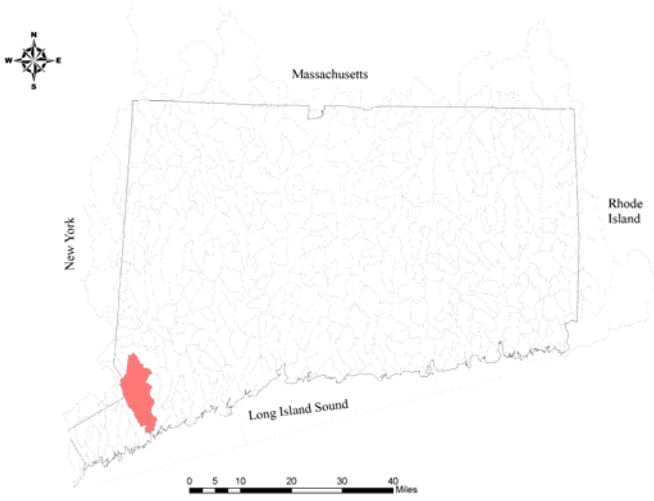
Appendix 1. Norwalk River Stressor Identification

<u>Waterbody:</u> Norwalk River and Ridgefield Brook

<u>Impairment Description:</u>
Designated Use Impairment: Aquatic Life Use Support
Total Length of Impaired Segment(s): 9.69 miles

Segment	Waterbody Segment ID	Description	Surface Water Class	Cause of Impairment	TMDL Priority
CT 7300-02_02	Ridgefield Brook_02	From Taylor Pond upstream to headwaters in Great Swamp	B	Cause Unknown	Low
CT 7300-00_01	Norwalk River _01	From Wall Street Crossing head of tide to confluence with Bryant Brook	B	Cause Unknown	High
CT 7300-00_03a	Norwalk River_03a	From Old Mill Rd upstream to Georgetown POTW	B	Cause Unknown	High

<u>Watershed Description:</u>



Tributary To: Long Island Sound
Subregional Drainage Basin Area: 32.55 square miles
Sub regional Basin Name (Code): Norwalk River (7300)
Regional Basin Name (Code): Norwalk River (73)
Major Basin Name (Code): Southwest Coastal (7)

Connecticut Watershed Towns: Norwalk, Redding, Ridgefield, Weston, Wilton

Town	Square Miles	Percent of Total
Norwalk	8.6	27
Redding	3.4	10
Ridgefield	9.9	30
Weston	0.3	1
Wilton	10.3	32
Total	***32.5***	***100***

Phase II General Permit applicable:
All watershed towns (listed above) are included in the Phase II Municipal Separate Storm Sewer System Program and are regulated under the Phase II Permit.

Applicable Season: All Seasons

Landuse for Sub regional Basin 7300:

Land Use Category	Area (Square Miles)	Percent Composition
Forested	14.36	44
Urban/Developed	12.69	39
Open Space	2.85	9
Water/Wetland	1.46	4
Agriculture	1.18	4
Total	32.54	100

Data Source: Connecticut Land Use Land Cover Data Layer LANDSTAT (2002) Thematic Mapper Satellite Imagery.

Stressor ID Procedure

The process of evaluating data to determine the most likely candidate causes of biological impairment has been the subject of many recent efforts [1-4]. The Stressor Identification (SI) Procedure followed here by CTDEP is similar to the approaches outlined in these references and involves 4 steps:

1) Listing the Candidate Causes;
2) Analyzing the Evidence;
3) Characterizing the Causes;
4) Identifying the Probable Candidate Cause.

These steps can lead to identifying the most likely candidate cause for impairments that have an undetermined cause. Ultimately, identification of the most probable cause can lead to management actions to eliminate or control the cause.

The impairments that were examined independently in this study were anthropogenic enrichment and poor macroinvertebrates multimetric index (MMI) scores. Anthropogenic enrichment is excess nutrient enrichment resulting from human influences by practices such as urban landuse development in the watershed and sewage treatment plants. Anthropogenic enrichment has the potential to threaten or impair aquatic life support or recreational designated uses.

Historical and more recent macroinvertebrate MMI scores from 2006 were evaluated for this study. Both data sets show a progressive decrease in MMI scores proceeding downstream from monitoring locations at Branchville to end of the study area at Route 123 (Figure 1). It was also notable that in all cases where there were comparable data from 1997, MMI scores collected at the same location were always lower in 2006.

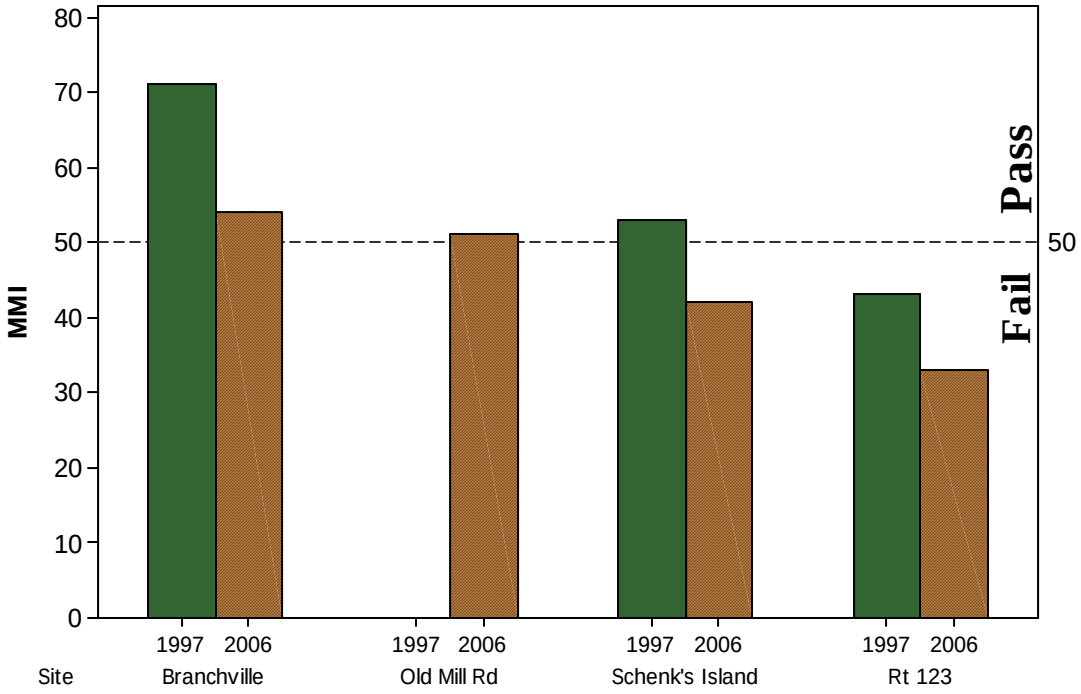


Figure 1. Macroinvertebrate Multimetric Index (MMI) Scores from four locations in the Norwalk River watershed listed from upstream (Branchville) to downstream (Rt 123). MMI is one of the factors used to determine aquatic life support designated use. A MMI > 50 indicates a site meets minimum aquatic life standards (Pass) and < 50 indicates a site does not meet minimum aquatic life standards (Fail).

Candidate Causes

The following data sources were considered to develop a list of candidate causes for the SI analysis for Norwalk River. A report summarizing data collection up to 2006 was recently completed by CTDEP [5].

Biological

- CTDEP fisheries surveys
- CTDEP macroinvertebrate surveys

Chemical

- CTDEP ambient surface water samples
- USGS water quality monitoring at Norwalk River at Winnipauk gage 1209710

Hydrologic

- USGS discharge (streamflow) monitoring at Norwalk River at South Wilton gage 1209700

Water Temperature

- Onset brand HOBO continuous water temperature data loggers deployed by CTDEP

Other

- Harbor Watch/River Watch Reports (*Escherichia coli* monitoring)
- Notes from field visits and visual observations
- GIS mapping of watershed
- Scientific literature
- Consultant Reports

After reviewing the available data, the candidate causes listed in Table 1 were explored further using conceptual model diagrams annotated with supporting lines of evidence.

Table 1. Candidate Causes and potential sources contributing to anthropogenic enrichment and poor macroinvertebrate MMI scores in study area.

Candidate Cause	Potential Sources
Phosphorus	Sewage plants, stormwater runoff from impervious surfaces
Toxic Contamination	Sewage plants, stormwater runoff from impervious surfaces, unknown sources
Water Temperature	Sewage plants, ponds, stormwater runoff from impervious surfaces
Low Dissolved Oxygen	Impoundments, stormwater runoff from impervious surfaces
Flow Alteration	Impervious surfaces cause extreme runoff volumes that remove organisms from their habitat. Impervious surfaces disrupt natural hydrologic cycle and cut-off vertical connectivity of surface water and groundwater. Dams, water diversions, and return flows can contribute to flow alteration.

