From: Marsh, Michael
To: Dierker, Carl; Williams, Ann; Catri, Cindy; Lederer, Dave; Colarusso, Phil; LeClair, Jacqueline
Subject: FW: NBH-NMFS call and modeling info
Date: Monday, July 22, 2013 12:55:42 PM
Attachments: image001.png
image002.png
Attachment 2_071813.pdf
Analysis of Time of Integration_071813.pdf
Attachment 1_071813.pdf

All – Here is a copy of Eric Hines' 7/18/13 email, with technical memoranda attached, regarding the blasting issue.

Mike

From: Hines, Eric [mailto:ehines@lemessurier.com]
Sent: Thursday, July 18, 2013 8:47 PM
To: Marsh, Michael; 'Chet Myers'
Cc: Hines, Eric
Subject: RE: NBH-NMFS call and modeling info

Mike and Chet,

Attached please find the memo and attachments. Mike, I look forward to talking it through with you tomorrow afternoon.

Eric

E. M. Hines, Ph.D., P.E.
Principal
LeMessurier Consultants
1380 Soldiers Field Road
Boston, MA 02135
phone: 617-868-1200 x440
fax: 617-661-7520

Professor of Practice
Department of Civil and Environmental Engineering
Tufts University
Medford, MA 02155
http://engineering.tufts.edu/cee/people/hines

From: Marsh, Michael [mailto:marsh.mike@epa.gov]
Sent: Thursday, July 18, 2013 4:43 PM
To: Hines, Eric; 'Chet Myers'
Subject: RE: NBH-NMFS call and modeling info
Sounds good. I will be working from home tomorrow… I will give you a call between 1 and 1:30 tomorrow.

Thanks,

SDMS Doc ID 548592

Mike

From: Hines, Eric [mailto:ehines@lemessurier.com]
Sent: Thursday, July 18, 2013 3:33 PM
To: 'Chet Myers'
Cc: Marsh, Michael
Subject: RE: NBH-NMFS call and modeling info

Thanks Chet.

Mike, I expect to get this to you tonight before I leave the office. Are you in tomorrow? Perhaps we can walk through it together sometime between 1 and 2pm?

Eric

E. M. Hines, Ph.D., P.E.
Principal
LeMessurier Consultants
1380 Soldiers Field Road
Boston, MA 02135
phone: 617-868-1200 x440
fax: 617-661-7520

Professor of Practice
Department of Civil and Environmental Engineering
Tufts University
Medford, MA 02155
http://engineering.tufts.edu/cee/people/hines

From: Chet Myers [mailto:cmyers@apexcos.com]
Sent: Thursday, July 18, 2013 3:27 PM
To: Hines, Eric
Cc: Marsh, Michael
Subject: FW: NBH-NMFS call and modeling info

Hi Eric,

Below is Mike Marsh's information:

marsh.mike@epa.gov

Phone: 617-918-1556

The one other thing that Mike wanted us to include in that memo was a retraction for the e-mail that I sent to them on July 10, 2013 at 6:27 PM (below). This was my initial interpretation of the "theta" value, based solely on Dzwilewski and Fenton, but before we had reconciled with Swisdak

et al.

The end result was the same, but the math is wrong, so we need an official retraction.

Maybe we could state early in the memo " this memo serves as a retraction and replacement to my 7/10/13 6:27 PM e-mail." Or something like that.

Thanks,

Chet Myers
Apex Companies, LLC
125 Broad Street, 5th Floor
Boston, MA 02110
O) 617-728-0070 x113 M) 617-908-5778

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From: Chet Myers
Sent: Wednesday, July 10, 2013 6:27 PM
To: 'Colarusso, Phil'; Marsh, Michael; Williams, Ann
Subject: RE: NBH-NMFS call and modeling info

Hi Phil,

We realize that there are more fish out there than just Atlantic Sturgeon; however, the modeling was based on the two standards (Peak Pressure and Peak Impulse) given to us by NMFS, and those standards were set via the previous paper I forwarded that evaluated impacts to shortnose sturgeon.

