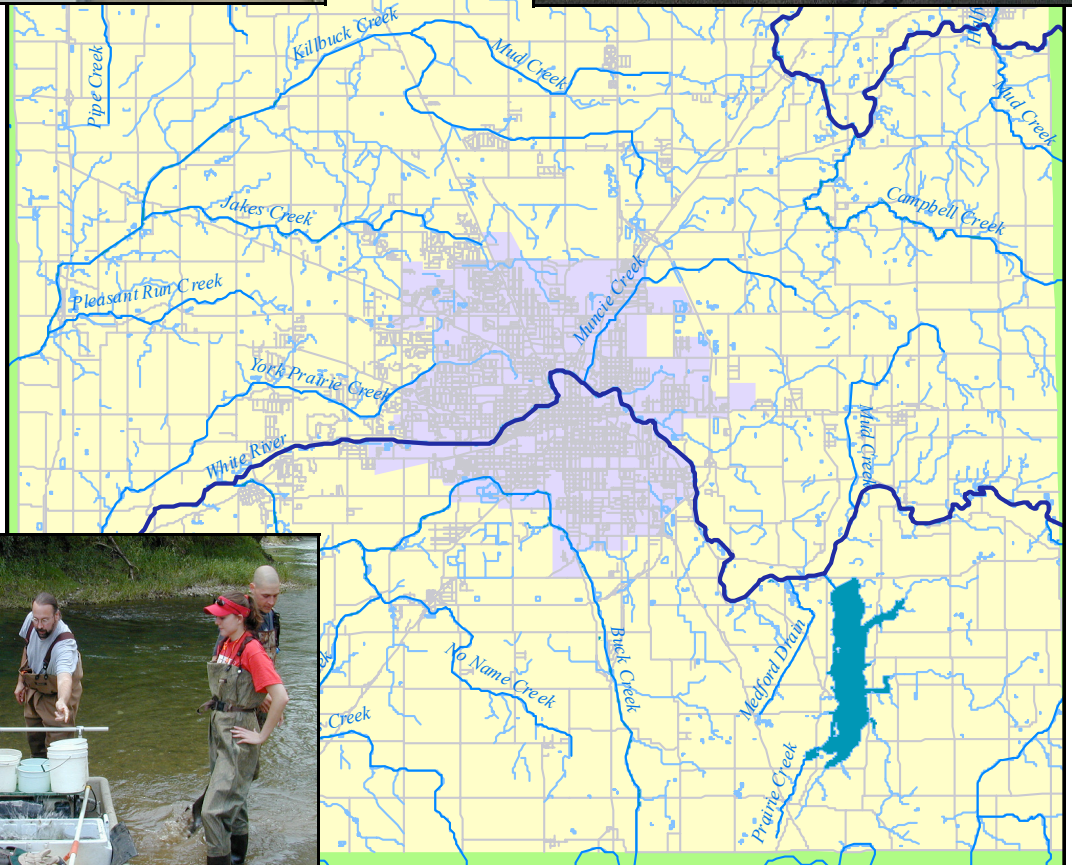


Supplement: GIS Mapping of Muncie and Delaware County Water Quality Information



**Muncie Sanitary District
Bureau of Water Quality
2006**



The Muncie Bureau of Water Quality (BWQ) was founded in 1972 by John Craddock. Today, the BWQ is one of the oldest local water pollution control agencies in the United States. Its continuing goal is to improve water quality of the White River and its tributaries for the citizens of Muncie and East Central Indiana.

The Bureau conducts both chemical and biological monitoring of local waterways. Chemical assessments investigate a range of parameters including nutrients (ammonia, nitrate, phosphate), toxic metals (chromium, zinc, lead), suspended solids and *E. coli*. Biological monitoring includes assessments of fish, aquatic macroinvertebrates (insects), and mussels. After conducting assessments, the Bureau produces annual comprehensive evaluations of aquatic ecosystem health and overall water quality.



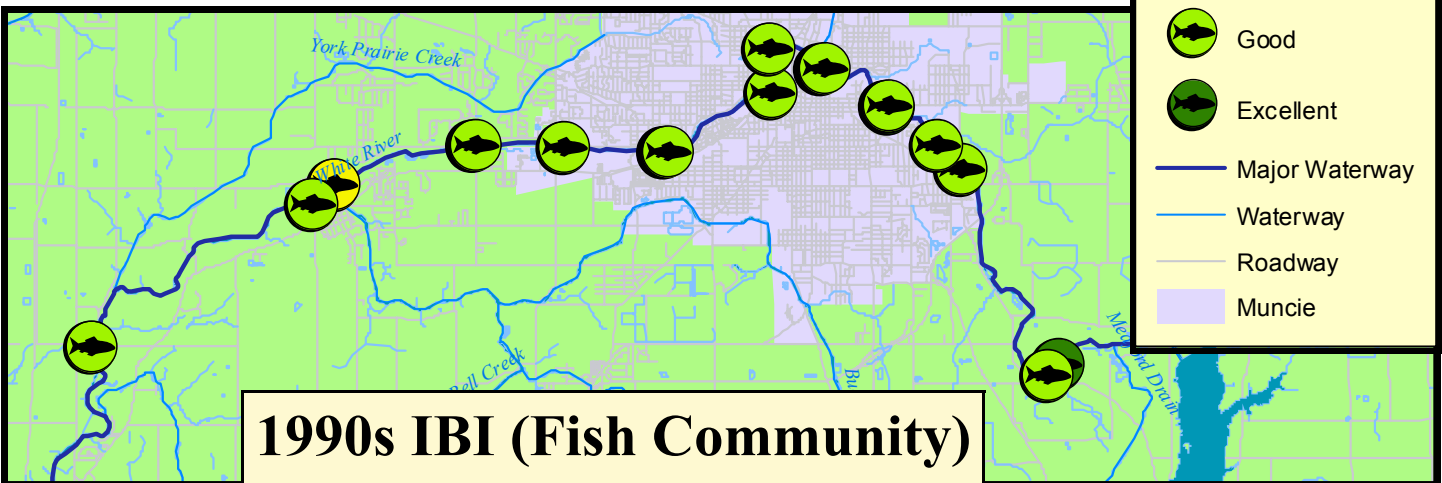
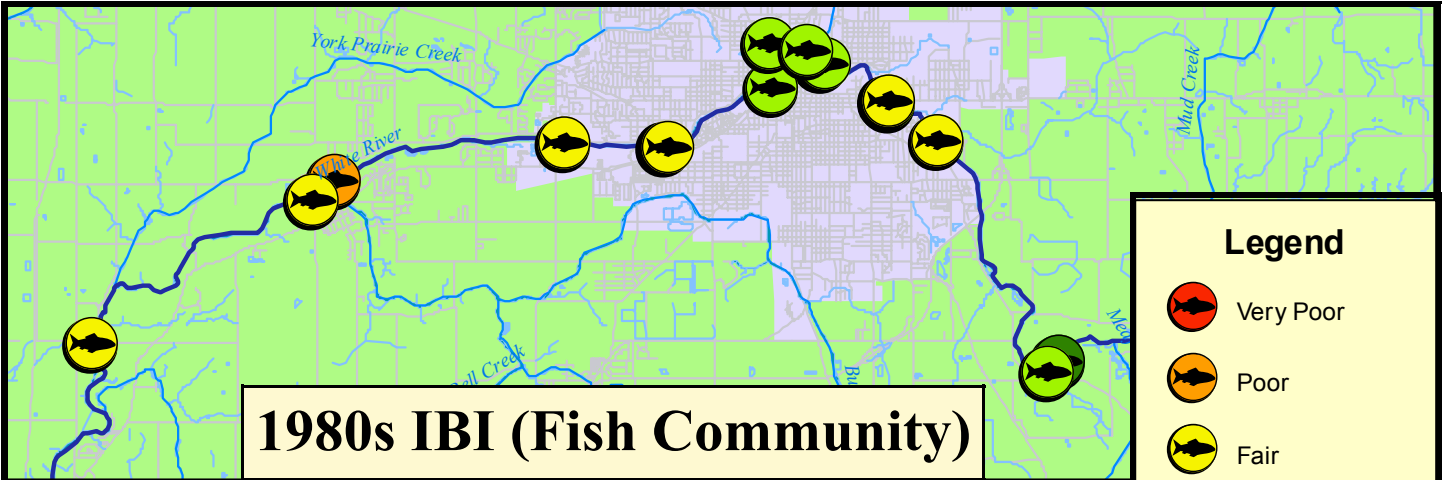
The Bureau of Water Quality, through a grant provided by the Community Foundation of Muncie and Delaware County, designed a project with the intention to create a system whereby the public can readily access water quality information for the city of Muncie and Delaware County. The result of this project is a redesigned BWQ website, complete with interactive and static maps (displaying chemical and biological change over the four decades the Bureau has been in existence), a timeline of the West Fork White River, raw chemical and biological data for several White River sites, and several past annual reports (available for download). The BWQ intends for its website, including this supplement, to be valuable to visitors of all backgrounds, both the general public and professionals in the field.



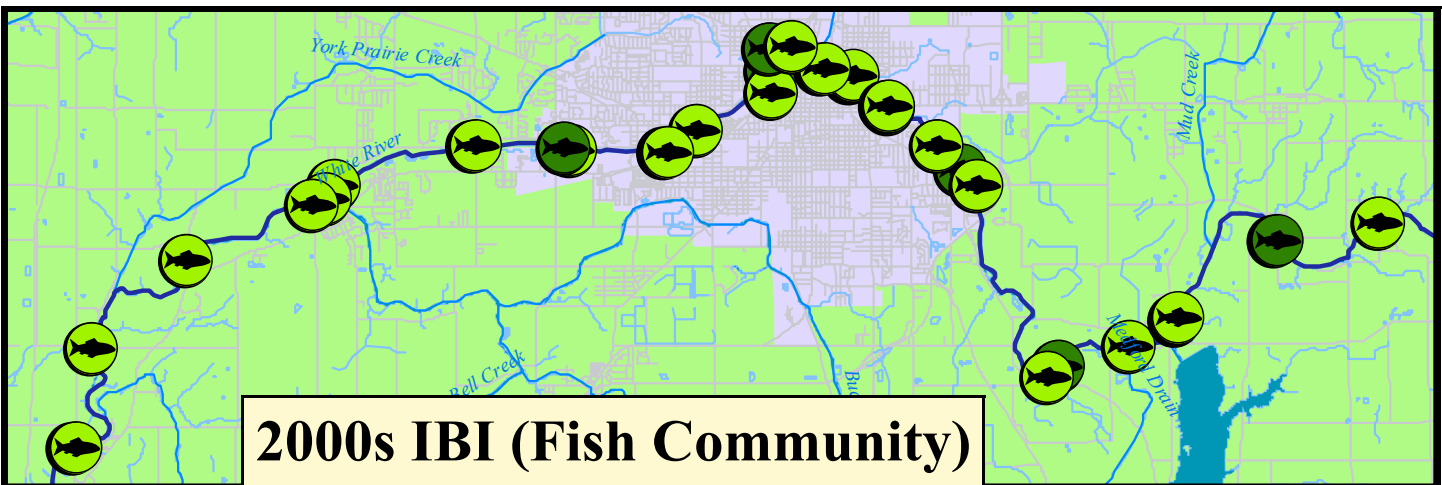
This supplement, *GIS Mapping of Muncie and Delaware County*, provides static maps that depict both chemical and biological parameters. Maps depicting both trends over time and current water quality are presented.



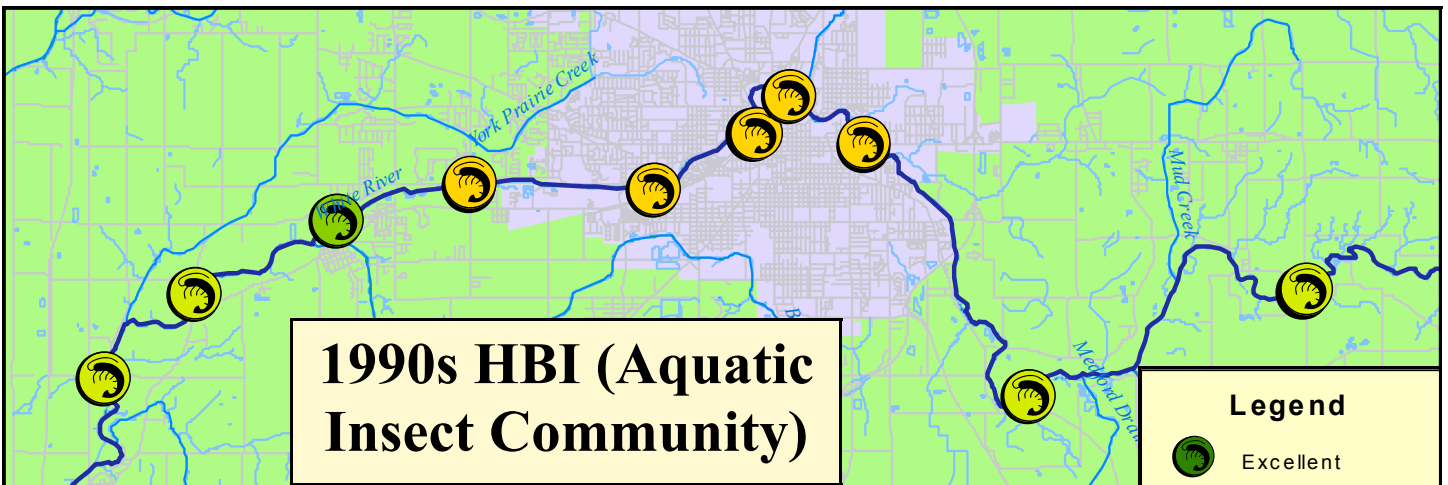
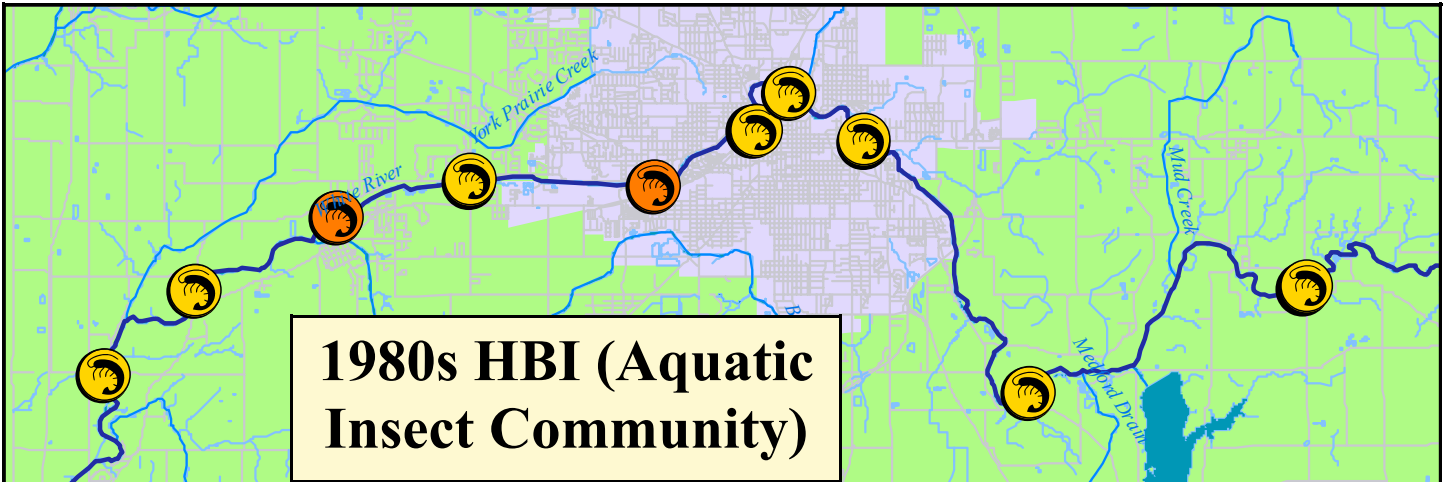
BWQ: White River IBI (Fish Community) Assessment



While the BWQ conducted some fish community sampling during the 1970s, the collection methods and equipment used during this period makes comparisons inaccurate. Since 1990, fish community quality has been determined through the use of Ohio EPA's guidelines for determination of biotic integrity scores. As equipment and methods were comparable between the 1990s and 1980s, Index of Biotic Integrity (IBI) scores were back-calculated for the 1980s. Maps on this page indicate there has been significant improvement in fish community health since the 1980s. In particular, White River sites located south of the Muncie wastewater treatment plant have improved greatly, averaging *fair/poor* in the 1980s to *good/excellent*. Sites within Muncie have also improved, from *fair/good* to *fair/excellent*.



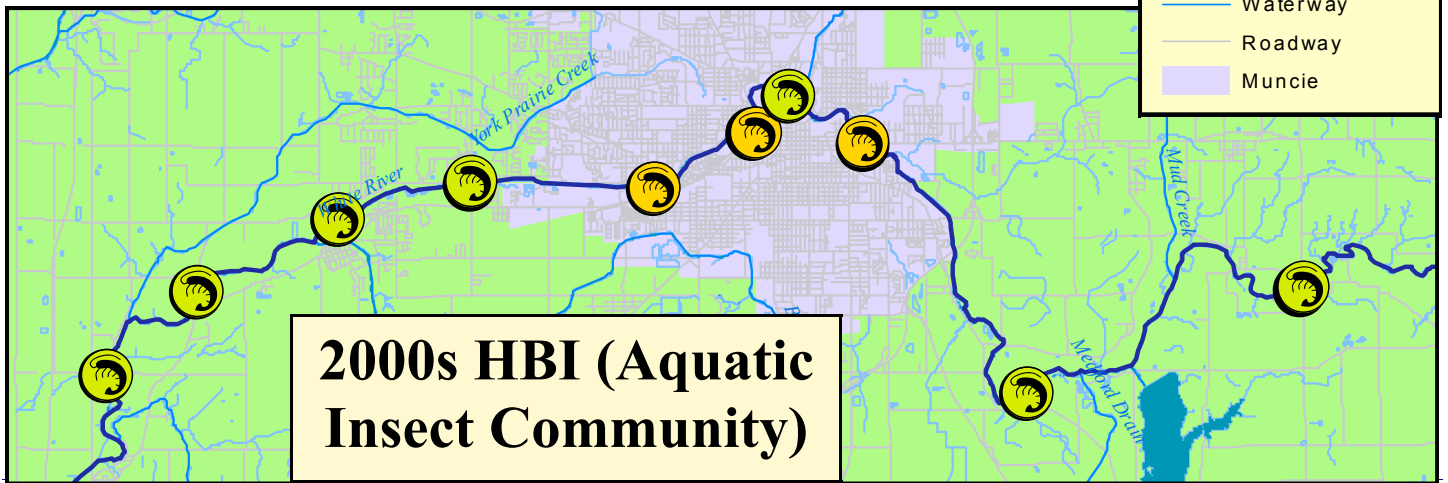
BWQ: White River HBI (Aquatic Insect Community) Assessment



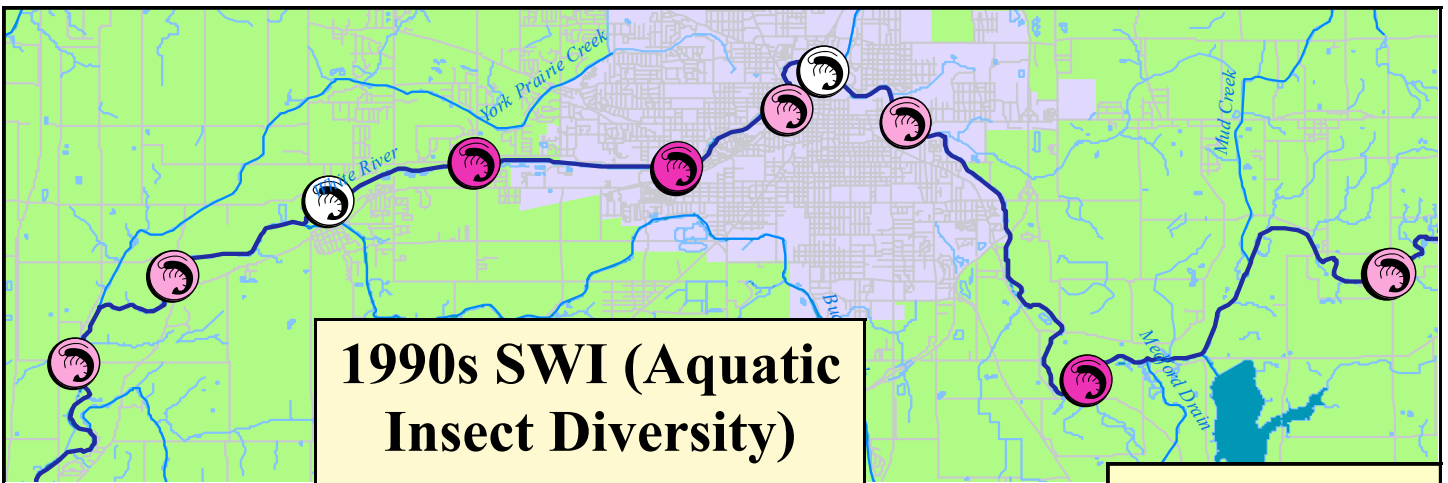
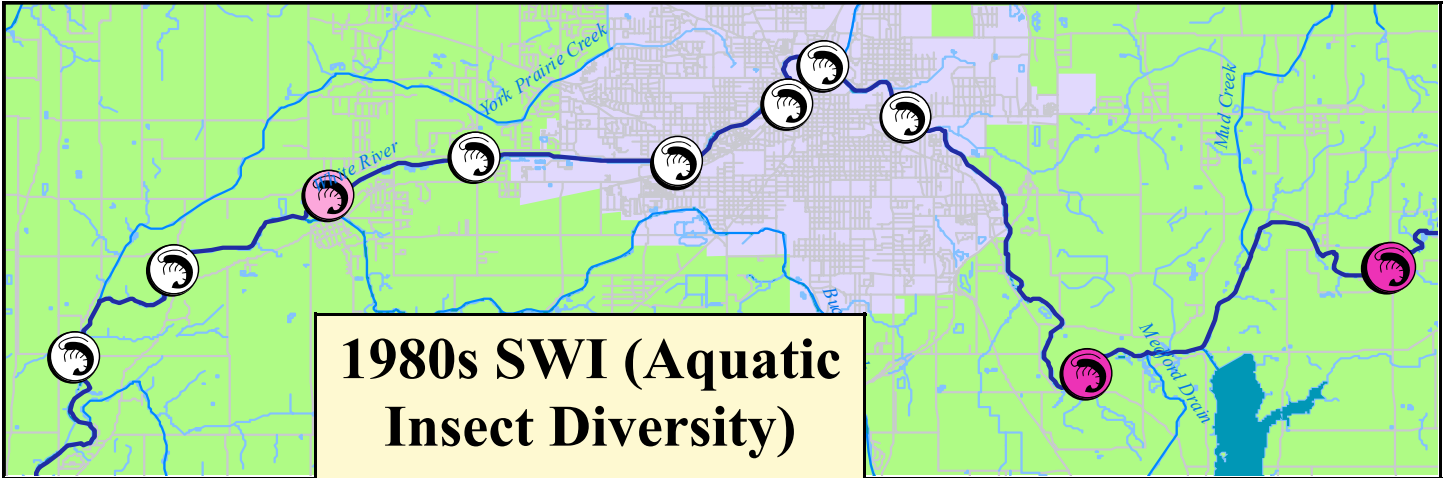
The Bureau has assessed macroinvertebrate (aquatic insect) community health since the mid-1970s. However, continuous data with reliable sampling techniques (to subsequent decades) is not available until the 1980s. Maps here depict changes in aquatic insect community health since the 1980s using the Hilsenhoff Biotic Index (HBI). Overall, community health averaging *fairly poor/fair* in the 1980s has improved to *fair/good* in the 2000s. Note that, while these maps display decade averages, several sites for a single sampling season) received a *very good* ranking in the 2000s.

