APPENDIX H

DRAFT UNANTICIPATED DISCOVERIES PLAN

Unanticipated Discoveries Plan

Lake Erie Connector Project

Prepared For

ITC Lake Erie Connector LLC
Novi, Michigan

May 8, 2015

Contents

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1 Introduction

ITC Lake Erie Connector LLC (ITC Lake Erie) is proposing to construct and operate the Lake Erie Connector Project (Lake Erie Connector or the Project), an approximately 72.4 mile (116.5 kilometer) 1,000 megawatt +/-320 kilovolt (kV) high-voltage direct current (HVDC) bi-directional electric transmission interconnection to transfer electricity between Canada and the United States. For purposes of permits being issued in the U.S., the Project consists of an approximately 42.5-mile (68.4 kilometer) HVDC transmission line that would be buried in the lakebed of Lake Erie from the U.S.- Canada border and be installed underground in Pennsylvania to a new converter station, called the Erie Converter Station, as well as approximately 1,900 feet to 3,000 feet (579 meters to 914 meters) of underground 345 kV alternating current (AC) cable between the Erie Converter Station and the nearby existing Penelec Erie West Substation. The transmission line cables in the U.S. are proposed to be installed entirely underground, with the vast majority of the route through Springfield, Girard, and Conneaut Townships to be placed within the existing right-of-way of township roads and Pennsylvania Department of Transportation highways.

Although unlikely, there is the potential that undocumented archaeological resources or human remains may be inadvertently discovered within the Project's area of potential effects (APE) during the course of Project construction activities. The procedures described in this Unanticipated Discoveries Plan (UDP) provide protocols for the inadvertent discovery of archaeological materials or human remains as a result of Project construction activities. Contact information for the parties described in this plan is provided in Section 6 of this UDP.

This UDP takes into consideration the following guidance documents:

- The Advisory Council on Historic Preservation's (ACHP) 2007 *Policy Statement Regarding Treatment of Burial Sites, Human Remains and Funerary Objects*.
- The Pennsylvania Historical and Museum Commission – Bureau for Historic Preservation's (PHMC-BHP) 2008 *Guidelines for Archaeological Investigations in Pennsylvania*.

2 UDP Coordinator

Prior to the start of Project construction activities, ITC Lake Erie will designate a UDP Coordinator who will be responsible for overseeing implementation of the UDP requirements. The UDP Coordinator will:

- Serve as the primary point-of-contact for parties consulted pursuant to this UDP;
- Have the authority to stop work in the vicinity of any reported unanticipated discoveries or human remains;
- Coordinate any notification and/or deliverables required under this UDP; and

- Coordinate training as described in this UDP and maintain applicable training records.

3 Training

Prior to the start of Project construction activities, ITC Lake Erie will provide training to assist On-Site Construction Superintendents in recognizing and reporting archaeological material and/or human remains that may be discovered during Project construction. This training will be conducted by a professional archaeologist[1], and will include:

- A description of the nature and type of archaeological resources that may be encountered within the Project's APE, including historic and prehistoric artifacts, deposits, and features; and
- A description of the procedures described in this UDP for reporting any unanticipated archaeological discoveries and/or human remains encountered during Project construction activities.

Additional training will be conducted on an as-needed basis (e.g., for new On-Site Construction Superintendents) during Project construction. The UDP Coordinator will be responsible for coordinating the training and will maintain an Unanticipated Discoveries Plan Training Log (UDP Log) documenting:

- The qualifications of the archaeologist conducting the training;
- The names of On-Site Construction Superintendents that have completed the training; and
- The date training was completed.

4 Procedures for the Unanticipated Discovery of Archaeological Resources

On-Site Construction Superintendents will immediately notify the UDP Coordinator in the event that a potential archaeological resource is encountered during Project construction activities. If a potential archaeological resource is encountered, the UDP Coordinator will take the following actions:

- The UDP Coordinator will direct ground-disturbing activities to be halted in the vicinity of the discovery. The area of work stoppage will be adequate to provide for the security, protection, and integrity of the potential resource. Vehicles, equipment, and unauthorized personnel will not be permitted to access the discovery site.

1 As used in this UDP, an "archaeologist" is defined as an individual who meets the Secretary of the Interior's Professional Qualification Standards for Archaeology (36 CFR Part 61).

  - At a minimum, the immediate area of any terrestrial archaeological discovery will be protected by a temporary barrier (e.g., snow fence) and the location will be marked on Project maps as a restricted area.
  - If a submerged archaeological resource is discovered, the location will be marked on Project maps as a restricted area.
- Within 24 hours of the find, the UDP Coordinator will direct an archaeologist to conduct limited investigations to make a preliminary identification and assessment of the find. This may include digital photos, measurements, and limited hand excavation.
- If the find is determined not be archaeological, work may proceed.
- If the find is determined to be archaeological, the UDP Coordinator will notify the PHMC-BHP as soon as possible.
- If the find is related to the precontact (Native American) period, the UDP Coordinator will also notify the Seneca Nation of Indians (SNI).
- The archaeologist will complete investigations and provide a summary report within 72 hours of notice-to-proceed from the UDP Coordinator.
- The UDP Coordinator will provide the archaeologist's summary report to the PHMC-BHP and the SNI (if the find is related to the precontact period).
- ITC Lake Erie will consult with the PHMC-BHP and the SNI (if the find is related to the precontact period) to develop a specific Management Plan for the inadvertent archaeological discovery. Management Measures may include (but are not limited to:
  - Avoidance and protection;
  - Phase II Site Evaluation; and
  - Mitigation (Phase III Data Recovery or alternative mitigation).

Work in the vicinity of the resource will proceed once a Management Plan has been approved by the PHMC-BHP or the site is determined to be ineligible for the National Register of Historic Places (NRHP).

