Welcome to the BOEM-Oregon Science Exchange

March 16, 2016 - 10:00 am
Audio: call toll free 1-877-612-1641, passcode: 5729109
We will begin shortly!

If you are having audio difficulties,
please send us a chat message on WebEx.

Pacific Region Marine Archaeologist

Dave Ball

Dave Ball is the Pacific Region Historic Preservation Officer and Regional Tribal Liaison for the U.S. Department of the Interior's Bureau of Ocean Energy Management (BOEM). Dave joined the BOEM Gulf of Mexico Region office in 1999 and transferred to the Pacific Region office in 2010. He received a Bachelor of Arts degree in anthropology from Sonoma State University in 1992 and a Master of Arts degree in anthropology from Florida State University in 1998. Dave currently serves as an elected Officer for the Advisory Council on Underwater Archaeology, an international advisory organization supporting underwater cultural heritage preservation. He has managed the important visual evaluations study for the Pacific Region.

Renewable Energy Visual Evaluations: *Visual Impact Evaluation System for Offshore Renewable Energy* (VIESORE)

Argonne National Laboratory and
Center for Advanced Spatial Technologies

Dave Ball
Pacific Region Historic Preservation Officer

BOEM Information Need:

A tool to assess the potential visual impacts associated with offshore wind energy projects.

"Visual impacts are defined as changes to the scenic attributes of the landscape brought about by the introduction of visual contrasts (e.g, development) and the associated changes in the human visual experience of the landscape."

From: Sullivan and Meyer (2014:17) ***Guide to Evaluating Visual Impact Assessment for Renewable Energy Projects***
http://visualimpact.anl.gov/npsguidance/

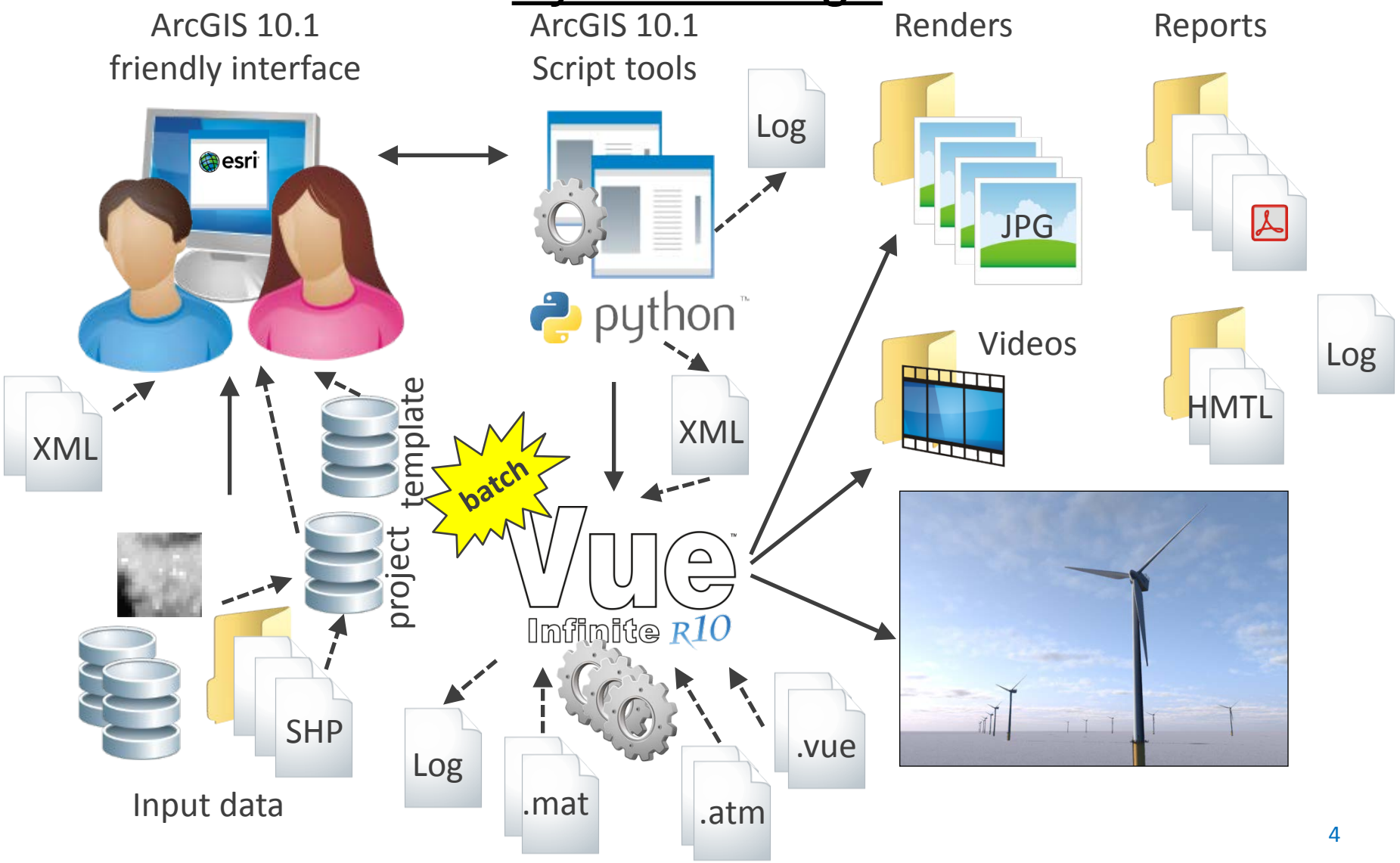
Renewable Energy Visual Evaluations

The primary sources of visual contrast associated with operating offshore wind energy facilities include:

- Vertical line contrasts associated with the wind turbine towers;
- Color contrast from the white or light gray tower and blade structures, generally seen against a sky backdrop when viewed from shore but occasionally viewed against a water backdrop from elevated onshore locations;
- Form contrast from the array as a whole;
- Motion of the wind turbine blades;
- Color contrast from aviation obstruction lighting at night; and
- Color contrast from marine navigation lighting at night.

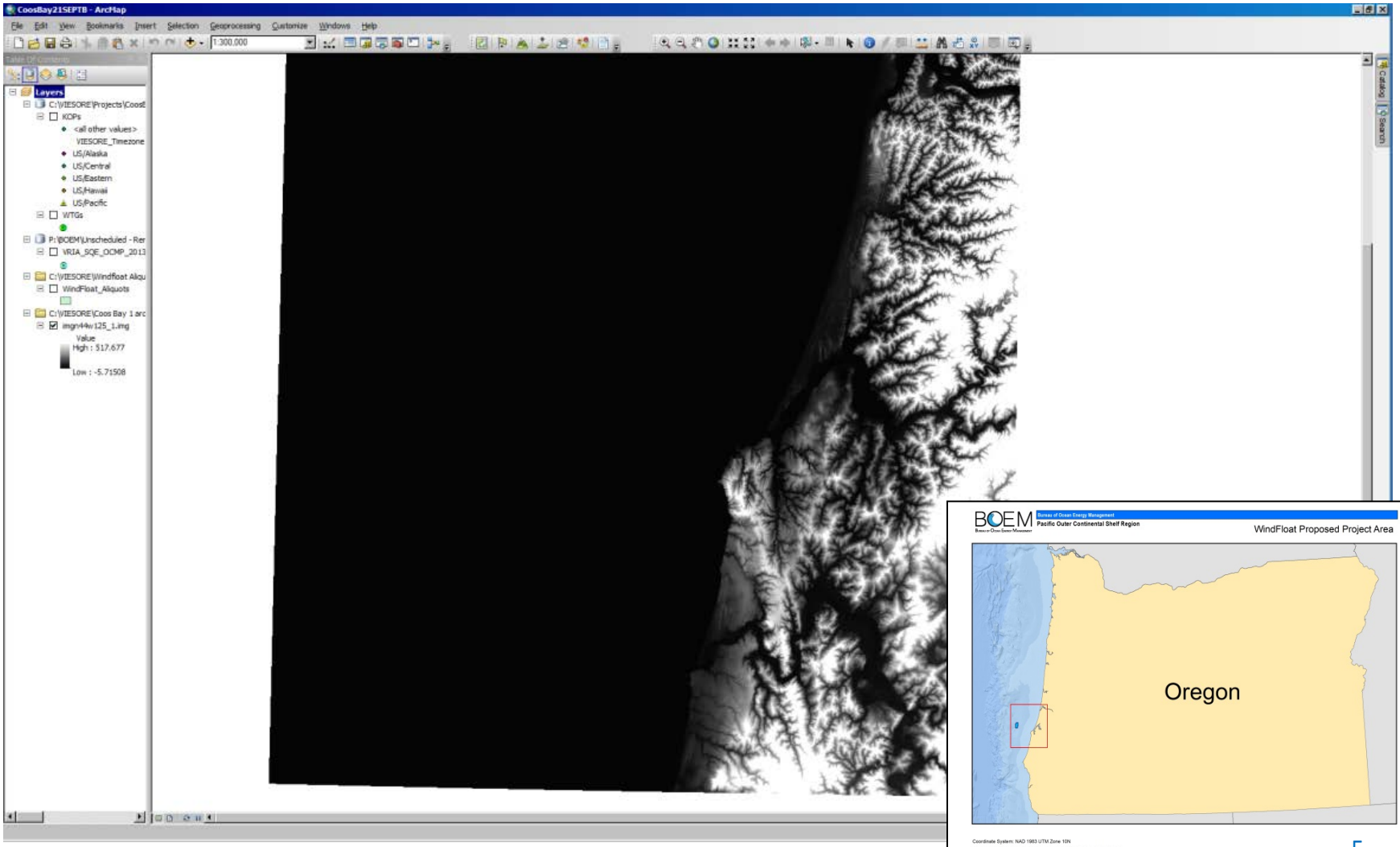
From Sullivan and Meyer (2014:55)