Analyzing Evidence

Conceptual model diagrams were obtained from EPA's Causal Analysis Diagnosis Decision Information System (CADDIS) website (http://cfpub.epa.gov/caddis/) and modified to complement the data collected on the Norwalk River and tributaries. Conceptual model diagrams were used to illustrate the link between potential sources, logical causal pathways, and the observed impairments of reduced macroinvertebrate MMI scores and anthropogenic enrichment. The data and conceptual model diagrams were then used to 1) eliminate causal pathways, 2) identify causal pathways that were weakened, and 3) provide evidence in support of a causal pathway. Conceptual models were completed for 5 site locations listed from upstream to downstream - Ridgefield Brook at Rt 35 (Fox Hill Condos), Norwalk River at Branchville, Norwalk River at Old Mill Road, Norwalk River at Schenk's Island, and Norwalk River at Route 123 (Figure 2). For each of the most likely candidate causes - anthropogenic enrichment, toxic contaminations, water temperature, and low dissolved oxygen- a conceptual model is presented and evidence to that supports, weaken, or is ambiguous is presented for each of the 5 locations.

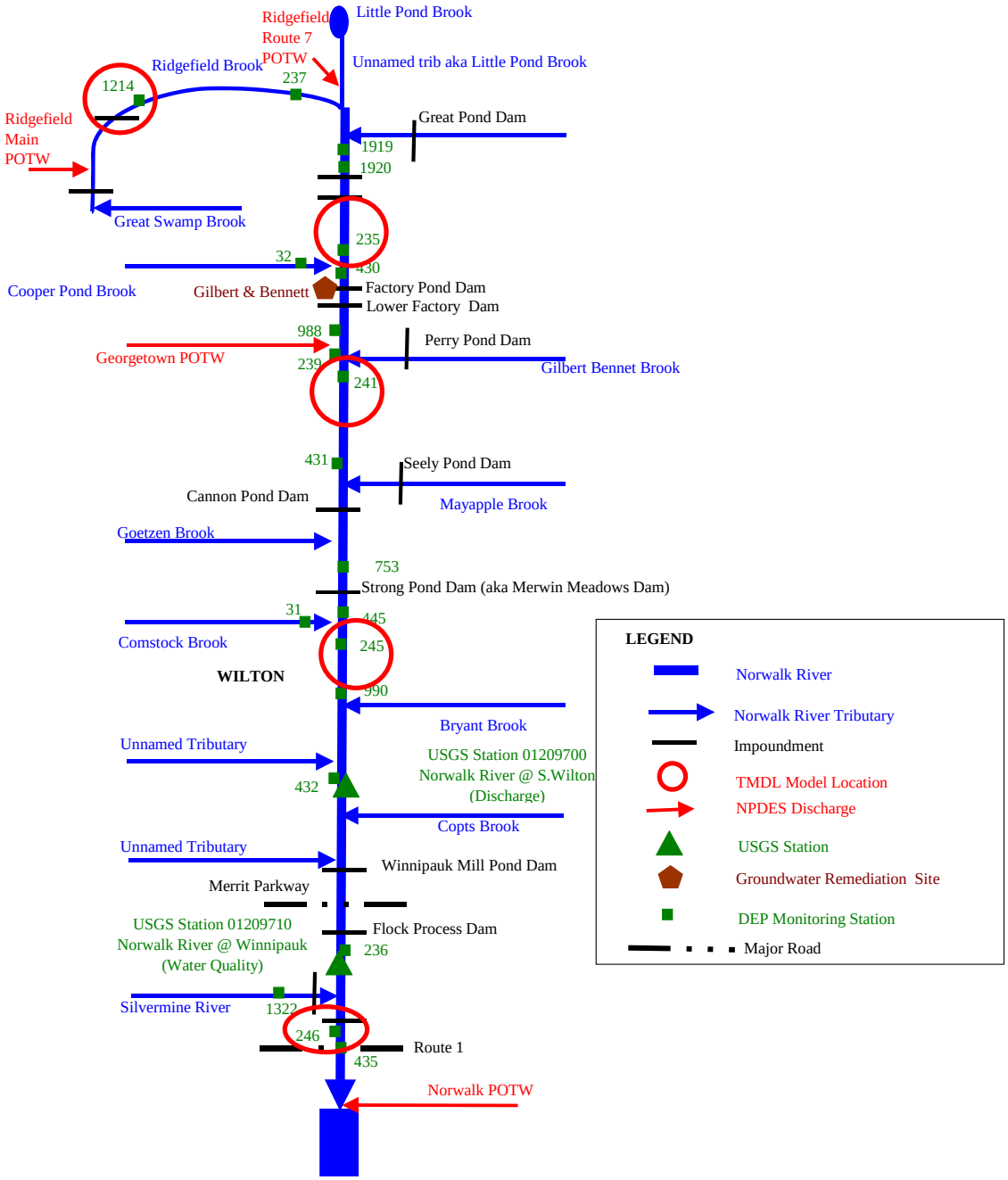


Figure 2. Map of study area with five potential TMDL model locations noted by red circles.

Conceptual Model of Phosphorus

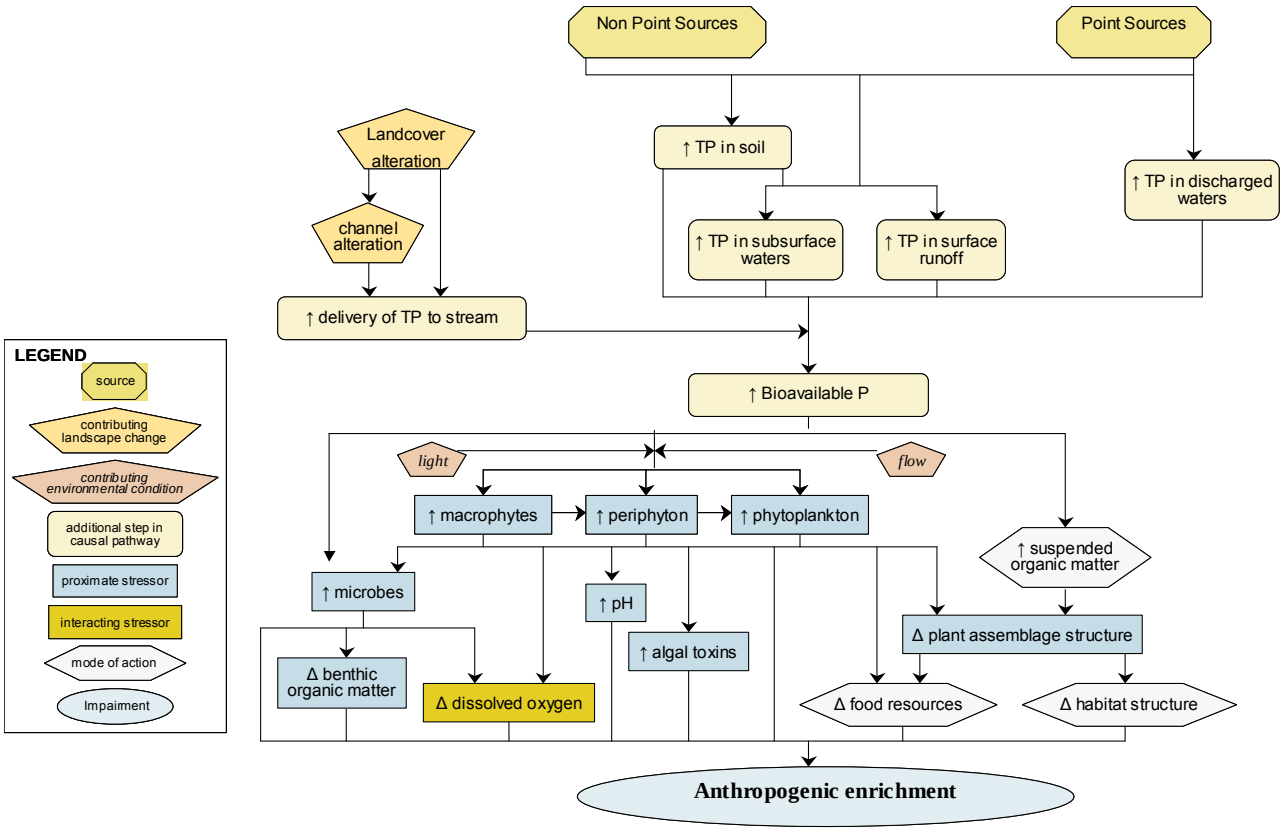


Figure 3. Conceptual model of phosphorus as the cause of anthropogenic enrichment.

