Metropolitan Water Reclamation District of Greater Chicago
Workshop on Microconstituents and Ecological Impacts of Biosolids and Effluent Reuse, June 26, 2008

Morning Session

Introduction by Mr. Richard Lanyon, General Superintendent, Metropolitan Water Reclamation District of Greater Chicago (District): I want to welcome you all to this workshop. I am very pleased to see all of you people here largely interested in this important subject. This is a very important subject for us. We have been a participant in activities in the Calumet area for many years, and we are working on a project with a couple of City of Chicago (City) departments on creating a treatment wetland using some of our property and some City property in the Calumet area. That project is the impetus for this workshop, happening because questions have been raised about the impact of effluent on wildlife in treatment wetlands and other issues. And, of course, there has been a long-standing debate of the Calumet area. We are more than happy to address these issues and work with other agencies and interested public trying to resolve these issues.

Introduction of Moderator by Mr. Richard Lanyon, District: Dr. David Homer is an Ecological Toxicologist with Tetra Tech EM, Inc. (Tetra Tech) and works for the City on ecological and toxicological issues. I think he has a vast knowledge of some of these issues and will be a very good facilitator and moderator for today's session.

Dr. David Homer, Tetra Tech: Thank you. I look at my role as helping to run through the ecotox process. It was a long process and an interesting process. There are so many different views and so many different ways you want to look at these problems. Hopefully, through this workshop we will get a chance to ask the questions and maybe not all our questions will get answered, but

at least we will start the discussion. We will open with Ms. Nicole Kamins, Program Director, City, Chicago Department of Environment (CDOE). Ms. Kamins has nine years of experience and has advanced the Calumet initiatives.

Presentation by Ms. Nicole Kamins, CDOE, "Framing the Issues – Overview of Calumet Area Restoration." Ms. Kamins presented an overview of the City of Chicago's effort in the restoration of the Lake Calumet Region, and indicated that biosolids can be used to help improve the rate of restoration of some of the sites and significantly reduce the cost of acquiring topsoil.

Presentation by Dr. Thomas Granato, District, "Biosolids Use in Restoration," as follows:

Dr. Thomas Granato, District: I am going to take a couple of minutes to familiarize everybody with our biosolids. Ms. Nicole Kamins, CDOE, did a great job of pointing out all the sites and some of the potential sites where biosolids will be used. The District services Cook County which includes the City of Chicago and 124 suburban communities. We operate seven water reclamation plants (WRPs), which collect and treat about a billion and a half gallons of wastewater daily. In the process of performing that reclamation, we generate about 180 thousand dry tons of biosolids every year, and we have had a beneficial reuse through a land-application policy in place since 1967. One of the misconceptions, that I hope is not out there, is that the District is viewing the Calumet Region as a potential new market for our biosolids. I want to dispel that misconception because we really have a very diverse and thriving program. Basically, it consists of what you can see here. About to 50 percent of biosolids go to farmland to

fertilize corn and wheat. About 5 to 20 percent go to landfill for final cover. That is what we are talking about at Cluster Sites. In fact, some biosolids have been used in the past at these sites as final cover. Another 5 to 20 percent is used in daily cover at local landfills, and then we have our urban use program which we refer to as our Controlled Solids Distribution Program. Somewhere between 5 and 20 percent go there. That's mostly used as a soil amendment or a fertilizer in preparing sites to grow turf or in maintaining turf at recreational facilities like parks, golf courses, athletic fields, and the like. Regarding the use of potential biosolids in the Calumet Region, we see it as an economic resource which would enable these projects to insitu restore the degraded soil. So, biosolids have properties that can bring nutrient value, and organic matter that can improve soil tilth. The biosolids matrix can provide effective reduction of bioavailability of legacy pollutants in contaminated soils. Biosolids are currently proposed for use in the biovegetative layer at the Lake Calumet Cluster Sites. That is Illinois Environmental Protection Agency (IEPA) Alternative 4 in the plan, and also in the plan that Tetra Tech has put forth for Indian Ridge Marsh on 14 of the 140 acres to restore prairie soil. How do we generate our biosolids? How do we arrive at a beneficial use product? We take the primary sludges and the waste-activated sludges that are produced in our water reclamation process. We take those and put them through a solids processing train. The first step is anaerobic digestion. Sludge is placed in digesters where it resides for about three to four weeks at average temperature of about 95 degrees, and we lose something on the order of one-third to 40 percent of the organic matter in these digesters. Most of it being converted to methane gas which is reused in the plants. This process stabilizes the organic matter and kills pathogenic organisms and also reduces the

potential of biosolids to later be odors. Following this, the biosolids are centrifuge dewatered to about 25 percent solids. At this point, they are 25 percent solid material and 75 percent water, and they are conveyed to large storage lagoons. They are held for at least 1½ years in these lagoons. They are outloaded and transported to paved drying cells where the biosolids are mechanically agitated and air-dried. In the process of air-drying, it is somewhat dependent on climatological conditions, but we do agitate. This process, in part, is undertaken with brown bears (which are horizontal augers) that produce a windrow product. This process resembles a composting operation. It is not operated specifically to compost biosolids but the process of drying, which takes about four to eight weeks on the cells, does produce a lot of compost effect which between the lagoon-aging and the air-drying produces a very stable product. We lose about 2/3 of the organic matter and total nitrogen in this process. We wind up with something that is similar to a compost material in the end. Biosolids are then stacked for final distribution, and they are very soil-like both in appearance and in properties. Most of our biosolids are used in recreational facility settings where we are looking to enrich the existing soil to promote healthy turf growth and provide a high-quality turf field and would be something on the order of a two-inch biosolids layer. Take that two-inch biosolids layer and incorporate it into six inches of topsoil, you have a 25 percent biosolids mix by volume. That amounts to 15 percent by weight biosolids mixture, 15 percent biosolids and 85 percent soil. Just as a rule of thumb, that is a very good mix to produce a very healthy turf for sports.

Presentation by Dr. Heng Zhang, District, “Effluent Treatment Wetlands.” Dr. Zhang presented overviews of design concepts

and the benefits of constructing the treatment wetlands and of using biosolids for restoration of sites such as the Cluster Site (Superfund Site) and Indian Ridge Marsh.

Presentation by Mr. Todd Nettesheim, United States Environmental Protection Agency (USEPA), Region V, and Dr. Heiko Schoenfuss, St. Cloud State University (SCSU), "Effects of Endocrine Disrupting Compounds on Fish – What do we know and what we don't know." Mr. Nettesheim presented data from studies on District WRP effluent and Chicago Area Waterways (CAWs) and other data. Dr. Schoenfuss presented data showing that a very diverse range of anthropogenic chemicals considered as endocrine disrupting compounds (EDCs) are released in the environment continuously.

