Geospatial Planning for Renewable Energy Development

Latin America Geospatial Forum

DNV GL Energy Advisory

10 November 2015

Geospatial Planning for Renewable Energy Development

- Site Characterization

  (elevation map, topographic map, land use, etc.)
- Environmental studies mapping
- Constraints Analysis (local scale)
- Multi-Criteria GIS Analysis for optimized site selection (country / regional scale)

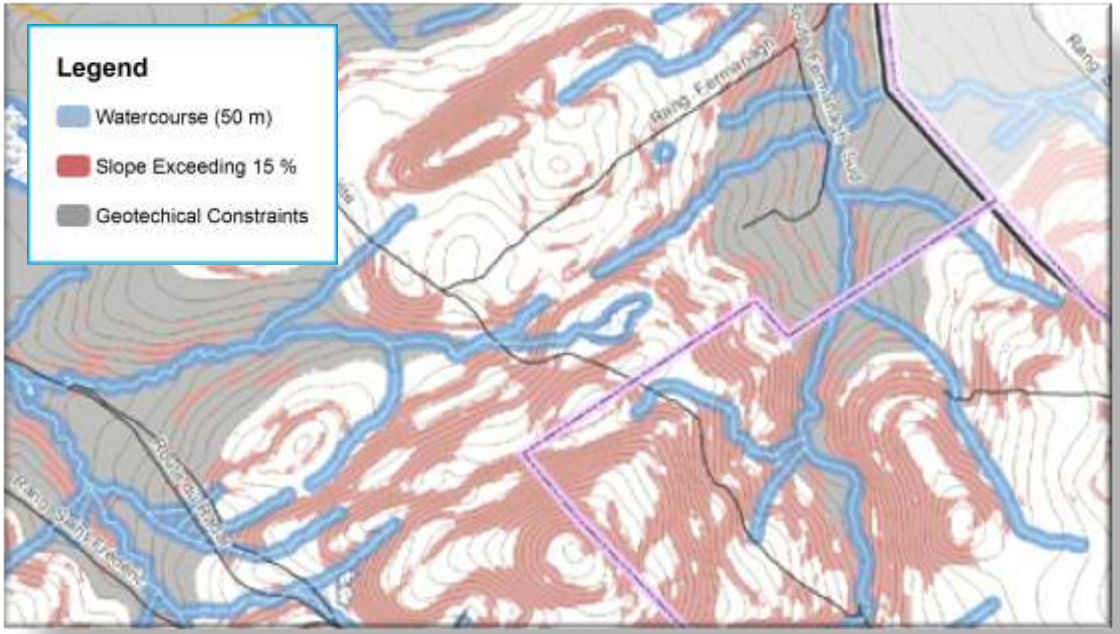
Geospatial Data Acquisition

- Geospatial layers example for wind project development:

Geospatial Data	
Project Infrastructures	
Base Map	Topographic Map (background)
	Administrative boundaries Cities/village
	Road
	Contours, Digital Elevation Model (DEM)
	Lakes and Rivers
	Urban Area
	Airport
	Buildings, including residences
Existing and planned transmission lines (including voltage), substations and power plants	
Land Use/ Land Ownership (private, public)	
Property lines	
Tourist Attraction	
National Park, Migratory Bird Sanctuaries, Important Bird Area Forest Reserve, Game Management Area	
Field Surveys locations, measurement points	
Wildlife Habitats	
Major Bird Flyways	
Archeological Sites	
Geological /Soil Map	
Wetlands, Floodzones	
Military Bases	
Radiocommunication systems, radars and microwave links	
Census data	
Vegetation (Forest, shrub)	
Wind Speed	

Environmental & Social Considerations

- **Mapping of Biological components** (wildlife, protected forest, etc.)
- **Mapping of Physical components** (slopes, soil, flood areas, watercourses, etc.)

