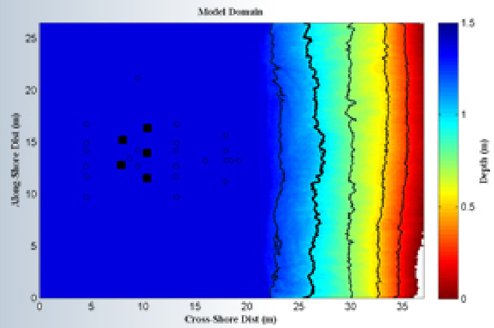
Exceptional service in the national interest

Sandia National Laboratories

SNL –SWAN

Simulating WAves Nearshore

Nearshore



SNL-SWAN Training Material

MOTT MACDONALD

Sandia National Laboratories

U.S. DEPARTMENT OF ENERGY

NNSA National Nuclear Security Administration

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Introduction to SNL-SWAN

<u>Sandia National Labs – SWAN (SNL-SWAN)</u>

- Wave energy converter (WEC) array simulation tool
- Open source code.
- Modification of the open source code, SWAN (Simulating WAves Nearshore) developed by TU Delft.
- SWAN computes random, short-crested wind-generated waves in coastal regions.
- SNL-SWAN has a WEC Module which improves how SWAN accounts for power performance of WECs and the effects on the wave field.
- The five methods for determining the transmission coefficient are employed through switches in the SNL-SWAN WEC module
- Uses WEC performance to estimate either a frequency-variable transmission coefficient in the SWAN Action Density Evolution Equation (shown below), or frequency constant transmission coefficient. SWAN then models the effects on wave climate in the far-field as usual.
- Funded by the U.S. Department of Energy's Wind and Water Power Technologies Office.
- User's guide provided at: http://snl-waterpower.github.io/SNL-SWAN/
- In addition to user-specified outputs SNL-SWAN supplies POWER_ABS.OUT. This file provides absorbed power for each modeled WEC (obstacle).

$$\left(\frac{1}{\Delta t} + \left(D_{x,1} + D_{x,2}\right) c^{+}_{x,i,,j} + \left(D_{y,1} + D_{y,2}\right) c^{+}_{y,i,,j}\right) N^{+}_{i,,j} - \frac{N^{-}_{i,,j}}{\Delta t} - D_{x,1}\left(c_x \boldsymbol{K_{t,1}}^{2} N\right)^{+}_{i-1,j}$$
$$- D_{y,1}\left(c_y \boldsymbol{K_{t,1}}^{2} N\right)^{+}_{i-1,j} - D_{x,2}\left(c_x \boldsymbol{K_{t,2}}^{2} N\right)^{+}_{i,j-1} - D_{y,2}\left(c_y \boldsymbol{K_{t,2}}^{2} N\right)^{+}_{i,j-1} = S^{+}_{i,j} \quad (1)$$

Tutorial: Objectives and Assumptions

- Tutorial intended to train specifically SNL-SWAN users
- Not intended to be a tutorial for SWAN. Assume user is trained on SWAN.
    - Note: Tutorial for non-SWAN users in addition to this tutorial may be developed as a separate document.
- To walk a user through the development of a SNL-specific model and incorporation of WEC devices.
- User must have WEC power performance estimates

Tutorial Outline

- Introduction
- Definitions (e.g., RCW, Obcase, etc…)
- SNL-SWAN Obcase Module Overview
- Summary of Module Applicability
- Implementation Overview
- Example Applications
  - Obcase 0 – Baseline SWAN
  - Obcase 1 – Power Matrix Real Seas
  - Obcase 2 - Relative Capture Width
  - Obcase 3 – Power Matrix Regular Waves
  - Obcase 4 – Relative Capture Width
- Best Practices
- FAQs

Definitions

- Power Matrix: Table of absorbed power (in Kilowatts, kW) by a WEC device over varying significant wave heights and peak wave periods
- RCW – Relative Capture Width
  - Power absorbed/Power incident to device
  - Can be calculated for each frequency
- OBCASE: SNL-SWAN models WECs as obstacles using the five “obcase” flags to determine the appropriate obstacle transmission coefficient.
- Baseline SWAN: Standard SWAN by TU Delft. Same as OBCASE = 0
- Normalization Width: WEC physical dimension along face of device

Power Matrix

- The WEC power matrix should be defined in kW absorbed by the WEC.
- Normalization Width of the WEC must be known.
- Typically given in terms of bulk seastate parameters (Hs, Tp).
  - Information not given related to shape of spectra
  - Limited to Obcase 1 if no spectral information available
- If Power Matrix is available for discrete wave periods (frequencies) and amplitudes, Obcase 3 may be used, theoretically.

$$P_{Flux-Absorbed} = \frac{P_{Absorbed}}{W}$$

$$P_{Flux-Incident} = \rho g \int \int E(\sigma,\theta) c_g \, d\sigma \, d\theta$$

$$K_t^2 = \frac{P_{Lee}}{P_{Incident}} = \frac{P_{Incident} - P_{Absorbed}}{P_{Incident}} = 1 - \frac{P_{Absorbed}}{P_{Incident}} = 1 - \frac{P_{Flux-Absorbed}}{P_{Flux-Incident}}$$

		Tp														
	MEAN	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Hs (m)	0.5	4.44	5.07	7.97	12.15	16.77	17.14	11.94	9.16	6.57	4.39	4.00	3.00	2.86	1.95	1.71
	1	16.65	19.00	29.48	46.94	56.61	52.38	37.14	28.73	19.84	16.62	12.94	9.33	7.29	7.40	4.49
	1.5	0.00	41.54	63.14	92.37	110.74	109.49	64.96	55.91	38.49	29.09	22.06	19.26	12.74	11.21	11.50
	2	0.00	66.29	99.03	150.67	200.97	164.91	105.27	85.30	58.63	52.31	40.56	28.76	24.22	19.31	17.57
	2.5	0.00	0.00	160.23	241.82	261.83	226.36	166.20	117.65	83.09	69.87	57.47	39.24	28.51	26.20	23.73
	3	0.00	0.00	212.52	319.26	372.09	327.17	210.96	151.98	116.43	93.66	75.42	66.09	44.81	42.09	30.83
	3.5	0.00	0.00	270.15	436.02	503.15	407.75	292.71	203.22	148.33	115.49	92.63	74.81	57.97	44.27	41.16
	4	0.00	0.00	0.00	553.82	540.26	521.33	355.46	260.73	191.66	144.19	122.78	84.04	81.01	55.80	53.24
	4.5	0.00	0.00	0.00	645.46	746.22	586.83	378.72	302.18	236.42	189.64	154.41	105.88	89.58	74.26	55.78
	5	0.00	0.00	0.00	796.15	926.13	694.67	485.91	341.06	287.07	211.41	167.83	135.72	111.21	93.81	77.53
	5.5	0.00	0.00	0.00	939.38	954.73	807.95	603.12	429.61	343.08	231.19	201.49	150.14	120.29	96.75	89.90
	6	0.00	0.00	0.00	0.00	1161.42	956.67	642.08	480.81	329.09	289.47	212.26	171.77	145.82	110.89	100.85
	6.5	0.00	0.00	0.00	0.00	1476.47	1039.27	702.04	487.62	396.60	311.56	236.66	203.88	153.43	120.26	102.25
	7	0.00	0.00	0.00	0.00	1664.93	1197.05	820.77	612.40	465.98	384.59	251.62	222.70	180.55	146.28	131.44
	7.5	0.00	0.00	0.00	0.00	1608.45	1407.61	922.63	703.98	508.65	373.47	325.45	229.49	190.53	151.78	149.26

