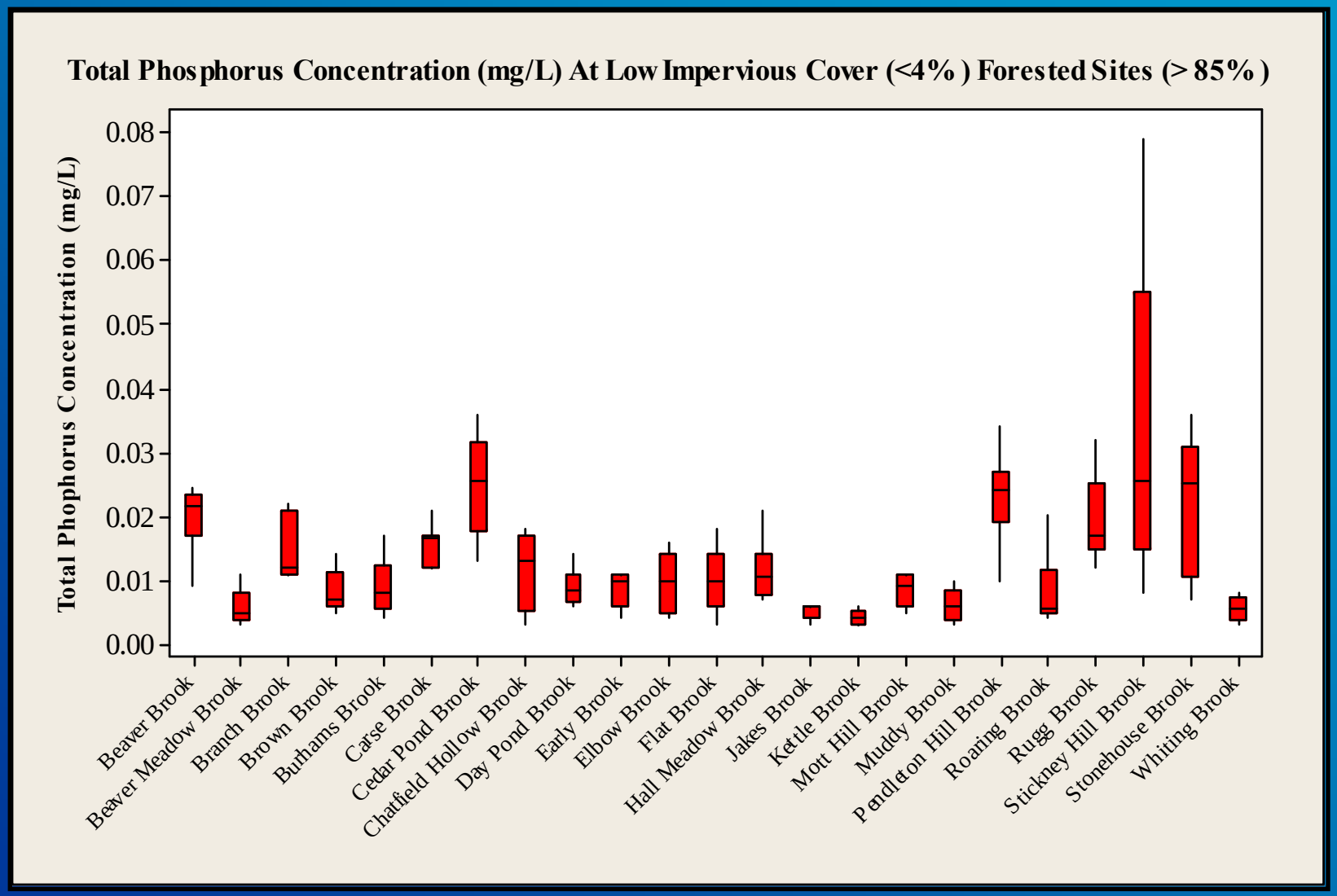




# Phosphorus is NOT a Threshold Pollutant



# Natural Variability



# ISSUES

## Impaired Uses

Is this enough green?

Is this too green?

Does green impair recreational uses?

# CURRENT WATER QUALITY STANDARDS

## Numeric Interpretation of Current Narrative Water Quality Standard

***8. Water Quality Criteria do not apply to certain conditions brought about by natural causes. Natural hydrologic and geologic conditions may cause excursions from established criteria. The meaning of the word 'natural' is not limited to only those conditions which would exist in water draining from pristine land. Conditions which exist in the surface water, in part due to normal uses of the land, may be considered natural, provided best management practices are used. It shall not be considered normal use of the land if excursions from established Criteria adversely impact an existing or designated use.***

***19. Best Management Practices, discharge limitations or other reasonable controls on point and non-point sources of phosphorus and nitrogen, including sources of atmospheric deposition, which contribute to the impairment of any surface water shall be required by the Commissioner on a case-by-case basis as necessary to ensure maintenance and attainment of existing and designated uses.***

**DEFINITIONS: Best Management Practices**

**means those practices which reduce pollution and which have been determined by the Commissioner to be acceptable based on, but not limited to, technical, economic, and institutional feasibility.**

# OBJECTIVES

**Limit 'excess' nutrient export to waterbodies**

**Work toward "reference conditions or the best attainable, most natural (trophic) conditions of the resource base at this time." (EPA, 2000)**

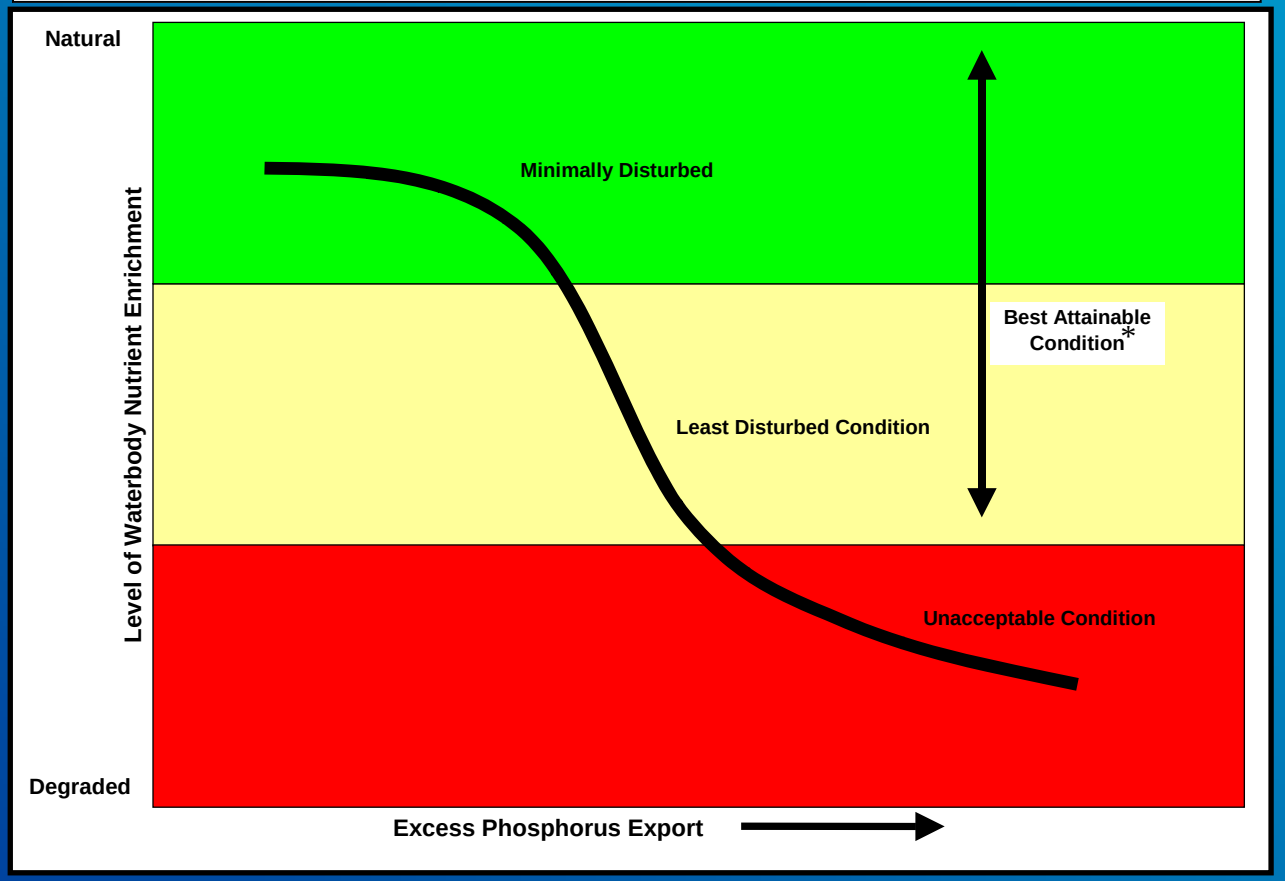
**Target waters at greatest risk of nutrient pollution**

