Best Management Practices for Bat Species Inhabiting Transportation Infrastructure

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Developed as Part of the White-nose Syndrome National Response Plan

by Holly J. Smith and Justin S. Stevenson

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This document is the product of the multi-agency WNS Conservation and Recovery Working Group established by the National WNS Plan (A National Plan for Assisting States, Federal Agencies, and Tribes in Managing White-Nose Syndrome in Bats, finalized May 2011). This guidance document will be updated as necessary to include the most current information and guidance available www.whitenosesyndrome.org/TBD

Photography by Justin Stevenson, RD Wildlife Management unless otherwise noted.

1. ***Introduction***

This document is the product of the multi-agency White-nose Syndrome (WNS) Conservation and Recovery Working Group, established by the WNS National Response Plan (A National Plan for Assisting States, Federal Agencies, and Tribes in Managing White-Nose Syndrome in Bats). Specifically, the WNS Conservation and Recovery Working Group identified the need for comprehensive best management practices (BMP's) to minimize negative impacts to local bat communities during operational and maintenance activities at transportation infrastructure (e.g., bridges, culverts). Although applicable to every bat species, these measures were developed specifically to protect those species whose populations have declined significantly due to WNS. As such, this document addresses concerns relative to bat occupancy, and outlines methods to minimize colony disturbance and the further expansion of WNS. Background information on the significance of, threats to, and biology and behavior of bats illustrate the context and justification for these standards.
For more information on WNS please visit http://whitenosesyndrome.org.

Globally, bats are intrinsic to healthy ecosystems, community integrity and vital ecological processes. They provide valuable ecosystem services (insect suppression, pollination, seed dispersal), products and provisions (tequila, sisal, cactus fruits), cultural benefits (educational, recreational, spiritual) and contribute considerably to mammalian diversity. Notwithstanding, bats confront multiple threats. Habitat destruction and modification, climate change, pesticides and pollution, disease and human development (e.g., wind turbine facilities, urbanization) cumulatively contribute to population level impacts. Additionally, roost availability and abundance are critical elements limiting chiropteran[1] populations. As the availability and abundance of natural roosts decline, manmade infrastructure (e.g., mines, buildings, bridges, culverts) become incalculable substitutes. Highway structures function as comparatively permanent, alternative roosts (i.e., diurnal roosts, nocturnal roosts, maternity roosts) and stepping-stone refugia (i.e., transitory roosts) for migrating populations. These anthropogenic structures proffer physical and thermal characteristics reminiscent of natural cavities (i.e., stable microclimatic conditions, predator protection) and proximity to elemental resources (water, optimal foraging sites).

In recent decades, environmental responsibility and stewardship practices have become inveterate to the project development process of state Departments of Transportation (hereafter DOT). Consideration to wildlife movements (mammal collision mitigation measures), ecosystem impacts and timetables (stream crossings and fish spawning, bird incubation periods) are now at the forefront of transportation planning. Moreover, numerous states have become environmental champions, actively engineering and retrofitting highway structures to accommodate bat colonies. Forty-five microchiropteran species of 19 genera and four families populate the United States. Of those species, 60% and potentially 89% exploit manmade transportation structures (Table 1-2). However, authoritative guidelines to address incidental bat occupation, including identification, mitigation and compensation measures are nonexistent.

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[1] Chiroptera refers to the taxonomic order of mammals consisting of megabats (Old World fruit bats), which constitute the suborder Megachiroptera; and microbats (echolocating "true bats"), which compose the suborder Microchiroptera.

[2] Exclusion | the process or state of excluding; the act of installing physical or mechanical means to prevent an animal from entering an area

[3] Eviction | the process or state of expelling; the employment of one-way devices whereby an animal leaves but cannot reenter

Operational activities that adversely affect bats primarily include roost destruction, modification of habitats and direct disturbance during critical life phases (maternity and weaning periods, hibernation). Even those projects with uncomplicated scopes (e.g., pavement rehabilitation and reconstruction, bridge deck replacement, guardrail and fencing installation) and minimal environmental impacts may cause disturbance to resident colonies. Additionally, landscape features are important habitat components; i.e., commuting routes, essential sources of insect prey, and potential roosts for both crevice- and foliage-roosting species.

North America's transportation system encompasses ca. 13 million structures (i.e., > 6 m bridges, box culverts, drainage structures) that equate to approximately one construction per quarter mile (400 m). With potentially millions of linear "bat-friendly" footage, DOT inadvertently composes the cornerstone of bat conservation. DOT provides thousands of artificial roosts per state, supporting an inestimable number of bats. Given the magnitude of present-day threats (e.g., WNS, turbine collisions) and concomitant population declines, it has become increasingly important to minimize ancillary sources of mortality. Thus, DOT can *further* safeguard our country's remaining bat communities by implementing simple guidelines to minimize or eliminate adverse impacts from construction and operational activities.

This document provides standards by which to minimize the aforementioned impacts on bat communities. These BMPs emphasize surveys, humane eviction[2] and exclusion[3] techniques, protocols for WNS and mitigation and compensation measures. Through these measures, we propose to provide comprehensible, practicable procedures to assist state DOTs and other transportation agencies with identifying and evaluating the potential and/or actual effects of a given project. These procedures are recommended to ensure bat welfare, consistency of approach and provide a sound, scientific foundation for effective planning and implementation of policies. The ensuing recommendations demonstrate exemplar measures; thus, they may necessitate modification for feasibility, site specific differences, and project constraints (e.g., phase of development, available budget, conservation status of respective bat species). As such, we denote sections which satisfy the minimum acceptable standards by which to mediate significant impacts.

