United States Department of the Interior

FISH AND WILDLIFE SERVICE
Kentucky Ecological Services Field Office
330 West Broadway, Suite 265
Frankfort, Kentucky 40601
(502) 695-0468

April 17, 2020

Ms. Todd Jeter
Division Administrator
Federal Highway Administration
330 West Broadway
Frankfort, Kentucky 40601

Re: FWS 2019-F-1687; Programmatic Biological Opinion on the Effects of Transportation Projects in Kentucky on the Indiana Bat and Gray Bat

Dear Mr. Jeter:

This letter transmits the enclosed biological opinion (BO) of the U.S. Fish and Wildlife Service (Service) for the implementation of transportation projects throughout Kentucky (Action). Acting on behalf of the Federal Highway Administration (FHWA), the Kentucky Transportation Cabinet will implement the Action. The Service received your letter requesting formal consultation for the Action and the Biological Assessment (BA) on September 27, 2019. You determined that the certain components of the Action are likely to adversely affect the Indiana bat (*Myotis sodalis*) and gray bat (*Myotis grisescens*).

The enclosed BO answers your request for formal consultation, and concludes that the Action is not likely to jeopardize the continued existence of the species listed above. This finding fulfills the requirements applicable to the Action for completing consultation under §7(a)(2) of the Endangered Species Act (ESA) of 1973, as amended.

The BA identified Conservation Measures to avoid and minimize effects on the Indiana bat and gray bat. Incidental take of listed species is exempted from the prohibitions against take under the ESA, provided the Action is implemented consistent with the manner identified in the BO.

Reinitiating consultation is required if the FHWA retains discretionary involvement or control over the Action (or is authorized by law) when:

a) the amount or extent of incidental take is exceeded;
b) new information reveals that the Action may affect listed species or designated critical habitat in a manner or to an extent not considered in this BO;

c) the Action is modified in a manner that causes effects to listed species or designated critical habitat not considered in this BO; or
d) a new species is listed or critical habitat designated that the Action may affect.

A complete administrative record of this consultation is on file in our office at the letter-head address. If you have any questions about the BO, please contact Phil DeGarmo by phone at 502-695-0468 x46110 or by email at Phil_Degarmo@fws.gov.

Sincerely,

VIRGIL ANDREWS

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Virgil Lee Andrews, Jr.
Field Supervisor

Enclosure

cc: Danny Peake, KYTC (electronic)
Doug Dawson, KDFWR (electronic)
Eric Rothermel, FHWA (electronic)

Programmatic Biological Opinion

Effects of Transportation Projects in Kentucky on the Indiana Bat and Gray Bat

FWS Log #: 04EK1000-2019-F-1687

Prepared by:

U.S. Fish and Wildlife Service
Kentucky Field Office
330 W. Broadway Street, Room 265
Frankfort, KY 40601

VIRGIL ANDREWS Digitally signed by VIRGIL ANDREWS Date: 2020.04.17 13:51:56 -04'00'

Virgil Lee Andrews, Jr.
Field Supervisor

April 17, 2020
Date

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CONSULTATION HISTORY

This section lists key events and correspondence during the course of this consultation. A complete administrative record of this consultation is on file in the Service's Kentucky Field Office.

April 2018 – July 2019	Early coordination meetings were held between the Federal Highway Administration (FHWA), Kentucky Transportation Cabinet (KYTC), and the Service to discuss project impacts and potential conservation measures.
September 27, 2019	The Service received a letter, dated September 27, 2019, and Biological Assessment (BA) from the FHWA requesting initiation of formal consultation on the Indiana bat and gray bat.
September 27, 2019	The Service responded to the FHWA, agreeing that the BA contains sufficient information to initiate formal consultation on adverse effects to the Indiana bat and gray bat, and formal consultation was initiated.
February 3, 2020	The Service and FHWA agreed in writing to extend the consultation timeframe one month.
February 9, 2020	The Service and FHWA agreed in writing to extend the consultation timeframe two weeks until March 23, 2020
March 19, 2020	The Service and FHWA agreed in writing to extend the consultation timeframe to allow sufficient time to review and comment on the draft document.
March 20, 2020	The Service submitted a draft Biological Opinion (BO) to the FHWA and the KYTC for their review.
April 8, 2020	The Service received comments on the draft BO.
April 17, 2020	The Service issued the final BO to the FHWA and the KYTC.

BIOLOGICAL OPINION

1 INTRODUCTION

A biological opinion (BO) is the document that states the opinion of the U.S. Fish and Wildlife Service (Service) under the Endangered Species Act of 1973, as amended (ESA), as to whether a Federal action is likely to:

a) jeopardize the continued existence of species listed as endangered or threatened; or
b) result in the destruction or adverse modification of designated critical habitat.

The Federal action addressed in this Programmatic BO is the Kentucky Transportation Cabinet's (KYTC) implementation of certain transportation projects throughout Kentucky (the Action) that would be funded or authorized by the Kentucky Division Office of the Federal Highway Administration (FHWA). FHWA supports State and local governments in the design, construction, and maintenance of the Nation's highway system through multiple funding programs. For the KYTC projects that involve federal permits, such as U.S. Army Corps of Engineers (USACE) permits under the Clean Water Act, the FHWA will generally be the lead federal agency for the purposes of consultation with the Service under Section 7 of the ESA. For the KYTC projects that involve Federal Land Management Agencies (FLMA), the FHWA would propose to use this programmatic consultation, initiate project specific consultation, or if applicable, use a consultation mechanism developed by the FLMA (e.g., existing consultations established for U.S. Forest Service, Tennessee Valley Authority, etc.). This BO considers the effects of the Action on the Indiana bat and gray bat. Together, these species will be referred to as the "covered" species.

Within the Action Area, the Service has designated critical habitat for the Indiana bat in Edmonson and Carter counties, Kentucky. Critical habitat has neither been designated nor is proposed for the gray bat. The Action will not affect Indiana bat critical habitat; therefore, this BO does not further address critical habitat.

A BO evaluates the effects of a Federal action, along with those effects resulting from interrelated and interdependent actions and effects from non-federal actions unrelated to the Action (cumulative effects), relative to the status of listed species and the status of designated critical habitat. A Service BO that concludes a proposed Federal action is *not* likely to jeopardize species and is *not* likely to destroy or adversely modify critical habitat fulfills the Federal agency's responsibilities under §7(a)(2) of the ESA of 1973, as amended.

"*Jeopardize the continued existence*" means to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species (50 CFR §402.02). "*Destruction or adverse modification*" means a direct or indirect alteration that appreciably diminishes the value of designated critical habitat for the conservation of a listed species. Such alterations may include, but are not limited to, those that alter the physical or biological features essential to the conservation of a species or that preclude or significantly delay development of such features (50 CFR §402.02).

Updates to the regulations governing interagency consultation (50 CFR part 402) were effective on October 28, 2019 [84 FR 44976]. This consultation was pending at that time, and we are applying the updated regulations to the consultation. As the preamble to the final rule adopting the regulations noted, "[t]his final rule does not lower or raise the bar on section 7 consultations, and it does not alter what is required or analyzed during a consultation. Instead, it improves clarity and consistency, streamlines consultations, and codifies existing practice." We have reviewed the information and analyses relied upon to complete this biological opinion in light of the updated regulations and conclude the opinion is fully consistent with the updated regulations.

2 PROPOSED ACTION

The proposed Action is the KYTC's implementation of projects funded or authorized by the FHWA in Kentucky. The KYTC maintains and constructs a wide variety of transportation infrastructure projects within Kentucky's 120 counties. The following provides a general description of the development, maintenance, and operation of these transportation infrastructure projects, and identifies components of the Action. These Action components have the potential to generate stressors that may affect the covered species or alter their environment. In addition, the FHWA and the KYTC are committed to implementing the conservation measures discussed below in order to avoid, minimize, and/or compensate for project effects to the covered species.

2.1 Action Components

There are several phases involved in the development, maintenance, and operation of transportation projects, and most projects are conducted in phases that are tied directly to funding authorizations for the entire project or specific phase. The phases in project development are considered the Action components of this proposed action and include:

1. Planning,
2. Preliminary Design and Environmental,
3. Detailed Design, Right-of-Way (ROW) and Utilities,
4. Construction,
5. Maintenance,
6. Operation, and
7. Other/Emergency Actions

However, not every KYTC project will include all seven Action components. For example, the Planning component is typically reserved for those projects where a large number of alternatives are assessed to fulfill a transportation need; the Utilities component is only necessary when relocation of existing utilities is required for construction; and emergency Actions cannot be predicted, and depending on the severity of the action, one or all of the aforementioned Action components may apply. Nonetheless, a more detailed description of each Action component follows, along with the identification of stressors that may affect the covered species.

2.1.1 Action Component 1: Planning

The planning component is comprised of gathering data, analysis, and public involvement. Corridors for possible highway improvements, either along existing or on new alignments, are analyzed for feasibility, public acceptability, potential to meet project purpose and need, and environmental impacts. Review and compilation of existing data (e.g., crash data, traffic data, etc.) is undertaken, with some field verification.

- No stressors with the potential to affect the covered species and/or alter their environment have been identified during the planning component of the Action. FHWA has determined that the planning component will have no effect on the covered species, and we agree with this conclusion.

2.1.2 Action Component 2: Preliminary Design and Environmental

During the preliminary design component of a project, potential solutions to address transportation needs are better defined and are more thoroughly examined for feasibility. The design team creates alternatives for study and analysis. Environmental investigations, including aquatic and terrestrial species studies, are also conducted during this component. Some of these activities, such as mist netting, cave exploration, etc. could affect the covered species, but these activities are conducted only by qualified biologists who possess a Scientific Wildlife Collecting Permit from the Kentucky Department of Fish and Wildlife Resources (KDFWR) and a Section 10 Recovery Permit (Federal Fish and Wildlife Permit) from the U.S. Fish and Wildlife Service. Any intentional take as a result of these surveys is authorized under the Section 10 federal permit and is, therefore, not a component of the prosed action. The outcome of this component is the selection of the location and type of transportation improvement that will be implemented.

- No stressors with the potential to affect the covered species and/or alter their environment have been identified during the preliminary design and environmental component of the Action. FHWA has determined that this component will have no effect on the covered species, and we agree with this conclusion.

2.1.3 Action Component 3: Detailed Design / ROW and Utilities

After establishing the preliminary alignment and grade of the proposed project, a more detailed level of design is undertaken. Line and grade are adjusted to better meet conditions, and drainage structures are designed. As plans are defined in greater detail, right-of-way acquisition and utility relocations are examined. Right-of-way activities include determining the land acquisition needs for the project, conducting negotiations with property owners, and acquisition of land. Existing utilities are analyzed to determine if relocation is necessary for the project. Geotechnical investigations may also be conducted during this component.

During this component, there are very few activities that could potentially impact the covered species. Geotechnical investigations may require removal of forested habitat to access drilling areas and conduct drilling operations. This type of activity is typically minimized to prevent excessive habitat disturbance, primarily because the KYTC often does not yet own or have an easement on the area where the activity is undertaken. Forested habitats may also be removed during ROW and utility activities in association with the detailed design component, although this occurs infrequently due to added mobilization and project costs.

- Geotechnical investigations and ROW and utility work activities could result in the following stressors that may affect the covered species: noise and vibration and tree removal. These effects on the covered species would be similar to those discussed in the following construction component and will be considered in conjunction with construction activities within the Effects of the Action Section of this BO.

2.1.4 Action Component 4: Construction

This Action component includes four primary sub-activities: 1) Site Preparation, 2) Bridge and Culvert Construction, 3) Roadway Construction, and 4) Post Construction.

Site Preparation

Site preparation may require removal of forested habitat to access the project site and prepare the area for construction. The KYTC anticipates the removal of approximately 1000 acres of forested habitat annually with projects considered in this consultation. This activity also includes implementation of Best Management Practices (BMPs) to avoid and minimize impacts to streams and other water bodies that may provide foraging habitat for the covered species.

Bridge and Culvert Construction

Bridge and culvert construction range from minor rehabilitation activities of existing structures to full structure replacement to construction of new structures at new locations. These activities are intended to extend the useful life of an existing structure or provide a new structure to maintain safe vehicular crossings. Bridge rehabilitation activities include maintenance and repair of existing structures and do not usually alter the existing form of the structure. The majority of bridge rehabilitation activities are limited to the repair or replacement of specific parts of the bridge deck, superstructure, or substructure and do not require complete replacement of major bridge components. Deck maintenance and repair are standard activities that typically occur on the top of the bridge deck. These activities include spall repair, crack sealing, barrier wall/railing repair, drain/scupper repair, and header/expansion joint repair. Repair of spalling and cracking on the bridge deck and barrier wall/railing requires the removal of loose or unsound material with jackhammers, concrete saws, milling or grinding equipment, or hydro-demolition equipment to expose sound material. Debris is collected using vacuum equipment, and the void is filled with the appropriate surfacing material (concrete or asphalt). Small surficial cracks can be repaired by sealing with epoxy or other suitable material to prevent water intrusion. Deck drains, scuppers, and other drainage structures that direct water away from the deck are typically maintained using hand tools, power washers, or compressed air to remove clogs. If severely deteriorated, pipes are cut using a cutting torch or other suitable tool, and a new section of pipe is added with a flexible coupler. Header and/or expansion joints allow expansion and contraction of the deck and are typically closed to prevent water intrusion. Closed joints typically consist of a concrete header with steel plates on the surface, with flexible material in the joint between the steel plates or under the plates. The sealing material in the joint can become dislodged, torn, or punctured and must be removed and replaced to reseal the joint. The steel plates of the expansion joints can become damaged by heavy vehicles or snow plows, and the concrete headers can be damaged or deteriorate. Depending on the severity of the damage and deterioration, a portion of the header or steel can be removed using a cutting torch or concrete saw.

Maintenance and repair activities on bridge superstructures and substructures include: spall and crack repair of girders/beams, caps-columns, end walls, and abutments; drilling/bolting of additional support members to metal beams; footer/piling repair; bearing replacement; metal repainting; scour repair around piers and abutments; and temporary work structures. Similar to maintenance of concrete on the bridge deck, spall and crack repair requires the removal of loose and unsound material; however, smaller, hand equipment such as hammer drills and hammer/chisel are used on the superstructure and substructure to avoid compromising these structures. Debris is collected using vacuum equipment or other methods, and the void or crack is filled with the appropriate surfacing material. Small surficial cracks may be repaired by sealing with epoxy or other suitable material. Maintenance and repair of metal components may require bolting or welding of additional plates to the existing structure. These activities require hand tools to clean and install the new support material. Replacement of bridge bearings requires the temporary use of hydraulic jacks to eliminate loads and provide support until new bearings are installed. Painting of metal structure components may be performed as a separate activity or in conjunction with other repair activities. Prior to painting, the surface is cleaned to remove loose material, and paint is applied using air compressors. Overspray is controlled through the use of temporary barriers or drapes. Scour repair involves the placement of rip rap or other channel protection around existing piers and abutments to replace lost material around the bases of these structures and prevent future scouring. Temporary coffer dams may be placed around piers and abutments to isolate these areas during repairs, create a safe, dry workspace, and prevent material from entering the stream.

Methods used to access the superstructure and substructure during rehabilitation activities include ladders, scaffolding, and truck mounted booms. Temporary structures, such as work pads or crossings, may be required to access longer bridges that span streams. Work pads are typically constructed of large rock placed within the stream channel to create a safe work platform for equipment. Temporary crossings are installed across streams when traffic must be restricted from the bridge during construction and a detour is not available or feasible. Crossings generally consist of large pipes laid in the stream channel parallel to flow and covered with rock. The size and placement of the pipes is determined by the stream hydrology.

Bridge replacement activities include replacement of major bridge components and full replacement of the entire structure. These activities require high intensity construction activities using heavy equipment and result in significant impacts to the existing structure, as well as potential changes to structure form. Activities include removal and replacement of the deck, support beams/girders, piers, and abutments. Temporary work structures, including coffer dams, work pads, and crossings, may also be required for replacement activities.

Culvert rehabilitation and replacement activities are similar to those associated with bridge activities; however, culvert activities are typically smaller in scale and more limited in scope. Rehabilitation activities generally include spall and crack repair on concrete surfaces and patching of metal surfaces through bolting/welding of additional plates. Culvert replacement involves the removal of the existing structure and installation of a new structure at the same location with similar materials. New structures may be completely or partially pre-fabricated off site or constructed on site, and heavy equipment is typically required during installation.

Roadway Construction

Roadway construction ranges from spot improvements, widening, and reconstruction of existing roadways within existing or new alignments to the construction of new roadways with completely new alignments. Activities associated with roadway construction may include demolition and removal of existing facilities, clearing, grubbing, excavation, blasting, grading, and reconstruction/construction of the roadway and associated structures. These activities typically require the use of heavy equipment, with activity intensity varying based on project type.

Post Construction

Following bridge, culvert, and/or roadway construction, the sites are stabilized and restored using a variety of techniques. Exposed areas are typically mulched and seeded and/or planted with shrubs or trees. Temporary access material is removed and areas are restored to a more natural grade and stabilized. This activity also includes implementation of permanent BMPs to avoid and minimize impacts to streams and other water bodies.

Construction Summary

The Construction component and its four primary sub-activities: 1) Site Preparation; 2) Bridge and Culvert Construction; 3) Roadway Construction; and 4) Post Construction will result in adverse effects on the covered species. The majority of these effects are due to removal or alteration of suitable roosting habitat. Suitable roosting habitat for Indiana bats consists of forested habitat, while suitable roosting habitat for gray bats is typically caves of cave-like habitat. However, both species will use certain bridges for roosting habitat. Conservation measures, such as sediment and erosion control measures, tree clearing restrictions during the timeframe when non-volant young are present, limiting impacts to no more than 250 acres of suitable, forested habitat per project, and avoidance of adverse effects on maternity colonies that utilize a bridge and hibernacula, will be implemented to avoid and minimize impacts to the species. Conservation measures that will be implemented as part of the proposed action are discussed below in section 2.4.

- We expect the construction component of the Action to generate the following stressors that may affect the covered species: noise and vibration, night lighting, aquatic resource loss and degradation, tree removal, collision, alteration or loss of roosting habitat of bridges. These stressors are discussed in detail within the Effects of the Action Section of this BO.

2.1.5 Action Component 5: Maintenance

In order to maintain safe roadways and ease congestion, the KYTC performs maintenance activities on roads and bridges year-round. The maintenance work is similar to the construction component but is typically on a much smaller scale and scope. The majority of the maintenance work performed does not result in significant adverse effects on the covered species. Some of these activities include installing/replacing guardrail and signage, striping, asphalt repair/patching, mowing of herbaceous growth within existing ROW, roadside ditch maintenance, removing debris from bridge piers, and repair existing lighting. Maintenance activities are anticipated to occur during daylight hours and will not require the use of lighting.

Occasionally, certain maintenance activities can have potential adverse effects on the covered species and those activities include slide repair, tree-trimming and clearing within existing ROW, herbicide application, and bridge/culvert maintenance. All of these activities are necessary to extend the life of existing infrastructure, and have the ability to impact habitat for the covered species.

- Maintenance activities have the ability to alter or remove suitable habitat for the covered species. We expect the maintenance component of the Action to generate the following stressors that may affect the covered species: noise and vibration, aquatic resource loss and degradation, tree removal, alteration or loss of roosting habitat of bridges. These stressors are discussed in detail within the Effects of the Action Section of this BO.

2.1.6 Action Component 6: Operation
After a project is completed, the roadway/bridge is expected to continue in operation indefinitely. Operation activities include vehicle traffic and roadway illumination. These activities vary depending on road size, location, time of day/year, and have the potential to affect the covered species.

- We expect the operation component of the Action to generate the following stressors that may affect the covered species: noise and vibration, night lighting, aquatic resource loss and degradation, and collision. These stressors are discussed in detail within the Effects of the Action Section of this BO.

2.1.7 Action Component 7: Other/Emergency Actions
The KYTC occasionally has emergency actions that require immediate attention and repair. These include, but are not limited to, bridge collapse or damage, rock fall or slides that endanger a roadway, and other potentially hazardous situations. These activities often occur in concert with a declared state of emergency (usually after severe weather such as; flooding, ice storm, tornado, or heavy snowfall) and have the potential to have adverse effects on the covered species depending on project specific scenarios.

- We expect that activities associated with the emergency action component of the Action to generate the same stressors as those previously discussed in the construction component. Emergency actions will be considered in conjunction with construction activities within the Effects of the Action Section of this BO.

2.2 Action Area
For purposes of consultation under ESA §7, the Action Area is defined as "all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action" (50 CFR §402.02). The action area for this consultation includes all lands within the geo-political boundaries of the Commonwealth of Kentucky and those portions of Missouri, Illinois, Indiana, Ohio, West Virginia, Virginia, and Tennessee that occur within 20 miles of the Kentucky state line (the Action Area). This Action Area recognizes that projects associated with the Action: (a) are likely to occur at scattered and undeterminable locations across the Commonwealth; (b) may cross into adjacent states; and (c) will vary in size and distribution on the landscape.

2.3 Project Review Process

The KYTC proposes to use a tiered programmatic approach for the project review process. This project review process will be used to determine if suitable habitat for any of the covered species is present within the affected area of a proposed project. The first tier involves the use of a Habitat Assessment Manual (HAM) developed by the KYTC in 2006, and revised in 2018 (See Appendix A of the BA). If habitat is determined, by a KYTC biologist or ecological consultant working for KYTC, not to be present for any of the covered species (as determined by the process contained within the HAM) then the project will have "no effect" on that particular species. Conversely, if habitat is present for one or more of the covered species, then the project will be evaluated as part of the second tier of the programmatic approach. The second tier involves the analysis of potential impacts (i.e., stressors) of proposed projects on the covered species and their habitats to determine if the project is likely to adversely affect the covered species. See Appendix B of the BA for an outline of the two-tiered methodology and a discussion of the programmatic project review process.

2.4 Conservation Measures

Conservation measures are those proposed actions taken to benefit or promote the recovery of the species. These actions taken by the federal agency (FHWA) or the applicant (KYTC) serve to avoid, minimize and/or compensate for project effects on the species under review and are included as an integral portion of the Action. The FHWA and the KYTC have committed to implement the following conservation measures as part of the Action:

2.4.1 Indiana Bat

Avoidance and Minimization Measures

1) The KYTC will utilize BMPs and sediment and erosion control measures to prevent non-point source pollution, control storm water runoff, and minimize sediment damage in order to avoid and reduce overall water quality degradation. Implementation would avoid and minimize negative effects on clean drinking water, aquatic insects that could be used as prey items by Indiana bats, and aquatic insect habitat. The BMPs proposed can be found in Appendix C of the BA.

2) The KYTC will restrict forested habitat removal during the time frame when non-volant Indiana bat pups could be present (June 1-July 31), minimizing the risk of potential effects on non-volant Indiana bats. If forested habitat removal during this timeframe is unavoidable, the KYTC will consult with the Service's Kentucky Field Office (KFO) on a project-specific basis in order to determine if use of the programmatic process is acceptable.

3) The KYTC will utilize the project review process discussed in Section 2.3 in order to determine potential project impacts on the Indiana bat. If a project requires the five types of impacts identified below, the KYTC will contact the KFO and request a project-specific consultation to consider those types of effects on the species and/or its habitat.
    a) Projects that identify caves, mine adits, rock shelters, and/or karst features that are suitable as either winter habitat and/or summer roosting habitat for the Indiana bat within a half mile of the project area.
    b) Project effects on a bridge structure that is known or has been identified as reasonably likely to support a maternity colony of Indiana bats.

c) Project impacts on a known Indiana bat maternity roost tree.
d) Project impacts within 1/2-mile of a known Indiana bat hibernacula (i.e., spring staging area).
e) Project impacts to more than 250 acres of suitable, forested habitat per project.

Compensation Measures

1) In order to offset unavoidable adverse effects on Indiana bats and their summer roosting and fall swarming habitat(s), the KYTC will contribute to the Imperiled Bat Conservation Fund (IBCF). The funds in the IBCF are used to permanently protect Indiana bat habitat in Kentucky for the conservation and recovery of the species. This mitigation measure would have a beneficial effect on the Indiana bat by ensuring that the species has suitable habitat available throughout their lifecycle. The contribution to the IBCF is expected to promote the survival and recovery of the species through protecting and managing existing forested habitat suitable to support the species, particularly those that would expand existing conservation ownerships and/or those in areas already known to be used by the species.

   The KYTC proposes that contributions to the IBCF will be determined and computed on a project-by-project basis and will be based on the following formula: (acreage of impact) X (median land cost) X (mitigation multiplier) = amount of contribution.

   The acreage of impact (Acreage) will be the number of acres of suitable Indiana bat forested habitat that a proposed project will adversely affect. For impacts to: a) continuous, unbroken habitat areas, the Acreage will be the number of acres to the nearest hundredth acre; b) areas containing widely spaced or less than 20 trees, the Acreage will be the number of trees that have been determined to exhibit those characteristics suitable for Indiana bat summer habitat (any tree over 5" diameter at breast height) present within the impacted area multiplied by 0.09 (the area occupied by a tree with a 35-foot crown radius); and c) projects containing both continuous, unbroken habitat and widely spaced, fragmented or less than 20 tree, Acreage will be determined using a combination of both calculation methods described above.

   Through an on-going assessment of bridges within the Commonwealth of Kentucky, the KYTC has reviewed 260 structures throughout the state. The assessed bridges have represented a variety of sizes and bridge types, including bridges from 21 to 727 feet long and bridge types, including channel beam, box beam, pre-stressed concrete beam, metal beams, box culverts, and numerous others. The majority (92%) of these structures were identified as either unsuitable for bats or no bats or signs of bat use were observed. The remaining bridges (8%) had bats of various species actively roosting on the structure or signs of bat use were observed. To determine the amount of potential roosting habitat for bats on each bridge, the bridge length and width were multiplied to calculate an acreage for each structure. Structures with documented bat use are generally larger than the average bridge, with a median size of 0.10 acre for bridges with bat use compared to 0.02 acre for all the bridges assessed to date. Based on this data, the KYTC proposes to use 0.10 acre per bridge to calculate the amount of suitable bat habitat loss for projects involving bridge impacts.

The median land cost will be the most recently published median agricultural land cost on a per acre basis. This cost is intended to provide an index of the estimated replacement cost of forested Indiana bat habitat in Kentucky. This number will be updated each time the United States Department of Agriculture publishes a new cost (typically the beginning of August).

The mitigation multiplier factor is derived from the habitat type that will be impacted and season when project impacts occur. The Indiana bat habitat map (attached as Appendix D in the BA) displays the habitat types that are based on the known records of Indiana bat captures and hibernacula locations. Table 1 shows each mitigation multiplier, based on habitat type, and the seasonal dates of each habitat type depicting when that habitat is expected to be active (i.e., in use) or inactive (i.e., not in use) by Indiana bats.

Table 1. Proposed Indiana Bat Mitigation Multiplier Matrix

Habitat Type	Active Season (**)	Active Dates	Inactive Season	Inactive Dates
Known Swarming	2.25 (2.75)	April 1 to Nov 14	1.75	Nov 15 – March 31
Known Summer	1.75 (2.25)	April 1 to Oct 14	1.25	Oct 15 – March 31
Unsurveyed	1.0 (1.5)	April 1 to Oct 14	0.5	Oct 15 – March 31

** Ratio for tree removal in June and July is in parentheses. Use of this ratio requires the KYTC's coordination with the KFO for project specific evaluation in advance of proposed impacts.
NOTE: For the purposes of the mitigation multiplier matrix, swarming active season dates also consider the active dates of known summer and unsurveyed habitat types because Indiana bats likely use known swarming areas during these active timeframes of their life cycle as well.

2) If it is determined that a different mitigation opportunity (i.e., range-wide ILF program, species mitigation bank, in-kind mitigation, etc.) is available and/or more appropriate, the KYTC will coordinate with the KFO to ensure project impacts are accounted for sufficiently.

