Fire Bridge Operations Zoom Session Synopsis 12-30-21

1. **Introduction –**

Who is Doc Hydro and how did the name come about?

Doc Hydro is me, Joseph Moylan. I have 15 years in the Wildland Fire Service specifically moving water. I specialize in highly complex hose-lay and water logistic issues. The Name Doc Hydro came about shortly after the Cold Springs Fire in 2017 in Austin Nevada while working at the Austin Airstrip on a remote SEAT base assignment. They had placed a call for a Water Tender operator to originally facilitate the hydrant that was supplied by a well and was only delivering 100 gallons per minute at max. The long story short is I was able to facilitate a plan that allowed the base to launch a SEAT every 3 minutes non-stop. The base operated with 5 of them. More on this and from the SEAT manager's own words is on the "About Me" link on the website. One of the co-workers then Dubbed me "*Doc Hydro*" – The ship has long since sailed.

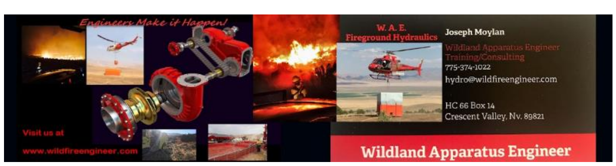
2. **Fire Bridge – brief description of what a bridge is and its purpose.**

*A **bridge** is a structure built to span a physical obstacle (such as a body of water, valley, road, or rail) without blocking the way underneath. It is constructed to provide passage over the obstacle, which is usually otherwise difficult or impossible to cross. There are many different designs of bridges, each serving a particular purpose and applicable to different situations. (Wikipedia)*

A Fire bridge in this case means an attempt to construct a Bridge of concepts and ideas that on one hand deals with Fire and its analysis and the other for using that analysis to engage in proper suppression that is logical and readily understood and easily executed by the foot soldiers in the field.

In short, a Fire Bridge, as is meant by Wildland Apparatus Engineer, SP, means to take the fire behavior numbers of Heat Per Unit Area (Btu/ft^2), Btu per foot per second(the intensity), and rate of spread of chains per hour(converted to feet per second), and allow a mathematical bridge to be constructed so that the Crews, Engines, Dozers, and Aircraft on the Operations side, can use the right amount & type of resources in the right areas to be successful for quick knockdown leading to extinguishment.

This is understood even more easily by thinking of the Fire itself as a fuel containing potential energy commonly known as an Energy Release component or Btu (British thermal Unit). The British Thermal-Unit is a unit of measurement that is used to determine the amount of energy needed to raise 1 pound of "a" substance by 1 degree. In our case as firefighters that substance is Water.



Once the Fire is started and develops other factors such as the Rate of Spread are obtained and are normally stated in Chains per hour and a chain is 66 feet.

Many other factors go into the physics of fire, however for our purposes, today, we need not concern ourselves with those details. We only need to know what the fire is doing at the instant our services are requested to use our "Mathematical Bridge" to close the gap on the operations stalemate and go to work.

3. **Factors that would be on the Fire side(minus the bridge) for this discussion are:**

Fire Fuel type – ex hardwood, softwood, shrubs, grass, etc. Oak vs Pine

Fuel Energy Release – normally expressed as Btu/lb of the substance, others are Btu per cord as in firewood. (more on this later), or even as Btu/ft/sec

Heat per unit area – measured as Btu/ft^2

Fire Intensity – stated as Btu/sec/foot

Fire Rate of Spread in chains per hour and again a chain is 66 feet. So if a fire is moving at 380 chains per hour, it is moving at 25,080 feet per hour or 7 feet per second[1]. This is important because depending upon the fuel type, the terrain, and temperatures, we can have a significant Btu content with this.

If our fire is traveling at 7 feet per second but is now 3,000 feet long, then we have a footprint of 7 x 3,000 feet = 21,000 square feet. If our heat per unit area is say 2200 Btu per square foot, then our Total energy release is now 21,000 x 2,200 = or 46,200,000 Btu per second!

Now we have a number we can use to construct our Bridge!

4. **Build the Bridge!**

Properties of WATER are used in like units of Btu. We already know that water absorbs a tremendous amount of heat even not being involved in fire. We can see this every time we put a pot of water on the stove to boil it and the time it takes changes depending on two other factors, the altitude at which the boiling pot is at, and the initial temperature of the water. The warmer[2] the water is the less time and energy it will require. While higher altitudes require less temperature to bring water to a boil, it also takes more time. Pending atmospheric conditions.

Water has two heat properties, Specific and Latent. Water first absorbs a specific amount of Btu for every pound and is based upon the current or initial temperature of the water we are going to use and the boiling temperature for the altitude the water is at (or to be used).