**Provide direction for BMP implementation**

**Develop Using Existing Data**

**reference conditions**

*Describe the characteristics of water body segments* ***least impaired*** *by human activities. As such,* ***reference conditions can be used to describe attainable biological or habitat conditions*** *for water body segments with common watershed/catchment characteristics within defined geographical regions.* **(EPA, 2000)**




* (Stoddard, 2006)

# METHODOLOGY

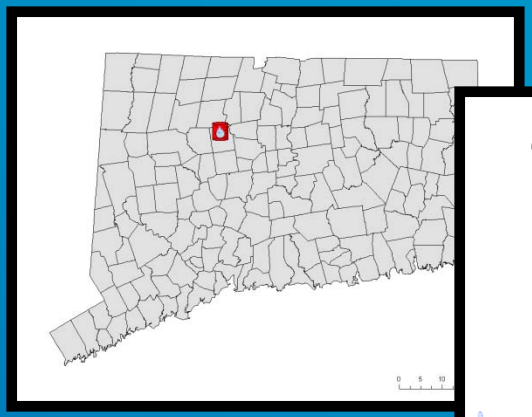
Pick a Location on Any Waterbody In the State and Delineate Watershed

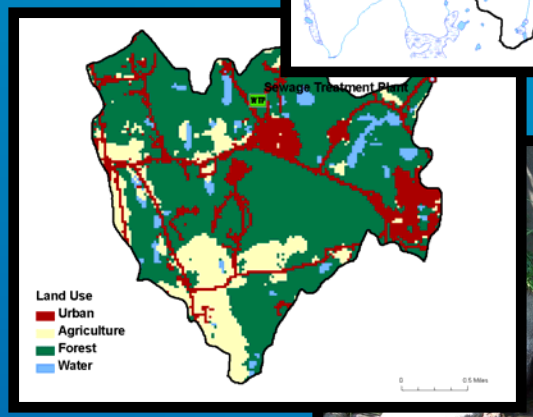
Classify Watershed by Land Cover and Presence of WWTP

Apply Best Management Practice (BMP) Land Cover and Discharge Export Coefficients

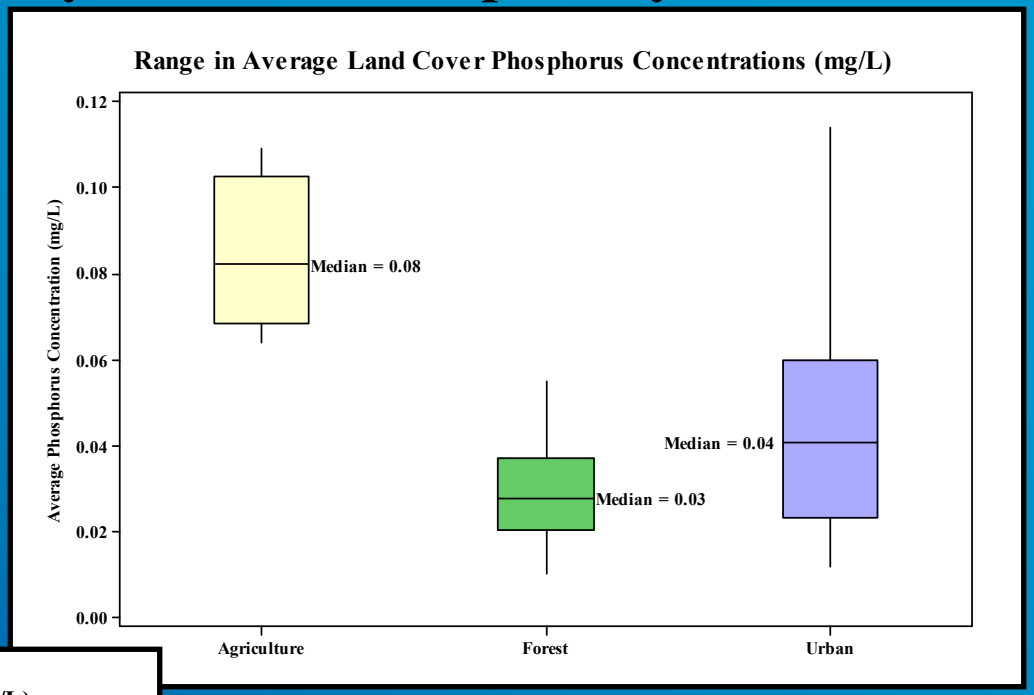
Calculate Best Attainable Condition (BAC) Nutrient Criteria for Watershed

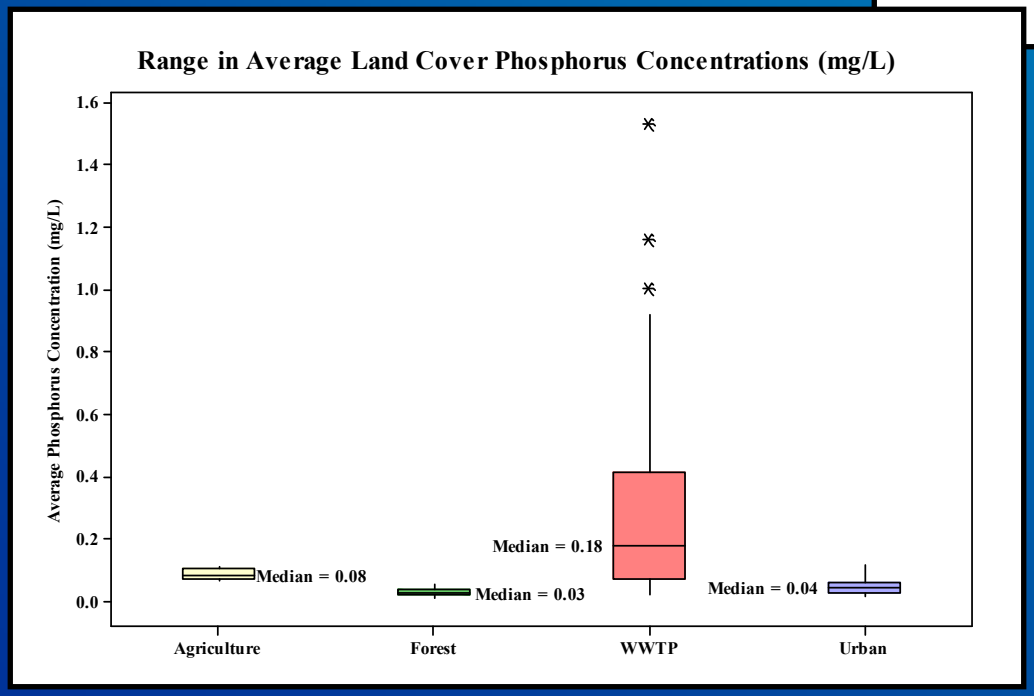
Develop Phosphorus TMDLs and Implement Nutrient Criteria





