EXPANSION OF THE OR-SAGE ANALYSIS TOOL TO COVER HAWAII

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In April 2015, Oak Ridge National Laboratory (ORNL) staff characterized eleven Air Force Space Command (AFSPC) sites for the potential for siting a small modular reactor (SMR) at each site using the Oak Ridge Siting Analysis for Power Generation Expansion (OR-SAGE) tool. An additional site characterization at Clear Air Force Station in Alaska was desired as part of this project. As a result, in May 2015, DOE-NE funded ORNL to add the capability to the OR-SAGE analysis tool to include SMR site analyses in Alaska. Hawaii was also included in the tool expansion to provide SMR site analysis in all fifty states. The OR-SAGE expansion for Alaska was completed in September 2015 and has been reported previously.

The OR-SAGE tool is a dynamic visualization database. The site evaluation criteria (SEC) represent the database fields from which specific (static) queries can be built. The SMR SEC typically include:

1. Population density less than 500 people per square mile within ten miles of the site boundary
2. Wetlands and open water are excluded
3. Protected lands (e.g., national parks, historic areas, wildlife refuges) are excluded
4. Land with moderate or high landslide hazard susceptibility is avoided
5. Land that lies within a 100 year floodplain is excluded
6. Land with a slope of greater than 18% (~10°) is avoided
7. Land too close to identified fault lines is avoided (the length of the fault line determines the standoff distance)
8. Land located in proximity to hazardous facilities (commercial airports with a 5-mile buffer and oil refineries with a 1-mile buffer) is avoided
9. Land with safe-shutdown earthquake peak ground acceleration (2% chance in a 50 year return period) greater than 0.50 g is excluded
10. Land areas that are more than 20 miles from sufficient cooling water makeup sources (based on taking no more than 10% of available stream flow calculated using 7-day, 10-year low flow data) of at least (bounding values – often select 65,000 gpm for SMR queries; ocean cooling is also considered in coastal areas)
    a. 84,000 gpm are excluded
    b. 20,000 gpm are excluded

The landslide hazard geographic information system (GIS) layer supported by the US Geological Survey does not currently cover Hawaii; however this GIS layer closely follows the slope GIS layer, which is available. Therefore, ORNL staff was able to replicate 9 of the 10 SMR (GIS) data layers noted above for Hawaii. All land was eliminated in the cooling water makeup analysis at 20,000 gpm; therefore, 84,000 gpm cooling water makeup was not evaluated. The individual GIS layers for Hawaii are shown on the subsequent pages in Fig. 1 through Fig. 10. Areas shown in magenta do not meet the SEC query value from the above list.

