

February 23, 2026

Julie Christian
Natural Resources Division Manager
Sleeping Bear Dunes National Lakeshore
Via email: julie_christian@nps.gov

2025 Final Report of Freshwater Mussel Surveys at Route 675 Crossings 1, 2, and 3 of Crystal River, Glen Arbor, Michigan / SWCA Project No.: 73781

Dear Julie Christian:

SWCA Environmental Consultants (SWCA) is pleased to provide you with this report summarizing the results of all our freshwater mussel work associated with Route 675 Crossings 1, 2, and 3 over the Crystal River in Glen Arbor, Michigan, including our 2025 survey and translocation efforts for freshwater mussels at Crossings 1 and 2. The Crystal River is classified as a Group 2 stream by the Michigan Natural Features Inventory and the Michigan Department of Natural Resources (MDNR), indicating that it is a river “likely to support populations of State Threatened and Endangered mussels”. It is our understanding that all native freshwater mussel species are state protected in Michigan and that nine state listed species occur within the Glen Lake-Frontal Lake Michigan Hydrologic Unit Coad (HUC), within which the Project is located.

In total, 990 live mussels representing five different species, were collected from the three crossing Survey Areas and relocated into suitable habitat. All mussels were identified to species, measured, and assessed for shell wear. All individuals appeared to be in good condition and healthy at the time of the survey. In 2024, SWCA relocated 111 mussels from the Crossing 3 survey area, including 106 *E. dilatata* and 5 *L. siliquioidea*. In 2025, SWCA relocated 463 mussels from the Crossing 1 survey area (*E. dilatata* 455, *L. siliquioidea* 5, *S. undulatus* 1, *L. cardium* 2, *L. compressa* 1) and 416 mussels from the Crossing 2 survey area (*E. dilatata* 360, *L. siliquioidea* 31, *S. undulatus* 16, *L. cardium* 8, *L. compressa* 1). *Lasmigona compressa*, a species of special concern in Michigan, was the least abundant species present, with only 2 individuals present within the survey areas, making up just 0.002% of all mussels relocated. It should be noted that several live *L. compressa* individuals were observed outside of the three survey areas.

If you have any questions or require additional information, please do not hesitate to contact me by phone at (413) 323-5748, or via email at stevejohnson@swca.com.

Sincerely,

Steve Johnson, Ph.D.
Lead Biologist

Jaelynn Knight
Staff Biologist

Attachments:
Attachment A - Figures
Attachment B - Photo Pages

PROJECT BACKGROUND

As part of a stream crossing improvement project, RCA, LLC, d/b/a Grand Traverse Engineering and Construction (GTEC) is proposing to replace the four culvert crossings on Leelanau County Road 675, three of which cross the Crystal River (Project), on behalf of the Grand Traverse Band of Ottawa and Chippewa Tribe (Figure 1). The proposed culvert crossings are in a section of the Crystal River classified by the Michigan Natural Features Inventory and the Michigan Department of Natural Resources (MDNR) as a Group 2 stream, indicating that it is a river “likely to support populations of State Threatened and Endangered mussels.” It is our understanding that all native freshwater mussel species are state protected in Michigan and that nine state listed species occur within the Glen Lake-Frontal Lake Michigan Hydrologic Unit (HUC), within which the Project is located. These include two State-Endangered species, one State-Threatened species and six species of Special Concern.

In 2022, SWCA’s mussel biologists conducted an initial freshwater survey at Crossing 3 to determine species diversity and distribution of mussels within this portion of the river, as well as brief reconnaissance surveys at Crossing 1 and 2 to determine if freshwater mussels are likely to be present at these locations as well (Figure 1). A total of 107 freshwater mussels were observed within the Crossing 3 Survey Area during the 2022 survey, comprised of two species: *Eurynia dilatata* and *Lampsilis siliquoidea*. During the Crossing 1 15-minute reconnaissance survey, eight live *E. dilatata* were observed, as well as a recently dead shell of *Sagittunio* (formerly *Ligumia*) *nasuta*, a state endangered species in Michigan. The 15-minute survey at Crossing 2 produced seven live *E. dilatata* and one *L. siliquoidea*.

OBJECTIVES AND METHODS

2022 SURVEY

The objective of the 2022 survey was to collect data on the distribution and density of freshwater mussel species in the Project area within Crystal River in Glen Arbor, Michigan. This data was to aid in determining future survey and translocation protocols prior to work occurring on the culvert systems. From August 9th through August 12th of 2022, two SWCA biologists conducted a variety of survey methods primarily in the Survey Area of Crossing 3 as well as timed meander surveys at Crossings 1 and 2.

Prior to surveys, SWCA developed a survey protocol as part of the collection permit application process. The protocol followed the Michigan Freshwater Mussel Survey Protocols and Relocation Procedures for Rivers and Streams, May 2021, Version 3 (MFMSRP), and was approved by the Michigan Department of Natural Resources – Fisheries Division (Scientific Collector’s Permit) and the National Park Service - Sleeping Bear (Scientific Research and Collecting Permit).

The Survey Area for Crossing 3 was designed to include the first 100 meters downstream of the crossing and the first 50 meters upstream of the crossing. The total Survey Area was 1,543.8 square meters (0.38 acres) in size, with 1,062.6 square meters (0.26 acres) surveyed north (downstream) of the crossing and 481.2 square meters (0.12 acres) south (downstream) of the crossing. The reconnaissance surveys conducted at Crossings 1 and 2 were 15-minute timed meander surveys that focused on the river immediately upstream and downstream of each crossing. The distance covered during these reconnaissance surveys was not documented.

At Crossing 3, SWCA biologists established survey cells, starting at the downstream end of the Survey Area, using weighted lines to demarcate the boundaries of each cell. Following the MFMSRP guidelines, SWCA dedicated two survey minutes per square meter in areas with heterogeneous substrates

and at least one minute per square meter in areas with homogeneous substrates. The biologists made a series of passes, collecting and recording all mussels observed during a given pass. A cell was considered complete when the last pass produced no live mussels, or a total that was less than 10% of the number observed during the first pass.

Two biologists used snorkel equipment to visually scan for mussels, while also using tactile methods to search for mussels below the substrate surface. During surveys in each survey cell, all live mussels and shells were collected and identified to species. Shell length and wear were recorded for all live mussels, as well as the survey cell it was found in, and representative photographs were taken of each species observed. All mussels were returned to their original location and placed into the substrate anterior end down.

During the reconnaissance surveys at Crossings 1 and 2, two biologist using snorkel equipment conducted 15-minute timed meander surveys involving visual and tactile searches for freshwater mussels.

2024 SURVEY

The objective of the 2024 survey was to collect all live mussels within the 150-meter-long segment of the Crystal River associated with Crossing 3 and relocate the mussels beyond the impact of the culvert removal. On August 20th, 21st and 22nd, 2024, SWCA mussel biologists Steve Johnson and Jaelynn Knight conducted time meander surveys and relocated any live mussels that were present within the Project disturbance area at Crossing 3. The 2024 Survey Area for Crossing 3 was the same as the one used in 2022, beginning 100 meters downstream of the crossing and continuing 50 meters upstream of the crossing. The total Survey Area was 1,543.8 square meters (0.38 acres) in size, with 1,062.6 square meters (0.26 acres) surveyed north (downstream) of the crossing) and 481.2 square meters (0.12 acres) south (downstream) of the crossing. All relocation work conducted in 2024 and 2025 was done under Scientific Research and Collection Permit # SLBE-2024-SCI-0015, study # SLBE-00197.

