Combined Sewer Overflow Control Technologies, Part 2
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Jim Collins: Good afternoon, and welcome to today's webcast, "Combined Sewer Overflow Technologies, Part 2." This webcast is sponsored by EPA's Office of Wastewater Management. My name is Jim Collins. I'm with Tetra Tech, and I will be moderating today's session. Thanks for joining us.

This webcast continues the discussion begun in the previous CSO webcast and will focus on some of the more advanced technology options available to CSO communities. Case studies on high-rate treatment and considerations for the design of disinfection technologies related to meeting TMDL wasteload allocations will also be presented. Please note that the CSO Technologies Part 1 archived webcast and other archived CSO webcasts can be found online through EPA's NPDES Web page.

We will get started in a few moments, but while we wait for others to join I would like to cover a few housekeeping items.

The materials in the webcast have been reviewed by EPA for technical accuracy. However, the views of speakers and the speakers' organizations are their own and do not necessarily reflect those of EPA. Mention of any commercial enterprise, product or publication does not mean that EPA endorses them. We have posted speakers' contact information in case you would like to contact them directly following the webcast.

There is also a list of relevant CSO resources available by pressing the resources button on your screen. You will need Adobe Acrobat Reader to review these materials. You can also access archives of the two previous, or three previous CSO webcasts for more information on the CSO policy and long-term control plans as well as the Part 1 technology webcast.

For those of you new to EPA's NPDES webcasts, I'd like to briefly summarize some of the webcast features. First, if you have any technical difficulties, you can call 1-800-833-2812, or simply click the Help button to receive technical support from ON24. You may also use the Ask a Question area to post any technical issues that you are experiencing. Please include a telephone number where you can be reached and we will try to help you troubleshoot your problem.

There will be several question-and-answer breaks during this webcast. To ask a question, simply type your question in the text box located in the lower left-hand corner of your screen, then click on the Submit Question button. You do not need to wait until the question-and-answer period to submit your question. In fact, we encourage you to submit it early.

We will try to answer as many questions as possible, but due to the number of participants all questions may not be answered. However, today's speakers' contact information has been provided on the screen should you have questions following the webcast.

There will also be several occasions when our presenters will ask you questions, and the presenter will post a question in the slide window. Please submit your answers in that same slide window, not in the Ask a Question box.

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At the end of the webcast, you will be asked to complete an evaluation survey. This survey will appear in a popup window, so please turn off your popup blocker at this time.

As mentioned, this webcast will be archived indefinitely so that it may be accessed after today's live presentation. The archived webcast will be posted within several weeks on this same website.

Finally, please don't forget to download a certificate of participation in today's webcast by clicking on the Certificate button to print the certificate after the webcast. It will not be mailed to you. If there are multiple people in the room with you, you can click on the link to customize your certificate and print a copy for everyone in attendance.

We are now ready to begin today's session. Speakers are Carol Hufnagel, of Tetra Tech, and Mark Boner, of Wet-Weather Engineering & Technology Company. Mohammed Billah, of the U.S. EPA, is also present and available for questions.

Mohammed is an environmental engineer, and his responsibilities include coordinating CSO and SSO issues. Previously, Mohammed worked with the New York State Department of Environmental Conservation as an environmental engineer and with the state of Maryland Department of the Environment as a public health engineer.

Carol Hufnagel is a professional engineer with 24 years of technical and regulatory experience. As a wet weather specialist, she serves as Tetra Tech's national practice leader for CSOs. Her wet weather project experience has focused on the areas of flow metering, hydraulic modeling, alternatives evaluation, long-term control plan development and CSO program planning and implementation. This includes conceptual design, hydraulic design and post-construction performance and operational evaluation. Carol has been involved in rehabilitation, sewer separation and wet weather facility projects and has participated in wet weather studies.

Mark Boner is an environmental engineer with 35 years of professional experience in the water and wastewater industry, with an emphasis on planning, design, construction and operation of wet weather treatment systems. He has served as a principal investigator of demonstration projects focusing on various physical separation and disinfection technologies. Mark's experience includes CSO and stormwater best management practice operations, performance testing, in-stream monitoring and modeling to demonstrate compliance with CSO regulations, TMDLs and water quality standards.

And Mark is going to begin.

Mark Boner: Thanks, Jim.

This is the agenda for today. We're going to talk about a number of case studies for CSO treatment.

Atlanta is the first one, and it involves screening, tunnel storage, screening after tunnel storage, degritting, settling, filtration and chemical disinfection. It is an off-line treatment system near the wastewater treatment facilities in Atlanta, but they do discharge separately. There is no blending.

The Toledo system involves screening, degritting, ballasted flocculation and chemical disinfection. It is at the treatment plant, and it discharges in a blended fashion to the river.

Columbus, Georgia, CSO facility involves screening, vortex separation, filtration and chemical and UV disinfection. There is another project in Columbus that's a stormwater treatment system. It involves flow control, screening, filtration and UV disinfection. It was implemented to meet TMDL requirements -- very similar to a CSO facility, and we'll talk something about it.

And then there's a couple of multiuse technologies, looking at innovative ways to try to treat both dry and wet weather treatment systems, maybe expanding the biological treatment as well as treating peak wet weather high-rate treatment

And then in the end we will talk about the disinfection, how designers look at disinfection and come up with design considerations, and then how you take that data and show compliance with water quality standards, like TMDL requirements.

The Atlanta system, Atlanta is located in a -- on a ridge line, the old city of Atlanta, represented by the shaded area in the middle. Half of the, or two-thirds of the combined sewer overflows flow to the Chattahoochee River, which goes to the Gulf of Mexico. The other third of the combined sewer system flows to the headwaters of the South River, which goes to the Atlantic Ocean.

Now, in the mid-'80s, Atlanta designed and built and implemented a tunnel system and treatment facility for the South River combined sewer overflows, because this part of the watershed had a very polluted stream and downstream Lake Jackson was eutrophicated. In the early '90s, Atlanta furthered their CSO program by building screening and disinfection facilities on the West Side CSOs, to the Chattahoochee River. And then in this decade, in the 2000 period, they've been in the past five years implementing further controls to add more tunnel system and upgrade the treatment facilities for their CSO treatment system.

The tunnels on the West Side facility include about eight miles of 26-foot diameter tunnel and a treatment facility that has a treatment capacity of about 85 MGD. That facility is currently being constructed. It is to be on line by November of this year. On the East Side, that facility has been actually operating for one year now, and the tunnel was increased by about 10 million gallons over the existing 35 million gallons of storage.

This is a picture of one of the tunnel systems on the East Side. It is a cavern. It's quite large, as you can see by the two people inside the cavern. It actually was built to add an additional 10 million gallons to the system. The cost of that facility is about $38 million.

The Atlanta controls include the screening, and then after a course in fine screening the CSO flows are dropped into the tunnel. As the tunnel starts to fill up, the pumps at the downstream end of the tunnel pump the flow to a physical chemical treatment system, and that tunnel, as it's dewatered -- it's required to be dewatered in a two-day period. For those flows that exceed the tunnel capacity, which are maybe four times a year on average, would go to the stream, and those flows also receive residual treatment. That residual treatment is for disinfection, where sodium hypochlorite is added, and a little bit downstream sodium bisulfite is added to dechlorinate those residual flows.

The treatment system includes after the tunnel is pumped it goes through another set of drum screens. It goes through vortex separators. The sodium hypochlorite for disinfection of the tunnel flows is added before a two-stage sedimentation process. After the two-stage sedimentation we have compressed media filtration, and then sodium bisulfite is added before it is discharged to the river. The screening from the coarse and drum screens are hauled off to the landfill.

This is a graphic of a typical screening facility before the tunnel. Each facility includes chemical disinfection storage areas for sodium hypochlorite, the pumping systems for that sodium hypochlorite and sodium bisulfite to dechlorinate further downstream. The coarse screen and the drum screens take out the solid in the flow stream, and they're dumped on the floor, and the material is removed from that area into dumpsters.

This is a picture of an event from one of the larger facilities. This is what's called Clear Creek. It's about a 3,000-acre combined sewer system area. After about a one-month period of no rain they had a big rainfall, and you can see the kind of materials that are removed from the climber type bar screens and the drum screens. They dump this material on the floor. Then they will take a Bobcat and actually scoop up this material and transfer it into big dumpsters, and those dumpsters are then taken to the landfill.

At one of these screening facilities the city has added what's called bending weirs. They are those metal things between the columns of the concrete there. They are installing these at this particular photograph. But they keep the water level up so that they maximize the flow into the -- through the screening systems and into the tunnel. The area upstream of the bending weirs is a pretty flat area, and it actually settles out a lot of material. This is purposely done so that the city can scoop up the grit materials before they go into the tunnel.

What the city has found from their tunnels in the mid-'80s that they built was that after about 20 years the tunnels were close to half full of grit material. They spent quite a bit of money a few years back scooping that material out. They tried different ways of doing it. This is put in to keep those materials from getting down into the tunnel.

