Speaker 1: Our last speaker in the session before we have the panel discussions is Steve Nebiker. Steve is vice president of the company, HydroLogics of North Carolina. This company and Steve work in the advancement of water management issues nationwide, focusing primarily on improved water allocations and rivers during drought. That will be the subject of his talk today, which is entitled, "Using simulation models to craft effective drought management protocols." So, Steve.

Steve Nebiker: Okay. I am very excited to be able to talk to this large and diverse group about a topic that's near and dear to my heart, drought management. I often do this talk at trade conferences and they stick me in a large convention center and there's five concurrent sessions, and there's a thousand seats in the banquet hall and there are about 20 people showing up. So this is a nice change. I go around the country promoting a campaign that I think you guys can remember, called "Taking the doubt out of drought", and when the rains end, the stream flows and the lake levels start to decline, the drought monitor is issued and it's for that week and it starts showing yellow blobs on the map, and the snowpack levels aren't great and everyone gets into a panic that the next big drought is upon us.

I hate to be so audacious as to say you end up being the losers, because as many of my clients and their utilities remind me and municipalities a [inaudible 00:02:02] down vote and the job plans that I see out there are generally lacking and don't do a good job of reducing that uncertainty. I've worked with a number of you in this audience and I'll call out Chris Goudreau because he's done a great job with helping organize this conference, and I've worked with them to develop effective drought management plans. He asked me in part to explain how we do that using simulation models.

This talk is actually well timed because it builds on some themes from earlier talks, collaborations, operations, and there is this discussion about using a quarry to restore or provide supplemental flows to the stream, predictive models, holy grail and hopefully I can be of some help here in explaining how we do this, but I think it's targeted exactly the kind of predictive tools that you need.

If there's one takeaway from this talk, it's build a useful model, and they will come. A caution to those who try to develop instream flow protocols without using a simulation model because it will be difficult, if not impossible to test the impacts of that instream flow protocol on other users. Caution to those who use a model that's not transparent, flexible and powerful. If you build a useful model, then you have stakeholders working with a model and they develop good working solutions, especially for dealing with drought. If there's another takeaway and you're in a drought, build a model, nine times out of 10, after I build a model, the rains come and the drought goes away.

Just a quick overview of the talk. I’ll cover the motivation behind building these models, the experience we've brought to bear on developing good water management solutions, the modeling process that we follow and if there's time, just a couple of case studies.

Here is a picture of a reservoir - I think there are about 80,000 dams in the country. So, most systems are regulated. We're dealing with competing objectives typically, and they may have started out as one and now multiplied. A lot of reservoirs were built for flood control. The goal there is to keep the lake level down to be able to store flood water. Over time, water supply may have been added. The goal there is to keep the lake level up. With hydropower facilities, the owners may have built a dam and it was intended to be used just for hydropower. Then unwittingly they sort of allowed residential development on the lakes and now those stakeholders are putting pressure on those hydro developers to keep the lake levels high. The competing needs and striking a balance between those competing needs gets more difficult with the so-called new normal, where we're seeing increasing hydrologic variability, we're seeing more and more demands on the resource. We're also seeing dramatically higher costs of adding new supply. So can we do a better job with the system we have, managing it more intensively for all the uses on that system.

This sets up the framework for what we call dynamic reservoir operations, which is a way of improving water management. We wrote the book on this for the Water Research Foundation a couple years back, as it pertains to addressing climate change. We found that those operating rules have become very useful for managing droughts. The information that goes into managing a reservoir is quite significant. We've got a lot of pieces on that plot, there's obviously snowpack for systems out West, but we're operators looking at demand levels. They may be looking at temperatures in the river below for establishing effective instream flow regimes. Obviously they're looking at storage and then they can look at information like climate outlooks and streamflow forecast.

There's a continuum of rules that we develop around that information. The question is, can we capture that information and put it into the rules? Rules could range from static where utilities and their communities often rely on a very simple drought trigger, which is the number of days of supply remaining. They ignore inflow and they ignore seasonality so it leads to a poorly timed drought response. Or it can range to more dynamics, which would include, say, snowpack or what I'll be talking about in flow forecasts.

I put this here just to give a sense of the experience of our company. We've been operating for about 35 years. We're only 10 people, so we've done a fair amount in a long period of time, and most of our work has been done recently on the East Coast, Delaware River Basin, and Susquehanna River Basin. We've developed models for those basins, and I took a screenshot here of one of the projects. Feel free to go to the website and I hope you do that because I spent a lot of time putting this thing together. This is the Little Tennessee River there in the corner. You can't see it probably from a distance, but if you go there, you will get some important information mainly that, that's where The Fugitive was filmed when Harrison Ford purportedly jumped off the dam. That project is at the Polka project, which was discussed in the FERC relicensing workshop on Tuesday.