<u>Phosphorus as a candidate cause at Ridgefield Brook at Route 35 Fox Hill Condos (Site ID 1214)</u>

<u>Data that supports</u>

- Eight out of 8 samples from one location > 0.06 mg/L Total Phosphorus (75th percentile of streams in southwest coastal basin).*

**** Note that 0.06 mg/L Total Phosphorus (TP) is not a numerical water quality criterion. Rather, it was used to evaluate TP in the Norwalk River against the values that have been collected in rivers in close proximity to the Norwalk River. Values > 75th percentile indicate that 75% of the time, values of TP in nearby rivers have been found to be lower and 25% of the time, values are found to be higher. The significance of a value > 75th percentile is that it can reasonably be expected to have been influenced by human activities.***

- Ridgefield Main POTW contributes TP to receiving water

- 19% Impervious Cover in watershed support landuse contributions of TP
- Connecticut DEP monitoring data show that urban landuse results in higher TP concentrations (Figure 4)
- Visual observations of the watershed show evidence of anthropogenic enrichment (Data Support Photo 1)

Data that weakens or refutes

- None

Data that is ambiguous

- None

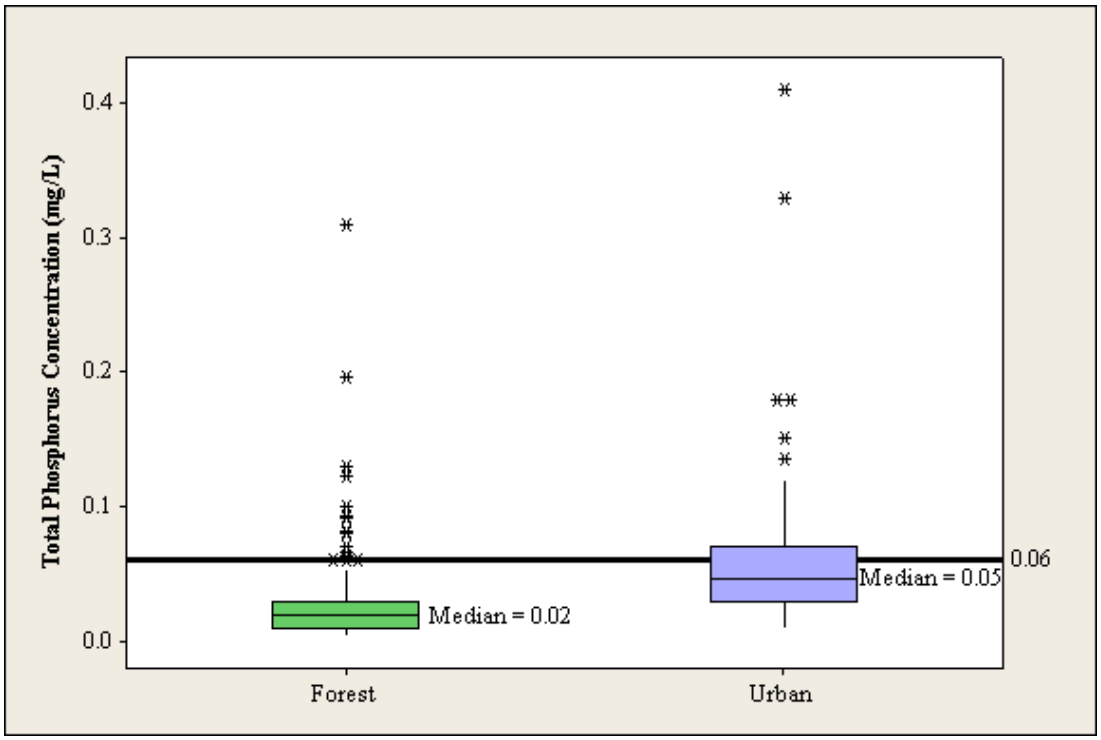


Figure 4. Relationship between total phosphorus concentration (mg/L) from streams in Connecticut and two landuse categories- forested (N=286) and urban (N= 138). The line at 0.06 mg/L represents the 75th percentile of sampled streams in the southwest coastal basin that was used in this evaluation (*should not be viewed as water quality criterion –see text for discussion **).

Data Support Photo 1. Ridgefield Brook at Route 35 Fox Hill Condos potentially caused by anthropogenic enrichment.

Phosphorus as a candidate cause at Norwalk River at Branchville (Site ID 235)

Data that supports

- Twenty nine out of 30 samples from 4 locations > 0.06 mg/L Total Phosphorus (75th percentile of streams in southwest coastal basin) *
- Route 7 POTW contributes TP to receiving water
- 15% Impervious Cover in watershed support landuse contributions of TP
- Connecticut DEP monitoring data show that urban landuse results in higher TP concentrations (Figure 4)
- Visual observations in the watershed show potential evidence of anthropogenic enrichment (Data Support Photo 2)

Data that weakens or refutes

- None

Data that is ambiguous

- None

Data Support Photo 2. Algae bloom on Little Pond, Norwalk River watershed.

Phosphorus as a candidate cause at Norwalk River at Old Mill Road (Site ID 241)

Data that supports

- Forty two out of 49 samples from 5 locations > 0.06 mg/L Total Phosphorus (75th percentile of streams in southwest coastal basin) *
- Georgetown POTW contributes TP to receiving water
- 15 % Impervious Cover in watershed support landuse contributions of TP
- Connecticut DEP monitoring data show that urban landuse results in higher TP concentrations (Figure 4)
- Visual observations of in watershed show evidence of anthropogenic enrichment (Data Support Photo 3 and 4)

Data that weakens or refutes

- None

Data that is ambiguous

- None

Data Support Photo 3. Norwalk River upstream North Main Street, below Factory Pond.

Data Support Photo 4. Norwalk River near Georgetown POTW outfall.

Phosphorus as a candidate cause at Norwalk River at Schenk's Island (Site ID 245)

Data that supports

- Twenty two out of 34 samples from 5 locations > 0.06 mg/L Total Phosphorus (75th percentile of streams in southwest coastal basin) *
- 14 % Impervious Cover in watershed support landuse contributions of TP
- Connecticut DEP monitoring data show that urban landuse results in higher TP concentrations (Figure 4)

Data that weakens or refutes

- None

Data that is ambiguous

- None

Phosphorus as a candidate cause at Norwalk River at Route 123 (Site ID 246)

Data that supports

- Five out of 24 samples from four locations > 0.06 mg/L Total Phosphorus (75th percentile of streams in southwest coastal basin) *
- 16 % Impervious Cover in watershed support landuse contributions of TP
- Connecticut DEP monitoring data show that urban landuse results in higher TP concentrations (Figure 4)

Data that weakens or refutes

- None

Data that is ambiguous

- None

Conceptual Model of Toxic Contamination

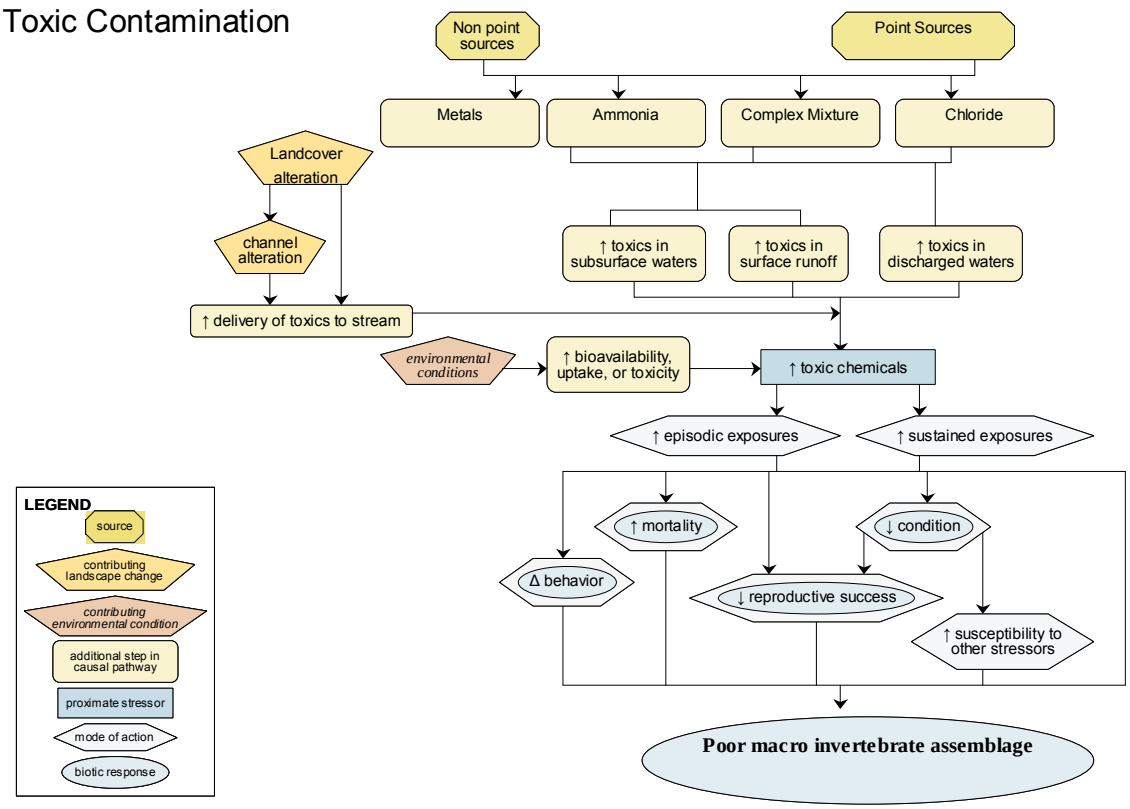


Figure 5. Conceptual model of toxic contamination as the cause of the poor benthic macroinvertebrate MMI scores.