This is one of the treatment facilities, the 85-MGD facility. It is not online yet. Both of these -- both of the treatment facilities, one on the East Side and the West Side, are about the same. They

include drum screenings, again, from the tunnel flow that -- the flow that's pumped out of the tunnel. Up in the upper right-hand corner you can see where the pump station is located down the tunnel shaft. It is pumped through a drum screen, and it goes through vortex separators to get out grit. And then it goes down to the sedimentation basins, where the sodium hypochlorite is added to the flow before sedimentation. After sedimentation it goes through compressed media filtration, and then it receives sodium bisulfite for dechlorination. Then it's discharged into the river.

There is also -- in the upper left-hand corner you can see an overflow from the tunnel. So once the tunnel is full they could actually then discharge out of the tunnel system for rates above the CSO treatment capacity. So there's a couple of places the flow can actually be discharged from the tunnel system.

These are -- this is a photograph of the sedimentation basins, a photograph of the compressed media filter system and a picture of the hose pumps, in this case, for dosing sodium hypochlorite into the flows. They actually have variable-feed drives that will control the dosing of this chemical.

The performance requirements for the city of Atlanta CSOs is to provide monthly reports of CSO events, where they've sampled influent and effluent, and they report the bacteria level. In Georgia it's fecal coliform bacteria, TSS, ammonia and phosphorus, and they have a TRC -- total residual chlorine -- level they have to measure. And there's a limit for fecal coliform and total residual chlorine. So far, at the facility on the East Side that has been operating for one year, there are no violations of these limits.

Atlanta also has to provide an annual report of events, with the TSS and BOD removals, where they have measured influent and effluent, and the requirements are they have to remove 60 percent of the TSS on an annual basis and 25 percent of the BOD on an annual basis. This report is in progress. They haven't had the first annual report yet for their CSOs.

There is a one-time post-construction study where they look at metals and they sample those metals and do biomonitoring to evaluate the initial findings before they built these facilities to confirm that there are no metal limits required. Right now there are no metal limits, but -- and if this study shows that that is -- confirms the original study, then it'll stay that way. And they use in the state of Georgia no reasonable potential determination to make that assessment.

There is also a one-time permit cycle priority pollutant scanning requirement that has been complete for the facilities on the East Side. That's every permitting cycle they do that.

The cost for the Atlanta CSO facilities, they have sewer separation, which is about 27 percent of that system that I showed on that first graph was separated. It had a cost of about $285 million. The tunnel systems on both sides, the upgrade in the 2000s cost $287 million. The treatment facilities, the two treatment facilities, totaled at $94 million. So you can look at that chart and see that per-acre cost, the sewer separation is the most expensive, which it typically is, at about $78,000 per acre. The tunnel system, at about $21,000 per acre, or you might look at it in terms

of $1.53 per gallon of storage capacity. The treatment system is typically the least costly, at about $7,000 per acre, and it is $0.90 per gallon of treatment capacity.

Carol Hufnagel: We're going to shift to the city of Toledo and look at the wet weather treatment system that the city installed at their wastewater treatment plant as part of their wet weather consent decree improvements. Toledo has a combined and separated sewer tributary area that serves approximately 300,000 people, and they entered a consent decree with EPA in 2002 which included requirements for wet weather treatment facilities at the wastewater treatment plant and development of a long-term control plan.

The Bay View Wastewater Treatment Plant, which is a single treatment plan that serves the city, has a variety of flow conditions that it was able to manage prior to the implementation of the consent decree. And the dry weather flow at the treatment plant is about 45 MGD, annual average flow of 70. And then the secondary treatment capacity has a firm capacity of 195 MGD, so quite a bit of peaking capacity.

But the collection system in Toledo is able to convey large amounts of flow to the wastewater treatment plant -- up to 400 MGD -- with the existing interceptor system. So at times the existing treatment system was overloaded. As part of the consent decree requirements, the city has implemented equalization at the wastewater treatment plant and a wet weather treatment system, using a ballasted flocculation process.

This figure shows the new facilities that were added as part of the consent decree. The facilities shown in red are the new facilities, and they basically included improvements to influent pumping station, this Bay View pumping station on the left side of the screen, and then prior to the wet weather treatment train there was addition of screening and grit removal for those flows to pretreat prior to ballasted flocculation.

Flows then enter high-rate clarification, which is in the center top of the screen, and as flows pass through high-rate clarification, they are initially sent to the equalization basin unless until such time as the equalization basin is full, and then those flows leave the plant through a chlorine contact facility and re-aeration. Some of the flow from the high-rate clarification actually enters the secondary process, the aeration basin, because there is more capacity in the secondary treatment than in the primary treatment at this plant.

As the city was evaluating the use of high-rate treatment, there was a question of what technology to use for the ballasted flocculation. And the various evaluation factors that were looked at included those shown on the screen. The discharge requirements clearly needed to be met, and a side-by-side pretreatment study was done, or a pilot study was done, of Actiflo and DensaDeg technologies. The city used those as chemical usage that is unique to their flow stream, as is true at most treatment plants. And the chemical dosage was evaluated as part of the planning for the facility.

Pretreatment needs that were required for the two different types of processes included pumping, fine screening and grit removal, and those had some differences between the two technologies.

Startup and shutdown requirements and solids handling were also important for the selection of technology.

Actiflo design considerations that were looked at as part of the planning study included the amount of screening that would be required ahead of the process, and in the case of Actiflo fine screening was required with less than quarter-inch openings. Grit removal was required. The sludge characteristics from Actiflo are relatively thin, and the volume of flow that needs to be recirculated is about 2 to 3 percent of the influent flow. Actiflo also uses an engineered media for ballast, and that requires that to be maintained during the use of this type of technology.

DensaDeg also requires screening, but half-inch screening opening as opposed to the quarter-inch for the Actiflo. It produces a concentrated sludge, 3 to 4 percent solids, which has less solids handling requirement than was anticipated with the Actiflo. The slower startup of DensaDeg takes longer to come online and get up to a level of performance that has effective solids removal, and that was not as much of an issue in the city of Toledo because the process is followed by either flow going into the secondary process of the plant or by going into the equalization. So that was not a critical issue in the case of Toledo.

There is somewhat less consistent performance due to the variability of the ballast media, but, again, in the case of Toledo, with the subsequent equalization or secondary treatment, that was not as much of a concern.

The city did select DensaDeg, and, as was mentioned at the beginning of this webcast, we're not here to promote any particular technology. I think the take-home message is that each case needs to be looked at individually to see how these considerations impact the particular site. But in the case of Toledo, DensaDeg process was selected. And this aerial photo of the plant sort of lays out the wet weather treatment train process. On the right side of the screen is the existing plant, with the clarifiers and existing treatment process, and on the left side is the wet weather treatment train. The DensaDeg unit, with a capacity of 232 MGD, is one of the larger ones that I know of in the country for this type of treatment process. The equalization basin as shown has a capacity of 25 million gallons. And then there are the additional facilities associated with grit removal and the effluent channel for re-aeration and chlorination.

Close-up of the high-rate treatment facilities and the equalization basis is shown here.

And then a photo of the DensaDeg unit high-rate treatment. So you can see the scale of the facility, there's a couple people standing in the foreground of the facility on the top surface. And this, again, is a 232-MGD facility.

Of course, with these facilities there is a substantial amount of equipment that's required to support the treatment process in terms of pipe gallery and sludge pumps are shown here.

This is a section of the -- what the DensaDeg unit looks like. As is similar to these processes, it's an enhanced settling process to remove the solids and associated pollutants, and with the effluent going on to other treatment plant processes.

The facility has been online for about a year and a half now and is in the process of a two-year performance testing study. Results that I'll have today are only available for about the first six months of the evaluation. But in these effluent TSS was a range of 7 to 38 mg/L, with an average of 25 mg/L, so pretty nice results with the TSS discharge. About 80 percent of the TSS was removed in the ballasted flocculation system.

And then the effluent CBOD had a range there, with an average of about 52 mg/L, and overall removal of about 55 percent. This was done including both dry and wet weather conditions during performance testing.

This is a little bit more detail about the performance testing of the first six months of the two-year study. The amount of flow that's gone through the ballasted floc has in this time period peaked up to 165 MGD, with 133 of that continuing on through the wet weather treatment train and the rest being diverted into the secondary portion of the plant.

And just graphically showing the removals of pollutants for during these wet weather events. BOD removal around 65 percent, solids removal around 85 percent and phosphorus removal around 80 percent.

So the performance effectiveness study is a two-year ongoing study that is being performed. It is going to be added to with an additional study to evaluate effectiveness and removal of other constituents of concern and wet weather discharges, including viruses and pathogens. And the exact scope of this study is currently being worked on between the city and EPA.

The facility continually undergoes an optimization process for chemical dosage, for enhancing of coagulation and settling, but it has been tested up to 390 MGD, which is essentially the maximum capacity of the influent to the plant.