We build simulation models with Oasis. Oasis is a software we developed years ago to help us, develop that footprint. It is a planning and operations model, but if you can't implement the plan, then developing the plan isn't all that much of use. So, we have a model that does both. About 20 percent of the US population is impacted by decisions that have been made with the software. Oasis is a very powerful tool so we can run long periods of record, usually we're running an 80 year inflow record in simulating the system and how it would respond to those flows on a daily basis. We do that in a few minutes, so we can basically test alternative strategies very quickly, and that gets us away from the wet/dry average year scenarios, which are problematic. They don't lead to as nearly as robust or precise solutions for drought management because every drought differs in timing and intensity.

Here's an example, I took a screenshot of one of our models. That's the Salt River project, the first reclamation project in the country, that's outside of Phoenix. Then there's another one near the New Jersey area.

My talk yesterday addressed about four aspects to getting to implementation. That's litigation, legislation, adjudication, regulation, and collaboration. So we focus on the collaboration aspect. There are some articles in American Waterworks Association Journal about some of the work on the Susquehanna River Basin Commission. Then there's a picture of Brian Richter (who's speaking at lunch), on work done for Charlottesville, Virginia area.

The process we follow is we develop performance measures, we build a schematic, develop the input data, evaluate the alternatives, implement the alternative, and then usually because these models are actively used, we do the training and then allow the stakeholders to get access.

It's important to note that there are three states that use Oasis, Tennessee, Kansas, and North Carolina. We're trying to promote collaborative modeling so the stakeholders have access to those models on the state servers. So we let them explore new ways of operating the systems. In terms of the performance metrics, I like to use the Nature Conservancy diagram, they are on the right, which is showing the timing and volume of flows needed to enhance, not just the aquatic habitat, but also the wildlife and even tree, seeds dispersal, and germination. Then there's on the left, those are ... You can do any pretty much any performance metric you want coming out, as long as you [generate 00:11:44] the flow and storage in the system. That one is related to recreational restrictions, based on how often the reservoir hits on storage levels, and then there's water supply frequency, severity and duration of restrictions.

We're able to capture that because what we're trying to do is develop operating rules that balance all these competing objectives. We can link Oasis with IHA, so IHA is seamlessly integrated, and you can get statistics from that. In Tennessee, we're also linking it with a USGS tool to come up with a diversity index in terms of all the different fish species.

When we build a model, we start with the schematics. This is the one in Charlottesville - all those red triangles are reservoirs. All those little arrows going into the reservoirs are unregulated inflows that we developed typically from USGS gauging stations. We build a long-term inflow record to capture the major drought events. In that area, drought in the 1930's was as big as the 2000's. Then we basically route water through the system subject to the competing interests. Usually these are simulations, not optimizations because optimizations mean that you know exactly what to optimize for, but this is multi-objective. So what we do is we'll simulate for meeting environmental flows first, then we'll simulate for meeting water supply first, and then we'll show the trade-offs.

Then we'll evaluate the alternatives. Here's a part coming out of the software that's showing three reservoirs on the bottom, and that's a period of record plot 1930 to present and you can't see it very well, but there's a lot of overlap right here. This is the thirties and the same, and the 2000's. Then you see periodically one of these reservoirs going down in the other years. So what this is saying, and we often find this, that the systems aren't necessarily as stressed as some are led to believe. This is now when we do a simulation, we're simulating the system today subject to a repeat of the historic inflows. This would suggest that the system would have been stressed on a repeat of those two drought events. Right? But we can bring that system to soft landing with good drought triggers and in all of these other years that frees up the system to meet other resource needs like environmental flows.

When we develop alternatives, we typically look at introducing a forecast, and the advantage of those as they were focusing on detecting droughts in time, and minimizing the false alerts. We can't run out of water supply, especially if the client is a water supplier. We want to minimize the false alerts because those cost the utility company money in terms of lost revenues. A from an environmental flows perspective, you don't do it to deprive the downstream flows or the users or the habitat of flow unnecessarily. So when we set up those drought triggers, it's an X percent chance of getting to some percent storage in the reservoir at some point in the future. You don't wait till you hit a certain storage level, you act on the probability of hitting that storage level, so you're being proactive, not reactive.

This is what they call a spaghetti plot. So let's say that's a beautiful looking plot there. All right. This is a time frame on the ... Here's storage on the y axis. The storage is coming down and it gets down about 50 percent. From this, what we can do is pass through, Oasis, all the historic years of inflow. One year at a time. So 1930, 1931, 1932. We're going to adjust all of those historic years to how wet or dry the basin is at the time we make the forecast. We're going to run that through the model that's going to spit out individual traces of reservoir storage. You're taking the inflows and you're converting it into storage through a simulation model and what you get is 80 equally likely traces of where storage could head at some point in the future, usually out a year.

