



IN REPLY REFER TO:

United States Department of the Interior  
FISH AND WILDLIFE SERVICE  
East Lansing Field Office (ES)  
2651 Coolidge Road, Suite 101  
East Lansing, Michigan 48823-6316

August 22, 2016

Mr. Patrick Marchman  
Environment and Realty Program Manager  
U.S. Department of Transportation Federal Highway Administration  
315 W. Allegan Street, Room 201  
Lansing, Michigan 48933

Subject: Biological Opinion for the I-196 Pier Extension project in the Grand River, Grand Rapids, Kent County, Michigan, Log No. 16-R3-ELFO-04.

Dear Mr. Marchman:

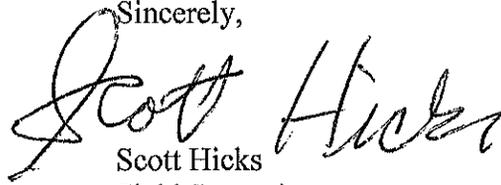
Pursuant to section 7 of the Endangered Species Act of 1973, as amended (16 U.S.C., 1531 *et seq.*) (Act), this document transmits the U.S. Fish and Wildlife Service's (Service) biological opinion (Opinion) for the Federal Highway Administration (FHWA) I-196 Pier Extension project in the Grand River, Grand Rapids, Kent County, Michigan, on snuffbox (*Epioblasma triquetra*). This project is being supported with federal funding through the FHWA while being developed by the Michigan Department of Transportation (MDOT). We received your request for formal consultation on May 19, 2016.

We base this Opinion on information provided in the Biological Assessment (BA) for the I-196 Pier Extension project in the Grand River, as well as telephone conversations and email correspondence with the MDOT and Michigan Department of Natural Resources Fisheries Division, and published literature. A complete administrative record of this consultation is on file at the Service's East Lansing Field Office.

With respect to compliance with the Act, all aspects of the project description are binding. Reasonable and prudent measures and the accompanying Terms and Conditions provided within the enclosed biological opinion are nondiscretionary, and are designed to minimize incidental take of listed species. In addition, FHWA must provide the Service with any new information that becomes available on the effects of the action on listed species or critical habitat in a manner or to an extent not considered in this opinion, as this may require reinitiation of consultation.

We look forward to future cooperation with FHWA to conserve our Nation's threatened and endangered species. If you have any questions, please contact Jessica Pruden of this office at 517-351-8245.

Sincerely,

A handwritten signature in cursive script that reads "Scott Hicks". The signature is written in black ink and is positioned above the printed name and title.

Scott Hicks  
Field Supervisor

cc: Scott Hanshue, Michigan DNR  
Jeff Gabarkiewicz, MDOT

# BIOLOGICAL OPINION

Effects to the Snuffbox Mussel  
from the proposed  
I-196 Pier Extension Project in the Grand River  
Grand Rapids, Kent County  
Michigan,

Prepared for:  
U.S. Department of Transportation  
Federal Highway Administration  
315 W. Allegan Street  
Lansing, Michigan 48933

Prepared by:  
U.S. Fish and Wildlife Service  
East Lansing Field Office,  
East Lansing, Michigan 48823

Log # 16-R3-ELFO-04

## Introduction

This document transmits the U.S. Fish and Wildlife Service's (Service) biological opinion (Opinion) on the effects of the Federal Highway Administration (FHWA) I-196 Pier Extension Project in the Grand River, Grand Rapids, Kent County, Michigan on snuffbox (*Epioblasma triquetra*), in accordance with section 7 of the Endangered Species Act (Act) of 1973, as amended (16 U.S.C., 1531 et seq.). This project is being supported with federal funding through the FHWA while being developed by the Michigan Department of Transportation (MDOT). We received your request for formal consultation on May 19, 2016.

We base this Opinion on information provided in the Biological Assessment (BA) for the I-196 Pier Extension project in the Grand River, as well as telephone conversations and email correspondences with the MDOT and Michigan Department of Natural Resources (MDNR) Fisheries Division, and published literature. A complete administrative record of this consultation is on file at the Service's East Lansing Field Office (ELFO).

## Consultation History

- On December 13, 2005, the Service provided written comments on the programmatic Environmental Assessment (11/4/2005) for the I-196 Pier Extension project.
- On August 29, 2012, staff from Michigan Department of Environmental Quality (MDEQ), URS Corporation, and MDOT met to discuss the project, snuffbox mussel survey results, and fishery impacts.
- On July 21, 2015, biologists from the Service and MDNR, as well as staff from MDEQ, MDOT, and consultants met to discuss the project, freshwater mussels, and fishery issues.
- On January 15, 2016, the Service and MDOT met to discuss the consultation process for the proposed project.
- On January 27, 2016, the Service, MDOT, and River Restoration, discussed the Grand Rapids Revitalization Project, Grand Rapids, Michigan.
- On February 23, 2016, the Service and MDOT met to discuss the project.
- On March 18, 2016, MDOT and the Service met to discuss the proposed project, mussel survey area, and proposed mussel relocation areas.
- On April 6, 2016, MDOT submitted a draft BA to ELFO.
- On May 3, 2016, the Service, MDNR, and MDOT participated in a conference call to discuss potential mussel relocation areas in the Grand River and some of the tributaries.
- On May 10, 2016, MDOT provided a second draft BA to ELFO.

- On May 19, 2016, FHWA provided the Final BA to ELFO and requested initiation of formal consultation.
- On May 25, 2016, ELFO sent FHWA a letter indicating that all information required to initiate consultation was received.
- On July 25, 2016, ELFO sent the Draft Opinion to MDOT for their review.

## BIOLOGICAL OPINION

### Description of the Proposed Action

#### Action Area

I-196 crosses the Grand River in Grand Rapids, Kent County, Michigan. The Grand River is approximately 155 meters wide at the project location. The proposed project encompasses the streambed beneath both westbound and eastbound I-196 as well as 45 meters upstream and 35 meters downstream of I-196.