The cost of construction for this facility, which was primarily constructed between 2006 and 2007, was $67 million, and that included not only the ballasted flocculation facility but also the ancillary facilities that were required for the project, including screening and pump station modifications, grit removal in the effluent channel and chemical storage and feed -- a total of $67 million for the project, which effectively works out to about $0.29 per gallon per day.

On the O&M side, costs were estimated for operating the facility based on the initial startup conditions, and they estimated -- and this example here is based on if 1,000 million gallons were treated per year. If you look at the line items in some detail you'll see that there are some of these items which are fixed cost and others which are variable cost. But based on an estimated 1,000 million gallons per year running through this system, the estimate for O&M was $89 per million gallons, or about $89,000 per year.

Mohammed Billah: Carol, I have a question for you.

Carol Hufnagel: Yes.

Mohammed Billah: The cost, do you think it's in the high end or the low end? For the O&M, especially, it looks like $89 per million gallons. Do you think that is the high-end cost or the low-end, or reasonable?

Carol Hufnagel: I think it's probably pretty reasonable. I think as the two-year performance study is completed, the city is collecting data on the actual costs that are being observed, and these numbers will be refined as they complete that study. This was an estimate based on early operation and preoperation. But it was pretty well thought out.

Mohammed Billah: That means the cost may go down.

Carol Hufnagel: May go down or may go up. It's hard to say.

Mohammed Billah: Okay. Thanks a lot. Thanks a lot, Carol.

Jim Collins: Okay. It is now time for the first of the poll questions, the interactive portion of the program, and we'd like to know from each of you whether you represent either a small combined sewer overflow community, a large CSO community, if you're a state, federal or local government employee, if you're a consulting firm or a member of the consulting community, if you're an industrial facility or if you're other. So if you can fill in this questionnaire and submit your answers, we'll have the results for you shortly.

We do have -- while we're waiting, we do have several questions, and I'm going to go ahead and start with the first one. I believe it would be probably directed to Mark, since Mark talked about tunnels. And that question is, what is the possibility of leakage from the tunnel itself to the ground, therefore adversely affecting groundwater?

Mark Boner: Well, in Atlanta, they're fortunate to have a good, solid bedrock of granite, and the tunnel is 200, 300 feet deep. And the only groundwater in that part of the country is really through the fissures in the rock itself, so groundwater contamination is not a problem in that tunnel system.

Mohammed Billah: Mark, I just want to tweak the question a little bit. When you are designing a deep tunnel, are you considering the leakage of the water when you are designing the tunnel itself? Do you need to consider the leakage of the tunnel itself?

Mark Boner: In Atlanta, it's very little, and, no, I don't think they considered the design of the volume for capture in that tunnel. Actually, they designed that tunnel to capture a certain amount of overflow. It was 187 million gallons. And they start pumping out right away. They were able to cut out about $125 million in tunnel costs by pumping out almost as soon as the water is coming into the tunnel. So they actually reduced the tunnel size somewhat. But they didn't consider any leakage from the tunnel in the calculation of that required volume.

Mohammed Billah: So my question is, like as a good engineering practice don't you think it would be wise to consider any kind of leakage from the tunnel?

Mark Boner: Well, you really don't want to have leakage from the tunnel --

Mohammed Billah: Yes.

Mark Boner: -- to go into the groundwater. So, I mean, in that you would --

Mohammed Billah: That was the answer that I was expecting from you, that you need to make sure that you are not leaking to the groundwater when you're storing that dirty water inside the tunnel.

Mark Boner: -- correct.

Mohammed Billah: Thanks a lot.

Jim Collins: Okay. Another question about the Atlanta system is, how would the low rainfall during this past year in the Atlanta area affect the benchmark testing for that CSO tunnel system?

Mark Boner: This past year we did have -- since the first facility was put in we did have quite a bit of rain, and then it did dry up. So we've had rainfall above and then below the normal. In general, we're still in a huge drought. In terms of the benchmark testing, what is pumped to the treatment facility still can be measured. The performance of the treatment facility is the only thing that's been measured so far. The results from the treatment facility that discharge into the stream is the additional (inaudible) that is ongoing to determine whether there is a -- what the water effects ratio is on aquatic biology for the metal of blank sink. But that is still underway. But it has not really affected the performance requirements that the city has to submit to the regulators.

Mohammed Billah: Mark, I have a quick question for you. It's regarding the Atlanta CSO control tunnel, estuaries and treatment system. But you said they have like four CSO per year. The question is, did they consider the presumption approach when they developed that LTCP or tunnel system for the CSO control?

Mark Boner: Atlanta has a long history in their CSO program. They started in the mid-'80s, and then in the early '90s they put in what they thought was required to meet the water quality standards in a receiving stream. They were under consent order through the federal courts to put in more. They had pretty much dictated, made them go to tunnels and treatment systems. But the four overflows per year is the presumptive approach-type thing. That is not a permit requirement, but on average they should have no more than four overflows per year that don't get into the tunnel. Even those four overflows are treated for bacteria. They're disinfected and dechlorinated. So it's a very dilute waste when you get to that level, and it is still treated. So they're pretty much treating everything in Atlanta.

Mohammed Billah: If I understand you correctly, that Atlanta is demonstrating if they can achieve the maximum flow overflow they can achieve the water quality standard in the receiving water.

Mark Boner: No, that is not a requirement. That was just a general requirement to design the system, but that is not part of the permit requirement. They are basically treating all of the flow. They're even disinfecting those residual overflows, those four overflows per year that don't get into the tunnel and treatment system. They're still treating that.

Atlanta has a bigger problem in that the capacity of the river -- Atlanta is at the top of a watershed, and the capacity of the river to assimilate all the waste, including the wastewater treatment plant discharges, is used up, and 80 percent of the load now of the capacity of that river system is taken up by sediment oxygen demands that come from stormwater runoff. So what Atlanta is doing in their tunnel system to capture all these flows is good for the river system itself. Stormwater is being considered and in the future in Atlanta will be a big thing to take care of to have the capacity of the river to assimilate wastewaters.

Mohammed Billah: Thank you, Mark, for clarification.

Jim?

Jim Collins: Thanks, Mohammed.

Well, we have the results from our poll, and we have about 15 percent CSO communities -- 9 percent smalls and about 6.5 percent large; we have almost 44 percent are government, whether state, federal or local; and then another 30 percent are consulting firms or individual consultants; and then probably only maybe one person from industry, 1.9 percent; and then other represents about 8 percent. So those are those results.

We do have time for some more questions. And I have received a couple questions on the Toledo system, so those will be for Carol. And that would be, well, specifically on some of the data that you presented there, Carol, the operation and maintenance costs on that last slide looked very low to this person, and they noticed that there was no power cost included.

And let me go ahead and roll another question into this and you can try to answer them in turn. Well, no, why don't you take that one on and then I'll go ahead?

Carol Hufnagel: Okay. That's a good catch on the power consumption. I haven't noticed that when I was looking through these slides before the presentation. But certainly that would add on to it, and I don't know what that number would be. I think that what you can do is take a look at some of what these costs are as a guide for what the costs associated with operating the facility would be, and consider other cost elements that would go into the mix.

One of the things with a facility of this type is that in this case it's located at the wastewater treatment plant, and being at the wastewater treatment plant, a lot of the labor can be shared with normal wastewater treatment plant operations, and the staff is already onsite. If you were going to try to use a facility of this type as a remote installation out in the system, you would have much more challenging labor conditions to manage it, particularly during wet weather. Those of us that have responded to wet weather events know it only rains in the middle of the night and on the weekend and never between eight and five Monday through Friday. So it's always a

challenge to operate these systems during those wet weather events. But they're correct. There is no power cost shown here.

Jim Collins: Okay. Another question about the Toledo presentation was that it appeared that the high-rate treatment system, or the high-rate treatment, went to the secondary system, and the question asked, wouldn't that starve the bacteria, the secondary treatment bacterial unit?

Carol Hufnagel: The managing of the biomass in the secondary process has been something that the city's been working with, and that is part of the optimization effort that they are going through. The primary point of discharge for the ballasted floc, as it starts up, and when it's in that mode of getting into smooth operation with good removals, it is -- the flow is directed to the secondary treatment process. And then during the course of the event there is an ongoing portion of the flow that goes to the secondary treatment process, while the rest of the flow is sent to wet weather equalization.

So the city needs to be careful as they manage their treatment plant to watch their secondary process and make sure that they're -- it's continuing to operate well, and they cannot sustain the maximum flow rate for an indefinite period of time. They can run their secondary over 200 MGD for a period of time, but then they have to start scaling it back just for that reason of maintaining the biomass in the secondary.

Jim Collins: Thanks. And one last question on Toledo, and I think you mentioned that fecal coliform was one of the limited permit -- in the permit, but the question is, are there other types of pathogens or virus evaluations going on with Toledo?