<u>Toxic contamination as a candidate cause at Ridgefield Brook at Route 35 Fox Hill Condos (Site ID 1214)</u>

<u>Data that supports</u>

- Three out of 8 samples from one location exceeds 65 *u*g/l (acute surface water criterion) for zinc
- One out of 1 sample exceeds > 50 mg/L chloride (75th percentile of streams in southwest coastal basin) **

***** Note that 50 mg/L chloride is not a numerical water quality criterion. Rather, it was used to evaluate chloride in the Norwalk River against the values that have been collected in rivers in close proximity to the Norwalk River. Values > 75th percentile indicate that 75% of the time values of chloride in nearby rivers have been found to be lower and 25% of the time, values are found to be higher. The significance to a value > 75th percentile is that it can reasonably be expected to have been influenced by human activities.***

- Stressor response of macroinvertebrate MMI scores with chloride concentration (Figure 6).
- Ridgefield Main POTW contributes to loading of chloride and zinc to receiving water
- 19% Impervious Cover in watershed support landuse contributions of chloride and zinc
- Stressor response of macroinvertebrate MMI scores and impervious cover [6] (Figure 7)

Data that weakens or refutes

- None

Data that is ambiguous

- None

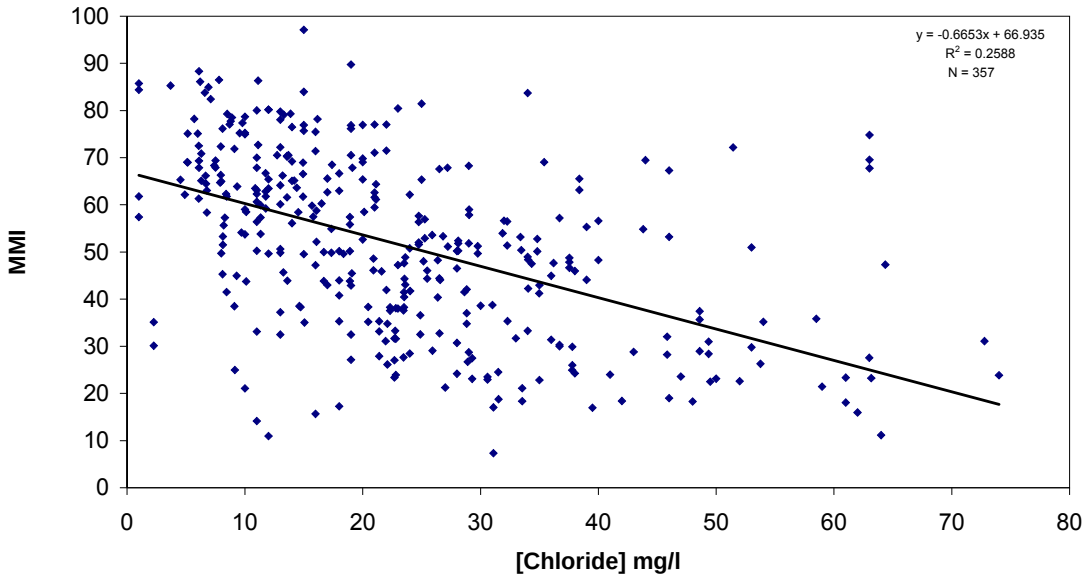


Figure 6. Relationship between chloride concentration (mg/L) and macroinvertebrate multimetric index (MMI). Benthic macroinvertebrate MMI data are from 357 DEP samples collected from 1998-2006. Chloride data were collected using YSI Model 600 XLM Sonde at the time of macroinvertebrate data collection.

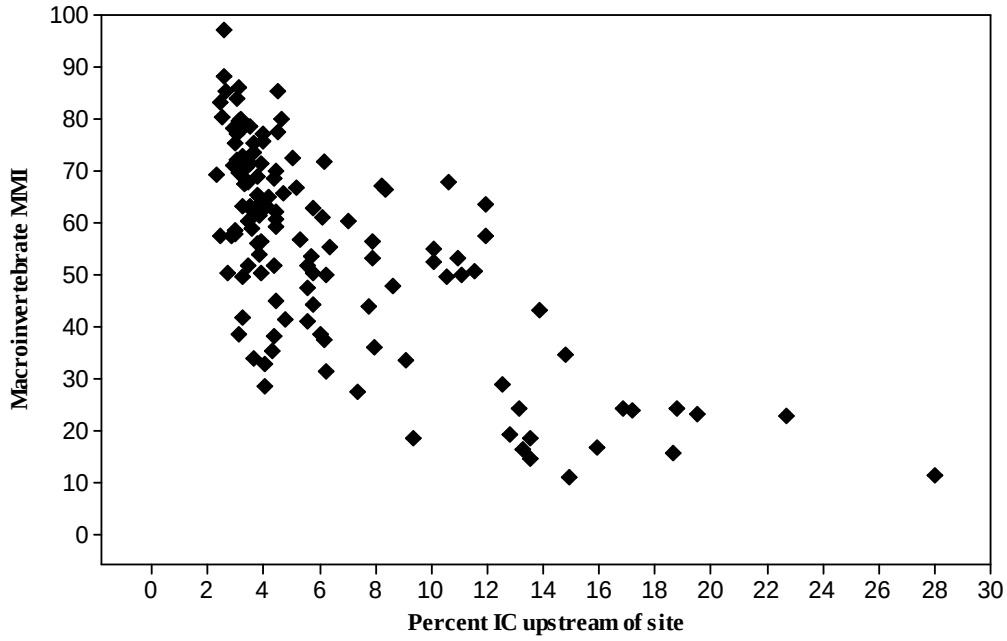


Figure 7. Relationship between impervious land cover (IC) and macroinvertebrate multimetric index (MMI). Data are from 125 DEP sites collected from 1998-2006 [6].

Toxic contamination as a candidate cause at Norwalk River at Branchville (Site ID 235)

Data that supports

- One out of 19 samples from three locations exceeds 25.7 *u*g/l (acute surface water criterion) for copper
- Eight out of 10 samples from 3 locations exceeds > 50 mg/L chloride (75th percentile of streams in southwest coastal basin) **
- Route 7 POTW contributes copper and chloride to receiving water
- 15% Impervious Cover in watershed support landuse contributions of copper and chloride

Data that weakens or refutes

- None

Data that is ambiguous

- Ponds in the watershed permitted to treat with copper sulfate for algae control

Toxic contamination as a candidate cause at Norwalk River at Old Mill Road (Site ID 241)

Data that supports

- Three out of 43 samples from 5 locations exceeds 65 *u*g/l (acute surface water criterion) for zinc
- 15 % Impervious Cover in watershed support landuse contributions to Zn
- Georgetown POTW contributes Zn to receiving water
- Groundwater sampling shows that zinc is the metal that most frequently exceeds Connecticut's Surface Water Protection Criteria from former Gilbert & Bennett that is undergoing remediation [7] (Data Support Photo 5)

Data that weakens or refutes

- None

Data that is ambiguous

- None

Data Support Photo 5. Norwalk River flowing through former Gilbert and Bennett Facility upstream of North Main Street, Georgetown, Connecticut.