One other issue that I failed to bring up in the previous e-mail is that we also reviewed the paper that contains the model that Jasco used (Dzwilewski and Fenton, 2003) to help determine what the integration time should be (to see if successive explosions would be additive).

That model has a metric for determining the suggested length of time that Impulse should be integrated over (see pages 20 and 21). It is apparently typically a multiple of the variable "theta" (the model describes two suggested calculations for "tau", one is 5 times "theta", and the other is 6.7 times "theta").

We used the following values for the "theta" equation:

W = 22.7 kg (50 lbs)
K (impulse) = 5.73 (the impulse K variable value for Pentolite, see page 23 of Jasco report)
Alpha (impulse) = 0.91 (see impulse alpha variable value for Pentolite, page 23 of Jasco report)
R = 68.5 meters (This is the radius of the "mitigated" 50 pound Impulse impact area – anything

inside this radius already exceeds the 18.4 psi-msec level. Using the unmitigated radius would be a value of 305 meters, which would be less conservative.)

When calculated, we get "theta" (equation 5 on page 20) to be: 0.89 milliseconds

5 times "theta" is: 4.46 ms
6.7 times "theta" is: 5.98 ms

Thus, our calculation of "tau" indicates that the integration time is extremely short (approximately 5-6 msec).

As a result, so long as the delay exceeded this value, there would be no overlap between successive impulse waves. Meaning the "peak" impulse would be the same for an individual explosion as for a delay explosion (so long as the delay was sufficiently long enough to prevent overlap).

In this case, 25 msec is approximately 4-5 times the calculated "tau" value.

Thanks,

Chet Myers
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From: Colarusso, Phil [mailto:colarusso.phil@epa.gov]
Sent: Wednesday, July 10, 2013 2:54 PM
To: Chet Myers; Marsh, Michael; Williams, Ann
Subject: RE: NBH-NMFS call and modeling info

Chet,

I have skimmed your response and the issue for blasting in the September time frame was Atlantic sturgeon, but anadromous fish mortality. Sturgeon mortality from blasting may not be the most sensitive endpoint to answer the anadromous fish question. I don't think anyone wants to go down the wormhole of whether the modeling results are overly conservative or conservative enough. Ultimately, we need to know that the blasting proposed by Cashman will be consistent/less impactful than what was modeled by Jasco. Perhaps having the expert you mentioned review both the JAsco model and the proposed blasting plan by Cashman would be sufficient to connect those dots. Before you do that, Mike and Ann should weigh in.

Phil

From: Chet Myers [mailto:cmyers@apexcos.com]
Sent: Wednesday, July 10, 2013 2:31 PM
To: Marsh, Michael; Williams, Ann; Colarusso, Phil
Subject: FW: NBH-NMFS call and modeling info

Mike, Ann, and Phil,

I went back to the source documents received from NMFS at the start of the modeling process to see if they could shed some light on the issues we discussed yesterday.

Attached to this e-mail, please find the study that was originally forwarded to Apex (from NMFS) prior to modeling. The study was used to determine whether Atlantic Sturgeon would be impacted by subaqueous blasting by testing shortnose sturgeon. The study was set up as follows:

- Shortnose sturgeon were set into cages at various distances from the detonation (35 feet, 70 feet, 140 feet, 280 feet, and 560 feet).
- The detonations were initiated, and the level of mortality in the sturgeon was assessed based on distance.
- The detonations consisted of 32-33 blasts, of 24-28 kg each (approximately 50-60 pounds each), that were delayed by 25 msec. (i.e. the total charge was 1600-2000 pounds, subdivided into 33 blasts of no more than 60 pounds, with a 25 msec delay between blasts.
- The results of the study concluded that peak pressure should be below 75.6 psi and peak impulse should be below 18.4 psi-msec, which is why those levels were set by Jasco when modeling was conducted.
- More specifically, the study states, on page 5: "Based on this and the best available information, we believe that peak pressure levels at, or below, 75.6psi, and peak impulse levels at, or below 18.4 psi-msec, will cause no injury or mortality to species of sturgeon, including Atlantic sturgeon."
- Please note that NMFS has stated "peak" impulse and not "total" impulse, indicating that they are looking to minimize the impulse over one delay, rather than the whole blast.
- Peak impulse then would be the integrated area under one blast curve. So long as a sufficient time period elapses between curves (so that they don't overlap), the peak impulses are considered separately, and are not additive. NMFS utilized a delay level of 25 msec, which is supported by the results of this study. It is possible that a shorter delay would also be acceptable, but we will accept EPA setting the delay at this level.
- The results are borne out based on the survival of the shortnose sturgeon, where mortality impacts occur at 35 feet, and injuries occurred at 70 feet, but that neither mortality nor injury occurred at 140 feet.
- Also please note that there was 100% survival at 140 feet from the explosions, whereas the Jasco model indicates that the peak impulse for a 50 pound blast would be approximately 1000 feet from the blast (unmitigated). This is further indication that the Jasco model is overly conservative, and indicates that the impacts from blasting associated with the NBMCT would be lower than anticipated based on the modeling results.