Legend

- Excellent
- Very Good
- Good
- Fair
- Fairly Poor
- Poor
- Major Waterway
- Waterway
- Roadway
- Muncie










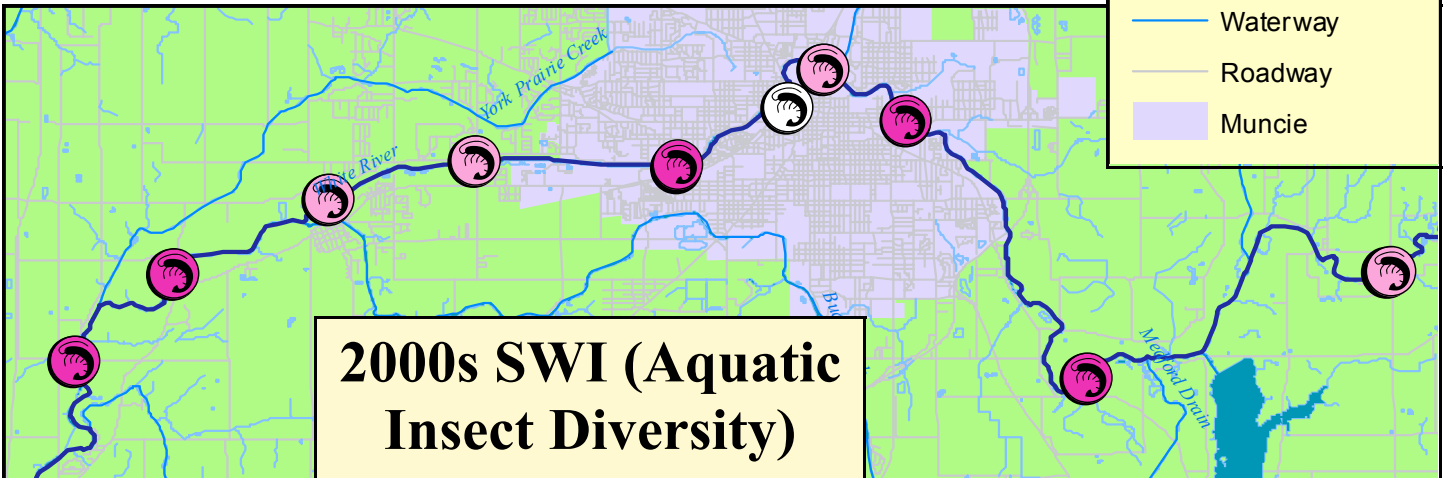
BWQ: White River SWI (Aquatic Insect Diversity) Assessment



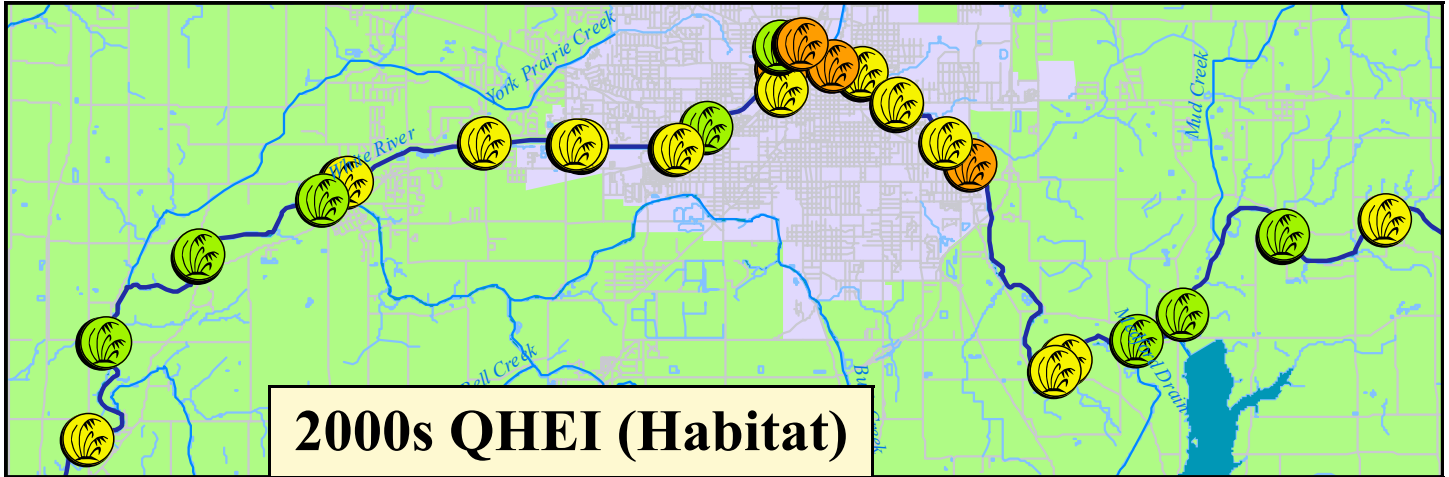
In addition to the HBI, the BWQ has assessed aquatic insect diversity using the Shannon-Weaver Index (SWI). This index measures both diversity and evenness within insect communities. Since there is no range of acceptable or unacceptable values for the SWI, the maps shown only indicate the change in SWI scores since the 1980s. SWI scores have increased at most sites. Notable increases have occurred within the Muncie city limits as well as downstream of the Muncie wastewater treatment plant. In the 1980s, seven of the ten sites were rated *below average*. Today, only one of the ten sites is rated *below average*.

Legend

-  Above Average
-  Average
-  Below Average
-  Major Waterway
-  Waterway
-  Roadway
-  Muncie



BWQ: White River QHEI (Habitat) Assessment



The Qualitative Habitat Evaluation Index (QHEI) measures variables pertinent to biological potential. These variables include riparian zone (area immediately adjacent to the waterway), channel morphology, substrate (the composition of the waterway channel), cover, and riffle-run-pool complexes. This assessment is valuable as it allows the Bureau to determine the contribution of habitat alterations versus the contributions of chemical pollution. QHEI scores can be compared with IBI and HBI scores to determine if impairment is caused by chemical pollution or poor habitat availability.

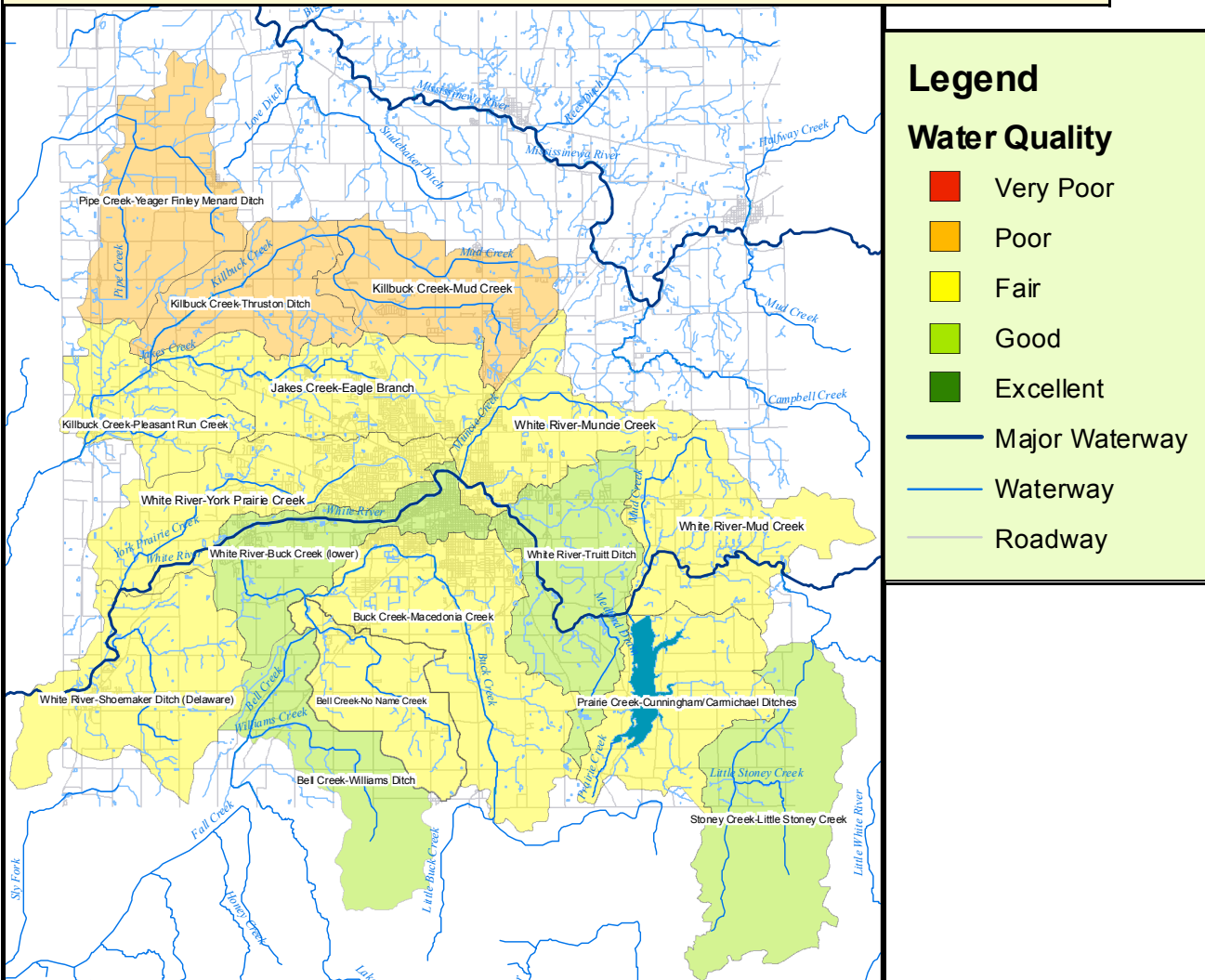
Severely altered habitats, caused by channelization, clear-cutting, and dredging, have low QHEI scores and, as a result, would be expected to have poor fish and insect community health. However, high quality habitat, with poor aquatic community health, would indicate possible chemical contamination.

As this map displays, no BWQ White River sampling site received an excellent habitat score. These scores reflect habitat loss primarily caused by channelization and riparian removal. The most frequent site rating was *fair*, followed by *good*. Several sites received a *poor* rating, as well.

Legend

-  Very Poor
-  Poor
-  Fair
-  Good
-  Excellent
-  Major Waterway
-  Waterway
-  Roadway
-  Muncie

Generalized Water Quality Within Subwatersheds of the West Fork White River Based on Fish Community Scores (IBI)



Legend

Water Quality

Very Poor

Poor

Fair

Good

Excellent

Major Waterway

Waterway

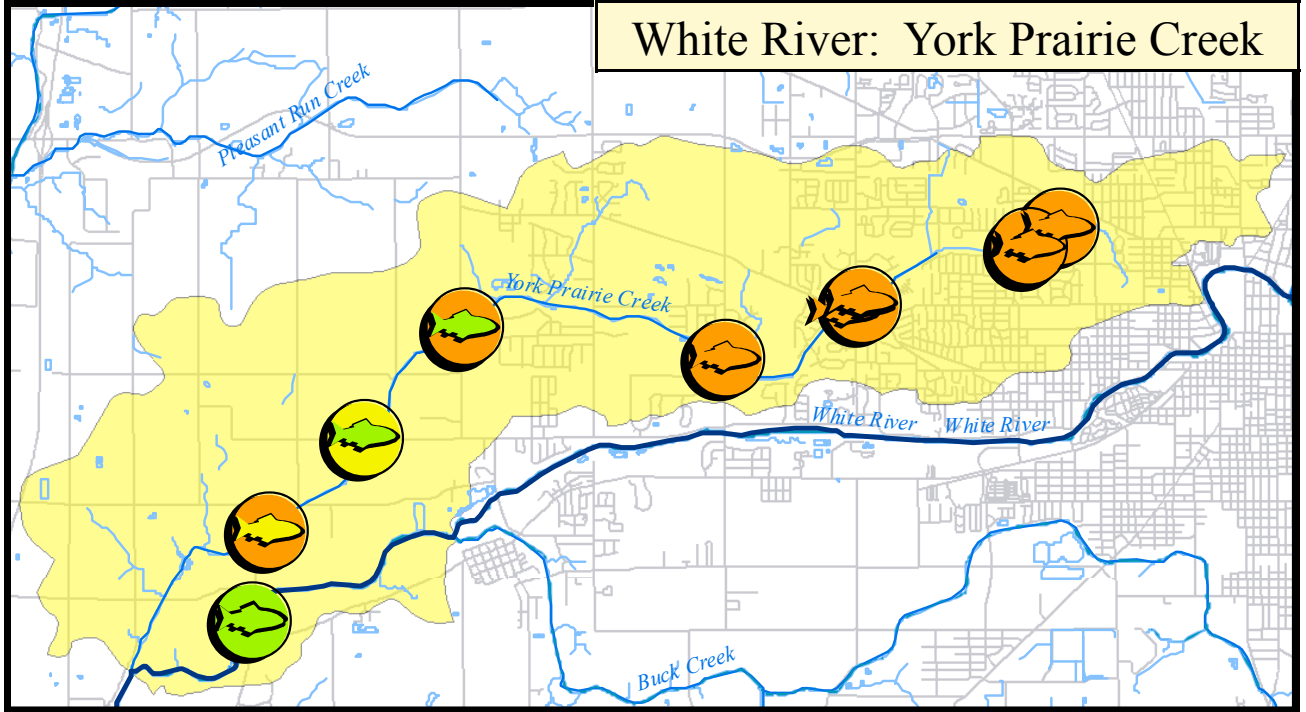
Roadway

This map, as well as the maps on the following pages, indicates water quality within several subwatersheds of the West Fork White River. Scoring was determined using only IBI (fish community) scores. IBI scores were selected as this assessment was present for each of the above subwatersheds. Chemistry and insect monitoring are primarily limited to the city of Muncie. Therefore, to compare all of the above subwatersheds, only IBI scores were selected. For each subwatershed, IBI scores taken since 2000 were averaged. This date was selected as all sites are not assessed in the same sampling season. The average subwatershed IBI score was then ranked using the Ohio EPA guidelines already applied in BWQ IBI scoring.

As shown above, no subwatershed received a ranking of *very poor* or *excellent*. Three subwatersheds received a ranking of *poor*. Nine subwatersheds received a ranking of *fair*. Three subwatersheds were rated as *good*.

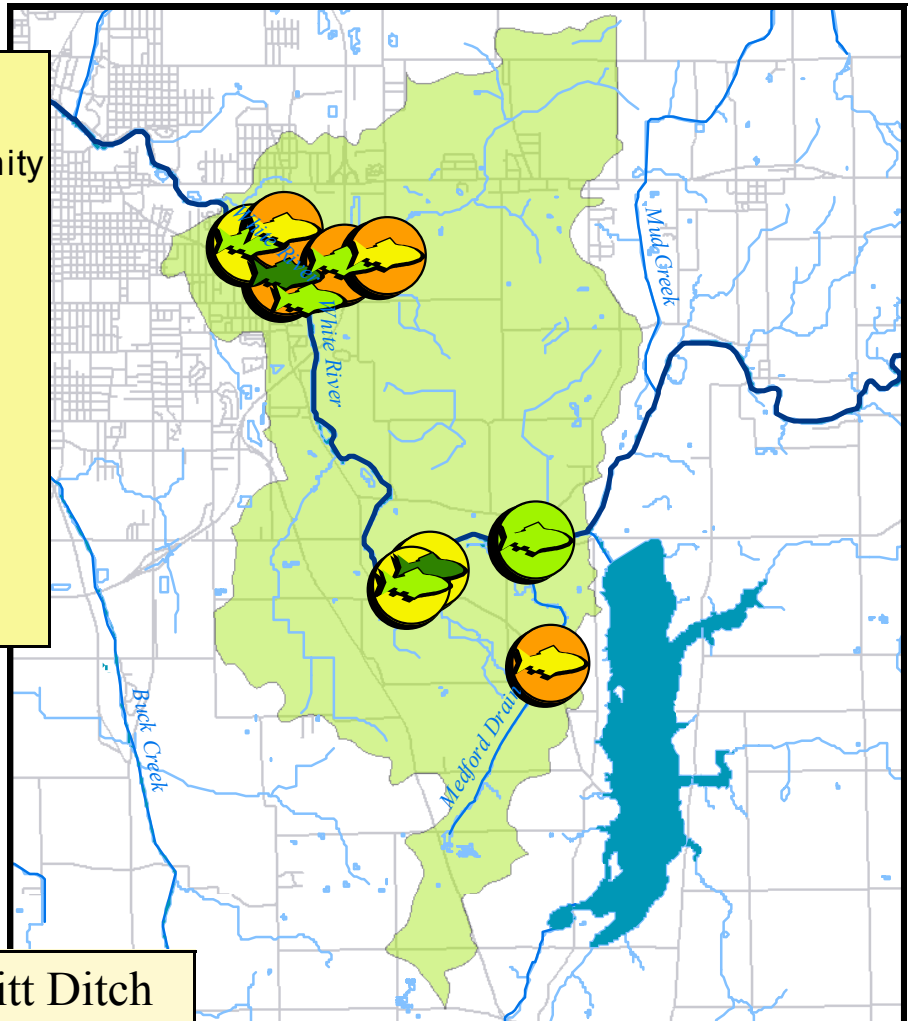
Maps on the following eight pages breakdown each subwatershed. Both IBI and QHEI scores are present for comparison. Background color remains identical to above for each map, indicating the overall water quality within each region.

BWQ: Delaware County Water Quality Assessment



Legend

-  Fish Community
-  Habitat
-  Excellent
-  Good
-  Fair
-  Poor
-  Very Poor



BWQ: Delaware County Water Quality Assessment

White River: Shoemaker Ditch

Legend



Fish Community



Habitat



Excellent



Good



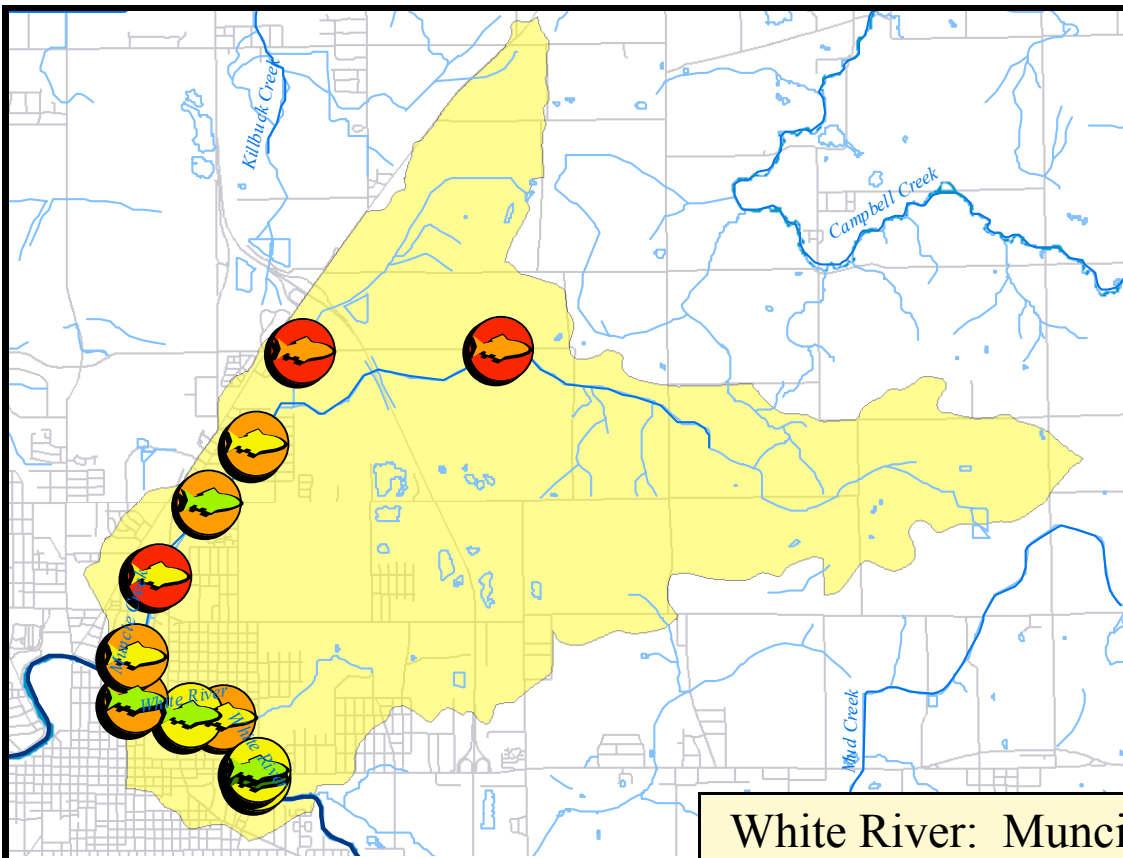
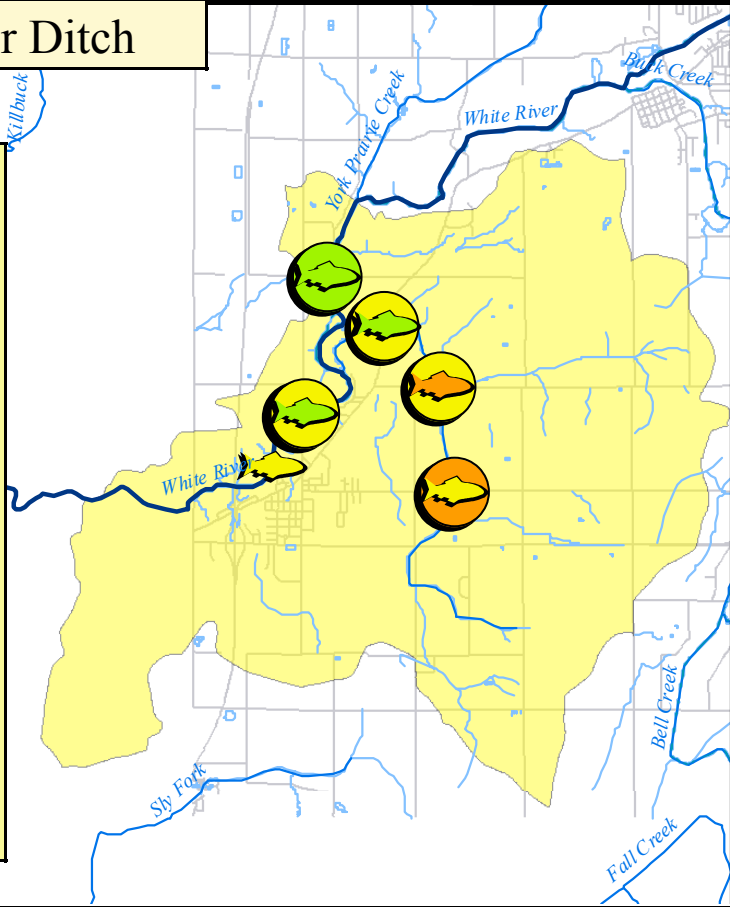
Fair



