Entergy's Record Flooding Across our Grid

Ricky Daniels Jr
Entergy Services, Inc.

Darryl Champagne, Jr., P.E., PMP
Entergy Services, Inc.

Daniel Alban
Entergy Services, Inc.

Mike Walcott, E.I., PMP
Entergy Services, Inc.

Abstract- This paper will discuss two flooding events that took place across our grid in 2016. Between March 8th and 9th of 2016 there was eighteen to twenty-one inches of rain in northern Louisiana, and over a foot of rain along the southwest portion of the state. A large portion of the rain water from northeast Texas to northwest Louisiana drains into the Toledo Bend Lake, continuing on into the Sabine River. With the torrential rainfall in the area, the Toledo Bend Lake soon filled up causing the dam to be opened. The Sabine River Authority had to open all eleven flood gates on March 9th for the first time in its history causing a massive amount of water to flow into the Sabine River. From August 12th to the 13th of 2016, a slow moving low pressure system brought substantial rainfall to the Baton Rouge and Kentwood Louisiana area causing record flooding. The rainfall totaled twenty-four inches within two days. This rain system was classified as a "1000 year rain", essentially a .1 percent chance of happening in a given year.

Introduction

Entergy is a large investor owned utility serving a four state area through operating companies in Arkansas, Louisiana, Mississippi, Texas, and New Orleans.

Hartburg is a critical substation within the Entergy Texas 500KV system, flowing power out of nearby generation and providing power into the 230KV grid via an auto-transformer. On March 15, 2016 the Sabine River crested near the Hartburg substation at 33.24 feet. This was a new record; as the highest crest ever recorded was in 1884 at 32.20 feet. This is also lower than what was anticipated by the Sabine River authority for this area. The unique aspect about this flooding situation was that it was foreseen because of the rain further north, unlike coastal flooding which only allows one to be reactive.

Taking a step back, in February of 2016 construction began at Kentwood substation in Louisiana to expand the facility in order to install a new 115KV operating bus, a new control house, high side breakers, and new relaying. Unfortunately, during the heavy rain events in August 2016, this station experienced approximately 5 feet of severe flooding.

This paper will focus on the technical challenges Entergy faced, the proactive approach Entergy used at Hartburg, and the substation restoration effort that took place after the flooding.

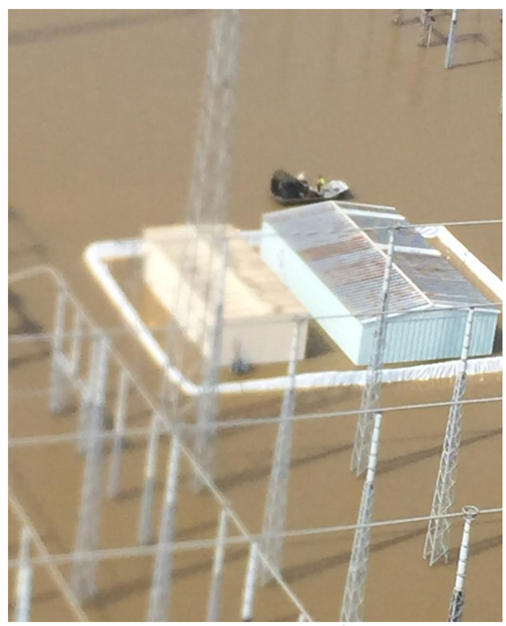

Figure 1: During the Hartburg flood

Figure 2: During the Hartburg flood

Proactive approach at Hartburg

With the Sabine River flood advisories available, Entergy took a proactive approach to mitigating the amount of damage the Hartburg substation would take. The physical equipment in the yard are all sealed devices with the exception of the control cabinets which house motors and terminal blocks for wiring. The only mitigation technique considered was to use spray foam to seal the conduit holes and around the doors even though they have rubber gaskets. This was done for the motor operated switch mechanisms, breaker control cabinets, CCVT junction boxes, and transformer cabinets. Unfortunately one or both did not hold a seal, as water made its way into the control cabinets that were below the water line.