Carol Hufnagel: Yes, Toledo is finalizing some discussions with EPA regarding an additional study on the facility to evaluate its ability to remove such things as Giardia, Cryptosporidium and various viruses. It's more of a research-type study to help build the science there. So the exact scope of that study is currently being discussed, and there will be a work plan developed probably early next year to put more specifics to that study. But it's expected that that may take several years to complete just because of the number of wet weather events that are observed, the number of times per year when the entire system is full and needs to discharge.

There is also a WERF study that's underway currently that's looking at viruses, pathogens and so forth during blending events at wastewater treatment plants, and that's been going on for a couple of years now and will help advance the science on that.

Jim Collins: Thanks, Carol.

Well, I think it's time to move on, and I believe, Mark, you'll be picking up.

Mark Boner: I'm going to talk about the Columbus, Georgia CSO system right now. Columbus initiated their program due to a state requirement that said all the cities -- there are five cities in Georgia that have CSOs -- to implement those by end of 1993, and then they extended that to end of 1995. Columbus, Georgia, took the demonstration approach. They have a river system that has an annual summer flow of about 3,500 CSS, and they saw the CSOs don't have any

pollutant problems other than the narrative parts of the wastewater permits, which is sewage debris and fecal coliform, or bacteria loading to the river itself, and so that's what they concentrated on in determining what was required.

This graphic kind of shows what they looked at. You have -- what they first did was to undo the hydraulic bottlenecks of getting the maximum amount of flow to the treatment plant and through the treatment plant, and then the excess CSO flows or excess wastewater flows -- wet weather flows went through a solid separation and disinfection system and then discharge to the river. In the initial stages they looked at what flow rate they need to treat, and they concluded that the 90 percent rainfall intensity was the knee of the curve design criteria, that we would basically treat 90 percent of all the rainfall hours, the runoff from all the rainfall hours, and those excess flows would go pretty much untreated into the river system.

And the demonstration would then be to show that these two discharges -- the treated flow, which would be most all of the rainfall events -- and then the untreated, or undisinfected flow into the river would in fact meet the bacteria standards. And I'm going to go through what they put in and then later on in this presentation, well, I'll show you how they concluded that they in fact do meet water quality standards, and they have demonstrated that there's no reasonable potential to cause or contribute to a bacteria standard exceedance.

This is one of the facilities. It's a -- there are two facilities that were implemented, one on the south end of town and one on the north end of town. This is the north end facility. It's kind of right down in the downtown area. There are facilities or buildings all around this facility. This is actually a two-block city park, and underneath the park is the CSO treatment system. It's called the Uptown Water Resources Facility.

Underground there's what you see in this graphic. There are screening, coarse screening, of the wet weather flows. The red pipe you see, or the red line, takes the -- used to take the wet weather flow out to the river. Now it's diverted to these treatment facilities. There's an inflatable dam at the point in between the two bar screens at the initial part of that graphic that would fail safe going down, so that any excess flows to prevent any upstream flooding would allow that to happen.

But the CSO flows are diverted to the treatment systems, which include vortex separation, compressed media filtration and disinfection, both chemical and UV disinfection. This facility received a $20 million federal grant to test different kinds of technologies, including different kind of disinfectants, chlorine with dechlorination as sodium hypochlorite, sodium bisulfite dechlorination, chlorine dioxide, peracetic acid, and bromine as BCDMH. So we've looked at a lot of different ways to disinfect the flow. And it included vortex separators, dissolved air flotation, chemical precipitation and compressed media filter. And then of course UV disinfection. If we remove a lot of the pollutants we ought to be able to get the light to the water to disinfect the bacteria.

The hydraulic profile of the high-quality side is shown in this treatment schematic. I should note that when the flow first occurs and goes into this facility, all those vessels are first filled up, before any discharge occurs. And they're just filling up those vessels takes out about 600,000

gallons for this 1,000-acre drainage area, and it prevents about 20 overflows that used to occur. So right away we've knocked overflows from about 60 down to 40.

And then after those vessels are full, the high-quality side treatment starts to take place. And that includes, of course, the screening upfront, the vortex separation, the compressed media filter and then UV disinfection. That flow, we found through testing of this facility for five years that that part of the facility will take about 15 MGD. The total plant is permitted for 48 MGD.

And then after the high-rate treatment system occurs, the other vortexes open back up and chemical disinfection occurs to treat the total waste stream. So there's actually two discharge points going into that outflow pipe. One is the UV-disinfected effluent and one is the chemical-disinfected effluent. Both of them typically have fecal coliform levels in the less than 100 fecal coliform counts per 100 ml.

I'm going to go through a series of photographs and talk about the operation. This is on the upper left-hand photograph you see a -- this is a diversion structure. There were 16 overflows in Columbus that were reduced down to two treatment facilities. And so most of these structures, these old outfalls, have a structure like this, where the dry weather flow goes -- comes down and goes through vortex valves, and these are rather large ones. They're about 60-inch diameter.

And so the dry weather flow goes through the vortex valve. When it rains, that vortex valve will start to limit the flow as the flow rate comes up and cause the water to back up. As the water backs up it goes over a weir -- under a baffle and over a weir. That baffle wall is shown by that guy's yellow hat, above his hat there. And there is also a vortex valve on the -- at the upper surface level that skims the solids off the surface as that water is backed up and going -- it's caught in that chamber there.

The photograph on the lower right is the inflatable dam that I mentioned a little while ago. It is the fail safe device. It's not somebody stuck up on the pipe, as it looks from the back end, but it is actually a rubber dam that's held with compressed air at about 4 psi, and that if the upstream -- the level upstream of the screen starts to get near the ground level, that inflatable dam will deflate. It goes completely flat on both sides, and excess flow would go through that system.

This is the bar screens from that facility. They are climber-type bar screens. They are one and a half inch opening, to take out mainly the trash -- the plastics and the sticks and rags and things like that. The dumpster shows the typical event, where that's the kind of material that's removed from this facility. Those dumpsters are rolled out the next day after an event, and the solid waste management people pick it up and take it to the landfill the next day. It's a real simple facility. It's easy to maintain.

The upstream of that bar screen includes a crane above it and a big opening, because what happens so often is you get materials in a combined sewer system that can cause all kinds of problems. When this facility first started we had tree trunks that actually came down the system. They caused the bar screen to torque out. And that became, then, a sediment pit, and it had to be dug out to get it back into operation.

What we've found in the years of operating this facility is that when it rains or you know it's going to rain, your rainfall monitoring equipment says, "Hey, we have a probable event," then the bar screens turn on. And they're actually on before the flow comes to them. And they're running at a pretty high rate, so that when the screenings get to it, it's removing them right away. Screenings and grit are flush related. That means they come in quickly. And after the high-intensity part of the runoff you get very dilute waste with very little screening.

This is an inside view of the vortex separator. Up in the upper left-hand corner is the -- this is a 32-foot diameter vortex unit. The flow comes in tangentially, and it sweeps around the vessel. It kind of flows down and back up into the center part and exits through the center, out a baffled kind of chamber. But the heavy solids are dropped out in this facility, the sand, anything, say, above 150-micron particle. It also removes 90 percent all the oil and grease.

You can go in the influent channel, the delivery channels to these vortex separators, and you'll see oil and grease caked on the walls, and you'll see sand and sediment in those channels that get flushed out like waves of sand coming into the system. But if you go into the effluent from these vortex separators in those underground channels, they're clean as a whistle. There's nothing on the walls. There's no sand or sediment that drops out.

These facilities in Columbus have a flow meter and a pinch valve that regulates the flow to the vortex separator, and that flow meter and that pinch valve is what causes the controls to let the vessels fill up and then go online and restrict the flow to those units. And that flow information is sent to our chemical metering pumps that meter in the chlorine and the dechlorination parts of the treatment process.

This is -- the underflow from the vortexes are pumped, and they're pumped to another vortex grid separation device, and this is where all the maintenance is. We have feed those pumps. They're hardened impellers. And they take -- they're very rugged, but they take all of the abuse. And this is where most of the maintenance of this facility is. And that's probably true for all these kinds of facilities. You get sand. It wears down these types of pumps, and they have to be removed and wear rings replaced and retrofitted on a pretty regular basis.

But for every pound of TSS we've measured going into the vortex system, we've removed about a pound and a half of sand and gravel. So that tells you when you're measuring for TSS you don't really measure everything that's going into a treatment system.

This picture shows the compressed media filter. It was a Japanese technology used for -- as a tertiary filter. It actually has two perforated plates. One plate moves. The other one is fixed. And there's one-inch fiber balls that are compressed, and then you filter through those balls. What we found was that very good removals in this facility, but we couldn't really compress it much because we're dealing with real dirty water, and the water would mat up on the surface real quick. So we basically uncompressed it and filtered through the media and we got much more depth of the particles into the media bed. It took about 15 minutes to backwash the filter, but used quite a bit of water in backwashing this filter system. But the removals were very good, very high hydraulic loading rate, at about 15 to 20 gallons per minute per square foot.