Poor

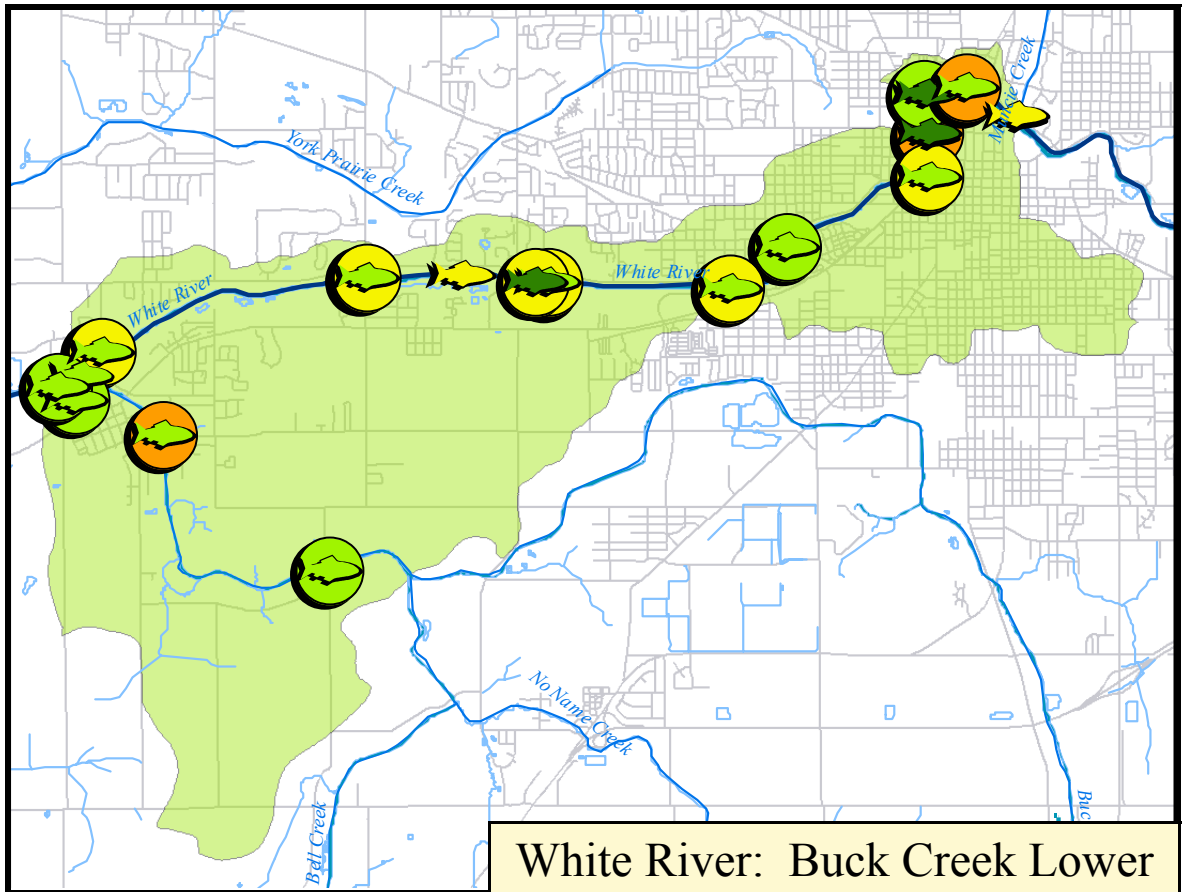
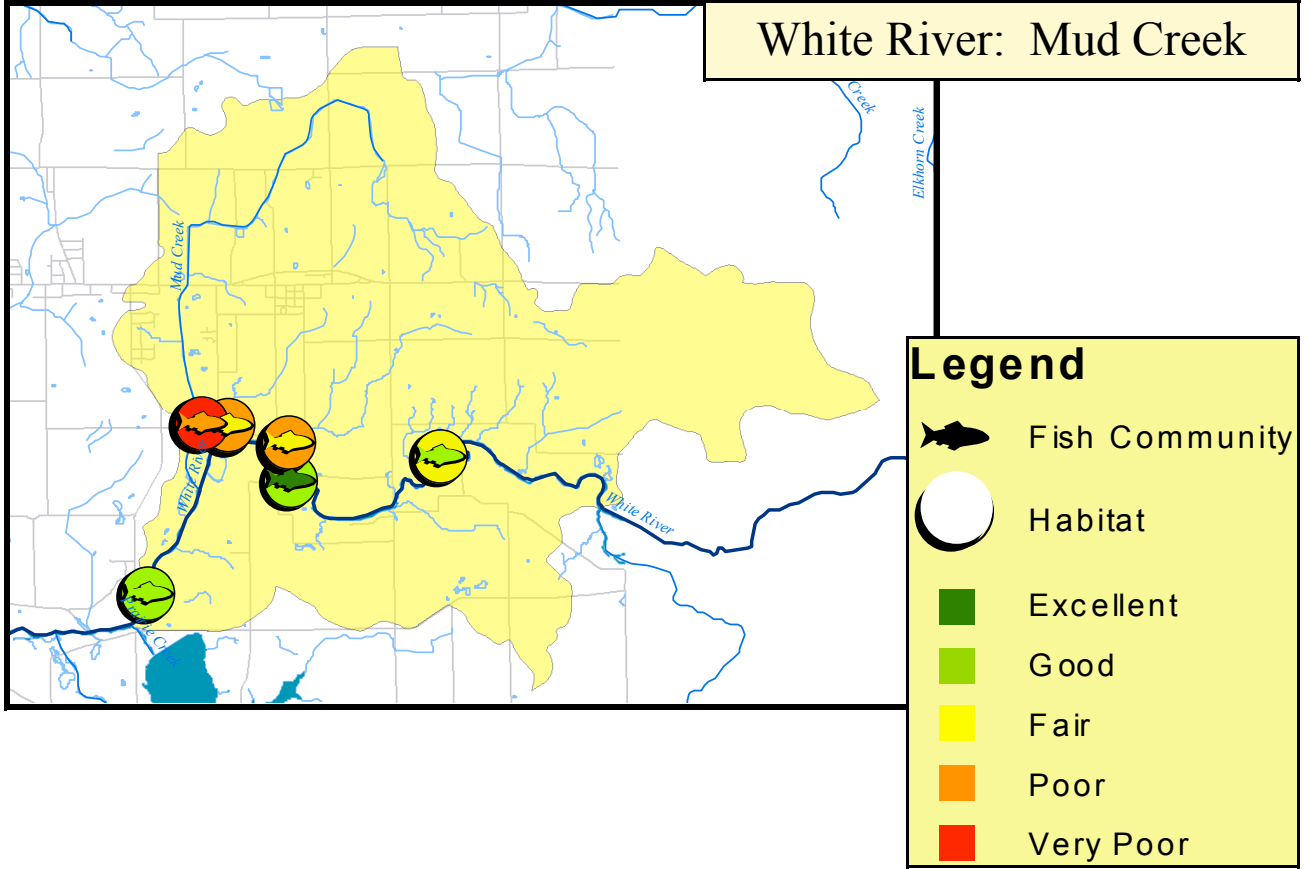


Very Poor

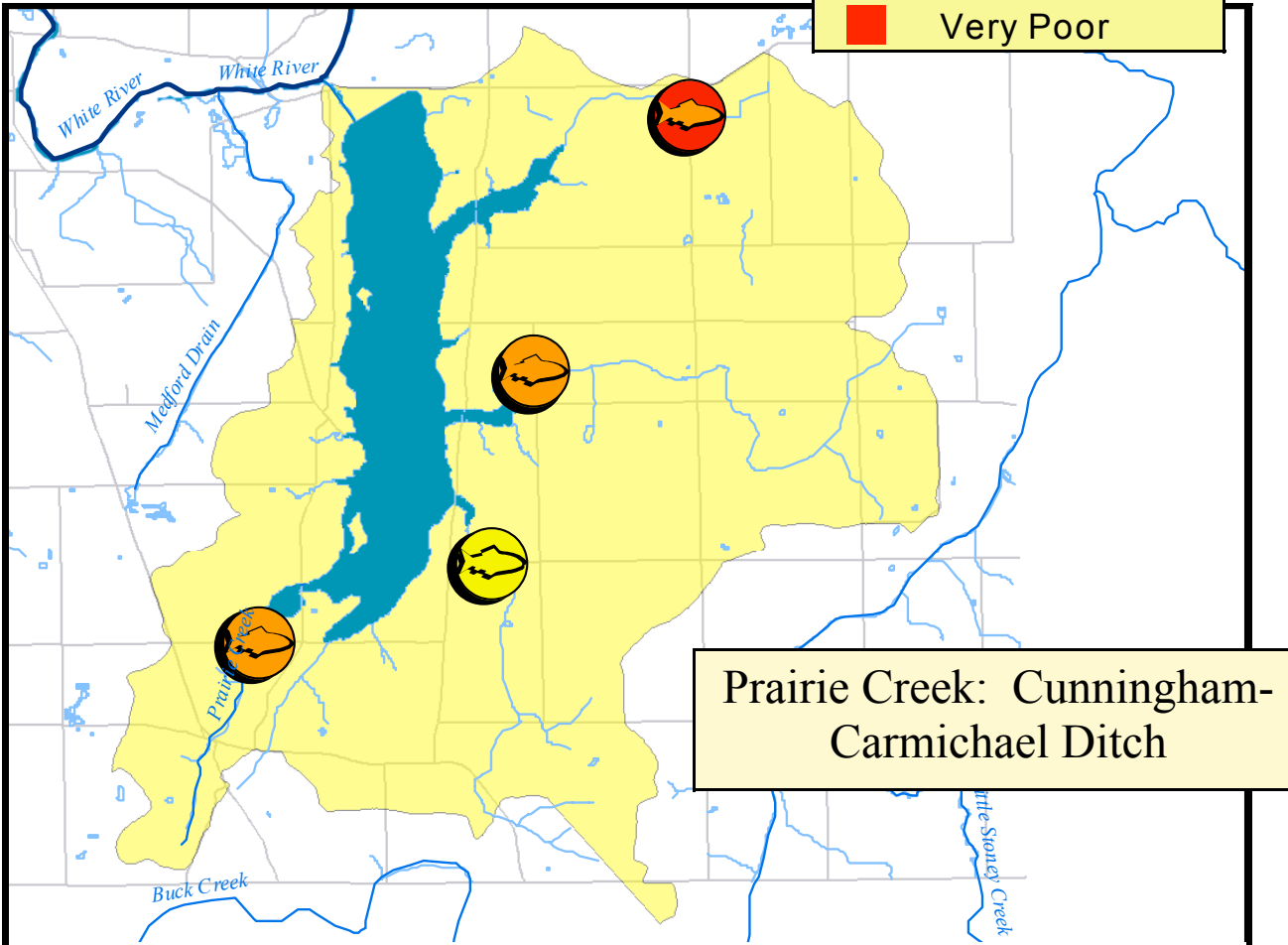
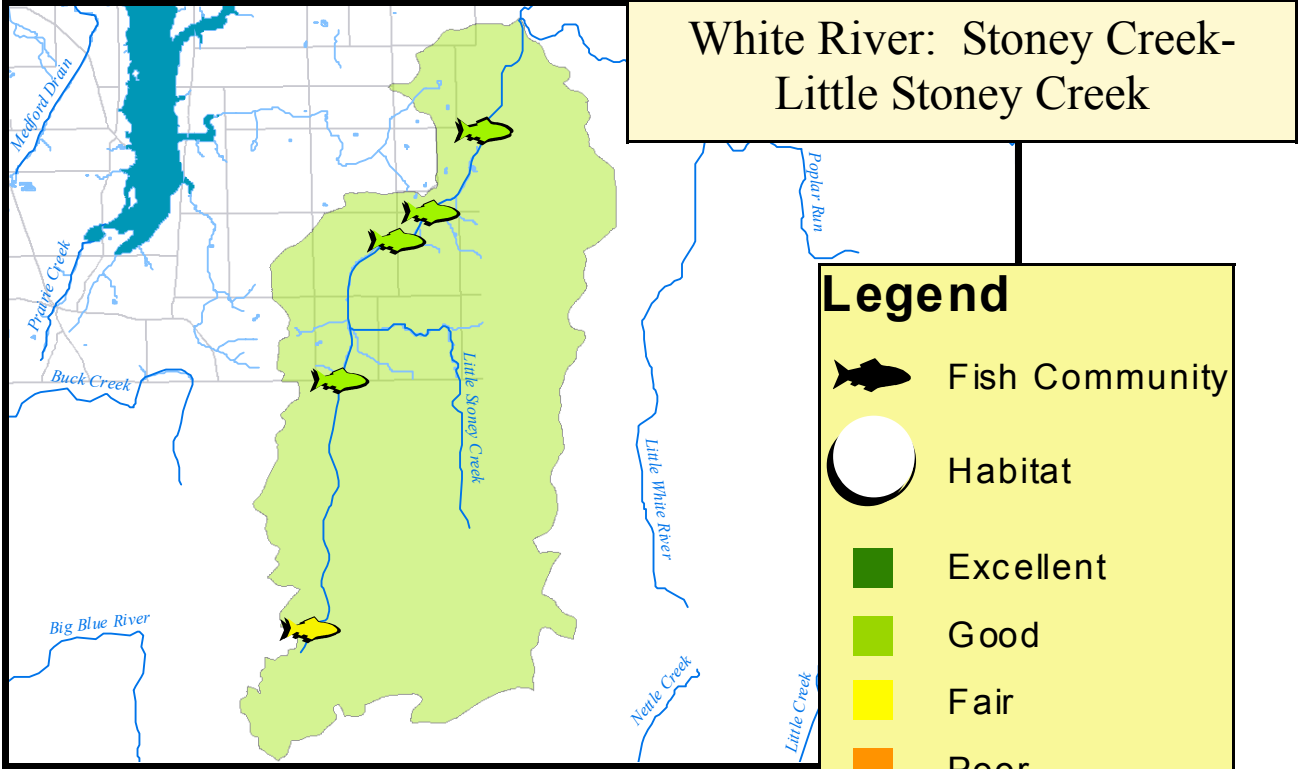


White River: Muncie Creek

BWQ: Delaware County Water Quality Assessment



BWQ: Delaware County Water Quality Assessment

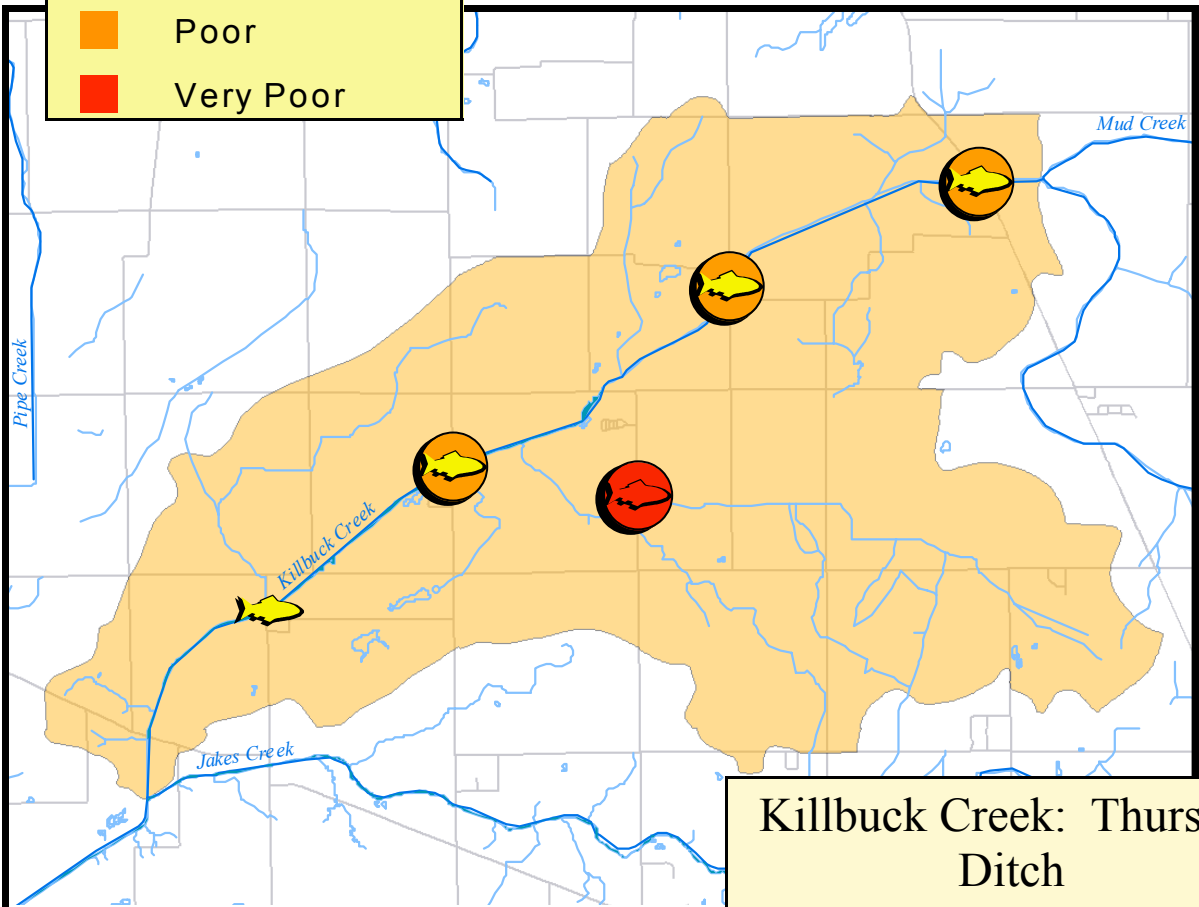
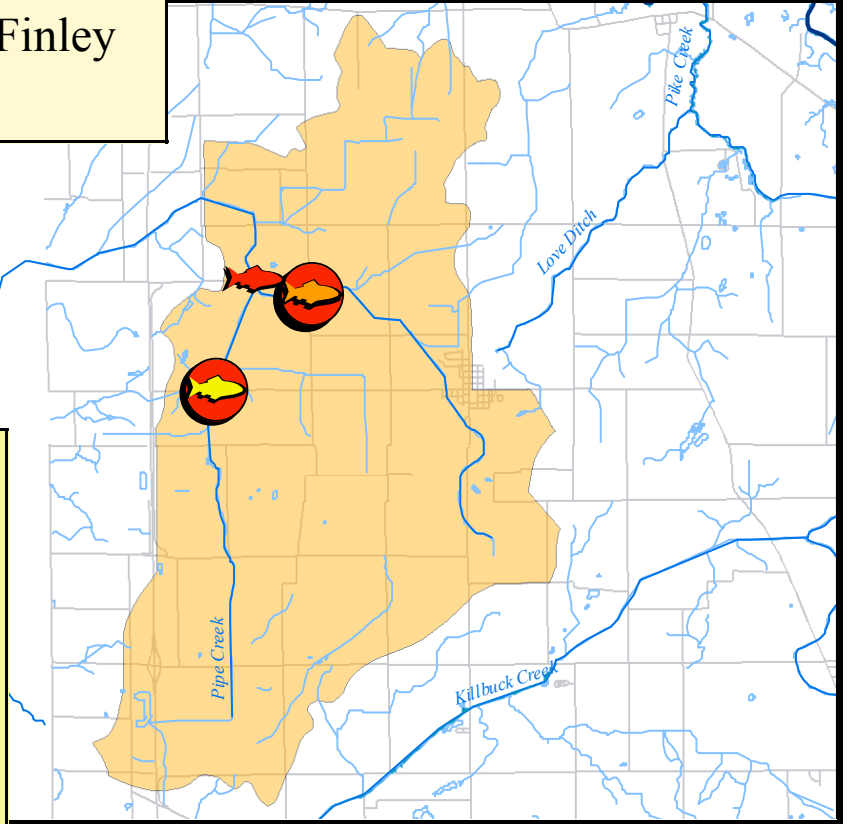


BWQ: Delaware County Water Quality Assessment

Pipe Creek: Yeager Finley
Menard Ditch

Legend

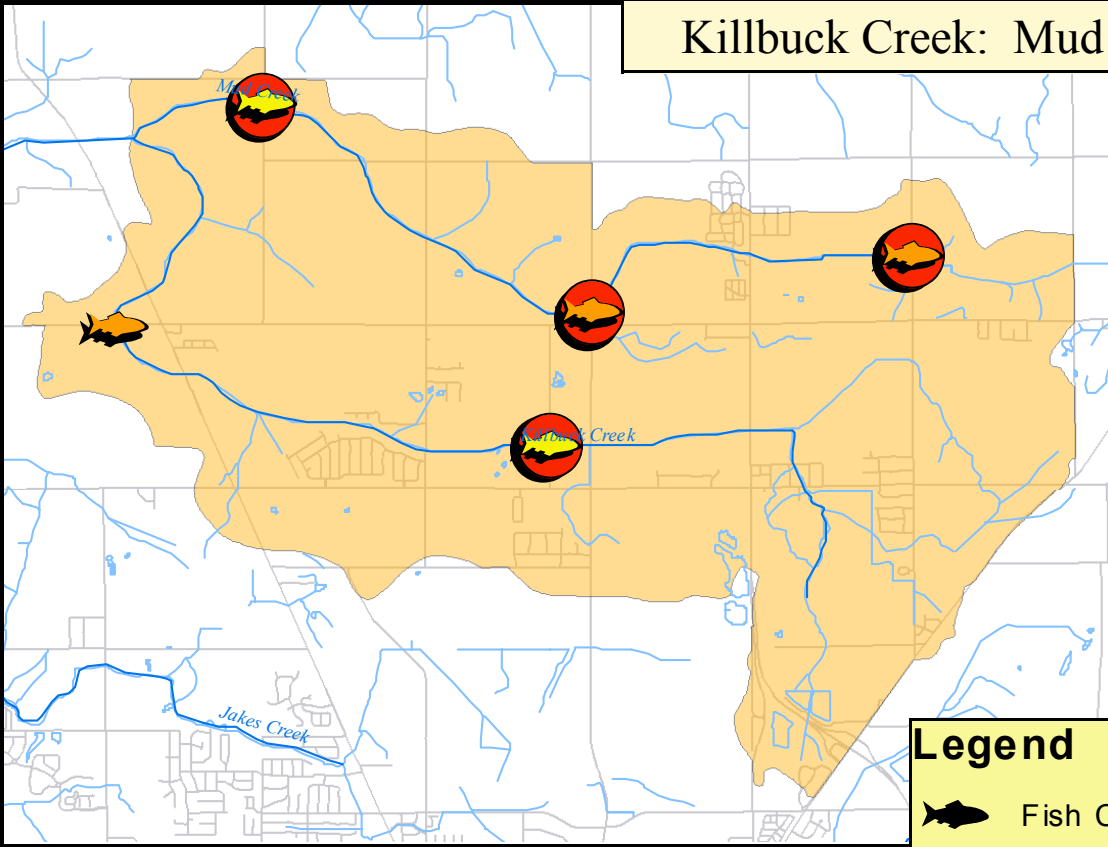
-  Fish Community
-  Habitat
-  Excellent
-  Good
-  Fair
-  Poor
-  Very Poor