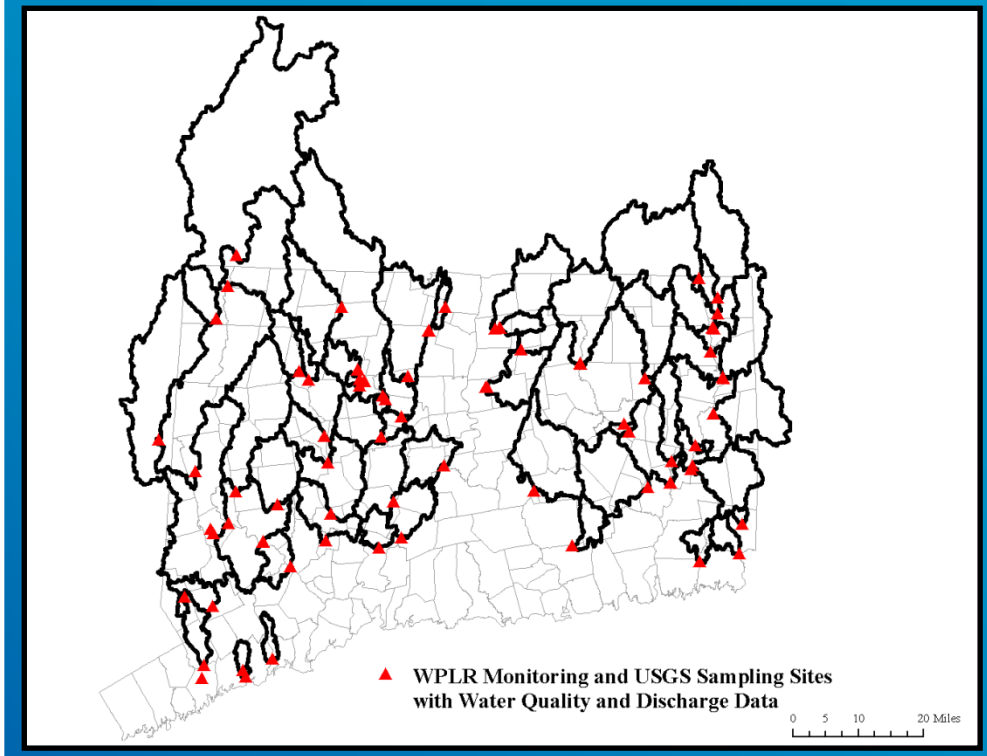

# METHODOLOGY: Classify Watershed Export By Land Cover and Upstream Discharges


# METHODOLOGY: Steps to Calculate BMP Land Cover Export Loads

1. Identified Sites With Seasonal (April through October) Water Quality and Discharge Data
2. Delineated Upstream Watershed from Gage Location and Calculate Land Cover (Uconn Clear, 2002)
3. Applied Criteria to Determine which Gages to Use in Export Coefficients Models
4. Modeled Export Coefficients Across Varying Flow Conditions
5. Compared Export Coefficient Loads to 'Actual' Loads and Literature Values
6. Applied Applicable BMPs to Final Export Coefficients Across Varying Flow Conditions to Calculate BAC Land Use Load

