Climate change and severe weather series #2:
Increasing solar project flood risk

Designing resilient solar projects to withstand catastrophic flooding events is a delicate balance to manage. Designs must meet or exceed code requirements, maintain structural integrity, and minimize both project capital costs and operating expenses. A well-balanced project design is one that maximizes use of the buildable land while avoiding costly impacts from flood damage during the operational period. The latter can be achieved by constructing solar arrays outside of expected flood areas or incorporating a structural design with adequate freeboard and structural strength to survive extreme flood events.

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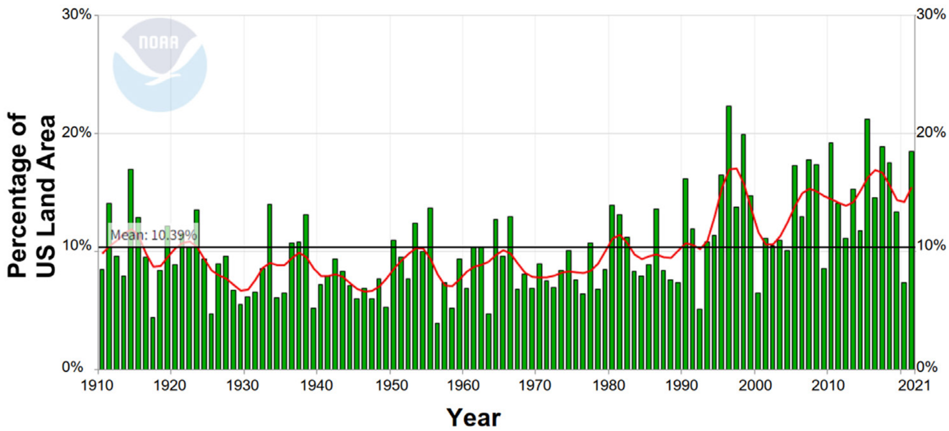
The 100-year flood is the common benchmark, or design flood, that engineers consider when determining solar array layouts and structural member sizes. This extreme event is defined as a flood that has a 1 in 100 chance of being equalled or exceeded in any given year. Given recent instances of climate change affecting renewable energy projects and our electrical infrastructure, the industry must begin to think critically about how climate change could impact flood protection design criteria utilized on solar projects. There is both statistical and anecdotal evidence supporting the claim that today's extreme flood events are more severe (i.e., greater depths, extents, and velocities) and more frequent than historical averages.

This is illustrated statistically in the data shown in **Figure 1.** This figure shows the annual percentage of land area across the contiguous United States where a greater than normal portion of total annual precipitation has come from extreme single-day events. The percentage of land area had been relatively consistent until the 1990s and has been increasing since, implying that more areas of the contiguous US are experiencing extreme single-day precipitation events, especially in the last 15 years. Anecdotally, we do not have to go far back in time to revisit two of the most devastating global extreme weather events in terms of flood damage losses - Hurricane Katrina, which took place in 2005, and Hurricane Sandy, which took place in 2012.

Fig 1: Extreme one-day precipitation events in the contiguous United States



Source: National Oceanic and Atmospheric Administration (NOAA) National Centers for Environmental Information