Killbuck Creek: Thurston
Ditch

BWQ: Delaware County Water Quality Assessment

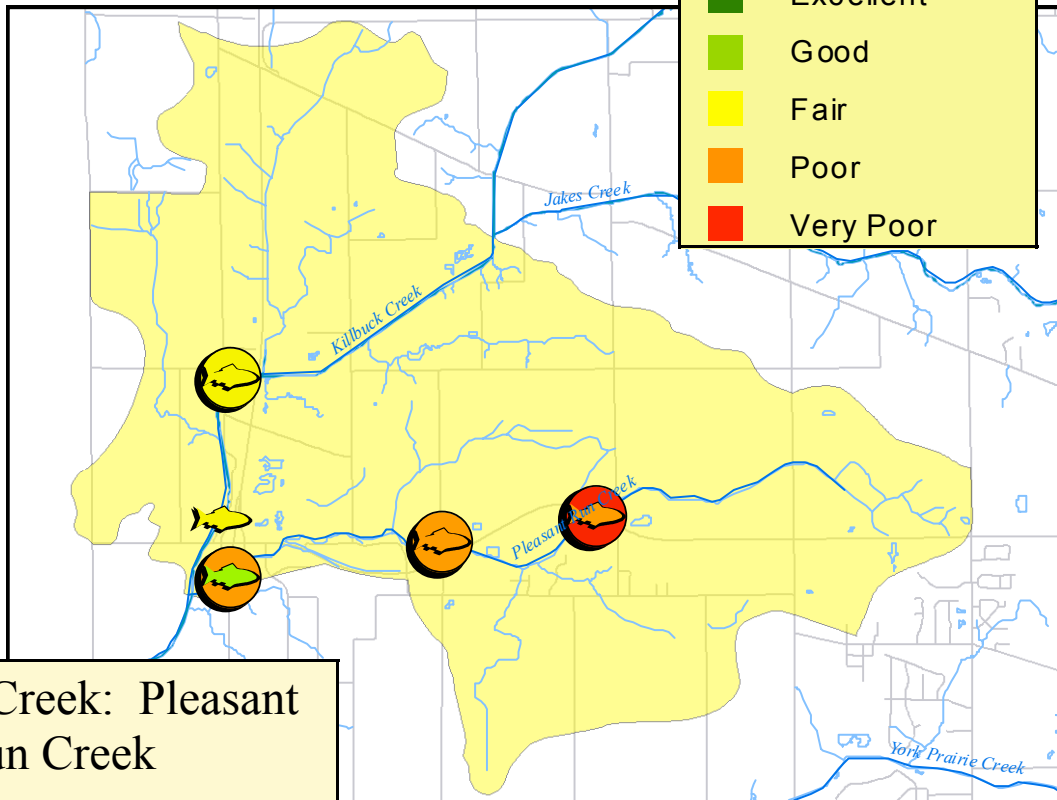
Killbuck Creek: Mud Creek



Legend

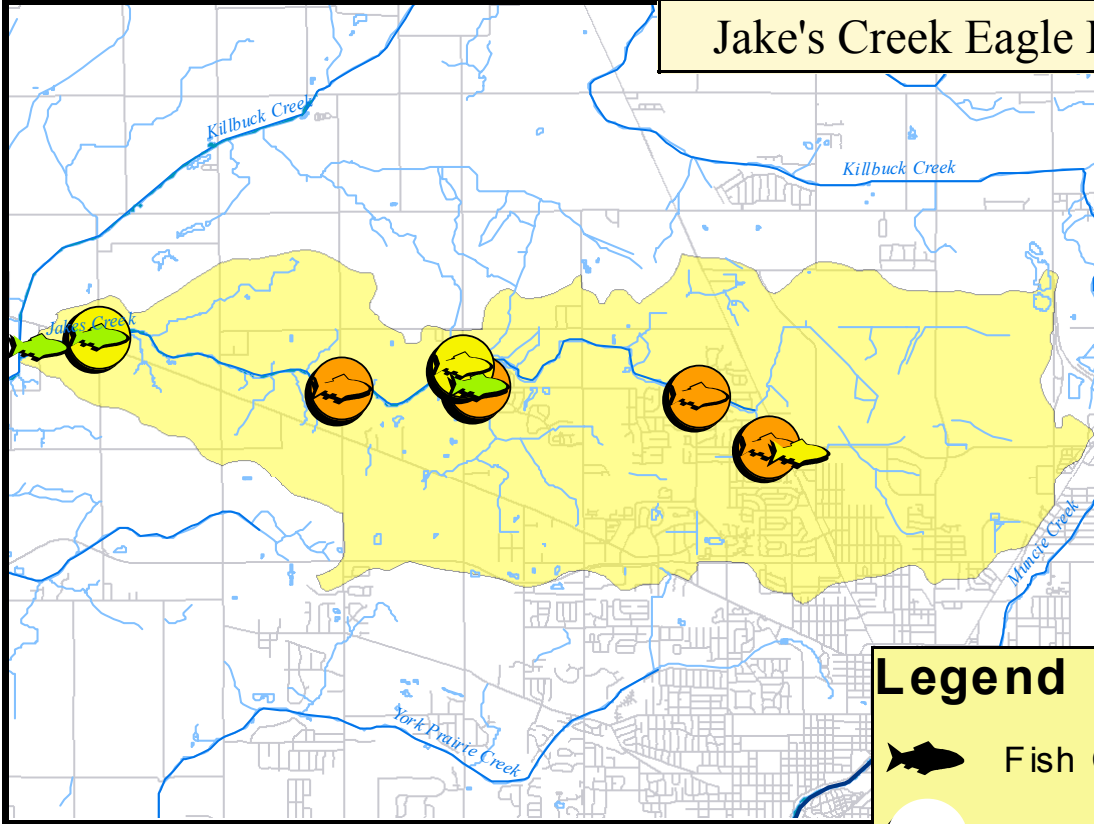
-  Fish Community
-  Habitat
-  Excellent
-  Good
-  Fair
-  Poor
-  Very Poor

Killbuck Creek: Pleasant Run Creek








BWQ: Delaware County Water Quality Assessment

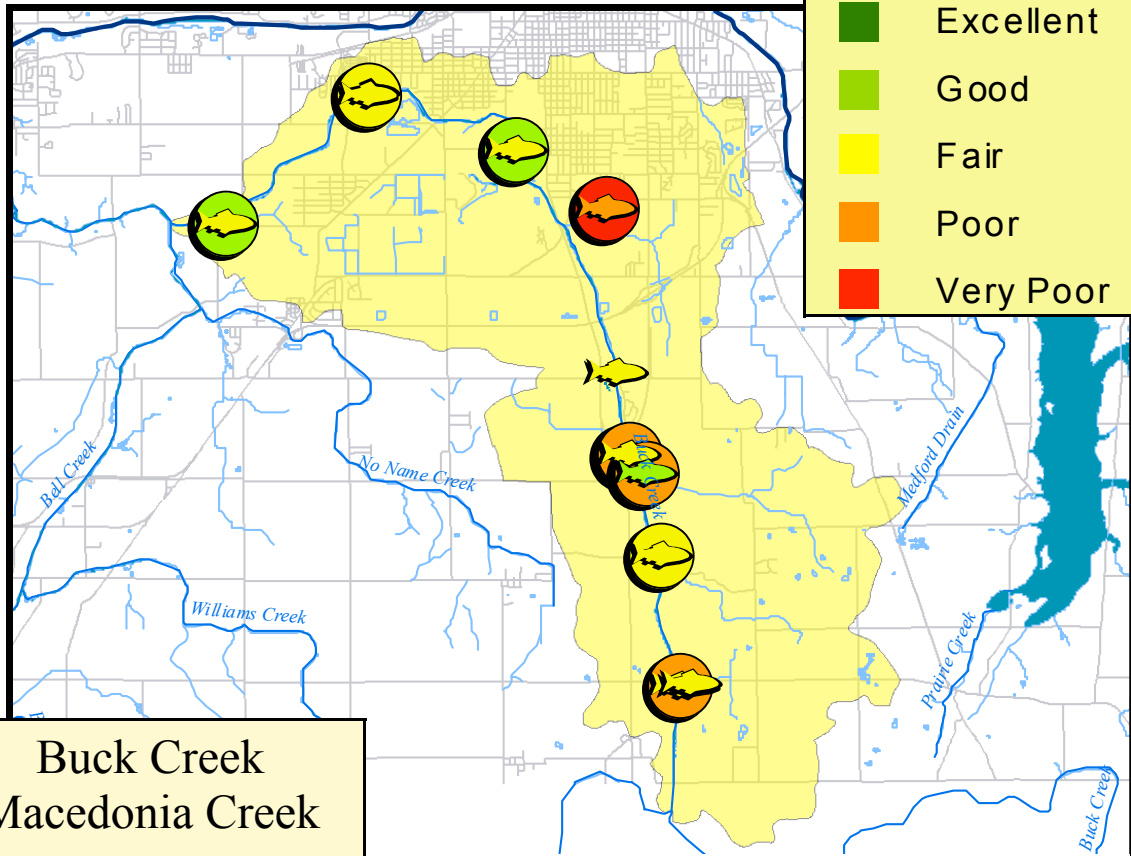
Jake's Creek Eagle Branch



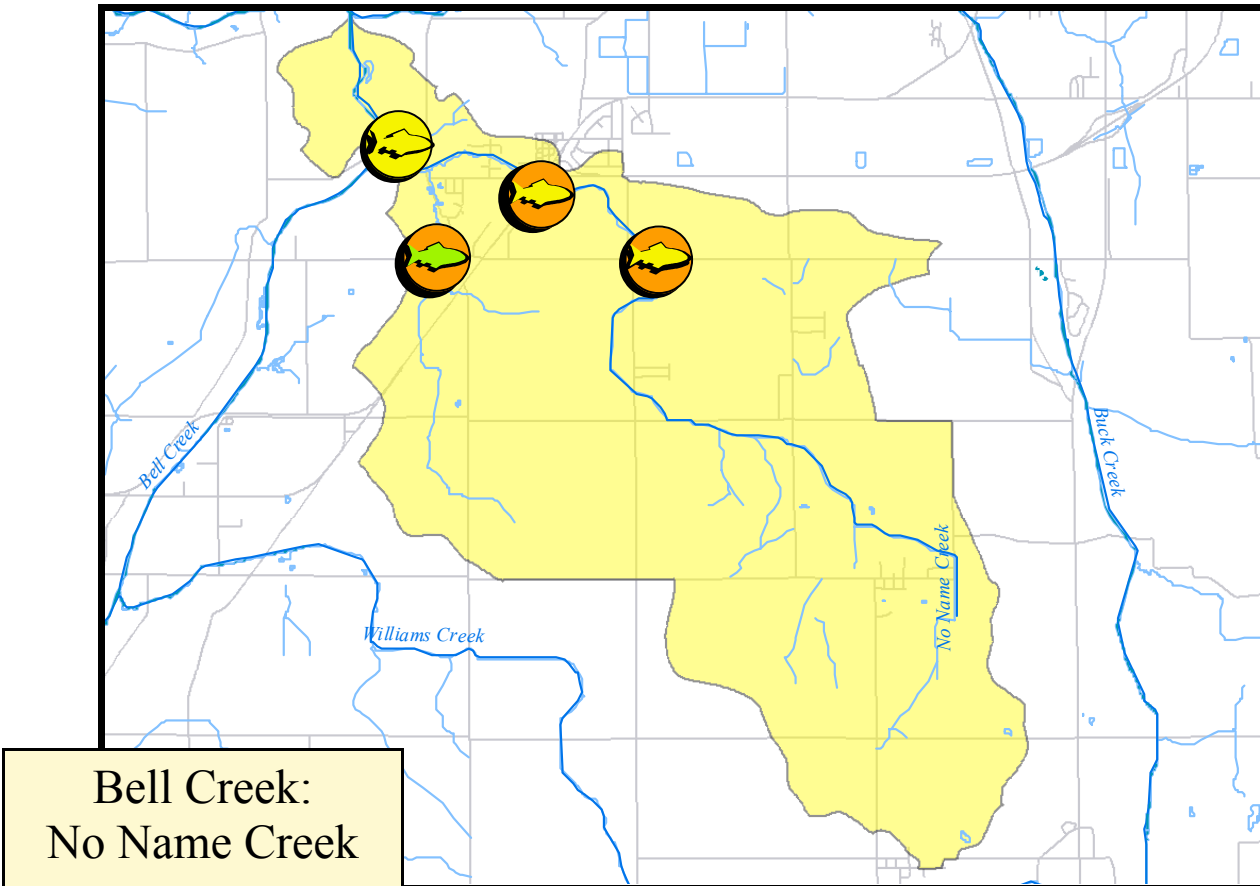
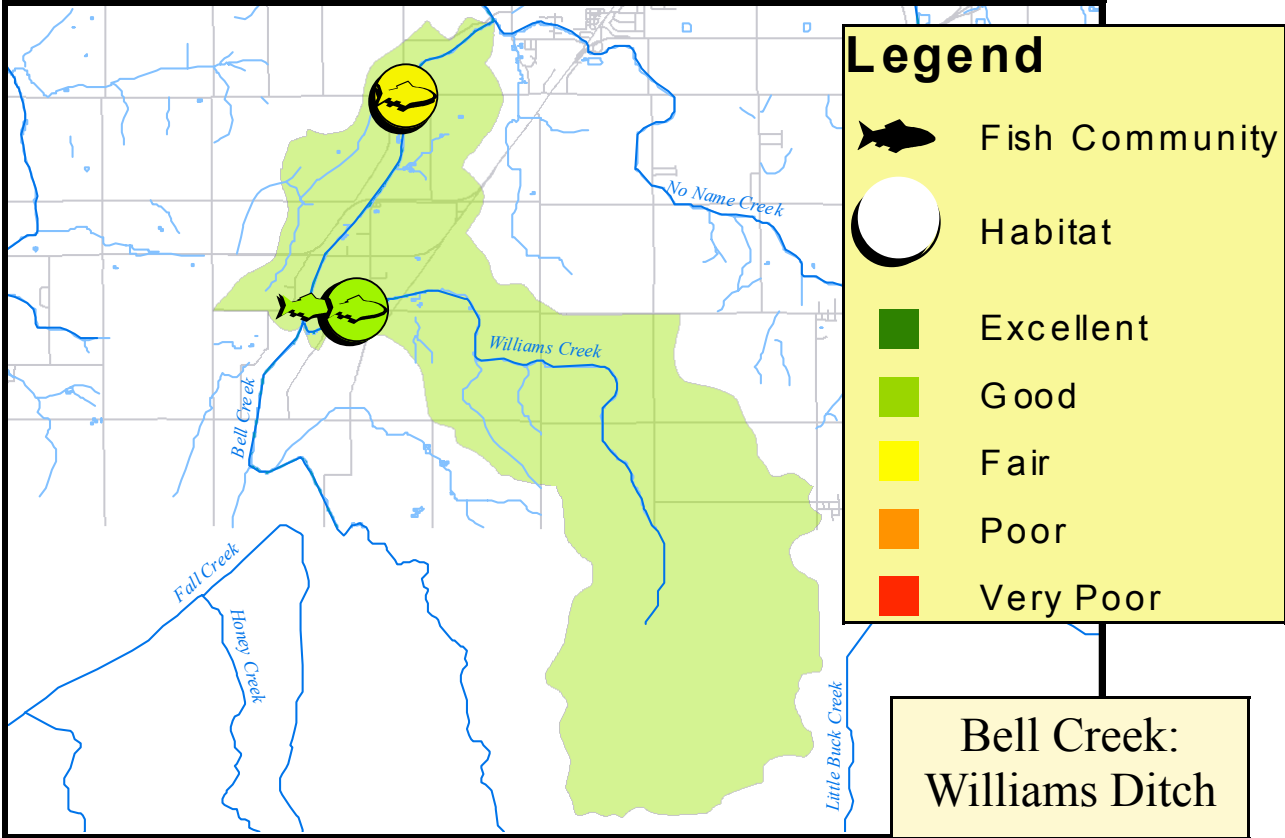
Legend

-  Fish Community
-  Habitat
-  Excellent
-  Good
-  Fair
-  Poor
-  Very Poor

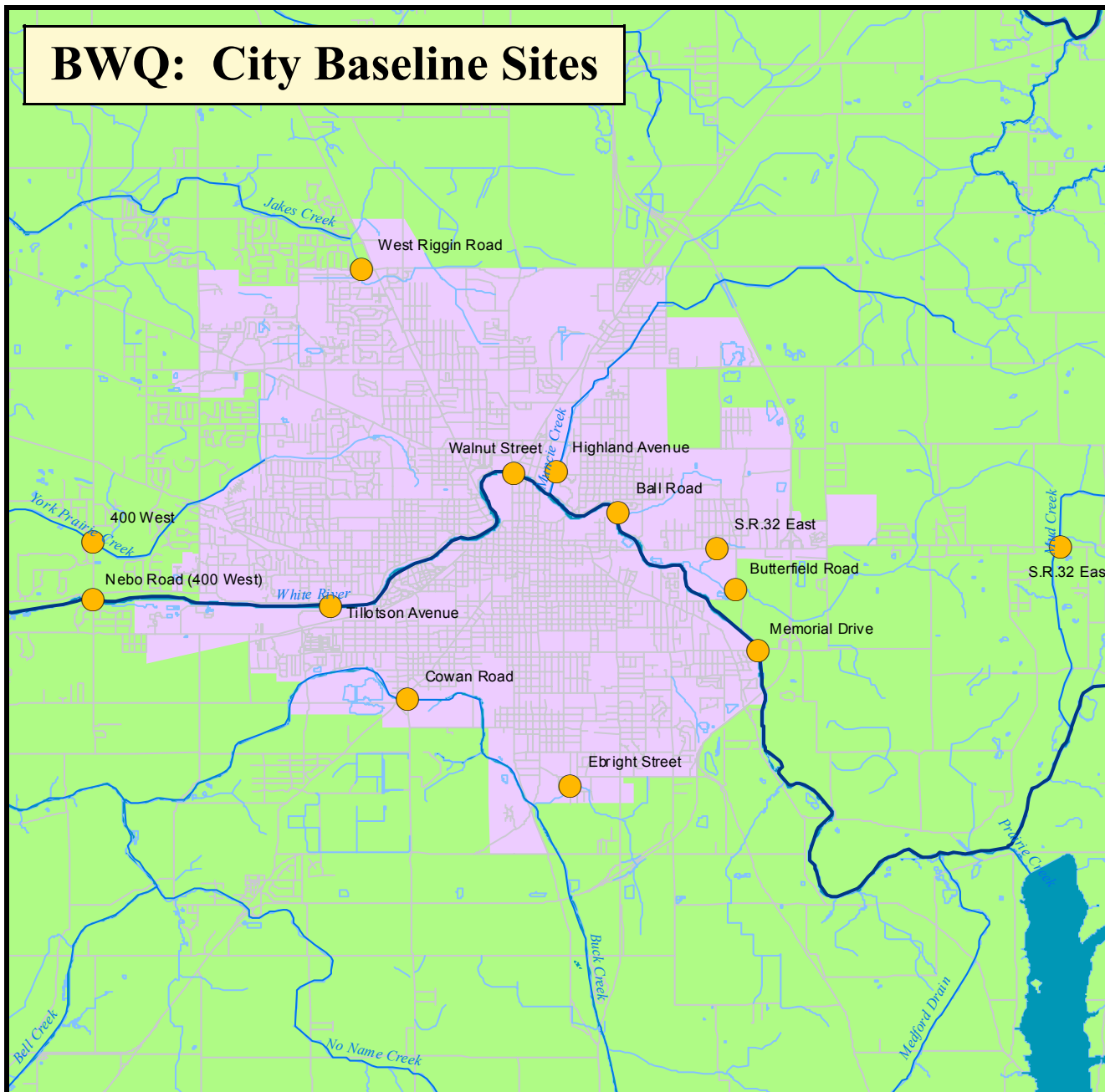
Buck Creek Macedonia Creek



BWQ: Delaware County Water Quality Assessment



BWQ: City Baseline Sites











City baseline sites, chosen by the BWQ, have undergone continuous chemistry sampling since the 1970s. These sites will appear on maps for the 1970s, 1980s, 1990s, and 2000s. Note that on maps displaying data for the 1980s and 1990s additional data is presented. A second baseline, consisting only of White River sites, was included as chemical sampling was conducted at these additional sites also. This baseline began during the 1980s and was terminated before 2000, explaining its absence in the 1970s and 2000s. Note also that one site, 575 West, remains from this terminated baseline on the 2000s maps as it was added to the city baseline sites.