Relative Capture Width

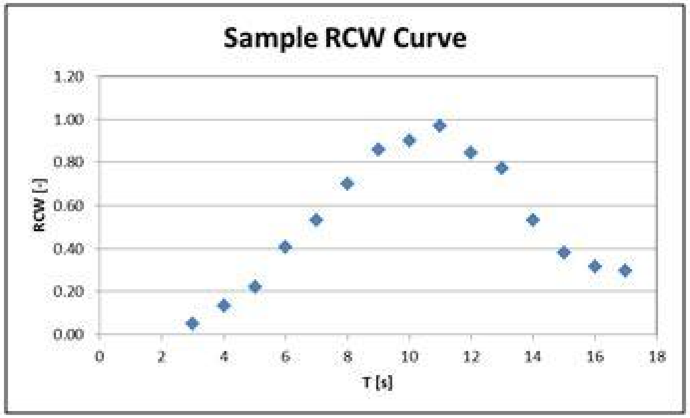
- The relative capture width curve is a table of absorbed power ratios by a WEC device at varying wave periods.

- May be estimated experimentally or numerically.

- SNL-SWAN RCW value at any wave period should not be greater than 1.0, though RCW values greater than 1.0 have been seen experimentally. SNL-SWAN can not remove more power from the wave-field than is available to the obstacle. SWAN cannot model any “antennae effect”.

T [s]	RCW [-]
3	0.05
4	0.13
5	0.22
6	0.41
7	0.53
8	0.70
9	0.86
10	0.90
11	0.97
12	0.84
13	0.77
14	0.53
15	0.38
16	0.32
17	0.30

$$K_t^2 = 1 - \frac{P_{Absorbed}}{P_{Incident}} = 1 - RCW$$



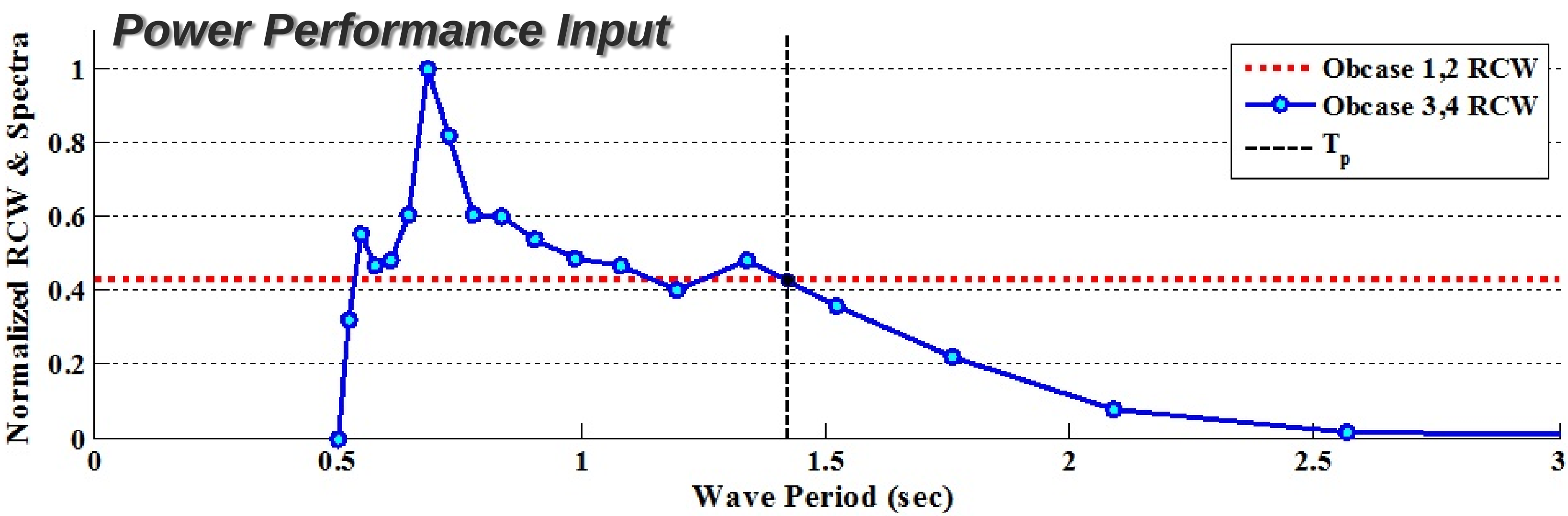
Obcase

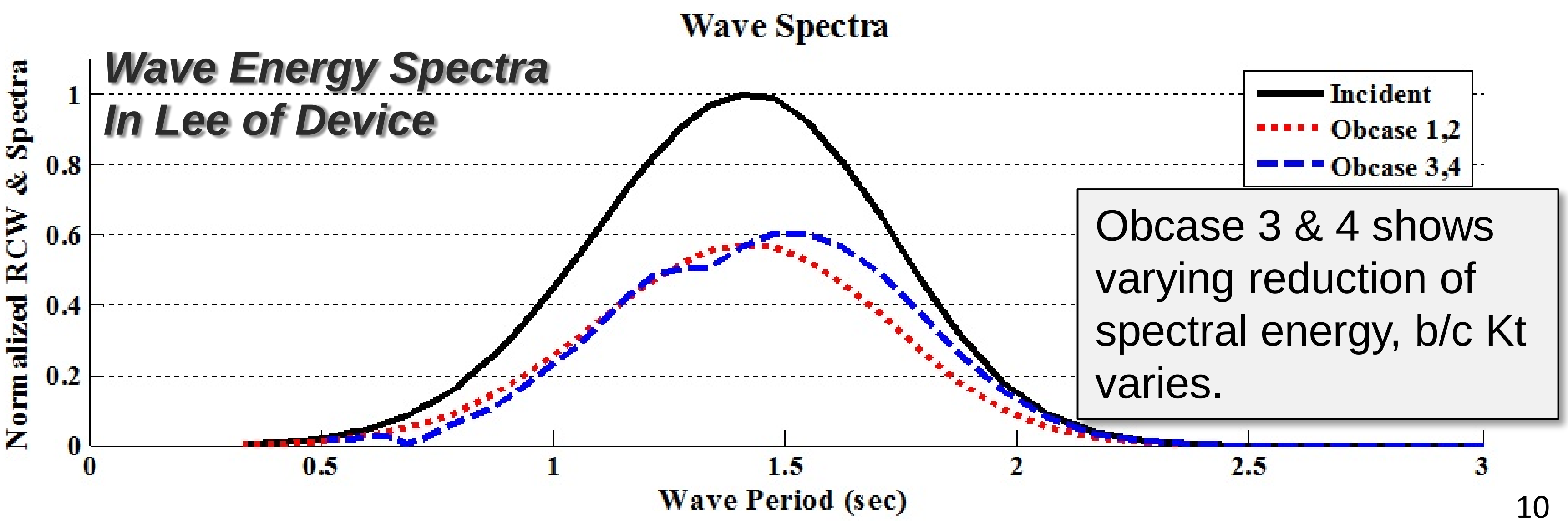
- Short for “WEC Obstacle Case”
- Method for determining Obstacle transmission (Kt) is determined by selecting Obcase 0, 1, 2, 3, or 4.
  - 0: Baseline (TU Delft) SWAN. Kt set in INPUT file.
  - 1: Kt based on Power Matrix and incident wave field (Hs, Tp). Equal across wave periods.
  - 2: Kt based on RCW value at peak incident wave period. Equal across wave periods.
  - 3: Kt based on Power Matrix and incident wave spectra. Varying across wave periods.
  - 4: Kt based on RCW curve. Varying across wave periods.
- Guidance for selecting Obcase is found next slide.

