MID-STATES CORRIDOR

APPENDIX F - Cumulative Impacts Baseline Trends

Mid-States Corridor
Tier 1 Environmental Impact Study

Prepared for

Indiana Department of Transportation
Mid-States Regional Development Authority

DECEMBER 7, 2021

Prepared by

Mid-States Corridor Project Consultant

TABLE OF CONTENTS

Tables

Figures

INTRODUCTION

The purpose of this appendix is to document and summarize baseline information for farmland, forests, wetlands, streams and karst for **Section 3.6 – Cumulative Impacts Analysis** for the Mid-States Corridor Tier 1 EIS. This includes the 12 County Study Area of: Crawford, Daviess, Dubois, Greene, Lawrence, Martin, Monroe, Orange, Perry, Pike, Spencer and Warrick counties. The analyses performed for each of these resources do not include the changes that would result from the direct or indirect impacts of the possible alternatives for the Mid-States Corridor or other specific future activities. These represent evaluation to establish baseline conditions and use of historic data to forecast general trends occurring within the study area.

FARMLAND

Past trends in farmland acreage and future projections were evaluated to analyze changes in agricultural land. **Table 1** presents the percent change for historical and forecast periods for farmland in the study area between 1974-2017 and the forecasted period of 2017-2045. To predict the 2045 acreage, a linear regression analysis was completed using the following historical data: 1974, 1978, 1982, 1987, 1992, 1997, 2002, 2007, 2012 and 2017. These data are taken from the United States Department of Agriculture (USDA) Census of Agriculture. A linear regression analysis was deemed appropriate to forecast as the r-squared values for the analysis were approaching 1.0 for most counties and had a value of 0.88 when combined for the 12 County Study Area (**Figure 1**). The closer the r-squared value is to the value of 1.0, the stronger the predictive relationship.

The historic data and the regression forecasts provide baseline trends and projections of farmland in the study area. The data and projection forecasts do not include the changes that would result from the direct or indirect impacts of the possible alternatives for the Mid-States Corridor or other future activities.

The baseline trends forecast substantial decreases in farmland acreage, but this data can be misleading in relation to the agricultural output over both the historical and forecast periods. Between 1948 and 2017, agricultural productivity increased at an annual rate of approximately one and a half percent (USDA, 2021). Although this growth rate will likely reduce over time, it is anticipated to continue and has allowed total agricultural outputs to increase while the volume of land and labor has decreased. New technologies, innovations, and process improvements have fueled these increases; however, the maximum yields are still largely dependent on the soil health and water management. The decline in farm acreage over the historical period correlates in part to consolidation of farming operations and conversion of marginal soils to uses other than farmland; this includes enrollment in USDA programs such as the Conservation Reserve Program (CRP) or Conservation Reserve and Enhancement Program (CREP) which seek to improve water quality by setting aside marginal farmland. The Mid-States study area is predominantly located in the Southwestern Lowlands and Crawford Upland Natural Regions which have a much lower density prime farmland soils compared to the Central Till Plains and Grand Prairie Natural Regions in Indiana.

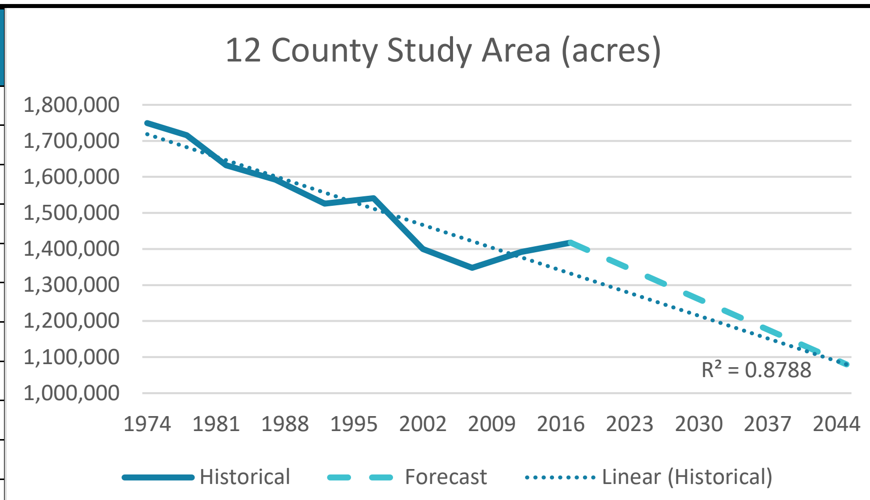
The consolidation of farming operations has resulted in an overall reduction of farmers while the average farm size has increased. Nationally, the number of farms were estimated to have decreased from approximately 4,000,000 to 2,000,000 between 1960 and 2015 (Sherrick, 2017). The consolidation of farms has resulted in roughly 24 percent of farmland nationally controlled by 4 percent of farming operations. Consolidation of farming operations and further fallowing of marginal lands are anticipated to continue through the forecast years. These trends are expected to result in the reduction of total acreage in agricultural use while output continues to increase through productivity gains from innovations.