For many contaminants, acceptable/unacceptable levels are either unavailable, undetermined, or have only drinking water standards (which often exceeded Bureau values). As a result, ranges for each contaminant were determined after construction of a Bell Curve. **Maps shown on following pages were intended to indicate change over time, not acceptable/unacceptable levels.**

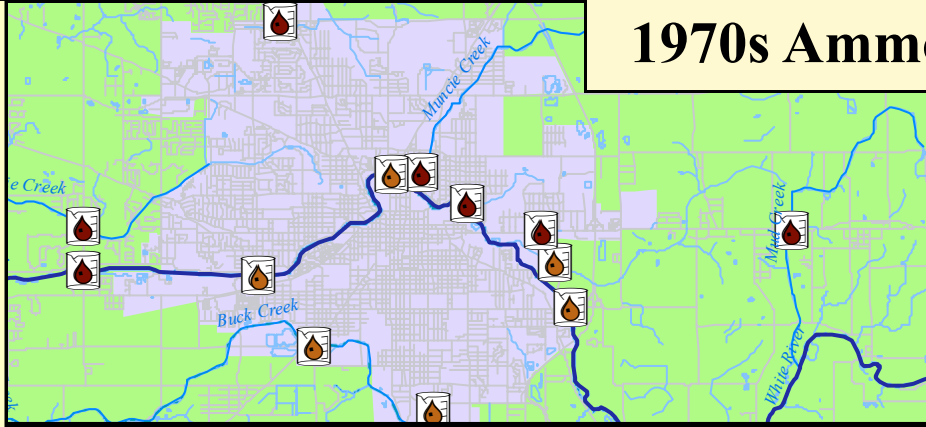
BWQ: White River Ammonia Assessment

Legend

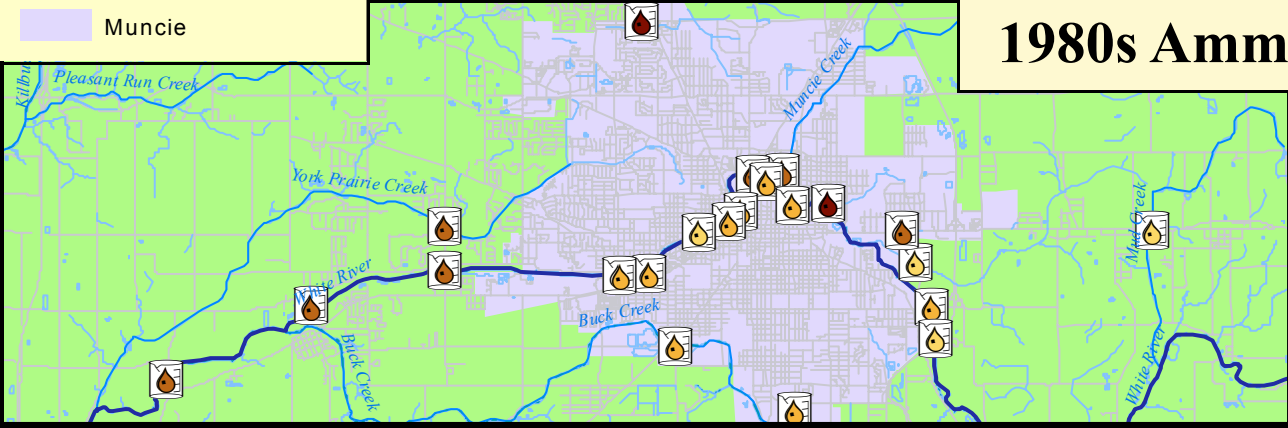
-  0.000 to 0.113 mg/L
-  0.114 to 0.150 mg/L
-  0.151 to 0.230 mg/L
-  0.231 to 0.800 mg/L
-  0.801 mg/L or above

-  Major Waterway
-  Waterway
-  Roadway
-  Muncie

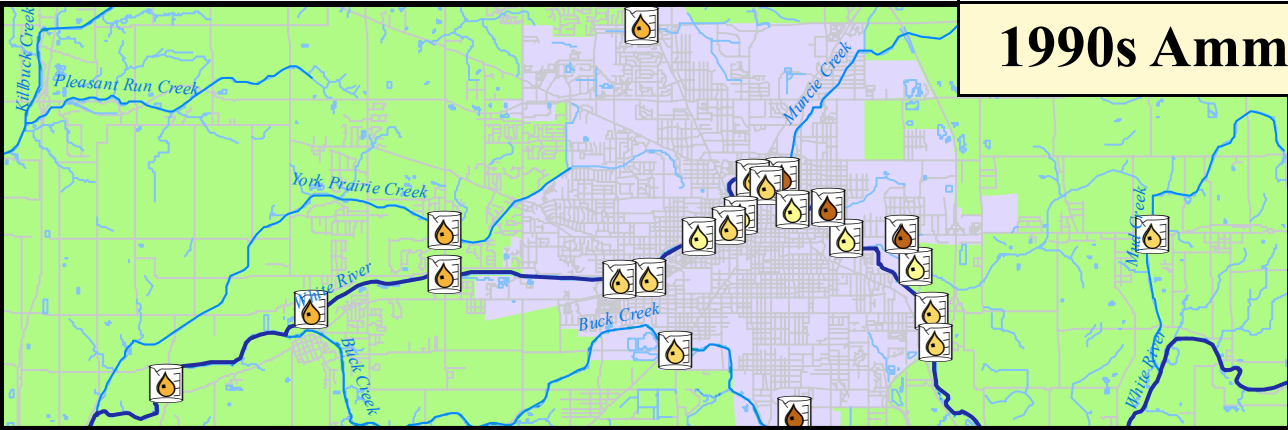
1970s Ammonia



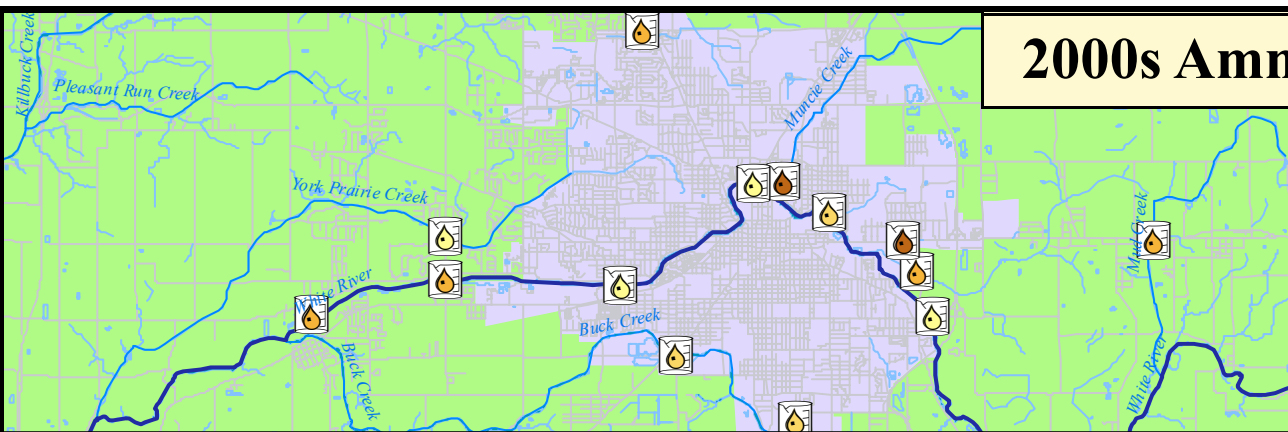
1980s Ammonia



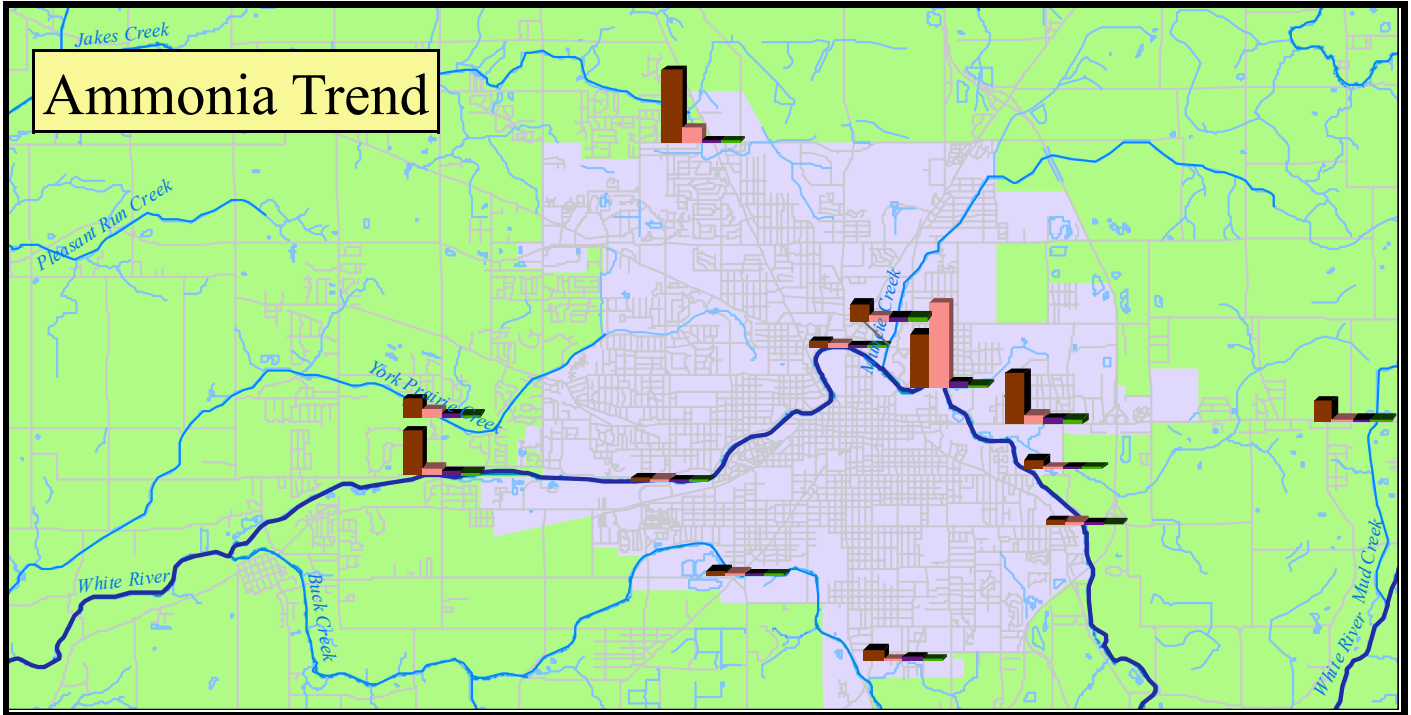
1990s Ammonia



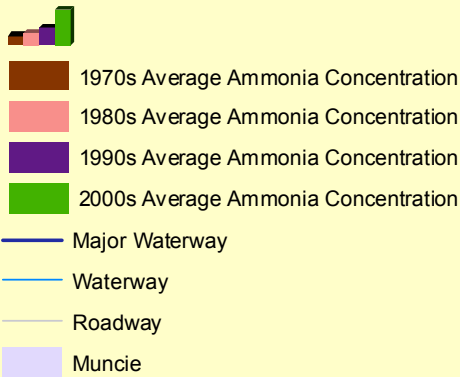
2000s Ammonia



BWQ: White River Ammonia Assessment








Legend







Ammonia (NH₃), has shown significant reductions since the 1970s. City baseline sites on West Riggan Road (Greenfarm Ditch) and Ball Road (Holt Ditch) both displayed a 96% reduction in ammonia since the 1970s. Several other sites, including Nebo Road (White River, 94%), 400 West (York Prairie Creek, 91%), and S.R. 32 East (32 Ditch, 90%) exhibit reductions of 90% or greater. Sites exhibiting a reduction of at least 75% include S.R. 32 East (Mud Creek, 86%), Ebright Street (Lennox Ditch, 81%), Highland Avenue (Muncie Creek, 77%), and Butterfield Road (Truitt Ditch 76%). Other reductions included Memorial Drive (White River, 67%), Cowan Road (Buck Creek, 61%), and Tillotson Avenue (White River, 59%).

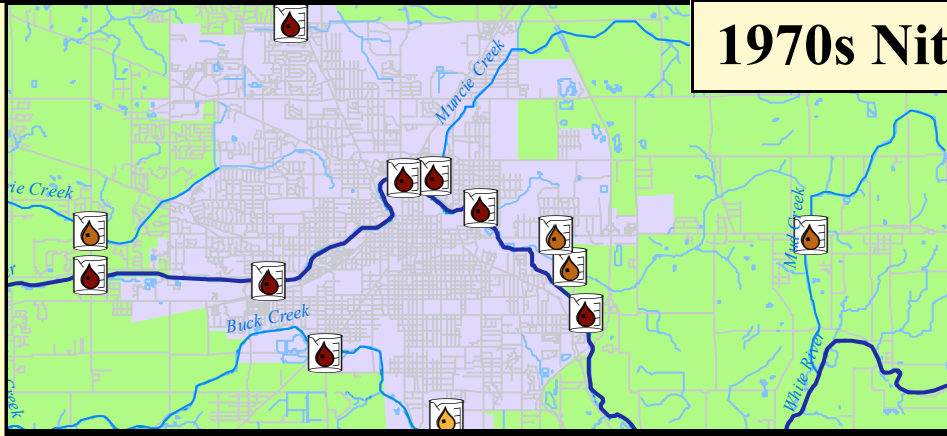
BWQ: White River Nitrate Assessment

Legend

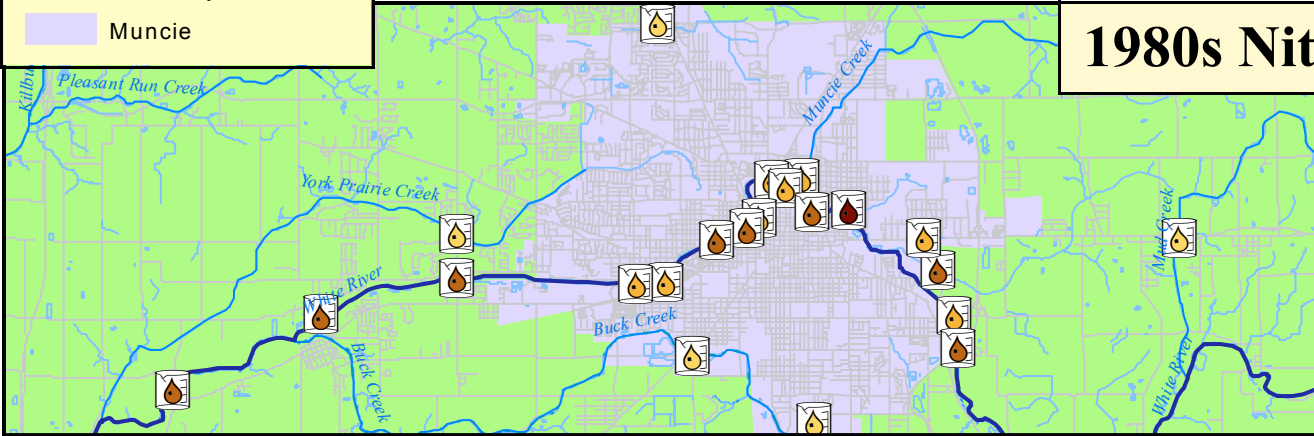
-  0.000 to 1.140 mg/L
-  1.141 to 2.180 mg/L
-  2.181 to 2.600 mg/L
-  2.601 to 4.300 mg/L
-  4.301 mg/L or above

-  Major Waterway
-  Waterway
-  Roadway
-  Muncie

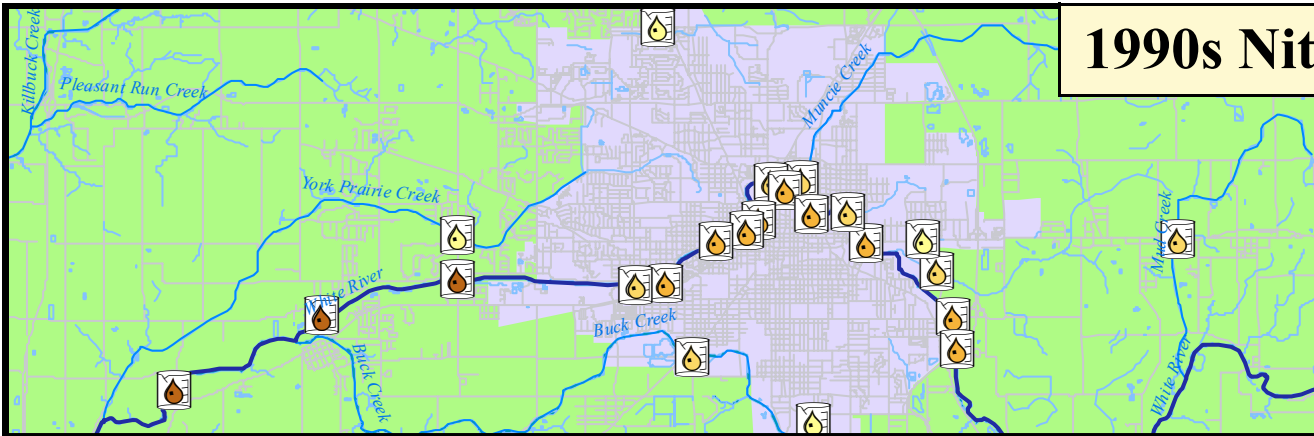
1970s Nitrate



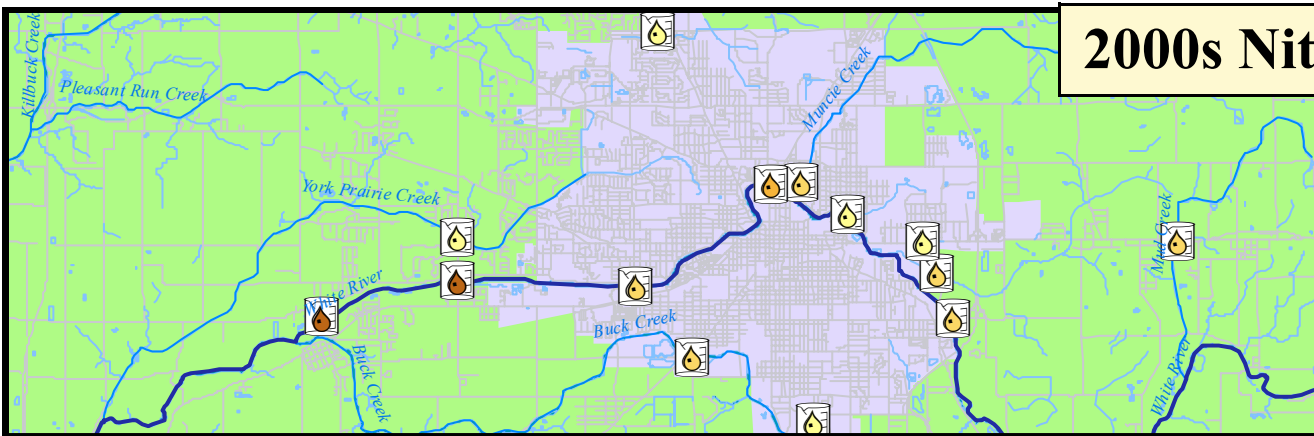
1980s Nitrate



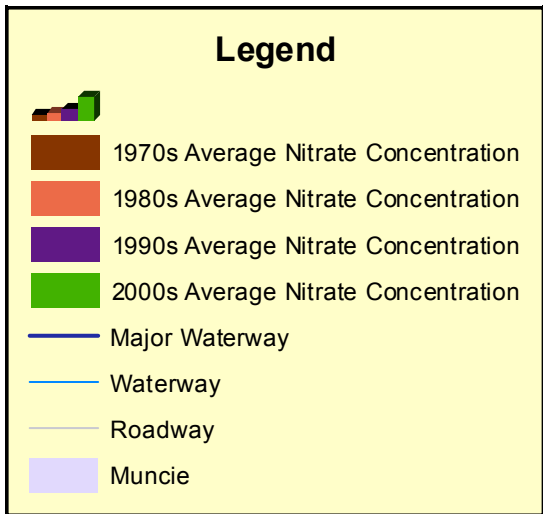
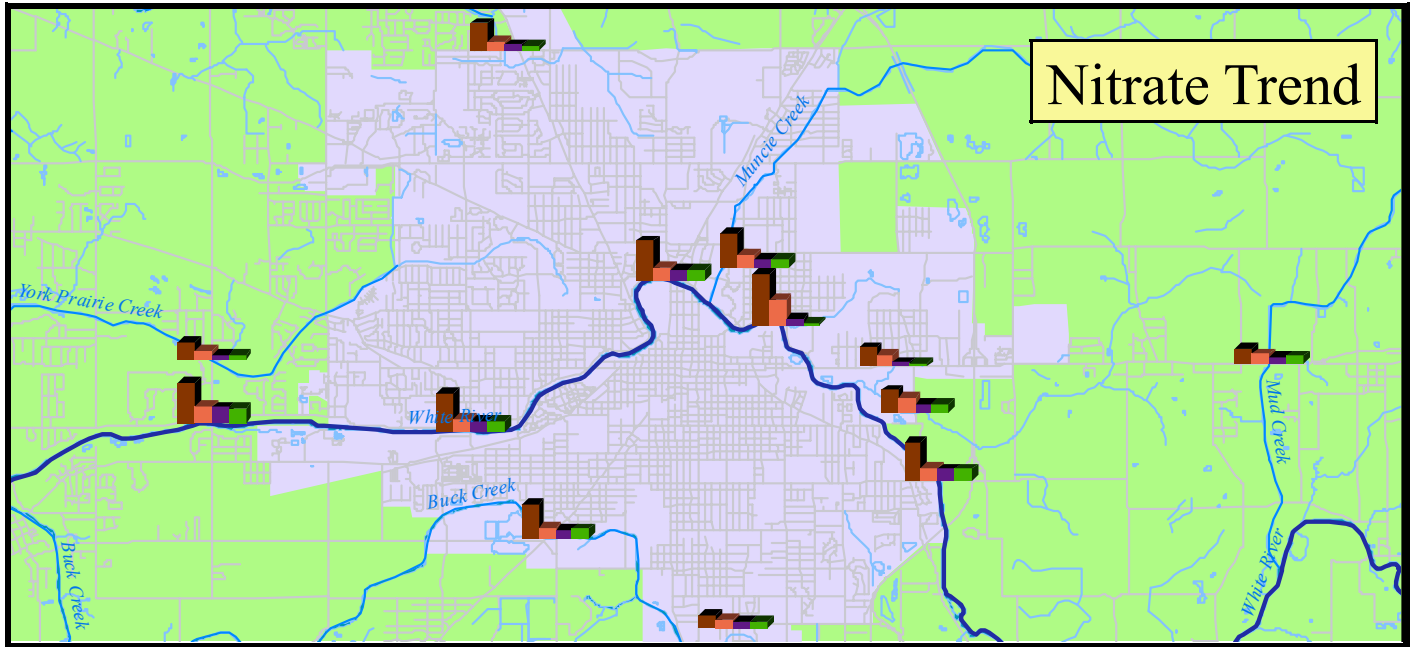
1990s Nitrate



2000s Nitrate



BWQ: White River Nitrate Assessment












Nitrate (NO₃) concentrations have seen large reductions from their 1970s values. Ball Road (Holt Ditch) witnessed a 95% reduction. Several sites have reductions equal to or greater than 70%, including S.R. 32 East (32 Ditch, 87%), West Riggin Road (Greenfarm Ditch, 81%), 400 West (York-Prairie Creek, 77%), Highland Avenue (Muncie Creek, 76%), Tiltotson Avenue (White River, 74%), Cowan Road (Buck Creek, 73%), Memorial Drive (White River, 70%), and Walnut Street (White River, 70%). Remaining sites had the following reductions: Butterfield Road (Truitt Ditch, 62%), Nebo Road (White River, 62%), Ebright Street (Lennox Ditch, 56%), and S.R. 32 East (Mud Creek, 47%),



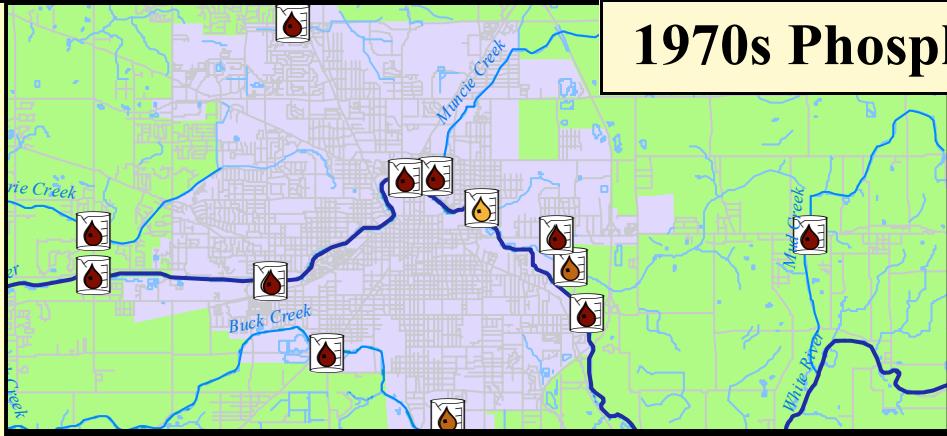
BWQ: White River Phosphate Assessment

Legend

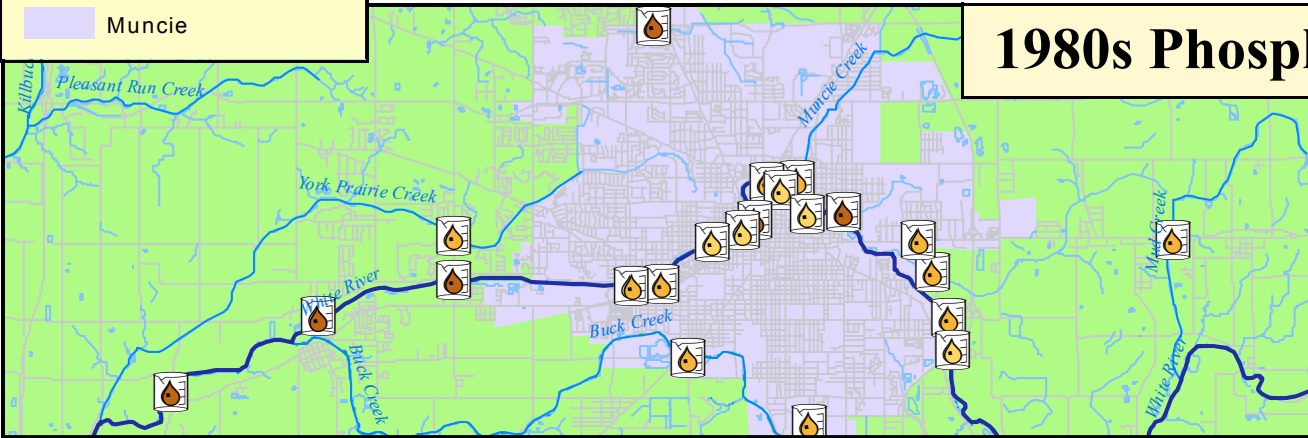
-  0.000 to 0.121 mg/L
-  0.122 to 0.142 mg/L
-  0.143 to 0.210 mg/L
-  0.211 to 0.430 mg/L
-  0.431 mg/L or above