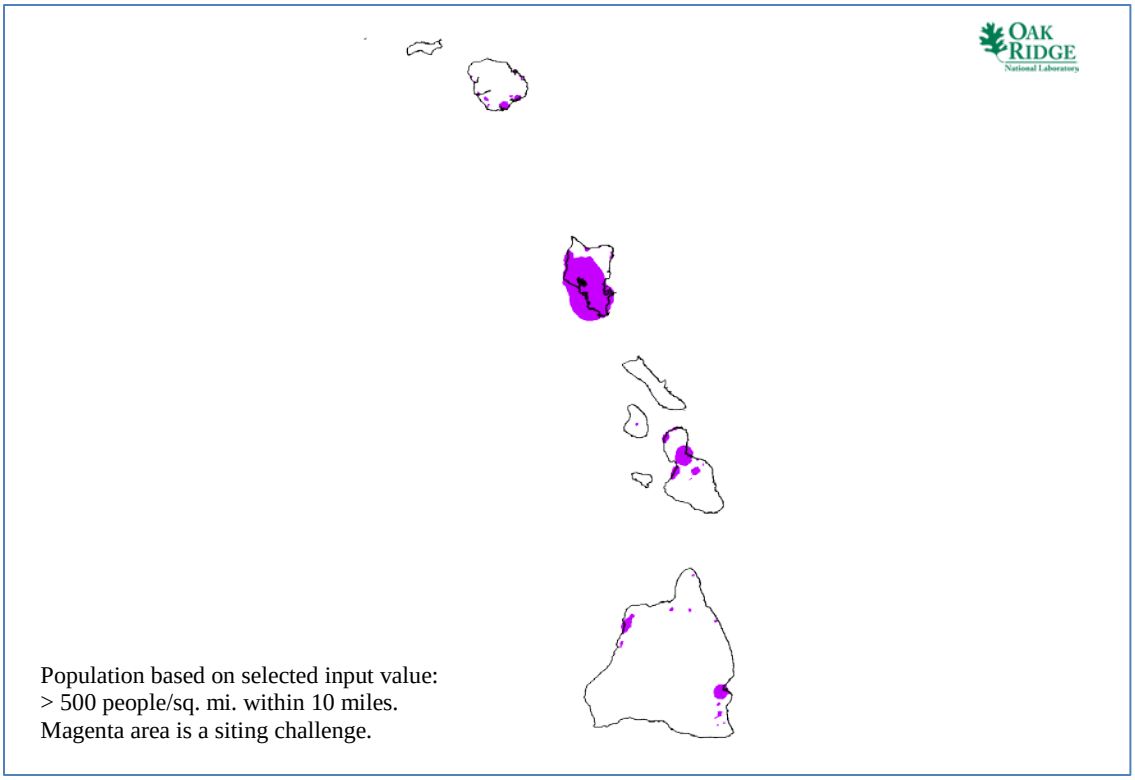

Fig. 1. Nominal, bounding SMR high-population SEC layer.

Fig. 2. Nominal, bounding SMR wetlands and open water SEC layer.

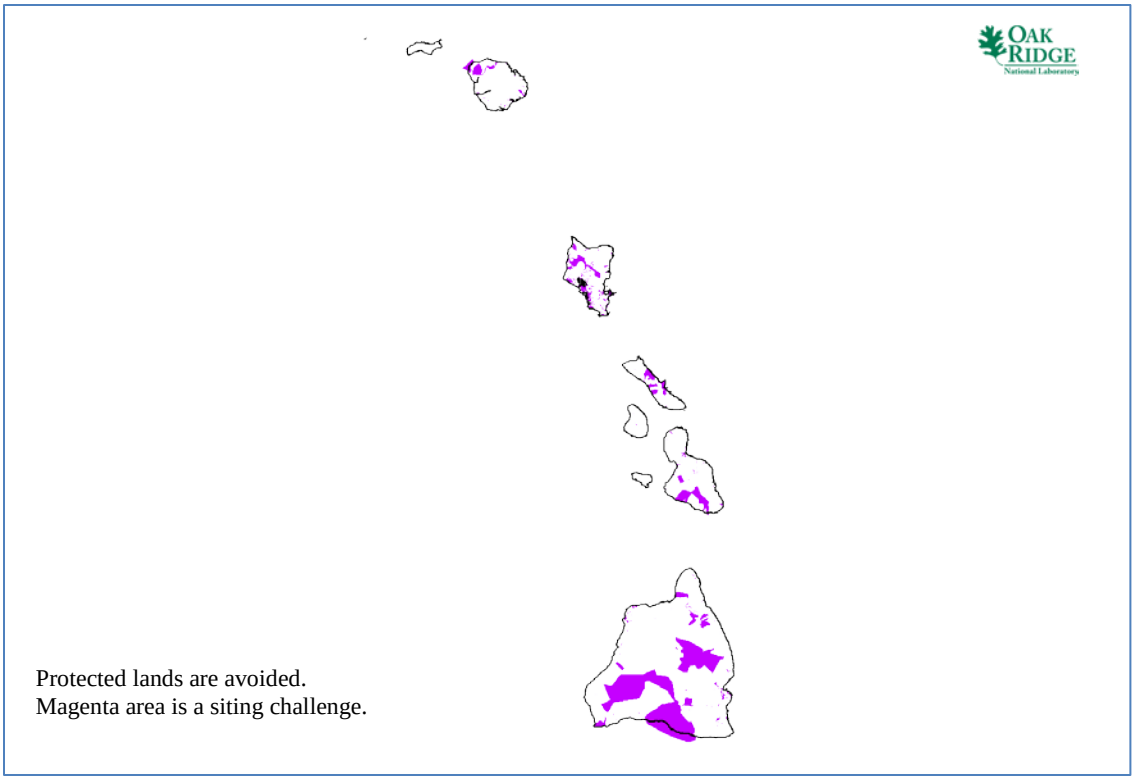

Fig. 3. Nominal, bounding SMR protected-lands SEC layer.

