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Biological and Water Quality Study of the West Branch DuPage River Watershed 2015

Cook and DuPage Counties, Illinois

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Cover photo: West Branch DuPage River (Station WB12) at Mack Road, near Warrenville (RM 13.6).

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2015 Biological and Water Quality Study of the West Branch DuPage River

DuPage, Cook and Will Counties, Illinois

Technical Report MBI/2017-8-8

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FOREWORD

What is a Biological and Water Quality Survey?
A biological and water quality survey, or "biosurvey", is an interdisciplinary monitoring effort coordinated on a waterbody specific or watershed scale. This may involve a relatively simple setting focusing on one or two small streams, one or two principal stressors, and a handful of sampling sites or a much more complex effort including entire drainage basins, multiple and overlapping stressors, and tens of sites. The latter is the case with the West Branch DuPage River biological and water quality study in that the West Branch represents a defined watershed of approximately 150 square miles in drainage area that has a complex mix of overlapping stressors and sources in a highly developed suburban landscape. This assessment is a follow-up to similarly intensive surveys of the West Branch done in 2012, 2009 and 2006, the first effort of comprehensive reach and scope accomplished for this watershed. Previous surveys and assessments by Illinois EPA and DNR were done at a less intense spatial scale. While the principal focus of a biosurvey is on the status of aquatic life uses, the status of other uses such as recreation and water supply, as well as human health concerns, can also be addressed.

Scope of the West Branch DuPage River Watershed Biological and Water Quality Assessment
Standardized biological, chemical, and physical monitoring and assessment techniques were employed to meet three major objectives:

1) determine the extent to which biological assemblages are impaired (using Illinois EPA guidelines);

2) determine the categorical stressors and sources that are associated with those impairments;

3) compare 2015 results to previous assessments of the West Branch DuPage River watershed to evaluate trends.

Data presented herein were processed, evaluated, and synthesized as a biological and water quality assessment of aquatic life use support status. The assessments are directly comparable to those accomplished in previous surveys of the watershed in 2006, 2009, and 2012 such that trends in status can be examined, and causes and sources of impairment can be confirmed, appended, or removed. For this report, 2015 results were primarily compared to the most recent surveys in 2012 and 2009. This study contains a summary of major findings and recommendations for future monitoring, follow-up investigations, and any immediate actions that may be needed to resolve readily diagnosed impairments. It was not the role of this study to identify specific remedial actions on a site specific or watershed basis. However, the baseline data established by this study contributes to a process termed the Integrated Priority System (IPS; MBI 2010a) that was developed for the upper DuPage watersheds to help determine and prioritize restoration projects.

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INTRODUCTION

A biological and water quality study of the West Branch DuPage River and selected Tributaries was conducted in 2015 to assess aquatic life condition status, identify proximate stressors, and examine chemical/ physical water quality and biological condition relative to publicly owned treatment works and other sources of stress and impact. The 2015 data were used to assess trends relative to recent watershed surveys in *Biological and Water Quality Study of the West Branch of the DuPage River* (2010b and 2014, respectively).

Data analyses and site selection for the West Branch DuPage watershed was facilitated by a geometric survey design. The chemical and biological results were displayed by increments of drainage area as ≤5, 10, 19, 38, 75, and 150 sq. mi. geometric panels. Pollution survey design sites targeted discharges of interest and filled gaps in the geometric design. MBI employed this design in prior surveys of the East and West Branch DuPage Rivers, Lower DuPage River, and Salt Creek 2006 and 2014 (MBI 2008a, 2010b, 2012, 2013, 2014, and Salt Cr. 2013-16 [in progress)]. Following the 2006 survey, a significant habitat restoration project was completed in the West Branch mainstem from river mile (RM) 15 to 9, and within the lower 1.5 miles of Kress Creek. The restoration was part of an on-going remediation of contaminated sediments[1] that resulted in the removal of low-head dams at McDowell and Warrenville Grove.

SUMMARY

The entirety of the West Branch DuPage River watershed remains impaired based on biological assemblages surveyed in 2015 (Figure 1; Table 1). In the West Branch mainstem, both chemical and biological conditions showed improvement over the low-flow stresses encountered in 2012 but the basic trends remain. As in the past, nutrient levels spike beginning downstream from

[1] http://www.epa.gov/R5Super/npl/illinois/ILD980823991.html

the first of a series of seven major municipal WWTPs[2,3] and remain elevated downstream to the mouth. The most degraded biological, water quality, and habitat conditions, and the highest concentration of wastewater effluents, occurred in the roughly 10 mile headwater reach (i.e., <20 sq. mi.) RMs 35 to 25. While still well above target, mainstem phosphorus and nitrate concentrations were actually reduced by over half between 2012 and 2015, the apparent result of higher base flows and increased effluent dilution during the "wetter" 2015 survey. Despite these reductions, the pattern of elevated nutrient levels and periodically low dissolved oxygen levels persisted along the mainstem with numerous WQS exceedances measured at continuous monitoring stations. In contrast to nutrients, chloride and dissolved solids trend levels below point source discharges were nearly identical and experienced only modest declines. It appears background and maintenance contributions from both point and non-point sources in larger, mainstem drainages, result in more stable, consistent concentrations downstream. One major difference between the 2012 and 2015 mainstem headwater results was the extremely high $cBOD_5$ levels found at the most upstream site (average 34.13 mg/L at WB25). Elevated $cBOD_5$ levels extended through the headwater reach, a section that has typically had the highest mainstem levels in previous surveys. WQS exceedances for D.O. and of threshold effects for NH_3-N were also encountered at WB25, but the source of pollutants remains unknown. Downstream from the headwaters, mainstem biological communities showed some additional improvement in 2015 but results makes it increasingly clear the Fawell Dam (RM 8.1) is a major impediment to recovery. Downstream from the dam where fish movements are unfettered, fish index scores were in the upper fair range and approached full attainment. In contrast, assemblages upstream from the dam remained consistently in the lower fair range, only slightly improved over previous surveys. With modification of the dam proposed for 2018/19, additional improvement extending upstream from the former impoundment is anticipated.

Mainstem biological and chemical results in 2015 reflected some moderation of the severe conditions and low-flow stresses in 2012 but the overall trend remains similar. Contrasting biological results and sharp differences in fish assemblage quality above and below the Fawell dam continue to suggest this barrier to fish movement contributes to impairments upstream. However, under more severe effluent dominated conditions, such as those encountered in 2012, biological and water quality impairment related to point and nonpoint sources remain a significant issue. Ultimately, maximum improvement in biological condition should hinge on modification of Fawell Dam (to improve connectivity to the downstream reach) and additional water quality improvements upstream. As in other DuPage River drainages, the most severe and consistent impairment in the biology were manifest in the smallest Tributary drainages which are proportionately more impacted than the larger streams given their close proximity to urban land use related stressors. In fact, since the initial bioassessment in 2006, no stream site draining less than 20 sq. mi. has fully attained the Illinois biological thresholds within the DuPage River or adjacent Salt Creek basins. These results reflect a consistent inability of small

[2] Major mainstem WWTPs include the MWRD Hanover Park, Roselle-J. Botterman, Hanover Park #1, Bartlett, and West Chicago facilities. Tributary plants include Carol Stream on Klein Creek and Wheaton on Spring Brook; the Bartlett WWTP "overflow" plant intermittently discharges to an unnamed West Br. tributary (95-906).

[3] In the 2012 survey report, a sharp increase in nitrate and phosphorus was mistakenly reported at WB31 (immediately upstream MWRD). It is possible that two samples attributed to WB31 were collected downstream from a point source(s) and misallocated. Further upstream at WB25 (RM 34.1), an NH_3-N exceedance in 2012 and extremely high BOD levels in 2015 do suggest additional, unknown sources.

drainages to support warmwater assemblages. As in previous surveys, impairments appear primarily related to urban land use and likely include a combination of chemical and physical factors such as flashy flows, impoundment, habitat alteration, and chemical contaminants delivered by runoff events. Both biological and chemical conditions in the Tributaries were roughly the same as in 2012 but dilution effects and higher base flows resulted in some lower concentrations in-stream. For example, both phosphorus and chlorides concentrations, while remaining elevated and largely above IPS target levels, were reduced by about one-third in 2015. Elevated BOD levels were widespread in Tributaries based on an average 3 mg/L threshold used to identify stream enrichment in Minnesota. When both 2015 and 2012 results are considered, 15 of 22 Tributary sites (68%) exceeded threshold. The high levels were often associated with small, densely urbanized watersheds or drained nearby impoundments and stormwater retention basins. Discharges of suspended organic material and algae from impoundments likely contributed to the enriched conditions.

Throughout the West Branch watershed, past surveys have displayed a consistent pattern of elevated chloride levels (see Figure 13 and 14). The low flow conditions of 2012 led to a significant increase in instream concentrations for that year, a situation that was reversed in 2015 when flows returned to 2009 levels. Chloride concentration is a function of flow and chloride inputs, itself a function of winter weather. Considering these variables, more work is needed to `identify the long term trend in chloride loadings. Elevated chloride levels throughout the West Branch and DuPage watersheds have been largely attributed to road salt applications and the resultant build-up of salts in urban soils and near surface groundwater (CH_2M Hill 2004, Kelly et al. 2012). Wastewater Treatment Plant discharges also contributed chlorides but monitoring indicates the influence of chlorides in waste water was most pronounced only in late summer and fall (Figure 15), when flows and inputs from the previous year's winter deicing activities, and prior to the commencement of winter road salt applications. In 2012 and 2009, highest chloride concentrations (and resultant effect exceedances) were detected in Winfield Creek at WB13, about 0.6 miles downstream from a salt storage facility. As a result, additional biological sampling was conducted at sites bracketing the facility in 2015. No significant differences were observed in biological quality, but chemical sampling again detected an exceedance for chloride, albeit at a lower concentration.

Within the West Branch Tributary sites, a modest reduction in habitat scores in 2015 pointed to a previously unnoticed increase in beaver activity and dam construction at a number of sites. Including the 2012 survey, impoundments associated with beaver dams are noted at 4-5 of the 24 Tributary stations sampled, or roughly 20%. While beaver activity is considered a natural condition or "shift" in habitat quality, the structures may negatively influence habitat scores by eliminating riffles and runs and increasing sediment deposition in the sluggish impoundments. Most beaver activity was located within park boundaries. Cress Creek (WB07) had an unusual deep green color during fish collection. The discoloration may have resulted from algal growth spurred by enrichment or fertilizer but may have also indicated "Aquashade" algal treatment from a nearby impoundment.

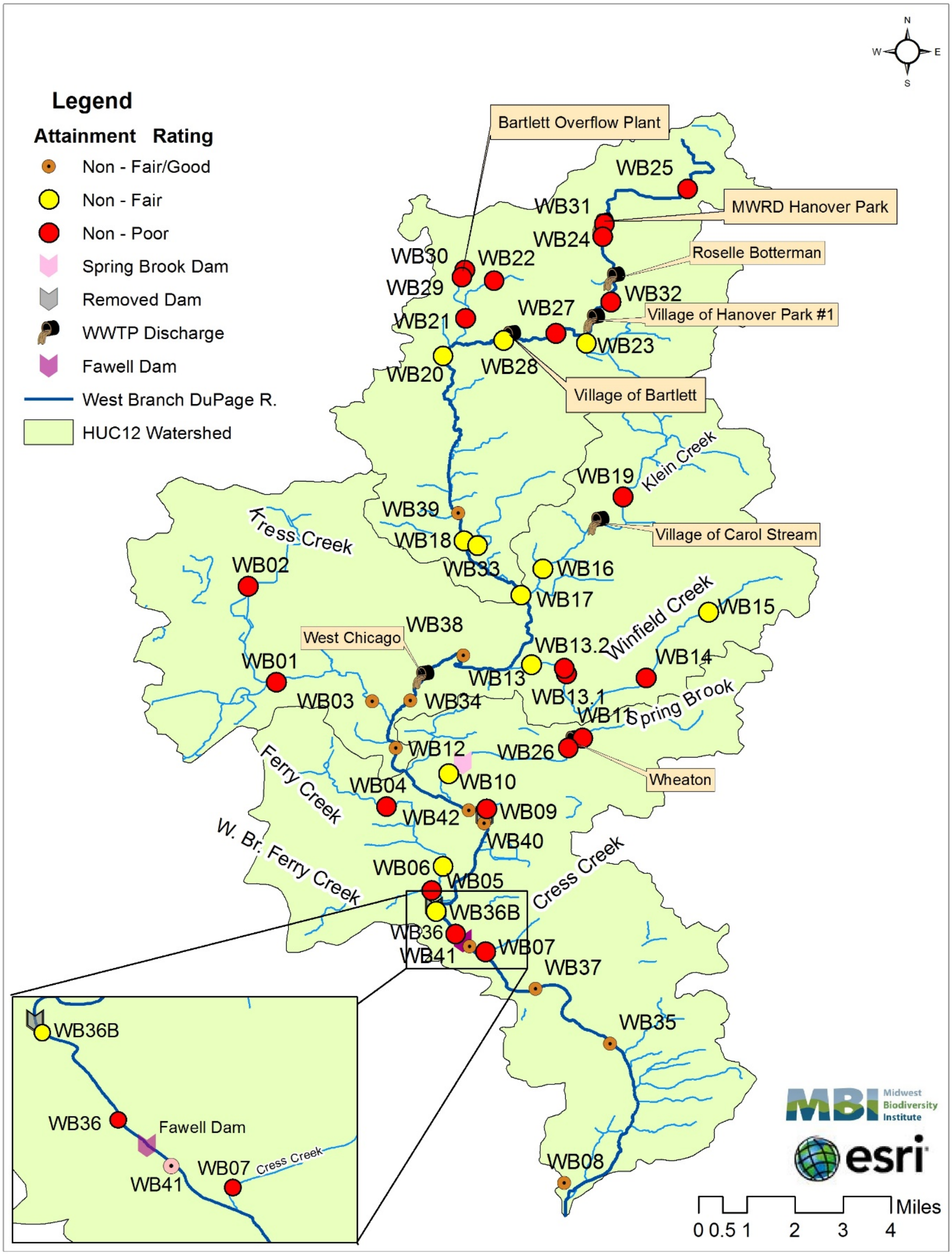

***Figure 1**. Aquatic life use attainment status at West Branch DuPage River watershed biological sampling sites in 2015. Non-attainment based on biological performance is noted with orange circles (mixed fair-good results), yellow circles (fair range), and red circles (poor). No sites were in full attainment.*

***Table 1**. Status of aquatic life use support for sites sampled in the West Branch DuPage River watershed study area in 2015. All sites with one or more fair or poor index scores are in non-attainment and categorized as follows: 1) sites with any index in the poor range (i.e., non-poor) are shaded in red and poor index scores are underlined; 2) fair quality sites (i.e., non-fair) are shaded in yellow; and 3) fair to good quality sites (i.e., non-fair/good) are shaded in green dot with "good" index scores in bold.*

Site ID	River Mile	D.A. (mi^2)	fIBI	MIwb	mIBI	QHEI	Attainment Status[a]	Causes[b]	2012	
									fIBI	mIBI
							West Branch DuPage River			
WB25	34.0	2.1	4.5	na	23.7	47.0	Non - Poor	Chloride, D.O., nutrients (NH3,TKN, P), BOD habitat alt.	2.0	26.3
WB31	31.9	4.9	13.5	na	25.0	54.5	Non - Poor	Chloride, nutrients (NH3, TKN P, N), D.O., BOD hab. alt.	10.5	26.1
WB24	31.6	5.4	10.0	na	21.5	51.5	Non - Poor	Chloride/TDS, nutrients (P, N), habitat alt.	15.5	20.7
WB32	30.1	7.4	18.5	na	28.0	61.0	Non - Poor	Chloride/TDS, nutrients (P, N, NH_3, TKN) BOD	21.0	15.6
WB27	28.7	14	17.0	na	32.5	66.0	Non - Poor	Chloride/TDS, nutrients (P, N, NH3, TKN) BOD	18.5	20.0
WB28	27.4	14	20.5	na	30.0	77.0	Non - Fair	Chloride/TDS, nutrients (P, N) BOD	22.0	27.2
WB20	25.6	19.7	22.0	na	32.9	79.0	Non - Fair	Chloride/TDS, nutrients (P, N, TKN), zinc, fish barrier	19.0	37.9
WB39	21.7	27.8	20.5	4.7	**49.2**	72.0	Non – F/G	Chloride/TDS, nutrients (P, N) fish barrier	20.0	40.4
WB33	21.3	28.1	24.5	6.9	37.0	79.0	Non - Fair	Chloride/TDS, nutrients (P, N, TKN) fish barrier	21.0	39.0
WB17	19.2	33.8	21.0	6.0	41.3	76.0	Non - Fair	Chloride/TDS, nutrients (P, N,TKN), fish barrier	20.0	**45.9**
WB38	16.0	58.4	25.0	6.5	**55.0**	69.3	Non – F/G	Chloride/TDS nutrients (P, N), fish barrier	18.5	32. 5
WB34	15.1	59.9	25.0	6.2	**48.5**	80.0	Non – F/G	Chloride/TDS nutrients (P, N), fish barrier	18.5	38.2
WB12	13.6	80.5	21.0	6.0	**48.3**	74.5	Non – F/G	Chloride/TDS, nutrients (P, N), fish barrier	16.5	39.6
WB42	11.6	89.9	23.0	6.00	**48.6**	84.3	Non – F/G	D.O, fish barrier (continuous monitor only)	21.0	**36.3**
WB40	11.1	89.9	21.0	5.50	**50.0**	67.0	Non – F/G	Chloride/TDS, nutrients (P, N), D.O, fish barrier	18.0	56.5
WB36B	8.6	104.9	--	--	35.2	--	Non – (Fair)	Chloride/TDS, nutrients (P, N), D.O, fish barrier	--	--
WB36	8.3	104.9	19.0	5.60	**--**	45.0	Non – (Poor)	Chloride/TDS, nutrients (P, N), D.O, fish barrier	21.0	24.8
WB41	8.0	105.2	28.0	7.09	**50.2**	74.0	Non – F/G	Chloride/TDS nutrients (P, N)	27.0	**44.9**
WB37	6.3	109.7	35.5	7.4	**47.6**	89.0	Non – F/G	Chloride/TDS nutrients (P, N)	30.0	**50.6**
WB35	4.2	115.3	37.0	7.4	**46.6**	87.8	Non – F/G	Chloride/TDS, nutrients (P, N)	26.0	30.7
WB08	0.85	124.5	36.5	7.9	**44.2**	82.0	Non – F/G	Chloride/TDS, nutrients (P, N)	25.5	**50.0**
							Trib. to W. Br. DuPage River (RM20.85)			
WB18	0.5	2.7	25.0	na	**27.3**	43.0	Non - Fair	Chloride/TDS, habitat alt.	23.0	31.0

Site ID	River Mile	D.A. (mi^2)	fIBI	MIwb	mIBI	QHEI	Attainment Status[a]	Causes[b]	2012 fIBI	2012 mIBI
Trib. (RM 1.65) to Trib. to W. Br. DuPage River (RM 25.5)										
WB22	0.15	0.7	19.5	na	22.1	28.0	Non - Poor	Chloride, Habitat alt., NH3, BOD	17.0	25.8
Trib. to W. Br. DuPage River (RM 29.25)										
WB23	0.15	2.5	20.5	na	35.4	40	Non - Fair	Chloride/TDS, nutrients (P, N, NH3, TKN) habitat alt.	13.5	33.2
Trib. to W. Br. DuPage River (RM 25.5)										
WB29	2.20	2.2	8.0	na	14.4	58.5	Non - Poor	Chloride/TDS, nutrients (P), BOD	9.5	20.6
WB30	1.90	2.6	13.5	na	15.4	48.0	Non - Poor	Chloride/TDS, nutrients (P), BOD, habitat alt.	11.0	--
WB21	0.90	4.2	15.0	na	25.7	40.5	Non - Poor	Chloride/TDS, nutrients (P), habitat alt.	29.0	25.7
Kress Creek										
WB02	5.10	4.2	25.0	na	17.6	36.5	Non - Poor	Chloride/TDS, habitat alt.	18.0	13.5
WB01	2.70	14.5	19.0	na	39.0	63.5	Non - Poor	Chloride	12.0	32.8
WB03	0.50	18.6	23.5	na	**42.7**	87.0	Non – F/G	Chloride, nutrients (P)	18.0	24.4
Ferry Creek										
WB04	2.80	3.3	19.0	na	15.3	40.5	Non - Poor	Nutrients (P, TKN), BOD, habitat alt.	14.5	15.9
WB06	0.70	5.5	20.5	na	31.0	49.5	Non - Fair	Chloride, nutrients (P, TKN), BOD, habitat alt.	19.0	30.5
W. Br. Ferry Creek										
WB05	0.25	4.3	21.0	na	17.7	55.0	Non - Poor	Chloride/TDS, nutrients (NH_3, P, TKN), BOD	19.5	17.5
Cress Creek										
WB07	0.20	3.8	25.5	na	11.5	65.0	Non - Poor	Chloride/TDS, nutrients (P), D.O., BOD Green water	28.5	14.0
Bremme Creek										
WB09	0.25	0.8	10.5	na	26.2	55.0	Non - Poor	Chloride/TDS, nutrients (N)	4.5	24.7
Spring Brook										
WB11	3.30	3.7	11.5	na	12.0	43.0	Non - Poor	Chloride/TDS, habitat alt., nutrients (NH_3, P), BOD., D.O.	15.0	20.7
WB26	3.00	3.9	12.0	na	17.0	61.0	Non - Poor	Chloride/TDS, nutrients (N, P) (Dst. WWTP)	11.0	20.1
WB10	0.75	6.8	22.0	na	34.2	64.5	Non - Fair	Chloride/TDS, nutrients (N, P, NH_3), BOD (Dst. WWTP)	21.5	36.6
Winfield Creek										
WB15	5.40	2	25.0	na	23.8	58.0	Non - Fair	Chloride/TDS, nutrients (P)	25.5	17.0
WB14	3.50	5	20.0	na	14.8	30.0	Non - Poor	Chloride/TDS, nutrients (TKN, P), D.O., habitat alt.	13.0	11.1
WB13.2	1.00	9	19.0	na	21.5	49.5	Non - Poor	Chloride/TDS (no chem.), habitat alt.	--	--
WB13.1	0.90	9	18.5	na	19.9	56.0	Non – Poor	Chloride/TDS (no chem.)	--	--

Site ID	River Mile	D.A. (mi^2)	fIBI	MIwb	mIBI	QHEI	Attainment Status[a]	Causes[b]	2012 fIBI	2012 mIBI
WB13	0.40	9.0	21.5	na	29.3	50.0	Non - Fair	Chloride/TDS, nutrients (P), D.O. habitat alt.	15.5	16.4
Klein Creek										
WB19	3.60	5.0	15.5	na	28.4	32.8	Non - Poor	Chloride, habitat alt.	14.0	32.8
WB16	1.00	9.0	20.0	na	27.9	87.0	Non - Poor	Chloride/TDS, nutrients (P, N), zinc, (Dst. WWTP)	15.0	35.3
Ferson Creek (Reference Site)										
F-2	7.6	11.4	26	na	66.8	70.8	Non - F/G	Chloride/TDS, nutrients (P)		
F-1	2.5	51.8	44	9.2	60.2	89.5	Full	--		
Otter Creek (Reference Site)										
F-3	0.9	33.8	--	--	61.7	--	(Full)	--		44.1

[a] [Attainment status] based on one organism group is displayed in brackets.

[b] Underlined nutrient parameters refer to "severe" exceedances of the least stringent of the target criteria (i.e., red shaded values in Table 9). Listings of metals, pH, D.O., and total NH_3-N as "causes" reflect threshold effect exceedances.

na The MIwb is not applicable to sites draining <20 mi.[2].

Narrative Ranges for Illinois fIBI and mIBI scores (IEPA 2013)

	fIBI		mIBI
Poor	0 - 20	Poor	0.0 - 20.9
Fair	>20 - <41	Fair	>20.9 - <41.8
Good	≥41	Good	≥41.8

METHODS

Watershed sampling sites (Figure 2) were selected systematically using a geometric approach by starting with the first site at the downstream terminus of the watershed. The selection process continued by choosing additional stream "panels" at intervals of one-half the drainage area of the preceding level. Thus, the upstream drainage area of each successive level, moving upstream, decreases geometrically. This produced seven levels of drainage area, starting at the mouth (150 $mi.^2$), and extending upstream to drainage areas of 75, 38, 19, 9, 5 and 2 mi^2. Pollution survey sites targeting stream reaches of particular interest, such as those with wastewater treatment plants (WWTPs) or dams, or to fill gaps left by the geometric design were added for 44 total sampling sites.

Sampling for fish, stream habitat, macroinvertebrates and water quality were collected at each site, except chemistry only at the Winfield Creek sites bracketing the DuPage Co. garage and salt storage facility. Sampling in the former Warrenville Grove dam pool (WB42) was limited to biological and habitat sampling and continuous dissolved oxygen (D.O.) monitoring. Water quality parameters at sampled sites included nutrients (nitrogen and phosphorus), indicators of organic enrichment (5-day biochemical oxygen demand, NH_3-N -nitrogen, total Kjeldahl nitrogen), indicators of ionic strength (chloride, conductivity, total dissolved solids), total suspended solids, dissolved oxygen, and water temperature. Water column metals (Ca, Cd, Cu, Fe, Mg, Pb, and Zn) and hardness) were included at 41 locations. Sediment quality was assessed at 26 locations and analyzed for metals, polycyclic aromatic hydrocarbons, and pesticides. Continuous D.O. monitoring was conducted at three mainstem locations.

Macroinvertebrate Assemblage

The macroinvertebrate assemblage was sampled using the Illinois EPA (IEPA) multi-habitat method (IEPA 2005) at all sites. The IEPA multi-habitat method involves the selection of a sampling reach that has instream and riparian habitat conditions typical of the assessment reach. Sampling reach requirements include flow conditions that approximate typical summer base flows, the absence of highly influential Tributary streams, the presence of one riffle/pool sequence or analog (i.e., run/bend meander or alternate point-bar sequence), if present, and a length of at least 300 feet. This method is applicable if conditions allow the collection of macroinvertebrates (i.e., to take samples with a dip net) in all bottom-zone and bank-zone habitat types that occur in a sampling reach. Habitat types are defined explicitly in Appendix E of the project QAPP (MBI 2006b). Conditions must also allow the sampler to apply the 11-transect habitat-sampling method, as described Appendix E of the Quality Assurance Project Plan[4] or to estimate with reasonable accuracy via visual or tactile cues the amount of each of several bottom-zone and bank-zone habitat types. If conditions (e.g., inaccessibility, water turbidity, or excessive water depths) prohibit the sampler from estimating the composition of the bottom or bank zone with reasonable accuracy throughout the sampling reach, the multi-habitat method is not applicable. In most cases, if more than one-half of the wetted stream channel cannot be seen, touched, or otherwise reliably characterized by the sampler,

[4] http://www.drscw.org/reports/DuPage.QAPP_AppendixE.07.03.2006.pdf

reasonably accurate estimates of the bottom-zone and bank-zone habitat types are unlikely; thus, the multi-habitat method is not applicable.

Multi-habitat samples were field preserved in 10% formalin. Upon delivery to the MBI lab in Hilliard, OH, the preserved samples were then transferred to 70% ethyl alcohol. Laboratory procedures generally followed the IEPA (2005) methodology. For the multi-habitat method, this requires the production of a 300-organism subsample from a gridded tray following a scan and pre-pick of large and/or rare taxa. Taxonomic resolution was performed at the lowest practicable resolution for the common macroinvertebrate assemblage groups such as mayflies, stoneflies, caddisflies, midges, and crustaceans. This goes beyond the genus level requirement of IEPA (2005); however, calculation of the macroinvertebrate IBI followed IEPA methods in using genera as the lowest level of taxonomy for mIBI scoring.

Fish Assemblage

Methods for the collection of fish at wadeable sites was performed using a tow-barge or long-line pulsed D.C. electrofishing apparatus utilizing a T&J 1736 DCV electrofishing unit described by MBI (2006b). A Wisconsin DNR battery powered backpack electrofishing unit was used as an alternative to the long line in the smallest streams and in accordance with the restrictions described by Ohio EPA (1989). A three-person crew carried out the sampling protocol for each type of wading equipment. Sampling effort was indexed to lineal distance and ranged from 150-200 meters in length. Non-wadeable sites were sampled with a raft-mounted pulsed D.C. electrofishing device. A Smith-Root 2.5 GPP unit was mounted on a 14’ raft following the design of MBI (2007). Sampling effort was indexed to lineal distance and was 500 meters in length. A summary of the key aspects of each method appears the project QAPP (MBI 2006b). Sampling distance was measured with a GPS unit or laser range finder. Sampling locations were delineated using the GPS mechanism and indexed to latitude/longitude and UTM coordinates at the beginning, end, and mid-point of each site. The location of each sampling site was indexed by river mile (using river mile zero as the mouth of each stream). Sampling was conducted during a June 15-October 15 seasonal index period.