5 Procedures for the Unanticipated Discovery of Human Remains

Treatment and disposition of any human remains that may be discovered will be managed in a manner consistent with the Native American Graves Protection and Repatriation Act (25 USC 3001 et seq.)[2] and the ACHP's 2007 *Policy Statement Regarding Treatment of Burial Sites, Human Remains, and Funerary Objects*. At all times human remains will be treated with the utmost dignity and respect. If a burial site, human remains, or bones thought to be human remains are encountered, the UDP Coordinator will take the following actions:

- The UDP Coordinator will immediately direct any ground-disturbing activities to be halted within a minimum of 100 feet of the discovery. The immediate area of any human remains or suspected human remains will be protected by a temporary barrier and the location will be marked on Project maps as a restricted area.
- The UDP Coordinator will immediately notify the PHMC-BHP, SNI, the Pennsylvania State Police (PSP) and the county coroner/medical examiner having jurisdiction and will arrange for inspection of the site.
- The coroner/medical examiner and PSP will make the official ruling on the nature of the remains, being either forensic or archaeological.
- If the remains are determined to be forensic in nature, the PSP will notify the ITC Lake Erie when work in the area may resume.
- If human remains are determined to be archaeological and Native American, the remains will be left in place and protected from further disturbance until a plan for their avoidance or removal can be generated.
    - Avoidance is the preferred choice of the ITC Lake Erie. ITC Lake Erie will consult with the PHMC-BHP and the SNI to develop a plan of action that is consistent with NAGPRA guidance.
- If human remains are determined to be archaeological and non-Native American, the remains will be left in place and protected from further disturbance until a plan for their avoidance or removal can be generated. The UDP Coordinator will coordinate with the PHMC-BHP to determine an appropriate plan of action based on consultation.
- Work will only resume following completion of appropriate treatment measures.

[2] Pursuant to 43 CFR Part 10, NAGPRA applies to human remains, sacred objects, and items of cultural patrimony (described as "cultural items" in the statute) located on federal or tribal lands or in the possession and control of federal agencies or certain museums. The Project will not occupy federal or tribal lands. Notwithstanding the limits of NAGPRA's applicability, the principles described in NAGPRA and its implementing regulations will serve as guidance should remains or associated artifacts be identified as Native American, and to the extent such principles and procedures are consistent with any other applicable laws, guidelines, statutes, and requirements.

6 Contact Information

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Pennsylvania State Police
Troop E
5950 Meadville Road
Girard, PA 16417
Phone: 814-774-9611

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Room 07
Erie, PA 16501
Phone: (814) 451-6331
After-hours phone: (814) 452-2911

APPENDIX I

LAKE ERIE CONNECTOR, BLASTING IMPACT ANALYSIS IN U.S. WATERS

LAKE ERIE CONNECTOR
BLASTING IMPACT ANALYSIS IN US WATERS
NOVEMBER 2015

INTRODUCTION

Project Description

ITC Lake Erie Connector LLC is proposing to construct and operate the Lake Erie Connector Project (Project), an approximately 116.5 km (72.4 mile) 1,000 megawatt (MW) +/-320 kilovolt (kV) high-voltage direct current (HVDC) bi-directional electric transmission interconnection to transfer electricity between Canada and the United States (US) through a submarine transmission cable across Lake Erie (Figure 1). The HVDC transmission line consists of two transmission cables, one positively charged and the other negatively charged, along with a fiber optic cable for communications between the converter stations located on either side of the border.

In most areas the cables will be buried in the lakebed by a jet plow to protect the cables from damage due to shipping traffic, fishing activity, and ice scour. Typical burial depths in jettable material range from 3 to 10 ft (1 to 3 m). At the Erie, Pennsylvania (US) landfall, bedrock is either exposed or very close to the surface near shore, preventing cable burial via jet plow. Due to these geological constraints, a trench may need to be excavated by confined stemmed blasting in the bedrock (primarily shale) for approximately 1 mile (1.6 km) from the exit of the horizontal directional drilling (HDD) bore (approximately 2,000 ft [609.6 m] from the shoreline) to softer lake bed material where jet plow burial can be utilized. Stemmed charges will involve explosive materials placed into holes drilled into the substrate.

Stemming is an approach that maximizes the propagation of shock forces into the substrate rather than into the water column, thereby increasing the efficiency of fracturing rock or consolidated materials while minimizing potential impacts to aquatic life and water quality. The trench would have a depth of approximately 6 ft (1.8 m) to grade, which includes bedrock and any overlying mud and silt, and would have a width of approximately 4 ft (1.2 m). This method of blasting was selected to minimize potential impacts compared to detonations in open water, which would produce both higher amplitude and higher frequency shock waves than contained detonations. The preferred technique of stemming charges has been demonstrated to reduce pressures and lower aquatic organism mortality than the same explosive charge weight detonated in open water (Hempen et al. 2007, Nedwell and Thandavamorthy 1992).

It is expected that a barge-mounted drill will drill 4-inch (10-cm) diameter blast holes to a depth of 4 ft (1.2 m) below the planned excavation grade. Additional blast holes will be required at similar intervals for the offshore sump pits will be excavated in the rock at the exit of the HDD (one bore for each HVDC cable and one bore for the fiber optic cable). Each of the three sump pits will be approximately 20 x 10 x 7 feet (6.1 x 3.1 x 2.1 meters). The holes will be packed with low-level Hydromite emulsion explosive, stemmed and detonated. The blasted rock will be removed by a barge-mounted excavator and side cast on the bottom. The trench will be bedded