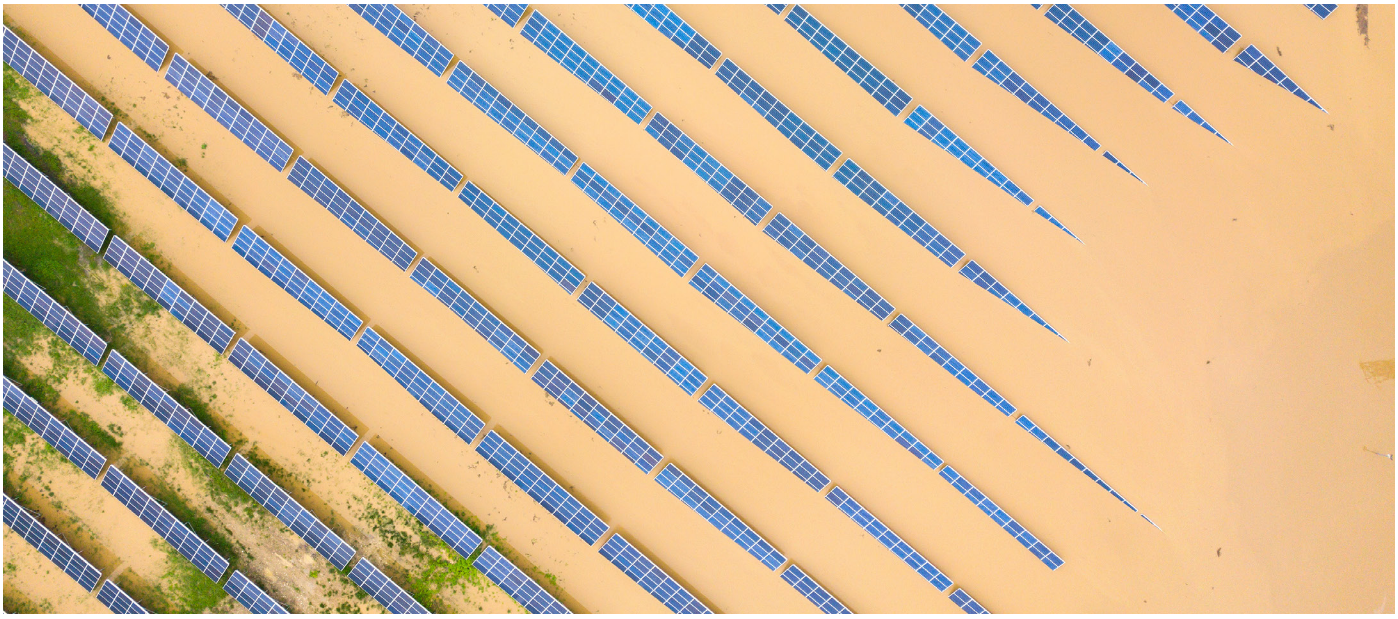


Fig 2: Flood inundation at a solar project

While extreme precipitation events appear the be occurring more frequently over time, the design requirements for flood protection have not become stricter to account for these changing conditions. Most solar projects today consider the same 100-year design flood that would have been considered 20 years ago. Flood studies are formed on the basis of a complex statistical analysis which is inherently dependent on historical precipitation and flood data. The result is that future conditions that may be different from the historical record are not accounted for in a solar project flood study. The Federal Emergency Management Agency ("FEMA") has publicly available Flood Insurance Rate Maps ("FIRMs") which delineate the 100-year floodplain across studied areas. It is common for developers to exclude site-specific flood studies when designing solar projects and instead use FEMA flood maps to determine solar array layouts. Unfortunately, a recent audit by the US Homeland Security revealed that 58% of all FEMA flood maps are considered inaccurate or out-of-date.[1] If flood protection design requirements do not evolve parallel to a changing climate, solar projects may see a higher rate of flood damage than expected over their 25 to 40 year lives.

FLOODING IMPACT ON RENEWABLES

An example of flood inundation at a solar project is shown in **Figure 2**. In addition to potentially negative consequences to structural and electrical components at solar projects, issues related to erosion control can occur. Accounting for flooding appropriately in the design of a solar projects is important to avoid increased downtime, increased equipment repair costs, and negative impacts to environmentally sensitive habitats.

SITE ACCESS

Solar facilities typically contain dirt or gravel roads to access important locations such as module blocks, electrical enclosures, and meteorological stations. Even minor flooding can erode or block off access roads at a solar site, preventing operations personnel from working on equipment that needs attention which can result in increased downtime. Sites that are topographically complex or contain cohesive soils that drain poorly are at an elevated risk to access issues resulting from erosion or extended periods of standing water.

STRUCTURAL FAILURES

Floods have the potential to damage structural racking framing and modules, particularly in locations where high flow velocities are expected during a flood event. Debris such as logs can be carried by moving flood water and these objects can impact and cause structural failure of racking members and modules. Conventional racking framing includes driven steel piles. Flowing water at the pile to soil interface can cause scour of the soil at the base of racking piles, effectively reducing the pile's embedment and load carrying capacity. Structural engineers rely on accurate flood depth and velocity estimates to size racking frame members and create design details for pile scour protection.

ENVIRONMENTAL DAMAGE

Environmentally sensitive habitats such as wetlands are often located nearby or within solar project boundaries. These environments can be degraded by sediment and contaminants transported from their watersheds during flood

1 https://www.oig.dhs.gov/sites/default/files/assets/2017/OIG-17-110-Sep17.pdf

events. It is important that solar projects are designed with established best management practices ("BMPs"), such as silt fences, runoff diversions, or stream buffers to prevent negative impacts to the surrounding environment. Accurate estimation of flood depth, velocity, and extent is important in forming the basis of design for stormwater management design features.

ELECTRICAL EQUIPMENT DAMAGE

Solar facilities contain a wide array of electrical equipment and conductors. Many of these components have ingress protection ratings but are typically not designed to be submersible. It is important for solar project electrical design to consider minimum freeboard requirements during the equipment layout process. Improper protection and layout of solar project electrical components can result in short circuits and damaged equipment requiring replacement. Accurate estimation of flood depth and extent plays a key role in electrical equipment layout and design specification requirements.

HOW NATURAL POWER CAN HELP

Natural Power has a team of engineers with experience and expertise assessing solar project flood risk across a wide range of project sizes and locations. Our experience includes reviewing both distributed and utility-scale solar projects. Reach out if you would like more information on how we can help you make your project more resilient to flooding. Specifically, Natural Power recommends and can support:

- Conducting critical reviews of local flood control regulations, permitting requirements, and flood studies against industry best practices;
- Ensuring FEMA FIRM maps are appropriate for your project; and
- Developing stress cases that consider flood events more severe than typical design standards.

Contact us to see how we can help to evaluate the risk of wildfires for your project or portfolio.

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See also #1 in the series on wildfires:

Climate change, severe weather and mitigating the risk for solar PV projects series: wildfires in the US (naturalpower.com)