Please become familiar with your state's endemic bat species and their respective maternity seasons, which vary by species and region. Contact your state wildlife agency to learn specific details about time-of-year restrictions, regulations, sensitive species (T&E species, state species of concern) statutes and/or requisite permits. Please note, the minimum standards provided here may not be sufficient to avoid, minimize, or mitigate impacts to listed bat species.

2. *Presence / Absence Surveys*

The survey and assessment of bat occupancy in structures requires expertise, experience and objectivity. "It is comparatively easy to determine use of a site by bats, but absence is more difficult to prove. It requires greater effort to demonstrate beyond reasonable doubt that bats are not present or likely to be present (Bat Conservation Trust 2007)." Surveyors must be mindful and respectful, to prevent roost abandonment and accidental injury to or mortality of bats. Additionally, the surveyor must be competent in identifying bats (may require capture and handling to determine/confirm species) and their respective habitat. The specialist must be able to characterize the existing environment and evaluate its significance. Where mitigation measures are necessary, the specialist must be capable of assisting the design and implementation of these measures.

Surveys should identify existing and potential roost sites, map important foraging areas and record principal commuting routes. This valuable information facilitates a strategic plan to be formed to protect local bat populations. All bat surveys should be undertaken at the appropriate time of year to collate the information required (i.e., summer surveys to detect maternity roosts and winter surveys to detect hibernating bats). A preliminary landscape analysis (maps.google.com) can identify probable roost locations and landscape features favorable to the presence or transit of bats (mature forests, large trees, small fields, presence of water and watercourses) prior to site survey(s). Additionally, searches performed prior to site surveys can provide information on the likelihood of vulnerable species being present (i.e., species of concern, T & E species).

Surveys to document overall impacts should include right-of-way property; including land necessary for accommodation access, machinery, construction staging, and post-construction maintenance. Caves and mature trees proximate to sites have the potential for various roost types; including maternity roosts, transitional roosts, bachelor roosts, and hibernacula.

All species (including those that occupy nearby natural roosts) are vulnerable to poor watercourse management, and removal of treelines and vegetative cover (vulnerable to predators, open spaces are more lit, no protection from wind/rain). Surveys must be sufficient to characterize the local environment and to provide defensible and robust impact predictions. Any sites supporting bat colonies of considerable conservation value may require more exhaustive inspections and documentation. This ensures the proper evaluation of impacts and mitigation measures. To determine movements and the connection of critical areas, surveys may require a broader survey zone. We recommend, when feasible, that comprehensive surveys identify the extent of all significant roosts and breeding sites within 1 km (National Roads Authority 2006, Sétra et al. 2009). To ensure reliability, several visits across biological seasons should occur (2-3 times per year). If impracticable, the optimum time for surveys is summer. While bats are active throughout the night, peak activity occurs at dusk and before dawn; and surveyors should address bat activity during these time frames to provide comprehensive information of site utilization. The most effective detector survey period is June - August, which will provide information on maternity roosts. Earlier studies (April and May) and later studies (September) will yield information on alternative roosts (National Roads Authority 2006). Mist netting to capture and identify local bat species that may or may not be identified with bat detectors may be appropriate in certain circumstances (i.e., where detailed information on specific species is required, or where species of concern or high conservation value may occur). In enclosed areas (e.g., bridges), harp-trapping may be employed to confirm the presence of species.

2.1 *Standard survey* †

A standard survey to establish presence/absence, assess probability or severity of impact(s), and acquire information to recommend mitigation and/or compensation measures should include:

- 2.1.1 Date
- 2.1.2 Site description (includes both location and structure information)
- 2.1.3 Proposed activity (demolition, repair, maintenance)
- 2.1.4 If bats are presently, or have been, within the structure
    - 2.1.4.1 Inspection of existing infrastructure
        - 2.1.4.1.1 Structural fissures (cracked or spalled concrete, damaged or split beams, split or damaged timber railings, et cetera)
        - 2.1.4.1.2 Crevices (expansion joints, space between parallel beams, spaces above supports piers, et cetera)
        - 2.1.2.1.3 Alternative structures (drainage pipes, bolt cavities, open sections between support beams, swallow nests, et cetera). Nests, when abandoned or unoccupied, provide ancillary roost habitat for bats worldwide. Occupancy rates

† Denotes minimum acceptable standards

can approach 39 percent. Bats that exploit *Hirundo rustica* nests lay nearly prostrate within the nest cup and those within *Petrochelidon pyrrhonota* nests (gourd-shaped enclosed structures) are typically concealed and undetectable without a borescope or fiberscope.

2.1.4.2 Cursory inspection of natural structures and trees in proposed activity "footprint." The presence of bats in trees or rock crevices can be difficult without external signs (presence of guano, sounds of bats). Occupancy can be established by examination of suitable crevices, cavities, limb fractures, and loose bark. Specialist equipment (e.g., rope access, borescope) may be required in certain circumstances (advanced survey).