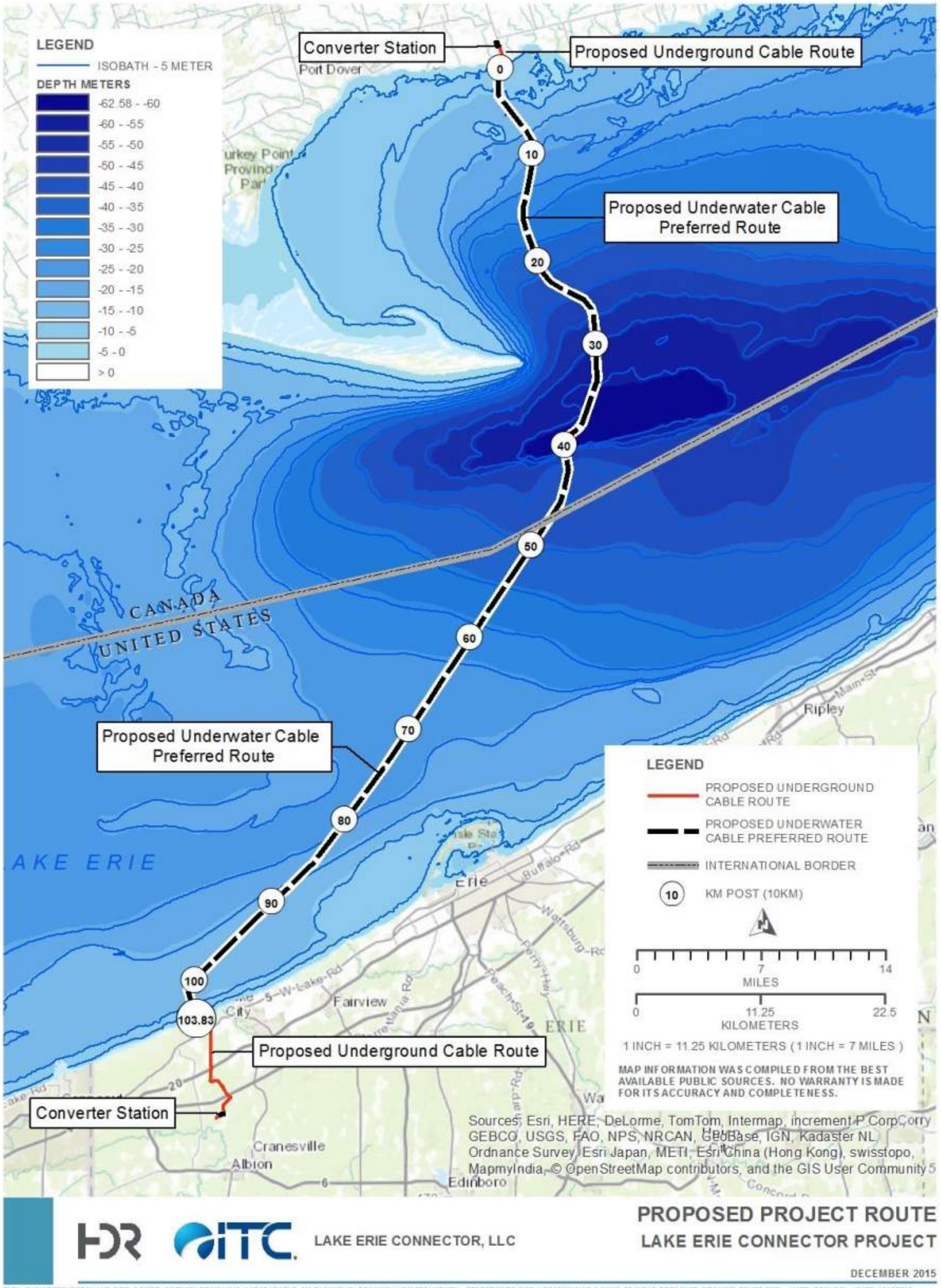


Figure 1. Proposed Project Route

and backfilled with a sand and gravel mixture (originating from an on-land source). According to the preliminary blasting plan, approximately 20 to 30 stemmed charges arranged in a zig-zag drill pattern over a trench length of 30 to 40 ft (9 to 12 m) will constitute an individual charge or “shot”. One shot would occur per day. This pattern would yield an approximate daily advance rate of 40 to 50 ft per day (12 to 15 m per day). Therefore completion of the blasting portion of the Project, assuming shots would occur on consecutive days, would require approximately 130 days between May and November.

Review of Existing Studies and Research

The detonation of explosives in or near water produces post-detonation compressive shock waves characterized by a rapid rise to a positive peak pressure followed by a rapid decay to below ambient hydrostatic pressure, creating a pressure deficit. The latter pressure deficit and the increase in peak particle velocity as a result of the detonation can have an adverse impact on aquatic life, particularly in fish spawning areas (Wright and Hopky 1998).

Depending on a number of variables, the detonation of explosives in or adjacent to fish habitat may cause disturbance, injury and/or death to fish, and/or the harmful alteration, disruption or destruction of their habitats (Wright and Hopky 1998). In some cases, blasting can cause mortality, physical injury, auditory tissue damage, permanent and temporary threshold shifts, behavioral changes, and decreased egg and larvae viability (Hastings and Popper 2005). The duration of temporary hearing loss varies depending on the nature of the stimulus, but, by definition, there is generally recovery of full hearing over time (Popper and Hastings 2009).

In general, the expected scales of potential impacts on local fish communities are contingent on multiple factors, including the characteristics of the explosion (e.g., type and amount of explosive charge, location in the water column or substrate, depth, substrate type) and morphology (e.g., presence/absence of swim bladder, size) and behavior (e.g., orientation to substrate) of the species exposed to blast forces. Factors that govern the scales of impact are reviewed in Continental Shelf Associates (2004) and Popper et al. (2014). Although the physical aspects of underwater explosions are relatively well understood and predictable, considerable uncertainty still surrounds the responses and meaningful thresholds of exposure for a large majority of fish species and life history stages. Popper et al. (2014) recommended exposure guidelines based on the existing state of knowledge relevant to sound pressure and particle motion. Using conservative estimates for juvenile and adult fishes in three groups (i.e. fishes with no swim bladder, fishes with swim bladders but no involvement in hearing, and fishes with swim bladders involved in hearing) based on Hubbs and Rechnitzer (1952) experimental data, Popper et al. (2014) identified 229 to 234 dB peak values referenced to 1 microPascal as exposure thresholds that could cause immediate or delayed mortality.