System design



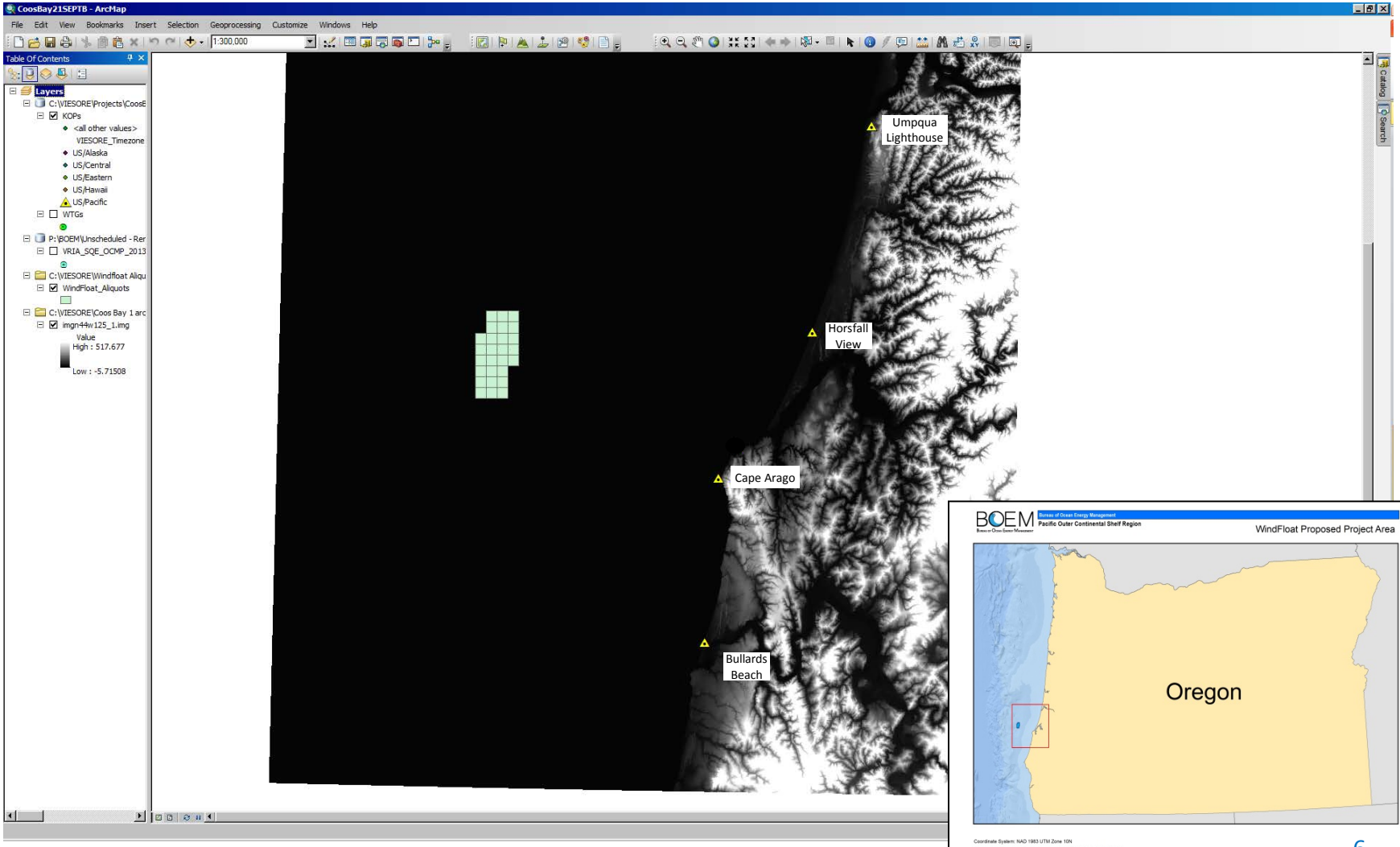
Renewable Energy Visual Evaluations

Import Digital Elevation Model (DEM) into ArcGIS 10.1



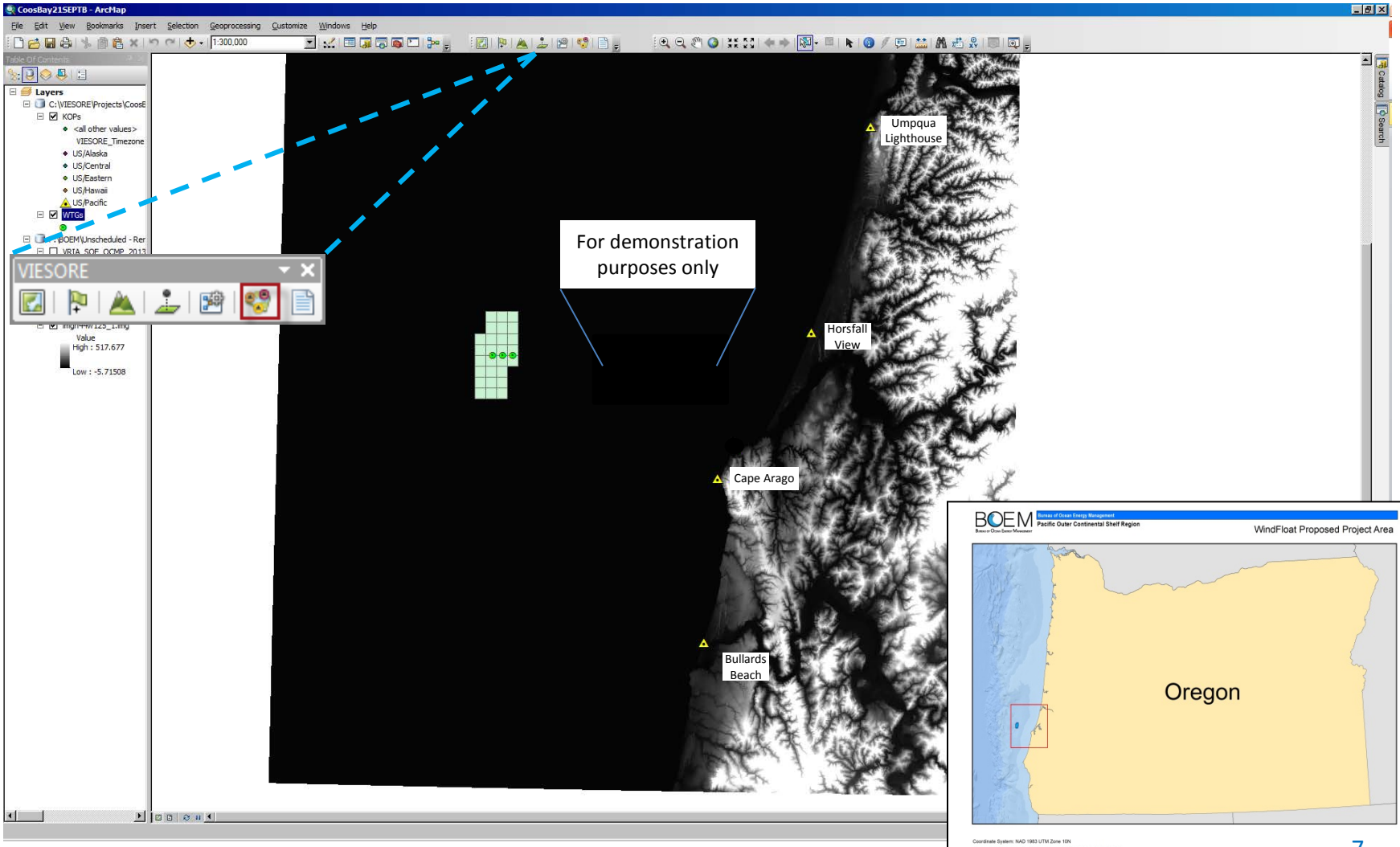
Renewable Energy Visual Evaluations

Create Known Observation Points (KOPs)