2.1.5 Species present

2.1.6 Roost information including type (e.g., diurnal, nocturnal), location, characteristics

2.1.7 Intensity (e.g., number of bats, time and duration of use)

2.1.8 Photographs to support written documentation

2.2 *Advanced survey*

Most sites will warrant standard surveys. However, where site-specific conditions or other findings suggest the potential for substantial adverse impacts to bats, advanced surveys designed to further evaluate specific concerns may be recommended. Thus, survey effort should be proportionate to survey purpose (i.e., to obtain adequate results for specific objectives) and may further identify:

2.2.1 Information from standard survey,

2.2.2 Species whose distribution includes site (identify potential for species of conservation concern),

2.2.3 Any features of particular ecological or conservation significance,

2.2.4 Specific roost sites (confirmed and potential) that occur in close proximity to site; detailed inspection of potential tree roosts identified by standard survey,

2.2.5 Any watercourses, flyways, crossing points, or foraging areas that may be impacted by construction and clearance activities,

2.2.6 Potential site-specific mitigation, compensation or enhancement measures,

2.2.7 Colony type and sex. Sexual segregation does occur within habitats of various species. Therefore, the occupation of habitats by males/females should be identified. This may become important (e.g., impact the selection of trees for felling) because a site that sustains females would be more significant than one that support males,

2.2.8 Identify time of survey with respect to biological season. Bat activity may differ between certain periods due to variations in availability of prey, recruitment of juveniles, or the availability of suitable roost sites. For example, summer roosts may not provide the appropriate microclimates necessary for hibernation. Therefore, a survey done outside the breeding season may impart a false impression of the site's importance,

2.2.9 Bat activity surveys. Appropriate during warmer months (April - September) and at dusk emergence and/or dawn re-entry, and may include documentation of active foraging and commuting habitats. emergence times and locations, intensity (estimate of population), species assessment via manual/automated bat detectors, and camera/video equipment (FLIR, infrared).

3. *Structure Specific Misconceptions*

The publication 'Bats in American Bridges' (Keeley and Tuttle 1999) remains the authoritative work for bats and transportation structures. Although this document provides an incredible wealth of information, people inaccurately consider their "ideal" characteristics as categorical requirements. This can precipitate misconceptions and erroneously influence surveyors or consultants and therefore, cause oversights with respect to bat occupancy. Bats exhibit considerable plasticity, both within and between species. Therefore, implementing a "one size fits all" approach to 27, and potentially 40, different bat species may effect devastating consequences.

3.1 *Bats require at least 3 m of vertical measurement to take flight. Therefore, the structure must be equal to or exceed 3 m to be suitable for bats.*
Although structures < 3 m may not be preferable, to dismiss these roosts would be imprudent and irresponsible. Bats commonly occupy the warmest 'end chambers' - terminal spans that typically occur over land, proximate to abutments. Sloping riverbanks and/or the application of fill to stabilize bridge supports often cause end chambers to be closer to the ground than center chambers, and occupied chambers occasionally are <2 m above ground. Suitable roosts within crevices and drainage pipes may be 2.28 m, with pipe entrances 1.20 - 2.59 m above ground. Furthermore, high occupancy rates may force bats to roost at substandard heights (.45 m from ground to roost entrance).

3.2 *Culverts must be between 1.5 and 3 meters in height and ≥ 100 m in length.*
Documentation of suitable culverts include lengths of 10 - 19 m, widths of 1.0 - 1.5 m and 1 - 4 m above ground or water. The IUCN near threatened species, *Choeronycteris mexicana*, has been found roosting within 45 - 61 cm wide corrugated metal culverts.

3.3 *Bats exhibit obvious signs of occupancy (e.g., bat vocalizations, guano and/or urine stains).*
Bats commonly roost between narrow spaces above bridge beams, above or behind intact expansion or insulation boards, within concrete spalls, pipe collars and similar crevices whose openings are not oriented towards the ground, where guano accumulation is evident.
Bats possess a complex, diverse repertoire of social vocalizations. However, roosting bats may display minimal movements and vocalizations.

3.4 *Bats require vertical crevices 12.7 to 31.75 mm wide and ≥ 304.8 mm in depth.*
Bats exhibit incredible plasticity with respect to amenable roost types and will exploit uncommon structures including concrete spalls; space above insulation boards; between guardrail posts and beams; between concrete piers and corrugated metal; within insulated pipes, swallow nests, wasps' nests, drainage pipes, recessed lighting housings and road signage. Although such roosts may not be preferable, surveyors should inspect every potential roost space.

3.5 *Bats only roost within bridges over water.*
For most species, a dramatic correlation exists between colony location and distance to water; riparian areas are often highly profitable foraging territories for insectivorous bats. Proximity to water may constitute minimum habitat characteristics for some species; however, flight enables bats to access widely distributed resources. For example, *Tadarida brasiliensis* may travel 40-50 km between day roost and foraging habitat. While proximity to water certainly increases habitat suitability, its presence or lack thereof not does determine occupancy.

3.6 *DOTs can conduct operations after October 1, when bats are absent. This interval coincides with autumnal migration and movements to local hibernacula.*

In temperate North America, colder months signify lower ambient temperatures and the concomitant reduction of insect prey. To circumvent this 'energetic bottleneck', migratory species relocate to warmer environments, whereas other species hibernate and remain relatively inactive. Some species exhibit intraspecific plasticity relative to winter activity patterns, which vary from sustained hibernation to intermittent dormancy. In the southern US, many non-migratory species are active year-round, even at low ambient temperatures (-8 - 22 C). The potential for overwintering or hibernating bats necessitates a survey to ensure the absence of bats from structures October - March.

3.7 *Roosts must receive full sun exposure*.
A recent study (Smith and Stevenson 2013b) supports the contention that small heterothermic (employ daily torpor) bats occupy relatively wide temperature ranges, and are opportunistic relative to roost structures and conditions. Additionally, their results illustrate that, for reproductive females; thermal stability, rather than high temperatures, determine roost selection. As such, wildlands bats choose natural tree cavities that exhibit minimal variation compared to ambient conditions. However, when temperatures are low (March-April), bats may roost within cavities exposed to direct sunlight, which imparts the opportunity to maintain body temperature passively.