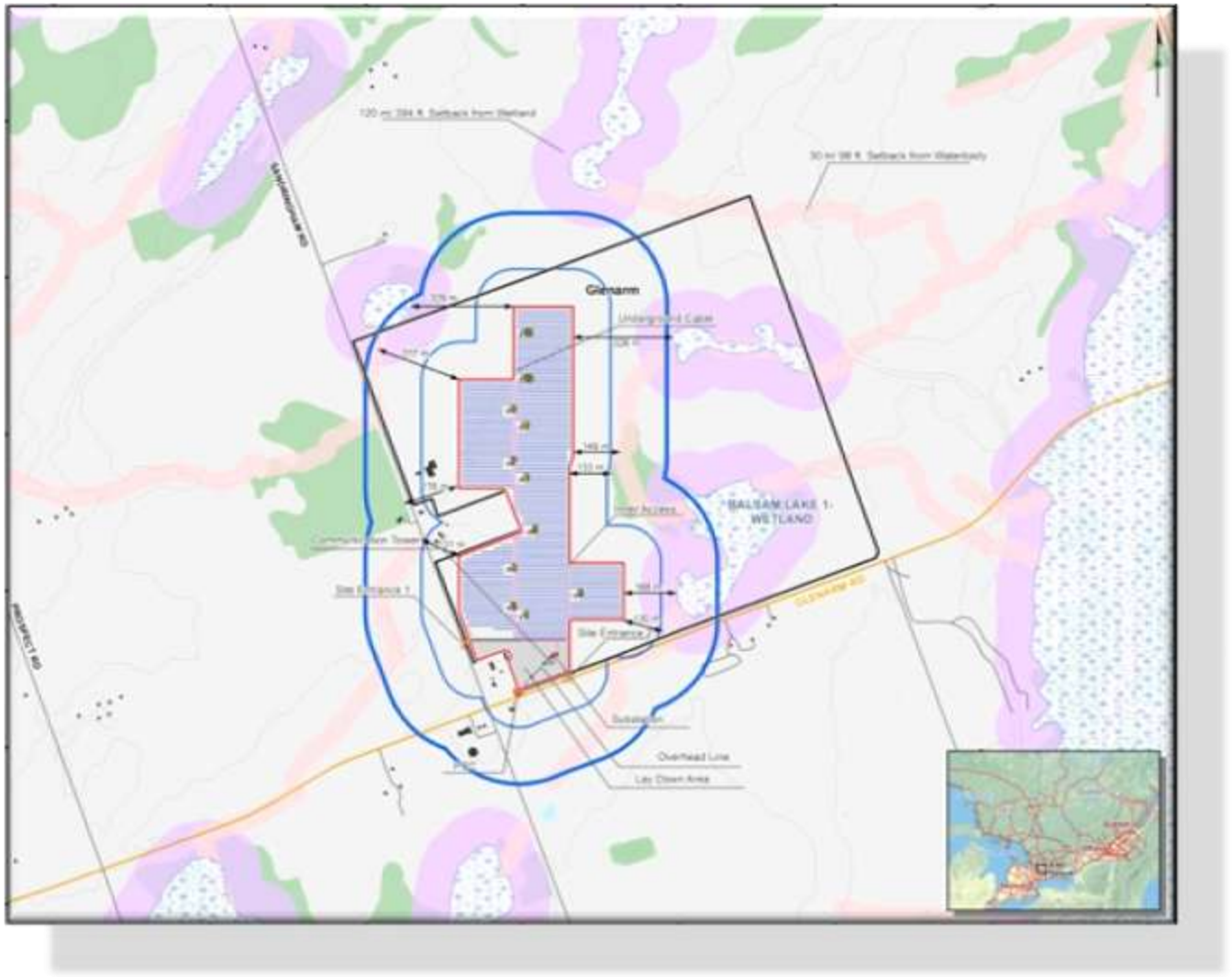


Environmental & Social Considerations

- **Mapping of social components**
  - Land Ownership
  - Land Use (agriculture, forestry, mining, hunting, etc.)
  - Heritage and Cultural Resource
  - Mapping of potential impacts: noise, shadow flicker, electromagnetic interference, air navigation safety, etc.

Example: Noise Isocontours Map

Site characterization: Solar Project



Constraints Mapping

Constraints Mapping

- Setbacks, exclusion zones, consultation zones
- Based on regulations, guidelines & best practices setbacks or exclusion zones

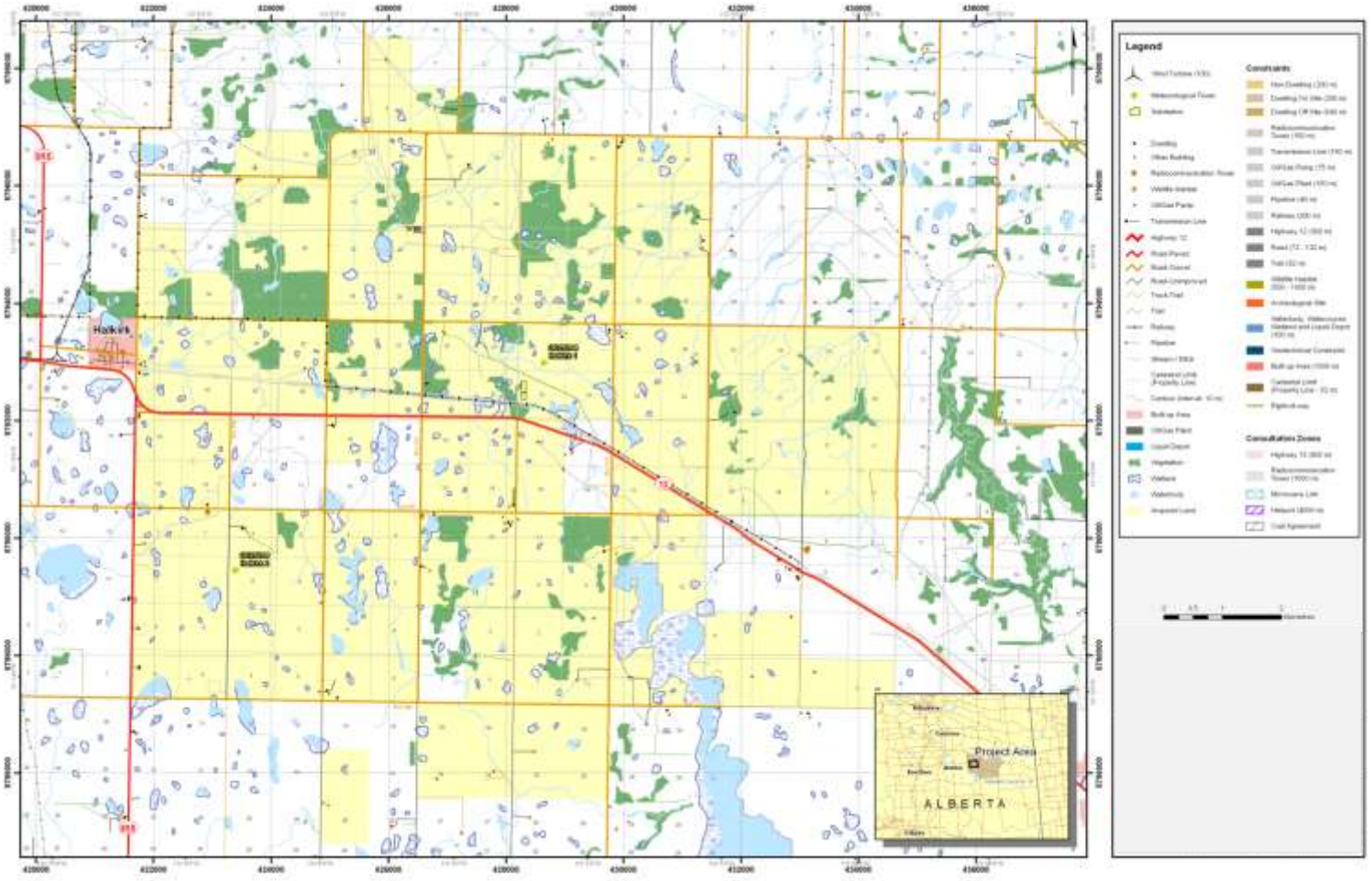
Features	Regulation		Best Practices	
	Setback	Consultation zone	Setback	Consultation zone
Built environment				
Point of Reception (dwelling, campground, school, church, picnic site, cemetery, etc.)	At least 500 m and max PSL of 40 dB(A)			
Property lines		Blade + 10 m and Hub height		
Other built structures (barns, silos, non-residential buildings, commercial, etc.)			Total Turbine Height + 10 m	Potential additional setback based on risk analysis
Project Boundary			Blade + 10	
Highway			Total Turbine Height + 10 m	
Airport, airfield, runway				4 km (Outer horizontal obstacle limitation surface)
Industrial areas such as quarries, pits, dumps, etc.			Blade + 10 m	Potential additional setback based on risk analysis