2.4.2 Gray Bat

Avoidance and Minimization Measures

1) Potential impacts to gray bat foraging and aquatic resources will be minimized by limiting tree clearing along streams to the extent possible, avoiding and minimizing impacts to streams during construction, and implementation of BMPs as listed in Appendix C in the BA.

2) The KYTC will utilize the project review process discussed in Section 2.3 in order to determine potential project impacts on the gray bat. If a project requires the two types of impacts identified below, the KYTC will contact the KFO and request a project-specific consultation to consider those types of effects on the species and/or its habitat.
   a) Projects that identify caves, mine adits, rock shelters, and/or karst features that are suitable as either winter habitat and/or summer roosting habitat for the gray bat within a half mile of the project area.

b) Project effects on a bridge structure that is known or has been identified as reasonably likely to support a maternity and/or bachelor colony of gray bats.

Compensation Measure

1) In order to offset unavoidable adverse effects on gray bats utilizing bridges as roosting habitat, the KYTC is committed to funding the protection of a known gray bat maternity site and surrounding habitat. This conservation measure would have a beneficial effect on the gray bat by ensuring that the species has suitable habitat available for roosting and rearing of pups during the summer period of its lifecycle. Funding this conservation measure is expected to promote the survival and recovery of the species through protecting and managing existing year round roosting habitat suitable to support the species, particularly one that would expand conservation ownerships.

2.5 Interrelated and Interdependent Actions

A BO evaluates the effects of a proposed Federal action. For purposes of consultation under ESA §7, the effects of a Federal action on listed species or critical habitat include the direct and indirect effects caused by the Action, plus the direct and indirect effects caused by interrelated or interdependent actions. "Indirect effects are those that are caused by the proposed action and are later in time, but still are reasonably certain to occur. Interrelated actions are those that are part of a larger action and depend on the larger action for their justification. Interdependent actions are those that have no independent utility apart from the action under consideration" (50 CFR §402.02).

In its request for consultation, the FHWA did not describe any interrelated or interdependent actions to the Action. If any interrelated or interdependent actions are identified in the future, the FHWA will determine if it is appropriate to be the lead federal agency for the purposes of consultation with the Service under Section 7 of the ESA. Use of this programmatic consultation and authorized incidental take would be determined at that time in coordination with the KFO. This BO does not further address the topic of interrelated or interdependent actions to the Action.

2.6 Summary

The programmatic BA considered the KYTC's activities across the state and identified several action components. Specifically, the Detailed Design Component (geotechnical work, ROW, and utilities), Construction Component, Maintenance Component, Operation Component, and Other/Emergency Actions Component have been identified as action components having the ability to impact the covered species. Activities associated with the Detailed Design Component (geotechnical work, ROW, and utilities) and Other/Emergency Actions Component would be similar to those discussed in the Construction Component Section (Section 2.1.4). Subsequently, KYTC considered the effects of these components in conjunction with the Construction Component in the Effects of the Action Section of the BA. The BA also identified stressors for each of these action components (Construction, Maintenance, and Operation) and provided an analysis of how those stressors would affect the covered species and/or their habitat.

These action components (Construction, Maintenance, and Operation) may take up to 6 years to complete, depending on the complexity of any individual project. Effects on the covered species may occur through impacts to the species or changes to the species' baseline habitat conditions (noise, lighting, water quality, and forested habitat, etc.) within the Action Area. Based on our evaluation of the BA and the aforementioned action components, the programmatic action will result in the following stressors as summarized in Table 2 below; these stressors and their effects on the covered species are discussed in the Effects of the Action Section of this BO.

Table 2. Stressors by Activity Component

	Activity Component		
Stressors	Construction	Maintenance	Operation
Noise and Vibration	X	X	X
Night Lighting	X		X
Aquatic Resource Loss and Degradation	X	X	X
Tree Removal	X	X	
Collision	X		X
Alteration or Loss of Roosting Habitat on Bridges	X	X	

3 INDIANA BAT

3.1 Status of the species

This section summarizes the best available data about the biology and current condition of the Indiana bat (*Myotis sodalis*) throughout its range that are relevant to formulating an opinion about the Action. The Service published its decision to list the Indiana bat as endangered on March 11, 1967 (Federal Register 32[48]:4001) under the Endangered Species Preservation Act of October 15, 1966 (80 Stat. 926; 16 U.S.C. 668aa[c]). The Endangered Species Act (ESA) of 1973 (87 Stat. 884, as amended; 16 U.S.C. 1531 et seq.) subsequently extended full legal protection from unauthorized take to the species. Critical habitat was designated for the species on September 24, 1976 (41 FR 14914). Thirteen hibernacula, including 11 caves and two mines in six states, were designated as critical habitat.

The Service has published a recovery plan that outlines recovery actions (U.S. Fish and Wildlife Service (USFWS) 1983). Briefly, the objectives of the plan are to: (1) protect hibernacula; (2) maintain, protect, and restore summer maternity habitat; and (3) monitor population trends through winter censuses. An agency draft of a revised recovery plan was provided for public review and comment in the Federal Register on April 9, 1999, but has not yet been finalized. A revised draft recovery plan was noticed in the Federal Register for public review and comment on April 16, 2007 (USFWS 2007).

The Service's Bloomington, Indiana Field Office completed a 5-Year Review of the Indiana bat (USFWS 2009), which summarizes the current status of the species, its progress toward recovery, and the remaining threats to the species. The draft recovery plan and 5-Year Review are available at http://www.fws.gov/midwest/Endangered/mammals/inba/index.html and are hereby incorporated by reference. The 5-Year Review found that all of the required recovery criteria for the Indiana bat had not been achieved, so the species should remain at its current endangered status.

3.2 Species Description

The Indiana bat is a temperate, insectivorous, migratory bat that hibernates in caves and mines in the winter and summers in forested areas. It is a medium-sized bat, having a wing span of 9 to 11 inches and weighing only one-quarter of an ounce. It has brown to dark-brown fur and the facial area often has a pinkish appearance. The Indiana bat closely resembles the little brown bat (*Myotis lucifugus*) and the northern long-eared bat (*Myotis septentrionalis*). It is distinguished from these species by its foot structure and fur color. The Indiana Bat Draft Recovery Plan (USFWS 2007) provides a comprehensive summary of the description of the species and is incorporated by reference.

3.3 Life History

The life cycle of the Indiana bat is summarized in Figure 1. The species hibernates in caves and mines in the winter (typically October through April) and migrates to forested summer habitat. When arriving at their traditional hibernacula in August-October, Indiana bats "swarm" for several weeks prior to hibernation. Some male bats may begin to arrive at hibernacula as early as July, but females typically arrive later. The time of highest swarming activity in Indiana and Kentucky has been documented as early September (Cope and Humphrey 1977). Swarming is a critical part of the life cycle when Indiana bats converge at hibernacula, mate, and forage until sufficient fat reserves have been deposited to sustain them through the winter (USFWS 1983). Swarming behavior typically involves large numbers of bats flying in and out of cave entrances throughout the night, while most of the bats continue to roost in trees during the day (Cope and Humphrey 1977). Body weight may increase by 2 grams within a short time, mostly in the form of fat. Copulation occurs on cave ceilings near the cave entrance during the latter part of the swarming period (USFWS 2007). Females may mate their first autumn, whereas males may not mature until the second year (USFWS 2007). By late September, many females have entered hibernation, but males may continue swarming well into October in what is believed to be an attempt to breed with late arriving females.

The initiation of hibernation may vary by latitude and annual weather conditions; however, most bats are hibernating by the end of November (USFWS 2007). Hibernation facilitates survival during winter when insect prey is unavailable. Hibernating Indiana bats cluster on cave ceilings from approximately October through April. Limited mating occurs throughout the winter and in early April as bats emerge (USFWS 2007).

Spring emergence occurs when outside temperatures have increased and insects (forage) are more abundant (Richter et al. 1993). Most Indiana bats emerge in late March or early April; the timing of annual emergence may vary across the range depending on latitude and annual weather conditions. Females emerge before males. Shortly after emerging from hibernation, the females become pregnant via delayed fertilization from the sperm that has been stored in their reproductive tracts through the winter (USFWS 2007). During the "staging" period, the bats forage for a few days or weeks near their hibernaculum before migrating to their traditional summer roosting areas.

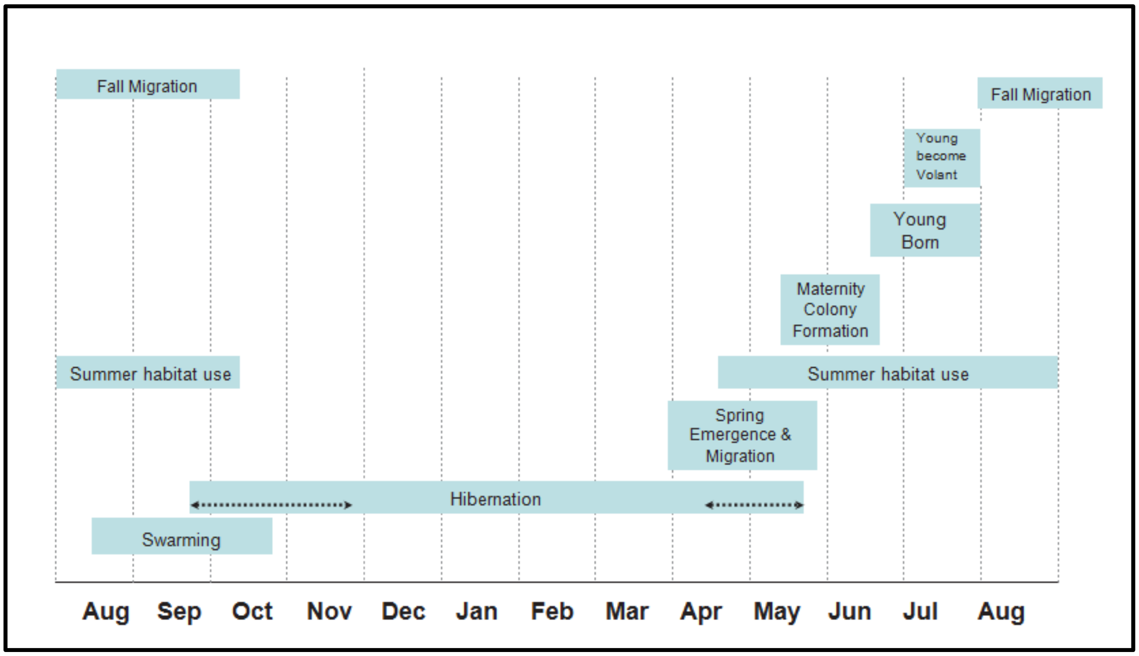

Figure 1. Indiana bat annual chronology (USFWS 2007).

Most populations leave their hibernacula to migrate to summer habitat by late April. Some reproductive females have been documented to migrate up to 357 miles (Winhold and Kurta 2006) to form maternity colonies; others have been found to form maternity colonies within only a few miles of their hibernacula (U.S. Army Garrison Fort Drum 2011). Males are commonly found roosting near the hibernacula but have also been documented to migrate long distances to their summer habitat (Kurta and Rice 2002). Migration is stressful for the Indiana bat, particularly in the spring when their fat reserves and food supplies are low. As a result, adult mortality may be the highest in late March and April.

Female Indiana bats, like most temperate members of the family Vespertilionidae, give birth to one young each year (Mumford and Calvert 1960, Humphrey et al. 1977, Thomson 1982). The proportion of female Indiana bats that produce young is not well documented. At a colony in Indiana, 23 of 25 female Indiana bats produced volant young during one year and 23 of 28 females the following year (Humphrey et al. 1977). Based on cumulative mist-netting captures over multiple years, Kurta and Rice (2002) estimated that 89% of adult females in Michigan maternity colonies were in reproductive condition (pregnant, lactating, or post-lactating).

Racey (1982) notes that a particular ratio of fat to lean mass is normally necessary for puberty and the maintenance of female reproductive activity in mammals. He suggests further that the variation in the age of puberty in bats is due to nutritional factors, possibly resulting from the late birth of young and their failure to achieve threshold body weight in their first autumn. Once puberty is achieved, reproductive rates frequently reach 100% among healthy bats of the family Vespertilionidae and young, healthy female bats can mate in their first autumn as long as their prey base is sufficient to allow them to reach a particular fat to lean mass ratio.

Studies by Belwood (2002) show asynchronous births among members of a colony. This results in great variation in size of juveniles (newborn to almost adult size young) in the same colony. Young Indiana bats are capable of flight within a month of birth. Young born in early June may be flying as early as the first week of July (Clark et al. 1987), with others flying from mid- to late July. Mortality between birth and weaning was found to be about 8% (Humphrey et al. 1977).

The average life span of the Indiana bat is 5 to 10 years, but banded individuals have been documented living as long as 14 and 15 years (Humphrey and Cope 1977). Using winter sampling of unknown-age bats over a 23-year period, Humphrey and Cope (1977) estimated annual survival. Female survivorship in an Indiana population was 76% for ages 1 to 6 years and 66% for ages 6 to 10 years. Male survivorship was 70% for ages 1 to 6 years and 36% for ages 6 to 10 years. Following 10 years, the survival rate for females dropped to only 4% (Humphrey and Cope 1977).

3.4 Habitat Characteristics and Use of the Indiana Bat

Winter Habitat

Indiana bats roost in caves or mines with configurations that provide a suitable temperature and humidity microclimate (Brack et al. 2003, USFWS 2007). Requirements for hibernacula are discussed in the draft Recovery Plan for the species (USFWS 2007).

Summer Habitat

Summering Indiana bats (males and females) use forested habitat for roosting, foraging, and commuting. Indiana bats are often associated with floodplain or riparian forests with large trees, scattered canopy gaps, and open understories (USFWS 2007). Research has showed adaptability in habitats used, including upland forests, forests altered by grazing, swine feedlots, row-crops, hay fields, residences, clear-cut harvests, and shelterwood cuts (Garner and Gardner 1992, USFWS 1999).

Suitability of a roost tree is determined by its condition (dead or alive), suitability of loose bark, solar exposure, spatial relationship to other trees, and tree's spatial relationship to water sources and foraging areas. Potentially suitable roost trees can be trees of any species with bark separating from the tree after the tree dies, senesces, or is injured and living species of hickories (*Carya* spp.) and large white oaks (*Quercus alba*) with shaggy bark. Many maternity colonies have been associated with oak-hickory and elm-ash-cottonwood forest types. Tree cavities, hollow portions of tree boles or limbs, and crevice and splits from broken tops occasionally have been used as roosts, usually by individual bats. Roost longevity is variable due to many factors, such as the rate at which bark sloughs off or the tree falls down. Some roosts may only be habitable for 1-2 years, but species with good bark retention, such as slippery elm (*Ulmus rubra*), cottonwood (*Populus deltoides*), green ash (*Fraxinus pennsylvanica*), and various oaks (*Quercus* spp.) and hickories (*Carya* spp.) may provide habitat for 4-8 years (USFWS 1999).

Trees in excess of 40 cm (15.7 in) diameter-at-breast-height (dbh) are considered optimal for maternity colonies, but trees in excess of 22 cm (8.6 in) dbh are used as alternate roosts (USFWS 2002). Females have been documented using roost trees as small as 14 cm (5.5 in) dbh (Kurta 2005). The average size of roost trees used by males tends to be smaller than the roost trees used by female maternity colonies; in one instance, a male was observed in a roost tree 6.4 cm (2.5 in) dbh (Gumbert et al. 2002).

Maternity colonies have been documented to use 8 to 25 roost trees per season (Callahan et al. 1997, Kurta et al. 2002). The extent and configuration of the roosting area is probably determined by availability of suitable roost trees. Distances between roosts can be a few meters to a few kilometers (Kurta et al. 1996, 2002). Primary roosts are generally larger in diameter and located in openings or at the edge of forest stands, while alternate roosts can either be in openings or the interior of the forest stand. Maternity colony movements among multiple roosts seem to depend on climatic changes, particularly solar radiation (Humphrey et al. 1977). Cool temperatures can delay fetal development and growth of juvenile young; selection of maternity roost sites may be critical to reproductive success. Kurta et al. (1993) suggest movement between roosts may be the way that bats deal with the ephemeral nature of roost trees. It is not known how many alternate roosts must be available to assure retention of a colony within a particular area, but large, nearby forest tracts would improve the potential for an area to provide adequate roosting habitat (Callahan 1993, Callahan et al. 1997).

Indiana bats feed on aquatic and terrestrial insects. Diet varies seasonally and among different ages, sexes, and reproductive status (USFWS 1999). Numerous foraging habitat studies have found that Indiana bats forage in closed to semi-open forested habitats and forest edges located in floodplains, riparian areas, lowlands, and uplands; old fields and agricultural fields are also used (USFWS 2007; Sparks et al. 2005). Indiana bats frequently forage along riparian corridors and obtain water from streams; ponds and water-filled road ruts in the forest uplands are also serve as water sources.

Very little research has focused on the use of travel corridors by Indiana bats. Apparently suitable, but distant, forest patches may not be available to Indiana bats unless they are connected by a wooded corridor; however, the maximum size of an opening Indiana bats may cross is not known. General observations and data collected incidentally in studies indicate that Indiana bats select forested corridors when commuting to avoid flying over open areas (ESI 2006; Murray and Kurta 2004). However, Indiana bats have been observed flying across gaps in habitat (Kniowski and Gehrt 2014) including major roads, though they are often deterred by traffic (Zurcher et al. 2010).

Home range, the area in which an Indiana bat forages, commutes, and roosts, may vary in size between seasons, sexes, and reproductive status of the females (Lacki et al. 2007). Menzel et al. (2005) tracked seven female and four male Indiana bats from May to August in Illinois. No significant differences in home ranges between males and females were observed, and home range estimates were subsequently grouped to obtain a mean summer home range of 144.4 hectares (357 acres). Watrous et al. (2006) calculated a mean home range of 83 hectares (205 acres) for 14 female Indiana bats in Vermont. Without site-specific data, the Service generally considers the potential home range for an Indiana bat to include all suitable habitat within 4 km (2.5 mi) of documented roost(s) (USFWS 2011), recognizing the area of actual use may be just a portion of that area.

Indiana bats show a high degree of fidelity to roost trees, roosting areas, and foraging areas (Gardner et al. 1991; Humphrey et al. 1977; Kurta et al. 1996, 2002; Kurta and Murray 2002; Gumbert et al. 2002). Bats using familiar foraging and roosting areas are thought to benefit from decreased susceptibility to predators, increased foraging efficiency, and the ability to switch roosts in case of emergencies or alterations surrounding the original roost (Gumbert et al. 2002).

Spring and Fall Habitat
In the spring, Indiana bats usually roost, forage, and commute in habitat similar to those selected during the summer. These areas are most typically within 10 miles of a P1/P2 hibernaculum and 5 miles of a P3/P4 hibernacula*; however, use of habitat areas that are farther than 10 miles from a P1/P2 hibernaculum or farther than 5 miles from a P3/P4 hibernaculum have been documented (Kiser and Elliot 1996; MacGregor et al. 1999; Rommé et al. 2002; Hawkins et al. 2005).

3.5 Numbers, Reproduction, and Distribution

Indiana bats are found over most of the eastern half of the United States. Winter surveys in 2016-2017 found hibernating Indiana bats dispersed across 17 states. However, over 95% of the estimated range-wide population hibernated in four states – Indiana (34%), Missouri (41.1%), Kentucky (11%), and Illinois (9.9%) (USFWS 2017). Summer distribution of the Indiana bat occurs throughout a wider geographic area than its winter distribution. Most summer occurrences are from the upper Midwest including southern Iowa, northern Missouri, much of Illinois and Indiana, southern Michigan, Wisconsin, western Ohio, and Kentucky. In the past decade, many summer maternity colonies have been found in the northeastern states of Pennsylvania, Vermont, New Jersey, New York, West Virginia, and Maryland. Maternity colonies have also been found in the south, including northern Arkansas, Georgia, Alabama, Mississippi (Copperhead 2017, Copperhead pers. comm. 2014), and southwestern North Carolina (Britzke et al. 2003, USFWS 2007). Non-reproductive summer records for the Indiana bat have also been documented in eastern Oklahoma, northern Mississippi, Alabama, and Georgia.

The data regarding Indiana bat abundance prior to federal listing are limited, but available information, summarized in the draft Recovery Plan (USFWS 2007), suggests that Indiana bats were once far more abundant than they were in the 1960s. When the Indiana bat was originally listed as endangered in 1967, there were approximately 883,300 bats, and most of these hibernated in a small number of hibernacula (Clawson 2002). Since the species was listed, its population numbers have apparently continued to decline through approximately 2001. Since being listed, large population declines have been observed, especially at hibernacula in Kentucky and Missouri. The range wide population estimate dropped approximately 57% from 1965 to 2001 (USFWS 2007). The range-wide, biennial population estimates had been increasing from 2001 to 2007, indicating that the species' long-term decline had been arrested and likely reversed (USFWS 2017). However, the arrival of White-Nose Syndrome (or "WNS"; see discussion below) is the probable cause of the observed range-wide decline since 2007. The Service

* Priority 1 (P1) hibernacula have a current or historical winter population of ≥ 10,000 Indiana bats; priority 2 (P2) have 1,000 -9.999 bats; priority 3 (P3) have 50-999 bats; and priority 4 (P4) have < 50 bats (USFWS 2007).

estimates the Indiana bat's 2019 range-wide population at 537,297 bats, which is a 4.0% decrease over the 2017 range-wide population estimate (Fig. 3).

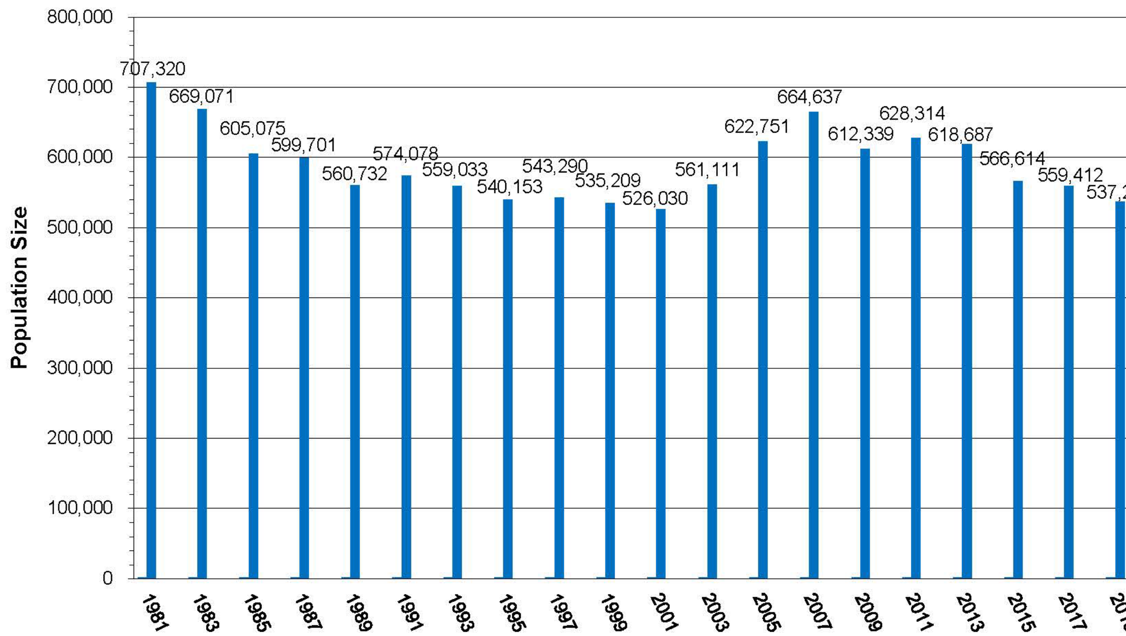

Figure 2. Indiana bat rangewide population estimates from 1981-2019.

3.6 Conservation Needs and Threats

Destruction/Degradation of Hibernacula

There are well-documented examples of modifications to Indiana bat hibernacula that affected the thermal regime of the cave and, thus, the ability of the cave to support hibernating Indiana bats, as summarized in the draft revised Recovery Plan (USFWS 2007). Generally, threats to the integrity of hibernacula have decreased since the time that Indiana bats were listed as endangered under the ESA. Increasing awareness of the importance of cave microclimates to hibernating bats and regulatory authorities under the ESA have reduced, but not eliminated, this threat. In addition to purposeful modifications, there are threats from stochastic events (*e.g.,* collapse in mines, flooding).

Loss/Degradation of Forested Habitat

Loss of forest cover and degradation of forested habitats have been cited as contributing to the decline of Indiana bats (USFWS 1983, Garner and Gardner 1992, Drobney and Clawson 1995, Whitaker and Brack 2002). Throughout the range of the Indiana bat, there is less forest now than there was prior to European settlement (Smith et al. 2003), particularly within the core of the species' range in the Midwest. Conversion to agriculture has been the largest single cause of forest loss. The conversion of floodplain and bottomland forests, recognized as high quality habitats for Indiana bats, has been a particular cause of concern (Humphrey 1978). More recently, since the 1950s, some marginal farmlands have been abandoned and allowed to revert to forest and there has been a net increase in forest within the range of the Indiana bat, particularly in the Northeast (Smith et al. 2003). Forest cover has also increased within the Midwest Recovery Unit (Smith et al. 2003). Not only has the amount of forest cover increased since the 1950s, but also the average diameter of trees has increased (Smith et al. 2003), which may equate to an increased supply of suitable roost trees for Indiana bats.

Urbanization and development is currently the greatest contributor to forested habitat loss within the range of the Indiana bat (Wear and Greis 2002; U.S. Forest Service (USFS) 2005, 2006), which results in permanent conversion to land uses generally unsuitable for Indiana bats. At a study site in central Indiana, Indiana bats avoided foraging in a high-density residential area (Sparks et al. 2005), although maternity roosts have been found in low-density residential areas (Belwood 2002). Duchamp (2006) found that greater amounts of urban land use was negatively related to bat species diversity in north-central Indiana; several bat species, including the Indiana bat, were less likely to occur in landscapes with greater amounts of urban and suburban development. Development directly destroys habitat and fragments remaining habitat.

Forest cover is not a completely reliable predictor of where Indiana bat maternity colonies will be found on the landscape (Farmer et al. 2002). Indiana bat maternity colonies occupy habitats ranging from completely forested to areas of highly fragmented forest. Nonetheless, trends in forest cover are of interest relative to Indiana bats, with increasing forest cover suggesting at least the potential for improved habitat conditions. Conversely, in areas where almost all forest land has been lost, the absence of woodlands on the landscape certainly equates to less habitat than in prehistoric and early historic periods.

Throughout the range of the Indiana bat, forest conversion is expected to increase due to commercial and urban development, energy production and transmission, and natural changes. The 2010 Resources Planning Act Assessment projects forest losses of 6.5-13.8 million hectares (16–34 million acres) (or 4–8% of 2007 forest area) across the conterminous United States, and forest loss is expected to be concentrated in the southern United States, with losses of 3.6-8.5 million hectares (9–21 million acres) (USFS 2012). Forest conversion causes loss of potential habitat, fragmentation of remaining habitat, and if occupied at the time of the conversion, injury or mortality to individuals.

Disturbance of Hibernating Bats

The original recovery plan for the species stated that human disturbance of hibernating Indiana bats was one of the primary threats to the species (USFWS 1983). The primary forms of human disturbance to hibernating bats result from cave commercialization (cave tours and other commercial uses of caves), recreational caving, vandalism, and research-related activities. Progress has been made in reducing the number of caves in which disturbance threatens hibernating Indiana bats, but the threat has not been eliminated. Biologists throughout the range of the Indiana bat were asked to identify the primary threat at specific hibernacula, and "Human disturbance" was identified as the primary threat at 41% of Priority 1, 2 and 3 hibernacula combined.

White-nose Syndrome

WNS is an infectious wildlife disease caused by a fungus of European origin *Pseudogymnoascus destructans* (Pd), which poses a considerable threat to hibernating bat species throughout North America, including the Indiana bat. White-nose syndrome is responsible for unprecedented mortality of insectivorous bats in eastern North America (Blehert et al. 2009; Turner et al. 2011). No other threat is as severe and immediate for the Indiana bat as the disease WNS. Since the disease was first observed in New York in 2007 (later biologists found evidence from 2006 photographs), WNS has spread rapidly in bat populations from the East to the Midwest and the South.

