APPENDIX A

Proceedings of Expert Consultation: Effectiveness of Wastewater Treatment Plants for Removal of Chemicals of Emerging Concern
January 25-26, 2011 – Romulus, MI

The meeting began with introductions and a review of the charge from the Commission. The charge is:

(1) to perform an analysis of WWTPs that discharge to the Great Lakes with respect to the effectiveness in reducing CECs and to identify treatment technologies that can enhance their reduction, and (2) assessment of potential ecological and human health impacts.

The information gained from these objectives will provide the Parties with a sampling of the information that may be derived if a more fulsome evaluation was undertaken.

The purpose of the meeting was to determine findings and recommendations, based on the projects carried out by the WWT work group, which will be included in the June draft report to the Commission.

Five projects were discussed:

1. Inventory/database of POTWs and GIS maps
2. Detailed survey of POTWs in the Great Lakes basin
3. Literature survey of CEC treatability information
4. Government and WERF projects
5. MOE/EC study

Inventory/database of POTWs and GIS maps

This project attempted to determine the number of WWT facilities that discharge into the GL basin, where they are located and the type of treatment practiced. In order to do this the GL watershed area needed to be defined. The goals for the project were to: a) create a database of all municipal POTWs which discharge in the basin and b) develop an interactive map for possible use by the public and the IJC. The Ontario map and database is complete and based on an existing database from the Ontario MOE and EC, which included a total of 470 facilities in which 59.7% operated at a treatment level of secondary or above. The data obtained for these facilities included treatment type (lagoon, primary, secondary), population served and average/max flow rates. The population boundaries were not based on provincial cut offs but were derived from the government database.

The data for the US facilities was coordinated with that of the data available for Ontario. The US data was pulled from the USEPA Clean Water and Clean Watersheds Needs Survey, which contained much of the same information as that of Canada. One of the main challenges was that some of the information was provided in US databases, but not in Ontario and vice versa. The Ontario database tended to be more specific. Filling in the gaps to make the information comparable on either side of the basin still needs to be addressed. There were also issues with differences in definitions of terms used by the US and Canada. For example "discharge mode" in the US includes open water or land, where as in Ontario this is defined at seasonal or continuous.

The types of US WWTP processes were defined only as secondary and advanced. However, there are an additional 375 plants that fall into the category of "not assigned", so it is currently unknown how many primary and lagoon facilities there are. Elizabeth Toot-Levy of the NEORSD indicated that she may be able to help with the ~230 "unassigned" facilities located in Ohio. In her preliminary look at these facilities she determined that some of them were not necessarily municipal works such as restaurants, apartment buildings or schools which is beyond the scope of this workgroup for the current cycle. Additionally, places with low populations were missing data and some of the cities included in the database are not in the Great lakes basin.

Henryk Melcer inquired about using "fact sheets" that are included in the reporting requirement by plants to be used to fill in gaps in the data. Nick indicated that these were looked at, but much of the information is not comparable to Ontario or cannot be used for comparative purposes. Another challenge was limited expertise in interpreting the data on the factsheets.

A US map was generated; however it shows only approximate locations of plants to give a general idea of the density of plants around the basin and does not indicate treatment types. The goal is to get the US side to the same level as the Ontario side before the end of the cycle.

NEXT STEPS: It was agreed by the group that someone with expertise in WWT treatment needs to handle the /interpret the data and fill in the information gaps for preparation of the June draft report.

Detailed Operational Survey (Brown & Caldwell)

Operational data for 25 WWTPs around the GL basin was collected to help determine effectiveness of WWT process in reducing CECs, based on operational parameters. Henryk commented that the response rate from facilities was excellent (25 of the 33 contacted) and felt that was due to the IJC's involvement in the project and their standing in the GL community, as Veronica mentioned the IJC in her initial stages of contacting plants.

Facilities were selected based on geographic distribution, treatment type, size, and disinfection technology which were not entirely representative of population distribution. Some of the operational parameters that were requested included, Q, T, TSS, BOD, HRT, SRT, F/M, etc. From the information collected it was possible to draw general conclusions as well as to make inferences regarding WWTP's effectiveness at removing CECs.