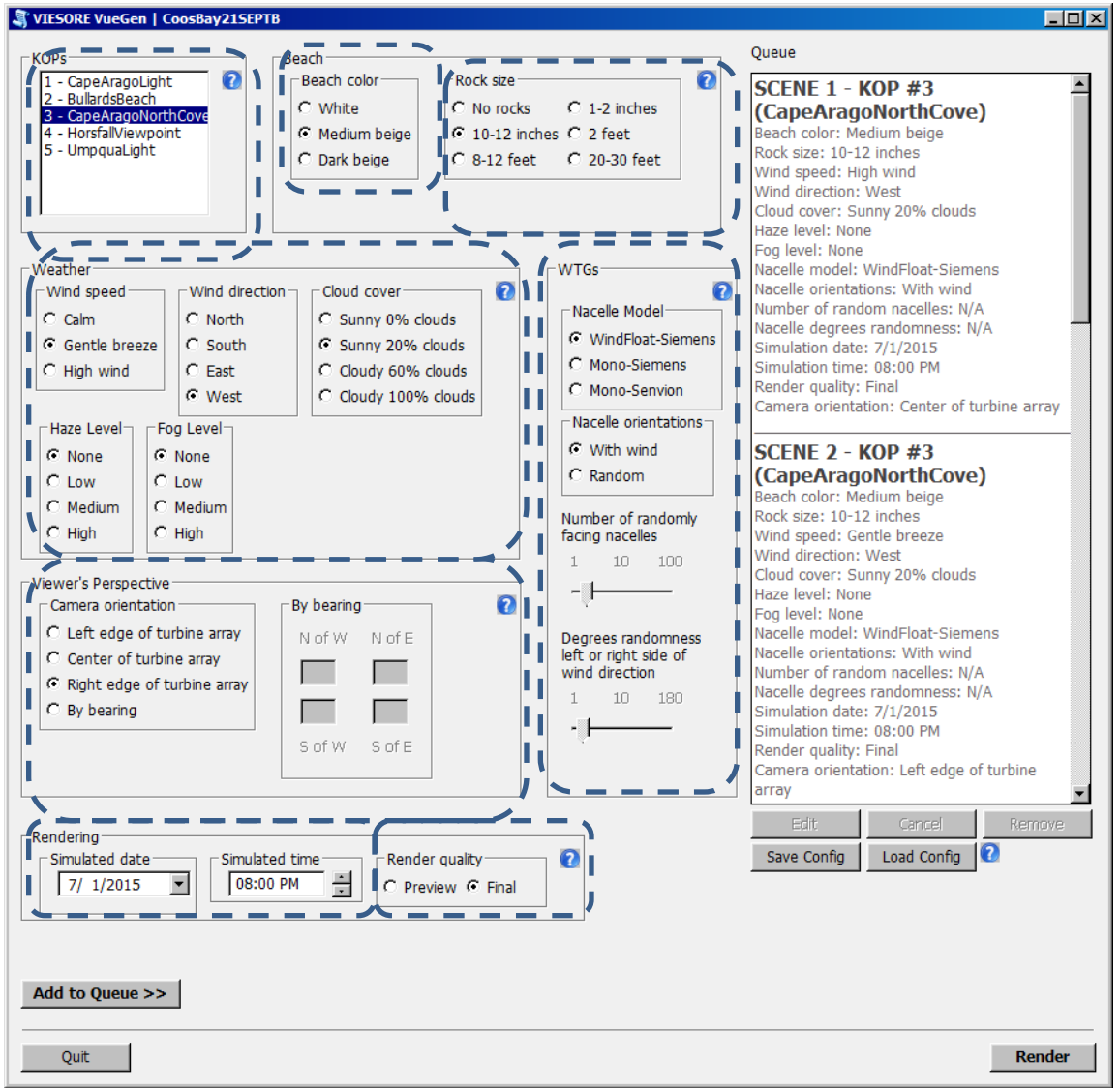
Renewable Energy Visual Evaluations

Add Wind Turbine Generator (WTG) locations

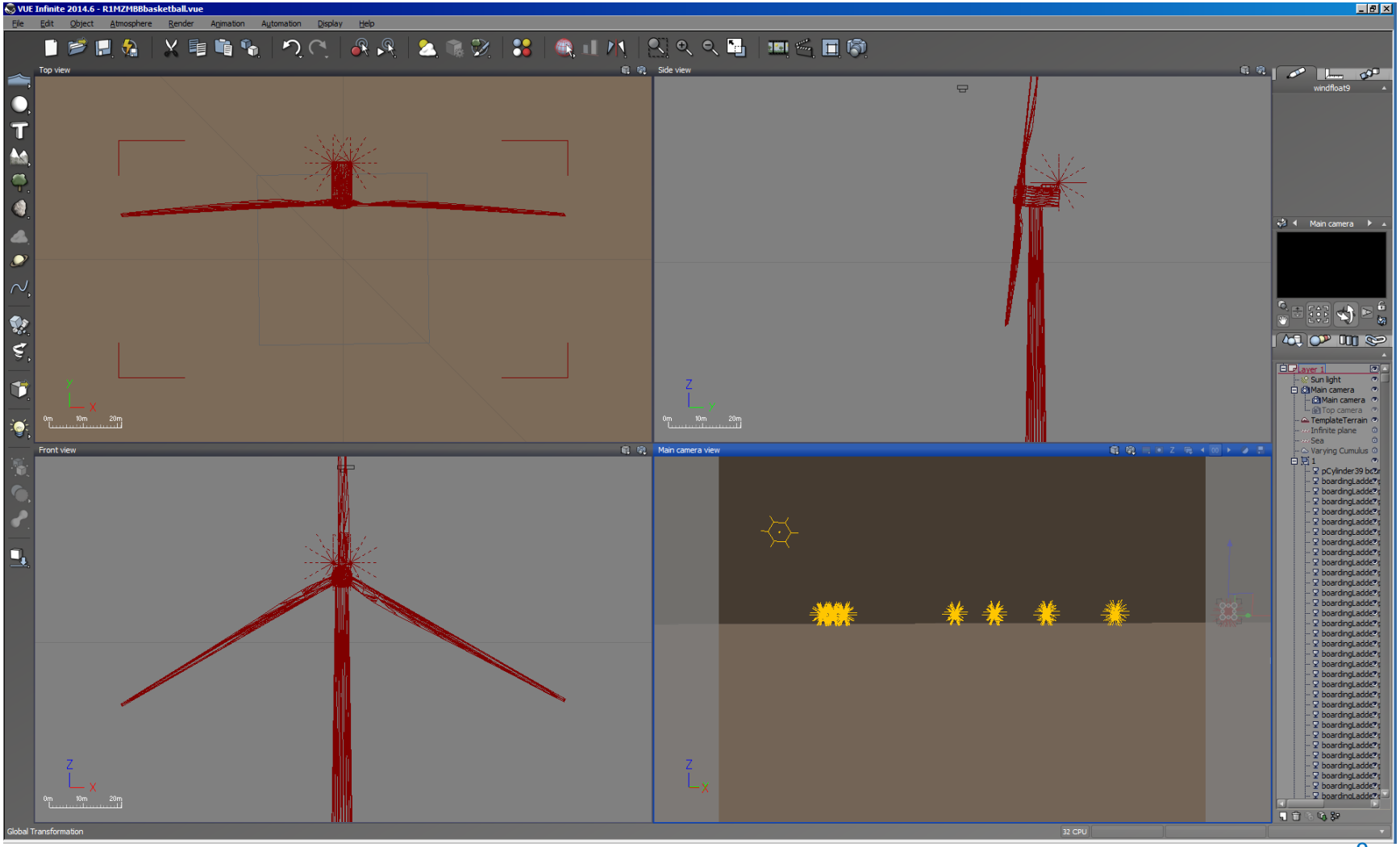


Renewable Energy Visual Evaluations: VueGen Module

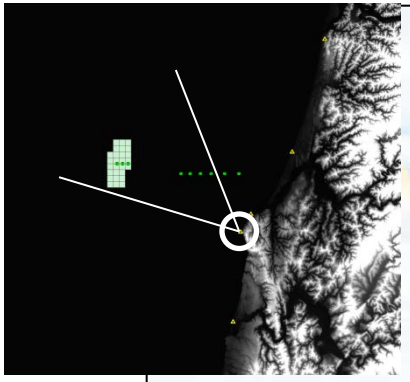
VueGen Module:

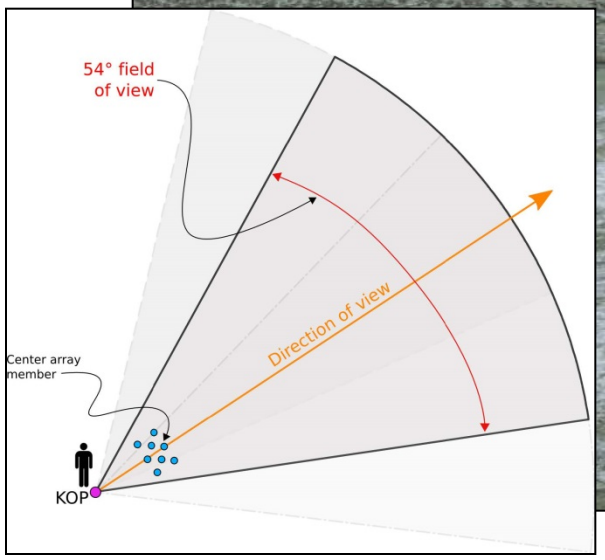


Rendering in Vue Infinite



Renewable Energy Visual Evaluations: Center Perspective





Proposed Windfloats: 16.5-17.5 miles

10.3 miles

9.5 miles

8.75 miles

8.0 miles

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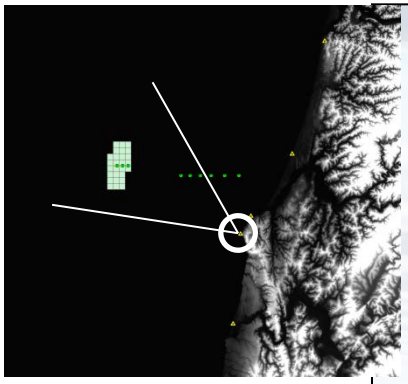
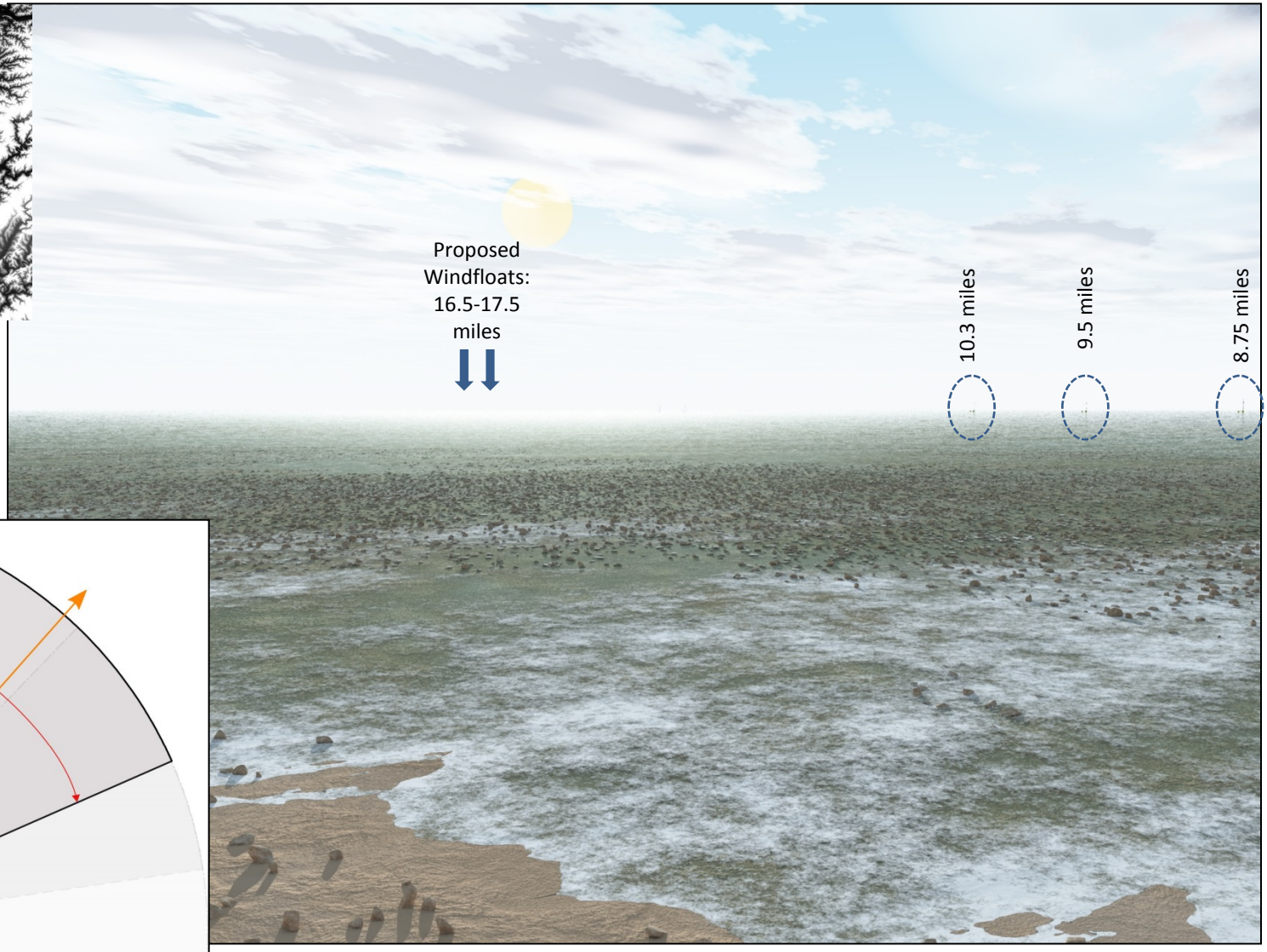
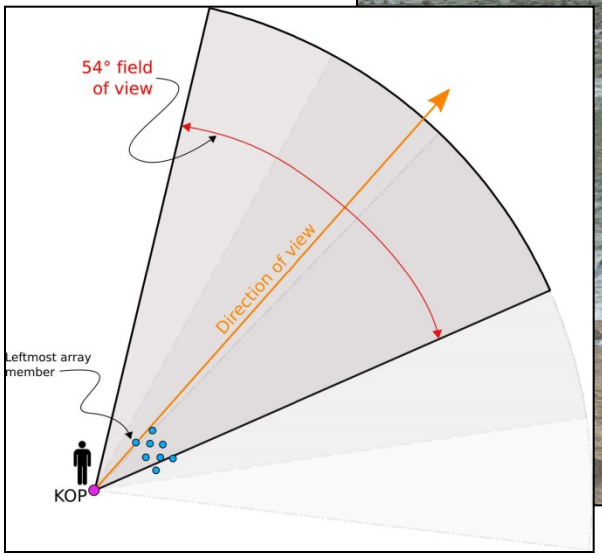
Renewable Energy Visual Evaluations: Left Perspective