Table 1: Farmland Baseline Forecast for 2045

Counties	Change Historical 1974-2017	Change Forecast 2017-2045
Crawford	-44%	-78%
Daviess	-3%	-11%
Dubois	-17%	-16%
Greene	-21%	-23%
Lawrence	-18%	-27%
Martin	-28%	-28%
Monroe	-38%	-6%
Orange	-19%	-24%
Perry	-29%	-43%
Pike	-19%	-33%
Spencer	-12%	-16%
Warrick	-17%	-17%
Total 12 County	**-19%**	**-23%**

Figure 1: Farmland Baseline Regression Analysis for 12 County Study Area

12 County Study Area	Historical	Forecast
1974	1,749,316	(- -)
1978	1,715,539	(- -)
1982	1,632,440	(- -)
1987	1,592,196	(- -)
1992	1,525,837	(- -)
1997	1,541,264	(- -)
2002	1,399,929	(- -)
2007	1,347,807	(- -)
2012	1,392,117	(- -)
2017	1,417,577	(- -)
2045	(- -)	1,079,835



FORESTS

Indiana has almost five million acres of forestland. Although not evenly distributed, it covers about 21 percent of the state. The United States Forest Service (USFS) developed and has conducted a Forest Inventory Analysis (FIA) annually for several decades. This survey produces annual estimates of forest density, type, composition, and stand age from established sampling plots. For the FIA, the USFS has divided Indiana into four survey units: Northern, Upland Flats, Knobs, and Lower Wabash (**Figure 2**). The Mid-States study area is within the Knobs and Lower Wabash survey units. The Knobs survey unit contains approximately 40 percent of the forested lands within Indiana.

Forest land in Indiana has been highly variable over the past century. Historical surveys have identified significant decreases in forests occurred from the period of settlement through the 1960s, it is estimated as much as 10 million acres of forest were cleared during early settlement (IDNR, 2018). During the 1960's, a shift in public sentiment regarding conservation occurred and expanding forested land was incentivized through tax law and sporting opportunities. This resulted in a rapid and steady increase in forest land throughout the state for roughly 40 years (**Figure 3**). Around 2010, as a statewide average, the increases began to level off.

FIGURE 2: FIA SURVEY UNITS

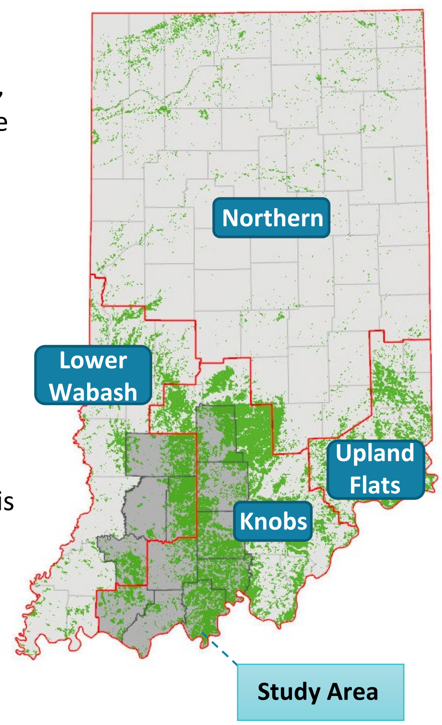
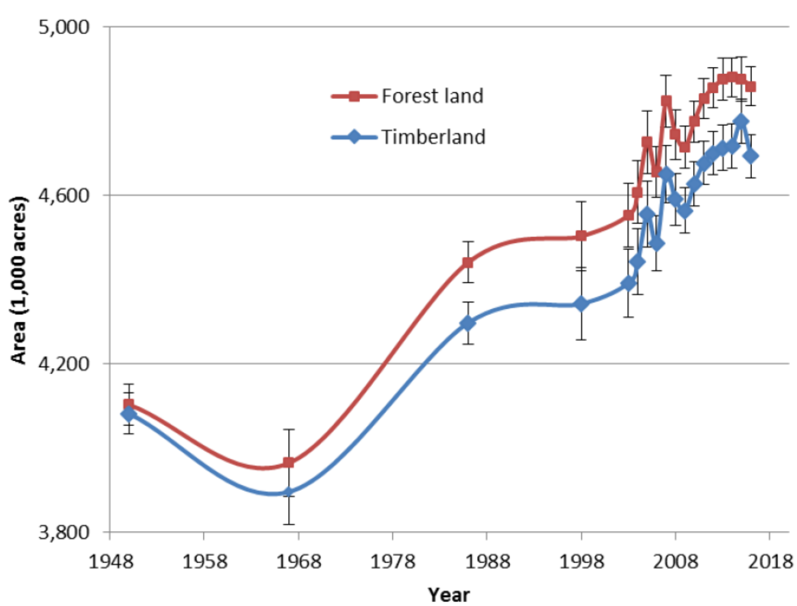