Samples from each site were processed by enumerating and recording weights by species and by life stage (young-of-the-year, juvenile, and adult). All captured fish were immediately placed in a live well, bucket, or live net for processing. Water was replaced and/or aerated regularly to maintain adequate D.O. levels in the water and to minimize mortality. Fish not retained for voucher or other purposes were released back into the water after they had been identified to species, examined for external anomalies, and weighed either individually or in batches. Weights were recorded at level 1-5 sites only. Larval fish were not included in the data and fish measuring less than 15-20 mm in length were generally excluded from the data as a matter of practice. The incidence of external anomalies was recorded following procedures outlined by Ohio EPA (1989, 2006a) and refinements made by Sanders et al. (1999). While the majority of captured fish were identified to species in the field, any uncertainty about the field identification required their preservation for later laboratory identification. Fish were preserved

***Table 2**. Biological sampling and chemical sampling sites in the West Branch DuPage River watershed study area, 2015 designated by site code, river mile (Mile), and UTM coordinates. Datasonde sites are indicated by site codes WBAD, WBBR, WBWD, and WBMG.*

Site ID	Mile	Latitude	Longitude	DA[5]	Width (ft.	Location	Samples
West Branch DuPage River							
WB25	34.00	42.01123	-88.11092	2.0	8.7	UST Braintree Drive, Schaumburg	C, F, M
WB31	31.90	42.00065	-88.13599	5.0	20.7	UST Longmeadow Ln. & MWRD WWTP	C, F, M, S
WB24	31.60	41.99676	-88.13637	5.0	23.2	Walnut Ave., Dst. MWRD WWTP	C, F, M, S
WB32	30.10	41.97719	-88.13406	7.0	33.4	DST SR 20, Hanover Park	C, F, M, S
WBAD	29.90	41.9750	-88.1386	--	NA	Arlington Drive	D
WB27	28.70	41.96771	-88.15060	13.0	25.2	UST County Farm Rd, Hanover Park	C, F, M, S
WB28	27.40	41.96565	-88.16631	14.0	21.9	DST Bartlett WWTP, Bartlett	C, F, M, S
WB20	25.60	41.96095	-88.18444	20.0	31.8	DST Struckman Blvd., Bartlett	C, F, M, S
WB39	21.70	41.91364	-88.17987	28.0	35.0	UST St. Charles Rd, W. Chicago	C, F, M
WB33	21.30	41.90527	-88.17825	28.0	32.2	UST Great Western Trail, Timber Ridge FP	C, F, M, S
WB17	19.20	41.88889	-88.16104	34.0	44.5	UST Geneva Rd. West Chicago	C, F, M, S
WB38	16.00	41.87088	-88.17831	58.0	47.1	UST Barnes Rd, UST W. Chicago WWTP	C, F, M, S
WB34	15.10	41.85730	-88.19427	60.0	47.0	DST Gary's Mills Rd.	C, F, M, S
WB12	13.60	41.84301	-88.19867	80.5	91.1	UST Mack Rd at dog park, Warrenville	C, F, M, S
WB42 / WBBR	11.6	41.82475	-88.17830	90.0	68.0	Butterfield Road (former dam pool)	F,M,D
WB40 / WBWD	11.1	41.82027	-88.17212	91.0	91.3	DST Warrenville Grove dam	C,F,M,S,D
WBMG	8.76	41.795983	-88.187222	--	NA	Ust former McDowell Grove dam at bridge	D
WB36	8.60	41.79377	-88.18663	105	NA	Dst. former McDowell Grove dam, ust Fawell Dam	M
WB36	8.30	41.78688	-88.18070	105	112.5	Adj Raymond Dr/Redfield Rd, ust Fawell dam	C, F
WB41	8.00	41.78329	-88.17648	105	60.0	DST Fawell Dam, UST Ogden Ave. Naperville	C, F, M, S
WB37	6.30	41.77050	-88.15664	110	98.8	Adj. Centennial Park/ Jackson Ave., Naperville	C, F, M, S
WB35	4.20	41.75396	-88.13423	115	118.2	Adj. Washington St. in Pioneer Park	C, F, M
WB08	0.85	41.78187	-88.17113	125	90.0	Knoch Knolls Park, Naperville	C, F, M, S
Trib. to W. Br. DuPage River (RM 20.85)							
WB18	0.30	41.90387	-88.17410	3.0	3.4	Prairie Path Trib., W. Chicago	C, F, M
Trib. (RM 1.65) to Trib. to W. Br. DuPage River (RM 25.5)							
WB22	0.15	41.98356	-88.16914	1.0	0.0	UST Coral Ave., Bartlett Village, Bartlett	C, F, M
Trib. to W. Br. DuPage River (RM 29.25)							
WB23	0.15	41.96480	-88.14138	2.5	5.7	DST Schick Rd, Mallard Lake FP	C, F, M
Trib. to W. Br. DuPage River (RM 25.5)							
WB29	2.20	41.98669	-88.17798	2.0	24.3	DST Devon Ave. adj. Leiseburg Park	C, F, M
WB30	1.90	41.98468	-88.17884	3.0	7.1	DST Amherst Drive/DST Bartlett WWTP	C, F, S
WB21	0.90	41.97220	-88.17770	4.2	0.0	DST Stearns Road	C, F, M
Kress Creek							
WB02	5.10	41.89163	-88.24309	4.0	5.4	DST Prairie Path xing, adj. Kress Rd.	C, F, M
WB01	2.70	41.86271	-88.23458	14.5	19.9	UST Road A, Fermi Lab Compound	C, F, M, S

[5] DA – Drainage Area in square miles.

Site ID	Mile	Latitude	Longitude	DA[5]	Width (ft.	Location	Samples
WB03	0.50	41.85701	-88.20567	19.0	29.8	UST intersection Joliet St./Wilson St. bridge	C, F, M, S
				Ferry Creek			
WB04	2.80	41.82527	-88.20142	3.0	22.7	DST SR 59 bridge adj. parking lot	C, F, M
WB06	0.70	41.80735	-88.18452	5.5	14.0	UST Ferry Rd bridge, Warrenville	C, F, M
				West Branch Ferry Creek			
WB05	0.25	41.79998	-88.18789	4.0	8.1	DST Raymond Ave, McDowell Grove FP	C, F, M
				Cress Creek			
WB07	0.20	41.78158	-88.17168	4.0	27.8	DST 5th Ave. bridge; South of Ogden Ave.	C, F, M
				Bremme Creek			
WB09	0.25	41.82457	-88.17131	1.0	6.3	DST Winfield Dr.; ust. W. Br. bike trail	F, M
				Spring Brook			
WB11	3.30	41.84597	-88.14260	4.0	20.7	UST Wheaton WWTP Sanitary discharge	C, F, M, S
WB26	3.00	41.84299	-88.14684	4.0	20.5	DST Mack Rd, WWTP at Allen Park, Wheaton	C, F, M, S
WB10	0.75	41.83518	-88.18279	7.0	27.3	Maintenance Bldg., Blackwell FP	C, F, M
				Winfield Creek			
WB15	5.40	41.88385	-88.10467	2.0	3.6	At St Mark's Catholic Church	C, F, M, S
WB14	3.50	41.86397	-88.12344	5.0	17.7	End of Liberty St., dst. Wheaton	C, F, M
WB13.2	1.00	41.86517	-88.14738	9.0	13.0	UST Co. Salt Storage facility	F, M
WB13.1	0.90	41.86692	-88.14797	9.0	10.0	DST Co. Salt Storage facility	F, M
WB13	0.40	41.86816	-88.15784	9.0	11.7	UST Winfield Rd. Creekside Park	C, F, M
				Klein Creek			
WB19	3.60	41.91849	-88.13046	5.0	19.3	UST Illini Dr @ Armstrong Park	C, F, M
WB16	1.00	41.89676	-88.15449	9.0	25.9	Klein Creek Farm, W. Chicago	C, F, M
				Ferson Creek			
F-2	7.6	41.96211	-88.36045	11.4	20	DST Burr Rd.	C, F, M
F-1	2.5	41.93327	-88.34133	51.8	39.7	UST Randell Rd.	C, F, M
				Otter Creek			
F-3	0.9	41.96936	-88.35584	35.6	26	DST Silver Glen Rd.	C, M
C – chemistry; D – Datasonde; F – fish/habitat; M – macroinvertebrates; S - sediment							

***Figure 2**. Sampling locations (white dots with associated "WB" site numbers), WWTP discharges (outfall symbols), and significant mainstem dam impoundments (dam symbols) in the West Branch DuPage River watershed study area, June-October 2015.*

for future identification in borax buffered 10% formalin and labeled by date, river or stream, and geographic identifier (e.g., river mile and site number). Identification was made to the species level at a minimum and to the sub-specific level if necessary. A number of regional ichthyology keys were used including the Fishes of Illinois (Smith 1979) and updates available through the Illinois Natural History Survey (INHS). Vouchers were deposited and verified at The Ohio State University Museum of Biodiversity (OSUMB).

Habitat

Physical habitat was evaluated using the Qualitative Habitat Evaluation Index (QHEI) developed by the Ohio EPA for streams and rivers in Ohio (Rankin 1989, 1995; Ohio EPA 2006b) and as recently modified by MBI for specific attributes. Various attributes of the habitat are scored based on the overall importance of each to the maintenance of viable, diverse, and functional aquatic faunas. The type(s) and quality of substrates, amount and quality of instream cover, channel morphology, extent and quality of riparian vegetation, pool, run, and riffle development and quality, and gradient are some of the metrics used to determine the QHEI score which generally ranges from 20 to less than 100. The QHEI is used to evaluate the characteristics of a stream segment, as opposed to the characteristics of a single sampling site. As such, individual sites may have poorer physical habitat due to a localized disturbance yet still support aquatic assemblages closely resembling those sampled at adjacent sites with better habitat, provided water quality conditions are similar. QHEI scores from hundreds of segments in the Midwestern U.S. have indicated that values greater than 55 in headwaters (i.e., <20 sq. mi.) and greater than 60 in larger streams and rivers are *generally* conducive to the existence of warmwater faunas. Habitat scores less than 45 generally cannot support an assemblage consistent with baseline Clean Water Act goal expectations (e.g., the General Use in Illinois). QHEI scores greater than 75 often typify habitat conditions capable of supporting exceptional fish assemblages.

Data Management and Analysis

MBI employed the data storage, retrieval, and calculation routines available in the Ohio ECOS system as described in the project QAPP (MBI 2006b). Fish and macroinvertebrate data were reduced to standard relative abundance and species/taxa richness and composition metrics. The Illinois Fish Index of Biotic Integrity (fIBI) was calculated with the fish data using programming supplied by Illinois EPA. The macroinvertebrate data were analyzed using the Illinois macroinvertebrate Index of Biotic Integrity (mIBI).

Determination of Causal Associations

Using the results, conclusions, and recommendations of this report requires an understanding of the methodology used to determine biological status (i.e., unimpaired or impaired, narrative ratings of quality) and assigning associated causes and sources of impairment utilizing the accompanying chemical/physical data and source information (e.g., point source loadings, land use). The identification of impairment in rivers and streams is straightforward - the numerical biological indices are the principal arbiter of aquatic life use attainment and impairment following the guidelines of Illinois EPA (2008). The rationale for using the biological results in the role as the principal arbiter within a weight of evidence framework has been extensively discussed elsewhere (Karr et al. 1986; Karr 1991; Ohio EPA 1987a,b; Yoder 1989; Miner and Borton 1991; Yoder 1991; Yoder 1995).

Describing the causes associated with observed biological impairments relies on an interpretation of multiple lines of evidence including water chemistry data, sediment data, habitat data, effluent data, biomonitoring results, land use data, and biological response signatures (Yoder and Rankin 1995; Yoder and DeShon 2003; MBI 2010). Thus the assignment of principal associated causes and sources of biological impairment in this report represents the association of impairments (based on response indicators) with stressor and exposure indicators using linkages to the biosurvey data based on previous experiences within the strata of analogous situations and impacts. The reliability of the identification of associated causes and sources is increased where many such prior associations have been observed. The process is similar to making a medical diagnosis in which a doctor relies on multiple lines of evidence concerning patient health. Such diagnoses are based on previous research that experimentally or statistically links symptoms and test results to specific diseases or pathologies. Thus a doctor relies on previous experiences in interpreting symptoms (*i.e.,* multiple lines from test results) to establish a diagnosis, potential causes and/or sources of the malady, a prognosis, and a strategy for alleviating the symptoms of the disease or condition. As in medical science, where the ultimate arbiter of success is the eventual recovery and well-being of the patient, the ultimate measure of success in water resource management is the restoration of lost or damaged ecosystem attributes including assemblage structure and function.

Hierarchy of Water Indicators
A carefully conceived ambient monitoring approach, using cost-effective indicators comprised of ecological, chemical, and toxicological measures, can ensure that all relevant pollution sources are judged objectively based on environmental results. A tiered approach that links the results of administrative actions with true environmental measures was employed by our analyses. The integrated approach is outlined in Figure 3 and includes a hierarchical continuum that ranges from administrative to true environmental indicators.

The six “levels” of indicators include:

1) actions taken by regulatory agencies (permitting, enforcement, grants);
2) responses by the regulated assemblage (treatment works, pollution prevention);
3) changes in discharged quantities (pollutant loadings);
4) changes in ambient conditions (water quality, habitat);
5) changes in uptake and/or assimilation (tissue contamination, biomarkers, assimilative capacity); and,
6) changes in health, ecology, or other effects (ecological condition, pathogens).

In this process, the results of administrative activities (levels 1 and 2) can be linked to efforts to improve water quality (levels 3, 4, and 5) which should translate into the environmental “results” (level 6). An example is the aggregate effect of billions of dollars spent on water pollution control since the early 1970s that have been determined with quantifiable measures of environmental condition (Yoder et al. 2005). Superimposed on this hierarchy is the concept of stressor, exposure, and response indicators. *Stressor* indicators generally include activities which have the potential to degrade the aquatic environment such as pollutant discharges (permitted and unpermitted), land use effects, and habitat modifications. *Exposure* indicators measure the effects of stressors and can include whole effluent toxicity tests, tissue residues, and biomarkers. Each provides evidence of biological exposure to a stressor or bioaccumulative agent. *Response* indicators are generally composite measures of the cumulative effects of stress and exposure and include the more direct measures of assemblage and population response that are represented here by the biological indices which comprise the Illinois EPA biological endpoints. Other response indicators can include target assemblages, *i.e.,* rare, threatened, endangered, special status, and declining species or bacterial levels that serve as surrogates for the recreational uses. These indicators represent the essential technical elements for watershed-based management approaches. The key, however, is to use the different indicators *within* the roles which are most appropriate for each (Yoder and Rankin 1998).

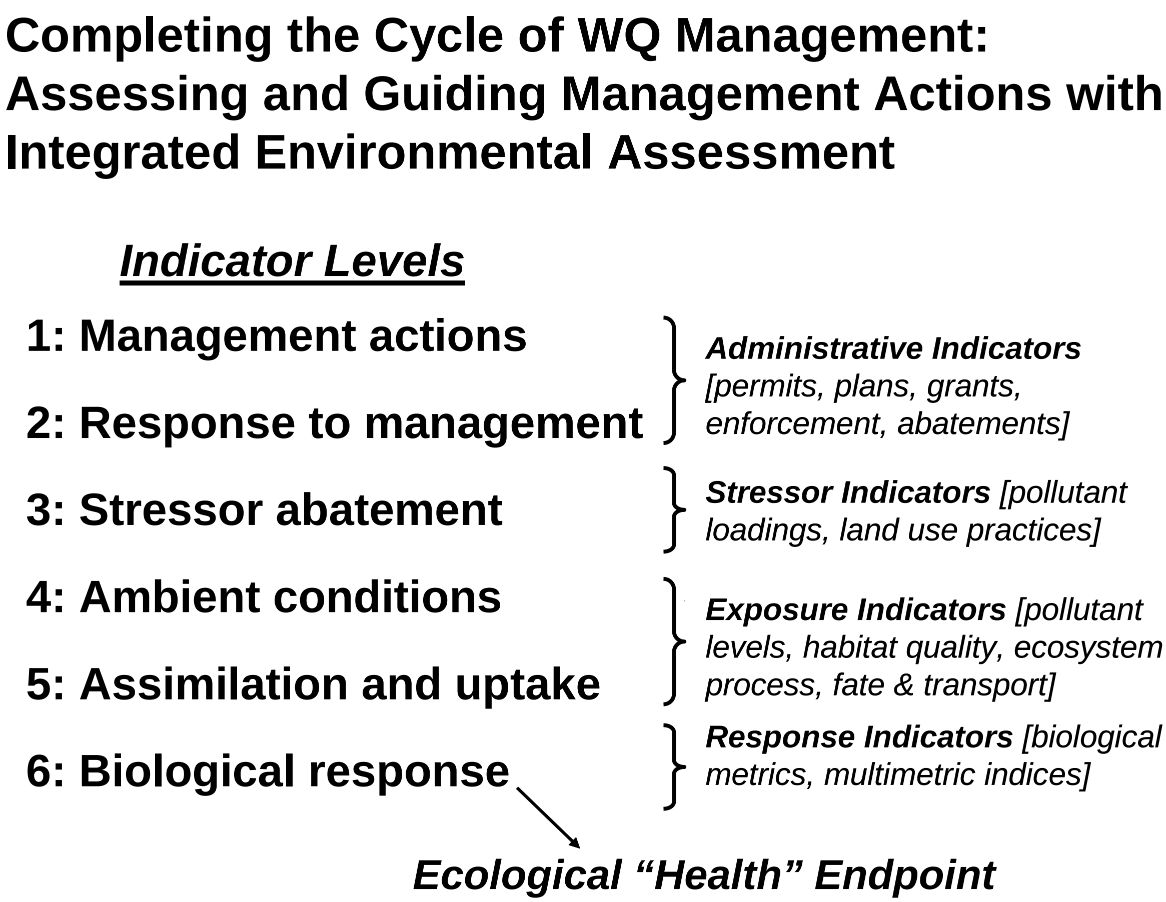

***Figure 3**. Hierarchy of administrative and environmental indicators that can be used for water quality management activities such as monitoring and assessment, reporting, and the evaluation of overall program effectiveness. This is patterned after a model developed by U.S. EPA (1995) and further enhanced by Karr and Yoder (2004).*

Determining Causal Associations

Describing the causes and sources associated with observed impairments revealed by the biological criteria and linking this with pollution sources involves an interpretation of multiple lines of evidence including water chemistry data, sediment data, habitat data, effluent data, biomonitoring results, land use data, and biological response signatures within the biological data itself. Thus the assignment of principal causes and sources of impairment represents the association of impairments (defined by response indicators) with stressor and exposure principal reporting venue for this process on a watershed or subbasin scale is a biological and water quality report. These reports then provide the foundation for aggregated assessments such as the Illinois Water Resource Inventory (305[b] report), the Illinois Nonpoint Source Assessment, and other technical products.

Illinois Water Quality Standards: Designated Aquatic Life Uses

The Illinois Water Quality Standards (WQS; IL Part 303.204-206) consist of designated uses and chemical criteria designed to represent measurable properties of the environment that are consistent with the goals specified by each use designation. Use designations consist of two broad categories, aquatic life and non-aquatic life uses. Chemical, physical, and/or biological criteria are generally assigned to each use designation in accordance with the broad goals defined by each use. The system of use designations employed in the Illinois WQS constitutes a general approach in that one or two levels of protection are provided and extended to all water bodies regardless of size or position in the landscape. In applications of state WQS to the management of water resource issues in rivers and streams, the aquatic life use criteria frequently result in the most stringent protection and restoration requirements, hence their emphasis in biological and water quality assessments. In addition, an emphasis on protecting for aquatic life generally results in water quality suitable for all other uses.

Aquatic life use support for a water body in Illinois is determined by examining all available biological and water quality information. Where information exists for both fish and macroinvertebrate indicators, and both indicators demonstrate full support, the water body is considered in full support independent of the water chemistry results. Where information for both biological indicators exists, and one indicator suggests full support while the other shows moderate impairment, a use decision of full support can be made if the water chemistry data show no indication of impairment. Where one biological indicator is severely impaired, non-support is demonstrated. If information for only one biological indicator exists, water chemistry information is used to inform the use support decision in that a biological result of full support can be overridden if the water chemistry results clearly demonstrate impairment.

STUDY AREA DESCRIPTION

The 2015 study area included the West Branch DuPage River and its perennial Tributaries (Figure 2). Sampling in 2015 largely duplicated past surveys in 2006, 2009 and 2012 and systematically covered the watershed down to an approximate 2-mi^2 drainage. Additional sites that bracket point sources or target specific segments of interest were also included (Table 2). Following discovery of chloride exceedances near the mouth of Winfield Creek in 2012, 2 sites bracketing a County salt storage garage located a short distance upstream were added in 2015. Since the 2015 study area is essentially the same, the remaining study area text from the 2012 survey report, with an updated and land use map and statistics, is reproduced below:

The West Branch DuPage River and its co-branch, the East Branch DuPage forms the DuPage River at Naperville in Knoch Knolls Park (Will County). The mainstem runs measures approximately 34 linear miles with a drop of 197 feet and drains 128 square miles of DuPage, Cook and northern Will Counties. Mean flow, measured at the USGS gage at Warrenville Road (station 05540095, Calculation Period is 1968-10-01 - 2014-09-30) was 123 cubic feet per second (cfs).

Twenty-one municipalities and 7 publicly owned treatment plants are located in the watershed and discharge to the mainstem and two Tributaries between RMs 31.2 and 15.3. There are no combined sewer overflows but the Bartlett WWTP overflow plant occasionally discharges to an unnamed Tributary (95-906) in the upper headwaters. Like the adjacent East Branch, Salt Creek, and DuPage River catchments, land uses in the West Branch are dominated by residential and urban developments (Figure 4) which accounted for over 80% of the watershed (Table 3). In contrast, agriculture occupied only five percent of West Branch drainage.

West Branch DuPage River Dams

The updated status of former and remaining West Branch DuPage River dams that were initially described in the 2009 assessment report are described below.

<u>Warrenville Grove Dam</u>: The Warrenville Grove Dam was fully removed in September 2011 under a cooperative project administered by the DuPage County Department of Stormwater Management and the Forest Preserve District of DuPage County (FPDDC). It was located on the West Branch of the DuPage River within the Warrenville Grove Forest Preserve in the City of Warrenville. The dam was one third of a mile upstream from Warrenville Road and 0.4 miles downstream from Butterfield Road (IL Route 56). The site is owned by the Forest Preserve District of DuPage County (FPDDC) and the dam was approximately 75 years old. Access to the site is best gained via the Forest Preserve parking lot on the east side of Batavia Road.

The dam was constructed of limestone facing placed in a stair step configuration with a concrete foundation and headwall on the upstream face of the spillway (Plate No. 1). The dam was 107 feet across with a curving spillway face that has a total crest length of about 125 feet. Dam height was 8.5 feet above the downstream river channel bottom with a total hydraulic height of 5.7 feet (from spillway crest to tailwater elevation under average flow conditions).

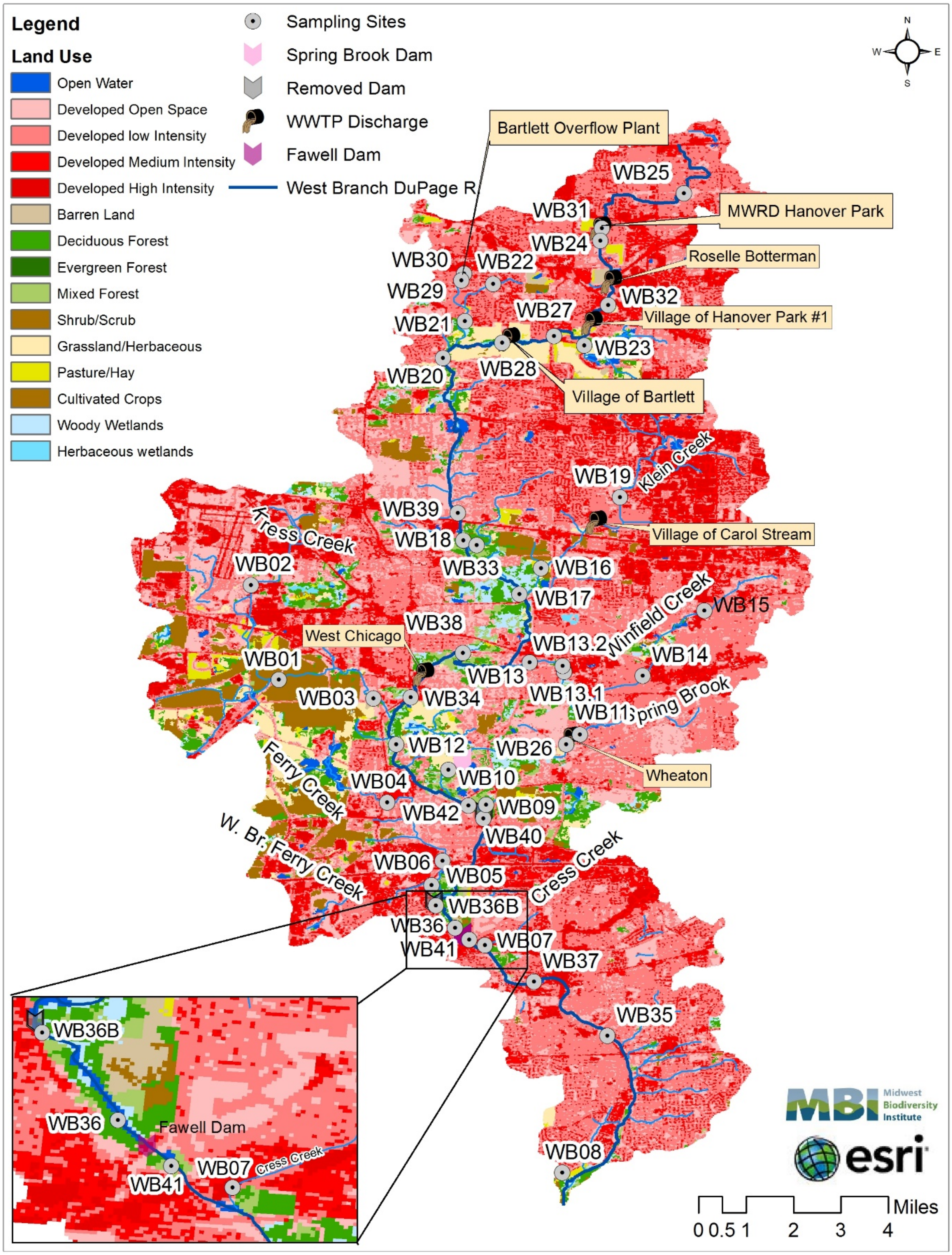

***Figure 4**. Land use types in the West Branch DuPage River watershed based on 2006 National Land Cover Dataset (NLCD). https://www.mrlc.gov/nlcd2011.php*

***Table 3**. Land uses types by area and percent for the West Branch DuPage River watershed. Percentages are based on total watershed area. Land use data is based on Chicago Metropolitan Agency for Planning (CMAP) 2013 land use data (Note: Table 4 is reproduced from the 2012 report).*

Land Use Category	West Branch DuPage River Watershed	
	Area (acres)	Area (percent)
Residential	28739	35.2
Commercial	4153	5.1
Institutional	8824	10.8
Industrial	4785	5.9
Transportation	4267	5.2
Agriculture	3349	4.1
Open Space	14138	17.3
Vacant	2474	3.0
Other	10964	13.4
Totals	**81,692**	**100**

The site still maintains the original millrace that was partially retrofitted in 1995 to function as a fish ladder and canoe chute. The original dam impoundment was approximately 1.2 miles in length and covered 16.9 acres.

***Plate No. 1**. The former Warrenville Grove Dam, looking upstream. The dam was removed in 2011.*

The dam was designed by the National Park Service and constructed by the Civilian Conservation Corps between 1936 and 1938 as part of a dam building program conveyed as a means to "reduce bank erosion". The dam site was chosen due to the presence of an older, abandoned milldam at the same location between 1847 and 1897.

McDowell Grove Dam: The McDowell Grove Dam was removed in mid-2008 under a cooperative project administered by DuPage County Department of Stormwater

Management and the FPDDC. The dam was located on the West Branch of the DuPage River within the McDowell Grove Forest Preserve in unincorporated DuPage County and was approximately 75 years old (Plate No. 1).