Say we are at a 5,000-foot altitude and our water temperature is 50 degrees.

To begin to have our bridge constructed, we need to make our foundation. Our foundation in this case is first determining how much thermal capacity water can hold for the altitude and water temperature we're to be working at and with! The second case is obtaining the fire outputs.

Water boiling temperature has a lapse rate of about 1.84 degrees per 1,000 feet. So this makes our calculation easy. 5,000 feet divided by 1,000 = 5. And 5 x the lapse rate of 1.84 = 9.2. Simply take this 9.2 and subtract it from 212 degrees (the boiling temperature at sea level) to obtain the new boiling temp for your altitude for 5,000 feet. This is 202.8 degrees.

Determine the water temperature[3] in your tank, or pond or stream, etc. You can estimate if you are good enough but the more accurate this number is, the better your results will be.

202.8 degrees – 50 degrees (from above) = 152.8. This is called the Specific Btu and the amount required to raise the water temperature from 50 degrees to the boiling temperature at 5,000 feet of altitude. If you do not apply at least 152.8 Btu worth of energy, the temperature will not reach the boiling phase.

(Our foundation is almost complete)

Latent Heat – The heat that will be absorbed by the water, just at a later time.

The term Latent means; (of a quality or state) existing but not yet developed or manifest; hidden or concealed. So think of the Latent heat quality as a hidden ability of water to absorb an additional amount of heat once it reaches certain criteria and that criteria are after the temperature of water hits the boiling phase.

Once the water reaches the boiling temperature, there is still the ability to absorb another 970.3 Btu worth of energy per pound of water in the conversion to steam. So if we had just one pound of water we would absorb or have to apply a total of 152.8 + 970.3 Btu's of energy for the one pound of water to raise it from 50 degrees to steam. That is 1123.1 Btu. This is the thermal capacity for these circumstances for this single pound of water.

Now the water has 8.34 pounds to a gallon. So 8.34 x 1,123.1 = 9,366.65, Btu per gallon. If you're on an engine using a 1" combination nozzle flowing 20 gallons per minute, then your nozzle can absorb, 20 x 8.34 = 166.8 lbs x 1123.1Btu/lb = 187,333.08 Btu worth of heat absorption per min.

So part of our foundation is determining the thermal capacity of each pound of water so that we can determine how much of it we will need. This is Bridge Pillar #2.

5. The Bridge items

Initial water Temp

Boiling Temp at altitude located or to be used

Thermal Capacity per pound – (Specific + Latent = Thermal Capacity).

Determine the amount of water required by dividing the Btu output of fire by the Btu absorption of the water.

The result tells you if you will be successful in your efforts and if it's short, you need to apply larger flows, etc.

For example, our fire was generating 46,200,000 Btu per foot per second. In 60seconds that is 2,772,000,000 Btu. Taking our 2.7 billion Btu and dividing by 1123.1(Thermal Capacity), tells us the amount of water we need in pounds. If we then take that number and divide it by the weight of water(8.34 lbs/gal) it will give you the gallons required. Example: 2,772,000,000 Btu / 1123.1 Btu/lb = 2,468,388.245 lbs. And 2,468388.245 lbs/8.34 lbs/gal = 295,969.8 gallons. This could be further broken down to 5,000 gallons per second that would be required.

So it is clear that no engine will attack this fire as they produce flows in Gallons per minute, and not in sufficient quantity. Now what? [deducing point]

Yet if we go back and think about our mathematical bridge and our foundation of the thermal capacity, then we can look at aircraft and see what comes close to the Btu capacity if we were able to apply it in that second of time. [time is going to become the critical component that forces one to rethink strategy to be effective]

This now leads to laying the bridge over the foundation. If we obtain the coldest water we can, and as much of it, we can use that to advantage and drop it from an aircraft and that is a second in time that could be used to more closely match the fire output.

The closest aircraft to the 46,200,000 Btu is the C-130 or the Boeing 737 at 37.5 million Btu per load. The next higher single aircraft is a DC10 with a Btu capacity of 108 million Btu. So, at least 2 aircraft will be needed just to cool the area. [Ditch the load and return thought process][4]

Fire Bridge does NOT work and is useless unless one understands WATER and applies the thermal properties of it to the fire's current conditions.

Once you determine what the fire is generating, and determine how much energy water can absorb for the altitude at which the fire is located, you can then determine what resources can carry or deliver enough to get knockdown and suppression of it.

Think of Fire Bridge as 3 separate components in one.