Presentation by Ms. Wendi Goldsmith, Bioengineering Group (BG), "Expectations for Aquatic Life Use Following Ecological Restoration: Are Biosolids and Effluents a Limitation in the Calumet Region?" Ms. Goldsmith advised that although information might not be available to address all stakeholder issues, the City should not overlook the opportunity to utilize resources that can be of a greater overall value to the region.

Morning Session
Open Forum

Q: Dr. David Homer, Tetra Tech: If the EDCs are destroyed by microorganisms, and we are also looking at removing nutrients out of the water, are we also looking at the mechanisms by which those EDCs are going to be destroyed?

A: Dr. Heiko Schoenfuss, SCSU: I think that speaks to complexity of the issue we are dealing with. Whenever we look at the partitioning of the EDCs, any alteration in the treatment processes will change how EDCs are partitioning into solids and aqueous phase, and it will impact the overall treatment efficiency or removal of EDCs. I don't think that there is a lot of work that has been completed on this topic. You are absolutely right, potentially; you can change the efficiency of treatment by the removal and departitioning of those compounds into the solids or aqueous phase.

Q: Dr. David Homer, Tetra Tech: You found endocrine disruptors inside tissues. Do we know if there is any relationship between finding them within the tissues themselves and the impacts on the organisms? Do sex changes occur? Will it have an impact on reproduction? If we find them in fish in the rivers, do those birds that feed on those organisms, will they in turn also be impacted or do the EDCs move up the food chain and are we worried about bioaccumulation aspects? Birds that feed on organisms, will they be affected.

A: Mr. Todd Nettesheim, USEPA: What do we know? You were asking about did we find evidence of ecological impacts in Chicago waterways? We did find some elevated levels of vitallogenin in male fish in the North Shore Channel. We did not find any evidence of intersex. We did see some abnormalities in the liver that show some impact of long-term exposure.

A: Dr. Heiko Schoenfuss, SCSU: Let me add to Todd's comment. When we find EDCs, we generally find many other compounds as well. For example, when we see the pathological

changes to the liver, and they are all indicative of overall high pollutant loads in the animals, we may or may not find changes to reproductive organs which may be more indicative of the estrogenic or endocrine disrupting effect. It makes it extremely difficult, however, to establish this linkage outside the laboratory. It is really difficult to answer that part of the question. As far as the issue of bioaccumulation and moving up the food chain, we can address that a little further. Most of these compounds are unlikely to bioaccumulate which has been shown by various labs. This is obviously a very broad generalization. For the most part, I've seen the food chain effect was another means by which exposure occurs at a higher level of the food chain. In other words, we have not seen bioaccumulation as a problem, but we may see fish for example being exposed to compounds not just through the water but also through their food. Many endocrine disruptor compounds have acute effects. The endocrine system usually works in a very immediate mode. You just have to think of something scarier than adrenaline that passes through the system. That is a very quick effect that lasts only a short period of time. EDCs are less likely to act on a longer scale but act on a very immediate scale. They can, however, upset the entire endocrine system on a longer scale. We have two levels of temporal scales that we have to deal with, but I don't think that bioaccumulation in fish tissue necessarily will tell us a whole lot more than what we wouldn't find in varying acute effects.

Q: What kind of response has the District received from the proposal to use some of the Calumet Wetlands as part of the treatment?

A: Dr. Heng Zhang, District: As far as I know regarding these

chemicals, we did not receive comments from the members of the workgroup. A lot of the concern is for the disruption of the eco-system during the construction phase of wetlands. There is a lot of concern about the effect on the birds and other critters in the ecosystem.

A: Ms. Nicole Kamins, CDOE: A lot of the concerns were from the U.S. Fish and Wildlife and the Department of Natural Resource covering exactly what you are mentioning. The intent is that we would like to see a lot more data and particular concern is how to balance the eco concern. How do we balance? They would like to see a lot more data.

Q: Mr. Richard Lanyon, District: I have two questions for Nicole Kamins, CDOE. First question is: You mentioned that the Indian Ridge site is being restored through a program by the Army Corps of Engineers; how are they dealing with the issue of toxins in the fill material that was used in that site over the years? The second question is: When you went through the number of sites, you mentioned the ownership to be determined; what is the long-term interest or plan of the City? Are you looking to spin these properties off to other entities? Who might that be and for what purposes?

A: Ms. Nicole Kamins, CDOE: Our original intent was primarily to transfer land to the Chicago Park District, their district, or the Illinois Department of Natural Resources when budgets were better six or eight years ago. The concept was created 16 years ago when we had a lot better budgets and vast resources to deal with. While that was the intent, we are in a different time. All areas have financial issues currently. Maybe there are other partners

that can help us manage these sites long-term. That is part of why I am here today. It is a fantastic opportunity for the City to have someone come in and use the recreation and carefully balance it with ecological needs and help us manage these sites long-term. A fence alone is hundreds of thousands of dollars. In this time when we don't have a lot of money, a lot of these sites are chomping at the bit. This is an incredible opportunity, as you will attest, as an alternative.

Q: Did you identify some areas with the problem of contamination as part of the design.

A: Dr. David Homer, Tetra Tech: We went through a process and worked with an ecotox team to identify the areas of the site that have been impacted with contaminants and from there we came up with options. Actually, the areas were somewhat isolated on the site primarily due to fly dumping. A long-term restoration will involve restrictions for site access to eliminate that in the future, and possibly some soil remediation at the site. One of the site features will be a parking lot by the access to the site. The idea being that we may be able to cover some of the contaminated areas by placing the parking lot there. One of the other things that we need to resolve at the site is that the quality of the soil needs to be improved. We are, hopefully, working with the District to incorporate biosolids.

Q: Question for Dr. Thomas Granato, District: Are there published standards or definitions for biosolids as to their physical property, chemical composition, and toxicological properties?

A: Dr. Thomas Granato, District: Yes, there are standards. We

are going to have a presentation this afternoon. Dr. Albert Cox, District, will make a presentation on all the regulatory controls that are in place at the federal, state, and local level. There are guidelines that must be met in order to provide biosolids in a safe way and utilize them. I can give you a quick preview of what he is going to talk about. By the way, all the presentations that are being given today will be posted on the District website. So, if you want to get the details on the presentations, please go to the District website sometime next week. If you have trouble finding where they are at, just send me an e-mail asking where they are posted.

