Finding Onkalo: Recreating Finland's Deep Geologic Repository Site Selection Process

Research Question

Worldwide, there is estimated to be between 250,000 and 300,000 tons of high-level radioactive nuclear waste. According to the International Atomic Energy Agency (IAEA), this waste will be harmful to humans and its surroundings for anywhere between one hundred thousand and one million years. This waste has to be stored in a stable environment for an unimaginable period of time, unable to harm the surrounding populace. Deep geologic repositories are the most effective form of storage available, such as the site planned for Yucca Mountain, and currently being implemented in Olkiluoto, Finland. The site in Finland is scheduled to become operational by 2100, at which point all of the country's high-level radioactive waste will be sealed half a kilometer underground for at least 100,000 years. The site selection process occurred between 1983 and 2000, as four and later one site was selected for the world's first deep geologic repository, Onkalo. This process was before the current ubiquity of easily accessible data and the methodology is not clear. The following study attempts to clarify the site selection process, and illustrate how the same data analyzed in different methods can drastically alter the results.

The following methodology goes through the process of ranking subsurface criteria in the order of most to least risk as a unit of a municipality, the smallest administrative division in Finland. There are 320 total in the country.

Methodology

1. Based on a review of literature about the subject, the following subsurface data was gathered for Finland to become a part of the final review.
   - Dyke Swarms
   - Flood Risk
   - Usable Groundwater
   - Kimberlite Regions
   - Mine Locations
   - Tectonic Faults
   - Minimum Bedrock Age

This information is primarily about evaluating the long-term stability of the bedrock, as a deep geologic repository buries the nuclear waste at least 500 meters below ground surface.

The first step was to normalize all this data by the unit of a municipality, and thus the summed length or area of the criteria was spatially joined to each municipality and then divided by its area. This created a feature layer with the risk per municipality. Each map was divided into five Jenks Natural Breaks.

2. Next, in order to perform the necessary calculations on the dataset as a whole, each feature layer had to be converted to a raster. This kept the original values of the layer in the raster.

3. Each raster was then reclassified, to provide a gradation of values. The data was changed to integer values between 1 and 5, with 5 being the riskiest subsurface and 1 being the least.

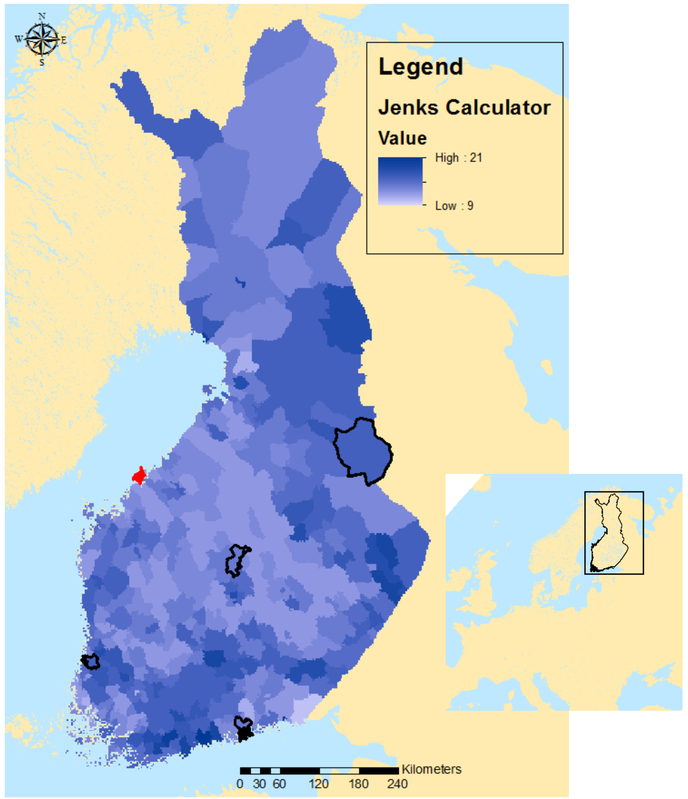
4. The raster calculator summed the results of all seven criteria and displayed it in a gradient map.

Findings

The four sites that were the final possibilities in the Finnish site selection process in 2000 were Romuvaara in Kuhmo, Kivetty in Äänekoski, Olkiluoto in Eurajoki, and Hästholmen in Loviisa. The four municipalities are shown in the results map below. These locations did not end up being the more feasible municipalities based on my selection process.