Table of setbacks excerpt

Constraints map

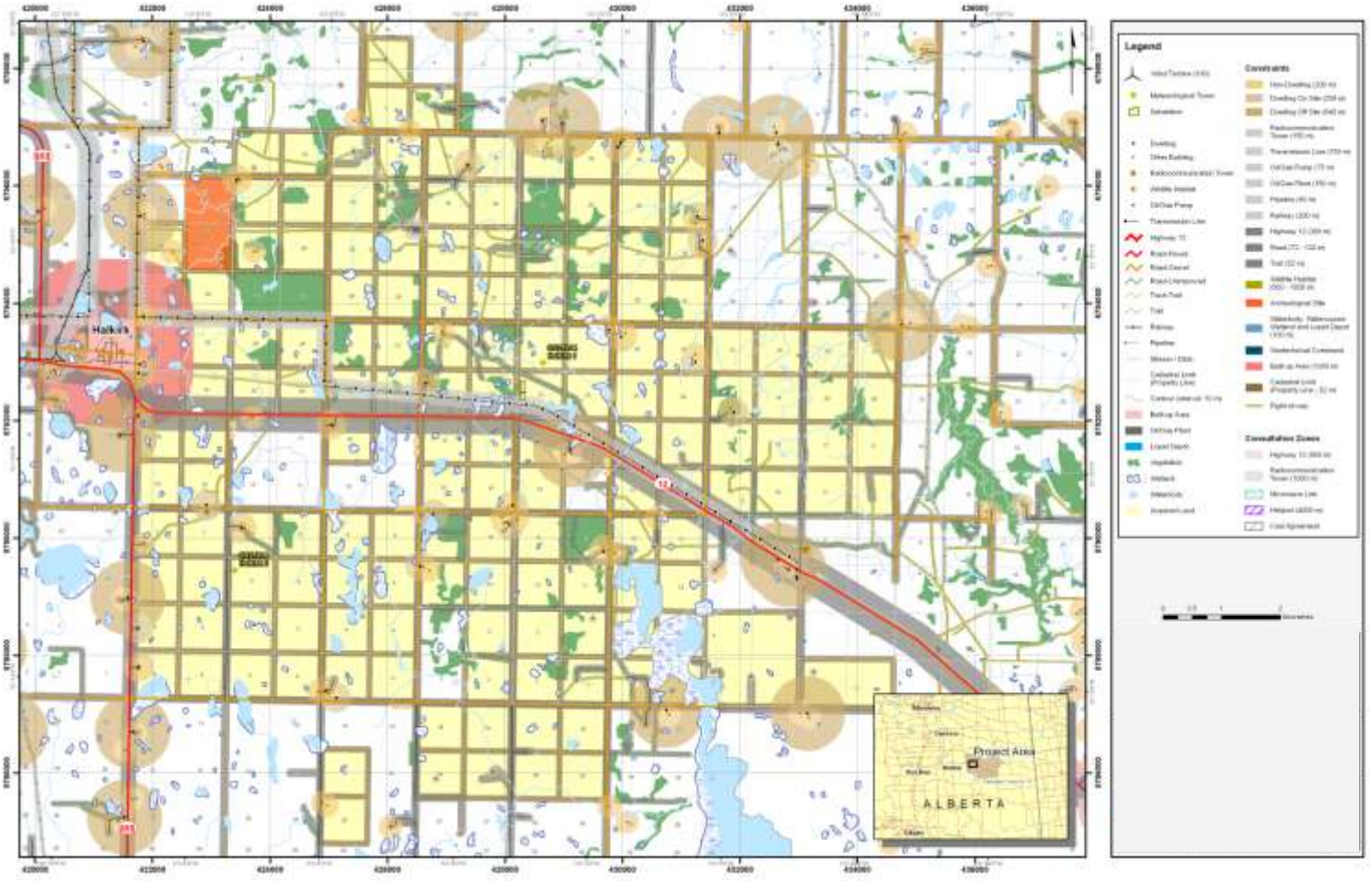
Constraints Mapping

- Base data



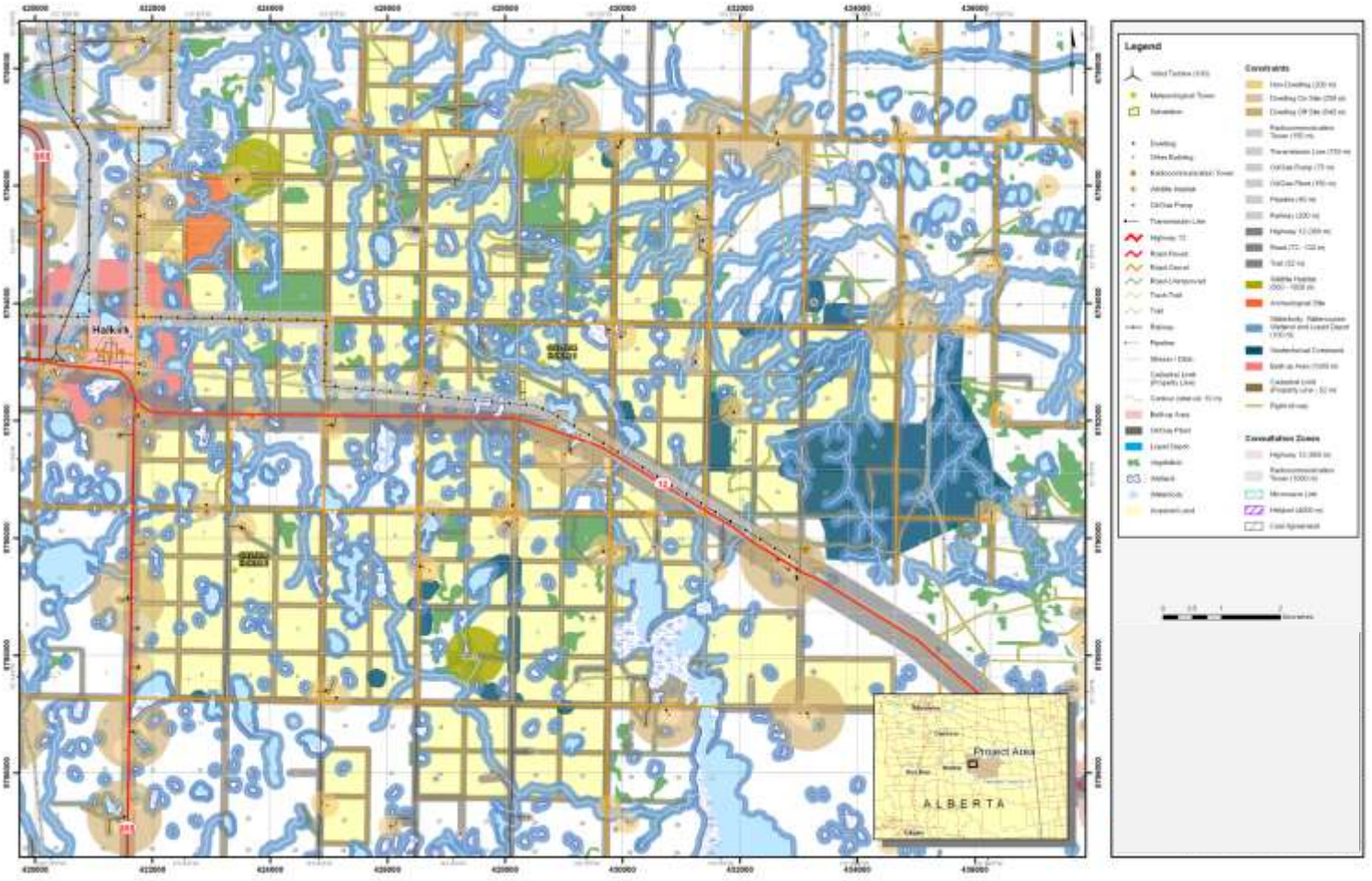
Constraints Mapping

- Human constraints



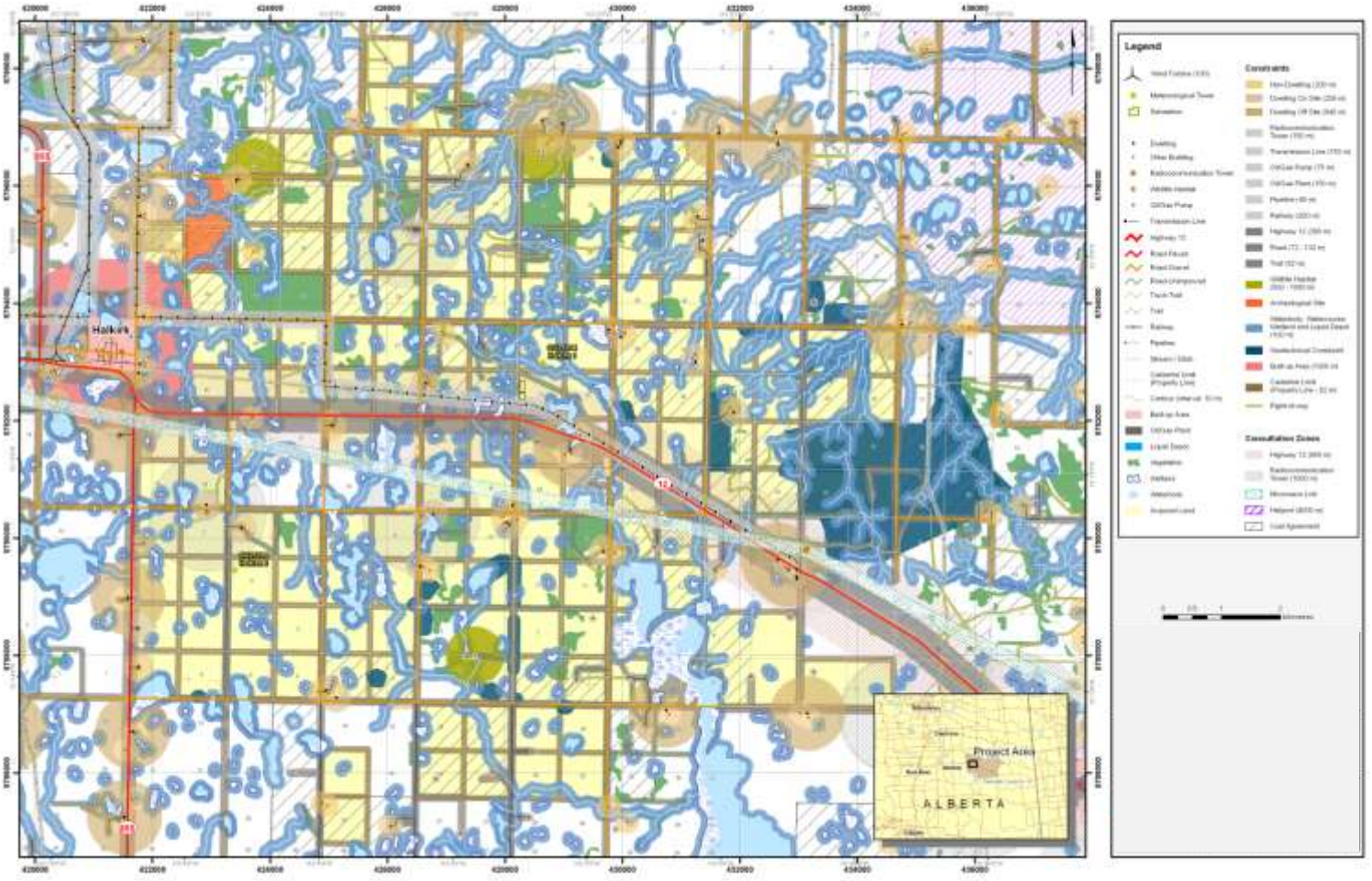
Constraints Mapping

- Biophysical Constraints



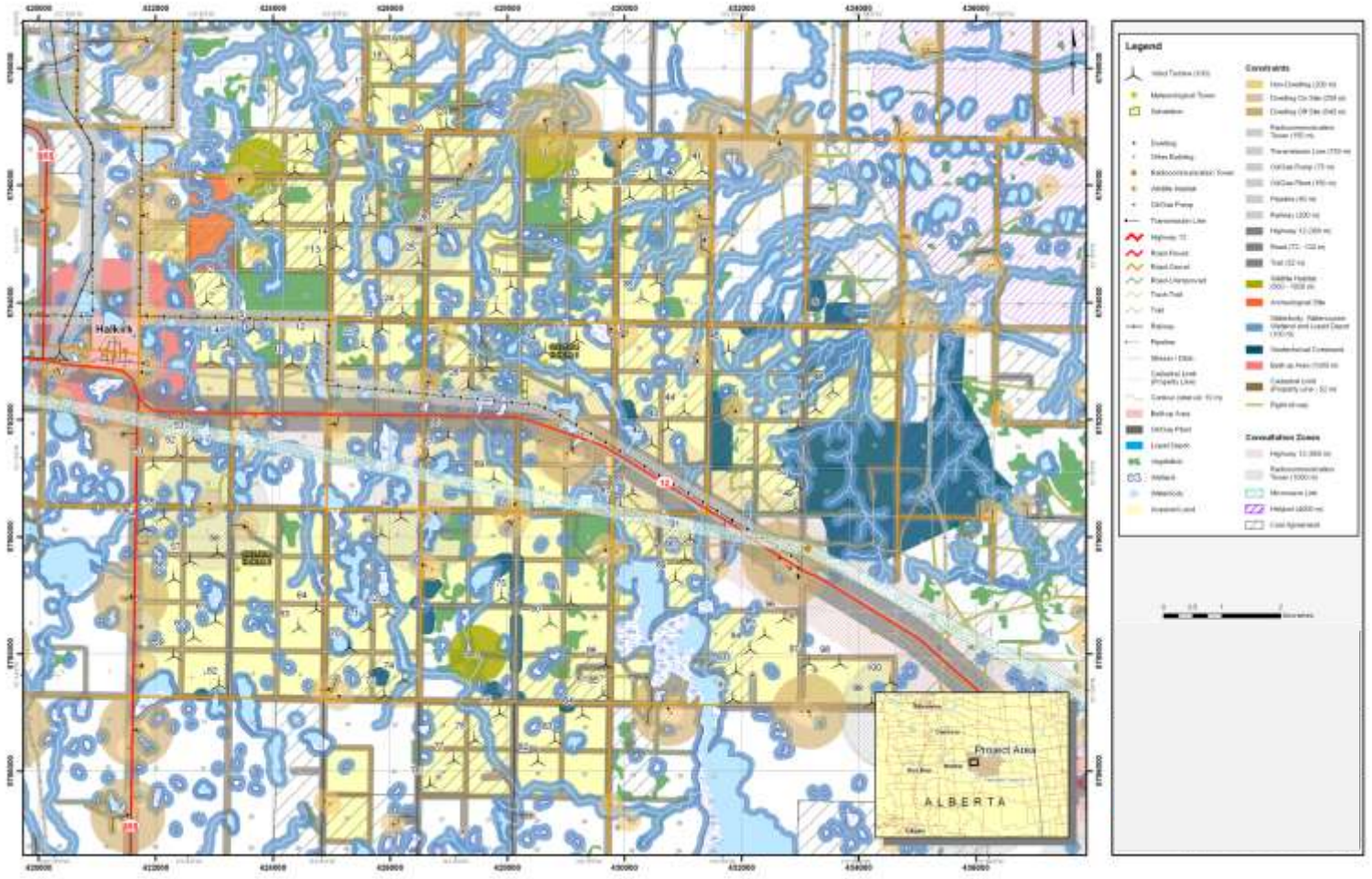
Constraints Mapping

- Consultation Zones (not prohibited, but development challenges)



Constraints Mapping

- Wind Turbine Layout



Multi-Criteria Analysis for optimized site selection

Multi-Criteria Analysis for optimized site selection

Determination of Exclusion Zones

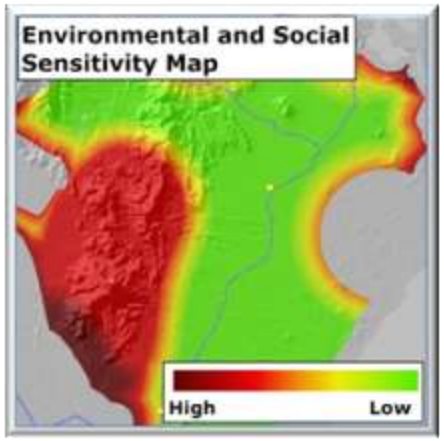