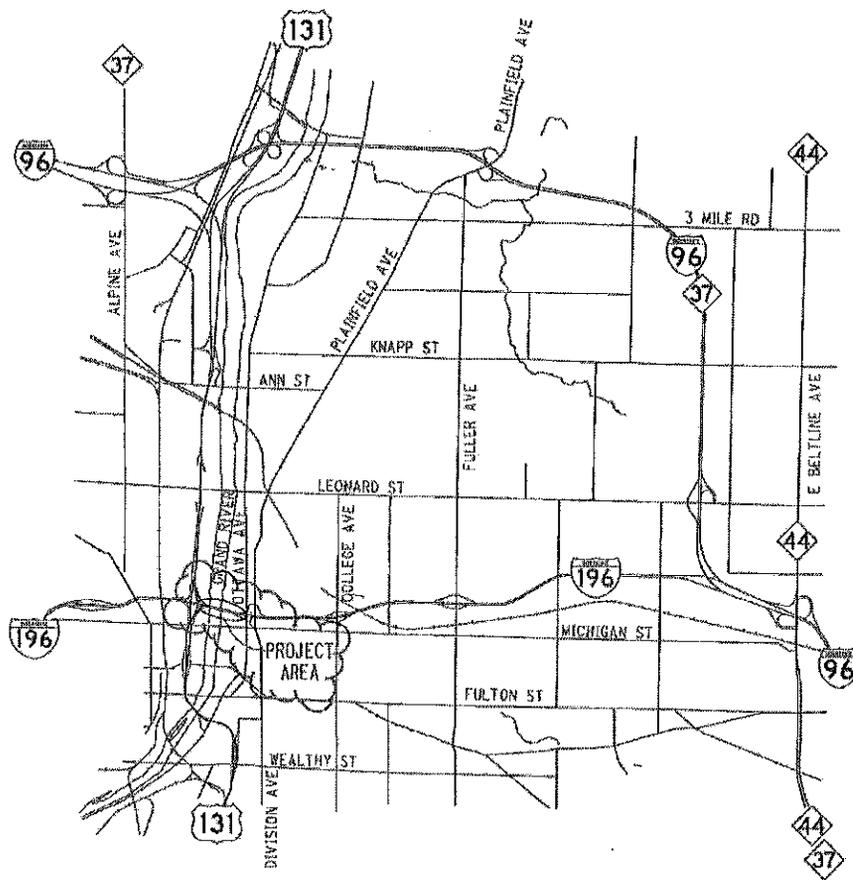


Figure 1. Vicinity map of the project area showing the I-196 bridge, Grand River, and Grand Rapids Metropolitan Area (Source: The FHWA BA for the I-196 Pier Extension in the Grand River)

### Project Description

Federal funding through the FHWA is being provided to the MDOT to complete the I-196 Pier Extension project. The proposed project will widen the westbound I-196 structure extending the median lane across the structure and upgrade the shoulder widths in accordance with American Association of State Highway and Transportation Officials standards. The expansion will improve the flow of traffic across the structure and increase the safety of the traveling public.

To complete the pier extension, temporary causeways (i.e. east and west causeway) and coffer dams will be constructed. The causeways will be staged over a one year period to ensure that half of the river is open for fish migration (Table 1). The maximum timeline is January 4, 2017, to August 15, 2018. This would allow the contractor to remove the west causeway during low water minimizing water quality impacts during removal. The pier extension and excavation area is approximately 150 m<sup>2</sup>. The construction of the east and west causeways temporarily encompasses in total approximately 10, 664 m<sup>2</sup> of streambed.

The construction sequence for the pier extension will begin with the construction of the east causeway, which requires the placement of heavy rip rap upstream of eastbound I-196. A turbidity curtain will then be installed adjacent to and just upstream of the 1<sup>st</sup> heavy rip rap line. The turbidity curtain will then be placed parallel to river flow followed by a second line of heavy rip rap parallel to river flow from the upstream to downstream end. The last turbidity curtain will then be placed on the downstream side perpendicular to river flow followed by the last line of heavy rip rap on the downstream side. After the heavy rip rap and turbidity curtain are installed, well graded rip rap and clean washed 21AA will be added to bring the causeway up to grade. The top width of the causeway will be 8.5 m, side slopes at 1:2, and highest proposed top elevation of 604 ft well below the 100 year flood elevation of 611.3 ft. This process will require two to four weeks. This sequence should help encapsulate the causeway construction area prior to the addition of finer aggregate. Upon installation of the temporary causeway, coffer dams will be installed around the pier excavation areas. Due to the presence of shallow bedrock, the sheeting may have to be braced inside the causeways. All activity within the cofferdams will be isolated from the Grand River.

Table 1. Construction Sequence Scenarios

<p><b><u>Scenario 1: Start prior to March 1st, 2017 and remove east causeway after June 30th, 2017</u></b></p>	<p><b><u>Scenario 2: Start prior after June 30th, 2017</u></b></p>	<p><b><u>Scenario 3: Start Prior to March 1st and remove east causeway by March 1st, 2017. With help of a possible accelerated award and early start date.</u></b></p>
<p>1. January 4, 2017 – February 10, 2017 East Causeway – Install rip rap and stone</p>	<p>1. July 1, 2017 – July 26, 2017 East Causeway - Install rip rap and stone</p>	<p>1. December 16, 2016 – December 30, 2016 East Causeway – Install rip rap and stone (double shifting and perfect weather and river conditions)</p>
<p>2. February 11, 2017 – June 30, 2017 – Work bridge piers 18 and 19</p>	<p>2. July 27, 2017 – September 15, 2017 - Work bridge piers 18 and 19</p>	<p>2. December 31, 2016 – February 9, 2017 – Work bridge piers 18 and 19</p>
<p>3. July 1, 2017 – July 20, 2017 East Causeway – Remove rip rap and stone</p>	<p>3. Sept 16, 2017 – Sept 30, 2017 East Causeway – Remove rip rap and stone</p>	<p>3. February 10, 2017 – February 28, 2017 East Causeway – Remove rip rap and stone (double shifting)</p>
<p>4. July 21, 2017 – August 8, 2017 West Causeway – Install rip rap and stone</p>	<p>4. October 1, 2017 – October 19, 2017 West Causeway – Install rip rap and stone</p>	<p>4. July 1, 2017 – July 19, 2017 West Causeway – Install rip rap and stone</p>
<p>5. August 9, 2017 – September 25, 2017 – Work bridge piers 15, 16, and 17</p>	<p>5. October 20, 2017 – December 6, 2017 – Work bridge piers 15, 16, and 17</p>	<p>5. July 20, 2017 – September 5, 2017 – Work bridge piers 15, 16, and 17</p>
<p>6. September 26, 2017 – October 14, 2017 West Causeway – Remove rip rap and stone</p>	<p>6. December 7, 2017 – December 21, 2017 West Causeway – Remove rip rap and stone</p>	<p>6. September 6, 2017 – September 20, 2017 West Causeway – Remove rip rap and stone</p>

### Conservation Measures

Conservation measures are part of the proposed action; therefore, we consider them in the analysis of effects. The BA includes the following conservation measures:

1. Stage the access road installation over a one year period, leaving half the river open for fisheries migration each year. This should benefit the movement of host fish for snuffbox.
2. Work will not be conducted in the water between the dates of March 1<sup>st</sup> and June 30<sup>th</sup>. This should be protective of host fish for snuffbox such as log perch that spawn in late spring.
3. Sequence the construction and removal of the temporary causeway to minimize the suspension and entrainment of fine sediments to the maximum extent practicable.
4. Require the use of clean washed aggregate to limit the potential for the suspension and downstream deposition of fine particles.
5. Turbidity curtains will be used to help control the movement of fine sediment.
6. Provide containment for the pier work that will isolate the excavation and construction from the river.
7. Require the disposal of all excavated material outside of the river (i.e., no sidecasting into the river).
8. Relocate snuffbox to a previously identified site upstream of the MDOT project area. All snuffbox will be measured and tagged with a Passive Integrated Transponder (PIT) prior to relocation. Mussels will be transported to the relocation site in an aerated, thermally insulated cooler. Time in the cooler will be minimized to the maximum extent practicable.
9. One or two monitoring events of the relocated mussels will be conducted to document survivorship and growth.