Plate No. 2. *Remnants of the McDowell Grove dam used to form a riffle after its removal in 2008. The rifle and former structures remain in place.*

Plate No. 3. *Temporary cofferdam constructed upstream from the former McDowell Grove Dam in 2008. The cofferdam was removed i the fall of 2012, immediately after the 2012 survey.*

The site is best accessed from the signalized intersection of McDowell Road and Raymond Drive, which provides an entrance to the parking lot within McDowell Grove Forest Preserve. During the 2012 survey, the majority of the impoundment still existed due to construction of a temporary steel sheet-piling cofferdam (see Plate 3) 0.8 miles upstream of the original dam. The cofferdam was needed until an ongoing thorium removal project was completed within the West Branch mainstem upstream. The temporary dam was removed entirely in September 2012. As shown in Plate No. 2, the foundation of the original dam was left in place to form a riffle feature.

Plate No. 4. *Aerial view of the Fawell Dam.*

<u>Fawell Dam</u>: The Fawell Dam is located on the West Branch of the DuPage River at river mile 8.1 (Plate No. 4). It is a flood control structure operated by DuPage County Department of Stormwater Management. The dam consists of a set of three gate structures that can control flow through a three-barrel concrete box culvert to impound water, as necessary, upstream within the McDowell Grove Forest Preserve. The existing three-barrel concrete box culvert consists of an 11’-10” wide by 10’ high center barrel and 10’ by 10’ side barrels. The culvert barrels are 80’

long and the bottom slopes down at 5% from the upstream end to the downstream end. There are concrete wing walls on the upstream side of the culvert structure and a 50' long concrete stilling basin structure on the downstream side (Plate No. 5). Atop the culvert, the grade slopes up from the ends to a 25' wide path running perpendicular to the structure, which is approximately 10' above the top elevation of the barrels. During low water events, when the structure is not operating, the upstream end of the culvert features a concrete sill set above the natural bed elevation of the river. The earth embankment is approximately 1000 feet in length.

***Plate No. 5**. Upstream view of the Fawell Dam.*

<u>Arrow Road /Spring Brook Marsh #1 Dam</u>: The dam is located at river mile 0.85 on Spring Brook # 1 in the Blackwell Forest Preserve and has been in place since 1983 (Plate No. 6). The structure consists of a 4.5' weir (approximately 35'in width), which spills into a reinforced concrete pipe that passes under Arrow Road. When the weir is fully closed, the impoundment is approximately 15 acres, the majority of which is less than 1 foot deep. The dam site and impoundment are wholly owned by the DuPage County Forest Preserve District.

***Plate No. 6**. Arrow Road Dam on Spring Brook looking upstream.*

Point Source Discharges

Seven major (>1 MGD design flow) permitted point sources are located within the West Branch DuPage River watershed. The design flows and locations of each discharger are listed in Table 4 while measured effluent flows and estimated annual loadings of $cBOD_5$, TSS and NH_3-N are illustrated in Figure 5. As in previous reports, trends in total nitrogen and phosphorus loadings remain unavailable because the parameters are not monitored at all of the plants examined.

Table 4. *Municipal wastewater treatment plants (WWTPs) located in the West Branch DuPage River watershed. ADF = average design flow in million gallons per day (MGD); MDF = maximum design flow (MGD).*

NPDES	Name	ADF (MGD)	MDF (MGD)	Receiving Stream	Latitude	Longitude
IL0036137	MWRD Hanover Park STP	12	22	West Branch	42.0008	-88.1361
IL0048721	Roselle-J. Botterman WWTF	1.22	4.6	West Branch	41.9822	-88.1139
IL0034479	Hanover Park STP #1	2.42	8.68	West Branch	41.9722	-88.1386
IL0027618	Bartlett WWTP	3.68	13.0	West Branch	41.5469	-88.1833
IL0023469	West Chicago STP	7.64	20.3	West Branch	41.5516	-88.1416
IL0031739	Wheaton S.D.	8.9	19.1	Spring Brook	41.8447	-88.1450
IL0026352	Carol Stream WRC	6.5	13.0	Klein Creek	41.9094	-88.1353

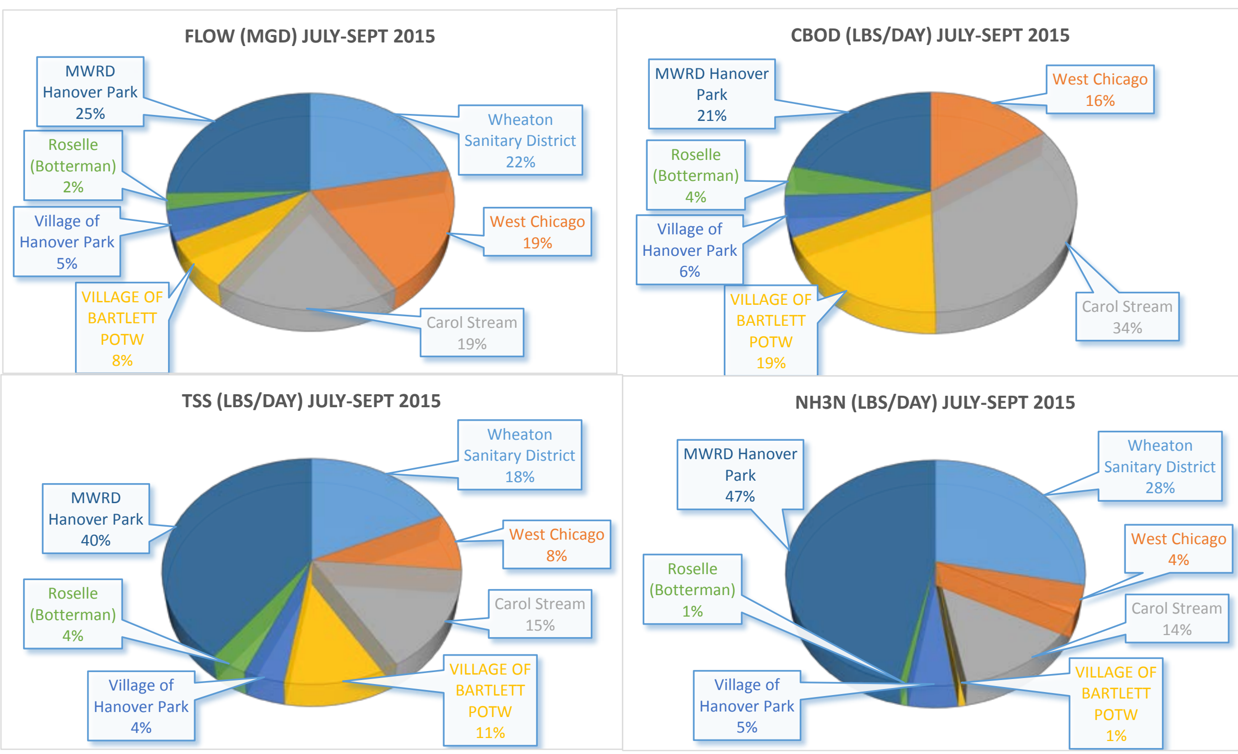

Figure 5. *Third quarter (July 1-Sept. 30, 2015) mean effluent volume and daily loadings (lbs./day) of TSS, $cBOD_5$, and NH_3-N (top) by % discharged by WWTPs to the West Br. DuPage River mainstem.*

The Hanover Park MWRD, located in the extreme upper mainstem, remained the largest contribution of wastewater flow in 2015 but was replaced by the Carol Stream WWTP as the largest source of cBOD5 (note: $cBOD_5$ loadings were not available for the Wheaton WWTP in 2015). In 2013-14, Wheaton, W. Chicago, Bartlett and Carol Stream plants also discharged higher loads of cBOD5 than Hanover Park MWRD (Table 5). The Bartlett WWTP was among the smallest effluent discharges. In 2012 but contributed a higher proportion of TSS and total NH_3-N loadings than any other individual facility. Since that time, NH_3-N loadings have been drastically reduced and Bartlett was among the lowest sources of point source NH_3-N loads. TSS loads from the Bartlett plant have also declined since 2012 and in recent years, loadings are roughly proportional to discharge flows from other facilities.

Table 5*. Third quarter (July 1-Sept. 30, 2015) daily flows (MGD) and loadings (lbs. /day) of TSS, $cBOD_5$, and NH_3-N from major WWTPs to the West Branch DuPage River in 2013, 2014, and 2015.*

2013: Total for July-Sept 2013						
Facility	**Flow (MGD)**	**CBOD (lbs/day)**	**TSS (lbs/day)**	**NH3N (lbs/day)**	**NO3 - N (lbs/day)**	**PHOS (lbs/day)**
Wheaton Sanitary District	5.4	95.1	130.8	5.1	1084.1	144.1
West Chicago	4.9	158.4	575.1	45.1	-	-
Carol Stream	3.9	134.6	135.4	10.2	1348.3	118.1
VILLAGE OF BARTLETT POTW	1.8	119.1	98.6	0.5	-	92.1
Village of Hanover Park	1.3	17.5	30.9	1.6	-	-
Roselle (Botterman)	0.6	18.9	24.3	0.4	-	-
MWRD Hanover Park	6.7	59.1	154.3	9.7	971.4	192.0

2014: Total for July-Sept 2014						
Facility	**Flow (MGD)**	**CBOD (lbs/day)**	**TSS (lbs/day)**	**NH3N (lbs/day)**	**NO3 - N (lbs/day)**	**PHOS (lbs/day)**
Wheaton Sanitary District	7.1	157.0	229.8	33.6	1082.6	142.7
West Chicago	5.8	121.4	154.2	2.4	-	-
Carol Stream	4.7	101.3	59.0	6.3	1265.5	136.0
VILLAGE OF BARTLETT POTW	2.3	122.5	109.1	0.6	-	89.7
Village of Hanover Park	1.5	26.9	45.3	3.4	-	-
Roselle (Botterman)	0.7	20.3	36.1	0.4	-	-
MWRD Hanover Park	8.5	119.7	320.3	9.0	998.9	187.5

2015: Total for July-Sept 2015						
Facility	**Flow (MGD)**	**CBOD (lbs/day)**	**TSS (lbs/day)**	**NH3N (lbs/day)**	**NO3 - N (lbs/day)**	**PHOS (lbs/day)**
Wheaton Sanitary District	6.4	-	113.6	15.6	1005.8	129.0
West Chicago	5.5	58.5	50.9	2.3	-	-
Carol Stream	5.6	130.1	93.2	8.0	1214.9	192.9
VILLAGE OF BARTLETT POTW	2.2	71.6	71.3	0.4	-	54.7
Village of Hanover Park	1.4	23.2	25.6	2.8	-	-
Roselle (Botterman)	0.7	16.5	22.5	0.4	-	-
MWRD Hanover Park	7.4	81.1	247.6	25.8	-	177.2

The volume of point source discharges in the West Branch dominates river flows during dry weather. For example, during extreme low flow periods in the first week of August 2009 and the second week of July 2012, effluent from the WWTPs in Figure 5 comprised ~89 and 87%, respectively, of the West Branch flow and 89-92% of the long-term 25th percentile flows at the Warrenville USGS gage. Extended periods of low-base flows were more prevalent in 2012 than in 2009 and 2015 (see Figure 6). It is clear from other assessments of effluent loadings that the total phosphorus and nitrogen regime are point source dominated (The Conservation Foundation 2011). Unlike nonpoint sources, that typically discharge only during elevated flow events, point source loadings persist at all flows and can have significant influences on aquatic life particularly high stress periods that occur under low flows.

West Branch DuPage River flow Conditions

West Branch DuPage River flows from the USGS gage near West Chicago in 2015 were generally at or above average for the May through September period. The trend represented a reversal of conditions in 2012 when below average flows dominated the survey period (Figure 6). In particular, late spring, early summer and late September flows in 2015 were substantially higher than in 2012 while mid-July through August conditions were roughly similar. Flow trends in 2015 essentially mirrored the average to above average flows during the 2009 survey.

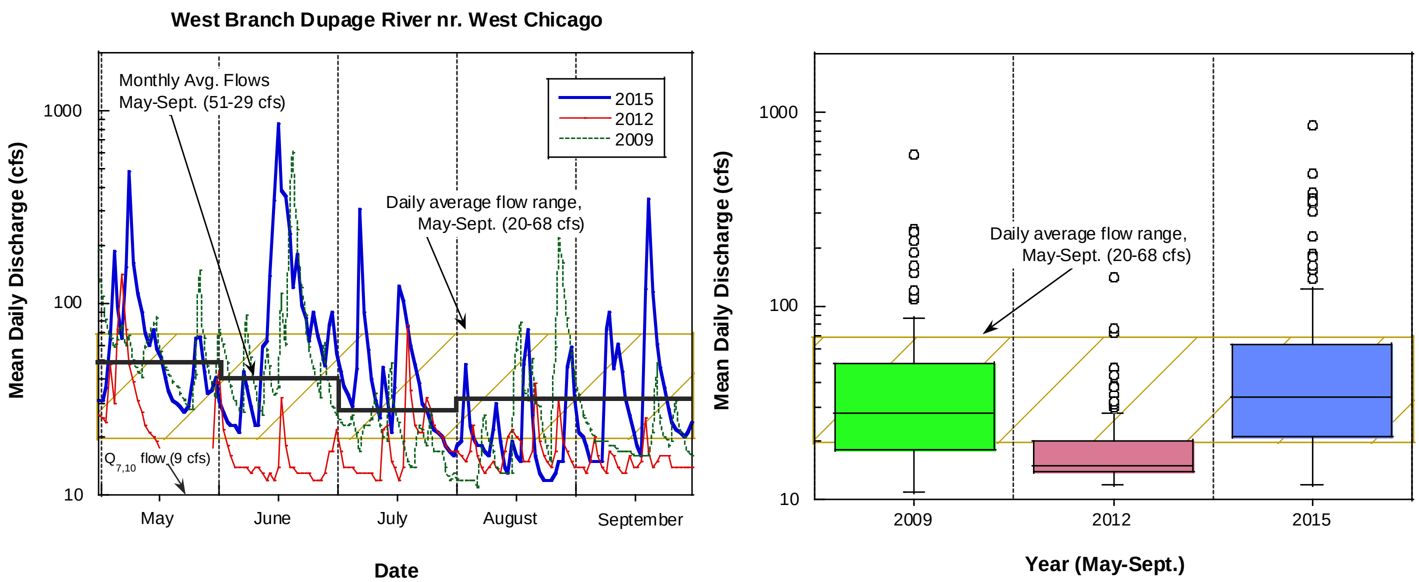

***Figure 6**. Flow hydrograph (left) and box and whisker plot (right) for the West Branch DuPage River near West Chicago (USGS station #05539900) from May through September, in 2009, 2012, and 2015. Average monthly flow, $Q_{7,10}$ (left) and the range of daily average flows during the May-September period (both plots) are depicted.*

RESULTS

West Branch DuPage River Watershed - Chemical Water Quality

The 2015 sampling results generally match the 2009 and 2012 bioassesment report conclusions that water quality in the West Branch DuPage mainstem is heavily influenced by treated wastewater while West Branch Tributaries tend to reflect the pervasive urban land use. The influence of effluent on the mainstem (and two Tributaries) remains most apparent in the sharp increases in total phosphorus (TP) and nitrate-nitrite nitrogen (NOx-N) found downstream (Figure 7). However, while the same pattern of increase held in 2015, actual concentrations declined by over half. The shift was most likely related to higher base flows and increased dilution during the survey period (Figure 8). Chloride levels remain elevated throughout the basin but while concentrations increased between 2006 and 2012 they leveled off or declined in 2015. In Tributaries and sites not influenced by wastewater discharges, chloride and phosphorus concentrations followed a very similar trend and declined by about a third (Figure 9). Downstream from wastewater sources in the larger mainstem drainages, chloride levels were more consistent and experienced only slight declines between surveys. This pattern suggests that the decline is mainly flow related. However the watershed is part of a program aimed at reducing chloride loadings from winter deicing operations which may also have contributed to the decline.

Unlike 2012, no exceedances of chemical water quality criteria in chemical grab samples were detected in 2015 (Table 7). WQS exceedances were limited to periodically low D.O. concentrations measured at three mainstem continuous monitors[6] (Table 8). Overall, mainstem D.O. levels continue to represent an increasing issue of concern as elevated nutrient levels continued to exceed reference and effect level thresholds. While outside of the summer sampling period, continuous monitoring data in spring months also showed a pattern of occasional, but very low D.O. concentrations in both the West Branch and other DuPage watershed monitoring sites. The low readings appear related to springtime runoff events.

West Branch DuPage River Mainstem

As noted in the 2012 Survey Report (see Figure 6) stream flow in the West Branch DuPage River is frequently effluent dominated during the summer-fall months. As such, water quality is highly influenced by the concentrations and composition of chemical constituents in the effluent as well as runoff from the urban and developed land cover in the watershed. Water quality sampling in both 2009-2012 and 2015 under variable flows continue to indicate the quality of treated effluent, with respect to regulated parameters (i.e., cBOD5, TSS, NH3), was generally good as highest concentrations were found in the upper mainstem, even upstream from known wastewater discharges. Effluents did not result directly in exceedances of water quality standards for these parameters. However, elevated nutrient levels and their attendant influence on mainstem D.O. regimes remain problematic.

[6] Datasonde continuous monitors were located at four West Branch sites at Arlington Drive between the Roselle Botterman and Hanover Park WWTPs (WBAD RM 29.0), Butterfield Road in the former Warrenville Grove dam pool (WBBR RM 11.6), downstream from the dam pool (WBWD RM 11.1) and upstream from the former McDowell Grove dam (WBMG RM 8.76).

The 2015 survey results continue to show sharply elevated nutrients (*i.e.,* phosphorus and nitrate) downstream from point source discharges. Overall, concentrations declined in 2015 compared to 2012 (Figure 7), but remained about one order of magnitude higher than levels in tributaries and the upstream control site. Increasingly, the trend in concentrations between 2009, 2012 and 2015 appear strongly related to both wastewater effluents and annual base flows with a correspondingly greater dilution of WWTP effluent under higher flows (Figure 8).

Since 2006, declining trends in mainstem NH_3-N have been largely attributed to more efficient wastewater treatment as median NH_3-N concentrations downstream from the WWTPs are typically at or close to detection limits (Figure 10, upper). By 2015, mean concentrations appear to have also stabilized at or close to detection suggesting consistent treatment and fewer episodic events. As in 2012, the highest mainstem concentrations were found in the headwaters both up and downstream from point sources. This extreme upper mainstem reach is the same location where an NH_3-N exceedance and highly elevated nutrients were found in 2009 and extremely elevated BOD levels were found in 2015. This segment merits further investigation to determine the sources of the elevated NH_3-N and nutrients.

TKN is a measure of organic nitrogen and NH_3-N in a waterbody and typically provides a strong signal of organic enrichment. There is no WQS for TKN in Illinois, but elevated levels of TKN above background levels can be used to infer excessive enrichment. In 2015, TKN concentrations roughly matched 2012 levels and were at or above the IPS threshold target levels.

Mainstem BOD trends were very similar between the 2012 and 2015 surveys with exceedances of target levels almost entirely restricted to the mainstem headwaters (Figure 12). A series of extremely high concentrations at WB25, the most upstream site at RM 34.0, suggest an unknown pollution source. Mean concentrations at the site were more than 10 times the 3.0 mg/L target. An unusually high value observed in 2012 at WB19, upstream from Carol Stream, was not duplicated in 2015.

Mainstem D.O. exceedances were common in 2012 and continued in 2015. Unlike the 2009 results when concentrations below the 7 day rolling average were limited to a few short duration events, exceedances in both 2012 and 2015 were more frequent and severe (Table 8). D.O. below the “not to exceed” and 7-day minimum criteria were measured at each site while exceedances of the 7-day rolling average were recorded at three of the four sites. As in 2012, D.O. above the rolling 30-day average criterion consistently occurred.

Despite the infrequent exceedances of D.O. criteria in 2009, concerns about the wide diel swings in D.O. and pH levels were raised at that time. Excessive swings are considered to be symptomatic of excessive nutrient enrichment and a source of stress to aquatic life (Heiskary and Markus 2003) and Miltner (2010). Given the more severe low flow conditions and greater frequency of D.O. exceedances in 2012 and 2015, these concerns about stresses to aquatic life have not diminished.

Outside of the variability observed in the extreme upper reaches of the mainstem, chloride and TDS concentrations remained elevated and unchanged since the 2009 survey (Figure 13). Mean chloride concentrations have exceeded the IPS thresholds associated with biological impairment for both the mIBI and fIBI, but remained well below the Illinois water quality criterion of 500 mg/L. A loadings analysis between 2009 and 2012 suggested that the 2012 increase was due wholly to the concentrating effect of reduced flow as opposed to increased inputs of chloride. Concentrations fell in 2015 a reflection of above normal flows and suggesting that combined contributions from nonpoint sources, point sources, or near surface groundwater are relatively consistent in the mainstem.

Following the 2012 survey, the DRSCW conducted effluent and stream sampling for chlorides at West Branch DuPage watershed sites bracketing the major WWTPs (Table 6). The receiving stream concentrations were, on average, equivalent or only slightly higher downstream from the WWTPs with all effluent values were below the state water quality standard of 500 mg/L. However, instream concentrations exceeded the IPS thresholds for fish and macroinvertebrates at nearly all wastewater sites, regardless of location. Sampling indicates summer low-flow chloride levels, (while elevated in 2012), are either maintained or experience only slight increases below the major WWTPs. Sites bracketing the Wheaton and Carol Stream WWTPs, located in the upper reaches of small tributaries, experienced the greatest variability, both positive and negative. The 2015 chloride results were in line with the post 2012 sampling by the DRSCW (Figure 9). Concentrations in 2015 remained above IPS targets, but were relatively consistent along the length of the mainstem (Figure 13) and between sampling years (Figure 9).

Table 6. *Chloride concentrations in effluent and stream samples collected upstream and downstream from the major wastewater treatment plants in the West Branch DuPage River watershed (2013).*

	Mean Concentration (mg/L)		
Wastewater Treatment Plant	**Upstream**	**Effluent**	**Downstream**
MWRD Hanover Park	203	114	120
V Hanover Park	139	144	140
Roselle	132	84	132
Bartlett	149	248	187
Carol Stream	224	112	154
West Chicago	125	225	137
Wheaton Sanitary District	71	142	134
Average	**140**	**159**	**147**

Two minor zinc exceedances were detected in 2015 compared to seven (7) for all heavy metals in 2012. The 2012 exceedances were mostly for copper and occurred the most frequently downstream from the WWTPs. The 2015 exceedances were likewise observed below WWTPs.

Comparatively higher base flows and correspondingly higher dilution of effluents was the likely reason for the reduction in exceedances in 2015.

West Branch DuPage River Tributaries

As in the previous surveys, the 2015 phosphorus levels in West Branch tributaries routinely exceeded both reference and Illinois EPA non-standard target thresholds and was markedly higher downstream from the Wheaton and Carol Stream WWTPs on Klein Creek and Spring Brook, respectively (Table 9). Compared to other, mostly urbanized West Branch Tributaries, the point source influenced concentrations were about one order of magnitude higher and exceeded both the recommended IEPA 1.0 mg/L effluent limit and the IEPA 0.6 mg/L non-standard based threshold. Intermittent discharges from the Bartlett WWTP overflow on the unnamed tributary to the W. Br. DuPage R. at RM 25.5 continued to have no discernible effect on mainstem water quality. Outside of WWTP influences, phosphorous concentrations in tributaries declined by one-third between 2012 and 2015, again the results of higher base flows and dilution in 2015. Despite the declines, concentrations remained above both the reference and IEPA non-standard thresholds at most sites.

Nitrate-N concentrations were likewise elevated downstream from the Wheaton and Carol Stream WWTP in 2015, but with only a few exceptions were below reference levels at non-WWTP influenced tributary sites (Table 9). One exception, Breeme Creek (WB09), had elevated nitrate-N similar to those encountered in 2006 and 2009, but no water samples were collected in 2012 due to stream desiccation. The nitrate-N levels were attributed to runoff associated with a large tract of cultivated farm fields immediately upstream. Elevated nutrient levels, including nitrates, were also found at WB23, a small, unnamed tributary immediately downstream from the 80-acre Mallard Lake in the Mallard Lake Forest Preserve. The site was also impounded by a series of beaver dams.

Elevated concentrations of NH_3-N and TKN were scattered throughout the tributaries and frequently the highest at sites downstream from WWTPs (Table 9). Elevated BOD_5 levels are an indicator of organic enrichment and threshold exceedances were widespread in the tributaries. An average threshold of 3 mg/L employed by Minnesota PCA to define excessive enrichment was used. When both the 2012 and 2015 results are considered, 15 of 22 tributary sites (68%) exceeded this 3 mg/L threshold. These high levels were frequently associated with small, densely urbanized watersheds in which small impoundments and stormwater retention basins were common. Discharges of suspended organic material including algae and humic materials from these impoundments likely contributed to the enriched conditions.

Still, an exceedance of the Illinois 500 mg/L WQS was again found at the Winfield Creek site (WB13) located 0.6 miles downstream from a DuPage County DOT salt storage facility, albeit at a lower concentration in 2015 (506 mg/L) than the 904 mg/L value observed in 2012 (Figure 14). In addition to increased dilution in 2015, the decrease between 2012 and 2015 may reflect improved BMPs in the watershed, including in storage (***Plate No. 7***). While the storage site remains the probable source of the concentration spike in in Winfield Creek, this has to be confirmed and the nature of the loading identified (legacy or current practice).

Plate No. 7. *Winfield Creek sampling sites (left panel) bracketing the DuPage County salt storage facility where runoff was suspected of contributing to chloride exceedances observed downstream at WB13 in 2012 and 2015. Two new sites more closely bracketing the facility (WB13.1 and 13.2) were sampled for biology and habitat only in 2015.*

D.O. exceedances were encountered at four tributary sites in 2015, but were less common and generally less severe than that found during the 2012 survey. Low D.O. was observed in Winfield Creek (WB14, WB13), Cress Creek (WB07; dry in 2012), and a ditched, marshy site in the extreme upper reach of Spring Brook (WB11). In 2012 D.O. levels were so low that wide diel D.O. fluctuations were a suspected cause of several pH exceedances; no pH exceedances were encountered in 2015. The remaining exceedance was for a single zinc sample from below the Carol Stream WWTP on Klein Creek (WB16).

***Table 7**. Chemical parameter concentrations (mg/L) exceeding Illinois water quality standards[7] in chemical grab samples from the West Branch DuPage River watershed in 2015 and 2012.*

Site ID	Basin	Stream	River Mile	Exceedance or Parameter of Interest	
				2015	**2012**
West Branch DuPage River					
WB25	95	900	34.0	D.O. (1.28)	Total NH_3-N (3.24)
WB31	95	900	31.9	--	D.O. (2.57)
WB24	95	900	31.6	--	--
WB32	95	900	30.1	--	--
WBAD	95	900	29.0	¥ D.sonde D.O. (Table 7)	¥ D.sonde D.O. (Table 7)
WB27	95	900	28.7	--	--
WB28	95	900	27.4	--	--
WB20	95	900	25.6	Zn (195)	--
WB39	95	900	21.7	--	--
WB33	95	900	21.3	--	--
WB17	95	900	19.2	--	Cu (72.40)
WB38	95	900	16.0	--	--
WB34	95	900	15.1	--	--
WB12	95	900	13.6	--	Cd (43.70); Cu (44.70); Pb (41.60)
WB42	95	900	11.6	--	D.O. (3.80)
WBBR	95	900	11.6	¥ D.sonde D.O. (Table 7)	¥ D.sonde D.O. (Table 7)
WB40	95	900	11.1	D.O. (4.77)	D.O. (4.60)
WBWD	95	900	11.1	¥ D.sonde D.O. (Table 7)	¥ D.sonde D.O. (Table 7)
WBMG	95	900	8.76	¥ D.sonde D.O. (Table 7)	--
WB36	95	900	8.6	--	D.O. (3.80)
WB41	95	900	8	--	--
WB37	95	900	6.3	--	--
WB35	95	900	4.2	--	--
WB08	95	900	0.85	--	--
Trib. to W. Br. DuPage River (RM20.85)					
WB18	95	902	0.5	--	--
Trib. (RM 1.65) to Trib. to W. Br. DuPage River (RM 25.5)					
WB22	95	904	0.15	--	D.O. (3.80)
Trib. to W. Br. DuPage River (RM 29.25)					
WB23	95	905	0.15	--	Not sampled
Trib. to W. Br. DuPage River (RM 25.5)					
WB29	95	906	2.2	--	Chloride (533)
WB30	95	906	1.9	--	pH (6.30), Chloride (503)
WB21	95	906	0.9	--	D.O. (4.80)
Kress Creek					

[7] Dissolved oxygen concentrations below the 5 mg/L water quality standard are listed in the table but do not qualify as actual exceedances because of inadequate sampling frequency.