Obcase Applicability

WEC Performance Information	Frequency-variable Kt	Frequency-constant Kt
No Information	N/A	Obcase 0
Power Matrix (real seas, peak period)	N/A	Obcase 1
Power Matrix (regular waves and amplitude)	Obcase 3	N/A
RCW Curve	Obcase 4	Obcase 2

Obcase Visualization





Obcase 3 & 4 shows varying reduction of spectral energy, b/c Kt varies.

SNL-SWAN Implementation Overview

A. Develop SWAN model grid and INPUT file
B. Download SNL-SWAN and copy into directory
C. Define WEC device performance in .txt file using RCW or Power Matrix
D. Modify SWAN INPUT file by adding new line using SET command: SET obcase= XX
E. Determine which obstacle case (OBCASE) to toggle (0 to 4) based on available WEC performance data and desired physics
F. Remainder of INPUT file is identical. However, SNL-SWAN-specific best practices are included in this tutorial

A. Setup SWAN (Grids, Input File, etc…)

- Follow SWAN TU Delft guidance
  - http://swanmodel.sourceforge.net/

SWAN

Simulating WAves Nearshore

Welcome to the SWAN home page

- Enter WEC location coordinates as obstacle coordinates in INPUT file. Set transmission (Kt) of obstacle to zero
  - Use seaward facing side of WEC face only
  - Do not modify input grids to incorporate WECs
- For additional best practices see slides XX

```
PROJECT  'SAMPLE ' 'TEST'
'SWAN MODEL for SANDIA NATIONAL LABS'

SET CARTESIAN
MODE STAT TWOD
COORD CARTESIAN

CGRID REG 0.0 0.0 0.0 1000 1000 100 100 CIRCLE 180 0.250000 5 20
INPGRID BOTTOM REG 0.0 0.0 0.0 100 100 10 10
READINP BOTTOM 1.0000 'Bathymetry.bot' 3 0 FREE

BOUND SHAPESPEC JONSWAP 1 PEAK DSPR POWER
BOUNDSPEC SIDE N CON PAR 1 10 0 20
BOUNDSPEC SIDE W CON PAR 1 10 0 20
BOUNDSPEC SIDE S CON PAR 1 10 0 20

BREAKING
FRICTION
OFF QUADRUPL
OBSTACLE TRANS 0.00 REFL 0.00 LINE 100 100 100 150
OBSTACLE TRANS 0.00 REFL 0.00 LINE  150 200 150 250
```

B. Download SNL-SWAN

http://snl-waterpower.github.io/SNL-SWAN/

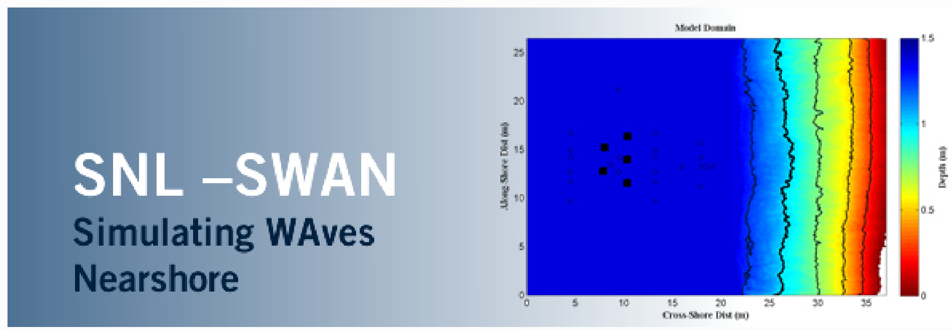
SNL-SWAN

Search docs

- Release Notes
- Getting Started
- Implementation
- Application
- Best Practices
- Online Forum
- Publications
- License

Docs » Project Overview

View page source



Project Overview

SNL-SWAN (Sandia National Laboratories - Simulating WAves Nearshore) is an open source wave energy converter (WEC) array simulation tool. The code is a modification of the open source code, SWAN (Simulating WAves Nearshore) developed by TU Delft. The SNL-SWAN code includes the addition of a WEC Module which improves how SWAN accounts for power performance of WECs and the effects on the wave field. For more information on the implementation and application of SNL-SWAN, please refer to the SNL-SWAN website. SNL-SWAN user questions should be posted on the SNL-SWAN online forum. The SNL-SWAN project is funded by the U.S. Department of Energy's Wind and Water Power Technologies Office.

B. Download SNL-SWAN

Downloading SNL-SWAN

SNL-SWAN is distributed through the SNL-SWAN GitHub site. There are three ways of obtaining the SNL-SWAN code, each of which are described in this section.

Option 1: Clone with GitHub (Recommended for Users)

SNL-SWAN can be obtained by cloning the repository with Git:

```
git clone https://github.com/SNL-WaterPower/SNL-SWAN
```

This method is recommended for most users because it makes it easy to update your local version of SNL-SWAN to the latest version using Git's pull command:

```
git pull
```

Option 2: Fork with Git (Recommended for Developers)

If you are planning to contribute to the SNL-SWAN code, please follow the forking instructions provided by GitHub. Should you make improvements to the code that you would like included in the SNL-SWAN master code, please make a pull request so that your improvement can be merged into SNL-SWAN master, and included in future releases.

Option 3: Static Code Download

The easiest way to obtain a copy of SNL-SWAN is to download the latest tagged release of the SNL-SWAN code available on Github, SNL-SWAN Release.

B. Download SNL-SWAN

Place executable in directory with other SWAN files (grids, INPUT, etc…)

Name	Date modified	Type	Size
Bathymetry.bot	8/7/2014 1:40 PM	BOT File	642 KB
INPUT	8/7/2014 1:40 PM	File	6 KB
Relative_Capture_Width.txt	8/7/2014 1:40 PM	Text Document	1 KB
swan-win-ser-ifort.exe	8/7/2014 1:40 PM	Application	3,260 KB

C. Define WEC Power Performance

Units: Meters

Hs units: Meters

Tp units: Seconds

```
50  # obstacle width
15  # number of significant wave height entries
0.5 # list of wave height entries
1
1.5
2
2.5
3
3.5
4
4.5
5
5.5
6
6.5
7
7.5
15  # number of peak period entries
3   # list of period values
4
5
6
7
8
9
10
11
12
13
14
15
16
17      # power matrix table is entered below
```

Tp

Units: KW

Hs

4.44	5.07	7.97	12.15	16.77	17.14	11.94	9.16	6.57	4.39	4.00	3.00	2.86	1.95	1.71
16.65	19.00	29.48	46.94	56.61	52.38	37.14	28.73	19.84	16.62	12.94	9.33	7.29	7.40	4.49
0.00	41.54	63.14	92.37	110.74	109.49	64.96	55.91	38.49	29.09	22.06	19.26	12.74	11.21	11.50
0.00	66.29	99.03	150.67	200.97	164.91	105.27	85.30	58.63	52.31	40.56	28.76	24.22	19.31	17.57
0.00	0.00	160.23	241.82	261.83	226.36	166.20	117.65	83.09	69.87	57.47	39.24	28.51	26.20	23.73
0.00	0.00	212.52	319.26	372.09	327.17	210.96	151.98	116.43	93.66	75.42	66.09	44.81	42.09	30.83