Given the lack of quantitative data on thresholds for non-permanent injury, temporary threshold shifts (TTS) which are short or long term changes in hearing capability, and behavioral responses (i.e. avoidance, change in feeding), Popper et al. (2014) relied on relative probabilities of impact (high, moderate, low) at distances from the source that are near (10s of meters), intermediate (100s of meters), and far (greater than 1,000 meters). The probability of non-lethal responses would be low at far field distances for all fish species. However, according to the Popper et al

(2014) predictions, fishes with swim bladders involved in hearing would experience high probabilities of all three categories of non-lethal impact at intermediate distances. At intermediate distances fishes with swim bladders that are not involved with hearing would experience high probabilities of recoverable injuries and behavioral responses, but moderate probabilities of TTS. Fishes lacking swim bladders would experience low probabilities of recoverable injuries and moderate probabilities of TTS and behavioral responses at intermediate distances (Popper et al. 2014).

Predicting non-lethal responses is more difficult owing to the diversity of fish species that might be present in the Project area. No evidence of TTS in fishes as a response to explosions has been documented, although the frequency of explosion events may come into play. Likewise, behavioral responses have not been documented for free swimming fishes near underwater explosions. Startle reactions, which are short in duration, would be the most probable response (Popper et al. 2014).

The above thresholds pertain to juvenile and adult stages of fishes. With respect to egg and larval stages, relatively little research has been conducted. Criteria applied by the Canadian government are based on findings that developing embryos could be damaged by shock waves propagating through the water column or through the substrate. In these cases particle motion is presumed to be the underlying cause of impact rather than sound pressure. Consequently Popper et al. (2014) refer to Wright and Hopky (1998) as the basis for setting 13 mm/s (0.51 in/s) as the maximum allowable peak particle velocity in a spawning habitat during any period when eggs are present.

Few previous studies of effects of underwater explosions have been performed in the Great Lakes region. Ferguson (1961) subjected caged yellow perch (*Perca flavescens*) to underwater blast pressures produced by charges of nitrone, nitrone primer, black powder, and squib cap near Wheatley, Ontario, Canada. All explosions occurred in 5 to 10 ft (1.5 to 3.1 m) of water at locations where bottom depths ranged up to 58 ft (17.7 m). Cages were placed at a depth of 10 ft (3.1 m) or rested on the bottom at distances from 25 to 207 ft (7.6 to 63.1 m). Black powder charges produced few injuries among any caged fish, and then only if a nitrone primer was used to detonate the charge. Nitrone primer detonated alone produced mortalities in almost all caged perch at 50 ft (15.2 m) and injured many at 200 ft (61.0 m). A 20 lb nitrone charge produced mortalities in almost all perch out to 200 ft (61.0 m). It is important to note that mid-water explosions are known to be much more damaging than stemmed charges detonated in the substrate. Also, yellow perch have well-developed swim bladders, rendering them sensitive to pressure changes, and are not representative of entire fish assemblages (Ferguson 1961), such as the range of fish species found in the Great Lakes.

The reduced impacts of stemmed charge/subterranean explosions versus mid-water explosions were illustrated by Traxler et al. (1992), who reported no mortalities or observable injuries among largemouth bass (*Micropterus salmoides*), bluegills (*Lepomis macrochirus*), and channel catfish (*Ictalurus punctatus*) held in cages placed directly above and at distances between 7.6 and 91.4 m (25 and 300 ft) from shot holes containing 4.5 and 9.1 kg of dynamite. Their experiments were conducted in a freshwater reservoir in Texas.

Teleki and Chamberlain (1978) monitored acute effects of blasting on fishes during deepening on a site in near-shore waters at Nanticoke, Long Point Bay, Lake Erie. Their experimental design involved deployment of caged specimens of 13 locally caught fish species at predetermined distances as far as 185 m (607 ft) from the explosion. Post-explosion monitoring included collection of free swimming fishes for a period of 30 minutes following the blast. Peak pressures at predetermined distances and depths were recorded over the course of 201 blasts. Explosions occurred in three types to fracture the limestone bedrock below overlying glacial till and silt: (1) "sinking cut" charges to expose the bedrock, (2) "production" charges to crush exposed rock face, and (3) "toe" charges to level any remaining high spots following the production blasts. Immediately after each explosion fishes were removed from the cages and autopsied for evidence of barotrauma or other injuries. Peak pressures associated with the blasts were influenced by the type of substrate and the depth of the drilled hole containing the charge. Among caged fishes pumpkinseed (*Lepomis gibbosus*), crappie (*Pomoxis* sp.), and white bass (*Morone chrysops*) were most sensitive to pressure changes, whereas rainbow trout (*Oncorhynchus mykiss*), yellow bullhead (*Ameiurus natalis*), and white sucker (*Catostomus commersonii*) were least sensitive. Other species exposed in cages were gizzard shad (*Dorosoma cepedianum*), yellow perch (*P. flavescens*), smallmouth bass (*Micropterus dolomieu*), rock bass (*Ambloplites rupetris*), freshwater drum (*Aplodinotus grunniens*), quillback (*Carpiodes cyprinus*), and common carp (*Cyprinus carpio*). Additional species occurred in the post-blast free swimming fish catches. Emerald shiners (*Notropis atherinoides*) occurred commonly among visibly injured fishes at the surface, with trout-perch (*Percopsis omiscomaycus*) and rainbow smelt injured less frequently. In sub-surface and bottom towed nets higher mortalities were observed in the upper stratum (< 4 m, 13.1 ft), which consisted primarily of alewives (*Alosa pseudoharengus*) and emerald shiners. Among the caged fishes the minimum peak pressure that produced immediate or delayed mortalities varied greatly between species, generally between 30 and 85 kPa (Teleki and Chamberlain 1978).