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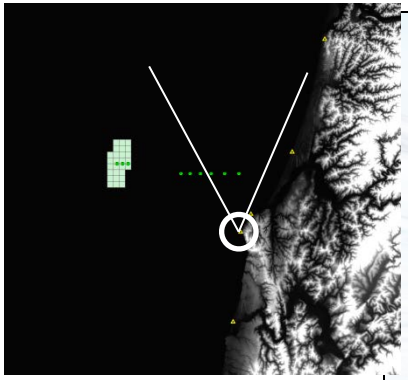
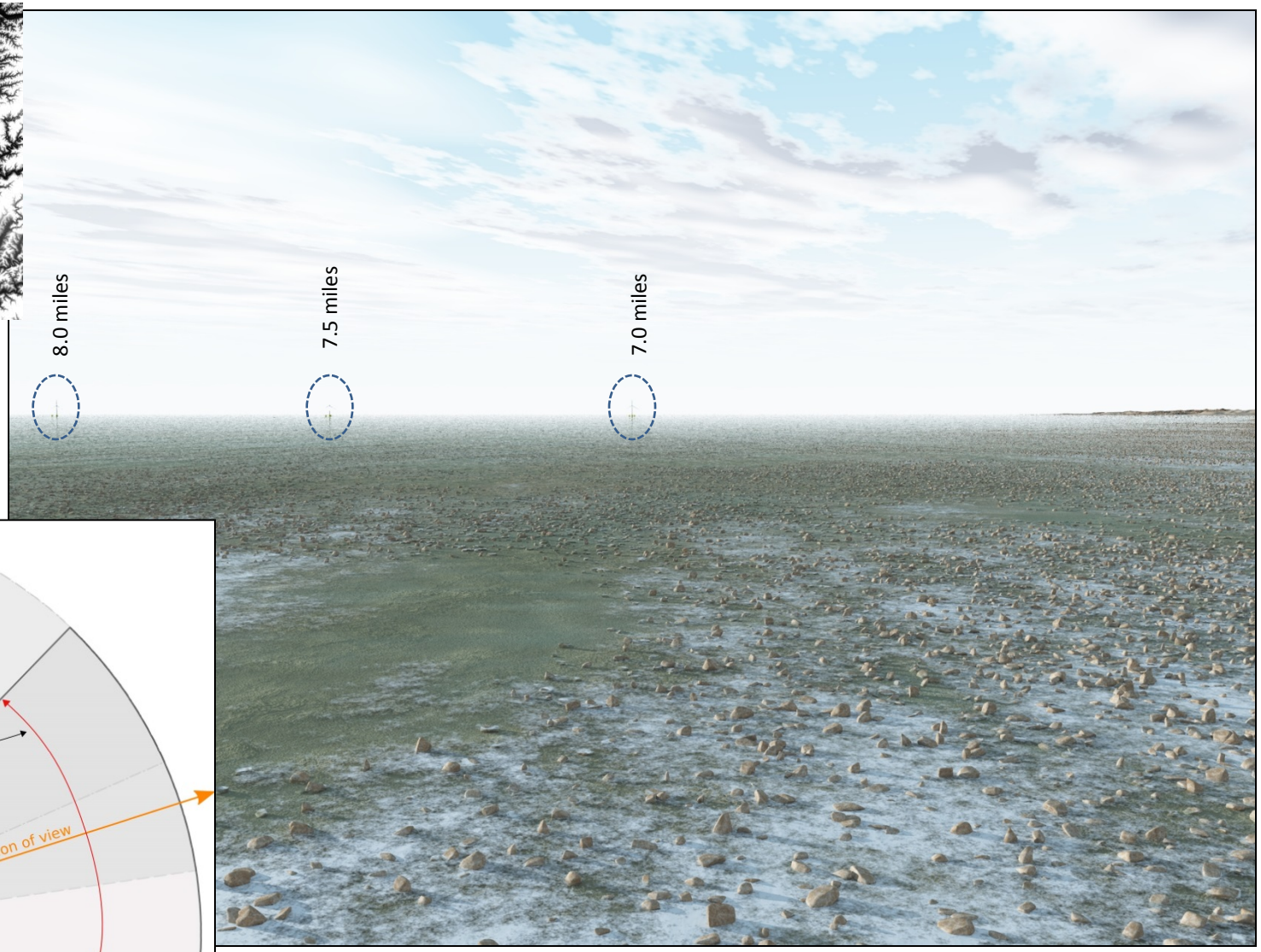
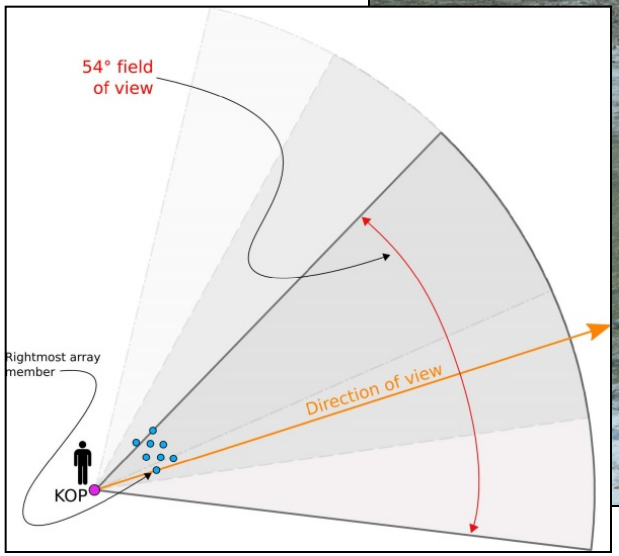
Renewable Energy Visual Evaluations: Right Perspective







The formula for calculating the horizontal field of view (FoV) is:

$$FoV = 2 \arctan \frac{w}{2f}$$

Where:

- FoV is the horizontal field of view in degrees (54.4 degrees for VIESORE)
- w is the width of the image (or camera sensor in a digital camera; 36 millimeters for VIESORE)
- f is the lens focal length in millimeters (35 millimeters for VIESORE)
- $arctan$ is a standard mathematical function, with the result expressed in degrees

The formula for calculating the correct viewing distance is:

$$V = \frac{i}{2} \Big/ tan \frac{FoV}{2}$$

Where:

- V is the correct viewing distance
- i is the width of the displayed image
- FoV is the horizontal field of view in degrees
- tan is a standard mathematical function

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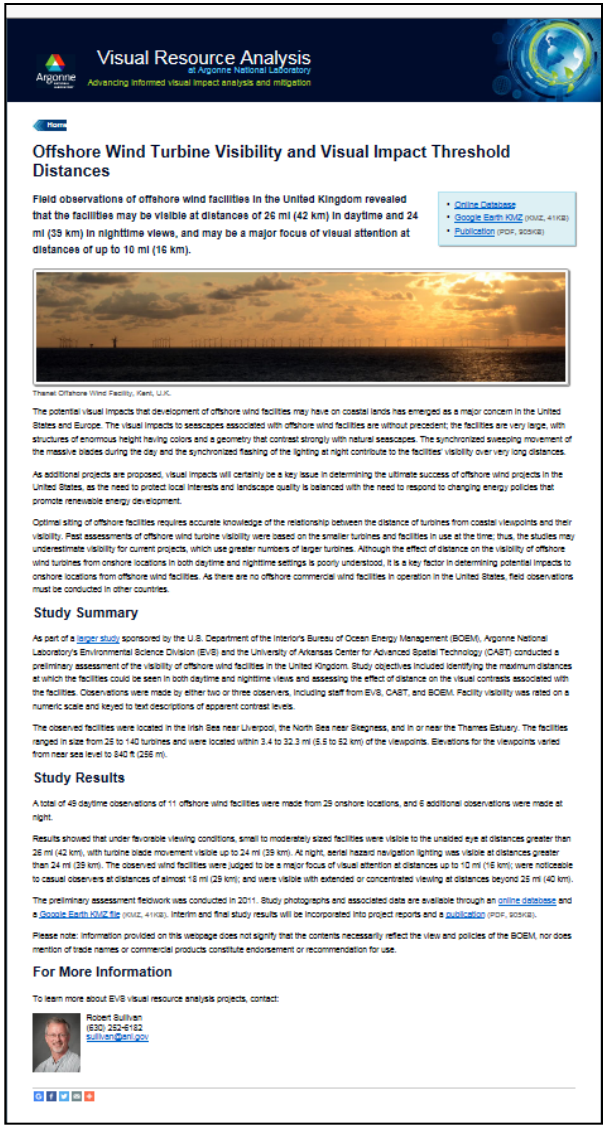
Renewable Energy Visual Evaluations: Threshold Distances



Visual Resource Analysis
at Argonne National Laboratory
Advancing informed visual impact analysis and mitigation

Home

Offshore Wind Turbine Visibility and Visual Impact Threshold Distances

Field observations of offshore wind facilities in the United Kingdom revealed that the facilities may be visible at distances of 26 mi (42 km) in daytime and 24 mi (39 km) in nighttime views, and may be a major focus of visual attention at distances of up to 10 mi (16 km).

- Online Database
- Google Earth KMZ (KMZ, 41KB)
- Publication (PDF, 905KB)

Thanet Offshore Wind Facility, Kent, U.K.