Site ID	Basin	Stream	River Mile	Exceedance or Parameter of Interest	
				2015	2012
WB02	95	910	5.1	--	NH_3-N (1.61, 1.37)
WB01	95	910	2.7	--	--
WB03	95	910	0.5	--	D.O. (4.20)
Ferry Creek					
WB04	95	920	2.8	--	D.O. (3.30)
WB06	95	920	0.7	--	--
W. Br. Ferry Creek					
WB05	95	925	0.25	--	D.O. (3.70)
Cress Creek					
WB07	95	930	0.2	D.O. (4.33)	Not sampled
Bremme Creek					
WB09	95	940	0.25	--	Not sampled
Spring Brook					
WB11	95	950	3.3	D.O. (4.02, 4.45)	D.O. (3.40); pH (6.40), Cu (13.30)
WB26	95	950	3.0	--	--
WB10	95	950	0.75	--	--
Winfield Creek					
WB15	95	960	5.4	--	--
WB14	95	960	3.5	D.O. (3.26; 4.15, 4.68)	D.O. (4.10)
WB13.1	95	960	0.4	Not sampled	Not sampled
WB13.2	95	960	0.4	Not sampled	Not sampled
WB13	95	960	0.4	D.O. (4.82), Chloride (546)	Chloride (904)
Klein Creek					
WB19	95	970	3.6	--	--
WB16	95	970	1.0	Zn (60.4)	Cu (38.80), (98.60)

Table 8. *Dissolved oxygen concentrations (mg/L) exceeding Illinois WQS in the West Branch DuPage River at Arlington Drive (WBAD), Butternut Road (WBBR), downstream from the former Warrenville Grove Dam (WBWD), and upstream from the former McDowell Grove Dam (WBMG), during 2008-2015.*

Site ID	River	Year	Date(s)	Parameter	Criteria	Standard
WBAD (RM 29.0)	**W. Branch DuPage R.**	**2015**	April – 23-27	D.O.	<6.0 mg/L	7-day Average
			June – 11-20	D.O.	<6.0 mg/L	7-day Average
			June 23	D.O.	<6.0 mg/L	7-day Average
			June 25-July 1	D.O.	<6.0 mg/L	7-day Average
			July 15-30	D.O.	<6.0 mg/L	7-day Average
			April – 23-27	D.O.	<4.0 mg/L	7-day Minimum
			Aug 4-Sept. 6	D.O.	<4.0 mg/L	7-day Minimum
			Sept. 17-19	D.O.	<4.0 mg/L	7-day Minimum
			June (2 days)	D.O.	<5.0 mg/L	Not to exceed
			Aug. (6 days)	D.O.	<3.5 mg/L	Not to exceed
			Sept. 2-3	D.O.	<3.5 mg/L	Not to exceed
			Sept. 15-17	D.O	<3.5 mg/L	Not to exceed
		2012	June 28-July 1	D.O.	<6.0 mg/L	7-day Average
			July 27-31	D.O.	<6.0 mg/L	7-day Average
			Sept. 27-31	D.O.	<6.0 mg/L	7-day Average
			Aug 5-10	D.O.	<4.0 mg/L	7-day Minimum
			Sept. 3-7	D.O.	<4.0 mg/L	7-day Minimum
			Sept. 17-19	D.O.	<4.0 mg/L	7-day Minimum
			July 20	D.O.	<5.0 mg/L	Not to exceed
			July 25-27	D.O.	<5.0 mg/L	Not to exceed
			Sept. 2-3	D.O.	<3.5 mg/L	Not to exceed
			Sept. 15-17	D.O	<3.5 mg/L	Not to exceed
		2009	June – 27-27	D.O.	<6.0 mg/L	7-day Average
WBBR (RM 11.6)	**W. Branch DuPage R.**	**2015**	May 28–June 1	D.O.	<6.0 mg/L	7-day Average
			June 14-July 1	D.O.	<6.0 mg/L	7-day Average
			June (9 days)	D.O.	<5.0 mg/L	Not to exceed
			July (2 days)	D.O.	<5.0 mg/L	Not to exceed
		2012	June 20-27	D.O.	<6.0 mg/L	7-day Average
			June 29 – July 9	D.O.	<6.0 mg/L	7-day Average
			July 17-28	D.O.	<6.0 mg/L	7-day Average
			Aug. 21- Sept. 7	D.O.	<5.0 mg/L	7-day Minimum
			June 20- July 31	D.O.	<5.0 mg/L	Not to exceed
			Aug. 05	D.O.	<4.0 mg/L	Not to exceed
			Aug. 11-12	D.O.	<4.0 mg/L	Not to exceed
			Aug. 21-23	D.O.	<4.0 mg/L	Not to exceed
		2009	July – 22-23	D.O.	<6.0 mg/L	7-day Average
WBWD (RM 11.1)	**W. Branch DuPage R.**	**2015**	May 28–June 1	D.O.	<6.0 mg/L	7-day Average
			June 14-28	D.O.	<6.0 mg/L	7-day Average
			Aug 7-8	D.O.	<4.0 mg/L	7-day Minimum
			June (6 days)	D.O.	<5.0	Not to exceed

Site ID	River	Year	Date(s)	Parameter	Criteria	Standard
			July (3 days)	D.O.	<5.0	Not to exceed
		2012	July 18 - 29	D.O.	<5.0	Not to exceed
			July 31	D.O.	<5.0	Not to exceed
			Aug. 5-9	D.O.	<4.0 mg/L	Not to exceed
		2009	--	D.O.	--	--
WBMG (RM 8.76)	W. Branch DuPage R.	2015	May 30–31	D.O.	<6.0 mg/L	7-day Average
			June 15-28	D.O.	<6.0 mg/L	7-day Average
			Aug 7-8	D.O.	<4.0 mg/L	7-day Minimum
			Aug 17	D.O.	<4.0 mg/L	7-day Minimum
			Aug 22	D.O.	<4.0 mg/L	7-day Minimum
			Sept. 6-9	D.O.	<4.0 mg/L	7-day Minimum
			June (11 days)	D.O.	<5.0 mg/L	Not to exceed
			July (3 days)	D.O.	<5.0 mg/L	Not to exceed
			Aug. (1 days)	D.O.	<3.5 mg/L	Not to exceed

Nutrient Conditions in the West Branch DuPage River Watershed

The impacts of nutrients on aquatic life has been well documented (Allan 2004), but the derivation of criteria and their form and application have yet to emerge. Unlike toxicants, the influence of nutrients on aquatic life responses is via indirect pathways such as the effect of algal respiration on D.O. fluxes or through the influence of decomposition on D.O. levels. In addition, nutrients can affect food sources for macroinvertebrates and fish and are also influenced by habitat (e.g., substrate composition), stream flow and scouring, and temperature and shading. Illinois is the leading state in terms of percent of the exported loading of nitrogen (16.8%) and phosphorus (12.9%) to the anoxic zone in the Gulf of Mexico (U.S. EPA 2009; U.S. EPA 2008).

In Illinois, as in other states, efforts are underway to derive nutrient water quality criteria for aquatic life. The U.S. EPA Inspector General (IG) concluded that the U.S. EPA, with regard to nutrient criteria, failed to adequately monitor and measure progress and "would consider promulgating numeric nutrient standards for a State if it had not substantially completed adopting numeric nutrient criteria in accordance with its plan by the end of 2004 (U.S. EPA 2009)." The IG concluded that U.S. EPA failed to sanction states who had not made progress and cited Illinois as an example based on the "apparent belief that it (Illinois) did not need numeric nutrient criteria (U.S. EPA 2009). Data from sites exceeding regional reference nutrient thresholds that are associated with excessive concentrations of nutrients were used herein. Table 9 lists four nutrient enrichment related parameters in relation to various benchmarks that have been established to associate nutrients with impaired aquatic life. The Illinois EPA derived targets for phosphorus and nitrates (and other parameters) that lack formal numeric criteria by using "a statistically derived numeric value or a field observation" that "may be used to identify potential causes of aquatic life use impairment". For total phosphorus, nitrates, and suspended solids, a numeric threshold based on an 85th percentile value derived from all available data in water years 1978-1996 at Ambient Water Quality Monitoring Network sites.

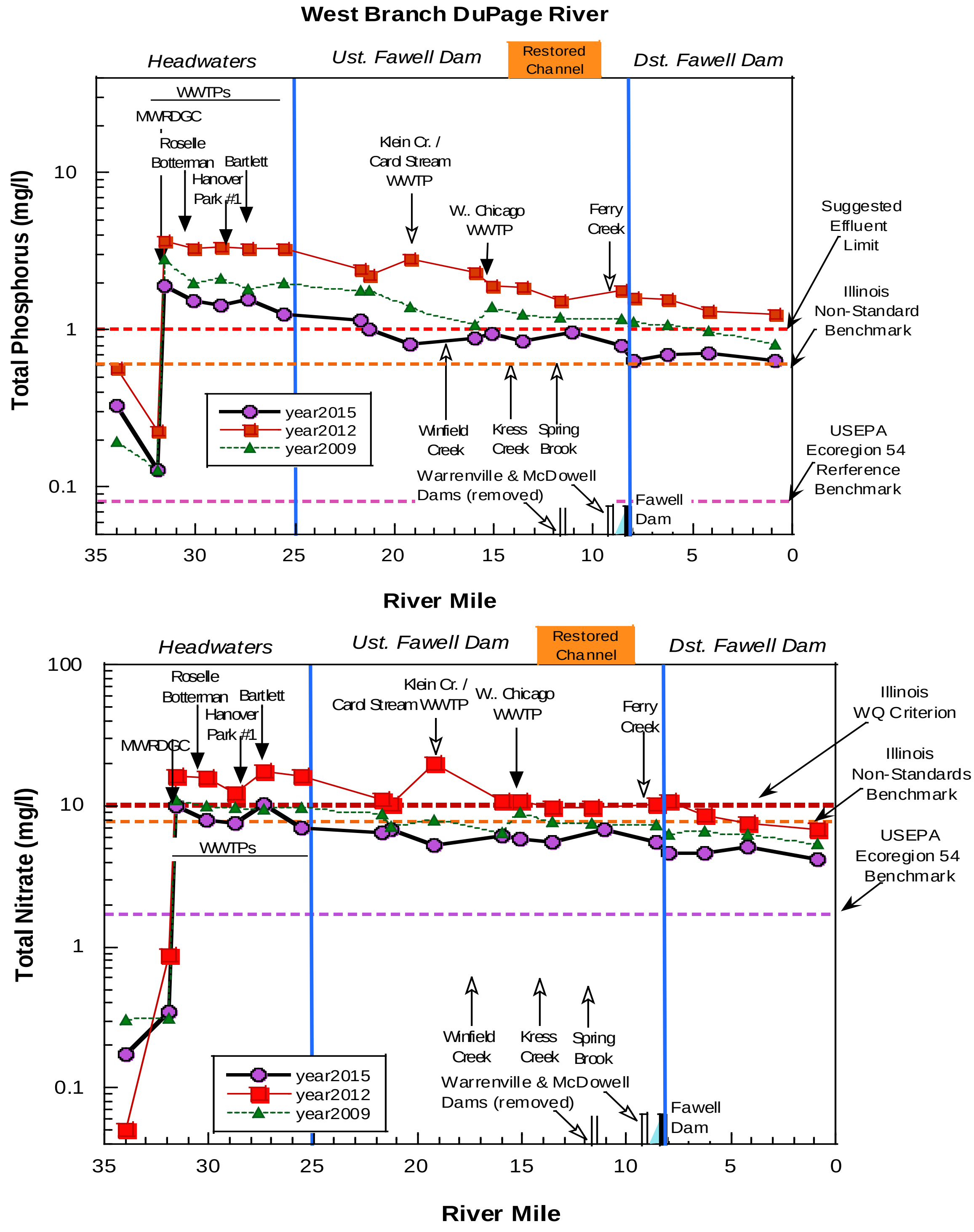

***Figure 7**. Mean concentrations of total phosphorus (top) and nitrate (bottom) in the West Br. DuPage River in 2015, 2012 and 2009. For phosphorus, dashed lines represent target total phosphorus concentrations for USEPA Ecoregion 54 (0.072 mg/L), the middle to high range of US EPA nutrient Ecoregion VI (0.61 mg/L), and the suggested effluent limit (1.0 mg/L). For nitrate, dashed lines represent target concentrations for USEPA Ecoregion 54 (1.798 mg/L), the Illinois EPA non-standard based criteria (7.8 mg/L) and the water quality criterion (10 mg/L). Note: The Wheaton WWTP discharges to Spring Brook at RM 3.2.*

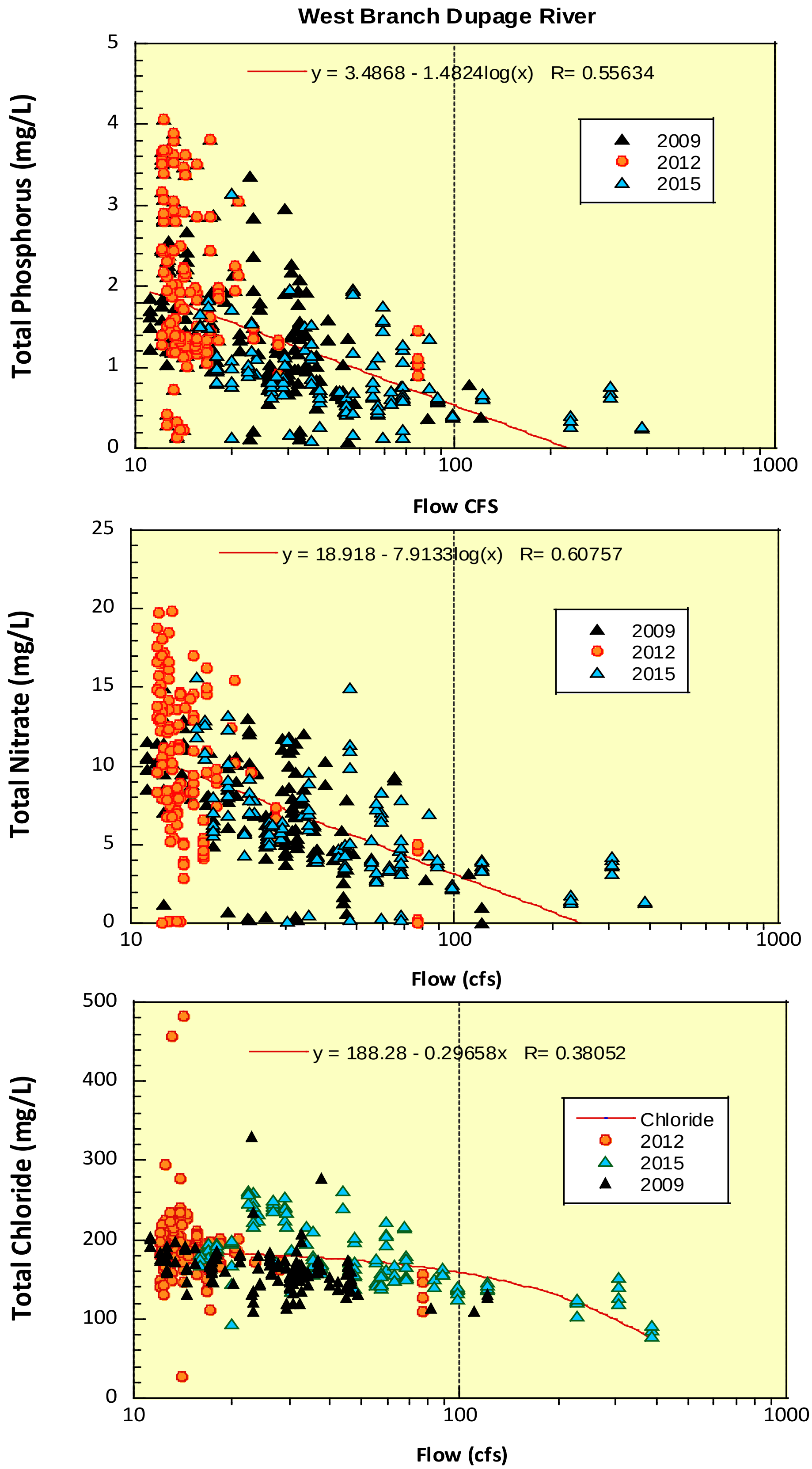

***Figure 8**. Concentrations of total phosphorus, nitrate, and chloride correlated with flow in grab samples collected from the West Branch DuPage River in 2009, 2012, and 2015.*

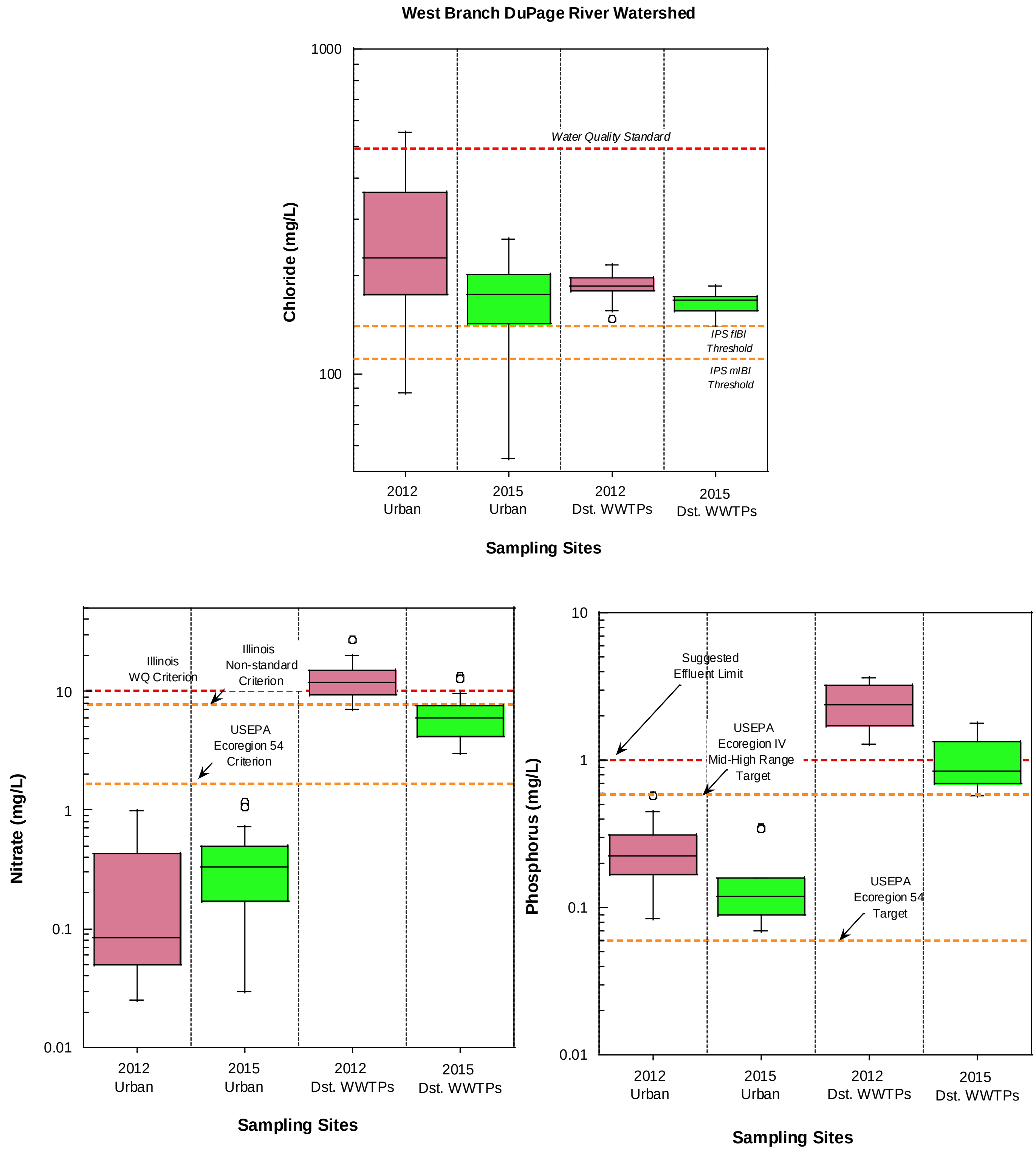

***Figure 9**. Box and whisker plots of mean chloride, nitrate and phosphorus concentrations from similar West Br. DuPage watershed sites in 2015 and 2012. The sites are categorized as WWTP and urban influenced (no WWTP discharges upstream). Most "urban" sites were on Tributaries while most "Dst. WWTP" sites were from the mainstem.*

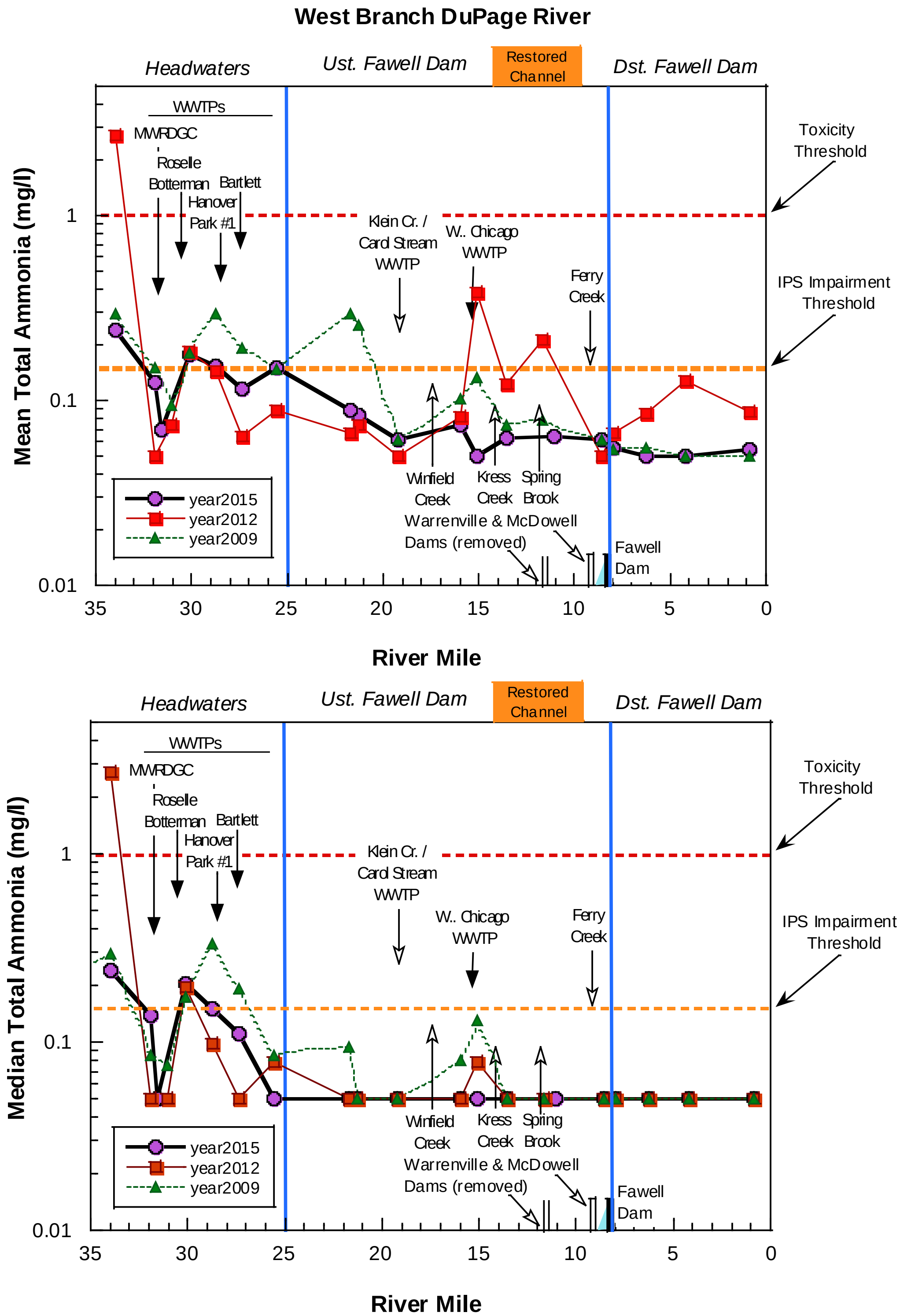

***Figure 10**. A comparison of mean concentrations of* NH_3-N *nitrogen in the West Br. DuPage River (top) with median concentrations (bottom) in 2015, 2012 and 2009. The upper dashed line in each graph represents a threshold concentration beyond which toxicity is likely while the lower dashed line (0.15 mg/L) is correlated with impaired biota in the IPS study. Note: The Wheaton WWTP discharges to Spring Brook at RM 3.2.*

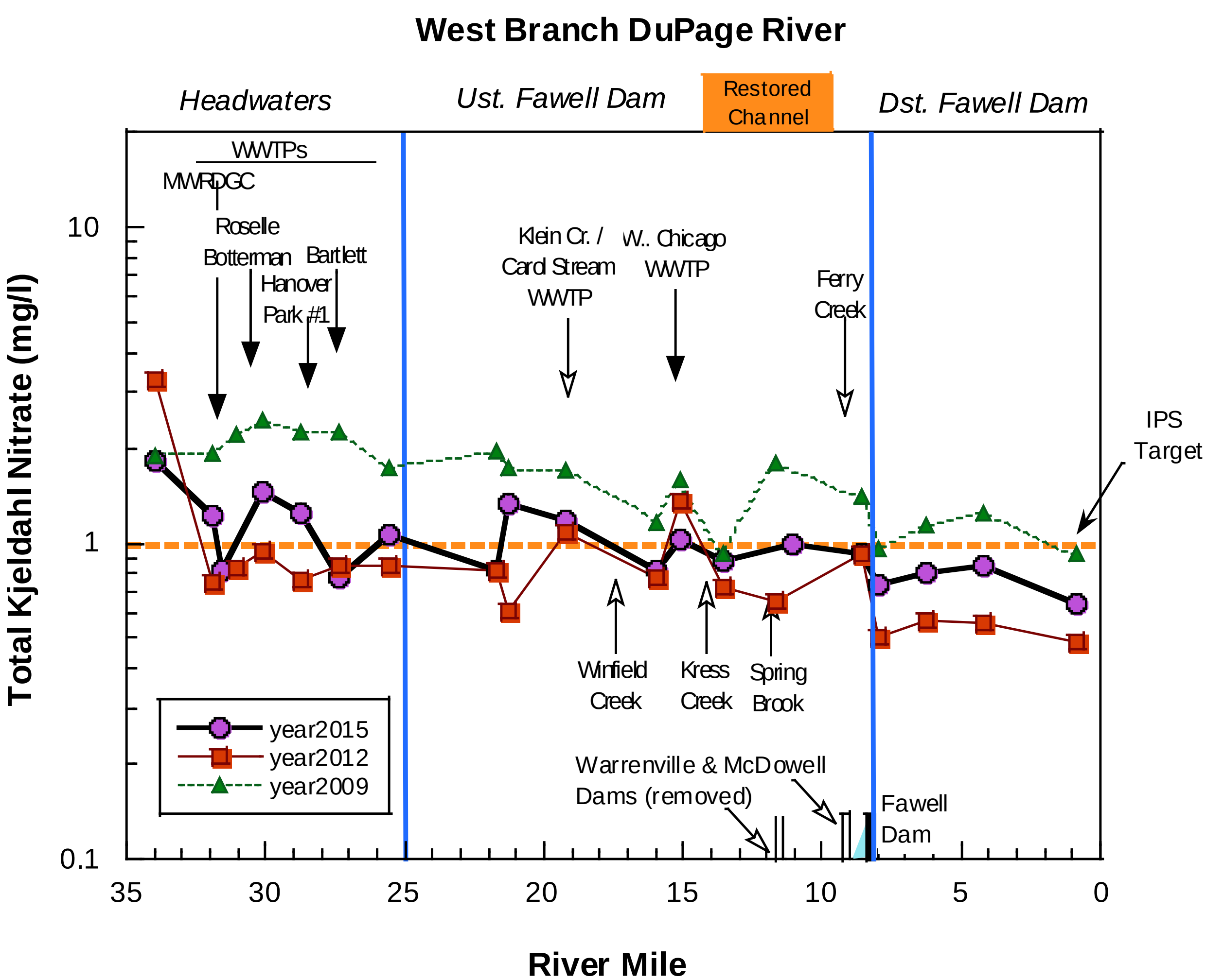

***Figure 11**.Median concentrations of total Kjeldahl nitrogen (TKN) in the West Br. DuPage River in 2015, 2012 and 2009. The dashed line represents the IPS TKN aquatic life target level. Note: The Wheaton WWTP discharges to Spring Brook at RM 3.2.*

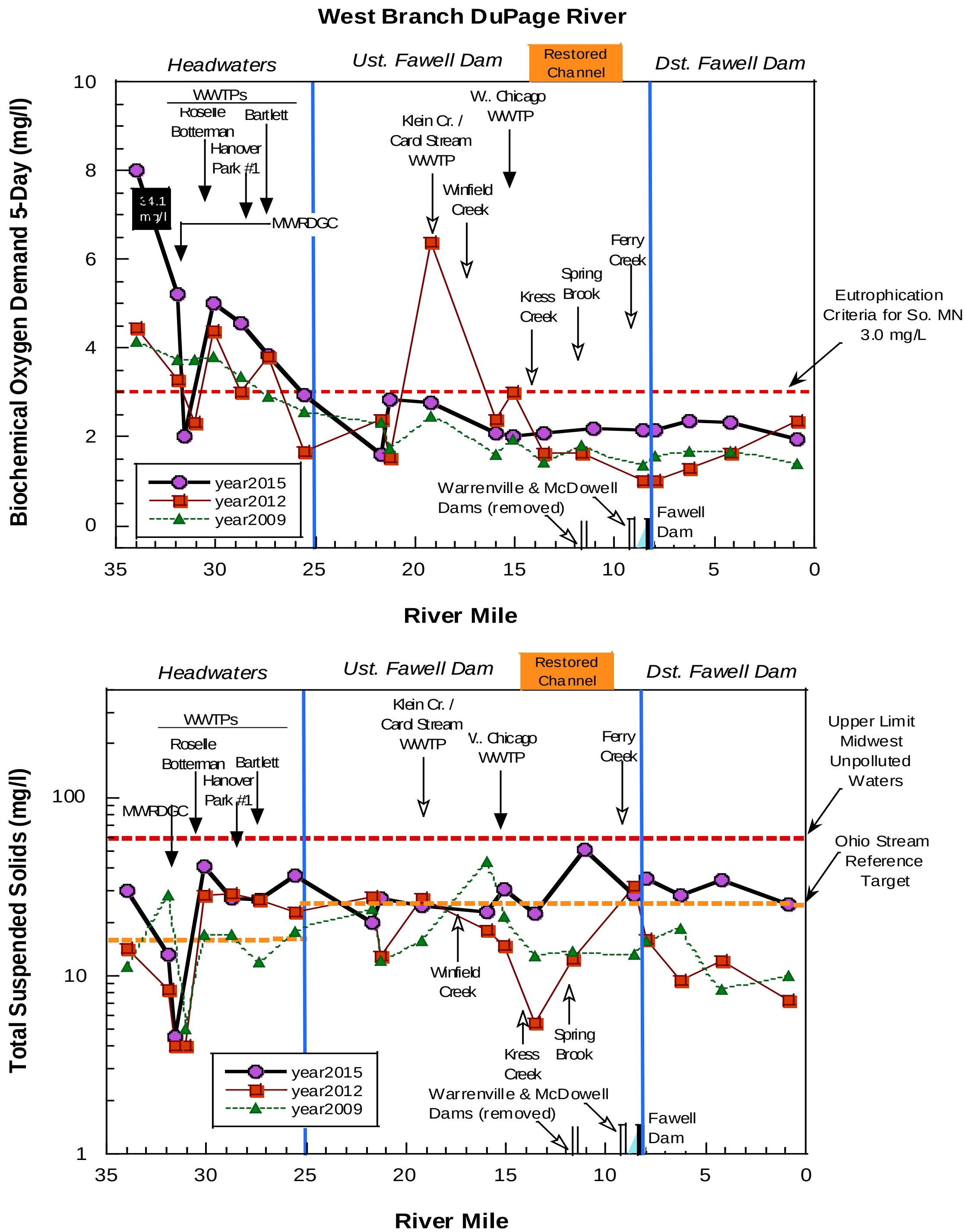

Figure 12. Median concentration of 5-day biological oxygen demand (BOD-top) and total suspended solids (TSS–bottom) in the West Br. DuPage River in 2015, 2012 and 2009. In the BOD plot, the dashed line (3 mg/L) represents the upper limit of concentrations typical of unpolluted waters in southern MN. In the TSS plot, the upper dashed line represents the upper limit of concentrations typical of unpolluted waters in the Midwest (60 mg/l); the lower target line (16-25 mg/l) is based on Ohio headwater and wading reference sites. Note: The Wheaton WWTP discharges to Spring Brook at RM 3.2.