The above field studies are relevant to juvenile and adult fishes, but concerns have also been expressed by regulatory agencies for protection of eggs, particularly those that develop while in intimate contact with the substrate. In theory, vibratory forces expressed as particle velocity in addition to pressure changes could detrimentally affect embryonic development and survival. In two separate studies Faulkner et al. (2006, 2008) examined the fates of lake trout (*Salvelinus namaycush*) and rainbow trout (*Oncorhynchus mykiss*) eggs exposed to blast forces. Lake trout eggs were exposed to blasts in an open water mining pit, whereas rainbow trout eggs were exposed to simulated blast parameters under controlled laboratory conditions. Measured peak particle velocities at the lake trout egg exposure site reached 28.5 mm/s (1.1 in/s), more than twice the established Canadian protection standard of 13 mm/sec (0.5 in/s). In terms of survival, when exposed lake trout eggs were compared to eggs at a reference site, no significant effects were observed. In the laboratory experiments increased mortality rates were found only when rainbow trout eggs were exposed to particle velocities greater than 132.3 mm/s (5.2 in/s) (Faulkner et al. 2006, 2008).

Another commonly used blasting assessment guidance document was developed by Baker (2008) which discusses recommendations for assessing impacts to protected species (threatened and endangered species and marine mammals), and mitigation planning for the use of explosives during the construction, operation, maintenance, or decommissioning phases of a project. The

Baker method used to calculate setback distance varies based on the blasting plan type (e.g. confined, unconfined). As noted in the guidance document, the method is believed to be highly conservative in estimating zones of influence for protected species because it is intended to protect more sensitive marine species such as marine mammals in addition to fish.

Therefore, as discussed in the Methods Section below, blasting standards established by the Alaska Department of Fish and Game (ADF&G 1991) and Timothy (2013) for Alaskan waters represent more appropriate and the most recent guidance available for the present Project scenario.

In Pennsylvania waters of Lake Erie, three fish species merit special consideration due to their status as state protected species: lake sturgeon (*Acipenser fulvescens*), eastern sand darter (*Ammocrypta pellucida*), and cisco (*Coregonus artedi*). Lake sturgeon spawn during April to June over gravel shoals and along rocky shorelines of lakes in water depths of 1 to 15 ft (PNHP 2015, GLIMDS 2015, Scott and Crossman 1998). Most eastern sand darters spawn during June and July (Crisewell 2013). They have not been observed to spawning in the wild (Adams and Burr 1994), but are reported to occur in clean sandy shoals along lakeshores (Criswell 2013), although this species has also been found in depths of 15 m to 20 m and greater in Lake Erie (Grandmaison et al. 2004, PFBC unpublished). Cisco spawn in late fall to early winter (ODNR 2014) and hatch soon after ice out (MDNR 2015). Spawning occurs in shallow water (1-3 meters) over gravel or stony substrate, but also may occur pelagically in midwater (Nature Serve 2015, Pritchard 1931, Smith 1956, Becker 1983, Scott and Crossman 1998). A search of the scientific literature found no data on blasting effects thresholds for these species.

For this Project, the potential for impacts to occur along the proposed underwater cable route was assessed by estimating the extent and duration of the sound pressure level and shock wave associated with the proposed blasting, and comparing these estimates to published guidelines and effects thresholds for fish species that have published criteria. The following sections provide the methods and the assessment.

METHODS

<u>Rationale for and Calculation of Setback Distance</u>

In order to assess the scales of potential impact of blasting on aquatic resources, one must determine the probabilities of a blast producing forces that exceed thresholds of detrimental effect and then relate the thresholds to meaningful levels of severity. That is, the calculation of setback distance approach evaluates exposures of fishes to blast-induced forces that could potentially cause mortality or sublethal responses. Therefore, an assessment must consider the magnitude or intensity of exposure with respect to distance from the blast. For example, as described below, studies in Alaska were used to establish "setback" distances to provide a margin of safety for permitting projects in the vicinity of known fish spawning habitat; restricting blasts to locations at distances greater than what would induce detrimental impacts would serve as an effective mitigation measure. In cases such as the present Project the near shore zone is used by multiple species for spawning, nursery and foraging habitat, the assumption can therefore be made that blasting will occur in proximity to one or more species.

In this case setback distances can be used to estimate spatial scales of impact at a predetermined level of severity, allowing the potential impacts to be placed into perspective and integrated into an overall assessment of their ecological significance. The approach applied in this analysis is inherently conservative, incorporating calculations of distances that would likely be overestimates of actual spatial scales of impact.

Methods

Methods for estimating the extent (distance) to energy and pressure thresholds based on the total net explosive weight of the blasting charge and delay have been established (ADF&G 1991, Timothy 2013). Blasting standards established by the Alaska Department of Fish and Game (ADF&G 1991) and Timothy (2013) for Alaskan waters represent the most recent and appropriate guidance available for the Project in U.S. waters. Setback distances specify the distance from the explosive source at which overpressure and particle velocity levels would fall below thresholds at which detrimental impacts on free swimming fishes (overpressure) or fish eggs (particle velocity) are anticipated to occur (Kolden and Aimone-Martin 2013). This concept can be used to estimate the spatial scales of potential impact surrounding an individual blasting event. Using the methods presented in ADF&G 1991, an estimate of the setback distance for confined explosives was employed to determine the area of effect near the US landfall using published critical values of both overpressure and peak particle velocity (Table 1).

The estimated charge weight per hole is 14 pounds (6.35 kg), with 32 holes per string, spaced 2.5 ft (0.76 m) apart with a charge delay of 25 ms.

Table 1. US Confined Explosive Guideline Criterion

Criteria	USA
Overpressure	7.3 psi
Peak Particle Velocity	2.0 in / s
Source	Timothy 2013

Computation of the setback distance for each guideline criteria is as follows:

Eqn 1.

Equation 1 describes the relation between acoustic impedance and the density and velocity of the medium through which the compressional wave travels:

$$Z_r^w = \frac{Z_w}{Z_r} = \frac{D_w C_w}{D_r C_r}$$

where:

D_w = density of water = 62.5 lbs/ft^3
D_r = density of substrate in lbs/ft^3
C_w = compressional wave velocity in water = 4,800 ft/s
C_r = compressional wave velocity in substrate in ft/s
Z_w = acoustic impedance of water
Z_r = acoustic impedance of substrate

Values for D_r and C_r for rock substrate are 165 lbs/ft^3 and 15,000 ft/s as given in ADF&G 1991.