### **Status of the Species**

#### Species Description

The snuffbox is a small to medium-sized mussel, with males reaching up to 2.8 in (7.0 cm) in length and females up to 1.8 in (4.5 cm) (Parmalee and Bogan 1998). The periostracum (external shell surface) is generally smooth and yellowish or yellowish-green in young individuals, becoming darker with age. Green, squarish, triangular, or chevron-shaped marks cover the umbo (the inflated area of the shell along the dorsal margin), but become poorly delineated stripes with age. The shape of the shell is somewhat triangular in females and oblong or ovate in males, with the valves solid, thick, and very inflated. The beaks, located somewhat anterior of the middle, are swollen, turned forward and inward, and extend above the hinge line (Cummings and Mayer 1992). Beak sculpture consists of three or four faint, double-looped bars (Cummings and Mayer

1992, Parmalee and Bogan 1998). The anterior end of the shell is rounded, and the posterior end is truncated, highly so in females. The posterior ridge is prominent, being high and rounded, while the posterior slope is widely flattened. The posterior ridge and slope in females is covered with fine ridges and grooves, and the posteroventral shell edge is finely toothed (Cummings and Meyer 1992). The ventral margin is slightly rounded in males and nearly straight in females. Females have recurved denticles (downward curved tooth-like structures) on the posterior shell margin that aid in holding host fish (Barnhart *et al.* 2008).

### Life History

The snuffbox is found in small to medium-sized creeks to large rivers. It occurs in swift currents of riffles and shoals over gravel and sand with occasional cobble and boulders. Individuals generally burrow deep into the substrate, except when spawning or attempting to attract a host (Parmalee and Bogan 1998).

Adults are suspension-feeders, spending their entire lives partially or completely buried within the substrate (Murray and Leonard 1962). Adults feed on algae, bacteria, detritus, microscopic animals, and dissolved organic material (Christian *et al.* 2004, Nichols and Garling 2000, Silverman *et al.* 1997, Strayer *et al.* 2004). Juvenile mussels utilize foot (pedal) feeding, consuming algae and detritus.

Age at sexual maturity in snuffbox is unknown. Males release sperm into the water. The sperm enter the female through the incurrent siphon tube, and the eggs are fertilized internally (Cummings and Meyer 1992). Fertilization success is influenced by mussel density and flow conditions.

Like other unionids, the snuffbox's life cycle includes a brief, obligatory parasitic stage on fish. Eggs develop into microscopic larvae, called glochidia, within special gill chambers (marsupia) of the female mussel. The female expels the mature glochidia, which must attach to the gills or the fins of an appropriate fish host to complete development. Following successful infestation, glochidia encyst (enclose in a cyst-like structure) and drop off as newly transformed juveniles.

To attract a host fish, a female snuffbox gapes its valves open. When a fish investigates and touches the mussel's exposed mantle, the mussel's valves snap shut, clamping down on the fish. The female snuffbox then releases glochidia directly onto the fish (Barnhart *et al.* 2008). Although snuffbox have successfully transformed on blackside darter (*P. maculata*), Iowa darter (*E. exile*), blackspotted topminnow (*Fundulus olivaceus*), banded sculpin (*C. carolinae*), Ozark sculpin (*C. hypselurus*), largemouth bass (*Micropterus salmoides*), and brook stickleback (*Culaea inconstans*) in laboratory tests (Barnhart 1998; Barnhart *et al.* 1998; Caldwell 2013; Hillegass and Hove 1997; Hove *et al.* 2000; McNichols and Mackie 2002, 2003, 2004; Sherman 1993, 1994; Mulcrone 2004; Yeager 1986; Yeager and Saylor 1995), the logperch (*Percina caprodes*) is likely the obligate host for snuffbox due to the mussel's trapping behavior that can kill other fish (Barnhart *et al.* 2008).

The snuffbox is a long-term brooder. Spawning typically occurs in late summer (late July – August); the female snuffbox then broods the developing glochidia in the marsupia over the winter and releases the glochidia the following May. Sherman (1994) documented glochidial

release beginning in mid-May, peaking in mid-June, and ending by mid-July although Caldwell (2016) found gravid females from June through October.

### Population Dynamics

The snuffbox now occurs in only 79 streams, representing a 62 percent decline in occupied streams. Because multiple streams may comprise a single snuffbox population, the actual number of extant populations is fewer than 79 (USFWS 2012). Extant populations, with few exceptions, are highly fragmented and restricted to short reaches. Of the 79 streams, 25 (32%) are considered to harbor extant populations represented by only one or two recent live or fresh dead individuals.

Butler (2007) categorized the extant populations into three groups based on population size, general distribution, evidence of recent recruitment, and assessment of current viability. Stronghold populations were identified as having sizable populations generally distributed over a significant and more or less contiguous length of stream [30 or more river miles (48 or more river km)], with ample evidence of recent recruitment, and currently considered viable. Significant populations were defined as small, generally restricted populations with limited recent recruitment and viability. Many significant populations are susceptible to extirpation, but this category has a broad range of quality. Marginal populations were described as very small and highly restricted populations, with no evidence of recent recruitment and of questionable viability. At the time of listing, there were 7 stronghold populations, 24 significant populations, and 48 marginal populations of snuffbox (USFWS 2012).

### Status and Distribution

Snuffbox was historically widespread, existing in 210 streams and lakes in 18 states and Ontario, Canada. Extant populations have been reduced to 79 streams in 14 states and one Canadian province within the upper and lower Great Lakes sub-basins, upper and lower Mississippi River sub-basins, lower Missouri River system, Ohio River basin, and White River system (USFWS 2012). This represents a 62 percent decline in occupied streams. However, realistically, much more than 62 percent of the habitat historically available for this species no longer supports its populations. Habitat losses measured in the thousands of miles have occurred range-wide (USFWS 2012).

The elimination of this species from scores of streams and thousands of miles of stream reaches indicates significant population losses and a precipitous decline in overall abundance. It is reasonable to estimate that total range reduction and overall population losses for the snuffbox each approximate, if not exceed, 90 percent. The snuffbox was listed as endangered on February 14, 2012 (77 FR 8632). Critical habitat has not been designated for this species.

The decline of the snuffbox is primarily the result of habitat loss and degradation (Neves 1991). Chief among the causes of habitat loss are impoundments, channelization, chemical contaminants, mining, and sedimentation (USFWS 2012). The majority of the remaining populations of the snuffbox is generally small and geographically isolated (Butler 2007). The patchy distributional pattern of populations in short river reaches makes those populations much more susceptible to extirpation from single catastrophic events, such as toxic chemical spills.

Furthermore, this level of isolation makes natural repopulation of any extirpated population virtually impossible without human intervention.

### Analysis of the Species Likely to Be Affected

This Opinion considers adverse effects to the snuffbox as a result of the proposed action. No critical habitat has been designated or proposed for this species. No other federally listed species are found within the action area.