The water levels in 2024 were down approximately 8-10” from the time of the previous efforts in 2022. Water levels ranged from 3-12” in both the upstream and downstream Survey Areas. The primary substrate throughout the Survey Area was coarse to fine sand with larger rocks and cobble at the outflow of the culvert crossing. Within the Survey Area, emergent and aquatic vegetation was present only near the shores of the Crystal River. No vegetation occurred in the middle of the channel.

Over the course of three days, SWCA biologists conducted a series of time meander surveys to locate and collect any live mussels present within the Survey Area limits. All mussels were collected, identified to species, measured for shell length and wear, and then relocated further upstream outside of the disturbance area.

2025 SURVEYS

The objective of the 2025 surveys was to collect all live mussels within the 150-meter-long segments of the Crystal River associated with Crossings 1 and 2 and relocate the mussels beyond the impacts of culvert removal activities. On June 6, 7, 8, 9, 10, 11, and 12 of 2025, SWCA mussel biologists Steve Johnson and Jaelynn Knight conducted cell surveys throughout Crossings 1 and 2 to find and relocate any live mussels within the Survey Areas. The 2025 Survey Areas for Crossings 1 and 2 began 100 meters downstream of each crossing and continuing 50 meters upstream of the crossings. The Survey Area for Crossing 1 was approximately 3,008 square meters (0.74 acres) in size, with 1,926 square meters (0.48 acres) surveyed north (downstream) of the crossing and 1,082 square meters (0.27 acres) south (downstream) of the crossing. The Survey Area for Crossing 2 was 2,178 square meters (0.54 acres) in

size, with 1,341 square meters (0.33 acres) surveyed south (downstream) of the crossing and 837 square meters (0.21 acres) north (downstream) of the crossing.

Following the MFMSRP guidelines, SWCA dedicated two survey minutes per square meter in areas with heterogeneous substrates and at least one minute per square meter in areas with homogeneous substrates. The biologists made a series of passes, collecting and recording all mussels observed during a given pass. A cell was considered complete when the last pass produced no live mussels, or a total that was less than 10% of the number observed during the first pass.

Over the course of seven days, SWCA biologists used snorkel equipment to visually scan for mussels, while also using tactile methods to search for mussels below the substrate surface. During surveys in each survey cell, all live mussels and shells were collected and identified to species. Shell length and wear were recorded for all live mussels, as well as the survey cell it was found in, and representative photographs were taken of each species observed. All mussels were collected, processed and translocated into appropriate relocation areas, placed into the substrate anterior end down.

SURVEY RESULTS

CROSSING 1

SWCA surveyed Crossing 1 on June 6, 7, and 8 and Crossing 2 on June 9, 10, 11, 12 of 2025. Water temperatures were in the low 70's Fahrenheit, with visibility over three meters.

A total of 463 live mussels were collected from within the Crossing 1 Survey Area (Table 3). Of these, 401 were found in the downstream 100 meters of the Survey Area, and 62 were found in the upstream 50 meters. Five species were observed, listed here in order of abundance: *E. dilatata* (455), *L. siliquioidea* (4), *Strophitus undulatus* (1), *Lampsilis cardium* (2), and *Lasmigona compressa* (1).

Table 3. 2025 Results of Crossing 1 Freshwater Mussel Survey

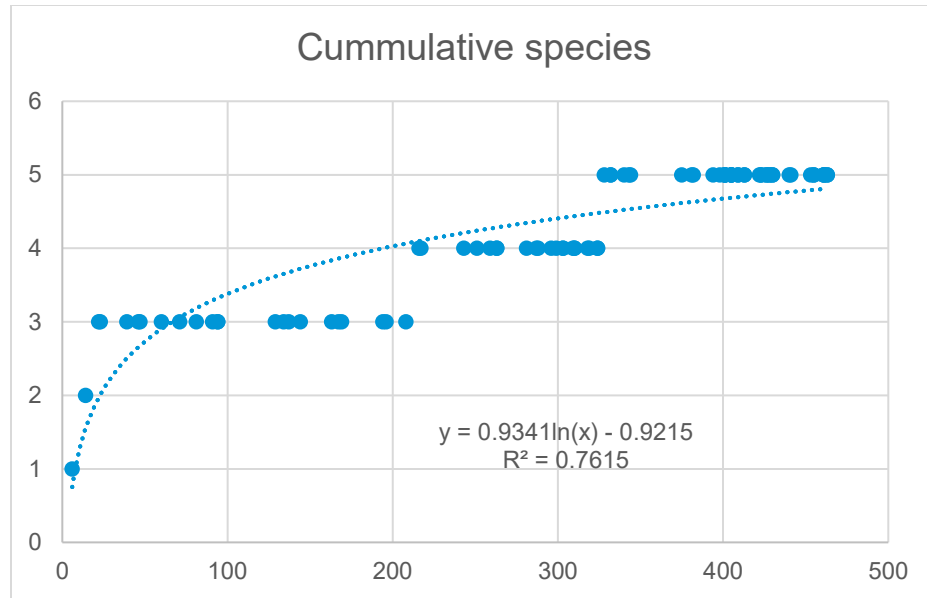
CELL NUMBER	SIZE (M ²)	CELL LOCATION	EUDI	LASI	STUN	LACA	LACO	TOTAL LIVE MUSSELS
1		Downstream	20	2	0	1	0	23
2		Downstream	24	0	0	0	0	24
3		Downstream	46	1	0	0	0	47
4		Downstream	43	0	0	0	0	43
5		Downstream	32	0	0	0	0	32
6		Downstream	27	0	0	0	0	27
7		Downstream	20	0	0	0	1	21
8		Downstream	45	1	0	0	0	46
9		Downstream	25	0	0	0	0	25
10		Downstream	15	0	0	0	0	15
11		Downstream	7	0	0	0	0	7
12		Downstream	9	0	0	0	0	9
13		Downstream	5	0	0	0	0	5
14.		Downstream	6	0	1	1	0	8
15		Downstream	12	0	0	0	0	12

CELL NUMBER	SIZE (M ²)	CELL LOCATION	EUDI	LASI	STUN	LACA	LACO	TOTAL LIVE MUSSELS
16		Downstream	38	0	0	0	0	38
17		Downstream	19	0	0	0	0	19
18		Downstream	0	0	0	0	0	0
19		Upstream	4	0	0	0	0	4
20		Upstream	0	0	0	0	0	0
21		Upstream	4	0	0	0	0	4
22		Upstream	4	0	0	0	0	4
23		Upstream	10	0	0	0	0	10
24		Upstream	3	0	0	0	0	3
25		Upstream	2	0	0	0	0	2
26		Upstream	2	0	0	0	0	2
27		Upstream	11	0	0	0	0	11
28		Upstream	14	0	0	0	0	14
29		Upstream	6	0	0	0	0	6
30		Upstream	0	0	0	0	0	0
31		Upstream	2	0	0	0	0	2
Totals			455	4	1	2	1	463

Note: EUDI = *Eurynia dilatata*, LASI = *Lampsilis siliquioidea*, STUN = *Strophitus undulatus*, LACA = *Lampsilis cardium*, LACO = *Lasmigona compressa*

There was a noticeable difference in mussel densities and species richness between the upstream and downstream segments of the Crossing 1 Survey Area. The average number of mussels encountered per cell in the downstream section was 22.28, with all 5 species observed. In contrast, the average number of mussels per cell in the upstream section was 4.77, and only one species, *E. dilatata* was observed. The greatest mussel densities were primarily in the 10 most downstream cell with an average of 30.3 mussels per cell; however, Cell 16, which was several cells further upstream and approaching the culvert crossing had a total of 38 mussels.