- Data acquisition, mapping and Identification of exclusion zones:
  - Exclusion zones based on identification of constraints applied on key features based on various data and documentation and regional requirements and best practices guidelines

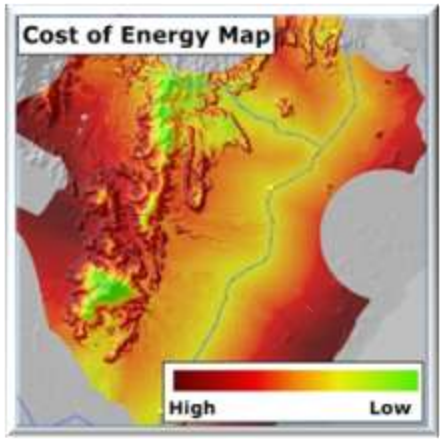
No.	Exclusion Zone	
C1	Wind resource	Wind speed below a certrain threshold are not considered as economically viable
C2	Maximum slope (Site access and civil engineering issues)	Exceeding 15 % or 20 % (as per common manufacturer specification for wind flow inclination and construction constraint).
C3	Maximal distance grid	Avoid distance exceeding a certain threshold from transmission line and substation to avoid prohibive cost.
C4	Inhabited areas	Variable setback from inhabited area depending on the population to minimize sound and visual impacts
C5	Major radiocommunication systems	Exclusion zones vary in function of the system type
C6	Airport	Setback from airport (Best practices to minimise impacts; setback from runway should be further assessed with relevant authorities)
C7	Environmental and sensitive area	Avoid regulatory protected areas and other sensitive areas.

Determination of Ranking Criteria

- A weighted scoring system is implemented considering economical, social and environmental considerations which include:

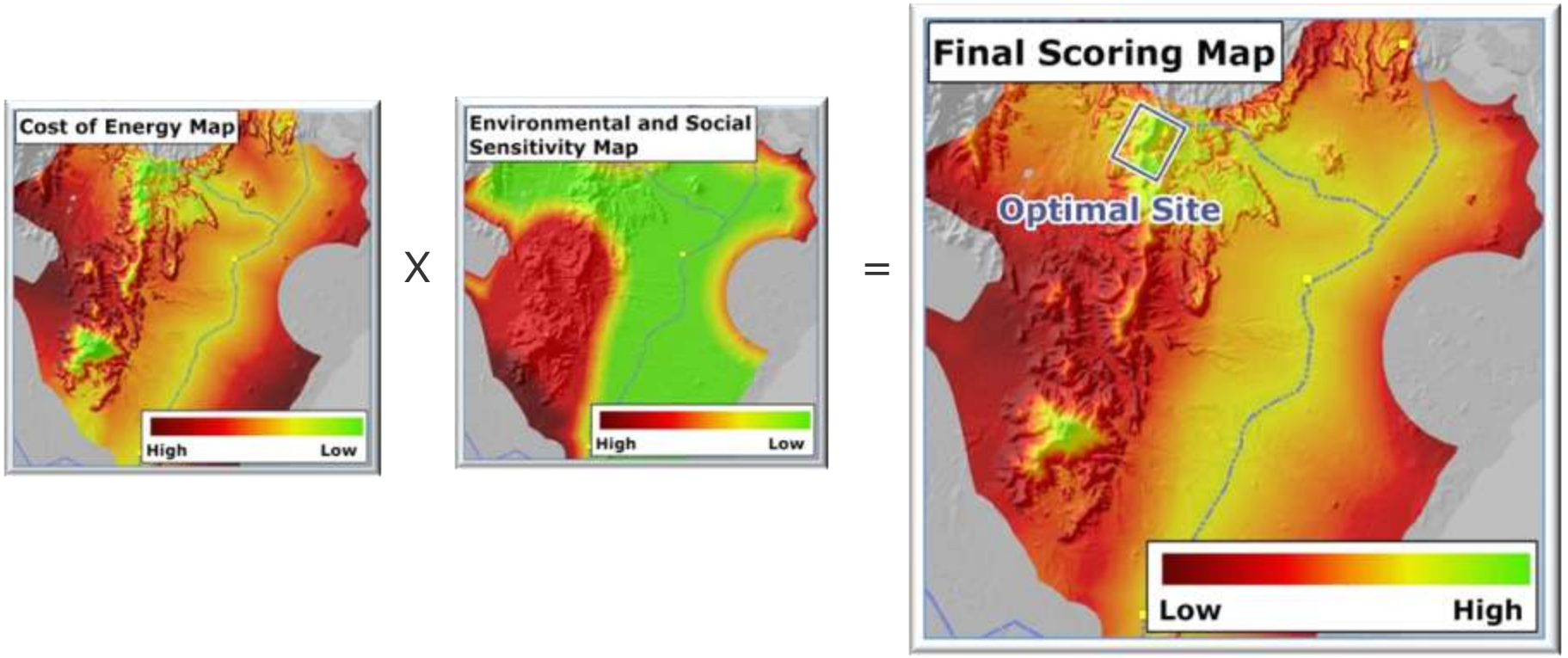
Criteria	No.	Subcriteria	Description	Weight (%)
Cost of Energy	F1	Wind resource	Wind resource plays an important role in determining the economic viability of any wind energy development. A well-designed wind measurement campaign to estimate the average mean wind speed across the region of interest at the proposed hub height is vital.	35
	F2	Air Density	Air density considerably affects the power output of wind turbines.	5
	F3	Accessibility / Terrain Complexity	Wind turbine construction costs increase with terrain complexity (slopes) and total cost for balance of plant such as need for new access roads.	15
	F3	Distance to Grid / Point of Interconnection	Grid connection proximity is highly sensitive to capital costs associated with electrical infrastructure and the difficulties often associated with achieving grid connection agreement with transmission system operators.	20
	F4	Remoteness / Distance to load	Distance to cities/towns affect the accessibility to concrete plants and labour. Energy losses are higher when the generation is further from electricity consumption centers.	10
Social and Environmental	F6	Visual impact / Distance to built-up areas	Visual impact concerns are a function of the distance of a potential wind development with urban areas, which may impact on project support from the local community.	5
