Assessment of Power Plants at Increased Flood Risk from Upstream Dam Failures in the U.S.

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Abstract

In the United States, power plants are vulnerable to temperature change, and climate change, which can cause events like floods. Power plants operate mostly from water availability and water temperature. This means that when there is a problem with their water source, like when the temperature of the water increases, the output of water is too high. When there is an insufficient amount of water available, the power plant has to be shutdown. As a result, the objective of this project was to locate the 34 vulnerable power plants in the US and their corresponding upstream dams to understand their impacts. The data for the at risk nuclear power plants were obtained from the Nuclear Power Information Tracker and the data for the upstream dams were taken from the National Inventory of Dams (NID). The data collected was recorded in Excel files which were then analyzed using ArcGIS/ArcMap, which are programs that take geospatial data and puts them into maps. The data included information about how much impact it would have on the population within a 10 mile radius, the power capacity in the summer and winter, the distance from the power plant to the dam, the capacity of the dam, the water shed area and the operational status of the power plant. In addition to human impact, it would also affect infrastructures like bridges, that could possibly collapse due to dam failures. Overall, this project analyzed the most vulnerable power plants due to dam failures, to understand the impacts it would cause in order to prepare for a likelihood event in the future.

Research Objectives

- The main objective of this research project was to identify the name and location of the vulnerable power plants in the U.S., store them in a database and understand their potential impacts.
- With information obtained from the Nuclear Power Information Tracker, 34 power plants were identified as at risk.
- Using the National Inventory of Dams (NID) database, 21 upstream dams were identified for the nuclear power plants.
- More information about the vulnerable power plants were given from the US Energy Information Administration, which was then analyzed using ArcMap and Microsoft Excel to understand how much of an impact power plants would have because of a dam failure.
- After analyzing the data, the information accumulated would be used to help reconstruct power plants and dams and help improve power plant efficiency.

Table 1. This table shows the sorted upstream dams based on their normal storage and the distance from the power plant.

Dam Name	Normal Storage (acre-ft)	Dam Name	Distance to Power Plant (km)
JOCASSEE	1160298	CP&L SLAG POND DAM	1.3
WATTS BAR	1009347	NORTH LOW DISSOLVED SOLIDS IMP DAM	2.5
WILSON	636543	WRICH DAM 2	5
TELLICO	392634	MUDDY RUN MAIN DAM	7
ASH BASIN NO 2 DAM	300778.02	BUCK CREEK DAM	16.8
OLD RIVER STRUCTURE	271778.02	JOCASSEE	18.9
CHESTERFIELD POWER STATION	225778.02	MELZINGAH DAM	22
PRIEST RAPIDS	191000	LOCK & DAM #2	24
OXFORD	127500	MUNSON DAM	25
LOCK & DAM #2	82000	AH JOHNSON RESERVOIR LEVEE	26
MUDDY RUN MAIN DAM	60500	TOWNSHEND DAM	33
OZARK WATER SUPPLY LAKE DAM	12000	WILSON	47
NEW JERSEY NO NAME # 3 DAM	1600	OXFORD	48
MUNSON DAM	1100	PRIEST RAPIDS	48.8
TOWNSHEND DAM	800	TELLICO	51.7
BUCK CREEK DAM	306.6	WATTS BAR	51.8
MELZINGAH DAM	178	NEW JERSEY NO NAME # 3 DAM	53
AH JOHNSON RESERVOIR LEVEE	178	CHESTERFIELD POWER STATION	63.5
WRICH DAM 2	78	OZARK WATER SUPPLY LAKE DAM	65
CP&L SLAG POND DAM	63	ASH BASIN NO 2 DAM	78
NORTH LOW DISSOLVED SOLIDS IMP DAM	38.5	OLD RIVER STRUCTURE	163

$$damage: \quad f(\text{distance, dam storage, exposed people})$$
$$d \rightarrow Minimum$$
$$\text{where; } d_{i,j} = \sqrt{(Lon_{D_i} - Lon_{P_i})^2 + (Lat_{D_i} - Lat_{P_i})^2}$$

The damage to the power plants can be a function of different factors, such as distance to upstream dams, etc.

This equation shows the approach to identify the nearest upstream dam, where i and j indicate the specified power plant and dam, respectively.