Fire - The size, type, and ERC in

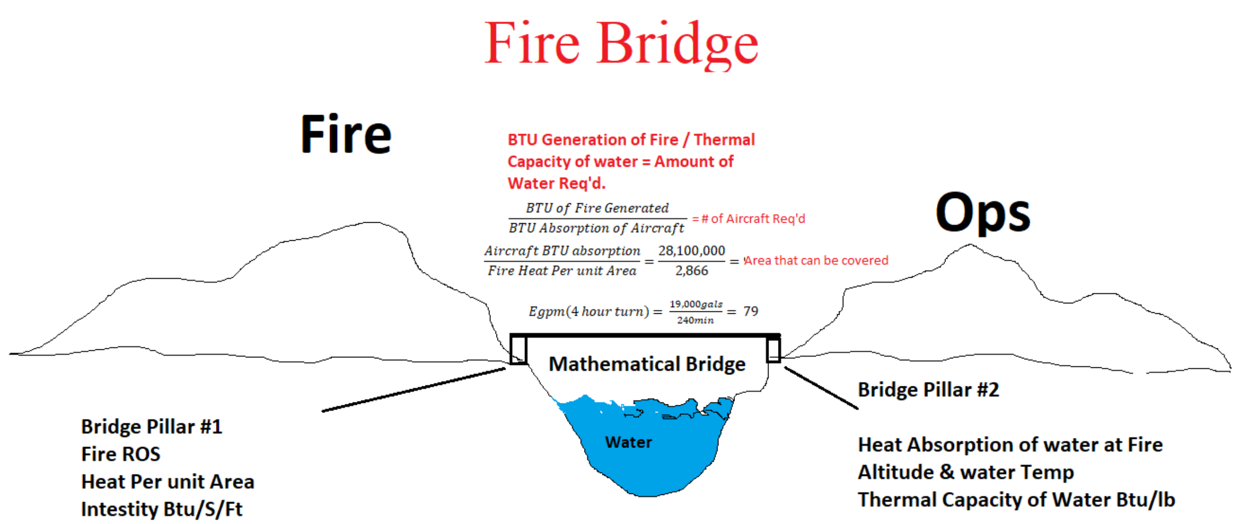
Bridge – The mathematical determinations of both the fire and the water required

Operations – The Crews, Apparatus, Dozers, and Aircraft necessary to carry out the Bridge portion

The first bridge pillar is the Fire-side

The second bridge pillar is the Operations side

And the bridge portion itself is the math that allows you to Equate the Btu of generation to absorption and the vehicles to which to move them.



1. WAE chooses to use Feet per Second instead of Feet per Minute with the Fire Bridge computations because, in a comparative sense, it is highly unlikely that your fire lines' active width will be of the scope and caliber as some think is being referenced or computed using a Nomogram. Since the Fire Rate of Spread is always given in Chains per hour (in the USA) and a chain is 66 feet, then this is automatically a Feet per Hour unit. However, a fire normally would not have a 3,960 foot wide active with, as in our sample model. As is evidenced in the Nomograms, the Heat per Unit Area is in Btu/ft^2 and the Actual intensity is in $Btu/S/ft^2$. If we look at Fuel Model 7, Southern Rough, and say we had a fire with a ROS of 60 chains per hour, assume the Heat per Unit Area is 500 Btu/ft^2, then we simply could not use a ROS converted to Feet per Minute because this would make the active fire line 66 Feet wide. 500 Btu/ft^2 x 66 feet = 33,000 Btu x whatever the fire line length is, is what our Btu generation would be. This further would throw out the Intensity side of the nomogram and be completely in error. So the nomogram intensity is set up for a Btu per Second basis and our Fire Rate of Spread is converted to 1.1 Feet per Second. 1.1 FPS x 500 = 550 Btu/ft^2. This further matches up with the nomogram & makes fire active width only 1.1 feet wide.
2. Warmer water will take less energy and time in bringing water to boil and subsequently to the conversion of steam, however, in the fire service we do not want nor should we desire such. We want the coldest water possible for the altitude we're about to drop at so we can have the maximum heat absorption capacity possible. We want our fire to have to work harder to keep producing energy. Cooler water allows us to use aircraft and nozzles more effectively since it's heat a fire produces, we want to try and match such for successful knockdown and extinguishment. Using warm water, as a general rule, will mean we have to use more loads or aircraft for the same size fire.
3. The easiest way of determining water temperature is to utilize the thermometers in your belt weather kit.
4. The Load and Return process is the standard methodology used today in the USA. This is very problematic at best as nearly every large aircraft ordered is loaded with retardant and they usually are not ordered up to make sequential drops (multiple aircraft dropping in rapid succession). This leads to ineffective cooling of the active fire and is used in an out-of-order or non-order process. This further reduces the effective Equivalent Gallon per Minute ratings of the aircraft and therefore allows for the fire to simply re-heat and re-ignite the fuel. Retardant only drops are a further degraded approach when used alone because there is actually less water in the retardant mix and therefore less cooling capacity per load.