Activated sludge (AS) was the most common secondary treatment technology used by the group (17/25 plants), which included nitrification, BNR, or membrane bioreactors. In general, plants with a higher SRT (>5 days) are more effective at reducing biodegradable CECs, which is attributed to the greater diversity of bacteria present at higher SRTs. There is also a correlation between ammonia removal efficiency and that of biodegradable CEC reductions. Plants discharging effluent with low ammonia concentrations tend to be more effective at CEC reduction. This is a result of the requirement to have higher SRTs to allow for growth of nitrifying bacteria. Ammonia removal may be used as indicator of CEC reduction. The second most common treatment technology used was biological fixed film (4/25). One of these four plants used trickling filters which does not achieve effective reduction of CECs due to its low HRT. The other three plants used biological aeration, which is a more advanced technology but requires more research to make a definitive conclusion about its CEC removal capacity. The remaining plants surveyed were lagoon systems (2) and primary systems (2). The operational survey also showed that smaller communities utilizing well operated lagoon systems can also achieve the same level of treatment (i.e. BOD removal, ammonia removal) as larger more advanced treatment plants (Example, Muskegon plant).

OVERALL CONCLUSIONS:

- Removal of biodegradable CECs is related to high SRT
- Plants that remove ammonia efficiently also have a better capacity to remove biodegradable CECs.

Literature Survey and Synthesis (University of Arizona)

Literature on the effectiveness of various WWT technologies on CEC reduction was collected from several sources including journals, conference proceedings, and government/agency reports with the main source being scientific journals. A total of 800 documents were collected and 500 were used to make-up the database. The criteria for screening was (1) the publications present information about liquid phase removal (influent vs. effluent), process type, and operating conditions, and (2) publications with occurrence data only were not included. It was found that there was limited data available for PFOS, PBDEs, and, CPs.

The database is organized by compound and treatment type and differentiates between removal and destruction of contaminants as data on complete removal was difficult to find. The database includes information on CEC reductions, K_{ow}, Henry's Law constant (k_H), treatment scale (lab, pilot, full), and biodegradation. When biodegradable CECs are excluded from consideration, an analysis of the database indicated that compounds with a low log k_H (< -7) and low log K_{ow} (<3.5) are difficult to remove from the liquid phase. Conversely, a compound with a high log k_H (>-7) and high log K_{ow} (>3.5) is more easily removed, likely due to adsorption. Therefore volatility and hydrophobicity can be identified as quantitative factors affecting compound reduction, although hydrophobicity shows clearer trends.

It was determined that operational parameters (i.e. SRT) play an important role in CEC reduction and further analysis is required to determine trends. It was also determined that quantification of biodegradability could be used as a measure of effectiveness for CEC reduction, but more data is required for most CECs. The study determined that a lot of information is available on antibiotic compounds and demonstrated that hormones are very well removed. The combination of volatility, hydrophobicity and biodegradability make it difficult to make conclusions about compounds.

NEXT STEPS: University of Arizona is in the process of creating their synthesis report that will include the information presented at the meeting.

OVERALL CONCLUSIONS:

- In order to make clear inferences ranking problems by probability estimation tools is the direction we need to move towards and,
- Explaining how to use this data tool is important for creating a powerful communication tool

Throughout the meeting Lana advised that the report ultimately generated by this group should be "useable" – i.e. will the government be able to act with the given information? Will the report provide direction of research investment? She emphasized the importance of linking the data to human health in order to inspire government action. She also indicated that a portion of the report should address over-arching issues such as climate change, lake levels, CSOs, biosolids,etc. Additionally, she indicated that "real-life" examples of BMPs, where an investment was made and a beneficial outcome attained, are useful to include in the report to the Commissioners.

Government and WERF Reports

The US EPA has created a literature review database on WWT technologies and their CEC removal rates. The database contains primary sources in which 88 were selected out of over 400 that were reviewed. Overall, the database contains information on 246 CECs.

WERF has published a number of reports pertaining to WWT plants and CEC removal. They are currently working on developing a list of CEC indicator compounds which would be useful for providing an indication of CEC removals. The report is expected to be released at the end of next year.

MOE Study

This study is an evaluation of the removal efficiencies of different treatment technologies at pilot and full scale wastewater treatment plants in Burlington and Windsor. The study is conducted in collaboration with the MOE, EC, University of Waterloo and University of Windsor and examines influent, effluent and primary sludge samples for 200 different contaminants. The purpose of the study is to understand the environment and health impacts of these contaminants, as well as the efficacy of WWT processes to reduce CEC concentrations.