Power Matrix

- Power Matrix File Name: POWER.txt
- Location: Same directory as INPUT file
- Width (line 1) should usually be the WEC's physical dimension. This term is used to normalize the absorbed power value from the matrix by the width over which it is absorbed

C. Define WEC Power Performance

Relative Capture Width

- RCW File Name: Relative_Capture_Width.txt
- Location: Same directory as INPUT file

Units: Seconds

3	0.05
4	0.13
5	0.22
6	0.41
7	0.53
8	0.70
9	0.86
10	0.90
11	0.97
12	0.84
13	0.77
14	0.53
15	0.38
16	0.32
17	0.30

Units: Unitless width ratio

D. Modify SWAN INPUT File

Relative Capture Width

- SET obcase = selected Obcase setting. This example shows “4”, so will use RCW with frequency variable Kt. The RCW file must be in the same directory.
- SET inrhog = 1 so that to output based on variance or based on true energy (see SWAN user manual).

```
PROJECT  'SAMPLE ' 'TEST'
'SWAN MODEL for SANDIA NATIONAL LABS'

SET CARTESIAN
SET inrhog= 1
SET obcase= 4
MODE STAT TWOD
COORD CARTESIAN

CGRID REG 0.0 0.0 0.0 1000 1000 100 100 CIRCLE 180 0.
INPGRID BOTTOM REG 0.0 0.0 0.0 100 100 10 10
READINP BOTTOM 1.0000 'Bathymetry.bot' 3 0 FREE

BOUND SHAPESPEC JONSWAP 1 PEAK DSPR POWER
BOUNDSPEC SIDE N CON PAR 1 10 0 20
BOUNDSPEC SIDE W CON PAR 1 10 0 20
BOUNDSPEC SIDE S CON PAR 1 10 0 20

BREAKING
FRICTION
OFF QUADRUPL
OBSTACLE TRANS 0.00 REFL 0.00 LINE 100 100 100 150
OBSTACLE TRANS 0.00 REFL 0.00 LINE  150 200 150 250
```

E. Determine Obcase

WEC Performance Information	Frequency-variable Kt	Frequency-constant Kt
No Information	N/A	Obcase 0
Power Matrix (real seas, peak period)	N/A	Obcase 1
Power Matrix (regular waves and amplitude)	Obcase 3	N/A
RCW Curve	Obcase 4	Obcase 2

```
PROJECT  'SAMPLE ' 'TEST'
'SWAN MODEL for SANDIA NATIONAL LABS'

SET CARTESIAN
SET inrhog= 1
SET obcase= 4
```

E. Run SNL-SWAN

- Run SNL-SWAN executable same as original SWAN

Name	Date modified	Type	Size
Bathymetry.bot	8/7/2014 1:40 PM	BOT File	642 KB
INPUT	8/7/2014 1:40 PM	File	6 KB
Relative_Capture_Width.txt	8/7/2014 1:40 PM	Text Document	1 KB
swan-win-ser-ifort.exe	8/7/2014 1:40 PM	Application	3,260 KB

- Check for error messages
- See FAQ section for troubleshooting

Obcase 0: Baseline SWAN

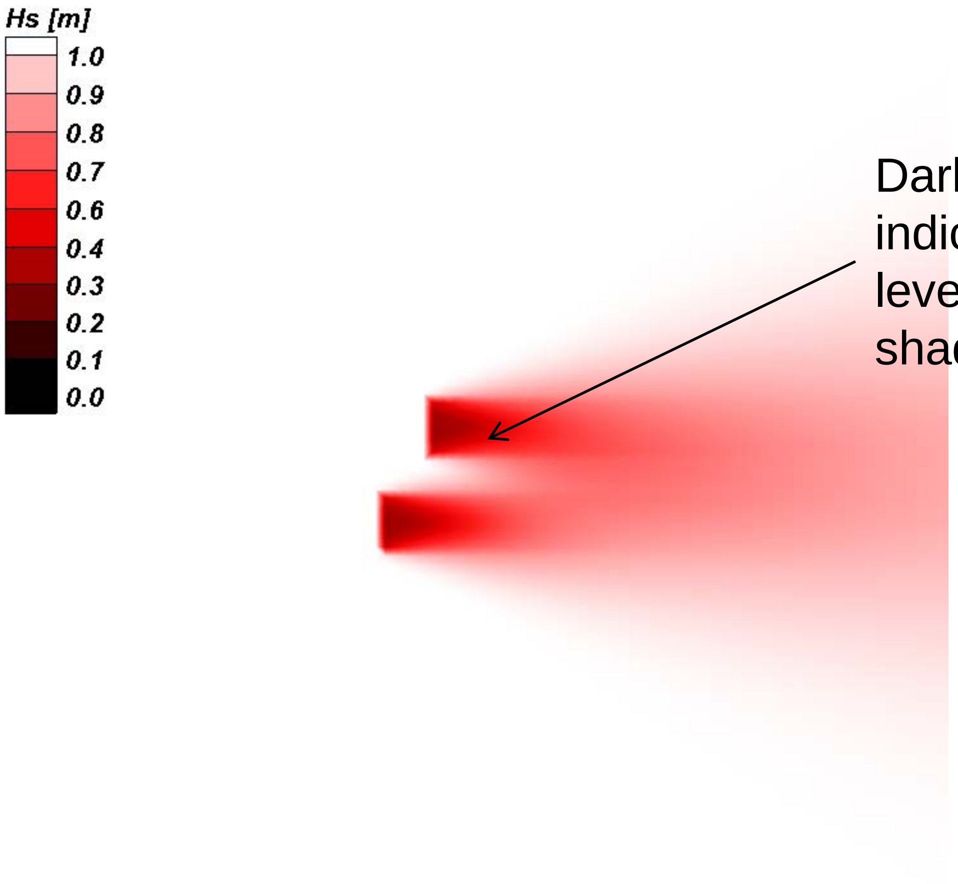
SET obcase to 0 must be selected, even for baseline SWAN runs with SNL-SWAN.exe

```
SET CARTESIAN
SET inrhog= 1
SET obcase= 0
MODE STAT TWOD
COORD CARTESIAN

CGRID REG 0.0 0.0 0.0 1000 1000 100 100 CIRCLE 180 0.250000 5 20
INPGRID BOTTOM REG 0.0 0.0 0.0 100 100 10 10
READINP BOTTOM 1.0000 'Bathymetry.bot' 3 0 FREE

BOUND SHAPESPEC JONSWAP 1 PEAK DSPR POWER
BOUNDSPEC SIDE N CON PAR 1 10 0 20
BOUNDSPEC SIDE W CON PAR 1 10 0 20
BOUNDSPEC SIDE S CON PAR 1 10 0 20

BREAKING
FRICTION
OFF QUADRUPL
OBSTACLE TRANS 0.3 REFL 0.00 LINE 100 100 100 150
OBSTACLE TRANS 0.3 REFL 0.00 LINE  150 200 150 250
```

Inputs shown as conceptual examples only

Obstacle Transmission must be manually toggled in the INPUT file. In this case 0.3 was selected. No RCW or Power Matrix files needed.

Obcase 0: Example Results



Darker colors indicate higher levels of wave shadowing.