	F7	Environmental and Human Sensitive Areas, Regulated Areas	Environmentally and socially sensitive areas should be avoided as much as possible.	5
	F7	Electromagnetic interferene and air navigation safety	Wind turbine could interfere with electromagnetic signal and air navigation routes.	5





Optimal Site Selection

- Final Scoring Map (or heat map) is generated highlighting promising sites for wind or solar energy development:



Heat Map, Most Promising Areas: Green

Site Ranking Matrix

- Ranking Matrix: a key tool for informed decision

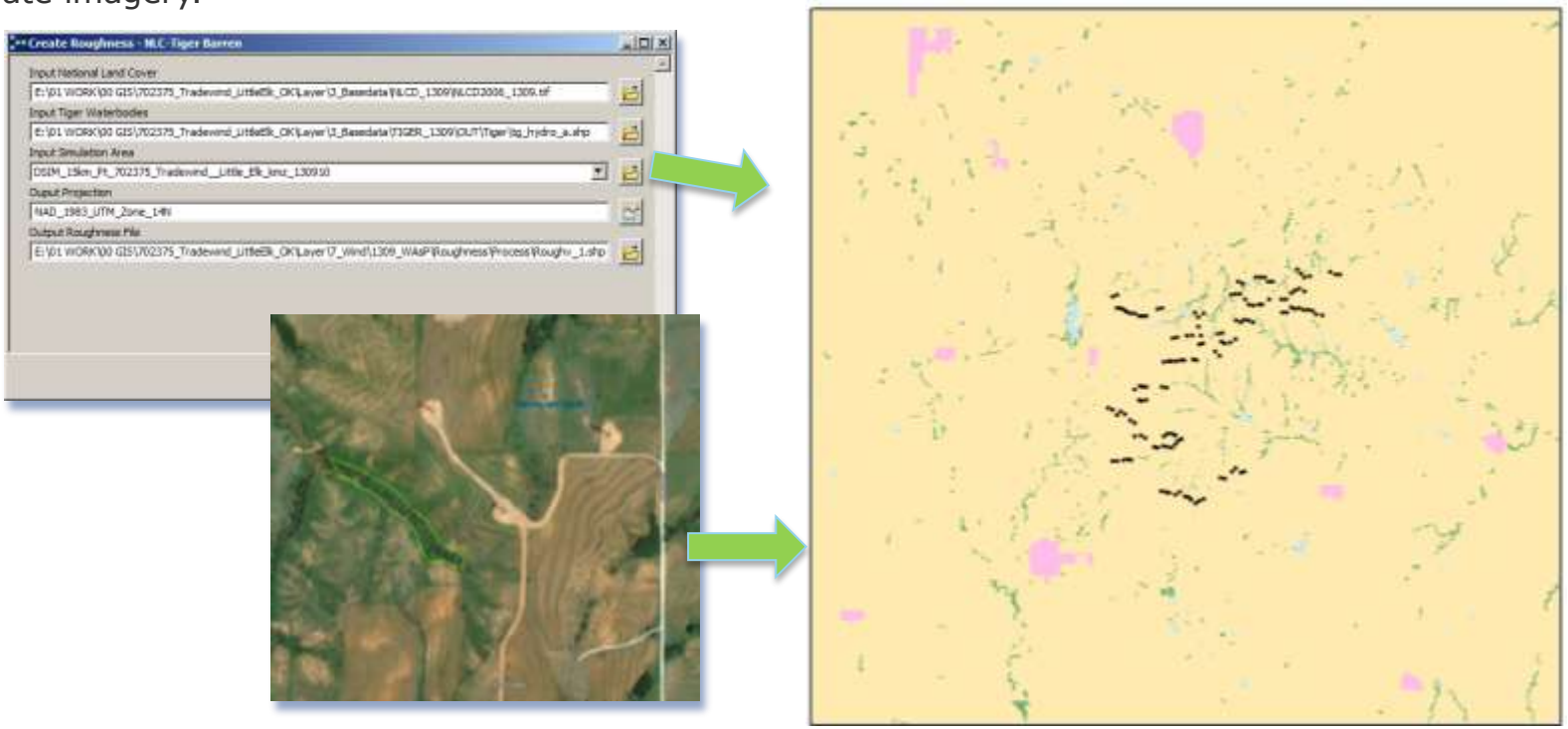
RELATIVE WEIGTH (%) ->		100	30	5	5	5	
RANK	Site Name	FINAL SCORE	CRITERIA 1 - Cost of Energy	CRITERIA 2 - Environmental and Social Sensitivity	CRITERIA 3 - Interconnection	CRITERIA 4 - Electromagnetic Interference and Air Navigation	C... Acc... Re...
1	Site A	8.5	10.00	6.81	7.59	10.00	1
2	Site B	8.4	8.72	6.80	6.79	9.99	1
3	Site C	7.4	5.81	7.62	7.63	7.87	1
4	Site D	7.4	5.75	7.70	0.60	8.74	1
5	Site E	7.2	4.91	8.38	2.75	9.38	1
6	Site F	7.1	4.70	8.60	3.52	8.77	1
7	Site G	6.7	6.39	9.37	8.92	8.45	1
8	Site H	6.6	3.07	9.11	2.93	7.24	1
9	Site I	6.5	8.60	9.27	9.97	6.87	
10	Site J	6.3	6.84	9.47	9.80	9.66	1
11	Site K	6.2	4.31	6.37	1.56	4.76	