A: Dr. Thomas Granato, District (Continuing): There is a federal regulation which is commonly referred to as Part 503. That's a federal regulation rule that was based on 14 terrestrial pathways which included some ecological pathways which were in biotoxicity pathways, soil biota exposure, predators of soil microbes, etc. The regulation looked at an array of chemical compounds including metals and trace organics, and the final rule established standards for nine metals. Many of the other compounds we've looked at were found not to be of sufficient risk and this afternoon we are going to look at that in detail in a couple of presentations. The State of Illinois (State) also has standards that really have more restrictive management practices than the federal rule in terms of use of biosolids in proximity of surface waters and other site features and how to manage biosolids to preclude runoff or migration to surface water. The CDOE requires us to meet the Tiered Approach to Correction Action Objectives (TACO) Standards, the Tier I residential limits, or alternative limits that were determined via a specific risk assessment that was done on our biosolids. More information will be presented in the afternoon. There are many tiers of regulations. We can also provide you

with a lot more information.

Q: In your presentation, you described the processing of the biosolids. I don't remember seeing where the biosolids goes through a drying process. At some point in time, someone was planning on building a biosolids-drying facility. Is that completed and in use?

A: Dr. Thomas Granato, District: Currently, the way we dry the biosolids is by placing it on paved drying cells. Then we mechanically agitate it and air-dry it. That is how the biosolids are dried and used for soil restoration in the Calumet Region. We have constructed, through a private contractor, a drying pellitizer, and right now is going through operational testing. It is not currently functioning or producing usable product.

Q: John Rogner, United States Fish and Wildlife: We had a side discussion earlier about work that has been done with EDCs and migratory birds. You also mentioned that EDCs pertaining to bioaccumulation would not be much concern. My question is that we are looking at the Calumet area, most of migratory birds, particularly the wetland birds, use these wetlands. Do you feel there is a need for more research to be done with EDCs and these birds being exposed to EDCs or even higher level birds such as amphibians and reptiles?

A: Dr. Heiko Schoenfuss, SCSU: That is a really important point that both length of studies on any level from amphibians, reptiles, birds, and mammals have been under studied. We have some medical knowledge from mamillian studies. Few studies suggest strong effects. They are really suggestive studies. When you

look at amphibians, some of the work that entire thesis have been done on amphibians metamorphosis in relationship to pesticides is probably applicable to any anthropogenic compound. Although they are separate issues. On the recurring side, they are just a couple of rogue studies. Just this spring, there was a study in the proceedings of the National Academy of Science, based on song birds feeding on biosolids that suggested some changes in behavior of song birds. Those are all very isolated studies that need to be based in a much larger context of endocrine disrupting work. This may suggest a dramatic need to fill those holes.

A: Dr. Heiko Schoenfuss, SCSU: One of the rivers, specifically chosen because we thought it was a pristine waterway in Minnesota, turned out it was one of the streams with the highest upstream loads of EDCs we found anywhere The upper watershed was over 90 percent forest. There were very few homes. There was absolutely no industry and hardly any agriculture. It just adds to the mystery and the need to study both the sources and the fate, the transport, and the impact of these compounds. There is a lot more unknown than there is known.

A: Mr. Rob Sulski, IEPA: A lot of times we start to divide things up so carefully under a microscope. We fail to look at what may be the proof is in the pudding. For example, I spend a lot of time on these waterways, and I know they are effluent dominated in the Chicago Region. I know that they contain these compounds yet no where else in the State do I see such abundance of State endangered birds such as the Black Crowned Night Heron along every inch of the way in some of the most highly contaminated reaches of any waterways in the whole State. There they are and there they nest and there they feed and there you see the young.

That is something else to keep in perspective.

Q: Dr. Nick Basta, The Ohio State University (OSU): A certain class of compounds 20 years ago was a cause of concern for biosolids, and they have done source reduction and eliminated them or reduced them by pretreatment. Maybe the solution is basically stopping the source of it. Just like it was done with some of the metals in the pretreatment options. You now have a cleaner product; biosolids, that you can use at the end for ecological restoration. Is it possible to say no more to some of these chemicals? Will that solve the problem?

A: Mr. Todd Nettesheim, USEPA: There is probably not a universal approach where you can stop everything. There are programs that are in place that are beginning to look at that problem. There are other cost-effective ways. There are retailers like Wal-Mart that have agreed to phase out products that contain ecotoxins. As the general public gets more informed, as corporations get more informed, the tide is slowly turning. Great Lakes Chemical is voluntarily phasing out pentabrominated diphenyl ethers. There are mechanisms in place, but it is a slow process.

A: Dr. Thomas Granato (District): It can be very difficult to control some of these things. The primary sources are coming out of our houses. Industries are producing a lot of these household chemicals, pharmaceuticals, personal care products, cleaning agents, etc. In the case of metals, we were controlling more or less by-products of manufacturing processes. Here we are talking about controlling the products that they sell and profit from. That is going to be a tougher fight than trying to get the industries to just treat their wastewater before it is discharged. I think society as a

whole is going to have to bear a greater cost in the product they use because these manufacturing companies, whether they are pharmaceutical or whatever, are going to have to now look at the cradle-to-grave life cycle analysis and fate of these compounds. Now that we know the ultimate fate of these things in the environment and the potential effects. It may be more costly to engineer and bring alternatives to the market. It is going to be expensive to prove out that they are safe and ultimately there is criteria involved. What about all the theory and the products that we question. We are going to have to really examine in great detail the contents of those things that we probably are not looking at. Taking them at their word at what is on the label and looking at, "Do these toys contain lead?" I think it is a very complex issue. It is also going to be very costly to treat at the WRP to remove them down to the levels that would be necessary to completely get below the effect levels. Even then, we have other sources that are not point sources and harder to control.

A: Ms. Wendi Goldsmith, BG: Well, this is why I introduced this principle of the natural step in my talk. It is the one approach that actually links the generation of synthetic compounds and the management of naturally occurring compounds. Right there is the ecological productivity of landscape scale systems and practical and economically available resources that meet current future human needs. That's all of it in a nutshell. All the natural step requires is that you cause the question to be asked and answered as a decision-making step. In Sweden, I actually found out how they are dealing with these surfactant questions. I don't know what's happened with other compounds. The story is how the natural step was put into practice. They either banned it or the substances or processes were simply recognized as having prob-

lems. They were stopped or there was some mechanism for accountability. You can sell that product but manufacturers have built into the price a collection fee, take it back and break it into parts, and then deal with the residue. There are different ways, either by banning or by accountability, for some final reclamation process on the part of the manufacturers. That is all packaged in their one tiny economic incentive. I don't see how you can afford to not use your available water, and your available organic materials, and nutrients, and your available land, and your available political wealth to restore some productivity in the landscape. Not to say that these issues aren't real and perplexing but to move forward with that while causing maybe some of the other problems to be solved. Looking at the end of the wastewater treatment process and expecting that's where a consolation takes place is not necessarily the best match. Don't let that slow you down from the bigger picture.