FIGURE 3: ESTIMATES OF FORESTED LAND IN INDIANA FROM 1950 TO 2016

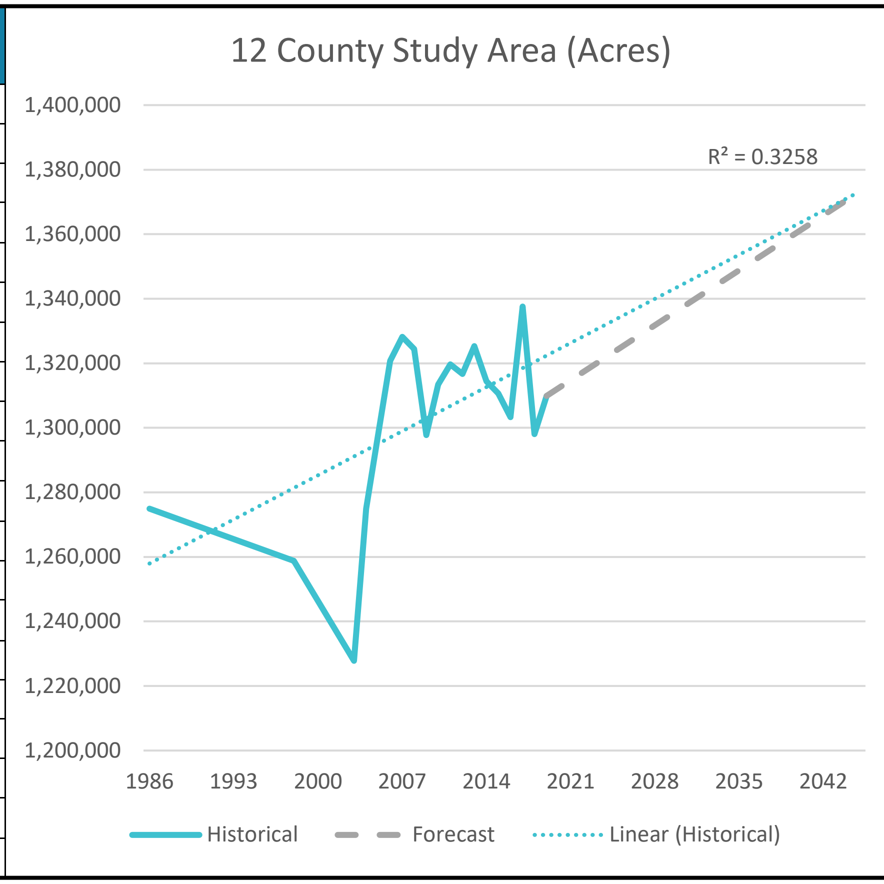


[Graphic taken from USDA resource update FS-127]

FIA data was accessed for each of the 12 counties in the study area for 1986, 1998, and 2003-2019 to analyze for trends. The study area falls within a part of the state containing a high volume of forest, accounting for approximately a quarter of the state's forest land. The annual FIA data captured a lot of variation from year to year across the counties. This variation prevented a linear regression analysis from producing predictable trends in any of the individual counties as well as the larger study area. Several counties had an r-squared value of less than 0.1, and the combined study area had a value of only 0.3 (**Figure 3**). The low r-squared value provides little confidence the six percent growth through the forecast period is accurate.