Fig. 4. Nominal, bounding SMR 100-year floodplain SEC layer.

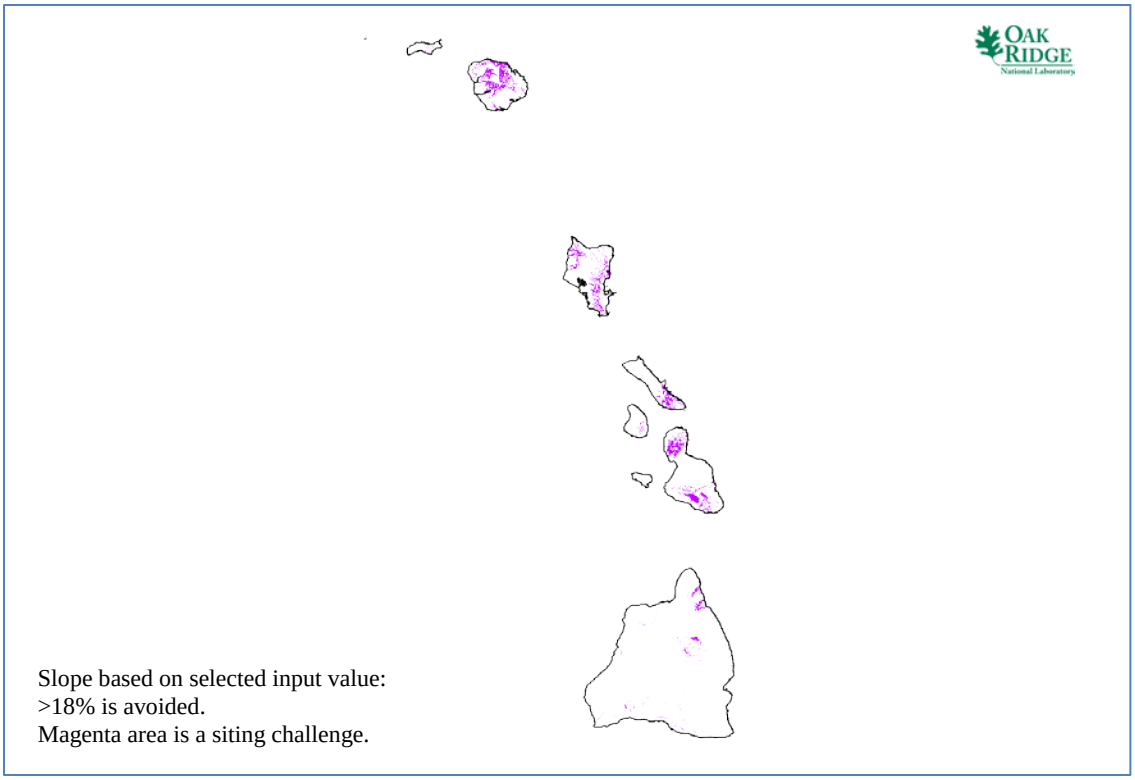

Fig. 5. Nominal, bounding SMR high-slope SEC layer.