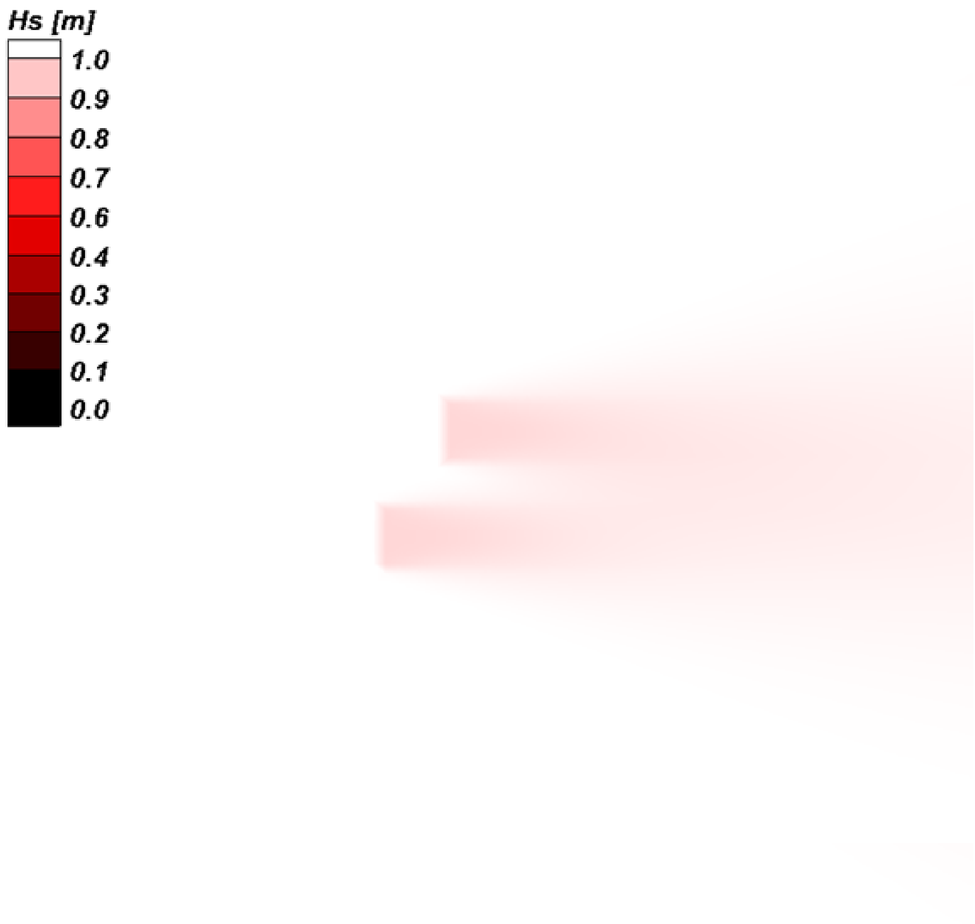
Obcase 1: Power Matrix, Constant Kt

```
SET CARTESIAN
SET inrhog= 1
SET obcase= 1
MODE STAT TWOD
COORD CARTESIAN

CGRID REG 0.0 0.0 0.0 1000 1000 100 100 CIRCLE 180 0.250000 5 20
INPGRID BOTTOM REG 0.0 0.0 0.0 100 100 10 10
READINP BOTTOM 1.0000 'Bathymetry.bot' 3 0 FREE

BOUND SHAPESPEC JONSWAP 1 PEAK DSPR POWER
BOUNDSPEC SIDE N CON PAR 1 10 0 20
BOUNDSPEC SIDE W CON PAR 1 10 0 20
BOUNDSPEC SIDE S CON PAR 1 10 0 20

BREAKING
FRICTION
OFF QUADRUPL
OBSTACLE TRANS 0 REFL 0.00 LINE 100 100 100 150
OBSTACLE TRANS 0 REFL 0.00 LINE  150 200 150 250
```

SET obcase to 1 must be selected.

Obstacle Transmission set to 0. POWER.txt file will supersede.

Obcase 1: Example Results



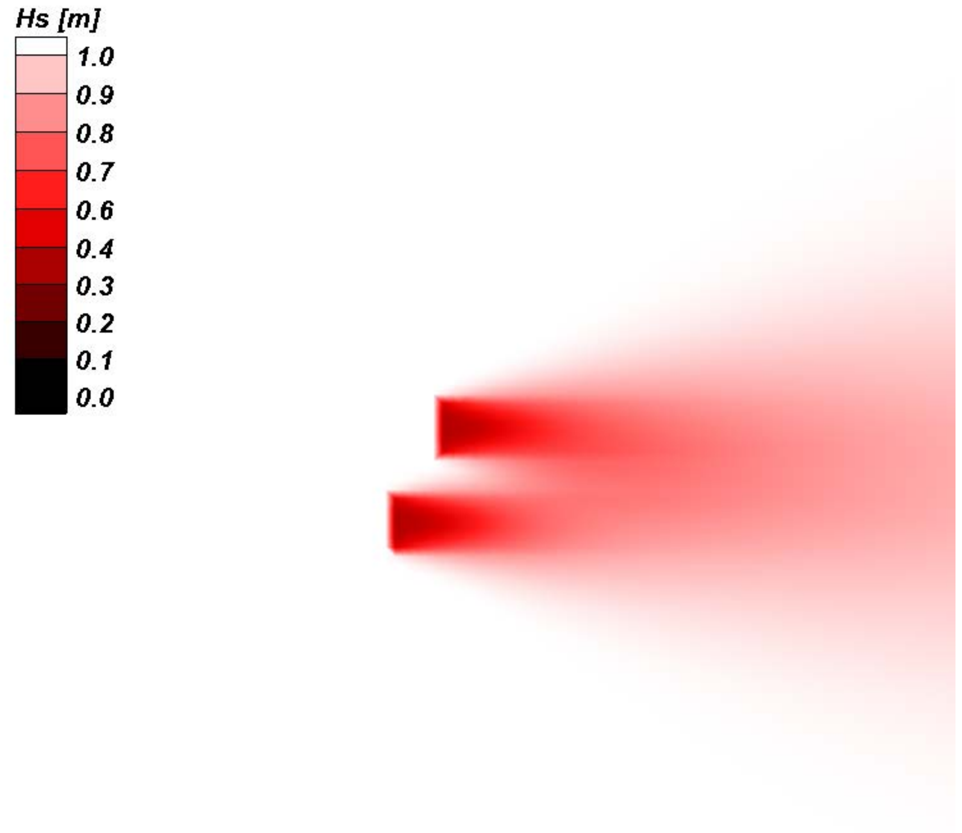
Obcase 2: RCW, Constant Kt

```
SET CARTESIAN
SET inrhog= 1
SET obcase= 2
MODE STAT TWOD
COORD CARTESIAN

CGRID REG 0.0 0.0 0.0 1000 1000 100 100 CIRCLE 180 0.250000 5 20
INPGRID BOTTOM REG 0.0 0.0 0.0 100 100 10 10
READINP BOTTOM 1.0000 'Bathymetry.bot' 3 0 FREE

BOUND SHAPESPEC JONSWAP 1 PEAK DSPR POWER
BOUNDSPEC SIDE N CON PAR 1 10 0 20
BOUNDSPEC SIDE W CON PAR 1 10 0 20
BOUNDSPEC SIDE S CON PAR 1 10 0 20

BREAKING
FRICTION
OFF QUADRUPL
OBSTACLE TRANS 0 REFL 0.00 LINE 100 100 100 150
OBSTACLE TRANS 0 REFL 0.00 LINE  150 200 150 250
```

SET obcase to 2 must be selected.

Obstacle Transmission set to 0. Relative_Capture_Width.txt file will supersede.