This photograph shows the sodium hypochlorite system. There are tanks, and it was in a containment area in case they break. But there's a metering pump that would -- in the case in Columbus, different from Atlanta, they are metering pumps that have variable-speed drives on both the speed and stroke. We have a control algorithm that I'll talk about later on how the chemicals fit into the changes throughout a CSO event. And those -- but they essentially pump in the chlorine into the vortex vessel influent, and then the sodium bisulfite, which also runs on an algorithm, is pumped in at the effluent of the vortex to take out the chlorine that -- any residual chlorine that was used up. I might ought to note that in Columbus we're treating or disinfecting the flow, the chemical side of the flow, before any solids are removed.

This is the medium pressure UV disinfection system. It is treating or disinfecting the flow after the filtration in the compressed media filters we're knocking down the solids. We're getting 70 percent removal after an initial 35 percent removal in the vortex separators. So we're up at about the 80, 80-plus percent removal. And the UV disinfection was found to be able to disinfect those flows quite well. The transmissivity after filtration was in the 30 percent, low 30 percent range. And what we found was that we would have to run the contact over the bulbs at about two seconds contact in order to achieve the disinfection. Hydraulically, the facilities -- the filter and UV were designed for about 24 MGD. Ultimately we rated that facility at about 15 MGD, mainly to achieve the disinfection using a two-second contact time.

In terms of Columbus CSO performance, there are monthly reports of events that are required by their NPDES permit, where they measure influent and effluent bacteria, TSS and phosphorus, but there are no limits. There are no effluent limits on these permits. Back in the late '90s we determined that and demonstrated that there's no reasonable potential for exceeding -- for the CSOs to exceed the water quality standards for bacteria, and therefore no permit limits were required.

Fecal coliform levels are always under 100, and many times in the UV system they're below 10 colonies per 100 mL. Average removal for TSS is about 80 percent range. The river sampling is required for every event that they monitor. The river sampling is upstream and downstream of the city, and a TMDL compliance analysis, like a mass budget, is conducted for that sampling, where you take the upstream sample plus the samples from the CSO facilities plus samples from the wastewater treatment plant discharges plus a calibrated model output from the tributaries, you add all those up and you compare it to the downstream measured values, and that's what is reported in Columbus.

Subsequent to implementing the program in Columbus there was a comprehensive multiyear watershed monitoring and modeling study, where just 6,000 sampling points were obtained in that study dealing with bacteria around the TMDL boundary for the CSOs itself to show that in fact they are in compliance with the water quality standards. The TMDL evaluation and implementation plan was also prepared to -- and used in the state's no reasonable potential analysis to support that no CSO effluent limit.

And then there is also as a part of their permitting cycle there's a one-time priority pollutant scan that's done. Initially it's done for all the overflow points, all 16, and then ultimately in subsequent permit cycles it was for the two treatment plant discharges.

In terms of the capital costs, the facilities in Columbus, they spent a total of about $95 million. That included -- there was some sewer separation. There was transport that combined the different CSOs into two major treatment systems, and the two treatment systems cost $43 million. The Uptown park includes lots of extra bells and whistles. If those were not put in it would have been at a cost of about $35 million. So in terms of cost per acre, much lower than Atlanta. In terms of sewer separation, I think Atlanta was in the $70,000 range, and Columbus is less than $60,000 per acre. Transport, $13,000 per acre. And the treatment without all the bells and whistles would have been down in the $13,000. Atlanta was like $9,000 per acre. But in terms of cost per gallon of treatment capacity, the system in Columbus is in about the $0.16 per gallon of treatment capacity, which is pretty good, pretty low compared to even the ones we were looking at in Toledo.

The operating costs, they actually have two people at each of those two plants in Columbus that operate these facilities. They do all of the maintenance, everything except for instrumentation work. They pretty much keep the grounds. They do all the maintenance on the equipment. They found that this is the best way to operate these facilities. They have four dedicated people that do this year-round.

They also, at each plant, one of them responds to a wet weather event. They will go down to the site. They're called on their cell phone at the facility, say, "Hey, we have a probable event." They go down to the facility just to monitor, make sure everything is working. It runs by itself, but they still do the logging of things, how the equipment is running, that kind of thing. And sometimes they have to go and implement the sampling, the upstream and downstream sampling. And then they get the samples that are picked up by the laboratory to do the performance analysis in their reporting. But in terms of O&M cost, if you put that on a present worth basis, it's about -- the O&M cost is about 6 percent of the capital cost, which is really a very low figure.

This is the Columbus facility. It is a stormwater treatment facility. It was implemented for a -- under a TMDL program. The Weracoba Creek is the creek outside of the combined sewer area, but it's the creek that was next developed, and this creek has been listed for impairments for bacteria and for aquatic biology. And this facility was actually just built this last year in '07. It started in '05 studying it and determining what could be put in to meet the requirements.

One of the main issues is right downstream of this facility is the city's premier park. It's got active and passive recreation. Right at the top end of the park is the children's playground, and they have access to the creek, and you'll see kids on a warm day going down into the creek. So one of the main reasons to do something here was to protect the public health and secondly to try to see what we can do to attenuate the stormwater runoff flows and improve aquatic biology.

This is the facility, a closer view of the facility. There is a structure that goes across the creek. It is a flow control structure. The dry weather flow on both sides of this structure is basically the same level. The flow control actually pushes the flow through the treatment plant. There are two -- there's a function during dry weather and there's also a function during wet weather. The dry weather function, because we had a dry weather bacteria problem, is to disinfect the dry weather flow. That dry weather flow actually goes to UV disinfection. And then when it rains the flow

control makes the level in upstream rise up, and it goes into the filter system and then back to the UV system before it's discharged.

This is a graphic representation. You can see better the flow structure across the creek. There are six 34-inch diameter opening pipes that go through that structure, and inside that structure there is a bladder that pretty much seals off that flow. One of these actually allows flow to go underneath the bladder. All these bladders are on a seat that seals the flow. There is water on top of the bladder that's contained in that structure, and it is to a level about the top of that, or near the -- six inches below the top of that weir.

In other words, if the rainfall occurs, the water level on the upstream side would have to get to be higher than the water inside on top of the bladder. That differential head then opens the bladder and lets the flow go by. But this kind of flow control allows a base flow to go through it, so fish can actually swim back and forth. But in this case right now in Columbus all the dry weather flow is being pushed through this facility and into the UV.

This is the insert that goes into that flow control structure. It's a metal insert, and the bladder is connected to it. Water is on the top of that bladder to seal the pipe underneath and restrict the flow that can go through it. It acts like an orifice, or it completely blocks that flow. So the dry weather flow is pushed through the coarse bar screens and then through a fine screen, and there's a float valve inside the fine screen that will close off the UV chamber once the wet weather occurs. The yellow piping actually houses the UV equipment. It's a medium-pressure UV system. And it exits the end of that -- the piping system. It goes back out into the creek. So the dry weather is pushed to the creek.

This picture shows a wet weather event, where the water level has increased and gone beyond the dry weather treatment capacity, is flowing through the filter now. The filter is under the grassed area. There's no grass there right now, but it has grass now. And then you can see it boiling out of the effluent, that white area that's coming out. That's after filtration UV disinfection. Not all of the flow is disinfected, though. But the flow control basically causes the three-foot -- about a three-foot differential head to push the flow through the system.

The flow path of wet weather are these two red lines. The first two MGD actually goes back through the UV system and out. When it goes above the two MGD, the filters will handle about 10 MGD, and it over -- it goes -- part of it goes through the UV disinfection and part of it goes through just the filter.

The filter itself in a dry weather state is uncompressed. It's similar to the compressed media filter that was used in the CSO facilities in Columbus, but in this case there's no mechanical device pushing the plate up and down. What we found was that in all the testing we did there was that we need that surface of the compressed media filter uncompressed. That way the big particles get removed on the top surface. As you go down through this filter you get smaller and smaller voids, and that's where the small particles get removed.

When the wet weather occurs, the flow starts to go into the filter system. The first thing it does, it enters the influent structure on the other side of these bladders, and the bladders actually

compress that media, causing that top to be uncompressed and the bottom to be compressed. This is a picture before the flow actually goes into the filter.

Then above that capacity the filtration system. The flow control bladders open up, and you can see in this picture that before it's starting to top over the wooden weir the flow is boiling out the back end of those flow control valves. It's actually those valves have opened up now and the flow is going through those valves. As the rainfall or runoff conditions get worse or get greater, the flow goes both under the -- through the flow control valve and over the weir itself. And it'll -- in Columbus we've had events that have topped that gabion wall you see to the right, and it's gone over the ground on the other end. But it pretty much acts like -- we had to do a HEC-RAS model to show that we have no rise or boundary chain in the 100-year flood elevation.

When the event is over, the next day -- these filters are not backwashed during the event, but they're backwashed after the event. The city comes in and hooks up the blower to each of those. There's three filter cells there. And the operator will just hook it up and turn on the blower, and in 30 minutes that filter is clean. And they remove trash from the upstream side of the flow control, which collects a lots of material. I mean, we get in the leaf season a tremendous amount of leaf load. But what we've found, which is so significant, is that we're getting about 7,000 pounds of sediments, and this is organic and sand and real fine sediments, that are trapped in this facility, that are removed on about a once every two-month basis.