3.8 *Bats will not roost over busy roadways.*
One of New Mexico's most significant bridge populations spans the exit-ramp off Interstate Highway 25. Although busy roadways may not be preferable, to dismiss these roosts would be imprudent and irresponsible.

3.9 *Bats do not occupy transportation structures within northern states because "few are warm enough to meet bat needs."*
Since the publication of 'Bats in American Bridges' ((Keeley and Tuttle 1999), more than 43.5 percent of 23 northern states and three Canadian provinces have documented bridge specific bat colonies. At least two earlier publications, Bailey (1926) and Mumford and Cope (1958), provide occupancy reports from the northern states of Montana and Indiana, respectively. Furthermore, an inspection of 130 south-central Montana highway structures determined 60 percent occupancy rates - a frequency "as high or higher than in many surveyed regions farther south (Kurtz and Hendricks 2006)."

4. *Health and Safety Recommendations*

4.1 *Rabies*
Before working near known roosts, maintenance crews should be encouraged to avoid disturbing the bats as much as possible, and taught not to handle them. These procedures will minimize the direct exposure of crews to bats and eliminate the possibility of personnel being bitten, which would then necessitate post-exposure rabies treatment.

4.2 *Histoplasmosis*
Bird and bat guano are classic reservoirs for *H. capsulatum*, the fungus that causes histoplasmosis, a systemic infection primarily of the respiratory tract. Outbreaks have been associated with demolition and earth-moving activities that aerosolize topsoil and dust (e.g., bridge reconstruction and demolition, jack- and air-hammering, waste disposal). Employees should wear personal protective equipment and employ dust-

suppression techniques when working in areas potentially contaminated with bird and/or bat droppings (Huhn et al. 2005).

5. ***Appropriate Time Schedules* †**

"A simple project with a defined design concept that will be ready for construction within two years may be programmed for the first two years of the STIP [Statewide Transportation Improvement Program]. The activities conducted in year one can encompass preliminary engineering, environmental certification, right-of-way acquisition, and final design. Year two can include construction" (New Mexico State Highway & Transportation Department 2009). Bennett et al. (2008) recommend an inspection interval of 3-5 times annually to determine use. Lengthy time intervals between biological investigations and construction increase the probability of occupancy; and therefore, the unreliability of those evaluations. (Chart 1).
Maternity colonies form from late May onwards and remain relatively cohesive through mid- to late August. Single young, born June-July, are non-volant (not capable of flight or evasive action, wholly dependent on mothers) for several weeks and thus, are extremely vulnerable to disturbance by human activities (restoration, reinforcement or demolition of structures).

5.1 *Wildlife exclusion*

Specific mitigation measures to exclude must be in situ prior to demolition or maintenance activities.

5.1.1 Migratory birds
Exclusion practices to prohibit migratory birds with ≥ 3/4" netting does not exclude bats. Any indication of bats necessitates the installation of 3/8" netting. If bats are present, installation should not occur May - August when bats are exceptionally vulnerable to disturbance. If hibernating bats are present, installation can not occur late November - early March.

5.1.2 Bats
Bats can be excluded with one-way valves, professional foam sealants and/or 3/8" exclusion netting. One-way devices (e.g., tubes, cones, mesh) permit bats to exit but not re-enter the structure(s). Exclusion may occur September - April. If bats are present, installation of one-way valves must occur prior to netting. Winter exclusion must entail a survey to confirm either, 1. bats are absent or 2. present but active (continuously active - not intermittently active due to arousals from hibernation). Application of foam products without prior surveying or professional exclusion can entomb bats. We therefore advocate the preclusion of foam sealants unless a qualified consultant confirms the absence of bats.

5.1.2.1 Please respect wildlife. Do not poison, pressure wash, trap, relocate, or in any other manner harm, harass or kill bats. These are ineffective, unnecessary techniques, potentially illegal, and do not comply with minimum acceptable standards.

5.2 *Maintenance*

Maintenance activities include cleaning, preventative maintenance to preserve and lengthen service life, technical and specialized repairs and stream channel maintenance. These activities can involve the operation of support vehicles and equipment, pavement repair, welding and grinding operations, and associated pollutants, which may impact nearby bat colonies.

5.2.1 Minor maintenance activities (e.g., wing wall repair or underpinning foundations) typically have minor or no impact on bats. However, more substantial maintenance operations, including replacement or strengthening of structures above water level, should entail a bat assessment (Bat

Conservation Ireland 2010). If bats are present, exclusion procedures should be implemented prior to maintenance activities.

5.2.2 Some maintenance activities (e.g., sealing cracks and crevices) may entomb bats or cause the abandonment of non-volant young. Additionally, these activities can create noise pollution, vibrations, and modify thermal conditions of roosts; and consequently, may promote roost abandonment.

5.2.3 Night-time maintenance activities can affect bats. Light, odors and noise can delay or discourage bats from emergence, or potentially, cause site abandonment. Activities adjacent to flyways and roosts should be avoided, especially when bats are most vulnerable (mid-April - end of July). If operations are inevitable, we recommend the installation of very localized lighting in the worksite zone, avoiding surrounding areas to reduce the barrier effect. The temporary erection of noise barriers and/or light screens may also be considered. Temporary infrastructure (stockpile areas, roads for construction traffic) should be constructed at a distance from roosts (Sétra et al. 2009).

5.2.4 Vibrations from noise disturbances within 0.5 miles of a known or suspected hibernaculum may cause arousal from hibernation. The disturbance to hibernating bats reduces the probability of survival because arousals and the return to euthermy (normal body temperatures) depletes imperative fat reserves (i.e., energy supply).

