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nhc
northwest hydraulic consultants

5 November2018

Da Vinci Energy Inc

Attention: **Mr. Hans Dysarsz**
Managing Director

Via email: **hdysarsz@telus.net**

Re: **DAVINCI ENERGY INC.**
JULY 2018 FLUME TESTING
SUMMARY OF RESULTS – REVISION 1

1 INTRODUCTION

Northwest Hydraulic Consultants Ltd. (NHC) is pleased to submit the following summary of results to support DaVinci Energy Inc.'s (DaVinci) development of their Translating Wing/Shuttle Foil (TW/SF) process in a flume facility within our North Vancouver hydraulic laboratory. The results are based on testing conducted on July 27th, 2018.

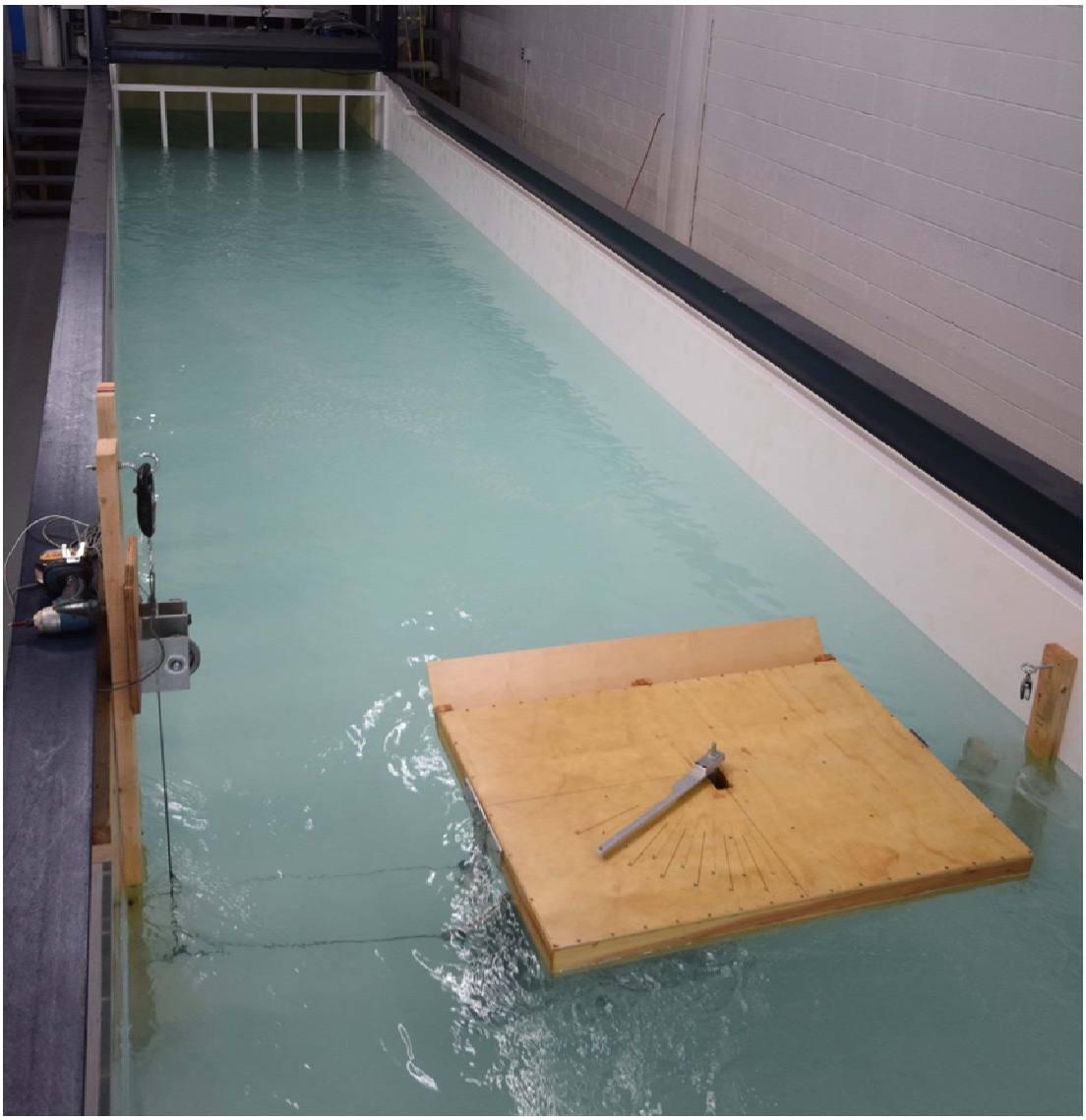
2 SCOPE OF WORK

2.1 Model Design and Fabrication

A simplified description of the model is presented in Photograph 1.