WNS may affect behavioral changes in infected individuals. For example, at some WNS-affected sites, a shift of hibernating bats from traditional winter roosts to roosts unusually close to hibernacula entrances has been observed. Bats have also been observed flying outside of hibernacula during winter (often during the day) at some affected sites. At some sites, bat carcasses (particularly of the little brown bat) have been found outside affected hibernacula. Many infected bats do not survive the winter. The exact processes by which the fungal skin infection leads to death are not known, but depleted fat reserves (i.e., starvation) contribute to mortality (Reeder et al. 2012, Warnecke et al. 2012) and dehydration may also have a role (Willis et al. 2011, Cryan et al. 2013, Ehlman et al. 2013). It is also suspected that some of the affected bats that survive hibernation emerge in such poor condition that they die soon after emergence or during the summer. Among those bats that do survive, it appears that productivity of female survivors may be negatively affected (Francl et al. 2012; Pettit and O'Keefe 2017).

The Northeast Recovery Unit, where WNS was first observed in the winter of 2006-2007, lost over 70% of its Indiana bats between 2007 and 2015. At the time dead bats were first observed in the winter of 2006-2007, it is not known how long the (previously unidentified) fungus, Pd, had been present in affected sites. Based on subsequent observations as WNS spread, it appears that the arrival of the fungus in an area may precede large-scale fatality of bats by several years. Between 2011 and 2015 the Appalachian Recovery Unit, where WNS was confirmed in the winter of 2008-2009, declined by 84%. The Midwest Recovery Unit, where WNS was confirmed in the winter of 2010-2011, declined by 16% between 2011 and 2015. The Ozark-Central Recovery Unit, where WNS was confirmed in the winter of 2011-2012, declined by less than 1% between 2013 and 2015. As of 2016, WNS or Pd was confirmed in all the states within the species' range. We expect further declines in Indiana bat populations from the disease in the future. Additional information on WNS, which is constantly evolving, can be found online at http://whitenosesyndrome.org/.

Environmental Contaminants

With the restrictions on the use of organochlorine pesticides in the 1970s, this significant threat to Indiana bats was reduced. However, cholinesterase-inhibiting insecticides, organophosphates, and carbamates have now become the most widely used insecticides (Grue et al. 1997), and the impact of these chemicals on Indiana bats is not known. Because of the unique physiology of bats in relation to reproduction, high energy demands and sophisticated thermoregulatory abilities, much more research needs to be done with these pesticides and their effects on bats. These and other contaminants likely remain a significant and poorly understood threat to Indiana bats. USFWS (2007) summarizes known and suspected contaminant threats to bats.

Climate Change
The capacity of climate change to result in changes in the range and distribution of wildlife species is recognized, but detailed assessments of how climate change may affect specific species, including Indiana bats, are limited. During winter, only a small proportion of caves provide the right conditions for hibernating Indiana bats because of the species' very specific temperature and humidity requirements. Surface temperature is directly related to cave temperature, so climate change that involves increased surface temperatures will inevitably affect the suitability of hibernacula. Impacts on the availability or timing of emergence of insect prey are also likely. Loeb and Winters (2013) modeled potential changes in Indiana bat summer maternity range within the United States; in their model, the area suitable for summer maternity colonies of Indiana bats was forecasted to decline significantly.

Wind Turbines
There is growing concern that Indiana bats (and other bat species) may be threatened by the recent surge in construction and operation of wind turbines across the species' range. Eight Indiana bat mortalities have been documented at wind turbines; five of those were during the fall migration period (USFWS 2014). Not all facilities conduct fatality monitoring and, even when monitoring is conducted, only a small proportion of dead bats are likely to be found. Based on this information, it is likely that additional Indiana bat mortality has occurred at these facilities and at other wind facilities throughout the range of the species.

4 ENVIRONMENTAL BASELINE

In accordance with 50 CFR 402.02, the environmental baseline refers to the condition of the listed species or its designated critical habitat in the action area, without the consequences to the listed species or designated critical habitat caused by the proposed action. The environmental baseline includes the past and present impacts of all Federal, State, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of State or private actions which are contemporaneous with the consultation in process. The consequences to listed species or designated critical habitat from ongoing agency activities or existing agency facilities that are not within the agency's discretion to modify are part of the environmental baseline.

4.1 Action Area Numbers, Reproduction, and Distribution

The Action Area's surface land coverage (Kentucky plus a 20-mile buffer around the state line) is approximately 62,254 square miles, which represents approximately 11 percent of the total range of the Indiana bat. The occupied range of the species (i.e., the collective home ranges of all individuals) within both the total range and the Action Area is unknown but is likely considerably smaller than the total range and Action Area, respectively, due to the presence of unsuitable habitats and unoccupied suitable habitats within both. According to our records, the Indiana bat is known from numerous locations, distributed across the Action Area.

The Action Area lies near the center of the species' range and numerous records of the species occupying summer and winter habitat exist. Occurrences of the species are clearly tied to the availability of the suitable summer and winter habitat. Potential winter habitat is static (assuming no anthropogenic alterations occur) in the landscape, because the caves and other underground features the species relies on for winter habitats do not change locations. However, the species will move from one habitat area to another to take advantage of better conditions or to abandon habitat that humans or other factors have altered or disturbed.

Within the Action Area there are 165 known hibernacula. Eleven of these are Priority 1 hibernacula (defined as harboring current or historic winter populations greater than 10,000 individuals and not identified as an ecological trap) (USFWS, unpublished data 2019) and three of these are designated as critical habitat (USFWS 2007). These eleven Priority 1 hibernacula had a combined estimated population of 245,596 Indiana bats in 2019, which represent approximately 45.7 percent of the rangewide estimated population (537,297) and 93.8 percent of the Indiana bats known to hibernate within the Action Area (261,576) (USFWS, unpublished data 2019). Of these eleven hibernacula, five are located within the 20-mile buffer around the Commonwealth of Kentucky that forms the outer boundary of the Action Area, including the three largest hibernacula by population count.

Seventy-two of the 165 hibernacula occur in areas of existing public or private conservation ownership. Of particular note are the Daniel Boone and Shawnee National Forests that are managed by the U.S. Forest Service, Mammoth Cave National Park and Cumberland Gap National Park that are managed by the National Park Service, Carter Cave State Resort Park that is managed by the Kentucky Department of Parks, Harrison-Crawford State Forest that is managed by the Indiana Department of Natural Resources, and several parcels along Pine Mountain in Kentucky that are owned by a variety of state agencies and land trusts.

Summer records for the species occur across the Action Area, and over 60 maternity areas have been documented along with a number of locations for solitary males and non-reproductive females. Like the hibernacula, these known maternity colonies are scattered throughout the state with notable clusters of maternity colonies occurring near the Fort Knox Military Reservation, Jefferson Proving Ground Military Reservation, Mammoth Cave National Park, Daniel Boone National Forest, Shawnee National Forest, Pine Mountain, the coalfields of eastern Kentucky, and along the lower Ohio River floodplains.

In general, the habitat availability at known maternity sites appears to reflect the overall distribution of forest cover for the state. Outside of the maternity colonies found on Fort Knox Military Reservation and Mammoth Cave National Park, those maternity areas with an availability of at least 80 percent forest cover occur in the eastern third of the state where forestland cover frequently exceeds 75 percent. Similarly, in the western third of the state where percent of land in forest is typically below 50 percent, the availability of forested habitat for known Indiana bat maternity colonies is also below 50 percent. Based on the wide distribution and availability of summer habitat across the Action Area, Indiana bats can be expected to occur at any location where its habitat needs can be met. Summer presence / probable absence surveys for the Indiana bat within Kentucky have found an average occupancy rate of 1.5 percent for post-WNS survey sites in potential maternity habitat. Given this occupancy rate and the regular discovery of new maternity colonies, the Service believes there are more maternity colonies within the Action Area than are currently documented.

4.2 Action Area Conservation Needs and Threats

It is difficult to identify specific factors affecting the Indiana bat's environment within the Action Area, because the Action Area has been defined as the Commonwealth of Kentucky and all portions of adjoining states that occur within 20 miles of the Kentucky border. This BO is based on analysis at a programmatic level rather than at an individual project scale. However, we are able to determine that there are a number of current and long-term land uses and demographic trends which could affect Indiana bats within the Action Area.

Forest Loss and Fragmentation

Unlike most winter sites, summer habitat for Indiana bats is typically not static. It changes over time in its location, quality, and quantity, and it is influenced by changes in land use, management and forest structure. Forest loss and fragmentation have significant impacts on the location, quality and quantity of available summer habitat. The Kentucky Division of Forestry has identified forest loss and fragmentation as key threats to Kentucky's forests (KDF 2010). Forest loss is simply the conversion of forestland to some other land use, while fragmentation is the breaking up of large forest tracts into smaller tracts. The predicted change in Kentucky's forestland found in Turner et al. (2004) anticipates that 31 of the 120 Kentucky counties will lose 1—5% percent of their forestland by 2020, and no county will increase its forest by more than 2 percent. A county by county comparison of percent forest cover as represented in the 2001 and 2016 editions of the National Land Cover Database found this to be generally true.

In the early 1900's, forest loss was primarily due to agricultural conversion; today, surface mining and urban sprawl are driving the loss (KDF 2010). However, as some forest is lost, other land is becoming forested. This is evidenced by the relative stability of Kentucky's forested land use over the last fifty 50 years, which has consistently been just below 50 percent (Oswalt 2012). However, this stability is across the state and local trends vary.

While the state-wide forest availability has been stable, these forests have, on average, aged and support larger trees. The number of acres in seedling and poletimber-size stands has decreased while acres in sawtimber-sized stands increased. Sawtimber has a minimum dbh of 11 inches for hardwoods, and the greatest growth has been seen in the volume of trees with a dbh of 12 or more inches (Turner et. al 2004). This is important as larger-diameter trees presumably provide thermal advantages and more spaces for more bats to roost. As with most tree-roosting bats (Barclay and Kurta 2007), female Indiana bats probably select trees, especially primary roosts, that are larger in diameter than nearby, apparently suitable, but unoccupied trees (Kurta et al. 1996, 2002; Britzke et al. 2003; Palm 2003; Sparks 2003).

Fragmentation is already a significant detriment to Kentucky's forest health. Although nearly half the state is forested, less than 14 percent of these 12.4 million acres are forest interior (KDF 2010), meaning they occur as large forest blocks. Within large forest tracts of 1,000 or more acres, 50 percent of the forest is considered edge habitat (300 foot buffer), 22 percent is small forest interior (less than 1,000 acres), and 28 percent is large forest interior (greater than 1,000 acres).

Forest loss and fragmentation can have significant impacts on Indiana bats, particularly at the local level. Any increase in conversion of forested land to agricultural and/or developed lands can be expected to further fragment and eliminate forested blocks of habitat that could be used by Indiana bats. The extent to which this effect will be offset by new forest regeneration is unknown; any regenerated forest will typically require decades before it becomes suitable roosting habitat. These habitat loss and degradation trends can be expected to receive increased scrutiny as protection of important summer habitat becomes a critical aspect of the species' recovery following the population declines due to white-nose syndrome (Johnson et al. 2012).

White-nose Syndrome

WNS was first discovered in one cave in Kentucky in 2011 but has since spread across the state. Mortality at infected sites first became apparent in 2013, with an increase in observed mortality in 2014. Preliminary reports indicate that Pd and/or WNS has been detected in approximately 74% of caves surveyed in Kentucky (T. Hemberger, pers. comm. 2017); however, many of those caves without positive records have not been surveyed in recent years. Indiana bats have shown declines at some hibernacula, and the overall post-WNS decline in Kentucky is estimated to be approximately 21% (USFWS 2019). Although the population and trend data following the arrival of WNS at Kentucky hibernacula is difficult to interpret, the data are currently not showing the near or total loss of Indiana bat populations that has been documented in the northeastern United States.

Because Indiana bats can migrate hundreds of miles from their hibernacula and WNS has been documented from Kentucky and all of the adjacent states, we expect that all the Indiana bats within the Action Area have been exposed to WNS. Therefore, Indiana bats in the Action Area are expected to be experiencing stress and reduced body weights from their exposure to WNS.

Other Factors

Numerous land use activities that could impact Indiana bats and that likely occur within the Action Area include: timber harvest, all-terrain vehicle (ATV) recreational use, recreational use of caves, underground and surface coal and limestone mining, gas production, and development associated with road, residential, industrial and agricultural development and related activities. These private actions are likely to occur within the Action Area, but the Service is unaware of any quantifiable information relating to the extent of private timber harvests within the Action Area, the amount of use of off-highway vehicles within the Action Area, or the amount of recreational use of caves within the Action Area. Similarly, the Service does not have any information on the amount or types of residential, industrial, or agricultural development that have or will occur within the Action Area. Therefore, the Service is unable to make any determinations or conduct any meaningful analysis of how these actions may or may not adversely and/or beneficially affect Indiana bats. All we can say is that it is possible that these activities, when they occur, may have adverse effects on Indiana bats and their habitats in certain situations (e.g., a private timber harvest during summer months within an unknown maternity colony may cause adverse effects to that maternity colony.). In stating this, however, we can only speculate as to the extent or severity of those effects, if any.

5 EFFECTS OF THE ACTION

In accordance with 50 CFR 402.02, effects of the action are all consequences to listed species or critical habitat that are caused by the proposed action, including the consequences of other activities that are caused by the proposed action. A consequence is caused by the proposed action if it would not occur but for the proposed action and it is reasonably certain to occur. Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action (see § 402.17).

The Service established additional requirements for making the determination of reasonably certain to occur, which must be followed after October 28, 2019, the effective date of new regulations under 50 CFR 402. After determining that the "activity is reasonably certain to occur," based on clear and substantial information, and using the best scientific and commercial data available, there must be another conclusion that the consequences of that activity (but not part of the proposed action or activities reviewed under cumulative effects) are reasonably certain to occur. In this context, a conclusion of reasonably certain to occur must be based on clear and substantial information, using the best scientific and commercial data available after consideration of three factors in 402.17(b)(1-3).

The 2019 regulatory changes do not alter how we will analyze the effects of a proposed action or the scope of effects. We will continue to review all relevant effects of a proposed action, as we have in past decades, but the Service determined it was not necessary to attach labels to the various types of effects through regulatory text. That is, we intend to capture all of those effects (now "consequences") previously listed in the regulatory definition of effects of the action – direct, indirect, and the effects from interrelated and interdependent activities – in the new definition. These effects are captured in the new regulatory definition by the term ''all consequences'' to listed species and critical habitat.

Based on the description of the Action and the species' biology, we have identified six stressor(s) to the Indiana bat (i.e., the alteration of the environment that is relevant to the species) that may result from the Action: (1) noise and vibration, (2) night lighting, (3) aquatic resource loss and degradation, (4) tree removal, (5) collision, and (6) alteration or loss of roosting habitat on bridges. Below, we discuss the best available science relevant to each stressor. Then, we describe the Stressor-Exposure-Response pathways that identify the circumstances for an individual bat's exposure to the stressor (i.e., the overlap in time and space between the stressor and an Indiana bat). Finally, we identify and consider how proposed conservation measures may reduce the severity of the stressor or the probability of an individual bat's exposure for each pathway.

5.1 Stressor 1: Noise and Vibration

Noise and vibration are stressors that may disrupt bats by causing individuals to flush from suitable roosting locations like bridges or suitable roost trees. Disruptions may occur during the day and/or night timeframes, and/or alter travel corridors and foraging behaviors. Bats may be exposed to this stressor during the construction, maintenance, and operation components of the Action. Significant changes in noise levels in an area could result in temporary to permanent alteration of bat behaviors. The novelty of these noises and their relative volume levels will likely dictate the range of responses from individuals or colonies of bats.

During the construction component of the Action, the felling of trees and operation of heavy equipment and tools will produce noise and vibrations. This could occur during any time of the year. During most of construction activities, the project area would be absent of trees and natural vegetation and will no longer provide habitat for the Indiana bat. Construction blasting may be conducted in areas that have previously been cleared of trees. Therefore, we expect that the exposure of Indiana bats to blasting would be reduced but not necessarily eliminated. This is because the distance between the blasting location and any remaining roost sites would increase after the initial tree removal occurs, but nearby forested areas would remain intact and available for occupation by Indiana bats.

Bats that currently use a project site would be exposed to noise and vibration from adjacent, facilities, interstate and major highways, and other urban, rural, and/or commercial land uses; therefore, we would expect them to be habituated to noise and vibration to some extent. During the operation component, noise and vibration will be limited to those effects caused by normal vehicular traffic. We expect Indiana bats to also become habituated to noise and vibration during operation.

Noise and vibration during the maintenance component are anticipated to be typically at or below levels caused by normal traffic. However, some maintenance activities may involve tree removal or bridge rehabilitation by use of heavy equipment and effects may be similar to those discussed above for construction activities. Bridge and roadway maintenance is expected to occur during daylight hours and will not disrupt foraging or commuting by bats.

Applicable Science

Bats exposed to noise and vibration may flush from their roost trees or bridges. Bats that flush during the daytime are at greater risk of harm due to predation (Mikula et al. 2016). Additionally, bats that flush their roost and/or avoid travel and foraging areas in response to this stressor may be harmed due to an increase in energy expenditure. Increased energy demands could have a significant effect on bats due to their low body mass. Because females require increased energy reserves during lactation (Kurta et al. 1989), an increased demand for energy in response to noise and vibrations could be especially detrimental to lactating females and, subsequently, their pups.

Studies have found that Indiana bats can tolerate some level of noise and vibration. For example, several construction projects, prior to documentation of white-nose syndrome, have occurred on Fort Drum adjacent to multiple known Indiana bat roosts (U.S. Army Garrison Fort Drum 2011). Construction around these project sites has been ongoing for multiple years during the active season. The last known capture and roosting locations of Indiana bats near these projects have been within approximately 800 and 400 meters (0.5 and 0.25 mi) of the construction activities, respectively. Further, military installations generally have large amounts of noise and disturbance, but Indiana bats have continued to occupy Fort Knox suggesting that noise from machinery may disturb colonies of roosting bats, but such disturbances would have to be severe to cause roost abandonment (Hawkins et al. 2008). Gardner et al. (1991) had evidence that Indiana bats continued to roost and forage in an area with active timber harvest. This suggested that noise and exhaust emissions from machinery could possibly disturb colonies of roosting bats, but such disturbances would have to be severe to cause roost abandonment. Callahan (1993) noted the likely cause of the bats in his study area abandoning a primary roost tree was disturbance from a bulldozer clearing brush adjacent to the tree. In another study near 1-70 and the Indianapolis Airport, a primary maternity roost was located 1,970 ft. (0.6 km) south of 1-70 (3D/International, Inc. 1996). This primary maternity roost was not abandoned despite constant noise from the Interstate and airport runways. However, the roost's proximity to 1-70 may be related to a general lack of suitable roosting habitat in the vicinity, and due to the fact that the noise levels from the airport were not novel to the bats (i.e., the bats had apparently habituated to the noise) (USFWS 2002). Noise and vibration could cause an Indiana bat to flush from its roost, expending extra energy and making it more vulnerable to predation (Mikula et al. 2016). Novel noises would be expected to result in some changes to bat behaviors, but research suggests that bats can become habituated to this stressor.

Effects Pathway – Indiana Bat #1	
Activity: Construction and Maintenance	
Stressor: Noise and Vibration	
Exposure (time)	April 1 – November 14 (active timeframe); duration of activity
Exposure (space)	Roosting habitat throughout Action Area
Resource affected	Individuals (adults and juveniles)
Individual response	• Flushing from bridge roost or roost trees results in extra energy expenditure that can reduce fitness, and result in reduced survival / reproductive success. • Flushing from bridge roost or roost trees will increase chances of predation. • Avoidance of the stressor can require extra energy expenditure that can reduce fitness and result in reduced survival / reproductive success.
Conservation Measures	Avoidance of project effects on: • A bridge structure that is known or has been identified as reasonably likely to support a maternity colony. • A known maternity roost tree. • A known Indiana bat hibernacula within ½ mile of the project area
Interpretation	Bats may become startled by the noise and/or vibrations and flush from their roosts. Most of the activities causing this stressor will occur concurrently with habitat removal or after the habitat has been removed when the species would no longer be present in the construction limits. Indiana bats exposed to this stressor during habitat removal are likely to respond in a way that would lead to adverse effects. Indiana bats exposed to this stressor during the construction and maintenance phase after habitat removal would be exposed to low levels of this stressor and, because of their current proximity to other sources of noise and vibration, we expect them to be habituated and to respond minimally to the stressor.
Effect	Harm
Amount or Extent of Adverse Effect	Because of the difficulty in determining the number of individual Indiana bats that will be adversely affected during this specific activity

	and stressor, the Service has determined that it is appropriate to consider the total amount of Indiana bats adversely affected by using the analysis for removal of summer and fall swarming habitat in this section. We believe that this reduces the potential to double count the number of individual Indiana bats impacted by the entire Action. A small, but indeterminable, portion of Indiana bats are expected to be injured or killed due to this activity and stressor. Disruption of normal behavior as a result of physical disturbance and/or habitat modification or degradation will account for the majority of adverse effects.

Effects Pathway – Indiana Bat #2	
Activity: Operation	
Stressor: Noise and Vibration	
Exposure (time)	April 1 – November 14 (active timeframe); indefinitely
Exposure (space)	Roosting and foraging habitat throughout Action Area
Resource affected	Individuals (adults, juveniles)
Individual response	• Flushing from bridge roost or roost trees results in extra energy expenditure that can reduce fitness and result in reduced survival / reproductive success. • Flushing from bridge roost, or roost trees will increase chances of predation. • Avoidance of the stressor can require extra energy expenditure that can reduce fitness and result in reduced survival / reproductive success.
Interpretation	The activities causing this stressor during operation will occur after the habitat has been removed. Thus, Indiana bats exposed will be limited to those using habitat on the margins of a project site. The bats that remain within the area during the operation of a new roadway and/or bridge are already exposed to noise and vibration from adjacent facilities, interstate and major highways, and other urban, rural, and/or commercial land uses. We would expect them to be habituated to this. We do not expect the additional noise and vibration contributed by the proposed Action to significantly increase the stressor in the Action Area. We do not expect Indiana bats to respond to the additional noise and vibration during operation in a way that would be significant.
Effect	Insignificant

5.2 Stressor 2: Night Lighting

Lighting may be required during the construction and operation of the Action. During construction, temporary lighting is likely to only occur within a small portion of Action Area at any one time. Lights may be used during early morning and evening hours during periods of fewer daylight hours (i.e., fall and winter) and may be visible immediately outside the disturbance limits. Construction lighting is anticipated to be downward facing and not directed horizontally where it would illuminate potential roosting, foraging or commuting habitat.

Permanent lighting during the operation component is expected to be the same prior to construction for existing roadways and bridges. Roadways and bridges with lighting before construction are expected to have lighting afterwards, and lighting is not anticipated to be added to facilities without previous lighting. Permanent lighting may be added to new roadways/bridges; however, lighting will occur in areas that were cleared of potential foraging and commuting habitat during construction and is typically limited to highly developed areas. Maintenance activities are anticipated to occur during daylight hours and will not require the use of lighting.

Applicable Science
Studies document highly variable responses among species to artificial lighting. Some bat species seem to benefit from artificial lighting, taking advantage of high densities of insects attracted to light (Jung and Kalko 2010); however, other species may avoid artificial light (Furlonger et al. 1987, Rydell 1992) or not be affected (Stone et al. 2012). Lighting can cause delays in night bat activity (Stone et al. 2009; Downs et al. 2003). Effects of artificial lighting on bat activity may vary with season and moon phase (Jung and Kalko 2010).

While there is limited information regarding Indiana bats' response to increased light levels, slow-flying bats such as *Rhinolophus*, *Myotis*, and *Plecotus* species have echolocation and wing-morphology adapted for cluttered environments (Norberg and Rayner 1987) and emerge from roosts relatively late when light levels are low, probably to avoid predation by diurnal birds of prey (Jones and Rydell 1994). In Indiana, Indiana bats avoided foraging in urban areas, and Sparks et al. (2005) suggested that it may have been in part due to high light levels. Using captive bats, Alsheimer (2011) found that a closely related species, the little brown bat (*M. lucifugus*), was more active in the dark than light.

Effects Pathway – Indiana Bat #3	
Activity: Construction	
Stressor: Night Lighting	
Exposure (time)	April 1 – November 14 (active timeframe); duration of activity
Exposure (space)	Roosting, foraging, and commuting habitat in and near construction limits
Resource affected	Summer and swarming habitat, used by individuals (adults, juveniles)
Individual response	• Increased visibility to predators increases chances of predation. • Avoidance of the stressor can require extra energy expenditure that can reduce fitness and result in reduced survival / reproductive success.
Interpretation	Indiana bats roosting underneath or in the bridge deck are unlikely to be affected by lighting on top of the bridge deck. Lighting will not be directed down toward night roosting bats. Additionally, should the activity alter the bridge allowing night lighting to reach roosting habitat, it is unlikely that the bats are still using the bridge (impacts associated with the alteration or loss of roosting habitat of bridges are addressed in Pathway # 16. Bats day roosting at the bridge may delay or avoid returning to the bridge at dawn. Lighting is unlikely to be used during this time, and

	bats that avoid the bridge likely have other available roosts in the immediate area. Lighting may cause bats to avoid using the bridge as a night roost; however, it is expected that bats can use alternate roosts in the area without significant additional energy expenditure. Indiana bats will likely avoid areas lit within roadway construction areas because they would be lit after they are cleared of forested roosting habitat. Foraging bats avoiding lighting can forage along other portions of a stream or nearby habitats. Commuting bats can use other travel routes to avoid lighting. Lighting is not expected to significantly affect the Indiana bat.
Effect	Insignificant

Effects Pathway – Indiana Bat #4	
Activity: Operation	
Stressor: Night Lighting	
Exposure (time)	April 1 – November 14 (active timeframe); indefinitely
Exposure (space)	Roosting, foraging, and commuting habitat throughout Action Area
Resource affected	Summer and swarming habitat, used by individuals (adults, juveniles)
Individual response	• Increased visibility to predators increases chances of predation. • Avoidance of the stressor can require extra energy expenditure that can reduce fitness and result in reduced survival / reproductive success.
Interpretation	Indiana bats that use the periphery of a lit roadway will likely be habituated to lighting already in the area and not significantly impacted by the additional lighting of the operation of the proposed project.
Effect	Insignificant

5.3 Stressor 3: Aquatic Resource Loss and Degradation

Loss of aquatic resources may occur during the construction component of the Action. Some projects may require the filling of streams or ponds during realignment of existing facilities or the construction of new facilities. Stream realignment may also be required for some projects, resulting in loss of a portion of the existing stream channel. Loss of aquatic resources may also occur during culvert installation due to the replacement of the natural stream substrate with an artificial structure. Aquatic resource loss is not anticipated during the operation or maintenance components.

Aquatic resource degradation may occur during the construction, operation, and maintenance components of the Action. Water quality may be affected as a result of increased sedimentation due to ground disturbance and runoff during construction or through the introduction of environmental contaminants during construction, operation, and/or maintenance. Activities that reduce the quantity or alter the quality of aquatic resources could impact the Indiana bats, even if conducted while individuals are not present. The introduction of environmental contaminants to waterways also has the potential to negatively affect bats by exposing them to toxic substances.

Bridge rehabilitation and replacement projects have the greatest potential to degrade aquatic resources due to their proximity to streams. Potential degradation of streams from bridge rehabilitation during the construction component are expected to be minimal. The majority of rehabilitation activities will not require work within the stream, and impacts to water quality are expected to be absent or minimal. Rehabilitation activities that occur over or near the stream could result in debris, materials, equipment, or contaminants entering the stream. Temporary structures, such as crossings or work pads, may be required for some bridge rehabilitation and replacement activities to maintain traffic or access portions of the bridge that cannot be reached from land or the bridge deck. These structures will be placed in the stream channel and will cause temporary impacts to the substrate and aquatic habitat. Coffer dams may also be placed in streams to create a safe, dry work area around piers, footers, and abutments during structure repair and rehabilitation of scour areas. Temporary structures will be removed after rehabilitation is complete, and the stream will be restored to pre-construction conditions.