In Burlington the study began in June of 2010 and is expected to be completed in February 2011. In Windsor the study is expected to be completed in November 2011.

EC Study

This is a life cycle study under the direction of Joanne Parrot.

1000L of effluent are collected every week . Under controlled conditions, it was determined that fish in Burlington were laying half the amount of eggs as in Windsor. It is uncertain what contaminants were causing this change in breeding.

CEC WWT Meeting – Conclusions and Recommendations January 26, 2011

Notes:

The objectives of this day's meeting were to develop a consensus on findings and recommendations concerning the effectiveness of WWTPs in the GL basin for the reduction of CECs. Henryk Melcer and team members will prepare the draft report and provide it to the IJC multi-board workgroup for comment and review. This draft will provide the basis for the report to be submitted in June to the Commission.

CONCLUSIONS

1. Identify the levels of treatment (on a percentage basis) in each of the countries.
   In Canada 55.9% of plants have secondary level of treatment or better
   In the US 70% of plants have secondary level of treatment or better

2. Identify the proportion of the population served by the various treatment types.
   The largest proportion of the population is serviced by state of the art treatment plants as such, the Great Lakes is primarily receiving effluent from good systems. Note that the database will be analyzed for treatment type versus wastewater flow or population.

3. The percentage of flows discharged from the various treatment types.

It was suggested that perhaps the design Q noted on facilities' discharge permits could be used to accomplish this. It was also suggested that a statement be made in the report to clarify that not all discharges to the GL from WWTPs may be treated, due to CSOs or sewage by-pass events and that industrial flows were not included.

4. Of the 25 plants surveyed 17 use advanced treatment technologies (i.e. AS) and are expected to have effective biodegradable CEC reduction, based on additional information from WERF reports.
   It was also noted that the survey is not a statistical representation of the plants in the basin and therefore basin-wide conclusions cannot be made. Additionally, plants with negative practices may not have volunteered to contribute and thus, the data may not accurately reflect the amount of inefficient practices in the basin.

5. There are a mix of plants that are operated very well and some that are not.
   There was discussion that communities should not be singled out by name regarding their plant operation performance, as this may hinder compliance for future information requests. However, if major gaps in treatment technology are identified (e.g., very large facilities designed for BOD removal only), such concerns should be raised.

6. CEC reduction is technology specific.

7. Primary treatment does not adequately reduce biodegradable CECs.
   Suggestion to make a recommendation to upgrade all primary plants in the basin.

8. Plants that operate at a higher SRT will have a greater reduction in CECs.

9. Conventional parameters are useful for determining biodegradable CEC reduction (i.e. BOD removal), however other/different indicators are required for the non-biodegradable compounds (i.e. carbamazepiene).

10. There is a lack of information/data on biodegradability of compounds.
    Approximately 250 of the 300 compounds analyzed in the literature review lacked data on biodegradability. Note that additional steps are being taken to provide more complete information.

11. There is a correlation between log K_{ow} and probability of removal by adsorption to sludge.
    There was mention of how to correlate lab scale results to field results.

12. There is a need to balance benefits of updating WWTP's technology to achieve improved CEC removal with the costs.
    There are not only capital and operation costs associated with plant upgrades, but environmental ones as well, such as increased NO_x and SO_x due to increases in energy

requirements to operate equipment. Preventing CECs from entering municipal treatment plants (e.g., pretreatment) should be explored as an option for cost effectiveness.

13. The probability of removal plots developed by the University of Arizona is a useful tool to help facilities determine percent removals of various CECs.

14. It is often stated that WWTPs are not designed for the removal of CECs, rather they are designed to comply with permit discharge requirements. However, even conventionally designed plants that are well operated are capable of achieving effective CEC reductions.

RECOMMENDATIONS

1. Look at the contribution of industrial flows and CSO/by-passes to CEC loadings to the Great Lakes for the next priority cycle.
   Jim Vukmanich indicated that Ontario is beginning a new reporting program (MUMPS) in which facilities report CSO and sewage by-pass data. Marc Mills indicated that some cities in the US are also required to submit by-pass flows. The suggestion was made that data from the upcoming MUMPS program for Ontario may be used to help gather data on CSO events.