SWCA divided the Crossing 1 Survey Area into 31 cells, 18 cells downstream of the crossing, and 13 cells upstream (Figure 2). A total of 86 passes were completed (Average 2.77 passes per cell). SWCA generated a species Richness Curve that indicated that an additional 221 passes would be required to find a sixth species (Graph 2).



Graph 2. Species Richness Curve generated for Crossing 1. Y = 6, X = 1652.

At Crossing 1, the upstream section above the crossing was characterized by a mucky substrate, indicative of organic-rich, fine sediments that often retain moisture and support lush plant growth. This environment fostered higher densities of vegetation, suggesting favorable conditions for aquatic plant communities. In contrast, the downstream portion of Crossing 1 exhibited a notable shift in substrate composition, transitioning to predominantly sandy material with reduced vegetation cover. Closer to the culvert, the substrate became increasingly mixed, featuring patches of cobble and gravel interspersed within the sand, which likely influenced both water flow and habitat structure.

A single SWCA mussel biologist conducted a brief reconnaissance for a suitable relocation site for mussels collected from Crossing 1. Suitable habitat was located starting approximately seven meters downstream of the Crossing 1 Survey Area and extended for 60 meters (Figure 2). During a 15-minute meander survey, 18 live *E. dilatata* were observed. Substrates were composed primarily of sand, with some woody debris. There were moderate flows throughout the relocation area, and the maximum depth at the time of relocation was 0.55 to 0.6 meters (22-24 inches).

SWCA also observed an adult mudpuppy (*Necturus maculosus*) within the upstream section of the Crossing 1 survey area. This individual was mostly buried in sand, with the head and front legs exposed. The biologist were able to survey around the salamander, and it was not disturbed from its location.

CROSSING 2

SWCA surveyed Crossing 2 on June 9, 10, 11, 12 of 2025. Water temperatures were in the low 70's Fahrenheit, with visibility over three meters.

A total of 416 live mussels were collected from within the Crossing 2 Survey Area (Table 4). Of these, 341 were found in the downstream 100 meters of the Survey Area, and 75 were found in the upstream 50 meters. Five species were observed, listed here in order of abundance: *E. dilatata* (360), *L. siliquioidea* (31), *Strophitus undulatus* (16), *Lampsilis cardium* (8), and *Lasmigona compressa* (1).

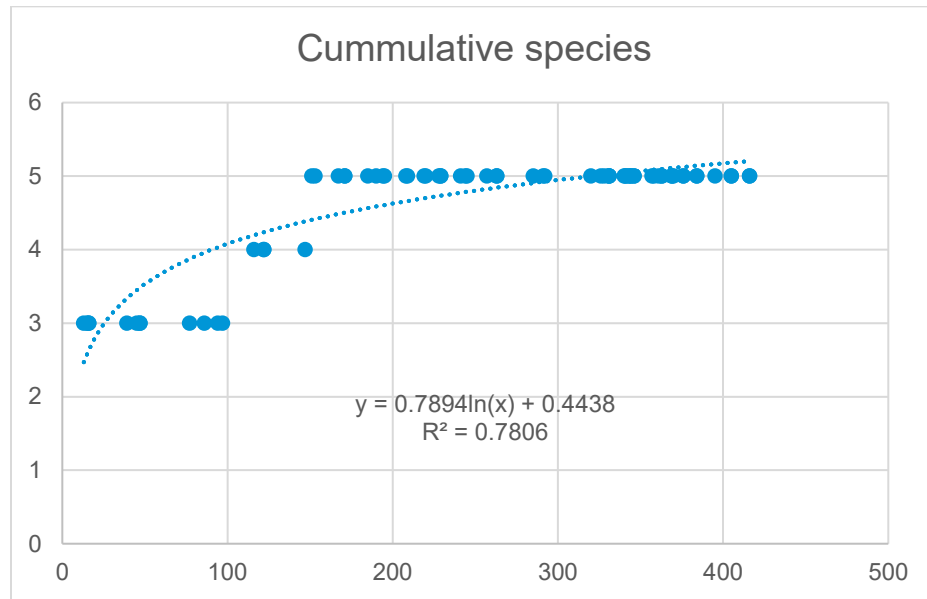
Table 4. 2025 Results of Crossing 2 Freshwater Mussel Survey

CELL NUMBER	SIZE (M ²)	CELL LOCATION	EUDI	LASI	STUN	LACA	LACO	TOTAL LIVE MUSSELS
1		Downstream	14	1	0	0	1	16
2		Downstream	30	1	0	0	0	31
3		Downstream	49	1	0	0	0	50
4		Downstream	23	0	2	0	0	25
5		Downstream	24	6	0	1	0	31
6		Downstream	14	3	1	0	0	18
7		Downstream	19	2	2	1	0	24
8		Downstream	12	2	0	0	0	14
9		Downstream	8	1	1	1	0	11
10		Downstream	6	3	0	0	0	9
11		Downstream	12	1	2	1	0	16
12		Downstream	12	1	3	2	0	18
13		Downstream	24	1	3	1	0	29
14.		Downstream	34	1	1	0	0	36
15		Downstream	3	0	0	0	0	3
16		Downstream	0	0	0	0	0	0
17		Downstream	9	0	1	0	0	10
18		Upstream	3	0	0	0	0	3
19		Upstream	2	0	0	0	0	2
20		Upstream	12	0	0	0	0	12
21		Upstream	5	0	0	0	0	5
22		Upstream	4	2	0	0	0	6
23		Upstream	0	1	0	0	0	1
24		Upstream	5	1	0	0	0	6
25		Upstream	6	1	0	1	0	8
26		Upstream	19	2	0	0	0	21
27		Upstream	11	0	0	0	0	11
Totals			360	31	16	8	1	416

Note: EUDI = *Eurynia dilatata*, LASI = *Lampsilis siliquioidea*, STUN = *Strophitus undulatus*, LACA = *Lampsilis cardium*, LACO = *Lasmigona compressa*

There was a noticeable difference in mussel densities and species richness between the upstream and downstream segments of the Crossing 2 Survey Area. The average number of mussels encountered per cell in the downstream section was 20.06, with all 5 species observed. In contrast, the average number of mussels per cell in the upstream section was 7.5, and only three species were observed, *E. dilatata*, *L. siliquioidea*, and *L. cardium*. These last two species only accounted for 8 (10.7%) of the total number of mussels observed in the upstream section. The greatest mussel densities were primarily in the 14 most downstream cell with an average of 23.4 mussels per cell.