5.2.5 Maintenance activities which involve the replacement of bridge components with contrastive products may modify roost microclimate, dimensions, illumination, et cetera; and consequently, may promote roost abandonment.

5.3 *Clearance activities*

Keeley (National Roads Authority 2005) asserts "the most significant impact of road construction upon bats is in the clearance phase of the scheme, namely tree-felling, the removal of hedgerows and other vegetation.." These landscape features are important habitat components for insectivorous bats.

5.3.1 Tree-felling

5.3.1.1 Tree-felling can commence 15 September and continue to 15 March. These months coincide with periods of volant young and hibernation, with the assumption that bats are not hibernating within the site footprint.

5.3.1.1.1 If bats are present, felling should not occur 15 April - 15 September to ensure the protection of maternity colonies and nonvolant juveniles.

54.3.1.1.2 Tree removal activities within 5 miles of a known or suspected hibernaculum can occur between 15 November and 15 March and between 15 September and 15 March within 10 miles of the hibernaculum (USFWS 2007).

5.3.1.2 Immediately prior to felling, trees should be examined for presence/absence of bats and/or other bat activity. A bat specialist should comprehensively inspect trees during daylight hours. Bats rarely roost openly, and are most commonly present within tight spaces and crevices; therefore, a borescope or fiberscope may be necessary for definitive presence/absence. The National Roads Authority (2006) further recommends a night time detector survey, which should occur from dusk through dawn to ensure that bats do not re-enter the tree. An inspection "confirms the status of the tree only at the time of inspection and where there is a delay of one day or greater the tree must be re-assessed."

5.3.1.3 If exclusion procedures must be implemented, the bat specialist will provide direction relative to the necessary actions and appropriate time periods.

5.3.1.4 If a roost tree must be felled outside the optimum season, the bat specialist must endeavor to remove any bats to safety. Live bats may be released once all tree-felling has concluded.
5.3.1.5 We encourage the implementation of mitigation measures to compensate for the loss of tree roosts.

6. ***Decontamination Measures for White-Nose Syndrome*** **†**

WNS affects cave hibernating bats throughout eastern North America and adjacent Canada. This fatal disease continues to cause mass mortality and precipitous population declines. Previously common species throughout the northeastern United States are presently at risk of regional extirpation or extinction due to white-nose syndrome. "WNS has led to unprecedented mortality in several species of bats and may threaten more than 15 additional hibernating bat species if it continues across the continent" (Flory et al. 2012).

Pseudogymnoascus destructans (Pd), the causative agent of WNS, thrives at temperatures of 3-15 C and > 90% relative humidity, conditions equivalent to bat hibernacula and bodies of hibernating bats. Pd affects bats by increasing the frequency and duration of arousals from the torpor of hibernation. Throughout the hibernation period, brief arousals to warm (euthermic) body temperatures are normal, but deplete fat stores. Typical arousal episodes span minutes or hours, with more frequent or lengthier arousal periods incurring significant energetic costs. Therefore, atypical arousal patterns due to white-nose syndrome prematurely deplete fat reserves crucial to overwinter survival. Additional WNS information available at http://www.whitenosesyndrome.org

6.1 *Decontamination protocol*
When activities involve close or direct contact with bats, their environments, and/or accompanying equipment and materials, please comply with decontamination protocols. Acceptable treatment options and supplemental information are available from http://www.whitenosesyndrome.org/topics/decontamination.

7. ***Mitigation Measures***

This section provides mitigation measures by which to avoid, minimize and if possible, remedy adverse effects. Where elimination is not possible, measures can be implemented to alleviate the severity of impacts (barriers, plantings). Species differ relative to sensitivity and exploitation (e.g., roost choice, travel corridors, flight heights, foraging strategy) of the landscape. Therefore, any mitigation measures should endeavor to accommodate the species with the most sensitive requirements or conservation status.

7.1 ***Avoidance***

Avoid disturbing sites while bats are present whenever possible. Avoid permanently destroying/altering bat roosts whenever possible. Avoidance of an area, structure, or site with bat presence remains the best mitigation measure for the protection of bats (See Section 5. Appropriate Time Schedules*)*. The significance of the roost may determine the appropriate mitigation measures.

7.2 ***Minimization***

7.2.1 ***Protection of proximate roosting / foraging habitat***

Those species that exploit transportation structures may benefit from proximate tree cavities and natural rock crevices. Therefore, clearance activities within the right-of-way may cause the destruction of secondary roosts and diminish habitat integrity (e.g., loss of foraging areas and structures that compose flyways). "A break, even a few metres long, in the linear structures that form flyways is likely to reduce or prevent access to foraging areas or more remote roosts" (Sétra et al. 2009).

The removal of trees and vegetation decreases the availability and abundance of foraging habitat and provisional roosts for individuals occupying structures, as well as, local bat assemblages that select trees as primary roost sites. Linear landscape features form an important component of the commuting routes for bats, as well as essential foraging sites. Hedgerows and treelines function as "roads," and migration or long-distance flights may be dependent on these discernible landscape features. USFWS (2007) proposes the protection of land via conservation easement or deed restriction to offset the loss of suitable habitat, particularly near waterways / riparian areas (stream corridors). We advocate native tree plantings to create future habitat and travel corridors and restore connectivity and landscape permeability. Additionally, the control of invasive plant species can further create quality habitat.

7.2.1.1 Where trees of importance to bats are situated along the periphery of the construction footprint, the potential of retaining these trees should be outlined in the EIS and discussed with relevant personnel prior to site clearance (National Roads Authority 2005).