Degradation of streams could occur as a result of bridge replacement during the construction component. Removal and installation of piers, pilings, and abutments will require work within the stream channel and disturb the substrate, which could result in degradation of the stream though habitat alteration and sedimentation within and downstream of the bridge footprint. Temporary structures, including crossings, work pads, and coffer dams may also be required during bridge replacement.

Environmental contaminants used in conjunction with equipment during construction activities may also lead to degradation of aquatic resources. Hazardous materials used during construction may include: diesel fuel, gasoline, hydraulic fluids, oils, lubricants, solvents, adhesives, and battery chemicals. Spills and/or leakage of these materials into aquatic resources could affect water and stream habitat quality.

During operation, hazardous materials could enter aquatic resources from spills associated with traffic accidents or leaks from disabled vehicles. Activities associated with snow/ice and vegetation control include the application of chemicals directly to the road surface or adjacent right-of-way. De-icing agents and salt could be carried from the roadway to aquatic resources through surface runoff, leading to short-term effects to water quality. Herbicides may be applied along roadway rights-of-way and could enter aquatic resources through wind-induced drift or runoff.

Applicable Science

Indiana bats feed on aquatic and terrestrial insects. Numerous foraging habitat studies have found that Indiana bats often forage in closed to semi-open forested habitats and forest edges located in floodplains, riparian areas, lowlands, and uplands; old fields and agricultural fields are also used (USFWS 2007). Drinking water is essential, especially when bats actively forage. Indiana bats obtain water from streams, ponds and water-filled road ruts in forest uplands.

The Indiana bat's diet varies seasonally and among different ages, sexes, and reproductive status (USFWS 1999). Four orders of insects contribute most: Coleoptera, Diptera, Lepidoptera, and Trichoptera (Belwood 1979, Brack 1983, Brack and LaVal 1985, Lee 1993, Kiser and Elliot 1996, Kurta and Whitaker 1998, Murray and Kurta 2002, Whitaker 2004). Various reports differ considerably in which of these orders is most important. Consistent use of moths, flies, beetles, and caddisflies throughout the year at various colonies suggests that Indiana bats are selective predators to a certain degree, but incorporation of other insects into the diet also indicates that these bats can be opportunistic (Murray and Kurta 2002). Brack and LaVal (1985) and Murray and Kurta (2002) suggested that the Indiana bat may best be described as a "selective opportunist."

Filling streams in the construction limits will permanently reduce aquatic insect habitat, which will reduce the amount of prey available to Indiana bats. The Action may also impact streams downstream of the construction limits. Negative impacts of sedimentation on aquatic insect larvae is well-documented. In a literature review, Henley et. al (2000) summarized how stream sedimentation impacts these communities. Sediment suspended in the water column affects aquatic insect food sources by physically removing periphyton from substrate and reducing light available for primary production of phytoplankton. Sediment that settles out of the water column onto the substrate fills interstitial spaces occupied by certain aquatic insect larvae. Increases in sedimentation can change the composition of the insect community in a stream. In a three-year study measuring sedimentation and macroinvertebrate communities before, after, and during disturbance from a highway construction site, Hendrick (2008) found increased turbidity and total suspended solids downstream from the construction that correlated with a shift in macroinvertebrate communities. The change, however, was not great, and the Hilsenhoff Biotic Index used to evaluate the effects decreased from "excellent" before construction to "good" after construction. The use of BMPs likely minimized the effects of the construction on the macroinvertebrate communities.

Effects Pathway – Indiana Bat #5	
Activity: Construction	
Stressor: Aquatic Resource Loss	
Exposure (time)	Indefinitely
Exposure (space)	Aquatic foraging habitat throughout the Action Area
Resource affected	Habitat, used by individuals (adults, juveniles)
Individual response	• Increased flight distances to access foraging resources requires extra energy expenditure that can reduce fitness and result in reduced survival / reproductive success. • Reduced foraging efficiency can reduce fitness and result in reduced survival / reproductive success.
Interpretation	Indiana bats are expected to use other streams within the same and/or adjacent watersheds
Effect	Insignificant

Effects Pathway – Indiana Bat #6	
Activity: Construction and Maintenance	
Stressor: Aquatic Resource Degradation (**s**edimentation)	
Exposure (time)	Active timeframe, temporary
Exposure (space)	Aquatic foraging habitat in and downstream of project site
Resource affected	Habitat, prey (aquatic insects), used by individuals (adults, juveniles)

Individual response	• Increased effort to access sufficient foraging resources requires extra energy expenditure that can reduce fitness and result in reduced survival / reproductive success. • Reduced foraging efficiency can reduce fitness and result in reduced survival / reproductive success.
Conservation Measures	Implementation of BMPs to limit impacts to streams and downstream aquatic resources
Interpretation	The effects of sedimentation on aquatic resources are expected to be minimal due to the temporary nature of the activity and implementation of the conservation measures.
Effect	Insignificant

Effects Pathway – Indiana Bat #7	
Activity: Construction, Operation, and Maintenance	
Stressor: Aquatic Resource Degradation **(**pollutants)	
Exposure (time)	Indefinitely
Exposure (space)	Aquatic foraging habitat in and downstream of the project site.
Resource affected	Habitat, prey (aquatic insects), used by individuals (adults, juveniles)
Individual response	• Increased effort to access sufficient foraging resources requires extra energy expenditure that can reduce fitness and result in reduced survival / reproductive success. • Reduced foraging efficiency can reduce fitness and result in reduced survival / reproductive success.
Conservation Measures	• Implementation of BMPs to limit impacts to streams and downstream aquatic resources. • Ensure proper use of herbicides • Limiting use of deicing agents to only the amount necessary.
Interpretation	Implementation of the conservation measures are expected to minimize and/or prevent contamination from pollutants.
Effect	Insignificant

5.4 Stressor 4: Tree Removal

The Action would result in the removal and loss of up to 1000 acres of forested Indiana bat habitat per year and no more than 250 acres of habitat per project. The majority of this removal of forested habitats would occur during construction; however, a small amount may occur during maintenance activities and detailed design (e.g. geotechnical investigations). Trees removed during the April – November timeframe may be occupied by Indiana bats when they are removed. We do not know which trees would be removed during the active timeframe or exactly which trees Indiana bats would be occupying. The resulting forested habitat loss would be permanent. The loss of this habitat may create a gap in forested habitat between larger blocks of forested habitat within the Action Area and potential foraging corridors. In addition to the applicable science discussed below for "Loss of Summer Habitat (active and inactive timeframes)", we also consider the science for "Forest Loss and Fragmentation" for our analysis of this specific stressor.

The KYTC has determined that this Stressor, Tree Removal, may result in the following sub-stressors:

- Removal of summer habitat, active timeframe
- Removal of summer habitat, inactive timeframe
- Loss and fragmentation of forested habitats
- Removal of swarming habitat, active timeframe
- Removal of swarming habitat, inactive timeframe

Removal of Summer Habitat (Active Timeframe) - Applicable Science
Risk of injury or death from being crushed when a tree is felled is most likely to impact non-volant pups, but adults may also be injured or killed. This risk is greater for adults during cooler weather when bats periodically enter torpor and would be unable to arouse quickly enough to respond (i.e., flush and potentially avoid being in the roost when it is felled). Belwood (2002) reported on the felling of a dead maple in a residential lawn in Ohio that resulted in the death of one adult Indiana bat female and the displacement of 33 non-volant young. Three of the young bats were already dead when they were picked up, and two more died subsequently. The rest were apparently retrieved later by adult bats that had survived the felling of the tree.

In addition to the expenditure of additional energy to find new roost trees, the removal of primary or alternate maternity roosts can lead to the fragmentation or break up of the maternity colony (Sparks et al. 2003, Silvis et al. 2014). The effect of colony fragmentation on Indiana bats is unknown. However, Indiana bats presumably congregate in large maternity colonies due to the benefits it provides. Barclay and Kurta (2007) stated that Indiana bats benefit from the formation of maternity colonies through (1) information sharing about roosting and foraging habitats, (2) reduced predation risk, and (3) thermoregulatory advantages. However, this colonial behavior also comes with risks, such as increased parasite transmission and competition for resources.

Effects Pathway – Indiana Bat #8	
Activity: Construction and Maintenance	
Stressor: Tree Removal, Removal of Summer Habitat (active timeframe)	
Exposure (time)	April 1 – October 14 (active timeframe)
Exposure (space)	Forested habitat throughout the Action Area
Resource affected	Summer habitat (roost trees), individuals (adults, juveniles)
Individual response	• Bats struck by equipment or crushed by a felled tree will be injured or killed. • Increased effort to find new suitable roosting habitat requires extra energy expenditure that can reduce fitness and result in reduced survival / reproductive success. • Colony fragmentation could decrease thermoregulation efficiency / decreased foraging efficiency that can decrease fitness and result in reduced survival / reproductive success. • Colony fragmentation will increase the risk of predation.
Conservation Measures	• Tree clearing restrictions will occur when non-volant pups would likely be present (June 1 – July 31). Consultation with the KFO would occur on a project specific basis in order to determine if tree

	clearing during the non-volant timeframe is acceptable under the programmatic process. • Avoidance of project effects on a known maternity roost tree. • Minimize project impacts to no more than 250 acres of suitable, forested habitat per project.
Interpretation	Bats occupying trees that are removed may be injured or killed. Injured bats may subsequently die. Those that survive will have to spend extra energy in addition to what is necessary to for foraging, pup rearing, social interactions, or other activities. The use of additional energy in response to habitat loss, especially when combined with the energy needs associated with normal life cycle processes (e.g., migration, pregnancy, lactation, etc.) or other stressors (e.g., WNS), is likely to reduce fitness and subsequently reduce survival and reproductive success.
Effect	Harm

<u>*Removal of Summer Habitat (Inactive Timeframe) - Applicable Science*</u>

The potential for adverse effects of tree removal of Indiana bats during the inactive timeframe is rooted in the well-documented knowledge that Indiana bats exhibit strong fidelity to their summer roosting areas and foraging habitat (Kurta et al. 2002; Garner and Gardner 1992; USFWS 2007). Adverse effects to Indiana bats associated with the removal of forested habitats occur through several pathways that lead to a reduction in individual fitness as a result of increased energy expenditure. This evaluation is supported by numerous bat researchers, including Kurta and Rice (2002), who commented:

> *"The U.S. Fish and Wildlife Service often allows potential roost trees to be cut after Indiana bats leave for hibernation in order to make way for developments such as new bridges, highways, and housing projects. This policy understandably is intended to allow human developments to proceed while preventing direct "take" of Indiana bats. This practice, however, should be limited, because it destroys potential roost trees without establishing whether they actually are used by Indiana bats, which may leave the bats with no shelter when they return in spring in an energetically stressed condition. Upon returning, the bats have just completed 6-7 months of hibernation and an extensive migration, and they arrive already pregnant and at a time when air temperatures are low and food (flying insects) is scarce. Excessive precipitation and/or colder-than-average temperatures drastically reduce reproductive success of temperate bats (Grindal et al. 1992; Lewis 1993), and such negative effects likely would occur even during normal weather if Indiana bats do not have adequate shelter."*

Indiana bats must have the energetic resources to carry out the different phases of their lifecycle. Certain processes in their life cycle are particularly costly (Kunz et al. 1998). Indiana bats must enter into hibernation with enough fat reserves to survive the winter (Speakman and Rowland 1999) and, for females, to trigger ovulation and gestation following emergence (Zhao et al. 2003). After migrating to their summer habitat, Indiana bats must be prepared to cope with spring conditions by having sufficient energy resources to thermoregulate during cooler weather conditions and at a time when prey is scarce (Kurta and Rice 2002). Additionally, they must have sufficient energy resources throughout the summer roosting period to cope with unpredictable stressors, such as unseasonably cold temperatures or high precipitation that can negatively affect reproductive success (Grindal et al. 1992) and survival.

Forested habitat loss or alteration during the hibernation season (i.e., while the bats are not present) harms Indiana bats by requiring the increased use of energy to respond to the habitat loss or alteration, when bats return to summer habitats. This is likely to impair essential behavior patterns associated with sheltering (roosting), breeding and/or feeding (foraging). This impairment, in turn, results in reduced survival and/or reproduction of the affected individuals. These effects are compounded in the Action Area because most of the returning bats are coming from hibernacula infected with white-nose syndrome (WNS). Individuals surviving WNS have additional energetic demands. For example, WNS-affected bats have less fat reserves than non-WNS-affected bats when they emerge from hibernation (Reeder et al. 2012; Warnecke et al. 2012) and have wing damage (Reichard and Kunz 2009, Meteyer et al. 2009) that makes migration and foraging more challenging. Females that survive the migration to their summer habitat must partition energy resources between foraging, keeping warm, maintain a successful pregnancy, rearing pups, and healing their own bodies.

Effects Pathway – Indiana Bat #9	
Activity: Construction and Maintenance	
Stressor: Tree Removal, Removal of Summer Habitat (inactive timeframe)	
Exposure (time)	Inactive timeframe (October 15 – March 31) removal will expose Indiana bats to effects from April 1 – October 14, for one season after removal.
Exposure (space)	Forested habitat throughout the Action Area
Resource affected	Summer habitat (roost trees), used by individuals (adults)
Individual response	• Increased effort to find new suitable roosting habitat requires extra energy expenditure that can reduce fitness and result in reduced survival / reproductive success. • Colony fragmentation could decrease thermoregulation efficiency / decreased foraging efficiency that can decrease fitness and result in reduced survival / reproductive success. • Colony fragmentation will increase the risk of predation.
Conservation Measures	• Avoidance of project effects on a known maternity roost tree. • Minimize project impacts to no more than 250 acres of suitable, forested habitat per project.
Interpretation	Adult Indiana bats will experience adverse effects after they arrive at their summer roosting habitat the first year after tree removal. The extra energy to find new habitat is in addition to what is necessary for foraging, pup rearing, social interactions, or other activities. The use of additional energy in response to habitat loss, especially when combined with the energy needs associated with normal life cycle processes (e.g., migration, pregnancy, lactation, etc.) or other stressors (e.g., WNS), is likely to result in adverse effects. Indiana bats are expected to adapt to

	this stressor in subsequent years after they have found new suitable habitat.
Effect	Harm

<u>Amount or Extent of Adverse Effects - Summer Habitats</u>
Analysis of the KYTC projects reviewed by the KFO between 2013 and 2018 found that impacts to known maternity habitat represented about 13.9 percent of the total forested impacts associated with these projects (USFWS, unpublished data, 2019). Assuming a similar level and distribution of impacts to maternity habitat across the 5,000 acres and 5 years of the Action, the Action will result in impacts to an estimated 695 acres of forested maternity habitat (5,000 acres X 0.139 = 695 acres). The Service assumes that maternity colonies require an average of 397 acres of habitat per colony (Menzel et. al 2005), that colonies do not overlap, and that each maternity colony represents 180 Indiana bats (60 adult females, 60 adult males, and 60 pups) (USFWS 2007). Based on these assumptions, the Action's effects on known summer maternity habitat would affect up to 360 Indiana bats:

- 695 acres of maternity habitat affected ÷ 397 acres per maternity colony ≈ 2 colonies; and
- 2 colonies X 180 bats per colony = 360 bats.

However, the Service finds it unlikely that all maternity colonies within the Action Area are known and is reasonably certain that all unknown suitable habitats have the potential to contain a maternity colony, unless survey data indicate otherwise.

The KFO reviewed Indiana bat presence/probable absence survey data in Kentucky post-WNS (2014-2017) and found that Indiana bats were detected at 1.5 percent (16 of 1,056 sites) of suitable mist-net sites (USFWS unpublished 2018 data). Applying this occupancy rate to the 4305 acres of potential maternity habitat predicts that 65 of these acres are occupied by maternity colonies. These 65 acres represent an approximately 1 maternity colony (180 Indiana bats):

- 5,000 acres suitable habitat – 695 acres known maternity habitat = 4305 acres potential maternity habitat;
- 4305 acres potential maternity habitat X 0.015 occupancy rate = 65 acres;
- 65 acres ÷ 397 acres per maternity colony = 0.2 potential maternity colonies; and
- ≈ 1 potential maternity colony X 180 bats per colony = 180 bats.

Combining the likely impacts to both known and potential summer maternity habitats, the Service anticipates that FHWA projects in known and potential summer habitat will affect up to 3 (2 + 1 = 3) Indiana bat maternity colonies or 396 (360 + 180 = 540) bats over a 5-year period. A small, but indeterminable, portion of these 540 Indiana bats are expected to be injured or killed by the Action. Disruption of normal behavior as a result of physical disturbance and/or habitat modification or degradation will account for the majority of adverse effects.

Impacts to non-maternity summer habitat are likely to affect non-reproductive adults. However, the Service has determined that it is appropriate to consider the total amount of non-reproductive adult Indiana bats adversely affected within non-maternity summer habitat by using the analysis (above) for removal of summer (maternity) and fall swarming habitat in this section. We believe that this reduces the potential to double count the number of individual Indiana bats affected by the entire Action.

Loss and Fragmentation of Forested Habitats – Applicable Science
In addition to removal of roosting habitat, tree removal often results in the loss and fragmentation of forested habitats, resulting in the degradation of Indiana bat foraging and commuting habitat. Patterson et al. (2003) noted that the mobility of bats allows them to exploit fragments of habitat. However, they cautioned that reliance on already diffuse resources (e.g., roost trees) leaves bats highly vulnerable, and that energetics may preclude the use of overly patchy habitats.

In a fragmented landscape, Indiana bats may have to fly across less suitable or unsuitable habitat. This could pose greater risk from predators (e.g., raptors) (Mikula et al. 2016). Indiana bats consistently follow tree-lined paths rather than cross large open areas (Gardner et al. 1991, Murray and Kurta 2004). Murray and Kurta (2004) found that Indiana bats increased their commuting distances by 55% to follow these paths rather than flying over large agricultural fields. However, if these corridors are not available, Indiana bats may be forced over open areas. For example, Kniowski and Gehrt (2014) observed Indiana bat flying across open expanses of cropland >1 km (0.6 miles) to reach remote, isolated woodlots or riparian corridors.

Indiana bat maternity colonies in Illinois, Indiana, Michigan, and Kentucky have been shown to use the same roosting and foraging areas during subsequent years (Gardner et al. 1991; Humphrey et al. 1977; Kurta and Murray 2002; Kurta et al. 1996, 2002). Bats using familiar foraging and roosting areas are thought to benefit from decreased susceptibility to predators, increased foraging efficiency, and the ability to switch roosts in case of emergencies or alterations surrounding the original roost (Gumbert et al. 2002). Conversely, bats that must use new or inferior habitats after a loss or alteration of their normal forested habitat would not have these same benefits.

Racey and Entwistle (2003) discussed the difficulties of categorizing space requirements in bats, as they are highly mobile and show relatively patchy use of habitat (and use of linear landscape features), although connectivity of habitats has some clear advantages (e.g., aid orientation, attract insects, provide shelter from wind and/or predators). Carter et al. (2002) found Indiana bat roosts in a highly fragmented landscape in their southern Illinois, although both the number of patches and mean patch size were higher in the area surrounding roosts than around randomly selected points. Kniowski and Gehrt (2014) suggest longer or more frequent commuting flights will be required by Indiana bats in highly fragmented landscapes, with smaller, more distant suitable habitat patches, to obtain similar resources compared to landscapes with larger, more abundant habitat patches. This has been observed directly in Ohio where radio tagged bats in areas with limited forested cover moved further than those with greater forested cover (K. Lott, USFWS, pers. comm.).

Effects Pathway – Indiana Bat #10	
Activity: Construction and Maintenance	
Stressor: Tree Removal, Loss and Fragmentation of Forested Habitats	
Exposure (time)	One time removal; exposure will be permanent

Exposure (space)	Forested habitat throughout the Action Area
Resource affected	Forested habitat, used by individuals (adults, juveniles)
Individual response	• Increased effort to access sufficient foraging resources requires extra energy expenditure that can reduce fitness and result in reduced survival / reproductive success. • Reduced foraging efficiency can reduce fitness and result in reduced survival / reproductive success. • Increased visibility to predators increases chances of predation.
Conservation Measures	Minimize project impacts to no more than 250 acres of suitable, forested habitat per project.
Interpretation	The loss of roost trees will adversely affect Indiana bats the first year after the removal of those trees (discussed in effects pathway #9). We expect them to find new roosting habitat that they will continue to use in subsequent years. The tree removal will create a larger gap in habitat between that Indiana bats may be using for foraging and commuting habitat. The gap would make access to these areas difficult, requiring more energy expenditure and/or exposure to predators, or would cut off access to habitat altogether. Individual Indiana bats that use the Action Area in the summer after habitat removal are expected to be harmed.
Effect	Harm
Amount or Extent of Adverse Effects	Because of the difficulty in determining the number of individual Indiana bats that will be adversely affected during this specific activity and stressor, the Service has determined that it is appropriate to consider the total amount of Indiana bats adversely affected by using the analysis for removal of summer and fall swarming habitat in this section. We believe that this reduces the potential to double count the number of individual Indiana bats impacted by the entire Action. A small, but indeterminable, portion of Indiana bats are expected to be injured or killed due to this activity and stressor. Disruption of normal behavior as a result of physical disturbance and/or habitat modification or degradation will account for the majority of adverse effects.

Removal of Fall Swarming Habitat – Applicable Science

The active fall swarming period is August 16 – November 14 and is a sensitive period for Indiana bats. This is when mating occurs and when bats are busy foraging to store sufficient fat reserves to survive winter hibernation. Suitable fall swarming habitat is comprised of forested/wooded habitats where they roost, forage, and travel, which is most typically within 5 to 10 miles of a hibernaculum. This includes forested patches as well as linear features such as fencerows, riparian forests, and other wooded corridors. These wooded areas may be dense or loose aggregates of trees with variable amounts of canopy closure.

In general, Indiana bats use roosting, foraging, and commuting habitat(s) in the fall similar to those selected during the summer. Therefore, we are considering the applicable science discussed above for "Loss of Summer Habitat (active and inactive timeframes)", and "Forest Loss and Fragmentation" for our analysis of this specific sub-stressor.

Effects Pathway – Indiana Bat #11	
Activity: Construction and Maintenance	
Stressor: Tree Removal, Removal of Fall Swarming Habitat (active timeframe)	
Exposure (time)	August 16 – November 14 (active timeframe)
Exposure (space)	Forested habitat throughout the Action Area
Resource affected	Swarming habitat used by individuals (adults, juveniles)
Individual response	• Bats struck by equipment or crushed by a felled tree will be injured or die. • Increased effort to find new suitable roosting habitat requires extra energy expenditure that can reduce fitness and result in reduced survival / reproductive success. • Increased effort to access sufficient foraging resources requires extra energy expenditure that can reduce fitness and result in reduced survival / reproductive success. • Reduced foraging efficiency can reduce fitness and result in reduced survival / reproductive success. • Increased visibility to predators increases chances of predation.
Conservation Measures	• Avoidance of project impacts on forested habitat within ½-mile of a known Indiana bat hibernacula • Minimize project impacts to no more than 250 acres of suitable, forested habitat per project.
Interpretation	Bats occupying trees that are removed may be injured or killed. Injured bats may subsequently die. During a period when weight gain is critical to survival, additional energy spent searching for new roost trees also results in less time for foraging, both of which could result in reduced weight gain. It can be expected that lower weight gains during fall swarming could result in lower fitness in those stressed individuals as exhibited by reduced survival and/or reproductive success.
Effect	Harm

Effects Pathway – Indiana Bat #12	
Activity: Construction and Maintenance	
Stressor: Tree Removal, Removal of Swarming Habitat (inactive timeframe)	
Exposure (time)	Inactive timeframe (November 15 – August 15) removal will expose Indiana bats to adverse effects from August 16 – November 14, for one season after removal.
Exposure (space)	Forested habitat throughout the Action Area
Resource affected	Swarming habitat used by individuals (adults, juveniles)
Individual response	• Increased effort to find new suitable roosting habitat requires extra energy expenditure that can reduce fitness and result in reduced survival / reproductive success. • Increased effort to access sufficient foraging resources requires extra energy expenditure that can reduce fitness and result in reduced survival / reproductive success. • Reduced foraging efficiency can reduce fitness and result in reduced

	survival / reproductive success. • Increased visibility to predators increases chances of predation.
Conservation Measures	• Avoidance of project impacts on forested habitat within ½-mile of a known Indiana bat hibernacula • Minimize project impacts to no more than 250 acres of suitable, forested habitat per project.
Interpretation	Indiana bats will experience adverse effects after they arrive at their fall swarming habitat the first year after tree removal. The extra energy to find new habitat is in addition to what is necessary for foraging, social interactions, or other activities. The use of additional energy in response to habitat loss, especially when combined with the energy needs associated with normal life cycle processes (e.g., migration and mating) or other stressors (e.g., WNS), is likely to result in adverse effects. Indiana bats are expected to adapt to this stressor in subsequent years after they have found new suitable habitat.
Effect	Harm

Amount or Extent of Adverse Effects – Swarming Habitats
According to the most recent winter counts conducted at known Indiana bat hibernacula, approximately 261,576 Indiana bats hibernate within the Action Area (USFWS unpublished 2019b data). Analysis of the KYTC projects reviewed by the KFO between 2013-2018 found that approximately 17.1 percent of forested habitat removal occurred within known swarming buffers (USFWS unpublished 2019a data). Impacts within the 10-mile swarming buffers around Priority 1 (P1) and Priority 2 (P2) hibernacula represent 13.6 percent of the total acres, and impacts within the 5-mile buffers around Priority 3 and Priority 4 (P3&4) hibernacula represent approximately 3.5 percent. Assuming a similar level and distribution of impacts to swarming habitat across the 5,000 acres, the Action will result in impacts to an estimated 855 acres (5,000 acres X 0.171 = 855 acres) of forested swarming habitat over a 5-year period.

We use the most recent winter count data to estimate the density of Indiana bats using Action Area swarming habitats that are within 10 miles of P1 and P2 hibernacula, and within 5 miles of P3&4 hibernacula, assuming within these circles an even distribution of bats and 50 percent forest cover:

- 245,596 bats in P1 hibernacula / 1.11 million acres of associated swarming habitat = 0.221 bats/acre;
- 14,683 bats in P2 hibernacula / 2.80 million acres of associated swarming habitat = 0.0052 bats/acre; and
- 1297 bats in P3&4 hibernacula / 1.99 million acres of associated swarming habitat = 0.00065 bats/acre.

P3&4 swarming habitats are combined due to the large number of sites and relatively low number of bats for these hibernacula. We do not combine P1 and P2 swarming habitats, because of the large difference in potential bat density. In order to estimate how many Indiana bats the Action will affect in swarming habitats (Table 3), these bat densities are applied to the acreage of swarming habitat that we are reasonably certain the Action will affect (13.6 percent of impacts to P1 and P2; 3.5 percent of impacts to P3&4). Since the KFO has tracked impacts to P1 and P2 swarming habitats jointly, we partition the estimated 13.6 percent of the Action's effects between these habitats assuming that Action effects are distributed in proportion to the availability of these two types in the Action Area, as follows:

- There are 3,906,477 acres of P1 and P2 swarming habitat within the Action Area;
- There are 1,105,148 acres of P1 swarming habitat within the Action Area;
- 1,105,148 acres P1 ÷ 3,906,477 acres of P1 and P2 = 0.28 of P1/P2 swarming habitat is P1;
- 0.28 X 0.136 of impacts in P1/P2 swarming habitat X 100 = 3.8 percent of expected impacts will occur in P1 swarming habitat;
- 13.6% – 3.8% of expected impacts that will occur in P1 swarming habitat = 9.8% of expected impacts that will occur in P2 swarming habitat.

"Total Acres Affected" in Table 3 below is calculated by applying the "Anticipated Percent of Impact" to the 5,000 acres of habitat covered under the Action. "Estimated Bat Density" is then applied to the "Total Acres Affected" to arrive at the estimated number of "Bats Affected Over 5 Years."