Results

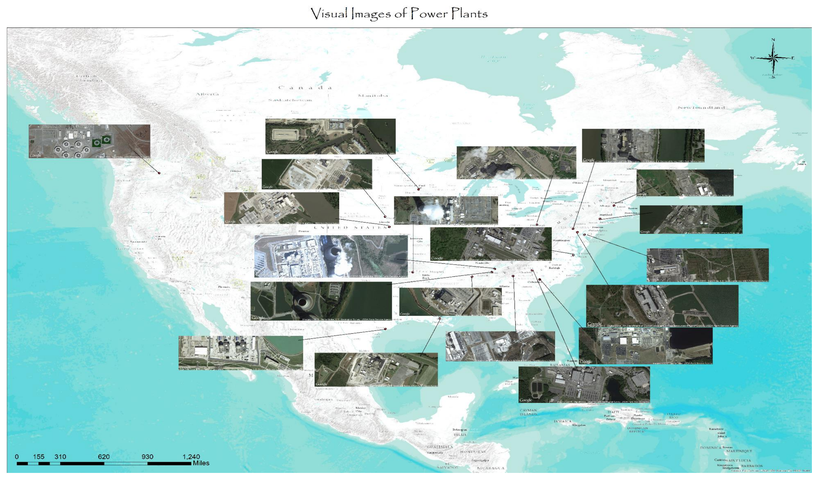

Fig. 1. The map indicates the location of vulnerable power plant to upstream dam failures in the U.S. and their respective satellite image.

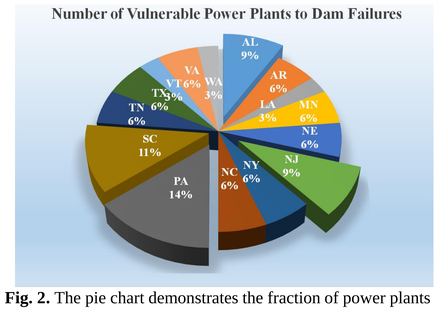

Fig. 2. The pie chart demonstrates the fraction of power plants per state that are at risk.

- The percentage shows the number of power plans at risk by each states.
- The states that are most vulnerable are taken out from the chart to show the vulnerability.

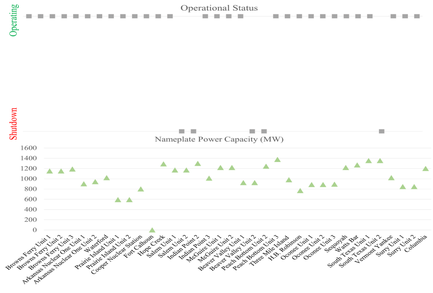

Fig. 3. The graph with rectangle points shows operation on top and bottoms are the one that are shutdown.

- The green points shows the power capacity measure by (MW). The horizontal axis shows the name of the power plants.

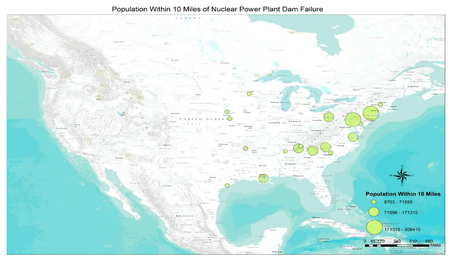

Fig. 4. The green circles shows the population within a 10 mile radius of the power plant. The bigger the circle the more populated it is.

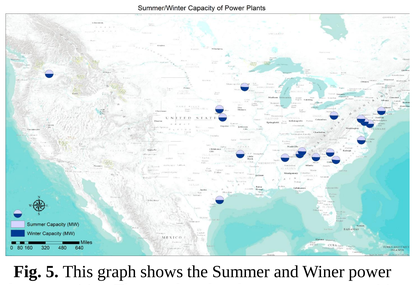

Fig. 5. This graph shows the Summer and Winer power plant capacities. The purple color shows summer capacities while the dark blue shows winter capacities.

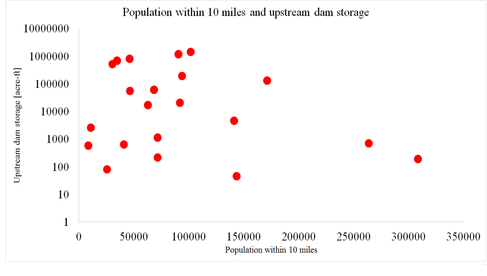

Fig. 6. This graph compares the population within ten miles to upstream dam storage.