## **Environmental Baseline**

### Status of the Species within the Action Area

Butler (2007) categorized the population of snuffbox in Grand River as “significant,” meaning the population is small and generally restricted with limited recent recruitment and viability. The snuffbox mussel is found throughout the Grand River and the Flat and Maple rivers, which are tributaries to the Grand (D. Woolnough, Central Michigan University, pers. comm. 2016). The population in the Grand River appears to be viable, with recruitment noted (USFWS 2012; Woolnough and Barnett 2013).

Mussel surveys were conducted within the action area during the summer of 2013 and 2014 (Cardno JF New and Associates, Inc. 2013 and 2014). In 2013 semi-quantitative visual surveys were only completed between the right downstream bank and the first pier. During the 2013 sampling effort within 15 person hours of visual sampling with a five-person team, samplers encountered snuffbox and discontinued semi-quantitative sampling. During the 2014 sampling effort, semi-quantitative visual surveys were completed in five additional areas. This semi-quantitative visual sampling effort covered a substantially greater area than 2013, but still did not cover the entire survey area. Quantitative surveys (i.e., quadrat excavation along transects) were conducted throughout the entire survey area. Typically, species richness curves are developed to confirm sampling effort adequately represents the number of species present at the project site. However, no species richness curves are available for the survey area. The survey area was determined by the area of direct impact plus upstream and downstream buffers (calculated to be 80 m by 150 m). However, after discussions in 2015 and 2016 between MDOT and the Service, it was determined that the original buffers are not adequate. MDOT and the Service agreed to increase both the upstream and downstream buffers to 15 m and 35 m respectively. The quantitative survey area thus represents a subset of the action area (Cardno JF New and Associates, Inc. 2013 and 2014).

The BA describes the extant mussel community present within this section of the Grand River as diverse and patchily distributed. Four hundred and eighty quadrat samples (.25 m<sup>2</sup>) were excavated within the sampling area over a two year period (Figure 2). A total of 15 live species have been identified at the I-196 site, with an additional two species found 0.85 miles upstream at Leonard Street (Kogge 2013; Richardson 2014a; Richardson 2014b). One snuffbox was found during quadrat sampling for an estimated density of .008 snuffbox/m<sup>2</sup>. The approach described in the BA to estimate the total population of snuffbox in the action area assumes snuffbox are randomly distributed. Based on survey data and the described assumption, 150 total snuffbox could potentially be found in the action area. The BA describes the level of uncertainty associated with this number as high and predicted by statistical theory given the low spatial

coverage (approximately 0.5%) and low population density. To inform this estimate, visual search data was examined. During 2013-2014 approximately 1,200 person-minutes were spent searching the project area and one snuffbox was found. Assuming a search efficiency of  $0.5\text{m}^2/\text{minute}$ , a density of  $0.002\text{ snuffbox}/\text{m}^2$  is calculated. As a result, assuming random distribution of snuffbox, an estimate of 37 total snuffbox could be found within the action area. Considering the range of estimated snuffbox densities calculated based on semi-quantitative and quantitative survey effort, between 37 and 150 snuffbox could be found within the action area.

State listed species include Black Sandshell (*Ligumia recta*) and Purple Wartyback (*Cyclonaias tuberculata*), with state species of concern Deertoe (*Truncilla truncata*) present as well. While diverse, most of the populations found during MDOT surveys were not particularly dense. This may be attributable to patchy habitat or any number of factors that may be affecting mussels within this reach. The substrate within the action area is heterogeneous comprised mostly of mixed sand and gravel, cobble, boulder, and exposed bedrock with very little vascular aquatic vegetation or large woody debris.

The Grand River supports a diverse fish community, including a number of confirmed hosts of snuffbox. Recent DNR sampling has documented a total of 37 species through this reach of the Grand River in downtown Grand Rapids. This fauna was dominated by Sand Shiner (*Notropis stramineus*) (28.2%), Shorthead Redhorse (*Moxostoma macrolepidotum*) (20.1%), and Rosyface Shiner (*Notropis rubellus*) (15.2%). Confirmed hosts of snuffbox made up 2.9% of the total catch by number, including Logperch (*P. caprodes*), Blackside Darter (*P. maculata*), and Largemouth Bass (*M. salmoides*). Although survey efforts associated with this project did not include fish species, logperch were documented in the action area during a 2014 MDNR fisheries survey (S. Hanshue, MDNR, pers. comm. 2015 in BA for the I-196 Pier Extension project in the Grand River, 2016).

The proposed relocation area is in Lowell, Michigan, 17 miles east (28 river miles upstream) of the I-196 project location (Figure 3). The proposed relocation site was first surveyed by the Michigan Natural Features Inventory (MNFI) in 2002 (Badra and Goforth 2003). The MNFI data points (D5 and D6 in Figure 3) are approximate and based on Badra and Goforth (2003). The location is at the confluence of the Grand and Flat River. Badra and Goforth (2003) documented 14 live snuffbox and most of the common species that were found at the I-196 bridge. The total density of mussels did not exceed  $1/\text{m}^2$ , with snuffbox estimated at  $.1/\text{m}^2$ . The MDNR documented 36 species from the Lowell area, including potential snuffbox fish hosts such as logperch, blackside darter, and largemouth bass. During these fishery assessments, logperch were particularly abundant representing 7.8% of the total catch by number. The substrate in the relocation area is 25% sand, 25% gravel, 40% pebble, and 10% cobble (Badra and Goforth 2003).