SWCA divided the Crossing 2 Survey Area into 27 cells, 17 cells downstream of the crossing, and 10 cells upstream (Figure 4). A total of 72 passes were completed (Average 2.67 passes per cell). SWCA generated a species Richness Curve that indicated that an additional 125 passes would be required to find a sixth species (Graph 3)



Graph 3. Species Richness Curve generated for Crossing 2. Y = 6, X = 1140.

Crossing 2 displayed a consistent sandy substrate both upstream and downstream of the crossing, with no significant variation in sediment type or texture along the surveyed reach. This homogeneity in substrate at Crossing 2 may result in more uniform hydrologic and ecological conditions relative to the more variable environment observed at Crossing 1.

A single SWCA mussel biologist conducted a brief reconnaissance for suitable relocation sites for mussels collected from Crossing 2. The biologist first considered habitat upstream of the crossing and found an area with mussels in a sand/silt substrate (Figure 2). A 16-minute meander survey produced 28 *E. dilatata* and 1 *L. cardium*; however, suitable habitat was limited at this location. The 75 individuals found in the upstream portion of the Crossing 2 Survey Area were relocated to this upstream relocation area. Significantly more suitable habitat was located downstream of the Crossing 2 Survey Area. An 18-minute meander survey produced 56 *E. dilatata*, 2 *L. siliquioidea*, and 5 *S. undulatus*. The substrate in this downstream relocation area was primarily sand, with silt/sand along the river edges. The maximum depth at the time of relocation was approximately 0.6 meters (24 inches).

CROSSING 3

2022 Survey

SWCA surveyed Crossing 3 August 9th through August 12th of 2022. Water temperatures were in the low 70's Fahrenheit, with visibility over three meters. The Crossing 3 survey area was broken into 19 survey cells (Figure 3).

Over two days, three live mussels were observed in the downstream 100 meters of the Survey Area. All three individuals were *Eurynia dilatata*. In contrast, a total of 104 live mussels were found over one

survey day in the upper 50 meters of the survey area. The majority of these were *E. dilatata* (100), but four were *Lampsilis siliquioidea* (Table 1).

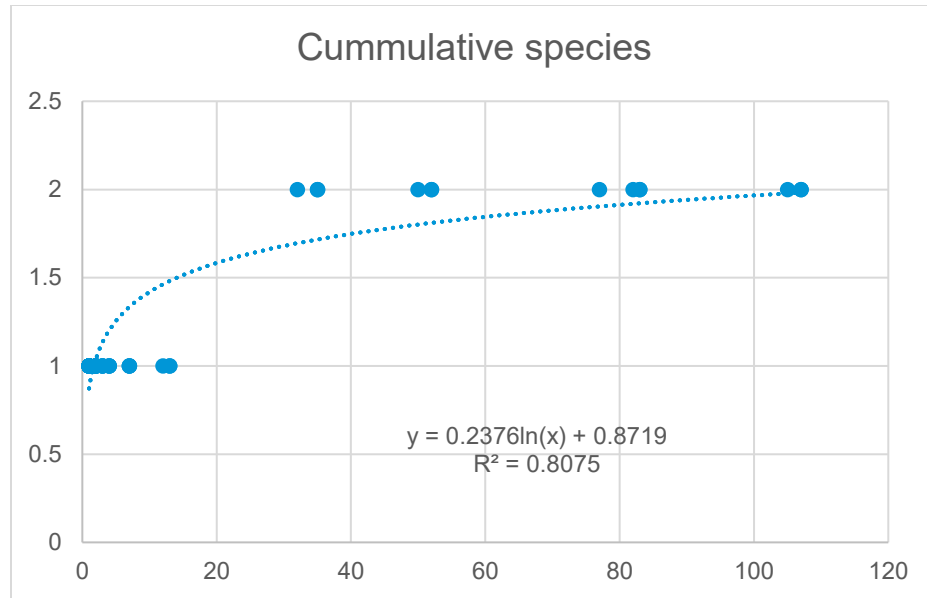
Substrate downstream of the crossing was comprised primarily of gravel, while that of the upstream section of the Survey Area was comprised primarily of fine sand, with fine silt and muck along the river edges.

During the Crossing 1 15-minute reconnaissance survey, eight live *E. dilatata* were observed, as well as a recently dead shell of *Sagittunio* (formerly *Ligumia*) *nasuta*, a state endangered species in Michigan. The 15-minute survey at Crossing 2 produced seven live *E. dilatata* and one *L. siliquioidea*.

Table 1. 2022 Results of Crossing 3 Freshwater Mussel Survey

CELL NUMBER	SIZE (M ²)	CELL LOCATION	TOTAL <i>E. DILATATA</i>	TOTAL <i>L. SILIQUOIDEA</i>	TOTAL LIVE MUSSELS
1	100	Downstream	0	0	0
2	94.1	Downstream	0	0	0
3	90.8	Downstream	1	0	1
4	77.9	Downstream	0	0	0
5	97.5	Downstream	0	0	0
6	93.4	Downstream	0	0	0
7	75.4	Downstream	0	0	0
8	86	Downstream	1	0	1
9	75	Downstream	0	0	0
10	91.3	Downstream	0	0	0
11	96.5	Downstream	0	0	0
12	64.5	Downstream	1	0	1
13	20.5	Downstream	1	0	1
14	93.1	Upstream	3	0	3
15	81.2	Upstream	6	0	6
16	67.4	Upstream	21	1	22
17	71	Upstream	17	0	17
18	75.7	Upstream	30	1	31
19	92.8	Upstream	22	2	24
Totals	1,543.8		103	4	107

SWCA divided the Crossing 3 Survey Area into 19 cells, 13 cells downstream of the crossing, and 6 cells upstream. A total of 49 passes were completed (Average 2.58 passes per cell). SWCA generated a species Richness Curve that indicated that an additional 3,510 passes would be required to find a third species (Graph 1).



Graph 1. Species Richness Curve generated for Crossing 3. Y = 3, X = 1652.

2024 Survey

SWCA surveyed Crossing 3 August 20th through 22nd of 2024. Water temperatures were in the low 70's Fahrenheit, with visibility over three meters. Substrate downstream of the crossing was comprised primarily of loose gravel, aside from the area immediately downstream of the culverts where boulder and cobble were dominant. In contrast, the upstream section of the Survey Area was comprised primarily of fine sand, with fine silt and muck along the river edges.

Over the three days, a total of 111 live mussels were collected from within the Survey Area (Table 2). Only one live *Eurynia dilatata* was observed in the downstream 100 meters of the Survey Area; however, 110 live mussels were located within the 50 meters upstream of the crossing. These mussels included 105 *E. dilatata* and 5 *L. siliquoidea*. Overall, the mussel population appeared to be in good health, with minimal shell wear. The collected *E. dilatata* ranged in length from 36 mm to 81 mm, suggesting a healthy range of age classes for that species.

All mussels collected from the Survey Area were relocated upstream to a location that we anticipated would have minimal impacts from the removal of the culvert crossings. We noted that the loose gravel substrate that dominated most of the downstream portion of the Survey Area gave way to more stable substrate with some aquatic vegetation immediately downstream. In a brief timed meander survey of the 25 meters immediately downstream of the Survey Area, SWCA observed 2 *Lasmigona compressa* (creek heelsplitter), 2 *E. dilatata*, and 1 *L. siliquoidea*. While no *L. compressa* were found within the Survey Area, SWCA did observe live individuals of this species immediately upstream of the Survey Area, along with several sub-fossil shells of *Strophitus undulatus* (creeper).