A: Dr. Heiko Schoenfuss, SCSU: There will also be some opportunities that we should not be on the adverse or negative side of. The State of Wisconsin, Department of Health, did a study on the amount of pharmaceuticals nursing homes have been flushing down the toilet literally. In the State of Wisconsin, they came up with $28 million worth of pharmaceuticals that were still originally packaged but for one reason or another were not used anymore. Everything that was still originally packaged had to be flushed down. That's $28 million in savings with a slight change in the rules. There are other opportunities. The City of Duluth did one-day recycling opportunity for unused pharmaceutical from 130 households which attributed to 200 pounds of pharmaceuticals that would have otherwise ended up somewhere in the waste either in a solid or in the aquatic waste stream. There are some

creative and very simple forms by which we can alleviate some of those problems. Maybe not solve them but alleviate them. Maybe even save by making money.

Q: Dr. Krishna Pagilla, Illinois Institute of Technology (IIT): We cannot diminish the biochemical or the chemistry level work of organisms on the ecosystem level. Have you seen reductions either in populations or the diversity of fish species or reductions in river stretches that have EDCs in them?

A: Dr. Heiko Schoenfuss, SCSU: In instances where reduction in population health has been recorded by usually the most severe cases, sometimes in places I would not have expected. I think Boulder Creek is probably the best study example. Boulder Creek's head waters are very pristine coming out of the Colorado Mountains. The City of Boulder contributes to the effluent, and there is a little dam just upstream of their inflow which separates the downstream fish population from the upstream fish population. Although the City of Boulder is not an industrial city, the effects are dramatic in downstream and White Suckers are almost all either female or intersex. Upstream the sex ratio of the entire population is 50/50. The question they are now addressing there is whether or not the downstream population is viable or just basically survives on downstream migration of the off stream population. I think that is something we are all concerned about whether we don't see reductions in fish populations per se in many places. But is this a result of a migration of fish from the source population to a sick population where no reproduction occurs. Whether we still have reproduction in those areas is a very difficult issue to identify and to solve. On the human side, it is important that we have determined that smoking is bad for us. Probably the most

cited studies are those that suggest that there was a significant reduction in sperm density in males of the western hemisphere since World War II and the chemical revolution. To link that to EDCs is hard and impossible to do. However, we know from animal tests and makeup of the compounds we study that EDCs will reduce sperm density and to some degree sperm fertility parameters in laboratory mammals. It is a stretch to extrapolate one to the other.

A: Dr. Edward Topp, Agriculture Canada (AC): The only other study to add to that is the study in the experimental lakes in the Canada area where they took a lake and separated it, hydrologically. Half to one side was dosed with the synthetic estrogen and the other side was control. It was dosed at much higher levels than what could be seen in the environment; I think five to six manograms per liter. They were looking for subtle effects to try and identify some of these population and the effects. They were shocked when three years later, the entire fish population collapsed. There is evidence that there can be effects, but as far as the true real study that it represents real environment, that has to be studied.

A: Dr. Heiko Schoenfuss, SCSU: To add to this one, this is a real important study, in my opinion, with the experimental lakes area in Canada. What was truly shocking to me having worked with fish, was the species really crashed in that experiment. What was shocking was that the effect was not with the male as we all expected. It was actually, to summarize what happened, the females would stay reproductively active. They were wasting energy producing eggs when the male had already shut down rather than getting ready for the winter. So less and less females could

survive the winter. After several years, there were no females to reproduce with. I don't think that is an effect that any of us would have picked up in any of our experiments conducted in the laboratory. It was really shocking because it questions everything we do.

Q: John Rogner, United States Fish and Wildlife: I have a comment on perception that I wanted to make. In my mind, when I think of fish and wildlife habitat in the care of the golf course, to solve the problem of pollutants getting into the reservoir is to reduce or eliminate the use of those chemicals and not to have a wetland that is going to be a receptacle for all those pollutants where wildlife would get exposed to that. I just wanted to make that comment. For me there is difference in perception sometimes when people are thinking about using a wetland for treatment and not thinking so much about it as a habitat for fish and wildlife. I also wanted to ask a question. Do you think about studies on aquatic invertebrates and any changes that may happen to the inhabitants in the aquatic population?

A: Dr. Heiko Schoenfuss, SCSU: There have been very few studies, and the principle reason is due to EDCs. Their principle mode of action, as it applies to vertebrates and invertebrates, is controlled by the endocrine system with some notable exceptions. North Carolina has done some studies on daphnia and some principle consumers in the primary food chain and has shown that alkyl phenols may have detrimental effects on invertebrates. Studies looking at shifting in invertebrate communities are extremely limited.

A: Dr. Heng Zhang, District: In the case of treatment wetlands,

we will be using treated water from the Calumet Plant. When you look at water quality, runoff from certain areas probably have more contaminants than our treated water. So you talk about the treatment as being a bad thing coming into the system which is not the case. When we see birds in the final effluent tanks, swimming there, the wetland attracts more birds and is a better option.

A: Dr. Lakwinder Hundal, District: Dr. Heiko Schoenfuss, SCSU, showed a slide showing higher levels of EDCs upstream and that part of the river was mainly fed by forested land and not even agricultural land. This highlights the point that even if you eliminate all the man-made EDCs, you may not be able to eliminate the phenomenon of endocrine disruption. Because one species' discharge may have effect on another specie. For example, discharge from wildlife may end up in surface water and fish may be exposed to that. All animals, males and females, discharge EDCs that may end up in surface waters. So fish will show the effects because of that. So, this means that we cannot eliminate these compounds from the environment. Several plants produce EDCs. Everyone loves soy which is loaded with estrogen. In a nutshell, EDCs are going to be with society for a long time. They are not going to go away. All we can do is minimize the manmade compounds to mitigate the effect of EDCs, but the effects cannot be eliminated all together.

Q: The demonstration of the USX site, you said they looked at a range of sludge to soil. What proportion looked to be optimal in this demonstration?

A: Dr. Thomas Granato, District: We were looking at basically a

range where 100 percent topsoil, 25 percent biosolids, 75 percent topsoil, 50:50 and 100 percent biosolids. We were really looking at supporting turf, and there were 12 varieties of ornamental woody species. We felt that the lowest biosolids rate was the best at 25 percent. A slightly lower rate would have been even better provided the best balance of fertile root zone, water holding capacity, all the properties to support plant growth, and minimizing any excess of nutrients.

A: Ms. Nicole Kamins, CDOE: The City guidance on the use of biosolids does have that 20 percent built in as a limit of that ratio.