Toxic contamination as a candidate cause at Norwalk River at Schenk's Island (Site ID 245)

Data that supports

- 14 % Impervious Cover in watershed support landuse contributions

Data that weakens or refutes

- No exceedances of water quality criterion observed

Data that is ambiguous

- None

Toxic contamination as a candidate cause at Norwalk River at Route 123 (Site ID 246)

Data that supports

- 16 % Impervious Cover in watershed support landuse contributions

Data that weakens or refutes

- None

Data that is ambiguous

- No exceedances of water quality criterion observed

Conceptual Model of Elevated Stream Temperature

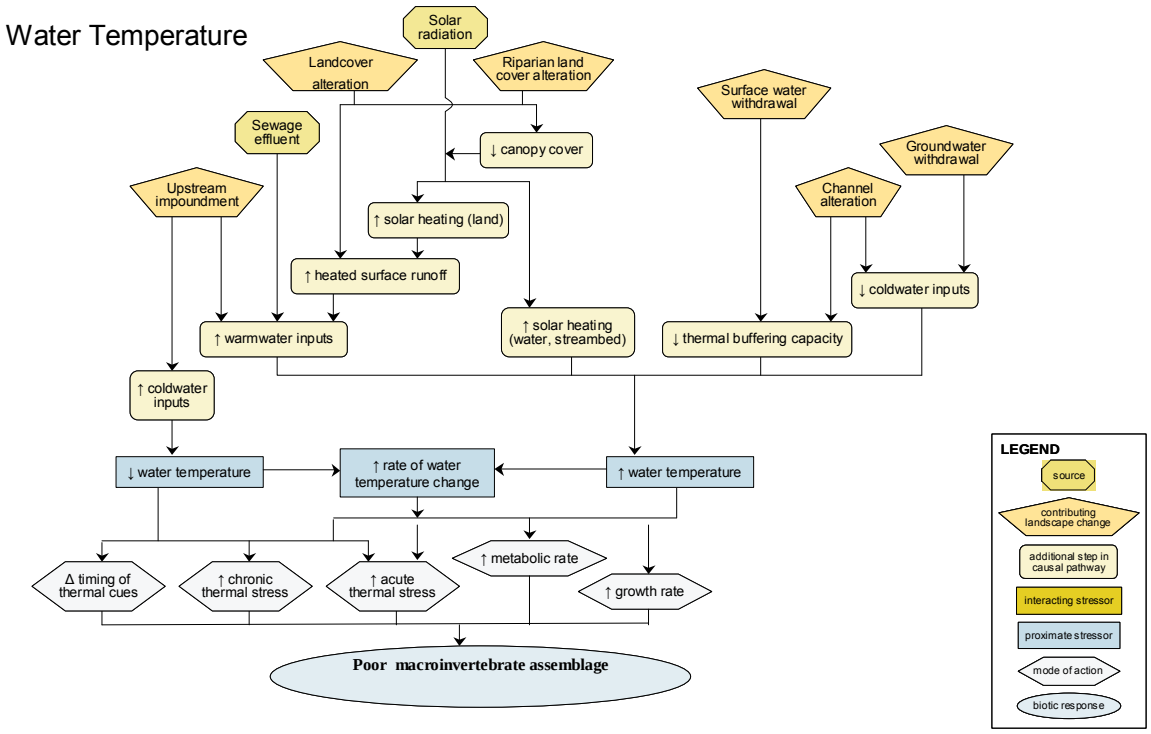


Figure 8. Conceptual model of elevated stream temperature as the cause of the poor benthic macroinvertebrate MMI scores.

<u>Elevated stream temperature as a candidate cause at Ridgefield Brook at Route 35 Fox Hill Condos (Site ID 1214)</u>

<u>Data that supports</u>

- 19% Impervious Cover in watershed supports episodic fluctuations in ambient stream temperatures
- YSI meter measurements show temperatures occasionally exceed 20 C. Maximum temperature of 8 trips was 21.48 C.

<u>Data that weakens or refutes</u>

- None

<u>Data that is ambiguous</u>

- Great Swamp likely contributes warm water to brook

Elevated stream temperature as a candidate cause at Norwalk River at Branchville (Site ID 235)

Data that supports

- Median August temperatures from continuous data loggers >20 C with extremes exceeding 25C [5]
- 15% Impervious Cover in watershed supports episodic fluctuations in ambient stream temperatures

Data that weakens or refutes

- None

Data that is ambiguous

- None

Elevated stream temperature as a candidate cause at Norwalk River at Old Mill Road (Site ID 241)

Data that supports

- Median August temperatures from continuous data loggers >20 C with extremes exceeding 25C[5]
- 15 % Impervious Cover in watershed supports episodic fluctuations in ambient stream temperatures
- Factory Pond Dam creates an impoundment on the Norwalk River that contributes to increasing stream temperatures (Figure 9,10; Table 2).
- Georgetown POTW contributes to increasing stream temperatures (Figure 9,10; Table 2).

Data that weakens or refutes

- None

Data that is ambiguous

- None

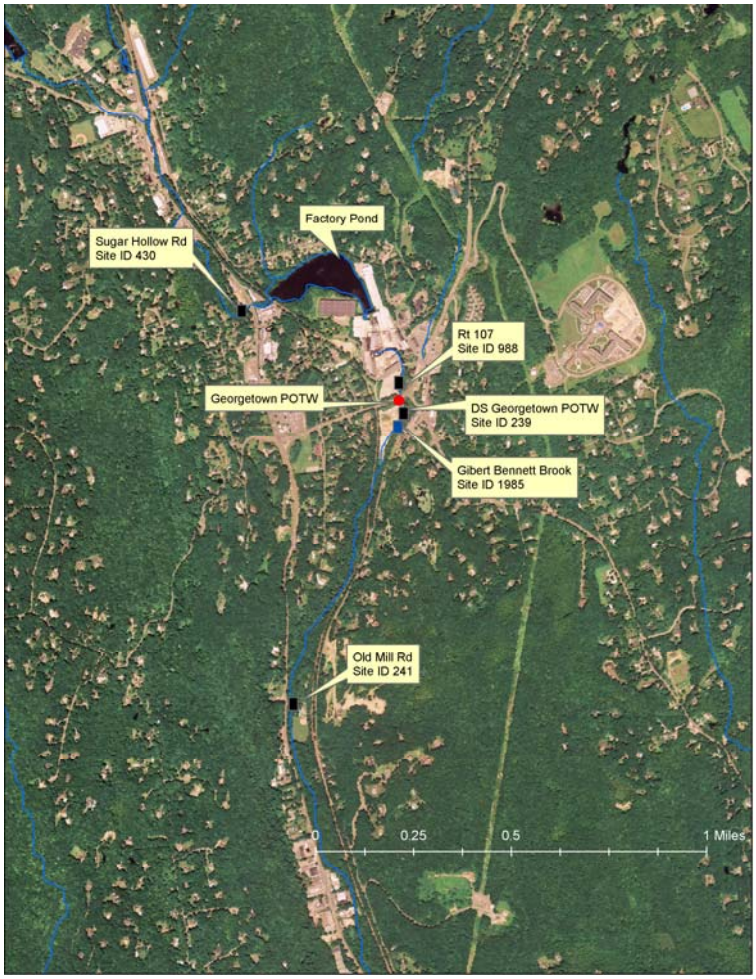


Figure 9. Map showing locations of monitoring locations in the Georgetown section of the Norwalk River. Monitoring sites are shown as black squares, the Georgetown sewage treatment plant is shown as a red circle, and tributaries are shown as a blue square.

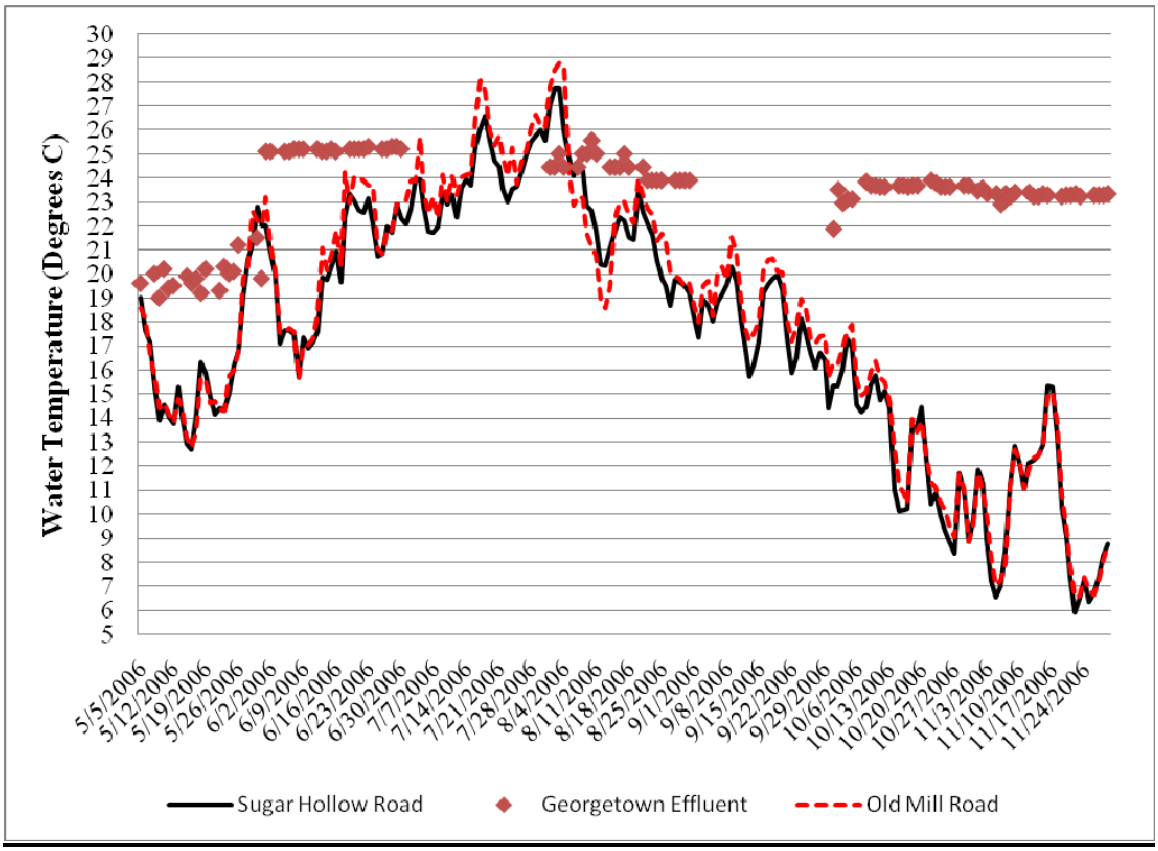
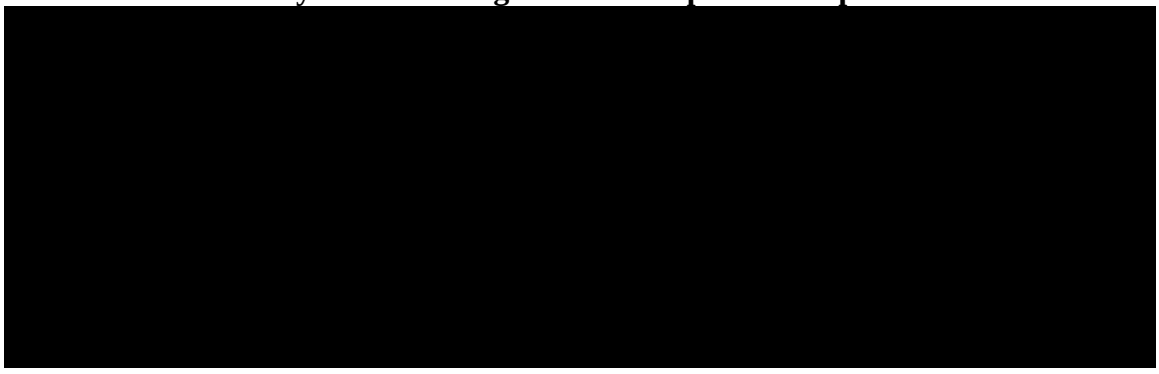