Ranking Matrix example

Geospatial Inputs for Energy Assessment

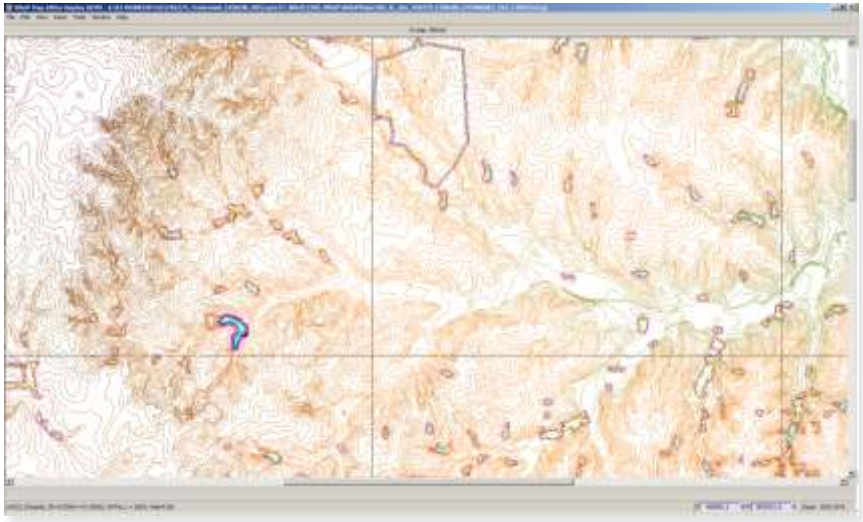
Automated Creation of Inputs for Energy Assessment – Wind Speed Modeling

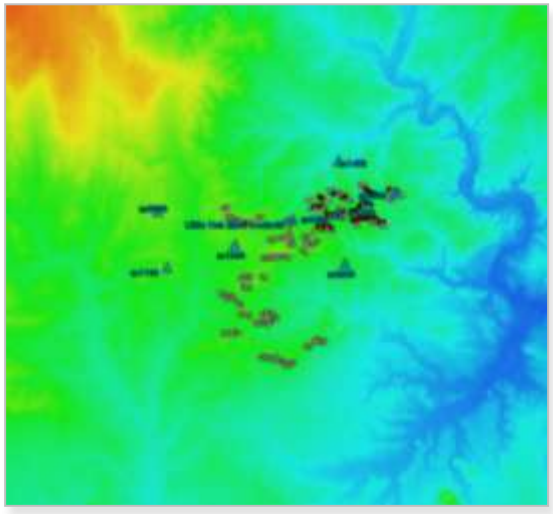
- Roughness
  - Surface roughness (wooded area, barren land, built-up area, water, etc.) have an important impact on the wind regime.
  - DNV GL developed tools for the creation of the surface roughness maps including processing of existing land cover data or satellite imagery classification. The surface roughness is also validated based on up-to-date imagery.



Automated Creation of Inputs for Energy Assessment – Wind Speed Modeling

- Elevation
  - Wind Speed is also largely influenced by local topography, and accurate Digital Terrain Model (DTM) is required when working with complex Computational Fluid Dynamics (CFD) flow modeling.
  - There is a need for high resolution DTM generated through 3D stereoscopic methods or LIDAR survey when the accuracy of the DTM/DSM do not meet the minimum requirement.





Thank you

For more information, please contact:

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