FIGURE 4: FOREST REGRESSION ANALYSIS FOR 12 COUNTY STUDY AREA

12 County Study Area		
Year	Historical	Forecast
1986	1,274,972	(- -)
1998	1,258,818	(- -)
2003	1,227,802	(- -)
2004	1,274,903	(- -)
2005	1,297,658	(- -)
2006	1,320,806	(- -)
2007	1,328,227	(- -)
2008	1,324,477	(- -)
2009	1,297,719	(- -)
2010	1,313,421	(- -)
2011	1,319,674	(- -)
2012	1,316,685	(- -)
2013	1,325,289	(- -)
2014	1,314,446	(- -)
2015	1,310,686	(- -)
2016	1,303,297	(- -)
2017	1,337,580	(- -)
2018	1,298,059	(- -)
2019	1,309,892	(- -)
2045	(- -)	1,373,164



The general trend in the study area is for an increase in forest land; however, the combination of natural mortality, weather event mortality, timber harvest, and land clearing are occurring at a dynamic rate such that regeneration and successional staging of forests cannot reliably be predicted through 2045. Except for isolated population centers such as Bloomington, the Study Area is not under pressure of urban development and will remain predominantly rural. Analysis of agricultural lands predicts more than 330,000 acres of lands in the study area will be removed from agricultural production between 2017-2045. While it is unlikely that the entirety of these lands would be allowed to convert to forest land, it is reasonable to presume a percentage of these lands will become forested. The regression analysis predicting an increase in approximately 74,000 acres of forest land may be unreliable but is not unreasonable. This would represent reforestation of 22 percent of the agricultural land removed from production. Through the forecast year, it should be anticipated forest land will increase.

WETLANDS

The state of Indiana, like much of the United States, has seen a large decrease in wetland acreage since the 1800s. According to the Indiana Department of Environmental Management (IDEM) there were at one time over 5.6 million acres of wetlands in the state. Millions of those acres were converted into farms and human settlements in the 1800s and 1900s, with over 4.7 million acres being converted by the late 1980s. In the 1700s, 25 percent of Indiana was estimated to be covered by wetlands. Due to wetland conversions the total wetland land cover of Indiana is now less than four percent. A report completed in 1996 by the U.S. Geological Survey (USGS) estimated Indiana continued to lose one to three percent of its wetlands annually.

Analysis of baseline trends for the study area was conducted in a qualitative manner only. National wetland data are primarily obtained from two reference sources: the National Wetland Inventory (NWI) maintained by the U.S. Fish and Wildlife Service (USFWS) and the NLCD. Both sources use various remote sensing techniques to identify areas of potential wetland. The NWI is routinely updated, with data typically released every two years. NLCD is updated less often, roughly every 5 years.

Quantitative forecasting of wetlands resources was not conducted for three primary reasons: resolution, methodology, and sensitivity. The NWI was initiated in the 1970s and began to be digitized in the late 1980s. Initially, USFWS identified wetlands via aerial photography only. Since mapping began digital tools have become significantly more robust and new methodologies have been routinely added to the remote sensing process. However, the single purpose of the NWI is to track the presence of wetland resources. The NLCD was first released in 2001 and is generated by a partnership of numerous federal agencies (which includes the USFWS) with the purpose of providing consistent and relevant national land cover information using satellite data as the principal source. Although wetlands are integrated into the land cover characteristics, they are only a subset of characteristics contained within the dataset and can create larger or smaller representative blocks than the NWI as they are characterized differently. While much newer than the NWI, NLCD has also made substantial gains in remote sensing tools to produce greater resolution over the 20 years of datasets produced, but the intended use remains separate from the NWI mapping and the data between the two sources are not intended to be comparable. **Table 2** provides a summary of the totals presented for both the NLCD and NWI related to wetlands.

Whether referencing the NLCD or NWI for discussion of wetland areas, comparison between different vintages to establish meaningful trends requires normalizing the data to eliminate variation based in changes in resolution and methodology between evaluation years. Additionally, this normalization process must account for sensitivities from natural variance between sample years (*e.g., drought years may reduce remote sensing of wetland areas while wet years may expand them*). Conducting this type of data normalization would be impractical for the scale of the Mid-States Corridor.