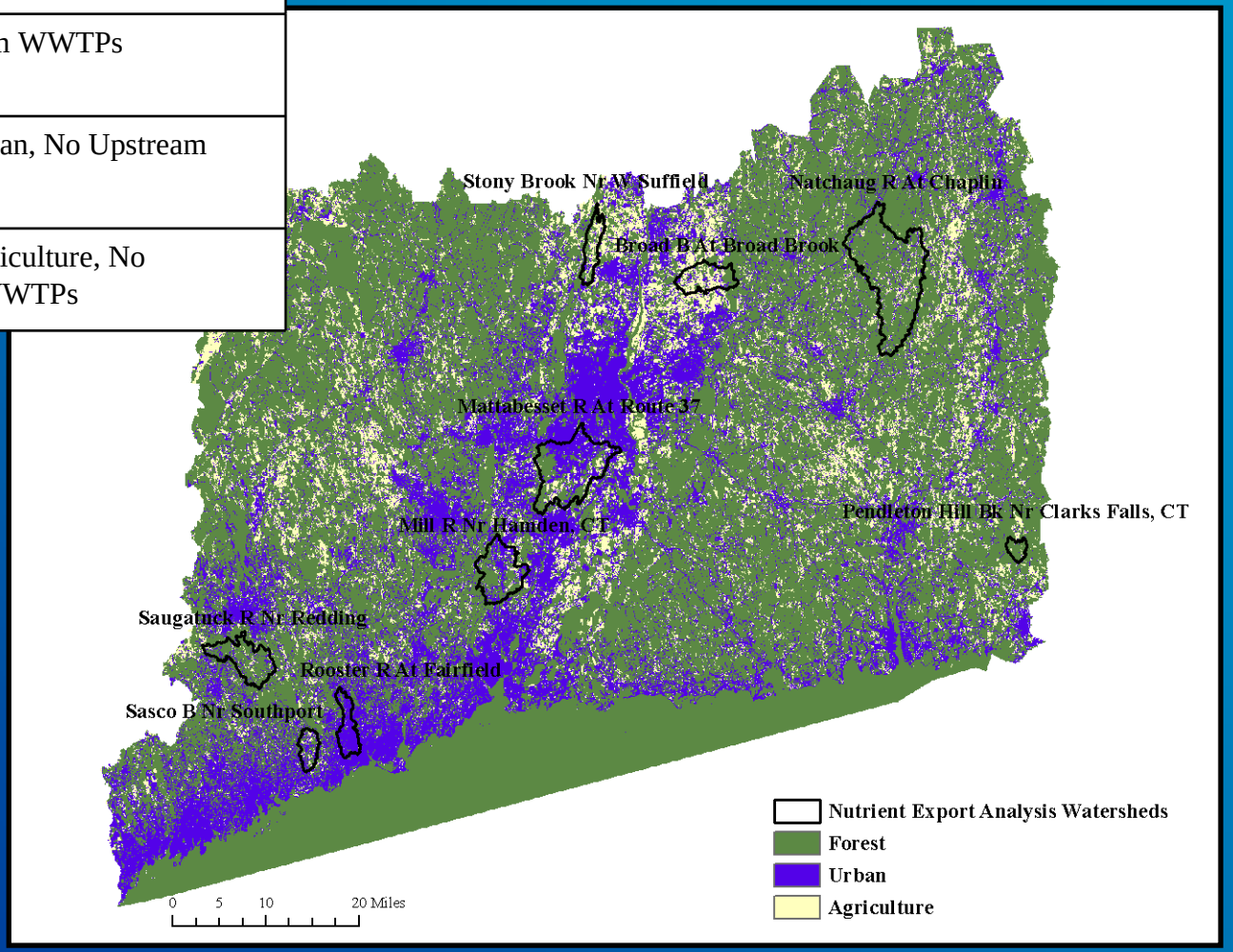


# METHODOLOGY: Delineated Watersheds, Calculated Land Cover and Determined if Site Met Criteria

Criteria to Determine Relevant Gages for Export Coefficient Model*

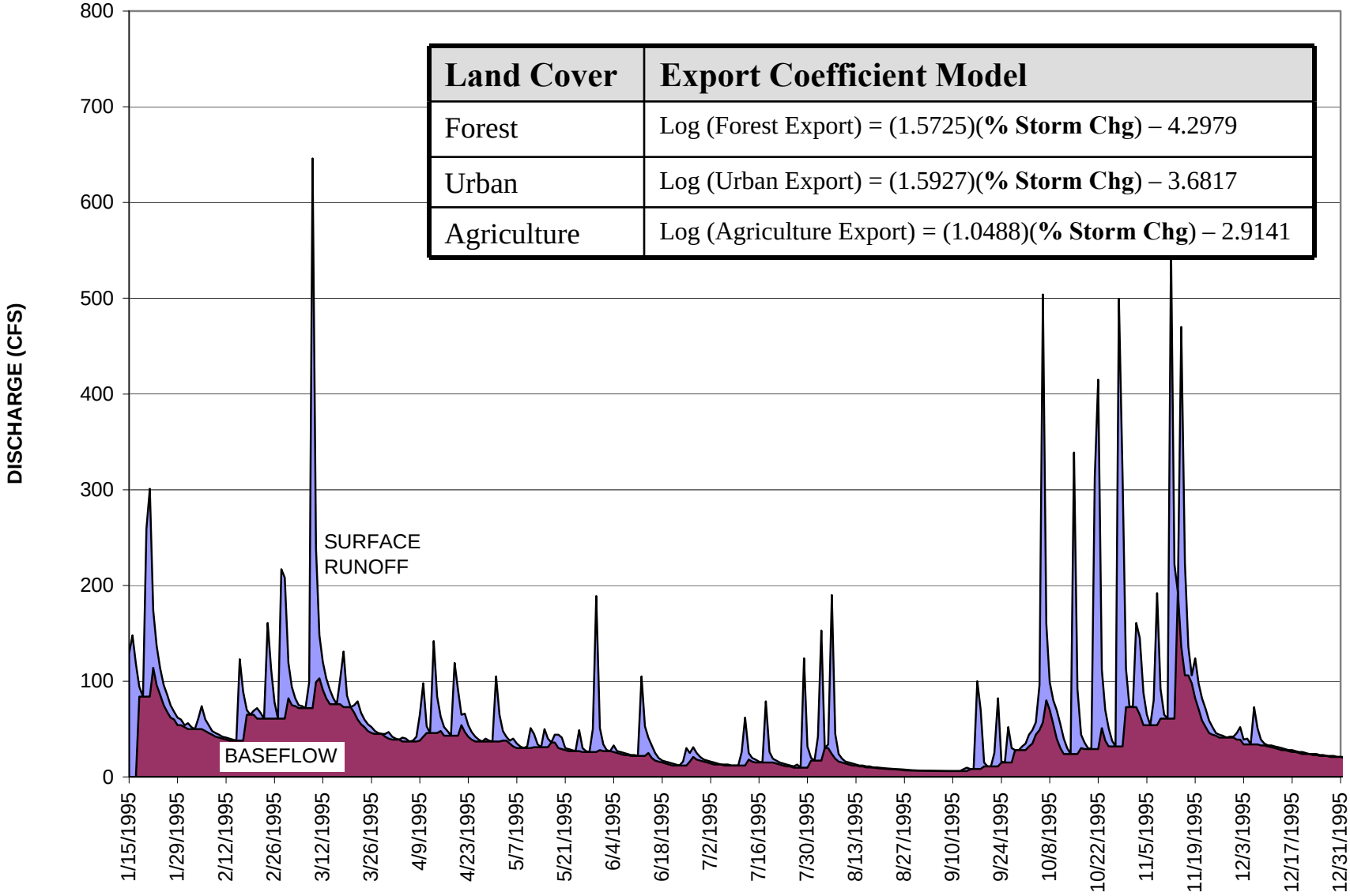
| Export Coefficient | Land Cover Criteria | Other Land Cover Criteria |
|---|---|---|
| Forest | > 80 % | No Upstream WWTPs |
| Agriculture | > 25% | <= 15% Urban, No Upstream WWTPs |
| Urban | > 25% | <= 15% Agriculture, No Upstream WWTPs |

* Criteria Based on Findings of Wickham, 2000



# METHODOLOGY: Model Export Coefficients Across Varying Flow Conditions

| Land Cover | Export Coefficient Model |
|---|---|
| Forest | Log (Forest Export) = (1.5725)(**% Storm Chg**) – 4.2979 |
| Urban | Log (Urban Export) = (1.5927)(**% Storm Chg**) – 3.6817 |
| Agriculture | Log (Agriculture Export) = (1.0488)(**% Storm Chg**) – 2.9141 |



# METHODOLOGY: Compare Export Coefficient Non-Point Source Current Loads with 'Actual' Current Loads

| Land Cover | Export Coefficient (lbs/acre/day)* |
|---|---|
| Forest | $1.03 * 10^{-4}$ |
| Urban | $4.33 * 10^{-4}$ |
| Agriculture | $19.75 * 10^{-4}$ |

| Station # | Station Name | Drainage Area (Sq. Mi.) | %Urban | %Forest | %Ag | Estimated Export Coefficient Load (lbs/day) | Actual Total Load (lbs/day) |
|---|---|---|---|---|---|---|---|
| 1608 | MIRY BROOK AT YE OLDE RD | 3.85 | 23.37% | 68.29% | 8.34% | 0.83 | 1.19 |
| 1192704 | MATTABESSET RIVER AT ROUTE 372 AT EAST BERLIN | 46.9 | 44.11% | 44.82% | 11.07% | 13.69 | 8.64 |
| 1184490 | BROAD BROOK AT BROAD BROOK, CT. | 15.6 | 12.09% | 41.31% | 46.60% | 10.12 | 12.72 |
| 1188000 | BUNNELL (BURLINGTON) BR NR BURLINGTON, CT | 4.2 | 17.12% | 67.45% | 15.43% | 1.21 | 1.21 |
| 1184100 | STONY BROOK NEAR WEST SUFFIELD, CT. | 10.5 | 10.37% | 55.03% | 34.60% | 5.30 | 4.81 |
| 1208990 | SAUGATUCK RIVER NEAR REDDING, CT. | 20.69 | 13.86% | 79.62% | 6.51% | 3.59 | 3.31 |
| 1748 | PENDELTON HILL BROOK | 4.01 | 5.31% | 86.22% | 8.46% | 0.72 | 0.29 |
| 1193500 | SALMON RIVER NEAR EAST HAMPTON | 100.63 | 15.49% | 72.77% | 11.74% | 24.13 | 15.39 |

*Average export coefficient based on a typical storm (20% storm change)

# METHODOLOGY: Apply Applicable BMPs to Final Export Coefficients Across Varying Flow Conditions to Calculate BMP Land Cover Export Load

**BMP Land Cover Load = Σ[Land Cover BMP Export * Upstream Land Cover Area]**

| Land Cover | Export Coefficient* (lbs/acre/day) | Literature Value BMP Percent Reductions (EPA, 1993) | BMP Percent Reduction Used for Current Analysis | BMP Export Coefficient* (lbs/acre/day) |
|---|---|---|---|---|
| Forest | $1.03 * 10^{-4}$ | 0% | 0% | $1.03 * 10^{-4}$ |
| Urban | $4.33 * 10^{-4}$ | 5 – 65 % | 60% | $1.73 * 10^{-4}$ |
| Agriculture | $19.75 * 10^{-4}$ | 30 –75 % | 60% | $7.9 * 10^{-4}$ |

*Average export coefficient based on a typical storm (20% storm change)

# METHODOLOGY: Steps to Calculate BMP WWTP Discharge Export Loads

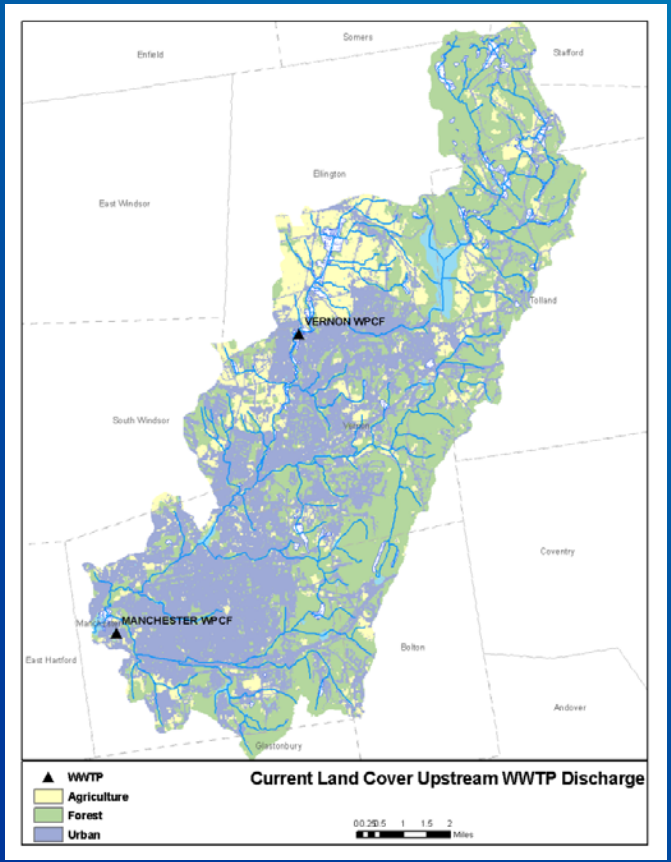
1. Calculate Enrichment Factor At Point of In-Stream Discharge
2. Calculate the Percent Contribution At Point of In-Stream Discharge
3. Analyze Enrichment Characteristic Similarities Among WWTPs
4. Apply Appropriate Seasonal Limits Based on Percent Load Contribution and Downstream Enrichment Characteristics
5. Calculate BMP Discharge Load Based on Current Flow