Eqn 2.

Equation 2 describes the transfer of shock pressure from the substrate to the water:

$$P_w = \frac{2\, Z_r^w P_r}{1 + Z_r^w}$$

where:

P_w = pressure (psi) in water
P_r = pressure (psi) in substrate

By setting the value of P_w to the criteria pressure levels from Table 1 the corresponding value for P_r can be computed.

Eqn 3.

Equation 3 describes the relation between the peak particle velocity (V_r) and the pressure, density and compressional wave velocity in the substrate:

$$V_r = \frac{2P_r}{D_r C_r}$$

Eqn 4.

Equation 4 represents the scaled distance relation and is used to equate the peak particle velocity to charge weight and distance:

$$V_r = 100\left(\frac{R}{\sqrt{W}}\right)^{-1.6}$$

where:

V_r = peak particle velocity in in/s
R = distance to the detonation point in ft
W = charge weight per delay in lbs

RESULTS

The resulting setback distance using the proposed charge weights, guidelines from Table 1 and equations 1 through 4 are summarized in Table 2 and shown graphically in Figures 2 and 3.

Table 2. Setback Distance for Guideline Criteria, Timothy 2013

Criteria	Setback Distance
Overpressure (fish)	63.3 ft
Peak Particle Velocity (eggs)	53.1 ft

Figure 2. Rock Blasting Pressure (psi) - USA

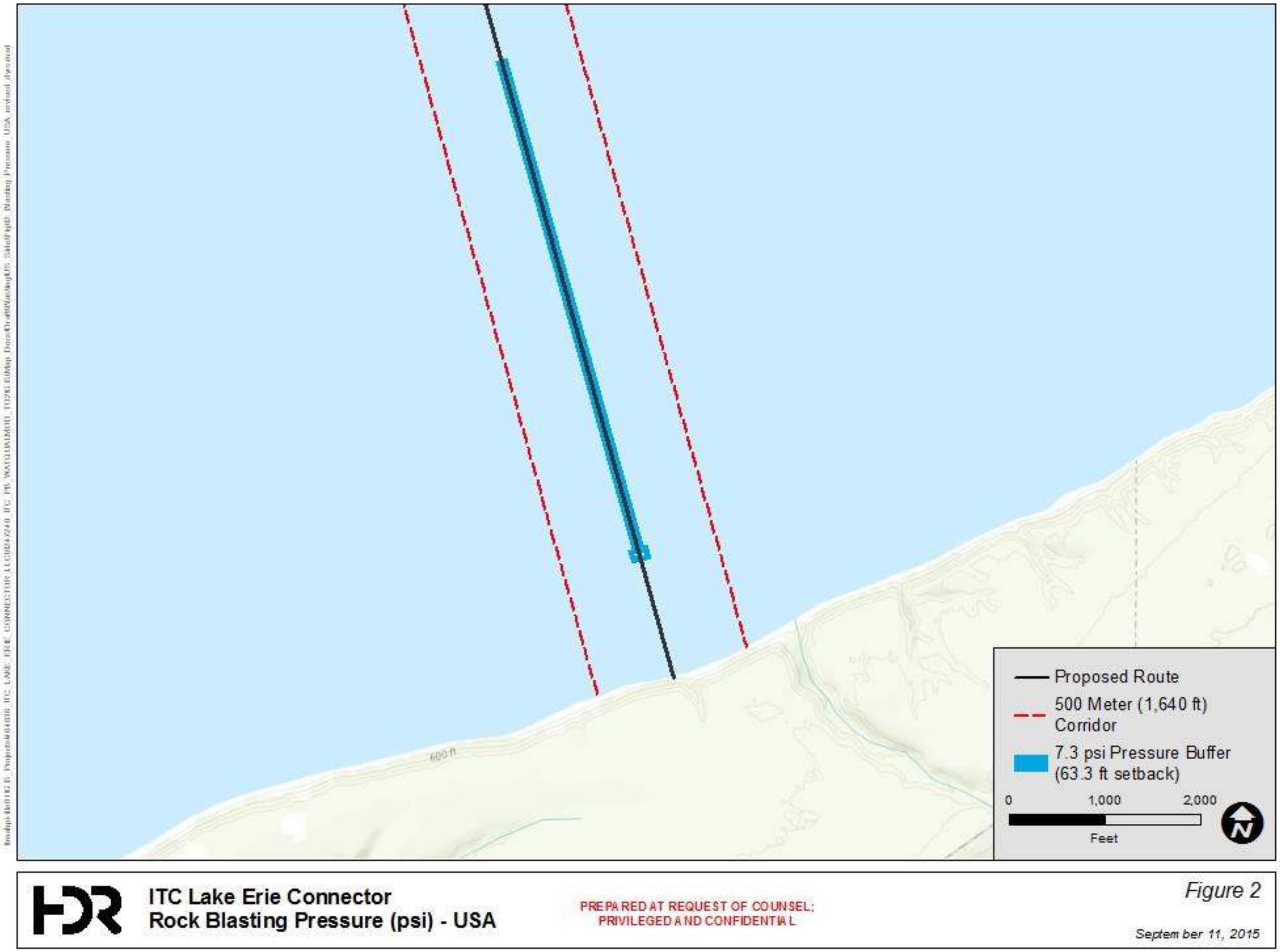
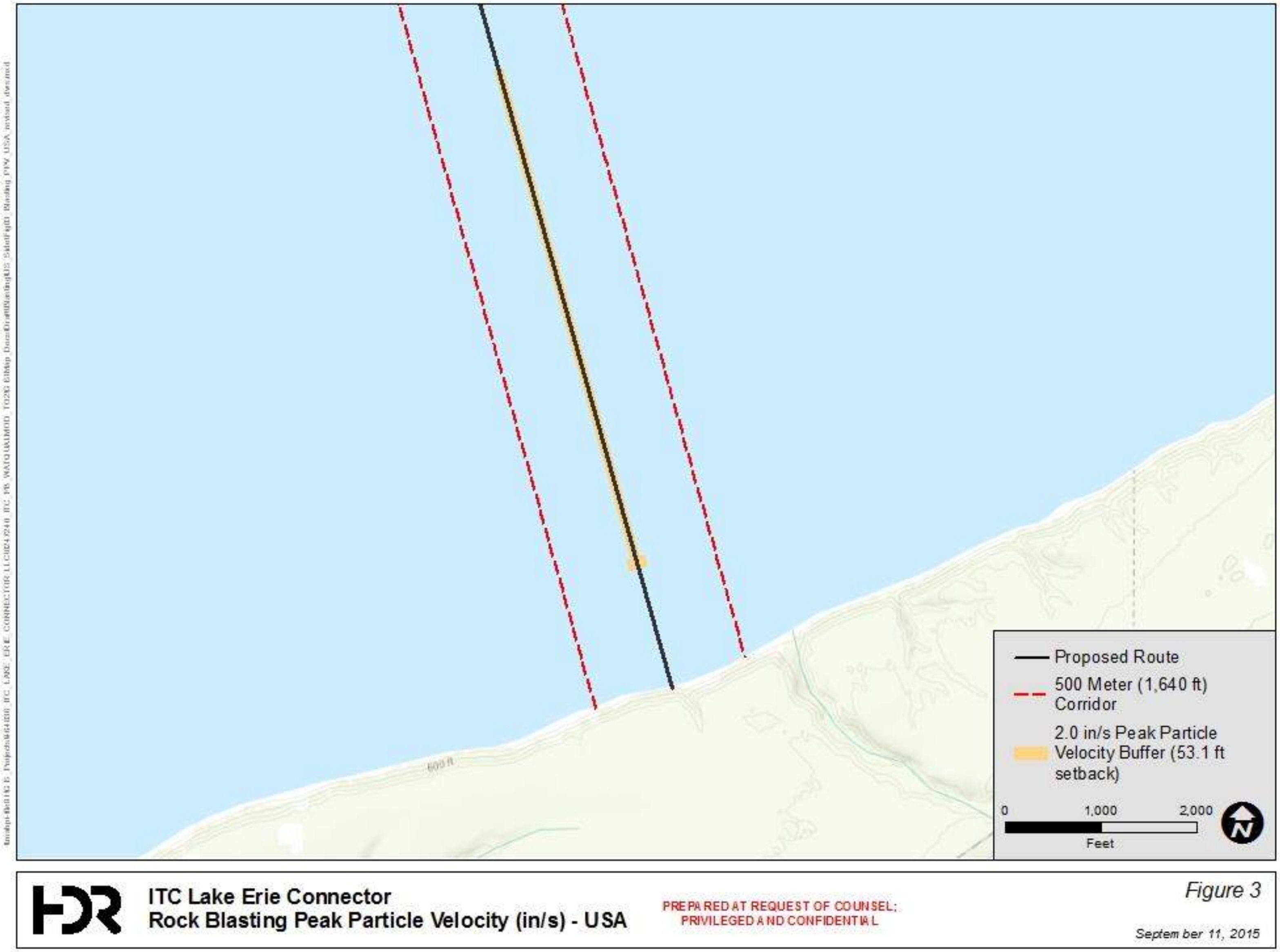