Obcase 2: Example Results



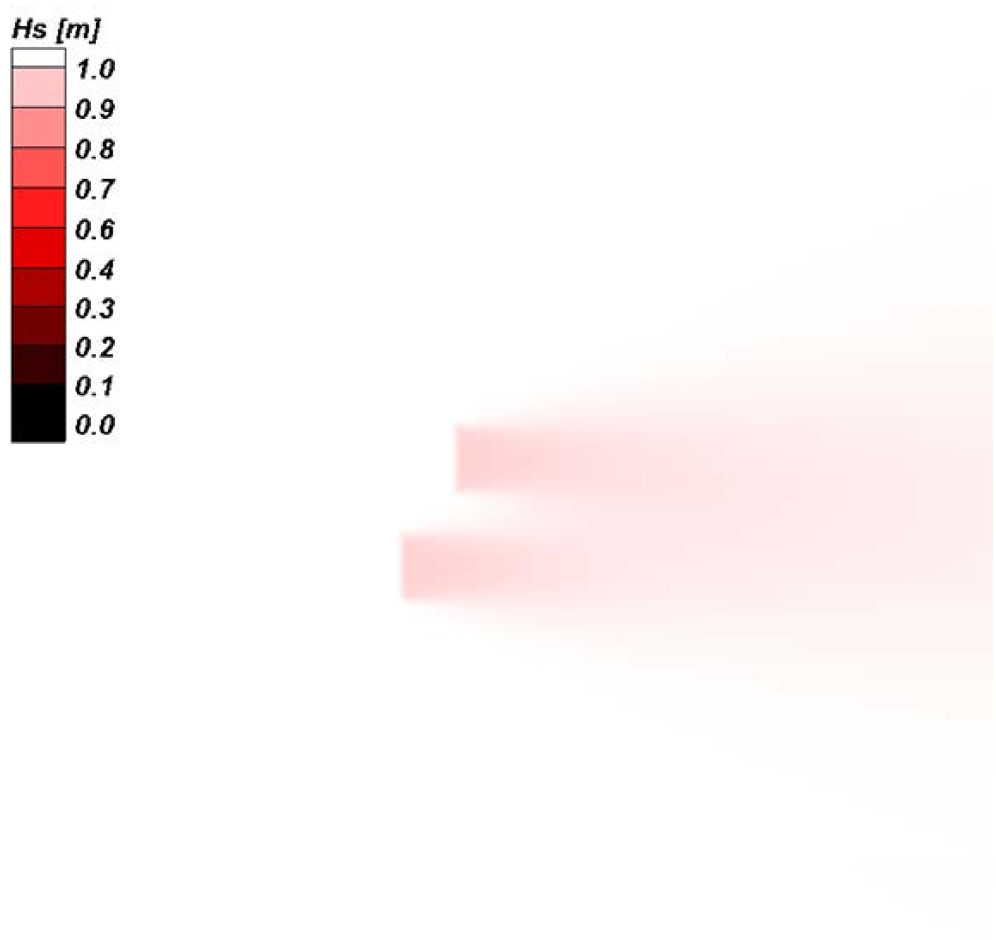
Obcase 3: Power Matrix, Variable Kt

```
SET CARTESIAN
SET inrhog= 1
SET obcase= 3
MODE STAT TWOD
COORD CARTESIAN

CGRID REG 0.0 0.0 0.0 1000 1000 100 100 CIRCLE 180 0.250000 5 20
INPGRID BOTTOM REG 0.0 0.0 0.0 100 100 10 10
READINP BOTTOM 1.0000 'Bathymetry.bot' 3 0 FREE

BOUND SHAPESPEC JONSWAP 1 PEAK DSPR POWER
BOUNDSPEC SIDE N CON PAR 1 10 0 20
BOUNDSPEC SIDE W CON PAR 1 10 0 20
BOUNDSPEC SIDE S CON PAR 1 10 0 20

BREAKING
FRICTION
OFF QUADRUPL
OBSTACLE TRANS 0 REFL 0.00 LINE 100 100 100 150
OBSTACLE TRANS 0 REFL 0.00 LINE  150 200 150 250
```

SET obcase to 3 must be selected.

Obstacle Transmission set to 0. POWER.txt file will supersede.

Obcase 3: Example Results



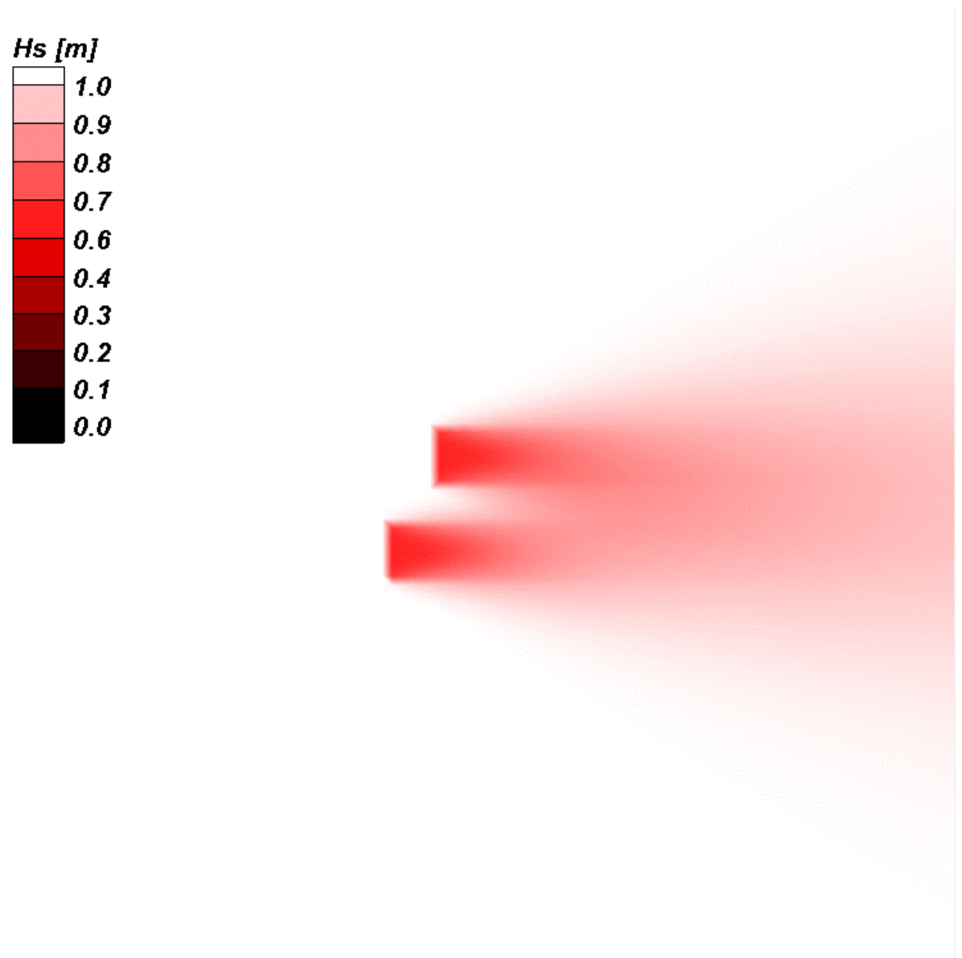
Obcase 4: RCW, Variable Kt

```
SET CARTESIAN
SET inrhog= 1
SET obcase= 4
MODE STAT TWOD
COORD CARTESIAN

CGRID REG 0.0 0.0 0.0 1000 1000 100 100 CIRCLE 180 0.250000 5 20
INPGRID BOTTOM REG 0.0 0.0 0.0 100 100 10 10
READINP BOTTOM 1.0000 'Bathymetry.bot' 3 0 FREE

BOUND SHAPESPEC JONSWAP 1 PEAK DSPR POWER
BOUNDSPEC SIDE N CON PAR 1 10 0 20
BOUNDSPEC SIDE W CON PAR 1 10 0 20
BOUNDSPEC SIDE S CON PAR 1 10 0 20

BREAKING
FRICTION
OFF QUADRUPL
OBSTACLE TRANS 0 REFL 0.00 LINE 100 100 100 150
OBSTACLE TRANS 0 REFL 0.00 LINE  150 200 150 250
```