The potential visual impacts that development of offshore wind facilities may have on coastal lands has emerged as a major concern in the United States and Europe. The visual impacts to seascapes associated with offshore wind facilities are without precedent; the facilities are very large, with structures of enormous height having colors and a geometry that contrast strongly with natural seascapes. The synchronized sweeping movement of the massive blades during the day and the synchronized flashing of the lighting at night contribute to the facilities' visibility over very long distances.

As additional projects are proposed, visual impacts will certainly be a key issue in determining the ultimate success of offshore wind projects in the United States, as the need to protect local interests and landscape quality is balanced with the need to respond to changing energy policies that promote renewable energy development.

Optimal siting of offshore facilities requires accurate knowledge of the relationship between the distance of turbines from coastal viewpoints and their visibility. Past assessments of offshore wind turbine visibility were based on the smaller turbines and facilities in use at the time; thus, the studies may underestimate visibility for current projects, which use greater numbers of larger turbines. Although the effect of distance on the visibility of offshore wind turbines from onshore locations in both daytime and nighttime settings is poorly understood, it is a key factor in determining potential impacts to onshore locations from offshore wind facilities. As there are no offshore commercial wind facilities in operation in the United States, field observations must be conducted in other countries.

Study Summary

As part of a larger study sponsored by the U.S. Department of the Interior's Bureau of Ocean Energy Management (BOEM), Argonne National Laboratory's Environmental Science Division (EVS) and the University of Arkansas Center for Advanced Spatial Technology (CAST) conducted a preliminary assessment of the visibility of offshore wind facilities in the United Kingdom. Study objectives included identifying the maximum distances at which the facilities could be seen in both daytime and nighttime views and assessing the effect of distance on the visual contrasts associated with the facilities. Observations were made by either two or three observers, including staff from EVS, CAST, and BOEM. Facility visibility was rated on a numeric scale and keyed to text descriptions of apparent contrast levels.

The observed facilities were located in the Irish Sea near Liverpool, the North Sea near Skegness, and in or near the Thames Estuary. The facilities ranged in size from 25 to 140 turbines and were located within 3.4 to 32.3 mi (5.5 to 52 km) of the viewpoints. Elevations for the viewpoints varied from near sea level to 840 ft (256 m).

Study Results

A total of 48 daytime observations of 11 offshore wind facilities were made from 29 onshore locations, and 6 additional observations were made at night.

Results showed that under favorable viewing conditions, small to moderately sized facilities were visible to the unaided eye at distances greater than 26 mi (42 km), with turbine blade movement visible up to 24 mi (39 km). At night, aerial hazard navigation lighting was visible at distances greater than 24 mi (39 km). The observed wind facilities were judged to be a major focus of visual attention at distances up to 10 mi (16 km); were noticeable to casual observers at distances of almost 18 mi (29 km); and were visible with extended or concentrated viewing at distances beyond 26 mi (40 km).

The preliminary assessment fieldwork was conducted in 2011. Study photographs and associated data are available through an online database and a Google Earth KMZ file (KMZ, 41KB). Interim and final study results will be incorporated into project reports and a publication (PDF, 905KB).

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For More Information

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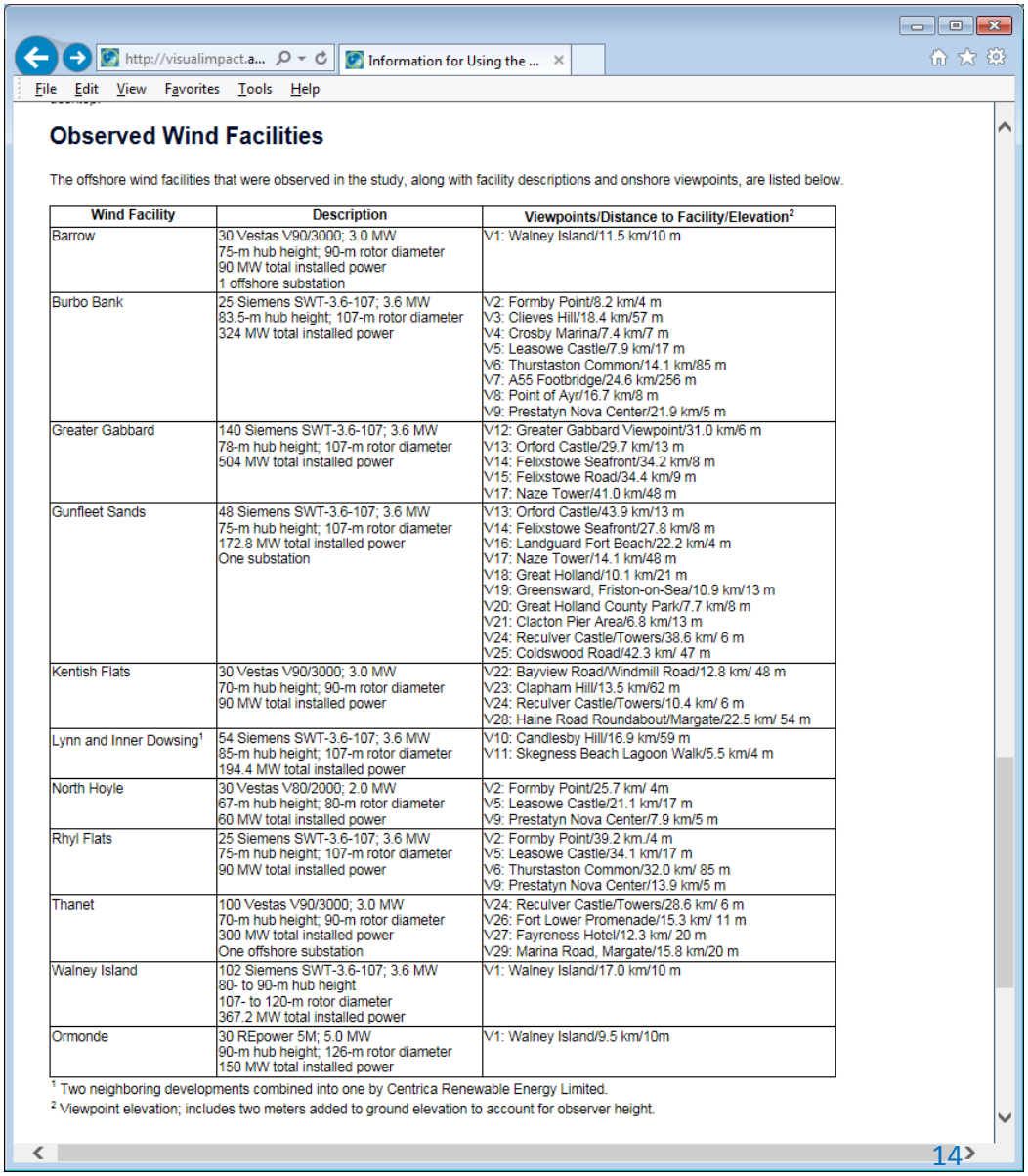
Robert Sullivan
(630) 252-6182
sullivan@anl.gov



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Observed Wind Facilities

The offshore wind facilities that were observed in the study, along with facility descriptions and onshore viewpoints, are listed below.

Wind Facility	Description	Viewpoints/Distance to Facility/Elevation[2]
Barrow	30 Vestas V90/3000; 3.0 MW 75-m hub height; 90-m rotor diameter 90 MW total installed power 1 offshore substation	V1: Walney Island/11.5 km/10 m
Burbo Bank	25 Siemens SWT-3.6-107; 3.6 MW 83.5-m hub height; 107-m rotor diameter 324 MW total installed power	V2: Formby Point/8.2 km/4 m V3: Clieves Hill/18.4 km/57 m V4: Crosby Marina/7.4 km/7 m V5: Leasowe Castle/7.9 km/17 m V6: Thurstaston Common/14.1 km/85 m V7: A55 Footbridge/24.6 km/256 m V8: Point of Ayr/16.7 km/8 m V9: Prestatyn Nova Center/21.9 km/5 m
Greater Gabbard	140 Siemens SWT-3.6-107; 3.6 MW 78-m hub height; 107-m rotor diameter 504 MW total installed power	V12: Greater Gabbard Viewpoint/31.0 km/6 m V13: Orford Castle/29.7 km/13 m V14: Felixstowe Seafront/34.2 km/8 m V15: Felixstowe Road/34.4 km/9 m V17: Naze Tower/41.0 km/48 m
Gunfleet Sands	48 Siemens SWT-3.6-107; 3.6 MW 75-m hub height; 107-m rotor diameter 172.8 MW total installed power One substation	V13: Orford Castle/43.9 km/13 m V14: Felixstowe Seafront/27.8 km/8 m V16: Landguard Fort Beach/22.2 km/4 m V17: Naze Tower/14.1 km/48 m V18: Great Holland/10.1 km/21 m V19: Greensward, Friston-on-Sea/10.9 km/13 m V20: Great Holland County Park/7.7 km/8 m V21: Clacton Pier Area/6.8 km/13 m V24: Reculver Castle/Towers/38.6 km/ 6 m V25: Coldswood Road/42.3 km/ 47 m
Kentish Flats	30 Vestas V90/3000; 3.0 MW 70-m hub height; 90-m rotor diameter 90 MW total installed power	V22: Bayview Road/Windmill Road/12.8 km/ 48 m V23: Clapham Hill/13.5 km/62 m V24: Reculver Castle/Towers/10.4 km/ 6 m V28: Haine Road Roundabout/Margate/22.5 km/ 54 m
Lynn and Inner Dowsing[1]	54 Siemens SWT-3.6-107; 3.6 MW 85-m hub height; 107-m rotor diameter 194.4 MW total installed power	V10: Candlesby Hill/16.9 km/59 m V11: Skegness Beach Lagoon Walk/5.5 km/4 m
North Hoyle	30 Vestas V80/2000; 2.0 MW 67-m hub height; 80-m rotor diameter 60 MW total installed power	V2: Formby Point/25.7 km/ 4m V5: Leasowe Castle/21.1 km/17 m V9: Prestatyn Nova Center/7.9 km/5 m
Rhyl Flats	25 Siemens SWT-3.6-107; 3.6 MW 75-m hub height; 107-m rotor diameter 90 MW total installed power	V2: Formby Point/39.2 km./4 m V5: Leasowe Castle/34.1 km/17 m V6: Thurstaston Common/32.0 km/ 85 m V9: Prestatyn Nova Center/13.9 km/5 m
Thanet	100 Vestas V90/3000; 3.0 MW 70-m hub height; 90-m rotor diameter 300 MW total installed power One offshore substation	V24: Reculver Castle/Towers/28.6 km/ 6 m V26: Fort Lower Promenade/15.3 km/ 11 m V27: Fayreness Hotel/12.3 km/ 20 m V29: Marina Road, Margate/15.8 km/20 m
Walney Island	102 Siemens SWT-3.6-107; 3.6 MW 80- to 90-m hub height 107- to 120-m rotor diameter 367.2 MW total installed power	V1: Walney Island/17.0 km/10 m
Ormonde	30 REpower 5M; 5.0 MW 90-m hub height; 126-m rotor diameter 150 MW total installed power	V1: Walney Island/9.5 km/10m

[1] Two neighboring developments combined into one by Centrica Renewable Energy Limited.