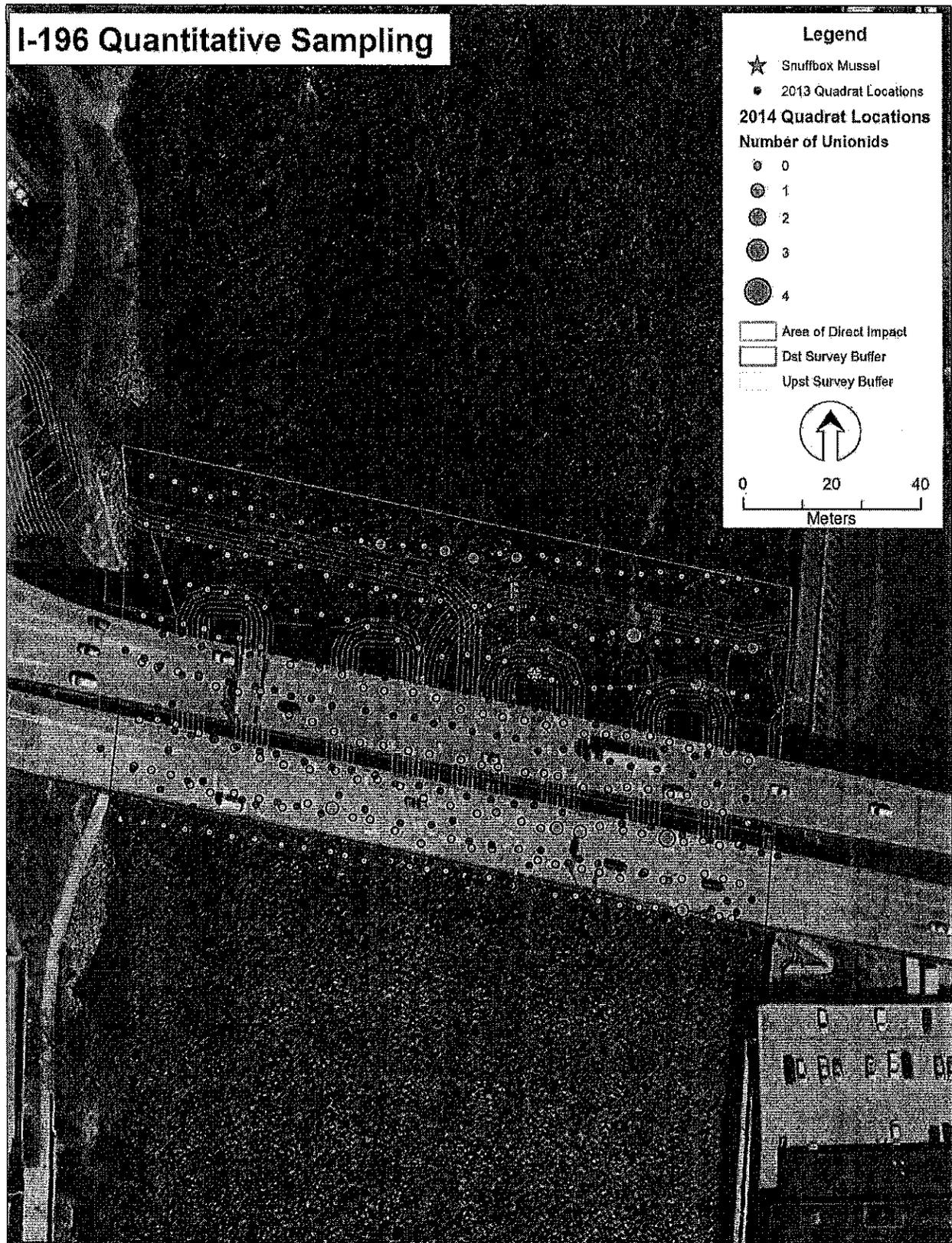


Figure 2. The 2014 quantitative sampling results showing the location of *E. triquetra* and graduated circles indicating the relative abundances of mussels per quadrat. (Source: The FHWA BA for the I-196 Pier Extension in the Grand River)



Figure 3. Aerial and locality map showing the approximate location of the proposed relocation site. (Source: The FHWA BA for the I-196 Pier Extension in the Grand River)

Factors Affecting the Species Environment within the Action Area

The Grand River at the project location is approximately 155m wide with depths measuring .1m to 1.5 m during typical late summer flows. Visibility is 1 m under optimal conditions. This area of the Grand River is large and flowing, but interrupted by a series of dams. The project is located approximately 200 m downstream of the 6<sup>th</sup> Street Dam and upstream of a low rise dam that is approximately 202 m downstream. As such, these two dams act as hydraulic control

points within this reach of the river. Sediment transport is also affected by the 6<sup>th</sup> Street dam, which likely traps larger particles changing the distribution of the substrate over time.

Water quality and habitat in the Grand River historically was impacted by combined sewer overflows, sanitary sewer overflows, industrial point discharge, dams, urban runoff, and agricultural runoff. Some of these sources of pollution have been eliminated such as combined sewer overflows in the City of Grand Rapids. However, the Lowell and Kent wastewater treatment plants still pose an ongoing threat to snuffbox and the mussel community as a whole in the action area. Both of these facilities have ammonia limits and freshwater mussel early life stages are particularly susceptible to ammonia (Grabarkiewicz and Davis 2008). Gillis (2012) determined that mussels exposed to urban runoff and wastewater treatment facilities have a lower condition factor and do not live as long as mussels located upstream of highly urban areas.

### **Effects of the Action**

Effects of the action refer to direct and indirect effects of an action on the species, together with the effects of other activities that are interrelated and interdependent with that action that will be added to the environmental baseline. 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. Indirect effects are those that are caused by the proposed action and are later in time, but are still reasonably certain to occur.

#### Effects of the Action on Snuffbox

As previously described the entire action area was not surveyed. The survey area represents a subset of the action area approximately 80 m by 150 m. After discussions in 2015 and 2016 between MDOT and the Service, it was determined that the original buffers were not adequate thus the upstream and downstream buffers were increased to 15 m and 35 m respectively. The action area where direct and indirect effects will occur is approximately 95 m by 150 m. The mussel data compiled for the survey area is likely representative of the entire action area given similarities between the survey and action area with respect to substrate, flow, and host fish community.

To minimize impacts, snuffbox will be relocated from the area of direct and indirect effect areas prior to commencement of any construction activities. Relocation will occur from August through September. Relocation of mussels may cause stress and disruption of normal behavior patterns, including spawning and fertilization.

One snuffbox was found during quadrat sampling in the survey area. This snuffbox was found within the area of direct impact. The BA calculates the area of direct impact to be 10,814 m<sup>2</sup>. Based on estimated density ranging from .002-.008 snuffbox/ m<sup>2</sup> in the survey area, the BA estimates that the population size within the area of direct impact likely ranges between 22 and 87 individuals. Given that the density of .008 snuffbox/ m<sup>2</sup> is based on quantitative survey effort, the Service and MDOT have agreed that it likely is most representative of the predicted density of snuffbox across the area of direct impact (J. Grabarkiewicz, MDOT, pers. comm. 2016). Based on these factors, 87 snuffbox are estimated to occur within the area of direct impact.

Finding and relocating all of the mussels is highly unlikely. Mussels may be overlooked, especially juvenile mussels and any mussels that have burrowed into the substrate may not be found. Assuming an 80 percent detection rate (D. Woolnough, Central Michigan University, pers. comm. 2015 in USFWS Biological Opinion for the Removal of Lyons Dam, August 17, 2015), 70 snuffbox will be relocated from the area of direct impact to the Lowell relocation site.

Those mussels remaining in the construction zones in the area of direct impact (i.e., snuffbox that could not be detected during relocation activities) will experience harm or mortality from crushing, suffocation, or desiccation. Mussels could be crushed, smothered, or removed during installation of the causeways as well as excavation around the piers. Mussels may also suffer mortality due to desiccation when cofferdam areas are dewatered. After relocation of mussels, we estimate 17 snuffbox will remain in the construction zones. These mussels will likely be lost from the population due to construction activities.

Mussels outside of the area of direct impact, but within adjacent areas extending 15 m upstream and 35 m downstream will be indirectly affected by construction activities. The total area where indirect effects are likely is 8,092 m<sup>2</sup>. Based on the density of .008 snuffbox/ m<sup>2</sup> 65 snuffbox are estimated to occur in this area. Given the 80% detection rate (D. Woolnough, Central Michigan University, pers. comm. 2015 in USFWS Biological Opinion for the Removal of Lyons Dam, August 17, 2015), 52 snuffbox will be relocated from the area where indirect effects are likely to occur to the Lowell relocation site.