-  Major Waterway
-  Waterway
-  Roadway
-  Muncie

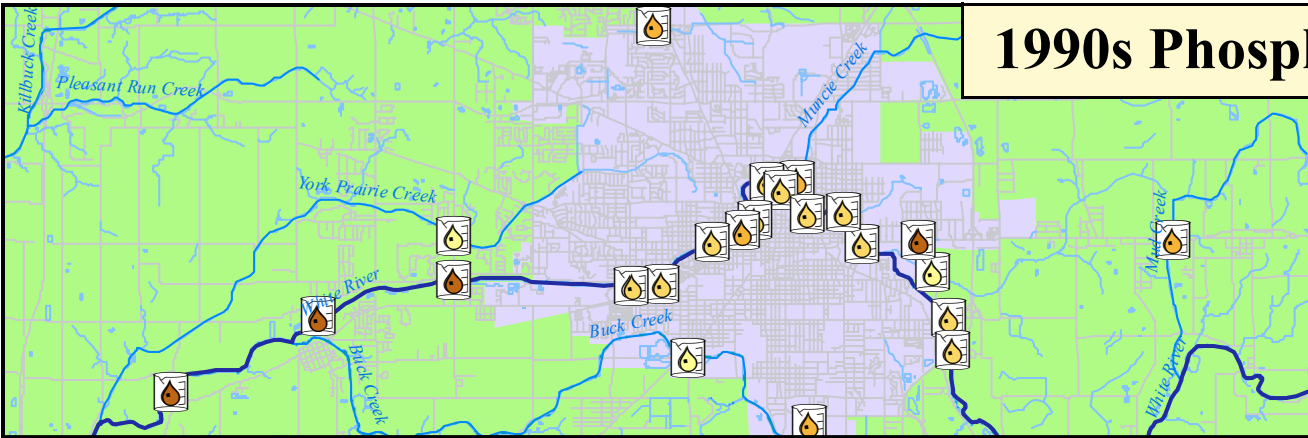
1970s Phosphate



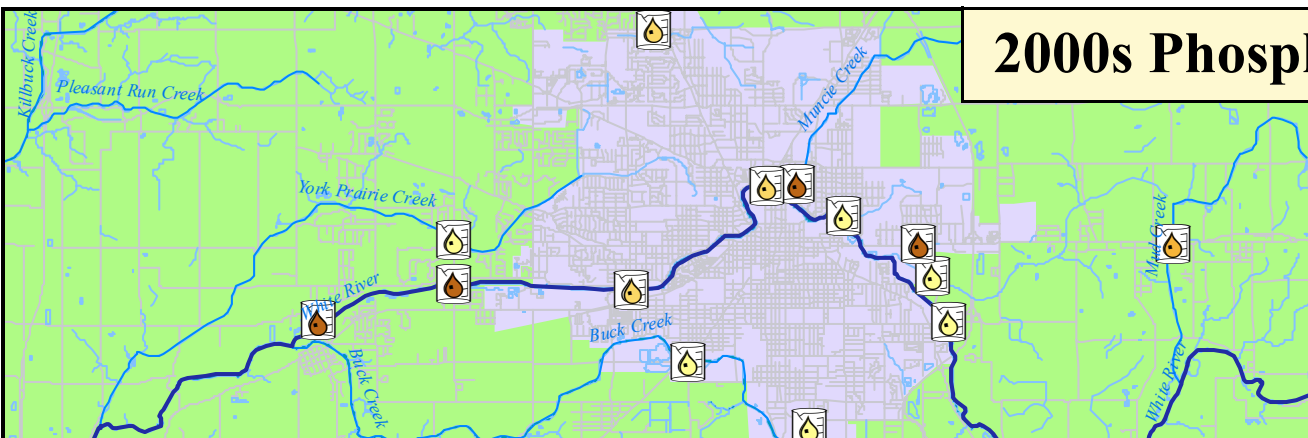
1980s Phosphate



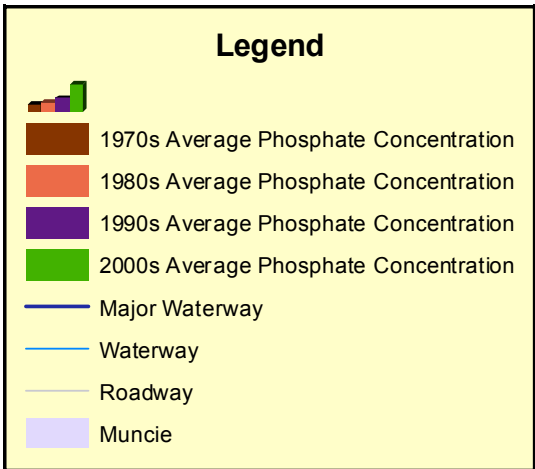
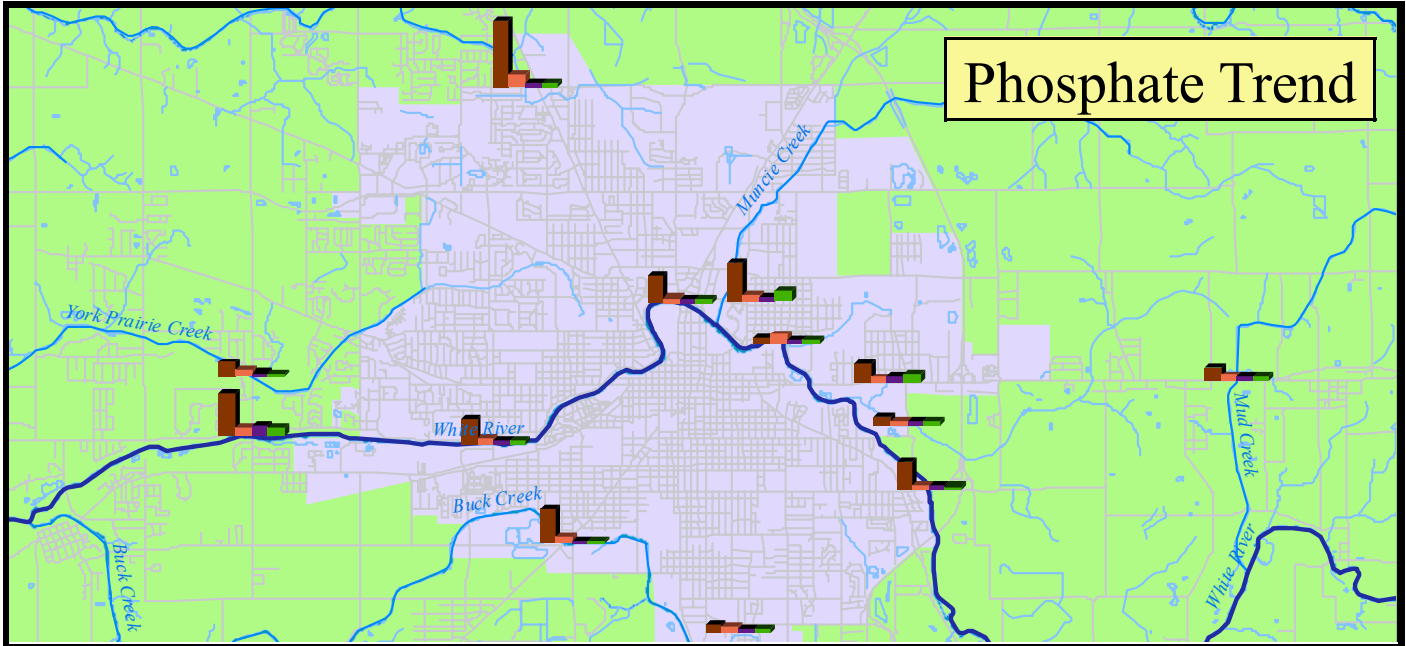
1990s Phosphate



2000s Phosphate



BWQ: White River Phosphate Assessment












Phosphate (PO₄) concentrations have been reduced significantly since the 1970s. West Riggin Road (Greenfarm Ditch) and Cowan Road (Buck Creek) witnessed reductions of 94% and 92%, respectively. Several sites witnessed reductions greater than 70%, including Memorial Drive (White River, 88%), Tillotson Avenue (White River, 86%), Walnut Street (White River, 85%), 400 West (York Prairie Creek, 84%), Nebo Road (White River, 78%), and Highland Avenue (Muncie Creek, 74%). Other significant reductions included Ebright Street (Lennox Ditch, 68%), S.R. 32 East (Mud Creek, 61%), Butterfield Road (Truitt Ditch, 60%), S.R. 32 East (32 Ditch, 59%), and Ball Road (Holt Ditch, 46%).



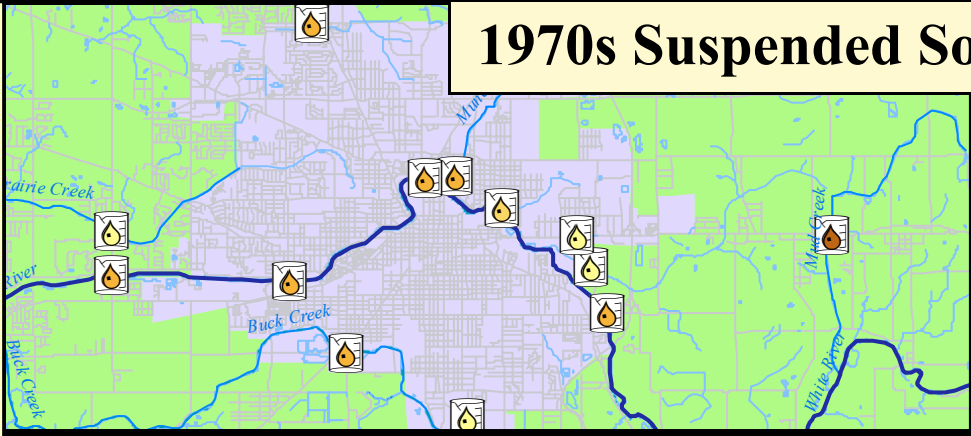
BWQ: White River Suspended Solids (SS) Assessment

Legend

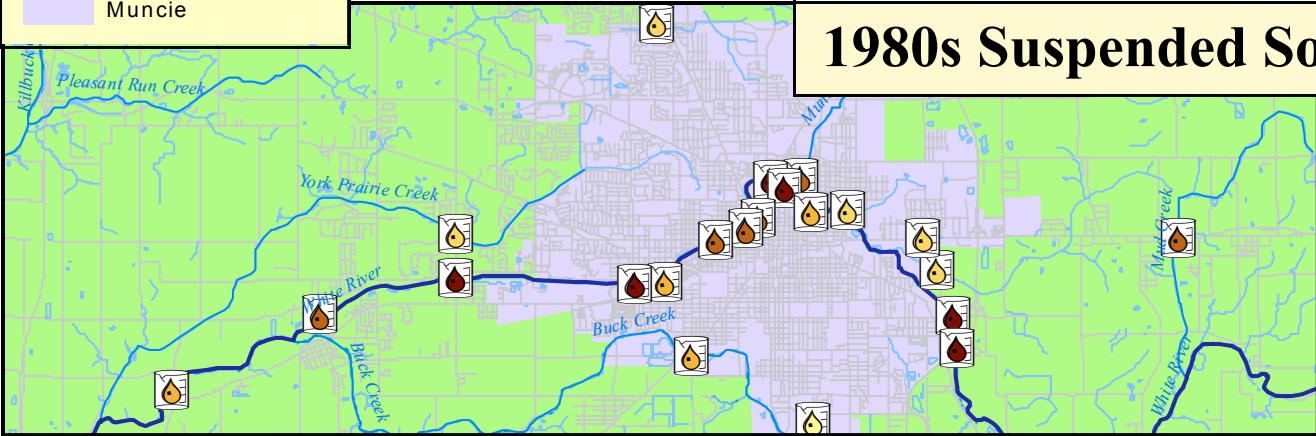
-  0.0 to 18.0 mg/L
-  18.1 to 32.0 mg/L
-  32.1 to 43.0 mg/L
-  43.1 to 53.0 mg/L
-  53.1 mg/L or above

-  Major Waterway
-  Waterway
-  Roadway
-  Muncie

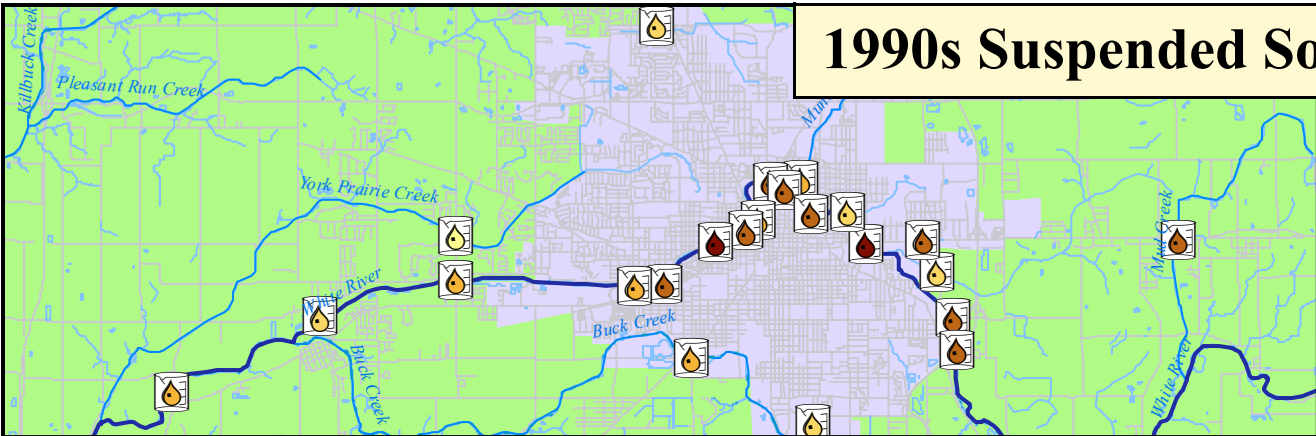
1970s Suspended Solids



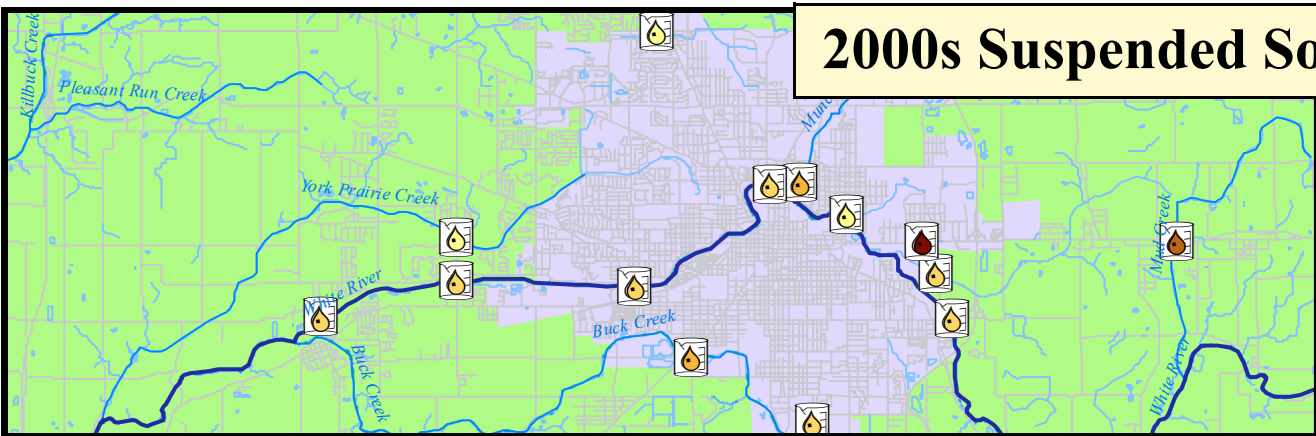
1980s Suspended Solids



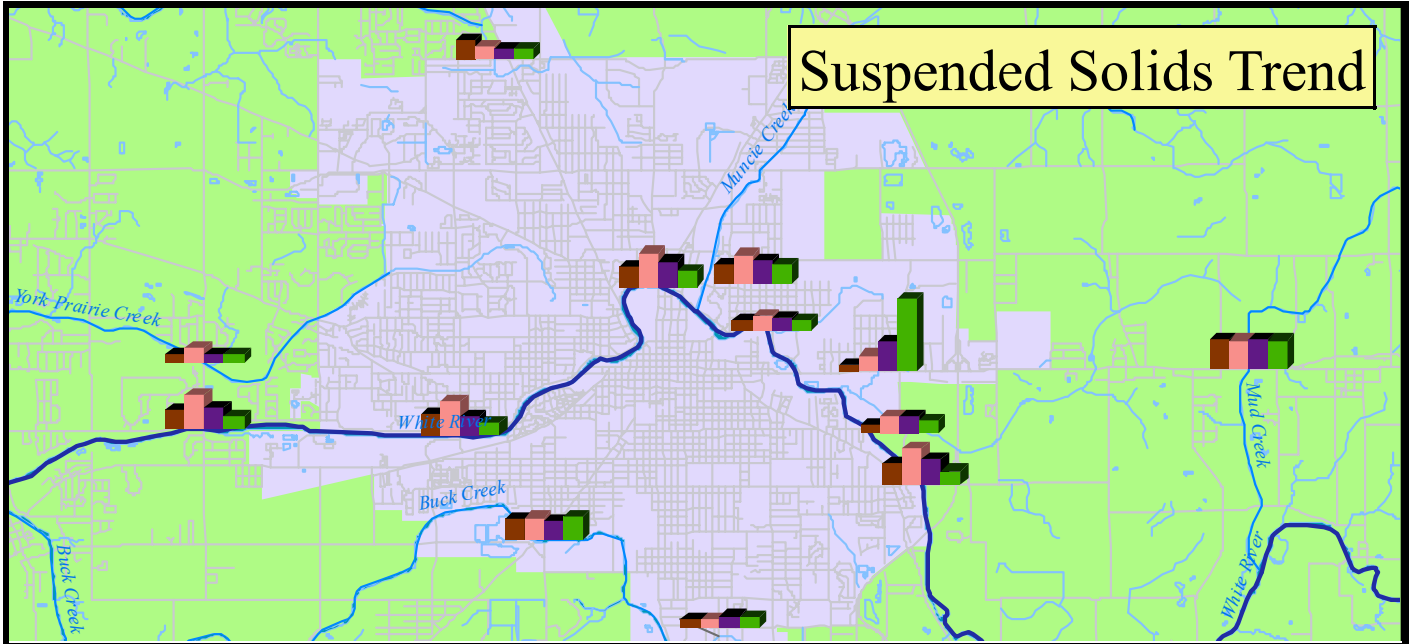
1990s Suspended Solids








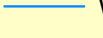
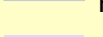
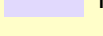
2000s Suspended Solids



BWQ: White River Suspended Solids (SS) Assessment












Legend

-  1970s Average SS Concentration
-  1980s Average SS Concentration
-  1990s Average SS Concentration
-  2000s Average SS Concentration
-  Major Waterway
-  Waterway
-  Roadway
-  Muncie

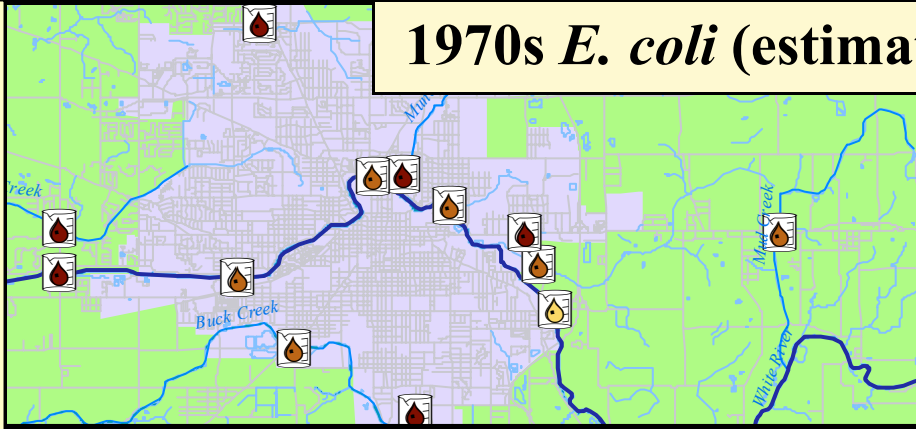
Suspended solids does not show significant reductions from 1970s concentrations at most city baseline sites. West Riggin Road (Greenfarm Ditch) witnessed a 46% reduction, the largest of any site. Other minor reductions include Memorial Drive (White River, 35%), Tillotson Avenue (White River, 35%), Nebo Road (White River, 34%), and Walnut Street (White River, 21%). Please note, however, that large fluctuations are present between decades. Large fluctuations observed in the 1980s (on White River sites in particular) are in part due to the numerous channelization projects undertaken. Suspended solids at S.R. 32 East (32 Ditch) have increased almost 900% since the 1970s, by far the highest increase of any site. Remaining sites witness no notable decrease or increase from their 1970s values.