[2] Viewpoint elevation; includes two meters added to ground elevation to account for observer height.

http://visualimpact.anl.gov/offshorevitd/

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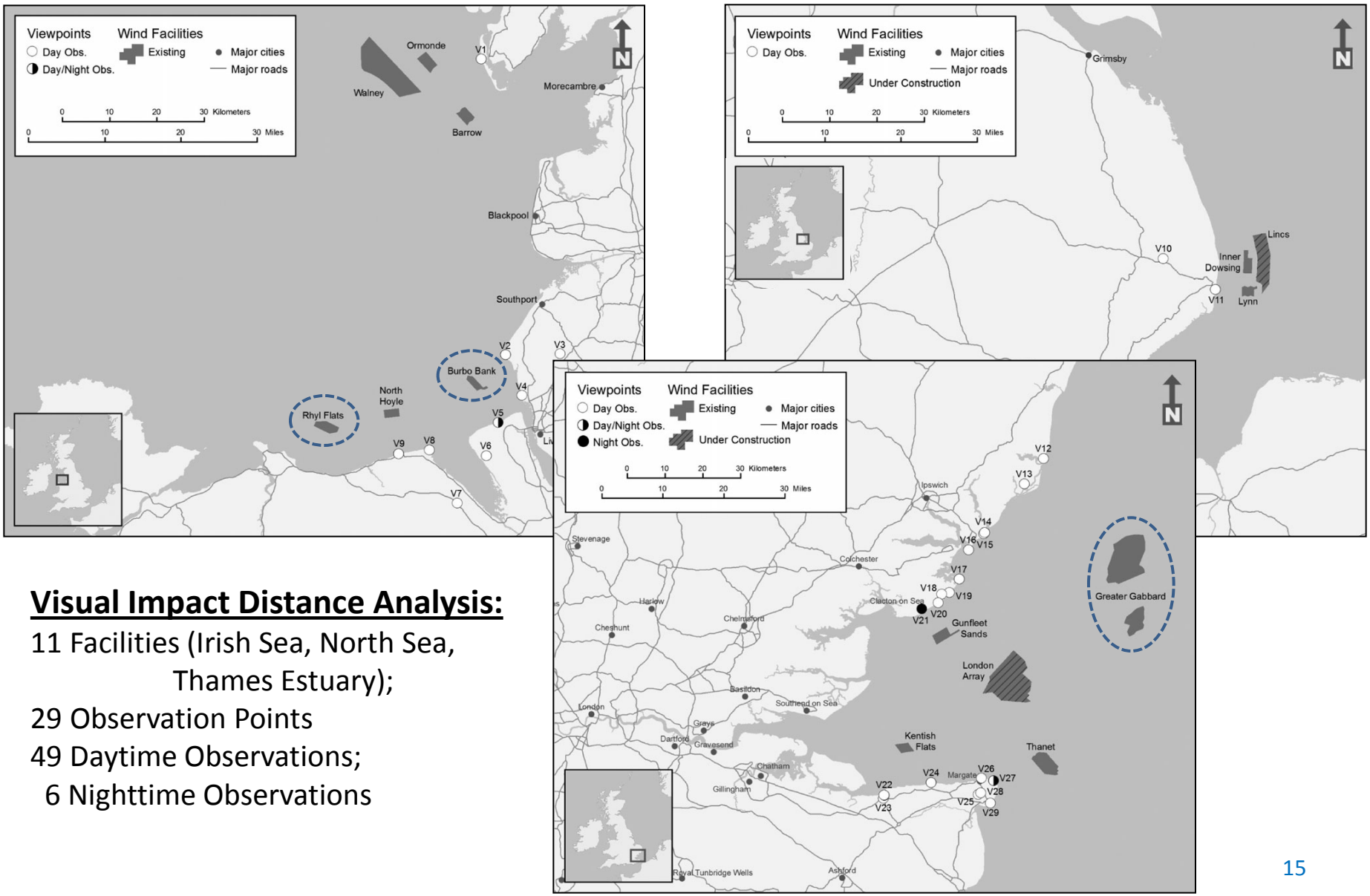
Renewable Energy Visual Evaluations: Threshold Distances



Visual Impact Distance Analysis:

11 Facilities (Irish Sea, North Sea, Thames Estuary);
29 Observation Points
49 Daytime Observations;
6 Nighttime Observations

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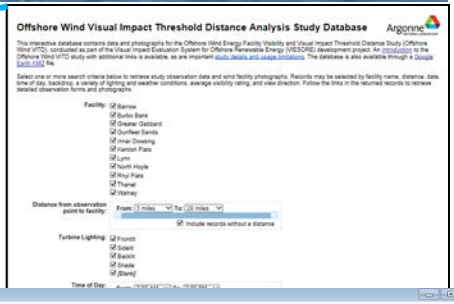

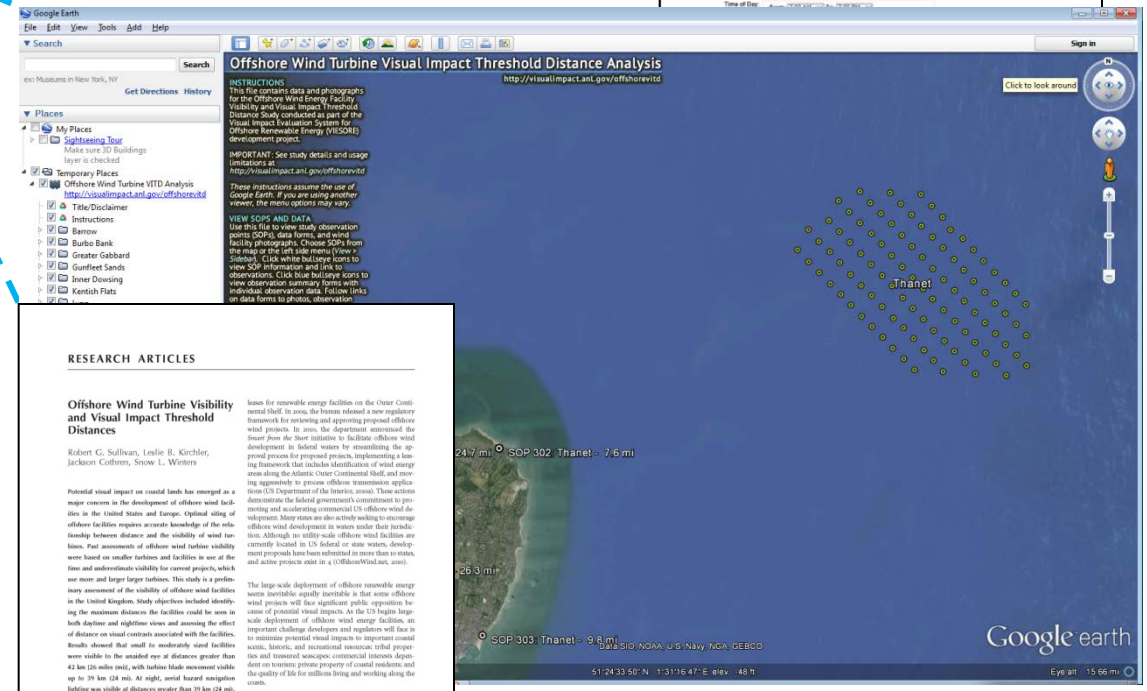

RESEARCH ARTICLES

Offshore Wind Turbine Visibility and Visual Impact Threshold Distances

Robert G. Sullivan, Leslie B. Kirchler, Jackson Cothren, Snow L. Winters

Potential visual impact on coastal lands has emerged as a major concern in the development of offshore wind facilities in the United States and Europe. Optimal siting of offshore facilities requires accurate knowledge of the relationship between distance and the visibility of wind turbines. Past assessments of offshore wind turbine visibility were based on smaller turbines and facilities in use at the time and underestimate visibility for current projects, which use more and larger larger turbines. This study is a preliminary assessment of the visibility of offshore wind facilities in the United Kingdom. Study objectives included identifying the maximum distances the facilities could be seen in both daytime and nighttime views and assessing the effect of distance on visual contrasts associated with the facilities. Results showed that small to moderately sized facilities were visible to the unaided eye at distances greater than 42 km (26 miles (mi), with turbine blade movement visible up to 39 km (24 mi). At night, aerial hazard navigation lighting was visible at distances greater than 39 km (24 mi). The observed wind facilities were judged to be a major focus of visual attention at distances up to 16 km (10 mi), were noticeable to casual observers at distances of almost 29 km (18 mi), and were visible with extended or concentrated viewing at distances beyond 40 km (25 mi).

Environmental Practice Page 1 of 17

The Energy Policy Act of 2005 provided the United States (US) Department of the Interior's Bureau of Ocean Energy Management with the authority to issue leases for renewable energy facilities on the Outer Continental Shelf. In 2009, the bureau released a new regulatory framework for reviewing and approving proposed offshore wind projects. In 2010, the department announced the *Smart from the Start* initiative to facilitate offshore wind development in federal waters by streamlining the approval process for proposed projects, implementing a leasing framework that includes identification of wind energy areas along the Atlantic Outer Continental Shelf, and moving aggressively to process offshore transmission applications (US Department of the Interior, 2010a). These actions demonstrate the federal government's commitment to promoting and accelerating commercial US offshore wind development. Many states are also actively seeking to encourage offshore wind development in waters under their jurisdiction. Although no utility-scale offshore wind facilities are currently located in US federal or state waters, development proposals have been submitted in more than 10 states, and active projects exist in 4 (OffshoreWind.net, 2010).

The large-scale deployment of offshore renewable energy seems inevitable; equally inevitable is that some offshore wind projects will face significant public opposition because of potential visual impacts. As the US begins large-scale deployment of offshore wind energy facilities, an important challenge developers and regulators will face is to minimize potential visual impacts to important coastal scenic, historic, and recreational resources: tribal properties and treasured seascapes commercial interests dependent on tourism; private property of coastal residents; and the quality of life for millions living and working along the coasts.