Figure 3. Rock Blasting Peak Particle Velocity (in/s) – USA



ASSESSMENT

In the area immediately adjacent to the shoreline out to approximately 2,000 ft (609m), HDD will be used to avoid important spawning habitat for the Lake Erie fish community. Blasting is being proposed in Lake Erie only for distances of approximately one mile beyond the lakeward extent of HDD where bedrock is either exposed or very close to the surface, before the bedrock transitions to silt amenably to use of jet plow cable installation.

Impact Assessment

Based on the review of existing literature and studies discussed above, the assumptions used to calculate the setback distance for peak particle velocity and pressure for this Project are conservative. Applying the above approach to estimating potential impacts on fish takes into consideration the fact that high risk of lethal or permanent injury would be confined to the immediate vicinity of the explosion where compressive forces of the shock wave predominate. Injuries at greater distances are generally caused by negative pressures associated with overshoot of the gas bubble formed by the explosion and reflection of the shock wave from the water's surface (Popper et al. 2014). The 229 to 234 dB re 1 microPascal threshold for mortality recommended by Popper et al. (2014) corresponds to 40 to 70 psi or 276 to 482 kPa. Thus the overpressure criteria identified in Table 1 (7.3 psi and 100 kPa) are very conservative. The potential for lethal impacts would be expected to occur in a very small footprint (less than 63.3 ft (19.2m) from the blast location) surrounding an individual blast.

A single blast per 24 hr period would not be expected to induce strong avoidance responses. Following startle responses, which might last only for seconds to minutes, fishes would return to the general vicinity of the blast. Blasting events will not be long in duration with repeated exposures sustained over periods as long as hours to days. Repetitive detonations over relatively short periods of time, which will not occur for this project, would have a greater risk of TTS and behavior responses. However, for this project we do not expect this to be the case and anticipate a lower likelihood of physiological impact or prolonged behavioral response due to the blasting plan.

Blasting can cause mortality, physical injury, auditory tissue damage, permanent and temporary threshold shifts, behavioral changes, and decreased egg and larvae viability. However, based on the setback calculation for this Project, the extent of direct impacts and mortality is limited to 63.3ft (19.2m). Peak pressures and particle velocities decrease with distance from the detonation and therefore potential impacts are reduced as well.