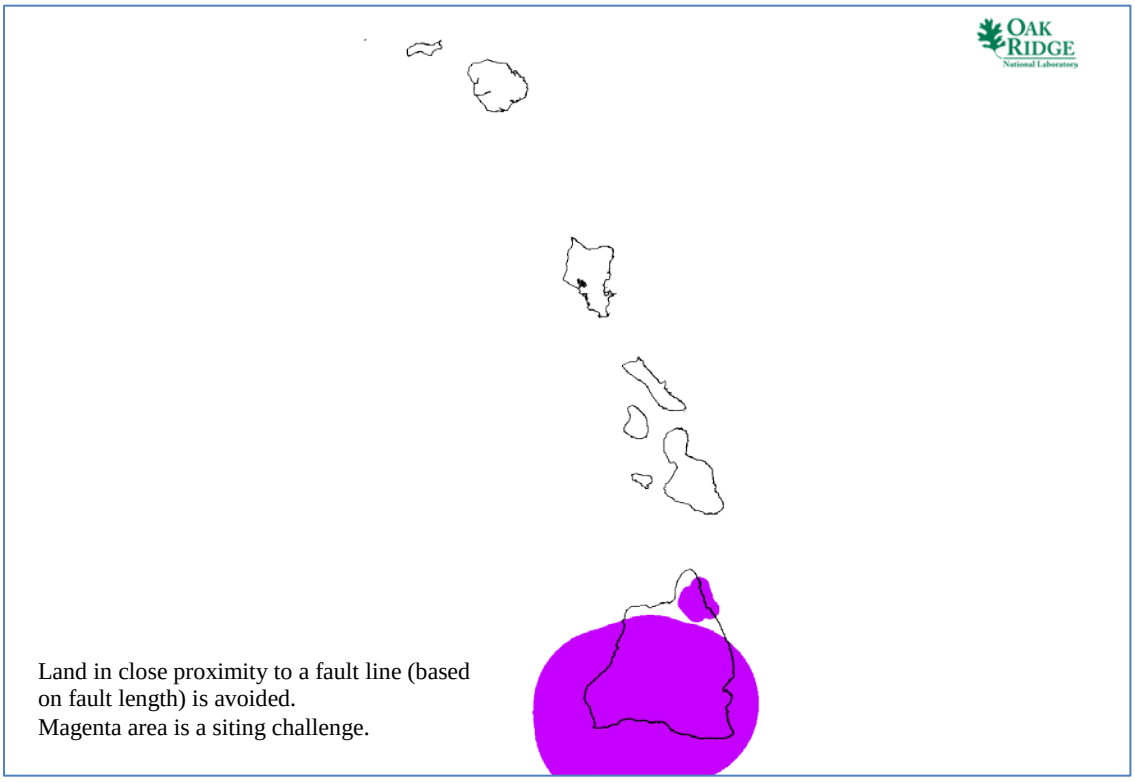

Fig. 6. Nominal, bounding SMR proximity-to-fault-lines SEC layer.