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Address correspondence to: Robert G. Sullivan, Program Manager/Coordinator, Environmental Science Division, Argonne National Laboratory, 9700 South Cass Avenue, Argonne, IL 60439; (phone) 630-252-6182; (fax) 630-252-6020; (e-mail) sullivan@anl.gov;

doi:10.1017/S1466046612000464

http://visualimpact.anl.gov/offshorevitd/

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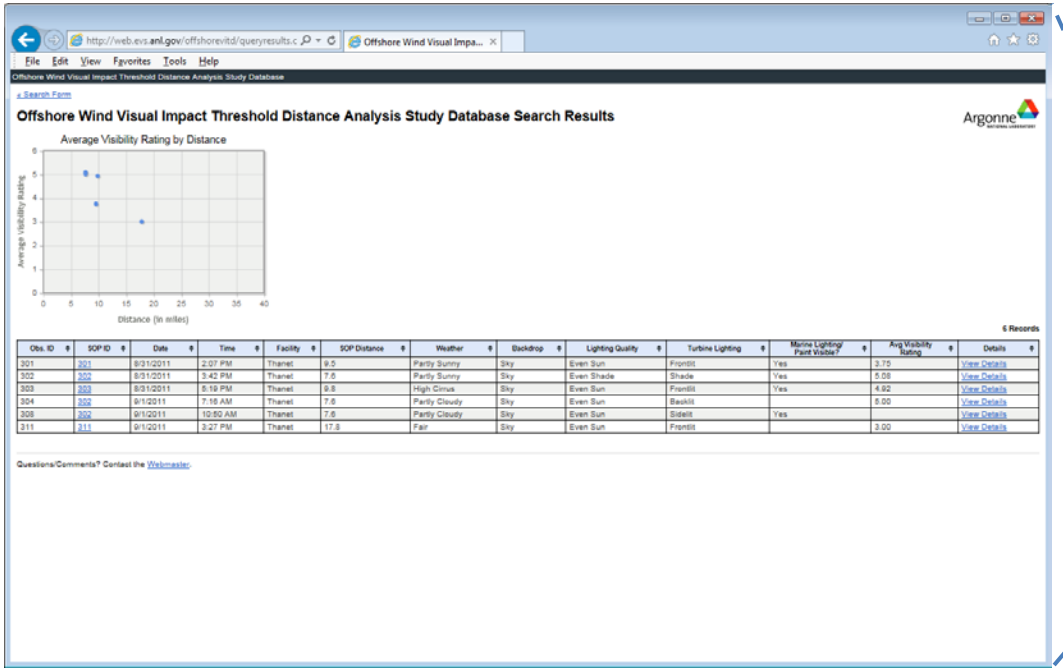
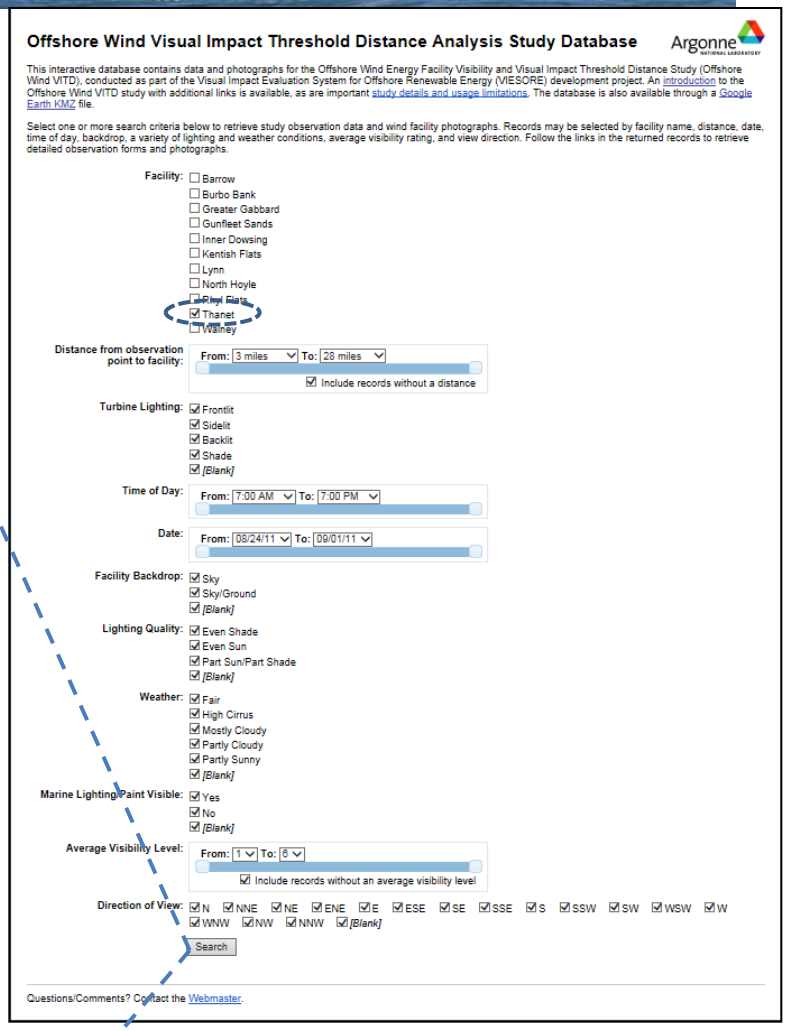
Renewable Energy Visual Evaluations: Threshold Distances

Offshore Wind Turbine Visibility and Visual Impact Threshold Distances: Online Databases





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Renewable Energy Visual Evaluations: Threshold Distances

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Offshore Wind Visual Impact Threshold Distance Analysis Study Database Search Results

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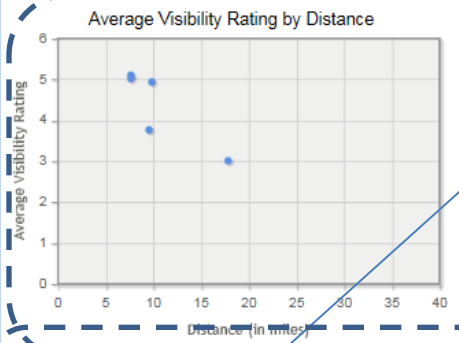

Obs. ID	SOP ID	Date	Time	Facility
301	301	8/31/2011	2:07 PM	Thanet
302	302	8/31/2011	3:42 PM	Thanet
303	303	8/31/2011	5:19 PM	Thanet
304	302	9/1/2011	7:16 AM	Thanet
308	302	9/1/2011	10:50 AM	Thanet
311	311	9/1/2011	3:27 PM	Thanet

Questions/Comments? Contact the Webmaster.

http://web.evs.anl.gov/

Offshore Wind Visual Impa...

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Offshore Wind Visual Impact Threshold Distance Analysis Study Database

« Search Form

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SOP 302

Facility:	Thanet
Latitude:	51.387693°
Longitude:	1.437141°
Distance:	7.6 mi
Direction:	ENE
Description:	Thanet - Fayreness Hotel

Observation(s) at SOP 302

Obs. ID	Date	Time	Facility	Obs. Distance	Weather	WTG Backdrop	WTG Lighting Quality	WTG Lighting Angle	Avg Visibility Rating	Details
302	8/31/2011	3:42 PM	Thanet	7.6 mi	Partly Sunny	Sky	Even Shade	Frontlit	5.08	View Details
304	9/1/2011	7:16 AM	Thanet	7.6 mi	Partly Cloudy	Sky	Even Sun	Backlit	5.00	View Details
308	9/1/2011	10:50 AM	Thanet	7.6 mi	Partly Cloudy	Sky	Even Sun	Sidelit Right	Not rated	View Details

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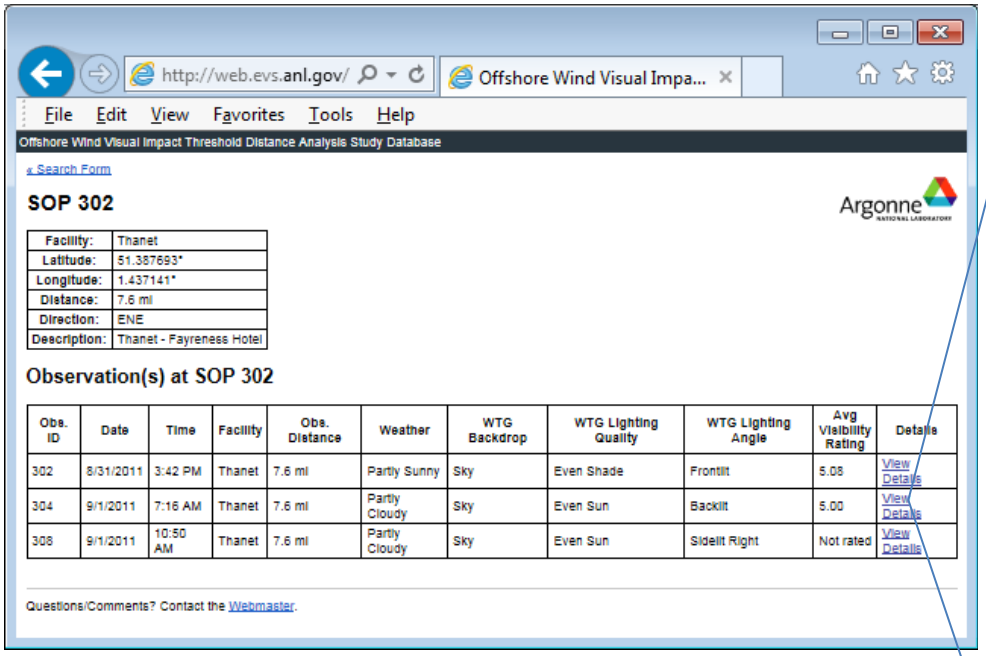
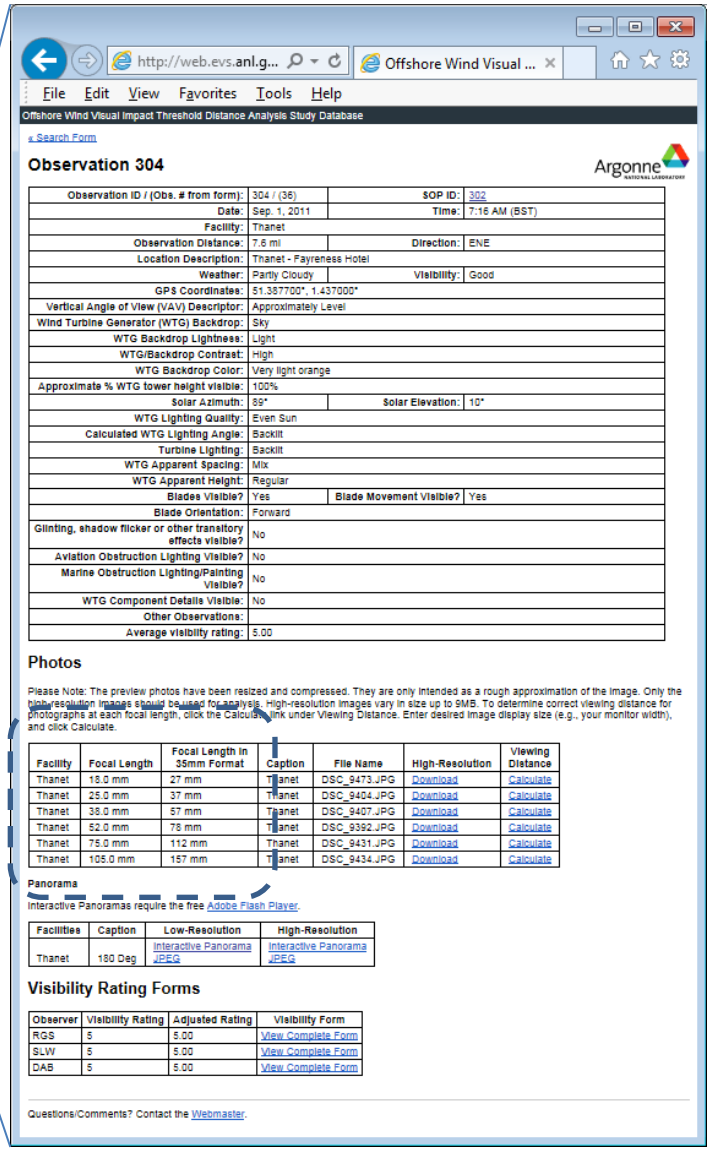
Renewable Energy Visual Evaluations: Threshold Distances