Table 2. Results of Crossing 3 Timed Meander Freshwater Mussel Surveys.

TIME (MINUTES)*	SURVEY LOCATION	TOTAL <i>E.</i> <i>DILATATA</i>	TOTAL <i>L.</i> <i>SILIUOIDEA</i>	TOTAL LIVE MUSSELS
135	Downstream	1	0	1
66	Downstream	0	0	0
62	Downstream	0	0	0

TIME (MINUTES)*	SURVEY LOCATION	TOTAL <i>E. DILATATA</i>	TOTAL <i>L. SILIGOIDEA</i>	TOTAL LIVE MUSSELS
75	Upstream – channel edges	51	3	54
60	Upstream – vegetated fringes	3	0	3
65	Upstream – mid channel	1	0	1
66	Upstream – channel edges	27	1	28
80	Upstream– vegetated fringes	4	0	4
62	Upstream – channel edges	12	1	13
65	Upstream– mid channel	6	0	6
60	Upstream – channel edges	1	0	1
Totals		106	5	111

*2 divers per survey.

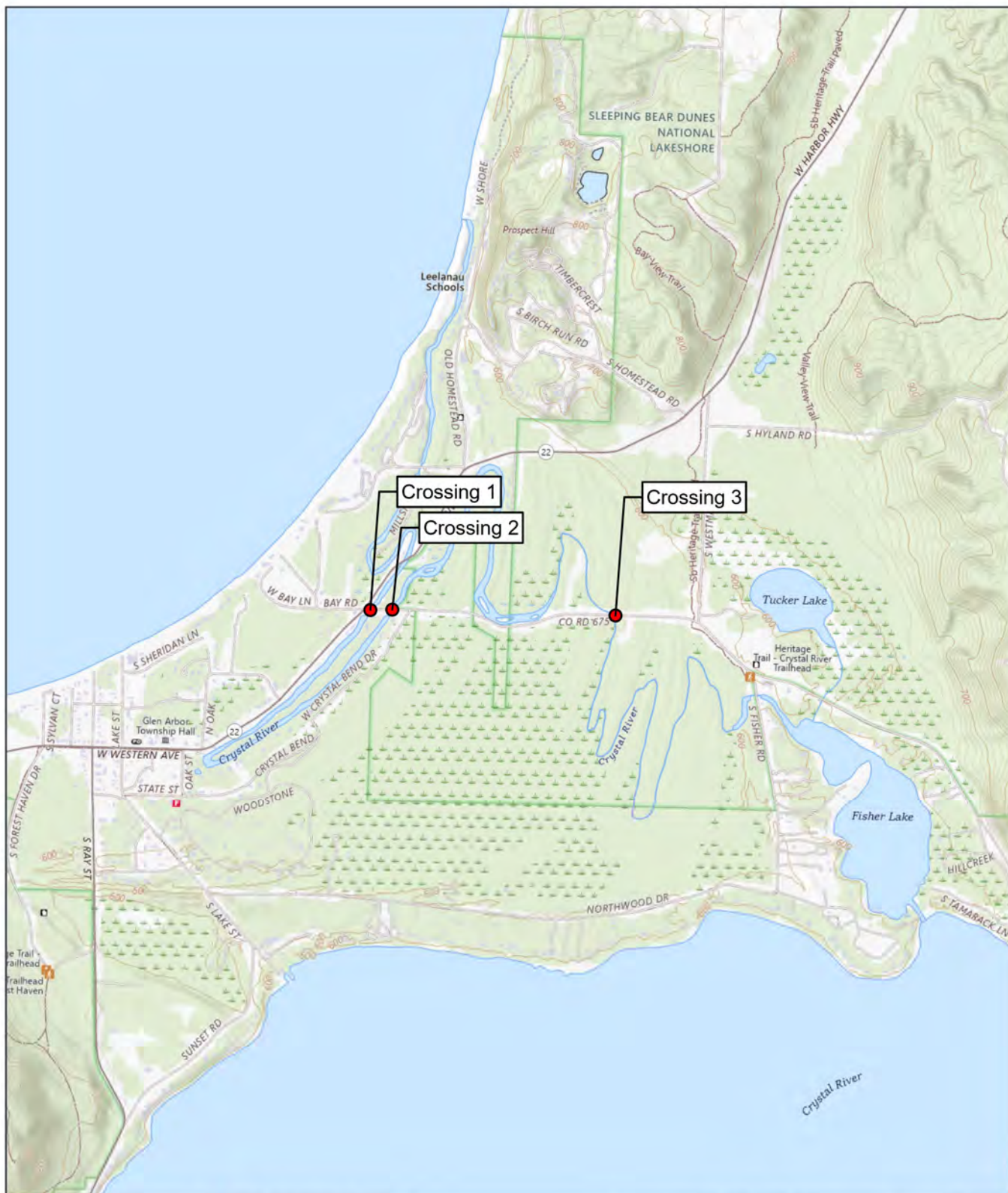
SUMMARY

In total, 990 live mussels representing five different species, were collected from the three crossing Survey Areas and relocated into suitable habitat. All mussels were identified to species, measured, and assessed for shell wear. All individuals appeared to be in good condition and healthy at the time of the survey. In 2024, SWCA relocated 111 mussels from the Crossing 3 survey area, including 106 *E. dilatata* and 5 *L. siligoidea*. In 2025, SWCA relocated 463 mussels from the Crossing 1 survey area (*E. dilatata* 455, *L. siligoidea* 5, *S. undulatus* 1, *L. cardium* 2, *L. compressa* 1) and 416 mussels from the Crossing 2 survey area (*E. dilatata* 360, *L. siligoidea* 31, *S. undulatus* 16, *L. cardium* 8, *L. compressa* 1). *Lasmigona compressa*, a species of special concern in Michigan, was the least abundant species present, with only 2 individuals present within the survey areas, making up just 0.002% of all mussels relocated. It should be noted that several live *L. compressa* individuals were observed outside of the three survey areas.

Zebra mussels (*Dreissena polymorpha*) were observed scattered throughout the Survey Areas, some of which were attached to live native mussels. Over time, as zebra mussels increase in number, they are likely to pose a threat to the population of native freshwater mussels within the Crystal River. We have observed severe *Dreissena* impacts to native mussels in several locations in Vermont and western Massachusetts and Connecticut.

Based on the findings at all three crossings, we suspect that the culverts altered the hydrodynamics of the sections of river immediately above and below the crossings. Finer, more stable sediments appear to have built up behind the culverts (Particularly at Crossing 3), while the downstream portions appeared to have moderate flows and courser substrate types, primarily sand and gravel, in the cases of Crossings 1 and 2, and higher flows and coarser, less stable sediments with far fewer mussels in the case of Crossing 3. We observed higher mussel densities and species diversity at Crossings 1 and 2, particularly in the downstream sections of each Survey Area. In contrast, we observed much lower mussel densities and low species diversity at Crossing 3, where the greatest densities and species richness occurred in the upstream section of the Survey Area. We also noted a third species of mussel immediately outside of the Crossing 3 Survey Area, along with shells of a fourth species, suggesting that species diversity increases as one moves away from the influence of Crossing 3. Due to the presumption that the culverts have influenced habitat conditions differently between the three crossings, the relative positions of the relocation areas, chosen to maximize optimal conditions for the relocated mussels, differed between the three crossings.