Kuhomo	16
Äänekoski	14
Eurajoki	16
Loviisa	14

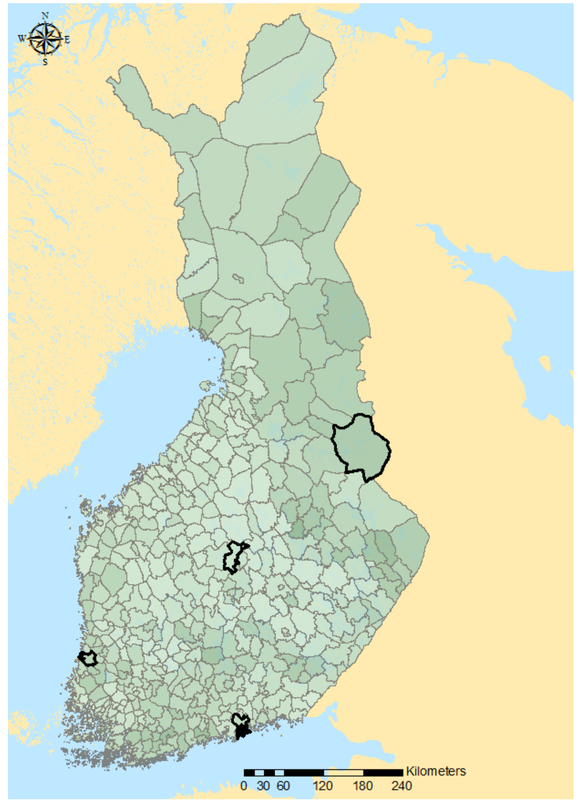
The actual results ranged from a minimum score of 9 to 21. The minimum scoring municipality was Luoto, on the coast in Western Finland. It is a small municipality, and had low risk across the seven criteria. It is highlighted in red in the map below. This is compared to the map on the right, which is a visual overlay of the feature maps on the bottom.



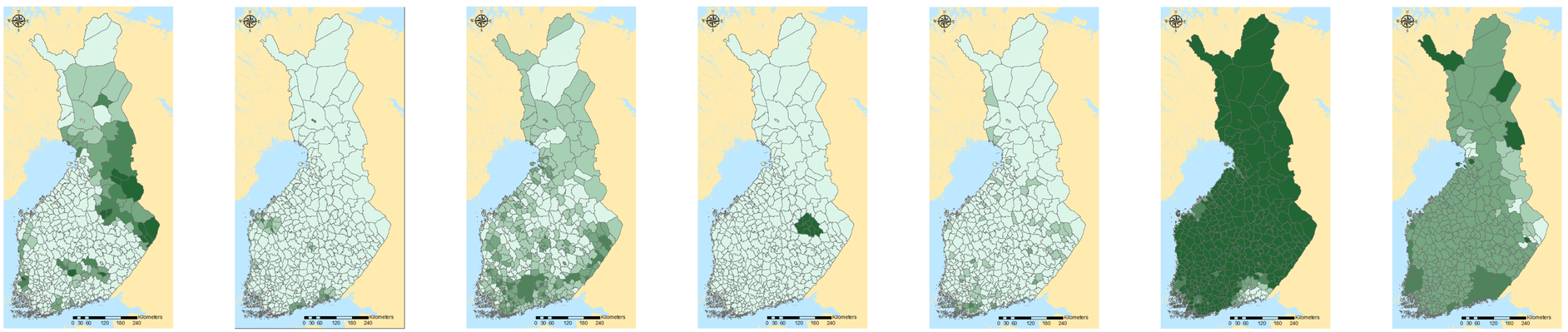
Conclusions

The results did not recreate the exact findings of the original site selection process. However, that was not the intended conclusion. Rather, this process ignored the distinctly human aspects of any site selection process. In actuality, the chosen municipality needs to be willing to shoulder the risk, and its citizens need to be embracing of nuclear energy already. In limiting the focus of this analysis to the subsurface domain, the results removed the political undertones that were probably a necessary part of choosing Onkalo as the deep geologic repository site.

These were the limitations of this recreation of the site selection process., since the original criteria that were used were either unknown or non-rigorous. This analysis is a beginning process of creating the ideal site selection that can be applied to other countries looking to store nuclear waste. In the future, the criteria below should be expanded to include some of the political ramifications that will need to be considered. Those criteria will be more fluid, and should be adapted for each country. The ones limited to in this report focus on the safety and stability of long-term nuclear waste storage.



Seven Criteria for Determining Subsurface Activity Classified by Jenks Natural Breaks (Dyke Swarms, Flood Risk, Groundwater, Kimberlite, Mines, Tectonic Faults, Lithological Age)



Sources

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Project by Gabriella Simundson for CEE 187.
Fall 2014 Tufts University Department of Civil Engineering
Original inspiration by the film Into Eternity.