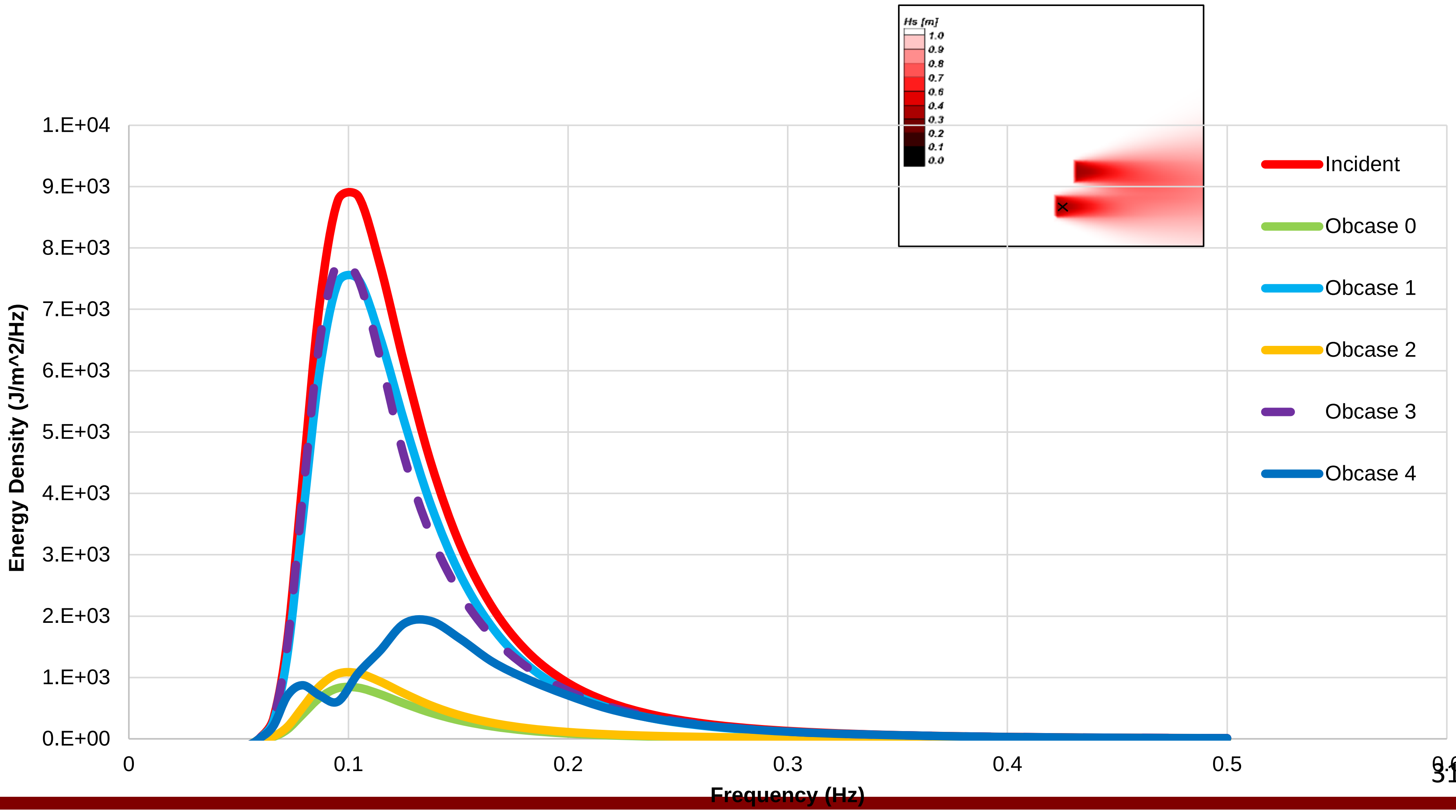
SET obcase to 4 must be selected.

Obstacle Transmission set to 0. Relative_Capture_Width.txt file will supersede.

Obcase 4: Example Results



Obcase: Spectra Results Example



Frequently Asked Questions

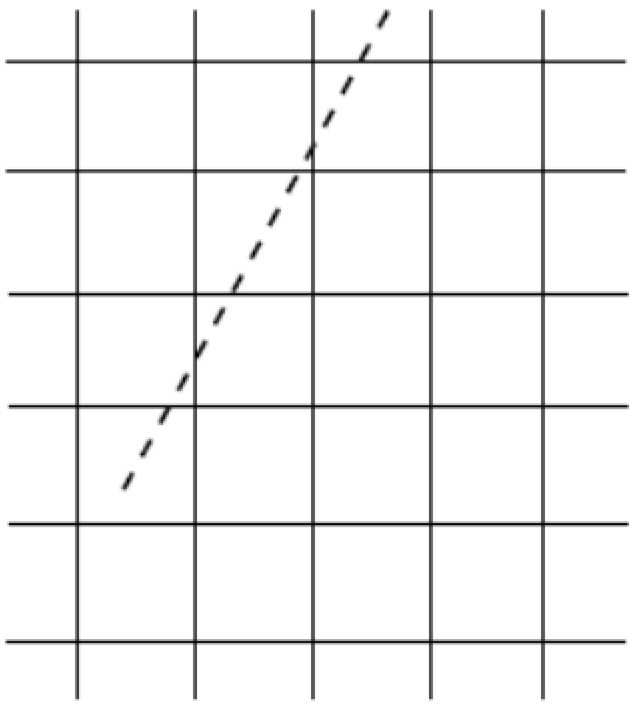
- All questions should be directed to our online forum:
  https://github.com/SNL-WaterPower/SNL-SWAN/issues

Best Practices and Limitations

- Grid resolution
- Obstacle location on grid
- RCW <= 1.0
- Transmission and reflection. Total energy reflected and absorbed cannot be greater than energy available.

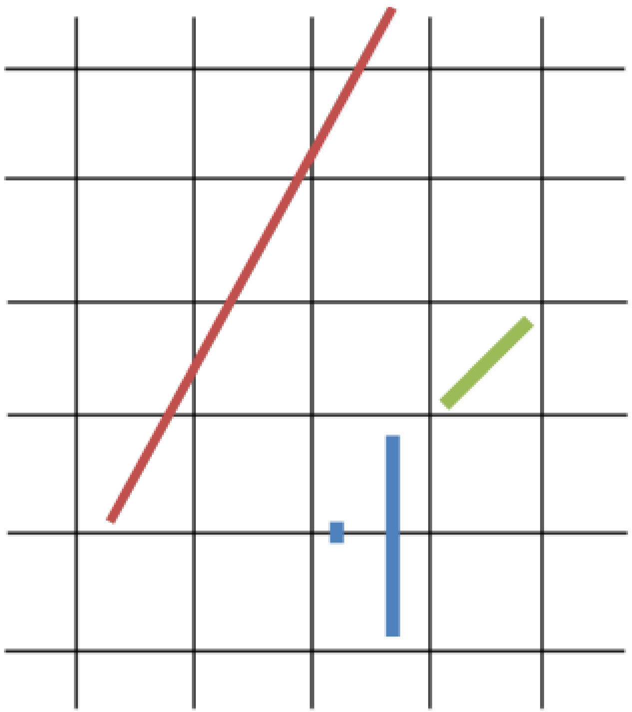
Best Practice: Grids

As noted in Section 3.10 of the SWAN Scientific and Technical Documentation, obstacles are treated as lines running through the computational grid. When calculating the action density flux from one grid point to its neighbors, SWAN first determines if the connecting grid line crosses an obstacle line. If and only if a grid line is crossed by an obstacle line, the transmission coefficient applied to the flux between those nodes.