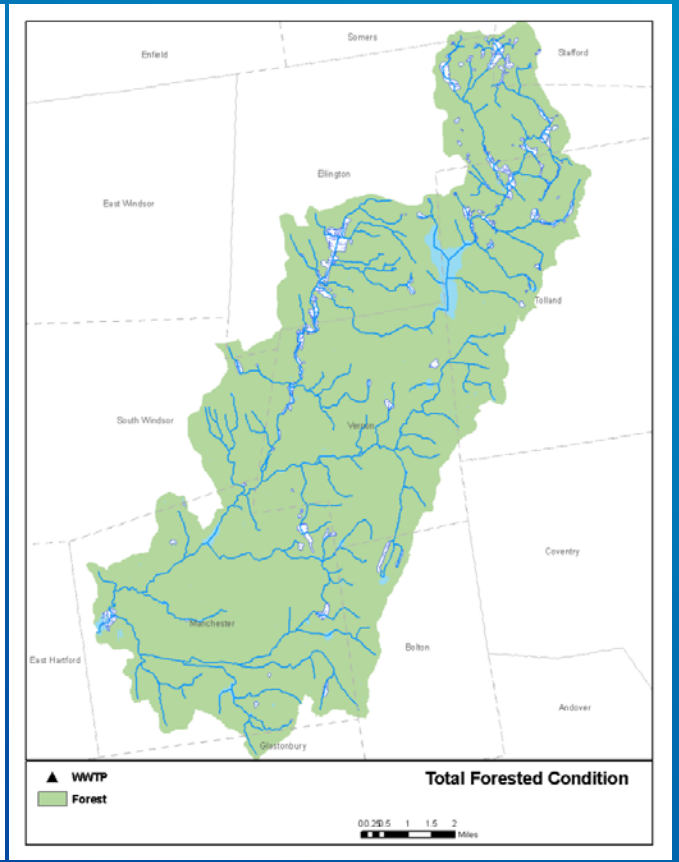
# METHODOLOGY: Identify Indicators of Nutrient Enrichment Downstream WWTPs

## Enrichment Factor

***Current In-Stream Phosphorus Load At Point of Discharge:***

***Total Forested Condition Phosphorus Load***



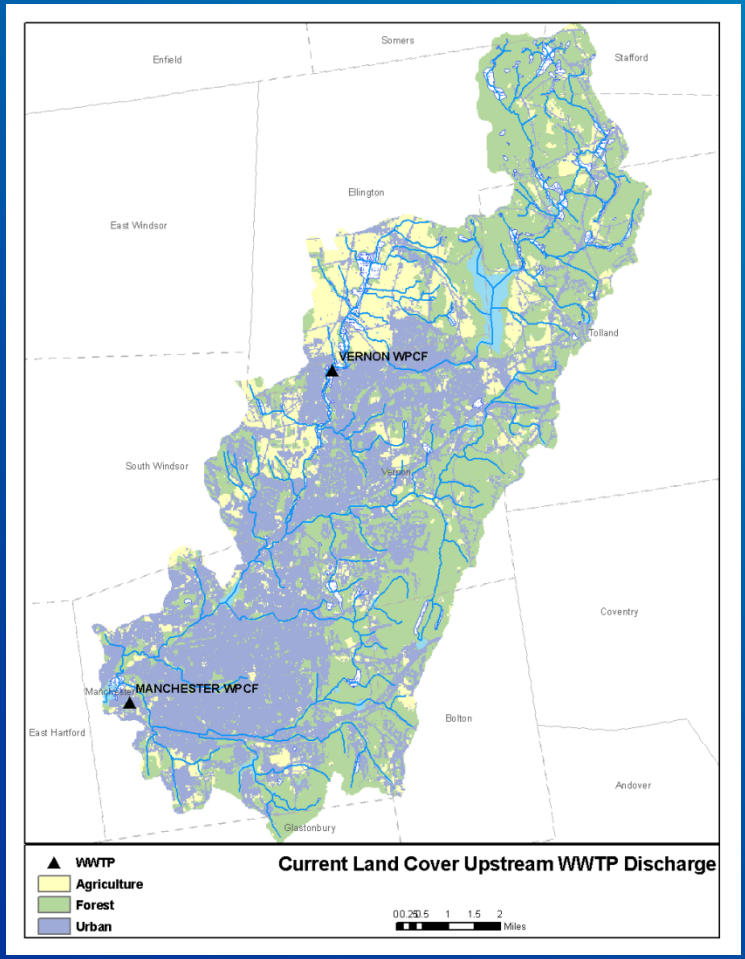

**Example:**

| Current Load (lbs/day) | 205.3 |
|---|---|
| Forested Load (lbs/day) | 4.80 |
| Enrichment Factor | 42.79 |

# METHODOLOGY: Identify Indicators of Nutrient Enrichment Downstream WWTPs

## In-Stream Percent Contribution At Point of Discharge

***(Current WWTP Phosphorus Load / Total In-Stream Phosphorus Load At Point of Discharge) *100***




**Example:**

| Current WWTP Load (lbs/day) | Total In-stream Load (lbs/day) | Percent Contribution |
|---|---|---|
| 110.40 | 205.30 | 53.78 % |

# METHODOLOGY: Identify Indicators of Nutrient Enrichment Downstream WWTPs

## Enrichment Factor BMP Matrix

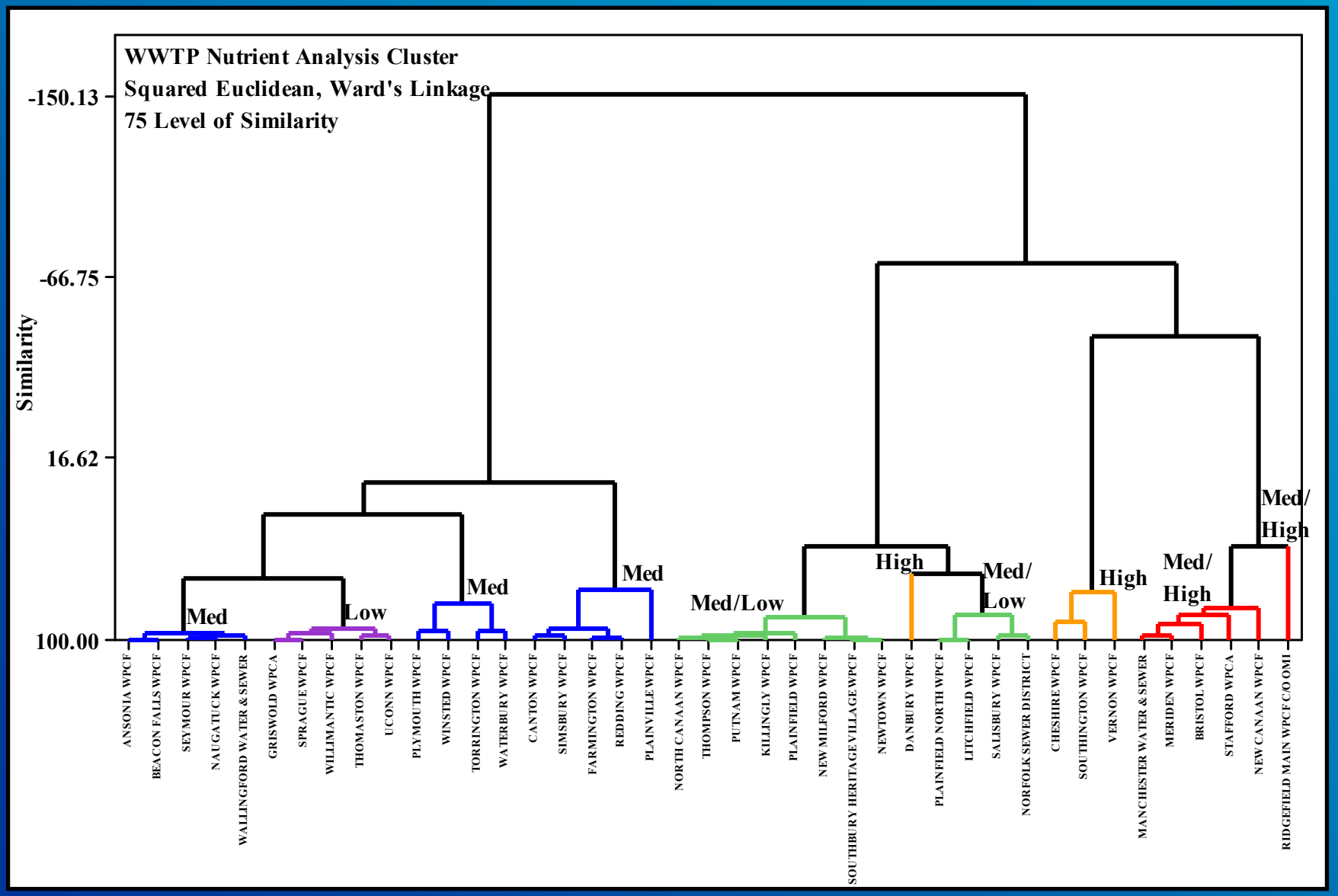
| Model Matrix | EF > 34.5 | 8.5 < EF > 34.5 | EF < 8.5 |
|---|---|---|---|
| %C > 15 % | HIGH | MED | LOW |
| 5% < %C > 15% | MED | MED | LOW |
| %C < 5% | LOW | LOW | LOW |