Our overall impression throughout this study is that the culverts at all three crossings have had negative impacts on the local mussel populations, with fewer mussels and lower species diversity as one approaches the culverts. We believe the local mussel community will respond positively to the removal of the culverts and construction of bank-to-bank bridges spanning the river. In June of 2025, less than one year after the removal of the culverts at Crossing 3, SWCA revisited the site to assess conditions associated with the new bridge system installed in September of 2024. Substrates and flows upstream, downstream, and directly under the bridge appeared to now be optimal for native mussel species. We anticipate that there will be an increase in mussel densities and species diversity near all three crossings, with the most dramatic improvements occurring at Crossing 3. Documenting these improvements in freshwater mussel density and diversity may be helpful in justifying future conversions of other culvert crossings to full-width bridges.



GTEC: CR675 STREAM
CROSSING EA

**Figure 1. Locus
Map**

● Crossing Location

Glen Arbor, MI
USGS 7.5' Quadrangle:
Glen Arbor
NAD 1983 StatePlane Michigan
Central FIPS 2112 Feet
44.9035°N 85.9682°W

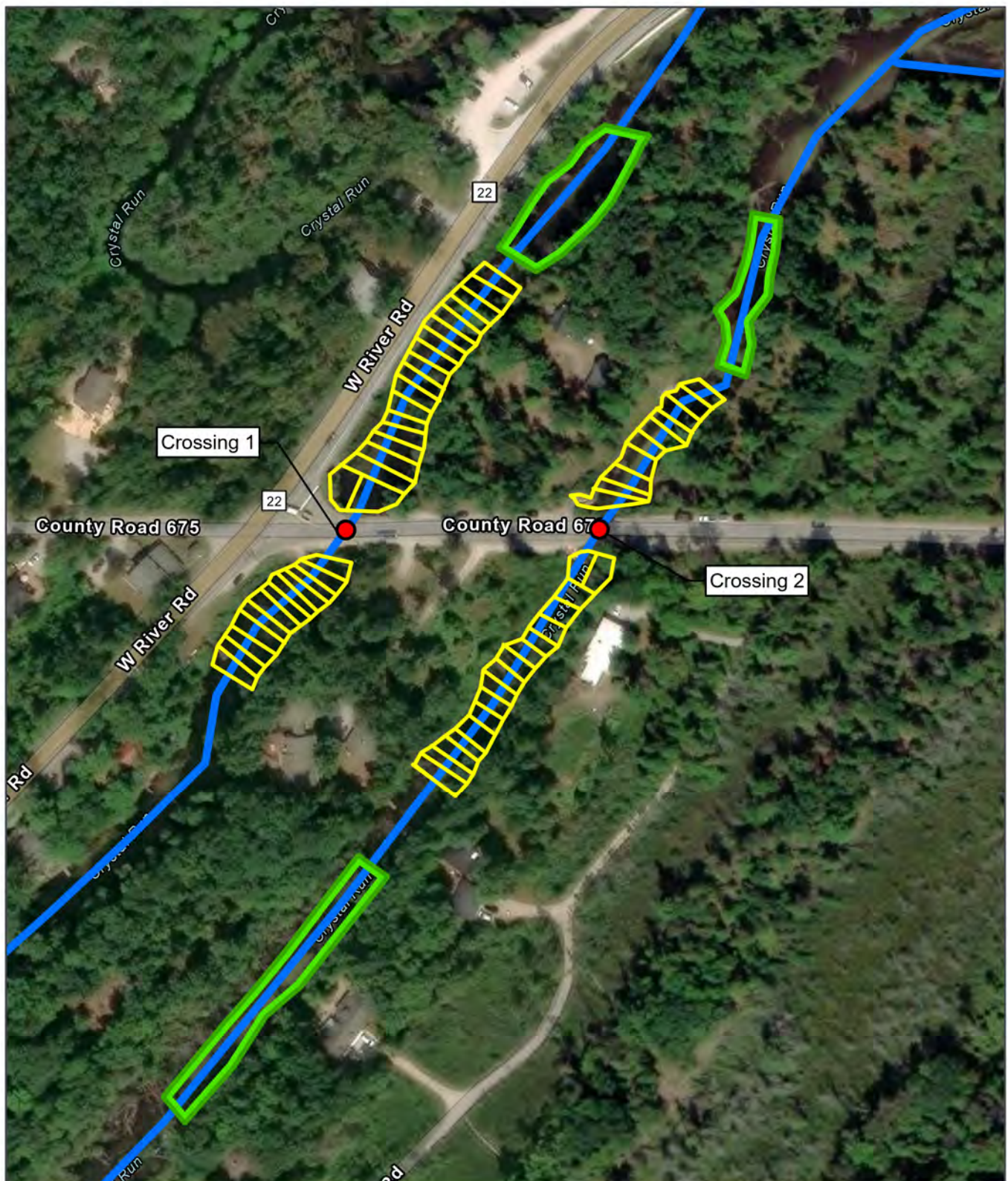
0 1,000 2,000
Feet
0 250 500
Meters



Base Map: Esri ArcGIS Online,
accessed January 2026
Updated: 1/5/2026
Project No. 73781
Layout: Fig 1 Locus
Aprx: 73781_Mussel_Surveys

1:24,000

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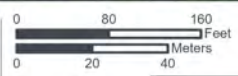