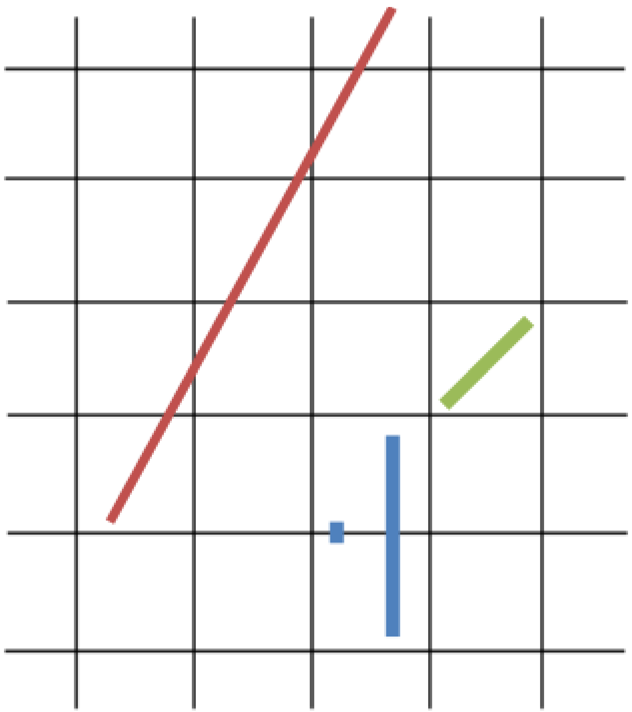
Best Practice: Grids

The two blue obstacles shown will have the exact same influence on the model solution, even though they have much different widths. Since both obstacles cross the same computation grid line, SWAN will apply their transmission coefficient the same volumetric fluxing face. Both obstacles correspond to the same face, and thus their obstacle coefficients will have the same impact on the model calculation.



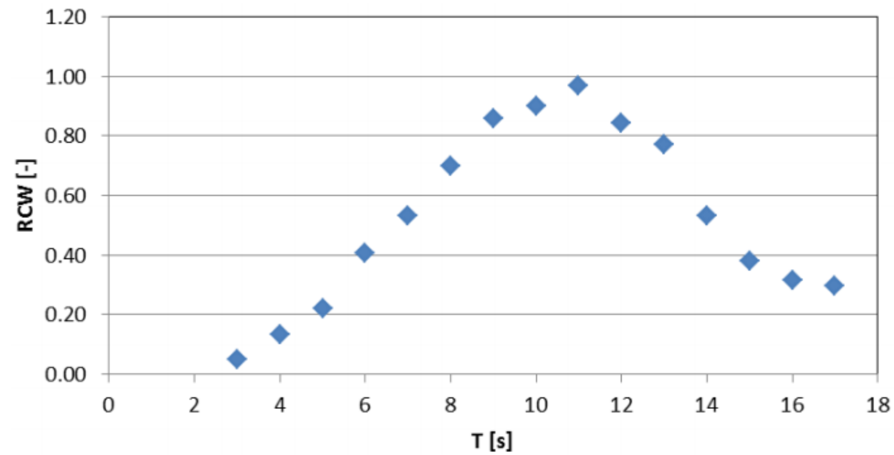
Best Practice: Grids

- Due to grid discretization, the green obstacle does not intersect and computational grid lines. In this situation it will have no effect, even though the obstacle is much larger than the small blue obstacle (which does have an effect).
- The red line shows the appropriate use of the obstacle implementation, where grid discretization is much finer than the obstacle length. This means that obstacles will span multiple grid lines and their length and transmission effects can be properly captured.



Best Practice: WEC Power

- RCW should be between 0 and 1.0
- If outside these limits, SNL-SWAN will force the limits.
- In choosing an obstacle case, attention should be paid to the way the Power Matrix or RCW curve was created.
- Using OBCASE equal to 3 or 4 is only appropriate when information is available about individual frequencies.
- OBCASE 1 and 2 are more appropriate when information is available about average sea states.



		Tp														
	MEAN	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Hs (m)	0.5	4.44	5.07	7.97	12.15	16.77	17.14	11.94	9.16	6.57	4.39	4.00	3.00	2.86	1.95	1.71
	1	16.65	19.00	29.48	46.94	56.61	52.38	37.14	28.73	19.84	16.62	12.94	9.33	7.29	7.40	4.49
	1.5	0.00	41.54	63.14	92.37	110.74	109.49	64.96	55.91	38.49	29.09	22.06	19.26	12.74	11.21	11.50
	2	0.00	66.29	99.03	150.67	200.97	164.91	105.27	85.30	58.63	52.31	40.56	28.76	24.22	19.31	17.57
	2.5	0.00	0.00	160.23	241.82	261.83	226.36	166.20	117.65	83.09	69.87	57.47	39.24	28.51	26.20	23.73
	3	0.00	0.00	212.52	319.26	372.09	327.17	210.96	151.98	116.43	93.66	75.42	66.09	44.81	42.09	30.83
	3.5	0.00	0.00	270.15	436.02	503.15	407.75	292.71	203.22	148.33	115.49	92.63	74.81	57.97	44.27	41.16
	4	0.00	0.00	0.00	553.82	540.26	521.33	355.46	260.73	191.66	144.19	122.78	84.04	81.01	55.80	53.24
	4.5	0.00	0.00	0.00	645.46	746.22	586.83	378.72	302.18	236.42	189.64	154.41	105.88	89.58	74.26	55.78
	5	0.00	0.00	0.00	796.15	926.13	694.67	485.91	341.08	287.07	211.41	167.83	135.72	111.21	93.81	77.53
	5.5	0.00	0.00	0.00	939.38	954.73	807.95	603.12	429.61	343.03	231.19	201.49	150.14	120.29	96.75	89.90
	6	0.00	0.00	0.00	0.00	1161.42	956.67	642.03	480.81	329.09	289.47	212.26	171.77	145.82	110.89	100.85
	6.5	0.00	0.00	0.00	0.00	1476.47	1039.27	702.04	487.62	396.60	311.56	236.66	203.88	153.43	120.26	102.25
	7	0.00	0.00	0.00	0.00	1664.93	1197.05	820.77	612.40	465.98	384.59	251.62	222.70	180.55	146.28	131.44
	7.5	0.00	0.00	0.00	0.00	1608.45	1407.61	922.63	703.98	508.65	373.47	325.45	229.49	190.53	151.78	149.26

Best Practice: WEC Power/Reflection

- Transmitted + reflected + absorbed energy cannot be greater than the incident wave energy
  - 1-kt + kr > 0
- Check this for all frequencies
- SNL-SWAN will produce an error message if energy is not conserved in this way.