7.2.1.2 If possible, retain treelines and vegetation adjacent to watercourses.

7.2.1.3 Confine operational activities on watercourses to one side of the channel to minimize damage to the wildlife corridor

7.2.1.4 Protect and identify (tags, flags, et cetera) trees and shrubs to be retained during operational activities

7.2.1.5 Implement a management scheme where removal of important trees and shrubs are replanted with similar or native species within the same year of activities. To minimize the potential for vehicle collisions, roadside plant species should not attract insects and hence, indirectly bats. Sétra (2009) recommends an approximately 10 m wide strip without woody vegetation on either side of the roadway.

7.2.2 *Vegetation removal*

Bats orient themselves by, and fly parallel to, linear landscape elements; including tall vegetative cover, transition zones (i.e, edge habitat), minor roads and waterways. Bats exploit these linear features to locate and capture prey and to safely commute between roosts and feeding areas. The removal of vegetative cover and tree-line, loss of mature trees and disturbance of wetlands all affect the availability of vertebrate prey and foraging sites for bats. A gap of 10 m or more (> 32') may cause some species to abandon both the commuting route and roosting site.

7.2.3 *Lighting*

Artificial light may affect the activity of some species and tolerance may vary from complete avoidance to no effect. Lighting can modify bats' roosting sites, commuting routes and foraging areas, especially along waterways. Bats commute and forage along dark wildlife corridors (e.g., rivers, canals) and consequently shy away from highly illuminated sections. Therefore, illuminated structures can impede their flight to suitable feeding areas. Lighting along waterways should be avoided at all times. In addition, buffer zones (dark zones) should be included adjacent to waterways. Intensely lit areas may impair bats' vision and cause disorientation; inhibit movements and prevent access to roosts and foraging areas. Bats may abandon a roost that is illuminated or may considerably delay their emergence. This can reduce foraging times (miss peak levels of insect activity, decrease foraging bouts) and thus, body weight, reproduction and winter survivability. Therefore, it is essential that lighting plans for a development site and around known roosts take into consideration the exit points, flight paths and foraging areas for bats and ensure these areas are not illuminated.

Light intolerance can be beneficial to dissuade some species from using customary commuting routes that cross traffic and thus, increase the potential for bat-vehicle collisions. Lights positioned close to identified crossing points can deter bats when placed at 10 m intervals.

7.3 *Compensation Measures*

Where impacts cannot be avoided or lessened, it may be possible to compensate for these impacts or restore some aspect of the natural environment to an approximation of its previous condition (planting of native trees and shrubs to compensate for the loss of hedgerows or woodland, habitat creation in areas adjacent to the road (including wetlands), connecting bridges or passages to help link fragmented habitats).

7.3.1 *Provision of safe crossing structures / points*

Crossing structures are site-specific movement corridors positioned over roadways that bisect important habitat. Green bridges and underpasses benefit European bat species by permitting them to cross roadways close to established commuting points (Sétra 2009). In certain circumstances, these structures offer a solution to allow bat movement from nearby roosts to foraging areas and alternative roosts. To encourage employment of these structures, plantings should direct bats towards the bridge or underpass. Bats instinctively follow these linear elements to crossing points. Planting of linear corridors should happen early in the construction phase and, where possible, should comprise relatively mature plants, both to ensure these are established quickly and, ideally, so that bats discover these routes before project completion. Valuable treelines or vegetation loss during the clearance phase can be detrimental to bat communities. The installation of hedges / shrubs can direct bats to safe crossing points. The time requirement for plants to grow reduces the effectiveness of this measure. Temporary netting or fencing can therefore be installed to avoid gaps. Hop-overs are created by means of tall trees or 6 m high wire netting with dense low vegetation to encourage bats to fly higher (Graphic 2).

Overpasses, when connected to landscape structures, can also direct bats over roadways. The addition of plants along the length of one side, or an opaque windbreak (between 1.5 m and 3 - 4 m) will further enhance this measure (Graphic 3).

Additionally, underpasses with lines of vegetation can encourage bats to employ these structures to cross roadways. Wire netting or a screen can also direct bats to enter the tunnel or fly over traffic. The consensus relative to width is "the wider the passage the more it will be used by bats" (Sétra 2009). A height of 4.5 m and width of 4 - 6 m has been recommended to ensure accessibility for all species. The optimal size for culverts is 3 m, with a minimum of 1.5 m (Graphic 4).

Simple removable overpass structures consist of wires or wire netting stretched horizontally between two masts on either side of the roadway. These may be installed either temporarily, to appraise the suitability of a location before installing more substantial structures or as a permanent mitigation measure (Graphic 5).

7.3.2 *Provision of alternative roosts*

Where sizable roost(s) are lost, alternative structures (bat houses, boxes) can be built to expiate these impacts. The structure should adequately support the displaced colony with respect to roost size (internal dimensions should correspond to target species), thermal value (i.e., traditional wooden bat boxes do not replicate the thermal dynamics of concrete or thick beam timber bridges). This measure should also include suitable boxes to satisfy the general requirements of different bat species present year-round. Alternative roosts may provide critical short-term roosting opportunities and should be employed to complement any mitigation measures to protect roosts. The institution of alternative roosts may reduce the impacts to local bat populations and provide safe roosting sites for colonies where natural sites are not available.

The erection of these roosts should be initiated prior to commencement of operations (site construction / demolition) and must be appropriately sited (adjacent to suitable foraging areas). Boxes should be monitored for acceptance and seasonal occupancy, and those that remain vacant for > 2 years should be relocated. Boxes should be installed on bridges with soffit > 1 m above highest recorded water levels, which permits bats to safely drop into flight from roosts. To improve the effectiveness of alternative roosts, we recommend installation two years prior to project commencement.