BWQ: White River *E. coli* Assessment

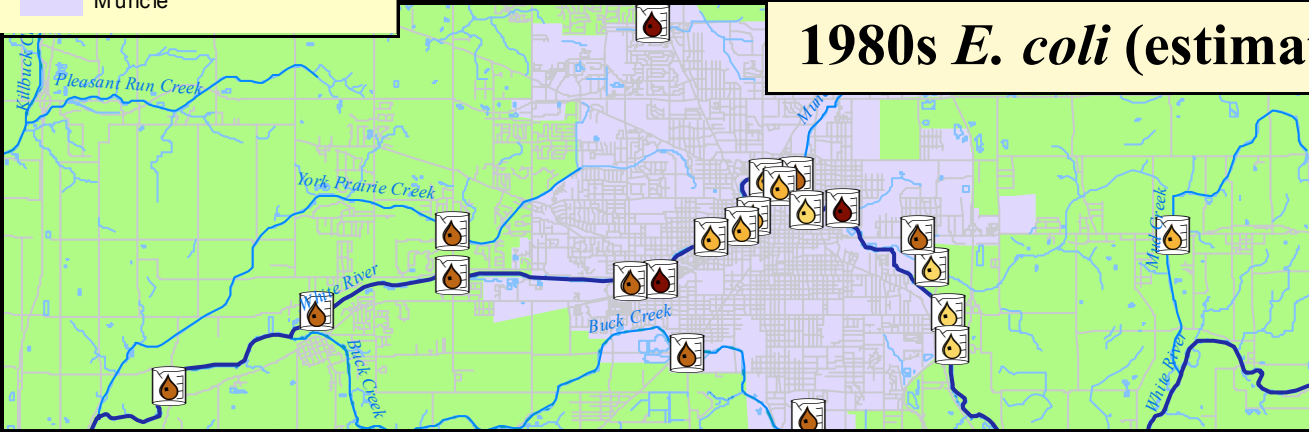
Legend

-  0 to 1300 per 100mL
-  1301 to 2600 per 100mL
-  2601 to 5000 per 100mL
-  5001 to 21500 per 100mL
-  21501 per 100mL or above
-  Major Waterway
-  Waterway
-  Roadway
-  Muncie

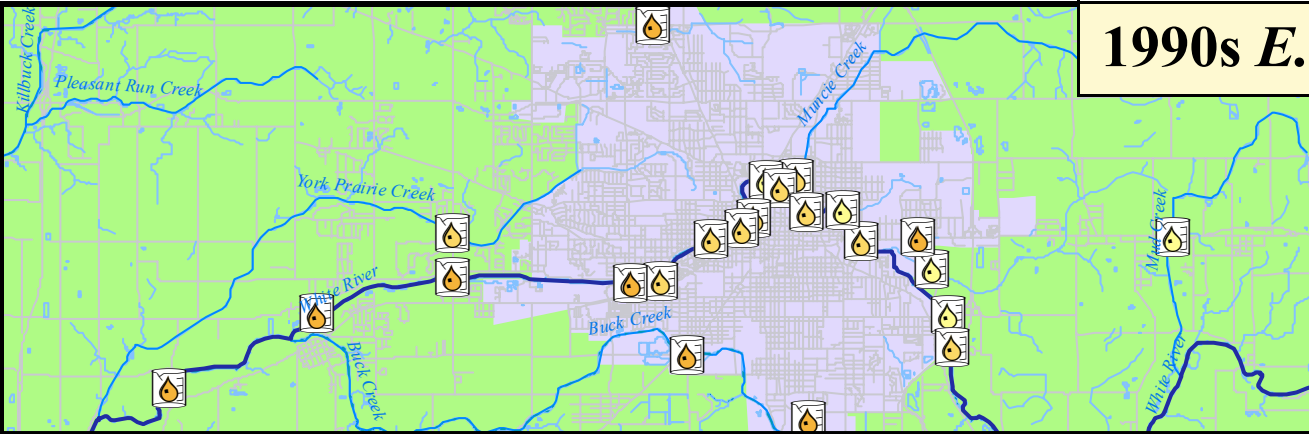
1970s *E. coli* (estimated)



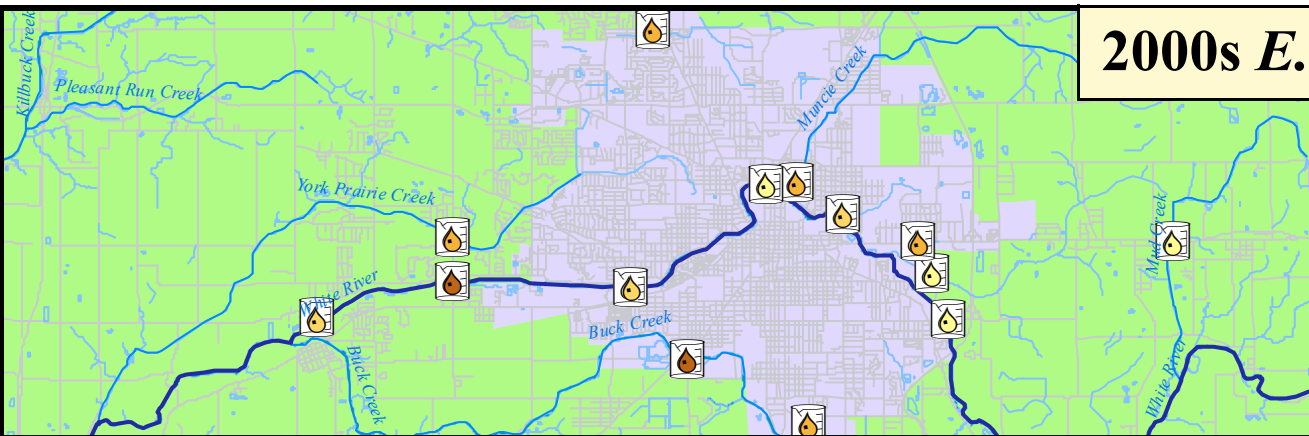
1980s *E. coli* (estimated)



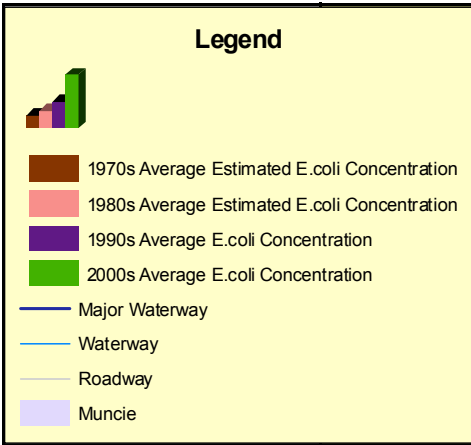
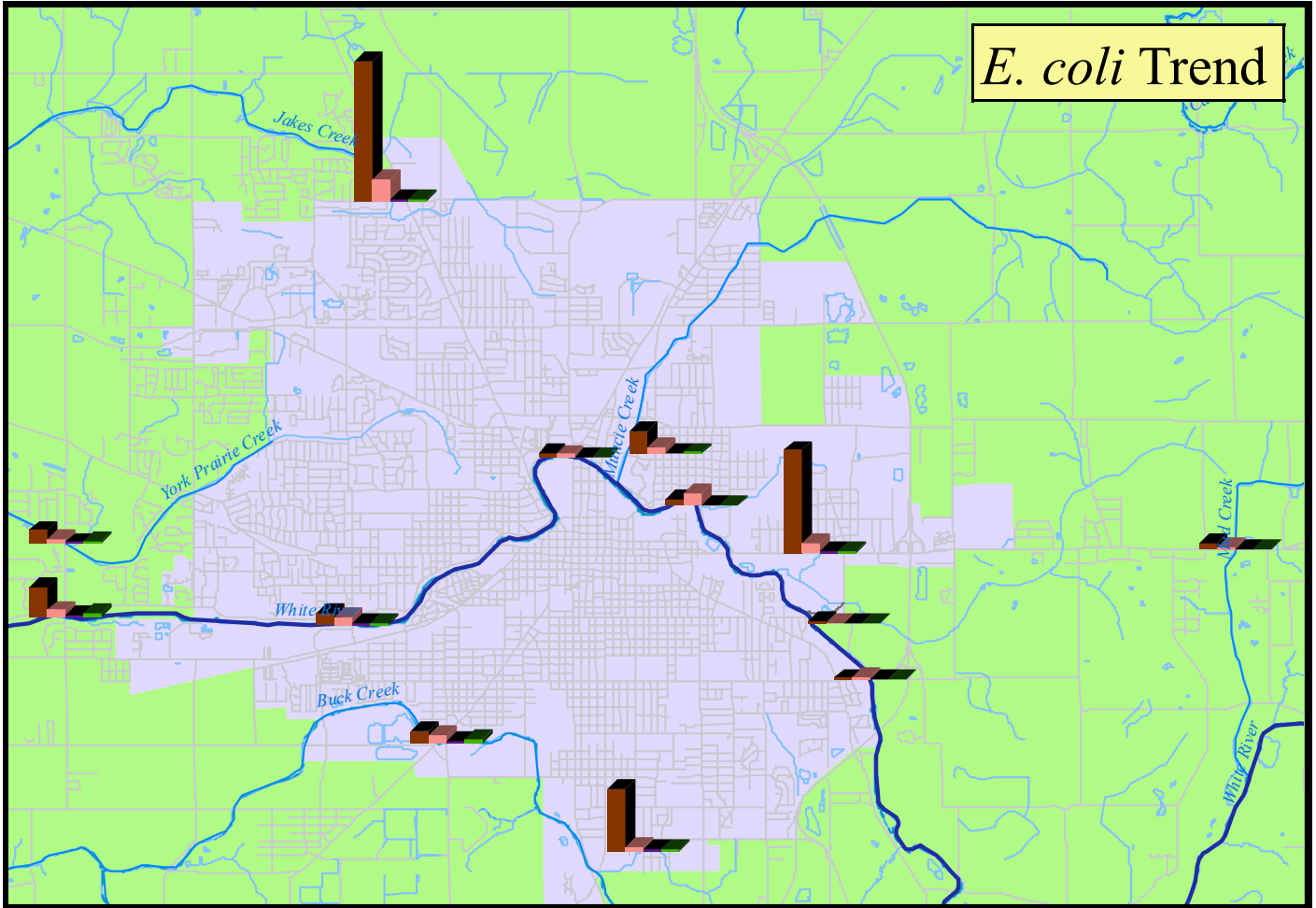
1990s *E. coli*



2000s *E. coli*



BWQ: White River *E. coli* Assessment












Please note that *E. coli* concentrations for the 1970s and 1980s are estimated figures. The BWQ monitored fecal coliform levels during these decades. A conversion, supported by BWQ simultaneous testing, determined that *E. coli* counts were approximately 62% of fecal coliform concentrations. This was used to determine estimated values.

E. coli concentrations have been significantly reduced from 1970s levels at all city baseline sites. Several sites witnessed reductions equal to or greater than 90%. These include West Riggin Road (Greenfarm Ditch, 99%), S.R. 32 East (32 Ditch, 98%), Ebright Street (Lennox Ditch, 97%), Highland Avenue (Muncie Creek, 91%), and S.R. 32 East (Mud Creek, 90%). Several sites had reductions equal to or greater than 80%, including Tillotson Avenue (White River, 89%), Butterfield Road (Truitt Ditch, 88%), Nebo Road (White River, 87%), Ball Road (Holt Ditch, 85%), Walnut Street (White River, 84%), and 400 West (York Prairie Creek, 80%). Other significant reductions included Cowan Road (Buck Creek, 73%) and Memorial Drive (White River, 59%).

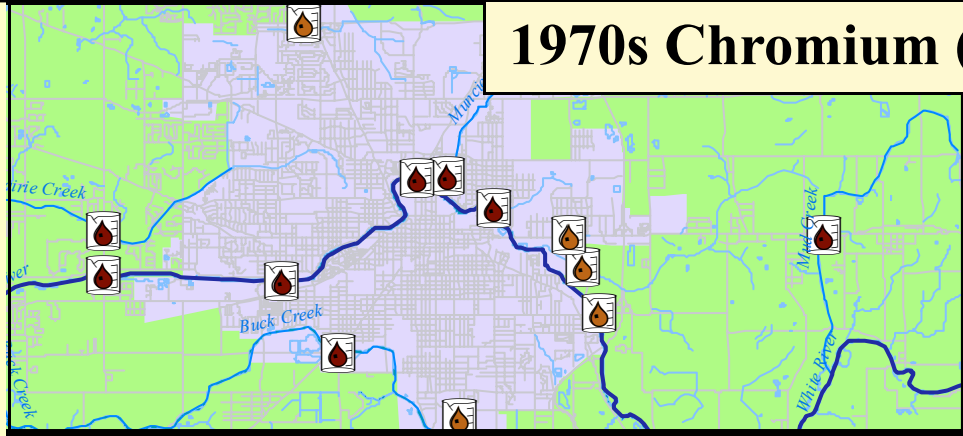


BWQ: White River Chromium (Cr) Assessment

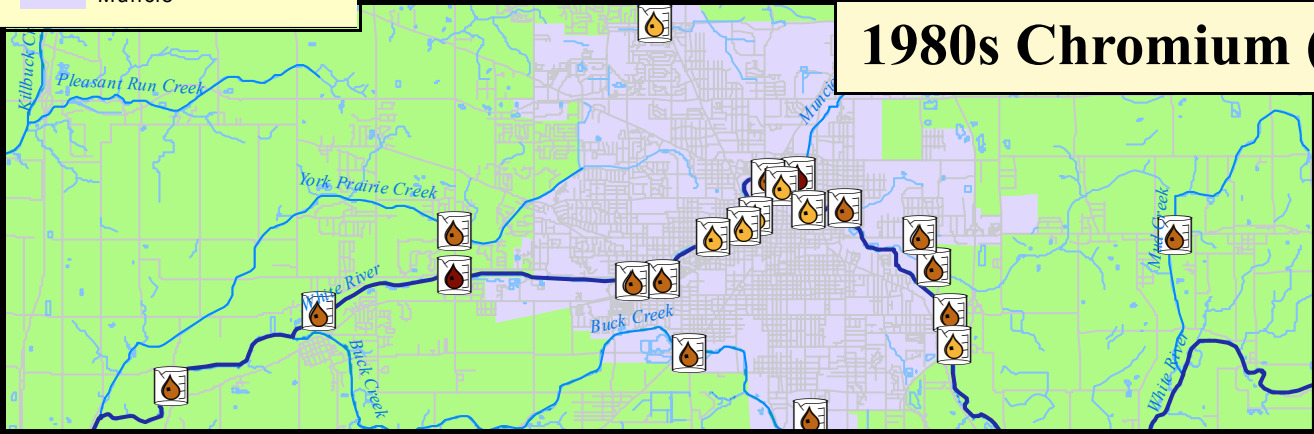
Legend

-  0.0000 to 0.0016 mg/L
-  0.0017 to 0.0030 mg/L
-  0.0031 to 0.0063 mg/L
-  0.0064 to 0.0079 mg/L
-  0.0080 mg/L or above
-  Major Waterway
-  Waterway
-  Roadway
-  Muncie

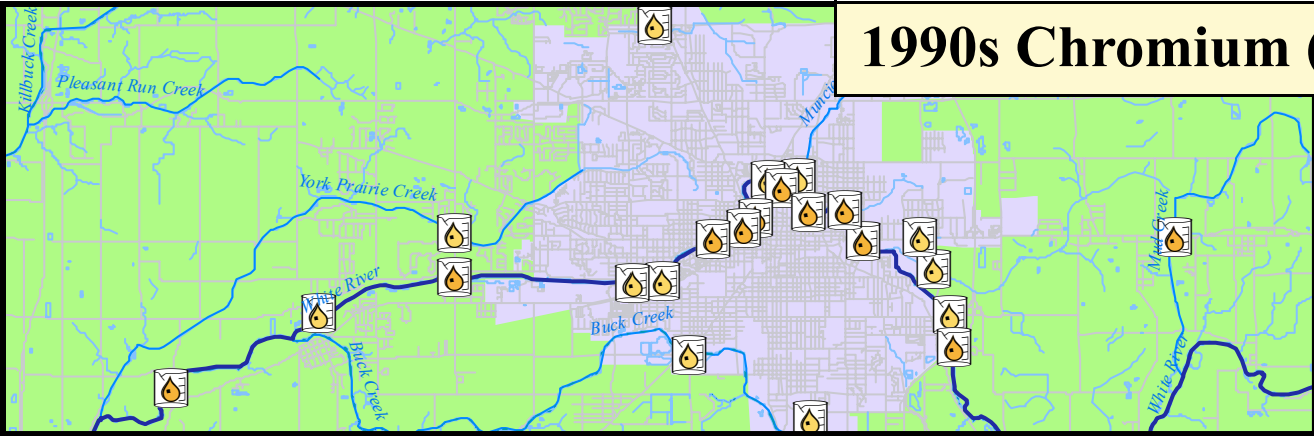
1970s Chromium (Cr)



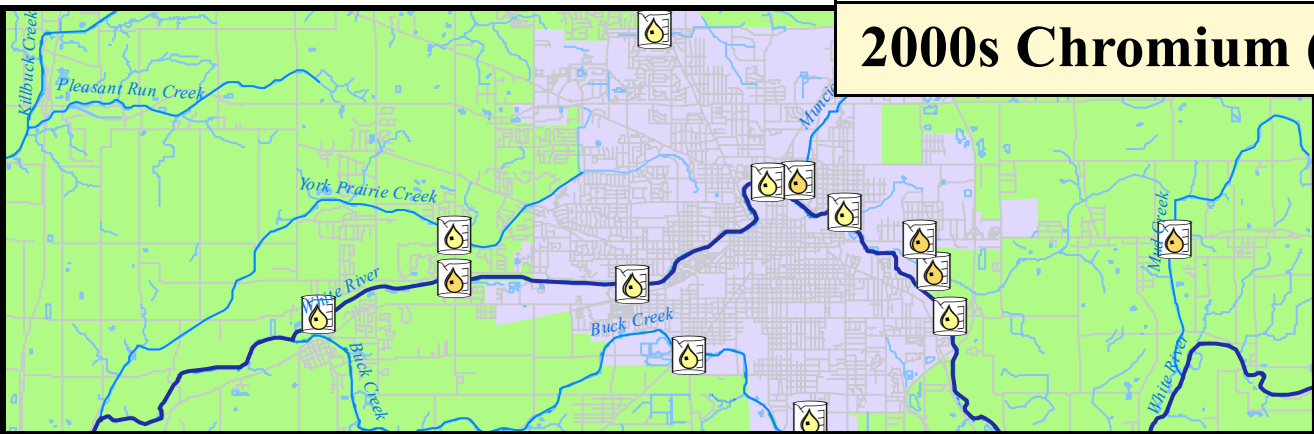
1980s Chromium (Cr)



1990s Chromium (Cr)

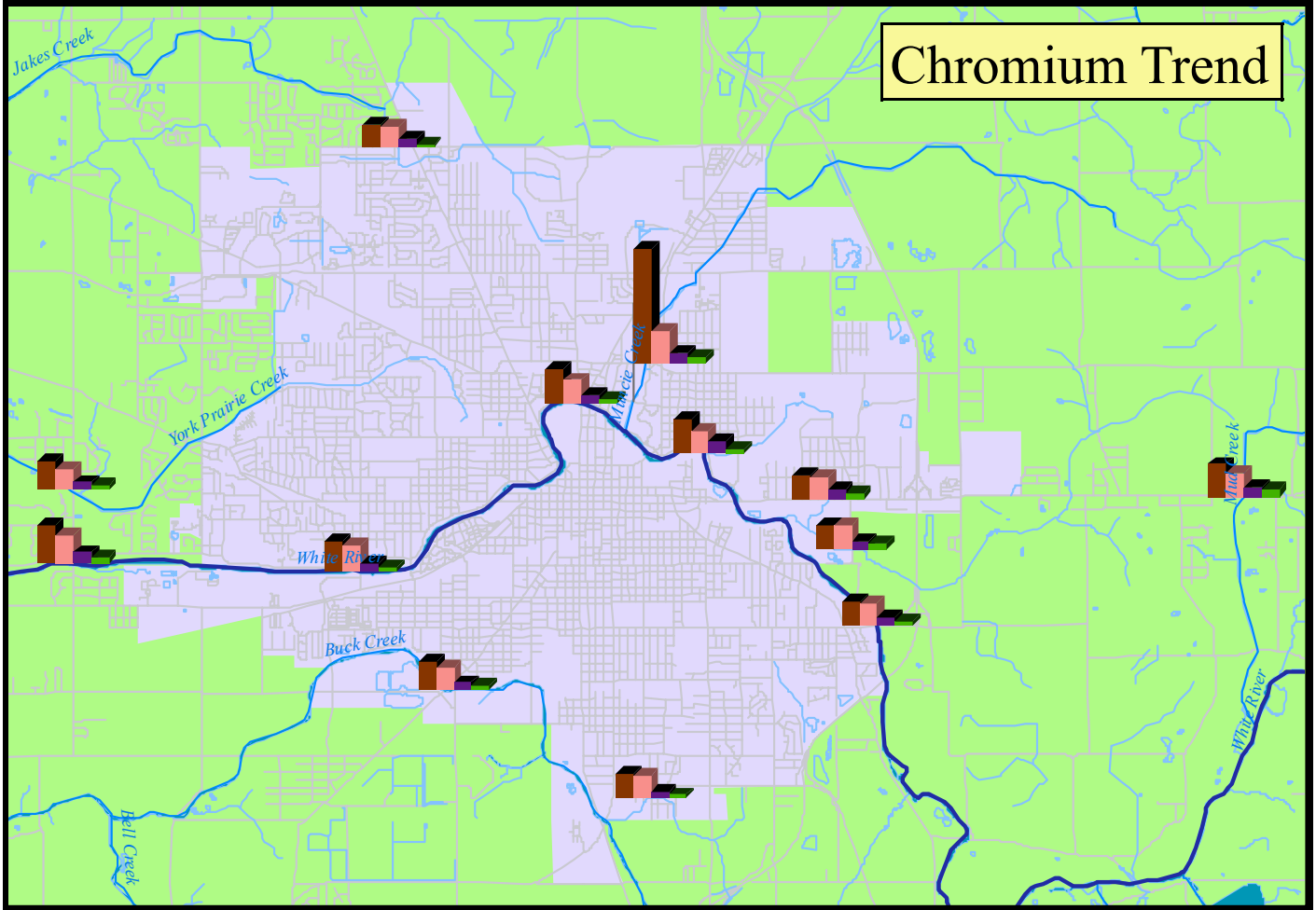


2000s Chromium (Cr)

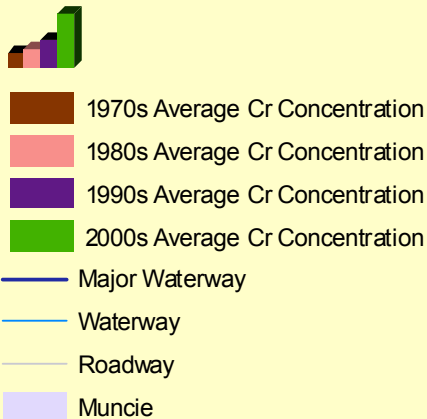


BWQ: White River Chromium (Cr) Assessment

Chromium Trend








Legend







Significant reductions in chromium concentrations from the 1970s to the 2000s were observed at every city baseline site. The highest reduction, 94%, was found at Highland Avenue (Muncie Creek). Most sites displayed reductions greater than 80%. These sites included Ball Road (Holt Ditch, 88%), Ebright Street (Lennox Ditch, 87%), West Riggin Road (Greenfarm Ditch, 86%), Walnut Street (White River, 86%), Cowan Road (Buck Creek, 84%), Memorial Drive (White River, 84%), Tillotson Avenue (White River, 84%), 400 West (York Prairie Creek, 84%), and Nebo Road (White River, 83%). Other significant reductions included Butterfield Road (Truitt Ditch, 77%), S.R. 32 East (Mud Creek, 76%), S.R. 32 East (32 Ditch, 75%).