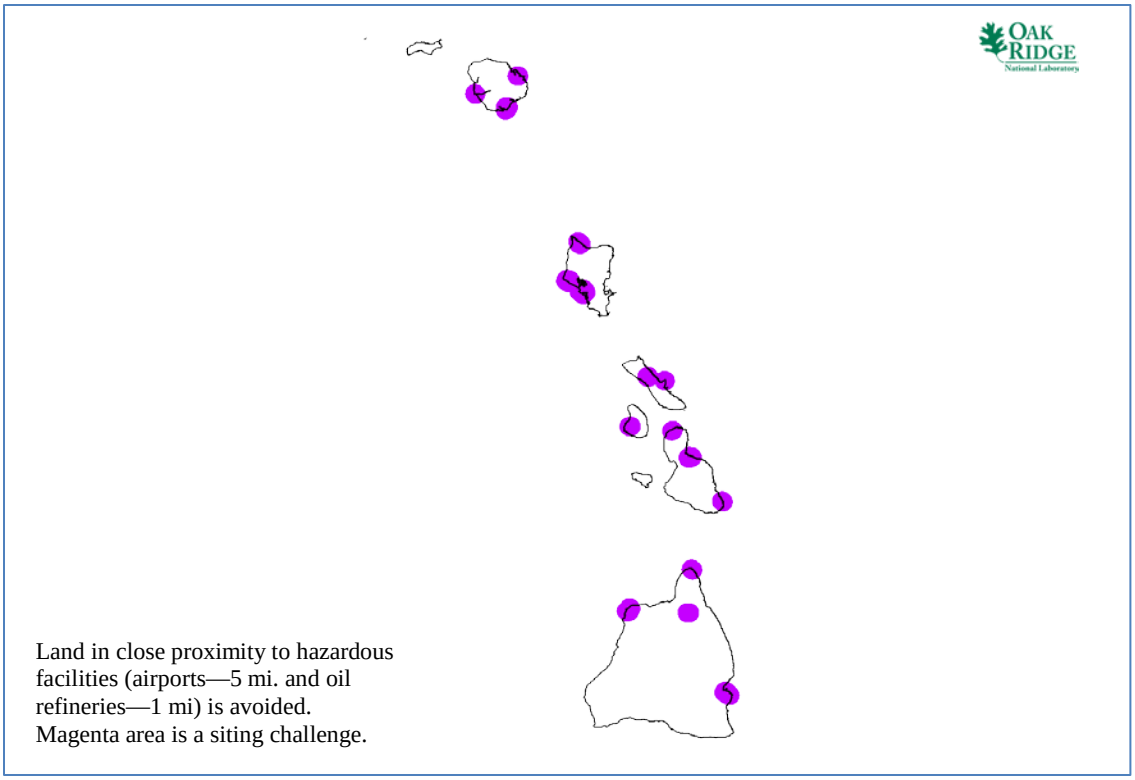

Fig. 7. Nominal, bounding SMR proximity-to-hazards SEC layer.

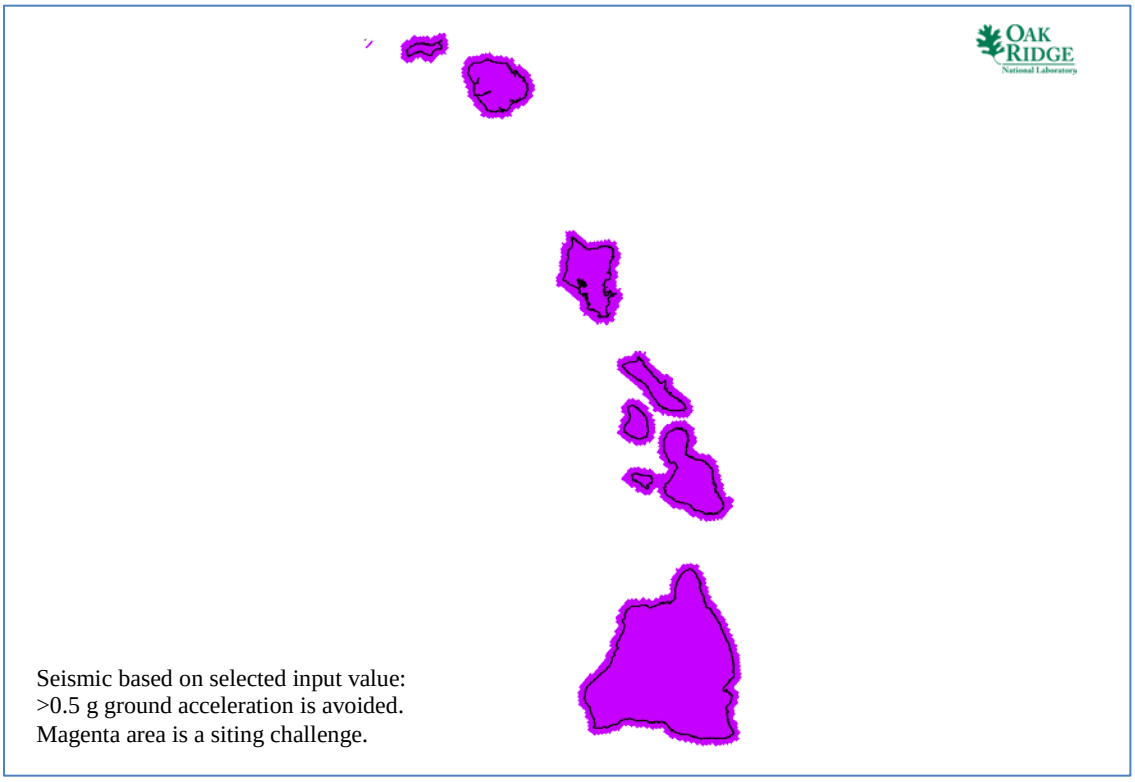

Fig. 8. Nominal, bounding SMR safe-shutdown earthquake SEC layer.