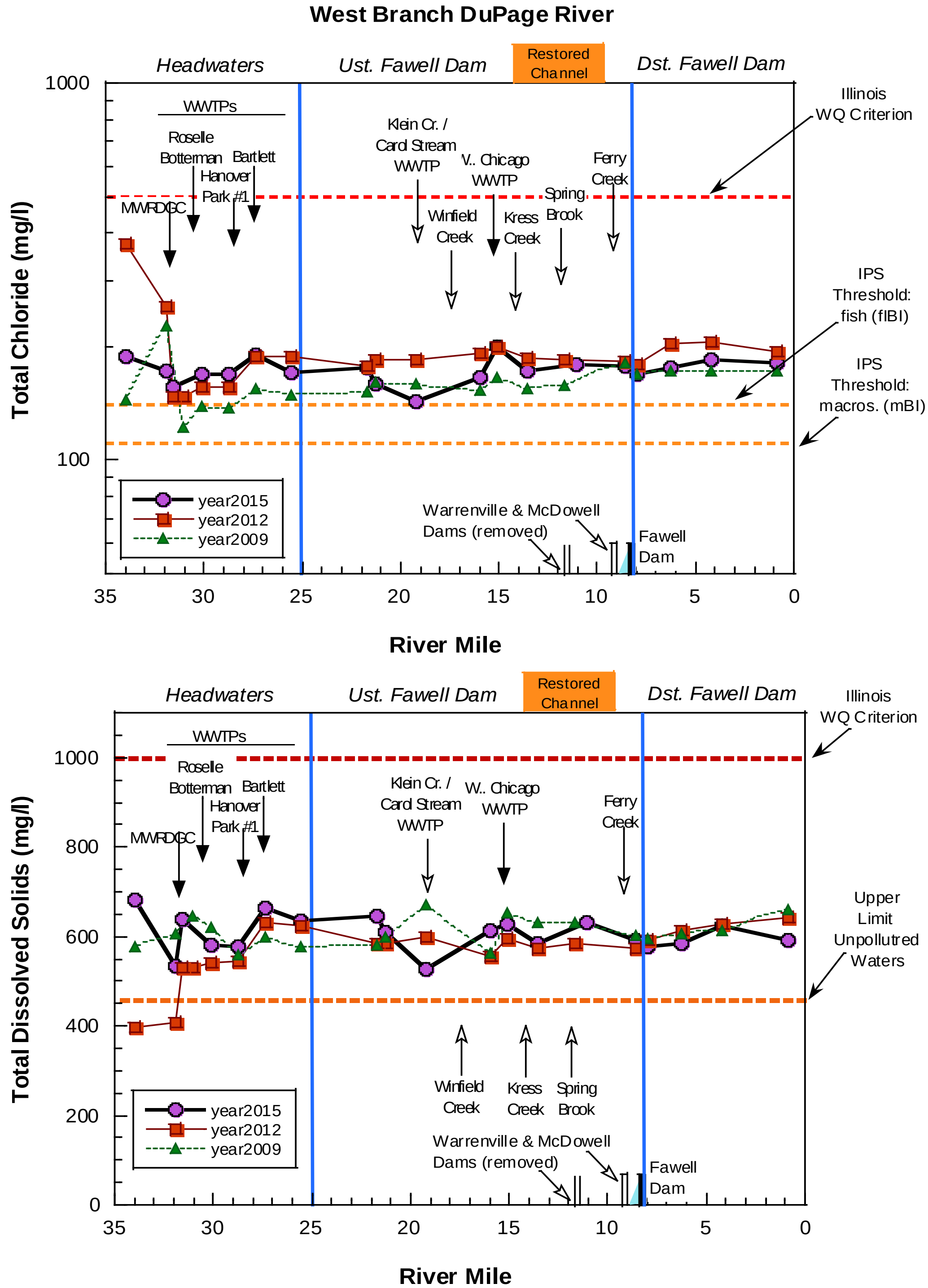

***Figure 13**. Mean concentrations of total chloride (top) and total dissolved solids (TDS-bottom) in the West Br. DuPage River in 2015, 2012 and 2009. For chloride, the upper, dashed line is the Illinois water quality criterion (500 mg/L); the lower dashed lines show IPS regression thresholds for the fIBI (141 mg/L) and mIBI (112 mg/L). For TDS, the upper dashed line is the existing Illinois water quality criterion (1000 mg/L) and the lower dashed line represents the 75th percentile TDS level for small rivers in Ohio. Note: The Wheaton WWTP discharges to Spring Brook at RM 3.2.*

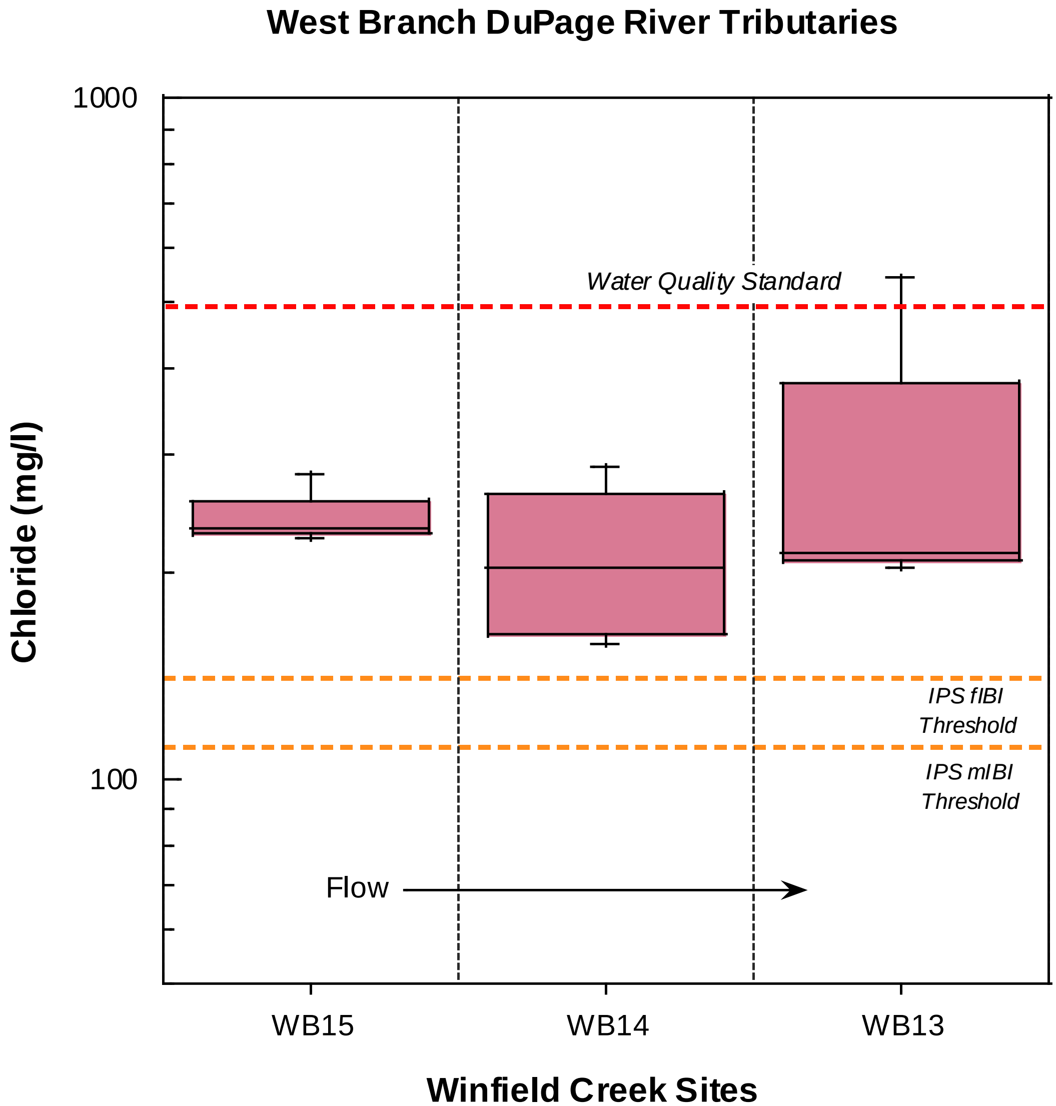

Figure 14. *Box and whisker plot of chloride concentrations at Winfield Creek stations in 2015. Site WB13 is located 0.6 miles downstream from a DuPage County salt storage facility and has experienced WQS exceedances for chloride in previous surveys.*

There have been a wide range of approaches to deriving the targets used to assign nitrate a possible cause of impairment. The 10 mg/L WQS is a human health-based criterion for drinking water supplies and at the point of use (e.g., water intakes). The IEPA non-standard criterion for nitrate is 7.8 mg/L. By contrast, the U.S. EPA (2000) developed ecoregion target (e.g., 25th percentile) for ecoregion 54 in nutrient ecoregion VI is 1.78 mg/L. In their Lower DuPage River watershed plan, the Conservation Foundation (2011) used a value of 3.2 mg/L that was selected as a middle to high value of the U.S. EPA derived nutrient ecoregion level "due to the wastewater treatment contributions in the watershed."

Sources of Nutrients

Nutrient trends in the 2015 West Branch DuPage watershed remain nearly identical to previous surveys with the highest levels encountered below WWTP discharges located on the mainstem and in Spring Brook and Klein Creek (Table 9). However, concentrations and nutrient threshold exceedances were almost universally lower in 2015, particularly below the WWTPs. For example mean nitrates exceeded 10 mg/L in 2012 at 11 of 18 mainstem sites and phosphorus exceeded 1.0 mg/L at all WWTP influenced sites from RM 31.6 to the mouth. In contrast, none of the mainstem nitrates averaged greater than 10 mg/L in 2015 and the number of mainstem sites with mean phosphorus >1 mg/L was cut by 50%. As discussed before, increased base flow levels and subsequent effluent dilution was considered the main reason for reduction. Urban tributaries and sites upstream from point sources also experienced declines in nutrients (particularly phosphorus) due to dilution, but not to the extent of those directly influenced by the WWTPs. Phosphorus levels from these smaller drainages were reduced by 36% in 2015 compared to 2012, but continued to exceed IPS threshold levels at the majority of sites.

As in 2012, nitrates remained low in urban tributaries outside of WWTP influences and fell almost entirely below target levels. An exception was WB09 (Breeme Creek) with elevated nitrates attributed to agricultural runoff; concentration were above target in 2006, 2009 and 2015, but the stream was dry and not sampled in 2012.

Most NH_3-N levels in the West Branch DuPage watershed were below IPS thresholds and near detection, reflecting lower concentrations than in 2012. For example, six tributary sites that had previously exceeded thresholds were below or just at detection in 2015 (*i.e.,* WB18, WB02, WB29, WB30, WB21, and WB14) and declines were noted at most other sites between surveys. As in 2012, most NH_3-N levels below point sources were near detection or not significantly elevated. The upper most mainstem site (WB25) remained above threshold but mean concentrations in 2015 (0.24 mg/L) were about one tenth of the 2.72 mg/L found in 2012. Still, extremely high BOD levels were encountered at WB25 in 2015 so concerns raised over an unknown pollution source after the 2012 survey continue. TKN levels also trended lower in 2015, which may be related to excessive algal growth associated with impoundments and retention ponds that were exacerbated under low-flow conditions in 2012. In general, tributary sites with elevated NH_3-N (and other nutrients and BOD) often drained nearby impoundments and retention basins in addition to urban sources.

Two new tributary sites were sampled in 2015. At WB22, only NH_3-N exceeded threshold levels, but at WB23, all nutrients exceeded thresholds and the mean phosphorus of 1.34 mg/L fell into the range of WWTP influences. The WB23 site is in a unique location, immediately downstream from the 80-acre Mallard Lake in the Mallard Lake Forest Preserve. The site was also impounded by a series of beaver dams.

***Table 9**. Median concentrations of key nutrient parameters including total NH3-N, nitrate, TKN, and phosphorus in the West Branch DuPage River watershed in 2015. Shading represents exceedances of various criteria or thresholds for nutrient parameters (see footnotes). Where more than one target was used, the most stringent criteria is red and least stringent is yellow.*

Site ID	Basin code	Stream Code	RM	NH_3-N[1] (mg/L)	Nitrate[2,3,4] (mg/L)	TKN[5] (mg/L)	T-Phosphorus[6.7,8] (mg/L)
West Branch DuPage River							
WB25	95	900	34.0	0.24	0.17	1.82	0.33
WB31	95	900	31.9	0.13	0.39	1.08	0.13
WB31 Dup.	95	900	31.9	0.15	0.3	1.54	0.12
WB24	95	900	31.6	0.05	9.63	0.9	1.66
WB32	95	900	29.3	0.21	7.83	1.5	1.49
WB27	95	900	27.7	0.15	6.84	1.36	1.37
WB28	95	900	27.4	0.11	8.94	0.71	1.53
WB20	95	900	25.6	0.11	6.99	1.17	1.31
WB20 Dup.	95	900	25.6	0.05	5.22	1.12	1.03
WB39	95	900	21.7	0.05	6.39	0.95	1.04
WB33	95	900	21.3	0.05	6.71	1.12	1.04
WB17	95	900	19.2	0.05	2.99	1.07	0.57
WB38	95	900	16.0	0.05	4.15	0.82	0.72
WB38 Dup.	95	900	16.0	0.05	7.76	0.66	1.09
WB34	95	900	15.1	0.05	3.93	0.99	0.68
WB12	95	900	13.6	0.05	4.38	0.99	0.71
WB12 Dup.	95	900	13.6	0.08	4.8	0.58	0.68
WB40	95	900	11.1	0.05	6.21	0.96	0.79
WB36	95	900	8.3	0.05	5.59	0.96	0.76
WB41	95	900	8.0	0.05	4.2	0.8	0.66
WB37	95	900	6.3	0.05	4.19	0.84	0.73
WB35	95	900	4.2	0.05	4.6	0.93	0.7
WB08	95	900	0.85	0.05	4.05	0.63	0.64
WB08 Dup.	95	900	0.85	0.05	3.75	0.25	0.58
Trib. to W. Br. DuPage River (RM20.85)							
WB18	95	902	0.3	0.05	0.33	0.81	0.09

Site ID	Basin code	Stream Code	RM	NH_3-N[1] (mg/L)	Nitrate[2,3,4] (mg/L)	TKN[5] (mg/L)	T-Phosphorus[6,7,8] (mg/L)
Trib. (RM 1.65) to Trib. to W. Br. DuPage River (RM 25.5)							
WB22	95	904	0.15	0.24	0.2	0.81	0.1
Trib. to W. Br. DuPage River (RM 29.25)							
WB23	95	905	0.15	0.18	7.19	1.03	1.34
Trib. to W. Br. DuPage River (RM 25.5)							
WB29	95	906	2.2	0.05	0.33	0.84	0.35
WB30	95	906	1.9	0.05	0.37	0.8	0.34
WB21	95	906	0.9	0.05	0.52	0.85	0.16
Kress Creek							
WB02	95	910	5.1	0.08	0.73	0.74	0.07
WB01	95	910	2.7	0.05	0.47	0.52	0.1
WB03	95	910	0.5	0.05	1.15	0.86	0.16
Ferry Creek							
WB04	95	920	2.8	0.05	0.04	1.65	0.16
WB06	95	920	0.7	0.05	0.5	1.01	0.12
W. Br. Ferry Creek							
WB05	95	925	0.25	0.16	0.12	1.41	0.13
Cress Creek							
WB07	95	930	0.2	0.05	1.05	0.87	0.11
Bremme Creek							
WB09	95	940	0.25	0.05	3.31	0.25	0.04
Spring Brook							
WB11	95	950	3.3	0.18	0.47	0.87	0.16
WB26	95	950	3	0.05	13.4	0.25	1.79
WB10	95	950	0.75	0.29	12.8	0.91	1.68
Winfield Creek							
WB15	95	960	5.4	0.09	0.51	0.88	0.12
WB15 Dup.	95	960	5.4	0.11	0.17	0.54	0.11
WB14	95	960	3.5	0.3	0.14	1.21	0.15
WB13	95	960	0.4	0.05	0.23	0.98	0.09
WB13 Dup.	95	960	0.4	0.05	0.28	0.71	0.09

Site ID	Basin code	Stream Code	RM	NH_3-N[1] (mg/L)	Nitrate[2,3,4] (mg/L)	TKN[5] (mg/L)	T-Phosphorus[6,7,8] (mg/L)
Klein Creek							
WB19	95	970	3.6	0.05	0.03	0.85	0.07
WB16	95	970	1.0	0.05	7.27	0.81	0.91
Ferson Creek (Reference Site)							
F-2	95	660	7.6	0.05	0.53	0.99	0.11
F-1	95	660	2.5	0.05	0.35	0.72	0.07
Otter Creek (Reference Site)							
F-3	95	659	0.9	0.05	0.33	0.91	0.08

[1]MBI IPS NH_3-N aquatic life target level (0.15 mg/L).
[2]U.S. EPA Ecoregion 54 reference target for nitrate (1.798 mg/L).
[3]Non-standards based numeric criteria for total nitrate (7.8 mg/L) in water based on the 85th-percentile values determined from a statewide set of observations from the Ambient Water Quality Monitoring Network, for water years 1978-1996 (Illinois EPA 2011).
[4]Illinois water quality criteria for nitrate (10.0 mg/L).
[5]MBI IPS TKN aquatic life target level (1.0 mg/L).
[6]U.S. EPA Ecoregion 54 reference target for total phosphorus (0.072 mg/L).
[7]Non-standards based numeric criteria for total phosphorus (0.61 mg/L) in water based on the 85th-percentile values determined from a statewide set of observations from the Ambient Water Quality Monitoring Network, for water years 1978-1996 (Illinois EPA 2011).
[8]Suggested protective effluent limit for total phosphorus (1.0 mg/L).

Dissolved Materials in Urban Runoff

As in previous surveys, dissolved material levels in West Branch tributaries as expressed by measurements of conductivity (µS/cm), total dissolved solids (TDS in mg/L) and chloride (mg/L) were almost universally elevated above IPS targets (Table 10). However, concentrations were reduced by about one-third in 2015 compared to 2012, owing mainly to higher base flows and increased dilution during the 2015 survey period. In contrast to 2012, WQS exceedances for chloride in 2015 were limited to a site on Winfield Creek (WB13) with a history of chloride exceedances located approximately 0.6 miles downstream from a road salt storage facility (see Plate No. 7, page 40). Additional 2012 chloride exceedances were limited to the Bartlett area (Unnamed Tributary to W. Br. DuPage River @RM 25.5), which drains a large expanse of urban and commercial development.

As previously discussed in other DuPage River watershed reports, the watersheds have experienced increasingly higher levels of salt and dissolved materials related to urban runoff and, of particular concern in northern climates, the concentration of chlorides from nonpoint sources such as application of road salt. Studies in Illinois and elsewhere have identified the accelerated salinization of surface and groundwater from increased loadings of chlorides over the past 30-40 years. Illinois EPA conducted a total chloride TMDL for the East Branch DuPage River in 2004 (CH_2M Hill 2004) and identified road salt and WWTP effluents as two key sources of chlorides in the watershed. Kelly et al. (2012) demonstrated that the recent increase in chloride concentrations in the Chicago area correlated with a pattern of increased road salt applications, particularly over the past 20 years. Kelly et al. (2012) also identified a strong, steady increasing trend in chlorides in the Illinois River at Peoria where the median increased from about 20 mg/L in 1947 to nearly 100 mg/L in 2004 with high values in the 1940s of less than 40 and spikes in 2003 of >300 mg/L. Even higher values occur in small urban streams well above the 500 mg/L Illinois WQS as evidenced by recent data from the East and West Branch DuPage watersheds. Winter conductivity data collected from the West Branch suggests that the system regularly exceeds the Illinois WQS during cold weather months.

The 2015 survey of the West Branch shows an interruption in the trend of increase in the concentration of chlorides and dissolved materials, particularly in the tributaries and smaller drainages that are not influenced by point sources (Figure 9). The decline was most likely related to higher base flows and increased dilution, but concentrations remained above the DRSCW IPS thresholds associated with fish and macroinvertebrate impairment. Kelly (2008) concluded that rather than a simple runoff and export mode of effect, chlorides and similar dissolved constituents accumulate in near surface groundwater, soils, and land surfaces adjacent to streams thus serving as a reservoir during non-winter periods. This is shown in Figure 15 with the gradual decline in concentrations being observed as we move through the summer.

Wastewater discharges are also a significant source of dissolved material in the watershed and concentrations remained consistently above the IPS thresholds in 2015. Still, chloride concentrations below WWTPs exhibited detectable declines between 2012 and 2015, but to a lesser extent than in the tributaries (Figure 9). In the West Branch mainstem it appears that periodic nonpoint source inputs coupled with the persistent background contributions from the WWTPs tended to maintain moderately elevated levels of dissolved solids downstream. Chloride sampling conducted in 2009, 2012 & 2015 on the West Branch mainstem indicated that nonpoint contributions gradually diminished over the summer months, leaving point sources as the predominate sources under late season, low flow conditions (Figure 15). Given the observed “tail off” in concentrations, it seemed that point sources only dictate ambient concentrations from the fall through to when deicing operations began again in December.

Median concentrations of copper (Cu) and zinc (Zn) were routinely detected above reference target levels throughout the watershed in both 2015 and 2012 (Table 10). As in 2012, elevated levels occurred at both tributary and mainstem sites, but were most common in effluent dominated reaches, an indication of municipal wastewater sources. While the trend in elevated metals was similar between 2015 and 2012 both the concentrations and frequency of exceedances were lower in 2015 a reflection of higher flow conditions and subsequent dilution of point source effluent in 2015.

West Branch DuPage River Sediment Chemistry

Sediment samples were analyzed for heavy metals, polycyclic aromatic hydrocarbons (PAHs), and pesticides from twenty-five locations in the West Branch DuPage River watershed and reference sites in 2015 (Table 11 and Table 12). Samples were evaluated against guidelines compiled by McDonald et al. (2000) and the Ontario Ministry of Environment (1993) that list ranges of contaminant values by probable effects on aquatic life (Table 11). Specifically, threshold effects levels (TEL) are those where toxicity is initially apparent, and likely to affect

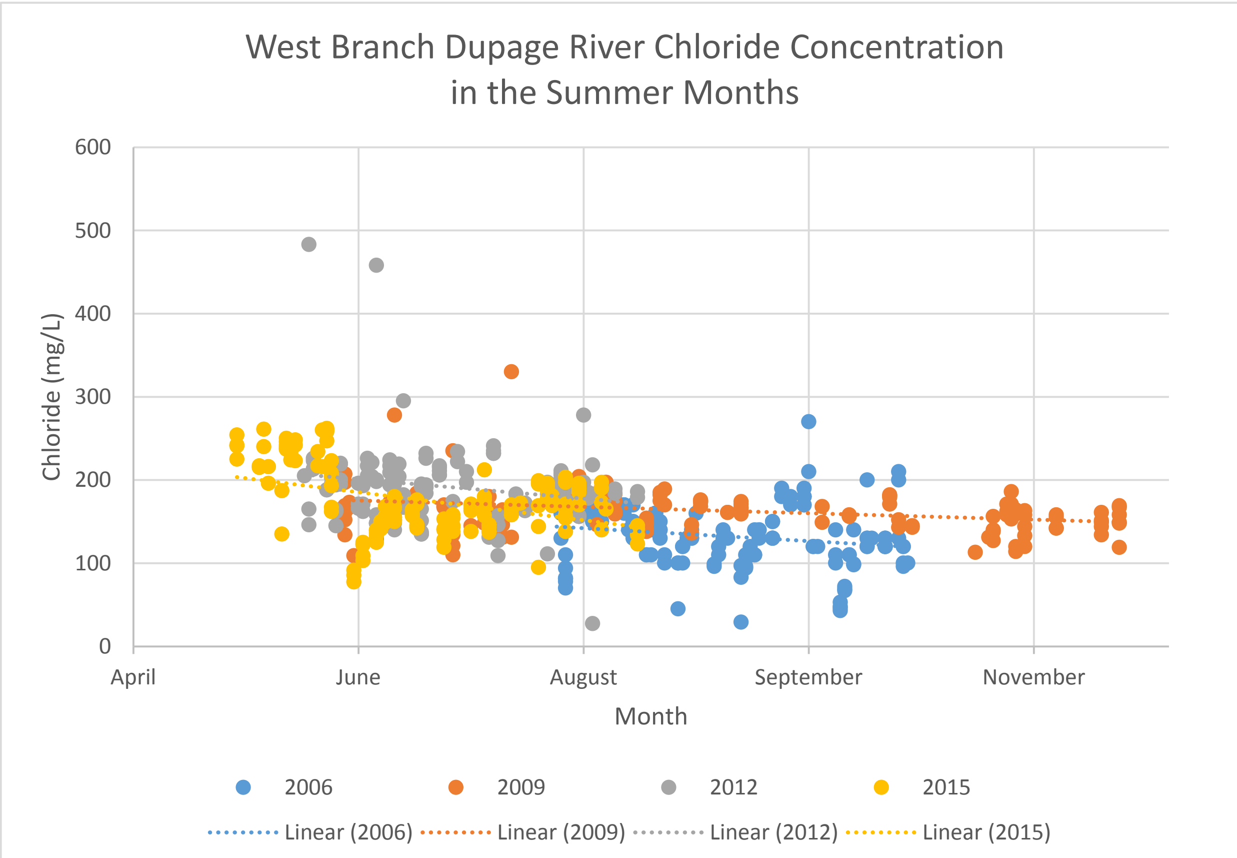

***Figure 15**. Chloride concentrations from the West Branch DuPage River during the summers of 2006, 2009, 2012, and 2015. Dotted lines are regressions through the data points for each year.*

only the most sensitive organisms. Probable effect levels (PEL) are those where toxicity is likely to be observed over a wide range of organisms. The 2015 sediment sampling essentially duplicated the 2012 and 2009 surveys.