Figure 10. Average daily water temperature from monitoring locations in the Norwalk River upstream (Sugar Hollow Road) and downstream (Old Mill Road) of the Georgetown sewage treatment plant. Norwalk River temperatures were collected using Hobo continuous data loggers deployed by CTDEP and average daily effluent temperatures for Georgetown were obtained from facility monthly operating reports.

Table 2. Instantaneous water temperature from monitoring locations in Georgetown section of the Norwalk River. Sites are listed from upstream (Sugar Hollow Road) to downstream (Old Mill Road) and shows the spatial location of Factory Pond. The Georgetown sewage treatment plant is listed in red and tributaries are listed in blue. Data were collected by CTDEP using a YSI multi-parameter probe.



Elevated stream temperature as a candidate cause at Norwalk River at Schenk's Island (Site ID 245)

Data that supports

- Median August temperatures from continuous data loggers >20 C with extremes exceeding 25C [5]
- 14 % Impervious Cover in watershed supports episodic fluctuations in ambient stream temperatures

Data that weakens or refutes

- None

Data that is ambiguous

- Strong Pond Dam (Merwin's Meadow Dam) and Cannon Pond Dam create impoundment on the Norwalk River that likely contributes to increasing stream temperatures

Elevated stream temperature as a candidate cause at Norwalk River at Route 123 (Site ID 246)

Data that supports

- 16 % Impervious Cover in watershed supports episodic fluctuations in ambient stream temperatures
- YSI meter measurements show temperatures exceed 20 C. Maximum temperature of 8 trips was 25.70 C.

Data that weakens or refutes

- None

Data that is ambiguous

- Winnipauk Mill Pond Dam and Flock Process Dam create impoundments on the Norwalk River that likely contribute to increasing stream temperatures

Conceptual Model of Low Dissolved Oxygen

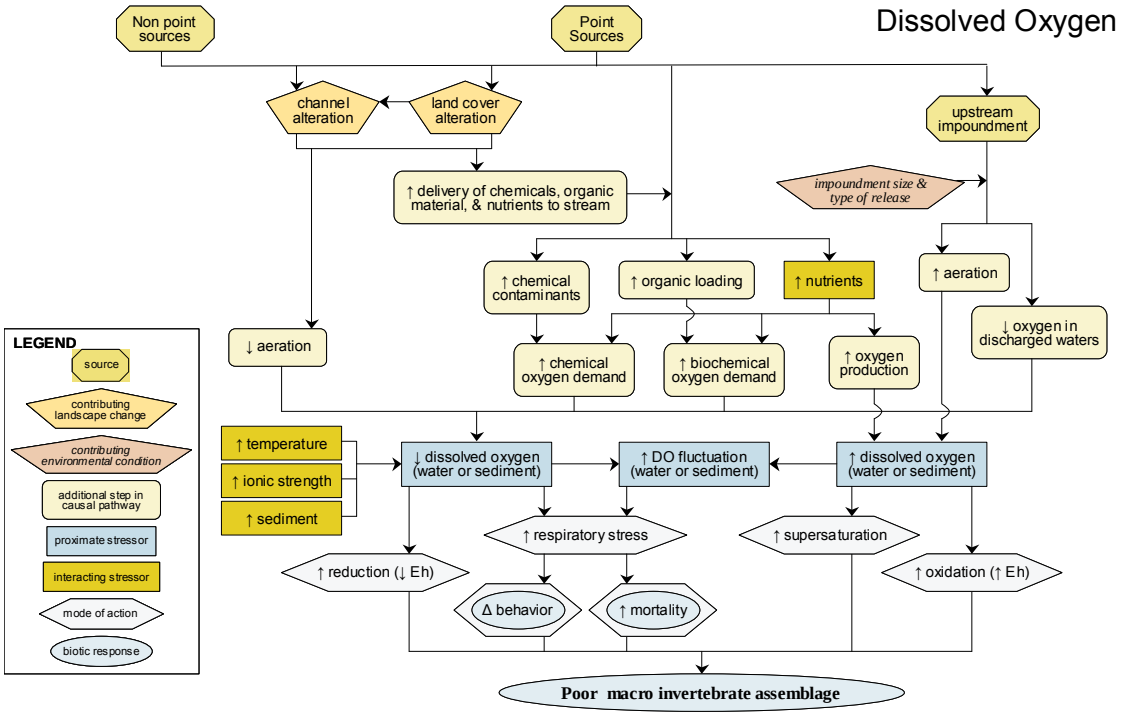


Figure 11. Conceptual model of low dissolved oxygen as the cause of the poor benthic macroinvertebrate MMI scores.

<u>Low dissolved oxygen as a candidate cause at Ridgefield Brook at Route 35 Fox Hill Condos (Site ID 1214)</u>

<u>Data that supports</u>

- 19% Impervious Cover in watershed support landuse contributions to deceasing dissolved oxygen in Ridgefield Brook
- Great Swamp likely contributes pulses of low dissolved oxygen to brook
- Elevated total phosphorus concentrations [5] create optimal conditions for aquatic plant growth and could exacerbate dissolved oxygen when plants die and decay

<u>Data that weakens or refutes</u>

- Dissolved oxygen levels during routine data collection by CTDEP were never less than the minimum dissolved oxygen standard of 5.0 mg/l [5]

<u>Data that is ambiguous</u>

- None

Low dissolved oxygen as a candidate cause at Norwalk River at Branchville (Site ID 235)

Data that supports

- 15% Impervious Cover in watershed support landuse contributions to deceasing dissolved oxygen to the Norwalk River
- Elevated total phosphorus concentrations[5] create optimal conditions for aquatic plant growth and could exacerbate dissolved oxygen when plants die and decay

Data that weakens or refutes

- Dissolved oxygen levels during routine data collection by CTDEP were never less than the minimum dissolved oxygen standard of 5.0 mg/l [5]

Data that is ambiguous

- None

Low dissolved oxygen as a candidate cause at Norwalk River at Old Mill Road (Site ID 241)

Data that supports

- 15 % Impervious Cover in watershed support landuse contributions to deceasing dissolved oxygen in Norwalk River
- Continuous YSI monitoring data collected by Harbor Watch River Watch in August 2006 shows dissolved oxygen below 5.0 mg/L (Figure 12)
- Elevated total phosphorus[5] concentrations create optimal conditions for aquatic plant growth and could exacerbate dissolved oxygen when plants die and decay