Mussels that are undetected during relocation and remain in the area will suffer harm and harassment due to interference with normal respiration, feeding, and reproduction. These effects are likely to occur as a result of construction activities that have the potential to increase sedimentation and channel shear stress, as well as chemical exposure. Haul road aggregate and stream bed substrate may be sources of fine sediment that are suspended and entrained during causeway construction, maintenance, and removal activities. An increase in the level of suspended sediments may negatively impact mussels by interfering with respiration, feeding, and reproduction as well as reduce streambed habitat quality. To minimize sedimentation careful consideration was given to haul road design, use of a turbidity curtain, and the installation/removal sequence. Furthermore, very little silt was documented on the streambed in this area (Kogge 2013; Richardson 2014). In addition, to sedimentation, the presence of the temporary causeways will result in channel constriction and it is possible there may be an increase in channel shear stress. This has the potential to cause displacement of mussels which may also interfere with feeding, reproduction, and result in movement of mussels into potentially sub-optimal habitat. Lastly, mussels have the potential to be exposed to chemicals due to an accidental fuel spill, which depending on the severity could result in mortality.

We estimate that 13 snuffbox will remain after relocation and will be harmed and harassed due to interference with normal respiration, feeding, and reproduction. The severity of impacts is dependent on flow, rainfall, effectiveness of best management practices (e.g., turbidity curtains, construction materials and sequencing etc.), and the sensitivity and response of snuffbox to disturbance. It is impossible to quantify how many individuals will suffer mortality and how many will suffer less severe short term effects but the total number affected will not exceed 13 individuals.

Hydraulic effects post construction due to the pier lengthening were considered, but are deemed to be negligible due to the very large surface area of the riverbed and banks when compared to the relatively short lengthening and surface area of piers 16-19.

In total, 122 snuffbox, will be relocated to Lowell. Relocation will also result in mortality of some mussels. Success of mussel relocations, in terms of recovery and survival of mussels, depends on several factors, including substrate stability, microhabitat requirements, methods of relocation, and timing (Cope and Waller 1995, Cope *et al.* 2003, Dunn and Sietman 1997, Dunn *et al.* 2000, Hamilton *et al.* 1997). Relocations with low mortality (< 1%) after one year have been linked to relocation sites with stable or consolidated substrate, species-specific habitat requirements, and careful handling of mussels (Dunn and Sietman 1997). The relocation site in Lowell has high quality mussel habitat and snuffbox present indicating that the relocation site should provide the necessary substrate and microhabitat features for snuffbox relocation. The relocation will be conducted in accordance with the Michigan Mussel Survey Protocols (Hanshue *et al.* 2016). Based on this information, we expect a high survival rate although other unknown or uncontrollable factors may influence survival. Following the relocation guidelines in Dunn *et al.* (2000), we assume a 5 percent mortality rate for relocated mussels is an appropriate estimate that will still reflect a high degree of success for the relocation. Based on this, we anticipate that 6 relocated snuffbox will not survive one year after relocation.

### **Cumulative Effects**

Cumulative effects include 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 pursuant to section 7 of the Act.

In addition to the work MDOT is planning at the I-196 crossing, a major project is planned for the Grand River through downtown known as the “Restore the Rapids” initiative. The initiative is a partnership between the City of Grand Rapids and the non-profit, Grand Rapids Whitewater (<http://grandrapidswhitewater.org>). The Restore the Rapids project aims to create opportunities for kayaking and whitewater enthusiasts, restore river habitat, modify existing dams, and increase river accessibility. While the project will not disturb the streambed directly below I-196, communication with the project consultants (River Restoration Inc.) indicate that areas both upstream and downstream of the bridge will be under construction as early as 2018. As such, relocating snuffbox to a site near the I-196 bridge is not possible because of possible future disturbance within this reach.

### **Conclusion**

After reviewing the current status of snuffbox, the environmental baseline for the action area, the effects of the proposed action, and the cumulative effects, we conclude that the I-196 Westbound Pier Extension project, as proposed, is not likely to jeopardize the continued existence of the snuffbox. No critical habitat has been designated for this species; therefore, none will be affected.

Regulations define “jeopardize the continued existence of a species” as “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.” We must analyze how the proposed action and potential effects could impact reproduction, number, and distribution of snuffbox.

A loss of up to 36 individuals will reduce the number of reproductive adults in the river. Additionally, harassment of 116 adult mussels may interfere with normal breeding activity, potentially reducing the number of glochidia produced in the year of relocation. This temporary and short term potential disruption to reproduction among relocated snuffbox will not detectably reduce the overall reproductive success of the snuffbox population in the Grand River.

A loss of up to 36 individuals will reduce the number of mussels in the river. The total snuffbox population estimated within the action area is 152. Thus, permanent loss of 36 individuals represents 23.6% of the localized population in the action area. In addition, 116 individuals representing 73.6% of the localized population will be permanently removed from the action area and moved to the relocation site in Lowell. While these individuals will not be lost from the snuffbox population as a whole in the Grand River, they will be permanently displaced from the localized population in the action area. The Restore the Rapids Project predicts an increase in the amount of available mussel habitat following completion of the project. If this is the case, it is possible that the loss of individuals from the localized population as a result of this project will be mitigated by the creation and recovery of snuffbox population throughout the action area and downtown Grand Rapids. We do not have a total population estimate for snuffbox in the Grand River. However, the potential viability is considered high with documented recruitment and a medium size population. In one reach of the Grand River in the Village of Lyons, Ionia County, Michigan, surveys revealed a localized population estimate of 11,488 snuffbox and there is evidence of recruitment. Recently, an additional population in the Maple River, a tributary to the Grand River, was discovered (D. Woolnough, CMU, pers. comm. 2016). While snuffbox presence and density is variable throughout the Grand River, there are areas where snuffbox density is significant in this river (USFWS Biological Opinion for the Removal of Lyons Dam, August 17, 2015). Data from the Grand Rapids Revitalization Project indicate that snuffbox in the action area are part of a larger population present throughout the downtown reach of the Grand River. The Grand Rapids Revitalization Project proposes to improve the mussel habitat throughout this reach of the river, which includes the action area. As such, future actions may in fact improve snuffbox habitat and possibly density in this area. For these reasons, we conclude that the proposed action, taken together with cumulative effects, would not directly or indirectly reduce the likelihood of both the survival and recovery of the snuffbox by reducing the species’ reproduction, numbers, or distribution.

#### INCIDENTAL TAKE STATEMENT

Section 9 of the Act and Federal regulation pursuant to section 4(d) of the Act prohibit the take of endangered and threatened species, respectively, without special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by the Service to include significant habitat

modification or degradation that results in death or injury to listed species by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering. Harass is defined by the Service as intentional or negligent actions that create the likelihood of injury to listed species to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered to be prohibited taking under the Act provided that such taking is in compliance with the terms and conditions of this Incidental Take Statement.

The measures described below are non-discretionary and must be undertaken by the Service so that they become binding conditions of any funding awarded to the project, as appropriate, for the exemption in section 7(o)(2) to apply. The Service has a continuing duty to regulate the activity covered by this incidental take statement. If the Service fails to assume and implement the terms and conditions of the incidental take statement, the protective coverage of section 7(o)(2) may lapse. In order to monitor the impact of incidental take, the Service must 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)]

#### **Amount or Extent of Take**

The Service anticipates up to 152 snuffbox could be taken as a result of this proposed action. We expect incidental take of 122 adults will occur in the form of harassment as a result of relocation. Incidental take of 36 adults will occur in the form of mortality, including 30 mortalities from construction-related activities and 6 post-relocation mortalities.