# METHODOLOGY: Identify Indicators of Nutrient Enrichment Downstream WWTPs

**Analyze Enrichment Characteristic Similarities Among WWTPs Using Cluster Analysis And Best Professional Judgment**

| Other Factors Considered |
| --- |
| STP Current Average Phosphorus Concentration (mg/l) |
| Distance to Nearest Downstream Dam (mi) |
| Percent Contribution At Nearest Downstream Dam |
| Distance to Nearest Downstream Impaired Water (mi) |
| Percent Contribution At Nearest Downstream Impaired Water |

# METHODOLOGY: Identify Indicators of Nutrient Enrichment Downstream WWTPs



# METHODOLOGY: Identify Indicators of Nutrient Enrichment Downstream WWTPs

## Modify Enrichment Factor Modeling Analysis Based on Cluster Analysis and Best Professional Judgment

| Quinnipiac Basin Group | Geospatial Modelling Analysis | | |
|---|---|---|---|
| Facility | Enrichment Factor | Percent Contribution At Discharge | BMP Requirement Based on Modeling Analysis |
| CHESHIRE WPCF | 44.56 | 42.61 | HIGH |
| MERIDEN WPCF | 52.74 | 36.20 | HIGH |
| SOUTHINGTON WPCF | 30.54 | 87.25 | MED |
| WALLINGFORD WATER & SEWER | 65.70 | 29.84 | HIGH |

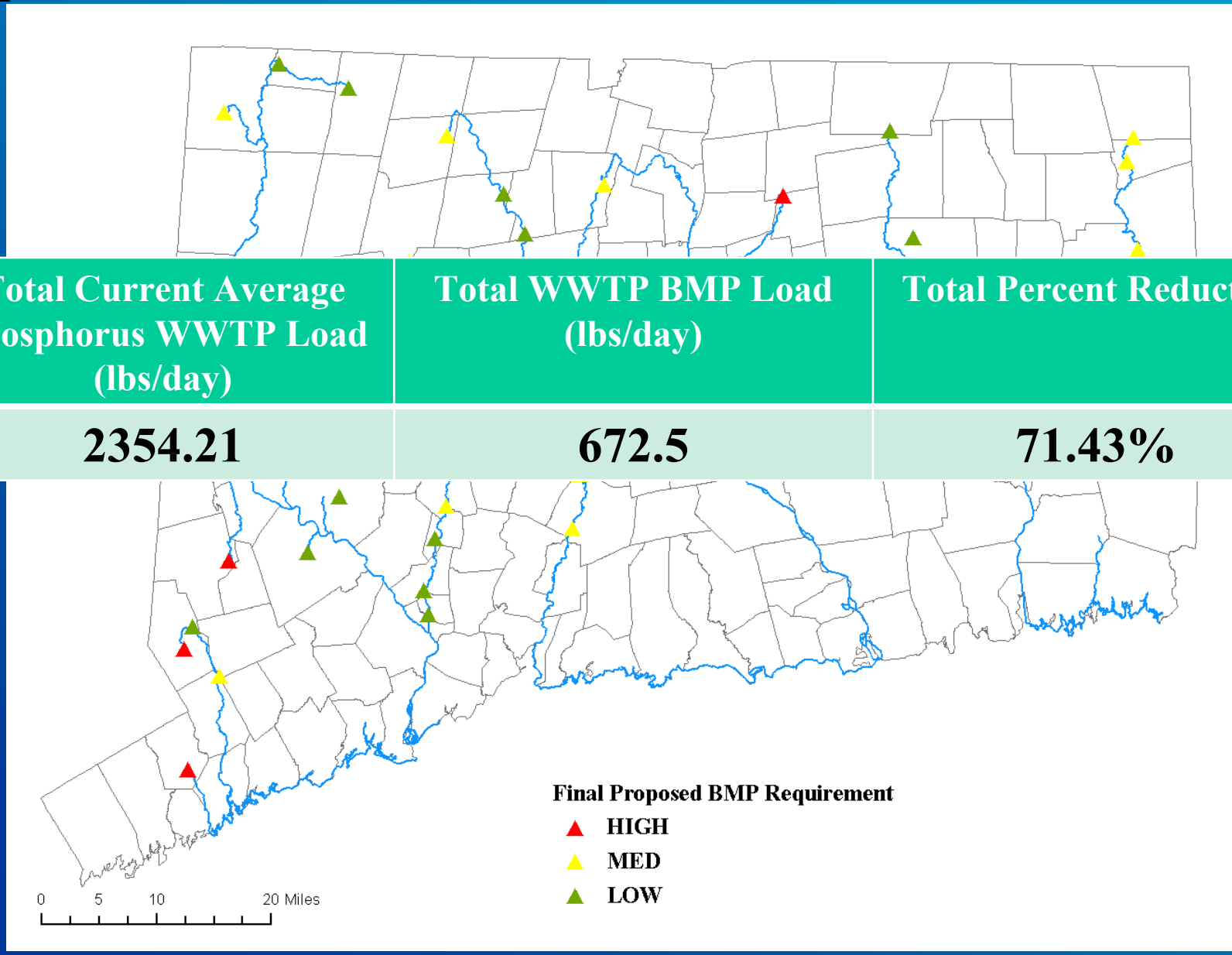
| Other Factors Considered / BPJ Analysis | | | | | | | | BMP |
|---|---|---|---|---|---|---|---|---|
| STP Current Average Phosphorus Concentration (mg/L) | Distance to Nearest DS Dam (mi) | Percent Contribution At Nearest DS Dam | Distance to Nearest DS IW (mi) | Percent Contribution At Nearest DS IW | Potental Limit Based on Cluster Analysis | BPJ Adjustment | | FINAL PROPOSED BMP REQUIREMENT |
| 4.61 | 1.72 | 0.42 | 1.72 | 0.42 | HIGH | no | | HIGH |
| 1.47 | 3.66 | 0.36 | Null | 0.00 | MED/HIGH | down one | | MED |
| 2.74 | 5.85 | 0.48 | 5.85 | 0.48 | HIGH | up one | | HIGH |
| 3.46 | Null | 0.00 | Null | 0.00 | MED | down one | | MED |