This study seems to answer the questions that were posed by Mike and Ann yesterday. We will still work on getting Jasco involved, but this seems to be pretty comprehensive evidence.

The blast pattern is virtually identical to what is being proposed (multiple 50 pound maximum blasts).

Please let me know if you would like to discuss.

Thanks,

Chet Myers
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From: Kelly Risotto [mailto:krisotto@landuse.us]
Sent: Tuesday, October 02, 2012 3:44 PM
To: Jay Borkland; Chet Myers; Marie-Noel Matthews
Subject: NBH-NMFS call and modeling info

Good Afternoon All,

Below is a summary of the discussion Chet and I had with Danielle Palmer of NMFS this afternoon regarding the acoustic modeling for NBH in-water work:

1. Blasting
    a. NMFS currently has no formal criteria for assessment of hydroacoustic impacts of blasting on finfish.
    b. Per Danielle, <u>do not use the criteria established for pile driving for assessment of blasting effects</u>. She emailed me the attached consultation wherein the assessment was performed using peak pressure levels reported in psi (≤ 75.6 psi no injury or mortality) and impulse pressure levels reported in psi-msec (≤ 18.4 psi-msec no injury or mortality).
2. Non-Blasting Rock Removal & Pile Driving
    a. <u>NMFS has dual criteria for assessment of injury in finfish</u>
        i. Threshold for onset of injury—peak measurement: peak SPL of any strike exceeds 206dB re: 1μPa
        ii. Threshold for onset of injury—cumulative measurement: cumulative SEL (cSEL), accumulated over all pile strikes, exceeds 187 dB re 1μPa•s
        iii. For vibratory hammer, assessment of cSEL can be done using two methods, either equating the # of vibratory periods to # of pile strikes, or using the duration of vibration in the calculation
    b. <u>NMFS has separate criteria for assessment of behavioral effects in finfish</u>

i. Threshold for behavioral effects: 150 dB_{RMS}

c. Map/Output can be a single figure that depicts the three metrics color coded to show the zones of potential impact, or we can produce a single figure for each metric (our choice).

3. # Locations to model for each of the above should be based on the existing conditions within the proposed work area. If a single location will produce results applicable to the entire project site, we can utilize one location; or, we must model one location for each significant change in conditions that would change the model output.

We should have a call to discuss the modeling required and revise our scenarios in light of our discussion with NMFS, to make sure that we produce the results that will enable EPA and NMFS to evaluate and sign off on the project. I am available all day tomorrow, Thursday morning, and all day Friday to discuss.

Thanks,

Kelly Risotto, Senior Ecologist
LAND USE ECOLOGICAL SERVICES, INC.
570 Expressway Drive South, Suite 2F, Medford, NY 11763
Tel. 631-727-2400 Ext. 302, Fax. 631-727-2605
Mobile 631-764-7983

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125 Broad Street, 5th Floor
Boston, MA 02110
1 Wamsutta Street
New Bedford, MA 02740
Telephone 617-728-0070
Facsimile 617-728-0080

Memorandum

To: Mr. Mike Marsh, USEPA

From: Chet Myers, Apex Companies, LLC

Date: July 17, 2013

Re: Analysis of Time of Integration Associated with Blast Impulse Calculation from JASCO Report

---

Mike, as you know, EPA has requested additional information in association with blasting and, more specifically, the blast modeling completed by JASCO Applied Sciences (JASCO). Enclosed, please find additional information generated by Apex through discussions with JASCO and via analysis of the JASCO report, as well as papers cited within it. Please also accept this memo as a formal modification to my 7/10/13, 6:27 pm email to your team entitled "NBH-NMFS call and modeling info." While the numerical results discussed in that email led to the same conclusions I will present here, you will find that I have corrected and clarified the method by which they are calculated.