- DaVinci provided the model with anchoring points and mounted the model in the flume.
  - The model consisted of a floating platform supporting three rectangular foils. Based on information provided by Davinci, each foil was 51.5 cm long and extended 45.7 cm from the underside of the platform. NHC did not confirm measurements of the model structure and was not provided with a design in any format.
- NHC recorded discharges in the supply pipes using ultrasonic flowmeters and determined velocities based on continuity.
- NHC recorded resistance using and equipment provided by DaVinci. Before and after the tests the resistance was calibrate and confirmed using known weights.
- Angle of the model platform was documented using photographs and video and measured with a protractor.

- Angle of the foils relative the platform was measure using markers on the top of the platform (as shown in the photograph below.
- Angles of the supporting wires relative to the general flow direction were recorded using a protractor from above and through the clear sidewall of the flume. These angels were accounted for in the presentation of results.
- Photographs and video were collected to document vessel and spool movement.



- **Photograph 1: View from above of the modelled Foil Array Tested in July 2018.**

2.2 Model Testing

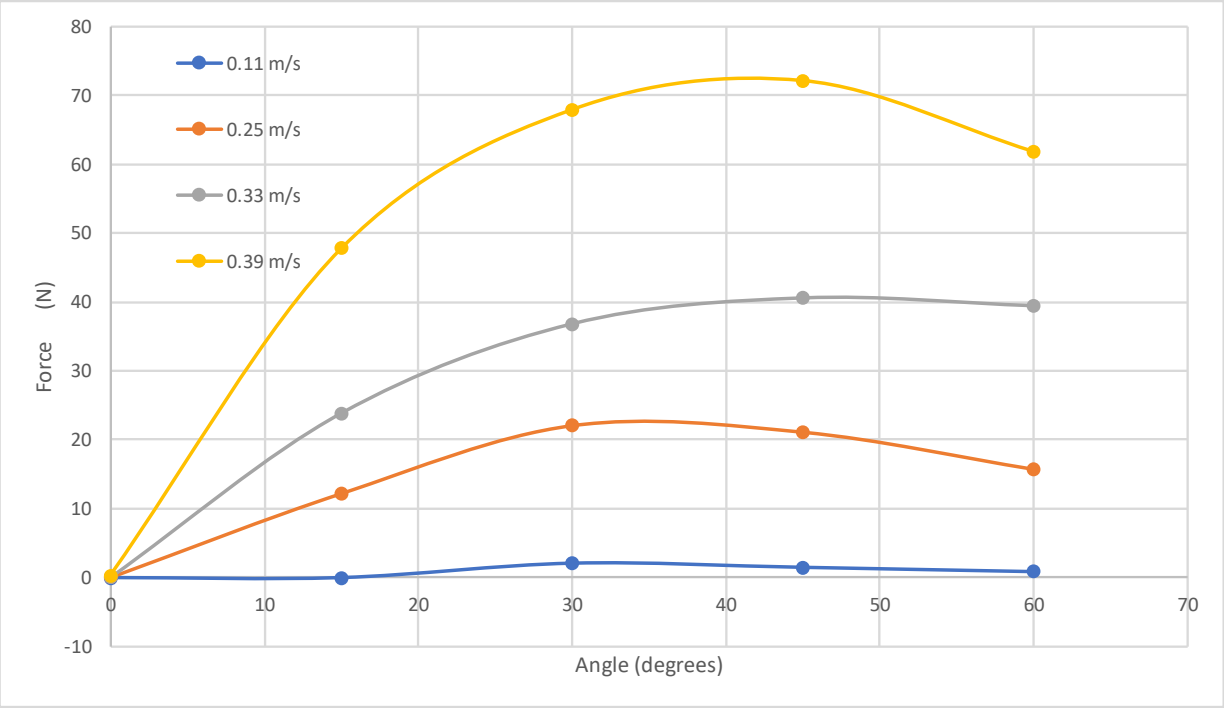
The model was kept close to the middle of the flume to minimize boundary effects. Data collected included the lateral force (force perpendicular to the flow) required to keep the array stationary and

upstream velocity. Dynamic stability (directional, pitch, or roll) was not be considered. Each test was documented using both photographs and video.