This picture shows the cleaning of that upstream side. They actually bypass the creek, and they put in a loader, and they scoop out this material and they put it in trucks and take it to the landfill. So that's about a once every two month maintenance thing. And then the UV bulbs are checked on a regular basis to see when they need replacement.

The requirements for the BMP -- under an MS4 permit, the city has to do sampling. Under the TMDL requirements, it's to reduce bacteria loads to meet stream standards. Now, the state of Georgia has issued or has prepared TMDL plans for the Chattahoochee River and for all the tributaries to that river, and using very simple data, very limited data, they say, okay, the worst data point to correct it down to the criteria you need to remove, in this case, they say 85 percent of the annual bacteria load. In the analysis we did with this facility we got a lot more data, and we did modeling with that data and look at a frequency of excursion rate to determine are we meeting the requirements of the standard.

There's also a future TMDL. Right now the stream is listed for macro invertebrates, that there will be a future TMDL that will say improve aquatic biology to some level. And what has been so significant for this BMP is that with all the solids removal -- we're removing annually about 35 percent of the annual solids yield -- and that has improved the downstream fine sediments in the substrate of the stream, and right away the people doing the aquatic biology service observed that the substrates are much better, and in fact the macro invertebrate community was found to be in some places as high as 60 percent -- I'm sorry, 600 percent improvement in the numbers of the species of macro invertebrates, enough to change it from, say, a Class C stream to a low A or a high B stream.

And we're also measuring about 80 percent fecal coliform load reduction -- not the 85 percent that the state kind of said here's the TMDL requirement, but it's enough that we feel from the modeling, and I'll show you later when we talk about disinfection, that gets us from a geometric mean excursion below 10 percent criteria. That criteria is a part -- not a part of the standards right now, but it's a part of the impaired water listing protocol.

In terms of cost, the BMP was built for about $900,000. Annualized cost of that is about $76,000. The annual O&M of that BMP -- that includes the backwash of the filter, the cleaner, the sediment and the maintenance of the UV system -- is about $64,000 per year, for a total annual cost of about $140,000. And that equates to about $104 per acre, or about $0.34 per pound of TSS. That includes both capital and O&M costs on an annualized basis.

Jim Collins: Thank you, Mark.

That brings us to our second poll question, and now that we know who you are or where you work, we want to know how many of you there are. So if you are all alone, just fill in -- enter A. As you can see, two to five would be B, and so on. And then we'll get a good sense of total number of participants today and how it's distributed.

And we do have questions while we're waiting for the poll question. First question is, for the Columbus, Georgia, project, Mark, was ballast flocculation considered, and if not, why not, if you know?

Mark Boner: No, it wasn't. Columbus did their studies in 1990 and 1991, where they measured the contaminants. And they looked at -- because it appeared that only fecal coliform was a problem, and all the other contaminants didn't cause a water quality standard violation or an exceedance. They looked at different ways to disinfect. And they did pilot testing on different technologies. They built pilot facilities right on one of their CSOs and tested vortex separation. They tested air flotation, chemical disinfection with both sodium hypochlorite and chlorine dioxide, and they also looked at UV disinfection. These were all pilot tests before they entered into a program that said hey, this is where we're going to go.

So after that pilot testing program -- and Water Environment Research Foundation was also a partner in that effort -- they decided that this is the way to go, and then it turned out that they went with two facilities, and one of them became this national demonstration project, where they got some federal funds to look at some other things.

Jim Collins: Thanks. Another question, and that is, how would you add disinfection to an existing CSO facility on a small footprint that does not have disinfection and virtually no room for chlorination/dechlorination, perhaps due to industrial wastes -- oh, because due to industrial waste UV would not be effective?

Mark Boner: Well, in Columbus it's a good example. It's the satellite facility. There is very little room in that facility. What you find is when you're disinfecting these kind of wastewaters you're not practicing combined chlorine disinfection like you do at a wastewater plant. So you don't have to have the 15, 30-minute contact time. You're talking about three to five-minute contact

time. The thing you want to do is get it dispersed good into the flow stream. And you're likely going to -- as we'll show you later when we talk about disinfection, you're having high doses of the oxidant to satisfy the different demands, so that you can -- there are going to be immediate demands that will use up that oxidant quickly, and they have to have enough of it in there to kill the bacteria and pathogens.

So to try to answer the question, a small footprint, three to five-minute contact time is not that large. I don't know what the questioner's facility looks like, but you can disinfect flows without removal of the solids, but you're going to put in a lot more chlorine. And when you put in a lot more chlorine, of course, there's more issues dealing with disinfection byproducts, because you'll have more precursors in there, and you're going to put in higher doses, so you're going to create that many more disinfection byproducts. So those are things you've got to consider in doing this. In Columbus there is no downstream water intake, so it's not as big of an issue in terms of the disinfection of the raw CSOs, so to speak.

Mohammed Billah: Mark, I have a question regarding that disinfection. Is it putting like too much chlorine? Isn't that the issue of the dechlorination?

Mark Boner: That's correct. As we'll talk about later, you put in enough chlorine to take care of what could occur. You usually look at the outer envelope of the concentration of pollutants that can come in. So you're going to be over-chlorinating at times, so then you tend to over-dechlorinate in order to get the residual down to a level. The residual is the problem. It's going to be toxic at very low concentration.

Mohammed Billah: If I understand you correctly, that means when I have a small footprint that is my option is put more chlorine, before you discharge it do more dechlorination that you meet the limit of the residual chlorine. Am I right?

Mark Boner: That's correct.

Mohammed Billah: Thanks, Mark.

Carol Hufnagel: Yes, I wasn't sure if the question had to do with a small footprint for the facility, but the predominant means of disinfection at CSO facilities has been using sodium hypochlorite. So in order to make a sodium hypochlorite disinfection system work, you have to have tankage to store the chemical in and disinfection feed pumps, and then some sort of dispersion system, potentially a mixer system, to disperse that into the flow. So in a lot of cases that will involve a building for chemical storage and feed pumps that would be on top of or in addition to the facility. And those can be relatively small footprint, but they do take a little bit of room. I think in a number of places they may be constructed on top of the existing storage tankage. So they're not real big, but they do take up some space.

Mohammed Billah: Thanks, Carol.

Jim Collins: Well, I'm going to -- we do have a couple more questions, but I want to push out the results from this poll. And, as you can see, most of you are by yourselves -- I hope you're not

too lonely -- about 67 percent. And then 26 percent of you are in groups of two to five. And it looks like a few people even larger groups, six to 10. So thanks for providing that information.

And we do have time for a few more questions. Let's see. There's a question that I think I can answer partially, and that is, have any of the cities you've dealt with considered using low-impact development techniques to reduce cost for CSOs?

Well, one answer is yes, but the focus of this webcast will not be on this. We call this in the CSO world green CSO controls, including low-impact development and other nonstructural -- sometimes nonstructural-type practices for reducing the stormwater component of CSOs. There will be webcasts in the future that address this topic in particular.

Now, having said that, I'll throw it back over to Mark and Carol, if they want from their experience to mention anything about that with some of the communities that you may have worked at -- worked for.

Carol Hufnagel: Yes, I think obviously green solutions are something that have multiple benefits for communities, not only in terms of reducing the amount of runoff that's generated that can head toward a combined sewer system but also in terms of the aesthetic and social benefits of those programs. And in some communities it's been very effective to use green solutions to reduce the rate of discharge to the system and make that a way to help reduce overall volume. The green solutions have helped in particular with the small storm events and reducing the volumes that's generated from those, in particular if there are amenable soils for infiltration and that aren't too steeply sloped. So it's been a favorable solution in a lot of places for CSO control, and it's gaining more interest as time goes on.

I don't know, Mark, do you want to say anything?

Mohammed Billah: Jim and Carol, I really appreciate your opinion on this green infrastructure, or the low-impact design issue. Just to let you know, EPA is pretty much open with the green technology or the low-impact design of the CSO control. And me personally, I think green technology is part -- a low-impact design or green infrastructure is a part of the CSO control technology. So, as Jim said, that we'll have a future webcast on the green technology for CSO control itself. So it's nothing -- I do not separate green infrastructure or the low-impact design with the other CSO control technology. It's a part of the CSO control technology. So EPA is pretty much open for this green technology.

Jim Collins: Thanks.

Well, Mohammed, since you're in the mood to talk, we have a question for you, and that is, do you think that EPA Office of Water would be interested in reviewing and reporting on the operation and experience of the various CSO control technologies?

Mohammed Billah: If I read the question correct, it says reviewing and reporting on the operation and experience of the various CSO control technologies. The answer is, EPA does not market or prescribe any particular CSO control technology, because it's case sensitive, and you

need to develop -- permittee is responsible to develop his own CSO control based on the technology that is most feasible both financially and technologically, and then present it to the permitting authority for their approval.