When you have this information, you are armed and you are dangerous. You're dangerous because you don't know, and if this is the water supply, the water supplier doesn't know what probability act upon. If you were to take action on this worst case scenario, then that means in most years you're taking action prematurely and that's a false alert. If you're acting on say, a median, a scenario which may be 50 percent or a wet scenario, then you may be acting too late when you're in that drought. If that drought is as severe, you may be acting too late. So you have to test those trigger parameters over the historic record and show the stakeholders that those triggers would have worked in a repeat of all droughts. We're also going to make sure that we're going to preserve a certain amount of storage so we can deal with droughts that are worse than in the historic records.

We come along here. This plot is useless from a distance, but that's fine. You can visualize. I've got here storage in the system. This is Charlottesville system, so I'm simulating storage over the historic record, and what is happening here, is here's the sort of the reservoir level that's part of the trigger. Oasis is basically using weekly forecasts as if they existed and if there's a high enough probability of dropping below that line, which is 80 percent storage, at some point in the future, then the drought trigger will be invoked, and that'll lead to a reduction in demand and a reduction in the minimum lease. So what happens here? Nothing. You can't see anything here. You can see there's a break here. That means the demand is less than the delivery. This is a drought trigger indication.

In the first year of a multiyear drought, it doesn't do anything. Oasis is saying basically the drought is developing late in the year, the refill likelihood going into spring, especially on the East Coast is high enough, don't do anything, but then it sees going into second year this is going to be a serious drought and it calls for actions. So we're making sure we preserve the reliability so that keeps the water supplier happy, but we're also minimizing false alerts which makes the other stakeholders happy. So if you can fine tune the drought plan now you're building credibility with. If it's the case of a water supplier that you're only taking action when really needed, and you're not putting their system at risk, you're also being able to provide for other needs in most of the other years.

Someone mentioned this talk yesterday, operation support to [inaudible 00:19:10] New York City, that's all sort of driven by Oasis and in this case we're feeding in all this data that I mentioned in that dynamic reservoir operations slide, water quality, temperature, snowpack, feeds into this oasis model. It figures out how to move water between the systems, so they can minimize turbidity and meet water supply needs and then it spits it all out on the back end, and you have this guy running the models basically daily. This is the implementation part. You come up with the rules and you need to be able to implement the rules. Then if we need to, we flush out more detail about how you would actually operate in a drought. We bring the stakeholders together, because a lot of times it's sort of anecdotal and we go through a virtual drought.

We'll do a tournament, we'll do an exercise. We'll go through a virtual drought based on historic hydrology and we'll ask them, "What are the system constraints you actually face and when are your operating preferences, and what's your risk tolerance?" We will flush out that draft plan and they will have a plan that works. I know it because the clients keep coming back and say, you know the uncertainty is much diminished. From what I understand, the fish are happy as well.

Success stories just briefly. Susquehanna River and Brian Richter, at the time with the Nature Conservancy, orchestrated this. He wanted to restore stream flows in the river to more natural levels. He had to make the case to the water supplier, which was rightfully concerned about any tampering of the minimum released policies could impact the water supply reliability.

So what we did is we developed a probability based route protocol, with the triggers that allow for improved environmental flows in most years, because the forecasts are saying this year is actually not going to be that bad, but in the worst years we're taking action early, being proactive and bringing the system to a soft landing, and not compromising the water supply reliability. Just in terms of how that was done, environmental flow studies are often very expensive. We actually settled upon a percent of inflow approach. It's sort of a way to move it along, and the idea there is you're still maintaining natural flow regime variability, you're just cutting back that percent as the drought incentive.

Smith Mountain, massive pump storage project in Virginia, and we asked the stakeholders earlier on what the problem was. This was a relicensing project and it was basically the hydropower from AEP was cutting back on the releases downstream in one shot. It was a draconian cutback. They waited too long, storage levels got down and they would cut back way too much. Then they would go to the state and ask for more cutbacks and no one was happy. So we said, "What about throwing in the idea of forecast, like weather forecast. If there's a high chance of rain, you bring the umbrella. If there's not, you leave it behind.", and they said, "That would be great. We want to be proactive."

So we developed some probability-based triggers for low flow protocol implementation. It's the only one in the nation embedded in a FERC license, and that approach was balancing needs. How do we show that? We showed the number of times as a probability distribution that recreation would be impacted and here's the percent of time downstream users would be impacted, and we just came to like in 20 percent of the time, something fairly simple and, and presentable.

Then Connecticut, there's one or two people in this, with the state agency. They've come up with instream flow standards. These are biologically driven and the first cut of those standards was that the field of the utilities would have been impacted by 50 percent and we concluded that because we had built models of some of the systems in Connecticut. So that informed their second iteration of the instream flow standards and now they're more aggressive. There is some loss of reliability, but we could well design triggers, everyone gets what they need.

That's what I've got. I'm done talking, thank-you