The test matrix considered four average approach velocities ranging between 0.11 m/s and 0.39 m/s and at five angles ranging from 0 degrees (aligned with the direction of flow) to 60 degrees.

2.3 Results

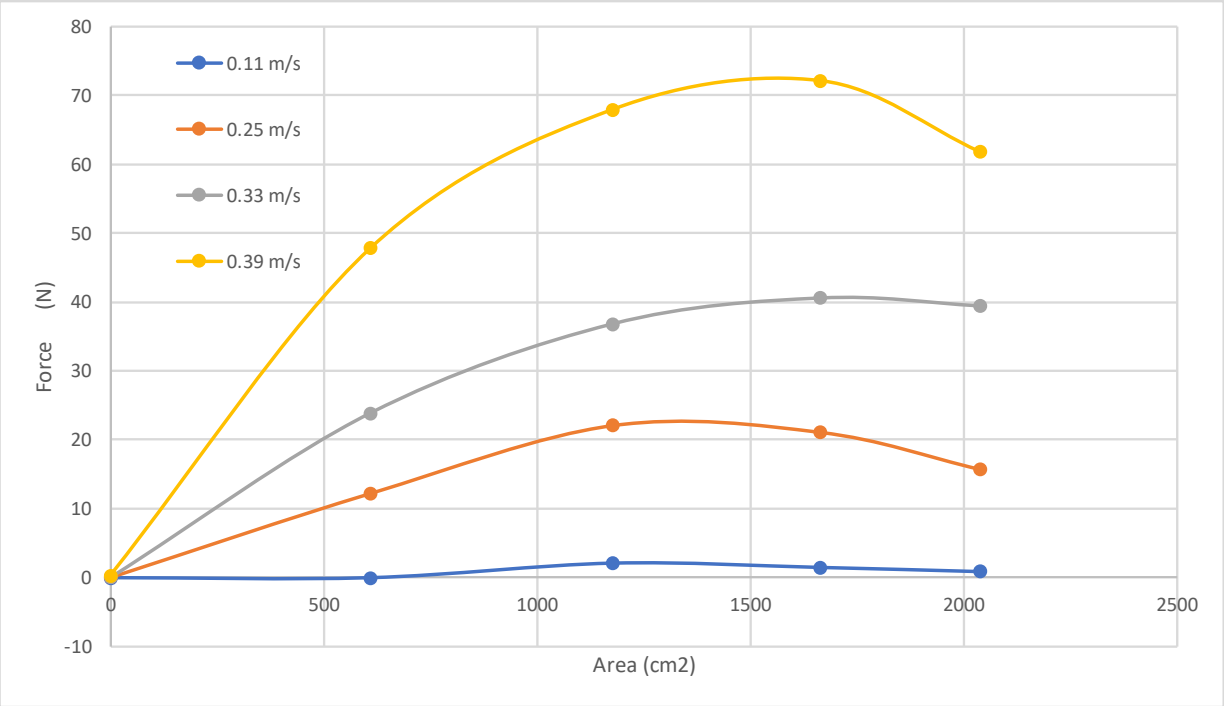
The test results are presented a function of the lateral resisting force relative to both the angle of the foil relative to the supporting platform, Figure 1 & Figure 2, and stream velocity, Figure 3. **Resistance force is defined as the component of force perpendicular to the direction of flow.**



DaVinci - Static Load Vs. Foil Angle							
0.11 m/s		0.25 m/s		0.33 m/s		0.39 m/s	
Angle *(degrees)*	Force *(N)*	Angle *(degrees)*	Force *(N)*	Angle *(degrees)*	Force *(N)*	Angle *(degrees)*	Force *(N)*
0	0	0	0	0	0	0	0
15	0	15	12	15	24	15	48
30	2	30	22	30	37	30	68
45	1	45	21	45	41	45	72
60	1	60	16	60	39	60	62