Table 3. Estimated number of Indiana bats affected by the Action within known swarming habitats (10-mile radius around known Priority 1 and 2 hibernacula; 5-mile radius around known Priority 3 and 4 hibernacula).

Swarming Habitat	**Anticipated Percent of Impact**	**Total Acres Affected**	**Estimated Bat Density (Bats/Acre)**	**Bats Affected Over 5 Years**
Priority 1	3.8	190	0.221	42
Priority 2	9.8	490	0.0052	3
Priority 3 & 4	3.5	175	0.00065	1
TOTAL	**17.1**	**855**		**46**

Very few, if any, of these 46 Indiana bats are expected to be injured or killed by the Action. Disruption of normal behavior as a result of physical disturbance and/or habitat modification or degradation will account for the majority of impacts.

5.5 Stressor 5: Collision

During the construction component of the Action, collisions could potentially occur between Indiana bats and construction vehicles and equipment. The majority of activities associated with these components will occur during daylight hours when flying bats are inactive. Some bridge replacement and road construction activities may occur at night (e.g., pouring of concrete); however, these activities will involve stationary or slow-moving vehicles. During the operation component, traffic will be present on roadways and bridges year-round and during the night. Vehicle collision may occur from dusk until dawn while Indiana bats are foraging and commuting. Collisions are not expected during the maintenance component due to these activities occurring during daylight hours.

Applicable Science

Collisions have been documented for Indiana bats and other myotids. Russell et al. (2009) assessed the level of mortality from road kills on a bat colony in Pennsylvania and collected 27 road-killed little brown bats and one Indiana bat. Butchkoski and Hassinger (2002) had previously studied this same colony in Pennsylvania and documented little brown bats that had apparently collided with vehicles along a major highway that separated the roosting habitat from the primary foraging areas. Russell et al. (2009) documented Indiana bat mortality at a site where the roost site was separated from the foraging areas by a major highway. This study noted that when bats crossed at open fields, they flew much lower than canopy height (< two meters), and when adjacent canopy was low, bats crossed lower and closer to traffic. Collision has also been documented for other myotids in Europe (Lesinski et al. 2011).

Collision risk of bats varies depending on time of year, location of a road in relation to roosting/foraging areas, flight characteristics of a species, traffic volume, and whether young bats are dispersing (Lesinski 2007, 2008; Russell et al. 2009; Bennett et al. 2011). In the Czech Republic, Gaisler et al. (2009) noted the majority of bat fatalities were associated with a road section between two artificial lakes. Lesinski (2007) evaluated road kills in Poland and determined that the number of young of year bats killed were significantly higher than adults. Also, low-flying gleaners (e.g., *Myotis daubentonii*) were killed more frequently than high-flying aerial hawkers (e.g., *Nyctalus noctula*). Indiana bats are considered a low-flying gleaner following canopy height and when there are breaks in the canopy, they fly lower than the adjacent canopy. Lesinski et al. (2011) indicated that a review of previously published literature on factors causing bats to be killed at roads are not consistent, and, therefore, it is difficult to predict exact sites where bats may be at risk. They also indicated that estimates represent a small portion of the number of bats actually killed.

It can be difficult to determine whether roads pose greater risk for bats colliding with vehicles or greater likelihood of deterring bat activity in the area (thus decreasing risk of collision). As discussed in the Noise and Vibration stressor section, many studies suggest that roads may serve as a barrier to bats (Bennett and Zurcher 2013; Bennett et al. 2013; Berthinussen and Altringham 2012; Wray et al. 2006). Bennett et al. (2011) indicated that three main characteristics contribute to the barrier effects of roads: traffic volume, road width, and road surface. Roads with very few vehicles and only two lanes had little effect on Indiana bat movement (Bennett et al. 2013). Zurcher et al. (2010) concluded that bats perceive vehicles as a threat and were more than twice as likely to reverse course if a vehicle was present than if it was absent. Berthinussen and Altringham (2012) found that bat activity and diversity was lower closer to roads, but that activity and diversity increased where there was continuity in trees and hedgerows. Kerth and Melber (2009) studied barbastelle bats (*Barbastella barbastellus*) and Bechstein's bats (*Myotis bechsteinii*) and found that roads restricted habitat accessibility for bats, but the effect was related to the species' foraging ecology and wing morphology. Foraging ecology of gleaning and woodland species were more susceptible to the barrier effect than high-fliers that feed in open spaces (Kerth and Melber 2009).

Effects Pathway – Indiana bat #13	
Activity: Construction	
Stressor: Collision	
Exposure (time)	April 1 – November 14 (active timeframe); duration of the activity
Exposure (space)	Bridge and roadway construction within the project area
Resource affected	Individuals (adults, juveniles)
Individual response	Mortality from collision with vehicles or equipment.
Interpretation	The most likely effect of collision between an Indiana bat and a moving vehicle is harm in the form of mortality. However, since most construction activities would occur during daylight hours, collisions would be avoided. Risk of collision with construction vehicles during night time is minimized by the slow speed of construction vehicles in the work area. Further, construction activities that occur from dusk through dawn hours are likely localized to one area and do not require a substantial amount of construction vehicle travel. Based on this information, construction vehicle collision with an Indiana bat is unlikely to occur; therefore, any potential effects are considered discountable.
Effect	Discountable

Effects Pathway – Indiana bat #14	
Activity: Operation	
Stressor: Collision	
Exposure (time)	April 1 – November 14 (active timeframe); indefinitely
Exposure (space)	Bridge and roadways, throughout the Action Area
Resource affected	Individuals (adults, juveniles)
Individual response	Mortality from collision with vehicles.
Interpretation	The risk of collision between a Indiana bat and vehicle travelling across a bridge while foraging is considered to be low due to the ability of bats to fly under bridges to avoid traffic and the reduced amount of traffic during evening hours when bats are active. However, collisions between bats and vehicles along roadways have been documented, and the bridge and roadways are expected to operate indefinitely. Exposure to this stressor is expected to harm an indeterminable number of Indiana bats within the Action Area.
Effect	Harm
Amount or Extent of Adverse Effects	Because of the difficulty in determining the number of individual Indiana bats that will be adversely affected during this specific activity and stressor, the Service has determined that it is appropriate to consider an average of one Indiana bat per year would be adversely affected. Indiana bats are expected to be injured or killed due to this activity and stressor, and effects are expected to occur indefinitely.

5.6 Stressor 6: Alteration or Loss of Roosting Habitat (Bridges)

Rehabilitation and replacement of bridges will result in alteration and loss of roosting habitat for Indiana bats during the maintenance and construction components. Bridge rehabilitation activities are generally considered as maintenance, and may occur in areas where bats typically roost on the superstructure and underside of the bridge deck. Activities such as patching and sealing of cracks on the superstructure, repairs to header/expansion joints in the deck, and cleaning of deck drains/scuppers could impact roosting bats and cause alteration or loss of roosting locations. Bridge replacement during construction will involve the removal of individual bridge components (i.e., deck, superstructure, and substructure) or the entire structure using heavy equipment and tools. Removal of the bridge deck will result in the loss of roosting habitat in the deck and will likely alter roosting locations on the superstructure. Impacts could also occur to Indiana bats roosting on these structures during removal. After replacement projects are complete, a bridge will be present at the same or similar location; however, the new structure may not provide roosting habitat, resulting in a potential loss of roosting habitat for Indiana bats.

Applicable Science

Indiana bats have been documented using bridges as roosting habitat during the spring, summer, and fall. No occurrences of this species hibernating in bridges during the winter have been reported. Concrete structures seem to be preferred for roosting due to their tendency to retain heat longer than other materials; however, metal and wood structures may also be used with less frequency. Indiana bats have been observed using bridges as both day and night roosts. Day roosts are typically used by bats between sunrise and sunset and consist of sheltered areas that provide protection from adverse weather conditions and predators (Keeley and Tuttle 1999, Kiser et al. 2002).

Night roosts are generally used by bats between sunset and sunrise to rest, digest food between foraging bouts, conserve energy, and avoid inclement weather (Ormsbee et al. 2007). Bridges with a concrete deck and concrete or metal girders seem to be preferred as night roosts (Keeley and Tuttle 1999, Kiser et al. 2002). This bridge type retains heat into the night, and the chambers between the girders trap heat rising from under the bridge and provide protection from wind, weather, and predators. Night-roosting bats are typically found on the vertical surface of the girder at the intersection with the underside of the deck. Areas near the bridge abutments and over land seem to be preferred over the central portion of the bridge and areas spanning water. Bridges that lack crevices/expansion joints or girders are rarely used as day or night roosts (Adam and Hayes 2000, Feldhamer et al. 2003, Ormsbee et al. 2007); however, structures with cave-like areas or other unique features that provide suitable roosting locations can also provide suitable roosting habitat.

Effects Pathway – Indiana Bat #15	
Activity: Maintenance (bridge rehabilitation)	
Stressor: Alteration or Loss of Roosting Habitat of Bridges	
Exposure (time)	April 1 – November 14 (active timeframe); duration of the activity
Exposure (space)	Bridges
Resource affected	Summer or swarming roosting habitat, individuals (adults, juveniles)
Individual response	• Flushing from bridge roost results in extra energy expenditure that can

	reduce fitness and result in reduced survival/reproductive success. • Flushing from bridge roost will increase chances of predation. • Increased effort to find new suitable roosting habitat requires extra energy expenditure that can reduce fitness and result in reduced survival/reproductive success.
Conservation Measures	Avoidance of project effects on a bridge structure that is known or has been identified as reasonably likely to support a maternity colony.
Interpretation	Bats may flush from their roosts on the bridge. Bats that flush during the daytime are at greater risk of harm due to predation. Additionally, bats that flush their roosts may be harmed due to an increase in energy expenditure. The most severe effects of flushing a bat from a bridge may result in harm if the bat was a female with a pup. The longer the female is absent, the more likely the effects to the pup would be significant. Bats that flush must also expend additional energy to locate other roosting habitat. The use of additional energy in response to habitat loss, especially when combined with the energy needs associated with normal life cycle processes (e.g., migration, pregnancy, lactation, etc.) or other stressors, is likely to reduce fitness and subsequently reduce survival and reproductive success. Indiana bats exposed to this stressor while roosting on the bridge are likely to respond in a way that would lead to adverse effects.
Effect	Harm
Amount or Extent of Adverse Effects	Because of the difficulty in determining the number of individual Indiana bats that will be adversely affected during this specific activity and stressor, the Service has determined that it is appropriate to consider the total amount of Indiana bats adversely affected by using the analysis for removal of summer and fall swarming habitat in this section. We believe that this reduces the potential to double count the number of individual Indiana bats impacted by the entire Action. A small, but indeterminable, portion of Indiana bats are expected to be injured or killed due to this activity and stressor. Disruption of normal behavior as a result of physical disturbance and/or habitat modification or degradation will account for the vast majority of adverse effects.

Effects Pathway – Indiana Bat #16	
Activity: Construction (bridge replacement)	
Stressor: Alteration or Loss of Roosting Habitat of Bridges	
Exposure (time)	April 1 – November 14 (active timeframe); duration of the activity
Exposure (space)	Bridges
Resource affected	Summer or swarming roosting habitat, individuals (adults, juveniles)
Individual response	• Mortality during bridge removal. • Flushing from bridge roost results in extra energy expenditure that can reduce fitness and result in reduced survival/reproductive success. • Flushing from bridge roost will increase chances of predation. • Increased effort to find new suitable roosting habitat requires extra energy expenditure that can reduce fitness and result in reduced

	survival/reproductive success.
Conservation Measures	Avoidance of project effects on a bridge structure that is known or has been identified as reasonably likely to support a maternity colony.
Interpretation	Bats roosting in bridge may be injured or killed. Injured bats may subsequently die. Bats may flush from their roosts on the bridge. Bats that flush during the daytime are at greater risk of harm due to predation. Additionally, bats that flush their roosts may be harmed due to an increase in energy expenditure. The most severe effects of flushing a bat from a bridge may result in harm if the bat was a female with a pup. The longer the female is absent, the more likely the effects to the pup would be significant. Bats that flush must also expend additional energy to locate new roosting habitat. The use of additional energy in response to habitat loss, especially when combined with the energy needs associated with normal life cycle processes (e.g., migration, pregnancy, lactation, etc.) or other stressors, is likely to reduce fitness and subsequently reduce survival and reproductive success. Indiana bats exposed to this stressor while roosting on the bridge are likely to respond in a way that would lead to adverse effects.
Effect	Harm
Amount or Extent of Adverse Effects	Because of the difficulty in determining the number of individual Indiana bats that will be adversely affected during this specific activity and stressor, the Service has determined that it is appropriate to consider the total amount of Indiana bats adversely affected by using the analysis for removal of summer and fall swarming habitat in this section. We believe that this reduces the potential to double count the number of individual Indiana bats impacted by the entire Action. A small, but indeterminable, portion of Indiana bats are expected to be injured or killed due to this activity and stressor. Disruption of normal behavior as a result of physical disturbance and/or habitat modification or degradation will account for the vast majority of adverse effects.

Effects Pathway – Indiana Bat #17	
Activity: Maintenance and Construction (bridge rehabilitation/replacement)	
Stressor: Alteration or Loss of Roosting Habitat of Bridges	
Exposure (time)	Inactive timeframe (November 15 – March 31) removal will expose Indiana bats to adverse effects from April 1 – November 14, for one season after removal.
Exposure (space)	Bridges
Resource affected	Summer and swarming roosting habitat, used by individuals (adults)
Individual response	• Increased effort to find new suitable roosting habitat requires extra energy expenditure that can reduce fitness and result in reduced survival/reproductive success.
Conservation Measures	Avoidance of project effects on a bridge structure that is known or has been identified as reasonably likely to support a maternity colony.
Interpretation	Adult bats will experience adverse effects after they arrive at their summer roosting habitat the first year after bridge rehabilitation/replacement. The extra energy to find new habitat is in

	addition to what is necessary for foraging, pup rearing, social interactions, or other activities. The use of additional energy in response to habitat loss, especially when combined with the energy needs associated with normal life cycle processes (e.g., migration, pregnancy, lactation, etc.) or other stressors, is likely to result in adverse effects. Indiana bats are expected to adapt to this stressor in subsequent years after they have found new suitable habitat.
Effect	Harm
Amount or Extent of Adverse Effects	Because of the difficulty in determining the number of individual Indiana bats that will be adversely affected during this specific activity and stressor, the Service has determined that it is appropriate to consider the total amount of Indiana bats adversely affected by using the analysis for removal of summer and fall swarming habitat in this section. We believe that this reduces the potential to double count the number of individual Indiana bats impacted by the entire Action. A small, but indeterminable, portion of Indiana bats are expected to be injured or killed due to this activity and stressor. Disruption of normal behavior as a result of physical disturbance and/or habitat modification or degradation will account for the vast majority of adverse effects.

5.7 Summary of Effects

Table 4. A summary of the effects of the Action on the Indiana bat.

Stressors: ***Activity***	**Adverse**	**Insignificant/ Discountable**
Noise and vibration: *construction and maintenance*	harm	
Noise and vibration: *operation*		insignificant
Night lighting: *construction and operation*		insignificant
Night lighting: *maintenance*		discountable
Aquatic resource loss: *construction*		insignificant
Aquatic resource degradation, sedimentation: *construction and maintenance*		insignificant
Aquatic resource degradation, pollutants: *construction, operation, and maintenance*		insignificant
Tree removal, summer habitat (active timeframe): *construction and maintenance*	harm	
Tree removal, summer habitat (inactive timeframe): *construction and maintenance*	harm	
Tree removal, forest loss and fragmentation: *construction and maintenance*	harm	
Tree removal, swarming habitat (active timeframe): *construction and maintenance*	harm	
Tree removal, swarming habitat (inactive timeframe): *construction and maintenance*	harm	
Collison (construction equipment): *construction*		discountable
Collison (vehicle): *operation*	harm	
Alteration or loss of roosting habitat of bridges (active timeframe): *maintenance* (rehabilitation)	harm	
Alteration or loss of roosting habitat of bridges (active timeframe): *construction* (replacement)	harm	
Alteration or loss of roosting habitat of bridges: *maintenance and construction* (rehab or replacement) (inactive timeframe)	harm	

6 CUMULATIVE EFFECTS

For purposes of consultation under ESA §7, cumulative effects are the effects of future state, tribal, local, or private actions that are reasonably certain to occur in the Action Area. Future federal actions that are unrelated to the proposed action are not considered, because they require separate consultation under §7 of the ESA.

Land use activities that may affect Indiana bats and that are likely to occur within the Action Area include: timber harvest, ATV recreational use, recreational use of caves, and development associated with road, residential, industrial, and agricultural development and related activities. These private actions are likely to occur within the Action Area, but the Service is unaware of any quantifiable information about the extent of private timber harvests within the Action Area, the amount of use of off-highway vehicles within the Action Area, or the amount of recreational use of caves within the Action Area. Similarly, the Service does not have any information on the amount or types of residential, industrial, or agricultural development that have or will occur within the Action Area. Therefore, the Service is unable to make any determinations or conduct any meaningful analysis of how these actions may or may not adversely and/or beneficially affect the Indiana bat. It is possible that these activities may have cumulative effects on Indiana bats and their habitat in certain situations (e.g., a private timber harvest during summer months within an unknown maternity colony may cause adverse effects to that maternity colony). In stating this, however, we can only speculate as to the extent or severity of those effects, if any.

7 CONCLUSION

In this section, we summarize and interpret the findings of the previous sections (status, baseline, effects, and cumulative effects) relative to the purpose of a BO under §7(a)(2) of the ESA, which is to determine whether a Federal action is likely to:

a) jeopardize the continued existence of species listed as endangered or threatened; or
b) result in the destruction or adverse modification of designated critical habitat.

"Jeopardize the continued existence" means to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species (50 CFR §402.02).

After reviewing the current status of the species, the environmental baseline for the Action Area, the effects of the Action and the cumulative effects, it is the Service's biological opinion that the Action is not likely to jeopardize the continued existence of the Indiana bat. The Action does not affect designated critical habitat for the Indiana bat; therefore, it is not likely to destroy or adversely modify critical habitat.

The Indiana bat is declining throughout its range as a result of WNS. Although the Action is not expected to reverse this decline, we have determined that the species' reproduction, numbers, and distribution will not be appreciably reduced as a result of the Action. This no jeopardy determination is supported by the analysis for the Effects of the Action and because:

- Except for the rare circumstance of felling trees while individuals, especially non-volant pups, are roosting in those trees, most of the Indiana bats affected will experience sub-lethal forms of harm.
- Most of the harm is expected to result in additional energy expenditures (reduced fitness) associated with a one-time loss or alteration of habitat. Affected bats are expected to fully recover from this harm within 1–2 years.
- Impacts to maternity colonies and their reproductive success are anticipated to be short-term (2–3 years) and would only affect a small proportion on the range-wide population.
- Impacts to the species reproduction and numbers will be limited by the avoidance and minimization measures implemented by the FHWA (e.g., exclusion of hibernacula, restrictions on tree removal during the non-volant and spring staging periods, and within close proximity to hibernacula).

- No reduction in the distribution of the species is expected as the Action Area occurs near the center of the species' range, and impacts from the Action are limited at both at the project and programmatic scales, and are dispersed across a large Action Area.

Further, the contribution to the Imperiled Bat Conservation Fund is expected to promote the survival and recovery of the species through protection and management of:

1) existing forested habitat that support potential maternity populations, particularly those that would expand existing conservation ownerships;
2) known priority hibernacula;
3) additional conservation lands that contain potential habitat for the species, particularly those that would expand existing conservation ownerships.

8 INCIDENTAL TAKE STATEMENT

ESA §9(a)(1) and regulations issued under §4(d) prohibit the take of endangered and threatened fish and wildlife species without special exemption. The term "take" in the ESA means "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct" (ESA §3). In regulations at 50 CFR §17.3, the Service further defines:

- "harass" as "an intentional or negligent act or omission which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering;"
- "harm" as "an act which actually kills or injures wildlife. Such act may include significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding or sheltering;" and
- "incidental take" as "any taking otherwise prohibited, if such taking is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity."

Under the terms of ESA §7(b)(4) and §7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered prohibited, provided that such taking is in compliance with the terms and conditions of an incidental take statement (ITS).

For the exemption in ESA §7(o)(2) to apply to the Action considered in this BO, the FHWA must undertake the non-discretionary measures described in this ITS, and these measures must become binding conditions of any permit, contract, or grant issued for implementing the Action. The FHWA has a continuing duty to regulate the activity covered by this ITS. The protective coverage of §7(o)(2) may lapse if the FHWA fails to:

- assume and implement the terms and conditions; or
- require a permittee, contractor, or grantee to adhere to the terms and conditions of the ITS through enforceable terms that are added to the permit, contract, or grant document.

In order to monitor the impact of incidental take, the FHWA must report the progress of the Action and its impact on the species to the Service as specified in this ITS.

8.1 Amount or Extent of Take Anticipated

This section specifies the amount or extent of take of the Indiana bat that the Action is reasonably certain to cause, which we estimated in the "Effects of the Action" section of this BO, using the best available data. We reference, but do not repeat, these analyses here.

We estimated the number of individuals reasonably likely to occur in the Action Area (see section 4, Environmental Baseline). We evaluated the potential for these individuals to be exposed to the stressors resulting from the proposed Action. Finally, we evaluated how the individuals' responses to their exposure to these stressors would apply to the statutory and regulatory definition of take (see section 5, Effects of the Action). From our evaluation, the proposed Action is reasonably certain to cause the incidental take of 587 individual Indiana bats. This taking is expected in the form of harm. The mechanisms of this taking and the basis for our estimation of its extent are described in section 5 (Effects of the Action) of this BO.

Table 5. Summary of Expected Incidental Take Resulting from the Action

Species	# of Individuals	Take Type
Indiana bat	540	Harm (Tree Removal, Summer Habitat)
Indiana bat	46	Harm (Tree Removal, Swarming Habitat)
Indiana bat	1 per year	Harm (Collision)

The Service anticipates the incidental taking of Indiana bats associated with this project will be difficult to detect for the following reasons:

- The individuals are small, mostly nocturnal, and when not hibernating, occupy forested habitats where they are difficult to observe;
- The Indiana bat forms small maternity colonies under loose bark or in the cavities of trees, and males and non-reproductive females may roost individually, which makes finding roost trees difficult;
- Finding dead or injured specimens during or following project implementation is unlikely; and
- Most incidental take is in the form of non-lethal harm and not directly observable.

Due to the difficulty of detecting take of Indiana bats caused by the proposed Action, the Service will monitor the extent of taking using the acreage of suitable habitat that projects remove or alter, which is up to 5,000 acres over a 5-year period, with no more than 1,000 acres occurring in any calendar year. This surrogate measure is appropriate because the majority of the anticipated taking will result from habitat removal/alteration and activities associated with that alteration, and because it sets a clear standard for determining when the extent of taking is exceeded.

8.2 Reasonable and Prudent Measures

The Service believes the following reasonable and prudent measures (RPMs) are necessary or appropriate to minimize the impact of incidental take caused by the Action on the Indiana bat.

RPM1. The FHWA will ensure that the programmatic process and conservation measures will be implemented, as appropriate, on a project-by-project basis as planned and documented in the BA and the BO.

RPM2. FHWA will coordinate with the KFO in order to develop a user's guide and/or key to assist in the implementation of the programmatic process in compliance with the programmatic consultation as documented in the BO.

RPM3. FHWA will coordinate with the KFO to develop a monthly accounting ledger that identifies specific roles and responsibilities, monitoring requirements, and other details regarding the use of the programmatic consultation.

8.3 Terms and Conditions

In order for the exemption from the take prohibitions of §9(a)(1) and of regulations issued under §4(d) of the ESA to apply to the Action, the FHWA must comply with the terms and conditions (T&Cs) of this statement, provided below, which carry out the RPMs described in the previous section. These T&Cs are mandatory. As necessary and appropriate to fulfill this responsibility, the FHWA must require the KYTC or any permittee, contractor, or grantee to implement these T&Cs through enforceable terms that are added to the permit, contract, or grant document.

T&C1. The FHWA shall conduct regular audits of specific projects and/or monthly ledgers to ensure proper adherence and consistent use of the programmatic consultation. FHWA shall contact the KFO within 30 days and provide a written explanation and plan of action of any irregularities identified because of the aforementioned audits. (This T&C is associated with RPM1).

T&C2. The FHWA shall develop a user's guide and/or key for the KYTC personnel implementing the programmatic process in order to maintain consistency. The guide shall clearly identify the key project factors, conservation measures, and the steps leading up to a proper species effects determination. The guide shall also include instructions on how to calculate and complete any required compensation and reporting requirements. Completion of this T&C shall occur within 30 days of the executed BO. (This T&C is associated with RPM2).

T&C3. The FHWA shall develop a monthly accounting ledger that is specific to each of the KYTC's monthly project letting schedules, and will include all covered projects, including those where conservation and/or compensation measures were not required. The ledger will identify those projects where compensation is required and the preferred method. Completion of this T&C shall occur within 30 days of the executed BO. Specific ledger information may include, but is not limited to, the following:

- Description of the proposed action (e.g., type of action, location, involved federal agencies);
- Verifies that the project is within the scope of the programmatic consultation;
- Provides details of impacts (e.g., acres of tree removal, timing of tree removal, bridge work); and
- Identifies all proposed conservation measures that will avoid, minimize and/or compensate the project's impacts. (This T&C is associated with RPM3).

8.4 Monitoring and Reporting Requirements

In order to monitor the impacts of incidental take, the FHWA, through coordination with the KYTC, shall report the progress of the Action and its impact on the species to the Service as specified in the incidental take statement (50 CFR §402.14(i)(3)). Completion of T&C3 shall be incorporated into this section providing the specific instructions for such monitoring and reporting. As necessary and appropriate to fulfill this responsibility, the FHWA must require any permittee, contractor, or grantee to accomplish the monitoring and reporting through enforceable terms that are added to a permit, contract, or grant document. Such enforceable terms must include a requirement to immediately notify the FHWA and the Service if the amount or extent of incidental take specified in this ITS is exceeded during Action implementation.

9 GRAY BAT

9.1 Status of the species

This section summarizes the best available data about the biology and current condition of the gray bat (*Myotis grisescens*) throughout its range that are relevant to formulating an opinion about the Action. The Service published its decision to list the gray bat as endangered on April 28, 1976 (41 FR 17736) under the Endangered Species Act (ESA) of 1973 (87 Stat. 884, as amended; 16 U.S.C. 1531 et seq.). No Critical habitat has been designated for the species.

The Service has published a recovery plan that outlines recovery actions (U.S. Fish and Wildlife Service (USFWS) 1982). Briefly, the objectives of the plan are to: (1) protect hibernacula; (2) maintain, protect, and restore summer maternity caves; and (3) monitor population trends through winter and summer censuses.

The Service's Columbia, Missouri Field Office completed a 5-Year Review of the gray bat (USFWS 2009), which summarizes the current status of the species, its progress toward recovery, and the remaining threats to the species. The draft recovery plan and 5-Year Review are available at http://www.fws.gov/midwest/Endangered/mammals/graybat/index.html and are hereby incorporated by reference. The 5-Year Review found that all of the required recovery criteria for the gray bat had not been achieved, so the species should remain at its current endangered status.

9.2 Species Description

The gray bat is one of the largest species in the genus *Myotis* in eastern North America with a wingspan 10.8 to 11.8 inches and weight between approximately 0.25 to 0.56 ounces. The gray bat can be distinguished from other species in the genus *Myotis* by: (1) the uniform color of its dorsal fur in which hair shafts are gray from base to tip, (2) the wing membrane, which attaches at the ankle of the foot instead of at the base of the toes, and (3) a notch in the claws of the hind feet (Barbour and Davis 1969; Harvey et al. 1981; Decher and Choate 1995; Tuttle and Kennedy 2005). The calcar on gray bats is not keeled and the skull has a distinct sagittal crest (Harvey et al. 1981; Mitchell 1998).