The three control houses contain equipment which are much more sensitive to water exposure, so it was imperative to try and mitigate these from flooding as best as possible. The local grid employees brought in an outside company to install a plastic berm around all of the control and microwave houses. Figure 1 above shows two of the control houses surrounded by the temporary berm.


Figure 3: Inside the berm

As you can see in figure 1 and 3, the temporary berm was not completely water proof. This berm is made of plastic units that were filled with water to hold them in place and then covered with a plastic tarp. Each plastic unit interlocks with the two adjacent ones but they do not form a water tight seal. The seam between the ground and the berm along with the cable trough are also not water tight. The cable trough was filled with sand in an attempt to stop the water from flowing. All of these leaks allowed water to seep inside of the berm but there was enough foresight to expect this possibility. Several water pumps were placed on the inside of the berm and in figure 3 above you can see the discharge hose coming over the side of the berm. The pumps were enough to keep the water level down to one inch of flooding inside these two control houses.

There was currently a project in the construction phase at the same time of this flooding at Hartburg. This project included a new control house for a 230KV expansion project. The new control house was placed at a lower elevation and the berms and pumps were not enough to keep the water down. The new control house was positioned next to the 230KV equipment, which had a lower ground elevation, so when it was placed at the same height above the ground it wasn't the same elevation as the older houses. This control house took on about sixteen inches of water, resulting in extensive damage to protective relay equipment.

Figure 4: Microwave house

The Microwave house contained telecom equipment, which is also easily damaged by water. This house was at a lower elevation as well and took on a substantial amount of water requiring all of the equipment inside of it to be replaced in the end.

If the Sabine River would have made it to the height that was forecasted by the Sabine River Authority, then all of the berms installed would have been topped with the flooding river. One initiative prior to the flooding was to mitigate as much damage as possible; the second initiative was to determine what impact it would have to the system if Hartburg was lost.

Losing this 500KV substation would have a substantial impact on the system in this region so a plan was developed to mitigate this. The flooding would never get high enough to impact the bus or transmission lines, it was mostly a concern for relaying and breaker control cabinets. If water made it into the relay panels, the water would theoretically cause the breaker to trip by shorting everything together or cause the relays to fail and not operate in a fault condition. To mitigate this, the dc to the panels could have been turned off, but it would also remove any necessary protection schemes that were in place. Having at least some type of protection was required. The station was switched into the configuration you see in figure 5 and 6 below.

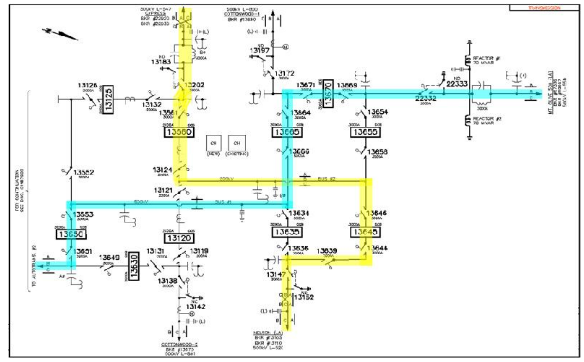

Figure 5: 500KV

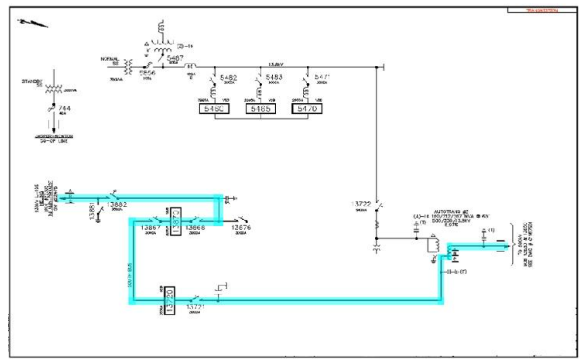

Figure 6: 230KV

Certain breakers and switches were opened to only allow power to flow in the configurations seen above. This would then allow the local protection at Hartburg to be turned off and the settings in the relays at the remote ends to be adjusted to protect through Hartburg. The two nodes to the nearby generation were opened since the generation plant was going offline.