Q: Is that a mix of biosolids with the slag soil or with the topsoil on top of the slag area?

A: Dr. Thomas Granato, District: No, this was soil that was brought in by the Park District. All of the amendments were premixed and placed on top of the slag. We did a test with two plots in each treatment where we put a very thin layer. We should have put a thicker layer of the heavier textured silt clay beneath the amendment layer. We were trying to reconstruct a soil profile. We had A horizon which was the topsoil-biosolids followed by a heavier textured B horizon just like in natural soil and then the slag would basically be your C horizon if you use a little imagination.

Q: For Dr. Heiko Schoenfuss, SCSU: Regarding the effluent from wastewater treatment plants, I wondered if you are aware of any studies or research that looked into the effluent from pharmaceutical manufacturing plants that discharge directly into river water or as part of the pretreatment program?

A: Dr. Heiko Schoenfuss, SCSU: We have not directly studied those. Most of the manufacturing companies do not process the pharmaceuticals on site. They have subcontractors, and they are very secretive as to what is produced there. So we have samples from half of the effluent that had low oxygen concentrations. That is the only thing I am aware of. No, we have never seen these studies.

Q: Question about putting effluent into a treatment wetland with EDCs as a show stopper for a treatment plant. A couple things come to mind. Putting in the effluent and doing all of this activity to get rid of the nitrogen and phosphorous, etc., and you have to take the EDCs out too. It would enter the water column much sooner than if you were going to go downstream. How analogous is the North Shore Channel which is an effluent dominated stream. Whether the impacts of those concentrations are analogous to what we would see in the initial cell of the treatment wetlands in the Calumet Area.

A: Mr. Todd Nettesheim, USEPA: I think Calumet and North Side are pretty similar. The population is certainly a little different. I think Calumet treats Tunnel and Reservoir Plan water, and Calumet has a higher industrial percentage. Concentrations could vary somewhat, but the North Shore Channel is pretty much 100 percent effluent dominated or 99 percent effluent dominated. Cal-Sag Channel is pretty close to that but maybe a little less.

A: Dr. Thomas Granato, District: They both have seasonal lake diversion water that results in dilution. I think it is 70 percent as a general term for the waterway. I guess the North Shore Channel

upstream of the North Branch is probably the most effluent dominated during the winter. Would you agree with that, Dick?

A: Mr. Richard Lanyon, District: It would also depend upon whether you are talking about dry weather or wet weather. Dry weather conditions with both the Cal-Sag and North Shore Channel would be 100 percent effluent dominated. But with the wet weather you are going to have the CSOs and direct storm run-off into the channel or tributary run-off coming either off the North Branch or the Calumet River. It might drop down to 60 percent effluent right after a large storm.

A: Mr. Todd Nettesheim, USEPA: I think the answer to the question is that both the treatment efficiencies at both plants would be very similar and that the concentrations at both plants for the compounds we look for be roughly in the same range as well.

Q: In that analysis, can we look to the North Shore Channel to predict how the treatment wetlands will work as far as EDCs are concerned? You never know how effective they will be until they are built. Can we gain some insight by your North Shore Channel data that will be comparable?

A: Mr. Todd Nettesheim, USEPA: I think that the only correlation you can make is that the effluent concentrations at the North Shore Channel would be your influent concentration roughly going into the treatment wetland. I think you can make an estimate of what would happen after that.

A: Dr. Thomas Granato, District: We have some limited data that has actually been measured on the Calumet WRP effluent which

would be the inflow to the first cell of wetland. This was a very big project, and this is just one little window into the project that we saw. One side study that was conducted looked at treatment efficiency mostly looking at these alkylphenolethoxylates. The Calumet Plant was found to be a plant that was included in the study, and one of the most efficient or perhaps the most efficient plant in removing these compounds because of the level of treatment that is found to be a close connection between nitrification efficiency and removal of these compounds. I think the bright spot is that the Calumet Plant functions very well for plants of its type at removing these chemicals from the liquid process stream. There is a lot more data to be looked at and evaluated than shown here.

A: Dr. Heng Zhang, District: I just want to add that the environment in the North Shore Channel versus Calumet wetlands is very different. The North Shore Channel is man-made, and does not have good habitat. The treatment wetlands are shallow. We have a lot more vegetation, and the environment for the biota is very different so you will see a very different response.

Q: Are there efforts by the Federal Drug Administration (FDA) or the pharmaceutical industry to kind of deal with this issue?

A: Mr. Todd Nettesheim, USEPA: There is a lot of discussion. The FDA is a partner in the interagency efforts to look at pharmaceuticals in the environment. The FDA is part of the regulations that have thresholds. If a compound is expected to be a certain concentration in the environment, there has to be a full environmental assessment of it. Unfortunately, that threshold is very high, milligrams per liter; therefore, there have not been any envi-

ronmental assessments. That was an old regulation based on toxicity rather than endocrine disruptor effects. I think the FDA is plugged into working on researching pharmaceutical companies. Pharmaceutical companies are not 100 percent supportive but are becoming more willing to come to the table and work on it. Some are more willing than others.

Afternoon Session

Presentations by Dr. Albert Cox, District; Dr. George O'Connor, University of Florida. Dr. Cox gave an overview of the local, state, and federal regulations and guidelines that are in place for the biosolids land application practice to protect human health and the environment. Dr. O'Connor gave an overview of the USEPA's Part 503 risk assessment protocol in which 200 organic compounds were evaluated, and USEPA determined that it was unnecessary to regulate those compounds in land-applied biosolids.

Presentation by Dr. Edward Topp, Agriculture Canada (AC), "Impact of Microconstituents in Biosolids and Soil and Aquatic Organisms." Dr. Topp presented data from a study in which spiking a lake with estrogenic compounds resulted in negative impacts on the reproductive physiology of fish.

Presentation by Dr. Nick Basta, OSU, "Ecological Effects of Land Application of Biosolids." Dr. Basta presented data showing that land application of biosolids improved soil productivity and immobilized potential contaminants with no negative impacts on survival and reproduction of soil invertebrates.

Afternoon Session
Open Forum

Q: Dr. David Homer, Tetra Tech: Some of the presentations got different reactions from different types of chemicals through bioavailability and how they move through the system. Some seem to move a lot quicker than others. Is there anything that you can say about the general class of these compounds physical properties, K_{oc} values, K_{ow} values, which is something that seems to be driving their movement through the system? Is there anything that is helping us understand the fate and transport of these chemicals as they move through the environment?