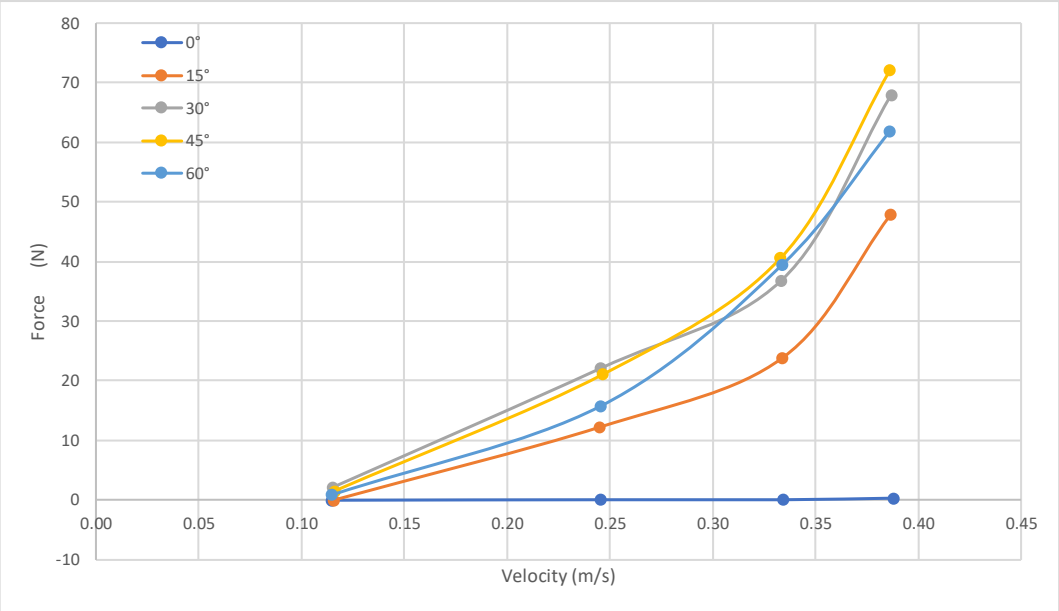
Figure 1: Load versus Angle of the Foil.

As the area of the exposed foil is directly proportionate to the foil angle Figure 1 could be plotted by replacing Foil Angle with Exposed Area of the **Leading Foil**, Figure 2.



DaVinci - Static Load Vs. Exposed Area of the Leading Foil							
0.11 m/s		0.25 m/s		0.33 m/s		0.39 m/s	
Area (cm^2)	Force *(N)*	Area (cm^2)	Force *(N)*	Area (cm^2)	Force *(N)*	Area (cm^2)	Force *(N)*
0	0	0	0	0	0	0	0
609	0	609	12	609	24	609	48
1177	2	1177	22	1177	37	1177	68
1664	1	1664	21	1664	41	1664	72
2038	1	2038	16	2038	39	2038	62

Figure 2: Load versus Expose Area of the Leading.



DaVinci - Static Load Vs. Velocity									
0°		15°		30°		45°		60°	
Velocity *(m/s)*	Force *(N)*	Velocity *(m/s)*	Force *(N)*	Velocity *(m/s)*	Force *(N)*	Velocity *(m/s)*	Force *(N)*	Velocity *(m/s)*	Force *(N)*
0.11	0	0.12	0	0.12	2	0.12	1	0.11	1
0.25	0	0.25	12	0.25	22	0.25	21	0.25	16
0.33	0	0.33	24	0.33	37	0.33	41	0.33	39
0.39	0	0.39	48	0.39	68	0.39	72	0.39	62