To minimize the potential for vehicle fatalities, particularly for bridge roosts over roadways, we alternately recommend the erection of purpose-built structures that are built within the right-of-way.

7.3.3 *Integral roosts*

Numerous states have become environmental stewards, actively engineering or retrofitting transportation structures to accommodate bat colonies. New construction offers an exceptional opportunity to incorporate bat roosts at minimal cost (Keeley and Tuttle 1999). At the conceptual design phase, bat specialists can communicate with and advise engineering contractors on appropriate dimensions to accommodate many different species.

To minimize vehicle fatalities, we recommended that 'integral' roosts not be incorporated into section(s) that will span traffic lanes.

The addition of ancillary, nonfunctional drainage pipes with sealed tops would provide integral roosts with minimal or no vandalism.

Table 1. North American bat species known to occupy highway structures; summarized from Keeley and Tuttle 1999, Hendricks et al. 2004, MacGregor and Kiser 1999, and Kunz and Reynolds 2003.

Species	Susceptible to white-nose syndrome
Antrozous pallidus, pallid bat	
Choeronycteris mexicana, Mexican long-tongued bat [4]	
Corynorhinus rafinesquii, Rafinesque's big-eared bat	
Corynorhinus townsendii, Townsend's big-eared bat [2, 3]	
Eptesicus fuscus, big brown bat	Yes
Lasiurus cinereus, hoary bat	
Lasionycteris noctivagans, silver-haired bat	
Leptonycteris curasoae, lesser long-nosed bat [3, 4]	
Macrotus californicus, California leaf-nosed bat	
Myotis austroriparius, southeastern myotis	
Myotis californicus, California myotis	
Myotis ciliolabrum, western small-footed myotis	
Myotis evotis, long-eared myotis	
Myotis grisescens, gray myotis [3, 4]	Yes
Myotis leibii, eastern small-footed myotis [1]	Yes
Myotis lucifugus, *M. l. occultus*; little brown myotis, Arizona myotis	Yes
Myotis septentrionalis, northern myotis [1]	Yes
Myotis sodalis, Indiana bat [3, 4]	Yes
Myotis thysanodes, fringed myotis [2]	
Myotis velifer, cave myotis	
Myotis volans, long-legged myotis	
Myotis yumanensis, Yuma myotis	
Nycticeius humeralis, evening bat	
Nyctinomops macrotis, big free-tailed bat [2]	
Perimyotis subflavus (formerly *Pipistrellus subflavus*), tri-colored bat	Yes
Pipistrellus hesperus, western pipistrelle	
Tadarida brasiliensis, Mexican free-tailed bat	

[1] Center for Biological Diversity petition to list, Endangered Species Act

[2] Bureau of Land Management Sensitive Species

[3] US Fish & Wildlife Endangered Species

[4] IUCN Red List, threatened, endangered, or vulnerable species <http://www.iucnredlist.org/>

Table 2. North American bat species that have the potential to occupy highway structures; summarized from Keeley and Tuttle 1999

Species	Susceptible to white-nose syndrome
Corynorhinus townsendii virginianus, Virginia big-eared bat [3]	
Corynorhinus townsendii ingens, Ozark big-eared bat [3]	
Euderma maculatum, spotted bat [2]	
Idionycteris phyllotis, Allen's lappet-browed bat [2]	
Leptonycteris nivalis, Mexican long-nosed bat [3, 4]	
Mormoops megalophylla, Peter's ghost-faced bat	
Myotis auriculus, southwestern myotis	
Myotis keenii, Keen's myotis	
Eumops glaucinus, Wagner's bonneted bat	
Eumops perotis, western mastiff bat	
Eumops underwoodii, Underwood's mastiff bat	
Molossus molossus, Pallas' mastiff bat	
Nyctinomops femorosaccus, pocketed free-tailed bat	

[1] Center for Biological Diversity petition to list, Endangered Species Act
[2] Bureau of Land Management Sensitive Species
[3] US Fish & Wildlife Endangered Species
[4] IUCN Red List, threatened, endangered, or vulnerable species <http://www.iucnredlist.org/>

Image Gallery 1. Typical indicators of bat presence

Guano accumulation below roosts (between box beams)

Guano accumulation below roosts (midline expansion joint)

Urine crystallization on edge of roost

Image Gallery 2. Photographs of common roosts

Myotis spp. day roosting on open beam

Myotis spp. day roosting within clogged drainage pipe

Tadarida brasiliensis (Mexican free-tailed bats) maternity colony with pups in expansion joint

Myotis spp. colony roosting in timber bridge between double beams

Myotis yumanensis exploiting concrete spall

Myotis spp. maternity colony with pups in expansion joint

Migrating *Tadarida brasiliensis* colony using bridge as transient roost site

Corynorhinus townsendii, using metal culvert as day roost

Lasionycteris noctivagans using culvert as day roost

Culvert drainage pipe serves as day roost for *Myotis* spp.