A: Dr. Edward Topp, AC: The question is what kind of chemicals would we be concerned about with respect to their mobility to be persistent in the environment. The chemicals that are persistent are the chemicals that tend to bind to things, PCB-type chemicals. In that class, the basic complaint would be with flame-retardants, which nobody has talked about. They would absorb strongly in soil. Other classes of chemicals would be things like triclocarban and things that are inherently persistent that may sorb strongly to soil materials and don't move horizontally or vertically. Those would probably be high up there.

A: Dr. Nick Basta, OSU: The things that you mentioned are important. The $K_{ow's}$, $K_{oc's}$, water solubility of organic compounds, and chemical properties, pH, etc. One thing that I wanted to mention is that both organic and inorganic chemicals are found in the soil. On another note, upon aging or in the long term, the contaminant becomes less available or more locked up by soil. This also happens with metals as well. That is the general phenome-

non. Over time, some of these organic contaminants become locked up in soil-organic matter and will not be released. As organic matter dissolves, some pollutants become even less bioavailable, more tightly bound, and won't be released.

Q: Dr. Lakwinder Hundal, District: Question to Dr. Edward Topp, AC: You've shown a couple of slides that show movement of contaminants such as triclosan in soil after biosolids application. You showed that triclosan was detected in tile water minutes after biosolids application. Could you describe the physical conditions of the soil? I mean were there any visible cracks on the surface. For triclosan to move that quickly, the biosolids slurry has to move through the cracks because triclosan binds strongly to soil and is less mobile. The second question is about your valium mineralization study. You showed that only a small amount of valium was mineralized. I was wondering if your lab extracted the soil afterwards to see if valium was still present because it could get sequestered and become bound residue.

A: Dr. Edward Topp, AC: What happens to valium if it's not being mineralized? In that particular experiment, we also extracted and determined residual bound. And the answer is no, it did not become bound. Some compounds will become bound and irreversibly become non-extractable, but that wasn't the case specifically with valium in those experiments. With respect to triclosan, immediately moving to tile water following biosolids applications thereafter, I should clarify with those of you who are unfamiliar, that it is essentially by preferential flow. Essentially the soil conditions are such that you have large pores that can be created by worms and roots that have decayed and left holes and cracks in soil if you have fine textured clay soils. Under those circum-

stances, you have these preferential flow paths down to a meter, roughly four feet, where the tiles typically are at three or four feet. You have movement of chemicals entrapped with silt or biosolids. Part of what we are doing is looking at mechanisms of exposure.

Q: Question to Dr. Nick Basta, OSU: Continuing on the discussion on the age of organic matter. Would you say that not all biosolids are equal? How can they be stabilized in the organic content in nature? Is aged biosolids an advantage over freshly dewatered or dry biosolids?

A: Dr. Nick Basta, OSU: The compounds are physically trapped. We really don't have a good feel for processing biosolids. The more mummified, the more aged, I think of as stability. We want to get past the decomposition stage. After several years is better. Are aged biosolids better? The answer is yes.

A: Dr. Edward Topp, AC: I think we need to follow up on that. When biosolids are added to soil, would that influence and change that weathering and aging system and would that change the chemical environment?

A: Dr. George O'Connor, UF: I think if you consider the nature of the association of the contaminant in the biosolids, I believe it is fundamentally important to keep a very clear mind. The contaminant comes in the waste stream and as the solids settle out and are digested by organisms, etc., and assumes biosolids form, the contaminant is not put upon the surface. Essentially, I see the contaminant as a part of the material. I suspect that there can be what is referred to as a priming effect when you add easily decomposable organic material to a soil, and usually it means if you

add low carbon nitrogen ratio to the soil, you actually increase the release of soil organic matter. It would, in fact, particularly with the Chicago product as stable as it is, and again considering the nature of binding of the organics through to the product, I would suspect minimal impact. But, we are both guessing here. There has been very little work on that. We are several steps away. I thought you were headed toward the simpler concept that Nick Basta, OSU, was talking about the metal time bomb theory. There have been those who worry about the organics time bomb. Once you degrade the organics, contrary to metals, metals are associated primarily with the inorganic component of biosolids. Organics are associated with the organic component of biosolids. What happens when biosolids degrade? I would say, probably not much. First of all, it is a highly stabilized material that does not easily degrade itself. Secondly, if what you are degrading is biosolids, biosolids consists of the contaminant, then why doesn't the contaminant degrade at the same rate as the organic matter? This concept is 35 years old and bound residues have not been pursued very much with organics in biosolids.

A: Dr. Nick Basta, OSU: I don't think too many cases. Some cases where people have added biosolids with small amounts of iron with good results. Where is the contaminant exactly? Bound to an outside surface or inside of structure or it just traveling around these organic structures and then decomposing? Had we never answered those questions in past years? Some of the good work is here at Argonne showing that metals would not be released even if all organic matter were decomposed.

Q: Question to Mr. Rob Sulski, IEPA: How does the IEPA view where you put the biosolids on a floodplain?

A: Mr. Rob Sulski, IEPA: We have some flexibility on that. Basically, set back from the surface waters, in sandy soil area, it starts to restrict based on the soil type whatever you are growing. However, if there is some way of protecting pathways either through limiting leaching or runoff, we have flexibility of allowing larger applications if there are mechanisms in place to control leaching and runoff until anything leachable or runoff material becomes stabilized on site. There is some flexibility there.

Q: In this assessment, the use and application of the biosolids, is there a concern for the inhalation exposure due to fugitive emission of the particulate matter?

A: Dr. Albert Cox, District: In both the USEPA Part 503 risk assessment and in the risk assessment that was done for TACO by the CDOE, inhalation of dust was actually one of the modes of exposure that was evaluated. Yes, there is protection for inhalation.

A: Dr. David Homer, Tetra Tech: Rarely, you would find fugitive dust as being a driver for an exposure pathway that drives a risk assessment. It is usually ingestion or other more critical pathways that you really have to be concerned about in overall exposure of compounds. It's usually evaluated but rarely drives a significant proportion of risk.

Q: Are you saying that fugitive emissions are not a problem in the risk assessment?

A: Dr. David Homer, Tetra Tech: What I am saying is that it is

not the main driver of the risk. It's added into it, but it's normally a very small percentage of the overall risk that is related to the fugitive emissions.

Q: Dr. Lakhwinder Hundal, District: Let me ask a general question to the panel. Could you outline an approach that the District should take to move forward with the projects at the Calumet area that were outlined this morning?