Applicability of Model to Multiple Delayed Explosions and Recommendation For Delay Timing

Explosive use is typically applied with respect to charge weight limits "per delay" rather than "per shot". In production blasting for the purposes of rock removal over large areas, each shot typically contains several delays which are timed in a manner that the resulting waterborne pressures and impulses affecting fish are not considered to be additive. It is our understanding that a common industry and regulatory standard for such delays is approximately 25 milliseconds.

For the purposes of the model produced by JASCO, the controlling "peak pressure" and "peak impulse" used as a basis of comparison were 75.6 psi and 18.4 psi-msec, respectively. These limits were derived from experimental results generated (and forwarded to Apex prior to the start of modeling in 2012) by NMFS. NMFS indicated that if the "peak pressure" and "peak impulse" of the charges could be kept below these factors, then there should be no injury and/or mortality outside of the area of impact.

EPA has requested written confirmation that the model produced by JASCO is applicable to a "charge per delay" use of explosives. As Attachment 1 to this memo, please find a letter from

JASCO confirming that the modeling conducted by JASCO for their report is applicable to "charge weights per delay for delays of 25 ms or greater." JASCO notes that the pressure waves in question generally have lengths of less than a few milliseconds, and recommends the 25 millisecond criterion as a well established regulatory limit broadly applicable to a variety of blasting situations. Note that NMFS also used 25 millisecond delays in their study.

Mathematical Questions

EPA has also requested an analysis of the mathematics cited within the JASCO report, particularly with reference to the derivation of Impulse, and the time period via which Impulse is calculated (which would then help confirm whether 25 milliseconds was, in fact, a reasonable time period for delay).

The JASCO report cites a 2003 report by Dzwileski and Fenton, whose calculations are taken from the empirical similitude equations presented in Swisdak et al. (1978). It is our understanding that the similitude equations in the Swisdak report formed the basis for JASCO's calculation of peak pressure and peak impulse. Since the equations in the Swisdak report are based on charges detonated in water, it was necessary for JASCO to modify the inputs to these equations in order to account for the fact that the charges at the NBMCT will be detonated inside of bore holes that are highly confined by the surrounding bedrock. JASCO references the Dzwileski and Fenton report in order to determine a "coupling efficiency" consistent with the highly confined condition of the charges.

While the JASCO report implicitly conforms to the 25 millisecond delays referenced in their letter (Attachment 1), it is possible to study the impulse integration period explicitly according to the similitude equations presented by Swisdak. Swisdak presents equations for peak pressure, peak impulse, time constant and energy flux. Of interest here is the Time Constant, Θ, and its relationship to the impulse integration period. For peak pressure and peak impulse, JASCO used the Swisdak equations and constants for the explosive pentolite. These are presented below for consistency along with the Time Constant, Θ, according to Swisdak. They are also included in Attachment 2 as the calculation sheet that we discussed yesterday by phone.

Peak Pressure:

$$P_{pk} = K_1 \cdot (W^{1/3} / R)^{\alpha_1}$$

Where:

- K_1 and α_1 are both constants related to the type of explosive utilized (however, these constants are different than those noted in the Time Constant equation noted below)
- W is the effective weight of explosive utilized in kilograms.
- And R is the "slant distance" (the hypotenuse of a triangle created by both the vertical and horizontal distance from the explosion, for the point under consideration).

Time Constant:

$\Theta = K_2 \cdot W^{1/3} \cdot (W^{1/3}/ R)^{\alpha 2}$

Where:

- K_2 and α_2 are both constants related to the type of explosive utilized (however, these constants are different than those noted in the Peak Pressure equation noted above).
- W is the weight of explosive utilized in kilograms.
- And R is the "slant distance".