The settings were modified to have zone 1 protect 80% and zone 2 protect 120% of the new lines through Hartburg for the primary 1 relays. The zone 2 timers were decreased to 10 cycles because of stability concerns. Hartburg to Nelson used tone communications for both primary 1 and primary 2 relay schemes, but between Hartburg and Cypress the primary 1 relay used carrier and the primary 2 relay used tone communications. The communications path was redirected where the tone for direct transfer trip, DTT, went between Nelson and Cypress for the primary 2 relays. The communications was turned off for the primary 1 scheme because of the materialistic challenge of getting another tone set installed at Cypress. The communications was never turned on between

Helbig and Mount Olive because of the mismatch in communication methods. Setting these distance elements for the remote relays was a challenge with the series auto transformer.

The Reactive response to Kentwood

Unlike the Hartburg disaster, we were not able to foresee the flooding that took place at Kentwood. The substation is currently located in an AE flood zone which is approximately 5-6 feet below the 100 year flood level. Earlier in March when Hartburg flooded, the Kentwood substation had flooded as well, which generated discussions about the site elevation and facility expansion for the ongoing construction project, no solution was selected.

With the station flooding a second time in the same year, the project team found it necessary to re-assess elevations for the ongoing project as well as a plan to protect the existing equipment from future flooding. The substation was completely de-energized for a period of time while the power was provided to customers from another substation until the low voltage breakers were replaced.

Figure 7: Kentood Flood

In order to prevent the station equipment from flooding again in the future the team re-worked the low voltage bus that would allow all the proper clearances for the low voltage breakers to be raised 6 feet resulting in the bottom of the breaker to be positioned at flood zone level. Also, all motor mechanisms were replaced and raised. Platforms were built to allow the cabinets to be serviced for routine maintenance. All of the junction boxes and conductors were replaced to prevent the possibility of future corrosion.

Conclusion

The temporary relaying scheme never tripped at Hartburg since there were no faults within its zones. Looking back, if the two remote ends had the same style of communications and the same relays, it would make bypassing a station for any reason much simpler and still allow for complete protection. After the flood, the construction group installing the 230KV control house ended up raising it and having to replace some components on the bottom of all of the panels. Another item taken away from this event is to install new control houses at least the same elevation as existing ones, not necessarily the same height above the ground. All of the MOS motor mechanisms had to be replaced and raised 6 feet along with outdoor AC and DC panels from going under water. Water didn't get high enough to get into the CCVT junction boxes. On average, the breaker cabinets had about 8 inches of water. There were a couple terminal blocks that got wet inside of the breaker cabinets, so they were replaced to avoid corrosion in the future.

If a more proactive approach was taken at Kentwood, it could have reduced the amount of damage that was done during the second flooding event in 2016. No flood mitigation was chosen after the March flood because of cost and schedule impact along with the unlikely event it would happen again, but it ended up costing more and created more down time for the substation in the end.

Darryl Champagne, P.E. PMP, BSEE-2010 Graduate of Louisiana State University. Darryl joined Entergy in 2010 as a relay design engineer. Prior to this he interned and worked as a consultant at one of Entergy's nuclear plants, Waterford 3. Darryl is a registered professional engineer.

Daniel Alban, BSEE-2014 Graduate of the University of Louisiana Lafayette. Daniel joined Entergy in 2015 as a relay design engineer. Prior to this he interned at Lafayette Utilities System.

Ricky Daniels Jr., BSEE-2014 Graduate of Southern University and A&M College. Ricky joined Entergy in 2015 as a Relay Design Engineer. Prior work experience includes electrical contract work with ISC at ExxonMobil Baton Rouge Refinery & Chemical Plant

Mike Walcott, E.I, PMP, BSEE-2012 Graduate of Louisiana State University. Mike joined Entergy in 2012 as a Relay Design Engineer. Currently Mike does relay settings at Entergy.