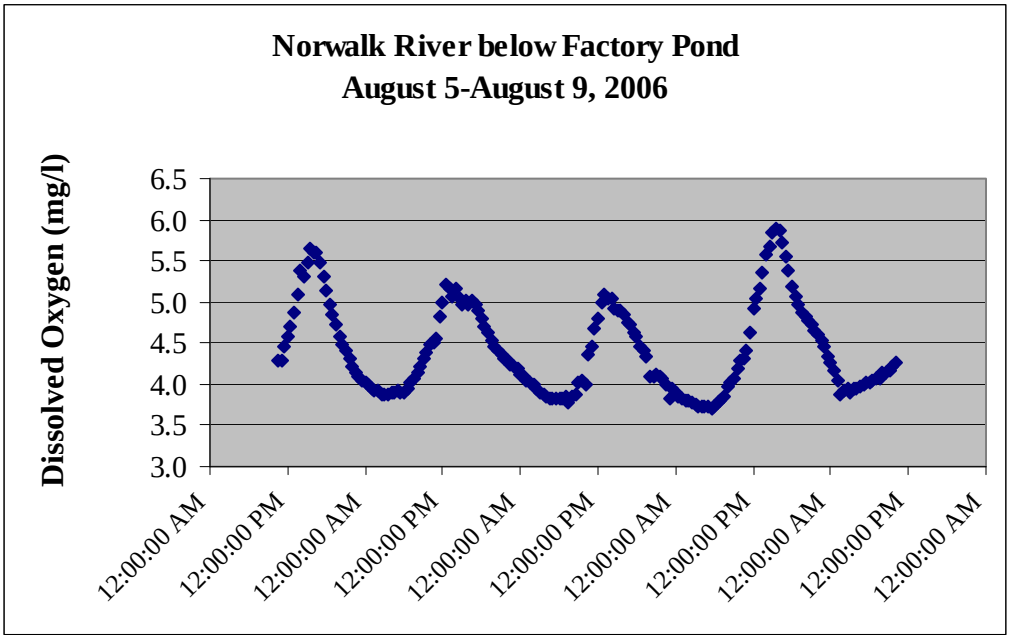


Figure 12. Dissolved oxygen profile in the Norwalk River below Factory Pond taken from August 5-9, 2006 with YSI Sonde.

Data that weakens or refutes

- None

Data that is ambiguous

- Factory Pond Dam creates an impoundment on the Norwalk River that could contributes pulses of low dissolved oxygen to the Norwalk River

Low dissolved oxygen as a candidate cause at Norwalk River at Schenk's Island (Site ID 245)

Data that supports

- 14 % Impervious Cover in watershed support landuse contributions to deceasing dissolved oxygen in Norwalk River
- Elevated total phosphorus concentrations[5] create optimal conditions for aquatic plant growth and could exacerbate dissolved oxygen when plants die and decay

Data that weakens or refutes

- Dissolved oxygen levels during routine data collection by CTDEP were never less than the minimum dissolved oxygen standard of 5.0 mg/l [5]

Data that is ambiguous

- Strong Pond Dam (Merwin's Meadow Dam) and Cannon Pond Dam create impoundments on the Norwalk River that likely contribute pulses of low dissolved oxygen to Norwalk River

Low dissolved oxygen as a candidate cause at Norwalk River at Route 123 (Site ID 246)

Data that supports

- 16 % Impervious Cover in watershed support landuse contributions to deceasing dissolved oxygen in Norwalk River
- Elevated total phosphorus concentrations create optimal conditions for aquatic plant growth and could exacerbate dissolved oxygen when plants die and decay

Data that weakens or refutes

- Dissolved oxygen levels during routine data collection by CTDEP were never less than the minimum dissolved oxygen standard of 5.0 mg/l [5]

Data that is ambiguous

- Winnipauk Mill Pond Dam and Flock Process Dam create impoundments on the Norwalk River that could contribute pulses of low dissolved oxygen to the Norwalk River

Conceptual Model of Flow Alteration

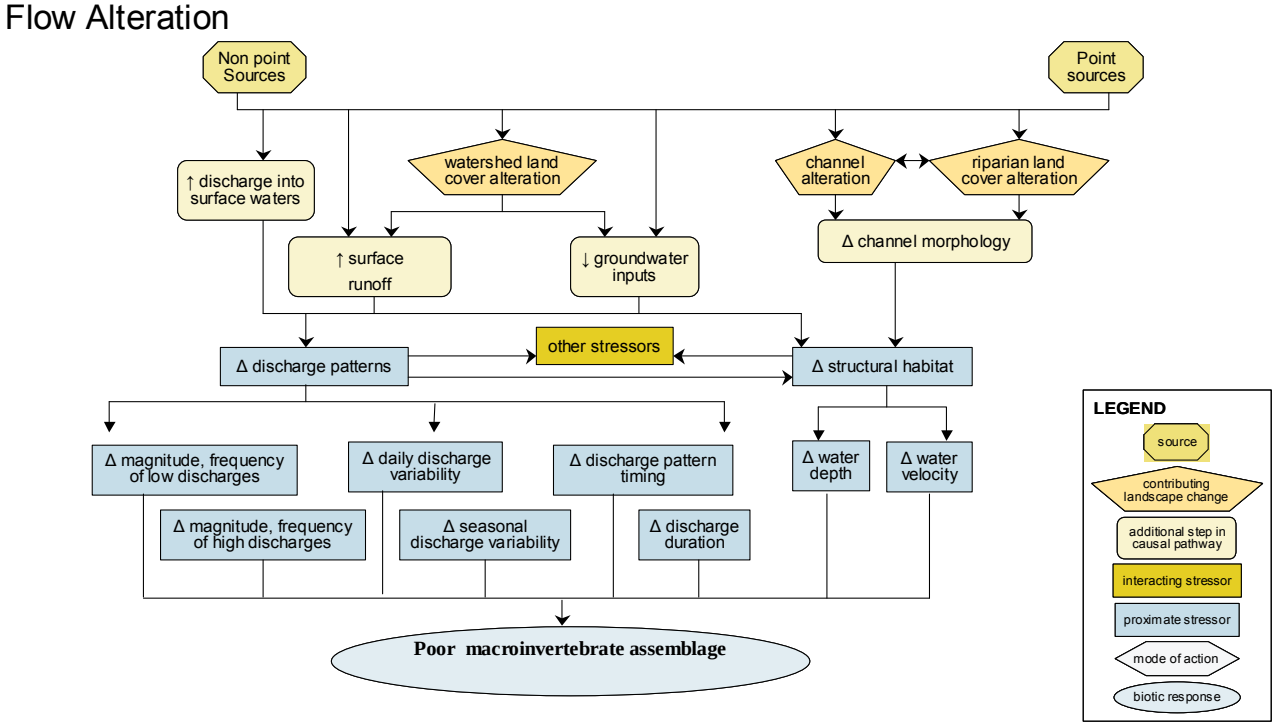


Figure 13. Conceptual model of flow alteration as the cause of the low benthic macroinvertebrate MMI scores.

<u>Flow Alteration as a candidate cause at Ridgefield Brook at Route 35 Fox Hill Condos (Site ID 1214)</u>

<u>Data that supports</u>

- 19% Impervious Cover in watershed contributes to an altered unnatural hydrograph by increasing stormwater runoff and decreasing groundwater recharge in Ridgefield Brook
- Ridgefield Main POTW contributes unnatural flow to receiving water

<u>Data that weakens or refutes</u>

- None

<u>Data that is ambiguous</u>

- None

Flow Alteration as a candidate cause at Norwalk River at Branchville (Site ID 235)

Data that supports

- 15% Impervious Cover in watershed contributes to an altered unnatural hydrograph by increasing stormwater runoff and decreasing groundwater recharge in the Norwalk River
- Route 7 POTW contributes unnatural flow to receiving water

Data that weakens or refutes

- None

Data that is ambiguous

- None

Flow Alteration as a candidate cause at Norwalk River at Old Mill Road (Site ID 241)

Data that supports

- 15 % Impervious Cover in watershed contributes to an altered unnatural hydrograph by increasing stormwater runoff and decreasing groundwater recharge in the Norwalk River
- Georgetown POTW contributes unnatural flow to receiving water

Data that weakens or refutes

- None

Data that is ambiguous

- None

Flow Alteration as a candidate cause at Norwalk River at Schenk's Island (Site ID 245)

Data that supports

- 14 % Impervious Cover in watershed contributes to an altered unnatural hydrograph by increasing stormwater runoff and decreasing groundwater recharge in the Norwalk River

Data that weakens or refutes

- None

Data that is ambiguous

- None

Flow Alteration as a candidate cause at Norwalk River at Route 123 (Site ID 246)

Data that supports

- 16 % Impervious Cover in watershed contributes to an altered unnatural hydrograph by increasing stormwater runoff and decreasing groundwater recharge in the Norwalk River

Data that weakens or refutes

- None

Data that is ambiguous

- None

Stressor ID Summary

The Norwalk River watershed has a long history of human settlement that has impacted water quality. The transportation infrastructure including railroad and roads and proximity to New York City has made this a densely populated watershed. Roads parallel and cross the entire watershed and riparian buffers are non-existent in many locations, particularly in the lower watershed.