The USFWS does prepare a report to congress approximately every decade to present the national status and trends of wetland resources. These reports undergo extensive review and adjustments of data to describe the observed trends. The most recent report submitted in 2011 was the most comprehensive and compared a subset of wetland data nationally (Dahl, 2011). This report identified wetland losses exceeded gains during the sampling/review period. The changes were not statistically significant but still represented a continued trend of decreasing wetland resources. The study identified artificially created freshwater ponds accounted for the most common gains for wetland habitat while coastal marshes and inland forested wetlands accounted for the greatest losses. The loss of coastal marshes is the more complex of these as their losses include impacts from sea level rise rather than associated land use changes.

Table 2: Comparison of Wetland Totals between NLCD and NWI

	Wetland Source (acres)	
County	NLCD	NWI*
Crawford	195	127
Daviess	4,306	11,913
Dubois	3,513	9,814
Greene	2,146	6,623
Lawrence	781	4,410
Martin	1,000	4,598
Monroe	700	3,076
Orange	230	2,308
Perry	1,229	1,179
Pike	7,895	17,722
Spencer	6,943	12,005
Warrick	9,771	9,093
12 County	**38,709**	**82,868**

**excludes category types that would be captured as open water in the NLCD*

With respect to completing the 2011 USFWS (Dahl) report, the Great Lakes/Atlantic Regional Office of Ducks Unlimited partnered with the agency to assist in the update of the NWI and comparison of the data. Ducks Unlimited aided in the states of Wisconsin, Illinois, Indiana, Michigan, and Ohio. Each state had their own sources of aerial photography for use in the update. Indiana's dataset included 2005 infrared and 2003 natural color aerial photography. Field investigations to validate the remote sensing were conducted in 2009 in all states. The Indiana field surveys found the remote sensing methods to be 86 percent accurate.

The Indiana data identified nearly 32,000 acres of wetland had been converted to upland between the 1980s and early 2000s comparison (IDNR, 2018). Conversion for agricultural land use accounted for 72 percent of the loss, 24 percent was associated with urban development. For the greatest types of wetlands lost, forested wetlands accounted for 32 percent and emergent wetlands 48 percent.

Forested wetlands account for roughly 50 percent of freshwater wetlands nationally. The analysis resulting from the 2011 USFWS report identified a 1.2 percent decline of these resources. The previous two studies by USFWS (1986-1997 and 1998-2004) found forested wetlands to be trending upward thus the decrease represented a reversal of the previously positive trend. These losses of forested wetlands were part of the national dataset, but they were most acutely associated with silviculture practices in the southeastern states.

Human development, whether for conversion of land for agricultural or urban use, is the primary cause of wetland loss in Indiana. Population growth within the Study Area through 2045 will be modest or negative depending on the county. Where growth occurs, it will be anticipated to concentrate around the existing regional population centers. Historical statewide data for wetland resources has trended negative; however, these losses have corresponded to areas of urbanization and heavy agricultural use. The Study Area is becoming more rural as populations are consolidating or leaving. The baseline discussion regarding agriculture and forests predicted a reduction of agricultural land use and an increase in forested land. The data for the 12 County Study Area identified when excluding potentially open water areas (lakes and ponds), 82 percent were associated with forested wetlands. Reduction of agricultural land in the study area will be from fallowing row crop fields on marginal land and not from conversion to urban development. Many of these agricultural properties, especially those in low lying floodplain areas, will likely return to forest. With these considerations, it is probable that the Study Area could exhibit a minor trend for increasing forested wetlands through 2045 even if statewide a negative trend persists.

STREAMS

Impacts to streams can occur either from changes to the water quality or by altering the morphology (*shape and flow of the channel*). An example specific to water quality effects is from the application of road salt. Chlorides from the salt applications can temporarily alter the water chemistry of the receiving water body as it is flushed off the roadway surface. The chlorides can also accumulate in the sediment of road ditches and streambeds causing longer term impacts to water quality. An example of altering morphology would be the channelization of a segment of streambed and/or placement of levees to limit the size of the floodplain. A meandering stream that is channelized without proper design characteristics may eliminate important habitat within that segment and if the channelization results in a shorter length of streambed could create unintended consequences well upstream from the location of the channelization. Placement of levees can alter stream dynamics by maintaining higher flood pulses and limit sediment deposition outside of the main channel while placement of dams can disconnect aquatic communities and prevent certain species from completing their lifecycles.