Fig. 9. Nominal, bounding SMR minimum low-stream-flow SEC layer at 20,000 gpm.

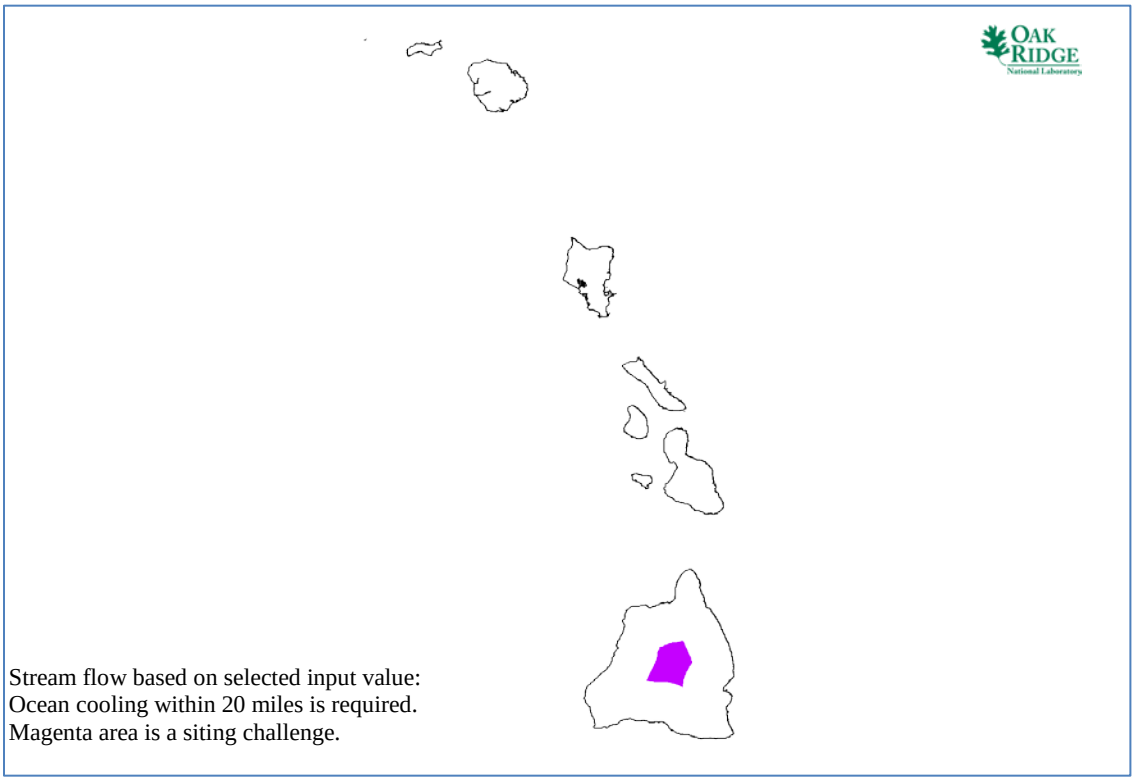

Fig. 10. Nominal, bounding SMR ocean cooling SSEC layer.

The OR-SAGE tool tracks the parameters for each 100- by 100-m cell. As a result, not only can the cells that are clear of all the SEC layer exclusions be displayed visually, but also cells that are tripped by one, two, or three or more exclusions can be tracked and displayed. This is known as the "SMR composite map," shown in Fig. 11 below evaluated at 20,000 gpm stream flow.

The entire state of Hawaii has safe-shutdown earthquake peak ground acceleration (2% chance in a 50 year return period) greater than 0.50 g (see Fig. 8). In addition, the stream gauge system in Hawaii is relatively sparse. All of the existing stream flow data does not support closed-cycle cooling for SMRs based on the 7-day low flow 10-year return criterion that is used in the OR-SAGE flow calculation. Therefore, the composite map depicted in Fig. 11 is not overly supportive of SMR siting in Hawaii. However, due to the island nature of Hawaii, once-through ocean cooling is viable for most areas of the state (compare Fig. 9 and Fig. 10). The composite map is indicative of the cumulative siting issues including the lack of stream flow cooling. If ocean cooling were considered instead of stream flow cooling, the composite map would improve by one category in most places (the notable exception is the middle of the island of Hawaii).