Figure 3: Load versus Stream Velocity

3 SUMMARY & DISCUSSION

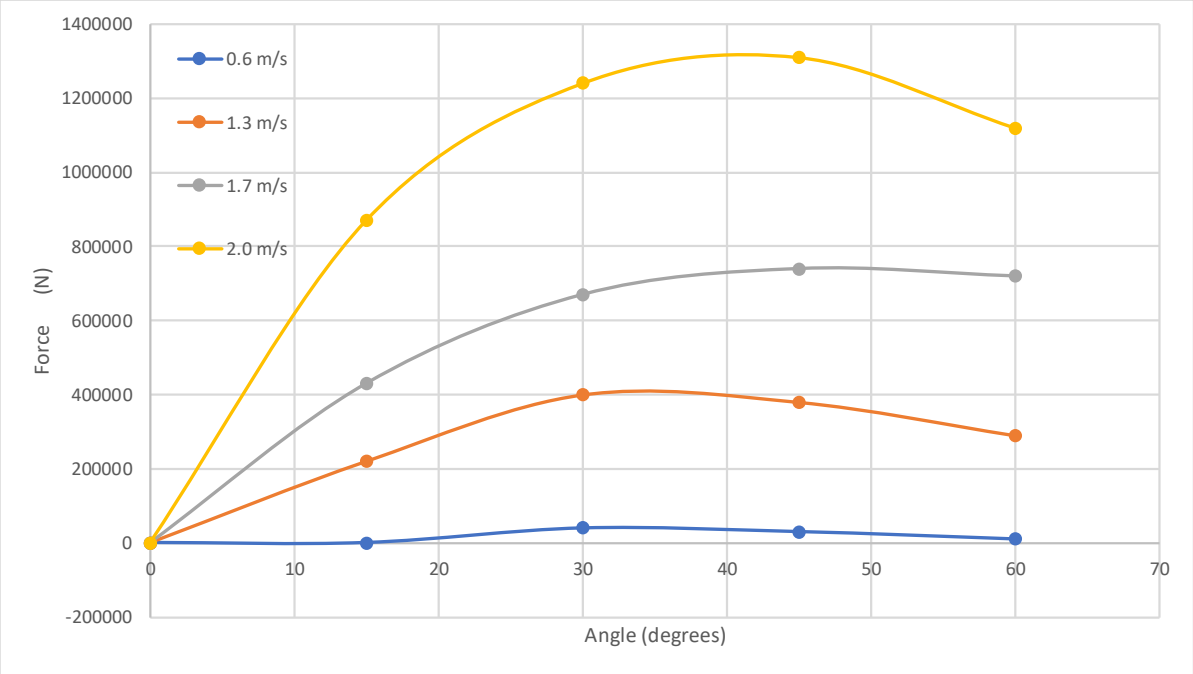
The results of the testing indicate that the geometry tested generates the most resistance force with foils set at between 35 degrees and 45 degrees relative the stream flow direction.

DaVinci requested that results be scaled to represent velocities of up to 2.0 m/s prototype. Adopting a Froud scale to represent the highest modelled velocity to 2.0 m/s results in system that is 26.3 times larger. The following table summarizes the resulting Froude scale relationships.

Froude Scale Relationships

Parameter	Relationship	Value
Length	L_r	1 : 26.3
Time	$L_r^{1/2}$	1 : 5.13
Velocity	$L_r^{1/2}$	1 : 5.13
Discharge	$L_r^{5/2}$	1 : 3,550
Force	L_r^{3}	1 : 18,200

Given similar geometry and boundary conditions forces required keep a prototype structure in-place are presented in Figure 4. Note that expected errors are approximately +/- 50,000 N.



DaVinci - Static Load Vs. Foil Angle							
0.6 m/s		1.3 m/s		1.7 m/s		2.0 m/s	
Angle *(degrees)*	Force *(N)*	Angle *(degrees)*	Force *(N)*	Angle *(degrees)*	Force *(N)*	Angle *(degrees)*	Force *(N)*
0	0	0	0	0	0	0	0
15	0	15	220,000	15	430,000	15	870,000
30	40,000	30	400,000	30	670,000	30	1,240,000
45	30,000	45	380,000	45	740,000	45	1,310,000
60	10,000	60	290,000	60	720,000	60	1,120,000

Figure 4: Load versus Angle of the Foil of a unit 26.3 times larger than modelled

NHC trusts that the above information is sufficient for your present needs. If you have any questions or require additional information, please contact me at (604) 980-6011 or KChristison@nhc-van.com.

Sincerely,

Northwest Hydraulic Consultants Ltd.

Ken Christison, P. Eng.
Principal