The watershed can be divided into 3 broad segments. The upper watershed from Ridgefield Brook to Route 7 POTW is low gradient and is contains the Great Swamp in Ridgefield. The middle part of the watershed - from Route 7 to Schenk's Island is steeper and the river maintains riverine characteristics, and has a DEP Trout Management Area. The lower watershed from below Schenk's Island to Route 123 is very urbanized along the river corridor. The watershed study area has 3 sewage treatment plants- Ridgefield Main, Route 7, and Georgetown. In addition, there is a Brownfield site being redeveloped at the former Gilbert and Bennett Facility in Georgetown under the guidance of the DEP Remediation program.

The entire study watershed shows evidence of anthropogenic enrichment and stresses associated with urbanization (Figure 14); however, it is unknown whether anthropogenic enrichment is a contributing cause to the poor MMI scores. Data analyzed by CTDEP [8] have not shown strong correlations between macroinvertebrate scores and total phosphorus concentrations (Figure 15). Nevertheless, this Stressor ID summary provides evidence that total phosphorus concentration in the Norwalk River are most likely influenced by human activities and are higher than would normally occur under natural conditions.

The percent impervious cover in the study watershed are at levels that have been shown to be detrimental to aquatic life as measured by MMI scores in other Connecticut watersheds. Impervious cover acts as a surrogate measure of the direct stressors associated with urbanization documented in this analysis (altered flow regime, elevated temperatures, low dissolved oxygen, and chloride) and several of these stressors may be interacting to affect aquatic life in the Norwalk River. In the upper watershed, the heavy metals copper and zinc may be contributing to degradation of aquatic life. In addition, zinc may be contributing to poor aquatic life in the vicinity of known contaminated groundwater sources.

Probable Cause of Impairment:

Poor Macroinvertebrate MMI Scores -Complex array of pollutants transported by stormwater runoff. Copper and zinc from stormwater water, point sources, and groundwater.

Anthropogenic enrichment - Total Phosphorus

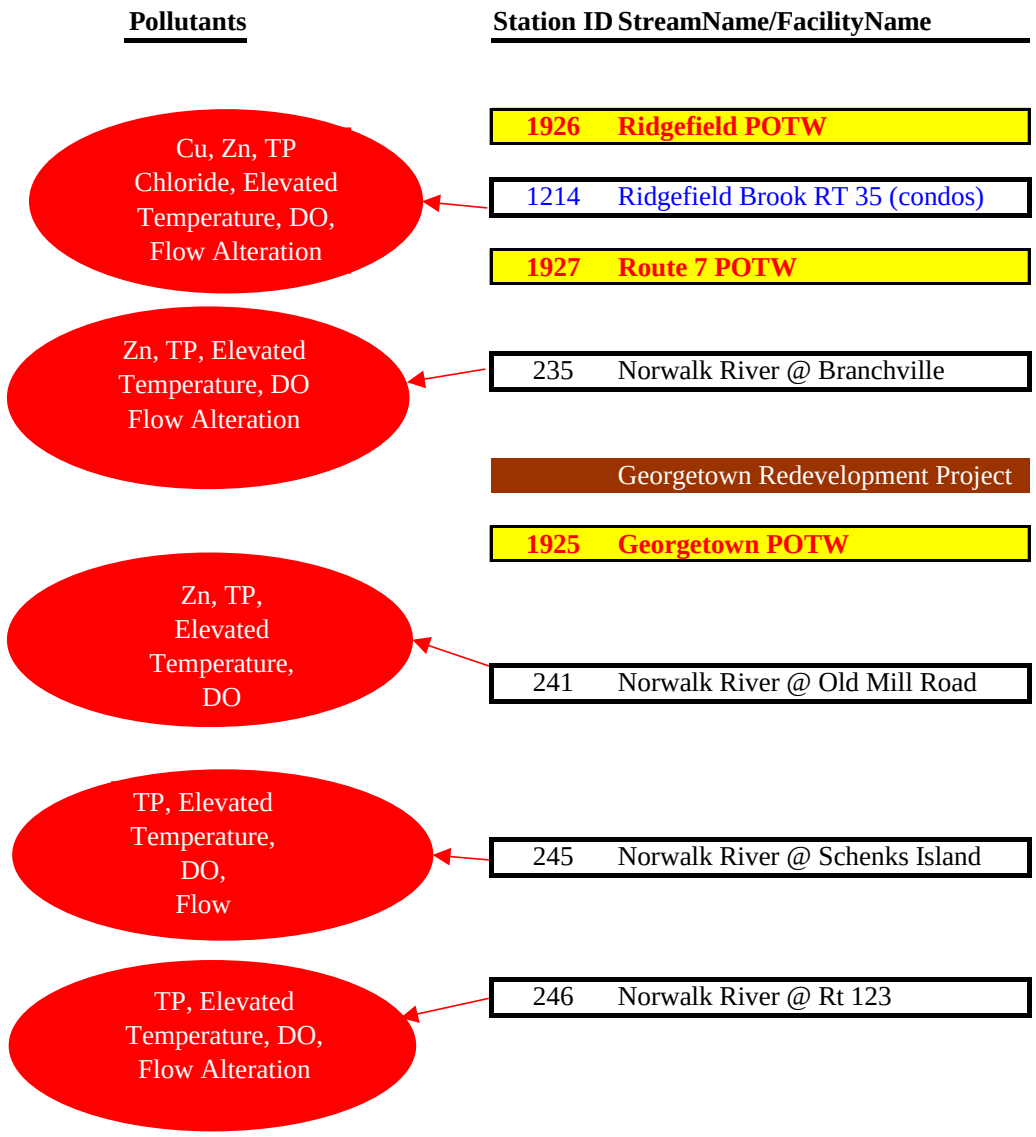


Figure 14. Summary of stressors in the Norwalk River watershed.

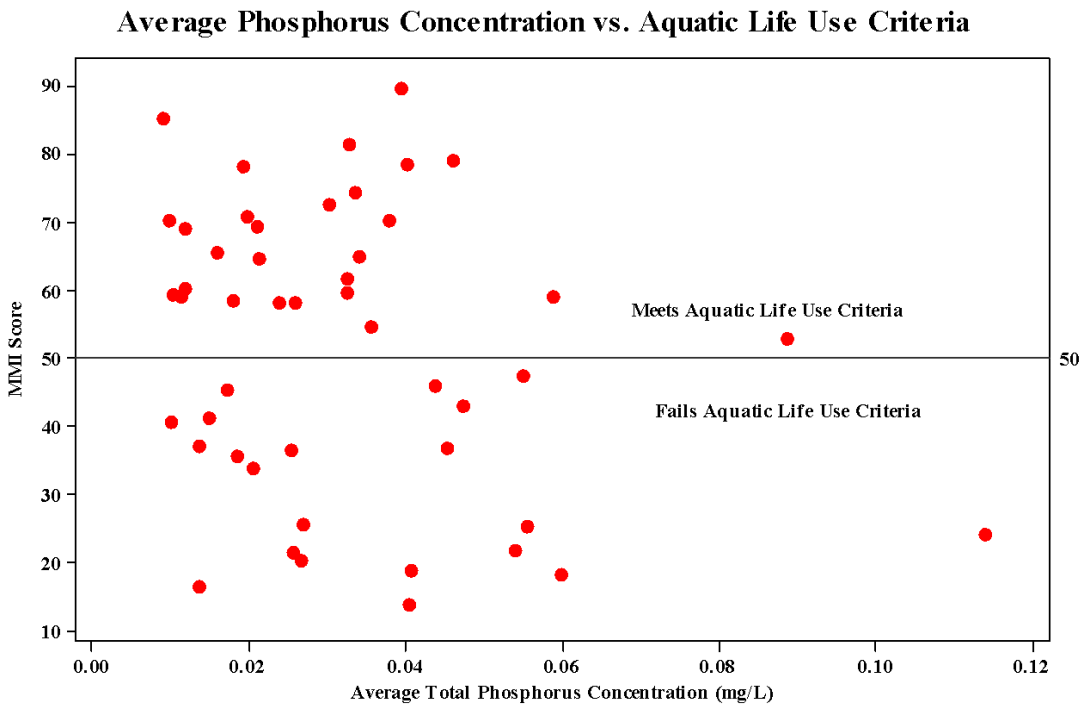


Figure 15. Relationship between average total phosphorus concentration and macroinvertebrate multimetric index score (MMI) from 48 streams in Connecticut. MMI is one of the factors used to determine aquatic life support designated use. A MMI > 50 indicates a site meets minimum aquatic life use criteria and < 50 indicates a site fails minimum aquatic life use criteria.

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