9.3 Life History

Life Span

Recorded longevity for the gray bat is approximately 14 to 17 years, but may be longer (Harvey 1992; Tuttle and Kennedy 2005). The species reaches sexual maturity at two years of age (Tuttle 1976a).

Diet

Gray bats are highly dependent on aquatic insects, especially mayflies, caddisflies, and stoneflies. The species is an opportunistic forager, however, and consumes beetles and moths (Harvey 1994; Tuttle and Kennedy 2005). Juveniles have a tendency to forage more in woodlands and consume more beetles than adults, and eat a less diverse diet than adults eat, possibly because juveniles are more dependent on high concentrations of prey (Brack and Laval 2006).

Staging, Spring Migration and Summer Roosting

The annual activity period of gray bats is April to October (Best et al. 1997). Adult female gray bats emerge from their winter hibernating caves (hibernacula) in late March or early April, followed by juveniles of both sexes and adult males. Ovulation in females occurs soon after their emergence from hibernation (Guthrie and Jeffers 1938). Juveniles and adult males typically emerge between mid-April and mid-May (Tuttle 1976b). This period following hibernation, but prior to spring migration, is typically referred to as "staging". Most gray bats migrate seasonally between their hibernacula and maternity caves. Spring migration is hazardous because gray bats that do not have sufficient fat reserves have difficulties surviving the stress and energy-intensive migration period. Consequently, adult mortality is highest in late March and April (Tuttle and Stevenson 1977; U.S. Fish and Wildlife Service 1982).

The distance traveled by an individual colony during migration (spring and fall) varies depending on geographic location (U.S. Fish and Wildlife Service 1982). Each summer colony occupies a traditional home range that often contains several roosting caves scattered over up to a 70 square kilometers (km2) (43.5 square miles [mi2]) area, adjacent to a river or reservoir. Colony members are extremely loyal to their colony home range, with males and non-reproductive females dispersing and congregating in smaller groups in more peripheral caves within that area (Tuttle 1976b).

The reproductively active females congregate in a single, traditional maternity cave (usually the warmest one available) within the colony home range (Tuttle 1976b). Gestation in gray bats lasts 60 to 70 days, with birth (parturition) occurring in late May or early June. Females give birth to one offspring per year. The young clings to the mother for about a week, after which they remain in the maternity colony until they are able to fly (Mitchell and Martin 2002). Reproductive females must maintain high body temperatures at their relatively cool roosts, requiring larger amounts of energy, especially during the period of lactation from late May to early July. During the period of peak demand, when young are roughly 20 to 30 days old, females sometimes feed continuously for more than 7 hours during a single night (U.S. Fish and Wildlife Service 1982).

Growth rates of non-volant (pre-flight) young are positively correlated with colony size (Tuttle 1975), because increasing numbers of bats clustering together reduce the thermoregulatory cost per individual (Herreid 1963, 1967). Growth rates are also affected positively by higher ambient cave temperatures (U.S. Fish and Wildlife Service 1982). Most young take flight in late June to mid-July by four weeks of age (at 20 to 25 days of age) (U.S. Fish and Wildlife Service 1982; Mitchell and Martin 2002). Where colonies have been reduced in size as a result of roost disturbance, days to volancy (flight) in young are sometimes increased up to 35 days following birth, and in severely reduced colonies, the young sometimes die before learning to fly (U.S. Fish and Wildlife Service 1982). For newly volant young, growth rates and survival are inversely proportional to the distance from their roost to the nearest aquatic (over a river or reservoir) foraging habitat (Tuttle 1976a). Although females continue to nurse their young for a brief period after they learn to fly, juveniles must learn how and where to hunt independently (Tuttle and Stevenson 1982).

Fall Migration, Swarming, Mating and Hibernation
Gray bats often migrate in large groups (Whitaker and Hamilton 1998a). Fall migration for gray bats occurs in approximately the same order as spring emergence, with females departing first (early September) and juveniles leaving last (mid-October). Gray bats have been documented to regularly migrate from 17 kilometer (km) (10.6 mi) to 437 km (271.6 mi) between summer maternity sites and winter hibernacula (Tuttle 1976b; Hall and Wilson 1966), with some individuals moving as much as 689 km (428.1 mi) to 775 km (481.6 mi) (Tuttle 1976b; Tuttle and Kennedy 2005).

Gray bats reach their hibernacula between August and October, with the females arriving first. "Swarming" and mating begin soon after the bats start arriving (Whitaker and Hamilton 1998a). Swarming behavior typically involves large numbers of bats flying in and out of cave entrances throughout night hours. After mating, females store sperm in their uteri through the winter (Guthrie and Jeffers 1938; Mitchell and Martin 2002). Following mating, some females enter hibernation as early as the first of September, and nearly all do so by early October (U.S. Fish and Wildlife Service 1982; Best et al. 1997). Males remain active for several weeks after mating, during which time fat reserves depleted during breeding are replenished. Juveniles of both sexes and adult males tend to enter hibernation several weeks later than adult females, but most are in hibernation by early November (Tuttle 1976b; Tuttle and Stevenson 1977; U.S. Fish and Wildlife Service 1982; Mitchell and Martin 2002).

Both males and females hibernate in the same caves (Martin 2007). Gray bat hibernacula are often made-up of individuals from large areas of their summer range (U.S. Fish and Wildlife Service 2009a). Based on band recovery data, Hall and Wilson (1966) calculated that a gray bat hibernaculum in Edmonson County, Kentucky, attracted individuals from an area encompassing 27,195 km2 (10.4 mi') in Kentucky, southern Illinois and northern Tennessee (Hall and Wilson 1966).

Hibernating bats arouse periodically from torpor (state of mental or physical inactivity), and each time a bat arouses it uses a significant amount of energy to warm its body and increase its metabolic rate (80 FR 17987). The cost and number of arousals are the two key factors that determine energy expenditures of hibernating bats in winter (Thomas et al. 1990). For example, little brown bats *(Myotis lucifugus)* used as much fat during a typical arousal from hibernation as would be used during 68 days of torpor; arousals and subsequent activity may constitute 84% of the total energy used by hibernating bats during the winter (Thomas et al. 1990).

9.4 Habitat Characteristics and Use of the Gray Bat

Gray bats are cave obligate (or cave dependent) bats, meaning that with very few exceptions (in which cave-like conditions are created in man-made structures), gray bats only live in caves, not in abandoned barns or other structures as other species of bats are known to do. Less than 5% of all available caves are inhabited by gray bats (Mitchell and Martin 2002). Gray bats use caves differently throughout the year. Populations of gray bats tend to cluster in caves, utilized as hibernacula, during winter hibernation. In contrast, their populations disperse during spring to establish sexually segregated colonies (Sherman and Martin 2006). Females form maternity colonies (also known as summer maternity roosts), while males aggregate in non-maternity or bachelor colonies. These bachelor colonies also house yearlings of both sexes (Sasse et al. 2007). Gray bats also utilize a third type of cave, the dispersal cave, which they inhabit only during migration (Brack and LaVal 2006).

Winter Hibernacula Habitat

Gray bats prefer deep, cool caves for hibernacula with average temperatures ranging from 41 to 52° F. Multiple entrances and good airflow comprise the other characteristics that gray bats find desirable. Winter hibernacula are already cold when gray bats begin arriving in September (Mitchell and Martin 2002).

Summer Roosting Habitat

Gray bat summer caves are usually located along rivers and have temperatures ranging from 57 to 77° F (Mitchell and Martin 2002). Summer caves typically contain structural heat traps (including domed ceilings, small chambers and porous rock surfaces) that capture metabolic heat from clustered gray bats, allowing the nursery populations to succeed. Preferred summer colony caves are within 1 km (approximately 0.6-mi) of a body of water and are rarely more than 4 km (2.5 mi) from a lake or major river (Mitchell and Martin 2002). The average roosting density of gray bats is 1828 bats/square meter [m2] (10.8 square feet [ft2]) (Sherman and Martin 2006).

Gray bats are also known to use bridges and culverts as roosting habitat during the spring, summer, and fall. Concrete structures seem to be preferred due to their tendency to retain heat longer than other materials; however, metal and wood structures may also be used with less frequency. Gray bats have been observed using bridges and culverts as both day and night roosts. Bridges used as day roosts are typically constructed of concrete and contain vertical crevices, expansion joints, or other locations that allow bats to retreat into the bridge deck or superstructure (Keeley and Tuttle 1999, Feldhamer et al. 2003, Cleveland and Jackson 2013). Bridges with a concrete deck and concrete or metal girders seem to be preferred as night roosts (Keeley and Tuttle 1999, Kiser et al. 2002). This bridge type retains heat into the night, and the chambers between the girders trap heat rising from under the bridge and provide protection from wind, weather, and predators. Night-roosting bats are typically found on the vertical surface of the girder at the intersection with the underside of the deck, often near the bridge abutments. Areas over land seem to be preferred more than the central portion of the bridge and areas spanning water. Bridges that lack crevices/expansion joints or girders are rarely used as day or night roosts (Adam and Hayes 2000, Feldhamer et al. 2003, Ormsbee et al. 2007); however, structures with cave-like areas or other unique features that provide suitable roosting locations can also provide suitable roosting habitat.

Culverts utilized by gray bats are typically concrete box culverts between five and 10 feet in height; however, this species may also use metal culverts with similar dimensions. These structures are generally 50 feet or longer and provide dark zones, protection from high winds, and are not susceptible to frequent flooding. Roosting locations preferred by gray bats include dark areas with crevices and structural imperfections. Culverts less than five feet high are not generally used as roosting habitat (Keeley and Tuttle 1999, USFWS 2009).

Foraging Habitat

Gray bats forage over water, including streams and reservoirs, in early evening hours where they consume night-flying insects, most of which have aquatic larval stages (Best et al. 1997), and in riparian forests near those water sources (Brack and LaVal 2006). Gray bat activity tends to be more concentrated over slower moving water or quiet pools than over areas of fast moving water. Foraging usually occurs below treetop height, but above 2 meters (m) (6.6 ft) (LaVal et al. 1977). Gray bats tend to fly downstream more often than upstream, suggesting a potential preference to forage over wider aquatic areas (more typical of lower stream reaches). The species tends to forage over extensive ranges, averaging 12.5 km (7.8 mi), spanning from approximately 2.5 km (1.6 mi) to 35.4 km (22 mi) (LaVal et al. 1977). When prey is abundant, gray bats have been shown to forage in small groups, especially during the early hours of the night; when prey is scarce, gray bats can become territorial. One to as many as 15, or more, gray bats may occupy foraging territories depending upon prey abundance Those territories tend to be controlled by reproductive females, which appear to claim the same territories, year after year (U.S. Fish and Wildlife Service 1982).

9.5 Numbers, Reproduction, and Distribution

The primary range of gray bats is concentrated in the cave regions of Alabama, Arkansas, Kentucky, Missouri and Tennessee, with smaller populations found in adjacent states, including a population in a quarry in Clark County, Indiana (Harvey et al. 1981; Brack et al. 1984; Harvey 1992; Harvey 1994; Mitchell 1998).

At the time the recovery plan was completed for the species (U.S. Fish and Wildlife Service 1982), gray bats were documented in approximately 290 caves (winter and summer caves) throughout 11 states (Alabama, Arkansas, Florida, Georgia, Illinois, Kansas, Kentucky, Missouri, Oklahoma, Tennessee and Virginia). The recovery plan did not include Indiana, where the species has since been documented (Brack et al. 1984; Brack 1985). Martin (2007) listed the species for 384 winter and/or summer caves scattered across 11 states, but that analysis also did not include Indiana (the 12th state within the range of the gray bat).

Overall, the gray bat's numbers have increased significantly in many areas (U.S. Fish and Wildlife Service 2009a). Rangewide, gray bats have been documented in a few hundred caves (U.S. Fish and Wildlife Service 1982). In Missouri alone, Elliott (2008) reported that gray bats had been documented in at least 219 caves or about 3.5% of all Missouri caves. This species' range has expanded in some areas (e.g., Georgia, Indiana and Kansas), and gray bats are using many caves where use by the species had not been documented prior to the completion of the 1982 Recovery Plan (U.S. Fish and Wildlife Service 1982, 2009a). Martin (2007) reported nearly 500,000 gray bats at eight hibernacula, where there had only been about 25,000 recorded historically. Martin's (2007) estimate included Coach Cave, Kentucky, that increased from zero in 1995 to 337,750 in 2007.

Other impressive increases include the following: 33 in 1985 to 128,005 in 2006 at Blanchard Springs Caverns, Arkansas; 50 in 1982 to 139,740 in 2006 at Cave Mountain Cave, Arkansas; and 347 in 1965 to 139,364 in 2006 at Bellamy Cave, Tennessee. Similarly, Martin (2007) and Elliott (2008) reported that populations of gray bat at Coffin Cave, Missouri, increased from an estimate of 250,000 in 1977-1979 to 561,000 bats in 2005.

Tuttle (1979) postulated that gray bats have not expanded into areas outside their historical range, and Elliott (2008) estimated that despite an overall increase in gray bat numbers in Missouri, the overall state population of this species was still only about 46% of the maximum historic population. In other areas (e.g., Florida) the species has declined significantly at both hibernacula and maternity sites (U.S. Fish and Wildlife Service 2009a).

Ellison et al. (2003) statistically analyzed 1,879 observations of gray bats obtained from 334 roost locations (103 maternity roosts and 12 hibernacula) in 14 south-central and southeastern states. These authors reported upward, downward, or no trends for all sites analyzed. The Service interpreted an upward trend to be defined as an increasing population, a downward trend to be defined as a decreasing population and no trend to be defined as a stable population (U.S. Fish and Wildlife Service 2009a). Of the 103 maternal colonies examined, Ellison et al. (2003) determined that 94.4% (85.4% no trend; 9% upward trend) of the populations showed stable or increasing populations while 6% revealed a decreasing population. Stable or increasing populations were reported for 83% (58% no trend; 25% upward trend) of the 12 hibernating colonies examined. For populations where there was a downward population trend, decreases in population numbers were mostly attributed to continued problems with human disturbance.

Sasse et al. (2007) analyzed data from 48 gray bat maternity sites involving three subpopulations in Missouri, Arkansas and Oklahoma between 1978 and 2002, and calculated that 79% of the colonies were stable or increasing. Elliott (2008) examined population trends of gray bats at nine Priority 1 caves and concluded that although the species had increased by approximately 21% between 1980 and 2005, it had only reached roughly 37% of its maximum historic populations at these sites. Based on general population trends across the range of the species, Dr. Michael Harvey of Tennessee Technological University attempted to estimate changes in the species status. He reported that the species increased from approximately 1,575,000 to roughly 2,678,000 in 2002 and to approximately 3,400,000 in 2004 (Ellison et al. 2003; Martin 2007). Martin (2007) noted that gray bat population levels have increased approximately 104% since 1982, when the species recovery plan was completed (U.S. Fish and Wildlife Service 1982).

Based on recent surveys of Priority 1 hibernacula, the current rangewide population estimate for the gray bat is approximately 5.1 million individuals (USFWS unpublished 2019 data).

Current Winter Distribution
The major gray bat wintering caves (hibernacula) occur primarily in Alabama, Arkansas, Kentucky, Missouri and Tennessee (Martin 2007). Approximately 95% of gray bats hibernate in 17 caves within these five states: Alabama (1); Arkansas (5); Kentucky (2); Missouri (4); and Tennessee (5) (Harvey et al. 2005).

Current Summer Distribution
As mentioned under "Status and Distribution", gray bats are known to occur in 13 states, Alabama, Arkansas, Florida, Georgia, Illinois, Indiana, Kansas, Kentucky, North Carolina, Missouri, Oklahoma, Tennessee and Virginia. This species' range has expanded in some states (e.g., Georgia, Indiana, Kansas, and North Carolina), and gray bats are using many caves where use had not been documented prior to completion of the 1982 Recovery Plan (USFWS unpublished data)

Maternity Colonies
The total number of maternity colonies that historically exist rangewide is not known. The Gray Bat Recovery Plan (U.S. Fish and Wildlife Service 1982) identified a total of 29 P1 maternity colonies in Alabama (6), Arkansas (2), Florida (3), Kentucky (3), Illinois (I), Missouri (7), Oklahoma (1) and Tennessee (6). Primary maternity caves is defined as those occupied now or in the past by 50,000 or more gray bats in northern Alabama and in Tennessee west of the Cumberland plateau; 40,000 in Kentucky; 10,000 elsewhere except for Florida, Oklahoma, Arkansas, Kansas, and southern Alabama where the number is 1,000. Surveys, conducted at the caves inhabited by these 29 maternity colonies, indicate 48% of the populations (in 14 of the maternity caves) are increasing or stable (U.S. Fish and Wildlife Service 2009a).

9.6 Conservation Needs and Threats

The tendency of gray bats to form large colonies makes the gray bat especially vulnerable to population decline due to both intentional and unintentional human disturbance (Sherman and Martin 2006). The gray bat congregates in larger numbers at fewer winter hibernacula than any other North American bat. Approximately 95% of gray bats hibernate in 11 winter hibernacula, with 31% hibernating in a single cave located in northern Alabama (Mitchell and Martin 2002). This concentration of such a large proportion of the known population into so few caves constitutes the real threat to their survival (Mohr 1972).

While gray bat habitat locations were always "patchy", their habitats have become increasingly more isolated and fragmented with human perturbation (U.S. Fish and Wildlife Service 1982). Tuttle (1976a, 1979) reported human disturbance and vandalism in caves to be primary causes of decline and demonstrated a close relationship between decline and frequency of disturbance. Each disturbance during hibernation is estimated to use energy that otherwise could sustain a gray bat through 10 to 30 days of undisturbed hibernation (U.S. Fish and Wildlife Service 1982). Once a bat's energy stores are exhausted, it likely will leave the cave prematurely in search of food, dying outside the hibernaculum where its fate will go unnoticed. A single disturbance at maternity caves from late May through mid-July can result in the death of thousands of flightless young on roosts (U.S. Fish and Wildlife Service 1982). When flightless young are present in June and July, females attempting to escape a disturbance may drop their young in panic, leading to increased juvenile mortality (Sasse et al. 2007).

Other suspected factors contributing to the gray bat's decline include impoundment of waterways (creation of dams, which caused flooding of caves formerly used by the species), natural flooding, cave commercialization, pesticides, water pollution and siltation, and local deforestation (Sherman and Martin 2006). Gray bat preference for caves near rivers has made their roosts particularly vulnerable to inundation by man-made impoundments. The little information which does exists, indicates that many important caves, and probably their bat populations, were lost to impoundments (U.S. Fish and Wildlife Service 1982). An account by McMurtrie (1874), describes a cave in Alabama, since flooded by a reservoir, which was "inhabited by countless thousands of bats" and had guano piles 4.5 m (14.8 ft) deep. Long-time residents living within the TVA reservoir system have told of many other such caves now submerged (U.S. Fish and Wildlife Service 1982). Although timing of initial flooding may be a critical factor in whether the flooded populations were immediately destroyed, the gray bat's strong site fidelity and narrow ecological requirements may have made survival of displaced populations questionable, even if they escaped initial destruction (U.S. Fish and Wildlife Service 1982). Furthermore, the reservoirs increased public access to gray bat habitat; many caves previously long distances from population centers and roads were made easily accessible by boat (U.S. Fish and Wildlife Service 1982).

Some of the largest gray bat colonies ever known have been extirpated as a result of cave commercialization. Some responsible owners of commercial caves have protected sections of their caves that were critical to gray bats, and those bats may have benefited from such protection. At other commercial caves, entire gray bat colonies have been lost as a result of poorly designed gates (adversely affecting bat movements and/or cave microclimates, and/or facilitating predation) intended to protect bats (Tuttle 1977; U.S. Fish and Wildlife Service 1982).

Pesticide use and manufacturing have been one of the most prevalently studied contributions to the population decline of the gray bat. Pesticides linked with gray bat population declines include dichlorodiphenyltrichloroethane [DDT], Dichlorodiphenyldichloroethylene [DDE] and Dichlorodiphenyldichloroethane [DDD] (Bagley et al. 1987), and dieldrin and aldrin, which have also been linked to increased mortality in other bat species (Sasse et al. 2007). Gray bat populations in the Tennessee River area of northern Alabama were noted to have higher than normal mortality, which was attributed to large amounts of DDTR (a combination of DDT, DDD and DDE) flowing through waterways from a DDT manufacturing site located on the Redstone Arsenal near Huntsville, Alabama, since 1947 (Bagley et al 1987). Lethal chemical concentrations of DDT in the brains of adult bats were found to be about 1.5 times higher than in juveniles. Because gray bats feed on many types of insects with aquatic larval stages, it is believed that this food source may have been the root of the chemical concentrations (Bagley et al 1987). Many of the bats tested in different studies were non-volant juveniles and, thus, were likely to have only consumed milk; concentration of these chemicals via lactation appeared to have caused mortality in some of these juveniles. Even though the manufacture of DDT ceased in 1970 and the manufacture of dieldrin and aldrin in October 1974, heavy contamination of biota persisted for a number of years. However, guano samples, collected between 1976 and 1985 showed a decline of 41% in DDE from Cave Springs Cave and a decline of 67% in DDE from Key Cave (Bagley et al 1987).

Chemical pollution or siltation of waterways over which gray bats forage has been suspected of gray bat declines (U.S. Fish and Wildlife Service 1982). Gray bats are known to forage over rivers, streams and reservoirs (Tuttle 1976a; LaVal et al. 1977) where they capture a variety of insects, including large numbers of mayflies (Tuttle 1976b; Rabinowitz and Tuttle 1982), as well as stoneflies and caddisflies (Brack et al. 1984). All three groups of insects are thought to be quite sensitive to aquatic pollution (U.S. Fish and Wildlife Service 1982). While Carlander et al. (1967) found that some siltation benefitted nymphs of two species of mayflies, additional studies indicated other species were unable to survive on mud or silt substrate (Lyman 1943; Minshall 1967). A census of gray bats along heavily silted waterways in in Alabama and Tennessee found that all colonies declined (Tuttle 1979).

WNS is an infectious wildlife disease caused by a fungus of European origin, *Pseudogymnoascus destructans* (Pd), poses a considerable threat to hibernating bat species throughout North America. WNS is responsible for unprecedented mortality of insectivorous bats in eastern North America (Blehert et al. 2009; Turner et al. 2011). Since the disease was first observed in New York in 2007 (later biologists found evidence from 2006 photographs), WNS has spread rapidly in bat populations from the East to the Midwest and the South. WNS was first confirmed in gray bats in 2012 in Hawkins and Montgomery Counties, Tennessee. While no mortality has been observed in gray bats that can be linked to WNS, the confirmation that gray bats can be infected is a concern. The impact of WNS on gray bats is still unknown; however, it appears that gray bats do not succumb to WNS like other *Myotis* species.

Although some threats to various caves remain, overall, gray bat populations have exhibited an increase in population numbers and distribution throughout the species' range since completion of the 1982 recovery plan (U.S. Fish and Wildlife Service, 2009a). Wide population fluctuations of gray bat numbers have been documented at many maternity sites across the species' range, but there have been significant population increases in some of the major hibernacula (U.S. Fish and Wildlife Service 2009a).

Currently, as a whole, the range-wide status of the species is stable. Priority 1 hibernacula were surveyed during the winter of 2019, providing the most complete coverage in years (P1s are located in AL, AR, KY, MO, and TN). The 2019 range wide estimate is approximately 5.1 million bats (USFWS unpublished data). In 2017, the estimate was approximately 4.5 million bats and in 2013 it was about 2.8 million bats; however, it is impossible to determine a trend since not all caves were surveyed every year. The primary factors influencing the status include destruction or modification of habitat such as hibernacula, maternity sites and foraging habitat, (USFWS 2009a).

For a more detailed account of the species description, life history, population dynamics, threats, and conservation needs, refer to http://www.fws.gov/midwest/Endangered/mammals/graybat/index.html.

10 ENVIRONMENTAL BASELINE

In accordance with 50 CFR 402.02, the environmental baseline refers to the condition of the listed species or its designated critical habitat in the action area, without the consequences to the listed species or designated critical habitat caused by the proposed action. The environmental baseline includes the past and present impacts of all Federal, State, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of State or private actions which are contemporaneous with the consultation in process. The consequences to listed species or designated critical habitat from ongoing agency activities or existing agency facilities that are not within the agency's discretion to modify are part of the environmental baseline.

10.1 Action Area Numbers, Reproduction, and Distribution

The Action Area lies near the center of the species range and numerous records of the species occupying summer and winter habitat exist. Higher concentrations of the species are known in the western and central portions of the Action Area and fewer occurrences in the eastern portions, with the largest concentrations of gray bats found in and around Mammoth Cave National Park in Edmonson County, Kentucky (USFWS 2009). Occurrences of the species are tied to the availability of suitable winter and summer habitat. Winter and summer habitat are static (assuming no anthropogenic alterations occur) in the landscape, because the caves and other underground features the species relies on do not change locations. However, the species will move from one habitat area to another to take advantage of better conditions or to abandon habitat that humans or other factors have altered or disturbed.

Several caves within the Action Area are known hibernacula, maternity, or bachelor colonies. Five of these are Priority 1 hibernacula (USFWS unpublished data 2019). These five Priority 1 hibernacula had a combined estimated population of 1.3 million gray bats in 2019, which represents approximately 25.5percent of the rangewide estimated population (5.1 million). Of these five hibernacula, two are located within the 20-mile buffer around the Commonwealth of Kentucky that forms the outer boundary of the Action Area.

Summer records for the species occur across the Action Area, and over 30 maternity sites have been documented along with a number of bachelor colonies and locations for solitary males and non-reproductive females. Similar to the hibernacula, these maternity colonies occur on public and private land. It is difficult to estimate the summer population within the Action Area because inventories of each site are not conducted in consecutive years in order to avoid repeated or over disturbance to the colony; however, we are able to document population trends at each roost and/or group of roosts, and those remain stable to increasing overall.

Multiple studies and surveys have reported gray bats roosting on bridges. One gray bat maternity colony is known to use a concrete box beam bridge over a large stream in central Kentucky, with the most recent estimated numbers ranging from 50 to more than 100 individuals (S. Martin, USFWS, pers. comm.). The colony roosts inside vertical expansion joints that are present between the concrete beams that comprise the bridge superstructure. Potential use of two additional concrete box beam bridges located upstream of the maternity colony has also been noted; however, these records have not been confirmed.

Through an on-going assessment of bridges within the Commonwealth of Kentucky, the KYTC has reviewed 260 structures throughout the state. The assessed bridges include a variety of sizes and bridge types, including bridges from 21 to 727 feet long and bridge types such as channel beam, box beam, pre-stressed concrete beam, metal beams, box culverts, and numerous others.

The majority (92%) of these structures were identified as either unsuitable for bats or no bats or signs of bat use were observed. The remaining bridges (8%) had bats (unidentified species) actively roosting on the structure or signs of bat use were observed.

Currently, the Service believes the status of the species within the Action Area is stable. P1 hibernacula and maternity population estimates within the Action Area have increased overall between 2013 and 2019.

10.2 Action Areas Conservation Needs and Threats

It is difficult to identify specific factors affecting the gray bat's environment within the Action Area, because the Action Area has been defined as the Commonwealth of Kentucky and all portions of adjoining states that occur within 20 miles of the Kentucky border. This BO is based on analysis at a programmatic level rather than at an individual project scale. However, we are able to determine that there are current and long-term land uses and demographic trends, which could affect gray bats within the Action Area.

Tuttle (1976a, 1979) reported human disturbance and vandalism in caves to be primary causes of decline and demonstrated a close relationship between decline and frequency of disturbance. In addition, some of the largest gray bat colonies ever known have been extirpated as a result of cave commercialization. Human disturbance, vandalism, and commercialization continue throughout the action area; however, although some threats to various caves remain, public education has improved conservation since Tuttle's reporting. Protection of lower priority caves is needed to maintain the species distribution across the landscape and reduce the potential of a catastrophic event to a single, densely populated hibernaculum or maternity cave.