#### **Effect of Take**

In the accompanying Opinion, we determined that this level of anticipated take is not likely to result in jeopardy to the species.

#### **Reasonable and Prudent Measures**

The Service believes that the following reasonable and prudent measures are necessary and appropriate to minimize the incidental take of snuffbox during the proposed action:

1. The FHWA will ensure that the proposed project components will occur as planned and as documented in the BA.
2. The FHWA will ensure that qualified mussel biologists relocate snuffbox within the 18,906 m<sup>2</sup> project impact area, as defined in the “Effects of the Action on Snuffbox” section of this Opinion.

3. The FHWA will ensure that qualified mussel biologists monitor the relocated mussels after relocation.
4. The FHWA will report on the progress of the I-196 Pier Extension Project and its impact on the snuffbox, as required pursuant to 50 CFR 402.14(i)(3).
5. The FHWA will ensure during construction activities in the action area that water quality standards are in accordance with their MDEQ National Pollutant Discharge Elimination System permit.

### **Terms and Conditions**

In order to be exempt from the prohibitions of section 9 of the Act, the Service must comply with the following terms and conditions, which implement the reasonable and prudent measures, described above, and outline reporting/monitoring requirements. These terms and conditions are non-discretionary.

#### Terms and Conditions to fulfill RPM #1

- 1.1 Notify contractors of conservation measures and ensure compliance with these measures.
- 1.2 Submit a report to our office within 60 days of completing the I-196 Pier Extension project. This report will describe the actions taken to implement the terms and conditions and include the dates of actual construction activities.

#### Terms and Conditions to fulfill RPM #2

- 2.1 Ensure relocation follows the West Virginia Survey Protocols, including:
  - Snuffbox shall be collected by hand, by “grubbing” while wading or snorkeling in shallow water, or by divers in deeper water.
  - Relocation effort shall be systematically conducted by a “moving transect” or establishing cells not to exceed 100 m<sup>2</sup>.
  - Effort shall meet the same standards as surveys, using standards for visual or surface searches.
  - Multiple passes shall be made through the area until less than 5 percent of the number collected on the original pass are recovered on the final pass.
  - Both valves of each snuffbox will be marked with shellfish tags.
  - All snuffbox will be tagged with a Passive Integrated Transponder (PIT).
- 2.2 Submit a report to our office within 60 days of completion of snuffbox relocation. This report should describe the actions taken to implement the terms and conditions and

include the dates of activities.

#### Terms and Conditions to fulfill RPM #3

- 3.1 Ensure post-relocation monitoring surveys are conducted 30 days after the initial relocation if possible and one year following relocation. Post relocation monitoring surveys should follow West Virginia Survey Protocols for monitoring.
- 3.2 Submit a report to our office within 30 days of completion of each of the snuffbox post-relocation monitoring events. This report should describe the actions taken to implement the terms and conditions and include the dates of activities.

#### Terms and Conditions to fulfill RPM #5

- 5.1 Notify the ELFO if NPDES permit limits are exceeded.
- 5.2 Notify the ELFO if an accidental spill during construction results in chemical exposure in the river.

### **CONSERVATION RECOMMENDATIONS**

Section 7(a)(1) of the Act directs Federal agencies to utilize their authorities to further the purposes of the Act by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on listed species or critical habitat, to help implement recovery plans, or to develop information. The Service has identified the following actions that, if undertaken by the FHWA, will further the conservation and assist in the recovery of snuffbox:

1. Conduct additional years of post-relocation monitoring to assess future survival and growth rates of relocated mussels.
2. Conduct or fund augmentation and/or reintroduction efforts for snuffbox within the Grand River watershed.
3. Support research on snuffbox ecology and distribution.

In order to keep the Service informed of actions minimizing or avoiding adverse effects or benefitting listed species or their habitats, we request notification of the implementation of any conservation recommendations.

### **REINITIATION NOTICE**

This concludes formal consultation on the proposed action. In accordance with 50 CFR §402.16, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of incidental take is exceeded; (2) new information reveals effects of the agency action

that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion; (3) the agency action is subsequently modified in a manner that causes an effect to the listed species or critical habitat not considered in this opinion; or (4) a new species is listed or critical habitat designated that may be affected by the action. In instances where the amount or extent of incidental take is exceeded, any operations causing such take must cease pending reinitiation.

We believe that no more than 152 snuffbox will be incidentally taken as a result of the proposed action. This includes harassment of 122 individuals during relocation prior to construction and mortality of 36 adults, six of which are associated with relocation. If any of the following occurs during the course of completing the project, then this represents new information, requiring reinitiation of consultation:

1. Fewer than 122 snuffbox are captured and removed prior to construction.
2. More than 152 snuffbox are captured and removed prior to construction.

**LITERATURE CITED**

- Badra, P. J. and R. R. Goforth 2003. Freshwater mussel surveys of Great Lakes Tributary Rivers in Michigan. Report number MNFI 2003-15. Report to Michigan Dept. of Environmental Quality, Coastal Zone Management Unit, Lansing, MI. 40pp.
- Barnhart, M.C. 1998. Fish hosts and culture of mussel species of special concern. Missouri Department of Conservation, Jefferson City. 44 pp.
- Barnhart, M.C., F.A. Riusech, and M.S. Baird. 1998. Hosts of salamander mussel, *Simpsonaias ambigua*, and snuffbox, *Epioblasma triquetra*, from the Meramec River system, Missouri. Triannual Unionid Report No. 16:34.
- Butler R.S. 2007. Status assessment report for the snuffbox, *Epioblasma triquetra*, a freshwater mussel occurring in the Mississippi and Great Lakes Basins. U.S. Fish and Wildlife Service, Asheville, NC.
- Caldwell, M.L. 2013. Host fish suitability tests and effects of invasive mollusks for snuffbox, *Epioblasma triquetra*, from Laurentian Great Lakes basins. M.S. Thesis, Central Michigan University, Mount Pleasant. 65 + viii pp.
- Caldwell, M. L., Zanatta, D. T. and Woolnough, D. A. (2016), A multi-basin approach determines variability in host fish suitability for unionids in tributaries of the Laurentian Great Lakes. *Freshw Biol*, 61: 1035–1048.
- Christian, A.D., B.N. Smith, D.J. Berg, J.C. Smoot, and R.H. Findlay. 2004. Trophic position and potential food sources of 2 species of unionid bivalves (Mollusca: Unionidae) in 2 small Ohio streams. *Journal of the North American Benthological Society* 23(1):101-113.
- Cope, W.G., M.C. Hove, D.L. Waller, D.J. Hornbach, M.R. Bartsch, L.A. Cunningham, H.L. Dunn, and A.R. Kapuscinski. 2003. Evaluation of relocation of unionid mussels to *in situ* refugia. *Journal of Molluscan Studies* 69: 27-34.
- Cope, W.G. and D.L. Waller. 1995. Evaluation of freshwater mussel relocation as a conservation and management strategy. *Regulated Rivers: Research & Management* 11:147-155.
- Cummings, K.S. and C.A. Mayer. 1992. Field guide to freshwater mussels of the Midwest. *Illinois Natural History Survey Manual* 5. 194 pp.
- Dunn, H.L. and B.E. Sietman. 1997. Guidelines used in four geographically diverse Unionid relocations. Pages 176-183 in K.S. Cummings, A.C. Buchanan, C.A. Mayer, and T.J. Naimo, eds. Conservation and management of freshwater mussels II: proceedings of a UMRCC symposium. Upper Mississippi River Conservation Committee, Rock Island, IL.