2. Primary treatment facilities should be encouraged to move toward upgrading to secondary treatment, perhaps with advanced treatment technologies. It is also recommended that secondary plants upgrade to include biological nutrient removal processes and other process optimization in order to improve reduction of biodegradable CECs.
   It needs to be clarified in the report that the recommendation of facilities to implement BNR is based on reports in which BNR leads to improved reductions of biodegradable CECs.

3. Sampling and analysis to determine CEC reduction during WWT should be conducted and done in conjunction with surrogate indicators (i.e. ammonia, BOD).

4. A list of criteria needs to be developed to define “indicator CECs” which could be used as surrogates to determine effectiveness of CEC removal (i.e., in addition to the conventional parameters of ammonia removal, BOD removal).
   The use of WERF reports to aid in this process was recommended.

5. Biosolids need to be considered a source of CECs to the environment as many CECs tend to adsorb to biomass. This is recommended for the next cycle.
   The movement of CECs through a WWTP needs to be measured as a mass balance through the plant. Biosolids are either land applied, landfilled or incinerated. Of particular concern are their land application and the potential for these CECs to re-enter the environment.

6. A list of CEC indicator compounds should be determined in order for plants to assess their treatment process regarding effectiveness of CEC reduction.
   Several issues arose from this including; the cost to have this analysis performed, lack of labs able (having the methods) and willing (some are worried about contamination of their equipment) to do the analysis. It was determined that (1) a list of indicators needed to be generated (2) methodologies need to be in place or developed (3) need the capacity to do the analysis and (4) need standard protocols in place for sampling and analysis. The compounds identified as "biodegradable" from Mario and Eduardo's work may be a starting point for the creation of the list. This list would need to be periodically reviewed for relevance and in light of improvements in analytical methods.

7. CEC research is available on ecological/toxicity effects, effectiveness of WWT technologies, and occurrence, but all this information needs to be matched-up/combined for the various CECs.

8. CECs found to be difficult to remove should form the basis of a list of compounds that require the development of a risk management strategy.

9. Further risk-based analysis of compounds needs to be conducted especially in regard to human health.
   Although these compounds are being discharged to the environment, are they posing a threat? At what concentrations to do they cause adverse impacts to human and aquatic life?

10. Biomonitoring of CECs needs to occur. For example, bioassays of wastewater effluents could be used in combination with chemical analysis.
    These studies should also take into account seasonal and temporal effects.

11. There is a need to have standardized methodology, including validated protocols, for the analysis of CECs. Further, there is a need to increase capacity in contract analytical laboratories.

12. Compounds need to be sorted according to those that are highly consequential in small concentrations (i.e. estrogens) versus those that are not (i.e. caffeine).

13. The use of advanced oxidation processes for reduction of CECs needs to be further explored.
    Research has shown that certain types of oxidation processes can generate by-products that are much more toxic than the parent compounds. These studies need to include bioassays in combination with the chemical analysis.

14. Research into the contribution of CSOs and sewage by-passes to the loadings of CECs to the Great Lakes needs to be conducted.
    The contribution of CEC loading by CSOs and sewage by-pass may be greater than that of WWTPs.

15. There needs to be an increase in public education regarding the use of PPCPs, their entrance into the environment and the wastewater treatment process.
    This public education would also include manufacturers in terms of promoting green chemistry. In addition, increasing public awareness of the CEC issue may in turn place pressure on manufacturers to produce more "green" products. With increased education, people care more about issues, inspiring governments to take action. Although health effects research to date is lacking, the "yuck factor" such as the feminization of fish, is enough to initiate citizen concern to encourage government action. A concrete example of public education at the community level is pharmaceutical drives.

16. Look into the feasibility of WW pre-treatments for facilities that would contribute high loadings of CECs to WWTPs (i.e. hospitals, nursing care facilities, laundries, etc).

ADVICE FOR FUTURE MEETINGS

- Would be great to have better Canadian representation
- The preparation slides were very helpful
- It is beneficial to get all of the technical information and presentations over with at the beginning
- It is important not to lose sight that in the end everyone is working to protect the Great Lakes.

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