# METHODOLOGY: Apply Appropriate Average BMP Seasonal (April through Oct.) Performance Limits And Calculate BMP Discharge Export Load

| Final Proposed BMP Requirement | BMP Average Performance | Feasibility |
|---|---|---|
| High | 0.2 mg/L | Technically Feasible with Additional Filters and Chemical Addition. |
| Medium | 0.7 mg/L | Technically and Economically Feasible with Chemical Addition Or Biological Treatment If Capacity Exists. |
| Low | Cap at Current Load | May Need Additional Treatment if Future Expansion is Planned. |

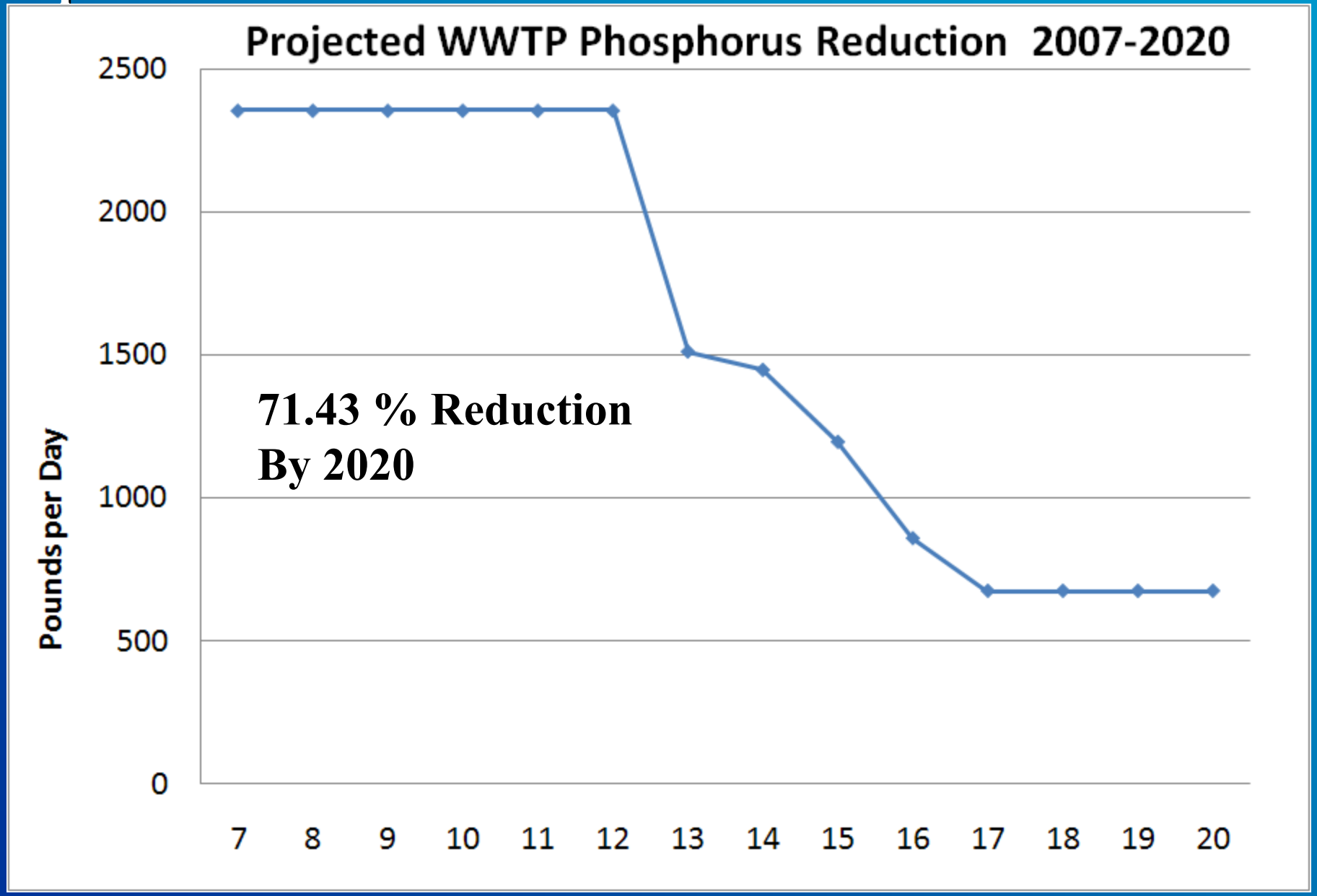
**BMP Discharge Export Load = Concentration * Current (5-Year) Average Flow Rate**

# METHODOLOGY: Apply Final Proposed BMP Requirements

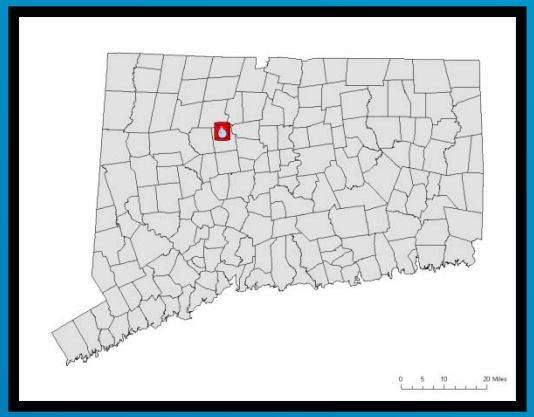



| Total Current Average Phosphorus WWTP Load (lbs/day) | Total WWTP BMP Load (lbs/day) | Total Percent Reduction |
|---|---|---|
| 2354.21 | 672.5 | 71.43% |

# METHODOLOGY: Apply Final Proposed BMP Requirements



# IMPLEMENTATION



Pick a Location on Any Waterbody In the State and Delineate Watershed

**BAC = BMP Land Cover Load + BMP WWTP Load**

Classify Watershed by Land Cover and Presence of WWTP

Apply Best Management Practice (BMP) Land Cover and Discharge Export Coefficients

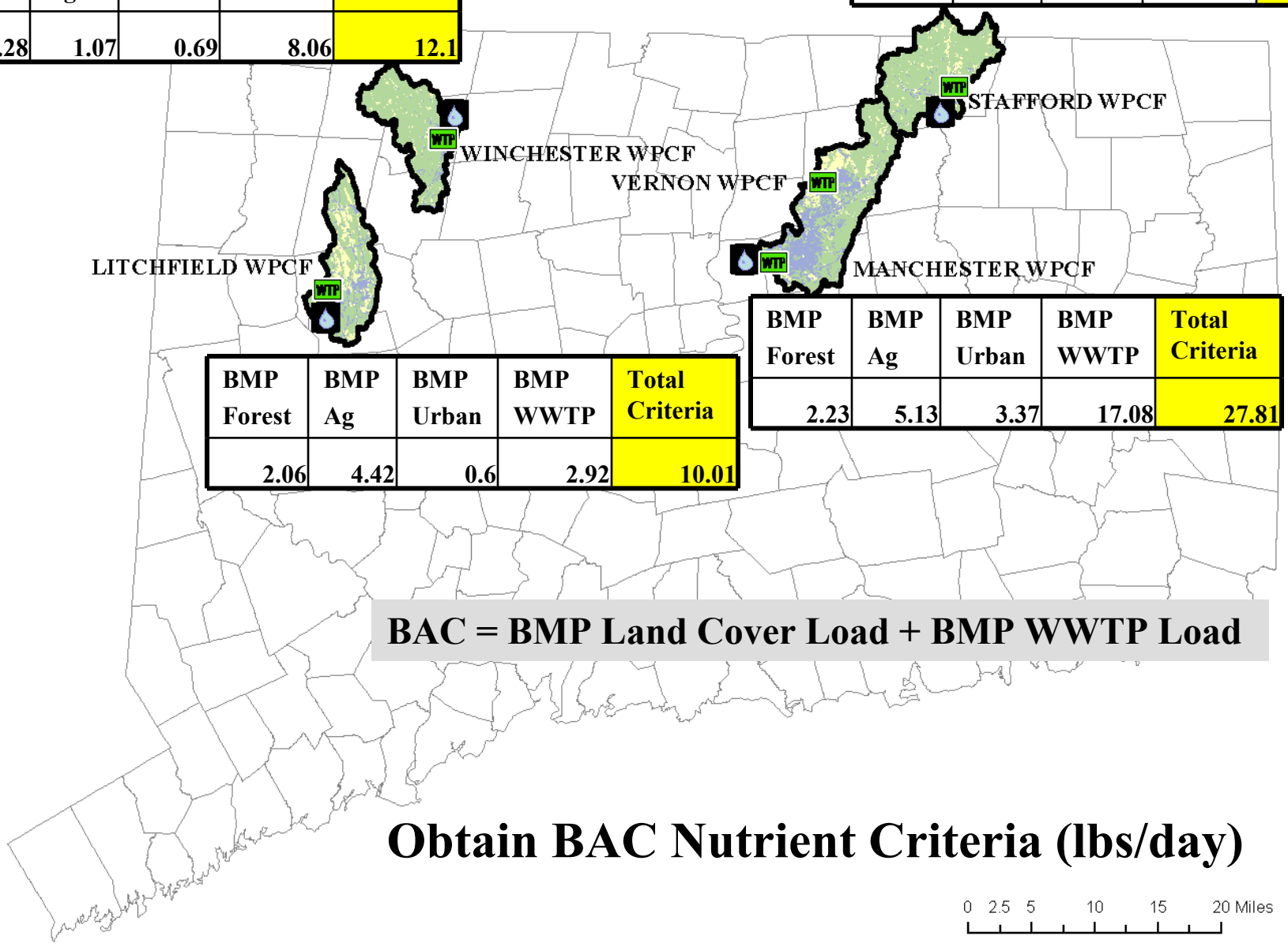
Calculate Best Attainable Condition (BAC) Nutrient Criteria for Watershed