A: Dr. George O'Connor, UF: First of all, are we talking about the wetlands portion and using effluent or the biosolids use to remediate badly disturbed lands or both. I think the use of biosolids to remediate drastically disturbed lands, you did a fine job in showing numerous examples of how it can be done to some really bad sites, superfund sites. One thing we often lose track of is when we are considering the safety of a remediation plan, we often neglect to consider what the situation is right now. When the morning presentations were going on, for instance, I thought about slag and waste. I wonder what the water quality is right now at those sites. Has anyone measured the EDCs or anything else in the water? With respect to soil remediation, it appears to me, State and City guidelines are very conservative. I have no doubt that they will work very well. I also appreciate the fact that you need to demonstrate this. You could set up some acre-size demonstration plots, and why don't you even replicate them and install some wells and apply treatments. With the exception of Baltimore, where they told those poor folks in the inner city who were dying from lead poisoning that they were using compost to protect their kids from lead poisoning. Somebody misread the risk that they had highly lead-contaminated land. The children had way above guidelines of blood levels of lead from the land. Compost product

made from biosolids was brought in to remediate contaminated land and grow vegetation on the barren grounds so the kids didn't have direct access to the lead-contaminated soil. Blood-lead levels went down, and it looked like a real success story. Then somebody accused researchers of exposing the minorities in the area to toxic biosolids materials forgetting all about the lead in the soil the children were exposed to prior to biosolids use. A couple of acres of demonstration plots, I would really want to see before moving forward at full scale at Calumet.

A: Dr. Nick Basta, OSU: I agree that there are some unique things that probably need to be demonstrated. We have different receptors such as birds, wetland areas, material hazardous, and mobilizing lead or other pathways. Some of these things can become more site specific. There are always site-specific questions that have to be grasped and experimented with. Demonstration done with replication of treatments because each site has its own unique qualities.

Q: David Homer, Tetra Tech: I suggest that we have some sites to do testing such as Harborside. Some of the sites, we can go back to and evaluate those sites to speed up the process. I know that demonstrations are great. What are your thoughts?

A: Dr. Edward Topp, AC: The bottom line is if people are concerned about the wetland proposal as this unique foreign body and how it is going to react to having effluent there. I think the answer would probably be, we don't know. I am not being a toxicologist, but that probably would be the answer. So you probably would want to see some demonstration experiments that are done at a scale of study that would encompass all of the biology that

people are concerned about including migratory birds whether that is feasible. It could be that the effects of eutrophication would be far more significant to that system than these original demonstrations are. I would have a fundamental question about how effective the wetlands would be for disposing of nutrients and exotic chemistry during the winter when I presume things get really cold here. I don't see it being effective, but maybe I'm missing something.

Q: Considering the fact that tolerance is on a sliding scale among populations with time, 35 or 40 years ago when they put slag, it probably was okay based on the current knowledge. Are biosolids the slag of today? Thirty years from now, will they say, "You put biosolids there? You have all those contaminants that you knew nothing about?"

A: Dr. George O'Connor, UF: Biosolids are probably the one class of waste products that has been studied more than anything I am aware of, and subjected to scrutiny more than anything I am aware of. Is it possible that there is something in biosolids that we haven't found yet that can ultimately come back and bite us? Sure, it is possible. If you can understand, you can never prove a negative. What I try to do with the public is try to find some level of comfort for them. We have a practice that if it is done well and done according to the rules that are in place in this State and region and has a track record of three to four decades with no problem, this practice is more than adequate and will handle the obvious problems. I also believe in risk assessment. I see no glaring holes in that risk assessment. Look at projects that have been going on for decades and using much worse quality material than we are dealing with today. There are much more liberal man-

agement application practices. Still, there is no documented human health effect and there are no uncontrollable or unmanageable effects. Ecological, particularly the aquatic organism, birds, that is still the biggest thing. Very difficult to get that work. As researchers, we live from one project to the next. I think it is only fair to say, try to put the risks in some order. You choose how you want to spend it. Grab my opinion, and probably you are going to find at the end of this discussion, good stable product and when biosolids are used at agronomic rates following proper setbacks, I think the risks will be minimal.

A: Dr. Nick Basta, OSU: I agree. I worry that 30 to 40 years from now people may say that you had this wonderful product, but you chose to do nothing. I am more concerned about doing nothing rather than taking a small risk especially when this material has such a good track record. In terms of risk-benefit scenario, the benefits outweigh the risks by far in this case.

Q: Are you all aware of any field study that measured soil invertebrate structure before and after application of biosolids?

A: Dr. Nick Basta, OSU: I can't think of any. But there are many earthworm studies done. They all show that earthworms did better in the biosolids treatments.

Conclusion

Mr. Richard Lanyon, District: First of all, I want to thank you all for attending. I would like to thank Ms. Nicole Kamins for raising this issue, and I would like to thank the U. S. Fish and Wildlife Service

for sending in the two letters that I received that got Ms. Kamins excited so that she can raise this issue; and here we are addressing a number of these questions. Where do we go from here? Yes, what next? Well, I think we have just begun the dialogue on these issues, and we need to continue. I will commit the resources of the District to pursue these issues. Working with the CDOE, we will address what we can as we have heard from our experts today. We don't have answers to some questions and it will take time to investigate them. So, we will pursue those. Now, we've initiated a dialog with the City on this project. We also have been working for several years on a project with a group called, "The Wetlands Initiative" on a wetland creation down near Hennepin on the Illinois River. We are also involved in the development of two wetland projects in the Lemont and Lockport areas, which will use water from the Sanitary and Ship Canal for treatment wetlands in Salt Creek. I know that there are organizations like the National Conservancy, etc. that are working on wetlands along the Illinois River, and the Corps of Engineers involved in the Upper Mississippi River, Illinois River Restoration Programs where they are working on wetlands. So, these questions are not specific to the Calumet project. These are questions that should address all these areas. Something is going on out there and I'm sure some agencies or organizations, if they haven't faced these questions already will be facing them soon and maybe they will be addressing these questions. We will be watching the progress on these projects and seeing what information can be retrieved from them. Mentioning the names of several federal agencies, U. S. Fish and Wildlife Service, USEPA, Corps of Engineers, etc., we need the national offices to address some of these issues because it may affect us here in Illinois, the Midwest, the folks on the East Coast and the West Coast, and the Gulf Coast as well.

Also, I want to thank all the panel speakers today for your excellent contributions. On a planetary scale, we are dealing with global sustainability and the issue of using treatment wetlands for nutrient reduction is one of global sustainability because the other option we have to remove nutrients is conventional technology which consumes a lot of energy. As a member of the Planet Change Taskforce, I know how important an issue of climate change is for the Mayor and the City of Chicago. I want to see what we can do at the District to reduce our dependence on fossil fuel electrical energy. And as we cascade down this inverted triangle or pyramid, the next thing is quality of life and so it does seem that the effects of climate change are going to affect our quality of life. Then we get down to the more local watershed scale. We are talking about stream health which affects our waterway system, the Illinois River which takes the urban drainage from our area down through the State, and I think we can improve stream health not only in our own area but also down river. I think this could be a project that could improve the ecological health of the Calumet Region. And, of course, we will get down into the details of the project with the perspective of the District. This is my vision of where we are going. With that, I would like to invite my dear colleague, Ms. Suzanne Malec-McKenna, CDOE, to present the perspective of the State.