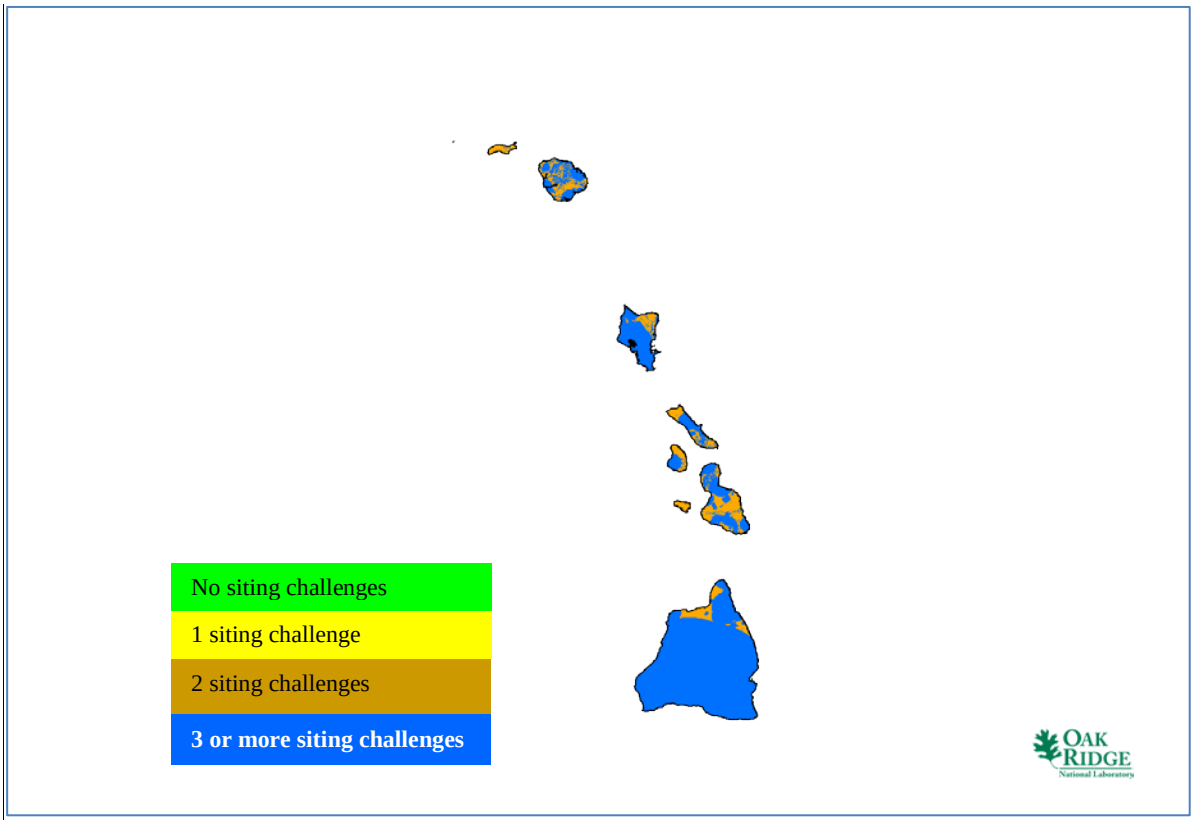

Fig. 11. Hawaii composite map at 0.5 g peak ground acceleration and 20,000 gpm stream flow.

Since the safe-shutdown earthquake peak ground acceleration (2% chance in a 50 year return period) greater than 0.50 g screening criteria impacts the entire state, there would still be no areas depicted in green in an upgrade to Fig. 11 based on the availability of once-through ocean cooling. The safe-shutdown earthquake peak ground acceleration remains limiting for values above 10 g. If safe-shutdown earthquake issues and cooling issues can be adequately addressed

based on enhanced SMR design, the composite map opens up considerably, as shown in Fig. 12. Many of the islands then have significant space with no further SEC issues. Population density and fault lines become dominant at this point.