A general overview of white-nose syndrome (WNS) and its effects on bat populations was previously provided in the section on the Status of the Species. WNS's effects within the Action Area are similar to those discussed within the range of the species. The impact of WNS on gray bats is still unknown; however, it appears that gray bats do not succumb to WNS like other *Myotis* species, as indicated by the stable population estimates of gray bats within the Action Area.

Other land use activities that could affect gray bats and that likely occur within the Action Area include timber harvest, all-terrain vehicle (ATV) recreational use, recreational use of caves, underground and surface coal and limestone mining, gas production, and development associated with road, residential, industrial and agricultural development and related activities. These private actions are likely to occur within the Action Area, but the Service is unaware of any quantifiable information relating to the extent of private timber harvests within the Action Area, the amount of use of off-highway vehicles within the Action Area, or the amount of recreational use of caves within the Action Area. Similarly, the Service does not have any information on the amount or types of residential, industrial, or agricultural development that have or will occur within the Action Area. Therefore, the Service is unable to make any determinations or conduct any meaningful analysis of how these actions may or may not adversely and/or beneficially affect gray bats. All we can say is that it is possible that these activities, when they occur, may have adverse effects on gray bats and their habitats in certain situations. In stating this, however, we can only speculate as to the extent or severity of those effects, if any.

11 EFFECTS OF THE ACTION

In accordance with 50 CFR 402.02, effects of the action are all consequences to listed species or critical habitat that are caused by the proposed action, including the consequences of other activities that are caused by the proposed action. A consequence is caused by the proposed action if it would not occur but for the proposed action and it is reasonably certain to occur. Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action (see § 402.17).

The Service established additional requirements for making the determination of reasonably certain to occur, which must be followed after October 28, 2019, the effective date of new regulations under 50 CFR 402. After determining that the "activity is reasonably certain to occur," based on clear and substantial information, and using the best scientific and commercial data available, there must be another conclusion that the consequences of that activity (but not part of the proposed action or activities reviewed under cumulative effects) are reasonably certain to occur. In this context, a conclusion of reasonably certain to occur must be based on clear and substantial information, using the best scientific and commercial data available after consideration of three factors in 402.17(b)(1-3).

The2019 regulatory changes do not alter how we will analyze the effects of a proposed action or the scope of effects. We will continue to review all relevant effects of a proposed action, as we have in past decades, but the Service determined it was not necessary to attach labels to the various types of effects through regulatory text. That is, we intend to capture all of those effects (now "consequences") previously listed in the regulatory definition of effects of the action—direct, indirect, and the effects from interrelated and interdependent activities—in the new definition. These effects are captured in the new regulatory definition by the term ''all consequences'' to listed species and critical habitat.

Based on the description of the Action and the species' biology, we have identified six stressor(s) to the gray bat (i.e., the alteration of the environment that is relevant to the species) that may result from the Action: (1) noise and vibration, (2) night lighting, (3) aquatic resource loss and degradation, (4) tree removal, (5) collision, and (6) alteration or loss of roosting habitat on bridges. Below, we discuss the best available science relevant to each stressor. Then, we describe the Stressor-Exposure-Response pathways that identify the circumstances for an individual bat's exposure to the stressor (i.e., the overlap in time and space between the stressor and a gray bat). Finally, we identify and consider how proposed conservation measures may reduce the severity of the stressor or the probability of an individual bat's exposure for each pathway.

We have focused the majority of our analysis for gray bats to those areas where the species and/or its habitat has the greatest potential for adverse effects to occur, which are bridges and related stream crossings. We believe this is appropriate due to the following:

- Gray bats primarily forage over open water bodies, such as rivers, streams, lakes, and reservoirs, and associated riparian areas;
- Gray bats are known to roost on bridges;
- Gray bat hibernacula and summer roost caves are excluded from this consultation;

- The mobility of gray bats allow them to adjust to ever-changing landscapes and forest fragmentation while commuting.

11.1 Stressor 1: Noise and Vibration

Noise and vibration are stressors that may disrupt bats by causing individuals to flush from suitable roosting locations like bridges, trees, rock shelters, etc. Disruptions may occur during the day and/or night timeframes, and/or alter travel corridors and foraging behaviors. Bats may be exposed to this stressor during the construction, maintenance, and operation components of the Action. Significant changes in noise levels in an area could result in temporary to permanent alteration of bat behaviors. The novelty of these noises and their relative volume levels will likely dictate the range of responses from individuals or colonies of bats.

Transportation projects approaching streams and bridge rehabilitation or replacement projects will result in noise and vibration during the construction, operation, and maintenance components. During the maintenance component, bridge rehabilitation may require heavy equipment and tools used to repair the bridge deck, superstructure, and substructure that will cause noise and vibration. Bridge replacements will also produce noise and vibration from the use of heavy equipment and tools during demolition and removal of existing bridge structure and construction of a new structure. During the operation component, noise and vibration from bridge rehabilitation and replacement will be limited to those effects caused by normal vehicular traffic.

The majority of activities during the maintenance component will be limited to the bridge deck or adjacent areas and will avoid potential roosting locations. However, some maintenance activities (e.g., painting, debris removal from piers, vegetative maintenance) may occur under the bridge near potential roosting locations. In general, maintenance activities will be localized to specific areas of a bridge and are generally completed over a short duration. Noise and vibration during the maintenance component varies and at times may be at or below levels caused by normal traffic. Bridge maintenance is expected to occur during daylight hours and will not disrupt foraging or commuting by bats.

Applicable Science

The effects of traffic noise on bats have been analyzed in several studies. For example, Schaub et al. (2008) found that captive greater mouse-eared bats (*Myotis myotis*) preferred silent chambers versus chambers with playback of close traffic noise 80 percent of the time. Berthinussen and Altringham (2012) conducted acoustic transects from 0 to 1,600 meters of a major road in the United Kingdom and found that bat (*Pipistrellus pipistrellus, Pipistrellus pygmaeus, Nyctalus* spp., and *Myotis* spp.) activity and species diversity increased with distance from the road. However, this could not be completely attributed to traffic noise. Noise levels decreased significantly with distance from the road, but 89 percent of the change occurred in the first 50 meters (164 feet) and no change was detected beyond 100 meters (328 feet). Ultimately, they found that the most likely explanation was a barrier effect from the road itself (opening).

Although noise can potentially affect the behavior of some bat species, studies have not shown measurable effects of military noise on bats. 3D/Environmental, Inc. (1996) examined the potential for various firing activities (e.g., demolitions, artillery, grenade simulators) and heavy equipment operation to disturb hibernating Indiana bats and a maternity roost of gray bats on Fort Leonard Wood in Missouri. Their research found that sound from munitions and equipment generally attenuated prior to reaching roost sites. Additionally, research was conducted to determine the effects of military noise, primarily high-caliber weapons fire, on foraging bat activity on Fort Knox in Kentucky (Martin et al. 2004; Martin 2005). The study obtained measurements of bat vocalizations using ultrasonic bat detectors, thermal infrared (TIR) imagery, and military noise monitoring technology. Statistical analysis of bat vocalizations, TIR detection, and military noise data showed extremely large variations in bat response across space and time, and results indicated that elevated noise levels associated with high-caliber weapons fire, as tested, did not have a significant effect on bat navigation and foraging activity (Martin et al. 2004).

Bats roosting or foraging in all of the examples above have likely become habituated to noise and vibration. However, novel noises from equipment and activities associated with bridge rehabilitation and replacement would be expected to result in some changes to bat behavior. Changes in behavior are most likely to occur during the construction component and some maintenance activities when heavy equipment and tools will be used within or directly adjacent to roosting habitat. Bats that roost on bridges are expected to be habituated to noise and vibration associated with normal operation.

Effects Pathway – Gray Bat #1	
Activity: Construction and Maintenance	
Stressor: Noise and Vibration	
Exposure (time)	Active timeframe; duration of activity
Exposure (space)	Roosting (bridge)
Resource affected	Individuals (adults, juveniles)
Individual response	• Flushing from bridge roost results in extra energy expenditure that can reduce fitness and result in reduced survival/reproductive success. • Flushing from bridge roost will increase chances of predation. • Avoidance of the stressor can require extra energy expenditure, in order to find suitable roosting habitat, which can reduce fitness and result in reduced survival/reproductive success.
Conservation Measures	Avoidance of project effects on a bridge structure that is known or has been identified as reasonably likely to support a maternity and/or bachelor colony.
Interpretation	Bats may become startled by noise and/or vibration and flush from their roosts on the bridge. Bats that flush during the daytime are at greater risk of harm due to predation. Additionally, bats that flush their roosts may be harmed due to an increase in energy expenditure. The most severe effects of flushing a bat from a bridge may result in harm if the bat was a female with a pup. The longer the female is absent, the more likely the effects to the pup would be significant. Gray bats exposed to this stressor while roosting on the bridge are likely to respond in a way that would lead to adverse effects.
Effect	Harm
Amount or Extent of	Because of the difficulty in determining the number of individual gray

Adverse Effects	bats that will be adversely affected during this specific activity and stressor, the Service has determined that it is appropriate to consider the total amount of gray bats adversely affected by using the analysis for alteration or loss of roosting habitat of bridges in this section. We believe that this reduces the potential to double count the number of individual gray bats impacted by the entire Action. A small, but indeterminable, portion of gray bats are expected to be injured or killed due to this activity and stressor. Disruption of normal behavior because of physical disturbance and/or habitat modification or degradation will account for the vast majority of adverse effects.

Effects Pathway – Gray Bat #2	
Activity: Construction	
Stressor: Noise and Vibration	
Exposure (time)	Active timeframe; duration of activity
Exposure (space)	Foraging, and commuting habitat in and near construction limits
Resource affected	Individuals (adults, juveniles)
Individual response	Avoidance of the stressor can require extra energy expenditure, in order to find suitable foraging and commuting habitat, which can reduce fitness and result in reduced survival/reproductive success.
Interpretation	Gray bats that utilize these habitats during construction are expected to become habituated to noise and vibration or not be affected by this stressor in a significant manner. There is no data that shows that gray bats are likely to modify their foraging and commuting behaviors during temporary periods of elevated noise and vibrations; therefore, gray bats are not expected to respond to the stressor during construction in a way that would significantly affect foraging and commuting behaviors.
Effect	Insignificant

Effects Pathway – Gray Bat #3	
Activity: Operation	
Stressor: Noise and Vibration	
Exposure (time)	Active timeframe; indefinitely
Exposure (space)	Roosting (bridge), foraging, and commuting habitat throughout the Action Area
Resource affected	Individuals (adults, juveniles)
Individual response	• Flushing from bridge roost results in extra energy expenditure that can reduce fitness and result in reduced survival/reproductive success. • Flushing from bridge roost will increase chances of predation. • Avoidance of the stressor can require extra energy expenditure, in order to find suitable roosting, foraging, and commuting habitat, which can reduce fitness and result in reduced survival/reproductive success.
Interpretation	Gray bats that roost on bridges and/or forage and travel around these structures and roadways during operation are assumed to be habituated

	and respond minimally to this stressor; therefore, noise and vibration from operation are unlikely to cause bats to flush or alter use of its habitat. Gray bats are not expected to respond to the stressor during operation in a way that would be significant.
Effect	Insignificant

11.2 Stressor 2: Night Lighting

Transportation projects approaching streams and bridge rehabilitation or replacement projects may require lighting during the construction, operation, and maintenance components. Bridge rehabilitation activities are not expected to occur at night, with the exception of minor, temperature-sensitive activities limited to the bridge deck (e.g., pouring concrete). Lighting during bridge replacement will be minimal and localized to the work area, occurring in the early morning, late evening, and rarely at night. Construction lighting is anticipated to be focused downward at the bridge and not directed horizontally where it would illuminate potential foraging and commuting habitat. Bridge lighting during the operation component is anticipated to be the same as before rehabilitation/replacement activities. Bridges with lighting before rehabilitation/replacement are expected to have lighting afterwards; however, lighting is not expected to be added to bridges without previous lighting. Bridge maintenance is anticipated to occur during daylight hours and will not require the use of lighting.

<u>*Applicable Science*</u>
Studies document highly variable responses among bat species to artificial lighting. Some species seem to benefit from artificial lighting, taking advantage of high densities of insects attracted to light (Jung and Kalko 2010); however, other species may avoid artificial light (Furlonger et al. 1987, Rydell 1992) or not be affected (Stone et al. 2012). Artificial lighting can cause delays in nightly bat activity (Stone et al. 2009; Downs et al. 2003), and effects from lighting may vary with season and moon phase (Jung and Kalko 2010).

Some bat species appear to avoid lights. Downs et al. (2003) found that lighting of *Pipistrellus pygmaeus* roosts reduced the number of bats that emerged. In Canada and Sweden, *Myotis* spp. and *Plecotus auritus* were only recorded foraging away from street lights (Furlonger et al. 1987; Rydell 1992). Stone et al. (2009) found that commuting activity of lesser horseshoe bats (*Rhinolophus hipposideros*) in Britain was reduced dramatically and the onset of commuting was delayed in the presence of high pressure sodium lighting. Stone et al. (2012) also found that light-emitting diodes (LEDs) caused a reduction in *Rhinolophus hipposideros* and *Myotis* spp. activity. In contrast, there was no effect of lighting on *Pipistrellus pipistrellus*, *Pipistrellus pygmaeus,* or *Nyctalus/Eptesicus* spp.

While there is little information regarding gray bats' response to artificial lights, other closely related *Myotis* species appear to avoid lighting. In Indiana, Indiana bats avoided foraging in urban areas, which may have been in part due to high light levels (Sparks et al. 2005). Using captive bats, Alsheimer (2011) found that the little brown bat (*Myotis lucifugus*) was more active in the dark than light. Based on the variable and contrasting responses by bats to artificial lighting, it is possible that gray bats could be affected by lighting associated with bridge rehabilitation and replacement.

Effects Pathway – Gray Bat #4	
Activity: Construction	
Stressor: Night Lighting	
Exposure (time)	Active timeframe; duration of activity
Exposure (space)	Roosting (bridge), foraging, and commuting habitat in and near the construction limits
Resource affected	Individuals (adults, juveniles)
Individual response	• Avoidance of day roost after foraging results in extra energy expenditure that can reduce fitness and result in reduced survival/reproductive success. • Increased visibility to predators increases chances of predation. • Avoidance of the stressor can require extra energy expenditure that can reduce fitness and result in reduced survival/reproductive success.
Conservation Measures	Avoidance of project effects on a bridge structure that is known or has been identified as reasonably likely to support a maternity and/or bachelor colony.
Interpretation	Gray bats roosting underneath or in the bridge deck are unlikely to be affected by lighting on top of the bridge deck. Lighting will not be directed down toward night roosting bats. Additionally, if the activity alters the bridge allowing night lighting to reach roosting habitat, it is unlikely that the bats would continue using the bridge (impacts associated with the alteration or loss of roosting habitat of bridges are addressed in Pathway # 13). Bats day roosting at the bridge may delay or avoid returning to the bridge at dawn. Lighting is unlikely to be used during this time, and bats that avoid the bridge likely have other available roosts in the immediate area (i.e., other bridges, cliff line/rock shelters, caves, or trees). Lighting may cause bats to avoid using the bridge as a night roost; however, we suspect that gray bats use alternate roosts in the area, as necessary and as previously discussed, without significant additional energy expenditure. Foraging bats avoiding bridge lighting can forage along other portions of the stream or nearby streams. Commuting bats can use other travel routes to avoid lighting. As a result of this combination of factors, lighting is not expected to significantly affect the gray bat.
Effect	Insignificant

Effects Pathway – Gray Bat #5	
Activity: Operation	
Stressor: Night Lighting	
Exposure (time)	Active timeframe; indefinitely
Exposure (space)	Roosting (bridge), foraging, and commuting habitat throughout the Action Area
Resource affected	Individuals (adults, juveniles)

Individual response	• Avoidance of day roost after foraging results in extra energy expenditure that can reduce fitness and result in reduced survival/reproductive success. • Increased visibility to predators increases chances of predation. • Avoidance of the stressor can require extra energy expenditure that can reduce fitness and result in reduced survival/reproductive success.
Interpretation	Gray bats roosting in the bridge and/or foraging and commuting near the road crossing during operation were likely using this habitat prior to rehabilitation/replacement. These bats will likely be habituated to lighting and not significantly impacted by this stressor.
Effect	Insignificant

11.3 Stressor 3: Aquatic Resource Loss and Degradation

Aquatic Loss

Loss of aquatic resources may occur during the construction component of the Action. Some projects may require the filling of streams or ponds during realignment of existing facilities or the construction of new facilities. Stream realignment may also be required for some projects, resulting in loss of a portion of the existing stream channel. Loss of aquatic resources may also occur during culvert installation due to the replacement of the natural stream substrate with an artificial structure. Transportation projects and bridge rehabilitation / replacement are not anticipated to result in overall significant loss of aquatic resources during the construction or operation component.

Aquatic Degradation (Sedimentation)

Potential degradation of aquatic resources from transportation projects and bridge rehabilitation during the construction component is expected to be minimal. The majority of these activities will not require work within streams or wetlands, and impacts to water quality are expected to be absent or minimal due to implementation of erosion and sediment control BMPs. Activities that occur over or near the aquatic resources could result in debris, materials, equipment, or contaminants entering them. Temporary structures, such as crossings or work pads, may be required for some bridge rehabilitation and replacement activities to maintain traffic or access portions of the bridge that cannot be reached from land or the bridge deck. These structures will be placed in the stream channel and will cause temporary impacts to the substrate and aquatic habitat. Cofferdams may also be placed in streams to create a safe, dry work area around piers, footers, and abutments during structure repair and rehabilitation of scour areas. Removal and installation of piers, pilings, and abutments will require work within the stream channel and disturb the substrate, which could result in degradation of the stream though habitat alteration and sedimentation within and downstream of the bridge footprint. Temporary structures will be removed after work is complete, and the stream will be restored to pre-construction conditions.

Aquatic Degradation (Pollutants)

During the operation component, hazardous materials from the roadway surface could enter streams through bridge deck drains and scuppers. Materials include oil, gasoline, diesel fuel, deicing agents, and other fluids associated with vehicular use of the bridge. These materials could enter streams directly from spills and leaks or through stormwater runoff, which could result in a short-term reduction in aquatic insects that provide prey for gray bats.

Bridge maintenance, such as painting and debris removal from piers/abutments, could result in minor degradation of aquatic resources. Paint could enter the stream through spills or runoff. Removal of debris that has collected against piers and abutments will result in temporary disturbance of the stream substrate and may lead to sedimentation downstream.

Herbicides may be used to control weed species along the right-of-ways and are generally applied once during the year either during the spring, summer, or fall. The herbicide application is applied during the day and in a method to minimize wind-induced drift. It is possible that some non-water safe herbicide could enter surface waters from either overspray or drift, which may affect bat's drinking water and/or cause bats to ingest chemicals through drinking or through bioaccumulation from eating affected insects. However, this is unlikely due to requirements that all herbicides be used in accordance to their label instructions and herbicide applicators should be appropriately licensed. Further, it is also unlikely since application would occur during the daytime and any chemical coming in contact with the water would have time to become diluted prior to bats foraging at night.

Applicable Science

Gray bats primarily forage over open water bodies, such as rivers, streams, lakes, and reservoirs, and associated riparian areas (Tuttle 1976, 1979; LaVal et al. 1977). While foraging, the gray bat consumes a variety of insects, most of which are aquatic-based (Brack and LaVal 2006). Insects in the orders Ephemeroptera, Tricoptera, and Plecoptera are especially important, as well as Lepidoptera, Coleoptera, and Diptera (Whitaker et al. 2001; Tuttle and Kennedy 2005). Juvenile gray bats tend to forage more frequently in riparian areas and woodlands near roosts and eat more beetles than adults (Brack and LaVal 2006).

Impacts to aquatic habitats can have detrimental effects on gray bats and their prey. Loss of aquatic habitats through fill will permanently reduce aquatic insect habitat, which will reduce the amount of prey available to gray bats. Sedimentation will also result in negative impacts to aquatic insect populations. Sediment suspended in the water column affects aquatic insect food sources by physically removing periphyton from the substrate and reducing light available for primary production of phytoplankton. In addition, sediment that settles out of the water column onto the substrate fills interstitial spaces occupied by certain aquatic insect larvae. Increases in sedimentation can also change the composition of the insect community in a stream (Henley et al. 2000). In a three-year study measuring sedimentation and macroinvertebrate communities before, after, and during disturbance from a highway construction site, Hendrick (2008) found increased turbidity and total suspended solids downstream from the construction that correlated with a shift in macroinvertebrate communities. The change, however, was not great, and the Hilsenhoff Biotic Index used to evaluate the effects decreased from "excellent" before construction to "good" after construction. The use of BMPs likely minimized the effects of the construction on the macroinvertebrate communities.

While foraging, gray bats may travel long distances, with individuals recorded up to 35 kilometers (22 miles) from their day roosts (LaVal et al. 1977, Tuttle and Kennedy 2005). Bats typically travel individually or in small groups that forage in an area for a short period before moving to another area. A radiotelemetry study in Alabama found that gray bats rarely foraged in one area for more than an hour (Thomas and Best 2000). During another tracking study in Missouri, one female bat foraged for approximately one hour along a 0.5-kilometer section of a river. Another female was recorded traveling along a 0.6-kilometer section of river over 21 minutes (LaVal et al. 1977). These studies suggest that gray bats visit multiple foraging areas during the night and travel frequently between these areas.

Effects Pathway – Gray Bat #6	
Activity: Construction	
Stressor: Aquatic Resource Loss	
Exposure (time)	Indefinitely
Exposure (space)	Aquatic foraging habitat in and near the project site
Resource affected	Habitat, used by individuals (adults, juveniles)
Individual response	• Increased flight distances to access foraging resources requires extra energy expenditure that can reduce fitness and result in reduced survival/reproductive success. • Reduced foraging efficiency can reduce fitness and result in reduced survival/reproductive success.
Interpretation	Loss of ephemeral and intermittent streams do not likely provide important foraging habitat for gray bats because of their relative size and flow status. Loss of perennial stream length is anticipated to have a temporary impact locally; however, data indicates that gray bats visit multiple foraging sites in one evening. Therefore, gray bats are expected to utilize other perennial streams and waterbodies in the affected watershed, thus reducing the likelihood of significant effects.
Effect	Insignificant

Effects Pathway – Gray Bat #7	
Activity: Construction and Maintenance	
Stressor: Aquatic Resource Degradation **(**sedimentation)	
Exposure (time)	Active timeframe; temporary
Exposure (space)	Aquatic foraging habitat in and downstream of the project site
Resource affected	Habitat, prey (aquatic insects), used by individuals (adults, juveniles)
Individual response	• Increased effort to access sufficient foraging resources requires extra energy expenditure that can reduce fitness and result in reduced survival/reproductive success. • Reduced foraging efficiency can reduce fitness and result in reduced survival/reproductive success.
Conservation Measures	Implementation of BMPs to limit impacts to streams and downstream aquatic resources.
Interpretation	The effects of sedimentation on aquatic resources are expected to be minimal due to the temporary nature of the activity and implementation of the conservation measures.
Effect	Insignificant

Effects Pathway – Gray Bat #8	
Activity: Construction, Operation, and Maintenance	
Stressor: Aquatic Resource Degradation **(**pollutants)	
Exposure (time)	Indefinitely
Exposure (space)	Aquatic foraging habitat throughout the Action Area
Resource affected	Habitat, prey (aquatic insects), used by individuals (adults, juveniles)
Individual response	• Increased effort to access sufficient foraging resources requires extra energy expenditure that can reduce fitness and result in reduced survival/reproductive success. • Reduced foraging efficiency can reduce fitness and result in reduced survival/reproductive success.
Conservation Measures	• Implementation of BMPs to limit impacts to streams and downstream aquatic resources. • Limiting use of deicing agents to only the amount necessary. • Ensure proper use of herbicides
Interpretation	Implementation of the conservation measures are expected to minimize and/or prevent contamination from pollutants.
Effect	Insignificant

11.4 Stressor 4: Tree Removal

Tree removal will result in fragmentation of forested areas on the landscape and has the potential to impact travel corridors as well as foraging areas for the gray bat. Road construction and maintenance will result in the loss of forested habitat in both linear corridors and blocks of habitat varying in width and length. Minimal tree removal may occur during the construction component of bridge replacement; however, tree removal is not expected to occur during the operation component. Tree removal during stream crossings is typically limited to areas immediately adjacent to the existing bridge to provide access for equipment and the installation of temporary crossings and work pads. For the majority of bridge replacement projects, tree removal is minimal and consists of a small number of trees in the riparian corridor on each side of the bridge. This type of tree removal results in widening of the cleared area that was created during the original construction of the bridge. Some projects involve realignment of the roadway associated with the bridge, causing the bridge to be replaced immediately upstream or downstream of the existing bridge. In this case, a higher number of trees may likely be removed for site preparation, access, and other construction-related activities. After removal of the existing bridge, the former site is typically allowed to revegetate naturally, which may close or reduce the gap in the riparian corridor.

Applicable Science

Foraging gray bats seem to prefer streams and other waterbodies bordered by forested habitat, and may avoid foraging in areas where the forested riparian corridor has been cleared (LaVal et al. 1977). Gray bats also travel along the forest canopy from their roosts to foraging areas, and may travel considerable distances to follow fence rows or other linear forested corridors (Brady et al. 1982). Patterson et al. (2003) noted that the mobility of bats allows them to exploit fragments of habitat. This behavior is believed to be a measure to avoid predation by aerial predators, such as screech owls, which have more difficulty capturing bats in the tree canopy (Tuttle 1979).

Effects Pathway – Gray Bat #9	
Activity: Construction and Maintenance	
Stressor: Tree Removal	
Exposure (time)	One time removal, exposure will be permanent
Exposure (space)	Forested habitat throughout the Action Area
Resource affected	Forested habitat, used by individuals (adults, juveniles)
Individual response	• Increased effort to access sufficient foraging resources requires extra energy expenditure that can reduce fitness and result in reduced survival/reproductive success. • Reduced foraging efficiency can reduce fitness and result in reduced survival/reproductive success.
Interpretation	Gaps in the riparian corridor are present along the majority of streams; gray bats foraging in the vicinity of a bridge are expected to be habituated to the existing gap in the forested riparian corridor at the bridge. Minor widening of and/or creation of a new gap is unlikely to alter foraging behavior. The mobility of gray bats allow them to adjust to ever-changing landscapes and forest fragmentation while commuting. Bats affected by tree removal within foraging and/or commuting habitat are expected to utilize other portions of these habitats across the landscape.
Effect	Insignificant

11.5 Stressor 5: Collision

During the construction component of the Action, collisions could potentially occur between gray bats and construction vehicles and equipment. The majority of activities associated with these components will occur during daylight hours when bats are inactive. Some bridge replacement activities may occur at night (e.g., pouring of concrete); however, these activities will involve stationary or slow-moving vehicles and equipment primarily on the bridge deck. During the operation component, traffic will be present on roadways and bridges year-round and during the night. Vehicle collision may occur from dusk until dawn while gray bats are foraging and commuting. Collisions are not expected during the maintenance component due to these activities occurring during daylight hours.

<u>*Applicable Science*</u>

The current literature does not include data on collisions between gray bats and vehicles; however, collisions have been documented for Indiana bats and other myotids. Russell et al. (2009) assessed the level of mortality from road kills on a bat colony in Pennsylvania and collected 27 road-killed little brown bats and one Indiana bat. Butchkoski and Hassinger (2002) had previously studied this same colony in Pennsylvania and documented little brown bats that had apparently collided with vehicles along a major highway that separated the roosting habitat from the primary foraging areas. Russell et al. (2009) documented Indiana bat mortality at a site where the roost site was separated from the foraging areas by a major highway. This study noted that when bats crossed at open fields, they flew much lower than canopy height (< two meters), and when adjacent canopy was low, bats crossed lower and closer to traffic. Collision has also been documented for other myotids in Europe (Lesinski et al. 2011).