Four watersheds within the Study Area occupy the majority of space where potential disturbances from alternatives may take place. These include the West Fork White River, East Fork White River, and Patoka River.

West Fork White River (8-digit HUC 05120202)

The streams located within this watershed are tributaries to the White River, which drains into the Wabash River. Several streams contain segments included in the State of Indiana's Section 303(d) list of impaired streams. Details regarding stream impairment for project alternatives are provided in **Appendix R – Section 303(d) Impact List.**

The following sub-basins are located within the West Fork White River watershed:

- First Creek-White River (10-digit HUC -05): This encompasses approximately 129,400 acres and drains the area southwest of Bloomington from State Road 54 south to E 900 N. This watershed has an approved TMDL.
- Kessinger Ditch-White River (10-digit HUC -09): This encompasses approximately 89,200 acres and drains the area west of Loogootee, from northwest of Washington to east of Washington near County Road 650.
- Prairie Creek (10-digit HUC -07): This encompasses approximately 97,300 acres and drains the area between the First Creek-White River and Kessinger Ditch-White River sub-watersheds west of Loogootee. This watershed has both an approved TMDL and an approved Watershed Management Plan (WMP).

East Fork White River (8-digit HUC 05120208)

The streams located within this watershed are tributaries to the White River, which drains into the Wabash River. Several streams in this watershed have segments included in the State of Indiana's Section 303(d) list of impaired streams from 2018, including Boggs Creek, Indian Creek, Lick Creek, French Lick Creek, Lost River, Sugar Creek, Salt Creek, Lower East Fork River, East Fork White River and West Fork Sugar Creek. Details regarding stream impairment for project alternatives are provided in **Appendix R – Section 303(d) Impact List.**

The following sub-basins are located within the East Fork White River major watershed:

- Barn Run-East Fork White River (10-digit HUC -14): This sub-watershed encompasses approximately 99,000 acres and drains the southern portion of Loogootee east to Mitchell.
- Boggs Creek (10-digit HUC -11): This sub-watershed encompasses approximately 57,000 acres and drains the area from SR 45 to the north side of Loogootee.
- Dry Branch-Lost River (10-digit HUC -12): This sub-watershed encompasses approximately 103,700 acres and drains the area south of SR 60 and east of Orleans. This watershed is part of an approved WMP.
- East Fork White River (10-digit HUC -15): This sub-watershed encompasses approximately 132,700 acres and drains the area northwest of Jasper from south of I-69 to northwest Jasper east to County Road 5. This watershed has an approved TMDL.
- Indian Creek (10-digit HUC -09): This sub-watershed encompasses approximately 110,300 acres and drains the area northeast of Loogootee, from SR 48 to SR 450 east of Loogootee.
- Leatherwood Creek-East Fork White River (10-digit HUC -10): This sub-watershed encompasses approximately 78,400 acres and drains the area south of SR 450 and north of SR 60 south of Bedford.
- Lick Branch-East Fork White River (10-digit HUC -03): This sub-watershed encompasses approximately 63,600 acres and drains the area south of Bedford east of SR 37.
- Lost River (10-digit HUC -13): This sub-watershed encompasses approximately 130,500 acres and drains the area northeast of Jasper, from County Road 5 to Paoli to the east. This watershed is part of an approved WMP.

- Salt Creek (10-digit HUC -08): This sub-watershed encompasses approximately 130,300 acres and drains the area northeast of Loogootee, from Bloomington down to Bedford. This watershed has an approved TMDL.

Patoka River (8-digit HUC 05120209)

The streams located within this watershed are tributaries to the Patoka River, which drains into the Wabash River. Several streams in this watershed are included in the State of Indiana's Section 303(d) list of impaired streams from 2018, including Dillon Creek, Buffalo Stream, Straight River, Short Creek, Bruner Creek, Ell Creek, Dick Creek, Altar Creek, Crooked Creek, Little Flat Creek and Flat Creek. Details regarding stream impairment for project alternatives are provided in **Appendix R – Section 303(d) Impact List.**

The following sub-basins are located within the Patoka River watershed:

- Altar Creek-Patoka River (10-digit HUC -04): This sub-watershed encompasses approximately 99,100 acres and drains the area from SR 56 northeast of Jasper to Old Holland Road southwest of Jasper. This watershed is part of an approved WMP.
- Flat Creek (10-digit HUC -05): This sub-watershed encompasses approximately 37,700 acres and drains the area from northwest of Jasper near the intersection of SR 56 and SR 61 to west of Jasper near S 650 W. This watershed is part of an approved WMP.
- Hunley Creek (10-digit HUC -03): This sub-watershed encompasses approximately 52,400 acres and drains the area south of Jasper from US 231 north of CR W 400 S to southeast of Huntington. This watershed is part of an approved WMP.
- Straight River (10-digit HUC -02): This sub-watershed encompasses approximately 43,300 acres and drains the area southeast of Jasper from 3rd Ave. to Birdseye. This watershed is part of an approved WMP.

Significant morphological changes to were made to numerous waterways in the Study Area historically to enhance farmland, expediate drainage, create impoundments, and relocate drainage for activities such as mining. In the process, many of these actions created significant harm to the stream systems and the habitat and aquatic organisms within them. Today, these types of activities (*physical modification of the waterways*) are heavily regulated to maintain channel stability and protect upstream and downstream communities. A roadway project such as the Mid-States Corridor will cross many waterways and indirect and incremental actions will be evaluated for anticipated impacts to streams in estimation to the linear feet of stream channel present. Tracking the amount of stream channel impacted is important; however, it is assumed for this baseline evaluation that all cumulative impacts will occur as authorized permitted actions. Further, it is assumed all "Other Actions" which would modify a stream would be appropriately permitted. Thus, the amount of stream channel impacted does not equal an amount of stream resource lost. This only reports the total amount of potential stream channel that may be disturbed, most often temporarily, during a construction phase.

The agencies responsible for authorizing these actions which physically disturb stream channels do allow relocations and limited channelization of stream segments as necessary but do require hydraulic modeling and maintenance of stream slope to do so. These studies dictate a minimum channel dimension, including length of the streambed required, to prevent upstream and downstream impacts and keep stream integrity within the modified section. Legacy impacts from mining, stream relocations, ditching, and other human actions to waterways that occurred prior to a well-regulated process persist. The legacy impacts will continue to influence watersheds for years to come, but the current regulatory environment in Indiana has generated a positive trend with respect to the physical conditions. Assuming that all identified actions are permitted appropriately, the trend related to morphological changes remains unchanged for the forecast period.

Known impairments to water quality of streams are captured in the 303(d) list. Within the Study Area, the identified impairments are most commonly assigned to E. Coli., nutrients, dissolved oxygen, and biological integrity. Locations with impairments from metals or other contaminants occur within the Study Area, but not with the same frequency as the former. These four are separate variables, but their impairment sources are linked and primarily associated with agricultural practices. The study area is in a rural setting with over a million acres of farmland. E. Coli. impairments are often seen in areas where livestock are allowed access to streams and/or where confined animal farming operations (CAFOs) dispose of their sanitary waste as untreated fertilizer on farm fields. These wastes not only include bacteria (E. Coli.) but also act as a nutrient source (primarily as ammonia nitrogen) which can enter waterbodies either through stormwater runoff or subsurface tile flow. Elevated nutrient levels in the waterway may also occur from other fertilizers applied to farm fields. Excess nutrients within the waterways can increase biological productivity and cause feedback loops which deplete oxygen levels in the water column. Streams experiencing regular occurrences of low dissolved oxygen levels and high nutrient levels will have lower diversity of aquatic macroinvertebrates and fish which reflects as an impact to biological integrity of the waterbody. The impairments in the Study Area are predominantly associated with agricultural non-point sources; none observed would be associated with a transportation source.

Review of current and prior Section 303(d) list, and watershed plans within the study area indicate these issues have been persistent but have been trending positive as Total Maximum Daily Loads (TMDLs) within several of the watersheds are being implemented. The rural nature of the study area and limited area of impervious surfaces where road salt is applied restricts the potential for chloride to cause a chronic water quality issue in any of the watersheds, but streambeds localized around urban centers such as Bloomington, Jasper, and Washington will likely maintain elevated concentrations of chloride relative to the background measurements in more rural locations. The study area is not anticipated to become significantly more urbanized by 2045 but is predicted to have a reduction of over 300,000 acres of farmland. These conditions in conjunction with expected further implementation of existing and future watershed management plans would indicate the potential for trending improvement in water quality over the forecast period (e.g., a reduction of stream segments on the 303(d) list).