$I(r) = K_3 \cdot W^{1/3} \cdot (W^{1/3}/ R)^{\alpha 3}$

Where:

- K_3 and α_3 are both constants related to the type of explosive utilized (however, these constants are different than those noted in the Peak Pressure and Time Constant equations noted above).
- W is the weight of explosive utilized in kilograms.
- And R is the "slant distance".

For pentolite, the following table reflects the values of the two constants for each of the three equations:

Equation	K	α
Peak Pressure	56.5	1.14
Time Constant	0.084	-0.23
Impulse	5.73	0.91

In order to calculate the effective weight of a charge surrounded by highly confined rock, JASCO used the Dzwileski and Fenton modification to the Swisdak equations. This modification calculates a coupling efficiency that can be used to determine the "effective weight" of a given charge. In order to calculate this coupling efficiency, JASCO modeled the rock as an equivalent steel pipe pile, 24 inches in diameter with a 1 inch wall thickness (pp. 22-23 of the JASCO report). The coupling efficiency equation is as follows:

Explosive Coupling Efficiency (%) = $34.37 + 0.005 \cdot p$

Where:

- p is the "pile parameter", further defined in the following equation:

$p = w \cdot d/ t$

Where:

- w = explosive weight in pounds.
- d = pile diameter in inches
- t = wall thickness in inches

Explosive Coupling Efficiency (%) = 34.37 + 0.005 · 50 · 24 / 1 = 40.37 %

The effective weight of a 50 lb charge is therefore: 50 lbs · 0.4037 = 20.185 lbs = 9.175 kg

Peak Pressure would be calculated by inserting the following values (for a 50 pound charge at the radius of influence shown on JASCO's maps):

- For K_1, 56.5
- For, α_1, 1.14
- For W, 9.175 kg
- For R, 127.4 meters (418 feet as shown on Figure 18 and Table 6 of the JASCO Report).

The calculated Peak Pressure is: 0.521 MPa, which converts to 75.6 psi.

Impulse would be calculated by inserting the following values (for a 50 pound charge at the radius of influence shown on JASCO's maps):

- For K_3, 5.73
- For, α_3, 0.91
- For W, 9.175 kg
- For R, 310 meters (1017 feet as shown on Figure 19 and Table 6 of the JASCO Report).

The calculated Impulse is: 0.1268 kPa-sec, which converts to 18.4 psi-msec.

The Time Constant is calculated by inserting the following values:

- For K_2, 0.084 (see table above)
- For α_2, -0.23
- For W, 9.175 kg
- For R, 127.4 meters and 310 meters (to see which is more conservative).

The result is that for 127.4 meters, the Time Constant is: 0.452 ms and for 310 meters, the Time Constant is: 0.554 ms, which are extremely similar. According to Swisdak as well as Dzwileski and Fenton the integration time period for Impulse, τ, is typically some multiple of Θ (Theta) – typically 5 or 6.7 times Θ. Therefore, the maximum value for the integration time period for a 50 pound explosion would be:

6.7 · 0.554 ms = 3.7 milliseconds,

which amounts to 15% of the 25 millisecond value referenced by JASCO in their letter.

ATTACHMENT 1

JASCO APPLIED SCIENCES

2305 – 4464 Markham Street
Victoria, British Columbia, Canada V8Z 7X8

Tel: +1-250-483-3300 info@jasco.com
Fax: +1-250-483-3301 www.jasco.com

To: Chet Myers
Apex Companies, LLC
125 Broad Street, 5th Floor
Boston, MA 02110

Date: 12 July 2013

RE: **Underwater Acoustic Modeling of Explosive Rock Removal Operations for the Marine Commerce South Terminal in New Bedford, MA.**