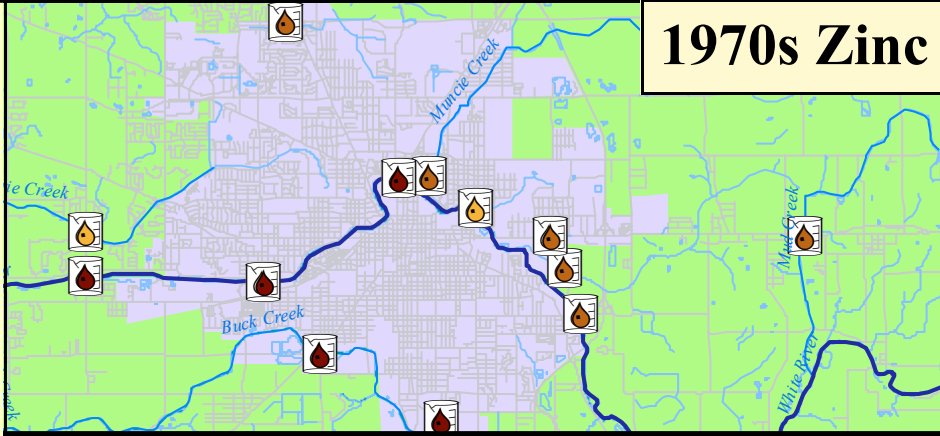
BWQ: White River Zinc (Zn) Assessment

Legend

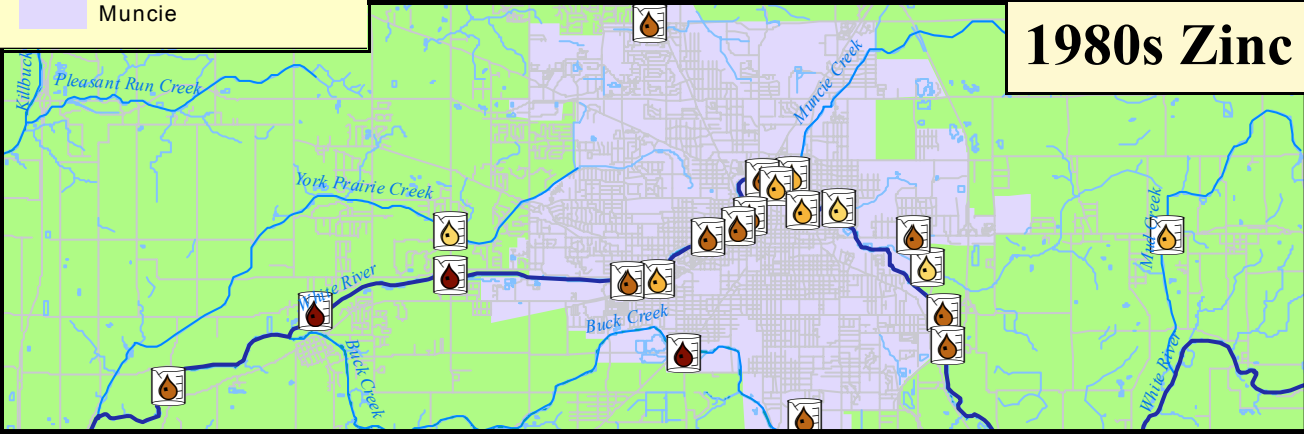
-  0.0000 to 0.0110 mg/L
-  0.0111 to 0.0220 mg/L
-  0.0221 to 0.0330 mg/L
-  0.0331 to 0.0550 mg/L
-  0.0551 mg/L or above

-  Major Waterway
-  Waterway
-  Roadway
-  Muncie

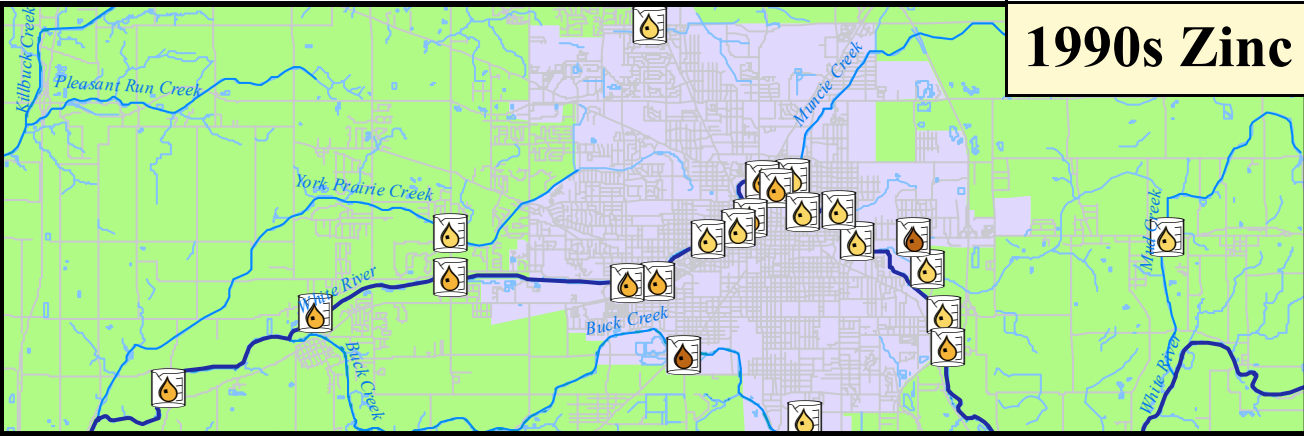
1970s Zinc (Zn)



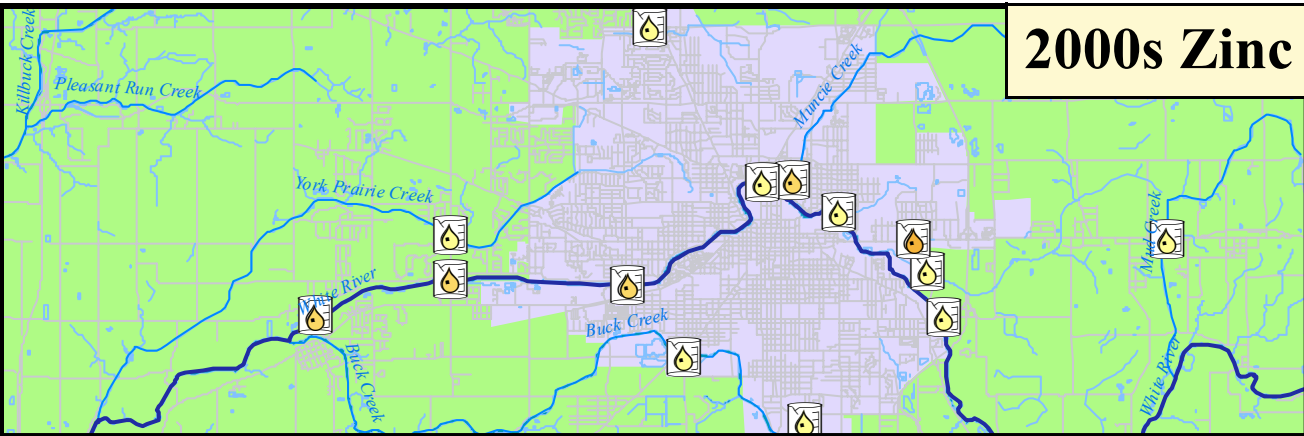
1980s Zinc (Zn)



1990s Zinc (Zn)

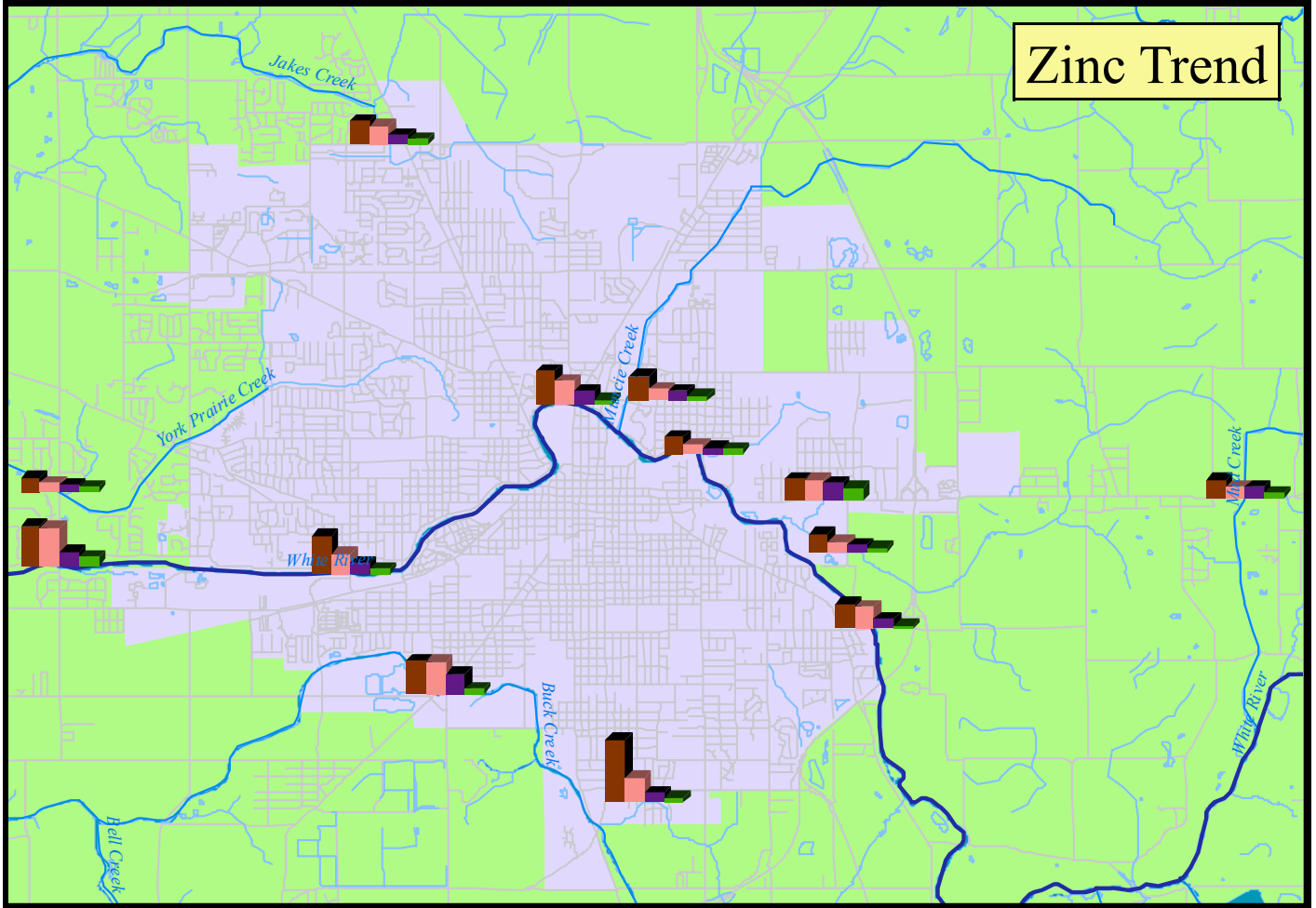


2000s Zinc (Zn)



BWQ: White River Zinc (Zn) Assessment

Zinc Trend



Legend



- 1970s Average Zn Concentration
- 1980s Average Zn Concentration
- 1990s Average Zn Concentration
- 2000s Average Zn Concentration

Major Waterway

Waterway










Roadway

Muncie

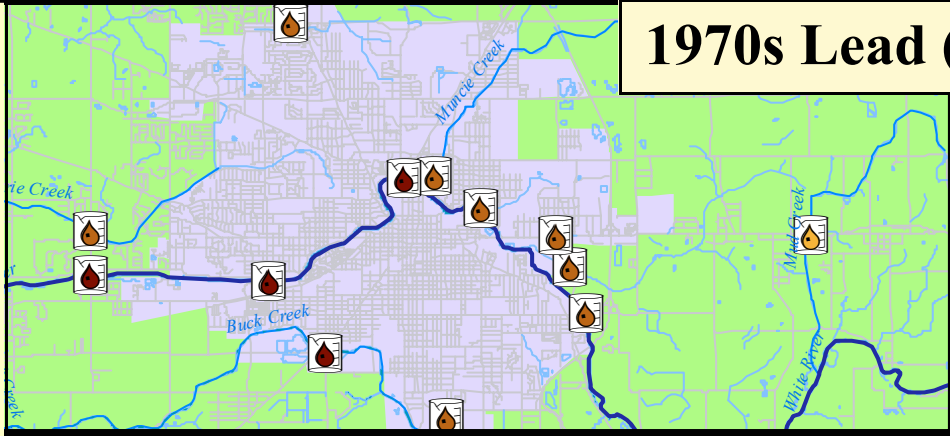
Zinc concentrations have decreased significantly from their 1970s concentrations at all BWQ city baseline sites. The highest reduction, 92%, was observed at Ebricht Street (Lennox Ditch). Many sites had reductions equal to or greater than 80%, including Walnut Street (White River, 87%), Cowan Road (Buck Creek, 86%), Memorial Drive (White River, 86%), and Tillotson Avenue (White River, 85%). Other significant reductions were found at the following sites: West Riggin Road (Greenfarm Ditch, 77%), Highland Avenue (Muncie Creek, 77%), Nebo Road (White River, 77%), Butterfield Road (Truitt Ditch, 75%), Ball Road (Holt Ditch, 73%), S.R. 32 East (Mud Creek, 71%), 400 West (York Prairie Creek, 61%), and S.R. 32 East (32 Ditch, 41%).

BWQ: White River Lead (Pb) Assessment

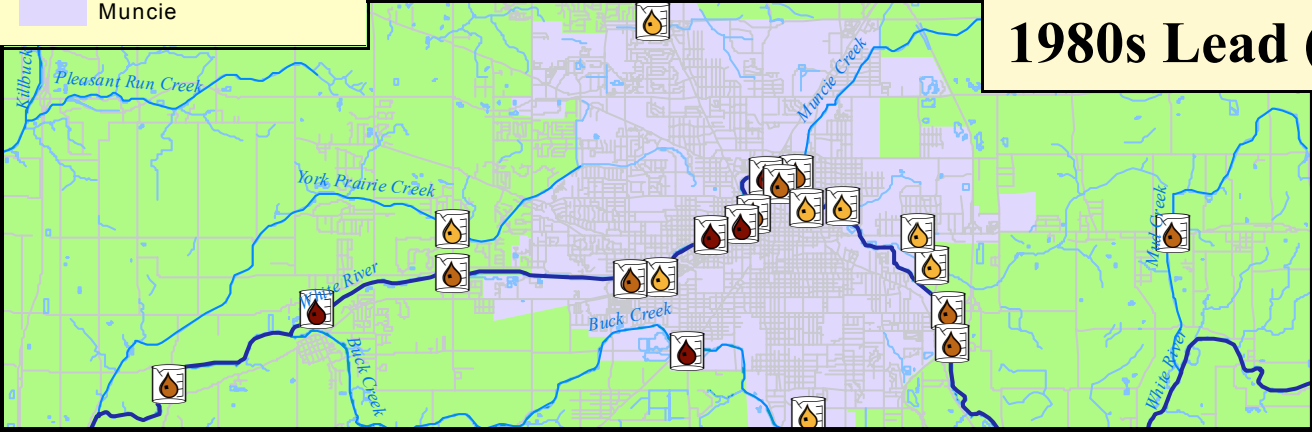
Legend

-  0.0000 to 0.0019 mg/L
-  0.0020 to 0.0148 mg/L
-  0.0149 to 0.0280 mg/L
-  0.0281 to 0.0429 mg/L
-  0.0430 mg/L or above
-  Major Waterway
-  Waterway
-  Roadway
-  Muncie

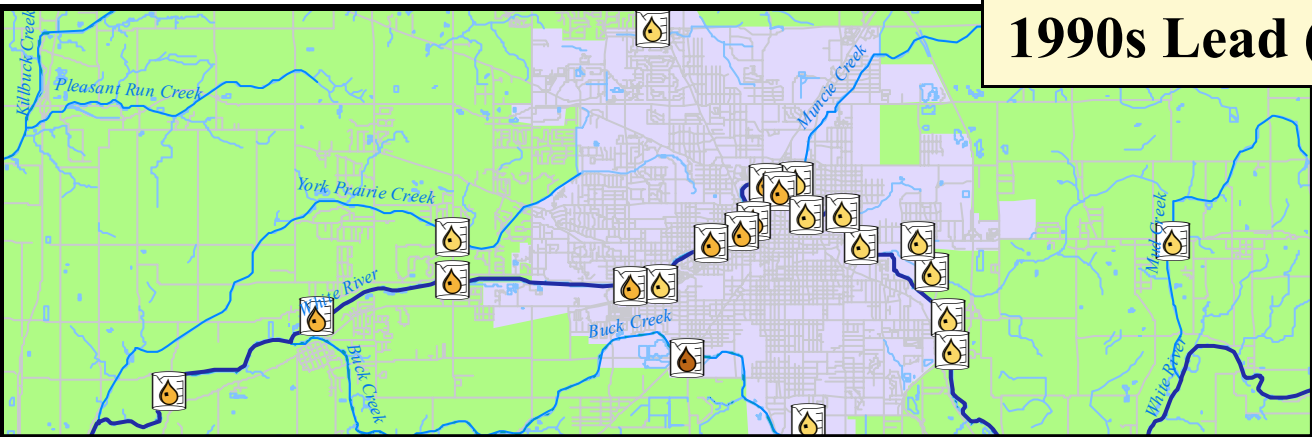
1970s Lead (Pb)



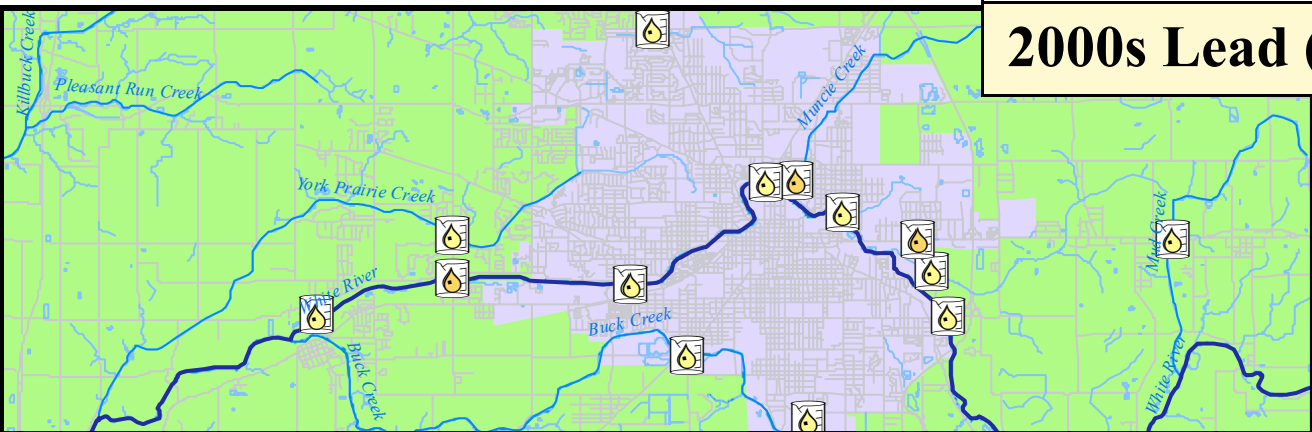
1980s Lead (Pb)



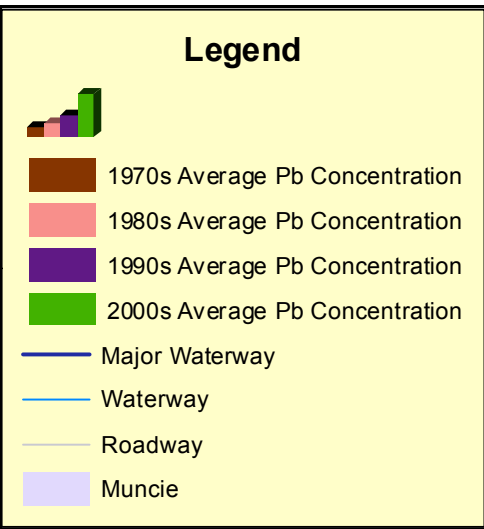
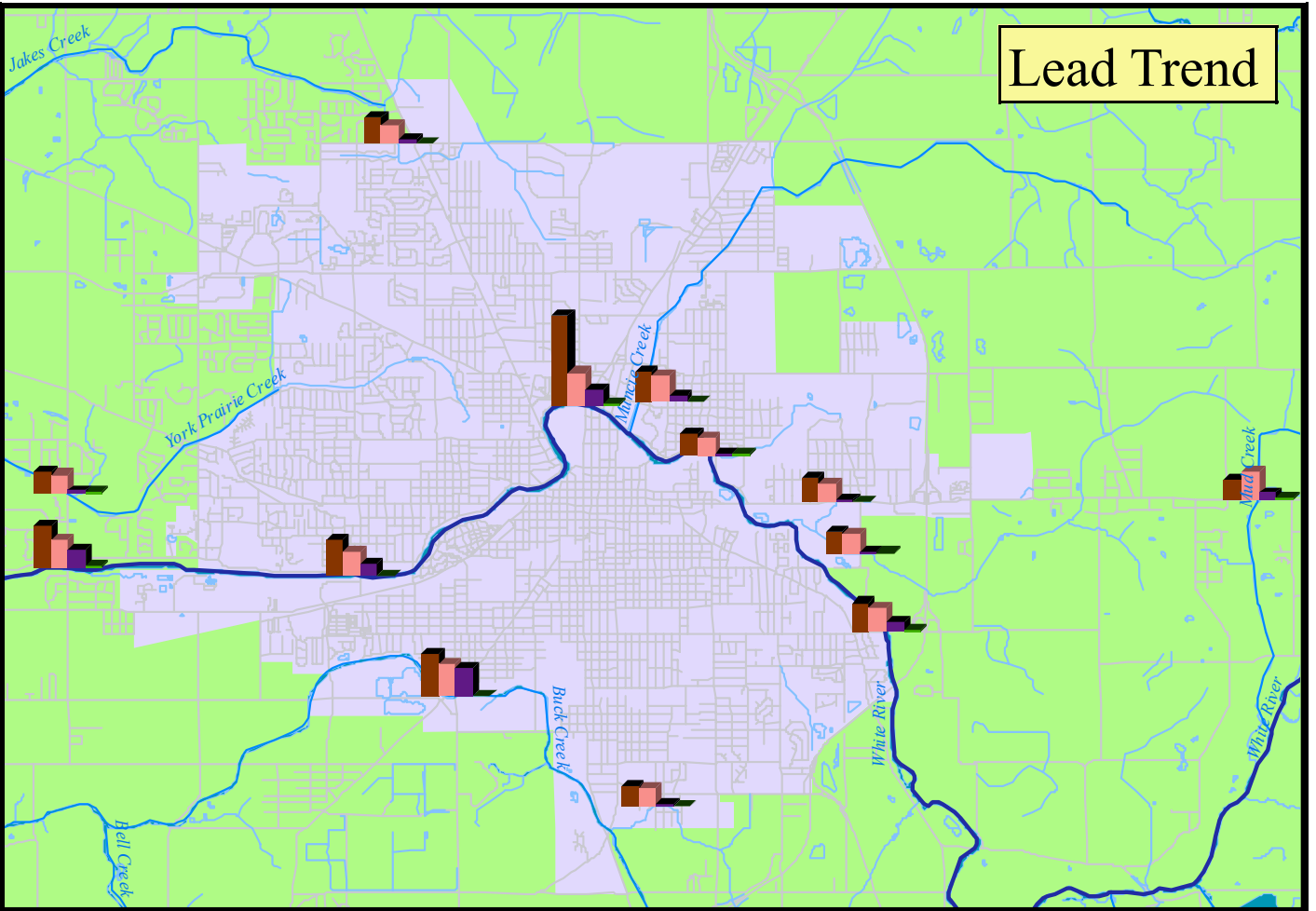
1990s Lead (Pb)



2000s Lead (Pb)



BWQ: White River Lead (Pb) Assessment



All city baseline sites experienced dramatic reductions in lead concentrations since the 1970s. Every site witnessed over a 90% reduction in lead. The percent reductions were as follows: Walnut Street (White River, 99%), West Riggins Road (Greenfarm Ditch, 97%), Cowan Road (Buck Creek, 97%), Memorial Drive (White River, 97%), Nebo Road (White River, 97%), Tillotson Avenue (White River, 97%), Ball Road (Holt Ditch, 95%), Ebright Street (Lennox Ditch, 95%), Highland Avenue (Muncie Creek, 95%), Butterfield Road (Truitt Ditch, 95%), 400 West (York Prairie Creek, 94%), S.R. 32 East (Mud Creek, 94%), and S.R. 32 East (32 Ditch, 93%).