A number of commercially, recreationally, or ecologically important fish species spawn in shallow Lake Erie habitats in spring and early summer. For example, yellow perch, white bass, walleye (*Sander vitreus*), alewives, rainbow smelt and spottail shiner (*Notropis hudsonius*) all spawn over sandy, gravel, or rocky substrates in March through April and into May (Daiber 1953, Bodola 1966, Leach and Nepszy 1976, Madenjian et al. 1996, Roseman et al. 1996). In addition, lake sturgeon, which is provided protected status, spawns primarily in tributaries but potentially also over gravel shoals and rocky shorelines in April through early June when water temperatures are between 55 and 64^{o}F (GLIMDS 2015, Dick et al. 2006, Scott and Crossman

1998). Other species spawn during warmer months, including brown bullhead (*Amieurus nebulosus*), channel catfish, pumpkinseed, and gizzard shad. Eastern sand darters spawn during June and July (Crisewell 2013). Although the required duration of blasting precludes avoiding all potential conflicts with fish spawning seasons, the period from July through November would avoid the peak spawning periods of a majority of species. Starting in June would provide additional flexibility to accommodate severe weather and other unanticipated delays in daily blast schedules while maintaining maximum protection of fishery resources. Extending the work period into fall months would be less problematic from an overall fishery resource perspective because most fall-spawning fishes, such as various salmon species and lake trout, move into tributaries to spawn.

As the criteria also apply to fish habitat, there will be direct impacts to benthic habitats at the blast zone. However, following cable installation, that area is expected to recolonize from recruitment from nearby, unaffected areas of the lake. Recovery for benthic communities varies, ranging from several months to several years, depending on the type of community and type of disturbance (DOE 2013). Depth contours will be returned to pre-existing conditions by filling the trench with upland-derived material. Excavated coarse material will be side-cast and in the long-term provide relief and habitat structure that could offset any temporary disruption of fish access to nearshore habitats.

As discussed above, the setback distance for this Project (e.g., the area of potential impact) was calculated using the following criteria developed by the Alaska Department of Fish and Game. The criteria are summarized below:

The instantaneous pressure rise in the water column in rearing habitat and migration corridors is limited to no more than 7.3 psi where fish are present. Peak particle velocities in spawning gravels are limited to no more than 2.0 in/s (50 mm/s) during the early stages of embryo incubation before epiboly is complete.

The proposed blasting plan was developed using the following best management practices to reduce potential impacts to spawning and early life stages of fish species and to satisfy the above criteria. Therefore, the Project is not expected to have a significant impact on fish species. The use of a confined stemmed bore hole blasting technique where charges are placed in confined holes rather than at the surface effectively reduces blast forces transmitted through the water column horizontally, and the depth of the blast hole collar was noted to also influence effects. Charge weight was found to be related to the scales of effects, although not in a linear relationship. Implementation of delays between the onset of multiple blasts by installing blasting caps was found to mitigate effects as long as the delay duration exceeded 25 msec, and preferably 50 msec. Finally, stemming, a technique in which the bore hole gap above the charges are filled with material to enhance containment of blast forces within the substrate was recognized as an effective mitigation measure, particularly when angular material such as crushed rock of greater than 1/12th the bore hole diameter was used as stemming material.

The Project may use additional impact avoidance techniques such use of blasting mats, deployment of bubble curtains or measures to mobilize and clear fish from the immediate blast area. Because the present Project will involve blasting in areas where fish occupation will change on a daily and seasonal basis, it is impossible to predict with absolute certainty that no fishes will be impacted detrimentally. However, existing guidelines and studies heavily suggest that detrimental impacts will be limited to within the calculated setback distance of 63.3 ft (19.3 m).

Both Keevin (1998) and Koschinski (2011) recognized the need for cost/benefit analyses in the selection and execution of additional impact avoidance techniques. For example, implementation of bubble curtains, although known to be effective, have many logistical issues, including size (i.e., required linear dimensions to enclosed the entire blast), provision of adequate compressed air, system movement between blasts, and operational feasibility during periods of marginal or severe weather, that factor into their expense and utility. Given the present Project schedule and location, a bubble curtain is likely unwarranted because the minimum required deployment distance around the blast area would be equal to or greater than the calculated setback distance, and therefore provide little or no protection benefit to fishes beyond the setback distance.

CONCLUSION

As previously noted, the confined and stemmed blasting method was selected to minimize potential impacts. Stemming charges will result in substantially reduced peak pressures and lower aquatic organism mortality rates than comparable open water detonations (Hempen et al. 2007, Nedwell and Thandavamoorthy 1992).

In addition, most impacts from noise would be either temporary or intermittent and it is expected that only a few individuals would be affected relative to the broadly dispersed stocks of any given species in Lake Erie. Of those species in the Project area, many individuals would be expected to react by moving away from noise sources. The amount of explosives used will be limited to the extent possible to avoid noise and vibration impacts on fishes. A detailed blasting plan, consistent with PADEP and PFBC requirements and including appropriate mitigation measures, will be developed prior to construction that will consider limiting noise impacts to fish and other aquatic organisms to the extent practicable. Additional consideration will be given to supplemental mitigation measures, including use of blasting mats, deployment of bubble curtains or measures to mobilize and clear fish from the immediate blast area.

With respect to recovery of fish habitat attributes and functions, the impacted area within the blasting zone is expected to be recolonized from recruitment from nearby, unaffected areas of the lake. Recovery for benthic communities varies, ranging from several months to several years, depending on the type of community and type of disturbance (DOE 2013). Some displacement of fishes from the active construction footprint of the Project will occur, but be limited in spatial extent at any given time. Depth contours will be returned to pre-existing conditions by filling the trench with upland-derived material. Excavated coarse material will be side-cast and in the long-term provide relief and habitat structure that could offset any temporary disruption of fish access to nearshore habitats.

In summary, the potential for any negative impacts on fishes and fish habitat can be minimized during blasting by meeting the criteria and using existing BMPs. It is anticipated that potential impacts to the fish community from blasting during construction will be temporary and do not pose a substantive risk to fish populations within the Project area due to their very limited spatial extent.

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