- Dunn, H.L., B.E. Sietman, and D.E. Kelner. 2000. Evaluation of recent unionid (*Bivalvia*) relocations and suggestions for future relocations and reintroductions. Pp. 169-183 in R.A. Tankersley, D.I. Warmolts, G.T. Watters, B.J. Armitage, P.D. Johnson, and R.S. Butler, eds. Proceedings of the first freshwater mollusk conservation society symposium, 1999. Ohio Biological Survey, Columbus.
- Gillis, P.L. 2012. Cumulative impacts of urban runoff and municipal wastewater effluents on wild freshwater mussels (*Lasmigona costata*). Science of The Total Environment 431: 348–56.
- Grabarkiewicz, J.D., and W.S. Davis. 2008. An Introduction to Freshwater Fishes as Biological Indicators. U.S. Environmental Protection Agency Office of Environmental Information, Office of Information Analysis and Access, Washington, DC. EPA-260-R-08-016.
- Hamilton, H., J. Brim Box, and R.M. Dorazio. 1997. Effects of habitat suitability on the survival of relocated freshwater mussels. Regulated Rivers: Research & Management 13:537-541.
- Hillegass, K.R., and M.C. Hove. 1997. Suitable fish hosts for glochidia of three freshwater mussels: strange floater, ellipse, and snuffbox. Triannual Unionid Report No. 13:25.
- Hove, M.C., K.R. Hillegass, J.E. Kurth, V.E. Pepi, C.J. Lee, K.A. Knudsen, A.R. Kapuscinski, P.A. Mahoney, and M.M. Bomier. 2000. Considerations for conducting host suitability studies. Pp. 27-34 in: R.A. Tankersley, D.I. Warmolts, G.T. Watters, and B.J. Armitage, eds. Part I. Proceedings of the conservation, captive care, and propagation of freshwater mussels symposium, March 1998, Columbus, Ohio. Ohio Biological Survey, Columbus.
- Kogge, S. 2013. Mussel Survey and Relocation JN 109771, I-196 Westbound Bridge, Grand River, Grand Rapids, Kent County, Michigan. J.F. New and Associates, Inc.
- McNichols, K. and G.L. Mackie. 2002. Fish host determination of endangered freshwater mussels in the Sydenham River, Ontario, Canada. Endangered Species Recovery Fund 2002/2003 Final Report. 22 pp.
- McNichols, K., and G.L. Mackie. 2003. Fish host determination of endangered freshwater mussels in the Sydenham River, Ontario, Canada. Endangered Species Recovery Fund 2003/2004 Final Report. 26 pp.
- McNichols, K., and G.L. Mackie. 2004. Fish host determination of endangered freshwater mussels in the Sydenham River, Ontario, Canada. Endangered Species Recovery Fund 2004/2005 Final Report. 26 pp.
- Mulcrone, R. Sherman. 2004. Incorporating habitat characteristics and fish hosts to predict freshwater mussel (*Bivalvia: Unionidae*) distributions in the Lake Erie drainage, southeastern Michigan. Ph.D. dissertation, University of Michigan, Ann Arbor. 139 pp.
- Murray, H.D. and A.B. Leonard. 1962. Handbook of the unionid mussels of Kansas. University of Kansas Museum of Natural History Miscellaneous Publication No. 28. 184 pp.

- Neves, R.J. 1991. Mollusks. Pp. 251-319 *in*: K. Terwilliger, coordinator. Virginia's endangered species. Proceedings of a symposium, April 1989, Blacksburg, Virginia. McDonald & Woodward Publishing Co., Blacksburg.
- Nichols, S.J. and D. Garling. 2000. Food-web dynamics and trophic-level interactions in a multispecies community of freshwater unionids. *Canadian Journal of Zoology* 78:871-882.
- Parmalee, P.W. and A.E. Bogan. 1998. *The freshwater mussels of Tennessee*. Knoxville: University of Tennessee Press.
- Richardson, J. 2014a. Mussel Survey and Relocation, Grand River at I-196 Bridge Downtown Grand Rapids, Michigan. Prepared for the Michigan Department of Transportation.
- Richardson, J. 2014b. Mussel Sampling and Relocation, Grand River at Leonard Street, Kent County, Michigan. Prepared for the Michigan Department of Transportation.
- Sherman, R.A. 1993. Glochidial release and reproduction of the snuffbox mussel, *Epioblasma triquetra*: timing in southern Michigan. Abstract, North American Benthological Society Bulletin 10(1):197.
- Sherman, R.A. 1994. Life history information critical to the management of the state endangered snuffbox mussel, *Epioblasma triquetra* (Bivalvia: Unionidae) in Michigan. M.S. thesis, University of Michigan, Ann Arbor. 40 pp.
- Silverman, H., S.J. Nichols, J.S. Cherry, E. Achberger, J.W. Lynn, and T.H. Dietz. 1997. Clearance of laboratory-cultured bacteria by freshwater bivalves: differences between lentic and lotic unionids. *Canadian Journal of Zoology* 75:1857-1866.
- Strayer, D.L., J.A. Downing, W.R. Haag, T.L. King, J.B. Layzer, T.J. Newton, and S.J. Nichols. 2004. Changing perspectives on pearly mussels, North America's most imperiled animals. *BioScience* 54(5):429-469.
- U.S. Fish and Wildlife Service (USFWS). 2012. Endangered and threatened wildlife and plants; determination of endangered status for the rayed bean and snuffbox mussels throughout their ranges. Final Rule. *Federal Register* 77(30):8632.
- U.S. Fish and Wildlife Service (USFWS). 2015. Biological Opinion for the Removal of Lyons Dam, Ionia County, Michigan; Log No. 15-R3-ELFO-05.
- Woolnough, D.A. and S.E. Barnett. 2013. Detection and quantification of snuffbox (*Epioblasma triquetra*) in Grand River Lyons, MI: section 7 permit requirements.

Yeager, B.L. 1986. *Epioblasma brevidens*, *Epioblasma capsaeformis* and *Epioblasma triquetra*. Pp. 45-47 in: D.M. Hill, ed. Activity 3: identification of fish hosts. Tennessee Valley Authority Cumberlandian Mollusk Conservation Program, Norris, Tennessee.

Yeager, B.L. and C.F. Saylor. 1995. Fish hosts for four species of freshwater mussels (Pelecypoda: Unionidae) in the upper Tennessee River drainage. American Midland Naturalist 133:1-6.