GTEC: CR675 STREAM
CROSSING EA

Figure 2.
Crossings 1 and 2
Survey Areas

- Crossing Location
- Crystal River
- Mussel Relocation Area
- Survey Cell

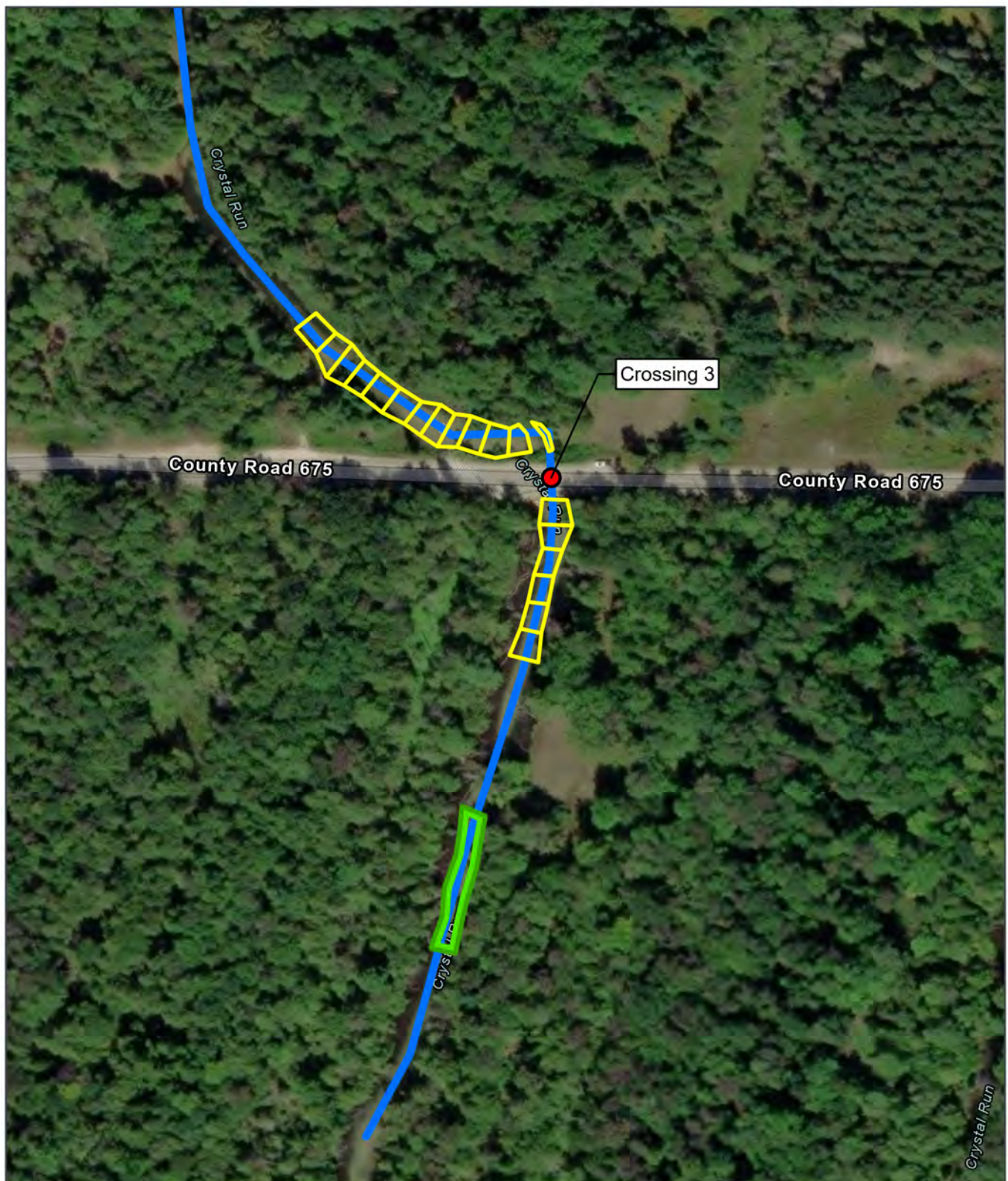
Glen Arbor, MI
USGS 7.5' Quadrangle:
Glen Arbor
NAD 1983 StatePlane Michigan
Central FIPS 2112 Feet
44.903°N 85.975°W



Base Map: Esri ArcGIS Online,
accessed January 2026
Updated: 1/5/2026
Project No. 73781
Layout: Fig 2 Crossing 1/2
Aprx: 73781_Mussel_Surveys

1:2,000

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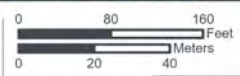
GTEC: CR675 STREAM
CROSSING EA

Figure 3.
Crossing 3
Survey Areas

- Crossing Location
- Crystal River
- Mussel Relocation Area
- Survey Cell

Glen Arbor, MI
USGS 7.5' Quadrangle:
Glen Arbor
NAD 1983 StatePlane Michigan
Central FIPS 2112 Feet
44.9027°N 85.9627°W

Base Map: Esri ArcGIS Online,
accessed January 2026
Updated: 1/5/2026
Project No. 73781
Layout: Fig 3 Crossing 3
Aprx: 73781_Mussel_Surveys



1:2,000

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APPENDIX B

Crystal River Mussel Survey & Translocation

Photographs



Photo B-1. Photograph of the Crossing 3 culvert system slated for replacement, 2024.



Photo B-2. Additional view of Crossing 3 culvert system with recreational paddler, 2024.



Photo B-3. View looking downstream from Crossing 3, 2024.



Photo B-4. Upstream view of Crystal River immediately above Crossing 3, 2024.



Photo B-5. Additional photograph of downstream section of Crossing 3 Survey Area, 2024.

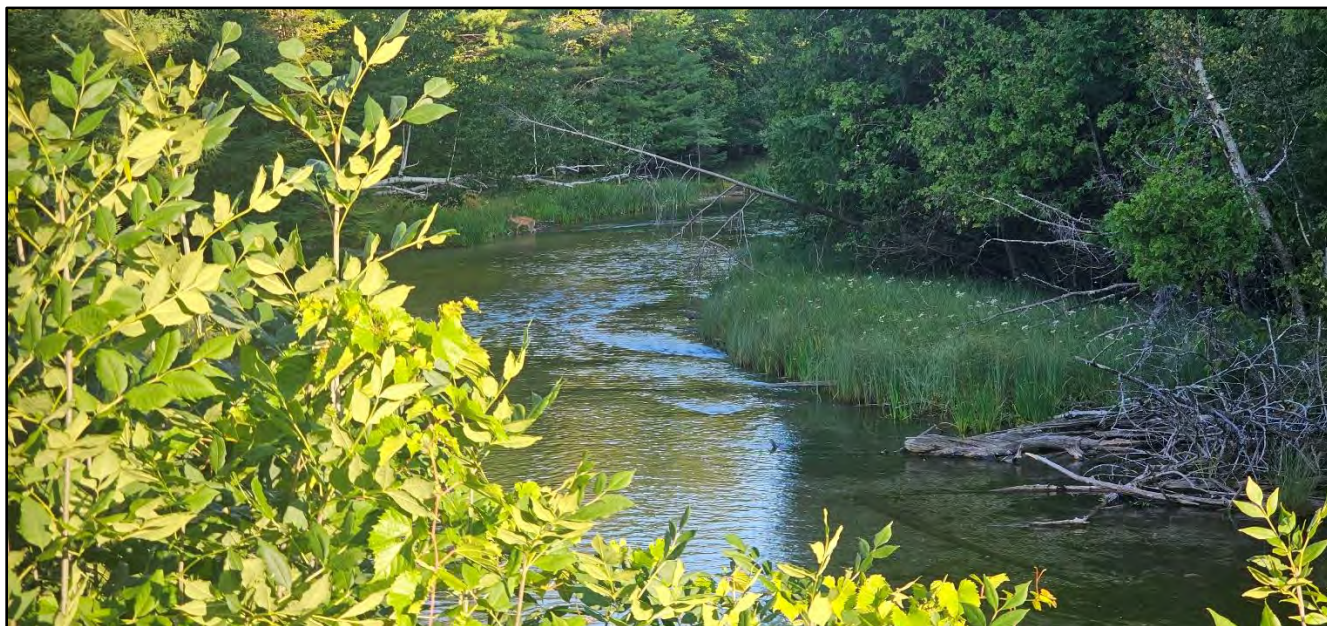


Photo B-6. Section of the Crystal River immediately downstream of Crossing 3 Survey Area, 2024.



Photo B-7. Lead biologist, Steve Johnson, conducting mussel survey via snorkel, Crossing 3 2024.



Photo B-8. Biologist, Jaelynn Stetson, relocating mussels upstream of Crossing 3 Survey Area, 2024.



Photo B-7. A portion of *E. dilatata* collected from upstream section of Crossing 3 Survey Area.



Photo B-80. A *Eurytnia dilatata* that measured 79.95 mm in length and had a shell wear score of 0.25. Crossing 3, 2024.



Photo B-91. A *Lampsilis siliquoidea* located in the upstream Crossing 3 Survey Area.