Ms. Suzanne Malec-McKenna, CDOE: Over the years, working on a range of things at Calumet, we have been through a ton over the past years. To build on what Dick said and get a general understanding of what I heard and what went on today, the bottom line is, you guys are just looking for more work. These researchers want to keep busy for the rest of their life, because it is going

to be a long haul as we continue to study this. I thought we were going to come in and say we've solved it all. We have our concrete answers and formula, and we are done. Of course, I didn't expect that because that is not what happens in nature and certainly is not what happened at Calumet and never has. I would like to prove a perspective about what we love to say is an ecological lemonade. We would like to make lemonade with our opportunities here. In 1998, a bunch of government agencies got together and called ourselves the Big Marsh Working Group. We got together because Big Marsh is blank and it was a technological nightmare. Of course, after several weeks, "We said well what about everything else?" At that time, the only land in public ownership of ecological value in that area was at Heron Pond and Lake Calumet. Now, ten years later, we have:

- Van Vallissingen Prairie, 140 acres,
- Hegewisch Marsh, 130 acres,
- Big Marsh, 290 acres,
- Herron Pond, 50 acres,
- Indian Ridge Marsh, 140 acres,
- High Wing Wetlands, 50 acres,

which amounts to 800 acres of land. It is the City ownership that has the potential. We know it has potential because regardless of what happened in its past; it is still supporting some ecological functions. Now the question is, "what do we do with those opportunities?" Another hat that I have been wearing a lot lately has been our climate action plan. As we said, in 1979 we knew there were energy issues. It seems like, in the past year, people all understand that it is no longer an argument. Is there anybody who is going to tell me that there is an argument that climate change ex-

ists? This morning, I spent time looking at what is going to be our carbon offset fund for the City of Chicago which we hope to expand to the Chicago Region in the next three years. The hot thing that came up there was the opportunity for grassland, looking at our slag cover. We have 33 billion cubic yards of slag in the Calumet Region. It is not going to be dug up and taken away. What is that? In essence, it is a green roof in Calumet because it is impenetrable, highly alkaline, maybe it is our prairie now. What is it? There are opportunities there to make something of the site that is currently barren and has no ecological value and that could be done by a combination of biosolids, soils, etc. and to put on top of that, a range of different species. What we've done, and we are actually going to see Dr. R. K. Pachauri (Chair of the Intergovernmental Panel on Climate Change) next week. He got the Nobel Prize last year. We have down scaled the international and national data to Chicago and we know what our carbon footprint is for the City and the region. We know how many million metric tons of carbon we need to reduce to play our part in the overall goal of climate change, mitigation and remediation, etc. Those areas for Chicago are residential, commercial, industrial, transportation, renewable and alternative energy, and waste and pollution. You look at the choice of biosolids versus soil stripping. One thing that a lot of carbon bankers are looking at now, how you can utilize smart growth as an actual banking credit (As opposed to going out into the greenfield and developing more.). Revitalizing your urban centers and bringing different types of waste product together that can serve in a functional capacity in soil structure and provide the habitat amendment. Provide the carbon sequestration opportunities:

- first is dumping them somewhere, or

- the hard engineering solution with biosolids, with effluent, etc., which is treat it, pump it, treat it, pump it.

What are the energy implications for that? Huge energy implications! We know that in the City of Chicago alone, we have a major mitigation strategy to reduce energy usage. How do we link those things together? How do we think about our ecological goals, our environmental, our economic goals and our waste goals? How do all those interconnect? Well it just so happens, we have this place called Calumet that has always interconnected and intercepted. It is messy and challenging and when we started in 1998, we had our first research summit in 2000; we said we have to learn about hydrology, we have to learn about sediments and toxicology, and from there we got a hydrologic master plan. We purchased land. We did an ecotox roundtable. Many of you were part of it. We've come a long way baby, but we have a long way to go. I would like to think that we are less daunted than we were ten years ago. We are less overwhelmed by the challenges of combining these efforts in order to achieve goals and now adding the climate change challenge to that, there is even more opportunity that we can gain as we address these issues together. I used to use this word, "rehabilitate" instead of "restore" because there is a big debate in restoration in the Chicago Region. But in this case, it is a good one to utilize and keep in mind. We are taking sites that are severely degraded, some have no ecological value such as total slag fields, other contaminants, etc., and somehow the critters are still there. But what could be possible if we made more space available? What could be possible if we expanded our grasslands, we expanded our wetlands? What could be possible in carbon sequestration? An ecological benefit in water quality in returning water to the lake and recreational op-

portunities? Think of all the incredible benefits that go along with this. Again, I can tease you scientists in the group, which is most of you, and say you have a big long career ahead of you and I am glad because we need to continue to work on this together and solve it. But in order to go the next step, it seems to me that it is time for a substantial pilot. We have the places for you to do that. I think we have the will, the inclination, the energy, the enthusiasm, and even some resources. What we ask of all of you is to continue to help us in that dialogue and to continue to help us think through what needs to happen. Your brain will hurt but, I think at the end of it, you will determine we have achieved some accomplishments. We always take risks in the work that we have been doing together in the past ten years, not knowing how things would end up. I think each effort that we have undertaken has come out with products, solutions, ideas and creativity that we would have never have imagined would have happened. I think that this is a great opportunity from all the gathering of information, the thinking, to now apply it specifically to sites. It seems to me that the next step is to take this assembled body of brains, resources, ideas and opportunities to look at how we can go forward with this specific project. Talking to Nicole Kamins, what I heard was the potential of looking at our ecotox team, who ever thought that they would be sticking around with us this long. But thinking about, are there people in the audience who might be willing to continue this conversation with us as we specifically look at sites and direct applications, taking the work on Collateral Channel, Bubbly Creek and Calumet, and the work that Dick mentioned in other locations. All of those are case studies which need other cases to compare to, as we move forward. As someone said earlier, 30 years from now we will be saying, “You had the opportunity and you didn’t do it. You stripped for soil in order to

make it happen or you did nothing." I think that is absolutely what we need to think about here. We have a tremendous opportunity in a period of shrinking government dollars as well as a tremendous opportunity in the market to take advantage of resources that can help us leverage better plans, better ecology, and better opportunities. So, I hope that is the direction we will go from here. Thank you very much.