So we do not prescribe any particular type of CSO control technology. But for sure we'll be happy to know and learn about the new technology that is available for the CSO control. That we do almost like almost like every month here at the headquarter, to listen to the people, what kind of new technologies are popping up outside, like in Europe, in Australia, in Asia, what new technologies are popping up, even in this country, for the CSO control. And we are pretty much open for that one.

And also the same, Jim, just to let you know that the EPA, we are indirectly developing a CSO control technology clearinghouse to put all those technology, those that are available, and we think those are good for the CSO control use, in one single place as a resource so that everybody can use. So EPA is always for new technology, always open to learn something new, but we do not prescribe any particular CSO control technology to be best or good for any CSO situation.

Jim Collins: Thanks, Mo.

One final question, then we'll move on, and that is, with sodium hypochlorite being used for wet weather facilities, are there problems with the shelf life of the chemical? And then, adding on to that, how does the storage for quantity and potency issues, how can that be handled for storage of the chemical?

Carol Hufnagel: Yes, we -- there is quite a number of facilities in Michigan that use sodium hypochlorite, and that's been one of the challenges has been having reliable concentration of chemical for the chemical feed systems. It loses potency over time. It's usually diluted upon delivery to a more stable amount of concentration. But nevertheless it will continue to lose potency if it's not used within a reasonable period of time. And if you have facilities that may not operate except for every six months or more, then you run the risk of losing quite a bit of the disinfection potential of the sodium hypochlorite.

There are systems that have been used to keep the chemical mixed so that it improves -- so that it does not stratify and lose -- and have variable potency throughout its depth. And then another issue is the ability to test the actual concentration of the stored chemical so that you know what you're dosing, because if you can keep tabs on what the potency of the chemical is, then you can potentially adjust your feed rates and your -- if you have a SCADA system, for example, that operates that disinfection feed system than you can up your application rate in order to account for some loss in potency.

Jim Collins: Okay. Well, we're going to move on. Thank you, Carol.

Mark Boner: We're going to talk a little about multipurpose processes to maximize the biological treatment at the wastewater treatment plant. In this figure, it shows ballasted flocculation acting as a -- to treat the excess flows from either the raw wastewaters coming into the plant during wet weather or from, say, if you have excess primaries to treat that effluent, or it

could actually be used during dry weather to act as an additional clarifier before the plant is disinfected and discharged.

So it serves multi purposes throughout the plant instead of just using it during wet weather, which lots of times it becomes a problem when you turn something on in wet weather. You've got to get it up to speed. You've got to, when it's over with, and lots of times rain events can be very short. So you could actually use it in this case to take some of the mixed liquor and return those solids back and keep it running all the time so it's ready to go when it's -- when the wet weather comes along.

The compressed media filter is also a technology that can be used for multiple purposes. It can be used as a tertiary filter. And actually in some cases where you just have a secondary plant you put it in as a tertiary filter. It removes 90 percent of the solids coming out of the secondary clarifiers during dry weather. And, combined with what it removes during wet weather, and it could actually remove a lot more of the load that's going to the receiving waters. It could actually then be used to, when the wet weather comes along you stress your biological system and the clarifiers start to overflow solids, compressed media filter, because it takes very high loading -- we've actually tested it up to about 1,600 mg/L mixed liquor, and it removes these solids 95 percent removal. And you can return those as return sludge back to the aeration system.

And then also it serves -- it could be used in treating the primary influent or primary effluent wastewaters if you have that kind of excess capacity or overflows from those parts of the system. So using the technology in multiple locations can sometimes do more things for you at the wastewater treatment plant than just treating the wet weather flow path. So the engineers looking at these opportunities would be well suited to provide greater pollutant removals.

This is just a picture of the compressed media filter similar to what was put in to Columbus. It has been tested for -- at different facilities for CSO treating, CSO flows. These are full-scale pilot facilities for the compressed media filter. And it has been looked at for SSO treatment, primary influent treatment, primary effluent and as a tertiary filter itself. The removals from the compressed media filter are in the 80 to 90 percent removal. And even during wet weather it produces pretty consistent effluent.

In filtration if you can take the high solids loadings what you're going to find is that the effluent from the filter system is going to be based on the particle size that they can get through the filter. So it'll produce a pretty consistent effluent no matter what you're feeding, whether it's the high solids loading or a diluted wet weather loading. As a tertiary filter, the filter has been tested to show that it gets down to below 1 mg/L, or below 1 NTU, whether those samples were just what's coming out of the clarifier or spike samples where you add return sludge to that testing.

I'm going to turn the focus now to disinfection -- this graphic shows Columbus again -- to talk a little bit about the different disinfectants and then how you take your disinfection results and use those in designing your system and then in determining compliance with water quality standards for bacteria.

In Columbus, as I mentioned before, we looked at sodium hypochlorite and sodium bisulfite for disinfection. We also looked at peracetic acid. There's a couple vendors now that are out there that have this product. There are still some certifications that need to be done to make this a legal disinfectant for some of the various waste streams. I think for shipboard waste I think peracetic acid is now a licensed disinfectant. I think in the state of Kentucky they've kind of licensed it for at least one year, and they're looking at various concentrations of that. But peracetic acid, although it's pungent, there's other issues to deal with it. It can leave a pretty much nontoxic effluent as long as you get the peracetic acid in the effluent in the 1 mg/L, may up to even 5 mg/L range.

Chlorine dioxide was tested in Columbus. It has -- it produces less disinfection byproducts than chlorine does. Bromine, there's a new product, bromine as BCDMH. It's like the stuff you put in your Jacuzzi to disinfect the water. It actually comes in powder form, or it can actually come in a thixotropic solution. And it disperses very well into the effluent. Of course, instead of -- chlorine forms chloramine, and the bromine forms bromines, but dibrobromine is the main component, and when it forms with ammonia, and it's very unstable. It's got a -- it's much more reactive than the chloramine. And so it has a tendency to do very well, very fast oxidant that dissipates quite fast. So these are some of the other disinfection areas besides a UV disinfection and possibly ozone.

When you look at a disinfectant you look at a dose/kill relationship, and in this graph it's showing raw CSO dosed at -- different samples of raw CSO with different doses and different quality. If you just look at the fecal coliform, the effluent from a test and the dose, you'll get a big scatter, and it's really hard to show anything. But if you normalize the data, the dose data, by the quality of the water, like for example TSS or BOD or COD, something like that, you'll start to see a trend or a regression equation that has some kind of -- that makes sense.

And temperature is another parameter that you need to consider if you're doing these dose/kill relationships. So if you normalize the dose, divide the dose by the, for example, level of TSS and then by temperature, you'll get a better and better equation to determine how you dose your CSO.

The other thing you need to know is, well, how does that quality change over time? This graph shows the quality, the TSS concentrations, over time, or over a cumulative volume of the CSO. The blue dots in this graph are from Columbus, which represent over 40 events that were sampled every five minutes in the initial part and then every 15 minutes as you got to the big event. And then on top of that the red dots are the data from Atlanta on the same basis. And that data is normalized by acre. So they kind of fall on top of each other, but it shows that there is a real flush effect.

These are two totally different systems, but if you look at them, say, an outer envelope of how the pollutants occur -- for example, that green line -- that's just a power equation through the data or kind of laying on top of the data, use that equation, that power equation, with your dose kill regression equation to determine -- to prepare an algorithm that you can then calculate and put in your SCADA system to the feeding curves, the chlorine or the dioxidant feed curves to control your feed pumps to cause your disinfection.

So in this case there's a family of curves here for different temperatures. And it's based upon that TSS data that says here's how we're going to dose our chlorine. So at the beginning you could have a very high dose. This is raw CSO used in Columbus that we're dosing. It could be from 40 to 60 mg/L at the very beginning, but it tailed out real quickly to levels well below 10, typically below five, in a dosing scheme.

As Carol mentioned a little while ago, one of the things you do, you check your chlorine levels, and the strength of the chlorine has to be entered into this algorithm or entered into your computer that says, okay, our strength is less, so the algorithm takes care of the increased dose you might need as the potency of the chemical subsides. And that is used in Columbus and it's producing effluents typically below 100 colonies per 100 mL at all times during that CSO process.

Another thing you might, the practitioner might look at is, well, what are we creating when we're putting these high doses in? Well, we're creating high total residual chlorine. And that high residual chlorine needs to be knocked down so we don't have toxic effluent and kill the aquatic life in the receiving water. So this plot shows the relationship between the dose that's normalized by COD and temperature versus effluent TRC. And you can see you have pretty high levels there, and you're going to have to dechlorinate, possibly according to a regression equation like this.

This just shows dose normalized by COD and temperature as compared to HAAs that are produced. So this is a disinfection byproduct. If that's a concern in the receiving water, then you want to be concerned about how you remove particles before you disinfect in that stream.