Photo B-102. Collected mussels that were processed and ready to be relocated. Crossing 3, 2024



Photo B-113. A *L. siliquoidea* relocated upstream of Crossing 3 Survey Area, 2024.



Photo B-124. Relocated *Eurynia dilatata* in sand substrate. Crossing 3, 2024



Photo B-135. Live *Lasmigona compressa* observed upstream of Crossing 3 Survey Area, 2024.

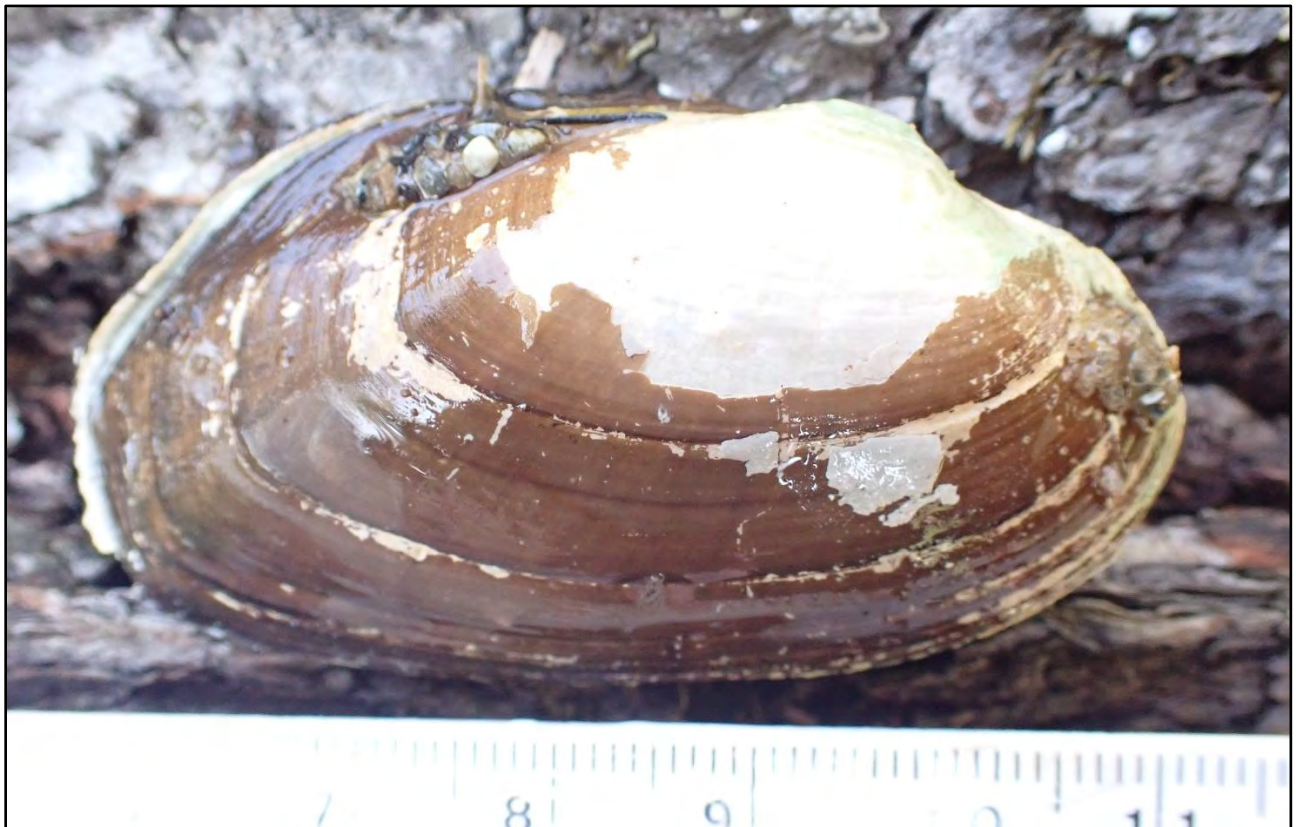


Photo B-146. Sub-fossil shell of *Strophitus undulatus* found immediately upstream of Crossing 3 Survey Area, 2024.



Photo B-17. Live *Lasmigona compressa* observed downstream of Crossing 3 Survey Area, 2024.



Photo B-18. Downstream view of Crossing 1, June 2025.



Photo B-19. Upstream view of Crossing 1, June 2025.



Photo B-20. Downstream section of Crossing 1 Survey Area, June 2025.



Photo B-21. Upstream section of Crossing 1 Survey Area, June 2025.



Photo B-22. Typical survey cell in downstream section Crossing 1 Survey Area, June 7, 2025.



Photo B-23. Survey cell with surveyor in downstream section Crossing 1 Survey Area, June 7, 2025.



Photo B-24. A selection of *E. dilatata* collected from Crossing 1 Survey Area, June 7, 2025.



Photo B-25. Juvenile *E. dilatata* collected from downstream section of Crossing 1 Survey Area.



Photo B-26. *Lampsilis siliquoidea* (left) and *L. cardium* (right) collected from Crossing 1 Survey Area, June 6, 2025.



Photo B-27. *Strophitus undulatus* collected from Crossing 1 Survey Area, June 6, 2025.



Photo B-28. Live *Lasmigona compressa* collected from Crossing 1 Survey Area, June 7, 2025.



Photo B-29. Mudpuppy (*Necturus maculosus*) observed in upstream section of Crossing 1 survey area, June 8, 2025.



Photo B-30. View of Crossing 2 culverts from upstream, June 9, 2025.



Photo B-31. Downstream section of Crossing 2 Survey Area, June 9, 2025.



Photo B-32. Upstream section of Crossing 2 Survey Area, June 9, 2025.



Photo B-33. Survey cell with surveyor in downstream section of Crossing 2 Survey Area, June 10, 2025.



Photo B-34. Survey cell with surveyor in downstream section of Crossing 2 Survey Area, June 10, 2025.



Photo B-35. Juvenile *E. dilatata* collected from Crossing 2 Survey Area, June 10, 2025.



Photo B-36. *E. dilatata* and *L. siliquoidea* collected from downstream section of Crossing 3 Survey Area, June 10, 2025.



Photo B-37. *L. cardium* collected from downstream section of Crossing 2 Survey Area, June 10, 2025.



Photo B-38. Two *S. undulatus* (upper left), three *L. cardium* (middle) and three *E. dilatata* (lower) collected from downstream section of Crossing 2 Survey Area, June 10, 2025.



Photo B-39. Tagged *Lasmigona compressa* relocated from Crossing 2 Survey Area, June 9, 2025.



Photo B-40. Tagged *L. compressa* observed filtering in downstream relocation area of Crossing 2, June 10, 2025.



Photo B-41. Zebra mussel (*Dreissena polymorpha*) attached to *E. dilatata* observed in Crossing 2 survey area, June 10, 2025.



Photo B-42. Filtering *L. cardium* observed in downstream relocation area of Crossing 2, June 10, 2025.



Photo B-43. View immediately downstream of Crossing 3, June 12, 2025. SWCA noted a significant increase in fine sand in this area.



Photo B-44. View immediately upstream of Crossing 3, June 12, 2025. SWCA noted a significant change from 100% fine sand and silt to a more natural mixture of sand, gravel and cobble in this area.