Mr. Myers,

From a physical standpoint, the distances to impulse levels for injury criteria (18.4 psi·s) stated in our report can be validly considered as distances for charge weight per delay for delays of 25 ms or greater. This statement is based on the fact that the integration period for the impulse metric is defined as the time elapsed from the onset of the primary pressure wave to its return to ambient, i.e. the duration of the first positive pressure wave; this will be applicable individually to the events in a delayed sequence of detonations as long as the onset of an event does not overlap the positive phase of the previous one. While the positive pressure phase of an event may last just a few milliseconds, in practice some standard delay guidelines are generally applied to ensure a clear separation under realistic conditions. Not having found official directives from NMFS regarding minimum acceptable delays, and in the absence of details about the charge layout geometry for the construction activities for the New Bedford terminal, we recommend a minimum time delay of 25 ms between detonations based on Canadian guidelines for the use of explosives in or near fisheries waters (Wright and Hopky 1998) and experimental results presented by the National Marine Fisheries Services (NMFS; Bullard, J. K. 2012).

JASCO's analysis was limited to the physical estimate of acoustic parameters, and does not attempt to provide an interpretation of the biological impact on fish.

Regards,

Marie-Noël R. Matthews

Project Scientist

Literature Cited

Bullard, J. K. 2012. RE: Route 52 Causeway Replacement & Somers Point Circle Elimination Contract B. Letter to Kostas Svarnas, U.S. Department of Transportation, New Jersey Division. 13 p.

Wright, D.G., and G.E. Hopky. 1998. Guidelines for the use of explosives in or near Canadian fisheries waters. Can. Tech. Rep. Fish. Aquat. Sci. 2107: iv + 34p. http://www.dfo-mpo.gc.ca/Library/232046.pdf

ATTACHMENT 2

LeMessurier Consultants Structural Engineers	By [illegible]	Date 7/17/15	File No. 81085.002	Sheet No. 1/1
	Subject NBMCT, BLAST RADII, NMFS LIMITS, INTEGRATION PERIOD			

BASIC SIMILITUDE EQN (SWISDAK 1978, 15)

$$\text{PARAMETER} = K\left(\frac{W^{1/3}}{R}\right)^{\alpha}$$

COEFFICIENTS FOR PENTOLITE (SWISDAK, 17)

	P	I	Θ
K	56.5	5.73	0.084
α	1.14	0.91	-0.23

EFFECTIVE WEIGHT

SWISDAK EQNS ARE FOR WATERBORNE EXPLOSIVES.
NBMCT EXPLOSIVES ARE BURIED IN BEDROCK UNDER OVERBURDEN
JASCO ASSUMES 4"ϕ BEDROCK UNDER OVERBURDEN CAN BE SIMULATED CONSERVATIVELY AS A CHARGE IN A 24"ϕ, 1" THICK PIPE (p.23)

$$\text{COUPLING EFFICIENCY} = 34.37 + 0.005\left(\frac{50^{\#}(24")}{1"}\right) = \underline{40.4\%}$$

(DOWILENSKI + FENTON 2003, 16)

$$W = \frac{50^{\#}(0.404)}{2.2\ \#/kg} = \underline{9.18\,kg} \qquad W^{1/3} = \underline{2.09}$$

NMFS LIMITS

$P = 75.6\,psi$ AT $R = 127.4\,m$

$$75.6 = (145\ \tfrac{psi}{MPa})(56.5)\left(\tfrac{2.09}{127.4}\right)^{1.14}$$

$$\Theta = 0.452\,ms = (2.09)(0.084)\left(\tfrac{2.09}{127.4}\right)^{-0.23}$$

$I = 18.4\,psi\text{-}ms$ AT $R = 310\,m$

$$18.4 = (145)(2.09)(5.73)\left(\tfrac{2.09}{310}\right)^{0.91}$$

$$\Theta = 0.554\,ms = (2.09)(0.084)\left(\tfrac{2.09}{310}\right)^{-0.23}$$

I IS INTEGRATED TO A TIME OF:

$\tau = 5\Theta$ (SWISDAK, 17)

$\tau = 5(0.554) = \underline{2.77\,ms}$

$\tau = 6.7\Theta$ (GLE 1993)

$\tau = 6.7(0.554) = \underline{3.71\,ms}$

$\underline{3.71\,ms \ll 25\,ms}$