As in 2012, several heavy metals were commonly above threshold effect levels (TEL) in 2015, but rarely exceeded probable effect levels (PEL). PEL exceedances were limited to manganese at Kress Creek RM 0.5 (WB03) and at a reference site in a different watershed. This pattern represented a reduction compared to 2012 when four West Branch sites exceed the PEL for copper, manganese, and silver. As in 2012 no clear spatial pattern to the detections was evident in terms of geographic location or stream size, other than being prevalent throughout the watershed.

Compared to 2012 mainstem results, exceedances of PEL thresholds for PAHs in 2015 were substantially lower (Table 12). Outside of WB31, located immediately upstream from the MCCD WWTP, none were detected in the mainstem between RM 31.6 and the mouth compared to 21 detections in 2012. In addition, no TEL exceedances were detected in the approximate 12-mile reach between the MCCD WWTP and Klein Creek (RM 31.6-19.2) and few were found in the remaining reach upstream from the Fawell Dam pool. To a somewhat lesser degree, the trend of fewer exceedances in 2015 was also noted in the tributary sites. The most

Table 10. *Urban parameter sampling results in the West Branch DuPage River watershed, summer 2015. Values above applicable reference targets are highlighted in yellow.*

Site ID	River Mile	Conductivity (µS/cm)		TDS (mg/L)		TSS (mg/L)		Chloride (mg/L)		TKN (mg/L)		T-Copper (µg/L)[3]		T-Lead (µg/L)[3]		T- Zinc (µg/L)[3]	
												Median					
		Median	Target[2]	Median	Target[2]	Median	Target[2]	Median	Target[1]	Median	Target[1]	2012	2015	2012	2015	2012	2015
West Branch DuPage River																	
WB25	34.0	1019	600	681	468	30.2	16	189	112	1.82	1.0	-	-	-	0.04	-	-
WB31	31.9	904	600	589	468	13.15	16	171	112	1.08	1.0	2.42	3.31	0.63	0.87	9.12	10.85
WB31 Dup	31.9	740	600	418	468	10.7	16	167	112	1.54	1.0	-	-	-	-	-	
WB24	31.6	1023.5	600	654	468	4.2	16	149	112	0.9	1.0	7.04	5.54	0.29	0.37	38.7	35.5
WB32	29.3	970	600	583	468	34.75	16	157	112	1.5	1.0	-	3.31	-	0.87	-	-
WB27	27.7	988	600	581	468	22.4	16	161.5	112	1.36	1.0	5.12	4.44	1.32	0.86	34	22.2
WB28	27.4	1060	600	659	468	20.2	16	186.5	112	0.71	1.0	6.88	5.95	1.17	0.82	35.4	25.3
WB20	25.6	1030	600	622	468	33.85	16	174.5	112	1.17	1.0	4.92	4.09	0.83	1.44	30.25	25.5
WB20 Dup	25.6	902	600	564	468	43.5	16	144	112	1.12	1.0	-	-	-	-	-	-
WB39	21.7	1071.5	610	598	522	15.75	25	172.5	112	0.95	1.0	4.79	3.37	0.53	0.75	24.6	16.05
WB33	21.3	924	610	584	522	25.8	25	148.5	112	1.12	1.0	4.08	3.77	0.64	0.71	19.7	19.75
WB17	19.2	904	610	542	522	25.2	25	139	112	1.07	1.0	72.4	3.49	0.95	0.83	24.3	12.75
WB38	16.0	952	610	553	522	25.4	25	156.5	112	0.82	1.0	7.12	4.31	0.52	1.01	23	15.7
WB38 Dup	16.0	1098	610	631	522	20.9	25	165.5	112	0.66	1.0	-	-	-	-	-	-
WB34	15.1	1126.5	610	627	522	25.15	25	184	112	0.99	1.0	6.27	5.85	0.50	0.87	19.5	16.8
WB12	13.6	1077.5	610	610	522	20.45	25	182.5	112	0.99	1.0	5.84	5.18	0.70	0.87	17.25	17
WB12 Dup	13.6	962.5	610	532	522	12.3	25	139.5	112	0.58	1.0	-	-	-	0.02	-	-
WB40	11.1	1034	610	614	522	24.6	255	171	112	0.96	1.0	5.42	4.58	0.71	0.76	15.7	16.2
WB36	8.3	1084.5	610	620	522	19.4	25	168.5	112	0.96	1.0	11	5.83	3.95	1.55	26	21.9
WB41	8.0	1043.5	610	549	522	28	25	161	112	0.8	1.0	6.88	4.71	0.82	1.1	14.25	15.6
WB37	6.3	1017.5	610	550	522	20.2	25	165	112	0.84	1.0	5.04	4.11	0.40	0.90	10.8	13.45
WB35	4.2	1052.5	610	571	522	24.1	25	169	112	0.93	1.0	4.58	4.56	0.78	1.02	12.3	14.25
WB08	0.85	1066	610	580	522	15.4	25	170	112	0.63	1.0	4.72	3.69	0.49	0.96	14.4	11.5
WB08 Dup	0.85	1063	610	562	522	15.6	25	168	112	0.25	1.0	-	-	-	-	-	-
Trib. to W. Br. DuPage River (RM 20.85)																	
WB18	0.3	927.5	610	517	468	12.4	16	150	112	0.81	1.0	-	3.49	0.83	0.83	-	-
Trib. (RM 1.65) to Trib. to W. Br. DuPage River (RM 25.5)																	
WB22	0.15	812	600	418	468	18.4	16	102.3	112	0.81	1.0	-	-	-	-	-	-

Site ID	River Mile	Conductivity (µS/cm)		TDS (mg/L)		TSS (mg/L)		Chloride (mg/L)		TKN (mg/L)		T-Copper (µg/L)[3]		T-Lead (µg/L)[3]		T- Zinc (µg/L)[3]	
												Median					
		Median	Target[2]	Median	Target[2]	Median	Target[2]	Median	Target[1]	Median	Target[1]	2012	2015	2012	2015	2012	2015
Trib. to W. Br. DuPage River (RM 29.25)																	
WB23	0.15	1053	600	604	468	16.3	16	150	112	1.03	1.0	-	-	-	-	-	-
Trib. to W. Br. DuPage River (RM 25.5)																	
WB29	2.2	1042	600	623	468	11	16	191	112	0.84	1.0	4.23	2.1	2.01	0.38	16.3	8.9
WB30	1.9	1006.5	600	604	468	11.4	16	202	112	0.8	1.0	1.17	2.4	0.34	0.49	7.82	10
WB21	0.9	1076	600	628	468	8.8	16	143	112	0.85	1.0	1.66	-	0.28	-	3.26	-
Kress Creek																	
WB02	5.1	1087	600	656	468	4.8	16	173	112	0.74	1.0	1.91	0.50	0.86	0.26	6.48	6.24
WB01	2.7	833.5	600	458	468	19.9	16	123.5	112	0.52	1.0	0.82	2.75	0.21	0.69	1.5	2.5
WB03	0.5	881.5	600	460	468	20	16	135	112	0.86	1.0	1.44	2.35	0.56	1.04	4.63	8.98
Ferry Creek																	
WB04	2.8	636.5	600	318	468	28.7	16	55	112	1.65	1.0	-	-	-	-	-	-
WB06	0.7	778.5	600	434	468	19.75	16	113.8	112	1.01	1.0	4.25	1.80	0.66	0.88	12.54	13.2
W. Br. Ferry Creek																	
WB05	0.25	905.5	600	514	468	26.15	16	172.5	112	1.41	1.0	-	-	-	-	-	-
Cress Creek																	
WB07	0.2	951.5	600	534	468	13.4	16	235	112	0.87	1.0	-	-	-	-	-	-
Bremme Creek																	
WB09	0.25	969.5	600	684	468	8	16	112.5	112	0.25	1.0	-	3.69	0.96	0.96	-	-
Spring Brook																	
WB11	3.3	1020	600	633	468	16.9	16	179	112	0.87	1.0	3.23	2.64	1.36	0.65	9.86	8.65
WB26	3	1126.5	600	679	468	3.4	16	181.5	112	0.25	1.0	5.6	4.14	0.18	0.38	35.4	20.8
WB10	0.75	1213.5	600	716	468	16	16	186	112	0.91	1.0	12.15	4.43	3.8	1.22	42.85	19.85
Winfield Creek																	
WB15	5.4	1250	600	692	468	8.2	16	252.5	112	0.88	1.0	1.87	1.76	0.86	0.54	5.52	2.5
WB15 Dup	5.4	1119	600	576	468	6.4	16	233	112	0.54	1.0	-	1.17	-	0.59	-	-
WB14	3.5	1083.5	600	638	468	12.8	16	203.5	112	1.21	1.0	-	1.95	-	1.51	-	-
WB13	0.4	1379.5	600	811	468	11.7	16	303.5	112	0.98	1.0	2.40	1.79	1.8	1.18	8.88	6.56
WB13 Dup	0.4	1016	600	620	468	15.6	16	215	112	0.71	1.0	-	1.95	1.51	1.51	-	-
Klein Creek																	
WB19	3.6	868	600	438	468	12.9	16	178	112	0.85	1.0	1.18	-	0.33	-	3.63	-

Site ID	River Mile	Conductivity (µS/cm)		TDS (mg/L)		TSS (mg/L)		Chloride (mg/L)		TKN (mg/L)		T-Copper (µg/L) [3]		T-Lead (µg/L) [3]		T- Zinc (µg/L) [3]	
												Median					
		Median	Target[2]	Median	Target[2]	Median	Target[2]	Median	Target[1]	Median	Target[1]	2012	2015	2012	2015	2012	2015
WB16	1	980.5	600	588	468	9.63	16	169	112	0.81	1.0	97.9	16.2	0.33	0.50	25.2	50.9
Otter Creek (Reference Site)																	
F-3	0.9	1175.5	610	656	463.5	11.8	25	171.5	112	0.91	1.0	-	2.94	-	0.52	-	7.39
Ferson Creek (Reference Sites)																	
F-2	7.6	1048.5	600	615	443	24	16	143	112	0.99	1.0	-	5.95	-	0.74	-	2.50
F-1	2.5	1143	610	622	463.5	6.5	25	169	112	0.72	1.0	-	1.69	-	0.25	-	7.32

[1]IPS thresholds (lowest) derived in the IPS study (total chloride)
[2]Median values above statewide reference levels (75^{th} percentiles) from similar Ohio waters (e.g., headwater, wadeable streams).
[3] Median values above statewide reference levels (75^{th} percentiles) from similar Ohio waters (Cu-5.0; Pb-2.5; Zn-15.0).
[a] Note: conductivity listings above are from field measurements during fish sampling.

pronounced reduction was at WB30, where no TEL exceedances were detected in 2015 compared to eight (8) compounds above the PEL and four (4) above the TEL in 2012. This, too, seems related to the differences in flows between 2012 and 2015, the former being much lower allowing pollutants to accumulate at higher concentrations than in 2015 when flows were higher. A common source of PAHs is the incomplete combustion of gasoline. There has been some recent work examining ratios of various PAH compounds (Yunker et al. 2002) to estimate sources of PAHs (e.g., distinguishing between vehicle emissions vs. wood sources and between combustion vs. petroleum), but detailing this would require further analysis. It is likely, given the high road density in the surrounding urban landscape, that sources are related to vehicle emissions and petroleum compounds in the West Branch. Another common source of PAHs are coal tar based sealants (USGS 2011). Coal tar is a byproduct of the carbonization of coal to produce coke. Coal tar sealants are used extensively in urban areas of the Midwest U.S. to protect and improve the aesthetic appearance of driving and parking surfaces. As the sealant erodes due to weathering and wear, it releases particles that enter waterways via runoff and atmospheric deposition.

Some authors have distinguished PAHs classified as low molecular weight (LMW) from high molecular weight (HMW) compounds with LMW compounds generally more toxic because of their high solubility in water (CCME 1999). In 2012, the three most common PAH compounds found above the PEL guidelines in the West Branch watershed were benzo(g,h,i)perylene, fluoranthene, and dibenzo(a,h)anthracene (Table 12) and all are all HMW compounds. In contrast, the frequency and concentration of these compounds in sediments were lower in 2015.

***Table 11**. Heavy metals detections in sediments from the West Br. DuPage River watershed and reference sites in 2015. Concentrations that exceeded threshold effects levels (TEL) in 2015 or probable effect levels (PEL) in 2015 and 2012 from McDonald et al. (2000) or Ontario Ministry of Environment (1993).*

Site ID	River Mile	Parameters Tested	Parameters Detected	Parameters >TEL Benchmark (Value, mg/kg) 2015	> PEL Benchmark (Value, mg/kg) 2015	> PEL Benchmark (Value, mg/kg) 2012
West Branch DuPage River						
WB25	34.0	11	11	Cu (44.50); Pb (51.30); Ni (23.20); Zn (199.00); Fe (25100.00)	--	--
WB31	31.9	11	11	Cu (41.20); Mn (637.00); Ni (25.60); Zn (200.00); Fe (28000.00)	--	--
WB24	31.6	11	11	Ni (24.40); Fe (27400.00)	--	--
WB32	30.1	11	11	--	--	--
WB27	28.7	11	11	Fe (25500.00)	--	--
WB28	27.4	11	11	Fe (38800.00)	--	--
WB20	25.6	11	11	Mn (477.00); Fe (26400.00)	--	--
WB33	21.3	11	11	Mn (614.00); Ni (24.30); Fe (23200.00)	--	--
WB17	19.2	11	11	Mn (805.00); Fe (22500.00)	--	--
WB38	16.0	11	11	Cu (35.00); Mn (711.00); Zn (122.00); Fe (22200.00)	--	--
WB34	15.1	11	11	Cu (45.60); Mn (680.00); Ni (25.30); Zn (142.00); Fe (23000.00)	--	Copper (111.00
WB12	13.6	11	11	Cu (32.40); Mn (550.00)	--	Manganese (2260.00)
WB40	11.1	11	11	Cu (39.00); Mn (752.00); Zn (126.00); Fe (20700.00)	--	--
WB36	8.3	11	11	Cu (44.20); Mn (568.00); Zn (132.00)	--	--
WB41	8.0	11	11	Cu (35.90); Mn (575.00); Fe (26300.00)	--	--
WB37	6.3	11	11	Cu (57.10); Mn (724.00); Zn (160.00); Fe (27500.00)		Copper (129.00)
WB08	0.85	11	11	Cu (46.60); Mn (648.00); Zn (136.00); Fe (22700.00)	--	--
Tributary to West Branch DuPage River						
WB30	1.9	11	11	Cu (36.80); Mn (544.00); Ni (27.70); Fe (28900.00)	--	--
Kress Creek						
WB01	2.7	11	11	Mn (644.00)	--	--
WB03	0.5	11	11	--	Mn (2030.00)	--
Spring Brook						
WB11	3.3	11	11	Cu (72.00); Pb (49.70); Zn (191.00)	--	Copper (212.00); Silver (4.34);

Site ID	River Mile	Parameters Tested	Parameters Detected	Parameters >TEL Benchmark (Value, mg/kg) 2015	> PEL Benchmark (Value, mg/kg) 2015	> PEL Benchmark (Value, mg/kg) 2012
WB26	3.0	11	11	Cu (53.80); Zn (138.00)		
Winfield Creek						
WB15	5.4	11	11	Cu (40.00); Pb (40.90); Mn (600.00); Ni (28.30); Zn (137.00); Fe (34600.00)	--	--
Ferson Creek (Reference Site)						
F2	7.6	11	11	Cu (80.30); Fe (31800.00)	Mn (1280.00)	--
F1	2.5	11	11	Mn (692.00)	--	--
Otter Creek (Reference Site)						
F3	0.9	11	11	Mn (913.00); Fe (36800.00)	--	--

***Table 12**. Polychlorinated biphenyls (PCBs), pesticides and polycyclic aromatic hydrocarbons (PAHs) concentrations in sediments from the West Br. DuPage River watershed and reference sites in that exceed threshold effects levels (TEL) in 2015 or probable effect levels (PEL) in 2015 and 2012 from McDonald et al. (2000) or Ontario Ministry of Environment (1993).*

Site ID	River Mile	Parameters Test	Parameters Detect	Parameters > TEL Benchmark (Value, mg/kg) 2015	Parameters > PEL Benchmark (Value, mg/kg) 2015	Parameters > PEL Benchmark (Value, mg/kg) 2012
West Branch DuPage River						
WB25	34.0	61	5	Benzo(b)fluoranthene (386.00); Benzo(a)pyrene (301.00); Chrysene (344.00); Fluoranthene (648.00); Pyrene (464.00)	--	Fluoranthene (2700.00); Benzo(g,h,i)perylene (609.00)
WB31	31.9	61	10	Benzo(b)fluoranthene (2340.00); Benzo(k)fluoranthene (814.00); Indeno(1,2,3-cd)pyrene (951.00); Benz(a)anthracene (1020.00)	Benzo(a)pyrene (1600.00); Chrysene (1920.00); Fluoranthene (3890.00); Phenanthrene (1210.00); Pyrene (2990.00)	--
WB24	31.6	61	1	--	--	Fluoranthene (3290.00); Benzo(g,h,i)perylene (697.00)
WB32	30.1	61	0	--	--	Fluoranthene (2970.00); Benzo(g,h,i)perylene (613.00)
WB27	28.7	61	0	--	--	Fluoranthene (2350.00); Dibenzo(a,h)anthracene (196.00)
WB28	27.4	61	0	--	--	Benzo(g,h,i)perylene (867.00)
WB20	25.6	61	0	--	--	--
WB33	21.3	61	6	--	--	Benzo(g,h,i)perylene (320.00)
WB17	19.2	61	3	--	--	Benzo(g,h,i)perylene (325.00)

Site ID	River Mile	Parameters Test	Parameters Detect	Parameters > TEL Benchmark (Value, mg/kg) 2015	Parameters > PEL Benchmark (Value, mg/kg) 2015	Parameters > PEL Benchmark (Value, mg/kg) 2012
WB38	16	61	5	Benzo(a)pyrene (157.00)	--	Fluoranthene (4410.00); Pyrene (3480.00); Dibenzo(a,h)anthracene (509.00)
WB34	15.1	61	7	Benzo(a)pyrene (178.00); Chrysene (174.00); Pyrene (227.00)	--	Fluoranthene (2510.00); Dibenzo(a,h)anthracene (213.00); Potassium (4760.00)
WB12	13.6	61	7	Pyrene (213.00)	--	Benzo(g,h,i)perylene (475.00)
WB40	11.1	61	7	Benzo(a)pyrene (155.00); Pyrene (197.00)	--	Fluoranthene (2700.00); Benzo(g,h,i)perylene (609.00)
WB36	8.3	61	7	Benzo(b)fluoranthene (291.00); Benzo(a)pyrene (212.00); Chrysene (213.00); Indeno(1,2,3-cd)pyrene (208.00); Pyrene (299.00)	--	Not Sampled
WB41	8.0	61	9	Benzo(b)fluoranthene (271.00); Chrysene (191.00); Pyrene (265.00)	--	Benzo(g,h,i)perylene (435.00)
WB37	6.3	61	10	Benzo(b)fluoranthene (988.00); Benzo(k)fluoranthene (329.00); Benzo(a)pyrene (513.00); Chrysene (692.00); Fluoranthene (1190.00); Indeno(1,2,3-cd)pyrene (511.00); Phenanthrene (353.00); Pyrene (926.00); Benz(a)anthracene (349.00)	--	Fluoranthene (2650.00)
WB08	0.85	61	9	Benzo(b)fluoranthene (367.00); Benzo(a)pyrene (184.00); Chrysene (249.00); Fluoranthene (434.00); Pyrene (354.00); Benz(a)anthracene (137.00)	--	Benzo(g,h,i)perylene (768.00)
Tributary to West Branch DuPage River						
WB30	1.9	61	6	--	--	Benzo(a)pyrene (3860.00); Chrysene (4270.00); Fluoranthene (8470.00); Phenanthrene (2350.00); Pyrene (6040.00); Benzo(g,h,i)perylene (2240.00); Benzo(a)anthracene (2250.00); Dibenzo(a,h)anthracene (491.00)
Kress Creek						
WB01	2.7	61	0	--	--	Benzo(g,h,i)perylene (391.00)
WB03	0.5	61	11	Benzo(b)fluoranthene (575.00); Benzo(a)pyrene (337.00); Chrysene (405.00); Fluoranthene (774.00); Indeno(1,2,3-cd)pyrene (334.00); Pyrene (548.00); Benz(a)anthracene (186.00)	Dibenzo(a,h)anthracene (160.00)	Fluoranthene (2810.00); Pyrene (2400.00); Dibenzo(a,h)anthracene (277.00)
Spring Brook						
WB11	3.3	24	11	Benzo(b)fluoranthene (2170.00); Benzo(k)fluoranthene (668.00); Benzo(a)pyrene (1140.00); Indeno(1,2,3-cd)pyrene (1120.00); Phenanthrene (742.00); Benz(a)anthracene (740.00)	Chrysene (1460.00); Fluoranthene (2550.00); Pyrene (1980.00); Dibenzo(a,h)anthracene (259.00)	Benzo(a)pyrene (3710.00); Chrysene (3670.00); Fluoranthene (6940.00); Pyrene (4480.00); Benzo(g,h,i)perylene (2870.00); Benzo(a)anthracene (2150.00); Dibenzo(a,h)anthracene (629.00)
WB26	3	24	10	Benzo(b)fluoranthene (394.00); Benzo(a)pyrene (211.00); Chrysene (285.00); Fluoranthene (551.00); Indeno(1,2,3-	--	Fluoranthene (2530.00); Dibenzo(a,h)anthracene (250.00)

Site ID	River Mile	Parameters		Parameters > TEL Benchmark (Value, mg/kg) 2015	Parameters > PEL Benchmark (Value, mg/kg) 2015	Parameters > PEL Benchmark (Value, mg/kg) 2012
		Test	Detect			
				cd)pyrene (203.00); Pyrene (415.00); Benz(a)anthracene (155.00)		
Winfield Creek						
WB15	5.4	24	7	Pyrene (203.00)		Dibenzo(a,h)anthracene (199.00)
Ferson Creek (Reference Site)						
F2	7.6	61	0	--	--	--
F1	2.5	61	0	--	--	--
Otter Creek (Reference Site)						
F3	0.9	61	0	--	--	--

West Branch DuPage River Watershed Physical Habitat for Aquatic Life

Qualitative Habitat Evaluation Index (QHEI) scores were calculated at each fish collection site in the West Branch watershed. Scores and their associated narrative ratings are displayed in Figure 16).

West Branch DuPage River Mainstem

Mainstem habitat quality measured in 2015 was very similar to 2012. With few exceptions, QHEI scores were good to excellent throughout most of its length and clearly adequate to support warmwater assemblages (Table 13). Impaired habitats were located in the extreme headwaters (upstream RM 30.1) and Fawell Dam pool (RM 8.3). In contrast to the free-flowing reaches, the Fawell Dam impoundment (WB36) was characterized by fine depositional substrates of muck and silt with dense beds of aquatic macrophytes. The QHEI of 45 dipped to the poor range in the impoundment zone.

The most significant change since 2012 was the quality of the former Warrensville Dam pool at WB42 (RM 11.6). Initial improvements in 2012 immediately following dam removal continued in 2015 as the QHEI increased by 15 points from “good” (69.5) to “excellent” (84.5). An increase of similar magnitude was also noted at WB35 (Pioneer Park) where the QHEI jumped 20 points (from 63 to 83) between 2012 and 2015. In this instance, the difference in scores appears more related to differences in flow; higher flows in 2015 provided access to a strong riffle/run complex that was not readily available under very low flow conditions in 2012.

***Plate No. 8**. Extensive riparian removal and bank erosion (upper photo) and subsequent sediment deposition along the opposite bank (lower photo) at West Branch site WB35.*

Despite the excellent QHEI score at WB35, habitat quality at the upper end of the zone has been declining in recent surveys due to riparian removal and bank erosion (Plate No. 8 - upper photo). First observed in 2012, manicured grass lawns now extend to the very edge of river and over the years, an estimated 12 feet of the destabilized bank has been eroded and lost. River margins in the vicinity have become heavily silted and shallow, reducing the quality of in-stream habitats and associated fish populations (Plate No. 8 - lower photo).