Myotis spp. colony using box culvert as day roost

Image Gallery 3. Photographs of uncommon and potentially overlooked roost sites

Drainage pipe roost

Bats roosting within ‘bolt cavity’ in insulated pipe

Myotis spp. roosting in void creating by concrete spall

Myotis spp. roosting in void creating by concrete spall

6.35 mm diameter roost opening

Bat prostrate in wasp's nest

Bats roosting inside intact swallow nests

Bats roosting in pipe collar

Bats roosting behind blue insulation board

Although urine staining is noticeable, a cursory view of a metal-clad concrete bridge would be deemed unusable with no further inspection

Bats roosting between beams and deck

Individual bat behind timber guardrail

Bats roosting between pier and deck

Foam sealant was used to exclude bats from obvious roost locations (between parallel beams). However incomplete exclusion attempts allows the potential for occupancy (please see photos below)

Foam did not completely fill the crevice between parallel beams, which still provides amenable roosting space for individual bats (particularly important for T&E species, whereby single bats are of high conservation value)

Although exclusion was "completed," (left and above), this roosting location (maternity colony roosting in space between road deck and timber beams) was overlooked

Left: Banded Myotis leibii roosting between adjacent concrete parapets / guardrails
Photograph by Blake Sasse

Below: View of parapet roost location
Photograph by Blake Sasse

Image Gallery 4. Potential risks of conducting bridge works without determining bat presence/absence

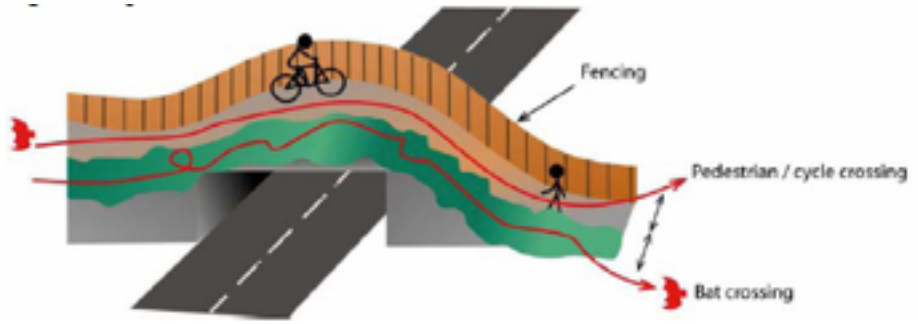
Tar seeping through parallel beams while bats were present

Above and below; consequence of tarring during hibernation period (*T. brasiliensis* colony).

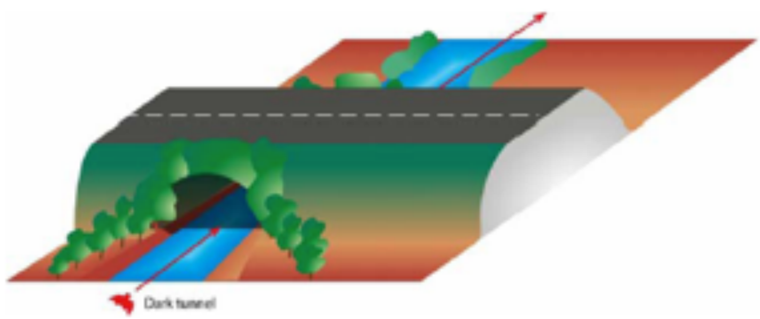
Bridge workers replacing elastomeric seal directly above bat roosts. Such maintenance activities should occur when bats are absent to prevent abandonment of roost and/or young.

Chart 1. Chart for appropriate activity timetables relative to life cycle. Red indicates 'Stop,' period when bats are exceptionally vulnerable to disturbance. Yellow represents "Caution," bats may be vulnerable depending on species and their location within the US. Green indicates "Go," period when bats should not be present and therefore, not impacted by activities.

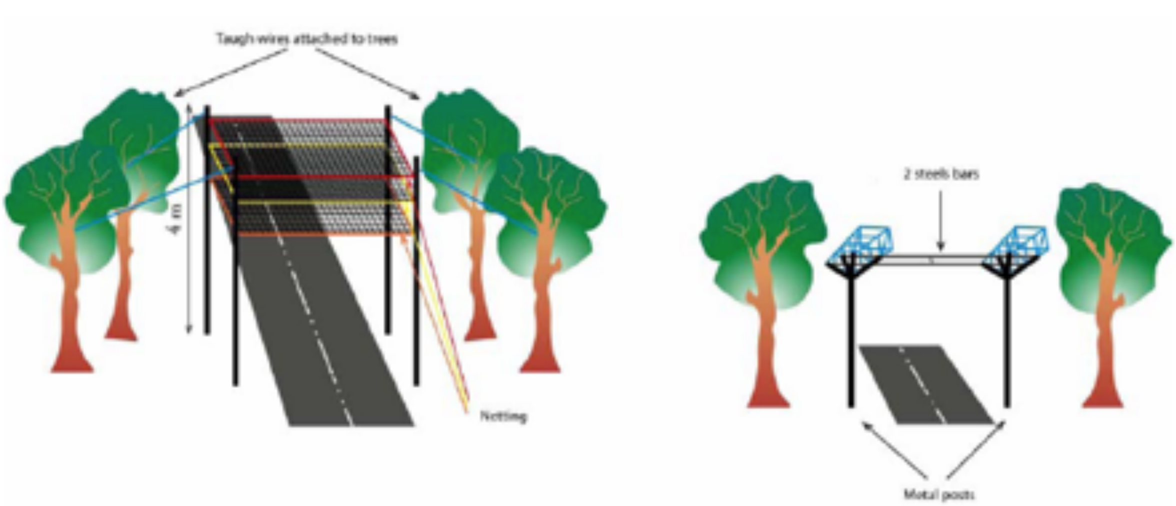
† The 'Go' phase may require a standard survey to confirm absence. Due to the unpredictability of winter activity, bats may be present and/or hibernating.



Graphic 3. Overpass design features that encourage bats (Sétra et al. 2009).



Graphic 4. Vegetation positioned at entrance to encourage bats to fly through the structure (Sétra et al. 2009).



Graphic 5. Temporary overpass structures (Sétra et al. 2009).

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