KARST FEATURES

The karst landscape in Indiana is primarily concentrated in Southern Indiana, which has several different types of karst features. Within the study area, the following features have been inventoried: cave entrances, springs, sinkholes and the acres of both sinkhole areas and sinking stream basins. A key factor for analyzing karst features is the sensitivity they can create for groundwater resources as karst features provide direct access to groundwater.

INDOT's Ecology and Waterway Permitting Office has developed the *Protection of Karst Features during Project Development and Construction* guide to minimize impacts to karst features. The guidelines and procedures laid out in this guide replace the Memorandum of Understanding (MOU) between INDOT, the Indiana Department of Natural Resources (IDNR), IDEM, and US Fish and Wildlife Service (USFWS) that was signed in 1993. Karst features are sensitive to contamination, because there are many ways for contamination to be introduced to the feature through surface runoff to create impacts to groundwater. Karst features are protected through state and federal laws, including the Federal Cave Resources Protection Act of 1988 and others.

The data used for the inventory of the karst features in the study area come from the Indiana Geological Survey. See **Table 3** for a breakdown of the karst features by county.

TABLE 3: KARST FEATURES BY COUNTY

Karst Features					
County	**Cave Entrances (#)**	**Springs (#)**	**Sinkholes (#)**	**Sinkhole Areas (acres)**	**Sinking Stream Basins (acres)**
Crawford	**92**	**26**	**518**	**3,673**	**180**
Daviess	**0**	**0**	**104**	**0**	**0**
Dubois	**7**	**4**	**25**	**0**	**0**
Greene	**29**	**43**	**170**	**0**	**5,414**
Lawrence	**224**	**70**	**10,317**	**34,665**	**39,647**
Martin	**41**	**17**	**59**	**0**	**0**
Monroe	**107**	**67**	**2,304**	**9,722**	**8,891**
Orange	**132**	**96**	**5,004**	**38,450**	**57,758**
Perry	**5**	**2**	**92**	**71**	**0**
Pike	**0**	**0**	**20**	**0**	**0**
Spencer	**0**	**0**	**98**	**0**	**0**
Warrick	**0**	**0**	**3**	**0**	**0**

Key notes related to these features:

- Cave entrances were provided by the Indiana Cave Survey. The majority of the cave entrances are located in the eastern half of the study area. Cave entrances are not recorded in Daviess, Pike, Spencer and Warrick Counties.
- Four counties (Daviess, Pike, Spencer and Warrick) do not have any springs mapped within their borders. Springs are identified as they are often associated with karst.
- Sinkholes occur when a portion of bedrock collapses and there is a void below that bedrock, causing an opening in the ground (Karst Geological Resources and INDOT Construction, 2017). Sinkholes are found throughout the Study Area. Most sinkholes are in Lawrence, Monroe and Orange counties.
- There is some overlap with the sinkhole area polygons in the project GIS. For this reason, acreage numbers are approximate. Seven counties do not have any sinkhole areas.

- Sinking streams have “a bed that allows water to flow directly into the underground system,” (Karst Geological Resources and INDOT Construction, 2017). Seven of the 12 counties did not have any sinking stream basins.

Karst features require geologic time to form and are associated with distinct geologic formations. Localized events may occur such as new sinkhole breaches or landowners conducting compaction grouting to seal access points. These direct physical impacts to known features must be accounted for, but an underlying risk with karst is associated with being in a karst area and not limited to where known features area exposed at the surface. Additional sinkholes or springs may be found during the forecast period, but their mapping would not necessarily equate to an increase in the resource in context to the potential presence of unknown cavities yet to breach. Consideration with this resource should include the risks associated with protection of groundwater quality, both for protection of water supplies and sensitive ecosystems associated with karst environments. Thus, included within the trend is to anticipate whether contamination risks to groundwater via karst features through the forecast years will increase, remain consistent, or decrease.

The study area is predominantly rural and land use is not predicted to substantively change through 2045. The areas of the study with the highest densities of karst features are affiliated with areas containing predominantly marginal soils; however, these have the lowest density of farmland. The anticipated reduction of agricultural land use and increase in forested land and implementation of watershed management plans throughout the study area discussed in prior sections correlate to the predicted trend of improvement of surface water quality during the forecast years. Surface water contaminants pose the greatest risk factors for groundwater in karst areas; thus, the risks should remain consistent to decreasing during the forecast period.