Collision risk of bats varies depending on time of year, location of a road in relation to roosting/foraging areas, flight characteristics of a species, traffic volume, and whether young bats are dispersing (Lesinski 2007, 2008; Russell et al. 2009; Bennett et al. 2011). In the Czech Republic, Gaisler et al. (2009) noted the majority of bat fatalities were associated with a road section between two artificial lakes. Lesinski (2007) evaluated road kills in Poland and determined that the number of young of year bats killed were significantly higher than adults. Also, low-flying gleaners (e.g., *Myotis daubentonii*) were killed more frequently than high-flying aerial hawkers (e.g., *Nyctalus noctula*). Lesinski et al. (2011) indicated that a review of previously published literature on factors causing bats to be killed at roads are not consistent, and, therefore, it is difficult to predict exact sites where bats may be at risk. They also indicated that estimates represent a small portion of the number of bats actually killed.

It can be difficult to determine whether roads pose greater risk for bats colliding with vehicles or greater likelihood of deterring bat activity in the area (thus decreasing risk of collision). As discussed in the Noise and Vibration stressor section, many studies suggest that roads may serve as a barrier to bats (Bennett and Zurcher 2013; Bennett et al. 2013; Berthinussen and Altringham 2012; Wray et al. 2006). Bennett et al. (2011) indicated that three main characteristics contribute to the barrier effects of roads: traffic volume, road width, and road surface. Roads with very few vehicles and only two lanes had little effect on Indiana bat movement (Bennett et al. 2013). Zurcher et al. (2010) concluded that bats perceive vehicles as a threat and were more than twice as likely to reverse course if a vehicle was present than if it was absent. Berthinussen and Altringham (2012) found that bat activity and diversity was lower closer to roads, but that activity and diversity increased where there was continuity in trees and hedgerows. Kerth and Melber (2009) studied barbastelle bats (*Barbastella barbastellus*) and Bechstein's bats (*Myotis bechsteinii*) and found that roads restricted habitat accessibility for bats, but the effect was related to the species' foraging ecology and wing morphology. Foraging ecology of gleaning and woodland species were more susceptible to the barrier effect than high-fliers that feed in open spaces (Kerth and Melber 2009).

Gray bats flying along streams below bridges are less likely to be affected by the barrier effect or collision as bats flying at or near roadway level. While foraging, gray bats typically fly within three meters of the water's surface (Tuttle 1976). The majority of bridges that have the potential to create a barrier effect and pose a risk of bat collision are two to four-lane bridges that are generally more than three meters over streams. Gray bats foraging along streams will be unlikely to avoid or fly over these bridges when they can maintain their normal foraging height by going under the bridges. These bridges also typically contain concrete barrier walls or guardrails on each side of the bridge, forcing bats flying over bridges to be higher than the level of the roadway. Bridges that are less than three meters from the water's surface are typically one to two-lane structures with low traffic volumes, especially at night, that contain vehicles traveling at slower speeds. The potential for collisions between gray bats and vehicles on these bridges is considered low.

Effects Pathway – Gray Bat #10	
Activity: Construction	
Stressor: Collision	
Exposure (time)	Active timeframe; duration of the activity
Exposure (space)	Bridge and roadway construction within the project area
Resource affected	Individuals (adults, juveniles)
Individual response	• Mortality from collision with vehicles or equipment.
Interpretation	The most likely effect of collision between a gray bat and a moving vehicle is harm in the form of mortality. However, since most construction activities would occur during daylight hours, collisions would be avoided. Risk of collision with construction vehicles during night time is minimized by the slow speed of construction vehicles in the work area. Further, construction activities that occur from dusk through dawn hours are likely localized to one area and do not require a substantial amount of construction vehicle travel. Based on this information, construction vehicle collision with a gray bat is unlikely to occur; therefore, any potential effects are considered discountable.
Effect	Discountable

Effects Pathway – Gray Bat #11	
Activity: Operation	
Stressor: Collision	
Exposure (time)	Active timeframe; indefinitely
Exposure (space)	Bridge and roadways throughout the Action Area
Resource affected	Individuals (adults, juveniles)
Individual response	• Mortality from collision with vehicles.
Interpretation	The risk of collision between a gray bat and vehicle travelling across a bridge while foraging is considered to be low due to the ability of bats to fly under bridges to avoid traffic and the reduced amount of traffic during evening hours when bats are active. However, collisions between bats and vehicles along roadways have been documented, and the bridge and roadways are expected to operate indefinitely. Exposure to this stressor is expected to harm an indeterminable number of gray bats within the Action Area.
Effect	Harm
Amount or Extent of Adverse Effects	Because of the difficulty in determining the number of individual Indiana bats that will be adversely affected during this specific activity and stressor, the Service has determined that it is appropriate to consider an average of one Indiana bat per year that would be adversely affected. Indiana bats are expected to be injured or killed due to this activity and stressor, and effects are expected to occur indefinitely.

11.6 Stressor 6: Alteration or Loss of Roosting Habitat on Bridges

Rehabilitation and replacement of bridges will result in alteration and loss of roosting habitat for gray bats during the maintenance and construction components. Bridge rehabilitation activities are generally considered as maintenance and may occur in areas where bats typically roost on the superstructure and underside of the bridge deck. Activities such as patching and sealing of cracks on the superstructure, repairs to header/expansion joints in the deck, and cleaning of deck drains/scuppers could impact roosting bats and cause alteration or loss of roosting locations. Bridge replacement during construction will involve the removal of individual bridge components (i.e., deck, superstructure, and substructure) or the entire structure using heavy equipment and tools. Removal of the bridge deck will result in the loss of roosting habitat in the deck and will likely alter roosting locations on the superstructure. Impacts could also occur to gray bats roosting on these structures during removal. After replacement projects are complete, a bridge will be present at the same or similar location; however, the new structure may not provide roosting habitat, resulting in a potential loss of roosting habitat for gray bats.

Applicable Science

Gray bats have been documented using bridges as roosting habitat during the spring, summer, and fall. No occurrences of this species hibernating in bridges during the winter have been reported. Concrete structures seem to be preferred for roosting due to their tendency to retain heat longer than other materials; however, metal and wood structures may also be used with less frequency. Gray bats have been observed using bridges as both day and night roosts. Day roosts are typically used by bats between sunrise and sunset and consist of sheltered areas that provide protection from adverse weather conditions and predators (Keeley and Tuttle 1999, Kiser et al. 2002). Bridges used as day roosts by gray bats are typically constructed of concrete and contain vertical crevices, expansion joints, or other locations that allow bats to retreat into the bridge deck or superstructure (Keeley and Tuttle 1999, Feldhamer et al. 2003, Cleveland and Jackson 2013).

Night roosts are generally used by bats between sunset and sunrise to rest, digest food between foraging bouts, conserve energy, and avoid inclement weather (Ormsbee et al. 2007). Bridges with a concrete deck and concrete or metal girders seem to be preferred as night roosts (Keeley and Tuttle 1999, Kiser et al. 2002). This bridge type retains heat into the night, and the chambers between the girders trap heat rising from under the bridge and provide protection from wind, weather, and predators. Night-roosting bats are typically found on the vertical surface of the girder at the intersection with the underside of the deck. Areas near the bridge abutments and over land seem to be preferred over the central portion of the bridge and areas spanning water. Bridges that lack crevices/expansion joints or girders are rarely used as day or night roosts (Adam and Hayes 2000, Feldhamer et al. 2003, Ormsbee et al. 2007); however, structures with cave-like areas or other unique features that provide suitable roosting locations can also provide suitable roosting habitat.

Multiple studies and surveys have reported gray bats roosting on bridges. A gray bat maternity colony is known to use a concrete box beam bridge over a large stream in central Kentucky, with estimated numbers ranging from 50 to more than 100 individuals (S. Martin, USFWS, pers. comm.). The colony roosts inside vertical expansion joints that are present between the concrete beams that comprise the bridge superstructure. Potential use of two additional concrete box beam bridges located upstream of the maternity colony has also been noted; however, these records have not been confirmed.

Gray bats have also been documented roosting in several concrete box beam bridges in western North Carolina (K. Etchison, North Carolina Wildlife Resources Commission, pers. comm.; J. Weber, Indiana State University, pers. comm.). Up to 1,000 individuals, including males and females, have been observed day-roosting throughout the summer in expansion joints between box beams at two separate bridges. Sporadic summer use of two other concrete box beam bridges has also been noted for smaller numbers of day-roosting gray bats. The same study also found gray bats day-roosting on several different bridges with concrete decks and concrete/metal girder superstructures, with over 300 bats roosting in vertical expansion joints in the bridge deck above columns and piers. The type of use (e.g., maternity colony, bachelor/non-reproductive colony) of these bridges has not been confirmed; however, it is possible that maternity colonies are using some of these bridges based on the number of individuals observed and the time of year.

Several observations of gray bats roosting on concrete girders at the intersection of the girder and bridge deck have been reported; however, these records typically consist of sporadic use by individual bats. During the North Carolina bridge study, two bats were found day-roosting at the intersection of girders and bridge decks (K. Etchison, North Carolina Wildlife Resources Commission, pers. comm.; J. Weber, Indiana State University, pers. comm.). Cervone et al. (2016) found two gray bats day-roosting under a concrete girder bridge on two different occasions, including one bat in April and a second bat in September. The timing of these occurrences suggest that these bats were using the bridge as a transient roost during the spring and fall migration periods. Gray bats have also been found day-roosting under a concrete girder bridge in southern Kentucky (S. Martin, USFWS, pers. comm.). Gray bats have been documented night-roosting at the intersection of girders and bridge decks, including 20 to 30 individuals found under two different bridges in northwest Georgia (Johnson et al. 2002). Other structures on bridges that provide sheltered areas may also be used as roosts. In North Carolina, a gray bat was found day-roosting in a clogged deck drainage pipe on a bridge (K. Etchison, North Carolina Wildlife Resources Commission, pers. comm.; J. Weber, Indiana State University, pers. comm.).

Gray bats show strong philopatry to their summer ranges and typically use the same roost sites year after year (Tuttle 1976, 1979; Martin 2007). Maternity colonies tend to concentrate at one roost site until the young are volant, then begin to alternate more frequently between other roost sites within their home range (Thomas 1994). Adult males and yearlings form bachelor colonies or small groups at roost sites separate from maternity colonies. These individuals typically alternate between roost sites more frequently than reproductive females.

Effects Pathway – Gray Bat #12	
Activity: Maintenance (bridge rehabilitation)	
Stressor: Alteration or Loss of Roosting Habitat of Bridges	
Exposure (time)	Active timeframe; duration of the activity
Exposure (space)	Bridges
Resource affected	Day or night roosting habitat, individuals (adults, juveniles)

Individual response	• Flushing from bridge roost results in extra energy expenditure that can reduce fitness and result in reduced survival/reproductive success. • Flushing from bridge roost will increase chances of predation. • Increased effort to find new suitable roosting habitat requires extra energy expenditure that can reduce fitness and result in reduced survival/reproductive success.
Conservation Measures	Avoidance of project effects on a bridge structure that is known or has been identified as reasonably likely to support a maternity and/or bachelor colony.
Interpretation	Bats may flush from their roosts on the bridge. Bats that flush during the daytime are at greater risk of harm due to predation. Additionally, bats that flush their roosts may be harmed due to an increase in energy expenditure. The most severe effects of flushing a bat from a bridge may result in harm if the bat was a female with a pup. The longer the female is absent, the more likely the effects to the pup would be significant. Bats that flush must also expend additional energy to locate other roosting habitat. The use of additional energy in response to habitat loss, especially when combined with the energy needs associated with normal life cycle processes (e.g., migration, pregnancy, lactation, etc.) or other stressors, is likely to reduce fitness and subsequently reduce survival and reproductive success. Gray bats exposed to this stressor while roosting on the bridge are likely to respond in a way that would lead to adverse effects.
Effect	Harm

Effects Pathway – Gray Bat #13	
Activity: Construction (bridge replacement)	
Stressor: Alteration or Loss of Roosting Habitat of Bridges	
Exposure (time)	Active timeframe; duration of the activity
Exposure (space)	Bridges
Resource affected	Day or night roosting habitat, individuals (adults, juveniles)
Individual response	• Mortality during bridge removal. • Flushing from bridge roost results in extra energy expenditure that can reduce fitness and result in reduced survival/reproductive success. • Flushing from bridge roost will increase chances of predation. • Increased effort to find new suitable roosting habitat requires extra energy expenditure that can reduce fitness and result in reduced survival/reproductive success.
Conservation Measures	Avoidance of project effects on a bridge structure that is known or has been identified as reasonably likely to support a maternity and/or bachelor colony.
Interpretation	Bats roosting in bridge may be injured or killed. Injured bats may subsequently die. Bats may flush from their roosts on the bridge. Bats that flush during the daytime are at greater risk of harm due to predation. Additionally, bats that flush their roosts may be harmed due to an increase in energy expenditure. The most severe effects of

	flushing a bat from a bridge may result in harm if the bat was a female with a pup. The longer the female is absent, the more likely the effects to the pup would be significant. Bats that flush must also expend additional energy to locate new roosting habitat. The use of additional energy in response to habitat loss, especially when combined with the energy needs associated with normal life cycle processes (e.g., migration, pregnancy, lactation, etc.) or other stressors, is likely to reduce fitness and subsequently reduce survival and reproductive success. Gray bats exposed to this stressor while roosting on the bridge are likely to respond in a way that would lead to adverse effects.
Effect	Harm

Effects Pathway – Gray Bat #14

Activity: Maintenance and Construction, (bridge rehabilitation/replacement)	
Stressor: Alteration or Loss of Roosting Habitat of Bridges	
Exposure (time)	Inactive timeframe removal will expose gray bats to adverse effects during the active timeframe for one season after removal
Exposure (space)	Bridges
Resource affected	Day or night roosting habitat, used by individuals (adults)
Individual response	• Increased effort to find new suitable roosting habitat requires extra energy expenditure that can reduce fitness and result in reduced survival/reproductive success.
Conservation Measures	Avoidance of project effects on a bridge structure that is known or has been identified as reasonably likely to support a maternity and/or bachelor colony.
Interpretation	Adult gray bats will experience adverse effects after they arrive at their summer roosting habitat the first year after bridge rehabilitation or replacement. The extra energy to find new habitat is in addition to what is necessary for foraging, pup rearing, social interactions, or other activities. The use of additional energy in response to habitat loss, especially when combined with the energy needs associated with normal life cycle processes (e.g., migration, pregnancy, lactation, etc.) or other stressors, is likely to result in adverse effects. Gray bats are expected to adapt to this stressor in subsequent years after they have found new suitable habitat.
Effect	Harm

<u>Amount or Extent of Adverse Effects – Summer Roosting Habitat (Bridges)</u>
Over the next 5-years, approximately 1,100 bridges associated with the Bridging Kentucky Program (BKY) are anticipated to be rehabilitated or replaced. In addition, KYTC anticipates an additional 40 bridge projects per year (i.e., ~200 projects over 5 years) that are not associated with BKY.

Through an on-going assessment of bridges within the Commonwealth of Kentucky, the KYTC has reviewed 260 structures throughout the state. The assessed bridges included a variety of sizes and bridge types, including bridges from 21 to 727 feet long and bridge types such as channel beam, box beam, pre-stressed concrete beam, metal beams, box culverts, and numerous others. The majority (92%) of these structures were identified as either unsuitable for bats or no bats or signs of bat use were observed. The remaining bridges (8%) had bats (unidentified species) actively roosting on the structure or signs of bat use were observed.

Assuming a similar correlation of bridges that have bats actively roosting on the structure or signs of bat use across the anticipated 1,300 bridge projects and 5 years of the Action, the Action will result in impacts to an estimated 130 bridges deemed suitable as roosting habitat by bats (1,300 bridges X .10 = 130 bridges). For simplicity, we rounded to 10 percent of bridges with active roosting and/or signs of bat use.

As a conservation measure, the Action avoids project effects on a bridge structure that is known or has been identified as reasonably likely to support a maternity and/or bachelor colony. According to the applicable science, the number of day and/or night roosting gray bats observed using bridge structures varies but is typically less than 5 bats. Therefore, the Service assumes that five individual gray bats will day and/or night roost on a suitable bridge. Based on these assumptions, the Action's effects on bridges serving as roosting habitat would affect gray bats:

- 130 active roosting bridges X 5 bats per bridge = 650 bats.

The Service anticipates that FHWA projects will affect up to 650 gray bats over a 5-year period. A small, but indeterminable, portion of these 650 gray bats are expected to be injured or killed by the Action. Disruption of normal behavior as a result of physical disturbance and/or habitat modification or degradation will account for the vast majority of adverse effects.

11.7 Summary of Effects

Table 6. A summary of the effects of the Action on the gray bat

Stressors: Activities	Adverse	Insignificant/ Discountable
Noise and vibration (bridge roosting): *construction and maintenance*	harm	
Noise and vibration (foraging): *construction*		insignificant
Noise and vibration: *operation*		insignificant
Night lighting: *construction and operation*		insignificant
Night lighting: *maintenance*		discountable
Aquatic resource: *construction*		insignificant
Aquatic resource degradation, (sedimentation): *construction and maintenance*		insignificant
Aquatic resource degradation, (pollutants): *construction, operation,*		insignificant

and maintenance		
Tree removal: *construction and maintenance*		insignificant
Collison: *construction*		discountable
Collison: *operation*	harm	
Alteration or loss of roosting habitat on bridges: *maintenance* (rehabilitation)	harm	
Alteration or loss of roosting habitat on bridges: *construction* (replacement)	harm	
Alteration or loss of roosting habitat on bridges: *maintenance and construction* (rehab or replacement) (inactive timeframe)	harm	

12 CUMULATIVE EFFECTS

For purposes of consultation under ESA §7, cumulative effects are the effects of future state, tribal, local, or private actions that are reasonably certain to occur in the Action Area. Future federal actions that are unrelated to the proposed action are not considered, because they require separate consultation under §7 of the ESA.

Land use activities that may affect gray bats and that are likely to occur within the Action Area include: timber harvest, ATV recreational use, recreational use of caves, and development associated with road, residential, industrial, and agricultural development and related activities. These private actions are likely to occur within the Action Area, but the Service is unaware of any quantifiable information about the extent of private timber harvests within the Action Area, the amount of use of off-highway vehicles within the Action Area, or the amount of recreational use of caves within the Action Area. Similarly, the Service does not have any information on the amount or types of residential, industrial, or agricultural development that have or will occur within the Action Area. Therefore, the Service is unable to make any determinations or conduct any meaningful analysis of how these actions may or may not adversely and/or beneficially affect the gray bat. It is possible that these activities may have cumulative effects on gray bats and their habitat in certain situations (e.g., cave exploration during spring/summer months within an unknown maternity colony may cause adverse effects to that maternity colony). In stating this, however, we can only speculate as to the extent or severity of those effects, if any.

13 CONCLUSION

In this section, we summarize and interpret the findings of the previous sections (status, baseline, effects, and cumulative effects) relative to the purpose of a BO under §7(a)(2) of the ESA, which is to determine whether a Federal action is likely to:

c) jeopardize the continued existence of species listed as endangered or threatened; or
d) result in the destruction or adverse modification of designated critical habitat.

"Jeopardize the continued existence" means to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species (50 CFR §402.02).

After reviewing the current status of the species, the environmental baseline for the Action Area, the effects of the Action and the cumulative effects, it is the Service's biological opinion that the Action is not likely to jeopardize the continued existence of the gray bat. No critical habitat has been designated for the gray bat.

The gray bat is stable throughout its range. We have determined that the species' reproduction, numbers, and distribution will not be appreciably reduced as a result of the Action. This no jeopardy determination is supported by the analysis for the Effects of the Action and because:

- Most of the harm is expected to be sub-lethal and result in additional energy expenditures (reduced fitness) associated with a one-time loss or alteration of habitat. Bats are expected to fully recover from this harm within 1–2 years.
- Impacts to maternity colonies and their reproductive success are not anticipated.
- Impacts to the species reproduction and numbers will be limited by the avoidance and minimization measures implemented by the FHWA (e.g., exclusion of hibernacula, restrictions on bridge work where a known or likely maternity or bachelor colony is present, and within close proximity to hibernacula).
- No reduction in the distribution of the species is expected as the Action Area occurs near the center of the species' range, and impacts from the Action are limited at both at the project and programmatic scales, and are dispersed across a large Action Area.

In order to offset unavoidable adverse effects on gray bats utilizing bridges as roosting habitat, the KYTC is committed to funding the protection of a known gray bat maternity site and surrounding habitat. This conservation measure would have a beneficial effect on the gray bat by ensuring that the species has suitable habitat available for roosting and rearing of pups during the summer period of their lifecycle. Funding this conservation measure is expected to promote the survival and recovery of the species through protecting and managing existing year round roosting habitat suitable to support the species, particularly one that would expand conservation ownerships.

Further, the conservation measure to fund the protection of a known gray bat maternity site and surrounding habitat is expected to promote the survival and recovery of the species by conserving additional lands that contain habitat for the species, particularly those that would expand existing conservation ownerships.

14 INCIDENTAL TAKE STATEMENT

ESA §9(a)(1) and regulations issued under §4(d) prohibit the take of endangered and threatened fish and wildlife species without special exemption. The term "take" in the ESA means "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct" (ESA §3). In regulations at 50 CFR §17.3, the Service further defines:

- "harass" as "an intentional or negligent act or omission which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering;”

- “harm” as “an act which actually kills or injures wildlife. Such act may include significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding or sheltering;” and
- “incidental take” as “any taking otherwise prohibited, if such taking is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity.”

Under the terms of ESA §7(b)(4) and §7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered prohibited, provided that such taking is in compliance with the terms and conditions of an incidental take statement (ITS).

For the exemption in ESA §7(o)(2) to apply to the Action considered in this BO, the FHWA must undertake the non-discretionary measures described in this ITS, and these measures must become binding conditions of any permit, contract, or grant issued for implementing the Action. The FHWA has a continuing duty to regulate the activity covered by this ITS. The protective coverage of §7(o)(2) may lapse if the FHWA fails to:

- assume and implement the terms and conditions; or
- require a permittee, contractor, or grantee to adhere to the terms and conditions of the ITS through enforceable terms that are added to the permit, contract, or grant document.

In order to monitor the impact of incidental take, the FHWA must report the progress of the Action and its impact on the species to the Service as specified in this ITS.

14.1 Amount or Extent of Take Anticipated

This section specifies the amount or extent of take of the gray bat that the Action is reasonably certain to cause, which we estimated in the “Effects of the Action” section of this BO, using the best available data. We reference, but do not repeat, these analyses here.

We estimated the number of individuals reasonably likely to occur in the Action Area (see section 10, Environmental Baseline). We evaluated the potential for these individuals to be exposed to the stressors resulting from the proposed Action. Finally, we evaluated how the individuals’ responses to their exposure to these stressors would apply to the statutory and regulatory definition of take (see section 11, Effects of the Action). From our evaluation, the proposed Action is reasonably certain to cause the incidental take of 651individual gray bats. This taking is expected in the form of harm. The mechanisms of this taking and the basis for our estimation of its extent are described in section 11 (Effects of the Action) of this BO.

Table 7. Summary of Expected Incidental Take Resulting from the Action

Species	# of Individuals	Take Type
Gray Bat	650	Harm (Summer Roosting Habitat, Bridges)

Gray Bat	1 per year	Harm (Collision)

The Service anticipates the incidental taking of gray bats associated with this project will be difficult to detect for the following reasons:

- The individuals are small, mostly nocturnal, and when not hibernating, occupy caves or cave-like habitats (i.e., bridges) where they are difficult to observe;
- Finding dead or injured specimens during or following project implementation is unlikely; and
- Most incidental take is in the form of non-lethal harm and not directly observable.

Due to the difficulty of detecting take of gray bats caused by the proposed Action, the Service will monitor the extent of taking using the number of suitable roosting structures (bridges) that projects remove or alter, which is up to 130 bridges over a 5-year period that have been determined to contain bats or show bat use. This surrogate measure is appropriate because the majority of the anticipated taking will result from habitat removal/alteration and activities associated with that alteration, and because it sets a clear standard for determining when the extent of taking is exceeded.

14.2 Reasonable and Prudent Measures

The Service believes the following reasonable and prudent measures (RPMs) are necessary or appropriate to minimize the impact of incidental take caused by the Action on the gray bat.

RPM1. The FHWA will ensure that the programmatic process and conservation measures will be implemented, as appropriate, on a project-by-project basis as planned and documented in the BA and the BO.

RPM2. FHWA will coordinate with the KFO in order to develop a user's guide and/or key to assist in the implementation of the programmatic process in compliance with the programmatic consultation as documented in the BO.

RPM3. FHWA will coordinate with the KFO to develop a monthly accounting ledger that identifies specific roles and responsibilities, monitoring requirements, and other details regarding the use of the programmatic consultation.

14.3 Terms and Conditions

In order for the exemption from the take prohibitions of §9(a)(1) and of regulations issued under §4(d) of the ESA to apply to the Action, the FHWA must comply with the terms and conditions (T&Cs) of this statement, provided below, which carry out the RPMs described in the previous section. These T&Cs are mandatory. As necessary and appropriate to fulfill this responsibility, the FHWA must require the KYTC or any permittee, contractor, or grantee to implement these T&Cs through enforceable terms that are added to the permit, contract, or grant document.

T&C4. The FHWA shall conduct regular audits of specific projects and/or monthly ledgers to ensure proper adherence and consistent use of the programmatic consultation. FHWA shall contact the KFO within 30 days and provide a written explanation and plan of action of any irregularities identified because of the aforementioned audits. (This T&C is associated with RPM1).

T&C5. The FHWA shall develop a user's guide and/or key for the KYTC personnel implementing the programmatic process in order to maintain consistency. The guide shall clearly identify the key project factors, conservation measures, and the steps leading up to a proper species effects determination. The guide shall also include instructions on how to calculate and complete any required compensation and reporting requirements. Completion of this T&C shall occur within 30 days of the executed BO. (This T&C is associated with RPM2).

T&C6. The FHWA shall develop a monthly accounting ledger that is specific to each of the KYTC's monthly project letting schedules, and will include all covered projects, including those where conservation and/or compensation measures were not required. The ledger will identify those projects where compensation is required and the preferred method. Completion of this T&C shall occur within 30 days of the executed BO. Specific ledger information may include, but is not limited to, the following:

- Description of the proposed action (e.g., type of action, location, involved federal agencies);
- Verifies that the project is within the scope of the programmatic consultation;
- Provides details of impacts (e.g., type bridge work); and
- Identifies all proposed conservation measures that will avoid, minimize and/or compensate the project's impacts. (This T&C is associated with RPM3).

14.4 Monitoring and Reporting Requirements

In order to monitor the impacts of incidental take, the FHWA, through coordination with the KYTC, shall report the progress of the Action and its impact on the species to the Service as specified in the incidental take statement (50 CFR §402.14(i)(3)). Completion of T&C3 shall be incorporated into this section providing the specific instructions for such monitoring and reporting. As necessary and appropriate to fulfill this responsibility, the FHWA must require any permittee, contractor, or grantee to accomplish the monitoring and reporting through enforceable terms that are added to a permit, contract, or grant document. Such enforceable terms must include a requirement to immediately notify the FHWA and the Service if the amount or extent of incidental take specified in this ITS is exceeded during Action implementation.

15 CONSERVATION RECOMMENDATIONS

§7(a)(1) of the ESA directs Federal agencies to use their authorities to further the purposes of the ESA by conducting conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary activities that an action agency may undertake to avoid or minimize the adverse effects of a proposed action, implement recovery plans, or develop information that is useful for the conservation of listed species. The Service has not identified any conservation recommendations for this BO.

16 RE-INITIATION NOTICE

Formal consultation for the Action considered in this BO is concluded. Reinitiating consultation is required if the FHWA retains discretionary involvement or control over the Action (or is authorized by law) when:

a) the amount or extent of incidental take is exceeded;
b) new information reveals that the Action may affect listed species or designated critical habitat in a manner or to an extent not considered in this BO;
c) the Action is modified in a manner that causes effects to listed species or designated critical habitat not considered in this BO; or
d) a new species is listed or critical habitat designated that the Action may affect.

This consultation was assigned FWS ID #04EK1000-2019-F-1687. Please refer to this number in any correspondence concerning this consultation.

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