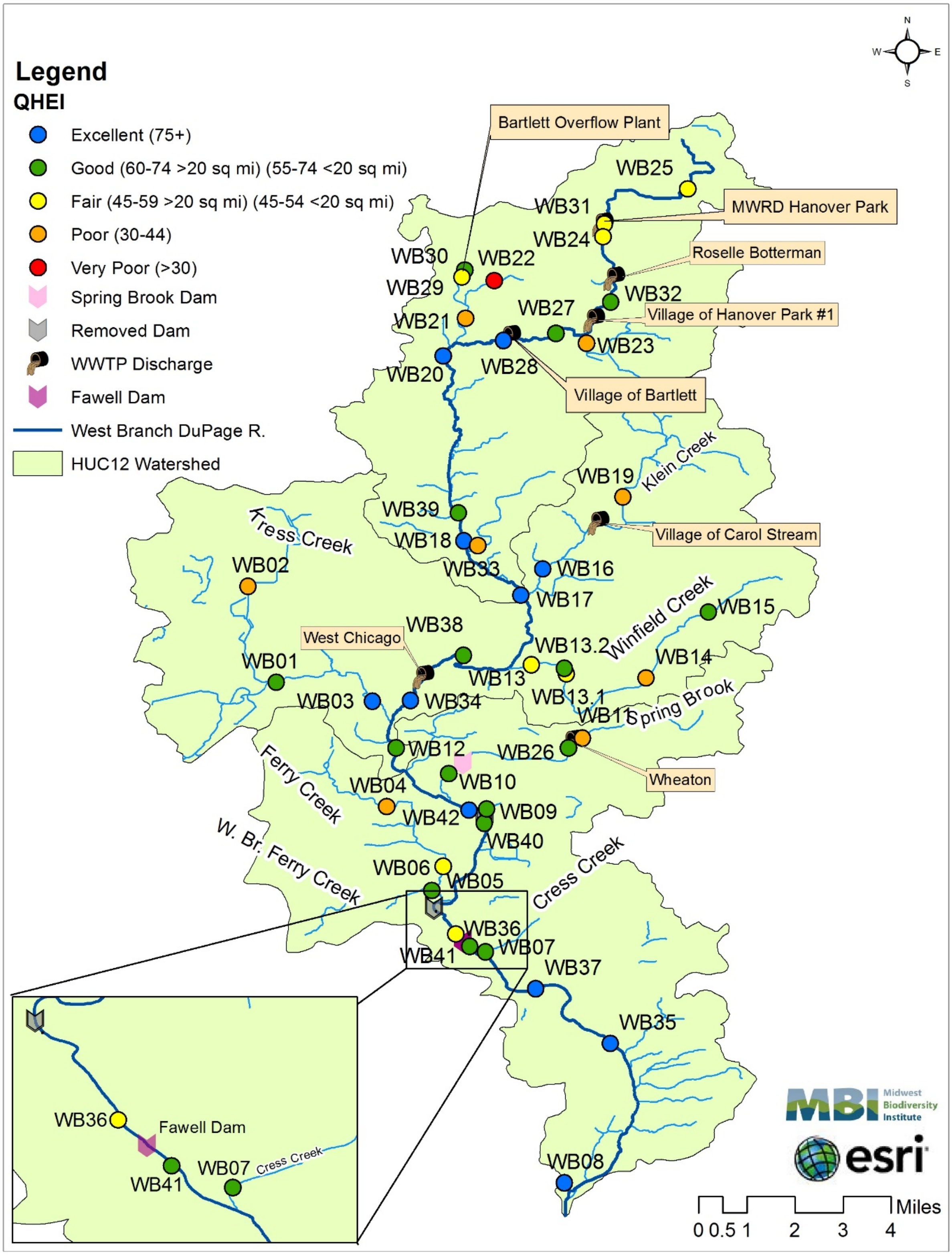

***Figure 16**. West Branch DuPage River watershed QHEI scores in 2015 mapped by narrative range. Chevron symbols denote dams while discharge pipes denote WWTP locations.*

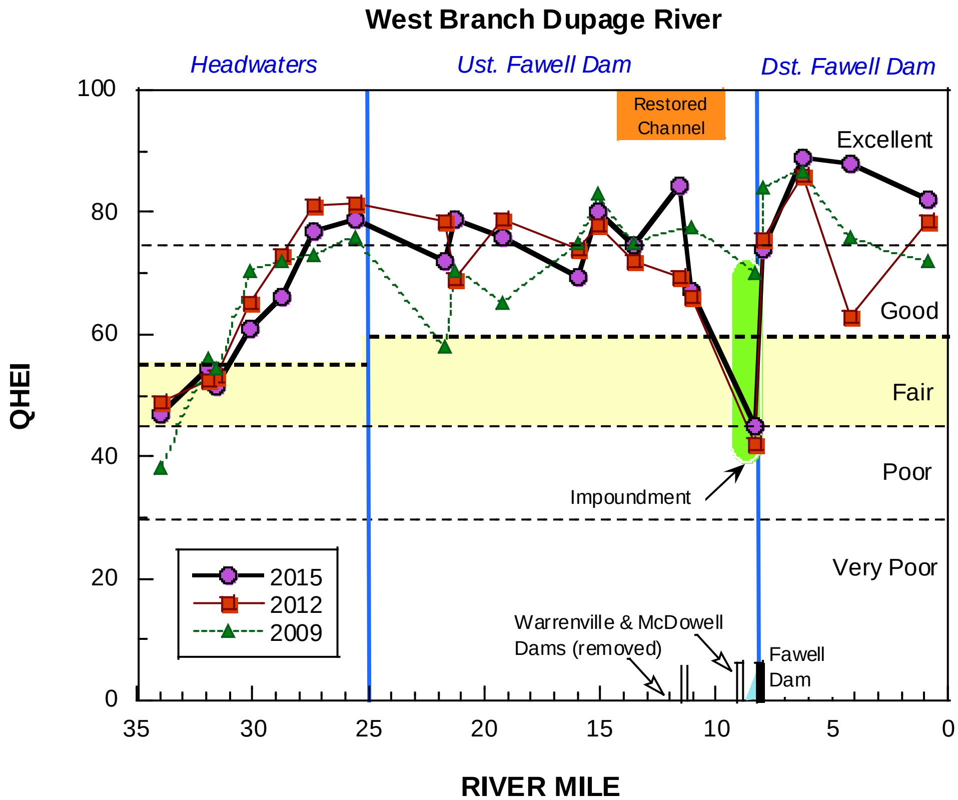

Figure 17. *Longitudinal trends in Qualitative Habitat Evaluation Index (QHEI) scores from the West Branch DuPage River mainstem in 2009, 2012 and 2015. For display and data analysis purposes, the mainstem was subdivided into three sections: 1) headwaters 2) upstream Fawell Dam and 3) downstream Fawell Dam. The tan shaded region depicts fair range scores where habitat quality is limiting to aquatic life. QHEI scores less than 45 are typical of highly modified channels or dam pools.*

West Branch DuPage River Tributaries

Since 2006, median QHEI scores in West Branch Tributaries generally fell in the fair or upper fair quality ranges but had seen gradual increases from 2006-12 (Figure 18). This trend was somewhat reversed in 2015 as median scores dropped back near 2006 levels. For the most part, the modest shift in scores in 2015 was not considered indicative of dramatic decline in quality. Rather, the largest shifts were associated with temporary construction projects, localized channel straightening or “dipping”, and impoundments related to beaver dam construction. Sites with beaver dams tend to have more erratic scoring from year to year (or consistently low scores), as the structures tended to effect substrate quality, silt deposition levels, and channel morphology. QHEIs at four sites with beaver activity averaged about 11 points lower in 2015 than in previous surveys. In addition, three sites with adjacent construction or channel modifications experienced an average 15-point decline. All these activities were considered largely temporary or, in the case of beaver, a natural shift in channel characteristics. They were not considered indicative of major declines in quality at the broad, watershed level.

Tributary sites that experienced significant changes in QHEIs in 2015 are discussed in more detail below:

1) WB02 - Kress Creek (95-910) adj. Kress Rd. (RM 5.1). A 15.5-point drop in scores between 2012 and 2015 was attributed to new beaver dam construction and subsequent impoundment in 2015.

2) WB04 - (Ferry Creek RM 2.8) dropped from fair (QHEI = 48.5) to poor (QHEI = 30.5) between 2009 and 2012 after the stream channel had been “dipped” or cleared of vegetation. In 2015, the QHEI indicated partial recovery as the score improved by 10 points. The increase was largely due to improved substrate scores and much lower levels of siltation.

3) WB05 – West Branch Ferry Creek (95-925) at Naperville McDowell Grove FP (RM 0.25). While maintaining “good” habitat quality, QHEI scores since 2009 have gradually declined from a high of 72 in 2009 to a low of 55 in 2015. The stream flows through a “forest/swamp” flood plain in the Naperville McDowell Grove Park and has been subject to beaver dam impoundment and construction activity in recent years. Reductions in substrate variability and increasing predominance of silt and muck substrates have characterized this largely “natural” shift in scoring.

4) WB14 - Winfield Creek (95-960) dst. Wheaton Rd. (RM 3.5). This channelized stream reach has consistently reflected marginal habitat quality since 2006 (mean = 49.8) but experienced an additional 23 point decline in 2015. The drop was almost entirely attributed to finer, less diverse substrates and loss of cover although trash and artificial substrates (introduced concrete, bricks, etc.) were partially responsible for the higher 2006/12 scores. Results suggest the channel may have been snagged or cleaned out at some point between the 2012 and 2015 surveys.

5) WB19 – Klein Creek (95-970) at Armstrong Park (RM 3.6). Despite historic channelization, QHEI scores from 2006-2012 fell consistently in the upper fair range (mean 53.8), just below the good quality benchmark of 55. A sharp decline to the lower poor range (32.8) in 2015 coincided with major construction activity immediately upstream of the site. There was an increase in High Influence Modified Attributes (3 in 2012 and 5 in 2015) with increases in silt muck substrate and a decrease in cover accounting for the decline in QHEI score. These changes indicate an increase in sediment runoff and deposition affecting the substrate at this site in and prior to 2015.

6) WB21 – Unnamed Tributary to the West Branch DuPage R. (95-906) at Sterns Rd. (RM 0.9). Erratic habitat scores ranging from 64.8 in 2009 to 40.5 in 2015 appear related to substrate and habitat variability in an area of beaver dam construction, particularly since 2012.

7) WB23 - Unnamed Tributary to the West Branch DuPage R. (95-905) Dst. Schick Rd, Mallard Lake FP (RM 0.15). QHEI scores at WB23 have remained consistently in the fair/poor range since 2006 but the site is mentioned because the area has been affected by beaver dam construction for at least the past two surveys.

8) WB29 - Unnamed Tributary to the West Branch DuPage R. (95-906) at Devon Ave. (RM 2.2). A roughly 20 point increase in scoring (from fair to good) between 2009 and 2012-15 appears primarily related to a change in flow conditions from “impounded” to free-flowing. The reason for impoundment was not indicated but it may have been related to beaver dam construction.

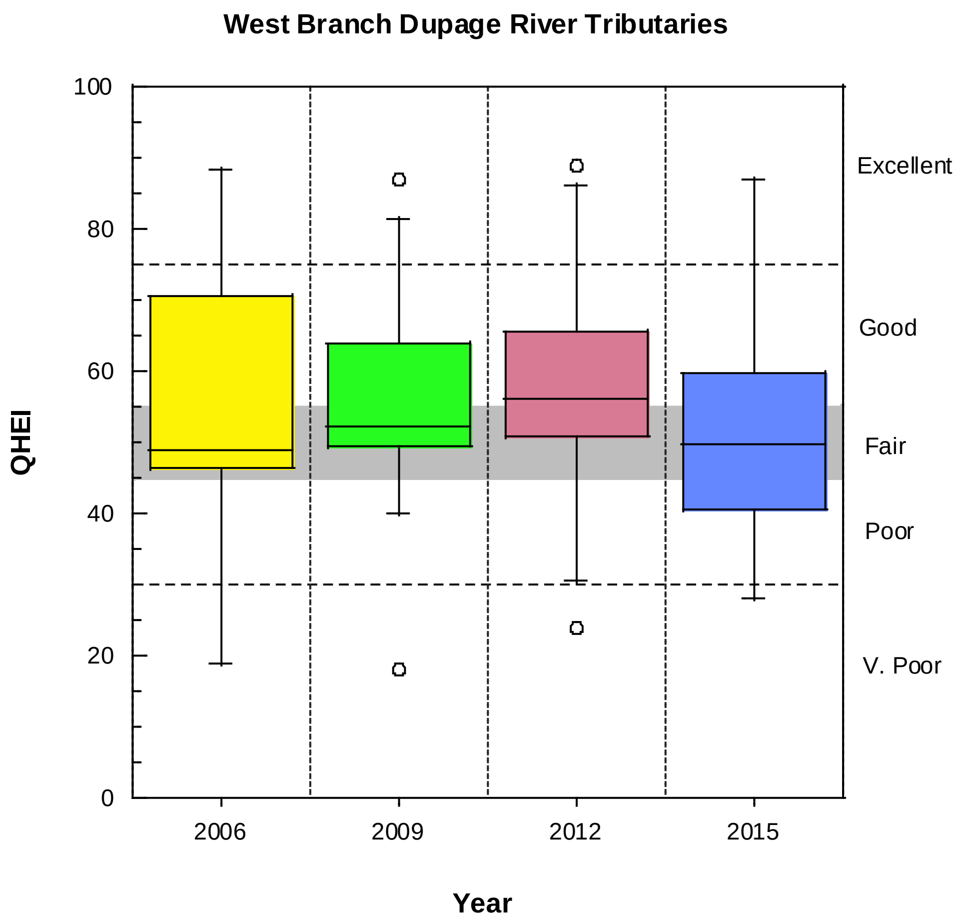

Figure 18. *Distributions of QHEI scores in West Branch Tributaries in 2006, 2009, 2012 and 2015.*

***Table 13**. Qualitative Habitat Evaluation Index (QHEI) scores showing Good and Modified Habitat attributes at sites in the West Branch DuPage River watershed and at reference sites sampled in 2015 (■ - good habitat attribute; ● - high influence modified attribute; ● - moderate influence modified attribute). Modified to good attribute ratios ≥2.0 are yellow, orange, or red highlighted in accordance with the predominance of modified attributes.*

			Good Habitat Attributes											High Influence Modified Attributes						Moderate Influence Modified Attributes													Ratios	
Site ID	River Mile	QHEI	No Channelization	Boulder, Cobble, Gravel	Silt Free	Good-Excellent Development	Moderate-High Sinuosity	Moderate-Extensive Cover	Fast Flow w Eddies	Little to No Embeddedness	Max Depth > 40 cm	No Riffle Embeddedness	"Good" Habitat Attributes	Channelized or No Recovery	Silt/Muck Substrates	No Sinuosity	Sparse No Cover	Max Depths <40 cm	High Influence Poor Attributes	Recovering from Channelization	Mod-High Silt Cover	Sand Substrates (Boatable sites)	Hardpan Origin	Fair- Poor Development	Low Sinuosity	≤ 2 Cover Types	Intermittent Flow or Pools <20 cm	No Fast Current Types	Mod-Extensive Embeddedness	Mod-Extensive Riffle Embeddedness	No Riffle	Poor Habitat Attributes	Ratio of Poor (High) to Good	Ratio of Poor (All) to Good
West Branch DuPage River																																		
WB25	34	47.0		■				■					2		●			●	2	●	●			●	●			●	●	●		7	1.00	4.50
WB31	31.9	54.5		■				■	■		■		4	●		●			2		●			●					●		●	4	0.50	1.50
WB24	31.6	51.5		■				■			■	■	4	●					1		●			●	●			●	●			5	0.25	1.50
WB32	30.1	61.0		■				■	■		■		4	●		●			2		●			●					●		●	4	0.50	1.50
WB27	27.8	66.0	■	■				■	■		■		5						0					●	●				●	●		4	1.20	0.83
WB28	27.4	77.0	■	■		■	■	■	■		■		7						0		●								●	●		3	0.00	0.43
WB20	25.6	79.0	■			■	■	■	■		■	■	7						0		●							●	●			3	0.00	0.43
WB39	21.7	72.0	■	■		■	■	■	■		■	■	8						0		●							●	●	●		4	0.00	0.50
WB33	21.3	79.0	■	■		■	■	■	■		■		7						0									●	●	●		3	2.00	0.50
WB17	19.2	76.0	■	■			■	■	■		■		6						0		●			●				●	●	●		5	0.00	0.86
WB38	16.0	69.3	■				■	■	■		■		5						0					●				●	●	●		4	0.00	0.80
WB34	15.1	80.0	■	■		■	■	■	■	■	■	■	9						0		●							●				2	0.00	0.22
WB12	13.6	74.5	■	■		■		■	■	■	■	■	8						0						●				●			2	0.00	0.25
WB40	11.7	67.0		■				■	■	■	■		5						0	●				●	●					●		4	0.00	0.80
WB42	11.6	84.3	■	■		■	■	■	■	■	■	■	9						0		●											1	0.00	0.11
WB40	11.1	67.0		■				■	■	■	■		5						0	●				●	●					●		4	0.00	0.80

			Good Habitat Attributes											High Influence Modified Attributes						Moderate Influence Modified Attributes													Ratios	
Site ID	River Mile	QHEI	No Channelization	Boulder, Cobble, Gravel	Silt Free	Good-Excellent Development	Moderate-High Sinuosity	Moderate-Extensive Cover	Fast Flow w Eddies	Little to No Embeddedness	Max Depth > 40 cm	No Riffle Embeddedness	"Good" Habitat Attributes	Channelized or No Recovery	Silt/Muck Substrates	No Sinuosity	Sparse No Cover	Max Depths <40 cm	High Influence Poor Attributes	Recovering from Channelization	Mod-High Silt Cover	Sand Substrates (Boatable sites)	Hardpan Origin	Fair- Poor Development	Low Sinuosity	≤ 2 Cover Types	Intermittent Flow or Pools <20 cm	No Fast Current Types	Mod-Extensive Embeddedness	Mod-Extensive Riffle Embeddedness	No Riffle	Poor Habitat Attributes	Ratio of Poor (High) to Good	Ratio of Poor (All) to Good
WB36	8.3	45.0						■			■		2		●		●		2		●			●	●			●	●		●	6	1.00	4.00
WB41	8.0	74.0		■				■	■	■	■	■	6	●		●			2		●			●								2	0.33	0.67
WB37	6.3	89.0	■	■		■	■	■	■	■	■	■	9						0													0	0.00	0.00
WB35	4.2	87.8	■	■		■	■	■	■	■	■	■	9						0													0	0.00	0.00
WB08	0.85	82.0	■	■		■		■	■	■	■	■	8						0						●			●				2	0.00	0.33
Trib. to W. Br. DuPage River (RM20.85)																																		
WB18	0.5	43.0						■					1		●		●	●	3	●	●			●	●			●	●	●		7	3.00	10.0
Trib. (RM 1.65) to Trib. to W. Br. DuPage River (RM 25.5)																																		
WB22	0.15	28.0						■					1	●	●	●		●	4		●			●				●	●	●		5	4.00	9.00
Trib. to W. Br. DuPage River (RM 29.25)																																		
WB23	0.15	40.0						■			■		2	●	●	●			3		●			●				●	●		●	5	1.50	4.00
Trib. to W. Br. DuPage River (RM 25.5)																																		
WB29	2.2	58.5		■		■		■		■			4			●		●	2	●					●			●		●		4	0.50	1.50
WB30	1.9	48.0		■				■					2					●	1	●	●			●	●			●	●	●		7	0.50	4.00
WB21	0.9	40.5						■			■		2		●				1		●		●	●	●			●	●		●	7	0.50	4.00
Kress Creek																																		
WB02	5.1	36.5						■			■		2		●	●			2		●			●				●	●		●	5	1.00	3.50
WB01	2.7	63.5		■		■		■		■	■		5						0	●			●		●			●		●		5	0.00	1.00
WB03	0.5	87.0	■	■		■	■	■	■	■	■	■	9						0													0	0.00	0.00
Ferry Creek																																		
WB04	2.8	40.5		■									1	●		●	●	●	4		●			●				●	●	●		5	4.00	9.00
WB06	0.7	49.5		■				■					2			●	●	●	3	●	●			●				●	●	●		6	1.50	4.50

			Good Habitat Attributes											High Influence Modified Attributes						Moderate Influence Modified Attributes													Ratios	
Site ID	River Mile	QHEI	No Channelization	Boulder, Cobble, Gravel	Silt Free	Good-Excellent Development	Moderate-High Sinuosity	Moderate-Extensive Cover	Fast Flow w Eddies	Little to No Embeddedness	Max Depth > 40 cm	No Riffle Embeddedness	"Good" Habitat Attributes	Channelized or No Recovery	Silt/Muck Substrates	No Sinuosity	Sparse No Cover	Max Depths <40 cm	High Influence Poor Attributes	Recovering from Channelization	Mod-High Silt Cover	Sand Substrates (Boatable sites)	Hardpan Origin	Fair- Poor Development	Low Sinuosity	≤ 2 Cover Types	Intermittent Flow or Pools <20 cm	No Fast Current Types	Mod-Extensive Embeddedness	Mod-Extensive Riffle Embeddedness	No Riffle	Poor Habitat Attributes	Ratio of Poor (High) to Good	Ratio of Poor (All) to Good
West Branch Ferry Creek																																		
WB05	0.25	55.0	■			■	■	■					4		●			●	2		●							●	●	●		4	0.50	1.50
Cress Creek																																		
WB07	0.20	65.0		■		■		■	■		■		5			●			1	●	●								●	●		4	0.20	1.00
Bremme Creek																																		
WB09	0.25	55.0	■				■	■					3		●			●	2		●			●				●	●	●		5	0.67	2.50
Spring Brook																																		
WB11	3.3	43.0		■				■			■		3	●	●	●			3		●			●				●	●		●	5	1.00	2.67
WB26	3	61.0		■				■	■		■	■	5	●		●	●		3					●					●			2	0.60	1.00
WB10	0.75	64.5		■				■	■		■		4						0	●	●			●	●			●	●	●		7	0.00	1.75
Winfield Creek																																		
WB15	5.4	58.0		■		■	■	■		■			5	●			●	●	3	●	●							●		●		4	0.80	1.40
WB14	3.5	30.0											0	●	●	●	●	●	5		●			●		●		●	●	●		6	10.0	11.0
WB13.2	1.0	49.5		■				■			■		3				●		1	●	●			●	●			●	●	●		7	0.33	2.67
WB13.1	0.9	56.0	■	■		■	■	■					5					●	1		●							●	●	●		4	0.25	1.00
WB13	0.4	50.0		■		■					■		3	●			●		2		●				●			●	●	●		5	0.67	2.33
Klein Creek																																		
WB19	3.6	32.8											0	●	●	●	●	●	5					●				●	●	●		4	10.0	9.00
WB16	1	87.0	■	■		■	■	■	■	■	■	■	9						0													0	0.00	0.00
Ferson Creek (Reference Site)																																		
F-2	7.6	70.8		■		■		■		■	■		5						0	●	●				●			●		●		5	0.00	1.00
F-1	2.5	89.5	■	■		■	■	■	■	■	■	■	9						0													0	0.00	0.00

West Branch DuPage River Watershed Biological Assemblages – Macroinvertebrates

Macroinvertebrates were collected from 44 mainstem and Tributary sites in 2015. The 2015 survey included re-sampling of 41 2012 survey sites and additional samples from WB30, immediately downstream from the Bartlett WWTP overflow plant, and two Winfield Creek sites at RMs 1.0 and 0.9 that bracketed a DuPage County salt storage facility. depicts associated mIBI narrative evaluations for each location. As a rule, Tributary and upper mainstem sites were in the poor to fair ranges while middle and lower mainstem sites vacillated between the fair and good ranges.

Mainstem macroinvertebrate performance remains somewhat erratic but improved in 2015 compared to 2012, particularly in the lower 16 river miles from above the West Chicago WWTP to the mouth. The improving trend was considered primarily related to higher base flows in 2015 compared to the very low flow conditions in 2012 and subsequently higher levels of nutrients and depressed dissolved oxygen levels in the effluent dominated reach. Under above normal flow conditions, 2015 results rebounded to near 2009 levels and reflected a lessening of the low-flow stresses. During each surveys, the upper reaches of the mainstem were of poorest quality and remain consistently degraded.

West Branch DuPage River Mainstem

West Branch macroinvertebrate assemblages in 2015 followed a roughly similar pattern to previous surveys in 2009 and 2012. Collections from the upper, headwater reach (*i.e.,* upstream RM 25) were most severely degraded but mIBI scores gradually improved with increased distance downstream (Figure 20). The combination urban drainage, marginal habitat quality and a series of four major WWTP discharges in the headwater reach were considered major contributors. In addition, chemical sampling revealed occasional high levels of NH_3-N (2012) and BOD_5 (2015) at the uppermost site (WB25) from an unknown source(s) that may contribute to the impairments.

Throughout the remainder of the mainstem, most mIBI scores reflected improvement over 2012 levels and, with few exceptions, mirrored 2009 trends. Macroinvertebrate performance was essentially “good” through the lower 16 river miles, from just upstream from the West Chicago WWTP to the mouth. The index dipped into the fair range at WB36B in a short reach between the former Warrensville dam and the Fawell dam impoundment; results suggest lingering effects of sediment releases from the former Warrensville impoundment. The trend of improved performance through the middle and lower mainstem in 2015 over 2012 was mostly attributed to the higher base flows encountered in 2015 compared to the very low flow conditions in 2012. Steam communities appeared to benefit from the increased dilution, lower nutrient levels and a lessening of low-flow stresses in the effluent dominated reach. As in previous surveys, persistent, severe impairment in the upper mainstem suggest overriding habitat, urban runoff, and point source influences at the small drainage level.

One mainstem site that continues to reflect significant declines since 2009 is WB17 (RM 19.2), immediately upstream from Klein Creek and the Carol Stream WWTP. No obvious reasons for the change is quality were apparent.

West Branch DuPage River Tributaries
After declining slightly from 2006 levels, mIBI scores from 2009-2015 Tributary samples remain almost exclusively in the fair to poor ranges and reflect minimal change in quality (Figure 21). Narrative ratings in 2006 were almost entirely fair and included only 2 sites (WB01/Kress Creek RM 2.7 and WB16/Klein Creek RM 1.0) that exceeded Illinois criteria. Since 2006, median mIBI scores have declined by an average 8.7 points in 2009-2015 with only 1 Kress Creek site exceeding standards in 2009 (WB01) and 2015 (WB03). The somewhat slight but consistent declines since 2006 have coincided with increasingly elevated chloride concentrations through 2012; the increasing concentration trend was somewhat reversed in 2015 due to dilution, higher base flows (see Figure 20, lower left), and perhaps a moderation of chloride inputs due to management changes. Macroinvertebrate performance remained relatively unchanged however.

West Branch DuPage River Watershed Biological Assemblages – Fish

In 2015, fish assemblages were re-sampled at the 42 West Branch mainstem and Tributary sites sampled in 2012 and at two additional Winfield Creek sites bracketing a DuPage County road salt storage facility. Figure 22 depicts associated fIBI narrative evaluations for each location. All survey sites fell consistently in the poor or lower fair ranges with higher scores found in the West Branch mainstem downstream from the Fawell Dam. As in past surveys, no West Branch sites met the 41-point criterion synonymous with a good quality assemblage.

West Branch DuPage River Mainstem
Mainstem fish performance continues to follow the trend observed in previous surveys with similar or somewhat improved conditions in 2015 (Figure 23). Headwater sites in the extreme upper mainstem remain poor while sites upstream from the Fawell Dam tended to improve from the poor to lower fair range. Sites downstream from Fawell Dam (RM 8.1), while fair, demonstrated the greatest improvement and highest quality of any previous survey.

Mainstem longitudinal trends continue to suggest the physical barrier imposed by Fawell Dam has a significant negative influence on upstream communities. As a result, effects of the structure on fish distribution patterns were evaluated following the 2012 survey and the 2015 survey results are updated below.

Influence of Dams on West Branch DuPage River Fish Assemblages
West Branch fish species collected upstream and downstream from the Fawell Dam were initially examined after the 2012 survey to assess the effects of the structure on fish distribution and performance. The results are updated with the 2015 fish sampling results and found in (Table 14).

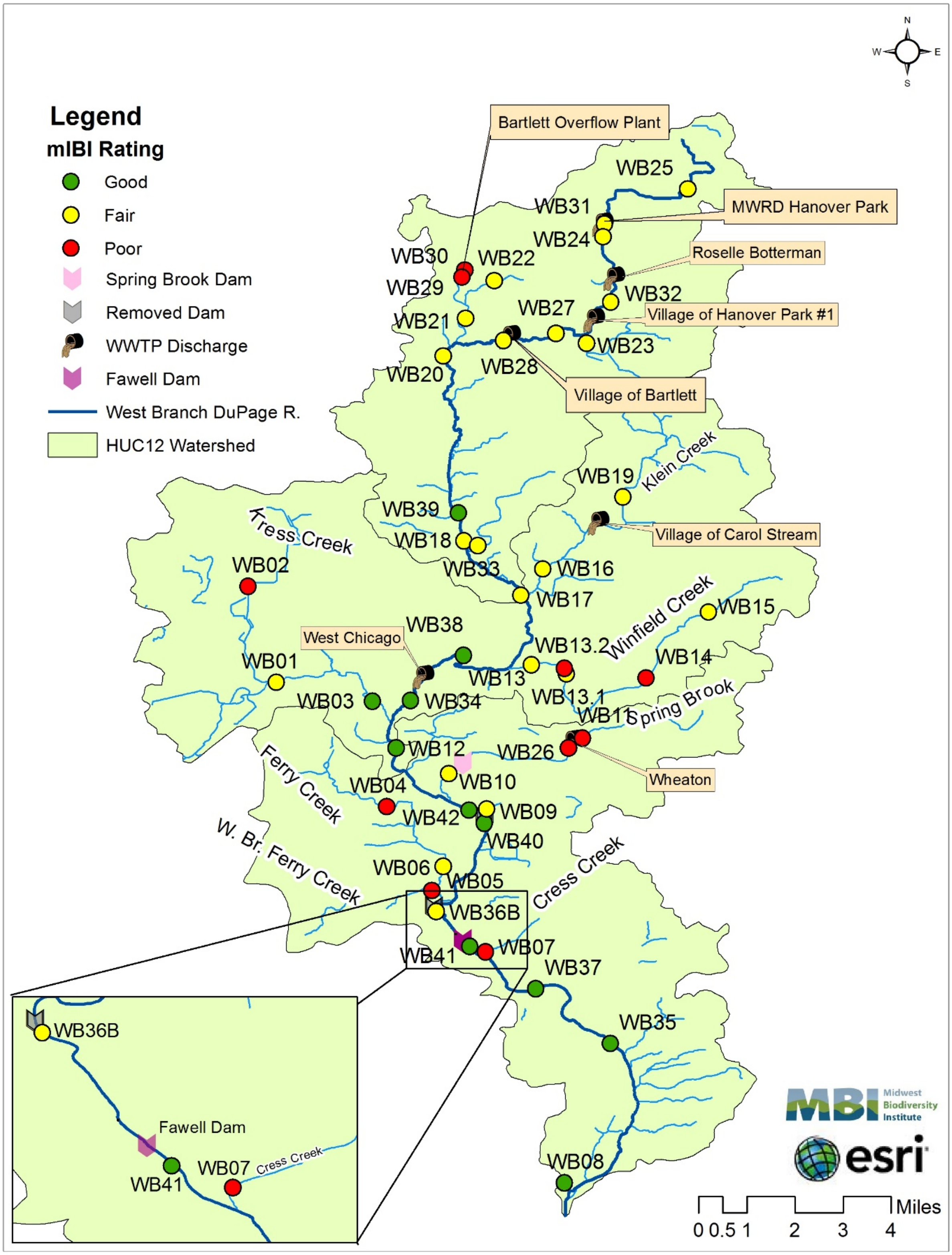

Figure 19. West Branch DuPage River watershed mIBI scores in 2015 mapped by Illinois EPA narrative ranges. Wedge-shaped symbols denote existing and former dams while discharge pipes denote WWTP locations.