Develop Phosphorus TMDLs and Implement Nutrient Criteria

# IMPLEMENTATION

| BMP Forest | BMP Ag | BMP Urban | BMP WWTP | Total Criteria |
|---|---|---|---|---|
| 2.28 | 1.07 | 0.69 | 8.06 | 12.1 |

| BMP Forest | BMP Ag | BMP Urban | BMP WWTP | Total Criteria |
|---|---|---|---|---|
| 2.85 | 1.7 | 0.69 | 8.61 | 13.85 |




| BMP Forest | BMP Ag | BMP Urban | BMP WWTP | Total Criteria |
|---|---|---|---|---|
| 2.06 | 4.42 | 0.6 | 2.92 | 10.01 |

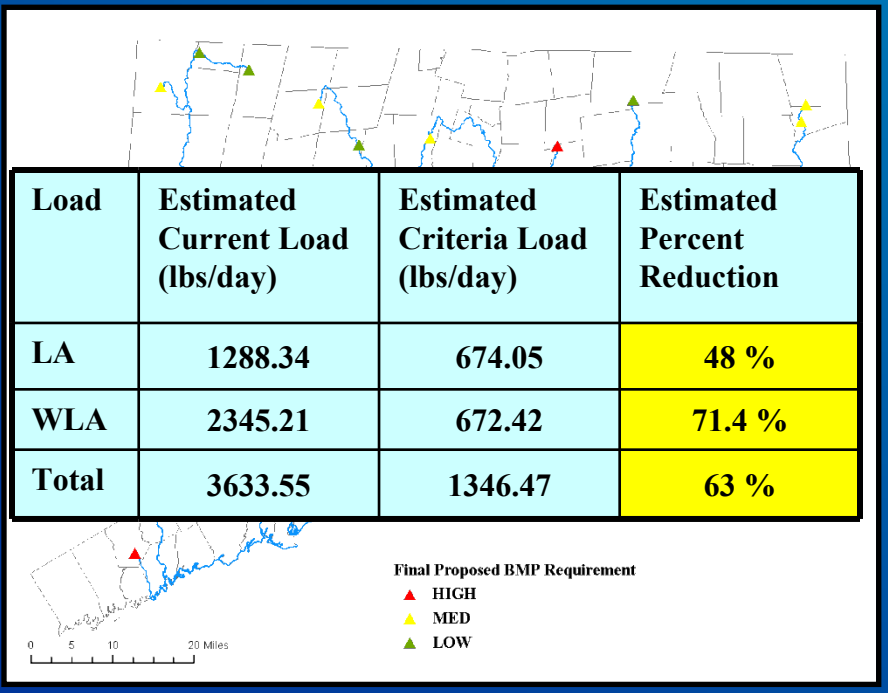
| BMP Forest | BMP Ag | BMP Urban | BMP WWTP | Total Criteria |
|---|---|---|---|---|
| 2.23 | 5.13 | 3.37 | 17.08 | 27.81 |

**BAC = BMP Land Cover Load + BMP WWTP Load**

**Obtain BAC Nutrient Criteria (lbs/day)**

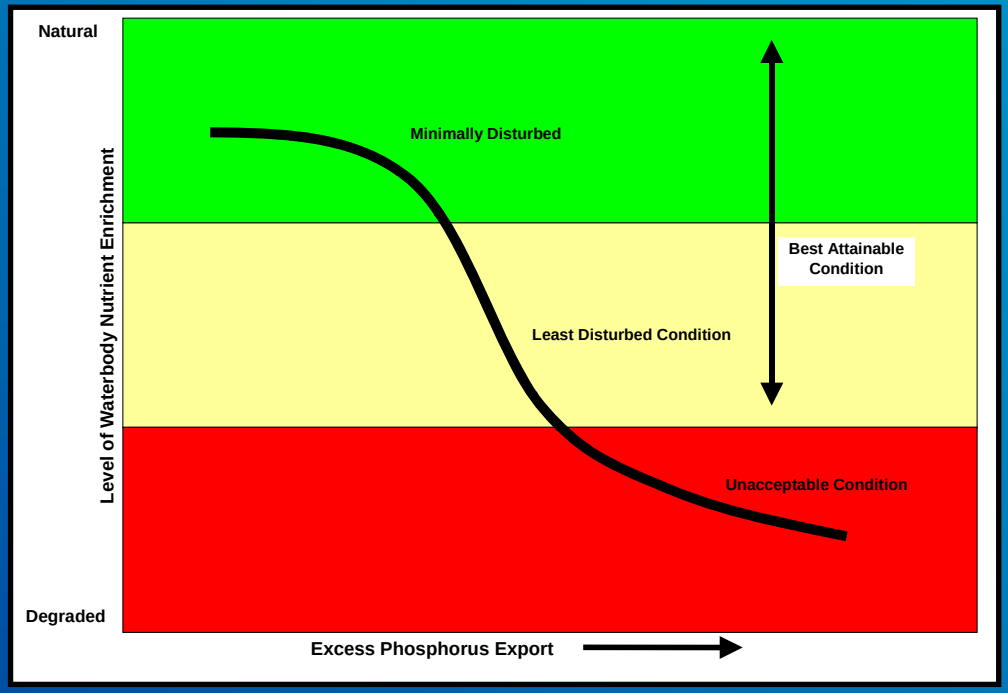
# IMPLEMENTATION: Getting Back to BAC

- Uses Existing Data
- Applied State-Wide
- Goal Is Specific To Site
- Immediate Implementation Efforts
- Easily Revisable As Better Information is Available
- Utilizes Geo-Spatial Tools That Can Be Applied to Public Accessible Tools



| Load | Estimated Current Load (lbs/day) | Estimated Criteria Load (lbs/day) | Estimated Percent Reduction |
|---|---|---|---|
| LA | 1288.34 | 674.05 | 48 % |
| WLA | 2345.21 | 672.42 | 71.4 % |
| Total | 3633.55 | 1346.47 | 63 % |





# QUESTIONS ?


**Mary Becker**

**mary.becker@ct.gov**




**Department of Environmental Protection**

**Bureau of Water Protection and Land Reuse**

**79 Elm Street, Hartford CT 06106**

**www.ct.gov/dep**