This is data from Atlanta, where we looked at disinfecting. The red line shows here's the dose that we would be putting in for disinfecting the raw CSO. The blue line is after the treatment process, and that process included filtration, knocking down the solids to about a 90 percent level. So at the beginning, if you were going to dose just the raw CSO itself you're putting in about four times the chlorine, in this case, and you can actually have about 10 times the precursors that could cause disinfection byproducts. So these are considerations that you need to take when looking at disinfection, how you design it and how you control it.

Conclusions about disinfection is that chemical and UV disinfection can be defined as a function of wastewater quality and temperatures. Those are the two main parameters that you look at in designing your system. Wet weather quality it rapidly changes, but it's predictable. If you get enough data you can predict how it's going to occur. And you're going to have to look at over-disinfecting, over-oxidizing and over-dechlorinating, taking out the chlorine residual. The oxidant dose can be correlated with TRC and can be used then to control the dechlorination feed process. Disinfection byproducts are a function of dose and quality, and it can be reduced through particulate removal of precursors or using UV disinfection.

I'm going to talk now about how you look at this information to determine whether you comply with water quality standards. I think it first would be beneficial to talk about definitions. If you look at the listing, impaired water listing guidance from EPA, they define an excursion when the -- a criteria with a duration as well as a magnitude is higher than the water quality standard.

That's an excursion. So a 30-day geometric mean would have, if it exceeds that standard, would have an excursion. It doesn't mean it's an exceedance. It only becomes an exceedance when the excursions exceed the frequency that's defined in their criteria. Not all states have a frequency. So if you don't have a frequency that means one excursion is an exceedance.

Same thing with digression. A digression is when a single-sample maximum, which are typical in water quality standards also, is higher than the water quality standard. And, again, an impairment is -- or an exceedance is only when there's -- digressions would exceed the frequency allowed in those criteria. And it only takes one exceedance to cause an impairment.

This is the work done in Columbus to show that the Chattahoochee River in Columbus is in fact in compliance with the water quality standards. The red line, which is a value of 200 fecal coliforms per 100 mL as the 30-day geometric mean in the summer, and it goes up in the winter to 1,000. The blue line is the rolling average of the calibrated model output of bacteria in the river. It includes the CSO. It includes the tributaries, the urban runoff, the treatment plants and the upstream value coming into the Columbus boundary, the TMDL boundary. And then the darker, the brown line is actually what's coming in to the upper end of Columbus.

And in this graph you can see that blue line goes above the criteria for about 12 days, and so you have 12 days of excursion. But that doesn't necessarily mean there's an exceedance. If you took that 12 days of excursions of the rolling average geometric mean, it would really only amount to about 3 percent of the days in a given year.

And in fact what we've found in Columbus is that over a nine-year period -- we've been looking at this for the past six years -- that there's only about 2 to 3 percent excursions of the geometric mean, and it's caused by a lot of rainfall. So when there's a lot of rainfall there's the potential for excursions of the water quality standards.

We even took that same model output, and this plot shows the CSO loadings from the untreated portion of the collection system. The treated portion is way low. It's below 100 counts per 100 mL. But this is the untreated portion that once in a while bypasses the treatment facility. And instead of using in this analysis for the frequency of excursions, we've looked at the outer envelope of the CSOs. And we've increased that to the pink line.

That regression equation shown by the pink line is about 10 times the average of the CSOs. And even then, in Columbus that shows we've gone from 3 percent excursions to about 6 percent excursion rate. This is well below the 10 percent that's allowed in their impaired water listing protocol. And the state of Georgia is actually looking at adding the frequency of excursion to their natural variability clause that's in their water quality standards.

This plot shows an EPA method of looking at the loads over a range of flows. In some -- in most water bodies you can't really use the waterway, in a lot of cases, when the flows are very high. So maybe in the upper range, where the blue dot, which is the 90 percentile in geometric mean, compares to the standard, that's the red line standard -- I see there's a registration that's off here -- but the red line is the standard over those various flows. And the pink dots are at the model output. That's the daily 30-day geometric mean output. And then the blue dot at the center point

of each one of those flow ranges represents the 90 percentile geometric mean from that output data.

So in this case we're always below the standard. The 90 percentile geometric mean is below the standard. But there's more excursions at the upper end and the lower end, and those are the ones you might want to concentrate on. But it may be that you're only using the water in the lower end. In the upper end you're not so concerned about the use, and thus you might set your site-specific requirements for CSO treatment based upon an analysis like this.

Another thing that's very interesting that we found from the model in Columbus is that we now have a calibrated model that has output, and we can look at 30 days of output, like the rolling 30-day geometric mean that we showed before, or we can take random numbers from that output. And the yellow line shows that there's a lot more noise if we take fewer samples. So it stands to reason. If we only have four random daily values of the 30-day geometric mean, we're bound to have around 12 percent excursion. But if we take 15 random samples, that excursion rate goes from 12 percent down to 6 percent. If we take 30-day excursions it goes down to about 3 percent. So, really, the number of samples you take is critical. In listing protocols by states often use the limited data set, and it shows a lot of times that you are going to exceed the standards. But if you look at enough data you can show that, hey, in fact, you are not exceeding the frequency of the excursion.

This plot shows the other project that I showed you on the stormwater BMP. We have a dry weather bacteria problem, and we're looking at the rolling average geometric mean in that creek -- this is the in-stream loading -- and it exceeds the standard, or there's 52 percent excursion in a given year, and it's all -- pretty much all during the summer. The wet weather loads are still high. But this is after the BMP -- excuse me, this is after the BMP, but no treatment of the dry weather flow.

When we treat the dry weather flow down to a 50 bacteria count -- in other words, we're pretty much having to treat all the dry weather flow in this case -- that we can cut that excursion rate down to below the 10 percent. But, again, we're disinfecting. We're sending the dry weather flow completely through the UV disinfection system. We're hoping that in Columbus that ultimately the dry weather bacteria load can be reduced and fixed and we'll only be treating a portion of that dry weather flow so that the flow control device also allows for migration of aquatic biology.

Jim Collins: Thank you, Mark.

Well, that concludes the presentation. We do have time for a few more questions. And, let's see, there's one about the Columbus system. Mark, how frequently is the filter media replaced at the Columbus -- oh, I'm sorry, I believe he means Columbus, Georgia, system.

Mark Boner: Well, the Columbus CSO facility has been in operation for 13 years now, and it has never been replaced. It is resilient. It may get a little bit discolored. But it has not been replaced. It does not appear -- it is a synthetic fiber material. Now, it only operates 5 percent of the time, so -- and after an event they backwash it, and actually in Columbus they use the potable water source to backwash it after an event. It only operates -- it's not backwashed during the

event. The other CSO facility -- excuse me, the stormwater BMP has just been put in. But we feel like that that will be -- have a similar kind of life in terms of the media itself.

Jim Collins: Thanks.

There's a question here about what is the typical dose and disinfection efficiency of UV disinfection systems.

Mark Boner: The one in Columbus, I can't tell you the dose. It is -- I usually refer to it as the contact time across those medium-pressure bulbs is about two seconds contact time. In that system, they are medium-pressure bulbs. There are 42 bulbs per bank. There are two banks. And it takes 15 MGD.

Jim Collins: And so efficiency would be a kill rate of --

Mark Boner: It takes it down to below 100 fecal coliforms per 100 mL, typically around 10 colonies per 100 mL. What comes in could be a lot more. It varies. What comes out of the vortex separators and goes through the filters, the filters remove about 90 to 99 percent of the bacteria that comes out of the vortex. But in terms of a log reduction we typically have not used that, because the influent can vary hugely. But the effluent is the consistent item.

Jim Collins: Thanks.

Let's see. Here's a question about removal of total suspended solids is a critical part of the success of these systems. Can you tell us where we can obtain more information on the filter media that was used, or that have been used?

Mark Boner: There are two systems. There's the Schreiber system and then the WETCO system. Then the Japanese have a system that they call Bio-Balls in Japan that are all using that same kind of synthetic fiber medium.

Jim Collins: Okay.

Well, that's about all the time we have for questions. Thank you, Mark and Carol and Mohammed.

Mohammed Billah: Thanks. Thanks, Mark and Carol.

Mark Boner: Thank you.

Jim Collins: I want to remind you that this seminar will be archived, so you can access it after today's live presentation. The archived webcast will be posted within several weeks, so revisit the NPDES training website to view the archived presentation.

We did post the speakers' contact information in case you would like to contact them after today. You can find a comprehensive resource list by pressing the Resources button on your screen, and you will need Adobe Acrobat Reader to view the document.

Finally, the webcast evaluation survey should soon appear on the screen, so please consider completing this survey and let us know your thoughts. We appreciate the feedback as we work to improve the webcasts. If you do not see the evaluation survey on your screen please turn off your popup blocker.

And also, I think the slide that was just previously up was the certificate, so you can feel free to download that. If you have multiple people at your location, you can actually download it, and it's a modifiable PDF, so you can type in each participant's name.

That ends our webcast for today. Thank you for joining us.