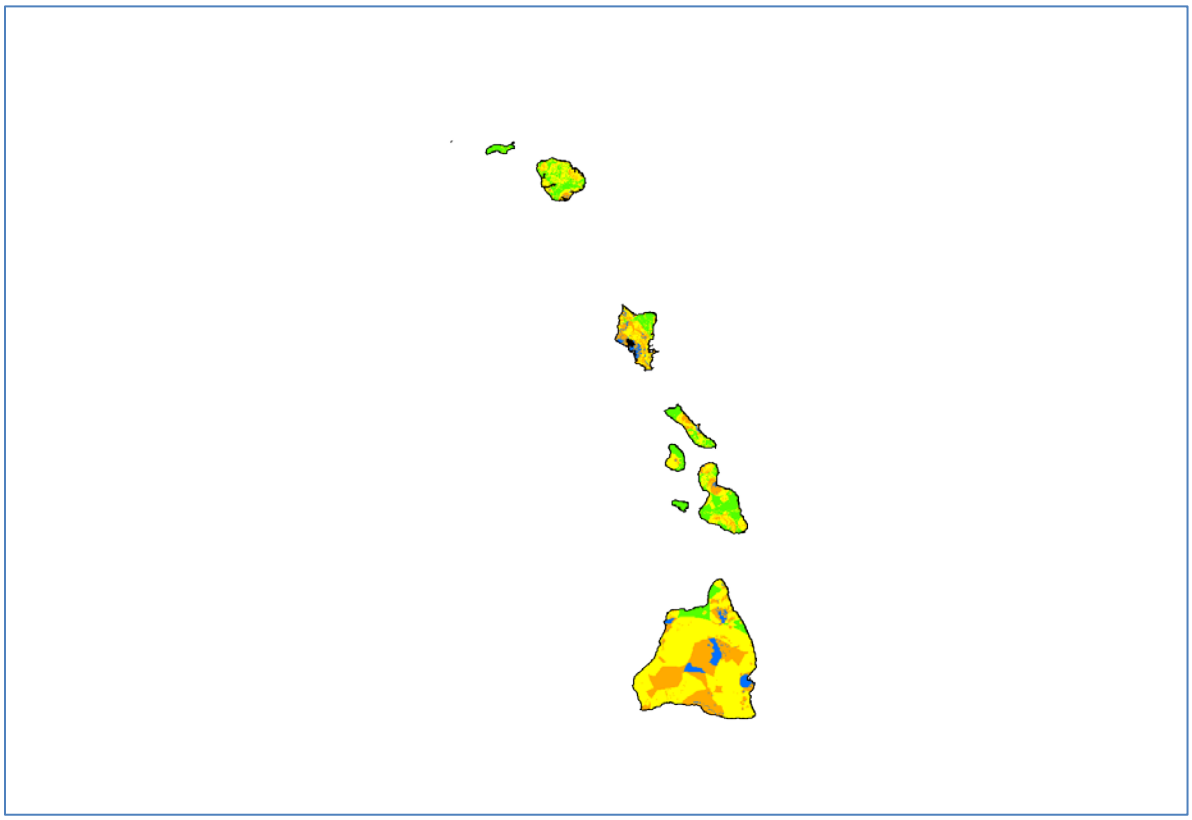

Fig. 12. Hawaii composite map without safe-shutdown earthquake or cooling SEC layers.

Summary

Hawaii presents limited SMR siting challenges. Seismic activity is the most significant SMR issue for Hawaii based on the magnitude of the limiting peak ground acceleration and the scale of the area affected. This issue could potentially be addressed by an SMR design that is specifically enhanced for this purpose. Closed-cycle stream flow cooling is also an issue throughout the state. The cooling issue may be addressed by considering once-through ocean cooling. Alternately, an expanded USGS gage system in Hawaii may provide additional fidelity to the available stream flow data; revealing some closed-cycle cooling opportunities. The remaining SMR SEC parameters evaluated for Hawaii are not limiting.