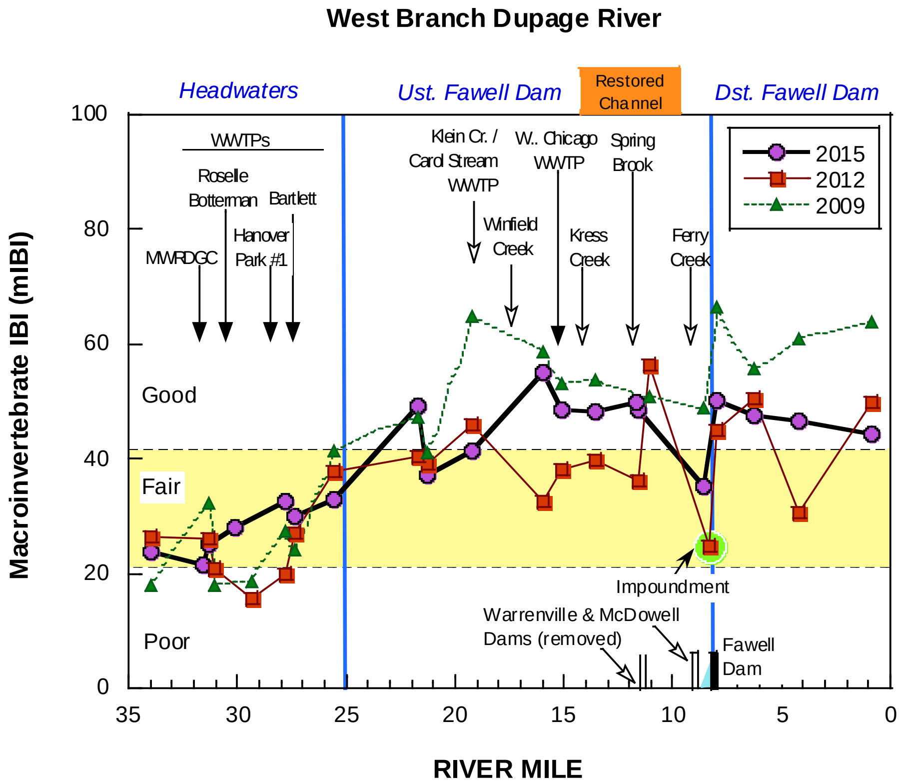

***Figure 20**. Longitudinal trends in mIBI scores from the West Br. DuPage River in 2009, 2012 and 2015 in relation to publicly owned sewage treatment plants (top) and the existing Fawell Dam. Note: The Wheaton WWTP discharges to Spring Brook at RM 3.2.*

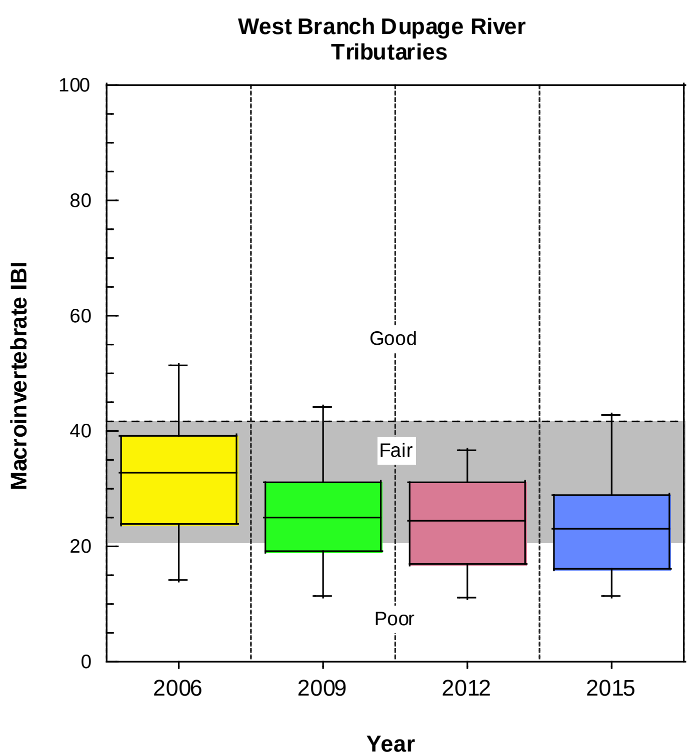

***Figure 21**. Box and whisker plot of mIBI scores from West Branch DuPage River basin tributaries in 2006, 2009 and 2012.*

In 2015, three additional species were found upstream from the dam that had previously been found only downstream and one species (walleye) was found upstream that had not been recorded in the West Branch. Finding a walleye above the dam was unusual and this single specimen may have been stocked or relocated. In the downstream reach, only gizzard shad, a common species, had not been reported prior to 2015. After updating with the 2015 results, 37 species have been found in the 25-mile reach upstream from the dam and 41 were found in the 8.1-mile reach downstream. Twelve species have been found exclusively below the dam and eight exclusively above the barrier for a net difference of 4 more species downstream. However, as stated in the previous report, the numbers of species between reaches are nearly equal but the upstream catch is based on four times the collection effort (i.e., 4x the number of sampling sites) compared to downstream. Elimination or modification of the Fawell Dam should enhance population movements upstream and improve fish performance upstream. At the same time, continued water quality impairment along the mainstem will likely inhibit biological performance and potentially limit improvements in the reach.

Longitudinal Patterns in the MIwb

The Modified Index of well-being (MIwb) is a composite fish index that includes measure of diversity based on abundance and biomass as well as log-weighted factors related to the total biomass and abundance at a site. The index ranges from zero to approximately 12, but the "good" criterion value of 8.0 is considered a reasonable expectation in the West Branch DuPage, especially at sites above 20 square miles in drainage. This is particularly true where habitat scores approach or exceed 60-70.

The MIwb values at West Branch mainstem sites greater than headwater size are below what would be expected for the existing habitat and represent a lowering of diversity and biomass likely related to the wastewater impacts and enrichment identified in this river (Figure 24). With few exceptions, MIwb scores from 2015 followed a similar trend to 2009 and 2012 surveys, particularly upstream from the Fawell dam. As in previous surveys, index scores increased sharply in the reach downstream from the dam and most were improved over 2012 sites. The only sites that approach or have exceeded the 8.0 benchmark are from the lower reach. Although sites with better habitat generally perform better than sites with poorer habitat, the MIwb values are not habitat limited, but likely impaired by nutrients and other chemical stressors. The MIwb stressor signal is consistent with that observed in the IBI and several of its metrics.

West Branch DuPage River Tributaries

Re-sampled fish assemblages from 2015 West Branch Tributary sites continued to reflect nearly identical conditions to that found in both 2006-12 (Figure 25). During each survey, performance based on fIBI scores reflect chronic and severe impairment; most assemblages were poor quality and no fIBI scores approached the benchmark of 41. A few more sites reached the lower fair range in 2015 but the overall trend remained stable and significantly impaired.

Two 2015 Tributary sites reflected significant changes in quality compared to previous surveys. Kress Creek (WB02) RM 5.1 improved from poor to fair (+7 fIBI points) while WB21, the

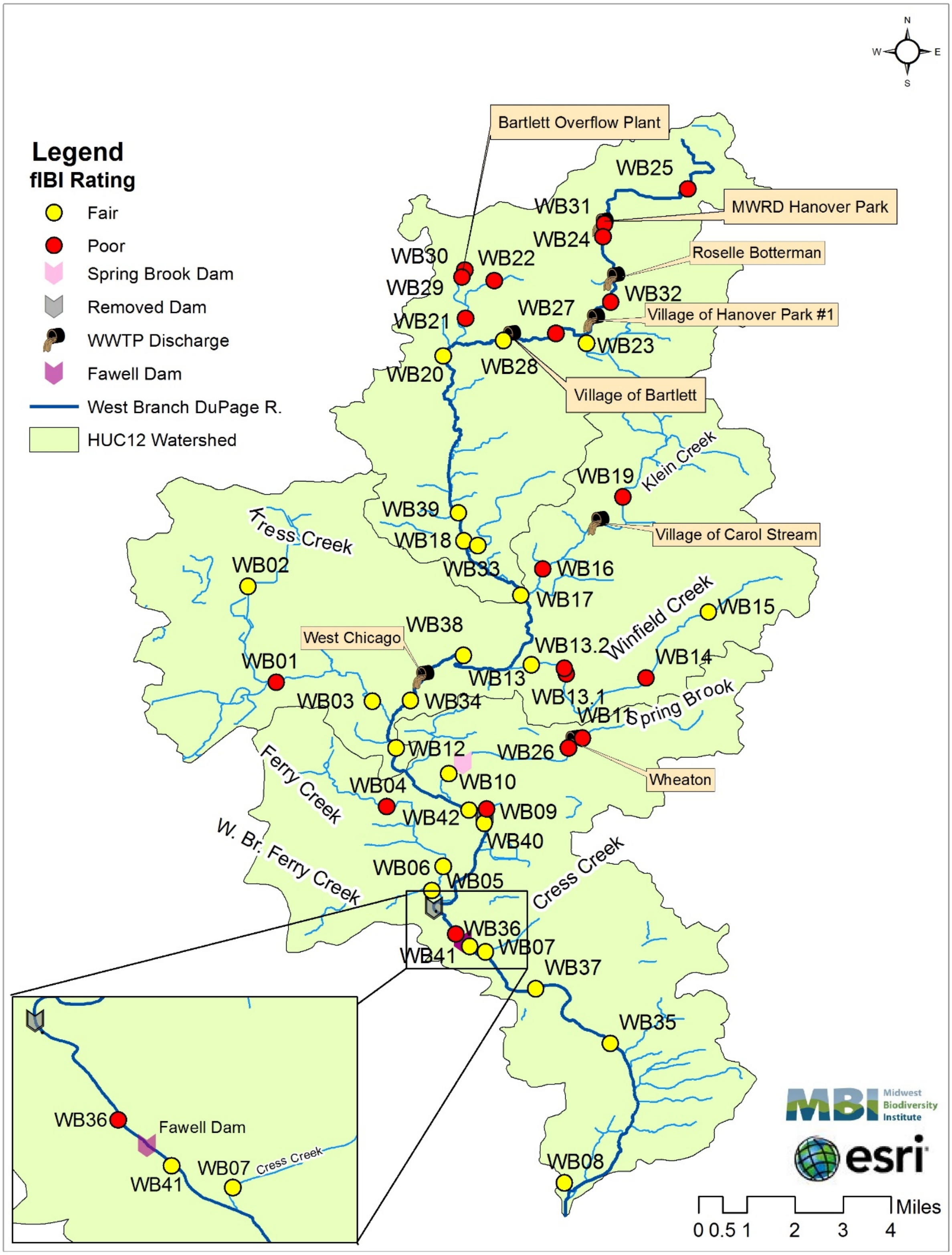

***Figure 22**. W. Br. DuPage River watershed fIBI scores in 2015 mapped by Illinois EPA narrative range (no sites met good or exceptional criteria). Wedge-shaped symbols denote existing and former dams while discharge pipes denote WWTP locations.*

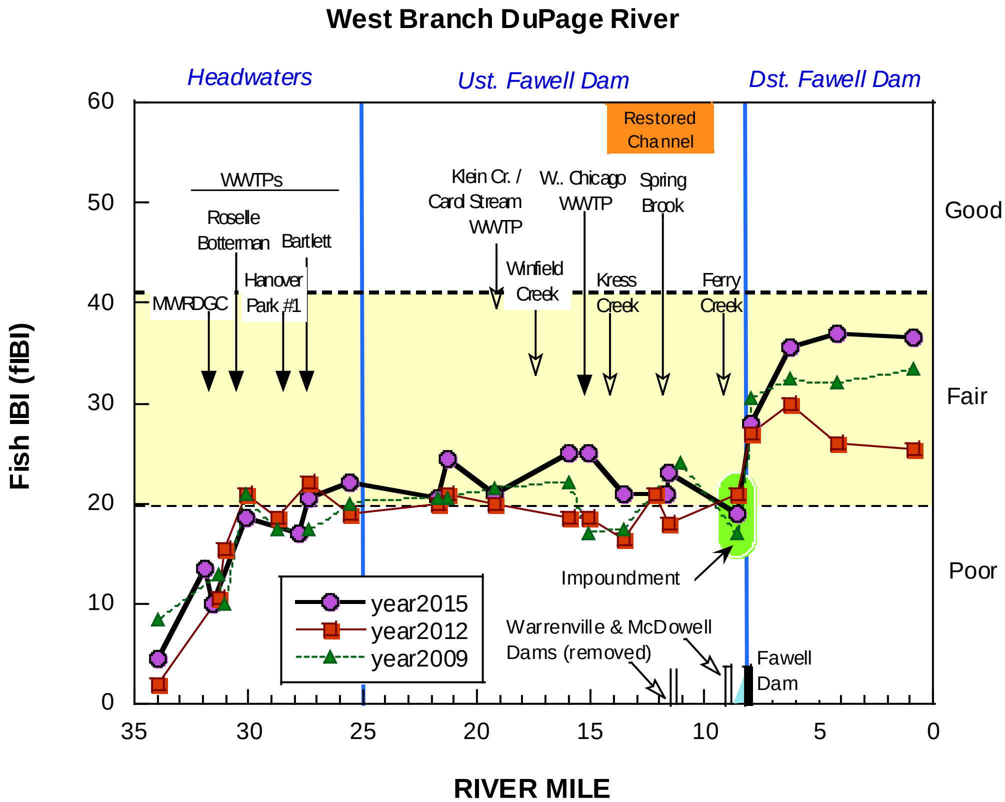

***Figure 23**. Longitudinal trends in fish Index of Biotic Integrity scores from the West Br. DuPage River mainstem in 2009, 2012 and 2015 in relation to publicly owned sewage treatment plants (top) and the existing Fawell Dam. For display and data analysis purposes, the mainstem was subdivided into three sections: 1) headwaters (<20 sq. mi drainage) 2) Upstream Fawell Dam and 3) Downstream Fawell Dam. The heavy dashed line corresponds to the benchmark score for unimpaired streams. Note: The Wheaton WWTP discharges to Spring Brook at RM 3.2.*

Unnamed Tributary. to the West Branch at RM 0.9 dropped 14 points from fair (fIBI=29) to poor (fIBI=15) between 2012 and 2015. In both instances, the changes in quality in both positive and negative directions coincided with declines in habitat (QHEI) scores related to impoundment and beaver dam construction. Winfield Creek has been repeatedly sampled since 2006 but two additional sites were added in 2015 to bracket a County salt storage facility suspected of contributing to elevated chloride levels downstream. During each survey, Winfield Creek fish performance has remained in the poor and lower fair ranges (Figure 26). Fish IBI scores bracketing the salt storage facility were nearly identical with no obvious changes attributable to the property.

Table 14*. West Branch DuPage River fish species collected upstream and downstream from the Fawell Dam between 1976 and 2015. Species unique to a reach are highlighted in blue. New species records for 2015 are noted in red font. Collection years for each species in a reach are given by superscript.*

Fish Species Common Name	Fish Species Scientific Name	Ust. Fawell Dam (RM 8.1)	Downstream of Fawell Dam (RM 0.0-8.0)
Hornyhead chub	*Nocomis biguttatus*		X[06,09,12,15]
Northern hog sucker	*Hypentelium nigricans*		X[12,15]
Striped shiner	*Luxilus chrysocephalus*		X[76,03,12,15]
Banded darter	*Etheostoma zonale*		X[12,15]
Bigmouth shiner	*Notropis dorsalis*		X[76,83,03]
Shorthead redhorse	*Moxostoma macrolepidotum*		X[09]
Emerald shiner	*Notropis atherinoides*		X[76,09]
Largescale stoneroller	*Campostoma oligolepis*		X[06]
Flathead catfish	*Pylodictis olivaris*		X[09]
Tadpole madtom	*Noturus gyrinus*		X[06.09,15]
White perch	*Morone americana*		X[09]
Longear sunfish	*Lepomis megalotis*		X[06]
Northern Pike	*Esox lucius*	X[12]	
Grass pickerel	*Esox americanus vermiculatus*	X[83,12]	
Yellow perch	*Perca flavescens*	X[12]	
Central mudminnow	*Umbra limi*	X[09,12,15]	
Yellow Bass	*Morone mississippiensis*	X[06]	
Redear sunfish	*Lepomis microlophus*	X[09]	
White crappie	*Pomoxis annularis*	X[83, 06]	
Walleye	*Sander vitreus*	X[15]	
Central stoneroller	*Campostoma anomalum*	X[15]	X[76,83,06,09,12,15]
Gizzard Shad	*Dorosoma cepedianum*	X[12,15]	X[15]
Blackstripe topminnow	*Fundulus notatus*	X[15]	X[03,12,15]
Rock bass	*Ambloplites rupestris*	X[15]	X[03,09,12,15]
River carpsucker	*Carpiodes carpio*	X[06, 12]	X[12]
White sucker	*Catostomus commersoni*	X[83, 03, 06,09,12,15]	X[76,83,03,06,09,12,15]
Common carp	*Cyprinus carpio*	X[83,06,09,12,15]	X[76,83,06,09,12,15]
Golden shiner	*Notemigonus crysoleucas*	X[83, 06,09,12,15]	X[76,83,12,15]
Creek chub	*Semotilus atromaculatus*	X[83,03,06,09,12,15]	X[76,83,03,06,09,12,15]
Spotfin shiner	*Cyprinella spiloptera*	X[03,06,09,12,15]	X[76,83,03,06,09,12,15]
Sand shiner	*Notropis stramineus*	X[83,03,06,09,12,15]	X[76,83,03,06,09,12,15]
Bluntnose minnow	*Pimephales notatus*	X[76,83,03,06,09,12,15]	X[76,83,03,06,09,12,15]
Fathead minnow	*Pimephales promelus*	X[76,83,03,06,09,12,15]	X[76,83,03,12,15]
Yellow Bullhead	*Ameiurus natalis*	X[03, 06,09,12,15]	X[83,03,06,09,12,15]
Black bullhead	*Ameiurus melas*	X[76,83,03,06,09,12,15]	X[76,83,03,06,09,12,15]

Fish Species Common Name	Fish Species Scientific Name	Ust. Fawell Dam (RM 8.1)	Downstream of Fawell Dam (RM 0.0-8.0)
Stonecat madtom	*Noturus flavus*	$X^{09,12,15}$	$X^{03,09,12,15}$
Black crappie	*Pomoxis nigromaculatus*	$X^{03,06,09,12,15}$	$X^{76,83,03,06,09,12,15}$
Smallmouth bass	*Micropterus dolomieui*	$X^{03,06,09,12,15}$	$X^{03,06,09,12,15}$
Largemouth bass	*Micropterus salmoides*	$X^{83,06,09,12,15}$	$X^{83,03,06,09,12,15}$
Green sunfish	*Lepomis cyanellus*	$X^{76,83,03,06,09,12,15}$	$X^{76,83,03,06,09,12,15}$
Bluegill sunfish	*Lepomis macrochirus*	$X^{03,06,09,12,15}$	$X^{76,83,03,06,09,12,15}$
Orangespotted sunfish	*Lepomis humilis*	$X^{76,83,03,06,09,12,15}$	$X^{06,09,12}$
Pumpkinseed sunfish	*Lepomis gibbosus*	$X^{09,12,15}$	$X^{12,15}$
Western mosquitofish	*Gambusia affinis*	$X^{12,15}$	$X^{03,12}$
Channel catfish	*Ictalurus punctatus*	$X^{12,15}$	X^{12}
Johnny darter	*Etheostoma nigrum*	$X^{12,15}$	$X^{03,06,09,12,15}$
Quillback carpsucker	*Carpiodes cyprinus*	X^{03}	$X^{83,03}$
Goldfish	*Carassius auratus*	$X^{83,06,09}$	$X^{83,15}$
Brown bullhead	*Ameiurus nebulosus*	X^{06}	X^{06}
Total Species: All Years (1976-2015)		**37 (27)**	**41 (28)**

* Hybrids are not included in the species list.

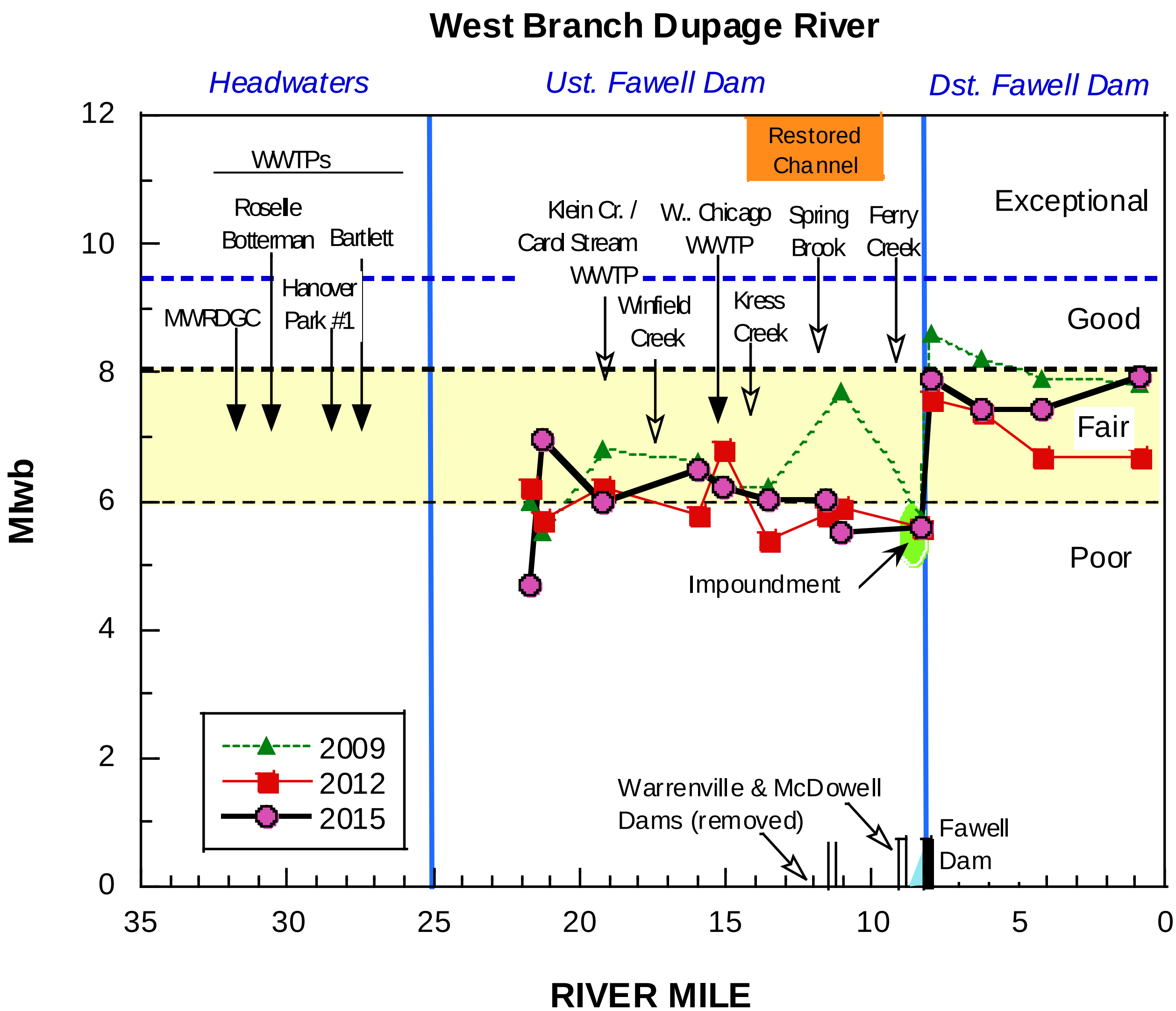

***Figure 24**. Mean Modified Index of well-being (MIwb) in the West Br. of the DuPage River, in 2009, 2012, and 2015. Bars along the x-axis note locations of existing dams. Note: The Wheaton WWTP discharges to Spring Brook at RM 3.2.*

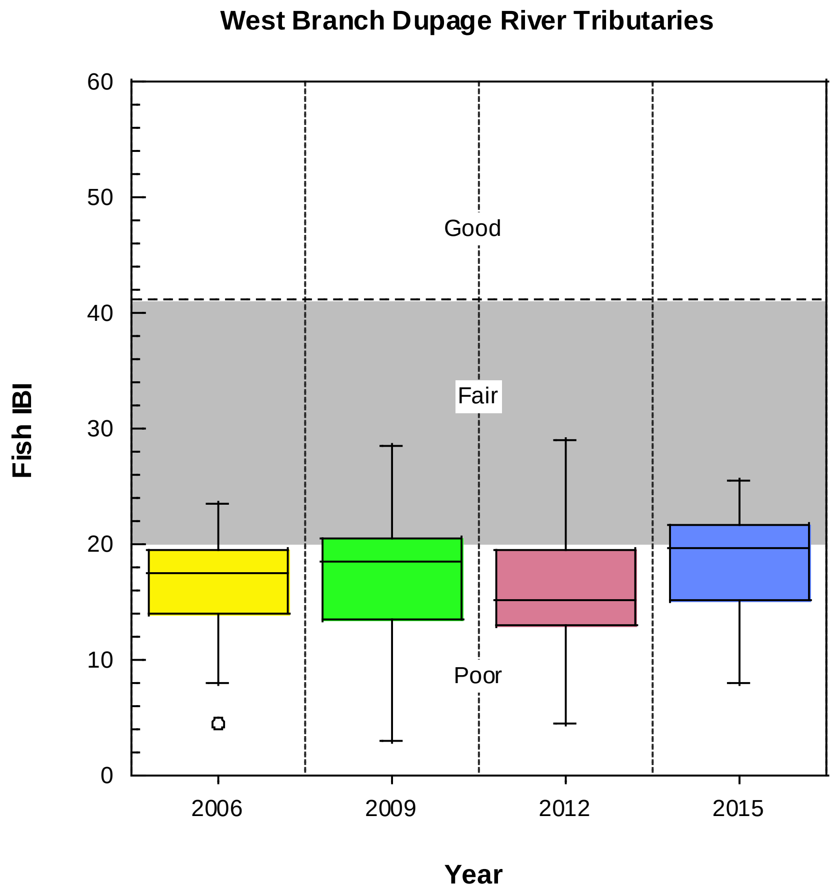

***Figure 25**. Box and whisker plot of fish Index of Biotic Integrity scores from West Br. DuPage River basin tributaries in 2006-2015.*

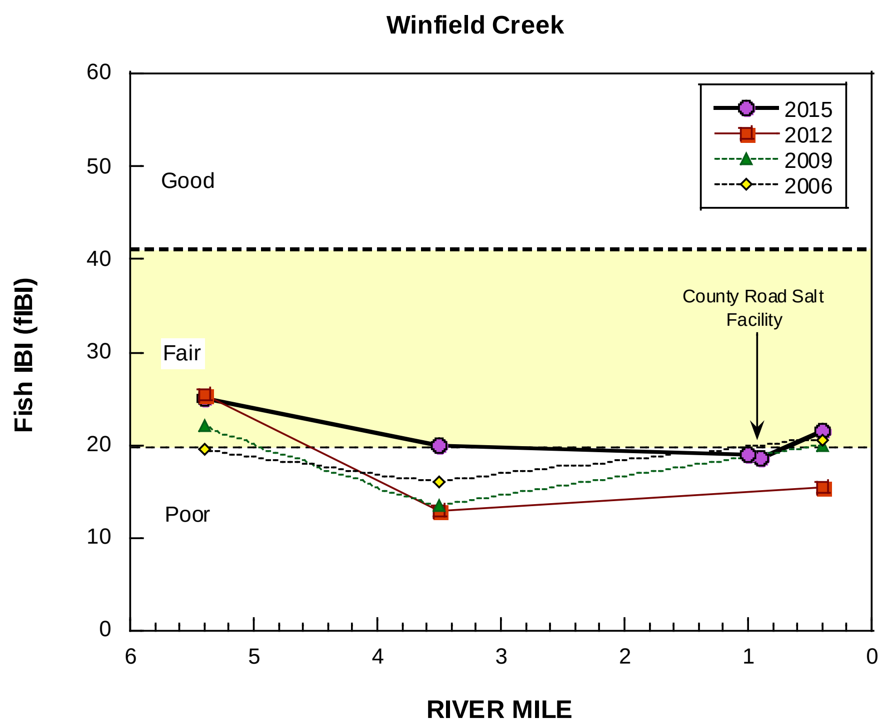

***Figure 26**. Fish IBI trend in Winfield Creek, 2006-15.*

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