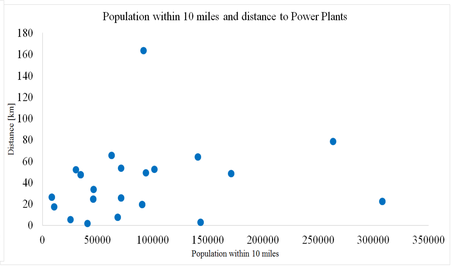

Fig. 7. This graph compares the population within ten miles to the distance from the power plant.

More Results

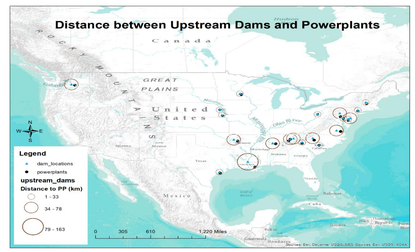

Fig. 8. This image shows the distance between upstream dams and power plants. The bigger the circle, the greater the distance between the dam and the power plant.

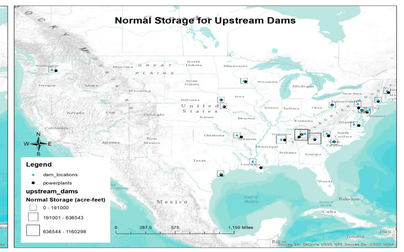

Fig. 9. This image shows the normal storage for the 21 upstream dams. The bigger the square, the more storage the dam has.

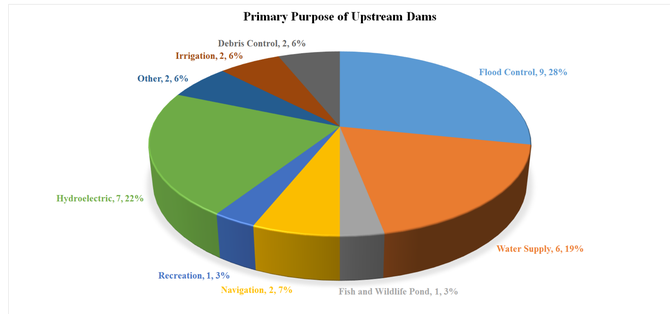

Fig. 10. This pie chart shows the primary purpose of the upstream dams. Some dams may have more than one purpose. The number shows the amount of dams included in that section.

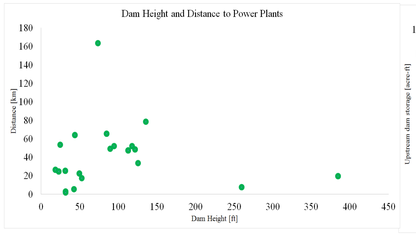

Fig. 11. This graph compares the dam height with the distance of the power plant

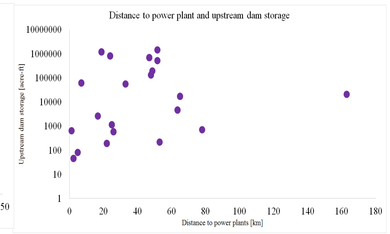

Fig. 12. This graph compares the distance to the power plant with the storage of the upstream dam.

Summary

- Out of the 34 power plants across the US, the power plants in Pennsylvania, South Carolina, Alabama and New Jersey, are the most vulnerable. In fact, power plants in Pennsylvania and New Jersey have been shut down already or are going to be shut down in the near future.
- The population within 10 miles of a power plant is bigger around states that are more power hungry, such as New York and Pennsylvania. This can pose a problem if a dam fails and leads to complications with a power plant. More people would be affected in these states. The minimum amount of people that would be affected would be 8,703 and the maximum would be 308,415.
- On average, the distances between the upstream dam and the power plant range from 34 to 78 km. The greatest distance is shown in Louisiana (163 km). Since this dam is located so far away from the powerplant, it would allow the people who live around the dam to be better prepared if this dam were to fail. The state would have more time to warn the people of Louisiana.
- Most dams have a primary purpose of either flood control, hydroelectric and water supply. These dams are more useful when it comes to protecting a power plant from being flooded, or providing the power plant with a sufficient amount of water.
- The dams with the greatest storage are found in Tennessee and South Carolina. These dams hold more water, and if these dams were to fail there would be little to no time to prepare for the damages that the water would cause, or to warn the people who live around the dam.

Acknowledgements

- This research project and my HIRES summer research internship are funded by The Pinkerton Foundation under the CUNY CREST Institute.
- Thank you to Prof. Naresh Devineni and my graduate mentors Nasser Najibi and Arun Ravindranath.