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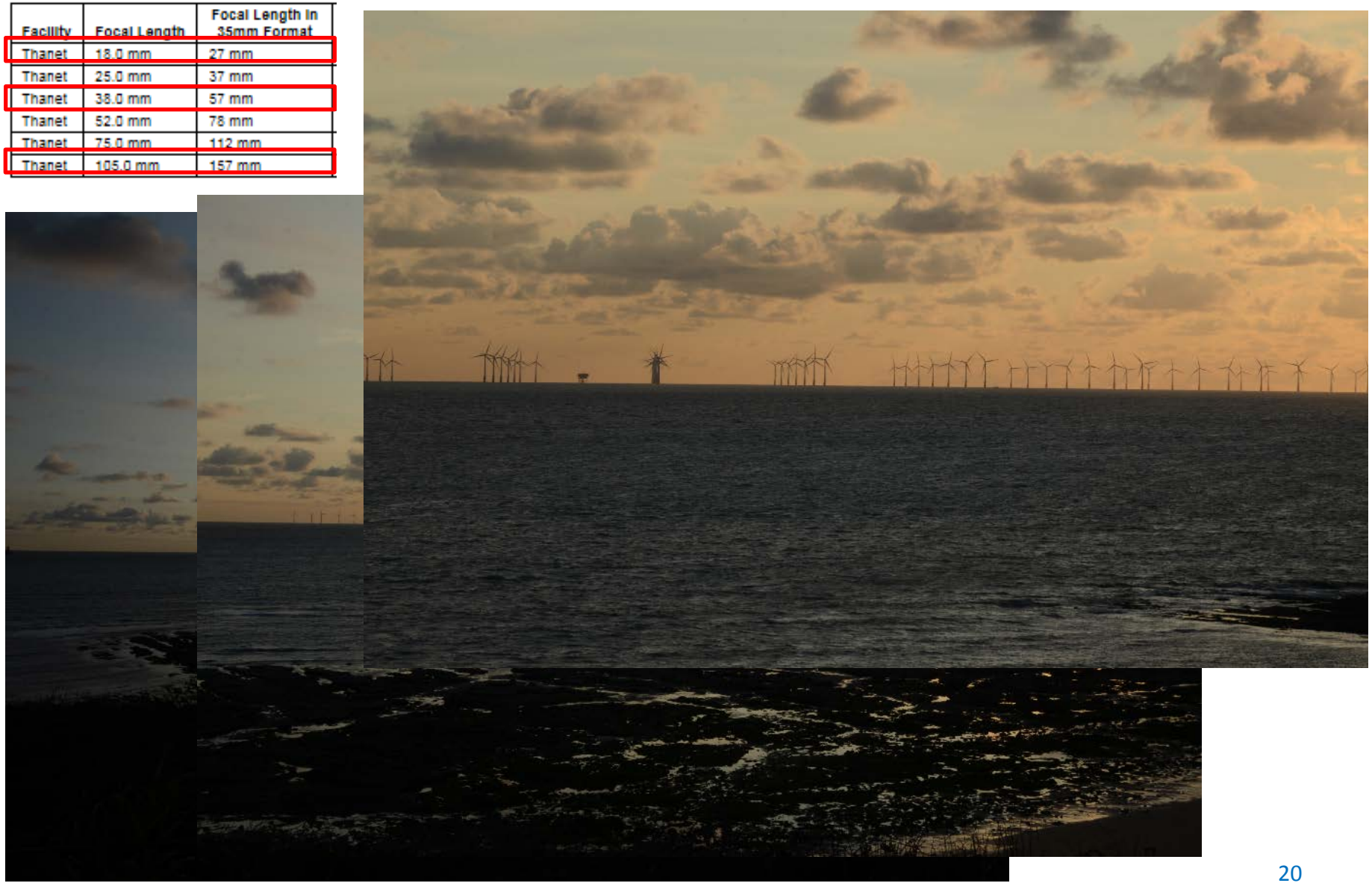
Renewable Energy Visual Evaluations: Threshold Distances

Facility	Focal Length	Focal Length in 35mm Format
Thanet	18.0 mm	27 mm
Thanet	25.0 mm	37 mm
Thanet	38.0 mm	57 mm
Thanet	52.0 mm	78 mm
Thanet	75.0 mm	112 mm
Thanet	105.0 mm	157 mm



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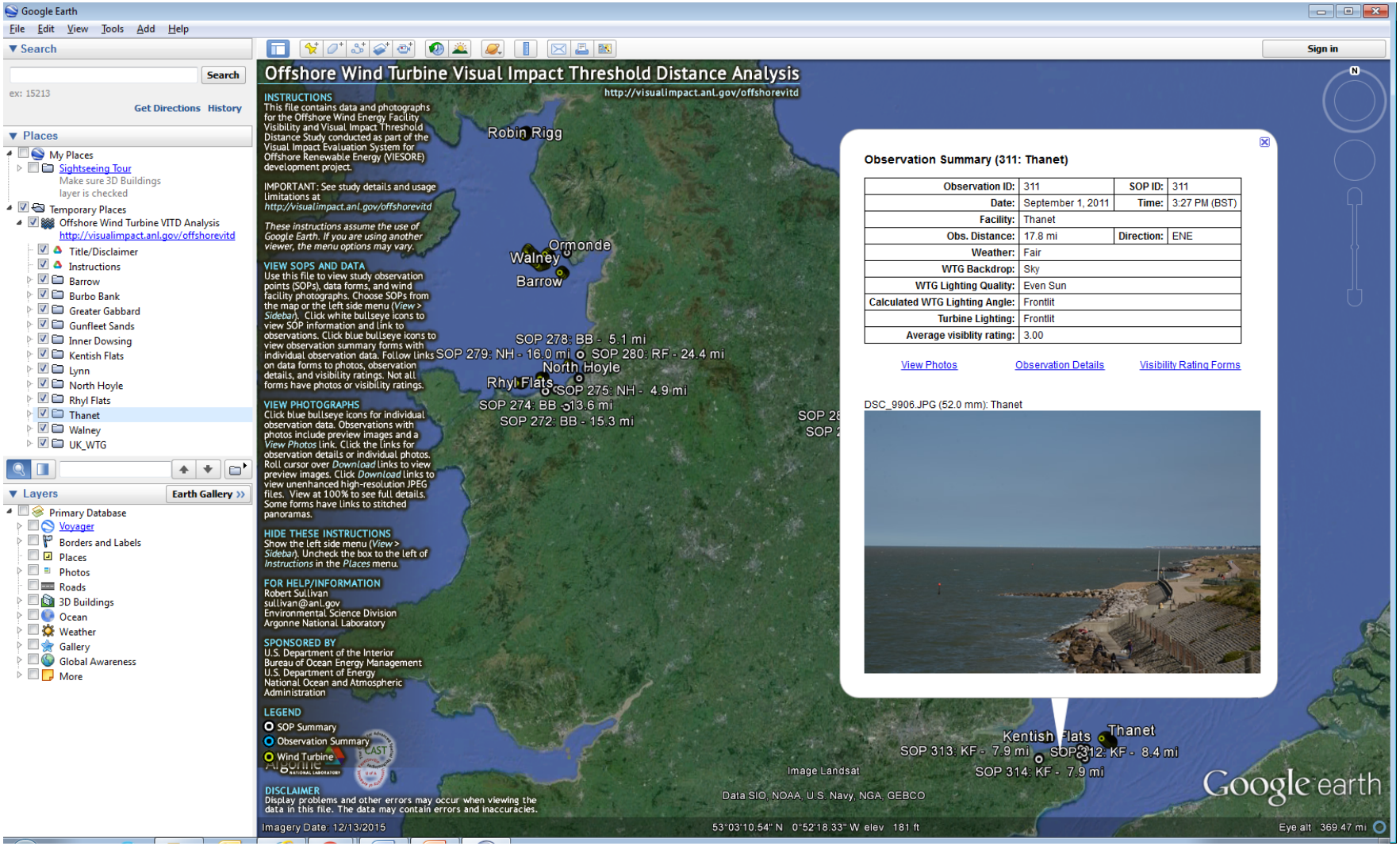
Renewable Energy Visual Evaluations: Threshold Distances



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Renewable Energy Visual Evaluations: Threshold Distances

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Renewable Energy Visual Evaluations: Threshold Distances

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For an overview of selected BOEM research informing renewable energy offshore Oregon, go to:

www.boem.gov/Oregon